NIKHEF-85

NIKHEF

NATIONAL INSTITUTE FOR NUCLEAR PHYSICS AND HIGH-ENERGY PHYSICS

1985

ANNUAL REPORT

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Scientific Report of the High-Energy Physics Section (NIKHEF-H)

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The National Institute for Nuclear Physics and High Energy Physics (NIKHEF) is a collaboration of FOM (Foundation for Fundamental Research on Matter), the University of Amsterdam, the Catholic University of Nijmegen, the Free University of Amsterdam and the Foundation Institute for Nuclear Physics Research (IKO). The laboratories and the linear electron accelerator (MEA) are located in the Science Research Centre Watergraafsmeer (WCW).
The Institute is operating since 1975. It has its own board and is managed by a directorate. About two thirds of the research activities is funded by FOM, the rest by the university partners.
Experimental High Energy Physics within the Netherlands is concentrated in NIKHEF section-H.
NIKHEF section-K is one of the two national centres for Nuclear Physics. Its research activities are coordinated through the national working group on Nuclear Physics.
Scientists from the State University of Utrecht (RUU) and the Delft University of Technology (THD) are also collaborating in several research programmes reported here. A formal collaboration of these universities within NIKHEF is expected for the near future.

The Directorate,
W. Hoogland,
J. Langelaar,
G. van Middelkoop.

HIGH ENERGY PHYSICS (H)

H.1. Preface

The scientific policy of the section-H of NIKHEF has been characterized in the past years by a far reaching concentration of its experimental activities. This is partly due to the ambition of the institute to use the unique opportunities offered by the new European accelerators LEP and HERA. These set new scales in the size of detectors and their sophistication. To free manpower and honour financial commitments it is necessary to stop current projects. This process, however, is amplified by a very significant reduction in the exploitation budget provided by FOM, the main funding agency of the institute.

In 1985 it has been decided to participate in ZEUS (one of the two detectors planned at the DESY electron-proton collider HERA). This decision became possible, because of a special grant from the ministery of Education and Science in the framework of the IAS, a new governmental initiative to set up a fund for large investments in projects initiated by para-university institutes. The IAS investment included apart from a contribution to the construction of the detector, a contribution to the cost of manufacturing the superconducting correction coils for HERA itself, the other half of these costs being covered by the ministery of Economic Affairs. The approval of the funding request for HERA is the result of a long process in which NIKHEF has actively promoted a collaboration with Dutch industrial partners for setting up an industrial base for applications in superconducting technology.
A letter of intent for the ZEUS detector has been submitted to the DESY Physics Research Committee. It will be followed by a detailed technical proposal to be ready in April 1986. NIKHEF has been able to play an important role in the overall design of the detector and in particular the design of barrel- and forward calorimeter.

As a consequence of the policy of concentration of efforts several experiments have been finished by the end of 1985 or will gradually be phased out in the coming years.
The bubble chamber era has come to an end in the Amsterdam laboratory by terminating all the scanning and measurement activities at the end of the year, leaving only the final analysis to be completed. In a similar way the hybrid EHS bubble chamber experiment will see its scanning and measuring activities stop in Nijmegen by the end of 1986.
The bubble chamber work has been for 25 years an important and in the beginning phase a dominant contribution of Dutch physicists to experimental particle physics. At the end of this period it is good to remember the important contributions of the bubble chamber experiments, including the ones in which Dutch physicists were involved, to our present understanding of subnuclear physics.

1985 has been the last year in which NIKHEF is actively participating in the MARK-J experiment at the PETRA e^+e^- collider of DESY. Lack of funds makes it unfortunately impossible to continue the participation of the institute during the last year that PETRA is running and in which the MARK-J detector may collect interesting physics using a newly installed high resolution vertex detector.

The TPC/PEP9 two-photon experiment has seen a good year of data collection. With the end of the data taking in February 1986 also the NIKHEF presence at SLAC has to come to an end. An analysis activity for PEP9 data has been started in Amsterdam.

At the SPS the ACCMOR experiment has continued to take data using a trigger on the production of charmed particles using the FAMP 2nd stage microprocessor trigger developed at NIKHEF. At the SPS collider, UA4 has taken data for the last time during the so-called ramping mode of the collider. Data have been collected on elastic scattering of protons on antiprotons at the highest energy so far reached.

The NIKHEF participation in UA1 will continue also after the completion of ACOL which is expected to raise the luminosity by a factor of ten. NIKHEF is contributing to the 2nd stage trigger for the upgraded detector. In order to set up an analysis facility at NIKHEF much effort has gone in the development of graphics software for Apollo Personal Workstations. This work is coordinated with similar activities going on for the LEP experiments.

In 1985 the amount of beam time given to LEAR has been very satisfactory. A large part of the experimental program of SING (the LEAR experiment, in which NIKHEF is participating) could accordingly be completed. In 1986 the last data will be taken.

Work on the LEP experiments has continued successfully. The production line for the L3 muon chambers has been set up. There is good hope that the tight production schedule can be met. Progress on the design, prototyping and production of the electronics is also very satisfactory.

For the DELPHI detector the work on the RICH proceeds very successfully. Major decisions have been taken on the sharing of responsibilities for the construction of the Barrel-RICH. NIKHEF will construct the outer cylinder of the Barrel-RICH, a challenging project in view of the size and the tight tolerances. The NIKHEF design for the small drift chambers reading out the Barrel-RICH information has been adopted. Finally the prototype of the inner detector has been succesfully tested at CERN in a magnetic field using the laser test set-up developed at NIKHEF. The behaviour of this jet chamber was as anticipated on the basis of calculations.

In general the progress of the experiments in which NIKHEF-H is participating as well as of the development and construction activities is going very well. A continued source of problems remains the funding situation. Although the ministery of Education and Science, through the special investment budget (IAS), has guaranteed a large part ($^2/_3$) of our financial commitments to the LEP and HERA experiments, the situation for the remaining third is worrying due to the deteriorating forecasts for the exploitation budget provided by FOM. Since this also affects the number of staff that can be paid there is a very serious threat to our international commitments.

W. Hoogland.

H.2. Research on ν and ν̄ interactions with deuterium in BEBC

WA25 Collaboration

At the end of 1985 the collaboration had measured 80% of the ν̄ and 90% of the ν pictures from its last exposure in 1983. The Data Summary Tape for this exposure contains 13,000 interactions of the ν run (67% of the total) and 4,000 interactions of the ν̄ run (45%) of the total. In Amsterdam the scanning and measuring activities were finished in December 1985. In total 5,378 (1,134) interactions of the ν (ν̄) run of 1983 were put on DST as the Amsterdam contribution.

Improved methods to use the picket-fence are under study. They will be applied in the last stage of the analysis since THIRA, the program that associates tracks with the picket-fence and the EMI hits was frozen for the sake of uniformity.
The percentage of events that cannot be identified on an individual basis as CC, NC, or hadron-induced amounts to 20% (13%) for the ν (ν̄) run. A further improvement of this percentage is expected.

The analysis of the pre-1983 data has resulted in 4 papers published in 1985. The results of two of these were discussed in the previous annual report. The other two deal with

(1) The fragmentation of the hadronic system into strange particles in ν and ν̄ CC interactions with protons and neutrons . This is in general well described by the predictions of the Lund fragmentation model. In this analysis some parameters of the model have to be given slightly different values from those obtained in other experiments. A large disagreement is found with the predicted value of the Σ(1385)/Λ production ratios. A part of the large cross section for Λ production in ν̄n scattering can be explained from the strange sea component of the nucleon.

(2) The evolution of the structure functions of the proton to leading order in perturbative QCD using the Altarelli-Parisi equations yields in principle the free parameter Λ of the theory. Our experimental data are well described by perturbative QCD with a value of Λ ranging from 100 to 300 MeV.

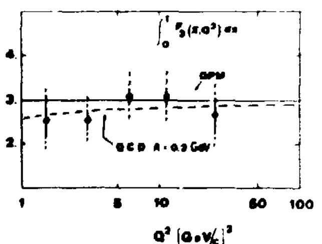
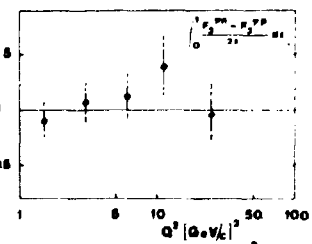


Fig. H1a). Test of the Gross-Llewellyn Smith sum rule versus Q^2.



Test of the Adler sum rule versus Q^2. Fig. H1b).

Moreover the Gross-Llewellyn Smith sum rule (number of quarks in a proton is 3) and the Adler sum rule (number of up-quarks minus number of down-quarks in a proton is 1) could be tested. These rules were verified at several Q^2 values and the predictions are in agreement with the data. Fig. H.1a shows our data for the Gross-Llewellyn Smith sum rule, fig. H.1b those for the Adler sum rule.

Apart from the investigations published in these papers we report on the following subjects.

Further work was done on the so-called EMC effect (the observation that the nucleon structure functions measured for nucleons in heavy nuclei are different from those measured in deuterium). Antineutrino-Ne scattering data from the WA59 collaboration is compared with our antineutrino D scattering data. The statistics is doubled, compared to the previous paper. The conclusions that no evidence for the EMC effect is seen, is confirmed. Similar work on neutrino interactions is in progress.

Deuteron properties are studied using our ν and $\bar{\nu}$ interactions. Current models are able to explain the data, such as the spectrum of the spectator protons, rescattering protons and prompt protons. No evidence is found neither for the existence of a Δ–Δ structure in the deuteron nor for the existence of deuterons in the final states.

Further studies are being carried out on the experimental detection of effects due to the concept of formation time (no evident disagreement), production of A1 mesons (evidence), production of bare 1-prongs in $\bar{\nu}$ CC interactions ((11.8±0.7)% compared with (12±2)% in a previous determination).

H.3. European Hybrid Spectrometer (EHS) (NA22)

The experiment studies π^+, K^+ and p interactions at 250 GeV/c with H_2, Al and Au targets. A total of 700000 triggers had been recorded in two running periods. In 1985, the measurements of the K^+ and p samples of both running periods were completed, the measurement of the π^+ sample was started.

The reconstruction chain has been further improved. First results have become available on charged particle identification and on π^0 reconstruction.

The physics analysis has started and includes the following first observations.

(1) The non-diffractive multiplicity distributions for π^+p and K^+p interactions at the highest available energy are well described by negative binomial functions and follow the trend observed by the UA5 collaboration. The observed difference for meson-proton and proton-proton collisions is under investigation.

(2) The transverse momentum behaviour at large centre-of-mass momenta resembles that observed in μ-data. It suggests an onset of a hard mechanism not included in present low p_t models.

(3) Correlations are observed for strange mesons in the region of small centre-of-mass

momenta, analogous to those observed for e^+e^- collisions.

(4) The x-dependence of π^0 production is different for π^+ and K^+ beams. The π^+/K^+ structure function ratio obtained from this difference agrees with that derived from Drell-Yan studies.

H.4. The ACCMOR experiments (NA11, NA32)

A search for secondary vertices associated with the trigger electron in the NA11 data of 1982 has yielded 40 events in the channel $D^\pm \to \bar{K}^*\pi^\pm e^\pm \nu$, where the $K\pi$-mass is within 50 MeV of the K^*-mass. A corrected life time of 9.8×10^{-13} s is derived from these events in good agreement with the PDG-value of 9.2×10^{-13} s for the charged D-meson. The control sample with like sign K/e events contains 5 events. The sample of 40 D events contains 30 D^- and 10 D^+ which is evidence for a leading particle effect, i.e. the outgoing D^- has one valence quark in common with the incoming π^-.

The analysis of the 600,000 inclusive $\phi(1020)$ events has been completed. The data have been compared with various parametrizations of the parton fusion model. Fig. H.4.1 shows the fit to the differential cross section $d\sigma/dx$ of the ϕ-meson using one of the favourite parametrizations of Duke and Owens. Within the framework of the parton fusion model this fit using our new ϕ-data yields

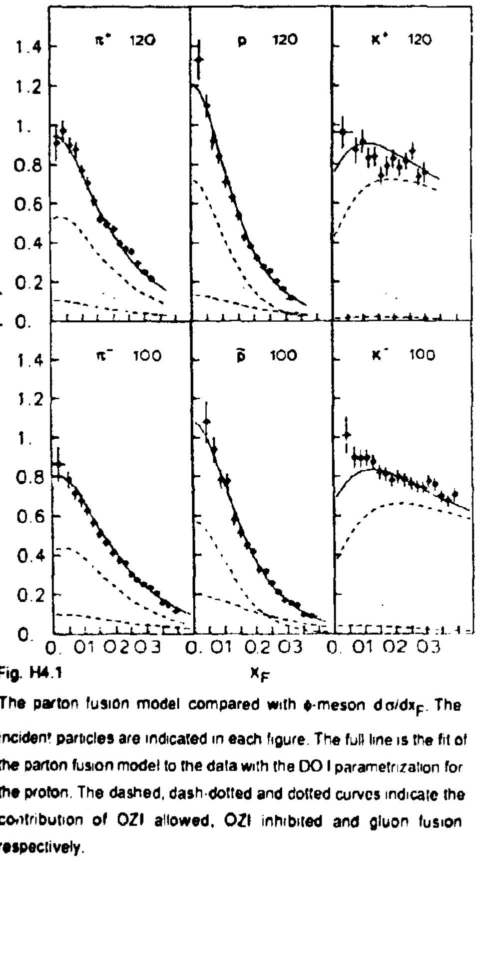


Fig. H4.1

The parton fusion model compared with ϕ-meson $d\sigma/dx_F$. The incident particles are indicated in each figure. The full line is the fit of the parton fusion model to the data with the DO I parametrization for the proton. The dashed, dash-dotted and dotted curves indicate the contribution of OZI allowed, OZI inhibited and gluon fusion respectively.

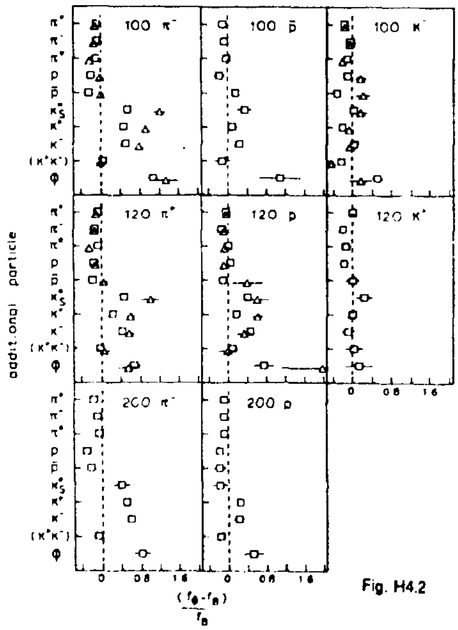


Fig. H4.2

The correlation between the ϕ and additional particles expressed in the variable $(f_\phi-f_B)/f_B$, where f_ϕ and f_B are the fractions of events with an additional particle for the ϕ and the background respectively. The type of additional particle and the incident particle are indicated in each figure. Correlations using trigger/clean selected K^+K^- pairs are indicated with □/Δ the strange quark distributions in the π– and K-mesons. They are much harder than the corresponding light quark distributions.

Another striking result is the joint production of the ϕ-meson and additional particles as function of the incident beam particle. In fig. H.4.2 this is shown in terms of a correlation variable $(f_\phi - f_B)/f_B$, where f_ϕ is the fraction of ϕ-events and f_B the fraction of non-resonant K^+K^--background events, as derived from the data. Qualitative predictions of the parton fusion model and also of the Lund model for this variable agree with the data. In particular the data show evidence for the joint production of ϕ–mesons and strange particles with non-strange incident particles, whereas this is suppressed for incident $K^\pm$-mesons.

The analysis chain for the data of the NA32 experiment with an active target in 1984 is now fully operational. All 5×10^6 triggers with incident K^- beam have been processed and are now in the final stage of analysis. The 22×10^6 π^--triggers are now in production and prepared for final scanning and analysis. The complete data set will provide an improved life time measurement of charmed particles.

In 1985 an experiment has been performed which was dedicated to the study of $F\rightarrow KK\pi$ and $\Lambda_c\rightarrow pK\pi$ decays for life time determination with increased statistics. A thin Cu target followed at 10 mm by two CCD's (charge coupled devices), which provide point coordinates with a resolution of ~5 μm transverse to the tracks, were used for the observation of secondary vertices in the air between target and CCD's for minimizing the background due to secondary interactions. The trigger uses the FAMP system as in the ϕ-experiment in 1982 to select KK and pK pairs of opposite charge for enrichment of the charm content in the collected data sample by about a factor twelve. We have collected 5×10^6 triggers in a π^- beam.

H.5. The UA1 experiment

In 1984 a large data sample of 264 nb^{-1} has been gathered. This enabled a more refined analysis of the properties of the intermediate vector bosons, based on an essentially background free sample of 172 $W \rightarrow e\nu$, 16$Z^0 \rightarrow e^-e^+$, 47 $W \rightarrow \mu\nu$ and 10 $Z^0 \rightarrow \mu^-\mu^+$. A summary of some of the quantitative results is given in table H.5.1. The study of events with a single jet led to the measurement of the τ decay of the W. The various decay modes of the W and Z are in good agreement with lepton universality. Z^0 decays with a hard γ are now seen at the level expected from QCD. Several new results are obtained on jet cross-sections, on jet fragmentation and on other jet properties. For the first time a difference between quark jets and gluon jets has been observed in hadronic collisions; quark jets have a significantly harder fragmentation and a higher degree of collimation.

In spring 1985 UA1 participated in a run in which the energy of the collider was varied between $\sqrt{s}$ of 0.2 and 0.9 TeV. Minimum-bias data has been used to study the energy dependence and the characteristics of the jets produced at low transverse energy. The jet differential cross-section is measured over nine orders of magnitude down to x_T of 0.01.

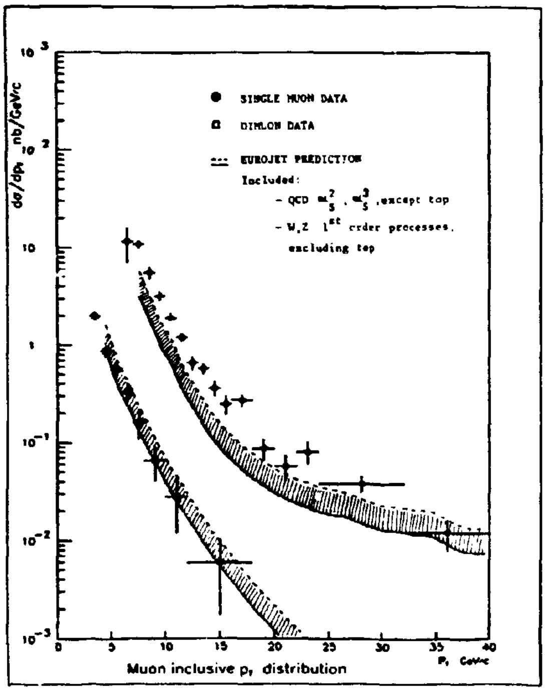


Fig. H5.1

The figure shows the muon inclusive p_T distribution for both single muons and dimuons. For both spectra we have calculated the Eurojet prediction, which includes QCD α_s^2, α_s^3 processes (except top) and W, Z first order processes (excluding top).
For p_T below 20 GeV/c the spectra are dominated by QCD, in this region we have 5 sources of uncertainty: the choice (1) of the structure function, (2) of the Q^2-scale, (3) of the ε's in the Peterson fragmentation function, (4) of the branching ratio's and (5) of the regularization of the infra-red divergences for α_s^3 processes. The sum of these uncertainties is shown as a band on the spectrum. For p_T above 20 GeV/c the W, Z first order processes are dominant. The band on the spectrum in this region allows for higher order processes.

Significant progress has been made in the study of muon events. The muon analysis software has been much improved and a new Monte Carlo program, EUROJET, has been developed by a NIKHEF physicist. The program also simulates the higher order QCD processes. Such a Monte Carlo program is indispensable to study complicated processes like $b\bar{b}$ mixing. The increased level of understanding of the muonic processes is visible in fig. H.5.1 that shows the differential inclusive μ cross-section and the predicted spectrum.

NIKHEF has also played an important role in the improvement of the software used for the interactive study of events on graphic work stations.

In spite of problems related to the newly installed micro-vertex detector and to the so-called 'critical days' during which the SPS cannot run, the autumn run delivered enough data to double the UA1 data sample. In the spring run of 1986 we expect to take an equal amount of data. This will be the last run before the com- missioning of ACOL, the new anti-proton accumulator ring.

In the data analysis we can strongly feel the limitations imposed by the present calorimeter. The lack of granularity will make it impossible to profit from the ten-fold increase in luminosity expected after ACOL. A lot of effort went into testing the various options to upgrade the calorimeter. It was realized that a uranium calorimeter was needed to obtain sufficient energy resolution. A warm liquid read-out using TMP as active medium appeared the only affordable solution with a high granularity. NIKHEF is involved in the design and production of a second level trigger for the new calorimeter.

Table H.5.1 A summary of the quantitative results coming from the analysis of $W^{\pm}\to e^{\pm}\nu_e$ and $Z^0\to e^+e^-$ event samples. The first errors are statistical and the second errors systematic.

a) Measured quantities	
$W^{\pm}\to e^{\pm}\nu_e$	$Z^0\to e^+e^-$
$\sigma\cdot B_W = 0.55 \pm 0.08\ (\pm 0.09)$ nb	$\sigma\cdot B_Z = 42\ ^{+25}_{-18}\ (\pm 6)$ pb
($\sqrt{s}$ = 546 GeV)	($\sqrt{s}$ = 546 GeV)
$\sigma\cdot B_W = 0.63 \pm 0.05\ (\pm 0.09)$ nb	$\sigma\cdot B_Z = 74\ ^{+23}_{-20}\ (\pm 11)$ pb
($\sqrt{s}$ = 630 GeV)	($\sqrt{s}$ = 630 GeV)
$\sigma\cdot B_{W^+} / \sigma\cdot B_{W^-} = 0.75 \pm 0.15$	
$m_W = 83.5\ ^{+1.1}_{-1.0}\ (\pm 2.7)$ GeV/c^2	$m_Z = 93.0 + 1.4\ (\pm 3.0)$ GeV/c^2
$\Gamma_W \leq 6.5$ GeV/c^2 (at 90% C.L.)	$\Gamma_Z \leq 8.3$ GeV/c^2 (at 90% C.L.)
Asym (W) = 0.77 ± 0.04	Asym (Z) = 0.25 ± 0.24
b) Derived quantities	
Mass-derived	$\sigma\cdot B$-derived
$(m_Z - m_W) = 9.5^{+1.8}_{-1.7}\ (\pm 0.5)$ GeV/c^2	$R = 9.6\ ^{+3.0}_{-2.1}$
$\sin^2\theta_W = 0.214 \pm 0.006\ (\pm 0.015)$	$N_\nu \leq 10$ (at 90% C.L.)
$\sin^2\theta_W = 0.194 \pm 0.032$	
$\rho = 1.026 \pm 0.037\ (\pm 0.019)$	

H.6. Proton-Antiproton Elastic Scattering and Total Cross Section at the CERN $p\bar{p}$ Collider

(UA 4-Collaboration)

The shape of the momentum transfer squared (t) distribution for elastic proton-antiproton scattering at $\sqrt{s}$=546 GeV is quite different from that observed both in proton-proton and in proton-antiproton scattering at the ISR. These results suggest that as the energy goes up from

the ISR to the Collider, the effective interaction radius of the proton increases and in addition the proton becomes more absorbing at small values of the impact parameter.
The analysis of the large-t data collected in 1984 at $\sqrt{s}$=630 GeV is now also finished and a publication is in preparation. The range in momentum transfer is extended to $-t=2.3$ GeV^2. The differential cross-section at $-t \approx 2$ GeV^2 still remains larger than at the ISR.

The analysis of diffraction dissociation events shows clearly that the fragmentation of a diffractively produced system of mass M is very similar to the hadronization process in a hadronic collision with centre-of-mass energy equal to M.

New data on elastic scattering at $\sqrt{s}$=546 GeV were taken with a modified set-up during a 6-day dedicated Collider run in June 1985. The machine optics in the interaction point was such that a minimum scattering angle of 0.13 mrad, corresponding to a momentum transfer squared $-t \approx 0.0015$ GeV^2, could be reached. This will allow the measurement of ρ (the ratio of the real to imaginary part of the forward scattering amplitude). A total of 850,000 triggers has been collected. The analysis is in progress.

H.7. The SING-experiment at LEAR

This year there was a substantial increase in beam-time given to LEAR and consequently to SING. The following summarizes results from the four different experiments included in the SING-program.

(1) No new data and thus no new results on the $\bar{p}p$ total cross section.

(2) The analysis of the $\bar{p}p$ small angle scattering measurements was successfully continued. The values for the ρ-parameter, the ratio of the real to imaginary scattering amplitude, are $\rho = 0.04 \pm 0.09$ and $\rho = 0.13 \pm 0.09$ for incoming momenta of 272 and 233 MeV/c respectively.
These values differ considerably from the values predicted by most theoretical models, which lie below -0.30. The dependence of the value of ρ on the values of the total cross section and of the slope of the differential elastic cross section was extensively investigated. A better knowledge of these data, would reduce our error on ρ.

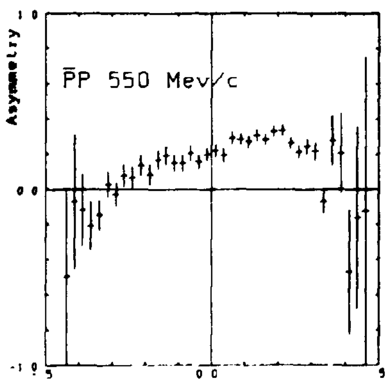


Fig. H7.1
The asymmetry parameter $A(\theta) = \frac{N_+ - N_-}{N_+ + N_-}$ in the reaction $p\bar{p} \rightarrow p\bar{p}$ at 550 MeV/c incoming momentum. N_+ and N_- are the counting rates at angle Θ with the spins of the protons respectively up and down in the polarized target. The measurements are made over the azimuthal range $-15° < \phi < 15°$.

(3) A letter on the results of the double-scattering experiment at a momentum of 550 MeV/c obtained in

1984 was written and published in Physics Letters.

(4) All our beam-time was devoted to data-taking for the two-body experiment at 12 different momenta between 400 and 1550 MeV/c. The apparatus, including the revised wire-chambers, functioned well. A large effort was spent on perfectioning TREMA, the analysis program for reconstruction of the two-body events ($\bar{p}p \rightarrow \bar{p}p$, $\bar{p}p \rightarrow K^-K^+$, and $\bar{p}p \rightarrow \pi^+\pi^-$). The analysis is now in progress. First results were obtained on the asymmetry in the elastic reaction as a function of the scattering angle at a beam momentum of 550 MeV/c.

H.8. The DELPHI experiment

NIKHEF has project responsibility for the Inner Detector of DELPHI and participates in the construction of the Ring Imaging CHerenkov (RICH) counters.

Inner Detector

The tests with the 'jet chamber' prototype continued through the year. The resolution was tested with cosmics and was 78 μm per point, while tracks crossing the wire grids were measured with an average resolution of 115 μm per point. The upper part of fig. H8.1 shows the reconstruction of a track, while the lower part shows the deviation of the individual points from the track.

Tests at CERN in a magnetic field resulted in a measured Lorentz angle of 5.04±0.16 degrees in 96/4 CO_2 isobutane; the change in drift velocity was measured to be 0.52%. Both the Lorentz angle and the change in drift velocity are small enough to be treated as corrections on a calibration at B=0. The electrostatic configuration of the final detector has been calculated. The results show that edge effects can be effectively compensated. The construction of module 1 has been started in the mechanical workshop. The front-end electronics has been defined and is partly delivered, partly ordered.

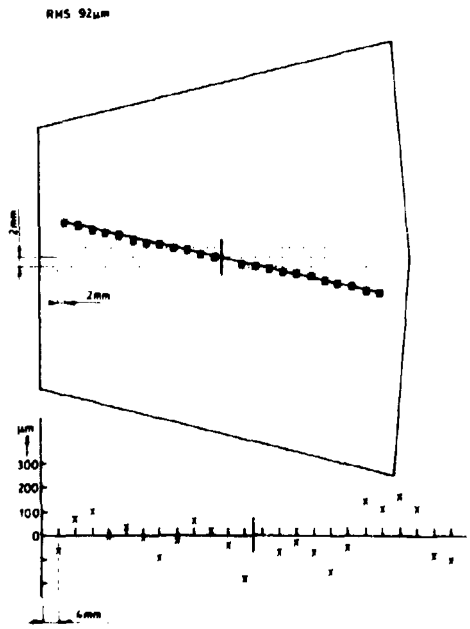


Fig. H8.1
The passage of a single cosmic-ray track through a segment of the inner detector giving a resolution of 92 μm per track. The wires are represented by points. The black dots are the measurements which are fitted by a straight line.

RICH Counters

In the course of 1985, the results from the full-scale prototype segment of the Barrel RICH

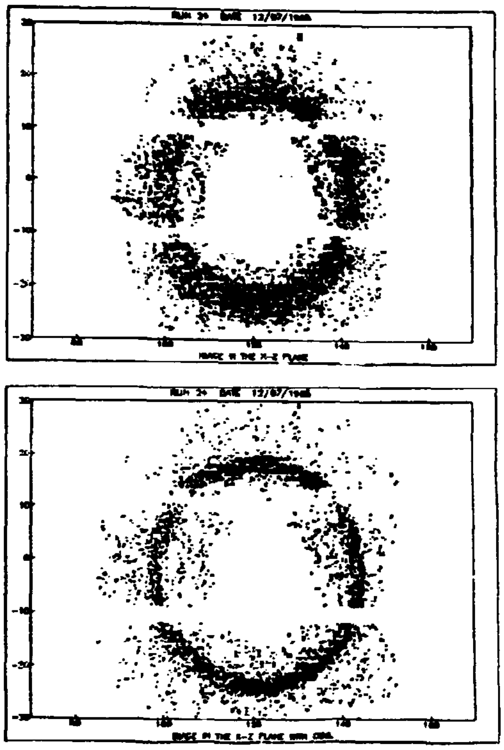


Fig. H8.2

Cherenkov rings from 10 GeV/c pions passing through the liquid radiator of the Barrel RICH prototype segment. Top - two-dimensional reconstruction from drift time and wire address. Bottom - addition of cathode strip read-out allows full three-dimensional reconstruction eliminating the image smearing due to varying photon conversion depth.

reached the design value for the reconstruction precision of Cherenkov angles. The number of detected photons per ring has surpassed the anticipated value. Together with the approval by the LEPC in June of the design proposal for the final Barrel RICH, these results cleared the way for placing the quartz order for the Barrel and Forward RICH counters. Delivery of the quartz will start in March 1986.

In order to provide for a well-defined drift field in the 150 cm long drift tubes, conductive strips must be deposited on the quartz walls of the drift tubes and of the liquid radiator containers. A method has been found to produce these strips in industry at an acceptable price. The last design choices for the wire chambers that are coupled to the drift tubes were taken in December. The production of 15 chambers at NIKHEF will start in March 1986.

In May it was concluded that for financial reasons major parts of the Barrel RICH pressure vessel must be built in-house by the participating institutes. The NIKHEF mechan- ical workshop will construct the outer cylindrical wall of the vessels out of Aluminium sandwich material. The drawings were finalized in November, orders for tools and materials were placed in December.

The liquid-radiator part of the prototype Forward RICH segment was shipped to CERN in the spring of 1985. Beam tests will continue until the summer of 1986. An improved construction technique for the liquid containers has been developed.

Detailing of the final design of the Forward RICH has started; production of the liquid-radiator part is scheduled to begin at NIKHEF by the middle of 1986.

Software

A program has been written to simulate the response of the Inner Detector. This has been used to develop first order versions of the programs for the pattern recognition in the r-ϕ projection, and for the graphical representation of the results on an Apollo workstation. Contributions have been given to the design of a pattern recognition program for the RICH detectors, the setting up of a data-base management system for the description of the DELPHI-detector, and to the design and standardization of hardware and software for an interactive system for the graphical representation of the events.

H.9. The L3 experiment

The Harvard test for the first octant of the muon chamber system effectively started at the beginning of 1985. All the calibration monitors, laser and alignment systems had been installed in their final form by that time and half of the octant was filled with three chambers (MI, MM, MO).

In fig. H9.1 the X- and Y-displacements as measured by the four quadrant diodes mounted on one of the three precision bridges of the NIKHEF chamber are displayed for a period of seven successive days. In the important direction for the momentum measurement of high energetic muons (x-direction) a systematic difference between the two systems of one chamber (X_1 and X_2) of less than 10 μm is observed, where ~ 30 μm is allowed. The variations, mainly due to temperature changes are the same for both systems and within tolerable limits. The measurement obtained in this way can be directly used to correct the data of muon tracks if necessary.

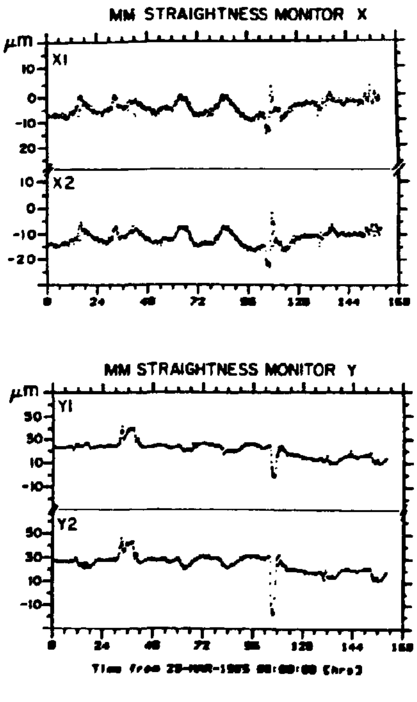


Fig. H9.1 MM straightness monitor output for 168 hours.

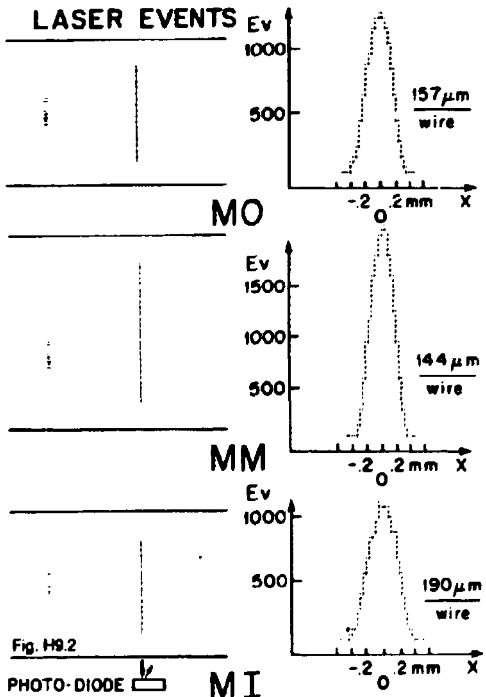


Fig. H9.2

Data for a laser shot through all three chambers. Beam is nearly vertical. Poorer resolution of MI is due to backscattering of laser light.

The laser system constructed by the mechanical workshop of NIKHEF was operated under computer control. With addressable beam directional elements the beam was distributed into four rays through the three chambers. An example of such a reconstructed event is shown in fig. H9.2. Individual wire resolutions for the different chambers are also displayed in this figure. The average resolution is 163 μm per wire. An estimate of the corresponding sagitta resolution can then be calculated to be Δs=47 μm. This value can be compared to the direct straightness measurement of the laser beam of 50 μm with 1000 events.

These results are well within the tolerances set in the technical proposal of 1983 and as a consequence it was decided to start the mass production of the chambers and octants.

By spring all the components for the middle chambers, the mechanical as well as the electrical ones were ordered for a total sum of ~ 2.3 Mf.

A special computer controlled milling machine for the production of the 1.50 m long aluminium end pieces of the chambers was delivered by the end of June. By the fall of 1985 part of the deliveries of the larger components like side panels, honeycomb covers, end pieces, precision bridges, etc. had arrived.

In the electronics workshop 240 amplifiers for the straightness monitors have been fabricated together with the light sources and the four-quadrant diodes. Some 60 systems were aligned and calibrated in order to start the production of the precision bridges at MIT. Various prints and multi-layer signal boards for the chambers have been designed and ordered. A large order to Philips for 30,000 hybridized pre-amplifiers has been placed. The discriminator design was finalized and a begin has been made for the design of the muon trigger and various components of the monitor system.

In the design office some 500 drawings have been made for the chambers including the assembly drawings. At the end of the year the designs of the laser system, the vertical alignment and a small test chamber were finalized.

The production started in October and by the end of the year work was in progress on three chambers simultaneously.

On the software side the complete geometry of the muon chamber system was incorporated in the general L3 software at Amsterdam. Together with the physicists from Nijmegen the simulation of Monte Carlo events including the simulation of the detector response has been started. Some 10^6 events/year will be generated. This is the first step in the NIKHEF contribution to the analysis of the L3 events.

Using simulated data on muon tracks the conditions for the proposed muon trigger were studied and optimized. A detailed estimate of the anticipated cosmic ray background rate to the muon trigger was made.

The temperature distribution in the muon chamber region of L3 has been simulated using the ESACAP program. A detailed model of one octant has been designed so that the temperature behaviour of the chambers could be studied in relation with the proposed cooling system of the L3 magnet. After discussions with the CERN engineers responsible for the magnet design and its fabrication, optimized parameters for the cooling system were adopted.

Finally, detailed studies are underway to investigate the Apollo graphics possibilities for the event display of the L3 data.

Amsterdam and Nijmegen have started together a study how to do the field mapping of the large L3 magnet. By the middle of 1986 the number and position of the magnetoresistive probes, which are attached to the muon chambers and which will allow the field to be reconstructed with 1% accuracy, has to be determined. In Nijmegen the behaviour of the probes was investigated as a function of field strength and temperature. Nijmegen will be responsible for the overall design, fabrication - including the VME-based read-out system - , and installation of the final system in close collaboration with the magnet and muon chamber groups of L3.

The work on the BGO read-out system of the Nijmegen group together with Princeton continued. The first part of the final design was succesfully tested with 100 BGO blocks in a test beam at CERN during the summer. Responsibilities for the final system were divided between Nijmegen and Princeton. NIKHEF will be responsible for the third and fourth layer of the BGO read-out system together with the event builder.

H.10. Bismuth Germanate Oxide (BGO)

The BGO-Bridgman crystal growth project is carried out in collaboration with the Nijmegen Crystallography group of Prof. Bennema and with the financial support of STW. It is carried out at the Universities of Utrecht and Nijmegen. The work in Utrecht has been transferred to Nijmegen.

The year 1985 brought a decisive break-through. The role and importance of the properties of the polycrystalline BGO-powder (used as a starting point) were clearly established. This led to a special technique for controlling and modifying the BGO input powder. The growth-technique itself was further improved by modifying existing furnaces and developing two new ones. All these activities culminated in a successful (reproducible) growth of 4 large crystals (3 crystals: 15x2.5 cm (round); 1 crystal 24x3 cm (round)) in September-October 1985. In subsequent tests at CERN these crystals were shown to have the resolution and transmission properties required for L3 crystals.

H.11. The TPC/TWO-GAMMA Experiment at PEP

This was the first full year of operation for the TPC/Two-Gamma Collaboration since they formally joined in November 1984. The new Collaboration consists of over 100 physicists from 15 Institutions. One of us (H.P.P.) has been appointed deputy spokesman by the directorates of LBL and SLAC.

The TPC/Two-Gamma detector has performed well during the 1985 running. The superconducting coil (13.2 kG) and gated grid have led to important improvements in the

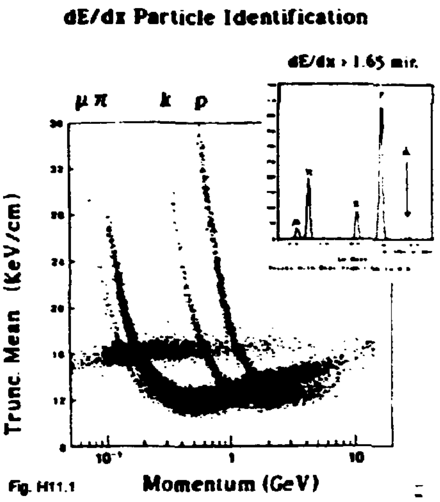


Fig. H11.1

Energy loss versus momentum as measured in the TPC.

momentum resolution ($\sigma/p = 0.6\%$ p (GeV/c) + 1.3% in quadrature) and dE/dx resolution (3.7%), see Fig. H.11.1. We can now distinguish pions and muons at low momenta. Four quadrants of thirty bismuth-germanate-oxide (BGO) crystals each have been operated successfully at very small distances (4 cm minimum distance) from the circulating beams. Elastic e^+e^- scattering has been used to monitor and calibrate the crystals. A resolution $\sigma/E \approx 2\%$ has been obtained. Valuable experience has been gained concerning the effects of radiation damage and photodiode read-out.

A total of 40 pb^{-1} was logged during the spring and, after the traditional summer shutdown, another 10 pb^{-1} in late fall. The data taking is scheduled to end on February 28 1986 with an expected additional 25 pb^{-1} logged. This then would give a total of 75 pb^{-1} in the high magnetic field configuration, together with 73 pb^{-1} from the earlier (1982-83) low field running.

Analysis is continuing on many subjects including those mentioned in the 1984 report but not yet published (hadronic structure function, η' formation, $\gamma\gamma \to 4\pi$). Some of the new subjects are:

(1) Meson pair production in $\gamma\gamma \to \pi^+\pi^-$ and K^+K^-, including f(1270) and f'(1525) formation. The cross sections for the non-resonant processes are shown in Fig. H.11.2. Thus far only the sum of the two processes has been published (by Mark II). It provides an important test of QCD (see Physics Today, 38, vol. 8 (1985) 17). The unique particle identification capabilities of the detector were used to separate pions from kaons (and muons). The results form the thesis of W.G.J. Langeveld. A publication is in the final stages of preparation.

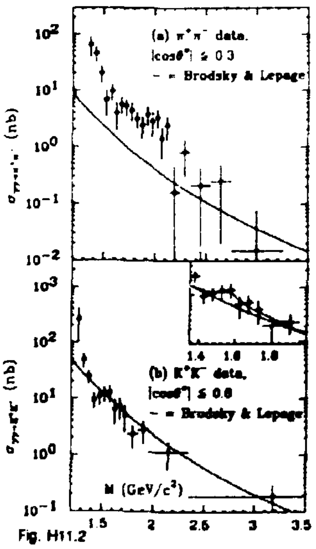


Fig. H11.2

The cross sections for the processes $\gamma\gamma \to \pi^+\pi^-$ and $\gamma\gamma \to K^+K^-$. The curves correspond to a QCD calculation by Brodsky and Lepage. The insert shows the signal of the f' resonance.

(2) Double-tag missing mass search for new resonances. The $\gamma\gamma$ centre-of-mass energy is determined on an event by event basis from the very precise measurement ($\sigma/E = 1\%$) of the tagged e^+e^- energy in the sodium-iodide crystals. Such a search using production by $\gamma\gamma$ collisions is complementary to those that use e^+e^- collisions. We do not find evidence for

resonance production in the mass range 5-20 GeV. Upper limits are traditionally given in terms of $\Gamma_{\gamma\gamma}$ the partial $\gamma\gamma$ decay width of a resonance, which is proportional to the cross section for production of the resonance. Upper limits on $\Gamma_{\gamma\gamma}$ at the 95% confidence level are shown in Fig. H.11.3 as function of mass. These are most stringent limits set thus far on such particle production. A publication is in preparation.

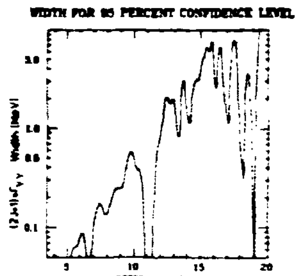


Fig. H11.3

95% confidence level upper limits for $(2J+1)\Gamma_{\gamma\gamma}$ of possible narrow $\gamma\gamma$ resonances versus the mass measured by the tagging electron and positron.

(3) Search for glueball signatures. The $\iota(1450)$ has been discovered recently in $J/\psi \rightarrow \gamma\iota$ radiative decay by Mark II. The lowest order diagram for it contains one photon and two gluons in the final state. The two gluons are supposed to be bound by the exchange of a gluon between them to form the ι. This implies that ι might be a good candidate for the long-sought glueball. The ι could be a linear superposition of such a glueball and one or more $q\bar{q}$ states. Its production rate in $\gamma\gamma$ collisions can shed light on this question since photons do not couple directly to gluons. We have looked for ι production through the reaction $\gamma\gamma \rightarrow \iota \rightarrow K^{\pm}K_S\pi^{\mp}$. There are five elements in the ι mass region. Using the experimentally determined decay properties of the ι (from Mark 3), we obtained a 95% confidence level upper limit of $B(\iota \rightarrow K\bar{K}\pi)\Gamma_{\gamma\gamma}(\iota) < 1.6$ keV. The branching ratio $B(\iota \rightarrow K\bar{K}\pi)$ is of order 70% so we conclude $\Gamma_{\gamma\gamma}(\iota) < 2.2$ keV. We can compare this with for example the η', a resonance containing approximately equal amounts of u, d and s quarks: $\Gamma_{\gamma\gamma}(\eta') \times m_\iota^3/m_{\eta'}^3 \approx 15$ keV (the scaling by m^3 takes care of a trivial mass dependence). This is indicative of a glueball content in the ι. These results have been submitted for publication.

The Collaboration has submitted a proposal to upgrade the PEP machine's instantaneous luminosity by a factor of at least five and upgrade the detector with a high precision vertex detector (14 layers of straws). This proposal was approved in October 1985. NIKHEF is not a partner in the future high luminosity era but some equipment (the sodium-iodide and drift chambers) may have a second life in the future running.

H.12. The MARK-J Experiment

During 1985 the electron-positron storage ring PETRA has run at energies of $\sqrt{s}=43.60$ and 38.28 GeV. In this period the MARK-J detector collected an integrated luminosity of 28.055 pb^{-1}.

Since in this energy region the electroweak effects increase with increasing energy, the data collected at 43.6 GeV offers a unique possibility of checking the validity of the standard model. The forward-backward charge asymmetry, defined by

$$A = (N_F - N_B)/(N_F + N_B),$$

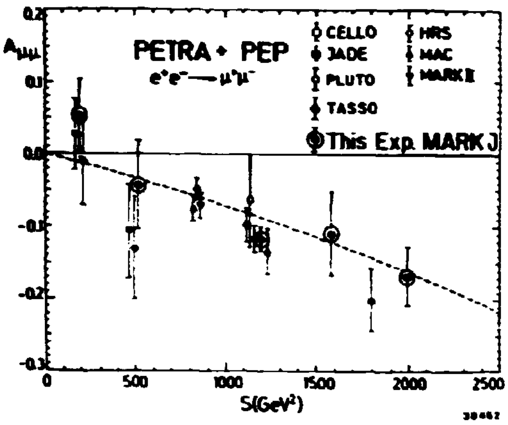


Fig. H12.1 Charge asymmetry for muon pairs as a function of s.

has been measured for μ-pair production as function of s and is shown in fig. H12.1. The solid curve is the QED prediction and the dashed curve is the prediction by the standard model. One sees that the data is in excellent agreement with the theory. The measured value for the charge asymmetry at $\sqrt{s}=44.6$ GeV is $A_{\mu\mu}=-16.7\pm4.0$ % to be compared with the predicted value of $A_{\mu\mu}=-16.0\%$. This leads to a determination of the electroweak mixing angle, $\sin^2\theta_W=0.17(^{+0.03}_{-0.02})\pm0.01$.

The same physical quantity is shown in a different way in fig. H12.2 for the τ-pair production. The solid curve is a fit to the data and gives a charge asymmetry of $A_{\tau\tau}=-12.7\pm6.9$ %.

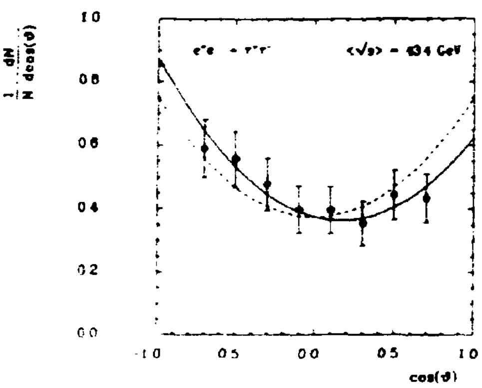


Fig. H12.2 Angular distribution for τ-pairs.

Another advantage of high energies is the fact that one can set stringent limits on the mass of new hypothetical particles. This year data has been taken with a new single photon trigger which will allow to set a strong limit on the mass of the photino's, the supersymmetric partners of the photons.

Using the energy-energy correlation method a complete second-order determination of the QCD scale parameter Λ has been carried out over the energy region 22 to 46.78 GeV. The use of data over a wide range of energies permits the separation of the effects described by perturbative QCD from the soft hadronization process so one can measure the QCD parameter Λ directly. The measured value is $\Lambda=100\pm30$ (+60 -45) MeV which yields for the strong coupling constant $\alpha_s=0.12\pm0.02$ at $\sqrt{s}=44$ GeV.

At the end of the year the new high-resolution vertex chamber (TEC) has been installed. After some initial start-up problems, the chamber now performs as designed and reaches a spatial resolution of 35 μm. Together with a lever arm of 10 cm, this gives a good outlook for measuring lifetimes of b-quarks and τ-leptons.

H.13. Crystal Ball Experiment

In 1985 the analysis of the Υ(2S) data collected in 1983-1984 got well underway; two publications appeared and two more were accepted by the Physical Review.

For the first time the three P-states (χ_b) were separated and their positions accurately determined. This observation eliminates nearly all non-QCD based potential models. Using the exclusive channel

$$\Upsilon(2S) \rightarrow \gamma\chi_b \rightarrow \gamma\gamma\Upsilon(1S) \rightarrow \gamma\gamma l^+l^-$$

it becomes possible to determine the hadronic widths of the χ_b states. These widths are found to be compatible with QCD-predictions, thus providing one of the rare experimental confirmations of a quantitative perturbative QCD-calculation. They also indicate that the QCD-discrepancies seen previously for the charmonium χ_c states are related to the $c\bar{c}$ system still being too relativistic and not to the QCD-assumptions as such.

Other results obtained are

- a more accurate determination of the $\Upsilon(2S)\rightarrow\pi\pi\Upsilon(1S)$ branching ratio,
- observation of δ(980) and A2(1320) in photon-photon collision.

Previous experiments at SPEAR and PETRA had seen A_2-formation but never δ-formation. The resulting γγ-coupling of the δ is compatible with calculations assuming the δ to be either a $q\bar{q}$ or a $q\bar{q}q\bar{q}$ state.

In terms of data taking, 1985 was devoted solely to running on the Υ(4S) - an 'open' $b\bar{b}$ resonance - for which the CB analysis capacities are limited. In compensation 1986 will be "kicked off" with a thirteen-week run on the Υ(1S).

H.14. The HERA Project

Various full size 6 m sextupole/quadrupole correction coils for the superconducting proton ring of HERA have now been produced by HOLEC, Slikkerveer. The units have field harmonics within specifications. The individual coils reach a quench close to the short sample limit. Simultaneous excitation of all coils results in a quench at more than two times the nominal values due to the deformation of the beam pipe which has 2 mm wall thickness. The final beam pipe will have 2.5 mm wall thickness which should improve the performance even more.

A special unit with heaters has been produced for simulating heat production due to beam loss in the coil which may lead to a quench. Measurements have been carried out and are now analyzed on this critical and poorly understood problem in the operation of a superconducting accelerator and storage ring.

A novel technique has been developed at NIKHEF-H for the production of saddle-type coils for the superferric dipole correction magnets. HOLEC has produced two units with this technique. These have been tested at DESY, show excellent field characteristics far above the specifications and reach a quench almost a factor 3 above the nominal design value.
The collaboration between NIKHEF-H and industry has now been extended to two other Dutch firms:

(1) SLE (Superconductors LIPS ECN), Drunen, for the production of the superconductive wire,
(2) Smit Draad, Nijmegen, for the insulation of the superconductor.

The Ministry of Economic Affairs is negotiating the Agreement with DESY for the donation of the correction elements for HERA. Funding of the donation is shared between the Ministry of Economic Affairs and the Ministry of Education and Science, where the first acts as contractor. IREM (Industrial Council for Energy and Environment) coordinates the contacts between the industries and the ministry. NIKHEF-H represents DESY for ascertaining that the quality control and time schedule is met by the industries according to the DESY specifications which are laid down in the Agreement.

A Technical Coordination Committee will be set up under the Agreement with two members each of DESY, NIKHEF and the State, and one member of IREM. Production of 440 sextupole/quadrupole correction coils and 250 correction dipole magnets will start in 1986.

H.15. The ZEUS Detector

In June 1985 a letter of intent titled "ZEUS, a detector for HERA" has been submitted to the Physics Research Committee of DESY, Hamburg. The physics aim is the construction of a detector for the measurement of structure functions of protons, electrons and quarks over the largest possible x, Q^2-range with the highest possible precision. It should allow to measure the structure and properties of electroweak currents and interactions, and of strong interactions, and to search for new particles, e.g. excited quarks and leptons, leptoquarks and supersymmetric particles. Photoproduction should be covered for studying the hadronlike and pointlike behaviour of the photon. It is also a copious source of heavy flavours and possibly of supersymmetric particles.

The detector should have hermetic electromagnetic and hadronic calorimeters, track detectors and magnetic analysis for angle and momentum measurement of charged particles, electron and muon detectors of isolated leptons and for leptons in jets, and a precise luminosity measurement. The lay-out of the detector is shown in fig. H15.1. It consists of a central wire chamber detector (CTD), three forward (FTD) and one rear (RTD) wire chamber detector for charged particle detection in the field of a solenoid (COIL, central field 1.8 T). The forward detector is interlaced with two transition radiation detectors (TRD) for hadron/electron identification in conjunction with the dE/dx measurement in CTD and FTD's. A vertex detector, not shown in the figure, surrounds the beam pipe in the interaction region.

This central part is surrounded entirely by electromagnetic and hadron calorimeters. These are in the forward direction an electromagnetic calorimeter (FEMC, 24 X_0,3λ) and a hadron calorimeter (FHAC, 2×(65 X_0,3λ)), in the transverse direction a barrel calorimeter (BEMC, 24 X_0,1λ; BHAC, 2×(43 X_0,2λ)), and a rear calorimeter (REMC, 24 X_0,1λ; RHAC, 65 X_0,3λ). The calorimeters consist

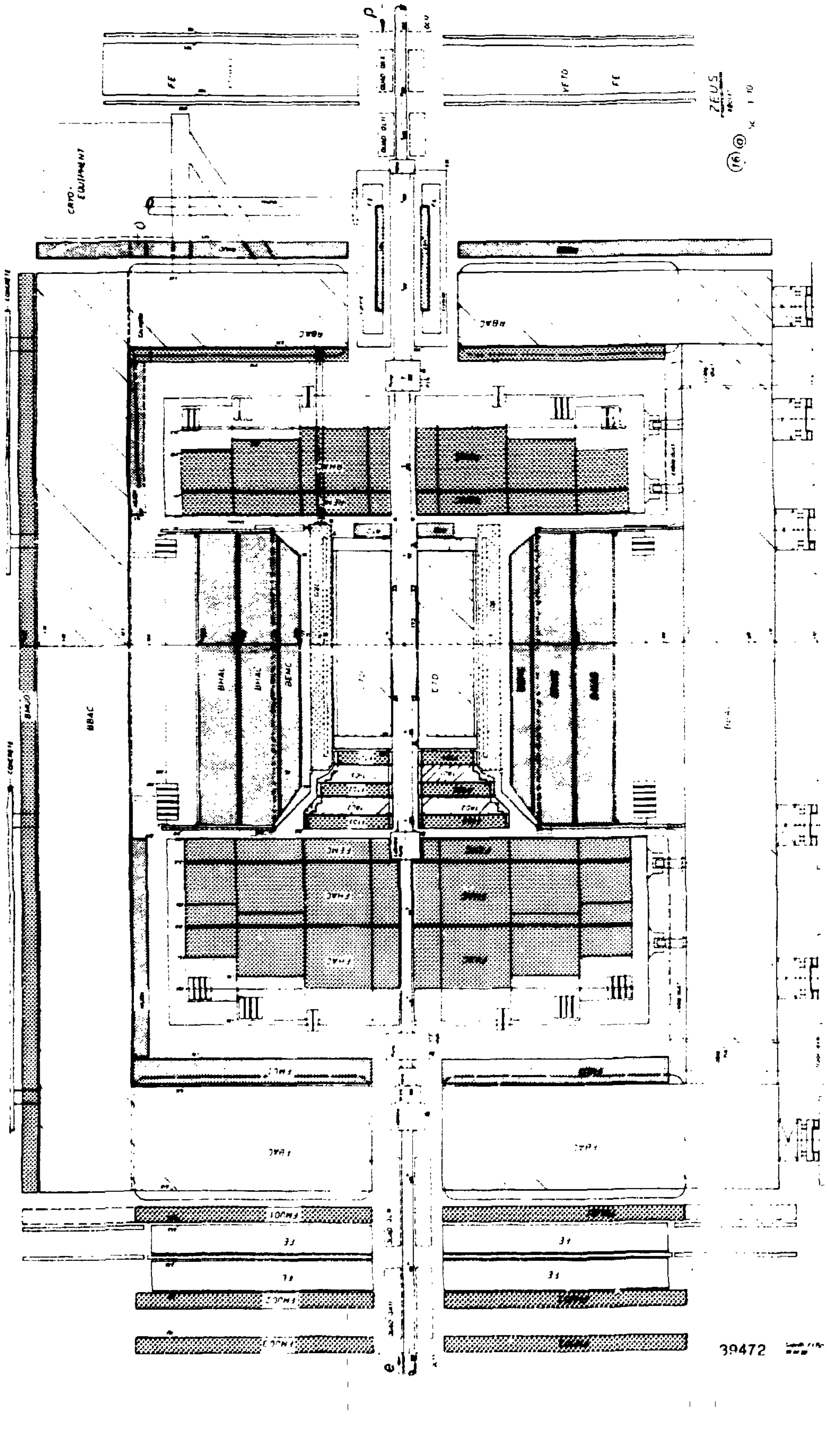


Fig. H15.1 Schematic diagram showing the various components of the ZEUS detector.

of sandwiches of depleted uranium and scintillator. The aim is to obtain a resolution of $\sigma(E)/E=(15/35\%/\sqrt{E}) + 1\%$ for electrons/hadrons, and equal response to electron and hadrons ($e/\pi=1$) with the compensation mechanism. The calorimeters are backed up by calorimetry (FBAC, BBAC, RBAC) in the iron return yoke of the magnetic field for tagging late hadron showers. The iron yoke is equipped with muon chambers at inside (FMUI) and outside (FMUO1/2/3, BMUO, RMUO). Inside chambers are also considered for the barrel and rear region. In the downstream p-direction a forward proton detector is located, in the downstream e-direction a luminosity monitor and a γ-tagging system for photoproduction are positioned.

A test program for calorimetry has started at CERN in September of this year. The aim is to make a systematic study of the geometry of depleted uranium and scintillator for obtaining the required resolution and e/π ratio. Test modules for these studies have been produced at NIKHEF-H. NIKHEF-H has made the design of the barrel calorimeter and has also worked out various ideas for the forward calorimeter.

H.16. The Instrumentation Group

The work of the group can be divided into contributions to 2 experiments (L3, DELPHI) and other research.

L3

A contribution was given to the L3 muon chamber test set-up in Harvard, especially to the nitrogen laser calibration. This method proved to be very useful for the alignment of the muon chamber octant. An alignment error in the drift chamber assembly of about 100 μm, not detected by other straightness checks, was discovered in this way.

Development work was done on the NIKHEF nitrogen laser. Attempts were made to improve the present one million pulses life time of the laser insulation. No success was obtained with the use of a pulsed high voltage power supply or with the removal of the air in the insulation area by silicon resins. However, the use of glass instead of kapton looks promising.

The use of nuclear magnetic resonance probes for measurement of the magnetic field in the L3 detector was studied. It was found that these probes have big advantages with respect to accuracy and stability, but still require much development work.

DELPHI

Assistence was given to the tests of the JET prototype vertex detector using a laser beam in a magnetic field at CERN. The tests were done using both a parallel beam and a focussed beam. The latter to measure the drift path.

Other research

The single electron diffusion set-up has been operational for several months. Besides accurate drift velocity measurements for Argon-ethane-nitrogen mixtures, diffusion and drift velocities were measured for various compositions of methane-ethane and methane-ethylene, and for carbondioxide-isobutane. The measurements will be continued.

A gas purification system was studied and tested. Pollution of detector gas is mainly caused by leakage and diffusion of air. Water and oxygen are already removed in various big detectors. This is not the case however for nitrogen. A calcium based purifier was built to absorb also this component. The first results are encouraging.

H.17. Theory Group

Recent developments in theoretical high-energy physics show a great variety in topics and directions of research. The global structure of the weak and electromagnetic interactions, as described by the successful Glashow-Weinberg-Salam model, is well-understood, but many details still remain obscure. In particular the mechanism of mass generation for the intermediary vector bosons (Higgs mechanism) has not found an experimental confirmation. Research in this area could be a starting point for the discovery of new physical phenomena in the range of energies above 100 GeV.

Likewise, for the strong interactions there is a good theory, Quantum Chromodynamics (QCD). However, it is difficult to obtain quantitative results that can be compared with experiments, because of the importance of non-perturbative aspects of the theory. Much time and energy is devoted worldwide to the development of numerical methods and their implementation in computer algorithms.

Besides the analysis of theories that offer an interpretation for present experimental results, it is of importance to try to integrate these theories in a wider context, which encompasses all known physical phenomena. Extensions of existing theories are pursued both in the direction of further unification and that of further substructure of matter. Concrete models offer predictions for a wide range of new physical phenomena, from magnetic monopoles to supersymmetry, which may be tested experimentally in the future. The long standing problem of incorporating gravity in quantum mechanics is an important guide in the search for such models. A complete new paradigm here is the idea, that the most elementary objects in nature may not be pointlike particles, but one-dimensional strings.

Most areas of research in theoretical physics mentioned above are reflected in the program of the NIKHEF-H theory group. In 1985 a study using Monte Carlo simulation was made of the reaction $e^+e^- \to \mu^+\mu^- q\bar{q}$, which is an important background for Higgs boson production at LEP energies. Another study was carried out to compute radiative corrections to the process $W \to q\bar{q}\gamma$, relevant to the study of QCD effects in weak-interaction physics. A third project, finished during 1985, was the study of radiative corrections in models with strongly coupled Higgs fields. In order to facilitate such phenomenological analyses in the future, a large-scale computer project known as

Experimental Simulation Program (ESP) has been initiated. The symbolic manipulation program which is part of ESP is to become operational during 1986.

The properties of hadrons and their weak and electromagnetic interactions can be described quite well with the aid of effective Lagrangians. The construction of an effective Lagrangian for the pions and the vector mesons (ρ, ϕ, A) was carried out in a joint project with the University of Amsterdam. Mathematical aspects of such effective Lagrangians (non-linear σ-models) have been investigated in the context of supersymmetric theories with strong interactions.

Numerical calculations in QCD are beset by technical complications. The effects of using a finite volume have been tested in 2-dimensional models. Also an analysis of systematic errors in the 2-loop approximation for the Λ-parameter of lattice gauge theory was undertaken.

Finally, part of the theory group is engaged in work on supergravity and string theory. This research has already led to several publications, and it is continued further, partly in collaboration with the University of Utrecht. A 2-weekly seminar on these topics, in which several university theory groups participate, is being conducted. In November a review of the present status of the subject was presented in a series of lectures by Prof. Di Vecchia from the University of Wuppertal.

H.18. The Computer Group

The year 1985 has been dominated by the selection process for the successor of the Cyber 173, of which the contract with CDC expires mid 1986. Following first round orientation and investigation of various possible solutions a request for negotiations with interested vendors narrowed down the choice to four candidates: DEC, Elxsi, Gould and IBM. The most attractive final offer was made by Gould. This choice was supported by the laboratory community, and approved by CRIVA.

A dual CPU Gould 9080 will be installed at NIKHEF-H in the spring of 1986. It will considerably increase the computer capacity of the institute, and provides virtual memory and interactive service that was lacking on the CDC. The machine will run the UNIX BSD4.2 operating system. The contract foresees the upgrading to a more powerful system at a later stage.

The Apollo network of personal workstations has been expanded from two to seven nodes, among which two colour stations and a fileserver. They are very successfully used for advanced interactive graphics applications and high quality program development.

In the fall of 1985 the Ethernet-based WCW Local Area Network became operational. It interconnects all institutes at the site. At NIKHEF-H it will link the Apollo network to the Gould facilities. Through the CWI gateway it provides world-wide electronic mail service.

The load on the Cyber 173 is gradually diminishing, as several experiments are being terminated, and the new experiments require virtual memory. Work has therefore migrated to the Apollo system.

See tables H18.1 and H18.2 for the Cyber 173 figures.

CERN cross-software has been installed on the Apollo PWS, and is now used for the VME-bus test systems. On these systems Fastbus software, together with PILS (an interactive interpreter) has been ported. VME and Fastbus modules, designed and constructed by the electronic workshop can now be tested.

The second level muon trigger in UA1 (based on the FAMP multiprocessor system) will be replaced by a completely new system: commercially available VME modules with software written in high-level languages. A preliminary version for a single processor is available. Since the required decision times are very short it is necessary to distribute the required tasks among multiple processors. Software development to this purpose has been started.

Table H18.1

Available machine time Cyber 173		*(hrs)*
Calendar clocktime		*8760*
Scheduled maintenance		*72*
Available clocktime		*8688*
Maintenance due to:	*hardware problems*	*20*
	software problems	*2*
Block time		*5*
Net available machine time		*8661*

Table H18.2

Batch time distribution in CP hours

	(hrs)
System	*199.1*
Administration	*18.4*
Mark-J (DESY)	*43.5*
DELPHI	*47.3*
HERA	*39.7*
LEAR	*68.7*
Section-K	*22.5*
Microprocessors	*8.6*
ACCMOR	*1591.6*
Neutrinos (D2)	*666.2*
UA4	*434.1*
Theory	*815.9*
UA1	*1.1*
Visitors	*17.1*
CDC	*1.8*
Neutrinos (NC)	-
PEP9	-
Total	*3975.6*

In collaboration with FVI/UvA further developments have been carried out on the FADOS distributed operating system.

For the L3 experiment the requirements have been defined for the distributed operating system to be used in the monitoring and calibration system for the muon chambers. It has been decided to use the commercially available DRM system from Philips. The system software has been tested, and the design and implementation of the application software has been started.

Research has started on the applicability of techniques used in image processing for second level triggering on hadron jets and electrons, based on an electromagnetic calorimeter with good granularity. The results of this research are potentially useful for the UA1 and ZEUS experiments.

H.19. Electronics Group

The group supports the major experiments of the institute. The activities are summarized below.

UA1

A FAMP-VME-interface module has been designed of which 22 modules have been built for UA1, the computer group and the electronics department itself.
DataSud VME systems have been tested both for the computergroup and for UA1. Several modifications had to be made to the processor. The CP/M-68k operating system has been adapted to the DataSud VME processors.
Much effort has been given to the electronics for the new uranium calorimeter. For the 2^{nd} level trigger a prototype of the 'LOCAL SUMMER' was made and tested. The design of the 'GLOBAL SUMMER' was further developed.

In order to send data via the VMX-bus of VME over distances up to 2 metres, a 'VMX-VMX-EXTENSION' module has been designed and built. The print lay-out is in an advanced stage.

Design, prototype and tests have been completed for 'FAXNIK', an interface of the FAMP-BB-bus with the VME-VMX bus.

DELPHI

Six units of the 8-channel 7-bits Flash ADC module 'FLAIRC' have been built. Some of them are in use in Strasbourg.

Much attention has been given to the question of the mounting of the electronics for the 2500 channels of the inner detector, in particular in view of the limited space available.

The charge amplifier for the trigger layers of the Inner Detector has been designed. Prototypes have been built and tested. Tenders have been called for a hybridized version containing 4 amplifiers on a carrier of ca. 1x2" squared.

L3

Our design of the hybridized pre-amplifiers is now in production at Philips MBLE. In total 37,500 of these amplifiers will be used for the muon chambers. They will also be produced for other customers, i.e. Rutherford Appleton Laboratory, the universities of Naples, Aachen, Beijing and for the Free University of Amsterdam and for NIKHEF Section-K.

The prototype of the 48-channel pre-amplifier board works as expected and will be taken in production. The prototype of the 48-channel discriminator-board, a 6-layer multilayer, also works satisfactorily. However, a number of tests is still necessary due to the spread in performance characteristics of the discriminator IC's. Philips MBLE hybridized RC-networks are used which give a substantial economy in utilizing the available space. These networks have also been supplied to the Free University of Brussels.

For the optical-electronical alignment system of the muon chambers the VME control module 'VRASNIK' has been designed and built. The high density of electronic components requires a complicated lay-out. The pre-amplifiers for RASNIK have been built and calibrated in a computer controlled test set-up.

The 'MPC' (Muon Personality Card), an add-on for the LeCroy FastBus TDC's, has been designed and a prototype was built and tested at CERN. A FastBus crate and several modules have been obtained, so that in-house FastBus developments can be done.

The muon chambers produced in the mechanical workshop are equipped with the necessary electronics. The production of the 5-layer multilayer for MI, MM and MO has been completed.

General activities

In view of the limitations of the present CADET lay-out system, much time was spent on an evaluation of Computer Aided Engineering (CAE): systems with the intention of extending the CAE facilities of the institute.

A NIM-module, 8-channel NIM-TTL converter, has been designed and built for the electronics Pool; also a FAMP Reset module was built for the computer group. Five special VME-crates have been built for UA1, the computer group, and the electronics department.

A terminal network 'TERNET' is installed in the institute. An 8-channel connection with the AMOLF VAX has been made.

The group has suffered this year severely from unfilled positions. In particular the Delphi project was understaffed.

H.20. Mechanics Group

This year the mechanical workshop was very closely involved with the LEP and HERA projects.

L3

For the L3 muon chambers all the smaller parts of the MM-detectors (middle muon drift chamber) have been made. There are also some parts produced for the MI and MO chambers.
In June a new milling machine has been installed for machining the end frames. In December 16 frames had been finished. After a slow start with the large muon chambers good progress is made and in December a start is made with the fourth muon chamber. The delivery of the side panels and the honeycomb covers by industry proceeds without major problems. This is also the case for the aluminium cast work necessary for the end-caps. So it seems likely that the intended production schedule of one chamber a month can indeed be achieved .

DELPHI

(a) Jet chamber

In August preparations were started for the Jet Chamber. Good progress is made with the measuring annex wire setting test stand.

(b) RICH

A quartz transmission device, and a number of test models for radiator boxes were made. These radiator boxes are part of the Combi-RICH and are made of carbon fibre. In September the construction of a sixth Barrel-RICH drift chamber was started, this one equipped with "alumina-cloisons".

In the first months of the year a pressure bench was made which will be used for testing the Jet Chamber glass epoxy cylinders. First studies were made for the construction of the outer cylinder of the Barrel-RICH. This cylinder has a diameter of 400 cm and a height of 360 cm and will be built in the NIKHEF workshop. This will be a major and difficult job for the workshop in 1986.

HERA

In the first half of the year one test module of a calorimeter was made. This module consists of 30 consecutive layers of scintillator strips with a thickness of 5 mm and lead plates of 4 mm thickness.

The sensitive area is 600×600 mm^2. In the second part of the year another three modules of this type were produced and sent to CERN.

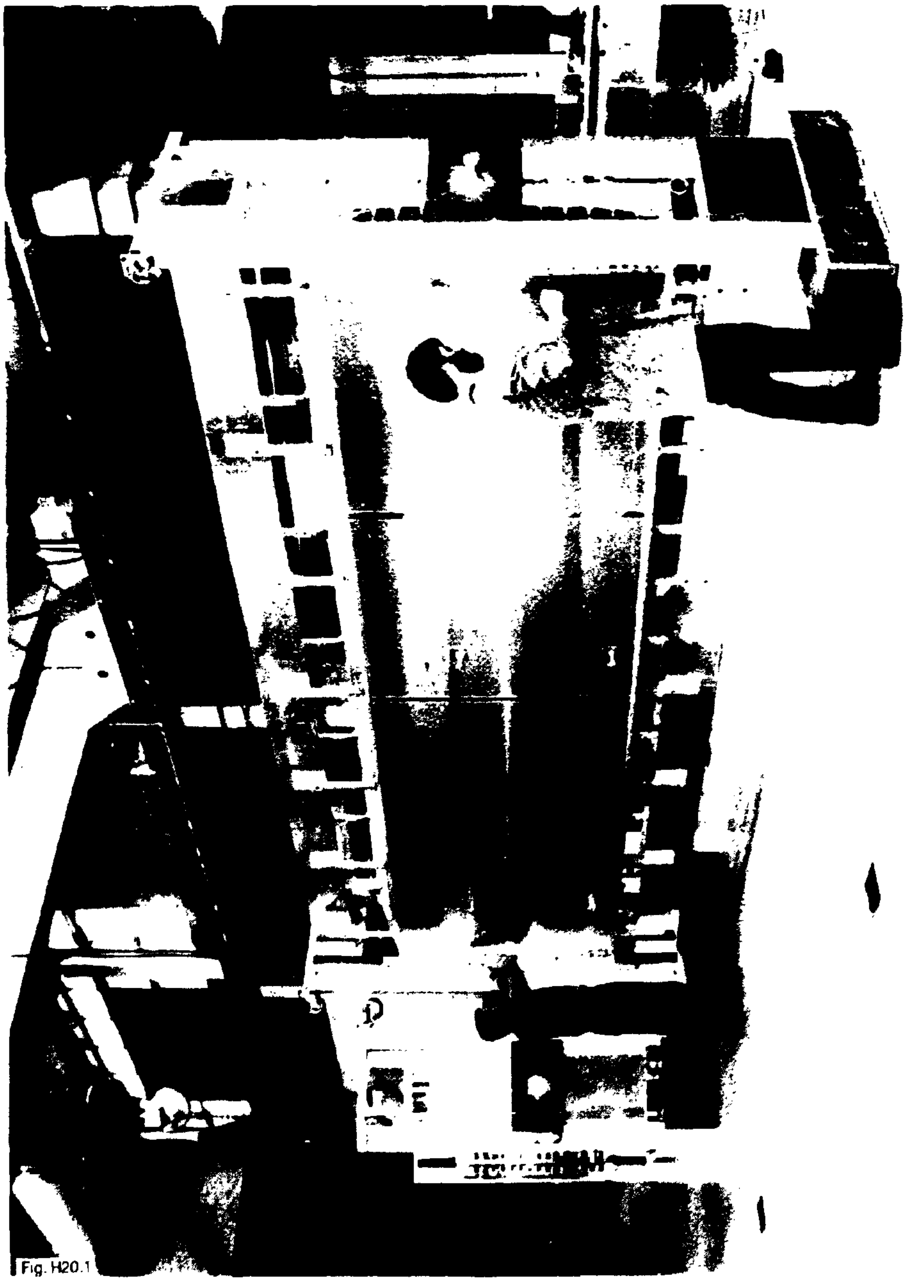


Fig. H20.1

L3 muon chamber under construction in the workshop.

The large workload leads to a staffing problem. New personnel has been hired on short term contracts. The highly specialized work requires that the senior skilled technicians spend a substantial fraction of their time in training the, generally young, newcomers. This role in training young technicians in the use of new techniques makes that NIKHEF-H gradually develops also here into an educational institution.

H.21. Mechanical Design Group

The design and drafting work for the two LEP experiments DELPHI and L3 is coming into its final phase. The work for the HERA experiment ZEUS has started this year.

DELPHI

(1) The Jet Chamber and the trigger layers (outer part) of the Inner Detector were designed in co-operation with an engineer of Cracow. Due to the high accuracy required, various alignment and measuring appliances were designed and discussed with the technicians producing the Jet Chamber parts.

(2) For the RICH-counters a test set-up was made for the UV-light transmission measurements of the quartz windows. Some engineering work was done on the support cylinders of the Barrel-RICH, which will be partly made at NIKHEF.
Drawings were made for the 6[th] prototype (7.5°) of the Barrel-RICH MWPC.

L3

Most work consisted in making the drawings for the series production of the muon chambers. The octant-alignment and the vertical alignment system have been designed in co-operation with MIT. Both half octants are now mechanically and optically coupled together. The design study of the cable carriage and the cable lay-out in an octant led to a major change and big improvement in the design. A new trapezium-shaped laser box was designed, which reduces the number of optical support parts per octant laser box, and accordingly the costs, significantly.

A design was made for the support structure of the mirrors reflecting the laser beam outside the muon chambers. Because of the lack of space between the magnet coil and the octant assembly carbon fibre pulltrusions were used as structural elements. The design of a small accurate calibration chamber (cell map) with three active cells and a wire length of 50 cm made use of the technique of static-determined mechanical support by means of a flexible torque box (see fig. H21.1).

ZEUS

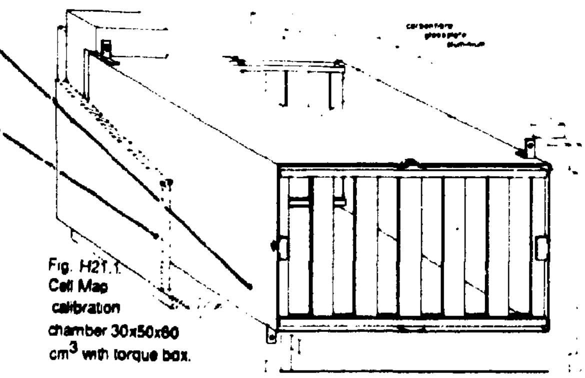


Fig. H21.1 Cell Map calibration chamber 30x50x60 cm^3 with torque box.

Concept designs and installation and maintenance scenario's of the detector were made. Important elements are the forward, the barrel- and the rear calorimeter. These will be presumably made of depleted uranium and scintillator plates with photo-multiplier read-outs. For the support of the barrel, the superconducting coil and the central detector, a rotateable structure was proposed to make it possible to load and unload the heavy modules by means of the crane ← (see fig. H21.2). In order to avoid dead space in the cak rimeters for support structures, we make use of the mechanical properties of the uranium material.

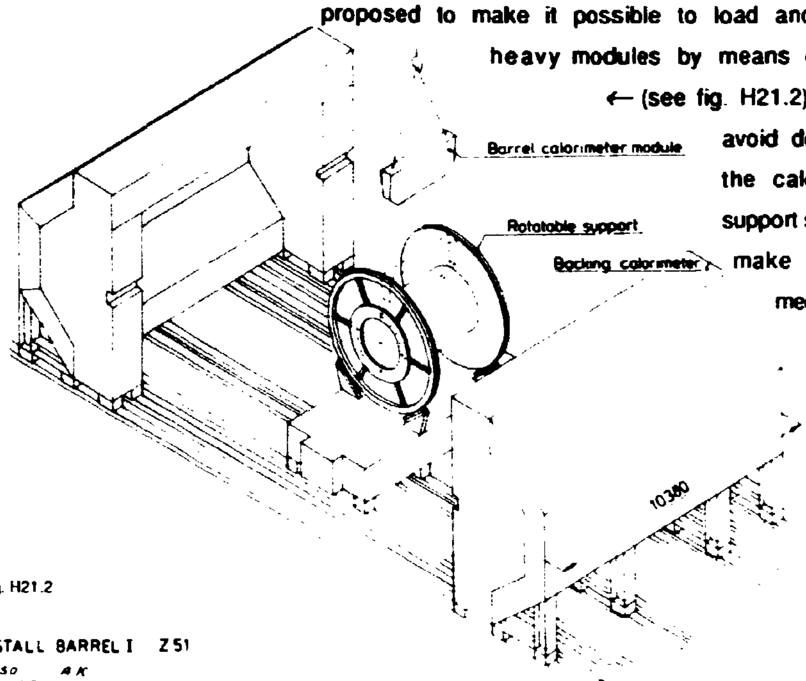


Fig. H21.2

Installation scene of the modules of the Barrel Calorimeter of the ZEUS experiment.

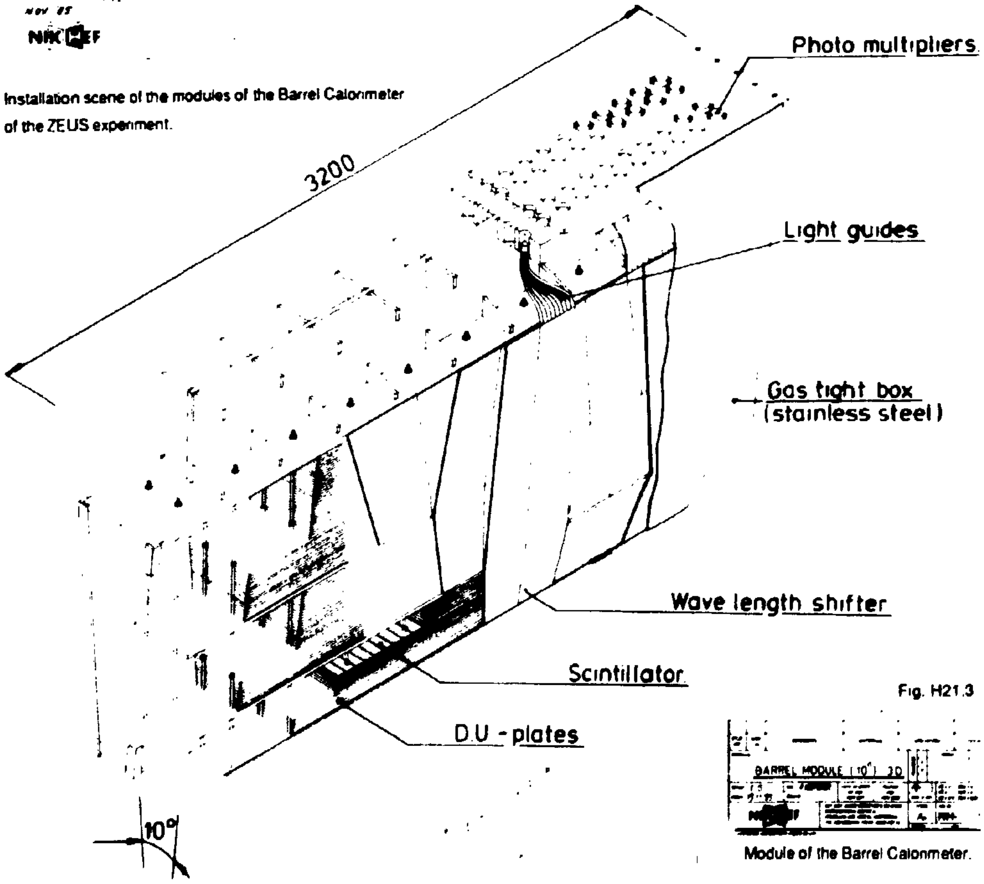


Fig. H21.3

Module of the Barrel Calorimeter.

The individual modules can be made by different institutes. The barrel modules were designed using a double pointing read-out system. Similar ideas were used for the movable forward calorimeter. For testing purposes a test module of 60×60×40 cm^3 was drafted.

CAD

A study was made of CAD systems for drafting and design work. In co-operation with AMOLF, a 2D-drafting package was rented for three months and installed on the Apollo work stations at NIKHEF. Various other packages were also evaluated.

H.22. Technical & Domestic Services

The year 1985 has not been too unfavourable for our service as far as down-time of the installations was concerned. An exception was the replacement of the chimneys in the boiler house of the new buildings. The failure was due to a wrong way of construction and an improper choice of material.

The maintenance of the housing in the old buildings raises problems since there is an enormous maintenance time-lag and there are no funds available. A quick start of new housing constructions for the section-K would be a big relief.

A start was made with the construction of rooms external to the building of section-H for the installation of gas-filled bottles. The pipelines leading to the various laboratory halls and the mechanical workshop were also installed. The rules of the fire-brigade do not allow any more for gas-filled bottles in the building.

The larger of the two cycle stores at the section-H has been provided with a gate and keyprocessor. In this way the store is protected against theft of bicycles. Everybody entering the store is now signalled and stored in the computer at the porters lodge of SARA.

The SL-tubes around the central hall at the section-H have to be replaced. They have been lighting since January 1982 except for six of them that were stolen. Even accounting for the high initial costs they have been a saving not only by virtue of low energy consumption but also reckoned by the few hours that had to be spent replacing them. With the conventional bulbs this took many hours of our staff.

Quite some work has been performed for the safety services, mechanical workshop and the scientific projects. E.g. the placing of fixed basins with foot control, the installation of gas tubes towards the construction hall and the construction of a covered external store for liquid waste. We have the feeling that the present budget is the minimum for maintenance of buildings and installations. In particular the budget for cleaning has reached the level of a bare minimum.

NUCLEAR PHYSICS (K)

Preface

The major part of the experimental work of the Nuclear Physics section of NIKHEF is concentrated around the Amsterdam 500 MeV electron linac MEA. Nuclear-structure studies with the electromagnetic probe were in the past year almost exclusively performed with the facilities at NIKHEF, many of them in international collaborations. Experiments with muons and hadronic probes (π,p), however, also benefitted greatly from the availability of installations abroad (SIN and CERN). The secondary pion beams at NIKHEF were mainly used for pion scattering and absorption experiments. Most of the radiochemistry research was done with low-energy secondary photon beams at MEA; only a minor part of the programme (muonium chemistry) was carried out at SIN. Although the accelerator MEA has produced less beam hours in 1985 than in the previous years, partly to save on electricity costs, the number of real data taking hours remained virtually the same due to a considerable increase in efficiency. A few highlights of the scientific work can be summarized as follows.

A hot topic in the electron scattering work was the study of nuclear-medium effects on the structure of nucleons. A significant effect was observed in exclusive proton knockout reactions on light nuclei. The interpretation of the ratio of longitudinal and transverse response functions for the ^{12}C(e,e'p) reaction confirmed, in a model-independent way, results earlier obtained in inclusive quasi-free scattering elsewhere. The effects are comparable to those observed with high-energy muons and electrons (EMC effect). The density dependence was studied with the ^{6}Li(e,e'p) reaction by detecting $l = 0$ as well as $l = 1$ knockout.

The long-standing question of $3s_{1/2}$ spectroscopic strength in the doubly magic nucleus ^{208}Pb obtained considerable attention. Both relative (^{206}Pb, ^{208}Pb) and absolute strength distributions were measured with the (e,e'p) reaction. The results are being interpreted together with those from (d,^{3}He) work (Bloomington, Tübingen) and inclusive electron scattering data (Saclay).

Dispersive effects in electron scattering were established by a precision measurement of the elastic form factor of ^{12}C in and around the first diffraction minimum. The experiment performed at energies between 240 and 430 MeV, showed an effect of up to 10 % on the cross section in the minimum. Although the measured energy dependence is described correctly by calculations, the magnitude of the effect is an order of magnitude larger than calculated.

The interaction between low-energy pions and nuclei was studied by elastic pion scattering and by absorption experiments. Scattering data were obtained at the NIKHEF pion beam for a liquid ^{4}He target at pion kinetic energies of 15 and 25 MeV. A begin was made with similar experiments on ^{3}He. Pion absorption at zero energy was investigated through the study of pionic atoms, notably by the detection of the 2p $\rightarrow$ 1s transition in pionic Al. This experiment was carried out at one of the continuous and intense pion beams available at SIN, in order to suppress contaminant muonic X-rays and nuclear γ-rays by a coincidence technique. In this way, the transition could be detected with a minimum of interfering lines.

The NIKHEF muon channel was used for exclusive experiments on pion absorption in flight. The $\pi^+ + {}^2H \rightarrow p + p$ reaction cross section was measured for T_π = 20 - 50 MeV by using an array of 16 large scintillator bars covering a total solid angle of 1.4 sr.

Nuclear-medium effects on nucleons bound in nuclei were also studied theoretically. It was pointed out that within the σ–ω model, Dirac spinors of bound nucleons and hence also the associated electromagnetic currents, are strongly affected by the nuclear environment. This could be an explanation for the effects found on the nucleon form factors in exclusive (e,e'p) experiments (see above). An alternative description of these data, by the concept of 'swollen' nucleons, was also studied extensively. The NIKHEF experiments could also be described by a 10 % increase of the charge radius and magnetic moment. This value is comparable to that found in a similar explanation of the EMC effect.

The emphasis in hot-atom chemistry was largely on reactions with multivalent atoms, in particular ${}^{15}O$ and ${}^{11}C$. The work with ${}^{11}C$ was concentrated on arenes and inorganic halides of ammonia. Measurements of astrophysical interest were performed in cooperation with the FOM-ECN Nuclear Physics group at Petten. With a beam of 24 keV neutrons from the Petten nuclear reactor, the capture cross section for the ${}^{175}Lu(n,\gamma){}^{176m}Lu$ reaction was precisely determined. The result is important for our knowledge on nucleosynthesis.

Although no decision as yet has been made for funding the UPDATE proposal, it is worth mentioning that our principal funding agency, the Foundation FOM, has allotted money for an upgrade of MEA. This upgrade consists of an increase of the maximum electron energy from 500 to 600 MeV and an increase of the maximum peak current from 10 to 50 mA. The first goal will be met by increasing the peak power of five modulator stations from 4 to more than 5 MW, the second by an update of the electron gun.

G. van Middelkoop

K1 ELECTRON SCATTERING (Group leader C. de Vries)

K1.1 Introduction

The past year two graduate students concluded their work with the defence of a Ph.D. thesis on investigations carried out with MEA, which signifies that the accelerator has now been operational for about four years. One thesis deals with a study of effective electro-magnetic operators in the 1f2p shell (Ti isotopes), the other with transverse excitations in ^{19}F. Three other subjects, monopole transition densities and transitions to natural-parity states in ^{58}Ni, 'IBA studies' on Pd isotopes and the investigation of (e,e'p) and (e,e'd) reactions on ^{3}He have virtually been completed.

A remarkable result was obtained in the search for dispersive effects in ^{12}C. A pronounced (10 %) energy dependence appeared by comparing data for 250 and 440 MeV scattering off the ground-state charge distribution around the first diffraction minimum. This result has triggered (accepted) proposals to get additional information (for low-q at NIKHEF and for 700 MeV at MIT).

Some other interesting results are:

(i) A significant nuclear-medium effect on the structure of nucleons, comparable to that seen in the high-energy muon and electron data (EMC effect), was found from the longitudinal/transverse separation of the response functions measured with the (e,e'p) reaction on ^{12}C.

(ii) The α-d momentum distribution for the ground state of ^{6}Li was obtained from the $^{6}Li(e,e'd)^{4}He$ reaction.

(iii) The final-state interaction, the knowledge of which is crucial for the extraction of wave functions for deeply bound nucleons, was studied with the (e,e'p) reaction on ^{12}C and ^{90}Zr.

For future experiments, the detection telescope in the QDD spectrometer was extended with a fourth wire chamber to improve the angular resolution (from 8 to 3 mrad). Tests were performed on a large-solid-angle (out-of-plane) charged-particle detector with moderate resolution for morefold coincidence studies. A low-pressure, thin-window wire chamber was designed for the (coincident) detection of light recoil particles (^{3}H, ^{3}He).

The collaboration with outside users from several countries has been intensified. The strong increase of the participation of the University of Utrecht should be mentioned in particular.

In November 1985 the fourth Mini-Conference on 'Nuclear structure in the 1p shell' was held; proceedings are available on request.

K1.2 Single-arm electron scattering experiments

K.1.2.1 Nuclear structure and model

Transitions densities in ^{58}Ni and ^{26}Mg

(H. Blok, H.P. Blok, J.F.A. van Hienen and G. v.d. Steenhoven (VUA); C.W. de Jager and H. de Vries; R. Sorndramayagam and K.K. Seth (Northwestern University); B.A Brown (Michigan State University))

Transition charge and current densities for levels up to 6.5 MeV excitation energy in ^{58}Ni, obtained from inelastic scattering data at forward and backward (154°) angles, have been compared with the result of nuclear model calculations. Shell-model calculations in a 1f2p-space give a fair description of the current density and the charge density in the nuclear interior, but severely underestimate the strength at the nuclear surface, see fig. K1.1. Effective charges are no remedy for the discrepancy, because the shapes of the measured and calculated charge densities are different. The lack of strength at the nuclear surface is thought to reflect the neglect of contributions from orbitals outside the model space (core polarization). Broken-pair calculations in a large model space succeed in general to describe this strength. The measured transition densities have a general tendency to peak at larger radii than the calculated ones. This is especially clear for the 6^+ state at 5.123 MeV which supposedly is a fairly pure $1f_{7/2}^{-1}1f_{5/2}$ T=0 state. This may indicate that ^{58}Ni is easily deformed, when it is excited.

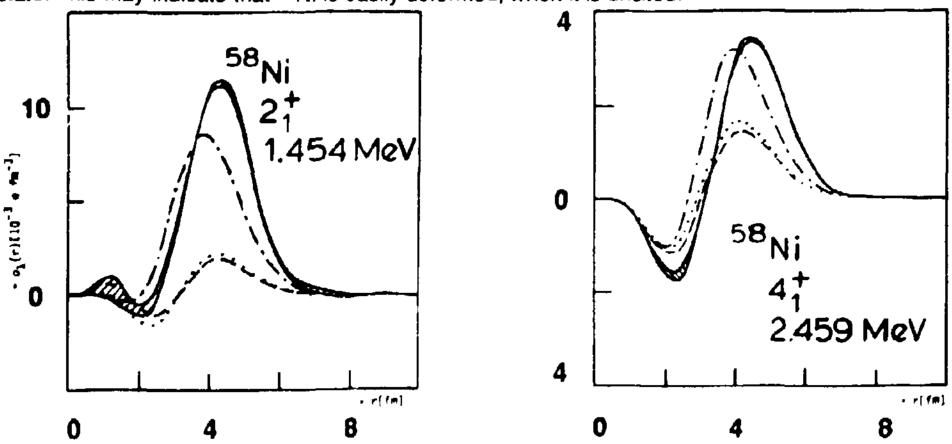


Fig. K1.1 Measured transition densities (—) for the 2_1^+ and 4_1^+ states in ^{58}Ni compared with the results of model calculations

The dataset for scattering off ^{26}Mg has been extended with measurements at 154° in the momentum transfer range of 0.85 to 2.60 fm^{-1} in order to determine the transverse components of the form factors. The reduction of the data, obtained at forward angles, to form factors for several 2^+ and 4^+ states has been completed. The backward angle data are being analysed by the Northwestern University group. Full analysis of the information from both data sets awaits the latter work.

Electric and magnetic excitations in ^{50}Ti

(A.M. Selig, P.K.A. de Witt Huberts, I.E. Zacharov)

This work has been completed and fully described as part of the Ph-D thesis (Dec. 1985) by A.M. Selig: "Effective electro-magnetic operators in the 1f2p shell investigated with (e,e') reactions". A publication concerning specifically this work is in preparation.

Tests of the interacting Boson Approximation for $^{104-110}Pd$ and ^{196}Pt

(J.B. van der Laan, A.J.C. Burghardt, C.W. de Jager and H. de Vries; W.T.A. Borghols, N. Blasi, M.N. Harakeh and S.Y. van der Werf(KVI))

For the final analysis of the electron-scattering data on even-A Palladium isotopes a new attempt was made to describe the low-lying positive-parity states within the IBA-2 model. In a fit to the excitation energies of the one-phonon 2^+ state, the two-phonon (0^+, 2^+,4^+) triplet and the three-phonon (0^+,2^+,3^+,4^+,6^+) quintuplet and the B(E2) -values to the first and second 2^+ states, the parameters ε, K, χ_v and e_π were varied. The ratio e_v/e_π was adjusted to the M_n and M_p strengths for the first 2^+ state determined in inelastic pion scattering. The value obtained in this way, 0.41, is quite different than that assumed in previous studies (i.e. 1.0). With the resulting parameter set a much better descripton than in previous calculations was obtained of the B(E2) values for the second 2^+ state, while other properties were described equally well. The two weakly excited 2^+ states observed in ^{110}Pd can now also be explained, whereas in previous calculations one of those states had to be assumed an intruder state.

With this set of IBA-2 parameters boson structure functions a(r) and b(r) were extracted from a simultaneous analysis of the transition charge densities of the first and the second 2^+ states. With the same pair of structure functions it was posssible to describe the shape and the strength of these transition charge densities. The data, however, showed no sensitivity to different shapes for the proton and neutron structure functions. The first 4^+ state in all four isotopes has a quite pure two-phonon character, which follows from the fact that the transition charge density is quite well reproduced by applying the assumption that the $\beta_4(r)$ structure function is identical to the $\beta_2(r)$ function. All other 4^+ states need a significant g-boson admixture.

A simultaneous analysis of the first 2^+, 3^- and 4^+ states and the second 2^+ state was also performed in the framework of the Anharmonic Vibrator Model. By expanding the ground state charge distribution by only 4 %, it proved possible to obtain an adequate description of all transition charge densities studied. The AVM thus is sensitive to the radial properties of the excitations without making any prediction on the excitation strength, whereas the IBA predicts the excitation strengths; the boson structure functions extracted can, however, only be compared to microscopic calculations that are at present unavailable.

In the analysis of the data on ^{196}Pt attention was now focussed on the negative parity states. Besides the (3^-,5^-,7^-)triplet at approximately 1.4 MeV excitation energy two strongly excited 3^- states were observed at 2.5 MeV. A first attempt was made to describe these states by coupling one f-boson to the system of s- and d-bosons used to describe the positive-parity states. Although the hamiltonian was kept as simple as possible, six parameters are introduced, three for the excitation energies and another three for the transition strengths. Therefore more systematic data are necessary for a serious study of negative-parity states in this region with the Interacting Boson Approximation. Nevertheless, our first attempt was quite successful: the excitation energies and the transition rates of all negative-parity states observed were reproduced quite well. The electron scattering data on ^{110}Pd have been used in the analysis of proton scattering results.

Quadrupole boson structure form factors for proton scattering from the IBA-model and electron scattering. Phys. Lett. ***162B*** *(1985) 1*

(R. De Leo, M. Pignanelli, W.T.A. Borghols, S. Brandenburg, M.N. Harakeh, H.J. Lie, S.Y. van der Werf, C.W. de Jager, J.B. van der Laan and H. de Vries)

ABSTRACT Inelastic proton scattering from ^{110}Pd has been measured at E_p= 30.7 MeV. Angular distributions for three low-lying 2^+ states are satisfactorily reproduced by employing reduced matrix elements from the IBA model and form factors evaluated from two quadrupole transition charge densities (determined from electron scattering) folded with a nucleon-nucleon interaction. The relative phase between these two transition charge densities could be determined because of coupled channel effects in inelastic proton scattering. This leads to boson structure form factors for proton scattering resembling a Woods-Saxon first derivative for the d-boson non-conserving part and a Woods-Saxon second derivative with a reduced radius for the d-boson conserving part.

Electroexcitation of the new antisymmetric mode in ^{164}Dy

(D. Bohle, U. Hartman, K.D. Hummel, G. Kilgus, A. Richter (Technische Hochschule Darmstadt); C.W. de Jager)

At the Darmstadt linear electron accelerator a new collective magnetic dipole excitation mode has recently been discovered in heavy deformed nuclei. In terms of the IBA-2 model this mode can be adequately described by a small amplitude oscillation of the angle between the symmetry axes of the deformed valence neutrons and protons -the so-called twisting or antisymmetric mode-. At the Darmstadt facility the momentum transfer range is limited to 0.6 fm^{-1}. Therefore the investigation was extended at NIKHEF-K for the nucleus ^{164}Dy in order to study the form factor behaviour at larger values of the momentum transfer and to search for the 3^+ member of this antisymmetric band. Data have been taken at five energies between 75 and 140 MeV at a scattering angle of 154°, thus covering an effective momentum transfer range of 0.9 to 1.6 fm^{-1}. In the same q-range a number of data have also been taken at forward angles. A resolution of between 20 and 25 keV was obtained, even at the backward angles. A preliminary analysis has shown that it will be very difficult to extract accurate form factor values from these spectra because of the high level density in the excitation energy range of interest. No indication has as yet been seen of the 3^+ member of the band under study. The search for this state will be considerably alleviated by the knowledge of the position of the 2^+ band member.

The transitional nuclei ^{198}Hg and ^{204}Hg

(A.J.C. Burghardt, C.W. de Jager, H. de Vries; R. Altemus, J. Laksanaboonsong, J.S. McCarthy, B.Norum, L.Orphanos, A.Saha (University of Virginia); J. Heisenberg, J. Wise (University of New Hampshire))

A severe delay in this experiment was caused by target problems. During the measurements at the end of 1984 it was noticed that the amount of oxygen in the target had increased dramatically, that the target itself had become inhomogeneous and that the thickness of the targets decreased under beam exposure. Therefore a new set of targets had to be bought which meant such a large investment that no budget is available for future studies of the other Hg isotopes.

The new targets became available in September 1985, after which the measurements on ^{198}Hg and ^{204}Hg were completed. The data have now been extended to a momentum transfer region of 0.4 to 3.0 fm^{-1} with an overall resolution of approximately 10^{-4}. The analysis of the data is in progress. It is clear already that in the spectra of each isotope about 35 states are observed up to an excitation energy of 5 MeV of which a large number, especially in ^{204}Hg, has not been observed previously.

Longitudinal form factors in ^{15}N

(J.W. de Vries, D. Doornhof and C. van der Leun (University of Utrecht); C.W. de Jager; R.P. Singhal and S. Salem (University of Glasgow); G.A. Peterson and R.S. Hicks (University of Massachusetts)).

Data taking on ^{15}N was completed using a room-temperature gas target by experiments at 430 MeV and scattering angles up to 95°. A comparison with the low q elastic data measured by Schütz [1] indicates that the present cross sections should be renormalized by 10%. This

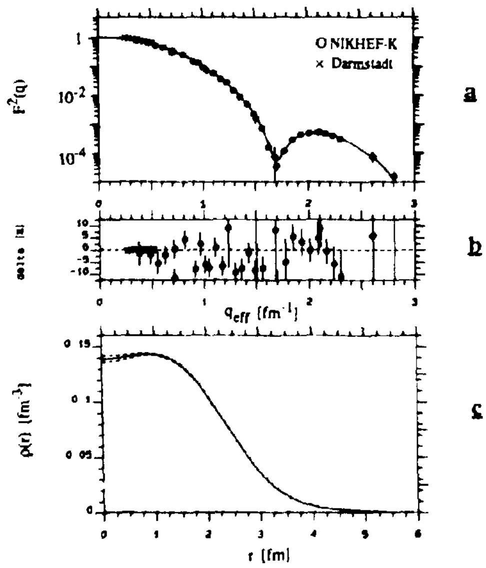


Fig. K1.2 The elastic form factor of ^{15}N and its Fourier-Bessel fit (a) + (b) and the corresponding charge distribution (c).

suggestion is supported by the comparison of our data for the $3/2^-_1$ level at 6.32 MeV with those measured by Macauley et al. [2]. The origin of this discrepancy is still not clear. A test has been performed by remeasuring the elastic form factor in a few points at low q. The scattering from a gascell filled with ^{16}O was also measured to check the ground-state form factor of this nucleus. These data are still being analysed.

The ground-state form factor, renormalized by 10 % and corrected for the transverse contribution with the data from Singhal et al. [3] has been fitted (see fig. K1.2) to a Fourier-Bessel series together with the data from Schütz. This yields the ground state charge distribution [4]. The deduced rms radius of 2.588(6) fm is in agreement with the value of 2.580(26) reported by Schütz. Inelastic data have been extracted up to an excitation energy of 13 MeV. Shell model calculations by Glaudemans and Van Hees [5] are capable to describe the ground state form factor and that of the $3/2^-_1$ level. For higher $3/2^-$ levels however the calculations underestimate the data by several orders of magnitude.

Transverse form factors of 1p shell nuclei at high momentum transfer

(L. de Vries, H.P. Blok (VUA); C.W. de Jager; R.P. Shinghal (University of Glasgow)

The measurement of transverse form factors in 1p-shell nuclei (^{15}N and ^{12}C or ^{16}O) to high momentum transfer (q = 3.0 - 4.5 fm^{-1}) is to be performed in the large solid angle QDQ spectrometer because of the low count rate. As a preparation for the (e,e') measurements the optical properties (dispersion matrix elements, aberrations) of the QDQ were investigated in detail with the help of special sieve-slit measurements for different settings of the entrance-(Qen)and exit-(Qex) quadrupole magnets, at three energies (265, 415 and 526 MeV). Especially the transverse focussing properties are more complicated than assumed. With the standard values for Qen and Qex the focal plane in the Y-direction is situated in front of the X1-wire chamber and tilted with respect to that wire chamber. It was also found that the opening angle is slightly asymmetric. Tight directional constraints and information from pulse height and timing in the scintillators will be used to reduce the background.

Inelastic scattering from ^{19}F

(A.J.H. Donné, G. van Middelkoop (VUA); L. Lapikas; P.W.M. Glaudemans and D. Zwarts(RUU))

Transverse electro-excitation of levels in ^{19}F at excitation energies less than 4.4 MeV was measured at 154° and 180°. The deduced form factors for the positive-parity states are compared with predictions from $0\hbar\omega$ and $2\hbar\omega$ shell-model calculations in the full 2s1d configuration space and a space made up of all shells up to the $1f_{7/2}$ orbit, respectively. The form factors for the negative-parity levels are calculated with a $1\hbar\omega$ shell model in the full 1p-2s1d configuration space. Form factors computed with the 1ħω model exhibit shapes similar to the experimental data for these non-natural parity levels. The strengths, however, are off by a factor 1.4 – 2 with respect to experiment. For the positive-parity states theory and experiment show interesting large discrepancies. The 2ħω generally gives slightly better predictons for the shapes of the form factors. The 0ħω calculation is, however, in somewhat better quantitative agreement with the data. The large differences between the predictions from the 0ħω and the 2ħω calculations indicate that the effects of space truncation should be studied in more detail. A Ph.D thesis including this subject (see also K1.2.2.: Elastic magnetic electron scattering from ^{19}F) has been completed (September 1985).

Compilation of nuclear charge density distribution parameters from elastic electron scattering
(H. de Vries, C.W. de Jager)

The publishers of Atomic Data and Nuclear Data Tables have asked us to update the compilation of charge and magnetization density parameters, published in 1974 [6]. Due to the large improvements in analyzing data in model-independent ways we have also included tables with Fourier-Bessel coefficients and Sum-of-Gaussian parameters. The table of magnetization density parameters has been skipped in this new compilation since there exist large ambiguities in the presentation of those parameters and extended review of magnetic scattering results has been presented by Donnelly and Sick [7].

K1.2.2. Magnetic Scattering

Elastic magnetic electron scattering from ^{19}F
(A.J.H. Donné, G. van Middelkoop (VUA); L. Lapikàs; T. Suziki; P.W.M. Glaudemans and D. Zwarts (RUU))

Elastic magnetic electron scattering from ^{19}F was measured at 154° and 180°. The large momentum transfer range covered ($q = 0.4$ -2.8 fm^{-1}) allowed to perform a model-independent analysis of the magnetic dipole form factor. It indicates the presence of strong configuration mixing. Shell model calculations in the full 2s1d configuration space are unable to account for the behaviour of the experimental data which exhibit an intermediate form factor maximum. A large basis shell-model calculation using all orbits up to the $1f_{7/2}$ shell produces such a maximum, as does a core-polarization calculation starting from shell model wave functions in the full 2s1d space. In both cases excitations from the 1s to the 2s shell are mainly responsible for the appearance of the intermediate maximum. Non-nucleonic degrees of freedom do not disturb this conclusion since they yield only small corrections to the form factor.

A paper on this subject is submitted to Nucl. Phys. A Ph.D thesis including this subject has been completed (September 1985). See also K1.2.1.: Inelastic electron scattering from ^{19}F.

K1.2.3. *High spin stretched configurations*

Electro-excitation of 8^--states in ^{52}Cr

(R. Ent and J.F.A. van Hienen (VUA); C.W. de Jager, E.A.J.M. Offerman and H. de Vries, D.F. Geesaman and B. Zeidman (Argonne)G.C. Morrison (University of Birmingham) D. Sober (Catholic University-Washington D.C.))

The analysis of the stretched 8^- states is in progress. The earlier ambiguity in identification of the levels as observed in electron scattering and transfer reactions is solved due to a renewed energy calibration of the electron scattering results. The analysis of the electron scattering results is performed at the Catholic University. Several candidates for 8^-states have been found.

Stretched spin configurations in ^{116}Sn

(C.W. de Jager, P. den Heijer, H. de Vries; N. Blasi, M.N. Harakeh, W.T.A. Borghols, S.Y. van der Werf (KVI); G.T. Emery (University of Indiana))

The data taking part of this experiment has been completed. Data are available at both forward and backward scattering angles over a momentum transfer range of 0.4 to 2.6 fm^{-1}. All spectra have now been analyzed up to an excitation energy of 3.5 MeV. Up till now attention has been focussed on the three high-spin states observed in that region with a predominant neutron configuration. A publication on that subject has been accepted by Physics Letters:

High-spin 1p-1h configurations in ^{116}Sn and their fragmentation as seen in the reactions $^{116}Sn(p'p)$, $^{116}Sn(e'e)$, ^{115}In (^3He, d) and ^{115}In (a,t)

S.Y. van der Werf et al., Phys. Lett. **116B** (1986) 372

__ABSTRACT__: Stretched spin configurations in ^{116}Sn have been studied via the reactions $^{116}Sn(p,p')$, $^{116}Sn(e,e')$, $^{115}In(^3He,d)$ and $^{115}In(a,t)$. The high-spin negative-parity two-neutron quasi-particle states within the N=51-82 major shell appear to be little fragmented. The most prominent examples are the $J^{\pi}=9^-$ state at E_x = 3.522 MeV and two 7^- states at 2.909 and 3.120 MeV. It is found that in contrast the proton configurations $(g^{-1}{}_{9/2},h_{11/2})$ and $(g^{-1}{}_{9/2},g_{7/2})$ are strongly fragmented. Large basis BCS shell model calculations, using SkE-force, have been made and DWBA analysis of the (e,e') and of the (p,p')-data are presented.

K1.2.4. Dispersive effects

A search for dispersive effects in electron scattering off ^{12}C

(C.W. de Jager, E.A.J.M. Offerman and H. de Vries; H.J. Emrich and G. Fricke (University of Mainz); H. Miska (Technische Hochschule of Darmstadt); D. Rychel (Max-Planck Institut of Heidelberg); L.S. Cardman (University of Illinois))

Large deviations of up to 12 % between existing data in the first minimum of the elastic form factor of ^{12}C have triggered this experiment. Calculations [8] have shown that the form factor might be energy dependent by contributions of dispersive effects due to virtual excitations. Therefore a careful study of this region was made at three energies; 238, 419 and 431 MeV.

At each of these energies an effective momentum transfer range of at least 1.6 to 2.1 fm^{-1} was covered. Data were collected on an event-by-event basis, so that corrections for aberrations in the QDD spectrometer could be optimized off-line. This resulted in a scattering-angle resolution of better than 4 mrad. The data taken with the full solid angle 80 x 80 $mrad^2$ were analyzed in 8 mrad bins in the scattering plane. The relative normalization between the three data sets was checked independently by comparing the inelastic data on the 4.439 MeV level and the elastic data measured simultaneously in the second spectrometer, the QDQ. Care has been taken to eliminate all possible sources of experimental uncertainties, such as target inhomogeneities, energy calibration, cross section normalization, folding over the finite solid angle acceptance.

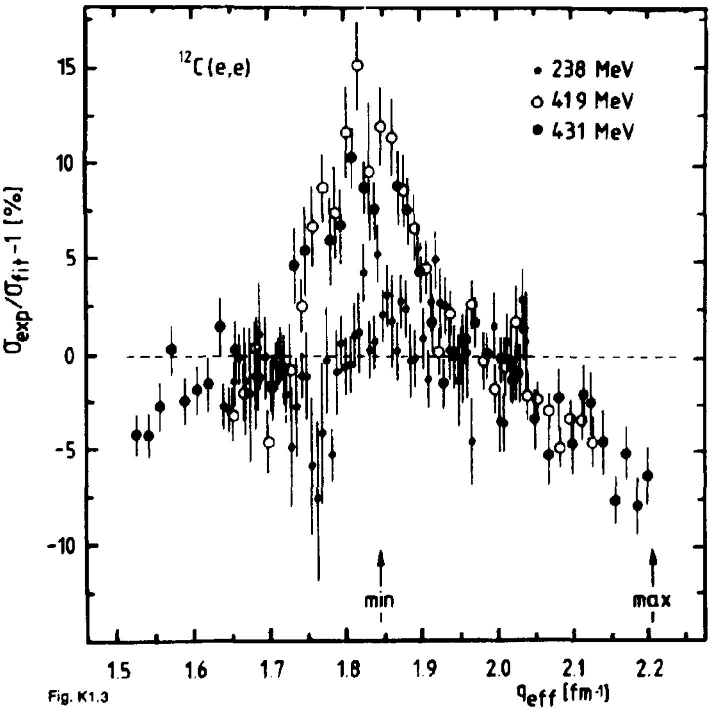


Fig. K1.3

The experimental data taken at 238, 419 and 431 MeV compared to the cross section calculated from the result of the Fourier-Bessel fit to the data at 238 MeV and those of Reuter et al.

First the 238 MeV data - 60 data points at 0.5° intervals - were evaluated model-independently in conjunction with Mainz data [9]. The charge distribution extracted from this Fourier-Bessel analysis was practically identical to that resulting from the analysis of Reuter et al. [9]. Next this charge distribution was used to predict the cross sections at the other energies, 419 and 431 MeV, which were then compared to the experimental data. The deviation between the predicted section and measured values is shown in fig. K1.3. It is clear that at an energy of more than 400 MeV the cross section overshoots the 238 MeV prediction by as much as 10 % in the minimum. Note that at the second maximum of the cross section the measured values are 6 % smaller than the prediction. Although the calculations 8) indeed describe the energy dependence observed in our data, the predicted maximum correction is nearly an order of magnitude smaller.

Measurement of the $0^+ \rightarrow 0^-$ transitions in ^{16}O

(C.W. de Jager, E.A.J.M. Offermann, H. de Vries; J. Friedrich, N. Vogler (University of Mainz))

After a careful analysis of the two high-quality runs taken at 250 MeV and scattering angles of 100° and 111° a resolution of 59 keV was obtained. Although this is significantly worse than was expected, extraction of cross-section information on the excitation of the 0^- levels was primarily hampered by two other experimental difficulties; uncertainty in the correction for wire efficiencies and in the position of broad levels. The latter problem is being investigated through a systematic study of all available spectra, the former will be solved by taking data at several spectrometer fields setting so that efficiency fluctuations are averaged out.

K1.3 Coincidence (e,e'X) experiments

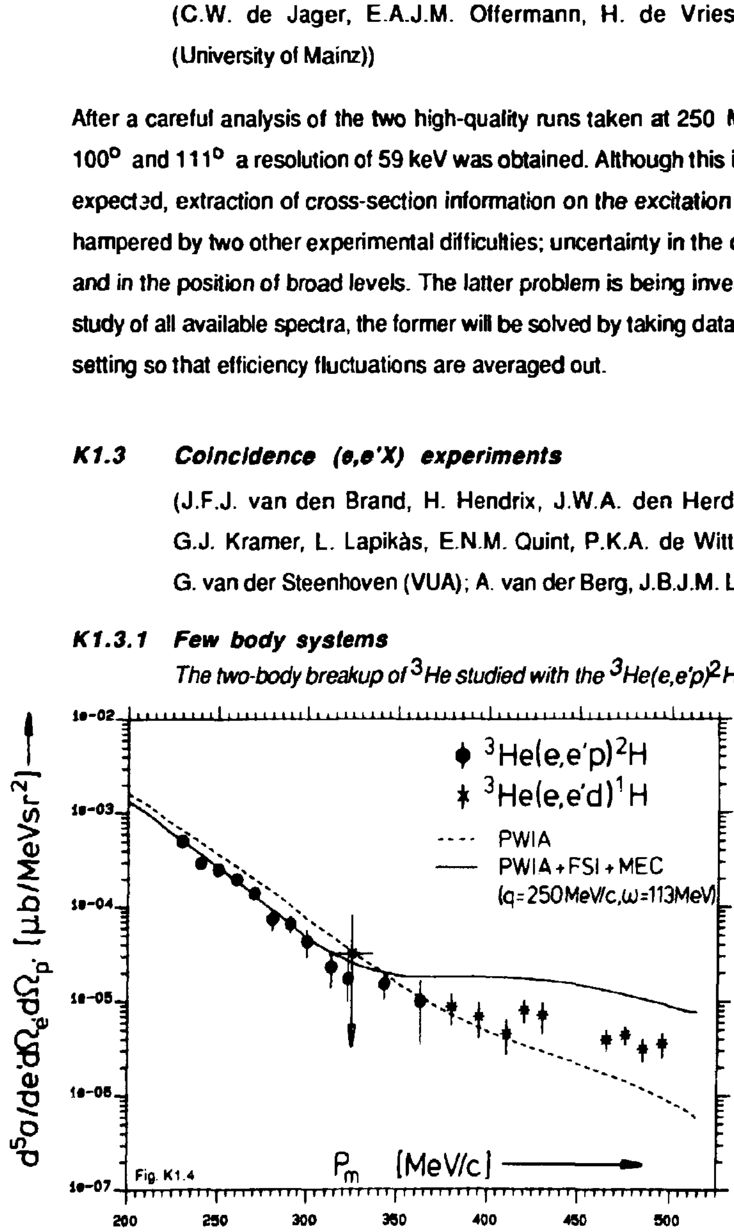
(J.F.J. van den Brand, H. Hendrix, J.W.A. den Herder, E. Jans, P.H.M. Keizer, G.J. Kramer, L. Lapikàs, E.N.M. Quint, P.K.A. de Witt Huberts; H.P. Blok, R. Ent, G. van der Steenhoven (VUA); A. van der Berg, J.B.J.M. Lanen (RUU))

K1.3.1 Few body systems

The two-body breakup of ^3He studied with the $^3He(e,e'p)^2H$ and $^3He(e,e'd)^1H$ reactions

(P.H.M. Keizer, E. Jans, L. Lapikàs , P. K. A. de Witt Huberts; H. Postma (Delft))

The analysis of the data, covering a missing momentum range of $220 < p_m < 500$ MeV/c has been completed. The result of this analysis is shown in fig. K1.4. The data obtained with the $^3He(e,e'p)^2H$ reaction are plotted as circles, the results obtained with the $^3He(e,e'd)^1H$ reaction in recoil kinematics as stars.



Coincidence cross sections for the $^3He(e,e'p)^2H$ (dots) and $^3He(e,e'p)^1H$ reactions as a function of the missing momentum, P_m. The dashed curve is the result of a Faddeev calculation in PWIA, the solid curve includes contributions due to the final-state interaction and meson exchange currents (J.M. Laget, private communication).

The dashed curve is a calculation in the Plane Wave Impulse Approximation (Faddeev) by Laget (private communication). The solid curve is a calculation including the final state interaction and contributions due to deuteron knock-out and meson exchange currents. Below p_m = 350 MeV/c the experimental result agrees very well with this calculation. However, at p_m > 350 MeV/c this calculation overshoots the data with a factor of 2-3. This might be an indication that in this region the FSI is not completely under control.

The two-body breakup of ^4He studied by the (e,e'X) reaction with X = p, ^3H,^3He

Serious discrepancies remain between theory and experiment for ^{4}He: a too low a binding energy (5 MeV), a too large a rms-radius (0.2 fm) and in incorrect point proton density. Due to its closed-shell character ^{4}He is of particular interest; it is tightly bound and compact and it is believed that short-range correlations cause significant modifications of the momentum distribution at missing momentum higher than 300 MeV/c. In this high recoil momentum region the coincidence real-to-random ratio is so small that it becomes the quantity which limits the accuracy of the cross section to be extracted. This can be overcome by applying the recoil detection technique. Therefore the experiment was divided into three parts. Phase 1 concerns the determination of the proton momentum distribution through the ^{4}He(e,e'p) reaction. In the second phase the high-momentum components in the ^{4}He wave function will be studied by the reaction ^{4}He(e,e'^{3}H). Finally the ^{4}He(e,e'n) reaction will be studied by detection of the recoiling nucleus. Most of the (e,e'p) part of the program has been carried out: The proton spectral function of ^{4}He has been measured for missing momenta between - 40 and 340 MeV/c for E_m = 15 - 35 MeV. A preliminary missing-energy spectrum is shown in fig. K1.5. Two measurements, at p_m = 140 and

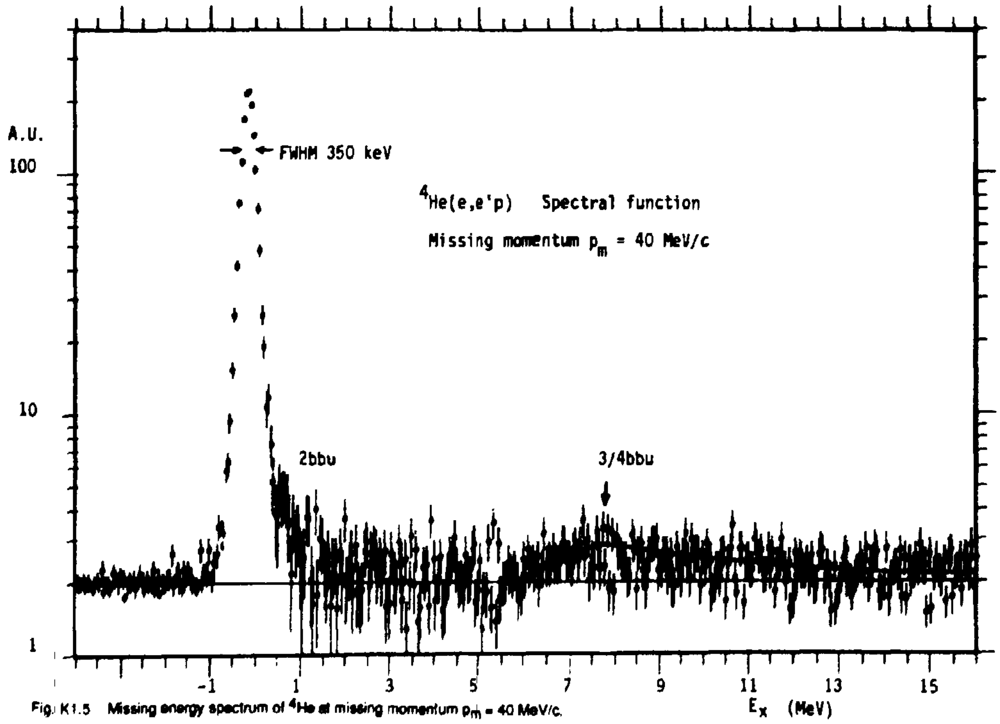


Fig. K1.5 Missing energy spectrum of ^{4}He at missing momentum p_m = 40 MeV/c.

220 MeV/c, have been performed at higher E_m values (E_m = 30 - 50 MeV). In order to study the dependence of distortion effects on the relative proton-triton energy in the center-of-mass system, the spectral function has, at fixed E_m (25 MeV) and fixed p_m (100 MeV/c), been measured at four $E_{p\text{-}cm}$ energies, i.e. at 35, 65, 75 and 105 MeV. At present the technical aspects (see also K5.3) concerning the thin-window target and the detection of low-energetic recoiling nuclei have been studied to a large extent. Therefore the recoil detection part of the program (phases 2 and 3) will be carried out in the course of 1986.

K1.3.2 Structure studies with the (e,e'p) reaction

The quasi-elastic proton-knockout reaction ^{6}Li(e,e'p)^{5}He
(in collaboration with A. van der Berg, J. Lanen (RUU))

The main purpose of the experiment is to locate an unknown state with spin and parity $J^\pi = 1/2^+$ in the ^{5}He system. Recent shell-model calculations [10] indicate the existence of two $1/2^+$ states with different spatial symmetry. The low-lying state (E_x = 10 MeV) is expected to be broad [10], and has a calculated strength which is 30 % of the spectroscopic strength of the E_x = 22.8 MeV state. Such a low-lying $1/2^+$ state has not been seen yet. For low missing momenta (p_m) the (e,e'p) reaction is particularly sensitive for $l = 0$ knockout. Hence cross-section measurements for missing momenta between - 100 and 130 MeV/c have been carried out. A preliminary analysis of the data indicates that there is no strong concentration of $l = 0$ strength in the E_x = 5 - 15 MeV range. During the further analysis, special attention will be paid to the determination of the distribution of the $l = 1$ and $l = 0$ strength in the excitation spectrum of ^{5}He.

The ^{12}C(e,e'p)^{11}B reaction
(in collaboration with P.W.M. Glaudemans, P.J. Brussaard, J. Dean, D. Zwarts (RUU))

Data taking on the ^{12}C(e,e'p)^{11}B reaction has been completed. Momentum distribution of six discrete states below 10 MeV excitation energy have been obtained in the missing momentum range of - 170 to 210 MeV.

The first three states correspond to the knock-out of a $l = 1$ proton. The relative spectroscopic strengths agree with the result found in other experiments. The shape of the $l = 1$ momentum distribution, however, was not properly described with standard optical-model calculations (see section K1.3.3).

The two $1/2^+$ states at 6.79 MeV and 9.85 MeV are due to $l = 0$ knockout. Their excitation indicates the presence of wave function components beyond the 1p shell and/or the breakup of the ^{4}He core in the ^{12}C ground state. Shell-model calculations, performed in a $2\hbar\omega$ configuration space that involves such components, yield a fair description of the shape of the $l = 0$ momentum distribution: G. van der Steenhoven et al., Phys. Lett. **156B** (1985) 151.

ABSTRACT. The spectral functions for the reaction $^{12}C(e,e'p)^{11}B$ leading to the $1/2^+$ state at 6.79 MeV in ^{11}B has been measured. The excitation of this non-normal parity state indicates the presence of wave function components beyond the 1p shell. A shell-model calculation, performed in a large configuration space, yields a fair description of the shape of the momentum distribution.

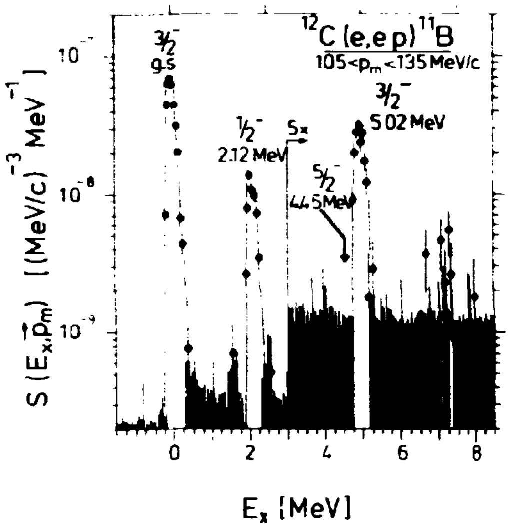


Fig. K1.6 Excitation-energy spectrum of ^{11}B observed in the $^{12}C(e,e'p)^{11}B$ reaction at 283 MeV and T_p = 40 MeV. No excitation strength is observed at E_x = 4.45 MeV, where a $5/2^-$ state is located.

The role of two-step processes has been investigated by studying the transition of the $5/2^-$ state at E_x = 4.45 MeV. In a $(1s)^4(1p)^8$ shell-model space this state cannot be excited by a one-step process, and a secondary process is therefore required. The absence of any detectable strength (see fig. K1.6) indicates that the influence of such processes can be neglected. Consequently, the (e,e'p) reaction offers a tool to investigate relatively small components of the nuclear many-body wave function with only minor interference by two-step processes. This work has been published: G. van der Steenhoven et al., Phys. Rev. **C32** (1985) 1787.

ABSTRACT. The role of the two-step processes in the $^{12}C(e,e'p)^{11}B$ reaction has been investigated by studying the transition to the $5/2^-$ state at E_x = 4.45 MeV. In a $(1s)^4(1p)^8$ shell-model this state cannot be excited by a one-step process, and a secondary process is therefore required. Such processes are found to be sufficiently small to enable the study of small wave-function components with the (e,e'p) reaction.

Study of the valence states in ^{51}V

The analysis of the quasi-elastic proton knock-out experiment on ^{51}V is in progress. The data have been measured at two proton energies and cover a missing momentum range up to 300 MeV/c. A preliminary analysis of the 70 MeV data (see fig.K1.7)

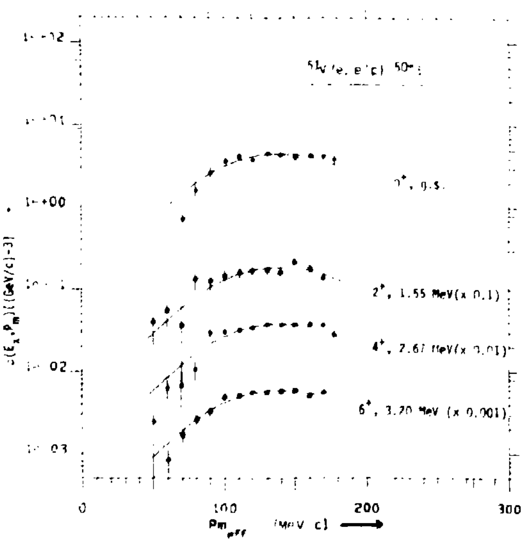


Fig. K1.7 Momentum distributions for proton knockout from ^{51}V leading to the $(1f_{7/2})^2$ quadruplet in ^{50}Ti. The amplitudes of the curves which represent DWIA calculations for l = 3 transitions, are scaled to fit the data.

yields a spectroscopic strength for the $l = 3$ quadruplet (0^+, 2^+, 4^+, 6^+) which is less than the sum rule value. The relative spectroscopic factors are in agreement with the result obtained by a (d,^3He) experiment [11].

Study of the proton-hole states in ^{90}Zr

The proton-hole spectral function in ^{90}Zr has been measured in a missing momentum range of $50 < p_m < 300$ MeV/c. The total 1f strength has been extracted with an estimated absolute error of about 30 % which is mainly due to the uncertainty in the treatment of the Final State Interaction: J.W.A. den Herder et al., Phys. Lett. **161B** (1985) 65.

__ABSTRACT__. The proton-hole spectral function of ^{90}Zr has been measured up to 20 MeV excitation energy by means of the (e,e'p) coincidence reaction. The deduced spectroscopic factors and fragmentation of the 1f-hole states are compared with results from hadronic reactions and with mean-field theory.

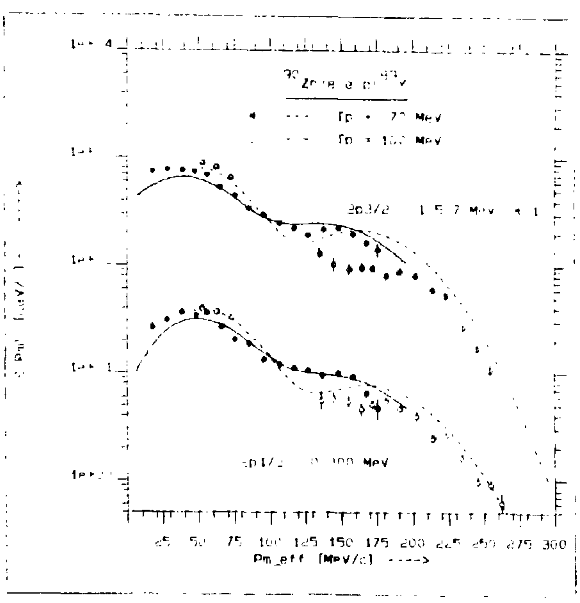


Fig. K1.8

Momentum distributions for 2p proton knockout in the reaction $^{90}Zr(e,e'p)^{89}Y$ measured at two different proton energies (T_p). The curves represent DWIA calculations with different optical potentials for the two proton energies, but with the same bound-state wave functions.

With a Hartree-Fock bound state wave function and the standard optical potential of which the parameters were fitted to elastic proton scattering data we calculated 2p momentum distributions. They do not describe the data above p_m = 140 MeV/c (see fig.K1.8). As this discrepancy can neither be resolved by small variations in the bound-state wave function, nor by a different parametrization of the optical potential (Dirac phenomenology, or double Woods-Saxon shape) this might be an indication that the shape of the bound state wave function in the nuclear interior should be modified.

K1.3.3 Final State Interaction

The $^{12}C(e,e'p)^{11}B$ reaction

The momentum distribution for the $^{12}C(e,e'p)^{11}B_{GS}$ reaction has been compared with several DWIA-calculations. Due to ambiguities in the optical-model parameters, there are uncertainties of about 30 % in the derived values of spectroscopic factors.

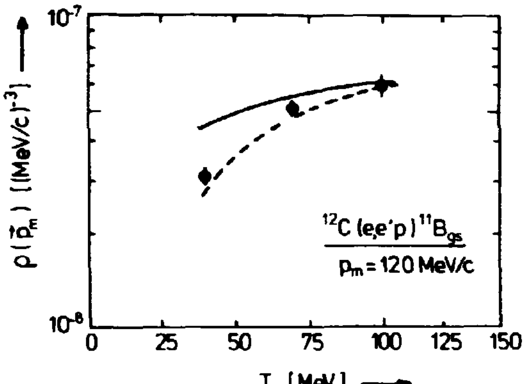


Fig. K1.9

Dependence of the momentum distribution $\rho(p_m)$ for the $^{12}C(e,e'p)^{11}B_{g.s.}$ transition on the energy T_p of the outgoing proton.

In order to reduce the uncertainties in the description of the final state interaction, we measured the same missing momentum region for three values of the proton kinetic energy T_p. The results for the ground state transition, covering a 30 MeV/c range around p_m = 120 MeV/c, are displayed in fig. K1.9. Also shown are two curves corresponding to optical-model parameters due to Jackson [12] (solid curve) and to Schwandt [13] (dashed curve). The data show a clear preference for the latter parameters, which are based on a systematic analysis of a large set of proton scattering data.

Energy dependence of the Final State Interaction in the $^{90}Zr(e,e'p)^{89}Y$ reaction

In order to achieve absolute calibration of spectroscopic factors the final-state interaction (FSI) of the knocked-out proton must first be understood quantitatively. The strategy followed in the preset (e,e'p) experiment and analysis is to exploit the kinematic freedom at hand in (e,e'p) to put an optimum of constraints on the optical potential. For this purpose the spectral function of the reaction $^{90}Zr(e,e'p)^{89}Y$ was determined in the range of missing momentum 120 - 160 MeV/c with proton energies ranging from T_p = 61 to 165 MeV. The result for the T_p-dependence of the spectral functions is shown in fig. K1.10. The data are compared with a DWIA calculation of the spectral function in which Woods-Saxon bound state wave functions were used with a radial size consistent with Hartree-Fock orbitals. The optical potential parameters were taken from a systematic parametrization of scattering data for 80 to 180 MeV protons by Schwandt et al. [13]. For ease of comparison the DWIA curves were normalized to the T_p = 114 MeV point for each individual transition.

The data for the $1g_{9/2}$ transition and the calculation agree rather well over the full T_p range. This implies that the optical potential used has the correct energy dependence near the nuclear surface. For the $1f_{5/2}$ orbit, that peaks somewhat more inside the nucleus, deviations are observed at low energies. Here the absence of a surface term in the optical potential that

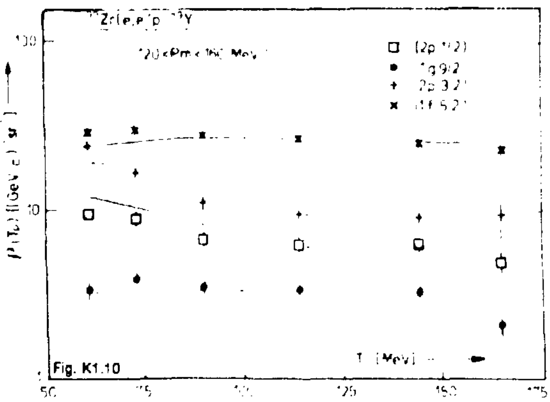


Fig. K1.10

Spectral function for various transitions at a fixed value of missing momentum p_m, as a function of outgoing proton energy T_p.

was used may play a role. Pronounced effects are observed for the $l=1$ transitions. This possibly indicates the inadequacy of the Woods-Saxon radial dependence of the optical potential in the nuclear interior. It may also indicate that the shape of the 2p wave function is different from the *mean field Woods-Saxon result.*

Final State Interactions (FSI) in the $^3He(e,e'p)^2H$ reaction

(P.H.M. Keizer, E. Jans, L. Lapikàs, P.K.A. de Witt Huberts; H. Postma (Delft))

The reduction of the experimental spectral function observed at Saclay for the $^3He(e,e'p)^2H$ reaction (E. Jans et al., Phys. Rev. Lett. **49** (1982) 974) with respect to the Faddeev calculation has led to speculations whether or not the discrepancy is due to FSI or a deficiency in the wave function. In the present experiment the relative kinetic energy of the proton and deuteron (T_{pd}) was varied by changing the angle between the momentum transfer vector ($q = 435$ MeV/c) and the missing momentum vector ($p_m = 100$ MeV/c). The result is plotted in fig. K1.11. The solid circles represent the spectral function for the two-body breakup at $p_m = 100$ MeV/c obtained in the present experiment. The open circle is the result obtained at Saclay. The dashed line is a fit to these data. In the range $20 < T_{pd} < 110$ MeV there is no dependence of the experimental spectral function on T_{pd}. This is in agreement with calculations by Laget (private communication) in which the effect of FSI and MEC is less than ±2 % in the T_{pd} range under consideration. The solid line represents the Faddeev calculation (PWIA). The observed reduction of 30% therefore may indicate a deficiency in the calculated wave function used in this calculation.

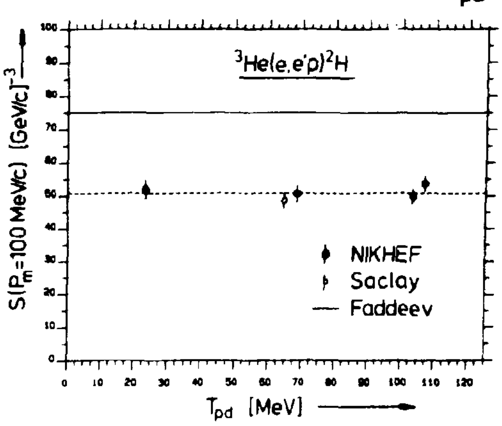


Fig. K1.11

Spectral function of ^3He for the two body breakup at missing momentum K = 100 MeV/c as function of the relative proton-deuteron energy T_{pd}. The black (open) circles correspond to the data obtained at NIKHEF (Saclay). The dashed line is a fit to the data, the solid line is the Faddeev calculation in PWIA due to Hajduk et al. (H. Meier-Hajduk et al., Nucl. Phys. **A395** (1983) 332.

Measurement of the $3s_{1/2}$ proton momentum density in ^{208}Pb

The $3s_{1/2}$ proton momentum density distribution $r(p_m)$ in ^{208}Pb has been measured from p_m= 50 up to 280 MeV/c with electron-inducedprotonknock-outleadingtotheground state of ^{207}Tl. A Hartree-Fock bound-state wave function and a standard optical potential for the distortion of the outgoing proton have been used to describe $\rho(p_m)$ (see fig. K1.12).

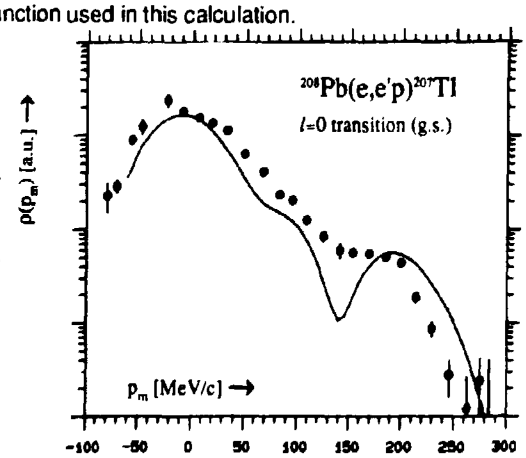


Fig. K1.12 Momentum density distribution of $3s_{1/2}$ protons in ^{208}Pb.

Although the curve fails to reproduce the data in detail, the relative height between the two maxima is predicted correctly. The more pronounced structure of the calculated curve is possibly due to the neglect of the Coulomb distortion of the electron in the calculation. The group of S. Boffi (Pavia) is presently working out the formalism for inclusion of this effect. The problem of absolute spectroscopic factors is in particular important for the doubly magic nucleus ^{208}Pb. The question whether in this case the spectroscopic strength of valence particles is close to unity has immediate implications for the validity of the mean-field approximation.

Relative $3s_{1/2}$ spectroscopic strength in ^{206}Pb and ^{208}Pb

(in collaboration with G.J. Wagner et al., University of Tübingen; B. Frois, CEN Saclay; H. Nann, IUCF, Bloomington (USA))

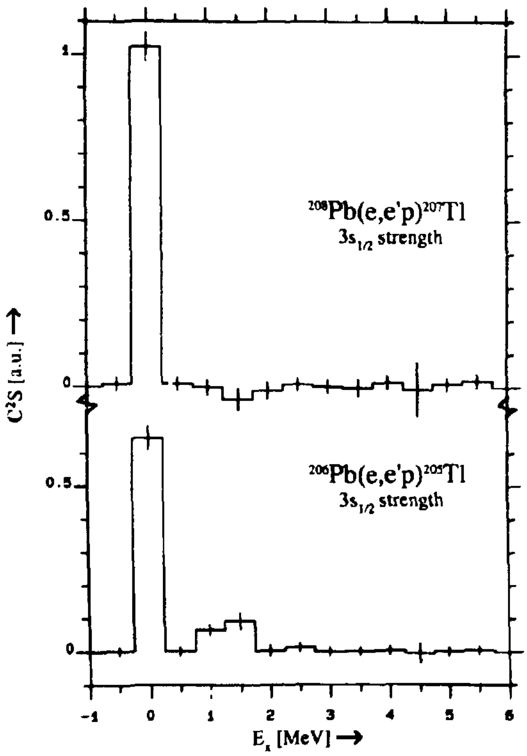


Fig. K1.13 Fragmentation of the $3s_{1/2}$ proton strength in ^{208}Pb and ^{206}Pb.

From a (e,e'p) measurement on both ^{206}Pb and ^{208}Pb relative $3s_{1/2}$ spectroscopic strength has been deduced. Interesting spectroscopic information in the $3s_{1/2}$ proton occupancy in ^{205}Tl and ^{206}Pb has been obtained from an absolute ground-state charge density difference measurement on the isotopes ^{206}Pb and ^{205}Tl. Since ^{207}Tl is unstable, it is impossible to obtain similar information for the truly interesting pair ^{207}Tl and ^{208}Pb, in which the neutron shell is closed. With an angular momentum decomposition method the $3s_{1/2}$ strength up to 5.5 MeV has been located in both isotopes (see fig. K1.13). The $3s_{1/2}$ strength is mainly concentrated in the knock-out leading to the ground-state in Tl, but there is also appreciable $3s_{1/2}$ strength [22 %] around 1.25 MeV in ^{205}Tl. The ratio of the strengths found in the ground-state transition (S_0^{206}/S_0^{208}) is 0.69(3). Up to 5.5 MeV we find 16(9) % more $3s_{1/2}$ strength in ^{208}Pb than in ^{206}Pb.

K1.3.4 Nuclear medium effects

A longitudinal-transverse separation has been carried out for the coincident quasi-free proton knock-out reaction on ^{12}C in the range of three momentum transfer 0.25 - 0.45 GeV/c. The deduced ratio of longitudinal and transverse response functions indicates a significant effect of the nuclear medium on the coupling of the virtual photon with the proton. The observed modification of this coupling is compared with model predictions for the change of the intrinsic nucleon properties due to the nuclear medium. Both the relativistic σ-ω model [14] and a calculation involving an enlarged quark-bag radius [15)] succeed in describing the data (fig. K3.1). At present it is impossible to discriminate between the two calculations. The density dependence of the two models, however, is different. Consequently protons knocked out from regions of different nuclear density could possibly be used to resolve this theoretical ambiguity. For this reason we also measured the $^{6}Li(e,e'p)^{5}He$ reaction. In this reactiuon both a low-density (l= 1 knockout) and a high-density (l = 0 knockout) region are probed (see section K1.3.2). The same range of momentum transfer has been covered as in the ^{12}C case. The data analysis including a LT-separation is in progress.

K1.3.5 Cluster knock-out reactions

To investigate nucleon correlations in nuclei the cluster knock-out $^{6}Li(e,e'd)^{4}He$ reaction was studied at E_e = 480 MeV. For the first time the α-d momentum distribution in the ground state of ^{6}Li could be determined (see fig. K1.14). By choosing a high centre-of-mass energy for the final α-d system, final-state interaction effects could be sufficiently reduced such that the minimum in the momentum distribution at p_m = 150 MeV/c that is predicted amongst others by α-p-n Faddeev calculations, was observed.

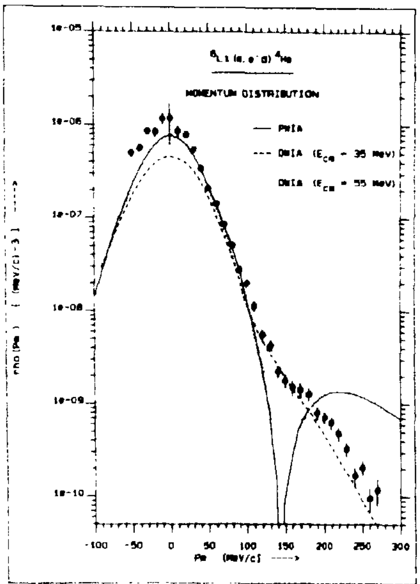


Fig. K1.14 Measured d-α momentum distribution in ^{6}Li.

Additional measurements were performed to check that the reaction proceeds indeed through direct deuteron knockout. A spectrum from the $^{12}C(e,e'd)^{10}B$ reaction has also been measured. The surprising result is that the 0^{+}, T = 1 state at E_x = 1.75 MeV in ^{10}B is strongly excited. In a direct process, in which the election scatters quasi-elastically from a deuteron inside ^{12}C such a transition is isospin forbidden.

K1.4 Electroproduction of negative pions from ^{13}C and ^{11}B

(P.C. Dunn, S. Kaarsgaarn, J.H. Koch; P. Stoler, P. Yergin (Rensselaer Polytechnic Institute (Troy, N.Y. (USA)); B. Schoch (Institut für Kernphysik (Mainz))

Cross sections for the electroproduction of π^- from ^{13}C and ^{11}B have been measured for a range of kinematics. We focussed on the ^{13}C (J^{π} = 1/2$^-$) $\rightarrow$ ^{13}N (J^{π} = 1/2$^-$) groundstate transition in

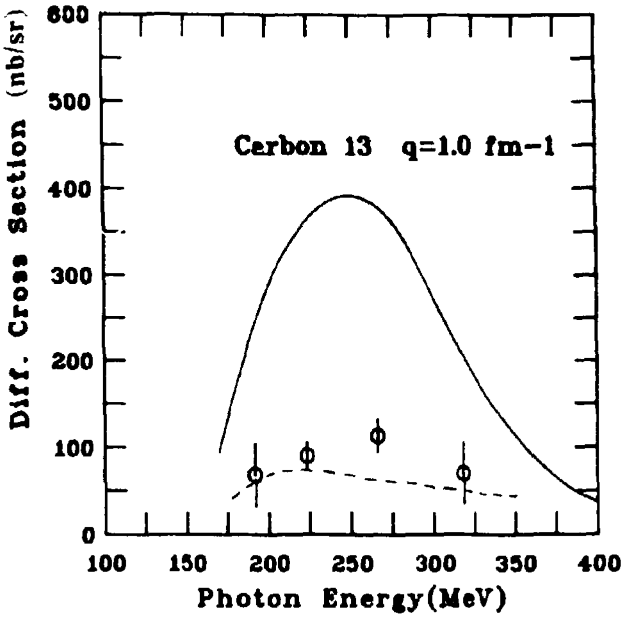


Fig. K1.15 Cross section for the reaction $^{13}C(\gamma\pi^-)^{13}N_{g.s.}$ as a function of photon energy. The solid line is a calculation in the DWIA approach including the delta-resonance degrees of freedom (L. Tiator (1985) private communication).

which transition multipolarities E0 and M1 are involved. Data were taken for pion kinetic energies in the range $T_\pi = 50 - 175$ MeV at a constant value of (nuclear) momentum transfer q = 1 fm^{-1} (corresponding to the minimum of the M1 form factor). At q = fm^{-1} the non-resonant spin-dependent pion production mechanism is strongly suppressed and thus delta-resonance excitation is emphasized. In order to also study the non-resonant production the full angular distribution has been measured at T_π = 80 MeV. Similar data were taken for ^{11}B.

The data of q = fm^{-1} for the reaction $^{13}C(\gamma\pi^-)^{13}N_{g.s.}$ are shown in fig. K1.15. Upon comparison with a calculation (L. Tiator (Mainz), private communication) a large discrepancy with the data is observed. A similar feature is apparent in the data for 50 MeV pions [16]. It would therefore seem that the resonant production of pions in the apparently simple case of a $1/2^- \rightarrow 1/2^-$ transition is not well understood at present.

K1.5 Experiments elsewhere

Elastic magnetic electron scattering from ^{49}Ti at $q < 3$ fm^{-1}

(L. Lapikàs, P.K.A. de Witt Huberts, in collaboration with Saclay and Basel)

In addition to earlier (1977) high-q measaurements of elastic magnetic scattering from ^{49}Ti between q = 2 and 3 fm^{-1} we determined the form factor up to q = 4 fm^{-1}. In this momentum transfer region the one-body contribution to the elastic magnetic form factor is small and two-body components arising from meson-exchange currents (MEC) may become important. The data show a diffraction minimum at 3.5 fm^{-1} and a secondary maximum near 4 fm^{-1}. Various calculations [17,18,19] involving exchange currents predict such a diffractive behaviour of the M7 form factor at high q. The most detailed calculation that includes a DDHFB wave function, core polarization effect and MEC, is a factor of two below the secondary maximum. This observation is different from the conclusion drawn from a high-q experiment [20] on ^{51}V, where the theory describes the data well up to 4 fm^{-1}. Further analysis is necessary to investigate whether this is an explicit signature of enhanced meson exchange currents.

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K1.7 Approved proposals for electron scattering

85-E13 Study of mixed symmetry states in IBA-2.

85-E14 Test of unbound features of the giant quadrupole resonance by inelastic electron scattering

85-E15 Investigation of the (e,e'd) reaction
(update of proposal 85-E10).

85-E16 Study of non-normal parity transitions in 1p-shell nuclei by the (e,e'p) reaction
(addendum to proposal 85-E11).

85-E17 A search for dispersive effects in elastic electron scattering off ^{12}C at momentum transfer values below the first diffraction minimum.

85-E18 A detailed investigation of elastic electron scattering off ^{208}Pb.

85-E19 Measurements of the magnetic monopole excitation of ^{16}O.

85-E20 The proton $2p_{3/2}$-$2p_{1/2}$ transition in odd-A f-p shell nuclei.

85-E22 Electrodesintegration of ^{4}He with the (e,e'X) reaction.

85-E23 Proton knockout from the $1f_{7/2}$-orbital in ^{40}Ca and ^{48}Ca.

85-E24 Occupation of the 3s proton shell in ^{205}Tl studied with the (e,e'p) reaction.

85-PM2 Pion absorption in flight
(addendum to 85-PM1).

85-PM3 Low energy pion scattering on $^{3,4}He$ nuclei
(addendum to proposal 84-PM4).

85-PM4 Reaction and absorption cross section for π^+ interactions with ^{3}He and ^{4}He.

K2 PHYSICS WITH PIONS, MUONS AND ANTIPROTONS

(Group leader R. van Dantzig)

K2.1 Introduction

The new two-step pion production target with a tungsten radiator in front of 5 cm graphite has been put into operation; it increased - according to expectation - the pion production efficiency by a factor of two. The electron beam power on target has been typically 35 kW. During the past year 8 weeks of beam time was allotted to the in-house pion-muon work.

The study of pion-nucleus interactions at low energy has been continued. The pionic atom programme with the local beam has been brought to a conclusion. A large part of the data on deeply bound pionic states obtained this year by the NIKHEF-K group (in collaboration with others) has been taken at SIN Further experiments on this subject as well as on muonic atoms and muon-induced fission have been prepared for SIN. Participation in experiments with low-energy antiprotons at LEAR (CERN) concerning protonium X-ray studies and the production of heavy hyper nuclei has been a stimulating side activity.

K2.2 Low energy pion absorption

(T.S. Bauer, R. van Dantzig, F. Geerling, J. Konijn, C.T.A.M. de Laat, Y. Lefevere, E.W.A. Lingeman, A. Taal, J.L. Visschers)

As the first step in a programme to study the pion absorption mechanism, a measurement of the reaction cross section for $\pi^+ + D \rightarrow p + p$ in the range of 20 to 50 MeV pion energy has been performed This reaction is considered as the most elementary process of nuclear pion absorption. There are numerous measurements even in the not easily accessible low-energy region, but the accuracy and the consistency of the data are not satisfactory. Moreover a recent study [1] of the inverse process shows an irregularity giving rise to speculations about a dibaryon resonance. The existing data on pion absorption are not good enough to give any (positive or negative) evidence on this point. Therefore, a series of consistent measurements in the low-energy region with better relative precision than those presently available, was considered to be of interest. An additional motivation for these measurements is that they can serve as a reference for the two-nucleon absorption mechanism in more complex nuclei, i.e. in a calibration of the physics.

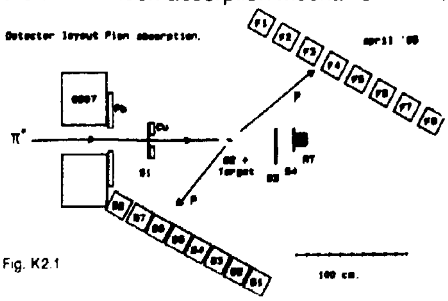

Fig. K2.1

Detection setup for the D(π^+,pp) experiment (topview) Coincidences are detected between 'forward' counters (F1-F8) and backward counters (B1-B8).

In the experiment two outgoing protons following pion absorption in flight on a CD_2 target were detected in two banks of eight scintillators each (fig. K2.1) with dimensions 100 x 18 x 18 cm^3. The solid angle acceptance was 1.4 sr. For each event pulse height and timing information from both ends of the scintillation bars were recorded. Full angular distributions were measured simultaneously, thus reducing relative normalization errors and beam time considerably. Data have been taken at 20, 25, 30, 35, 40 and 50 MeV pion lab energy. The error in relative normalization of the integrated cross section as a function of energy is mainly determined by the precision with which the incident pion flux can be measured (expected at the ± 7 % standard deviation level). Data reduction is in progress.

In the off-line analysis the energy of each detected proton as well as its impact position and light time are determined. A clear separation between the contribution from absorption on deuterium and on ^{12}C is achieved (fig. K2.2). The experiment is simulated in a newly developed Monte Carlo computer programme based on a grid projection method that is considerably faster than conventional tracking algorithms. Using this simulation all relevant instrumental effects can be accounted for in the analysis. A preliminary angular distribution is presented in fig. K2.3.

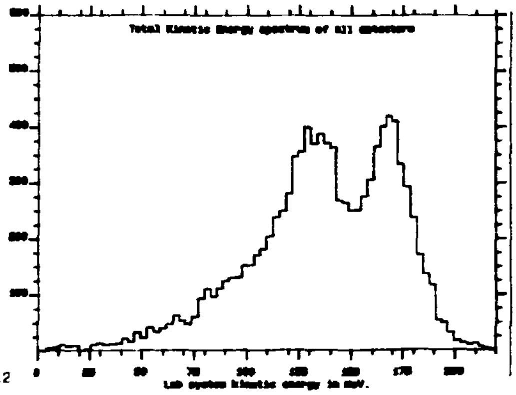

Fig. K2.2

Sum-energy spectrum for two protons detected in coincidence following pion absorption in a CO_2 target at 30 MeV lab energy. The data represent a sample over the full solid angle acceptance in the experiment. The peak at right corresponds to absorption in deuterium.

In the experiment also data on the reaction $^{12}C(\pi^+,pp)$ were obtained covering a large kinematical range. These will give information on the Quasi-Deuteron Absorption process in this nucleus.

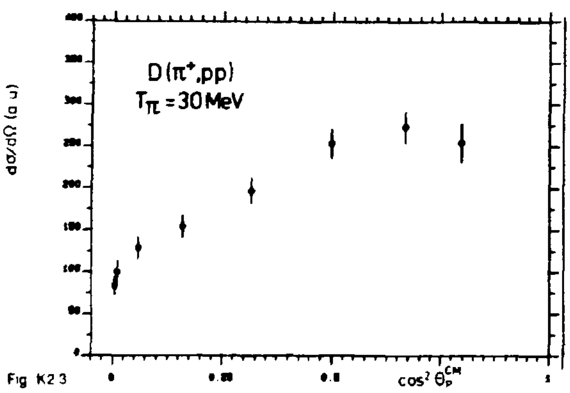

Fig. K2.3

The $\cos^2\theta_p^{CM}$ dependence of the cross section in the $D(\pi^+,pp)$ reaction at 30 MeV lab energy (preliminary data).

We have made preparations for an extensive study of nuclear pion absorption to start in 1986. Each of the 16 detectors is being equipped with a 1 cm thick ΔE detector on the front side. These detectors, also with read-out on both sides will be used to distinguish pions, protons, deuterons and neutrons. Single and coincident events will be recorded with large solid angle and moderate energy resolution. Measurements with multiplicity above two will be included. As target nucleus ^{16}O has been chosen because isospin makes it a favourable case.

K2.3 Low energy pion-nucleus interactions

(J.B.R. Berkhout, R. Boontje, J.P. Elfrink, R. Hamers, W.H.A. Hesselink, E. Kappert, T.J. Ketel, G. van Middelkoop, T.P.E. Prins, R. Sandor, P.M.M. Schoonejans, H. Verheul, P. Verzijden, M. de Vries (VUA))

The new pion production target has been tested. It was found to satisfy the expected yield improvement near 400 MeV primary electron beam energy. At lower energy the improvement was less, which indicates that for the two-stage (tungsten/graphite) production target, the yield is a steeper function of energy than for the previously used (copper) target.

A beginning has been made with the study of low energy pion scattering on ^{3}He and ^{4}He nuclei. Angular distributions of elastically scattered pions have been measured at 15 MeV and 25 MeV. The measurements on ^{4}He have been completed in summer. The experimental problem of distinguishing the forward scattered pions from decay muons has been solved by double dE/dx discrimination and track reconstruction in the off-line analysis. At the lowest energy for the ^{4}He experiment, true absorption is the only inelastic contribution to the total reaction cross section. To study the pion absorption process spectra of protons (and deuterons) have been measured in the same experiment.

One of us (T.P.E. Prins) has participated in a π-$^{3,4}He$ scattering experiment above 35 MeV at TRIUMF by the group of Prof. dr. K.M. Crowe from Berkeley.

To study the pion-nucleus reaction cross section for energies $T \leq 50$ MeV as a function of atomic number, a transmission experiment has been performed. The set-up includes five large plastic scintillation detectors to define different solid angles for acceptance of transmitted pions. The results for ^{12}C at 50 MeV agree quite well with existing data [2]. The analysis is in progress.

A design for a range telescope to detect negative pions with a solid angle of 200 msr and an energy resolution of 1 MeV has been completed.

K2.4 Double charge exchange in pionic atoms of ^{58}Ni

(J. Konijn, C.T.A.M. de Laat, A. Taal, W. Duinker; W. Bertl (SIN, Villigen); S. Egli, C.H. Grab, E.A. Hermes, A. van der Schaaf (Physik Institut Univ. Zürich)

At incident pion energies of about $T = 50$ MeV single-charge exchange reactions show a minimum in the reaction cross section at foreward angles, due to a nearly perfect cancellation of the repulsive S- and attractive P-wave isovector interactions for the π–nucleon amplitudes at this energy. Double-charge exchange (DCX) reactions at the same conditions, however, have surprisingly large reaction cross sections. For some pionic atoms the reaction (π^{-},π^{+}) is energetically possible ($Q > 0$). The reaction rate would provide additional information for theoretical explanations of the DCX reaction mechanism, where effects of the double isobaric analog states, isospin and multi-nucleon effects are involved. A search for DCX in pionic atoms has been performed with the pion beam at SIN, Switzerland, using the large-solid-angle magnetic spectrometer SIN-DRUM [3]. The reaction chosen for this experiment was $^{58}Ni(\pi^{-},\pi^{+})^{58}Fe$, with $Q = +903$ keV. In a 30 h run about 10^{9} π^{-} were stopped in the 100 mg/cm^{2} Ni-target. The experiment was set up to detect the decay of the produced π^{+} into a μ^{+} that subsequently decays into a high energy positron which easily can leave the target. In the off-line analysis tracks were identified as e^{+} events if the following requirements were met only one hit per wire chamber, an energy smaller than $m_{\mu}/2$, an intersection point in the target and the timing with respect to the incident pion in agreement with the muon life time. The experiment was calibrated with a π^+ beam of the same intensity. Approximately 45000 π^+-stops were recorded. The time spectrum of the selected events showed the muon life time. The momentum distribution of these events display a nice Michel-type spectrum. The total number of non-prompt positrons from the π^--stops was 14, half of which could be attributed to background due to scattered π^-s which were stopped in the hodoscope counters and that gave rise to an electron traversing the detectors from the outside towards the target yielding the signature of a positron. By also subtracting the number of events in the unphysical time region from that in the physical one we arrive at an upper limit for the DCX branching of 2.1×10^{-7} per π^- in a pionic ^{58}Ni orbit.

K2.5 *Strong interaction effects in pionic ^{27}Al*

(W. Duinker, J. Konijn, C.T.A.M. de Laat, A. Taal; C. Gugler, L. Schaller, L. Schellenberg (Inst. Phys.Univ. de Fribourg); P. David, H. Janszen, F. Risse, W. Schrieder (Inst. für Strahlen- und Kernphysik, Univ. Bonn); C. Petitjean (SIN, Villigen); A. van der Schaaf (Physik Inst. Univ. Zürich)

Although standard optical potentials can explain shifts and widths of peripheral pionic atom levels, they fail to simultaneously describe the more deeply bound states which have widths smaller than calculated[4-6]. This effect has been ascribed to an extra S-wave repulsion in the pion-nucleus optical potential [7].

In pionic Mg and notably in pionic ^{27}Al the broad and weak pionic 2p $\rightarrow$ 1s transitions are partly obscured by muonic X-rays and nuclear γ-ray transitions. A coincidence requirement between specific nuclear γ-ray transitions, following pion absorption by the nucleus, and the pionic X-ray cascade would reduce these unwanted contributions. In the present experiment an array of five (BGO) Compton-suppressed Ge spectrometers was used to register the pionic X-rays and a total of eight 5" x 5" NaI(Tl) crystals to simultaneously detect prompt nuclear γ-radiation. In this way the two strong peaks superimposed on the 2p $\rightarrow$ 1s πX ray of pionic Al, for example, would disappear (see fig. K2.4a)

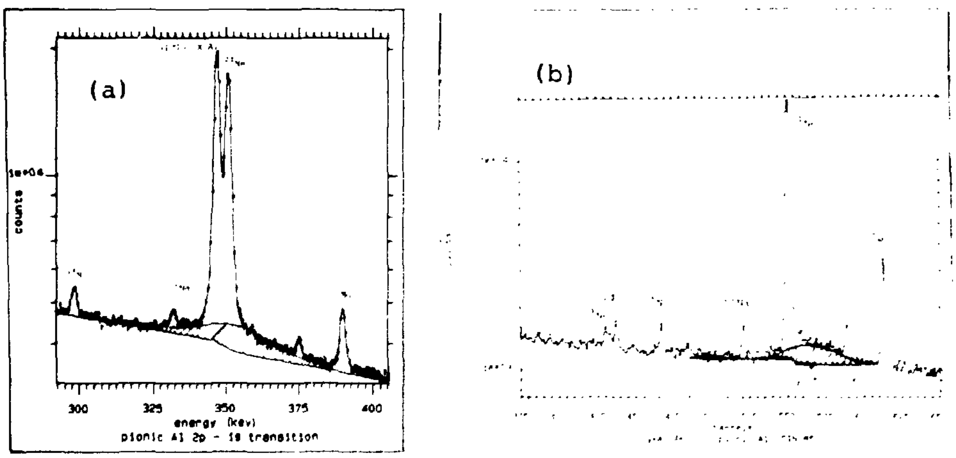

Fig. K2.4a Data of the 2p $\rightarrow$ 1s region of pionic Al, recorded at NIKHEF in singles mode.

Fig. K2.4b Same energy region of the data taken at SIN, but now in coincidence with prompt radiation detected in a NaI(Tl) detector

The experiment was performed with a pion beam (μ E4) at SIN. Unfortunately, due to insufficient beam time, it was necessary to put the detectors close to the target such that time-of-flight discrimination between γ-rays and neutrons was impossible. Therefore nuclear γ-rays resulting from reactions in which neutrons are emitted could not be suppressed. Preliminary results from one of the detectors are given in the accompanying figures. Fig. K-2.4a shows the old NIKHEF singles data of the 2p → 1s energy region of pionic Al. In fig. K2.4b the corresponding region is shown for the pionic Al coincidence data taken at SIN.

K2.6 Pionic and muonic atom studies for ^{237}Np

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The X-ray spectrum of muonic and pionic ^{237}Np has been investigated with stopped muons and pions in a NpO_2 target *, containing about 10 g of ^{237}Np, which has a thickness of 0.94 g/cm^2. Electromagnetic as well as strong interaction nuclear parameters were deduced from this measurement. From the splittings of the muonic $5g_{9/2} \rightarrow 4f_{7/2}$ and $5g_{7/2} \rightarrow 4f_{5/2}$ hyperfine complexes an accurate value for the nuclear spectroscopic quadrupole moment, Q = 3.63 ± 0.02 b, was determined. Comparison of the splitting of the pionic 5g → 4f hyperfine complex with that of the muonic $5g_{9/2} \rightarrow 4f_{7/2}$ and $5g_{7/2} \rightarrow 4f_{5/2}$ hyperfine complexes yields values for the strong interaction shift and width parameters. The deduced monopole shift with respect to the point Coulomb energy is $\varepsilon_0(4f)$ = 5.29 ± 0.14 keV. The observed absorption width is $\Gamma_0(4f)$ = 3.88 ± 0.26 keV. For the pionic 4f state the measured strong interaction shift and width are reasonably well reproduced by standard optical model calculations. The experimental value for the strong interaction quadrupole shift ε_2 = 0.46 ± 0.08 keV, however, is not in agreement with theory.

The nuclear charge distribution parameters have been determined from the analysis of the muonic X-ray spectra. The Fermi parameters obtained from the experimental muonic X-ray transition energies are c = 7.03 fm and t = 2.3 fm, respectively. With the same target also the possibility for the 3d → 1s radiationless transition in muonic ^{237}Np was determined to be (8±4) %. This result was obtained from a comparison of singles and coincidence(with the 2p → 1s transition) measurements.

* *We gratefully acknowledge the production and preparation of the target by the European Institute for Transuranium, G.F.F. Karlsruhe, W. Germany.*

K2.7 Search for heavy hypernuclei formation following $\bar{p}$ annihilation (CERN exp. PS177)

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The aim of this experiment is to measure the lifetimes of heavy hypernuclei. Experiments were performed on U and Bi targets (thickness 100 $\mu g/cm^2$) with beams of antiprotons with momenta of 105 and 200 MeV/c. Pairs of *prompt* fission fragments can only be detected at angles of 90^0 to the beam direction due to the thick targetbackings used (2.5 - 10 mm). *Delayed* fission fragments, which are emitted after the fissioning nuclei have been knocked out of the target into vacuum, can, however, be detected in pairs of forward and backward positioned counters. A preliminary analysis of the time-of-flight of the coincident fragments from delayed fission along with Monte Carlo calculations and the measured distribution of events over forward-backward counter parts yields a lifetime for the hypernuclei of 0.1 - 0.3 ns. This is consistent with that of the free Λ (τ = 0.26 ns)

K2.8 Measurement of the population of the pionic 3d state in Mg and its relevance to the π^- mass

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A coincidence measurement has been performed between the 4f $\rightarrow$ 3d (26 keV) and the 3d $\rightarrow$ 2p (75 keV pionic X-rays in pionic Mg. This experiment permits the determination of the strong interaction width of the 3d level independently of additional information on the electron shell populations, which are ususally obtained from atomic cascade calculations. Furthermore, the experiment solves an ambiguity in the analysis of earlier crystal-spectrometer experiments [8] on the pionic 4f $\rightarrow$ 3d transition, aiming at a 2 ppm accurate mass determination of the negative pion. The coincidence experiment was performed at the πE3 pion beam at SIN, Switzerland, with two large planar intrinsic Ge detectors. Preliminary results indicate that the pion mass value [1] can be determined unambiguously.

K2.9 Study of $\bar{p}$H, $\bar{p}$D and $\bar{p}$He X-rays at LEAR (CERN, exp. PS174)

(E.W.A. Lingeman; C.A. Baker, C.J. Batty, S.A. Clark, A.I. Kilvington, J. Moir, S. Sakamoto (Rutherford & Appleton Labs); J.D. Davies, J. Lowe, J.M. Nelson, G.J. Pyle, A.K. Selvarajah, C.T.A. Squier (Univ. Birmingham); R.E. Welsh, R.G. Winter (College William & Mary); C.W.E. van Eijk, R.W. Hollander, D. Langerveld, W.J.C. Okx (Univ. of Technology, Delft))

The first results of the protonium L X-ray measurements have been published in Physics Letters **162B** (1985) 71. The past year measurements were performed on gaseous hydrogen and

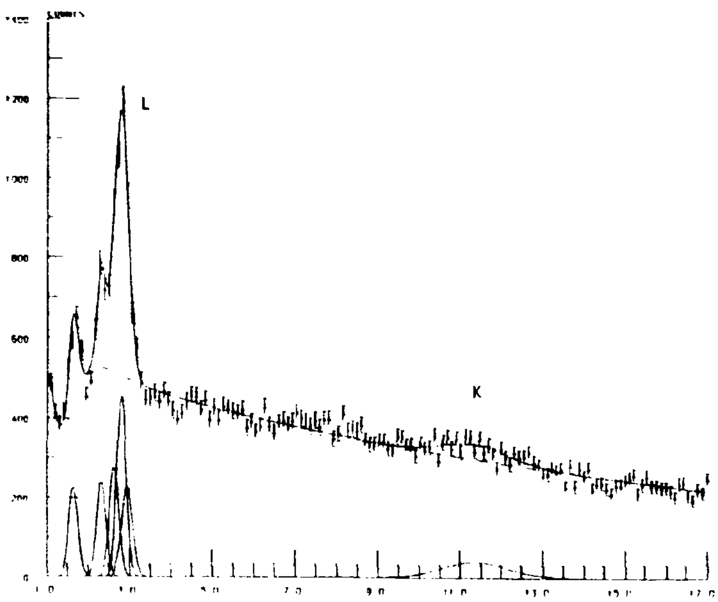

Fig. K2.5 Protonium X-ray spectrum measured at 0.25 atm. gas pressure.

deuterium targets at low pressure (0.25 atm.) in order to reduce Stark mixing which suppresses the KX-ray yield (see previous Annual Report). In this way the K_α line of $\bar{p}$H was observed for the first time; see fig. K2.5. The aim of these experiments is to determine the $\bar{p}$-N s-wave scattering length from the measured shifts and widths of K X-ray transitions.

A newly developed gas scintillating proportional counter (GSPC) was tested; it showed promising efficiency and energy resolution at low X-ray energies.

K2.10 *Searches*

Axions

(F.W.N. de Boer, R. van Dantzig; K. Abrahams (ECN, Petten); A. Balanda (VU, Amsterdam); H. Bokemeyer (GSI, Darmstadt); J.F.W. Jansen, J. van Klinken, D. Kotlinski, M.J.A. de Voigt (KVI, Groningen))

Positron peaks [9)] observed from super heavy collision systems at GSI show puzzling characteristics which might arise from the formation and decay of a weakly interacting neutral pseudoscalar particle [10)], possibly an axion [11,12)]. This particle would have a mass of about 1.7 MeV and - according to the standard model [13)] - have a lifetime of 10^{-11} s and a Higgs expectation value ratio X = 0.045 [11,12)]. If such axions indeed exist, they can be expected to be substantial competitors to gamma-rays in magnetic nuclear transitions of sufficient energy. The axion decay branching ratio for certain isoscalar M1-transitions can then be as large as 30 %. Previous axion searches have been sensitive only to lifetimes at the level of 10^{-10} s or longer, due to the minimum time for an axion to pass any shielded region of the source.

We have prepared an experimental setup with four Mini-Orange Spectrometers at backward angles to search for positron-electron pairs that might arise from a very short lived particle emitted in isoscalar and isovector nuclear M1 transitions induced by inelastic scattering of low energy protons. The first cases to be investigated at the KVI-cyclotron are the 2.87 and 3.59 MeV isoscalar transitions depopulating the 3.59 MeV level of ^{10}B. The background expected from direct pair production has been estimated to be at least four orders of magnitude below the contribution from a 'standard' axion.

Multi-pion multi-nucleon bound states

(R. van Dantzig, F.W.N. de Boer; J. Bisterlich, R. Bossingham, A. Chacon, K.M. Crowe, C. Meyer, T. Humanic, J. Rasmussen (Lawrence Berkeley Lab.); A. van der Schaaf (Univ. of Zürich))

In continuation to an earlier measurement at SIN [14]), an experiment is in preparation at the Lawrence Berkeley Laboratory to search for the possible occurrence of long-lived bound clusters of neutrons and negative pions (pineuts [15])). The experiment in a Bevalac beam of ^{40}Ar at an energy of 1.8 GeV/A will be performed with the JANUS double-dipole spectrometer tuned to detect doubly charged negative heavy particles from collisions of Ar nuclei with a uranium target. A short testrun has been made to investigate the background situation. Data taking runs are foreseen for 1986.

Muon spin rotation

(E.W.A. Lingeman; R.I. Grynszpan, Ph. Bouteilloux, C.E. Stronach (Virginia State Univ., Petersburg, USA); W. Lankford (George Mason Univ., Fairfax, USA))

In continuation of muon-diffusion experiments at NIKHEF-K on Nickel-based alloys, showing indications for trapping at interstitial sites close to impurities, we have performed measurements with improved statistics at the ALS accelerator at Saclay. Alloys of Ni(Pt) were studied in a zero-field muon-spin rotation setup. No additional frequency signal corresponding to distorted lattice cells has been observed.

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K3. *THEORY (group leader J.H. Koch)*

K3.1 Tests of the σ-ω model with the (e,e'p) reaction

(T. de Forest, Jr.)

In the σ-ω model, the mean nuclear potential is described as being due to a strong scalar and a strong vector potential whose combined effect almost cancels. However, the Dirac spinors of the bound nucleons, and thus also their electro-magnetic current, are strongly affected. Such modifications can be studied in the (e,e'p) reaction (T. de Forest, BUTG Workshop, MIT, July 1984). As shown in fig. K3.1, the model is able to explain the recent measurements performed at NIKHEF (see K1.3.4).

K3.2 The relativistic Coulomb sum rule

(T. de Forest, Jr.)

An important ingredient in constructing the Coulomb sum rule is the choice of the appropriate nucleon form factor. We show that this is crucial for obtaining Z in the limit of high momentum transfers. The surprising result of Matsui (T. Matsui, Phys. Lett. **132B** (1983) 260) that the relativistic Coulomb sum rule approaches the value Z/2, implying that only half of the protons are seen by the photon, is traced to a particular choice of this form factor.

K3.3 Change of scale for nucleons in nuclei from quasielastic electron scattering and the (e,e'p) reaction

(P.J. Mulders)

Quasielastic electron scattering (Q^2 = 0.1 - 1 GeV^2) may be well suited to measure modifications of nucleons in nuclei. From an analysis of the longitudinal and transverse structure functions for inelastic electron scattering off ^{12}C in the region Q^2 = 0.1 - 0.25 GeV^2, indications are found (P.J. Mulders, Phys. Rev. Lett. **54** (1985) 2560) for an increase of the charge radius

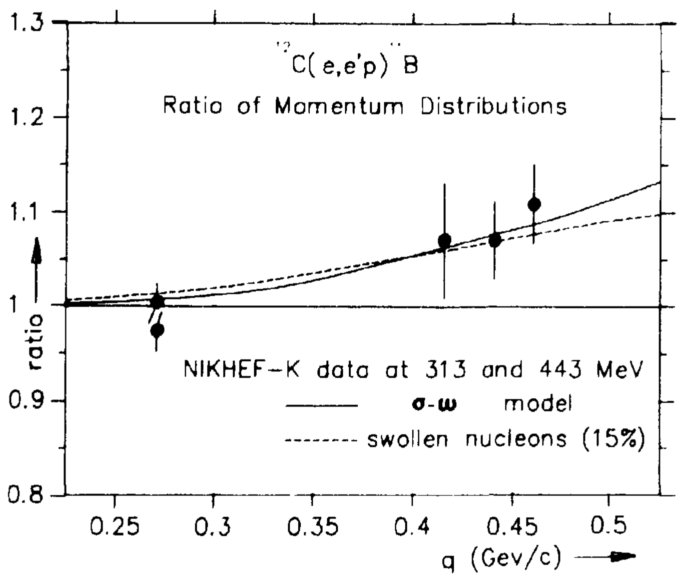


Fig. K3.1. Effects of the nuclear medium on the nucleon compared with experimentally measured deviations of the impulse approximation.

and the magnetic moment of nucleons in ^{12}C. The mean square radius of the magnetic form factor shows virtually no increase. We also applied this concept of a 'swollen' nucleon to the (e,e'p) measurements (see K1.3.4). It is found that the trend of the data is correctly reproduced (fig. K3.1).

K3.4 Photoproduction of charged pions to discrete nuclear states

(T. Suzuki, T. Takaki and J.H. Koch)

The nuclear photoproduction of charged pions to discrete final states was investigated. The model for the nonresonant production amplitude uses the experimental single nucleon multipoles. The resonant production mechanism includes the medium effects of delta-propagation in the framework of the Δ-hole model. This goes beyond the standard DWIA approach by carefully treating important medium modifications. Applications were performed for p-shell nuclei and the results compared to the available data.

K3.5 Pion photoproduction in the σ-ω model

T. Suzuki and J.H. Koch, Phys. Lett. 164B (1985) 245

ABSTRACT. Threshold photoproduction of pions on nuclei was studied in the σ–ω model. Only small modifications of the production operator were found for charged pions whereas the medium effects for π^0 photoproduction were found to be very large.

K3.6 Atomic masses

(A.H. Wapstra)

A table giving values for atomic masses of many nuclides as calculated from different theoretical models is being prepared. As input values for this calculation an up-dated version of the 1983 mass table, that appeared in the beginning of 1985, will be used.

In order that calculations of best values of atomic masses from experimental data can be transferred to somebody else within a few years, the list of some 7000 input data is being critically reviewed and provided with explanatory notes where helpful. Results from several older data could be improved in the course of this work by recalculating derived reaction or decay energies. For this purpose new calibrations or theoretical constants in combination with new data on level or decay schemes were used.

The work on atomic masses as part of the research program of NIKHEF-K has been terminated in June 1985, though some help will still be given to its continuation in another connection.

K4 RADIOCHEMISTRY *(Group leader: L. Lindner)*

(C.N.M. Bakker, G.A. Brinkman, J.J. van Gelder, B.W. van Halteren, P. Kuipers, G.A.J. Leurs P.W.F. Louwrier, P. Polak, C.J.S. van Rijn, W. van der Veen, J.Th. Veenboer, J. Visser)

K4.1 Introduction

The electron accelerator MEA was used primarily for hot-atom chemistry and to a lesser extent for the production of radionuclides and related investigations. The satisfactory performance of the accelerator favourably contributed to reaching a number of research goals.

An academic position was filled with the aim to start a program on the chemical effects associated with the beta decay process $^{32}Si \rightarrow {}^{32}P$.

Cooperative research projects with a number of off-site groups were continued:
- muonium chemistry (with the University of Zürich)
- labelling of radiopharmaceuticals with ^{18}F (with the Free University Amsterdam)
- labelling of radiopharmaceuticals with ^{123}I and ^{125}I (with the Ophthalmology Institute Leiden)
- production of ^{67}Cu (with the Agricultural University Wageningen).

New cooperative projects have been inititiated on the following subjects:
- measurements of neutron capture cross sections at 25 keV (with the FOM/ECN group at Petten)
- production of $^{11}CO_2$ with high specific activity for the study of assimilation in plants (with the University of Amsterdam)
- meteorite research (with the Technical University of Denmark at Lyngby and with the University of Utrecht, Van de Graaff Laboratory).

A considerable effort was put into the writing of a proposal for a new Bremsstrahlung facility provided with a thick convertor and better target geometry with the aim to improve substantially on the photon flux density presently available in the 'clean' photon beam.

For students of the University of Amsterdam a graduate course 'Radiochemistry' was given.

K4.2 Hot atom chemistry/radiation chemistry

The study on the behaviour of multivalent recoiling atoms was intensified. In parallel, investigations were carried out to gain a better appreciation of the usefullness and limitations of 'clean' photon beams for hot atom chemistry.

^{15}O reactions

A beginning was made with the study of recoiling divalent ^{15}O atoms inserting into the C-H bond of gaseous hydrocarbons RH, resulting in the formation of labelled alcohols R-^{15}O-H. The irradiations were carried out in the presence of large amounts of neon gas, the neon being both a source of ^{15}O through the reaction $^{20}Ne(\gamma,\alpha n)^{15}O$ and an efficient moderator for the thermalization of the recoiling ^{15}O atoms. As a matter of fact, a considerable fraction of the ^{15}O activity originated from the wall of the glass ampoule due to the reaction $^{16}O(\gamma,n)^{15}O$. The alkanes under investigation are propane, butane and isobutane, containing primary as well as secondary and/or tertiary hydrogen atoms. Total yields of labelled alcohols amount to several tens of percent.

The distribution of ^{15}O among the different alcohols is all but statistical and reflects a strong preference for insertion into the weaker C-H bond; see table K4.1. This observation is neither compatible with reactions of thermal ground state ^{15}O (^3P) atoms which supposedly do not insert at all, nor with reactions of thermalized ^{15}O in the first excited electronic state ^1D which is known to insert approximately statistically irrespective of bond type.

Table K4.1 Relative insertion yields for the reaction RH + $^{15}O \rightarrow R^{15}OH$, relative insertion probabilities for different C-H bonds

Target RH	Insertion yield $R^{15}OH$	Insertion probability ratios (per C-H bond)
C_3H_8	1-C_3H_7OH : 74 ± 2 2-C_3H_7OH : 26 ± 2	$\frac{\text{sec. H}}{\text{prim. H}}$ = 8.6 ± 0.3 (exp.) 0.33 (stat.)
n-C_4H_{10}	1-C_4H_9OH : 24 ± 3 2-C_4H_9OH : 76 ± 3	$\frac{\text{sec. H}}{\text{prim. H}}$ = 4.7 ± 0.2 (exp.) 0.67 (stat.)
i-C_4H_{10}	cis-C_4H_9OH : 45 ± 4 tert-C_4H_9OH : 55 ± 4	$\frac{\text{tert. H}}{\text{prim. H}}$ = 11.0 ± 1.0 (exp.) 0.11 (stat.)

^{11}C *reactions*

The study of reactions of tetravalent ^{11}C recoiling atoms was continued on arenes and started with regard to inorganic halides of ammonia (NH_4X).

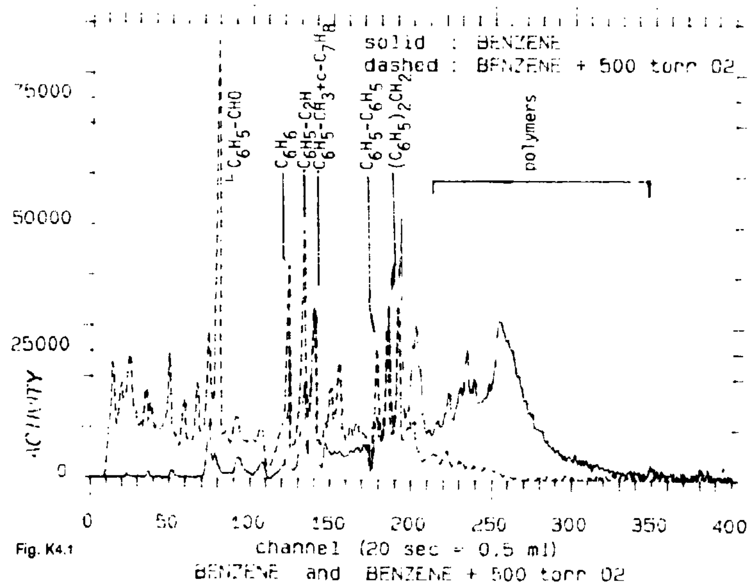


Fig. K4.1

Radio-HPLC-chromatograms for the reactions of recoil ^{11}C atoms with benzene (–) and benzene + 500 torr O_2 (---).

Arenes. The investigations were mainly on systems of liquid C_6H_6 using the reaction $^{12}C(\gamma,n)^{11}C$ as the source of ^{11}C. An important result of recent work is the crucial influence of small amounts of impurities in benzene on the reproducibility of the results. Oxygen in particular gives rise to considerable changes in the distribution of the ^{11}C. For instance, the yield of labelled higher polymers (see fig. K4.1, channel number 210-320) is reduced by a factor of four due to oxygen whereas the most prominent new labelled product is benzaldehyde, C_6H_6CHO (channel number 80).On the other hand addition of 10 mol % of isopropylbenzene (cumene), a donor of H atoms in radiolysis, has little - if any - effect on both the product spectrum and the ^{11}C distribution.

NH_4X, solid salts. Ammonium halides have been studied by others by using the nuclear reaction $^{14}N(p,\alpha)^{11}C$. These systems displayed a high resistance with regard to radiation damage. Furthermore such systems are useful for the production of ^{11}C-precursors for more elaborate syntheses. Therefore it was decided to reinvestigate such systems but with the reaction $^{14}N(\gamma,2pn)^{11}C$, as a pilot case for photonuclear hot atom chemistry in inorganic solid systems. Preliminary experiments are in progress and have pointed at the interference from radiohalogens produced simultaneously by (γ,n) reactions, in the counting of ^{11}C.

^{34m}Cl, ^{38}Cl, ^{39}Cl reactions. Nucleogenic chlorine atoms were used for hot atom chemical investigations and as a means for studying thermal isotopic *Cl-for-Cl exchange reactions.

$^{34m,38,39}Cl$ intercomparison. These three radionuclides can be produced simultaneously with comparative yields, by the irradiation with high-energy photons of gaseous mixtures of Ar and Cl-containing compounds, e.g. $CFCl_3$ and CH_2Cl_2:

$^{35}Cl(\gamma,n)^{34m}Cl$

$^{40}Ar((\gamma,pn)^{38}Cl$

$^{40}Ar(\gamma,p)^{39}Cl$.

Despite the addition of 4 % of C_3F_6 as a scavenger, *Cl-for-Cl substitution yields appeared to be difficult to reproduce. No significant isotope effect could be observed in the labelled products, neither for $CFCl_3$ nor for CH_2Cl_2 as the target compound (research in collaboration with Dr. R.N. Bhave, Poona University, India.).

^{34m}Cl-for-Cl exchange. Relative reaction rates for thermal Cl exchange by ^{34m}Cl atoms, produced by the $^{35}Cl(\gamma,n)^{34m}Cl$ reaction under high radiation dose conditions, were measured in mixtures of substituted chlorobenzenes. In I_2 scavenged 1 : 1 : 1 mixtures of ortho, meta and para-C_6H_4ClX (X = F, Cl, CH_3, CF_3), the hot substitution yields are close to statistical. Thermal ^{34m}Cl-for-Cl exchange yields exhibit high selectivity not only in mixtures of isomeric C_6H_4ClX compounds, but also in mixtures of C_6H_5Cl and C_6H_4ClX (fig. K4.2). This selectivity is related to

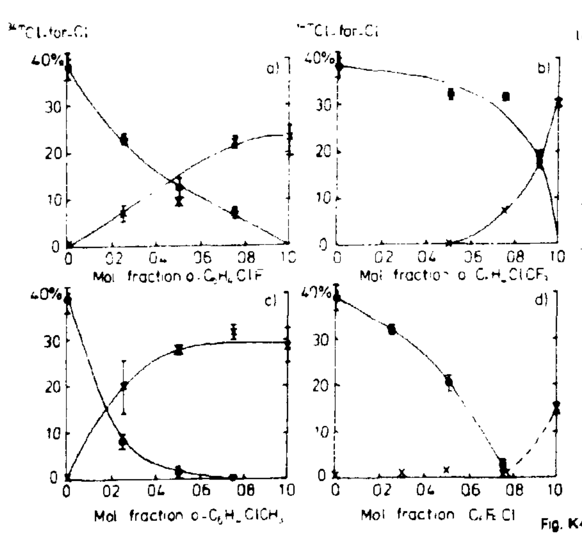


Fig. K4.2

^{34m}Cl-for-Cl substitution yields in mixtures of C_6H_5Cl with o-C_6H_4ClF (a), o-$C_6H_4ClCF_3$ (b), o-$C_6H_4ClCH_3$ (c), and C_6F_5Cl (d).

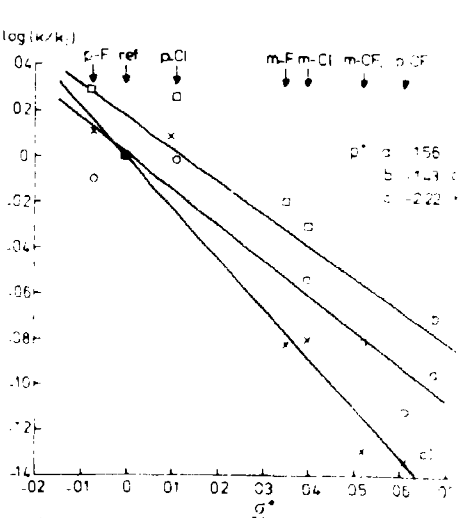


Fig. K4.3 Hammett plots for a) thermal ^{34m}Cl-for-Cl substitution in C_6H_4ClX compounds, b) thermal ^{38}Cl-for-H substitution in C_6H_5X compounds, c) thermal Cl-for-Br substitution in C_6H_4BrX compounds. Points of reference are C_6H_5Cl (a), C_6H_6 (b) and C_6H_5Br (c), respectively.

the rate constants for σ-complex formation, which is a slightly electrophilic reaction with a Hammett parameter of $\rho^+ = -1.56$ (fig. K4.3). As a consequence of the strong electron withdrawing properties of F atoms, even low concentrations of C_6H_5Cl can readily compete with C_6F_5Cl for thermal ^{34m}Cl-for-Cl exchange (submitted for publication in Radiochimica Acta).

K4.3 Muonium chemistry

Muonic radicals

Since the phase diagram of $C_6H_6 + C_6F_6$ shows the formation of a 1 : 1 complex, we have measured the fractional radical yield (f_r) of $\cdot C_6H_6Mu$ and $\cdot C_6F_6Mu$ radicals in mixtures of the two compounds. However, there appears to exist a linear relation between radical yields and the composition of the mixtures with no significant deviation for 1 : 1 mixtures. Still, the rate constant for addition of Mu to C_6H_6 is twice that for C_6F_6.

Rate constants

Progress was made in the determination of rate constants for reactions of Mu with aromatic compounds dissolved in inert solvents. For reactions with C_6H_6 the rate constants (in 10^9 mol^{-1} s^{-1}) were 2 (in H_2O), 4 (in n-C_6H_{14}) and 8 (in CH_3OH). For the reaction with $C_6H_5NH_2$ (in n-C_6H_{14}) the rate constant is 6.5×10^9 $mol^{-1}s^{-1}$ or about 1.6 times faster than for C_6H_6. The latter value is in reasonable agreement with the value of 1.3 ± 0.1 as determined previously in mixtures of $C_6H_5NH_2$ and C_6H_6 from the fractions of muonic radicals.
The agreement between both types of measurements is less satisfactory for p-$C_6H_4F_2$: a direct measurement (in n-C_6H_{14}) yields $k = 1.5 \times 10^9$ $mol^{-1}s^{-1}$ or about 0.4 relative to C_6H_6, whereas previously a relative value of 0.74 ± 0.05 was derived from mixtures of p-$C_6H_4F_2$ and C_6H_6.

Azo compounds

Hyperfine coupling constants (A_μ) and fractional radical yields (f_r) were measured for radicals formed by addition of Mu to the N=N bond in asymmetrical azo-compounds $R_1N{=}NR_2$ (table K4.2).

Table K4.2 Mu addition to $R_1N{=}NR_2$

R_1	R_2	A_μ	f_r
C_2H_5	i-C_3H_7	32.3 ± 0.1 MHz	0.55 ± 0.02
C_2H_5	n-C_4H_9	26.2 ± 0.1 MHz	0.46 ± 0.01

No radical formation was observed in the case of cyclic 1,3,5-triazine ($C_3H_3N_3$) with aromatic properties. The temperature dependence of A_μ of the muonic radical of 2.2' azo bis-propane was measured (fig. K4.4). The results indicate that in the equilibrium configuration the two $CH(CH_3)_2$ groups tend to a trans-configuration with only a small

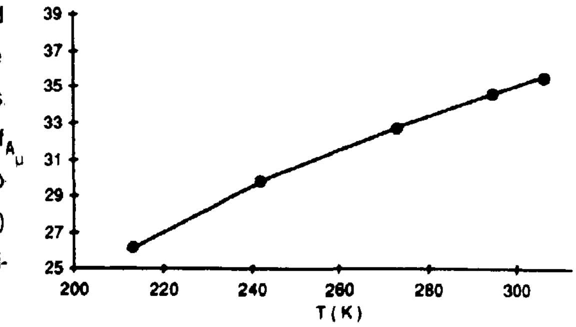


Fig. K4.4 Hyperfine coupling constant (A_μ) as a function of temperature for the $(CH_3)_2CH\,N\,N\,(CH_3)_2$ radical (Mu) coupling between the electron spin and the muon spin. Increasing the temperature increases the internal vibration, giving rise to a larger interaction (research in collaboration with Dr. E. Roduner, University of Zürich).

K4.4 Radionuclide production

Cross sections

In view of the intention to employ the waste beams of the electron accelerator as a means for the production of radionuclides, a program for measuring cross sections and estimating production yields was carried out. Table K4.3 lists the obtained photonuclear reaction cross sections for Bremsstrahlung generated in a thin (0.14 radiation length) W convertor by electrons of about 120 MeV. The reaction $^{58}Ni(\gamma,n)^{57}Ni$ with σ_q = 13.6 mb was used as a monitor.

Table 4.3 Measured photonuclear reaction cross section σ_q for E_{e^-} ≈ 120 MeV

Reaction	$t_{1/2}$	σ_q (mb) *)
$^{30}Si(\gamma,2p)^{28}Mg$	21 h	0.044
$^{40}Ar(\gamma,2p)^{38}S$	2.9 h	0.018
$^{41}K(\gamma,3p)^{38}S$	2.9 h	0.002
$^{58}Ni(\gamma,\alpha 2n)^{52}Fe$	8 h	0.015
$^{67}Zn(\gamma,2p)^{66}Ni$	55 h	0.010
$^{70}Zn(\gamma,p)^{67}Cu$	62 h	8.3
$^{69}Ge(\gamma,2n)^{68}Ge$	287 d	1.6

*) Error ca 10 %.

^{67}Cu

The method for the production of ^{67}Cu by the reaction $^{68}Zn(\gamma,p)^{67}Cu$ was further improved, whereas sources of radiochemically pure ^{67}Cu were used for the study of copper metabolism in milk cows (cooperative research with Dr. W.T. Binnerts, Agricultural University, Wageningen).

$^{11}CO_2$

For CO_2 uptake studies in plant roots, first ^{11}CO was made with 50% yield by irradiating CO_2 gas in flow target. This fraction was separated in flow from the bulk of the target CO_2 gas by absorption of the latter on pellets of NaOH. The ^{11}CO was subsequently oxidized by hot CuO to $^{11}CO_2$ with high specific activity. Preliminary experiments gave sufficiently encouraging results to continue the effort.

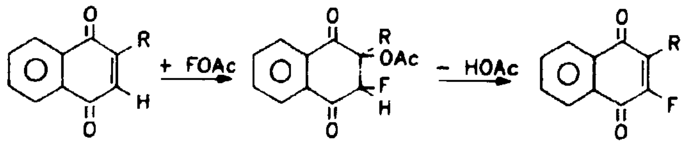
^{7}Be

Water used as a coolant for equipment in which large amounts of energy of the accelerated electron beams is dissipated is a useful source of ^{7}Be produced in mCi amounts by the spallation reaction $^{16}O(\gamma,2\alpha n)^{7}Be$. A study is in progress to recover this ^{7}Be from the ion-exchange filters placed in the cooling circuits.

K4.5 *Labelling*

^{18}F

Fluorinated chinones, like chinones themselves are of interest because of their cytotoxic activity. Therefore the addition of $CH_3COO^{18}F$ (F-OAc) to chinones was studied:



For different substituents R, measured yields (in brackets) of the products are

-OCH_3 (25 %), -N (12 %), -$NHCH_3$ (10 %)

-CH_3 (8 %), -H (0 %), -Br (0 %).

Structure 3 was confirmed by GC/MS in so far the compounds were formed. The yields are according to expectation in view of the e^--withdrawing (e^--donating) properties of R except for substituents containing nitrogen. This is probably due to reverted addition with F attached to the same C-atom as R in which case simple elimination of - OAc is not possible.

Fluorination with $CF_3O^{18}F$ of cytosine nucleosides with both -OH and =NH groups unprotected gives rise to 25-30 % radiochemical yields of compounds such as 5-^{18}F-uridine, 5-^{18}F-cytidine and 5-^{18}F-deoxycytidine (research in collaboration with Dr. G.W.M. Visser, Free University, Amsterdam).

$^{123,125}I$

The compound 5-iodo-2-thiouracil was labelled with ^{125}I (for animal experiments) and with ^{123}I (for patient studies) for the diagnosis of melanoma in the eye (research in cooperation with the Ophthalmology Institute, Leiden.

K4.6 *Miscellaneous*

^{66}Ni, β-energy

This radionuclide decays by a pure beta ground-state transition with $t_{1/2}$ = 55 h to ^{66}Cu ($t_{1/2}$ = 5.1 min). The decay energy is known but with little precision (E_{β^-} ≈ 0.20 MeV). The nuclide was obtained in µCi amounts as a byproduct of ^{67}Cu production runs, by the reaction ^{68}Zn(γ,2p)^{66}Ni. We have obtained a new value of E_{β^-} = 230 ± 10 keV with the same liquid scintillation counting method that was previously used successfully for the determination of the beta energy of ^{32}Si. The uncertainty is mainly due to interference by ^{56}Ni and ^{57}Ni.

^{175}Lu, capture cross section

The iron filtered 24 keV neutron beam recently installed at the HFR in Petten is particularly suited to measure capture cross sections at that energy, i.e. at an energy corresponding with stellar temperatures. Such measurements are therefore of astrophysical interest in particular for nucleosynthesis via the s-process. As a first result a value σ = 0.87 ± 0.03 b is reported for the capture process ^{175}Lu(n,γ)^{176m}Lu ($t_{1/2}$ = 3.63 h). The fair precision in the final result is due to high efficiency absolute beta counting with liquid scintillators. The present precision settles an existing discrepany of 30 % between two other reports, of which one is obviously wrong, while the other is in agreement with the present value. This work has been submitted for publication. Because of the important astrophysical implications, continuation of such measurements is seriously considered (research in cooperation with Dr. K. Abrahams et al. of FOM/ECN, Petten).

Meteorites

A rather modest contribution is given to an interdisciplinary effort to set up meteorite research in the Netherlands.

'Algarrobo'. This new iron meteorite found in Chile has been classified on the basis of bulk and trace element analysis and its metallurgical properties. This fine to medium octahedrite most probably belongs to the rare group II D (research in cooperation with Dr. V. Buchwald, Denmark).

Cosmic ages. The knowledge of cosmic, or exposure, ages of meteorites contributes to an understanding of both the history of the intensity of galactic cosmic rays, the origin of meteorites and the evolution of our planetary system. Preliminary experiments on some meteorites measuring cosmic ray induced ^{10}Be ($t_{1/2}$ = 1.67 x 10^6 y) with the tandem accelerator at Utrecht and ^{28}Al ($t_{1/2}$ = 0.72 x 10^6 y) with a low-level Ge counter are promising (research in cooperation with Dr. K. van der Borg, Van de Graaff Laboratory/Utrecht).

K5 TECHNICAL DEVELOPMENTS

(P.J.T. Bruinsma, A.P. Kaan, E. Kwakkel, P. Koldewijn, Y. Lefèvere, G. Luijckx)

K5.1 Introduction

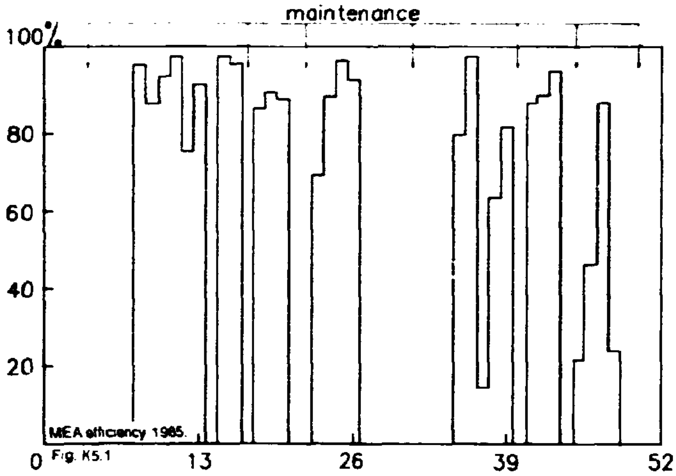


Fig. K5.1

Over the year, about 3900 beam hours were scheduled for MEA, including some 100 hrs for accelerator studies. The weekly efficiency for accelerator performance is displayed in fig. K5.1. Overall operation performance is displayed in fig. K5.2. Although a considerable number of hours were lost in the Fall, due to injector failures (filament and collimator), the number of data taking hours (2400) was comparable to last year's figure (2500). The weekly average of data-taking hours, however, increased by almost 25 %. In the past year only 27 weeks were scheduled for operation - against 35 in 1984 - in order to keep the electricity bill within the budgetary constraints. This significant efficiency increase is the result of an intensive equipment improvement program.

Continuous effort is needed to reduce the time needed to deliver beams with ever increasing tight tolerances for high accuracy experiments on target.

The delivered energy varied between 75 and 520 MeV at repetition rates of 300 Hz. The beam pulse width was 30 μs.

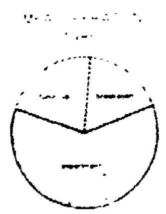


Fig K5 2

In the experimental halls, the major extensions and improvements were made in the electron-scattering end station (EMIN). For exclusive pion-absorption experiments to be performed in 1986, a new piece of equipment (ΔE-E plastic scintillator telescopes) has been designed (PIMU).

Accelerator and experiment computer control comprises an extensively growing enterprise. Developments in this field are reported in some detail, along with the associated networking.

Finally, some selected technical activities (also for third parties) are briefly presented.

K5.2 The accelerator MEA and its beam lines

K5.2.1 Major accelerator systems

Modulators: The solid-state pfn-type modulators operated reliably. Most of the breakdowns were caused by failures of the klystron focussing supplies. By the end of the year all of the 50 power supplies had been replaced by improved units.

Klystrons: The performance at the 4 MW power level has been improved by means of new processing and operating procedures and special equipment. The accumulated number of high-voltage hours is displayed in fig.K5.3. In total 240.000 hrs have been accumulated. The mean time between failures (MTBF) now is 34.000 hrs.

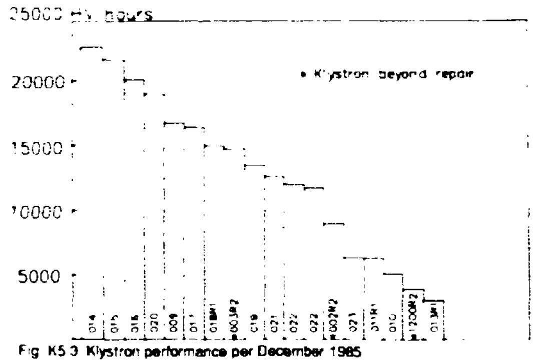


Fig K5.3 Klystron performance per December 1985

Control systems: About half of the local accelerator minicomputers, including DIG processors, have been replaced by Capro-68k systems. The central control system has been adapted to enable a more user-friendly test to operate the accelerator on a pulse-to-pulse basis.

Cooling systems: The hydrogen recombining system in the beam switch yard has not performed well at high average beam powers. The radiation safety department has initiated the development of a new system.

Injector: The existing hot deck has been equipped with faster electronic circuitry. During the Fall two two gun replacements were necessary. In addition an erratic vacuum leak in the chopper collimator resulted in considerable loss of beam time. The solenoid focussing system has been improved with the installation of high stability power supplies.

Monitors: After the successful completion of the improved travelling wave type beam position monitor (built for Saskatoon) a gradual replacement has been started for the accelerator monitors. All the associated electronic systems have been installed.

Vacuum system: The complicated control equipment in the beam switch yard and EMIN hall has been replaced by a new industrial type PLKC system. It now also includes a system to inject dry N_2 gas into the vacuum equipment for maintenance purposes.

K5.2.2 Accelerator research

Only 100 hours of beam time were available for accelerator studies. In addition to the continuing effort in determining standard settings for steering coils and klystrons phasing, more information could be obtained on the primary reasons of the loss of the first 10 μs of the beam current pulse. As a result a modulator improvement program was started.

K5.2.3 Upgrading program

RF power system: The present klystron processing facility is being upgraded in order to process the klystrons at a power output higher than 4 MW.

Modulators: A design has been made to improve the beam pulse duration from the present 30 μs to 40 μs. The output pulse will be improved when all modulators have been equipped with special damping circuits. A transient absorbing choke was designed; it is evaluated in the klystron test facility.

Gun research: A facility has been built for gun emission studies; it has been detrimental to the development of faster gun pulser electronics.

K5.3 Experimental equipment

Only some major improvements of the facilities and test measurements are reported for the EMIN and PIMU halls.

K5.3.1 The EMIN hall

A cryogenic thin-window ^4He gas target

For electro-desintegration measurements on ^4He it is essential to use a cryogenic thin-walled gas target if particles like deuterons, tritons or ^3He particles are to be detected. In order to limit straggling effects, especially at low momentum the target should have thin foils and a low working pressure; escaping ^3He particles down to p = 150 MeV/c for instance can be successfully detected at a working pressure of 25 kPa when mylar foils with a thickness of 1.5 μm are used. For coincidence measurements on the $^4He(e,e'^3H)p$ reaction, up to triton momenta of 500 MeV/c, the cross section drops by several orders of magnitude. In order that such measurements can be performed in a reasonable time span, the product of beam current and effective target thickness has to be optimized. For a working pressure of 400 kPa a product of 2500 μA mg/cm² can be obtained. In order to remove the power dissipated by the electron beam a heat exchanger, capable of handling up to 10 W and minimizing the temperature gradient in the target cell, is installed. The target system employs the method of natural convection. The target cell is shown in fig. K5.4. The target cell has been sucessfully operated at a pressure of 400 kPa (at 10 K), with a 6 μm thick mylar window supported by a stainless steel wire frame, while with a 1.5 μm thick mylar foil a working pressure of 25 kPa could easily be maintained.

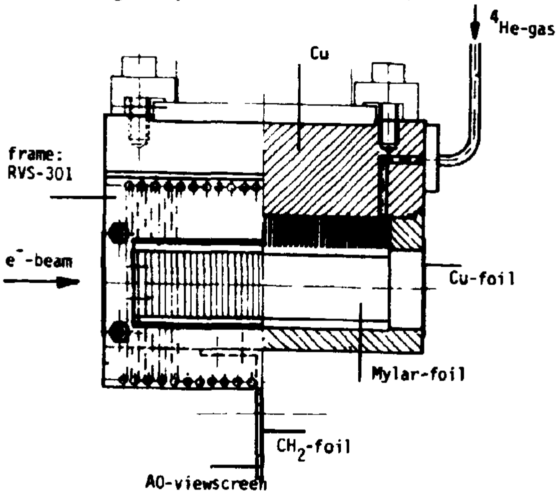


Fig. K5.4 The cryogenic ^4He gastarget-cell.

A low-pressure focal plane detector

A proto-type low-pressure position sensitive focal plane detector has been constructed and tested. The device is to be used for the detection of low-energy recoil products from (e,e'X) reactions; it will be installed in the focal plane of the QDQ spectrometer. For particle identification, the energy loss signal and the residual energy will be measured by a combination of an ionization and proportional chamber and a plastic scintillator, respectively. The proto-type detector has a length of 20 cm and the gas-filled ΔE section has a depth of 6 cm. With isobutane at 30 torr, the resolution of the energy loss signal for 5.5 MeV alpha-particles is of the order of 15 %. The position along the focal plane was obtained with the time projection method, which resulted in a typical resolution of 4 mm and a corresponding angular resolution of 5 degrees. This has to be improved to 1 degree.

Extension of the wire chamber system of the QDD spectrometer

For extended targets, like gas targets and the like, it is possible to avoid lengthy tuning procedures and to improve the resolution by determing the electron-momentum vector at the focal plane of the spectrometer with angular precision of better than 4 mrad. Therefore the QDD spectrometer will shortly be equipped with a newly constructed second Y-chamber. The set-up includes a thin dE/dx scintillator counter for particle identification.

Coincidence detection efficiency

Since a significant part of the experimental (e,e'p) program (see section K1.3) aims at the measurements of absolute spectroscopic factors, it is important to determine the coincidence detection efficiency with high accuracy. Efficiency measurements have been carried out since 1982. The accurate analysis of the data, however, awaited the full understanding of various corrections. Since these corrections are now understood, we were able to determine the coincidence efficiency from the simultaneously measured reactions $^1H(e,e'p)$ and $^1H(e,e')$ with a CH_2 target. For the first reaction the yield is proportional to $\varepsilon_e\varepsilon_p\varepsilon_c$, for the second to ε_e, where the subscripts e, p and c refer to electron, proton and coincidence (efficiency), respectively. By forming the yield ratio one finds $\varepsilon_p\varepsilon_c$, which is shown in fig. K5.5 for various electronic settings of the data taking mode. The average value of all data, 99±1 %, and their spread (3 %) demonstrate the accuracy and reproducibility of the present system. Together with other experimental uncertainties (target thickness, energy and angle calibration, solid angles) we now arrive at a systematic error of 5 % in the absolute cross sections measured with the coincidence set-up.

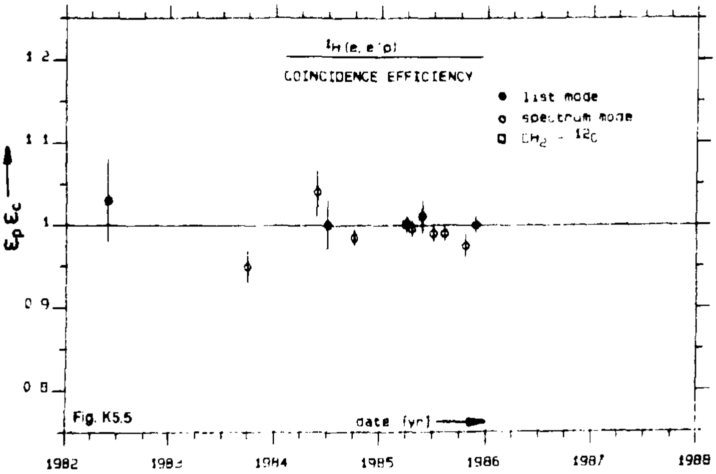


Fig. K5.5

Product of the efficiencies for coincidence (ε_c) and proton (ε_p) detection measured with the overcomplete $^1H(e,e'p)$ reaction on a CH_2 target (see text). The open and black circles represent two different settings of the electronic detection mode, the black square refers to an experiment where the simultaneously measured ^{12}C quasi-elastic peak has been subtracted from the CH_2 data.

K5.3.2 The PIMU hall

Routing interface

A routing interface (hardware [1]) and software [2]) has been developed for four 13-bits (LABEN 8215) ADC's. On-line single spectra can be accumulated and - at the same time - coincident data can be written to magnetic tape under control of the PDP-11/34 (with IAS) computer. Additional routing interfaces can be used in parallel so that complex data collection of multi-parameter events can be accomplished.

All ADC output words are routed to two 16k CAMAC histogramming modules (LRS 3588) while - under control of an externally applied event trigger - events can be selected for storage into four 64-words deep 16 bits wide first-in/first-out (CERN 175) CAMAC modules. All CAMAC modules allow for simultaneous inputs by the routing system.

K5.4 Computer facilities

The activities of the Computer Systems Group were divided over the following categories:

a) extension and renovation of the distributed accelerator control system and its operator console facilities,
b) improvements and support of the experimental facilities at the testing sites and of experiment control of the data-acquisition systems,
c) enhancements and upgrades of the general facilities of the IKONET network as a terminal and file server,
d) management and support of the central computing facility for data analysis and of personal computers for administration purposes.

Due to external circumstances, the personnel turn-over remains high, causing a substantial change in the management of the group and constant training of new staff to ensure continiuty of the on-going projects.

K5.4.1 The IKONET accelerator and experiment control network

Accelerator control

The Capro-68k (an MC68000 system in Camac from INCAA), for which a portable version of the FENIX real time operating system was developed (CENIX, in C) supports the modified DIG-2 processor in the new accelerator control software package. The first system was installed in April to replace one of the local minicomputers (Alpha-LSI/2) and later about half of the local accelerator machines were replaced.

The central part of the accelerator control system is extended steadily, with emphasis on centralization of general control and status-watch applications and improvements of the central database administrator functions. The computer-control system has been adapted to enable more user-friendly tests to operate the accelerator on a pulse-to-pulse basis. In essence, this is a dual-beam mode of operation, requiring three different settings (the actual switching is done by dedicated micro-computer systems, an ACE output multiplexer triggered by the master timing system, the beam tables being filled-in via the central control system). Successful tests have been possible at a basic repetition rate of 10 Hz with simultaneous beams in the low-energy and high-energy beam-switch yards.

The operator console facilities have been extended. The control of the low-energy beam-switch yard (LEBU) has been integrated into the main console system. Similar work is in progress for the control of the high-energy beam-switch yards (AFBU), with fine-tuning possibilities near or in the experiment control room (where an additional console machine is available). The most important development was the implementation and test of an operator interface for the control of the modulators by means of a relatively simple personal workstation (Apple Lisa), based on the utililisation of high-resolution bit-mapped graphics and mouse-driven menu selection to provide the operator with a means to manipulate a software model of the accelerator. This project aims at a general improvement of the man-machine interaction and shortening of the beam-tune procedures.

Experiment control

A new version of the experiment control program (MEJAZ) for the control of the EMIN electron scattering experiments has been developed and is being tested. The new version utilizes the same database techniques as the MEA control system and allows several status surveys on different (graphics) terminals. The final version will also incorporate the improved tuning of the spectrometer magnets and the control of the spectrometer positioning as well as the improved control of the complex AFBU/HEF vacuum system.

The EMIN experiment control machine (a PDP-11/44) has been equipped with an additional fast 330 Mb Winchester disk, to improve the on-line (and off-line) data analysis capabilities during the experimental runs.

The BIRA (11/23+) systems used art the DIGEL electronics laboratory for testing and development purposes (also used at some of the smaller experimental sites), have been improved by the employment of Rodime disks. These systems run the standard Fenix and Unix network software, and are incorporated in IKONET (see fig. K5.6). Some basic software tools have been developed tc aid tests with the fast time digitizer. The PION program for the PIMU experimental site is regularly adjusted to the changing layout of the experimental set-up.

K5.4.2 Management of the network and central computer facilities

Network facilities

The development of the IKONET accelerator and experiment control network over the past ten years is described in ref. 3. The schematic of the network layout by the end of 1985 is given in fig. K5.6. It now consists of some 35 computers in total, including the central computing facility (GOULD 32/9705), which also serves as gateway to the Local Area Network (WCWLAN)

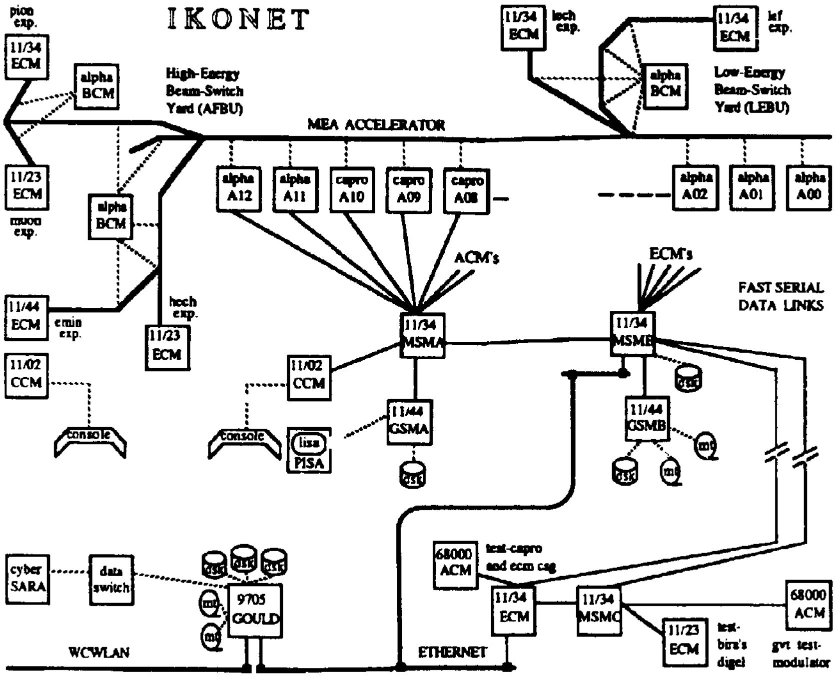


Fig. K5.6 The NIKHEF-K accelerator and experiment computer network layout.

connecting the mainframes of the scientific center, and from there to other national and international networks (DATANET, EARN, BITNET). The originally designed star-structured IKONET network has developed into what is best described as a transparent, central oriented network, in which in principle each node can serve as a message switching machine.

A major improvement has been the replacement of the long distance fast serial data links by an Ethernet connection, to ensure future reliability. Due to the distance, the connection is realized using fiber optics. This will be the basis for a gradual upgrade of the network towards international standards such as Ethernet and its associated TCP/IP protocols. For the time being, the standard Arpanet control (UDP/IP) is utilised for conversion to the IKONET datagram protocol via the gateway machines shown in fig. 5.6. Possibilities to couple the accelerator control machines to ethernet via a Camac-Ethernet interface are being investigated in cooperation with DIGEL, but this will imply a substantial upgrade of the current network protocol.

Much effort has been put into improvement of the TERMINET and remote login facilities, to accommodate the still increasing user demands and to further ensure the reliability of the network as whole. MSMC (fig. K5.6) now is dedicated to the task of terminal concentrator. The terminet facilities now are completely serviced in the real-time system. There is a general tendency to standardize to UNIX systems for the general service machines and to confine the home-made real-time systems (MTSR, FE CENIX) to the machines with real-time hardware control tasks only

Central and personal computing facilities

The new GOULD 32/9705 central computer was officially accepted in January, after a successful functional test. The current UTX-32 operating system, version 1.1C, is a derivative of Berkeley 4.2 UNIX with AT & T System-V enhancements. The software conversion of PDP-10 or PDP-11/44 application and system programs has been continued and the production in the field of data analysis and administration applications has grown rapidly. Various CERN software packages have been made available to physicists. Due to the increased speed and functionality, work is in progress to use the Gould to generate operation systems for other network machines. The generation of various Alpha-LSI systems is already fully operational.

The system currently supports 40 direct terminal connections (including modems and connections to and from the SARA dataswitch) and 32 pseudo terminals for remote login. For text processing applications, an Apple Laserwriter has been acquired to replace the daisywheel printers and to offer - in due course - a more advanced high-quality print facility. The popularity of the Gould and the increased possibilities have given rise to a rather sudden problem with the available diskspace (3 Winchester disks of 340 Mbytes, unformatted) for permanent and temporary storage.

This year has shown a long expected but sudden breakthrough in the use of personal computers. For text processing, technical documentation and associated administration purposes, the Apple Macintosh has been chosen as a standard. Another Apple Laserwriter has been made available as central printing facility, connected to a central Macintosh via a standard Appletalk connection. For small-scale technical applications, IBM (compatible) PC's are chosen in various configurations. Coupling of (local area networks of) PCV's to the central computer for centralized storage and file backup are being studied. For the time being, we offer limited possibilities for communication via standard terminal connections and standard protocols as offered by Versaterm (from SARA) and Kermit. The Macintosh can also be used as a graphics output device for standard (GKS or HPLOT based) graphics display utilities.

K5.4.3 Application software, PEEP; SNOOPY

The Distorted Wave Impulse Approximation code PEEP is used for the analysis of quasi-free (e,e'p) experiments (see section K1.3). In the past year a collaboration with Prof. S. Boffi and co-workers (Pavia, Italy) was initiated in order to improve the program. Presently a new version is available on the GOULD computer, which includes the following main features:

- a completely unfactorized expression for the coincidence cross section
- spin orbit term in the optical potential
- relativistic kinematics
- automatic generation of either parallel, perpendicular or (q,ω)-constant kinematics
- an option for Dirac-equivalent optical model potentials

- options for numerical input of the bound-state wave function and/or optical potential
- application of either the non-relativistic σ_{ep}^{NR} (McVoy-Van Hove) or the relativistic current-conserved σ_{ep}^{CC} (De Forest).

The phase shifts calculated with the program agree to within 0.5 % with those from DWBA codes for hadron scattering. Coulomb distortion of the electron waves has still to be implemented. In order to obtain optical potential parameters for the calculation of the distorted proton waves in (e,e'p) reactions the code SNOOPY [4] was implemented. This code allows for a fit of elastic proton scattering data with various forms of the optical potential or its Schrödinger-equivalent Dirac formalism.

A Hartree-Fock code (SKSLD) based on the Density Matrix Expansion method of Negele and Vautherin [5] has been implemented. The present version allows the use of partially occupied orbits [6].

K5.5 Project UPDATE

The proposal for UPDATE MEA to increase the duty factor (to 90 %) and the maximum energy (to 700 MeV) of the accelerator has not been funded in 1985. This project has now been given highest priority by FOM and the Netherlands' Organization for the Advancement of Pure Research (ZWO) in their requests for financing to the Dutch Government in 1986. Meanwhile, the NIKHEF and FOM Boards have approved and funded a small project to increase the maximum energy of MEA to 600 MeV by upgrading five modulator stations. At the same time the maximum peak current will be brought up to 50 mA. This upgrading fits into UPDATE.

K5.6 Work for third parties

Synchrotron radiation line at Daresbury (UK)

On behalf of ZWO, NIKHEF-K designed, built, tested and maintains equipment for experiments with synchrotron radiation at the Daresbury Laboratory. A description of the project can be found in the Annual Report 1982-1983.

Most of 1985 was spent on testing the optics and the experimental equipment with synchrotron radiation; a few weeks of User beam could be provided on both the small angle scattering (SAS) station and the EXAFS station. The vacuum, control, detection and data acquisition systems of both stations came successfully into operation. Although the tests showed that the basic design ideas are sound, several problems were encountered during commissioning. One year after installation, mirrors showed cracks at the support location while the reflectivity had deteriorated because of radiation damage, and one mirror appeared to be overbent because of floating effects in the quartz. Both monochromators suffered either from mechanical and thermal instability (SAS) or produced a spectrum with many spurious reflections, called glitches (EXAFS). Almost all optical systems are presently in the process of being overhauled to overcome at least part of the problems. The aim is to provide operational stations by early March 1986. Further modifications and improvement are planned during the 6 months Daresbury SRS shutdown that starts October 1, 1986.

CERN

For the second generation anti-proton accumulator project of CERN (ACOL) a spare pulsed septum magnet has been fabricated based on the 1984 NIKHEF-K design.

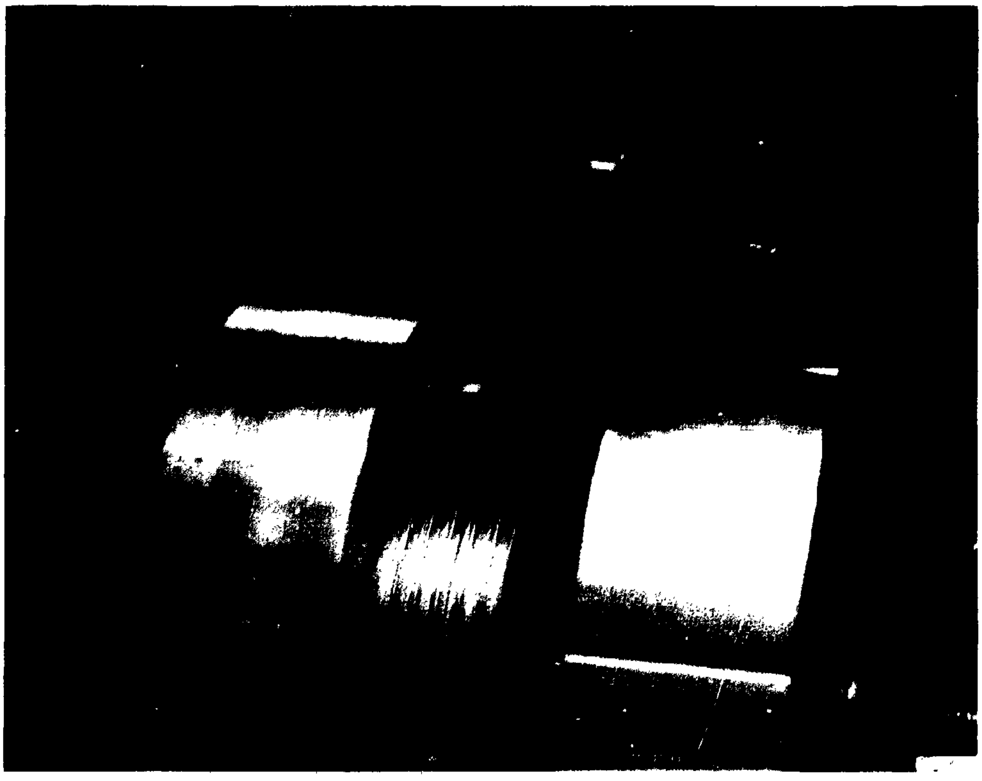
Impurities in Si wafers

In cooperation with the Philips group a sensitive method has been developed to measure the concentration and nature of impurities in silicon wafers. The system is based on opto-microwave reflection techniques. By means of light, charge carriers with a life-time between 10 and 500 ms are generated depending on the energy level of traps (caused by metals for example) or doping level. For metals the lower limit on the sensitivity is 10^{11} atoms/cm^3.

K5.7 Other technical activities

Flexible bellows

For the flexible connection of components of ultra-high-vacuum installations in a high radiation dose environment, a technique has been developed to weld lamellae of 0.3 mm thick aluminium with a leak through of less than 10^{-10} torr.l.s^{-1}. Nested bellows constructed that way have a flexibility of 0.3 mm per lamella for bellows with inner (outer) diameter of 117 (125) mm. The welding procedure proceeds through the so-called TIG method in which He gas is used instead of the commonly applied Ar gas. The photograph (fig. K5.7) shows a result of the described process.



The photograph shows the (partly removed) jig with which the aluminum lamellae are clamped together in order to get the right temperature balance during the welding process.

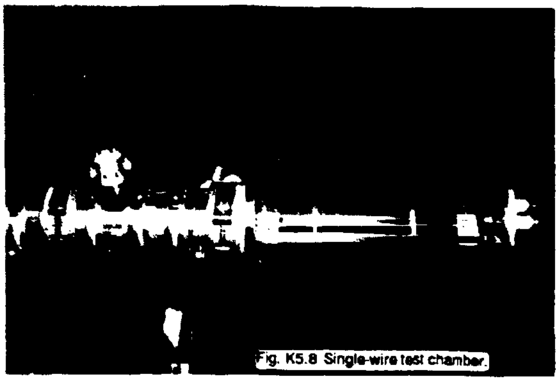


Fig. K5.8 Single-wire test chamber.

High temperature counter (HTPSC)

The feasibility of a high temperature position sensitive counter is being studied. This type of counter can be applied in the field of gaschromatography, as practised by the radiochemistry department; it leads to a significant increase of the experiment efficiency.

A (single wire) test chamber (Fig. K5.8) was built to obtain experience with the influence of higher temperature (350 °C) on insulation materials, gas mixtures, stability, pulse shape, aging. A flat temperature distribution over the chamber was realized by the insertion of a Cu pipe with a thickness of 2 mm between the furnace and the chamber. Difficulties with leakage through heated insulators were cured by introducing guard electrodes. As a first test, electrons from a ^{90}Sr source were successfully detected at 300 °C.

Fast time digitizer

Several tests have been carried out to check the time resolution and linearity of the fast time digitizer (FTD). The time resolution has been measured using a fixed repetition rate asynchronous input signal. This results in a peak with a width of (max) 3 channels (see fig. K5.9) expressing the distances between successive input pulses. Based on the same method the profile of adjacent channels has been determined (see fig. K5.10). A pseudo random time interval generator has been used to measure the differential linearity of the digitizer. Fig. K5.11 shows a difference between adjacent channels of less then 5 %.

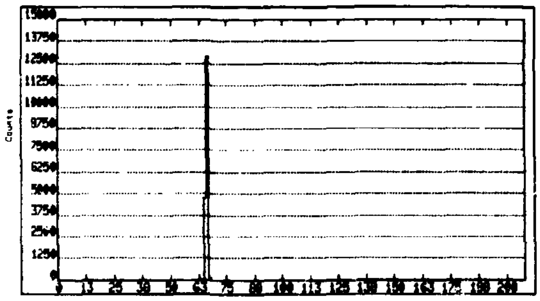


Fig. K5.9 Fixed time-interval measurement.

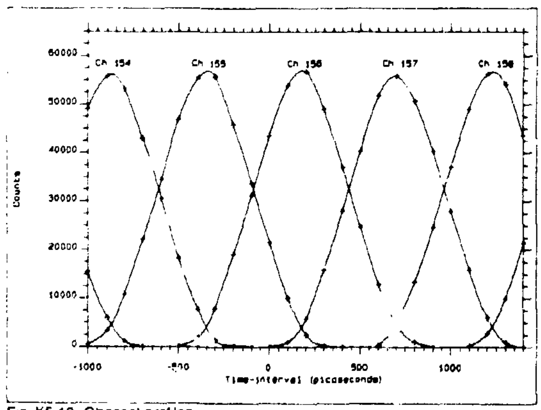


Fig K5.10 Channel profiles.

A parasitic experiment has also been done to test the performance in a physics environment. For this purpose the FTD has been preliminary interfaced to a Camac + PDP11/23 system. With this simplified set-up it was possible to test the electronics at maximum

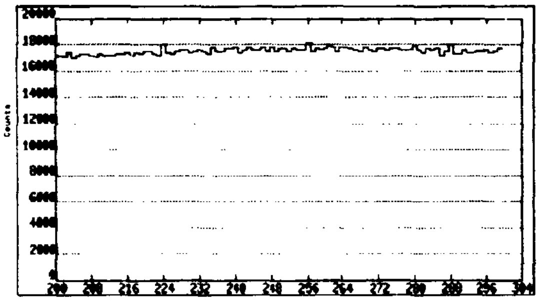
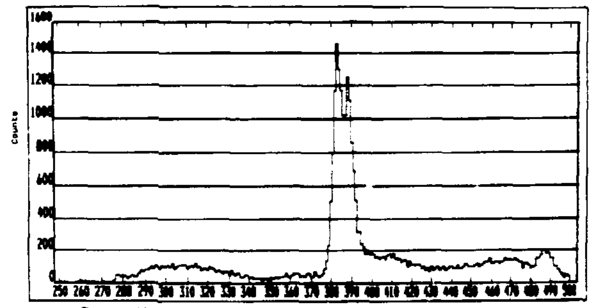


Fig. K5.11 Differential linearity.

speed over short periods (ca. 40 µs, due to memory limitations). Fig. K5.12 shows a time-of-flight spectrum for a beam with an instantaneous rate of $10^6\ s^{-1}$, containing 100 MeV/c muons and electrons over a distance of 1.6 m. The width of the two peaks, separated by ca 2.5 m, is determined by the momentum profile of the beam.



K5.12 Time-of-flight spectrum (channel width 0.53 ns).

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1.2. Ph.D. Theses

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(April 25 1985, Catholic University Nijmegen KUN).

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1.3 Contributions to conferences

Section-H

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(1) "Cross-Sections and Multiplicity Distributions for K^+p and π^+p Interactions at 250 GeV/c".
(2) "Multiparticle Production in π^+ and K^+ Interactions with Al and Au Nuclei at 250 GeV/c".
(3) "The Event Shape of 250 GeV/c K^+p and π^+p Interactions".
(4) "$K^+/\pi^\pm$ Ratios in the Forward Region of K^+p and π^+p Collisions at 250 GeV/c".
(5) "p^+/π^- Ratio in Proton Fragmentation from K^+p and π^+p Collisions at 250 GeV/c".
(6) "Neutral Pion Production in K^+p and π^+p Interactions at 250 GeV/c".

Kittel, W.
"Low p_t Soft Collisions in the Light of Hard Collisions - An Experimental Review".

TPC/PEP9 Collaboration (Aihara, H., et al. (Armitage, J.C., Buijs, A., Driel, M.A. van, Erné F.C., Langeveld, W.G.J., Linde, F.L., Paar, H.P., Sens, J.C., Timmer, J. and Uitert, B. van)).
"Recent two-photon results from the TPC/Two-Gamma Experiment".

4th Marcel Grossman Meeting, Rome (Italy), June, 1985

Kowalski-Glikman, J.
"Positive energy theorem for eleven-dimensional Kaluza-Klein supergravity".

Conference on Computing in High-Energy Physics, Amsterdam, June 25-28

Hertzberger, L.O., Mullender, S.J., Poletiek, G., Renesse, R. van, Tanenbaum, A.S., Tuynman, F., Vermeulen, J.C.
"The Design of a Real-Time Distributed System".

5th International Conference on Physics in Collision, Autun (France), July 3-5, 1985

Crystal Ball Collaboration.
"Υ Spectroscopy".

TPC/PEP9 Collaboration (Aihara, H., et al. (Armitage, J.C., Buijs, A., Driel, M.A. van, Erné, F.C., Langeveld, W.G.J., Linde, F.L., Paar, H.P., Sens, J.C., Timmer, J. and Uitert, B. van)).
"Recent Results of the Study of Photon-Photon Collisions".
Invited talk by J.C. Sens.

International EPS Conference on High Energy Physics, Bari (Italy), July 18-24, 1985

EHS-NA22 Collaboration.
(1) "Cross Sections and Multiplicity Distribution for K^+p and π^+p Interactions at 250 GeV".
(2) "Multiparticle Production in π^+ and K^+ Interactions with Al and Au Nuclei at 250 GeV".
(3) "The Event Shape of 250 GeV/c K^+p Interactions".
(4) "Neutral Pion Production in K^+p and π^+p Interactions at 250 GeV/c".

WA25 Collaboration.
"Q^2 dependence of the proton and neutron structure functions from neutrino and antineutrino scattering in deuterium".

TPC/PEP9 Collaboration (Aihara, H., et al. (Armitage, J.C., Buijs, A., Erné, F.C., Langeveld, W.G.J., Linde, F.L., Paar, H.P., Sens, J.C., Timmer, J. , van Driel, M.A. and van Uitert, B.)).
(1) "Exclusive production of p p-bar $\pi^+\pi^-$ in photon-photon collisions".
(2) "Exclusive production of p p-bar $\pi^+\pi^-$ and K^+K^- $\pi^+\pi^-$ in photon-photon collisions".
(3) "Measurement of the Photon Structure Function $F_2(x,Q^2)$ in the Range $0.2 < Q^2 < 7$ GeV^2 at PEP".

1st Torino Meeting on Superunification and extra dimensions, Torino (Italy), September, 1985

Kowalski-Glikman, J.
"The vacuumstates and their stability in N=1, D=10 anomaly-free Yang-Mills supergravity".

Topical Conference on the Quark Structure in Matter, Strasbourg (France) / Karlsruhe (West-Germany), September 26 - October 1, 1985

Crystal Ball Collaboration.
"Recent Results from the Crystal Ball".

Section-K

Third LEAR Workshop, Tignes, France, January 19 - 26

C.A. Baker, C.J. Batty, S.A. Clark, J.D. Davies, T.P. Gorringe, A.I. Kilvington, E.W.A. Lingeman, J. Lowe, I. Moir, J.M. Nelson, S.M. Playfer, G.J. Pyle, S. Sakamoto, G.T.A. Squier, R.E. Welsh, R.G. Winter.
"Results in light exotic atoms".

C.A. Baker, C.J. Batty, S.A. Clark, J.D. Davies, C.W.E. van Eijk, T.P. Gorringe, R.W. Hollander, A.I. Kilvington, E.W.A. Lingeman, J. Lowe, I. Moir, J.M. Nelson, W.J.C. Okx, G.J. Pyle, S. Sakamoto, G.T.A. Squier, R.E. Welsh, R.G. Winter.
"Detector for future X-ray experiments".

NNV Spring Meeting, Leiden, April 4

A. Taal.
"Strong interaction effects in pionic ^{208}Pb".

C.T.A.M. de Laat.
"Radiationless transitions in muonic ^{237}Np".

1985 Particle Accelerator Conference, Vancouver, Canada, May 13 - 16

R. Maas, P.J.T. Bruinsma, F.B. Kroes, G. Luijckx, J.G. Noomen, A.G.C. Vogel, C. de Vries.
"The Amsterdam pulse stretcher".

P. Pearce, T.R. Sherwood, P.J.T. Bruinsma, H. de Boer Rookhuizen, A.G.C. Vogel.
"A large aperture pulsed septum magnet for antiproton injection into the CERN AC ring".

Proc. X-European symposium on the dynamics of few body systems, Balatonfüred, Hungary, June ..

R. van Dantzig, R. Moddemeyer, G.J.F. Blommesteijn, J.A. Tjon, C. Stolk, W.M. Kloet, I. Slaus.
"Full phase space analysis for pd → ppn at T_p^{lab} = 50 MeV".

Int. Symposium Mesons and Light Nuclei, Bechyne Castle, Czechoslovakia June ..

R. van Dantzig, F.W.N. de Boer, A. van der Schaaf.
"On multi-pion multi-nucleon bound states".

Conference on Nuclear Physics with Electromagnetic Probes, Paris, France, July 1 - 5

P.J. Mulders.
"Change of scale for nucleons in nuclei".

48th Annual Meeting of the Meteoritical Society, Bordeaux, France, July 16 - 19

L. Lindner (NIKHEF-K), V.F. Buchwald (Lyngby Denmark).
"Algarrobo, a new iron meteorite from Chile".

MIT: Bates Users Group, MIT, USA, August 9

T. de Forest.
"Tests of the Sigma-Omega model with the (e,e'p) reaction".

T. de Forest.
"Comments on the relativistic Coulomb sum rule".

SON Werkgemeenschap voor Organodynamica, Lunteren, November 28 - 29

G.A. Brinkman, P.W.F. Louwrier, E. Roduner.
"Bepaling van de snelheidsconstante voor de reactie van Muonium met aromaten".

European Science Foundation (ESF), Workshop on Polar Research, Oslo, Norway, November 27 - 29

L. Lindner.
"Antarctic Meteorites".

NNV Fall Meeting, Petten, November 29

J. Konijn, W. Bertl, W. Duinker, S. Egli, C. Grab, E.A. Heines, C.T.A.M. de Laat, H.S. Peuys, A. van der

Schaaf, A. Taal.
"Measurement of the DCX-cross section in pionic atoms of ^{56}Ni".

A. Taal, C. Gugler, P. David, H. Janszen, C.T.A.M. de Laat, A. van der Schaaf, L.A. Schaller, L. Schehlenberg, J. Konijn.
"Strong interaction effects in pionic Mg and ^{27}Al using coincidence techniques".

W. Beer, R. Frosch, K.L. Giovanetti, P.F.A. Goudsmit, J. Hartmann, B. Denckelmann, J. Konijn, C.T.A.M. de Laat, H.J. Leisi, A. Rütschi, A. Taal, S. Thomann.
"Measurement of the population of the pionic 3d state in Mg to determine the mass of the negative pion".

E.W.A. Lingeman (NIKHEF-K), (University of Birmingham, Rutherford & Appleton Labs., College of William and Mary).
"X-rays from light antiprotonic atoms".

I.E.E.E. Conference on Nuclear Physics, Los Angeles, USA.

W.J.C. Okx, C.W.E. van Eijk, R. Ferreira Marques, R.W. Hollander, D. Langerveld, A. Stanovnik, C.A. Baker, J.D. Davies, I. Moir, S. Sakamoto, E.W.A. Lingeman, R.E. Welsh, R.G. Winter.
"A gas scintillating proportional detector for exotic hydrogen atoms X-rays".

1.4 Reports

Section-H

I.4.a. DELPHI Publications (DELPHI internal reports):

DELPHI-Collaboration/
'Status Report on Data Acquisition and Computing'.
DELPHI 85-17 GEN-20 / CERN LEPC 85-7.

DELPHI-Collaboration/
'The Second Milestone for the Barrel RICH'.
DELPHI 85-18 GEN-22 / CERN LEPC 85-10.

I.4.b. HERA / ZEUS Reports (1985)

'ZEUS a detector for HERA', Letter of Intent.
DESY, Hamburg, June 1985.

Kisielewska, D., Engelen, J., Suszycki, L.:
'Fast Luminosity Monitoring at HERA'.
DESY HERA 85-25, December 1985.

1.4.c. CERN Reports

UA1-Collaboration/
'Heavy quark production at the CERN proton-antiproton collider'.
CERN EP/85-45.

UA1-Collaboration/
'Experimental observation of events with large missing transverse energy'.
CERN EP/85-52.

UA1-Collaboration/
'W and Z production properties at the CERN SPS Collider'.
CERN EP/85-63.

UA1-Collaboration/
'Experimental observation of lepton pairs of invariant mass around 95 GeV/c^2 at the CERN SPS Collider'.
CERN EP/85-98.

UA1-Collaboration/
'Inclusive Jet Production at $\sqrt{s}$=546 GeV'.
CERN EP/85-116.

Eijk, B. van/
'EUROJET, a Monte Carlo program for jet simulations'.
CERN EP/85-121.

UA1-Collaboration/
'Results from UA1'.
CERN EP/85-160.

UA1-Collaboration/
'Intermediate Vector Boson Properties at the CERN Super Proton Synchrotron Collider'.
CERN EP/85-185.

UA1-Collaboration/
'Study of Minimum-Bias-Trigger Events at $\sqrt{s}$=0.2-0.9 TeV with Magnetic and Calorimetric Analysis at the CERN Proton-Antiproton Collider'.
CERN EP/85-196.

Eijk, B. van, et al./
'Hand Hadronic collisions: extrapolation of standard effects'.
CERN TH/3959.

I.4.d. SLAC Publication

Sens, J.C.
'Recent Results of the Study of Photon-Photon Collisions'.
SLAC-PUB 3754, August 1985.

I.4.e. University Preprints

Aihara, H., et al. (Armitage, J.C., Buijs, A., Erné, F.C., Langeveld, W.G.J., Linde, F.L., Paar, H.P., Sens, J.C., Timmer, J., van Driel, M.A., van Uitert, B.K.).
'Charged D^* Meson Production in e^+e^- Annihilation at $\sqrt{s}$=29 GeV'.
Iowa State University preprint, IS-J-1848 (1985).

Aihara, H., et al. (Armitage, J.C., Buijs, A., Erné, F.C., Langeveld, W.G.J., Linde, F.L., Paar, H.P., Sens, J.C., Timmer, J., van Driel, M.A., van Uitert, B.K.).
'Study of η Formation in Photon-Photon Collisions'.
University of California at Los Angeles preprint, UCLA-85-013 (1985).

I.4.f. NIKHEF-H -Scientific- Reports

#1 J.J. van der Bij:
Does low-energy physics depend on the potential of a heavy Higgs-particle?

#2 F.C. Erné:
Resonance production in $\gamma\gamma$ collisions, II.
Inv. paper at the VIth International Workshop on Photon-Photon Collisions, Tahoe, September 10-13, 1984.

#3 E.G. Floratos, D. Petcher:
Finite size effects and the mass gap of the O(N) model for arbitrary values of N.
#4 J. Timmermans:
Large-t elastic scattering and diffraction dissociation.
#5 The ACCMOR Collaboration (E. Belau et al.):
Observation of hadronically produced charmed F-mesons.
#8 Paul M. Fishbane, K.J.F. Gaemers:
Calculation of the decay $\mu^- \rightarrow e^- e^+ \nu_\mu \nu\text{-bar}_e$.
#9 J. Smith, W.L. van Neerven, J.A.M. Vermaseren:
QCD Radiative Corrections to the Decay W→q q-bar γ.
#10 J. Kowalski-Glikman:
The vacuum states and their stability in N=1, D=10 anomaly-free Yang-Mills supergravity.
#11 S. Aoyama, J.W. van Holten:
σ-Models on quaternionic manifolds and anomalies.
#12 J.W. van Holten:
On the quantization of non-compact field theories in Minkowski space.
#13 Maarten F.L. Golterman, N.D. Hari Dass:
On the QCD Effective Action for Pions and Vector Mesons.
#14 Jheroen Dorenbosch:
Triggers in UA2 and UA1.

1.4.g. Articles for the lay-public

NRC

Kunne, R.A.:

'De oerknal en de superkracht'.
March 7, 1985.
'De jacht op de magnetische monopool'.
March 21, 1985.
'Kernfusie bij kamertemperatuur'.
August 8, 1985.
'De ontbrekende massa in het universum'.
November 28, 1985.
'Kosmische versneli[illegible]s'.
December 19, 1985.

Kluyver, J.C.:
'Hoe groot is een proton?'.
December 12, 1985.

ADDENDUM II Scientific Lectures

II.1 Colloquia held at NIKHEF Section-H, Amsterdam

Dorenbosch, J. (NIKHEF-H):
Presentatie over UA1.
January 14, 1985.

Daum, C. (NIKHEF-H):
Presentatie over ACCMOR.
January 14, 1985.

Landelijk Seminarium (Theoretische) Hoge-Energiefysica, January 25, 1985:

Wallace, D. (Edinburgh):
Lattice Gauge Theory, Status and Prospects.
Dietz, K. (Bonn):
Nicolai maps and Stochastic Observables from a Coupling Constant Flow.
Schoenmaker, W. (Kaiserslautern):
Stochastic Quantization.
Stam, K. (Groningen):
Dynamical Chiral Symmetry Breaking.

Jong, T. de (UvA):
IRAS: geboorte en dood van sterren.
February 1, 1985.

Frère, J.-M. (U.L. Brussels):
CP violation in the K-system.
February 8, 1985.

Schroeder, H. (DESY):
Particle searches with ARGUS.
February 15, 1985.

Steger, H. (Max Planck Inst. München):
CP violation in the B^0- $\bar{B}^0$ system.
February 20, 1985.

Annual Scientific Meeting NIKHEF-H, February 21/22, 1985:

Eijk, B. van (NIKHEF-H): Status Report UA1.
Peng, Y. (NIKHEF-H, People's Republic of China): Progress report LEP3.
Jansen, H. (NIKHEF-H): Progress report DELPHI.
Eijndhoven, N.J.A.M. van (NIKHEF-H): Results from WA25.
Rijk, G.A.F. de (NIKHEF-H): Results from ACCMOR.
Linssen, L.H.A.J. (NIKHEF-H): Results from SING.
Scholten, A.J. (NIKHEF-H (Nijmegen)): Status report NA22/EHS.
Wassenaar, E. (NIKHEF-H): Computing at NIKHEF.
Walk, W. (NIKHEF-H (Nijmegen)): Results from Crystal Ball.
Kuijer, P.G. (NIKHEF-H): Results from Mark J.
Erné, F.C. (NIKHEF-H): Results from PEP-9.
Bij, J.J. van der (NIKHEF-H): Theory projects at NIKHEF-H.

Hoogland, W. (NIKHEF-H): Report on the organization and the experimental program of NIKHEF-H.
Schmueser, P. (DESY): Present status of the HERA machine.
Peccei, R. (DESY): Physics opportunities at HERA.
Engelen, J. (NIKHEF-H): ZEUS, a HERA detector.
Wigmans, R. (NIKHEF/CERN): Calorimetry at HERA.

Landelijk Seminarium (Theoretische) Hoge-Energiefysica, February 22, 1985:

Hoogeveen, F. (Amsterdam):
The gluon fusion mechanism for Higgs boson production.
Smit, J. (Amsterdam):
Introduction to staggered fermions.
Golterman, M. (Amsterdam):
Symmetries of staggered fermions.

Vermaseren, J.A.M. (NIKHEF-H):
$\gamma\gamma$ physics.
March 1, 1985.

Ellis, S. (CERN, Univ. Washington):
W's, Z's and jets: monojets or not?
March 8, 1985.

Udo, F. (NIKHEF-H):
De inner detector van DELPHI.
March 15, 1985.

Hoeve, F. (NIKHEF-H):
De nieuwe uranium calorimeter in het UA1 experiment.
March 22, 1985.

Timmermans, J. (NIKHEF-H):
Elastic scattering and total cross-sections of pp and $p\bar{p}$ at high energies.
March 29, 1985.

Daverveldt, P. (Leiden):
Four-lepton production processes in e^+e^- collisions at LEP energies.
April 4, 1985.

Bij, J.J. van der (NIKHEF-H):
The standard model.
Workshop,
April 12, 1985.

Pietrzyk, U. (Wuppertal):
Electromagnetic structure functions from nucleons and nuclei.
April 19, 1985.

Gaemers, K.J.F. (NIKHEF-H):
Higgs searches (part I).
Workshop.
May 3, 1985.

Diddens, A.N. (NIKHEF-H):
Higgs searches (part II).
Workshop.
May 10, 1985.

Rubinstein, H. (Weizmann Institute, Rehovoth):
Superstrings.
May 13, 1985.

Rubinstein, H. (Weizmann Institute, Rehovoth):
QCD sum rules.
May 14, 1985.

Beekveldt, E. (NIKHEF-H):
Proton decay.
May 24, 1985.

Luit, E.J. (NIKHEF-H):
Production of $\mu\mu\gamma$ events in e^+e^- collisions.
May 29 1985.

Binon, F. (IISN, Belgium):
Glueball hunting.
May 31, 1985.

Holthuizen, D.J. (NIKHEF-H):
UA1 results.
Workshop.
June 7, 1985.

Vermaseren, J.A.M. (NIKHEF-H):
The ESP project: cross section calculations in the LEP / HERA era.
June 21, 1985.

Hoppe, J. (Aachen):
Quantum theory of a relativistic surface.
August 9, 1985.

Kooijman, P. (Argonne):
Recent results from the High Resolution Spectrometer at PEP.
August 16, 1985.

Dijkstra, H. (NIKHEF-H):
High statistics inclusive ϕ-meson production at SPS energies.
September 6, 1985.

Landelijk Seminarium Conferentieverslagen Bari/Kyoto, October 4, 1985;

Petcher, D. (NIKHEF-H):
Theorie.
Vermaseren, J.A.M. (NIKHEF-H):
Theorie.
Tenner, A. (NIKHEF-H):
Weak Interactions.
Erné, F.C. (NIKHEF-H):
Spectroscopy, Future Accelerators.
Jongejans, B. (NIKHEF-H):
Sp$\bar{p}$S Collider experiments, Cygnus-X3.
Jonker, M. (SLAC):
Results from the Anomalous Single Photon Collaboration at PEP.
October 7, 1985.

Wind, H. (CERN):
Processing Magnetic Field Data.
October 15, 1985.

Tenner, A. (NIKHEF-H):
Bouw en Gebruik van Computers in Japan.
October 18, 1985.

Langeveld, W.G. (U.C. Riverside):
Pion and Kaon pair production in photon-photon collisions.
October 25, 1985.

Dijkman, W. (NIKHEF-H):
Removal of contaminants from driftchamber gasses.
November 1, 1985.

Holten, J.W. (NIKHEF-H):
Supersymmetry in particle physics.
Workshop.
November 8, 1985.

Demarteau, M. (NIKHEF-H):
New particle searches in e^+e^-.
November 15, 1985.

Fontannaz, M. (Orsay):
Real photon processes and perturbative QCD beyond leading order.
November 22, 1985.

Vecchia, P. Di (Univ. Wuppertal / Nordita):
String Theorie.
November 19, 20, 21, 1985.

Landelijk Seminarium (Theoretisch) Hoge-Energiefysica, November 29, 1985:

Jarlskog, C. (Stockholm):
CP violation.
Jurkiewicz, J. (Utrecht):
A numerical study of discrete euclidean polyakov surfaces.
Groot, E. de (Utrecht,Bielefeld):
Multiplicity distributions in $p\bar{p}$ collisions at 540 GeV and the "Bremsstrahlung analogy".
MacArthur, I. (Cambridge):
Anomalies in supersymmetric Yang-Mills theories.

Korthals-Altes, C. (Marseille):
Finite-size effects and boundary conditions in Yang-Mills theory.
December 5, 1985.

Engelen, J. (NIKHEF-H):
Exotic phenomena at HERA.
Workshop.
December 13, 1985.

Jongejans, B. (NIKHEF-H):
Het einde van het bellenvattijdperk. Een beschouwende terugblik.
December 19, 1985.

Tenner, A.G. (NIKHEF-H):
Het einde van het bellenvattijdperk Neutrino's.
December 19, 1985.

Zonjee, N. (NIKHEF-H):
Some aspects of synchrotron radiation.
December 20, 1985.

II.2 Colloquia held at NIKHEF Section-K

D. Heyman (Rice University, Houston):
Thermonuclear processes in nature and their records in meteorites.
January 3, 1985.

A. Rinat (Weizmann Institute of Science, Rehovot):
Some questions regarding deep-inelastic scattering on, and scaling for nuciei.
January 14, 1985.

P. Vernin (ALS-Saclay):
Monte Carlo efficiency calculations of plastic neutron counters.
February 12, 1985.

C.W.E. van Eijk (TH-Delft):
CPT-invariance.
February 28, 1985.

K. Elsener (ETH-Zürich):
Parity violation in light nuclei.
March 4, 1985.

M. Kohno (Universität Regensburg):
Quasi-elastic electron scattering on nuclei.
March 7, 1985.

C. Schuhl (CEN, Saclay):
The last results obtained with the Saclay linac beams and the 1985 program.
March 21, 1985.

P. Weber (Universität Mainz):
Recoil corrections in the distorted wave analysis of electron-scattering data.
March 29, 1985.

M.N. Harakeh (KVI, Groningen):
Recent developments in the study of giant resonances.
April 11, 1985.

K. Heyde (University of Gent):
A possible description of new collective proton-neutron modes in nuclei.
April 18, 1985.

C. Conci (KFA, Jülich):
Quasi-particle RPA calculations with effective forces and meson exchange.
April 23, 1985.

R. Kamermans (Rijksuniversiteit Utrecht):
Reaction processes in neon-induced collisions between 200 and 400 MeV.
April 25, 1985.

R.F. Casten (Universiteit Keulen):
(N_p-N_n) systematics in heavy nuclei.
May 2, 1985.

W.J. Oosterkamp (KEMA):
Fuel management for the nuclear power station at Dodewaard.
May 9, 1985.

H. Rubinstein (Weizmann Institute of Science, Rehovot):
Isospin is not a good quantum number. Some low QCD effects.
May 13, 1985.

K. Abrahams (ECN, Petten):
Virtual meson contributions to the interaction of low-energy neutrons with polarized light nuclei.
May 23, 1985.

W. Dickhoff (Tübingen / VU):
A new piece in the nuclear jig-saw puzzle!
(New approach to understand nuclear spectra).
June 6, 1985.

H. Sagawa (Michigan State University):
Core polarization effects on electromagnetic form factors.
June 10, 1985.

P. Gaspar (Washington university, St. Louis):
The recoil chemistry of multivalent atoms.
June 11, 1985.

G.M. Temmer (Rutgers University):
Electron channeling radiation.
June 13, 1985.

H.T. Fortune (University of Pennsylvania):
New results in pion double charge exchange.
June 20, 1985.

M. Fujiwara (Osaka University):
Recent experimental results from the RCMP cyclotron.
June 21, 1985.

T. Suzuki (Kyoto / Jülich):
Quasi-elastic electron scattering in the relativistic σ–ω model.
June 24, 1985.

A. Dellafiore (University of Florence / Oxford):
Particle-hole calculation of the longitudinal response function of ^{12}C.
June 27, 1985.

P.J. Mulders (NIKHEF-K):
Modifications of nucleons in nuclei and the EMC effect.
September 12, 1985.

J.R.H. Smith (Surrey):
Recent developments on pion chemistry at the University of Surrey.
September 19, 1985.

H. Rebel (Kernforschungszentrum Karlsruhe):
The role of laserspectroscopy in studies of the isotopic variation of nuclear charge radii.
October 10, 1985.

H. Savaloni (University of Edinburgh):
3 MeV polarized neutron scattering from medium-mass nuclei.
October 15, 1985.

J. Heisenberg (University of New Hampshire):
The particle vibration coupling in the shell model.
October 17, 1985.

A.J.H. Donné (FOM-Instituut voor Plasmafysica, Nieuwegein):
Transverse excitations of ^{19}F.
October 24, 1985.

A.M. van de Berg (Rijksuniversiteit Utrecht):
Quasi-elastic transfer reactions for Ni-induced reactions on medium-heavy nuclei.
November 7, 1985.

B.M.K. Nefkens (UCLA):
Relativistic kinematics at low energies.
November 8, 1985.

H. Arnold (GKN):
De kernreactor in Dodewaard.
December 12, 1985.

II.3 Scientific lectures outside NIKHEF.

Section-H

Crijns, F.
"European Academic Research Network".
Seminar Akademie der Wissenschaften,
Berlin/Zeuthen (GDR), November 28 1985.

Daum, C.
"Toepassing van supergeleiding in de hoge-energie fysica".
Colloquium Technische Natuurkunde,
TH-Delft, March 25 1985.

De Rijk, G.
"Charm hadroproduction in the ACCMOR collaboration".
The Moriond Workshop on Flavour Mixing and CP Violation,
La Plagne (France), January 13-19 1985.

De Rijk, G.
"Heavy flavour Hadroproduction".
Department of High-Energy Physics, University of Valencia,
Valencia (Spain), March 20 1985.

De Rijk, G.
"Charm hadroproduction and decays in the ACCMOR Collaboration".
Department of High-Energy Physics, University of Valencia,
Valencia (Spain), March 21 1985.

Duinker, P.
"The muon chamber system of L3".
L3 Collaboration Meeting,
CERN, Geneva (Switzerland), September 24 1985.

Dijkstra, H.
"High statistics inclusive phi-meson production at SPS energies".
CERN particle physics seminar,
Geneva (Switzerland), July 2 1985.

Erné, F.C.
"Study of η and η' formation in photon-photon collisions".
Bari International Conference,
Bari (Italy), July 18-24 1985.

Erné, F.C.
"Exclusive production of $p\bar{p}\,\pi^+\pi^-$ and $K^+K^-\,\pi^+\pi^-$ in photon-photon collisions".
Bari International Conference,
Bari (Italy), July 18-24 1985.

Faber, G.
"The Vertical Alignment System for the L3 Muon Detector".
L3 Collaboration Meeting,
CERN, Geneva (Switzerland), September 25 1985.

Gosman, D.
"Work at Nikhef-H on fastbus".
Fastbus software workshop,
CERN, Geneva (Switzerland), September 23-24 1985.

Groenstege, H.
"The Muon trigger for the L3 experiment developed at NIKHEF, Amsterdam".
L3 Trigger Meeting,
CERN, Geneva (Switzerland), February 13 1985.

Hoogland, W.
"Hoge Energie Fysica".
Colloquium FOM, RIJNHUIZEN,
Rijnhuizen, January 15 1985.

Hoogland, W.
"The HERA project".
Symposium Landelijk Overleg Technische Supergeleiding,
Nijmegen, June 21 1985.

Hoogland, W.
"Report of the High Energy Physics Coordination Committee on Computing".
Scientific Policy Committee meeting,
CERN (Switzerland), September 17 1985.

Hoogland, W.
"Report of the High Energy Physics Coordination Committee on Computing".
European Committee on Future Accelerators meeting,
CERN (Switzerland), December 6 1985.

Jansen, H.
"Progress Report on CX".
DELPHI-meeting,
CERN, Geneva (Switzerland), November 20 1985.

Jongejans, B.
"Neutrino Forschung in Deuterium mit BEBC".
Institut für Hochenergiephysik,
Zeuthen (GDR) January 30 1985.

Kittel, W.
"Ähnlichkeiten der Teilchenerzeugung bei e^+e^-, Lepton-Hadron und Hadron-Hadron Kollisionen".
Physik Seminar, RWTH Aachen,
Aachen (West-Germany), April 29 1985.

Kittel, W.
"Low p_t Soft Collisions in the light of Hard Collisions - An Experimental Review".
XVI International Symposium on Multiparticle Dynamics,
Kiryat Anavim (Israel), June 12 1985.

Koene, B.
"The Barrel RICH Vessel Cylinders".
DELPHI Padova Meeting,
Padova (Italy), September 9 1985.

Koene, B.
"Drift tube and liquid radiator equipotentials".
DELPHI-meeting,
CERN, Geneva (Switzerland), January 23 1985.

Kowaiski-Glikman, J.
"Positive energy theorem for eleven dimensional Kaluza-Klein supergravity".
4th Marcel Grossmann Meeting,
Rome (Italy), June 1985.

Kowalski-Glikman, J.
"The vacuum states and their stability in N=1, D=10 anomaly-free Yang-Mills supergravity".
1st Torino Meeting on Superunification and extra dimensions,
Torino (Italy), September 1985.

Linssen, L.
"Physics at LEAR".
Valencia (Spain), March 20 1985.

Linssen, L.
"$\bar{p}p$ total cross sections and $\bar{p}p$ forward elastic scattering at low incoming p momenta".
LEAR Workshop,
Tignes (France), January 19-26 1985.

Meijers, F.
"NA22 Results".
International Europhysics Conference on High Energy Physics,
Bari (Italy), July 20 1985.

Miranda, R.
"FLAIRC; Flash ADC Instrumentation Read by CAMAC".
DELPHI-meeting,
CERN, Geneva (Switzerland), July 22 1985.

Onvlee, J.
"Magnetic Field Calculations".
L3 Collaboration Meeting,
CERN, Geneva (Switzerland), December 4 1985.

Paar, H.P.
"New experimental results in photon-photon interactions, as observed in high energy e^+e^- collisions".
University of California Physics Department,
Los Angeles (U.S.), February 12 1985.

Paar, H.P.
"Experimental determination of the total hadronic cross section of photon-photon collisions".
University of California Physics Department,
Los Angeles (U.S.), February 13 1985.

Paar, H.P.
"e^+e^- Physics at High Luminosities".
Presentation to the Experimental Program Committee of the Stanford Linear Accelerator Center,
Stanford (California, U.S.), April 12 1985.

Paar, H.P.
"Report on the Workshop on e^+e^- Physics at High Luminosities".
Presentation to the Scientific Policy Committee of the Stanford Linear Accelerator Center,
Stanford (California, U.S.), May 17 1985.

Paar, H.P.
"Report on the Workshop on e^+e^- Physics at High Luminosities".
Presentation to U.S. Department of Energy representatives,
Stanford (California, U.S.), July 23 1985.

Paar, H.P.
"Resonance production in photon-photon collisions".
Illinois University Physics Department Seminar,
Urbana-Champaign (Illinois, U.S.), November 4 1985.

Paar, H.P.
Resonance production in photon-photon collisions".
Florida University Physics Department Seminar,
Gainesville (Florida, U.S.), November 11 1985.

Paar, H.P.
"Resonance production in photon-photon collisions".
Syracuse University Physics Department Colloquium,
Syracuse (N.Y., U.S.), November 13 1985.

Paar, H.P.
"Resonance production in photon-photon collisions".
Indiana University Physics Department Seminar,
Bloomington (Indiana, U.S.), December 3 1985.

Petcher, D.
"Field theory in a small universe".
University of Edinburgh,
Edinburgh (U.K.), January 14 1985.

Petcher, D.
"Field theory in a small universe".
Rutherford-Appleton Lab.,
Chilton, Didcot (U.K.), January 16 1985.

Petcher, D.
"Field theory in a small universe".
Oxford University,
Oxford (U.K.), January 18 1985.

Petcher, D.
"On the mass gap of the O(N) model in finite volume".
Deutsches Elektronen-Synchrotron,
Hamburg (West-Germany), January 22 1985.

Petcher, D.
"Can you get big results by thinking small? Field theory in a finite volume".
Fermilab,
Batavia (Illinois, U.S.), August 19 1985.

Petcher, D.
"Can you get big results by thinking small? Field theory in a finite volume".
T.J. Watson Research Center, IBM,
Yorktown Heights (N.Y., U.S.), September 18 1985.

Petcher, D.
"How asymptotic is 'asymptotic scaling'?".
Indiana University,
Indiana (U.S.), September 3 1985.

Petcher, D.
"How asymptotic is 'asymptotic scaling'?".
Brookhaven National Laboratory,
Upton (N.Y., U.S.), September 20 1985.

Sens, J.C.
"BGO detectors".
California Institute of Technology Seminar,
Pasadena (California, U.S.), April 2 1985.

Sens, J.C.
"Operational experience with a BGO spectrometer at PEP".
L3 Meeting, MIT,
Cambridge (Massachusetts, U.S.), April 15 1985.

Swider, G.
"QCD Tests from Mark J for $14 \leq \sqrt{s} \leq 46.78$ GeV".
Deutsches Elektronen-Synchrotron,
Hamburg (West-Germany), January 29 1985.

Tiecke, H.
"Observation of hadronically produced charmed F-mesons".
International Conference on Hadron Spectroscopy, Univ. of Maryland,
Maryland (U.S.), April 20-22 1985.

Tiecke, H.
"The ZEUS Detector".
The quark structure of matter,
Strasbourg (France) / Karlsruhe (West-Germany), September 26 - October 1 1985.

Timmermans, J.
"Large-t elastic scattering and diffraction dissociation".
International Symposium on Physics of Proton-Antiproton Collision,
Tsukuba (Japan), March 13-15 1985.

Timmermans, J.
"Elastische verstrooiing van protonen en antiprotonen en de totale werkzame doorsnede bij zeer hoge energieën".
Algemeen Natuurkunde Colloquium Katholieke Universiteit Nijmegen,
Nijmegen, December 3 1985.

Toet, D.
"Barrel RICH MWPC's - status/future".
DELPHI RICH Meeting,
Amsterdam, February 28 1985.

Udo, F.
"Inner Detector Results".
DELPHI-meeting,
CERN, Geneva (Switzerland), March 19 1985.

Udo, F.
"Results of the prototype Inner Detector".
DELPHI-meeting,
Padova (Italy), March 13 1985.

Udo, F.
"Investeringen in Hoge-Energie Fysica".
Voordracht 'Dutch Scientific',
Amsterdam, May 2 1985.

Van Apeldoorn, G.W.
"Meten van de uctuur van de bouwstenen van de atoomkernen".
Exposition 'Het Instrument', RAI,
Amsterdam, October 4 1985.

Van der Graaf, H.
"Status of the NIKHEF muon chamber production".
L3 Collaboration Meeting,
CERN, Geneva (Switzerland), July 17 1985.

Van de Walle, R.T.
"Fundamenteel Materie Onderzoek".
'Slotvoordracht', Congres Nederlandse Vereniging Onderwijs Natuurwetenschappen,
Utrecht, February 9 1985.

Van Driel, R.
"A possible on-line monitor software system for L3".
L3 Collaboration Meeting,

CERN, Geneva (Switzerland), September 25 1985.
Van Eijk, B.
"Same sign dimuons, sign for $b\bar{b}$ mixing at collider".
SLAC Seminar,
Stanford (California, U.S.), May 17 1985.

Van Hal, P.
"Results from NA22".
XVI International Symposium on Multiparticle Dynamics,
Kiryat Anavim (Israel), June 12 1985.

Van Holten, J.W.
"Supersymmetry".
Lecture at 2^{nd} Hellenic School on Elementary Particle Physics,
Corfu (Greece), September 1985.

Van Holten, J.W.
"Symmetries in supersymmetric field theories".
University of Amsterdam Theoretical Seminar,
Amsterdam, November 14 1985.

Van Holten, J.W.
"Effective actions and supersymmetry".
State University of Utrecht Theoretical Seminar, December 18 1985.

Vermeulen, J.
"The Philips DRM system".
L3 Collaboration Meeting,
CERN, Geneva (Switzerland), December 4 1985.

Walk, W.
"The χ_b-States".
International Europhysics Conference on High Energy Physics,
Bari (Italy), July 20 1985.

II.4 Invited talks outside NIKHEF, Section-K

(A). Invited talks at conferences:

International Symposium on Artificial Radioactivity, Poona, India, January 8-12:

G.A. Brinkman, J.Th. Veenboer;
"Polymerization induced by ^{11}C atoms".

Third LEAR Workshop, Tignes, January 19-26:

P.J. Mulders;
"Theoretical description of the $N\bar{N}$ interaction".

Conference on Perspectives in Nuclear Physics at Intermediate Energies, Trieste, March 25-29:

C. de Vries;
"Future developments at NIKHEF-K, Amsterdam".

P.K.A. de Witt Huberts;
"High resolution (e,e'p) experiments".

J.H. Koch;
"Delta excitation in nuclei by pions and photons".

NNV Spring Meeting, Leiden, April 4:

E.W.A. Lingeman;
"De Nederlandse Natuurkundigen: onderzoek naar werkgelegenheid".

XI[th] Europhysics Divisional Conference 'Nuclear Physics with Electromagnetic Probes', Paris, July:

P.K.A. de Witt Huberts:
"High resolution (e,e'p) experiments, spectroscopic factors and correlations".

J.H. Koch:
"Photo- and Electroproduction of pions at intermediate energies to discrete nuclear states".

Dronten Summer School on Nuclear Dynamics, Dronten, August 5-17:

J.H. Koch;
"Photonuclear reactions at intermediate energies".

P.J. Mulders;
"Models for the structure of hadrons: bags, solitons".

1985 NATO Advanced Study Institute 'New Vistas in Electro-nuclear Physics', Banff, Canada, August 22 - September 4:

P.K.A. de Witt Huberts;
"High resolution quasifree (e,e'p) experiments".

IUCF Workshop 'Nuclear Structure at high-spin, excitation and momentum transfer', Bloomington, October 21-23:

P.K.A. de Witt Huberts;
"Complementary aspects of the quasi-free (e,e'p) reaction and the (d,^{3}He) reaction".

(B). Colloquia outside NIKHEF:

A.H. Wapstra.
"The Atomic Mass Table 1985".
Mainz, January 8 1985.

P.J. Mulders.
"Twist four effects in deep inelastic scattering and the Weinberg angle".
CERN, Geneva, January 17 1985.

T. de Forest.
"The relativistic Coulomb sum rule".
University of Colorado, Boulder, February 4 1985.

H.P. Blok.
"Nuclear structure studies using electrons and protons".
University of Virginia, Charlottesville, February 7 1985.

H.P. Blok.
"Recent results at the Amsterdam electron accelerator".
George Washington University, Washington D.C., February 8 1985.

H.P. Blok.
"Proton knock-out reactions with high energy electrons".
University of New Hampshire, Durham, February 11-13 1985.

Th.A. Bauer.
"Interferenzen in der Quasifreien Pionstreuung $^{16}O(\pi^+\pi^+p)$ und die Δ-Kern-Wechselwirkung".
Schleching, Experten treffen, February 26 1985.

T. de Forest.
"Nucleon structure and the nuclear medium".
Free University, Amsterdam, March 13 1985.

G. van Middelkoop.
"Proton-hole states in nuclei".
Manchester University, March 14 1985;
Birmingham University, March 13 1985.

P.J. Mulders.
"Skyrmions: a low-energy model for nucleons".
Intermediate energy physics meeting, Utrecht, March 15 1985.

P.K.A. de Witt Huberts.
"Enkele aspekten van kernstruktuur, bestudeerd met elektronverstrooiing".
Rijksuniversiteit Utrecht, Algemeen Natuurkunde Colloquium, April 18 1985.

P.K.A. de Witt Huberts.
"Nucleonische en niet-nucleonische vrijheidsgraden in atoomkernen".
Landelijk Seminarium Theoretische Fysica held - May 10 1985.

G. van der Steenhoven.
"Recent results obtained with the $^{12}C(e,e'p)^{11}B$ reaction".
IFN-Pavia, June 19 1985,
Verona, June 22 1985.

G. van Middelkoop.
"Proton knock-out induced by electrons".
Brookhaven National Laboratory, Upton, August 19 1985,
Rutgers University, August 26 1985.

H. de Vries.
"Electron scattering results from NIKHEF-K".
Amherst, Massachusetts, September 11 1985.

P.J. Mulders.
"Modifications of nucleon properties in nuclei".
Stony Brook, New York, September 16 1985.

P.J. Mulders.
"Modifications of nucleon properties in nuclei, as viewed in electron scattering".
MIT, Cambridge, Massachusetts, September 17 1985.

W.H.A. Hesselink.
"Low energy pion physics at NIKHEF".
LAMPF, Los Alamos, September 18 1985.

J.H. Koch.
"Pion photoproduction at low and intermediate energies".
MIT-Bates Linear Accelerator Center, Massachusetts, September 18 1985.

G. van der Steenhoven.
"Nuclear medium effects studied by the quasi-free $^{12}C(e,e'p)^{11}B$ reaction".
Bosen - September 26 1985.

P.J. Mulders.
"Combined analysis of quasi-elastic and deep-inelastic electron-nucleus scattering".
U.C., Santa Barbara, October 8 1985.

P.J. Mulders.
"Combined analysis of quasi-elastic and deep-inelastic electron-nucleus scattering".
Stanford University, Palo Alto, October 25 1985.

Th.A. Bauer.
"The isobar doorway model from an experimentalist's point of view".
KFA Jülich, October 30 1985.

T. de Forest.
"The relativistic Coulomb sum rule".
Saclay, November 7 1985.

P.J. Mulders.
"Combined analysis of quasi-elastic and deep-inelastic electron-nucleus scattering".
Los Alamos National Laboratory, Los Alamos, New Mexico, November 7 1985.

P.J. Mulders.
"Combined analysis of quasi-elastic and deep-inelastic electron-nucleus scattering".
Caltech, Pasadena, November 8 1985.

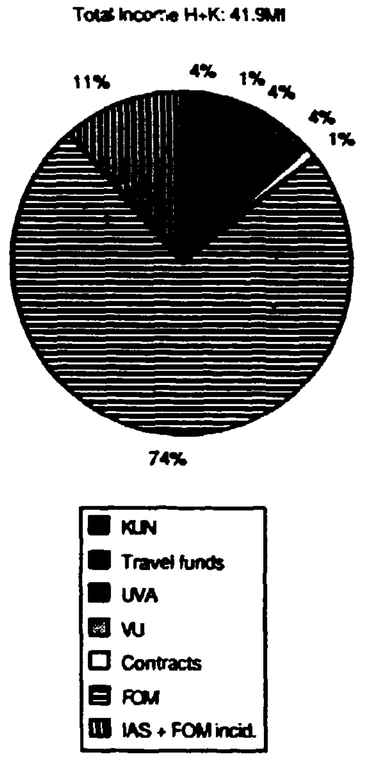
II.5. Algemeen WCW Colloquium

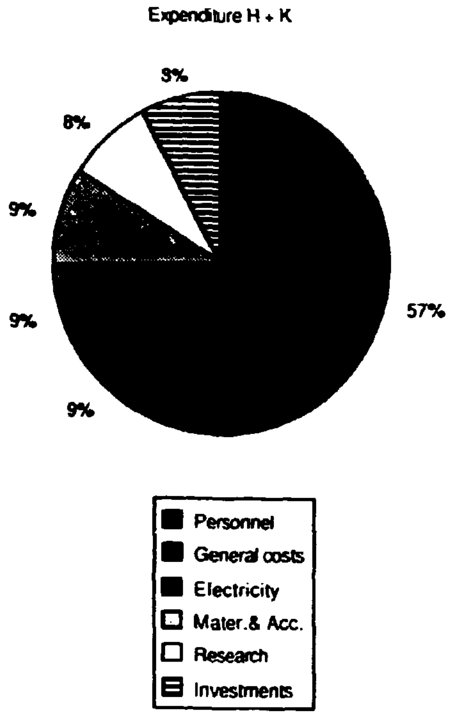
Grivell, L.A. (Afd. Molec. Biol. vakgr. Biochemie):
Mitochondriaal DNA: "Small but Beautiful".
February 12, 1985.

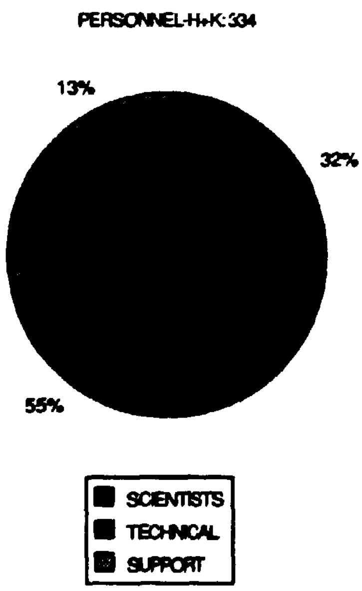
Gaemers, K.J.F. (NIKHEF-H / UvA):
Het standaard model van elementaire deeltjes en het nog niet ontdekte Higgs boson.
May 6, 1985.

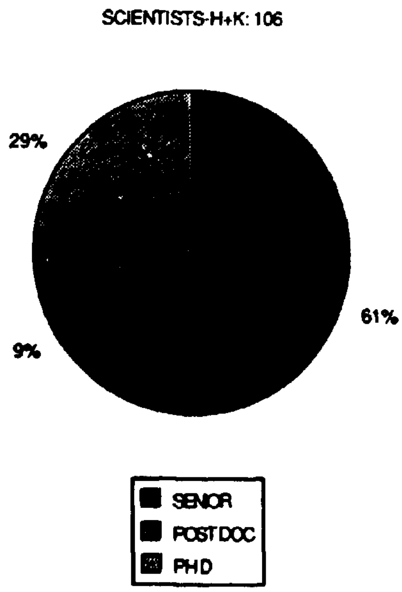
Witt-Huberts, P.K.A. de (NIKHEF-K / RUU):
Licht op atoomkernen.
December 2, 1985.

ADDENDUM III Resources

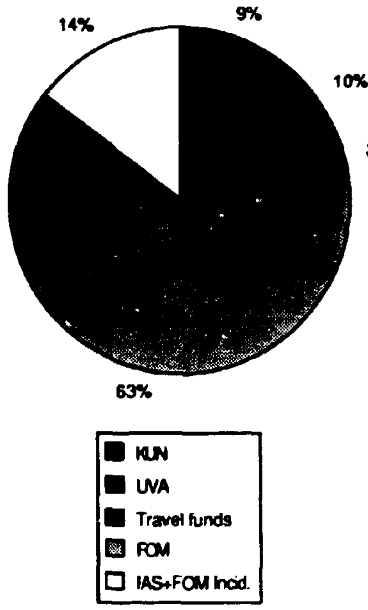




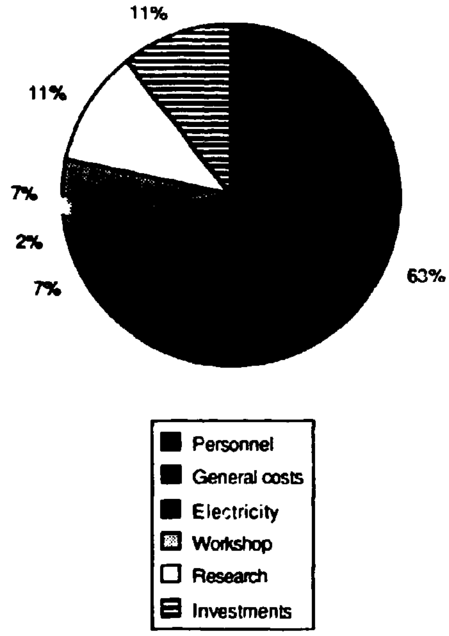




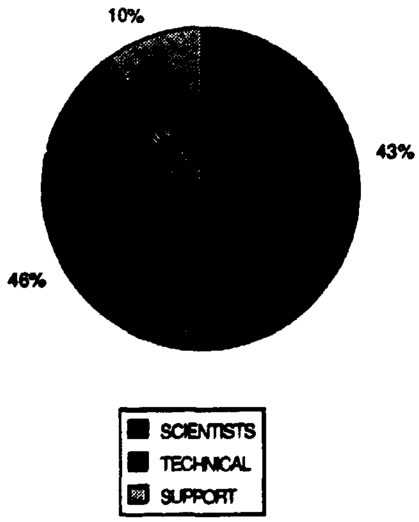
Total Income H: 18.5Mf



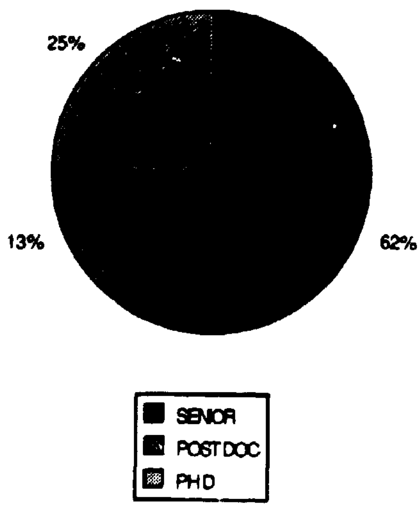
Expenditure H

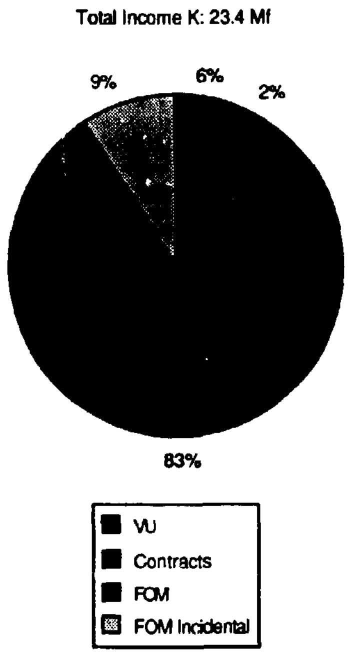


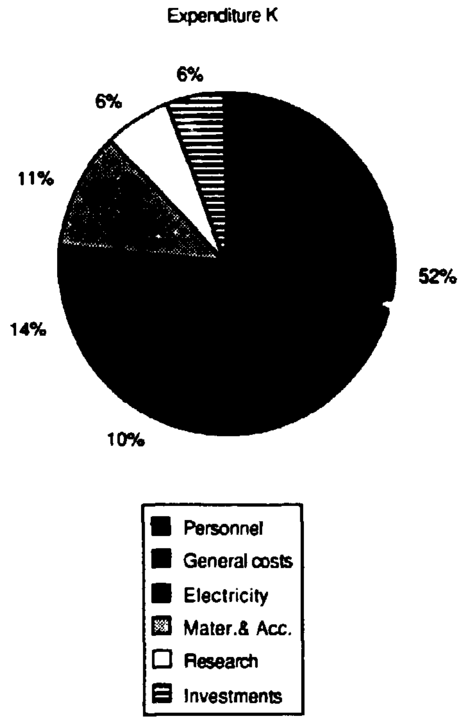
PERSONNEL-H: 151

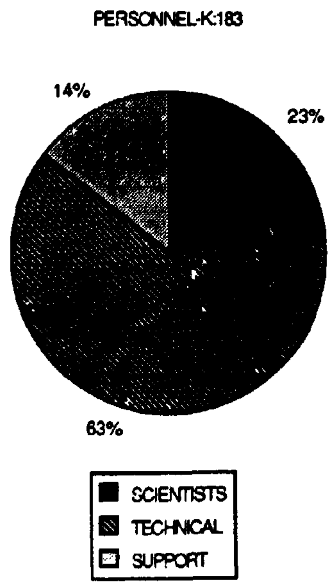


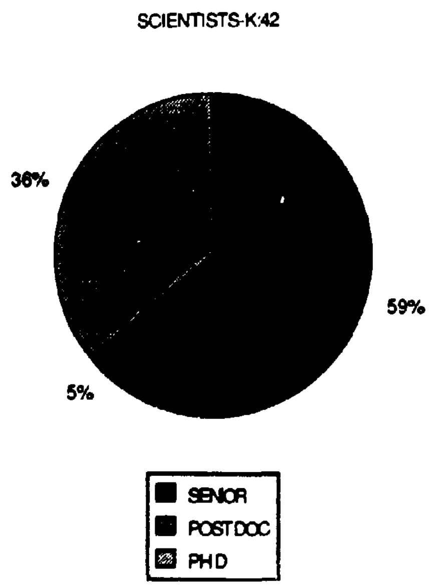
SCIENTISTS-H: 64




Total Income K: 23.4 Mf
9%
6%
2%
83%
VU
Contracts
FOM
FOM Incidental


Expenditure K
6%
6%
11%
52%
14%
10%
Personnel
General costs
Electricity
Mater.& Acc.
Research
Investments


PERSONNEL-K:183
14%
23%
63%
SCIENTISTS
TECHNICAL
SUPPORT


SCIENTISTS-K:42
36%
59%
5%
SENIOR
POSTDOC
PHD

ADDENDUM IV Memberships of Boards, Councils and Committees

NIKHEF-Council per 12/31/1985

Blok, J. (FOM / deputy chairman)
Dymanus, A. (KUN)
Heuvel, E.P.J. van den (UvA)
Jongerius, R.T. (UvA)
Kluyver, J.C. (FOM)
Kokkedee, J.J.J. (FOM / chairman)
Verheul, H. (VUA)
Walle, R.T. van de (KUN)

Vuren, H.G. van (secretary, no membership)

The meetings are attended by the NIKHEF directorate:

Hoogland, W.
Langelaar, J.
Middelkoop, G. van

- minutes: Hofman, Mrs. E.

NIKHEF Works Council

A. Boucher	(section-K)
A.J.C. Burghardt	(section-K)
G.W. Faber	(section-H)
E. Heine	(section-K)
B. Jongejans (chairman)	(section-H)
G.N.M. Kieft (dep. secretary)	(section-H)
M.J.M. Kroezen	(section-H)
G.A.J. Leurs	(section-K)
J.G. Noomen (secretary)	(section-K)
M.C. Vonk	(section-H)
L.W. Wiggers (dep. chairman)	(section-H)
A.N.M. Zwart	(section-K)

Section-H

CERN council: Kluyver, J.C., Vice President

European Commitee of Future Accelerators, restricted committee: Hoogland, W.

ECFA, extended committee: Holthuizen, D., Walle, R.T. Van der

HERA machine committee: Daum, C.

HERA management board: Daum, C., Hoogland, W.

Physics Research Committee DESY: Hoogland, W.

Extended Scientific Policy Committee DESY: Hoogland, W.

High Energy Physics Board, European Physical Society: Sens, J.C.

High Energy Physics Computing Coordinating Committee: Hoogland, W.

Scientific Policy Committee (CERN): Diddens, A.N.

SPSC (CERN): Hoogland, W.

Scientific Advisory Committee (Wetenschappelijke Advies Commissie) Section-H per 12/31/1985

Dam, P.H.A. van
Daum, C.

Diddens, A.N.
Duinker, P.
Gaemers, K.J.F. (chairman)
Hoogland, W.
Scholanus, D.J.

Leeuwen, W.M. (secretary, no membership)
Langelaar, J. (auditor, no membership)

Section-K

Program Advisory Committee, Massachusetts Institute of Technology

Koch, J.H.

Program Advisory Committee, University of Mainz

Witt Huberts, P.K.A. de

Program Advisory Committee (PAC)

Dieperink, A.E.L. (KVI, Groningen)
Domingo, J.J. (SIN, Villigen)
Mougey, J. (ALS, Saclay)
Redwine, R.P. (MIT, Cambridge, Massachusetts)
Turchinetz, W. (MIT, Cambridge, Massachusetts)
Koch, J.H. (NIKHEF-K, secretary)

Also attending:

Middelkoop, G. van (Scientific Director NIKHEF-K)
Vries, C. de (NIKHEF/consultant)

Scientific Advisory Committee (Wetenschappelijke Advies Commissie) Section-K

Domingo, J.J. (SIN, Villigen)
Koch, J.H. (NIKHEF-K)
Leun, C. van der (Phys. Lab. RUU)
Middelkoop, G. van (NIKHEF-K, ex off.)
Mougey, J. (ALS, Saclay)
Redwine, R.P. (MIT, Cambridge, Massachusetts)
Tjon, J.A. (RUU/chairman)
Turchinetz (MIT, Cambridge, Massachusetts)

ADDENDUM V Personnel per December 31, 1985

A. NIKHEF-H (Amsterdam)

1. Experimental physicists

Apeldoorn, Dr. G.W. van		UvA	Neutrino (D2), DELPHI
Bos, Dr. K.	FOM		LEAR/SING, UA1
Buys, Drs. A.	FOM		Two-photon physics (PEP9)
Dam, Dr. P.H.A. van		UvA	Neutrino (D2), DELPHI
Daum, Dr. C.	FOM		ACCMOR, ZEUS
Demarteau, Ir. M.W.J.M.	FOM		MARK J, L3
Diddens, Prof. Dr. A.N.	FOM		DELPHI
Dorenbosch, Dr. J.	FOM		Neutrino (NC)
Driel, Dr. M.A. van	FOM		Two-photon phys.(PEP9)L3
Duinker, Dr. P.	FOM		PETRA, L3
Dijkman, Dr. W.H.	FOM		Instrumentation
Engelen, Dr. J.	FOM		ZEUS
Eijk, Drs. B. van	FOM		UA1
Eijndhoven, Drs. N.J.A.M. van		UvA	Neutrino (D2)
Erné, Dr. Ir. F.C.	FOM		Two-photon physics (PEP9)
Graaf, Ir. H. van der	FOM		L3
Have ten, Mw. Ir.I.	FOM		UA1
Harting, Prof. Dr. D.		UvA	MARK J, L3
Hartjes, Drs. F.G.	FOM		Instrumentation
Holthuizen, Dr. D.J.	FOM		UA1
Hoogland, Dr. W.	FOM		Scient. dir., ACCMOR, ZEUS
Jansen, Drs.H.	FOM		DELPHI
Jongejans, Dr. B.	FOM		Neutrino (D2)
Kluit, Ir. P.M.	FOM		UA4
Kluyver, Prof. Dr. J.C.		UvA	LEAR/SING
Koene, Dr. B.K.S.	FOM		UA4, DELPHI
Kunne, Drs. R.A.	FOM		LEAR/SING
Kuyer, Drs. P.G.	FOM		MARK J
Langerveld, Ir. D.	FOM		DELPHI
Linde, Drs. F.L.	FOM		Two-photon physics (PEP9)
Linssen, Mw. Drs. L.A.H.J.	FOM		LEAR/SING
Massaro, Dr. G.G.G.	FOM		MARK J, L3
Miranda, Drs. R.T.	FOM		DELPHI
Onvlee, Drs. J.		UvA	L3
Paar, Dr. H.P.	FOM		Two-photon physics (PEP9)
Peng, Y.	FOM	+	L3
Rijk, Drs. G.A.F. de	FOM		ACCMOR
Sens, Prof. Dr. Ir. J.C.	FOM		Two-photon phys.(PEP9)L3
Swider, Dr. G.M.	FOM		MARK J, L3
Tenner, Prof. Dr. A.G.		UvA	Neutrino (D2) ZEUS
Tiecke, Dr. H.G.J.M.	FOM		ACCMOR, ZEUS
Timmermans, Dr. J.J.M.	FOM		UA4, DELPHI
Toet, Dr. D.Z.	FOM		DELPHI
Udo, Dr. F.	FOM		DELPHI
Uitert, Drs. B.K. van	FOM		Two-photon physics (PEP9)
Voorthuis, Dr. H.		UvA *	Software Support
Wiggers, Dr.L.W.	FOM		ACCMOR, ZEUS
Wigmans, Dr. M.E.J.	FOM		Leave of absence, ZEUS
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2. Theoretical physicists

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Heymens-Visser, P.	FOM	
Leeuwen, Drs. W.M. van	FOM	
Petten, R. van	FOM	
Poletiek, G.	FOM *	
Sastradiwiria, D.A.	FOM	
Schäfer, J.S.E.		UvA
Vermeulen, Dr. Ir. J.C.		UvA
Wassenaar, Drs. E.	FOM	
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Euwe, E.	FOM *	
Hof, G. van 't	FOM *	
Jager, H. J. de	FOM *	
Molenaar, Mw. Drs. C.M.	FOM *	
Visser-Jansen, Mw. J.H.	FOM *	
Westbroek-Phillips, Mw. S.	FOM *	

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G[illegible]t, J.I. de	FOM	
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Brussee, R.	DELPHI
Fikke, E.R.	Microprocessors
Groenland, J.A.	Microprocessors
Hoeve, F.	UA1
Hulsman, E.	NEUTRINO (D2)
Jong, B.P. de	Theory group
Jong, S.J. de	NEUTRINO (D2)
Josephus Jitta, F.H.D.	UA1
Leijtens, X.J.M.	L3
Lioen, W.	L3
Poletiek, G.	Microprocessors
Rademakers, A.A.	DELPHI
Schaap, B.	Two-photon phys. PEP9
Stad, R.van der	ACCMOR
Veen, R. van 't	UA1
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Vorenkamp, T.	L3
Wilhelm, R.	L3
Zonjee, N.G.M.	DELPHI

8. Apprentices over 1985

Dee, F.T. van
Goede, G. de
Haytema, Y.S.
Horst, G.C. van der
Krijger, F.
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Sanders, R.C.M.A.
Schutte, A.
Tanger, J.W.
Tol, A.H.J. van
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B. NIKHEF-H (Nijmegen)

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König, Dr. A.C.		KUN	Crystal Ball, L3
Metzger, Dr. W.J.		KUN	Crystal Ball, L3
Meijers, Drs. F.		KUN	EHS
Pols, Dr. Ir. C.L.A.		KUN	EHS, Crystal Ball, L3
Raaymakers, Drs. M.C.T.		KUN	Instrumentation
Reidenbach, Dr. M.	FOM		Crystal Ball
Scholten, Drs. A.J.	FOM		EHS (NA22)
Schotanus, Dr. Ir. D.J.		KUN	Crystal Ball, L3
Smet, Ir. F.M.	FOM		Instrumentation
Van de Walle, Prof. Dr. R.T.		KUN	Crystal Ball, L3
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Burghardt, Drs. A.J.C.	FOM		Emin
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Donné, Dr. A.J.H.	FOM/	VUA	Emin
Ent, Drs. R.	FOM/	VUA	Emin
Hamers, Drs. R.	FOM/	VUA	Pimu
Herder, Drs. J.W.A. den	FOM		Emin
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Offerman, Drs. E.A.J.	FOM		Emin
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Steenhoven, Drs. G. van der	FOM/	VUA	Emin
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Taal, Ir. A.	FOM		PiMu
Vries, Prof. Dr. C. de	FOM		Emin
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As, R. van
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Bueren-Kooij, Mw. J. van	FOM *		
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Jansen, J.L.	FOM
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They left us in 1985 ----

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Bergsma, Drs. F.
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Blok, Drs. H.
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Abbreviations:

--- FOM - Foundation for Fundamental Research on Matter
--- KUN - Catholic University of Nijmegen
--- UvA - University of Amsterdam
--- VUA - Free University of Amsterdam
--- WAD - Additional Administrative and Support Personnel (Werkverband Administratie en Dienstverlening

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