NIKHEF--84

NIKHEF NATIONAL INSTITUTE FOR NUCLEAR PHYSICS AND HIGH-ENERGY PHYSICS

1984

ANNUAL REPORT

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

(B) Scientific Report of the Nuclear Physics Section (NIKHEF-K)

ADDENDA:

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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 - operating since 1975; officially started in 1981 - is managed by the NIKHEF-board and a directorate. The major part of the research activities is funded by FOM.
NIKHEF section-K is one of the two national centres for Nuclear Physics. Its research activities are coordinated within the national working group on Nuclear Physics.
Experimental High Energy Physics within the Netherlands is concentrated in NIKHEF section-H.
In view of the extensive international contacts is has been decided to present for both sections the NIKHEF annual report in English.

HIGH ENERGY PHYSICS (H)

H.1 Introduction

The section-H of NIKHEF carries out experiments at the large accelerator laboratories CERN (Genève), DESY (Hamburg) and SLAC (Stanford, United States).

At the European centre CERN, which plays a central role in the experimental program, NIKHEF-H participates in experiments with the Super Proton Synchrotron (SPS), the proton-antiproton collider (SppS) and the Low Energy Antiproton Ring (LEAR), while it is involved in the preparation of experiments for the new LEP collider. Although maintaining the role of CERN in the experimental program at approximately 75%, the increasing scale of the experiments and consequently the manpower and financial resources to be allocated to them, necessitates a reduction in the number of experiments. In particular the continuously increasing demands of the LEP experiments require that some of the older experiments are gradually brought to an end.

The SPS accelerates protons to a maximum energy of 450 GeV. These protons are ejected from the ring and are used to produce secondary particle beams. NIKHEF has participated in the CERN neutrino program in two experiments, WA18 and WA25. The participation in WA18 practically has come to an end. WA25 is a bubble chamber experiment of which the scanning and measuring phase will be stopped at the end of 1985.
Secondary beams of π-mesons and protons are used to study the interactions of strongly interacting particles (hadrons). Experiments in which NIKHEF participates are NA32 (ACCMOR) and NA22 (EHS). It has been decided to stop at the end of 1986 the scanning and measurements for the (hybrid) bubble chamber experiment NA22.
In the $Sp\bar{p}S$ the SPS-ring is used to store high intensity beams of protons and antiprotons at an energy of approximately 300 GeV. These beams collide in two intersection points. In the first, NIKHEF takes part in the Nobelprize winning UA1 experiment. In the second intersection point NIKHEF participates in the small elastic scattering experiment UA4. The antiprotons which are accumulated in a special accumulator ring can also be decelerated. LEAR is designed to produce very pure low energy antiproton beams. NIKHEF takes part in the LEAR program in the SING experiment.

TABLE H1				
Experiment	Accelerator	Technique, & Expir.	Reaction	Experimental topics
CHARM (WA18, WA65, PS181)	CERN-SPS	C; 1984	$(\bar{\nu})_\mu$-marble	ν-quark & ν-electron interactions. Fundam. parameters weak interaction. ν - oscillations.
WA25	CERN-SPS	B; 1985	$(\bar{\nu})_\mu$-D_2	ν-quark interactions. Fundamental parameters weak interaction. Chiral coupling constants u- & d-quarks.
ACCMOR (NA11, NA32)	CERN-SPS	C; 1985	π/K/p-Be	Quark-quark & gluon-gluon interactions. Production charmed particles, "glueballs".
EHS (NA22)	CERN-SPS	B/C; 1985	π/K/p-p	Quark-quark & gluon-gluon interactions; production charmed particles; quark fragmentation.
UA1	CERN-$\bar{p}p$ coll.	C; ?	p-$\bar{p}$	Quark-(anti)quark interactions; production $W^{\pm}$, Z^0, quark and gluon jets.
UA4	CERN-$\bar{p}p$ coll.	C; 1984	p-$\bar{p}$	Total and elastic cross sections $\bar{p}p$ at highest centre-of-mass energies.
SING (PS172)	CERN-LEAR	C; 1986	p-$\bar{p}$	Study of $\bar{p}p$-systems at low energy; baryonium.
MARK-J	DESY-PETRA	C; 1985	e^+-e^-	Possible detection top-quark; fundamental parameters electroweak interaction.
Crystal Ball	DESY-DORIS	C; 1985	e^+-e^-	Study of bound $b\bar{b}$ system (b=bottom quark). Strong interaction.
PEP-9	SLAC-PEP	C; 1986	e^+-e^-	Study of photon-photon interactions; parameters strong interaction.
DELPHI	CERN-LEP	C; ?	e^+-e^-	Production and properties Z^0, W±, parameters electroweak interactions; Higgs particles.
LEP-3	CERN-LEP	C; ?	e^+-e^-	Production and properties Z^0, W±, parameters electroweak interaction; Higgs particles.

Explanation: C=Counter experiment, B=Bubble Chamber experiment

The new LEP collider should come into operation at the beginning of 1989. In the first phase of LEP electrons and positrons will collide at a centre of mass energy of up to 100 GeV. Detectors will be constructed around four intersection points, equally spaced around the 30 km circumference tunnel. NIKHEF contributes to two of these detectors (DELPHI and L3). The preparations for these experiments move into the construction phase.

At DESY NIKHEF is involved in experiments with the electron-positron colliders DORIS and PETRA. The DORIS machine, with its centre of mass energy of about 1 GeV, is particularly suited for studying the physics of the bottom quark. A NIKHEF group from Nijmegen participates in the CRYSTAL BALL experiment. So far the largest centre of mass energies reached with electron-positron colliders are obtained with PETRA (46 GeV). A NIKHEF team participates in the MARK-J experiment. PETRA will stop end 1986. A new collider project HERA which aims for collision of very high energy electrons (30 GeV) and protons (820 GeV) should be ready in 1990. The NIKHEF participation in MARK-J is gradually phased out, while a new HERA team is being formed.

At SLAC, NIKHEF physicists take part in the PEP4/9 collaboration which does experiments with an advanced detector at the electron-positron collider PEP. The beam energy of PEP is comparable to that of PETRA (15 GeV). It presently has, however, a larger luminosity. The NIKHEF presence at SLAC will come to an end in 1986.

Apart from the experimental groups NIKHEF-H has a theory group which has an independent scientific program.

A summary of the 1984 experimental program is given in Table H1. The scientific advisory committee of NIKHEF-H (WAC-H) which recommends experiments for approval to the NIKHEF board has endorsed the proposal of a long term experimental program that is concentrated on a few large experiments at the leading high energy physics accelerators in Europe with manpower and resources roughly divided over LEP (50%), SppS (25%) and HERA (25%).

* * * *

H.2 Bubble chamber search for ν and ν̄ interactions in deuterium (Amsterdam, Bergen, Bologna, Padua, Pisa, Saclay, Torino - Collaboration)

G.W. van Apeldoorn, P.H.A. van Dam, N.J.A.M. van Eijndhoven, B. Jongejans, A.G. Tenner, C.P. Visser, M.E.J. Wigmans.

From the 1983 exposure 39,000 frames out of 88,000 antineutrino- and 15,000 frames out of 57,000 neutrino pictures are scanned and measured. From these 20,000 antineutrino frames are fully processed and available for analysis.
The picket fence, the system of proportional chambers surrounding BEBC makes it possible to determine whether an event is a charged current interaction, a neutral current one or is a hadron induced event. The program relating the picket fence information to the measured event is ready and works satisfactorily.

The analysis of the pre-1983 data has concentrated on the following subjects.

-(1)- The determination of the probability for finding an up- or down-quark in the proton as a function of the Bjørken scaling variable x and the four momentum transfer Q^2. From this the Q^2-dependence is found to be in good agreement with the predictions of the Altarelli-Parisi equations.

-(2)- The fragmentation functions of quarks and diquarks into charged and strange hadrons. In fig. H2.1 these distributions are shown for positive and negative pions as a function of the Feynman variable x_F for νp, νn, ν̄p and ν̄n reactions. The predictions of the Lund model are indicated. The agreement is remarkably good. The same conclusion holds for strange particle production.

-(3)- The measurement of the transverse momentum distribution of charged hadrons in charged current interactions of both neutrino's and antineutrino's. Transverse momentum balance requires soft gluon emission and a primordial transverse momentum of the quark. A three-jet structure is observed for events with hadronic energy greater than 7 GeV.

-(4)- Deuteron production in neutrino and antineutrino charged current interactions. Evidence is found for diffractive rescattering of the interacting nucleon. No evidence is found for the existence of a double delta state of the deuteron.

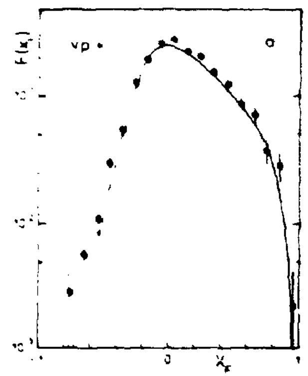

Fig. H2.1.a)

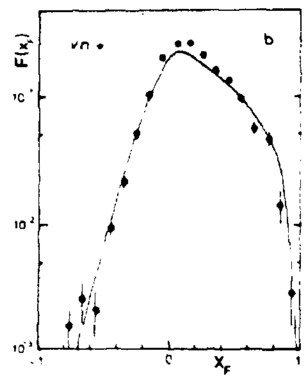

Fig. H2.1.b)

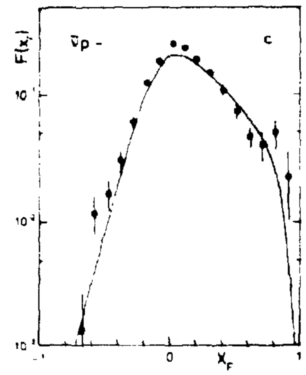

Fig. H2.1.c)

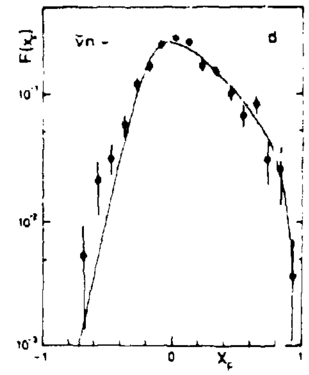

Fig. H2.1.d)

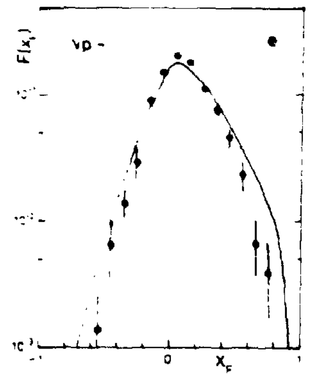

Fig. H2.1.e)

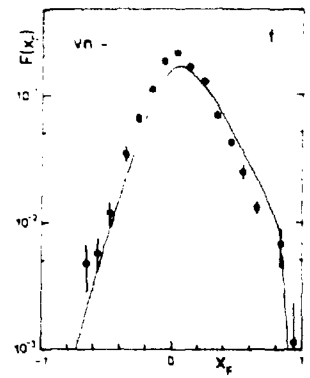

Fig. H2.1.f)

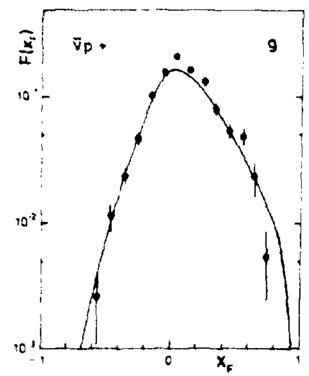

Fig. H2.1.g)

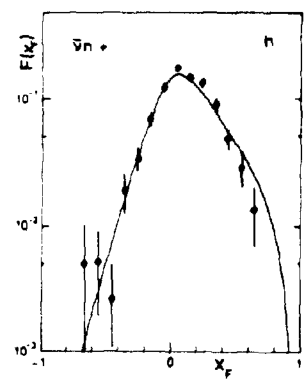

Fig. H2.1.h)

-(5)- A search for an enhancement in the $\mu\pi$ invariant mass distribution based on results from other experiments. No signal is found, although our statistics is considerably larger.

-(6)- The study of inclusive ρ^0 production in charged currents (anti-)neutrino interactions. About 15% of the pions are due to ρ^0 decays. The main features of ρ^0 production are very similar to that observed in hadron-hadron, lepton-hadron and e^+e^--reactions.

-(7)- The comparison of the structure functions measured in (anti-)neutrino interactions on Neon and deuterium (WA59 and WA25) respectively. The data do not show evidence of the so-called EMC effect.

H.3 European Hybrid System (EHS)

F.J.G.H. Crijns, P. van Hal, E.W. Kittel, F. Meijers, C.L.A. Pols, M.C.T. Raaymakers, A.J. Scholten.

The analysis of the 1982 and 1983 exposures (K^+/π^+ beams of 250 GeV/c on hydrogen and on plates of Aℓ and Au) has been continued during 1984. The reconstruction of events from the 1982 data was completed. For the 1983 run, the scanning of the K^+ interactions was finished. The scanning of the π^+ nucleus interactions which is next in priority was started.

The physics analysis was started still using so far scan-information only. New results for K^+ and π^+ collisions with nuclei could thus be presented at the Lund Multiparticle Symposium and at the Leipzig Conference. The K^+ sample (now already larger than for any previous experiment in this energy region) shows clear differences with earlier π^+ and p results in terms of the multiplicity of the secondary particles produced (per projectile-nucleus collision). The origin of this effect will be examined further using the fully reconstructed events.

To maintain our scan and measurement capacity, respectively to increase it, a number of tables were overhauled and improved (special magnifications, more light output, etc.). In March and April the two NIJDAS scan tables were adapted to the EHS film format.

H.4 The ACCMOR experiments (NA11, NA32)
(Amsterdam, CERN, Cracow, München, Rutherford, Bristol)

C. Daum, H.B. Dijkstra, W. Hoogland, G. de Rijk, H.G.J.M. Tiecke, L.W. Wiggers.

The final result of the charm life-time measurements with the ACCMOR spectrometer using the single electron trigger and silicon microstrip detectors has been established. It yields
$\tau_{D^\pm} = (10.6\ (^{+\,3.6}_{-\,2.4}))\times10^{-13}$ s based on 28, and
$\tau_{D^0} = (3.7\ (^{+\,1.0}_{-\,1.7}))\times10^{-13}$ s based on 26 fully reconstructed decays of the charmed mesons $D^\pm \to K^\mp\pi^\pm\pi^\pm$, and $\overset{(-)}{D}{}^0 \to K^\mp\pi^\pm$ and $K^\mp\pi^\pm\pi^\mp\pi^\pm$. The systematic errors are smaller than 1.5×10^{-13} s and 0.5×10^{-13} s, respectively. The ratio $\tau_{D^\pm}/\tau_{D^0} = 2.8\ (^{+1.1}_{-0.8})$.

The 600,000 inclusive $\phi(1020)$ events, obtained with the FAMP-trigger, have been used for the determination of $d\sigma/x_F$, $d\sigma/dp_T^2$ and $d\sigma/d\Omega$. The large data sample for all incident partides ($\pi^\pm$, $K^\pm$, p and $\bar{p}$) in the range $0.0 < x_F < 0.4$ enable the determination of the strange quark distribution of the kaon using the quark fusion model. The observation of associated production of strange particles and ϕ, observed in previous ACCMOR data, is confirmed. The decay of D(1285) and E(1420) is seen in the $K^+K^-\pi^0$ channel. Up to now, these particles were primarily seen in decays into $K^\pm\pi^\mp K^0$.

The NA32 experiment using an active target of silicon microstrip detectors has collected 38×10^6 triggers (22×10^6 π^-, 11×10^6 p-, and 5×10^6 K^- -interactions) for precise life-time measurements of charm particles. Off-line preselection of charm is under development. In 10% of the π^- data 30 fully reconstructed D^0 and $D^\pm$ decays have been found. A special search for F-mesons is made in the K^--interactions. First candidates have been found.

H.5 The MARK-J experiment
(Aachen, DESY, MIT, Madrid, NIKHEF, Pasadena, Peking)

M.W.J.M. Demarteau, P. Duinker, D. Harting, P. Kuijer, E.J. Luit, G.G.G. Massaro, H. Rykaczewski, G.M. Swider.

In this year the electron-positron storage ring PETRA reached its highest energy ($\sqrt{s}$ = 46.8 GeV). During this period the MARK-J experiment took data in the energy region $44 < \sqrt{s} < 46.8$ GeV with a total integrated lumimosity of 18.4 pb^{-1}.

At the highest PETRA energy the total cross-section for $e^+e^- \to$ hadrons is still in good agreement with the predicted value for five quark flavours. Also the jet-characteristics of these events do not show evidence for a sixth (top) quark. In fig. H5.1 all MARK-J data in the quantity

$$R = \frac{\sigma(e^+e^- \to \text{hadrons})}{\sigma(e^+e^- \to \mu^+\mu^-)}$$

are shown as a function of $\sqrt{s}$. The full line is a fit to the data which takes into account the effects of QCD and the weak interaction. The rise of the cross-section at high energy is due to the approach of the Z^0 mass.

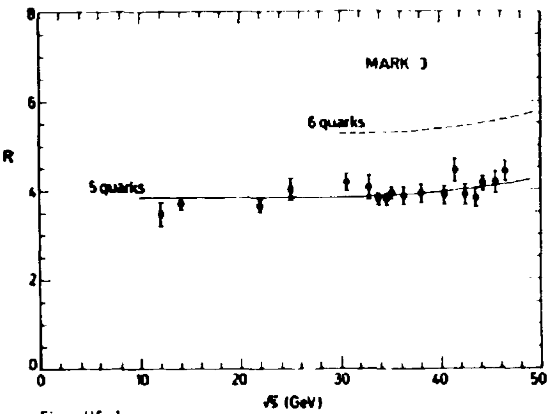

Fig. H5.1

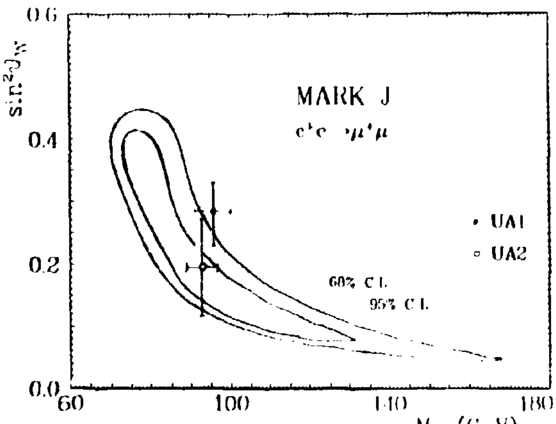

Fig. H5.2

We carried out a complete second-order QCD calculation of the the strong coupling constant α_s using the high energy hadronic event sample ($\langle\sqrt{s}\rangle$ = 45 GeV). When compared to the values found at lower energies the result is in agreement with the energy dependence predicted by QCD. The corresponding value for the QCD scale parameter is $\Lambda_{\overline{MS}} = 100 \pm 30\ (^{+70}_{-45})$ MeV.

We have now collected a total of 5500 events of the purely leptonic reaction $e^+e^- \to \mu^+\mu^-$ in the energy region 14-46.8 GeV. The MARK-J detector allows a precise analysis of these events in which background and other systematic effects can be kept at the 1% level or lower. Also at the highest energies the results are in excellent agreement with the so-called Standard Model. In fig. H5.2 we compare the limits for the quantities M_{Z^0} and $\sin^2\Theta_W$ obtained from our data on the total cross-section and the forward/backward charge-asymmetry of the muons with the values measured in 1984 by the $p\bar{p}$-collider experiments UA1 and UA2.

Leptons and quarks appear as point-like particles in the standard model. From the MARK-J data we conclude that any deviations from the standard model must occur at energy scales in excess of 200 GeV or equivalently at distances smaller than 5.10^{-16} cm. The lower limit for the mass of new leptons within the standard model was put at 22.5

GeV. For the allowed masses of particles suggested by supersymmetric or technicolour models we found lower limits in the range 17 to 25 GeV.

At the end of this year we started preparations for the installation of the new high-resolution vertex chamber (TEC). For this a carbon-fibre beampipe and a new set of drift-tubes was installed. In addition a leadglass counter hodoscope was installed to study single photon/electron production. This also increases our acceptance by bringing down the minimum scattering angle for particle detection from 16° to 5°.

H.6 The PEP two-photon experiment
(Lawrence Berkeley Laboratory, the University of California at Davis, Los Angeles, Riverside, San Diego and Santa Barbara, the Johns Hopkins University at Baltimore, the University of Massachusetts at Amherst and the University of Tokyo)

A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, F.L. Linde, H.P. Paar, J.C. Sens en B.K. van Uitert.

In the summer of 1983 the central detector was moved out of the PEP intersection for installation of a superconducting coil and a gated grid in the Time Projection Chamber. Also revision and maintenance were necessary for the Inner Drift Chamber, the Hexagonal and Pole Tip Calorimeters in the central detector, and the first drift chamber and the NaI and shower calorimeters in the forward detectors. Reinstallation found place in the summer of 1984. In the fall of 1984 a small amount of data corresponding to an integrated luminosity of 4 pb^{-1} was taken with the magnetic field now operating at 13.5 KG, versus 3.9 KG in earlier running.

In the period January-April 1984 a BGO calorimeter consisting of twelve $2\times2\times24$ cm^3 crystals was tested in the SLAC beam-line P19 prior to installation at PEP. The energy resolution in the range of interest for two-photon physics at PEP ($5 < E < 15$ GeV) was σ/E = 1-1.5%. The impact point on a crystal could be determined with a resolution of 2-3 mm. The time dependence of the BGO response at PEP was determined with measurements on Bhabha scattering.

A proposal to add 120 BGO crystals to the PEP9 apparatus, based on the experience gained in these tests was accepted by SLAC in May 1984. Modification of the PEP vacuum chamber, the acquisition of the BGO crystals, construction of electronics, verification in the P19 test-beam, and installation of two forward hodoscopes was completed by the end of the year.

Analysis of the reaction $e^+e^- \to e^+e^- X$

Data analyzed was taken in the period October 1982 - June 1983; it corresponds to an integrated luminosity of 73 pb^{-1} for untaggea events and 50 pb^{-1} for tagged events.

[1] The QED structure functions of the photon $F1(x,Q^2)$ and $F2(x,Q^2)$ were determined in the reaction $e^+e^- \to e^+e^- \mu^+\mu^-$. This is the first measurement of F1. The results were published.

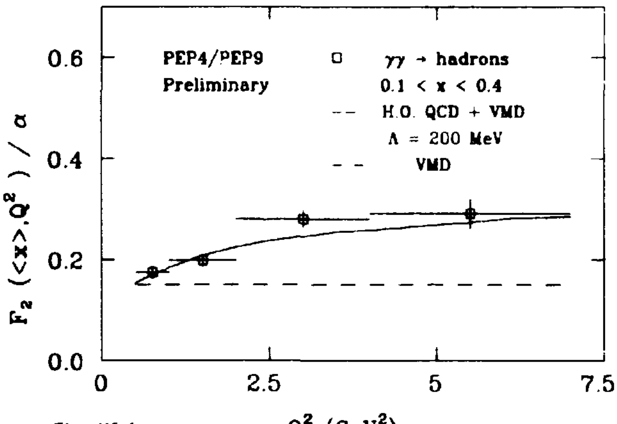

Fig. H6.1

[2] The hadronic structure function $F2(x,Q^2)$ was measured at $\gamma\gamma$ centre-of-mass energies between 1 and 12 GeV and Q^2 between 0.5 and 7 GeV^2. The results are compatible with a logarithmic increase of F2 with Q^2 and a QCD scale-breaking parameter Λ = 200 MeV. The comparison is shown in fig. H6.1.

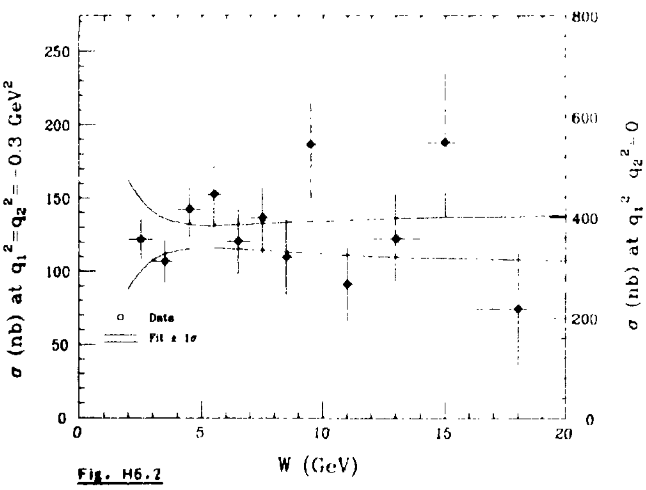

Fig. H6.2

[3] The total cross-section for hadron production in photon-photon collisions was measured as function of the $\gamma\gamma$ centre-of-mass energy W in the region 2 to 20 GeV. With increasing W the cross-section drops from 500 to 300 nb and then flattens. The behaviour versus W is shown in fig. H6.2. The Q^2 dependence for $Q^2 < 1.5$ GeV^2 is compatible with parametrizations in Generalized Vector Dominance Models introduced in the description of deep-inelastic lepton-hadron scattering. The results were submitted to publication.

[4] In the process $\gamma\gamma \to f^0(1270) \to \pi^+\pi^-$ the $\gamma\gamma$-width of the f^0 and its Q^2 dependence were measured, as well as the angular distribution of f^0 decay. The $\gamma\gamma$-width at $Q^2 = 0$ was determined to be 2.39 ± 0.06 ± 0.30 keV, in good agreement with the average of values found by other experiments. The $\gamma\gamma$-width decreases with increasing Q^2, while the angular distribution points to a dominating

helicity = 2 amplitude at $Q^2 = 0$. The $\pi^+\pi^-$ continuum was measured for $0.5 < W < 3.2$ GeV. For $W > M(f^0)$ the cross-section decreases with increasing W and its W-dependence follows approximately a QCD prediction by Brodsky and Lepage.

[5] The processes $\gamma\gamma \to \eta' \to \pi^+\pi^-\gamma$ and $\gamma\gamma \to A2(1320) \to \pi^+\pi^-\pi^0$ were observed. A preliminary value for the width of the η' was determined; it was found to decrease with increasing Q^2.

[6] The cross-section for the reaction $\gamma\gamma \to K^+K^-\pi^+\pi^-$ was measured for $1.7 < W < 3.7$ GeV. The total cross-section rises to ~15 nb between threshold and ? GeV in centre-of-mass energy and then falls slowly. Clear evidence is found for the production of $\phi\pi^+\pi^-$, $K^{*0}(890)K^-\pi^+$ and its charge conjugate. No significant $\phi\rho^0$ and $K^{*0}(890)\,\bar{K}^{*0}(890)$ production is observed.

[7] In the reaction $\gamma\gamma \to 2\,\pi^+\,2\,\pi^-$ it was found that the unexpectedly high cross-section, found earlier at $Q^2 = 0$, was also present in the region $0.1 < Q^2 < 7$ GeV^2. The W and Q^2 dependences are also shown in:

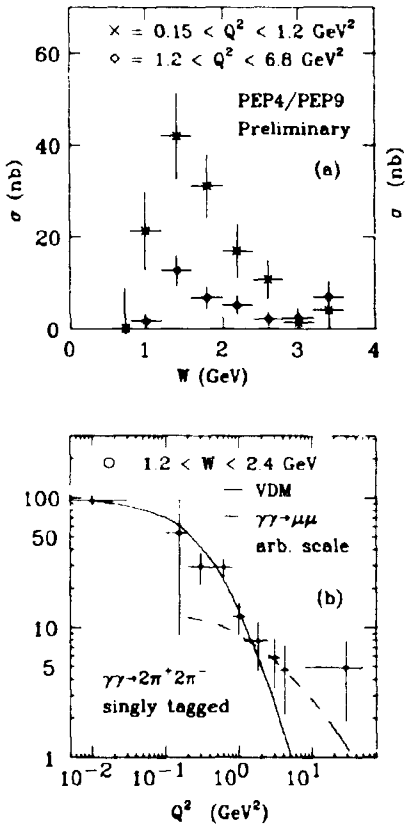

fig. H6.3.

The majority of the results above is in agreement with the expectations of Vector Meson Dominance. We expect that the coming two years of data taking will yield enough statistics to explore the processes mentioned and others at higher Q^2, where the direct photon-quark coupling will influence the measurements significantly.

H.7 Bismuth Germanate Oxide (BGO)

M.A. van Driel and J.C. Sens / A. König, W.J. Metzger, C.L.A. Pols, M.C.T. Raaymakers, D.J. Schotanus, R.T. Van de Walle, W. Walk.

Since 1975 a new scintillator material, with the composition $Bi_4Ge_3O_{12}$ (BGO), is under study for practical use in nuclear and high-energy physics experiments as replacement for NaI crystals. Since BGO is nonhygroscopic and the radiation length is only half of that of NaI a considerable decrease in size of detector can be achieved. These characteristics create a strong demand for this material in electron and photon detectors. An example is the LEP3 experiment at CERN where 12,000 crystals, with a total weight of 6 tons, are needed. Disadvantages are the higher price and the complex production procedures.

In order to contribute to optimal production methods an investigation was started between NIKHEF and solid state physicists of the RUU and the KUN and nuclear physicists of the RUU.
In Nijmegen the work concentrated on the growth of crystals using the Bridgman method. Much progress was made this year. A perfect 10 cm crystal was grown in March, while a (nearly totally clear) 20 cm long tapered crystal became available in December.

Throughout the whole year a lot of attention and work was devoted to improvements and extensions of the BGO ovens and their control electronics. Different temperature gradients and profiles were tried, melt-rotations imposed, etc. A small testoven was constructed for in situ observations during the crystal growth process. Set-ups were built and/or improved to test the optical quality and energy resolution of the crystals produced. A lot of effort was also invested in technical research on the cutting and polishing of BGO crystals.

From September onwards the study of the remaining problems (inclusions and colorizations) was tackled in a more systematic and fundamental way thanks to the approval of an STW grant request.
At the RUU the work concentrated on a complementary program:

-(1)- analysis of the material,
-(2)- measurement of the phase diagram,
-(3)- growth of crystals to study crystal defects,
-(4)- study of zone-refining.

Røntgen diffraction was used to study Bi_2O_3, GeO_2 compounds in the molecular ratio 6:1, 1:1, 2:3 and 1:3. These data will be combined with results from our differential thermal analyses (DTA) to obtain the phase diagram.

Several attempts were made to grow crystals. Initial failures could be explained by temperature effects. The equipment is now completely under computer control and three crystals of good quality with a length of 1.6 and 8 cm and a diameter of 1 to 4 cm were grown with the Czochralski method.

To recover the waste material a zone-refining unit was made operational and it appeared possible to refine BGO. The concentration of the remaining unwanted elements was determined at the Reactor Institute at Delft with the neutron activation method.

H.8 Proton-antiproton experiment UA1

J. Dorenbosch, B. van Eijk, D.J. Holthuizen.

In 1984 the work at the CERN proton-antiproton collider has been rewarded by Nobel prizes for Simon van der Meer and Carlo Rubbia.

The study of the Intermediate Vector Bosons, the $W^{\pm}$ and the Z^0, has continued and the data taken in 1983 have been fully processed. Sixty-eight (14) W-decays to a neutrino plus an electron (muon) were found and 4 (5) Z-decays to electron (muon) pairs. From the observed decays the masses of W and Z were determined to be 80.9 and 93.9 GeV with an error of 2.9 GeV.
From the ratio of the masses one can determine the Weinberg angle: 0.226 ± 0.006 and the ρ-parameter: 0.96 ± 0.05.
The width of the Z is measured to be less than 8.5 GeV. This measurement limits the number of different neutrinos to at most six.
The charge asymmetry of the W-decay was measured; it is compatible with V-A currents and a spin of J=1 for the W-boson.
The study of two-jet events with a muon has revealed the first hints of the decay of the Z to a quark anti-quark pair. This decay is particularly hard to observe because of the high background from strong interactions (QCD).

A selection of events with a narrow jet and a neutrino has shown the decay of the W-boson to the charged member of the third lepton family: the τ. The decay rate to τ is in agreement with lepton universality.
In the same event sample so-called "mono-jets" were found. These events, with a single high energetic jet and a large missing energy, are hard to explain within the traditional models of electromagnetic, weak and strong interaction.

In the events with two jets and a muon, a signal has been observed that is compatible with the decay of the top quark. In the fall of 1984 CERN announced the discovery of this quark.

A large amount of events with two muons has been seen. The bulk of these events most probably comes from the decay of bottom quarks. The large fraction of equal sign dimuon events suggest a possible bottom anti-bottom mixing.

In October a three-month period of data-taking started. The peak luminosity and the beam life-time of the collider have significantly been improved and an integrated luminosity of 395 inverse nanobarns was delivered. The detector performed very well and a few thousand tapes of data were taken. Preliminary analysis of these data has already revealed about 160 W's and more than 10 Z's.

H.9 Proton anti-proton elastic scattering and total cross-section at the CERN $\bar{p}p$ Collider (UA4) (Amsterdam, CERN, Genova, Naples, Pisa Collaboration)

P.M. Kluit, B.K.S. Koene, R.W. van Swol, J.J.M. Timmermans.

The analysis of the data on forward elastic scattering and on the total cross-section, collected during a special Collider run in 1983 at $\sqrt{s}$ = 546 GeV, has been completed. The results are (see fig. H9.1):

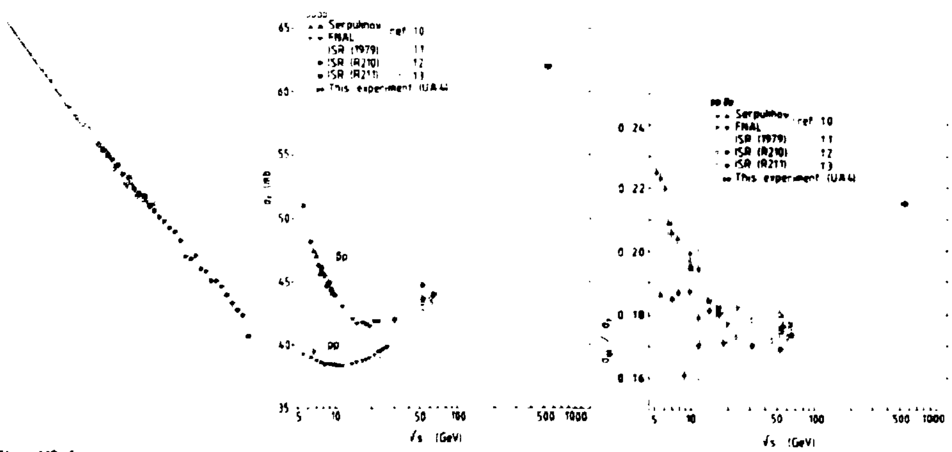

Fig. H9.1

-(a)- The differential elastic cross-section in the momentum transfer interval $0.03 < -t < 0.15$ GeV^2 is well described by a simple exponential exp(bt) with a constant slope parameter $b = 15.2 \pm 0.2$ GeV^{-2}. This value is significantly larger than the slope value in the interval $0.21 < -t < 0.50$ GeV^2, which amounts to $b = 13.4 \pm 0.3$ GeV^{-2}.

-(b)- The value for the $\bar{p}p$ total cross-section is $\sigma_{tot} = 61.9 \pm 1.5$ mb. The increase of the total cross-section from ISR to Collider energy is very close to a $\ln^2 s$ behaviour.

-(c)- The ratio of the elastic to total cross-section is $\sigma_{e\ell}/\sigma_{tot} = 0.215 \pm 0.005$, definitely larger than the nearly constant value at ISR energies.

The analysis of the 1983 data on large-t elastic scattering ($0.5 < -t < 1.6$ GeV^2) is also finished and a publication is in preparation. New large-t data were taken in 1984 at the higher energy $\sqrt{s} = 630$ GeV. This will allow to extend the accepted t-range to ~2.0 GeV^2.

Preparations have started for the measurement of elastic scattering at very small t ($-t < 0.04$ GeV^2), which is scheduled for 1985. This measurement will allow the determination of the ρ-parameter, the ratio of the real to the imaginary part of the forward scattering amplitude.

H.10 The SING-experiment at LEAR
(Amsterdam, Bedford, Geneva, Queen Mary College, Surrey, Triest)

K. Bos, J.C. Kluyver, R. Kunne, L.H.A.J. Linssen.

The competition from the $S\bar{p}pS$ and ISR for the cooled antiprotons in 1984 was very strong. Only 40 days resulted for all LEAR physics. The beam time allotted to SING was used for the following measurements:

- At 300 MeV/c, for measuring small angle elastic scattering to obtain the ρ-parameter, the ratio of the real and imaginary parts of the scattering amplitude, data were obtained at three different momenta (using degraders).

- At 1500 MeV/c, for first tests of the equipment to measure the two-body reactions $\bar{p}p \to \pi^-\pi^+$, K^-K^+ and $\bar{p}p$.

- At 600 MeV/c, for double scattering experiments with carbon and hydrogen targets to measure the analyzing power of carbon and for further tests of the two-body experiment and the first data-taking at 600 MeV/c and 530 MeV/c (by degrading the beam).

The measurements taken in 1983 of the $\bar{p}p$ total cross section between 390 and 600 MeV/c were evaluated and showed no sign of the controversial S-meson nor of any other resonance. An upper limit for the strength of the S-meson of 2 mb MeV/c^2 was obtained.

The analysis of the ρ-parameter data progresses well, the results show, that ρ is surprisingly small (of the order of 0.05), the study of systematical errors is continuing.

The results of the double-scattering experiment is that at a momentum of 550 MeV/c the carbon asymmetry as function of the scattering angle θ° may be represented by $A_c(\Theta_c) = (6\pm6).\Theta\times10^{-3}$ for θ<20°. This result excludes the use of carbon to analyze the polarization of antiprotons in our two-body experiment, at least at momenta below 600 MeV/c. The measurement will be repeated at higher momenta.

As a result of the equipment tests, two of the three wire chambers were sent to Amsterdam for revision. One of these is back in CERN. Much work was invested in writing and testing the TREMA (Two-body REconstruction with MAtrices) analysis program. Reconstruction of events obtained during the run proceeds well, but full efficiency is not yet achieved.

H.11 Electron-positron interactions in the bottonium field ($b\bar{b}$-spectroscopy)

(Caltec, Carnegie-Mellon, Cracow, DESY-Hamburg, Harvard, Princeton, SLAC-Stanford, Erlangen, Firenze, Nijmegen, Wurzburg)

W.J. Metzger, C.L.A. Pols, M.C.T. Raaymakers, D.J. Schotanus, R.T. Van de Walle, W. Walk, A. König, P.F. Klok.

Crystal Ball

In the months of January and February, the Υ(2S) run - started in 1983 - was completed. In total about 208 K hadronically decaying Υ(2S) events were observed. In May/June the first (large) Υ(4S) run took place.

In January the installment of the new inner tube chamber read-out electronics was completed. In April two extra outer layers of tube chambers, complete, with their electronics, were installed and tested. Since then the central detector has performed reliably.

In a 100 K Υ(1S) sample, collected in 1982 and 1983 during the Υ(2S) run primarily for studying the background, indications were found for a long-living 8.33 GeV state with Higgs-type properties. This finding was reported at the Leipzig conference. In the course of August and September an additional sample of some 200 K Υ(1S) events was collected. The new sample did not confirm the earlier result. Possible explanations for this discrepancy are still being searched for.

The analyses work in Nijmegen concentrated on the so-called exclusive Υ(2S) decay-channels, i.e. processes of the type $\Upsilon(2S) \to \Upsilon(1P)+\gamma_1 \to \Upsilon(1S)+\gamma_2+\gamma_1 \to e^+e^-(\mu^+\mu^-) + \gamma_2 + \gamma_1$ with all final state particles detected and identified. A lot of effort was invested in efficiency calculations for these decays, using Monte Carlo techniques. A publication is in its final phase.

H.12 DELPHI

- P.H.A. van Dam, A.N. Diddens, D.J. Holthuizen, E.W. Kittel, B.K.S. Koene, A.M. Stergiou, J.J.M. Timmermans, D.Z. Toet, F. Udo.

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

[A] Inner Detector

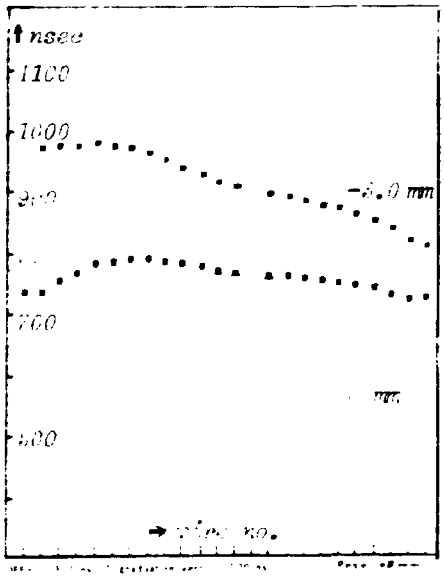

Fig. H12.1. [illegible]

The first item of the final design, the inner carrying cylinder has been designed, ordered and delivered. The material used is aramide epoxy. A pressure test is in preparation.

Measurements on the prototype of the outer layers have been terminated. The conclusions are used in the final design. This work is done together with a group in Cracow.

The prototype of the Jet Part has been succesfully tested this year. Fig. H12.1 shows, that the arrival times of the electrons are strongly dependent on the position of the origin of a track as planned in the proposal. Calibration stability is excellent: 20 deviations exceeding 20 μ anywhere in the driftvolume were detected during a run of 30 days. This calibration (obtained with the NIKHEF laser set-up) will be used in the next run with cosmic rays. For this it was necessary to calculate the electrical field in the jet volume accurately as this field is inhomogeneous and the electron drift velocity is non-saturated. These calculations are nearly terminated.

Machine background has been simulated to calculate the radiation on the Inner Detector. The results are documented in a Delphi-report.

[B] RICH detectors

The DELPHI prototype of the Barrel-RICH this year has produced rings for gas and liquid radiators. The number of detected photo-electrons per ring was 15 and 7 respectively.
The wire chambers that detected these electrons were constructed at NIKHEF. A total of 7 chambers of 3 different types have been tried in the set-up.
It was already foreseen that one needs to measure the conversion depth of the photon to reach the optimum resolution for the rings.
Our electronics department has developed a CAMAC unit with 8 flash ADC's to measure this induced charge on the cathode strips of the detector and thus the photon conversion depth.

A major problem is the construction of UV-transparent drifttubes with a well-defined electric field. The deposition of conducting strips on quartz is a technical challenge. This has been tackled in collaboration with several industries and the initial help of the space research laboratory in Utrecht.
Two systems are still under study: laser lithography and a conventional print technique. The UV-transmission of the treated quartz is a key parameter in this work, so a machine to measure UV transmission has been designed and tested.

The photo-electrons should drift fast and efficiently over long distances (170 cm), so a test laboratory is installed to measure drift properties of single electrons in different gasses.
The quality of the electrostatic field in the drifttubes determines the position accuracy and the drift efficiency. It was necessary to calculate the transversal component of the electric field to 10^{-4} of the main field.

This has been done on the CYBER-205 of the SARA computing centre.

H.13 The LEP3 experiment

M.A. van Driel, P. Duinker, F.C. Erné, D. Harting, J. Konijn, G.G.G. Massaro, J.C. Sens.

The first large drift chamber for the muon detection system (fig. H13.1) of the LEP3 experiment has been produced by the mechanical workshop in the first half year of 1984. This chamber (0.50×1.50×5.80 m^3) was succesfully tested in Amsterdam in July and transported to Harvard, Cambridge, USA in the first week of August. All the other components for the first full scale octant test, designed and fabricated

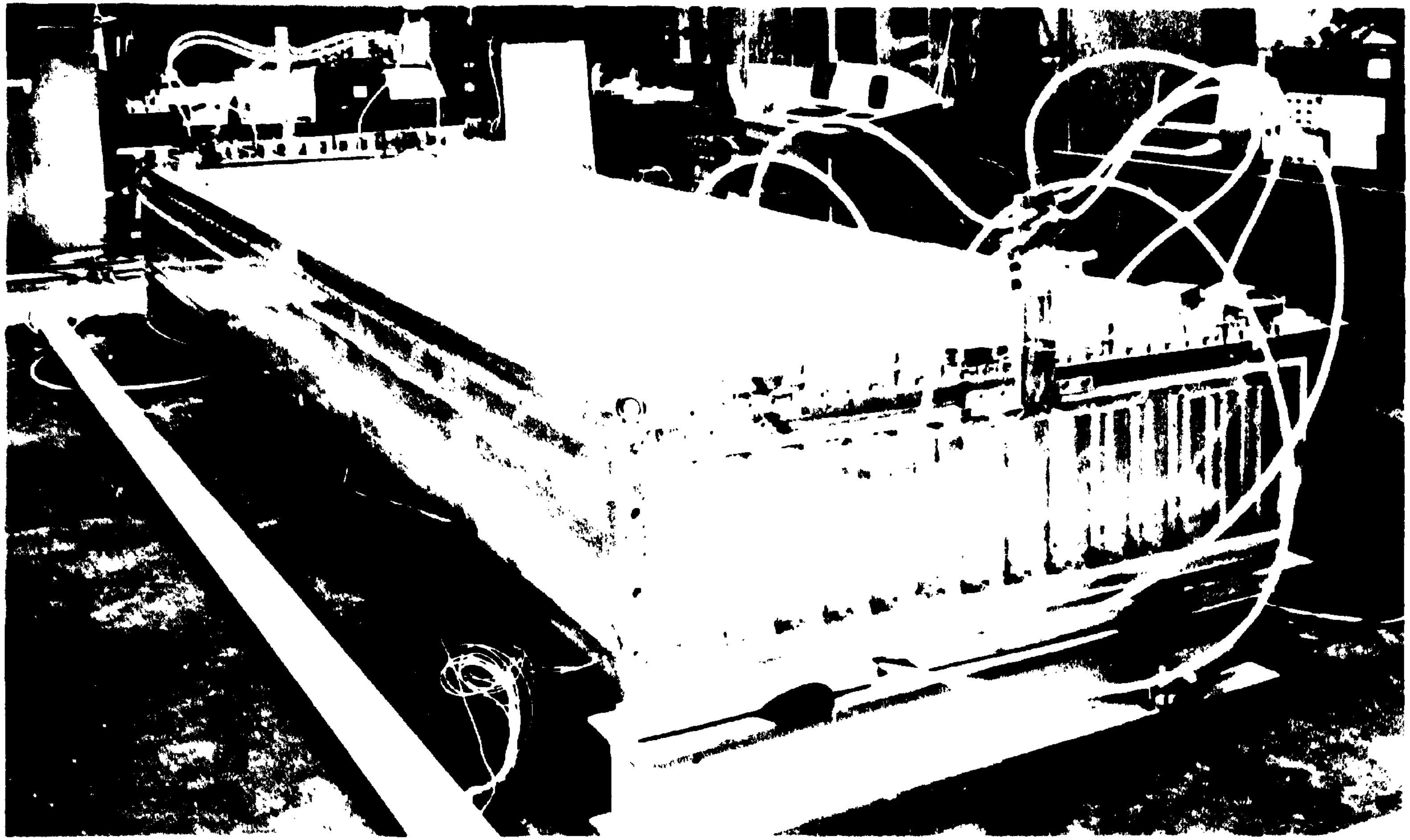

Fig. 413.1: The MM chamber at Harvard.

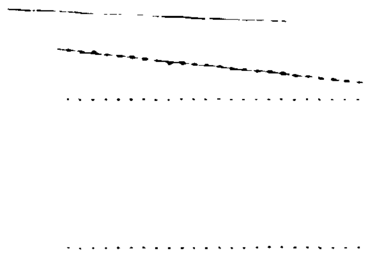

Fig. H13.2: A cosmic ray traversing MM chamber

at NIKHEF, like the accurate gas mixing system, the chamber electronics and the laser system were sent overseas with the same transport. The chamber containing about 2,500 wires of 5.80 m length each, reached Harvard without any broken wire and was operational after one week. With cosmic rays (fig. H13.2) a resolution of σ=175 μm was obtained, and this could be improved after solving some of the grounding problems of the pre-amplifiers to σ=136 μm, a value considerably better than anticipated in the technical proposal (σ=250 μm).

By the end of the year the chambers MI and MO produced by Madrid and MIT, our collaborators in the muon chamber system, were ready and in january 1985 the octant was loaded with all the chambers (fig. H13.3).

Fig. H13.3: The octant at Harvard with the chambers (from top to bottom) MO, MM and MI.

During the second half of 1984 in Amsterdam the preparations were started for the mass production of 34 MM chambers. With the help of the RIB office the first big orders were placed in industry. It is hoped that all the orders will be placed by the end of February 1985, so that mass production can start by the middle of that year.

The Nijmegen group got involved in the read-out system of the 12,000 BGO crystals which will form the electromagnetic calorimeter of the LEP3 experiment.
The read-out system of the crystals will consist of a complicated hierarchy of microprocessors placed in so-called VME-crates. A sophisticated program will have to be developed to control this system of distributed intelligence. It is anticipated that Nijmegen will take part in the electronical and software development of this system together with the universities of Princeton and Rome. The aim is to have a prototype of the hardware ready by April 1985 for test beam measurements of an array of BGO blocks at CERN.

A test set-up was made using 3 microprocessors from the UA1-experiment and manufactured by DATA-SUD and FORCE. To couple this set-up both to our local VAX and to the LEP3 test VAX, a special I/O unit and CAMAC interface was designed and constructed. To implement the system software, use was made of CERN cross-software and the ACE cross-compiler. Our local VAX can now be used to down-load programs written in Fortran, C or Assembler into the microprocessors.

H.14 Instrumentation group

F.G. Hartjes, J. Konijn.

LEP3

The group is responsible for the alignment system of the muon detector with nitrogen lasers. The straightness of a laser induced calibration line as seen by a prototype muon drift chamber was examined over a distance of 10 metres. It appeared to be possible to generate a line with a straightness better than 10 μm over 4 metres. Computer simulation for the whole process of laser beam profile depending ionization, broadening by gas diffusion and avalanche formation resulted in a good correspondence with the experimental results, indicating that the process is well understood.

A system with two nitrogen lasers and related optics was built and transported to Harvard for installation in the muon detector test set-up. An accurate CAMAC controlled gas flow calibrating machine was also brought in operation at this set-up.

DELPHI

A prototype JET drift chamber has been tested. A track coming from the interaction point was simulated by a rotateable nitrogen laser beam. The drift field could be shaped such that equal drift times were obtained for all possible laser beam angles, enabling a fast trigger facility.

Other research

Measurements of the longitudinal diffusion and drift velocity using laser induced single electron events were continued for pure methane. After an interruption the set-up was re-installed nearby the end of the year. See fig. H14.1.-

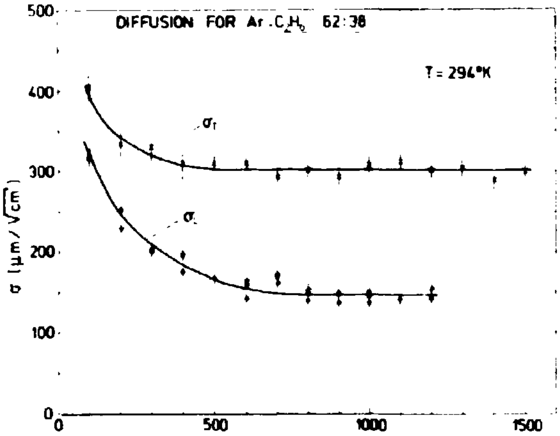

Fig. H14.1

With a slightly modified set-up the transverse diffusion could also be calculated from the slope of the amplitude curve of a movable electron cluster. The cluster was generated by a strongly focussed nitrogen laser beam.

H.15 The theory group

J.J. van der Bij, K.J.F. Gaemers, N.D. Hari Dass, J.A.M. Vermaseren, B.Q.P.J. de Wit, G.F. Wolters.

The phenomenology of an extension of the standard model with heavy fermions was studied in the context of rare modes in muon decays.

The work on radiative corrections to two photon physics was completed, showing the important finding that two photon reactions enable indeed an accurate test of QCD, due to "factorizability".

The variational investigations of lattice gauge theories were continued to improve the vacuum functional on one hand, and to carry out the first stages of a mass gap calculation on the other.

The study of large Higgs mass effects in two loop corrections in the standard model was completed. The main conclusions are that if the

Higgs mass is larger than a few TeV perturbation theory breaks down, and that there is a great amount of freedom in choosing the Higgs potential.

The spin asymmetry in elastic proton-proton scattering at p_L = 28 GeV/c, $\theta_{CM} \approx \pi/4$ was scrutinized. It turns out that this effect cannot be explained by simple models for hard scattering.

A begin was made with the making of a computer program that should automatically compute cross sections for a large class of interactions. Preliminary studies have shown the feasibility of this long term project.

An SO(7) invariant solution of 11-dimensional supergravity was constructed. This solution is the first of a whole new class. The seven extra dimensions were compactified.

N=2 supergravity coupled to matter was studied extensively. In some cases supersymmetry is broken spontaneously while the potential disappears (and with it the cosmological term).

It was found that deviations from gauge couplings lead to quadratic divergences, even at the one loop level.

Finite size effects on the mass gap in the O(N) model were studied to obtain infinite volume mass gap estimates.

A begin was made with the study of radiative corrections to the standard model under HERA conditions.

H.16 HERA

The HERA project of DESY, Hamburg, has been approved by the federal minister for science and technology of the German Federal Republic and the senator for science of the city of Hamburg on April 6, 1984. Letters of intent are asked for by June 1985. NIKHEF-H physicists have joined a protocollaboration around the TASSO group at PETRA.

In a collaboration between NIKHEF-H and HOLEC, Slikkerveer, a second 1 m sextupole/quadrupole coil and a first full size 6 m sextupole/quadrupole coil for the superconducting proton ring of HERA have been shipped to DESY for test. Two prototype superferric dipole magnets have been produced at NIKHEF-H and sent for test at DESY.

H.17 The Computer Group

For co-operating personnel, see Addenda, V.

The CYBER 173 and NORD-100 performed well. The FAMP-based CYBER/NORD link became operational.

In June 2 Apollo personal work stations (DN300 and DN460) were installed, mainly used for:

- programs with graphics I/O,
- programs needing virtual memory,
- development of programs with the use of interactive debugging,
- cross software for microprocessor development.

TABLE 1

Available clocktime	(1984) hrs/year
Calendar Clocktime	8784
Scheduled Maintenance	72
Available Clocktime	8712
Unscheduled Maintenance due to: Hardware Problems	48,5
Software Problems	4
Blocktime	10,8
Net Available Clocktime	8648.7

Part of the computing was done on the SARA computers: the CYBER 170/750 was mainly used for the ACCMOR experiment; on the CYBER 205 calculations were done for lattice gauge theories in collaboration with CERN, and programs were executed for detector development.

TABLE 2

Batch Time Distribution in CP Hours and System Seconds for Various Projects

	1^{st} qrt.	2^{nd} qrt.	3^{rd} qrt.	4^{th} qrt.	hrs/year	SS/year
System	89	50	56	68	263,2	393365,161
Administration	1,8	1	1,6	1	5,4	5249,224
Neutrinos (NC)	-	-	-	-	-	
DESY exp.MARKJ	19.9	29,5	22	29	100,4	146705,172
Delphi exp.	1,4	43,4	50,6	1,8	97,2	95297,545
LEAR	12,5	24,7	38,3	65	140,5	246659,998
Section-K	0,1	0,08	5,5	6,5	12,2	14211,846
Micro proc.	0,6	0,06	5,1	2,7	8,5	9396,911
ACCMOR	597	887,8	526,2	1108,4	3119,4	6891144,554
Neutrinos (D2)	262,7	306,6	131	242,1	942,4	1779846,717
UA4	80,8	21,2	1,3	67,3	170,6	366575,267
Theory	125	62,8	242,7	70,1	500,6	559210,721
UA1	-	4,4	-	-	4,4	7705,202
Pep 9	-	-	-	-	-	
Visitors	0,4	0,2	-	-	0,6	1614,671
CDC	0,8	0,7	2	0,5	4	5668,357
Total	1192	1432,44	1082,3	1662,6	5369,4	10522651,346

NIKHEF is connected, via SARA, to Datanet I, the PTT operated PSN, through which it has access to international X25 networks.

Concerning the replacement of the CYBER 173 mid 1986 a selection procedure for the new system has started.

A number of FAMP modules has been produced, while a print version was made of the interface between VME bus and external FAMP bus.

Several CERN programs are being installed on a stand-alone VME system which is used for electronics test jobs.

For UA1 the development and monitoring facilities of the FAMP system have been improved using FADOS.

As a continuation of the FADOS project a study was started of distributed real-time operating systems in view of the needs of the large LEP and HERA experiments. This work is done in close collaboration with the Facultaire Vakgroep Informatica (FVI) of the University of Amsterdam while also contacts exist with the Centrum voor Wiskunde en Informatica (CWI).

H.18 Electronics Department

For co-operating personnel, see Addenda, V.

- DELPHI

An eight-channel CAMAC module has been designed and built using 7-bits 15 MHz FLASH-ADC's, programmable logic sequencers (FPLS) and programmable logic arrays (FPLA).
A twelve-channel discriminator NIM module has been designed and built. The lay-out of the inner detector, in particular the positioning of the pre-amplifiers and cables has been modelled.

- LEP3

The optical-electronical outline system (RASNIK) for the L3 detectors has been built (five CAMAC units). A resolution of less than 5 μm has been achieved. Tests of the hybridized wire amplifiers have been completed and negotiations for the production of 25,000 hybrids are in an advanced stage.

Electronics has been built, and a prototype chamber was wired, for the "Harvard" test.
A multi-layer strip consisting of five layers, the XFLEX, has been developed. A prototype Tϕ-calibration (TϕCAL) system was produced achieving a time resolution of 200 ps.
For the laser calibration a CAMAC control system was built.

- UA1

The production of the FAMP-Remus interface (FAREM) has been completed. About 50 FAMP units of various types have been built for UA1 as well as for the FVI (Facultaire Vakgroep Informatica).
A "FAMP-VME Interface" module was designed and a prototype constructed. In connection with the upgrading of the calorimeter a beginning was made with the design of a new second-level muon trigger.

- The CADET lay-out system was heavily used. Apart from designs of 4-, 5- and 6-layer multi-layer a number of two-sided FAMP and VME boards as well as smaller PC boards and flexible PC's were developed. Newly installed software in the PDP-11/34 has greatly improved its performance.

  The available software for PAL's has been strongly improved. The DATA I/O programmer is equipped with a PAL facility. For the new FPLA's and FPLS'ses software of AMOLF and hardware of the Free University of Amsterdam (VUA) is used.

  The FLANS/FLINK NORD-CDC link has been completed together with a test set-up for the CDC-3000-channel components. The possibility of a fast VME-VMX link over large distances was studied.

Apart from the aforementioned issues maintenance has been going on for the Department's as well as Pool apparatus, and support was given to current experiments and jobs around the institute itself. The maintenance and support of various electronics systems has been an important activity of the group. This is in particular the case for the DTR and DEC units of the ACCMOR experiment, the FAMP units and various modules in the electronics pool.

H.19 Mechanical Workshop

For co-operating personnel, see Addenda, V.

- LEAR-SING
  Tests of the 170° circular drift chamber show a slow mechanical deformation of the inner cathode planes. The planes have been reinforced which greatly improved their performance. A similar improvement program for the 150° chamber was started in the autumn.

- LEP-DELPHI
  Activities for this project include the construction of

  + a prototype Liquid RICH,
  + a model Forward RICH,
  + Barrel RICH small substrate chambers,
  + a prototype Jet Chamber,
  + a gas test chamber,
  + a second model Jet Chamber,
  + a small 90° Barrel RICH chamber,

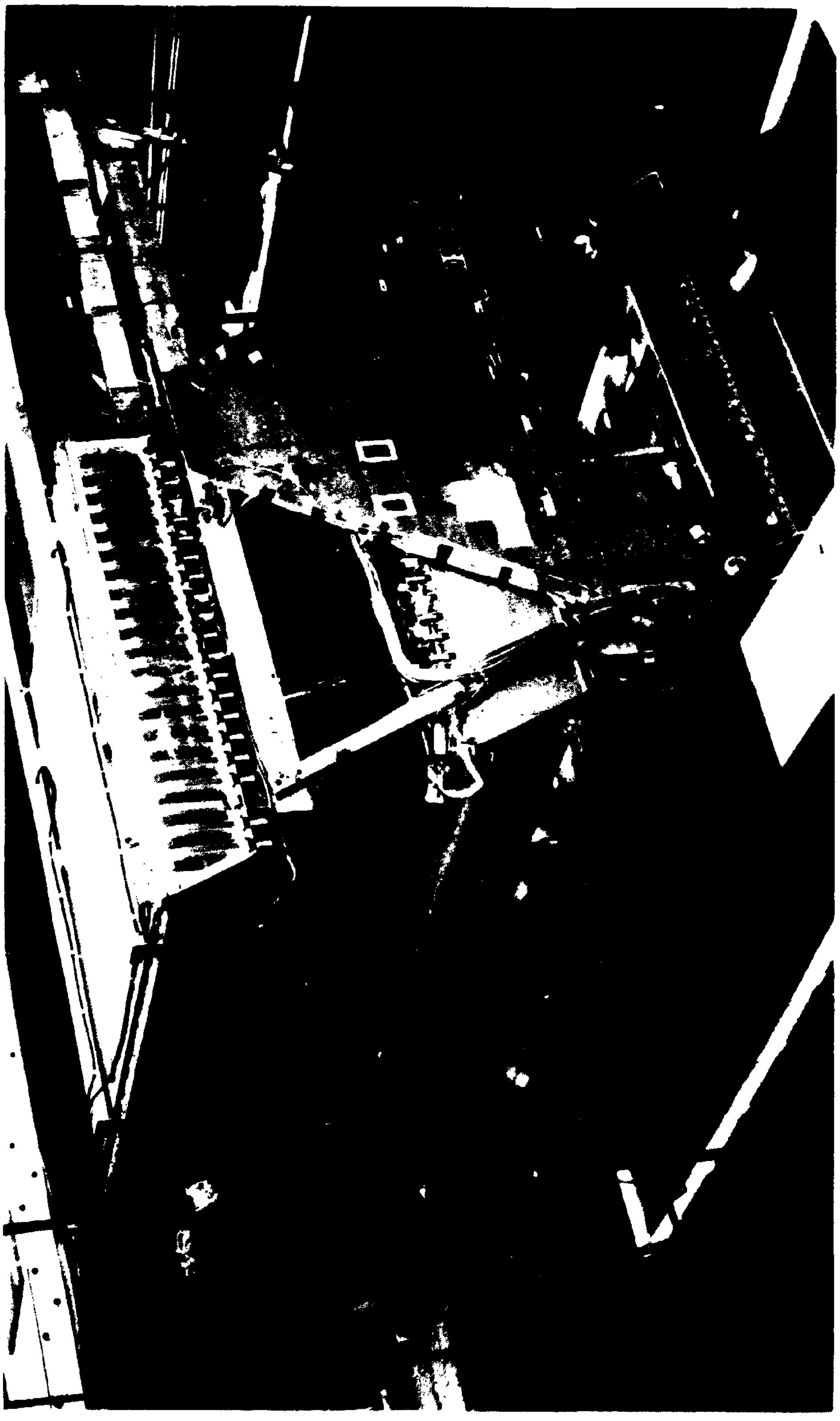

Fig. H19.1: Muon chamber at 'Harvard' test.

+ a 90° Segment Combi RICH,
+ two Barrel RICH chambers,
+ various moulds and test appliances in connection with Aramide fibre tubes.

- LEP3

  The first muon chamber was completed and was sent to Harvard (see figure) together with a complete gas system and the laser octant. For the series production of the muon MM chambers four locations were defined in the assembly hall where successive production steps will take place.

  In October a start was made with the milling of the motor blocks and the side panels for the second chamber. Production of the components for the MM chambers has started, as well as of various components for the MI and MO chambers. In addition various smaller jobs connected with the muon chamber project were done.

- HERA

  Several prototypes for the correction dipole magnets have been constructed. Particular emphasis was given to the winding and the construction of the so-called saddle coils. The work has now been transferred to HOLEC. For the HERA detector construction of a model calorimeter module was started.

- UA4

  One of the (20) small wire chambers was rewired.

- General

  In this category fall various smaller jobs not specifically related to the NIKHEF-H experiments. It also includes some work done for outside institutes.

H.20 Mechanical Design Office

For co-operating personnel, see Addenda, V.

The activities have concentrated exclusively on the two LEP-experiments.

- DELPHI

  A design for the Inner Detector was made consisting of a central supporting cylinder, which absorbs all the forces, and two double walled glass-fibre end flanges for wire attachment. The support cylinder has been wound by TNO out of seven layers of Aramide fibre. The cylinder-flange construction has been analyzed using NASTRAN (see fig. H20.1). For testing a trial stand was designed. Since a wire accuracy is required of less than 10 μm, a three-dimensional grid comb was developed.

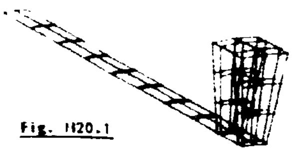

Fig. H20.1

As supporting construction it was decided to use a framework of carbon fibre pulltrusion tubes. This makes it possible to easily manipulate the Inner Detector and also makes it possible to attach the electronics.

- Combi-RICH
  This is a combination of the liquid and the gas End-Cap RICH.
  A design for a 90° test segment of the liquid radiator part was made. It consists of carbonfibre epoxy. The fibre orientation has been chosen such that the expansion coefficient approximately equals that of the quartz plates. At the same time a light but rigid construction is obtained.

- LEP3
  For the Harvard test of the first prototype muon chamber octant a gas system was developed. A laser calibration system was designed. Detail and composite drawings were made of the middle chamber constructed at NIKHEF, as well as for the inner (see fig. H20.2) and outer chambers built by JEN and MIT.

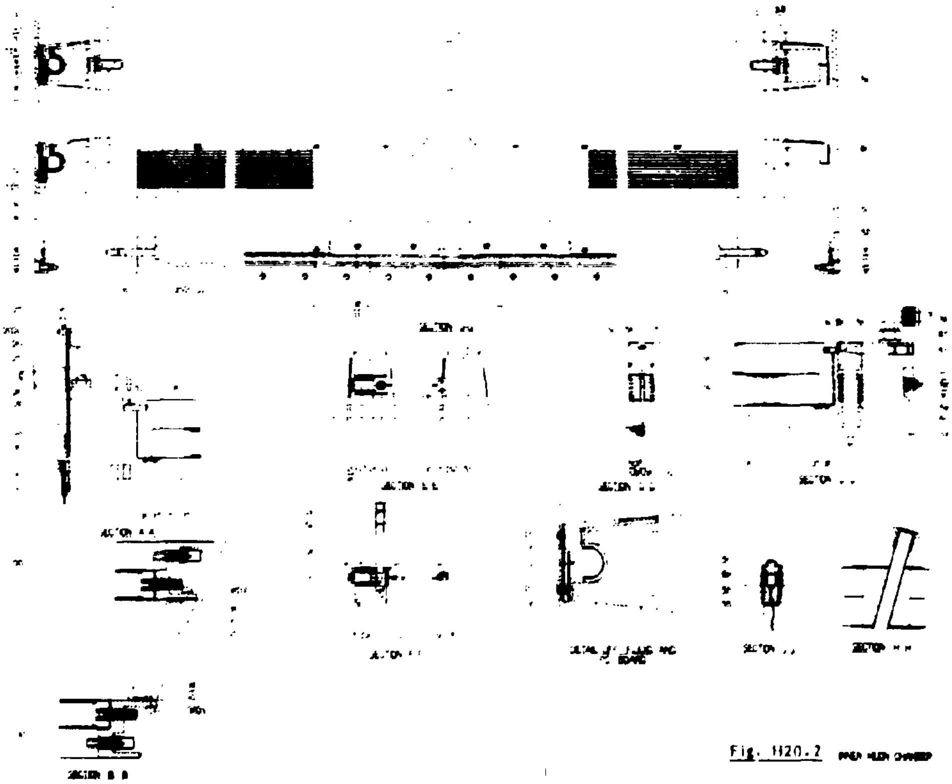

Fig. H20.2

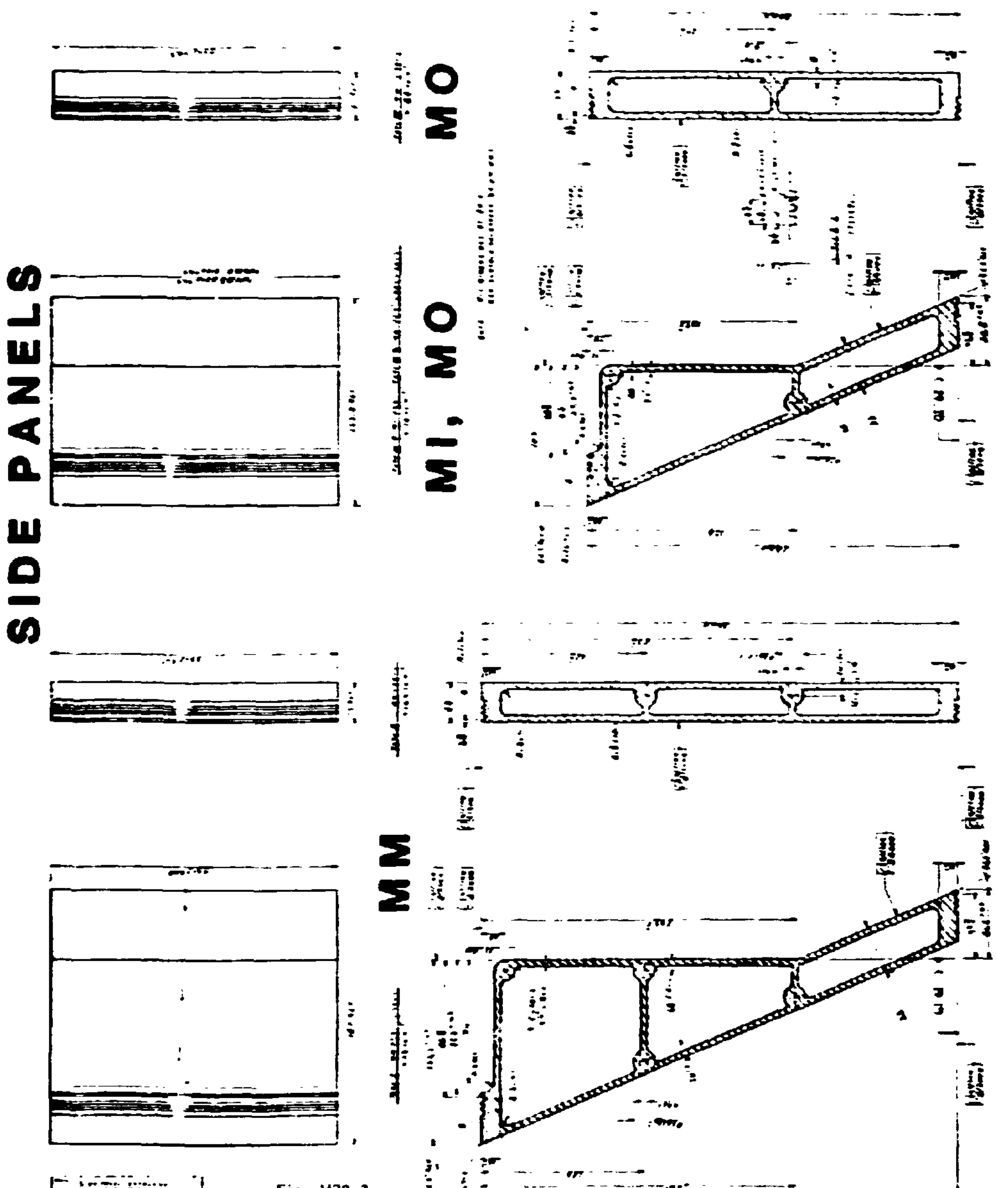

Fig. H20.3

For the series production other techniques are chosen to shorten the production time and to lower costs.
The side panels of all chambers are extruded out of aluminium (see fig. H20.3 (rotate)). For the end parts (motor blocks) it was decided to use aluminium cast work. The honeycomb covers were modified as well, resulting in lower costs and a strongly improved design. Finally a Cable Carriage was designed for the large number of cables and conduit pipes as well as for mounting the discriminators.

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NUCLEAR PHYSICS (K)

Preface

This report covers the scientific and technical progress of the section Nuclear Physics in the year 1984. For the first time the annual reports of the sections High-Energy Physics and Nuclear Physics of NIKHEF in the English language are combined. In the present report emphasis is given to the second half of 1984 since the first half has been covered in the previous NIKHEF-K annual report (July 1983 - June 1984).

The performance of the accelerator MEA has been excellent. The average efficiency, that is the fraction of the planned time that a beam could be delivered, amounted to 85%. Of the totally available 4,500 hours, 500 were used for accelerator development and 2,500 for real data taking.

In the past year some ten electron-scattering experiments were concluded with a scientific publication. Worth mentioning are the results obtained from the study of the proton-deuteron break up of ^{3}He. From experiments in which knocked-out deuterons were detected in coincidence with scattered electrons, it was found that coupling of photons with correlated proton-neutron pairs plays an important role.

Coincidence experiments with the (e,e'p) reaction on ^{90}Zr exhibited interesting results on the strength distribution of 1f proton-hole states in ^{89}Y. It was found that the total strength, integrated over 20 MeV of excitation energy comes out a factor of two smaller than from corresponding (d,^{3}He) work. This remarkable difference must partly be ascribed to strong-interaction effects between reaction particles and the nucleus.

Excitations of the, commonly assumed inert, ^{4}He core in 1p-shell nuclei were revealed in a coincidence study of the ^{12}C(e,e'p)^{11}B reaction. This observation is qualitatively well described by large-scale shell-model calculations performed at Utrecht.

Indications for non-nucleonic contributions to nuclear wave functions were observed from the investigations of a number of magnetic transitions induced by inelastic electron scattering. Four monopole transitions in ^{24}Mg and ^{58}Ni showed the necessity to include 2 $\hbar\omega$ excitations in the transitions. A number of sensitive tests of the interacting boson approximation of nuclei was performed with inelastic scattering on Pd and Pt isotopes.

Some sixty percent of the experiments with electrons was performed together with guest groups from abroad. In several experiments other Dutch laboratories were involved.

Pion nucleus interaction was studied in a series of experiments on pionic atoms and also in low-energy elastic pion scattering. For the pionic atom measurements use was made of a number of Ge detectors surrounded by BGO Compton-suppression shields. These systems were obtained in a joined effort of KVI (Groningen), the Free University (Amsterdam) and NIKHEF-K. Both the efficiency and the precision of such experiments were thereby greatly improved. From pionic Mg and Al atom experiments it was found that pion absorption from the atomic 1s orbit is also suppressed. This could be an indication that the s-wave repulsion in the pion-nucleus optical potential is stronger than that found from scattering experiments.

Successful tests were performed on elastic pion-nucleus scattering at a pion kinetic energy as low as 15 MeV. This is of importance for planned π-^{4}He scattering experiments. Towards the end of the year a new two-step pion converter was completed. With the converter the intensity of the secondary pion and muon beams is doubled with respect to that with the original single-stage copper converter, whereas the electron contamination is a factor of four smaller than previously.

Theoretical research was focussed for a great deal on aspects related with the experimental programme. Attention was among others given to the Coulomb sum rule and to quark-bag models in connection with the electromagnetic current operator and contributions of six-quark clusters as well as with respect to the electromagnetic nucleon and delta form factors. The above-mentioned contribution of s-wave repulsion in pion-nucleon interaction was studied in a phenomenological optical potential. With an enhanced repulsion the experimental pionic-atom data could be described qualitatively. The Δ-hole model was further extended for application to π^0 photoproduction and Δ-nucleon interaction in inelastic pion-nucleus scattering.

Radiochemistry work, finally, was performed on hot-atom reactions and related radiation chemical effects as well as on dosimetry, isotope production and the labelling of organic molecules. Most experiments were carried out with the institute's Bremsstrahlung beam. Reactions with muonium and muonic radicals were investigated with the μSR technique at SIN, Switzerland.

Through radiation of a Ne-gas target with deuterons at the Free University cyclotron, ^{18}F was obtained for labelling purposes. At NIKHEF the isotopes ^{123}I and ^{125}I and sources of ^{102}Rh and ^{175}Hf were produced.

Part of the staff has been actively involved in the development of plans for future research. The results of this study were laid down in a report entitled "NIKHEF-K proposal for UPDATE MEA". This proposal deals with the construction of a pulse-stretcher ring for increasing the duty factor from 2% to 90%. At the same time the maximum energy of MEA should be increased to 700 MeV.

The Dutch beam line for synchrotron radiation at Daresbury (UK) was opened officially on November 1st. This line has been almost entirely built by NIKHEF-K. For CERN a prototype septum magnet for the new antiproton collector has been constructed.

K1. Electron scattering

(group leader C. de Vries)

K1.1 Introduction

In the past year a number of experiments were carried to a conclusion which led to the publication or submission of some ten papers. Especially worth mentioning are the results obtained on the proton-deuteron break up of ^{3}He. Deuteron knock-out from ^{3}He measured in coincidence with scattered electrons showed that also the coupling of photon to correlated proton-neutron pairs must be taken into account to describe the data properly. Interesting results were obtained on the distribution of the strength of 1f proton-hole states in ^{89}Y from coincidence (e,e'p) experiments. The integrated absolute strength is at least a factor of two lower than in recent (d,^{3}He) measurements. Clear indications for the break up of the ^{4}He core in 1p shell nuclei have been found from a study of the ^{12}C(e,e'p)^{11}B reaction.

The investigation of magnetic transitions has in several cases yielded among others indications for non-nucleonic contributions to nuclear wave functions. Monopole transitions observed in ^{24}Mg and ^{58}Ni showed the necessity for including 2 $\hbar\omega$ particle-hole excitations in shell-model transitions. The interacting boson model was tested for Pd and Pt nuclei.

Some sixty percent of the experimental activities was carried out together with guest teams from abroad. In a number of experiments also colleagues from other Dutch laboratories took an active part.

An important contribution was given to a forward look on nuclear structure studies with the electromagnetic probe. The results of this study were laid down in a proposal for an upgrade of the accelerator facility; see also section 5.

K1.2 Single-arm electron-scattering experiments

K1.2.1 Nuclear structure and models

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

[H. Blok, H.P. Blok, J.F.A. van Hienen and G. van der Steenhoven (VUA); C.W. de Jager and H. de Vries; A. Saha and K.K. Seth (Northwestern University); B.A. Brown (Michigan State University)]

The experimental data on four monopole transitions, two in each nucleus, have yielded an interesting result. Shell-model calculations within a 1 $\hbar\omega$ space do not describe the form factors at all. The

inclusion of particle-hole components in the ground states from outside the model space also does not reconcile theory with experiment. It was found that an admixture of only a few percent (intensity) of 2 $\hbar\omega$ 1p-1h giant-monopole-resonance like excitations in the shell-model transitions sufficed to describe the data properly (see Phys. Lett. 149B (1984) 441).

For other natural parity states up to 6.5 MeV excitation energy in ^{58}Ni transition-charge densities have been obtained, by taking into account the - mostly small - contributions of transition currents.

The measured form factors (q = 0.3 - 2.5 fm^{-1}) for several 2^+ and 4^+ states of ^{26}Mg are well described by 2s1d shell-model calculations. From a comparison with proton-scattering results, transition matrix elements for both protons and neutrons have been determined. Experiments at backward angle (154°) are in progress to better determine transverse contributions.

Electric and magnetic excitations in ^{50}Ti

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

Electric excitations. From a comparison with shell-model calculations[1] of measured form factors for the $J^\pi = 0^+, 2^+, 4^+, 6^+$ members of the $(1f_{7/2})^2$ multiplet, it was found that the polarization charge needed to fit the data decreases as a function of multipole order: $\delta e_p(C2) = 0.61(3)$, $\delta e_p(C4) = 0.39(3)$ and $\delta e_p(C6) = 0.14(3)$. It should be noted that for ^{52}Cr, which has a more complicated shell-model structure, one has found[2] $\delta e_p(C6) = -0.11$. This is an indication that the effective charge depends on the choice of the shell-model basis wave functions. It is interesting to note that from the present C6 form factor for ^{50}Ti one finds a value for the RMS value of the $1f_{7/2}$ proton orbit of 4.29(3) fm, which is 5.5% larger than that found[3] from the M7 form-factor data for ^{51}V ($\langle r^2\rangle^{1/2}$ = 4.06(5) fm). In the latter value the 1.4% effect of meson-exchange currents, which in first order play a role in magnetic scattering only, has been incorporated. It may be that this difference in radii is due to collective deformation effects. These could shift the radial C6-transition density outwards, similarly to effects calculated for the C4 operator in the sd shell[4].

Magnetic excitations. From a systematic Rosenbluth-separation survey, several purely transverse transitions were found to levels up to 10 MeV excitation energy. From their form factors unique multipolarity assignments could be made. These assignments and the resulting spins and parities for the final states are listed in table K1.1 along with the single-particle transitions that are consistent with the experimental form-factor shapes.

Table K1.1. Transverse excitation in ^{50}Ti

E_x (MeV)	$M\lambda$	J^π	Single-particle transition
4.884(5) a)	M5	5^+	$\nu(1f_{7/2} \rightarrow 2p_{3/2})$
7.293(10)	M4	4^-	$\pi(1d_{5/2} \rightarrow 1f_{7/2})$
8.755(10)	M8	8^-	$1f_{7/2} \rightarrow 1g_{9/2}$ π or ν
9.061(10)	M3	3^+	$\pi(1f_{7/2} \rightarrow 1f_{5/2})$
9.188(10)	M5	5^+	$\nu(1f_{7/2} \rightarrow 1f_{5/2})$
9.442(10)	M8	8^-	$1f_{7/2} \rightarrow 1g_{9/2}$ π or ν

a) also identified in (n,γ) and (d,p) reactions [5]

For the lowest of these states a (2p-2h) shell-model calculation is available[1]. The Woods-Saxon radial parameters r_0 = 1.17 fm used in this calculation stems from the M7 elastic form factor of ^{49}Ti [3]. For good agreement with the present data, however, an 8% larger r_0-value is obviously required; see fig. K1.1. The experimental strength is only 33±4% of the calculated one.

Tests of the IBA for $^{104-110}$Pd and ^{196}Pt

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

Transition-charge densities for several 2^+ and 4^+ states of these nuclei have been determined. The strength of the third and following 2^+ states in each Pd isotope is always less than 0.5% of that of the first 2^+ state, contrary to the suggestion[6] that 2^+ states with mixed symmetry are to be expected with a relative strength of some 10%. The transition-charge densities of the 4^+ states can be classified as follows. The first 4^+, member of the 2^+, 4^+, 0^+ triplet has a second derivative-like behaviour, whereas the other 4^+ states peak at the surface of the nucleus at slightly different radii. The charge densities of the lowest 2+ and 4+ states suggest that the Pd isotopes can be

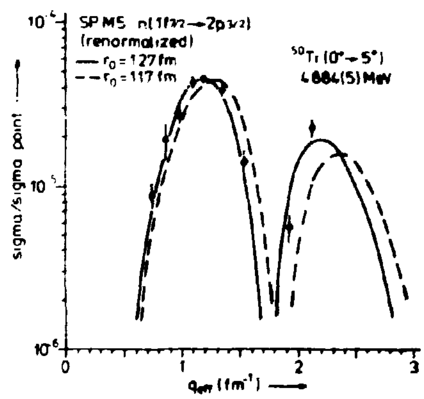

Fig. K1.1: Experimental magnetic form factor for the $0^+ \rightarrow 5^+$ 4.88 MeV transition in ^{50}Ti along with renormalized M5 single-particle form factors.

described as anharmonic vibrators. The strength of 0^+ excitations has been found to be negligible. In each isotope at least one 3^- state is observed and several excitations to higher spin. In the cases that no spin assignment was available, there is agreement with (p,p') data[7].

Form factors for transitions to three 4^+ states in ^{196}Pt yield structures that largely deviate from liquid-drop model predictions. They provide an indication for the need of including g-bosons in IBA. Papers on first results for 2^+ states in ^{110}Pd and 4^+ states in ^{196}Pt have been accepted for publication in Phys. Lett. B.

The transitional nuclei ^{198,204}Hg

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

This work is part of a study of even-mass Hg isotopes in the transition region form oblate (^{198}Hg) to spheroidal (^{204}Hg) nuclei. The aim is to obtain ground state and transition densities in a model-independent way. An attempt will be made to describe the collective states in terms of the IBA.

So far, high-resolution (better than 10^{-4}) data have been obtained in the momentum transfer range of $q = 0.9 - 2.2$ fm^{-1}. The lithium-amalgam targets, sandwiched between two thin Be foils, withstand beam currents up to 40 μA provided the targets are being rotated during beam exposure. Experiments for low q-values had to be postponed due to poor target conditions.

Longitudinal form factors in ^{15}N

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

Light nuclei represent a testing ground for large-scale shell-model calculations in which $2\hbar\omega$ excitations are included and no inert core is assumed[8]. For ^{15}N transverse form factors have recently become available[9]. Since these might show non-nucleonic effects, such as mesonic exchange currents, it is worth knowing whether the longitudinal form factors are properly being described by the purely nucleonic shell model.

With a room-temperature gas target (see NIKHEF-K Annual Report 1983-1984) longitudinal data have been collected for $q = 0.4 - 2.3$ fm^{-1}. The data cover excitation energies between 0 and 20 MeV. Due to the relatively large dimension of the target in the beam direction (4 cm) the resolution is only 90 keV (FWHM). The temperature of the gascell - filled to a pressure of 4 atm., corresponding to a thickness of 8 mg/cm^2 - did not rise above 70 °C. For normalization purposes an identical cell filled with helium was used. The background was obtained from scattering off an empty cell.

For 16 of the 22 levels known up to 11 MeV excitation energy form factors could be extracted for the highest energy (300 MeV) measurements. In fig. K1.2 the longitudinal component of the elastic form factor is shown.

For $q_{eff} > 1.5$ there is a clear discrepancy with data from Dally et al.[10].

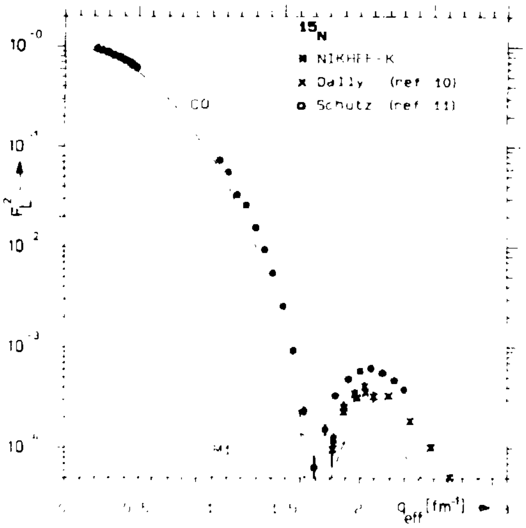

Fig. K1.2: Longitudinal form factor for the N ground state. Shown are the present data with those of Dally et al.[10] and Schütz[11]. The solid curve shows the shell model calculation[9]. The dashed curve shows the subtracted M1 component calculated with data from Singhal[8].

Transverse form factors of 1p-shell nuclei
[L. de Vries, H.P. Blok (VU-A); C.W. de Jager; R.P. Singhal (University of Glasgow)]

In order to obtain explicit information on non-nucleonic contributions to nucleonic wave functions, transverse form factors will be measured for some 1p-shell nuclei (^{15}N and ^{12}C or ^{16}O); see also the preceding paragraph. Such measurements require low background in view of the expected low counting rates. Possible background reduction in the QDQ spectrometer has been investigated through adjustments of windows on ADC spectra such that only electrons are detected and by measuring the time differences between the top and bottom scintillators in the spectrometer. The latter will enable us to distinguish particles entering from above (cosmic radiation) and from below (electrons). The test results are promising.

K1.2.2 Magnetic scattering

The ground state magnetic form factor of ^{19}F
[A.J.H. Donné, J. de la Mar and G. van Middelkoop (VJA); L. Lapikás]

The final analysis of the backward scattering data (at 180° for q < 1.4 fm^{-1} [12] and at 154° for q = 1.3 - 2.7 fm^{-1}) for the 1/2$^+$

ground state of ^{19}F has been completed. The charge-scattering contribution to the measured cross sections was determined from a Fourier-Bessel fit to the longitudinal cross sections measured at MIT-Bates [13]. The experimental magnetic form factor is given in fig. K1.3 together with results from two shell-model calculations.

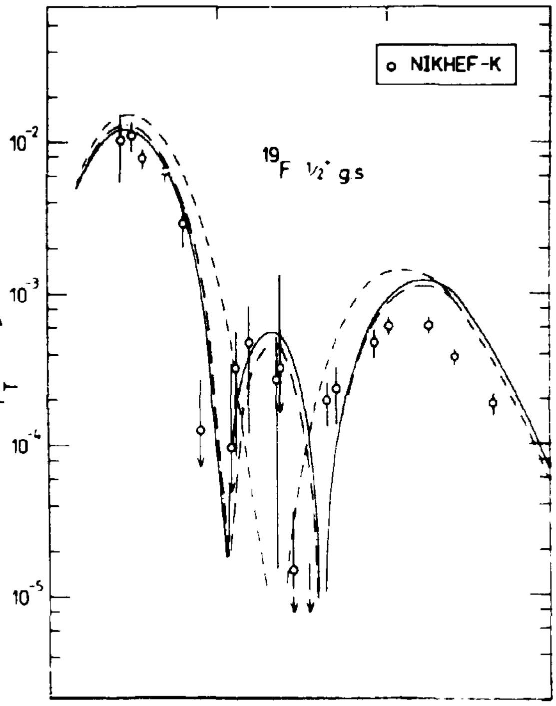

Fig. K1.3: Experimental data for the magnetic elastic form factor of ^{19}F compared with the shell-model calculation by Brown et al.[14] (- - -) and with core-polarization calculations by Suzuki[16]: (-•-•-) shell model[14] + core polarization (M3Y); (——) shell model[14] + core polarization (M3Y) + exchange currents (pair + pionic) + Δ-hole excitation (π+ρ).

The dashed curve from the full sd shell calculation (^{16}O core) does not exhibit the experimentally found second maximum. This could be reproduced, however, by a core-polarization calculation (see NIKHEF-K Annual Report 1983-1984). Extended calculations[14] in which no inert core was assumed and 2 ħω excitations were included provide an improved description of the data (full curve). The main difference lies in a reduced $1d_{5/2} \rightarrow 1d_{3/2}$ contribution together with a contribution from the $1s_{1/2} \rightarrow 2s_{1/2}$ (2 ħω) transition, which is of course absent in the sd-shell calculation.

Magnetic transitions

Four experiments - on ^{39}K, ^{49}Ti, ^{88}Sr and ^{208}Pb - have been concluded. The results have been published or have been accepted for publication; they can be summarized as follows.

-*- Electro-excitation of the first-excited state in ^{39}K

[C.W. de Jager, P.H.M. Keizer, E.A.J.M. Offerman and H. de Vries; M.V. Hynes, S. Kowalski, C.N. Rad and C.F. Williamson (MIT)]

Phys. Lett. 150B (1985) 421
Electro-excitation of the first excited state in ^{39}K has been studied in the momentum transfer region of 0.8 - 2.5 fm^{-1}. Separation of the longitudinal and transverse form factor components has been obtained. The longitudinal form factor has been analyzed model-

independently. A B(M1) value for this 1-forbidden transition was also obtained. Presently available theoretical predictions are unable to reproduce the B(M1) value or the transverse form factor data.

-*- **Quenching of the elastic magnetic response function of ^{49}Ti**
[A.M. Selig, T. Suzuki, L. Lapikás and P.K.A. de Witt Huberts; S.K. Platchkov and B. Frois (Saclay); R.B.M. Mooy, L. Zybert and P.W.M. Glaudemans (University of Utrecht)]

Phys. Lett. 151B (1985) 330
Cross sections for elastic magnetic electron scattering from ^{49}Ti have been obtained in the momentum transfer range $0.75 \leq q \leq 1.40$ fm^{-1}. Apart from the M1 and M7 moments the observed quenching of the response function cannot be described by the present large space shell-model calculations. Core-polarization calculations including the effect of meson-exchange current yield a considerably better description of the present data.

-*- **Electro-excitation of the 1^+ state at E_x = 3.486 MeV in ^{88}Sr**
[L.T. van der Bijl, H. Blok, H.P. Blok, and R. Ent (VUA); J. Heisenberg and O. Schwentker (University of New Hampshire); A. Richter (Darmstadt); P.K.A. de Witt Huberts]

Nucl. Phys. A423 (1984) 365
The differential cross section for excitation of the 1^+ state at E_x = 3.486 MeV in ^{88}Sr by inelastic electron scattering has been measured for values of the momentum transfer q between 0.22 and 2.57 fm^{-1}. Both nuclear core polarization and Δ-hole polarization seem to be necessary to describe the observed reduction of the B(M1) value and data at low q and the behaviour of the cross section at intermediate values of q.

-*- **High resolution inelastic electron scattering and the isoscalar nature of the M1 transition to the $J^\pi = 1^+$ state at E_x = 5.846 MeV in ^{208}Pb**
[H.P. Blok and H. Blok (VUA); C.W. de Jager and H. de Vries; J. Wambach (University of Illinois); S. Müller, G. Küchler and A. Richter (Darmstadt)]

Phys. Rev. Lett., accepted for publication
The relative weight of proton and neutron spin-flip contributions to the M1 excitation of the recently discovered $J^\pi = 1^+$ state at E_x = 5.846 MeV has been determined by comparing the momentum transfer dependence of the measured electron scattering form factor (q_{eff} = 0.44 - 1.59 fm^{-1}) to results from a simple two-state model and from RPA calculations using a spin- and spin-isospin dependent effective separable interaction. The M1 transition is shown to be predominantly of isoscalar nature.

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. Offermann and H. de Vries; D.F. Geesaman and B. Zeidman (Argonne); G.C. Morrison (University of Birmingham)]

Several 8^- states have been identified from a preliminary analysis. The form factor of the one at 15.5 MeV is shown in fig. K1.4; the curve corresponds to a single nucleon $1f_{7/2} \rightarrow 1g_{9/2}$ M8 transition. The data are being compared with results obtained with hadronic probes: proton and pion scattering on ^{52}Cr and the (^{3}He,d) reaction on ^{51}V.

Stretched-spin configurations in ^{116}Sn

[C.W. de Jager and H. de Vries; N. Blasi, M.N. Harakeh and S.Y. van der Werf (KVI); G.T. Emery (University of Indiana)]

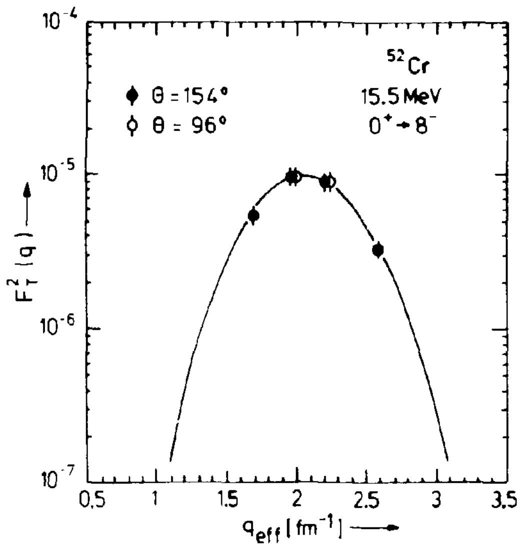

Fig. K1.4: Form factor for the 15.5 MeV state in ^{52}Cr. The data represented by full circles were taken at 154°, the others at 96° and 115°. The curve corresponds to the theoretical prediction for a single nucleon $1f_{7/2} \rightarrow 1g_{9/2}$ M8 transition.

Through elastic scattering experiments in addition to studies of the (p,p), (α,t), (^{3}He,d) and (α,tγ) reaction, the proton or neutron character and configuration fragmentation of (nearly) stretched-spin states is being determined. A preliminary analysis of the data, collected at forward and backward (154°) angles, indicates that stretched states below $E_x \approx 3.8$ MeV are predominantly neutron excitations, based on the configurations $(g^{-1}_{7/2}, h_{11/2})$ and $(d^{-1}_{5/2}, h_{11/2})$. The most prominent examples are the states at 2.909 MeV (7^-) and 3.522 MeV (9^-). The form factors of these states show a strong transverse component, while the behaviour of the form factor of the 7^- states differ appreciably from each other.

K1.2.4 Dispersive effects

Investigation of the first diffraction minimum in elastic electron scattering from ^{12}C

[C.W. de Jager, E.A.J.M. Offermann and H. de Vries; H.J. Emrich and H. Miska (University of Mainz); L.S. Cardman (University of Illinois)]

The aim of this experiment is to measure the elastic form factor of ^{12}C in the first minimum with high accuracy in order to have an experimental test of the existence of dispersive effects in elastic electron scattering. These ^{12}C data should also assist in the extension of ^{12}C as a reference standard for electron scattering to momentum transfers well above 1 fm^{-1}.

From the focal-plane angle of a detected electron in the spectrometer, it is possible to calculate its scattering-angle at target. By subdividing the scattering-angle acceptance the analysis of one spectrum results in cross sections at several angles. Especially near the form factor minimum the scattering-angle resolution should be high to permit division into small bins which prevent large unfolding-factors in the analysis. With sieve-slit measurements (see K5.3) in the QDD spectrometer it is possible to determine backtracing elements for converting focal-plane angles to target angles which give a scattering-angle resolution better than 4 mrad over the full solid-angle (80 × 80 $mrad^2$).

Test runs were performed with the QDD spectrometer at E_0 = 299 MeV covering the elastic form factor from the first minimum up to about the second maximum. The data were sorted in 8 mrad scattering-angle bins, resulting in a form factor with 3% accuracy. Comparison with the results obtained from a Fourier-Bessel analysis (without dispersion-corrections) of the Mainz-data [15] which are taken at q-values on both sides of the q-value of the first form factor minimum but not in the minimum, showed in the minimum a deviation of less than 5%. Following these test runs data were taken at E_0 = 240 and 420 MeV, each covering the elastic form factor from just before the first minimum up to the second minimum with 1% statistical error for each 8 mrad scattering-angle bin.
Analysis is in progress.

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

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

The investigation of $0^+ \rightarrow 0^-$ transitions is a unique way of testing two-step processes in electron scattering. In order to measure a background-free ^{16}O spectrum a special waterfall-target was developed by the Mainz group (see NIKHEF-K Annual Report 1983-1984). The first measurements did not yield an energy-resolution good enough to separate the $0^+ \rightarrow 0^-$ transitions due to insufficient target-homogeneity and scattering angle resolution. Under improved conditions (see also

Chapter 5.3) data were taken at E_0 = 250 MeV and Θ = 100° and 110°. The improvements resulted in an energy-resolution of better than 2.2×10^{-4} over the full focal plane. This resolution allows in principle the $0^+ \rightarrow 0^-$ transitions to be resolved from strongly excited neighbouring levels. The raw data are being corrected for, among others, detection wire - efficiencies.

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

[J.F.J. van den Brand, H. Hendriks, J.W.A. den Herder, E. Jans, P.H.M. Keizer, L. Lapikás, E.N.M. Quint and P.K.A. de Witt Huberts; H.P. Blok and G. van der Steenhoven (VUA)]

K1.3.1 The two-body break up of ^{3}He studied with the ^{3}He(e,e'p) and ^{3}He(e,e,'d) reactions

[in collaboration with P. Dunn and J.M. Laget (Saclay); H. Postma (Technical University, Delft)]

The contradictory results obtained in previous quasi-elastic electron scattering experiments[16,17] on ^{3}He motivated the present experiment. The kinematics were chosen to enable the study of different aspects of this three-nucleon system. Up to a recoil momentum of k = 350 MeV/c data were taken in conventional (e,e'p) kinematics. At higher recoil momenta the recoiling deuteron was detected instead of the knocked out proton. Since the majority of the accidental coincidences is due to the high flux of protons, particle identification allowed to improve the signal-to-noise ratio by a factor of 5-10 in the case of deuteron detection.

A preliminary analysis of these data indicates an excess cross section compared to Faddeev predictions. Calculations by J.M. Laget[18] show that part of this excess cross section is due to the knock-out of deuterons, while another important contribution is due to the final state interaction. In order to study these aspects separately two other experiments were performed.

Parallel kinematics were chosen to emphasize deuteron knock-out and to suppress proton knock-out. In this way optimum advantage is taken of the exponential fall-off of the spectral function for two-body break up. In this kinematics the photon-deuteron coupling was studied at fixed momentum transfer (q = 380 MeV/c) and recoil momenta ranging from k = 0 -200 MeV/c. The dependence of the momentum transfer was also studied by varying it from 350 to 450 MeV/c while keeping the recoil momentum fixed (k = 60 MeV/c).

The data support the proposed photon-deuteron coupling (see fig. K1.5). The observed dependence on recoil momentum as well as on momentum transfer are reproduced in the calculations including photon-deuteron coupling. A paper on this subject has been submitted to Phys. Lett.

Data to study the effects of the final state interaction were also obtained. For this purpose the relative kinetic energy of the residual p-d pair was varied at fixed recoil momentum (k = 100 MeV/c) and at fixed momentum transfer (q = 450 MeV/c). Relative kinetic energies of 30, 70 and 110 MeV were obtained in this way. The analysis of these data is in progress.

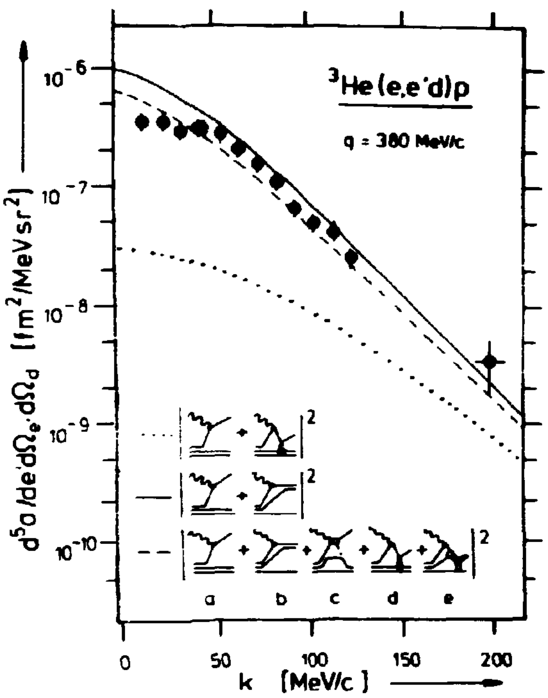

Fig. K1.5: Experimental coincidence cross sections as a function of recoil momentum (k) at fixed momentum transfer (q). The curves correspond to photon-proton coupling including FSI (dotted), photon-proton and photon-pn coupling in PWIA (solid) and a full calculation including also FSI (dashed). The relevant diagrams are shown in the inset.

K1.3.2 The $^{12}C(e,e'p)^{11}B$ reaction

[in collaboration with P.W.M. Glaudemans, P.J. Brussaard, J. Dean and D. Zwarts (University of Utrecht)]

The spectral function 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 in the one-step (e,e'p) reaction indicates the presence of wave function components beyond the 1p-shell. A shell-model calculation, performed in a large configuration space, yields the following major components of the ^{12}C ground-state wave function:

$$\langle ^{12}C_{gs} \rangle = 0.80(1s)^4(1p)^8 + 0.33(1s)^3(1p)^8(2s3d)^2 + 0.25(1s)^4(1p)^6(2s1d),$$

indicating both the break up of the ^{4}He-core and the occupation of the 2s-orbit. Together with a calculation for the $1/2^+$ state in ^{11}B this results in a momentum distribution which gives a fair description of the shape of the data (see fig. K1.6).

A paper on this subject has been accepted for publication in Phys. Lett.

Contribution from the unresolved $7/2^-$ state at 6.74 MeV in ^{11}B have also been estimated (fig. K1.6; dashed curve). Another state with an l=0 momentum distribution has been observed at 9.85 MeV. It presumably corresponds to a second $1/2^+$ state at E_x = 10.65 MeV as predicted by the shell-model calculations.

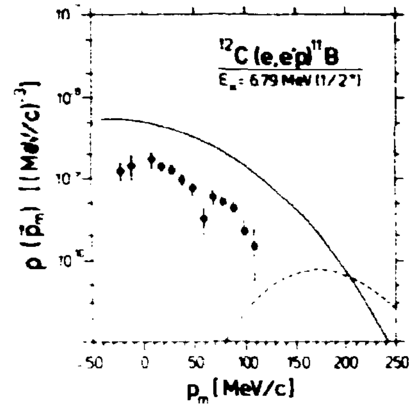

Fig. K1.6: Missing momentum distribution of the $1/2^+$ state at 6.79 MeV in ^{11}B. The full curve represents the shell model calculation and the dashed curve represents the calculated strength of the $1f_{7/2}$ state at 6.74 MeV.

K1.3.3 Study of valence and deep-hole states in ^{51}V and ^{90}Zr

In the quasi-elastic proton - knock-out experiment on ^{51}V and ^{90}Zr the spectral function is being studied in the excitation energy range E_x = 0 - 20 MeV for missing momenta $-50 < p_m < 300$ MeV/c. The data-taking has been completed.

From the analysis of the $^{90}Zr(e,e'p)^{89}Y$ experiment absolute spectroscopic factors have been extracted. Whereas the total experimental error on the cross section is estimated as 10%, the theoretical treatment of the final state interaction (FSI) between the outgoing proton and the residual nucleus as well as other theoretical ambiguities give an uncertainty of approximately 30% in the extracted spectroscopic factors. An improved theoretical treatment of the FSI is thus required to exploit fully the possibilities of the (e,e'p) reaction.

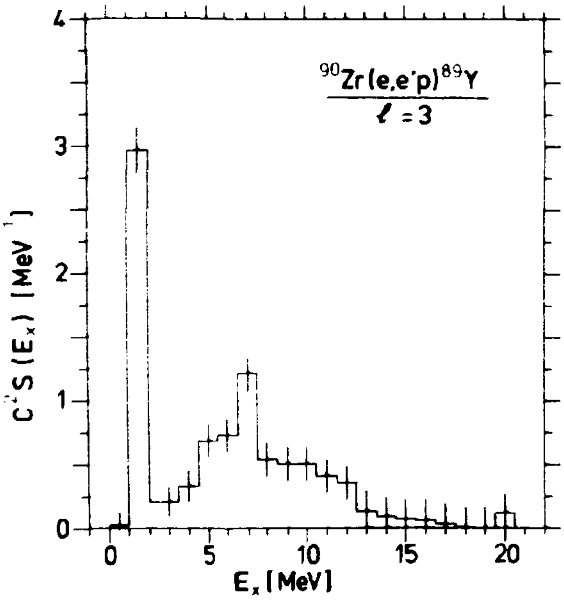

Fig. K1.7: Fragmentation of the 1f-hole strength observed in the $^{90}Zr(e,e'p)^{89}Y$ reaction. The indicated errors are of statistical origin only.

Concentrating on 1f-proton hole states in ^{89}Y we observed a significantly smaller occupancy than previously determined from the hadronic (d,τ) reaction[19]. The observed sum-rule value of 8.9 is in qualitative agreement with a mean-field calculation that includes short-range correlations[20]. Fig. K1.7 shows the fragmentation of the 1f strength as a function of the excitation energy. The strength extends to an excitation energy of 20 MeV which is more than that observed in the hadronic reaction (11 MeV).

K1.3.4 The (e,e'p) reaction on ^{208}Pb

The proton-hole structure of the doubly magic nucleus ^{208}Pb was measured with the (e,e'p) reaction. Experimental information on the structure of this nucleus is of fundamental importance in e.g. self-consistent many-body calculations. It will also be interesting to compare the spectral function as derived from this electromagnetic reaction with that from hadronic reactions. The experiment was performed at an average beam current of 25 μA with a 14 mg/cm^2 ^{208}Pb target mounted in a rotating frame. So far measurements have been carried out in a missing momentum range from - 50 MeV/c up to 280 MeV/c with an outgoing proton kinetic energy of 100 MeV.

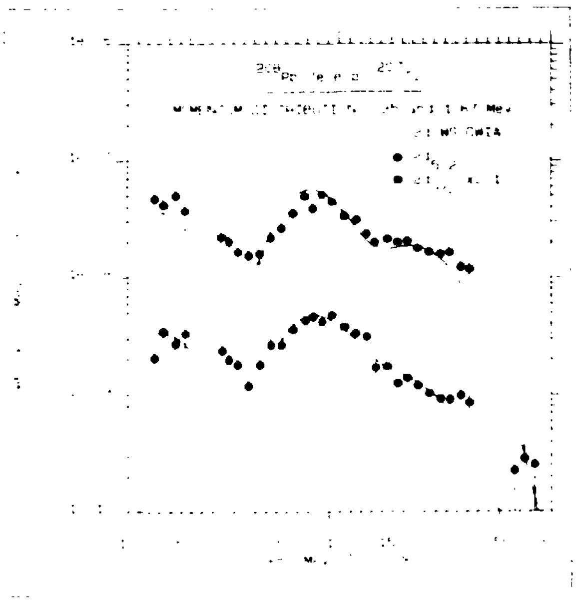

Fig. K1.8: The 2d proton momentum density distribution determined with the (e,e'p) reaction together with the corresponding distorted-wave impulse approximation curves calculated for a Woods-Saxon potential.

Momentum density distributions have been extracted for the low-lying discrete states, examples of which ($2d_{3/2}$ and $2d_{5/2}$) are shown in fig. K1.8. We will shortly perform a relative $1s_{1/2}$ proton knock-out experiment for ^{208}Pb and ^{206}Pb in order to link the 30% quenching of the $3s_{1/2}$ strength observed [21] in elastic electron scattering from the isotone pair ^{206}Pb, ^{205}Tl with the result of the present (e,e'p) experiment on ^{208}Pb.

K1.3.5 Radiative unfolding for (e,e'p) spectra

In order to check the radiative unfolding procedure that is applied to all (e,e'p) spectra, the reaction $^2H(e,e'p)n$ was measured up to 20 MeV missing energy (E_m) with a CD_2 target. In the missing-energy spectrum a single peak for deuteron break up at E_m = 2.2 MeV is followed by a pure radiative tail extending to the threshold at E_m = 16 MeV for the $^{12}C(e,e'p)$ reaction. After radiative unfolding the cross section in the region E_m = 3 - 15 MeV is found to be consistent with zero. We find $\lfloor\sigma_{unf}^{tail}/\sigma_{exp}^{tail}\rfloor$ = - 0.03(10) for the unfolded cross section relative to the experimental tail cross section $\sigma_{exp.}^{tail}$ in this region and $\sigma_{unf.}^{tail}/\sigma(2.2)$ = - 0.01(3) relative to the cross section σ(2.2) for the deuteron break up peak at 2.2 MeV.

K1.3.6 Test measurement for future (e,e'π) experiments

As a test for future (e,e'π) experiments on nuclei we studied the reaction $^{1}He(e,e'\pi)n$ at 408 MeV. With a 67 mg/cm^2 CH_2 target and 5 μA beam current, 20 real against 40 accidental coincidences per hour were measured in the full phase space, in agreement with an earlier experiment[22] carried out at Saclay. The real/accidental ratio of 1/2 could only be attained with a 3 mm thick Al plate mounted in front of the QDQ detection system in order to prevent pile-up in the wire chambers. Without the plate the low-energy protons were no longer stopped and the singles rate in the wire chambers rose from 1 to 40 per burst.

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

[A. Kaarsgaarn, J.H. Koch and P.K.A. de Witt Huberts; B. Schoch (University of Mainz); P. Stoler and P.F. Yergin (Troy)]

Differential cross sections for pions with T_π = 48 MeV produced in the reaction $^{13}C(\gamma,\pi^-)^{13}N$ between mirror states have been determined at pion-detection angles around 90°. The measured cross sections are larger than previously reported for θ_π = 90° and T_π = 42 MeV, but smaller than calculated from theory. These results have been published: Phys. Lett. 143B (1984) 69.

The data acquisition for photoproduction at constant values of the nuclear momentum transfer, q = 1.0 and 1.25 fm^{-1}, and a range of pion kinetic energies, T_π = 48 - 180 MeV across the delta-resonance, has been completed. The aerogel electron suppression system[23], the full orbit reconstruction with four wire chambers and the timing and pulse-height information from the trigger detectors enabled us to measure the small $^{13}C(\gamma,\pi^-)^{13}N_{gs}$ production cross section at θ_π = 38° and T_π = 180 MeV under an intense electron background condition. The relatively large cross section of the $^{11}B(\gamma,\pi^-)^{11}C_{gs}$ reaction is used to fix the endpoint of the pion-energy spectrum for the $^{13}C(\gamma,\pi^-)^{13}N_{gs}$ transition that is at nearly the same energy.
Data analysis is in progress.

K 1. 5 References

[1] L. Zybert et al., Z. Phys. A318 (1984) 363,
[2] J.W. Lightbody et al., Phys. Rev. C27 (1983) 113,
[3] S.K. Platchkov et al., Phys. Rev. C25 (1982) 2318,
[4] H. Sagawa, B.A. Brown, Phys. Lett. 105B (1985) 247,
[5] Nuclear Datasheets (1984) 379,

[6] F. Iachello, Phys. Rev. Lett. 53 (1984) 427,
[7] R. DeLeo, private communication,
[8] P.W.M. Glaudemans and G. Dean, private communication,
[9] R.P. Singhal et al., Phys. Rev. C28 (1983) 513 and private communication,
[10] E. Dally et al., Phys. Rev. C2 (1970) 2057,
[11] W. Schütz, Z. Phys. A273 (1975) 69,
[12] A.J.H. Donné et al., Nucl. Instr. Meth. 224 (1984) 97,
[13] C.F. Williamson et al., Phys. Rev. Lett. 40 (1978) 1702,
[14] Gl. Zwarts,
[15] W. Reuter, G. Fricke, K. Merle, H. Miska, Phys. Rev. C26 (1982) 806,
[16] D. Day et al., Phys. Rev. Lett. 43 (1979) 1143,
[17] E. Jans et al., Phys. Rev. Lett. 49 (1982) 974,
[18] J.M. Laget, private communication,
[19] A. Stuirbrink et al., Z. Phys. A297 (198-) 307,
[20] V.R. Pandharipande, C.N. Papanicolas and J. Wambach, Phys. Rev. Lett. 53 (1984) 1133,
[21] B. Frois et al., Nucl. Phys. A396 (1984) 409c-418c,
[22] G. Bardin et al., Nucl. Phys. B120 (1977) 45,
[23] P.C. Dunn, Nucl. Instr. Meth. 224 (1984) 106.

K1.6 Approved proposals for electron scattering experiments

85-E1 "Electroexcitation of the new antisymmetric M1 mode in heavy deformed nuclei and search for the M3 mode"

85-E2 "Measurement of (e,e') cross sections for ^{15}N" (extension of 83-E8)

85-E5 "High-spin (stretched) particle-hole states in ^{116}Sn" (extension of 82-E4)

85-E6 "Inelastic electron scattering from ^{42}Ca and ^{44}Ca"

85-E7 "Final state interaction effects in the (e,e'p) reaction"

85-E8 "Study if the $3s_{1/2}$-orbit in ^{206}Pb and ^{208}Pb with the (e,e'p) reaction"

85-E9 "Investigation of the σ-ω model with the (e,e'p) reaction"

85-E10 "A proton here, a neutron there, or deuterons everywhere?" A study of deuteron knock-out by high-energy electrons

85-E11 "Study of non-normal parity transitions in 1p-shell nuclei by the (e,e'p) reaction"

85-E12 "Electrodisintegration of ^4He with the (e,e'X) reaction"

* * *

K2. Physics with pions, muons and antiprotons (Group leader R. van Dantzig)

K2.1 Introduction

In the half-year period since our previous annual report (1983–1984) exotic atoms and low-energy pion scattering continued to be the main topics for the pion-muon group. The μSR work, after successful initial tests, has suffered from problems with the superconducting solenoid of the muon channel and of the accelerator. Work at other laboratories is a valuable ingredient of the program of the group. Exotic atom studies on ^{208}Pb and ^{237}Np have been undertaken at SIN. There has been further modest participation in experiments at CERN.

Concerning the pion-muon facility, a welcome improvement has been made by the installation of a new pion production target, made of pyrolytic graphite with a tungsten Bremsstrahlungs-radiator in front of it. With this target the pion flux increases by a factor two while the beam contamination by electrons reduces by a factor of typically four.

K2.2 Pionic and muonic atoms

K2.2.1 Pionic ^{208}Pb; pionic and muonic ^{237}Np

[W. Duinker, J. Konijn, C.T.A.M. de Laat, A. Taal, A.H. Wapstra; J.F.M. d'Achard van Enschut (Delft University of Technology); P. David, J. Hartfield, H. Janszen, T. Mayer-Kuckuk, W. Müller, R. von Mutius (Inst. für Strahlen- und Kernphysik der Univ. Bonn); T. Krogulski (Univ. of Warsaw); C. Petitjean, H.W. Reist (SIN, Villigen); S.M. Polikanov (GSI, Darmstadt); C. Gugler, L.A. Schaller, L. Schellenberg (Inst. de Physique, Univ. de Fribourg)]

The X-ray spectrum of pionic ^{208}Pb (15 g of PbO and 20 g of $Pb(NO_3)_2$ enriched to 99% in mass 208) has been studied. Data have been taken, initially at NIKHEF and in a later stage at SIN, Villigen. The experimental set-up and measuring technique, including a bismuth germanate (BGO) Compton suppression system, were the same as described in earlier measurements[1] on strong interaction shifts ε_0 and widths Γ_0 of 3d levels in pionic Pt and Au. In fig. K2.1 the prompt pionic X-ray spectrum up to 1600 keV is shown, with inserts showing details of the same spectrum, the 5g → 4f and 4f → 3d transitions, respectively. The solid lines represent fits to the data points. They include all known transitions, mainly nuclear ones from levels in Tl, in the energy region of interest. This makes it possible to largely reduce systematic errors. From this point of view it should be noted that our results differ from recent other work[2]. In table K2.1 the strong

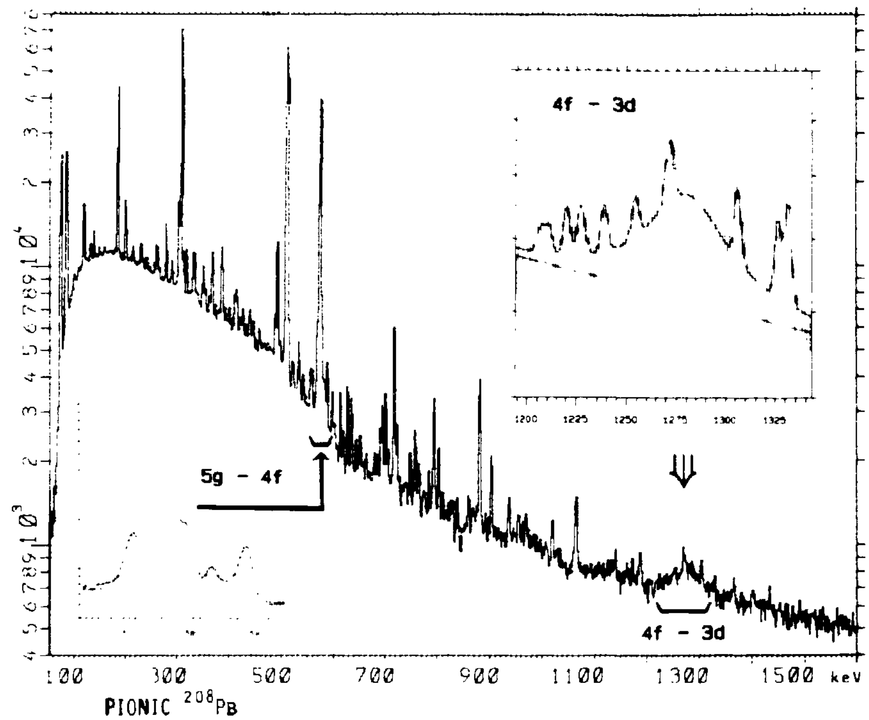

Fig. K2.1: The pionic X-ray spectrum of ^{208}Pb. The inserts display details of the same spectrum, the 5g → 4f and 4f → 3d pionic transitions, respectively.

interaction shifts and widths of the 4f and 3d levels are presented together with the results from ref. [2] and theoretical predictions[3-5] based on standard optical potentials. The ε_0 (4f) and Γ_0(4f) have the values and the trend with Z^{2l+3} as expected from theory. The 4f states are still dominated by the velocity dependent p-wave term of the optical potential. For the 3d states the picture is different. Due to increasing influence of the repulsive s-wave part of the potential ε_0(3d) steadily decreases with increasing Z-value. The optical model predictions fail to describe ε_0(3d) as well as Γ_0(3d). The absorption widths are a factor of 1.5 smaller than predicted. A phenomenological explanation for this anomaly has been suggested by Olivier, Koch and Thies[6]. The results on pionic ^{208}Pb have been submitted for publication in Phys. Lett.

A NpO_2 target containing about 10 g of ^{237}Np has been used for various investigations at SIN, Villigen, using stopped pions and muons. As a continuation of our earlier experiments, in September 1984 two weeks of beam time were used to investigate the radiationless transitions in muonic ^{237}Np. As has been shown in the case of ^{238}U [7] prompt muon-induced fission is mainly caused by the radiationless 3d → 1s quadrupole transition. For this transition we observed a (10±5)% probability (preliminary results). Furthermore we observed a (13.0±2.4)% probability for the radiationless 2p - 1s transition in muonic ^{237}Np. A possible explanation for the lower suppression of the 2p → 1s than in the case of ^{238}U may be due to the fact that the neutron emission channel is not open.

Table K2.1. Strong interaction monopole shifts ε_0 with respect to the calculated point Coulomb energy and absorption widths Γ_0 for the pionic 4f and 3d levels in Pt, ^{197}Au (depicted from ref. [1]) and ^{208}Pb.

Nucleus	Experiment intensity balance	Experiment direct	Optical potential calculation I[a] ξ=1	II[b] ξ=1	III[a] ξ=0	IV[c] ξ=1	reference
			Γ_0(keV) Pionic 4f level				
Pt	0.69±0.10	0.59±0.05	0.63	0.64	0.74	0.55	[1]
^{197}Au	0.81±0.13	0.77±0.04	0.72	0.74	0.85	0.63	[1]
^{208}Pb		1.30±0.03*	1.09	1.09	1.37	0.93	[2]
^{208}Pb	1.2 ±0.3	1.21±0.03	1.09	1.09	1.37	0.93	This paper
			Γ_0(keV) Pionic 3d level				
Pt		37 ± 5	61.5	55.3	73.0	45.1	[1]
^{197}Au		34 ± 4	65.6	60.4	80.2	47.7	[1]
^{208}Pb		47.4± 2.6*	84.2	73.9	104.4	60.3	[2]
^{208}Pb		46 ± 4	84.2	73.9	104.4	60.3	This paper
			ε_0(keV) Pionic 4f level				
Pt		1.08±0.04	1.02	1.06	1.10	0.96	[1]
^{197}Au		1.36±0.07	1.13	1.18	1.22	1.05	[1]
^{208}Pb		1.64±0.02*	1.62	1.66	1.79	1.48	[2]
^{208}Pb		1.49±0.03	1.62	1.66	1.79	1.48	This paper
			ε_0(keV) Pionic 3d level				
Pt		23.4±1.7	29.7	26.0	38.1	18.7	[1]
^{197}Au		20.0±1.4	31.4	26.5	39.5	18.4	[1]
^{208}Pb		13.2±0.6*	33.5	27.2	46.8	17.5	[2]
^{208}Pb		15.9±1.3	33.5	27.2	46.8	17.5	This paper

*) not including the systematic errors claimed by ref. [2]; these are reported to be 0.05 and 1.0 keV for the shifts and 0.08 and 4.6 keV for the widths of the pionic 4f and 3d levels, respectively.

a) Tauscher[3],
b) Batty, et al.[4],
c) Seki and Masutani[5] (the "b-2R" set of parameters).

K2.2.2 Pionic Mg

[W. Duinker, P.J. van den Hoek, J.H. Koch, J. Konijn, C.T.A.M. de Laat, W. Poeser, A. Taal, A.H. Wapstra; J.B.R. Berkhout, W.H.A. Hesselink, T.J. Ketel, G. van Middelkoop, T.P.E. Prins (VUA); J.F.M. d'Achard van Enschut, C.W.E. van Eijk, W. Lourens (Delft University of Technology)]

The pionic 2p → 1s transition has been observed in Mg (see fig. K2.2). For the strong interaction monopole shift a value has been measured of $\varepsilon_0(1s) = 81.6 \pm 0.6$ keV with respect to the point Coulomb energy, in general agreement with standard optical potential predictions. The observed strong interaction absorption width $\Gamma_0(1s) = 17.2 \pm 1.6$ keV is about a factor of 1.5 smaller than expected from current models. This measurement confirms the trend of 'anomalously' small strong interaction widths for deeply bound pionic states already observed in heavier elements[8,9]. The results on pionic Mg have been submitted for publication in Phys. Lett.

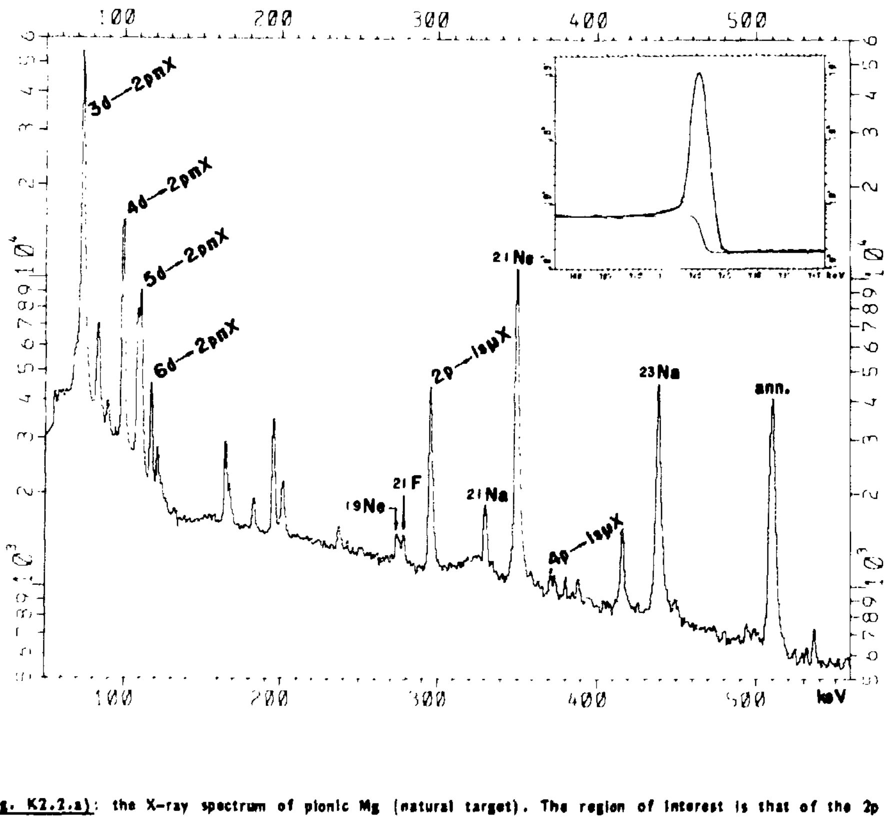

Fig. K2.2.a): the X-ray spectrum of pionic Mg (natural target). The region of interest is that of the 2p → 1s transition which is shown in a blow-up in b). The insert shows the detector response (on a log-scale) of the 320 keV ^{51}Cr calibration line.

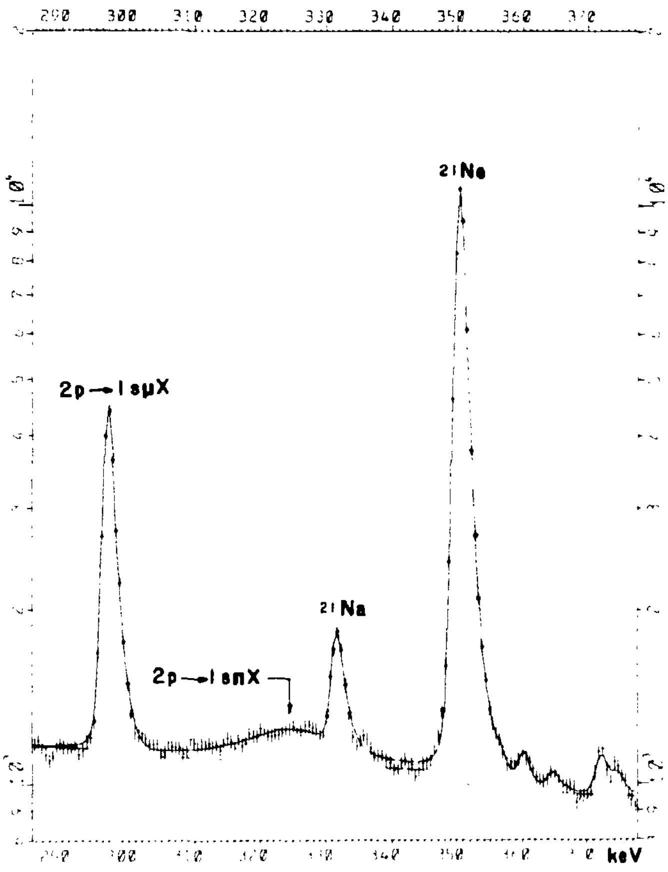

Fig. K2.2.b): best fit to the energy region of the pionic 2p → 1s transition in the spectrum depicted in fig. 2.2.a. The use of an accurate detector response function (see insert of fig. 2.2.a) in the analysis of the Lorentzian line shape and the nuclear gamma-ray transition is of vital importance.

K2.3 Elastic scattering of low-energy pions and pion absorption

[J.B.R. Berkhout, J.P. Elfrink, R. Hamers, W.H.A. Hesselink, 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 feasibility of experiments on pion scattering and on pion absorption at quite low pion energy (T_π), down to 15 MeV, is under investigation at the pion channel. The low energy region is of interest as it bridges for the pion-nucleus interaction the zero energy (pionic atom) data with the region where scattering data are presently available ($T_\pi \geq 50$ MeV).

Two problems occur at the very low pion energies. Firstly the beam intensity is low. A new pion production target, which has been installed gives 10^5 π^-/s at T_π = 15 MeV. The intensity is sufficient for

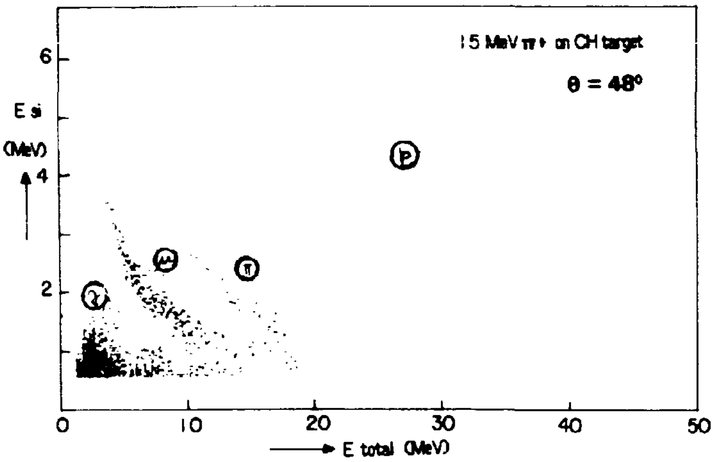

Fig. K2.3: dE/dx signal of a 1 mm thick Si detector versus the total energy loss deposition (E_{tot}) in the detector telescope. The scattering data for π^+ at 15 MeV on a CH target are taken at 48°. The gamma-rays, μ^+, π^+ and protons are clearly separated in this plot.

the elastic scattering experiments for negative and positive pions at 15, 30 and 45 MeV on liquid ^3He and ^4He targets, which are in preparation. Secondly a strong background of muons arises from pion decay near the target. In a successful test measurement on $^{12}C\ (\pi^+,\pi^+)^{12}C$ at T_π = 15 MeV it has been shown that this background can be sufficiently reduced by track reconstruction of the scattered pions and by dE/dx determination with a 1 mm thick Si-detector in front of the Ge-detectors (fig. K2.3). The detection in the telescope of protons from the pion absorption process looks promising from the view point of the planned studies of the (π^+,2p) pion absorption channel.

K2.4 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. Sakomoto (Rutherford Appleton Laboratories); J.P. Davies, T.P. Gorringe, I. Lowe, J.M. Nelson, S.M. Playfer, G.J. Pyle, G.T.A. Squier (University of Birmingham); R.E. Welsh and R.G. Winter (College of William and Mary, USA)]

Following antiprotonic He X-ray measurements (see Annual Report 1983-1984) experiments have been performed for hydrogen and deuterium gas targets at three different densities and at room temperature. Under these conditions no K_α $\bar{p}$p lines could be observed to any significant extent. Recent calculations by Batty et al. from the collaboration indicate that one has to go to lower gas density in order to reduce Stark mixing. Preparations have been made for runs at typically 0.5 bar using a new X-ray detector (gas-scintillation proportional wire chamber) developed at the Technical University on Delft by C.W.E. van Eijk and R. Hollander.

K2.5 Instrumentation

In November 1984 a measurement on pionic atoms was performed with four Compton suppression systems all consisting of Ge detectors surrounded by BGO shields. Two prototypes of BGO shields have been used, one in which the Ge-detector is placed concentric and another in which it is placed asymmetrically. The Compton-suppressed ^{60}Co spectra have been studied for both types. The differences of the two systems are a slightly lower overall suppression factor but a better suppression of high energy gamma-rays for the asymmetrical configuration. The overall suppression factor obtained is 5.5.

Data acquisition

(C.T.A.M. de Laat; J.G. Kromme (Interuniv. Reactor Institute Delft))

A set of easy-to-use general purpose software routines for data acquisition in experiments using a GEC-ELLIOTT CAMAC interface has been developed. The software running under DIGITAL's IAS real-time operating system consists of a fast multi-user CAMAC driver, a number of service routines and a FORTRAN library of user-friendly subroutines. The multi-user approach gives the possibility of several data acquisition programs to be run simultaneously on different terminals. The CAMAC driver supports direct memory access channels and hardware lists. For software driven lists and loops it has a speed of 40k words per second. This software is now in use for pionic- and muonic-atom experiments at NIKHEF-K in Amsterdam as well as in muon-induced fission experiments at SIN, Villigen, Switzerland. A paper on this work has been accepted for publication in Nucl. Instr. Meth.

K 2. 6. References

[1] J.F.M. d'Achard van Enschut et al., Phys. Lett. 136B (1984) 24,

[2] A. Olin et al., Proc. Particles and Nuclei, Xth Int. Conf. PANIC, Heidelberg 1984, Book of Abstracts Vol. II, contr. L9,

[3] L. Tauscher, Proc. Int. Sem. on π-Meson-Nucleus Interactions, Strassbourg 1971 (CNRS, Strassbourg 1971), p. 45,

[4] C.J. Batty et al., Nucl. Phys. A402 (1983) 411,

[5] R. Seki and K. Masutani, Phys. Rev. C27 (1983) 2799,

[6] J.G.J. Olivier et al., Nucl. Phys. A429 (1984) 477,

[7] T. Johansson et al., Phys. Lett. 116B (1982) 403,

[8] J.F.M. d'Achard van Enschut et al., Phys. Lett. 136B (1984) 24,

[9] J.F.M. d'Achard van Enschut et al., 'Pionic ^{208}Pb'; submitted for publication.

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K3. Theory (Group leader J.H. Koch)

K3.1 On the field theoretic description of the nuclear Coulomb sum rule
(T. de Forest, Jr.)

The field theoretic derivation of the relativistic Coulomb sum rule is examined. It is shown that, if only the contributions of the positive-energy nucleon states are kept, this sum rule is equivalent to those obtained by relativistic extensions of the non-relativistic sum rule (to be published in Phys. Lett.).

K3.2 Multiquark contributions in electron scattering off nuclei
[T. de Forest, Jr., P.J. Mulders; A.K. Kerman (MIT)]

The electromagnetic current operator, written down in terms of one-body (three quarks) contributions, was modified by also including two-body operators (six quarks). In order to avoid double counting we used projection operators in coordinate space, working with the coordinates of the baryons (three quarks). With this modified operator we will be able to calculate (e.g. in a Fermi gas model, but in principle in any model) electron scattering cross sections, not only in inclusive but also in double and triple coincidence experiments.

K3.3 Hybrid chiral bag models
(P.J. Mulders)

In the bag model chiral symmetry can be implemented by coupling a pion field to the bag. The pion field can be treated perturbatively as in the cloudy bag model, but it also can be treated in a non-perturbative way similar to the Skyrme model. We have studied some of the problems due to vacuum contributions in bag model operators, like the baryon number operator, the axial current operator and the hamiltonian (Casimir energy).

K3.4 Higher twist corrections in deep inelastic scattering
(P.J. Mulders; P. Castorina (Catania/MIT))

Higher twist corrections in deep inelastic scattering vanish as $1/Q^2$. These corrections, from interactions between the parton from which the photon (or weak boson) scatters and the rest of the target, have been studied using the formalism set up by Jaffe and Soldate. We have calculated the corrections to the neutral and charged weak current cross sections in neutrino scattering and to the asymmetry in polarized electron deuteron scattering.

K3.5 Review of the P-matrix approach
[P.J. Mulders; B.L.G. Bakker (VUA)]

We are writing a review of the P-matrix formalism, its use in the analysis of hadron-hadron scattering processes and its role in connecting these results with the spectra of confined quarks and gluons.

K3.6 Electromagnetic transition form factors
(J.H. Koch, P.J. Mulders)

The electromagnetic form factors of the nucleon and the delta are being studied as well as the nucleon-delta transition form factor in the bag model. Important are the center-of-mass constraints which yield sizeable corrections. The results are compared with experimental results and will also be applied to the calculation of electron scattering.

K3.7 Anomalous widths in pionic atoms and the problem of s-wave repulsion
[J.H. Koch; J.G.J. Olivier and M. Thies (VUA)]

An attempt is made to relate the anomalously small widths observed in the 3d-levels of heavy pionic atoms to a property of the phenomenological pion-nucleus optical potential. Qualitatively, a strong enhancement of the repulsive s-wave potential inside the nucleus is required. This leads to a slower increase of the 3d-widths with Z, without however producing saturation. The long-standing problem of the increased s-wave repulsion in low-energy pion-nucleus interactions thus becomes even more acute.

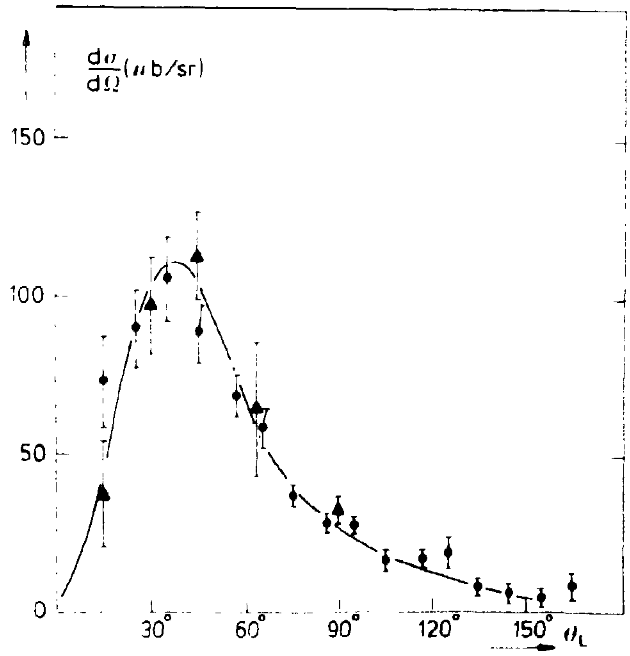


Fig. K3.1: Coherent and incoherent π^0 photoproduction cross section on ^{12}C at k_L = 240 MeV compared to recent data from Bonn and MIT-Bates. The incoherent cross section contains contributions for final nuclear states with ω_{ex} < 15 MeV.

K3.8 Coherent and incoherent π^0 photoproduction at intermediate energy
(T. Takaki, T. Suzuki and J.H. Koch)

The photoproduction of neutral pions on nuclei to discrete final states has been investigated. Both photoproduction and distortion of the π^0 are dominated by Δ-excitation. We therefore investigated the sensitivity of this reaction to medium effects on propagation. The Δ-nucleus dynamics is treated in the Δ-hole approach, which has been used to describe a variety of pion- and photon-induced nuclear reactions. It is shown that the distorted wave impulse cannot be used for π^0 photoproduction. Results for low-lying excitations in ^{12}C are compared with the available data; see fig. K3.1.

K3.9 Inclusive electron scattering from light nuclei at intermediate energies
[J.H. Koch, N. Ohtsuka]

The Δ-hole approach is extended to the description of inclusive electron scattering from nuclei. We compare our calculations to recent measurements on ^4He, ^{12}C and ^{16}O at intermediate energies [Nucl. Phys. A435 (1985) 765].

K3.10 Delta-nucleon interaction and pion-nucleus inelastic scattering
(T. Takaki)

The effect of the Δ-N interaction is quantitatively discussed in pion-nucleus inelastic scattering using the Δ-h formalism. In particular the energy dependence of the $\sigma(T=0)/\sigma(T=1)$ ratio for the 1^+ excitation in ^{12}C is studied in detail. The importance of the Δ-N interaction is demonstrated and the possibility is discussed to specify the Δ-h interaction from the analysis of the 1^+ data. Furthermore in the isoscalar longitudinal and isovector excitation the role of the Δ-N interaction is investigated (to be published in Annals of Physics).

K3.11 Photo- and electroproduction of kaons and the study of hypernuclei
[T.W. Donnelly (MIT); J.H. Koch]

We studied the photoproduction of positive kaons on nuclei, leading to the formation of Λ-hypernuclei. Using an effective Lagrangian approach for the kaon photoproduction, we examined the sensitivity of this reaction to the hypernuclear wave function.

K3.12 Atomic mass evaluation
[A.H. Wapstra, R. Hoekstra; G. Audi (Chalk River)]

The 1983 Atomic Mass Table appeared in Nuclear Physics A432. The collection of new data is being continued. The input table for atomic mass calculations is now being maintained on the new Gould computer of this Institute, using the possibilities of UNIX. The checking programs had partly to be rewritten, this work is nearly finished.

The possibility of calculating masses of a few excited states of every nuclide, introduced in the 1983 evaluation in order to be able to treat isomers and isomer mixtures, is now also being used to treat other states of importance in atomic mass calculations, e.g. isobaric analogue states.

We found that several reported decay energies calculated from measured electron capture ratios in different electron shells did not agree with the reported ratios and the newest theoretical formulae and constants. We also found that improvements could be made in the energy calibration of several reactions, especially in that of gamma rays in (n,γ) and (p,γ) reactions. In view of our experiences in this work, all input data are now being systematically rechecked for such points.

K4. Radiochemistry

(C.N.M. Bakker, G.A. Brinkman, E.L. Diemer, J.J. van Gelder, B.W. van Halteren, P. Kuipers, G.A.J. Leurs, L. Lindner, P.W.F. Louwrier, P. Polak, W. van der Veen, J.Th. Veenboer, J. Visser, R. van der Vlist)

K4.1 Introduction

The research was focussed on chemical reactions of hot atoms and associated radiation chemistry and on dosimetry, isotope production and labelling of organic molecules. Most irradiations were performed using Bremsstrahlung provided by MEA.

Some investigations were carried out in cooperation with others.

For the study of the reactions of muonium and muonic radicals use was made of the muon beams at the 600 MeV proton accelerator of SIN in Villigen.

In cooperation with the Radio-Nuclide Centre of the Free University at Amsterdam, irradiations were performed with a gaseous Ne target for the production of ^{18}F, intended for the labelling of organic compounds.

For the Ophtalmology Institute in Leiden 5-iodo-2-thiouracil was labelled with ^{123}I and ^{125}I.

Sources of ^{102}Rh and ^{175}Hf were prepared for the University of Technology in Delft.

For future research an external scientific committee advised on priorities to radionuclide production, labelling, μSR, pionic and muonic capture in chemical compounds, special systems for hot atom chemistry and special aspects of activation analysis.

K4.2 Hot atom chemistry / radiation chemistry

The reactions with arenes of ^{11}C recoiling from (γ,n) reactions was further investigated. To examine the role of diffusive reactions, irradiations were performed with liquid C_6H_6 scavenged with I_2 and with solid C_6H_6 (at 195 K). Some results for lower boiling ^{11}C-products are given in table K4.1.

Addition of I_2 and the transition to the solid phase have a similar effect on product yields. The observation that the yield of $C_6H_5CH_3$ has been halved whereas the yield of CHT did not change, provides an indication that more than one precursor leads to the formation of either compound.

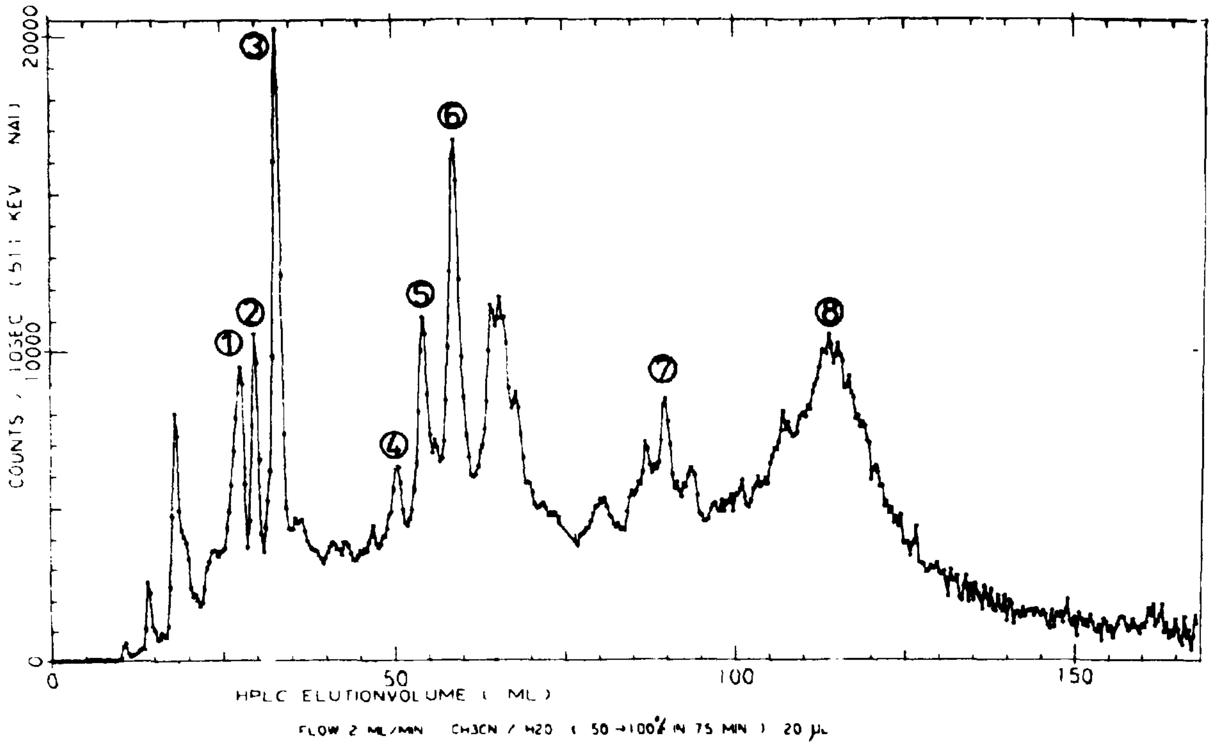
Table K4.1. Product yields (%) for the reaction of recoil ^{11}C atoms with C_6H_6

Product	Liquid -	 2% I_2	Solid (195 K)
C_6H_6	2.6 ± 0.3	1.6 ± 0.1	1.6 ± 0.1
$C_6H_5CH_3$	2.1 ± 0.1	1.1 ± 0.1	1.3 ± 0.1
CHT *)	2.3 ± 0.1	1.9 ± 0.1	2.2 ± 0.2
$C_6H_5C{\equiv}CH$	1.8 ± 0.1	0.3 ± 0.1	0.4 ± 0.1

*) cycloheptatriene

Fig. K4.1. shows the ^{11}C-product spectrum from C_6H_5 for the high-boiling species after HPLC separation. In the presence of I_2 as a scavenger the occurrence of truly polymeric products (beyond 5) is greatly reduced whereas much ^{11}C-C_6H_5I is formed.

Radioactive tracers are ideally suited for studying chemical exchange processes. It has been shown - using ^{34m}Cl atoms recoiling from (γ,n) reactions - that in aromatic compounds of the type C_6H_4ClX, thermal ^{34m}Cl-for-Cl exchange is highly specific. For instance in meta-C_6H_4ClX exchange is little for X=CH_3, F, Cl (o-,p-directing), but most efficient for X=CF_3 (m-directing). Carried out in equi-molecular mixtures of pairs of compounds of the type o-C_6H_4ClX/o-C_6H_4ClY one readily obtains relative exchange rates, as the absolute yield ratio, of chlorine exchange in either molecule (table K4.2).



<u>Fig. 4.1</u>: HPLC radiochromatograms for the reaction of recoil ^{11}C atoms with C_6H_6.

1. C_6H_6 2. $C_6H_5C{\equiv}CH$ 3. $C_6H_5CH_3$ + CHT 4. $(C_6H_5)_2$ 5. $(C_6H_5)_2CH_2$ 6. C_6H_5–$C_6H_5CH_3$ + C_6H_5 – CHT

7. trimers 8. tetramers

Table K4.2. Absolute thermal ^{34m}Cl-for-Cl substitution yields (%) in equimolar mixtures of two ortho-monosubstituted chlorobenzenes

Compounds		Thermal substitution yields	
A	B	A	B
$C_6H_4Cl_2$	C_6H_4ClF	11.2 ± 3.5	5.5 ± 1.6
$C_6H_4Cl_2$	$C_6H_4ClCH_3$	0.5 ± 0.5	12.6 ± 1.3
$C_6H_4Cl_2$	$C_6H_4ClCF_3$	21.5 ± 3.9	1.2 ± 1.1
C_6H_4ClF	$C_6H_4ClCF_3$	6.3 ± 0.9	12.8 ± 0.7
C_6H_4ClF	$C_6H_4ClCF_3$	30.5 ± 2.1	0
$C_6H_4ClCH_3$	$C_6H_4ClCF_3$	28.8 ± 1.5	0

The effect of the substituent on the exchange rate is in the sequence of CH_3 > Cl > F > CF_3 for ortho substituent groups. This sequence is similar to the Hammet σ_m^+ and σ_p^+ constants for Cl-for-H substitution at the ortho position in C_6H_5X, indicating that the exchange reactions have an electrophilic character. In different mixtures of C_6H_5Cl with o-$C_6H_4ClCF_3$ it was shown that the absolute amount of exchanged ^{34m}Cl activity present in each compound is equal for a 1:10 mixture, indicating a ten-fold faster Cl-exchange in C_6H_5Cl compared with o-$C_6H_4ClCF_3$.

Chlorobenzene was tested as a dosimeter for measuring Bremsstrahlung doses to which targets for hot atom chemistry research are subjected. This dosimeter consists of a mixture of $C_6H_5Cl/CH_3OH/H_2O$ = 100/860/40. The amounts of H^+ and Cl^- formed during irradiation (G = 4.75) are titrated with NaOH, respectively $AgNO_3$. Measured dose rates range from 100 to 250 $Gy\cdot min^{-1}\cdot \mu A^{-1}$ for tungsten Bremsstrahlung converters from 0.05 to 0.50 mm thickness, in close correspondence with the calculated fraction of the photon beam traversing the sample.

K4.3 Research with muons

The collaboration with the University of Zürich (E. Roduner) on muonium chemistry was continued.

The measurements on the rate constants of the ortho-, meta- and para-muonic cyclohexadienyl radicals of anisole with benzoquinone and duroquinone were terminated.

A start was made with the determination of the rate constants for the reaction of muonium with aromatic compounds dissolved in several inert solvents. By comparing these reaction rates with those measured for hydrogen atoms, and by evaluating the effects of different solvents, more insight will be obtained on the factors that control these addition reactions, such as viscosity of the solvent, clathration, tunneling and diffusion.

As an example fig. K4.2 shows the rate of the relaxation of the muonic polarization (λ) as a function of the concentration of benzene in n-hexane. The reaction rate constant k ($mol^{-1}s^{-1}$) can be calculated from the equation

$$\lambda = \lambda_0 + k[S],$$

where λ_0 is the relaxation rate for the pure solvent and [S] the concentration of the aromatic compound (mol), the solute.

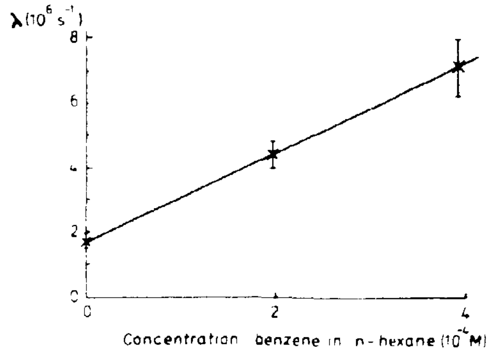


Fig. K4.2: Relaxation rates of muonic polarization for the reaction of Mu with C_6H_6.

For the first time the addition of muonium to N=N double bonds of (symmetrical) azocompounds was observed (table K4.3).

Table K4.3. Reactions of μ with symmetrical azocompounds (R-N=N-R)

R	Hyperfine coupling constants (MHz)	Radical yield (%)
C_2H_5	29.7	42
n-C_3H_7	25.4	43
i-C_3H_7	34.7	42
C_6H_5	40.7	*)

*) measured in solution (ether)

In direct comparison with our value of 34.7 MHz in the azocompound with R = i-C_3H_7, the hyperfine coupling constant for the radical formed by the abstraction of an H-atom from the corresponding hydrazo compound is 10.3 MHz as measured by others by means of ESR. This 'isotope' effect of 3.4 is far greater than observed for all other addition reactions (with alkenes, arenes) and is held to be due to obstructed rotation.

K4.4 Radionuclide production/labelling

Feasibility studies are in progress with regard to the usage of Bremsstrahlung from high energy electron (waste) beams for radionuclide production. Due to the penetrating power of photons, the low cross sections for photon induced reactions and the angular spread of the beam caused by the converter it is necessary to use bulky targets causing specific problems in the chemical treatment after bombardment. ^{67}Cu and ^{52}Fe are among the test cases.
^{67}Cu: for studies of the behaviour of copper in biological systems there is, in addition to the most widely used ^{64}Cu ($t_{1/2}$ = 12.8 h), a need for a longer-lived tracer. ^{67}Cu ($t_{1/2}$ = 62 h) is the only alternative. One way to produce ^{67}Cu is to irradiate zinc with medium energy photons. The target material (ZnO) was subjected to a separation procedure based on the difference in adsorption between Cu^{2+} and Zn^{2+} on a chelating resin (CHELEX 100) from a buffered solution of sufficiently high pH (≈3.5). It strongly adsorbs Cu^{2+} even when the resin is saturated with Zn^{2+}, whereas the excess Zn^{2+} runs through the column. At a lower pH the Cu^{2+} comes off the resin together with a small amount of Zn^{2+}. A final purification is performed by anion exchange. In a 4.7 h irradiation with 85 μA at E=135 MeV at a distance of 60 cm from the converter (0.94 g of Ta cm^{-2}) a target of 88 g of ZnO yielded a 3 mCi ^{67}Cu source. The cross section for the reaction $^{68}Zn(\gamma,p)^{67}Cu$ is found to be 8.2±0.2 mb for 135 MeV Bremsstrahlung. The ^{67}Cu tracer thus produced is being used - at the Wageningen Agricultural University - in experiments on the uptake and excretion of Cu by cattle.
^{52}Fe: the isotope ^{52}Fe ($t_{1/2}$ = 8.2 h) is a β^+ emitter; it is the parent of ^{52m}Mn ($t_{1/2}$ = 21 min). It has been produced by means of the reaction $Ni(\gamma,\alpha xn)^{52}Fe$ for which a cross section σ_q = 12±2 μb was measured at E=120 MeV. Production yields of several mCi are envisaged.

In cooperation with the Radionuclide Centre of the Free University of Amsterdam (Dr. G.W.M. Visser), ^{18}F-F was regularly produced by the $^{20}Ne(d,\alpha)^{18}F$ reaction with 15 MeV deuterons. The reactions of $CH_3COO^{18}F$ in CH_3COOH - a proven agent for controlled fluorination with ^{18}F - with cyclohexane and cyclohexene were investigated in more detail. The pathways of the five main products for the reaction with c-C_6H_{10} are shown in fig. K4.3. Using deuterated reagents it was shown that the acetoxy group in compound 5 finds its origin in the solvent and not in CH_3COOF. Accordingly, when CH_2Cl_2 is used as the solvent compound 5 is not found. The methylgroup in compound 2 comes from CH_3COOF.

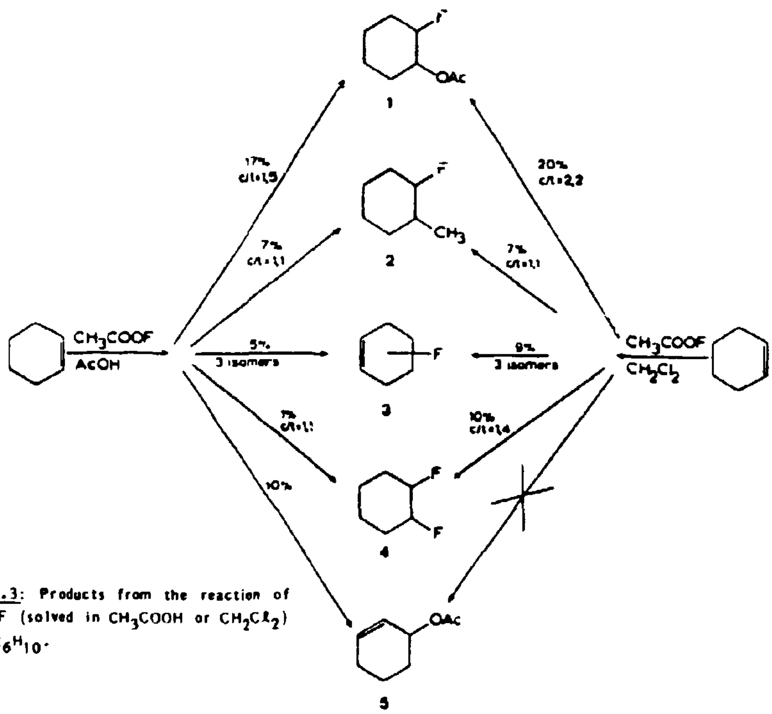
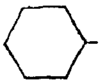
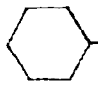
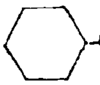
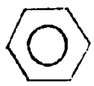


Fig. K4.3: Products from the reaction of CH_3COOF (solved in CH_3COOH or CH_2Cl_2) with $c\text{-}C_6H_{10}$.

Using $c\text{-}C_6H_{12}$ as the substrat ., the main products were:

-F (2%), -OAc (30%) and -CH_3 (6%).

More experiments were performed using $CH_3COO^{18}F$ for the regio-specific fluorination of aromatic compounds via fluorodemercuration:

X  HgCl + $CH_3COO^{18}F$ → X-  ^{18}F.

If X is an electron withdrawing group, almost no fluorodemercuration was observed, although all $CH_3COO^{18}F$ had reacted in 5 minutes. The main reaction products were

X-  -CH_3 and X-  -OAc,

both substituents originating from CH_3COOF and not from the solvent. This behaviour can be understood by assuming two reaction mechanisms: an electrophilic one (introduction of F) and a radical one (F abstracts the Hg-group, which is followed by the introduction of a $\cdot CH_3$ or $\cdot OAc$ group).

A potential tumor-seeker 5-^{18}F-cytosine was produced for the first time by the reaction of $CH_3COO^{18}F$ with cytosine. However, subsequent experiments with rats have shown that 5-^{18}F-uracil and (^{18}F)-2-fluoro-2-deoxyglucose are more suited for the localization of tumors than 5-^{18}F-cytosine.

K5. Technical developments

(Group leaders H. Arnold (until December 1984), P.J.T. Bruinsma, M. van Gelderen (until May 1, 1984), A.P. Kaan, E. Kwakkel, G. Luijckx, T.W. van der Raay)

K5.1 Introduction

Over the past year, about 4,500 beam hours have been scheduled for MEA, including some 500 h for accelerator studies. The weekly efficiency for accelerator performance is displayed in fig. K5.1. The number of hours effectively used for data taking amounted to about 2,500 h.

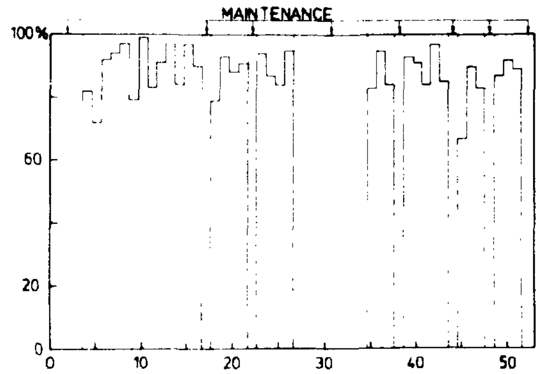


Fig. K5.1: Efficiency of accelerator performance 1984

In order to increase this number a still rather large effort is required to reduce the time needed to deliver beams with the necessary tight tolerances for high accuracy experiments on target. Progress in this respect is foreseen from further accelerator and beam handling physics.

Although research is still going on to operate the costly klystrons at a fail-safe 4 MW r.f. output level, the accelerator has delivered a large number of hours with an energy of over 400 MeV, requiring about 6 (of a total of 12) modulator klystron units to work at the 4 MW level. The research mentioned is required to push this energy to a nominal value of 450 MeV (occasionally 500 MeV).

The duty factor was kept at 1% mainly to save electricity costs. At the end of 1984 the pulse repetition rate was increased from 250 pps to 300 pps without reducing the reliability of the machine.

All experimental halls (LEF, LECH, EMIN, PIMU) are fully operational such that the technical departments were mainly concerned with the maintenance of the rather complex equipment. A few projects, however, are worth mentioning in this introduction.

The converter for generating pions has been replaced to increase the pion yield considerably while reducing the electron contamination of the pion beams into the experimental halls. For the new anti-proton accumulator at CERN presently under construction, NIKHEF-K has designed and constructed a septum magnet. Tests of this magnet at CERN were successful. NIKHEF-K will continue to provide maintenance and upgrade of the existing beam lines at Daresbury (UK) for Dutch synchrotron radiation scientists. The design studies for the project UPDATE, in order to achieve a close 100% duty factor beam, have been completed to the extent that the specifications could be laid down in an official proposal.

K5.2 The accelerator MEA and its beam lines

K5.2.1 Major accelerator systems

MODULATORS: the 480 solid state pfn-type modulators operate reliably. Breakdowns are mainly due to auxiliary systems, like control circuits, power supplies. A new modulator control unit (DIG-2) has been designed to accomodate the replacement of the Alpha LSI-2 mini-computer by the Capro-68k micro (see below). All the klystrons filament transformers have now been replaced by more reliable units.

KLYSTRONS: some of the high power klystrons do not recover immediately from internal arc-overs at the 4 MW mode of operation, sometimes resulting in long processing times. To avoid serious klystron damage in case of arcing a large damped air-core coil (whose stray magnetic field of ≤ 1 gauss does not affect the klystron operation) has been developed to prevent capacitive discharge of the pulse transformer secondary. As a consequence of limited space the coil, which is electrically connected in series with the cathode, had to be installed around the gun of the tube.

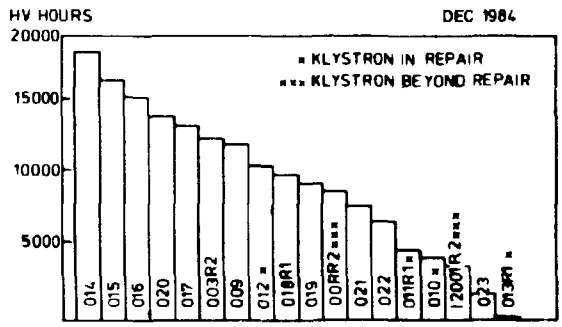


Fig. K5.2: Accumulated number of high-voltage hours per specified klystron.

The accumulated number of high-voltage hours is displayed in fig. K5.2. In total over 175,000 hours have been accumulated. The mean time between failures (MTBF) now is 30,000 HV hours.

CONTROL SYSTEMS: long beam tune-up times and loss of beam were mainly due to break-downs of the local minicomputers (Alpha-LSI-2) and a number of hardware failures in the central computer system. Using a portable version of the FENIX real-time operating system (now called CENIX) as a basis, a new accelerator control software package has been developed for the Capro-68k (a Motorola 68000 system in CAMAC from INCAA). This package incorporates support for the modified DIG-2 processor, which now interfaces to CAMAC instead of directly to the bus of the old Alpha LSI-2.

The development of an experimental operator interface to the entire accelerator control system, using a LISA personal workstation (from Apple) with bitmap graphics and mouse, has been continued.

POWER SUPPLIES: inadequate stability of solenoid and klystron focussing power supplies resulted in increased tune-up times. A program has been started to modify 60 critical units.

INJECTOR: the new fibre optics system performs well. Future high-current operation of the linac requires precise timing control (< 100 ns) in order to compensate for transient beam-loading effects. A design has been completed to modify the existing hot-deck electronic circuits. Through replacing the bipolar transistors by power FET's, timing accuracies of better than 100 ns will be obtained.

K5.2.2 Accelerator research

In order to increase the number of beam hours, tuning procedures are constantly being improved. The beam-spot size and beam-position stability have been improved to 0.02 mm·mrad at 400 MeV. For those electron-scattering experiments requiring a very high resolution, the electron energy can now be maintained within 0.1% during long operation periods without operator interaction.

Experiments show that, although the injector is able to deliver peak beam currents of up to 35 mA, stable linac operation at those high peak currents is not possible. This is due to the related stringent requirements on several beam-steering systems. Continuing effort is being made to enable future beam currents of 40 mA peak.

K5.2.3 Upgrading program

KLYSTRONS: in view of the project UPDATE (see section K5.5) experiments have been made to increase the r.f. peak output of the klystrons beyond 4 MW. A modulator improvement program to raise the r.f. peak power to 5.5 MW is in progress. The modulator in the test-facility will be modified to enable the processing of the klystrons at high peak powers.

KICKER MAGNETS: initial beam tests have been performed with the low-energy kicker magnet system. The computer-control program has been adapted and protection systems modified. As a result beam-sharing between the LECH and AFBU lines on a pulse-to-pulse basis have been shown possible. With MEA operating at 250 Hz, 50 pps were available in LECH and 10 pps in AFBU for tuning purposes. The main limitations so far are 20 ms rise and fall times of the present kicker magnet. The kicker facility will be implemented in 1985.

BEAM SWITCH YARD SYSTEM: the new collimator system in the 400-line (see Annual Report 1983-1984) has been instrumental to have the 500 MeV switch yard (AFBU) working successfully even at high currents (100 µA). As a result this system has shown to be no longer the cause of data taking inefficiencies.

K5.3 Experimental equipment

Referring to earlier Annual Reports and to some recent papers[1,2] describing most of the equipment in the electron scattering halls (EMIN and LEF) we here report on the most important improvements only.

K5.3.1 The EMIN hall

The experimentally obtained resolution in the scattering angle in the QDD spectrometer could not be made better than 8 mrad, while the theoretical limit is 4 mrad. Improvement of this angular resolution is important for the energy resolution in electron scattering experiments on light nuclei. The discrepancy is probably due to the use of a set of non-optimal back-tracing elements for converting focal-plane angles to target angles.

A method was developed to determine the proper back-tracing elements. In the slit system of the QDD spectrometer (maximum solid angle 80 mrad × 80 mrad) a stainless steel plate is installed with a grid of small holes spaced 12.5 mrad in both the dispersive direction and the direction perpendicular to it. A program is available to optimize the backtracing elements with the list-mode data measured with this sieve-slit.

Measurements to determine a new set of back-tracing elements were made with a thin platinum target at E_0 = 210 MeV. The dependence of these elements on (a) the position of an event in the focal plane, (b) the tuning of the quadrupole and (c) the position of the beam spot on target relative to the aperture of the spectrometer was determined. With the new set it was possible to obtain a scattering-angle resolution better than 4 mrad at E_0 = 420 MeV on a 30 mg/cm^2 BN-target over the full solid angle. The sieve-slit measurements revealed also that, in order to obtain a good angular resolution, large focal plane angle corrections are needed for electrons scattered from positions which are shifted in the non-dispersive direction from the central object point. For those targets the present angular resolution is restricted to about 20 mrad. This will be improved by the installation of a fourth wire chamber, which allows the determination of position and angle in the non-dispersive direction at the focal plane.

For use in recoil detection experiments ($^4He(e,e'^3H)p$ and $^4He(e,e'^3He)n$) a cryogenic He gas target system has been designed. The target, operating at 20 K and in the pressure range of 0.25 - 4.10^5 Pa, can handle an electron power dissipation of 10 W. The maximum value for the product of beam current and target thickness amounts to 4,000 µA mg/cm^2. The target foils will be made of mylar and the thickness will, depending on the experimental conditions, vary from 1.5 to 6.0 µm. The length of the target will be 8 cm, which prevents that its entrance and exit foils lie within the spectrometer acceptances. The effective target length viewed at 90° by the QDD and QDQ spectrometers amounts to 2.5 cm. The target system will be movable over 12 cm in the vertical direction; two fixed positions are planned.

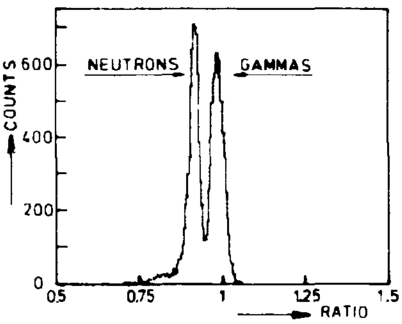


Fig. K5.3: Neutron- and gamma-rays separation.

In order to investigate the possibility to detect neutrons in an electron scattering experiment, two liquid (NE213) neutron counters (on loan from SIN) have been installed in the EMIN hall. During the first tests a 15 cm lead and 20 cm boron-loaded paraffine thick shielding has been used. The discrimination between neutrons and gamma rays is performed by means of an analog pulse shape discrimination (PSD) method. In the neutron energy range of 6 - 20 MeV gamma rays and neutrons can be separated as is illustrated in fig. K5.3. Further tests are scheduled to optimize both the shielding and the PSD method.

K5.3.2 The LEF hall

For the 180° electron scattering equipment an interface adapting the NRL (USA) refrigerated gas target (Nucl. Instr. and Meth. 77 (1970) 136) to the LEF target box has been tested. A fail-safe high pressure reducing valve in this system has been constructed with the following features (see Annual Report 1983-1984, fig.5.5),

.. the pressure is remotely adjustable between vacuum and 10 bar by varying mechanically the height of a liquid nitrogen dewar, which cools a spiralized cooling tube,
.. complete recovery of expensive target gas is possible by means of a gas-recovery trap tubing,
.. the pressure can be read out remotely in steps of 0.01 bar.

The gas transfer system has been tested under beam conditions, using ^{36}Ar and ^{40}Ar as target gas. The temperature in the target cell can be measured with an accuracy of 1 K by means of four Pt100 resistances positioned off-axis.

As the first step to improve the resolution of the 180° electron scattering facility, a multiwire proportional chamber (MWPC) has been constructed. The wire chamber is based on a design used at MIT (Nucl. Instr. and Meth. 141 (1977) 457). It consists of 16 measuring wires separated from each other by three field-shaping wires at distances of 2 mm. The distance between the measuring wires is 8 mm and the gap is 10.8 mm. The implementation of the wire chamber with its intrinsic resolution of 10^{-4} will improve the overall resolution from 1.25×10^{-3} to 7×10^{-4}.

The wire chamber has been dry-tested with a ^{106}Ru source before it was implemented in the focal plane of the Penner-type spectrometer. The test runs performed under beam conditions were successful.

K5.3.3 The PIMU hall

A two-stage pion production target has been constructed and installed as a source for the pion/muon channels. It consists of a 1.5 mm thick tungsten "radiator" followed by a 5 cm thick pyrolytic graphite "productor" (see figure).

Fig. 5.4: Newly installed two state pion production target. The photograph shows in the middle the vacuum flange with feed-throughs for cooling and temperature measuring devices. The target itself consists of the 1.5 mm thick high Z - radiator (at the right) and the 5×1 cm pyrolytic graphite "productor".

The high-Z radiator, converting electron energy into Bremsstrahlung gamma rays, is based on a design from SLAC. The low-Z productor material has been selected on the basis of pion production yield, density and heat properties. Following a technique from LASL, the productor is fixed mounted and water-cooled. It is placed in a vacuum box connected to the electron beam line using a remotely controlled coupling. Between the target and the beam dump a thin walled conic bag filled with Helium or Argon gas encloses the emerging beam to avoid the generation and escape of toxic and corrosive compounds in air. The target replaces a rotating 1 cm thick single-stage copper pion production target. An increase in pion yield by typically a factor two and a reduction of the electron contamination of the beam by a factor four is expected.

The muon channel has been equipped with a combined diaphragm/beam-stopper at the entrance of the superconducting solenoid.

K5.4 Computer facilities

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

(a) enhancement, extension and renovation of the IKOnet accelerator and experiment control computer network,
(b) replacement of the central computing facility, and integration of the new facility into the IKOnet network,
(c) the management of the IKOnet network and central computing facilities.

Due to rather high personnel turn-over a considerable amount of time has been spent on the training of new staff to fulfil the vacant positions.

K5.4.1 IKOnet accelerator and experiment control computer network

Hardware improvements

A new ECM-type system has been added to the IKOnet network, i.e. a BIRA system in the DIGEL electronics laboratory. This system runs the standard Fenix and Unix network software.

After the final shut-down of the DEC-System-10 (see K5.4.2, next page), the Message Switching Machine C (MSM-C) has been reconfigured as a Terminet terminal multiplexer, this improving the access to the IKOnet network from the main building.

Software improvements

The communication protocol utilized over the IKOnet FSDL network links (a derivative of X.25) has been enhanced in order to behave more robustly than ever when encountering intermittent hardware failures, thus resulting in a further reduction of the down-time of the Vital Message Switching Machines MSM-A and MSM-B. Various changes and extensions of the central accelerator control software resulted in increased reliability and improved operator response times.

K5.4.2 Replacement of the central computing facility

The installation, functional testing and acceptance testing of the Gould 32/9705 computer system has required substantial effort from the Computer Systems Group during the entire report period (the system has been finally accepted on January 10, 1985). In September, a start was made with transferring users from the old DEC-System-10 to the new Gould system. For some users, this also meant learning to use the UTX-32 operating system (a derivative of Berkeley 4.1c Unix and ATT

System V Unix), and to use the ANSI Standard Fortran-77 language. The DEC-System-10 was taken out of service on November 1, 1984.

Plotting facilities have been improved by the installation of a HP7550A plotter (8 colours, A3/A4 paper size). Device drivers for this plotter and for the Gigi color graphics terminal have been added to the standard GKS (Graphical Kernel System) package. The popular CERN libraries HBOOK and HPLOT have been ported to the Gould system. A graphics display facility based on GKS, has been added, supporting all graphics output devices for which GKS has a driver.

A provisional integration of the services offered by SARA (the University Computing Centre) has been implemented through standard 2400 baud asynchronous lines, allowing both interactive access to and file transfer to and from the SARA machines. Improvements are waiting for the realization of the WCW Local Area Network.

Work has started on integration of the services of the Gould machine into the existing IKOnet network, and vice versa. The hardware connection is made through standard Ethernet hardware. On the Gould side, use is made of a standard Arapanet protocol (UDP/IP), which is converted by a gateway machine of the IKOnet datagram protocol (the gateway machine is actually an existing member of the IKOnet network).

Various software conversion projects have been completed, thus easing the transition of user software from DEC-System-10 to Gould 32/9705; these included an inventory management system for the Digital Electronics Group and a drawing administration system for the Mechanical Engineering Group.

K5.4.3 Management of the network and central computing facilities

Management of computers in the open-shop fashion as currently practized at NIKHEF-K, centers around fool-proof backup procedures, simple boot procedures and sufficient documentation. All these items seem to have developed in the past few years up to a satisfactory level of usability (also by non-experts). Facilities to simplify the increasing amount of file backup (cf. increased amount of on-line disk storage) have been developed and put into operation. The transition to the new Gould 32/9705 central computer required many additional system management activities.

K5.5 Project UPDATE

On July 1 of the year reported NIKHEF-K has put forward an official proposal called UPDATE aiming at an increase of beam duty factor to

90% by adding a pulse-stretching magnetic device to MEA while increasing the maximum energy to 700 MeV. For more details see Annual Report 1983-1984.

After the submission the project has undergone reviewing by the Dutch nuclear physics community and a technical committee with favourable results. At the end of 1984 the project was still under consideration for financing by the Dutch government.

K5.6 Work for third parties

K5.6.1 Saskatoon Accelerator Laboratory

For the Saskatoon Accelerator Laboratory (Canada), two beam position monitors have been constructed and delivered. The design is based on the non-interfering traveling-wave type monitors in use at the various MEA beam lines.

K5.6.2 CERN

For the second-generation antiproton accumulator project of CERN, a septum magnet has been designed and constructed with the following main features: maximum magnetic field of 1.1 Tesla in a volume of 1.6 m long by 0.11 m wide by 0.09 high. In order to reduce the dissipated electric power from 250 kW to 500 W the magnet is to be used in pulsed operation (0.4 pps at 5 ms pulse width). The construction of the core has been simplified by employing rectangular stampings which have been glued together. A thin wedge provides a rigid support for the septum under pulsed operating conditions. The magnet has been shipped to CERN for final tests.

K5.6.3 Synchrotron radiation line at Daresbury (UK)

On behalf of ZWO, the Organisation for the Advancement of Pure Research, NIKHEF-K designed, built and tested equipment for experiments with synchrotron radiation at the stations (for EXAFS and for SDA/SAS experiments), beam transport lines and X-ray optics. A full description of the project can be found in the Annual Report 1982-1983. Part of the beam transport line was delivered in May 1983. All remaining hardware of the beam lines, the optics and the equipment for the experimental areas has now been installed by technicians of the Daresbury Laboratory. The beam pipes and vacuum vessels have been lead-cladded for shielding purposes; commissioning of vacuum and safety control has been completed. Synchrotron light was already transmitted successfully through the beam lines up to the Beryllium window. Although all components were correctly aligned and the full beam could be accepted, there is still a consistent difference in radiation intensity transmitted through the EXAFS and the SDA/SAS lines. This is probably due to the source point of the beam line being located in the fringe field of the bending magnet.

The high-resolution monochromator made by TPD Delft was tested with a conventional low power X-ray source by scanning through the Cu K alpha spectrum lines. Two of the three crystal units showed the required energy resolution (1 to 3 eV). The third unit, containing a doubly bent crystal is roughly 50% outside specifications but will first be tested with full beam power. Commissioning of the experimental stations is scheduled for Spring 1985. NIKHEF-K will continue to provide maintenance and upgrade on the existing lines and will also assist Dutch users in preparing their equipment.

K5.7 General technical activities

New developments are in study which concern gaseous detectors, operating at lower than atmospheric pressure, in order to participate demands for detection of particles like p, d, ^{3}H, ^{3}He.

Based on a LISA a system has been installed to be used for the design of print-layouts and circuit diagrams. A considerable reduction in design effort has been obtained for small (EUROCARD size) projects and prototype systems.

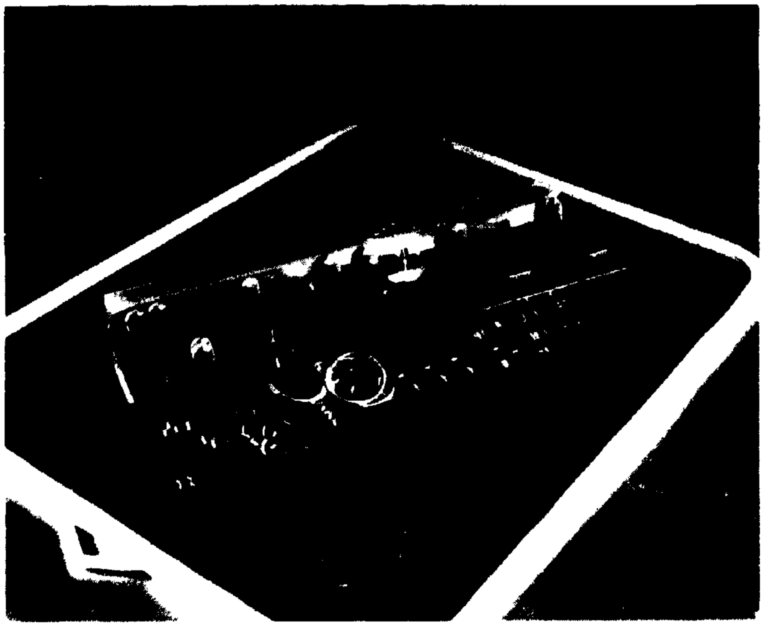


Fig. K5.5: Multilayer printed circuit board (both sides are shown!).

Microstrip and striplines, frequently used in high speed interconnections on (multilayer) printed circuit boards must have a specific impedance. The problem of the mismatch between theoretical and measured values when using thin (0.3 mm) layers has been studied. Several methods of measurements have been used to determine the dielectric constant (ε_r) of multilayer printed circuit board materials, this being one of the important impedance parameters. As a result transmission line impedances can now be calculated with reasonable accuracy.

The second board of the time digitizer (fig. K5.5) has been tested successfully. The first time measurements have been made to check the main specifications (e.g. differential linearity). Measurements in a physics environment will be carried out shortly.

A high efficiency (85–95%) switch mode power supply has been designed for future replacement of beam control power supplies. The design is based on the fly-back converter principle, resulting in flexible output specifications. A (8051) microcontroller performs the user interface and internal control functions. The main specifications are: output current 16 A max., output voltage 400 V max., output power 3 kW, current/voltage stability 1% (T_{amb} = 0 - 50 °C), setting times 1 ms. A prototype is being assembled.

ADDENDUM I Publications

I.1 Research articles

Section-H

Adeva, B., et al. (Demarteau, M.W.J.M., Duinker, P., Harting, D., Kuijer P., Luit, E.J., Massaro, G.G.G., Rykaczewski, H., Swider, G.M.).
"A summary of experimental results from MARK J: High Energy e^+e^- Collisions at PETRA".
Phys. Rep. 109 (1984) 131.

Adeva, B., et al. (Demarteau, M.W.J.M., Duinker, P., Harting, D., Kuijer, P., Luit, E.J., Massaro, G.G.G., Rykaczewski, H., Swider, G.M.).
"Search for New Particles in e^+e^- Annihilation from 39.79 to 45.52 GeV".
Phys. Rev. Lett. 53 (1984) 134.

Adeva, B., et al. (Demarteau, M.W.J.M., Duinker, P., Harting, D., Kuijer P., Luit, E.J., Massaro, G.G.G., Rykaczewski, H., Swider, G.M.).
"Search for the Supersymmetric Partner of the Z^0 and $W^{\pm}$".
Phys. Rev. Lett. 53 (1984) 1856.

Aguilar-Benitez, M., et al. (Kittel, W., Stergiou, A.).
"D meson branching ratios and hadronic charm production cross sections".
Phys. Lett. 135B (1984) 237.

Ali, A., et al. (Eijk, B. van).
"Hard Hadronic Collisions: extrapolation of standard effects".
Proceedings of the CERN-ECFA workshop on Large Hadron Collider in the LEP-tunnel.

Allasia, D. et al. (Barlag, S., Jongejans, B., Apeldoorn, G. van, Dam, P. van, Visser, C., Wigmans, R.).
"Fragmentation functions in high energy ν and $\bar{\nu}$ deuterium interactions".
Phys. Lett. 124B (1983) 543.

Allasia, D., et al. (Jongejans, B., Tenner, A., Apeldoom, G.W. van, Dam, P. van, Wigmans, R.).
"Fragmentation in neutrino and antineutrino charged current interactions on proton and neutron".
Zeitschrift für Physik C24 (1984) 119.

Allasia, D. et al. (Barlag, S., Jongejans, B., Tenner, A., Apeldoorn, G. van, Dam, P. van, Visser, C., Wigmans, R.).
"Measurement of the neutral current coupling constants in neutrino and antineutrino interactions with deuterium".
Proceedings of the leptonic session of the 18th Rencontre de Moriond, vol. 2 (1983).
Phys. Lett. 133B (1983) 129.

Allasia, D., et al. (Barlag, S., Jongejans, B., Tenner, A., Apeldoorn, G.W. van, Dam, P. van, Visser, C., Wigmans, R.).
"Measurement of the neutron and proton structure functions from neutrino and antineutrino scattering in deuterium".
Phys. Lett. 135B (1984) 231.

Allasia, D., et al. (Barlag, S., Wolf, E. de, Jongejans, B., Tenner, A., Apeldoorn, G.W. van, Dam, P. van, Visser, C., Wigmans, R.).
"Measurement of the ν_μ and $\bar{\nu}_\mu$ nucleon charged current total cross sections and the ratio of ν_μ neutron to ν_μ proton charged-current total cross sections".
Nucl. Phys. B239 (1984) 301.

Allasia, D. et al. (Barlag, S., Dam, P. van, Jongejans, B., Tenner, A., Apeldoorn, G. van, Visser, C., Wigmans, R.).
"Production of neutral strange particles in $\bar{\nu}_\mu d_2$ and $\nu_\mu d_2$ charged current interactions".
Nucl. Phys. B224 (1983) 1.

Allasia, D. et al. (Barlag, S., Jongejans, B., Kunne, R., Tenner, A., Apeldoorn, G. van, Dam, P. van, Visser, C., Wigmans, R.).
"Single pion production in charged current $\bar{\nu}D$ interactions at high energies".
Z. Phys. C20 (1983) 95.

Armitage, J., et al. (Buys, A., Driel, M. van, Erné, F., Uitert, B. van, Langeveld, L., Paar, H., Sens, J.).

"Leptonic structure functions of the photon".
Phys. Lett. B147 (1984) 232.

Arnison, G., et al. (Dorenbosch, J., Eijk, B. van, Holthuizen, D.J.).
"Angular distributions and structure functions from two-jet events at the CERN SPS $p\bar{p}$ Collider".
Phys. Lett. 136B (1984) 294.

Arnison, G., et al. (Dorenbosch, J., Eijk, B. van, Holthuizen, D.J.).
"Associate production of an isolated, large-transverse-momentum lepton (electron or muon), and two jets at the CERN $\bar{p}p$ Collider".
Phys. Lett. 147B (1984) 493.

Arnison, G., et al. (Dorenbosch, J., Eijk, B. van, Holthuizen, D.J.).
"$D^{*\pm}$ production in jets at the CERN SPS Collider".
Phys. Lett. 147B (1984) 222.

Arnison, G., et al. (Dorenbosch, J., Eijk, B. van, Holthuizen, D.J.).
"Experimental observation of events with large missing transverse energy accompanied by a jet or a photon(s) in $p\bar{p}$ collisions at $\sqrt{s}=540$ GeV".
Phys. Lett. 139B (1984) 115.

Arnison, G., et al. (Dorenbosch, J., Eijk, B. van, Holthuizen, D.J.).
"Observation of muonic Z^0-decay at the $\bar{p}p$ Collider".
Phys. Lett. 147B (1984) 241.

Arnison, G., et al. (Dorenbosch, J., Eijk, B. van, Holthuizen, D.J.).
"Observation of the muonic decay of the charged Intermediate Vector Boson".
Phys. Lett. 134B (1984) 469.

Arnison, G., et al. (Dorenbosch, J., Eijk, B. van, Holthuizen, D.J.).
"Search for massive $e\nu\gamma$ and $\mu\nu\gamma$ final states at the CERN Super Proton Synchrotron Collider".
Phys. Lett. 135B (1984) 250.

Bailey, J., et al. (Blokzijl, R., Bos, K., Kluyver, J.C., Konijn, J., Linssen, L.):
"A polarized antiproton beam at LEAR".
Proceedings of workshop on Physics at LEAR with low-energy cooled antiprotons May 9-12, 1982, Erice (Italy).

Bailey, R., et al. (Daum, C., Rijk, G. de, Dijkstra, H., Hardwick, C, Hoogland, W., Tiecke, H., Wiggers, L.).
"A silicon strip detector telescope for the measurement of production and decay of charmed particles".
Nucl. Instr. Meth. 226 (1984) 56.

Bailey, R., et al. (Daum, C, Rijk, G. de, Dijkstra, H., Hardwick, C., Hoogland, W., Tiecke, H., Wiggers, L.).
"A-dependence study of inclusive ϕ-production".
Zeitschrift für Physik C22 (1984) 125.

Bailey, R., et al. (Daum, C, Rijk, G. de, Dijkstra, H., Hardwick, C., Hoogland, W., Spierenburg, W., Tiecke, H., Wiggers, L.).
"Inclusive $K^{*0}(890)$ and $\bar{K}^{*0}(890)$ production on Beryllium by K^-, π^- at 175 GeV".
Zeitschrift für Physik C24 (1984) 11.

Bailey, R., et al. (Daum, C., Rijk, G. de, Dijkstra, H., Hardwick, C., Hoogland, W., Tiecke, H., Wiggers, L.).
"Measurement of Mass and Lifetime of Hadronically Produced Charmed F Mesons".
Phys. Lett. 139B (1984) 320.

Bailey, J., et al. (Blokzijl, R., Bos, K., Kluyver, J.C., Konijn, J., Linssen, L.).
"Status report on experiment PS 172".
Proceedings of a workshop held May 9-12, 1982, Erice (Italy) on Physics at LEAR with low-energy cooled antiprotons, p.427.

Bailey, R., et al. (Daum, C., Dijkstra, H., Hardwick, C., Hoogland, W., Spierenburg, W., Tiecke, H., Wiggers, L.).
"Upper limits for charm production in 150 GeV pBe interactions".
Nucl. Phys. B239 (1984) 15.

Bailey, J.L., et al. (Crijns, F., Hal, P. van).
"Topological cross sections and charged particle multiplicities in pp interactions at

360 GeV/c".
Z. Phys. C23 (1984) 205.

Barber, D.P., et al. (König, A., Schotanus, J., Walle, R.T. Van de, Walk, W).
"A precision measurement of the ϒ' meson mass".
Phys. Lett. 135B (1984) 498.

Barth, M., et al. (Gatignon, L., Stergiou, A., Walle, R.T. Van de).
"Evidence for two back-to-back high-p_T jets in K^+p interactions at 70 GeV/c".
Z. Phys. C22 (1984) 1.

Barth, M., et al. (Gatignon, L., Stergiou, A., Walle, R.T. Van de).
"Inclusive photon and π^0 production in K^+p interactions at 70 GeV/c".
Z. Phys. C22 (1984) 23.

Bergsma, F., et al. (Dorenbosch, J., Jonker, M., Nieuwenhuis, C.).
"A new measurement of the ratio of the cross sections of muon-neutrino and muon-antineutrino scattering on electrons".
Phys. Lett. B147 (1984) 481.

Bergsma, F., et al. (Dorenbosch, J., Jonker, M., Nieuwenhuis, C.).
"A search for oscillations of muon neutrinos in an experiment with L/E ≈ 0.7 km/GeV".
Phys. Lett. B142 (1984) 103.

Bergsma, F., et al. (Dorenbosch, J., Jonker, M., Nieuwenhuis, C.).
"Experimental limits on the production of fractionally charged particles in proton-nucleus and neutrino-nucleus collisions".
Z. Phys. C24 (1984) 217.

Bergsma, F., et al. (Dorenbosch, J., Jonker, M., Nieuwenhuis, C.).
"Experimental study of the nucleon structure functions in charged current neutrino and antineutrino interactions".
Phys. Lett. B141 (1984) 129.

Bij, J. van der.
"Two loop large Higgs mass corrections to vector boson masses".
Nucl. Phys. B248 (1984) 141.

Bobbink, G.J., et al. (Linde, F.L., Sens, J.C.).
Invited paper ~ publication,
"Performance of BGO in a high radiation environment".
Proceedings of Third International Conference on Instrumentation for Colliding Beam Physics, Novosibirsk, USSR, March 15-21 1984.

Bozzo, M., et al. (Koene, B., Swol, R. van, Timmermans, J.).
"Low momentum transfer elastic scattering at the CERN proton-antiproton Collider".
Phys. Lett. 147B (1984) 385.

Bozzo, M., et al. (Koene, B., Swol, R. van, Timmermans, J.).
"Measurement of the proton-antiproton total and elastic cross sections at the CERN SPS Collider".
Phys. Lett. 147B (1984) 392.

Bozzo, M., et al. (Koene, B., Swol, R. van, Timmermans, J.).
"Single diffraction dissociations at the CERN SPS Collider".
Phys. Lett. 136B (1984) 217.

Brick, D.H., et al. (Crijns, F., Bock, H. de, Kittel, W., Metzger, W., Pols, C., Schouten, M., Walle, R. Van de).
"Planar events produced in hadron-proton collisions at 147 GeV/c and their jet-like structures".
Z. Phys. C24 (1984) 19.

Brick, D., et al. (Bock, H. de, Crijns, F., Kittel, W., Metzger, W., Pols, C., Schouten, M., Walle, R.T. Van de).
"Search for long-lived charge +2 hadrons".
Phys. Rev. D30 (1984) 1134.

Buijs, A., et al. (PEP-4 TPC/PEP-9 Two Gamma Collaboration / Driel, M.A. van, Erné, F.C., Langeveld, W.G.J., Paar, H.P., Sens, J.C., Uitert, B.K. van, Wassenaar, E.).
"Results on the total hadronic cross section and four-prong production in photon-photon interactions".
Proceedings of the 1984 SLAC Summer Institute.

Clough, A.S., et al. (Bos, K., Kluyver, J.C., Kunne, R.A., Linssen, L.).
"Evidence against the S-meson".
Phys. Lett. 146B (1984) 299.

Cooper, A.M., et al. (Apeldoorn, G.W. van, Tenner, A., Wigmans, R.).
"An investigation of the EMC effect using antineutrino interactions in deuterium and Neon".
Phys. Lett. 141B (1984) 131.

Corbett, J., et al. (Dorenbosch, J.).
"Report of the trigger working group".
Proceedings of the CERN-ECFA workshop on Large Hadron Collider in the LEP-tunnel.

Corsmit, A.F., et al. (Driel, M.A. van, Elsenaar, R.J., Hoogenboom, A.M., Sens, J.C. and Hoeff, P. v.d.).
"Structural analysis of bismuth germanate compounds".
CERN/LEP3 Conference Note, February 1984.

Crijns, F., et al. (Metzger, W.J., Pols, C., Spuijbroek, T.).
"A study of high transverse energy interactions of 300 GeV pions and protons on hydrogen using a streamer chamber".
Nucl. Phys. B234 (1984) 1.

Daum, C., et al. (Hertzberger, L., Hoogland, W., Peters, S., Deurzen, P. van).
"Evidence for a non-$q\bar{q}$ tensor meson at 1410 MeV produced in the reaction $\pi^-p \rightarrow K_S^0K_S^0n$ at 63 GeV".
Zeitschrift für Physik C23 (1984) 339.

Daum, C., et al.
"Superconducting correction coils for HERA".
J. Phys. Colloq. (France) 45 (1984) C1.267.

Denby, B.J., et al. (Daum, C.).
"Inelastic and elastic photo-production of $J/\Psi(3097)$".
Phys. Rev. Lett. 52 (1984) 795.

Dijkstra, H.
"Measurement of mass and lifetime of hadronically produced charmed F-mesons".
Proceedings of the Nineteenth Rencontre de Moriond (ed. J. Tran Thanh Van), Editions Frontières, Gif-sur-Yvette, France, 1984.

Dorenbosch, J., et al. (Hertzberger, L.).
"Computers bij experimenten in de hoge-energie fysica".
Ned. Tijdschrift voor Natuurkunde A50 (1984) 78.

Dorenbosch, J., et al. (Gosman, D., Hertzberger, L.O., Holthuizen, D.J., Tuynman, F., Vermeulen, J.C.).
"Work in Amsterdam on local intelligence".
Proceedings of the "Symposium on Recent Developments in Computing, Processor and Software Research for High-Energy Physics", Guanajuato, Mexico, May 8-11 1984.

Hari Dass, N.D., et al. (Lauwers, P.G.).
"On the details of the variational investigations of SU(2) Euclidean lattice gauge theories".
Nucl. Phys. B235 (1984) 535.

Hari Dass, N.D., et al. (Patkos, A. and Lauwers, P.G.).
"On the presence of lower dimensional confinement mechanisms in 4-d SU(2) gauge theory".
Phys. Lett. 136B (1984) 395.

Hartjes, F.G.
"Recent drift chamber calibrations".
Proceedings of the meeting on laser ionization in gases, University of Glasgow (UK) February 28 1984.

Hertzberger, L.O., Tuynman, F., Vermeulen, J.C.
"Portable Software for microprocessor systems".
Proceedings of the General Assembly of the ESONE committee, Legnano/Padova, 27-28 september 1984.

Linssen, L.
"Results from PS 172".

Proceedings of the 7th European Symposium on Antiproton Interactions, Durham (UK), July 9-13 1984.

Mazzo, C. de, et al. (Crijns, F., Kittel, W., Metzger, W.J., Pols, C., Spuijbroek, T., Walle, R.T. Van de).
A study of high transverse energy interactions of 300 GeV pions and protons on hydrogen using a streamer chamber".
Nucl. Phys. B234 (1984) 1.

Mazzo, C. de, et al. (Crijns, F., Kittel, W., Metzger, W.J., Pols, C., Spuijbroek, T., Walle, R.T. Van de).
"Dependence of multiplicity and rapidity distributions on the number of projectile collisions in 200 GeV/c proton-nucleus interactions".
Phys. Rev. D29 (1984) 2476.

Mazzo, C. de, et al. (Crijns, F., Kittel, W., Metzger, W.J., Pols, C., Spuijbroek, T., Walle, R.T. Van de).
"Measurement of the average transverse momentum and of the pion-emission volume in proton-nucleus and anti-proton-nucleus reactions at 200 GeV".
Phys. Rev. D29 (1984) 363.

Ruckstuhl, W., et al. (Bos, K.).
"Precision measurement of the 2p-1s transition in muonic 12C: Search for new muon-nucleon interactions or accurate determination of the rms nuclear charge radius".
Nucl. Phys. A430 (1984) 685.

Sens, J.
"Production of leptons and hadrons in photon photon interactions in the PEP9/PEP4 detector".
Proceedings of the XIXth Rencontre de Moriond, March 4-10 1984.

Sijacki, D., et al.
"Maximal supergravity".
Frontiers in Particle Physics 83;
Proc. of the Adriatic Meeting on Particle Physics (eds. Bilic, N., Dragov, C.B.), Dubrovnik (Yugoslavia), June 15 **1983**.

Summers, D.J., et al. (Daum, C.).
"Study of the decay $D^0 \rightarrow K^-\pi^+\pi^0$ in high-energy photoproduction".
Phys. Rev. Lett. 52 (1984) 410.

Swol, R. van.
"Total Cross Section of $\bar{p}p$ Collisions".
Proceedings of Joint Spring Meeting on Elementary Particle Physics, Bielefeld, April 2-4, 1984.

Timmermans, J.
"Elastic scattering and Total Cross Section at the CERN SPS Collider".
Proceedings of XXII International Conference on High Energy Physics, Leipzig, July 19-25, 1984.

Timmermans, J. et al. (The UA4 Collaboration).
"Elastic $\bar{p}p$ scattering at a centre-of-mass energy of 540 GeV".
Proceedings of the Third Moriond Workshop - CNRS (Ed. Tran Than Van, J.), **1983**.

Vermaseren, J., et al. (Neerven, W. van).
"Large loop integrals".
Phys. Lett. 137B (1984) 241.

Vermaseren, J., et al. (Neerven, W. van).
"Radiative corrections to two photon physics".
Nucl. Phys. B238 (1984) 73.

Vermaseren, J., et al. (Neerven, W. van).
"The role of the five-point function to radiative corrections to two-photon physics".
Phys. Lett. 142B (1984) 80.

Wit, B. de, et al. (Nicolai, H.).
"A new SO(7) invariant solution of d=11 supergravity".
Phys. Lett. 148B (1984) 60.

Wit, B. de, et al. (Lauwers, P.G., Philippe, R., Su, S.Q. and Proeyen, A. Van).

"Gauge and matter fields coupled to n=2 supergravity".
Phys. Lett. 134B (1984) 37.

Wit, B. de.
"Gauged N=8 supergravity in d=11 dimensions".
Proceedings of the Eighth Johns Hopkins Workshop on Current Problems in Particle Physics, Johns Hopkins University, Baltimore, June 20-22 1984.

Wit, B. de.
"Introduction to supergravity".
Proceedings of the Trieste Spring School on Supersymmetry and Supergravity, April 4-14 1984, 1984, ed. Wit, B. de and Nieuwenhuizen, P. van.

Wit, B. de, et al. (Lauwers, P. and Philippe, R. a.o.).
"Noncompact N=2 supergravity".
Phys. Lett. 135B (1984) 295.

Wit, B. de, et al. (Nicolai, H.).
"On the relation between d=4 and d=11 supergravity".
Nucl. Phys. B243 (1984) 91.

Wit, B. de, et al. (Proeyen, A. Van).
"Potentials and symmetries of general gauged n=2 supergravity Yang-Mills models".
Nucl. Phys. B245 (1984) 89.

Wit, B. de, et al. (Nicolai, H.).
"The parallelizing S^7 torsion in gauged N=8 supergravity".
Nucl. Phys. B231 (1984) 506.

Wolf, E.A. de, et al. (Gatignon, L., Stergiou, A., Walle, R.T. Van de).
"Inclusive baryon production in K^+p interactions at 70 GeV/c".
Nucl. Phys. B246 (1984) 431.

Section-K, publications

J.F.M. d'Achard van Enschut, J.B.R. Berkhout, W. Duinker, C.W.E. van Eijk, W.H.A. Hesselink, T. Johansson, T.J. Ketel, J.H. Koch, J. Konijn, C.T.A.M. de Laat, W. Lourens, G. van Middelkoop, W. Poeser.
"Anomalous strong interaction shifts and widths of the 3d state in pionic Pt and Au".
Phys. Lett. 136B (1984) 24.

L.T. van der Bijl, H. Blok, H.P. Blok, R. Ent, J. Heisenberg, O. Schwentker, A. Richter, P.K.A. de Witt Huberts.
"Electro-excitation of the 1^+ state at Ex = 3.486 MeV in ^{88}Sr".
Nucl. Phys. A423 (1984) 365.

H. Blok, H.P. Blok, J.F.A. van Hienen, G. van der Steenhoven, C.W. de Jager, H. de Vries, A. Saha, K.K. Seth.
"Contribution of $2\hbar\omega$ transitions to the excitation of 0^+ states in ^{58}Ni and ^{26}Mg in inelastic electron scattering".
Phys. Lett. 149B (1984) 441.

F.W.N. de Boer, R. van Dantzig, M. Daum, J. Jansen, P.J.S. Watson, L. Felawka, C. Grab, A. van der Schaaf, T. Kozlowski, J. Martino, A.I. Smirnov.
"Search for bound states of neutrons and negative pions".
Phys. Rev. Lett. 53 (1984) 423.

D. Brandt, J. Langelaar, J.D.W. van Voorst.
"Coherente anti Stokes Raman spectroscopie; principe en toepassingen".
Ned. Tijdschrift voor Natuurkunde A50 (1984) 23.

G.A. Brinkman.
"Reactions of radioactive recoil atoms with (halo)methanes".
Chem. Rev. 84 (1984) 299.

V. Brückner, E.A.J.M. Bente, J. Langelaar, D. Bebelaar, J.D.W. van Voorst.
"Raman echo on a picosecond time scale in nitrogen gas".
Optics Commun. 51 (1984) 29.

J.D. Davies, T.P. Gorringe, J. Lowe, J.M. Nelson, S.M. Playfer, G.J. Pyle, G.T.A. Squier, C.A. Bakker, C.J. Batty, S.A. Clark, S. Sakamoto, R.E. Welsh, R.G. Winter, E.W.A. Lingeman.
"Measurement of strong interaction effects in antiprotonic helium atoms".
Phys. Lett. 145B (1984) 319.

J.H.J. Distelbrink, E. Kok, H. Blok, J.L. Visschers, P.K.A. de Witt Huberts.
"A fast and flexible focal-plane detection system for electron scattering experiments".
Nucl. Instr. Meth. 220 (1984) 433.

A.J.H. Donné, G. van Middelkoop, L. de Vries, L. Lapikás, J.B. van der Laan, C. de Vries, J.G. Noomen.
"The 180° electron-scattering facility at NIKHEF-K".
Nucl. Instr. Meth. 224 (1984) 97.

P.C. Dunn.
"A charged pion detection system with large electron suppression".
Nucl. Instr. Meth. 224 (1984) 106.

T. de Forest, Jr.
"Electromagnetic interactions of nucleons in nuclei".
Workshop on 'Perspectives in Nuclear Physics at Intermediate Energies', Trieste, 1983, S. Boffi et al., eds., World Scientific Press, Singapore (1984), p.293.

T. de Forest, Jr.
"The relativistic Coulomb sum rule for electron scattering in the independent-particle model".
Nucl. Phys. A414 (1984) 347.

G. Fournier, A. Gérard, J. Miller, J. Picard, B. Saghai, P. Vernin, P.Y. Bertin, B. Coupat, E.W.A. Lingeman, K.K. Seth.
"Differential cross section for elastic π^+He isotopes scattering from 25 to 65 MeV".
Nucl. Phys. A426 (1984) 542.

C. Gaarde, J.S. Larsen, H. Sagawa, N. Ohtsuka, J. Rapaport, T.N. Taddeucci, C.D. Goodman, C.C. Foster, C.A. Goulding, D. Horen, T. Masterson, E. Sugarbaker.
"Spin-dipole strength in ^{12}N".
Nucl. Phys. A422 (1984) 189.

D. de Jong, G.A. Brinkman, B.W. van Halteren.
"Chemical effects of the 76,77Kr → 76,77Br decay in fluoromethanes".
Radiochimica Acta 35 (1984) 185.

D. de Jong, G.A. Brinkman, B.W. van Halteren.
"Chemical effects of the 76,77Kr → 76,77Br decay in gaseous propane and cyclopropane".
Radiochimica Acta 34 (1984) 93.

J.H. Koch, E.J. Moniz, N. Ohtsuka.
"Nuclear photoabsorption and Compton scattering at intermediate energy".
Annals of Physics 154 (1984) 99.

J.H. Koch.
"The Δ-hole approach to intermediate energy photonuclear reactions".
Proceedings of the Fourth Course of the International School of Intermediate energy nuclear physics, San Miniato, Italy, August 19-28, 1983; R. Bergere, S. Costa, C. Schaerf (eds.), World Scientific, Singapore, 1984, 339.

J. Korsse, P.W.F. Louwrier, J.N. Louwen, A. Oskam.
"Redox potentials of the aquo, cyano and EDTA complexes of some transition metal ions by CNDO calculations".
Inorg. Chim. Acta 88 (1984) 67.

J. Langelaar, R.P.H. Rettschnick.
"Laser-spectroscopie aan s-tetrazine".
Ned. Tijdschrift voor Natuurkunde A50/1 (1984) 15.

J. Langelaar, D. Bebelaar, R.P.H. Rettschnick.
"Photodissociation of s-tetrazine and vibrational predissociation processes of its argon van der Waals complexes".
K.B. Eisenthal, Appl. of Picosecond Spectroscopy to Chemistry (1984) 293-313 by D. Reidel Publ. Company.

J. Langelaar.
"Spectroscopy and vibrational predissociations of van der Waals complexes".
Proceedings of the IIIrd International School on Laser Applications in Atomic, Molecular and Nuclear Physics, Vilnius, USSR, September 1984.

L. Lapikás, P.K.A. de Witt Huberts.
"Excitation of nuclear hole states by the (e,e'p) reaction".

Proceedings of the International Symposium on Highly excited states and nuclear structure, Orsay, France, Sept. 5-8, 1983. N. Marthy, Nguyen Van Giai (eds.), Journal de Physique, Colloquia 45 (1984) C4-57.

P.W.F. Louwrier, G.A. Brinkman.
"Spectroscopie de muon".
JECR, 1984. Mont Saint-Odile, July 12-15, 1984; Proc. d'étude sur la chimie des radiations, CNRS, Soc. Française de Chimie, 1984, 1.

P.J. Mulders.
"Solitons and Chiral bag models; Solitons in nuclear and elementary particle physics".
Proceedings of the Lewes Workshop, June 2-16 1984 (eds. A. Chodos, E. Hadjimichael, C. Tze), World Scientific Publ. Co., Singapore, 1984, 158.

J.G.J. Olivier, M. Thies, J.H. Koch.
"Anomalous widths in pionic atoms and the problems of s-wave repulsion".
Nucl. Phys. A429 (1984) 477.

P. Polak, et al. (L. Lindner).
"Liquid scintillation β spectroscopy".
Radiochimica Acta 35 (1984) 23.

H. Postma, et al. (J.P. Boogaard, P.H.M. Keizer, L. Prins, P.K.A. de Witt Huberts).
"A higher power liquid ^{3,4}He target system for electron scattering experiments".
Nucl. Instr. Meth. A219 (1984) 292.

B.S.M. Rao, et al. (G.A. Brinkman, J.Th. Veenboer).
"Reactions of recoil T atoms with chloroanilines".
Radiochimica Acta 35 (1984) 57.

B.S.M. Rao, et al. (G.A. Brinkman, J.Th. Veenboer).
"Reactions of recoil Cℓ atoms with chloroanilines".
Radiochimica Acta 35 (1984) 61.

E. Roduner, et al. (G.A. Brinkman, P.W.F. Louwrier).
"Muonium-substituted organic free radicals in liquids. Isomer distributions and end-of-track radiolytical processes determined from studies of cyclohexadienyl radicals derived from substituted benzenes".
Chem. Phys. 88 (1984) 143.

E. Roduner, et al. (G.A. Brinkman, P.W.F. Louwrier).
"Rate constants for the reactions of cyclohexadienyl type radicals with quinones".
Hyperfine Interactions 17-19 (1984) 797.

E. Roduner, et al. (G.A. Brinkman, P.W.F. Louwrier).
"Relative rate constants for the formation of muonic radicals in liquid aromatic systems".
Hyperfine Interactions 17-19 (1984) 803.

P. Stoler, et al. (P.F. Yergin, A. Farah, P.C. Dunn, P.K.A. de Witt Huberts, A. Kaarsgaarn, J. Koch, B. Schoch).
"A measurement of the photopion reaction $^{13}C(\gamma,\pi^-)^{13}N_{g.s.}$ at a pion kinetic".
Phys. Lett. 143B (1984) 69.

G.W.M. Visser, et al. (B.W. van Halteren, J.D.M. Herscheid, G.A. Brinkman, A. Hoekstra).
"Reaction of acetyl hypofluorite with aromatic Mercury compounds: a new selective fluorination method".
J. Chem. Soc., Chem. Commun. (1984) 655.

C. de Vries, C.W. de Jager, P.K.A. de Witt Huberts.
"Dieper graven in de kernmaterie".
FOM Jaarboek 1982, Stichting voor Fundamenteel Onderzoek, 167.

C. de Vries, C.D. de Jager, L. Lapikás, G. Luijckx, R. Maas, H. de Vries, P.K.A. de Witt Huberts.
"The 500 MeV electron-scattering facility at NIKHEF-K".
Nucl. Instr. Meth. 223 (1984) 1.

J. Visser.
"Radioactiviteit. Radioactiviteit als natuurkundig verschijnsel. Feiten en misverstanden. Gevaarlijk of niet?".
AULA Pocket 730; het Spectrum, Utrecht, etc. 1984.

I.2 Contributions to conferences

Section-H

American Physical Society Meeting at Washington DC (U.S.), April 23-26, 1984

Buijs, A., et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, H.P. Paar, J.C. Sens, B.K. van Uitert).
"Observation of single tagged $\phi\pi^+\pi^-$ and $\rho\pi^+\pi^-$ events in photon-photon collisions at PEP".

Kwong, K.K., et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, H.P. Paar, J.C. Sens, B.K. van Uitert).
"The study of ε tagged gamma gamma $\rightarrow \pi^+\pi^-$ at PEP".

Langeveld, W.G.J., et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, H.P. Paar, J.C. Sens, B.K. van Uitert).
"Study of resonance formation in the $\pi^+\pi^-$, K^+K^- and $p\bar{p}$ channels in photon-photon collisions at PEP".

Lindsey, C.S., et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, H.P. Paar, J.C. Sens, B.K. van Uitert).
"Exclusive four charged particle final states in untagged $\gamma\gamma$ events at PEP".

McNeil, R.R., et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, H.P. Paar, J.C. Sens, B.K. van Uitert).
"Study of the exclusive hadron pair continuum in photon-photon interactions with non-zero Q^2 at PEP".

Schwitkis, K.A., et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, H.P. Paar, J.C. Sens, B.K. van Uitert).
"Observation of single tagged η' and A2 resonance from two photon production at PEP".

Uitert, B.K. van, et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, H.P. Paar, J.C. Sens, B.K. van Uitert).
"Study of $\eta' \rightarrow \pi^+\pi^-\gamma$ in untagged photon-photon collisions at PEP".

APS-Meeting, Santa Fe (U.S.), September 6-8, 1984

Crystal Ball Collaboration.
"Latest results from the Crystal Ball".

XVth International Symposium on Multiparticle Dynamics, Lund (Sweden), June 10-16, 1984

EHS-NA22 Collaboration.
"Multiple collisions inside nuclei in π^+ and K^+ interactions with Aℓ and Au nuclei at 250 GeV/c".

Crystal Ball Collaboration.
(1) "Evidence for a narrow massive state in the radiative decays of the upsilon".
(2) "Exclusive cascades from the ϒ(2S)".
(3) "Two photon results from the Crystall Ball".

6th Vanderbilt Symposium on High Energy e^+e^- Interactions, Nashville (Tennessee, U.S.), April 5-7, 1984

Crystal Ball Collaboration.
"Radiative Transitions from the ϒ(2S)-Resonance".

Physics in Collision IV, Santa Cruz, August 22-23, 1984

Paar, H.P.
"New experimental Results in Two-Photon Physics".
Invited contribution.

Workshop Physics at LEAR with Low-Energy Cooled Antiprotons, Erice (Italy), May 9-12, 1982

Bailey, J., et al. (Blokzijl, R., Bos, K., Kluyver, J.C., Konijn, J., Linssen, L.).
(1) "A polarized antiproton beam at LEAR".
(2) "Status report on experiment PS 172".
Proceedings, 1984 Plenum Press, New York / London, 455, 427 resp.

The VI International Workshop on Photon-Photon Collisions, Tahoe (U.S.), September 10-13, 1984

Bintinger, D., et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, F.L. Linde, H.P. Paar, J.C. Sens, B.K. van Uitert).
"Total Hadronic Cross Section in Photon-Photon Collisions".

Buijs, A., et al. (M.A. van Driel, F.C. Erné, W.G.J. Langeveld, F.L. Linde, H.P. Paar, J.C. Sens, B.K. van Uitert).
"Investigation of $\gamma\gamma \to 2\pi^+ 2\pi^-$ at 2.9-3.7 GeV".

Lindsey, C.S., et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, F.L. Linde, H.P. Paar, J.C. Sens, B.K. van Uitert).
"Study of $\gamma\gamma$ to four charged particles at PEP".

McNeil, R.R., et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, F.L. Linde, H.P. Paar, J.C. Sens, B.K. van Uitert).
"Study of exclusive proton-antiproton pair production in photon-photon interactions at $Q^2 \neq 0$ at PEP".

Smith, J.R., et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, F.L. Linde, H.P. Paar, J.C. Sens, B.K. van Uitert).
"Study of ee $\to$ eeX; hadrons via $\gamma\gamma$ interactions".

XXIIth International Conference on High Energy Physics, Leipzig (DDR), July 19-25, 1984

Bailey, R., et al. (Daum, C., Rijk, G. de, Dijkstra, H., Hardwick, C., Hoogland, W., Tiecke, H., Wiggers, L.).
(1) "Measurement of mass and lifetime of hadronically produced charmed F mesons".
(2) "Measurement of the lifetime of charged and neutral D mesons with high resolution silicon strip detectors".

Crystal Ball Collaboration.
(1) "Evidence for a narrow massive state in the radiative decays of the upsilon".
(2) "Two photon results from the Crystal Ball".
(3) "Exclusive cascades from the $\Upsilon(2S)$".

WA25 Collaboration.
(1) "Q -dependence of the proton and neutron structure functions from νD and $\bar{\nu} D$ scattering".
(2) "Transverse momentum of charged hadrons produced in neutrino and anti-neutrino deuterium charged current interactions".
(3) "An investigation of the EMC effect using anti-neutrino interactions in deuterium and Neon".

EHS-NA22 Collaboration.
"Multiple collisions inside nuclei in π^+ and K^+ interactions with Aℓ and Au nuclei at 250 GeV/c".

J.G. Layter et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, H.P. Paar, J.C. Sens, B.K. van Uitert)
(1) "Exclusive production of $\pi^+\pi^-\pi^+\pi^-$ and $\pi^+\pi^-K^+K^-$ in photon-photon collisions".
(2) "Study of f^0 formation and its decay into $\pi^+\pi^-$ in photon-photon collisions at PEP".

H.P. Paar et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld, J.C. Sens, B.K. van Uitert)
"Measurement of the hadronic photon-photon cross section in a double tagged experiment".

S.J. Yellin et al. (A. Buijs, M.A. van Driel, F.C. Erné, W.G.J. Langeveld,

H.P. Paar, J.C. Sens, B.K. van Uitert)
"Study of η' formation in photon-photon collisions at PEP".

1983 International Symposium on lepton and photon interactions at high energies, Cornell (U.S.), August 4-9

WA25 Collaboration.
(3) "Measurement of the neutral current coupling constants in ν and $\bar{\nu}$ interactions with deuterium".
(1) "Measurement of the neutron and proton structure functions with ν and $\bar{\nu}$ scattering in deuterium".
(4) "Measurement of the ν_μ and $\bar{\nu}_\mu$ – nucleon charged current total cross sections and the ratio of ν_μ neutron to ν_μ proton charged current total cross sections".
(2) "Transverse momentum of charged hadrons in ν and $\bar{\nu}$ charged current interactions on a deuterium target".

IX International Workshop on weak interactions and neutrinos, Talloires (France), 4 – 10 September 1983

WA25 Collaboration.
"A comparison of charged current differential cross sections for $\bar{\nu}$ interactions on deuterium and neon".

Section-K, contributions to conferences

BUTG Workshop on 'Nucleon and Nuclear Structure and Exclusive Electromagnetic Reaction Studies', MIT, USA, July 23 – 24 1984

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

Gordon Conference on Photonuclear Reactions, New Hampshire, USA, July 16 – 20 1984

E. Jans.
"High-resolution (e,e'p) experiments at NIKHEF-K".

International Conference on Nuclear Radiochemistry, Lindau, October 7 – 13 1984

L. Lindner, P. Polak.
"Production of ^{32}Si and ^{67}Cu with medium energy accelerators".

E. Roduner, G.A. Brinkman, P.W.F. Louwrier.
"Determination of reaction rates of muonium with arenes and of muonic radicals with quinones".

International Symposium on Nuclear Shell Models, Drexel University, Philadelphia, USA, October 31 – November 3 1984

C.W. de Jager.
"Inelastic electron scattering as a test of the IBA".

International Workshop on Interacting B-B and B-Fermion Systems, Gull Lake, USA, May 28 30 1984

C.W. de Jager.
"Inelastic electron scattering as a test of the IBA".

NNV – Spring meeting, (Nijmegen), April 26 1984

J.F.M. d'Achard van Enschut, J.B.R. Berkhout, W. Duinker, C.W.E. van Eijk, W.H.A. Hesselink, T.J. Ketel, J.H. Koch, J. Konijn, C.T.A.M. de Laat, W. Lourens, G. van Middelkoop, W. Poeser, T. Prins, A. Taal, A.H. Wapstra.
"Anomalous shifts and widths in pionic atoms of Mg, Aℓ, Pt, Au", (p.42).

H.P. Blok, A.M. Selig, P.K.A. de Witt Huberts, J.E. Zacharov.
"Electroexcitation of Yrast 2^+, 4^+, 6^+ states in ^{50}Ti", (p.41).

R.J.M. Bonnie, P.W.M. Glaudemans, C.W. de Jager, H. de Vries.
"Electroexcitation of natural parity states in ^{11}B", (p.41).

W.T.A. Borghols, M.N. Harakeh, C.W. de Jager, J.B. van der Laan, S.Y. van der Werf.
"Electron scattering from ^{196}Pt", (p.41).

J. van der Brand, J.W. den Herder, E. Jans, A. Kaarsgaarn, P.H.M. Keizer, L. Lapikás, E.M.N. Quint, P.K.A. de Witt Huberts, H.P. Blok, G. van der Steenhoven.
"High-resolution (e,e'p) coincidence experiments at NIKHEF-K", (p.43).

A.J.H. Donné, G. van Middelkoop, L. de Vries, L. Lapikás, A.M. Selig, P.K.A. de Witt Huberts, J.E. Zacharov.
"Elastic magnetic electron scattering from ^{18}F and ^{49}Ti", (p.43).

W. Duinker, J. Elfrink, W.H.A. Hesselink, J. Jansen, J. Konijn, J. Penninga, W. Poeser, H. Riezebos, A. Stolk, M.J.A. de Voigt.
"An anti-Compton multi-detector system for gamma-ray spectroscopy", (p.42).

P.C. Dunn, A. Farah, A. Kaarsgaarn, J.H. Koch, B. Schoch, P. Stoler, P.F. Yergin, P.K.A. de Witt Huberts.
"The photopion reaction $^{13}C(\gamma,\pi^-)^{13}N$ at pion kinetic energy of 50 MeV", (p.40).

R. Ent, J.F.A. van Hienen, C.W. de Jager, E. Offerman, H. de Vries.
"Excitation of stretched states in the $^{51}V(^3He,d)^{52}Cr$ reaction", (p.43).

S. Muller, F.-G. Kuchler, A. Richter, H.P. Blok, H. Blok, H. de Vries, C.W. de Jager.
"High-resolution inelastic electron scattering and the isoscalar nature of the M1-transition to the 5.846 MeV state in ^{208}Pb", (p.41).

PANIC, Particles and Nuclei, Tenth International Conference, Heidelberg, July 30 - August 3 1984

J.F.M. d'Achard van Enschut, J.B.R. Berkhout, W. Duinker, C.W.E. van Eijk, W.H.A. Hesselink, J.P. van der Hoek, T.J. Ketel, J.H. Koch, J. Konijn, C.T.A.M. de Laat, W. Lourens, G. van Middelkoop, W. Poeser, T. Prins, A. Taal, A.H. Wapstra.
"Anomalous strong interaction in pionic atoms of Mg and Aℓ", (contr. L6).

J.F.M. d'Achard van Enschut, P. David, W. Duinker, C. Gugler, J. Hartfield, H. Janszen, J. Konijn, T. Krogulski, C.T.A.M. de Laat, T. Mayer-Kuckuck, R. von Mutius, C. Petitjean, S.M. Polikanov, H.W. Reist, L.A. Schaller, L. Schellenberg.
"Pionic and muonic X-ray studies of ^{237}Np", (contr. L7).

C.A. Baker, C.J. Batty, S.A. Clark, J.P. Davies, T.P. Goringe, E.W.A. Lingeman, J. Lowe, J.M. Nelson, S.M. Playfer, G.J. Pyle, S. Sakamoto, G.T.A. Squier, R.E. Welsh, R.G. Winter.
"Measurement of strong interaction effects in antiprotonic He-atoms", (contr. L3).

C.A. Baker, C.J. Batty, S.A. Clark, J.P. Davies, T.P. Goringe, E.W.A. Lingeman, J. Lowe, J.M. Nelson, S.M. Playfer, G.J. Pyle, S. Sakamoto, G.T.A. Squier, R.E. Welsh, R.G. Winter.
"X-rays from antiprotonic hydrogen and deuterium", (contr. L4).

L. Lapikás.
"Recent results of high-resolution (e,e'p) experiments at NIKHEF-K".

12th International Hot Atom Conference, Balaton, Hungary, September 25 - 29 1984

E. Roduner, G.A. Brinkman, P.W.F. Louwrier.
"Reactions of muonium with aromatic compounds".

J.Th. Veenboer, G.A. Brinkman.
"Selectivity in thermal $^{34m}Cℓ$-for-Cℓ exchange in substituted chlorobenzenes".

Invited talks at conferences, NIKHEF-K

C. de Vries:
"Future developments at NIKHEF-K, Amsterdam".
'Perspectives in Nuclear Physics at Intermediate Energies', Trieste, March 25 1984.

P.K.A. de Witt Huberts:
"High-resolution (e,e'p) experiments".
'Perspectives in Nuclear Physics at Intermediate Energies', Trieste, March 25 1984.

P.K.A. de Witt Huberts:
"High-momentum components and (e,e'p) reactions".
International School on Nuclear Physics, Erice, Italy, April 8–20, 1984.

C. de Vries:
"High-resolution coincidence experiments with intermediate energy electron beams".
Europhysics Conference on Nuclear Reactions, Crete, June 24 – July 7, 1984.

P.W.F. Louwrier:
"Spectroscopie du muon".
Journées d'Etudes sur la chimie des radiations, Mont Sainte Odile, June 1984.

T. de Forest, Jr.:
"Nuclear medium effects and (e,e'N)".
BUTG Workshop on 'Nucleon and nuclear structure and exclusive electromagnetic reaction studies', July 1984.

P.K.A. de Witt Huberts:
"Excitation of Nuclear Hole States by the (e,e'p) reaction".
HEHANS, Orsay, September 5 – 8, 1984.

G.A. Brinkman:
"New results in hot atom chemistry by liquid organic compounds".
12th Int. Hot Atom Conference, Balaton, Hungary, September 1984.

P.J. Mulders:
"Hybrid bags and topological solitons".
Workshop on 'Electron and photon interactions at medium energies', Bad Honnef, October 1984.

G. van Middelkoop:
"Single-particle aspects of nuclei";
"Pion-nucleus interactions at low energies".
International School on Atomic and Nuclear Physics, Poiana Brasov (Rumania), September 1984.

I.3 Ph.D. Theses

Section-H

Linders, P.W.J.
"Mass determination based on electron scattering in electron probe x-ray micro-analysis of thin biological specimens".
(October 18 1984, Catholic University Nijmegen KUN).

Barlag, S.J.M.
"Quasi-elastic interactions and one-pion production by neutrinos and anti-neutrinos on a deuterium target".
(April 18 1984, University of Amsterdam UvA).

I.4 Internal Reports, Section-H,

NIKHEF-H -Scientific- Reports

#1 A. van Inge.:
Vertical position determination in the SING LEAR experiment.
#2 W.L van Neerven, J.A.M. Vermaseren:
The role of the five-point function in radiative corrections to two photon

physics.

#3 J.J. van der Bij:
Two-loop large Higgs-mass correction to vector boson masses.

#4 A. Van Proeyen, B. de Wit:
Potentials and symmetries of general gauged N=2 supergravity - Yang Mills models.

#5 G.F. Wolters.
Comment on the electric potentials of the nucleon.

#6 B. de Wit:
Introduction to supergravity.
Lectures given at the 1984 Spring School on Supersymmetry and Supergravity, Trieste, April 4-14, 1984.

#7 Joseph I. Kapusta, Vladimir Višnjić:
$\pi^{+}-\pi^{0}$ Mass Difference at Finite Temperature.

#8 L.O. Hertzberger, F. Tuynman:
A distributed real-time operating system.

#9 J. Dorenbosch, D. Gosman, L.O. Hertzberger, D.J. Holthuizen, F. Tuynman, J.C. Vermeulen:
Work in Amsterdam on local intelligence.
Contribution to "Recent Developments in Computing, Processor, and Software Research for High-Energy Physics", Guanajuato, Mexico, May 8-11, 1984.

#10 Iris Abt, Bob Jongejans:
An absolute calibration of the solid state detectors in the narrow band neutrino beam at CERN.

#11 Hari Dass, N.D.:
Lattice Theory for Nonspecialists.
Lecture notes.

#12 Hari Dass, N.D.:
On the analytical evaluation of the partition function for unit hypercubes in four dimensions.

#13 Hari Dass, N.D.:
Variational estimates for the mass gap of SU(2) Euclidean lattice gauge theory.

#14 Remarks on nucleon-nucleon hard scattering.
Contribution to the Second Workshop on High Energy Spin Physics, Serpukhov, U.S.S.R., October 1984.

#15 J.J. van der Bij:
Two-loop large Higgs mass corrections to vector boson self-couplings.

#16 H.P. Paar:
New experimental results in two-photon physics.

DELPHI Publications (DELPHI internal reports):

Koene, B.:
Performance of the Liquid RICH End Cap.
DELPHI 83-70.

Ypma, T.J.:
Influence of fiber fraction and fiber orientation on modulus of elasticity and expansion coefficient of composite materials.
DELPHI 84-19 GEN-6.

Udo, F.:
Proposal for a first level trigger.
DELPHI 84-31.

Stergiou, S.:
The effects of off-energy electrons in DELPHI.
DELPHI 84-32.

Udo, F.:
The second level trigger of DELPHI.
DELPHI 84-35.

LEP3/CERN Conference Note

Corsmit, A.F., et al. (Driel, M.A. van, Elsenaar, R.J., Hoogenboom, A.M., Sens, J.C. and Hoeff, P. v.d.):
Structural analysis of bismuth germanate compounds.
CERN/LEP3 Conference Note, February 1984.

Max Planck Publication

Paus, F., et al. (Daum, C., Hoogland, W.):
Forward particle production in $\pi^{-}p$ and $K^{-}p$ collisions at 58 GeV/c and comparison with quark models.

MPI-PAE/Exp.El.143, November 1984.

SLAC Publication

Bobbink, G.J. et al. (Linde, F.L., Sens, J.C.):
Performance of BGO in a high radiation environment.
SLAC-pub-3339, May 1984.

Preprints, Section-K

#1 M. van der Ley, B.W. van Halteren, G.A. Brinkman:
Photonuclear production of ^{18}F from F, Ne and (metallic) Na.
Submitted to Int. J. Appl. Rad. Isot.

#2 T. Takaki, T. Suzuki, J.H. Koch:
Photoproduction of neutral pions to discrete nuclear states.

#3 P.J. Mulders:
Theoretical description of the N$\bar{N}$ interaction.
Invited talk at the Third LEAR Workshop, Tignes, France.

#4 J.F.M. d'Achard van Enschut, J.B.R. Berkhout, W. Duinker, C.W.E. van Eijk, W.H.A. Hesselink, P.J. van den Hoek, T.J. Ketel, J.H. Koch, J. Konijn, C.T.A.M. de Laat, W. Lourens, G. van Middelkoop, W. Poeser, T. Prins, A. Taal, A.H. Wapstra:
Anomalous strong interaction in pionic Mg.
Submitted to Phys. Lett.

#5 J.H. Koch:
Delta-excitation in nuclei by pions and photons.
Invited talk at the Second Workshop on Perspectives in Nuclear Physics at Intermediate Energies, Trieste (Italy).

#6 J. Bijleveld, S.S. Hasnain, A.P. Kaan, G. Luijckx, P.K. Murray, W. Smith, J.S. Worgan:
A new beam line at the SRS: Line 8. Abstract.
Submitted to Nucl. Instr. Meth.

#7 M.J. van der Hoek, W. Werner, P. van Zuylen, B.R. Dobson, S.S. Hasnain, J.S. Worgan, G. Luijckx:
A slit-less double crystal x-ray monochromator for EXAFS and XANES measurements. Abstract.
Submitted to Nucl. Instr. Meth.

#8 P.J. Mulders:
Change of scale for nucleons in nuclei from quasi-elastic electron scattering.
Submitted to Phys. Rev. Lett.

#9 P. Polak, S.R. Garcia, W.A. Taylor, J. Barnes, L. Lindner, H.A. O'Brien, K.E. Thomas:
A ^{32}Si source from proton spallation of vanadium.
Submitted to Radiochimica Acta.

#10 E.W.A. Lingeman:
The employment of physicists in the Netherlands.
Submitted to Czechoslovak Journal of Physics.

#11 M. Berrada, J.P. Bouquet, M. Epherre, G. Eriksson, T. Johansson, J. Julien, K. Kilian, J. Konijn, T. Krogulski, M. Maurel, E. Monnand, J. Mougey, H. Nifenecker, P. Perrin, S. Polikanov, C. Ristori, G. Tibell:
A search for hypernuclei formation in $\bar{p}$ annihilation on heavy nuclei.
Presented at the LEAR Workshop in Physics in the ACOL Era with Low-energy cooled antiprotons, Tignes.

ADDENDUM II Scientific Lectures

II.1 NIKHEF Section-H, Amsterdam

Rykaczewski, H. (NIKHEF-H):
Hadron production at PETRA.
January 6, 1984.

Leermakers, R. (Amsterdam):
Effective electron mass in finite temperature QED.
Landelijk Seminarium Hoge-Energiefysica,
January 13, 1984.

Mendels, E. (Den Haag):
Power series expansion of Feynman diagrams.
Landelijk Seminarium Hoge-Energiefysica,
January 13, 1984.

Petronzio, R. (CERN):
An overview of QCD.
Landelijk Seminarium Hoge-Energiefysica,
January 13, 1984.

Todorov, I. (Sofia):
Recent applications of conformal invariance to field theory.
Landelijk Seminarium Hoge-Energiefysica,
January 13, 1984.

Tuynman, F. (NIKHEF-H):
Programmeeromgevingen voor special purpose computer systemen.
January 20, 1984.

Saris, F.W. (AMOLF):
Alchemie in de hedendaagse atoomfysica.
Algemeen WCW-colloquium,
January 24, 1984.

Linssen, L. (NIKHEF-H):
Meting van σ_{tot} ($\bar{p}p$) bij LEAR.
January 27, 1984.

Annual Scientific Meeting NIKHEF-H, February 2/3 1984:

Wigmans, M.E.J. (NIKHEF-H): Status report WA25 (D2).

Kunne, R.A. (NIKHEF-H): Status report SING (LEAR).

Koene, B.K.S. (NIKHEF-H): Progress report DELPHI (LEP).

Paar, H.P. (NIKHEF-H): Results from PEP 9.

Meyers, F. (NIKHEF-H (Nijmegen)): Results from NA22 (EHS).

Demarteau, M.W.J.M. (NIKHEF-H): Results from Mark-J (PETRA).

Dijkstra, H.B. (NIKHEF-H): Results from NA11 (ACCMOR).

Timmermans, J.J.M. (NIKHEF-H): Results from UA4 ($p\bar{p}$).

Dorenbosch, J.P. (NIKHEF-H): Results from UA1 ($p\bar{p}$).

Hari Dass, N.D. (NIKHEF-H): Theory projects at NIKHEF-H.

Bergsma, F. (NIKHEF-H): Results from WA18 (CHARM).

Graaf, H. van de (NIKHEF-H): Progress report LEP-3.

Raaymakers, M.C.T. (NIKHEF-H (Nijmegen)): Status of the BGO project.

Driel, M.A. van (NIKHEF-H): Status of the BGO project.

Vermeulen, J.C. (NIKHEF-H): Microprocessor development.

Walk, W. (NIKHEF-H (Nijmegen)): Recent results from Crystal Ball (DORIS).

Hoogland, W. (NIKHEF-H): Status report on the organization and the experimental program of NIKHEF-H.

Wit, B.Q.P.J. de (NIKHEF-H): Physics at very high energies.

Hoogland, W. (NIKHEF-H): Review of high energy accelerator projects.

Daum, C. (NIKHEF-H): Superconducting magnets for present and future accelerators.

Lawson, J.D. (Rutherford): New accelerator techniques.

Weiland, T. (DESY): The wake-field accelerator.

Bij, J.J. van der (NIKHEF-H):
Effecten van zware Higgs-deeltjes bij energie beneden de 90 GeV.
February 10, 1984.

Petcher, D.N. (Bern):
Meson masses in asymptotically free two-dimensional models.
February 15, 1984.

Bais, F.A. (Leiden):
An introduction to the Rubakov-Callan effect.
Landelijk Seminarium Hoge-Energiefysica,
February 17, 1984.

Gross, D. (Paris, Princeton):
Is Quantumgravity predictable?
Landelijk Seminarium Hoge-Energiefysica,
February 17, 1984.

Kleiss, R.H. (Leiden):
Towards a spinor calculus for complicated Feynman diagrams.
Landelijk Seminarium Hoge-Energiefysica,
February 17, 1984.

Veltman, M. (Ann Arbor):
Composite Vector Bosons.
Landelijk Seminarium Hoge-Energiefysica,
February 17, 1984.

Tenner, A.G. (NIKHEF-H):
Elementaire deeltjes in de astronomie.
February 24, 1984.

Inge, A. van (NIKHEF-H):
De positron camera.
March 9, 1984.

Vermeulen, J.C. (NIKHEF-H):
Computer-instrumentatie in de hoge-energiefysica.
March 23, 1984.

Foster, B. (Imperial College):
The TASSO vertex chamber.
March 30, 1984.

Hazewinkel, M. (CWI, Amsterdam):
Experimenten, monsters en symmetrie (in de hedendaagse wiskunde).
Algemeen WCW-colloquium,
April 2, 1984.

Fishbane, P. (NIKHEF-H / University of Virginia):
Threshold nucleon-antinucleon annihilation into mesons.
April 6, 1984.

Chang, K.H. (Ministerie van O&W):
Turbulenties in eerste en tweede geldstroombeleid.
Algemeen WCW-colloquium,
April 10, 1984.

Gaemers, K.J.F. (NIKHEF-H):
Alles wat U altijd al over LEP wilde weten, en niet durfde vragen...•
TAS-colloquium,
April 11 and April 18, 1984.

Vermaseren, J.A.M. (NIKHEF-H):
Radiative corrections in two photon physics.
April 13, 1984.

Barlag, S.J.M. (CERN):
The Asterix experiment.
April 19, 1984.

Schotanus, D.J. (NIKHEF-H (Nijmegen)):
Status van het Crystal Ball experiment.
April 27, 1984.

Swider, G. (NIKHEF-H):

Recent results on QCD from e^+e^- reactions at PETRA.
May 4, 1984.

Hulsman, E. (NIKHEF-H):
Experimentele bepaling van de Kobayashi-Maskawa matrix elementen.
May 11, 1984.

Matthews, P.T. (Cambridge):
Stellar evolution - White dwarfs and black holes.
EPS - lectures,
May 18, 1984.

Dray, T. (Utrecht):
Particle definitions in Robertson-Walker spacetimes.
May 21, 1984.

Hari Dass, N.D. (NIKHEF-H):
Lattice gauge theory.
Academic Training Series,
May 24/28/29/30, 1984.

Dray, T. (Utrecht):
Introduction to Hawking radiation.
May 25, 1984.

Meshkov, S. (US National Bureau of Standards):
Gluonium.
May 25, 1984.

Damme, R. van / Hooft, G. 't (RU Utrecht):
Two-loop anomaly in supersymmetric gauge theories.
June 6, 1984.

Aerts, A. (CERN):
Strangeness and dibaryon physics.
June 7, 1984.

Yang, C.N. (Leiden / Stony Brook):
Multiplicity distributions in particle production at the $p\bar{p}$ collider.
June 8, 1984.

Erné, F.C. (NIKHEF-H):
Recent results from the PEP-4 - PEP-9 two-photon experiment.
June 12, 1984.

Višnjić, V. (Minnesota University):
Strong weak interactions.
June 14, 1984.

Hoogland, W. (NIKHEF-H):
Hadron botsingen bij LEP.
June 15, 1984.

Rindani, S.D. (Madras University):
Modified equivalent-photon approximation for the production of massive spin-one particles.
August 7, 1984.

Bij, J.J. van der (NIKHEF-H):
Massive vector-bosons with non gauge couplings.
August 16, 1984.

Dray, T. (Utrecht):
Gravitational shockwave of the photon.
August 17, 1984.

Schellekens, B. (Stony Brook):
Classical Solutions of higher dimensional Einstein-Yang-Mills equations.
September 4, 1984.

Klinkhamer, F. (UC Santa Barbara):
On non-perturbative structure of the electroweak interactions.
September 28, 1984.

Paar, H.P. (NIKHEF-H):
The experimental determination of the total hadronic cross section of photon-photon

scattering.
September 28, 1984.

Trost, H.-J. (DESY):
Recent results from Crystal Ball.
October 10, 1984.

Panman, J.K. (CERN):
Electroweak neutral currents.
October 15, 1984.

Patkos, A. (Eötvös University, Budapest / CERN):
An improved iterative algorithm for Hamiltonian spectrum calculations o a lattice.
October 16, 1984.

Apeldoorn, G.W. van (NIKHEF-H):
Report on Neutrino-conference Dortmund.
October 19, 1984.

Dam, P.H.A. van (NIKHEF-H):
Report on Leipzig-conference (I).
October 19, 1984.

Kluyver, J.C. (NIKHEF-H):
Report on Leipzig-conference (II).
October 19, 1984.

Burgers, G. (Leiden):
On constructing interactions involving higher-spin massless particles.
Landelijk Seminarium Hoge-Energiefysica,
October 26, 1984.

Jurkiewicz, J. (Utrecht):
Lattice scales from Monte-Carlo measurements: success or failure?
Landelijk Seminarium Hoge-Energiefysica,
October 26, 1984.

Proeyen, A. Van (Leuven):
Geometric structure of N=2 supergravity-matter coupling.
Landelijk Seminarium Hoge-Energiefysica,
October 26, 1984.

Vannucci, F. (LPNHE/CERN):
Searching for decays of heavy neutrinos.
Landelijk Seminarium Hoge-Energiefysica,
October 26, 1984.

Pohl, M. (ETH Zürich):
Parallel computing for large scale scientific dataprocessing - the Loosely Coupled Attached Processor System.
November 2, 1984.

Graaf, H. v.d. (NIKHEF-H):
De muonkamers voor LEP3.
November 16, 1984.

Engelen, J.J. (CERN):
Hard scattering with real photons with the emphasis on deep inelastic Compton scattering.
November 30, 1984.

Bongaarts, P.J.M. (Leiden):
Supergeometry.
Landelijk Seminarium Hoge-Energiefysica,
December 7, 1984.

Grisaru, M.T. (Utrecht/Brandeis):
Covariant supergraphs.
Landelijk Seminarium Hoge-Energiefysica,
December 7, 1984.

Smith, G. (Penn-State):
Search for $N\bar{N}$ states near threshold.
Landelijk Seminarium Hoge-Energiefysica,
December 7, 1984.

Smith, J. (Stony Brook):
A possible way to measure the anomalous magnetic moment of the W-boson?
December 13, 1984.

Meertens, L. (CWI, Amsterdam):
B, een programmeertaal voor personal computing.
Algemeen WCW Colloquium,
December 17, 1984.

Roy, D.P. (Univ. Dortmund / Tata Institute Bombay):
Phenomenology of top quark production at the $\bar{p}p$ collider.
December 21, 1984.

Nijmegen

Janssen, H. (NIKHEF-H (Nijmegen)):
QCD Inequalities among Hadron Masses.
Landelijk Seminarium Hoge-Energiefysica,
March 16, 1984.

Reinders, L.J. (CERN, Genève):
Recent advances in QCD Sum Rules.
Landelijk Seminarium Hoge-Energiefysica,
March 16, 1984.

Swart, J.J. de (Nijmegen):
Exotic Strange Hadrons.
Landelijk Seminarium Hoge-Energiefysica,
March 16, 1984.

Timmers, P. (NIKHEF-Nijmegen):
Parametrization of a Resonance in the Presence of a Multichannel background.
Landelijk Seminarium Hoge-Energiefysica,
March 16, 1984.

II.2 Colloquia held at NIKHEF Section-K

A.H. Wapstra (NIKHEF-K):
De eerste Nobelprijzen in de Astrofysica.
(February 16).

J. Verbaarschot (Heidelberg):
Chaos and Randomness in Nuclear Physics.
(February 21).

B. Metsch (Erlangen):
Pion production in proton-nucleus collisions: a microscopic model.
(March 1).

P.J. Mulders (MIT):
Hitting quarks in the nucleus.
(March 6).

T. Takaki (NIKHEF-K):
The delta-nucleon interaction and pion-nucleus inelastic scattering.
(March 8).

O. Scholten (Michigan State University):
Microscopic calculations for the IBA-model.
(March 15).

J. de Kam (Fokker BV):
The special role of the pion.
(March 20).

J.C. Kluyver (NIKHEF-H):
Antiproton physics at LEAR.
(March 22).

R.S. Hicks (University of Massachusetts):
Isospin mixing determination from inelastic pion scattering and the charge-dependence of the strong interaction.
(March 27).

A.H. Wapstra (NIKHEF-K):
Atoommassatabellen 1983.
(April 12).

B. Norum (University of Virginia):
The continuous electron beam accelerator facility.
(April 19).

W.H.A. Hesselink (Free University, Amsterdam):
Neutron emission following nuclear muon capture.
(May 3).

W. Duinker (NIKHEF-K):
Pionic atoms: absorption and double charge exchange.
(June 7).

P. Decowski (K.F.A. Jülich):
Fast nucleon emission in high-energy alpha scattering from heavy nuclei.
(June 14).

H.L. Hagedoorn (TH-Eindhoven):
Versnelling, energievariatie en energiedefinitie in circulaire versnellers.
(June 21).

A.M. Nathan (University of Illinois):
Photon scattering studies at Illinois.
(June 28).

C. Papanicolas (University of Illinois, Urbana):
(e,e'γ) experiments at Urbana.
(July 26).

B.K. Nefkens (University of California):
Violation of nuclear charge symmetry.
(August 31).

D. Zwarts (University of Utrecht):
Shell-model calculations of 1p-shell nuclei.
(September 13).

R. Kouw (Free University, Amsterdam):
The nuclear current operator and charge conservation.
(September 27).

D. Goutte (Saclay):
A determination of the quadrupole boson densities of Germanium isotopes by inelastic electron scattering.
(October 18).

E. Roduner (University of Zürich):
The positive muon, a probe for fast chemical processes in organic matter.
(November 1).

E. Hermes (SIN, Villigen):
Technical problems of the Sindrum detector.
(November 2).

K. Crowe (Lawrence Berkeley Laboratory):
Non spherical pion sources in relativistic ion collisions on iron at 1.7 GeV/A.
(November 8).

G.J. Wagner (University of Tübingen):
Nature of giant resonances studied with hadronic and electromagnetic probes.
(November 9).

T. Krogulski (University of Warsaw):
A search for heavy hypernuclei at LEAR.
(November 13).

D.F. Jackson (University of Surrey):
Pion interactions in complex molecules.
(November 15).

H. Schneuwly (University of Fribourg):
The formation of exotic atoms and the chemical bond.
(November 15).

J. Wood (Georgia Institute of Technology):
Shape coexistence in nuclei: a new class of low-energy nuclear structure near Z=80, N=104.
(November 22).

H. Baer (LAMPF):
Pion single and double charge-exchange reactions.
(December 5).

E. Henley (University of Washington, Seattle):
Electron scattering as a test of the Weinberg-Salam model.
(December 6).

L.S. Cardman (University of Illinois):
Electron scattering coincidence studies of nuclear structure.
(December 13).

II.3 Scientific lectures outside NIKHEF,

Section-H

Bos, K.
"Physics at LEAR".
Oak Ridge National Laboratory (U.S.), October 24 1984.

Daum, C.
"Hadronic production and decay of charmed particles".
Leningrad Nuclear Physics Institute (U.S.S.R.), October 16 1984.

Dijkstra, H.
"Charm Search in hadron collisions".
Bielefeld (West-Germany), April 2-4 1984.

Dijkstra, H.
"Measurement of mass and lifetime of hadronically produced charmed F-mesons".
Rencontre de Moriond,
La Plagne, Savoie (France), March 4-10 1984.

Duinker, P.
"Resultaten van het MARK-J experiment bij PETRA".
Algemeen Natuurkunde Colloquium KUN,
Nijmegen, April 4 1984.

Duinker, P.
"Laser toepassingen bij een LEP experiment".
Laser Vier Daagse,
Lisse, October 22-25 1984.

Erné, F.C.
"Results on the total hadronic cross section and four prong production in photon-photon interactions".
Stanford Linear Accelerator Center (Cal., U.S.), July 23 / August 2 1984.

Hari Dass, N.D.
"Variational determination of mass gap in SU(2) lattice gauge theory".
University of Amsterdam UvA,
Amsterdam, September 15 1984.

Hari Dass, N.D.
"Gauge field theories on a lattice".
International Symposium on Theoretical Physics,
Bangalore (India), October 20 1984.

Hari Dass, N.D.
"Quantum chromodynamics of lattice gauge theories".
Raman Research Institute,
Bangalore (India), lecture set from November 3 - December 27 1984.

Hari Dass, N.D.
"Field theories on lattice".
Institute of Mathematical Sciences,
Madras (India), November 17-18 1984.

Hartjes, F.G.

"Recent drift chamber calibrations".
University of Glasgow,
Glasgow (U.K.), February 28 1984.

Jansen, H.
"Detectors for experiments in high energy physics".
Huygenslaboratorium,
Leiden, March 12 1984.

Kluyver, J.C.
"Antiproton physics at LEAR".
Kern Versneller Instituut,
Groningen, February 14 1984.

Kluyver, J.C.
"Antiproton-proton experimenten op CERN".
TH-Twente,
Twente, March 7 1984.

Kluyver, J.C.
"Antiproton physics at LEAR".
NIKHEF section-K,
Amsterdam, March 22 1984.

Koene, B.
"Fysica bij de hoogste energieën".
VU Amsterdam,
Amstelveen, September 17 1984.

Kunne, R.A.
"Simon van der Meer en de stochastische koeling".
TH-Twente,
Twente, November 28 1984.

Langeveld, W.G.J.
"Resonance formation in two photon physics".
Lawrence Berkeley Laboratory, Berkeley (U.S.), November 22 1984.

Leeuwen, W.M. van.
"Het gebruik van Apollo personal Work Stations in de elementaire deeltjesfysica".
Groningen, December 14 1984.

Linssen, L.
"Results from PS172".
Durham (U.K.), July 9-13 1984.

Paar, H.P.
"Measurement of the total hadronic cross section in $\gamma\gamma$ collisions".
Stanford Linear Accelerator Center (Cal. U.S.), June 14 1984.

Paar, H.P.
"Physics aspects of the electron-proton collider HERA".
U.C. Davis / October 1984.

Paar, H.P.
"Two Photon physics".
Stanford Linear Accelerator Center (Cal. U.S.), December 1 1984.

Petcher, D.
"Mass gap in a small volume".
University of Amsterdam UvA,
Amsterdam, November 1 1984.

Raaymakers, M.
"First results on growing BGO with the Bridgman method".
CERN, Geneva (Switzerland) January 24 1984.

Sens, J.C.
"BGO in Two-gamma physics".
Lake Tahoe (U.S.), September 10-13 1984.

Sens, J.C.
"Production of leptons and hadrons in photon-photon interactions in the PEP9/PEP4 detector".
Rencontre de Moriond,
La Plagne, Savoie (France), March 4-10 1984.

Sens, J C.
"Radiative Bhabha's as calibration for the LEP3 detector".
CERN, Geneva (Switzerland), September 5 1984.

Swol, R. van.
"Total cross section of $p\bar{p}$ collisions".
Bielefeld (West-Germany), April 2-4 1984.

Timmermans, J.
"Elastic scattering and total cross section at the CERN SPS Collider".
Leipzig (DDR), July 19-25 1984.

Udo, F.
"LEP experiments".
Scand. Phys. Soc.,
Spåtina (Scandinavia), January 12 1984.

Vermaseren, J.
"The role of the five-point function in radiative corrections in 2 photon physics".
$\gamma\gamma$ Seminar,
Paris (France), April 6 1984.

Vermeulen, J.C.
"Work in Amsterdam on local intelligence".
Guanajuato (Mexico), May 8-11 1984.

Walle, R.T. van de.
"Status Papp-smear analysis with BioPEPR".
Lab. Naz. dell'INFN,
Frascati (Italy), February 24.

Invited talks outside NIKHEF,

Section-K

P.K.A. de Witt Huberts:
"Progress in high-resolution (e,e'p) experiments".
Séminaire Générale, Saclay, January 13.

J. Konijn:
"Anomalous strong interaction effects in deeply bound pionic orbits".
Inst. für Strahlen- und Kernphysik, Univ. Bonn, January 26.

J.H. Koch:
"Photonuclear reactions at intermediate energies".
University of Groningen, February 13.

G. van Middelkoop:
"Het binnenste van atoomkernen".
Universities of Groningen and Utrecht, Groningen & Utrecht, February.

L. Lindner:
"Meteorieten; herkenning, herkomst, ontstaan en belang voor de wetenschap".
Teyler's Museum, Haarlem, April 17.

P.J. Mulders:
"Quarks and nuclei - the EMC effect".
University of Nijmegen, July 25.

P.J. Mulders:
"Soliton-quark modellen".
Free University, Amsterdam, September 26.

P.J. Mulders:
"Soliton Bag models".
KVI, Groningen, September 26.

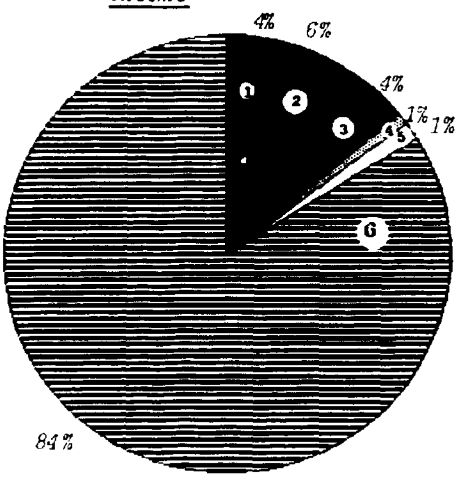
P.K.A. de Witt Huberts:
"Perspectives in heavy-ion and electron physics".
Daresbury, United Kingdom, November 27.

P.J. Mulders:
"Hybrid bags and topological solitons".
University of Karlsruhe, December 3.

ADDENDUM III NIKHEF Budget 1984

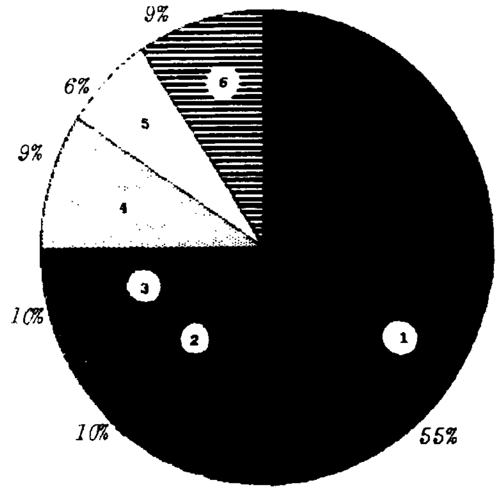
Total 41.2 Mf

Income



(1) - VUA
(2) - KUN
(3) - UvA
(4) - Travel funds
(5) - Contracts
(6) - FOM

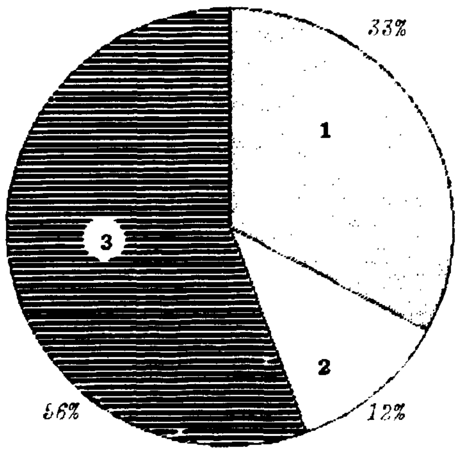
Expenditure



(1) - Personnel
(2) - General casts
(3) - Workshop & Accelerator
(4) - Material research
(5) - Investments
(6) - Electricity

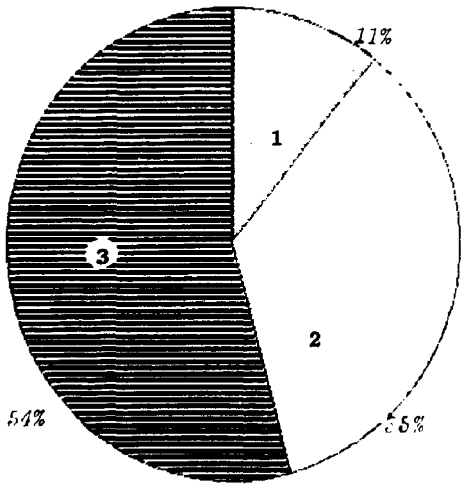
Personnel

Total 330



(1) - Scientists
(2) - Support
(3) - Technical

Scientists 109



(1) - Post-doc
(2) - Junior (PhD)
(3) - Senior

ADDENDUM IV Memberships of Boards and Committees

Section-H

CERN council: Kluyver, Prof.Dr. J.C.

European Committee of Future Accelerators, restricted committee: Hoogland, Dr. W.

ECFA, extended committee: Holthuizen, Dr. D., Walle, Prof.Dr. R.T. v.d.

HERA machine commitee: Daum, Dr. C.

HERA management board: Daum, Dr. C., Hoogland, Dr. W.

High Energy Physics Board, European Physical Society: Sens, Prof.Dr.Ir. J.C.

High Energy Physics Computing Coordinating Committee: Hoogland, Dr. W.

Scientific Policy Committee (CERN): Diddens, Prof.Dr. A.N.

SPSC (CERN): Hoogland, Dr. W.

NIKHEF-Council per 12/31/1984

Aarts, Dr. C.J.M. (KUN)
Blok, Prof.Dr. J. (FOM / deputy chairman)
Heuvel, Prof.Dr. E.P.J. van den (UvA)
Jongerius, Dr. R.T. (UvA)
Kluyver, Prof.Dr. J.C. (FOM)
Kokkedee, Prof.Dr.Ir. J.J.J. (FOM / chairman)
Verheul, Prof.Dr. H. (VUA)
Walle, Prof.Dr. R.T. van de (KUN)

Boumans, Dr. A.A. (secretary, no membership)

The meetings are attended by the NIKHEF directorate:

Hoogland, Dr. W.
Langelaar, Dr. J.
Middelkoop, Prof.Dr. G. van

- minutes: Johannes, Mrs. E.N.H.J.

Scientific Advisory Committee (Wetenschappelijke Advies Commissie) Section-H per 12/31/1984

Dam, Dr. P.H.A. van
Daum, Dr. C.
Diddens, Prof.Dr. A.N.
Duinker, Dr. P.
Gaemers, Prof.Dr. K.J.F. (chairman)
Hoogland, Dr. W.
Schotanus, Dr.Ir. D.J.

Leeuwen, Drs. W.M. (secretary, no membership)
Langelaar, Dr. J. (auditor, no membership)

Section-K

Program Advisory Committee (PAC)

Dieperink, A.E.L (KVI, Groningen)
Domingo, J.J. (SIN, Villigen)
Duclos, J. (ALS, Saclay)
Mougey, J. (ALS, Saclay)
Redwine, R.P. (MIT, Cambridge, Massachusetts)
Scheck, F. (Univ. Mainz)
Turchinetz, W. (MIT, Cambridge, Massachusetts)
Koch, J.H. (NIKHEF, Amsterdam / secretary)

Also attending:

Middelkoop, G. van (Scientific Director Section-K)
Vries, C. de (NIKHEF / consultant)

Scientific Advisory Committee (Wetenschappelijke Advies Commissie) Section-K

Duclos, Dr. J. (ALS, Saclay)
Koch, Dr. J.H. (NIKHEF)
Leun, Prof.Dr. C. van der (Phys. Lab. RUU)
Middelkoop, Prof.Dr. G. van (NIKHEF / ex off.)
Mougey, Dr. J. (Inst. Laue-Langevin, Grenoble)
Scheck, Prof. F. (Univ. Mainz)
Siemssen, Prof.Dr. R.H. (KVI, Groningen / chairman)
Turchinetz, Dr. W. (MIT, Boston)

ADDENDUM VI **Personnel per December 31, 1984**

A. NIKHEF-H (Amsterdam)

1. Experimental physicists

Apeldoorn, Dr. G.W. van		UvA	Neutrino (D2)
Bergsma, Drs. F.	FOM		Neutrino (NC)
Bos, Dr. K.	FOM		LEAR/SING
Buys, Drs. A.	FOM		Two-photon physics (PEP9)
Dam, Dr. P.H.A. van		UvA	Neutrino (D2)
Daum, Dr. C.	FOM		ACCMOR
Demarteau, Drs. M.W.J.M.	FOM		PETRA
Diddens, Prof.Dr. A.N.	FOM		DELPHI
Dorenbosch, Dr. J.	FOM		Neutrino (NC)
Driel, Dr. M.A. van	FOM		Two-photon physics (PEP9)
Duinker, Dr. P.	FOM		PETRA, LEP3
Dijkman, Dr. W.H.	FOM		Instrumentation
Dijkstra, Drs. H.B.	FOM		ACCMOR
Eijk, Drs. B. van	FOM		UA1
Eijndhoven, Drs. N.J.A.M. van		UvA	Neutrino (D2)
Erné, Dr. F.C.	FOM		Two-photon physics (PEP9)
Graaf, Ir. H. van der	FOM		LEP3
Harting, Prof.Dr. D.		UvA	PETRA, LEP3
Hartjes, Drs. F.G.	FOM		Instrumentation
Holthuizen, Dr. D.J.	FOM		UA1
Hoogland, Dr. W.	FOM		Scient. dir. /ACCMOR
Jansen, H.	FOM		DELPHI
Jongejans, Dr. B.	FOM		Neutrino (D2)
Kluyver, Prof.Dr. J.C.		UvA	LEAR/SING
Koene, Dr. B.K.S.	FOM		Sigma total ($\bar{p}p$), DELPHI
Kunne, Drs. R.A.	FOM		LEAR/SING
Kuijer, Drs. P.G.	FOM		PETRA
Linde, Drs. F.L.	FOM		Two-photon physics (PEP9)
Linssen, Drs. L.H.A.J.	FOM		LEAR/SING
Luit, Drs. E.J.	FOM		PETRA
Massaro, Dr. G.G.G.	FOM		PETRA, LEP3
Miranda, Drs. R.T.	FOM		DELPHI
Onvlee, Drs. J.		UvA	LEP3
Paar, Dr. H.P.	FOM		Two-photon physics (PEP9)
Peng, Y.	FOM†		LEP3
Rijk, Drs. G.A.F. de	FOM		ACCMOR
Sens, Prof.Dr.Ir. J.C.	FOM		Two-photon physics (PEP9)
Swider, G.M.	-		PETRA / LEP3
Swol, Drs. R.W. van	FOM		Sigma total ($\bar{p}p$)
Tenner, Prof.Dr. A.G.		UvA	Neutrino (D2)
Tiecke, Dr. H.G.J.M.	FOM		ACCMOR
Timmermans, Dr. J.J.M.	FOM		Sigma total ($\bar{p}p$), 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	Education
Wiggers, Dr. L.W.	FOM		ACCMOR
Wigmans, Dr. M.E.J.	FOM		Neutrino (D2)

2. Theoretical physicists

Bij, Dr. J.J. van der	FOM	
Gaemers, Prof.Dr. K.J.F. *		UvA
Hari-Dass, Dr. N.D.	FOM	
Horst, Drs. M. van der		UvA
Vermaseren, Dr. J.A.M.	FOM	
Wolters, Dr. G.F.	FOM	

3. Computer group

Blokzijl, Dr. R.	FOM	
Gosman, Drs. D.		UvA
Leeuwen, Drs. W.M. van	FOM	
Vermeulen, Dr. J.C.		UvA
Wassenaar, Drs. E.	FOM	

† Visitor from the People's Republic of China, on behalf of the collaboration of the Netherlands with the PRC.

*) part-time

Heymens-Visser, P.		FOM	
Linde, T.J. van der		FOM	
Macnack, N.G.		FOM	
Petten, R. van		FOM	
Sastradiwiria, D.A.		FOM	
Schäfer, J.S.E.			UvA
Zwart, F. de		FOM	

4. Scan and measuring group

Brogt, W.	*	FOM	
Cate, T. ten	*	FOM	
Emanuel-Melkas, K.	*	FOM	
Euwe, E.	*	FOM	
Hof, G. van 't	*	FOM	
Molenaar, C.M.	*	FOM	
Visser-Jansen, J.H.	*	FOM	
Westbroek-Phillips, S.	*	FOM	
Wischhoff-Bos, J.H.	*	FOM	

5. Mechanical Workshop and Design

Boer, R.P. de	FOM	
Brouwer, G.R.	FOM	
Buis, R.	FOM	
Buskens, J.P.M.		UvA
Ceelie, L.		UvA
Groot, J.I. de	FOM	
Homma, J.	FOM	
Hunck, P.J.	FOM	
Jaspers, M.G.F.		UvA
Kok, J.W.	FOM	
Koning, N. de		UvA
Kroezen, M.J.M.	FOM	
Kuilman, W.C.	FOM	
Leguijt, R.	FOM	
Mulder, G.R.	FOM	
Rietmeijer, A.A.	FOM	
Rietveld, P.E.	FOM	
Vink, H.G.A.	FOM	
Faber, G.W.	FOM	
Oosterhuis, W.L.	FOM	
Postema, Ing. W.J.	FOM	
Scnuijlenburg, Ing. H.W.A.	FOM	
Ypma, T.J.	FOM	

6. Elektronics Department

Akker, Th.G.M. van den	FOM	
Bakker, J.P.H.	FOM	
Berkien, A.W.M.	FOM	
Bodenstaff, P.J.		UvA
Breemen, Ing. R.G.A.	FOM	
Evers, G.J.	FOM	
Gotink, G.W.	FOM	
Groenstege, Ing. H.L.	FOM	
Horneman, G.D.	FOM	
Hulman, F.W.M.	FOM	
Jungbauer, K.O.R.W.	FOM	
Kieft, Ing. G.N.M.	FOM	
Knaap, J.W.	FOM	
Kristel, C.Th.		
Pauw, Ing. A.H.L.		UvA
Rewiersma, Ing. P.A.M.	FOM	
Vries, Ing. G.A. de		UvA
Weber, Ing. J.	FOM	

7. Students

Altink, H.E.
Beekveldt, E.
Burger, J.M.
Hoek, P.J. van den
Hulsman, E.
Jong, S.J. de
Leijtens, X.M.
Oldenborgh, G.J. van
Poletiek, G.
Rademakers, A.A.
Stad, R. van der
Starreveld, A.G.
Tuynman, F.
Veenhof, R.J.
Vorenkamp, T.
Wilhelm, R.
Zonjee, N.G.M.

*) part-time

8. **Volonteers**
Bentvelzen, P.W.M.
Petten, O.R. van
Proosdij, A. van
Ransijn, B.
Tsao, P.M.T.

B. NIKHEF-H (Nijmegen)

1. **Experimental physicists**

Enckevort, Dr. W.J.P.	* FOM		Instrumentation
Hal, Drs. P.A. van	FOM		EHS
Kittel, Prof.Dr. E.W.		KUN	EHS
König, Drs. A.C.	FOM		Crystal Ball
Metzger, Dr. W.J.		KUN	Crystal Ball
Meyers, Drs. F.		KUN	EHS
Pols, Dr.Ir. C.L.A.		KUN	EHS, Crystal Ball
Raaymakers, Drs. M.C.T.		KUN	Instrumentation
Scholten, Drs. A.J.	FOM	(KUN)	EHS (NA22)
Schotanus, Dr.Ir. D.J.		KUN	Crystal Ball
Smet, Ir. F.M.	FOM		Instrumentation
Van de Walle, Prof.Dr. R.T.		KUN	Cryst. Ball
Walk, Drs. W.		KUN	Crystal Ball

2. **Computer programmers**

Crijns, Dipl.Phys. F.J.G.H.	FOM	
Klok, Drs. P.F.	FOM	

3. **Scan and measuring group**

Antheunis, E.C.		KUN
Brouwer, Ing. C.		KUN
Derks-van den Reek, H.J.M.	*FOM	
Dijkema, Ing. J.A.		KUN
Mulder-de Grood, G.E.	*FOM	
Oosterhof-Meij, J.E.G.	FOM	
Rohde, F.H.A.		KUN
Thörig, Ing. J.		KUN
Veerdonk-Elbers, C.G.H.van de	*FOM	
Wijnen, Ing. T.A.M.		KUN

4. **Administration**

Dikmans-de Koning, A.C.M.		KUN

*) part-time

C. NIKHEF-K (Amsterdam)

1. Experimental physicists

Arnold, H.	FOM	PiMu
Bauer, Th. S.	FOM	PiMu
Berkhout, J.D.R.	VUA	PiMu
Blok, H.	FOM/VUA	Emin
Blok, H.P.	FOM/VUA	Emin
Brand, Drs. J.F.J. v.d.	FOM	Emin
Burghardt, Drs. A.J.C.	FOM	Emin
Dantzig, Dr. R. van	FOM	PiMu
Donné, A.J.H.	FOM/VUA	Emin
Herder, Drs. J.W.A. den	FOM	Emin
Hesselink H.A.	VUA	PiMu
Jager, Dr. C.W. de	FOM	Emin
Jans, Dr. E.	FOM	Emin
Keizer, Drs. P.H.M.	FOM	Emin
Ketel, T.J.	FOM/VUA	PiMu
Konijn, Dr.Ir. J.	FOM	PiMu
Laan, Drs. J.B. v.d.	FOM	Emin
Laat, Drs. C.T.A.M. de	FOM	PiMu
Lapikàs, Dr. L.	FOM	Emin
Lingeman, Dr. E.W.A.	FOM	PiMu
Luijckx, Ir. G.	FOM	Emin
Maas, Dr. R.	FOM	PiMu
Middelkoop, Prof.Dr. G. van	VUA	Scientific director
Offerman, Drs. E.A.J.	FOM	Emin
Prins, L.	FOM/VUA	PiMu
Quint, Drs. E.N.M.	FOM	Emin
Selig, Drs. A.M.	FOM	Emin
Steenhoven, G. van der	FOM/VUA	Emin
Taal, A.	FOM	PiMu
Vries, Prof.Dr. C. de	FOM	Emin
Vries, Dr. H. de	FOM	Emin
Vries, L. de	FOM/VUA	Emin
Witt Huberts, Dr. P.K.A. de	FOM	Emin

2. Radiochemistry

Brinkman, Dr. G.A.	FOM
Kuipers, Drs. P.	FOM
Lindner, Dr. L.	FOM
Louwrier, Dr. P.W.F.	FOM
Polak, Dr. P.	FOM
Bakker, C.N.M.	FOM
Diemer, E.L.	FOM
Gelder, J.J. van	FOM
Halteren, B.W. van	FOM
Leurs, G.A.J.	FOM
Veen, W. v.d.	FOM
Veenboer, J.Th.	FOM
Visser, J.	FOM

3. Theoretical physicists

Forest, Dr. T. de	FOM
Koch, Dr. J.H.	FOM
Mulders, Dr. P.J.G.	FOM
Suzuki, Dr. T.	FOM
Takaki, Dr. T.	FOM
Wapstra, Prof.Dr. A.H.	FOM

4. GVT (Group Accelerator Technique)

Bakker, K.	FOM
Bar, H.	FOM
Boer Rookhuizen, H.	FOM
Bosscher, E.J.	FOM
Bruinsma, Ir. P.J.T.	FOM
Buitenhuis, W.E.J.	FOM
Conijn, W.A.M.	FOM
Engeland, W.A. van	FOM
Groen, P.J.M. de	FOM
Heine, E.	FOM
Heutenik, B.	FOM
Hoekstra, Ir. R.	FOM
Hoetmer, N.	FOM
Jansen, L.W.A.	FOM
Koenderink, G.J.	FOM

Kroes, Ir. F.B.	FOM
Kuijer, L.H.	FOM
Kuijt, Ing. J.J.	FOM
Moerman, C.	FOM
Noomen, Ir. J.G.	FOM
Noteboom, C.W.J.	FOM
Schiebaan, Ing. C.	FOM
Schimmel, A.	FOM
Schwebke, H.	FOM
Sluijk, Ing. T.G.B.W.	FOM
Spelt, Ing. J.B.	FOM
Steman, W.A.	FOM
Stoffelen, A.C. v.	FOM
Stroo, R.	FOM
Timmer, P.F.	FOM
Vogel, Ing. A.G.C.	FOM
Voort, A.M.A. van der	FOM
Vriese, H.C.	FOM
Wieman, J.P.A.M.	Asd
Wieten, P.	FOM

5. **CSG (Computer System Group)**

Albers, F.J.A.	FOM
Bie, Dr. J.E.P. de	FOM
Eijgenraam, J.M.	FOM
Hart, Ing. R.G.K.	FOM
Heubers, W.P.J.	FOM
Huis, C.M.	FOM
Koldewijn, Dr. P.	FOM
Lindgreen, R.J.T.	FOM
Maaskant, Ing. A.	FOM
Oudolf, J.D.	Asd
Raaij, Drs. T.W. v.d.	FOM
Tierie, Mw. J.J.E.	FOM
Wijk, R.F. van	FOM

6. **DIGEL (Elektronics Department)**

Boer, J. de	FOM
Boerkamp, A.L.J.	FOM
Born, E.A. v.d.	FOM
Dekker, J.P.	FOM
Dijkstra, N.	FOM
Es, J.T. van	FOM
Feijen, C.	Asd
Geerling, F.	FOM
Harmsen, C.J.	FOM
Hogenbirk, J.J.	FOM
Kate, Ing. P.U. ten	FOM
Kok, E.	FOM
Kruijer, A.H.	FOM
Kwakkel, Ir. E.	FOM
Oostveen, Ing. K.	FOM
Paape, J.	FOM
Peek, H.Z.	FOM
Reen, A.T.H. van	FOM
Ros, E.	FOM
Schendeler, W.J.	FOM
Schipper, J.D.	FOM
Stolte, J.	FOM
Trigt, J.H. van	FOM
Verkooijen, J.C.	FOM
Visschers, Dr. J.L.	FOM
Zwart, Ing. A.N.M.	FOM

7. **MTG (Mechanical Technology Department)**

Arink, R.P.J.	FOM
Beumer, H.	FOM
Bijleveld, Ing. J.H.M.	FOM
Boomgaard-Hilferink, Mw.J.G.	FOM
Bosman, G.J., Jr.	FOM
Boucher, A.	FOM
Bron, M.	FOM
Bruijne, H.G.	FOM
Daalmeijer, P.	FOM
Doets, M.	FOM
Doornik, H.F.R. van	FOM
Gerritsen, G.C.	FOM

Heemskerk, Ing. J.A.	FOM
Kaan, Ir. A.P.	FOM
Koehof, G.H.	FOM
Koopman, G.	FOM
Langedijk, J.S.	FOM
Lassing, P.	FOM
Lefevere, Y.	FOM
Lunteren, J. van	FOM
Nifterik, B.H. van	FOM
Sallé, P.	FOM
Schreuder, P.	FOM
Spruit, D.	FOM
Thobe, P.H.	FOM
Ton, D.J.	FOM
Touw, J.	FOM
Veen, J. van	FOM
Verlegh, W.F.H.P.	FOM

9. **Students**

Bekkers, F.F.	Pimu
Beugeling, W.A.	Pimu
Bonnie, R.J.M.	Emin
Borghols, W.T.A.	Emin
Bronkhorst, A.W.	Emin
Gorter, W.	Emin
Goudoever, J. van	Pimu
Hendriks, J.A.	Emin
Heijer, P. den	Emin
Hoek, P.J. van den	Pimu
Poeser, W.A.	Pimu
Prins, L.	Emin
Veerman, H.P.J.	Pimu
Zacharov, J.	Emin

10. **Volenteers over 1984**

Boer, P. de
Damen, A.C.M.
Deenen, B. van
Fakkeldij, P.J.
Griekspoor, P.
Ham, M.A. van den
Heeman, P.M.
Hond, P.I. d'
Jansen, E.J.
Kock, J.C.H.M. de
Koek, B.H.
Mekken, R.A.
Mul, R.A.
Mulder, B.N.
Omta, C.F.
Pieters, F.L.
Praat, J.J.P.
Prinse, R.
Schoonderbeek, E.J.
Schut, J.J.
Smits, T.T.
Stumpel, M.A.J.B.M.
Tange, A.R.
Teunen, M.F.T.
Timman, R.A.
Tijook, F.T.
Verschuren, J.A.M.
Vlist, R. van de
Waard, J.J. de
IJlst, P.
Zeldenrust, P.
Zuur, M.M.

D. NIKHEF, **Management and administration**

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Abbreviations:
--- FOM - Foundation for Fundamental Research on Matter
--- KUN - Catholic University of Nijmegen
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Publication: NIKHEF information service
Post Box 41882, 1009 DB Amsterdam
Telephone (020) 592 9111
Telex 10262

Editors: NIKHEF directorate
Lay out and cover: Marinus de Bakker
Press: Papyrus Printing Co., Diemen