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edited by

A. Chalupka
E. Wild
and
G. Dirniger

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Full address:
Institut für Radiumforschung und Kernphysik der Österreichischen Akademie der Wissenschaften,
Boltzmanngasse 3, A-1090 Wien, AUSTRIA

Herausgeber: Institut für Radiumforschung und Kernphysik der Österreichischen Akademie der Wissenschaften, Boltzmanngasse 3, A-1090 Wien

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NUCLEAR THEORY

QUARKS, ISOBARIC EXCITATIONS, MESONIC EXCHANGE CONTRIBUTIONS AND THE NN-INTERACTIONS *)

H. Baier, W. Bentz [1], M. Schaden [2] and M. Meinhart

Introduction

Following our general program (see IRK-progress report 1982) we continued work on charge asymmetry in nucleon system /1-5/. Problems related to the $N\bar{N}$-system are at present under investigation. The influence of monopoles on nuclear decay processes is another field of our interest.
Lattice calculations (M. Meinhart) till now have not given any results directly applicable to nuclear problems. Therefore work in that direction will not be continued in the near future. M. Schaden, working presently at Regensburg University (and sponsored partly by our project on quark problems) solved (together with E. Werner, Univ. Regensburg) some interesting problems related to the quark structure of the pion-baryon coupling. In addition he collaborated with the Regensburg group on the application of chiral dynamics to the NN-problem.

Results

1.) Pionic contribution to the charge asymmetry in two and three nucleon systems /1,2/:
The charge symmetry breaking effects of 2π-exchange and $\pi^0\gamma$-exchange on the three nucleon binding energy and the nucleon-nucleon scattering length were investigated. As a main result we find that the 2π-exchange mechanism increases the discrepancy to experiment considerably. The following tables show the results quantitatively.
Fig. 1 shows the basic graphs used in the 2π-exhchange calculations.

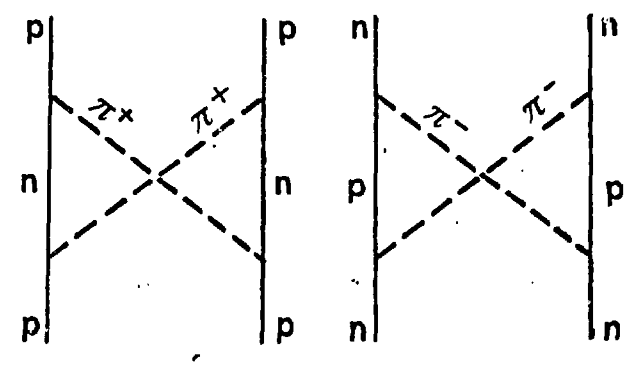


Fig.1.

2.) Perturbative $Q\bar{Q}$-polarization effects on the pion-baryon-coupling (M. Schaden, E. Werner, univ. of Regensburg), Project 4614 /3/:
The effect of virtual $q\bar{q}$-excitations on the pion-baryon coupling in the framework of the linearized version of the cloudy bag model and of a potential model has been investigated. The main effect is a change of the normalization of the pion field in each partial wave.

3.) In connection with the above mentioned project-work, M. Schaden collaborated with a Regenbsurg group /4/ on problems connected to chiral invariance and the Goldstone nature of the pion. As an essential result a selfconsistency condition relating key properties of the confining potential to the effective qq-interaction has been derived.

Table 1. Contributions of pion-exchange to the binding energy difference $\Delta E = E(^3He)-E(^3H)$

	E(keV)
$\pi^0\gamma$-exchange without intermediate $N\bar{N}$-pairs	6.2
$\pi^0\gamma$-exchange with intermediate $N\bar{N}$-pairs	-22.9
2π-exchange	-98.0
sum	-114.7

Table 2. Contributions to the scattering length difference $\Delta a = a_{pp} - a_{nn}$

	Δa(fm)
$\pi^0\gamma$-exchange with intermediate $N\bar{N}$-pairs	-0.5
2π-exchange	-1.1
combined effect	-1.4

Table 3. Contributions of pion-photon exchange processes to the binding energy difference $\Delta E = E(^3He)-E(^3H)$ calculated in this work and others

	E(keV)
two body processes calculated in this work	-16.7
processes with intermediate Δ-isobar /2/	9.0
three body process	- 7.1
sum	-14.8

[1] University of Tokyo, Japan 6264003P
[2] University of Regensburg, FRG 8200835DE

* supported by Fonds zur Förderung der wissenschaftlichen Forschung in Österreich

Table 4. Contribution of charge symmetry breaking 2π-exchange to the binding energy difference $\Delta E = E(^3He) - E(^3H)$ calculated in this work and others

	E(keV)
two body process calculated in this work	-98.0
processes with intermediate Δ-isobar /2/	3.0
sum	-95.0

The result quoted from ref. /2/ corresponds to the Δ-mass splitting as expected from the naive quark-model.

/1/ H. Baier, W. Bentz, Ch. Hajduk and P.U. Sauer, Nucl. Phys. A386 (1982) 460

/2/ H. Baier, W. Bentz, P.U. Sauer (submitted for publication)

/3/ M. Schaden, E. Werner, Perturbative $q\bar{q}$-polarization effects on the pion-baryon coupling, Univ. Regensburg preprint, 1983

/4/ V. Barnard, R. Brockmann, M. Schaden, W. Weise, E. Werner, in: Few body problems in physics, contributions, advanced copy, Karlsruhe, BRD, 21.8-27.8.1983, p. 273, 275

/5/ M. Schaden, H. Baier, Lett. al Nuovo Cimento 35 ,17 (1982) 491

NUCLEAR MODEL CALCULATIONS

REVISED NUCLEAR MODEL CALCULATIONS OF NEUTRON INDUCED CROSS SECTIONS FOR ^{93}NB

B. Strohmaier

Starting from two former cross section evaluations for neutron induced reactions on ^{93}Nb /1,2/, new calculations were performed regarding new experimental data, particularly for proton emission /3,4/. These calculations are based on the same nuclear reaction models as the previous ones, but employ slightly different options with respect to energy and angular momentum dependence of preequilibrium emission. In this way the new experimental data could be reproduced (fig. 1) while maintaining the description of the data on which the former evaluations were based /5/.

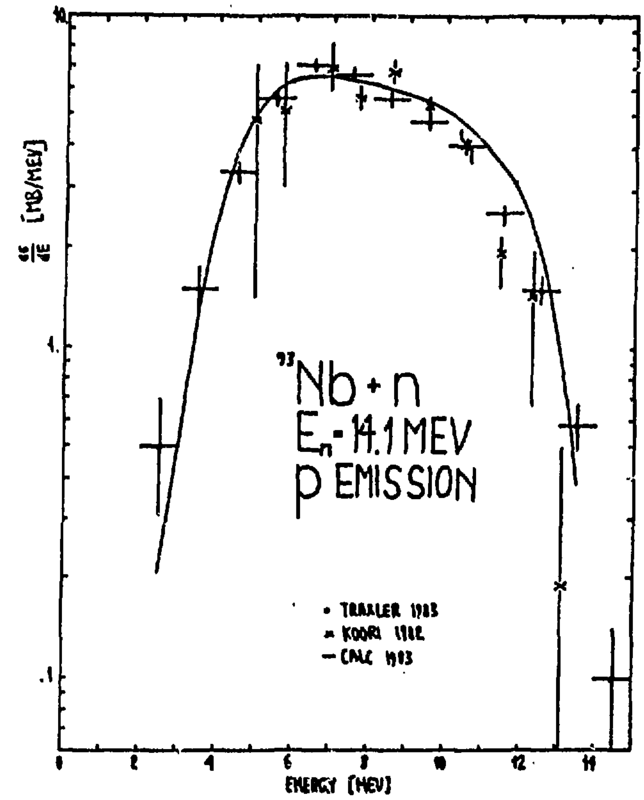


Fig. 1. Proton production (C.M. system) from ^{93}Nb+n at 14.1 MeV incident neutron energy. The calculation comprises the contributions of (n,p) and (n,np).

/1/ B. Strohmaier, S. Tagesen, H. Vonach, Physics Data 13-2 (1980)

/2/ B. Strohmaier, Ann. Nucl. Energy 9 (1982) 397

/3/ N. Koori, to be published
Data displayed in M. Hanita et al., NEANDC(J)-83/U, p. 59, JAERI Progr. Rept. July 81-June 82

/4/ G. Traxler, Thesis Univ. Vienna (1983)

/5/ B. Strohmaier, Proc. IAEA Consultants' Meeting on Nuclear Data for Structural Materials, Nov. 2-4, 1983, Vienna, in press

NEUTRON OPTICAL POTENTIALS IN THE A $\sim$ 50 MASS REGION

B. Strohmaier

The corresponding investigations in 1982 /1/ have been continued. At present, the interest concentrates on the low energy region. There, the experimental data base on which the parameter studies are based has been extended and also further optical potentials have been included in these studies.

/1/ B. Strohmaier, Progress Rept. 1982

APPLICATION OF THE DIRECT REACTION THEORY FOR CONTINUUM PARTICLE EMISSION SPECTRA TO NEUTRON INDUCED REACTIONS

M. Uhl

Recently Tamura et al. /1/ developed an approach which extends direct reaction theories, usually applied in the region of low lying "discrete" levels of the residual nucleus, to the transitions of high excited states in the "continuum". In this way precompound processes, which formerly were mainly treated by simple phenomenological models, can be described in the frame of quantum mechanical reaction theory.

So far the theory of Tamura et al. /1/ was mainly applied to the analysis of double differential cross sections for proton induced reactions at incident energies between 45 and 65 MeV. Therefore we started to investigate the applicability of this approach to neutron induced reactions of the type (n,n'), (n,p) and (n,α) at incident energies of 14 and 25 MeV. The calculations were performed by means of the code ORION-TRISTAR 1, kindly made available to us by Prof. Tamura; in this program the treatment of the direct reactions is restricted to the one-step DWBA. In general the calculated cross sections reproduced experimental data quite satisfactorily. As a typical example fig. 1 shows a comparison of the ^{56}Fe(n,n') data of Marcinkowski et al. /2/ to the prediction of the theory. However, the model parameters employed often differed substantially from those reported for the corresponding proton induced reactions; this was true in particular for the ^{93}Nb(n,α) reaction. Furthermore in the case of ^{93}Nb(n,n') it turned out to be difficult to reproduce experimental data at incident energies of 14.4 and 25.7 MeV with the same set of model parameters; while the shape of the angular distributions of the emitted neutrons was reasonably reproduced at both incident energies, discrepancies up to a factor of two showed up in the absolute cross sections.

These investigations will be continued as the approach of Tamura et al. /1/ represents an important improvement compared to the phenomenological preequilibrium models. It is planned to include the code ORION TRISTAR 1 in our general nuclear reaction cross section program MAURINA under development.

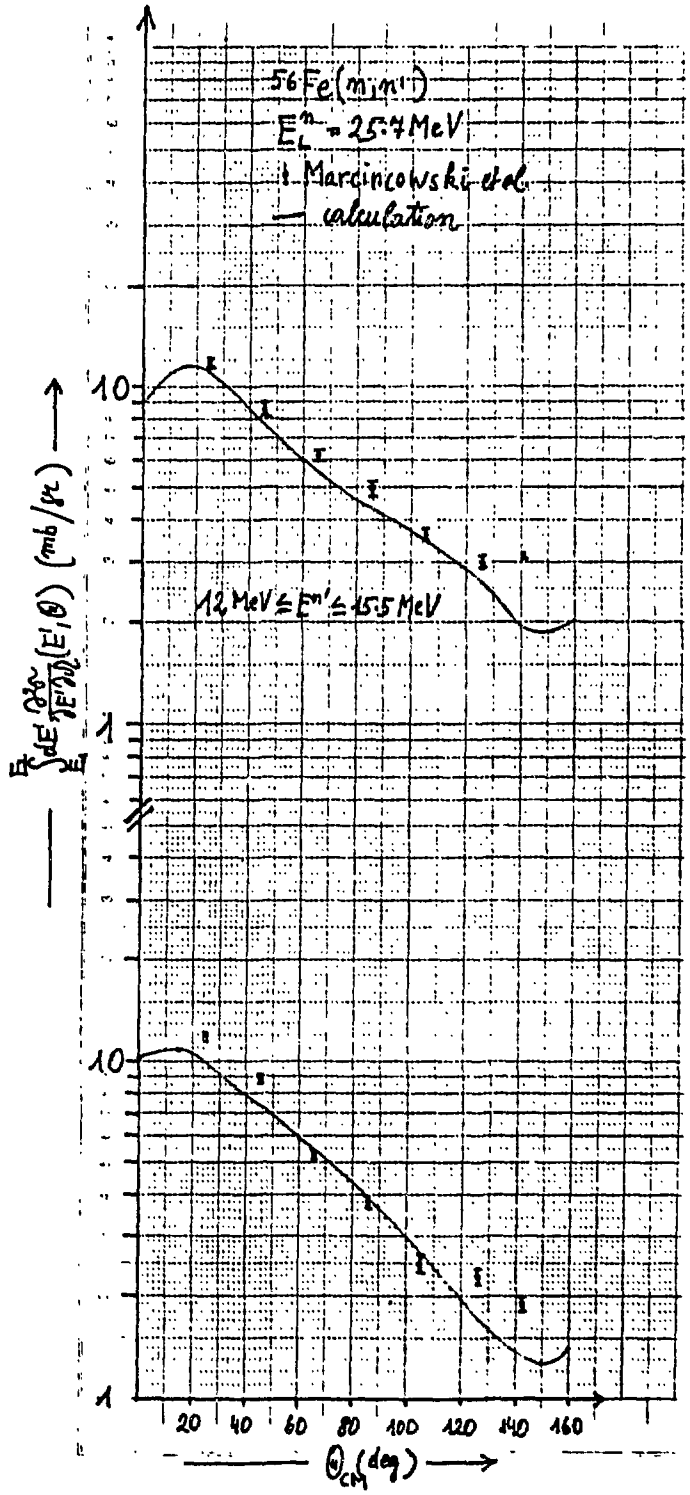


Fig. 1. Comparison of experimental /2/ and theoretical cross sections for ^{56}Fe(n,n') at 25.7 MeV

/1/ T. Tamura et al., Phys. Rev. C26 (1982) 379 and other references therein

/2/ A. Marcinkowski et al., Nucl. Sci. Eng. 83 (1983) 13

DEVELOPMENT OF A GENERAL NUCLEAR REACTION CROSS SECTION COMPUTER CODE

M. Uhl

Work on the new cross section code MAURINA which accounts for compound nucleus-, direct- and preequilibrium reactions is in progress. The program section supplying the optical model transmission coefficients has been completed and tested. It comprises optical model routines which generate the transmission coefficients on a suitably chosen grid of channel energies and routines which by means of a cubic spline calculate these quantities at the meshpoints of the numerical integrations required for the compound nucleus model.

The routines which handle first chance compound nucleus reactions under consideration of width fluctuation, fission, isospin mixing and angular distribution have been debugged. As a first application of this program section the experimental α-particle angular distributions resulting from $^{56}Fe(n,\alpha)$ and $^{60}Ni(n,\alpha)$ by Fischer et al. /1/ were analized. The direct reaction mechanisms which will be considered are inelastic scattering with macroscopic form factors and stripping- and pickup reactions with cluster form factors in case of transfer of more than one nucleon. The calculation will be performed by means of the DWBA code DWUCK /2/. The required interface routines are being developed. In a later stage a suitable coupled channel program will be included so that also inelastic scattering on deformed nuclei can be treated adequately.

A program section which deals with precompound reactions in the frame of the exciton model, has been completed. In addition to the well known formulation of this model the routines account also for isospin mixing, the spin distribution in the residual nuclei under the assumption of an exciton number dependent spin-cutoff factor and angular distributions employing the systematics of Kalbach and Mann /3/. Further a simple statistical treatment of direct transfer, knockout and inelastic scattering reactions following the approach of Kalbach /4/ has been included; in this way also cross sections for (n,d), (n,t) and $(n,^{3}He)$ reactions, which are important for fusion related technological applications, can be predicted. The exciton model is intended to be used for routine applications where many cross sections are to be calculated at a large number of incident energies. For the analysis of specific experiments the theory of Tamura et al. /5/ will be used for the precompound portion of the emission spectra.

/1/ R. Fischer et al., IRK Progr. Report 1982, p. 12

/2/ P.D. Kunz, unpublished

/3/ C. Kalbach et al., Phys. Rev. C23 (1981) 112

/4/ C. Kalbach, Z. Phys. A283 (1977) 401 and "PRECO-D", informal TUNL report, 1980

/5/ T. Tamura et al., Phys. Rec. C26 (1982) 379

EXPERIMENTAL NUCLEAR PHYSICS, NEUTRON INDUCED REACTIONS

MEASUREMENT OF DIFFERENTIAL (N,CHARGED PARTICLE) CROSS-SECTIONS BY MEANS OF THE VIENNA MULTITELESCOPE SYSTEM *)

A. Chalupka, R. Fischer, P. Maier-Komor [1], B. Strohmaier, G. Traxler, M. Uhl and H. Vonach

A) $^{56}Fe(n,\alpha)$ and $^{60}Ni(n,\alpha)$

The analysis of the $^{56}Fe(n,\alpha)$ and $^{60}Ni(n,\alpha)$ measurements described in the last annual report was completed. The results obtained from this analysis can be summarized as follows:

1) Angle integrated α-emission cross-sections:

Table 1 gives the results for the angle-integrated α-emission cross-sections for 1 MeV energy bins which corresponds roughly to the experimental energy resolution. The errors give effective 1σ errors obtained by summing the statistical errors and estimates of all identified sources of systematic error quadratically. In Figs. 1 and 2 these results are compared with the existing measurements of Grimes et al. /3/, which for this purpose have been transformed into the c.m. system. There is good overall agreement between the two measurements but in detail there exist two areas of disagreement.

At low energy ($E_{\alpha ch}$ < 6 MeV) the α-emission cross-section of ref. 2 is much smaller than ours, which cannot be explained by the slightly different incident neutron energies. In this energy range our measurements are complicated by rather a large background and also the Livermore data /3/ indicate experimental problems as there are considerable discrepancies between the emission cross-sections for the different angles.

Considering the different incident neutron energies the high-energy parts of the α-spectra in the $^{60}Ni(n,\alpha)$ reaction definitely disagree beyond experimental errors. No obvious reason for this discrepancy could be found.

Table 1: Angle-integrated α-particle emission cross-sections for the $^{56}Fe(n,x\alpha)$ and $^{60}Ni(n,x\alpha)$ reactions at E_n=14.1 MeV

E_α(chann.E_n)	$\frac{d\sigma}{dE_\alpha}$ (^{56}Fe+n)	$\frac{d\sigma}{dE_\alpha}$ (^{60}Ni+n)
5 - 6	1.69 ± .20 ::	2.98 ± .25 ::
6 - 7	4.39 ± .28	5.59 ± .26
7 - 8	8.60 ± .43	10.91 ± .55
8 - 9	10.63 ± .51	15.23 ± .73
9 - 10	7.45 ± .37	13.54 ± .65
10 - 11	4.63 ± .25	8.96 ± .44
11 - 12	2.98 ± .18	4.87 ± .26
12 - 13	2.06 ± .13	3.35 ± .18
13 - 14	.75 ± .08	1.46 ± .11
14 - 15	.23 ± .06	1.04 ± .09
15 - 16		.28 ± .06

:: the fully correlated part of the erorrs amounts to 4.4% of the cross-section values

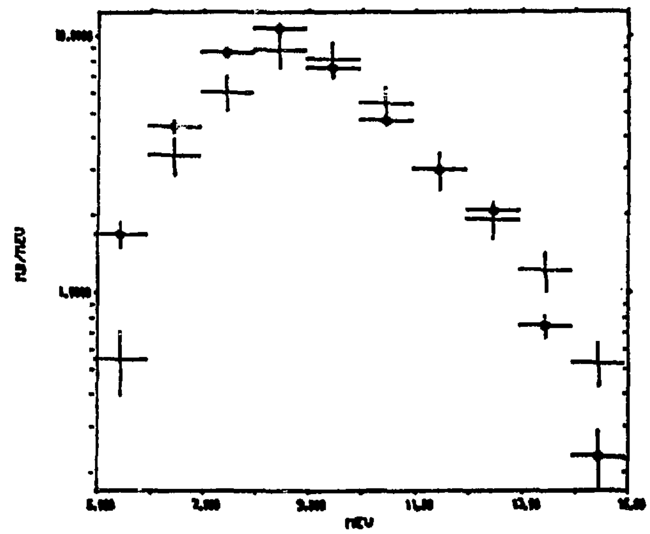


Fig. 1. The angle integrated α-emission cross-section for the $^{56}Fe(n,\alpha)$ reaction
• present results (E_n = 14.1 MeV),
+ results of ref. 3 (E_n = 15 MeV)

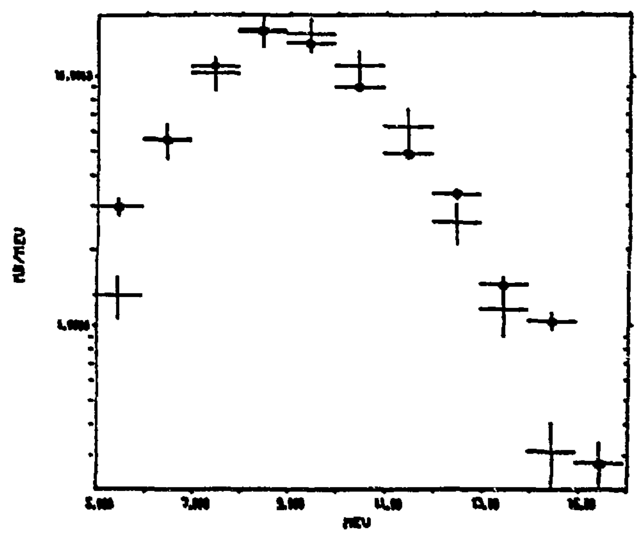


Fig. 2. The angle integrated α-emission cross-section for the reaction $^{60}Ni(n,\alpha)$
• present results (E_n = 14.1 MeV),
+ results of ref. 3 (E_n = 15 MeV)

* supported by Fonds zur Förderung der wissenschaftlichen Forschung in Österreich

[1] Physikdepartment, TU München, FRG

2) Total α-emission cross-sections:

The total α-emission cross-sections obtained by numerical integration of the $d\sigma/dE_\alpha$ values are given in table 2. As the table shows there is good agreement both with the results of ref. /3/ and the results of helium accumulation measurements /4/; in this comparison it has to be considered that at the higher incident neutron energies of ref. 3 and 4 the α-emission cross-sections should be about 5-10% higher than at our energy of 14.1 MeV.

Table 2: Total α-emission cross-sections in the ^{56}Fe(n,xα) and ^{60}Ni(n,xα) reactions

E_n (MeV)	σ(^{56}Fe(n,xα)	σ(^{60}Ni(n,xα))	Ref.
14.1	44 ± 2.	69.6 ± 3.1	this work
15	41 ± 7.	76 ± 12	2
15	48 ± 3.	79 ± 6.	4

3) Angular distribution of α-emission:

The gross-features of the angular distributions have already been presented in the last progress report (p. 13, figure 2). As shown in this figure there are considerable contributions from non-compound reactions at the highest α-particle energies probably due to collective excitation of low-lying levels as already found in the study of the ^{50}Cr(n,α) reaction /5/. In the region of the evaporation peak (Progress Rep. 1982, p. 13, fig. 2b) the angular distributions are approximately symmetrix around 90° and show a small minimum at 90° as expected according to Hauser-Feshbach theory. The size of this minimum is about the same as in our ^{50}Cr(n,α) measurements /5/ and much smaller than in some of the early work on (n,α) reactions /6,7/ which probably suffered from some unidentified systematic errors.

B) ^{93}Nb(n,p)

The improved Vienna multitelescope system /2/ was used to investigate the reaction ^{93}Nb(n,p) with 14 MeV neutrons. The raw data from this experiment, which have partly been shown in the last progress report, were analysed in detail; after file reduction to physically relevant events, which turned out to be approx. 18 000 (gathered in 220 hours measuring time), the data were converted into double differential cross sections. The value for the total proton production cross section (44 ± 3 mb) is in excellent agreement with the result of Koori /8/.
Fig. 3 shows the angle integrated proton production spectrum in comparison with the data of other authors; one can find a good agreement with the cross section measured by Koori /8/, whereas the energy distribution published by Grimes /9/ et al. indicates a much larger production of low energy protons, which is, however, not in accordance with statistical model calculations, including preequilibrium decay. Such calculations had been performed on the basis of experimental cross section data existing in 1981 for all major neutron induced reactions and were now adjusted /10,11/ so as to reproduce the newly measured spectrum (fig. 4) together with the previously existing body of data. This could

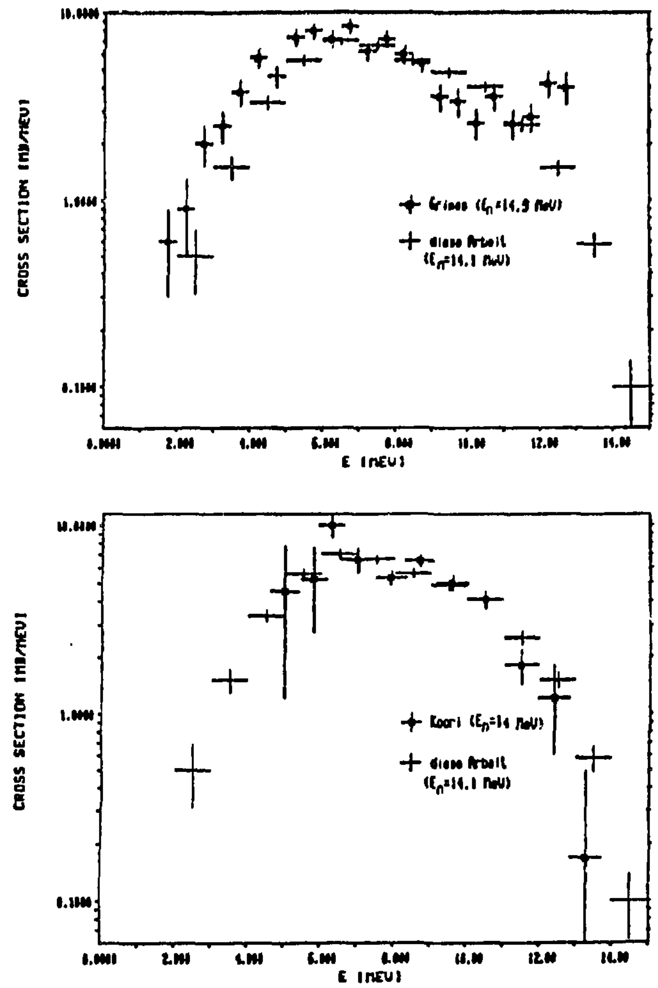


Fig. 3. Angle-integrated p-emission cross-section from the ^{93}Nb(n,p) reaction at E_n = 14.1 MeV; in comparison with the data of a) Grimes et al.; b) Koori et al.

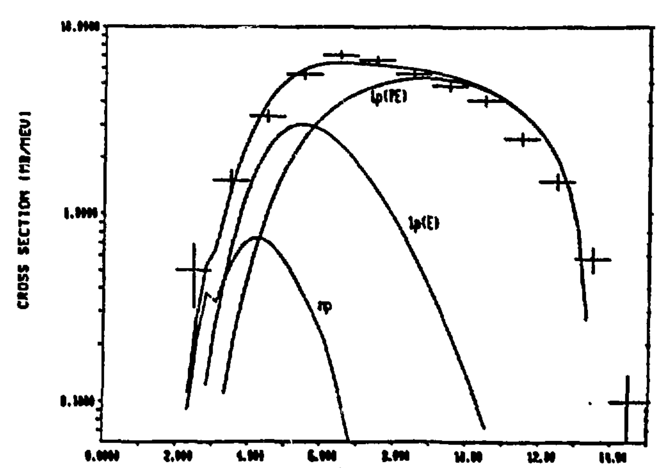


Fig. 4. Calculated p-emission cross-section obtained with computer code STAPRE compared to experimental data (E: equilibrium-, PE: preequilibrium emission)

be achieved by introducing a pairing correction in the particle hole state densities in the preequilibrium decay model and by assuming a different spin distribution of the population resulting from preequilibrium decay with respect to equilibrium decay. As one can expect from the predominant effect of preequilibrium emission, the angular distributions show a forward-backward asymmetry, which increases strongly with proton energy (fig. 5). A detailed analysis of these data is now in progress: calculations will be performed in order to test phenomenological models and the applicability of statistical DWBA calculations.

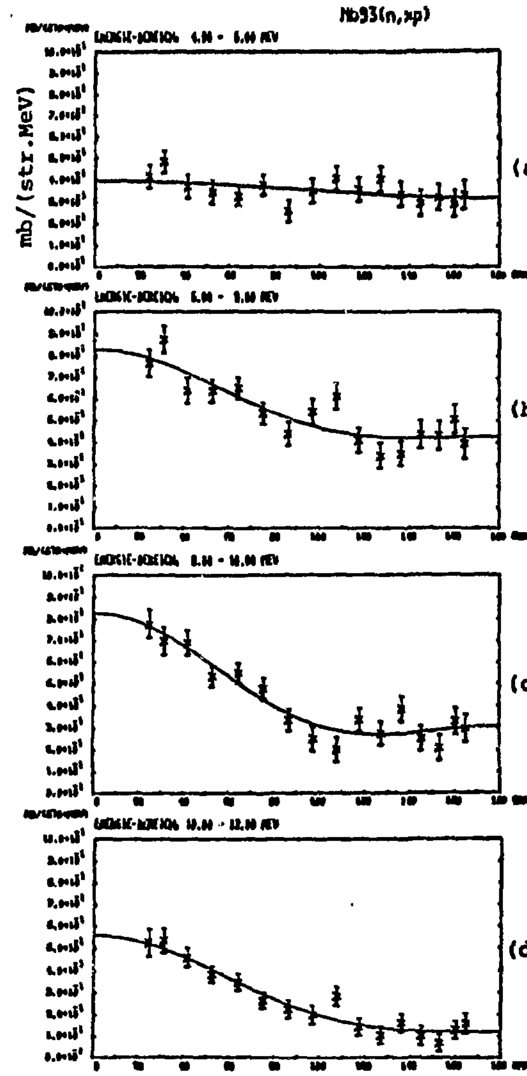


Fig. 5. Angular distributions of protons from the ^{93}Nb(n,xp) reaction at E_n = 14.1 MeV for different p-energy regions (errors only statistical)
(a) E_p = 4 - 6 MeV
(b) E_p = 6 - 8 MeV
(c) E_p = 8 - 10 MeV
(d) E_p = 10 - 12 MeV

/1/ C. Derndorfer et al., Nucl. Instr. & Meth. 187 (1981) 423

/2/ G. Traxler, R. Fischer and H. Vonach, Nucl. Instr. & Meth. 217 (1983) 121

/3/ S.M. Grimes et al., Phys. Rev. C19 (1979) 2127

/4/ D.W. Kneff et al., Symp. on Neutron Cross-Section from 10-50 MeV, BNL-NCS-51245, p. 289

/5/ C. Derndorfer et al., Z. Physik A301 (1981) 327

/6/ W. Patzak and H. Vonach, Nucl. Phys. 39 (1962) 263

/7/ M. Bormann, Habilitationsschrift Hamburg 1965

/8/ N. Koori, to be published, from: NEANDC(J)-83/U

/9/ S.M. Grimes et al., Phys. Rev. C17 (1978) 508

/10/ B. Strohmaier, Proc. IAEA Consultants' Meeting on Nucl. Data for Structural Materials, Vienna, Nov. 2-9, 1983, in press

/11/ B. Strohmaier, contribution to this report

MEASUREMENT OF THE ENERGY- AND ANGULAR DISTRIBUTION OF THE HIGH-ENERGY PART OF INELASTICALLY SCATTERED 14 MEV NEUTRONS *)

G. Staffel, G. Winkler, A. Pavlik and H. Vonach

The construction work on the new time-of-flight equipment described in the last year's report has been completed so far that first test measurements could be performed. The main features of the new system are: the scattering sample and the $^{3}T(d,n)^{4}He$ neutron source are located inside a tube system which can be evacuated; the incident neutron energy can be kept constant when changing the scattering angle by moving the sample along the access channel axis of the detector. Background measurements showed that using polyethylene for the extension collimator (extending into the 80-cm diameter tube containing source and sample) and also for its throat was a good choice. Fig. 1 demonstrates the reduction of background achieved by evacuating the flight-tube system using a rotary vacuum pump. The effect is most pronounced in the time-of-flight region of the elastic and the low-cross-section high-energy inelastic portion of the scattered neutrons.

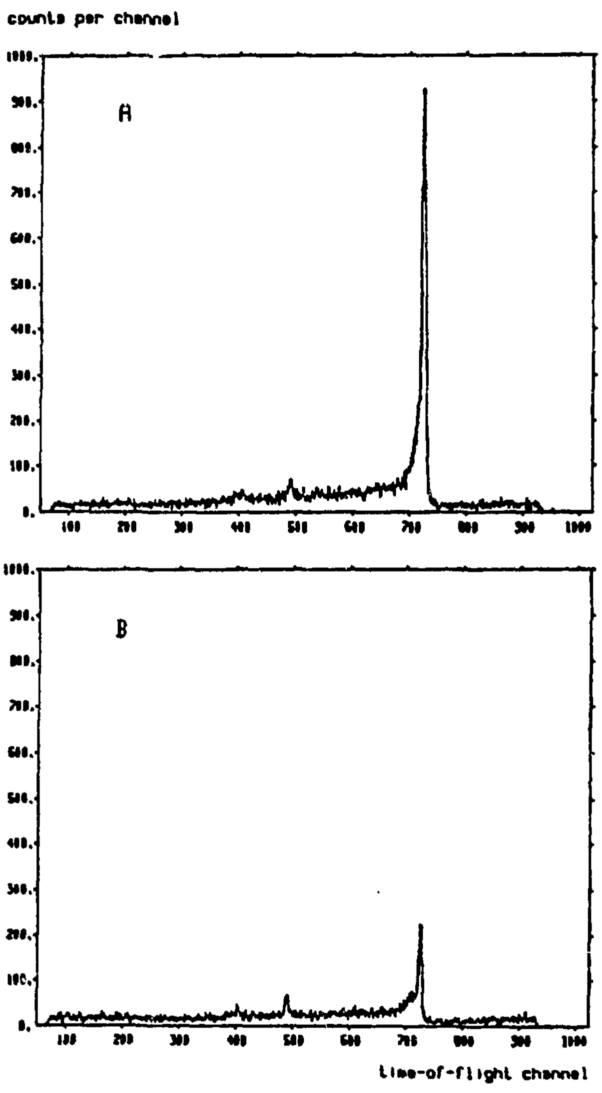


Fig. 1. Background distributions with flight-tube system under normal pressure (A) and after evacuating to < 10 Pa (B), both in the same scale. The flight path from the point of 90° scattering angle to the centroid of the 12.7-cm-diameter 5.1-cm thick detector scintillator (NE 213) was 4.52 m, the calibration of the time-of-flight coordinate was 0.426 ns per channel. The total neutron yield was 2 x 10^{12} neutrons into the full solid angle. The detector threshold was set at 1/2 Compton edge from a ^{137}Cs source.

* supported by the Jubiläumsfonds der Österreichischen Nationalbank

PRECISE MEASUREMENT OF CROSS SECTIONS FOR THE REACTION ^{65}CU(N,2N)^{64}CU IN THE 14 MEV REGION AND SIMULTANEOUS REEVALUATION OF SOME IMPORTANT CROSS SECTIONS AT 14.70 MEV

G. Winkler and B. Ryves [1]

The activation measurements concerning the ^{65}Cu(n,2n)^{64}Cu dosimetry reaction, already described in the last year's report, were finally evaluated at 13.692, 14.473 and 14.822 MeV neutron energy achieving an accuracy of 1.4 - 1.5% (equivalent standard deviation, systematic errors included) relative to well-known cross sections for the reference reaction ^{27}Al(n,α)^{24}Na. The new measured precision value for the β^+-branching ratio of ^{64}Cu (Christmas et al., see RADIONUCLIDE METROLOGY, this report) was employed. The new cross section values were incorporated in a reevaluation of the ^{65}Cu(n,2n)^{64}Cu cross section simultaneously with some other important cross sections at 14.70 MeV by the weighted least-squares method yielding a consistent set with uncertainties (1σ) of 0.6 - 2.0%. The uncertainty for the evaluated ^{65}Cu(n,2n)^{64}Cu cross section could be reduced to 1.2%; the cross section value is 4.1% above the value from the ENDF/B-V (1981) evaluation, which assumes the same cross section shape in the 14 MeV region. A renormalization of the ENDF/B-V data in the 14 MeV region may be recommended. The work above has been published in detail in Ann. Nucl. Energy 10, No. 11 (1983) 601.

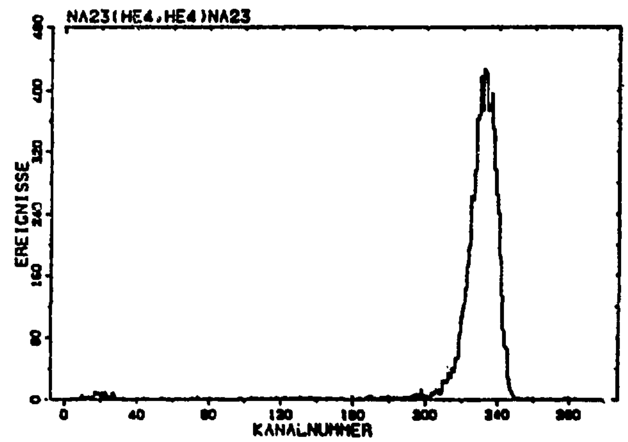
[1] National Physical Laboratory, Teddington, England

DETERMINATION OF Q-VALUES AT THE MUNICH Q3D SPECTROGRAPH *)

A. Chalupka, E. Huenges [1], H.J. Scheerer [1] and H. Vonach

A series of accurate Q-value measurements for (α,d) reactions in the mass-range A = = 17-35 has been started in order to determine more accurately the mass of ^{28}Si relative to the atomic mass unit, which appears interesting in connection with efforts to use perfect ^{28}Si crystals to connect the macroscopic and nuclear mass units /1/.

These measurements are performed in the following way. At the Munich MP tandem the respective targets are bombarded with α-particles of such energy that both the elastically scattered α-particles and the deuterons from the (α,d) reaction are emitted with the same magnetic rigidity (this means that the c.m. α-energy is chosen as $2|Q_{\alpha,d}|$) and both kinds of particles are observed by means of a multiwire counter /2/ in the focal plane of the Munich Q3D spectrograph (fig. 1). Simultaneously the energy of the bombarding α-particles is measured to a precision of $10^{-5}$by means of the 147 m Munich precision time of flight measuring system /3/. From this energy values and the observed small difference in the magnetic rigidity of the elastically scattered α-particles and the deuterons from the (α,d) reaction (s. fig. 1) the (α,d) Q-value can be calculated with similar precision.



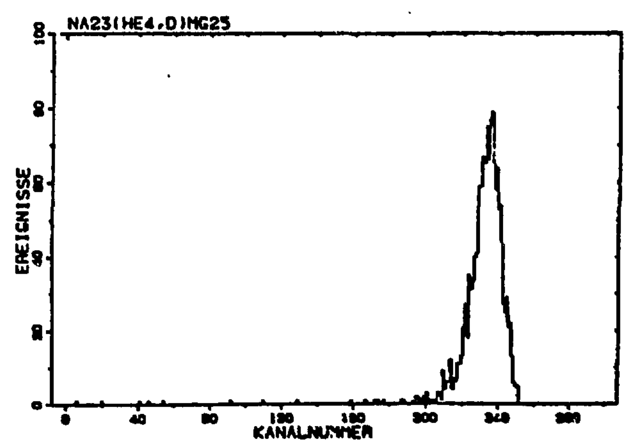


Fig. 1. Simultaneous measurement of elastically scattered α-particles (a) and deuterons (b) from the ^{23}Na(α,α) and ^{23}Na(α,d) reactions in the focal plane of the Munich Q3D spectrograph. 1 ch ≙ .5 mm ≙ $\Delta p/p$ = 2.5.10^{-5} spectrograph angle = 120 degrees

[1] Physikdepartment der TU München, FRG

* supported by Fonds zur Förderung der wissenschaftlichen Forschung in Österreich

The chosen type of reaction is especially favorable for accurate Q-value measurements for the following reasons:

1) The two reactions which are compared in the Q-value measurement occur simultaneously in the same target thus there is no possibility of systematic error resulting from shifts of the image due to small changes of the beam spot (object) on the target and fluctuation of the spectrograph field.
2) The α-particles and deuterons to be compared are emitted with almost equal velocities, therefore both particles have the same dependence on lab. energy or angle; the observed position difference (s. fig. 1) is almost independent of the reaction angle thus the uncertainty in this angle does not contribute to the systematic error.
3) If the measurements are performed at backward angles also the effects of the finite target thickness cancel to a large extent, that is the centroids of the α- and the deuteron peak are shifted by almost equal amounts because of the energy loss of the particles in the target. Thus the uncertainty in target thickness gives only very small error contributions.

Thus the achievable accuracy should essentially be limited only by the accuracy of the length of the 147 m flight path and the accuracy achievable for the difference of the centroids of the α- and deuteron peaks and it is hoped that a total uncertainty of about 200 eV for the Q-values can be obtained. Preliminary measurements have been done for the $^{23}Na(\alpha,d)^{25}Mg$ and $^{25}Mg(\alpha,d)^{27}Al$ indicating that the ^{23}Na-^{25}Mg mass-difference deviates by about 2.5 keV from the present mass evaluation of Wapstra whereas almost perfect agreement with Wapstra's mass values is found for the ^{25}Mg-^{27}Al mass difference.

/1/ A.H. Wapstra and K. Bos, At. and Nucl. Data Tables 20 (1977) 13

/2/ A. Chalupka et al., Nucl. Instr. & Meth. 217 (1983) 113

/3/ H. Huenges, H. Vonach and J. Labetzki, Nucl. Instr. & Meth. 121 (1974) 307

RESULTS FROM THE PARTICIPATION IN THE INTERNATIONAL COMPARISON OF D+T NEUTRON FLUENCE AND ENERGY USING NIOBIUM AND ZIRCONIUM ACTIVATION

G. Winkler

The results of the Nb/Zr intercomparison in the 14 MeV neutron energy range, which took place during the two years before, were distributed to the participants by the organizer, V.E. Lewis /1/. The IRK result for the niobium specific activity/unit fluence was within < 0.1% of the weighted mean of the results from the participating laboratories. The fluence measurement at IRK was based on the simultaneous irradiation of aluminium samples and employing a high-accuracy $^{27}Al(n,\alpha)^{24}Na$ cross section evaluated earlier at IRK /2/. The induced ^{24}Na activity was measured by means of the 12.7 x 12.7 cm NaI(Tl) well-type detector installed at IRK (see section RADIONUCLIDE METROLOGY, this report). The results for the energy scale based on the Nb/Zr activity ratio according to the calibration at NPL were also in very good agreement with the values calculated at IRK on the basis of the effective incident deuteron energy, Q-value of the T(d,n) reaction, dE/dx (E_d) values, and the angular position of the sample /3/. An energy loss of 10 ± 10 keV in a tritium-depleted zone of the neutron target and a tritium-to-titanium ratio of 1.5 ± 0.5 was assumed.

/1/ V.E. Lewis, Division of radiation science and acoustics, National Physical Laboratory, Teddington, England; report presented at the meeting of Section III of CCEMRI at BIPM in Sèvres, May 1983; to be published in Metrologia

/2/ S. Tagesen and H. Vonach, Physics Data 13-3 (1981), Fachinformationszentrum Karlsruhe

/3/ A. Pavlik, G. Winkler, H. Vonach, A. Paulsen and H. Liskien, J. Phys. G: Nucl. Phys. 8 (1982) 1283

CALIBRATION OF NEUTRON DETECTORS IN A 'KNOWN' NEUTRON FIELD

P. Doll [1], B. Haesner [1], H.O. Klages [1] and A. Chalupka

With the availability of a ^{252}Cf neutron-source embedded in a small low-mass highly efficient ionisation chamber /1/ it is challencing to calibrate neutron detectors in the energy range of "say" 1-8 MeV. This device gives a start signal when a neutron is emitted at spontaneous fission of ^{252}Cf, thus allowing a time-of-flight measurement for the fission neutron between the chamber and the neutron detector. The recommended value for the total neutron emission multiplicity for spontaneous fission of ^{252}Cf is 3.745 ± 0.010 /2/ per fission. The so-called "Golden Californium-chamber" /3/ with improved characteristics, concerning the neutron flux modifications due to the steel backing and the housing of the intense fission activity, was exploited to calibrate a liquid He-scintillator /4/ and a large (14 cm Ø, 20 cm high) NE 213 scintillator. Very recently also other groups /5/ exploited this fission-chamber and investigated the neutron flux distribution. Despite a considerable number of different measurements, the characteristics of the spectrum is not entirely settled but a temperature of T = 1.42 ± 0.018 MeV is mostly accepted in the energy range from 0.8 and 8 MeV (fig. 3 in ref. 6) where uncertainties of 3% as maximum are quoted. As a goal in practical application, therefore, an accuracy of ≤ 3% should be obtained. We combined these efforts with the operation of a non-standard liquid-^{3}He scintillator /4/ which offers the capability to detect without any threshold neutrons with a well determined efficiency once the scintillator dimensions, the density of the liquid ^{3}He and the n+^{3}He → p+t cross section as function of neutron energy are known. Detailed publication of experimental conditions, data reduction and results is forthcoming.

/1/ A. Chalupka, Nucl. Instr. & Meth. 164 (1979) 105
/2/ J.W. Boldeman, Neutron Standards and Applications, National Bureau of Standards 493 (1977) 182
/3/ A. Chalupka, B. Strohmaier, IRK Progress Report 1982, p. 24
/4/ R. van Staa, J. Reher, B. Zeitnitz, Nucl. Instr. & Meth. 136 (1976) 241
/5/ H. Klein, Contribution to the XII. Int. Symp. on Nuclear Physics, 22.-26.Nov. 1982, Gaußig/Dresden and R. Böttger, H. Klein, A. Chalupka, B. Strohmaier, PTB-Braunschweig, progress report 1982, p. 7 and p. 25
/6/ J.A. Grundl and C.M. Eisenhauer, Symp. on Neutron Standards and Applications, Gaithersburg 28-31, 1977, National Bureau of Standards, 493

[1] Inst. f. Kernphysik, Kernforschungszentrum Karlsruhe, FRG

INSTRUMENTATION AND DETECTORS

APPLICATION OF SI-μSTRIP-DETECTOR ARRAYS FOR LINEAR X-RAY SENSING

R. Nowotny and J. Kemmer [1]

Current imaging techniques in radiography (computer tomography, digital projection radiography) use linear arrays of discrete radiation sensors. Particularly for frequently performed examinations as conventional lung radiography it would be advantageous to use direct radiation sensing. The sensor arrays available give not the spatial resolution required (i.e. a pixel size of about 250 μm^2). A possible solution is the use of μstrip detectors. Pixel size is then determined by Si-wafer thickness and the width of the strip electrode. Main disadvantage is the low energy absorption of Silicon. A detector thickness of greater 20 mm is required to give an energy absorption of around 20%. Hence strip electrode length of one diode should exceed 20 mm.

The feasibility of an application in digital projection radiography was studied with a μstrip-detector fabricated by J. Kemmer /1,2/. Pixel size was 215 μm x 300 μm. The ionisation currents from 27 strips of 6.7 mm length each were measured with simple current-to-voltage converters. Fig. 1 shows the homogeneity of response and normalized signal currents for two absorbers. The edge electrodes collect ionization currents from larger volumes. Noise equivalent power is about 3.5×10^{-14} W/√HZ. The linear range exceeds dose rates of 25 R/sec. Long-term properties should be improved (passivation). Tube loading could be a limiting factor if fast data acquisition is required.

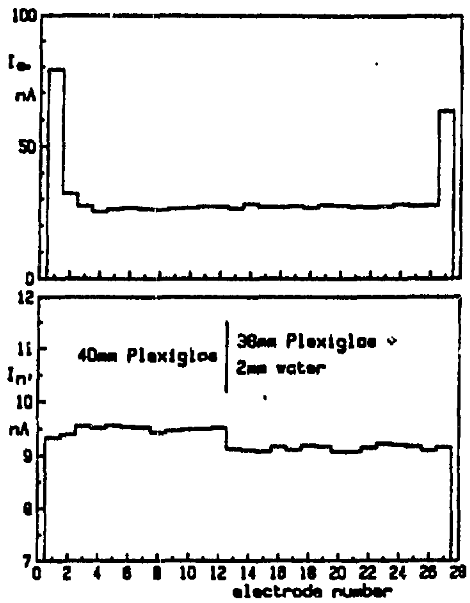


Fig. 1. Distribution of signal currents I_s for uniform irradiation (80 kV, 100 mA, 75 cm distance) and normalized output I_n for two different absorbers.

/1/ R. Nowotny, Nucl. Instr. & Meth. (in press)
/2/ R. Nowotny and J. Kemmer, Proc. 3. Jahrestag. ÖGKP, Salzburg, 1983

[1] TU München, FRG

EVALUATION OF NUCLEAR DATA AND NUMERICAL DATA PROCESSING

EVALUATION OF THE ^{58}NI(N,2N)^{57}NI CROSS-SECTIONS

A. Pavlik and G. Winkler

The cross sections for the ^{58}Ni(n,2n)^{57}Ni dosimetry reaction were reevaluated in the energy range from threshold to 20 MeV including the new precise experimental data (see the last year's report). The results have been published as a IAEA Nuclear Data Section report, INDC(AUS)-9/L, June 1983.

RADIONUCLIDE METROLOGY

THE DECAY SCHEME OF ^{64}CU

P. Christmas [1], S.M. Judge [1], T.B. Ryves [1], D. Smith [1] and G. Winkler

The evaluation of the measurements to clarify longstanding discrepancies concerning the branching ratios (β^+, β^-, EC) in the decay of ^{64}Cu, already mentioned in the last year's report, has been completed and the results published /1/. Six distinct but partially correlated measurements were used to determine all branching ratios. From this data, best estimates, including covariances, were obtained. The β^+/β^--ratio was determined by magnetic β-spectrometry and separately by $4\pi\beta$-γ coincidence-counting using a gas proportional counter. $4\pi\beta$-γ liquid scintillation counting using a multidimensional computer discrimination technique with different γ-channel settings /2/ was employed to determine the total β-ray-branching ratio and the total disintegration rate of the ^{64}Cu sources. The positron branching ratio was measured by means of a Ge(Li) detector, comparing the emission rates of annihilation γ-rays from sources of ^{64}Cu and ^{22}Na of known activity, and independently by counting the total γ-rays from a copper foil, with the activity known from an irradiation in a standard thermal-neutron field, by means of a calibrated NaI(Tl) well-type detector. The yield of the low-intensity 1.34 MeV γ-ray was determined with a calibrated Ge detector. Magnetic β-ray spectrometry also provided highly accurate β^- and β^+ end-point energies. The new more reliable branching ratios were used for a precise measurement and reevaluation of the ^{65}Cu(n,2n)^{64}Cu cross section in the 14 MeV region (see section EXPERIMENTAL NUCLEAR PHYSICS, NEUTRON INDUCED REACTIONS).

/1/ P. Christmal et al., Nucl. Instr. and Meth. 215 (1983) 397
/2/ D. Smith and L.E.H. Stuart, Metrologia 11 (1975) 67

[1] National Physical Laboratory, Teddington, England

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SURVEY OF STANDARDIZATION POSSIBILITIES WITH A NAI(TL) WELL-TYPE DETECTOR

A. Pavlik and G. Winkler

The standardization capabilities of the 12.7 cm x 12.7 cm NaI(Tl) well-type detector installed at IRK were investigated for a series of 27 radionuclides of practical interest with different complexity of the decay schemes. Total detection efficiencies and their uncertainties were calculated for low-mass point-like sources, for 1-cm^3 aqueous solutions, and also for the nuclides being homogeneously incorporated in a 1-g solid sample with 20-mm diameter. The physical consistency of the chosen decay schemes was tested within their limits of uncertainty which enabled tightening the efficiency-uncertainty limits taking a choice among different versions of the decay-scheme data. The work was presented at the 7th meeting of the "Comite Consultatif pour les Etalons de Mesure des Rayonnements Ionisants (Section II)" at BIPM in May 1983, and at the ICRM ("Internat. Committee for Radionuclide Metrology") Seminar in Geel in May 1983. The results, the underlying procedures and concepts of the used computer code have been published as Refs. 1-3, respectively.

/1/ A. Pavlik and G. Winkler, Int. J. Appl. Radiat. Isot. 34, No. 8 (1983) 1167
/2/ G. Winkler and A. Pavlik, Int. J. Appl. Radiat. Isot. 34, No. 2 (1983) 547
/3/ A. Pavlik, Sitzungsber. Österr. Akad. Wiss., mathem.-naturw. Kl., Abt. II, 191, Heft 8-9 (1982) 253

DATING AND ISOTOPE GEOLOGY

I R K RADIOCARBON DATING LABORATORY

H. Felber

The Vienna Radium Institute Radiocarbon Dating Laboratory is concerned with interdisciplinary cooperation in the fields as archaeology, prehistory, palynology, geography, glaciology, limnology, climatology, geology, mineralogy, hydrology, oceanography, botany, forestry, soil sciences, mining, etc, preferably with Austrian universities, museums and other scientific institutions, but also cooperation with foreign universities is practised in case of free capacity. Dating up to 40.000 years B.P. is done by a methane proportional counter low level system with internal screening counter arrangement. Details concerning the application of the method for users are summarized in /1/. Annual reports on the dating work are given in Anzeiger der mathem.-naturw. Klasse der Österreichischen Akademie der Wissenschaften /2,3/ and in Radiocarbon /4,5/.

/1/ H. Felber and P. Hille, Anwendung der Radioisotopendatierung in der Archäologie, Sitzber. d. Österr. Akad. Wiss. 191, 149-184 (1982)
/2/ H. Felber, Altersbestimmungen nach der Radiokohlenstoffmethode am Institut für Radiumforschung und Kernphysik XVIII, Anz. Österr. Akad. Wiss., mathem.-naturw. Kl., Jg. 1982, 133-141
/3/ H. Felber, Altersbestimmungen nach der Radiokohlenstoffmethode am Institut für Radiumforschung und Kernphysik XIX, Anz. Österr. Akad. Wiss., mathem.-naturw. Kl., Jg. 1983, in press
/4/ H. Felber, Vienna Radium Institute Radiocarbon Dates XII, Radiocarbon 24, (2), (1982)
/5/ H. Felber, Vienna Radium Institute Radiocarbon Dates XIII, Radiocarbon 25, (3), (1983) in press

SULFUR ISOTOPE INVESTIGATIONS

E. Pak

For the investigation of mineral deposits (salt, gypsum, base metal ores, etc.) and for several other problems (e.g. oil prospection, hydrology, precipitate pollution,...) sulfur isotope measurements have attained great interest. Therefore, some years ago a mass spectrometer laboratory has been established at IRK as a service to earth scientists.

In 1983 the collaboration with several institutions was continued to prosecute some previous projects: stratigraphic studies in Austria and Hungary, age determination of North Alpine saline deposits, investigation of ore deposits in the Triassic of the Limestone Alps (see also list of publications).

CARBON ISOTOPE INVESTIGATIONS

E. Pak and H. Felber

The method established for sulfur isotope measurements has been extended to carbon isotopes, and easily could be applied for oxygen isotopes as well.
In collaboration with oil geochemists, carbon isotopes in natural gas were investigated in order to study the genesis of gas and corresponding hydrocarbons. A method for the quantitative oxidation of methane to carbon dioxide has been developed.

DATING OF FOSSIL BONES FROM AUSTRIAN CAVES AND THE PROBLEM OF LATE PLEISTOCENE CLIMATE *)

P. Hille and E. Wild

In our last reports /1/ we described methods for dating fossil bones applied to samples of cave bear bones collected from caves situated in the limestone region of the Austrian Alps at altitudes up to about 2000 m above sea level. Cross dating by the U-series- and ^{14}C-method established beyond doubt, that the Ramesch Cave (Upper Austria) was inhabited by cave bears until about 35 000 years B.P. Up to 3 m of bone bearing sediments proof that the cave bear was present for a longer period of time - the oldest bones found at the bottom of the cave showed U-series-ages above 100 000 years. It is not completely clear up to now, whether the cave was populated continuously by bears during this period of whether there were interruptions due to glaciations. (We hope to find out in the near future.)

From U-series-ages of 50 000-60 000 years determined for bone samples from older layers in the sediment of the same place, together with the 35 000 years for the youngest samples given above, it is clear however that there was a period of rather favourable climate in the middle of the last cold period (Wisconsin or Weichsel or Würm stadial). During this period, which could be associated with the "4-Würm I-II interstadial" according to the nomenclature for Alpine climatic phases, or with "Isotope Stage 3" according to the $\delta^{18}O$-records in deep-sea cores following Emiliani (see e.g. /2/), it was obviously possible for the cave bear to survive in the Austrian Alps at 2000 m altitude. This implies that the Alps must have been essentially free of permanent glaciation, and that there was enough food (grass and herbs) growing during summer in high altitudes to feed the herbivorous bear. One is lead to the conclusion, that climatic conditions in our Alpine region at 2000 m might have been even less adverse than today.

This suggestion must however be confronted with the record of world-wide glaciation we know rather accurately from the measurement of $\delta^{18}O$, the oxygen isotopic composition of planktonic foraminifera in deep-sea drilling-cores (see e.g. /3/). Selected tests are formed primarily at some depth below sea surface so that changes in surface temperature do not greatly affect the temperature at which the carbonate is secreted. Down-core variations in $\delta^{18}O$ thus reflect changes in isotopic composition of the ocean, caused by the waxing and waning of ice sheets (primarily of the Northern Hemisphere).

Fig. 1 shows such a typical $\delta^{18}O$-record. A characteristic feature is a saw-tooth like temporal variation of the global ice masses, with a period of about 100 000 years. The last saw-tooth shown in fig. 1 is typical. It starts with isotope stage 5, a very warm period some 125 000 years ago. From then on the mean trend is an increase of ice, until ca. 18 000 years B.P. a glaciation maximum is reached /4/. At this time ice sheets covered most of Northern Europe and America but afterwards vanished rather quickly about 10 000 years ago.

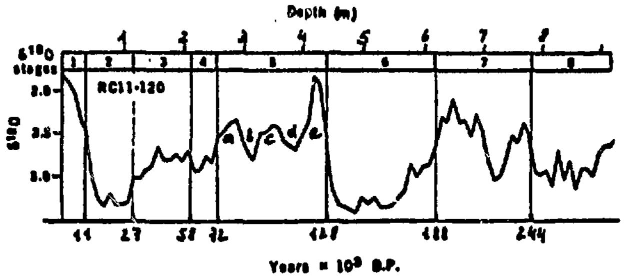

Fig. 1. Depth plot of oxygen isotopic composition changes $\delta^{18}O$ (in per mil) measured in core RC11-20 located in the southern Indian Ocean. Also indicated on top of the figure are the Emiliani isotope stages discriminating between periods of waxing and waning global ice sheets. (Direction of increasing ice downwards.) The chronology of isotope stages, given at the bottom of the figure, is due to a modern version of the Milankovitch astronomical theory of paleoclimates /3/. (Figure taken from /3/ and modified.)

Superimposed on this general trend there are minor but characteristic fluctuations of the ice sheets of shorter periods as indicated by the isotope stages. The period between about 35 000 and 60 000 years under discussion here can very well be associated with isotope stage 3 in the deep-sea record. Isotope stage 3 was a period of warmer climate, but as can be seen from fig. 1, global ice sheets did not really melt substancially but only stop to increase. According to the $\delta^{18}O$-record global ice sheets during isotope stage 3 must have been larger than today.

The Finno-Scandinavian ice sheet however did never reach the Alps, as can be seen from its reconstructed extent during the last glaciation maximum 18 000 years ago /4/. Differences between variations in global ice sheets and glaciation-cycles of the Alps are therefore conceivable and must have occured to explain our findings concerning the presence of cave bears in the Alps at 2000 m above sea level during isotope stage 3.

A clue for an explanation might be found in different responses of the large Northern Hemisphere ice sheets and of Alpine glaciers to different driving forces, external and auto-cyclic respectively - as we want to discuss now:

After decades of discussion it seems to be generally accepted now, that changes in global ice volume are at least triggered (if not forced) by insolation variations. The last decade has witnessed a revival of the old Milankovitch astronomical theory of paleoclimates /5,6/, which tried to show in a quantitative way how changes in climate are caused by long term variations of the Earth's orbital elements (eccentricity of the

* supported by Fonds zur Förderung der wissenschaftlichen Forschung in Österreich

elliptic orbit, obliquity of the Earth's axis upon the ecliptic and the longitude of the perihelion relatively to the moving vernal equinox). As described in the two reviews just cited, this old theory needed some essential refinements and also the fundamental proof that there is indeed significant correlation between insolation curves calculated from the astronomical elements and geological data. This could be shown recently (see /5,6/). Also the discussion about the details of the mechanism of glaciations will be with us for a while, it seems to be clear that changes of the seasonal and latitudinal distributions of insolation really do initiate the spreading of ice. If northern summers get colder, southern summers will automatically get warmer and southern winters colder - given the present distribution of continents (a southern polar continent and a land-locked northern polar sea), this is however just what is needed to initiate an ice-age: Cool summers in the northern hemisphere will prevent winter snow and ice from melting, thus keeping the albedo high during northern summer, which will hasten the development of glaciation, especially when winters are relatively warm, so that large amounts of water can evaporate to precipitate as snow. On the other hand, in the southern hemisphere snow which falls on the open sea will melt anyway (and there is almost no land at high latitudes not already permanently covered with ice), so the only way to increase the ice cap is the spreading of sea-ice, which only can occur during very severe winters /5/. To illustrate this triggering of climatic changes by insolation patterns fig. 2 shows the variation of mid-month insolations for June and December during the last 150 000 years for 60° north latitude. The curves were calculated using the convenient formulas given by Berger /7/. Also indicated in the figure are the Emiliani-deep-sea isotope stages 1-6 and the long-term mean value of mid-month insolations. As one can see changes from warm to cold periods and vice versa are occuring about 6000 years after the June-insolation curve passes the long-term mean value in one direction or the other. These boundaries between Emiliani-stages also coincide rather accurately with minima and maxima in the insolation curves for June or December respectively. (This finding turns out to be approximately true for the $\delta^{18}O$ deep-sea record of the last 750 000 years.) The June insolation curve for 47,5° northern latitude (the latitude of the Alpine Ramesch cave investigated) looks very similar to that for 60° shown in fig. 2.

During about 30 000-65 000 years B.P. corresponding to isotope stage 3 and to the period when the cave bear was present in 2000 m altitude in the Austrian Alps respectively, June insolation was higher than today. So if the climate in the Alps had followed the insolation curve in an essentially linear way, this could be part of the explanation for a climate less adverse than today as needed to understand the bear's presence in high mountain regions. This assumption however implies different dynamics for the growth of the large Northern Hemisphere ice sheets and of the large Alpine glaciers after triggering by the insolation pattern, as already pointed out. The essential difference might be the following: The great northern ice sheets, the Laurentide and the Eurasian may continue to grow, even if insolation increases -Model calculations show /8/ that this is due to the feedback between surface elevation of the

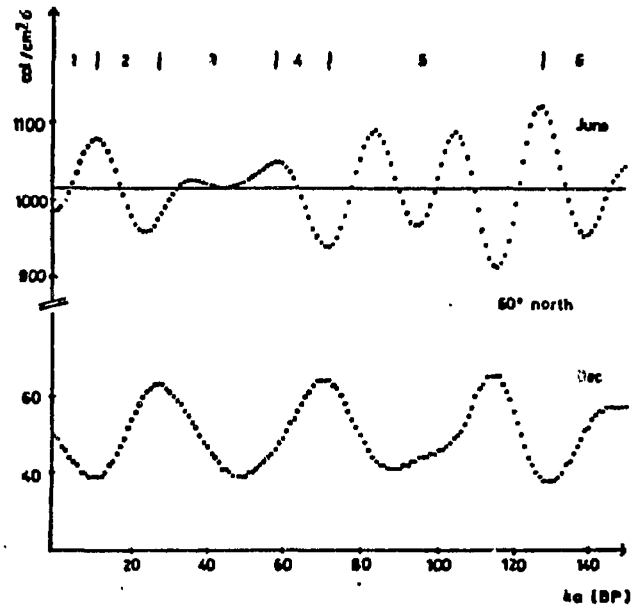

Fig. 2. Midmonth-insolation curves for the last 150 000 years calculated for June and December at 60° north latitude. Horizontal line indicates the long-term mean insolation. Boundaries of isotope stages 1-6 are shown for comparison.

growing ice sheet and mass balance. An autocycle is started thus, which will be terminated by bedrock sinking under the weight of the accumulated ice. Another global glacial cycle can start when bedrock has raised again and summer insolation is well below normal /8/.

Although it is clear that the large ice sheets will influence the climate not only of the Alpine region but on a global scale through atmospheric and oceanic teleconnection, ice in the mountains should behave in a different way, at least in the beginning when the highland is not wholly covered by sheet-ice. Glaciation of highland typically starts with the accumulation of snow in valley-heads. Settling under its own weight the snow is compressed to firn and later to ice. In the present climate of the Austrian Alps about 50 m thickness is enough to set the ice in motion, and the well known sculpturing of the highland by glacial erosion begins (like corrie-cutting and forming of glacier troughs) /9/. The essential point we want to make is that the ice is moving downwards in the beginning of glaciation and therefore there can be no positive feedback between surface elevation and mass balance as in the case of ice-caps. A valley-glacier should not continue to grow when insolation increases again, but should follow more closely the insolation pattern than ice-sheets do.

Of course it is not possible to estimate the influence of the Northern Hemisphere icesheet, which were larger during isotope stage

3 than today (see fig. 1), on the climate of the Alps, without doing calculations within the framework of very sophisticated climatic models. We think however that our dating of cave bear bones proves decoupling to some extent of the local Alpine climate from the general trend of global glaciation. We hope that further dating of bones from Alpine caves in the near future will give us some more quantitative information concerning the local cycles of glaciation.

/1/ P. Hille, E. Wild and H. Vonach, Inst. f. Radiumforschung und Kernphysik, Progr. Report 1981 pg. 23, and P. Hille and E. Wild, Progr. Report 1982, pg. 28

/2/ J.J. Morley and J.D. Hays, Towards a high-resolution, global, deep-sea chronology for the last 750 000 years, Earth Plan. Sc. Letts. 53 (1981) 279

/3/ J.D. Hays, J. Imbrie and N.J. Shakleton, Variations in Earth's Orbit: Pacemaker of the Ice Age, Science 194 (1976) 1121

/4/ CLIMAP Project Members, The Surface of the Ice-Age Earth, Science 191 (1976) 1131

/5/ A. Berger, The Milankovitch Astronomical Theory of Paleoclimates: A Modern Review, Vistas in Astronomy 24 (1980) 103

/6/ J. Imbrie, Astronomical Theory of the Pleistocene Ice Ages: A Brief Historical Review, Icarus 50 (1982) 408

/7/ A. Berger, Long-Term Variations of Daily Insolation and Quaternary Climatic Changes, J. Atmos. Sc. 35 (1978) 2362

/8/ J. Oerlemans, Model experiments on the 100 000-yr glacial cycle, Nature 287 (1980) 430

/9/ G.H. Dury, The Face of the Earth, Penguin Books Ltd., 4th ed. (1976)

AN ATTEMPT TO DETECT NATURAL ^{41}CA

H. Ernst [1], W. Henning [2], P. Hille, G. Korschinek [1], P. Kubik [1], W. Mayer [1], H. Münzer [3], E. Nolte [1] and H.J. Scheerer [1]

We have tried to use the Munich MP-Tandem as an accelerator mass spectrometer for ^{41}Ca, a radioisotope which perhaps can be used for dating fossil bones. Characteristic features of our experiment are: Acceleration of CaH_3^--ions, a Wien-velocity filter in front of the 90°-analysing magnet and the use of a magnetic spectrograph in connection with a focal plane detector designed for good particle identification properties. Although we missed in our first experiment the sensitivity needed for the detection of natural ^{41}Ca by estimated two orders of magnitude, the tandem mass spectrometer described in principle seems to be suitable to solve the problem after some minor improvements. Background will not be the main problem we learnt from our first experiment, but too low intensity of useful Ca-ion current. Some pre-enrichment step might thus turn out to be unavoidable. Background due to ^{41}K however does not seem to be the stumbling-block suspected.

[1] Fachbereich Physik der TU München, FRG
[2] On leave from Argonne NL, Argonne, USA
[3] Accelerator Lab. of the Munich Universities, FRG

APPLICATIONS IN MEDICINE

QUALITY ASSURANCE MEASUREMENTS IN DIAGNOSTIC RADIOLOGY *)

R. Nowotny, W. Rechtberger, J. Bliem [1] and H. Pokieser [1]

In a continuing effort a quality control program is being installed. The measurements which can be made at the moment are focus/image receptor distance, congruency of light and radiation field, exposure time, exposure linearity and reproducibility, automatic exposure control, tube protection devices, focal size, raster positioning, film/screen contact, film sensitometry, dark chamber integrity, developer temperature and viewing panel illumination.
Besides a film retake analysis was performed. An example for the results obtained is shown in fig. 1.
The expenditures for such a program comprise a minimum investment of around S 120.000,- but about 29 working hours per year and X-ray unit including an appropriate number of viewing panels and X-ray cassettes /1/. For the retake analysis about 3 min per day and unit are required.

/1/ R. Nowotny, J. Bliem, W. Rechtberger and H. Pokieser, Proc. 64. Deutscher Röntgenkongreß, Hannover, 1983 (in press)

* supported by mediz.-wiss.Fonds d. Bürgermeisters d. Bundeshauptstadt Wien, Austria

[1] Zentrales Institut für Radiodiagnostik, Univ. of Vienna, Austria

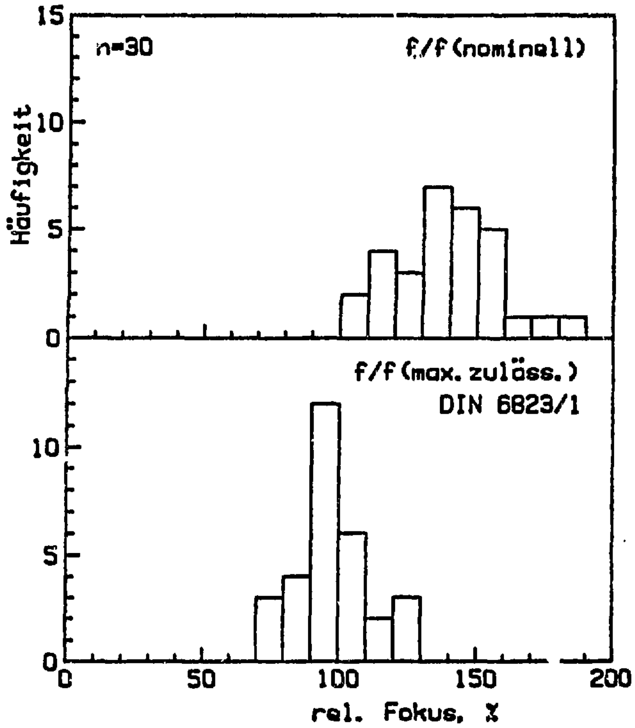

Fig. 1. Measured focal spot size normalized to nominal (top) and maximum permissible (bottom) focal spot size

A SENSITOMETER FOR DIAGNOSTIC FILM-SCREEN COMBINATIONS USING ^{241}AM-γ-RADIATION *)

R. Nowotny and J. Bliem [1]

The sensitivity of film-screen combinations in radiography ideally should be determined with an X-ray sensitometer. As the expenditures in particular for the X-ray unit are high, a sensitometer was devised which uses essentially the 60 keV gamma radiation of ^{241}Am for exposure. The source contains about 5 Ci ^{241}Am. Self-absorption results in negligible intensity of the lower energy photons and an effective activity of 3.18 Ci. Sequential exposures are made by moving a cassette carriage on a bench of 2.7 m length. Exposure time is held constant (1-2 sec). The individual positions are chosen to give logarithmic dose increments of 0.15. The films are then developed and the optical density is determined with a densitometer. The sensitivity S is then given by $S = 2,58.10^{-4}/J$ where J denotes exposure (R), which is given by irradiation time and position (fig. 1). Expenditures for such a sensitometer /1/ are relatively low. The source strength is suitable for a measurement of sensitivity numbers > 500. Absolute measurements of film and/or screen sensitivity are possible.

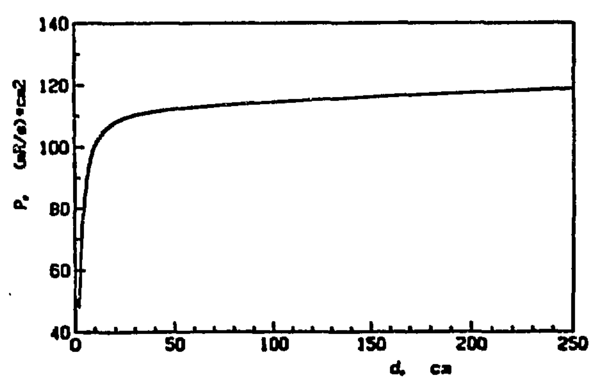

Fig. 1. Dose rate x square distance, P, versus distance. Deviations from a constant value are due to the source geometry

/1/ R. Nowotny and J. Bliem, Proc. 64. Deutscher Röntgenkongreß, Hannover, 1983 (in press)

* supported by mediz.-wiss. Fonds des Bürgermeisters der Bundeshauptstadt Wien, Austria

[1] in collaboration with Zentrales Institut für Radiodiagnostik, Univ. of Vienna, Austria

DOSE REDUCTION BY CARBONFIBER-CASSETTES

P. Hajek [1] and R. Nowotny

The entrance window of a conventional radiographic film cassette is usually made from aluminium. Recently cassettes with carbonfiber enforced plastic sheets have become available. As transmission of X-rays in the lower energy region is enhanced as compared to aluminium radiation dose for constant optical density will decrease. The actual dose reduction was calculated using spectral data from /1/ and mass aborption coefficients from /2/ for various intensifying screens. Measurements were made in a low scatter geometry. Fig. 1 shows experimental and calculated ratios for mAs data required to give an optical density of 1 above base plus fog for the two materials. Dose reduction amounts up to 10% (fig. 1) which increases for thicker Al-windows (up to 2 mm) to 30% at 60 kV tube voltage. The results are being published in /3/.

/1/ R. Birch, M. Marshall and G.M. Ardran, Scient. Rep. Ser. 30, HPA, London, 1979
/2/ W.H. McMaster et al., UCRL-50/74, Sec. 2, 1969
/3/ P. Hajek and R. Nowotny, Fortschr. Röntgenstr. (in press)

[1] Zentrales Institut für Radiodiagnostik, Univ. of Vienna, Austria

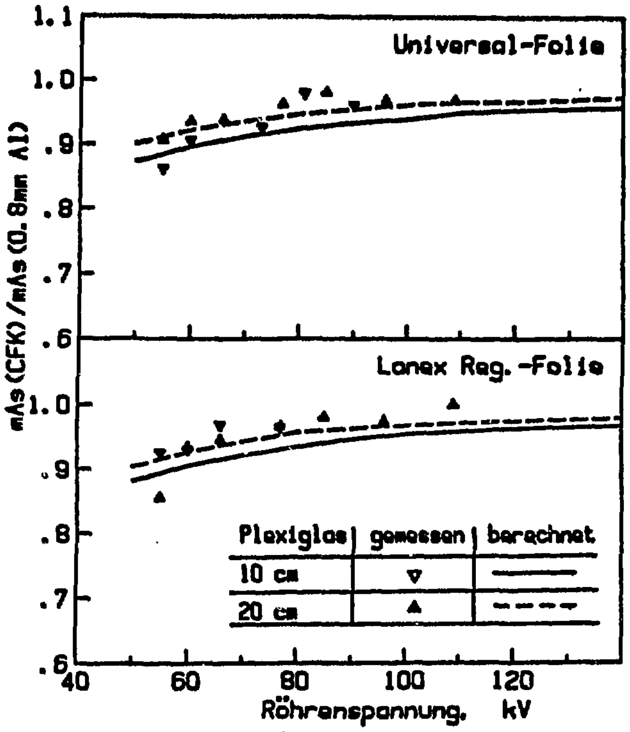

Fig. 1. Exposure for carbon fiber cassettes (CFK) relative to aluminium (0.8 mm) required for an optical density of 1 versus tube voltage for Universal-screens (top) and Lanex Regular screens (below)

A COMPUTER CODE FOR THE CALCULATION OF DIAGNOSTIC X-RAY SPECTRA *)

A. Höfer and R. Nowotny

Radiographic imaging can be performed under various conditions and with different equipment and image receptors. For a simulation and an evaluation of the various imaging properties in a specific situation X-ray spectra are required as input data. For this purpose a computer code basing essentially on the method given in /1/ was developed which calculates X-ray spectra for tungsten anodes in a tube voltage range from 50 to 140 kV. Other input parameters are tube anode angle, voltage ripple (DC, 2 pulse to 12 pulse, multipulse), inherent filtration and additional absorbers.
Characteristic K-radiation was considered using an empirical relationship given in /2/. Data from /3/ for the mass and energy absorption coefficients were taken to generate polynomial fits which were then used in the code. Using this code a spectrum library for commonly used diagnostic tubes and tube voltages from 50 to 140 keV in 5-keV-steps was created.

/1/ R. Birch and M. Marshall, Phys. Med. Biol. 24 (1979) 505
/2/ M. Green and V.E. Cosslett, Brit. J. Appl. Phys. 1 (1968) 425
/3/ J.H. Hubbell, Int. J. Appl. Radiat. Isot. 23 (1982) 1269

* in collaboration with Zentrales Institut für Radiodiagnostik, Univ. of Vienna, and supported by L. Boltzmann-Institut f. radiol.-physik. Tumordiagnostik, Vienna, Austria

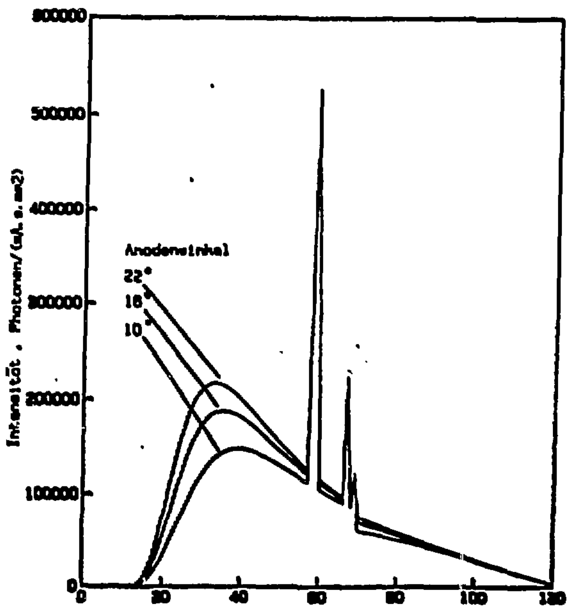

Fig. 1. Variation of absolute photon intensities for 120 keV constant tube voltage with target angle in 0.75 m distance from the tube.

APPLICATIONS IN GEOPHYSICS

RADON MEASUREMENTS FOR EARTHQUAKE PREDICTION RESEARCH *)

K. Aric [1], H. Friedmann, R. Gutdeutsch [1], F. Hernegger, C.Y. King [2]

a) Radon Measurements in Austria

In 1983 the radon concentration in the observed spring in Warmbad Villach was rather constant compared to 1981 and 1982 /1/ (fig. 1). Even there are some fluctuations in the radon concentration we did not expect any outstanding seismic activity within a distance D, which fullfils $M \geq 2.4\ D - 0.43$ (M..magnitude of an earthquake). The results of the radon measurements made in Sicheldorf are still under investigation.

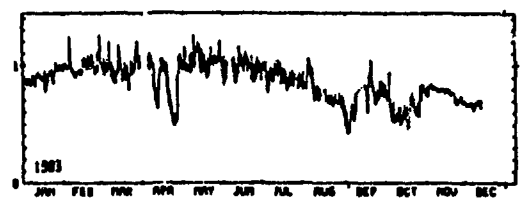

Fig. 1. The ^{222}Rn concentration (in nCi/l) in the spring of Warmbad Villach in 1983

b) Radon Measurements in Turkey

The measurements of the radon concentration in the spring of Bolu started in March 1983. Up to now we have got the results until beginning of October 1983 (fig. 2). In that time only one stronger earthquake occured (Biga, July 5th, 1983, 40°15' N 27°22' E, M = 4.9) which seems to have a distance too large to influence our spring. For the strong earthquake in Erzurum (Oct. 30th, 1983) which again is probably too far away from our spring, we still have not got the radon data. On 5 different sites soil gas measurements were done by the use of track etch detectors. As an overall tendency it seems that the radon concentration is increasing.

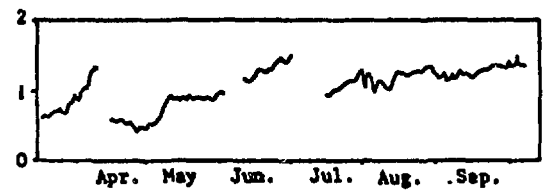

Fig. 2. The ^{222}Rn concentration (arbitrary units) in the spring of Bolu (Turkey)

c) Theory on Earthquake Precurser Radon Anomaly

To explain the form of radon anomalies before earthquakes a theory on the propagation of an epicentral stress change was developed. Including the radon transport by the spring water to the surface, a parameter could be deduced which correlates with the epicentral distance. This is in good agreement with the observed data /2/.

/1/ H. Friedmann, Anomalies in the Radon Content of Spring Water as Earthquake Precurser Phenomena, presented at the EGS/ESC Conf. in Leeds 1982, to be published in Earthquake Prediction Research

/2/ H. Friedmann, The shape of radon anomalies in spring water before earthquakes and the distance to the epicenter - a theoretical approach, presented at the AGU Meeting in San Francisco 1983.

* supported by Fonds zur Förderung der wissenschaftlichen Forschung in Österreich (Grant No.: 3295, 4305, 4688)

[1] Institut für Meteorologie und Geophysik der Universität Wien, Austria
[2] Geological Survey, Office of Earthquake Studies, Menlo Park, California, USA

DOSIMETRY AND ENVIRONMENTAL STUDIES

RADON AND RADIUM CONCENTRATION IN AUSTRIAN SPRING WATER

H. Friedmann and F. Hernegger

In 1983 the radium and radon determinations in spring water were carried on. Since 1976 in more than 100 springs the ^{226}Ra concentration was determined (fig. 1) and in about 100 springs the ^{222}Rn-content was measured (fig. 2) /1,2/.

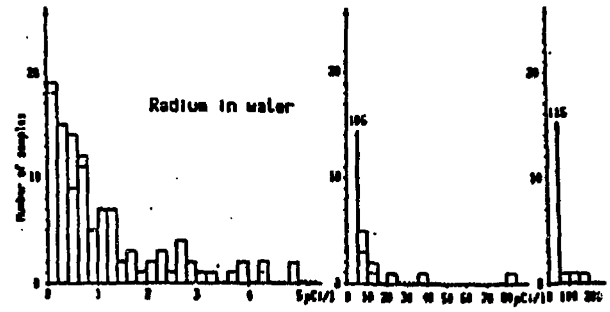

Fig. 1. The ^{226}Ra distribution among Austrian springs. The full line indicates all measured springs, the dashed line indicates springs which are used for drinking water.

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/2/ H. Friedmann, A Portable Radonmeter, Rad. Prot. Dosim. 4, No. 2 (1983) 119-122

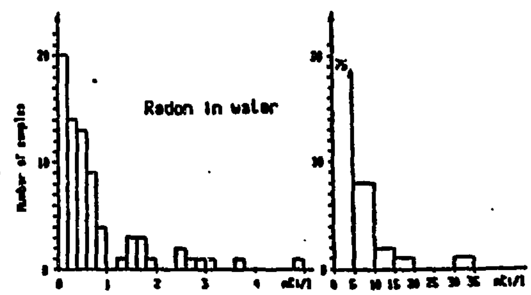

Fig. 2. The ^{222}Rn distribution among Austrian springs.

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