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CONTENTS

Vorliegender Bericht, der erste dieser Art unseres Institutes, dient vor allem einer zusammenfassenden Darstellung der Forschungs- und Entwicklungstätigkeit während des Jahres 1981. Die Beiträge sollten die während dieses Zeitraums laufenden oder abgeschlossenen Projekte und Arbeiten beschreiben. Bewußt wurde auf die Wiedergabe von Kurzfassungen (Abstracts) der 1981 erschienenen Veröffentlichungen (vgl. Seiten 29-31), der Diplomarbeiten und Dissertationen, sowie eine Liste der (über 50) in- und ausländischen Institute und Forschungsstellen, mit denen auf verschiedenen wissenschaftlichen Gebieten zusammengearbeitet wird, verzichtet.

Die Redakteure danken allen Kolleginnen und Kollegen, die trotz mancher Schwierigkeiten zum Entstehen des 'Progress Report 1981' beigetragen haben, insbesondere wäre ohne die hilfreiche Kooperation mit Herrn G. Fellner und Fr. Ch. Schwingenschlögl eine so schnelle Fertigstellung unmöglich gewesen.

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NUCLEAR THEORY

THEORY OF FEW NUCLEON SYSTEMS

H. Baier, W. Bentz, E. Hammel, M. Schaden

We investigate the effects of non-nuclear degrees of freedon in nuclear 2- and 3-body problems. Relativistic corrections are included in a systematic manner. Between else we calculated the influence of isobaric excitations on the structure of the deuteron, on NN-scattering and on charge asymmetry in the 3N-systems. At the moment we study problems related to the quark structure of NN-interactions.

THEORETICAL ANALYSIS OF MUON-CAPTURE IN NUCLEI *)

H. Baier, W. Grimus [1], E. Hammel, M. Schaden

We found that a consistent treatment of exchange effects leads to quite an interesting but quantitatively small contribution to the μ-capture Hamiltonian. Most important however is the fact that we can use our treatment (based on a method of Fukuda - Sawada - Taketani) to include relatistic effects in all interesting two- and three-body problems in quite a consistent manner.
For instance we treat the charge asymmetry question in that manner. Using covariant versions of Fadeev's theory and applying separable potential models we obtain a practical theory of relativistic effects in nuclear 2- and 3-body systems. We conclude that the influence of isobaric and mesonic corrections should be treated together with a consistent relativistic framework. Total μ-capture in 3-He was calculated and it seems that relativistic corrections to the wave functions largely cancel relativistic corrections for the Primakoff-Hamiltonian.
Further work should include the above mentioned exchange effects more carefully than usually accepted; there remains however the problem with the induced pseudoscalar interaction in μ-capture, a major obstacle to a generally acceptable μ-capture theory.

i. W. Grimus, H. Baier, Relativistic corrections to weak exchange currents and the μ-proton capture, Lett. al. Nuovo Cimento 25, 12 (1979) 353
ii. H. Baier, Exchange currents, isobaric excitations and the deuteron, F. d. Physik 27, 5 (1979)
iii. H. Baier, E. Hammel, A. Rinat, Relativistic corrections on three-nucleon observables, Phys. Lett. 85B (1979) 193
iv. H. Baier, E. Hammel, Covariant approach to the three-nucleon bound states with separable interaction, Lett. al. Nuovo Cimento 53A (1979) 359
v. E. Hammel, Relativistic corrections of three-nucleon wave functions and muon-capture in 3-He, Phys. Rev. C22, 5 (1980) 2258

*) Partly financed by Fonds zur Förderung der wissenschaftlichen Forschung in Österreich

[1] Institut für Theoretische Physik der Universität Wien

ISOBARIC EXCITATIONS AND RELATIVISTIC EFFECTS IN 3N-SYSTEMS *)

H. Baier, W. Bentz, E. Hammel, M. Schaden

It turns out that specially chosen relativistic reductions of the Bethe-Salpeter-equations might introduce hard core effects and the effects of the usually purely ad hoc introduced σ-particle starting from simple one boson exchange models of NN-interactions.As an example Gross's reduction of Bethe-Salpeter equation using specially constructed separable potentials can be applied to the nuclear two and three-body problem.
As a first result we obtained the S, D, P-parts of the deuteron wave functions using as input parameters $3\text{-}S_1$, $3\text{-}D_1$-NN-phase shifts, deuteron binding energy and P-state admixture. Fairly good agreement with meson-theoretical results of more elaborate treatments were obtained.
The off mass shell deuteron wave functions might easily by applied to future work on relativistic 3-body problem.
In this respect it turned out, that Gross's approach can be generalized to reduce the 3N-Bethe-Salpeter-equation in a fairly straightforward way.
To include isobaric excitations in the few-body problem a system of coupled covariant equations was deduced and used to derive the isobaric parts of the deuteron state and to calculate observables of the deuteron. Our simple model

agrees well with more elaborate treatments of this problem. It is possible to apply the approach to 3-H, 3-He.

i. E. Hammel, Relativistic deuteron wave functions with separable potentials, Phys. Rev. C23(5) (1981) 2324
ii. E. Hammel, Relativistiv Three-Body Theory for Scalar and Spin Particles Three-Body Forces in Triton, IRK-PUB-80-7
iii. E. Hammel, M. Schaden, A Three-Dimensional Reduction of the 3-Particle Bethe Salpeter Equation Generated Three-Body Forces, IRK-PUB-80-1
iv. E. Hammel, M. Schaden, H. Baier, 3N-Observables and Relativistic Reduction Formalism, Poster contribution to: Int. Conf. High Energy Physics and Nuclear Structure, Versailles, France, 1981

*) Partly financed by Fonds zur Förderung der wissenschaftlichen Forschung in Österreich

RELATIVISTIC PHYSICS OF FEW NUCLEON SYSTEMS *)

H. Baier, H. Zingl [1], E. Hammel, M. Schaden, W. Bentz, W. Plessas [1], L. Mathelitsch [1], K. Schwarz [1], H. Zankl [1]

We investigate systematically all the observables of the 2N- and 3N-system by using different reduction formalism of Bethe-Salpeter-equation. In his dissertation M. Schaden tries to give a new explanation for the medium range attractive part of NN-interactions usually ascribed to the σ-meson.Using a special designed relativistic reduction scheme he produces an attraction term in the interaction, coming purely from 1π-exchange and to be added to the usual OBE-exchange potentials. At present numerical problems don't allow him to decide whether such an approach would be sufficient to simulate the effects of the σ as sometimes guessed in literatura.

i. H. Baier, M. Schaden, Pol-reduction of the Bethe-Salpeter propagator including negative energy states and application to the NN-problem (in preparation, spring 1982)

*) Partly financed by Fonds zur Förderung der wissenschaftlichen Forschung in Österreich

[1] Institut für Theoretische Physik der Universität Graz

CHARGE ASYMMETRY EFFECTS IN THE NUCLEAR THREE-BODY PROBLEM *)

H. Baier, W. Bentz

Mechanism of isospin violation in the nuclear force due to the Δ-isobar and mesonic as well as photonic exchange process are studied. Such effects arise for instance from the coupling of the nucleonic Δ-excitation to the photon and from charge splitting of the Δ-mass. As to the exchange processes we concentrate on $\pi^0\gamma$-and 2π exchange. The contribution of these effects to the mass splitting of the 3-He, 3-H nuclides is calculated, giving a small but nevertheless countable result. The main result is a rather detailed estimate of the theoretical uncertainty in field theoretic calculations of such effects. Work is done in this direction in close collaboration with a group at the T.U. Hannover (Prof. Sauer).

i. H. Baier, W. Bentz, Ch. Hajduk, P.U. Sauer, Δ-Isobar Contributions to the Charge Asymmetry of the 3N-Bound States (submitted to Nucl. Phys.)
ii. H. Baier, W. Bentz, Ch. Hajduk, P.U. Sauer, Pionic contributions to the charge asymmetry in 3N-bound states (to be submitted for publication)

*) Partly financed by Fonds zur Förderung der wissenschaftlichen Forschung in Österreich

INFLUENCE OF QUARK DEGREES OF FREEDOM ON THE NUCLEAR TWO- AND THREE-BODY PROBLEM *)

H. Baier, W. Bentz, M. Schaden

We started an investigation on the short range part of NN-interaction. Together with a group at the TU-Vienna seminaries on the subject were initiated and will be extended to include a group at the university of Graz. Bag and potential models will be studied in detail. Problems of the possible non existence of hard core will be investigated as well as a gluon exchange model of 3-body forces. Fadeev's approach will be applied.

*) Partly financed by Fonds zur Förderung der wissenschaftlichen Forschung in Österreich

NUCLEAR MODEL CALCULATIONS

EVALUATION OF CROSS SECTIONS OF NUCLEAR REACTIONS BY MEANS OF REACTION MODEL CALCULATIONS

B. Strohmaier and M. Uhl

1. Cross sections of neutron induced reactions on 52-Cr, 55-Mn, 56-Fe, 58,60-Ni and 93-Nb

Cross sections for most reactions of the most abundant isotopes of the elements Cr, Mn, Fe and Ni were calculated for incident energies to 30 MeV [*)] and for Nb to 20 MeV. All these materials are of importance for the technology of fusion reactors. For the calculations, the optical model, the exciton model and the compound nucleus model were used. A consistent set of model parameters was chosen so as to reproduce the existing experimental cross section data simultaneously as good as possible. Comparisons of calculated and experimental cross sections are displayed in figs. 1-4.

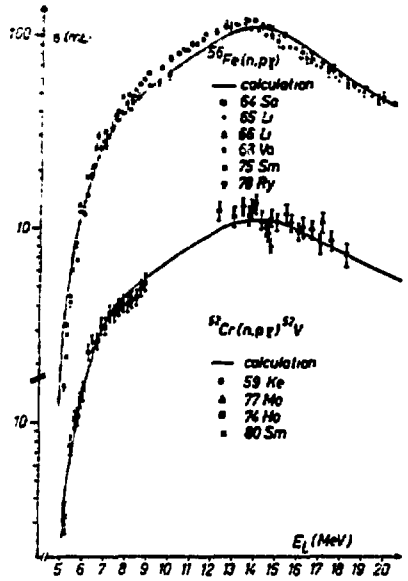


Fig. 1. Activation cross sections for the (n,p) reaction on 56-Fe and 52-Cr

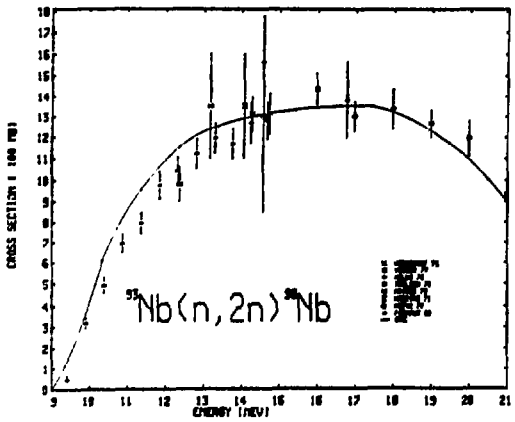


Fig. 3. Activation cross section for the reaction 93-Nb(n,2n)

*) Supported by the European Communities through EURATOM

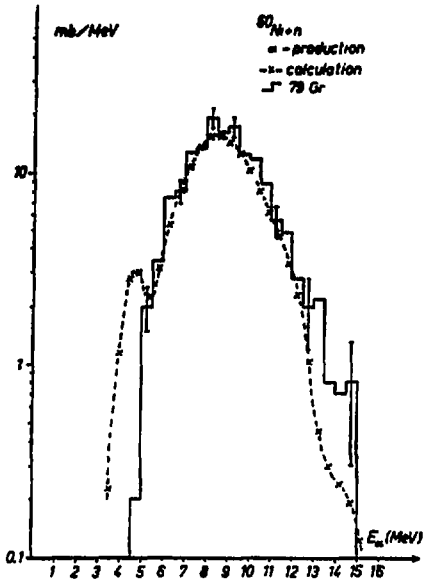


Fig. 2. Alpha-particle production spectrum from 60-Ni + n at 15 MeV incident neutron energy

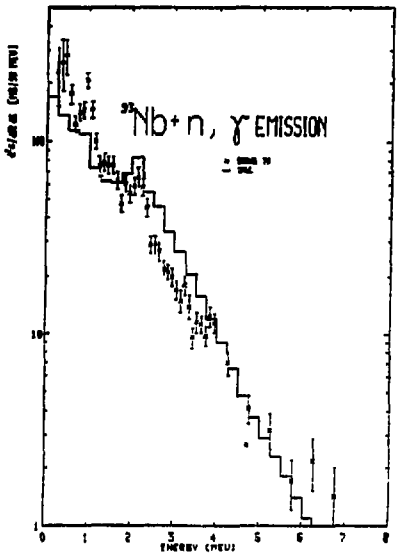


Fig. 4. Gamma-ray production spectrum from 93-Nb + n at 14 MeV incident neutron energy

2. Cross sections of neutron induced fission of 237-Np

Following the same principles as in section 1, the fission cross section was calculated between threshold and 20 MeV. The calculation of this cross section which is applicable for neutron dosimetry purposes, simultaneously represents a study of the applicability of the statistical model under consideration of a double humped fission barrier for the calculation of fission cross sections. Fig. 5 shows a comparison of the calculated cross section and experimental data.

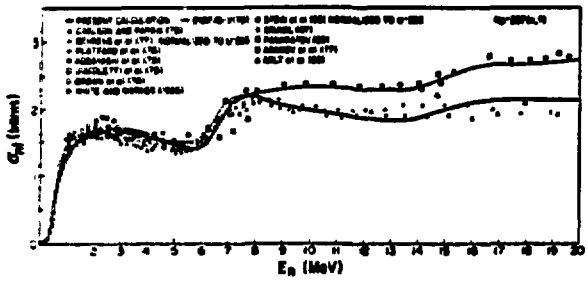


Fig. 5. Neutron induced fission cross section for 237-Np

3. Program development

A universal computer program for calculating cross sections of nuclear reactions is being developed. In the course of this work, recently the parts of the code for the calculation of fission cross sections and level densities were programmed.

THE USE OF STATISTICAL-MODEL CODES FOR AN A-PRIORI CALCULATION OF ISOTOPE PRODUCTION YIELDS

R. Nowotny

Both codes ALICE /1/ and STAPRE /2/ have been used for the calculation of charged particle induced excitation functions. From these the isotope production yields can be calculated under given presumptions for particle energy, target material and purity.
A number of yield calculations were done for medically important radionuclides produced via proton induced reactions /3/.
The comparison of data from the literature with calculated yields shows that both data agree to within a factor of two (fig. 1). This covers also all experimental uncertainties which quite often are not given in the literature.
While calculated excitation functions for proton induced reaction fit well to experimental data (fig. 2), calculated data for other particles show less accuracy (fig. 3, /4/) and further efforts are required to establish the reliability of such data for an a-priori estimation of yield figures.

/1/ M. Blann, Rep. COO-3494-29 (1976) and Rep. COO-3494-34 (1977)
/2/ M. Uhl and B. Strohmaier, Rep. IRK 76/01 (1976)
/3/ R. Nowotny, Int. J. Applied Radiat. Isotopes 32 (1981) 73
/4/ R. Nowotny, Rep. IRK 80/34, Paper presented at the IAEA Consultants' Meeting on Nuclear Data for Medical Radioisotope Production, Vienna, 1981

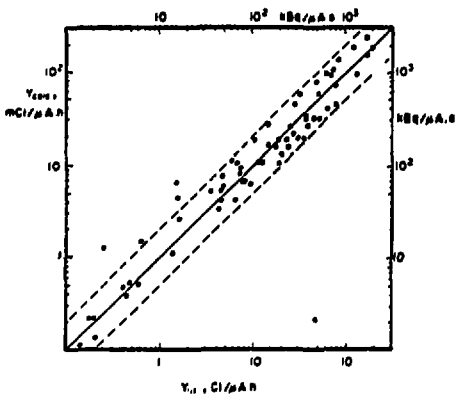


Fig. 1. Calculated radioisotope production yiels Y_{calc} vs literature data Y_{lit}. Broken lines indicate a deviation by a factor of 2

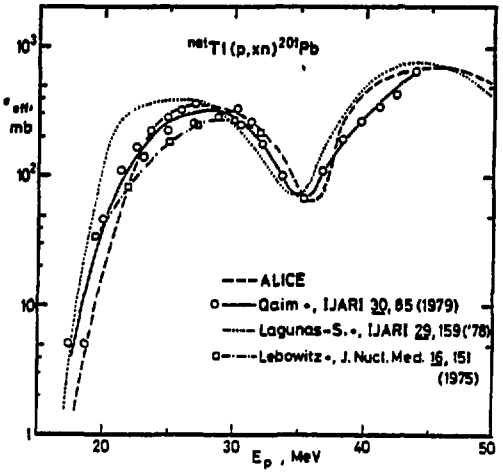


Fig. 2. Excitation function for the production of 201-Pb (201-Tl) with protons on ^{nat}Tl

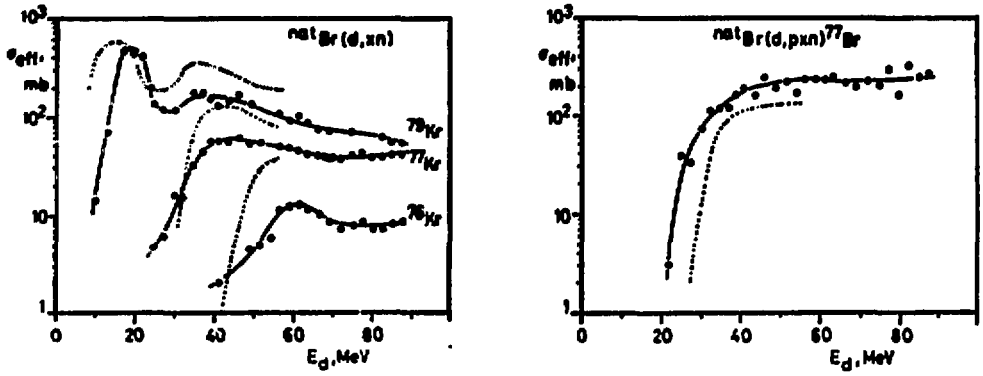


Fig. 3. Excitation functions for $^{nat}Br(d,xn)+$ (d,pxn) reactions. (Experimental data are from S.M. Qaim et al., Int. J. Applied Radiat. Isotopes 28 (1977) 947)

EXPERIMENTAL NUCLEAR PHYSICS.

NEUTRON INDUCED REACTIONS

PRECISE MEASUREMENT OF CROSS SECTIONS FOR THE REACTIONS $^{90}ZR(N,2N)^{89}ZR$ AND $^{58}NI(N,2N)^{57}NI$ FROM THRESHOLD TO 20 MEV

A. Pavlik, G. Winkler, H. Vonach, A. Paulsen [1], H. Liskien [1]

The threshold-reactions above are of importance for dosimetry of the high energy parts of technically important neutron spectra. The excitation functions were measured in the energy region 12.3 to 19.6 MeV in steps of 0.2 to 0.8 MeV using activation techniques. The reaction T(d,n)4-He was employed as neutron source reaction. Neutron fluences were determined by means of a proton-recoil telescope at zero degree and the differential neutron production cross sections. Additionally in the energy range 13.4 to 14.8 MeV measurements were performed in smaller energy steps (0.02 to 0.15 MeV) relative to well known cross sections for the reference reaction 27-Al(n,α)24-Na. Special attention was paid to obtaining a reliable energy scale throughout the whole energy region. The activity measurements were done with a 12.7 cm x 12.7 cm NaI(Tl) well-type detector. The new results provide a significant improvement of the previous data base. Fig. 1 shows the results of a new evaluation of the excitation function for the reaction 90-Zr(n,2n) including the new results, compared with the previously existing evaluation. Fission spectrum averaged cross sections were calculated for 235-U and 252-Cf and compared with experimental data. Obviously measurements of the integral response with a series of high threshold reactions, the differential cross section data of which have been carefully determined, may serve to better define the high energy part of the fission spectra of practical importance.

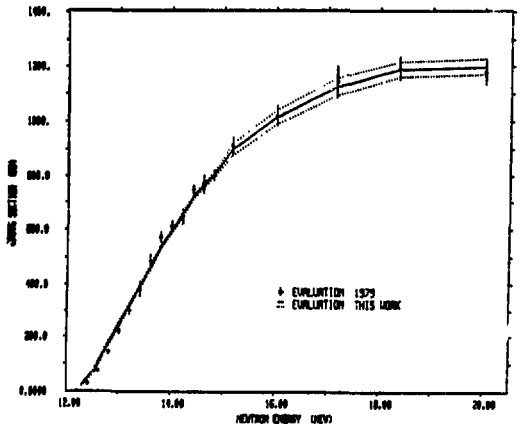


Fig. 1. Results of the updated evaluation of the 90-Zr(n,2n)89-Zr cross sections using the new experimental results as compared with the previous evaluation by Tagesen et al. (Physics Data 13-1, Fachinformationszentrum Karlsruhe, 1979)

[1] CEC-JRC Central Bureau for Nuclear Measurements, Geel, Belgium

MEASUREMENT OF ^{65}CU(N,2N)^{64}CU CROSS SECTIONS IN THE 14 MEV REGION

G. Winkler and B. Ryves [1]

Significant discrepancies exist between experimental results reported by different authors for this dosimetry reaction. Therefore new measurements were carried out where the induced activities were determined by using different techniques detecting the β- and/or γ-radiation. Possibly the existing discrepancies are due to the different measurement methods used, which are sensitive to the knowledge of the decay-scheme of the reaction product 64-Cu. As especially a recent evaluation of the decay-scheme (Nuclear Data Sheets 28 (1979) 179), partly based on calculated transition rates, gives significantly different results as compared to previous evaluation, a new study of the decay-scheme of 64-Cu in cooperation with the NPL, Teddington, is planned.

[1] National Physical Laboratory, Teddington, England

MEASUREMENT OF THE AVERAGE ACTIVATION CROSS SECTION FOR THE REACTION ^{63}CU(N,α)^{60}CO IN THE SPONTANEOUS FISSION NEUTRON FIELD OF ^{252}CF

G. Winkler, V. Spiegel [1], C.M. Eisenhauer [1] and D.L. Smith [2]

The threshold-reaction 63-Cu(n,α)60-Co is of special importance in reactor dosimetry (pressure vessel surveillance) for long-term fast-flux integration. Therefore a benchmark-test of the excitation function was carried out measuring the average cross section absolutely in the 252-Cf neutron field by activation in compensated flux geometry with an accuracy of about 2.4% (1σ). A near-point source of 252-Cf and a light mass source-detector assembly in a low-scattering environment was used. Activity measurement was done with a 4π-γ-detector. There is very good agreement (within 5%) between the experimental and the calculated average cross section, if recent excitation function data (G. Winkler et al., Nucl. Sci. Eng. 76 (1980) 30 and NBS Special Publication 594 (1980) 199) are used. The agreement is even better (≈ 1%), if for the spectrum representation of the 252-Cf neutron spectrum a pure Maxwellian distribution with the average energy 2.13 MeV (NBS reference Maxwellian) is chosen instead of the NBS segments adjusted representation (J. Grundl and C.M. Eisenhauer, Technical Document IAEA-208, 1 (1978) 53). Within accuracies there is now no further integral-differential discrepancy, and the reaction 60-Cu(n,α) fulfills the conditions for a Category I neutron-dosimetry reaction for fission reactor applications.
Fig. 1 shows the response function of the 63-Cu(n,α)60-Co reaction in a 252-Cf spontaneous fission neutron field together with the spectral distribution and the excitation function.

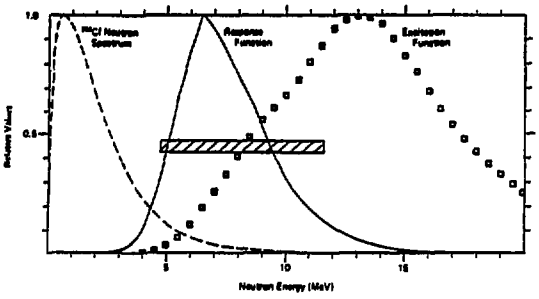


Fig. 1. The spectral distribution function for the 252-Cf spontaneous fission neutron spectrum (dashed line), the excitation function for the reaction 63-Cu(n,α)60-Co (squares), and the resulting response function (solid line). The solid bar indicates the 5 to 95% response range.

[1] National Bureau of Standards, Washington D.C., USA
[2] Argonne National Laboratory, USA

THE REACTION ^{63}CU(N,α)^{60}CO AND ITS USABILITY FOR REACTOR DOSIMETRY

G. Winkler (Habilitationsschrift, University of Vienna, 1981)

Detailed energy-differential and integral data for the reaction 63-Cu(n,α)60-Co have been documented for the energy region from threshold to 20 MeV. The requirements have been met which make this reaction a useful monitor for long term fast neutron flux integration, especially by conducting new measurements of the excitation function, evaluating existing integral data for the 235-U-fission spectrum, and measuring the integral activation cross section in a 252-Cf-fission neutron spectrum. Due to the elimination of previously existing differential-integral discrepancies this reaction has been cancelled from the "Discrepancy-File" at the 12th INDC-Meeting (5-9 Oct. 1981, IAEA, Vienna).

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

G. Staffel, G. Winkler and H. Vonach

Designing an improved experimental set-up is in progress for measuring double-differential scattering cross sections using the time-of-flight technique on a series of elements of practical importance. A reduction and better definition of the background is hoped to be achieved using an evacuated flight-path. Sample and neutron-source will be arranged in an evacuated tube 80 cm in diameter (to reduce the influence of neutrons scattered from the tube wall). The variation of the scattering angle (20^{o} - 140^{o}) is performed by moving the scattering sample along the collimator axis of the neutron detector. Choosing a reaction angle of 90^{o} for the source reaction T(d,n)4-He keeps the incident neutron energy constant. The expected experimental data should allow a more significant comparison with precompound model predictions.

*) Supported by Jubiläumsfonds der Österreichischen Nationalbank

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

C. Dernedde[r], R. Fischer, P. Hille, H. Vonach, G. Stengl [2], B. Strohmaier, G. Traxler and P. Maier-Komor [1]

A new method for the measurement of energy and angular distributions of charged particles from neutron induced reactions has been developed during the last years /1/.
A small cylindrical multiwire chamber in connection with a central CsI(Tl) scintillator allows simultaneously the measurement of the energy of charged particles at all reaction angles, the particle identification via the dE/dx-E detector system and via pulse shape discrimination, and the measurement of the background, thus reducing accelerator and measuring time (fig. 1). Data acquisition is made on-line via CAMAC to a PDP 11 computer.

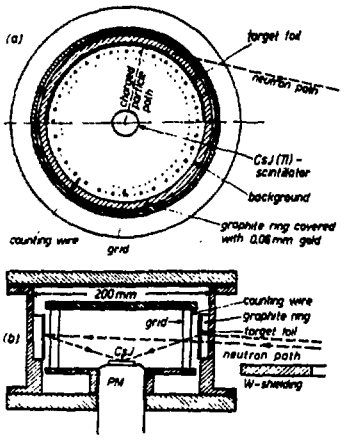


Fig. 1. The Vienna multi-telescope system (schematics (a) Top view, (b) side view

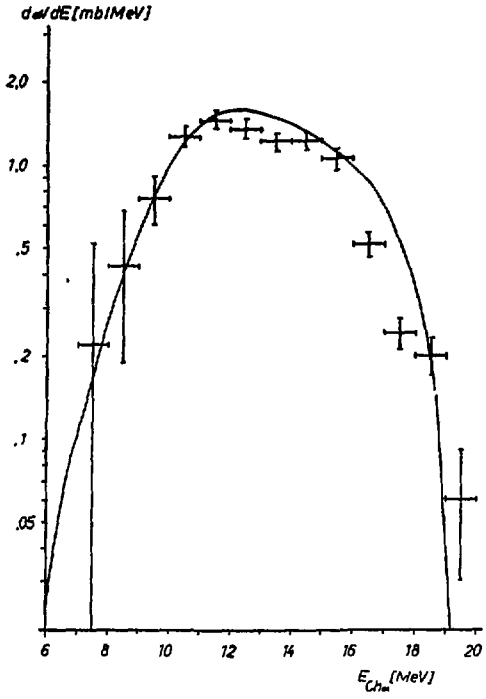


Fig. 2. Angle integrated α-emission spectrum from 93-Nb+n at E_n=14.1 MeV
. this work
— statistical model calculations folded with 1.5 MeV rectangular resolution function

*) Supported by Fonds zur Förderung der wissenschaftlichen Forschung in Österreich

[1] Physikdepartment der TU München, BRD
[2] Now with Sacher-Technik, Wien

The new multitelescope system was applied in studies of the 50-Cr(n,α) reaction /2/ and in the investigation of the α-particle emission from the reaction of 93-Nb with 14 MeV neutrons /3/. Figs. 2 and 3 show the energy spectra compared with calculations based on the statistical model of nuclear reactions including precompound processes. Fig. 4 gives an example of angular distributions measured with the new system, which is now being improved by inserting a second ring of proportional counters.

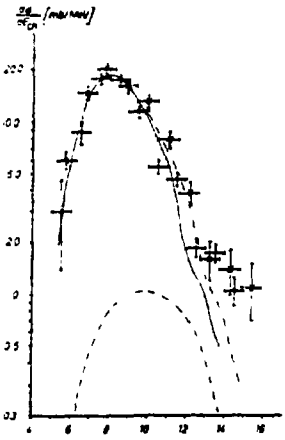


Fig. 3. Angle-integrated α-emission spectrum from bombardment of ^{50}Cr with 14-15 MeV neutrons. • This work (E_n=14.1 MeV). × Grimes et al. [4] (E_n=15 MeV). Statistical model calculations: —E_n=14 MeV; - - - E_n=14 MeV precompound contribution; ·····E_n=15 MeV, all calculations folded with 1 MeV rectangular resolution function

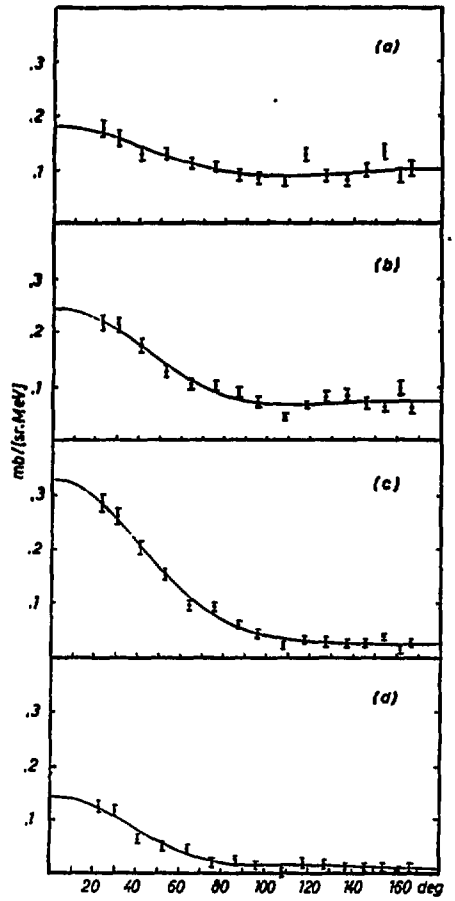


Fig. 4. Angular distributions for different α-energy bins
(a) $E_{ch\alpha}$=10-12 MeV, (b) $E_{ch\alpha}$=12-14 MeV
(c) $E_{ch\alpha}$=14-16 MeV, (d) $E_{ch\alpha}$=16-18 MeV
The solid line indicates the 4th order Legendre fit.

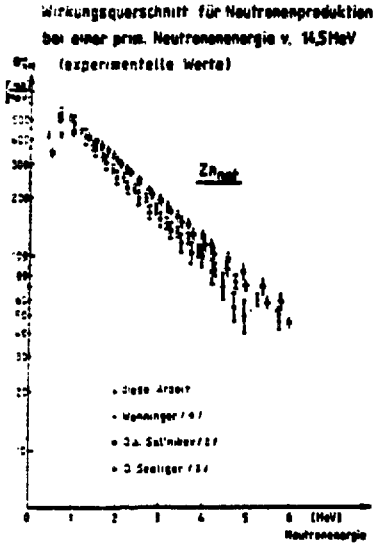
/1/ C. Derndorfer et al., Nucl. Instr. & Meth. 187 (1981) 423
/2/ C. Derndorfer et al., Z. Phys. A301 (1981) 327
/3/ R. Fischer et al., (1981) in preparation

BESTIMMUNG DER ENERGIEDIFFERENTIELLEN NEUTRONENPRODUKTIONSQUERSCHNITTE UND UNTERSUCHUNG DES KONKURRIERENDEN NEUTRON- BZW. GAMMAZERFALLS NACH INELASTISCHER NEUTRONENSTREUUNG AN ZINK BEI 14 MEV EINSCHUSSENERGIE

H. Kratschmar, S. Tagesen und H. Vonach

Das Ziel dieser Arbeit war:
a) Die Messung des beim Beschuß mit 14 MeV Neutronen auftretenden Verdampfungsspektrums und Vergleich der Ergebnisse mit Berechnungen im Rahmen des statistischen Modells.
b) Die Klärung der Voraussetzungen für die Ermittlung der für die Zerfallsart der Kontinuumszustände maßgeblichen Größe $\Gamma_\gamma/\Gamma_{tot}$.

Das Neutronenproduktionsspektrum an Zink konnte im Energiebereich zwischen 0,7 und 4,9 MeV in guter Übereinstimmung mit anderen experimentellen Ergebnissen /1,2,3/ ermittelt werden. Die Übereinstimmung mit Berechnungen im Rahmen des statistischen Modells, die mit dem Computercode STAPRE /4/ durchgeführt wurden, kann als gut bezeichnet werden.
Die Messung des Verdampfungsspektrums wurde in einer für die Messung der Zerfallsart der Kontinuumszustände optimierten Anordnung durchgeführt, da zur Auswertung der Zerfallsartmessung (n-γ Koinzidenzspektrum) auch die Kenntnis des Verdampfungsspektrums bei identischer Meßanordnung nötig ist.
Die Voraussetzungen für die Ermittlung von $\Gamma_\gamma/\Gamma_{tot}$ im Rahmen einer n-γ Koinzidenzmessung wurden geklärt.



Die Meßanordnung für obige Untersuchungen bestand aus einer gepulsten 14 MeV Neutronenquelle, einer Halbkugel aus Zink mit 2 cm Radius als Probe, 2 Stück 5 x 1" NE 213 Neutronendetektoren /5/ in 81 cm Entfernung und einem 7% Ge(Li) Gammadetektor in 46 cm Entfernung. Die Detektorsignale wurden unter Verwendung von NIM-Elektronik und einem PDP 11 on line Rechner /6,7/ analysiert.
Diese Arbeit wurde im Rahmen einer Dissertation /8/ durchgeführt.

/1/ F. Wenninger, Dissertation, Univ. Wien 1980
/2/ O.A. Salnikov, Anufrienko, YK-15 (1974)129
/3/ D. Seeliger, ZfK 277 U
/4/ M. Uhl, B. Strohmaier, STAPRE, A Computer Code for Particle Induced Activation Cross Sections and Related Quantities, IRK 76/01, Vienna 1976
/5/ A. Chalupka et al., Proc. 2nd ISPRA Nucl. Electronics Symp., EUR 5370 e 7975, p. 179
/6/ S. Tagesen, MPEXP 6, Programmbibliothek d. IRK-Rechners
/7/ R. Fischer, MPASW, Programmbibliothek d. IRK-Rechners
/8/ H. Kratschmar, Dissertation, Univ. Wien 1981

THE REACTION $^{12}C(N,N')3\alpha$ IN A NEUTRON TIME-OF-FLIGHT EXPERIMENT AT E_N = 14 MEV

R. Koch, W.H. Breunlich, P. Kammel, M. Cargnelli [1], J. Marton [1], J. Zmeskal [1], W.H. Bertl [2]

A coincidence experiment of the 12-C(n,n')3α reaction at E_n = 14.3 MeV has been performed, using two liquid organic scintillators NE 213. One of them was used as an active 12-C target, while the scattered neutronswere detected with the other scintillator.
With the aid of pulse-shape discrimination in both detectors and time of flight techniques alpha-events were clearly separated from proton- and gamma-events.
The angular distributions from 30° to 150° and integrated cross sections were extracted from the data for the following reaction channels:

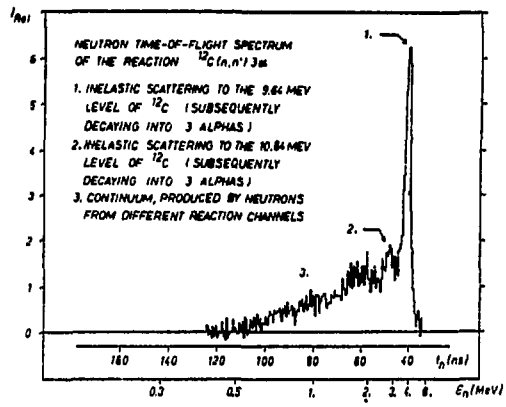
$^{12}C(n,n')^{12}C^*(3\alpha)$ for the excited states in 12-C with

Q = - 9.64 MeV(3^-) (σ = 166 ± 14 mb) and
Q = - 10.84 MeV(1^-) (σ = 34 ± 6 mb)

respectively.

For low energy scattered neutrons a continuum was observed. The possible mechanismswhich can contribute to the continuum were investigated. The integrated cross section (σ = 467 ± 98 mb) as well as the double differential cross sections $(\frac{d^2\sigma}{d\Omega dE_n})$ were determined for tnis continuum too.

Comparing our result with the quite controversial literature we conclude, that the reaction mechanism is not sufficiently well understood. Another motivation for this investigation is the essential contribution of this reaction to the light output of organic scintillators at higher neutron energies.



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DETERMINATION OF THE NEUTRON ENERGY SPECTRUM FROM THE SPONTANEOUS FISSION OF ^{252}CF IN THE ENERGY RANGE OF 2 MEV ≤ E_N ≤ 14 MEV

R. Boettger [1], H. Klein [1], A. Chalupka

In order to measure the energy spectrum of the fission neutrons from 252-Cf a low mass, fast ionization chamber /1/ for detection of the fission fragments has been installed at the PTB time-of-flight (TOF) spectrometer /2/. The properties of the fission chamber such as the time resolution and the detector efficiency for fission products were determined in coincidence with a shielded small scintillation detector.
With 10^5 fissions per second and a total efficiency of about 97.5% the chamber was finally used in a TOF experiment with four scintillation detectors (5.07 cm x 25.4 cm ∅) behind a 12 m long flight path. The TOF spectra (fig. 1) (total range 1 µs) recorded in a running time of about 320 h for detectors with bias levels of about 500 keV electron energy have to be corrected for random background events as well as for uncorrelated stops /3/ from the ionization chamber and in addition for dead time losses.
The results for the absolute efficiency of the liquid scintillation detectors including air attenuation and collimator-inscattering are compared with further methods of detector calibration. A best set of parameters ν and E_o with respect to the energy range 2 MeV ≤ E_n ≤ 14 MeV will be extracted. Data analysis is in progress.

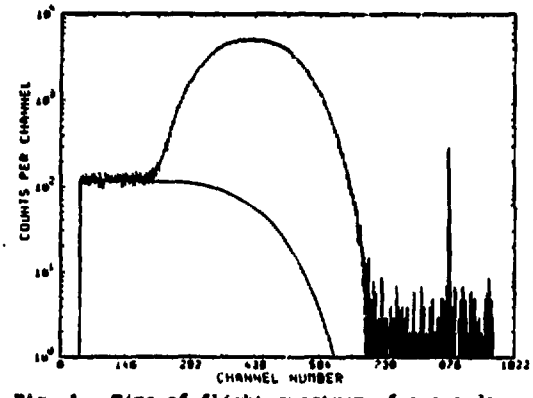

Fig. 1. Time-of-flight spectrum of a one day run recorded with detector no 2

/1/ A. Chalupka, Nucl. Instr. & Meth. 164 (1979) 105 and
A. Chalupka, B. Strohmaier, 'The IRK golden fission chamber', this report
/2/ H. Klein et al., Nucl. Instr. & Meth. 169 (1980) 359
/3/ A. Chalupka, Nucl. Instr. & Meth. 165 (1979) 103

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

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

Precision measurements of nuclear masses were performed with the Q3D-spectrograph and the precision time of flight system /1/ for measuring of the beam energy of the Munich tandem accelerator. For these measurements the new 28 cm long multiwire proportional counter /2/ which allows particle identification, was used. The 56-Fe-57-Fe mass difference and the masses of 10-B and 14-O were determined, respectively. The latter is of interest for the theory of superallowed ß-decay. Data analysis is in progress and data will be published after remeasuring the length of the flight path to an accuracy of $\Delta L/L \leq 2.10^{-5}$.

*) Supported by Fonds zur Förderung der wissenschaftlichen Forschung in Österreich

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/1/ E. Huenges, H. Vonach, J. Labedzki, Nucl. Instr. & Meth. 121 (1974) 307
/2/ A. Chalupka et al., A New Multiwire Proportional Counter for the Munich Q3D Spectrograph, this raport

MEDIUM ENERGY PHYSICS

FORMATION OF MUONIC MESOMOLECULES IN LIQUID $^1H/^2H$ MIXTURES [a)]

E.G. Mahler [1], W.H. Breunlich, P. Kammel, W. Reiter, W.H. Bertl [2], C. Petitjean [3], W.J. Kossler [4], L.A. Schaller [5], L. Schellenberg [5]

Fusion processes, subsequent to the formation of pid molecules, were the first experimentally observable example of the exotic process of cold muoncatalyzed fusion (see L.W. Alvarez, Nobel Lecture, 1968). The complexity of mesomolecular processes, taking place in such isotopic hydrogen mixtures, is illustrated in the figure. Today high precision experiments investigate these reactions to test theoretical 3 body scattering and boundstate calculations and to obtain indispensible information for the analysis of weak interaction capture experiments.
In our experiment using a liquid hydrogen target with deuterium admixtures between 0.1 - 12% time spectra and yields of fusion gammas after muonstop were measured with a large NaJ detector. The fusion rate λ_f determined in this work is in excellent agreement with previous experiments. Moreover, our data provide new information about the hyperfine population of ud atoms in 1-H/2-H mixtures.
An increased accuracy of the absolute gamma yield determination combined with a refined analysis allows the extraction of preliminary results for the hyperfine transition rates:

$$\lambda_p = (4 \pm 2.5).10^6/s$$
(process $\mu d(F=3/2) + p \rightarrow \mu d(F=1/2) + p$)

$$\lambda_p = (35 \pm 20).10^6/s$$
(process $\mu d(F=3/2) + d \rightarrow \mu d(F=1/2) + d$)

Above all the new result for λ_p is interesting, because it strongly differs from the theoretical predictions and the assumptions used in the analysis of existing experiments on muon capture in deuterium.

Concerning the absolute fusion gamma yields in contrast to previously used values our new results for the hyperfine transition rates (see also: First Observation of Hyperfine Transitions in Muonic Deuterium Atoms via Resonant dud Formation at 34 K, P. Kammel et al., this report) indicate perfect agreement between experiments and theory.

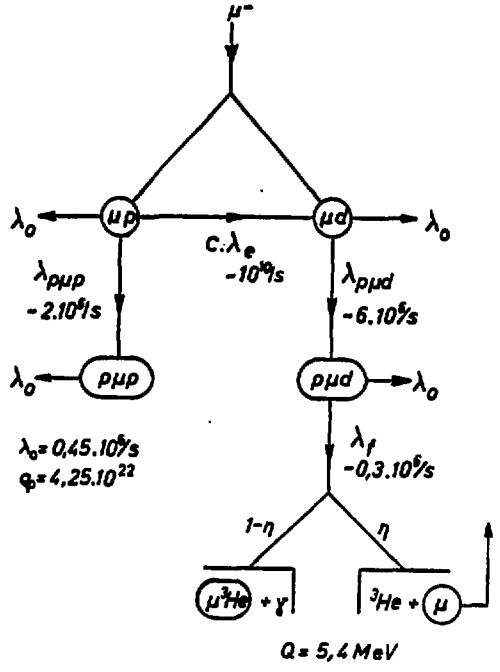

Fig. 1. Illustration of the reaction chain taking place in a mixture of liquid hydrogen and deuterium. (The reaction rates, normalized to liquid density ϕ_0, are indicated; λ_0 is free muon decay rate.)

a) Supported by Österreichische Akademie der Wissenschaften, Fonds zur Förderung der wissenschaftlichen Forschung in Österreich and Schweizerisches Institut für Nuklearforschung

[1] Österreichische Akademie der Wissenschaften
[2] ETH Zürich
[3] Schweizerisches Institut für Nuklearforschung
[4] College of William and Mary, USA
[5] Université de Fribourg

MESOMOLECULAR FORMATION IN PURE, LIQUID DEUTERIUM [a)]

H.G. Mahler [1], W.H. Breunlich, P. Kammel, W. Reiter, W.H. Bertl [2], C. Petitjean [3], W.J. Kossler [4], L.A. Schaller [5], L. Schellenberg [5]

The molecular formation process

$$d\mu + d \rightarrow d\mu d \quad \text{with the rate } \lambda_{dd}$$

deserves special interest, because a resonant dependence of the formation rate as a function of temperature was observed in 1977. While systematic studies cover the temperature range above 120 K, low temperature data are scarce. In this first counter experiment in pure, liquid deuterium, molecular dμd formation was monitored by detecting neutrons from the fast fusion process (dμd → 3-He + n + μ). In addition a new technique was successfully employed. By detecting electrons from the delayed muon decay with a large NaJ detector, fusion neutrons were identified by their characteristic neutron-electron time correlation. Using this method of delayed coincidences the total yield of fusion neutrons was determined, including contribution from the prompt time region after muonstop, which is concealed by strong background in conventional counter experiments. To our surprise the number of neutrons extrapolated from the delayed region only amounted about 67% of the total yield.
This effect is a first indication of a hyperfine resonance in the molecular formation rate. (For a detailed explanation we refer to: 'First Observation of Hyperfine Transitions in Muonic Deuterium Atoms via Resonant dμd Formation at 34 K', P. Kammel, this report). The enhanced fusion yield in the prompt time region is due to the high molecular formation rate from the F = 3/2 μd atomic state. Therefore a new analysis of the two existing bubble chamber results was performed, which correctly distinguishes between the molecular formation from the two hyperfine states.

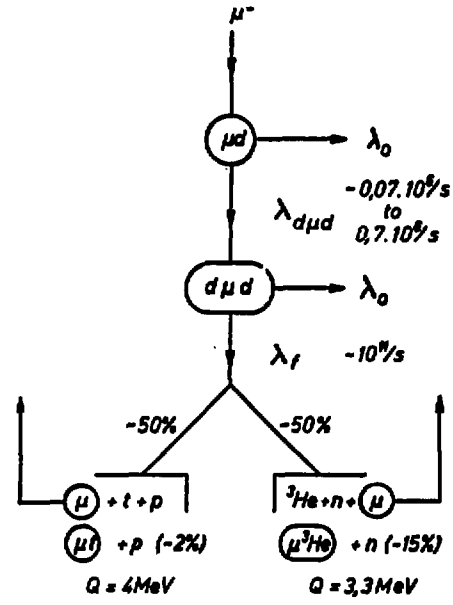

Fig. 1. Reaction chain of mesomolecular processes in liquid deuterium as predicted by theory disregarding the hyperfine states of the μd atom. New results lead to a correction of this chain (see "Resonant Formation of the Muonic Dμ-Molecule-Study of Hyperfine Effects in the Temperature Range from 25.6 to 150 K", this report, fig. 1). In about 90% of the fusion processes the muon is set free and can induce the typical reaction chain once more. The disappearance rate of muons is governed by free muon decay. Thus, fusion neutrons are accompanied by muon decay electrons in delayed coincidence, characterised by the muon life time.

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FIRST OBSERVATION OF HYPERFINE TRANSITIONS IN MUONIC DEUTERIUM ATOMS VIA RESONANT DμD FORMATION AT 34 K [a)]

P. Kammel, W.H. Breunlich, M. Cargnelli.[1], H.G. Mahler [1], J. Marton [1], J. Zmeskal [1], W.H. Bertl [2], C. Petitjean [3]

We discovered a resonant formation process of the dμd mesomolecule from the upper F = 3/2 hyperfine state of the μd atom, while detecting neutrons from the muoncatalyzed fusion (dμd → 3-He + n + μ) in cold deuterium gas. Since the molecular formation rates from the two hyperfine states (F = 3/2 and 1/2) are found to differ by nearly two orders of magnitude, the first direct observation of the lifetime of the μd (F = 3/2) hyperfine state was possible. This yields an accurate value for the hyperfine transition rate:

$$\lambda_d = (42.6 \pm 1.7) \times 10^6/\text{s}.$$

Thus we succeeded to experimentally answer the question of hyperfine population of the μd atoms, a problem which remained unsolved for more than twenty years and has important consequences on the capture rates in deuterium.

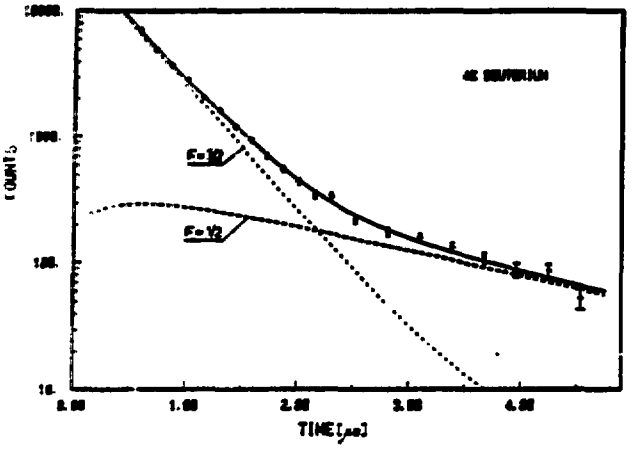

Fig. 1.
Time distribution of fusion neutrons after μ - stops in cold deuterium gas at 4 percent of liquid density. The dashed lines represent the contribution of the μd hyperfine state F=3/2 and F=1/2, respectively.

*) Supported by Österreichische Akademie der Wissenschaften, Fonds zur Förderung der wissenschaftlichen Forschung in Österreich and Schweizerisches Institut für Nuklearforschung.

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RESONANT FORMATION OF THE MUONIC D_2^+-MOLECULE — STUDY OF HYPERFINE EFFECTS IN THE TEMPERATURE RANGE FROM 25.6 TO 150 K *)

J. Zmeskal, W.H. Breunlich, P. Kammel, M. Cargnelli [1], J. Marton [1], W.H. Bertl [2], C. Petitjean [3]

With the aid of a cryogenic gas target we investigated the time and energy spectra of neutrons produced in the muon catalyzed fusion process

$$dud \rightarrow n + {}^3He + \mu$$

in pure deuterium. Data were taken for different gas densities (2 and 4 percent liquid density) in the temperature range 25.6 to 150 K.

The aim of this experiment is to search for the temperature dependence of the resonant molecular formation rates (λ_{dd}) starting from the two hyperfine states (F = 3/2 and F = 1/2) of the μd atom. Moreover, the full complexity of the magnetic effects to be revealed must include the magnetic splitting of the molecular states.

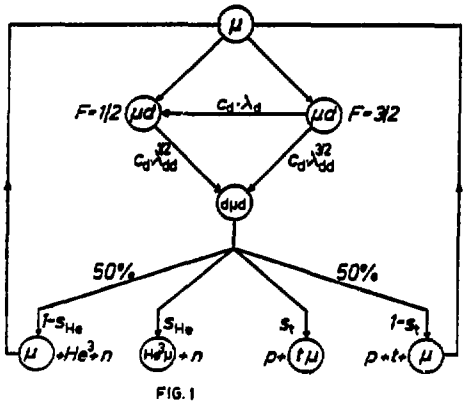

FIG. 1
Reaction chain of molecular processes in pure deuterium, taking into account the hyperfine splitting of the ground state of the μd atom. $\lambda_{dd}^{3/2}$ and $\lambda_{dd}^{1/2}$ represent the molecular formation rates from these data. The hyperfine transition rate is given by λ_d.

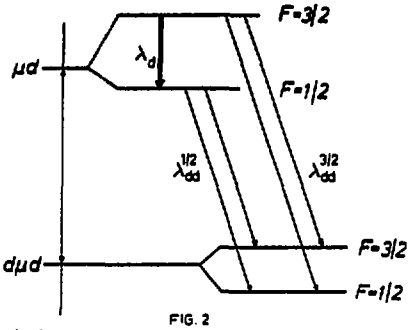

FIG. 2
Possibilities of resonant formation of the dud molecule from the two hyperfine states of the ud atom. The dud molecule in the J = 1 state under consideration splits into two hf-components also.

It should be emphasized that the dμd is the closest analogon to the dμt molecule, the system which is currently discussed for possible applications in energy production. In addition these results also provide valuable insight to the three body Coulomb problem. It is possible to determine the energy of the participating highly excited mesomolecular state with a unique experimental precision (< 1 meV), corresponding to a precision of less than 1 ppm of the muonic Rydberg.

*) Supported by Österreichische Akademie der Wissenschaften, Fonds zur Förderung der wissenschaftlichen Forschung in Österreich and Schweizerisches Institut für Nuklearforschung.

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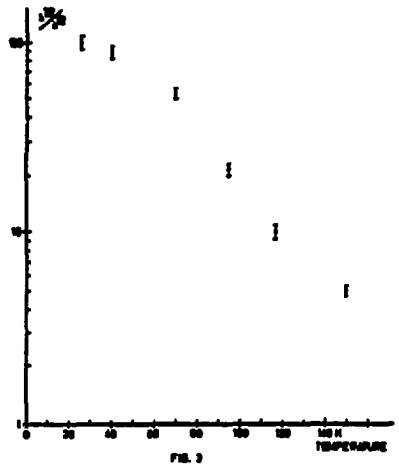


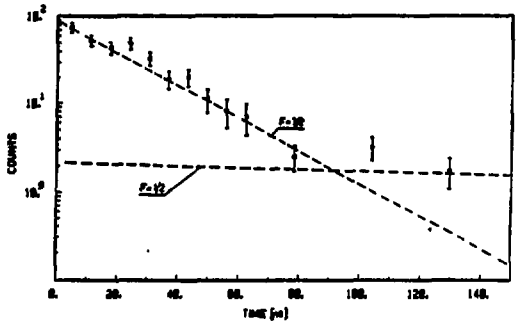
Temperature dependence of the ratio $\lambda_{dd}^{3/2}/\lambda_{dd}^{1/2}$.

The striking hf-effect of these rates found in the experiment reported above ("First Observation of Hyperfine Transition in Muonic Deuterium Atoms via Resonant dμd Formation at 34 K") shows a pronounced temperature dependence which is due to the resonance mechanism.

MULTIPLE CATALYSIS OF DD-FUSION BY MUONS*)

W.H. Breunlich, P. Kammel, M. Cargnelli [1], H. Fuhrmann [1], J. Marton [1], P. Pawlek [1], T. Strehl [1], J. Werner [1], J. Zmeskal [1], W.H. Bertl [2], C. Petitjean [3]

Successive dd-fusion processes, which are catalyzed by the same muon, were studied in a counter experiment for the first time. While in the pioneering bubble-chamber experiments at Berkeley (see L.W. Alvarez, Nobel-Prize Lecture 68) about 25 years ago only two examples of twofold catalysis were found, we recorded around thousand delayed coincidences of consecutive fusion neutrons using two neutron detectors (see "Performance and Efficiency of a Large Liquid Scintillation Counter for the Detection of Fast Neutrons", H. Marton et al., this report).
This type of experiment provides a promising tool for studying the kinetics of mesomolecular processes, especially in the short time range of the order of several ten nanoseconds. This time range is usually very difficult to investigate with standard techniques when stopping muons in hydrogen. Thus, we succeeded in the first direct observation of hyperfine effects in liquid deuterium, where the lifetime of the upper hf-state of the μd-atom is only 23 ns, i.e. only ∿1% of the muon lifetime.



Neutron-neutron correlation time of successive fusion processes catalyzed by the same muon in pure liquid deuterium. The two time components show the depopulation (τ = 23 ns) of the F = 3/2 hyperfine state and the life time (τ = 2.2 s) of the F = 1/2 hyperfine state of the d-atom, respectively.

*) Supported by Österreichische Akademie der Wissenschaften, Fonds zur Förderung der wissenschaftlichen Forschung in Österreich and Schweizerisches Institut für Nuklearforschung

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MUON CAPTURE IN DEUTERIUM *)

M. Cargnelli [1], H. Fuhrmann [1], J. Marton [1], P. Pawlek [1], T. Strehl [1], J. Werner [1], J. Zmeskal [1], W.H. Breunlich, P. Kammel, W.H. Bertl [2], C. Petitjean [3]

The capture of muons by deuterium nuclei

$$\mu^- + d \rightarrow n + n + \nu_\mu$$

is of considerable theoretical interest and was thus investigated experimentally for many years.
Since the rate for muon capture in deuterium depends strongly on the hyperfine state of the μd atom (F = 1/2 or 3/2), in which the process occurs, it is necessary to use the correct hyperfine populations in the analysis.
The ratio of the hf-populations was investigated experimentally only recently by our group. Thus, the assumptions entering into the anslysis of the old experiments could be checked and were found to be in contradiction to the new experimental result.
Our reanalyzation of the old experiments using the new information about the population of the hf-states leads to a striking discrepancy between the two experimental values.
This emphasizes the necessity to remeasure the capture rate using the latest experimental techniques. The main experimental problem arises from the fact that neutrons originating from a rather rare process with a continuous energy distribution peaked at about 1.3 MeV have to be detected in the presence of comparatively high background components.
After careful study of atomic and molecular processes of muonic atoms in hydrogen it was decided to perform a capture experiment in pure deuterium for the first time (the old experiments were performed in hydrogen with small deuterium admixture). An essential tool for separating capture neutrons from neutrons emitted in muon induced nuclear fusion is the method of delayed coincidences between fusion neutrons and μ-decay electrons, which is also used for calibration purposes. The experimental program is in progress.

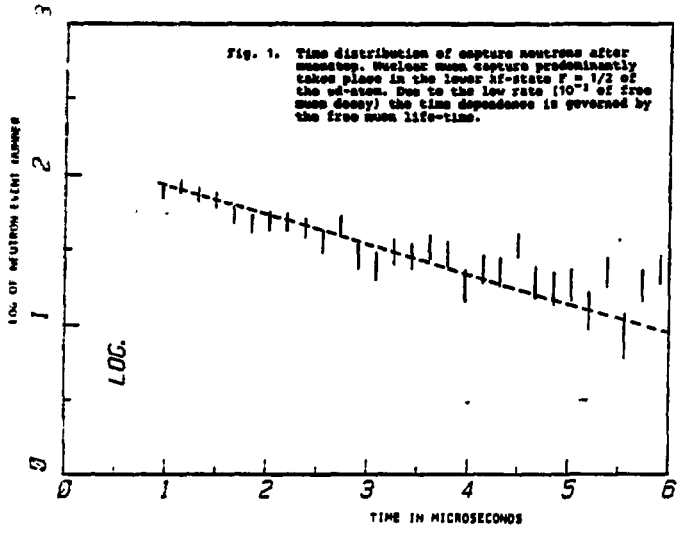

Fig. 1. Time distribution of capture neutrons after muonstop. Nuclear muon capture predominantly takes place in the lower hf-state F = 1/2 of the μd-atom. Due to the low rate (10^{-3} of free muon decay) the time dependence is governed by the free muon life-time.

*) Supported by Österreichische Akademie der Wissenschaften, Fonds zur Förderung der wissenschaftlichen Forschung in Österreich and Schweizerisches Institut für Nuklearforschung.

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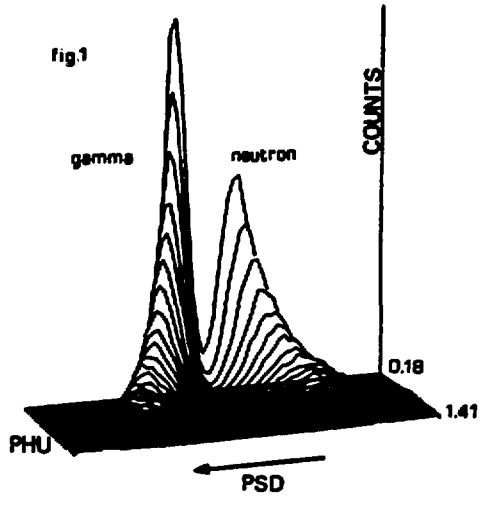
INSTRUMENTATION AND DETECTORS

PERFORMANCE AND EFFICIENCY OF A LARGE LIQUID SCINTILLATION COUNTER FOR THE DETECTION OF FAST NEUTRONS *)

J. Marten [1], H. Fuhrmann [1], P. Pawlek [1], M. Cargnelli [1], W.H. Bertl [2], W.H. Breunlich, P. Kammel, W.L. Reiter

This neutron detector of high efficiency consists of a large cell (26 · 14 × 10 cm) filled with liquid scintillator NE 213. Two photomultipliers (XP 2041) viewing the volume from both ends allow a compensation for geometrical effects on the time resolution. Uniformity, energy resolution and n-γ pulse shape discrimination (PSD) have been tested using the sum of the anode signals of the photomultipliers. The applied PSD method is based upon the comparison of two weighted time integrals of the detector signal. Its performance in the low energy range (≥ 0.06 MeV in equivalent electron energy) is represented by the figure of merit and alternative definitions. The energy- and pulse height-dependent efficiency (response matrix) has been calibrated in a time of flight arrangement with a 252-Cf-fission chamber.



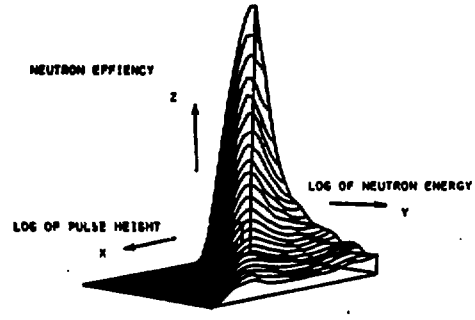


Fig. 2. Proton response matrix as determined in a time-of-flight experiment using a 252-Cf prompt fission source.

*) Supported by Österreichische Aksdemie der Wissenschaften, Fonds zur Förderung der wissenschaftlichen Forschung in Österreich and Schweizerisches Institut für Nuklearforschung.

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DEVELOPMENT OF A SILICON-DIODE POCKET RADIATION CHIRPER

R. Nowotny

Small sized pocket radiation chirpers have been shown to be useful as a personal warning device. Usually GM-tubes or CdTl diodes are used for the detection of X- or gamma radiation. In previous papers /1,2,3/ it was shown that small Silicon-PIN-photodiodes are capable of energy-dispersive photon detection. Hence a pocket radiation chirper was designed in which such diodes are employed.
Fig. 1 shows the intrinsic full energy peak efficiency for a BPW 34 and an ion implanted diode /4/.

Three BPW 34 were operating in parallel to give a sensitivity similar to GM-tubes. Pulses are fed through a charge sensitive amplifier into a trigger with a threshold set to 40 keV. Trigger output pulses are integrated to give approximately one chirp per 10 uR. The sensitivity was tested with several calibrated radioactive sources (table 1). The device works up to 48° C with 40 keV threshold setting and sustains dose rates of greater 15 kR/h.
A detailed description will be published /5/.

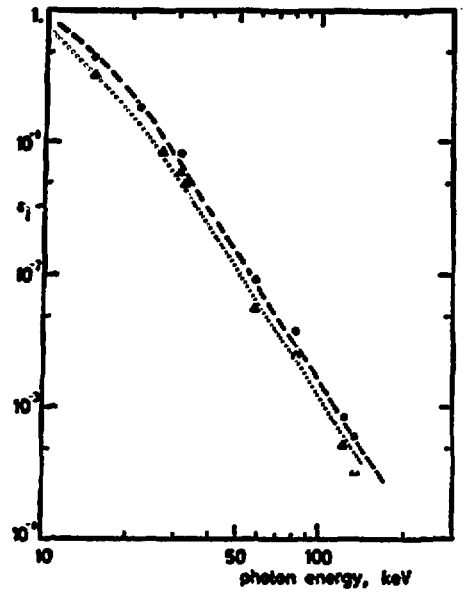


Fig. 1. Intrinsic full-energy peak efficiency ε_i for a BPW 34 diode (Δ) and an ion-implanted diode /4/(•)

Radio-nuclide	Sensitivity, $\frac{\text{chirps/min}}{\mu R/h}$	
	3 x BPW 34	diode no. 59-13-4
^{241}Am	1.9	2.1
^{197}Hg	1.7	2.0
^{57}Co	1.9	1.8
^{133}Ba	3.0	3.2
^{137}Cs	5.3	5.6
^{60}Co	5.1	5.2

Table 1: Sensitivity of the chirper for several radioactive sources

/1/ R. Nowotny, W.L. Reiter, Nucl. Instr. & Meth. 147 (1977) 477
/2/ R. Nowotny, W.L. Reiter, Nucl. Instr. & Meth. 153 (1978) 597
/3/ R. Nowotny, Health Physics 39 (1980) 310
/4/ J. Kemmer, Nucl. Instr. & Meth. 169 (1980) 499
/5/ R. Nowotny, Health Physics (accepted for publication)

A NEW MULTIWIRE PROPORTIONAL COUNTER (MWPC) FOR THE MUNICH Q3D SPECTROGRAPH

A. Chalupka, H. Vonach, K.U. Bahnsen [1], J.Labedzki [1], H.J. Scheerer [1], G. Ziegler [1]

Especially for Q-value measurements /1/ at the Munich Q3D spectrograph a ca. 28 cm long MWPC was built. The position sensitive part of the detector consists of 576 wires of 6 µm diameter at wire distances of 0,5 mm in connection with 576 preamplifiers and discriminators. A main feature is the possibility of particle identification for light particles as p, d, t, 3-He, α...

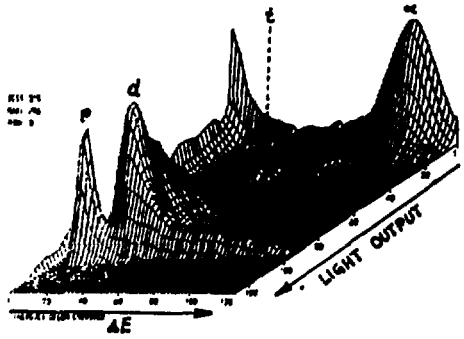


Fig. 1. Plot of ΔE versus light output of the scintillator showing a small but clearly separated peak of tritons and large amounts of background due to p, d, α

This is achieved by processing the signals derived from the cathode (ΔE) and from the light output when the particles are stopped in a NE 110 scintillator viewed by a photomultiplier.
Fig. 1 illustrates the particle separation power of the instrument in an X(3-He,t)Y experiment.
A similar detector of approximately 2 m length is being constructed. Recently promising tests with electronics installed for 1600 wires were performed.

/1/ H. Vonach, A. Chalupka, E. Huenges, H.J. Scheerer, Determination of Q-values at the Munich Q3D spectrograph, this report

[1] Physik-Department, TU München

THE IRK GOLDEN FISSION CHAMBER

A. Chalupka, B. Strohmaier

The development of a detector for fragments of the spontaneous fission of 252-Cf finally resulted in the construction of a low mass fast ionization chamber made from 197-Au taking advantage of its 100% natural occurrence, high chemical resistance and absence of resonances in σ_{tot} above 10 keV.

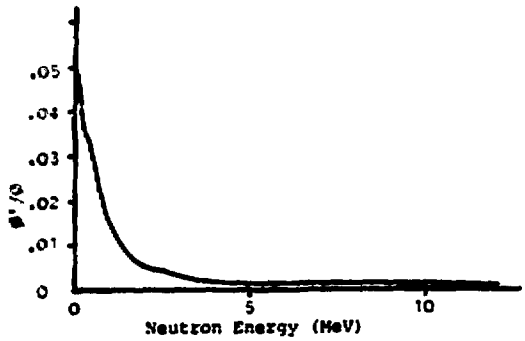


Fig. 1. Scattered flux $\phi'(E_n)$ relative to 252-Cf neutron flux $\phi(E_n)$

This instrument is intended to be used as a start detector for time of flight measurements of the 252-Cf fission neutron spectrum /1/. Detailed studies of the alteration of this spectrum due to interactions of the neutrons with the source backing and the chamber were carried out with the code COGOLD (Fig. 1). Improved electronics using cascaded fast preamplifiers allow pile up free processing of high fission rates with excellent timing and α-discrimination (Fig. 2).

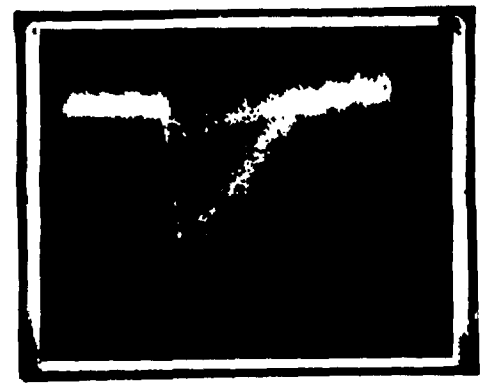


Fig. 2. Output signals recorded by a sampling oscilloscope (vertical: 50 mV/div, horizontal: 5 nsec/div). α and fission events correspond to the smaller and larger amplitudes, respectively.

/1/ R. Boettger, H. Klein, A. Chalupka, Determination of the Neutron Energy Spectrum from the Spontaneous Fission of 252-Cf in the Energy Range of 2 MeV ≤ E_n ≤ 14 MeV, this report

EVALUATION OF NUCLEAR DATA AND NUMERICAL DATA PROCESSING

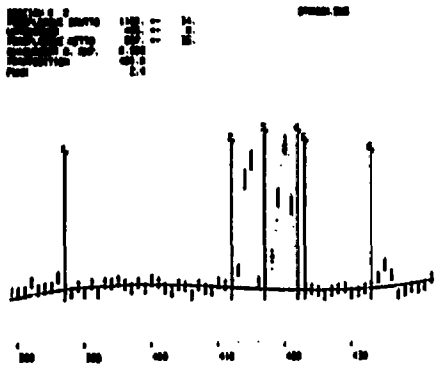
SPASW, A PROGRAM FOR INTERACTIVE ANALYSIS OF LINE-SPECTRA, MEASURED BY NUCLEAR RADIATION DETECTORS

S. Tagesen

One of the most frequent problems in nuclear data analysis is tackled in a very simple yet reliable way. The problem is, to calculate a "peak-area" in a reproducible manner with reliable error estimates. Many automatic spectra analysis codes make use of more or less complex peak-fitting methods. Common disadvantage of such algorithms is, that they require either detailed a priori information on line shape or numerous data points with good statistics to enable a multiparameter fit with sufficient quality.

In SPASW the experimentalist has a high resolution graphics display and a plotter for documentation at his disposal (PDP 11/34 A with VT 11 + light pen). He directs the program via background "regions of interest" (fig. 1, marker 1-2 and 5-6) to calculate a "background" polynomial (dotted line), which is used to calculate the background below the peak (markers 3-4). The display itself and the indication of χ^2 serves to judge the quality of the background fit. The error is calculated from the actual number of counts in the

contributing channels. The "gaussian"-fit to the peak serves solely for determination of the peak-position and FWHM, which gives an indication of a reasonably well isolated "single" peak.
If window settings are kept constant in the analysis of calibration peaks and successive spectra, most "systematic" errors cancel in first order, thus within one series of spectra peak area ratio errors are in fact determined by counting statistics.
Even in "absolute" peak area determinations from a single spectrum the inherent subjectivity has proven to be equally or more reliable and sensitive than usual fit quality criteria.



A NEW UNFOLDING METHOD APPLIED TO PROTON RECOIL SPECTRA FROM A LIQUID SCINTILLATOR *)

M. Cargnelli [1]

A numerical procedure for the reconstruction of the neutron energy spectra (by unfolding the proton-recoils) was developed recently and tested using a measured response function from a large liquid scintillator NE 213 and various experimental and simulated recoil spectra.
The basic problem in unfolding resolution smeared spectra is the instability of the backward transformation, which leads to useless pseudo-solutions unless special care is taken. The essential improved performance of the new method is due to the suppression of the pseudo-components by two measures: The energy distribution is approximated by a sum of either harmonic- or Legendre-polynomial basis functions (thus preventing high frequency spurious oscillations) under the constraint that the solution be greater than zero. These basis functions are folded with the response function and then used as components for a constrained least-square fit to the pulse-height data. So the essence of the procedure is a sequence of multi-parameter minimizations subject to a set of unequality constraints.

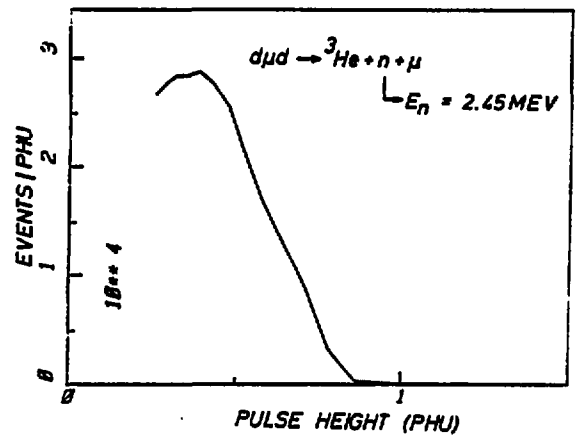


Fig. 1. Experimental pulse-height spectrum of neutrons resulting from the muon catalyzed fusion process d + d → 3-He + n

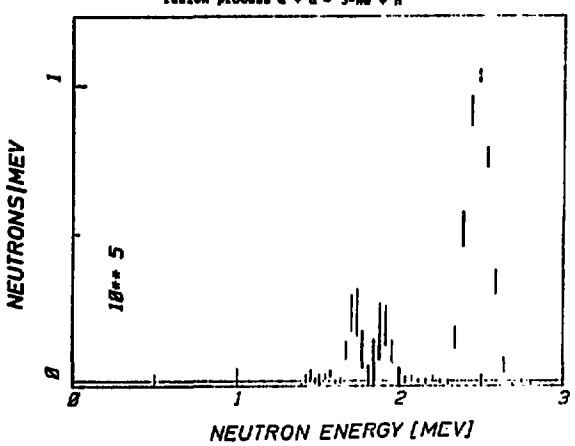


Fig. 2. Unfolding of the above pulse-height spectrum results in the neutron energy spectrum shown here. The dominating peak of fusion neutrons at 2.45 MeV is accompanied by two peaks at lower energies due to inelastic scattering from iron and copper.

*) Supported by Österreichische Akademie der Wissenschaften, Fonds zur Förderung der wissenschaftlichen Forschung in Österreich and Schweizerisches Institut für Nuklearforschung.

[1] Österreichische Akademie der Wissenschaften

EVALUATION OF EXCITATION FUNCTIONS FOR SOME IMPORTANT NEUTRON-DOSIMETRY-REACTIONS (THRESHOLD TO 20 MEV) *)

H. Vonach, S. Tagesen, B. Strohmaier

During the last years an extended research program has been executed to evaluate (reevaluate) important dosimetry reaction cross sections, not yet contained in the ENDF/B-file /1/. The first step has been to develop a method for an as accurate as possible treatment of existing data, taking into account the often very poor uncertainty information /2/ as well as recent changes of reference data. A computer program /3/ has been designed to create the necessary data files and perform the calculations for generation of excitation functions and covariance matrices. In cases, where in some energy region no experimental data were existing, the experimental data set has been complemented by theoretical data, derived by model-calculations with the code STAPRE /4/. Results have been published on the following reactions: 24-Mg(n,p)24-Na, 64-Zn(n,p)64-Cu, 63-Cu(n,2n)62-Cu, 90-Zr(n,2n)89-Zr /5/; 19-F(n,2n)18-F, 31-P(n,p)31-Si, 93-Nb(n,n')93m-Nb, 103-Rh(n,n')103m-Rh /6/; 27-Al(n,α)24-Na /7/. The most recent data on 27-Al(n,α) reveal a considerable change of the cross section against previous evaluations in some energy regions and in addition a remarkable decrease of uncertainty.

/1/ ENDF/B-IV Dosimetry File, ed. D.A. Magurno, BNL-NCS-50446 (1975)
/2/ H. Vonach and S. Tagesen, "Evaluation Methods and Procedures with emphasis on handling experimental data", Proc. Int. Conf. on Evaluation Methods and Procedures, Brookhaven, Sept. 1980
/3/ S. Tagesen, "EVA, ein Programmsystem zur Evaluation von Anregungsfunktionen und Kovarianzmatrizen für Neutronendosimetrie-Reaktionen", Anz. Österr. Akad. Wiss., Jg. 1979, Nr. 7, 166
/4/ B. Strohmaier, M. Uhl, Proc. Winter Course on Nuclear Theory for Applications, Trieste, 1978, IAEA-SMR-43 (1980) 313
/5/ S. Tagesen, H. Vonach and B. Strohmaier, Physik Daten/Physics Data Nr. 13-1 (1979)
/6/ B. Strohmaier, S. Tagesen and H. Vonach, Physik Daten/Physics Data Nr. 13-2 (1981)
/7/ S. Tagesen and H. Vonach, Physik Daten/Physics Data Nr. 13-3 (1981)

*) Partly supported by both the IAEA, Vienna and the Bundesministerium für Wissenschaft und Forschung

SOME ASPECTS OF ACTIVITY MEASUREMENTS WITH NaI(Tl) WELL-TYPE DETECTORS

G. Winkler and A. Pavlik

A FORTRAN computer program has been developed to calculate the total efficiency of high-efficiency gamma-detectors for radionuclides with complex decay schemes. It includes a check of the physical consistency of the assumed decay scheme and an error analysis which also takes into account correlations using the generalized error propagation law. In line with a description of the essential features of this procedure for efficiency determinations some special problems are discussed which are encountered on measuring the activity of thick samples for several applied purposes, or when low energy coincident gamma-radiation or X-rays are present. Fig. 1 shows the increase of the total detector efficiency for 60-Co distributed in a copper matrix with the sample thickness due to Compton scattering of the emitted gamma-radiation by the sample.

(This work is to be published in Proc. ICRM-Seminar on Gamma- and X-Ray Spectrometer Techniques and Applications, Int. J. Applied Radiation and Isotopes)

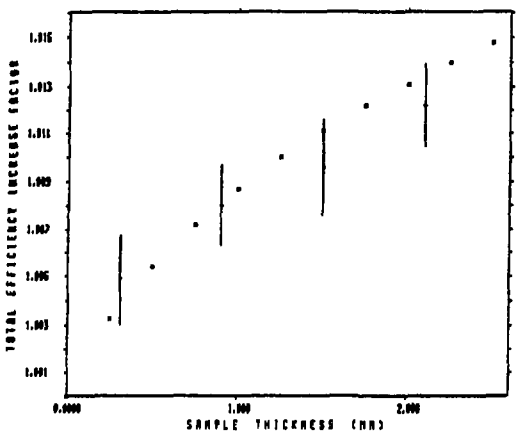


Fig. 1. The increase of the total detector efficiency for 60-Co in a copper matrix with the sample thickness (sample diameter ∿ 13 mm): i) calculated on the basis of Compton scattering (data represented by crosses) and ii) experimental results (data with error bars)

DATING

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 science, mining, preferably with Austrian Universities, museums and other scientific institutions.
Dating up to 40 000 years B.P. is done by a methane proportional counter low level system with internal screening counter arrangement.

ABSOLUTE DATIERUNG FOSSILER KNOCHEN IM ALTERSBEREICH 10 000 - 300 000 JAHRE *)

P. Hille, E. Wild und H. Vonach

Seit einigen Jahren wird am Institut für Radiumforschung und Kernphysik versucht, fossile Knochen mit physikalischen Methoden absolut zu datieren. Diese Bemühungen sind Teil interdisziplinärer Zusammenarbeit, die vom Fonds zur Förderung der wissenschaftlichen Forschung in Österreich gefördert wird.

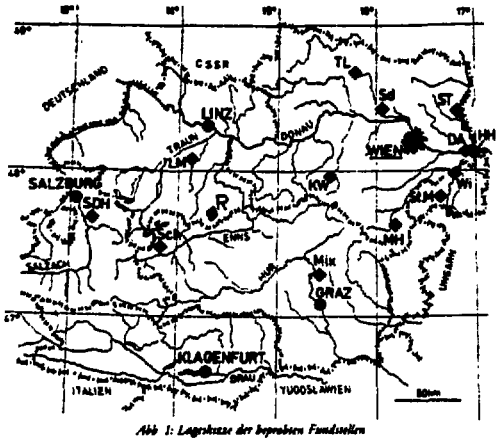


Abb. 1: Lageskizze der beprobten Fundstellen

Abkürzungen:

DA: Bad Deutsch-Altenburg	Sd: Stranzendorf
HH: Hundsheim (Knochenspalte)	SDH: Schlenken-Durchgangshöhle
KW: Köhlerwandhöhle	ST: Stillfried
LM: Lorenzmayerhöhle	StM: Sankt Margarethen
MH: Mehlsackhöhle	TL: Teufelslucke
Mix: Mixnitz (Drachenhöhle)	Wi: Winden (Bärenhöhle)
Sch: Schomloch	R: Ramesch

Das jüngste Projekt (Nr. 4370) läuft unter obigem Titel seit Mai 1981 und wird von Prof. R. Pittioni (Institut für Ur- und Frühgeschichte der Universität Wien), Prof. J. Korkisch und Dr. I. Steffan (Institut für Analytische Chemie der Universität Wien), Doz. G. Rabeder und Doz. N. Vavra (Institut für Paläontologie der Universität Wien), Dr. K. Mais (Naturhistorisches Museum, Wien) und Prof. P. Hille getragen.
Im Rahmen des Projekts wird der Fragenkreis der Geschichte des Neanderthalers im alpinen Bereich in engem Zusammenhang mit dem paläontologischen Fragenkomplex der Datierung von Höhlenfaunen, besonders des Höhlenbären, behandelt. Das Projekt baut auf den Erfahrungen

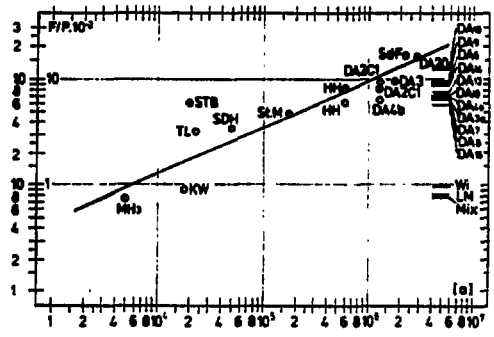


Abb. 2: Doppelt logarithmische Darstellung der Zeitabhängigkeit der Fluoraufnahme von fossilen Knochen. Die durchgezogene Gerade entspricht einem Fit, der die relativen Fehler minimalisiert

und Erbegnissen früherer Projekte auf [1]). Es geht u.a. darum, Steinartefakte, die als Zeugnisse menschlicher Anwesenheit in hochalpinen österreichischen Höhlen gefunden wurden, zu datieren. Diese Datierung wird über verschiedene physikalisch-chemische Methoden versucht, die sich auf Knochen, die aus dem gleichen Fundhorizont geborgen wurden, anwenden lassen. Es wird vermutet, daß es sich bei den Herstellern der gefundenen Steinwerkzeuge um Neanderthal-Jäger handelt, denen es möglich war, in einer Periode warmen Klimas dem Höhlenbären ins Gebirge zu folgen, um ihn zu jagen. Da der zu datierende Zeitbereich wahrscheinlich außerhalb der Reichweite der 14-C-Methode liegt, müssen andere Methoden angewendet werden. (Ein Überblick über alle bewährten Methoden wird in /1/ gegeben.)
Die Uran-Serien-Methode, der Stickstoff/Fluor-Test, und die Analyse des Abbaus von Aminosäuren bzw. deren Razemisierung wurden bisher, teilweise nach Adaptierung auf eine größere Anzahl von Knochenproben angewendet (siehe /2-4/). Die methodischen Vorarbeiten konnten 1981 zu einem vorläufigen Abschluß gebracht werden. Abb. 1 zeigt eine Lageskizze beprobter Fundstellen. In Abb. 2 sind die bisherigen Ergebnisse bezüglich der Zeitabhängigkeit der Fluoraufnahme von fossilen Knochen aus österreichischen Höhlen dargestellt. Abb. 3 zeigt das Gaschromatogramm eines Aminosäuregemisches aus einem Bärenknochen.

Bei der Uran-Serien-Methode werden U und Th aus der Knochenmatrix chemisch abgetrennt /4/, und die Isotopenverhältnisse 230-Th/234-U und 227-Th/235-U über Messung der α-Strahlung bestimmt. Abb. 4 zeigt das α-Spektrum der U-Fraktion aus einer Knochenprobe. Details der methodischen Vorgangsweise werden und wurden an anderer Stelle veröffentlicht /2,3,4/.

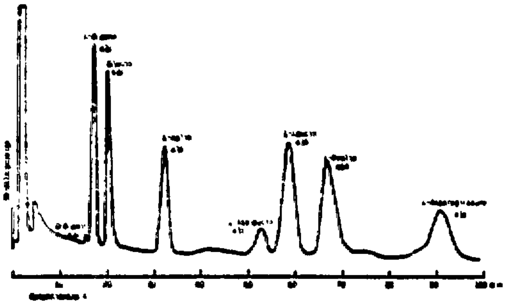


Abb. 3. [illegible]

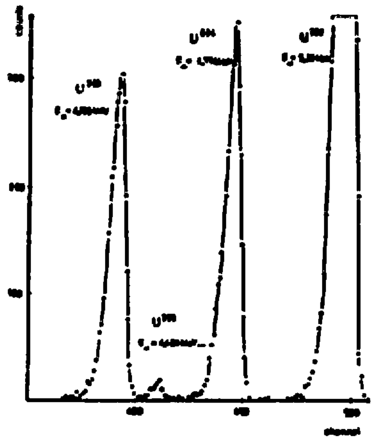


Abb. 4. α-Spektrum der U-Fraktion aus einer Knochenprobe (232-U wurde als Radioindikator zur Feststellung der chemischen Trennausbeuten zugesetzt)

/1/ H. Felber und P. Hille, Anwendung der Radioisotopendatierung in der Archäologie (in Vorbereitung für Sitzber. d. Österr. Akad. Wiss.)

/2/ P. Hille, K. Mais, G. Rabeder, N. Vavra und E. Wild, Über Aminosäuren- und Stickstoff/Fluor-Datierung fossiler Knochen aus österreichischen Höhlen, Die Höhle 32, 3 (1981) 74-91

/3/ E. Wild, P. Hille und G. Rabeder, Improvements and some results of the N/F-activation method for dating fossil bone, J. Radioanal. Chem. (in Druck)

/4/ J. Korkisch, I. Steffan, P. Hille, H. Vonach und E. Wild, Uranium-series-method applied to fossil bone, J. Radioanal. Chem. (in Druck)

[1]) Projekt 3019: "Altersbestimmung von Fossilien mit neuen physikalischen und chemischen Methoden" (Projektleiter: G. Rabeder) und
Projekt 3671: "Altersbestimmung von Fossilien nach der Uran-Thorium und Uran-Protactinium Methode" (Projektleiter: H. Vonach)

*) Unterstützt vom Fonds zur Förderung der wissenschaftlichen Forschung in Österreich

SCHWEFELISOTOPENUNTERSUCHUNGEN

E. Pak

Das Arbeitsgebiet der Isotopengeochemie (Häufigkeitsbestimmung stabiler Isotope) leitet sich im Institut einerseits her von der traditionellen Beschäftigung mit Altersbestimmungen, andererseits aus dem Vorhandensein eines für diesen Zweck ausgezeichnet geeigneten Massenspektrometers. Die Möglichkeit der Altersbestimmung von evaporitischen Sulfatgesteinen aufgrund ihrer Schwefelisotopenzusammensetzung (34-S/32-S) besteht deshalb, weil sich diese im Sulfat der Meere im Laufe der Erdgeschichte verändert hat (dieser Methode liegt also nicht etwa eine "radioaktive Uhr" zugrunde, sondern die Einordnung anhand der für die geologischen Epochen jeweils charakteristischen Werte).
Auf diese Weise sind in den letzten Jahren umfangreiche Untersuchungen mit Hauptgewicht auf den österreichischen Salzlagerstätten und allgemein der Perm-Trias-Abgrenzung durchgeführt und größtenteils zu einem vorläufigen Abschluß gebracht worden. Im Berichtszeitraum wurde dieser Bereich nur noch mit vereinzelten Proben weiter verfolgt. Hingegen hat sich der Schwerpunkt der Schwefelisotopenuntersuchungen auf das sowohl rein wissenschaftlich als auch wirtschaftlich bedeutungsvolle Gebiet der sulfidischen Erzlagerstätten verlegt.

Die Isotopenzusammensetzung der Buntmetallsulfide läßt auf die Art der Entstehung der Lagerstätten schließen. In erster Linie gelingt die auf anderem Wege oft unmögliche oder unsichere Unterscheidung zwischen magmatogen-hydrothermaler und bakteriogen-sedimentärer Bildung fast stets, da bei bakterieller Mitwirkung stärkere Anreicherung des leichten Schwefelisotops und größere Streuung der Werte beobachtet werden, während die aus Hydrothermen abgeschiedenen Erze einheitlichere Isotopenzusammensetzung aufweisen und die Mineralparagenesen im Falle bestehender Isotopenfraktionierungsgleichgewichte eine Abschätzung der Bildungstemperatur zulassen. Hinweise auf die Mitwirkung des Meerwassers ergeben sich durch gleichzeitige Isotopenuntersuchungen beim Schwefel der Schwerspäte.
Im Berichtszeitraum wurde in erster Linie eine mehrjährige, umfangreiche Bearbeitung der Pb-Zn-Lagerstätte Bleiberg (Kärnten) abgeschlossen und publiziert [1]). Diese Lagerstätte ist wegen des Auftretens von mindestens 6 Vererzungshorizonten und wegen mannigfachen Sekundärprozessen (Diagenese, Metamorphose) sehr komplex. Die Schwefelisotopenmessungen ergaben, daß die Erze bakteriell, also sedimentär entstanden sind,

wobei aber mindestens zwei aufeinanderfolgende Mineralisationsphasen (Generationen) eine stufenweise Anreicherung von leichtem Schwefel zur Folge hatten.

[1], [2] Gemeinsam mit Prof. Schroll (Arsenal, Wien) und Prof. Schulz (Universität Innsbruck)

Verschieden umfangreiche Untersuchungen [2] von Lagerstättenbereichen in Österreich wurden im Berichtszeitraum begonnen (Nördliche Kalkalpen), weitergeführt (Karawanken, Karwendel, Tauern) oder abgeschlossen (Kreuzeckgruppe, Schladming).

APPLICATIONS IN MEDICINE

METHODS FOR QUALITY ASSURANCE IN DIAGNOSTIC RADIOLOGY *)

R. Nowotny, W. Rechtberger

A programme is under way to establish and evaluate standard methods for the measurement of physical and technical parameters for apparatus in diagnostic radiology.
Besides, new methods are developed in which nuclear measurement techniques are used. The peak voltage of fluoroscopy equipment can be determined via energy dispersive X-ray spectrometry. The tube output is measured with a PIN-diode as a photon detector /1/. The peak voltage is then determined from the high-energy end point of the pulse height distribution (fig. 1).

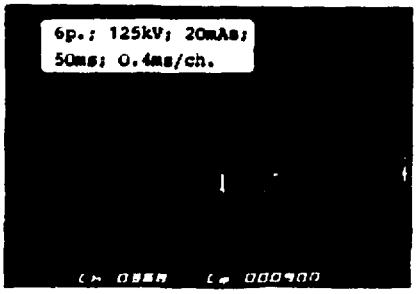


Fig. 1. Pulse-height spectra for various kV settings obtained with a constant potential X-ray generator

In another technique PIN-diodes could be employed to determine the dose output of X-ray tubes with a recording bandwidth of up to 10 kHz /2/. High voltage ripple, timing and various artifacts can be seen on such recordings (fig. 2).
It is the intention to increase the number of methods where electronic recording of data is used instead of photographic films. A retake analysis programme will serve to control the effect of the various measures taken.

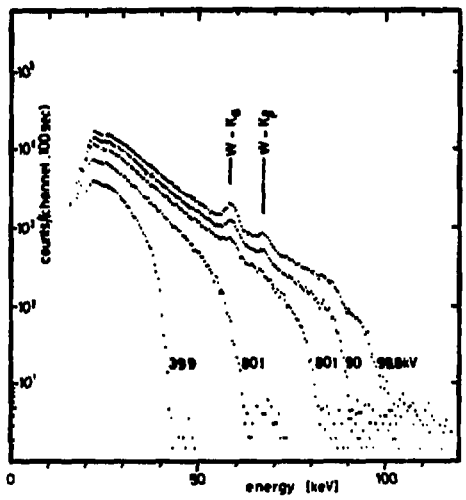


Fig. 2. Dose rate with time for a 6-pulse X-ray generator (time interval 0.4 ms per channel)

/1/ R. Nowotny, Health Physics 39 (1980) 310
/2/ R. Nowotny, H. Jantsch, Proc. 12. Jahrestagung der DGMP, München, 1981

*) Partly supported by L. Boltzmann Institut für radiologisch-physikalische Tumordiagnostik (Prof. Dr. H. Pokieser)

STUDY ON THE USE OF FIBRINOGEN ADHESIVE MATERIAL WITH TENDONS

P. Bösch [1], H. Hertz [2], F. Lintner [3] and R. Nowotny

The availability of fibrinogen adhesive material (FAM) renders feasible various interesting applications. Previous studies /1,2/ have been made to determine the physical characteristics of FAM. Among others it became important to learn if the application of FAM speeds up the healing processes. In particular this problem was studied for the healing of achilles tendons.
FAM of Immuno AG, Vienna was used together with a suture of heel tendons of 69 rabbits. The achilles-tendon cut through was anastomosed in a typical way. Besides homologeous fibrinogen-cryoprecipitate was applied in one group.
Histological and biomechanical evaluation of the anastomosis was carried out after one, two and four weeks. The mechanical strength of the tendon was determined in-vitro in a stress-strain experiment (fig. 1). Results indicate that the application of FAM does not accelerate the healing process of tendons /3/.

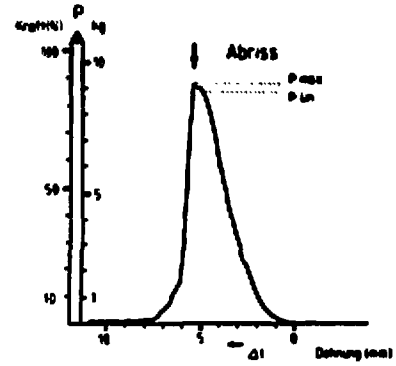


Fig. 1. Typical curve for stress (P) vs. strain (Δl) of a tendon until rupture of the anastomosis (FAM-group, 2 weeks)

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/2/ R. Nowotny, A. Chalupka, Ch. Nowotny, P. Bösch, Biomaterials 1980 (G.D. Winter, D.F. Gibbons, H. Plenk, eds.) p. 677, Wiley & Sons, 1982
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[1] Orthopädische Universitätsklinik
[2] 1. Klinik für Unfallchirurgie
[3] 1. Chirurgische Universitätsklinik, Abteilung für Experimentelle Chirurgie

DOSIMETRY AND ENVIRONMENTAL STUDIES

RADIOACTIVITY MEASUREMENT OF AIR AND WATER SAMPLES

H. Friedmann, F. Hernegger, E. Pak

Routine measurements were made on the 226-Ra and 222-Rn content of water samples, as well as total β-activities were determined. This was done for radiation protection purposes in drinking water and in the water of spas. Measurements were also done to determine 222-Rn and 220-Rn concentration in air samples. Additionally the 228-Ra concentration in industrial waste water was surveyed, whereby Dr. Hernegger developed a method to remove 228-Ra from a solution which is used by a special type of industry. This was necessary to keep the 228-Ra concentration in the waste water below the values which were required by local authorities.

NEUTRON DOSIMETRY WITH SOLID STATE NUCLEAR TRACK DETECTORS (SSNTD)

W. Schmidt, R. Nowotny

Methods for neutron dosimetry using SSNTD-techniques are under development. So far, the use of Makrofol KG (Bayer AG) and LR 115 (Kodak) for such an application was investigated. An integrating dosimeter for area monitoring based on the detection of thermal neutrons with SSNTD in the centre of a moderating polythene sphere was designed. The response of such spheres is well known /1/.

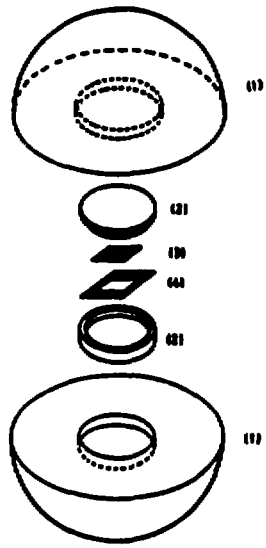

Fig. 1. Area monitoring system
(1) polythene sphere,
(2) polythene box,
(3) radiators and
(4) SSNTD foils

A diameter of 25 cm was chosen to obtain an acceptable sensitivity at 14 MeV neutron energy. The detector consists of sandwiches of both metallic uranium foils and enameled ceramic disks as radiators and Makrofol KG detector foils positioned at the centre of the sphere (fig. 1). The plastic foils are fixed in commercial slide frames to facilitate handling and processing. After etching (28% KOH, 60° C, 2 h) the track number is determined by spark counting /2/ (see fig. 2). Up to track densities of 3000 per cm^2 the spark number varies linearly. At higher densities the curve levels off due to the formation of isolated islands on the aluminized electrode. Hence, a radiator with U-enamel giving reduced sensitivity is included to cover a larger dose range.

For calibration of the assemblies several irradiations at various n-energies (thermal, 3 MeV, 14 MeV, Cf-252, Am-Be) have been made which gave an average sensitivity of 2.20 tracks/mrem for a radiator surface of 4 cm^2. Spontaneous fission of U-238 (1.4 tracks/(cm^2. day)) limits the sensitivity threshold to 39 mrem (3s of background) for a measurement period of one month. With both radiator types this dosimeter system covers a range up to 500 rem which could be further extended by the use of other counting methods.
Further efforts are made in the development of a personal neutron dosimeter also based on SSNTDs.

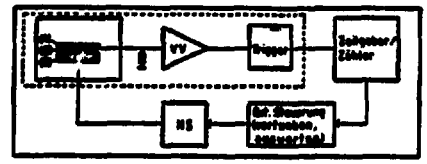

Fig. 2. Spark counting circuit
(1) aluminized polyester foil,
(2) perforated detector foil, and
(3) brass electrode

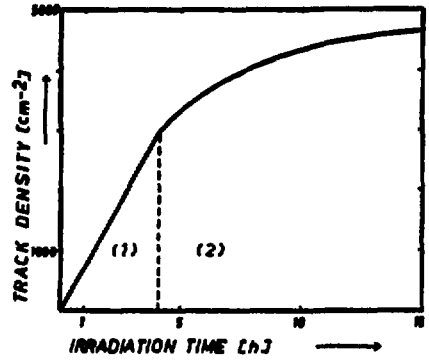

Fig. 3. Track density vs irradiation time
(1) linear region,
(2) formation of electrically isolated islands

/1/ Nachtigall, D., Burger, G., in: Topics in Radiation Dosimetry (Attix, F., ed.), Suppl. p. 385, Acad. Press, N.Y., 1972
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RADON MEASUREMENT FOR EARTHQUAKE PREDICTION *)

H. Friedmann

Different investigations in China, USSR, Japan and the USA showed significant Radon anomalies prior to earth quakes. For this reason we developed an apparatus for a continuous measurement of the Radon content in water. Supported by the "Fonds zur Förderung der wissenschaftlichen Forschung in Österreich" (Projekt No. 3295 & 4305) this project shall lead to a better understanding of earthquake precurser phenomena and in future to possible earthquake prediction.
In 1979 we observed a significant anomaly in a spring which we survey since 1977. This anomaly could be attributed to the strong earthquakes in Yugoslavia (15.4.1979 and 24.5.1979) as well as to an earthquake in Italy (19.9. 1979). In 1981 there was another Radon anomaly, where the beginning of the anomaly was clearly related to an earthquake in Austria (Obdach) (fig. 1). Nevertheless, the last anomaly is still existing which perhaps indicates an abnormal stress in this area.
Further investigations were carried out to determine the distance from the point where the anomaly was detected to the future epicentre of the earthquake. A double logarithmic correlation between the shape of the radon anomaly and the distance could be discovered for springs far outside the epicentre area (≥ 60 km) (fig. 2).

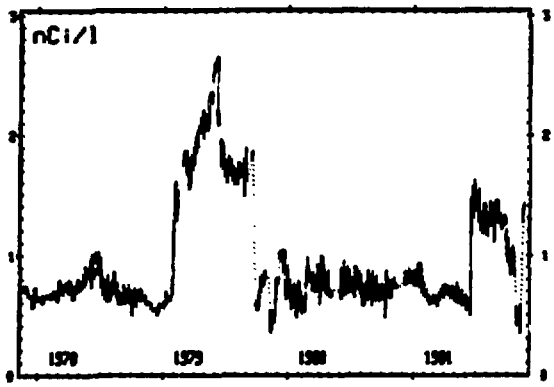

Fig. 1. Radon concentration in a spring during the time period Nov. 1977 to Nov. 1981. The peak in the anomaly in 1979 coincidences with the strong earthquake in Montenegro.

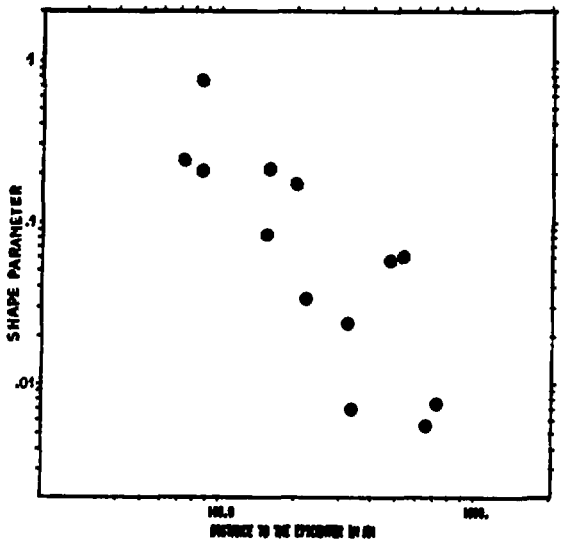

Fig. 2. A parameter deduced from the shape of Radon anomalies detected in China, USSR, USA and Austria plotted vs. the distance to the epicentre

*) Supported by Fonds zur Förderung der wissenschaftlichen Forschung in Österreich

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