NEANDC(E) - 182 "U"
VOL. III - EURATOM
INDC(EUR) - 010/G

COMMISSION OF THE EUROPEAN COMMUNITIES

Joint Research Centre

CENTRAL BUREAU FOR NUCLEAR MEASUREMENTS

GEEL-BELGIUM

Nuclear Data

Progress Report 1976

NEANDC(E) - 182 "U"
VOL. III - EURATOM
INDC(EUR) - 010/G

COMMISSION OF THE EUROPEAN COMMUNITIES

Joint Research Centre

CENTRAL BUREAU FOR NUCLEAR MEASUREMENTS

GEEL-BELGIUM

Nuclear Data Progress Report 1976

TABLE OF CONTENTS

ELEMENT S	A	QUANTITY	TYPE	ENERGY MIN	MAX	DOCUMENTATION REF	VOL	PAGE	DATE	LAB	COMMENTS
H	001	ELASTIC SCAT	REVW-PROG	NDG		NEANDC(E)-182U		16	2/77	GEL	LISKIEN.FOR LOWELL CONF 76
LI	006	TOTAL XSECT	EXPT-PROG	80+4	30+6	NEANDC(E)-182U		12	2/77	GEL	KNITTER+ANALYS COMPL
LI	006	DIFF ELASTIC	EXPT-PROG	22+5	30+6	NEANDC(E)-182U		12	2/77	GEL	KNITTER+ANALYS COMPL
LI	006	N TRITON	THEO-PROG	00+0	10+5	NEANDC(E)-182U		14	2/77	GEL	WEIGMANN.D-EXCHANGE PROCESS
LI	006	N TRITON	REVW-PROG	NDG		NEANDC(E)-182U		16	2/77	GEL	LISKIEN.FOR LOWELL CONF 76
LI	006	N TRITON	EXPT-PROG	NDG		NEANDC(E)-182U		13	2/77	GEL	BASTIAN+IN PREPARATION REL 10B(N,A)
B	010	N ALPHA	REVW-PROG	NDG		NEANDC(E)-182U		16	2/77	GEL	LISKIEN.FOR LOWELL CONF 76
B	010	N ALPHA	REVW-PROG	NDG		NEANDC(E)-182U		16	2/77	GEL	WATTECAMPS.FOR 19TH NEANDC MEETING
B	010	N ALPHA	EXPT-PROG	10+5	20+6	NEANDC(E)-182U		13	2/77	GEL	LISKIEN+IN PREPARATION REL PROD 7LI*
C	012	ELASTIC SCAT	REVW-PROG	NDG		NEANDC(E)-182U		16	2/77	GEL	LISKIEN.FOR LOWELL CONF 76
MO		TOTAL XSECT	EXPT-PROG	40+5	18+6	NEANDC(E)-182U		10	2/77	GEL	WEIGMANN+ORELA TOF
MO	024	RESON PARAM	EXPT-PROG	46+4	18+6	NEANDC(E)-182U		10	2/77	GEL	WEIGMANN+ORELA TOF
MO	024	N GAMMA	EXPT-PROG	46+4	18+6	NEANDC(E)-182U		10	2/77	GEL	WEIGMANN+ORELA TOF
MO	025	RESON PARAM	EXPT-PROG	20+4	26+5	NEANDC(E)-182U		10	2/77	GEL	WEIGMANN+ORELA TOF
MO	025	N GAMMA	EXPT-PROG	20+4	26+5	NEANDC(E)-182U		10	2/77	GEL	WEIGMANN+ORELA TOF
MO	026	RESON PARAM	EXPT-PROG	69+4	43+5	NEANDC(E)-182U		10	2/77	GEL	WEIGMANN+ORELA TOF
MO	026	N GAMMA	EXPT-PROG	69+4	43+5	NEANDC(E)-182U		10	2/77	GEL	WEIGMANN+ORELA TOF
ZR	091	RESON PARAM	EXPT-PROG	10+2	32+3	NEANDC(E)-182U		7	2/77	GEL	BRUSEGAN+
NB	093	RESON PARAM	EXPT-PROG	10+2	26+3	NEANDC(E)-182U		6	2/77	GEL	MEUISSEN+
MO	100	TOTAL XSECT	EXPT-PROG	10+1	25+4	NEANDC(E)-182U		10	2/77	GEL	WEIGMANN+ORELA TOF
MO	100	SPECT N,GAM	EXPT-PROG	10+1	50+3	NEANDC(E)-182U		10	2/77	GEL	WEIGMANN+ORELA TOF WITH GE(LI)-DET
RH	103	INELAST SCAT	EXPT-PROG	10+5	70+6	NEANDC(E)-182U		3	2/77	GEL	PAULSEN+ACTIV ISOM STATE RH103
IN	115	INELAST SCAT	EXPT-PROG	35+5	70+6	NEANDC(E)-182U		3	2/77	GEL	PAULSEN+ACTIV ISOM STATE IN115
I	127	SPECT N,GAM	EXPT-PROG	20+1	20+3	NEANDC(E)-182U		8	2/77	GEL	ROHR+
HF	177	RESON PARAM	EXPT-PROG	10+0	17+2	NEANDC(E)-182U		7	2/77	GEL	CORVI+FOR 38 RESONANCES
HF	177	SPECT N,GAM	EXPT-PROG	10+0	17+2	NEANDC(E)-182U		7	2/77	GEL	CORVI+INTENS FOR 29 TRANSITIONS
AU	197	N GAMMA	THEO-PROG	10+4	50+5	NEANDC(E)-182U		14	2/77	GEL	LISKIEN+
AU	197	N GAMMA	REVW-PROG	NDG		NEANDC(E)-182U		16	2/77	GEL	LISKIEN.FOR LOWELL CONF 76
U	233	FISSION	EXPT-PROG	20-3	80-2	NEANDC(E)-182U		14	2/77	GEL	VAN GILS+CRYST SPEC BR2
U	233	FISSION	EXPT-PROG	20-3	15-1	NEANDC(E)-182U		14	2/77	GEL	BUYL+CHOPPER BR2
U	235	FISSION	THEO-PROG	10+4	50+5	NEANDC(E)-182U		14	2/77	GEL	LISKIEN+
U	235	FISSION	REVW-PROG	NDG		NEANDC(E)-182U		16	2/77	GEL	LISKIEN.FOR LOWELL CONF 76
U	235	FISSION	EXPT-PROG	20-3	80-2	NEANDC(E)-182U		14	2/77	GEL	VAN GILS+CRYST SPEC BR2
U	235	FISSION	EXPT-PROG	50+0	30+4	NEANDC(E)-182U		13	2/77	GEL	BARTHELEMY+REL 10B(N,A)
U	235	SPEC FISS N	REVW-PROG	NDG		NEANDC(E)-182U		16	2/77	GEL	KNITTER.FOR IAEA CONSULT MEET NOV 76
U	235	FISS FRAG SP	EXPT-PROG	70+0	35+1	NEANDC(E)-182U		10	2/77	GEL	BARTHELEMY+
U	238	RESON PARAM	EXPT-PROG	90+0	42+3	NEANDC(E)-182U		5	2/77	GEL	CORNELIS+
U	238	FISSION	REVW-PROG	NDG		NEANDC(E)-182U		3	2/77	GEL	KNITTER.AVER XSECT IN U235 FISS SPEC
U	238	FISSION	REVW-PROG	NDG		NEANDC(E)-182U		3	2/77	GEL	KNITTER.REL TO U235 FISS XSECT
NP	237	RESON PARAM	EXPT-PROG	80+0	20+2	NEANDC(E)-182U		5	2/77	GEL	ANGELETTI+
PU	239	FISSION	EXPT-PROG	20-3	80-2	NEANDC(E)-182U		14	2/77	GEL	VAN GILS+CRYST SPEC BR2
PU	239	FISSION	EXPT-PROG	10+1	50+4	NEANDC(E)-182U		9	2/77	GEL	BARTHELEMY+
PU	239	NU	EXPT-PROG	10+1	50+4	NEANDC(E)-182U		9	2/77	GEL	BARTHELEMY+
PU	241	FISSION	EXPT-PROG	20-3	80-2	NEANDC(E)-182U		14	2/77	GEL	VAN GILS+CRYST SPEC BR2
CF	252	SPEC FISS N	REVW-PROG	SPON		NEANDC(E)-182U		16	2/77	GEL	KNITTER.FOR IAEA CONSULT MEET NOV 76

1. FAST NEUTRON DATA

Determination of Excitation Functions for the Reactions $^{103}Rh(n,n')\,^{103}Rh^m$ and $^{115}In(n,n')\,^{115}In^m$ in the Region from Threshold to 7MeV

A. Paulsen, H. Liskien, R. Widera, F. Arnotte

Relative activation measurements were made between 100 and 400 keV neutron energy in steps of 50 keV for the $^{103}Rh(n,n')^{103}Rh^m$ reactions.As the results between 100 and 300 keV suffer from poor counting statistics these measurements were repeated several times. The results of that energy region indicate some structure in the cross section which has not been found in earlier measurements. The influence of this structure on the average cross section in the fission neutron spectrum of ^{235}U is negligible but can be considerable in softer spectra. Further relative activation measurements were carried out between 1.9 and 4.1 MeV neutron energy for the $^{115}In(n,n')^{115}In^m$ reaction. An absolute cross section determination was done at 1.8 MeV for Rh and at 2.1 MeV for In. The neutron fluence was measured by means of a proton recoil proportional counter and the absolute counting efficiencies of the activation detectors were determined by calculation in the case of Rh and by calibration sources in the case of In. The results are :

$^{103}Rh(n,n')^{103}Rh^m$	at 1.8 MeV	σ = 935 mb $\pm$ 10 %
$^{115}In(n,n')^{115}In^m$	at 2.1 MeV	σ = 297 mb $\pm$ 5 %

The relative activation measurements will be extended up to 7 MeV and further absolute determinations will be carried out.

Status Reports for NEANDC

H.-H. Knitter

As requested by NEANDC for its 19th meeting in Stockholm,Sept., the status reports on "The average fission cross section of ^{238}U in the fission neutron spectrum of ^{235}U induced by thermal neutrons" and on "The ratio of the fission cross section of ^{238}U to the one of ^{235}U" were updated and rewritten.

Determination of Fast Neutron Induced Fission Cross Section Ratios

H.-H. Knitter, C. Budtz-Jørgensen, M. Mailly, R. Vogt

Preliminary tests have been performed with a twin-chamber fission detector, developed and constructed at CBNM. A paper describing this detector was presented at the "NEANDC/NEAGRP Specialists'Meeting, June 28th-30th 1976, Argonne" with the following abstract :
"A twin ionization chamber for fission fragment detection is described. The chamber allows to extract both fast timing- and energy proportional signals. A time resolution of 1.62 ns FWHM was obtained between two fission fragments detected in the two halves of the chamber. For ^{241}Am α particles the chamber gave an energy resolution of 1.3 %. As couting gas methane NTP was used."

The fast timing characteristics of the detector (and of the use of a pulsed neutron beam) made it possible to correct for fission events (^{235}U) induced by room-scattered neutrons. The long term stability of the set-up was checked by measuring the $^{238}U/^{235}U$ fission ratio at a fixed neutron energy. The observed variations (< 1%) of the ratio were within the statistical errors.

Neutron Yields of (α,n) Reactions by Bombardment of Thick Targets

H. Liskien, A. Paulsen, R. Widera, F. Arnotte

Simulating α emitters by means of the CBNM Van de Graaff accelerators, it is planned to perform measurements on (α,n) reactions to determine thick target total neutron yields and spectra for various materials of environmental interest for α-energies up to 7 MeV. Preparations have been made to use an available Cadarache "directional counter" as 4π neutron detector for yield determinations.

Development of a Reaction Chamber for the Study of (n,p) and (n,α) Reactions

A. Paulsen, H. Liskien, F. Arnotte, R. Widera

The construction of a reaction chamber containing five telescopic charged particle detectors at 18°, 54°, 82°, 107° and 139° relative to the 0° neutron direction (direction of the accelerator ion beam) is nearly completed. The charged particle detectors consist of 2 mm thick discs of CsI(Tl) scintillation crystals coupled by quartz light guides to XP 1180 photomultipliers. Between the sample foil and the scintillation detectors two proportional counters are inserted. They act as dE/dx counters and will allow a considerable background reduction by demanding triple coincidences. They will also allow particle identification by E x ΔE discrimination. The counters and the associated electronics have been tested with an ^{241}Am α source. For this source the energy resolution is about 9%. The minimum coincidence resolution time is about 0.5 μs. The neutron flux will be measured by means of the same reaction chamber with the sample replaced by a hydrogenous radiator foil and by observing the recoil proton with the 18° scintillator in a separate run. The counting efficiencies have been calculated.

Development of a Fission Chamber with Intrinsic Suppression of the Alpha Background

C. Budtz-Jørgensen, H.-H. Knitter, M. Mailly, R. Vogt

The phenomena that 5-6 MeV αparticles have a range in matter of about twice that of fission fragments was made use of in the construction of a fission chamber with intrinsic reduction of the α background. The α pulse height spectrum from a weak ^{241}Am source was analysed and was used in computer simulations of the behaviour of the chamber with very high α activity. The simulations showed that the separation between fission pulses and α pile-ups is sufficient for fission cross section measurements even with an α count rate as high as 10^8 s^{-1}. The chamber will now be tested with an ^{241}Am source of corresponding activity.

2. RESONANCE NEUTRON DATA

Resonance Parameters of ^{238}U

E. Cornelis[xx], L.Mewissen[x], F. Poortmans[x], G. Rohr, R. Shelley, T. van der Veen, G. Vanpraet[xx], H. Weigmann

A series of transmission, scattering, capture and self-indication experiments on ^{238}U were performed in 1975. The experimental details have been given in the previous report (NEANDC (E) 172 "U" 1975).

The analysis of the transmission data is completed for all samples thicknesses in the energy range between 9 eV and 4262 eV. The analysis of the capture measurements is finished for the three thinnest samples in the same energy range. The scattering measurements were performed up to 1.2 keV. The analysis of these data is nearly completed.

Up to now, the neutron width has been determined for 286 levels below 4262 eV and the capture width for 62 levels up to 3.9 keV. Taking into account the l-assignments of ^{238}U resonances by Corvi et al. (F. Corvi, G. Rohr and H. Weigmann, Proceedings of the Conference on Neutron Cross Sections and Technology, NBS Spec. Publ. 425 (1975), p. 733) we have deduced the following results for the average properties of s-wave neutron resonance parameters (energy range 0 - 4260 eV) :

s-wave strength function : $S_o = (1.06 \pm 0.11)\ 10^{-4}$ number of resonances : 174

mean s-wave level spacing: $D_o = (21.82 \pm 0.85)$eV

mean s-wave capture width: $\Gamma_\gamma = (23.43 \begin{cases} \pm\ 0.11) \text{ meV } (1\sigma\text{-statistical error}) \\ \pm\ 0.70) \text{ meV } (\text{systematic error}) \end{cases}$

The distribution of the Γ_γ values around the mean value is very narrow, the dispersion being only 0.85 meV. No correlation between Γ_γ and Γ_n° has been found.

The results mentioned above are of preliminary nature. Minor changes could be necessary after completion of the analysis of all the data. The analysis of the capture experiments with the two thickest samples is in progress. An analysis of the scattering data was started initially taking into account only the effect of self-screening and of absorption of the scattered neutrons. Meanwhile an area analysis code has been written which contains Monte-Carlo methods to correct for multiple scattering effects.

Resonance Parameters of ^{237}Np

A. Angeletti, E. Cornelis[xx], L. Mewissen[x], F. Poortmans[x], G. Rohr, T. van der Veen, G. Vanpraet[xx], H. Weigmann

The analysis of our ^{237}Np data in the energy range from 8 eV to 204 eV has been completed. A shape and area analysis of the transmission measurements was performed using the Atta-Harvey code. The capture and scattering cross section data were analysed with the area method.

---

x S.C.K.-C.E.N., Mol, Belgium

xx R.U.C.A., University of Antwerp, Belgium

The neutron widths were determined for 213 resonances up to 204 eV. The following value was obtained for the s-wave strength function :

$$S_o = (0.95 \pm 0.09) 10^{-4}$$

By fitting the reduced neutron width distribution to a Porter-Thomas distribution above a bias of $\Gamma_n^o = 0.02$ meV, we obtained the following result for the s-wave mean level spacing :

$$D_o = (0.74 \pm 0.03)\,\text{eV}$$

The total capture width was deduced from a shape analysis of the transmission data with various sample thicknesses, of capture and of scattering data up to 50 eV. As a result of this analysis the capture width was obtained for 27 resonances. The mean value is :

$$\bar{\Gamma}_\gamma = (41.2 \pm 0.5)\,\text{meV} \quad (1\sigma\text{-statistical error})$$

The fluctuation of Γ_γ around this mean value are small (standard deviation = 3meV) except for three resonances at 38.3 eV, 39.0 eV and 40.0 eV, respectively, for which Γ_γ is about 50 % larger.

Resonance Parameters of ^{93}Nb

L.Mewissen[x], F. Poortmans[x], G. Rohr, T. van der Veen, J. Winter

The low energy γ-ray spectrum from the $^{93}Nb(n,\gamma)^{94}Nb$ reaction has been measured in individual resonances up to a neutron energy of 2.6 keV with a Ge(Li)-detector. Fig. 2.1 shows intensity ratios of the 100 keV, 114 keV and 293 keV γ-ray lines.

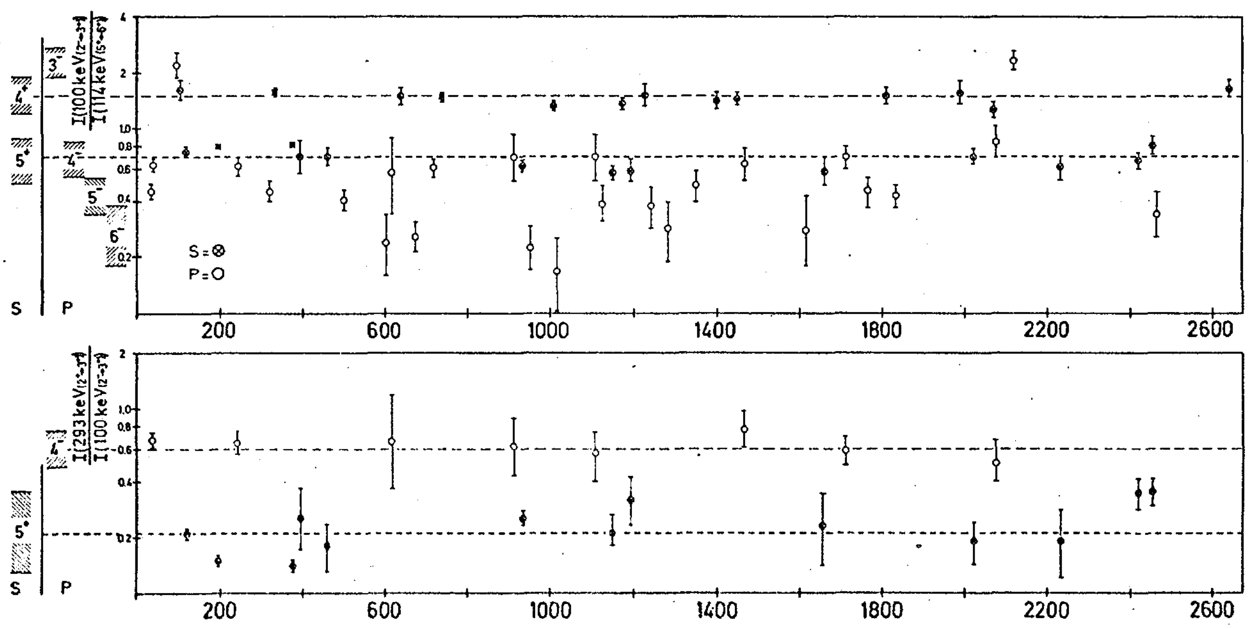


Fig.2.1 Ratios of low energy γ-ray intensities in ^{93}Nb + n resonances.

x S.C.K.-C.E.N., Mol (Belgium)

These γ-rays depopulate the low lying level with $J^{\pi} = 2^-$, 5^+ and 2^+, respectively. As expected, the intensity ratios fall into groups which allow a resonance spin classification. On the left of Fig. 2.1 bands of ratio values (average $\pm$ 1σ) are given as obtained from 22 resonances in the neutron energy range up to 1.5 keV, the spins of which are known from the work of T.J.Haste and B.W. Thomas published in J. Phys. G 1, 967 (1975)

With the aid of the data shown in Fig. 2.1 spin values for 24 further resonances could be determined. The lower part of Fig. 2.1 serves to separate resonances with spin 5^+ and 4^-, which fall together in the upper figure. Most of the parity assignments are, however, known from the transmission data.

The analysis of the total and capture cross section measurements on ^{93}Nb performed in 1975, has been finished. The analysis of scattering cross section data is in progress. A paper describing this work was presented at the International Conference on the Interactions of Neutrons with Nuclei, Lowell, USA, July, 1976.

Resonance Parameters of ^{91}Zr

A. Brusegan, F. Corvi, G. Rohr, T. van der Veen

Spin and parity assignments

Low and high energy γ rays from resonance neutron capture in an enriched sample of ^{91}Zr have been measured with a Ge(Li)detector for neutron energies less than 3.2 keV. The low-level population method was applied by calculating the intensity ratios between the 561 keV and the 934 keV transitions. By combining such results with the observation of primary γ rays, spins and parities listed in Table 2.1 were deduced. Some assignments are in conflicts with those reported in BNL 325, Third Edition, Vol. I (1973).

Neutron and gamma widths

Capture and self indication data obtained with an enriched ^{91}Zr sample have been analysed up to 6.6. keV with the area method. The results will be combined with transmission data from CNEN, Bologna in order to obtain the final parameters. It is planned to extend the analysis up to about 15 keV.

Table 2.1. Spin and parity of some ^{91}Zr neutron resonances

E_n(eV)	J^{π}	E_n(eV)	J^{π}
182	3^+	1954	3^-
240	2^-	1998	$4^-(3^-)$
293	2^+	2012	2^-
449	3^-	2384	3^-
682	2^+	2756 b)	1^-
893	4^-	3158	4^-
1533 a)	2^+		

a) probably double

b) overlapped with the 2762 eV resonance

Resonance Neutron Capture γ Rays in ^{177}Hf

F. Corvi and M. Stefanon[x]

A paper with this title has been accepted for publication in Nuclear Physics.

The abstract is as follows :

"Primary capture γ-rays have been studied for 38 ^{177}Hf neutron resonances with energies

x Comitato Nazionale per l'Energia Nucleare, Bologna, Italy.

in the range 1-165 eV. Intensities were measured for 29 transitions ending at states with an excitation energy in ^{178}Hf up to 2050 keV. The analysis was facilitated by the previous knowledge of the spin and parity of all neutron resonances and of most low-lying states. For 9 final levels, which had not previously been seen, information on J and π was deduced from the corresponding average intensities. The distribution of partial widths was fitted with a χ^2 function with $\nu = 1.38^{+0.18}_{-0.13}$ degrees of freedom for E1 radiation and $\nu = 1.15^{+060}_{-040}$ for M1 radiation. The average E1 reduced photon strength was found to be $\bar{S}_{E1} = \langle \Gamma_{\gamma ij}/DE_\gamma^5 \rangle A^{-8/3} = (4.8 \pm 1.0) \times 10^{-15}$ MeV^{-5} and the ratio between E1 and M1 intensities equal to 5.5 ± 1.4. A comparison of this value for the E1 strength with those reported for other nuclei with A $\geq$100 showed that the intensities follow the A-dependence predicted by the Brink-Axel model. A non-statistical effect was observed, consisting of an enhancement of E1 transition probabilities to K = 2, 3 final states as compared to K = 0, 4 states."

Resonance Parameters of ^{127}I

G. Rohr, R. Shelley, A. Brusegan

The results of measurements on ^{127}I were presented at the International Conference on the Interactions of Neutrons with Nuclei, Lowell, 1976. The abstract is as follows :
"A series of capture, selfindication and transmission measurements have been carried out at a 60 m flightpath using PbI_2 samples and a pair of C_6F_6 detectors, within the energy range 20 eV - 5 keV. For the capture cross section data the pulse height weighting method proposed by Maier-Leibnitz was used. Absolute normalisation of the capture cross section was obtained by the saturated resonance technique using Ag resonances. For the total cross section and the flux measurements the capture sample was replaced by a ^{10}B slab.

The area analysis of the experimental data has been done with a modified TACASI area programme which includes corrections for Doppler and resolution effects. The influence of multiple scattering on the capture area is taken into account by means of a Monte Carlo programme.

For a number of resonances in the 20 eV - 900 eV energy range, the transmission data have been analysed using the Atta-Harvey programme for comparison. In total, the Γ_n values of approximately 200 resonances have been obtained between 20 eV and 2 keV.

For broad resonances ($\Gamma_n > \Gamma_\gamma$), $2g\Gamma_\gamma$ has been determined. These values tend to fall into two groups, indicating that the Γ_γ is possibly independent of the spin. The average value is $2g\Gamma_\gamma = (86 \pm 10)$meV, which is considerably smaller than the value of 130meV indicated from systematics (H. Weigmann and G. Rohr, Nuclear Physics with Thermal and Resonance Energy Neutrons, Petten 1973, Reactor Centrum Nederland Report RCN-203, p. 194).

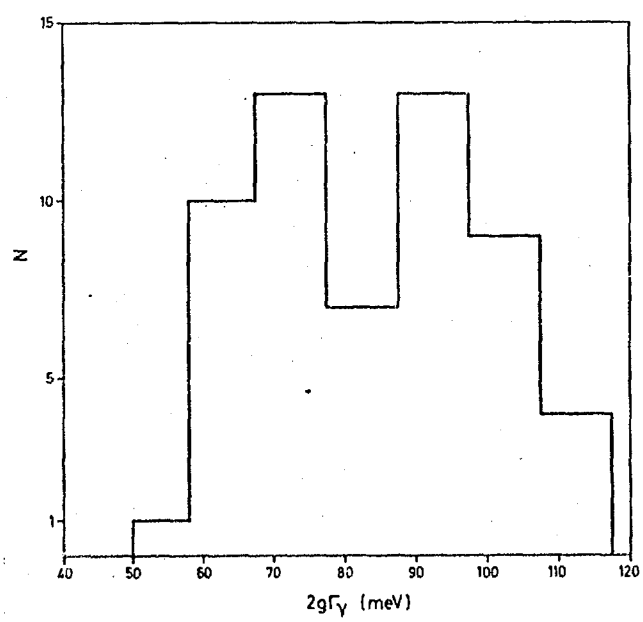


Fig.2.2 Distribution of $2g\Gamma_\gamma$-values obtained for ^{127}I+n resonances.

The capture data, measured with C_6F_6 detectors, have been used for parity assignment of the resonances by comparing the resonance areas of a time-of-flight spectrum taken with a high and with a low amplitude bias. Values for the s- and p-wave strength function will be given and compared with the predictions of the optical model."

The distribution of in total 57 $2g\Gamma_\gamma$ values is shown in Fig. 2.2. The present data have been taken into account in the re-evaluation of ^{127}I cross sections performed by H. Gruppelaar, Reactor Centrum Nederland, Petten.

Possible Intermediate Substructure Observed in the Mass Region of the 4s-Resonance

G. Rohr

A paper with this title was presented at the International Conference on the Interactions of Neutrons with Nuclei, Lowell, 1976. The abstract is as follows :

"The spin and energy dependence of the neutron strength function of ^{177}Hf have been studied elsewhere (G. Rohr and H. Weigmann, Nucl. Phys. A 264, 93 (1976)). There we reported a strong energy dependence of the strength function for $J = 4^-$ resonances. In the energy range 0 - 100 eV the stength function is more than three times as large as the corresponding value for the range 100 - 300 eV. The error bars of the two values do not overlap even if the error limits refer to a 99% confidence interval. Furthermore, we have shown that statistical tests for intermediate structure give positive results to a significance level of 99%, due to two groups of strong resonances at about 5 eV and 65 eV neutron energy.

In ^{144}Nd we observed an anticorrelation of primary transitions to one- and two-phonon states in the energy range 0 - 450 eV for 3^- resonances (G. Rohr and H.Weigmann, 2nd Intern. Symp. on Neutron Capture Gamma Ray Spectroscopy and Related Topics, Petten, 1974, Reactor Centrum Nederland, Petten, p. 306). In the same energy range we observed for the target nucleus ^{143}Nd a strength function which is more than a factor three larger than the corresponding value in the range 450 - 1220 eV. A plot for the reduced neutron widths versus the neutron energy shows a bump in the lower energy range. Tests for intermediate structures are positive at a significance level of > 96%.

The very narrow structures observed in ^{177}Hf and ^{143}Nd may be interpreted as intermediate structures caused at a higher hierarchy level of the nuclear compound process as suggested by Block and Feshbach (Ann. Phys. 23, 47 (1963)). The possibility that the spreading width becomes smaller at the end of the compound process will be discussed. For both isotopes the 4s-single particle is expected at the neutron threshold energy."

Fission Cross Section and Neutron Multiplicity of ^{239}Pu

R. Barthélémy, C. Wagemans[x], J.A. Wartena, H. Weigmann

Measurements of the ^{239}Pu fission cross section (relative to ^{235}U fission) and of the relative neutron multiplicity were made in 1975. The analysis of these data in the neutron energy range from 10 eV to about 50 keV is in progress. The measurements, particularly of the fission cross section via fragment detection with large area surface barrier detectors, will be continued when the Linac is operational again.

---

x Nationaal Fonds voor Wetenschappelijk Onderzoek, Brussels, Belgium

Fission Fragment Kinetic Energy and Mass Distribution for the Neutron Induced Fission of ^{235}U

R. Barthélémy, C. Wagemans[xxx], G. Wegener-Penning[x], H. Weigmann

The analysis of the first series of measurements made in 1974, has been completed. A paper describing the details of the experimental set-up is being prepared.

Neutron Interactions with ^{100}Mo

H. Weigmann, S. Raman[xx], G.G. Slaughter[xx], J.A. Harvey[xx], R.L. Macklin[xx] and J. Halperin[xx]

This work was performed at Oak Ridge National Laboraty, Oak Ridge, Tenn., U.S.A.

Neutron capture in the isotopes ^{92}Mo and ^{98}Mo is known to be dominated by the "valence capture" mechanism. Among the observations related to valence capture there are strong correlations between reduced neutron widths of p-wave resonances and partial radiation widths to final states with large (d,p) spectroscopic factors such as the ground state. The nuclide ^{100}Mo was considered another candidate for valence capture, particularly because a strong concentration of p-wave strength occurs between 1 and 2.5 keV neutron energy. Therefore, neutron capture γ-ray spectra were measured in separated resonances of ^{100}Mo. As neutron widths given in the literature for the resonances in question are strongly discrepant, a transmission measurement was also performed to redetermine neutron widths. Simultaneously total capture data, measured earlier with the ORELA neutron capture cross section measurement facility, were analysed.

The capture γ-ray spectra were measured with a 40 cm^3 Ge(Li) detector, using a 10.2 m flight path for neutron time-of-flight spectroscopy. Capture γ-ray spectra have been obtained for individual resonances up to about 5 keV neutron energy. The transmission measurement was performed at an 80 m flight path and resonance analysis is being done up to about 25 keV.

Although analysis of the data is still in progress, two main results can already be given: (1) The neutron widths of the strong p-wave resonances between 1 and 2.5 keV neutron energy are considerably (up to a factor of three) smaller than those given in BNL-325, Third Edition, Vol. I (1973). This reduces the probability that valence capture dominates and may in part explain the second observation; (2) Valence capture does not play a dominant role in these resonances : For instance, a transition to the ground state of ^{101}Mo (spectroscopic factor 0.42) is not observed in three of the four strongest p-wave resonances.

Neutron Interaction with Mg Isotopes

H. Weigmann, R.L. Macklin[xx] and J.A. Harvey[xx]

This work has been performed at Oak Ridge National Laboratory, Oak Ridge, Tenn., U.S.A.

Resonance neutron capture and transmission by the stable isotopes of magnesium were measured at the Oak Ridge Electron Linear Accelerator time-of-flight facility; capture by separated isotope and natural metal samples at 40 meters, transmission by a natural metal sample (78.7% ^{24}Mg) at 200 meters. Twenty-six resonances in ^{24}Mg + n up to 1.8 MeV were fitted

---

x S.C.K.-C.E.N., Mol, Belgium

xx Oak Ridge National Laboratory, Oak Ridge, Tenn., U.S.A.

xxx Nationaal Fonds voor Wetenschappelijk Onderzoek, Brussel, Belgium with R-matrix parameters. The data were sufficient to assign spin and parity to 19 of these. The capture data were analysed up to 850 keV for $^{24}Mg + n$, 265 keV for $^{25}Mg + n$ (17 resonances), and 440 keV for $^{26}Mg + n$ (4 resonances).

Average capture at stellar interior temperatures was calculated. In the system $^{24}Mg + n$, three T = 3/2 levels, the isobaric analogues of the ground state and the first two excited states of ^{25}Na, are observed as neutron resonances. To our knowledge, this is the first time that a $T = T_z + 1$ state was observed in a neutron induced reaction. As is well-known, the neutron decay of analogue states is isospin forbidden and can proceed only via isospin impurities. Thus, the present measurement of the neutron widths of the three T = 3/2 levels may be used to obtain information on the isospin purity of highly excited states in ^{25}Mg.

Three other $^{24}Mg + n$ resonances exhibit reduced neutron widths, each several percent of the Wigner limit, which may be understood in terms of simple shell model configurations.
A paper describing this work in detail was published in Phys. Rev. C 14, 1328 (1976).

3. STANDARD NEUTRON CROSS SECTION DATA AND RELATED INVESTIGATIONS

Neutron Total and Elastic Scattering Cross Sections of ^6Li in the Energy Range from 0.1 to 3.0 MeV

H.-H. Knitter, C. Budtz-Jørgensen, M. Mailly, R. Vogt

The analysis of the measured total neutron cross section of ^6Li in the primary neutron energy range from 80 keV to 3.0 MeV, and of the differential elastic neutron scattering cross sections measured in the neutron energy range from 220 keV to 3.0 MeV has been completed.

Least squares fits to the angular distributions with a Legendre polynomial expansion yielded the integrated elastic neutron scattering cross sections of ^6Li and the Legendre coefficients B1 to B4.

A simultaneous fit to the total and angle integrated scattering cross sections was made by using the single level Breit-Wigner formula plus linear background terms. The $1/\sqrt{E}$ dependence of the (n,t) cross section was also included.

$$\sigma_{tot} = a_1 + a_2 E + \frac{0.14956}{\sqrt{E}} + \frac{\pi \lambda\!\!\!^{-2}(2J_0+1)}{(2i+1)(2I+1)} \cdot \frac{\Gamma_n^{\ 2} + \Gamma_n \Gamma_\alpha}{(E_0+\Delta-E)^2 + {}^1/_4\,(\Gamma_n+\Gamma_\alpha)^2}$$

$$\sigma_{n,n} = a_3 + a_4 E + \frac{\pi \lambda\!\!\!^{-2}(2J_0+1)}{(2i+1)(2I+1)} \cdot \frac{\Gamma_n^{\ 2}}{(E_0+\Delta-E)^2 + {}^1/_4\,(\Gamma_n+\Gamma_\alpha)^2}$$

The following numerical results were obtained :

a_1	=	(0.616 ± 0.020)b	a_2	=	(0.209 ± 0.015)b	MeV^{-1}
a_3	=	(0.631 ± 0.049)b	a_4	=	(0.090 ± 0.048)b	MeV^{-1}
γ_n^2	=	(1.082 ± 0.017)MeV	Γ_α	=	(0.0357 ± 0.0015)	MeV
E_0	=	(0.2502 ± 0.07)MeV				

The maximum of the total cross section appears at the incident neutron energy of (247 ± 3)keV and has a value of (11.27 ± 0.12)b.

The $^6Li(n,t)^4He$ cross section was calculated by means of the relation $\sigma_{n,t} = \sigma_{tot} - \sigma_{n,n}$. The upper and lower limit for the $^6Li(n,t)^4He$ cross sections determined from the above parameters and their error propagation are shown as the two full lines in Fig.3.1, where a comparison with direct measurements of the (n,t) cross section is given.

This has been found to agree very well with the most recent measurement of G.P. Lamaze et al., as presented at the International Conference on the Interactions of Neutrons with Nuclei, Lowell, U.S.A., July, Paper P.B.1/F3.

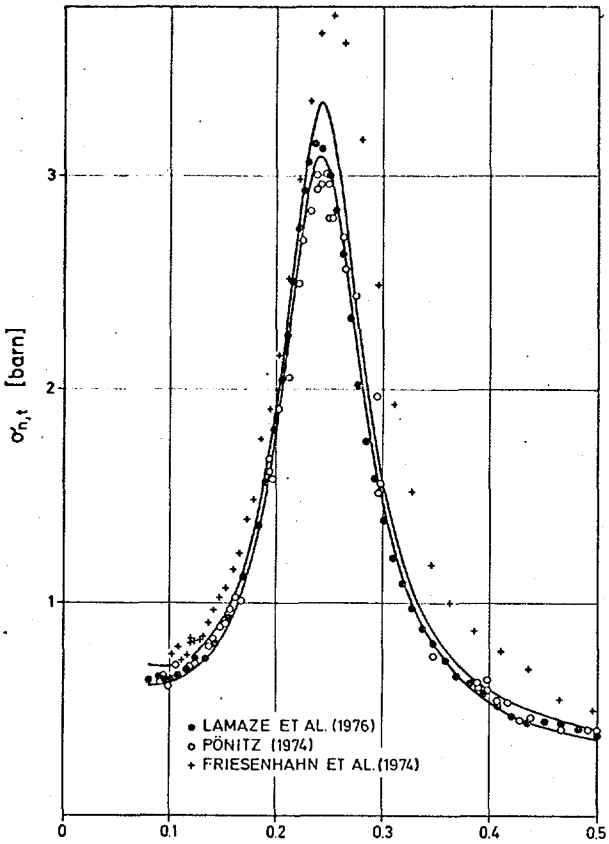


Fig.3.1 Comparison of recent $^{6}Li(n,t)\alpha$ cross section measurements with the present data obtained from the fit.

Determination of the Energy Dependence of the Reaction $^{10}B(n,\alpha\gamma)^{7}Li^{x}$ in the 0.1 to 2.0 MeV Range

H. Liskien, R. Widera

This information is needed for the application of "boron-slab" detectors. Measurements are planned relative to the known angular distributions of the source reactions $^{7}Li(p,n)$ and T(p,n) (Nucl. Data Tables 11, 569 (1973); Atomic Data and Nuclear Data Tables 15, 57 (1975)). Adaptations have been made with the pivot system and a collimator, used in the past mainly for the determination of differential scattering cross sections. Tests in which B_4C has been observed by a 6 cm^3 Ge(Li) detector demonstrated that time-of-flight discrimination against events from spurious neutrons of degraded energy was indispensable. A two-parameter (γ-energy, neutron time-of-flight) experiment has been prepared.

Measurement of the $^{6}Li(n,\alpha)/^{10}B(n,\alpha)$Ratio

C. Bastian, G. Le Dez

The α particles of both reactions are detected by the scintillation in xenon gas. The scintillator, its purification loop and the associated electronics have been tested in a provisory tank. The time resolution is 2ns. The definitive tank includes a sample changer working in xenon atmosphere. It has been assembled and tested.

Measurement of the Fission Cross Section of ^{235}U in the Energy Region from 5eV to 30 keV

R. Barthélémy, J. Van Gils, C. Wagemans[x]

A paper was accepted for publication in Ann. Nucl. Energy with the following abstract :
"The neutron induced fission cross section of ^{235}U was measured up to 30 keV at a 30 m flight path of the CBNM Linac. The fission reaction rate and the neutron flux were determined simultaneously with surface barrier detectors placed on each side of back-to-back ^{235}U and ^{10}B layers. The fission cross section was deduced by assuming a 1/v behaviour of the $^{10}B(n,\alpha)^{7}Li$ cross section and normalized to $\int_{7.8eV}^{11\ eV} \sigma_f(E)dE$ = 240 barn.eV. The average fission cross section was calculated in several energy regions and compared with other results. The fission intergral $\int_{1\ eV}^{1keV} \sigma_f(E)dE$ was also calculated, yielding 16.16 barn keV; for the epicadmium dilute resonance integral we obtained I_f = (280 $\pm$ 7)barn."

---

x "Nationaal Fonds voor Wetenschappelijk Onderzoek" Ghent State University and SCK-CEN Mol

Determination of the Fission Cross Section of ^{233}U from 2meV to 0.15 eV and its Reference Value at 2200 m/s

R. Buyl, J. Van Gils, E. Wattecamps

To improve the statistical accuracy of fission cross section measurements at the chopper facility of the BR-2 reactor a new detection system consisting of five surface barrier detectors has been designed, built and tested. This improvement, and the increase of the beam flux in the tangential beam hole T 7 by a factor of two, have allowed to complete a measurement run of two ^{235}U and two ^{10}B samples in a single BR-2 cycle of 21 days. The recently developed computer code "ANGELA" (Sec.8) has been used and adapted to analyse the data properly. For the test case of ^{235}U, the accuracy achieved so far is about 1% and will be improved by measuring over a longer period, and by the use of surface-barrier detectors with better pulse height resolution.

Measurement of σ_f for ^{235}U, ^{233}U, ^{239}Pu, ^{241}Pu below 10 meV for Accurate g_f Determination

J. Van Gils, C. Wagemans[x], E. Wattecamps

The largest contribution to the uncertainty on the Westcott g_f-factor is due to the poor knowledge of the fission cross section shape below 10meV. Therefore fission cross section measurements have been performed with the crystal spectrometer at a radial beam of the BR-2 reactor. At each of the energies 1.66 meV, 4.75 meV, 12 meV and 80 meV samples of ^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu have been irradiated successively. A sample of LiF was used for flux calibration. Fission fragments or αparticles, escaping from the back to back samples, were detected by surface barrier detectors placed outside the beam on both sides of the samples. A first run involving four energies and four samples has demonstrated the feasibility of the experiment, but some additional runs are planned to reduce systematic errors in positioning the samples, and to improve the statistical accuracy.

Monte Carlo Simulation of Cross Section Fluctuations for the Standard Reactions $^{197}Au(n,\gamma)$ and $^{235}U(n,f)$

H. Liskien and H. Weigmann

The applicability of the reactions $^{197}Au(n,\gamma)$ and $^{235}U(n,f)$ as cross section standards is limited because of the fluctuations present in these cross sections due to resonance parameter statistics. In order to study this problem quantitatively, the cross sections and their fluctuations have been determined by Monte Carlo sampling of resonance sequences. The resulting cross section fluctuations are used to determine the minimum width of the averaging interval necessary to keep errors due to fluctuations of the standard cross section at a prescribed level. A letter to the editor has been accepted for publication in Ann. Nucl. Energy.

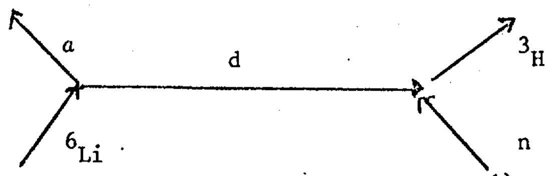
The 1/v Part of the $^{6}Li(n,t)^{4}He$ Cross Section

H. Weigmann

In R- and S-matrix theories the large 1/v cross section of the $^{6}Li(n,t)^{4}He$ reaction is either

---

x "Nationaal Fonds voor Wetenschappelijk Onderzoek", Ghent State University and SCK-CEN Mol assumed to be due to distant levels of positive parity, or treated as an empirical background amplitude. However, the α+d cluster nature of the ^{6}Li ground state suggests its interpretation as a d-exchange process according to the following graph :



The cross section for this graph may be written as [1] :

$$\frac{d\sigma}{d\Omega} = \frac{\hbar^2 c^2}{4\pi} m_{n,Li}\; m_{\alpha,t} \frac{(2J_\alpha+1)(2J_t+1)}{(2J_n+1)(2J_{Li}+1)} \frac{P_t}{P_n} |A|^2$$

with

$$m_{a,b} = \frac{m_a m_b}{m_a+m_b} \qquad A = \frac{g_{Li-\alpha d}\, g_{t-dn}}{\vec{P}_d^{\,2} - 2m_d E_d}$$

and[2]

$$g^2_{Li-\alpha d} = C^2(Li-\alpha d) \frac{m_{Li}}{m_\alpha} \sqrt{2\frac{B(Li-\alpha d)}{m_{\alpha,d}c^2}}$$

and corrsspondingly for g^2_{t-dn}. Here, $B(Li-\alpha d) = 1.471$ MeV is the separation energy of ^{6}Li into α and d. The momentum transfer $\vec{P}_d$ and E_d are determined by the prerequisite that momentum and energy be conserved at both vertices; at very low neutron energies (1/v part of the cross section) the propagator may be approximated as

$$\vec{P}_d^{\,2} - 2m_d E_d = 2(m_t - m_d)E_t + 2m_d B(t-dn)$$

C^2 (Li-αd)is the normalization of the asymptotic α+d cluster wave function, and can be obtained from related reactions like α-^{6}Li scattering.
With $C^2(Li-\alpha d) = 4.4$ [3] and $C^2(t-dn) = 3.4$ [4]
one obtains from the above equations

$$4\pi \frac{d\sigma}{d\Omega} = 158 \;\; b\sqrt{eV} \;\; \frac{1}{\sqrt{E_n^{lab}}}$$

in excellent agreement with the experimental results.
The angular distribution [5], however, is not reproduced by the pure d-exchange graph, not even at very low neutron energies. Presumably the interference of the d-exchange with the p-wave resonance amplitudes has to be taken into account for an accurate description of the angular distribution. This improved model will be studied in collaboration with the Institut für Kernphysik, Technische Hochschule Darmstadt.

1) I.S. Shapiro, Nucl. Phys. 28, 244 (1961).
2) G.R. Plattner, M. Bornand and K. Alder, Phys. Lett. 61B, 21 (1976).
3) T.K. Lim, Phys. Lett. 56B, 321 (1975).
4) T.K. Lim, Phys. Rev. Lett. 30, 709 (1973).
5) J.A. Harvey, private communication.

Status Reviews

Neutron standards and their application

H. Liskien

An invited paper has been presented at the International Conference on Interactions of Neutrons with Nuclei, Lowell, July, 1976 with the following reduced abstract : Work has been concentrated on the improvement of absolute cross sections(the so-called "standard" reactions)and further work has been performed for other reactions, very often relative to these cross section standards. Each of these standards reactions has to meet the following requirements : (a) large and accurately known cross section, (b) cross section slowly varying with neutron energy, (c) availability of a neutron detector based on that reaction having interesting properties such as stability, fast timing, γ-discrimination, etc. At present the following six reactions are regarded as cross section standards : H(n,n), ^{6}Li(n,t), ^{10}B(n,α), ^{12}C(n,n), ^{197}Au(n,γ), ^{235}U(n,f). In addition to these neutron cross section standards the introduction of neutron energy standards and of a standard neutron spectrum has also been found useful.

The present status of neutron standards is discussed with respect to the necessary data, to the relevant neutron detectors and to target materials.

Standard fission neutron spectra of ^{235}U and ^{252}Cf

H.-H. Knitter

On demand of the nuclear data section of the International Atomic Energy Agency a status report on "Standard Fission Neutron Spectra of ^{235}U and ^{252}Cf" was presented at the IAEA Consultants'Meeting on Integral Cross Section Measurements in Standard Neutron Fields for Reactor Dosimetry, Vienna, November 1976.

Cross section data for ^{10}B(n,α)^{7}Li

E. Wattecamps

A status report was submitted to the 19th NEANDC meeting held at Stockholm, Sept. 1976. Comparative graphs and renormalisations of all available experimental and evaluated data have been made with the help of the recently developed computer code "ANGELA".

4. NON-NEUTRON NUCLEAR AND ATOMIC DATA

Half-Lives of Actinides

Determination of the half-live of ^{233}U

R. Vaninbroukx, P. De Bièvre, Y. Le Duigou, V. Verdingh

This work has been finished and its results were published in Phys. Rev. C 13, 315 (1976) with the following abstract : "Combining different methods, all based on the measurement of the specific activity of a large number of samples from two different batches of uranium oxides, both enriched to nearly 100% ^{233}U, a new determination of the half-life of ^{233}U was made. The activities of the samples were determined by α counting techniques : low geometry, liquid scintillation, and 4π-proportional counting. The uranium content of the samples was determined by mass spectrometric isotope dilution techniques and by controlled potential coulometry. The half-life was measured as $(1.5925 \pm 0.0010) \times 10^5$ yr. The uncertainty quoted is the over-all uncertainty at the 99.7% confidence level, taking into account both statistical and systematic effects. This result is in close agreement with the value published recently by A.H. Jaffey et al., Phys. Rev. C 9, 1991 (1974), and with the new recommended value, evaluated by H.D. Lemmel, Proceedings of the Conference on Nuclear Cross Sections and Technology, Washington, March 1975, Paper EA 2.

Determination of the half-life of ^{241}Pu

R. Vaninbroukx, G. Bortels, J. Broothaerts, P. De Bièvre, B. Denecke, M. Gallet, G. Grosse, W. Zehner

A new determination of the half-life of ^{241}Pu is in progress at CBNM. This is an attempt to resolve the existing discrepancy of about 7% between the reported values as obtained by a direct measurement of the ^{241}Pu decay using mass spectrometric techniques and those values as obtained by the ^{241}Am-growth method using α- and γ-counting techniques.

Fractions of a Pu master sample were used which initially (19 January 1976) contained 0.009% ^{238}Pu, 1.150% ^{239}Pu, 4.053% ^{240}Pu, 92.727% ^{241}Pu, and 2.061% ^{242}Pu. The ^{241}Pu content of the sample at the date of the separation, was determined by isotope dilution mass spectrometry with an overall uncertainty of 0.2%. The following methods have been applied :

(a) Mass spectrometric determination of the ^{241}Pu decay by measurements of the change in the $^{241}Pu/^{240}Pu$ ratio and the $(^{241}Pu/^{240}Pu)/(^{240}Pu/^{239}Pu)$ ratio of ratios as a funtion of time;
(b) Measurement of the ^{241}Am ingrowth both by α counting in a defined low geometry solid angle, and by γ counting using Si(Li) detectors, calibrated for the 60 keV line of ^{241}Am.

For the mass spectrometric method the $^{241}Pu/^{240}Pu$ ratios and the $(^{241}Pu/^{240}Pu)/(^{240}Pu/^{239}Pu)$ ratios were measured twice with an interval of about 10 months. Before each measurement the ^{241}Am grown into the sample was separated from the Pu using ion exchange techniques. The overall uncertainty of the half-life value observed is still 3%, mainly because of the short time period covered. The preliminary results are between 14.3 years and 14.9 years for the ratio method and between 14.2 years and 14.8 years for the ratio of ratios method. Continuation of the measurements over a much longer period will improve the accuracy.

In the case of α couting a correction had to be applied for the contribution of the other Pu isotopes in the sample including the small α branch of ^{241}Pu. Typical values for this contribution are 100% at the date of the separation, 50% one month and 10% ten months after the separation. In the case of γ counting a correction had to be applied for the contribution of ^{237}U, growing into the sample from the α branch of ^{241}Pu. Typical values for this contribution are : 35% at the separation, 15% one month and 2% ten months after the separation. The preliminary result of the half-life obtained with both counting methods is (14.7 $\pm$ 0.2) years. The uncertainty quoted is the maximum spread of the results.

Half-life of ^{239}Pu

R. Vaninbroukx

On behalf of the NEANDC the status file on the half-life of ^{239}Pu was updated .
Two new but still preliminary values became available in 1976. The convergence of all the results reported since 1971 and obtained by different methods suggests that very probably a reliable value for this half-life can be recommended in the near future. Until the final results of several ongoing measurements are available the use of the following value is suggested :

$$T_{1/2}(^{239}\text{Pu}) = (2.411 \pm 0.010) \times 10^4 \text{ years.}$$

Half-Lives of other Nuclides

The half-lifes of ^{58}Co, ^{60}Co, ^{139}Ce, and ^{141}Ce

R. Vaninbroukx, G. Grosse

This work has been finished and a paper describing summarily the measurements and their results has been accepted for publication as a Technical Note in Int. J. Appl. Radiat. Isotopes. The results are given in Table 4.1. The uncertainties quoted are overall uncertainties at the 99.7% confidence level, both random and systematic effects having been taken into account.

Table 4.1. Half-lives of ^{58}Co, ^{60}Co, ^{139}Ce, ^{141}Ce

Nuclides	Half-lives
^{58}Co	(70.81 $\pm$ 0.10)d
^{60}Co	(5.283 $\pm$ 0.008)a
^{139}Ce	(137.66$\pm$ 0.13)d
^{141}Ce	(32.50 $\pm$ 0.04)d

Determination of the half-lives of ^{95}Zr and ^{95}Nb

H.H. Hansen, G. Grosse, D. Mouchel, R. Vaninbroukx

The work on this subject has been completed and a paper was published in Z. Physik A 278, 317 (1976) with the following abstract : "The half-lives of ^{95}Zr and ^{95}Nb have been determined by γ-ray counting with the aid of a Ge(Li) detector and a NaI(Tl) crystal. Data were recorded at regular time intervals during time periods up to nine times the respective half-life. The results obtained are $T_{1/2}(^{95}\text{Zr})$ = (64.05 $\pm$ 0.06) days and $T_{1/2}(^{95}\text{Nb})$ = (34.97 $\pm$ 0.03) days. A detailed discussion of the measurements and the uncertainty assignment is given."

Study of Decay Scheme Parameters

Internal conversion data for the 165.8 keV transition in ^{139}La

H.H. Hansen, D. Mouchel

The results of this investigation were published in Z. Physik A 276, 303 (1976) with the following abstract : "The internal conversion process of the 165.8 keV γ-ray transition in the decay of ^{139}Ce has been reinvestigated. The emission rate of the K-shell internal conversion electrons was determined by an (electron)-(X-ray)-(X-ray) triple coincidence experiment using a magnetic β-spectrometer and two Si(Li) detectors. From electron spectra, recorded as a function of momentum, conversion electron ratios were also determined. The disintegration rate of the sources has been obtained by $4\pi\beta$-γ coincidence experiments. The following results were obtained : the probability for internal conversion in the K-shell $a_K = 0.1719 \pm 0.0020$ and the conversion ratios $K/(L+M+...) = 5.84 \pm 0.17$, $K/L = 7.45 \pm 0.20$, and $L/(M+...) = 3.63 \pm 0.29$. The internal conversion coefficients deduced are $\alpha = (0.2520 \pm 0.0050)$, $\alpha_K = (0.2152 \pm 0.0033)$, and $\alpha_L = (0.0289 \pm 0.0012)$. The results are well in agreement with previous experimental values and with theoretical data calculated for a M1 transition of 165.8 keV in ^{139}La."

The decay of ^{133}Ba

H.H. Hansen, D. Mouchel

The work for a careful redetermination of decay scheme parameters of ^{133}Ba has been started. Existing experimental results have been compiled as a basis for the studies to be planned. Especially the available experimental results on the electron-capture branchings, on the intensities of the γ rays and the internal conversion electrons, and on conversion coefficients are very inconsistent. First measurements on the relative intensities of the γ rays and internal conversion electrons were performed with a Ge(Li) detector and a magnetic β-ray spectrometer, respectively.

Studies on the decay of ^{141}Ce

H.H. Hansen, D. Mouchel

Preparatory measurements of the continuous β^--spectra and the internal conversion electrons following the ^{141}Ce decay were performed with a magnetic β-ray spectrometer. Before starting the coincidence experiments for the determination of the internal conversion probability a fast electronic chain had been installed.

Studies on the decay of $^{93}Nb^m$ and ^{93}Mo

D. Reher, W. Bambynek

The reaction $^{93}Nb(n,n')^{93}Nb^m$ is very useful for the determination of fast neutron fluences especially for radiation damage studies of reactor pressure vessels. However, the decay scheme parameters of $^{93}Nb^m$ have to be known more accurately. A feasibility study for the determination of those parameters was made. It has turned out that the half-life, which is known by a factor of two, can be determined within 10% when the decay is followed for only one year. The value of the K conversion probability, the uncertainty of which is about 20%, can be improved to about 5%, and that of the K-shell fluorescence yield of Nb to 4%. These figures can only be obtained, if very pure $^{93}Nb^m$ sources are available, containing the smallest possible quantity of ^{182}Ta.

K-Shell Internal Ionization Probabilities in Nuclear β^- Decay

H.H. Hansen

A paper has been published in Phys. Rev. C 14, 281 (1976) with the following abstract : "Total K-shell internal-ionization probabilities per β^- decay of the isotopes ^{63}Ni, ^{143}Pr, and ^{204}Tl have been determined by X-ray spectroscopy with a high-energy-resolution Si(Li) detector. The number of emitted KX rays was deduced in comparison to the absolute β^--decay rate. The results of $(4.6 \pm 0.4) \times 10^{-4}$ for ^{63}Ni, $(2.92 \pm 0.16) \times 10^{-4}$ for ^{143}Pr, and $(1.12 \pm 0.11) \times 10^{-4}$ for ^{204}Tl are compared with previous experimental values and recent theoretical calculations of J. Law and J.L. Campbell, Nucl. Phys., A 185, 529 (1972). Good agreement is found between this theory and the present experimental results."

Total Photon Interaction Cross Section

H.H. Hansen, K. Parthasaradhi[x]

The study has been accomplished and a paper was published in Z. Physik A 277, 331 (1976) with the following abstract : "Total photon interaction cross sections at 10 energies between 59.6 and 1332.5 keV have been determined for the elements V, Cu, Mo, Sn and U. Measurements were performed with the transmission technique using a high energy resolution Ge(Li) detector in a good geometry arrangement."

Review on Orbital Electron Capture by the Nucleus

W. Bambynek, H. Behrens[xx] M.H. Chen[xxx], B. Crasemann[xxx], M.L. Fitzpatrick[ooo], K.W.D. Ledingham[+], H. Genz[++], M. Mutterer[++], R.L. Intemann[+++]

An extensive survey has been accepted by Rev. Mod. Phys. The abstract is as follows : "The theory of nuclear electron capture is reviewed in the light of current understanding of weak interactions. Experimental methods and results regarding capture probabilities, capture ratios, and EC/β^+ ratios are summarized. Radiative electron capture is discussed, including both theory and experiment. Atomic wave-function overlap and electron exchange effects are covered, as are atomic transitions that accompany nuclear electron capture. Tables are provided to assist the reader in determining quantities of interest for specific cases."

---

x Department of Nuclear Physics, Andhra University, India

xx Zentralstelle für Atomkernenergie-Dokumentation, Karlsruhe, Germany

xxx Department of Physics, University of Oregon, Eugene, U.S.A.

ooo Department of Natural Philosophy, University of Glasgow, Scotland

\+ On sabbatical leave from Department of Natural Philosophy, University of Glasgow, Scotland

++ Institut für Kernphysik, Technische Hochschule, Darmstadt, Germany

+++ Department of Physics, Temple University, Philadelphia, U.S.A.

Compilations

Internal conversion data

H.H. Hansen

Experimental results of internal conversion coefficients and ratios published later than November 1965 for nuclides with $Z \leq 60$ are being compiled. This work is part of a comprehensive compilation for all nuclides performed in collaboration with the Max-Planck-Institut für Physik, Heidelberg and the Zentralstelle für Atomkernenergie-Dokumentation, Karlsruhe.

Isotope abundance and atomic weights of the elements

P. De Bièvre, M. Gallet

Interim values for uniform isotopic compositions of the elements have been submitted to the IUPAC Commission on Atomic Weights. They are part of the commission's report entitled "Atomic Weights of the Elements 1975" which is at press in Pure Appl. Chem.
A survey has been made on "Values and Accuracies of the Atomic Weights of the Elements in the period 1959-1975."

Metrology of Radionuclides

International Intercomparisons

I.W. Goodier[x], R. Vaninbroukx, E. Celen, W. Zehner

Within the framework of intercomparisons, as organized by the Bureau International des Poids et Mesures (BIPM), Paris, determinations of the radioactive concentration of solutions of ^{57}Co and ^{139}Ce have been carried out by means of the $4\pi(AX)$-γ coincidence counting extrapolation technique. The extrapolation to 100% efficiency was performed by a linear fit to the data points. It was proved that a quadratic fit does not improve the result of the extrapolation.

Investigation of count-rate dependent correstions for $4\pi\beta$-γ coincidence counting

R. Vaninbroukx, I.W. Goodier[x], E. Celen

The intercomparison arranged by BIPM, to assess experimentally the validity of approximations made in coincidence counting and to check the range of counting rates to which they are applicable has been continued. Two series of ^{60}Co sources with activities ranging from $2 \times 10^3 s^{-1}$ to $10^5 s^{-1}$ have been measured in 1976. A detailed analysis of the data obtained at the various participating laboratories is in progress at the National Physical Laboratory (NPL), Teddington.

---

x Left CBNM in April 1976, present address : National Physical Laboratory, Teddington, U.K.

Improvements of Techniques to Measure Nuclear and Atomic Radiations

Numerical methods to analyse γ-ray spectra

D. Reher

A computer programme RETEØH for the analysis of Ge(Li) and SI(Li) γ-ray spectra has been written. It is a modified version of a programme described by W. Teoh in Nucl. Instr. Methods 109, 509 (1973). A simple gaussian shape on a straigth line underground or alternatively a gaussian plus an exponential shape on a non-linear underground (complex shape) are fitted to the experimental points. Peaks with a full-width-half-maximum of less than four channels can only be treated with the simple shape technique. If in those cases the complex shape technique has to be used, the spectra must be "stretched" by an interpolation method.

The programme is tested, CBNM participating in two intercomparisons. In the first which is organized by the Department of Research and Isotopes of IAEA, Vienna, nine semi-artificial spectra with about 200 peaks were analysed by the three methods offered by the programme. The evaluation report will be published in spring 1977 by IAEA.

In the second intercomparison, which is organized by the "Arbeitskreis Auswertung von γ-Spektren" of the Kernforschungsanlage (KfA), Jülich, two Ge(Li) spectra, containing about 80 peaks each were analysed in the same way as the IAEA spectra. A report is to be expected at the beginning of next year.

Alpha-ray spectrometry

G. Bortels

The computer code to evaluate α-ray spectra has been tested further by using a series of spectra obtained from Pu sources of gradually increasing thickness (from a few $\mu g/cm^2$ to 1000 $\mu g/cm^2$). For an isotopic composition, which corresponds to a $^{238}Pu/(^{239}Pu + ^{240}Pu)$ activity ratio of about two, the standard deviation of this ratio deduced from a set of five of these spectra was 1.1%. The 1σ uncertainty originating from the counting statistics was already between 0.4% and 0.9%. Measurements are going on to examine the reliability of the code at various activity ratios.

A 4π CsI(Tl) scintillation spectrometer for the detection of low energy photons

K.W.D. Ledingham[x], B. Denecke

A 4π scintillation spectrometer is under development which is genuinely 100% efficient for photons of energies between 20 keV and 130 keV. It consists of two open CsI(Tl) crystals of 5 cm diameter and 2.5 cm thickness. These crystals have a hemisphere ground of 1 cm diameter exactly in the center of the inner side of each crystal.

The source is placed between the two crystals. Measurements on the thickness of possible dead

x On sabbatical leave (until end of August) from the Department of Natural Philosophy, University of Glasgow, Scotland layers indicate that any absorption in the dead layers is certainly less than 0.2% for even low energy (< 20 keV) photons.

Mass determination by α-activity counting

B. Denecke, W. Bambynek

About 150 samples have been measured on request. The activity is determined by counting α particles in a defined solid angle. From the half-lives and the isotopic composition of the sample the mass of the requested nuclide can be deduced. About 100 certificates have been issued.

Radioactive source preparation

W. Oldenhof

A technique is under development to prepare semi-quantitatively radioactive sources of small area by the electrospraying of solutions. Parameters influencing the reproducibility are under study.

5. SAMPLE AND TARGET PREPARATION

Special Preparations

W. Dobma, W. Lycke, J. Mast, H. Mast, M. Parengh, J. Pauwels, F. Peetermans, J. Tjoonk, J. Triffaux, J. Van Audenhove, J. Van Gestel

During 1976 the supply of special samples and targets for CBNM and for outside users has been continued. The total number of samples amounted to about 6000 covering 124 orders. About 56% of these orders are for bulk samples not requiring support on a backing, and used mainly as materials with certified composition in solid state physics and analytical chemistry. These samples are listed in Table 5.1.

Table 5.1. Bulk Samples delivered in 1976

Materials	Applicants See list (a)	Number of Samples	Def. Meth. See list (b)	Prep. Meth. See list (c)
^{237}Np	(55)	6	α count	Solution-Can.
^{238}U	(55) (56)	10	MD	R-C
Al-Co alloys	(4) (55)	4	QA	LM-R
Cu-B alloys	(4)	2	QA	LM-R
Pb-Ag alloys	(55)	18	QA	LM-R
Al-Th alloys	(56)	2	QA	LM-R
Al-U alloys	(56)	2	QA	LM-R
Nb/Mo/W (traces)	(16)(5)	1	QA	LM-R
Nb/Ir/Mo/Hf/Co (traces)	(16)(5)	1	QA	LM-R
V	(57)	20	DC	R-M
Al; Al-Si; Pb Pb-Sn-Cd; Cu Zr; Ti; TA6V W; Zr; Ta; Be	(2)(3)(4)(5)(9) (10) to (41) (49)	3569	DC	M; R;
Na	(3)(34)(42)	74	-	V.C.-Can.
Cu-10ppm Au-1000ppm Ag Cu-50ppm Au-2500ppm Ag Cu-100ppm Au-5000ppm Ag	(17)(3)(18)(2) (31)(19)(5)(33) (11)(4)(22)(32) (9) (43) to (48)	1007	QA	LM; M; R; WD
Zn-ores First series	(11)(60)(33)(58)	86	-	T.T.-Hom.
Zn-ores Reference Materials	(49)	950		- Can.

The remainder consists of very thin samples usually requiring a backing and used mainly as targets for nuclear measurements. For this type of samples a great effort was made in 1976 in order to rationalize the production by improving and extending the existing facilities for vacuum evaporation. Furthermore, a study of quantitative transformation of small amount of $^{239}PuO_2$ in $^{239}PuF_3$ was started in order to supply evaporated $^{239}PuF_3$ targets in the framework of an international cooperation.
The list of samples prepared in 1976 is given in Table 5.2.

Table 5.2. Thin samples delivered in 1976

Layers	Applicants See list (a)	Number of Samples	Def. Meth. See list (b)	Prep. Meth. See list (c)
^{233}U	(1)	5	α count	ES
^{235}U	(2) (3) (4)	25	MD, α count XRF; MSID	ES
^{235}U + Ta	(5)	5	MD; α count	ES + VD
^{236}U	(6) (7) (8)	8	MD; α count	ES
$^{235}U + ^{238}U$	(2)	3 + 3	MD	ES
^{238}U	(1) (2)	5	XRF; MD; MSID	ES
^{232}Th	(3)	3	MD	ES
^{231}Pa	(2)	1	α count	ES
^{237}Np	(2)	2	MD; α count	ES
^{239}Pu	(1) (2)	5	α count	ES
^{240}Pu	(9)	6	α count	ES
^{241}Pu	(2) (6)	2	MD	ES
^{241}Am	(2) (6)	4	MD	ES
$^{241}Am + ^{252}Cf$	(4)	5	α count	ES + ST
^{243}Am	(6)	1	MD	ES
^{6}Li	(2)	1	MD	ES
^{10}B	(2)	17	MD	ES-VD
^{88}Sr	(3)	3	MD	ES
$^{235}UF_4$	(2) (3) (29)	38	MD-IDMS	VD
$^{232}ThF_4$	(2) (29)	13	MD-IDMS	VD
nat. UF_4	(50)	1	MD	VD
$^{235}UO_2$/Ta	(51)	66	MD-IDMS α count	VD
^{6}Li/F	(2)	7	MD-IA	VD
Ta/C	(34)	6	MD	CS
Zr/C	(34)	3	MD	VD
Au	(31)	6	MD	VD
Tristearine	(52)	4	CA	VD
^{252}Cf	(2)(29)(31)(53)(54)	11	α count	ST
Ag, Al, W, Ta, Au, Vyns	(2)	40	DC-MD	VD

(a) List of Applicants

(1) Australian Atomic Energy Commission (AUS)
(2) CBNM, Geel (B)
(3) CEN Saclay (F)
(4) JRC Ispra (I)
(5) KFA Jülich (BRD)
(6) IAEA, Vienna (A)
(7) Universität Bonn (BRD)
(8) Universität Hamburg (BRD)
(9) Gesellschaft für Kernforschung, Karlsruhe (BRD)
(10) Universität Frankfurt (BRD)
(11) BAM, Berlin (BRD)
(12) R. Bosch, Stuttgart (BRD)
(13) Krupp Forschungsinstitut, Essen (BRD)
(14) Staatliches Materialprüfungsamt NR-WF, Dortmund (BRD)
(15) Hüttenwerke Kayser, Lünen (BRD)
(16) Max Planck Institut für Metallforschung, Schwäbisch Gmünd (BRD)
(17) T.U. München (BRD)
(18) CNRS Orléans (F)
(19) CEN Grenoble (F)
(20) E.N.S. Paris (F)
(21) Centre de Recherches Péchiney, Voreppe (F)
(22) Univ. Claude Bernard, Villeurbanne (F)
(23) Ugine Aciers, Ugine (F)
(24) Ugine Carbone, Grenoble (F)
(25) SICN, Veurey (F)
(26) Centre d'Etudes Vallourec, Aulnoye (F)
(27) CEN Fontenay-aux-Roses (F)
(28) CEN Valduc, Is-sur-Tille (F)
(29) CEN Bruyères-le-Châtel, Montrouge (F)
(30) Centre d'Etudes de Chimie Métallurgique, Vitry-sur-Seine (F)
(31) Rijksuniversiteit Gent (B)
(32) Université de Liège (B)
(33) Métallurgique Hoboken-Overpelt (B)
(34) SCK-CEN, Mol (B)
(35) CNR/LTM, Milano (I)
(36) Metallwerk Plansee, Reutte (A)
(37) BNF Metals Technology Centre, Wantage (GB)
(38) National Physical Laboratory, Teddington (GB)
(39) Imperial Metal Industries, Walsall (GB)
(40) Imperial Metal Industries (Kynoch) Ltd., Birmingham (GB)
(41) H. Wiggin and Company Ltd., Hereford (GB)
(42) Ecole de Chimie, Mulhouse (F)
(43) Degusa, Wolfgang
(44) Norddeutsche Affinerie, Hamburg (BRD)
(45) Comptoir Lyon Allemand Louyot (F)
(46) Ugine Kuhlmann (F)
(47) Université de Pavia (I)
(48) Fac. Universitaire de Namur (B)
(49) BCR - DG XII, EEC Brussels (B)
(50) Eidg.Inst.Reaktorforschung (CH)
(51) Inst.Max von Laue - P. Langevin, Grenoble (F)
(52) Physikalisch Technische Bundesanstalt Braunschweig (BRD)
(53) Universität Tübingen (BRD)
(54) Kernforschung Risø (DK)
(55) Westinghouse Europe - Brussels (B)
(56) ECN, Petten (NL)
(57) Universiteit Leuven (B)
(58) Kempische Zinkwitmij., Buedel (NL)
(59) Vieille Montagne, Angleur (B)
(60) Minemet Recherches Trappes (F)

(b) List of Definition Methods

XRF	:	X-ray fluorescence
MD	:	Mass definition
α count.	:	counting of α particles
IDMS	:	Isotope Dilution - Mass Spectrometry
IA	:	Isotope Analysis
DC	:	Dimensional control
QA	:	Quantitative alloying

(c) List of Preparation Methods

ES	:	Electrospraying
VD	:	Vacuum deposition
ST	:	Self transfer
CS	:	Cathodic sputtering
Can.	:	Canning
R	:	Rolling
LM	:	Levitation melting
M	:	Machining
VC	:	Vacuum casting
TT	:	Thermal treatment
Hom.	:	Homogenisation

Preparation of high activity ^{241}Am samples

W. Leidert, H. Silvester, V. Verdingh

In close collaboration with AERE, Harwell, two ^{241}Am samples were prepared for scattering and transmission measurements at the Harwell and CBNM linear accelerator. The base material ≈ 80 Ci ^{241}Am was delivered by AERE, Harwell. According to schedule two samples were produced; they have the following specifications :

- 10 Ci, a Ø 14 mm, thickness of 14 mm;
- 30 Ci, a Ø 50 mm, thickness of 3 mm.

Both samples were prepared by vacuum-canning.
A double containment was used, consisting of a 0.2 mm tin soldered nickel container which was placed in an outer aluminium container of 0.2 mm wall thickness with both O-ring and araldite sealing. The samples were delivered contamination free and were used for neutron measurements in the open air. The containment has proved its endurance as no leakage has been observed after 10 months.

6. ACCELERATORS AND INSTRUMENTATION

Electron Linear Accelerator

Modernisation of the linear accelerator

J.M. Salomé, R. Cools, R. Forni, F. Massardier, F. Menu, R. Pijpstra, P. Siméone, F. Van Reeth, C. Waller

During this year the accelerator has partly been rebuilt in order to improve its characteristics. The new components were delivered from February to April. Essentially these are a 2 m long standing wave bunching section, two travelling wave sections, each 6 m long, an injection system with an 80 kV triode gun, and a 13 MW modulator for long pulses to drive the buncher. The installation was finished by the end of April. The first electron beam reached the target on May 20, 1976. The configuration of the new machine is shown in Fig. 6.1.

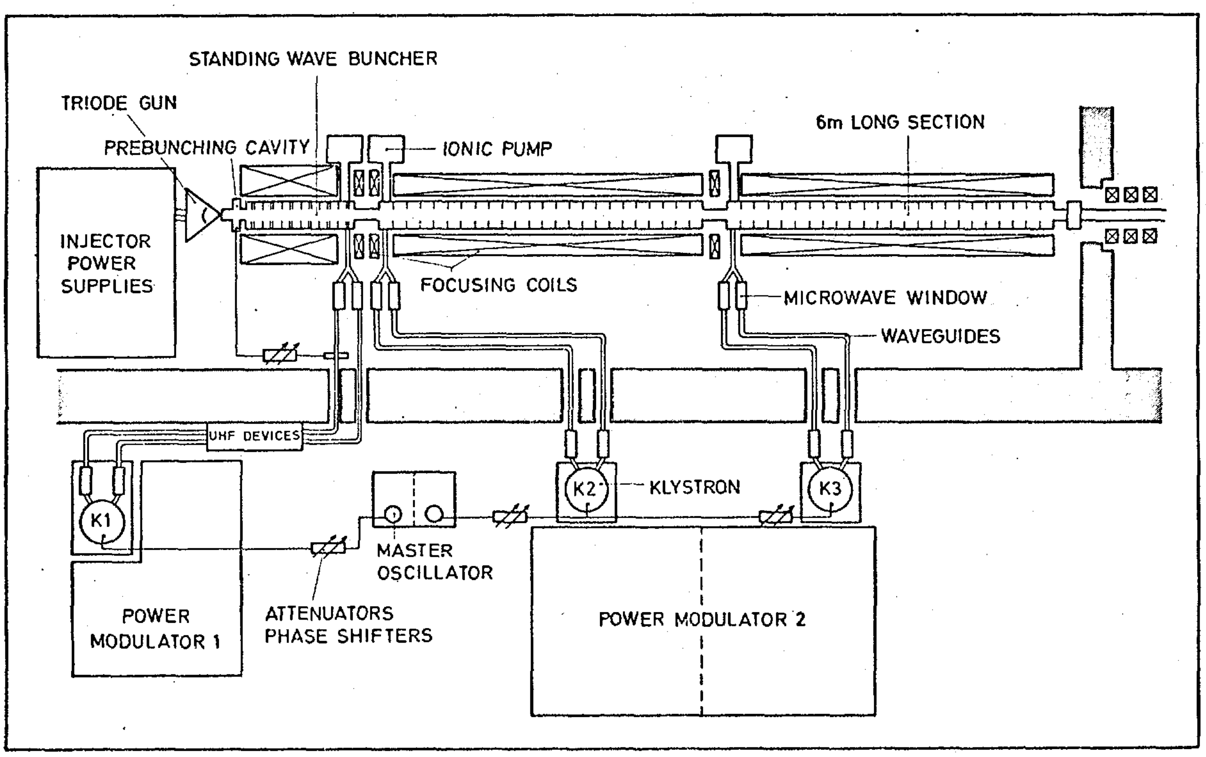


Fig.6.1 Configuration of the new electron linear accelerator.

In June most of the guaranteed machine parameters could be obtained under low pulse repetition rate conditions. A punctual high repetition rate test has successfully delivered 11 kW on the target. However, it was impossible to meet the high peak current specifications in the short pulse width range. It turned out that this deficiency was mainly due to a radial magnetic field component of 3% measured along the axis of the first two meters of the machine where

$0.2\ Wb/m^2$ are used to suppress the space charge effects at high currents. The radial field component could partly be compensated by correction coils. After the additional application of an improved shielding against the residual magnetic field near the cathode, pulses of 5 ns with 10A peak current at 120 MeV were observed.

The contractor CGR-MeV will present the accelerator for the reception tests before the end of 1976. The operation of the Linac for neutron experiments is planned for the beginning of 1977.

A magnetic deflection system was delivered and will be installed in the target room after the reception tests of the Linac. This system will be used to deflect a 20 to 35 MeV electron beam to a platinum target to be used for photon activation analysis experiments.

Development of targets and moderators

J.M. Salomé, J. Wartena, R. Cools, P. Siméone

Two targets are now assembled having the same geometry, a diameter of 30 mm and a mercury cooling system. One consists of natural uranium, the other of natural uranium with an enriched ^{235}U core.

The installation of a lead ring near the target for γ-flash shielding and of beryllium-canned water moderators will be finished by the end of 1976.

A mercury cooled rotary natural uranium target has been designed to dissipate the increased beam power of the modernised Linac (14 kW). The construction will be carried out by CERCA. The cooling system composed of an electromagnetic pump and a mercury-air heat exchanger will rotate together with the target. 2000 A for the pump are supplied by sliding contacts. Target, pump and exchanger are expected to be available in March 1977 and the complete system (Fig. 6.2) by the middle of 1977.

For photon activation analysis experiments a platinum target with improved cooling is under construction.

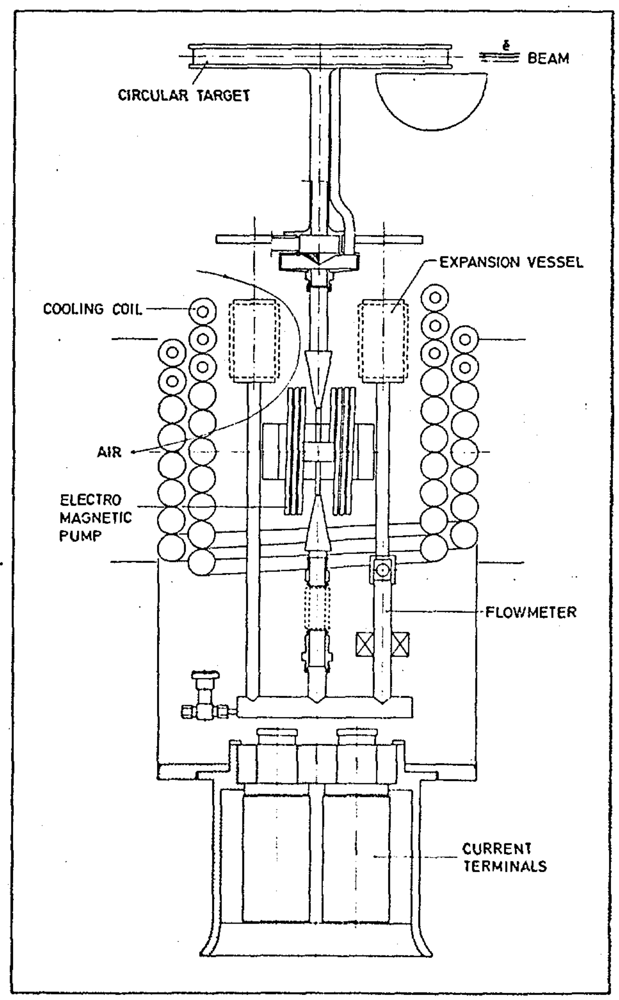


Fig.6.2 Rotary heat exchanger with mercury cooled target

To measure the beam parameters during the reception tests of the Linac, a water cooled coaxial target with a molybdenum core was constructed at CBNM by which pulses with 2 ns rise time can be measured at a beam power level of up to 5 kW.

Van de Graaff Accelerators

Operation and maintenance of the KN - 3.7 MV Van de Graaff Accelerator

A. Crametz, P. Falque, J. Leonard, R. Smets

Due to the installation of the CN-7 MV Van de Graaff Accelerator, the operation time of the KN - 3.7 MV accelerator has considerably been reduced as compared with 1975.

For the first part of the year the accelerator was only in operation for 570 night hours, which are divided in 270 hours for neutron irradiations, 100 hours for Rutherford backscattering, 40 hours for experimental tests and 160 hours for general maintenance. For the second half of the year the accelerator could practically not be operated except for about 25 hours to test experimental equipment. In the future this accelerator will only be operated with a DC or a 10 ns pulsed beam.

The Mobley magnet will be disconnected and the analysing magnet and the beam handling system will be moved to avoid any heavy material in the vicinity of the targets of the CN-7 MV accelerator.

A new study of the beam optics is in preparation.

Installation of the CN-7 MV Van de Graaff Accelerator

A. Crametz, P. Falque, J. Leonard, R. Smets

The upgraded, klystron bunched CN-7 MV accelerator was delivered after a five months delay. The mechanical installation was started in May by the transportation of the 16 ton pressure vessel and the tank base plate through the flat roof of the 29 m high accelerator tower. By the end of July all the accelerator components were assembled and aligned. A three ton crane was installed in the magnets room for the positioning of the analysing and switching magnets and the quadrupole doublet lens. The 0° and 45° beamlines, developed by Van de Graaff staff are ready for use.

In August and September all the vacuum problems for the accelerator tube and the beam handling system could be solved. Under the responsibility of the Van de Graaff Group and the Technical Service of CBNM the following work was completed : the electrical connections, the water and air cooling system, and the insulating gas transfer system. In September the first proton beam was obtained.

In October and November the electrical tests were continued and the beam alignment improved. Tests with DC and pulsed beams up to 5 MeV were completed.
On November 10, 15% of SF_6 were added to the initial insulating N_2 + CO_2 gas mixture in order to reach 7MV. With this new gas mixture the machine has been conditioned for a further 200 hours.

7. SCIENTIFIC PUBLICATIONS OF CBNM IN 1976

Publication in Periodicals

ROHR G. and WEIGMANN H., Short Range Energy Dependence of the Neutron Widths of ^{177}Hf Resonances, Nucl. Phys. A 264, 93 (1976).

WEIGMANN H., MACKLIN R.L. and HARVEY J.A., Isobaric Analog Impurities from Neutron Capture and Transmission by Magnesium, Phys. Rev. C 14, 1328 (1976).

BEER H. and ROHR G., Study of keV-Resonances in the Total Cross Section of ^{63}Cu and ^{65}Cu, Z. Physik A 277, 181 (1976).

WAGEMANS C. and DERUYTTER A., Measurement and Normalisation of the Relative ^{241}Pu Fission Cross Section in the Thermal and Low Resonance Energy Region, Nucl. Sci.Eng. 60, 44 (1976).

VANINBROUKX R., DE BIEVRE P., LE DUIGOU Y., SPERNOL A., VAN DER EIJK W. and VERDINGH V., New Determination of the Half-Life of ^{233}U, Phys. Rev. C 13, 315 (1976).

HANSEN H.H. and MOUCHEL D., Internal Conversion Coefficient for the 165.8 keV Transition in ^{139}La, Z. Physik A 276, 303 (1976).

HANSEN H.H., K-Shell Internal-Ionization Probabilities in Nuclear β^-Decay, Phys. Rev. C 14, 281 (1976).

HANSEN H.H., GROSSE G., MOUCHEL D. and VANINBROUKX R., Accurate Determination of the Half-Lives of ^{95}Zr and ^{95}Nb, Z. Physik A 278, 317 (1976).

HANSEN H.H. and PARTHASARADHI K., Total Photon Interaction Cross Sections for Photons of Energies between 60 and 1 333 keV, Z. Physik A 277, 331 (1976).

LE DUIGOU Y. and LEIDERT W., Influence of a Photochemical Reaction on the Controlled Potential Coulometric Determination of Plutonium in a Mixture with Uranium, Z. Anal. Chem. 278, 29 (1976).

LE DUIGOU Y. and LEIDERT W., A Test for the Reliability of the Controlled Potential Coulometric Method to Determine Plutonium in Uranium-Plutonium Mixtures, Z. Anal. Chem. 279, 29 (1976).

ESCHBACH H.L. and WERZ R., A Generalized Correction Factor for the Knudsen Radiometer Gauge with Arbitrary Vane and Heater Shape, Vacuum 26, 67 (1976).

Submitted for Publication in Periodicals

LISKIEN H. and WEIGMANN H., Monte Carlo Simulation of Cross Section Fluctuations for the Standard Reactions $^{197}Au(n,\gamma)$ and $^{235}U(n,f)$, Ann. Nucl. Energy, in press.

STEFANON M. and CORVI F., Resonance Neutron Capture Gamma Rays in ^{177}Hf, Nucl. Phys.

WAGEMANS C. and DERUYTTER A., Neutron Induced Fission Cross Section of ^{235}U in the Energy Region from 0.008 eV to 30 keV, Ann. Nucl. Energy.

VANINBROUKX R. and GROSSE G., New Determination of the Half-Lives of ^{58}Co, ^{60}Co, ^{139}Ce, and ^{141}Ce, Int. J. appl. Radiat. Isotopes, in press.

BAMBYNEK W., BEHRENS H., CHEN M.H., CRASEMANN B., FITZPATRICK M.L., LEDINGHAM K.W.D., GENZ H., MUTTERER M. and INTEMANN R.L., Orbital Electron Capture by the Nucleus, Rev. Mod. Phys. in press.

LE DUIGOU Y. and LEIDERT W., Influence of the Effect of Residual Amounts of Oxygen on the Accuracy of Coulometric Titration of Uranium, Z. Anal. Chem.

MICHELENA A., PEETERS G., VANSANT E.F. and DE BIEVRE P., The Adsorption of Carbon Monoxide and Carbon Dioxide in Calcium Exchanged Zeolite Y, Recueil des Travaux Chimiques des Pays-Bas, in press.

MICHELENA A., VANSANT E.F. and DE BIEVRE P., Effect of the Treatment of the CaA Zeolite on the CO Adsorption, Recueil des Travaux Chimiques des Pays-Bas, in press.

DE BIEVRE P., GALLET M., HOLDEN N.E. and BARNES I.L., Isotope Abundance and Atomic Weights of the Elements, J. Phys. Chem. Data, in press.

Paper Presented at Scientific Conferences

MUTTERER M., DE ROOST E. and BORTELS G., Internal Ionization Accompanying the Electron Capture Decay of ^{7}Be, Second International Conference on Inner Shell Ionization Phenomena, Freiburg, Germany, March 29 - April 2, 1976, edited by W. Mehlhorn and R. Brenn, Fakultät für Physik, Universität Freiburg, p. 188.

BAMBYNEK W. and GENZ H., Orbital Electron Capture by the Nucleus, Second International Conference on Inner Shell Ionization Phenomena, Freiburg, Germany, March 29 - April 2, 1976, edited by W. Mehlhorn and R. Brenn, Fakultät für Physik, Universität Freiburg, p. 191

LEDINGHAM K.W.D., Electron Capture to Positron Ratios, Second International Conference on Inner Shell Ionization Phenomena, Freiburg, Germany, March 29 - April 2, 1976, edited by W. Mehlhorn and R. Brenn, Fakultät für Physik, Universität Freiburg, p. 196.

DE BIEVRE P. and VAN AUDENHOVE J., An Accurate Procedure to Safeguard the Fissile Material Content of Input and Output Solutions of Reprocessing Plants, Safeguarding Nuclear Materials, Proceedings of a Symposium, Vienna, Austria, October 20-24, 1975, STI/PUB/408, IAEA, Vienna, 1976, p. 493.

DE BIEVRE P., BROOTHAERTS J., GALLET M., LOOPMANS A. and SATTLER E., Performing Accurate Measurements of Fissile Material for Safeguard Purposes in Reprocessing Plants in Europe, Proceedings of the 17th Annual Meeting of the Institute for Nuclear Materials Management, Seattle, Wash., U.S.A., June 1976, in press.

LISKIEN H., Neutron Standards and their Application, Proceedings of the International Conference of the Interactions of Neutrons with Nuclei, Lowell, Mass., U.S.A., July 6-9, 1976, edited by E. Sheldon, Technical Information Center, Springfield, CONF.760715-P2, 1976, p.1110.

ROHR G., SHELLEY R. and BRUSEGAN A., Resonance Parameters of ^{127}I, International Conference on the Interactions of Neutrons with Nuclei, Lowell, Mass., U.S.A., July 6-9, 1976, Ibid.p.1249.

WINTER J., MEWISSEN L., POORTMANS F., ROHR G. and SHELLEY R., Spin and Parity Assignments of ^{93}Nb Neutron Resonances, International Conference on the Interactions of Neutrons with Nuclei, Lowell, Mass., U.S.A., July 6-9, 1976; Ibid. p. 1248.

ROHR G., Possible Intermediate Sub-Structure Observed in the Mass Region of the 4s Resonance, International Conference on the Interactions of Neutrons with Nuclei, Lowell, Mass., U.S.A., July 6-9, 1976, Ibid. p.1258.

BEER H. and ROHR G., Investigation of $^{63,65}Cu$ Total Cross Sections in the Energy Range 30-150 keV, International Conference on the Interactions of Neutrons with Nuclei, Lowell, Mass., U.S.A., July 6-9, 1976, Ibid. p.1386.

KNITTER H.-H. and BUDTZ-JØRGENSEN C., Measurements of Neutron Total and Scattering Cross Sections of ^{6}Li, International Conference on the Interactions of Neutrons with Nuclei, Lowell, Mass., U.S.A., July 6-9, 1976, Ibid. p. 1387.

POORTMANS F., CORNELIS E., MEWISSEN L., ROHR G., SHELLEY R., VAN DER VEEN T., VANPRAET G. and WEIGMANN H., Cross Sections and Neutrons Resonance Parameters for ^{238}U below 4 keV, International Conference on the Interactions of Neutrons with Nuclei, Lowell, Mass., U.S.A., July 6-9, 1976, Ibid. p. 1264.

MEWISSEN L., ANGELETTI A., CORNELIS E., POORTMANS F., ROHR G., VANPRAET G. and WEIGMANN H., Resonance Parameters of ^{237}Np, International Conference on the Interactions of Neutrons with Nuclei, Lowell, Mass., U.S.A., July 6-9, 1976, Ibid. p. 1263.

CORVI F. and STEFANON M., High Energy γ Rays from ^{177}Hf Neutron Resonances, International Conference on the Interactions of Neutrons with Nuclei, Lowell, Mass., U.S.A., July 6-9, 1976, Ibid. p. 1259.

DE BIEVRE P., Accurate Isotope Ratio Mass Spectrometry : Some Problems and Possibilities, 7th International Mass Spectrometry Conference, Firenze, Italy, August 30 - September 3, 1976.

STÜBER W., A Computer Controlled Data Acquisition System for Mass Spectrometry, Proceedings of the Digital Equipment Computer Users Society (DECUS), Vol. 3, No. 1, 1976, Europe Symposium, München, Germany, September 8-10, 1976, edited by Digital Equipment Corporation, Maynard, Mass., U.S.A., 1976.

WEBER G., DAVID D., QUAGLIA L., PAUWELS J. and VAN AUDENHOVE J., Surface Treatment of Non-Ferrous Metals Samples to be Certified for their Oxygen, Nitrogen and Carbon Content, International Conference on Modern Trends in Activation Analysis, München, Germany, September 13-17, 1976, edited by F. Lux, Institut für Radiochemie, Technische Universität München, p. 1354.

BUDTZ-JØRGENSEN C. and KNITTER H.-H., Ionisation Chamber with Fast Timing Properties and Good Energy Resolution for Fission Fragment Detection, Proc. of the NEANDC/NEACRP Specialists Meeting on Fast Neutron Fission Cross Sections of ^{233}U, ^{235}U, ^{238}U, and ^{239}Pu, NEANDC(US)-199/L (1976), p. 415.

KNITTER H.-H., A Review on Standard Fission Neutron Spectra of ^{235}U and ^{252}Cf, IAEA Consultants Meeting on Integral Cross Section Measurements in Standard Neutron Fields, Vienna, Austria, November 15-19, 1976, INDC(NDS)-81, to be published.

Reports

WERZ R. and ESCHBACH H.L., Abhängigkeit der Schubkraft beim Molekularvakuummeter von Form und Abstand der Platten, EUR 5471d (1976)

DENECKE B. and GOODIER I.W., Development of a Technique for the Measurement of Superficial Density Changes Typically of the Order of 50 $\mu g/cm^2$ by Electron Absorption with Possible Application of the Quantitative Determination of the Concentration of Suspended Particulate Matter in Air, EUR 5477e (1976).

DE BIEVRE P., DE BOLLE W., GALLET M., MÜSCHENBORN G. and SATTLER E., The Characterization of Test Materials for the GfK/Dornier Interlab Test on UF_6, EUR 5503e (1976), KfK 2340 (1976).

KNITTER H.-H., BUDTZ-JØRGENSEN C., MAILLY M. and VOGT R., Neutron Total and Elastic Scattering Cross Section of ^{6}Li in the Energy Range 0.1 to 3.0 MeV, EUR in press.

DEBUS G.H. (ed), Proceedings of the First ASTM-EURATOM Symposium on Reactor Dosimetry, EUR 5667e (1976)

QUAGLIA L., WEBER G., DAVID D., VAN AUDENHOVE J. and PAUWELS J., Surface Treatment of Non-Ferrous Metals for the Purposes of Gas Analysis, ITE-90 (1976).