Commission of the European Communities

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JOINT
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ANNUAL PROGRESS REPORT ON NUCLEAR DATA 1991

CENTRAL BUREAU FOR NUCLEAR MEASUREMENTS

GEEL (BELGIUM)

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CATALOGUE N° : CD-NA-14514-EN-C

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Editor: H.H. Hansen

Note : For further information concerning the Project Nuclear Measurements (Nuclear Data, Nuclear Metrology), please contact A.J. Deruytter, Project Manager.

EXECUTIVE SUMMARY

A.J. Deruytter

In 1991 the efforts for the improvement of the set of **standard neutron cross-sections** and other quantities selected within the INDC/NEANDC Standards File continued. In particular in view of improving the knowledge of the ratio of two important standard cross-sections $^{235}U(n,f)/H(n,p)$ several octacosanol layers, as hydrogen containing layers, were studied by means of the cosΘ dependence of the signals in a gridded ionization chamber for neutron energies between 0.3 and 2 MeV. α-Particle emission probabilities of ^{236}Pu, ^{243}Am and ^{239}Pu were measured in a CBNM-CIEMAT collaboration yielding improved values. Preliminary results for the major alpha branches in ^{239}Pu decay differ significantly from presently recommended data.
In the field of **nuclear data for fission technology** work was concentrated on European requests in the NEA High Priority Request List. Measurements of the energy dependence of the capture to fission ratio, α, of ^{235}U yielded an increase of α-values by about 9 % in the subthermal region as compared to the thermal value, corresponding to a 1.2 % decrease in η, which is in agreement with our earlier direct determinations of η. Subthermal and low energy fission cross-sections for ^{241}Pu, indicate that earlier thermal normalizations may have to be revised.
The experimental weighting function of C_6D_6 n-capture detectors determined earlier at CBNM was used to recalculate resonance parameters and capture areas for 97 levels in the neutron energy range from 1 to 300 keV for the resonance neutron capture in ^{56}Fe. The comparison of the new results with those obtained with the old weighting shows that the capture areas have varied by a relative amount going from −10 % to + 5 %.
Resonance parameters for ^{58}Ni + n below 305 keV and for ^{60}Ni + n below 550 keV were obtained by analysis of very high resolution transmission measurements obtained thanks to the outstanding high resolution performance of GELINA.
In the field of **nuclear data for fusion technology** measurements continued aiming at an improvement of relevant data for neutron transport calculation in the blanket and for prediction of gas production, in particular double differential neutron emission cross-sections of ^{9}Be were transmitted for use in EFF and double differential (n,xα) cross-sections of ^{nat}Ni, ^{58}Ni, ^{60}Ni, ^{nat}Cu, ^{63}Cu and ^{65}Cu in the neutron energy range from 5 to 14 MeV were published. Total prompt α-yields agree with recent evaluations for copper but not for the nickel data.

The **radionuclide metrology** subproject follows three lines: determination of decay-scheme data, preparation of special standards and the improvement of measurement techniques including international comparisons. In 1991 a second EUROMET intercomparison of ^{192}Ir brachytherapy sources was organised with eight participating laboratories which measured air kerma rate and activity showing agreement to better than 2 %. Also measurements were performed on volcanic-rock powder samples using the low-level HP Ge γ-ray detector system to obtain information on the disequilibrium in natural radioactive series and consequently on the age of the rocks.

At a deflected beam-line of GELINA a set-up to produce transition radiation was installed. Spectra and angular distributions of soft X rays emitted by different radiators were measured to find optimal conditions for production of high-intensity X ray beams useful for applications when experiments will be possible at the direct beam-line.

NUCLEAR DATA

NUCLEAR DATA FOR STANDARDS

The objective of the work on standard nuclear data is to improve the set of neutron data to be used in measurements consistency checks. Competing reactions, angular and kinetic energy distributions of the reaction products have to be studied to increase the reliability of the given standard cross sections. Appropriate research topics are selected from listings of the INDC/NEANDC Standards File. Complementary work is devoted to radionuclide decay data and associated atomic data requested for calibration and reference purposes.

Neutron Data for Standards

Standard Cross Section Ratio $^{235}U(n,f)/H(n,n)$

F.-J. Hambsch, R. Vogt, G. Willems*, P. Robouch, J. Van Gestel, J. Pauwels, A. Rodríguez, R. Besenthal

In the previous progress report[1] it has been outlined that an investigation has started with the aim to improve the cross section ratio ^{235}U(n,f)/H(n,n). From the various organic compounds with high H-content investigated, octacosanol (CH_3-$(CH)_{26}$-CH_2OH) was chosen as the most appropriate one.

In the present reporting period several evaporations of this compound on highly polished tantalum backings were carried out to prepare six deposits of various thickness ranging from 137 $\mu g/cm^2$ to 550 $\mu g/cm^2$.

Due to the fact that our Frisch gridded ionization chamber, used as the proton recoil detector acts like a microphone, the noise and the vibrations of the experimental platform caused severe problems, which could be solved during the cause of the reporting period.

Also during the present experimental campaign we were faced with many problems of electronical instabilities which had first to be solved and had caused a remarkable delay of the measurements. Recently the final measurements have been started to check the homogeneity by means of the cosine-dependence of the ionization chamber signals. The neutron energy range covered was about 0.3 MeV to 2 MeV.

Due to the resulting low energy of the proton-recoils the reduction of the electronical noise level by selection of the best electronic components was a

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(1) CBNM Annual Report 90, EUR 13456 EN

severe problem. The resolution finally achieved is about four channels FWHM in 1024, or approximately 12 keV.

The experimental setup is schematically shown in Fig. 1. The cathode of the chamber supports on one side an uranium tetrafluoride layer and on the other side the octacosanol foil. From the recoil ionization chamber two coincident

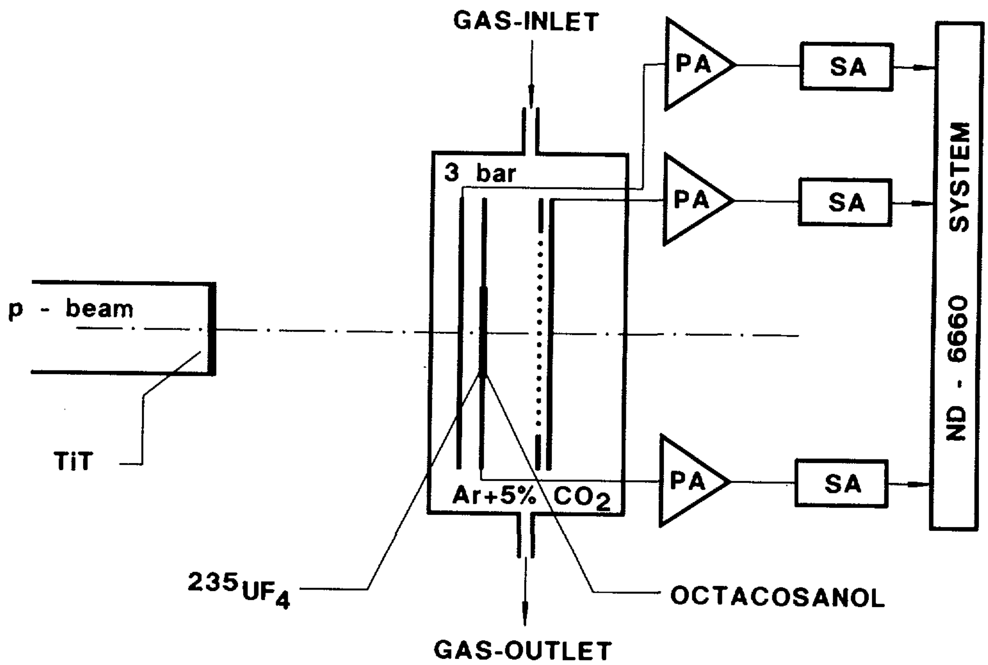

Fig. 1. Schematic experimental set-up

signals per recoil event are registered. The anode signal is proportional to the recoil energy

$$q_a \sim E$$

The second signal obtained from the cathode is a function of the recoil energy E, the cos Θ of the emission angle with respect to the normal of the cathode and of the quantity $\bar{X}$(E,A,Z).

$$q_c \sim E(1 - \frac{\bar{X}}{D} \cdot \cos\Theta)$$

$\bar{X}$(E,A,Z) depends on the particle type and energy. The registration of these two signals permits therefore a rather effective background discrimination by selecting an area of interest for the recoils in a two dimensional representation of the anode signal versus the ratio of cathode to anode signal as seen in Fig. 2. A set of recoil spectra taken at about 2 MeV incident neutron energy are shown in Fig. 3. The long plateau of the proton recoils and the thickness effect of the sample can be seen, together with, at lower energies, the recoils of carbon and oxygen, which are present in the octacosanol layer and the counting gas. The data acquisition and analysis are ongoing. A final conclusion of whether the compound can fullfil all demands is at the moment not possible.

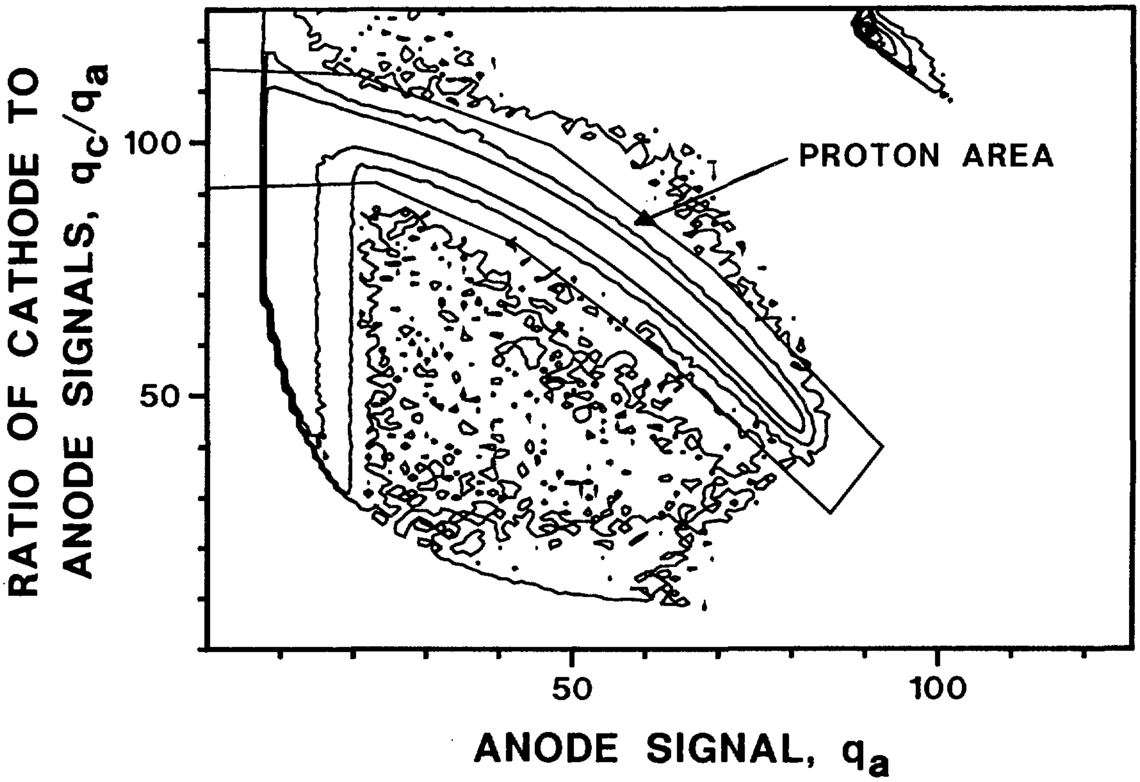

Fig. 2. *Two dimensional proton recoil spectrum. The ratio of cathode to anode signals q_c/q_a is plotted versus the pulse-height of the anode signal q_a*

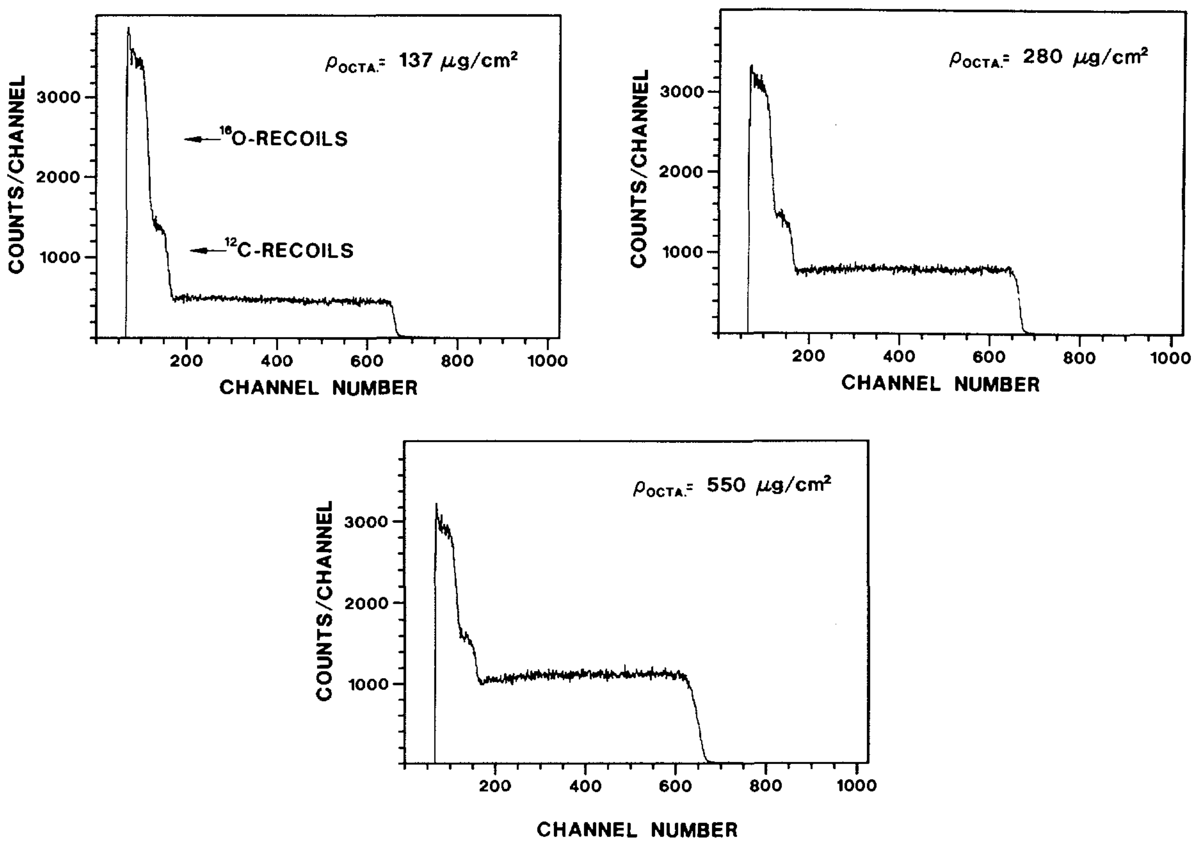

Fig. 3. *Recoil spectra measured with three octacosanol radiator foils of different thickness at ~ 2 MeV incident neutron energy*

Investigation of the Correlation Between Prompt Gamma-Ray Emission and Fission Fragments from $^{252}Cf(sf)$

F.-J. Hambsch, R. Vogt

The data evaluation had been started at the begin of the present reporting period. However, it has been found out that a shift had happened different for the measured experimental distributions of the anode and the sum signal of the anode and the grid of the used Frisch gridded ionization chamber. This shift, however, was not seen in the signal of the precision puls generator, otherwise always used for calibration and correction purposes. Due to this effect and change of priorities the data acquisition and evaluation had been stopped for the time being.

Cold fragmentation properties of ^{252}Cf (SF)

F.-J. Hambsch, H.-H. Knitter*, R. Vogt

In the previous progress reports(1,2) already a comprehensive picture is given of the so-called cold fragmentation region of the spontaneous fission of ^{252}Cf, where the reaction Q-value is nearly exhausted by the total kinetic energy of the fragments. A paper on the matter has been accepted for publication in Nucl. Phys.

We have also completed the evaluation of our cold fragmentation data introducing a cut in total kinetic energy following the shape of the Q-value surface as already mentioned in the previous progress report(2). Again it should be stressed, that it is important for the calculation of odd-even effects and the comparison of different fissioning systems, to have for all charge splits as function of mass, the same excitation energy available. Otherwise artificial structures might be visible as already outlined in(2). If, however, the shape of the Q-value surface is followed the odd-even effects for protons and neutrons become negative, as can be read from Table 1.

Also the relative yield of fragments with even-even (EE), odd-odd (OO), even-odd (EO) and odd-even (OE) proton and neutron numbers have been drastically changed. With the constraint of constant total excitation energy the even charge fragmentations are no longer preferred. These two findings, negative odd-even effects, higher odd-charge fragmentation yield, are a clear indication that odd-even effects cannot be linked to pair breaking and excitation energy or to the intrinsic temperature at scission as proposed by(3). The Q-value surface

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* retired
(1) CBNM Annual Report 89, EUR 12615EN
(2) CBNM Annual Report 90, EUR 13456EN
(3) H. Nifenecker, G. Marolopoulos, J.P. Bocquet, R. Brissot, Ch. Hamelin, J. Crançon and Ch. Ristori, Z. Phys. A308 (1982) 39

Table 1. ***The odd-even effects for fragment mass, nuclear charge and neutron number. The four lowest lines give the relative yields for even-even, odd-odd, even-odd and odd-even nuclear charge and neutron number respectively***

	BIN 1 (6-8) MeV	BIN 2 (8-10) MeV	BIN 3 (10-12) MeV
δA	-0.056±0.009	-0.038±0.018	-0.063±0.036
δZ	-0.103±0.015	-0.088±0.019	-0.020±0.003
δN	-0.258±0.007	-0.220±0.012	-0.152±0.006
EE [%]	14.5±0.3	16.4±0.2	19.1±0.1
OO [%]	32.6±0.5	31.8±0.3	27.7±0.2
EO [%]	30.3±0.5	29.2±0.3	29.9±0.2
OE [%]	22.5±0.5	22.6±0.3	23.3±0.2

as function of light fragment mass A_L and charge Z_L is the dominating factor for all experimental parameters, certainly in the energy region covered by this experiment.

Neutron induced fission of ^{237}Np(n,f)

P. Siegler, F.-J. Hambsch, R. Vogt

Information about fission properties from the reaction ^{237}Np(n,f) are of special interest due to the fact that this nuclide is an important standard for fast and thermal reactors.

It is planned to measure the mass-, energy- and angular-distribution of both fission fragments as function of incident neutron energy with a double Frisch gridded ionization chamber using the 7MV VG accelerator as a neutron source. The neutron energy will be varied between 0.3 and 5.5 MeV to perform measurements in the threshold and in the plateau region. The ^{237}Np target consists of 69 μg/cm^2 NpF_4 evaporated onto a 25 μg/cm^2 thick polyimide foil covered with a 50 μg/cm^2 gold layer to support an electrical shielding between both sides of the ionization chamber.

In the past , it has been experienced that the thickness of the gold layer around 30 μg/cm^2 shows a statistic behaviour for the electrical shielding ability due to uncertainties in the thickness determination. Therefore 30 μg/cm^2 gold seems to be a lower limit for a full electrical conducting surface. This conductivity of the backing has been checked by means of α-particles from the neptunium sample.

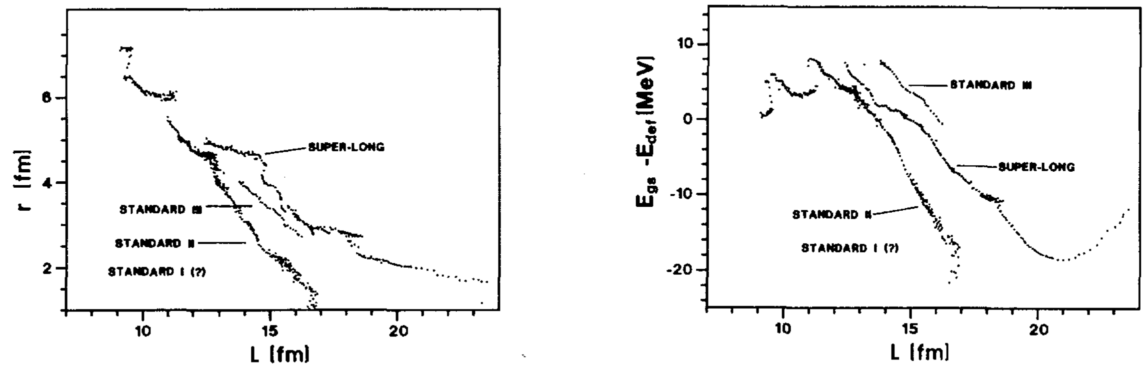

Fig. 4. ***Calculation results for fission channels in ^{238}Np. Left part: Projection of the fission paths to the plane represented by the chosen parametrization of the nucleus. Right part: Potential energy $E_{gs} - E_{def}$ of the deformed nucleus for the different fission paths as function of the elongation parameter l***

In the meantime calculations based on the multi-channel random neck-rupture model of Brosa, Grossmann and Müller(1) have been made.

The relating programs for the calculation of the potential energy for a parametrized fissioning system, coming from Brosa, have been installed. We have started with the search for fission paths in the compound system ^{238}Np, which means continuous valleys in the potential energy landscape from the groundstate to the scission point.

The finally found pre-scission shape parameters for each fission path lead with the help of the random neck rupture to fission fragment properties which can be compared to experimental results.

The up to now achieved results for the calculations of the fission channels are shown in Fig. 4.

(1) U. Brosa, S. Grossmann and A. Müller, Phys. Reports 197 (1990) 167

Non-Neutron Nuclear Data For Standards

Emission probabilities of ^{236}Pu, ^{243}Am and ^{239}Pu

G.Bortels, D. Mouchel, M. Aceña*, E. García-Toraño*

The alpha-particle emission probabilities, $P\alpha$, of the nuclides ^{236}Pu, ^{239}Pu and ^{243}Am have been measured in the frame of a CBNM-CIEMAT collaboration. High accuracy was achieved by using enriched isotopes, ion-implanted silicon detectors (PIPS) of 8.7 keV FWHM intrinsic peak resolution, optimum experimental conditions and two different peak fitting models for analysing the spectra.

In the case of ^{236}Pu, measurements were made at CBNM and spectra were analysed at both CBNM and CIEMAT. Final values of the emission probabilities are listed in Table 2. The quoted uncertainties in brackets are estimates of the overall uncertainties including systematic components. The results have been published.

Table 2. Measured alpha-particle emission probabilities

Nuclide	Level in daughter nuclide [keV]	$P_\alpha \cdot 100$
^{236}Pu	156.6	0.207 (5)
	47.6	30.52 (6)
	0	69.27 (6)
^{243}Am	348	0.0016 (5)
	320	0.0033 (5)
	267	0.0056 (7)
	241	0.010 (1)
	173.3	1.36 (1)
	117.7	11.46 (3)
	74.67	86.74 (6)
	31.1	0.190 (7)
	0	0.230 (7)
^{239}Pu	51.7	12.0 (2)[a)]
	13.0	17.1 (2)[a)]
	0	70.7 (1)[a)]

a) Preliminary values

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For ^{243}Am, sources were made at CBNM. Measurements and analyses were done at both laboratories. The final results are given in Table 2. The work has been published.

The highly enriched ^{239}Pu material was provided by NIST. It contains less than 0.005 % of ^{240}Pu by activity and negligible amounts of ^{238}Pu, ^{241}Pu, ^{242}Pu and ^{241}Am. Sources of about 700 to 1700 Bq were produced at CBNM by sublimation in vacuum.

Four spectra with between $8 \cdot 10^5$ and $1.6 \cdot 10^6$ total counts were measured in geometries of 0.8 and 0.46 % of 4π sr. Peak resolution was 9.1 keV FWHM. A typical spectrum is shown in Fig. 5. Preliminary results for the major alpha branches are listed in Table 2. The result differs significantly (more than 3 % for the predominant emission) from the recommended data. This large difference for a very important nuclide requires clarification.

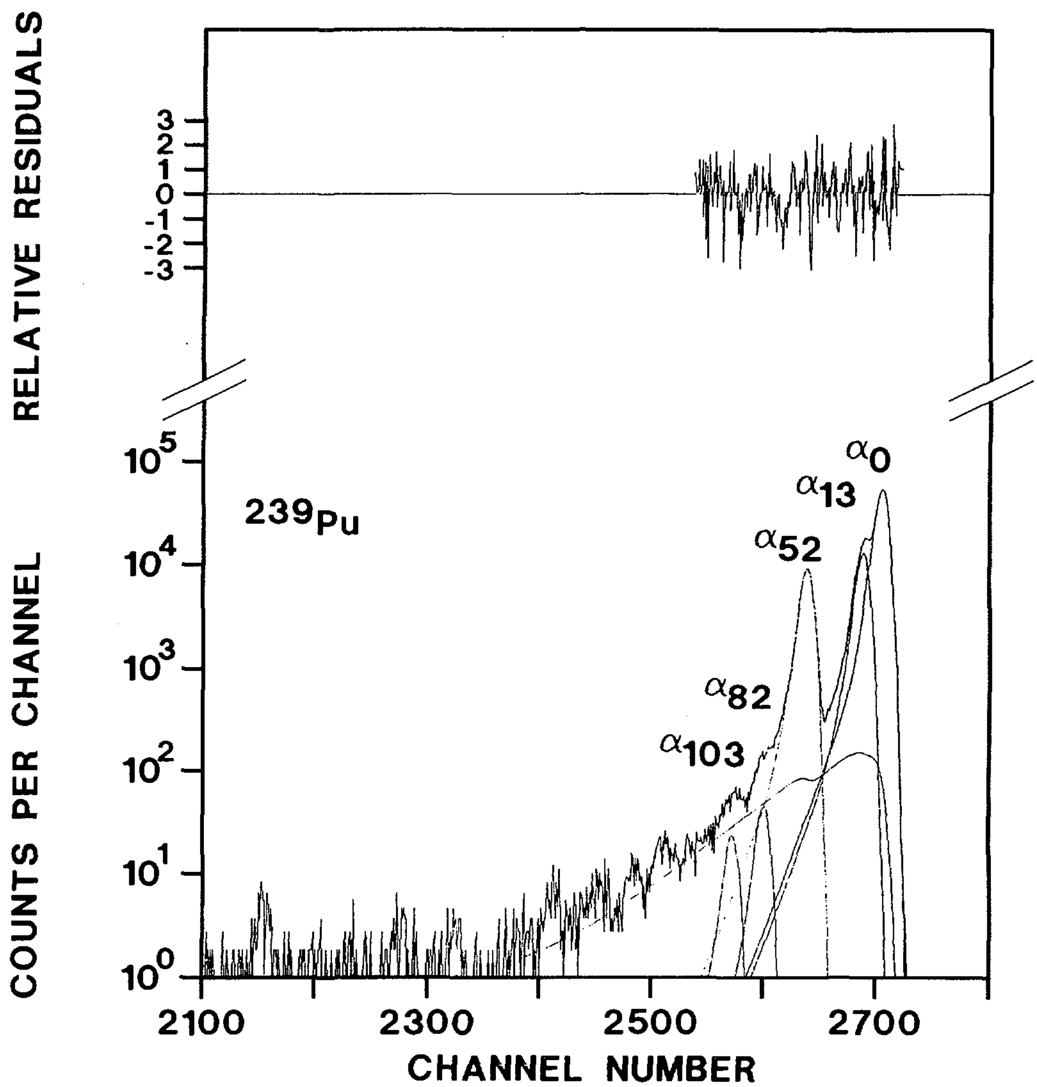

Fig. 5. Typical α-particle spectrum of ^{239}Pu

The Half Life of ^{192}Ir

D.F.G. Reher, G. Sibbens, M.J. Woods*, S.E.M. Lucas*

In the past years ^{192}Ir has become an important radionuclide in radiotherapy. During the current work of EUROMET project no. 219 on the metrology of ^{192}Ir brachytherapy sources, a re-evaluation of the half life showed that its uncertainty is too large.
A new value of the half life was measured at NPL and at CBNM, both laboratories using high pressure re-entrant ionization chambers. The decay of ^{192}Ir sources was followed and the stability of the systems was checked after each measurement with sealed ^{226}Ra sources. Impurity checks were made regularly by gamma-ray spectrometry. The recommended new value of the half life of ^{192}Ir is (73.830 ± 0.018)d.

Electron-Capture Probabilities

W. Bambynek

Electron-capture probabilities P_K, P_{L1} and P_{L2} have been calculated on request of the Institute for Nuclear Physics of the University of Gent. They were calculated under the assumption that all transitions are allowed transitions, what seems to be a rather good approximation. The calculations were made using electron wave functions and exchange and overlap corrections as described by Bambynek et al.(1)

Evaluation of X- and Gamma-Ray Emission Probabilities

W. Bambynek

The evaluation performed in the frame of an IAEA Coordinated Research Project on X- and Gamma-Ray Standards for Detector Efficiency Calibration has been published.

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* National Physical Laboratory, Teddington U.K.

(1) W. Bambynek, H. Behrens, M.H. Chen, B. Crasemann, M.L. Fitzpatrick, K.W.D. Ledingham, H. Genz, M. Mutterer, R.L. Intemann, Rev. Mod. Phys. 49 (1977) 77

NUCLEAR DATA FOR FISSION TECHNOLOGY

The objective of the work on nuclear data for fission technology is to reach a more accurate knowledge of data requested in fission research and in fission technology. Measurements cover actinide fission cross section data as well as structural material neutron interaction data. Research topics are taken to fulfil European demands collected in the NEA High Priority Request List.

Neutron Data of Actinides

Fission Cross-Section of ^{239}Pu

C. Wagemans*, A.J. Deruytter, R. Barthélémy, J. Van Gils

One of the conclusions[1] of the NEANDC/NEACRP Subgroup on the ^{239}Pu fission cross-section between 1 and 100 keV was that part of the observed discrepancies might be due to an insufficient knowledge of σ_f in the interval from 100 eV to 1000 eV, used for internormalization purposes. Verification experiments are prepared at GELINA to check this cross-section and its thermal normalization.

Subthermal Fission Cross-Section of ^{241}Pu

C. Wagemans*, P. Schillebeeckx**, A.J. Deruytter, R. Barthélémy, J. Van Gils

Final results for the ^{241}Pu(n,f) cross-section have been presented at the International Conference on Nuclear Data for Science and Technology, held in Jülich.

The histogram in Fig. 6 represents the experimental $\sigma_f(E)\sqrt{E}$-data from 0.002 eV up to 1 eV obtained in the present experiments; the full line stands for the corresponding ENDF B6 evaluation. This figure illustrates the constancy of $\sigma_f(E)\sqrt{E}$ below 40 meV, demonstrating an almost perfect 1/v-shape of the ^{241}Pu(n,f) cross-section in this energy region. This result disagrees with all previous data, which suffered from absorption and/or self-absorption effects or uncertain background corrections. Consequently, the thermal normalizations of these earlier measurements are likely not to be very accurate. This had its impact on the ENDF B6 evaluation, which significantly deviates from the present results in the region of the 0.26 eV resonance, as can be seen in Fig. 6.

* Rijksuniversiteit Gent, Belgium
** Present address: JRC, Ispra, Italy
(1) E. Fort, H. Derrien, M. Kawaï, C. Lagrange, T. Nakagawa, C. Wagemans, L. Weston, P. Young, Proc. Int. Conf. on Nuclear Data for Science and Technology, Jülich (D), 1991

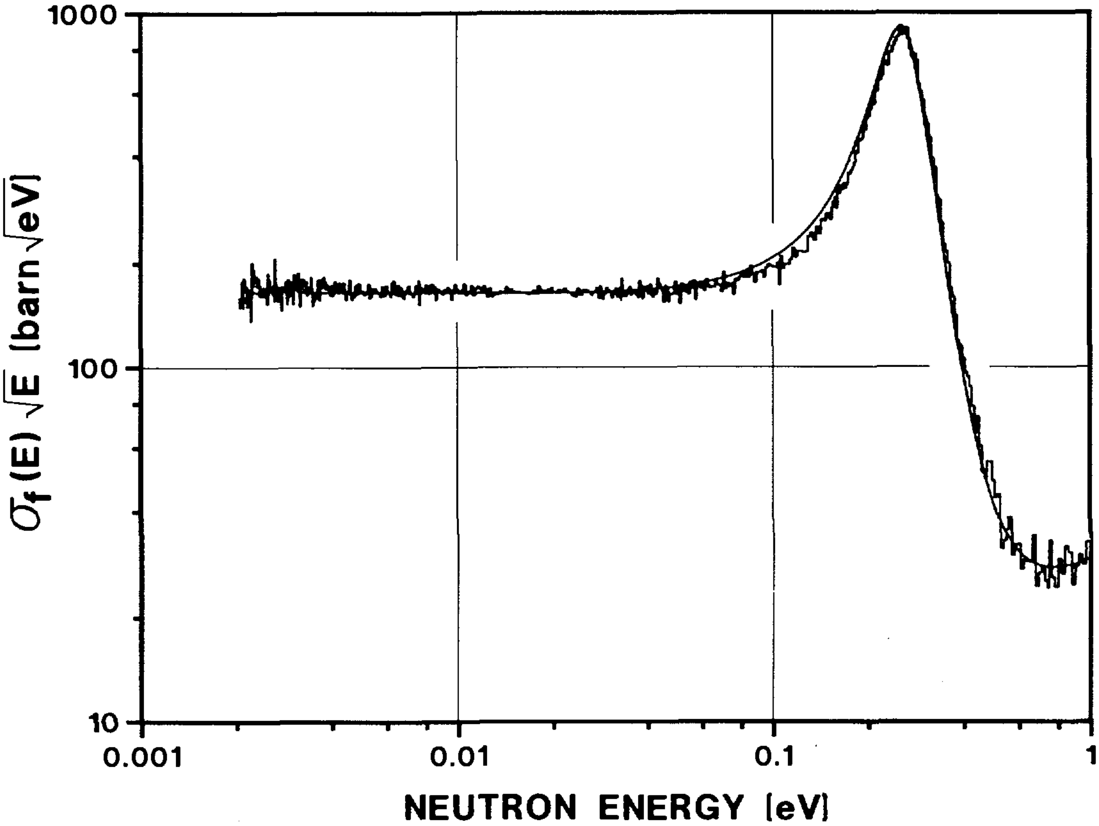

Fig. 6. *Comparison of the present $\sigma_f(E)\sqrt{E}$ data for ^{241}Pu with the ENDF-B6 evaluation (full line)*

As explained in detail at the Jülich Conference, we believe that a revision of ENDF B6 is needed below 300 eV.

A Multi-Purpose Charged Particle Detection System

C. Wagemans*, S. Druyts**, R. Barthélémy, J. Van Gils

A multi-purpose charged particle detection system (consisting of two gridded gas-flow ionization chambers and two 2000 mm^2 large 1000 µm thick surface barrier detectors) has been further developed, as well as the corresponding data acquisition system.
In its simpliest mode using only one gridded ionization chamber, the $^{35}Cl(n,p)^{35}S$ reaction has been studied from thermal up to 5 keV neutron energy. By combining each ionization chamber with the corresponding surface barrier detector, a double ΔE-E telescope is formed, enabling a separation of light charged particles. In this operation mode, test experiments have been

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** EC Fellow from KU Leuven, Belgium

performed to study the ternary particle emission as a function of the neutron energy in the fission of ^{235}U.

On Alpha of ^{235}U for Sub-Thermal Neutron Energies

H. Weigmann, J.A. Wartena, C. Bürkholz

An experiment to measure the energy dependence of the capture to fission ratio, α, of ^{235}U has been described in the previous progress report. The experiment is based on the measurement of specific low energy capture γ-rays and prompt fission γ-rays with a Ge detector. The liquid methane moderator of the Geel linac is used as a pulsed source of subthermal neutrons, the neutron energy being determined by time-of-flight. The method requires that the relative yields of the measured γ-rays per capture and fission event, respectively, do not vary over the energy range considered.
The measurements have been concluded and the data analysed. Resultant α-values show an increase by about 9 % in the subthermal region as compared to thermal energy, corresponding to a 1.2 % decrease in η.

Neutron Data of Structural Materials

Resonance Neutron Capture in ^{56}Fe

F. Corvi, G. Fioni*, A. Mauri** and K. Athanasopoulos

Advances in the accuracy of the measurements performed with total energy detectors were made in recent years by replacing the previously used calculated weighting function by one experimentally determined. In this way the long-standing discrepancy between capture and transmission results for the neutron width of the 1.15 keV resonance of ^{56}Fe was successfully solved. As it is very likely that the same kind of systematic errors exists in data concerning other resonances of this isotope, the ^{56}Fe capture data obtained at GELINA some years ago[1] have been subjected to a new analysis with the correct weighting function.

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* Present address: ILL, Grenoble, France
** National expert from ENEA, Bologna, Italy
(1) F. Corvi, A. Brusegan, R. Buyl and G. Rohr, Proc. Consult. Meet. on Nuclear Data for Structural Materials, 1983, Vienna, Report INDC(NDS)-152L (1984)

The data were analysed by taking into account recently published results[1] on ^{56}Fe resonance parameters: in particular only confirmed spin and parity assignments were accepted. In total, resonance parameters and capture areas were re-calculated for 97 levels in the range 1 - 300 keV.
The comparison of the new results with those obtained with the old weighting shows that the capture areas have varied by a relative amount going from -10 % to +5 %. For each resonance the amount and the sign of this variation should be related to the shape of its capture spectrum. Finally, the following average radiation widths and their standard deviations were calculated:

$<\Gamma\gamma> = (0.96 \pm 0.39)$ eV for s-waves
$<\Gamma\gamma> = (0.49 \pm 0.21)$ eV for p-waves
$<\Gamma\gamma> = (0.72 \pm 0.33)$ eV for d-waves

This work has been presented at the 1991 Jülich Conference on Nuclear Data for Science and Technology.

Resonance Parameters of $^{58}Ni+n$ and $^{60}Ni+n$ from Very High Resolution Transmission Measurements

A. Brusegan, G. Rohr, R. Shelley, C. Van der Vorst, C. Baracca*, Zhou Enchen**, F. Poortmans***, L. Mewissen***, G. Vanpraet•

The measurements presented here were made as a continuation of the investigation about neutron cross sections of structural materials required for reactor design; the total cross section is, moreover, needed in order to correct the capture data for self shielding and multiple scattering. These nickel measurements were among the first being performed at the GELINA after it was substantially upgraded by the addition of a compression magnet to produce a 1 ns burst width, enabling very high energy resolution.
With the accelerator operating at a frequency of 800 Hz, several measurements were performed along collimated flight paths ranging from 50 to 400 m. The neutron beam was moderated, except for the 400 m case, immediately after the target and three different nickel samples (on loan from ORNL) were used.
The neutron transmission spectra were analysed, below 305 keV and 550 keV for ^{58}Ni and ^{60}Ni, respectively, with the Reich-Moore multilevel routine MULTI[2] in order to deduce the energy, neutron width, spin and parity.

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*** Studiecentrum voor Kernenergie, Mol, Belgium
• Rijksuniversitair Centrum Antwerpen, Belgium

(1) C.M. Perey, F.G. Perey, J.A. Harvey, N.W. Hill and N.M. Larson, Report ORNL/TM-11742 (1990)
(2) G.F. Auchampaugh, Report CA-5473-MS (1974)

In the present analysis published radiation widths[1,2] have been used, with the exception of the 2.25 keV resonance in ^{60}Ni, for which the resonance parameters result from the simultaneous analysis of the 50 and the 100 m data with the code REFIT[3]. Fig. 7 shows a plot of the 50 m data and of the calculated shape. The 2.25 keV p-wave resonance, similarly to the 1.15 keV resonance of ^{56}Fe, has a neutron width much smaller than the capture width, i.e. (30.9 ± 2.0) meV and (533 ± 100) meV respectively, assuming $J^{\Pi} = 3/2^-$. The capture area of this resonance provides a useful normalization value for the capture measurements. The s-wave strength functions and the average level spacings are listed in Table 3; no correction for missed levels is applied and the quoted errors are $(2/N)^{0.5}\cdot S_0$ and $(0.273N)^{0.5}\cdot D_0$, respectively, where N is the number of resonances.

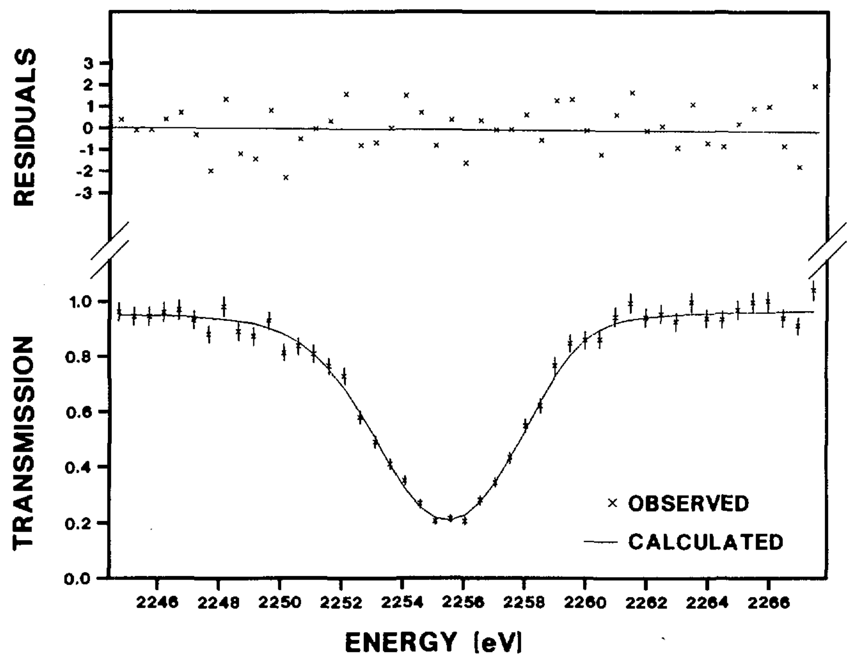

Fig. 7. Shape analysis of the 2.25 keV resonance in ^{60}Ni

Comparative Study of the Calculated and Measured Transmission for ^{238}U

A. Brusegan

The transmission of a 16.4 cm thick ^{238}U metal sample (with 0.35 % of ^{235}U) has been measured in order to investigate the spectral properties of a neutron filter for reactor applications.

The experimental data allow moreover a test of the known resonance parameters for ^{238}U.

(1) C.M. Perey, F.G. Perey, J.A. Harvey, N.W. Hill, M.M. Larson, R.L. Macklin, Report ORNL/TM-10841, ENDF-347

(2) C.M. Perey, J.A. Harvey, R.R. Macklin, F.G. Perey, R.R. Winters, Phys. Rev. C27-6, 2556 (1983)

(3) M.C. Moxon, AEA-InTec-0470

Table 3. Average level spacings and strength functions for s-wave resonances in ^{58}Ni and ^{60}Ni

Isotope	D_0[keV]	$S_0 \times 10^4$
^{58}Ni	17.1 ± 2.1	3.40 ± 1.13
^{60}Ni	16.1 ± 1.5	2.50 ± 0.62

In the neutron energy below 200 eV, the results have been compared with the transmission calculated with the program REFIT[1] and with the recent set of resonance parameters fitted by M.C. Moxon for the JEF file. The calculated and observed transmission areas agree within 1 %, but larger deviations are observed between the shapes.

Fig. 8 shows a plot of the calculated and experimental points at the 186 eV total cross-section minimum.

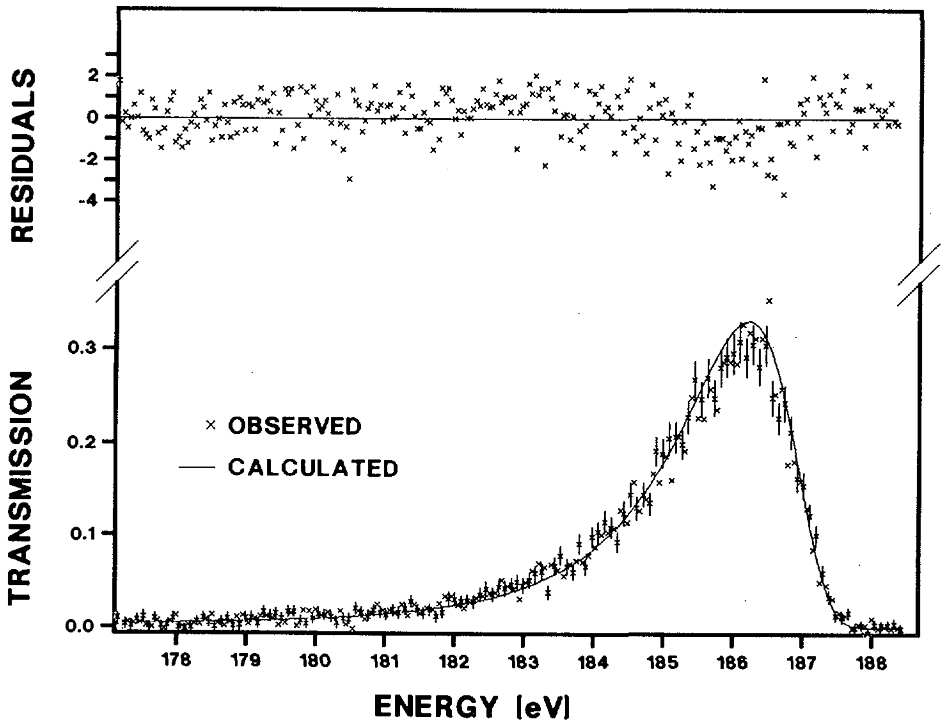

Fig. 8. Observed and calculated transmission for ^{238}U

(1) M.C. Moxon, AEA-InTec-0470

NUCLEAR DATA FOR FUSION TECHNOLOGY

The objective of the work on nuclear data for fusion technology is to contribute to an improved knowledge of data for neutron transport calculation in the blanket and for an estimate of the gas production. Measurements are presently done in three areas: (1) double-differential neutron emission cross sections; (2) double-differential charged particle emission cross sections and (3) total and radiative capture cross sections for nickel isotopes; since the latter are related to fission as well as to fusion technology, they are described in the section on fission technology.

Double-Differential Neutron-Emission Cross-Sections

J.A. Wartena, H. Weigmann, C. Bürkholz

The experimental methods applied as well as the main steps in the data analysis have been desribed in the preceding progress report[1], and a short account of these measurements has been presented at the conference on Nuclear Data for Science and Technology at Jülich. Since then, the Monte Carlo code used to calculate multiple scattering corrections has been improved by allowing for anisotropic angular distributions of secondary neutrons from the (n,2n) reaction which in the earlier version of the code had been assumed to be isotropic. The (n,2n) angular distribution obtained from the first analysis are used as an input to the refined multiple scattering corrections. The final analysis is in progress.
On the experimental side measurements on ^{207}Pb are being prepared. Prior to the start of actual measurements the data acquisition procedures have been improved in order to have a better control of the stability of the electronic circuits, especially of the pulse shape discriminators.

Measurement of Double Differential (n,xα) Cross Sections of ^{nat}Ni, ^{58}Ni, ^{60}Ni, ^{nat}Cu, ^{63}Cu and ^{65}Cu in the 5 to 14 MeV Neutron Energy Range

E. Wattecamps

Alpha yield data by neutron irradiation of natural nickel, natural copper and enriched single isotopes were measured. The neutron energy was varied between 5 and 10 MeV and at a single value of 14 MeV. The prompt α-particle production was measured simultaneously by five telescopes. The α-yield data of

(1) CBNM Annual Report 90, EUR 13456 EN

natural nickel and natural copper were measured relative to the elastic scattering cross section of hydrogen, whereas the yield data of the samples with enriched isotopes were measured relative to the yield of ^{58}Ni. By integration of the double differential data over α-particle energy and emission angle the total prompt α yield has been obtained. Compared with the data from the ENDF/B6 evaluation good agreement is found for the copper data but not for the nickel results. A paper on this subject was presented at the International Conference on Nuclear Data for Science and Technology, held in Jülich.

A 27 cm^2 Scintillator for the Detection of Alpha Particles of some MeV with 28 % Energy- and 240 ps Time-Resolution

E. Wattecamps, G. Rollin

A hexagonal pilot-U scintillator of 6 cm sidelength, 27 cm^2 surface area, 1 mm thickness and with two photomultipliers on opposite edges of the slab was investigated. For irradiation on a central spot of 0.6 cm^2 by mono-energetic α particles an energy resolution of 24 % and a time resolution of 186 ps is obtained. For irradiation of the entire scintillator the energy resolution is 37 % and the time resolution amounts to 960 ps. Systematic irradiations on nine small spots across the entire surface area of the scintillator were made to determine the light attenuation, the pulse-height resolution and the time delay versus location. A correction procedure was developed to take into account the spatial effects, thus reducing the energy and time resolution for whole area irradiation to 28 % and 240 ps, respectively. The procedure is applicable for multi-energetic α-particle sources since it relies on the measurement of pulse-height ratios. A communication about the detection system has been published.

A Specific Light Ion "dE-E-T" Telescope

E. Wattecamps, G. Rollin

A telescope was developed and tested. It is specific in its particle identification, and is used at the 7 MeV-300 ps burst-width Van de Graaff accelerator. The telescope is made of two multi wire parallel plate avalanche counters (MWPPAC), providing energy loss dE and time T, and a hexagonal pilot-U scintillator, viewed by two photomultipliers, providing time T and energy E. By measuring the ratio of amplitudes on opposite sides of the scintillator, and by applying an on-line time- and pulse-height-correction procedure the time resolution of the pilot-U scintillator could be reduced to 300 ps and the pulse-height resolution from 35 to 28 %. Two-dimensional spectra of dE versus E, and E versus time-of-flight, are measured for ^{241}Am and for samples of nickel and tantalum, irradiated by 8.0 MeV neutrons. Particle energy spectra with outstanding foreground to background ratio and reasonable statistical accuracy have been deduced in short acquisition times.

A paper on this subject was presented at the International Conference on Nuclear Data for Science and Technology, held in Jülich.

SPECIAL STUDIES

Spin Assignment of ^{238}U p-Wave Resonances

F. Corvi, H. Postma*, F. Gunsing**, A. Mauri***, K. Athanasopoulos

Since the discovery of the parity-violating nature of the weak nuclear interactions, which are responsible for e.g. beta-decay, one has searched for admixing of nuclear states with opposite parity, but the same spin. Due to the weakness of this interaction compared to the strong nuclear forces, which are largely responsible for nuclear structure, only very small parity mixing of the order of one part per million is normally expected. However, when nuclear levels with the same spin but opposite parity are very close together, a more substantial mixing may be expected. Notably, this is the case for p-wave and s-wave neutron resonances with spin I ± 1/2, where I is the spin of the target nucleus. Parity mixing can be observed in transmission of polarized neutrons through targets of unpolarized nuclei. Recent work at Los Alamos demonstrated that in fact a fairly large number of p-wave resonances of ^{238}U and ^{232}Th show parity mixing(1,2).

The main task of the present investigations is to interpret (and in a certain way to check) the results recently obtained in Los Alamos. In fact, parity non-conservation should only be observable in p1/2 resonances since s-waves (which have spin J = 1/2 in both ^{238}U and ^{232}Th) can only be mixed with p1/2 and not with p3/2 waves. A knowledge of the spins of the concerned resonances allows a better determination of the average strength of the weak interaction.

The spin assignment method used consists of measuring with a high resolution Ge detector the neutron capture γ-ray spectrum in single p-wave resonances of ^{238}U. Since the population of the low-lying levels reached by the gamma cascade depends strongly on the initial spin, the relative intensities of the γ-ray transitions de-exciting them are a signature of the spin of the relevant neutron resonance.

A preliminary measurement was carried out at GELINA using a flight distance of 12.84 m. A metal disc of depleted ^{238}U of 11.5 cm diameter and weight 260 g was viewed by a large coaxial Ge detector and data were collected in the neutron energy range from 10 to 1000 eV. The results are currently being analysed. A fit of a limited part of the low energy γ-spectrum is shown in Fig. 9 for the 20.9 eV s-wave and for the 89.2 eV p-wave, respectively. One may notice that the 539.9 keV transition de-exciting a $J^{\Pi} = 5/2^-$ state is comparatively more intense in the 89.2 eV than in the 20.9 eV resonance. This is an indication that the spin of the 89.2 eV is J = 3/2.

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*** National expert from ENEA, Bologna, Italy
(1) J.P. Bowman et al., Phys. Rev. Lett. 65 (1990) 1192
(2) C.D. Bowman et al., Phys. Rev. Lett. 67 (1991) 564

Anyway, a purer sample and a run with higher statistics are needed in order to derive this kind of information for a sizeable number of p-waves.

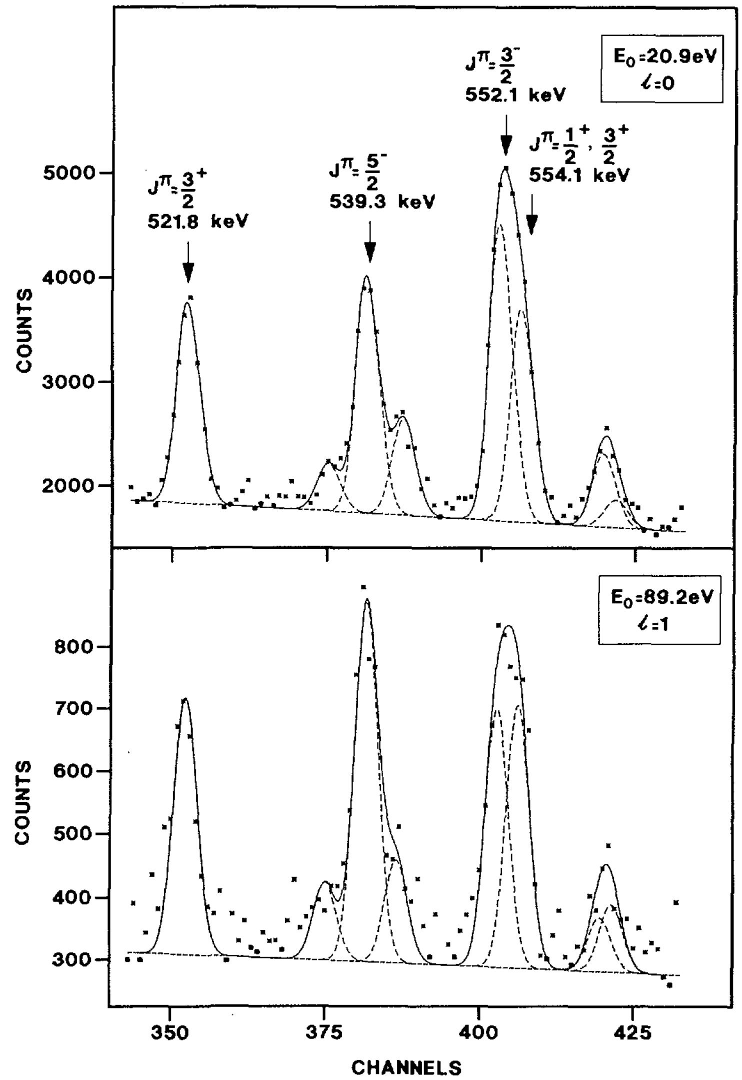

Fig. 9. ***Plot of the fitted γ-ray spectrum in the range 515-570 keV following neutron capture in the 20.9 eV and 89.2 eV resonance, respectively. The transition energy, spin and parity of the corresponding excited state is given above the most important peaks***

Measurement of γ-ray Spectra from Single Levels Excited by Neutron Capture in ^{53}Cr

C. Coceva*, A. Spits**, G. Fioni***, A. Mauri•

The measurement program on ^{53}Cr was completed and the absolute efficiency of the Ge-telescope detector was determined in the full energy range up to 10 MeV. A preliminary analysis was carried out using only approximately one third of

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• National Expert from ENEA, Bologna, Italy

the collected data. On this basis a contribution was presented at the 1991 International Conference on Nuclear Data for Science and Technology held in Jülich.

In the experiment on the partial radiative widths of neutron resonances of ^{53}Cr, neutron energy is selected by time-of-flight and gamma-ray energy is measured by a Ge-crystal with anticoincidence shielding. Partial widths are measured for single s-wave resonances from 4 to 30 keV. An improved Average Resonance Capture method is applied to p-wave resonances from 13 to 70 keV. Transition probabilities are obtained for states with excitations up to 4.3 MeV. A new method is described to deduce absolute values of $\Gamma_{\gamma i}/\Gamma_\gamma$. Estimates are obtained of E1 and M1 strengths and of their energy dependence.

Fig. 10 shows the time-of-flight spectrum. Shaded areas indicate 30 time-of-flight intervals in which separate gamma spectra were measured.

From this preliminary analysis, the following strengths were obtained for electric dipole and magnetic dipole radiations:

$< k_\gamma (\Gamma_\gamma)/A^{2/3} >_{E1} = 1.5 \times 10^{-9}\ \mathrm{MeV}^{-3}$

$< k_\gamma (E_\gamma) >_{M1} = 8.9 \times 10^{-9}\ \mathrm{MeV}^{-3}$

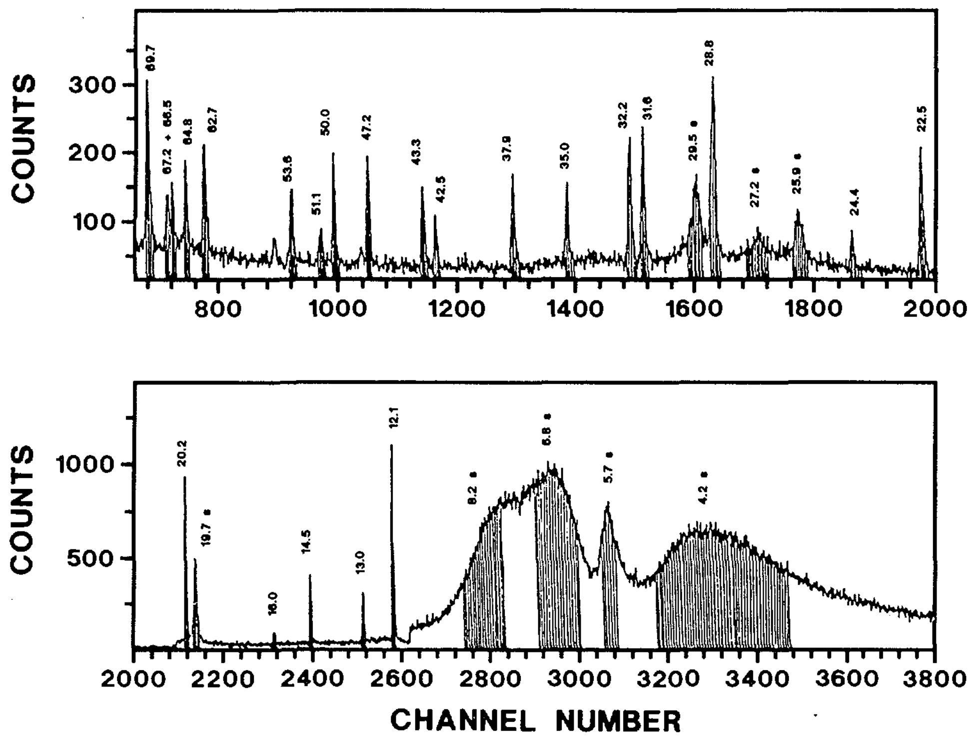

Fig. 10. Time-of-flight spectrum of γ-rays from neutron capture in ^{53}Cr. Resonance energies are in keV

Both values are significantly smaller than previously estimated average values, based on the whole atomic mass range.

The energy behaviour of the reduced E1 widths is shown in Fig. 11. The full line, corresponding to an E_γ^2 law, is the best fit to the experimental reduced widths, in agreement with the Brink-Axel hypothesis on the giant E1 resonance built on excited states.

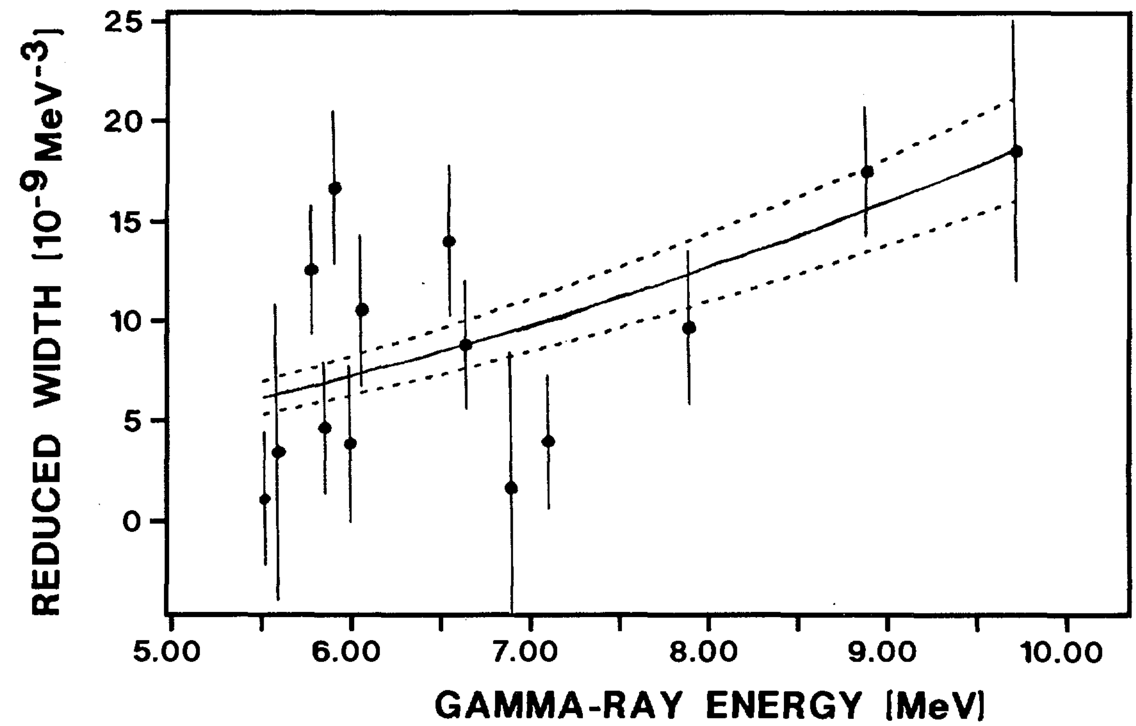

Fig. 11. Behaviour of the reduced E1 widths vs transition energy

Present results are not in disagreement with a constant energy behaviour of M1 reduced widths. However, this is of little significance because of the poor statistical accuracy of the experimental data considered in this analysis.

Spin Values of Nuclear levels in ^{192}Ir Deduced from Neutron-Capture Gamma Rays

C. Coceva*, P. Giacobbe**

According to the "population ratio" method[1], the spin of a low-excitation level can be deduced by comparing the intensities of its gamma decay in the neutron-capture γ-ray cascades originating in resonances having different spins.

An account of such population ratios experiments, performed on a natural iridium target at GELINA, was published[2] earlier. The same experimental data have now been re-analyzed in the light of new information available on the

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(1) C. Coceva, P. Giacobbe, F. Corvi, M. Stefanon, Nucl. Phys. A218 (1974)61
(2) C. Coceva, P. Giacobbe, Neutron Capture Gamma-ray Spectroscopy, R.E. Chrien, W.R. Kane ed. Plenum Press, 1978, p.588

level scheme of ^{192}Ir. The results are summarized in Table 4. The new information was included in a comprehensive paper on the nuclear level scheme of ^{192}Ir, written as a joint effort of 10 different institutions, co-ordinated by J. Kern.

Table 4. Population ratios R deduced from observed transitions and spin assignments of initial levels

Transition energy [keV]	R	Spin	Initial level [keV]	Transition energy [keV]	R	Spin	Initial level [keV]
118.8	>1.5	3,4	118.78	261.9	1.35±0.21	2	366.72
179.0	0.85±0.09	1	235.75	148.8	1.04±0.40	1,2	389.71
151.6	2.33±0.50	3	267.12	124.8	> 1.5	(2) 3,4	unknown
183.6	1.51±0.41	2,(3)	288.39	180.7	0.91±0.20	1,(2)	unknown
206.2	1.08±0.20	} (1),2	310.99	190.2	>2.0	3,4	unknown
254.3	0.97±0.16			193.7	>2.5	3,4	unknown
126.9	>6.0	4	319.89	216.9	3.0±1.0	3	unknown
187.5	1.14±0.42	} 2	331.07	222.5	0.87±0.17	1,(2)	unknown
226.3	1.08 ±0.12			250.7	1.35±0.26	2	unknown
267.4	1.25±0.35	(1),2	351.69	259.3	1.60±0.45	2,3	unknown

NUCLEAR METROLOGY

RADIONUCLIDE METROLOGY

The objective of the work on radionuclide metrology is to advance the experimental know-how in the field of radioactivity. This is done in four major areas: the determination of decay-scheme data, the improvement and development of measurement techniques, the preparation of particular standard and reference samples and the participation in international comparisons and evaluations.

Asymmetry of Peaks in Alpha-Particle Spectra

G. Bortels, E. Steinbauer*, P. Bauer*

Monte-Carlo calculations using a modified version of the TRIM code (TRansport of Ions in Matter) have been made which indicate strongly that the asymmetry in the alpha peak shape may be attributed to elastic collisions of the alpha particles and the silicon nuclei in the detector lattice. The work can provide essential information on the validity of the convolution model used in alpha-peak fitting. The results of the calculations are compared with measurements of ^{148}Gd, ^{238}Pu, ^{240}Pu and ^{244}Cm. The work is continuing.

Low-Energy X-Ray Standards

B. Denecke, G. Grosse, T. Altzitzoglou

The method to produce metallic deposits of ^{55}Fe on thin copper rings in an electrolytic cell was further developed. The punched 0.05 mm thick copper rings were replaced by precisely machined more solid and geometrically stable rings of 0.5 mm thickness. Strongly adherent layers of iron could be produced. A holder for the preparation of 3 mm diameter layers of 100 MBq ^{55}Fe on 8 mm diameter copper backings has been constructed and tested. The ^{55}Fe layers were covered with thin beryllium foils and all source parts were glued together under vacuum. From a low activity ^{55}Fe solution quantitative sources were made in order to determine the yield of the electrolytic deposition of iron. A gas proportional counter with a vacuum source chamber has been set up to measure the highly active ^{55}Fe deposits under a defined low solid angle.

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* Johannes Kepler University, Linz, Austria

Efficiency Calibration of Photon Detectors

T. Altzitzoglou, L. Delfosse

An efficiency calibration of the photon detectors in use for X- and gamma-ray measurements has been started. To the present, a HPGe detector has been calibrated for four different source-detector distances. Several standard sources of radionuclides emitting photons of one or two energies have been used, along with multi-gamma sources (e.g. ^{152}Eu) corrected for the summing effect. Corrections for the dead time and the self attenuation were applied. The data acquisition for the efficiency calibration of this and other solid state detectors is in progress.

Standardization of ^{192}Ir

D.F.G. Reher, E. De Roost, G. Sibbens, B. Denecke, T. Altzitzoglou, M.J. Woods*, C. Ballaux**, E. Funck***

During the current work of EUROMET project no. 219 on the metrology of ^{192}Ir brachytherapy sources, the activity of such sources had to be measured.

^{192}Ir brachytherapy sources consist of thin iridium wires, typically 0.1 mm thick, surrounded by an inactive envelope of platinum. Such wires cannot be standardized directly; a comparison with an absolutely standardized solution is necessary. On the other hand, ^{192}Ir is difficult to standardize, as it decays by electron capture to ^{192}Os (4.7 %) and by β^-decay to ^{192}Pt (95.3 %).

NPL and CBNM exchanged two solutions and standardized them independently, using the $4\pi\beta$-γ-coincidence method. CBNM also used a 4πCsI spectrometer sandwich and the 4π-γ-counting method. The overall uncertainty of the result was 0.3 %, corresponding to one standard deviation. Traceability was established to BIPM for the ^{192}Ir activity measurements.

Second EUROMET Intercomparison of ^{192}Ir Brachytherapy Sources

D.F.G. Reher, G. Sibbens

In 1990 the first EUROMET intercomparison of ^{192}Ir brachytherapy sources had been organized among four laboratories (NPL, RUG, NMI, CBNM). Air kerma rate and activity measurements were carried out, and the spread of the results was 5 %. This was regarded as unsatisfactory, and hence a new comparison was organized with four additional laboratories (NIRH, SSI-NIRP, JAERI, NRC). A

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first evaluation of the results shows that activity and air kerma rates of ^{192}Ir brachytherapy sources can be measured with less than 2 % uncertainty.

Measurement of K-Shell Fluorescence Yields
V.A. Solé*, B. Denecke, D. Mouchel, G. Grosse, W. Bambynek

Following a review on K-shell fluorescence yields for elements with atomic number below thirty, the fluorescence yield of iron has been measured by means of a (γ-ray)-(X-ray) coincidence method. Measurements of the same parameter for copper using the same method were performed. Data evaluation is in progress.
In order to measure fluorescence yields of other elements by means of X-ray excitation of solid targets an ultra-high-vacuum chamber with a windowless Si(Li) detector has been set-up. The X-ray excitation sources will be produced by electrodeposition of ^{55}Fe. Electrodeposition of inactive iron on copper was performed successfully. A Monte Carlo program to simulate excitation of multielemental targets and a program for peak analysis of X-ray spectra have been developed.

Measurement of Low-Level Radioactivity in Environmental Samples
D. Mouchel, R. Wordel

Field sampling of common meadow plants, *phragmites communis,* and *juncus communis* has been performed. Gamma-ray measurements, performed on dry matrices after treatment of the fresh materials, indicate low-level radioactivity contents of the nuclides ^{134}Cs, ^{137}Cs, ^{60}Co, ^{232}Th, ^{226}Ra, ^{7}Be and ^{40}K distributed in the plants. It can be concluded that both selected plants are suitable bioindicators to measure the distribution of some anthropogenic and natural radionuclides in the environment. This work was presented at the ICRM Symposium on Low Level Measuring Techniques and Alpha-particle Spectrometry held in Monaco and has been published.

Measurements on Volcanic Rocks
R. Wordel, D. Mouchel

On request and in collaboration with the University of Leuven, measurements of volcanic-rock-powder samples using a low-level HPGe γ-ray detector system were done, in order to study the disequilibrium between ^{238}U and ^{230}Th,

* EC Fellow from the University of Valencia, Spain

respectively ^{230}Th and ^{226}Ra. From these values one can obtain information on the age of the rocks. The decay series arising from ^{232}Th and ^{238}U and ^{235}U contain radionuclides of many different elements. The daughters of uranium or thorium may be separated from their parents and from each other during geochemical processes like melting of rock in the earth mantle and crystallisation of the magma on its way to the surface of the earth. Due to their half lives and assuming that the geochemical processes act instantaneously, the disequilibrium between ^{238}U and ^{230}Th, and ^{230}Th ^{226}Ra lasts 300 000 and 8 000 years, respectively. A report is in preparation.

TECHNICAL APPENDIX

Electron Linear Accelerator

J.M. Salomé

The GELINA electron beam was available during 1831 h for physics experiments.
Neutrons are produced in a rotary uranium target via (γ,n) and (γ,f) reactions. According to the requested neutron energies, various moderators are placed on both sides of the target. Twelve flight paths are equipped for neutron time-of-flight experiments. On the average, 4.8 neutron beams were used simultaneously when GELINA was operated at very short bursts and 3.7 when operated in other conditions. This neutron source is installed on the O° electron beam line.
On one side of this main line, between two magnetic deflections, are performed Transition Radiation Experiments. Very low beam currents (< 1 μA peak, 2 ns pulse length) are produced to allow X-ray spectra measurements with a Si(Li) detector. Another magnetic deflection has been set up on the opposite side in view of other applications as Photon Activation Analysis.
Several maintenance works were achieved on the building and the accelerator a.o. a new air extraction system for the target room, an improved master pulse generator and a "biological" wall for protection of personnel.
Some parts of the accelerator, specially the focusing coils, are in a very bad condition and put in danger the operation of the machine. In view of the extended programme of this facility and the improved parameters which will be requested for the new applications in Radiation Physics, a project of modernization and the feasibility of an experimental room are being studied.

Study of Transition Radiation

X. Artru*, P. Dhez**, P. Goedtkindt***, N. Maene•, F. Poortmans•, P. Rullhusen, J.M. Salomé, P. ter Meer, F. Van Reeth, K. Riemenschneider, L. Wartski**

Transition Radiation (TR) is generated when energetic electrons cross the boundary between two media. The radiation can extend from microwave to X-ray frequencies and is emitted into a narrow cone in forward direction.

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*** EC Fellow from the VUB, Brussels, Belgium
• SCK/CEN, Mol, Belgium

At the deflected beamline II of GELINA a setup to produce transition radiation was installed. Several precautions were taken in order to monitor the electron beam at the very low currents needed to be able to characterize the radiation using a high-resolution Si(Li) detector. The spectra and angular distributions of soft X rays emitted by different radiators were measured. Fig. 12 shows a spectrum produced by a stack of 11 aluminium foils of 0.8 μm thickness each. These measurements will be continued in order to find optimal conditions for the production of high-intensity X-ray beams useful for applications, when experiments will become possible at the direct beamline I.

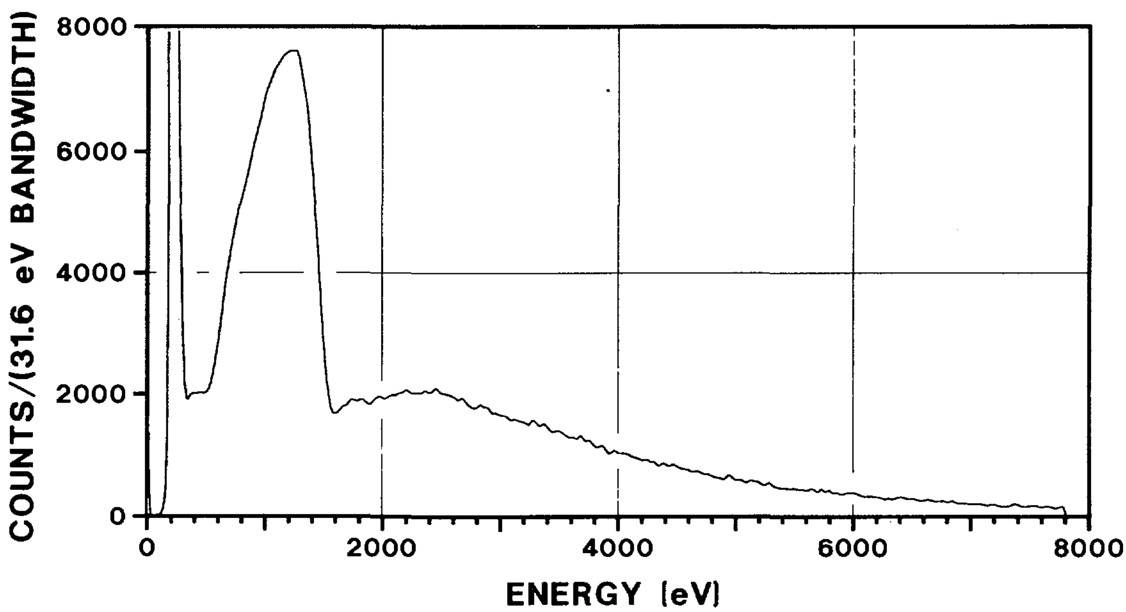

Fig. 12. *X-ray transition radiation from a stack of 11 aluminium foils of thickness 0.8 μm. Measured with a Si(Li) detector*

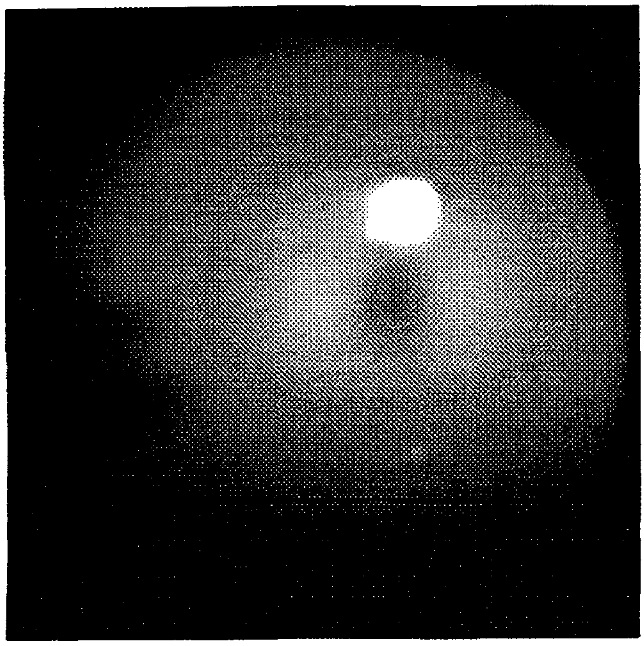

Fig. 13. ***Optical transition radiation used in electron beam parameter measurements***

In a second experiment a 1.5 μm aluminized mylar foil was introduced into the direct beam line of the accelerator and the optical transition radiation emitted at 90° to the beam axis was used to measure simultaneously the size and angular divergence of the electron beam.

Fig. 13 shows the optical transition radiation as measured with a CCD camera. The white spot indicates the image of the heated cathode of the accelerator. From the analysis of the angular distribution the energy of the electrons, the divergence of the beam and, with knowledge of the beam size, the beam emittance can be determined. The development of computer codes for these evaluations are in progress and will eventually result in an online monitoring system for the operation of the accelerator.

Van de Graaff Accelerators

A. Crametz, P. Falque, J. Leonard, W. Schubert

The total working time of the two accelerators was 2736 hours. The CN-7MV Van de Graaff has been opened twice, the first time for the replacement of the RF ion source after 1390 working hours and the second time for repair of the gas selector.

A fifth beam tube extension (L_2) has been fully installed at level 4.6 m for the ^{237}Np(n,f) experiment. The fence around the neutron target at zero level was removed as well as the ^{137}Cs γ-ray source. Equipment was installed for accelerator-based nuclear analytical techniques namely for nuclear reaction analysis (NRA) and for charged particle activation analysis (CPAA).

CBNM Computer Network

C. Bernard, C. Cervini, H. Horstmann, C. Van den Broeck*, P. Van Roy

A number of improvements have been made in order to increase the functionality of the CBNM computer network:

- The X.400 message handling systems of the IBM 4381 computing server and the XEROX office automation system have been combined.
- The job entry subsystems (JES) of the mainframe computers at Ispra and Geel have been connected across public X.25 lines.
- The XEROX mailsystem can now make use of IXI for communications with the JRC Institutes at Ispra.
- The software product SNAPAD has been installed to give IBM 4381 users access to any data processing system on the X.25 public network.
- For the support of distributed printing of text and graphics the software package VPS (VTAM Printer Support) has been installed on the IBM 4381.
- The Informatics Plan '92-'96 for CBNM[1] has been prepared. It describes objectives, strategies and their budgetary implications.

PC Based Program for Analysis of Alpha Particle Spectra

T. Babeliowsky, G. Bortels

The CBNM computer program for interactive analysis of alpha spectra which uses a convolution-type peak-fitting model[2] has been converted to a version for PC. It has been used sucessfully for accurate analysis of complex alpha spectra. The program allows for tailing subtraction, which in the case of plutonium spectra for safeguards greatly facilitates the analysis of the ^{238}Pu + ^{241}Am components. The program is written in APL2/PC, with time consuming calculations implemented in ASM. Also graphical display of spectra and fitted tail, windows, peaks etc. is done via compiled code. Mouse and cross hairs are available for window selection and input of peak parameters. Relevant data are stored on the PC hard disk together with the spectrum. Numerical and graphical output on a printer is provided. Tests on a 486 based PC have shown the high speed and versatility of the program.

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* Comparex, Brussels, Belgium

(1) H. Horstmann, CBNM Internal Report GE/R/DE/7/91

(2) G. Bortels and P. Collaers, Appl. Radiat. Isot. A38 (1987) 831

Multiparametric Event Acquisition and Analysis Using Transputers

C. Bastian, S. de Jonge, J. Gonzalez

An improved version of the event coder module (multiplexer) was designed in order to process high peak count rates. The four ADC data inputs are buffered by 512 words FIFOs with 200 ns dead time. The buffer output is serialized and fed into 2 links of a 16-bit transputer. The coincidence logic at FIFO input and the serialization at FIFO output are performed by programmable gate arrays. The transputer performs the proper event coding to a sequence of coincidence pattern plus data words. Up to four event coding modules can be chained to a 16-parameter multiplexer.

A software workbench was designed to test user written event processors in keyboard-screen dialog. Blocks of event processors thus tested can be implemented in realtime analysis programs on networks of 32-bit transputers.

Concurrently, a transputer interface to a magneto-optical disk is being prepared to complement the line of event acquisition/event analysis modules with an event list storage module of large capacity.

Development of a Time Discriminator

S. de Jonge, K. Hofmans

A time discriminator in a single width NIM module with a start and a stop input has been developed. The start signal generates a delayed time window and stop signals appearing within the window will cause an output. The lengths of the window can be switched to 0.25, 0.5 and 1 µs. The delay is fine adjustable by a helipot. A ramp output is provided for monitoring, where the ramp is intensified at the moment a stop signal is accepted within the adjusted time range.

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GLOSSARY

AERE	Atomic Energy Research Establishment, Harwell (GB)
ANL	Argonne National Laboratory, Argonne (USA)
BIPM	Bureau International des Poids et Mesures, Sèvres (F)
CBNM	Central Bureau for Nuclear Measurements (JRC-Geel), Geel (B)
CEA	Commissariat à l'Energie Atomique, Paris (F)
CEC	Commission of the European Communities
CERN	Centre Européen pour la Recherche Nucléaire
CIEMAT	Centro de Investigación Energética, Medio Ambiental y Tecnología
CRNS	Centre National de la Recherche Scientifique
CRP	Coordinated Research Programme
DFN	Deutsches Forschungsnetz
DG	Direction Générale
EC	European Community
EFF	European Fusion File
ENDF	Evaluated Nuclear Data File
ENEA	Comitato Nazionale: Energia Nucleare e Energia Alternative
FWHM	Full Width at Half Maximum
GELINA	Geel Electron Linear Accelerator
IAEA	International Atomic Energy Agency, Vienna (A)
ICRM	International Committee for Radionuclide Metrology
ILL	Institut Laue-Langevin, Grenoble (F)
INDC	International Nuclear Data Committee
IPN	Institut de Physique Nucléaire, Lyon (F)
IRK	Institut für Radiumforschung und Kernphysik, Wien (A)
JAERI	Japan Atomic Energy Research Institute, Tokai-Mura (Japan)
JEF	Joint European File
JENDL	Japanese Evaluated Data Library
JRC	Joint Research Centre
KFA	Kernforschungsanlage, Jülich (D)
KFK	Kernforschungszentrum Karlsruhe, Karlsruhe (D)
KU	Katholieke Universiteit, Leuven (B)
LURE	Laboratoire pour l'Utilisation du Rayonnement Electromagnétique
NBS	National Bureau of Standards, Gaithersburg (USA)
NEA	Nuclear Energy Agency, Paris (F)
NEANDC	Nuclear Energy Agency's Nuclear Data Committee
NIRH	National Institute of Radiation Hygene, Osteras (N)
NIST	National Institute of Standards and Technology, Gaithersburg (USA)
NMI	Nederlands Meetinstituut, Bilthoven (NL)
NPL	National Physical Laboratory, Teddington (GB)

N R C	National Research Council, Ottawa (CAN)
P T B	Physikalisch-Technische Bundesanstalt, Braunschweig (D)
R U G	Rijksuniversiteit Gent, Ghent (B)
S C K/ C E N	Studiecentrum voor Kernenergie/ Centre d'Etudes Nucléaires, Mol (B)
S I R	Système International de Référence
S S I - N I R P	Statens Strålskyddinstitut - National Institute for Radiation Protection, Göteborg (S)
T O F	Time of Flight
T R	Transition Radiation
W R E N D A	World Request List for Neutron Data Measurements

CINDA ENTRIES LIST

ELEMENT		QUANTITY	TYPE	ENERGY		DOCUMENTATION		LAB	COMMENTS
S	A			MIN	MAX	REF VOL PAGE	DATE		
Cf	252	SF	EXPTL-PROG	SPON		INDC(EUR)026-06	-92	GEL	HAMBSCH + KNITTER COLD FRAGMENTATION
Np	237	NF	EXPTL-PROG	30 + 5	55 + 6	INDC(EUR)026-07	-92	GEL	SIEGLER + HAMBSCH NEUTRON IND. FISSION
Pu	241	NF	EXPTL-PROG	20-3	10 + 1	INDC(EUR)026-12	-92	GEL	WAGEMANS SUBTHERMAL XSECTION
U	235	NG	EXPTL-PROG	COLD		INDC(EUR)026-14	-92	GEL	WEIGMANN RATIO NG/NF
U	238	NG	EXPTL-PROG	20 + 2	80 + 2	INDC(EUR)026-22	-92	GEL	CORVI SPIN ASSIGNM. P-WAVES
Cr	053	NG	EXPTL-PROG	40 + 3	30 + 4	INDC(EUR)026-23	-92	GEL	COCEVA GAMMA RAY SPECTRA
Fe	056	NG	EXPTL-PROG	10 + 3	30 + 5	INDC(EUR)026-15	-92	GEL	CORVI RESONANCE NEUTRON CAPTURE
Ni	058	NG	EXPTL-PROG	10 + 3	30 + 5	INDC(EUR)026-16	-92	GEL	BRUSEGAN RES. PARAM. FROM TRANSM.
Ni	060	NG	EXPTL-PROG	10 + 3	55 + 5	INDC(EUR)026-16	-92	GEL	BRUSEGAN RES. PARAM. FROM TRANSM.
U	238	TOT	EXPTL-PROG	17 + 2	20 + 2	INDC(EUR)026-18	-92	GEL	BRUSEGAN COMP. CALC/MEASURED
Ni	058	NNA	EXPTL-PROG	50 + 6	14 + 7	INDC(EUR)026-19	-92	GEL	WATTECAMPS DOUBLE DIFF.
Ni	060	NNA	EXPTL-PROG	50 + 6	14 + 7	INDC(EUR)026-19	-92	GEL	WATTECAMPS DOUBLE DIFF.
Cu	063	NNA	EXPTL-PROG	50 + 6	14 + 7	INDC(EUR)026-19	-92	GEL	WATTECAMPS DOUBLE DIFF.
Cu	065	NNA	EXPTL-PROG	50 + 6	14 + 7	INDC(EUR)026-19	-92	GEL	WATTECAMPS DOUBLE DIFF.

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