NEANDC (OR) - 154 / L
INDC (SWT) - 14 / L

PROGRESS REPORT TO NEANDC FROM SWITZERLAND

May 1980

F. Widder
Swiss Federal Institute for Reactor Research
Würenlingen

PREFACE

This document contains information of a preliminary or private nature and must be used with discretion. Its contents may not be quoted, abstracted, reproduced, transmitted to libraries or societies or formally referred to without the explicit permission of the originator.

CONTENTS

I. Institut de Physique, Université de Neuchâtel

1. The n-d elastic differential cross section at low energy

Ch.-H. Godet and J. Weber

Our results {1} at E_n = 2.48 MeV and $\cos\theta_{CM} < -0.8$ are very different from earlier results {2}. Therefore we have decided to confirm these results through another experimental method, namely the use of a C_2-H_2-D_2 polyethylene target and a surface barrier detector telescope (ΔE,E) {3}. The neutrons are produced by the D(d ,n)^{3}He reaction; the detection of the ^{3}He associated particle allows an appreciable signal to background ratio enhancement through time-of-flight spectrometry. This experimental set-up is currently under extensive tests.

Meanwile we are preparing the measurement of the n-d elastic differential cross section at 2.0 MeV which is not well known yet {2}.

References

{1} P. Chatelain, Y. Onel and J. Weber, Nucl. Phys. A319 (1979) 71.

{2} M.D. Goldberg, V.M. May and J.R. Stehn, Brookhaven Nat. Lab. Report, BNL-400, vol. 1 (1962).

{3} L. Amtén, L. Gönczi, A. Johansson, L. Nilsson and B. Sundqvist, Tandem Lab. Reprot, Uppsala (1976), TLU 26/74 (revised version).

2. The ERA analysis of the (n-d) cross section and depolarization data

R. Viennet and J. Weber

Our ERA code {1} has been modified so as to be able to include higher partial waves than $\ell = 2$ on one hand, and on the other hand, to include our depolarization {1,2} results as data to be fitted. This new code is currently under test.

References

{1} D. Bovet, P. Chatelain, R. Viennet and J. Weber, J. Phys. G 4 (1978) 1313.

{2} P. Chatelain, Thesis, Université de Neuchâtel (1979); Progress Report to NEANDC from Switzerland, p. 3, June 1979 .

3. Proton analyzing power measurement in the D (p,2p)n reaction

P. Chatelain, F. Foroughi, H. Vuillème and Ch. Nussbaum

For an incident energy of 22.7 MeV, we measured the proton analyzing power A_y, for a symmetric coplanar configuration ($\theta_1 = -\theta_2 = 41{,}7^{o}$), in a complete deuteron breakup experiment.

A coplanar configuration implies that $A_x = A_z = 0$ {1}, therefore the measure of A_y needs less modifications {2} of two body methods than otherwise. The choice of a symmetric configuration allows the elimination of some artificial asymmetries {3}. We used a deuterium gas target in order to minimize the rate of unwanted events (no contaminant). A preliminary study {4} guided us for the choice of material for the cell windows. The entrance and exit windows are respectively made of Havar (2,5 µm) and Al (10 µm). The lateral windows (through which low energy protons travel) are in Kapton (10 µm). The analyzing power reaches large values for low proton energy (less than 1 MeV).

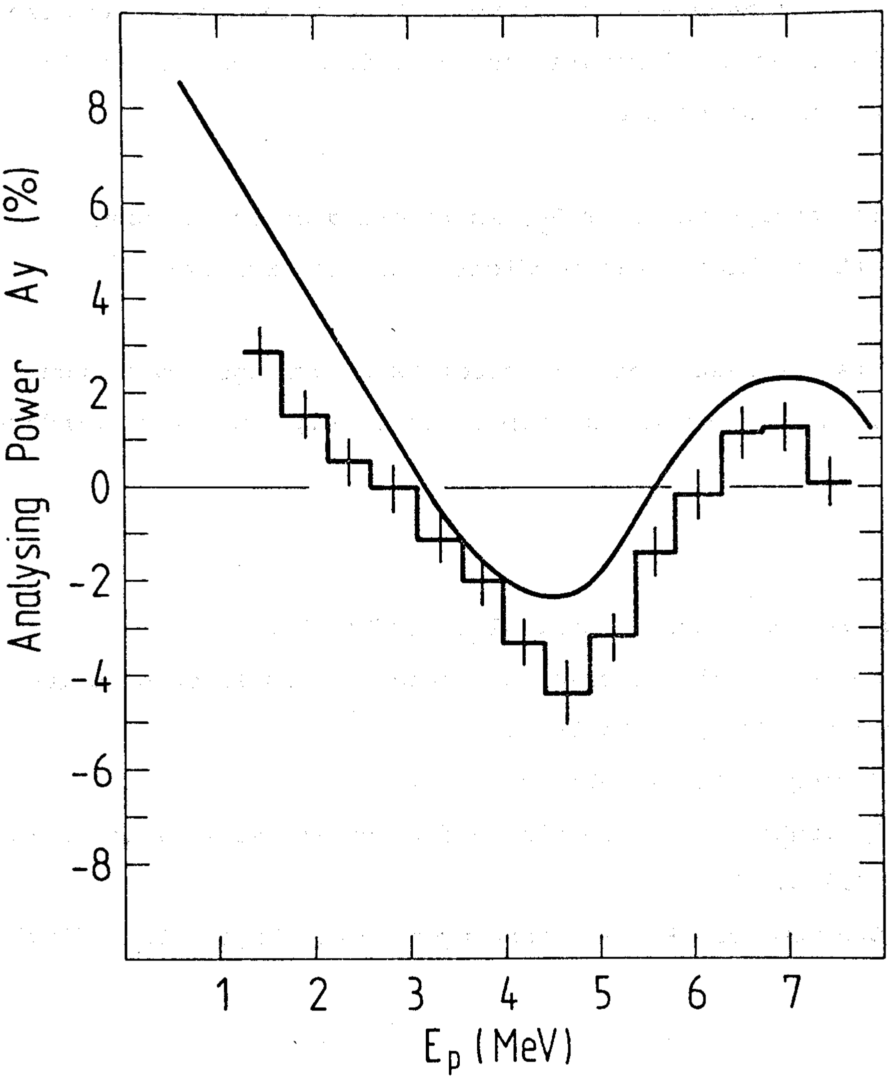

Figure:

Measured proton analyzing power. The curve is the result of a theoretical prediction by Bruinsma et al. {5}, averaged over instrumental effects.

Therefore no particle identification was possible. The outgoing breakup protons were detected by two 3 mm thick Si surface barrier detectors. The time-of-flight between the two detectors was also measured in order to eliminate some artificial asymmetries {3} produced by the background.

The measured analyzing power A_y, is reported on the figure, together with a theoretical prediction due to Bruinsma {5}.

The curve is the result of this prediction averaged over angular apperture, energy loss and multiple scattering, in target windows.

References

{1} L.D. Knutson, Nucl. Phys. A198 (1972) 439.

{2} F. Foroughi, 5ème session d' études, biennale de physique nucléaire, Aussoix (1979), LYCEN 7902.

{3} F. Foroughi, to be published.

{4} F. Foroughi, B. Vuilleumier and E. Bovet, Nucl. Inst. & Meth. 159 (1979) 513.

{5} J. Bruinsma and R. Van Wageningen, Nucl. Phys. A282 (1977) 1.

II. Institut de Physique, Université de Fribourg

1. Nuclear levels in ^{242}Am

M. Gasser and J. Kern

The analysis of the data on the ^{241}Am (n,γ) ^{242}Am reaction which were collected with the pair spetrometer at EIR (Eidg. Institut für Reaktorforschung, Würenlingen) has been completed. The interpretation of these results should have been performed together with those of other groups. Due to various difficulties, these other experiments are not yet complete or the results are of insufficient quality. We have therefore till now only a partial interpretation of our own results (see figure) which is presented in {1}. Some interesting anomalies in the intensity of the primary γ-rays have been observed, which do not seem to result from statistical fluctuations. A possible explanation would be that the capture state and low energy levels have different deformations, a problem which deserves our future attention.

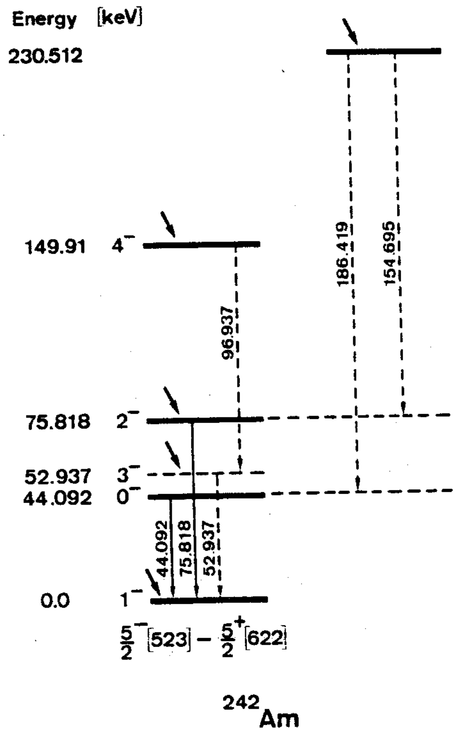

Figure:
Partial level scheme of ^{242}Am

References

{1} M. Gasser and J. Kern,
Report of the University of Fribourg IPF-SP-008 (1979)

2. Study of the ^{165}Ho (α, 2n) ^{167}Tm reaction

S. Olbrich, V.A. Ionescu, J. Kern, Cl. Nordmann and W. Reichart

The reaction ^{165}Ho (α, 2n) ^{167}Tm was originally selected to test the performances of our instruments and methods. The γ-ray spectra have been observed for different α-beam energies between 21 and 27.3 MeV with a small Ge(Li) detector having a good energy resolution and with our Compton-suppression spectrometer (CSS) {1}. This yields so-called excitation curves. In a coincidence experiment 4 x 10^7 events have been registered on magnetic tape and subsequently sorted off-line; ∿140 gates have been examined. Finally angular distributions with a small (2,2 cm^3) and a large (50cm^3) semiconductor detector have been observed. All spectra have been analysed and the data interpreted. The points of particular interest are the following:

- Due to the good sensitivity of our CSS, 440 transitions have been observed, compared to 70 in previous works {2}, {3}.

- We have extended the level scheme from about 50 to more than 100 levels. In the hitherto known $7/2^-$(523), $7/2^-$(404), $1/2^+$(411) and $1/2^-$(541) rotational bands we have established 2 to 4 new levels in each. The highest spin state observed in 33/2 in the $1/2^-$(541) band. Since ^{165}Ho has a ground spin 7/2, we have thus observed the transfer of 13 ħ units of angular momentum. This value is exactly the maximum expected for a collision (at grazing incidence) of 27 MeV α-particles on our target.

- When we started our experiment, we were told by specialists in the field that we would not be able to observe levels in other bands than in the above mentioned Yrast bands. We therefore regard as a fine success the observations of four new rotational bands, one of them up to spin I = 27/2. A partial level scheme showing two of the new rotational bands, to which we have assigned the Nilsson configuration $3/2^{+}$(411) and $5/2^{+}$(402) is presented in the figure. The assignment of other two new bands are {$7/2^{+}$(404); K+2} and $3/2^{-}$(532) + {$1/2^{-}$(541); K-2}.

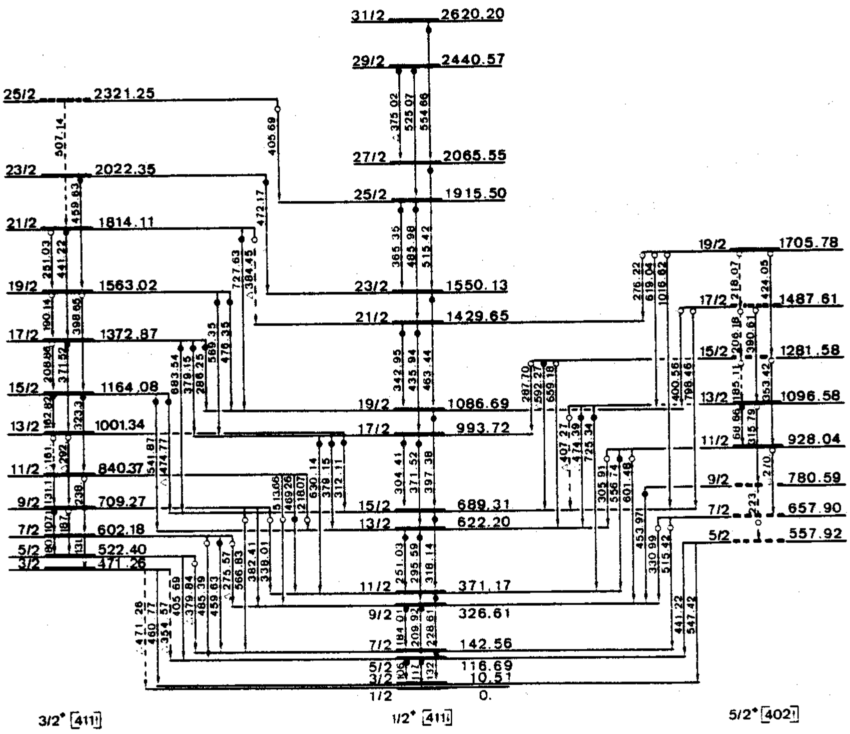

Figure: Partial level scheme of ^{167}Tm

- Several bands are perturbed. This is particularly the case for the $3/2^{+}$ (411) band. If we approximate the level energies by a simple rotational formula, we note diviations up to 30 keV. The fit is improved by including additional terms and by taking into account the Coriolis coupling between the 1/2 (411), 3/2 (411) and 5/2 (402) bands. The average deviation decreases to 2.2 keV. It must be stressed that the Coriolis interaction increases very strongly with the angular speed, so that the effects become very significant at high spins.

- We have observed the presence, confirmed by the coincidence experiments, of $\Delta K = 3$ transitions between the members of the $7/2^+$(404) and of the $1/2^+$(411) rotational bands. The correlation of this finding with similar phenomena in ^{165}Tm {4}, where initial and final states have the opposite signature, gives a strong indication for the existence of a effective $\Delta K = 3$ coupling.

References

{1} V. Jonescu, J. Kern, C. Nordmann, S. Olbrich and Ch. Rhême, Nucl. Instr. Meth. 163 (1979) 395

{2} G. Winter et al., Nucl. Phys. A151 (1970) 337

{3} Ann. Report ZfK Rossendorf 1972, p.66

{4} C. Foin et al., Phys. Rev. Lett. 35 (1975) 1967

3. Study of the ^{176}Yb (p,3n) ^{174}Lu reaction

J. Kern, J.B. Carlson, R.G. Lanier, L.G. Mann and G.L. Struble

In the deformed rare earth region, all doubly odd nuclei next to and on the neutron rich side of a stable isotope have been studied by (n,γ) and (d,p) reactions. This series of studies has been completed only very recently by a work of ^{152}Eu {1}.On the neutron deficient side the situation is quite different. In general the only information we have, has been gained by direct transfer reaction. Studies of these nuclei by (HI,xn) reactions are very sparse. These experiments would however provide the possibility to observe the effect of two unpaired particles on the moment of inertia at high angular velocity.

Our approach to this problem is rather cautious. We have selected the ^{176}Yb(p,3n)^{174}Lu reaction because many levels have been established by proton and neutron transfer reaction {2}. We are of course aware that we will not populate very high spins and not observe backbending.

In view of the expected difficulties, it is necessary to approach the problem by several different experiments: measurement of excitation functions, observation of prompt/delayed spectra and of coincidences and perhaps resolution of close multiplets with the crystal spectrometer. The study of prompt/delayed spectra was made in collaboration with a group in Livermore. Using a "multispectrum analysis" (MSA), we were able to observe many delayed transitions to establish the existence of two isomers (see fig.).

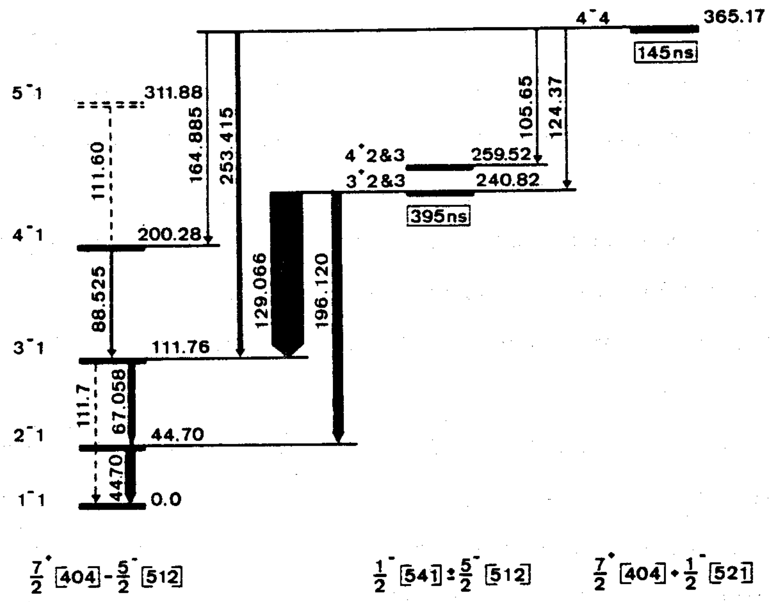

Figure: Partial level scheme for ^{174}Lu.

It is possible to understand qualitatively the hindrance factors of the observed transitions. A quantitative microscopic analysis is not yet possible.

References

{1} T. von Egidy et al., Z. f. Physik A286 (1978) 341

{2} R.A. O'Neil and D.G. Burke, Nucl. Phys. A195 (1972) 207

1. Absolute yields of ^{99}Mo and ^{132}Te in the reactor-neutron-induced fission of ^{232}Th

H.N. Erten, H.R. von Gunten and E. Rössler

Recently there has been a revival of interest in the study of Th-232 fission by reactor neutrons. This may be due to the possible use of Thorium as a breeding material as well as checking theoretical considerations of the fission process. The existence of a small third peak in the symmetric region of the mass-yield curve as was first observed by Turkevich and Niday {1} and subsequently by Iyer et al. {2} has not yet been neither well established nor well understood.

Together with the nuclides ^{89}Sr and ^{140}Ba, ^{99}Mo and ^{132}Te are important references in fission yield determinations. It may be seen from the recommended yield values of these nuclides in the fission of ^{232}Th by reactor neutrons that there still exist serious disagreements among various values.

In view of the above considerations a re-determination of the absolute fission yields of ^{99}Mo and ^{132}Te in the reactor-neutron-induced fission of ^{232}Th was undertaken.

The absolute measurement technique utilized in our work involves direct fission counting and is described in {3}.

Our results are averages of 10 different experiments. In the table a comparison with other published values is shown. Our result of $(2.98 \pm 0.15)\%$ for ^{99}Mo is in good agreement with previous experimental

Table: Published Values for the Yields of ^{99}Mo and ^{132}Te in the Reactor Neutron Induced Fission of ^{232}Th

Author	Fission Yield (%)	
	^{99}Mo	^{132}Te
a) Measurements		
Turkevich and Niday {1}	2.90 ± 0.30	2.40 ± 0.70
Coryell and Sugarman {4}	3.16 ± 0.47	1.91 ± 0.29
Kennet and Thode {7}		2.87 ± 0.02 *
Kabayashi et al. {8}		2.50 ± 0.30
Chauvin {9}	2.45 ± 0.32	2.70 ± 0.35 **
Brasca et al. {10}		2.62 ± 0.26
Deen {5}		1.90 ± 0.20
Iyer et al. {2}	2.78	
Crook and Voight {11}	3.10 ± 0.32	
Dubrovina et al. {12}	2.83 ± 0.44	
This work	2.98 ± 0.15	2.76 ± 0.16
b) Evaluations		
Rider and Meek {6}	2.87 ± 0.17	2.88 ± 0.08
Crouch {13}	2.96 ± 0.18	2.80 ± 0.21
Nethaway and Barton {14}	2.86 ± 0.11	2.67 ± 0.11
Recommended value (this work)	2.94 ± 0.04	2.77 ± 0.06

* Cumulative yield of ^{132}Xe

** Cumulative yield of ^{132}I

as well as evaluated values. Our result of (2.76 ± 0.16) % for ^{132}Te is also in good agreement with previous experimental and evaluated results except with those of Coryell and Sugarman {4} and of Deen {5}. Our experimental errors for both nuclides are however much smaller than most of the earlier measurements. Since most of the earlier measurements were relative measurements they need to be updated; in suggesting recommended values, we have therefore considered the means of evaluated values for ^{99}Mo (2.90±0.03) and for ^{132}Te (2.78±0.06) and our results. We recommend values of (2.94±0.04) % for ^{99}Mo and (2.77±0.06) % for ^{132}Te.

Based on the average number of neutrons emitted per fission $\bar{\nu}_T$=2.32 as given by Rider and Meek {6}, ^{99}Mo and ^{132}Te are expected to be nearly complementary products. A difference of about 8% in their yields may be due to 50 proton, 82 neutron shell effects on the neutron emission probabilities thus changing $\bar{\nu}_T$ significantly from its average value $\bar{\nu}_T$.

References

{1} A. Turkevich and J.B. Niday, Phys. Rev. 84, 52 (1951)

{2} R.H. Iyer, C.K. Mathews, N. Ravindran, K. Rengan, D.V. Singh, M.V. Ramaniah and H.D. Sharma, J. Inorg.Nucl. Chem. 25, 465 (1963)

{3} H.N. Erten, H.R. von Gunten and E. Rössler, Technical Report, EIR-TM-44-80-5

{4} C.D. Coryell and N. Sugarman, Radiochemical Studies: The Fission Products. National Nuclear Energy Series, Div. IV-9, Appendix B, Fission Yields, McGraw-Hill Book Co. Inc., New York (1951)

{5} J.R. Deen, Trans. Am. Nucl. Soc. 17 (1973) 531

{6} B.F. Rider and M.E. Meek, NEDO-12154 (1978)

{7} T.J. Kennett and H.G. Thode, Can. J. of Phys. 35, 969 (1957)

{8} K. Kabayashi and I. Kimura, Annual Report, Research Reactor Institute, Kyoto Univ. 3, 84 (1970)

{9} C. Chauvin, Thesis, Grenoble (1973)

{10} M. Brasca, A. Cesana, V. Sanguist, M. Terrani, Energia Nucleare 20, 691 (1973)

{11} J.M. Crook and A.F. Voigt, IS-558 (1963)

{12} S.M. Dubrovina, V.I. Novgorodtseva, L.N. Morozov, V.A. Pchelin, L.V. Chistyakov, V.A. Shigin, V.M. Shubko, Yadern. Fiz. 17, 470 (1973)

{13} E.A.C. Crouch, Atomic and Nuclear Data Tables, 19, 417 (1977)

{14} D.R. Nethaway and G.W. Barton, UCRL-51458 (1973)

2. Radioisotope yields and cross sections in As, Br and Rb targets bombarded with 580 MeV protons

A. Grütter

In order to investigate the possibility of producing radioisotopes for medical applications by means of spallation reactions of 580 MeV protons the irradiations of suitable target materials at the SIN accelerator {1} were continued. For the determination of production yields in Arsenic, Bromine and Rubidium ultrapure targets of As_2S_3, NaBr and RbCl were used. The evaluated cross sections are quoted in tables 1 - 3 on the following pages. Direct cross sections are indicated by i, effective (cumulative) cross sections by e. Only errors greater than 7% are given. In the case of Br (Rb) the values given for ΔA are based on a mean target mass of 80 (86).

References

{1} F. Hegedüs and N.F. Peek, Progress Report, NEANDC (OR) - 152 "L" Part B, INDC (SWT) - 13/L

{2} A. Grütter, EIR Internal Report, TM-CH-217 (1979)

{3} A. Grütter, EIR Internal Report, TM-CH-220 (1979)

{4} A. Grütter, EIR Internal Report, TM-CH-222 (1979)

Table 1: Production cross sections in As with 580 MeV protons

(mCi / μA · g(As) · cm^{-2}) = 1.35·σ (mb)

Isotope	ΔZ	ΔA	kind	cross section (mb)	Isotope	ΔZ	ΔA	kind	cross section (mb)	Isotope	ΔZ	ΔA	kind	cross section (mb)
Se-75	+1	0	i	1.94	Zn-69 m	-3	-6	i	1.86	Fe-59	-7	-16	e	1.47
Se-73	+1	-2	i	2.62	Zn-65	-3	-10	e	30.6	Fe-52	-7	-23	e	0.039±0.014
Se-72	+1	-3	i	1.41±0.22				i	27.2	Mn-56	-8	-19	e	2.29
As-76	0	+1	i	0.53±0.05	Zn-63	-3	-12	e	7.1±0.6	Mn-54	-8	-21	i	8.35
As-74	0	-1	i	59.5	Zn-62	-3	-13	e	1.17	Mn-52m	-8	-23	i	0.63
As-72	0	-3	i	21.9	Cu-67	-4	-8	e	0.9±0.4	Mn-52	-8	-23	i	2.28
As-71	0	-4	e	15.2	Cu-61	-4	-14	e	6.71	Cr-51	-9	-24	e	6.00
As-70	0	-5	e	4.40	Cu-60	-4	-15	e	1.50	V-48	-10	-27	e	1.77
Ge-69	-1	-6	e	24.2±3.0	Ni-57	-5	-18	e	0.27	Sc-48	-12	-27	i	0.20±0.13
Ge-68	-1	-7	e	11.0±1.8	Co-62m	-6	-13	e	0.70±0.06	Sc-47	-12	-28	i	0.76
Ge-67	-1	-8	e	2.13	Co-60	-6	-15	i	7.2±1.0	Sc-46	-12	-29	i	1.18
Ga-73	-2	-2	i	1.03±0.08	Co-58m	-6	-17	i	12.7±1.7	Sc-44m	-12	-31	i	0.56
Ga-72	-2	-3	i	3.29±0.34	Co-58	-6	-17	e	15.0	Sc-44	-12	-31	i	0.40
Ga-68	-2	-7	i	28.8±4.9				i	2.2±1.9	Sc-43	-12	-32	i	0.23±0.07
Ga-67	-2	-8	e	29.0	Co-57	-6	-18	e	11.1	K-43	-14	-32	e	0.213
			i	26.9				i	10.8					
Ga-66	-2	-9	e	12.6	Co-56	-6	-19	e	2.85					
Ga-65	-2	-10	e	3.38±0.48	Co-55	-6	-20	e	0.41					

Table 2: Production cross sections in Br with 580 MeV protons

$(mCi/\mu A \cdot g\ (Br) \cdot cm^{-2}) = 1.26 \cdot \sigma\ (mb)$

Isotope	ΔZ	ΔA	kind	cross section (mb)	Isotope	ΔZ	ΔA	kind	cross section (mb)	Isotope	ΔZ	ΔA	kind	cross section (mb)
Kr-79	+1	-1	i	2.76±0.25	As-78	-2	-2	i	1.3±0.4	Zn-65	-5	-15	e	22.8
Kr-77	+1	-3	i	1.80	As-76	-2	-4	i	5.24				i	19.8±1.7
Kr-76	+1	-4	i	0.52	As-74	-2	-6	i	18.8	Zn-63	-5	-17	e	2.1±1.1
Br-82	0	+2	i	0.25	As-72	-2	-8	i	22.4	Zn-62	-5	-18	e	0.69±0.07
Br-80m	0	0	i	15.1	As-71	-2	-9	e	20.4	Cu-61	-6	-19	e	4.17
Br-80	0	0	i	9.24±0.84	As-70	-2	-10	e	6.92	Cu-60	-6	-20	e	0.98±0.08
Br-78	0	-2	i	40.8±3.3	As-69	-2	-11	e	2.9±0.7	Ni-57	-7	-23	e	0.145±0.015
Br-77	0	-3	e	26.9	Ge-69	-3	-11	e	23.1	Co-62m	-8	-18	e	0.53±0.06
			i	25.1				i	20.2	Co-58	-8	-22	i	8.31
Br-76	0	-4	e	22.4	Ge-68	-3	-12	e	11.4±1.4	Co-57	-8	-23	e	7.17±0.72
			i	16.3	Ge-67	-3	-13	e	2.47±0.20				i	7.02±0.72
Br-75	0	-5	e	7.75	Ga-73	-4	-7	e	0.311±0.025	Co-56	-8	-24	e	1.46
Br-74A	0	-6	i	1.73	Ga-72	-4	-8	i	1.63±0.32	Fe-59	-9	-21	e	0.83
Se-75	-1	-5	e	41.3	Ga-68	-4	-12	i	19.7±2.4	Mn-56	-10	-24	e	1.12
			i	33.5	Ga-67	-4	-13	e	23.5	Mn-54	-10	-26	i	3.90
Se-73m	-1	-7	e	10.3±1.1				i	21.0	Mn-52	-10	-28	i	0.98
Se-73	-1	-7	e	14.0	Ga-66	-4	-14	e	10.7	Cr-51	-11	-29	e	2.58
			i	5.7±1.3	Ga-65	-4	-15	e	3.0±0.5	V-48	-12	-32	e	0.69
Se-72	-1	-8	e	5.57	Zn-69m	-5	-11	i	1.20	Sc-48	-14	-32	i	0.084

Table 2 (continued)

Isotope	ΔZ	ΔA	kind	cross section (mb)	Isotope	ΔZ	ΔA	kind	cross section (mb)	Isotope	ΔZ	ΔA	kind	cross section (mb)
Sc-46	-14	-34	i	0.51±0.04										
Sc-44m	-14	-36	i	0.220										
Sc-44	-14	-36	i	0.143±0.025										

Table 3: Production cross sections in Rb with 580 MeV protons

$(mCi/\mu A \cdot g\ (Rb) \cdot cm^{-2}) = 1.18 \cdot \sigma\ (mb)$

Isotope	ΔZ	ΔA	kind	cross section (mb)	Isotope	ΔZ	ΔA	kind	cross section (mb)	Isotope	ΔZ	ΔA	kind	cross section (mb)
Sr-85m	+1	-1	i	0.66±0.05	Kr-85m	-1	-1	i	2.02	Se-72	-3	-14	e	5.10
Sr-85	+1	-1	e	2.93	Kr-79	-1	-7	e	26.3	As-76	-4	-10	i	2.50±0.22
			i	2.35				i	23.4	As-74	-4	-12	i	12.8
Sr-83	+1	-3	i	3.97	Kr-77	-1	-9	e	8.10	As-72	-4	-14	i	19.3
Sr-82	+1	-4	i	2.59	Kr-76	-1	-10	e	18.3±1.6	As-71	-4	-15	e	16.3
Rb-86	0	0	i	17.9	Br-82	-2	-4	i	4.45	As-70	-4	-16	e	5.68
Rb-84m	0	-2	i	23.8	Br-77	-2	-9	e	30.6	Ge-69	-5	-17	e	16.1±2.4
Rb-84	0	-2	e	53.2				i	22.3	Ge-68	-5	-18	e	8.0±1.2
			i	29.4	Br-76	-2	-10	e	42.4	Ge-67	-5	-19	e	1.50
Rb-83	0	-3	e	44.8				i	19.7±1.2	Ga-73	-6	-13	e	0.21±0.02
			i	40.8	Br-75	-2	-11	e	10.6±1.5	Ga-72	-6	-14	e	1.09±0.08
Rb-82m	0	-4	i	19.6	Br-74A	-2	-12	i	2.48±0.18	Ga-67	-6	-19	e	14.9
Rb-81m	0	-5	i	11.8±1.0	Se-75	-3	-11	e	36.7				i	13.4
Rb-81	0	-5	e	21.1				i	26.1	Ga-66	-6	-20	e	6.74
			i	8.1±1.5	Se-73m	-3	-13	e	8.84±0.83	Ga-65	-6	-21	e	1.65±0.35
Rb-79	0	-6	e	2.89±0.20	Se-73	-3	-13	e	13.3					
								i	6.2±0.9					

Table 3 (continued)

Isotope	ΔZ	ΔA	kind	cross section (mb)	Isotope	ΔZ	ΔA	kind	cross section (mb)	Isotope	ΔZ	ΔA	kind	cross section (mb)
Zn-69m	-7	-17	i	0.91	Sc-46	-16	-40	i	0.224					
Zn-65	-7	-21	e	12.7	Sc-44m	-16	-42	i	0.067±0.005					
			i	11.1										
Zn-62	-7	-24	e	0.31±0.09										
Cu-61	-8	-25	e	1.95±0.20										
Co-58	-10	-28	i	3.46										
Co-57	-10	-29	e	3.07±0.22										
Co-56	-10	-30	e	0.51										
Fe-59	-11	-27	e	0.43										
Mn-56	-12	-30	e	0.50										
Mn-54	-12	-32	i	1.59										
Mn-52	-12	-34	i	0.31										
Cr-51	-13	-35	e	0.96±0.12										
V-48	-14	-38	e	0.211±0.010										
Sc-48	-16	-38	i	0.051±0.010										

3. Radiation damage studies

U. Stiefel

For the investigation of radiation damages in wall materials for fusion reactors very intense sources of 14 MeV neutrons are needed. Since no such neutron sources are available until today the simulation of neutron induced damages by proton beams of high intensity and proper energy is a good alternative method. For this reason a proton-irradiation experiment (PIREX) was installed at the accelerator of the Swiss Institute for Nuclear Research (SIN) where proton beams of 590 MeV and 100 μA are available.

First irradiations of high purity aluminium foils with up to 2 dpa (displacements per atom) were already carried out. Further experiments are in progress and irradiations of other materials are planned. Several groups of other institutes (Los Alamos, Risø, Ispra, KFA Jülich) are participating in this programme.

The irradiated specimens are analysed by means of transmission-electron microscopy by groups of specialists at Los Alamos and Risø. The development of a method for the determination of the Helium production is in progress at the University of Zurich. In order to interpret the experimental results extensive physical computations are carried out at EIR. For the time being the NMTC (Neutron-Meson-Transport Code) is used for this purpose. Later on an extended neutron-transport theory will be applied taking into account the strongly anisotropic scattering of the charged particles too.