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Progress Report

on Neutron Physics Research and Dosimetry in Yugoslavia

Compiled by
Guy Paić,
Institute "Ruđer Bošković"
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Contents

Laboratories in SFR Yugoslavia working in the field of neutron physics research

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NEUTRON PHYSICS RESEARCH

Prompt γ-ray spectra from the radiative capture of 14,4 MeV neutrons in Cu, Se, Br, In, and I

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The γ-ray spectra and corresponding integrated cross sections due to the radiative capture of 14,1 MeV neutrons in monoisotopic In and I, and polyisotopic Cu, Se and Br are presented.

The experimental technique has been previously described[1-3].

Unfolded γ-ray spectra from the radiative capture of 14,1 MeV neutrons in Cu, Se, Br, In, and I are shown in figs. 1-5. Corrections due to the absorption of γ-rays and the scattering of neutrons in samples were taken into account. The error bars include the statistical fluctuation of counts, the uncertainties due to the background corrections, and the error introduced by the unfolding procedure.

Integrated cross section data presented in the table are obtained by the integration of γ-ray spectra over all γ-ray energies higher than E_n, the relative energy in the C.M. system. The errors of the integrated cross section values include besides the errors of the spectral intensity, also the uncertainty of the spectrometer efficiency and the uncertainty of the flux determination.

Spectra reported here have not been previously measured, except the spectrum of iodine[4]. In this experiment the γ-ray spectrum was measured with a NaI(Tl) crystal at 90° to the neuutron beam and is therefore not directly comparable with our spectrum which is integrated

over a solid angle of 4π . However, both data are presented in fig.5 without any correction. The average agreement is better than the experimental error. This can be seen from the comparison of Dinter's value of 1090 ± 170 /ub. It would therefore appear that the angular distribution is rather isotropic.

Integrated cross section values are presented in table 1. Their values lie around 1 mb and agree with the expected smooth mass dependence[5].

Comparison of integrated cross section values with the data obtained by the activation technique (σ_{act}) shows that the two cross sections agree only for Se, for other elements the σ_{act} are higher than σ_{int}. Such a behaviour was qualitatively discussed in refs[5,6] with the conclusion that the two cross sections agree only for nuclei in the vicinity of closed neutron shells.

Cross sections for the radiative capture of 14.1 MeV neutrons and parameters of the samples.

Sample	Density of the sample (g/cm^3)	Diameter (cm)	Integrated cross section (μb)	Isotopes	Activation cross section (μb)
Cu	8.92	2.0	770±110	^{63}Cu (69.1%)	2560± 380[a]
				^{65}Cu (30.9%)	6300±1900[a]
Se	1.42	3.0	860±130	^{80}Se (50.0%)	
				^{78}Se (23.6%)	
				^{76}Se (9.1%)	
				^{82}Se (8.8%)	650± 200[a]
				^{77}Se (7.5%)	
				^{74}Se (1.0%)	
Br	3.09	3.0	1100±160	^{79}Br (50.6%)	
				^{81}Br (49.4%)	3500± 850[b]
In	7.28	2.0	1200±200	^{115}In (95.8%)	5970± 810[a]
				^{113}In (4.2%)	
I	3.10	3.0	1100±160	^{127}I (100 %)	2500± 500[a]

a) Data taken from ref.[7]
b) Data taken from ref.[8]

References

1) F. Cvelbar, A. Hudoklin, M.V. Mihailović, M. Najžer and V. Ramšak, Nucl. Phys. A130 (1969) 401

2) F. Cvelbar, A. Hudoklin, M.V. Mihailović, M. Najžer and M. Petrišić, Nucl.Phys. A130 (1969) 413

3) F. Cvelbar, A. Hudoklin and M. Potokar, Nucl.Phys. A138 (1969) 412

4) H. Dinter, Nucl.Phys. A111 (1968) 360

5) F. Cvelbar, A. Hudoklin and M. Potokar, Nucl.Phys. A158 (1970) 251

6) F. Rigaud, J.L. Irigaray, G.Y. Petit, G. Longo and F. Saporetti, Nucl.Phys. A173 (1971) 551 and A176 (1971) 545

7) J.L. Perkin, L.P.O'Connor and R.F. Coleman, Proc. Phys. Soc. 72 (1958) 505

8) H.O. Menlove, K.L. Coop and H.A. Grench, Phys. Rev. 163 (1967) 1299

Figure captions

Fig.1. Corrected γ-ray spectrum from the radiative capture of 14.1 MeV neutrons in natural copper, containing 69% of ^{63}Cu and 31% of ^{65}Cu

Fig.2. Corrected γ-ray spectrum from the radiative capture of 14.1 MeV neutrons in natural selenium, containing mainly ^{78}Se (23,6%) and ^{80}Se (50%)

Fig.3. Corrected γ-ray spectrum from the radiative capture of 14.1 MeV neutrons in natural bromium, containing 50.6% of ^{79}Br and 49.4% of ^{81}Br.

Fig.4. Corrected γ-ray spectrum from the radiative capture of 14.1 MeV neutrons in natural indium, containing mainly ^{115}In (95,8%)

Fig.5. Corrected γ-ray spectrum from the radiative capture of 14.1 MeV neutrons in ^{127}I.

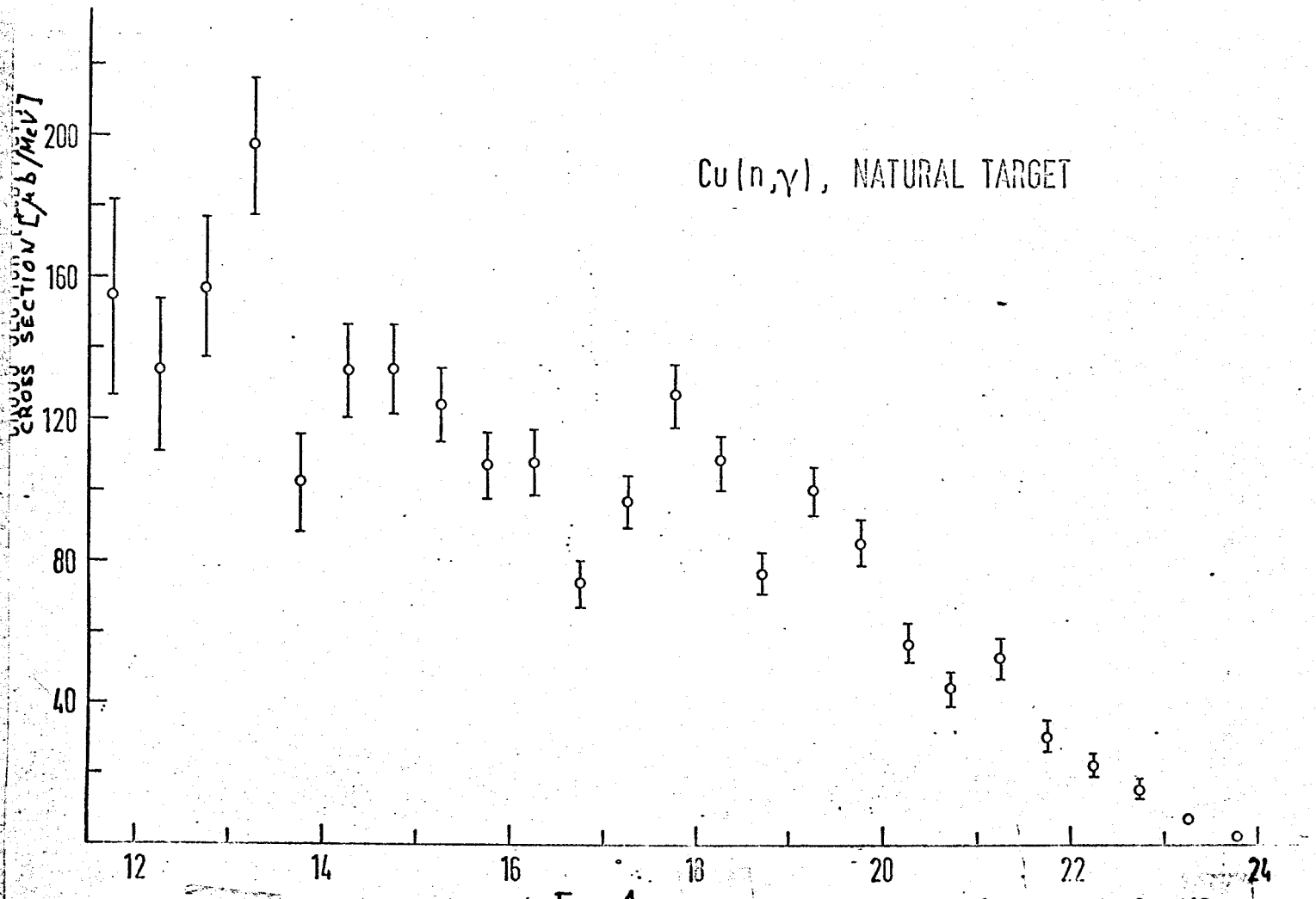
Cu(n,γ), NATURAL TARGET
CROSS SECTION [μb/MeV]
200
160
120
80
40
12
14
16
18
20
22
24
γ-RAY ENERGY [MeV]

Fig.1

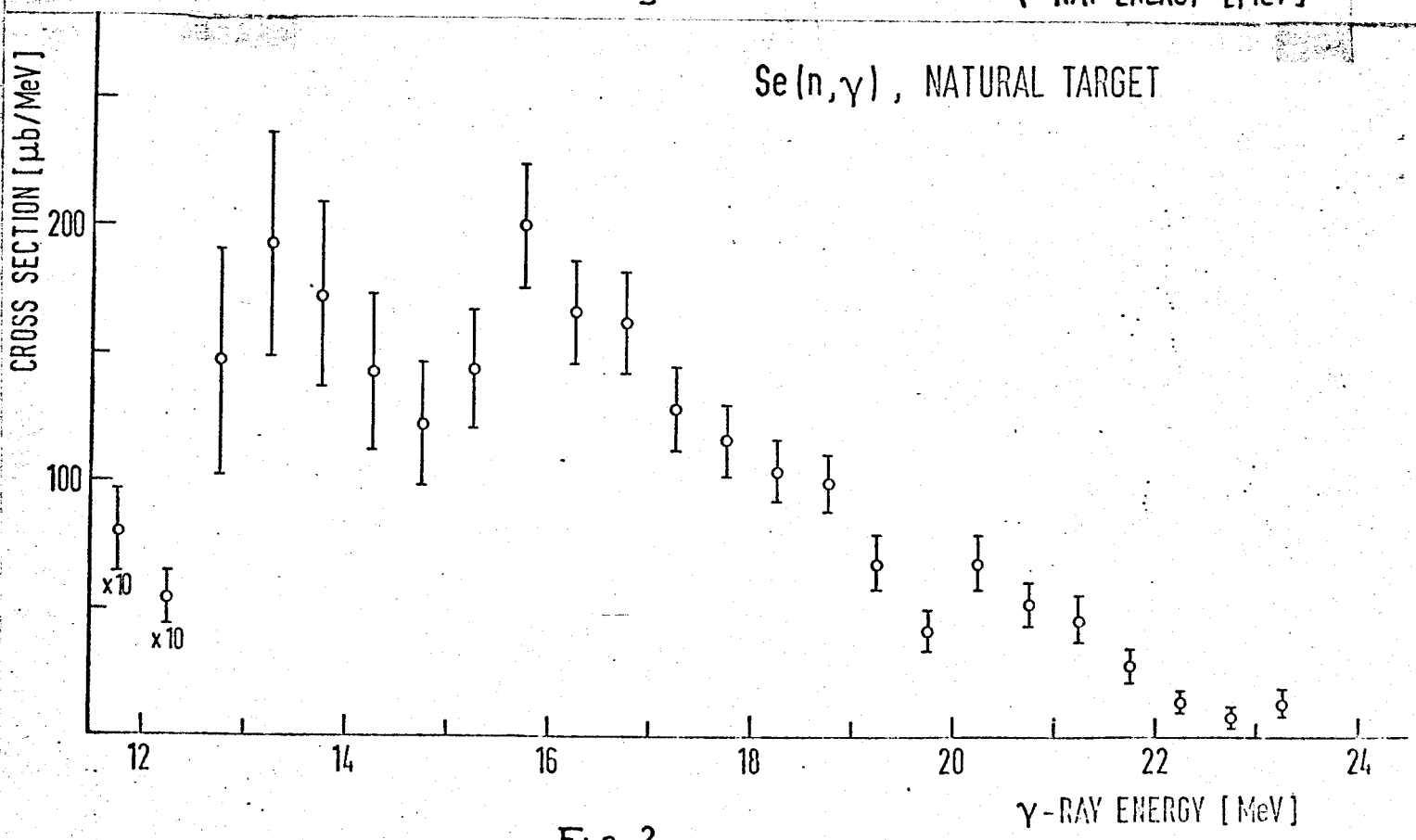
Se(n,γ), NATURAL TARGET
CROSS SECTION [μb/MeV]
200
100
x10
x10
12
14
16
18
20
22
24
γ-RAY ENERGY [MeV]

Fig.2

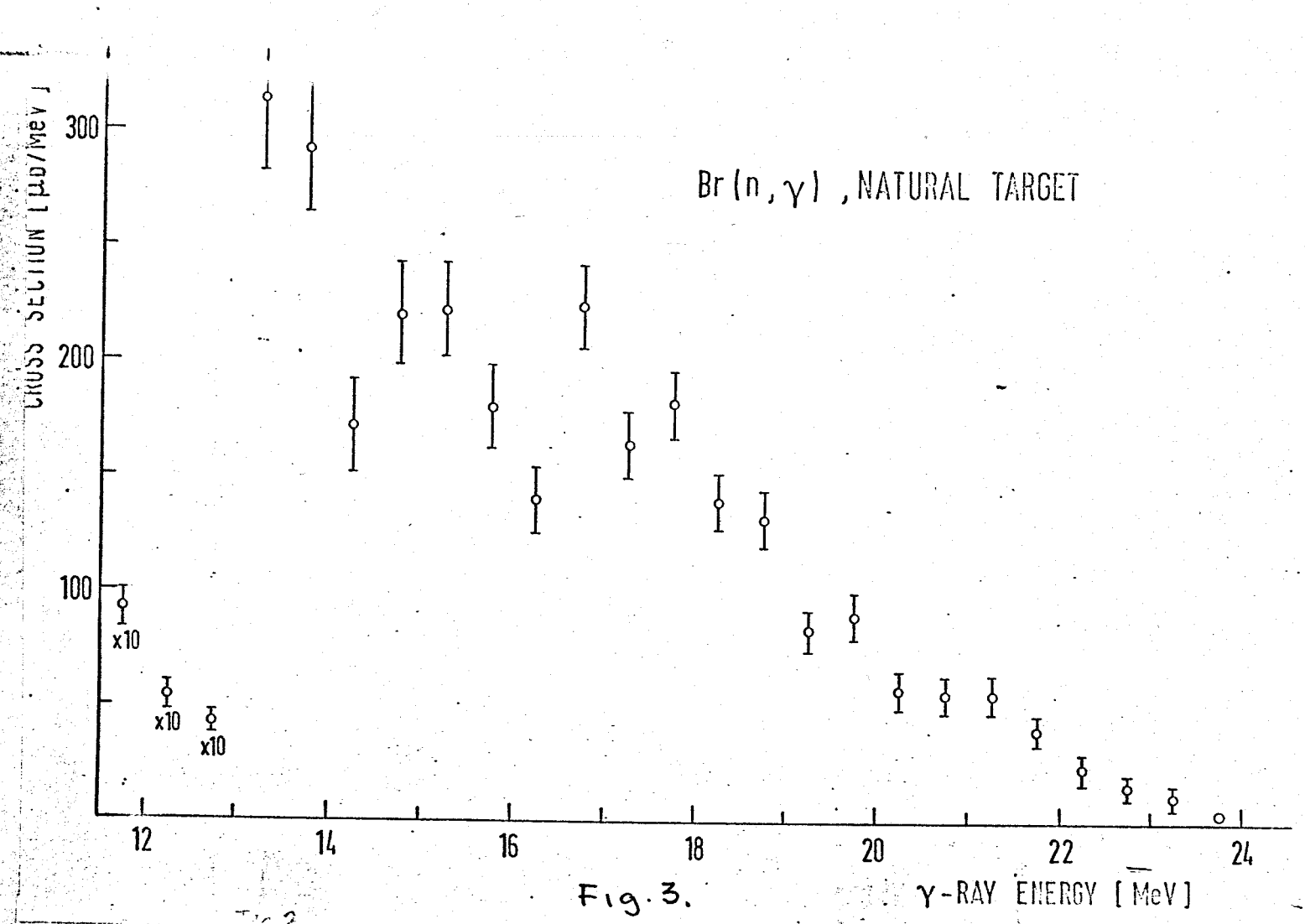
CROSS SECTION [μb/MeV]
300
200
100
x10
x10
x10
Br(n,γ), NATURAL TARGET
12
14
16
18
20
22
24
γ-RAY ENERGY [MeV]

Fig. 3.

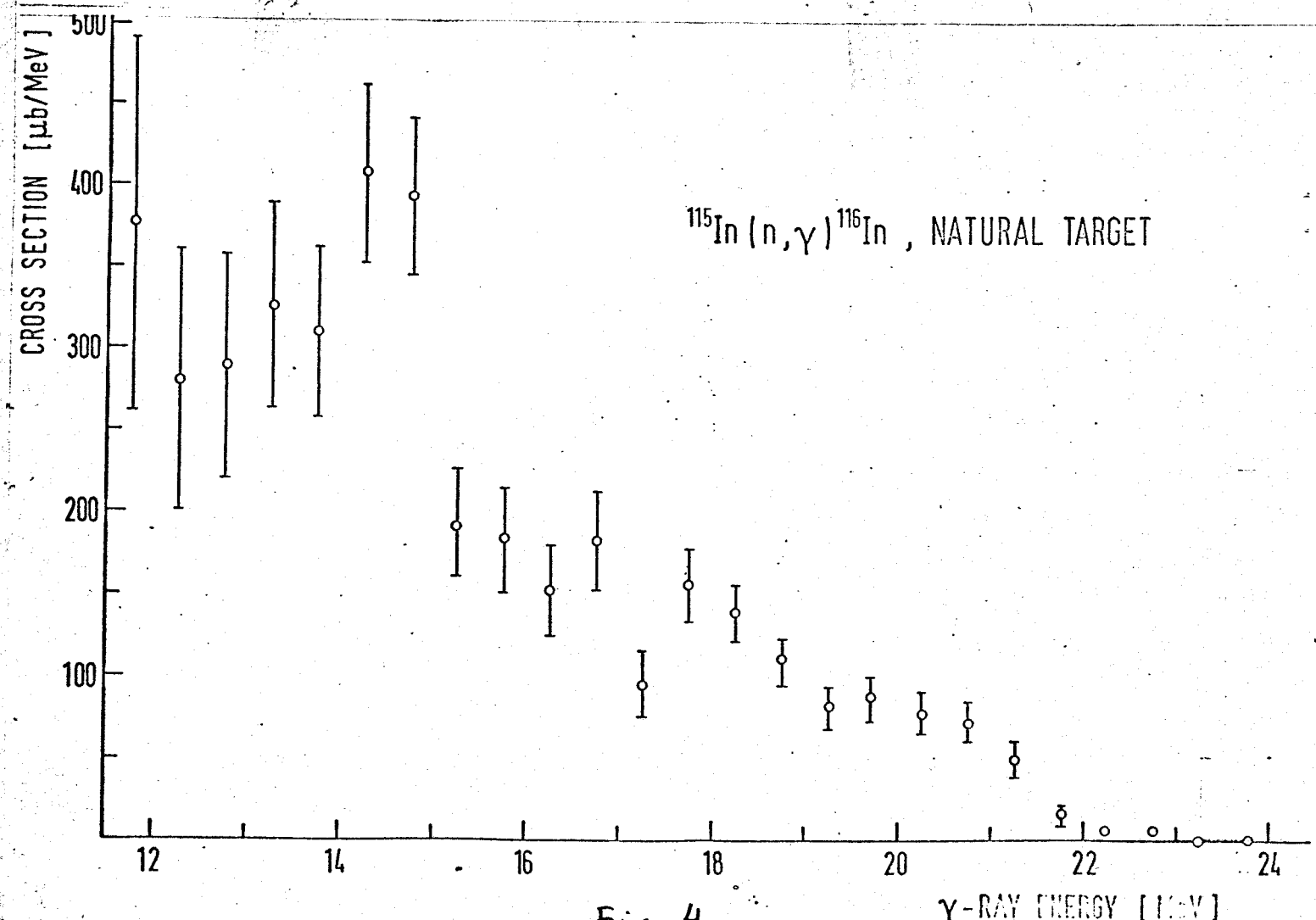
CROSS SECTION [μb/MeV]
400
300
200
100
$^{115}In(n,\gamma)^{116}In$, NATURAL TARGET
12
14
16
18
20
22
24
γ-RAY ENERGY [MeV]

Fig 4.

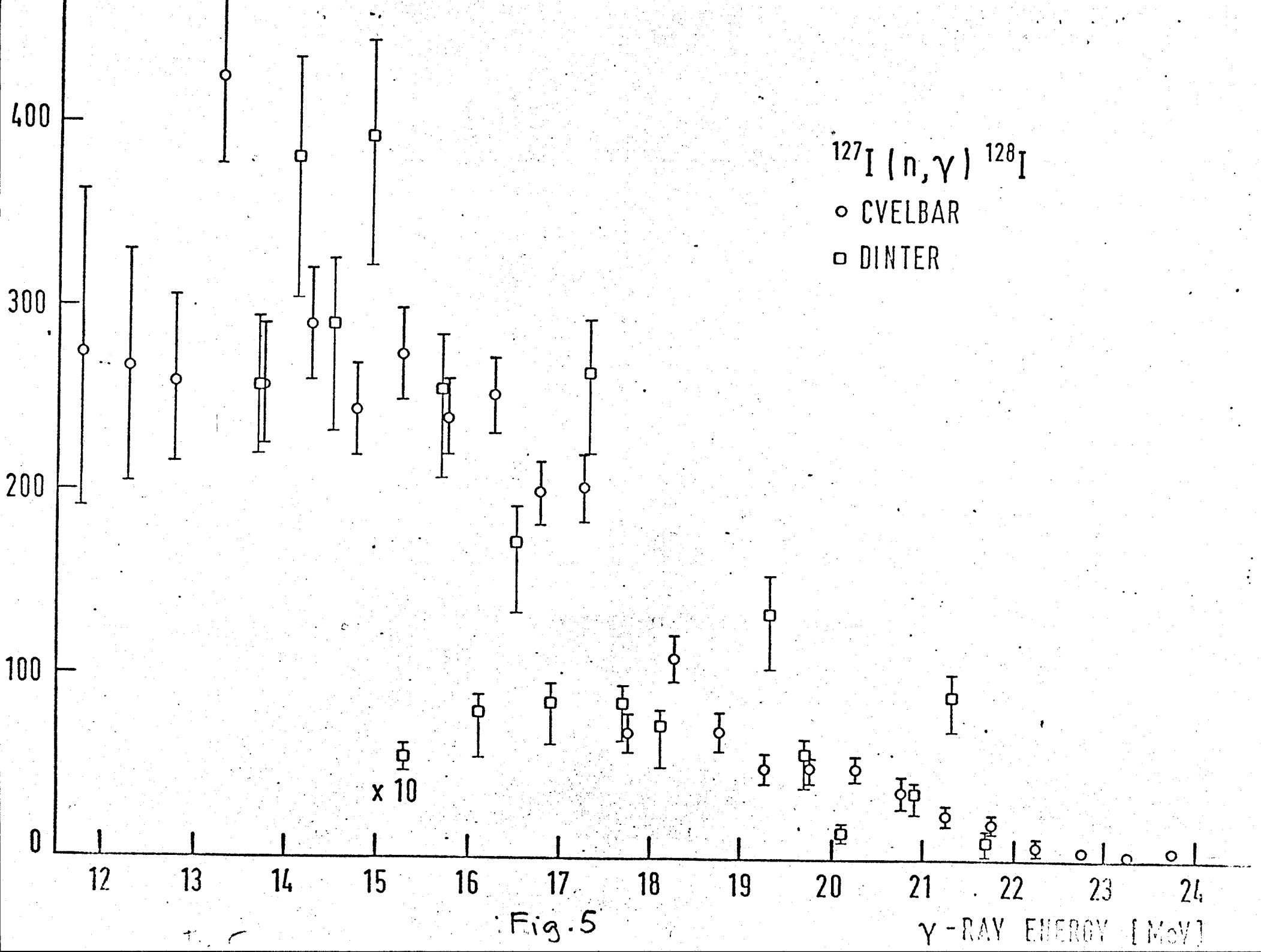
$^{127}I(n,\gamma)^{128}I$
CVELBAR
DINTER
400
300
200
100
0
x 10
12
13
14
15
16
17
18
19
20
21
22
23
24
γ-RAY ENERGY [MeV]

Fig. 5

Mass dependence of the cross section for the radiative capture of 14 MeV neutrons

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To be presented at "Nuclear Structure Study with Neutrons", Budapest

There are two methods in the study of the cross sections for the radiative capture of fast neutrons: activation technique and measurements of prompt γ-ray spectra. In contrary to the activation cross section values (σ_{act}) which include all radiative transitions into bound states, the integrals of the prompt γ-ray spectra (σ_{int}), due to the experimental reasons, cover only the (one step) transitions to the bound states of final nuclei. Therefore $\sigma_{act} \geqslant \sigma_{int}$. The difference between the two cross sections was expected to be of the order of few tens of percent. Experimentally the σ_{act} values were found to be up to 20 times higher than σ_{int}. As a function of mass number the σ_{act} data are scattered in the region between 0,5 mb and 20 mb. The σ_{int} data on the other hand show a rather smooth mass dependence [1].

The difference between the two cross section data is not yet well understood but it seems, that the new precise measurement of σ_{act} have to be preformed before

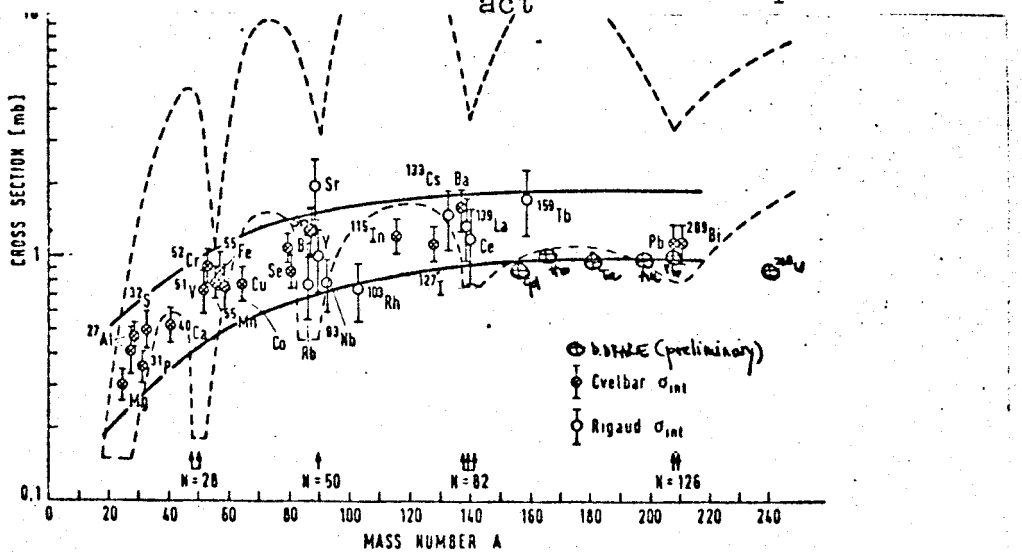

Fig.1 Mass dependence of cross sections for the radiative capture of 14 MeV neutrons. The dashed line limites the region of σ_{act} data.

the theoretical study of the transitions via unbound states which should be responsible for the real difference between the σ_{act} and σ_{int} will be done.

The aim of this contribution is i) to show that also the σ_{int} value of Pb for which only preliminary data exist 2) and that of Bi for which prompt γ-ray spectrum was not presented before, fit into the extrapolated band of the data measured for lighter nuclei, and ii) to present the new preliminary result of the measurement of γ-ray spectrum and corresponding σ_{int} for ^{88}Sr.

From Fig.1 one can see that σ_{int} value of Sr 1970 μb $\pm$ 580 μb does not fit into already mentioned band of other experimental values. As the corresponding spectrum was measured at about 90° relative to the neutron direction [3], it was expected that this outstanding value might be due to the anisotropy in angular distribution of capture γ-rays. We repeated the measurements with the technique in which the spectrum is averaged over half sphere (2π geometry). The result is presented in Fig.2 together with the original results [3]. On the difference in low energy part of the spectra not much conclusion could be done, but the difference around the $S_{1/2}$ level might be due to the anisotropy in angular distribution of γ-rays. This expectation is supported also by the shape of the calculated spectrum (integrated over 4π) which reproduces our experimental data. The details of the calculation will be published. The σ_{int} value of the experimental spectrum presented in Fig.2 is 1260 $\pm$ 260 μb.

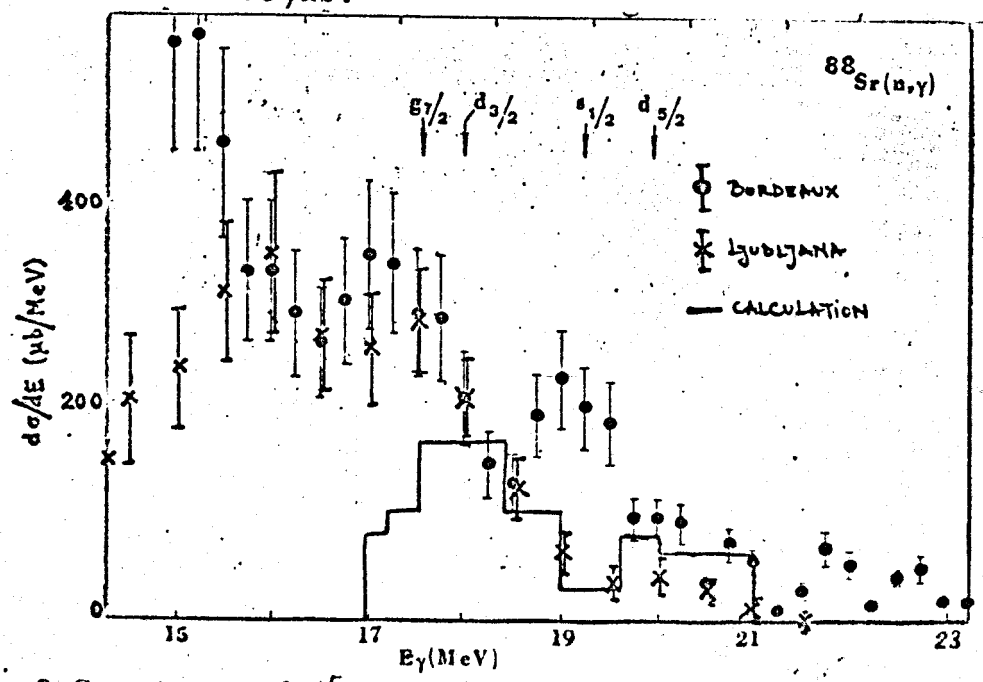

Fig.2 Spectrum of γ-rays from the radiative capture of 14 MeV neutrons in ^{88}Sr.

References

1) F. Cvelbar et al. Nucl. Phys. A158 (1970) 251
2) D. Drake et al. Phys. Lett. 36B (1971) 557
3) F. Rigaud et al. Nucl. Phys. A154 (1970) 243

Mass dependence of direct-semi-direct theory calculations for the 14 MeV neutron radiative capture

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The experimental spectra of prompt γ-rays following the radiative capture of 14,1 MeV neutrons in ^{28}Si, ^{40}Ca, ^{88}Sr, ^{138}Ba, and ^{208}Pb are compared with the spectra calculated according to three current approaches of the direct--semi-direct (DSD) theory and by the modified approach developed by the author. As an example the spectra of ^{40}Ca and ^{208}Pb are presented.

The spectra of prompt γ-rays following the radiative capture of 14,1 MeV neutrons have been recognized as an effective tool for testing the DSD theory for the dynamics of fast nucleon capture reaction. In order to examine systematically how approapriate are different current formulations of this theory (1,2,3) the spectra of ^{28}Si, ^{40}Ca, ^{88}Sr, ^{138}Ba and ^{208}Pb are calculated. All experimental quantities which enter into calculations (i.e. single particle energies, spectroscopic factors, depth of the isospin potential V_1 (4,5), and position, width and dipole sume of the giant dipole resonance) are the most recent experimental data.

It is found that the approach due to Lushnikov and Zaretsky (LZ), while reproducing very well the spectra of light nuclei, does not explain the experimental results for the heavier nuclei. The calculated cross sections being typically too low by a factor of 4.

The calculation according to Clement, Lane, and Rook (2) (CLR) give good agreement with the experiment for ^{28}Si

and ^{40}Ca, but the agreement becomes steadily worth with encreasing A. In the case of ^{208}Pb there is on average a factor of 2 between the calculated and experimental spectral intensities.

In the case of the calculation by Zimanyi, Halpern, and Madsen (3) (ZHM), the coupling constant is vague, because it depends on the number of neutrons and protons that are active in the semi-direct process. In most cases this number is not well defined. For ^{40}Ca and ^{208}Pb, where it is well defined, the cross sections are too high for a factor of 2 and 1,5, respectively.

A different coupling interaction (6), developed by the authors following the CLR approach but calculating the nuclear matrix element more exactly, has been tried. The spectra calculated by this approach are in good agreement with the experimental ones over the whole mass region.

The calculated spectra for ^{40}Ca and ^{208}Pb shown as an example on fig.1 and fig.2 in comparison with the experimental spectra.

References:

1) A. Lushnikov and D.F. Zaretsky, Nucl.Phys. 66 (1965) 35

2) C.F. Clement, A.M. Lane and J.R. Rook, Nucl.Phys. 66 (1965) 273

3) J. Zimanyi, I. Halpern, and V.A. Madsen, Phys. Letters 33B (1970) 205

4) D.J. Millener and P.E. Hodgson, Phys. Letters 35B (1971) 495

5) V.A. Krutov and L.N. Savushkin, J. Phys. (London) A2 (1969) 463

6) M. Potokar, to be published

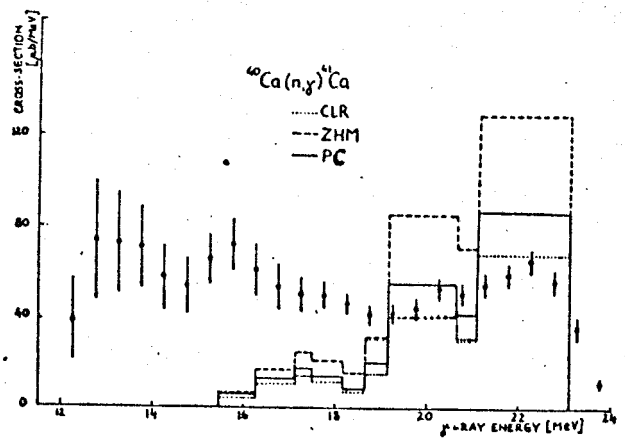

Fig.1. Experimental spectrum of γ-rays from the radiative capture of 14,1 MeV neutrons in Calcium, compared with spectra calculated according to CLR approach of DSD theory (dotted line), ZMH approach (dashed line), and the modified approach by the authors (PC) (solid line).

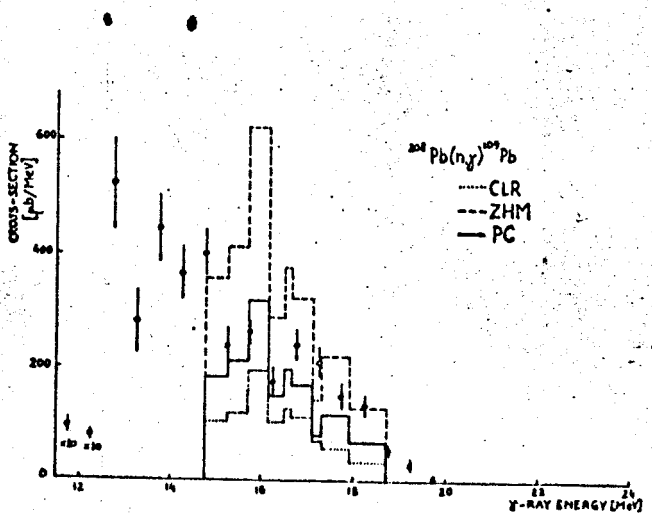

Fig.2. Experimental spectrum of γ-rays from the radiative capture of 14,1 MeV neutrons in lead compared with spectra, calculated according to CLR approach (dotted line), ZHM approach (dashed line) and PC approach (solid line).

Search for systematics in fast neutron radiative capture*

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The existing differences in fast neutron capture cross sections obtained by the activation (σ_{act}) and integration methods (σ_{int}) are presently the subject of considerable interest. In principle, σ_{int} could be smaller than σ_{act}, since the former quantity measures only the decay to the bound states of the final nucleus, while the latter includes the decays to the bound and unbound states. This difference, however, should not be too large, since the decay to the unbound states leads mainly to particle emission; gamma rays compete favourably with particle emission only in the narrow region just around the binding energy.

The present experimental evidence shows that σ_{int} follow a smooth path in the whole region from A=23 to A=238 /1,2/ (dotted region), On the other hand, activation cross sections vary considerably as a function of A, but also σ_{act} measured by different authors yield results differing by more than a factor of two.

We started a systematic survey of 14 MeV (n,γ) reactions by the activation method.

Table 1

Target	σ_{act}(mb)	Target	σ_{act}(mb)
^{23}Na	0.25±0.04	^{55}Mn	1.4±0.2
^{27}Al	0.33±0.1	^{41}K	2.0±0.3
^{37}Cl	1.8 ±0.2	^{127}I	7.0±0.5
^{51}V	1.4 ±0.2		

* To be presented at "Nuclear Structure Study with Neutrons" Budapest

The obtained results (Fig.1 and Tab.1) show that σ_{act} are generally larger than σ_{int}. This difference appears to be small near the closed neutron shells, but for from them it may reach an order of magnitude.

References

1) F. Cvelbar, A. Hudoklin and M. Potokar, Nucl. Phys. A138 (1969) 412; A158 (1970) 251

2) D. Drake, I. Bergquist and D.K. McDaniels, Phys.Lett. 36B (1971) 557.

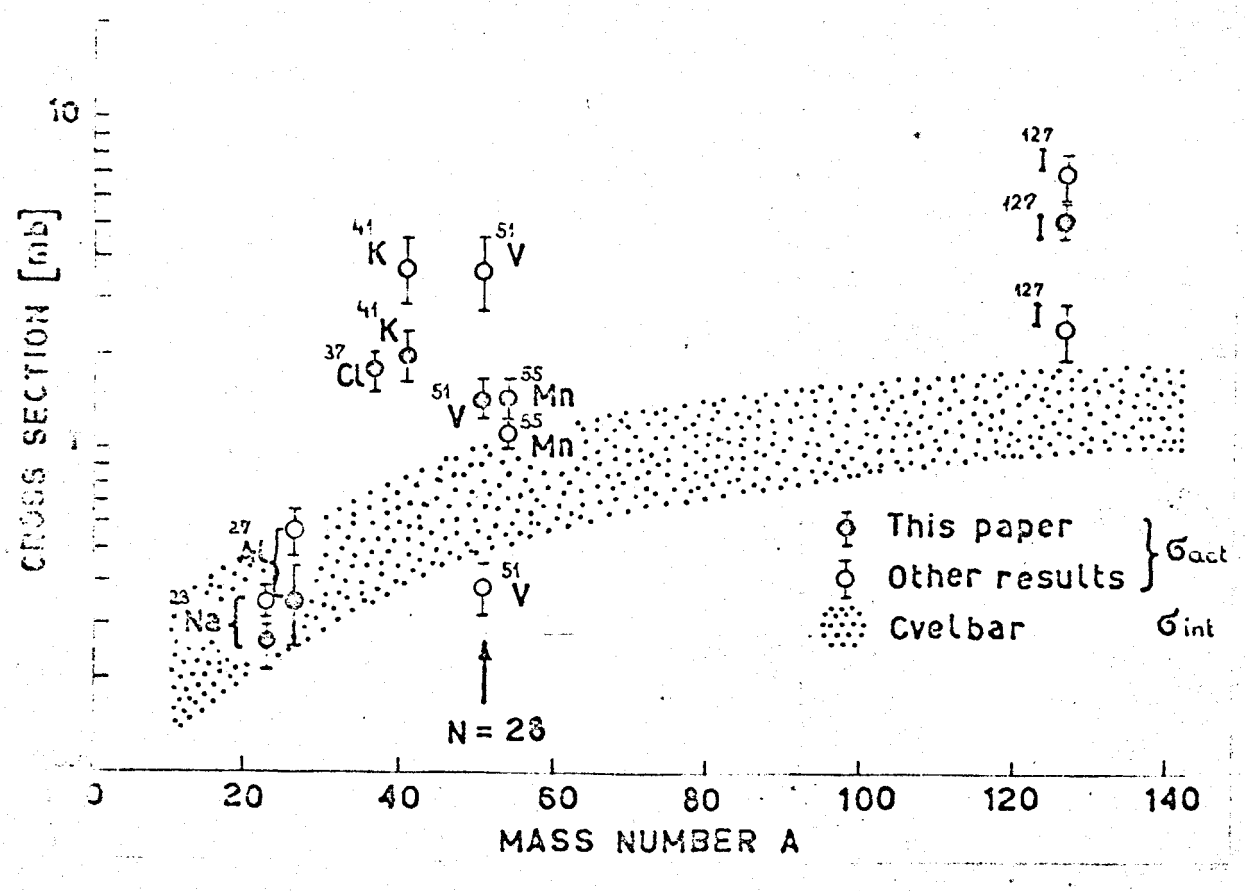

Fig. 1. Interaction and some activation (n,γ) cross sections

Correlation measurements of neutron-induced multiparticle reactions in nuclear emulsions

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Nucl.Instr. and Meth. 100 (1972) 211-216

The complete measurement of three and more particle breakups has become feasible by the use of nuclear emulsions loaded with the element on which the reaction is to be studied. In fact, such an arrangement offers an almost 4π detection geometry with a twofold advantage over the standard two-counter experiments. The yield of the reaction is considerably increased in comparison with that obtained with the two-counter setup. Moreover, measurements performed by this technique are extended to almost the whole solid angle. Thus the condition of exploring the large momentum space, so important in the study of multiparticle breakup reactions, is also fulfilled.

A procedure of using nuclear emulsions in complete measurements of three-body breakup reactions is described.

Study of the $^{12}C(n,n)3$ alpha reaction in a kinematically complete experiment

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The breakup of the ^{12}C into three alpha particles was studied via the inelastic $^{12}C(n,n')^{12}C(3\alpha)$ process and the excited states involved are 9.6, 11.8 and 12.7 MeV.

The reaction $n+^{12}C \longrightarrow n+\alpha+\alpha+\alpha$ was investigated using nuclear emulsions. The emulsions contain a large amount of ^{12}C(17.6% per atoms) and can therefore be used simultaneously both as a target and a detector. The three alpha prong events were measured and selected from the other three prong processes by the energy and momentum balance with the aid of an off-line CAE 90-40 code.

The neutron and alpha particle spectra in the ^{13}C centre-of-mass system as well as the spectrum of the ^{5}He relative energies were analyzed in order to define the contributions of different sequential processes:

1. $n+^{12}C \longrightarrow n+^{12}C(\alpha)^{8}Be(2\alpha)$
2. $n+^{12}C \longrightarrow \alpha+\ ^{9}Be(n)^{8}Be(2\alpha)$
   $\hookrightarrow\ ^{9}Be(\alpha)^{5}He(n,\alpha)$
3. $n+^{12}C \longrightarrow\ ^{8}Be(2\alpha)+^{5}He(n,\alpha)$

It was found that the $^{12}C(n,\alpha)^{9}Be(n)2\alpha$ reaction contributes only in the intermediate 2.43 MeV state of ^{9}Be. The presence of this reaction manifests as a distinct peak on the continuum of the three alpha energies generated in process 1. The intensity of the sequential process via ^{9}Be is 9.8%, but due to the kinematical conditions it coincides only with the events of process 1 involving ^{12}C

excitations higher than 11.5 MeV. In this region of ^{12}C excitations, therefore, the mixing of processes 1 and 2 becomes considerable and one has to be cautious in the interpretation of the respective ^{12}C-3α data. Fortunately, the $^{9}Be_{2.43}(n)^{8}Be(2\alpha)$ sequence involves only the formation of ^{8}Be in its ground state, which is not of primary interest in this study.

No evidence was found for the process proceeding via ^{5}He in the ground state.

The three alpha correlation spectra for ^{12}C resonances at 9.6, 11.83 and 12.71 MeV are presented in triangular Dalitz diagrams. Only those data were analyzed for which the ^{12}C excitation falls between the narrow strip of $\pm$0.3 MeV around the resonance.

The three alpha breakup of the ^{12}C nucleus in the 9.63 MeV excited state ($I^{\pi} = 3^{-}$) is shown in fig.1. The density distribution of the data is typical of a sequential decay through the $^{8}Be_{g.s.}$ with the strong intensity peaks near the maximum energies of the three alphas. There is no trace of evidence for the simultaneous breakup to be present.

The data on the three alpha breakup of the 11.83 MeV state of the ^{12}C nucleus are presented in fig.2. The scheme of the loci of relative energies corresponding to the ground and first excited state of ^{8}Be is also given. The main features of the reaction resulting from the Dalitz diagram are as follows: 1) high density of events along the line corresponding to the transition via the ground state of ^{8}Be; 2) clustering of experimental points along the lines corresponding to the transition to the first excited state of ^{8}Be, although the points are more scattered due to the large width of the 2.9 MeV ^{8}Be state; 3) very weak intensity at the intersections of the two bands of the same relative energies (2.9 MeV of ^{8}Be).

The spin and parity of the 11.83 MeV state were not established with certainty[1]. The tentative spin - parity assignment is 2^-, but 1^- was not ruled out. The present results show that a large part (25%) of the $^{12}C(11.83\ MeV)$ - 3 alpha decay proceeds via the $^8Be_{g.s.}(0^+)$. Hence, due to spin and parity conservation laws, the 1^- assignment for the 11.83 MeV state is the only possible one.

Figure 3 shows the Dalitz plot of the breakup of the 12.71 MeV ($I^{\pi} = 1^+$) ^{12}C excited state into 3 alpha. The spin and parity considerations exclude the transition to the ^8Be ground state. The population of points along the lines corresponding to the ground state transition is due to the contribution of the $^{12}C(n,\alpha)^9Be(n)^8Be(2\alpha)$ chain. In this diagram the intersections of the lines corresponding to the 2.9 MeV relative energies of ^8Be come close together around the centre. As expected, the experimental points cluster in the centre.

Reference

1) F. Ajzenberg-Selove, T. Lauritsen, Nucl.Phys. A114 (1968) 1.

Fugure caption

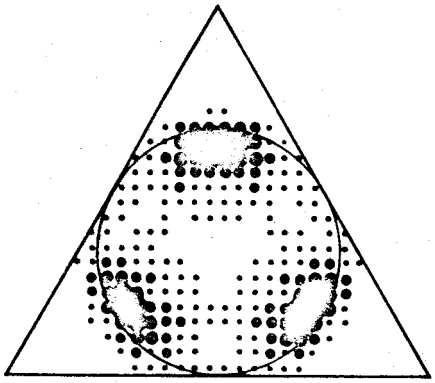
Fig. 1. Dalitz diagram of the three alpha breakup of the ^{12}C nucleus in the 9.63 MeV state. The loci of relative energies corresponding to the ground state of ^{8}Be are given in the lower scheme.

Fig. 2. Dalitz diagram of the three alpha breakup of the ^{12}C nucleus in the 11.83 MeV state. The loci of relative energies corresponding to the ground and first excited state of ^{8}Be are given in the lower scheme.

Fig. 3. Dalitz diagram of the three alpha breakup of the ^{12}C nucleus in the 12.71 MeV state. The loci of relative energies corresponding to the ground and first excited state of ^{8}Be are given in the lower scheme.

$^{12}C \longrightarrow 3\alpha$

$E^{*}_{^{12}C} = (9.64 \pm 0.3)\,MeV$



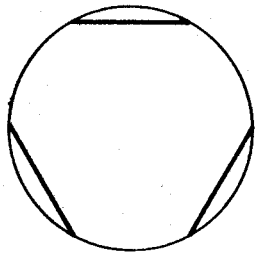
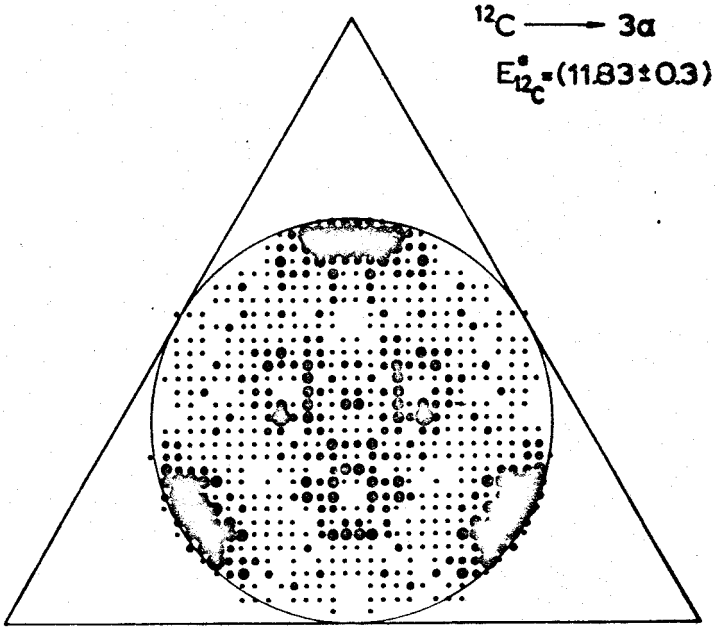


Fig. 1.

$^{12}C \longrightarrow 3\alpha$

$E^{*}_{^{12}C} = (11.83 \pm 0.3)\,MeV$



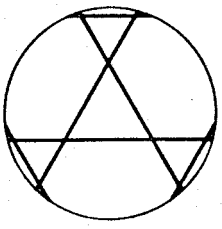
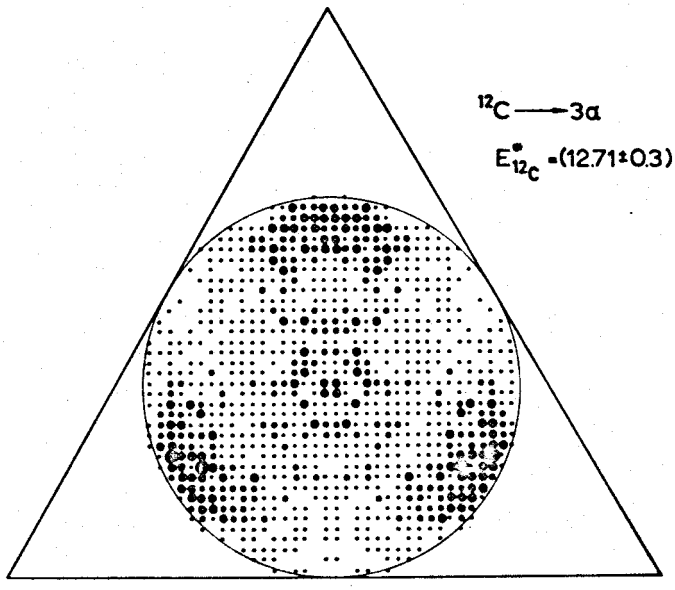
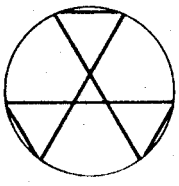


Fig. 2.

$^{12}C \longrightarrow 3\alpha$

$E^{*}_{^{12}C} = (12.71 \pm 0.3)\,MeV$





Isomeric cross section ratios for (n,p) reactions induced by 14.6 MeV neutrons in Te isotopes

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Although the isomerism in isotopes of tellurium is well established, the available data on the yield ratio for the isomeric pair formation of tellurium isotopes are scarce for 14-15 MeV neutrons. In this work we have measured the (n,p) cross sections for the metastable and ground states of all unstable tellurium isotopes.

Irradiations were performed at 14.6 ± 0.2 MeV with neutrons obtained from the $^{2}H+^{3}H$ reaction using 200 keV Cockcroft-Walton generator of the Institute "Ruđer Bošković". The neutron flux was about 2×10^{9} n/sec, and the total neutron yield was monitored by the associated α-particles. Gamma-ray spectra were measured using 25 cm^{3} Ge(Li) detector coupled to the 400-channel analyser.

In Table 1 the experimental and theoretical results isomeric ratios for (n,p) reactions are shown. Calculations of the isomeric ratio were performed for several values of (ν = 1,2,3,4,5) and for several values of the cut-off parameter σ (σ = 3,4,7) included in the known formula for spin-dependent level density[1].

Reference

1) C. Bloch, Phys.Rev. 93 (1954) 1094.

Table 1

Target	Product	Exp.val. (mb)	σ_m/σ_g	Theoretical values									
				σ = 3 or 4					σ = 7				
				1	2	3	4	5	1	2	3	4	5
^{120}Te	^{120m}Sb	64±10	0.78	.241	.243	.247	.251	.273	.505	.584	.588	.669	.722
	^{120g}Sb	82±13											
^{122}Te	^{122m}Sb	21±6	0.81	.120	.130	.138	.144	.148	.302	.364	.422	.473	.519
	^{122g}Sb	17±3											
^{124}Te	$^{124m1}Sb$	5±0.8	0.38	.830	.870	.882	.923	.949	.644	.648	.638	.637	.632
	$^{124m2}Sb$	2±0.3											
	^{124g}Sb	13±2	0.15	.272	.337	.386	.434	.475	.159	.172	.179	.183	.185
^{126}Te	^{126m}Sb	1.5±0.1	0.50	.177	.212	.240	.268	.286	.262	.328	.376	.423	.466
	^{126g}Sb	3±0.9											
^{128}Te	^{128m}Sb	1±0.1	0.67										
	^{128g}Sb	1.5±0.3											
^{130}Te	^{130m}Sb	0.9±0.2	0.64										
	^{130g}Sb	1.4±0.3											

for ^{126}Te σ = 3

FAST NEUTRON DOSIMETRY

An effort has been recently made on developing methods of fast neutron dosimetry. The following two contributions are representative of the work done so far.

New chemical systems for low-level fast neutron dosimetry

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The response of two dosimetric systems, (1) 0.20 m$\underline{M}$ ferrous sulphate, 5.0 m$\underline{M}$ benzoic acid and 0.20 m$\underline{M}$ xylenol orange in 0.05$\underline{N}$ sulphuric acid, and (2) 2,2,4-trimethylpentane + 10% (by volume) ethanol + 10% chlorobenzene + $2 \times 10^{-6}\underline{M}$ K-thymolsulphonphthalein + upto 0.1% water + HCl, to 14.7 MeV neutrons was studied. The average neutron flux in the irradiation cell was measured by filling the cell with magnesium acetate solution. The neutron flux incident on the surface of the cell was measured by aluminium activation. Efforts have been made to use the best available cross section data and to achieve the highest possible experimental accuracy. The G-values and other details for the use of these systems in fast neutron dosimetry are given.

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Neutron dosimetry experiments using a tissue equivalent proportional counter

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An experimental method for measurement of dose equivalent in mixed radiation field is presented. The method is based on the measurement of energy deposition in a very small tissue-equivalent volume. The experimental arrangement consists of a small, sealed off, tissue-equivalent counter and the associated electronics.

A thin wall polyethylene plastic sphere 30 cm in diameter is filled with tissue equivalent liquid. The shape and the diameter of the tissue-equivalent phantom are chosen according to the ICRU Report 19. The tissue-equivalent proportional counter is located within the plastic phantom and can be easily positioned at any place within the sphere. The pulse height spectra obtained from the proportional counter were processed by a standard electronic analyzing system. The pulse height distributions thus obtained contain valuable information on the dose per event distribution which is used for evaluation of quality factor of the radiation in question.