TRANSMUTATION OF ^{129}I BY SECONDARY NEUTRONS OF THE GAMMA-MD SETUP EXPOSED TO 2.33 GEV DEUTERONS: EXPERIMENT AND MODELING

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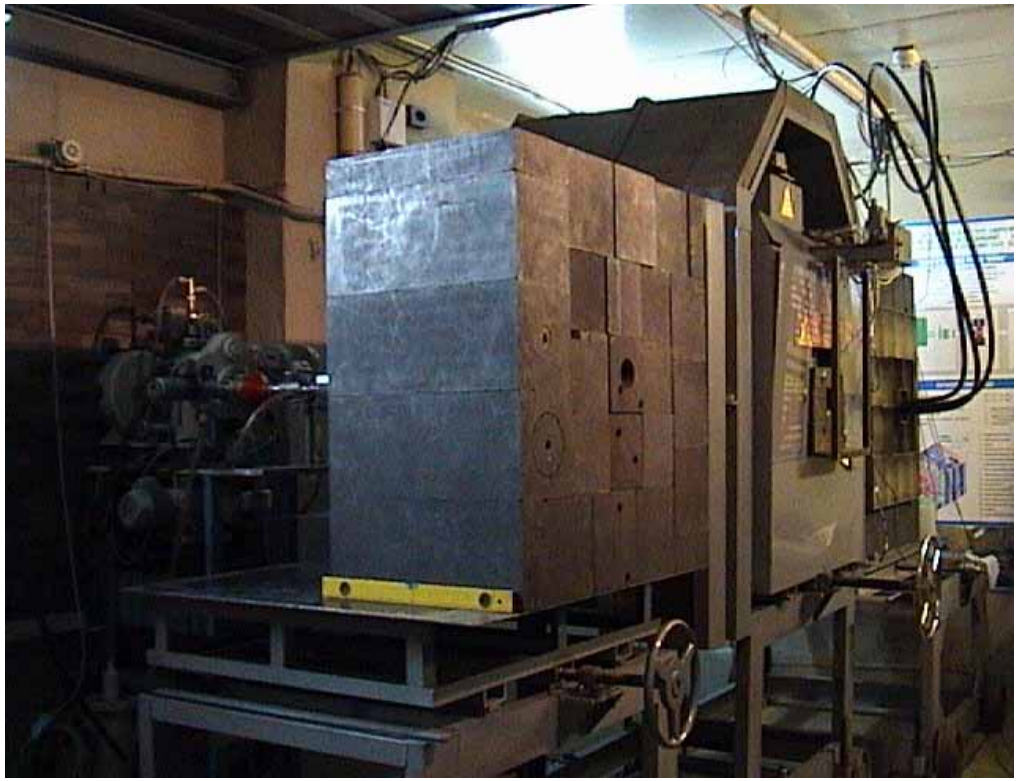
GAMMA-MD setup –model of a reactor core



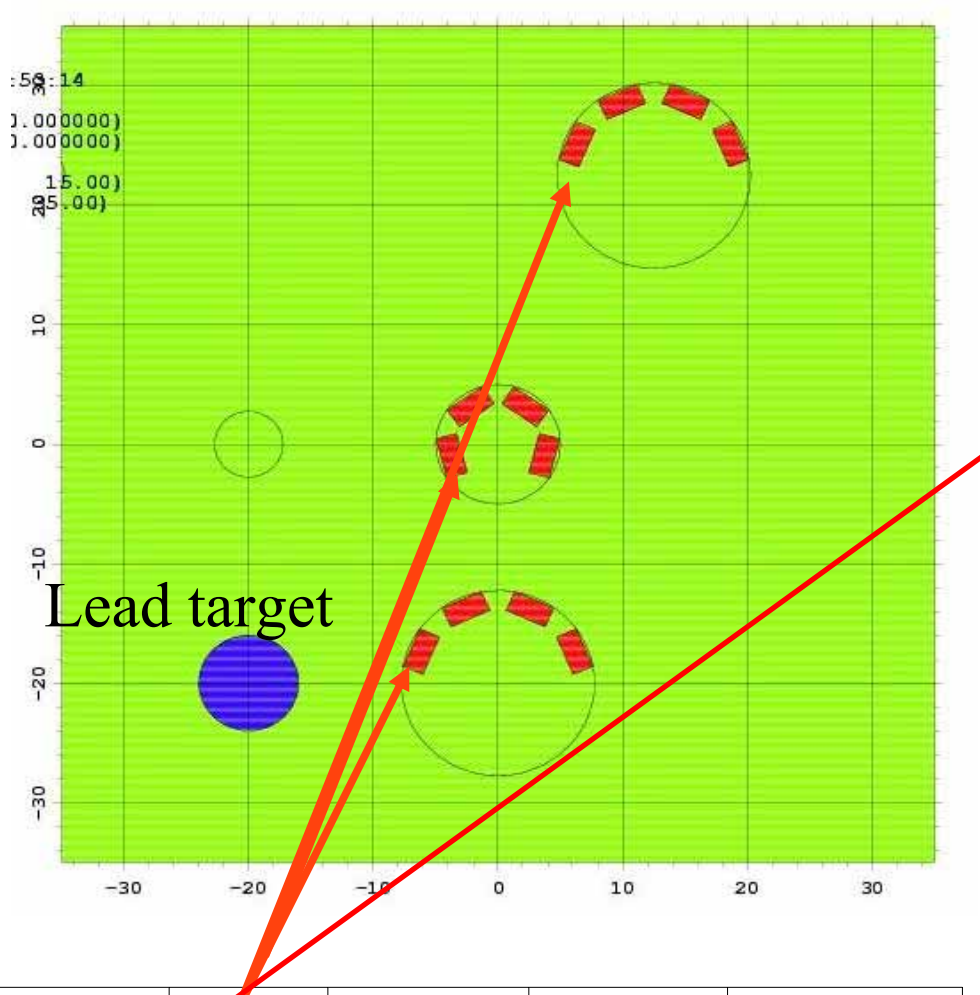
Sizes: 110×110×60 cm (blocks 25×25×60 cm and 20×20×60 cm, lead target d=8 cm, 60 см length

T_{ml} = 3800 °C, T_{fire} (air) = 750 °C (safe) σ(absorb, term)=0,0035 b, λ = 50 cm(water σ = 0,33 b, λ = 5 cm)

Deuteron total kinetic energy, GeV	Gaussian beam FWHM parameters (cm)		Coordinates of the beam center (cm)		Intergral deuteron fluence	Beam percent hit the lead target (%)	
	X	Y	Xc	Yc			
2.33	1,5±0,1	2,4±0,1	0,7±0,1	0,2±0,1	$1{,}85\cdot10^{13}$	$1{,}7\cdot10^{13}$	92.2%

GAMMA-MD setup at the Nuclotron beam

Location of the samples in GAMMA-2MD



Block No	I-129	Np-237	Pu-239	Pu-238
	L (cm)	L (cm)	L (cm)	L (cm)
14	13,8	17,5	23,3	26
9	24	29,3	33	30,8
4	51,3	56,3	59,8	58,5

Other samples used in the experiment:

threshold detectors Mg, Fe, Al, Co, Cu, Bi, Au, In, Y,Nb, W, V, Au, Lu, Dy, Ni, Sb

radiochemical sensor La-139, 11 samples

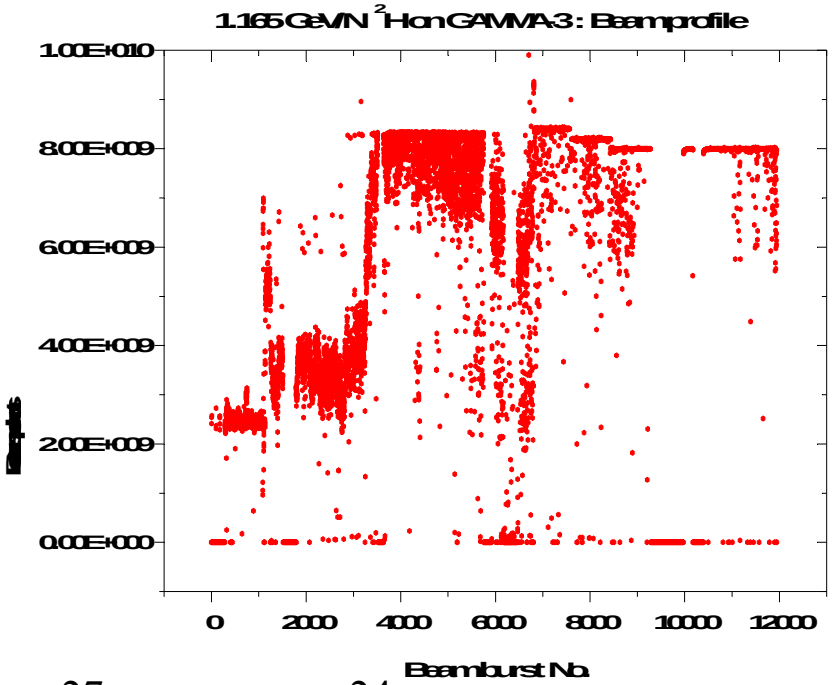
He-3, He-4 neutron counters, track detectors CR39+B-10 (+Cd) Lexan+U-5, Th-232, Au-197, Bi-209 U-8, Au-197, Cd foils

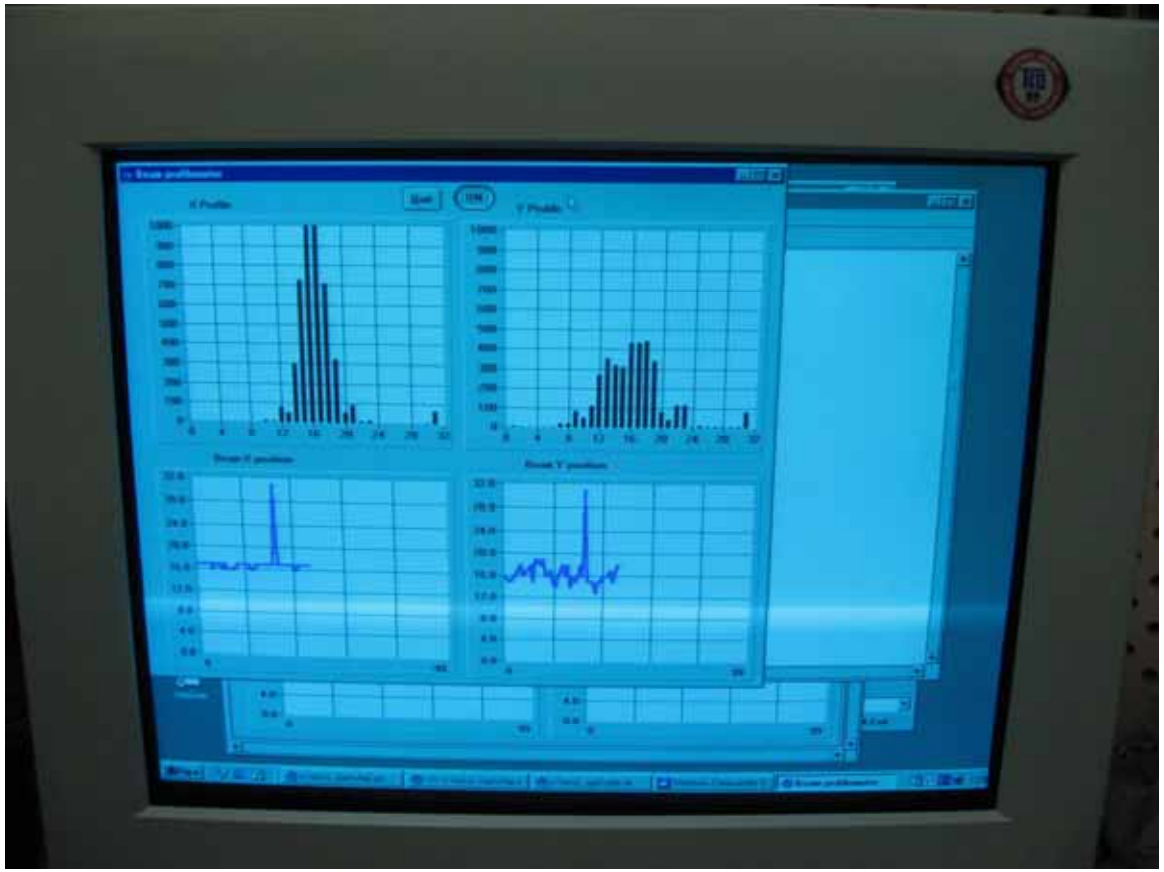
Samples used in the GAMMA-MD irradiation

Маркировка образцов	Чистый вес, г		Лигатурный вес, г		Активность, МБк (мКи)	Удельная Активность, МБк/г (мКи/г)
I-129-1 1,57·E7 лет	I-129	0,521	NaI	0,739	3,4 (0,092)	5,24 (0,147)
I-129-2	I-129	0,591	NaI	0,838	3,86 (0,10)	5,24 (0,147)
I-129-3	I-129	0,339	NaI	0,480	2,2 (0,06)	5,24 (0,147)
I-129-4	I-129	0,218	NaI	0,309	1,42 (0,038)	5,24 (0,147)
Np-237-1 α-2,14·E6 лет	Np-237	0,987	NpO_2	1,121	25,5 (0,69)	25,9 (0,7)
Np-237-2	Np-237	1.115	NpO_2	1,266	28,86 (0,78)	25,9 (0,7)
Np-237-3	Np-237	1,085	NpO_2	1,232	28,12 (0,76)	25,9 (0,7)
Np-237-4	Np-237	1,011	NpO_2	1,147	26,27 (0,71)	25,9 (0,7)
Pu-239-1 α-2,44·E4 лет	Pu-239	0,503	PuO_2	0,571	ГБк (мКи) 1,15 (31,19)	МБк/мг (мКи/мг) 2,3 (0,062)
Pu-239-2	Pu-239	0,511	PuO_2	0,579	1,17 (31,68)	2,3 (0,062)
Pu-239-3	Pu-239	0,455	PuO_2	0,516	1,04 (28,2)	2,3 (0,062)
Pu-239-4	Pu-239	0,456	PuO_2	0,506	1,02 (27,65)	2,3 (0,062)
Pu-239-5	Pu-239	0,462	PuO_2	0,524	1,06 (28,64)	2,3 (0,062)
Pu-239-6	Pu-239	0,454	PuO_2	0,515	1,04 (28,15)	2,3 (0,062)
Am-241-1 α-432 года	Am-241	0,183	AmO_2	0,208	ГБк (мКи) 23,2 (627)	МБк/мг (мКи/мг) 127 (3,43)
Am-241-2	Am-241	0,183	AmO_2	0,208	23,2 (627)	127 (3,43)
Am-241-3	Am-241	0,186	AmO_2	0,211	23,6 (638)	127 (3,43)
Pu-238-1 87,7 лет	Pu-238	0,0517	PuO_2	0,0734	879	17,1
Pu-238-2	Pu-238	0,0516	PuO_2	0,0733	877	17,1
Pu-238-3	Pu-238	0,0477	PuO_2	0,0677	811	17,1

From IPPE, Obninsk

Deuteron beam properties and monitoring techniques





$d(^{27}Al, 3p2n)^{24}Na$ (Banaigs)

monitored by Dr. W.Westmeier

σ = 15.38±1.12 mb

Start at 13:44 on 17.03.08

Stop at 15:01 on 18.03.07

Ring dimensions	^{24}Na activity in Bq	Deuterons per cm^2
r=10.5 mm to r=40 mm	307.1 ± 13.4	3.593E11 ± 1.568E10
r=40 mm to r=60 mm	20.2 ± 1.2	1.760E10 ± 1.045E9
r=60 mm to r=80 mm	5.978 ± 0.566	3.721E9 ± 3.523E8
r=0 mm to r=10.5 mm	4.217 ± 0.998	6.673E10 ± 1.579E10

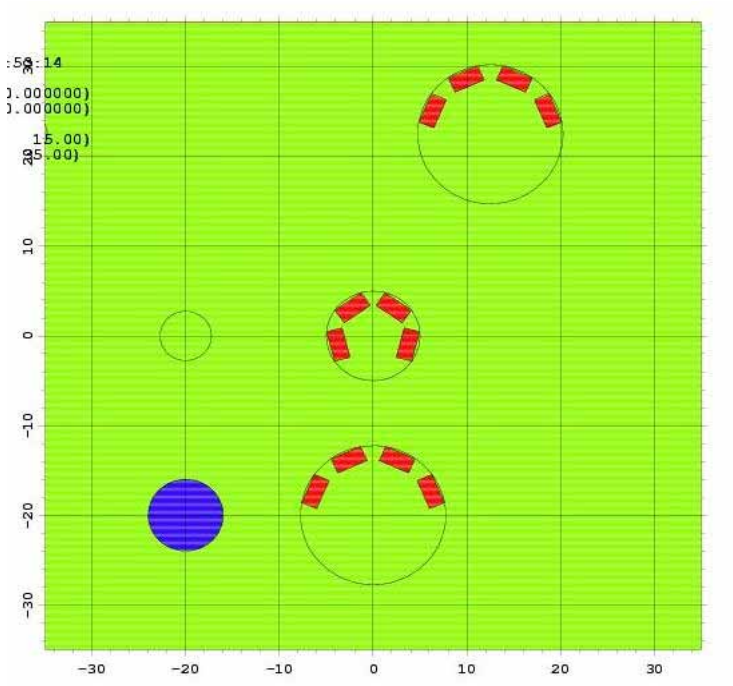
Spectrometry with HPGe detectors

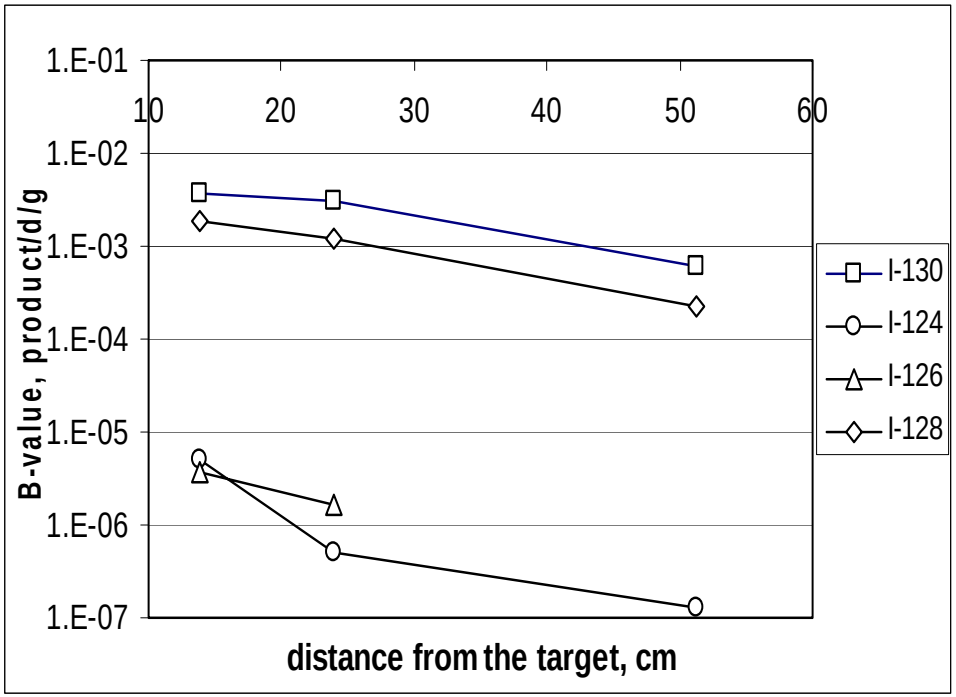
Gamma-spectra analysis was performed using
The following program codes:
GAMMAW (Dr. Westmeier GMBH), monitors
DEIMOS32 (Dr. Frana, Rez near Prague),
Fitzpeaks (Dr. Fitzgerald, math of SAMPO80)

Program package J. Adam, V.S. Pronskikh, A.R. Balabekyan et al, P10-2000-28, Measurement Techniques, 44(2001) 93-100.
Energy, efficiency calibration, background correction, surplus peaks removal, nuclide identification, cross section calculations, selective averaging

HPGe detector	CANBERRA GR1819	ORTEC GMX-23200	ORTEC GMX-20190-P	CANBERRA GC1520
Rel. efficiency	18.9 %	27.7 %	28.3 %	15%
Resolution at (E_g 1332 keV)	1.78 keV	1.86 keV	1.80 keV	2.0 keV
Amplifier	ORTEC 973	CANBERRA 2024	CANBERRA 2026	CANBERRA 2002
ADC	ORTEC 921 SPECTR. MASTER	ORTEC 919 SPECTR. MASTER	ORTEC 919 SPECTR. MASTER	CANBERRA

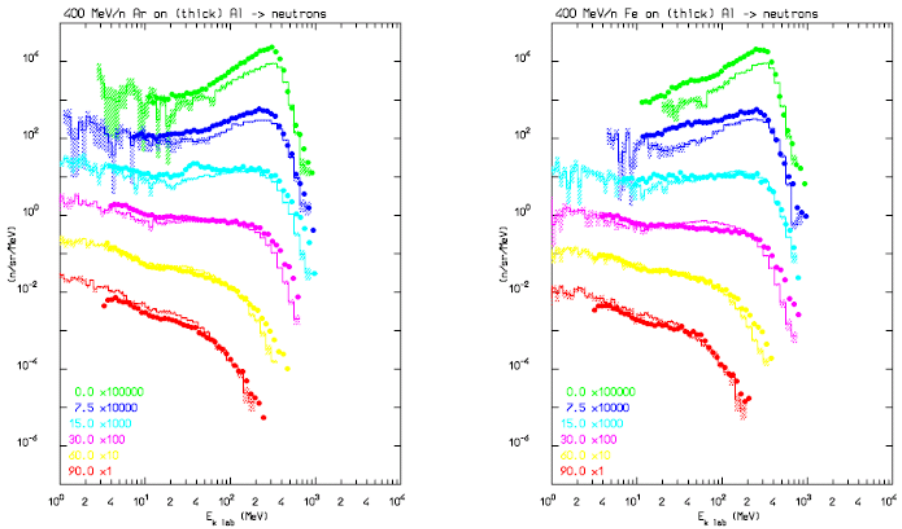
Transmutation rates B





Product	Target	Relative rates B [g^{-1}, d^{-1}]		
		19 cm	29 cm	55 cm
^{130}I	^{129}I	3.8(5)E-3	3.1(4)E-3	6.0(9)E-4
^{124}I	^{129}I	5.1(6)E-6	5.0(7)E-7	1.3(3)E-7
^{126}I	^{129}I	3.8(5)E-6	1.6(1)E-6	----------
^{128}I	^{127}I	1.9(2)E-3	1.2(1)E-3	2.2(3)E-4
Transmutation I=10mA, 30d	^{129}I (%)	23.8	18.8	3.8

Monte-Carlo simulations with FLUKA code

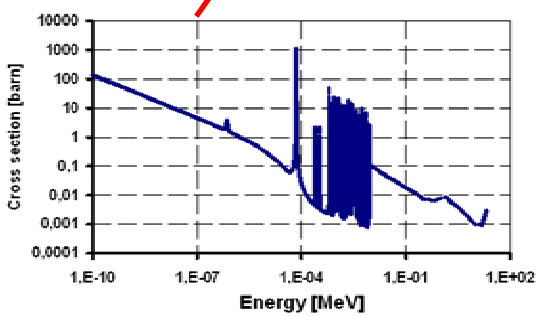


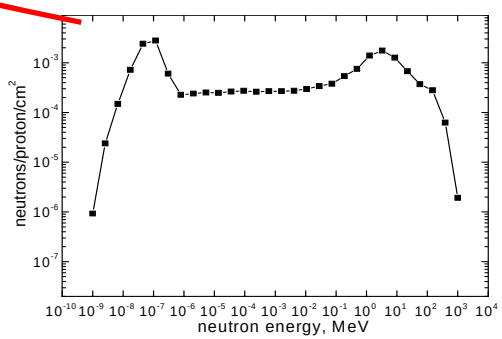
Double differential neutron yield by 400 MeV/n Ar (left) and Fe (right) ions on thick Al targets, histo FLUKA, dots exp. data (PRC62 044615 (2000)).

$$B = \frac{N_{at}}{m \cdot N_p} \quad [\text{ion}^{-1} \cdot \text{gram}^{-1}]$$

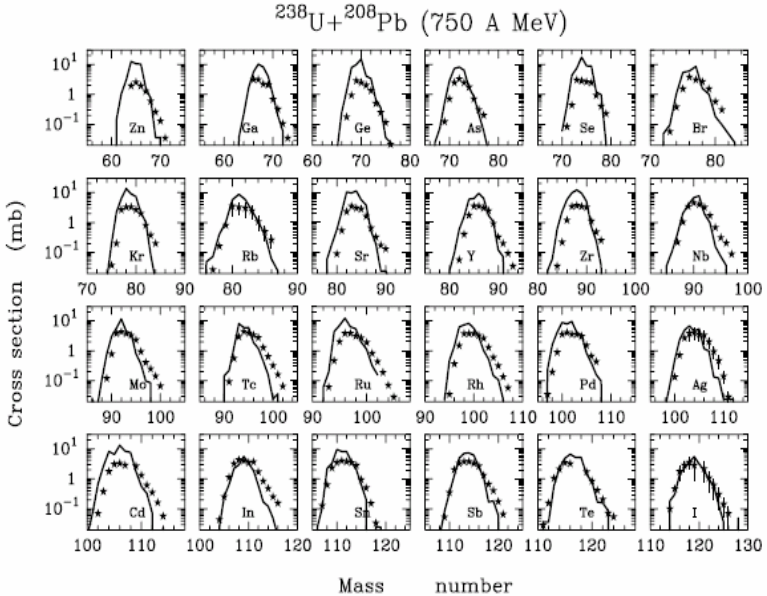
$$R = \frac{B \cdot A}{N_A} =$$

$$= \int_{E_{\min}}^{E_{\max}} \sigma(E)\Phi(E)\mathrm{d}E \quad [\text{deuteron}^{-1}\text{atom}^{-1}]$$





From F. Ballarini et al., ND2004

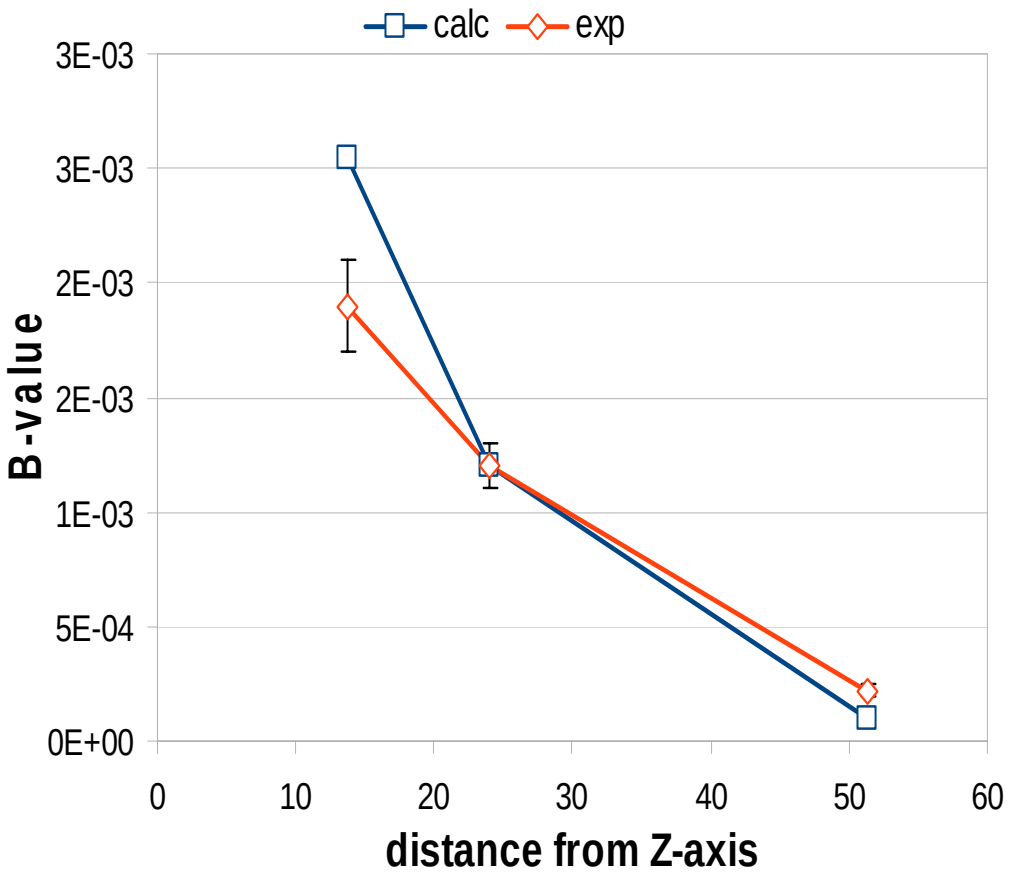


G. Battistoni et al., Braz.J.Phys. 2004

Fluka (RQMD fully integrated). Improvement of classical INC by adding dynamical modelling of the nuclear field among nucleons in the course of the reaction, with similar treating of individual two-body scattering/interactions. Applicable from 0.1 GeV/n to hundreds GeV/n.

Comparison with the experimental data on ^{130}I production

B-values for the cylinders at 13.8, 24, and 51.3 cm distances from the Z-axis, respectively



Differential B-values for the three cylinders calculated for each of the 72 neutron groups separately using JEFF-3.1 cross section library and employing NJOY program code