STUDYING OF NEUTRON FIELDS IN THE "GAMMA-MD" SETUP IN LHEP JINR (DUBNA) UNDER 2.33 GEV DEUTERON IRRADIATION

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LEAD / GRAPHYTE - ASSEMBLY "GAMMA - MD" FOR INVESTIGATION OF TRANSMUTATION OF RADIOACTIVE WASTE IRRADIATED BY DEUTERON BEAM WITH ENERGY 2.33 GEV OF THE NUCLOTRON (JINR, DUBNA)

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What is the purposes of this work:

- **To determine deuteron beam parameters**

- **To measure a number of neutrons generated in the lead target per one beam part and a number of neutrons leaving the system GAMMA-MD**

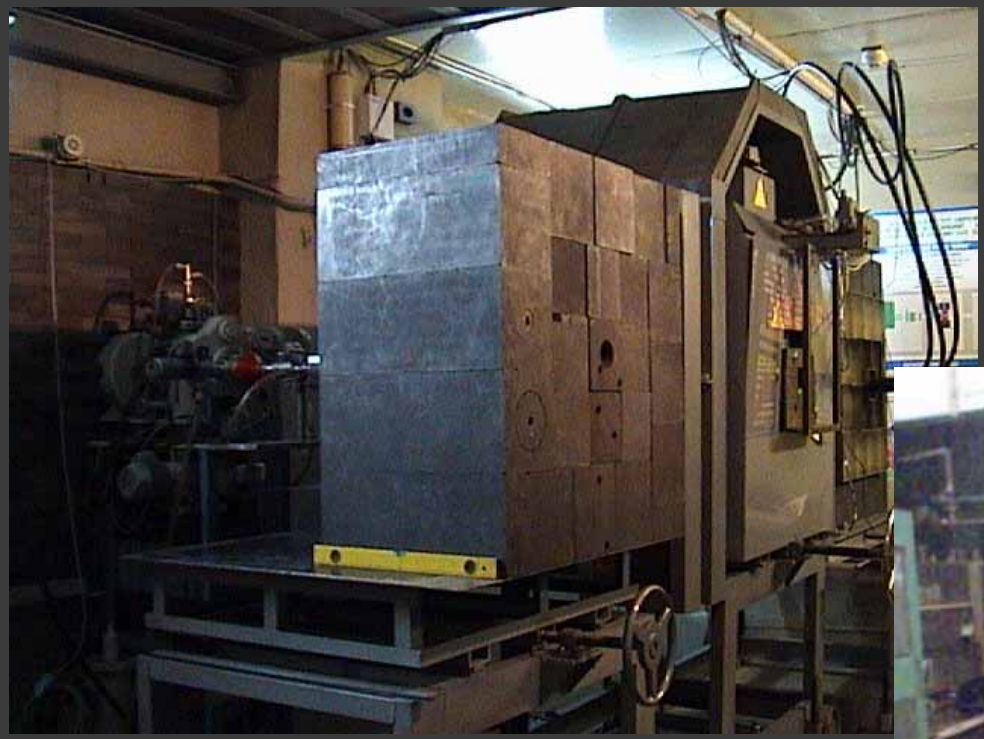
- **To develop combine γ-track technique of** $\sigma^{238U}_{capture} / \sigma^{235U}_{fission}$ **spectral index measurement**

- **To investigate topography of neutron fields**
  - **for thermal (to investigate distribution of U-235 fission reaction rates, reaction rates of radiation capture for U-238 (n, γ), Au197 (n, g) isotopes)**
  - **for fast neutrons (to investigate distribution of U-238 fission reaction rate**

- **To obtain spatial distribution of spectral index** $\sigma^{238U}_{capture} / \sigma^{235U}_{fission}$

- **To obtain spatial distribution of spectral index** $\sigma^{238U}_{fission} / \sigma^{235U}_{fission}$

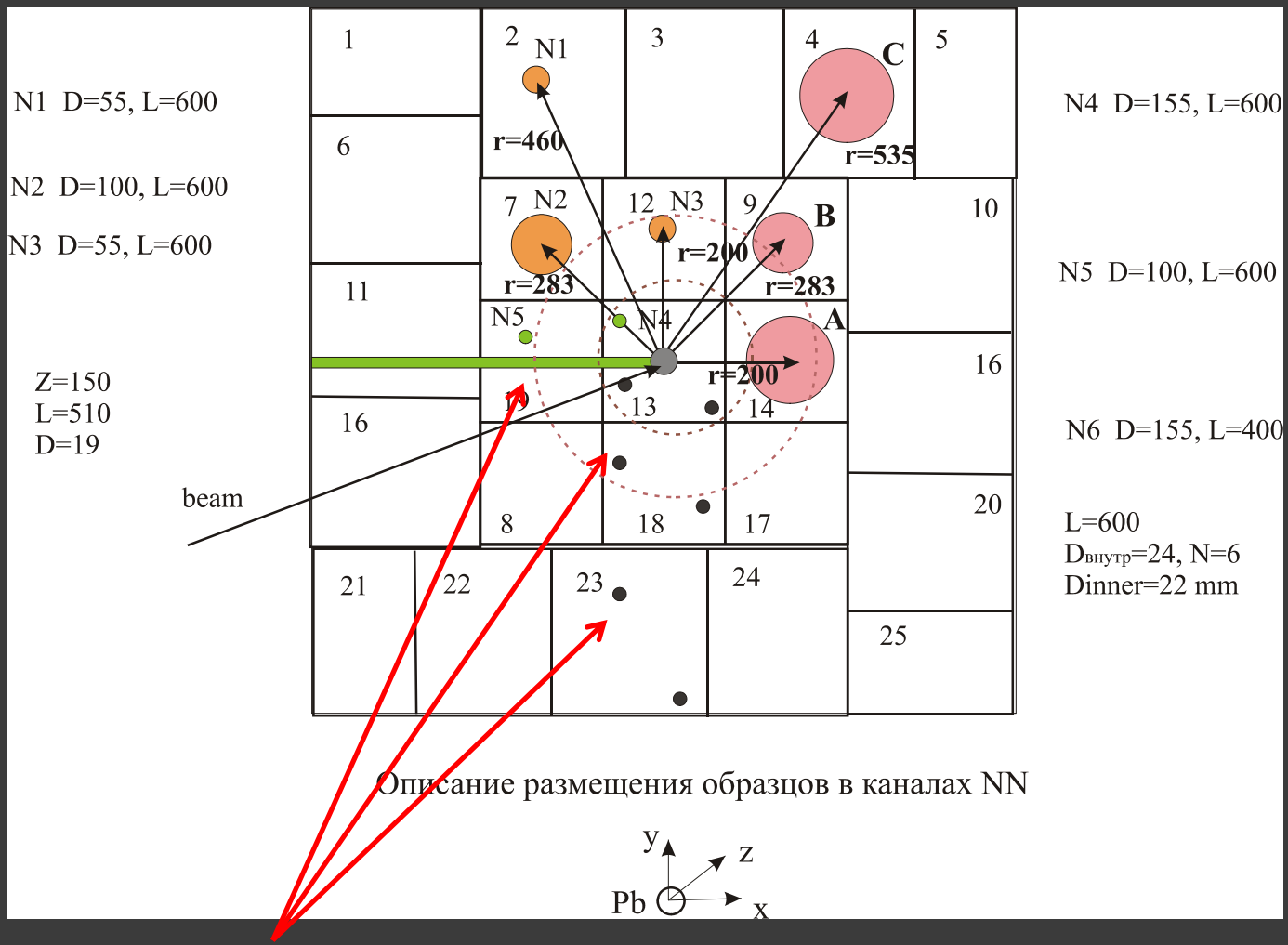
GAMMA-MD : how it's looks



In JIPNR (Belarus, Minsk)

… and in LHEP (JINR ,Dubna)

THE SCHEME OF A FACE-TO-FACE PLANE OF THE GAMMA-MD SETUP WITH THE EXPERIMENTAL CHANNELS FOR ACTIVATION AND TRACK DETECTOR, AND FOR TRANSMUTATION SAMPLES

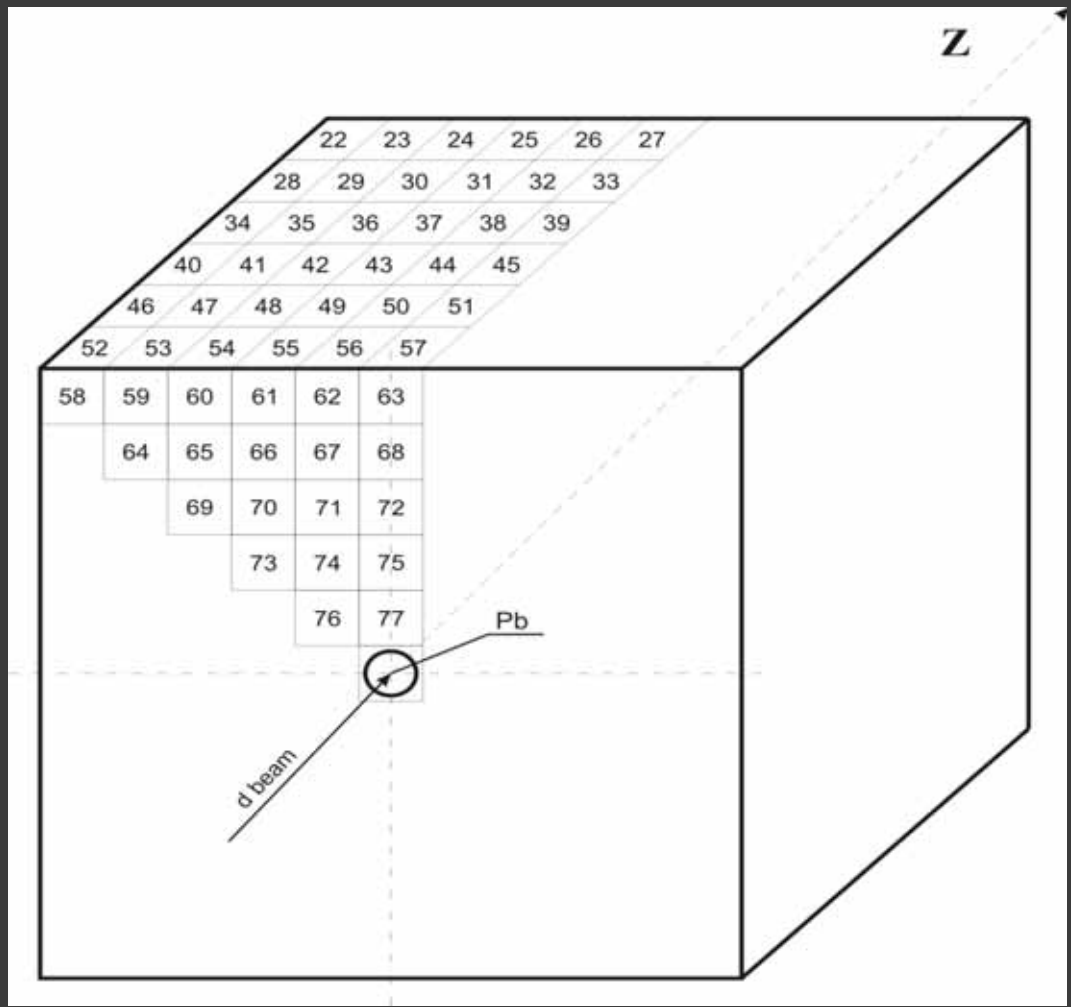


Experimental channels which were used in the present work are in green and

THE GRAPHITE CYLINDER WITH TRANSMUTATION SAMPLES IN THE EXPERIME ^{237}NP, ^{239}PU AND ^{238}PU

Baldin Seminar on High Energy Physics Problem, 2008

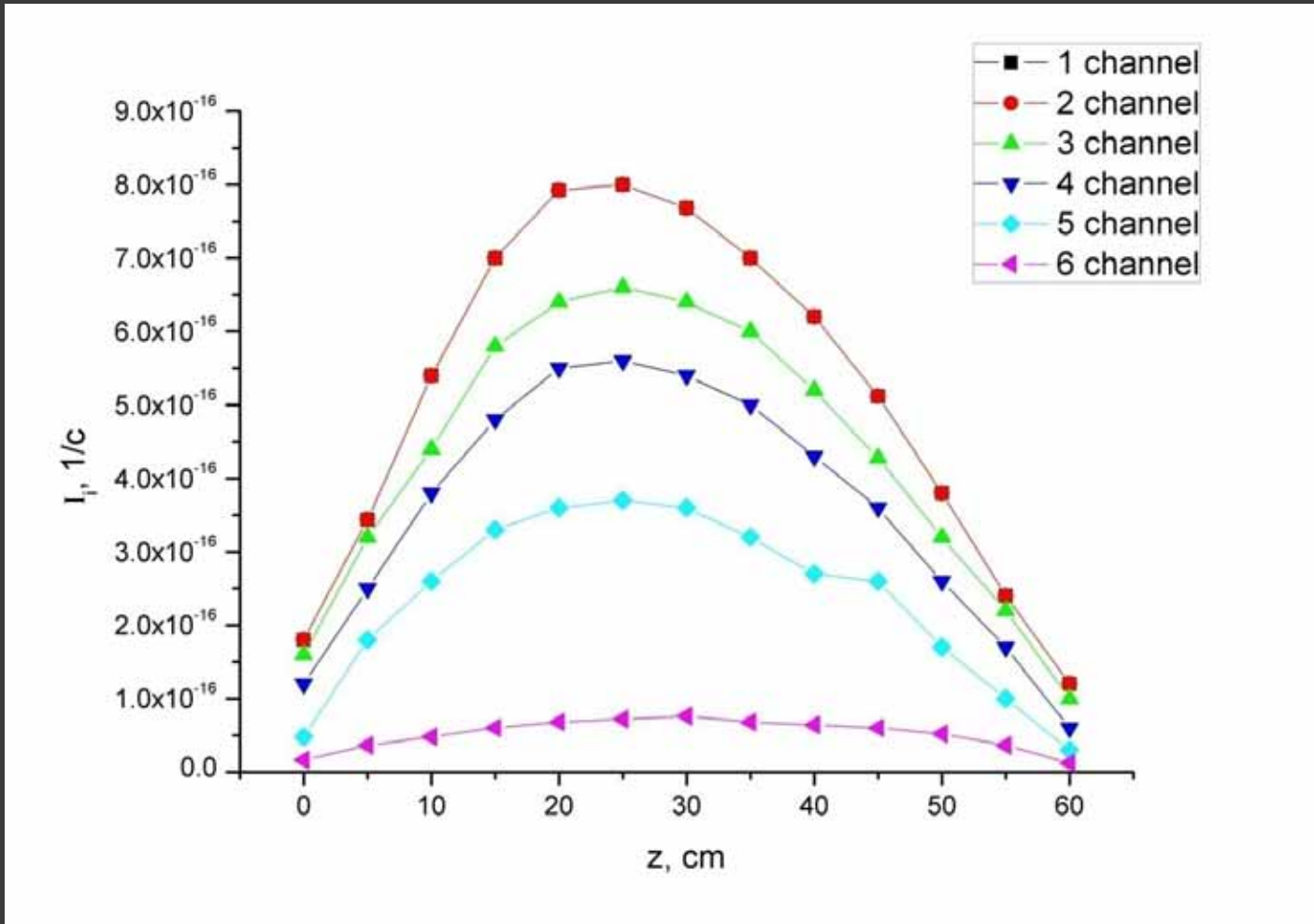
PLACEMENTS OF SAMPLES SB_2O_3 ON THE INSTALLATION SURFACE (ON FORWARD AND BACK SIDES SAMPLES SETTLED DOWN EQUALLY)



The number of neutron generated in the lead target per 2.33GeV deuteron:

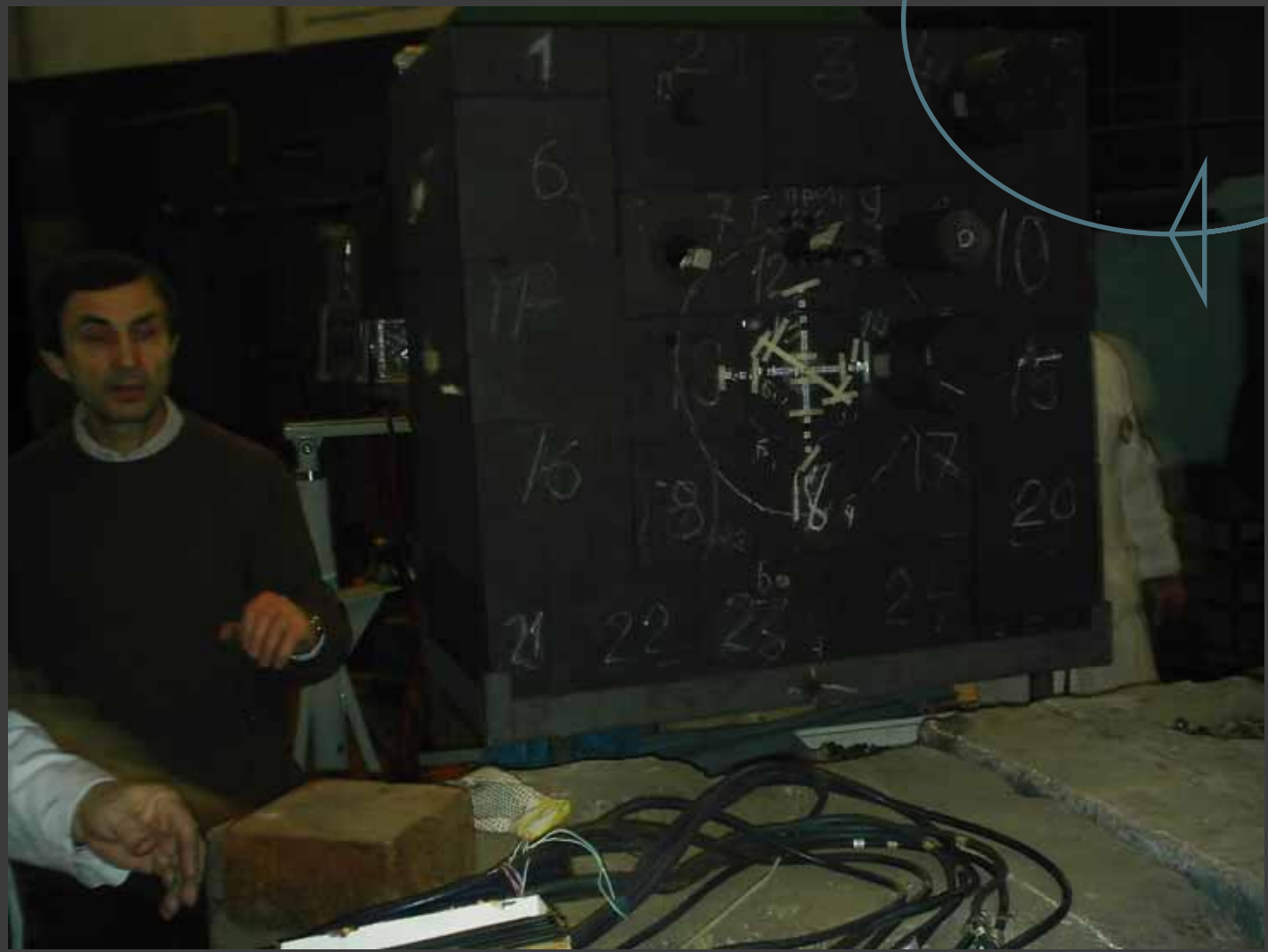
Experiment:
40±5 neutron/deuteron
(using measurement of (n,γ) reactio
In Sb123 samples on the surface
In Au197 activation foils in the volume
Of the setup (the next slide)

FLUKA simulations:
53.8 neutron/deuteron

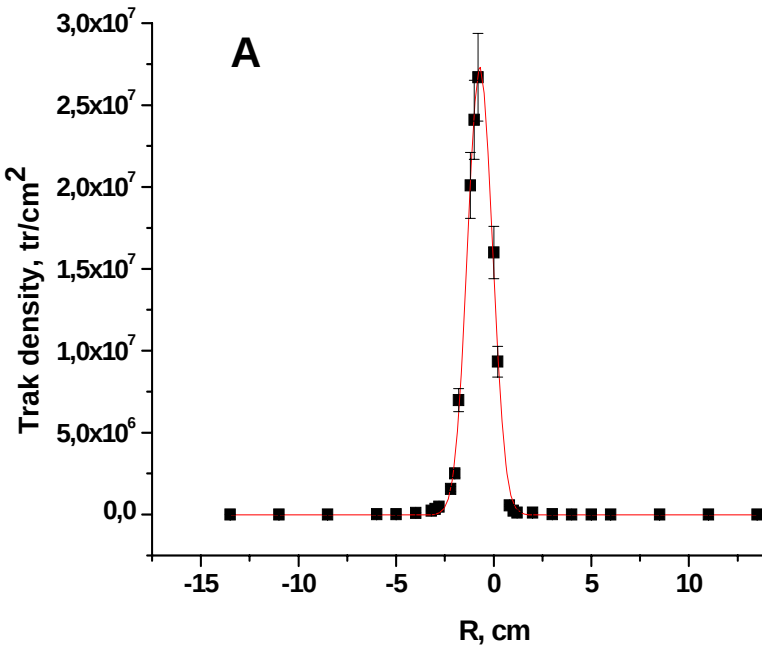


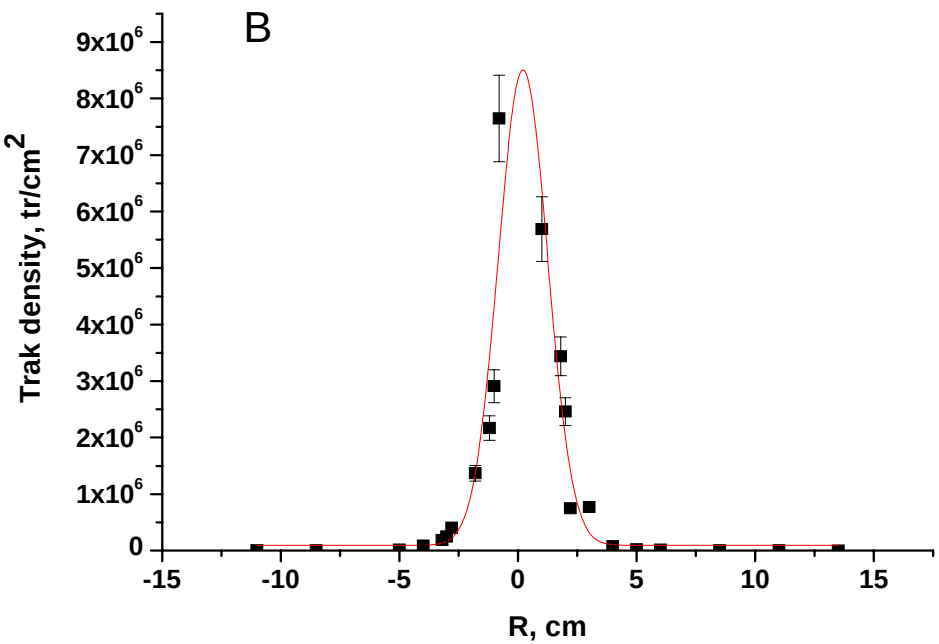
Axial distribution of capture reaction rates ($^{197}Au(n,\gamma)^{198}Au$) in six experimental channels in the bottom of the setup
R=6; 11; 18; 25; 35; 53 cm

GAMMA-MD setup with SSNTD detectors
for determination of deuteron beam parameters



Deuteron beam parameters





Distribution of lead fission track densities

A - Azimuth 0 - 180° (horizontal axis X)

B - Azimuth 90 - 270° (vertical axis Y)

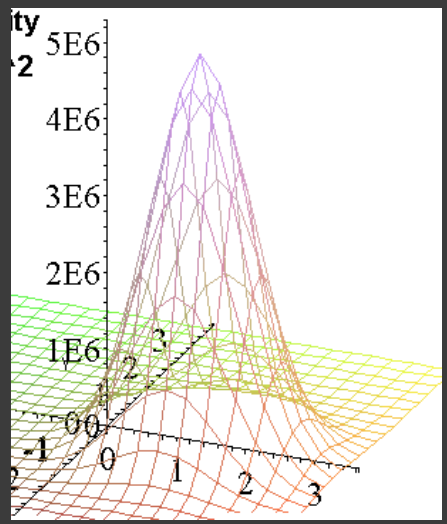
DEUTERON BEAM PARAMETERS

Deuteron Energy, GeV	FWHM (cm)		Center position (cm)		Fluens	The part of the beam which has got to a target, (%)
	X	Y	Xc	Yc		
2.33	1,5±0,1	2,4±0,1	0,7±0,1	0,2±0,1	5.9×10^{12}	99,8*

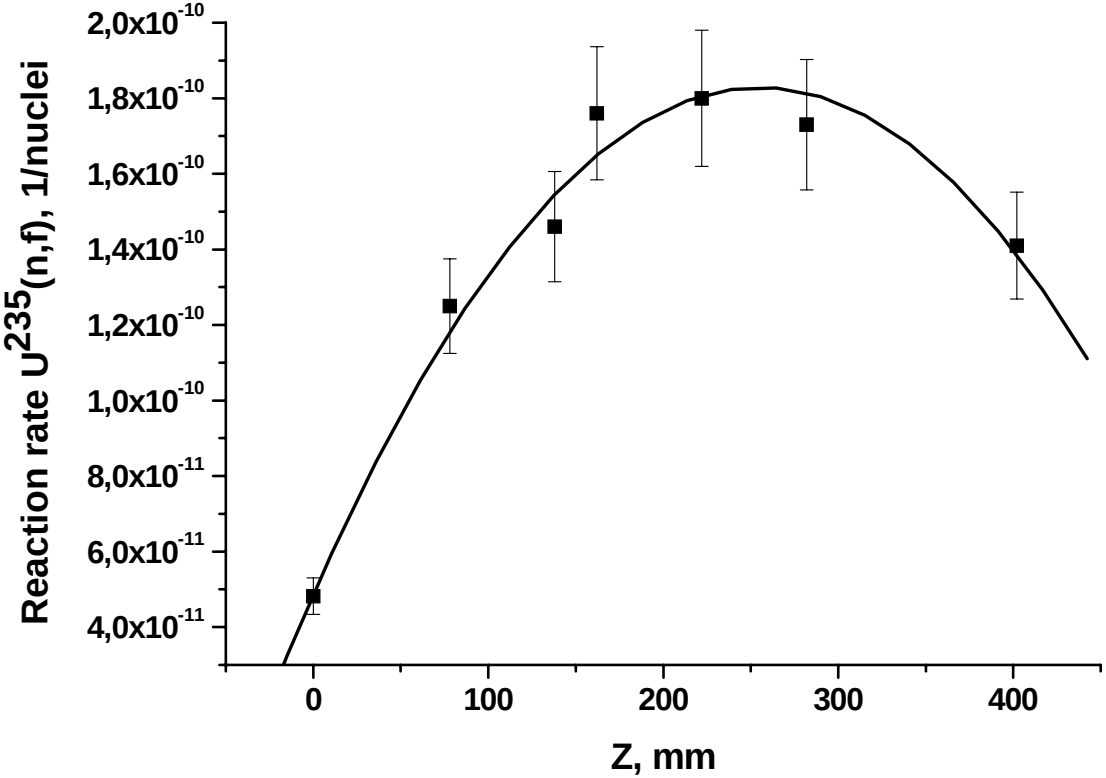
*** In assumption of the Gaussian shape of the beam**

Polaroid film with a trace of the 10^9 deuteron bunch

… And Gaussian shape of the track densities distribution

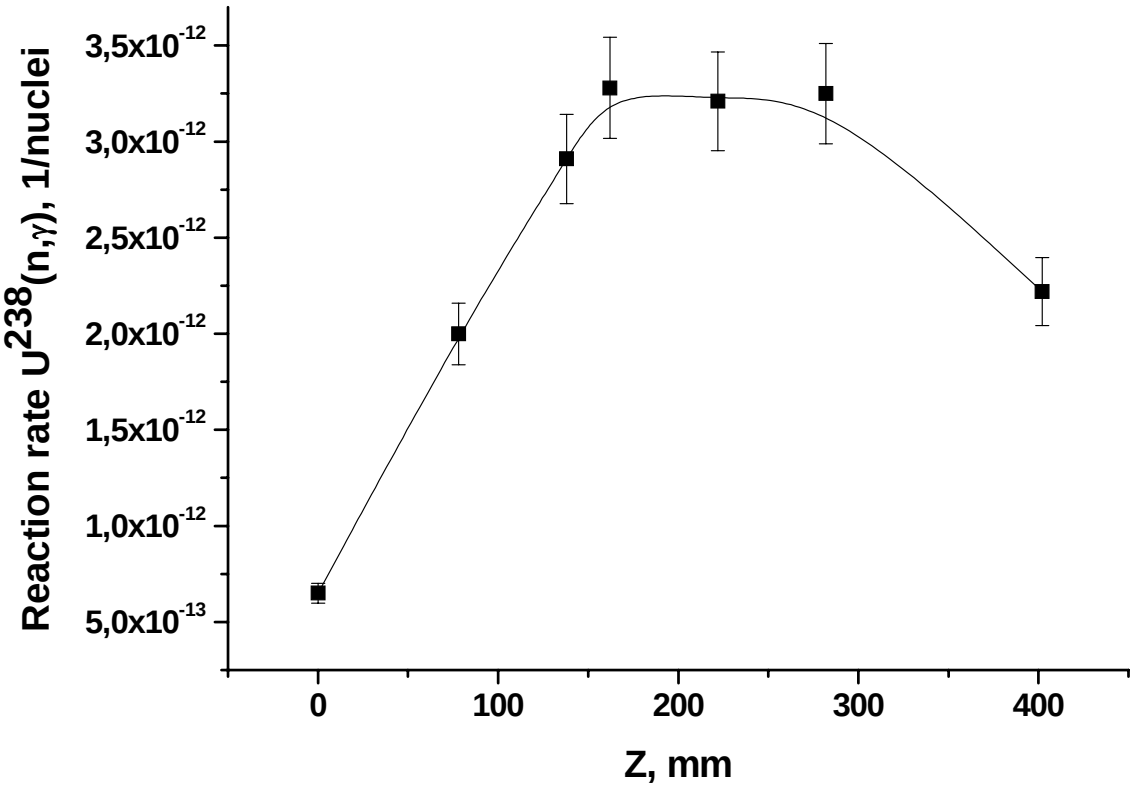


Axial distribution of ***U-235*** fission rates



The axial experimental channel passed on radial distance of 125 mm from axis of the setup.
Axial distance Z:
0; 78; 138; 162; 222; 282 and 402 mm.

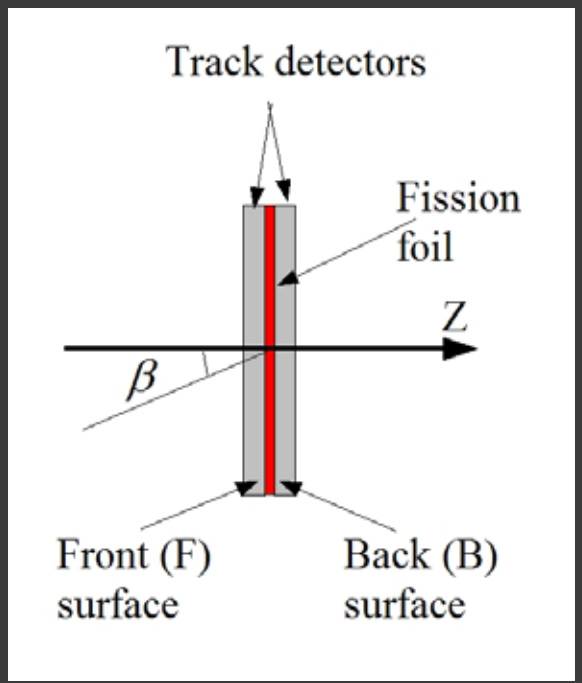
Axial distribution of *U-238 capture reaction rate*



The axial experimental channel passed on radial distance of 125 mm from axis of the setup.
Axial distance Z:
0; 78; 138; 162; 222; 282 and 402 mm.

COMBINE γ-TRACK TECHNIQUE OF SPECTRAL $\overline{\sigma}_{capture}^{238U} / \overline{\sigma}_{fission}^{235U}$ INDEX MEASUREMENT

Schematic drawing of sensor consisted of track detectors and radiator (source of fission fragments)



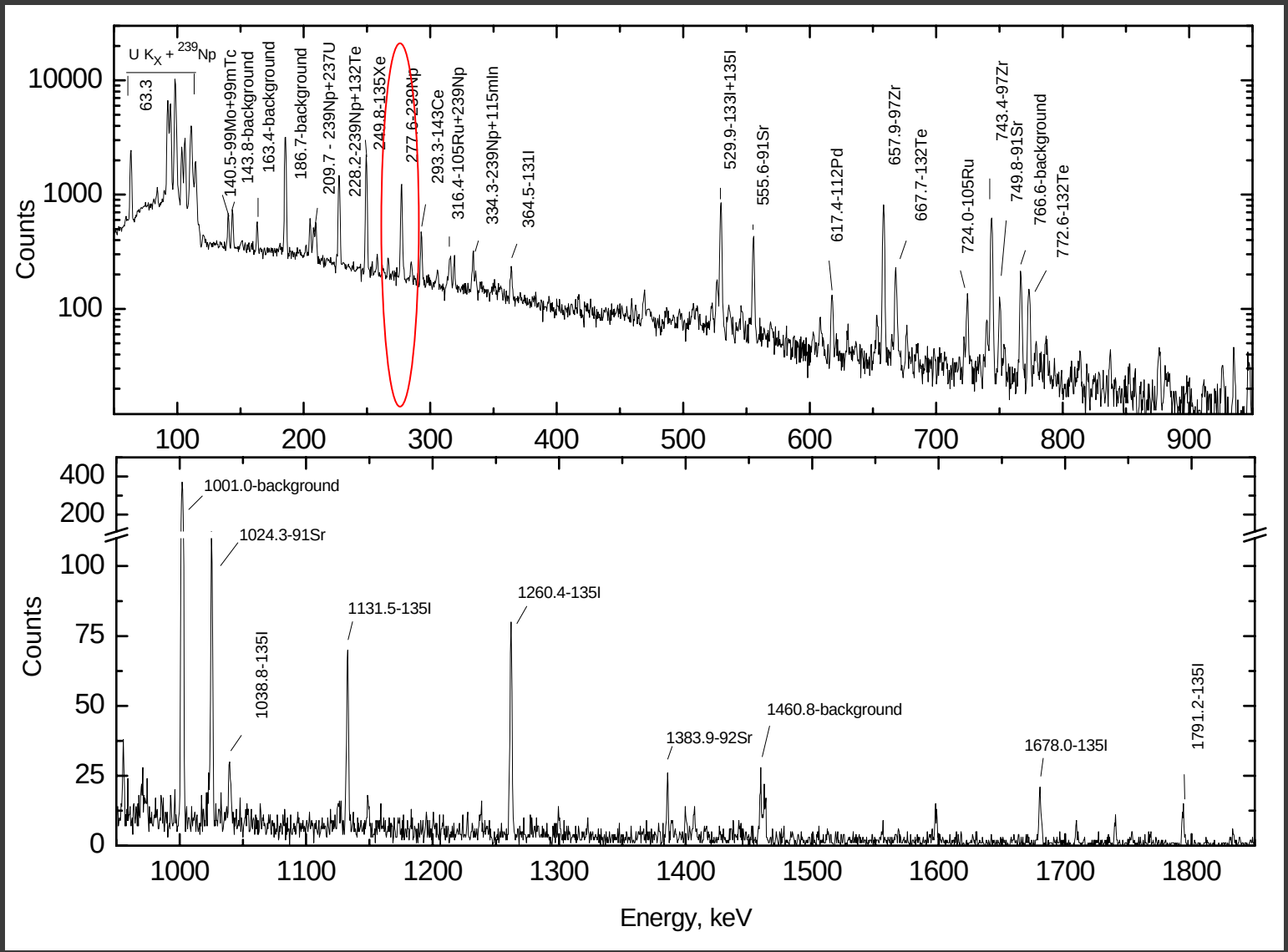
Solid nuclear track detector (SSNTD) + radiator (fission foil)

SSNTD: Track counting and fission rate determination

Fission foil: Activation measurement and capture reaction rate determination

The procedure of combining the track counting and gamma-spectrometry techniques for the determination of spectral indices is a new development. It involves reception of information from the same sample by SSNTD-methods, i.e. counting the fission tracks of ^{235}U, and by γ-ray spectrometry methods, i.e. counting a γ-line from the nuclide ^{239}Np at 277.6 keV.

$$^{238}U(n,\gamma)^{239}U^{*} \xrightarrow{\beta^{-};T_{1/2}=23,4\,\min} {}^{239}Np^{*} \xrightarrow{\beta^{-};T_{1/2}=2,36d} {}^{239}Pu^{*} \xrightarrow{\alpha;T_{1/2}=2,41.10^{4}\,y}$$

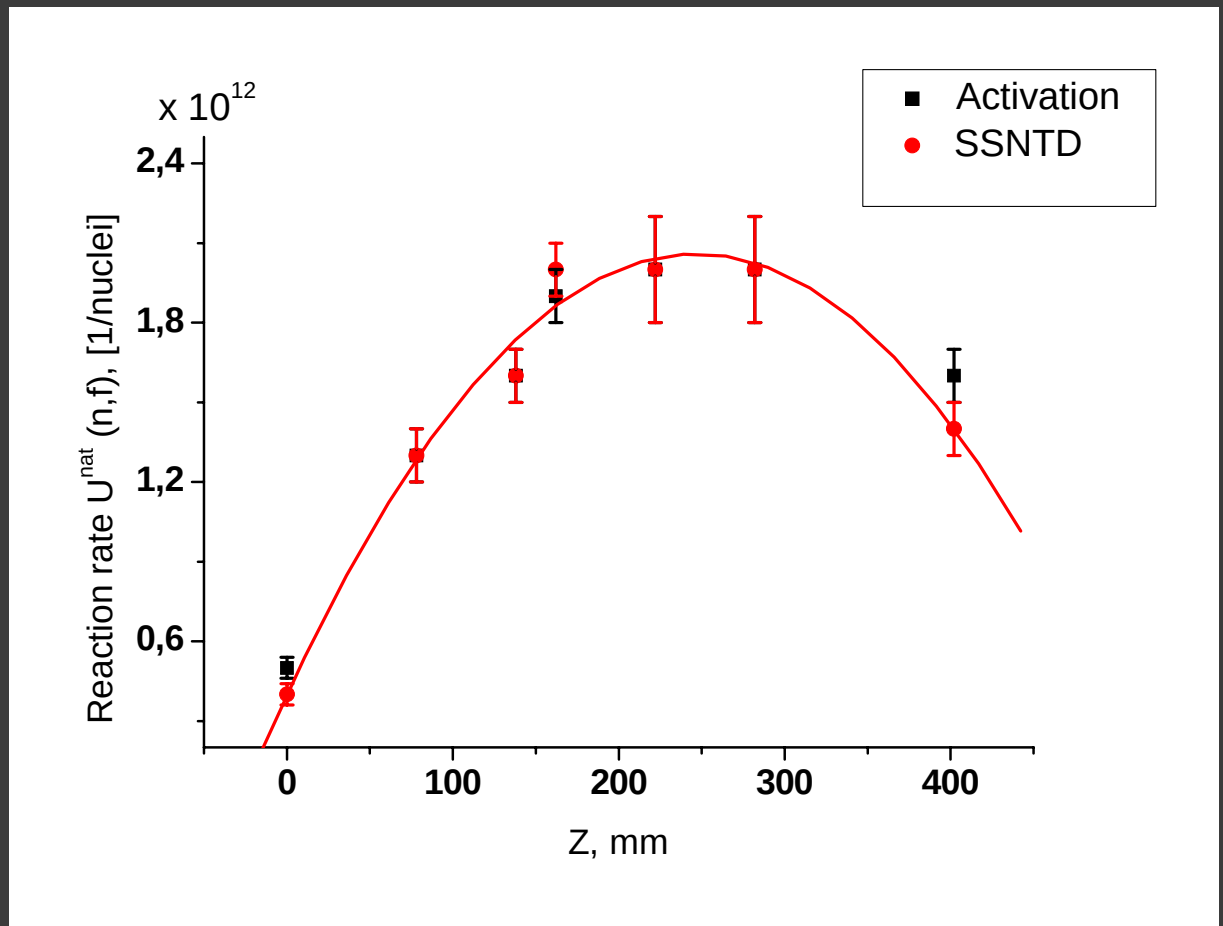


Line of ^{239}Np at 277.6 keV is in red …

^{97}Zr (Y=5.7%)
^{131}I (Y=3.6%)
^{133}I (Y=6.3%)
^{143}Ce (Y=4.3%)

Typical spectrum of irradiated Uranium foil. With the gamma lines accompanying ^{239}Np decay, in a spectrum lines of fission fragments in the range of mass number A=91 … 143 were identified: (^{91}Sr; ^{97}Zr; ^{105}Ru: ^{131}I; ^{132}Te; ^{133}I; ^{135}I; ^{135}Xe; ^{143}Ce ……)

AXIAL DISTRIBUTION OF NATURAL URANIUM FISSION RATES WAS MEASURED USING TWO INDEPENDENT TECHNIQUES: SSNTD AND ACTIVATION

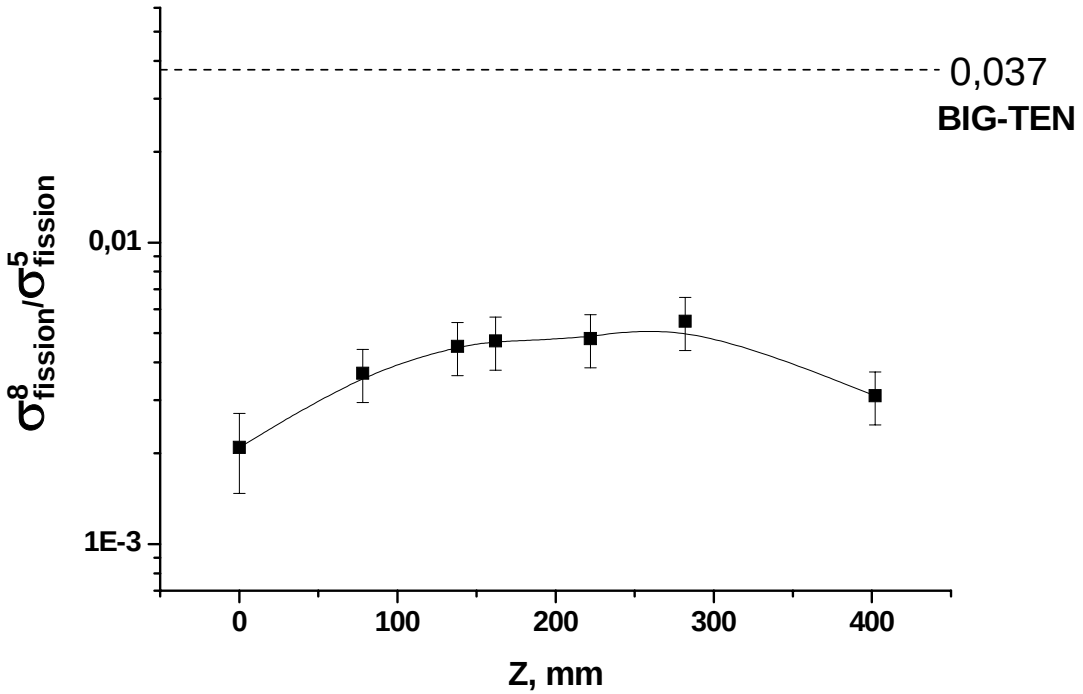


The axial experimental channel passed on radial distance of 125 mm from axis of the setup.
Axial distance Z:
0; 78; 138; 162; 222; 282 and 402 mm.

Line is drawn to guide the eyes

Axial distribution of spectral inde

$\sigma^{238U}_{fission} / \sigma^{235U}_{fission}$



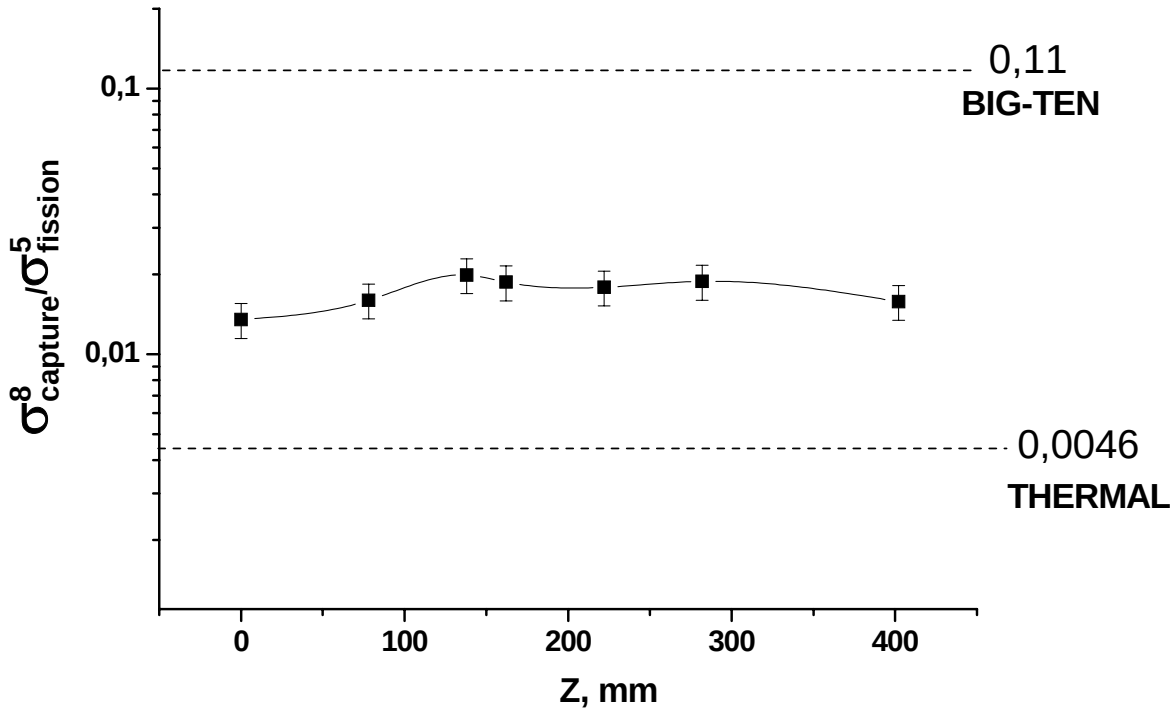
The spectral index is equal 0,242 for fission spectrum

BIG-TEN:
Average neutron energy
0.58 MeV
Median neutron energy
0.31 MeV

Solid line is drawn to guide the eyes

Dotted line is the value of spectral index for standard neutron field in the BIG-TEN setup (see J. Grundl and C. Eisenhauer, **Benchmark neutron field for reactor dosimetry,** Contribution to neutron cross section for reactor dosimetry, Proc. IAEA Consultants Meeting, Vienna, November 15-19, 1976, Report IAEA, Vol. I, p 53 (IAEA, Vienna, 1978)

Axial distribution of spectral index $\sigma^{238U}_{capture} / \sigma^{235U}_{fission}$



BIG-TEN:

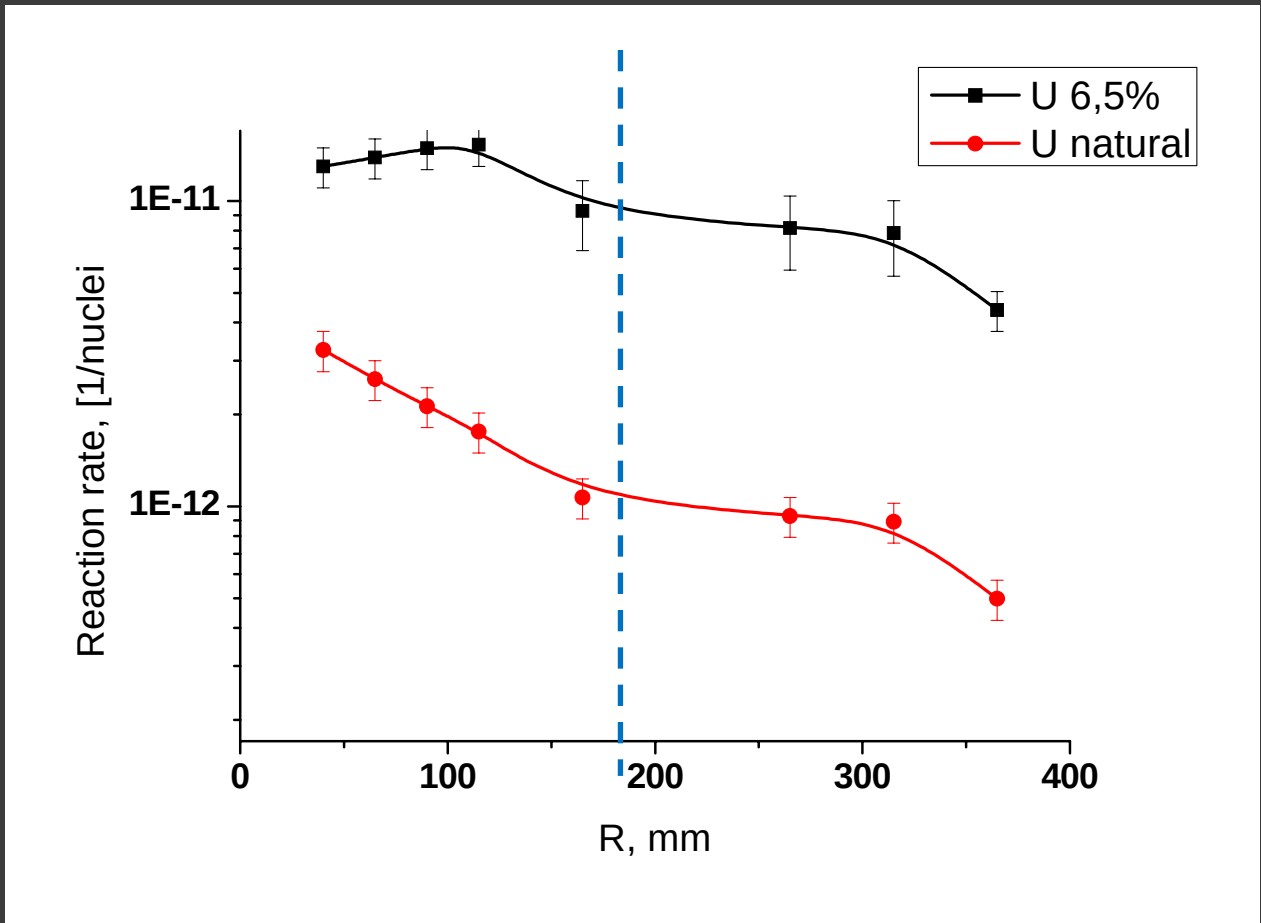
Average neutron energy 0.58 MeV

Median neutron energy 0.31 MeV

Solid line is drawn to guide the eyes

Dotted lines is the value of spectral index for standard neutron field in the BIG-TEN setup and thermal spectrum

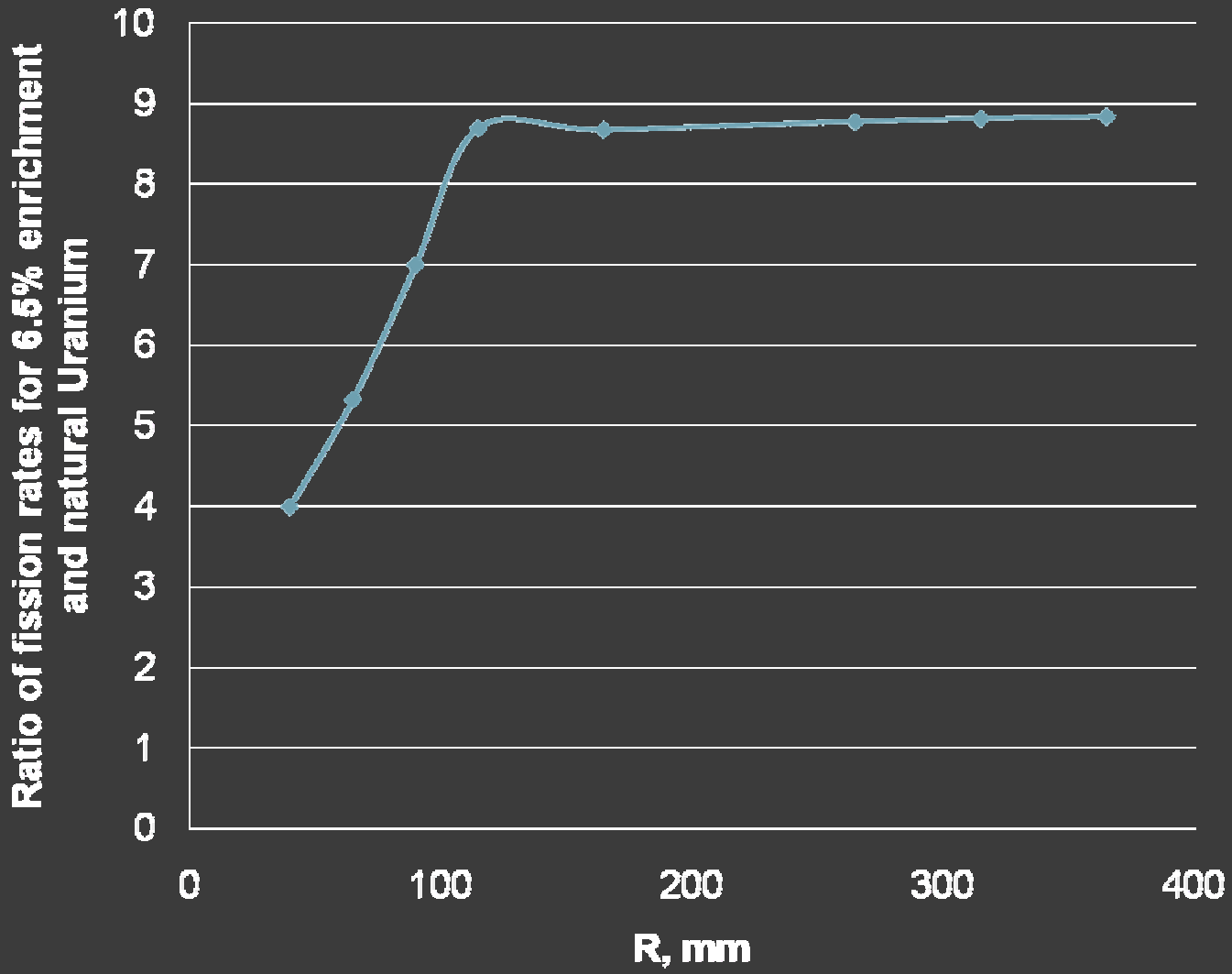
RADIAL DISTRIBUTION OF NATURAL AND 6.5 % ENRICHMENT URANIUM FISSION RATES



With increasing of radial distance, neutron spectrum more and more becomes similar thermal

From 150-160 mm, ratio of fission reaction rates is equal – 8.7 - 9

Ratio of U-235 contamination in the sample of 6.5% enriched uranium and natural uranium sample is ~ 9.02



Ratio of U-235 contamination in the sample of 6.5% enriched uranium and natural uranium sample is ~ 9.02

Conclusion:

- **Primary deuteron beam parameters were obtained**
- **A number of neutrons generated in the lead target per one beam particle and a number of neutrons leaving the system GAMMA-MD were measured experimentally and obtained using Monte-Carlo simulation**
- **Combine γ-track technique of** $\sigma_{capture}^{238U} / \sigma_{fission}^{235U}$ **spectral index measurement was developed**
- **Thermal and fast part of neutron spectra in the volume of the setup were investi**
- **Spatial distribution of spectral indexes** $\sigma_{capture}^{238U} / \sigma_{fission}^{235U}$ $\sigma_{fission}^{238U} / \sigma_{fission}^{235U}$ **were obtained**

Цель работы

1.-проведены расчеты по программе MCNPX спектров нейтронов и скоростей ядерных реакций в экспериментальных каналах уст

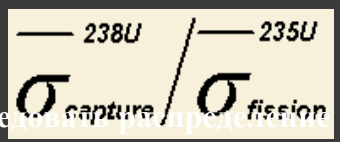
1.Определить параметры первичного дейтронного пучка

2.-измерить потоки нейтронов, выходящих через поверхность установки ГАММА-2МД, и определено число вторичных нейтрон

3.-разработать треково-γ -спектрометрическую методику измерений отношения скорости захвата ^{238}U к скорости деления для ну

4.– определить топографию полей тепловых (**исследовать распределение скорости реакции деления U-235, скорости реакции U-238**)

1.Исследовать распределение значений спектрального индекса



1.Исследовать распределение значений спектрального индекса

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THANK YOU