Study of neutron fields generated in the massive uranium target bombarded by deuterons and ^{12}C ions with energy of 1-4 GeV/A

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Project «E and T – RAW»

Study of deep subcritical electronuclear systems and feasibility of their application for energy production and radioactive waste transmutation

The project aims to determine potential new scheme of Electronuclear mode of neutron production based on **Relativistic Nuclear Technologies.**

International collaboration "Energy + Transmutation RAW"
Main purposes of the project «E and T – RAW»

Determination of optimum energy and type of particles (protons - deuterons).

The study of the processes of the neutron formation and the spatial distribution of neutron spectra.

Determination of dependence of the beam power amplification on energy of the incident protons and deuterons.

Determination of the spatial distribution of dynamic of production destruction (fission) ^{239}Pu depending on its concentration and determination its equilibrium concentration.

Determination of the reaction rate of processing the most relevant isotopes from the spent nuclear fuel.

Obtaining a set of experimental data for modifying existing models and transport codes.

Main purposes

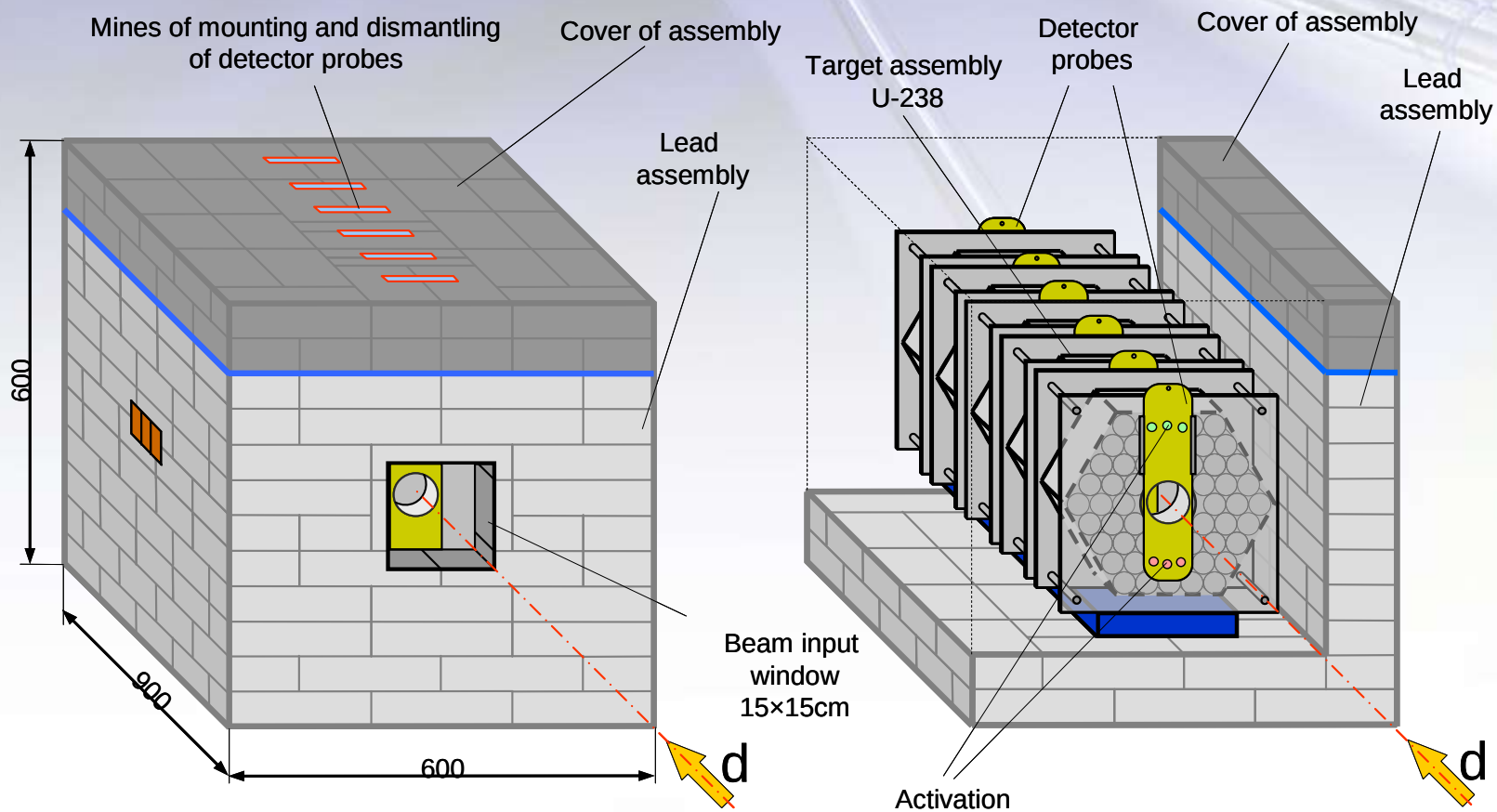
to perform the monitoring of deuteron and ^{12}C ion beam;

to obtain spatial distributions of density of radiative capture reactions (the number of accumulating ^{239}Pu nuclei) and density of ^{238}U fissions in the volume of uranium target of assembly "QUINTA";

to obtain spatial distribution of spectral indices;

to compare obtained experimental results in dependence on the energy of deuteron beam and type of particles (per unit of beam power).

Experimental assembly “QUINTA”



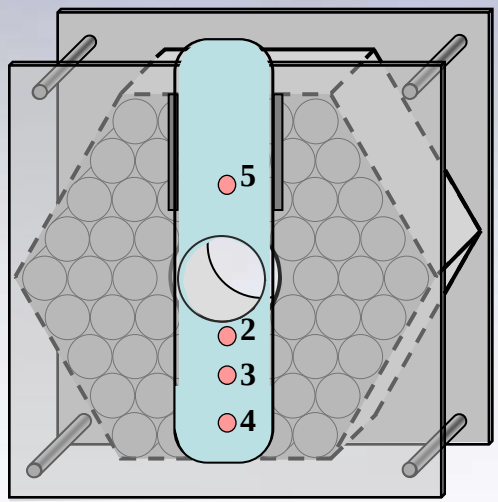
$m_{\Sigma} \approx 3100$ kg

$m_{Pb} \approx 2545$ kg

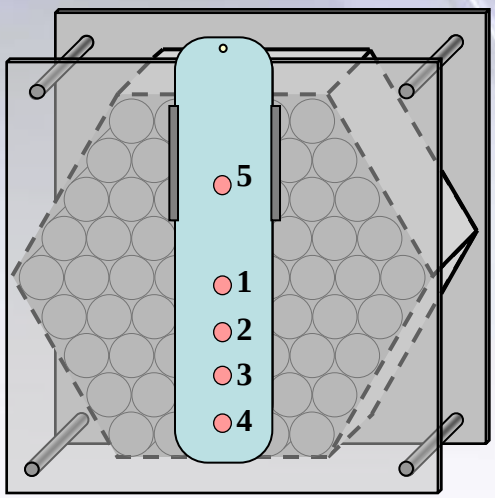
$m_{U} \approx 512$ kg

Location of detectors on the plate

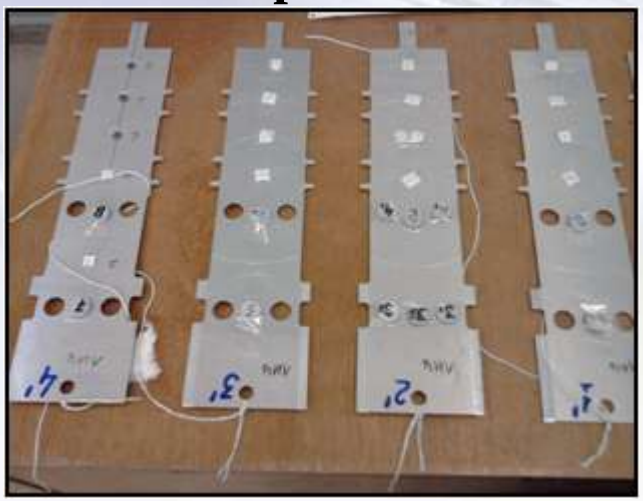
Section № 1

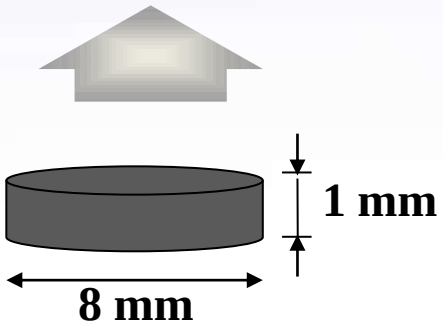


Sections № 2,3,4,5



Detector plates

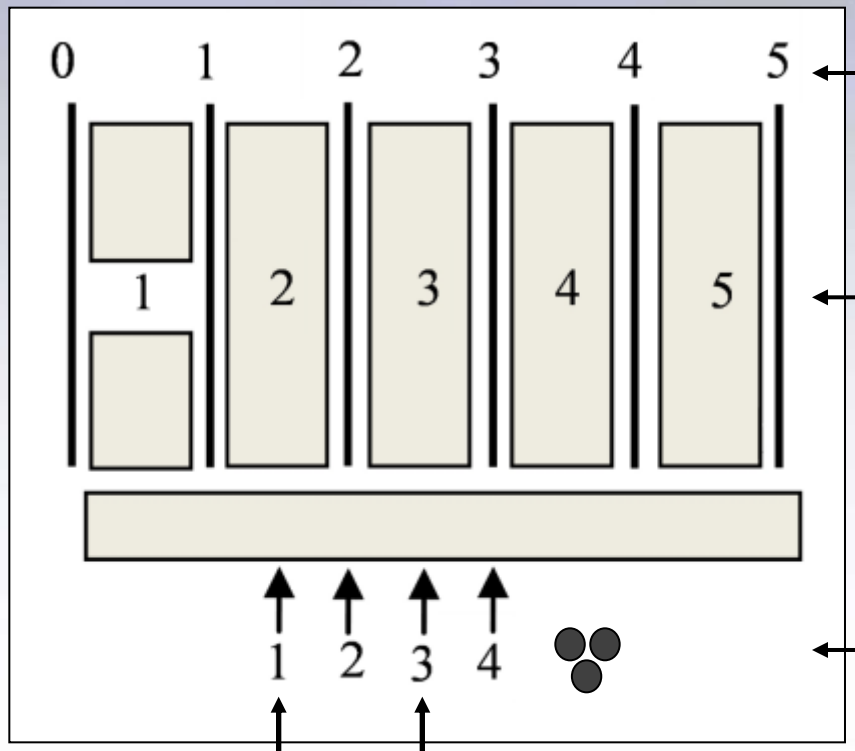




- **5** R = -80 mm
- **1** R = 0
- **2** R = 40 mm
- **3** R = 80 mm
- **4** R = 120 mm

0 plate	-	-	-40	-80	-120
1 plate	-	0	-40	-80	-120
2 plate	+80	0	-40	-80	-120
3 plate.		0	-40	-80	-120
4 plate.	+80	0	-40	-80	-120
5 plate.	-	0	-40	-80	-120

QUINTA with detector plates



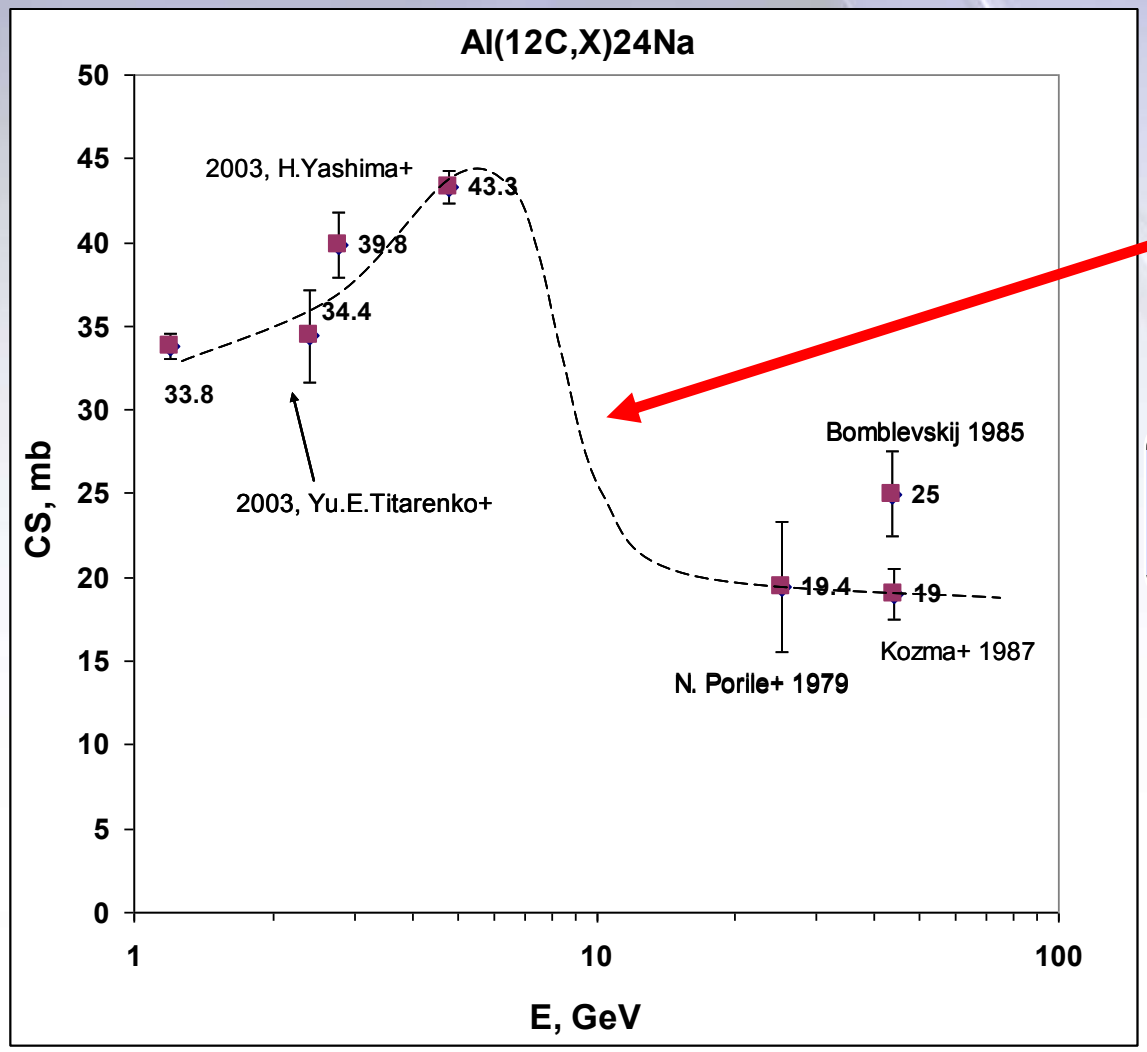
№ of plate

№ of section

№ of uranium foils (3 pieces glued together), placed on the QUINTA outside on Pb

thin-film breakdown counters

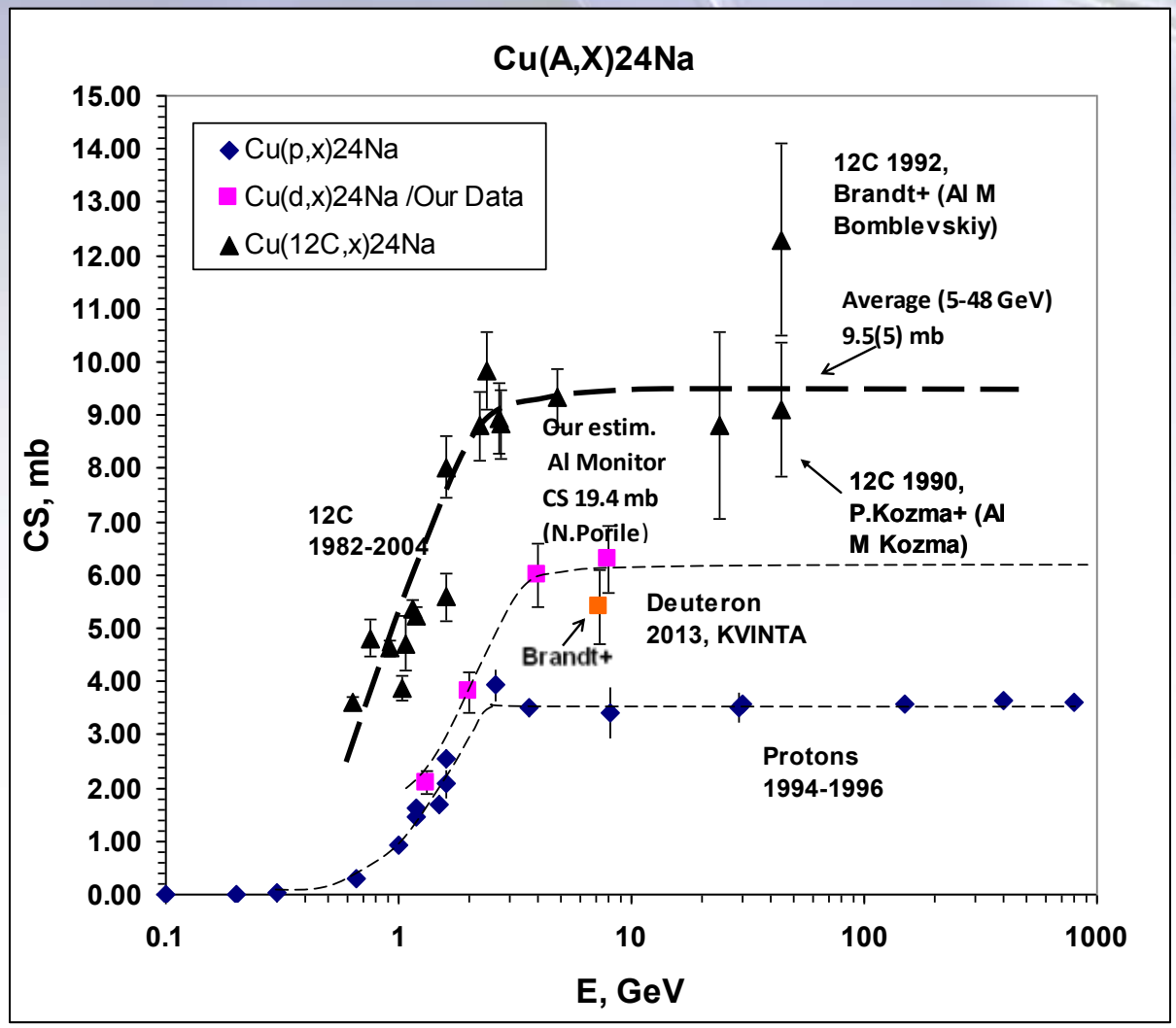
Cross section of the reaction $Al(^{12}C,X)^{24}Na$



???

$Al(n,\alpha)^{24}Na$

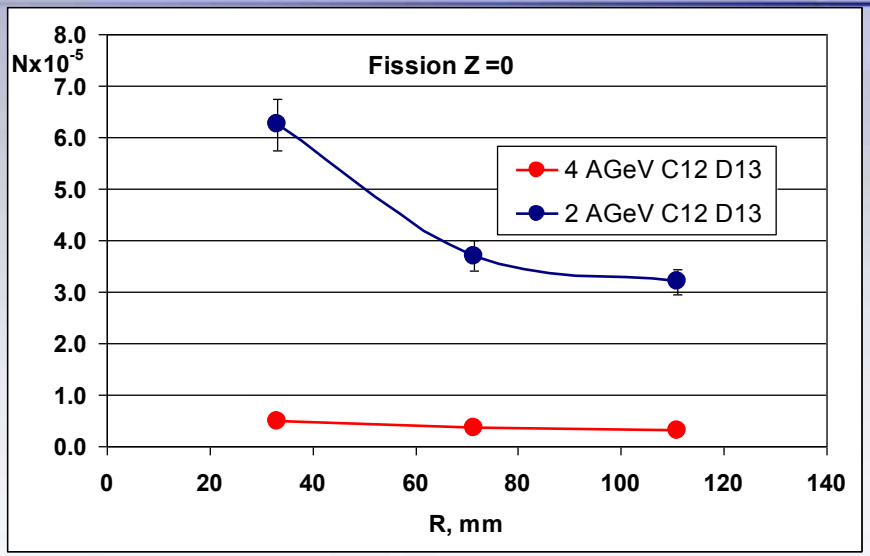
Cross section of the reaction Cu(A,X)^{24}Na

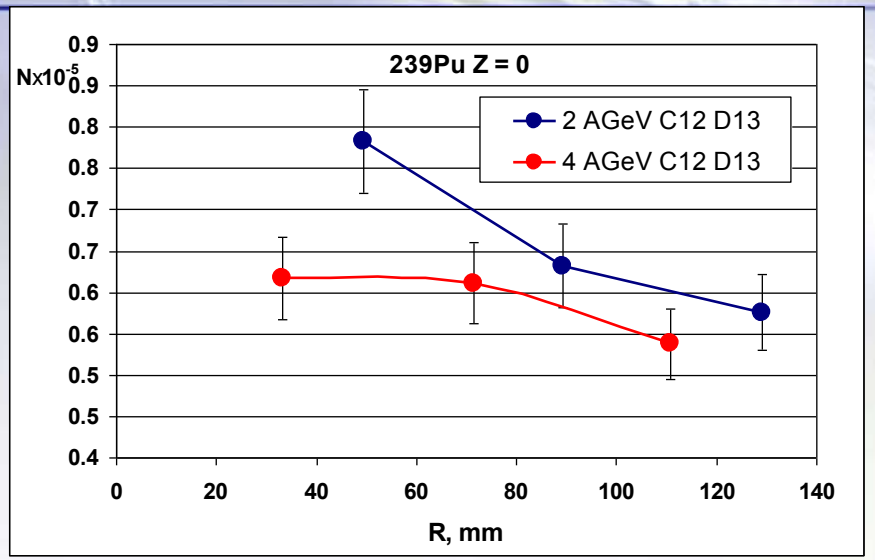


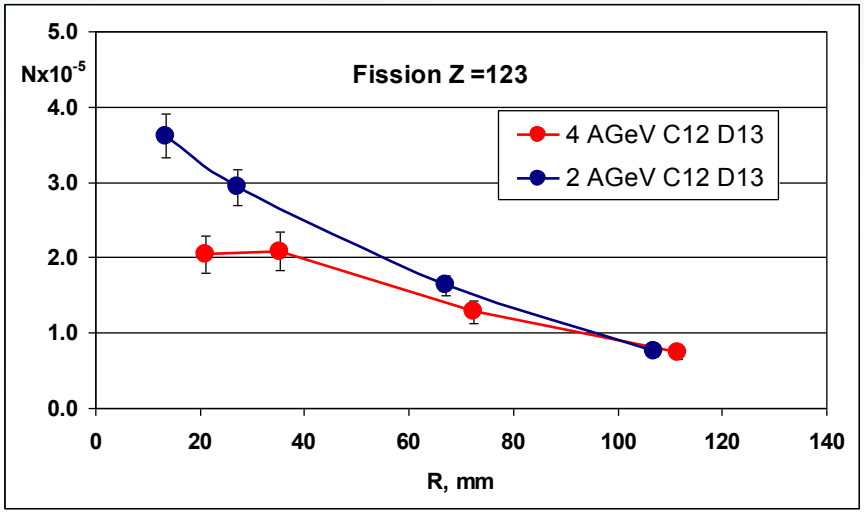
Total flux

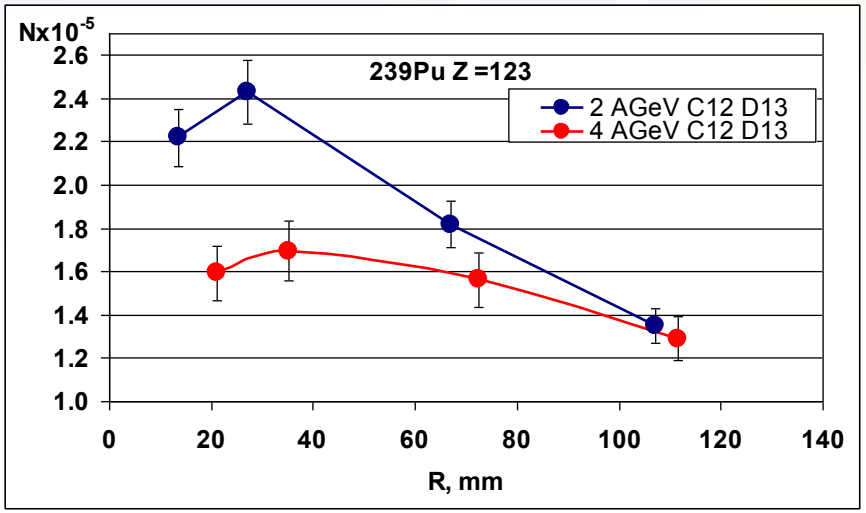
	Energy, GeV/A	Flux
Deuterons	2	$2.16 \cdot 10^{13}$
	4	$6.11 \cdot 10^{12}$
^{12}C	2	$2.14 \cdot 10^{11}$
	4	$6.18 \cdot 10^{10}$

Radial distributions of density of $^{nat}U(n,f)$ and $^{238}U(n,\gamma)$ reactions per 1 gram, 1 nucleus ^{12}C and 1 GeV at Z = 0 mm and Z = 123 mm

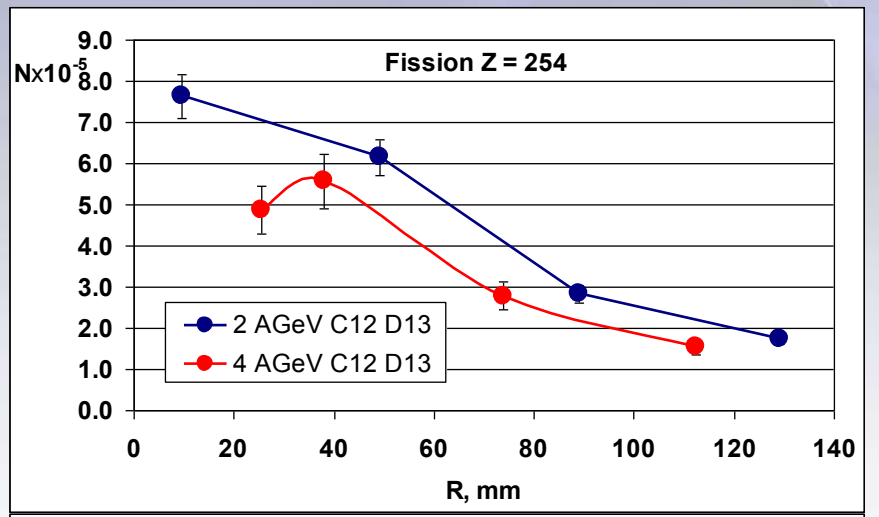


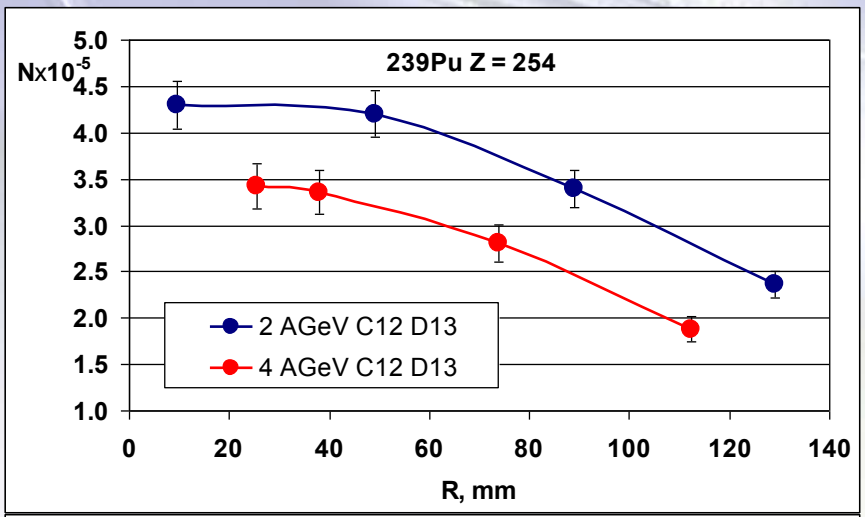


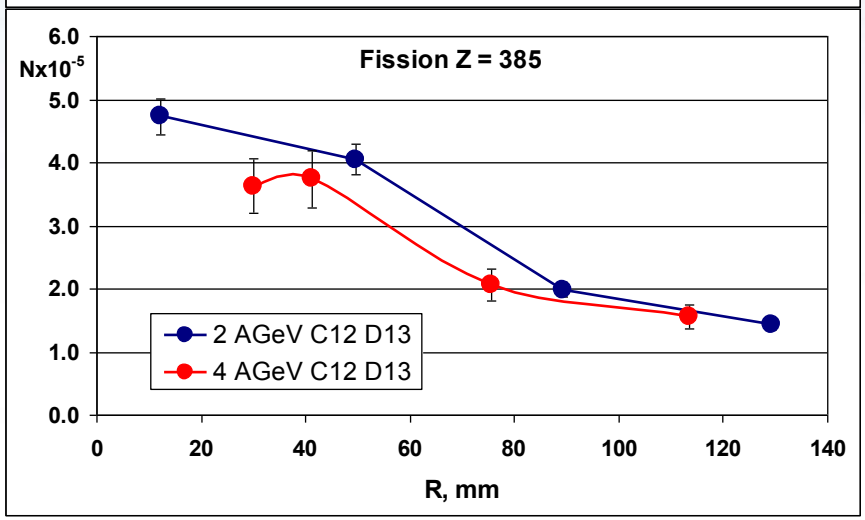


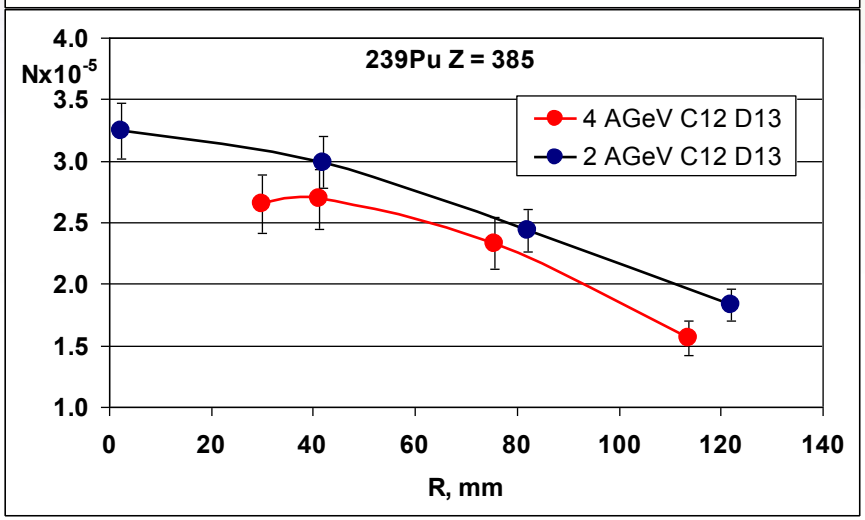


Radial distributions of density of $^{nat}U(n,f)$ and $^{238}U(n,\gamma)$ reactions per 1 gram, 1 nucleus ^{12}C and 1 GeV at Z = 254 mm and Z = 385 mm

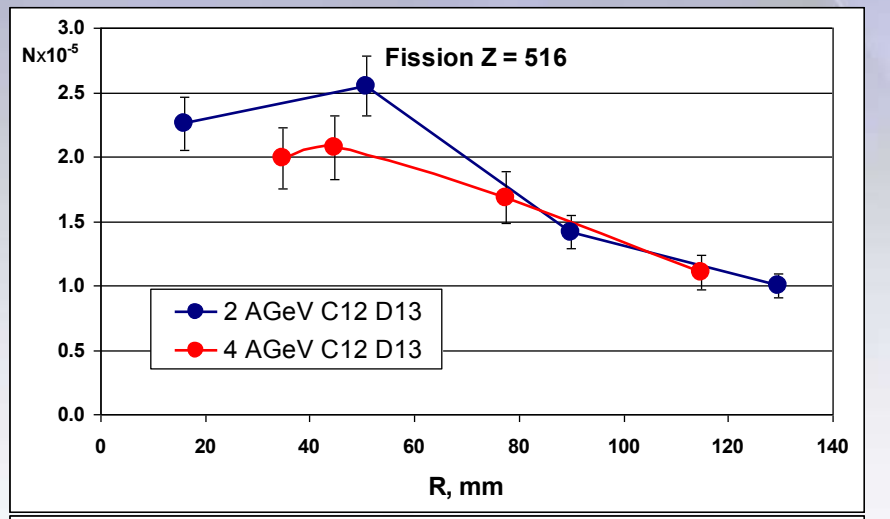


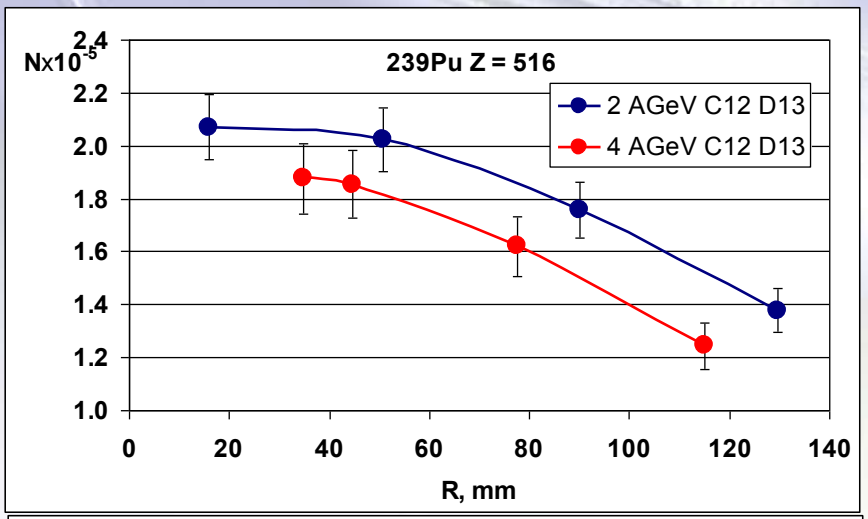


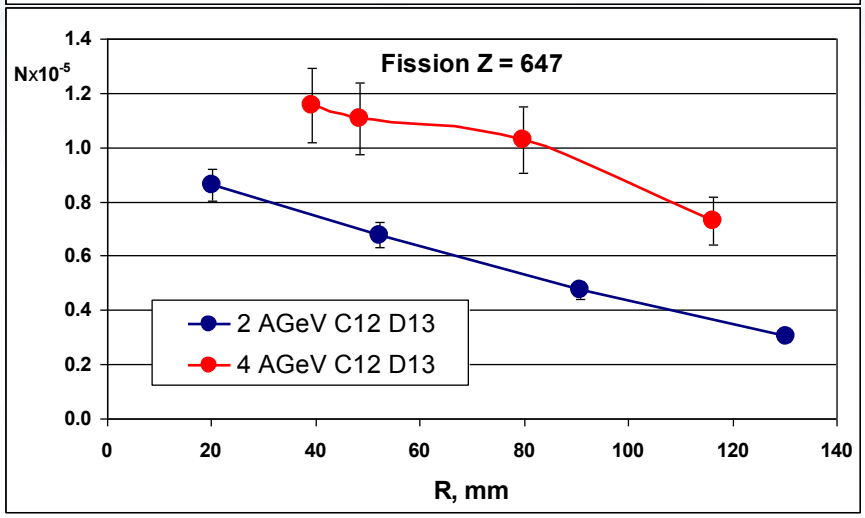


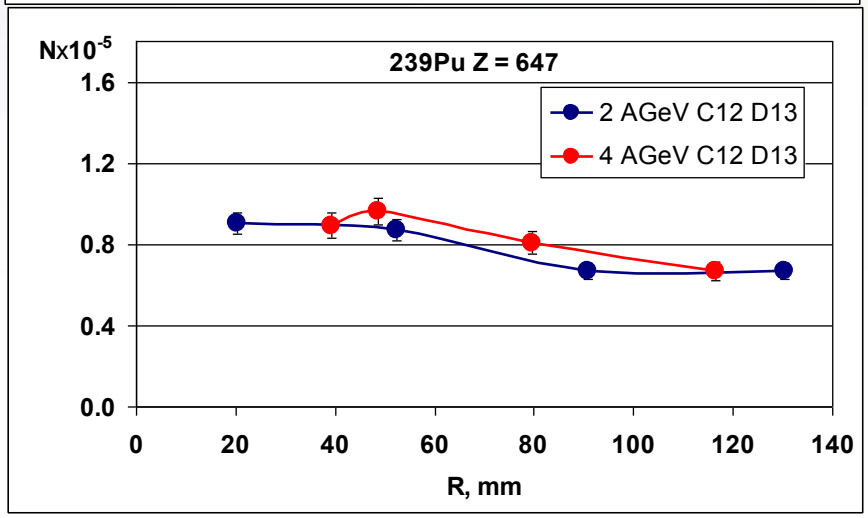


Radial distributions of density of $^{nat}U(n,f)$ and $^{238}U(n,\gamma)$ reactions per 1 gram, 1 nucleus ^{12}C and 1 GeV at Z = 516 mm and Z = 647 mm

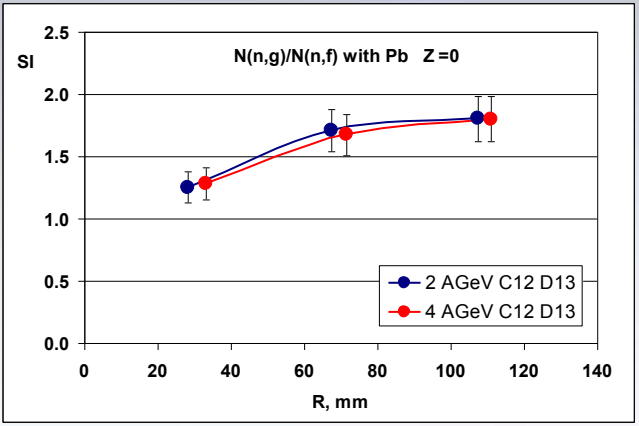


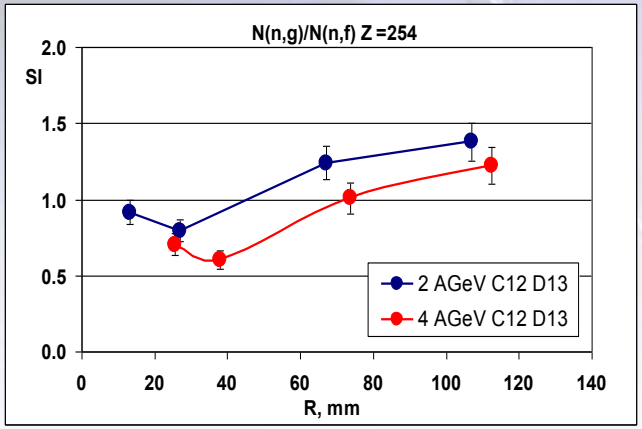


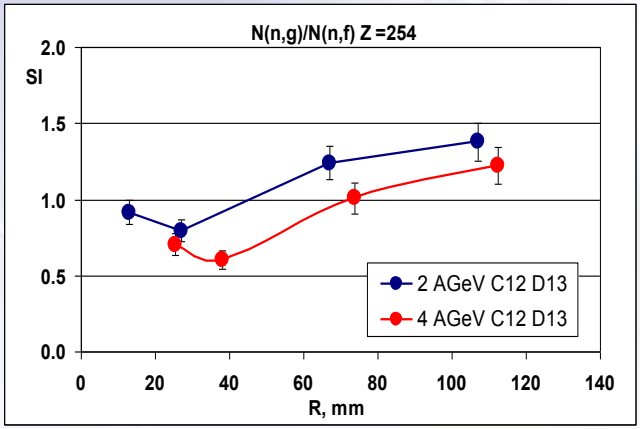


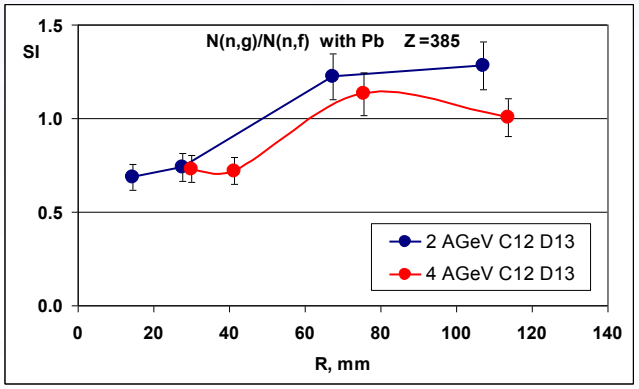


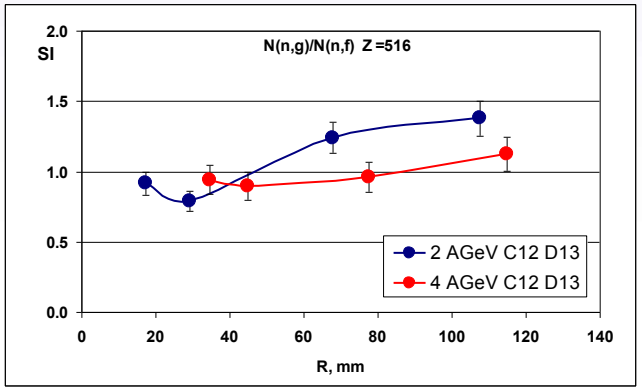
Radial distributions of spectral indices ($^{238}U(n,\gamma)$ /$^{nat}U(n,f)$) at Z = 0, 123, 254, 385, 516, 647 mm

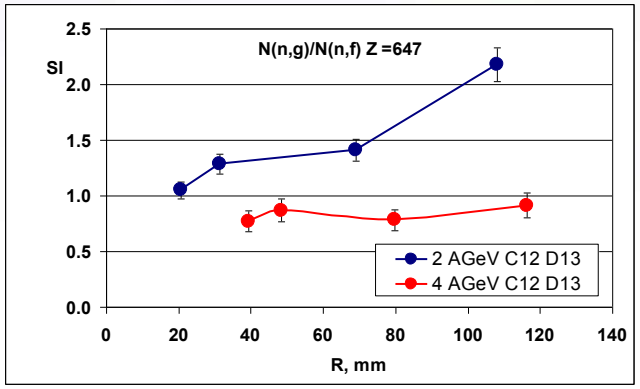




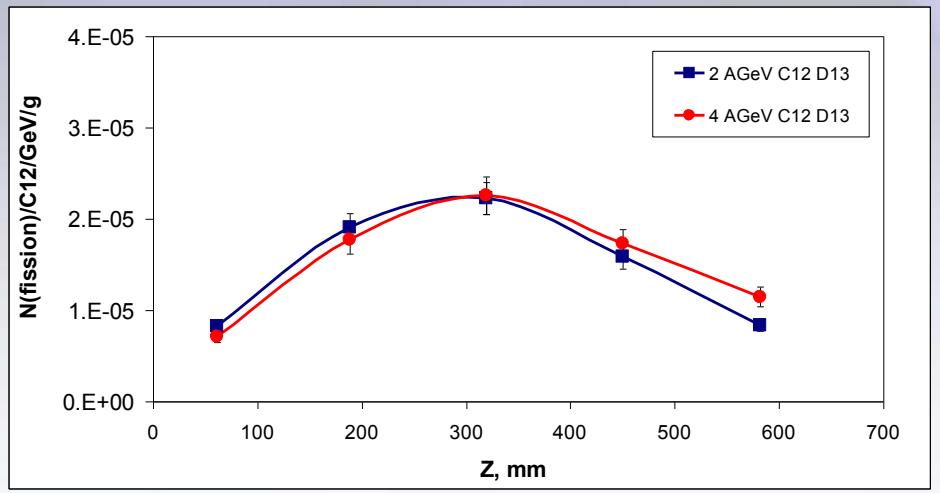


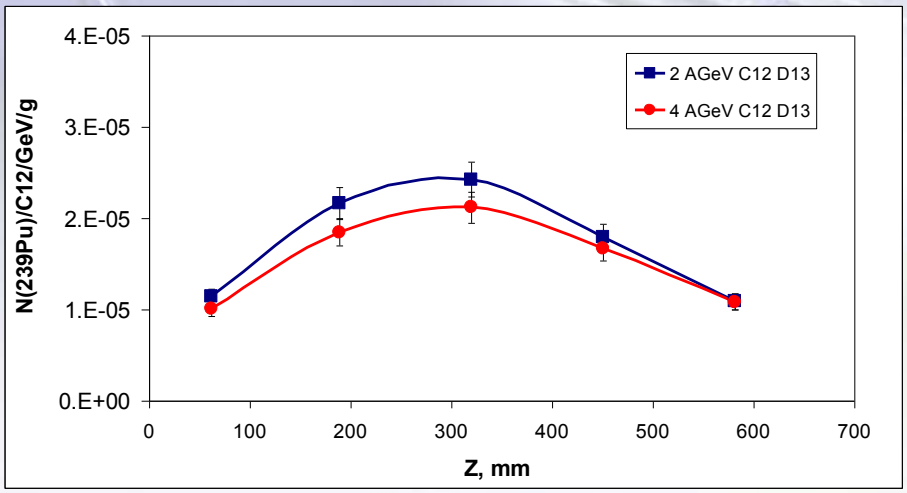


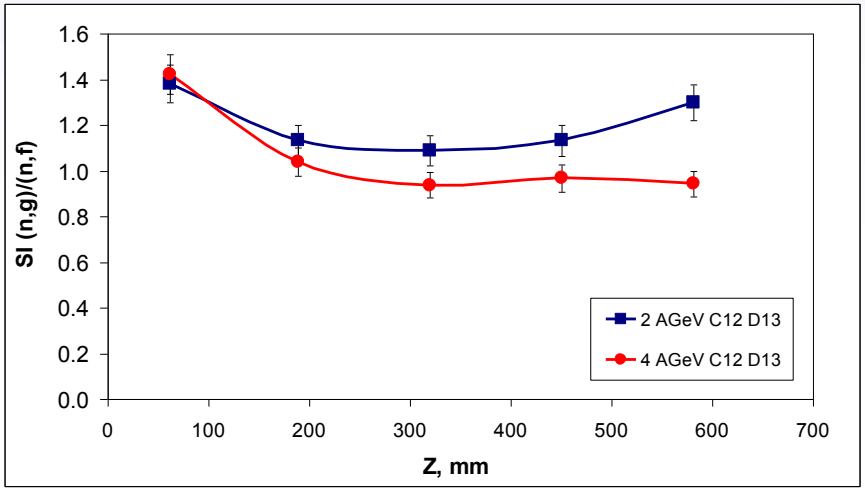




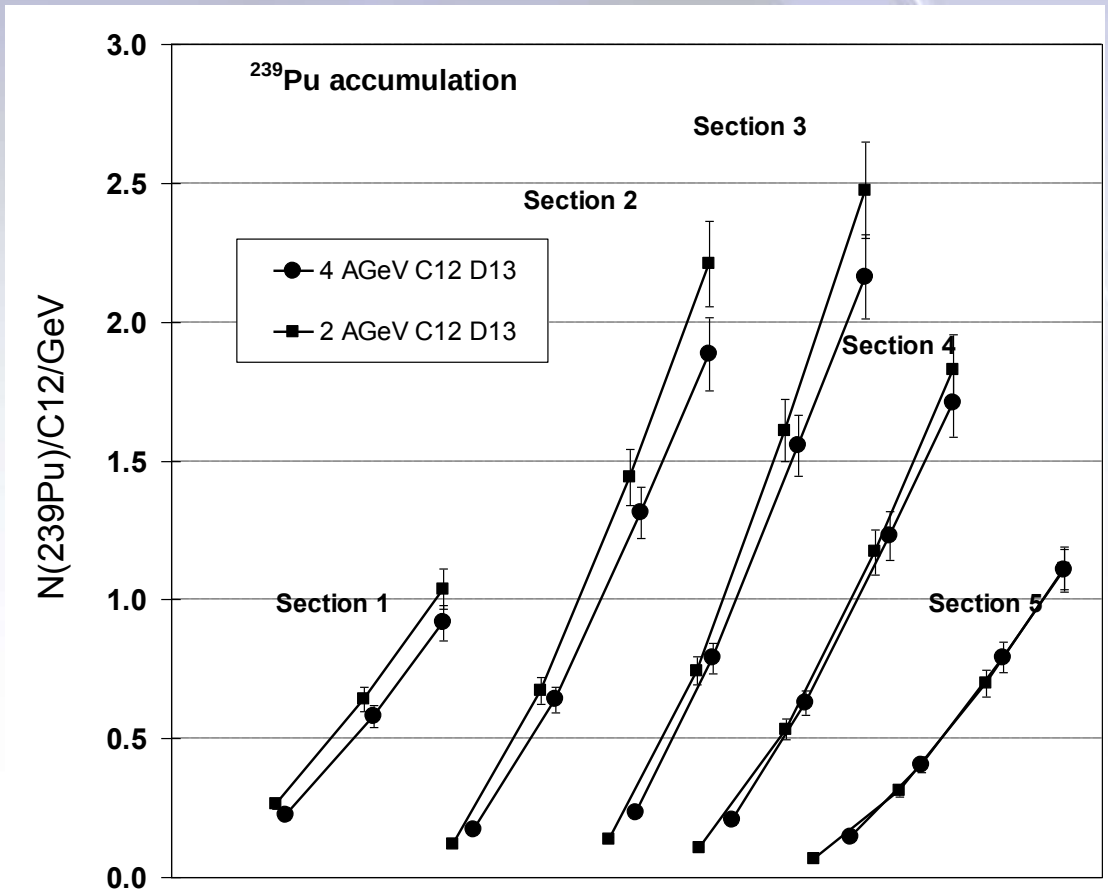
Average spatial distributions of (n,γ), (n,f) reactions and spectral index

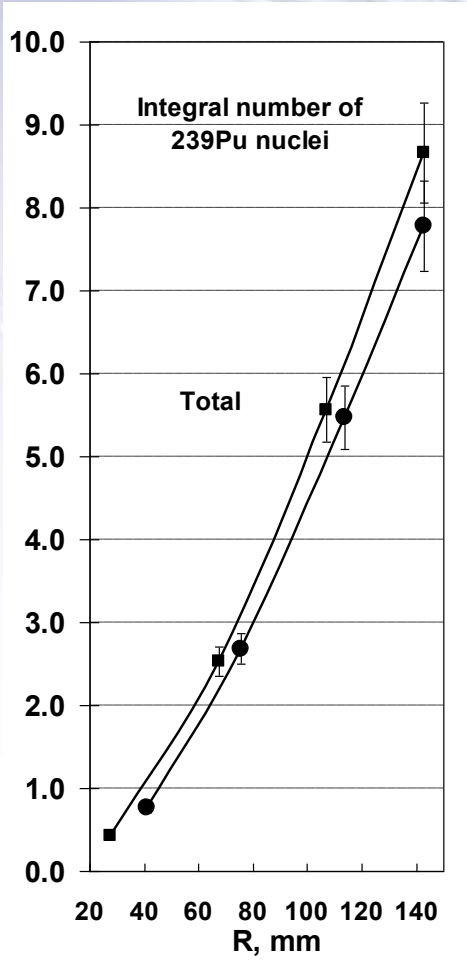




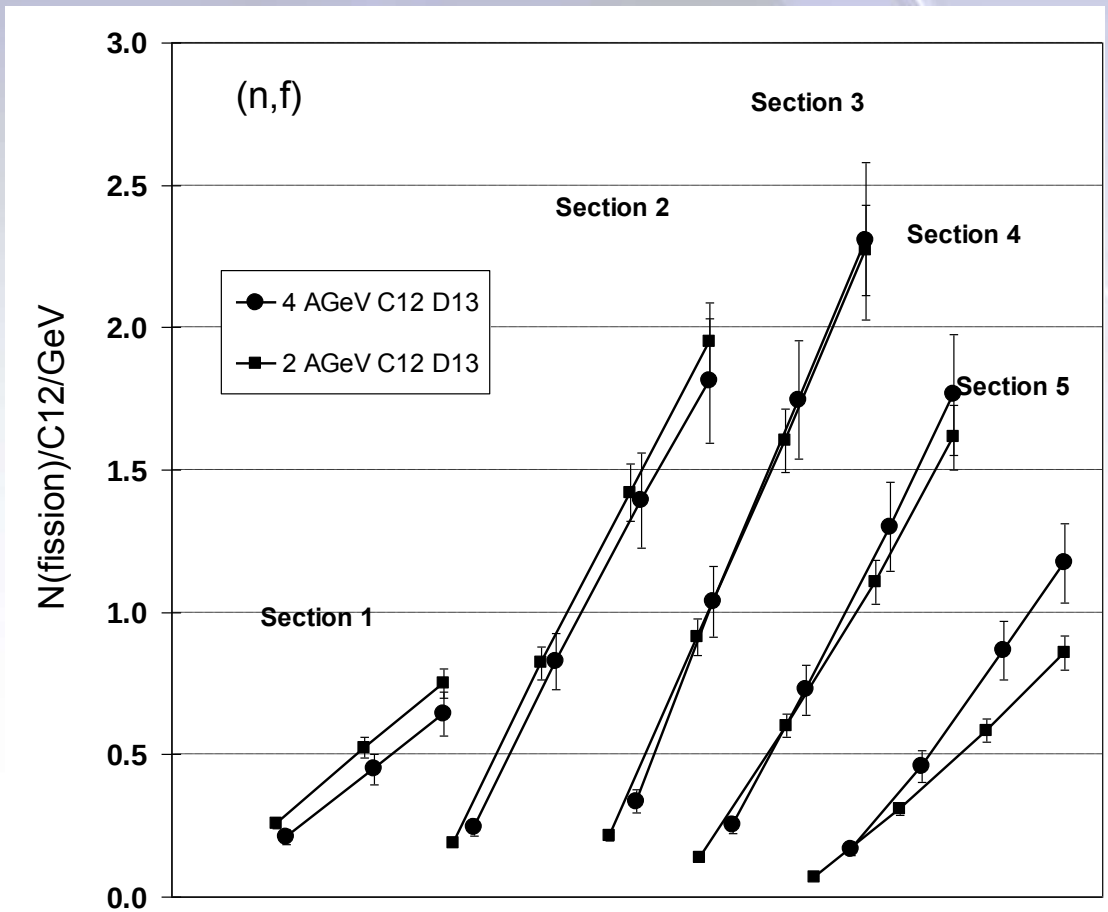


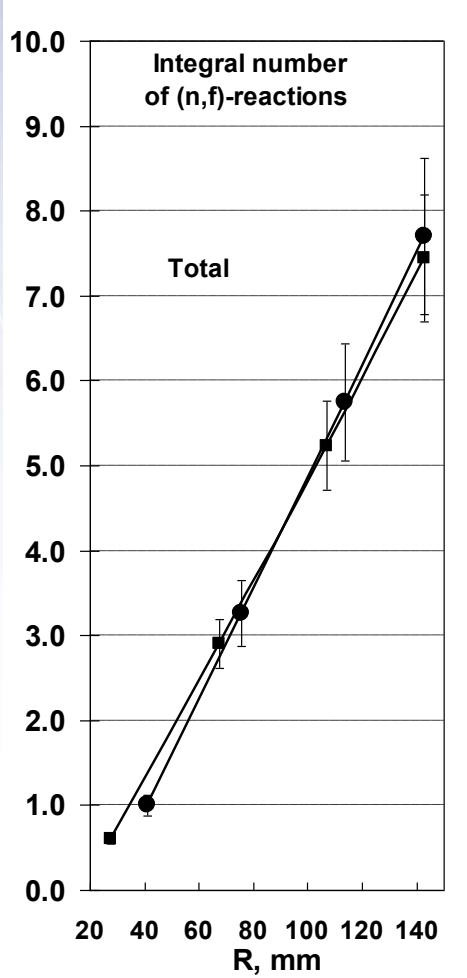
Integral distribution of (n,γ) reaction (dependencies on uranium target radius)



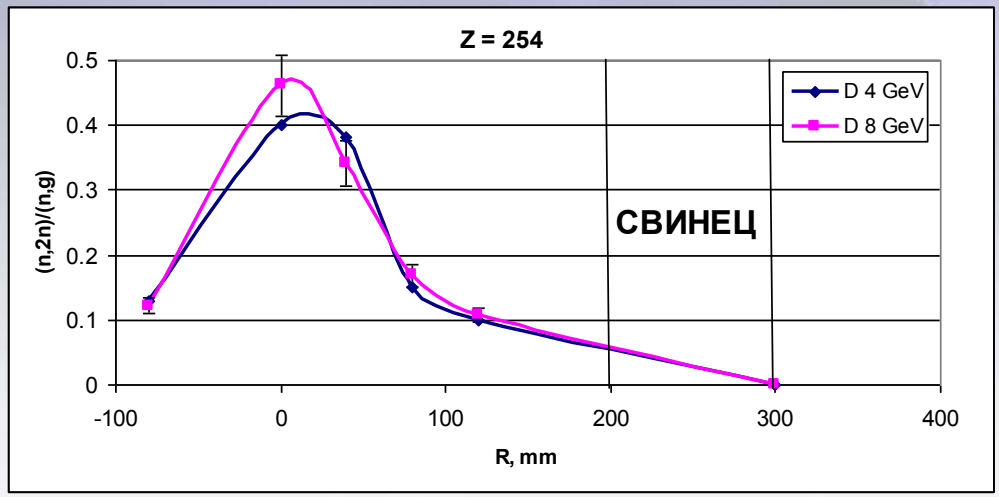


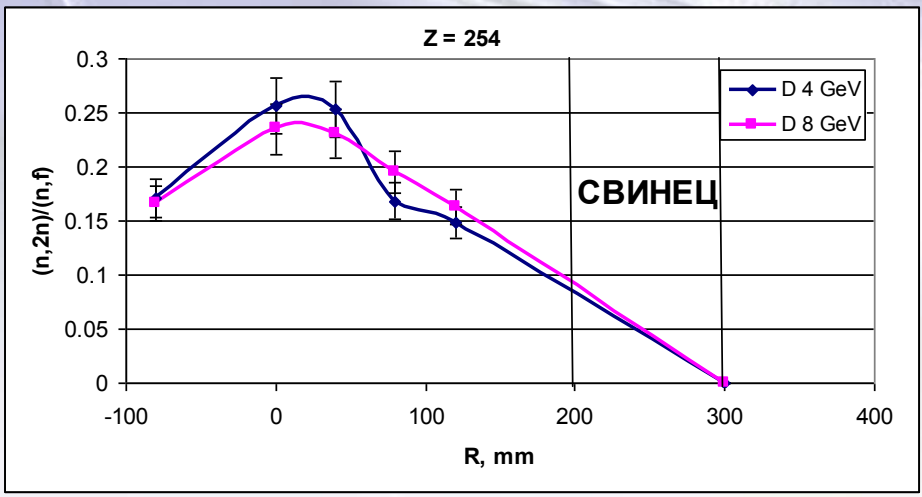
Integral distribution of (n,f) reaction (dependencies on uranium target radius)

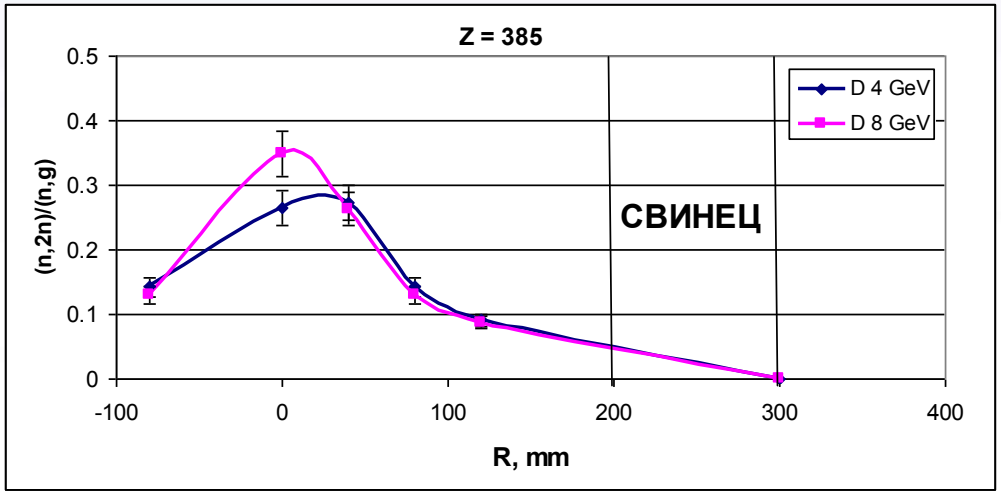


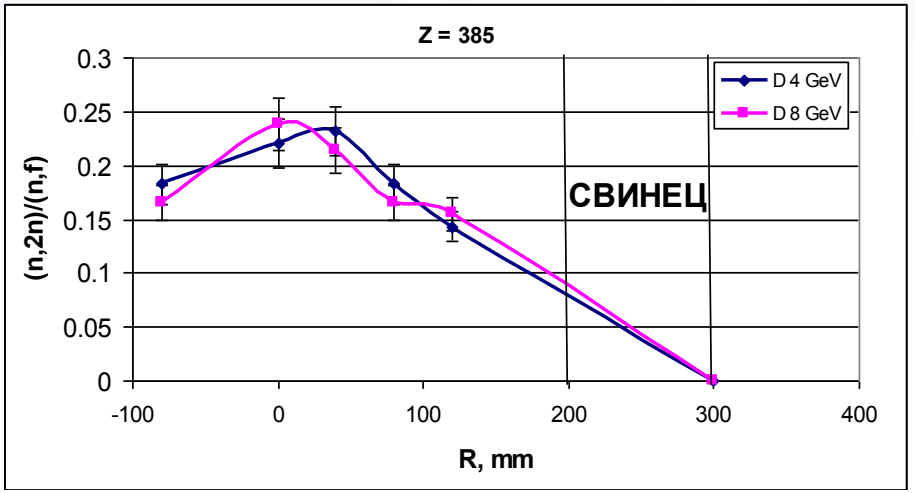


Radial distributions of spectral indices (^{238}U(n,2n)/ ^{238}U(n,γ) and ^{238}U(n,2n)/^{nat}U(n,f)) at Z = 254 mm and Z = 385 mm



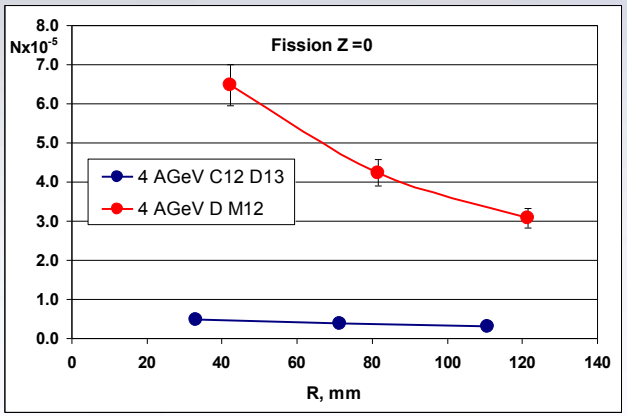


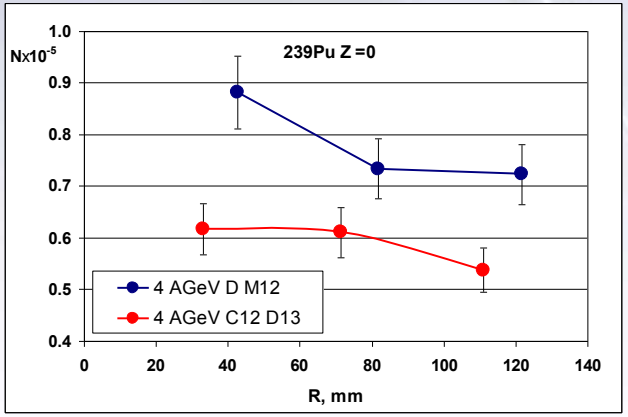


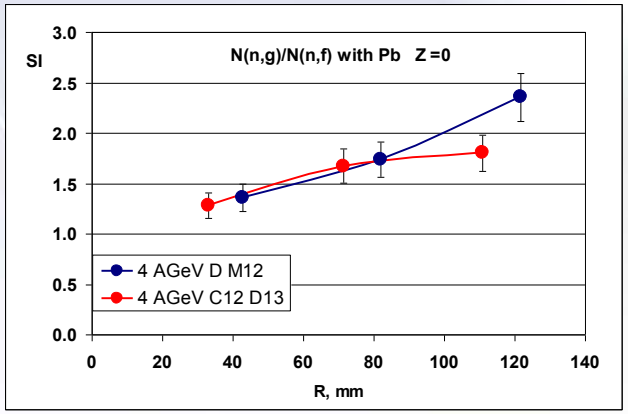


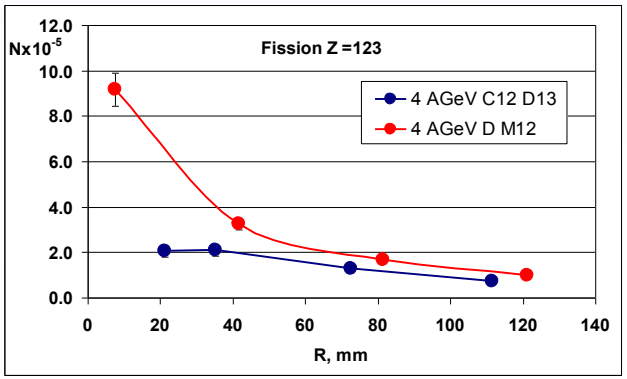
Comparison of results between irradiations by deuterons and ^{12}C ions

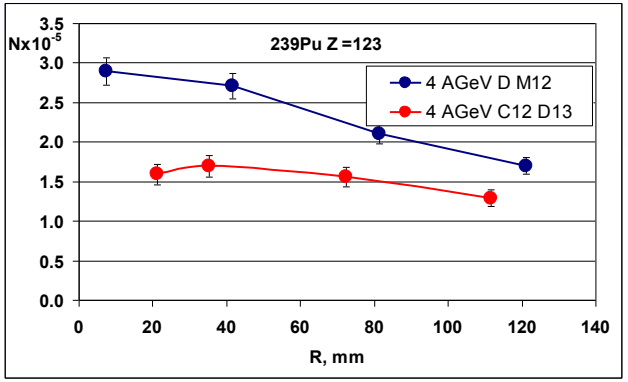
Radial distributions of density of $^{nat}U(n,f)$, density of $^{238}U(n,\gamma)$ reactions and spectral indices per 1 gram, 1 accelerated particle and 1 GeV at Z = 0, 123 mm

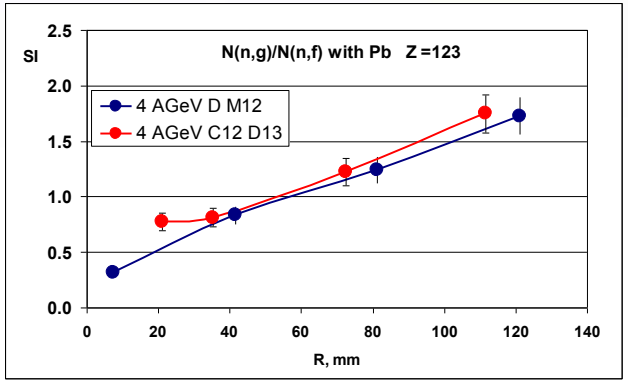






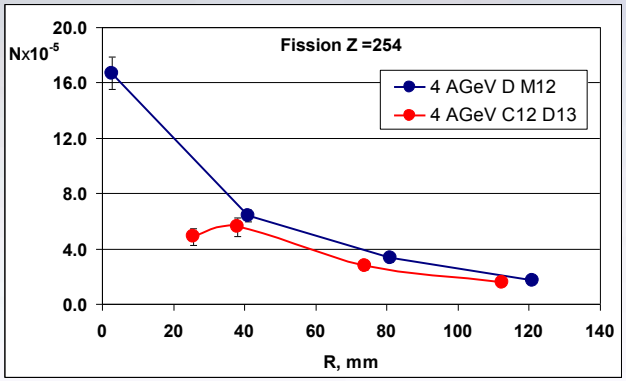


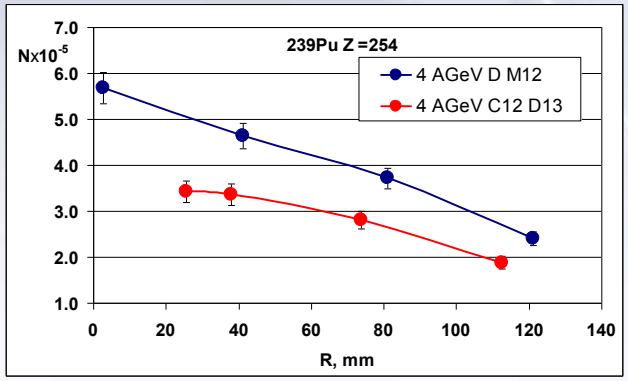


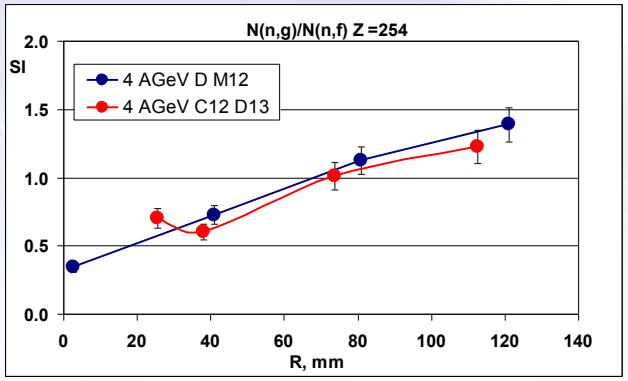


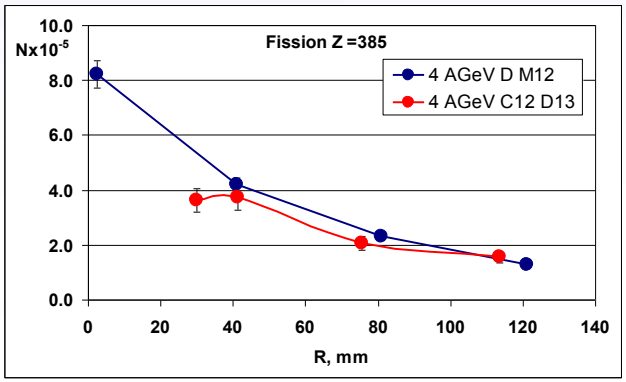
Comparison of results between irradiations by deuterons and ^{12}C ions

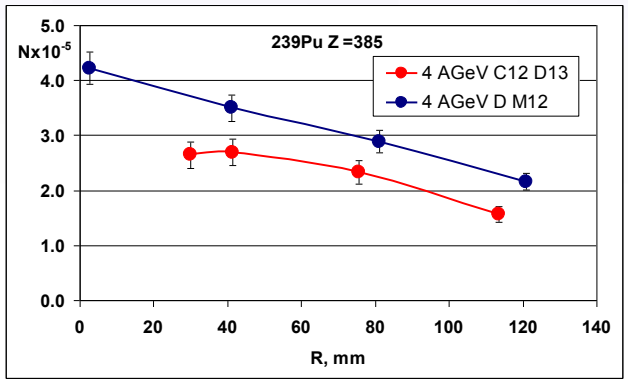
Radial distributions of density of $^{nat}U(n,f)$, density of $^{238}U(n,\gamma)$ reactions and spectral indices per 1 gram, 1 accelerated particle and 1 GeV at Z = 254, 385 mm

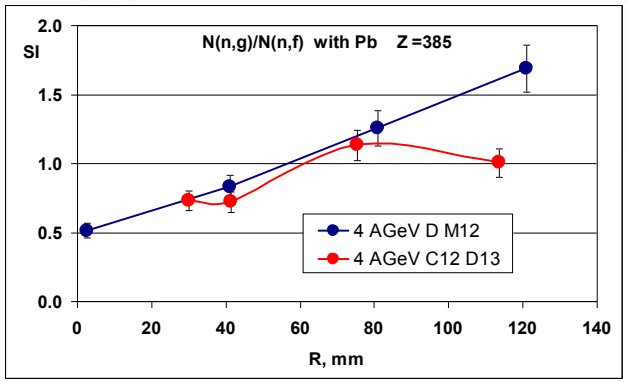






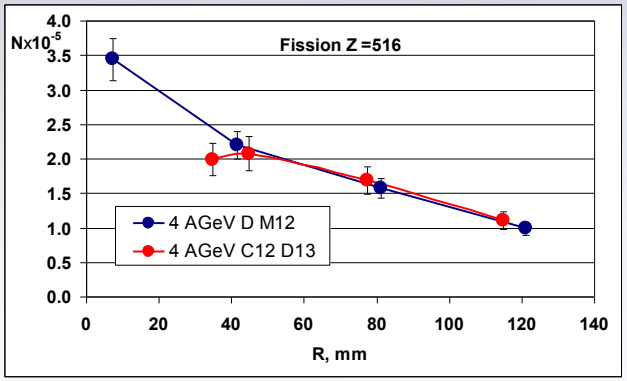


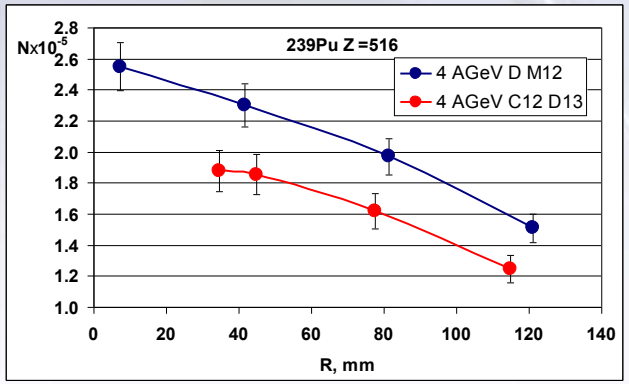


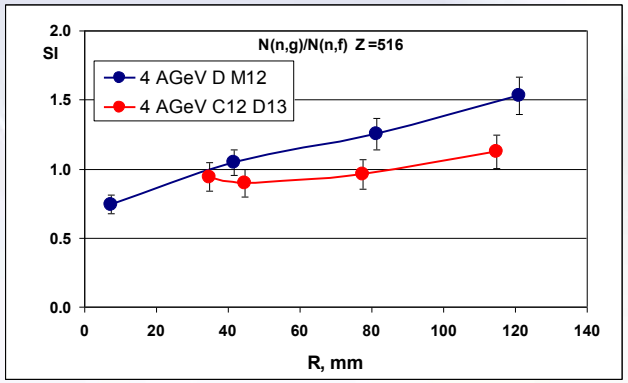


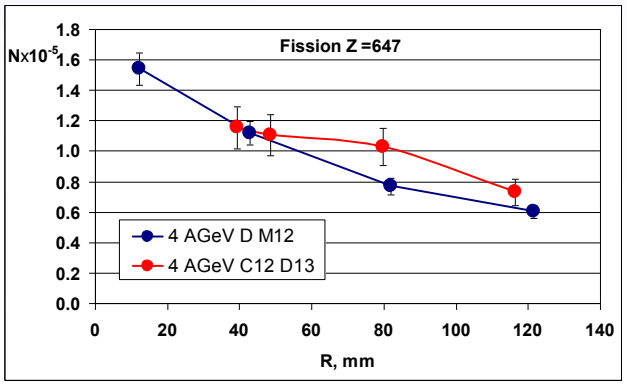
Comparison of results between irradiations by deuterons and ^{12}C ions

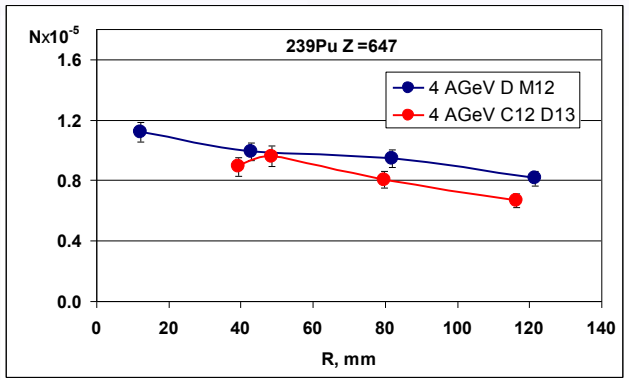
Radial distributions of density of $^{nat}U(n,f)$, density of $^{238}U(n,\gamma)$ reactions and spectral indices per 1 gram, 1 accelerated particle and 1 GeV at Z = 516, 647 mm

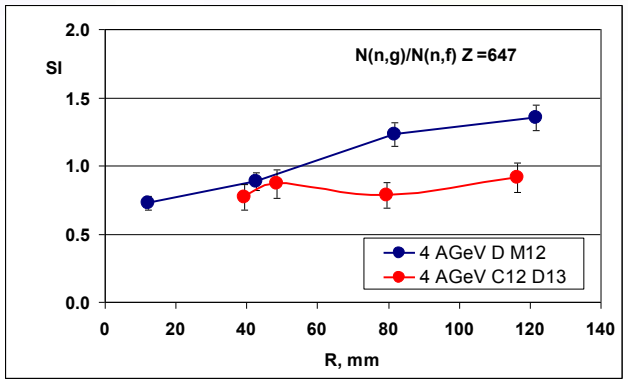




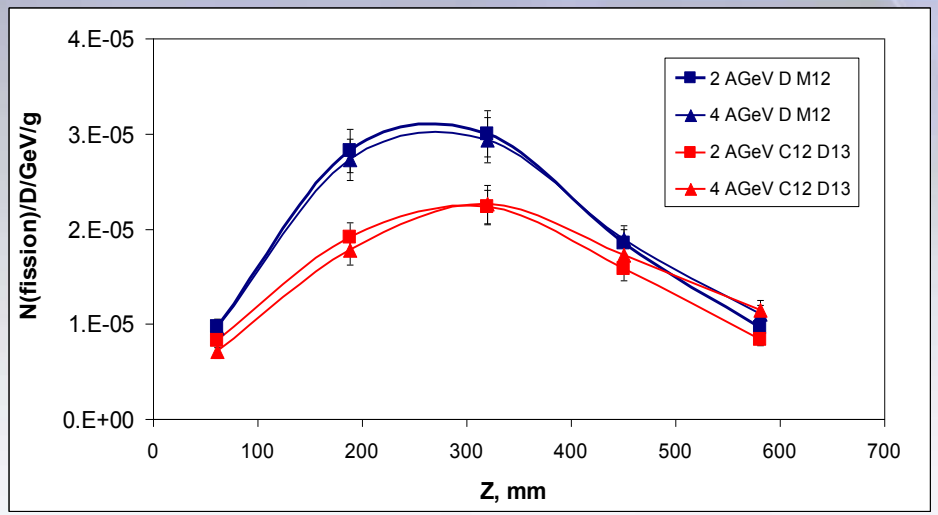


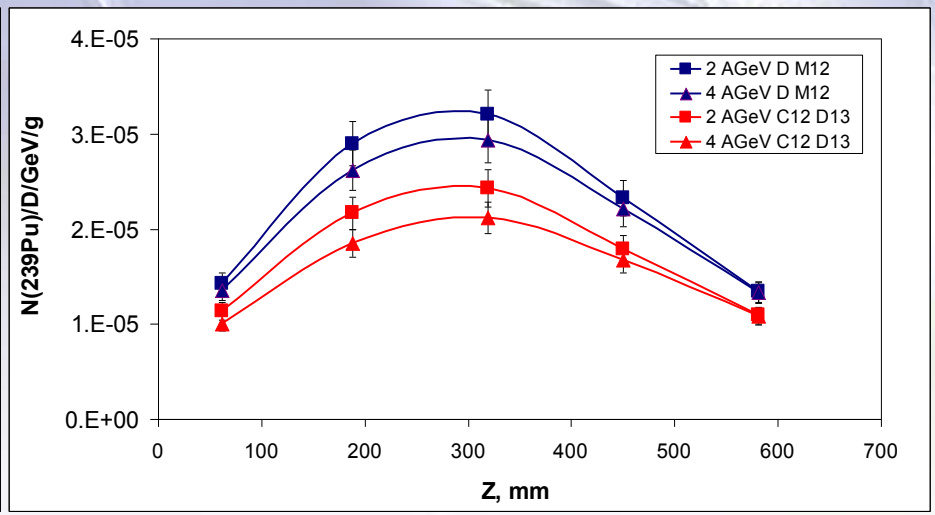


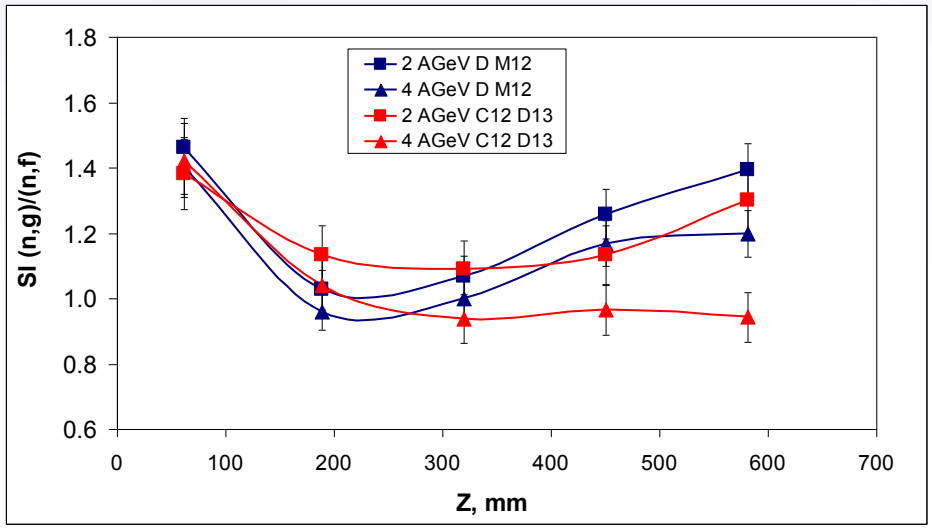




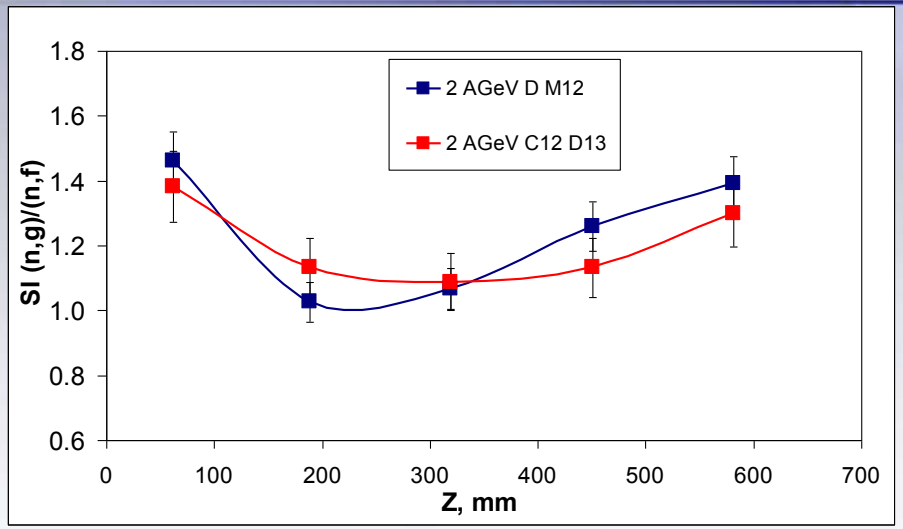
Comparison of results between irradiations by deuterons and ^{12}C ions

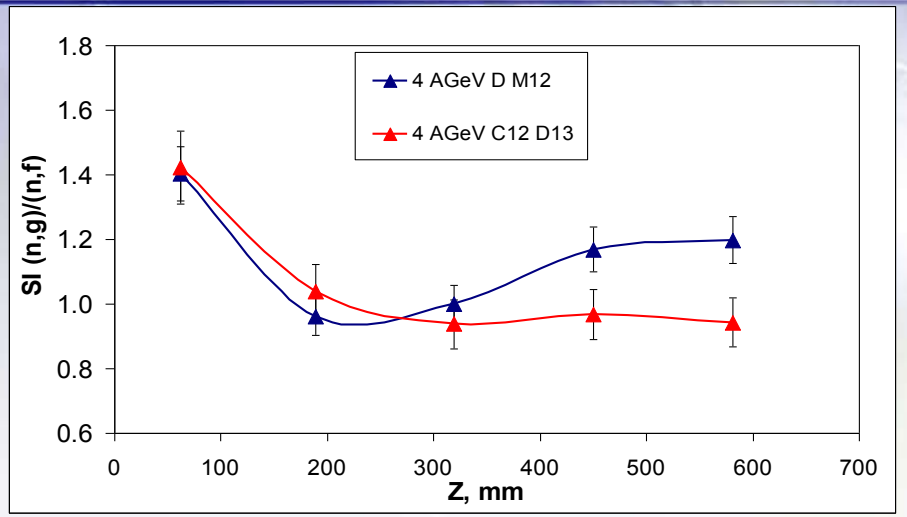


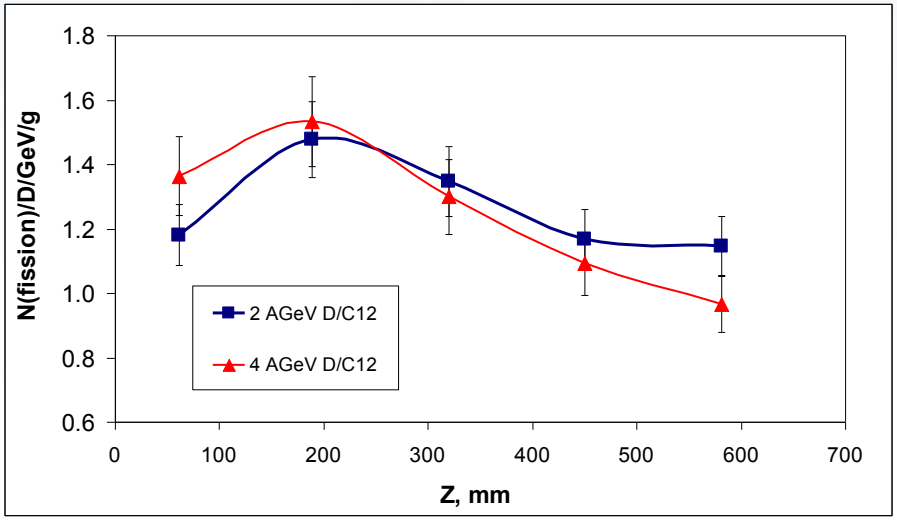


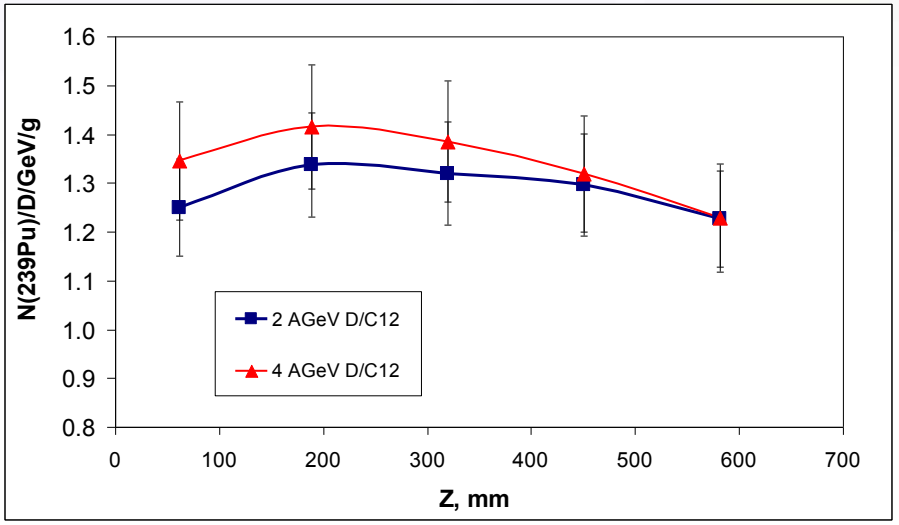


Comparison of results between irradiations by deuterons and ^{12}C ions









Integral numbers of ^{239}Pu accumulation and ^{nat}U fissions in the volume of uranium target

	Energy, GeV/A	(n,γ)	(n,f)
Deuterons	2	11.3 ± 0.6	9.6 ± 0.7
	4	10.5 ± 0.6	9.5 ± 0.7
^{12}C	2	8.7 ± 0.7	7.5 ± 0.8
	4	7.8 ± 0.7	7.7 ± 0.8

CONCLUSIONS

In case of ^{12}C ions the number of Pu accumulation and fissions are approximately the same within our statistical errors for energies 2 and 4 GeV.

The spectral index changes from the Carbon beam axis to the periphery of the uranium target from about 0.5 to 2 for “QUINTA” and behave identically for all cross sections of assembly.

Comparison of two runs with deuteron and ^{12}C ions showed that in the case of the deuteron the number of neutron capture reactions is more about 25% and the number of fissions more about 20%.

Due to the low intensity of the ^{12}C ion beam it would be advisable to repeat this experiment with higher intensity to verify all received data.

Thank you for your attention !!!