COMPARISON BETWEEN DEUTERON AND CARBON BEAMS AT “QUINTA” SET-UP

M. M. Paraipan[1,2], A. A. Baldin[1], A. Berlev[1], I. Kudashkin[1], G. Mogildea[2], M. Mogildea[2], S. I.Tiutiunikov[1]

[1]Joint Institute for Nuclear Research, Dubna, Russia

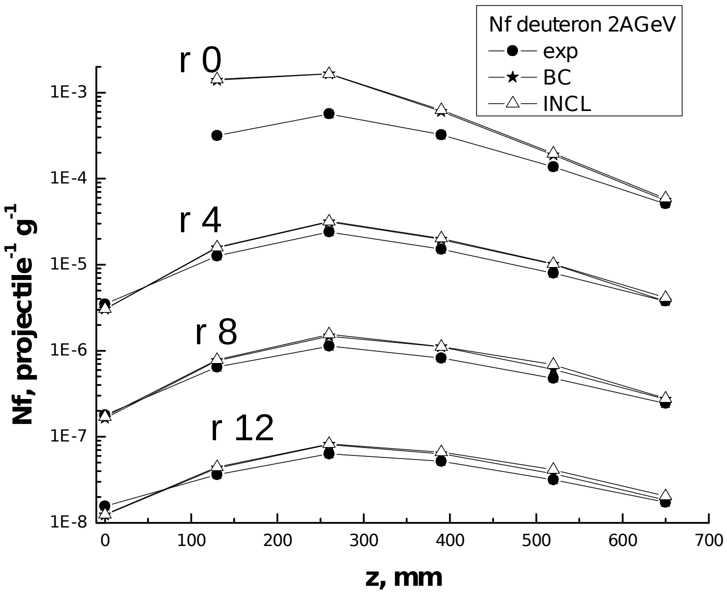
[2]Institute of Space Sciences, Bucharest-Magurele, Romania

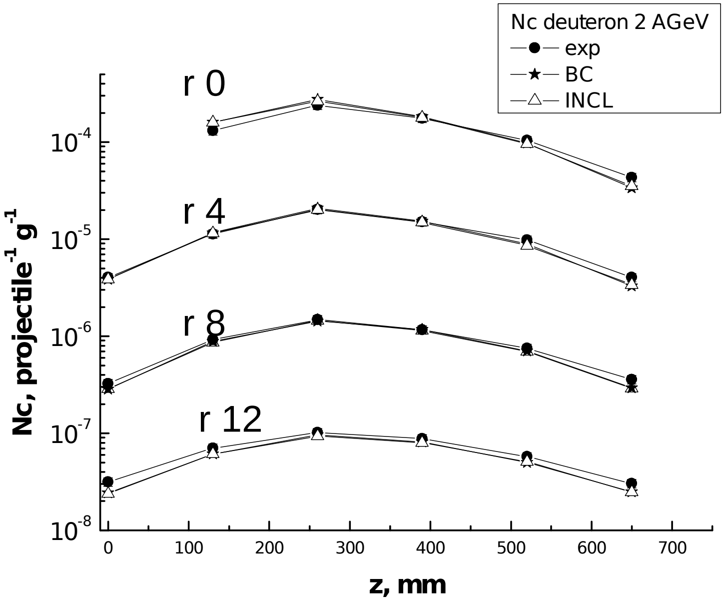
Baldin ISHEPP XXII, September 15-20, 2014

Spatial distribution of fission and capture reactions

- the experimental results (from [1]) are compared with simulations in Geant4

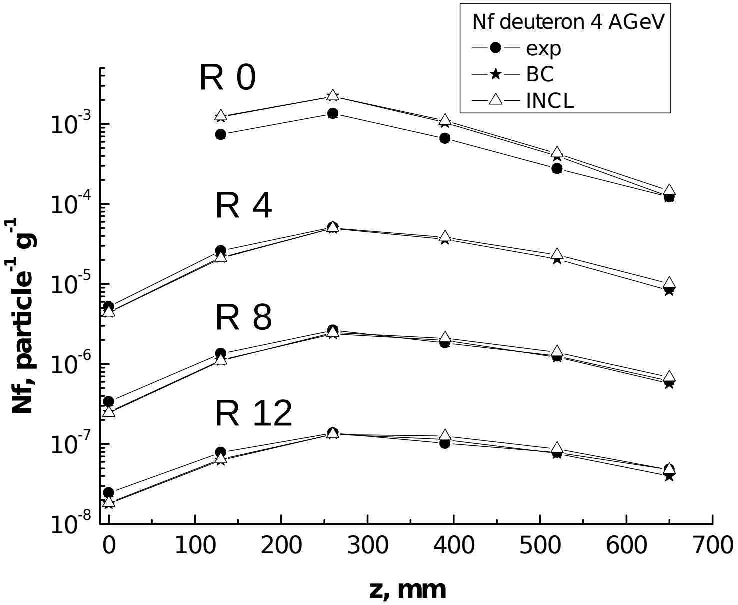
Deuteron 2 AGeV

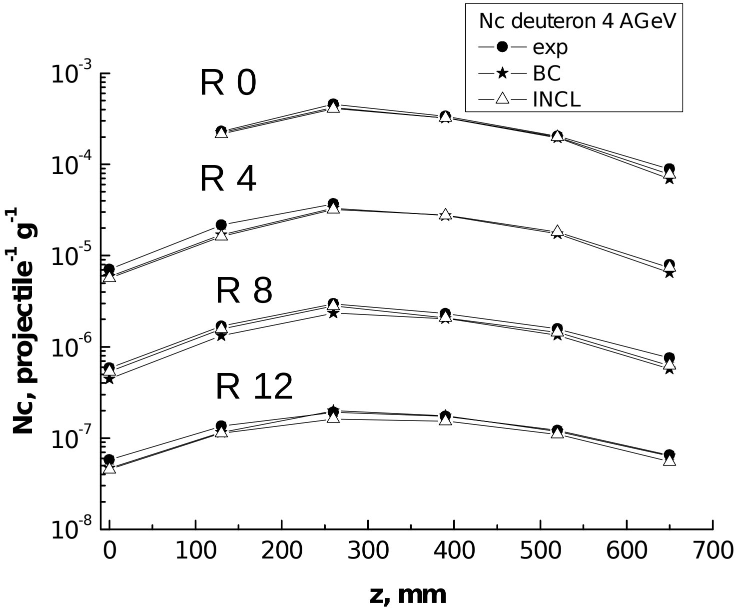




Longitudinal distribution for radius 0 cm, 4 cm 8 cm and 12 cm.
The data with are scaled with a factor of 0.1 from a radius to another.

Deuteron 4 AGeV

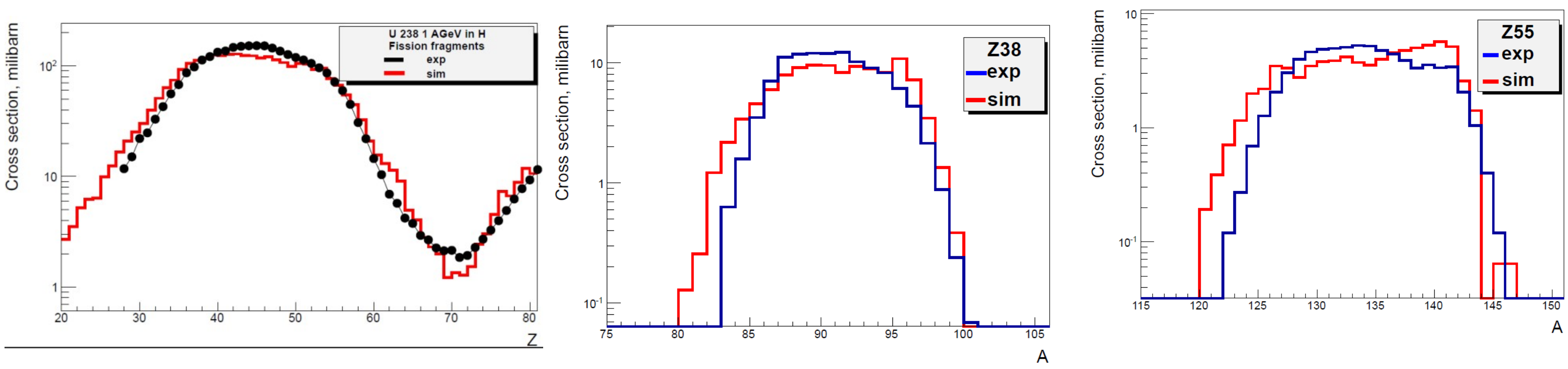




- The two models used for the simulation of inelastic interaction (BC and INCL) simulate well the experimental data, except the values for fission in r0.
- An explanation for the discrepancies in r0 can be the difference between the cumulative fission yield of fragments produced by hadrons and ions with high energy, and the yield obtained with low energy neutrons.

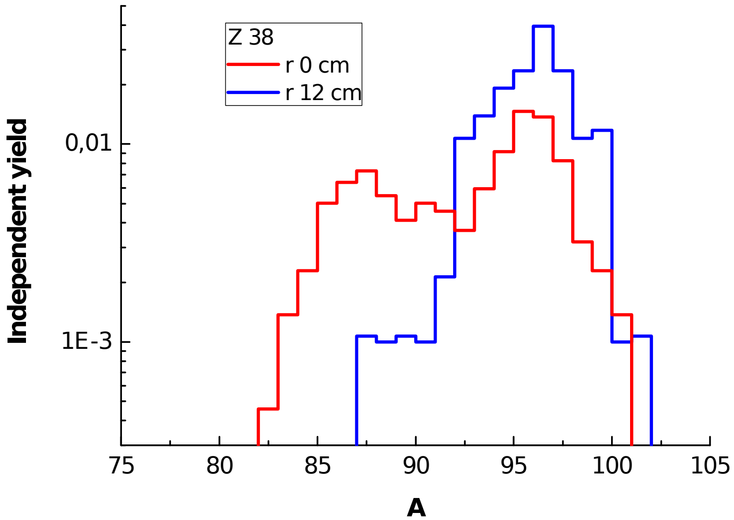
Estimation through simulation of the cumulative yield

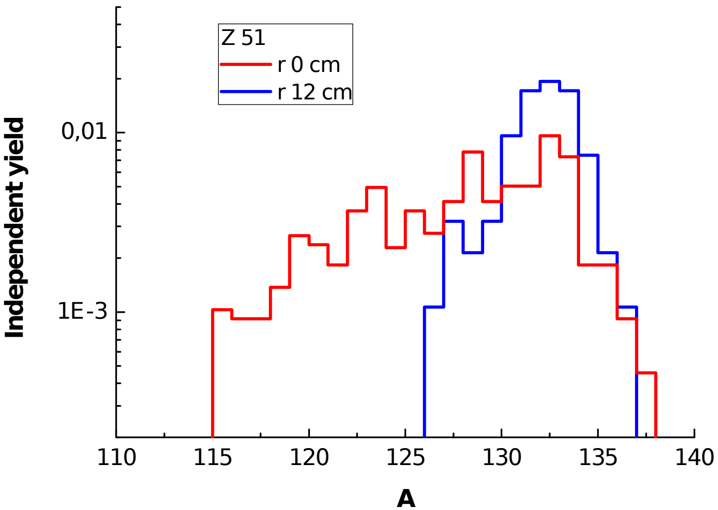
Fragments distribution in the reaction U238 1 AGeV on proton.
-the experimental data form ref [2] are compared with the simulation
- the simulation slightly overestimates the production of rich neutron fragments
-the estimation through simulation of the cumulative yield in r0 could give yields higher than the real ones.



The fragments distribution in the fission region for beam of U 238 1 AGeV in H (experimental data and simulation).

Mass distribution for Sr and Sb isotopes in r0 and r12, after the second section

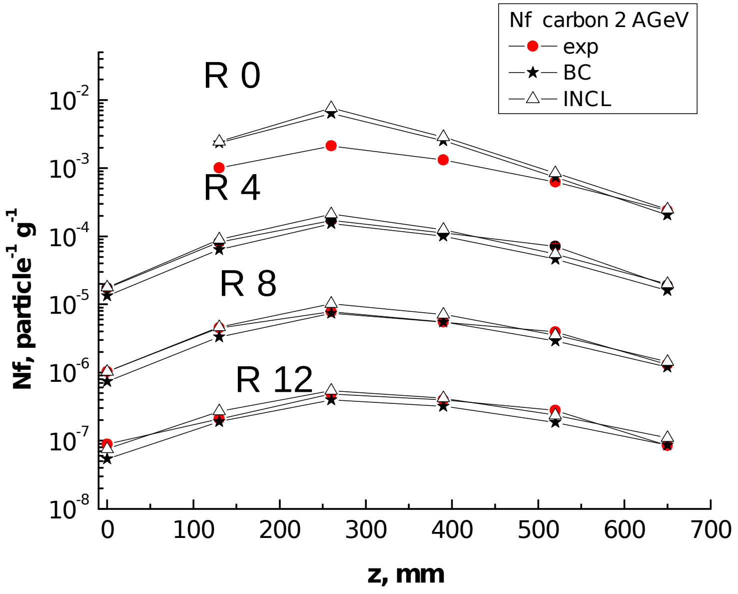


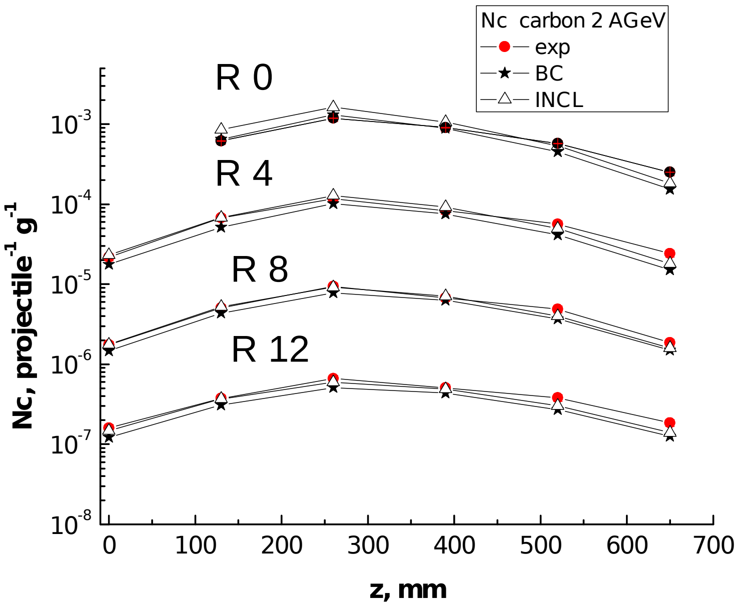


Cumulative yield for Zr97, I131, I133 and Ce143: A- values obtained with experimental data for U238 1 AGeV on proton, B- values from simulation in Quinta in r0, after second section, C- values used in the experiment in [1].

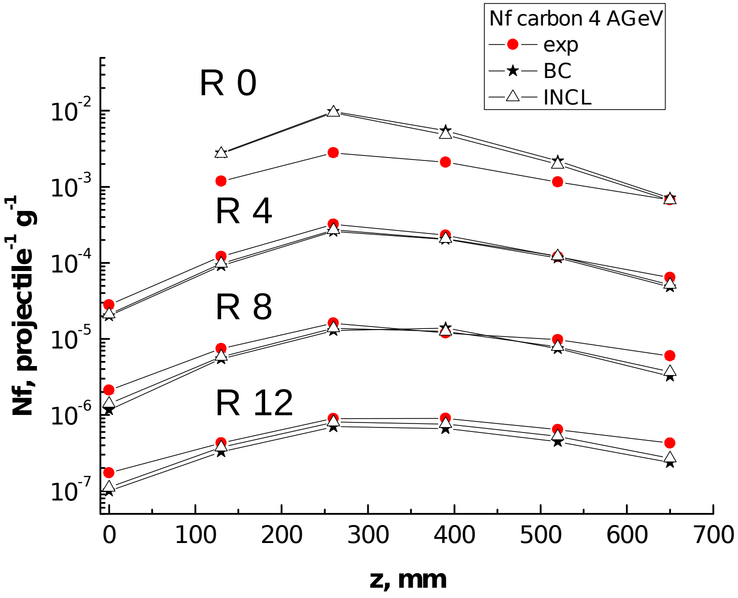
Isotope	A, %	B, %	C, %
Zr 97	1.47	3.7	5.7
I 131	0.89	1.87	3.6
I 133	0.66	2.7	6.3
Ce 143	0.55	2.15	4.3

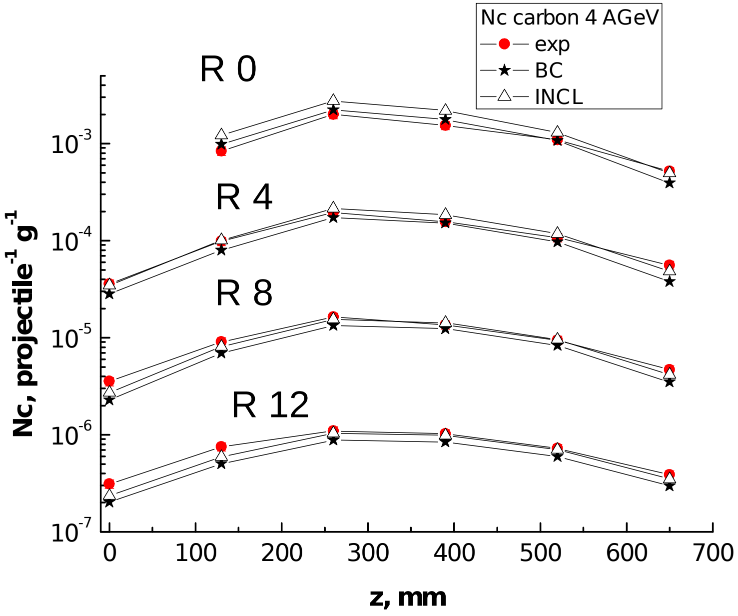
Carbon 2 AGeV





Carbon 4 AGeV





In the case of deuteron 2and 4 AGeV and carbon 2 AGeV the differences between simulation and experimental data are lower than 30 %, except r0. For carbon 4 AGeV the simulation predicts lower values at high distances from the center of the target (especially for fission).

Integral results

Total number of fission and capture in uranium target

	Fission exp	Fission BC	Fission INCL	Capture exp	Capture BC	Capture INCL
Deuteron 2 AGeV	30.38	42.9	45.2	38.6	41.2	43.1
Deuteron 4 AGeV	68.1	74.1	77.9	74.8	78.1	76.2
Carbon 2 AGeV	201.5	200.8	207.1	226.6	207.9	216.2
Carbon 4 AGeV	410.9	389.4	395.8	422.7	406.1	412.4

Energy, AGeV	Efficiency C/D exp	Efficiency C/D BC	Efficiency C/D INCL
2	6.63	4.68	4.58
4	6.03	5.25	5.08

Proton, deuteron and carbon in Quinta

- The fission yield in Quinta target was compared for proton, deuteron and carbon beam with energies 2 AGeV and 4 AGeV and the efficiency of ions instead of protons was calculated, taking into account that the particle at the same energy per nucleon is 2 times higher for deuteron and carbon than for proton.
- The simulation was made with BC model.

Beam	2 AGeV	4 AGeV	Efficiency 2 AGeV	Efficiency 4 AGeV
proton	22.4	33.1		
deuteron	42.9	74.1	0.99	1.13
carbon	200.8	389.4	4.48	5.88

Carbon versus proton in quasi infinite target

- The simulation was realized with BC model, in a cylindrical uranium target, with radius 60 cm an length 150 cm .
- The total number of fission is presented, for energies 0.5, 1, 4 and 8 AGeV.

Energy, GeV	Proton	Carbon	Efficiency C/p
0.5	4.8	29.9	3.12
1	12.74	131.7	5.17
4	52.7	841.4	7.98
8	103	1697.8	8.24

- The efficiency of carbon rises faster from the energy 0.5 AGeV to 4 AGeV, and slower from 4 to 8 AGeV, suggesting an optimum in the ran.ge 4-8 AGeV.

Conclusions

1. The simulation with Geant4 produces results in good concordance with the experimental measurements for deuteron beams of 2 and 4 AGeV, and carbon beam 2 AGeV.
2. For carbon beam 4 AGeV the simulated spatial distribution of fission and capture at large distances from the center of the target is lower than the experimental data.
3. However, the integrated numbers of fission and capture are in good agreement for all beams and all energies.
4. The experimental data and the simulation demonstrate the higher energetic efficiency of carbon beam.
5. The simulation in quasi infinite uranium target shows the increased efficiency for carbon with respect to proton. The efficiency rises with the rise in beam energy, from 3 at the energy 0.5 AGeV to 8.2 for 8 AGeV, but with a slower increase between 4 and 8 AGeV, which suggests a possible optimum in this energy range.

References

1.M Artiushenko et. all, Baldin ISHEPP XXII, September 15-20, 2014
2.M. Bernas et. all, preprint submitted to Elsevier preprint