INR ADS: Final draft on 26 February 2017 points

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Abstract

INR ADS is simulated by the GEANT4 tools - the mass layered geometry and scoring. The INR ADS target was simulated with different geometries of cooling layers. The neutron output spectra as well as energy deposition profiles are shown. The INR ADS power (and other parameters) dependence on breeder thickness are shown.

1 Outline

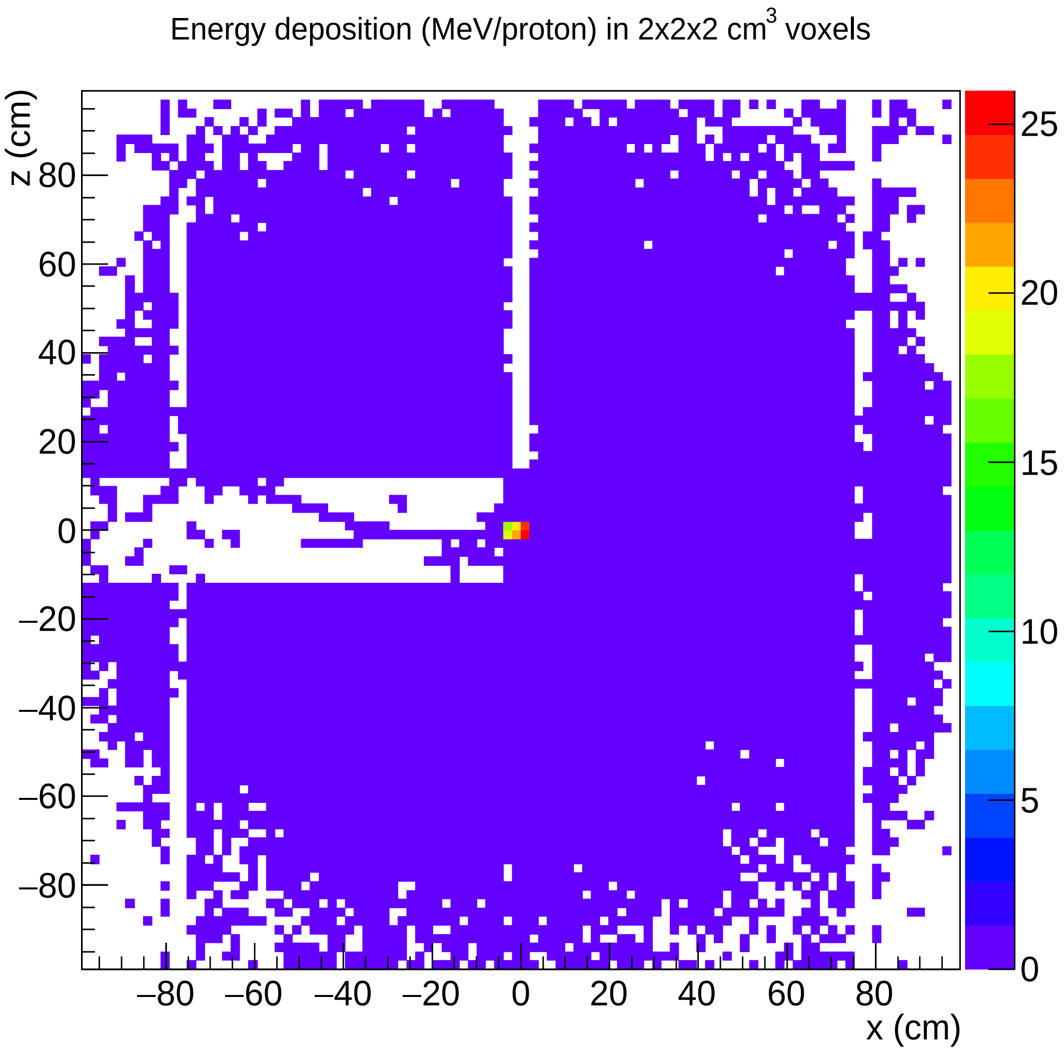
1. Geant4 Mass layered geometry and scoring
2. Energy deposition profiles.
3. Neutron flux profiles.
4. Target neutron flux and energy deposition profiles.
5. Power vs. breeder thickness dependence.

2 Geant4 mass layered geometry and scoring

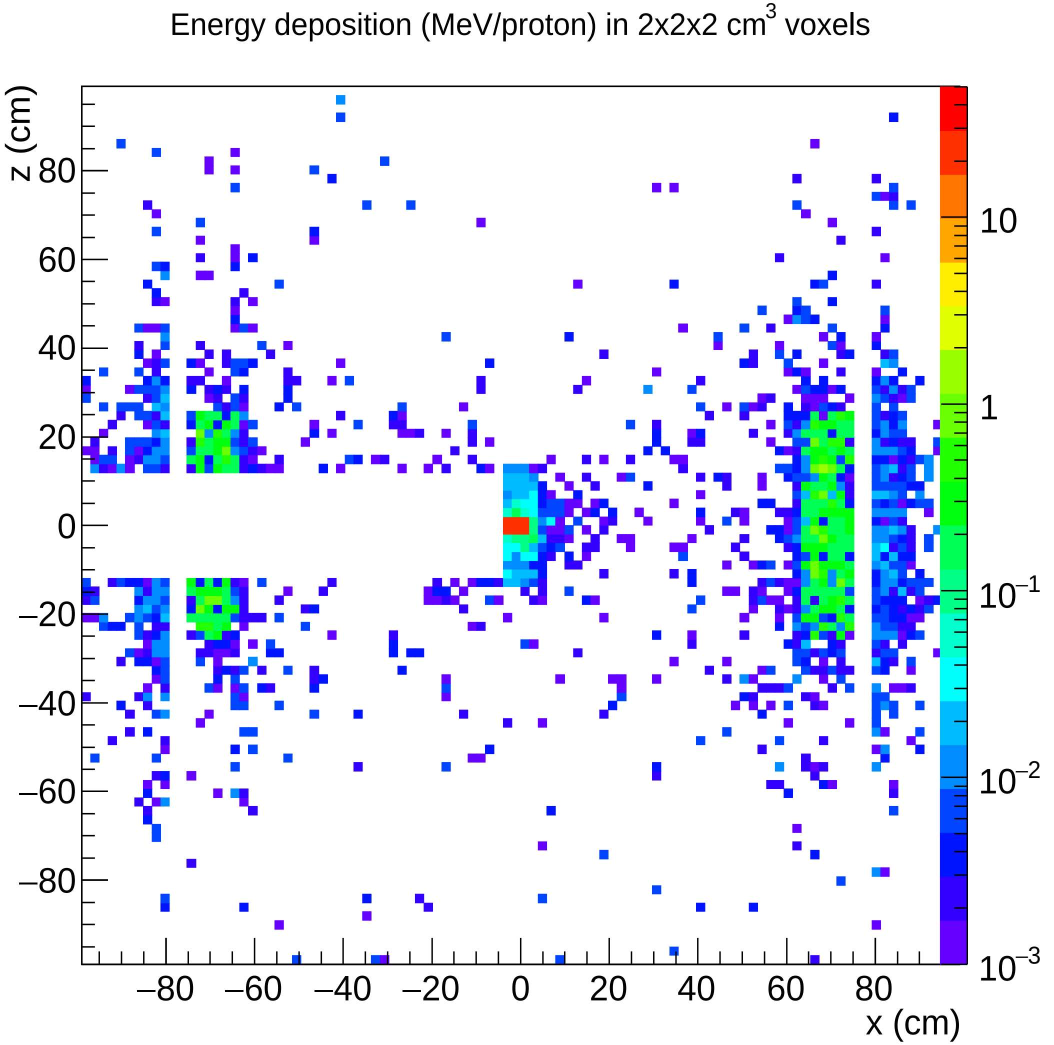
The Geant4 mass layered parallel geometry was applied to describe the proton beam pipe and the cooling channel. Both primitives were created in the mass parallel world and interfaced to the physical tracking.

Geant4 scoring tools were applied to describe energy deposition and neutron flux profiles in the central part of INR ADS. The scoring mesh with 2x2x2 m^3 volume was subdivided by 1 million 2x2x2 cm^3 voxels, where the local energy deposition and neutron flux were accumulated. The mesh was centered by the target position.

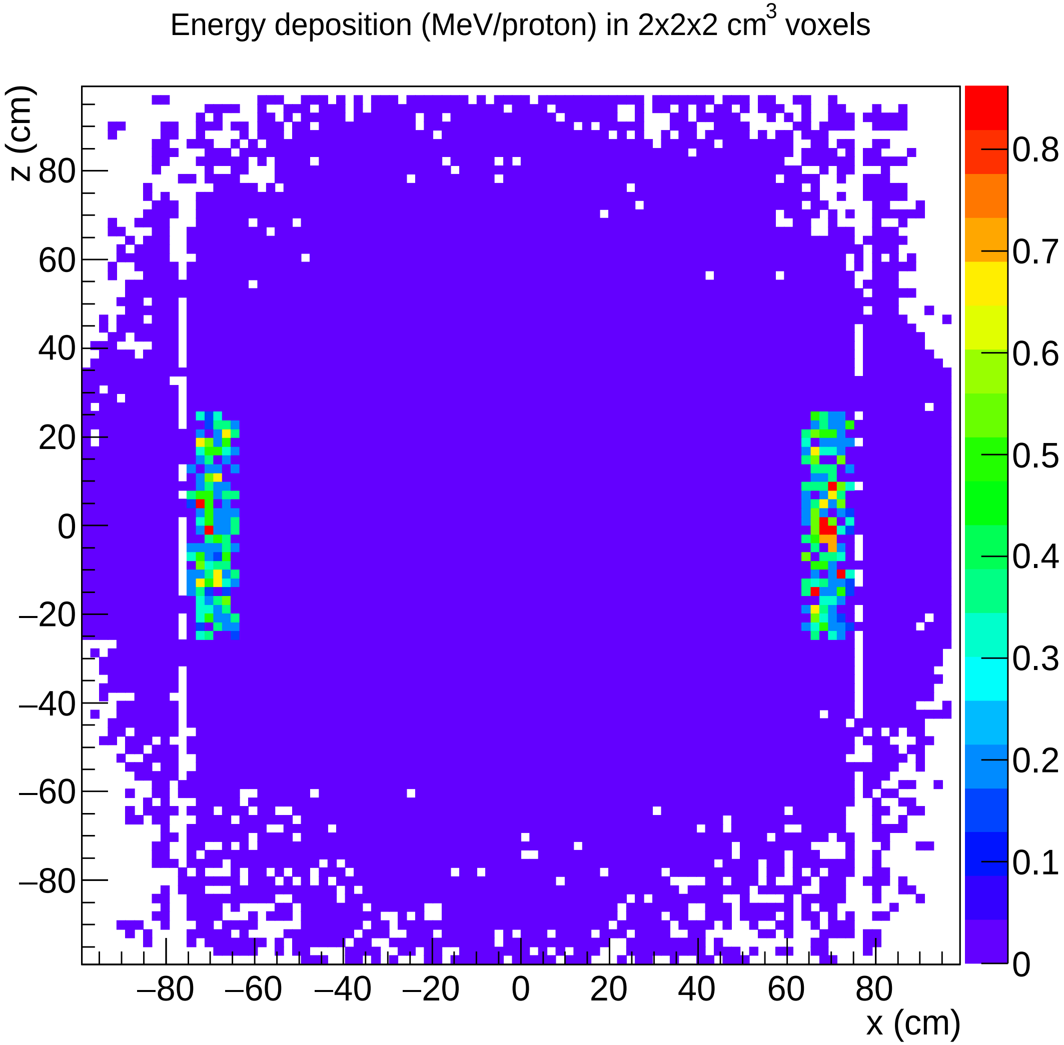
All simulations were done at 9.7 cm thick driver zone corresponding roughly to 1 MW of produced power. Realistic INR ADS geometry with tungsten-water (six 1 mm layers) target was used.



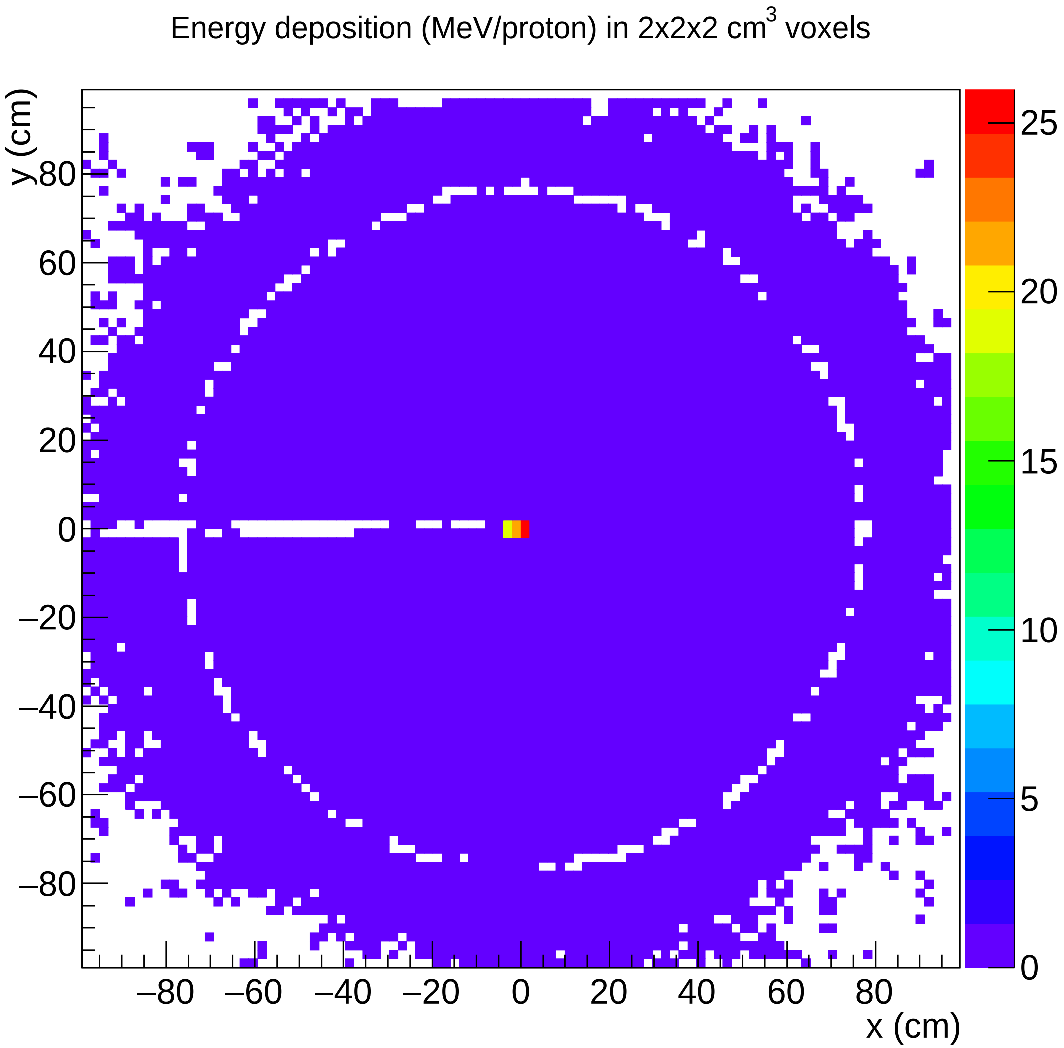
XZ-profile of the energy deposition at the target center. Both proton beam and cooling pipes are visible.



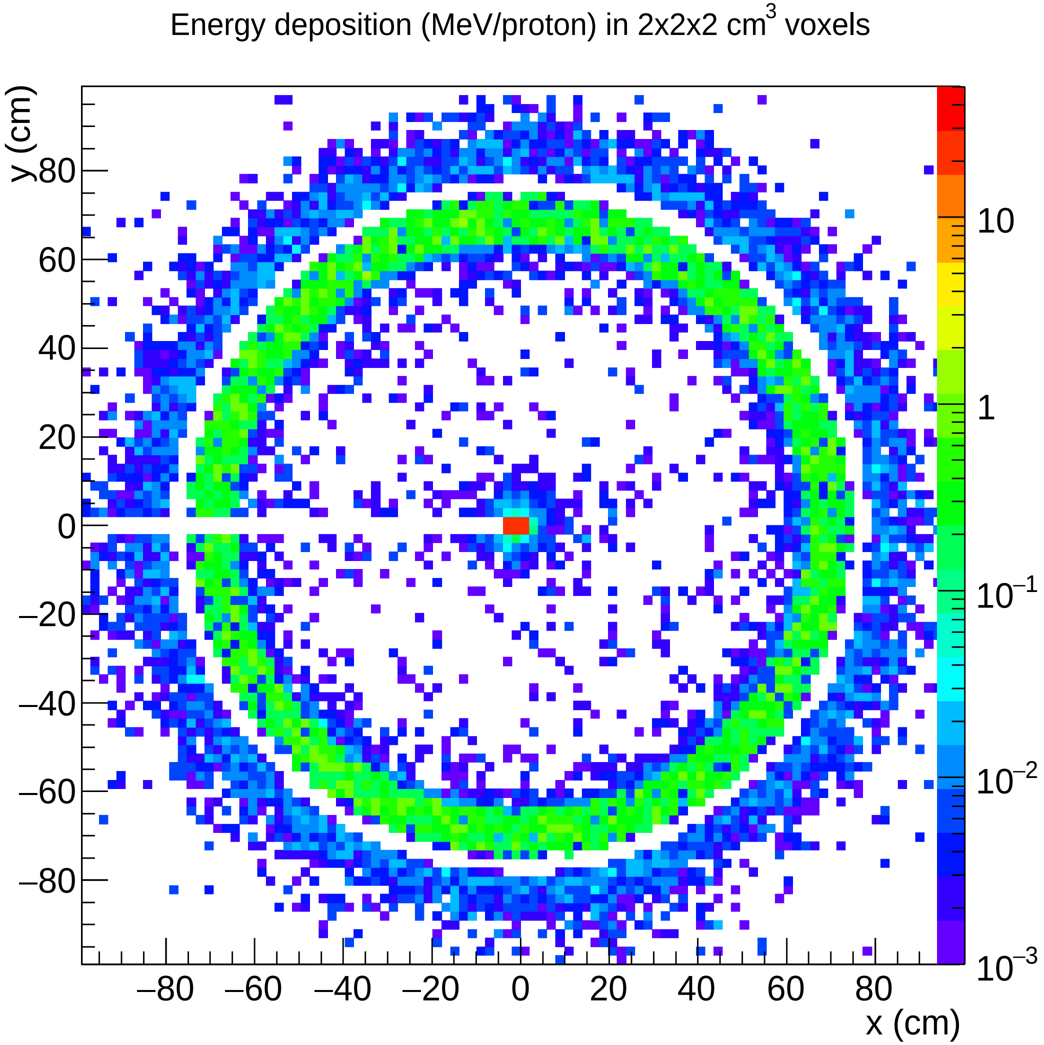
XZ-profile of the energy deposition at the target center. Logarithmic scale of color palette.



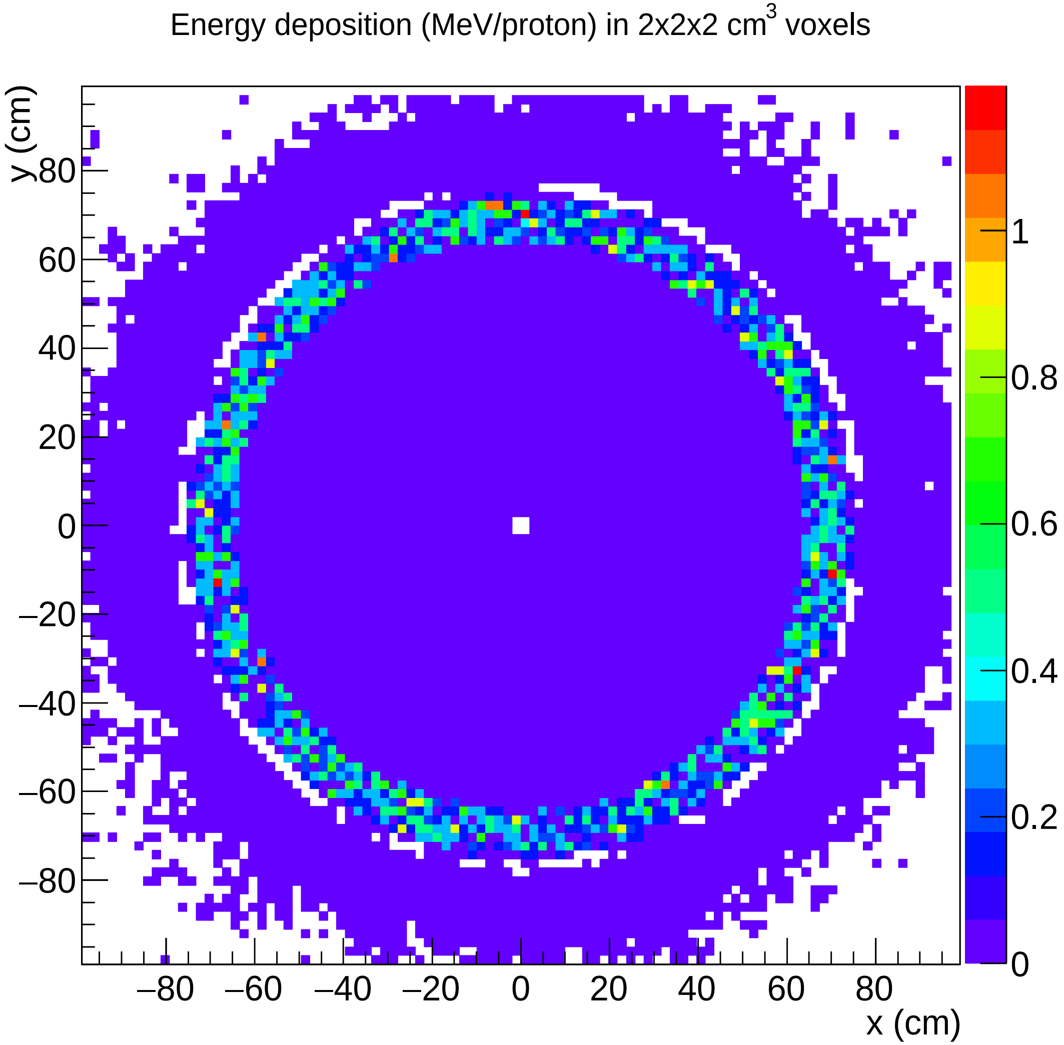
XZ-profile of the energy deposition near target. The driver zone is clearly visible



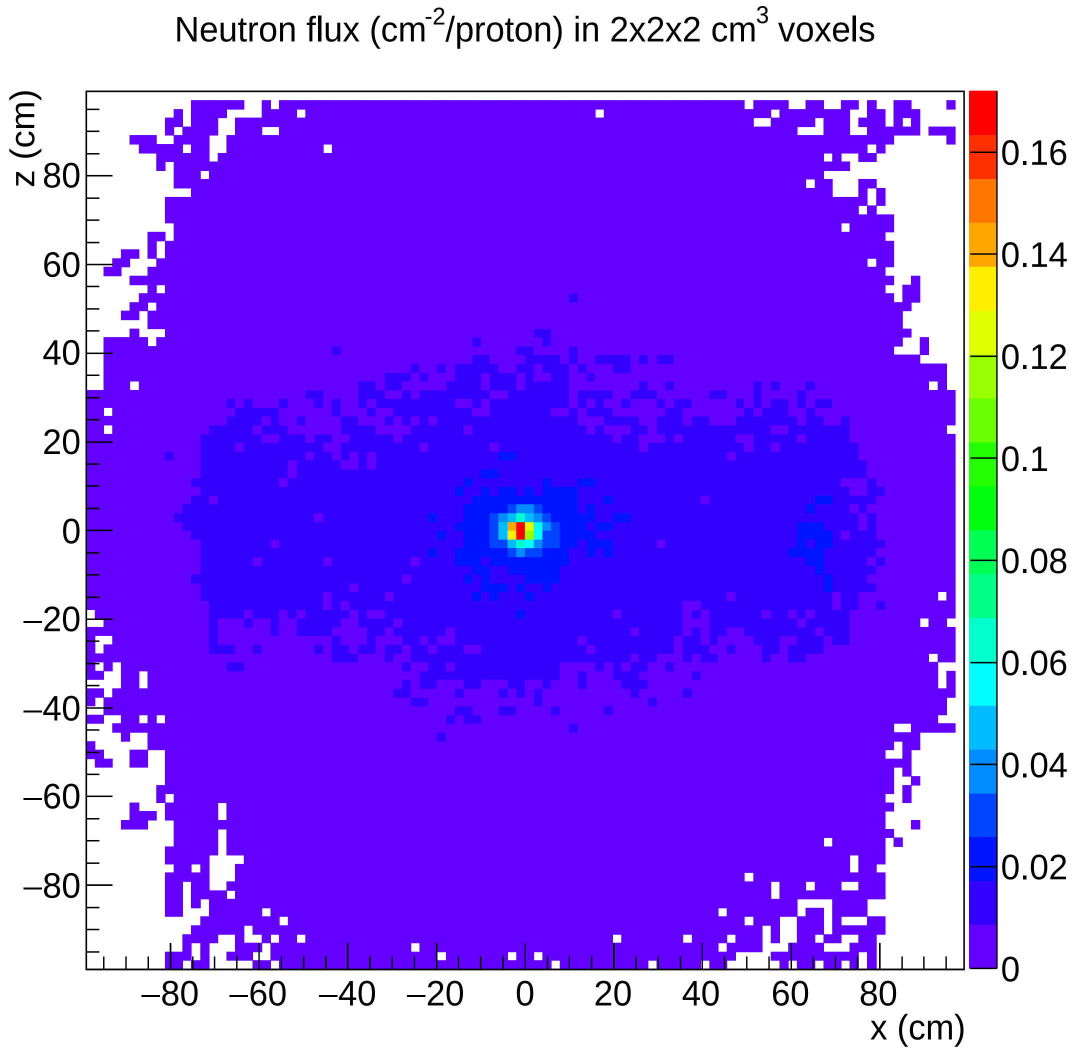
XY-profile of the energy deposition at the target center. Proton beam pipe is visible.



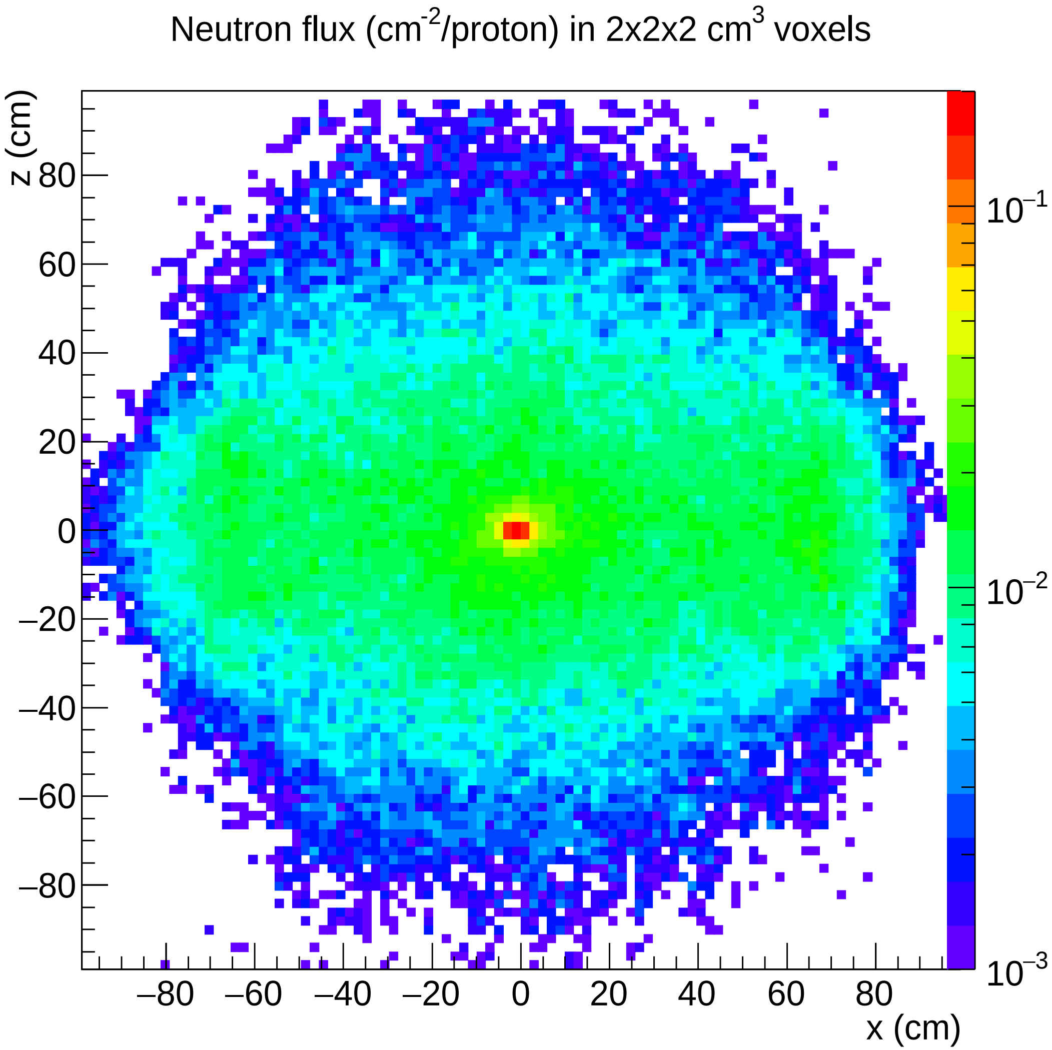
XY-profile of the energy deposition at the target center. Logarithmic scale of color palette.



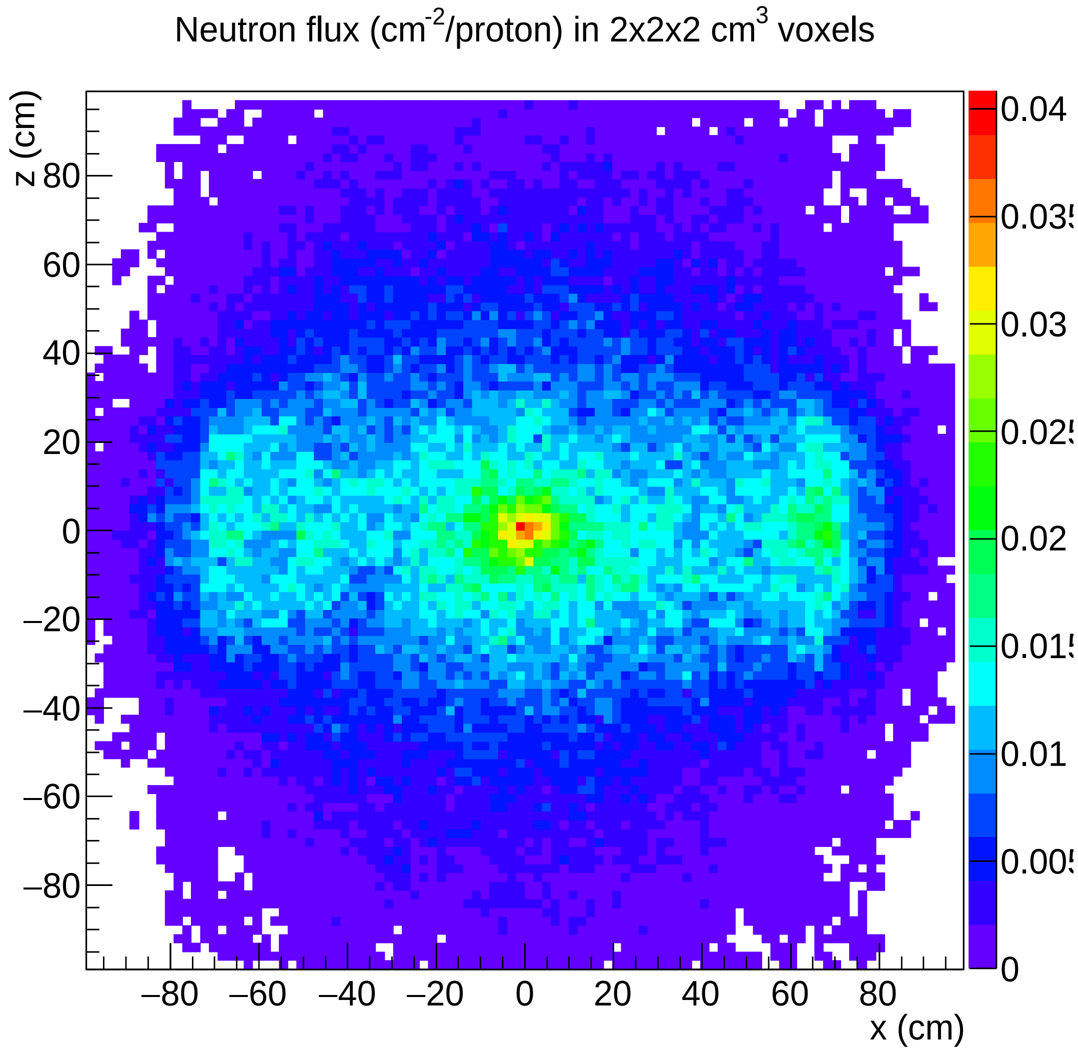
XY-profile of the energy deposition near target. Cooling pipe and driver zone are visible.



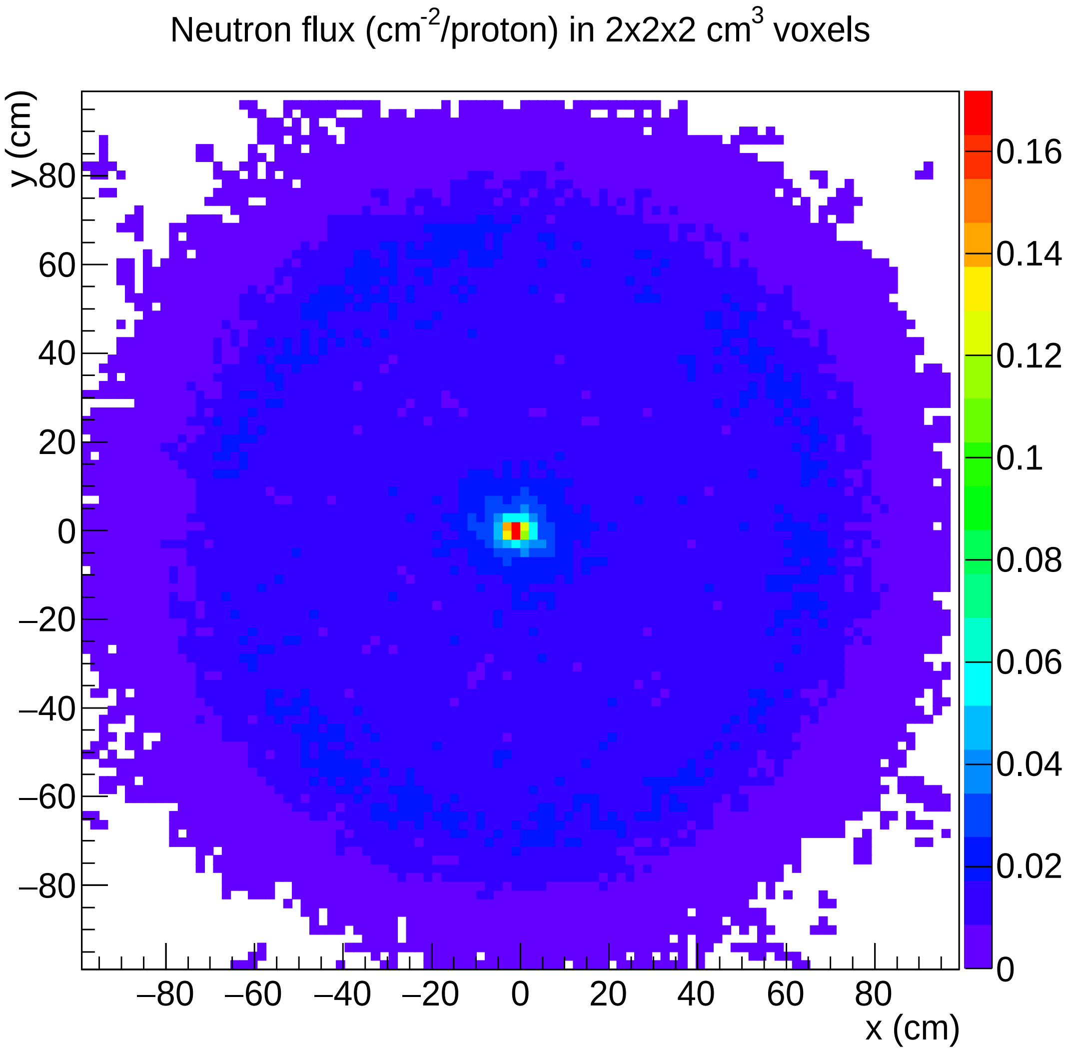
XZ-profile of the neutron flux at the target center.



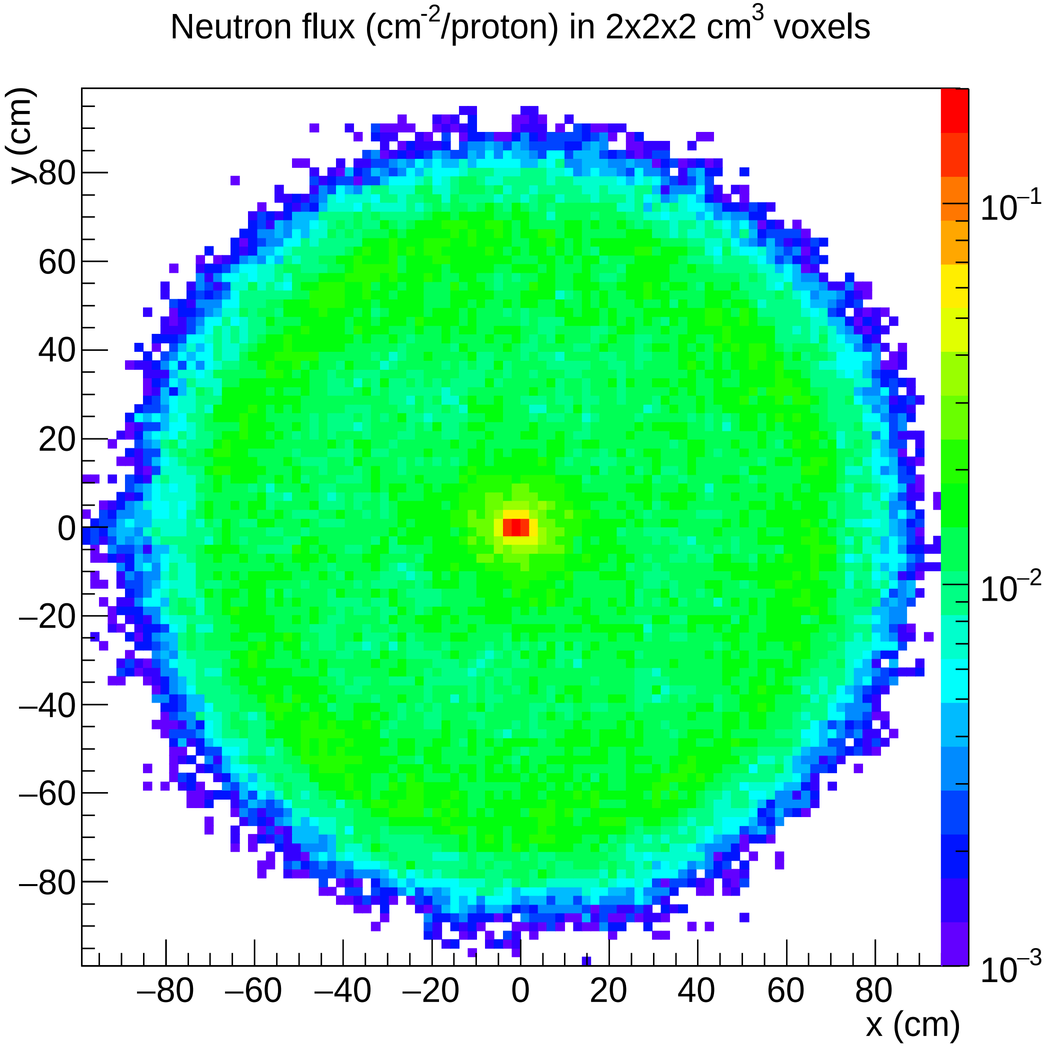
XZ-profile of the neutron flux at the target center. Logarithmic scale of color palette.



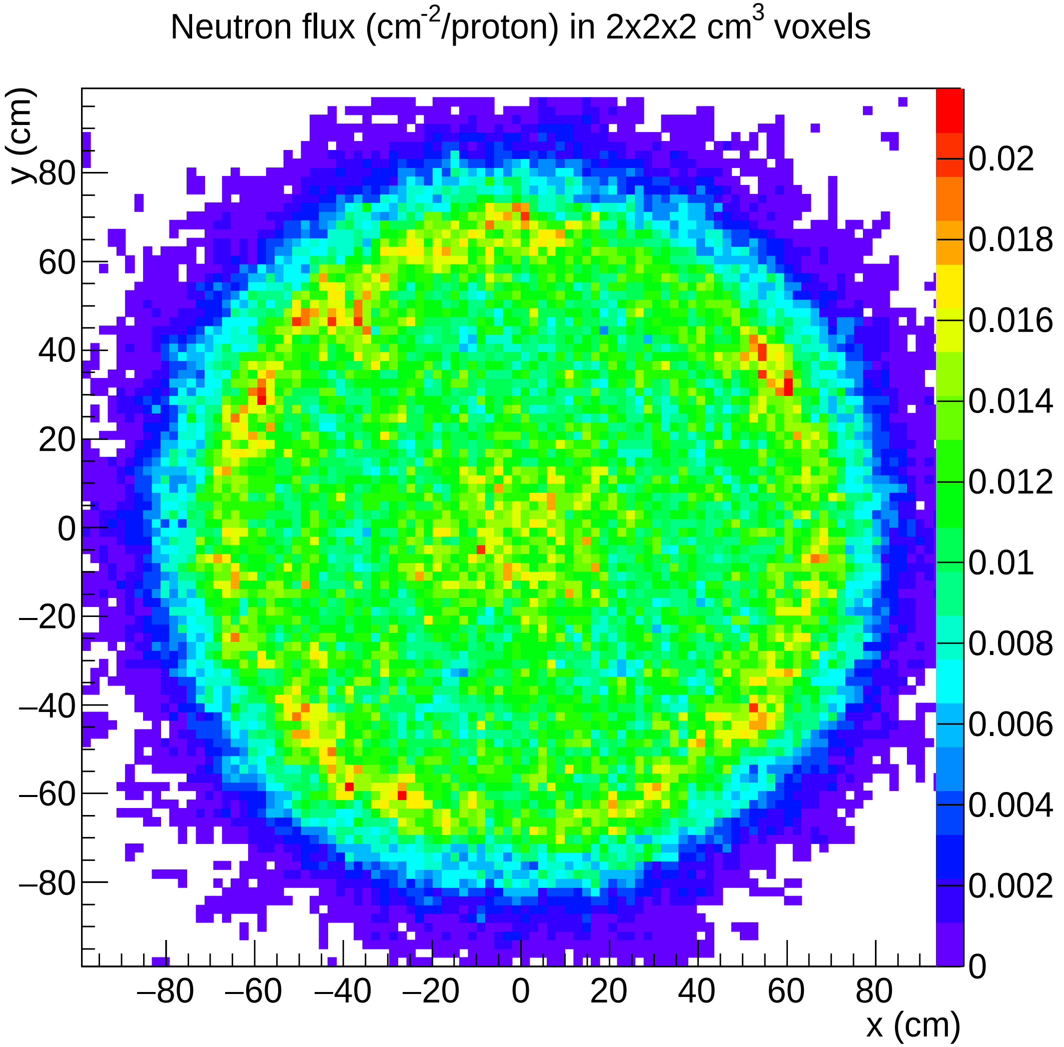
XZ-profile of the neutron flux near target.



XY-profile of the neutron flux at the target center.



XY-profile of the neutron flux at the target center. Logarithmic scale of color palette.

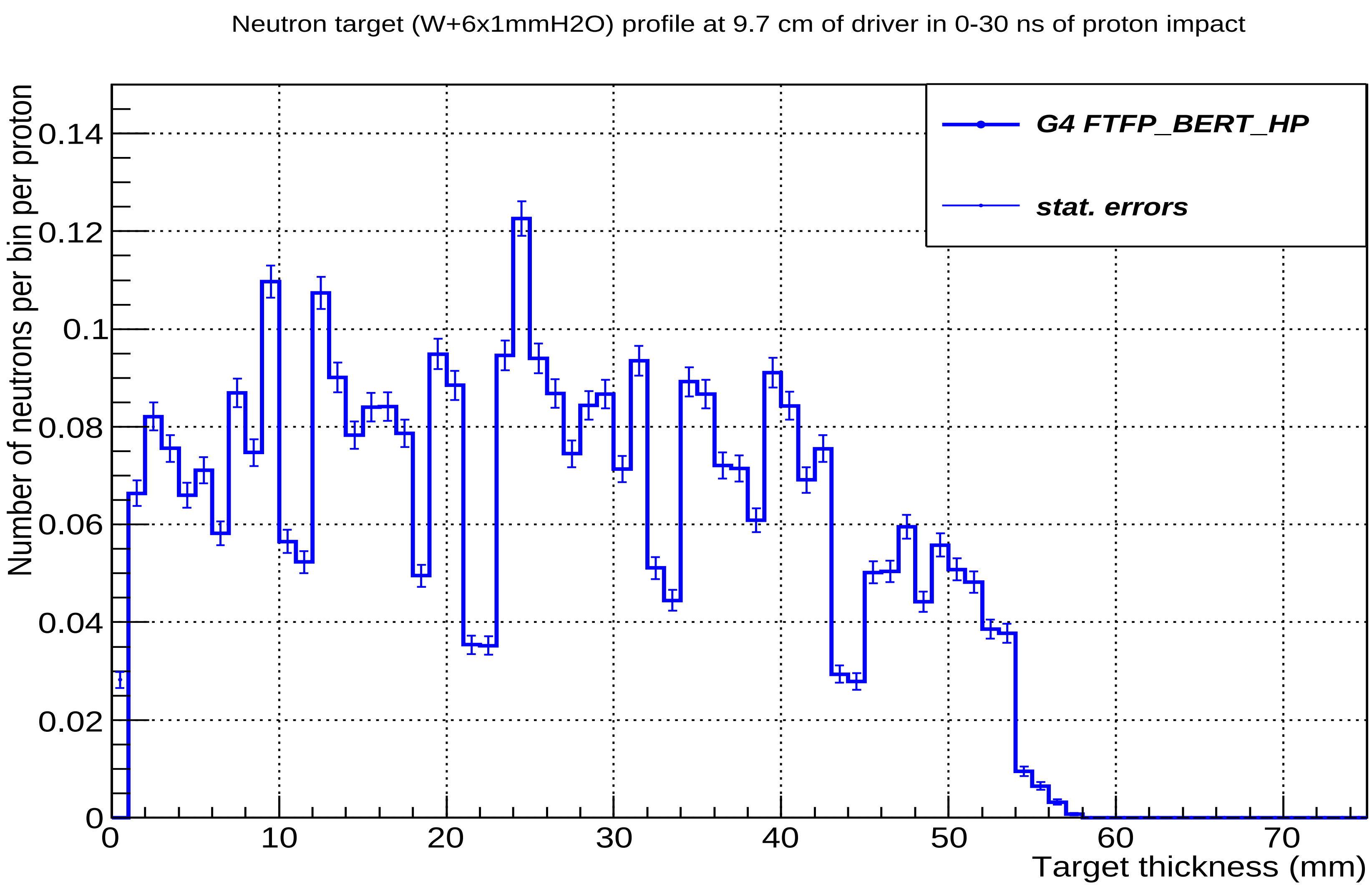


XY-profile of the neutron flux near target.

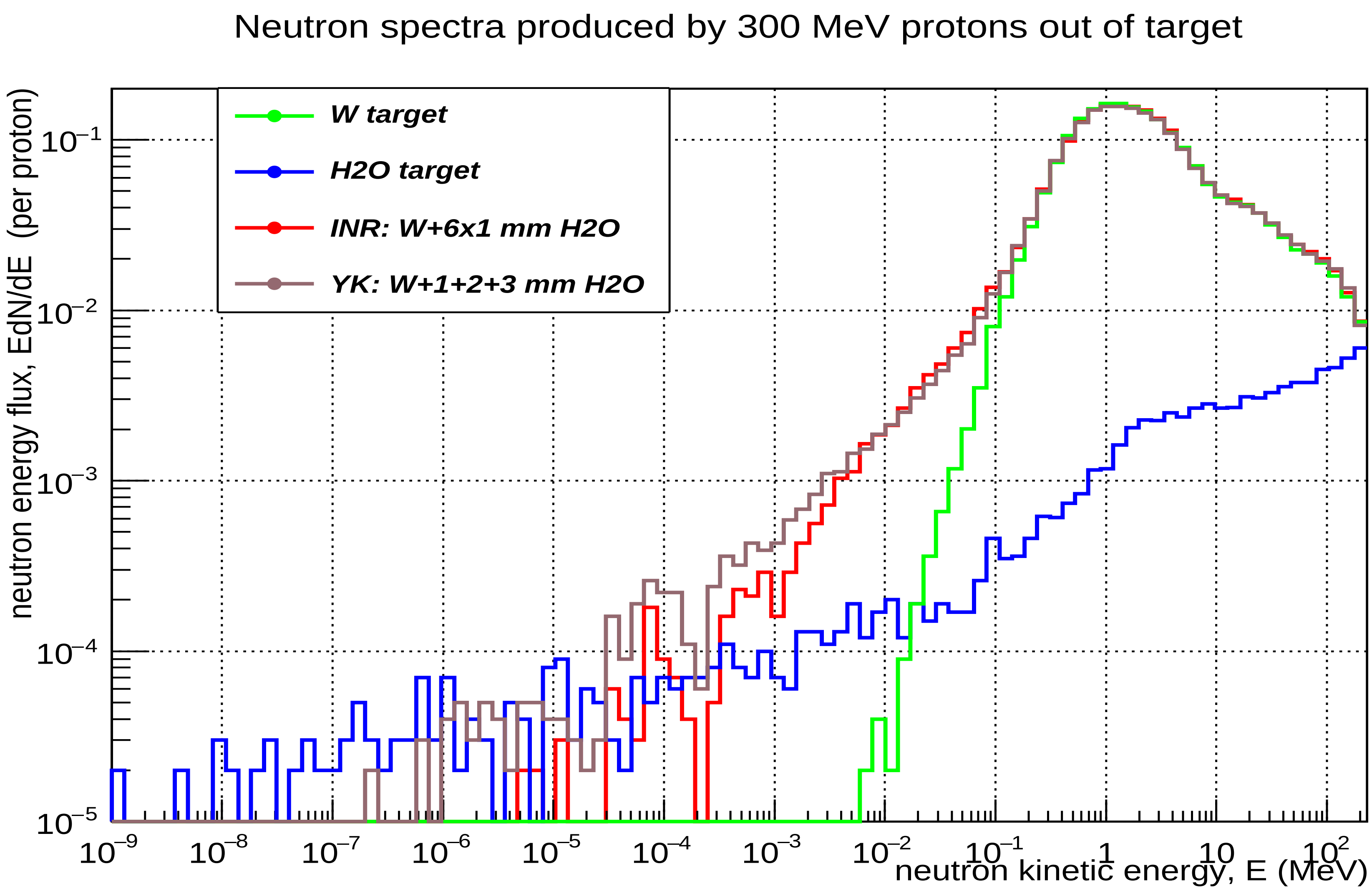
3 Target simulation set-up

The target was the tungsten box with realistic INR geometry (76x45x250 mm^3). Six 1 mm thick water layers were uniformly distributed along x-axis with 11 mm period. The Yacine geometry consists of three water layers, 1, 2 and 3 mm thick. The target is surrounded by thin (0.1 mm) check volume with galactic material. Neutron spectra produced by 300 MeV protons along x-axis are detected in the check volume, while energy deposition is measured inside the target.

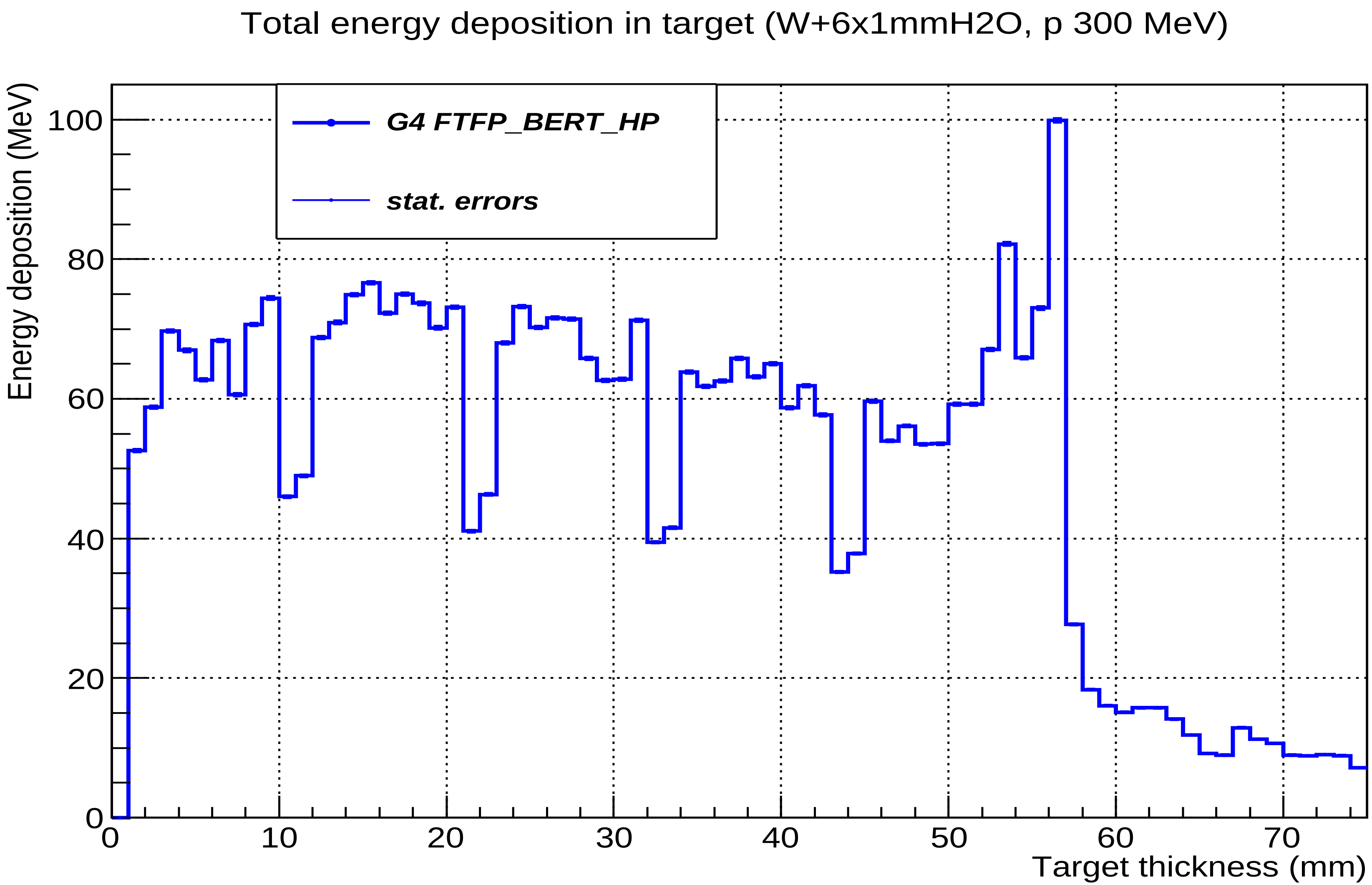
One mode is energy deposition of initial proton, another - from all particles in the target. FTFP_BERT_HP physics list was used (the same as was used in the simulation of all INR ADS realistic geometry)



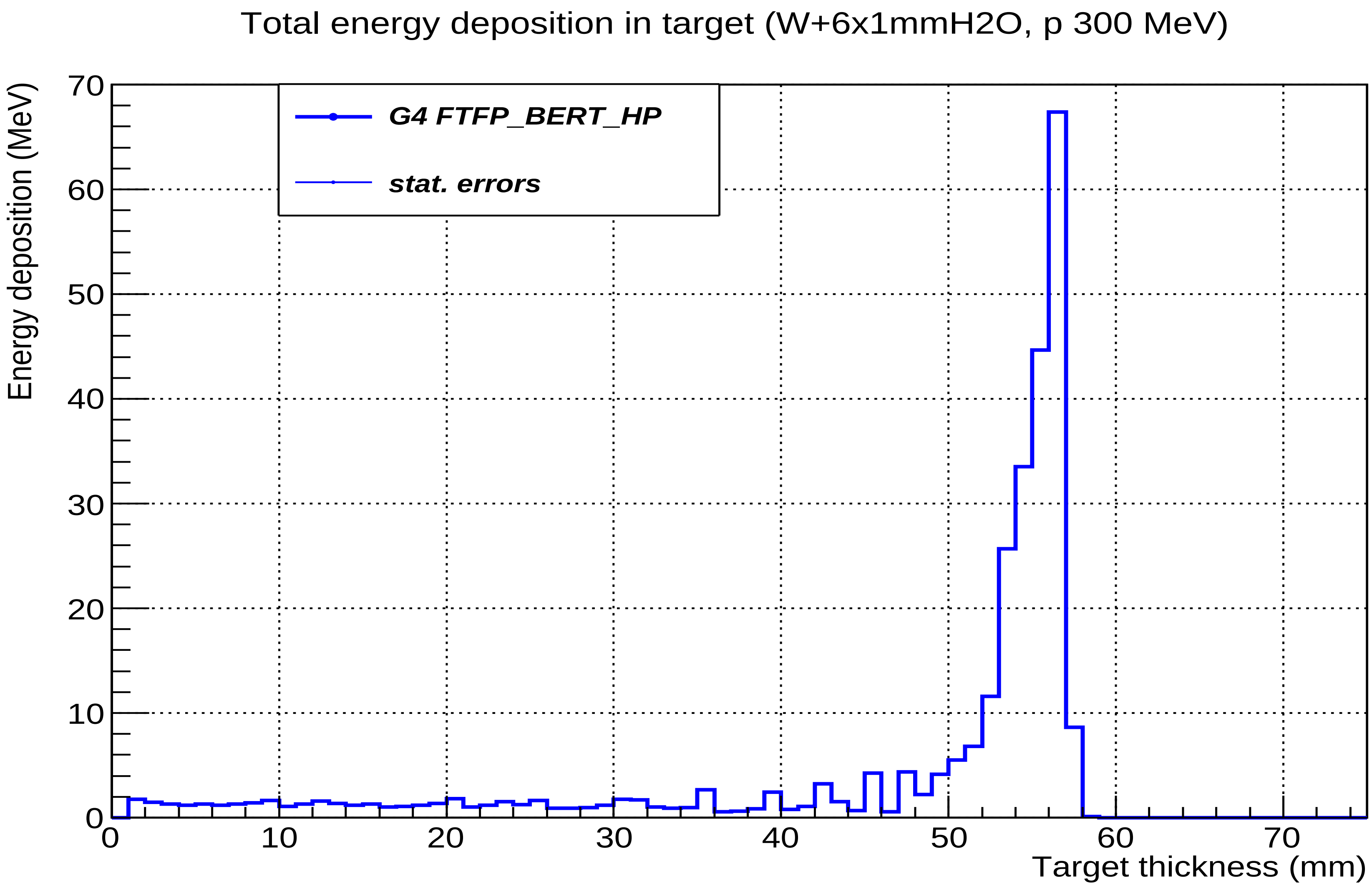
The neutron track origin x-position profile along the beam line direction.



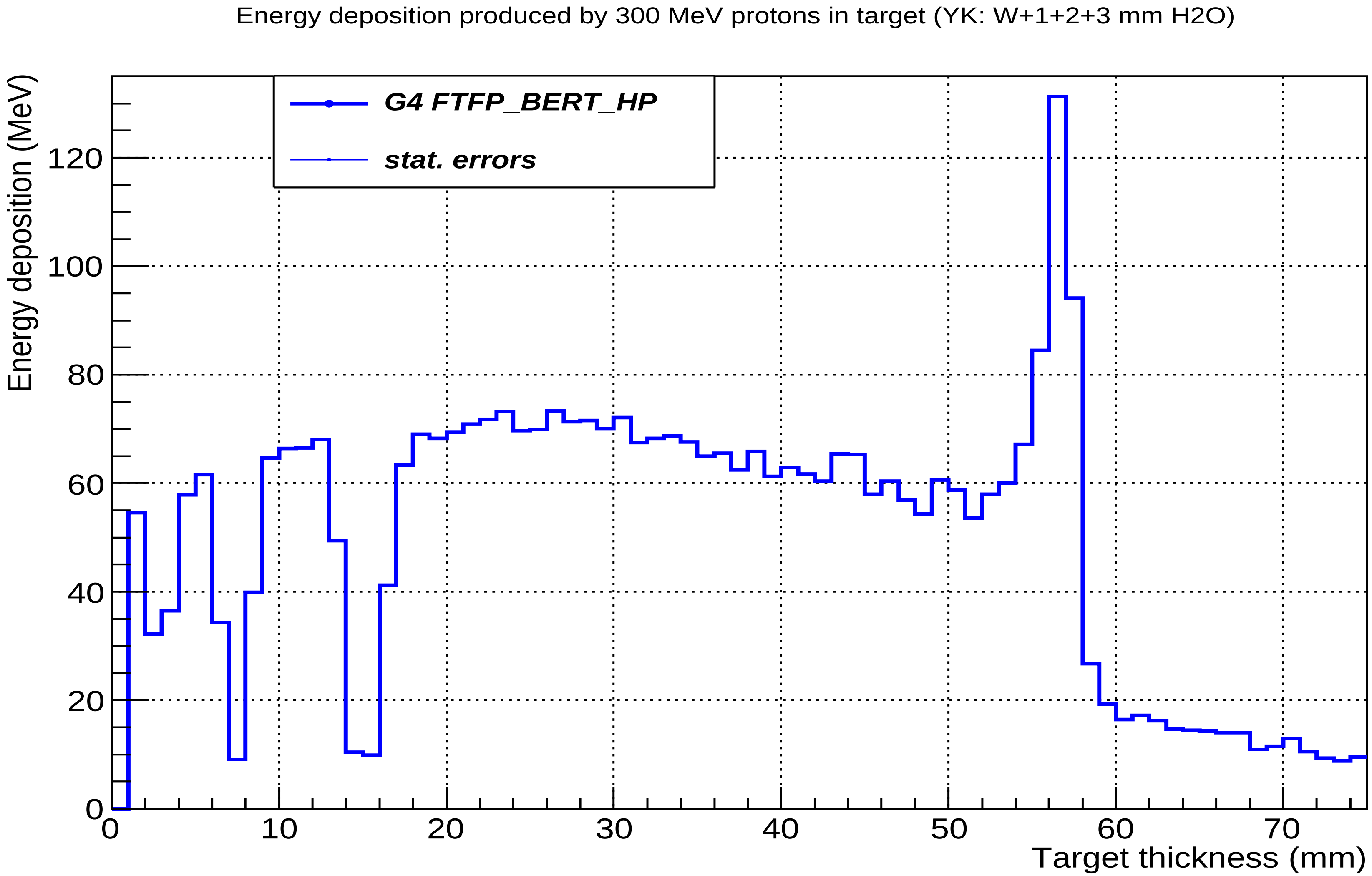
The neutron spectra measured around the target. The total neutron yield in the check volume is ∼3 neutrons/proton for both INR and Yacine geometries.



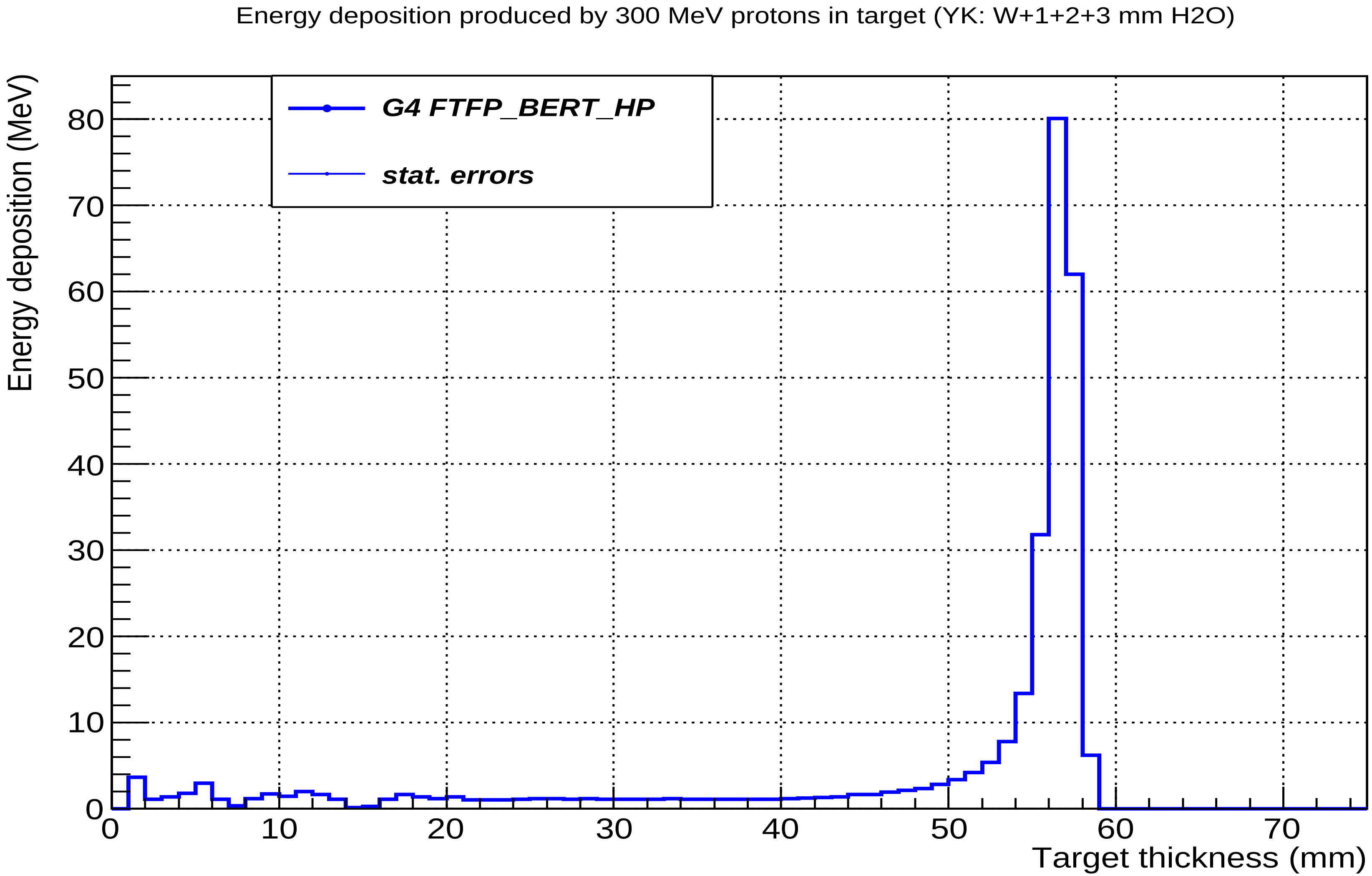
Total energy deposition profile in the INR target.



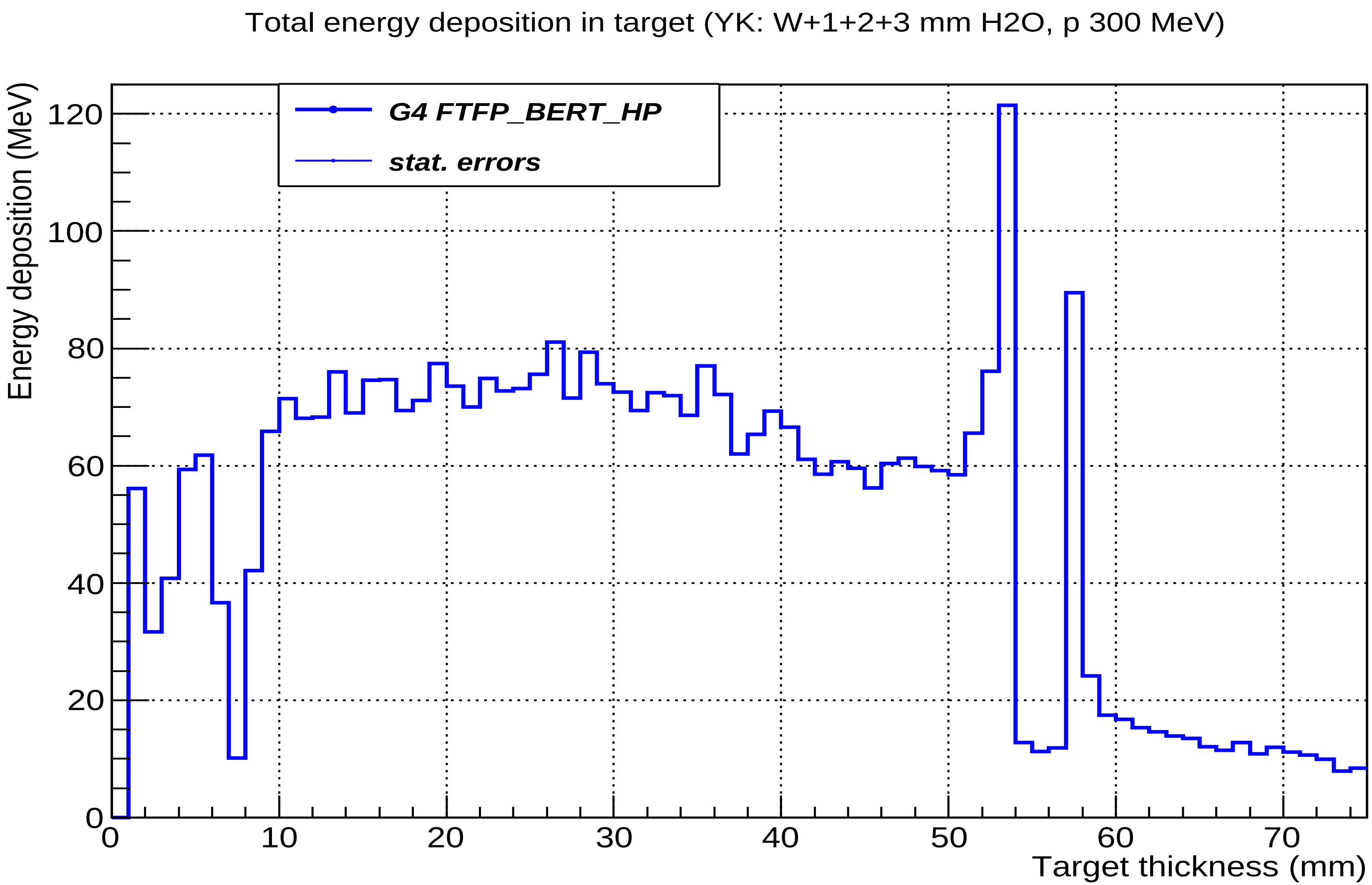
Beam proton energy deposition profile in the INR target.



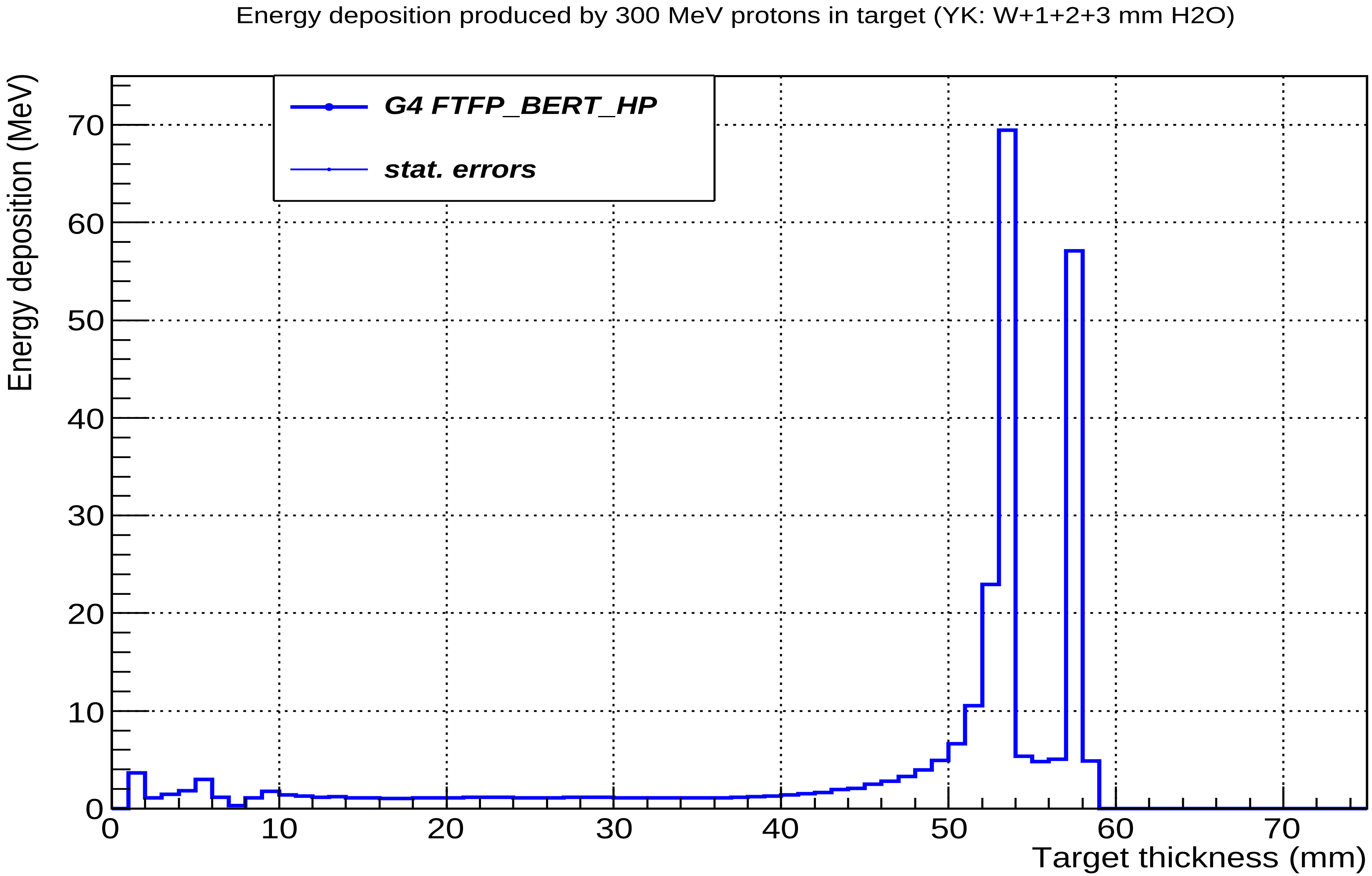
Total energy deposition profile in the Yacine target.



Beam proton energy deposition profile in the Yacine target.



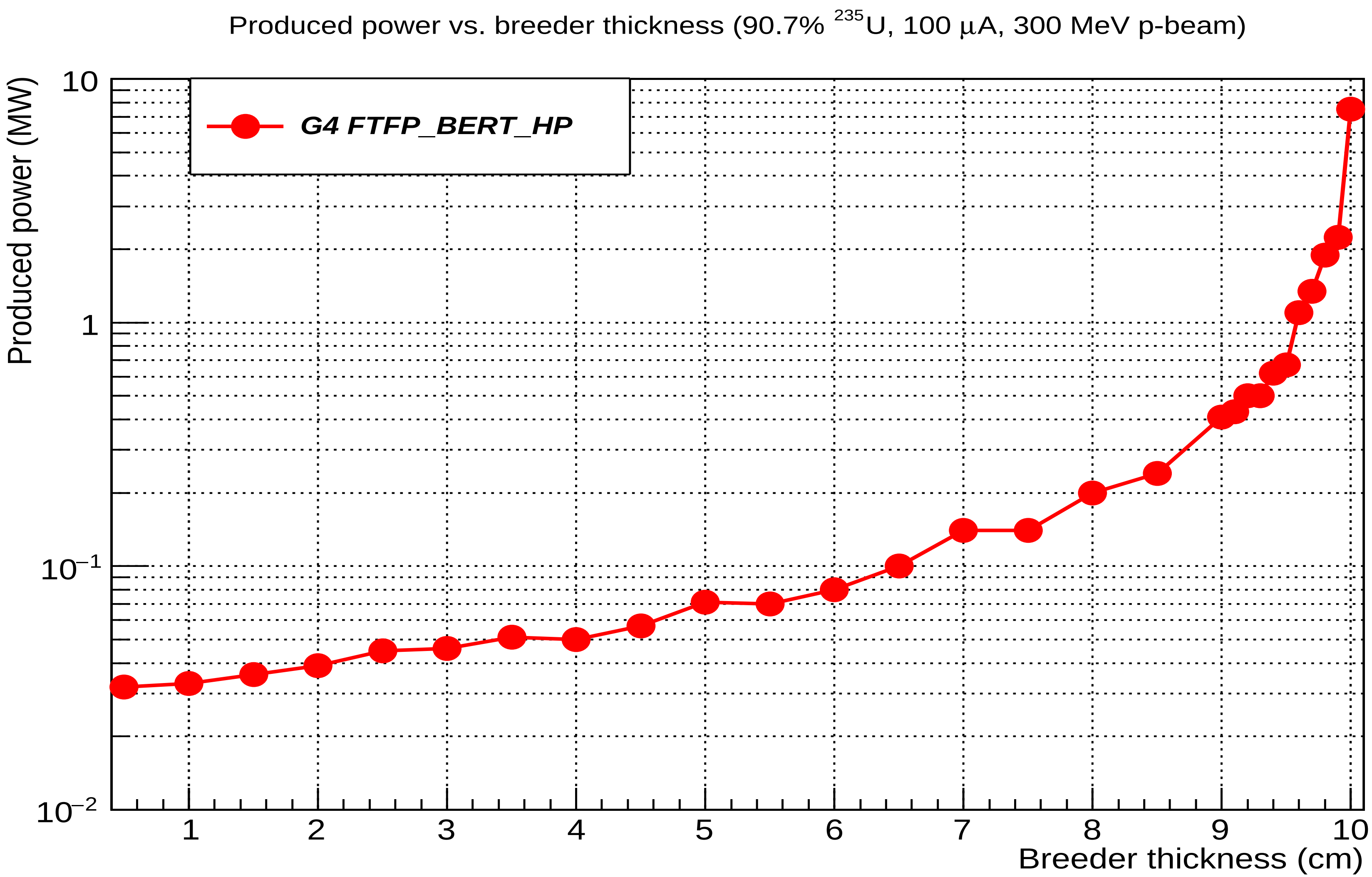
Total energy deposition profile in the modified (3 mm water gap in the position of the Bragg peak) Yacine target.



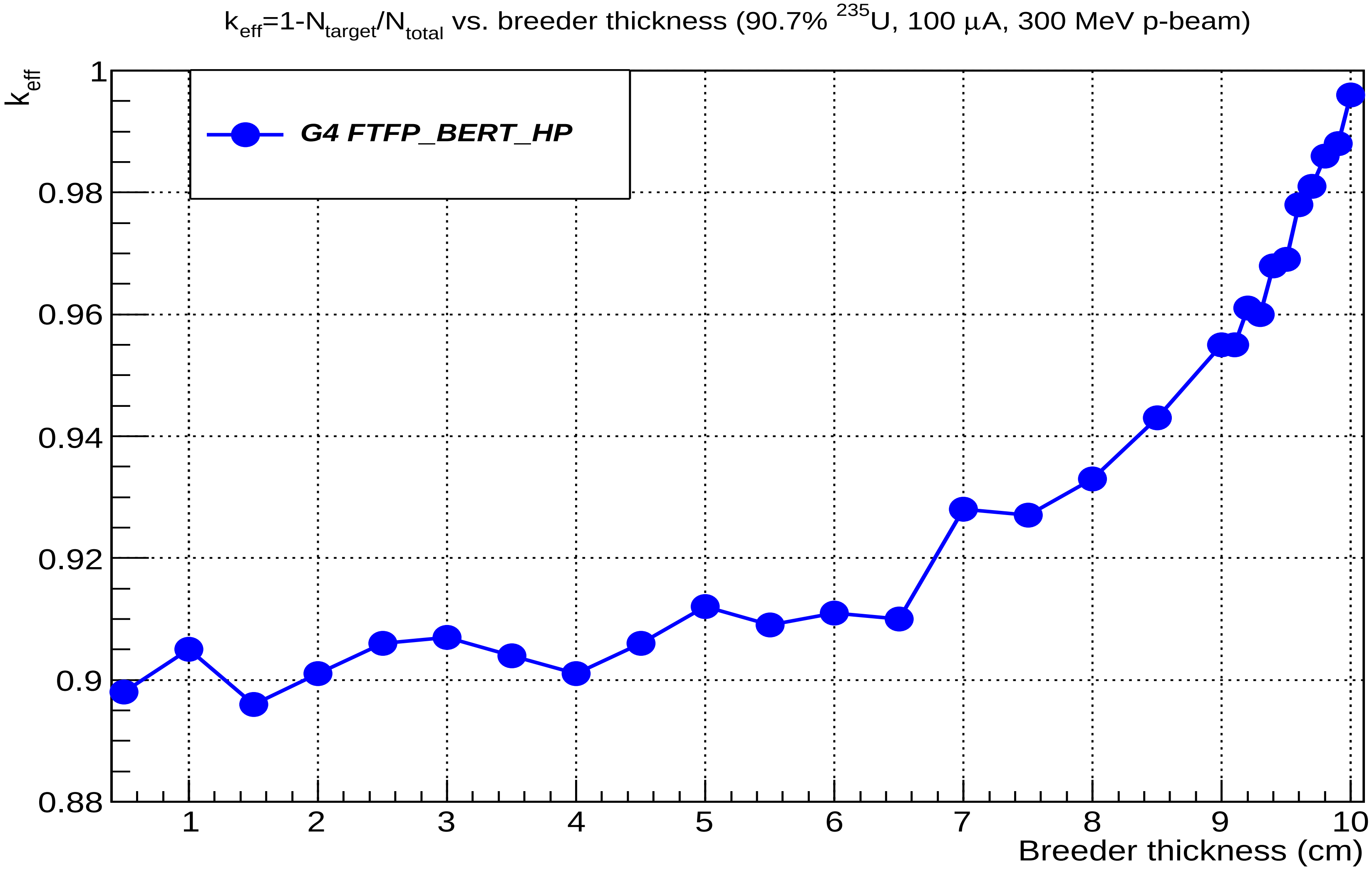
Beam proton energy deposition profile in the modified (3 mm water gap in the position of the Bragg peak) Yacine target.

The neutron multiplicity, M_n, in different geometries of water layers

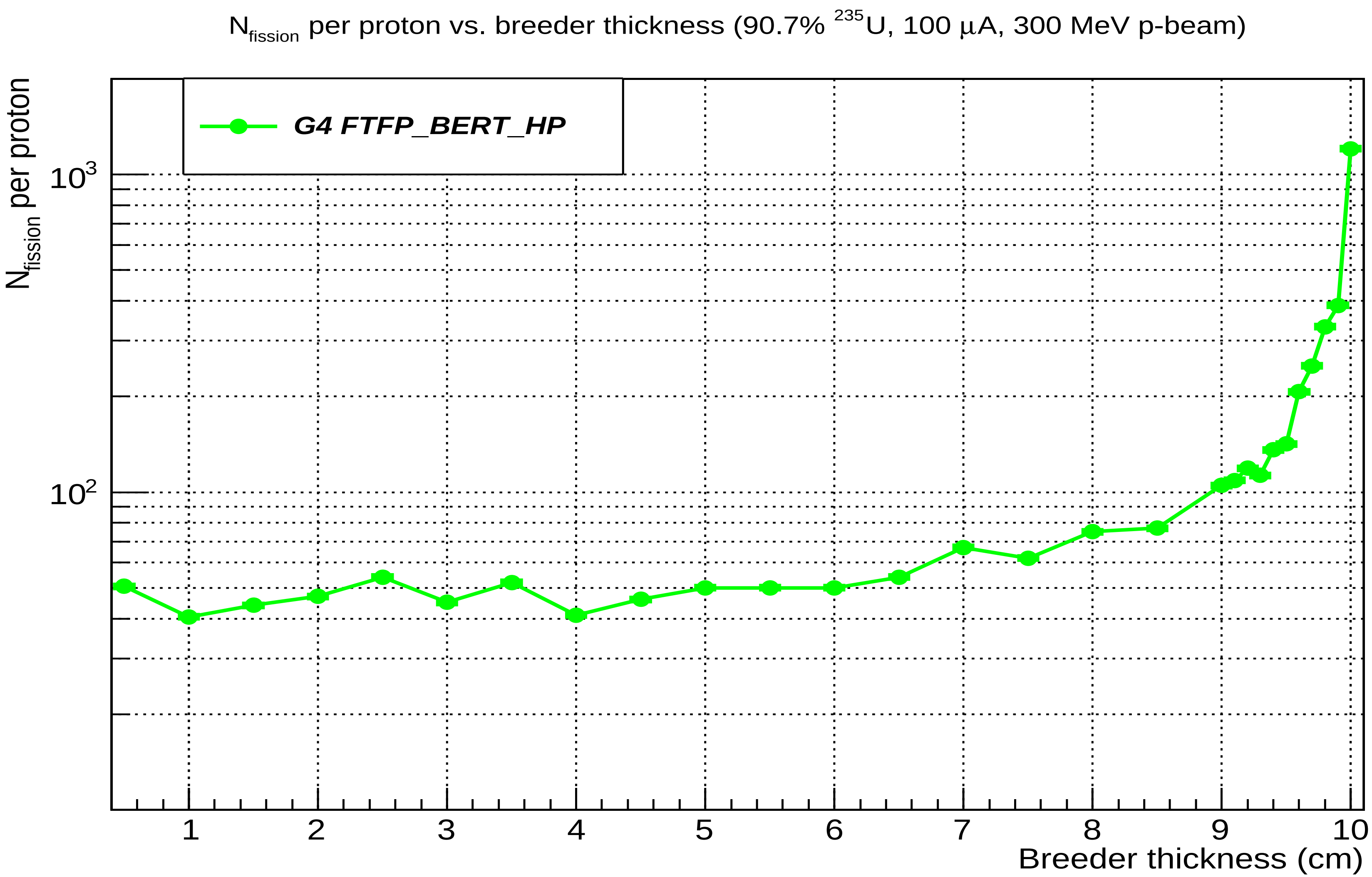
Geometry	M_n
6x1 mm, INR	3.12
1+2+3 mm, Yacine	2.95
1+2+3 mm, in Bragg peak	3.01



Produced power versus driver thickness (100 μA, 300 MeV proton beam).



k_{eff} versus driver thickness (100 μA, 300 MeV proton beam). Preliminary.



N_{fis} versus driver thickness (100 μA, 300 MeV proton beam). Preliminary.

4 Summary

1. GEANT4 mass layered geometry allows one to describe drilled pipes in terms of physical tracking.
2. Energy deposition and neutron flux profiles scored in the central part of INR ADS look to be reasonable
3. Target neutron spectra and energy deposition profiles look reasonable for the FTFP_BERT_HP physics list.
4. The target neutron yield (multiplicity) is the same of all geometries of water layers in 10% limits.
5. At $k_{eff} \sim 0.98$ (the driver thickness ∼9.7 cm), the simulated power is ~ 1 MW in agreement with the MCNPX simulation.