GEANT4 simulation of ADS

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Abstract

Acceletator driven system (ADS) is simulated by the GEANT4 tools - the mass layered geometry and scoring. The ADS target was simulated with different geometries of cooling layers. The neutron output spectra as well as energy deposition profiles are shown. The ADS power (and other parameters) dependence on driver thickness are shown. The medical isotope production is simulated in the batch mode (2000 jobs with 5000 events each)

1 Outline

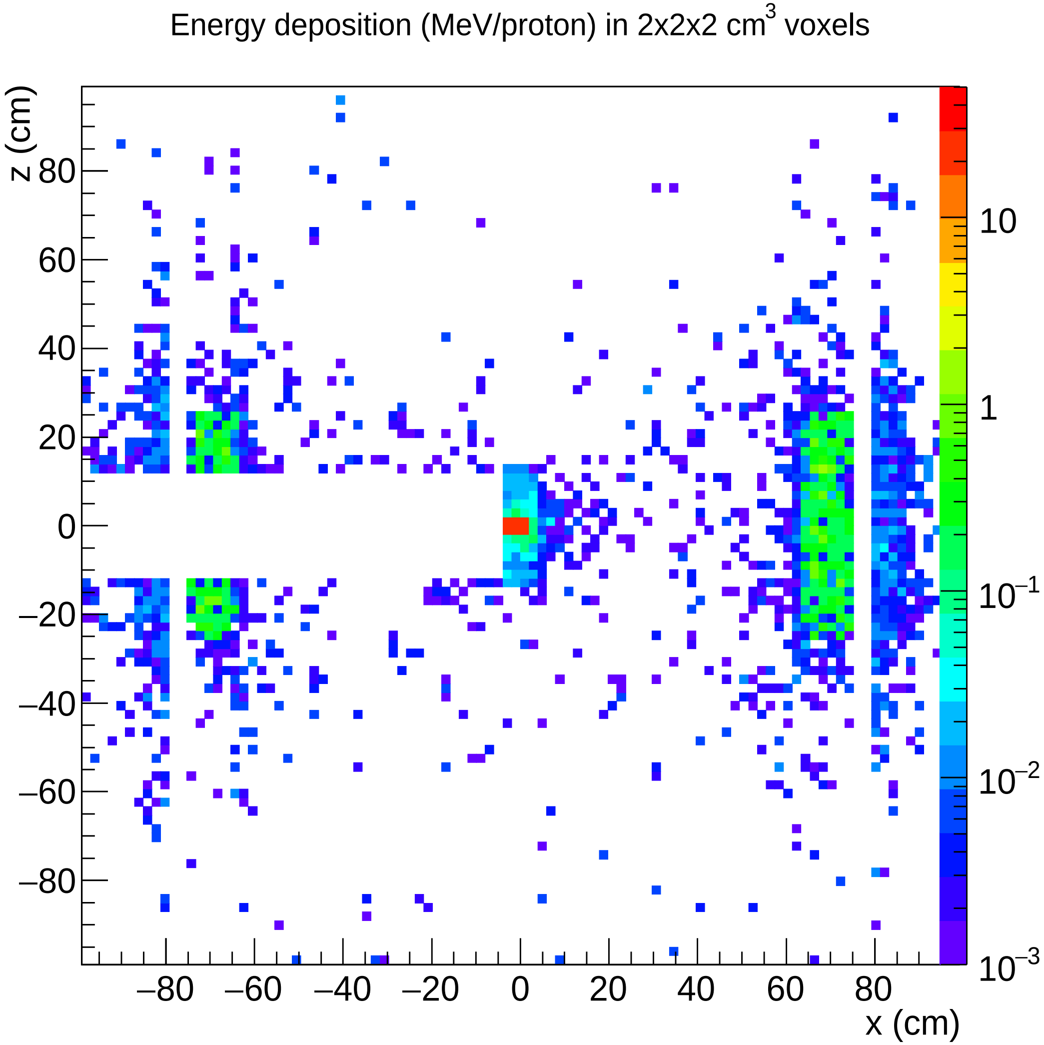
1. GEANT4 Mass layered geometry and scoring
2. Energy deposition profiles.
3. Target neutron flux and energy deposition profiles.
4. Medical isotope production
5. Power vs. driver thickness dependence.

2 GEANT4 mass layered geometry and scoring

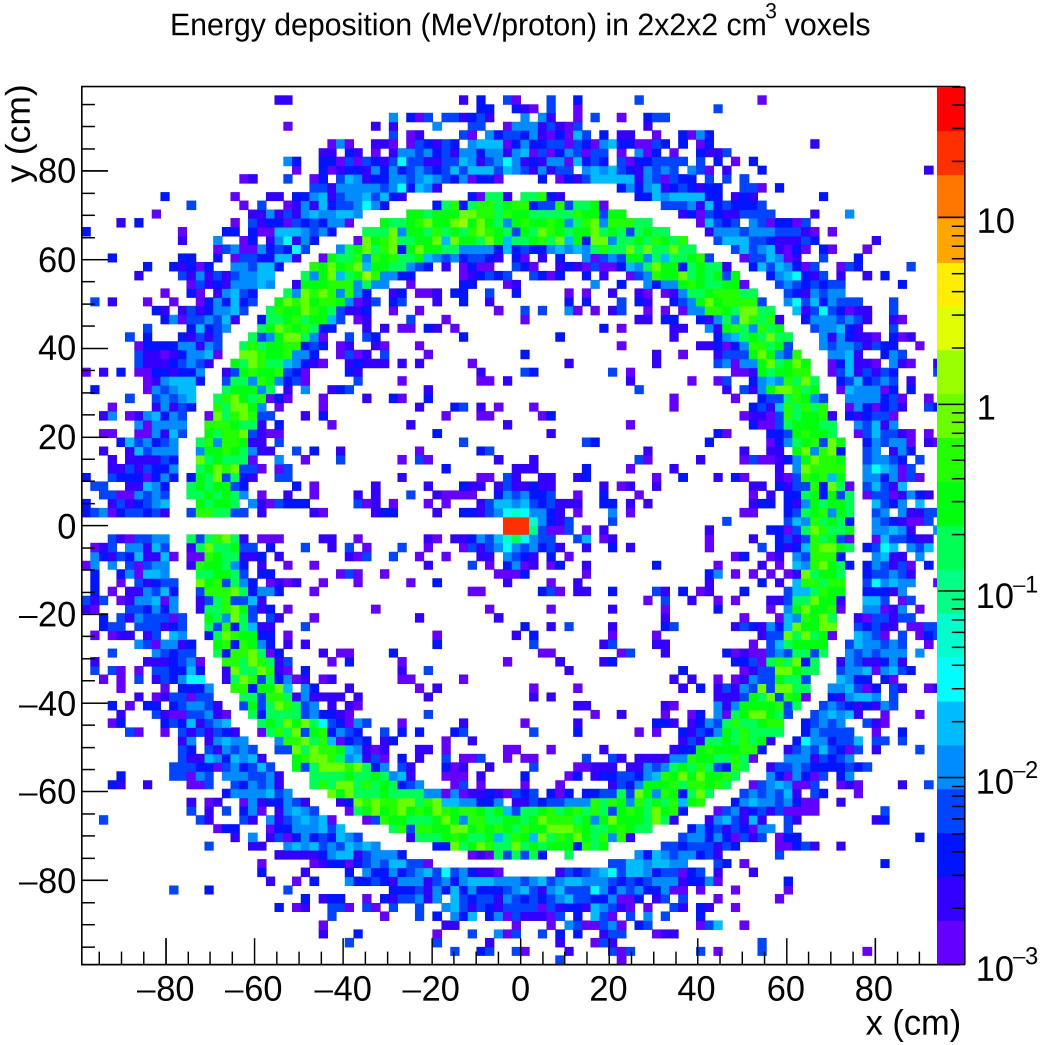
The GEANT4 mass layered parallel geometry was applied to describe the proton beam pipe and the cooling channel. Both primitives were created in the mass parallel world and interfaced to the physical tracking.

GEANT4 scoring tools were applied to describe energy deposition and neutron flux profiles in the central part of 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.

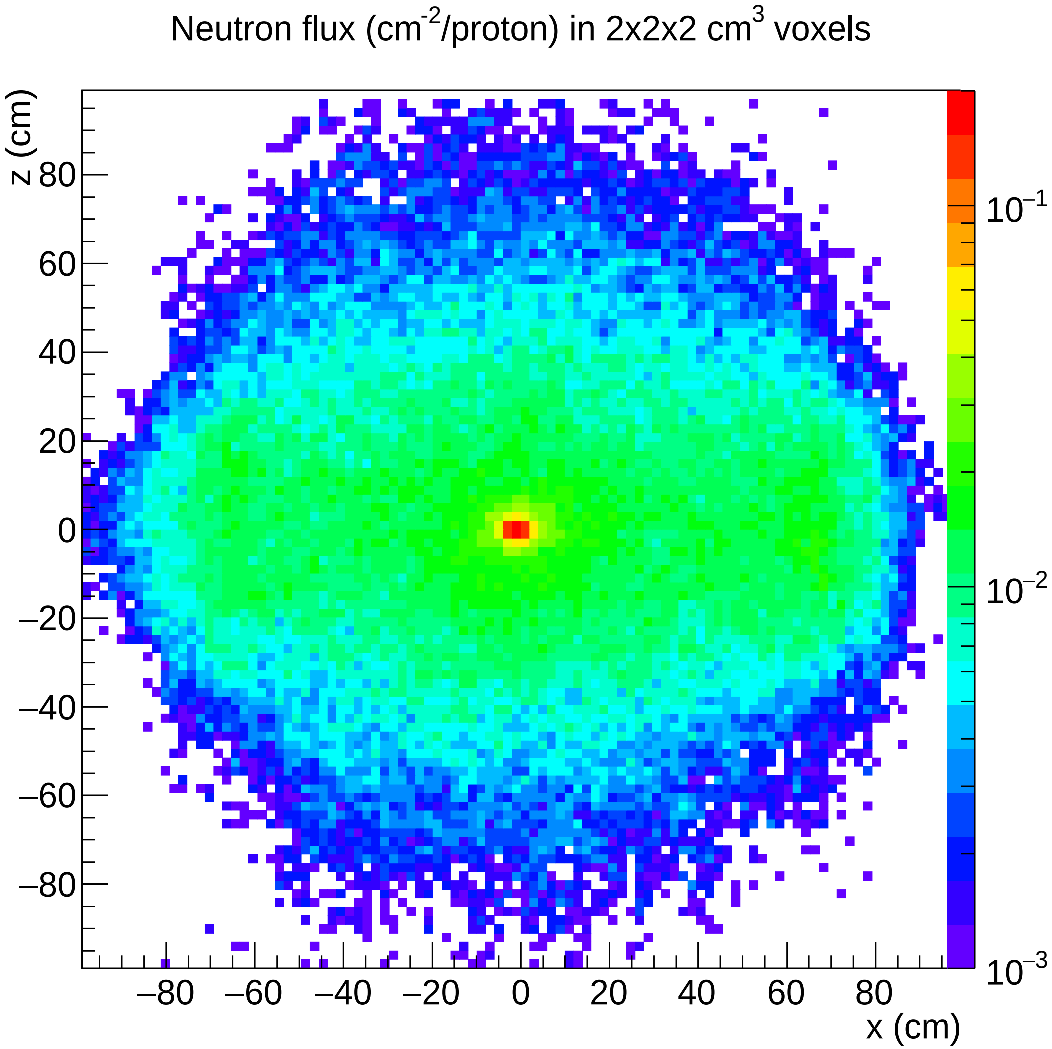
All simulations were done at 9.7 cm thick driver zone corresponding roughly to 1 MW of produced power. Realistic ADS geometry with tungsten-water (six 1 mm layers) target was used.



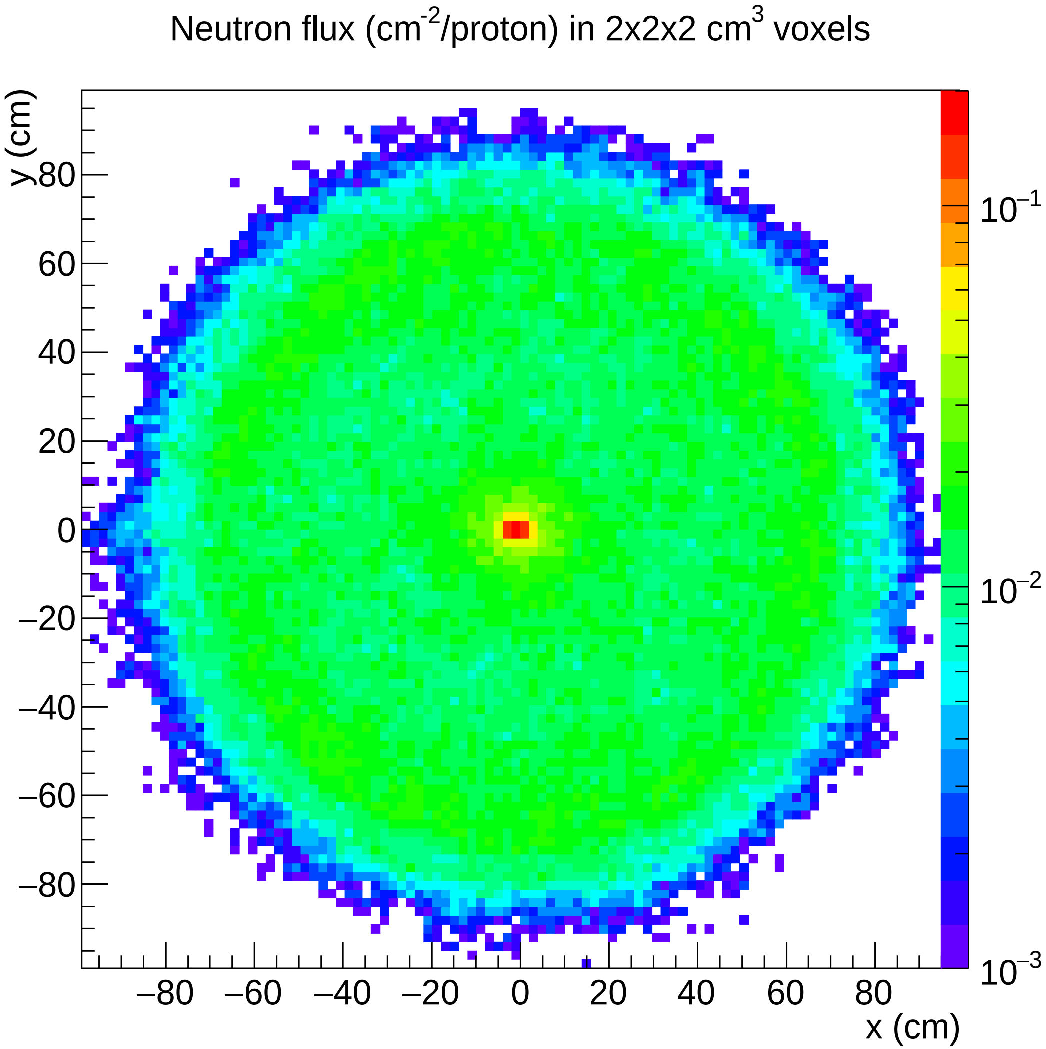
XZ-profile of the energy deposition at the target center.



XY-profile of the energy deposition at the target center.



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

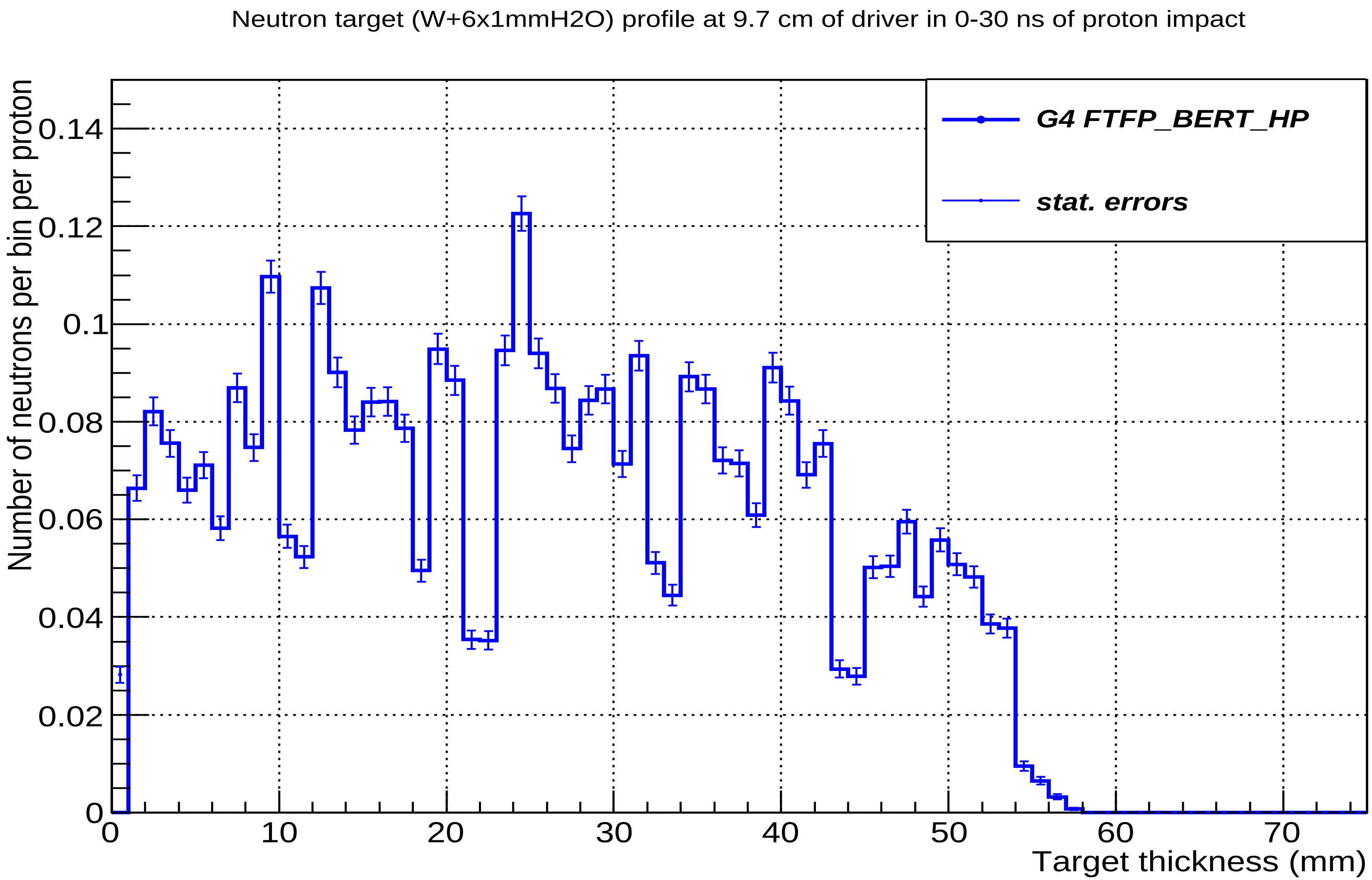


XY-profile of the neutron flux at the target center.

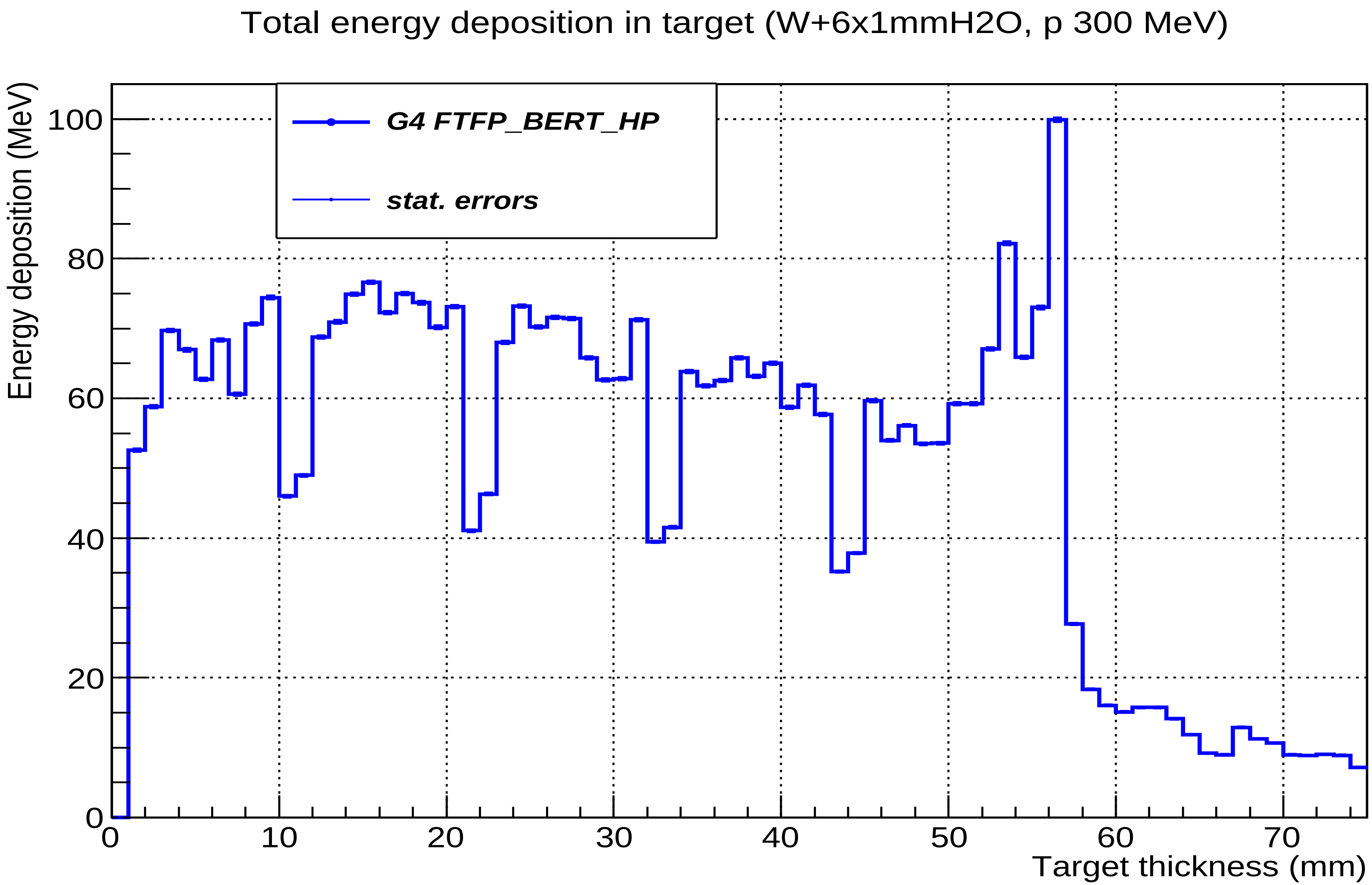
3 Target simulation set-up

The target was the tungsten box with realistic ADS geometry (76x45x250 mm^3). Six 1 mm thick water layers were uniformly distributed along x-axis with 11 mm period. The target is surrounded by thin (0.1 mm) check volume with galactic material.

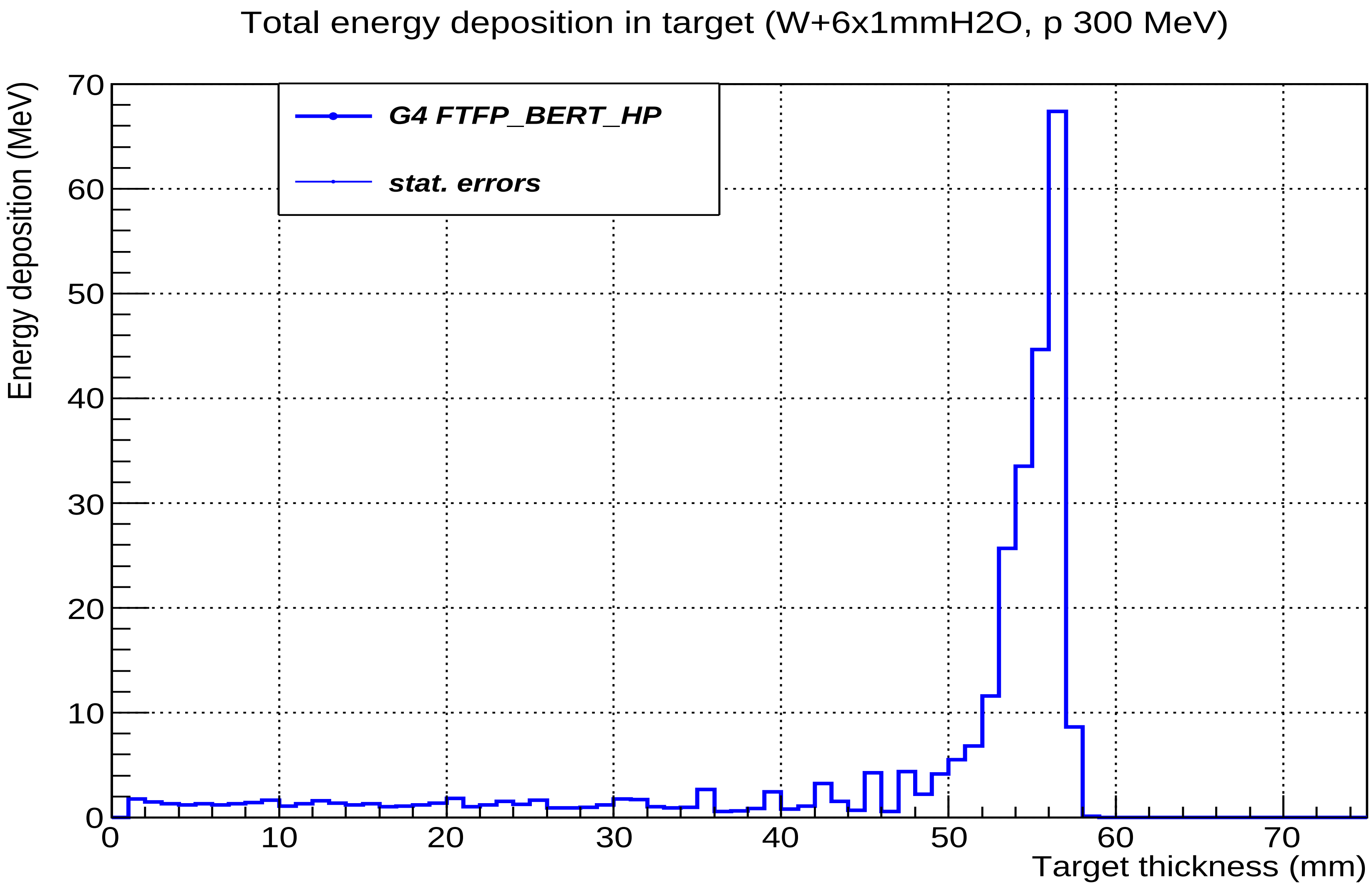
One mode is energy deposition of initial proton, another - from all particles in the target. FTFP_BERT_HP physics list was used (the same as was used in the simulation of all ADS realistic geometry)



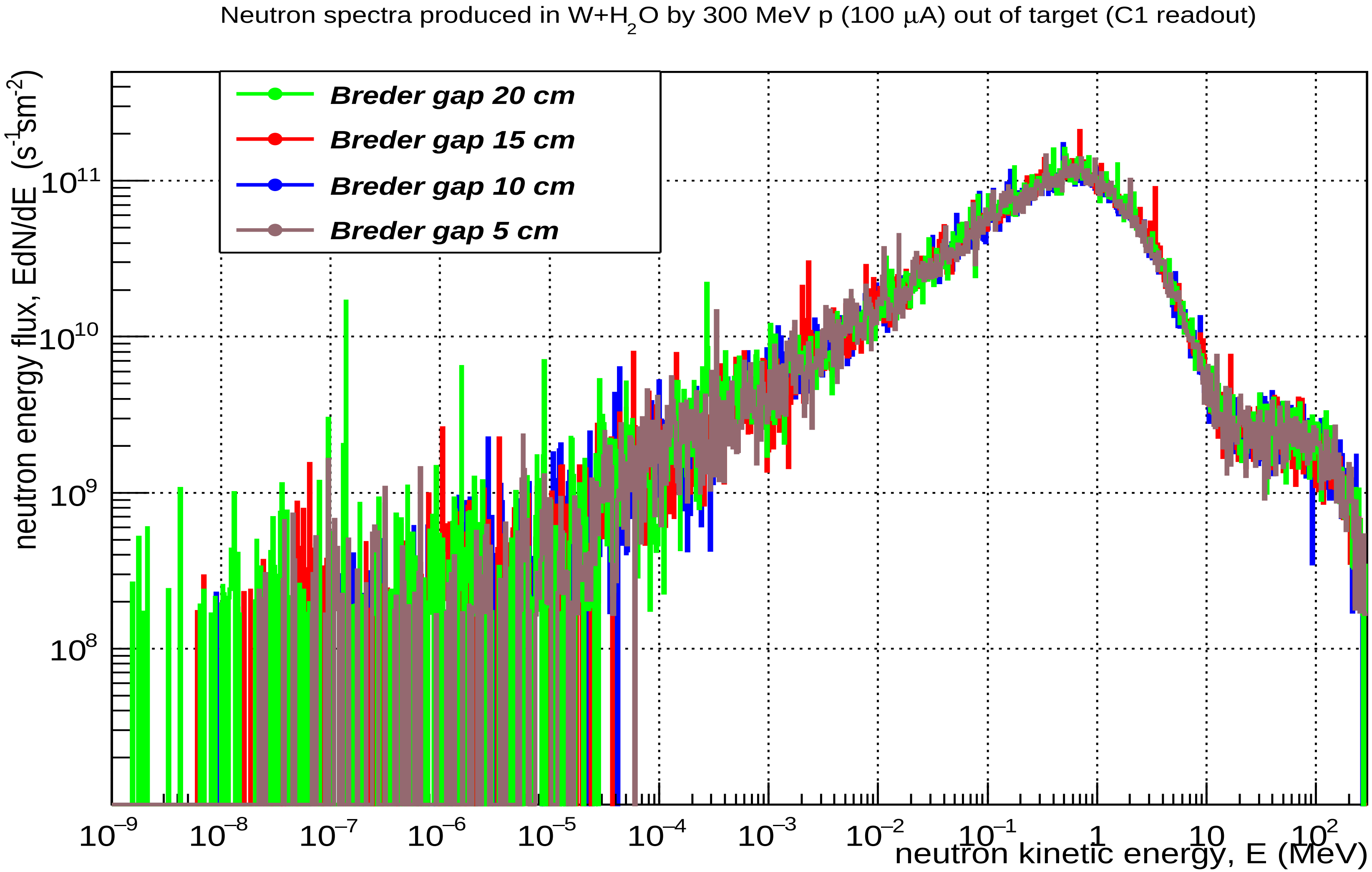
The neutron track origin x-position profile along the beam line direction.



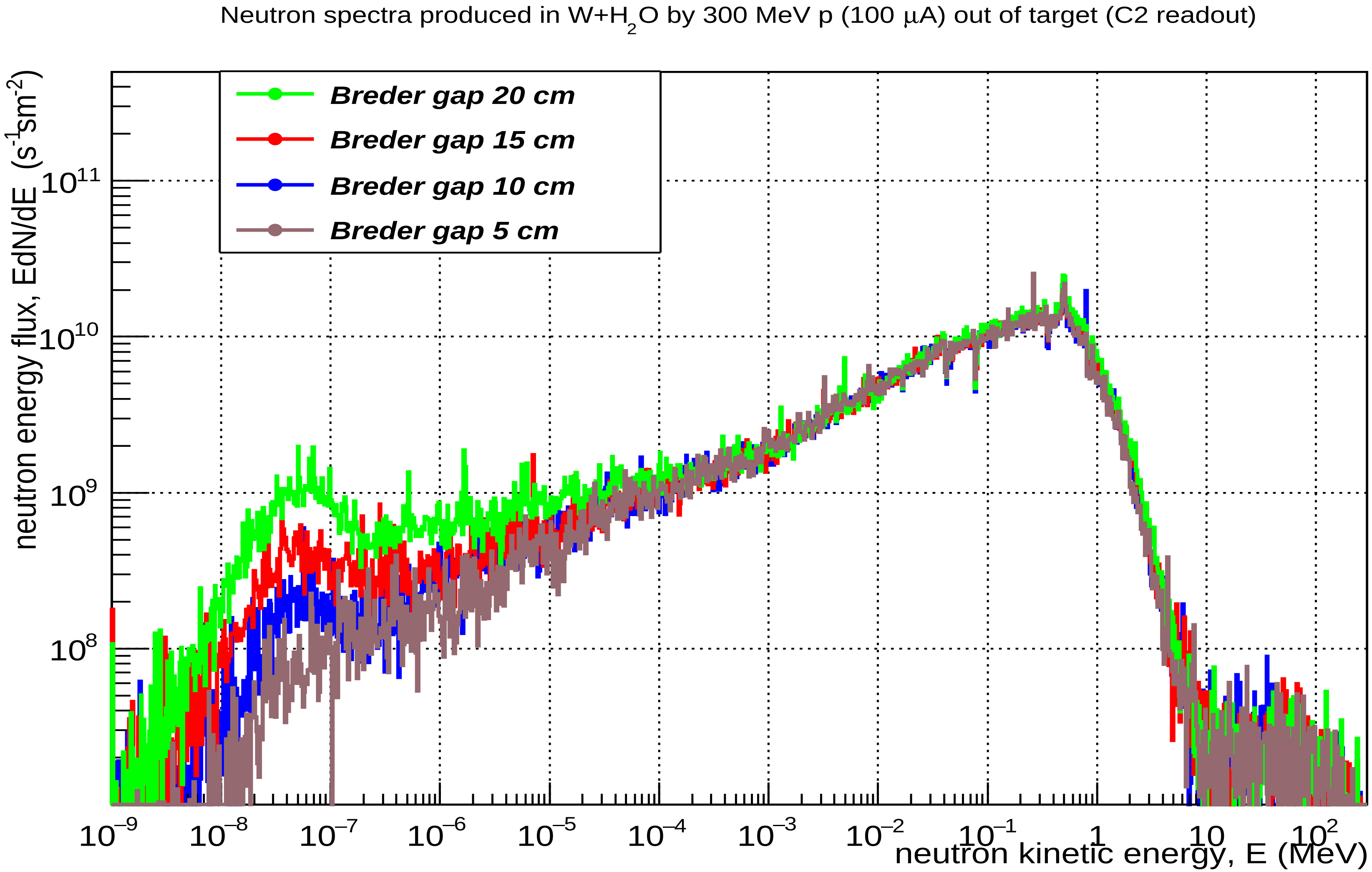
Total energy deposition profile in the ADS target.



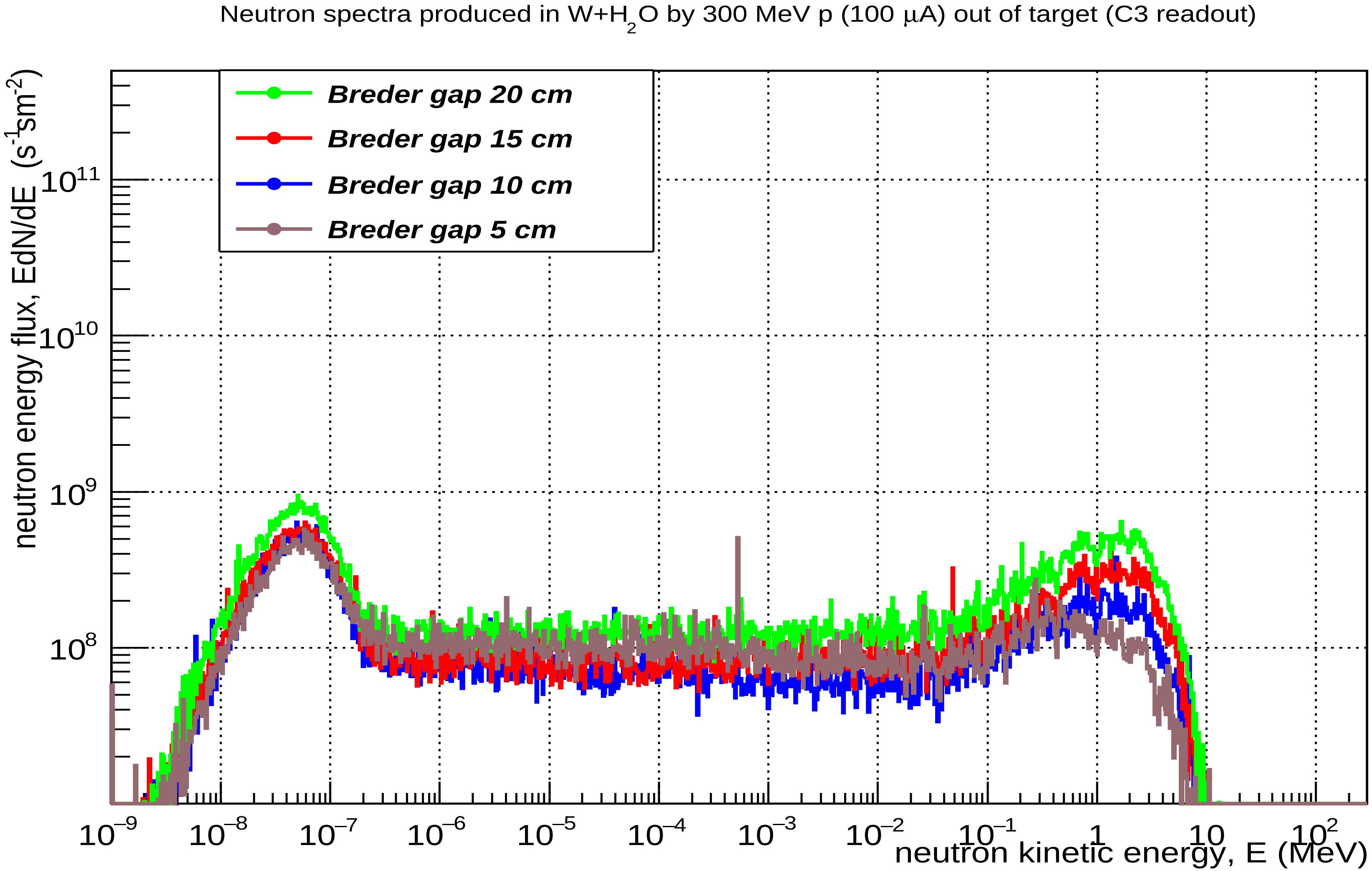
Beam proton energy deposition profile in the ADS target.



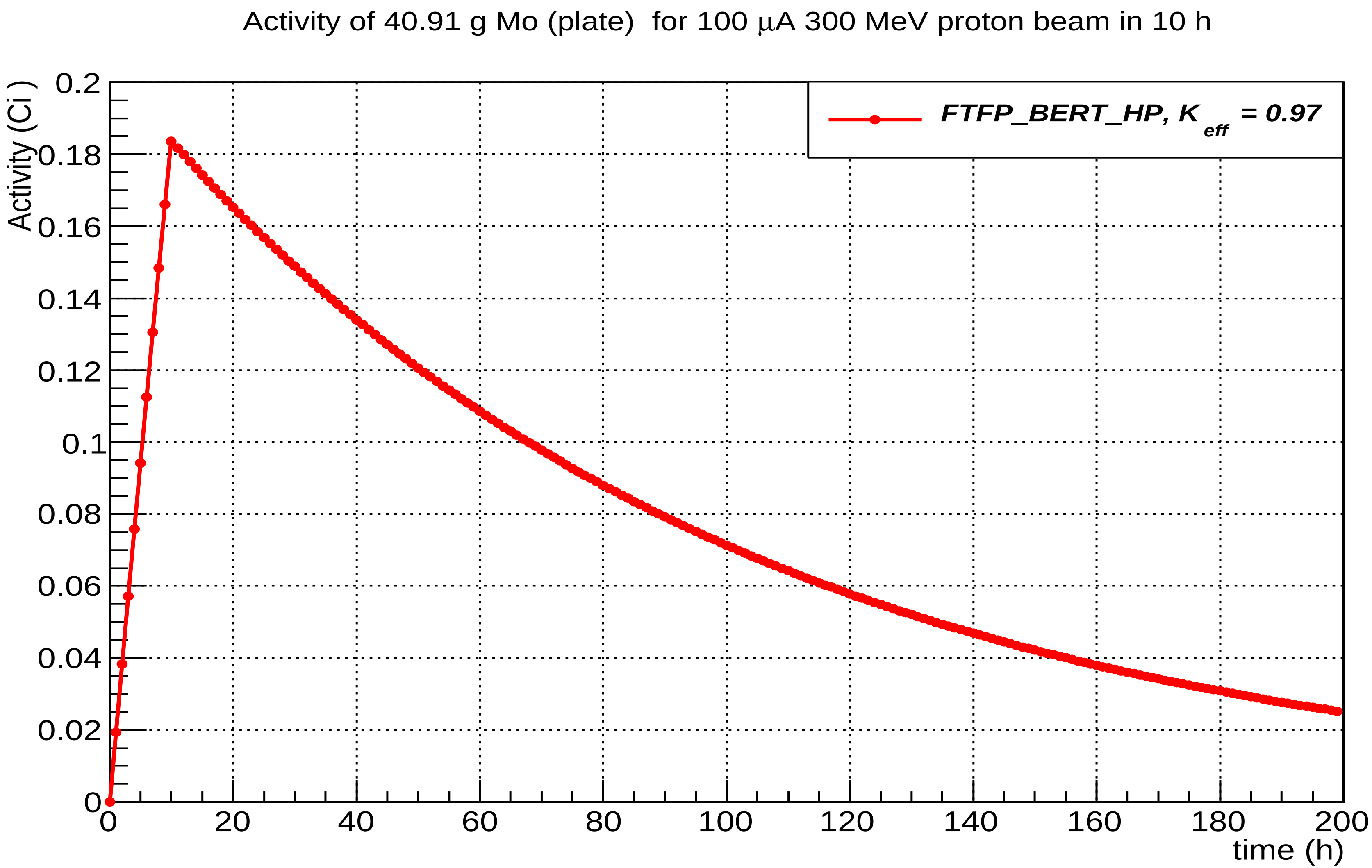
The neutron spectrum near target.



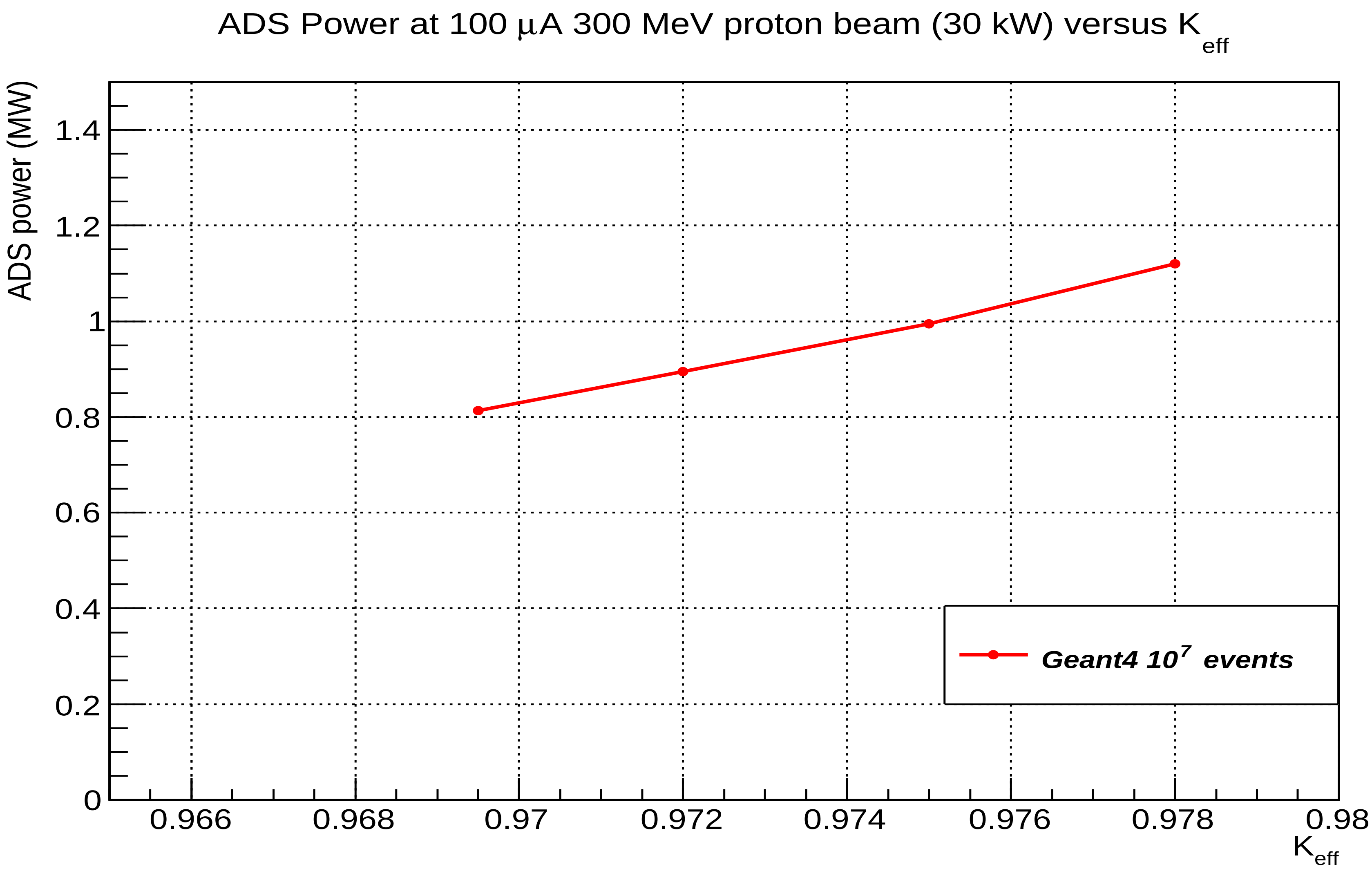
The neutron spectrum in the middle of Pb diffusor.



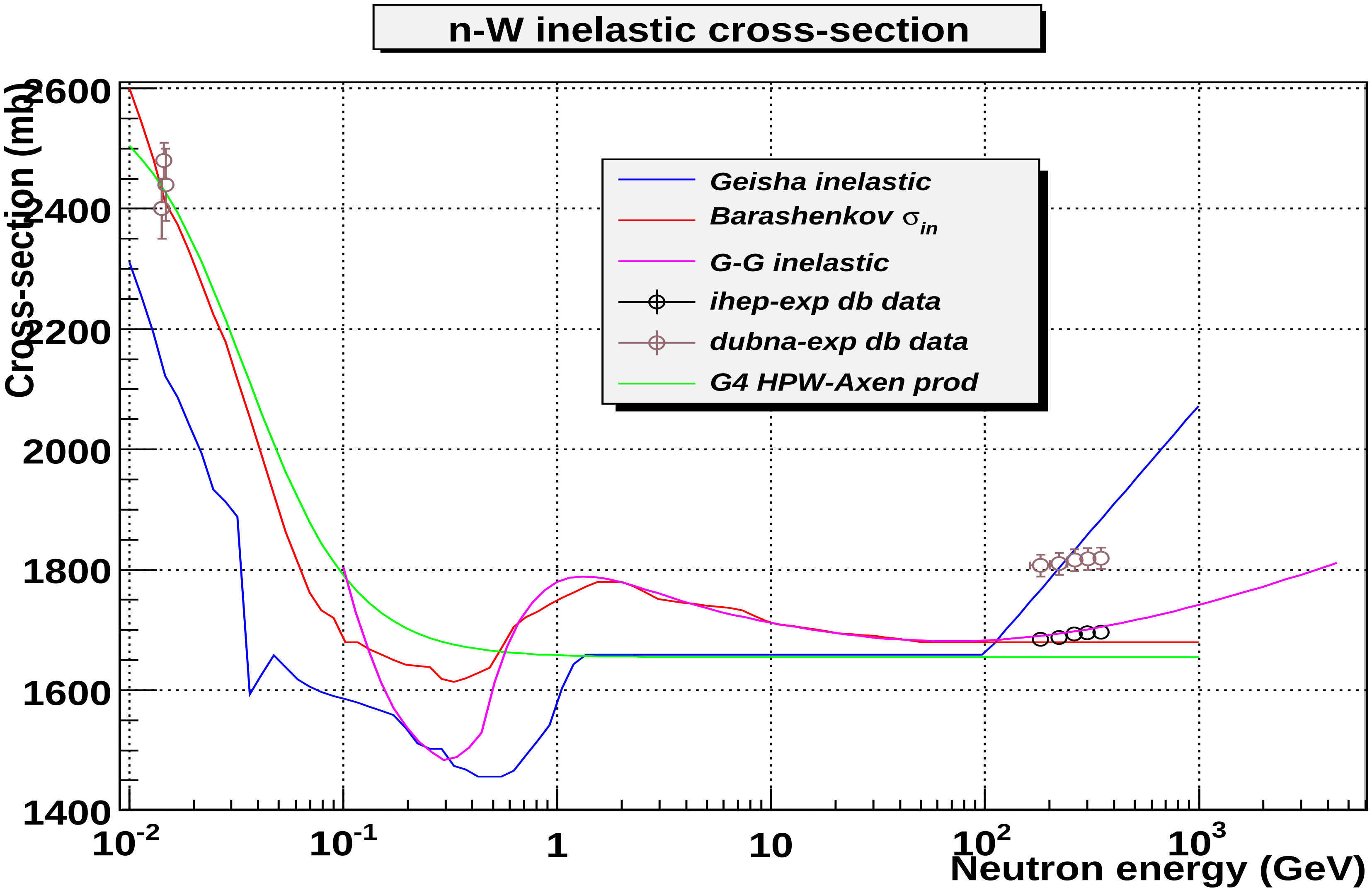
The neutron spectrum near driver ($U+H_2O$).



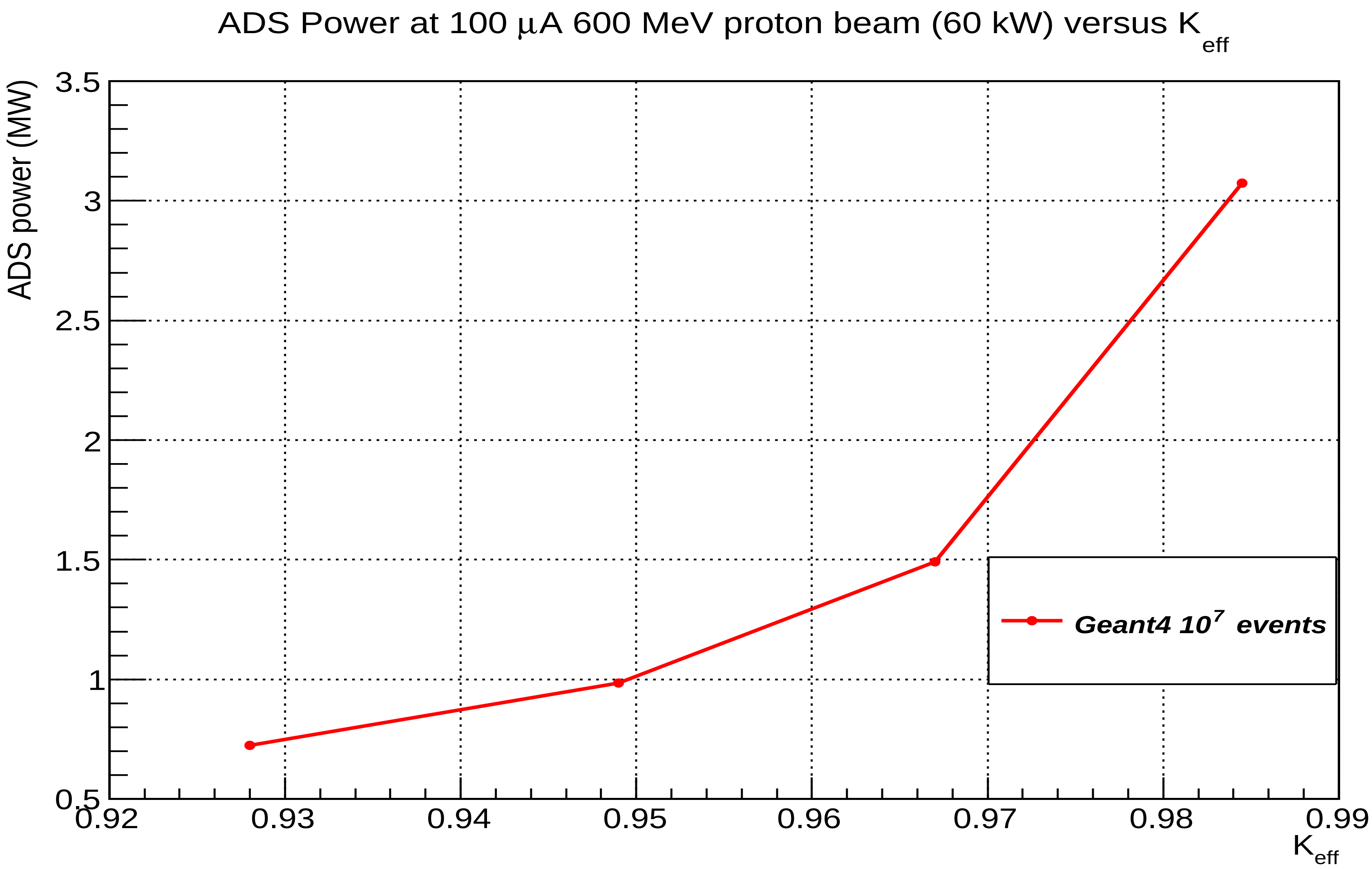
Activity (^{99}Mo) of 40.91 g natural Mo plate (6.33x6.323x0.1 cm^3) at 100 μA 300 MeV proton beam and K_{eff}=0.97. Irradiation time is 10 hours.



ADS power versus the rectivity. The reactiviy K_{eff}=0.9695∼0.97 (T_{driver}=9.55 cm) was selected to study isotope production ($K_{eff} = 1 - N_{sp}/Nfis$).



Inelastic neutron tungsten cross section vs. the neutron energy.



Power at 100 μA 600 MeV proton current versus K_{eff}.

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 ADS look to be reasonable

3. GEANT4 shows resonable simulation of medical isorope production.

4. At $k_{eff} \sim 0.98$ (the driver thickness ∼9.7 cm), the simulated power is ~ 1 MW in agreement with the MCNPX simulation.