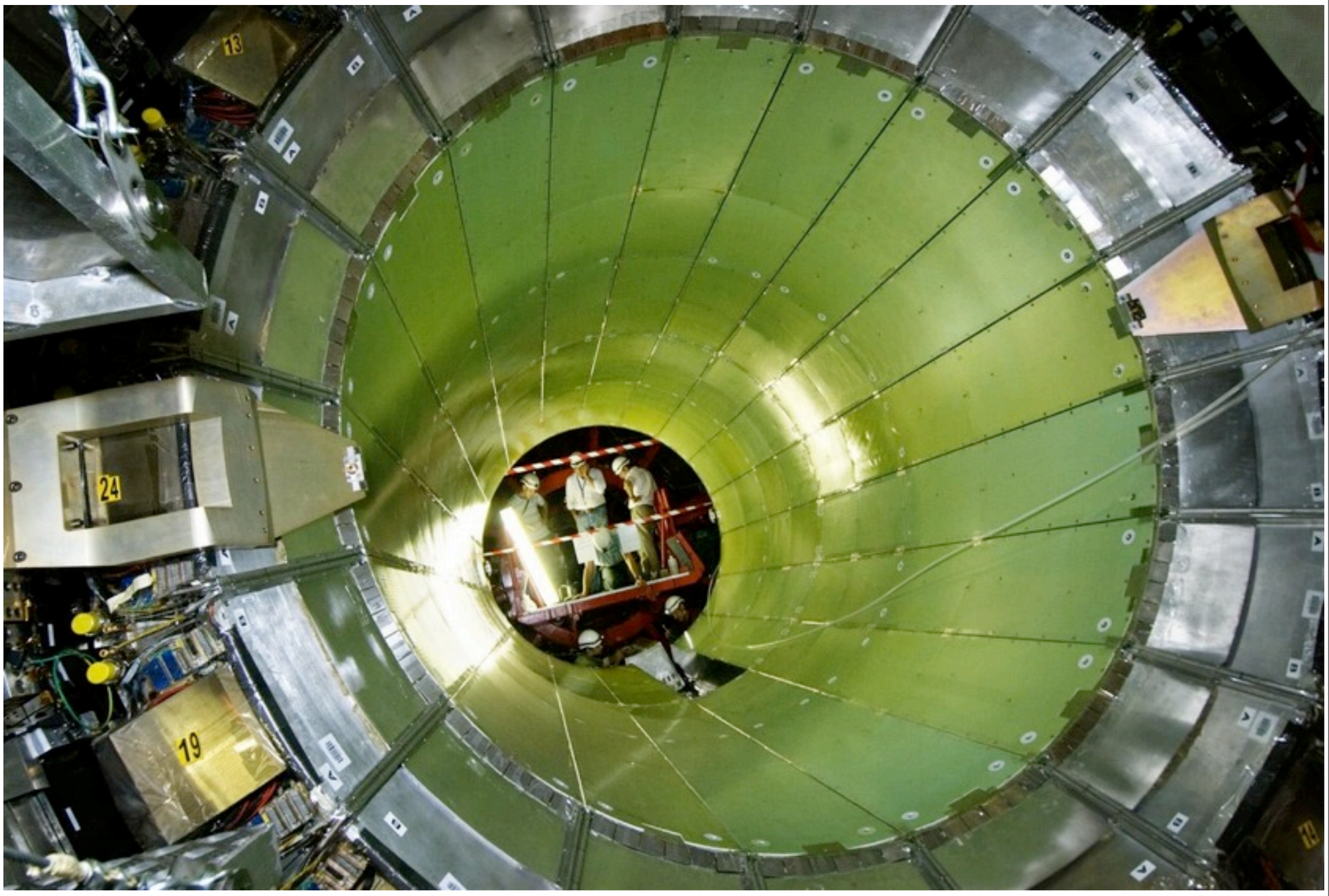


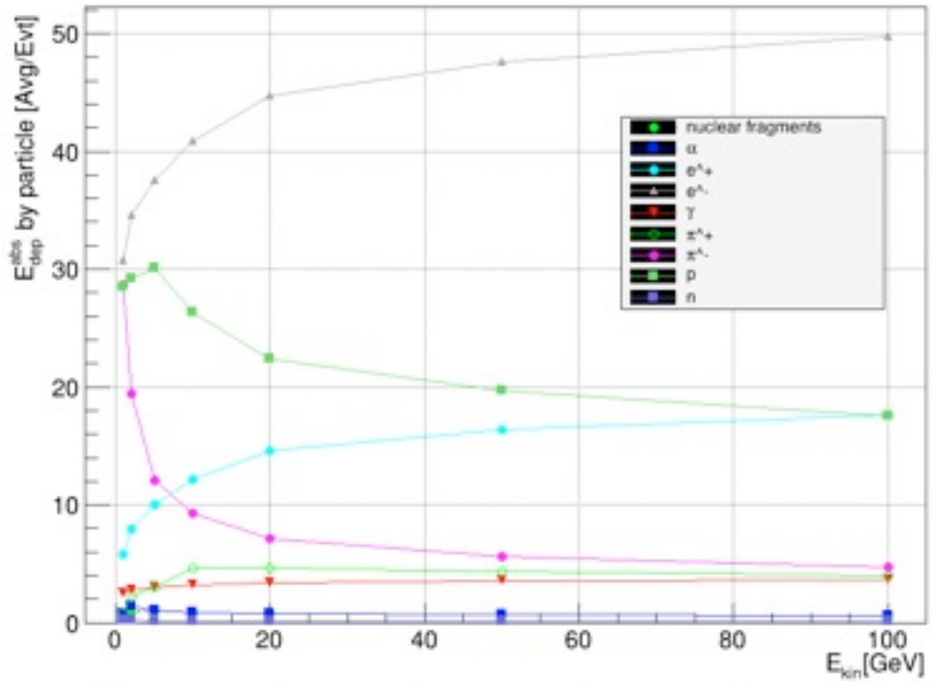
Status Report

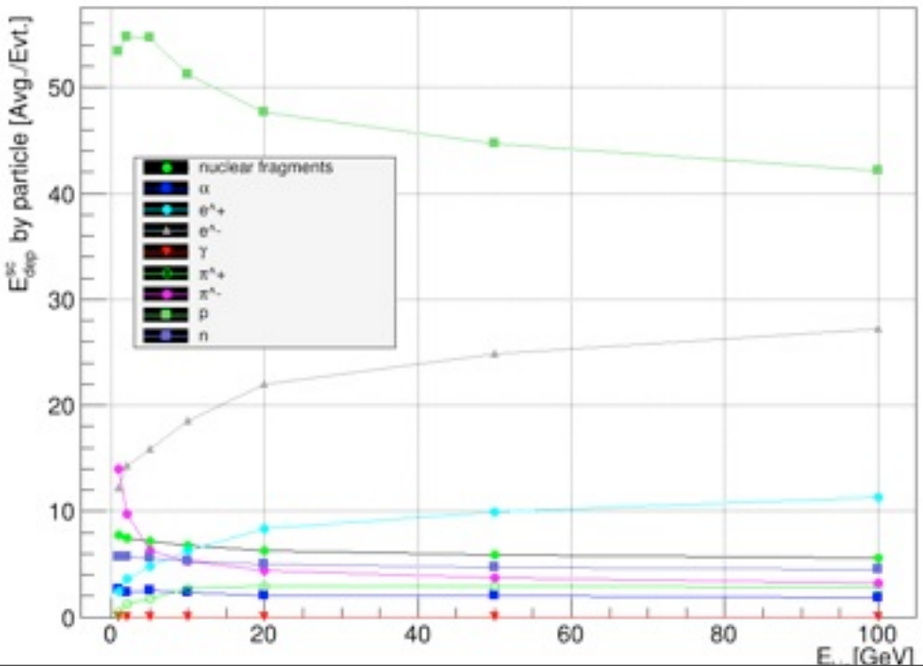
Andrea Delgado

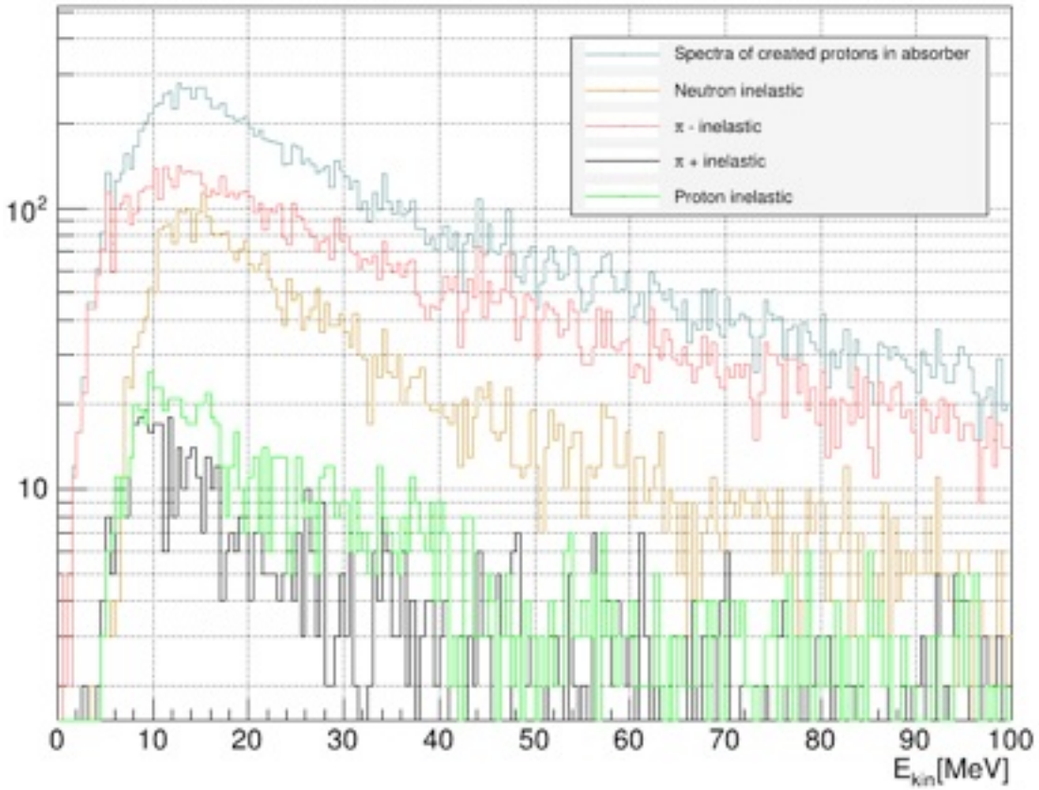
Nuclear spallation reactions

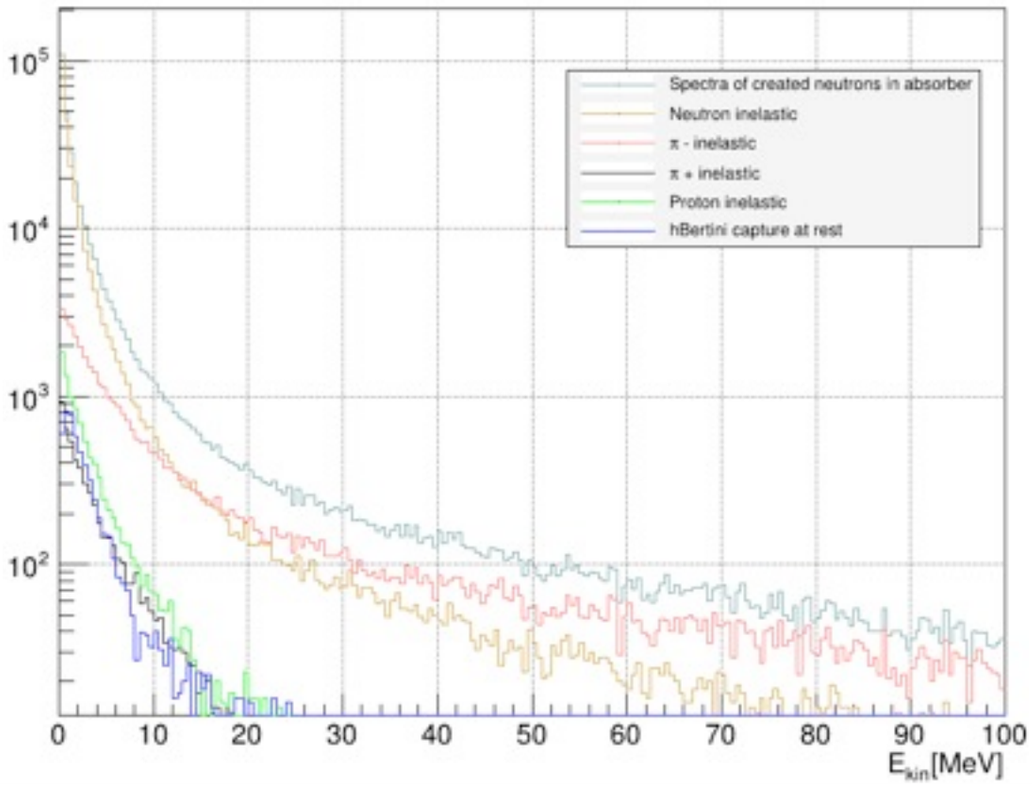
- Most likely process to occur when an incoming high-energy hadron strikes an atomic nucleus.

Contribution to energy deposition comes primarily from protons, neutrons and electrons.







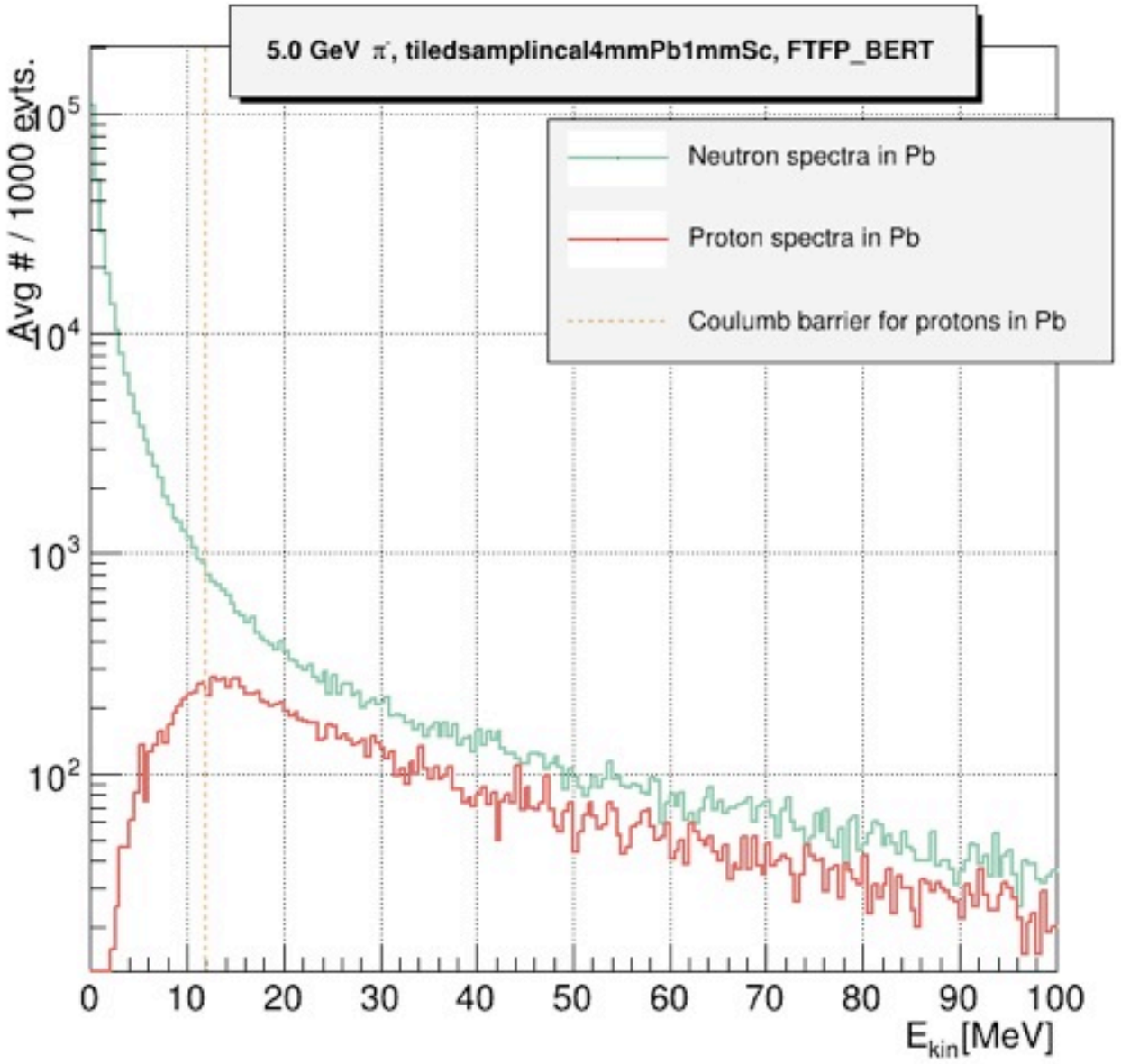


Nuclear spallation reactions

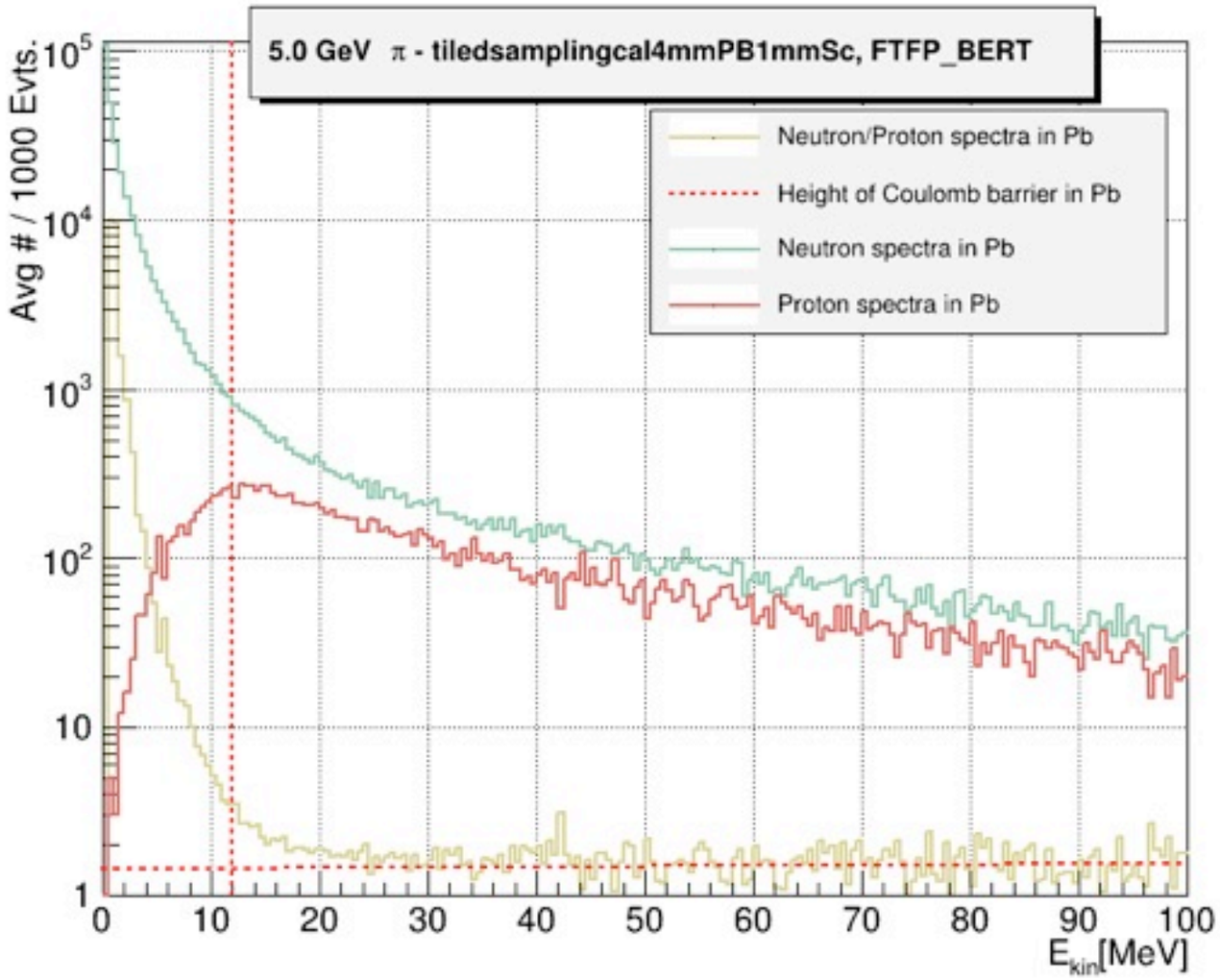
- Most likely process to occur when an incoming high-energy hadron strikes an atomic nucleus -> p,n, gamma as a result.

Two step process:

- (Fast) intra-nuclear cascade: incoming hadrons makes quasi-free collisions with nucleons inside the struck nucleus.
- Evaporation or de-excitation: most of the particles involved are free nucleons and it goes on until excitation energy is less than binding energy.



Nuclear spallation reactions



- Height of Coulomb barrier (~12 MeV in Pb) is given by:

$$\frac{z_1 z_2 e^2}{4\pi\varepsilon_0 r}$$

where

r = Pb atomic radius (~ 0.175 nm)

e = proton charge

Z = Pb atomic number (82)

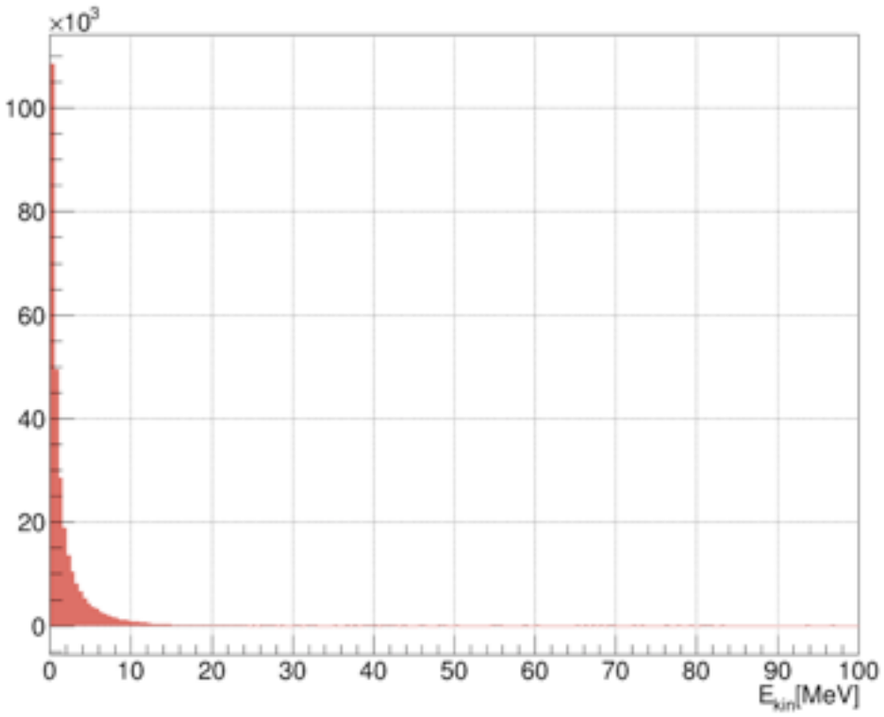
- In the fast cascade stage, protons and neutrons are emitted in a ratio that reflects the numerical presence of nucleus in target nuclei.

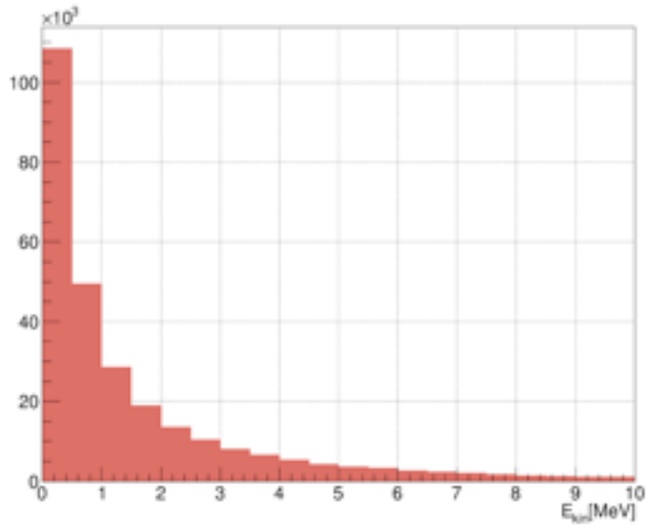
Pb_{82}^{208}

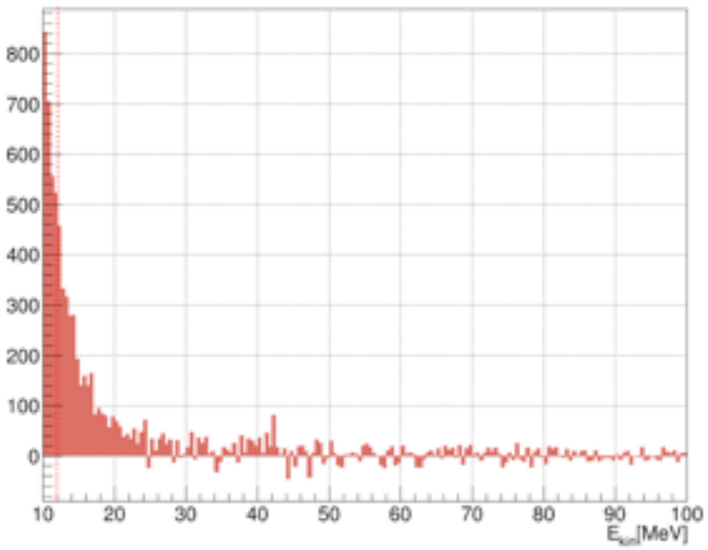
for every cascade proton,~1.5 cascade neutrons

Nuclear spallation reactions [Pb + Plastic sampling cal]

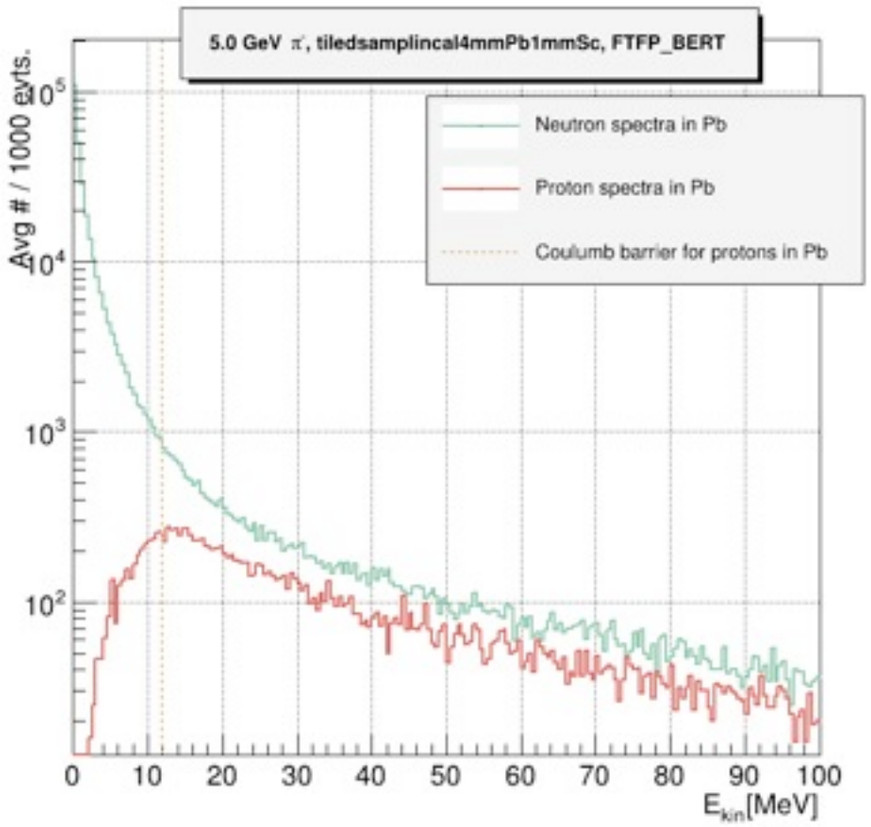
of neutrons - neutron/proton ratio
82/208*# of protons

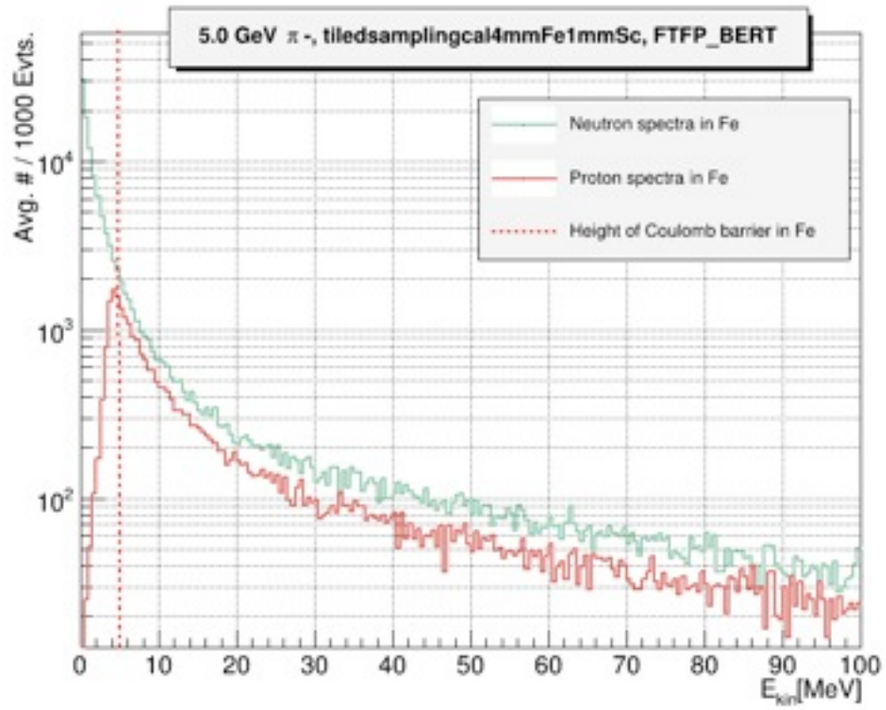




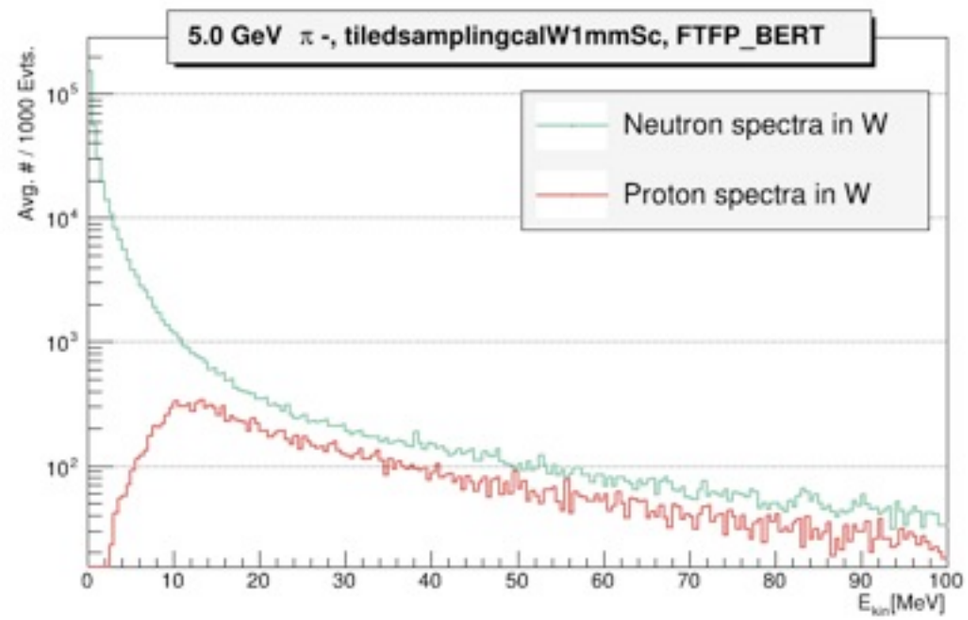


Nuclear spallation reactions

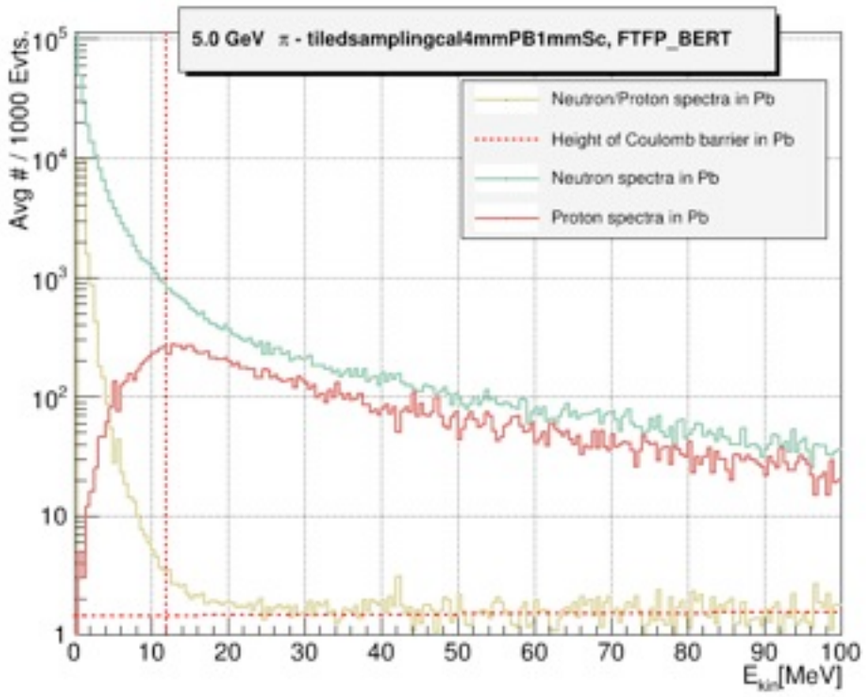


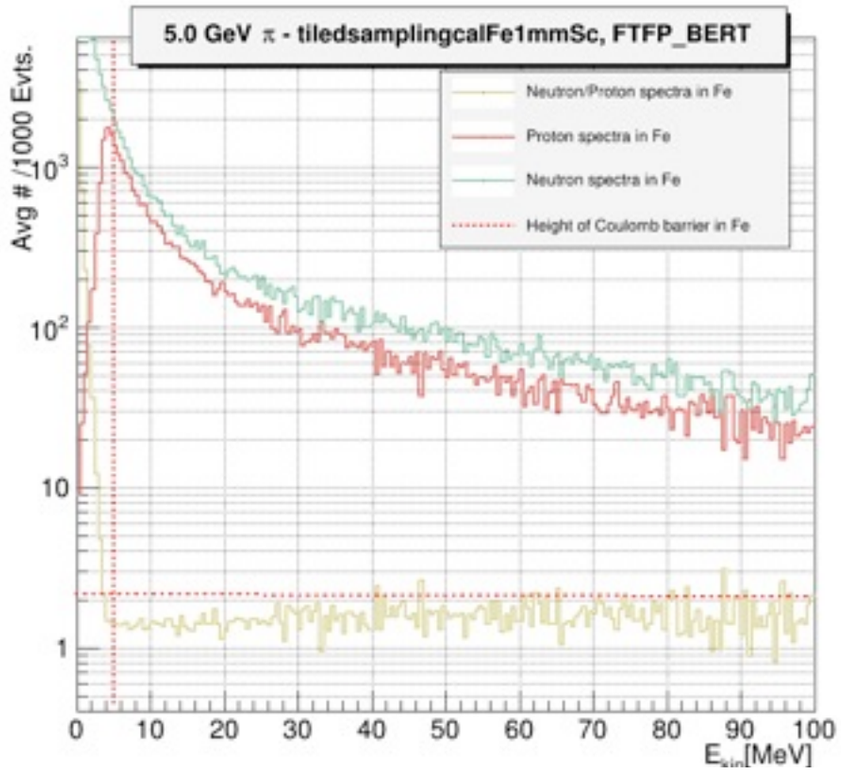


- Coulomb barrier height is lower for Fe.
- Difference in nuclear binding (~7.9 MeV in Pb, ~8.8 in Fe) -> more nucleons are released in Pb.

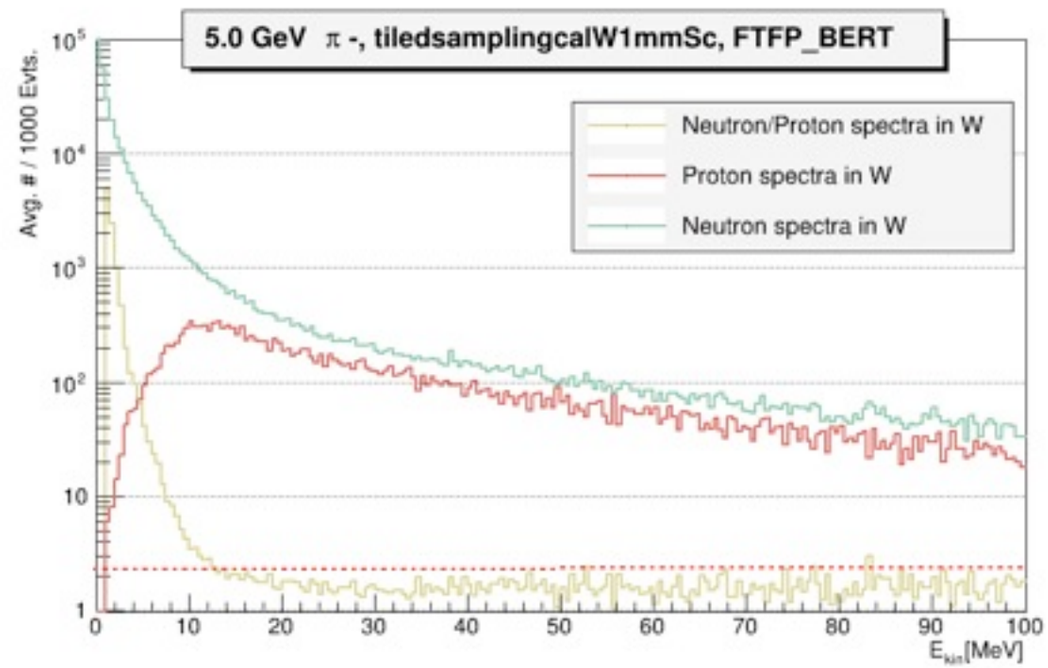


Nuclear spallation reactions



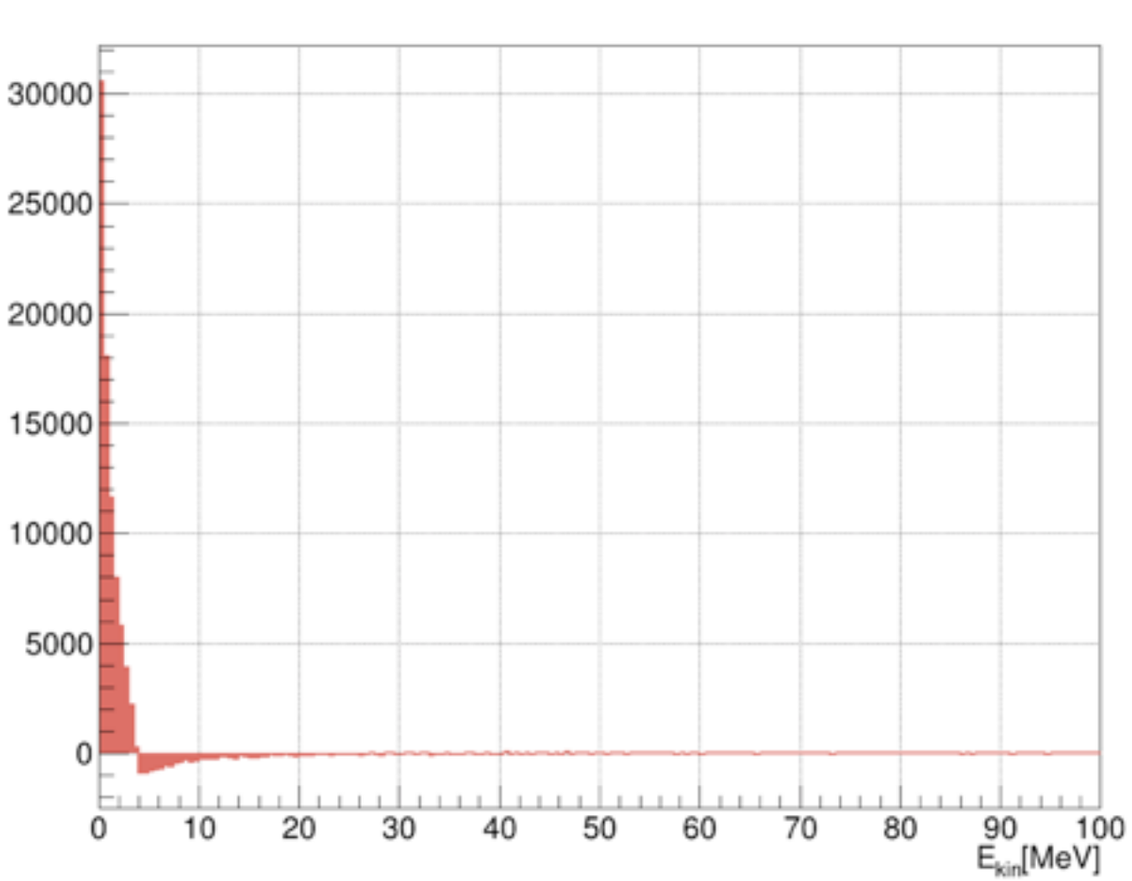


In general, total number of nucleons in collisions with Pb is larger than the number for collisions with Fe.



Nuclear spallation reactions [Fe+ Plastic sampling cal]

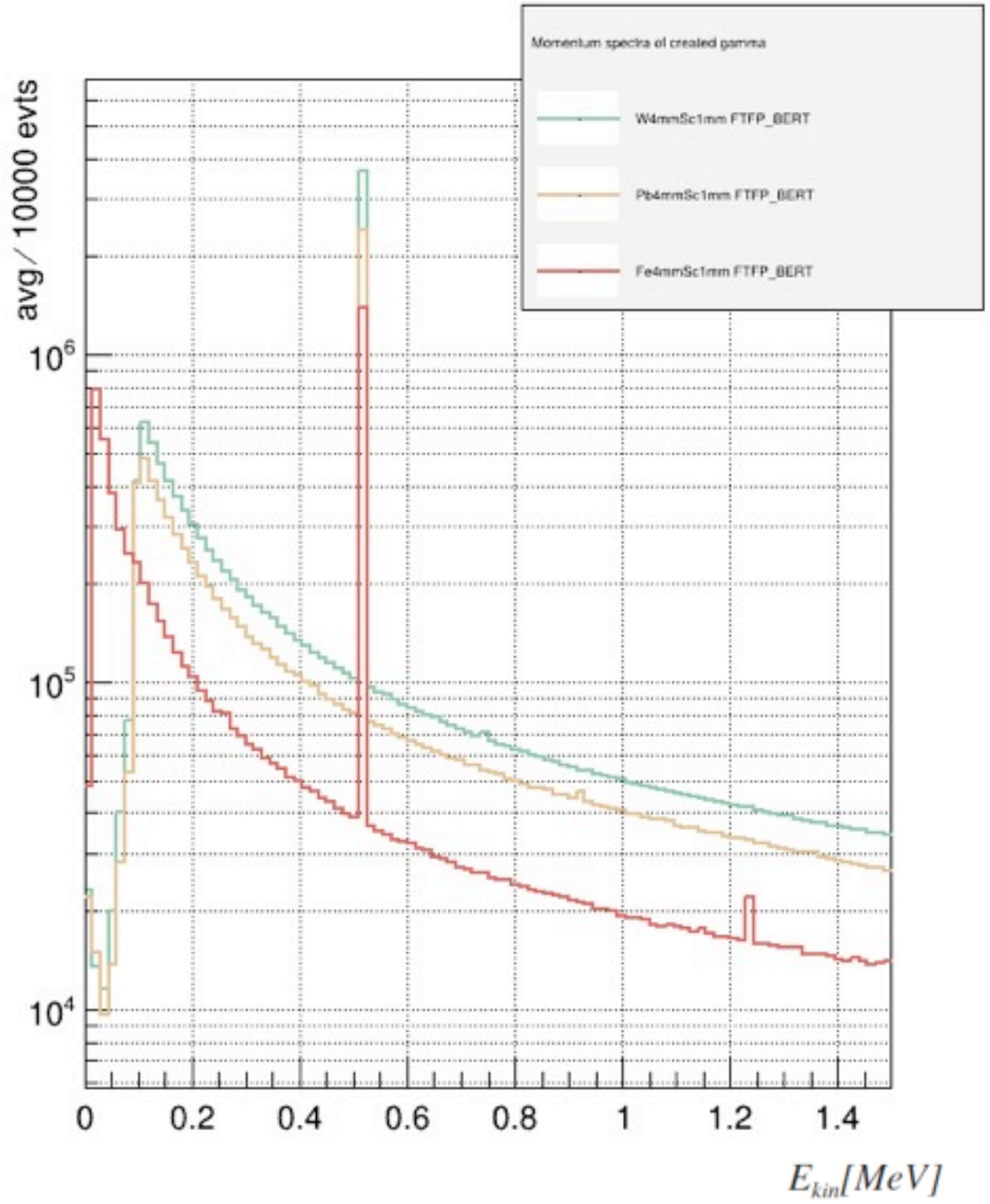
of neutrons - (neutron/proton ratio ~56/26)*# of protons



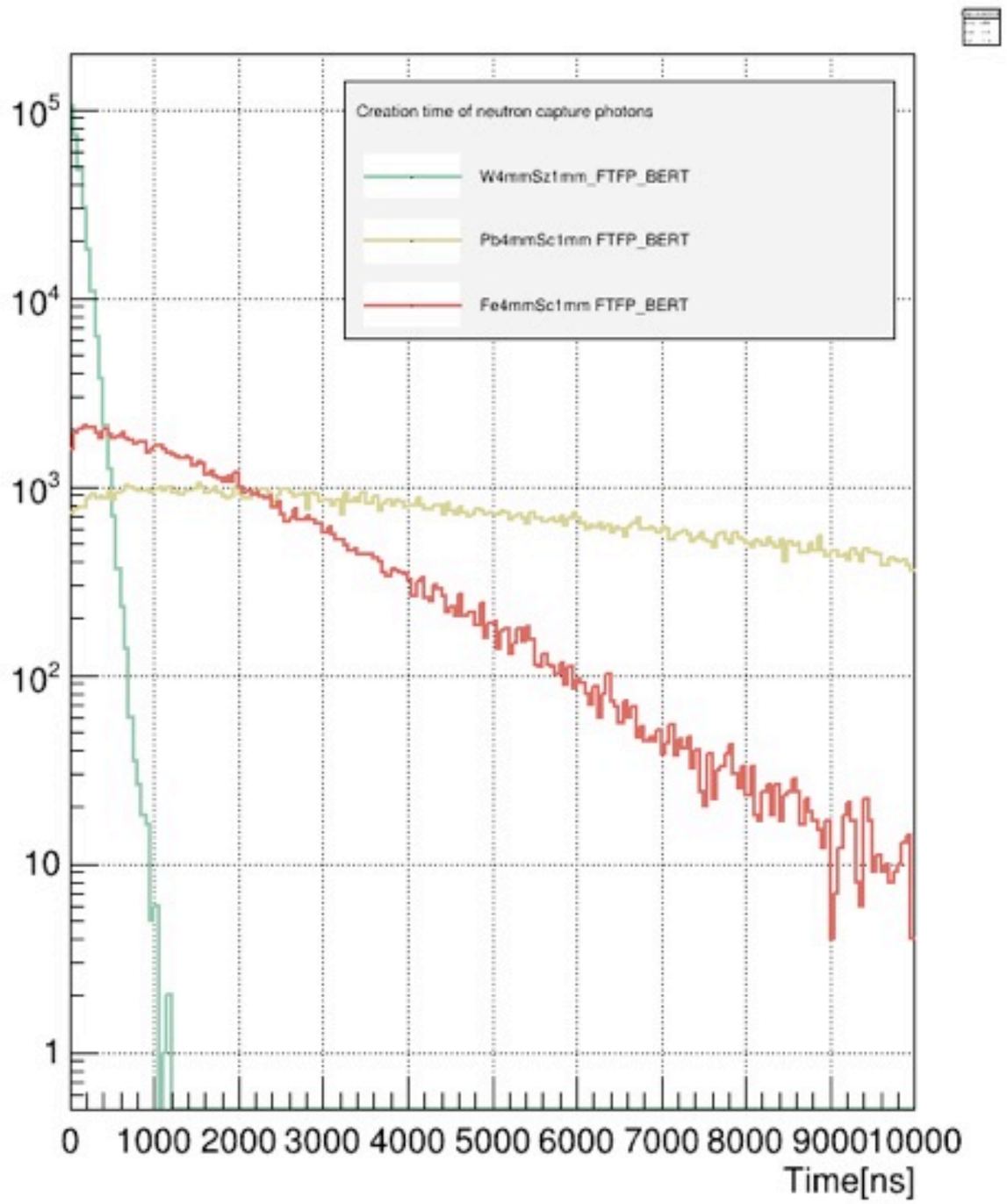
In general, total number of nucleons in collisions with Pb is larger than the number for collisions with Fe.

- Proton/neutron asymmetry (difference in proton/neutron ratios lead to a larger fraction of available energy for nuclear excitation in Pb), since kinetic energy carried away by escaping protons is not used in nuclear excitation.

Momentum spectra of created gamma



Creation time of neutron capture photons



beta spectrum of created electrons