Geant4 Validation for n3He

Description of the simulation process:

In Geant4 you specify:

- Volumes with material attributes
  - elemental composition, density, temperature, phase, pressure
- Particles of interest that interact with the material
  - primaries, secondaries (without specifying them G4 does not make them!)
- For each particle you specify a list of processes/interactions you are interested in
  - Elastic, inelastic, E&M, hadronic, high energy, low energy, etc.

Geant4 execution:

- Primaries and tracks them in steps through the geometry
- Track step lengths are limited by the process with the shortest mean free path (*)
- If applicable secondaries are generated along the track and/or at the end of the track
- For stopped particles, the final state of *it* and any final products is calculated based on the processes and models that were registered for the particles (*)
- Along the track energy deposition and momentum changes can be extracted
- Final state energy, momentum, positions, … can all be extracted

Geant4 Validation for n3He

Description of the n3He simulation setup:

As of yet simple geometry …

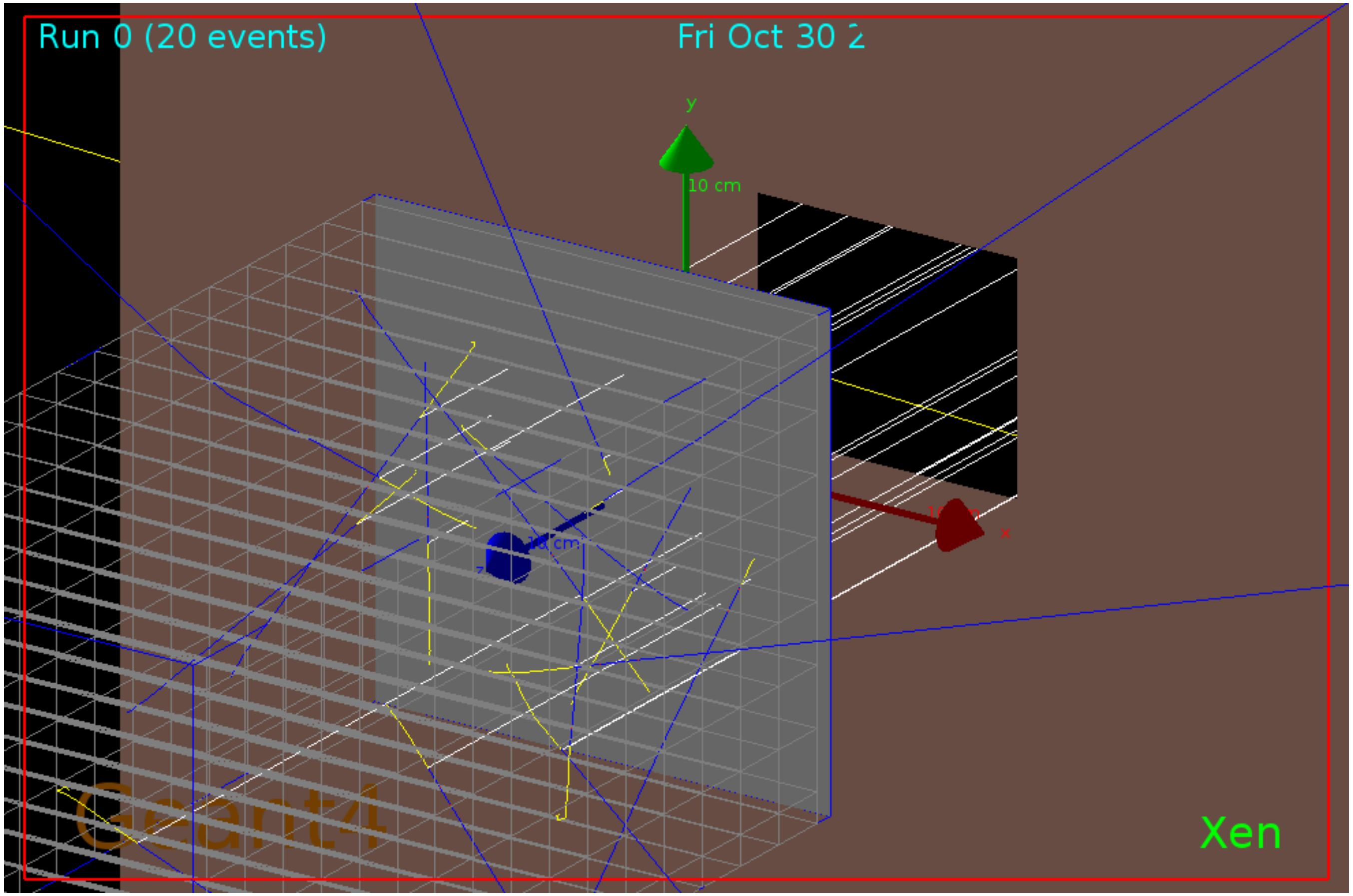
Coordinates:

Z – beam direction
Y – beam up
X – beam left

Each cell is an individual sensitive detector
(easy to implement twist)

White = neutrons
Blue = protons
Yellow = tritons

alphas, gammas, electrons, are not drawn



Registered processes: Neutrons: elastic, inelastic, capture-gamma, radioactive decay, fission
Protons: low energy ionization, elastic, bremsstrahlung
Tritons: low energy ionization, elastic, low energy hadronic (inelastic) and radioactive decay

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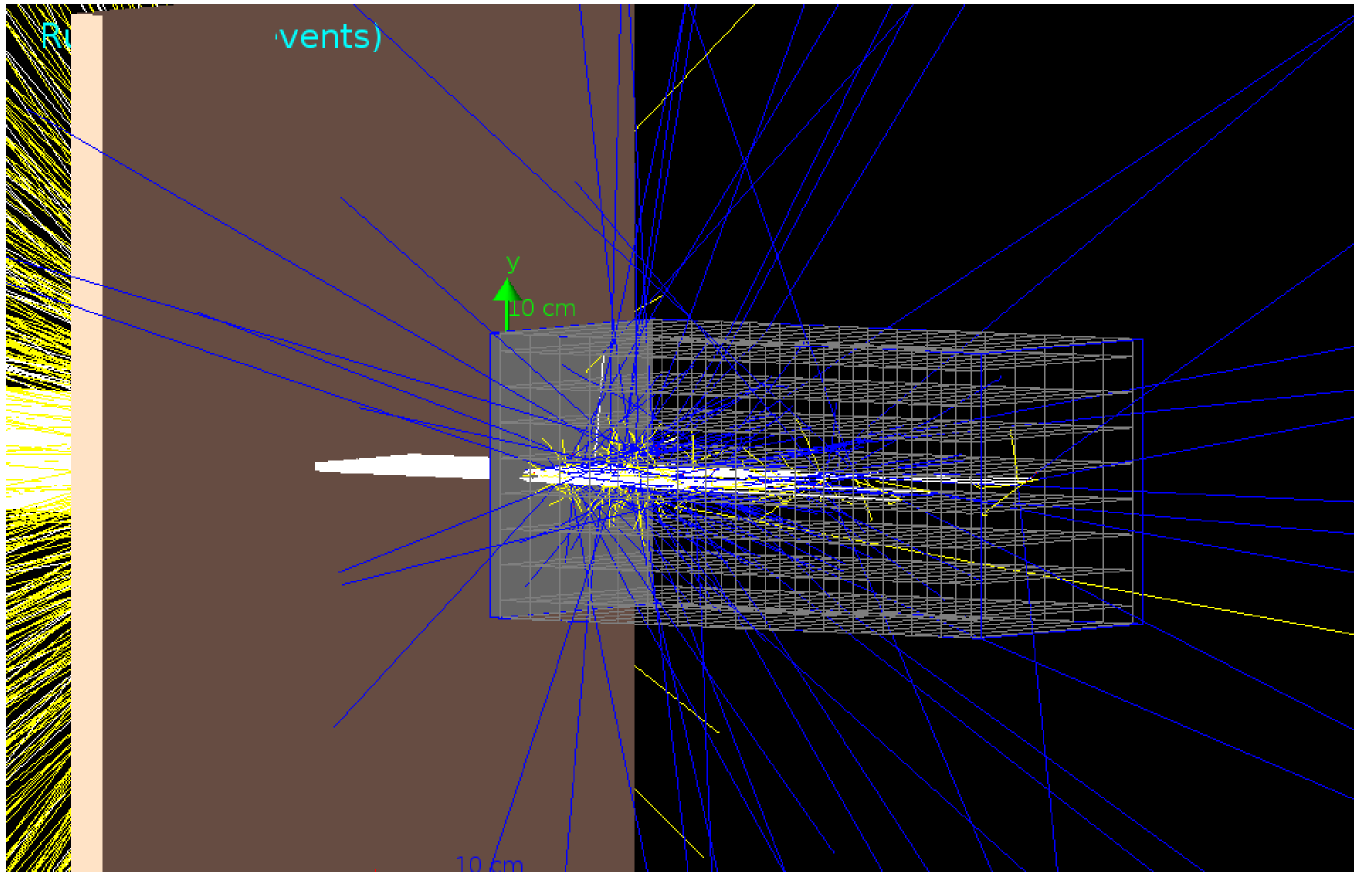

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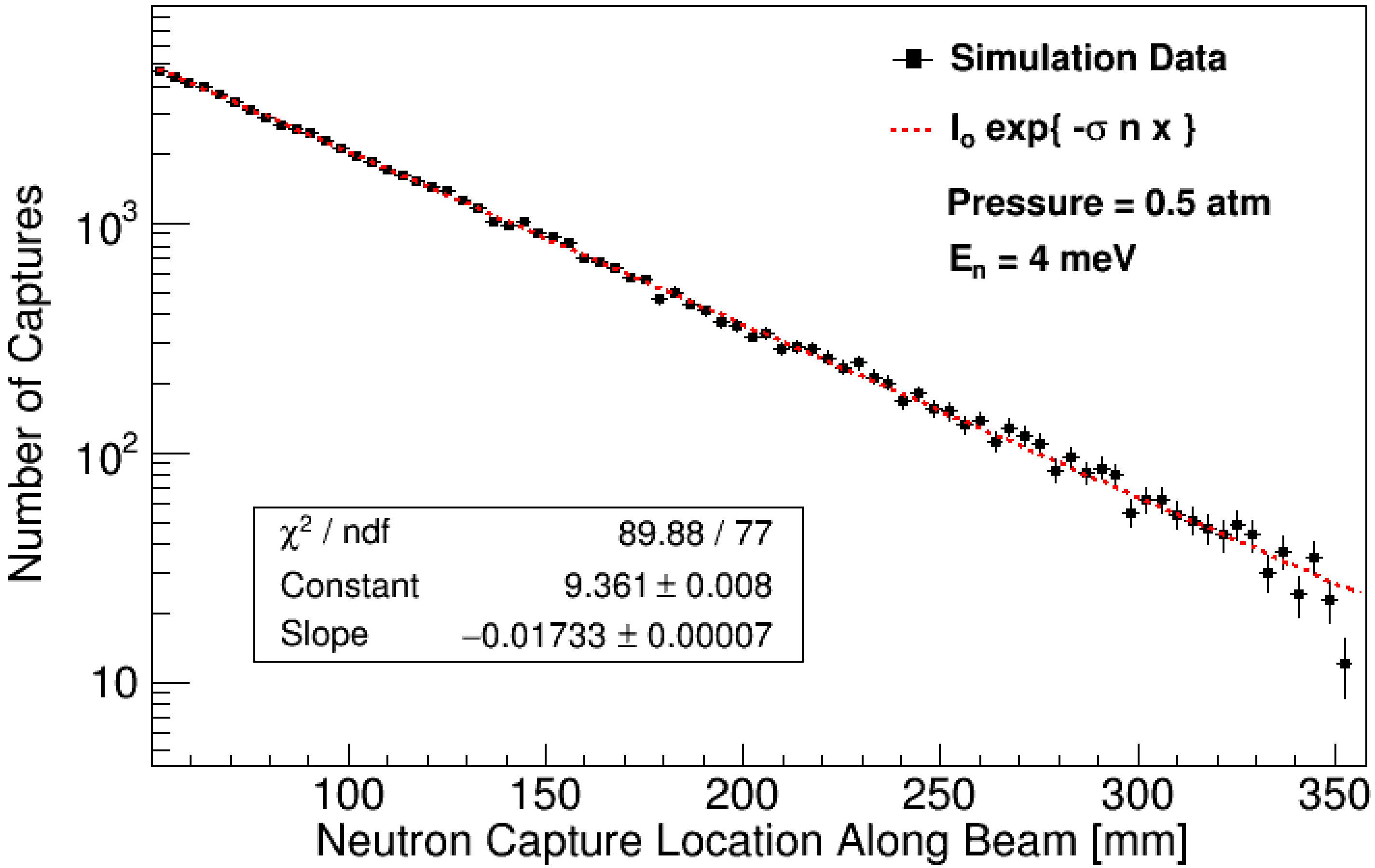
Simulation output verification:

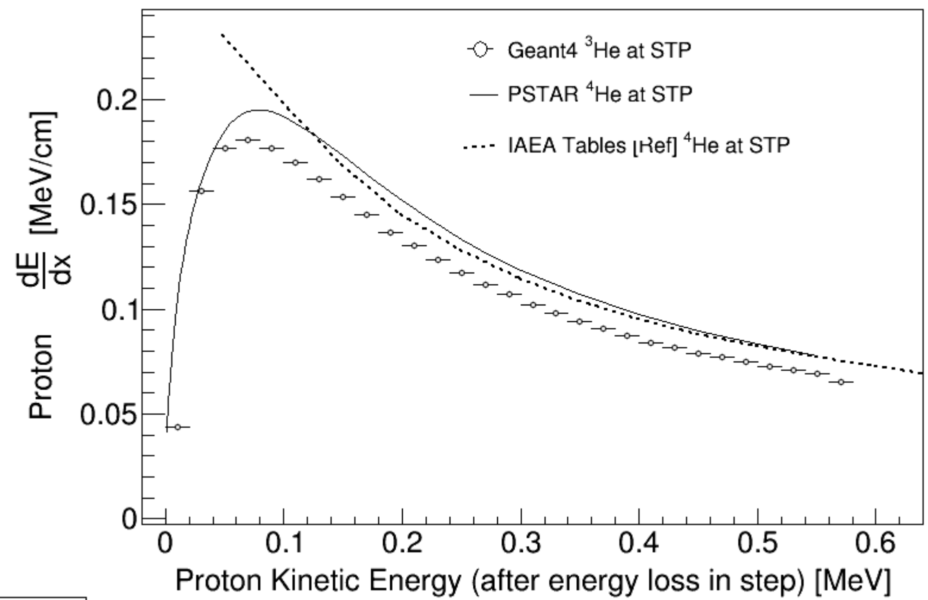
1) Neutron capture profile:

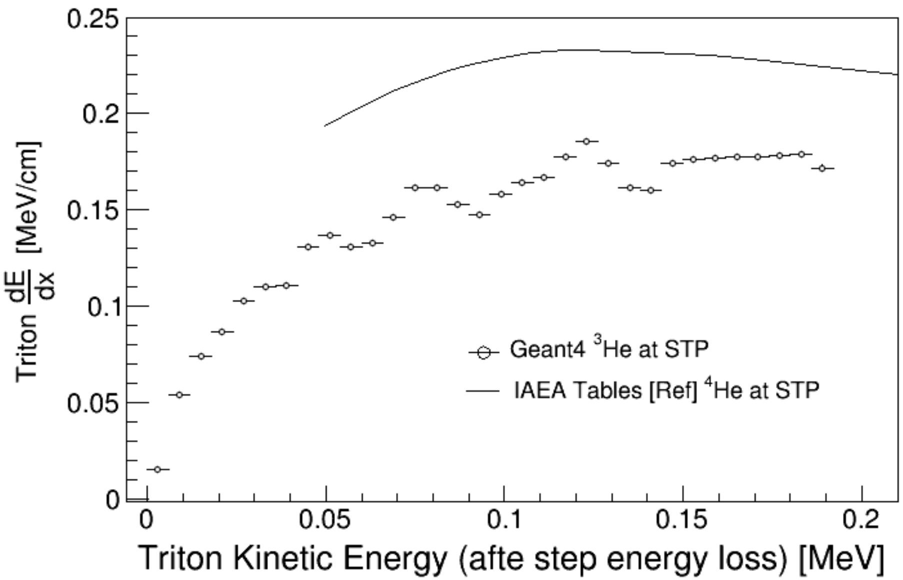


Geant4 Validation for n3He

Simulation output verification:

2) Proton / triton energy deposit:

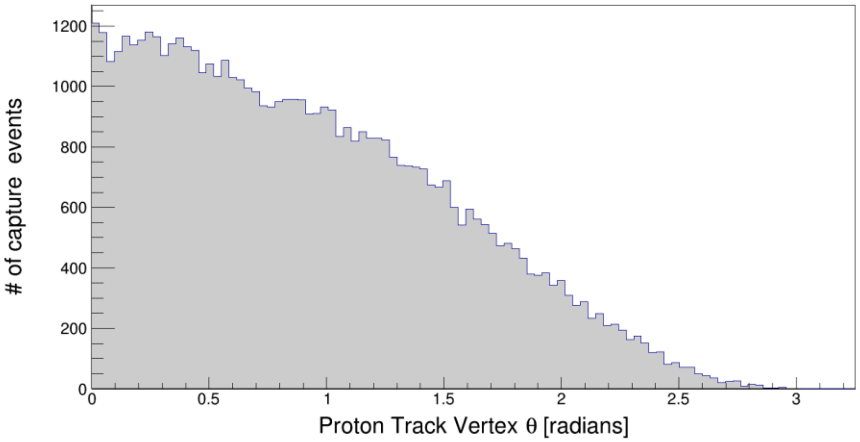


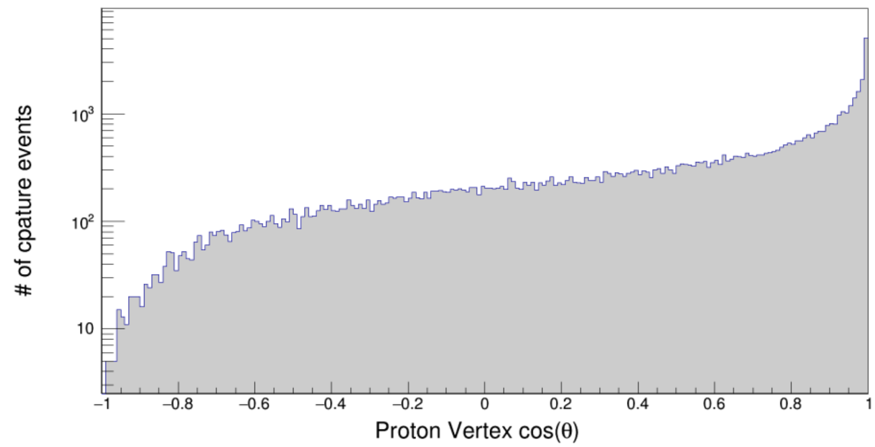


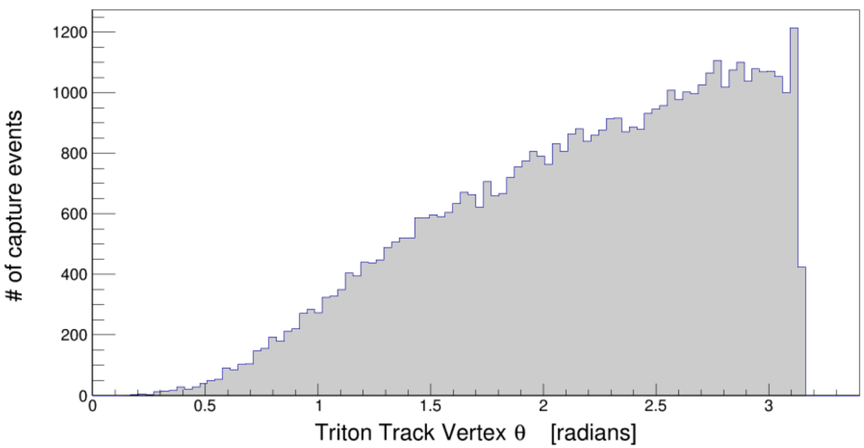
Geant4 Validation for n3He

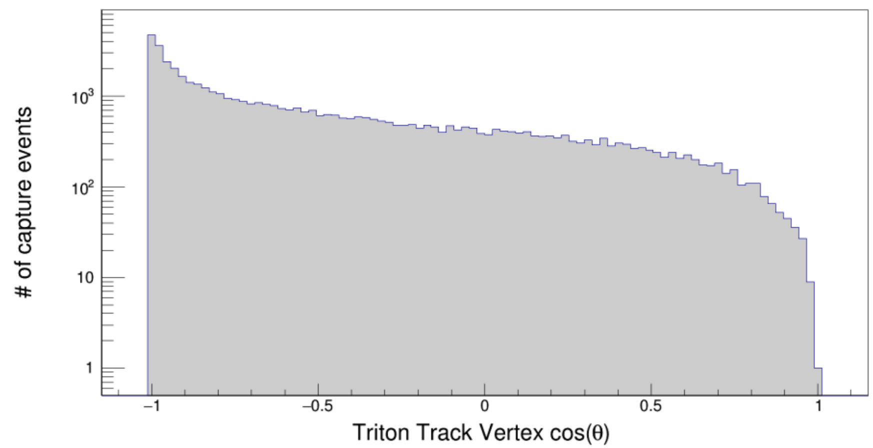
Simulation output verification:

2) Proton / triton momentum and angle distributions (found odd code snippet buried deep in G4 code …): contacted developers, but easy to fix for n3He standalone …







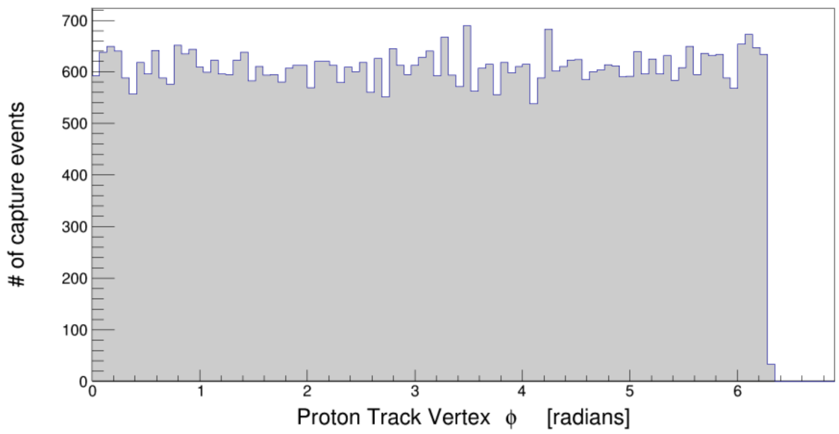


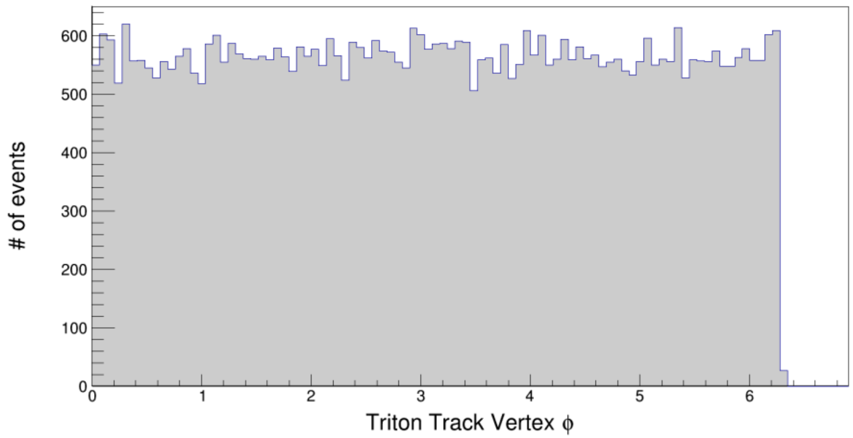
Geant4 Validation for n3He

Simulation output verification:

3) Proton / triton momentum and angle distributions (found odd code snippet buried deep in G4 code …): contacted developers, but easy to fix for n3He standalone …

Phi looks okay!





Geant4 Validation for n3He

Simulation output verification:

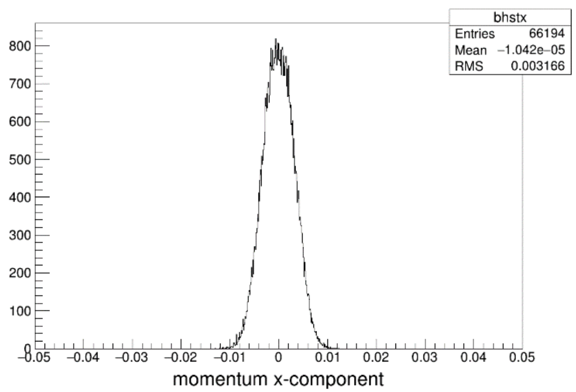
The strange theta distribution lead to a hunt into the dungeons of the Geant4 code …

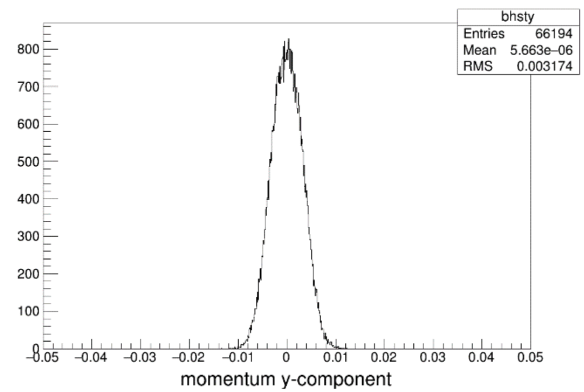
"Discoveries":

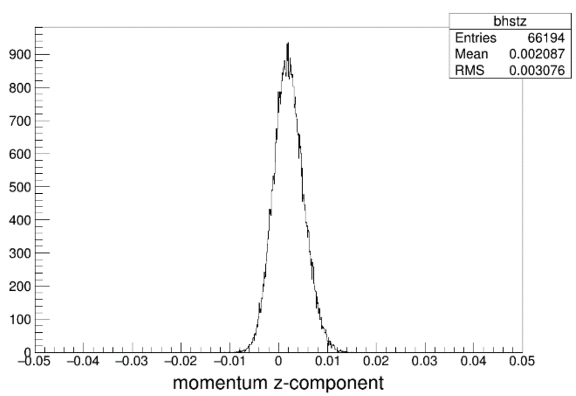
1) Geant4 takes into account target motion, at T = 293 K

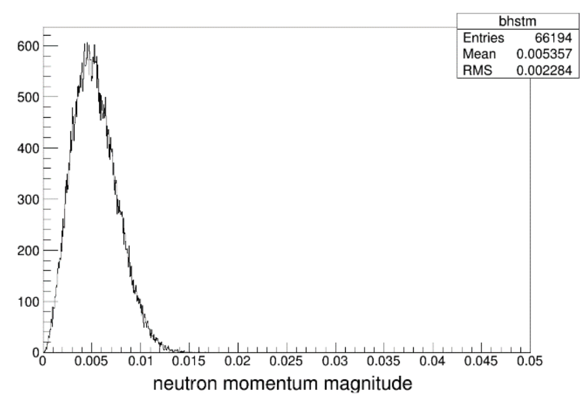
Primary neutrons were specified to have an initial momentum in the positive Z-direction only !

More to come …





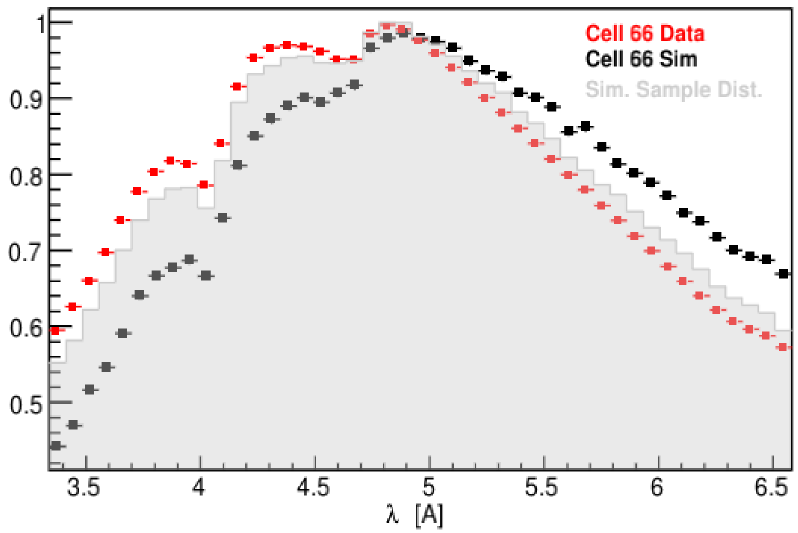


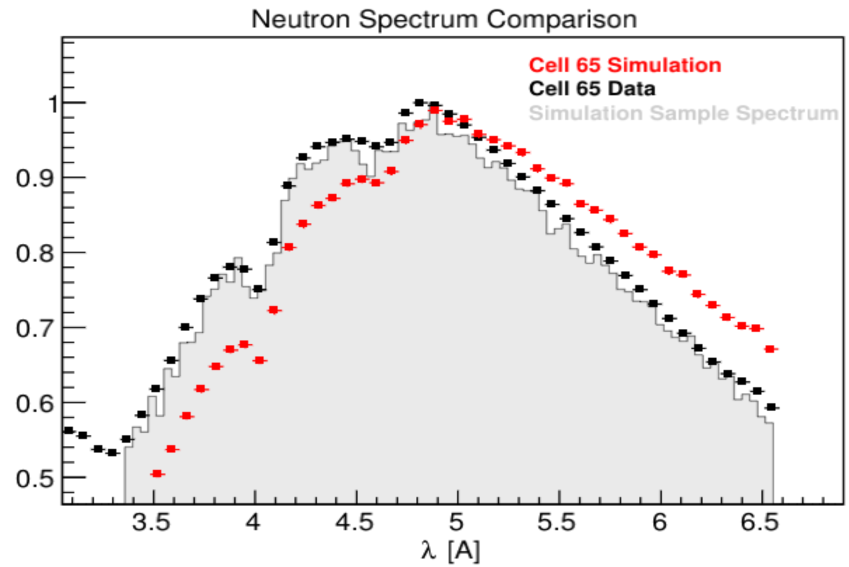


Geant4 Validation for n3He

Some very preliminary comparison between G4 and n3He data (for old collimation runs):

1) Comparison of TOF cell spectra (example) … need to find out what is going on with this …

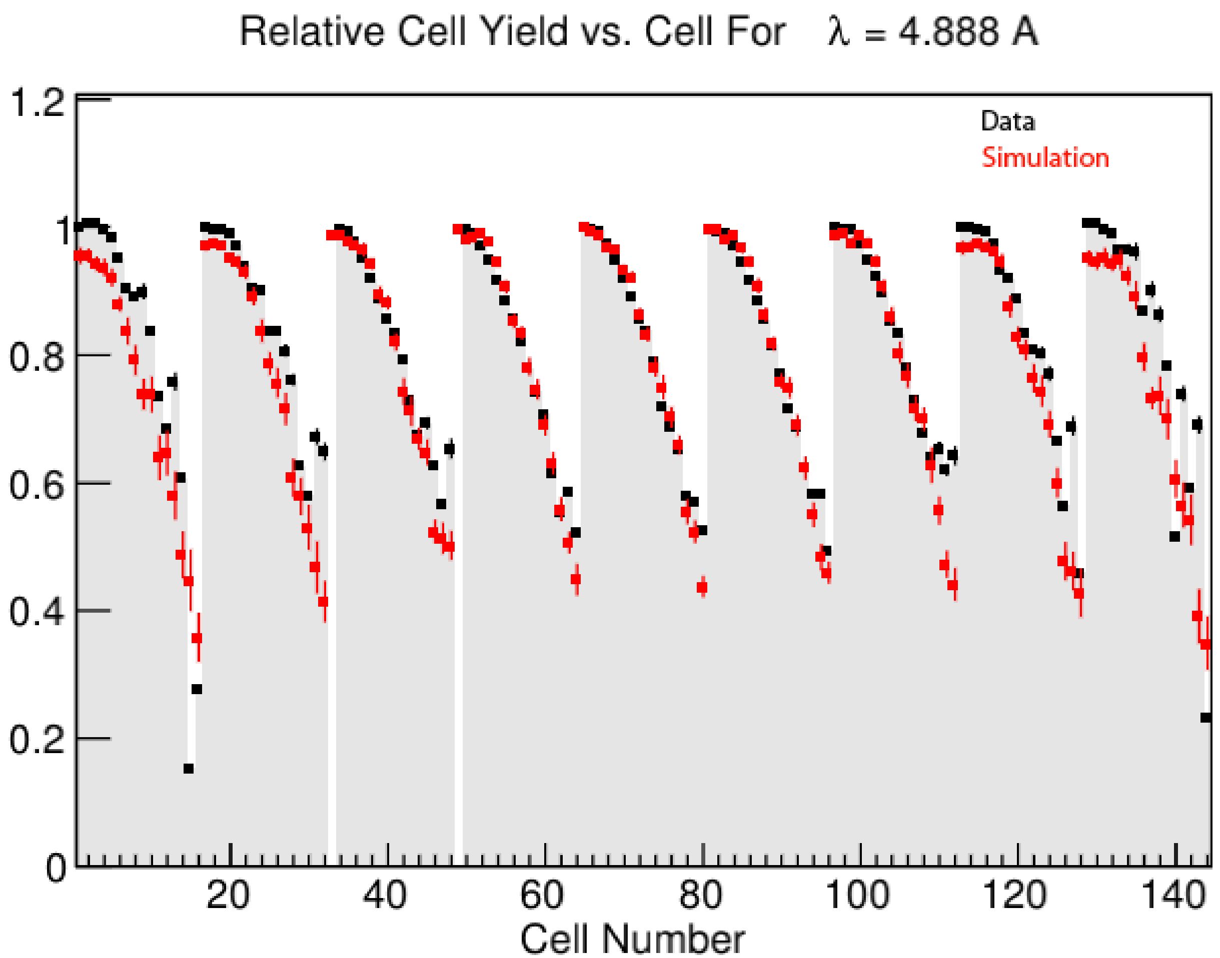




Geant4 Validation for n3He

Some very preliminary comparison between G4 and n3He data (for old collimation runs):

2) Collimation run comparisons



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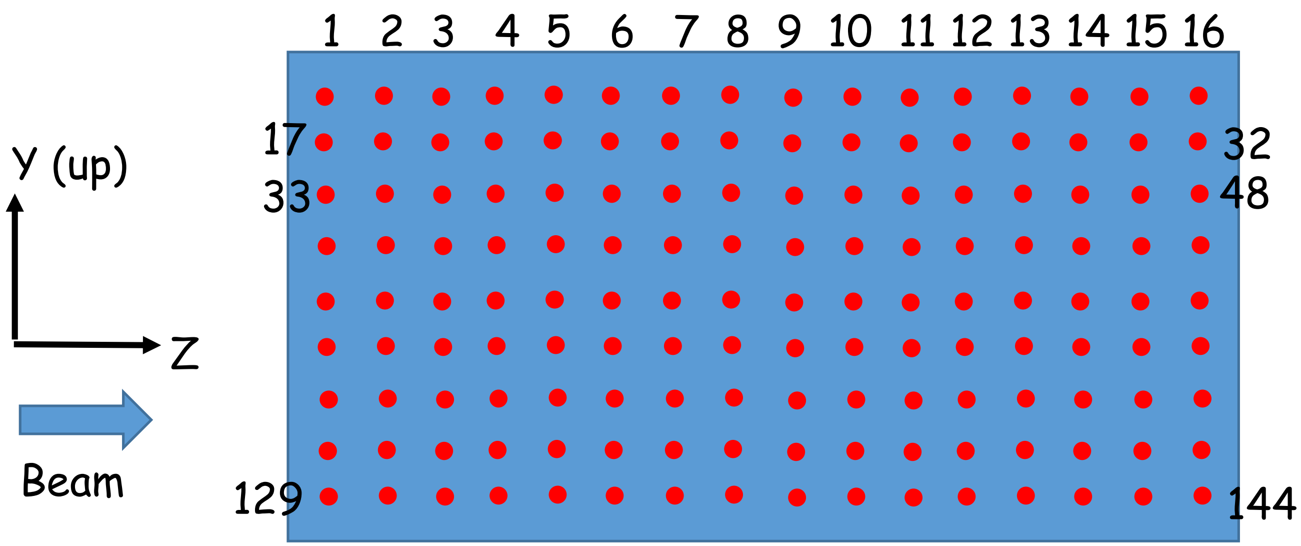
Cell or wire numbering scheme in the data presented here:



Makes the plots easier to interpret …

Geant4 Validation for n3He

Some definitions for the purpose of discussion:

Wire signal: $S_w(\lambda_n) = g_w N_w(\lambda_n) f_w(\lambda_n) + p_w$

w = 1 … 144 (wire number)

n = 1 … 49 (wavelength bin)

g_w = gain for wire (w) (all inclusive)

$N_w(\lambda_n)$ = number of neutron captures for λ_n at wire (w)

$f_w(\lambda_n)$ = some functional behavior due to p and T track length and energy deposition

Geant4 Validation for n3He

We'd like to compare $N_w(\lambda_n) \times f_w(\lambda_n)$ between simulations and data.

Problem: Simulation does not know about g_w or p_w

Try to get around that by computing

$$\frac{S_w(\lambda_n)/S_W(\lambda_n)}{(S_w(\lambda_N)/\ S_W(\lambda_N))}$$

Where

$S_W(\lambda_n)$ is the cell (W) with maximum integrated yield

$S_w(\lambda_N)$ is the maximum wavelength bin yield for this cell

$S_W(\lambda_N)$ is the maximum bin yield for the cell with maximum integrated yield