LUXE GEANT4 Simulation
Versions 10.6.p01, 11.0.p03 (and FLUKA)

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LUXE S&A Meeting
January 9, 2023

Geant4 versions

Geant4 version 10.6 – patch-01 (10.06.p01), released 14 February 2020

- used for CDR and TDR simulations

Geant4 11.0 – patch-03 (11.0.p3), released 16 September 2022

- Requires changing the code
- Changes in G4String interfaces;
- G4EmProcessOptions class has been removed, another way to set parameters for EM physics lists;
- Changes in hadronic physics list;
- Changes in optical physics list.

Recently (December 9, 2022) released Geant4 11.1.

Not used in this study

Geant4 simulation

- **Simulation with y-laser geometry;**
- **2.3499e+07 e- of 16.5 GeV (~1.57% BX), for v10.6.p01;**
- **3.229e+07 e- of 16.5 GeV (~2.15% BX), for v11.0.p03;**

Geant4 offers **Command-based scoring**

- It is realized as parallel geometry;
- Step size limited by the histogram bin;
- Each histogram is saved to ascii file;
- Long simulation time;
- Huge output files and it takes substantial time to save them (2h of simulation and 0.5h writing);

```
##########################################
/score/create/boxMesh boxMesh_XFELDumpPLC
#
/score/mesh/boxSize 2000.0 1500.0 800.0 mm
/score/mesh/translate/xyz  -3400 -1478 -13500 mm
/score/mesh/rotate/rotateY  0.115366 radian
/score/mesh/nBin 400 300 160
#
/score/quantity/cellFlux gFlux
/score/filter/particle gammaFilter gamma
#
/score/close
```

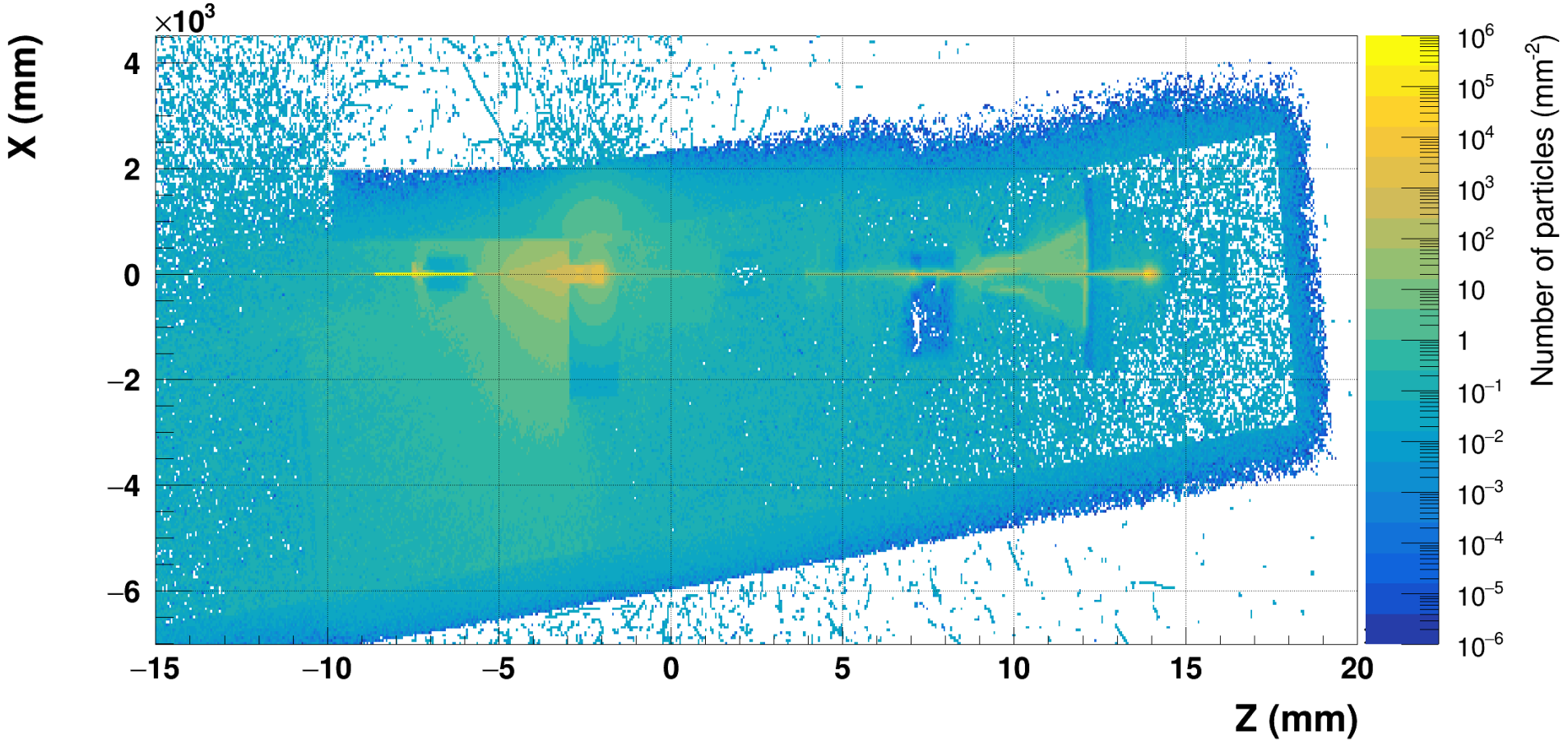
Another approach was used:

- The area of interest was covered by regular 3D histograms;
- In UserSteppingAction action function each step was tested to belong to the region of 3D hist;
- Each bin was filled along the step;
- 10 times faster and final histograms are in the same root file (with TTrees).

In both approaches the fluence histograms are filled with a weight: L/V,
where L – step length within the bin of volume V. It gives units 1/area. (mm^{-2}).

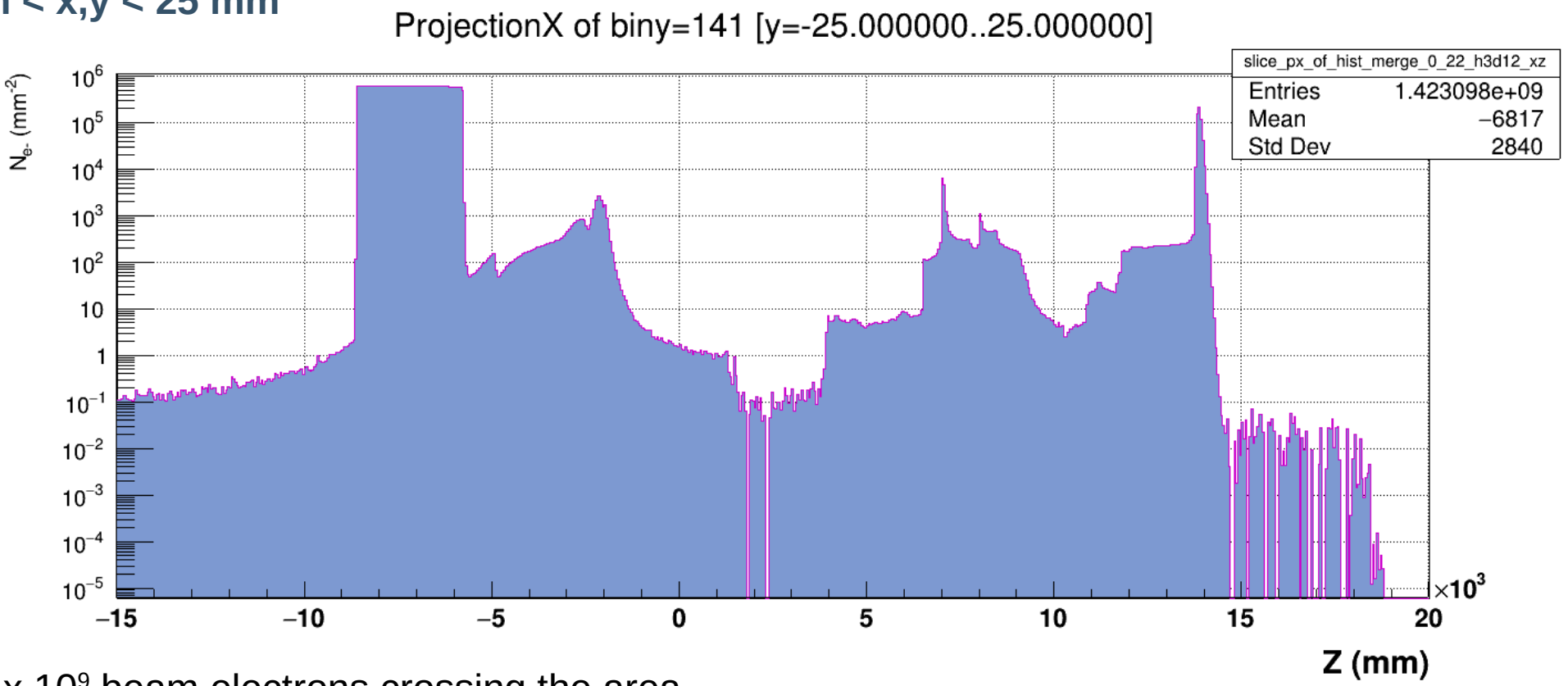
Electrons fluence in the beam line plane

-25 mm < y < 25 mm



Electrons fluence along the beam line

-25 mm < x,y < 25 mm



1.5 x 10^9 beam electrons crossing the area of the bin 50 by 50 mm^2 give fluence:

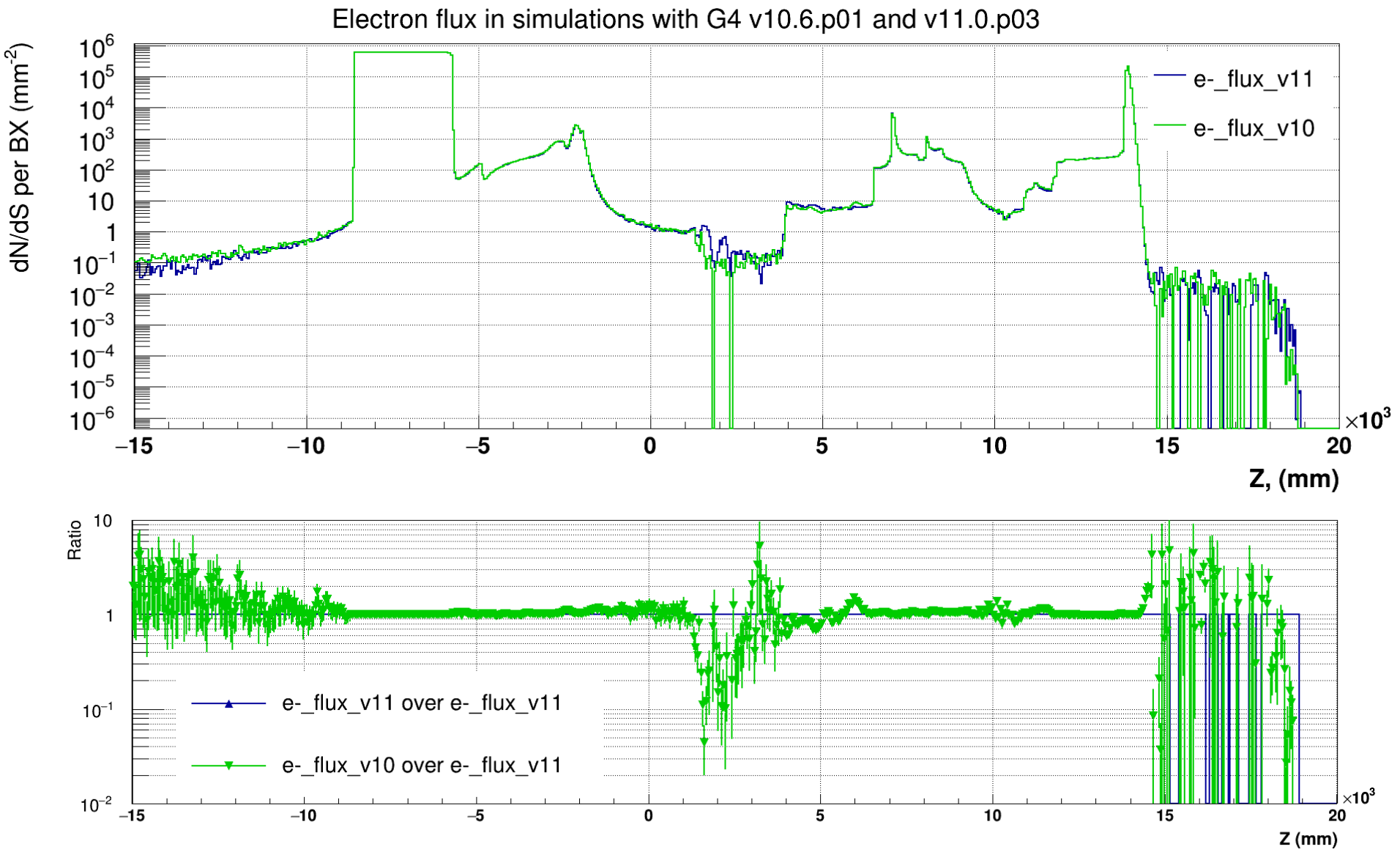
1.5 x 10^9 / 2500 = 600000

- It matches well the numbers in the histogram downstream electron initial position and till the magnet deflects them.
- Then they “move” to another slice of the 3D histogram.

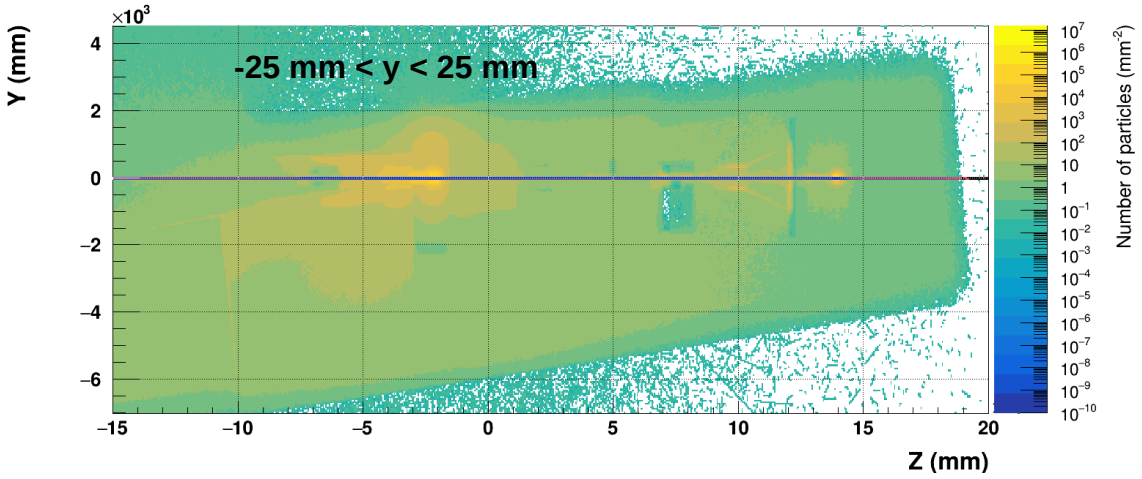
…
fSumw[125][141]=1.8042, x=-8775, y=0, error=0.208542
fSumw[126][141]=1.96096, x=-8725, y=0, error=0.213718
fSumw[127][141]=2.14466, x=-8675, y=0, error=0.223576
fSumw[128][141]=117.076, x=-8625, y=0, error=0.231883
fSumw[129][141]=599888, x=-8575, y=0, error=123.75
fSumw[130][141]=600003, x=-8525, y=0, error=123.773
fSumw[131][141]=600003, x=-8475, y=0, error=123.773
fSumw[132][141]=600003, x=-8425, y=0, error=123.774
fSumw[133][141]=600004, x=-8375, y=0, error=123.774
…

Electrons fluence along the beam line

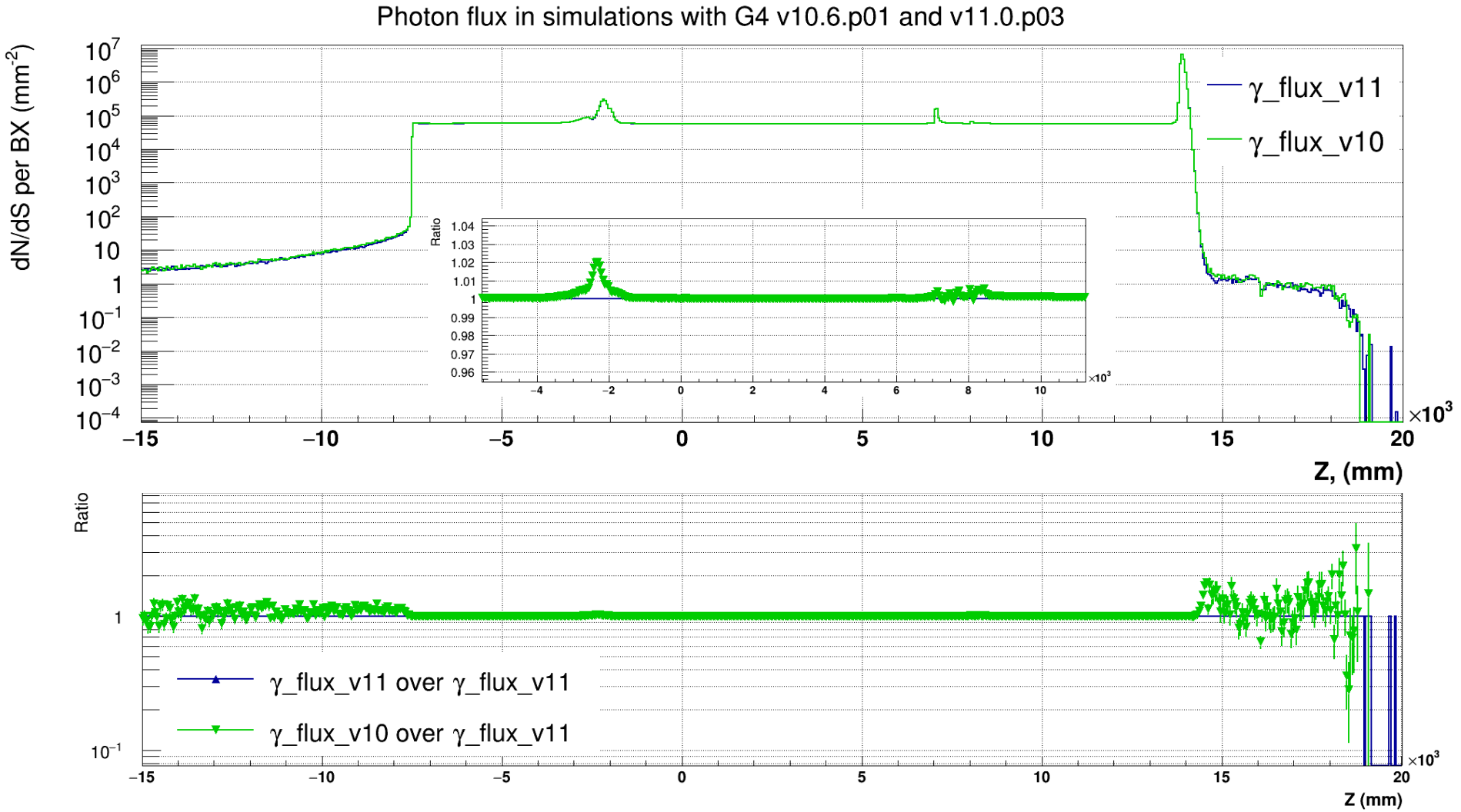
-25 mm < x,y < 25 mm



Photon fluence along the beam line

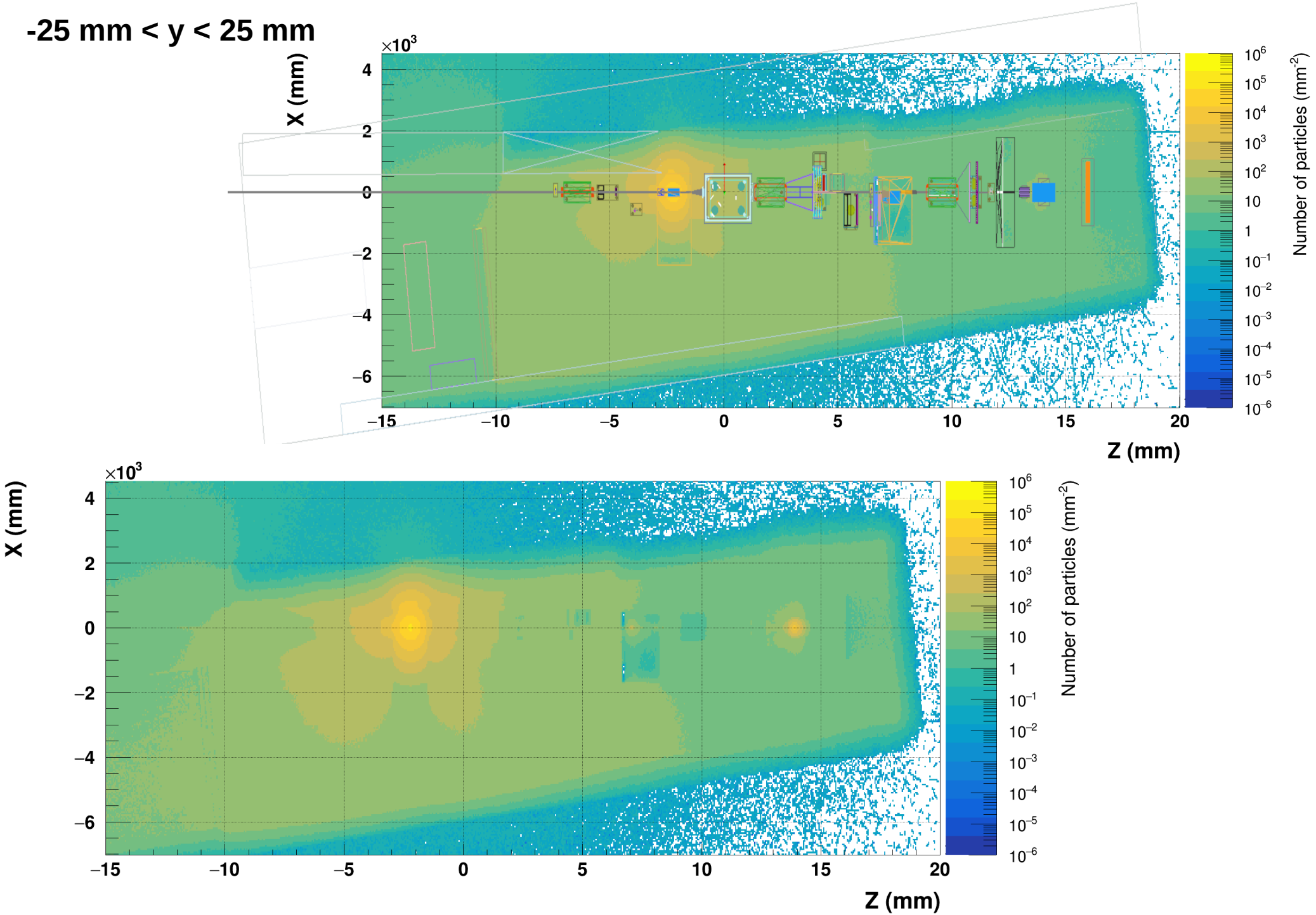


-25 mm < x,y < 25 mm



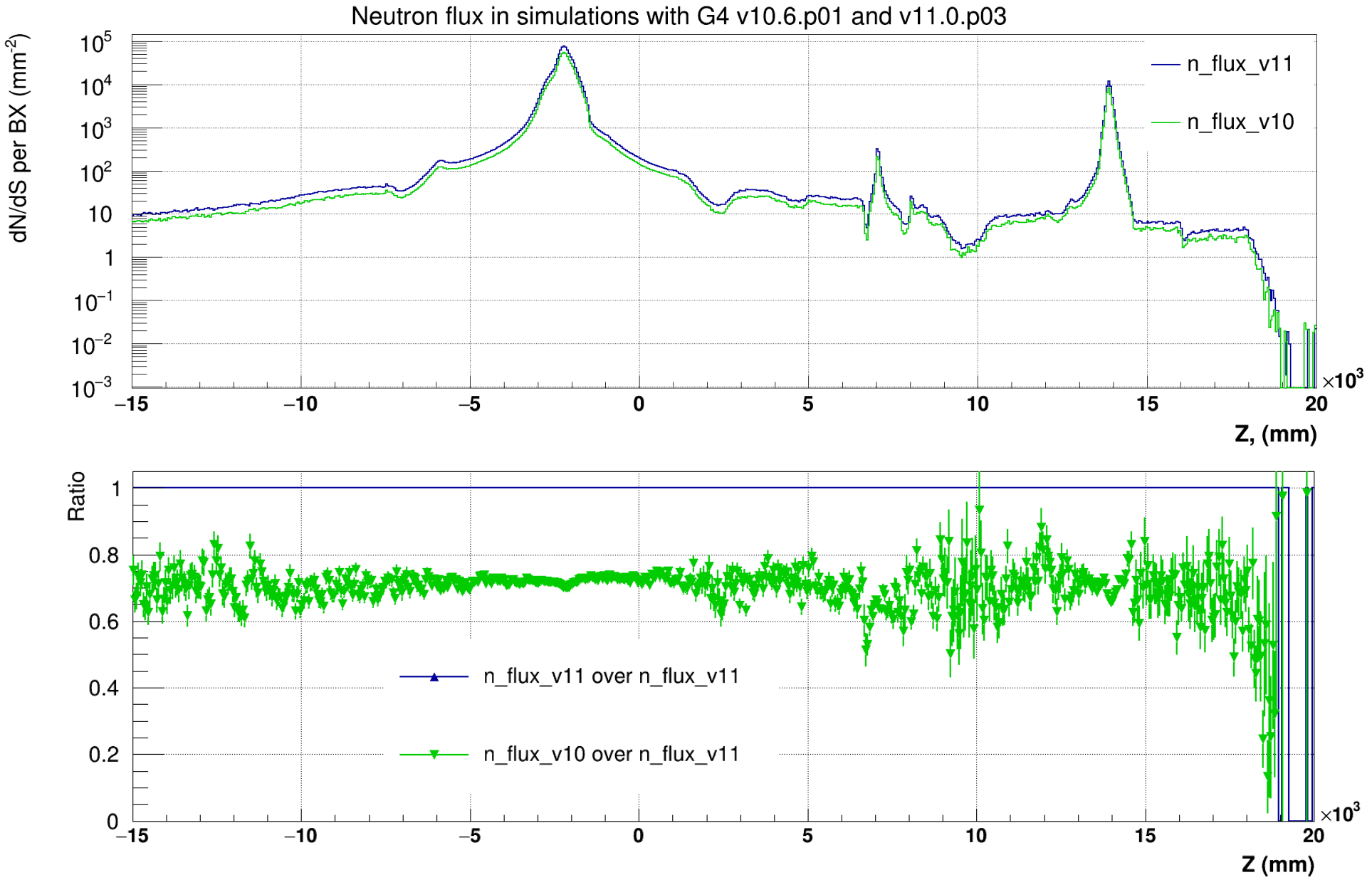
Neutron fluence in the beam line plane (xz)

-25 mm < y < 25 mm

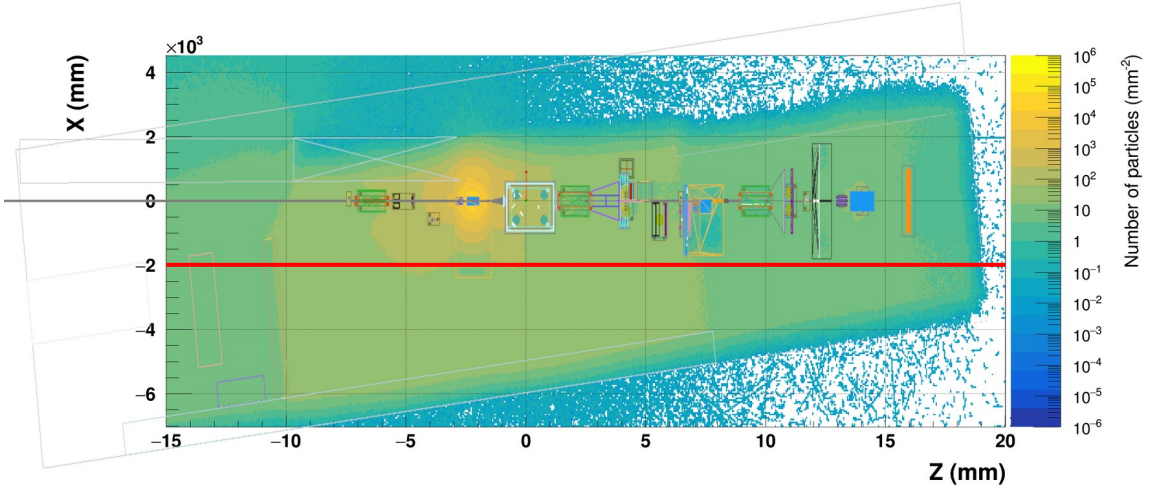


Neutron fluence along the beam line

-25 mm < x, y < 25 mm

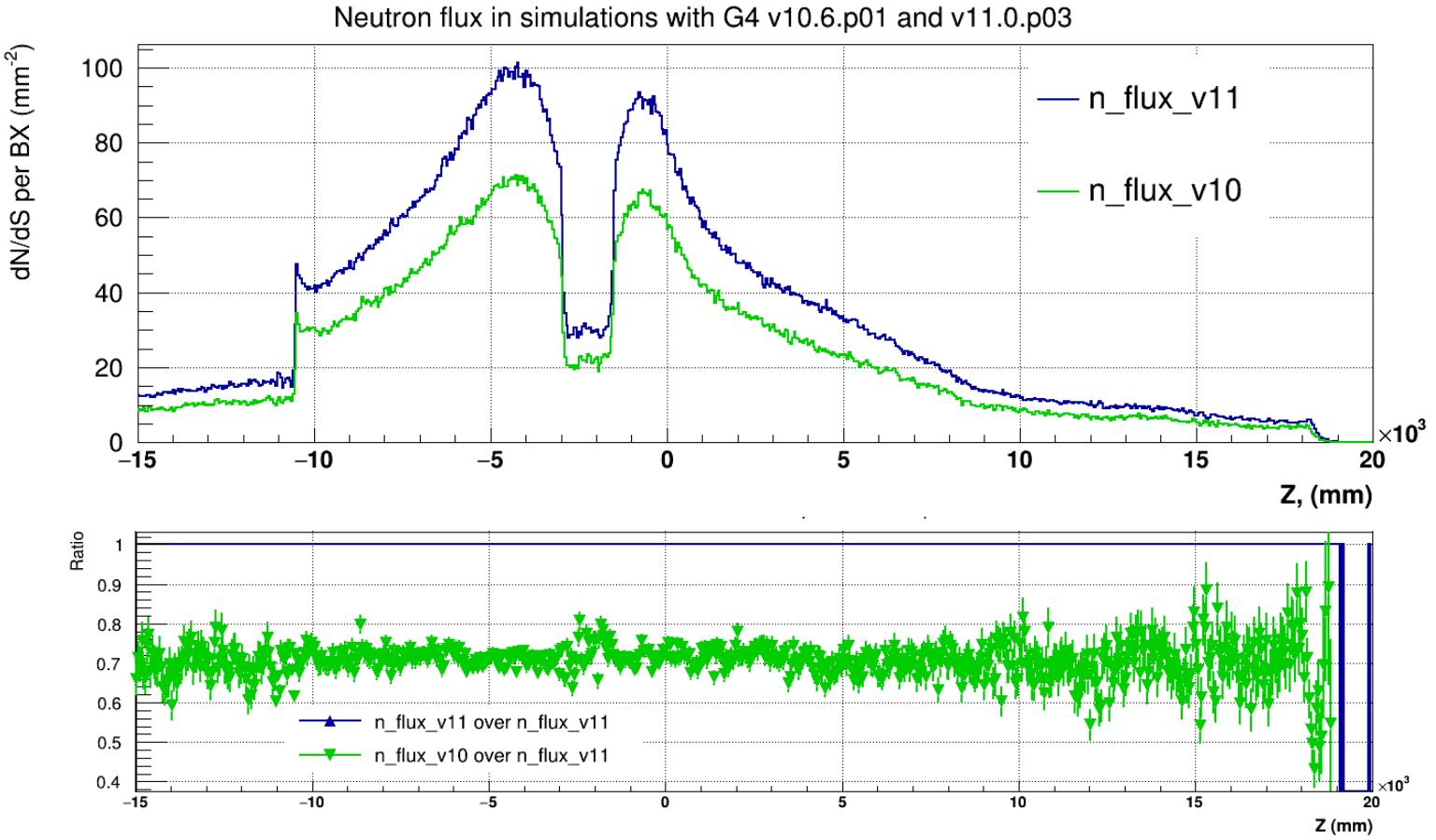


Neutron fluence
at x = -2 m

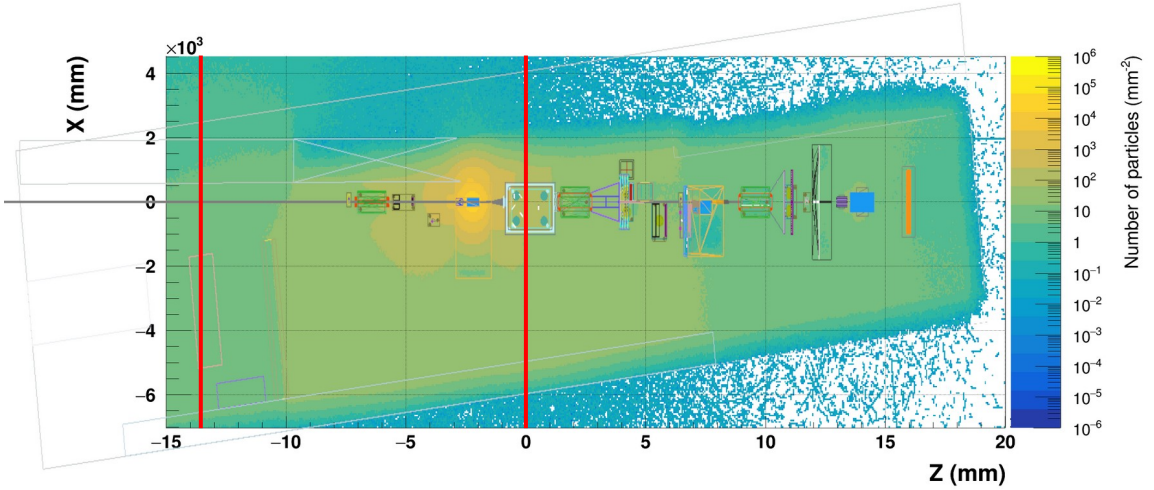


-25 mm < y < 25 mm

X = -2 m

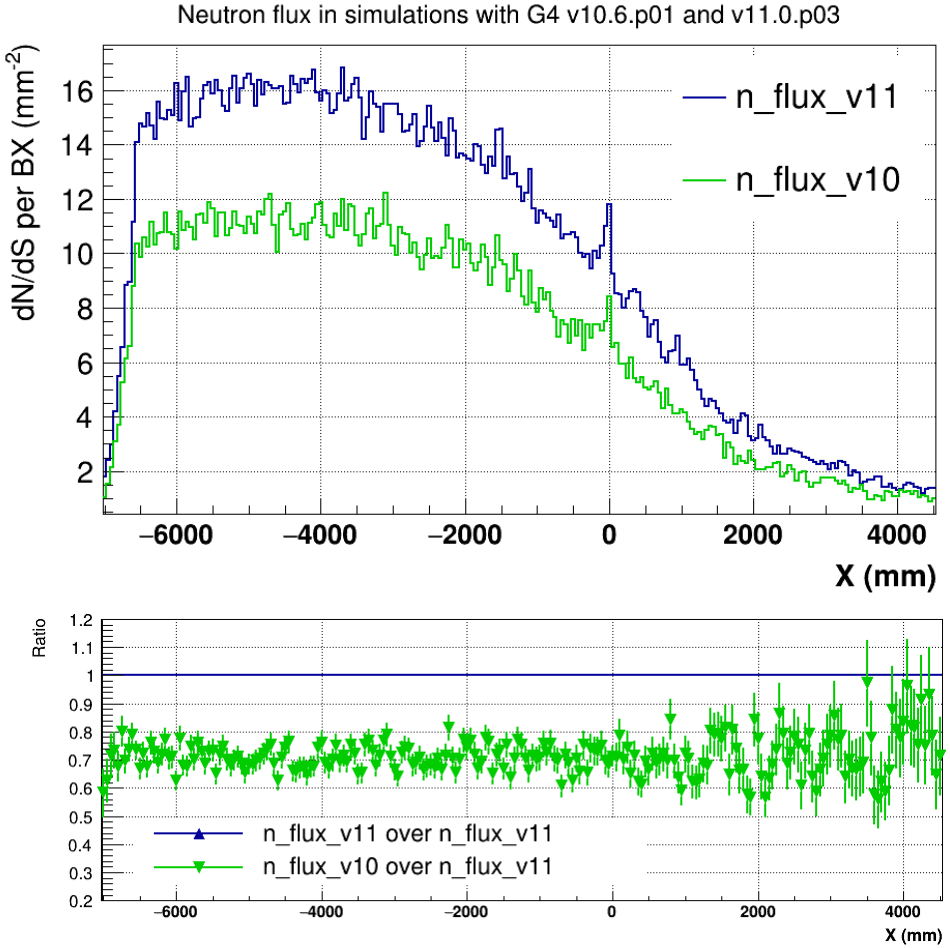


Neutron fluence

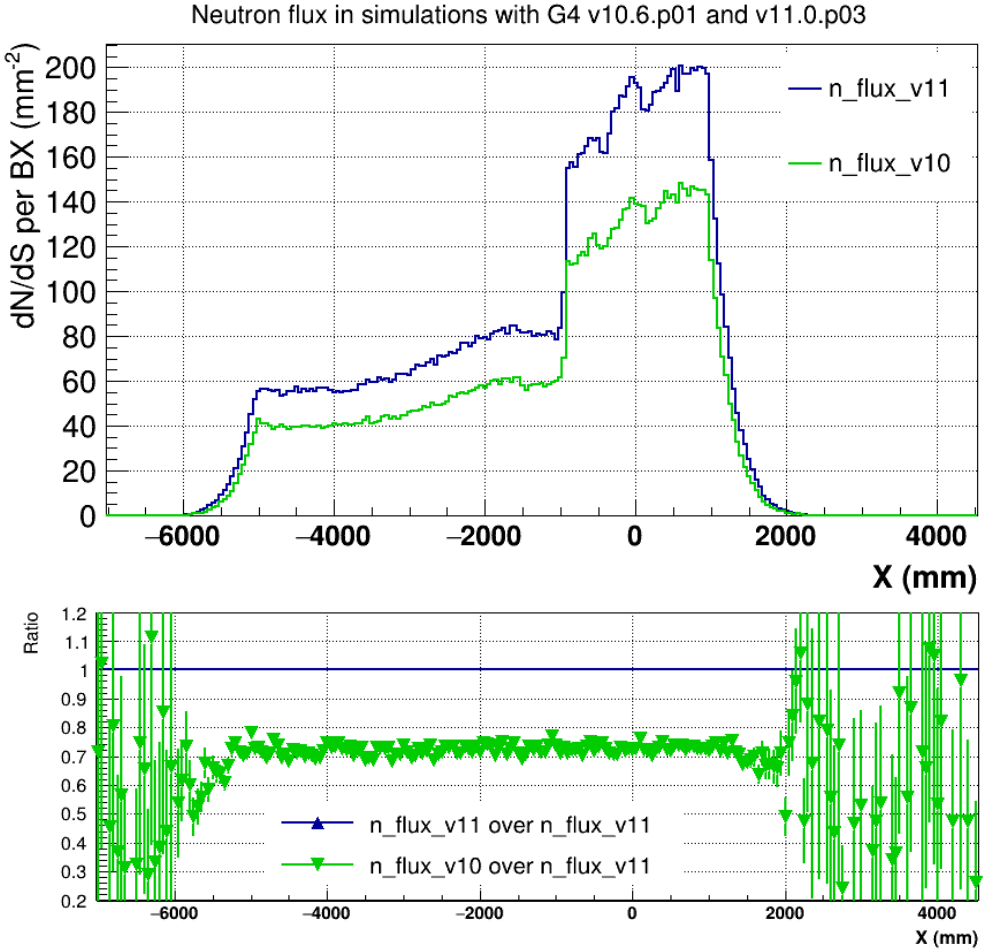


-25 mm < y < 25 mm

Z = -13.5 m

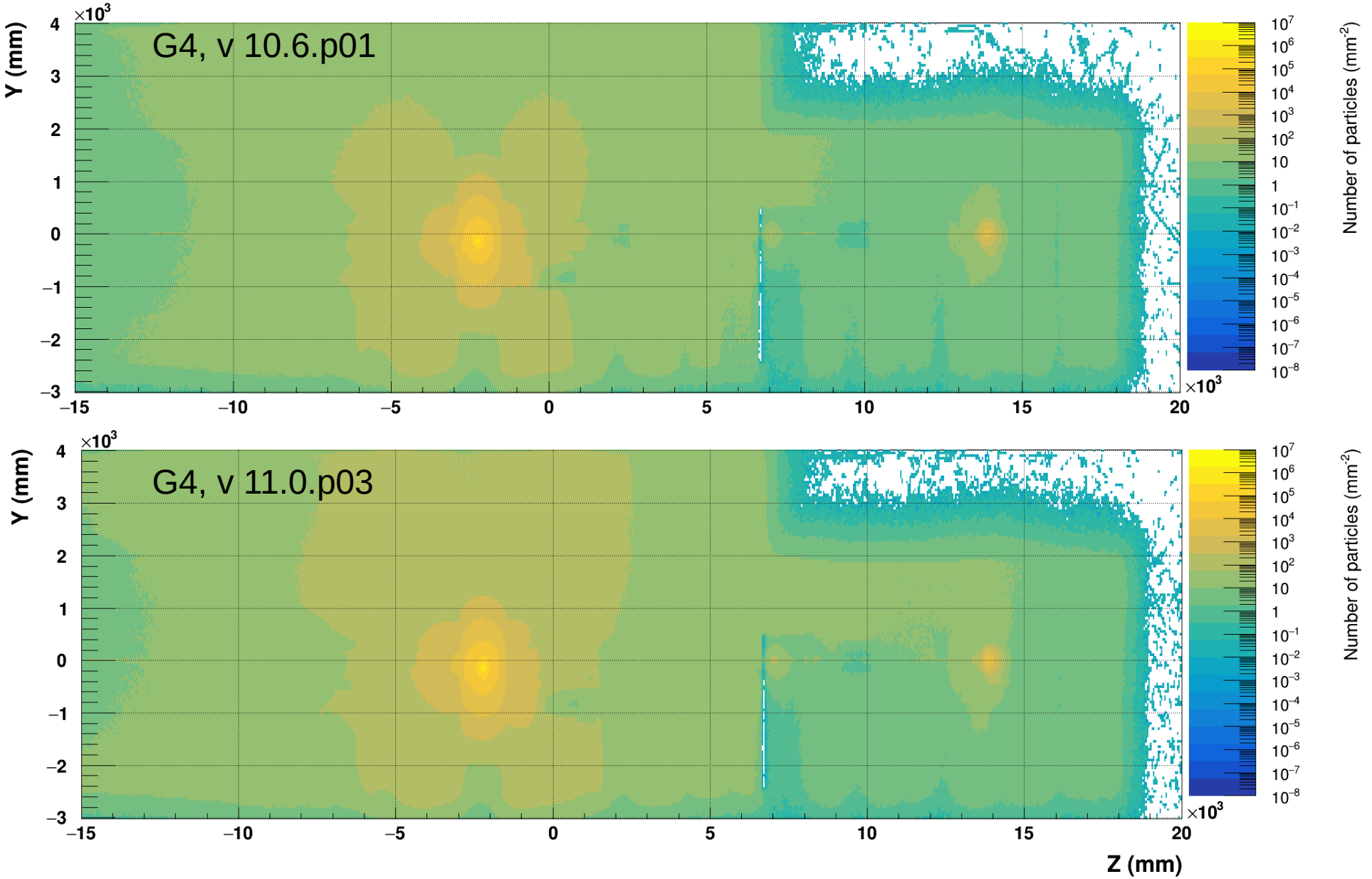


Z = 0



Neutron fluence in the beam line plane (yz)

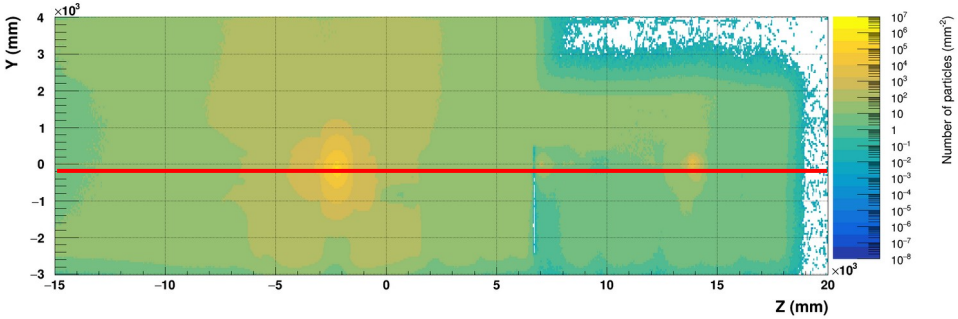
-25 mm < x < 25 mm

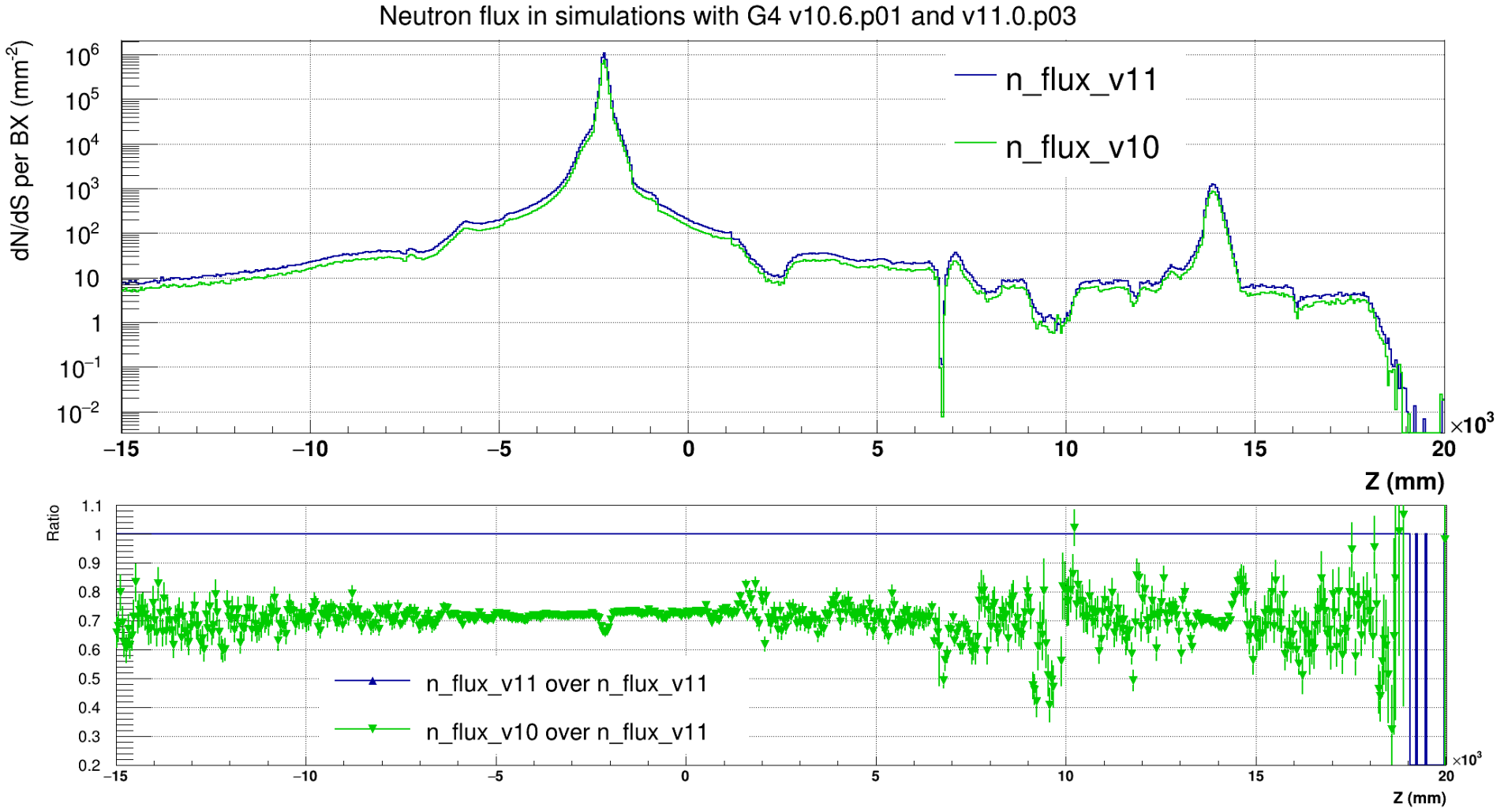


Neutron fluence in maximum

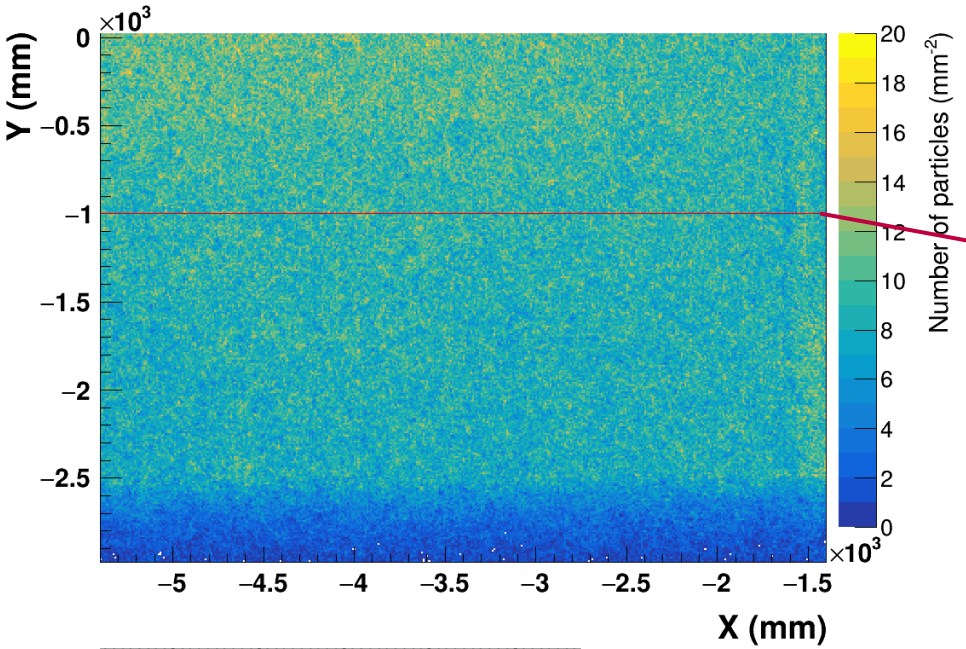
-25 mm < x < 25 mm

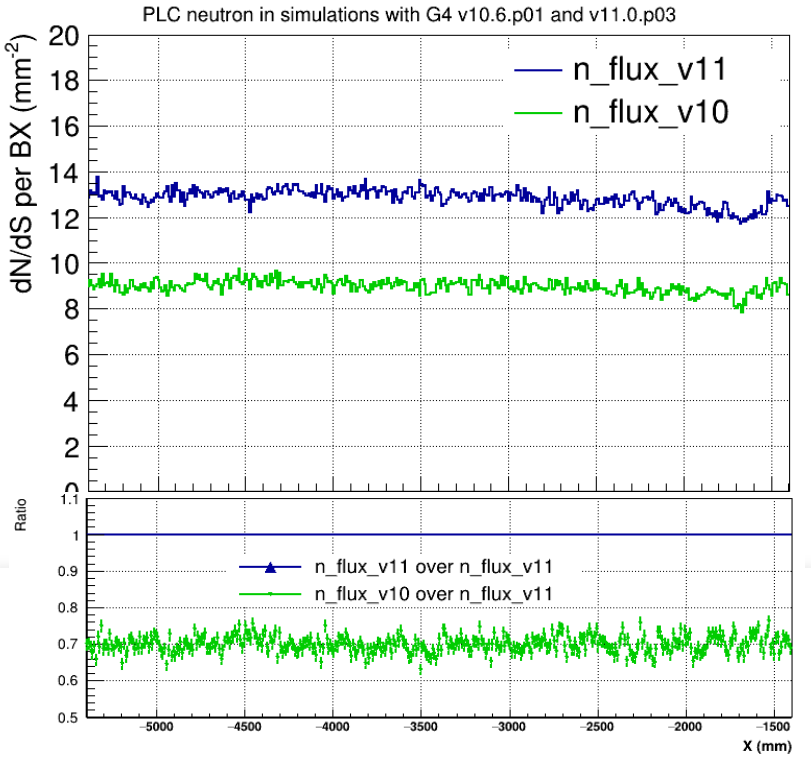
y = -150 mm

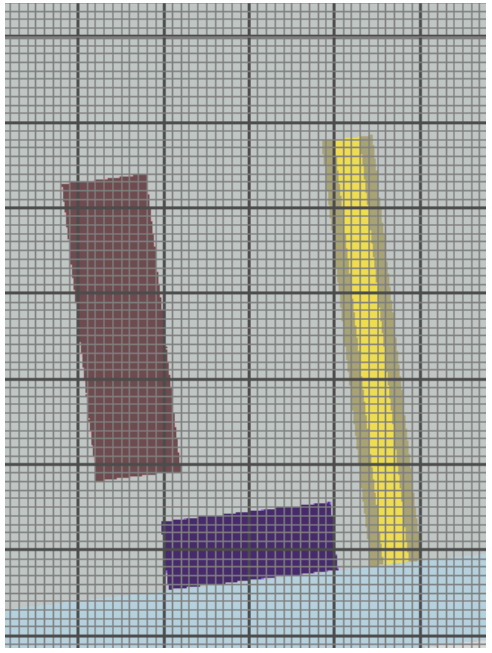


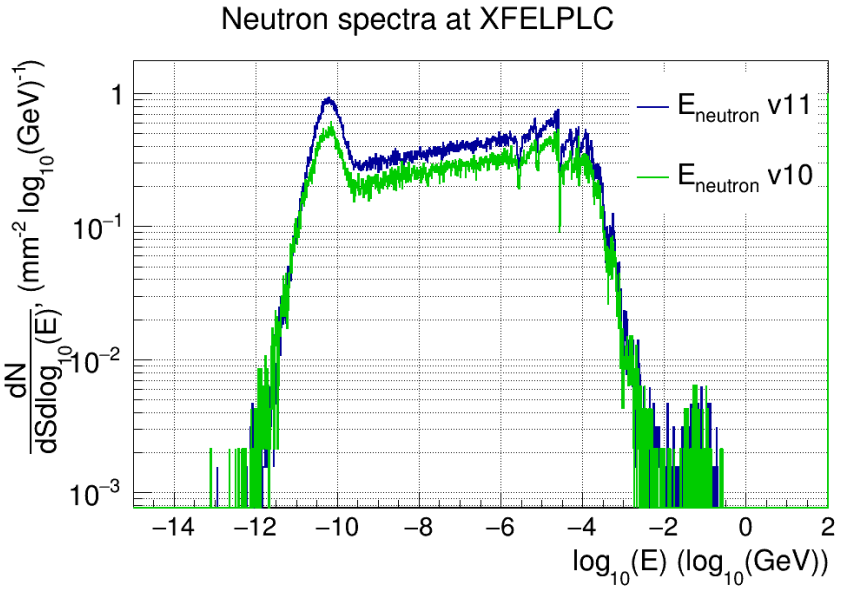


Neutron fluene in XFELDumpPLC









Summary

- Comparison of LUXE background in Geant4 simulations with version 10.6.p01 and 11.0.p03;
- Electron and photon background looks identical;
- Neutron flux is about 40% higher in new version (11.0.p03).
- Neutron spectra looks also identical.

Backup

Neutrons flux with different number of simulated electrons

Just to test the normalization and get idea of uncertainty