FastSim Parametrization of Beam Dump: Comparing random generation with original distribution

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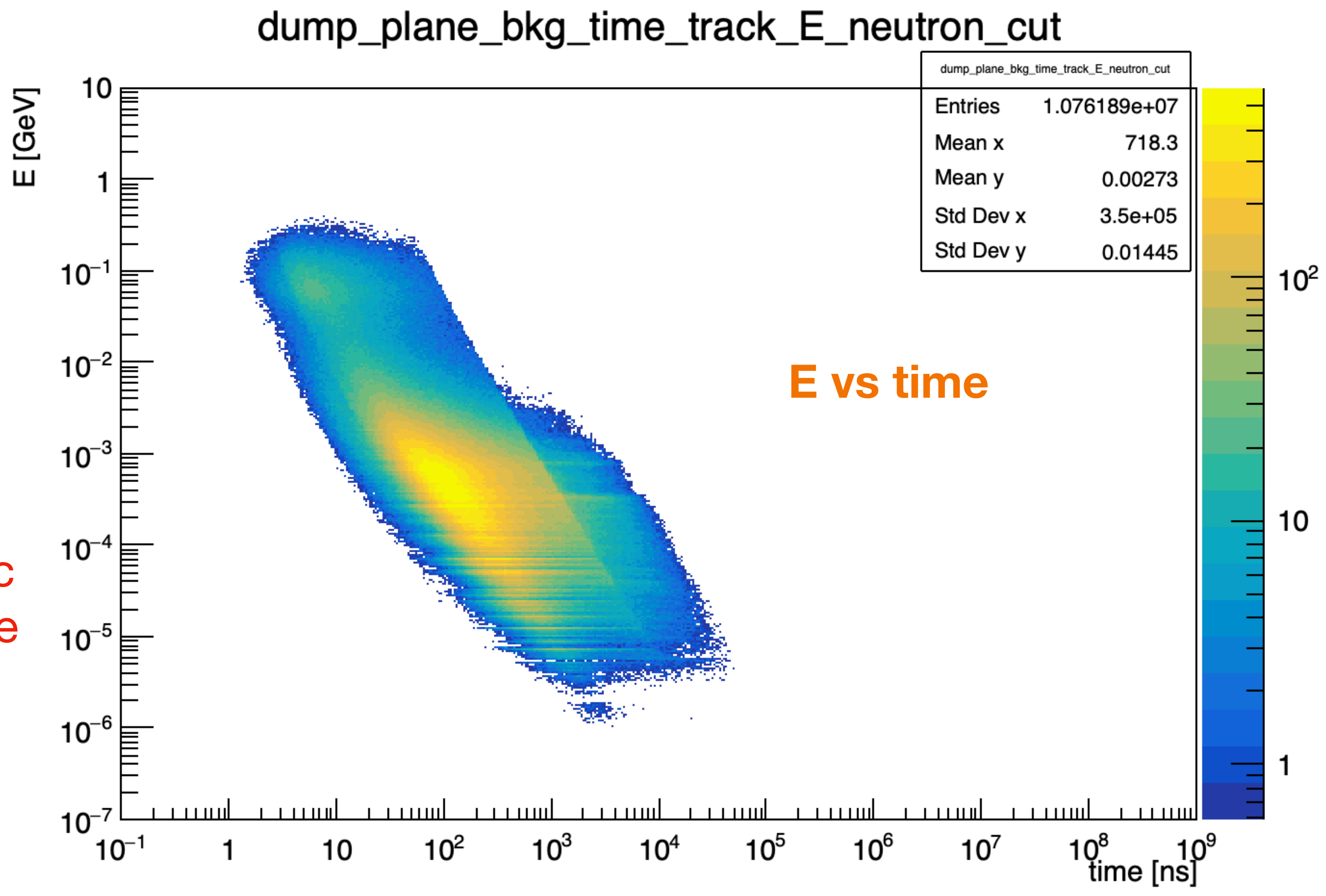
Introduction

- ★ Goal is to disable the dump from FullSim and replace all its “output” by source-like particles.
- ★ We looked at the distributions of r (=$\sqrt{x^2 + y^2}$), E, momentum polar angle (θ_p), momentum azimuthal angle (ϕ_p) and position azimuthal angle (ϕ_{pos}) from particles generated from dump.
- ★ Trying to generate particles from those FullSim distributions.
    - ★ Used TH1D::GetRandom() and TH2D::GetRandom2() (for variables that are correlated) methods.

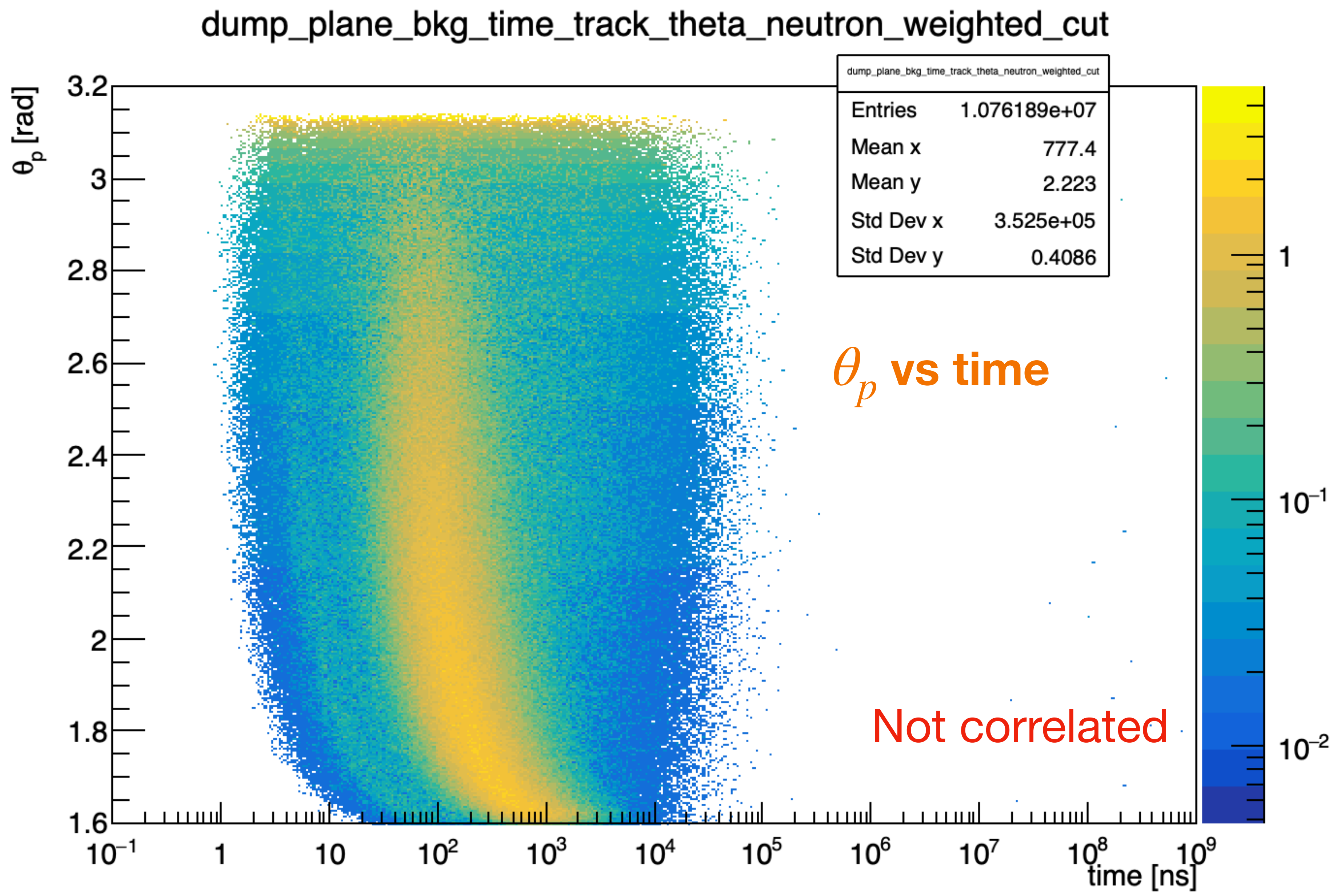
- ★ New in this talk:
    - ★ Observed that time is correlated with energy for neutrons
        - ★ Less energetic neutrons move slowly, hence take more time to reach detector planes.
    - ★ No such correlation for photons
    - ★ There was an issue which made FastSim particles more focused.
        - ★ This is now fixed.
    - ★ The normalization difference of FastSim and FullSim was also another issue
        - ★ This is now fixed as well.

Correlation with time: neutron



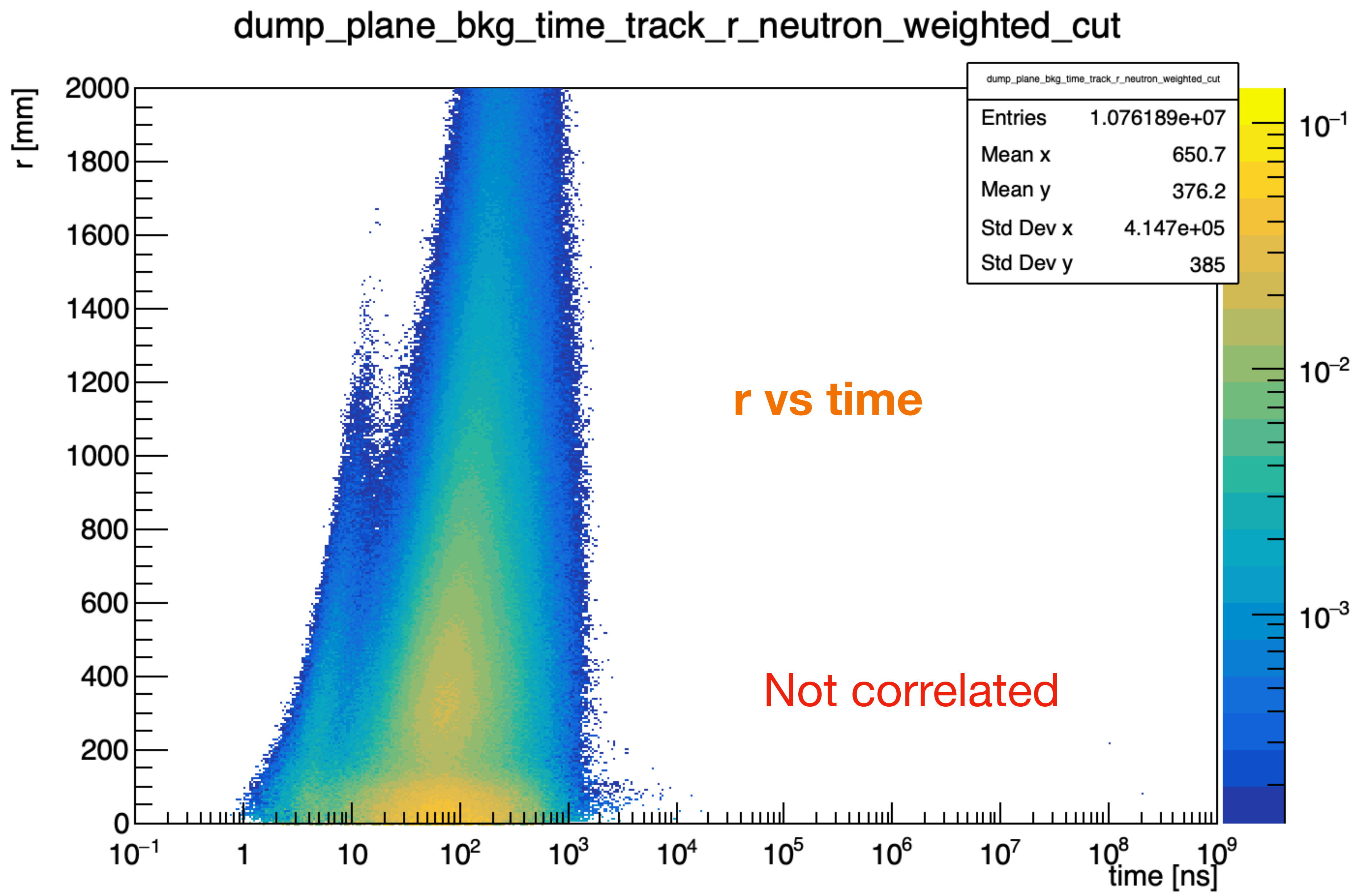
E vs time

Less energetic neutrons move slowly



θ_p vs time

Not correlated



r vs time

Not correlated

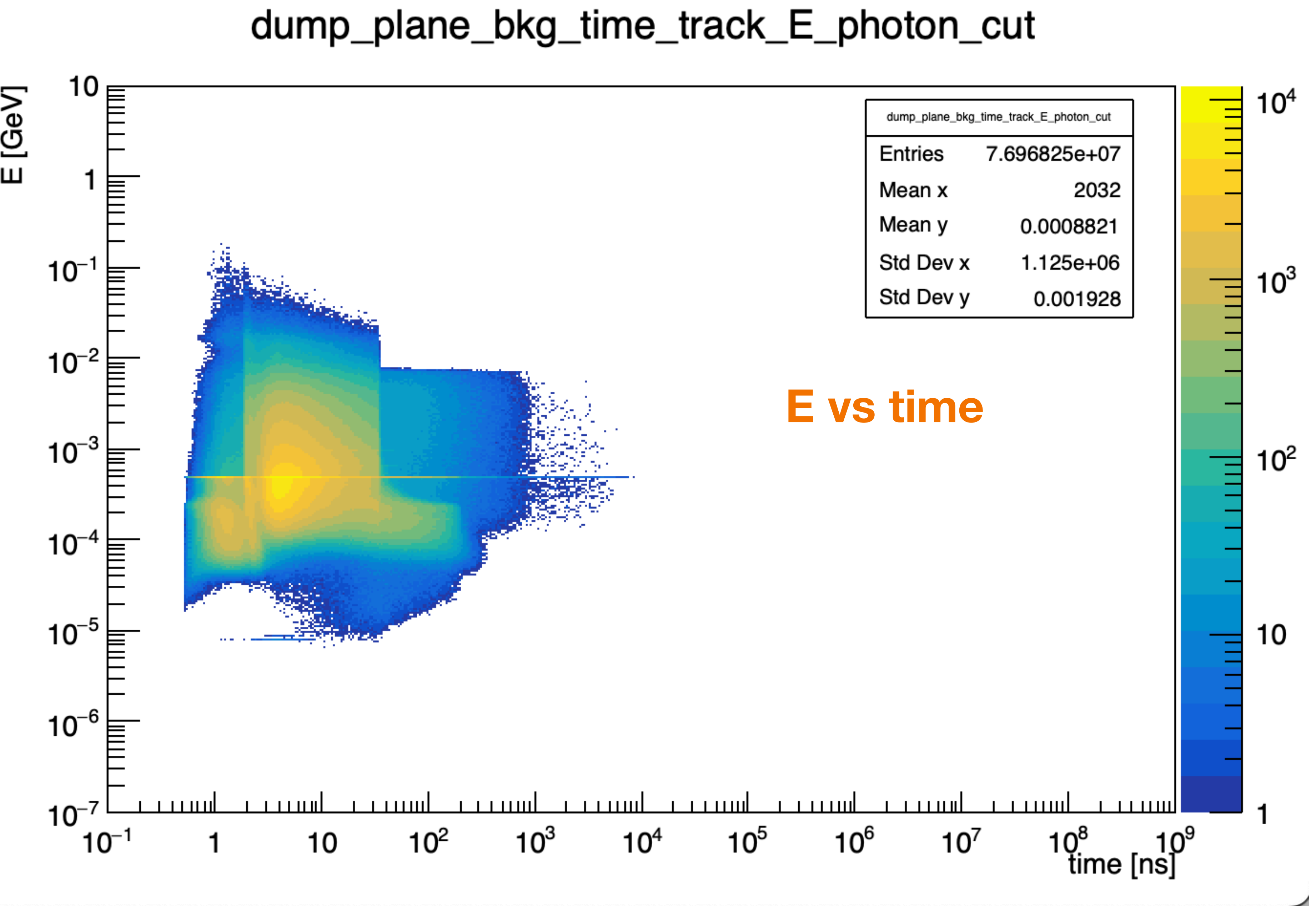
★Time for neutron is generated from E vs t 2D plot

★In previous processing, we had a upper limit of t at 1000 ns, keeping in mind the resolution of our sub-detectors.

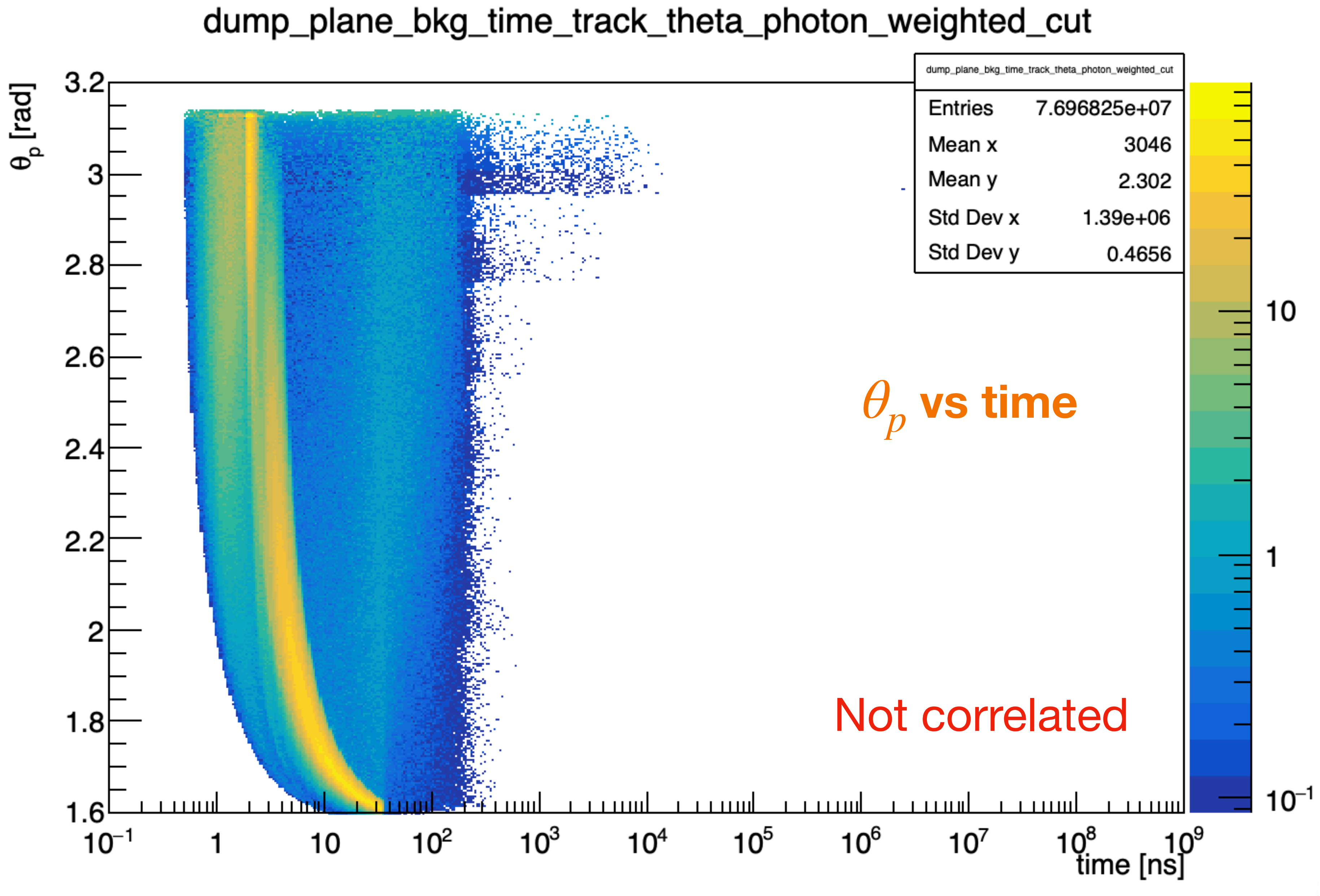
★This upper limit is **now removed** in this iteration.

Correlation with time: photon

No E vs time correlation

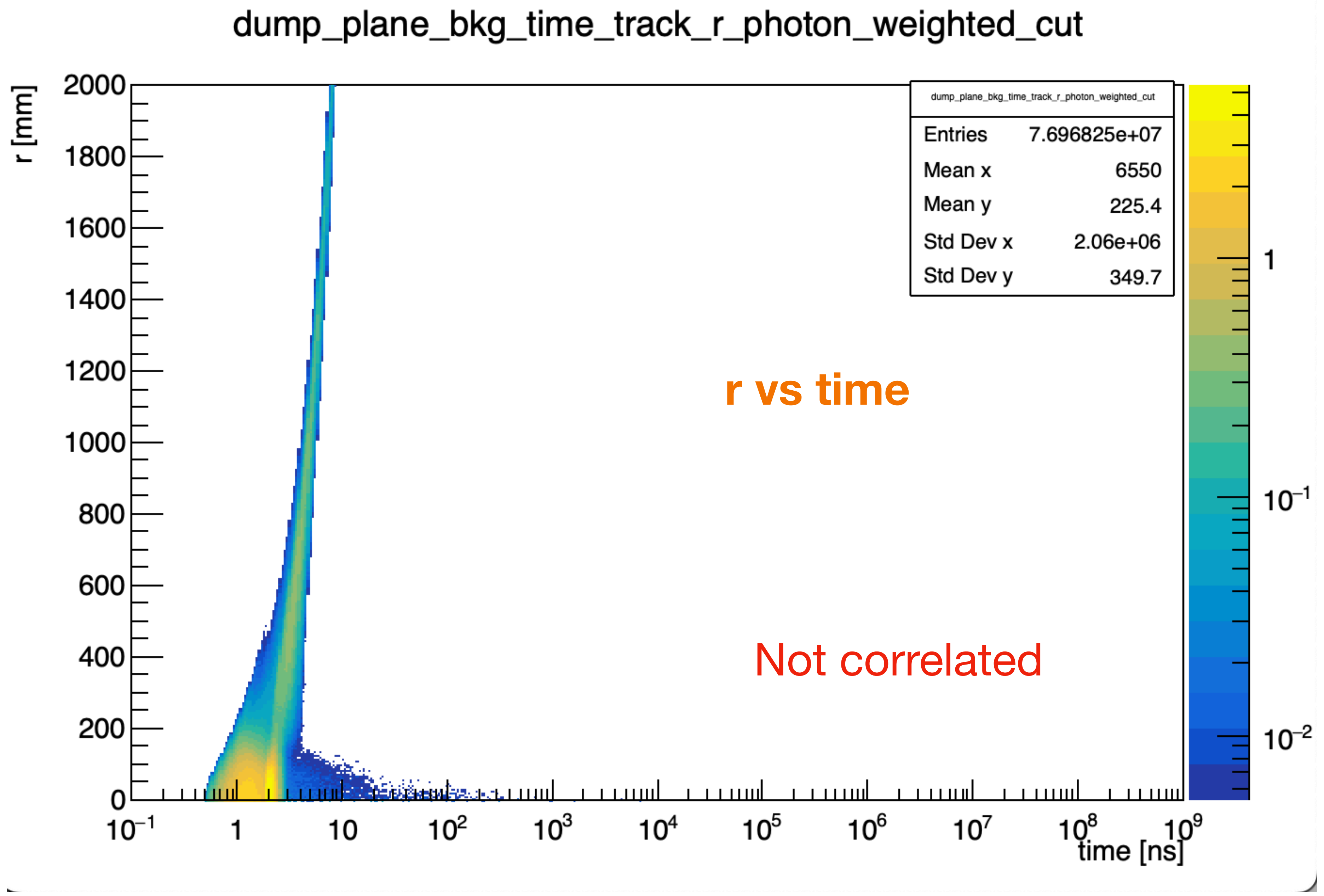


E vs time



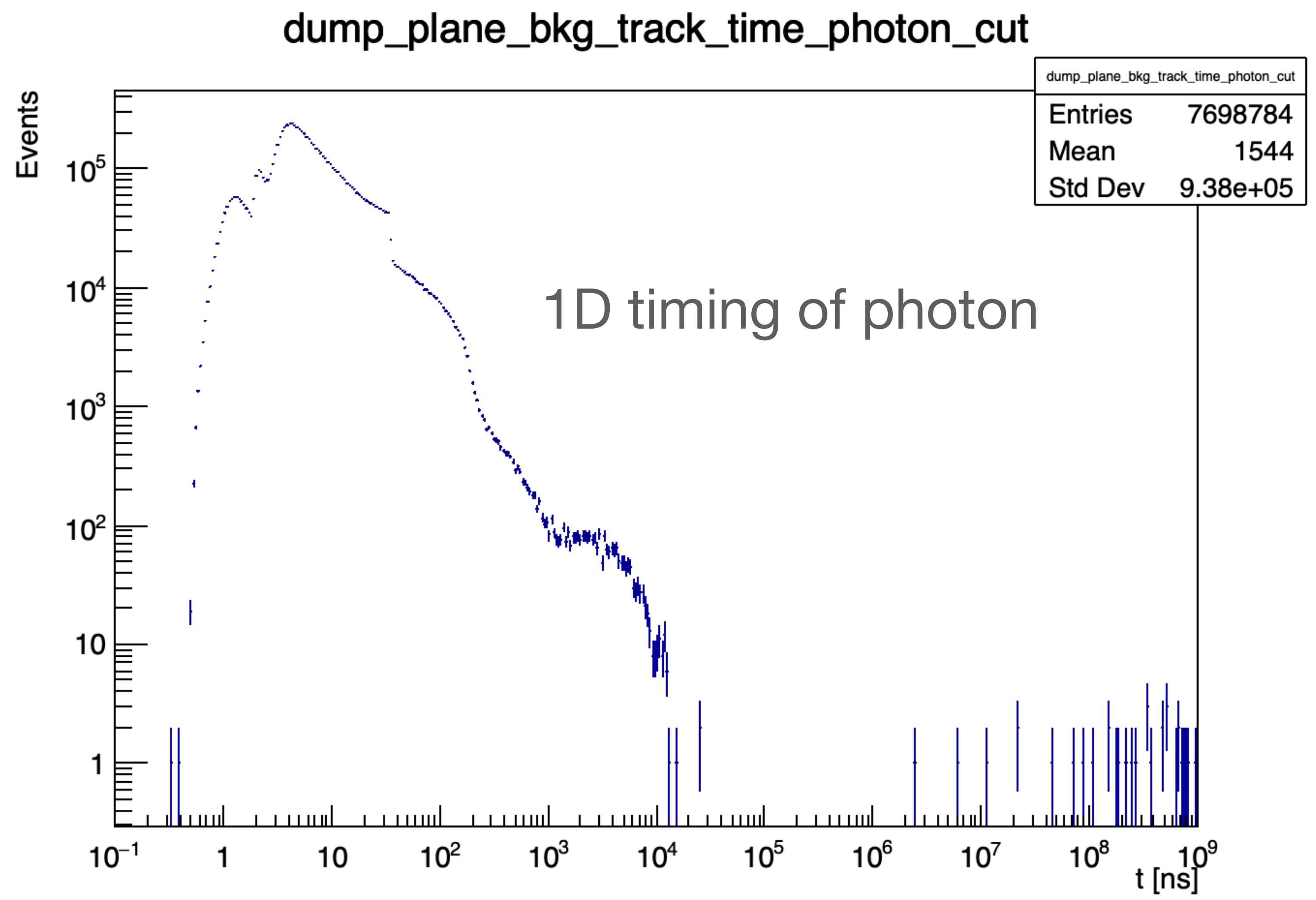
θ_p vs time

Not correlated



r vs time

Not correlated

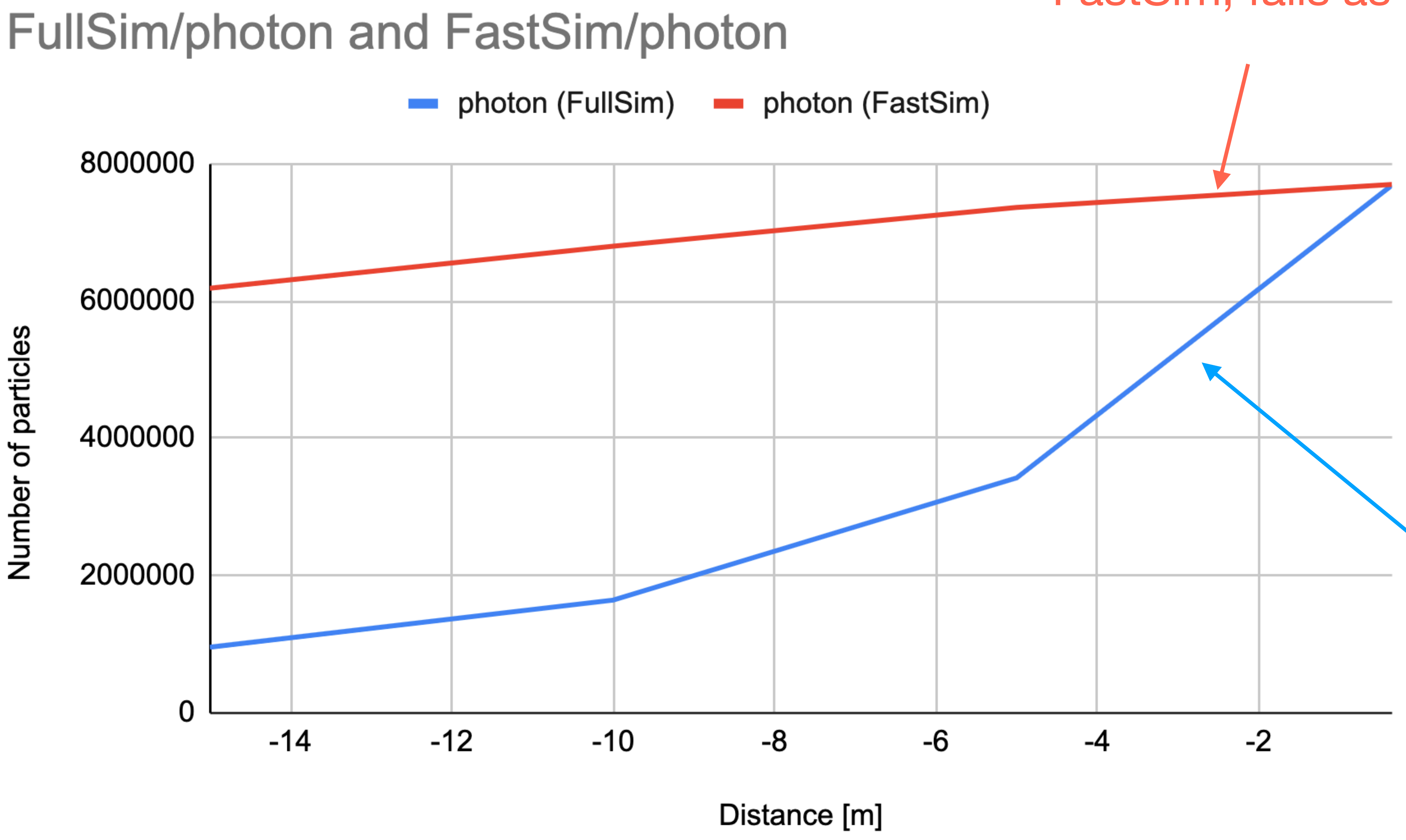


1D timing of photon

★Time for photon is generated from time 1D plot of photons

★ Removed the upper limit of 1000 ns in this iteration.

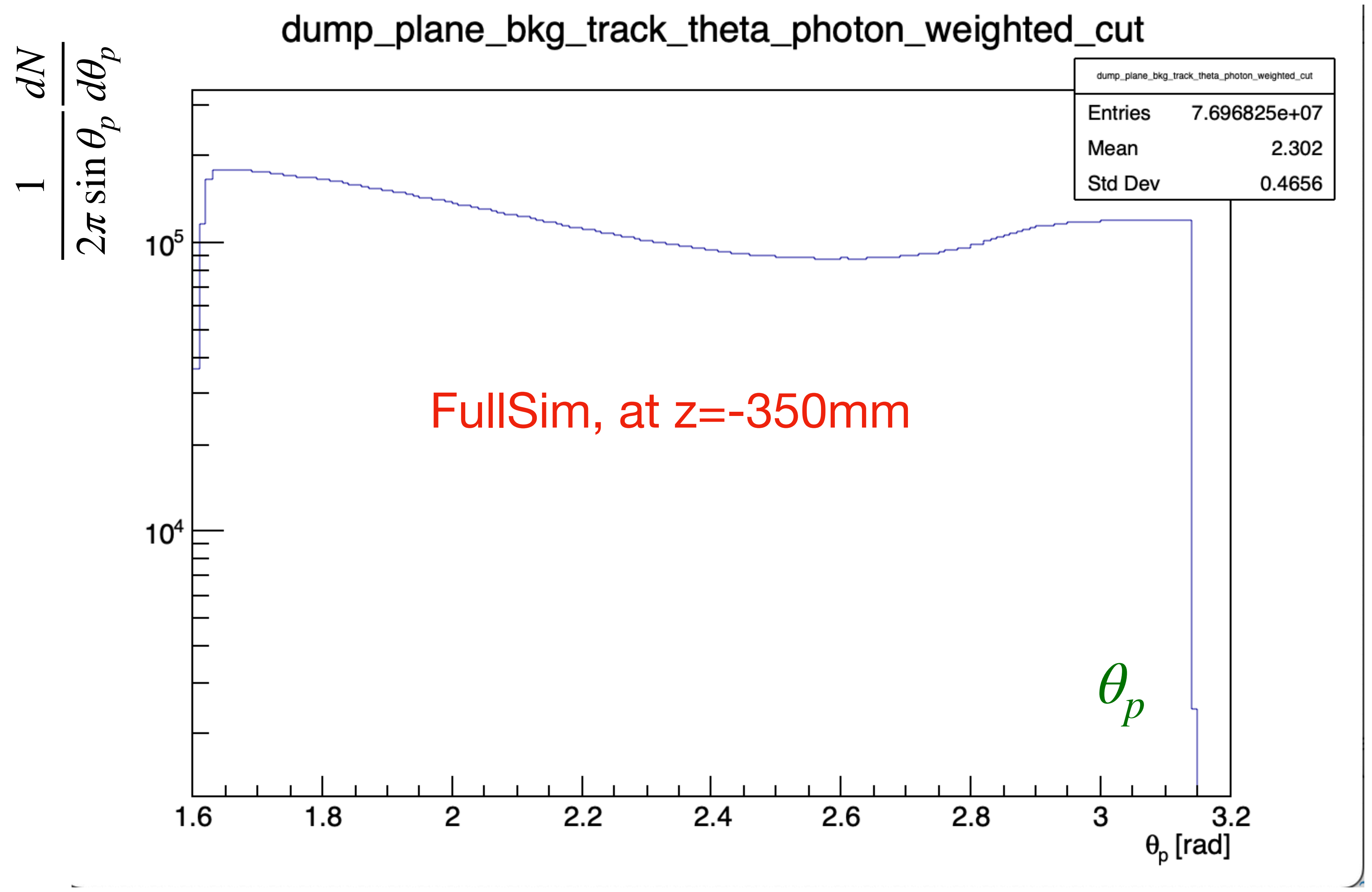
Issue with the normalization of particles in previous iterations



FastSim, falls as~ -kr

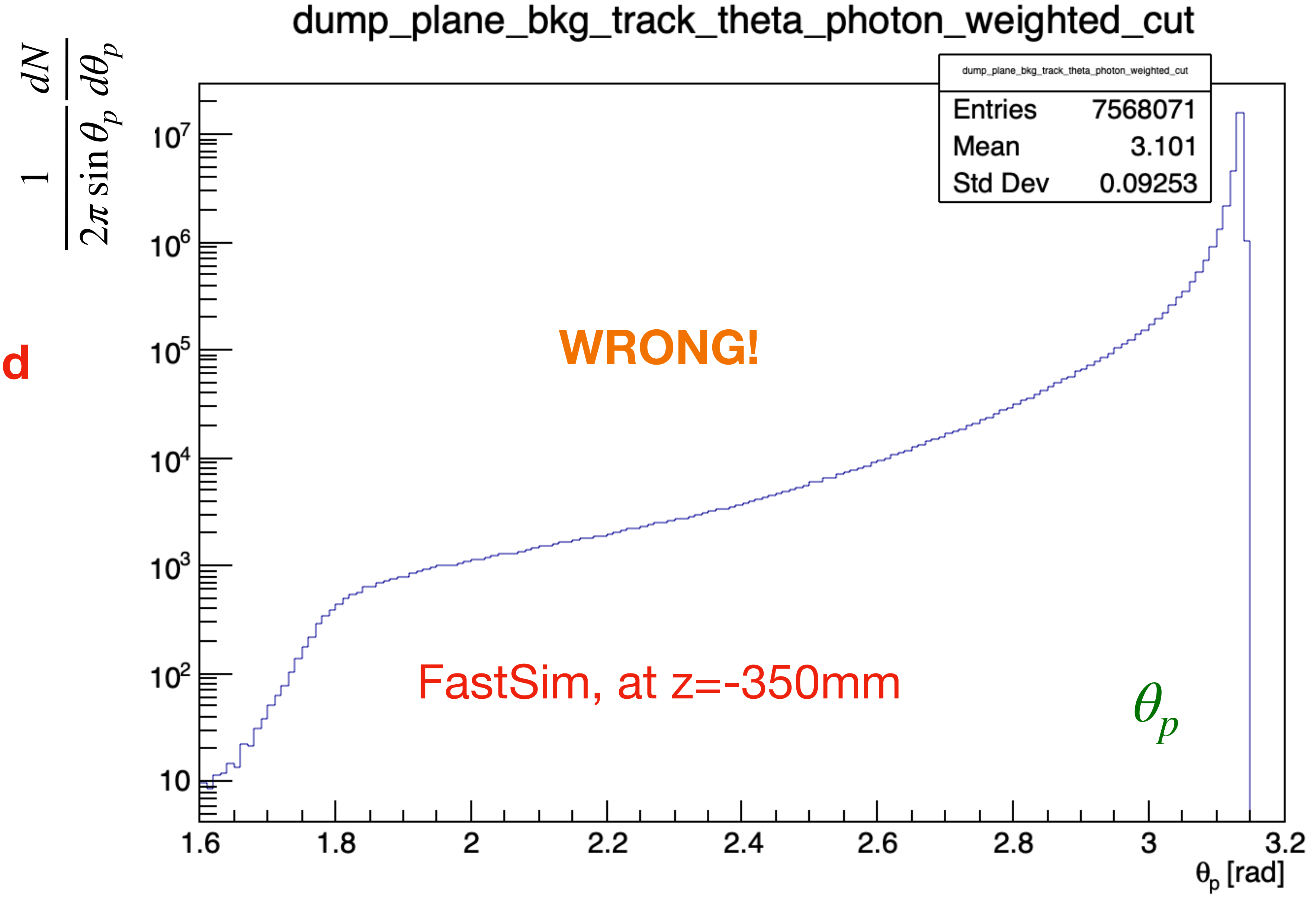
Starting point of simulation, -0.35m

FullSim, falls as~1/r^2



FullSim, at z=-350mm

θ_p



WRONG!

FastSim, at z=-350mm

θ_p

FastSim samples are more focused than FullSim samples

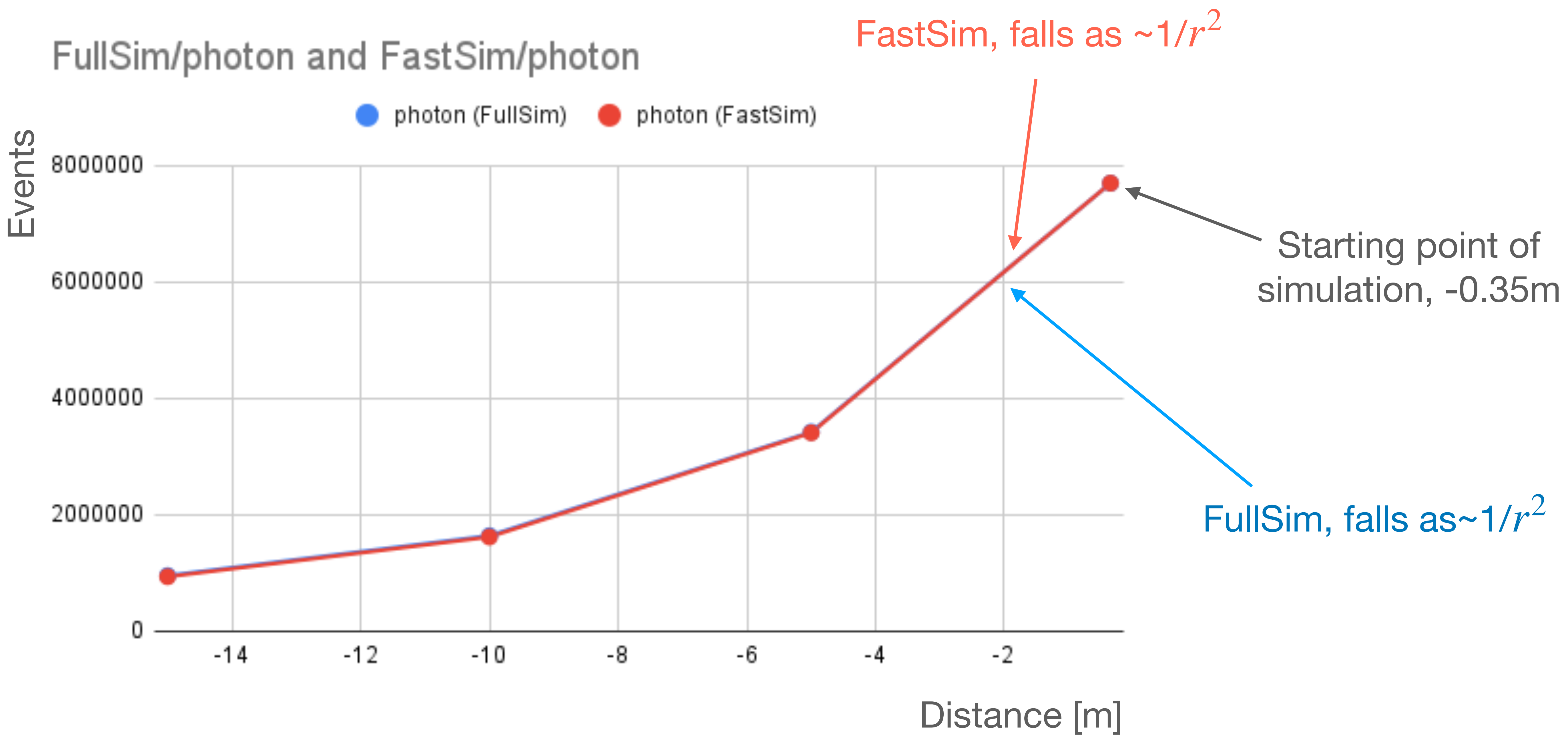
★The reason is that we used phase space weight to prepare the correlation plot of $r \ vs \ \theta_p$.

★The phase space weight was $\frac{1}{2\pi r} \times \frac{1}{2\pi \sin\theta_p}$

★We removed this weight before randomly drawing r and θ_p

Slide from August 15

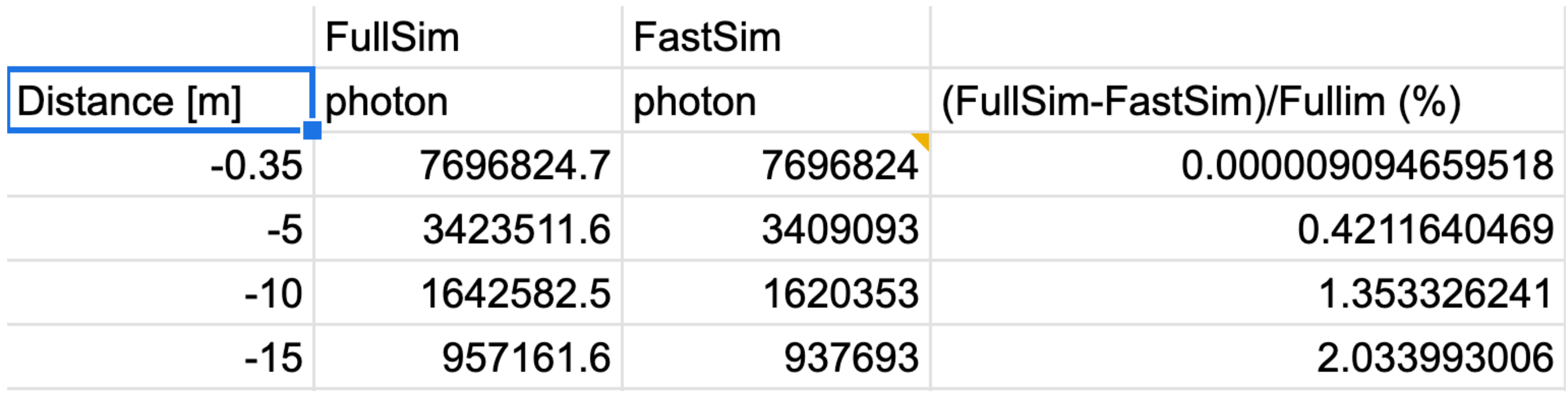
Fixing the Issue with the normalization: photon



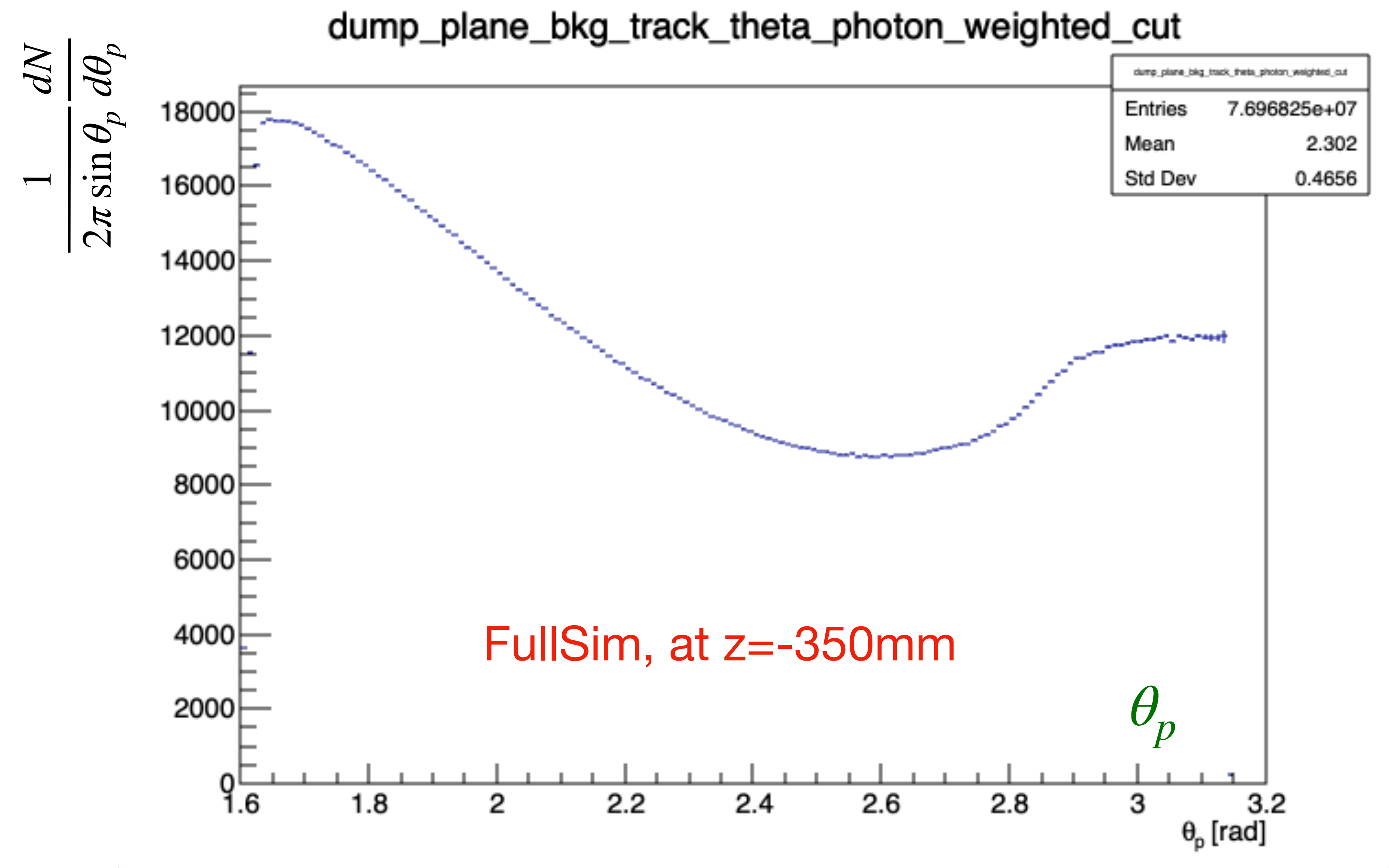
FastSim, falls as ~$1/r^2$

Starting point of simulation, -0.35m

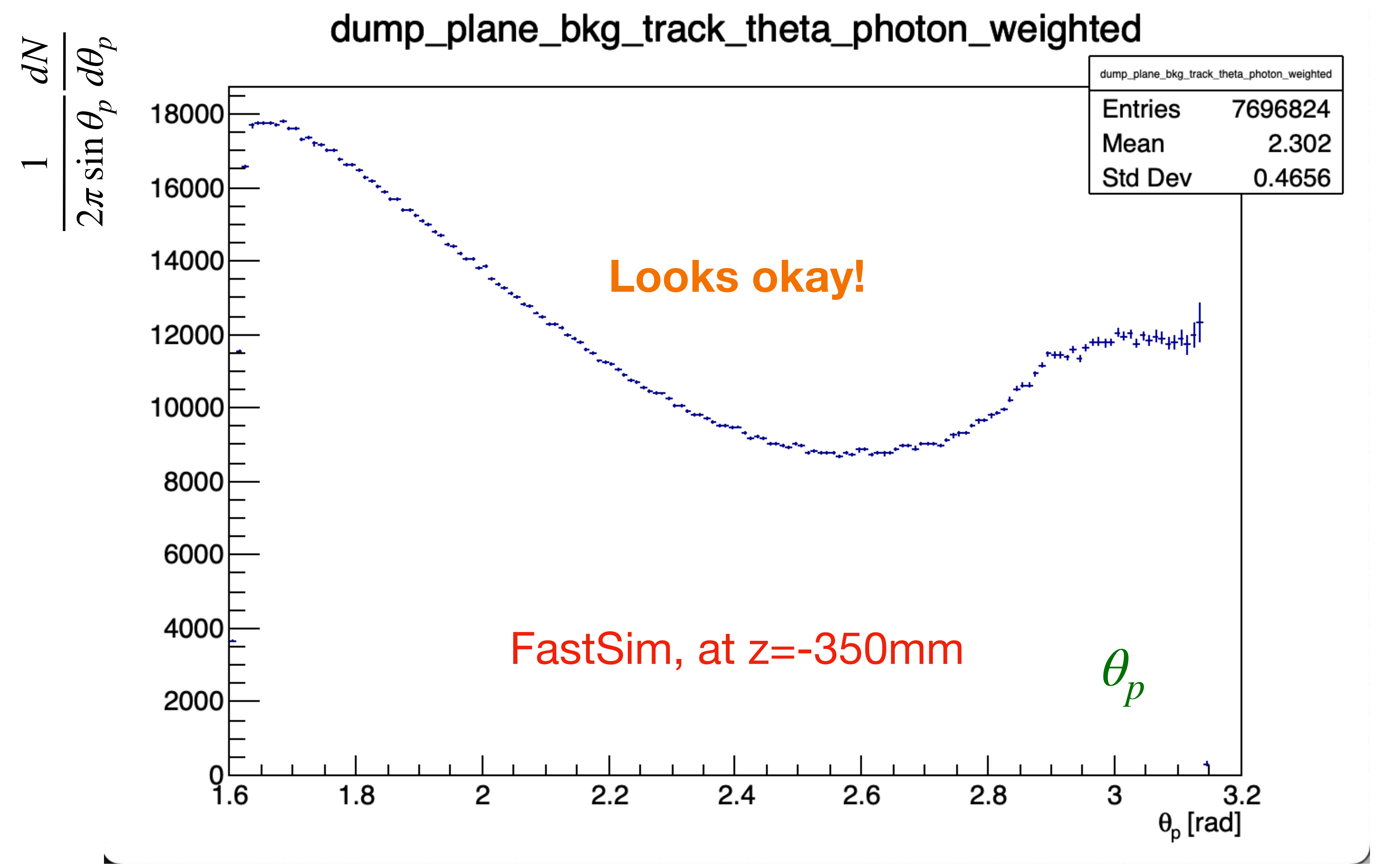
FullSim, falls as~$1/r^2$



	FullSim	FastSim	
Distance [m]	photon	photon	(FullSim-FastSim)/Fullim (%)
-0.35	7696824.7	7696824	0.000009094659518
-5	3423511.6	3409093	0.4211640469
-10	1642582.5	1620353	1.353326241
-15	957161.6	937693	2.033993006



FullSim, at z=-350mm

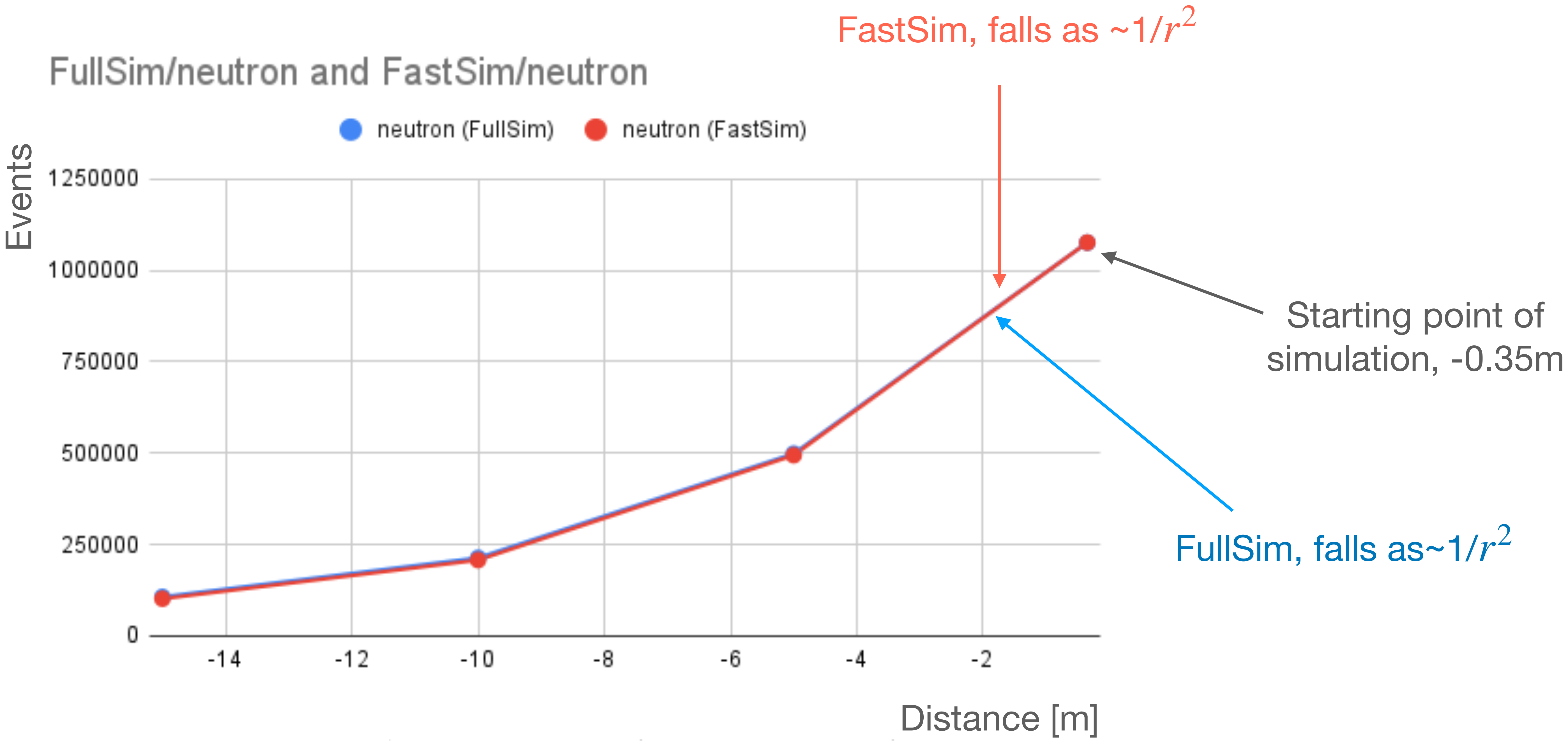


Looks okay!

FastSim, at z=-350mm

★The momentum azimuthal angle distribution looks similar between FastSim and FullSim.
★The photon normalization looks okay at different z

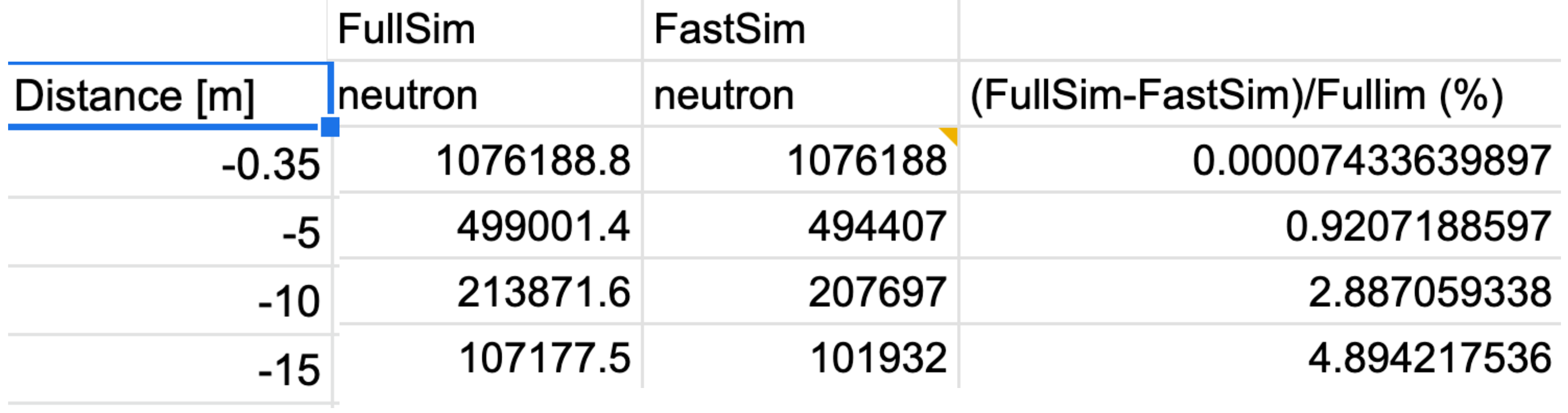
Fixing the Issue with the normalization: neutron



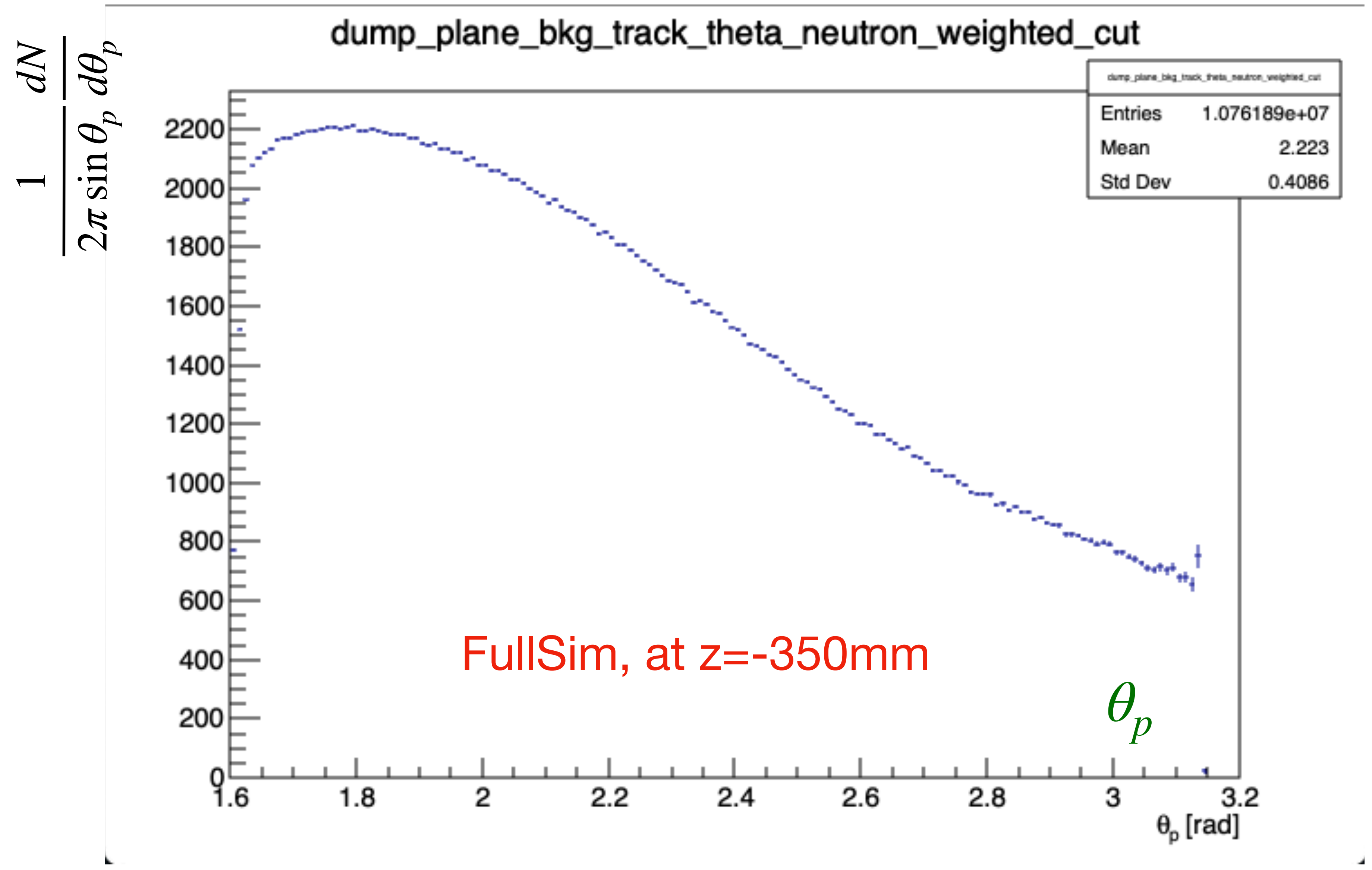
FastSim, falls as ~$1/r^2$

Starting point of simulation, -0.35m

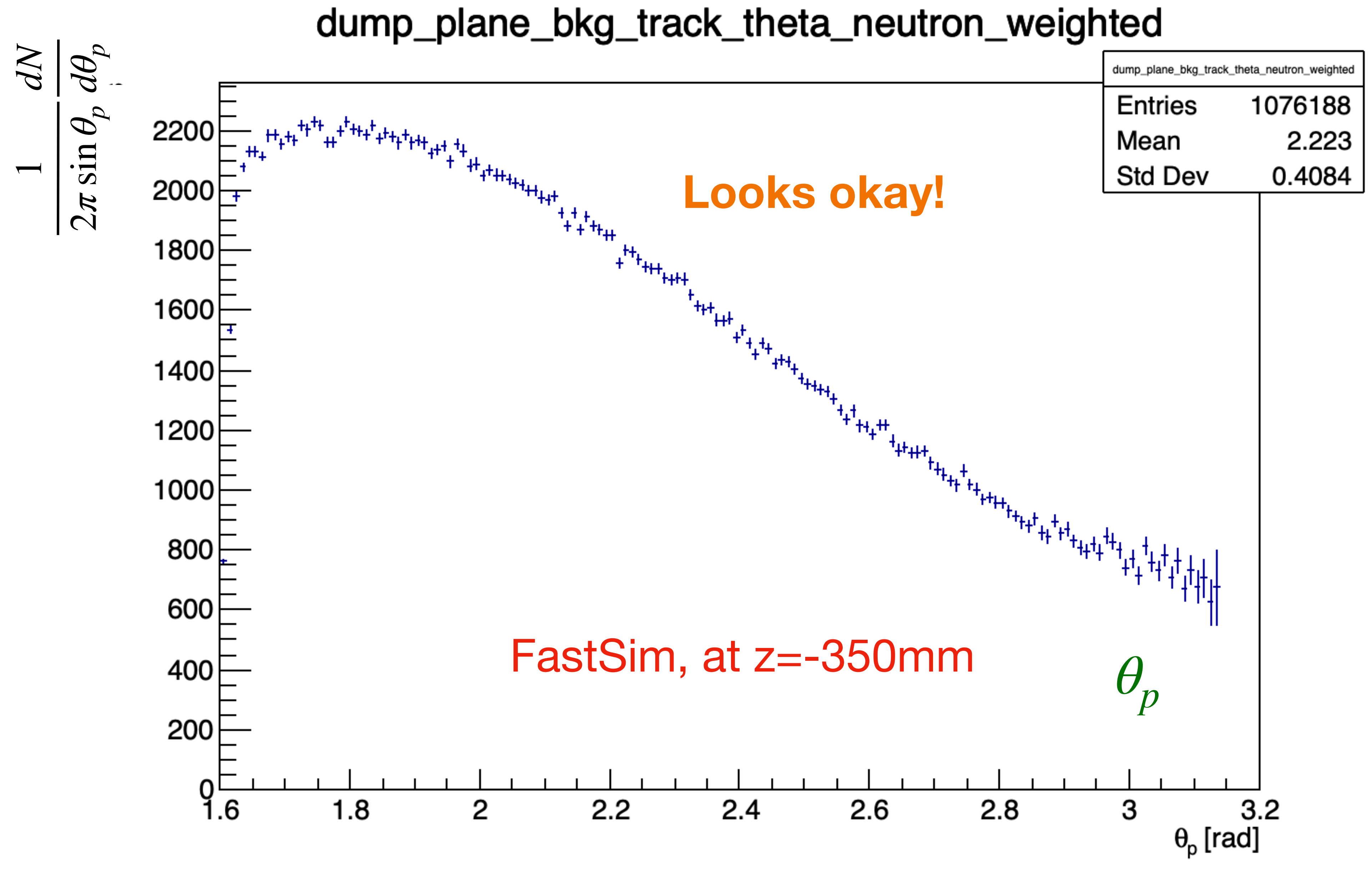
FullSim, falls as~$1/r^2$



	FullSim	FastSim	
Distance [m]	neutron	neutron	(FullSim-FastSim)/Fullim (%)
-0.35	1076188.8	1076188	0.00007433639897
-5	499001.4	494407	0.9207188597
-10	213871.6	207697	2.887059338
-15	107177.5	101932	4.894217536



FullSim, at z=-350mm



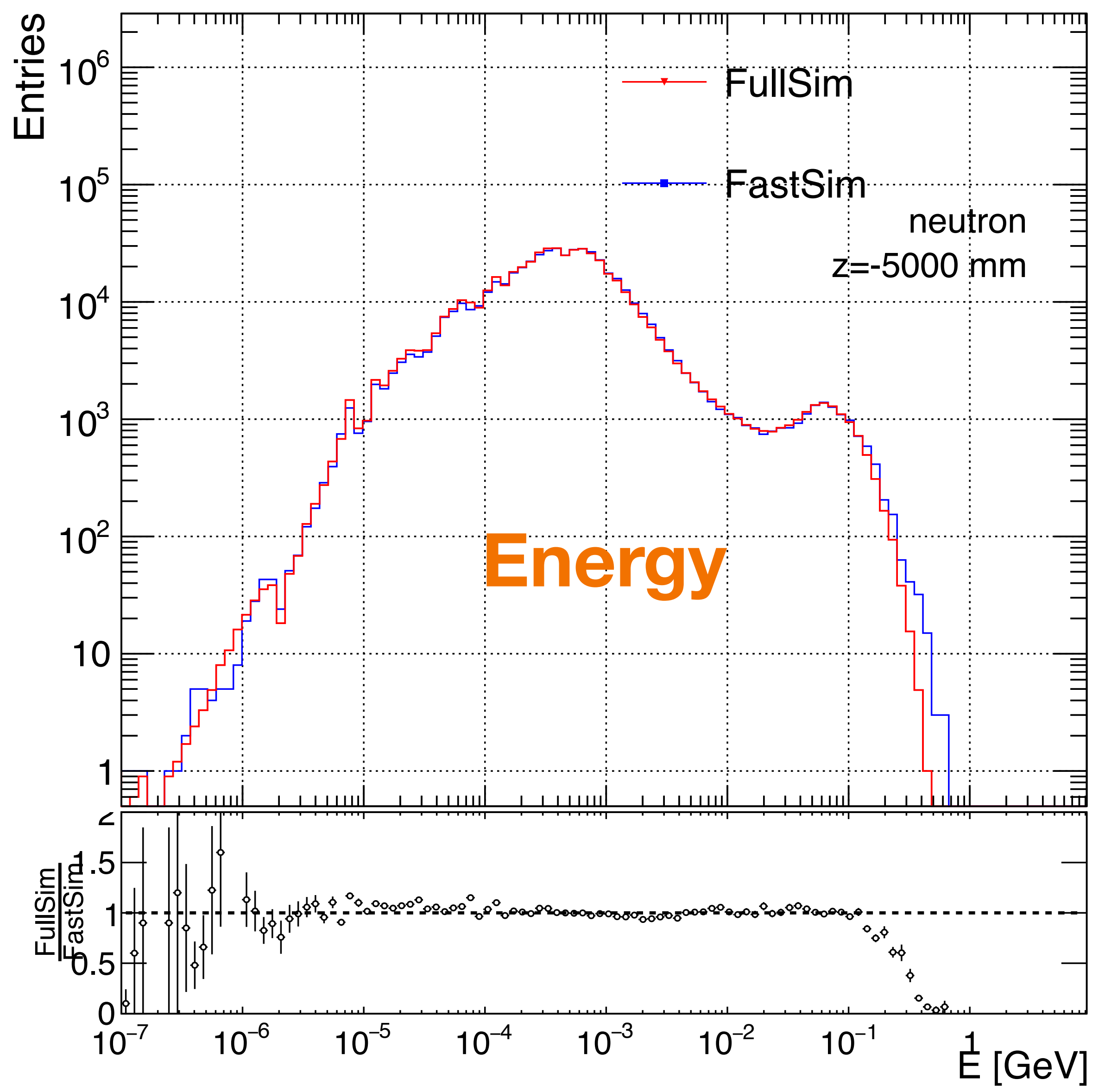
Looks okay!

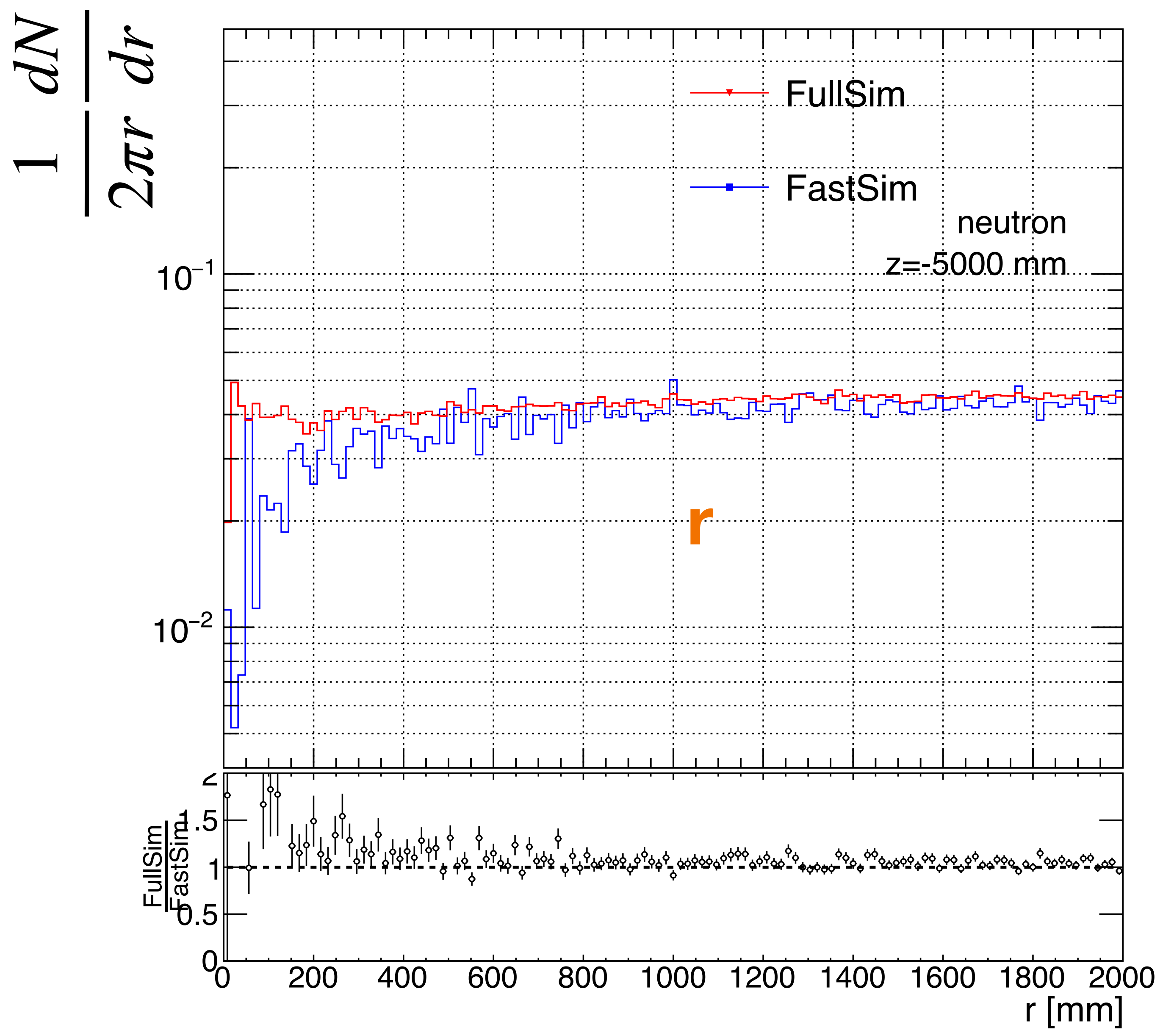
FastSim, at z=-350mm

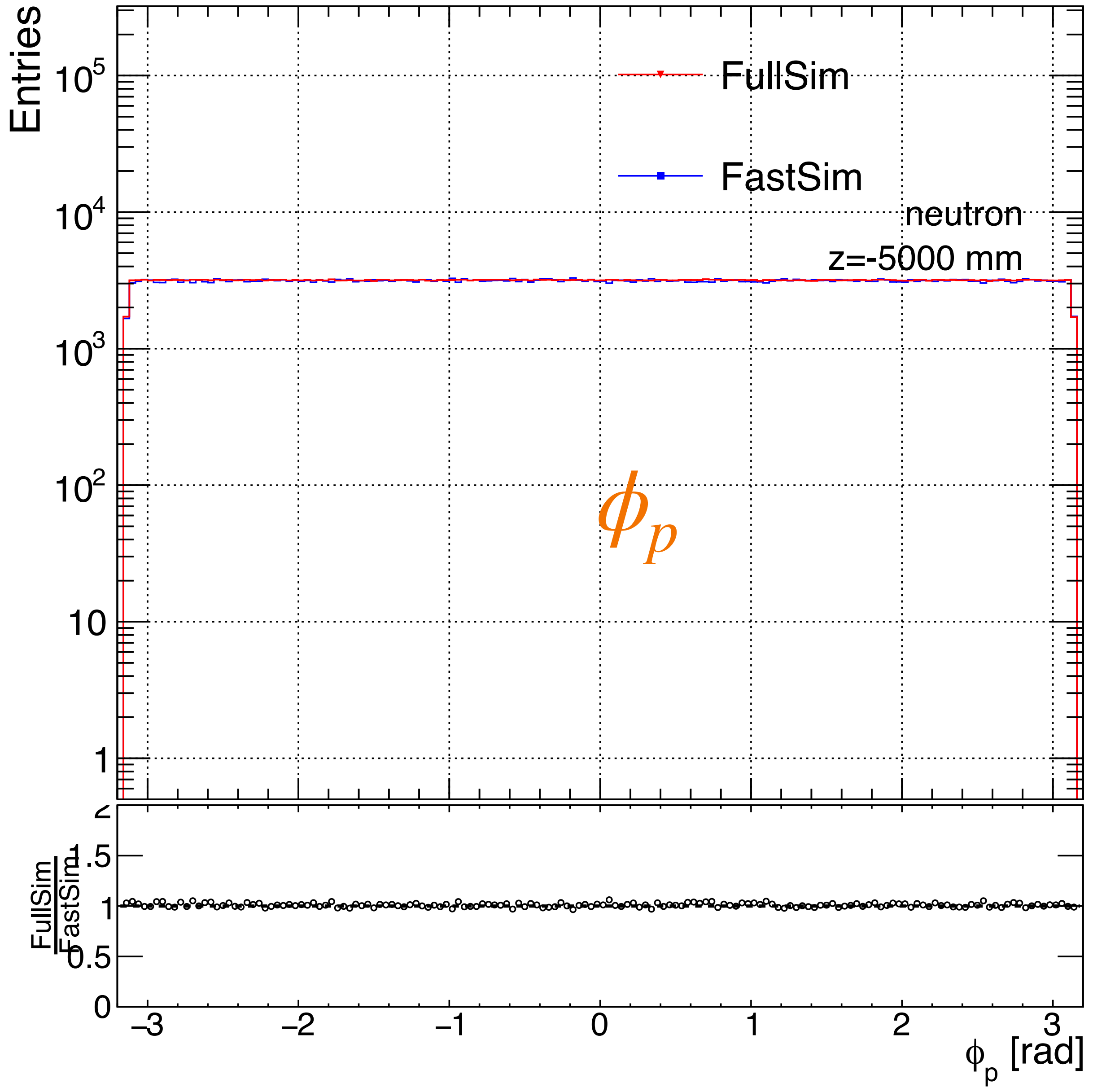
★The momentum azimuthal angle distribution looks similar between FastSim and FullSim.

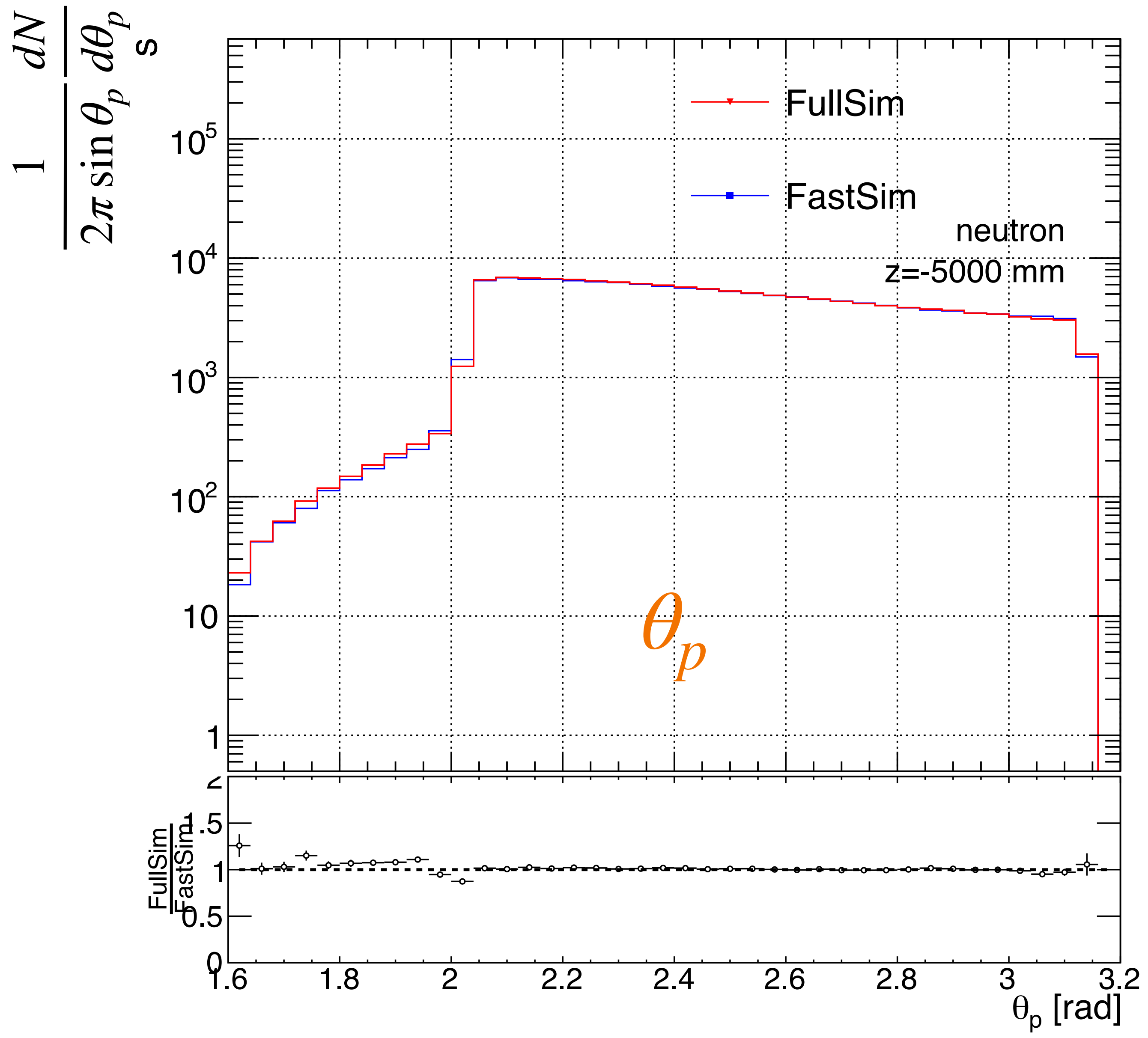
★The neutron normalization looks okay at different z

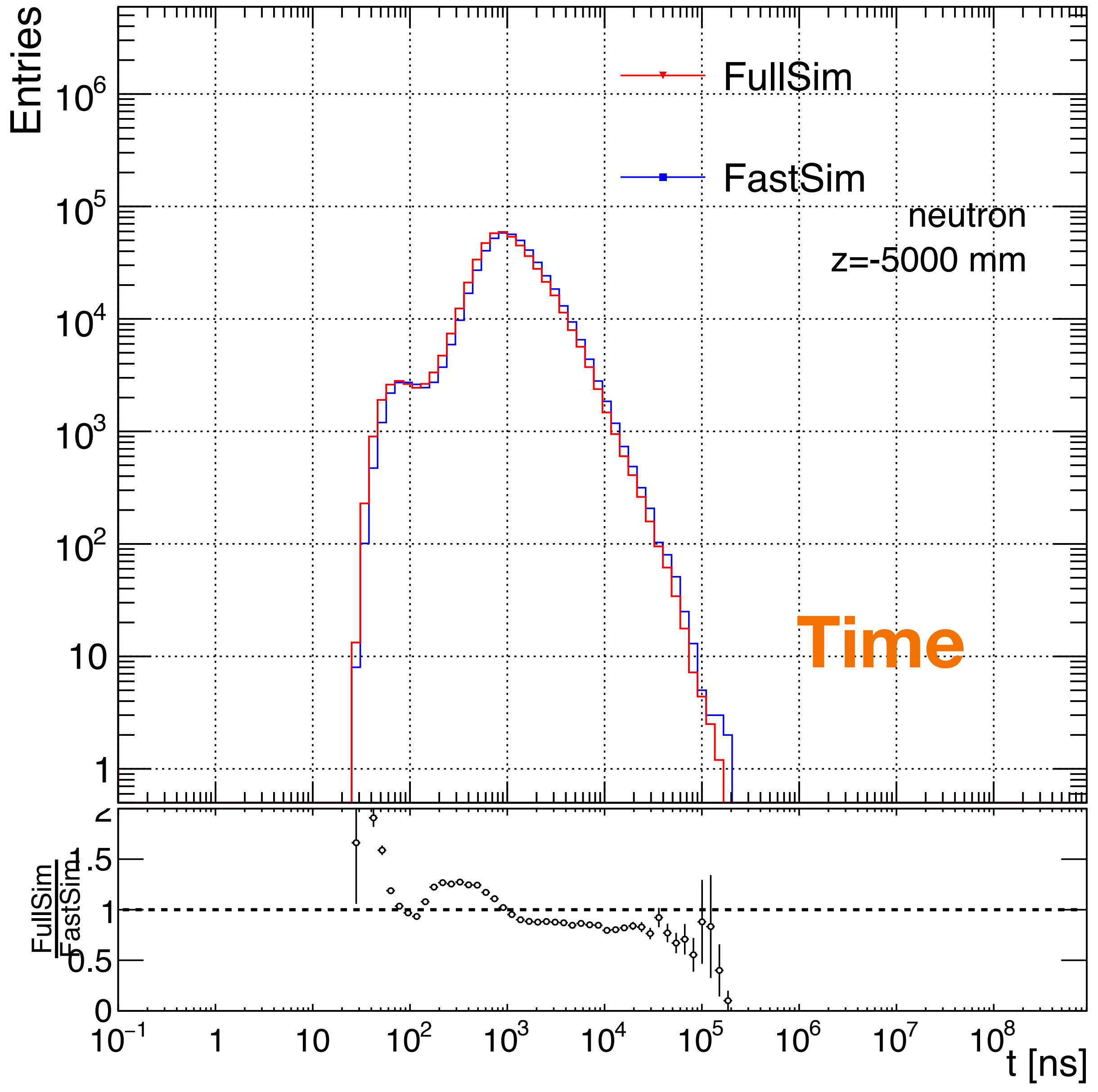
A few 1D distributions between FastSim and FullSim: neutron





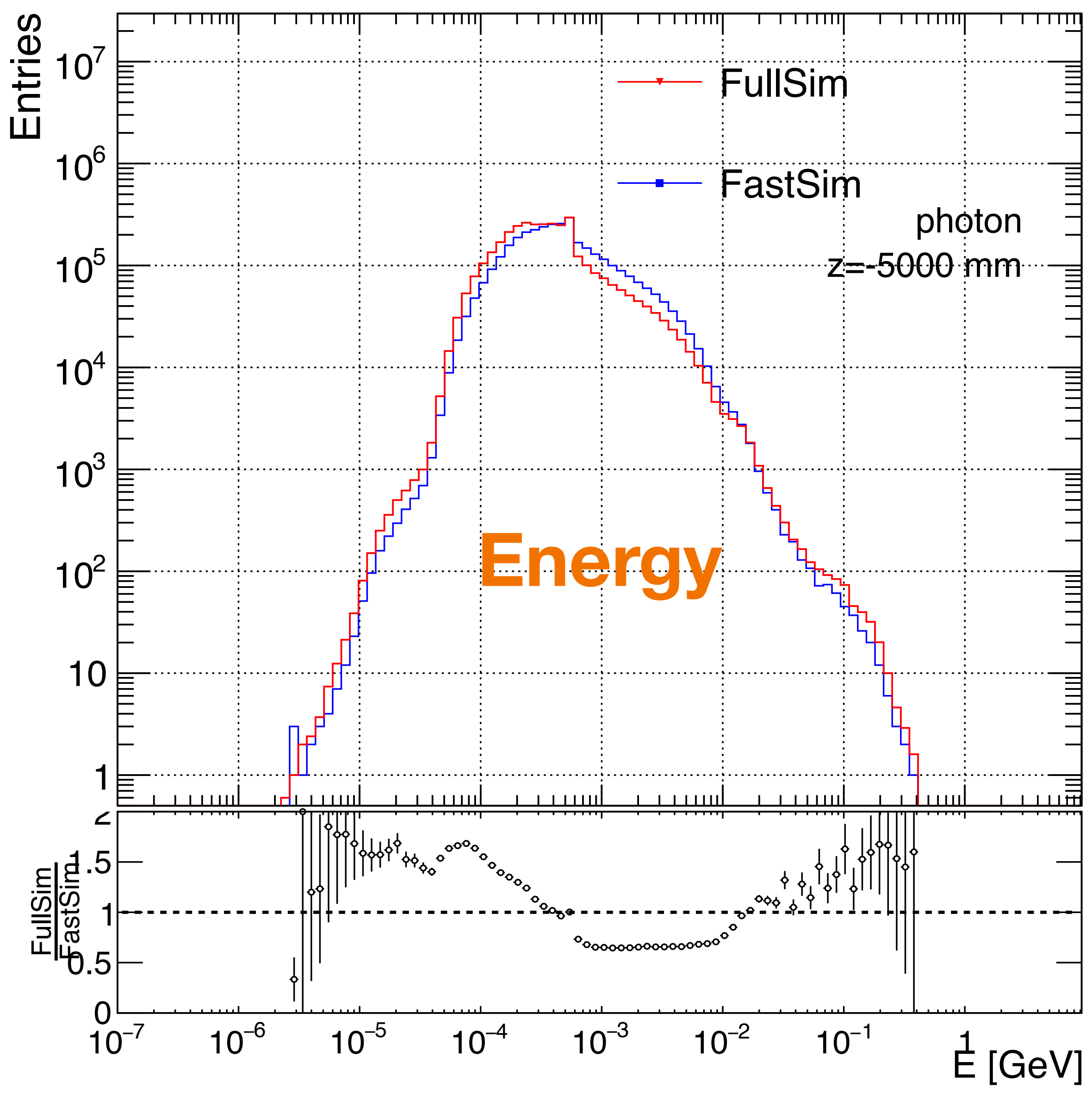


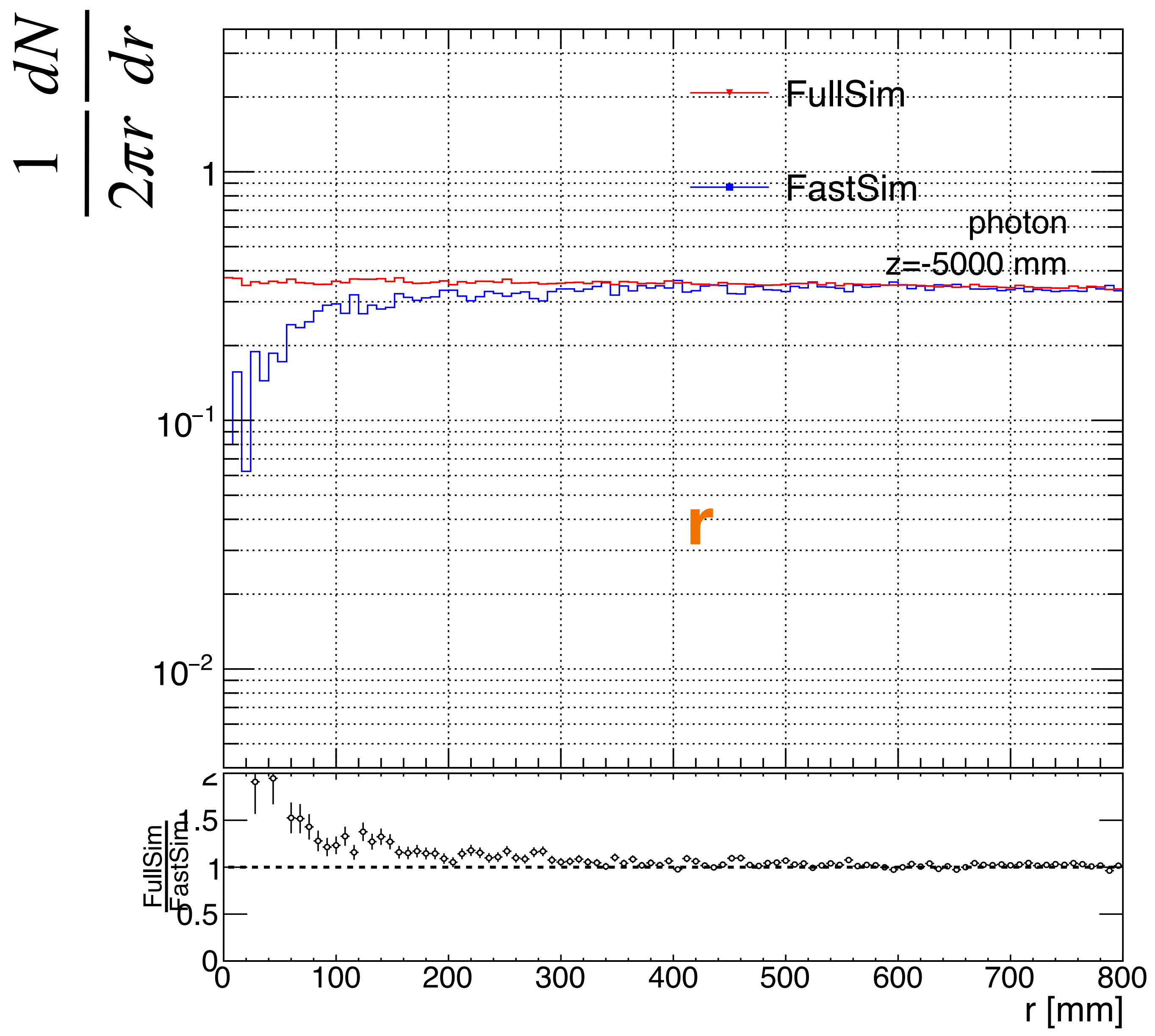


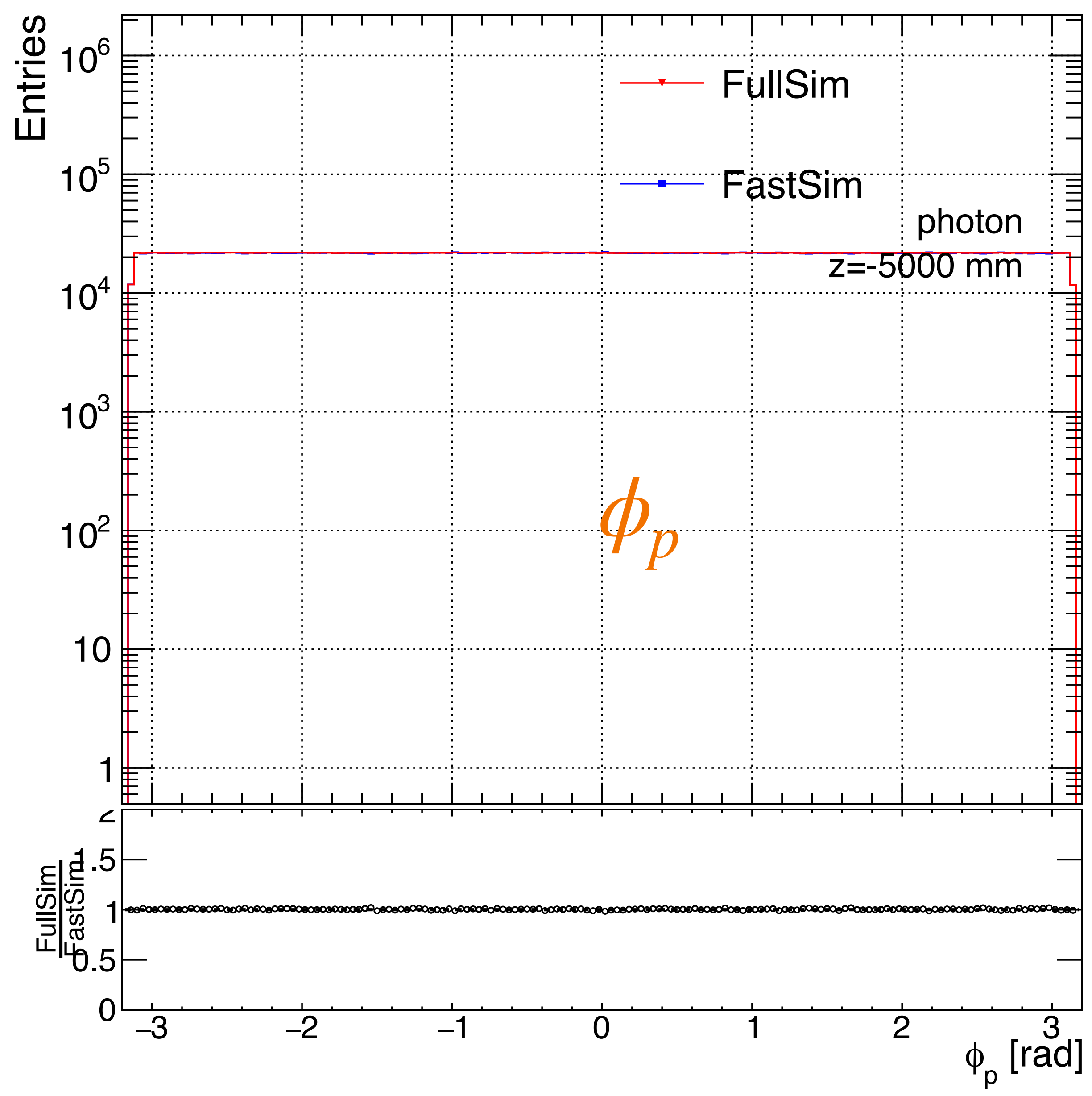


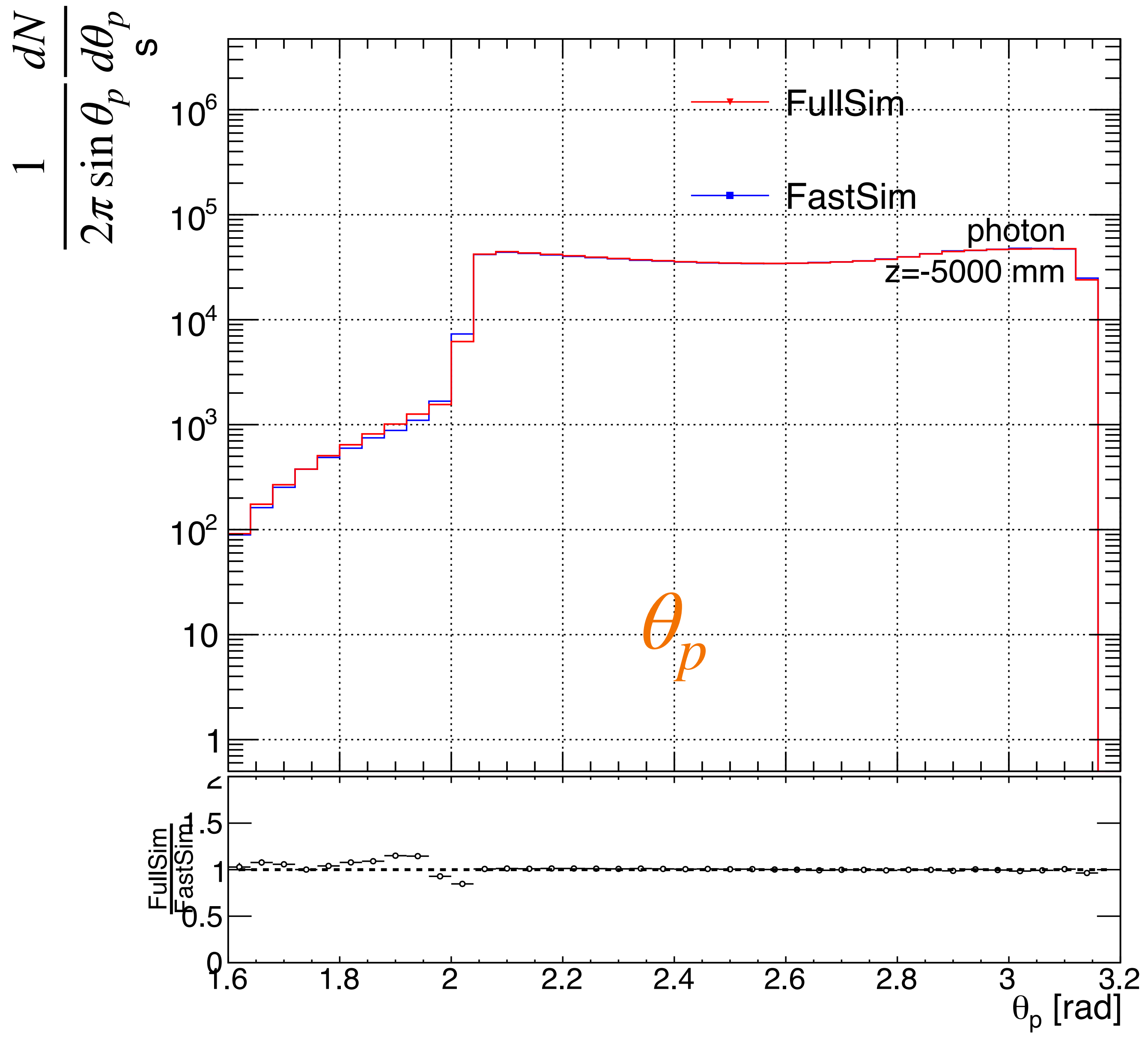
★Distributions are looked at **z=-5000mm**.
★FullSim has 10 times more statistics (for now).
★FullSim and FastSim distributions are comparable.

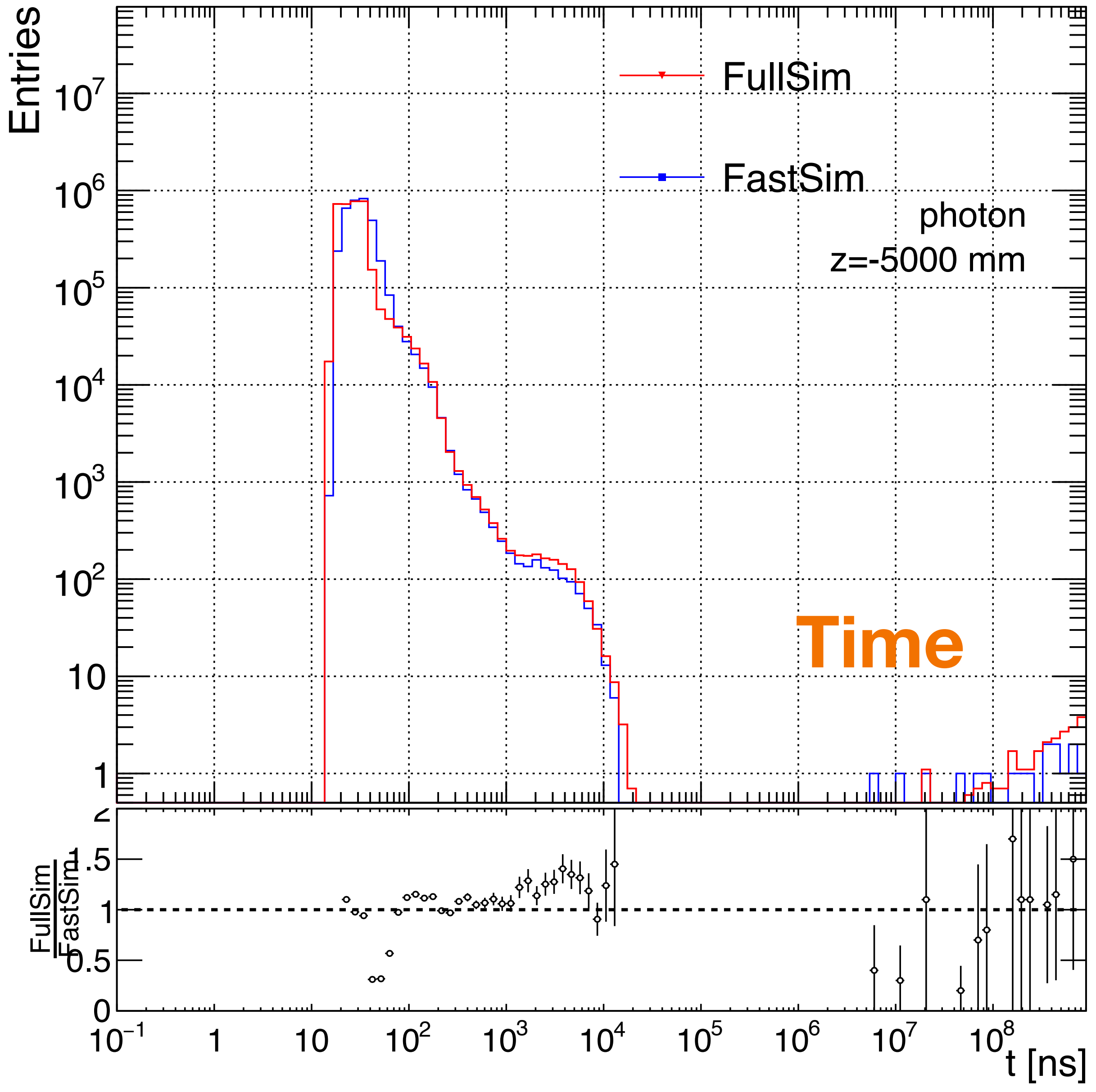
A few 1D distributions between FastSim and FullSim: photon











★Distributions are looked at **z=-5000mm**.

★FullSim has 10 times more statistics (for now).

★FullSim and FastSim distributions are comparable.

Summary and next steps:

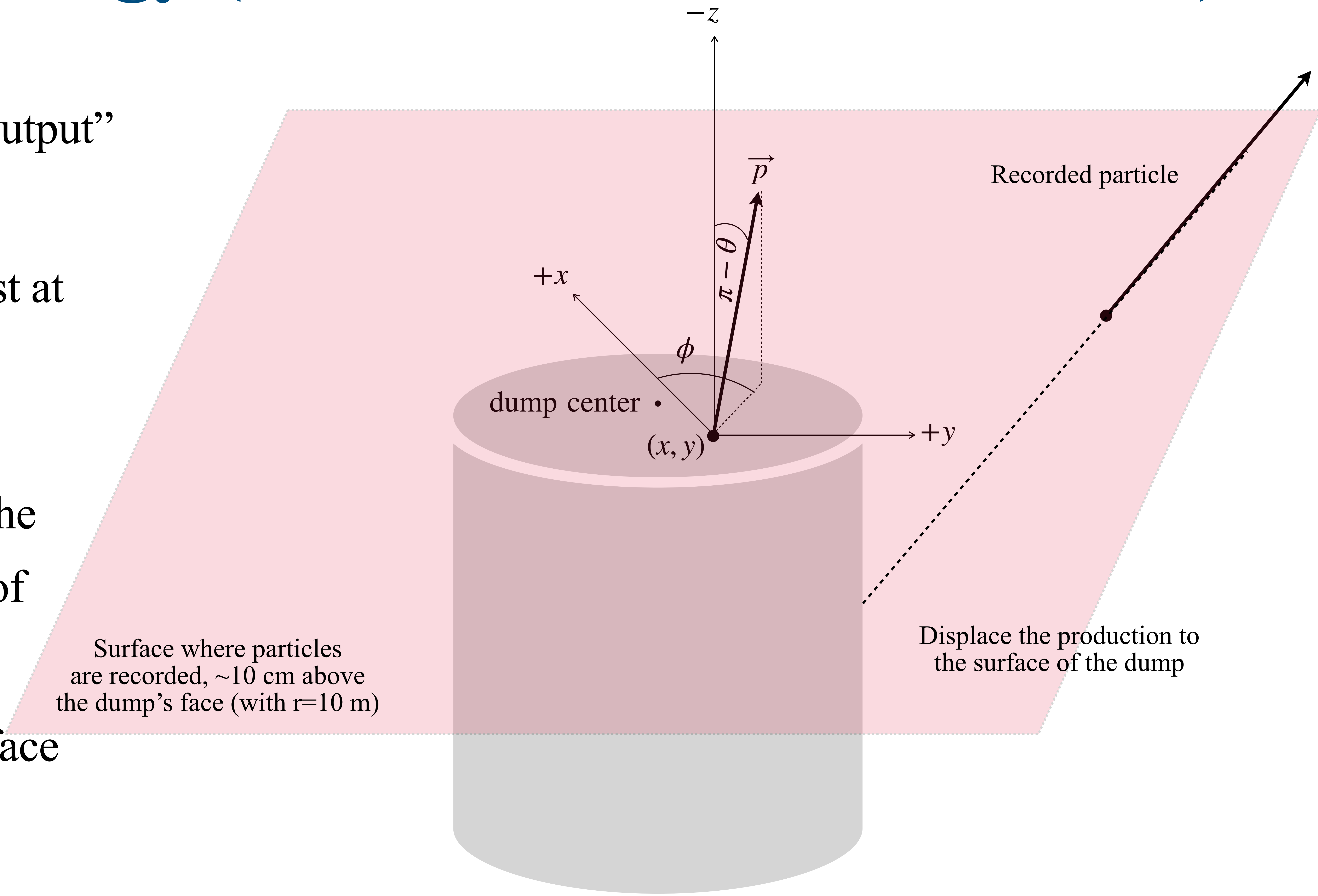
- Normalization issue with FastSim is solved.
    - Distributions between FastSim and FullSim are now comparable at different distances.
        - Shown z=-5000 mm here, but no showstopper in z=-10000 mm and z=-15000 mm.
        - Distributions at z=-350 mm is similar by construction.
- Time is generated from the FullSim t vs E correlation plot for neutron
- Time is generated from 1D FullSim time distribution for photon
    - No upper cap on time.
- Next steps:
    - Translate from simple dump only geometry to LUXE dump geometry.
    - Produce FastSim LUXE Background sample.

Back up

Fast simulation strategy (Sasha, Arka, Shan & Noam)

- Disable the dump and replace all its “output” by source-like particles

- Look at the dummy volume located just at the surface of the dump
  - Arka will plot $\frac{dN}{dE}, \frac{d^2N}{drd\theta_\mathrm{p}}$
    - r is just $\sqrt{x^2+y^2}$ and θ_p, ϕ_p is the polar angle and azimuthal angle of momentum-> representative of direction of the particle.
  - Later: generate from the dump surface according to these plots



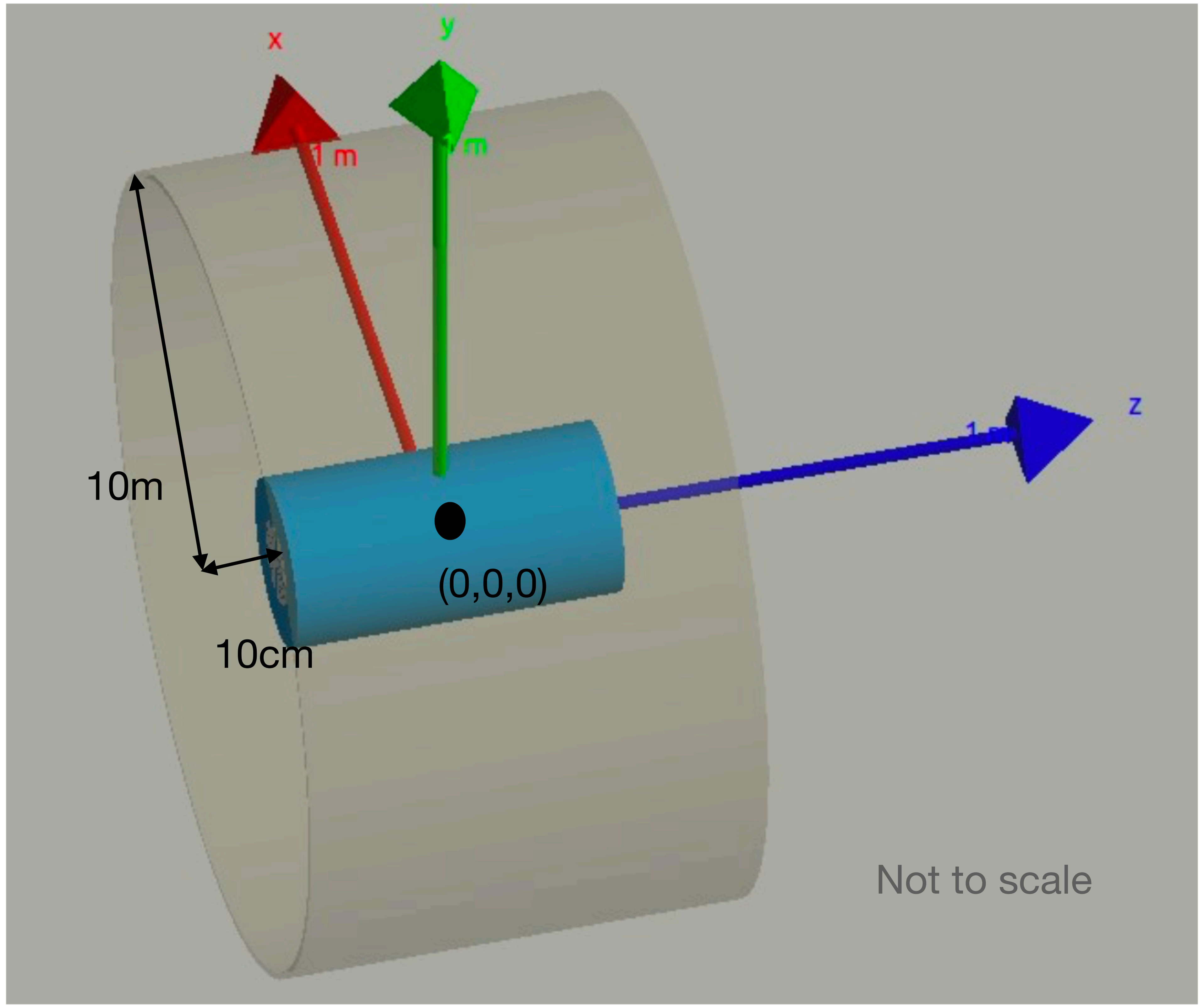
Surface where particles are recorded, ~10 cm above the dump’s face (with r=10 m)

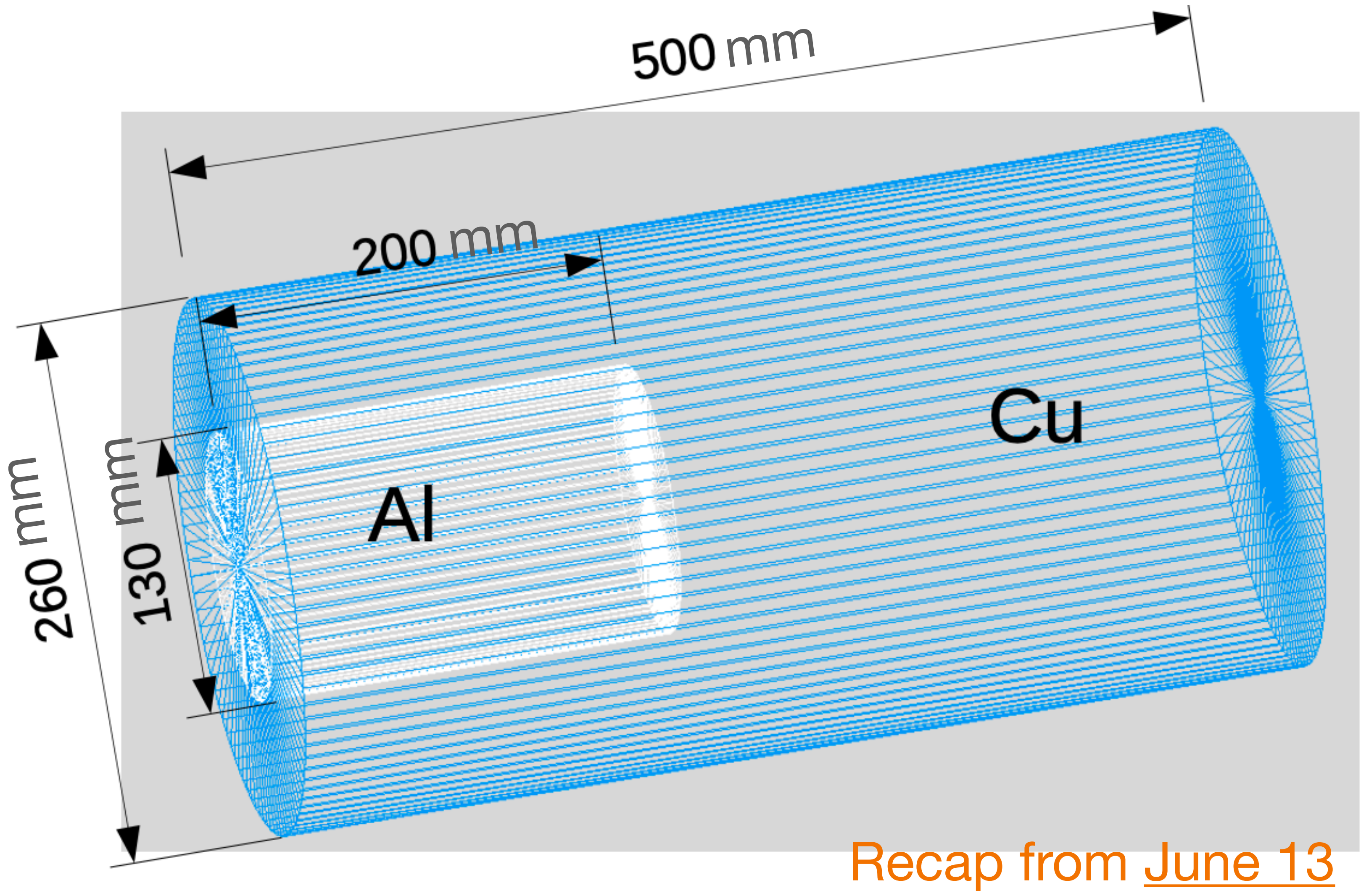
Displace the production to the surface of the dump

Recap from June 13

Simulation for dump only geometry:

- Sasha produced 10BX of dump only simulation
- Electron beam of 16.5 GeV directly hitting the dump
- Dump is made of Aluminum and Copper
  - The origin is at the center of the dump.
  - The face of the dump is at z = -250mm
- The surface which records particles is at z=-350mm, 100 mm away from dump face.
- Previous discussion was here.





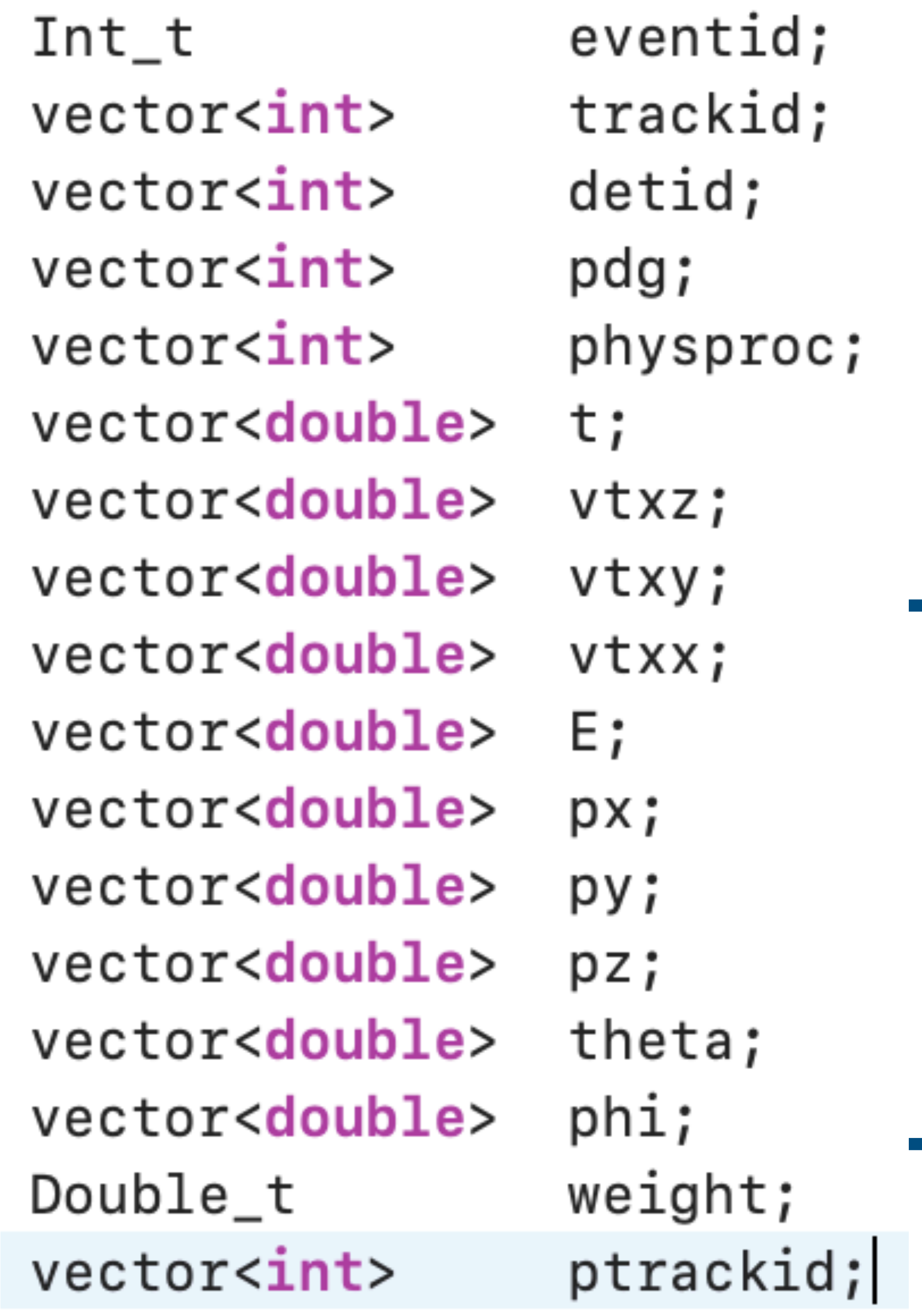
Recap from June 13

Input tree for Geant4 simulation

- Putting the distributions in tree branches for Geant4 input

- The name of the branches are same as the Tracks tree used by Sasha

  - Branch details:



```
Int_t            eventid;
vector<int>      trackid;
vector<int>      detid;
vector<int>      pdg;
vector<int>      physproc;
vector<double>   t;
vector<double>   vtxz;
vector<double>   vtxy;
vector<double>   vtxx;
vector<double>   E;
vector<double>   px;
vector<double>   py;
vector<double>   pz;
vector<double>   theta;
vector<double>   phi;
Double_t         weight;
vector<int>      ptrackid;
```

For photons and neutrons, track id from 0 to number of generated particles.

detid==-10 —> assignment to particles randomly generated from dump distributions

physproc==7000 for particles randomly generated from dump distributions.

Uniformly generated from 0 to 1000 ns

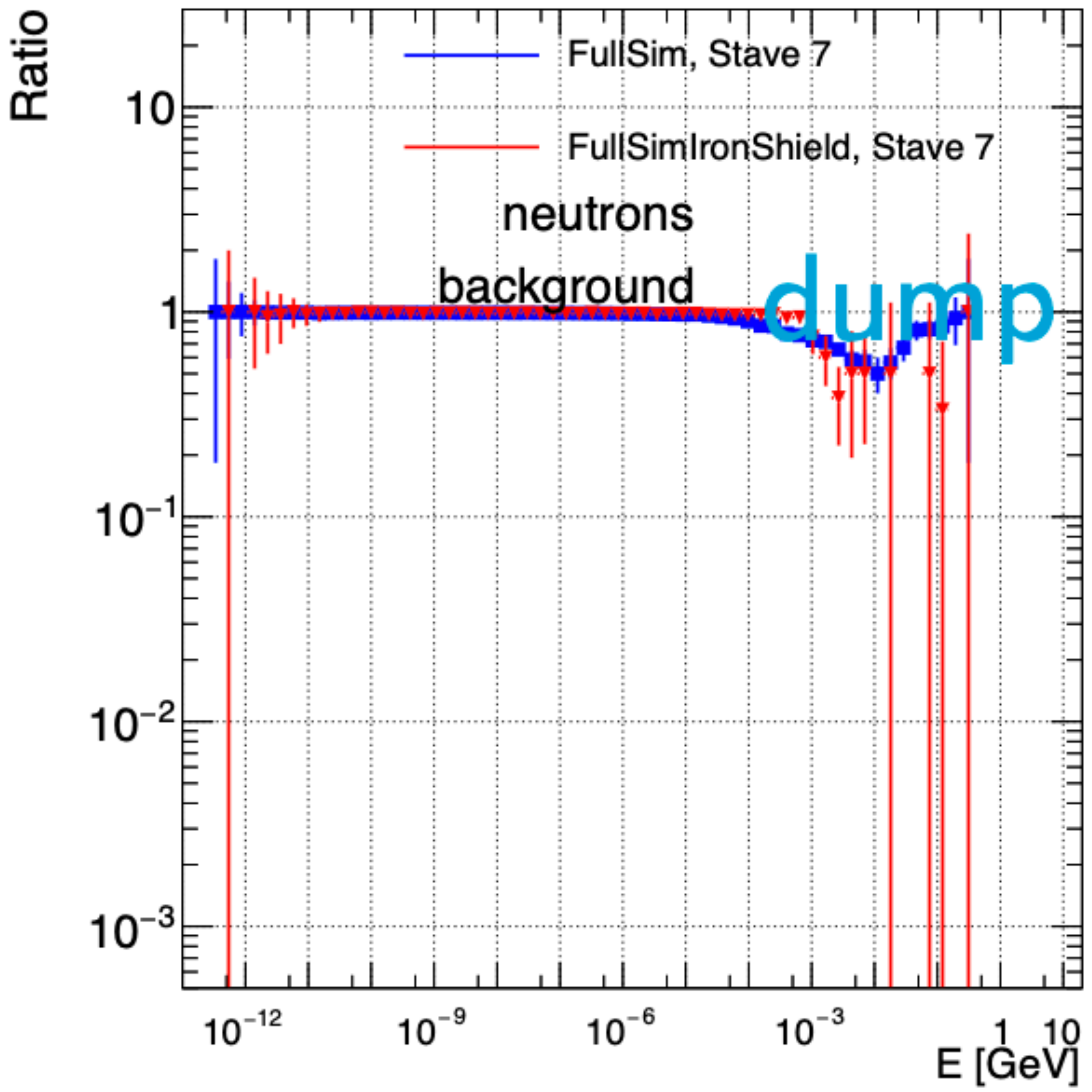
Constant at the dump surface

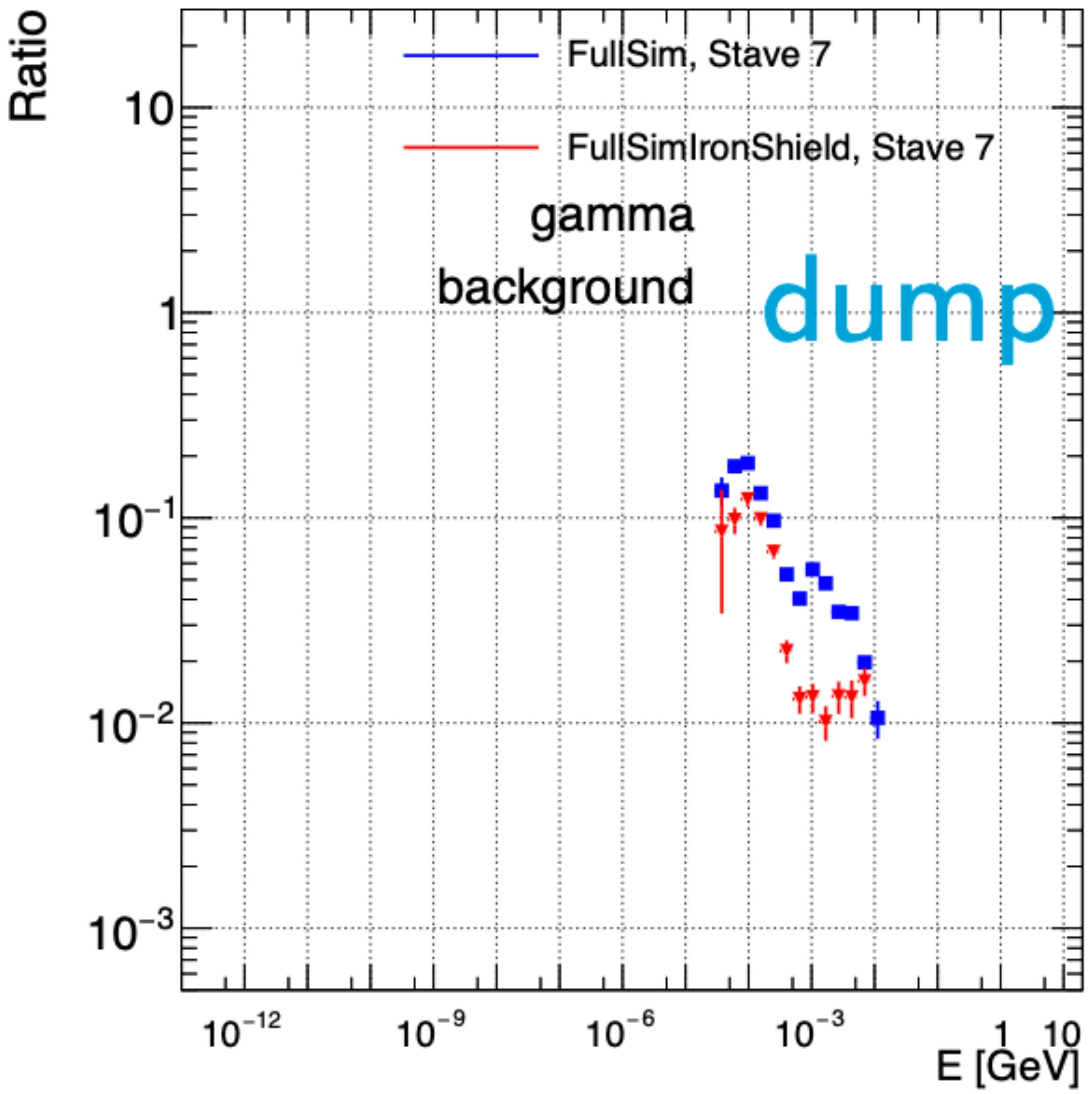
Randomly generated from dump distributions

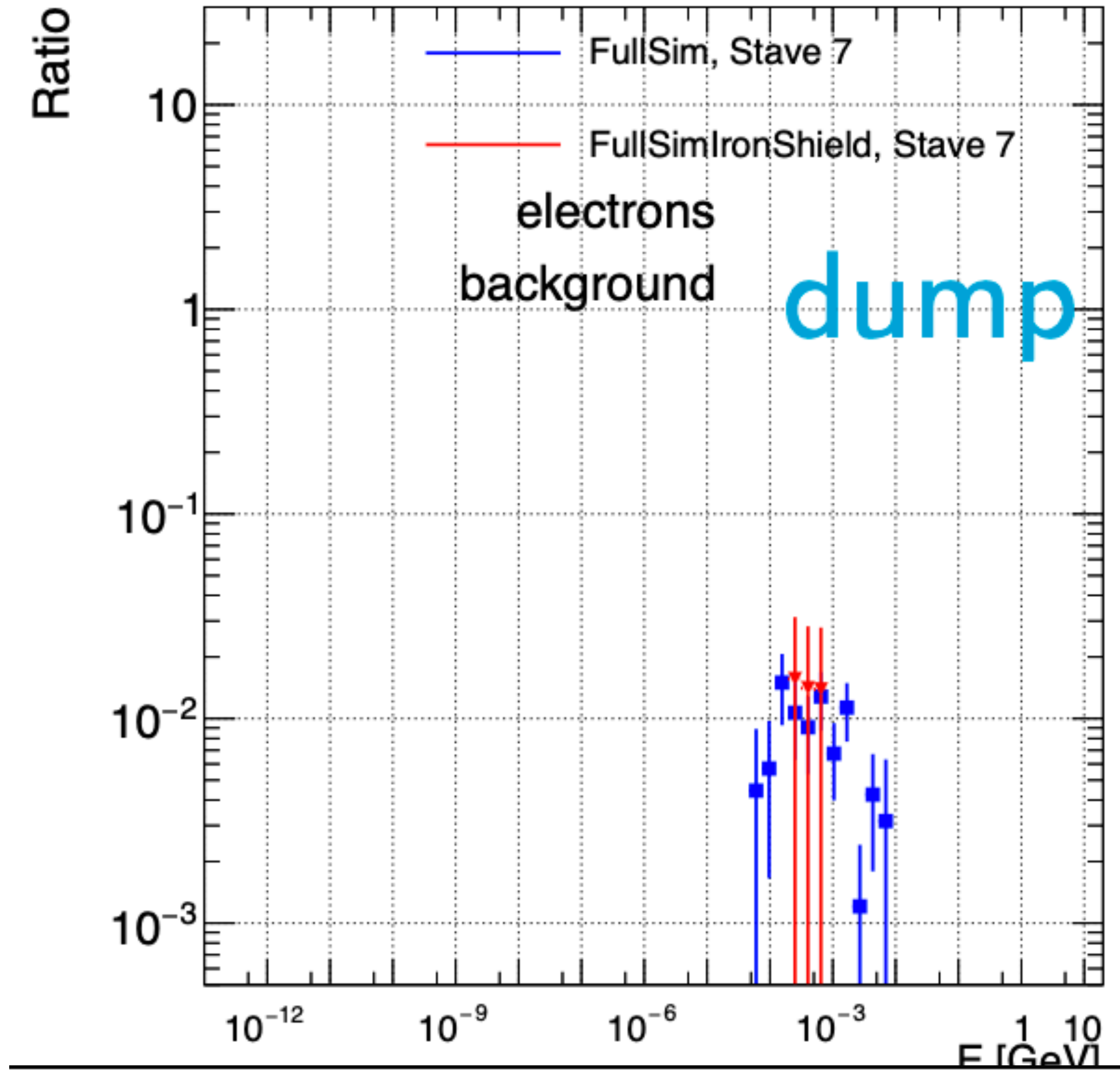
weight==1, for background particles

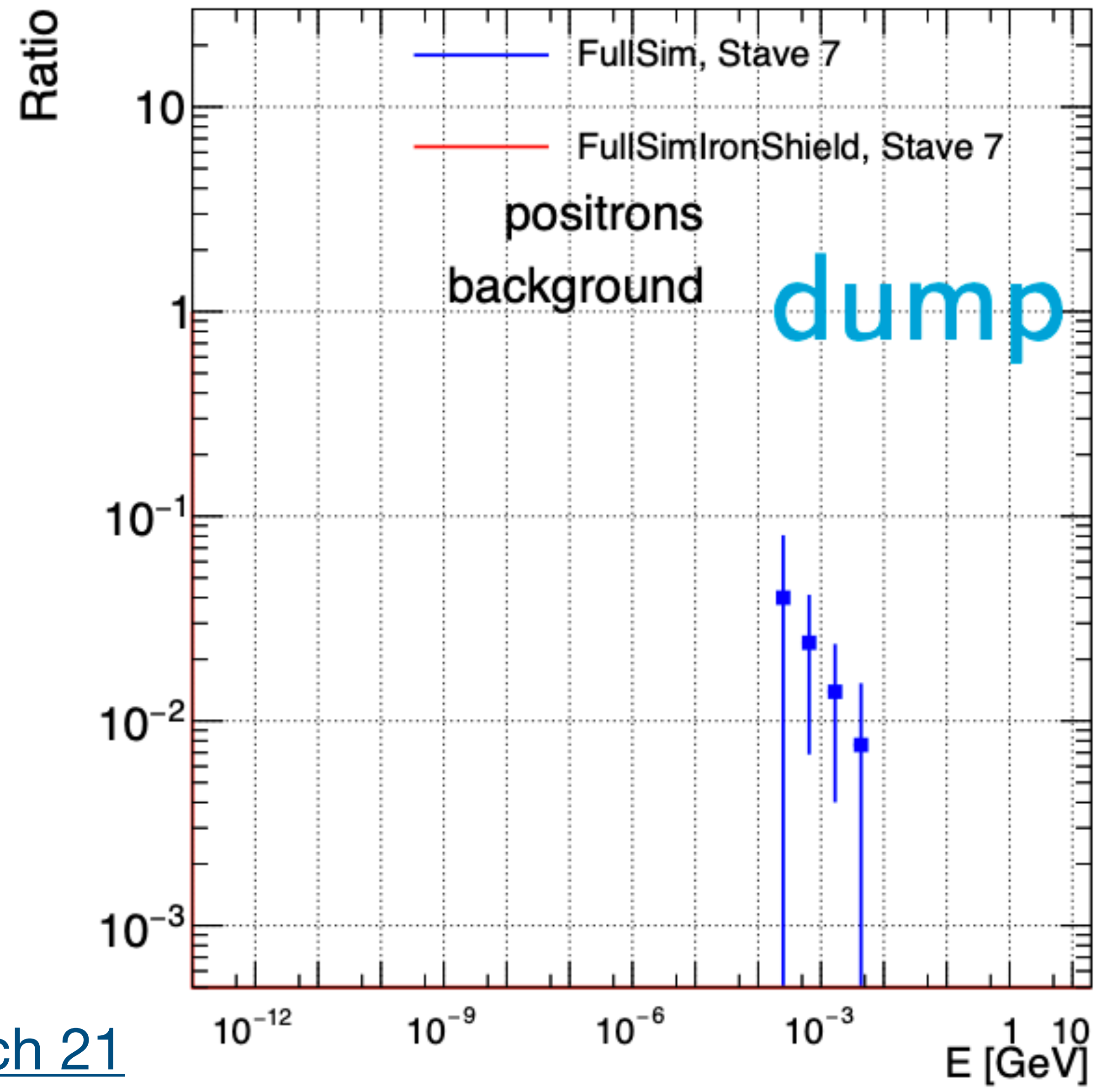
ptrackid==-10 —> assignment to particles randomly generated from dump distributions

Different particles generated from dump:









Y-axis is ratio of particle coming from dump over all the sources to the tracker last layer.

- ★At the tracker last layer
  - ★100% of the neutron come from dump
  - ★>10% of the photons come from dump
  - ★~1% of the electrons and positrons from the dump

Plots shown on March 21