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U.S. DEPARTMENT OF ENERGY
Office of Science

ZDC Acceptance Studies

Tyler Hague
LBNL

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RNC EIC Meeting

Outline

- ZDC Studies for neutron tagging of e+p->e+n+pi$^+$
  - Investigation of low efficiency in 5x41 GeV events
  - First a look at angular efficiency
    - Where did the neutrons go?!
  - A look at energy efficiency

Part 1
First Study
Neutrons generated according to $e+p \to e+n+\pi^+$ kinematics

Generator Properties

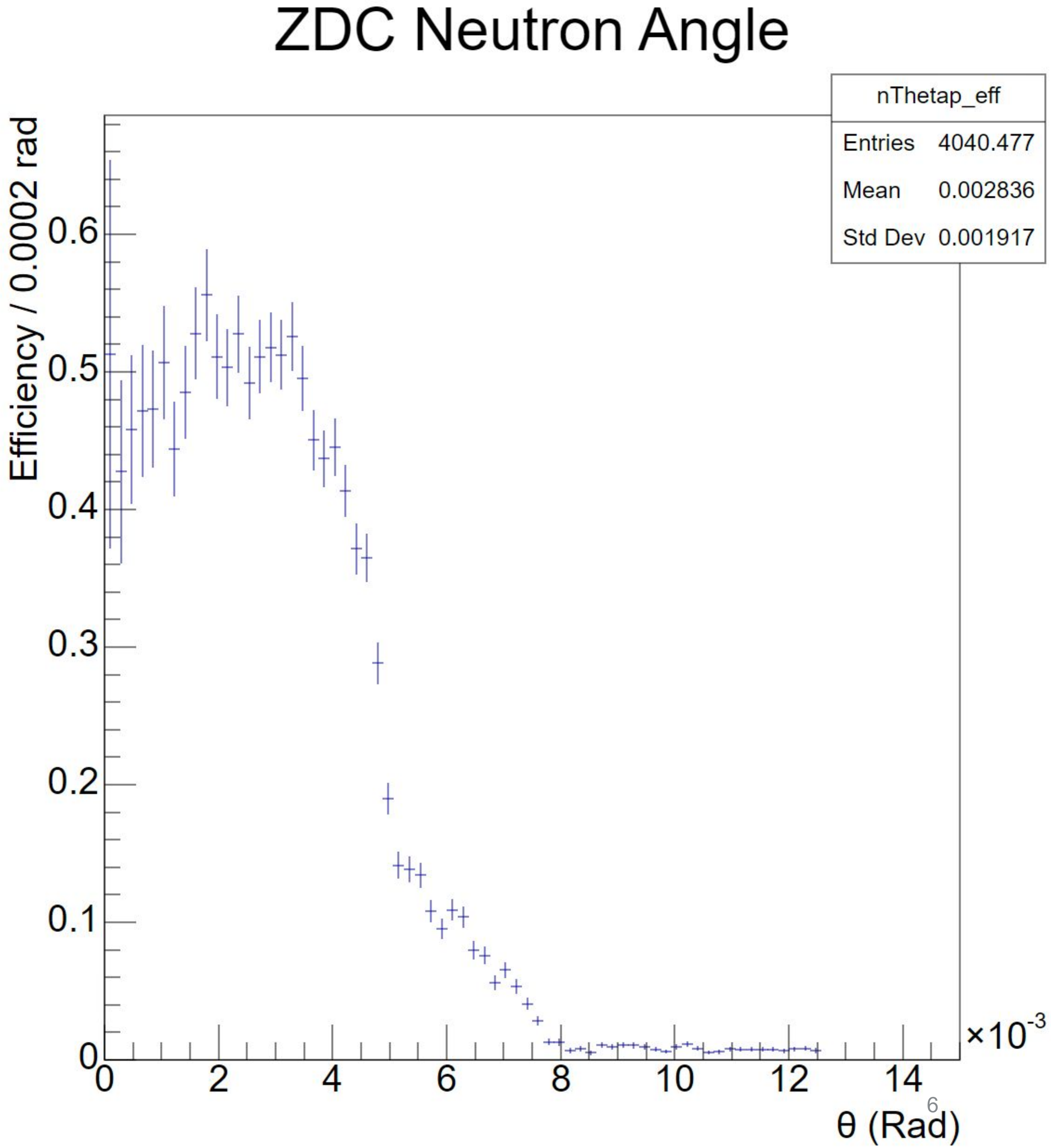
- Only throws the neutron, ensures it matches physical kinematics
  - No cross-section weighting
- Cuts
  - $0 < -t < 1$ GeV^2
  - 0 < theta < 13.5 mrad (later reduced to 8.5 mrad)
    - Defined with respect to proton beam axis (center of ZDC)

I wrote a generator that only produces the neutrons in order to investigate the neutron acceptance since I noticed lower acceptance than expected. Single particle simulations run faster ;)

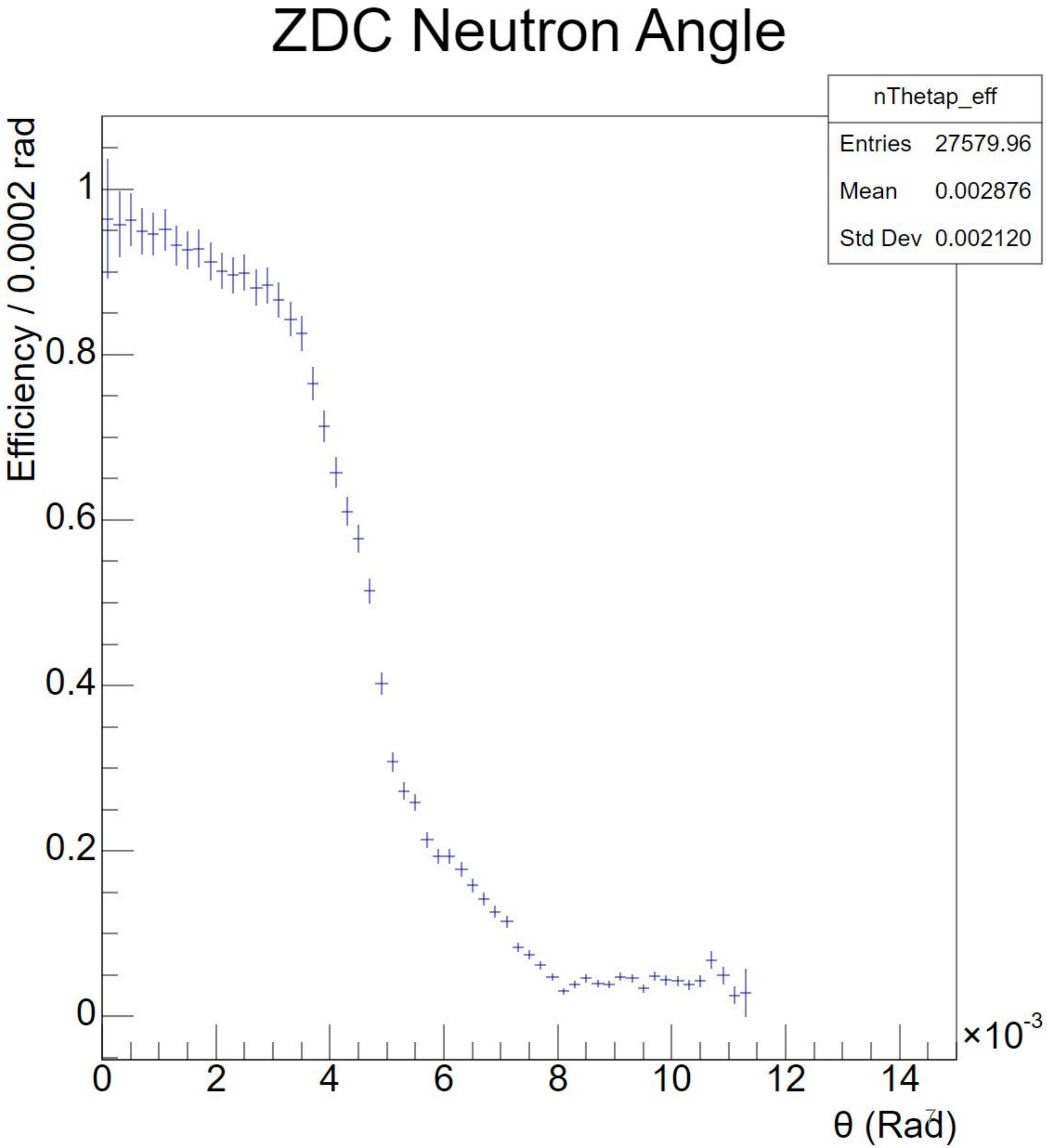
Definition of "Efficiency"

- Loop through all hits in ZDC and to check if the thrown neutron is associated with any hit
  - In this situation, a rescattered neutron that hits the ZDC is not accepted
  - Does not currently look at any daughter particles
- Binned according to thrown kinematics, does not take into account anything from the ZDC other than "did it make it there?"

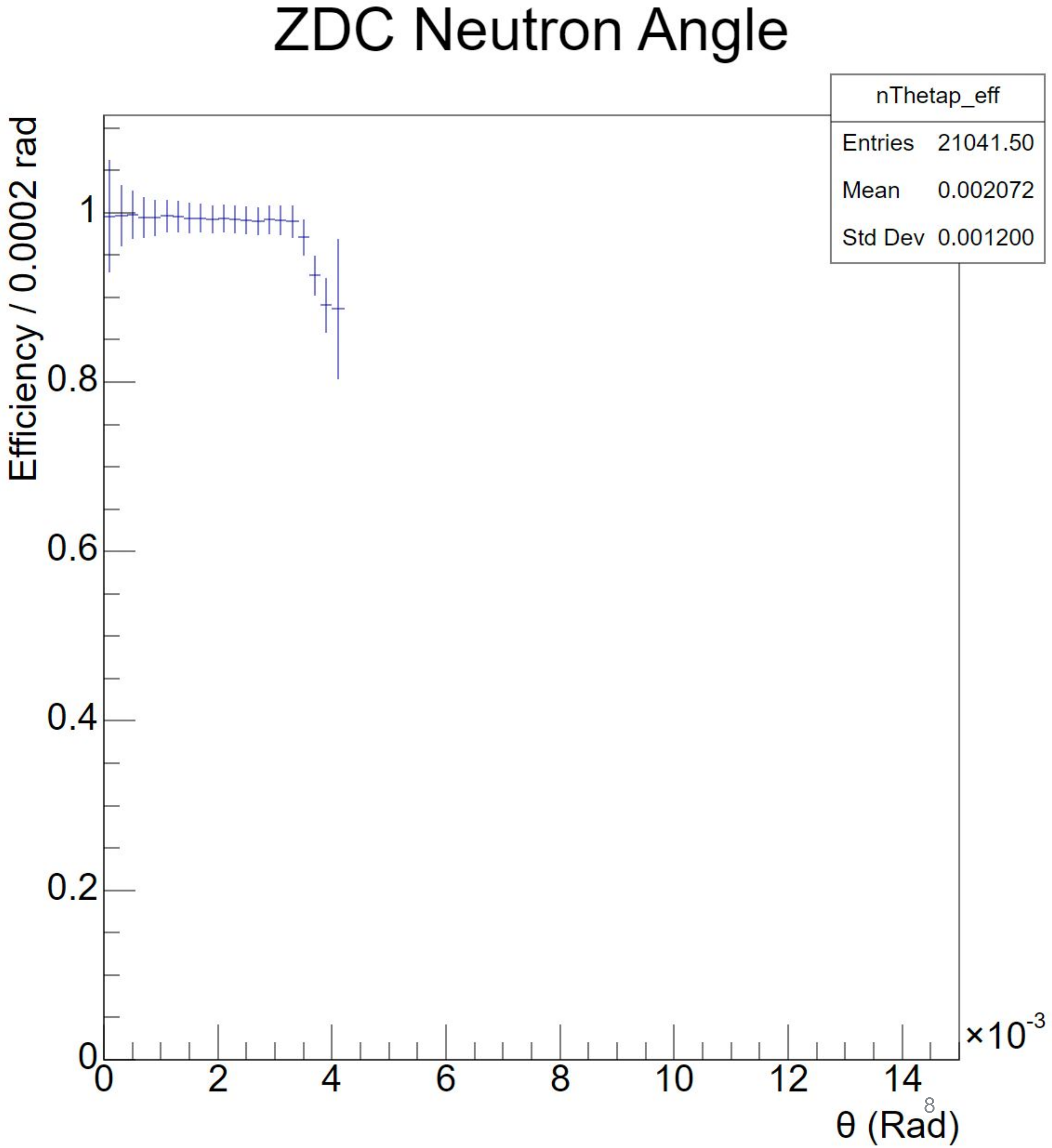
41 GeV proton beam
BryceCanyon geometry



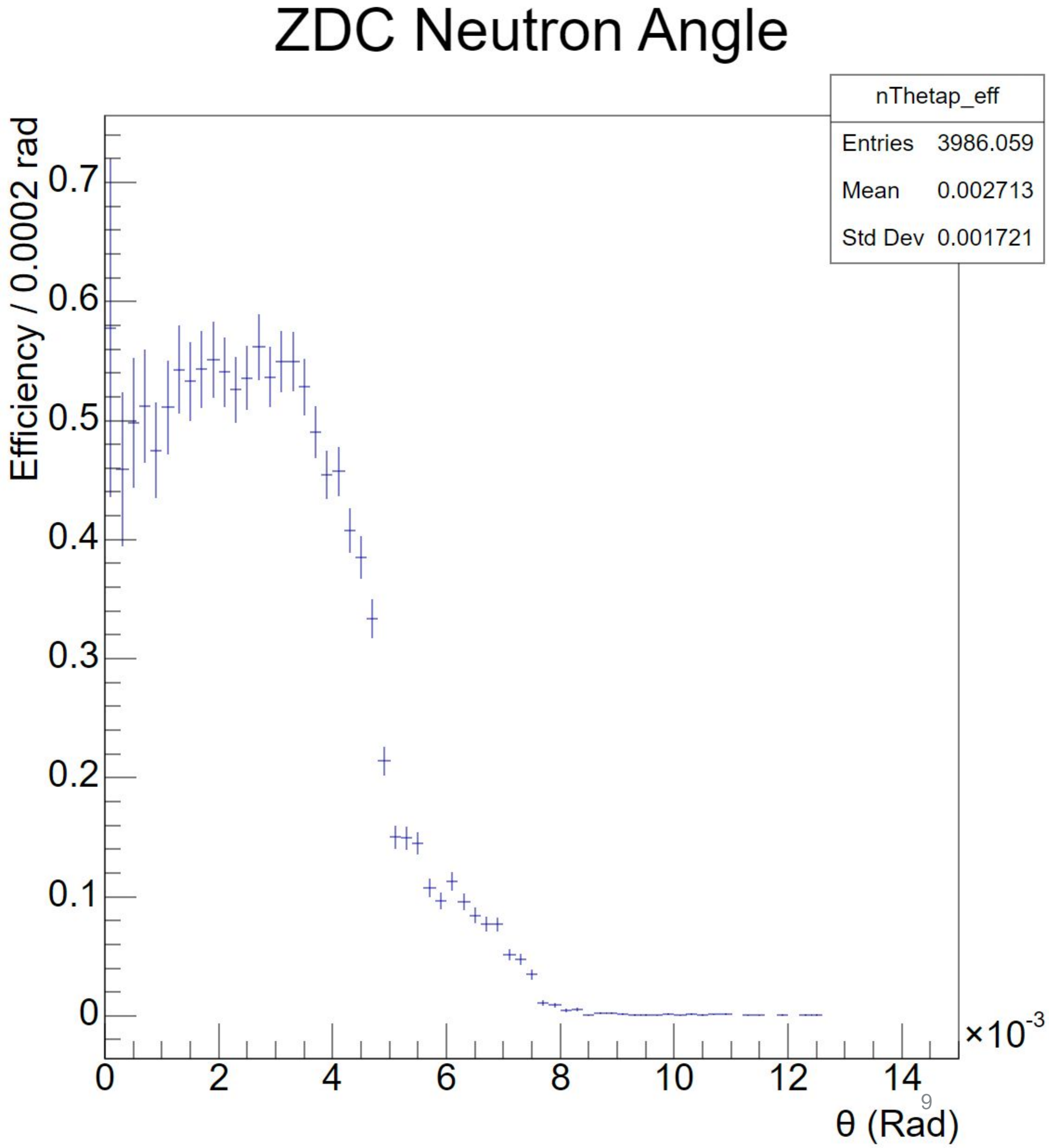
100 GeV proton beam
BryceCanyon geometry



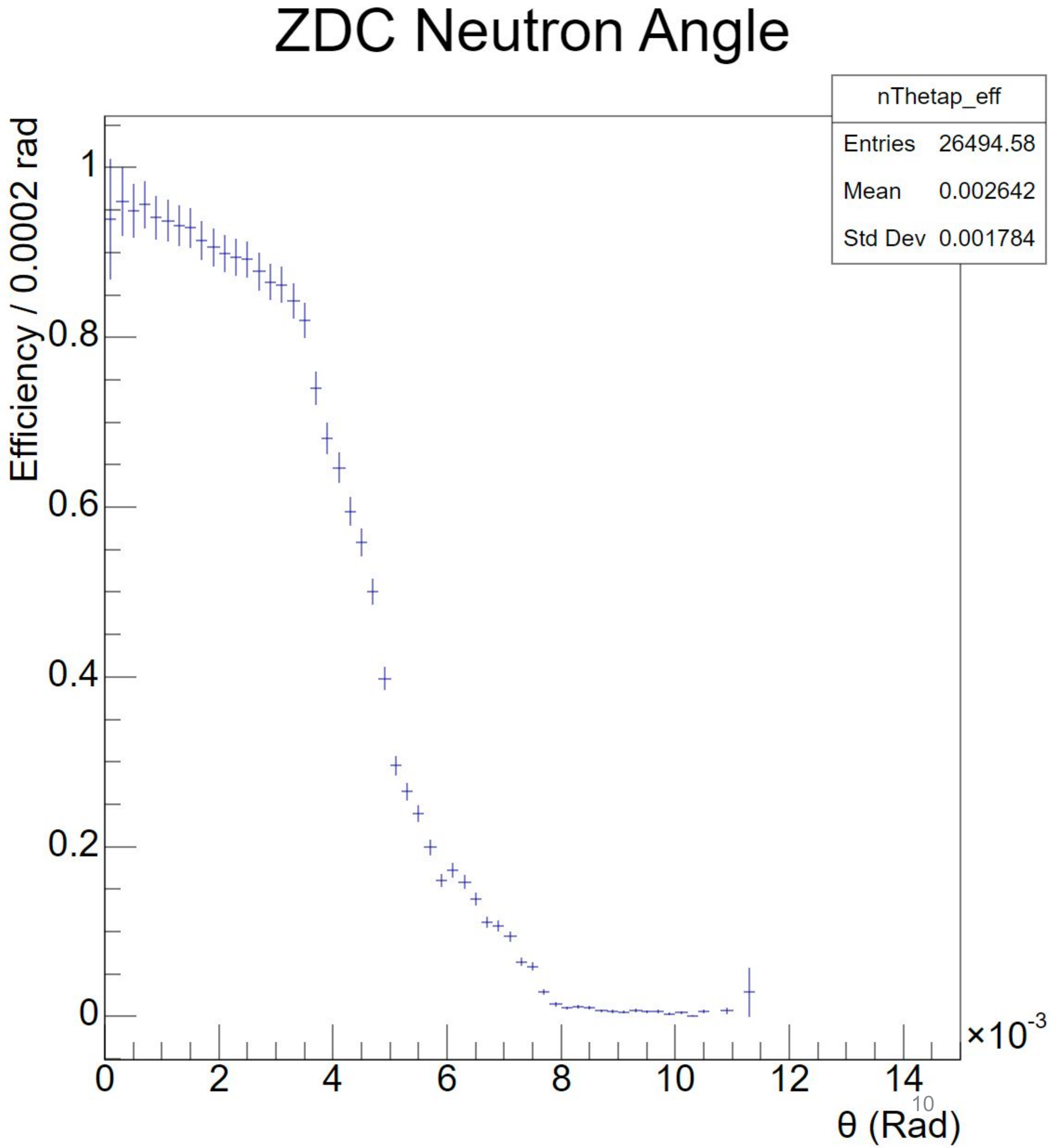
275 GeV proton beam
BryceCanyon geometry



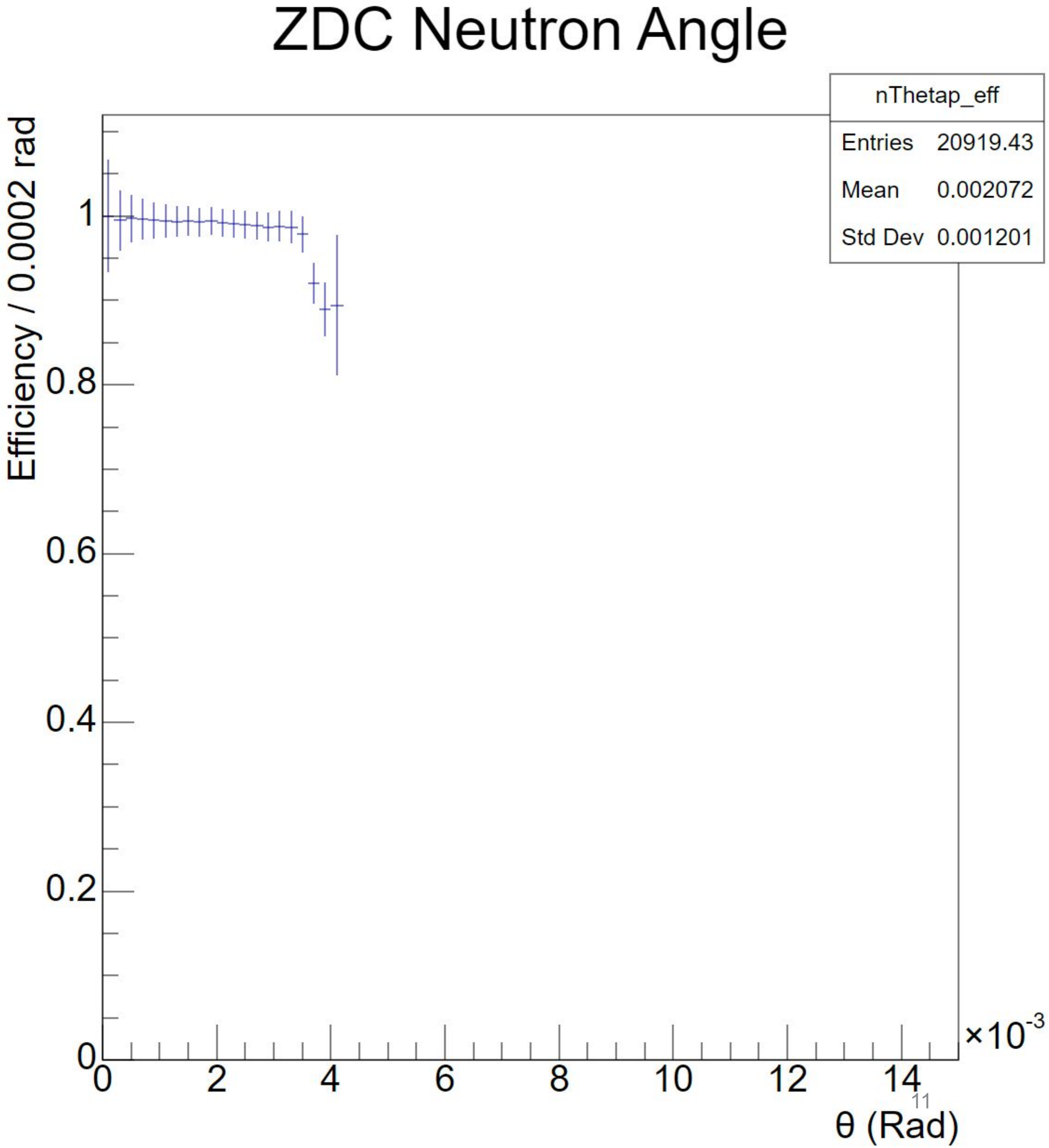
41 GeV proton beam
BryceCanyon geometry
+ World set to vacuum



100 GeV proton beam
BryceCanyon geometry
+ World set to vacuum

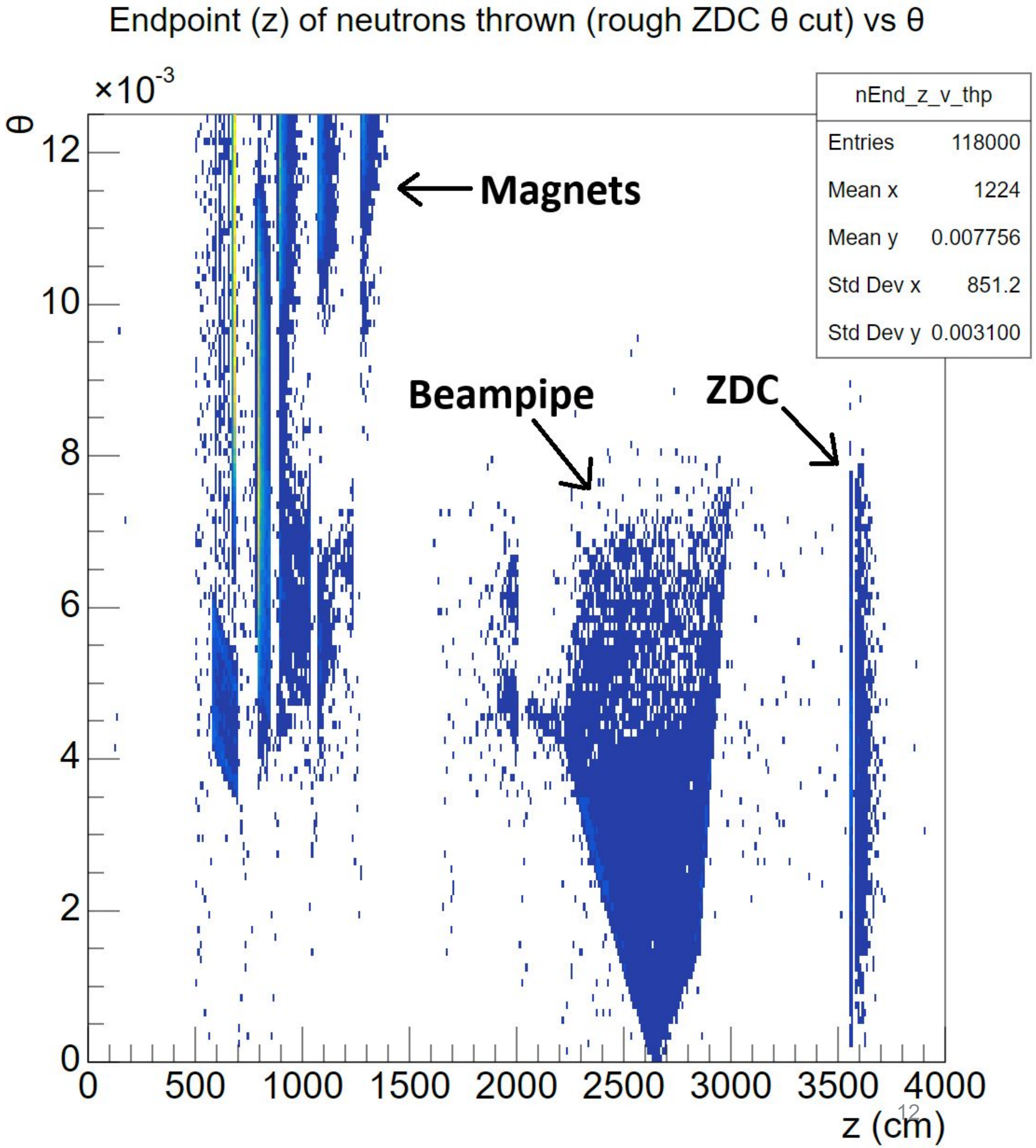


275 GeV proton beam
BryceCanyon geometry
+ World set to vacuum



Where are we losing events?

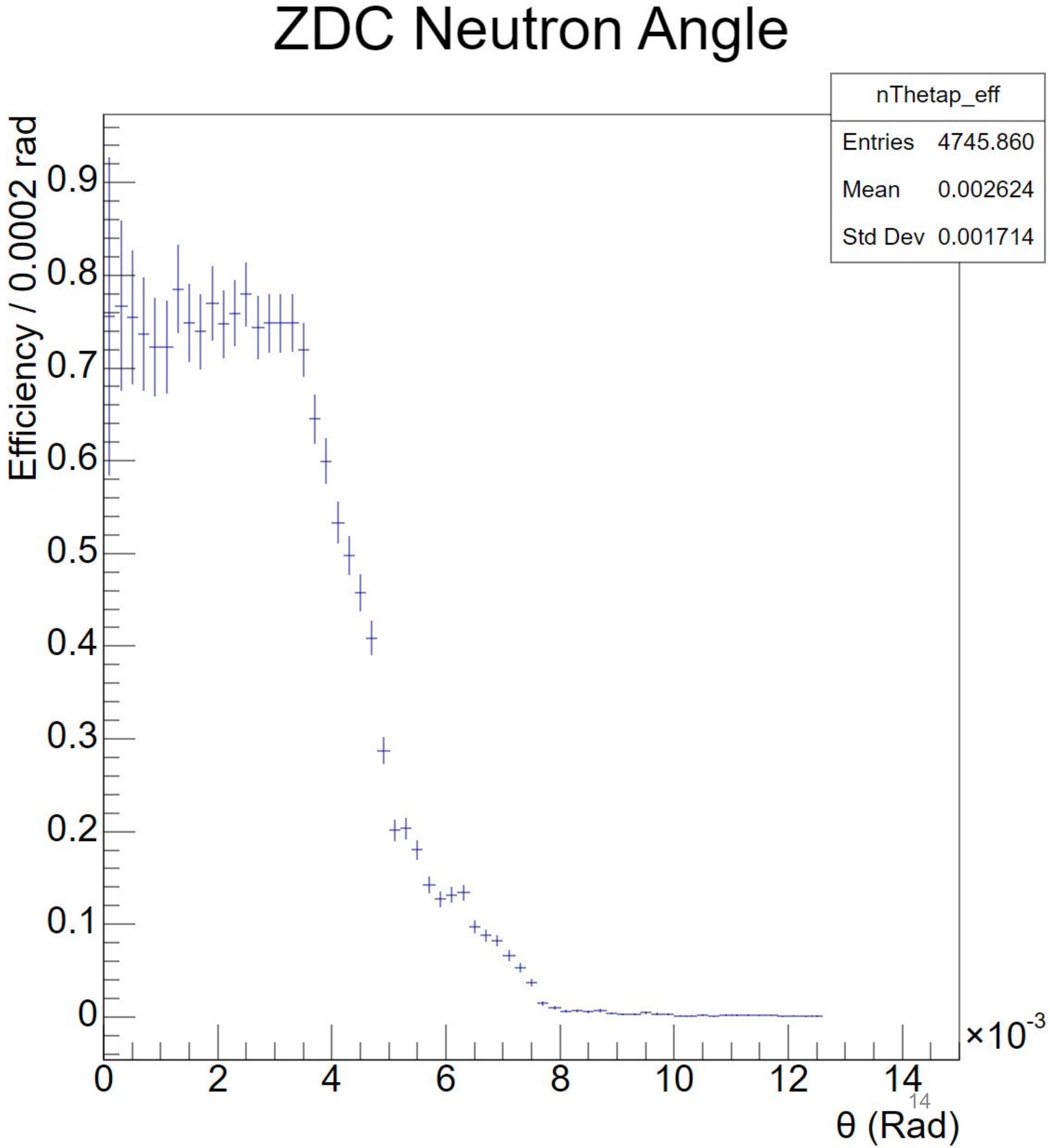
- Biggest problem in 5 on 41
- Plotting stopping location of the MC Particle vs thrown angle (since some are thrown outside of nominal acceptance)



Next Test:
Set beamline material to aluminum
(to verify that it is the beampipe)

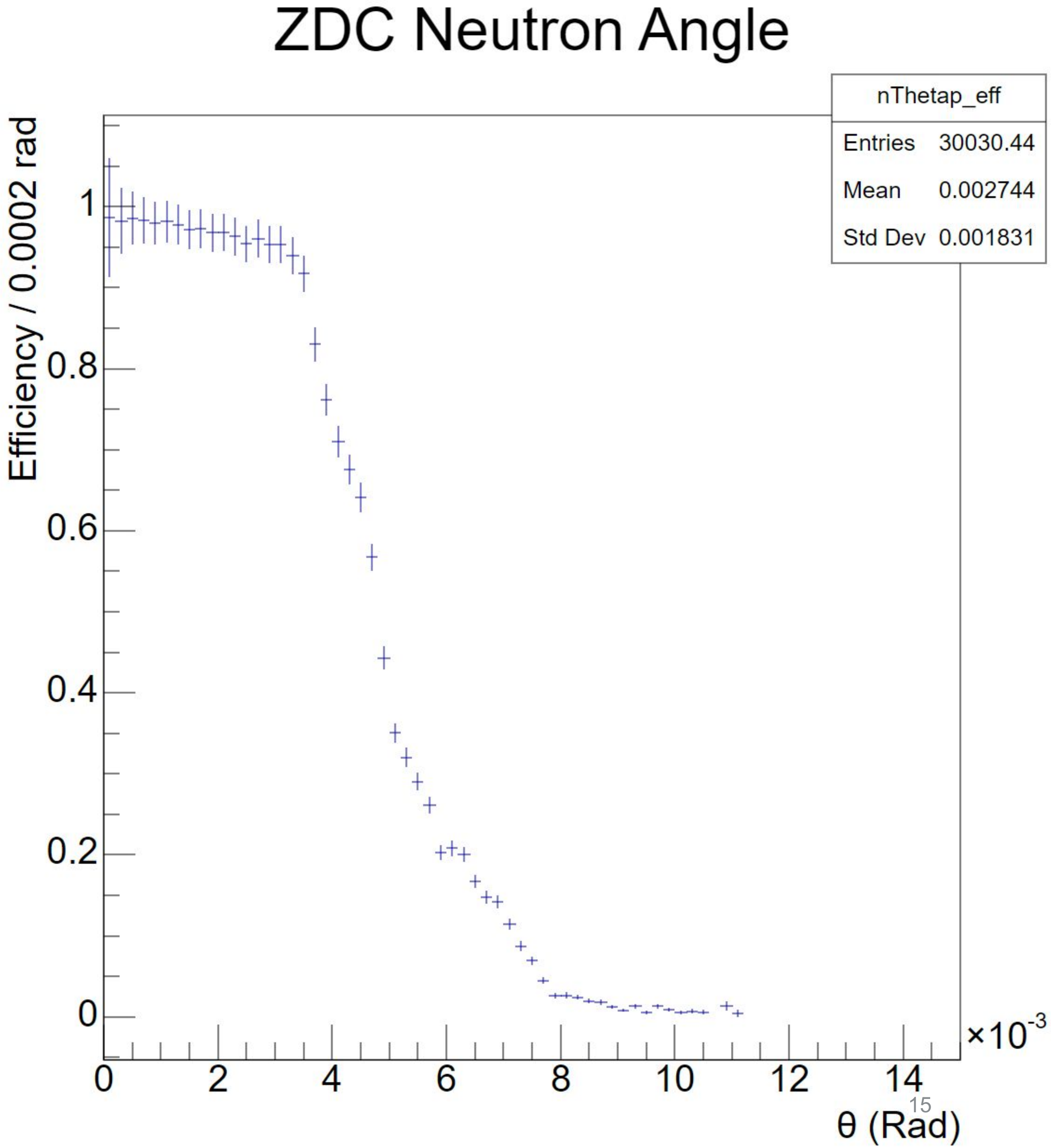
41 GeV proton beam
BryceCanyon geometry

- **World set to vacuum**
- **Aluminum beampipe**



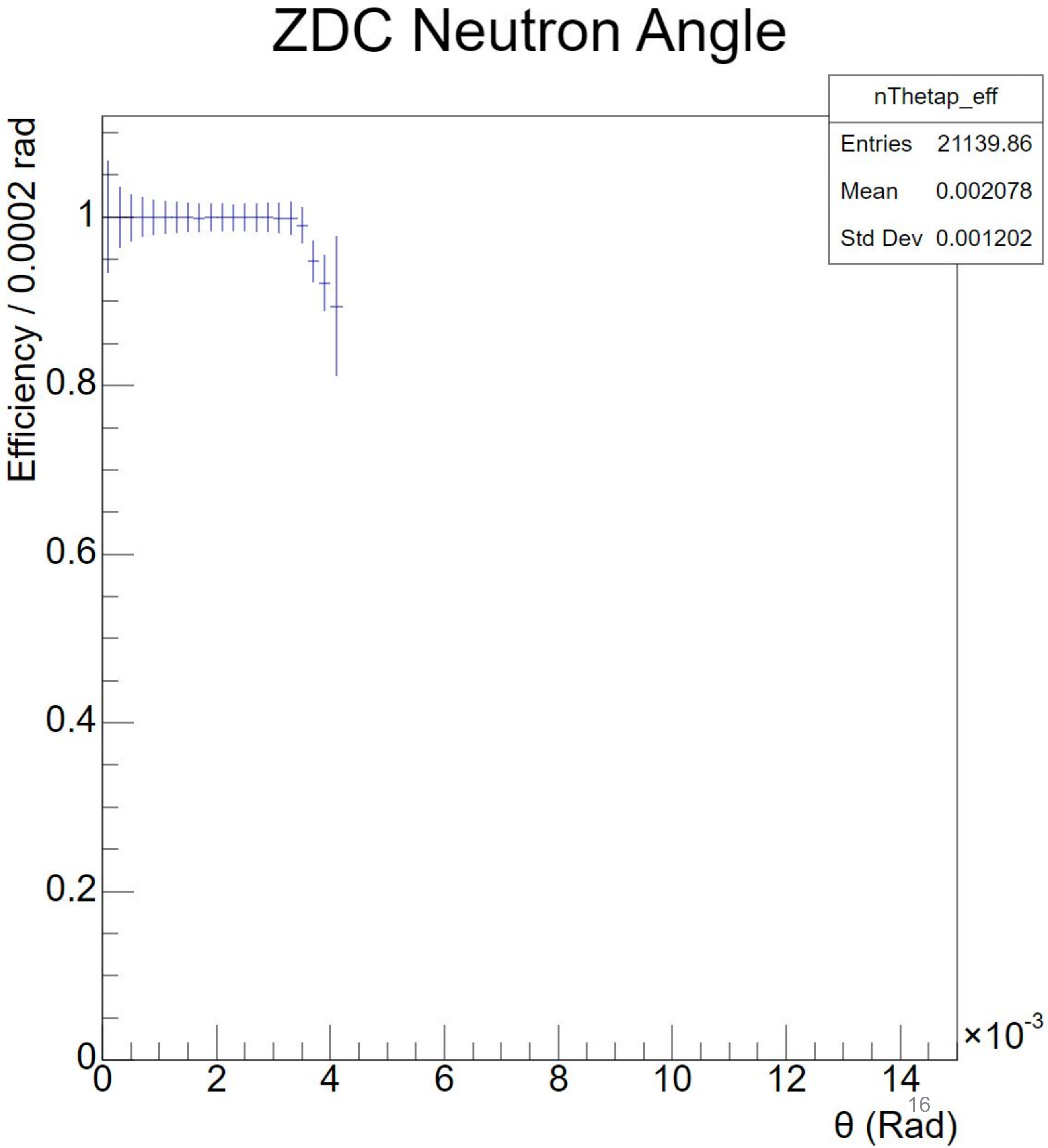
100 GeV proton beam
BryceCanyon geometry

- **World set to vacuum**
- **Aluminum beampipe**



275 GeV proton beam
BryceCanyon geometry

- **+ World set to vacuum**
- **+ Aluminum beampipe**

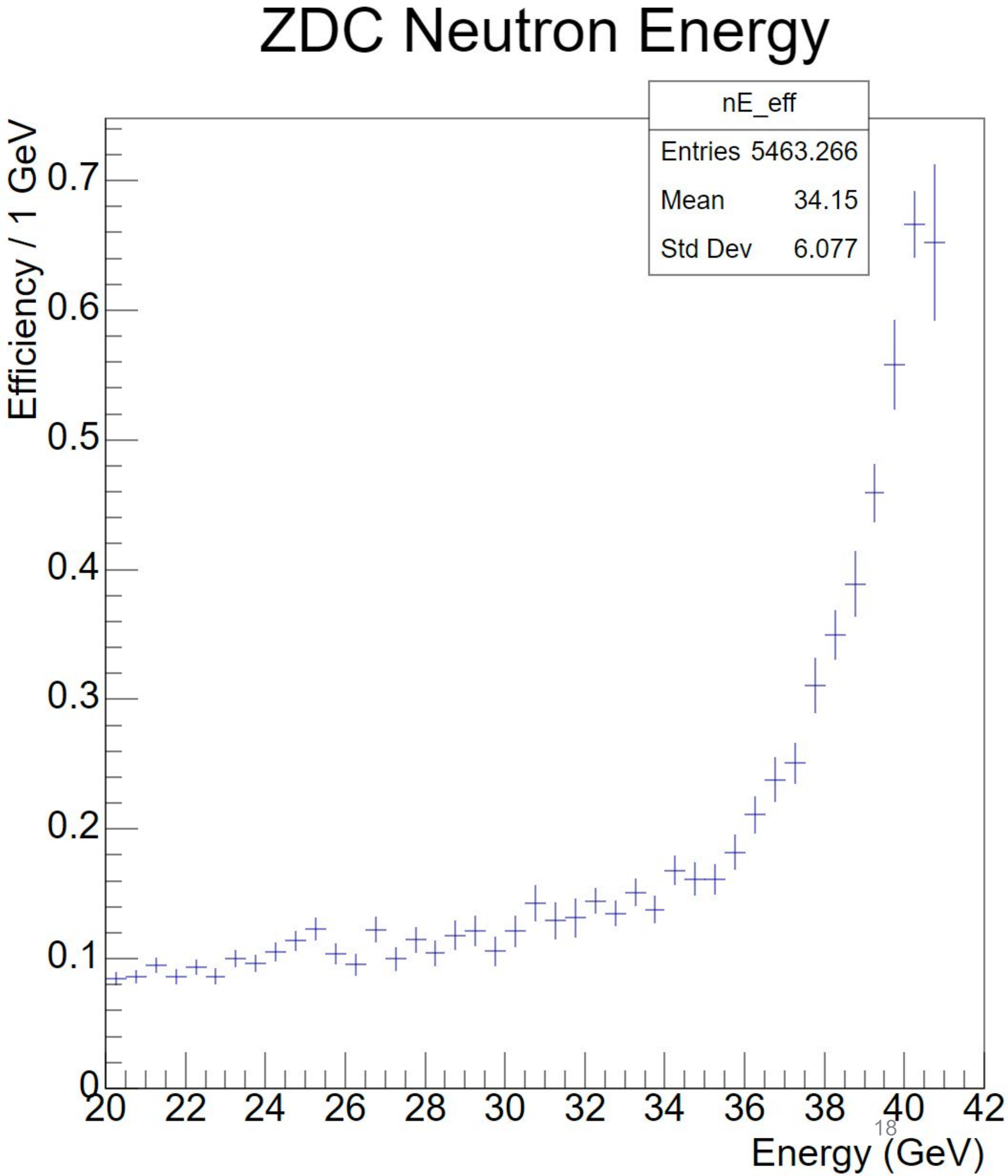


What does the energy efficiency look like?
(since 5x41 seems to have the worst problem)

41 GeV Energy Efficiency

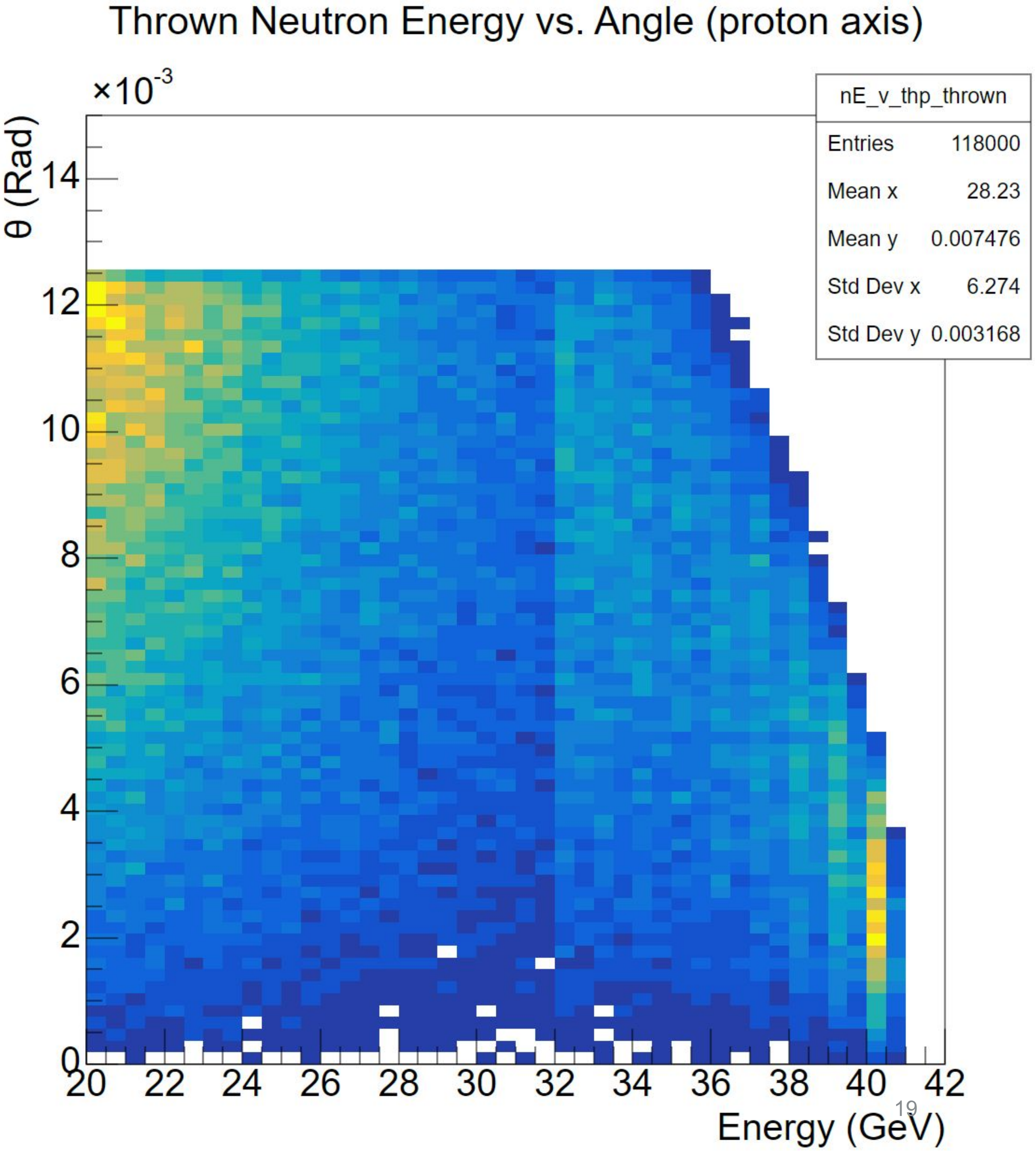
Is the angular efficiency dragged down by the low low-energy acceptance?

Plot to the right uses stock Bryce Canyon geometry (SS beampipe)



A look at the Energy Distribution (41 GeV)

- My generator has a *lot* of low energy neutrons thrown
  - Important caveat: I have begun a preliminary comparison of this to a cross section weighted set of simulated events. While the kinematics *should* be good, the distribution seems to be rather different than a realistic distribution.
  - In the future I will be using the realistic events, but the simple “neutron only” simulation runs substantially faster
- What happens if we ignore the kinematics and just throw 41 GeV neutrons?
  - Presumably the lower energy neutrons won’t be as prominent when weighted by cross section



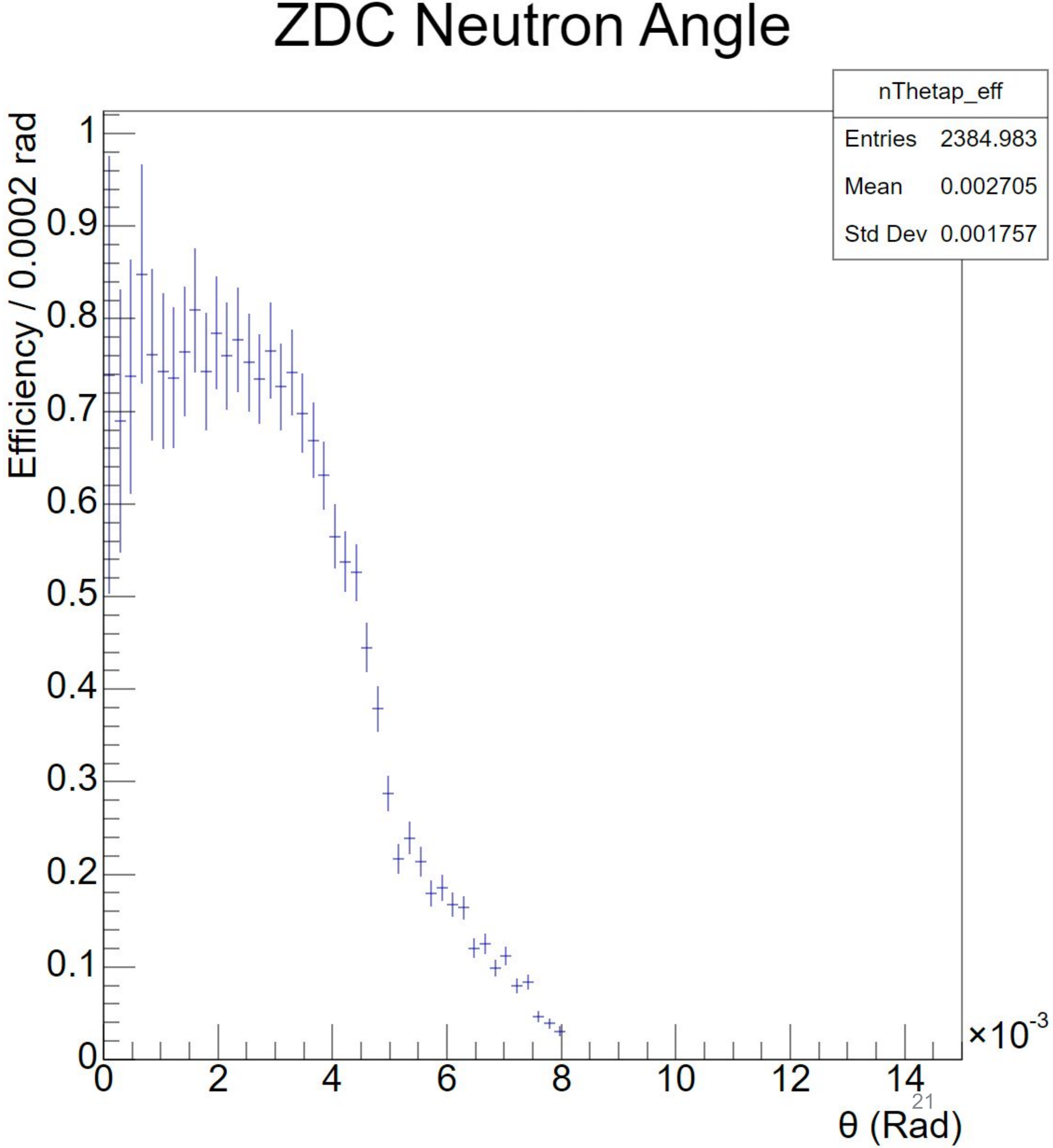
Single Energy Neutron Generator

- Throws neutrons of a single energy (41 GeV here)
- 0 < theta < 8 mrad (defined w.r.t. proton axis)
- No physics or cross sections

41 GeV neutrons
Stock BryceCanyon
(SS beampipe restored)

The efficiency looks a lot better

This suggests that the energy efficiency is driving the effect



Summary

- The beamline, as is in the simulation geometry, causes problems detecting “low” energy neutrons
  - More than 50% rescatter when energy is below ~39 GeV
- With the beampipe curving off, the neutrons see a very large amount of material in the path to the ZDC
  - The plot on slide 9 seems to suggest that the most material is seen around 4 mrad, with neutrons rescattering in material over approximately 9 meters
  - In this region, the shallow angle with respect to the ZDC direction causes particles to see approximately 10cm of stainless steel
    - The azimuthal angle drives where in that 9 meters the particle enters the 10cm of stainless steel
- The current beampipe design is a limiting factor in studying physics processes that rely on the ZDC

Thank You!