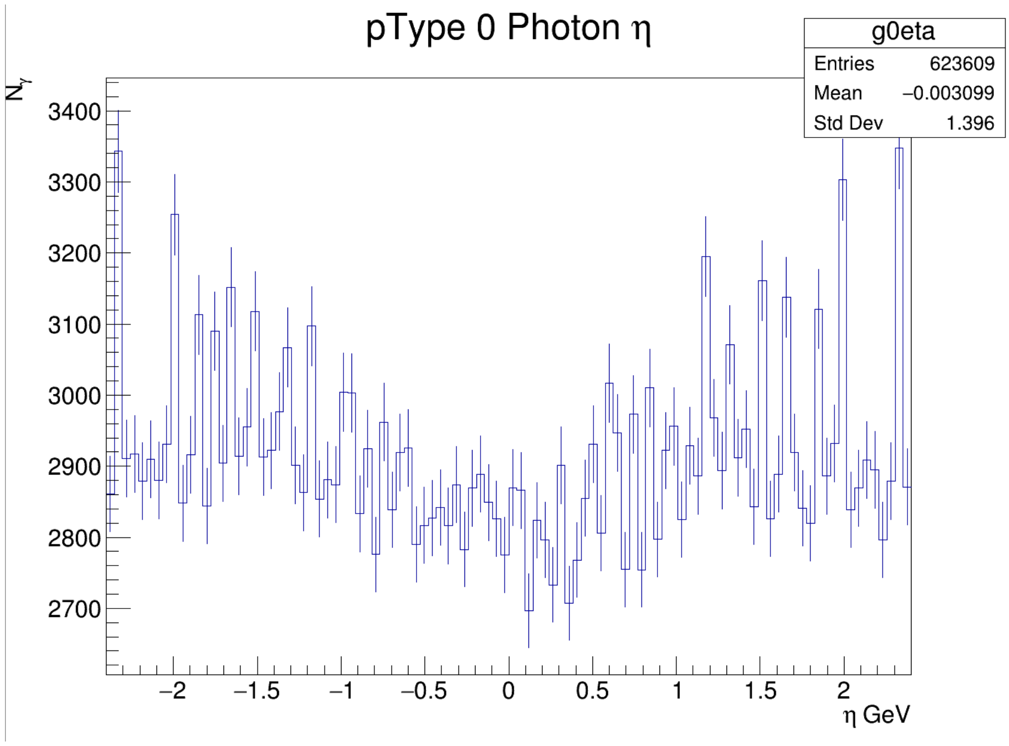
PC update 3-4-21 (γ flux)

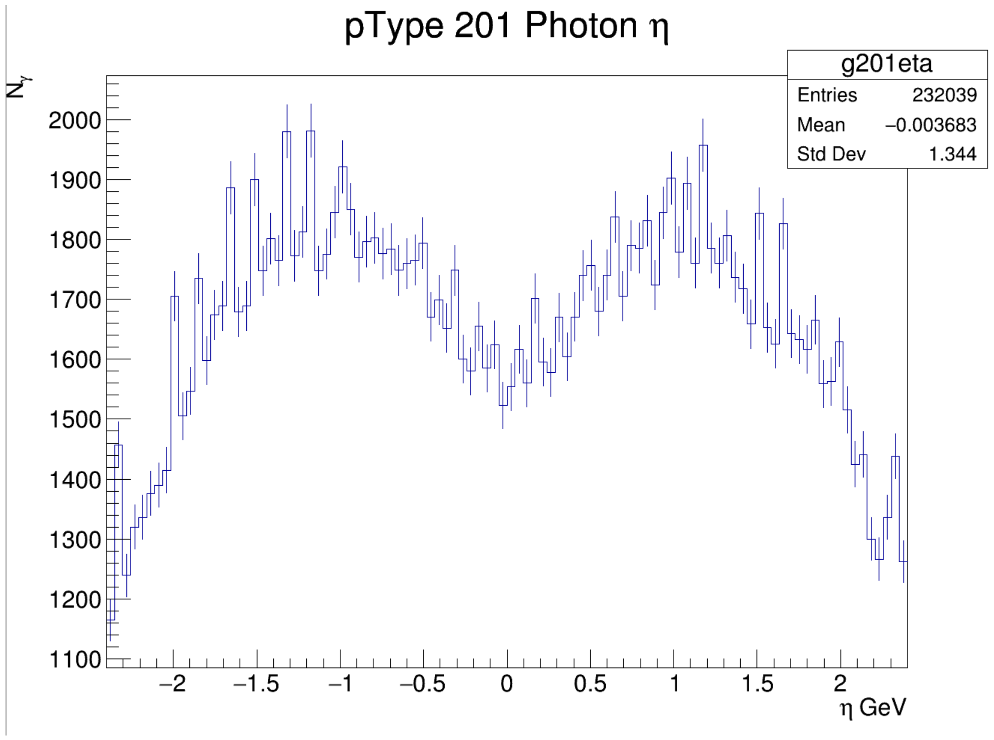
- Studied photon flux and f_{geom} factor
- After going through flux math, needed to confirm and understand if assumptions made are valid
- The current assumptions from AN2010_040_v2 are:
  - photons originate from (0,0,0)
  - all photons come from π^0s
  - number of photons interacting with material is negligible
- The f_{geom} for a spherical detector is $\propto \frac{1}{R^2 \sin^2\theta}$
- I tested this assumption with Sim. photons radiating outward from a unit sphere in MinBias events.

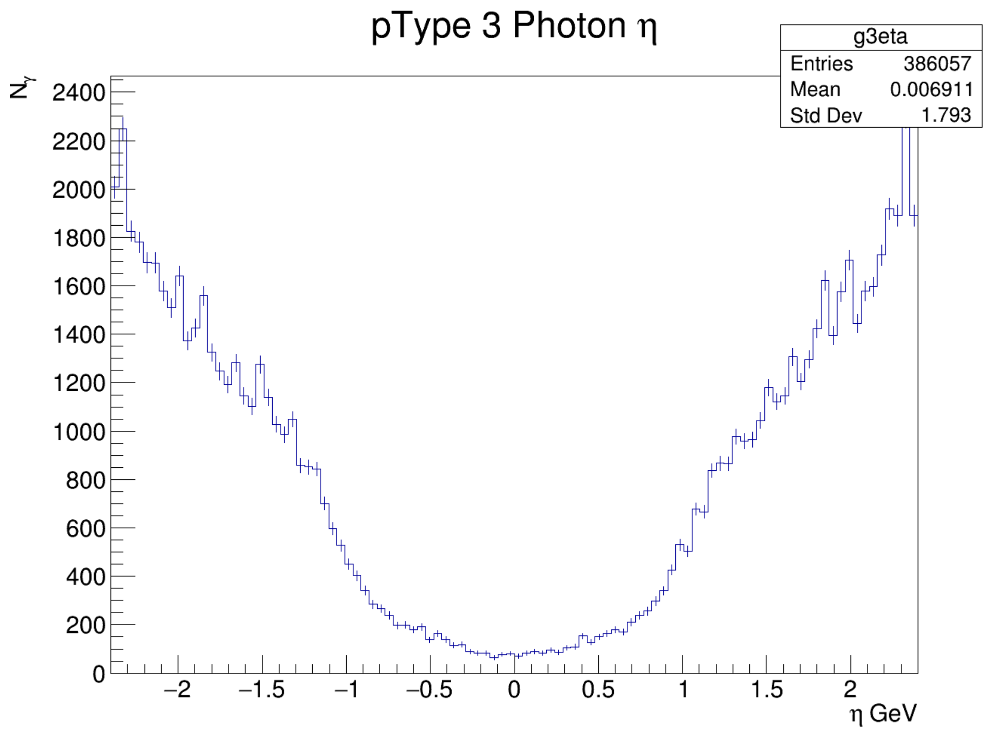
There are 3 sim. process types for photon production.

- ptype = 0
  - these originate from from primary interaction
  - I suspect these are from π^0s but they don't have a traceable parent
- ptype = 201
  - these are decay events, i've only seen 201 with π^0 decay in the events I looked at
  - I thought many of these decays would be near the PV, but it turns out these processes are all over the place. The majority are not involved in the primary interaction
- ptype = 3
  - Brem events
  - for the current spherical model, I can't really study these yet. There are no brems (or no material) in the unit sphere which particles are produced.

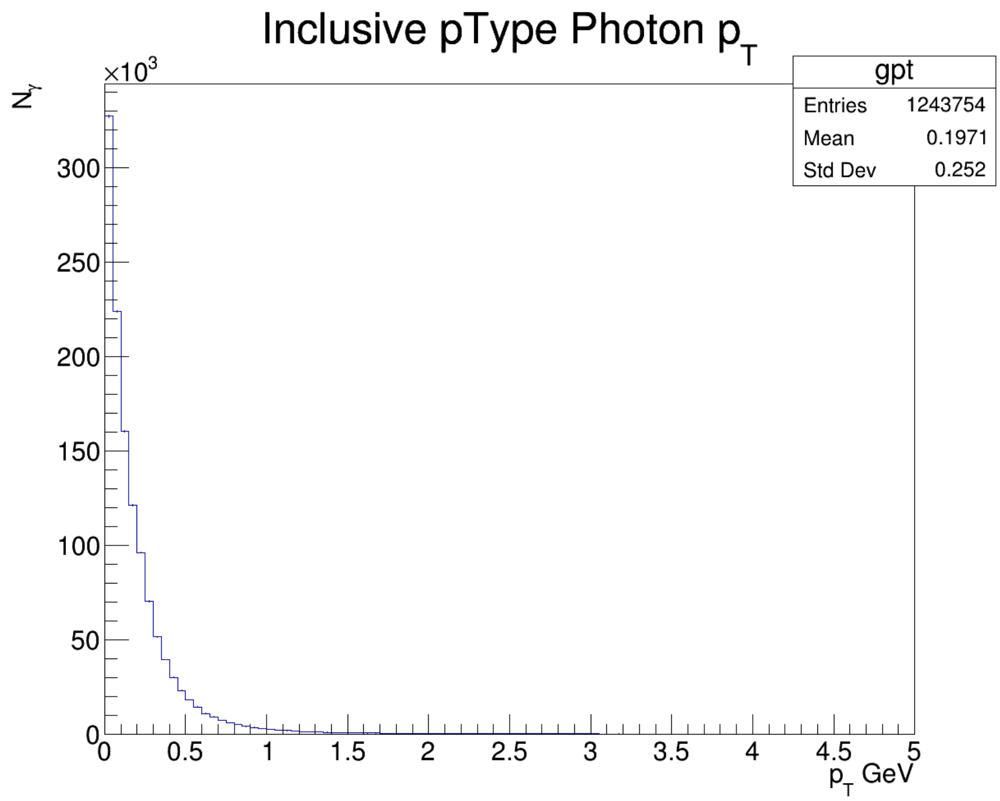
  Here are the angular distributions for all of the ptypes. I did not apply ANY cuts. ignore x-axis units...

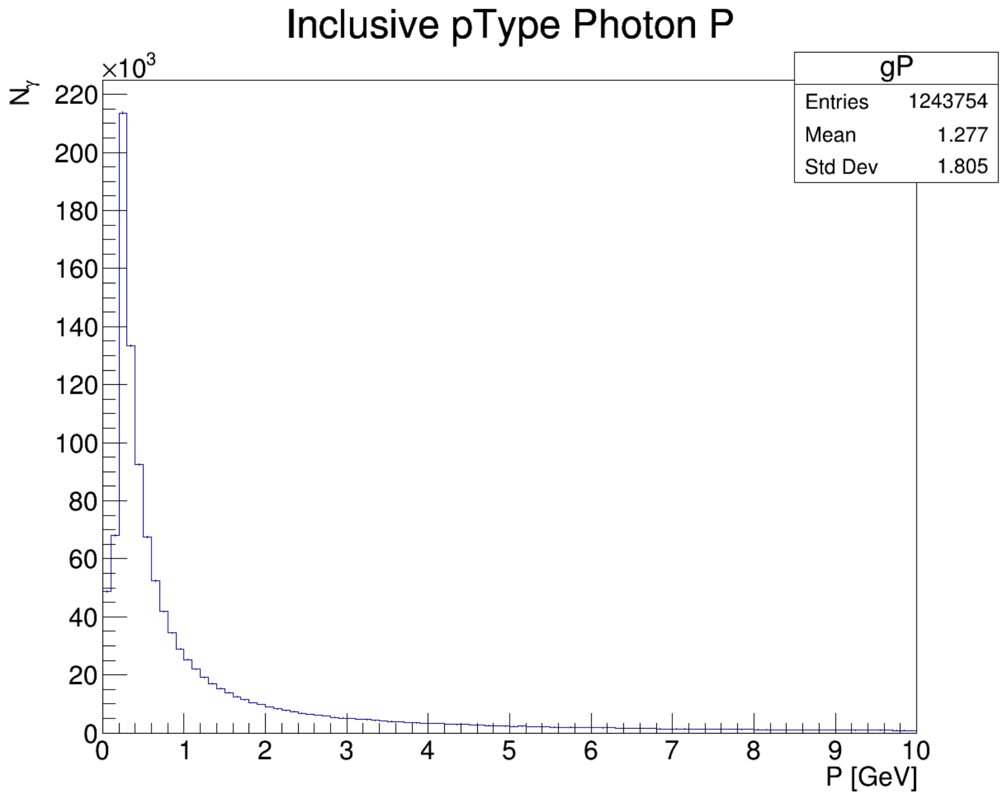

pType 0 Photon η
g0eta
Entries 623609
Mean −0.003099
Std Dev 1.396
N_γ
3400
3300
3200
3100
3000
2900
2800
2700
−2
−1.5
−1
−0.5
0
0.5
1
1.5
2
η GeV


pType 201 Photon η
g201eta
Entries 232039
Mean −0.003683
Std Dev 1.344
N_γ
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
−2
−1.5
−1
−0.5
0
0.5
1
1.5
2
η GeV



Here are the P and pt distrbutions inclusively. The individual distributions have the same shape but only get slightly softer from $0 \rightarrow 201 \rightarrow 3$



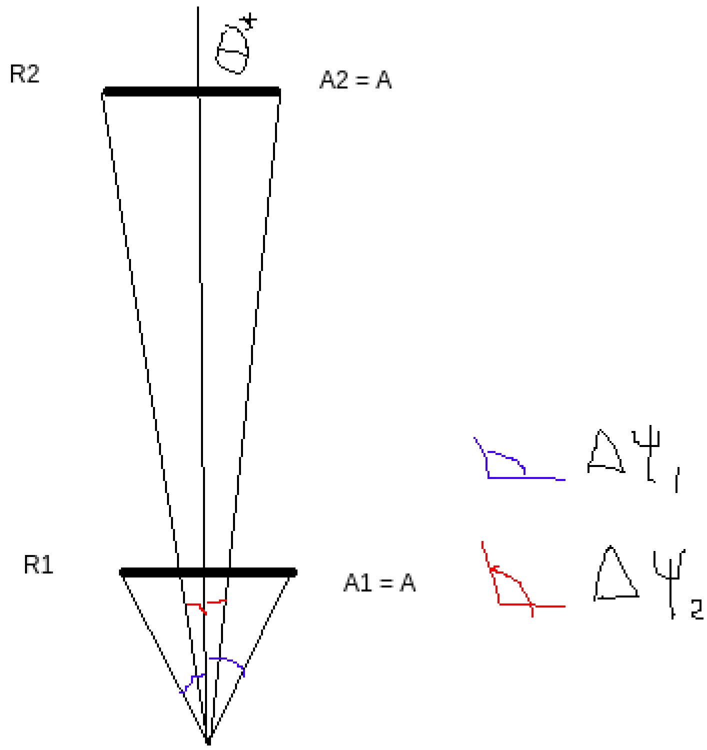


To test the photon flux, I counted the number of photons that would pass through a fixed area segment in a spherical coordinates and translated that fixed segment around the sphere. The study the R dependence i set a fixed area centered on θ^* and counted the number of photons that would pass through the area at various radii. I also looked at the angular dependence θ by fixing R and scanning from $0 \rightarrow \pi$

- Side note, originally i solved this problem with a "square" like area centered on (θ^*, ϕ^*) this implementation was fine, but I settled on a fixed area ring and integrated over 2π.. this approach gives better stats and works better with small angle approx used.

implementation concepts: for a photon radiating outward through fixed area, the angular spread of the area at further R will be smaller. So, to count photon at various R i calculate the symmetrical spread $(\Delta\psi)$ from θ^* then see if the photon falls into the range of $\Delta\psi(R)$

Here is a rudimentary drawing of the concept



The math details are as follows, in a spherical detector

$$A = \int^R \int^\theta \int^\phi R^2 \sin\theta dR d\theta d\phi$$

integrating R from 0 to R and ϕ from 0 to 2π we get

$$3A/2\pi R = -\cos(\theta)|_{\theta_1}^{\theta_2}$$

From our angular centerpoint θ^* we define the spread of the area at some R as $\Delta\psi$:

$$\theta_2 = \theta^* + \Delta\psi$$

$$\theta_1 = \theta^* - \Delta\psi$$

Using this θ_i definition in the integral evaluation we get

$$3A/2\pi R = -\cos(\theta^* + \Delta\psi) + \cos(\theta^* - \Delta\psi)$$

applying some trig identities we get

$$\frac{3A}{4\pi R \sin\theta^*} = \sin\Delta\psi$$

Then to first order approximation .. if we keep A small or R large we get

$$\frac{3A}{4\pi R \sin\theta^*} = \Delta\psi$$

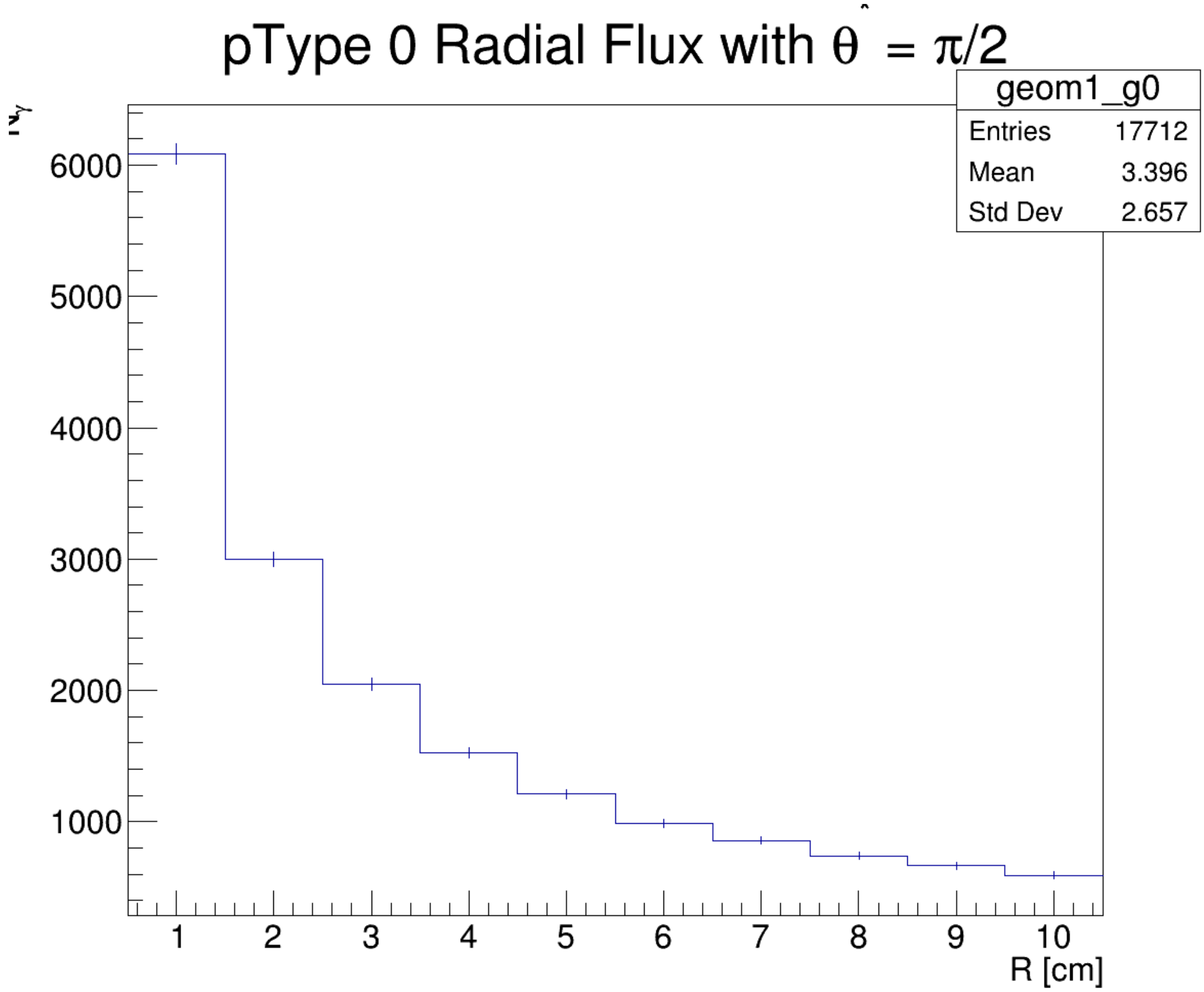
- In the case of using a fixed (θ^*, ϕ^*) the solution is (assuming $\Delta\psi = \Delta\theta = \Delta\phi$)

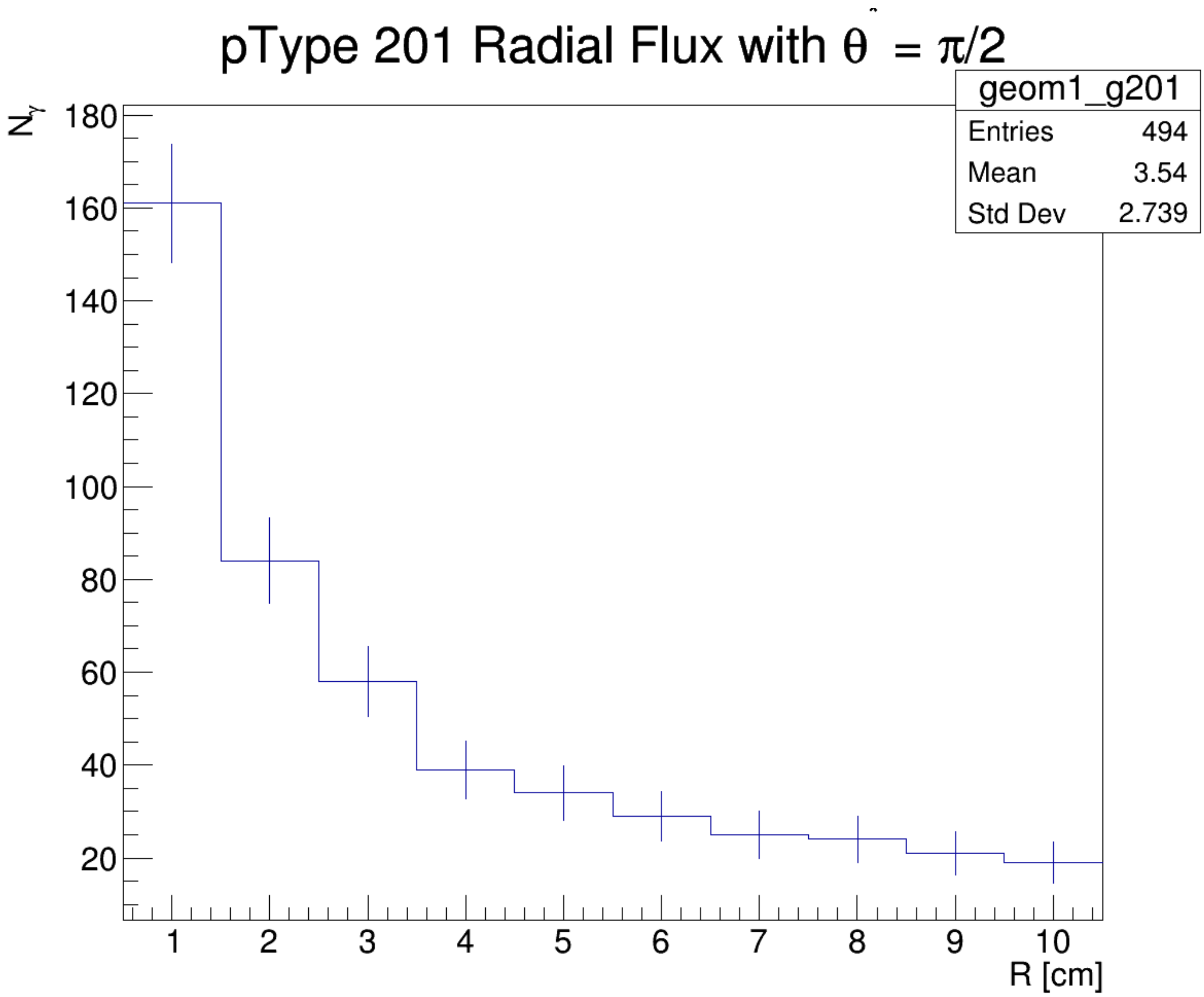
$$\frac{3A}{4R \sin\theta^*} = \Delta\psi^2$$

In this case to satisfy the small angle approximation we should take $A < 1$

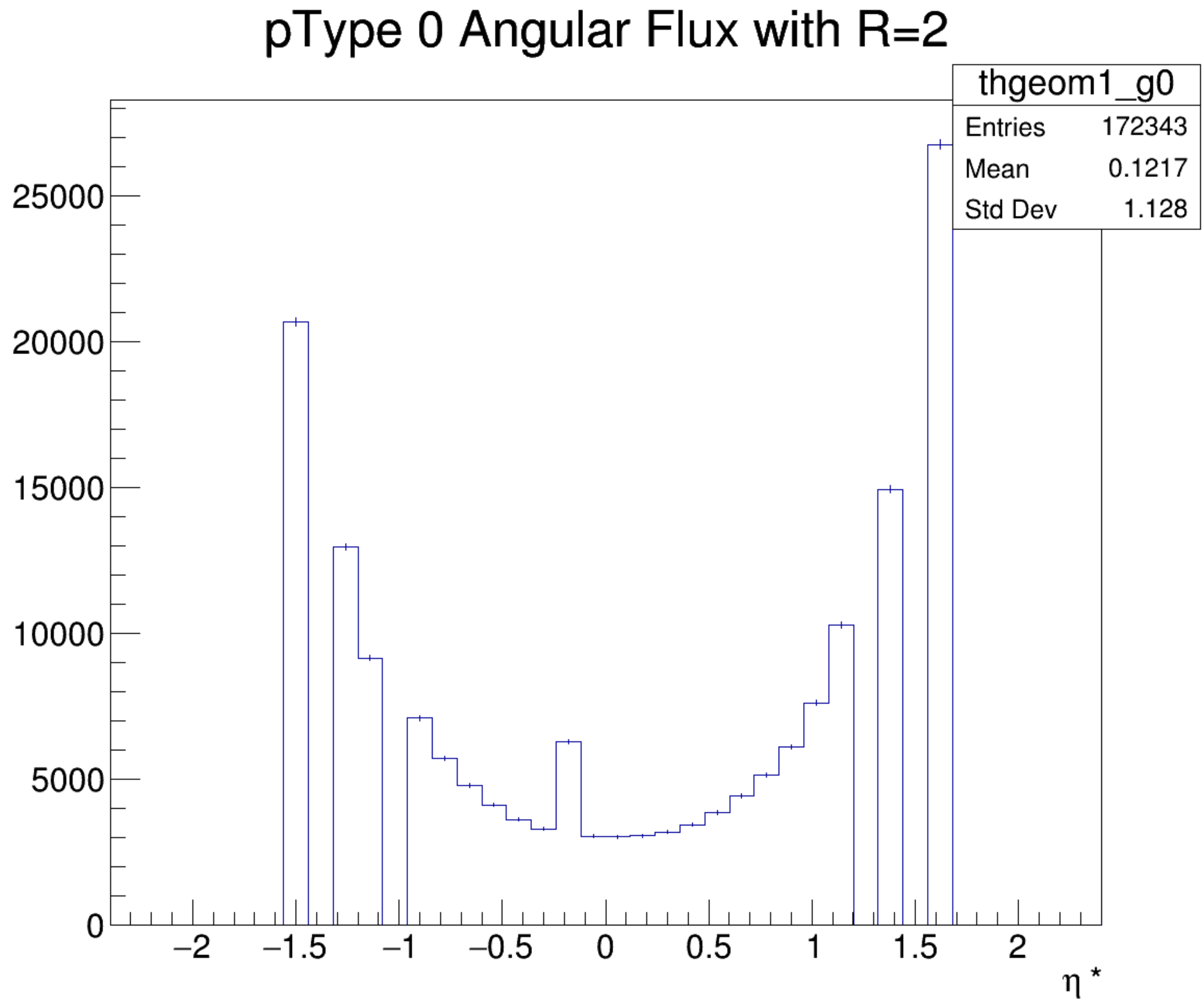
Here are the resulting f_{geom} distributions for the different ptypes

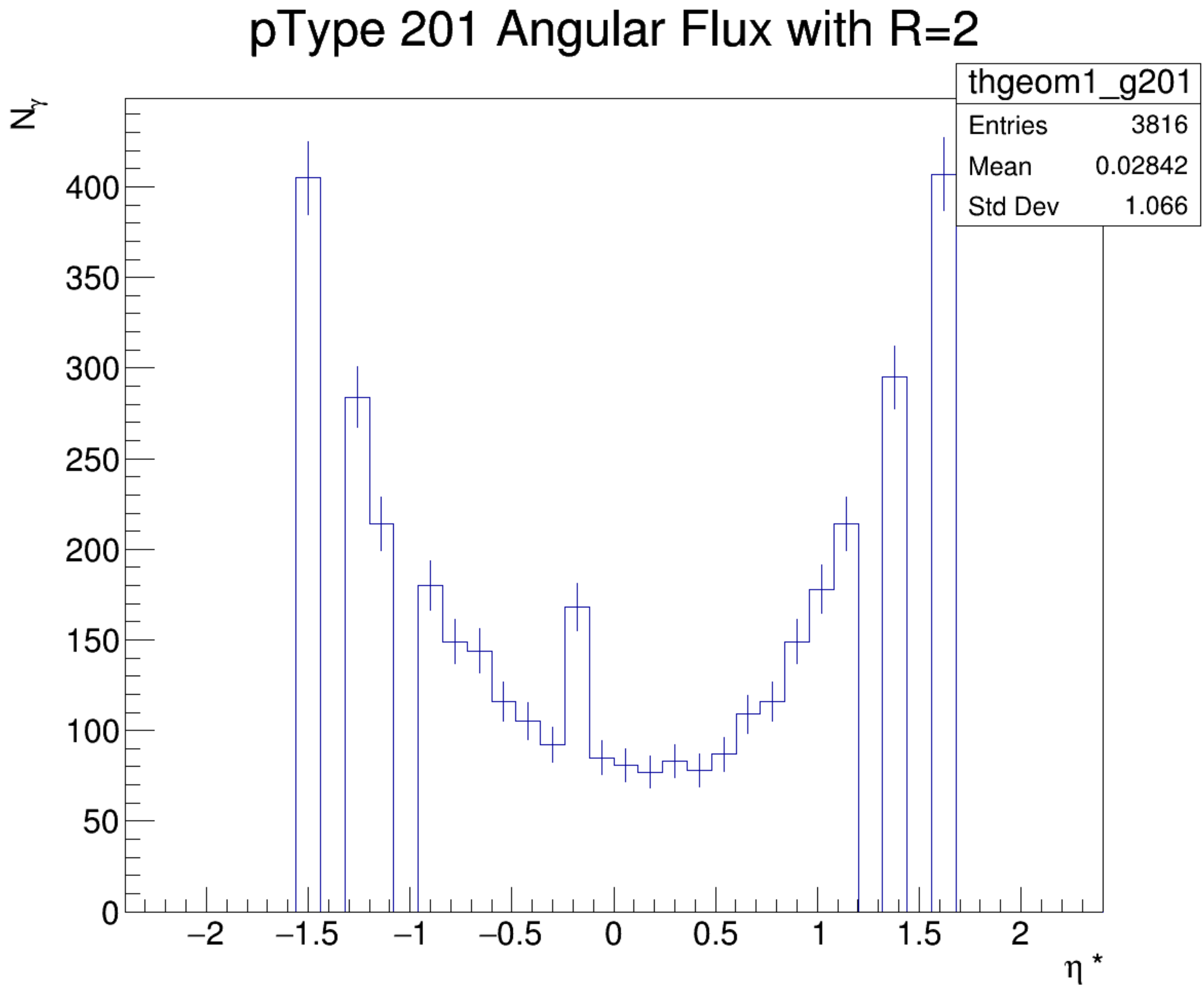
Radial dependence


pType 0 Radial Flux with θ̂ = π/2
geom1_g0
Entries 17712
Mean 3.396
Std Dev 2.657
6000
5000
4000
3000
2000
1000
1
2
3
4
5
6
7
8
9
10
R [cm]

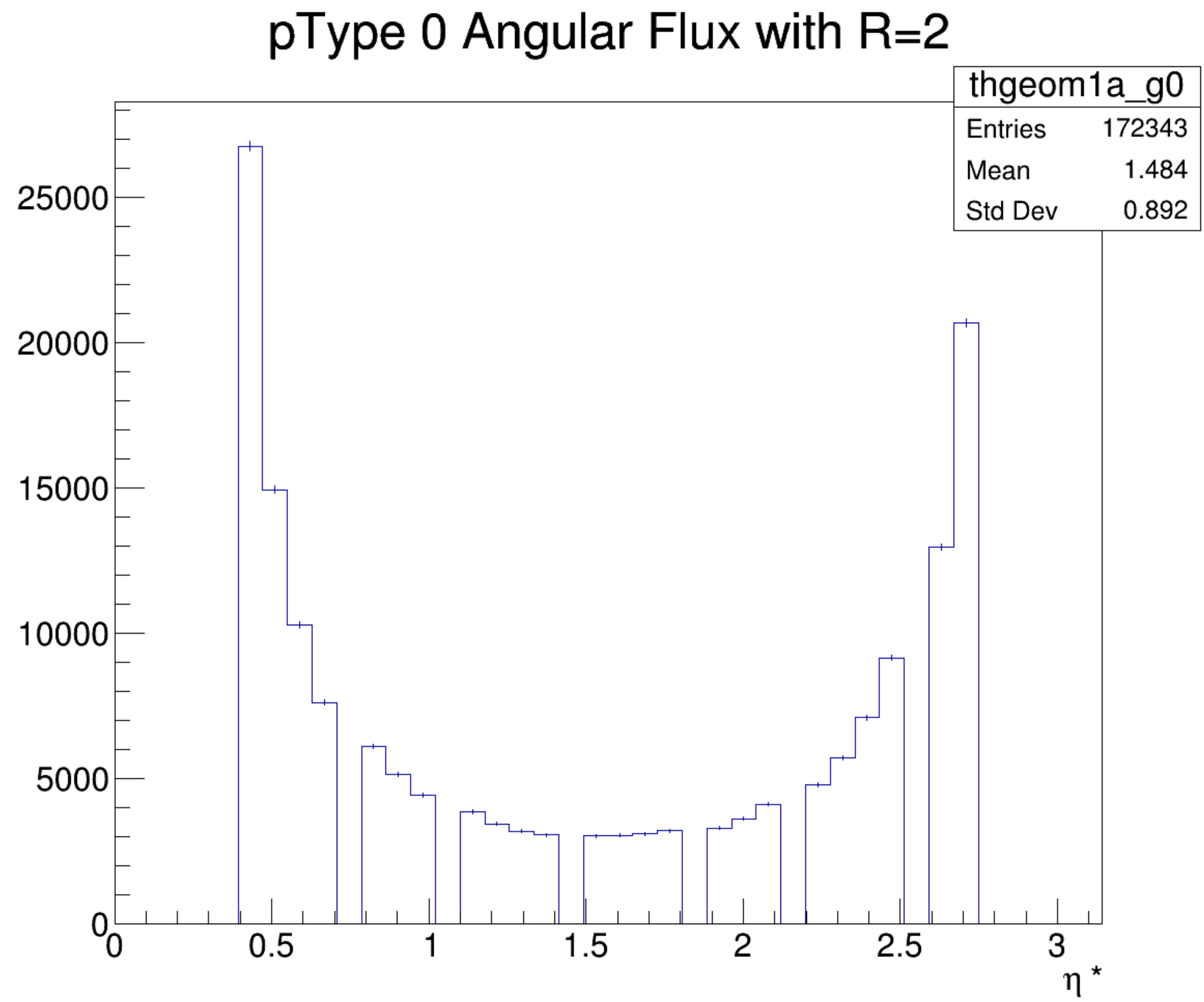

pType 201 Radial Flux with θ = π/2
geom1_g201
Entries 494
Mean 3.54
Std Dev 2.739
N_γ
180
160
140
120
100
80
60
40
20
1
2
3
4
5
6
7
8
9
10
R [cm]

eta dependence

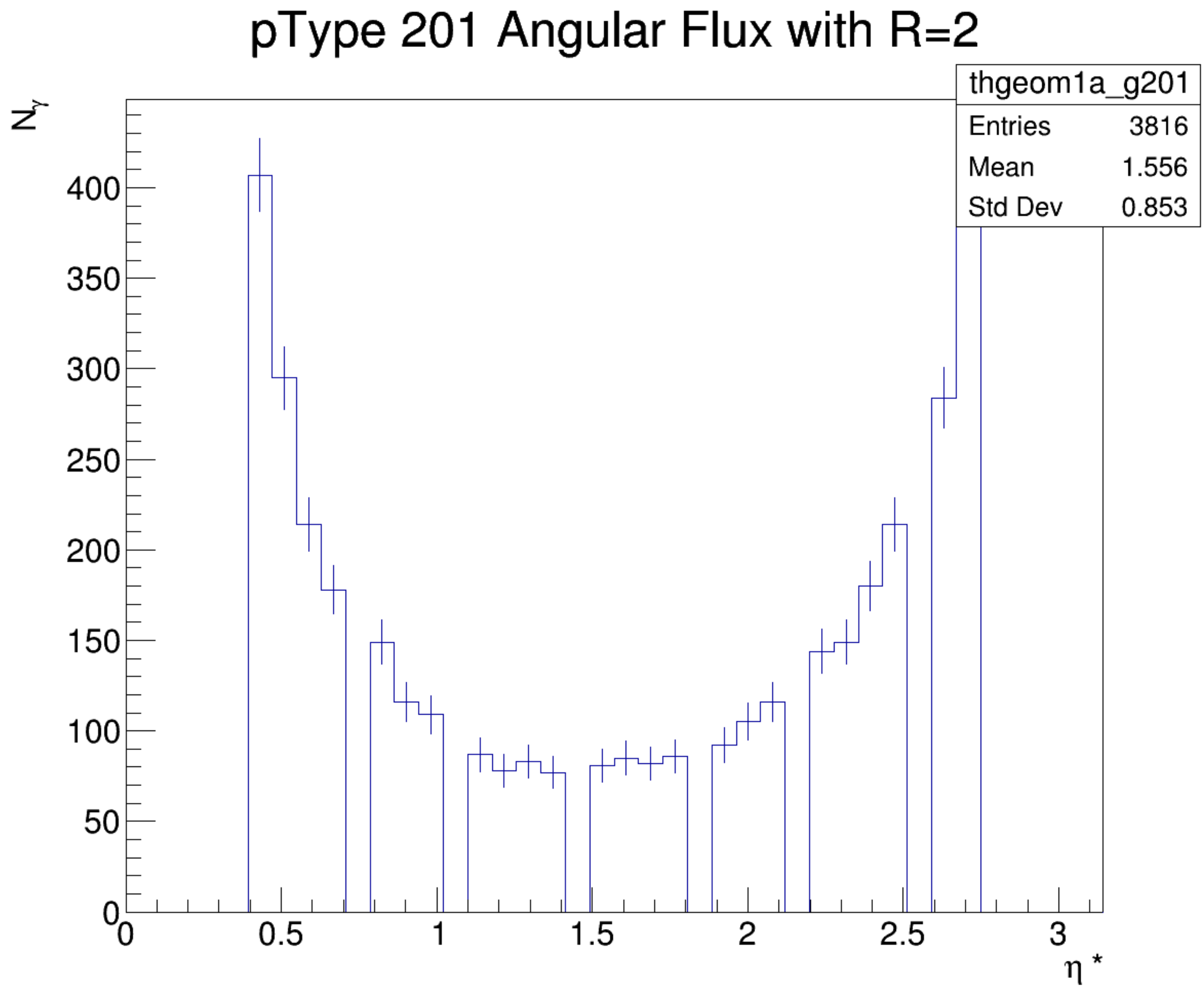




theta dependence



pType 0 Angular Flux with R=2
thgeom1a_g0
Entries 172343
Mean 1.484
Std Dev 0.892
0
5000
10000
15000
20000
25000
0
0.5
1
1.5
2
2.5
3
η *



At a glance, with these spherical constraints (photons produced with $R < 1$) the earlier assumption of $f_{geom} \propto \frac{1}{R^2 \sin^2 \theta}$ looks pretty good

Future thoughts --

- repeat this exercise with cylindrical detector
- look at photons produced anywhere in the detector, not just origin
- get a better feel of the extra photons from electrons .. Nconv and Ngamma become circularly dependent in this case
- do some fits and test numerically how good this f_{geom} actually is, could propagate errors based on sin approximation
- long term idea , if we get the full contributions from all processes to Ngamma we could do a simultaneous fit in R and theta to get a sim driven f_{geom} factor. This approach would probably need to be binned in PU