Neutron Related Background

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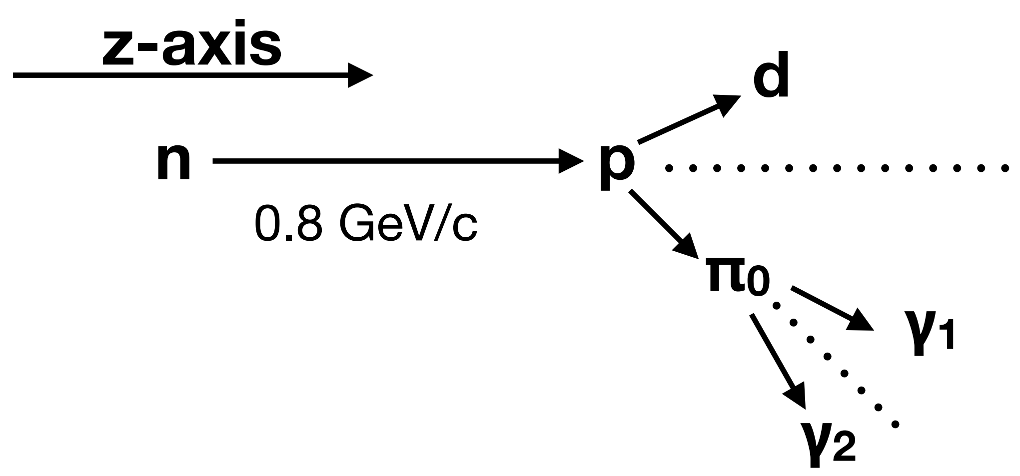
Contents

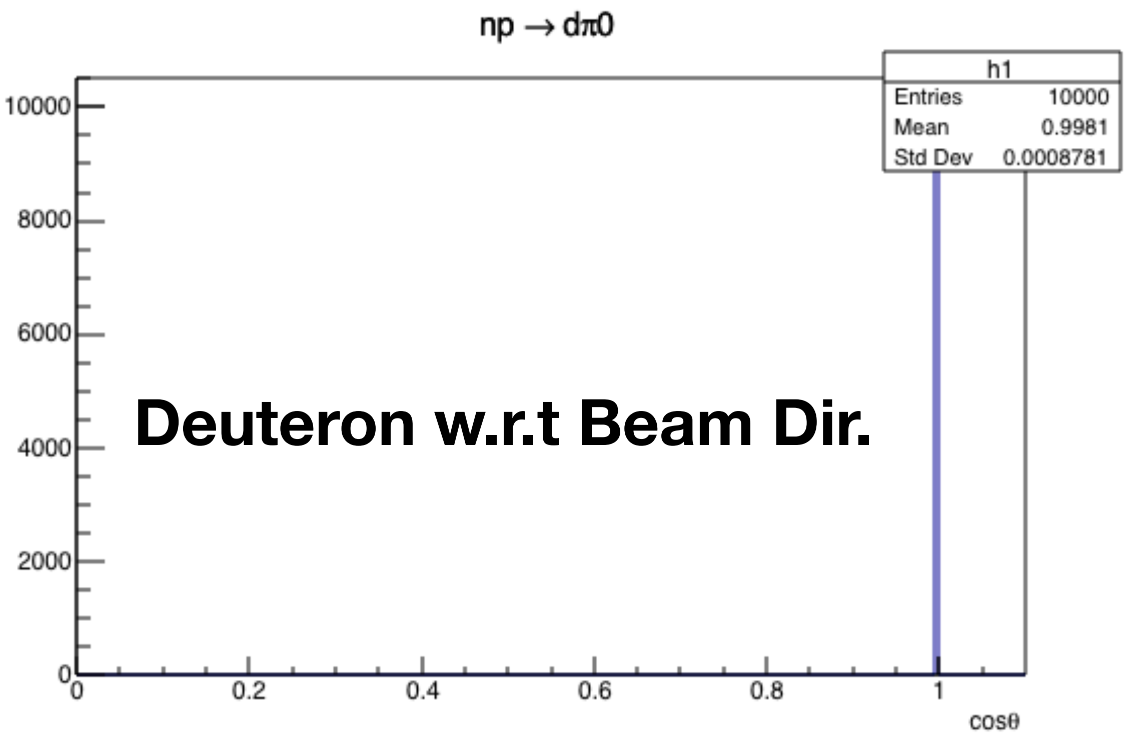
- Mainly about Background Process concerned with Neutron (Interaction of Neutron of Momentum near 1.0 GeV/c)
- Calculation of Two-Body Kinematics for np->dπ_0 process (with π_0->2gamma Decay)
- Estimated Hit Position of Gamma by assuming the cylindrical barrel w.r.t Interaction Position
- Calculation of Interaction Rate per Unit time (Function of Pressure)

$np \to d\pi_0$

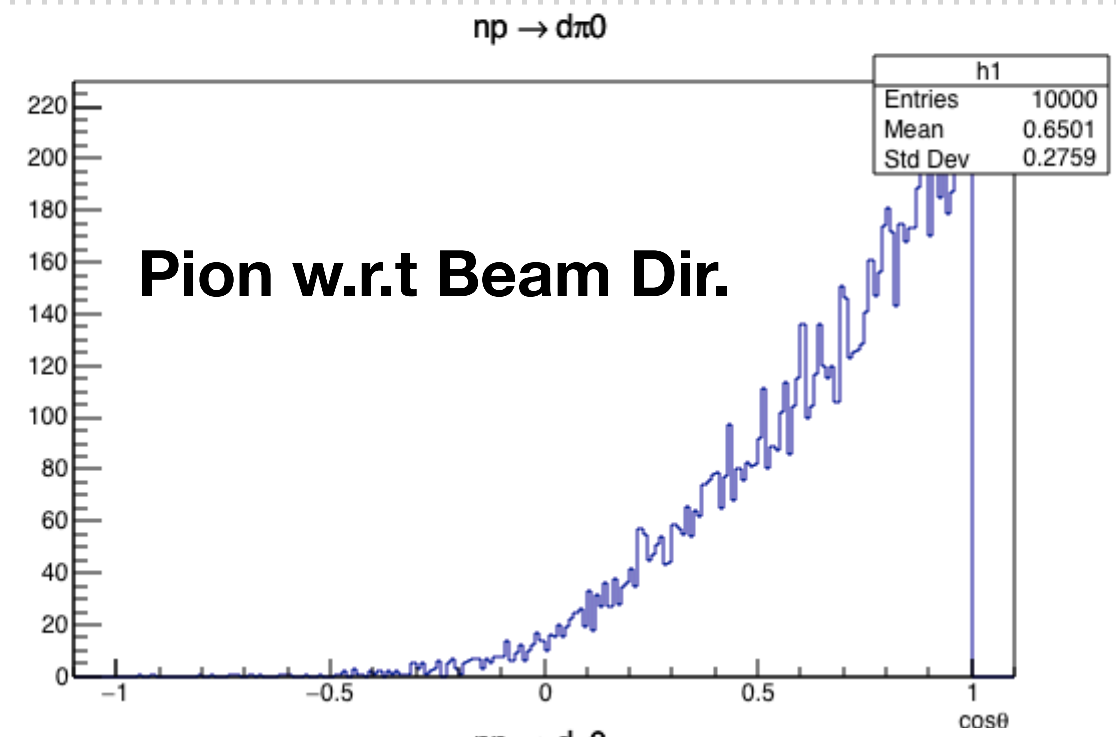


- Calculated Two-Body Kinematics in Two Steps ($np \to d\pi_0$; $\pi_0 \to 2\gamma$)
- Plots of cosine values of Angles in Lab Frame
  (Generating LorentzVector in Random Sphere in CM Frame -> Boost)

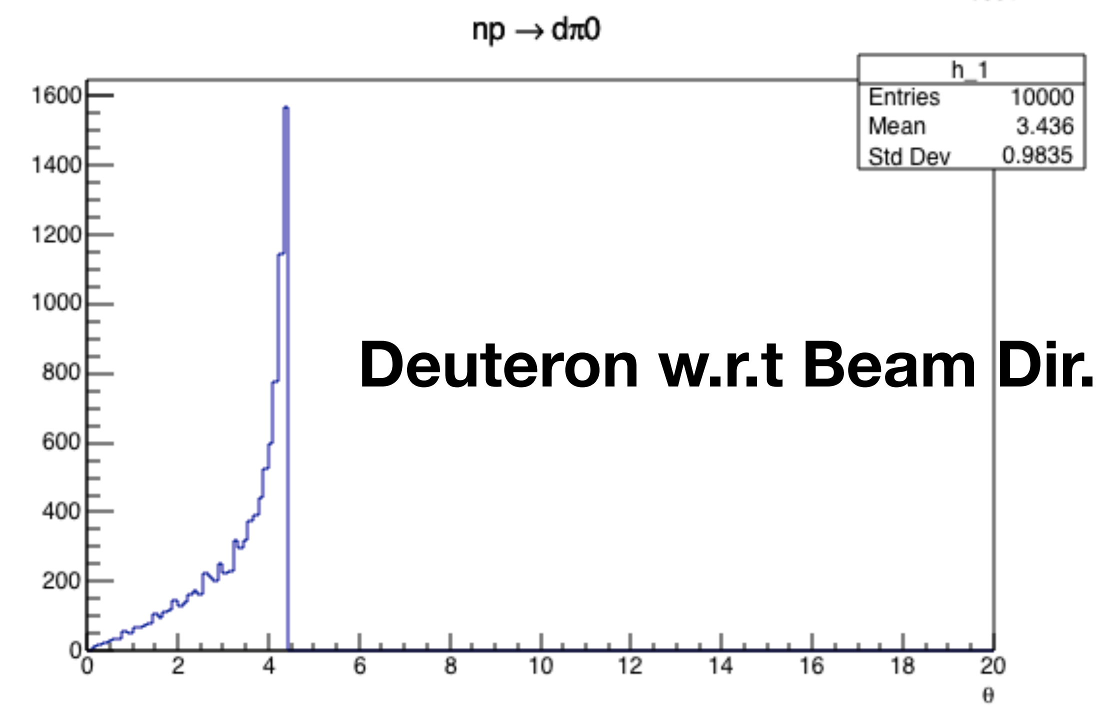
np->dπ0



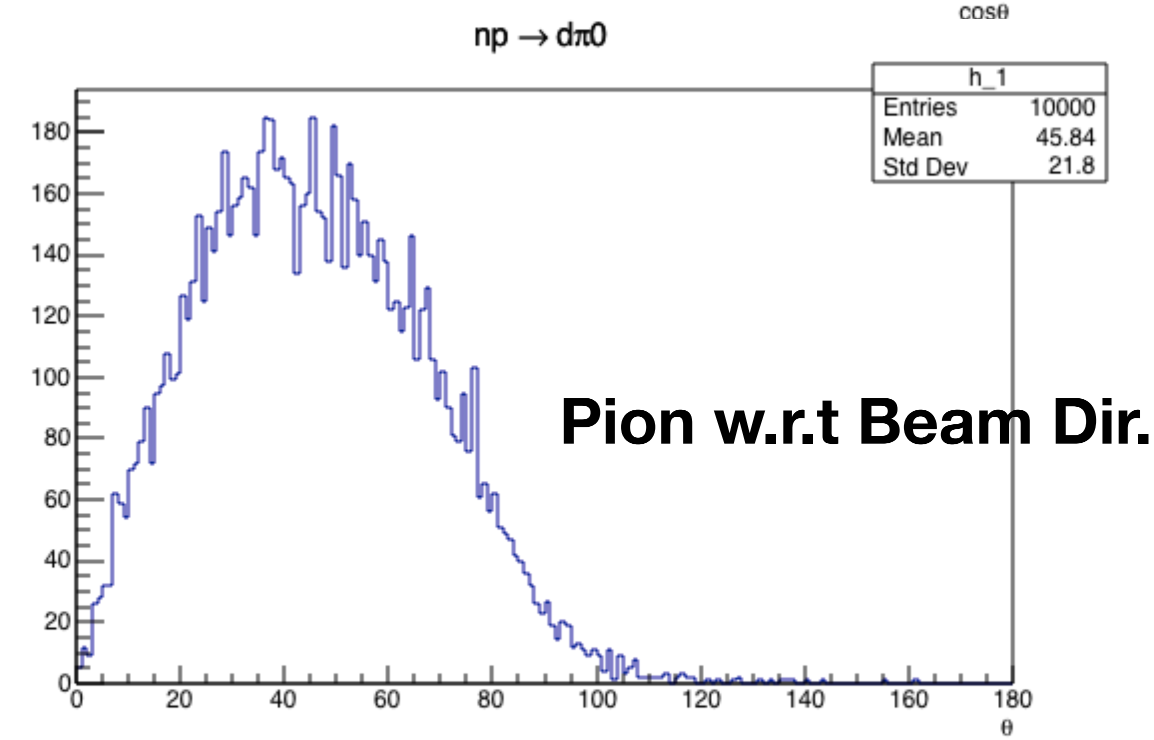
np → dπ0
h1
Entries 10000
Mean 0.9981
Std Dev 0.0008781
Deuteron w.r.t Beam Dir.
cosθ



np → dπ0
h1
Entries 10000
Mean 0.6501
Std Dev 0.2759
Pion w.r.t Beam Dir.
cosθ

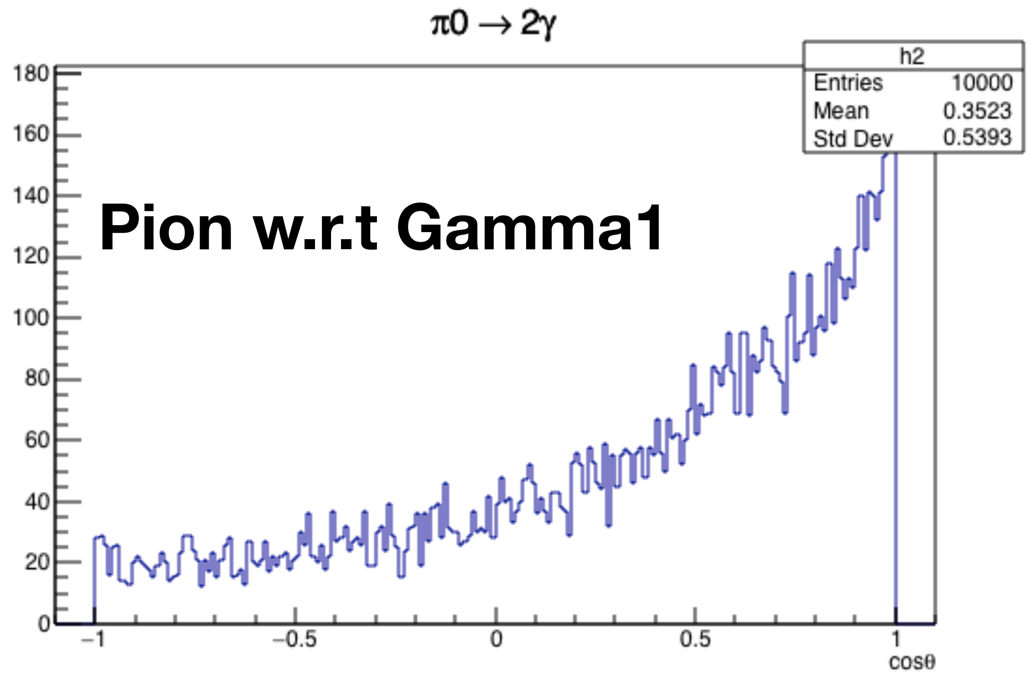


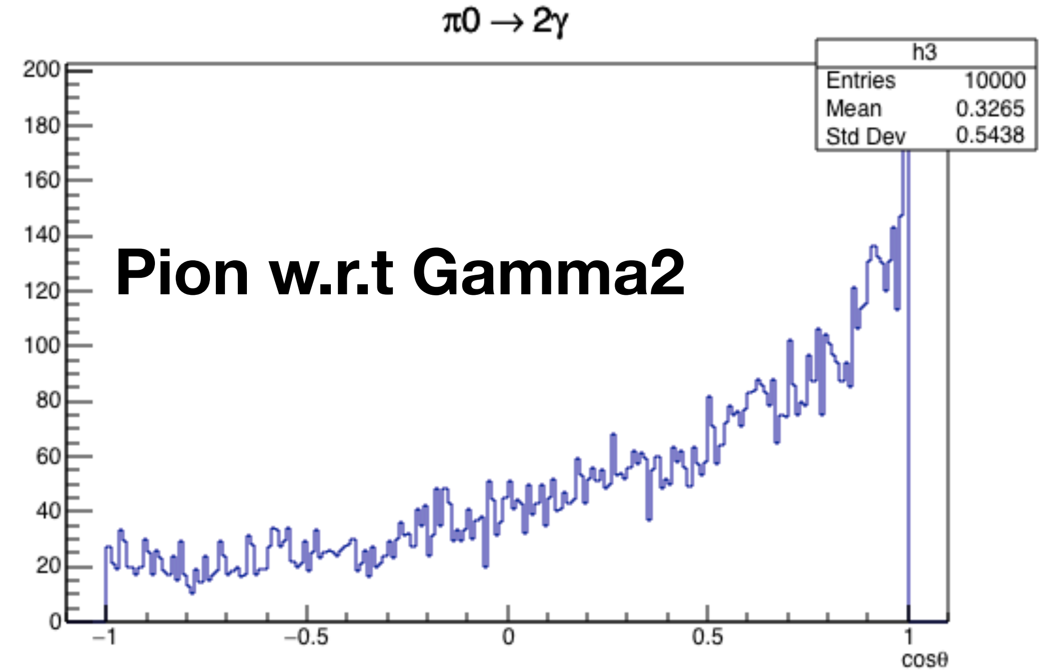
np → dπ0
h_1
Entries 10000
Mean 3.436
Std Dev 0.9835
Deuteron w.r.t Beam Dir.
θ

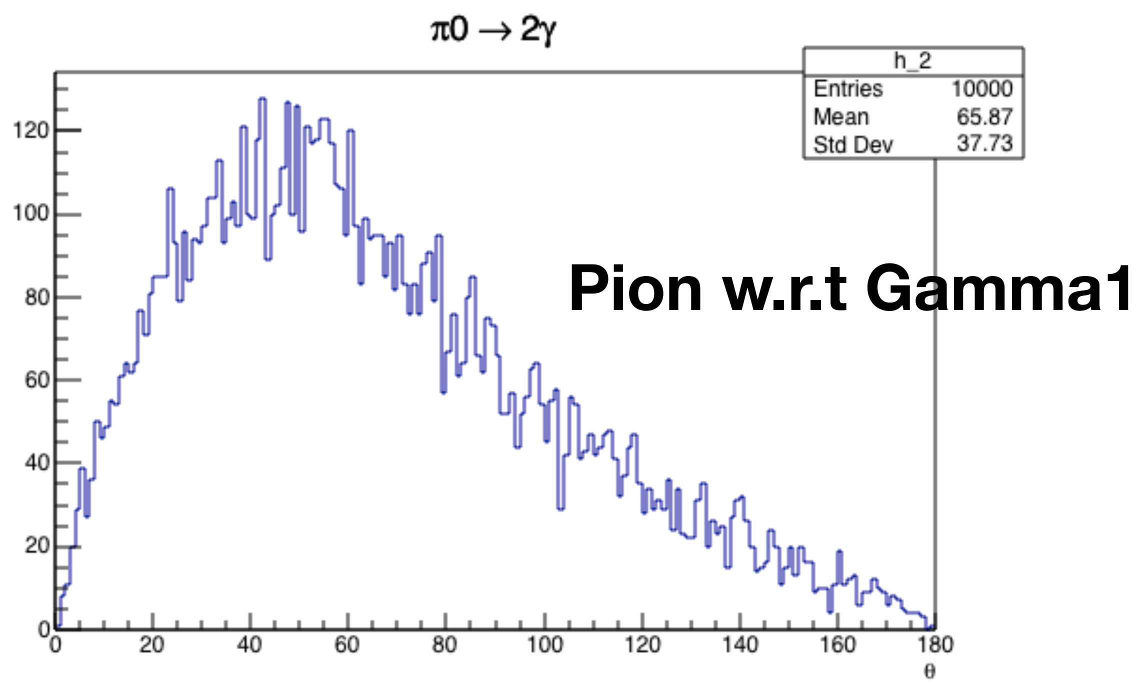


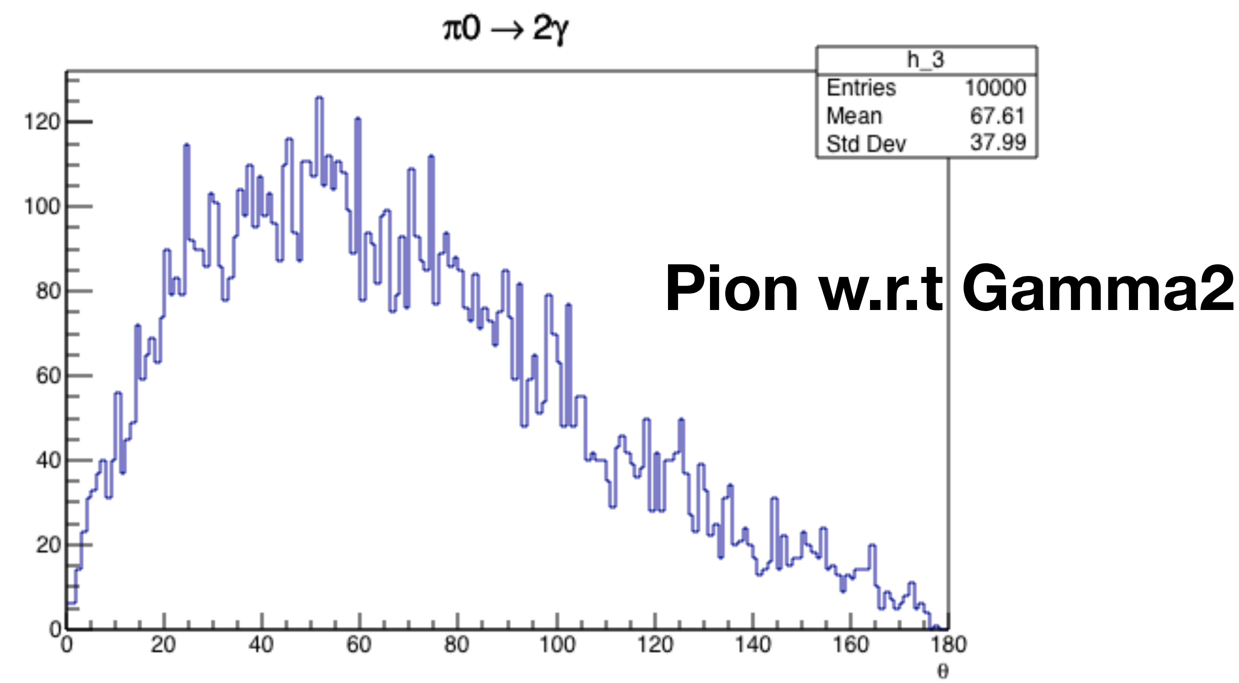
np → dπ0
h_1
Entries 10000
Mean 45.84
Std Dev 21.8
Pion w.r.t Beam Dir.
θ

np->$d\pi_0$

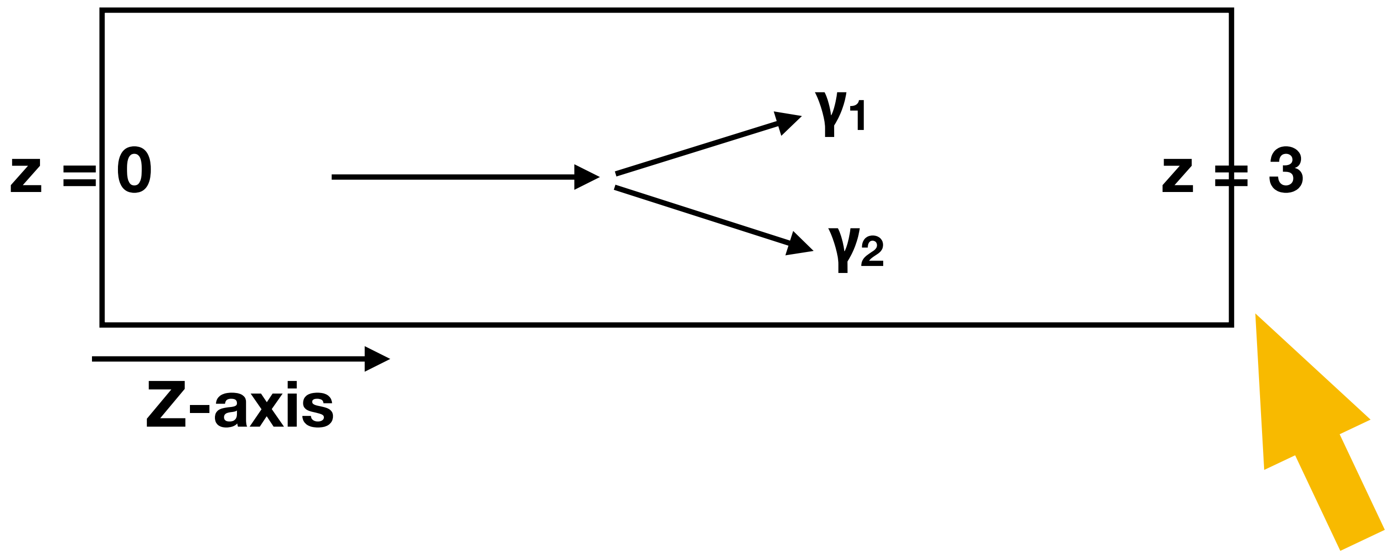

π0 → 2γ
h2
Entries 10000
Mean 0.3523
Std Dev 0.5393
Pion w.r.t Gamma1
0 20 40 60 80 100 120 140 160 180
−1 −0.5 0 0.5 1
cosθ


π0 → 2γ
h3
Entries 10000
Mean 0.3265
Std Dev 0.5438
Pion w.r.t Gamma2
0 20 40 60 80 100 120 140 160 180 200
−1 −0.5 0 0.5 1
cosθ


π0 → 2γ
h_2
Entries 10000
Mean 65.87
Std Dev 37.73
Pion w.r.t Gamma1
0 20 40 60 80 100 120
0 20 40 60 80 100 120 140 160 180
θ

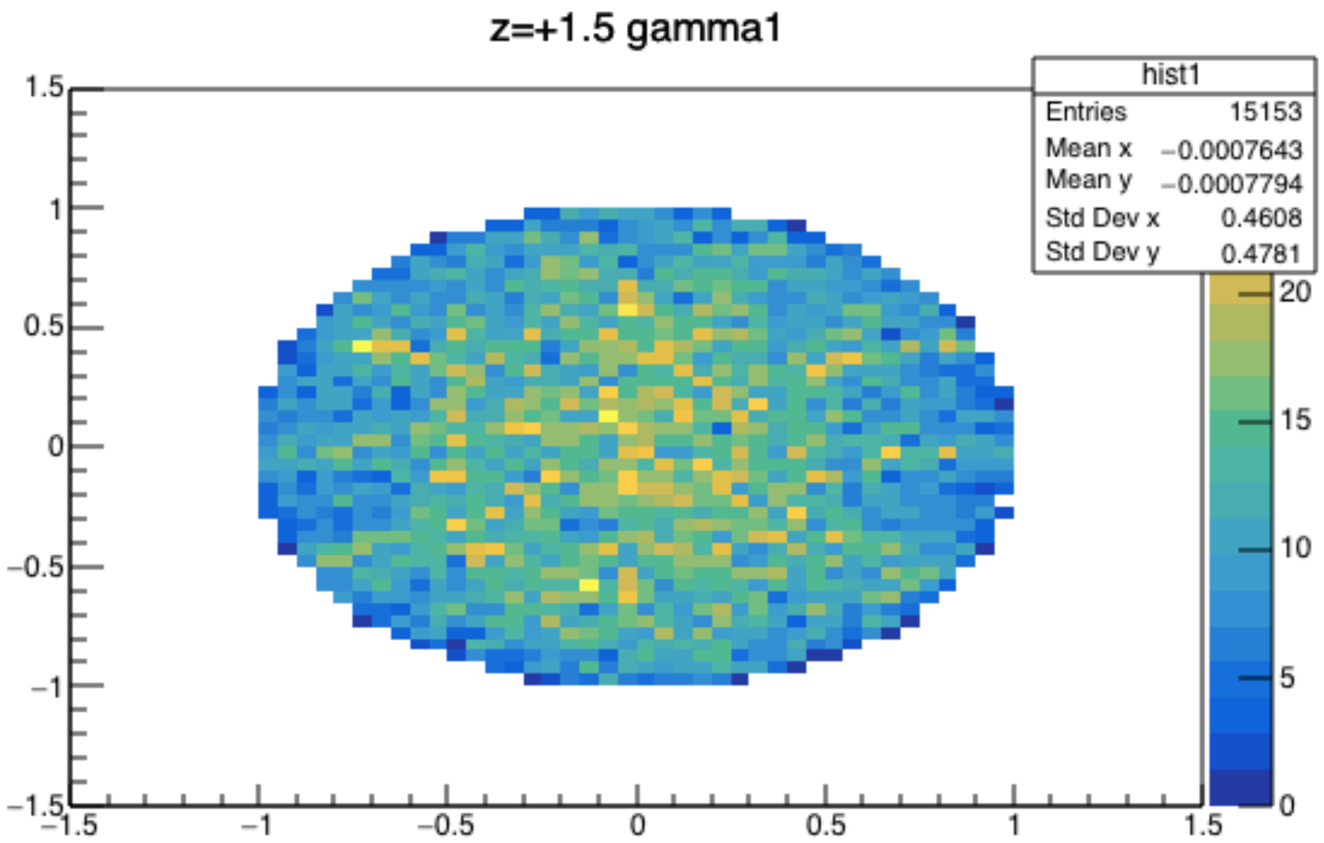

π0 → 2γ
h_3
Entries 10000
Mean 67.61
Std Dev 37.99
Pion w.r.t Gamma2
0 20 40 60 80 100 120
0 20 40 60 80 100 120 140 160 180
θ

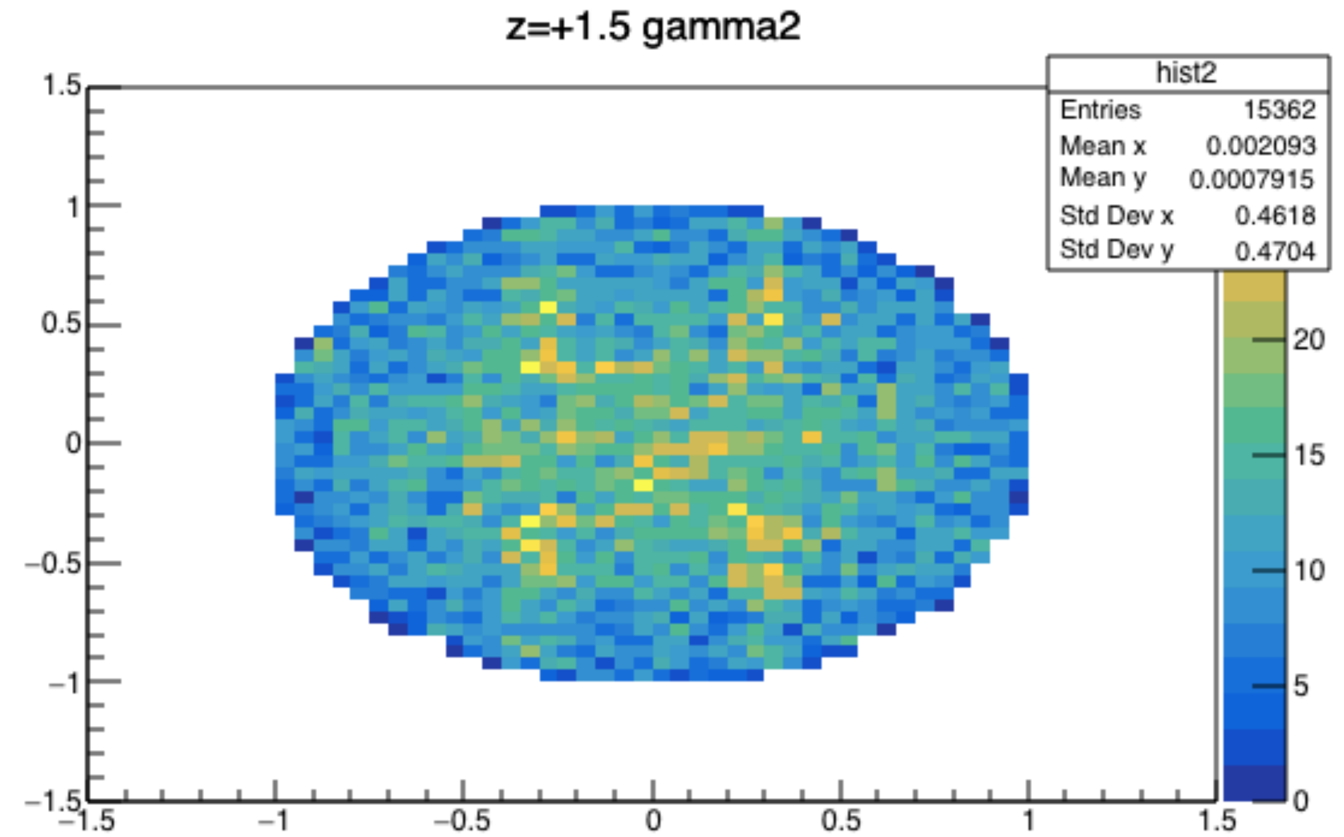
Hit Position of 2γ



- Assume a cylindrical barrel (rad : 1 m ; length : 3 m) and the process occurs inside of it
- By simple calculation, it is able to estimate the hit position of 2γ in the circle of radius 1 m.
- 2γ creation point : in the middle of cylinder (z = 1.5) and z= +1.0 m respectively.

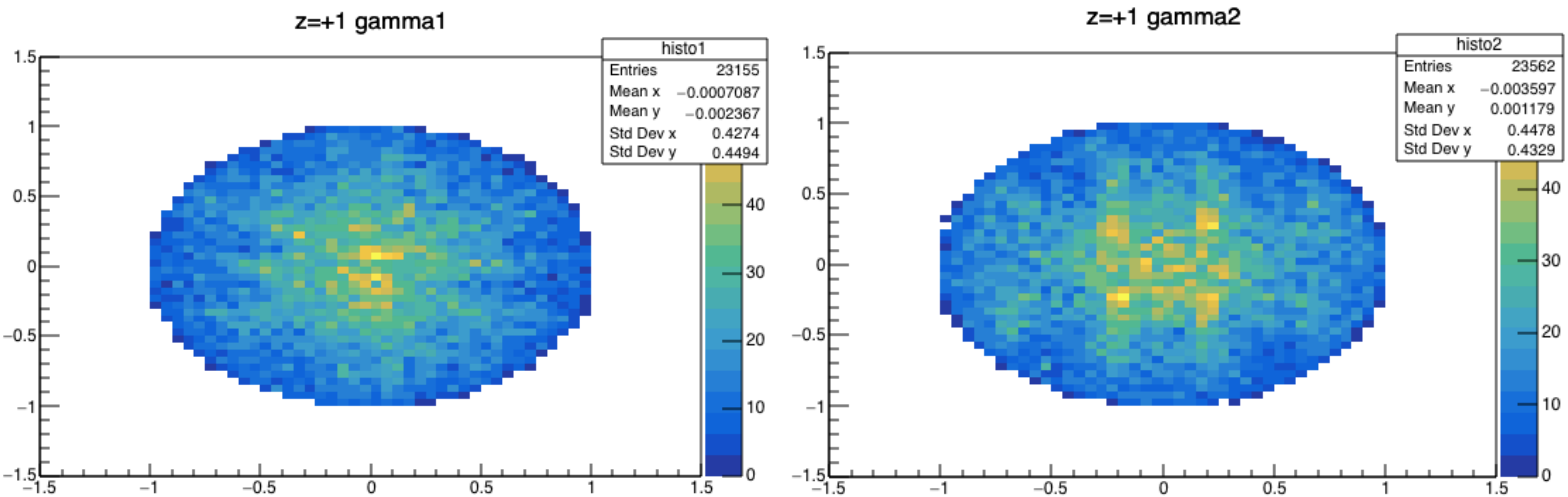
Hit Position of 2γ





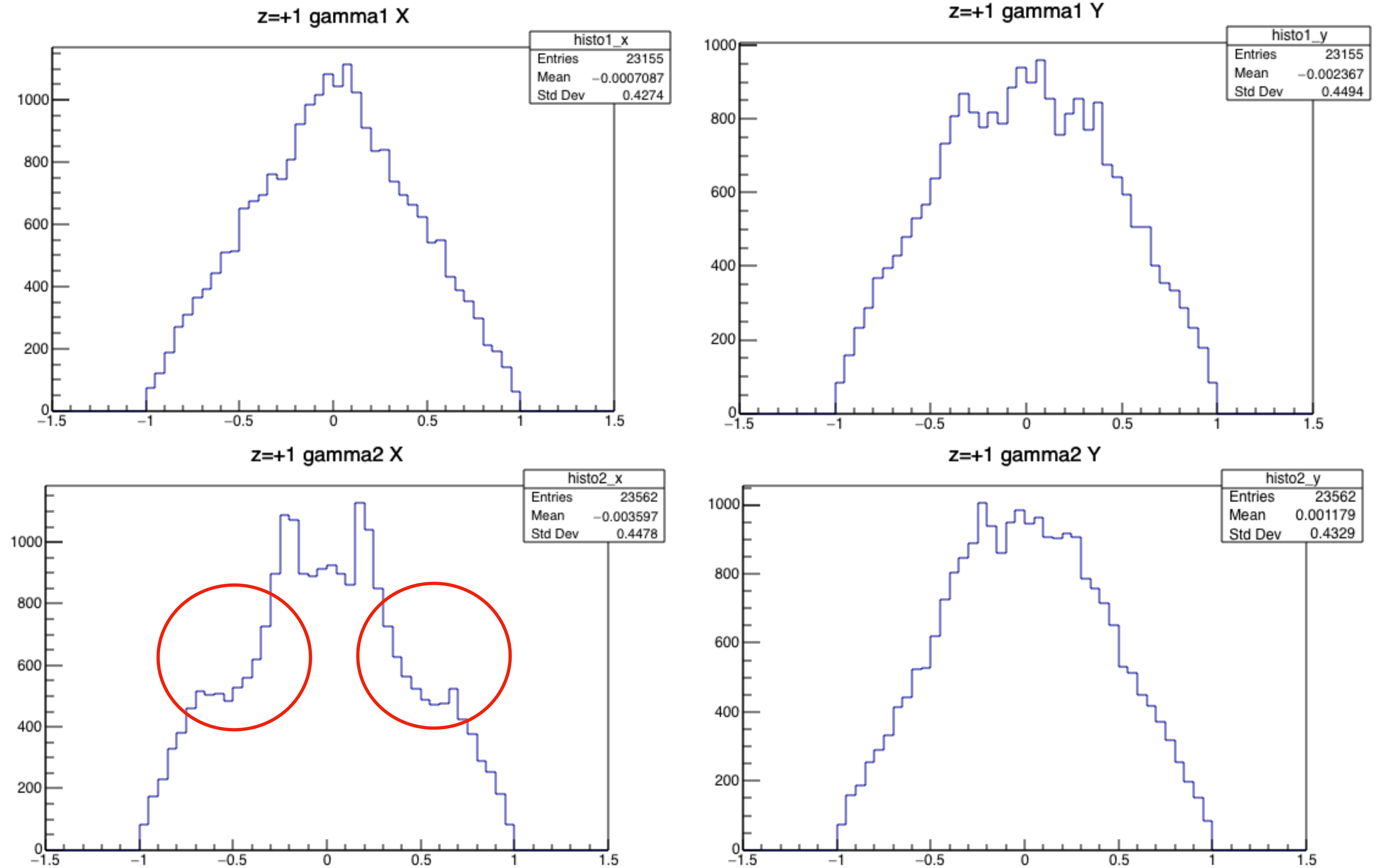
- z = 1.5 m case
- No specific difference of hit position between 2γ
- γ1 : 15153 Hits / 100000 Events (~ 15 %) ; γ2 : 15362 Hits / 100000 Events (~ 15 %)

Hit Position of 2γ



- z = 1.0 m case
- Slight Difference of Hit pattern in the centre of the circle -> Check the projection to each axis.
- γ1 : 23155 Hits / 100000 Events (~ 23 %) ; γ2 : 23562 Hits / 100000 Events (~ 24 %)

Hit Position of 2γ



Interaction Rate

- Assume the pressure inside the cylindrical barrel is 10^{-5} Pa
- Residual Gas in such pressure would be mainly Hydrogen Gas
- Therefore, in the cylinder number of Hydrogen Molecules would be (approximate its volume as 9 m^3)

$$n = \frac{PV}{RT} = \frac{10^{-5}[Pa] \cdot 9\ [m^3]}{8.31\ [J/mol^{-1} \cdot K] \cdot 293\ [K]} = 3.7\times10^{-8}\ mol$$

$$N = nN_A = 3.7\times10^{-8}\ [mol] \cdot 6.03\times10^{23}\ [mol^{-1}] = 2.2\times10^{16}$$

Interaction Rate

- Number of Target (Proton) Calculation

$$n_{target} = \frac{N_A}{W}\rho L = \frac{6.03\times10^{23}\ mol^{-1}}{1\ g/mol}\cdot\frac{3.7\times10^{-8}\cdot 2\ g/mol}{9\times10^{6}\ cm^{3}}\cdot 300\ cm = 5\times10^{11} cm^{-2}$$

- Interaction Rate Calculation

$$Y(P,F_n) = F_n n_{target}\sigma = F_n\frac{N_A}{W}\rho L\sigma = F_n\frac{N_A}{W}\frac{2nW}{V}L\sigma = 2F_nN_A\frac{n}{\pi r^2}\sigma$$

$$Y(P,F_n) = 2F_nN_A\frac{PV}{\pi r^2\cdot RT}\sigma = 2F_nN_A\frac{P}{RT}\sigma L$$

Summary

- By calculating two-body kinematics of np->dπ_0 ->d2γ , it is possible to measure the angle of daughters w.r.t the mother particle
- Also, when the interaction is occurred in the cylindrical barrel, Hit Pattern of Gamma is also able to estimate. -> No Special Dependence
- At 293K, by using Ideal Gas Law, the Interaction Rate can be expressed as a function of Pressure and Number of Beam