Beam Asymmetry in γ p $\rightarrow$ η Δ^+ at GlueX

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Motivation (Physics) Σ beam asymmetry

- **Σ (-t)** provides insight into beam-target exchange(production mechanism)

Channel : $\gamma\, p \rightarrow \eta\, \Delta^{+}$

Where : $\eta \rightarrow \gamma\ \gamma$

$\Delta^{+} \rightarrow p\ \pi^{0}$

- From V.Mathieu (JPAC theory group)
  Exchanges similar to **γp → ηp**
  Expect Σ ≈ 1 natural parity exchange

- Experimentally, analysis tools from previously done **γp → π⁻ Δ⁺⁺** beam asymmetry analysis in GlueX are adapted with very minor tweaks

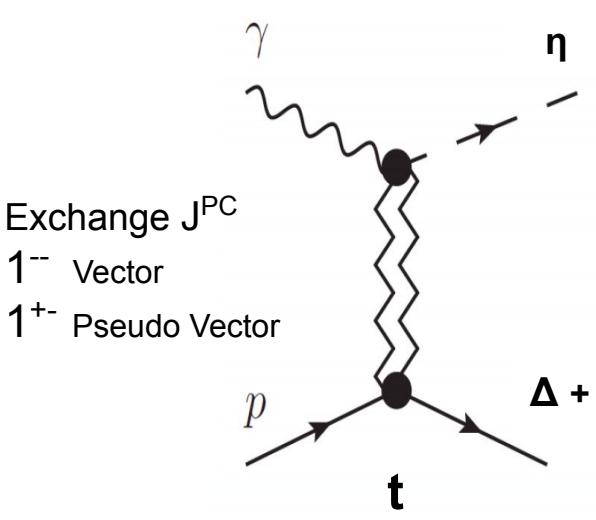


Fig. Exchange interaction

- 2017 data set (GlueX-I) with standard cuts
- Coherent peak energy : 8.199 < E < 8.8001
- Standard ReactionFilter cuts
- 51<vertex z<78 cm // vertex r < 1.5 cm
- χ 2 /NDF < 20

Beam asymmetry Σ (Method)

- Direct fit to **φ** distribution :

$$\textbf{Yield Asym} = \frac{Y_\perp - F_R Y_\parallel}{Y_\perp + F_R Y_\parallel} = \frac{(P_\perp + P_\parallel)\Sigma \cos(2(\phi - \phi_0))}{2 - (P_\perp - P_\parallel)\Sigma \cos(2(\phi - \phi_0))}$$

$p_{\parallel,\perp}$ are polarization values

F_R Flux ratio

Σ Is the free parameter to fit

- "Moment-Yield " method: Implemented in GlueX for **γp → π⁻ Δ⁺⁺**

$$\Sigma = \frac{Y_2^\perp - Y_2^\parallel}{\frac{P_\parallel}{2}(Y_0^\perp + Y_4^\perp) + \frac{P_\perp}{2}(Y_0^\parallel + Y_4^\parallel)}$$

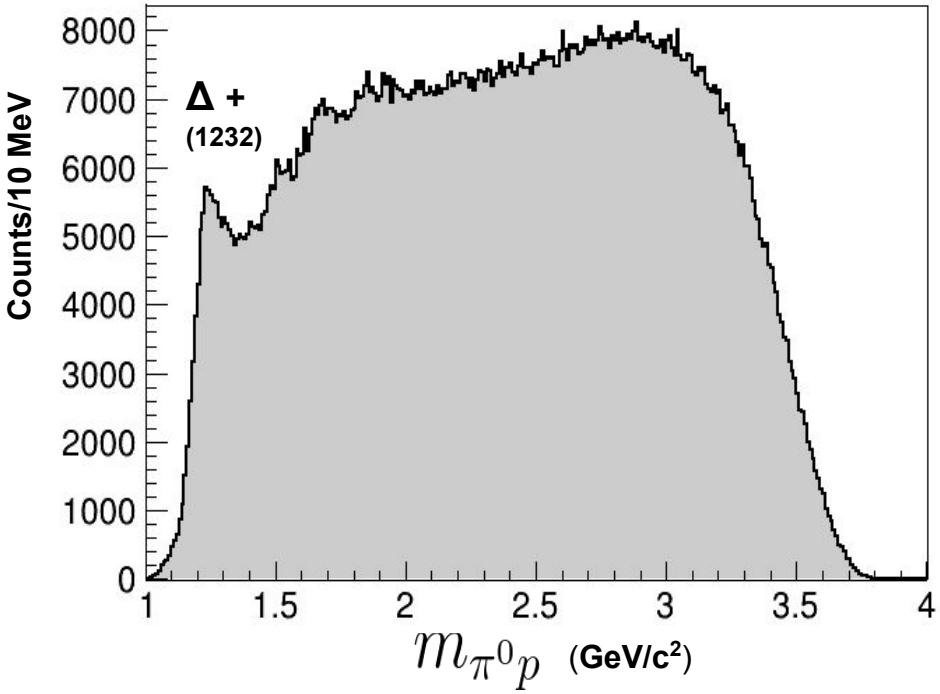
$Y_n^{\parallel,\perp}$ are yields from moment weighted (cos**n**φ) histograms. **n**=0,2,4,...
PARA and PERP combination removes any instrumental asymmetry

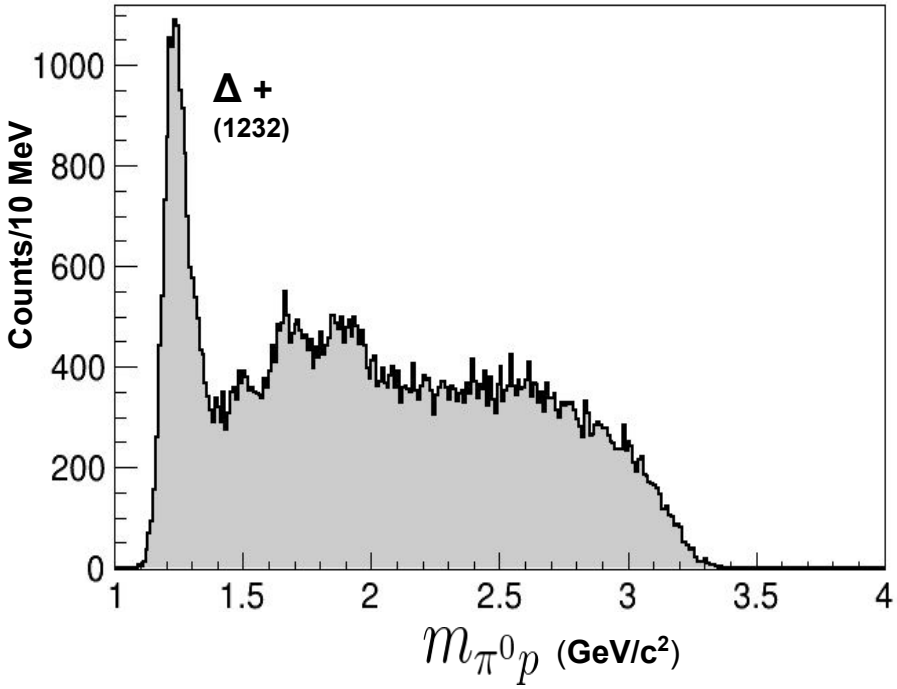
π^0 p Mass Distribution (2017 Data)

Before π^0, η Mass selection cuts

$0.125 < \pi^0 < 0.150$
$0.50 < \eta < 0.60$

After π^0, η Mass cuts





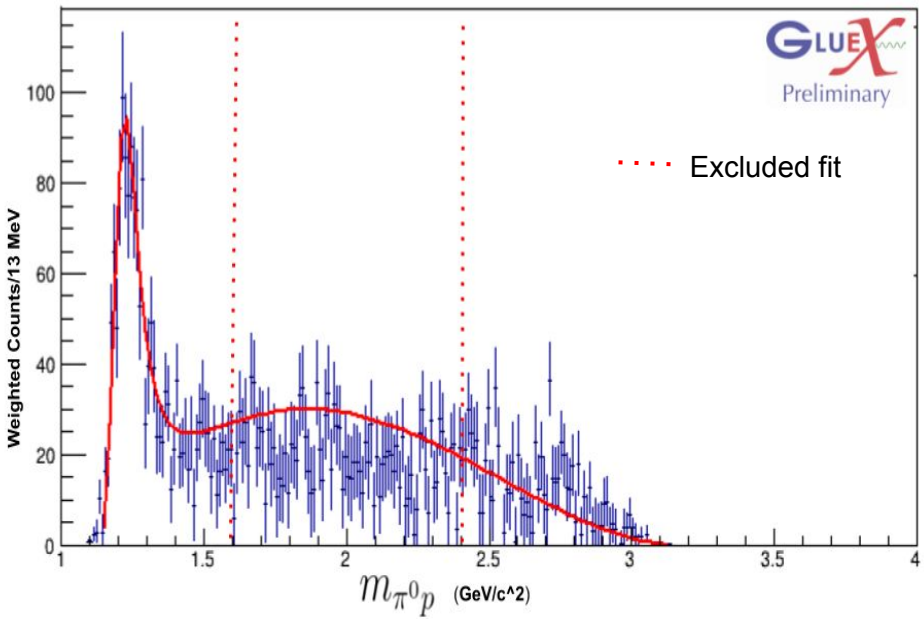
Extraction of Σ_η

$$\Sigma = \frac{N}{D} = \frac{Y_2^{\perp} - Y_2^{\parallel}}{\frac{P_\parallel}{2}(Y_0^{\perp} + Y_4^{\perp}) + \frac{P_\perp}{2}(Y_0^{\parallel} + Y_4^{\parallel})}$$

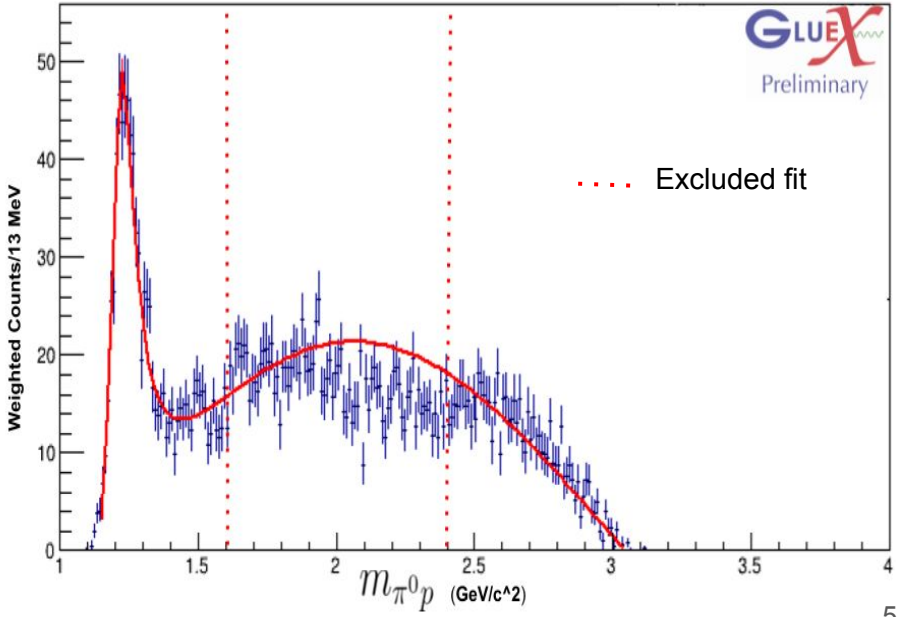
Signal -> Breitweigner (Dynamic)
Background-> bernstein polynomial

0/90 orientation & 0.2 < |t| < 0.35 Gev^2

Numerator Histogram



Denominator Histogram



Preliminary uncertainty in **Σ** (statistical)

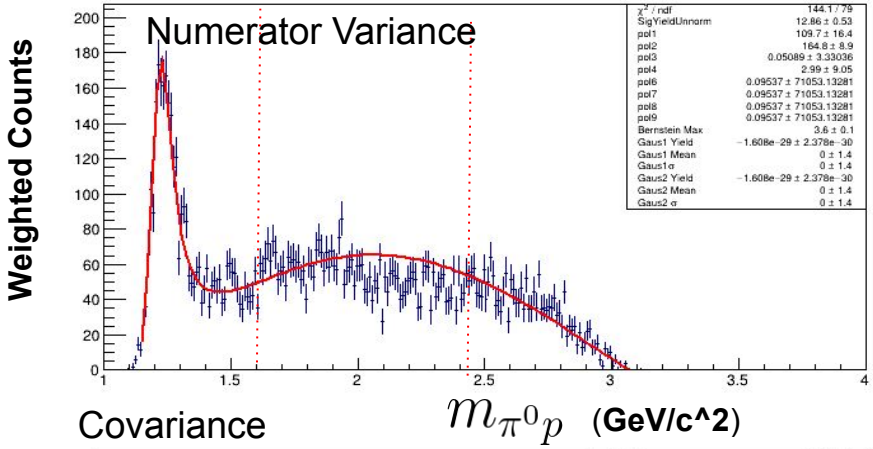
$$\sigma_\Sigma^2 = \frac{1}{2}\left(\frac{\sigma_N^2}{N^2} + \frac{\sigma_D^2}{D^2} - \frac{2Cov(N,D)}{ND}\right)$$

$$\sigma_N^2 = \frac{1}{2}(Y_{\perp 0} + Y_{\perp 4}) + \frac{1}{2}(Y_{\parallel 0} + Y_{\parallel 4})$$

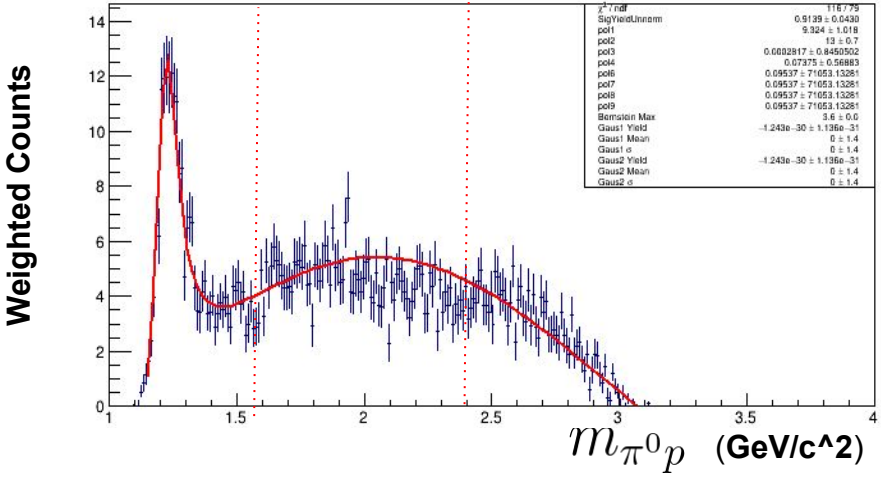
$$\sigma_D^2 = \frac{P_\parallel^2}{4}(Y_{\perp 0} + \frac{1}{2}(Y_{\perp 0} + Y_{\perp 8}) + \frac{1}{2}(Y_{\parallel 0} + Y_{\parallel 4}) + (\perp \Leftrightarrow \parallel)$$

$$Cov(N,D) = \frac{P_\parallel}{4}(3Y_{\perp 2} + Y_{\perp 6}) - (\perp \Leftrightarrow \parallel)$$

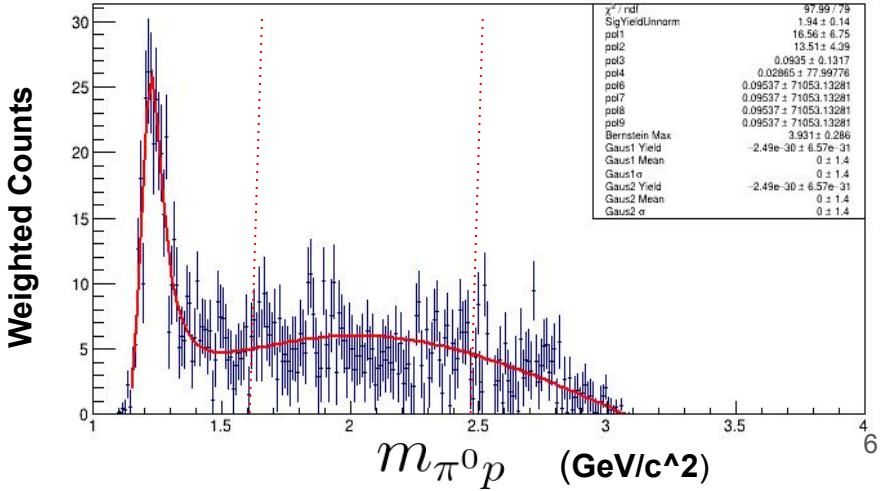
Numerator Variance



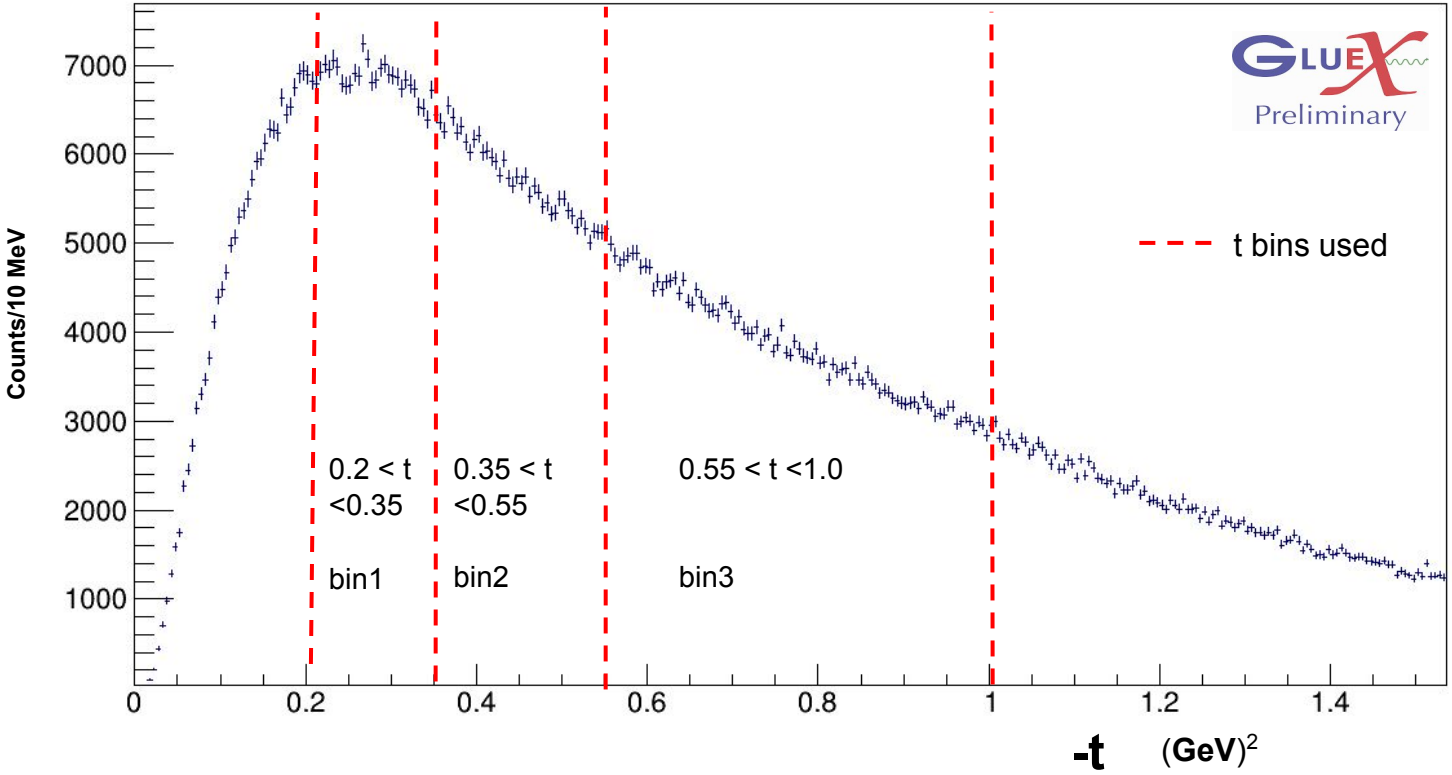
Denominator Variance



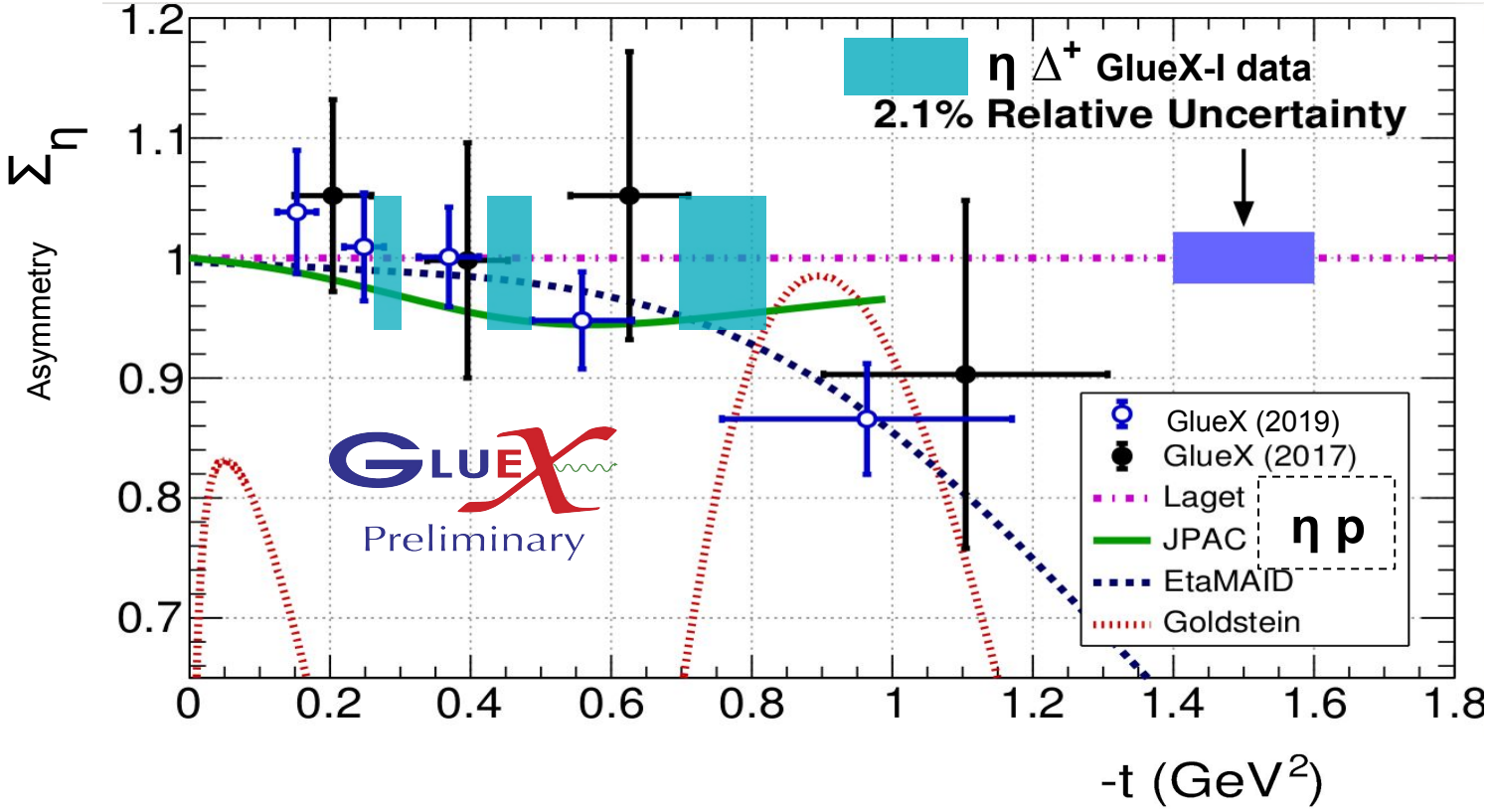
Covariance



Mandelstam **t** distribution



Projected Preliminary uncertainty in Σ_η



MC efficiency studies

MC genr8 - 2017 spring

Efficiency as a function of

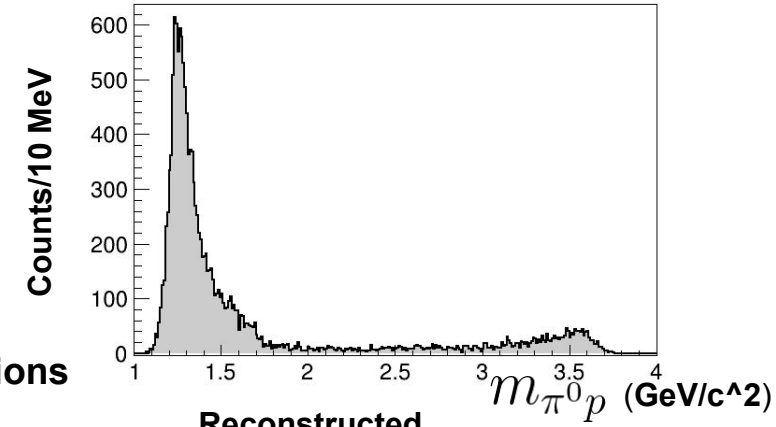
- Pi0 Proton Mass distributions

  For corrections to BW lineshape

Used cuts same as data

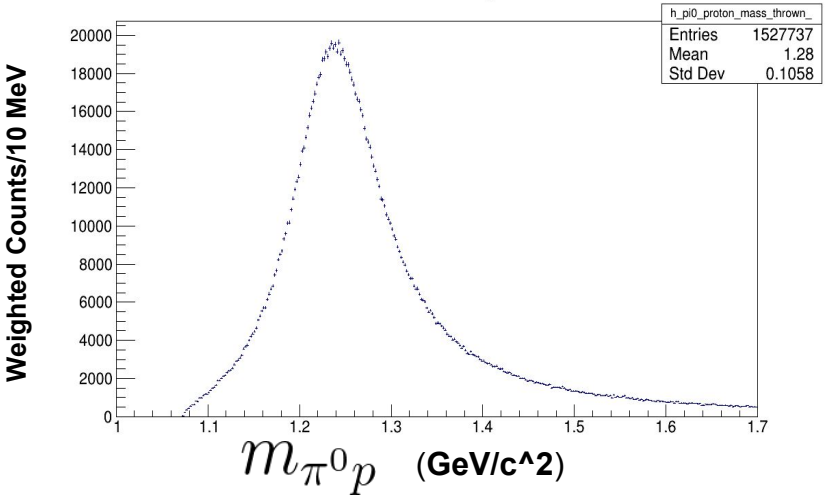
0.125 < π_0 < 0.150

0.50 < η < 0.60

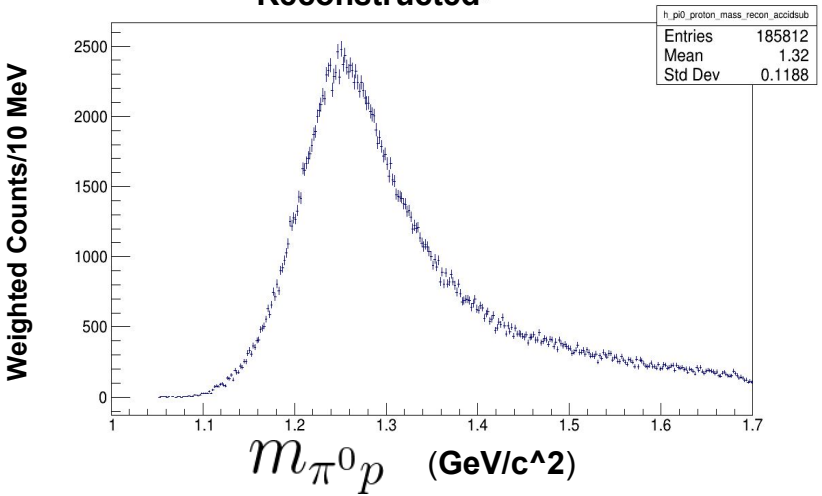


Pi0 Proton Mass distributions

Thrown

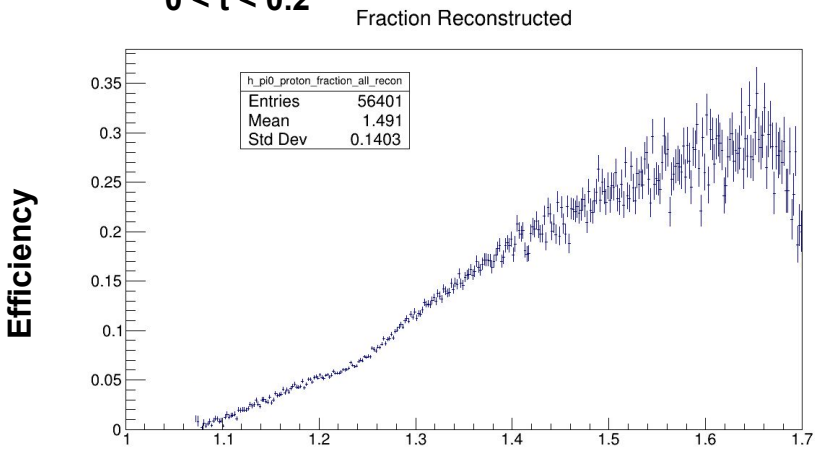


Reconstructed

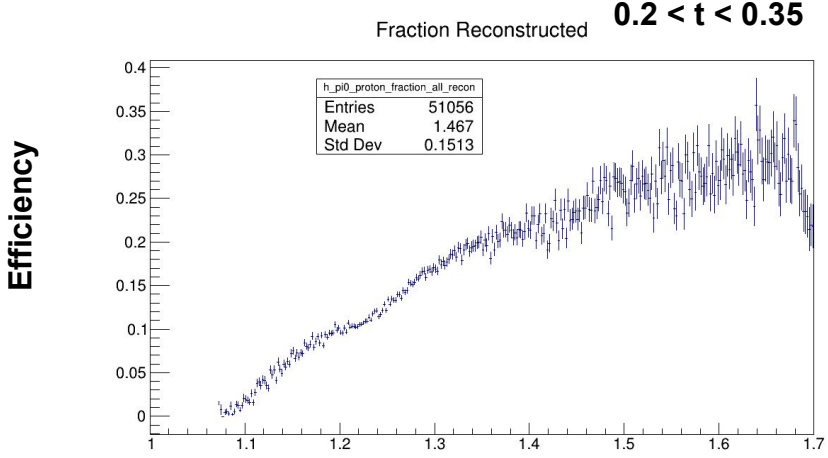


Efficiency as a function of mass (pi0 proton)

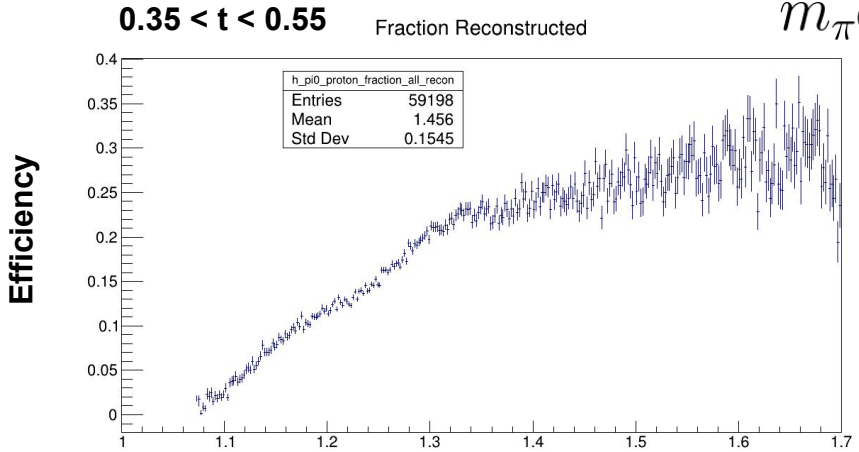
0 < t < 0.2



0.2 < t < 0.35

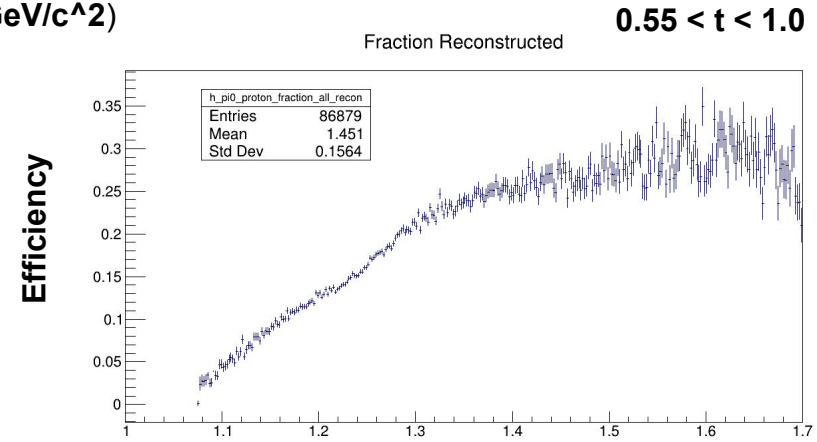


0.35 < t < 0.55



$m_{\pi^0 p}$ **(GeV/c^2)**

0.55 < t < 1.0



Efficiency as a function of GJ decay angles

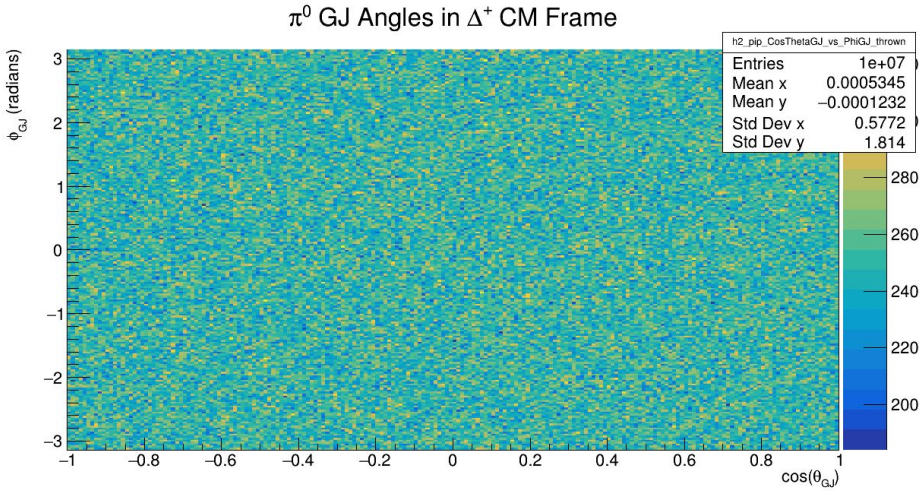
MC genr8 - 2017 spring

Efficiency as a function of

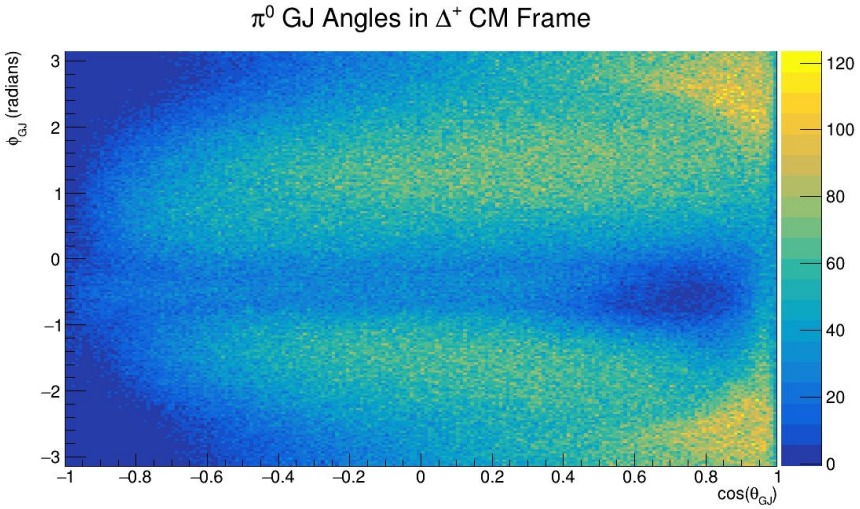
- GJ Delta decay angle

  For spin density matrix element (SDME) acceptance bias correction

Thrown



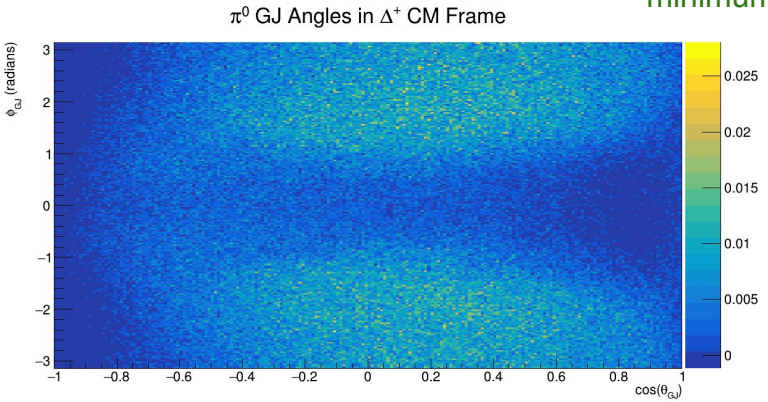
Reconstructed



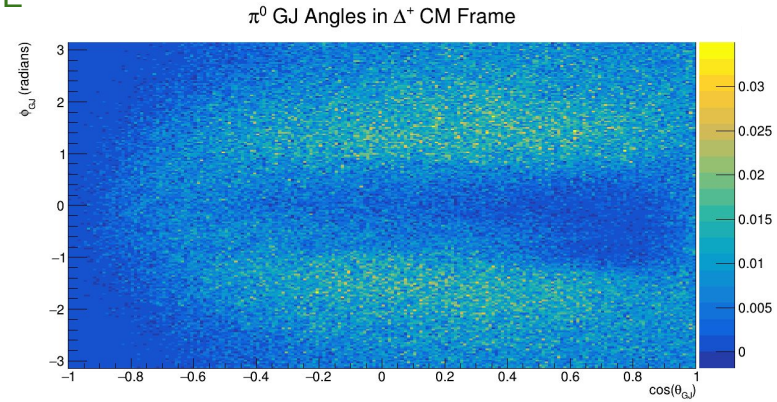
Efficiency as a function of GJ decay angles

study lowering BCAL minimum cluster E

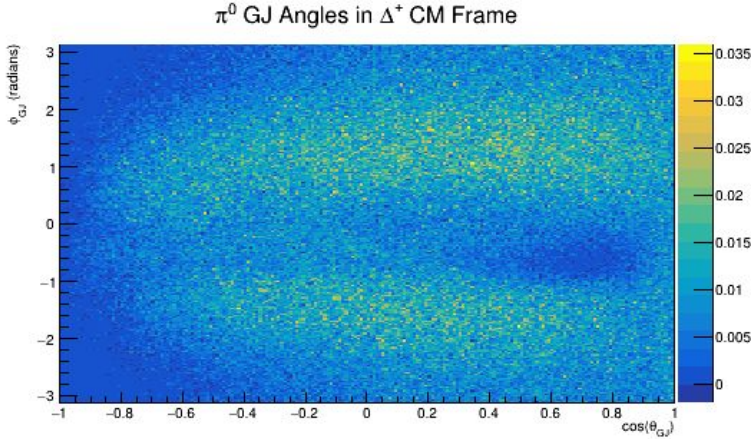
0 < t < 0.2



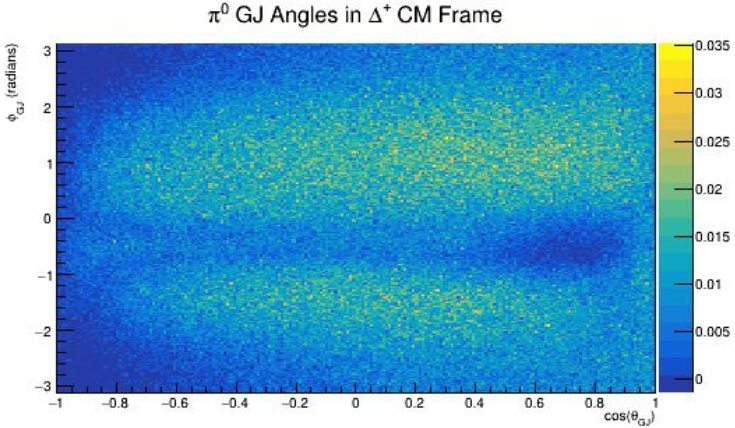
0.2 < t < 0.35



0.35 < t < 0.55



0.55 < t < 1.0



Summary

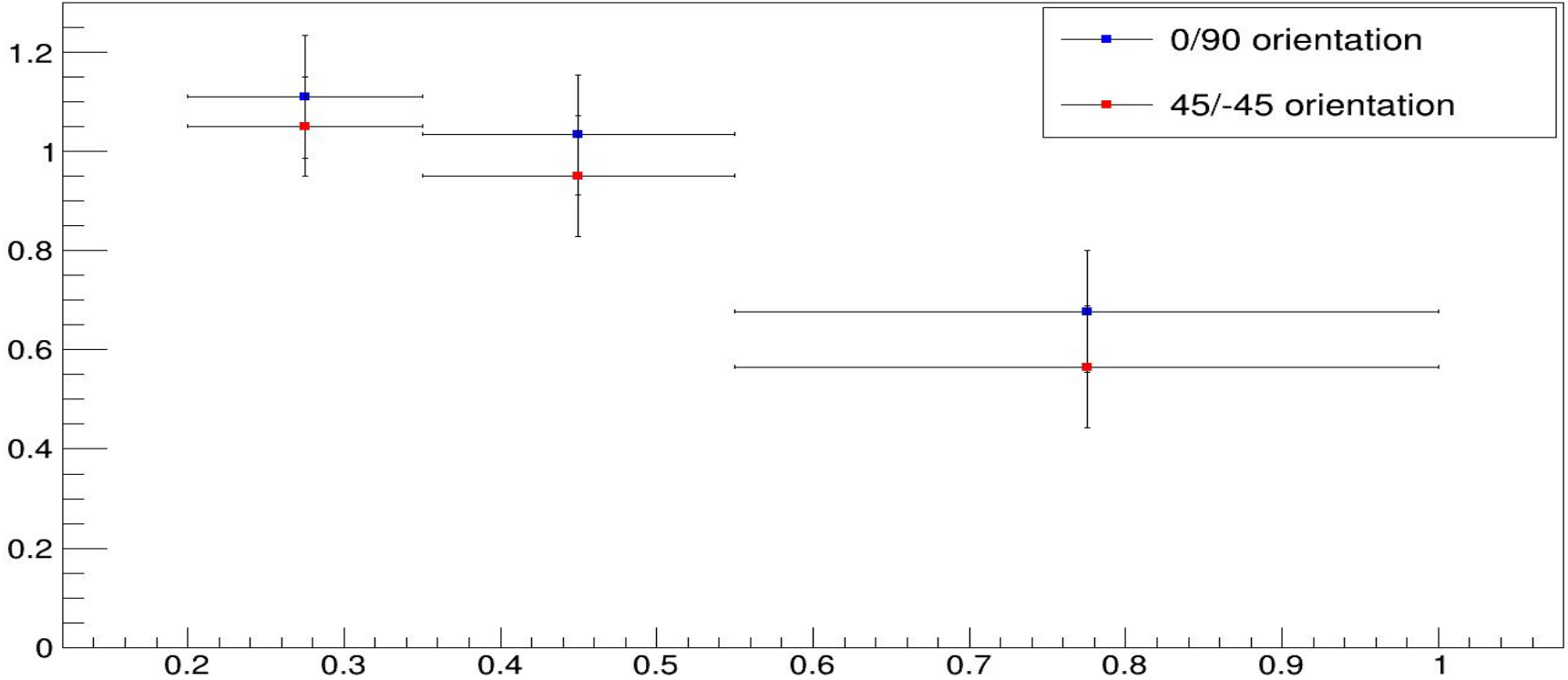
- Preliminary analysis is done with 20 % of GlueX-I dataset
- This analysis will be an external validation of $\gamma\, p \rightarrow \eta\, p$
- Efficiency studies are going on using MC genr8 samples

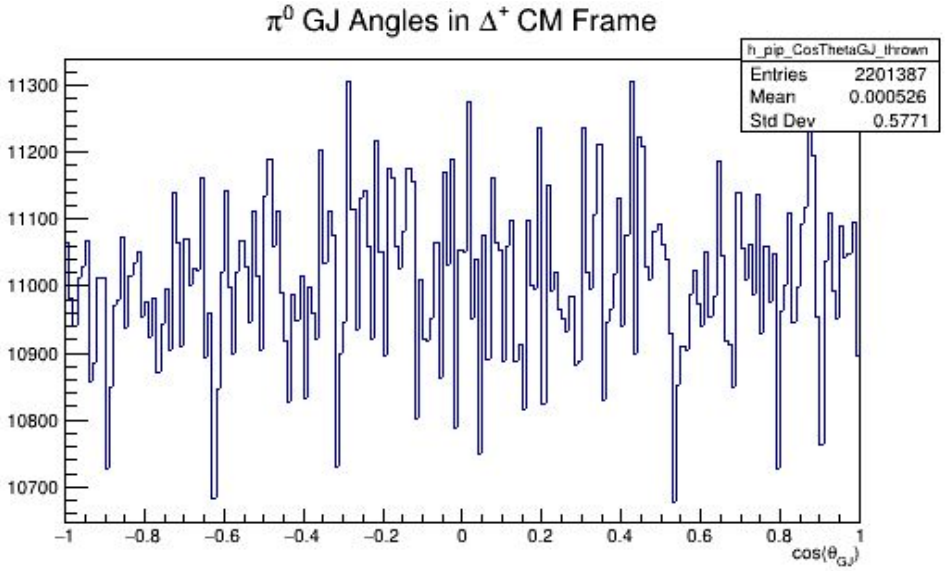
Next..

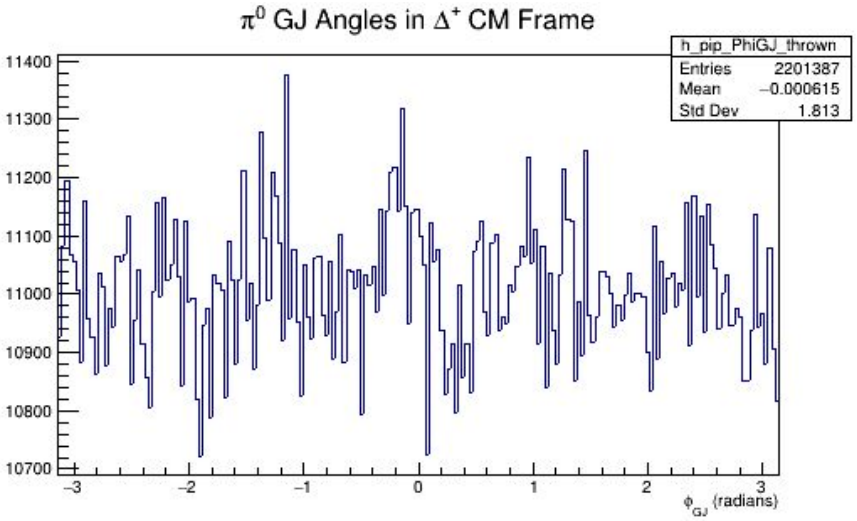
- Will look into systematic and statistical uncertainties in detail with complete GlueX-I dataset (more statistics !!)
- Apply efficiency corrections

Thank You !!!

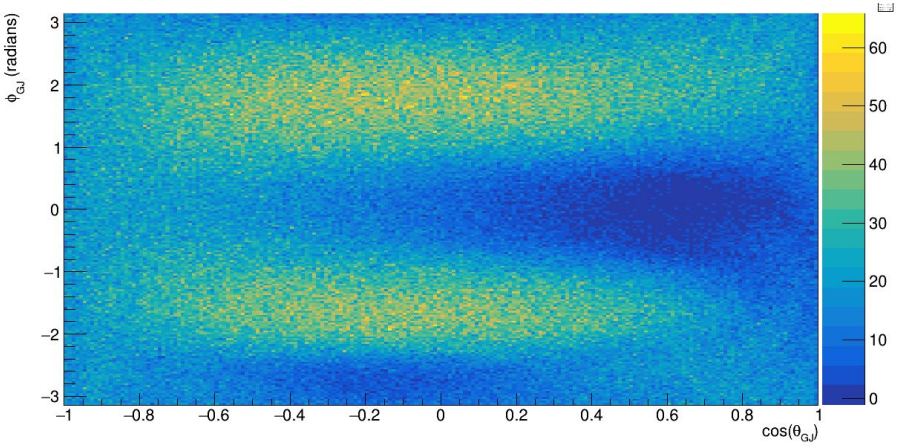
Asymmetry


0/90 orientation
45/-45 orientation
1.2
1
0.8
0.6
0.4
0.2
0
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

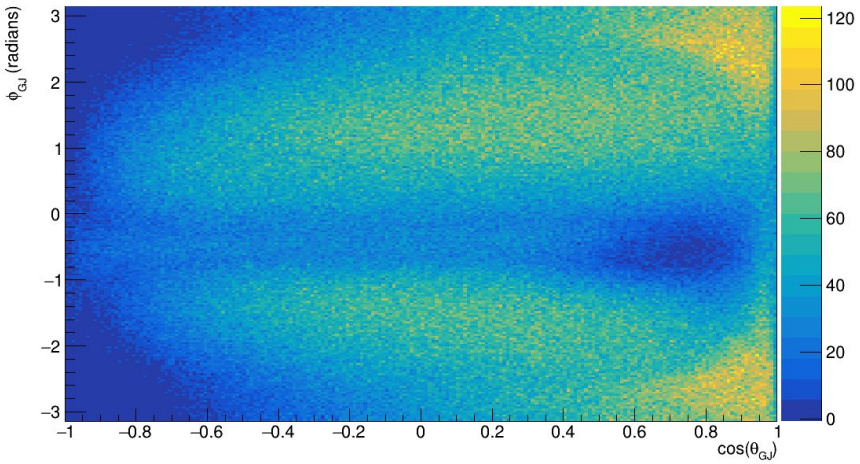

π^0 GJ Angles in Δ^+ CM Frame
h_pip_CosThetaGJ_thrown
Entries 2201387
Mean 0.000526
Std Dev 0.5771
11300
11200
11100
11000
10900
10800
10700
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1
$\cos(\theta_{GJ})$


π^0 GJ Angles in Δ^+ CM Frame
h_pip_PhiGJ_thrown
Entries 2201387
Mean −0.000615
Std Dev 1.813
11400
11300
11200
11100
11000
10900
10800
10700
−3
−2
−1
0
1
2
3
ϕ_{GJ} (radians)

Helicity


ϕ_{GJ} (radians)
3
2
1
0
−1
−2
−3
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1
$\cos(\theta_{GJ})$
60
50
40
30
20
10
0

GJ


ϕ_{GJ} (radians)
3
2
1
0
−1
−2
−3
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1
$\cos(\theta_{GJ})$
120
100
80
60
40
20
0