# Progress Towards a Measurement of the $\Sigma$ Beam Asymmetry of the $\vec{\gamma}p \to a_0^0(980)p$ Reaction at $E_\gamma \approx 9$ GeV

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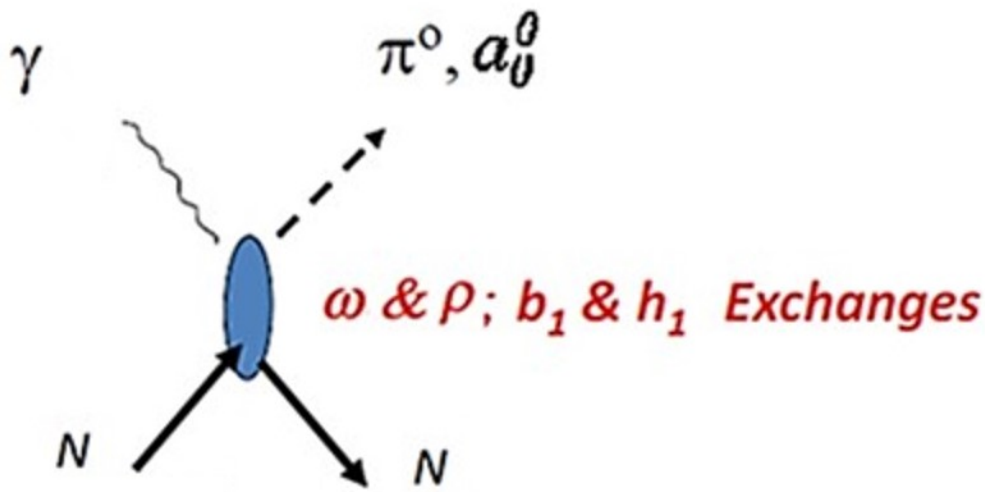
# Photoproduction of the $a_0(980)$

- We are interested in measuring the $\Sigma$ beam asymmetry of $\gamma p \to a_0^0 p$, and comparing with $\gamma p \to \pi^0 p$ asymmetry. We will compare scalar and pseudoscalar meson photoproduction.
- $\eta\pi^0$ decays into $4\gamma$



# $\Sigma$ Beam Asymmetry of $\vec{\gamma}p \to pa_0^0(980)$

- The Beam Asymmetry measures how the yield of a reaction changes given different polarizations of the incident particle, in this case a photon.

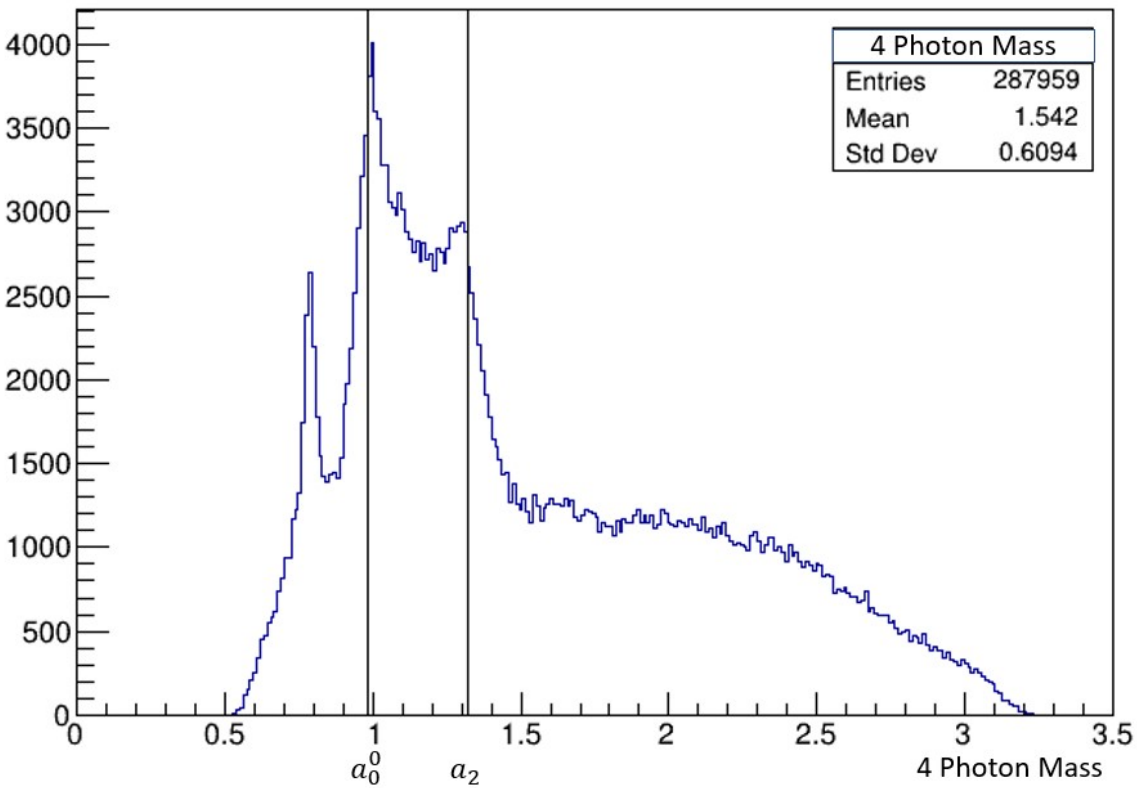
$$\frac{N(\phi)_{\parallel} - N(\phi)_{\perp}}{N(\phi)_{\parallel} + N(\phi)_{\perp}} = f(\Sigma)$$

  - This gives us a first insight into the dynamics of $\vec{\gamma}p \to pa_0^0(980)$.
  - Dynamics elucidate the relevant degrees of freedom.

# Reaction Filter and Basic Cuts

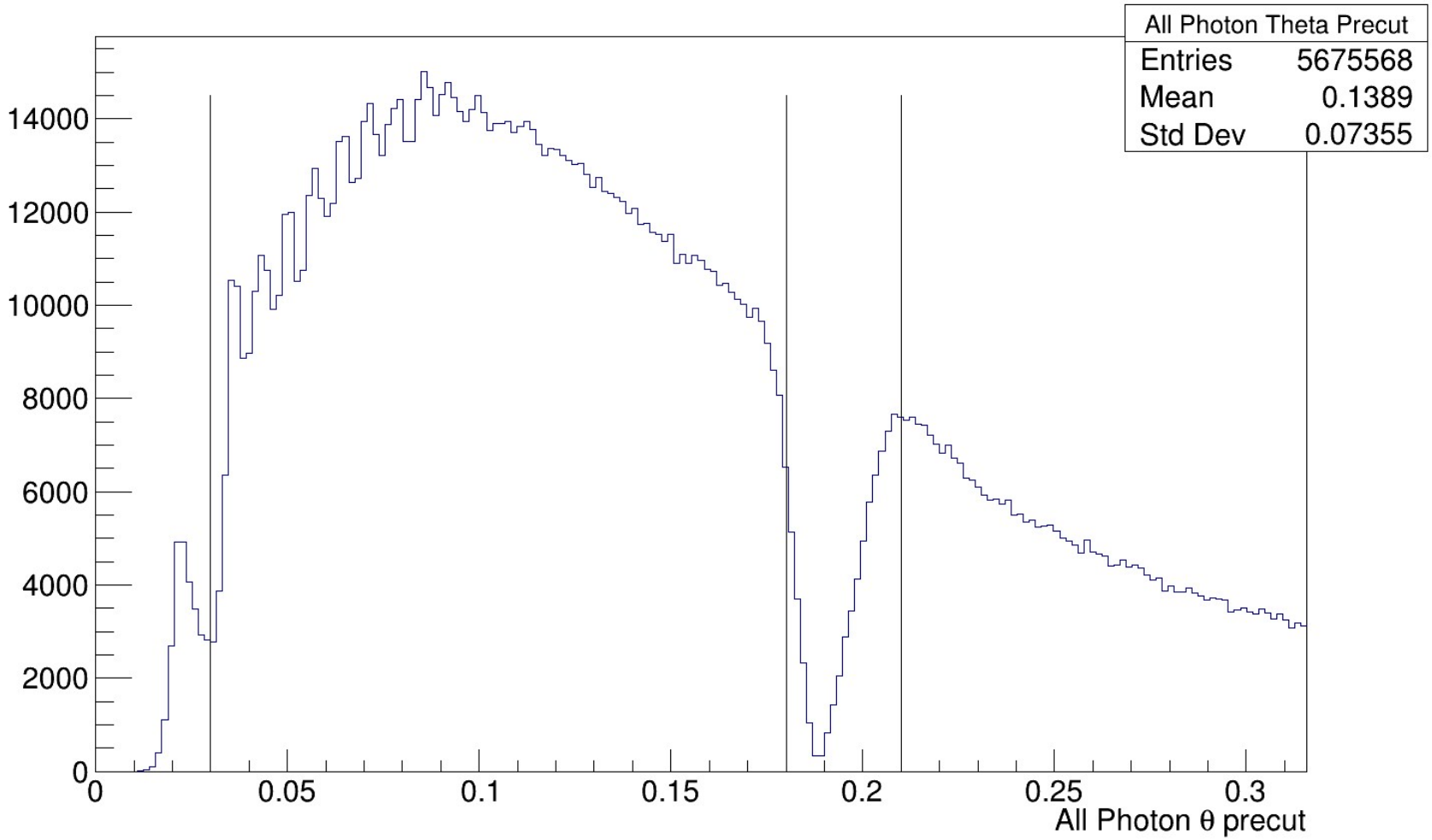
- Data and Reaction Filter
  - Final state is $4\gamma$
  - Using version 52 of 2017 Analysis Launch Data
  - Reaction Filter options: tree_pi0eta__B4_M17_M7
- First Data Reduction Cuts
  - Confidence level cut at 0.01
  - Beam Energy Cut for Coherent Peak $8.2 < E_\gamma < 8.9$ GeV
- Fiducial Cuts
  - Cuts around gap between FCAL and BCAL
  - Particle ID
- Accidental Subtraction
- *Nota Bene*: Uniqueness Tracking

# 4-Photon Mass Pre-Cuts and Weighting



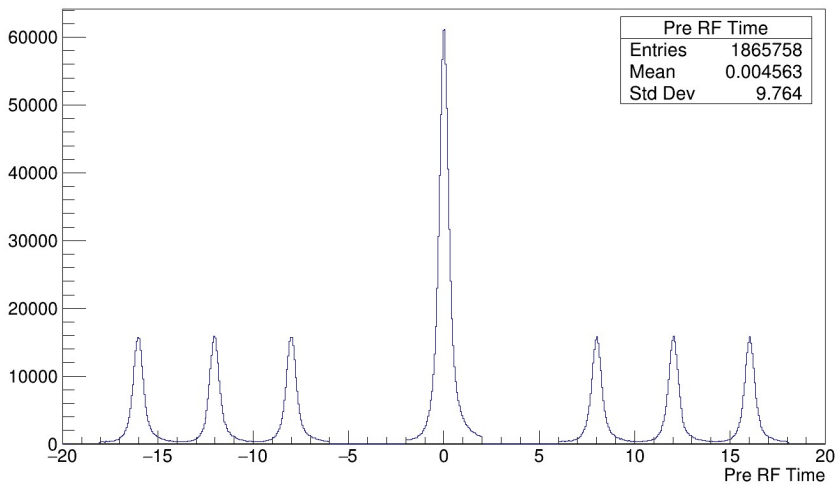

- After reaction Filter
- $8.2 < E_\gamma < 8.9$ GeV
- CL $> 0.01$
- No accidental Subtraction Yet
- No Fiducial Cuts Yet

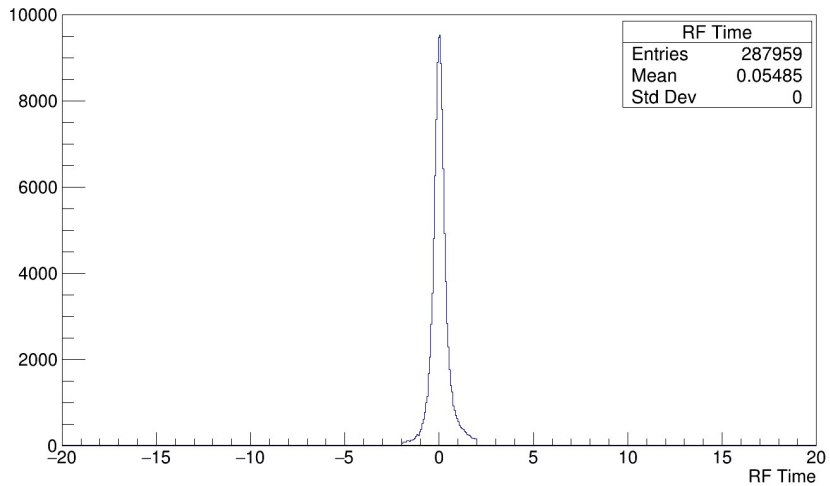
# Fiducial Cut




The end of the BCAL and the gap between the BCAL and FCAL are evident. We cut events with photons near the edge.

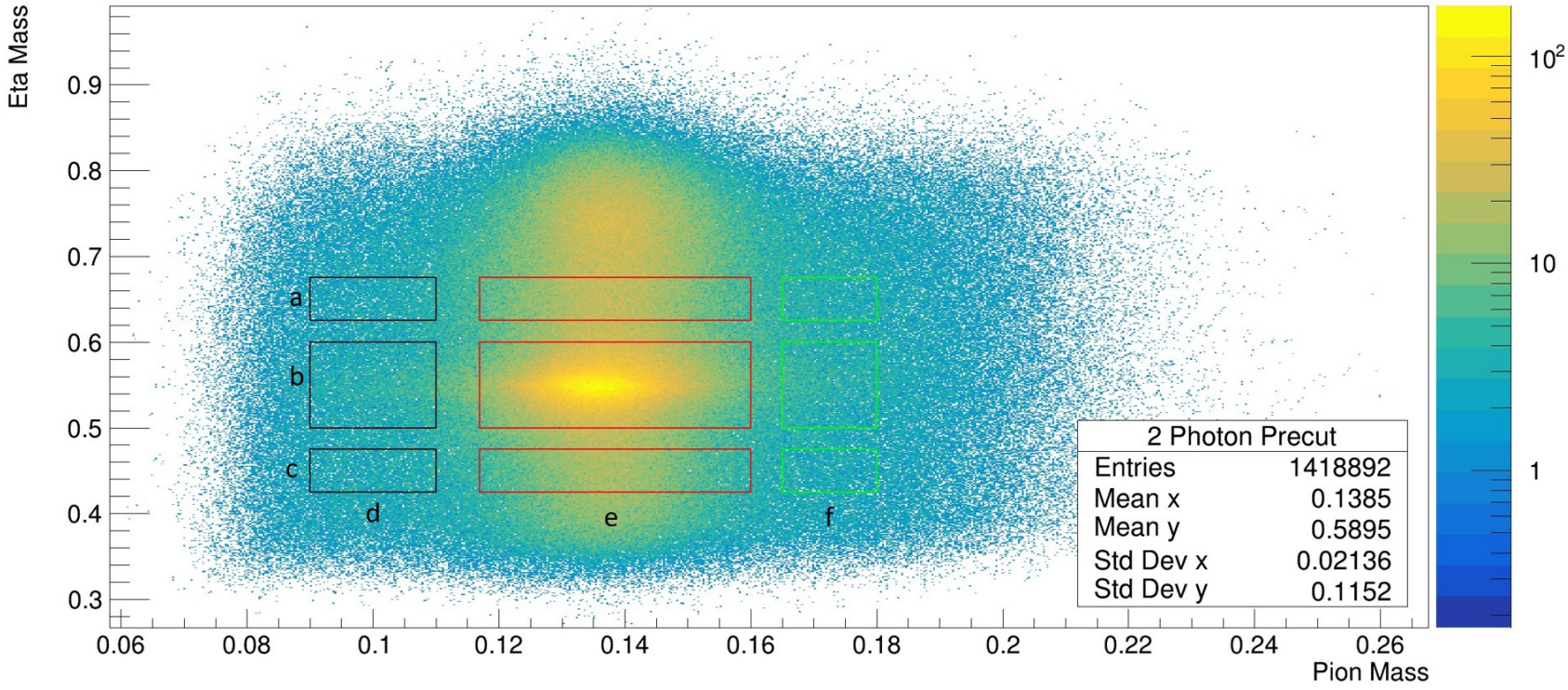
# Accidental Subtraction




There is a 4th RF bump on either side that is excluded. The rest of the out of time hits are weighted at -1/6 and the central peak is weighted 1.

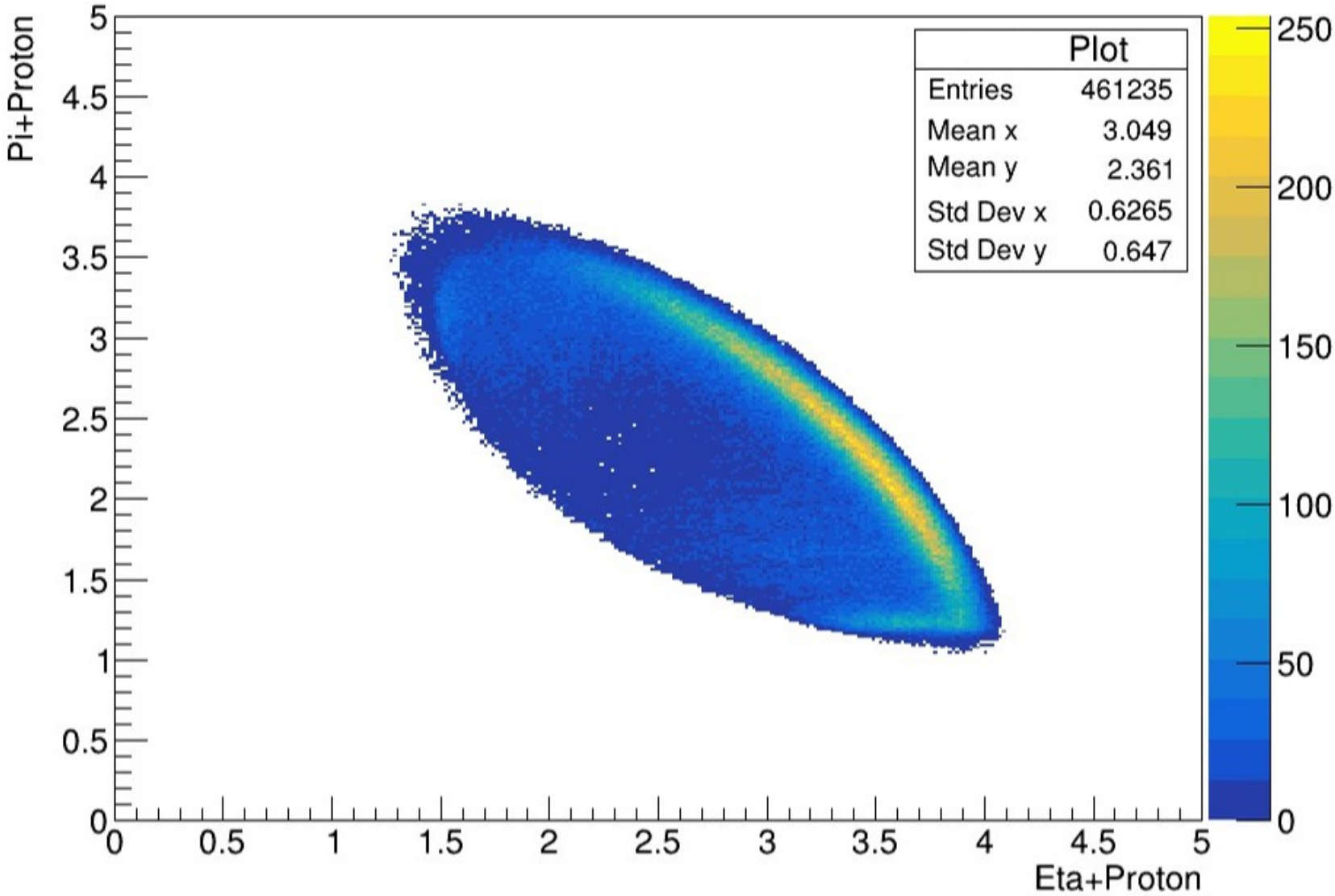
# Tic-Tac-Toe Subtraction



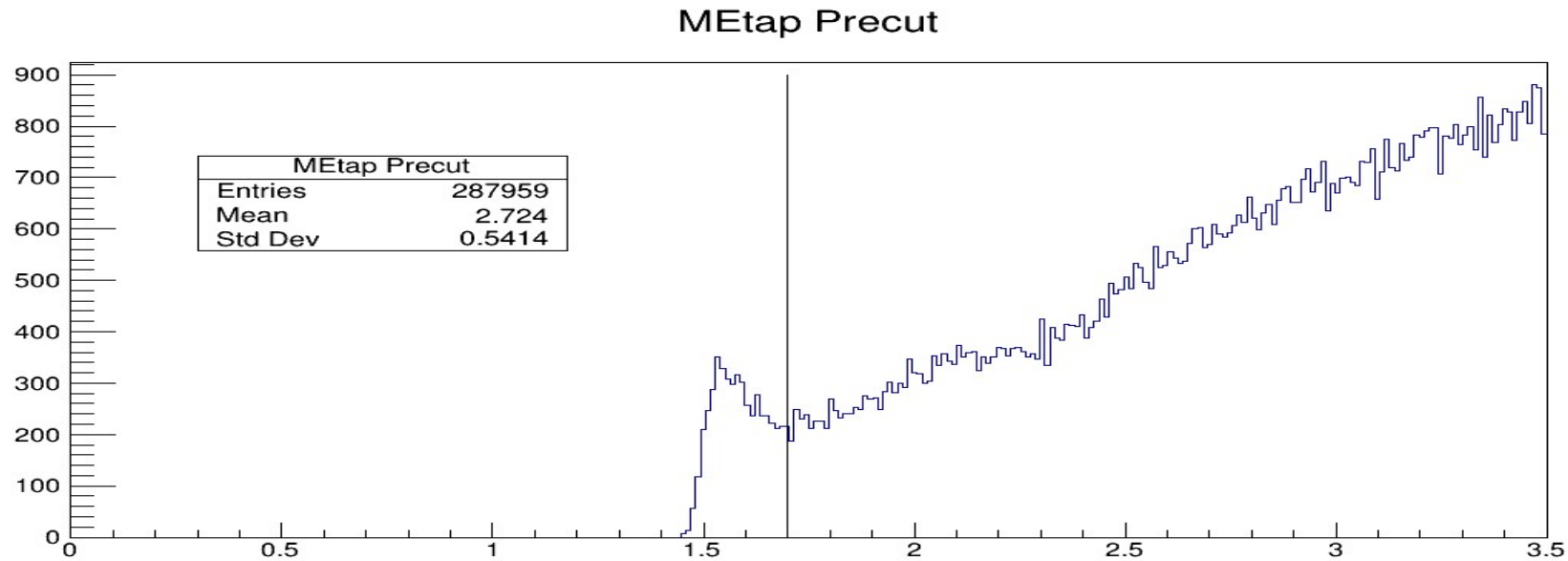

Weighting scheme is:

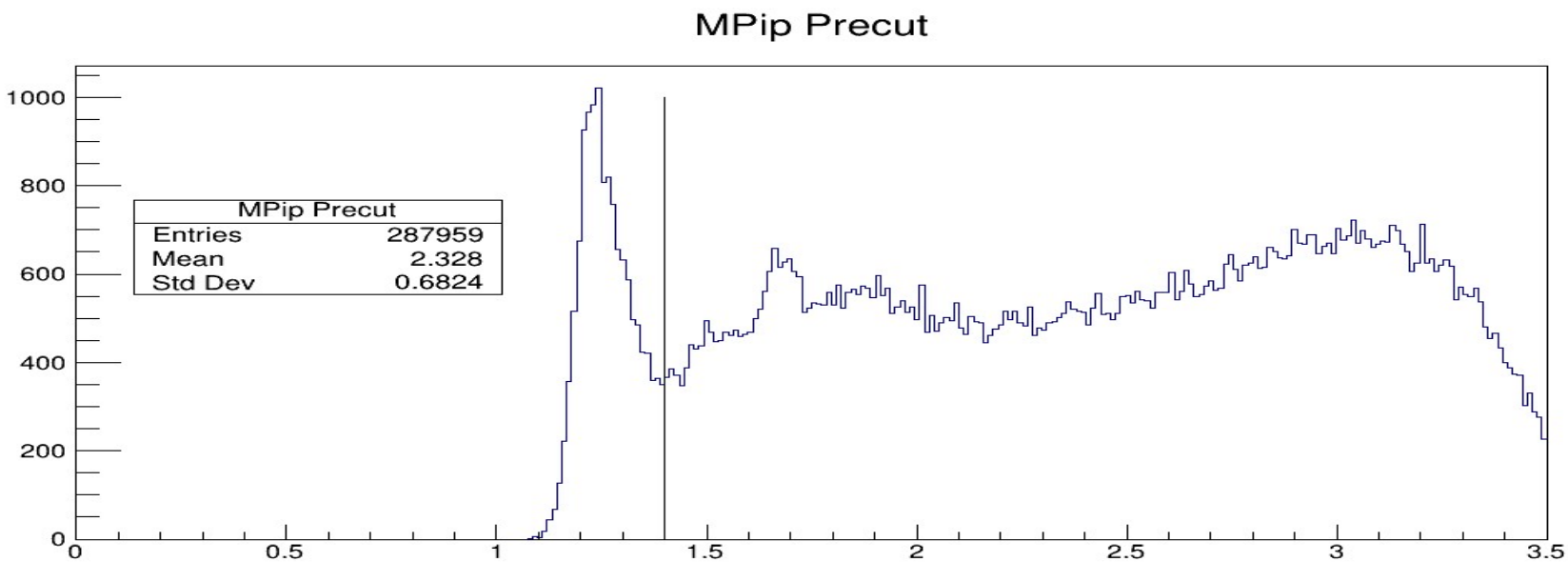
- Central box is 1
- Eta Sideband weighted as $-\frac{b}{a+c}$
- Pion Sideband weighted as $-\frac{e}{d+f}$
- Corners are as: $\frac{be}{(a+c)(d+f)}$

# Baryon Cuts

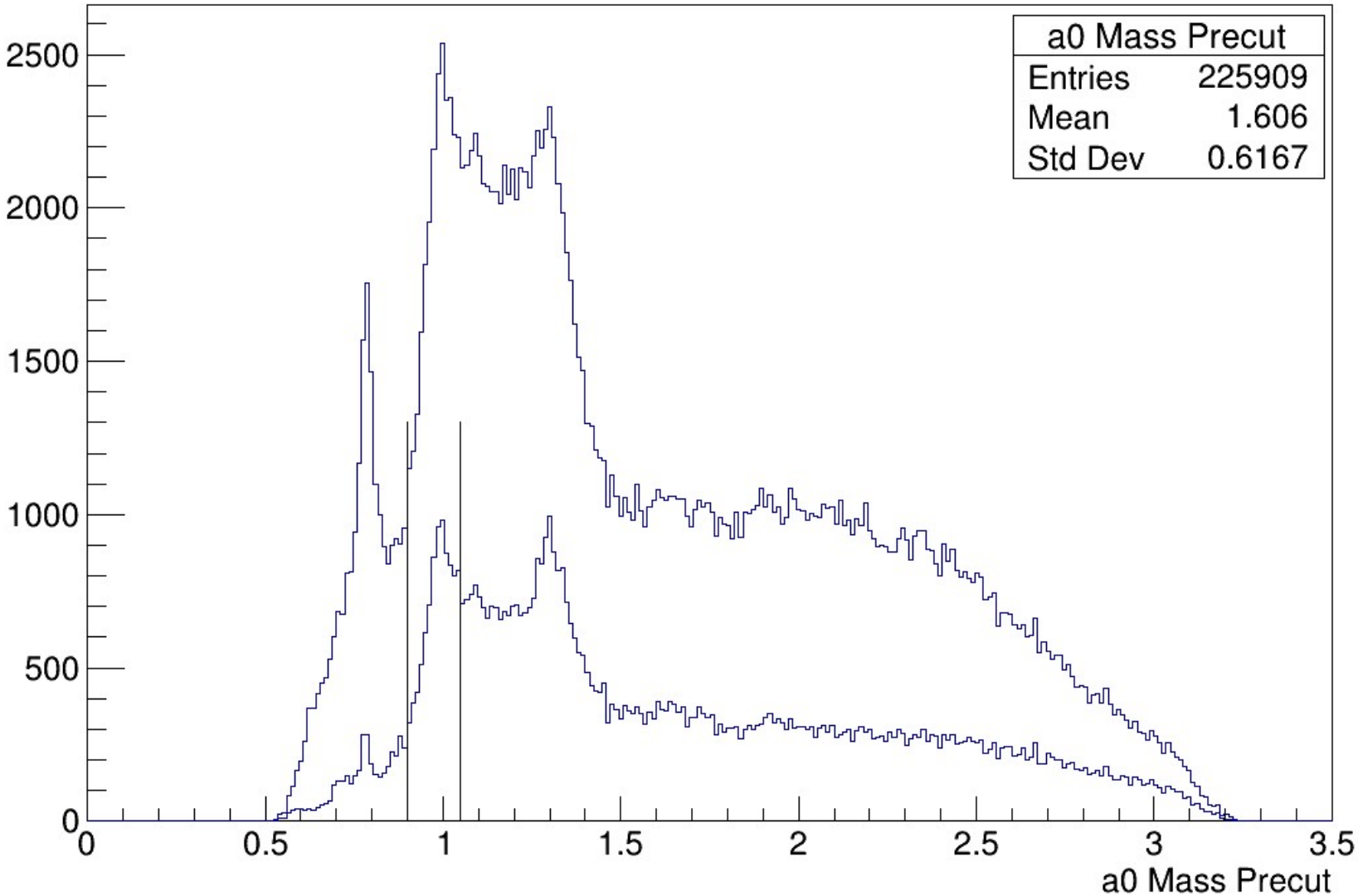

Plot
Entries 461235
Mean x 3.049
Mean y 2.361
Std Dev x 0.6265
Std Dev y 0.647
Pi+Proton
Eta+Proton
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
250
200
150
100
50
0

# Baryon Cuts

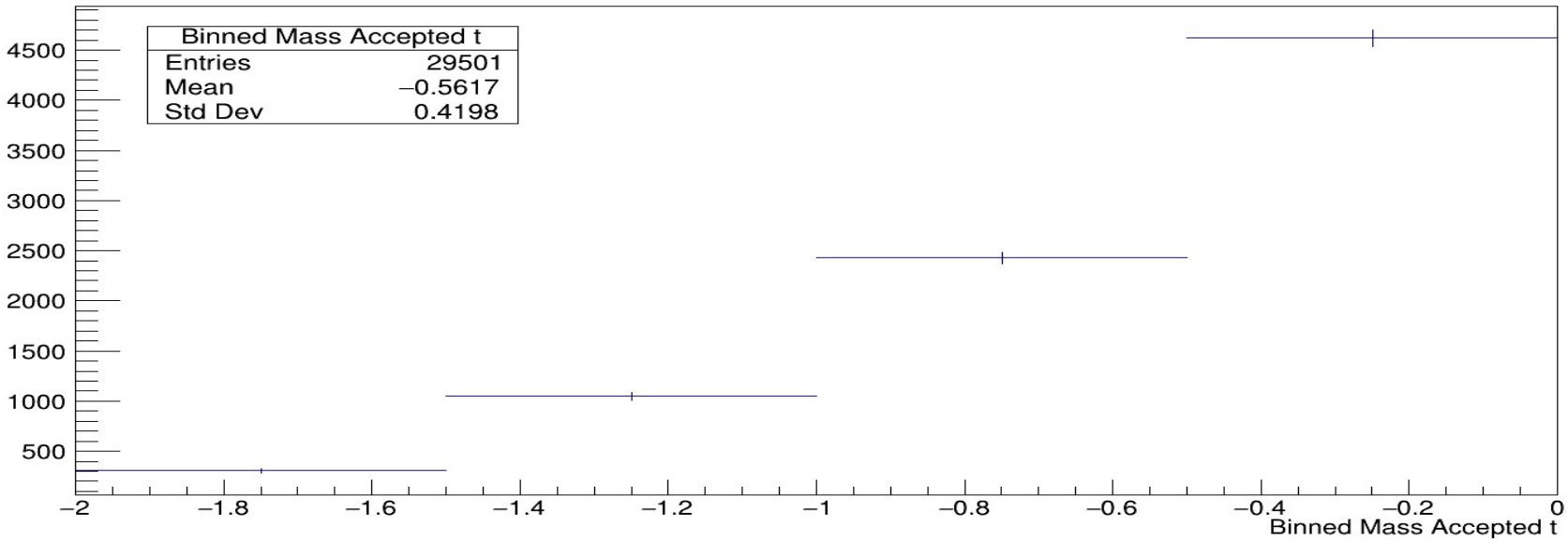

MEtap Precut
MEtap Precut
Entries 287959
Mean 2.724
Std Dev 0.5414
900
800
700
600
500
400
300
200
100
0
0
0.5
1
1.5
2
2.5
3
3.5

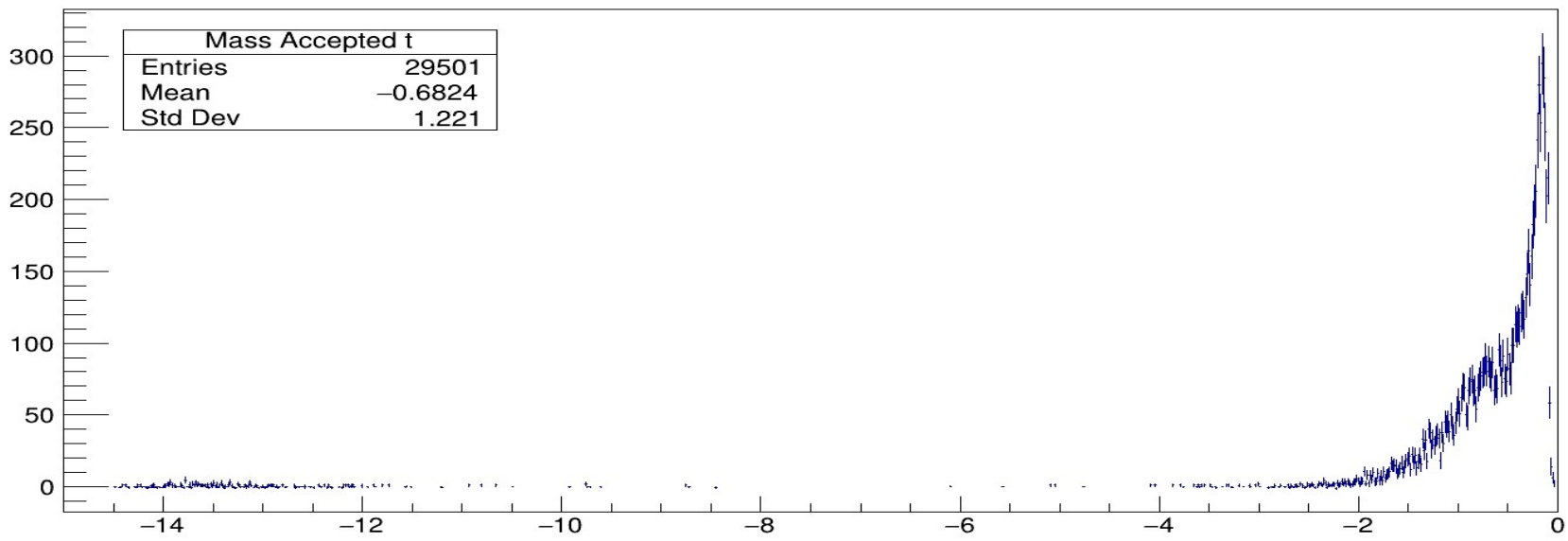

MPip Precut
MPip Precut
Entries 287959
Mean 2.328
Std Dev 0.6824
1000
800
600
400
200
0
0
0.5
1
1.5
2
2.5
3
3.5

# The Resulting 4-Photon Spectrum



# t Binning


Binned Mass Accepted t
Entries 29501
Mean −0.5617
Std Dev 0.4198
4500
4000
3500
3000
2500
2000
1500
1000
500
−2
−1.8
−1.6
−1.4
−1.2
−1
−0.8
−0.6
−0.4
−0.2
0
Binned Mass Accepted t

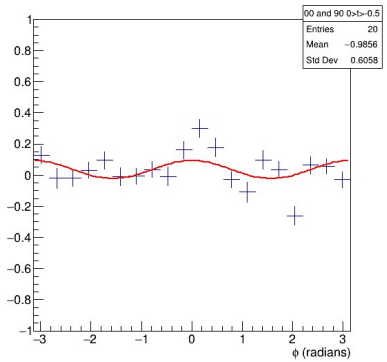

Mass Accepted t
Entries 29501
Mean −0.6824
Std Dev 1.221
300
250
200
150
100
50
0
−14
−12
−10
−8
−6
−4
−2
0

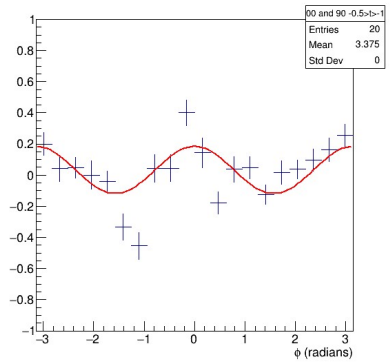
# Asymmetry Calculation

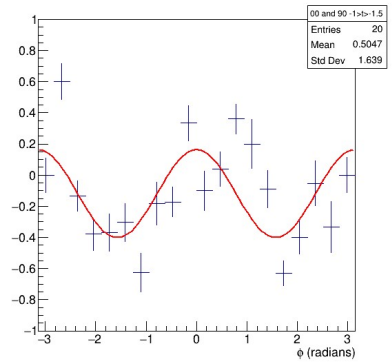
$$\frac{N(\phi)_{\parallel} - N(\phi)_{\perp}}{N(\phi)_{\parallel} + N(\phi)_{\perp}} = \frac{F_R - 1 + \frac{F_R P_R + 1}{P_R + 1} 2\bar{P}\Sigma \cos(2(\phi - \phi_0))}{F_R + 1 + \frac{F_R P_R - 1}{P_R + 1} 2\bar{P}\Sigma \cos(2(\phi - \phi_0))}$$

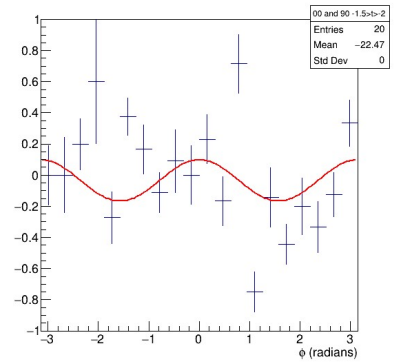
$$\frac{N(\phi)_{\parallel} - N(\phi)_{\perp}}{N(\phi)_{\parallel} + N(\phi)_{\perp}} = A + B \cos(\phi - \phi_0)$$

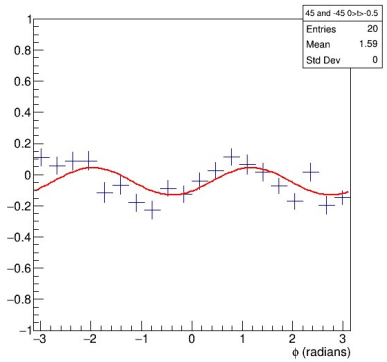
# Asymmetry Plots

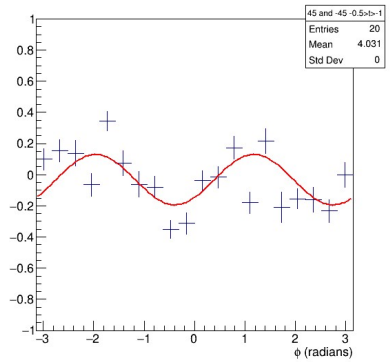


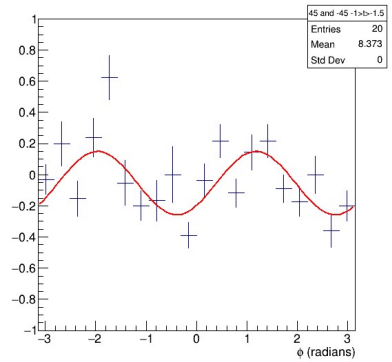



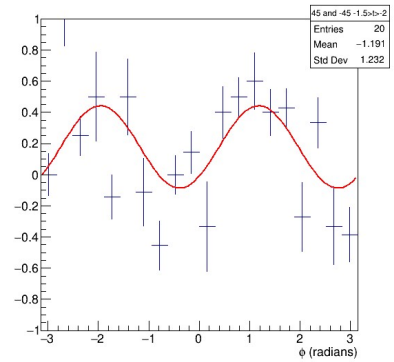



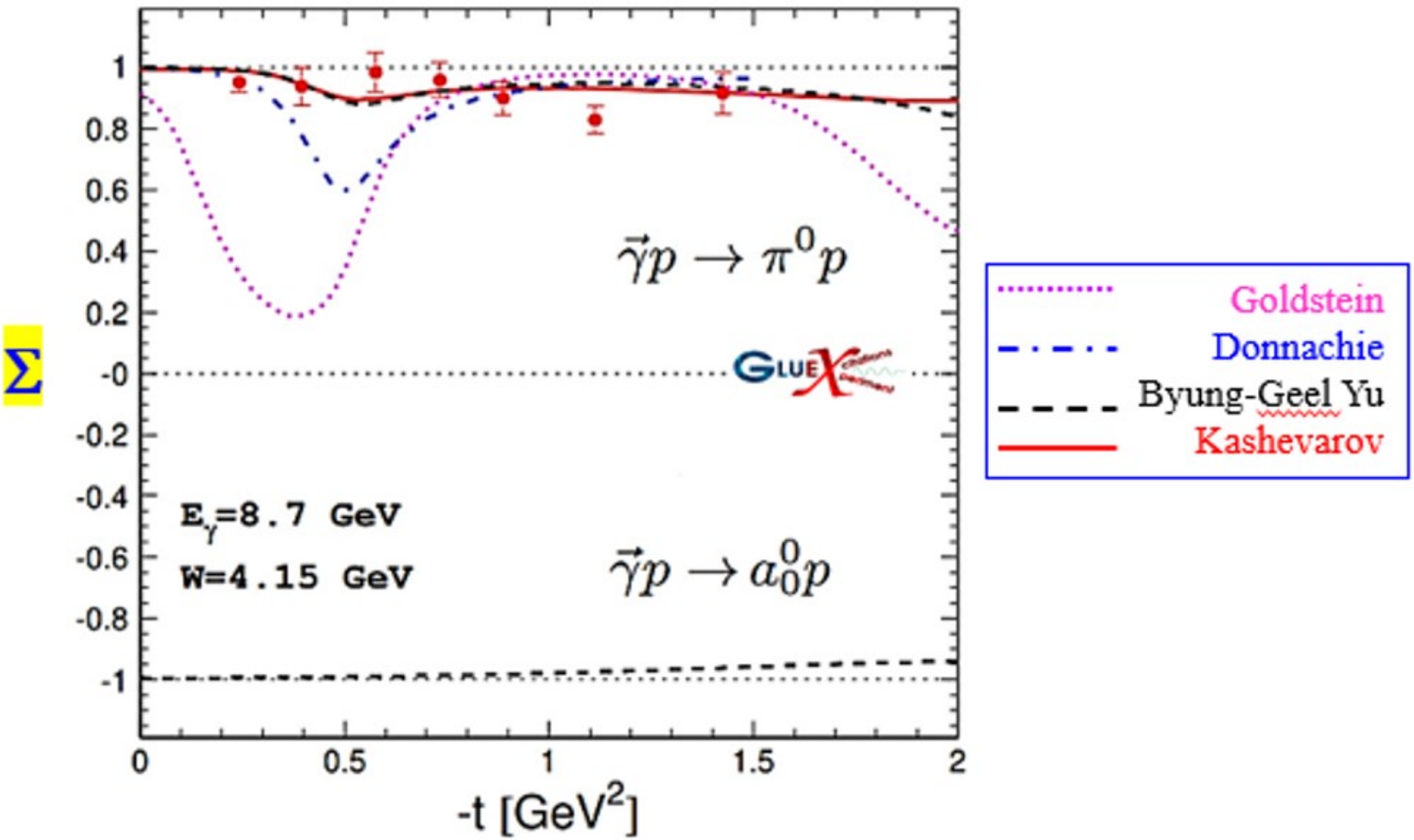



# Theoretical Predictions

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# Closing Remarks and Planning

- Check $\frac{dE}{dx}$ for proton to ensure reasonable PID
- Dilution factor (non-smooth backgrounds)
- Systematics
- Beam Polarization
- Extract $\Sigma$ beam asymmetry from full fit and compare with Regge cut model predictions.

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