Analysis of the Radiative Decay of Eta in CLAS

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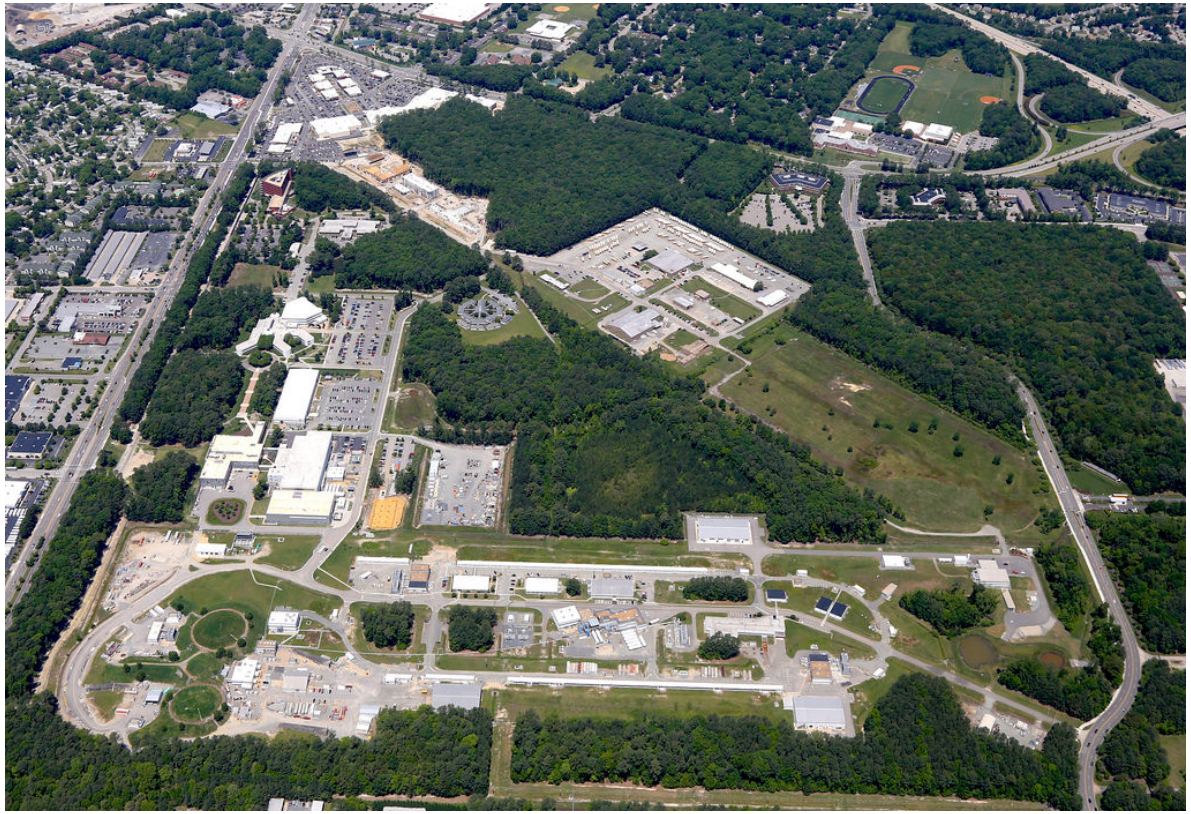

On behalf of the CLAS Collaboration

Jefferson Lab

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JSA

Light Meson Decay Program at CLAS

- Access to multiple light meson decays via

$$\gamma + p \rightarrow p + X$$

where

$$X = \pi^0, \eta, \omega, \rho, \eta', \; and \; \phi$$

Dalitz decays	$\pi^0, \eta, \eta' \rightarrow e^+e^-\gamma$	Transition form factor
Radiative decays	$\eta, \eta' \rightarrow \pi^+\pi^-\gamma$	Box anomalies, FSI
Hadronic decays	$\eta, \eta' \rightarrow \pi^+\pi^-\pi^0$ $\eta' \rightarrow \pi^+\pi^-\eta$	Dalitz plot analysis, quark mass ratio,

Eta Meson Properties

$$M_\eta = 547.862 \pm 0.017 MeV$$

$$\tau = 5 \cdot 10^{-19} s$$

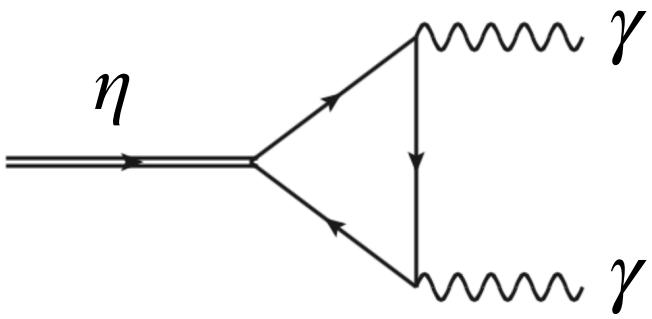
$$\Gamma = 1.31 \pm 0.05 keV$$

Decay	Branching Ratio
$\eta \rightarrow \pi^+\pi^-\pi^0$	$(22.92 \pm 0.34)\,\%$
$\eta \rightarrow \pi^+\pi^-\gamma$	$(4.22 \pm 0.08)\,\%$
$\eta \rightarrow e^+e^-\gamma$	$(6.9 \pm 0.4) \times 10^{-3}$
$\eta \rightarrow \mu^+\mu^-\gamma$	$(3.1 \pm 0.4) \times 10^{-4}$

Triangle and Box anomalies

- At the chiral limit, all decays are determined by Wess-Zumino-Witten Lagrangian

$$A_{\eta\to\pi^+\pi^-\gamma} \propto \frac{e}{4\sqrt{3}\pi^2 F_\pi^3}\left(\frac{F_\pi}{F_8}\cos\theta - \sqrt{2}\frac{F_\pi}{F_0}\sin\theta\right)$$



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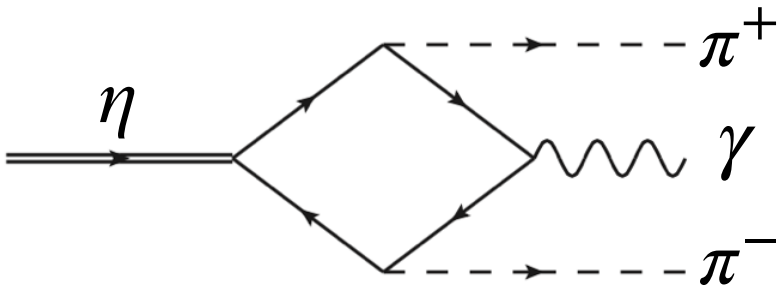


- Amplitude is sensitive to box anomaly and predicts decay width of 35.7 eV[1]

The Box Anomaly

- Must properly include momentum dependence to describe experimental data

$$\Gamma^{expt}(\eta \to \pi^+\pi^-\gamma) = 55.3 \pm 2.4eV$$

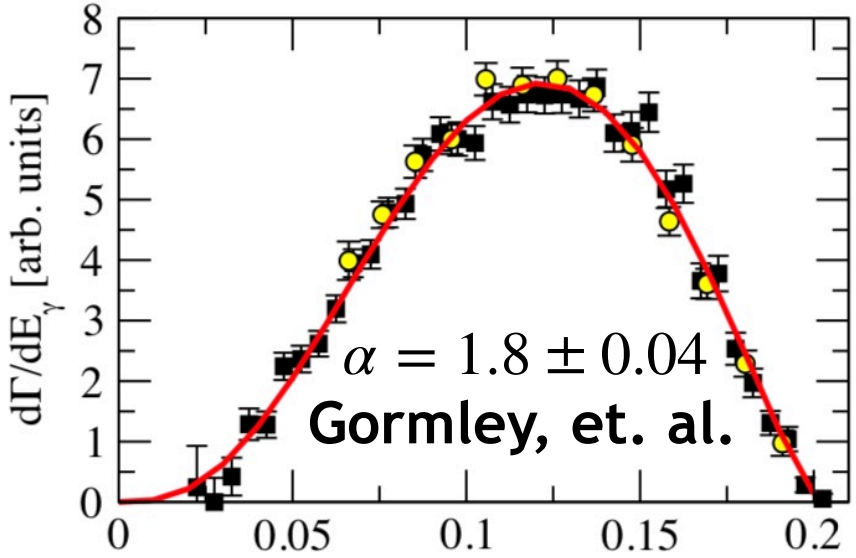
- Modify amplitude by reaction specific polynomial and pion vector form factor[4]

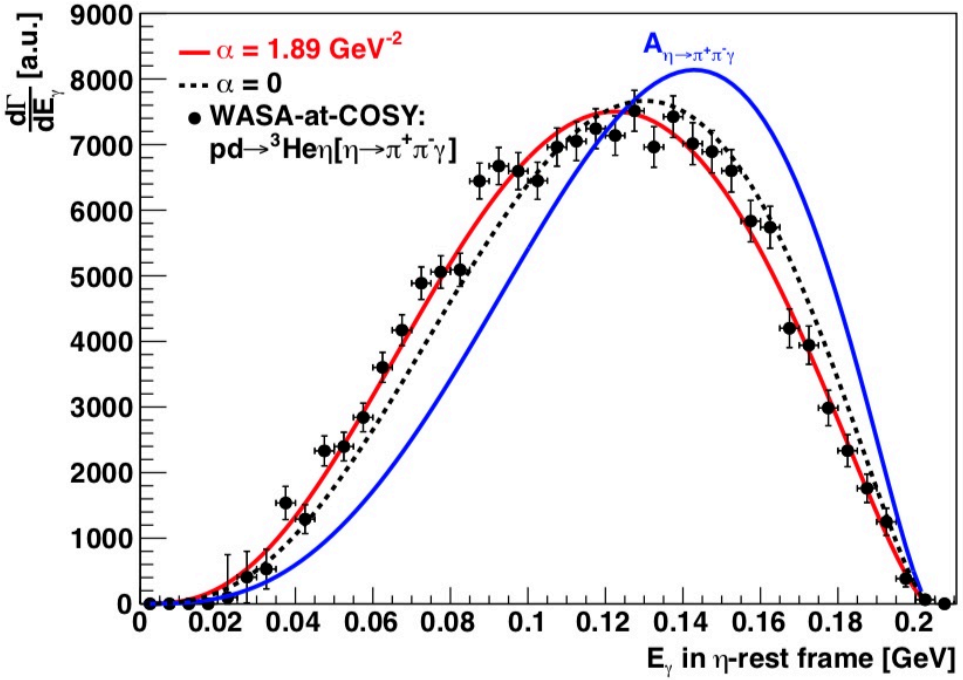
$$A_{\eta\to\pi^+\pi^-\gamma} \times [F_{PV}(s_{\pi\pi}) \cdot (1 + \alpha s_{\pi\pi})]$$

- **Want to measure alpha parameter for decay:**

$$\eta \to \pi^+\pi^-\gamma$$

Previous measurements of alpha parameter



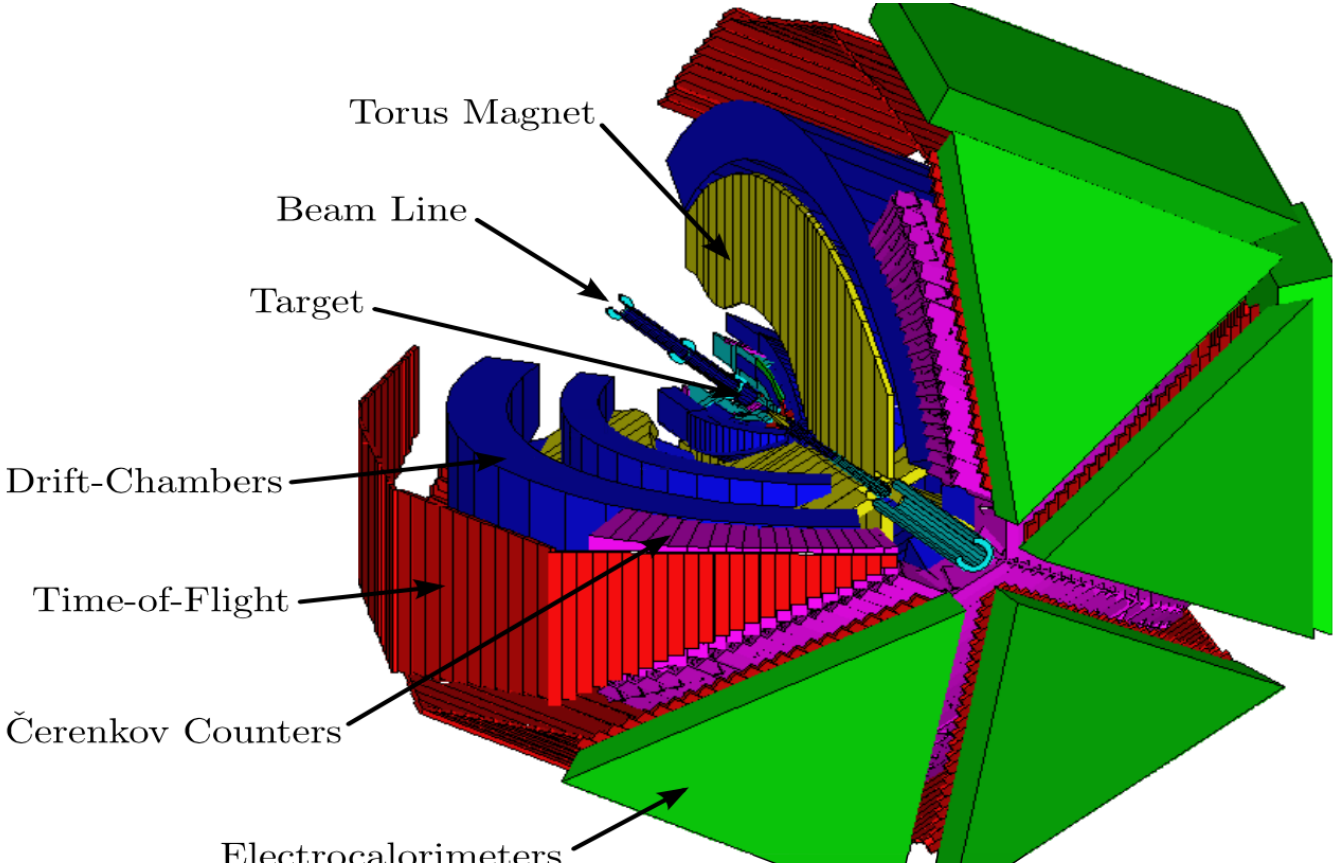


Experiments	α parameter
WASA-at-COSY	1.89 ± 0.86
KLOE	1.32 ± 0.08
CLAS	ongoing
BESIII	ongoing

Theoretical Models	α parameter
N/D	0.64 ± 0.02
HLS	0.23 ± 0.01
$(O(p^6) + 1\text{ - loop})$	-0.7 ± 0.1
Box anomaly	-1.7 ± 0.02

The g11 experiment with CLAS at JLAB

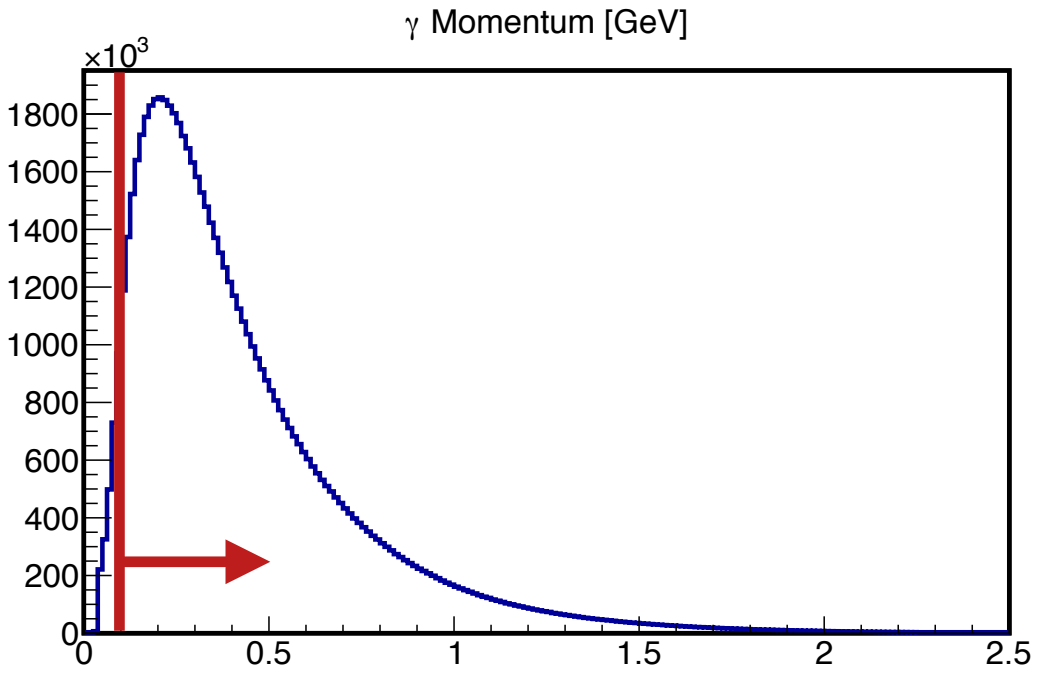
- May 17, 2004 - July 29, 2004
- Beam energy: 4 GeV
- Photon beam energy: 1.5-3.5 GeV
- Liquid H2 target
- 21 TB of raw data collected

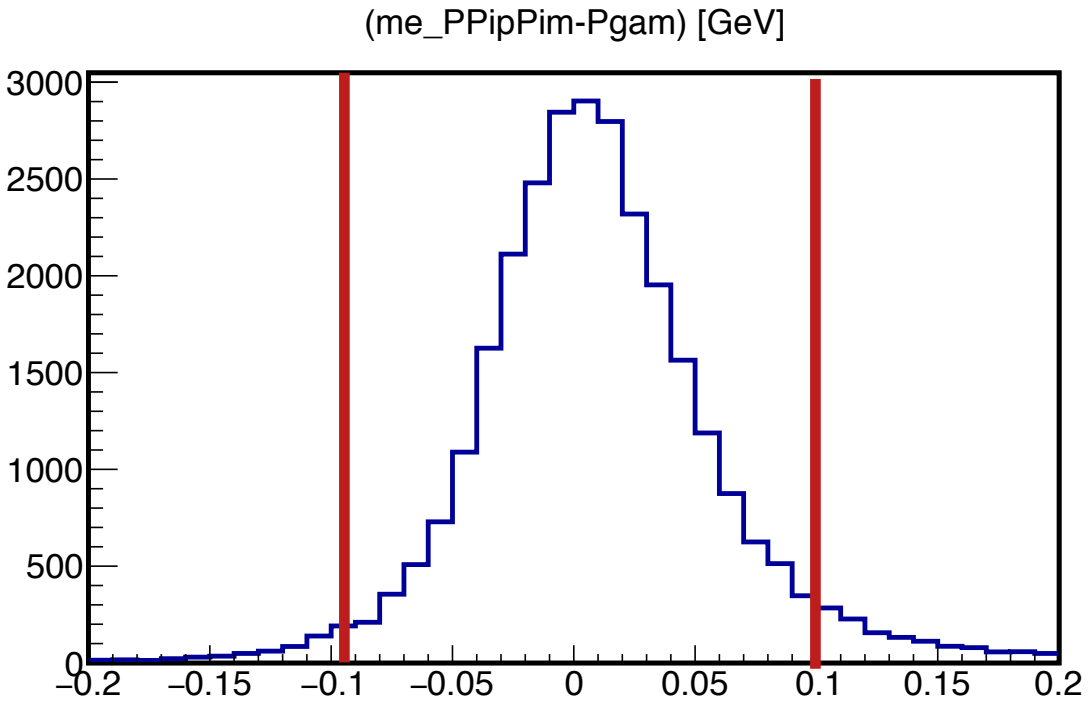


Event Selection and Particle ID

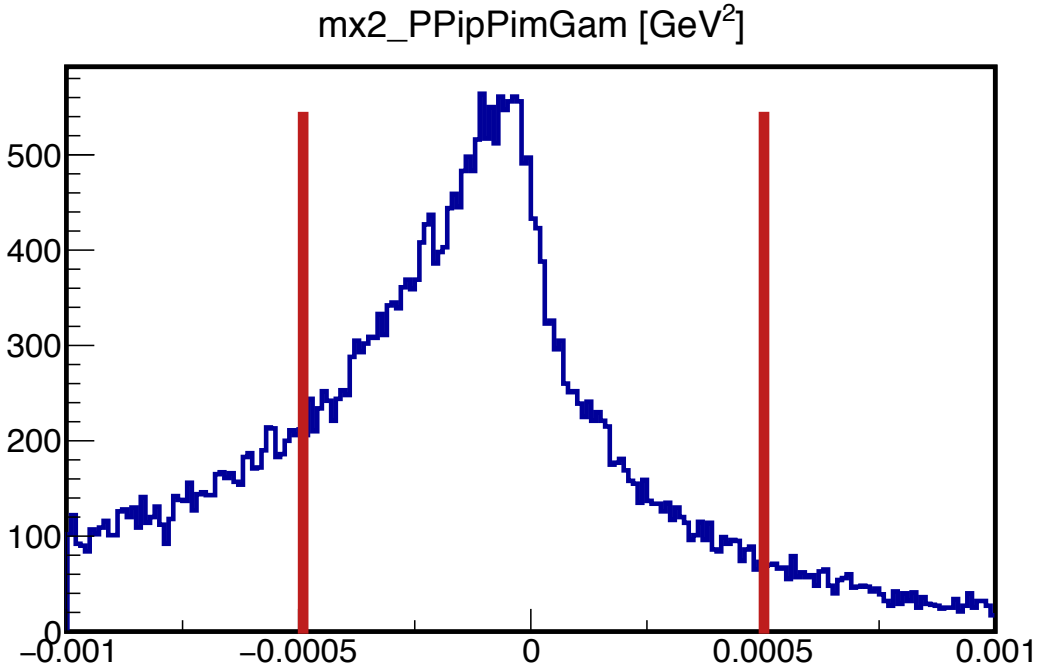
- ☑ Trigger required two charged tracks in different sectors
- ☑ Required events with three charged tracks corresponding to
- ☑ Required events to have at least one photon
- ☑ Time of Flight (TOF) was used for particle identification
- ☑ Detect all final state particles

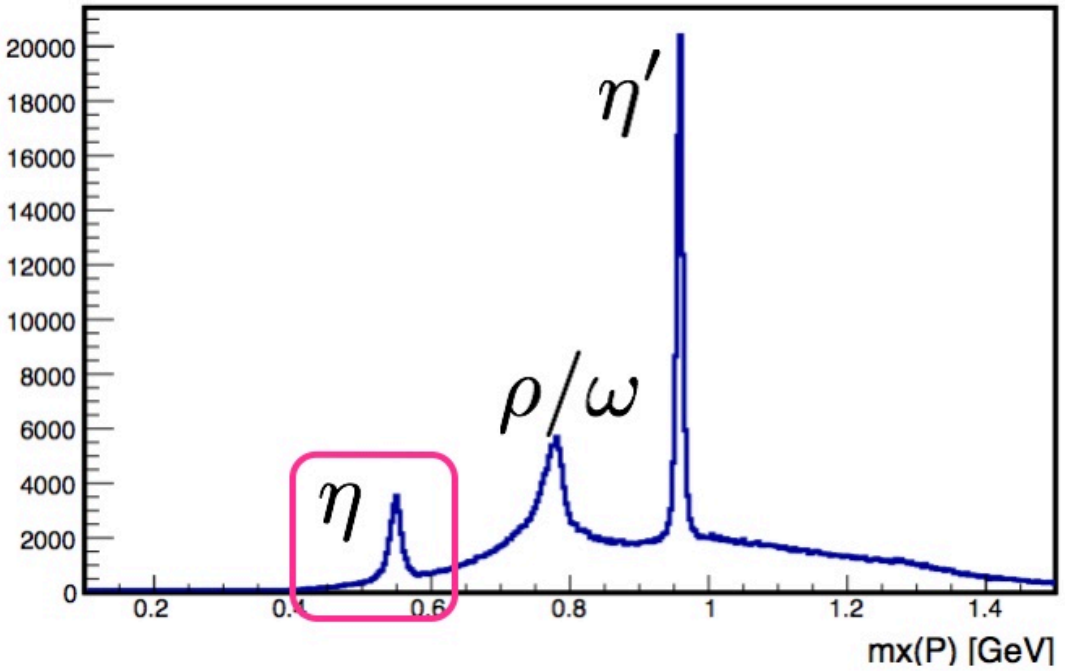
Data Cuts


γ Momentum [GeV]
×10^3
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.5
1
1.5
2
2.5


(me_PPipPim-Pgam) [GeV]
3000
2500
2000
1500
1000
500
0
−0.2
−0.15
−0.1
−0.05
0
0.05
0.1
0.15
0.2

Data Cuts





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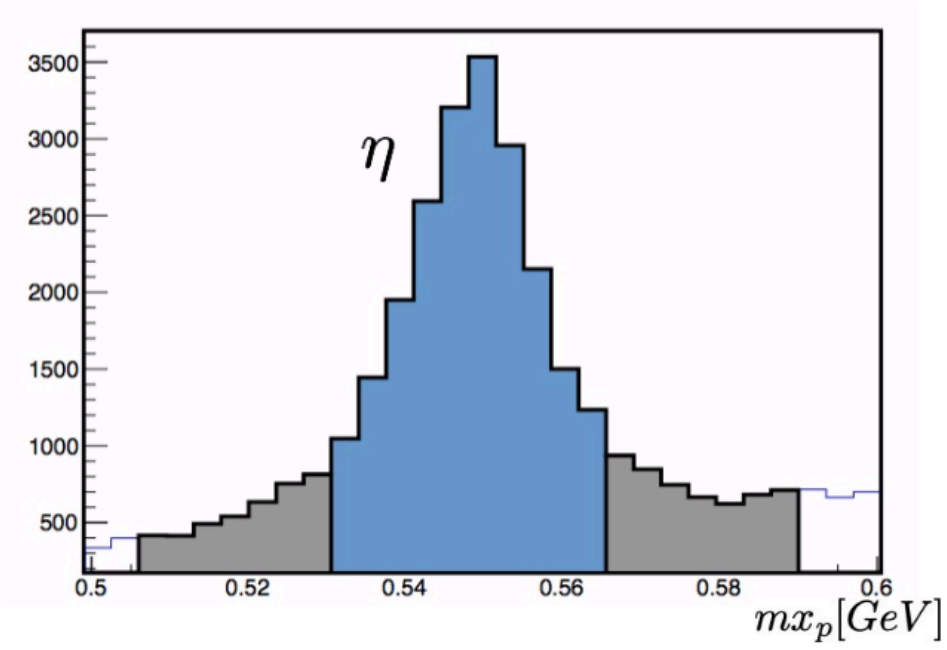
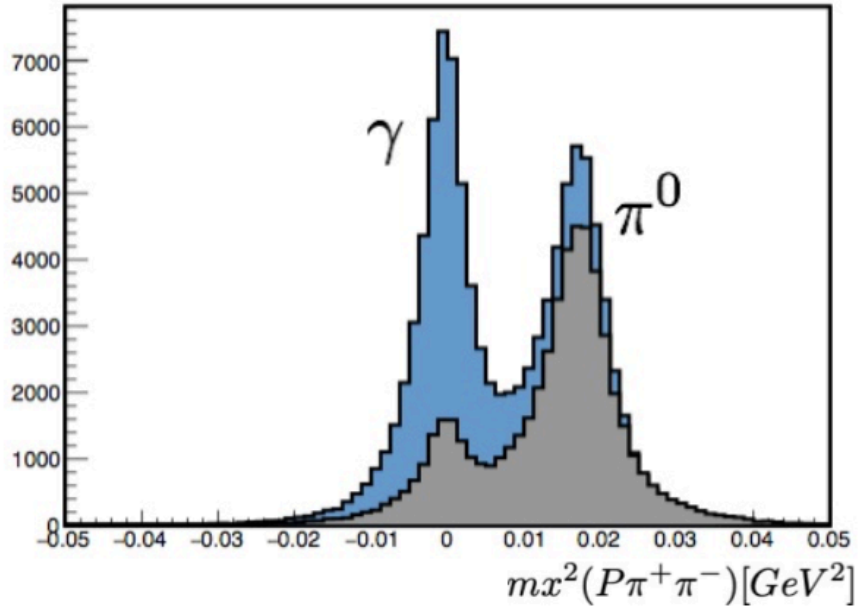
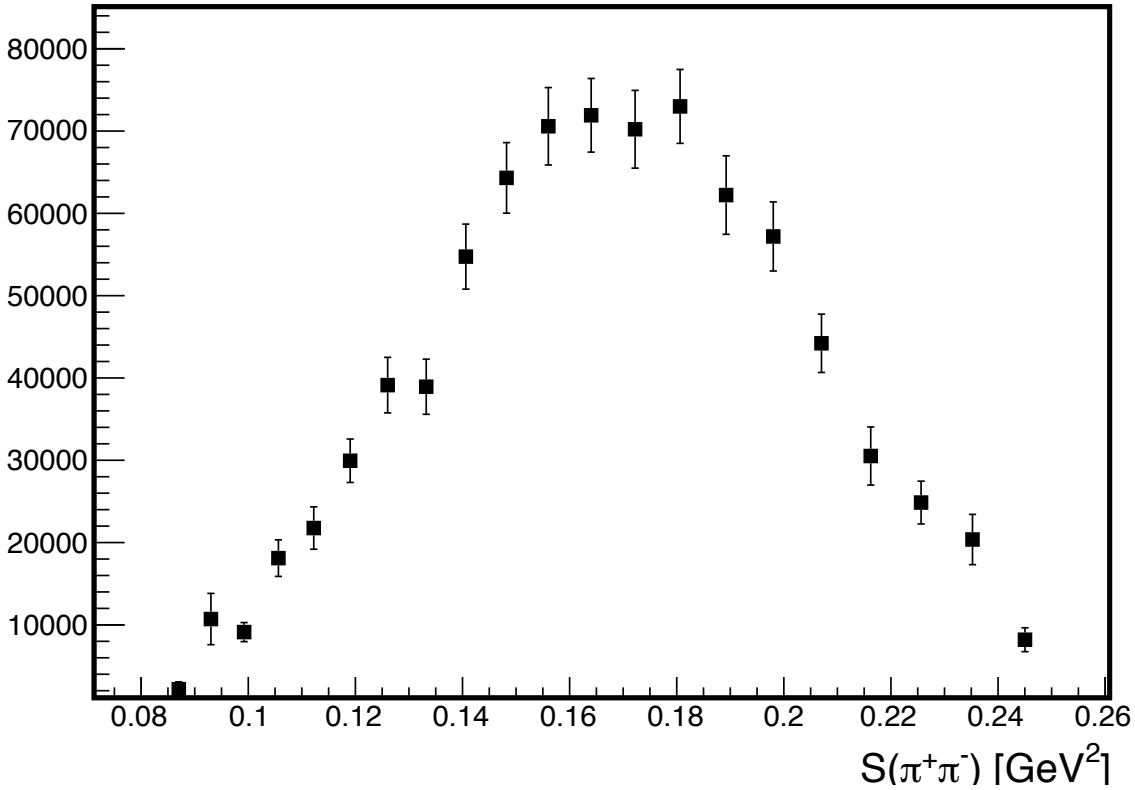
Analysis







Not acceptance corrected

Simulations

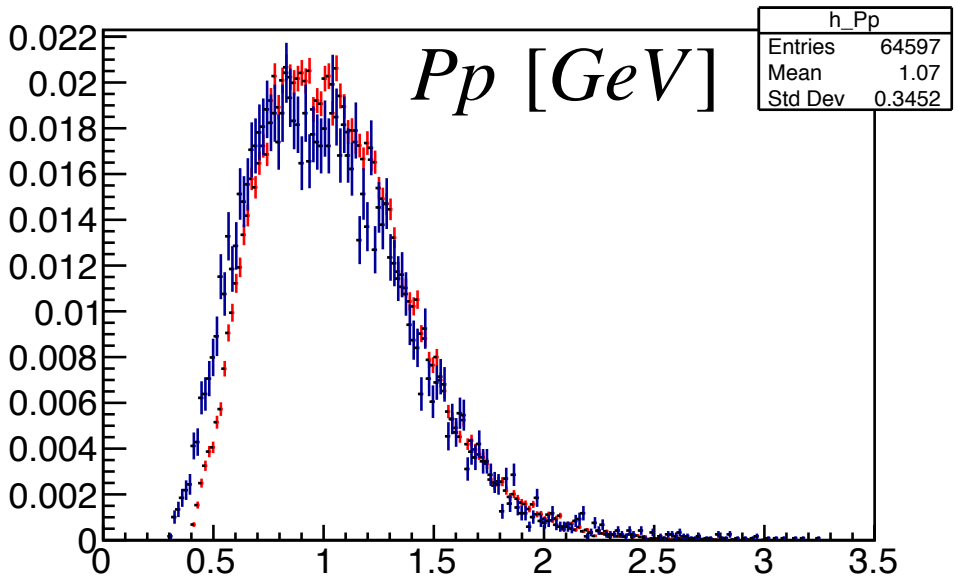
1. Simulate IM($\pi^+\pi^-$) from 0.30 GeV to 0.50 GeV

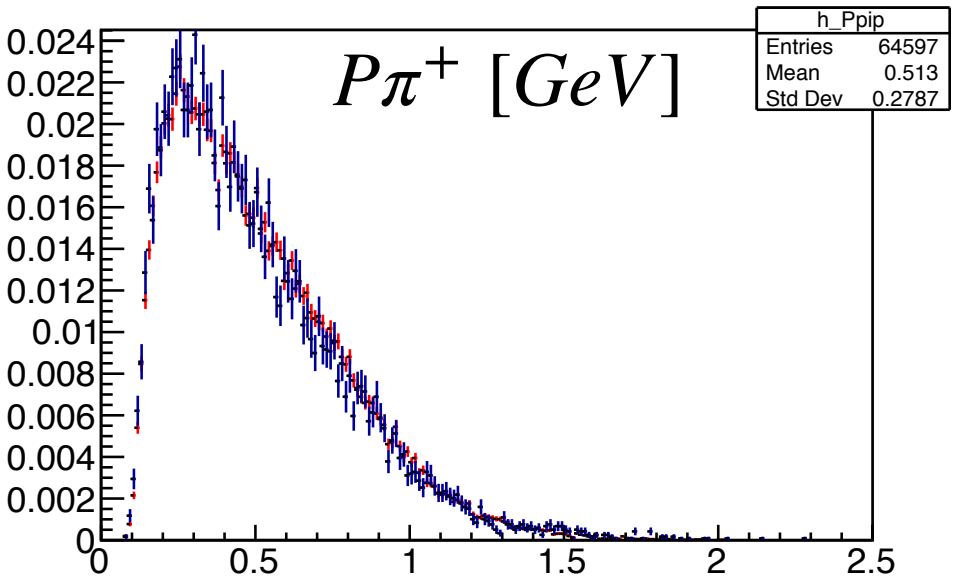
2. GSIM: generated events were passed through GEANT software in CLAS

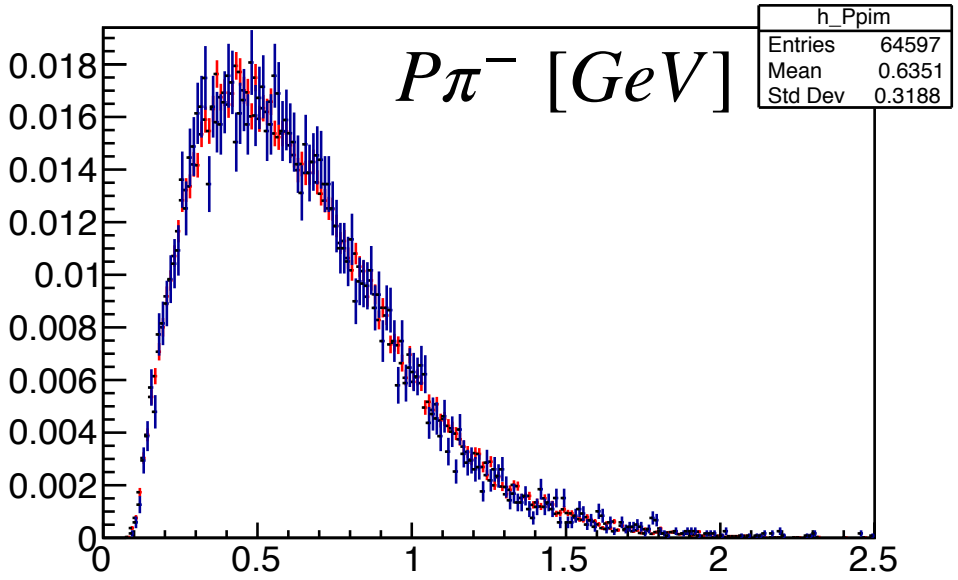
3. GPP: GSIM Post Processor is used for smearing due to detector response

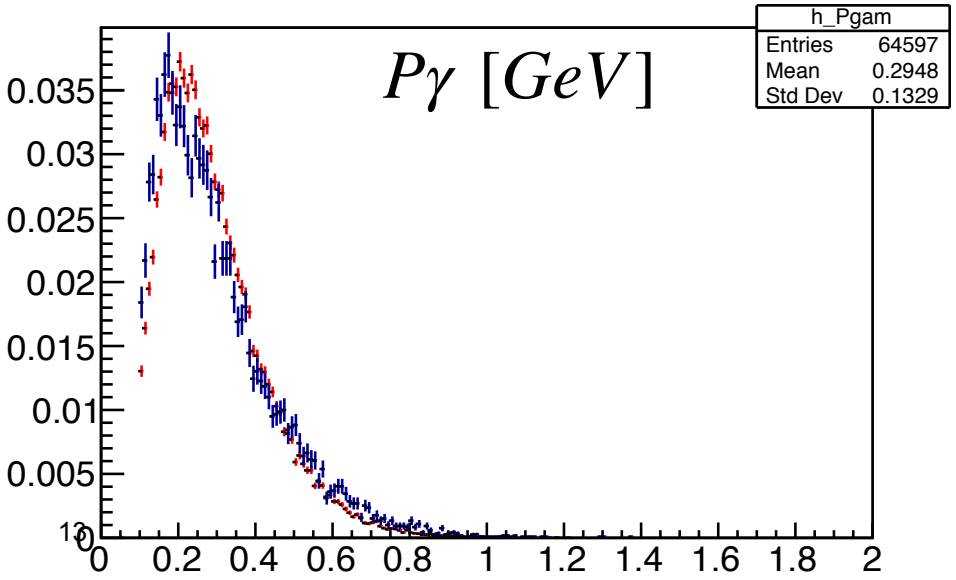
4. RECIS: Reconstruction program to analyze GSIM output in same manner as raw data

MC and Data Comparison









Data

recMC

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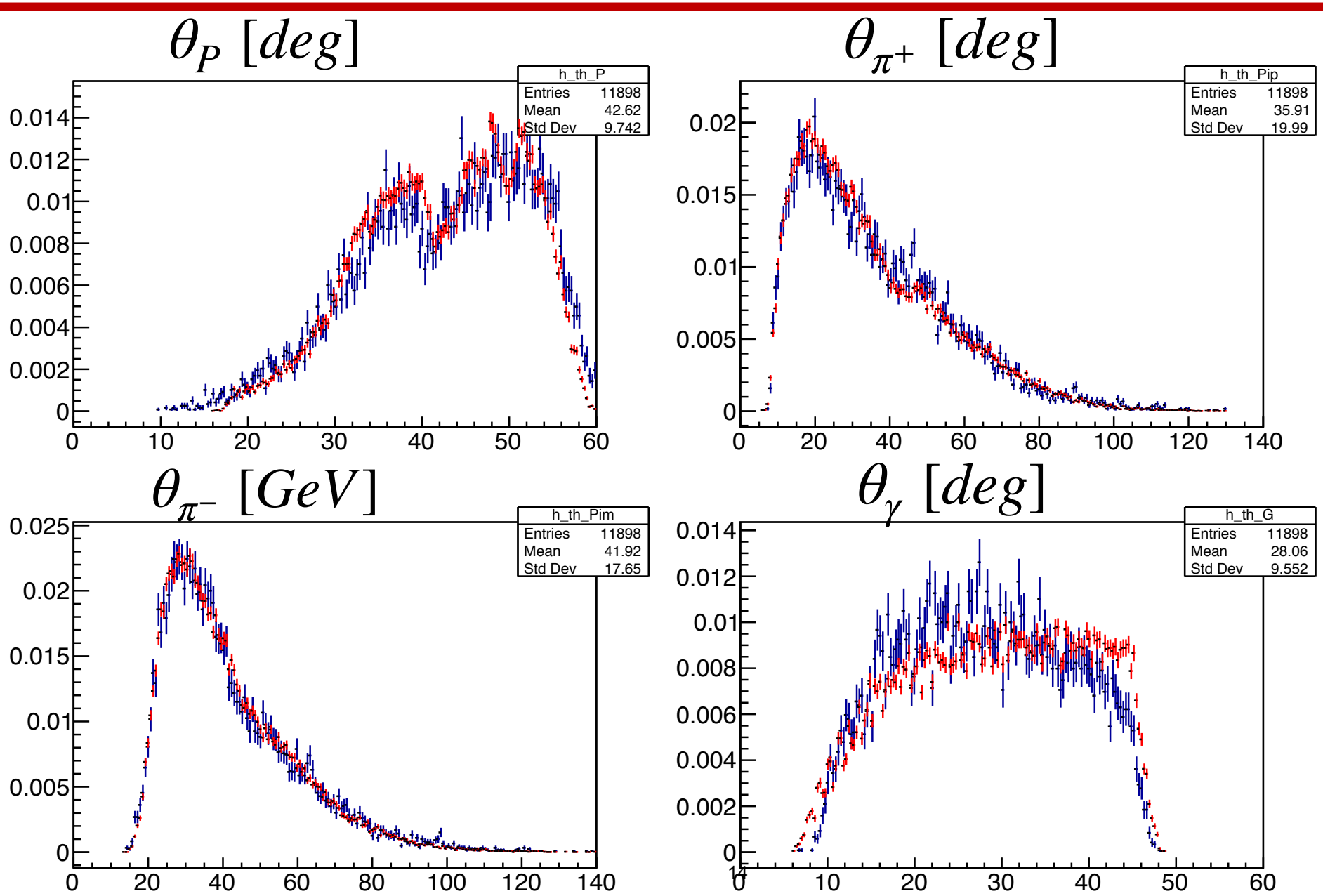
MC + Data Comparison II



Data

recMC

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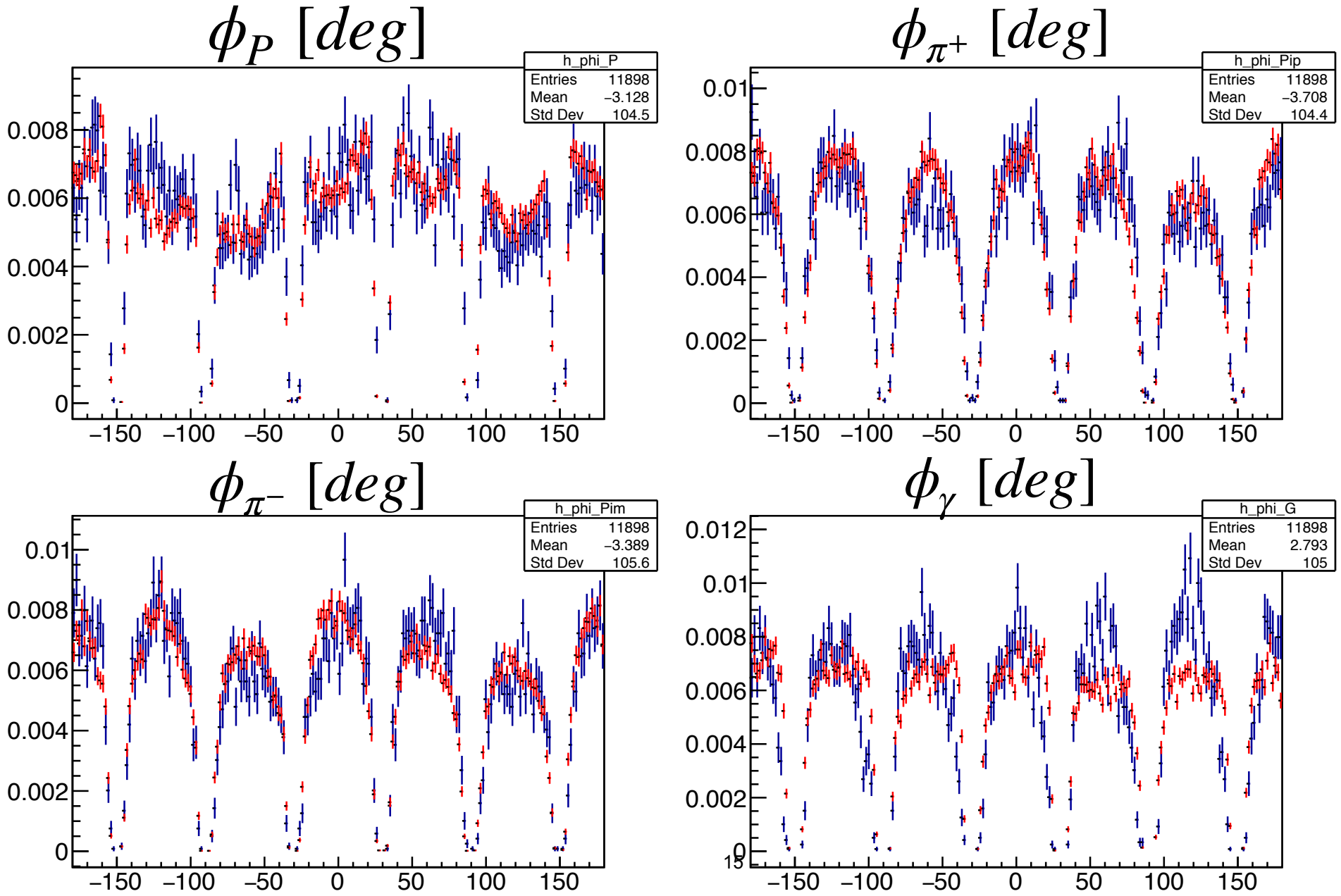
MC + Data Comparison III



Data

recMC

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Summary and Future Work

- Box anomaly is important to describe experimental distributions
- Alpha parameter has been measured previously but measurements are not consistent with theoretical descriptions
- Acceptance and systematic error calculations in progress

References

1. B.R. Holstein, Phys. Scripta, T99:55-67, 2002

2. PDG, Chin. Phys, 090001, 2014

3. WASA-at-COSY Phys. Letter. B707, 243-249, 2012

4. F. Stollenwerk et al., Phys. Lett. B707, 184-190, 2012

5. KLOE Phys. Letter. B718, 910-914, 2013