

# Physics Validation for FD Tracking beyond Pass2

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**March 12, 2024**

**CLAS Collaboration Meeting**

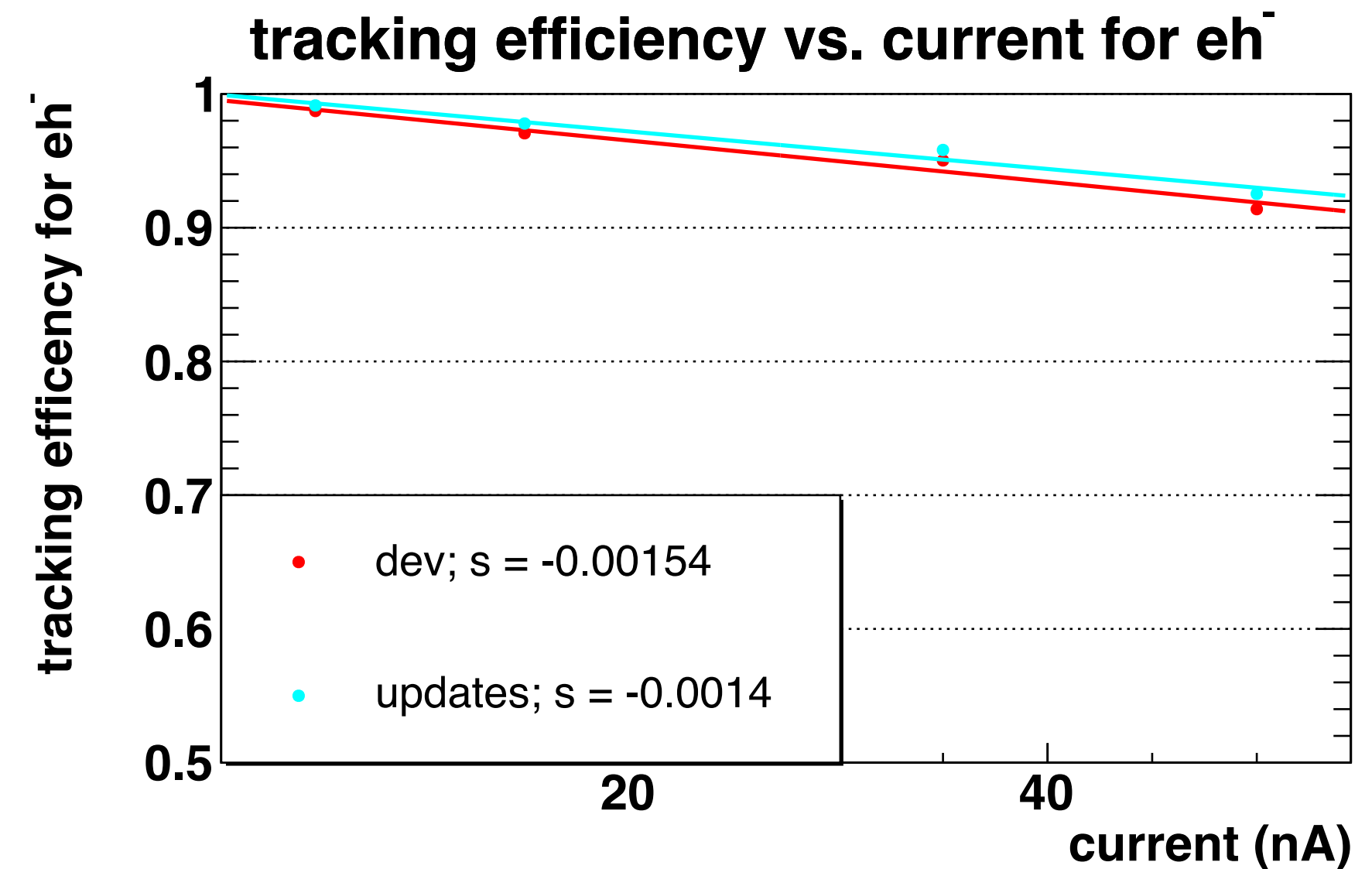
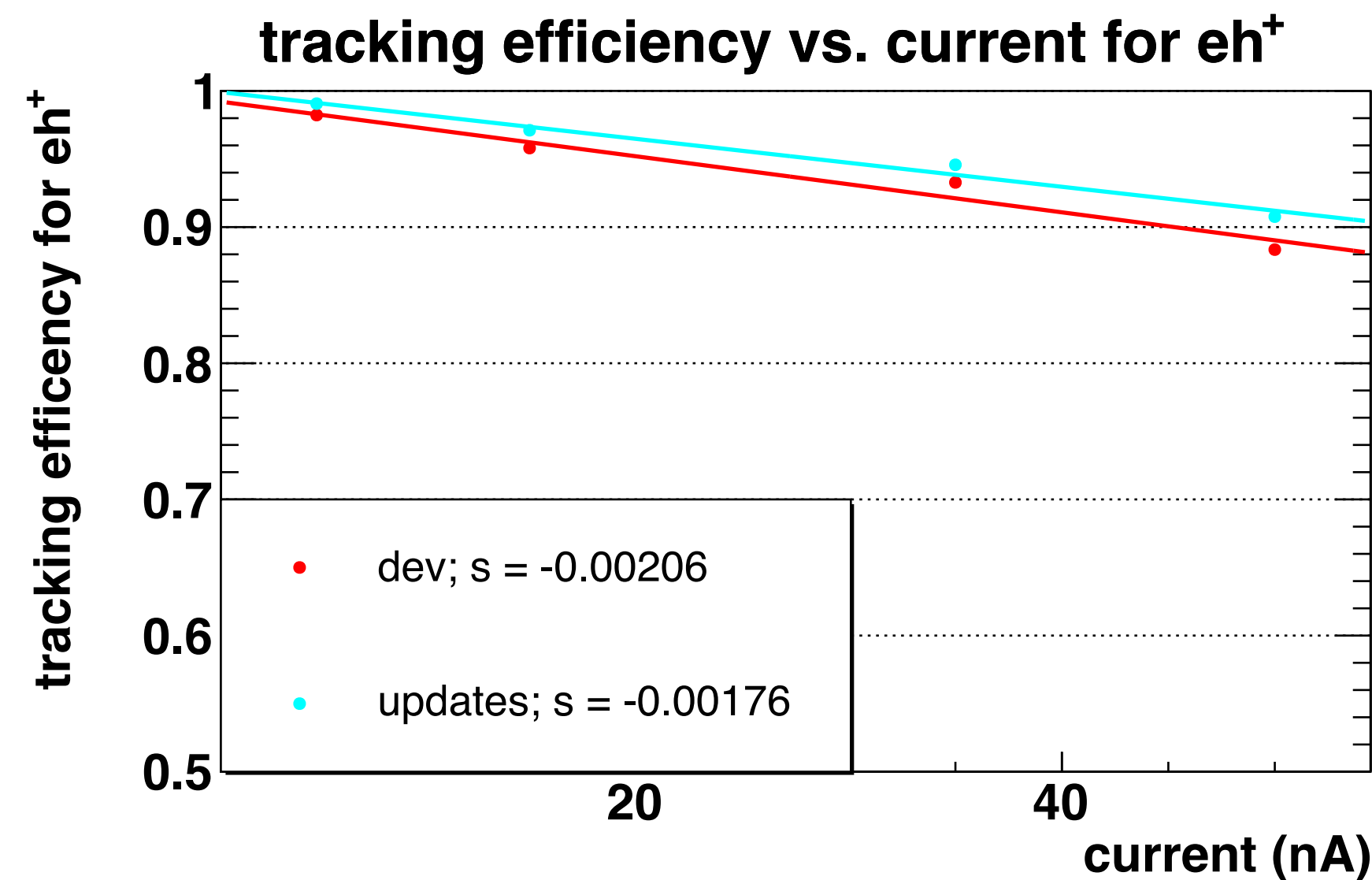
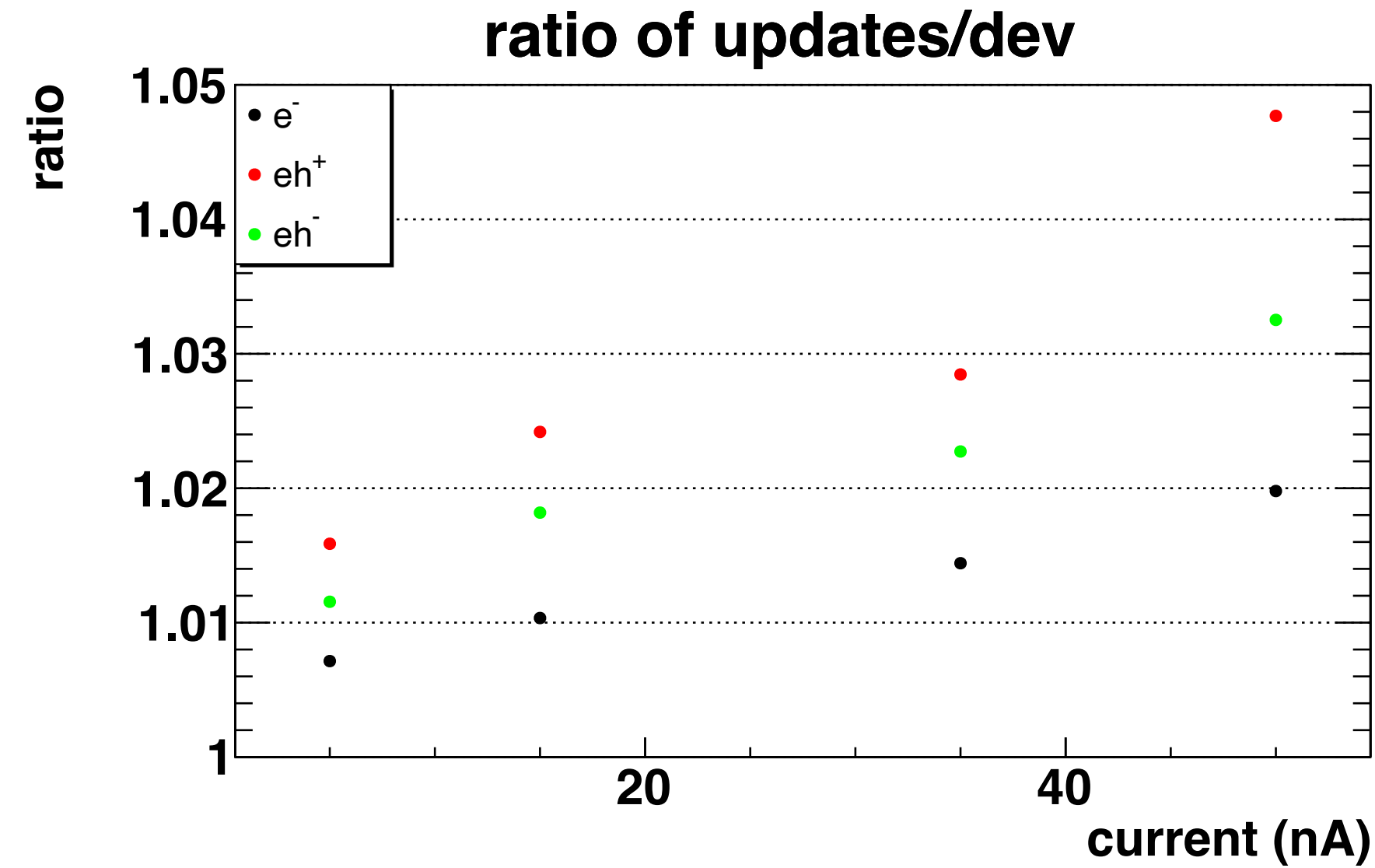


# Introduction

- Main FD tracking software updates in [PR#107](#) include:
  1. Refactored Kalman Filter (KF) package
  2. Improved pattern recognition
  3. Reset covariance matrix for seed construction
  4. Reset initial covariance matrix for the second and following iterations in tracking
  5. Applied Deterministic Annealing Filter (DAF) to incorporate with KF
- Details of updates were presented in previous collaboration meetings: [talk1](#), [talk2](#).
- Validation for the updates will be presented, including:
  - Tracking and reconstruction efficiencies by RGB
  - Resolution and reconstruction efficiency by RGA, RGA-SIDIS MC and RGK
  - CPU efficiency by standard RGK cooking

# Tracking and Reconstruction Efficiencies

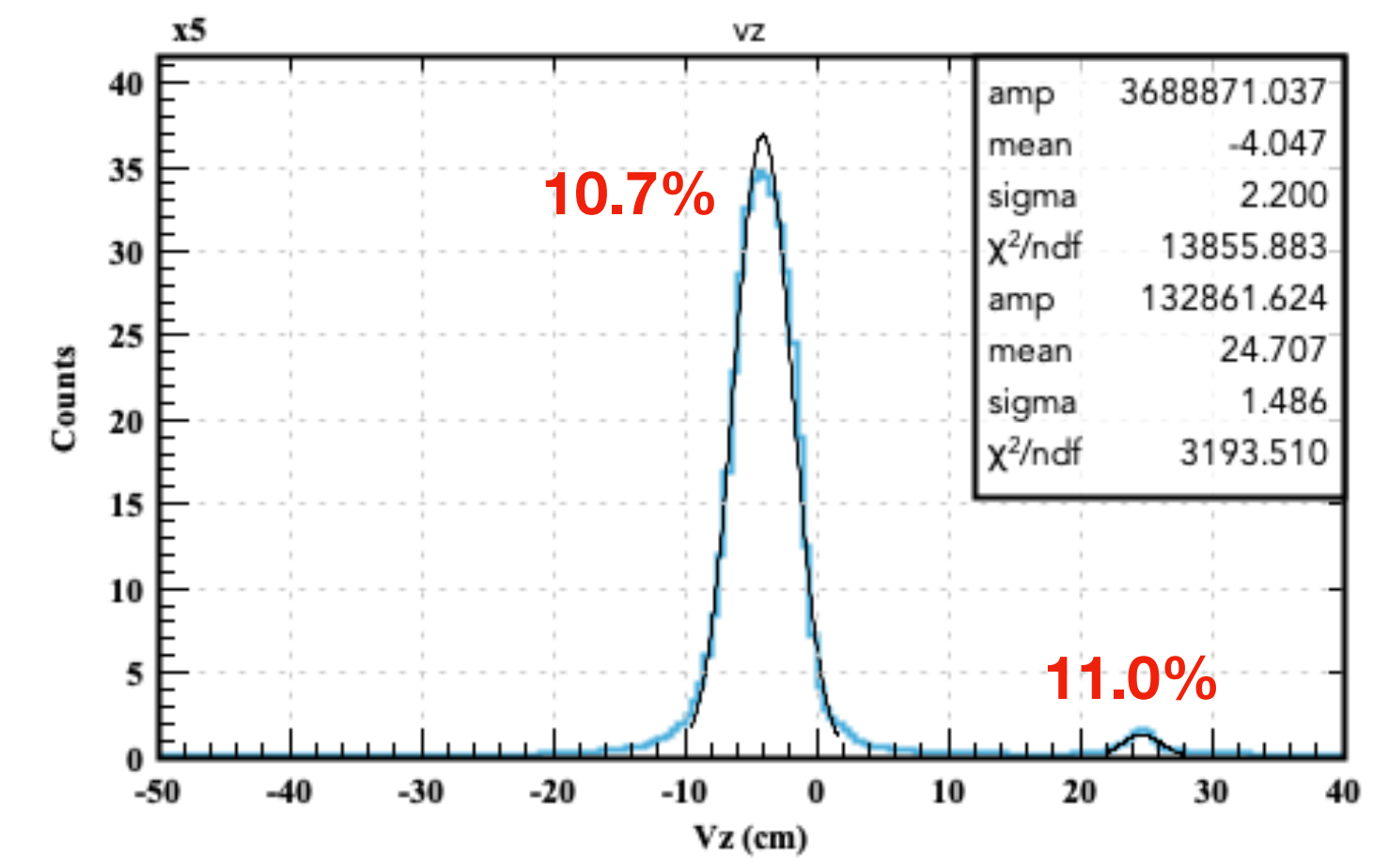
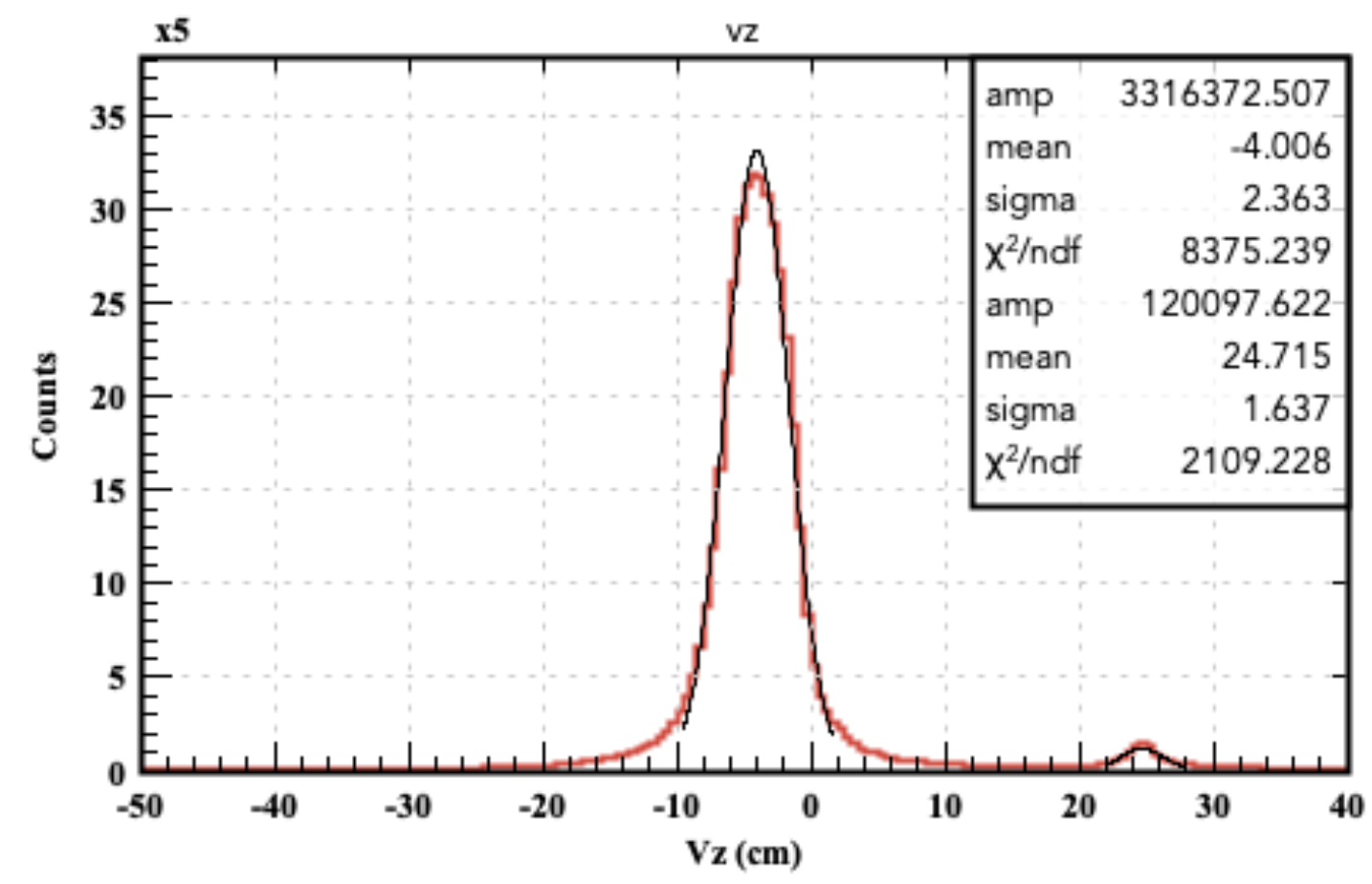
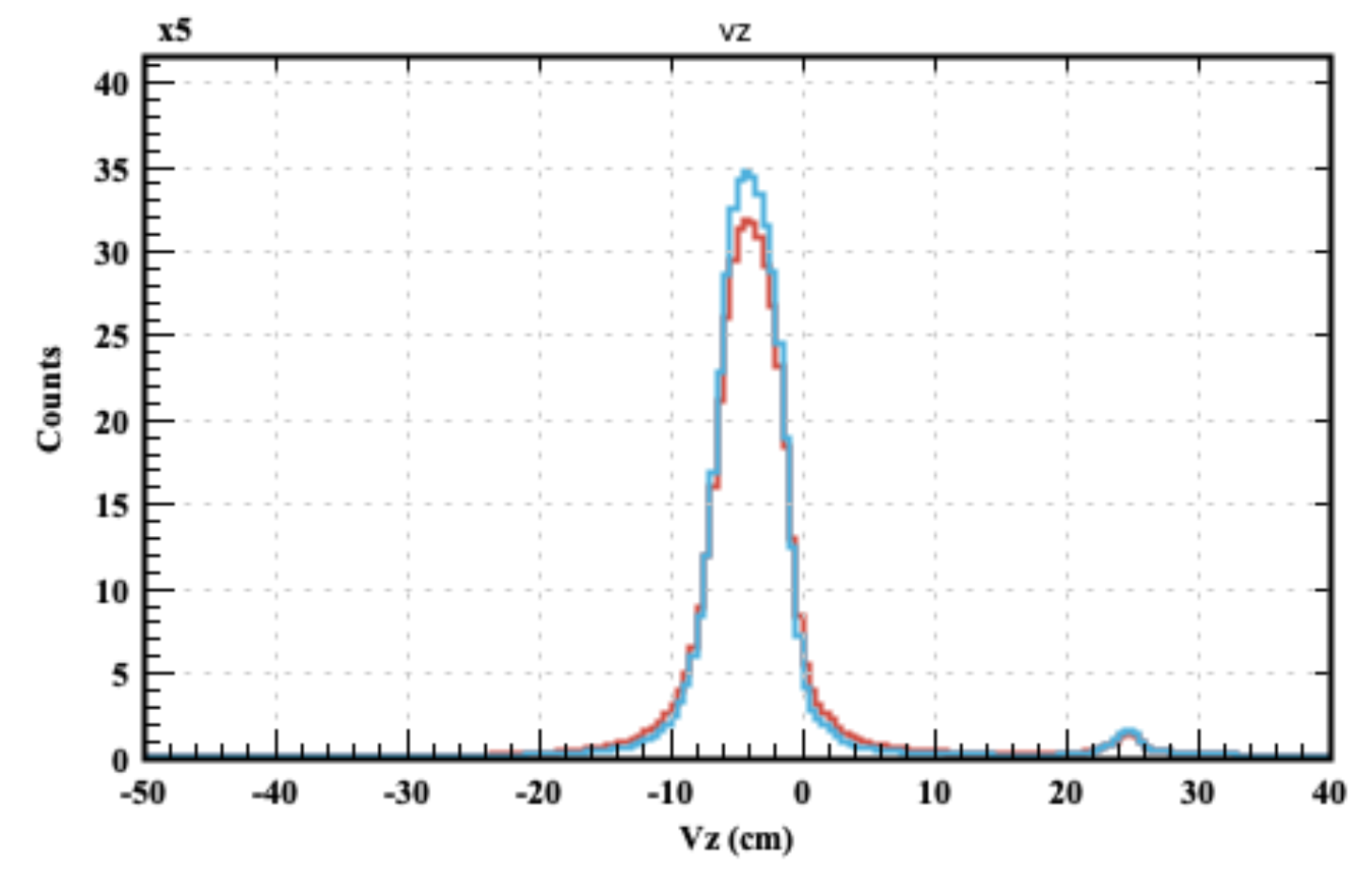
RGB	Current
6226	5 nA
6227	15 nA
6225	35 nA
6299	50 nA



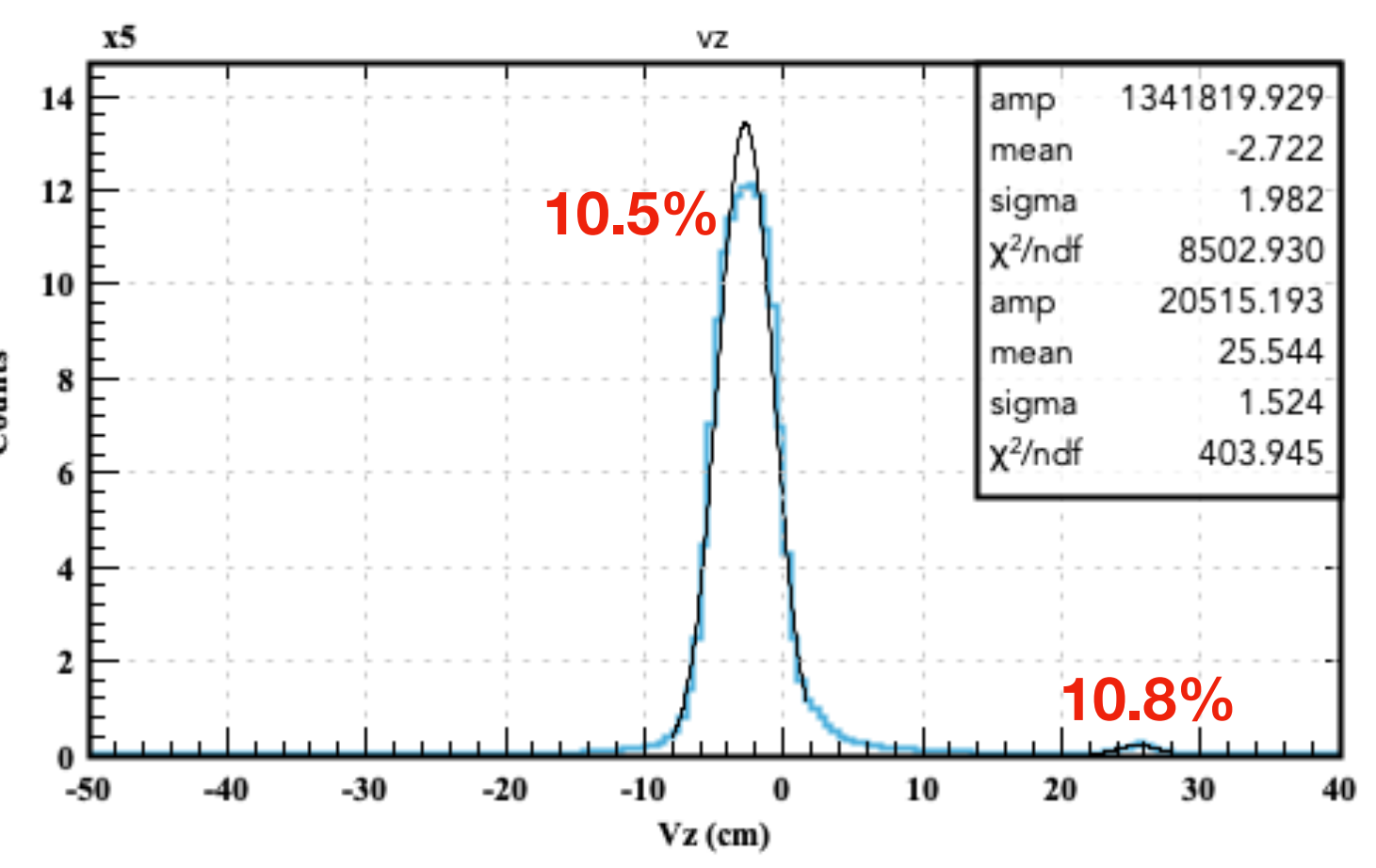
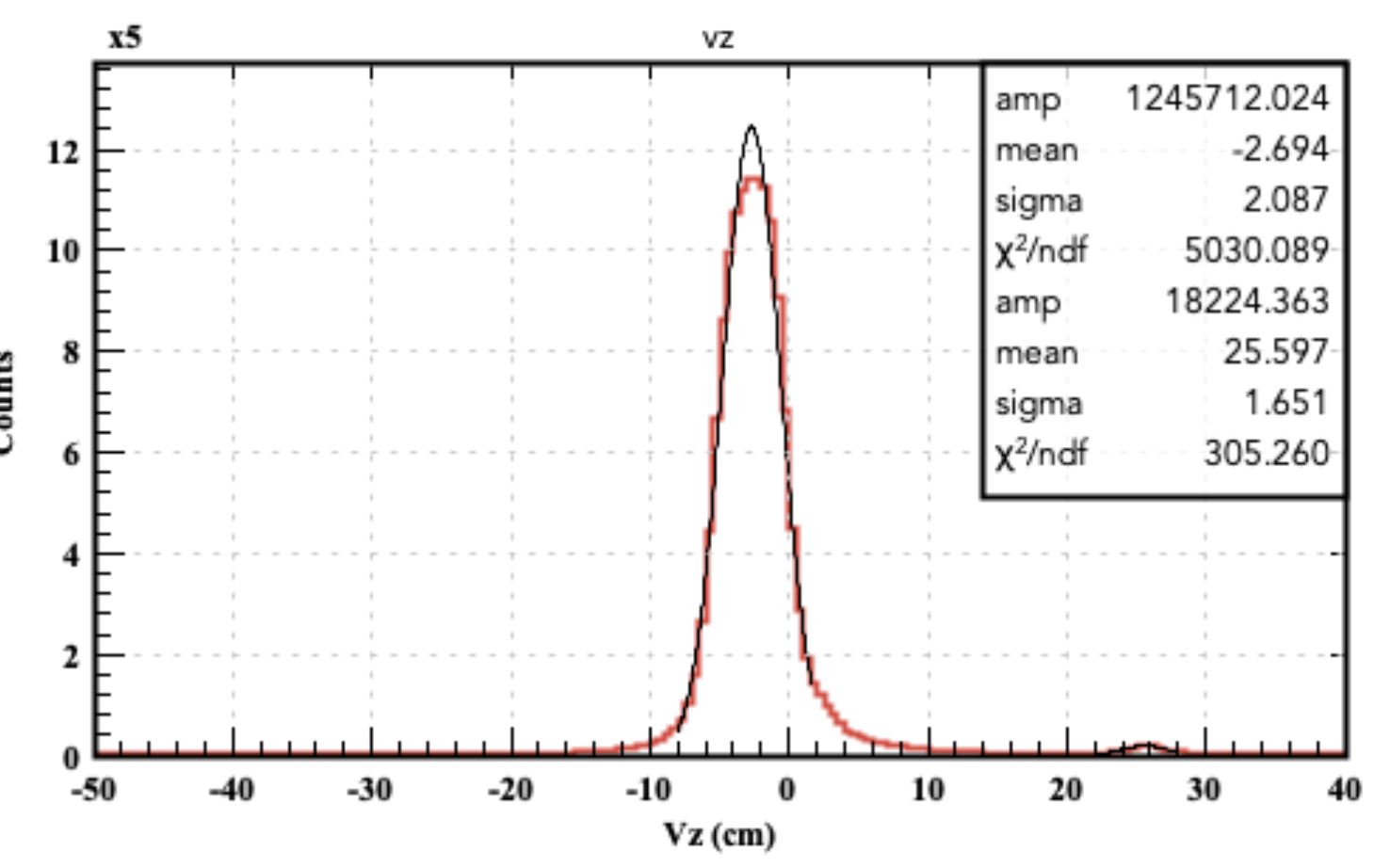
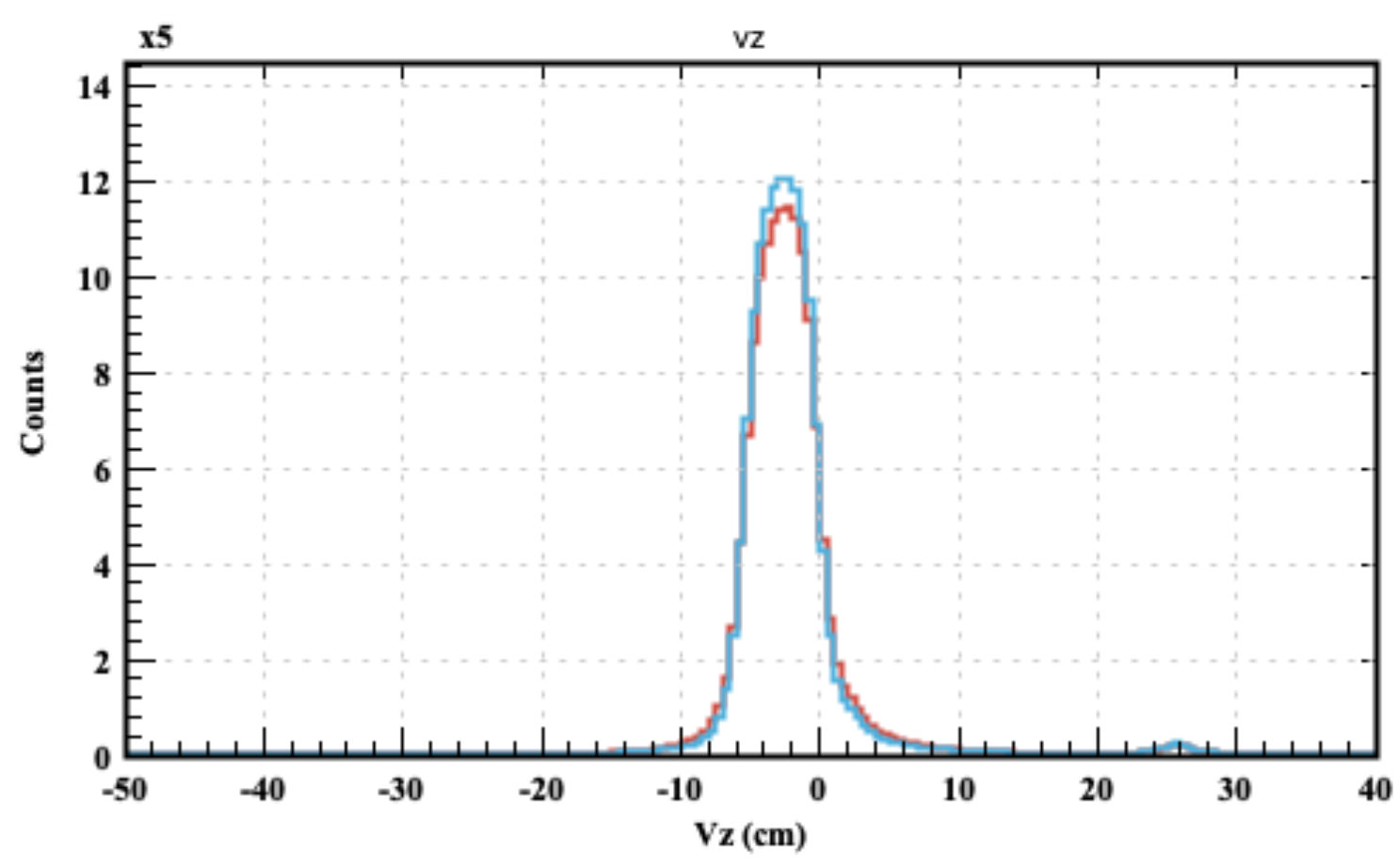
# Resolution: Vertex Z

- Red: dev  
- Blue: updates

Neg. Tracks



Pos. Tracks

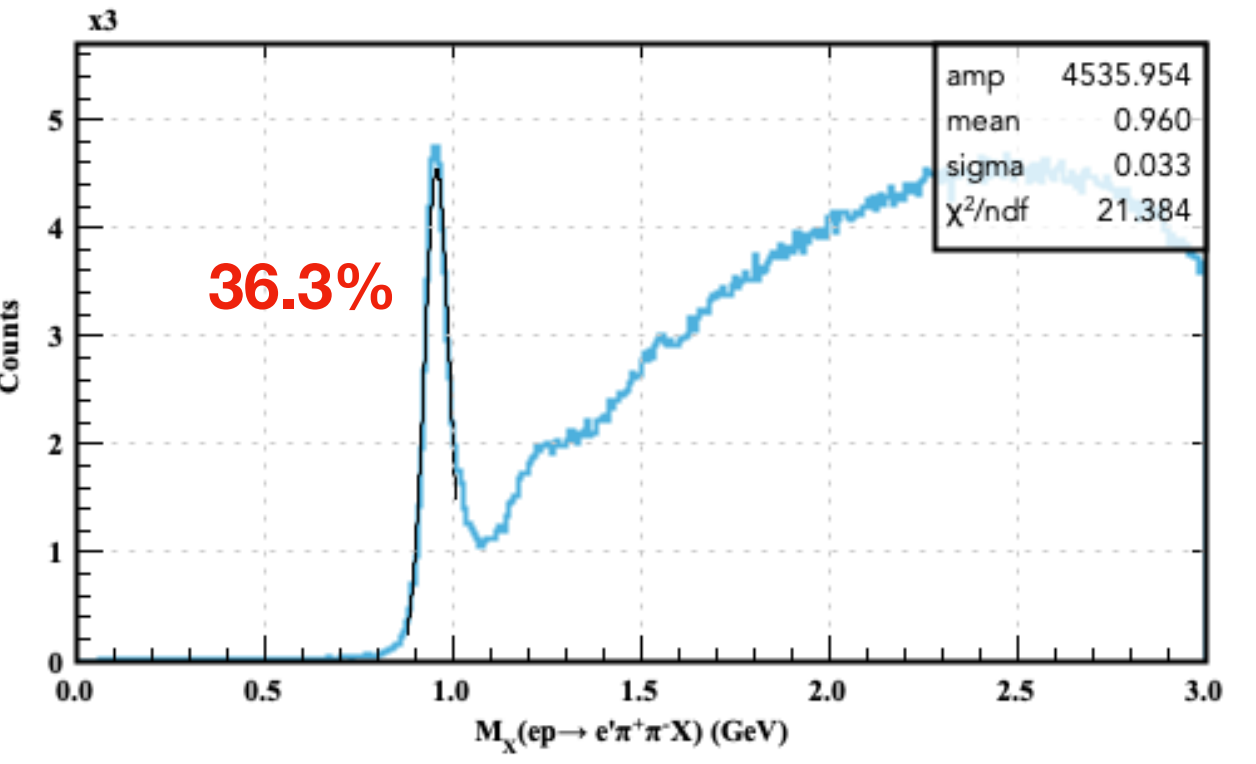
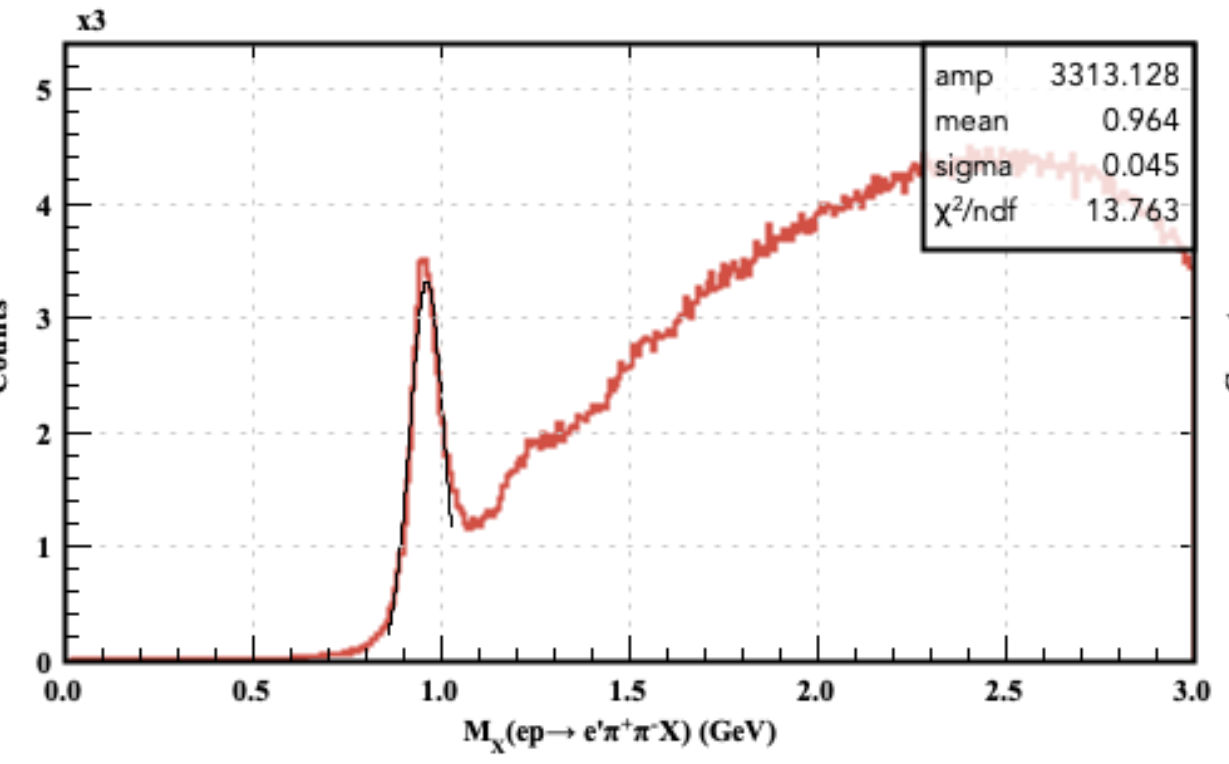
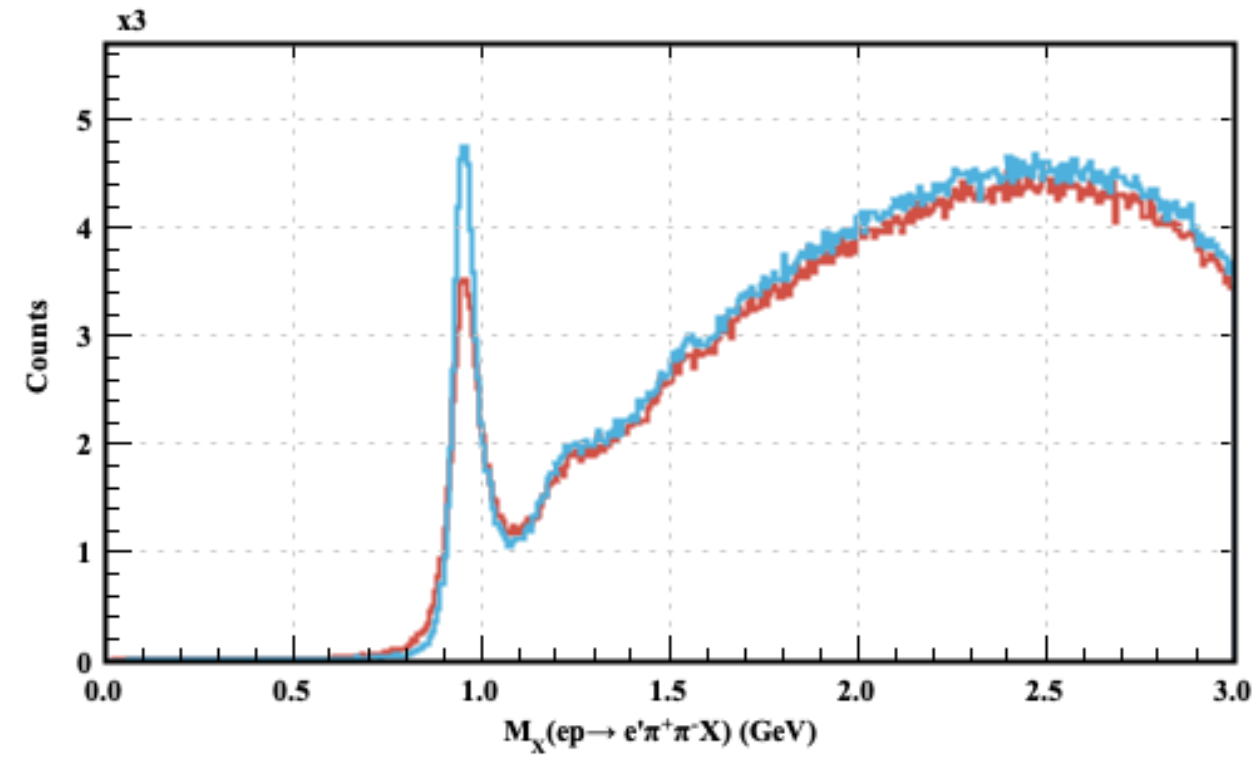




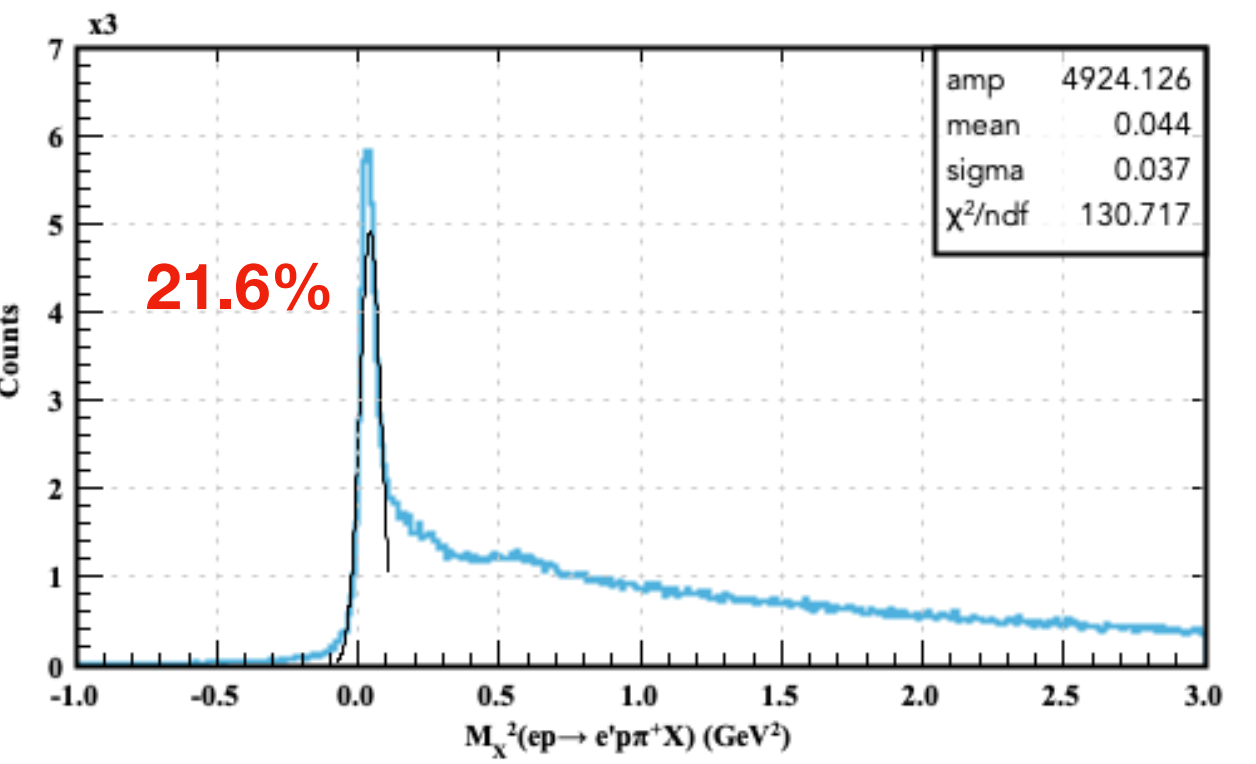
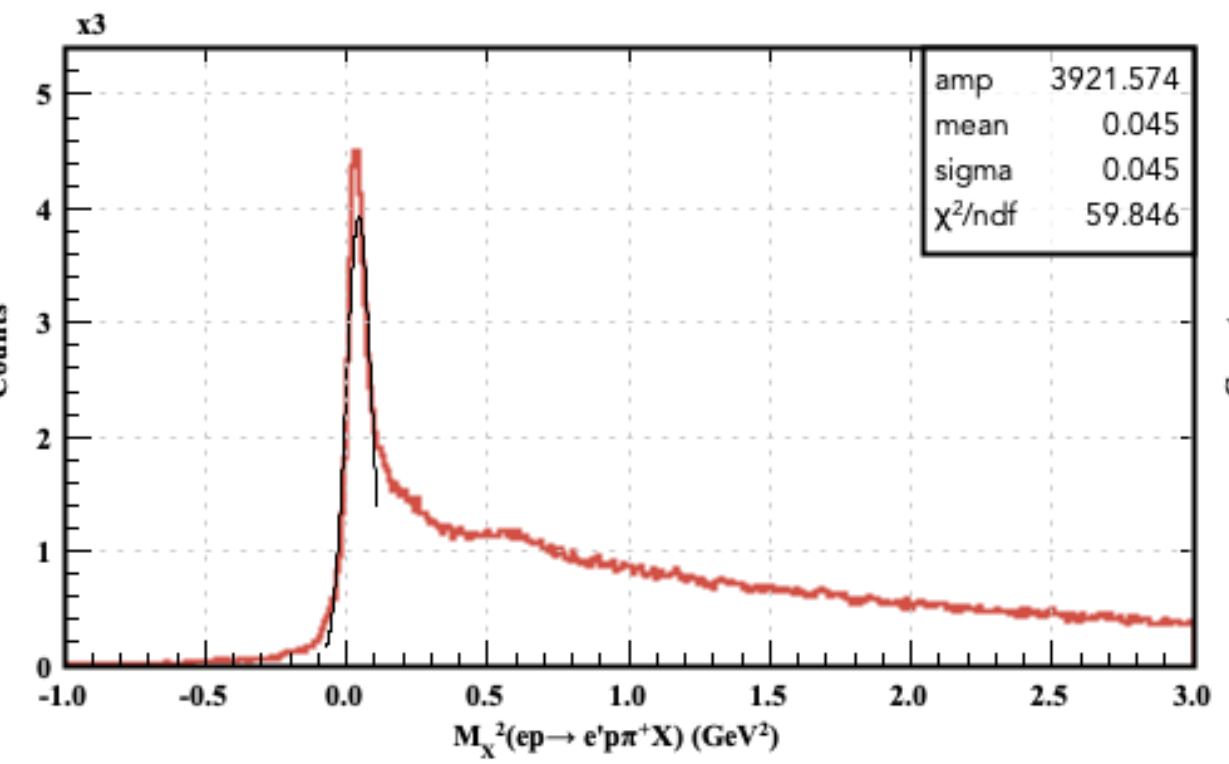
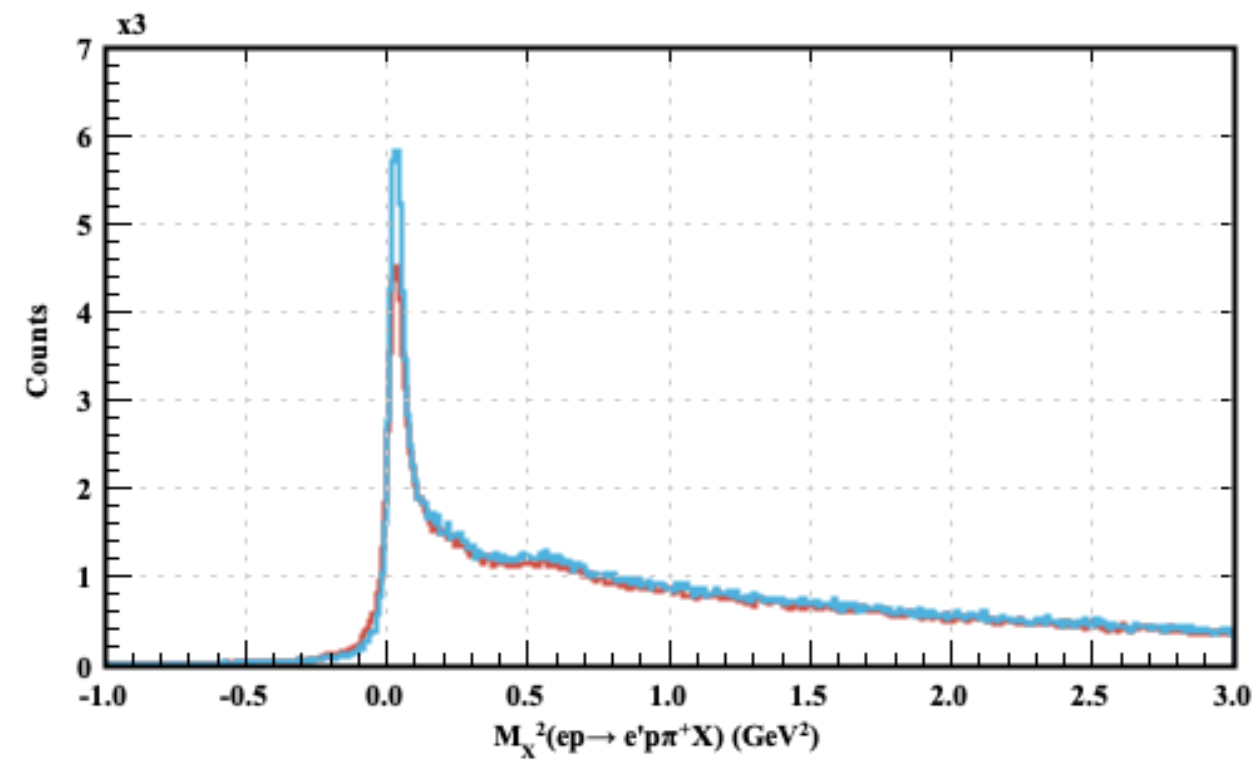
# Resolution: MM for 3-FSP Channels

- Red: dev  
- Blue: updates

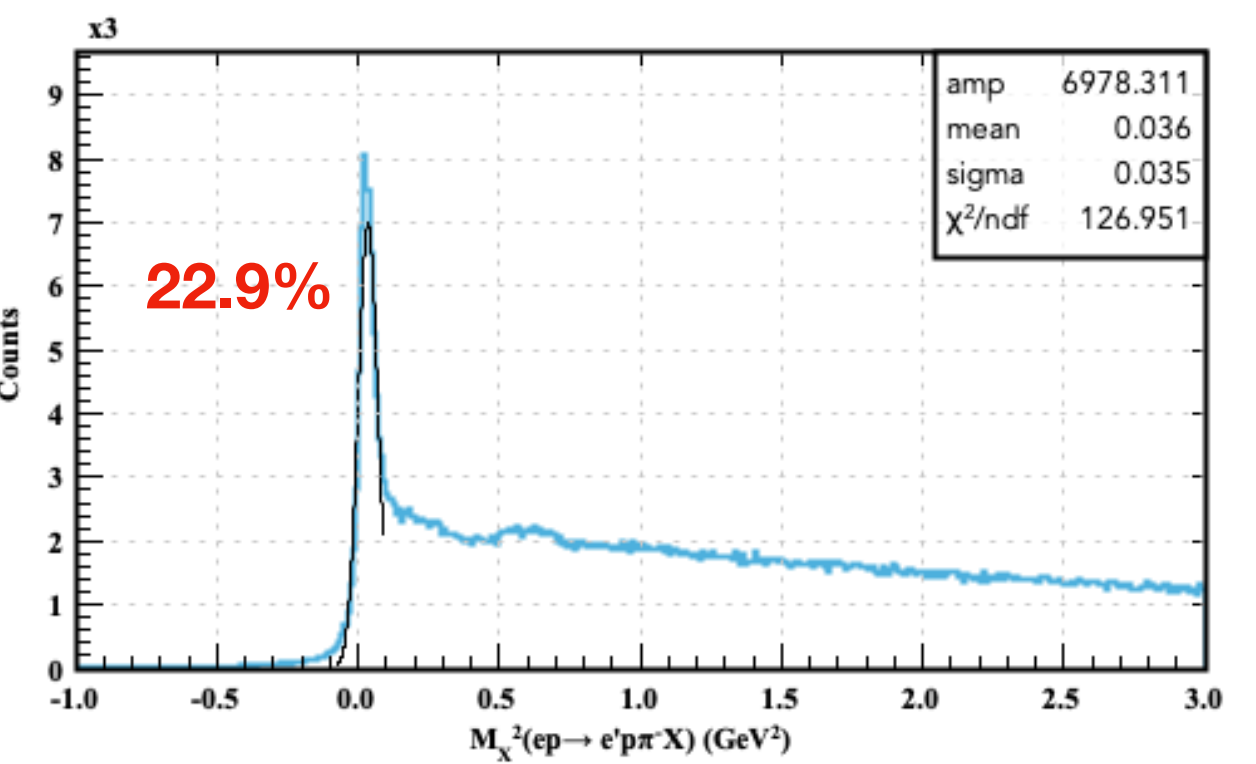
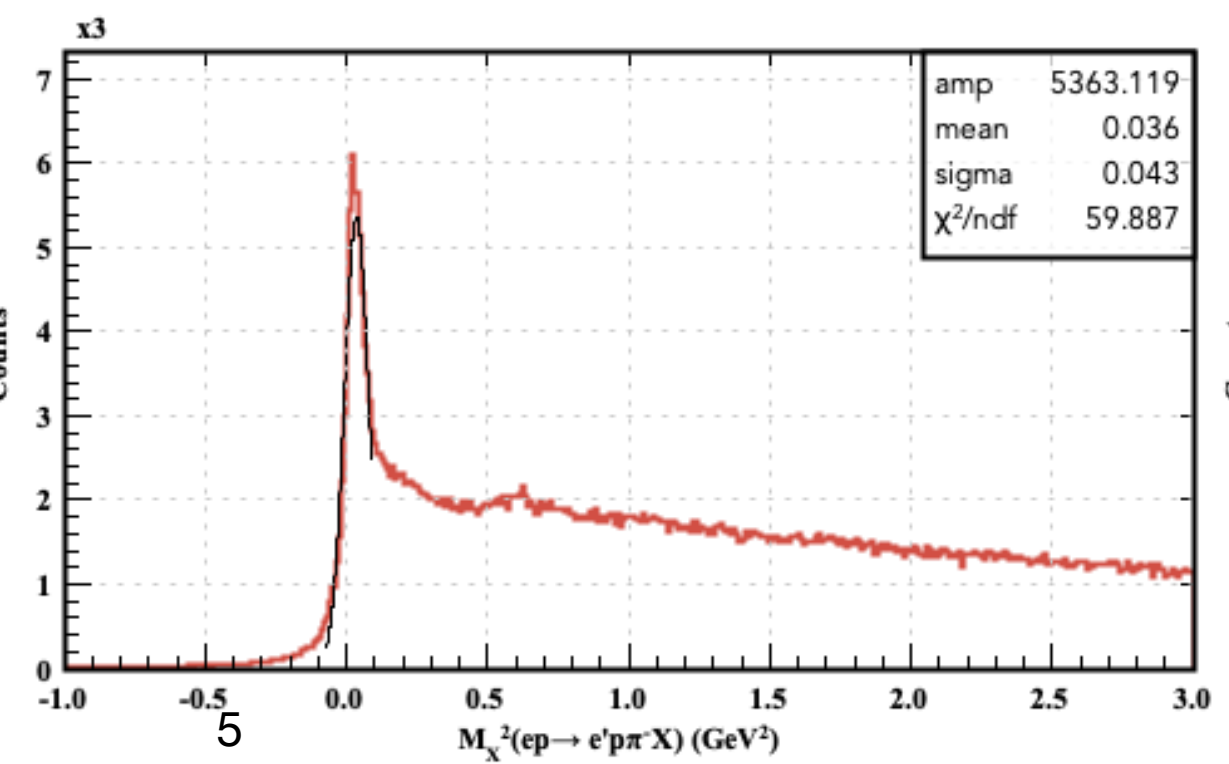
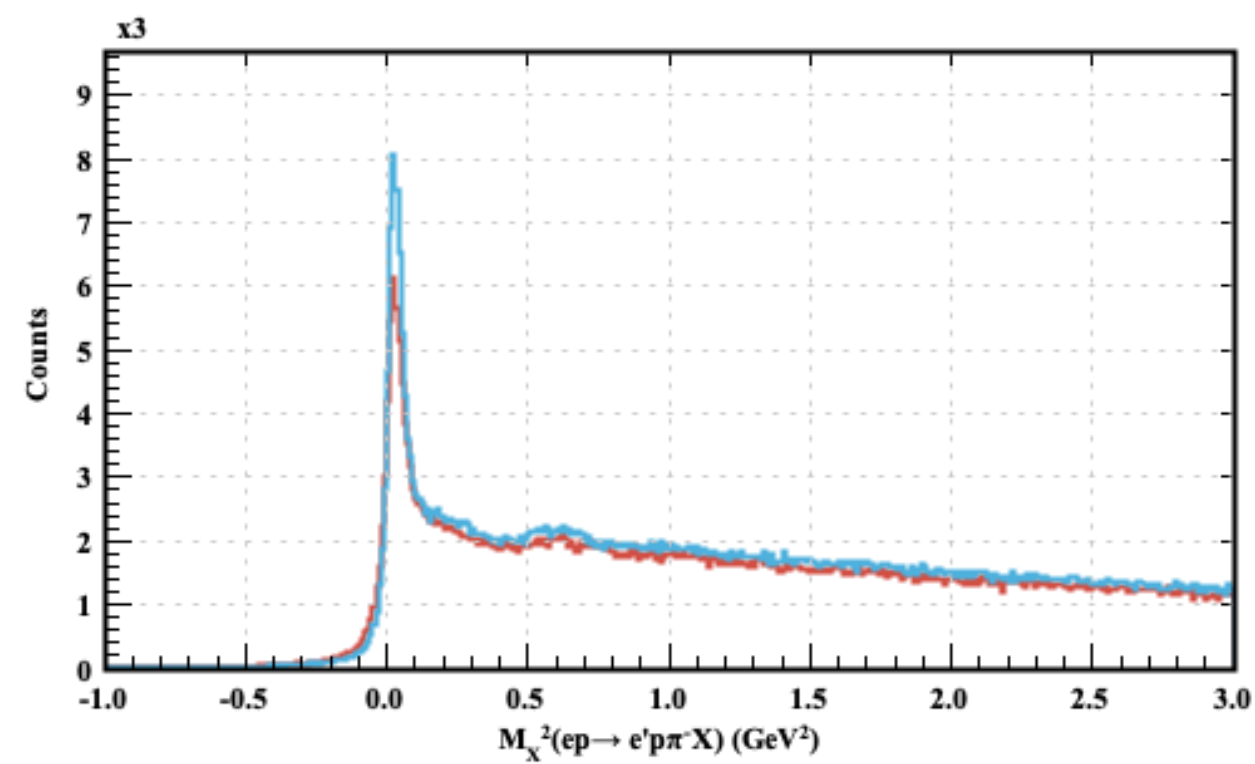
$$ep \rightarrow e' \pi^+ \pi^- X$$



$$ep \rightarrow e' p \pi^+ X$$



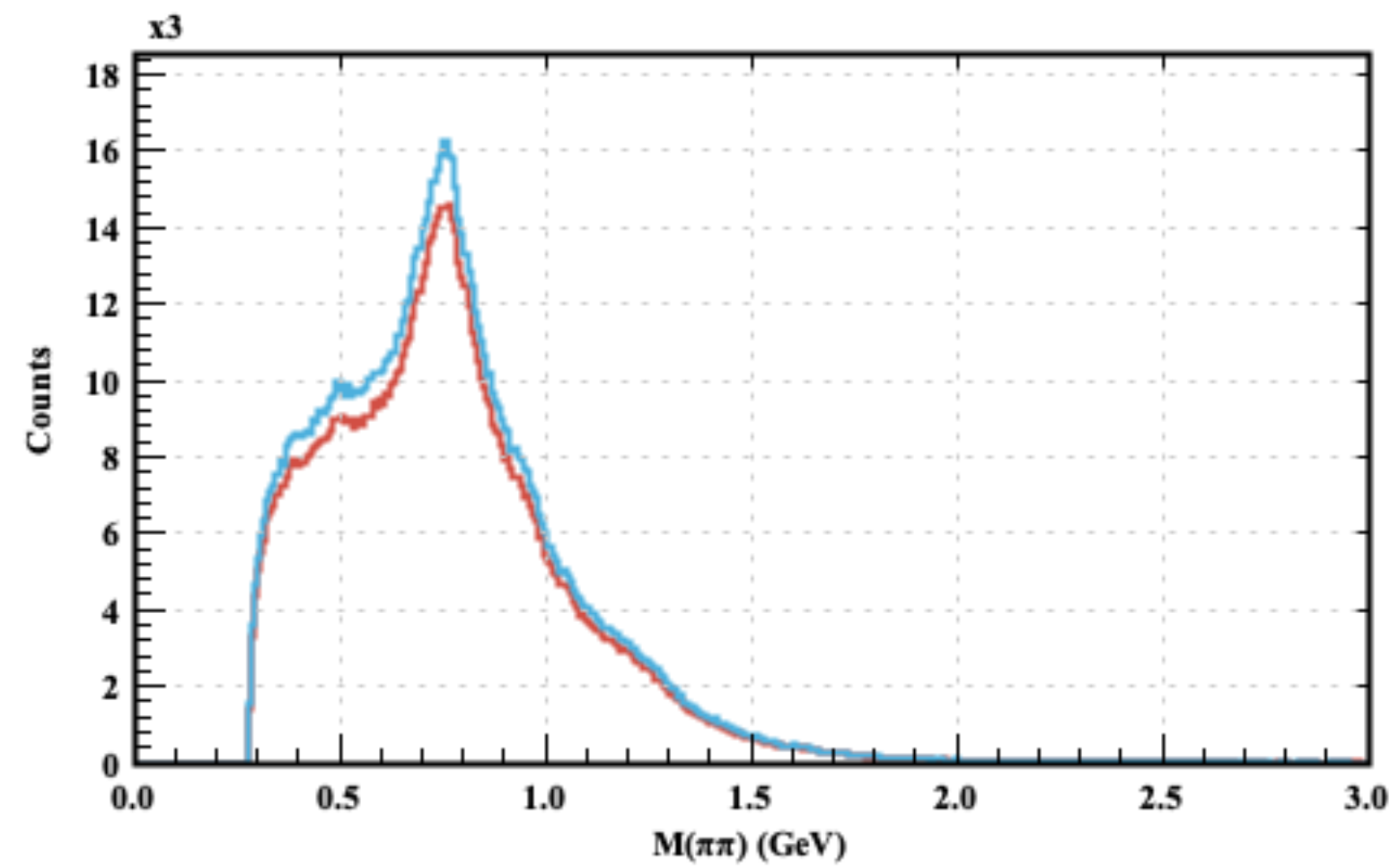
$$ep \rightarrow e' p \pi^- X$$



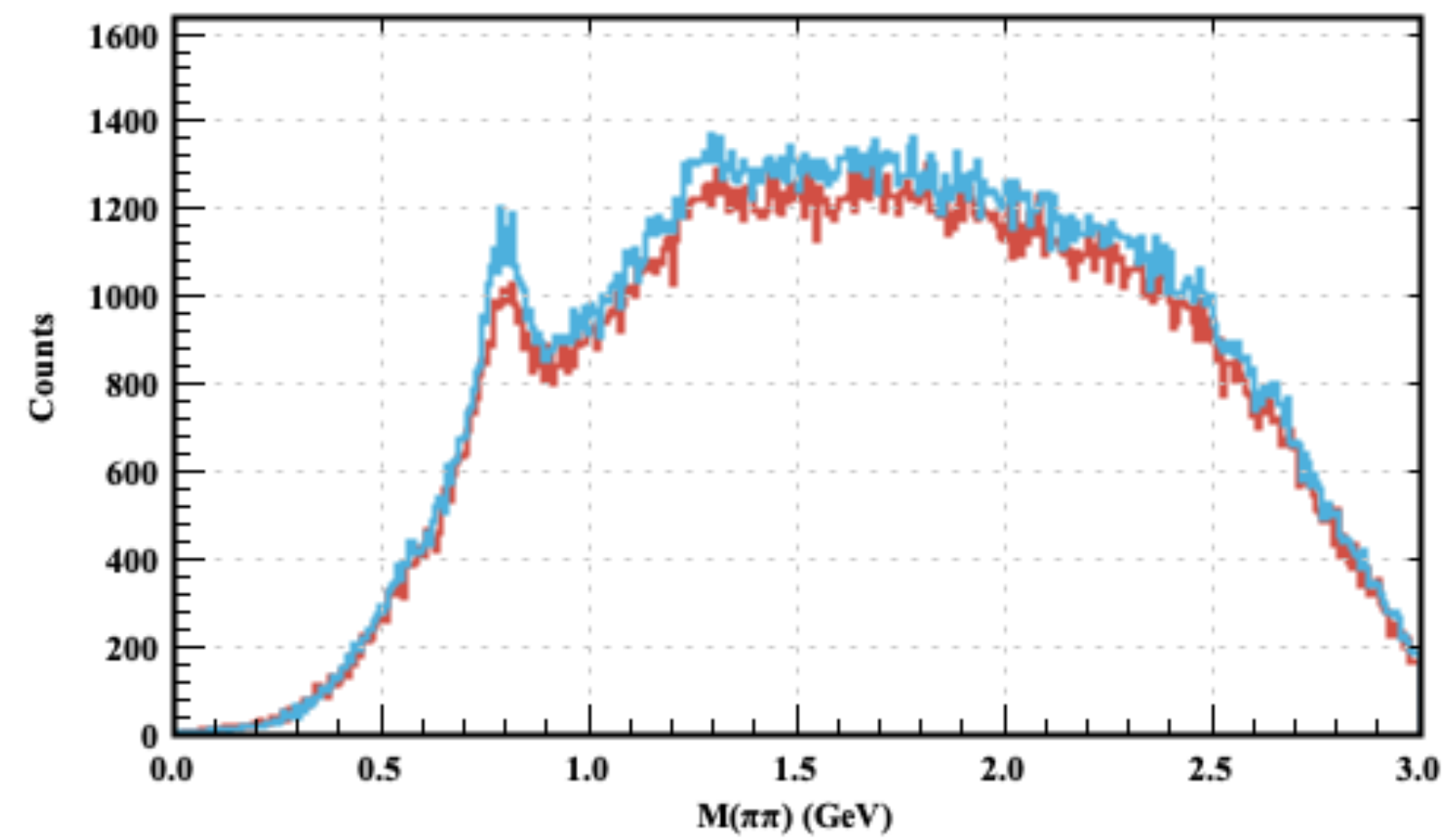
# Resolution: $M(\pi^+\pi^-)$ for 3-FSP Channels

- Red: dev  
- Blue: updates

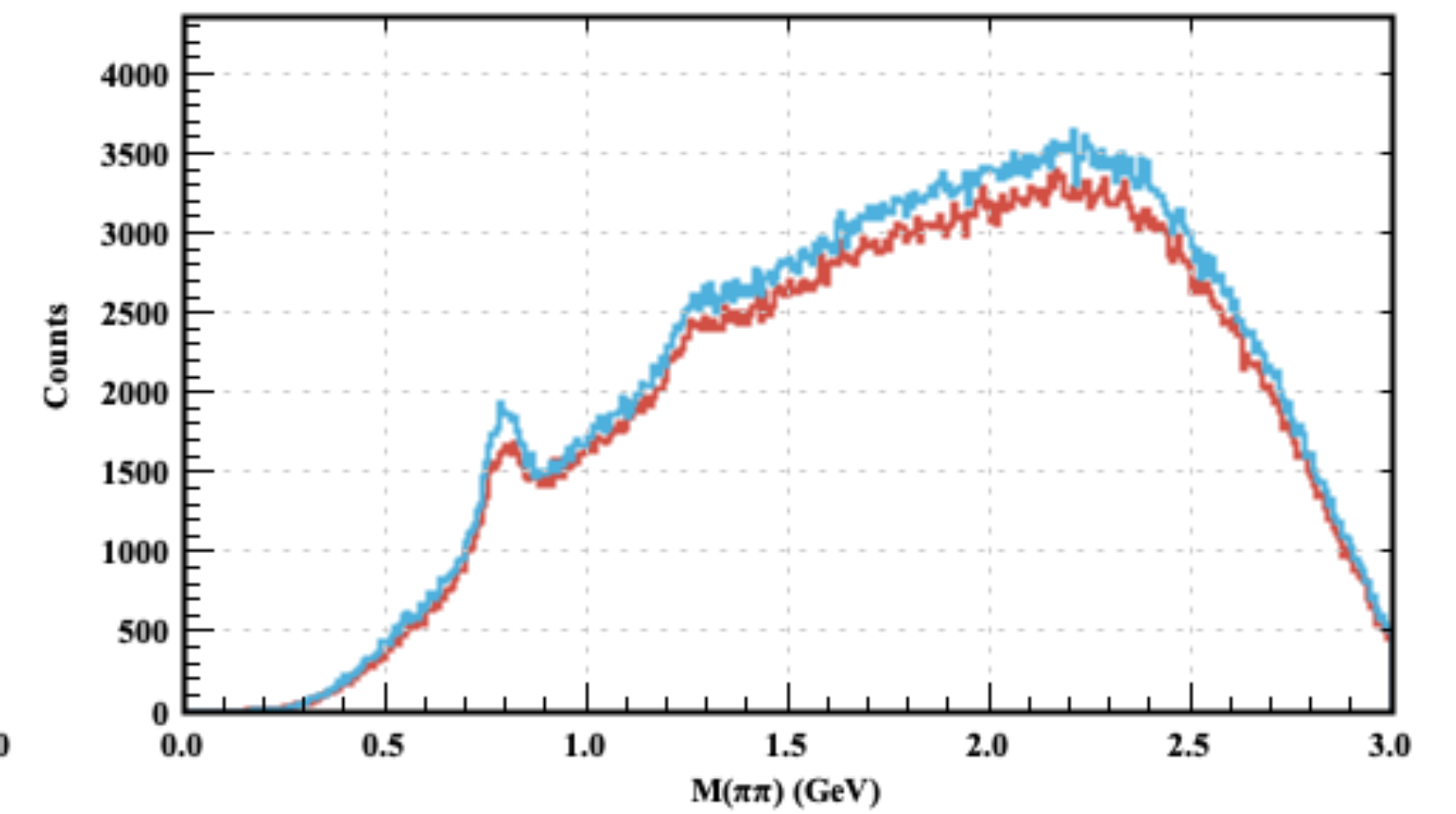
$$ep \rightarrow e' \pi^+ \pi^- X$$



$$ep \rightarrow e' p \pi^+ X$$



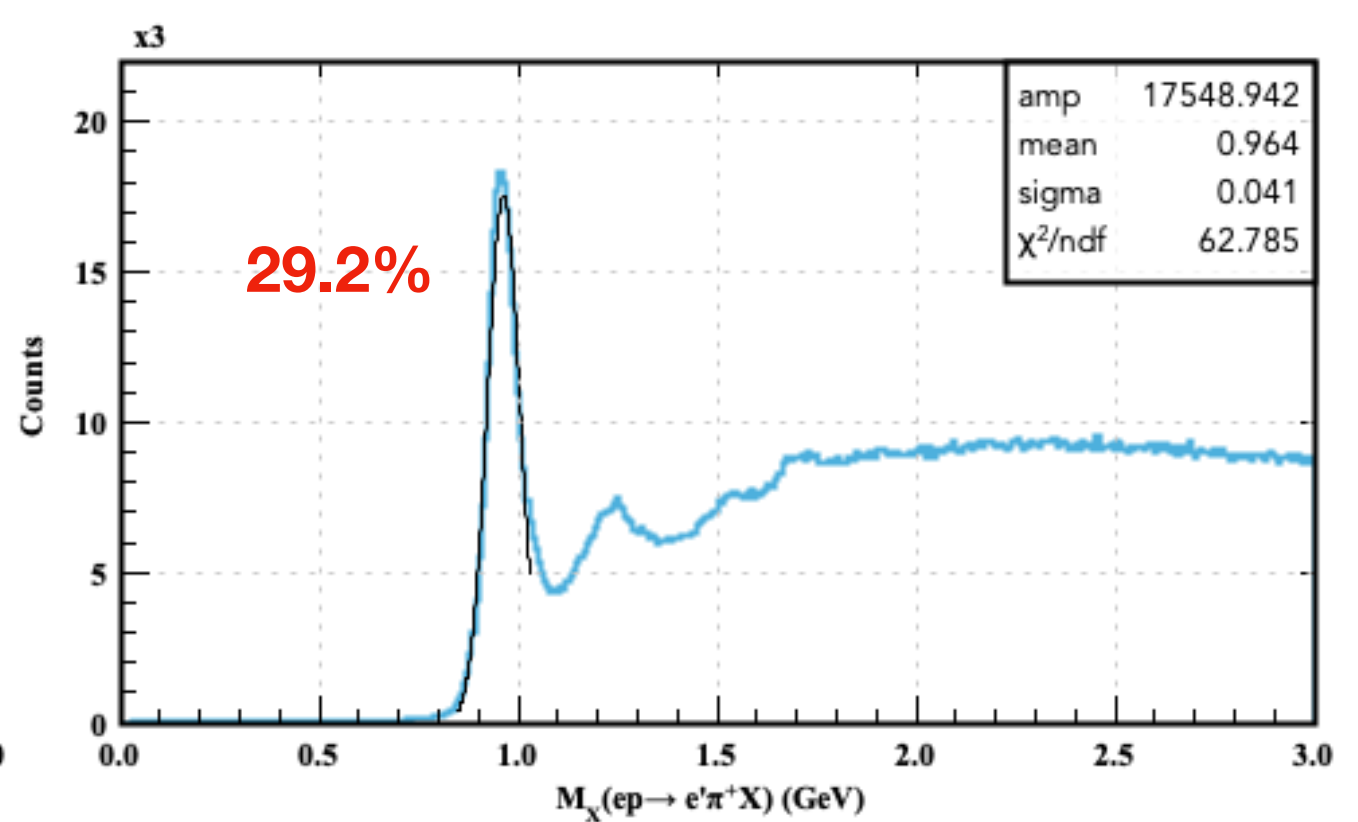
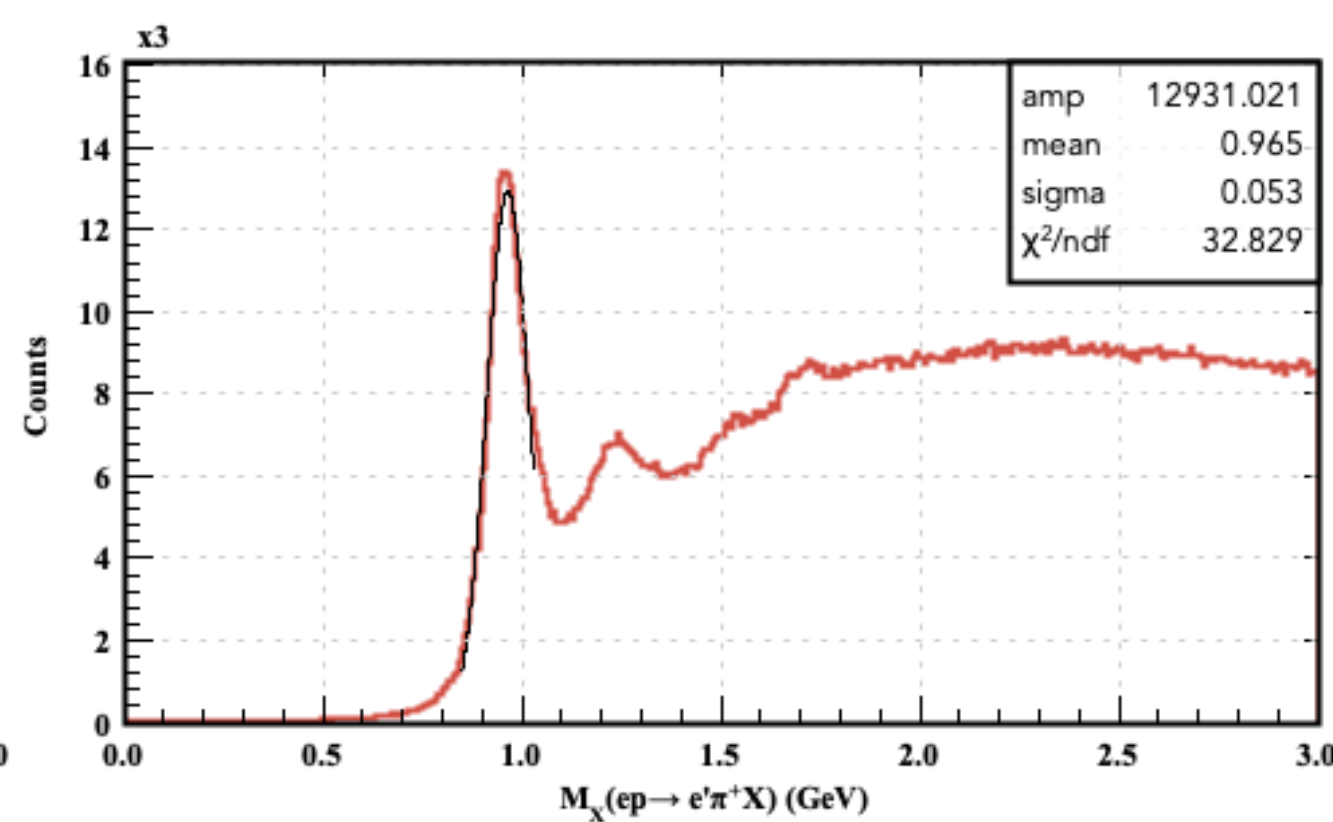
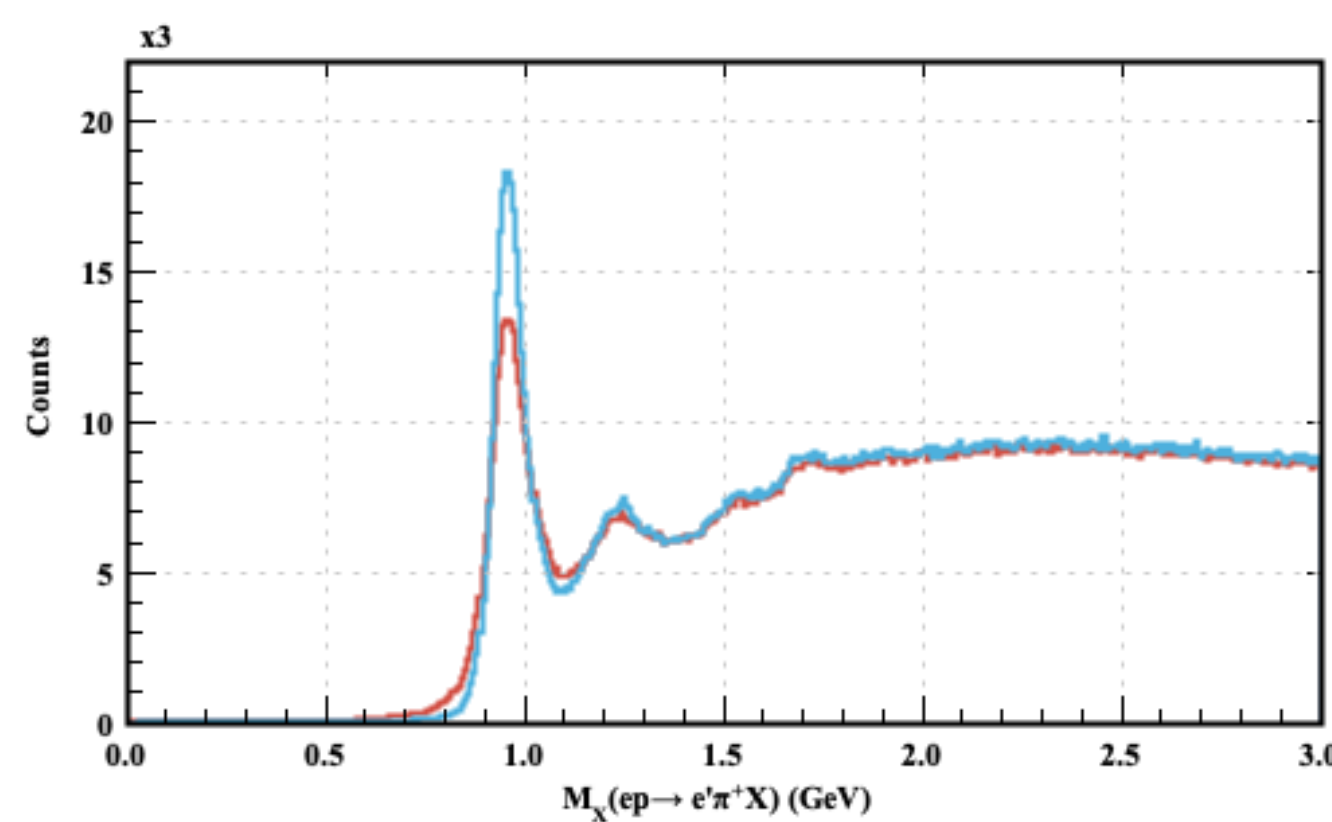
$$ep \rightarrow e' p \pi^- X$$



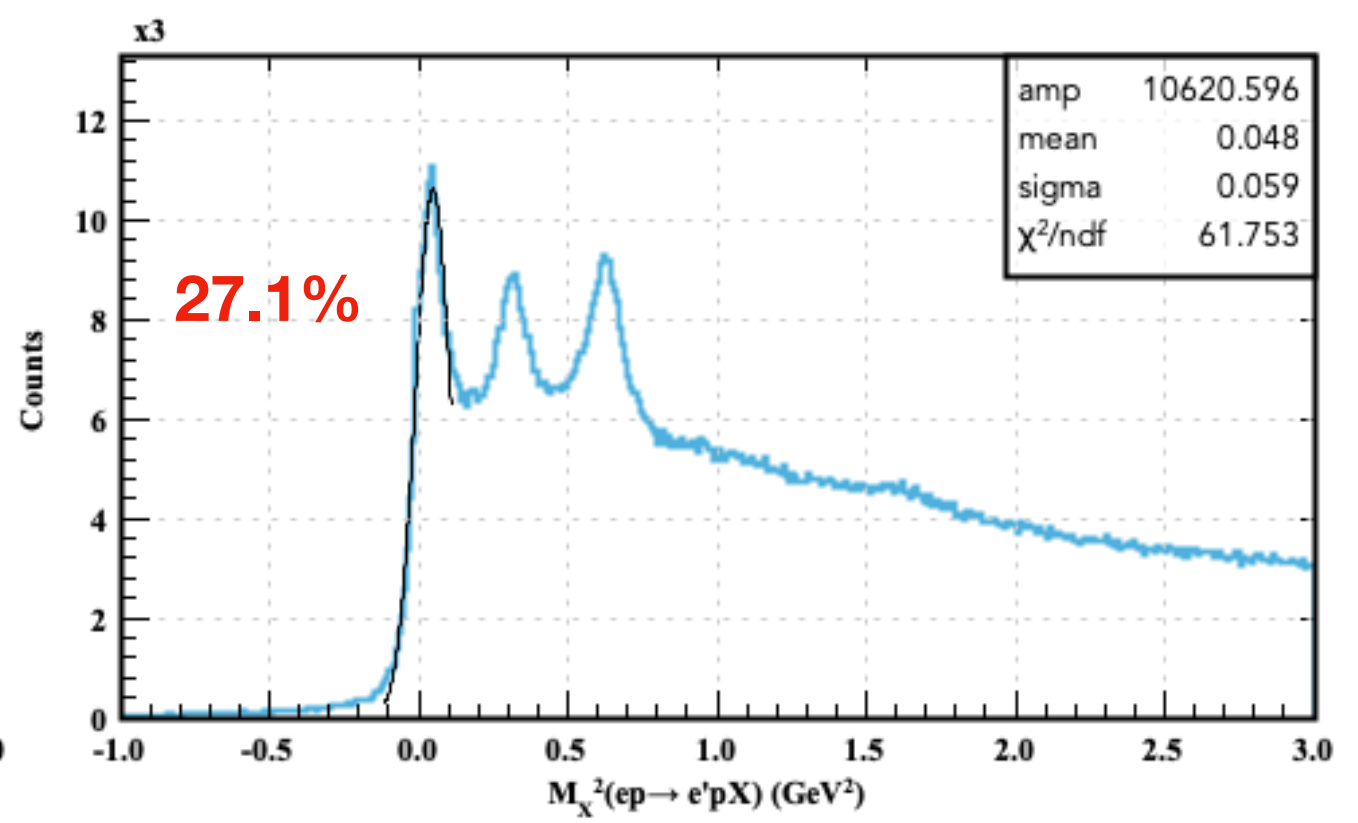
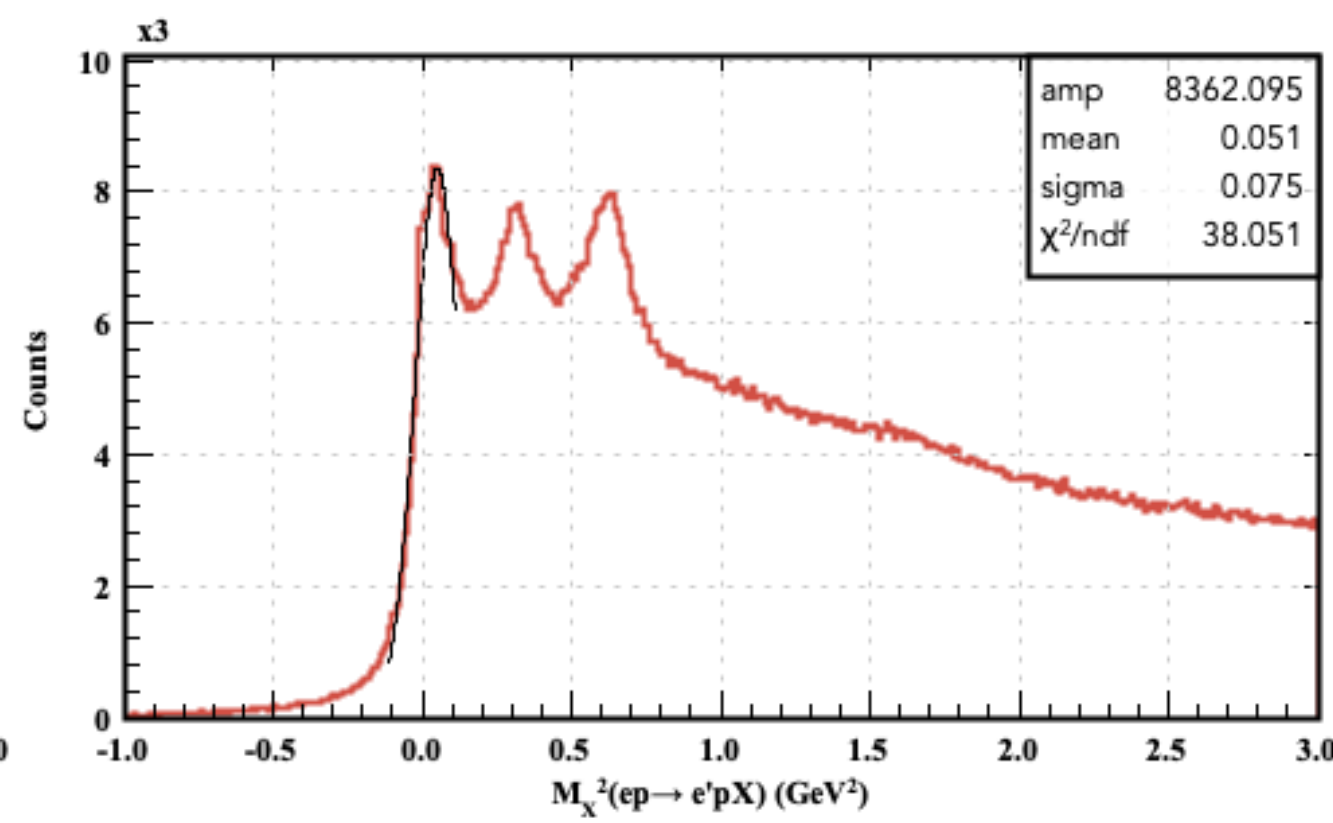
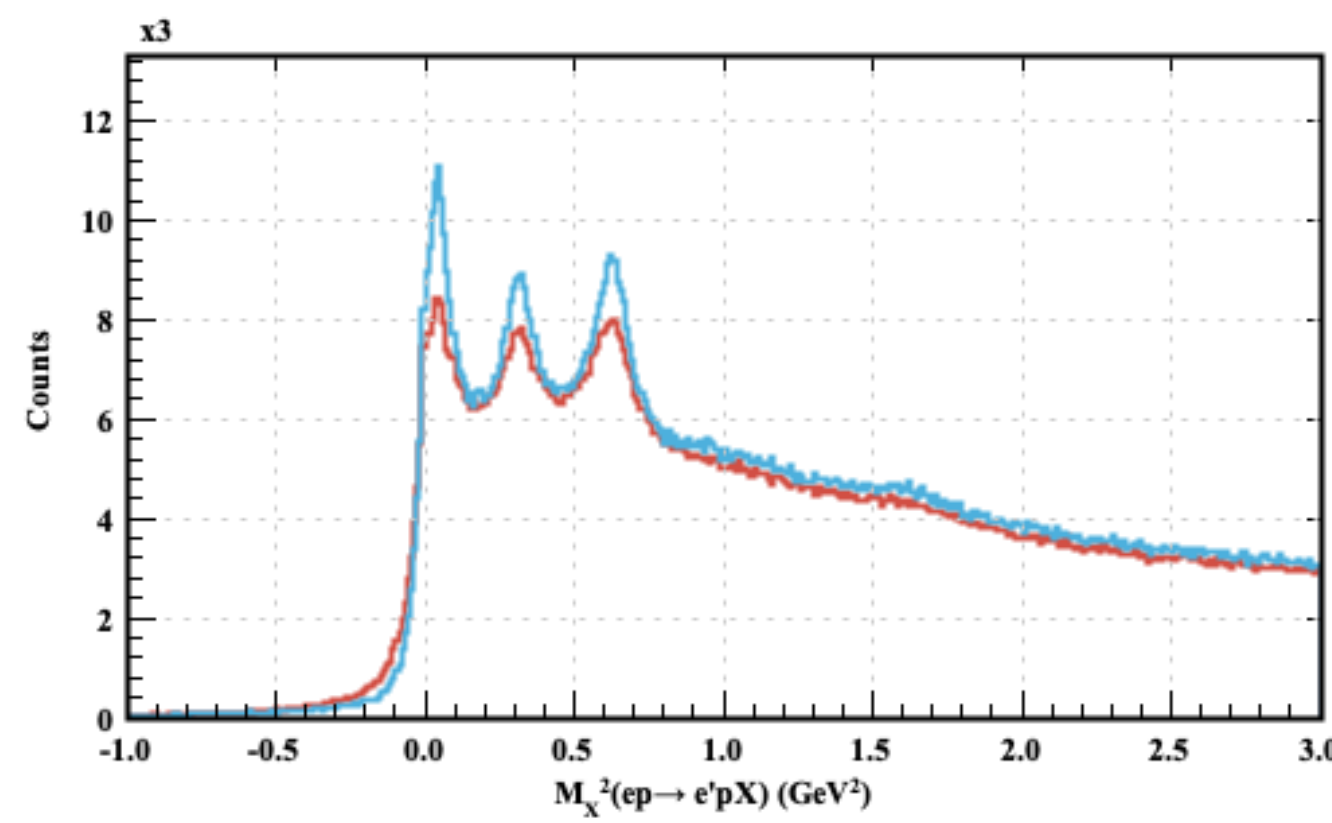
# Resolution: MM for 2-FSP Channels

- Red: dev  
- Blue: updates

$$ep \rightarrow e' \pi^+ X$$



$$ep \rightarrow e' p X$$

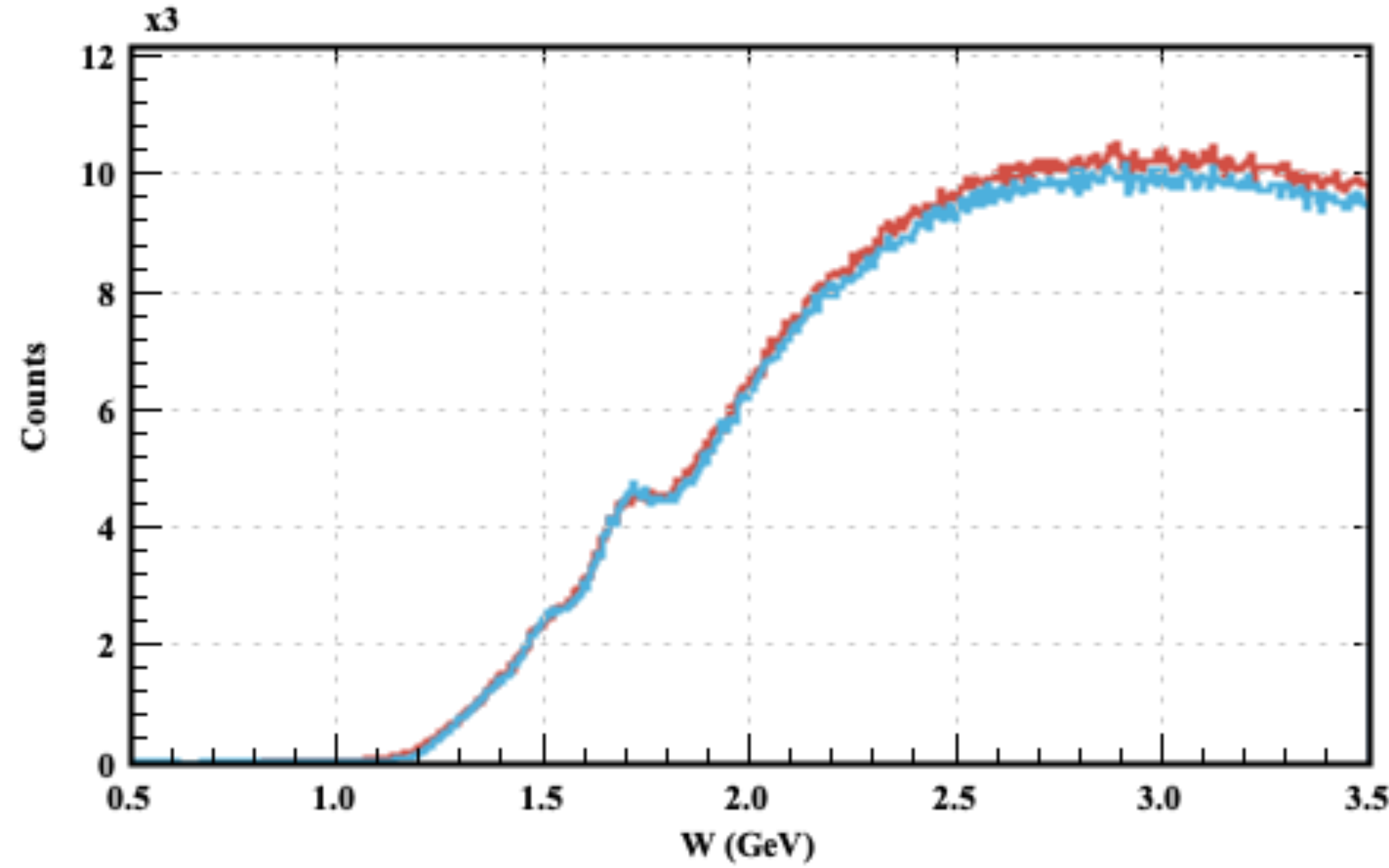




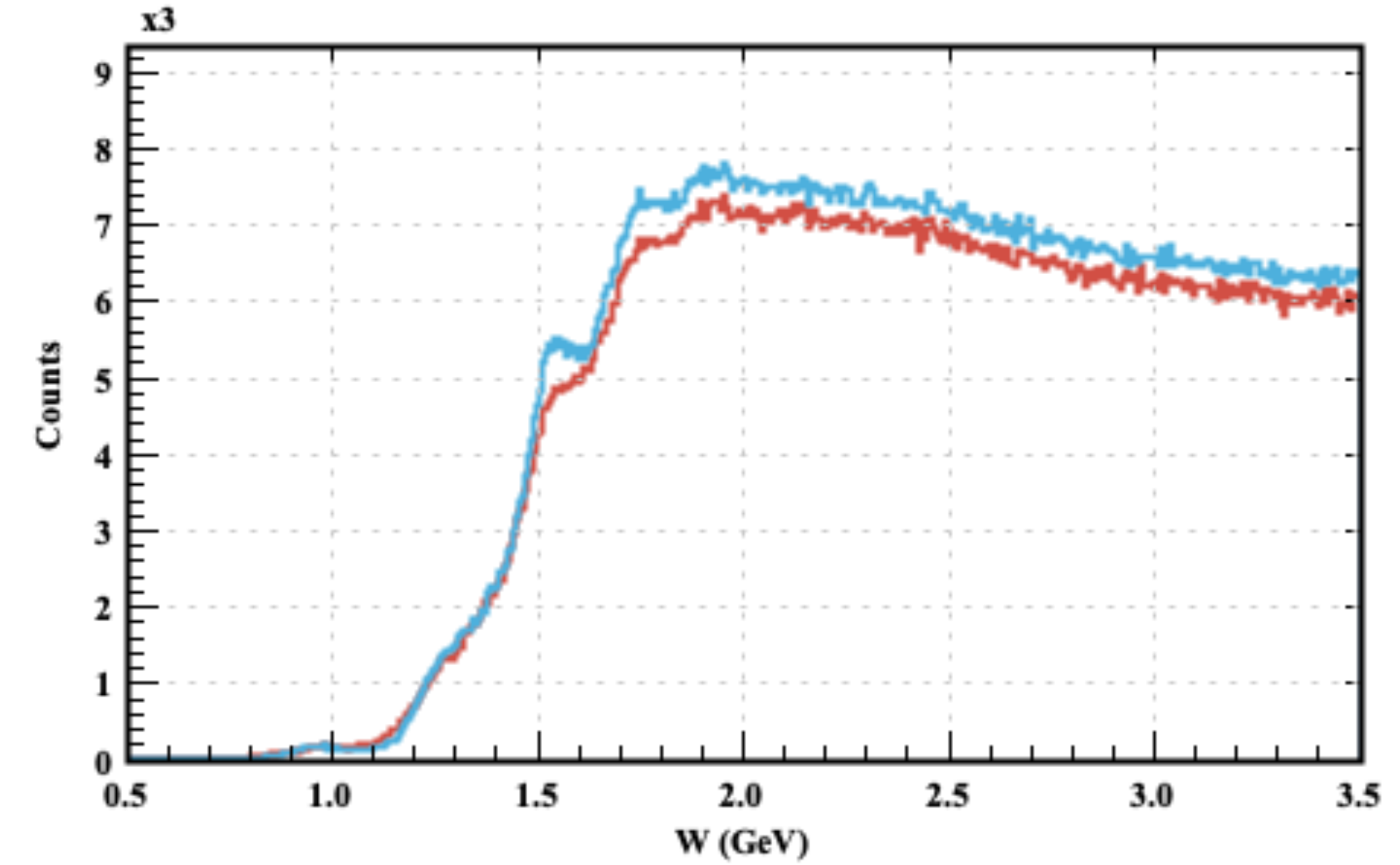
# Resolution: W (M<sub>x</sub> of $ep \rightarrow e'X$ ) for 2-FSP Channels

- Red: dev  
- Blue: updates

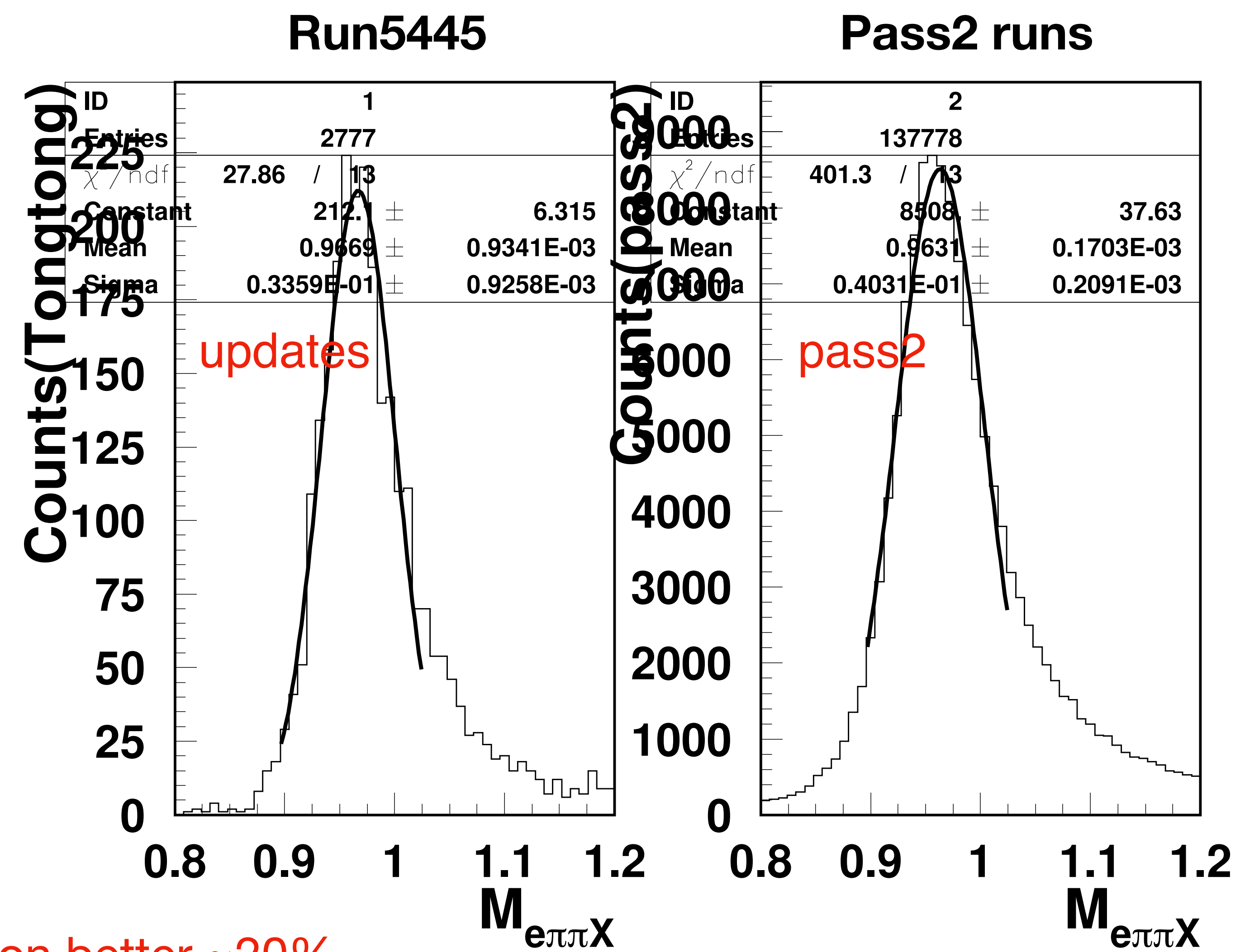
$$ep \rightarrow e'\pi^+ X$$



$$ep \rightarrow e'pX$$



# RGA Validation by Harut



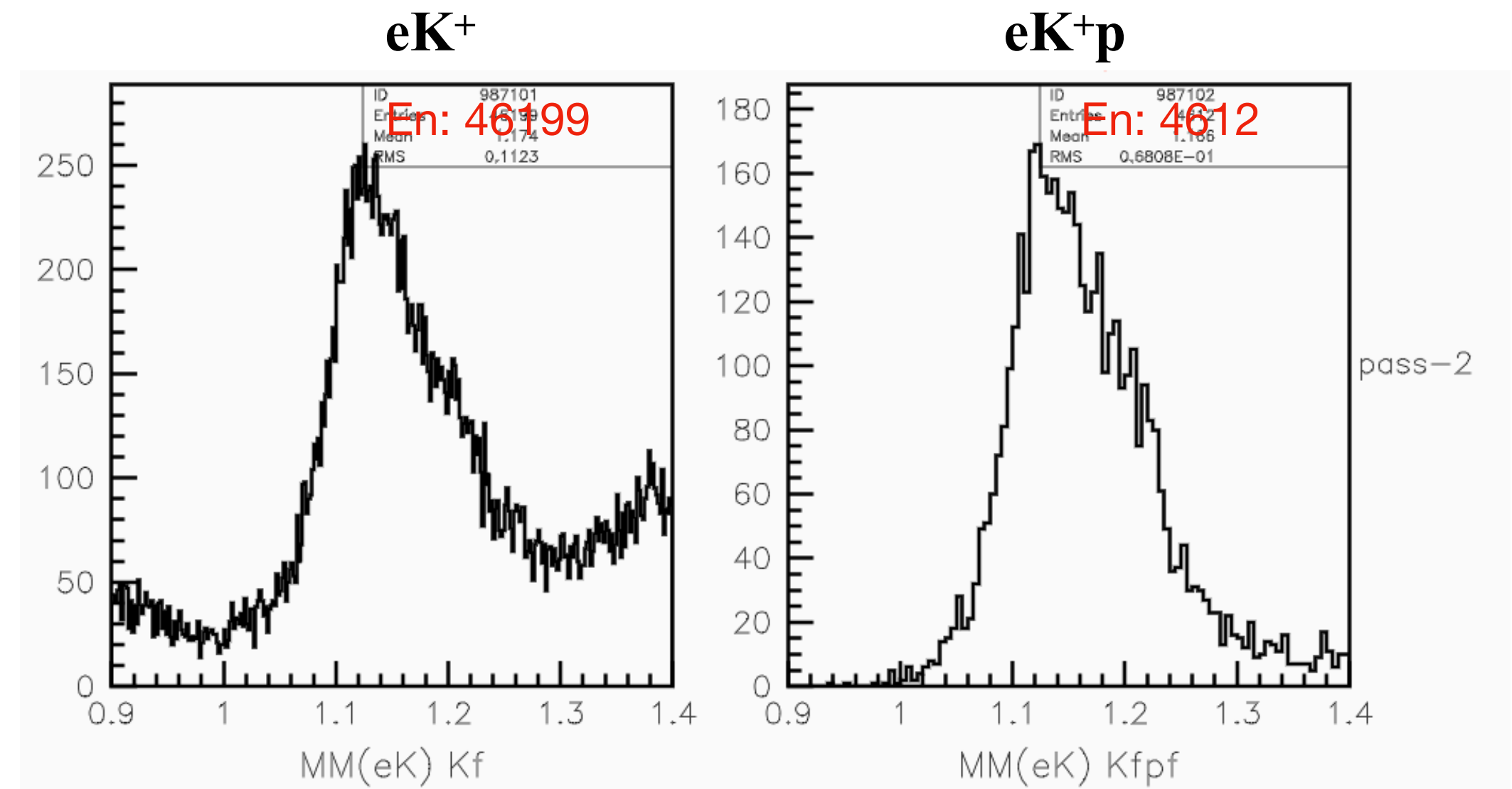
Resolution better ~20%



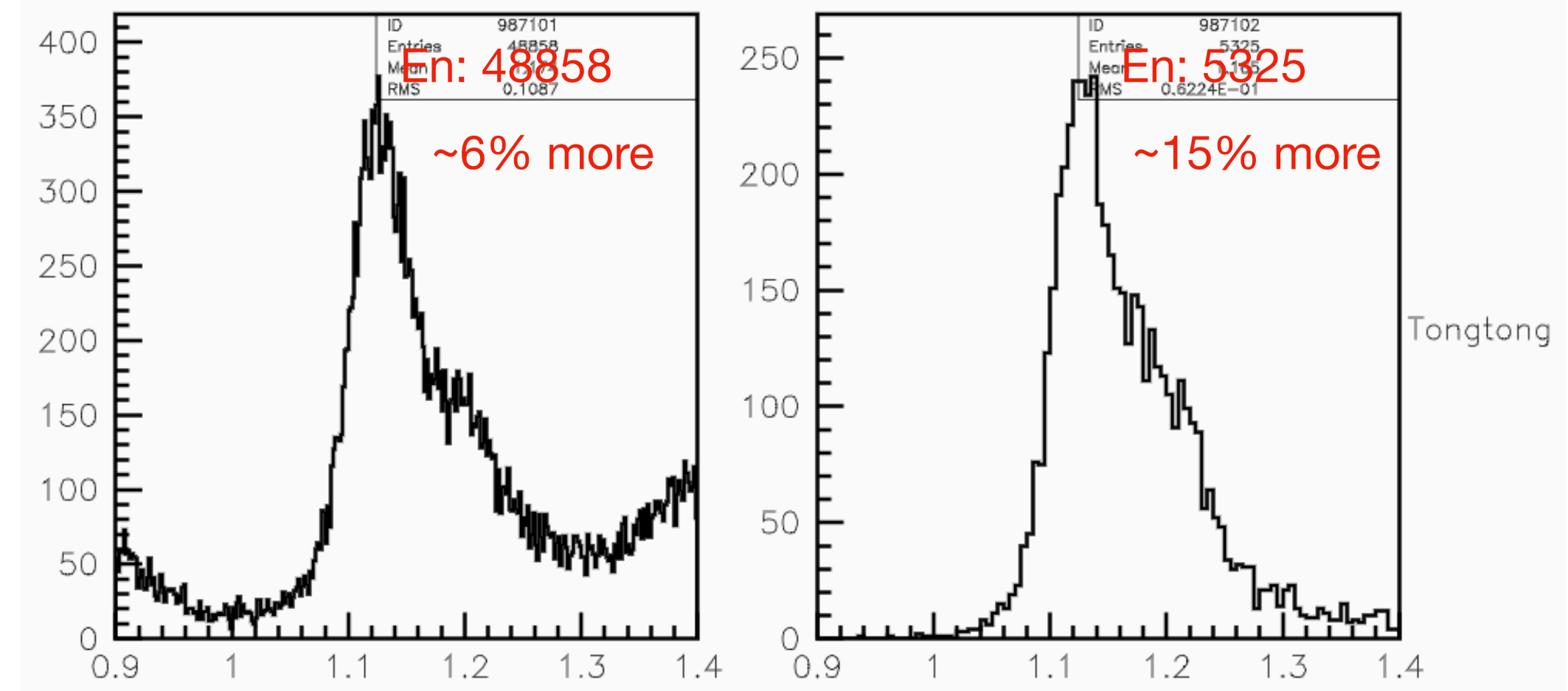
# RGA Validation by Daniel

## MM(eK<sup>+</sup>)

pass2

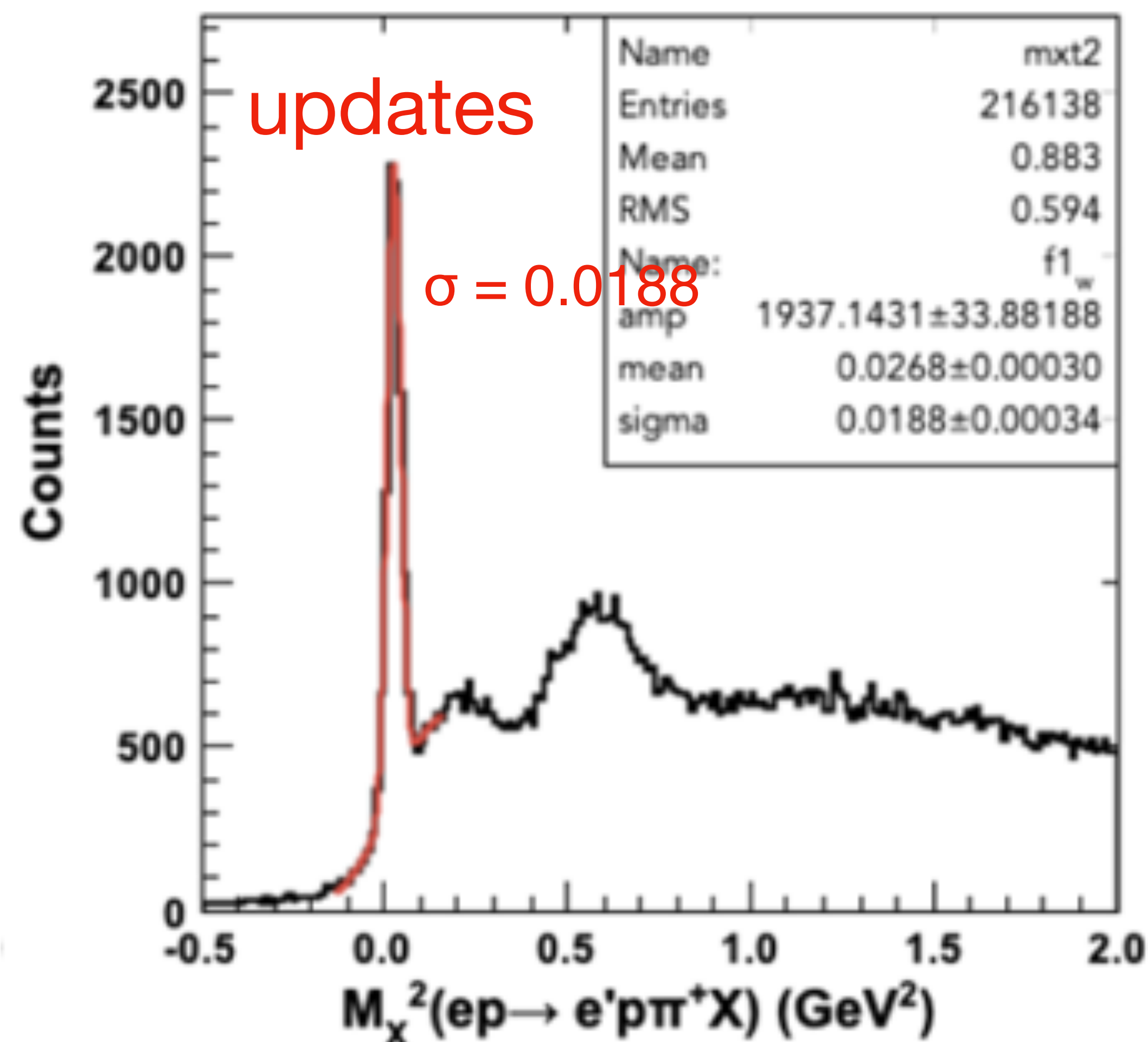
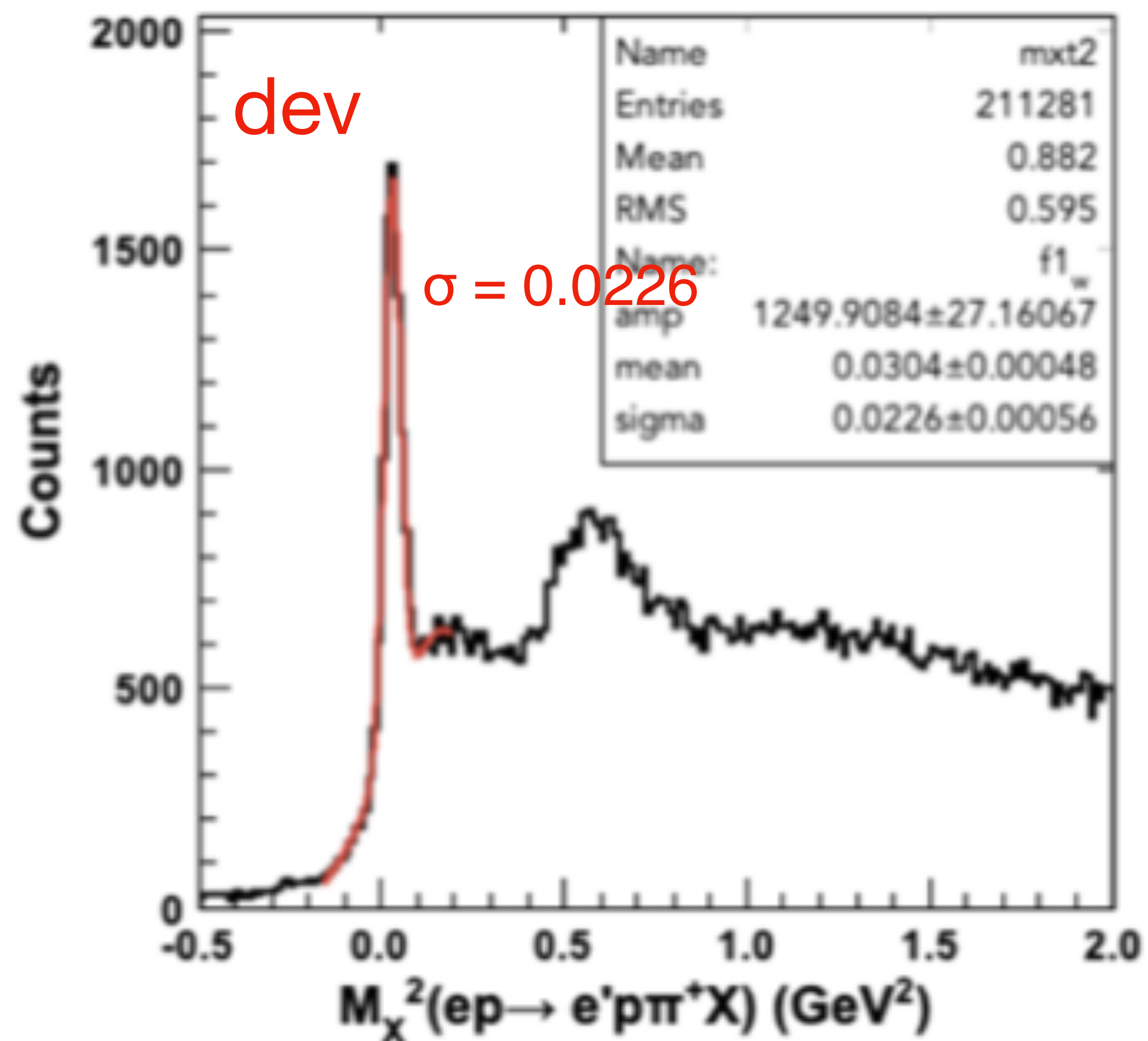


updates



Better for both resolution and reconstruction efficiency

# Validation for RGA-SIDIS MC by Raffaella



# Validation for RGA-SIDIS MC by Raffaella

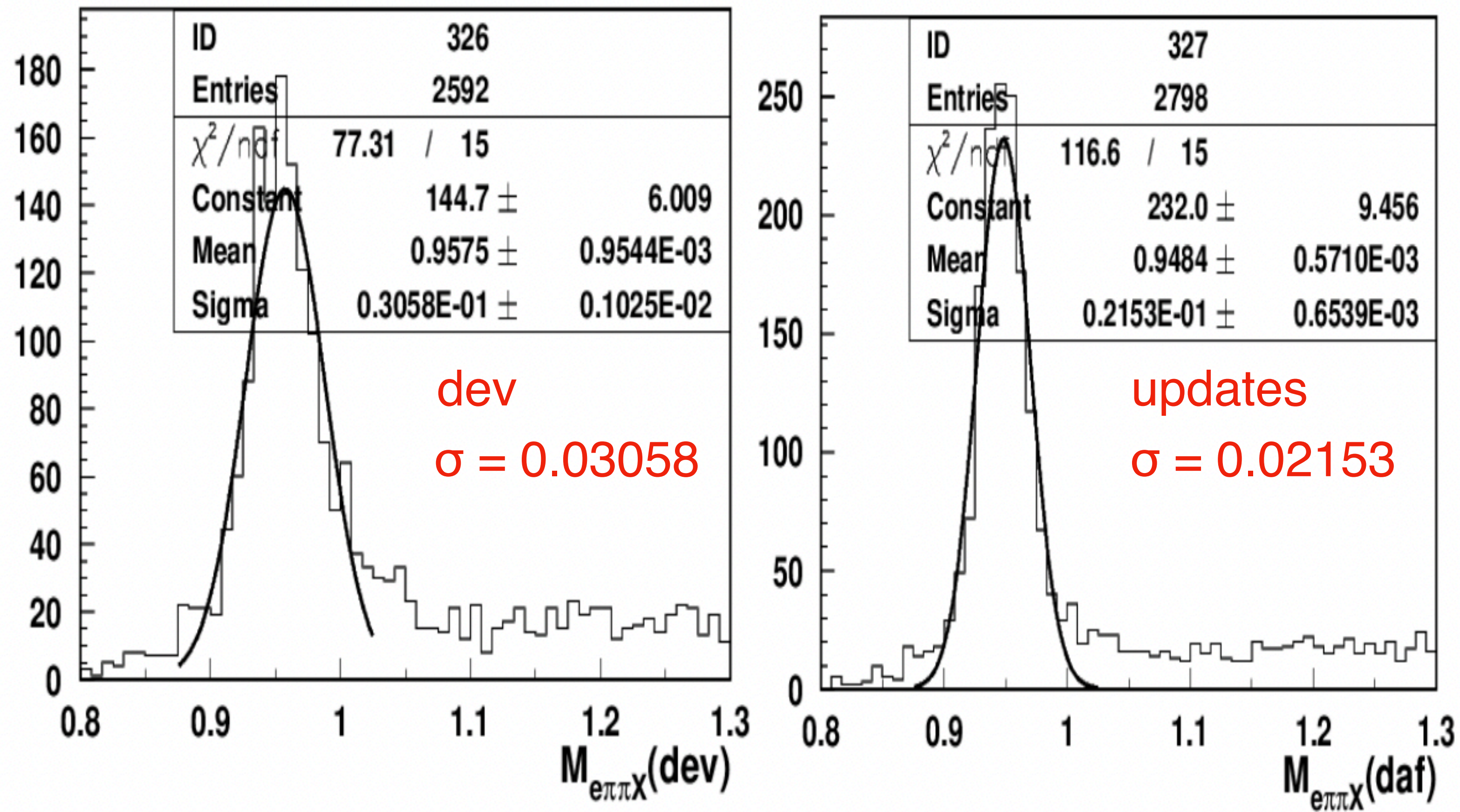
## Summary for Resolution

	3-FSP channels (MeV)			2-FSP channels(MeV)	
	$M_X(e\pi^+\pi^-)$	$M_X(ep\pi^+)$	$M_X(ep\pi^-)$	$M_X(e\pi^+)$	$M_X(ep)$
dev/No BG	18.6	19.2	16.8	21.2	35.5
updates/No BG	17.0	18.3	13.9	19.1	32.5
<b>Improvement</b>	<b>9.4%</b>	<b>4.9%</b>	<b>20.9%</b>	<b>11.0%</b>	<b>9.2%</b>
dev/BG	24.4	22.6	19.3	25.0	38.1
updates/BG	17.7	18.8	14.7	20.7	34.6
<b>Improvement</b>	<b>37.9%</b>	<b>20.2%</b>	<b>31.3%</b>	<b>20.8%</b>	<b>10.1%</b>



# RGA-SIDIS MC Validation by Harut

## Resolution for $M_x(e\pi^+\pi^-)$

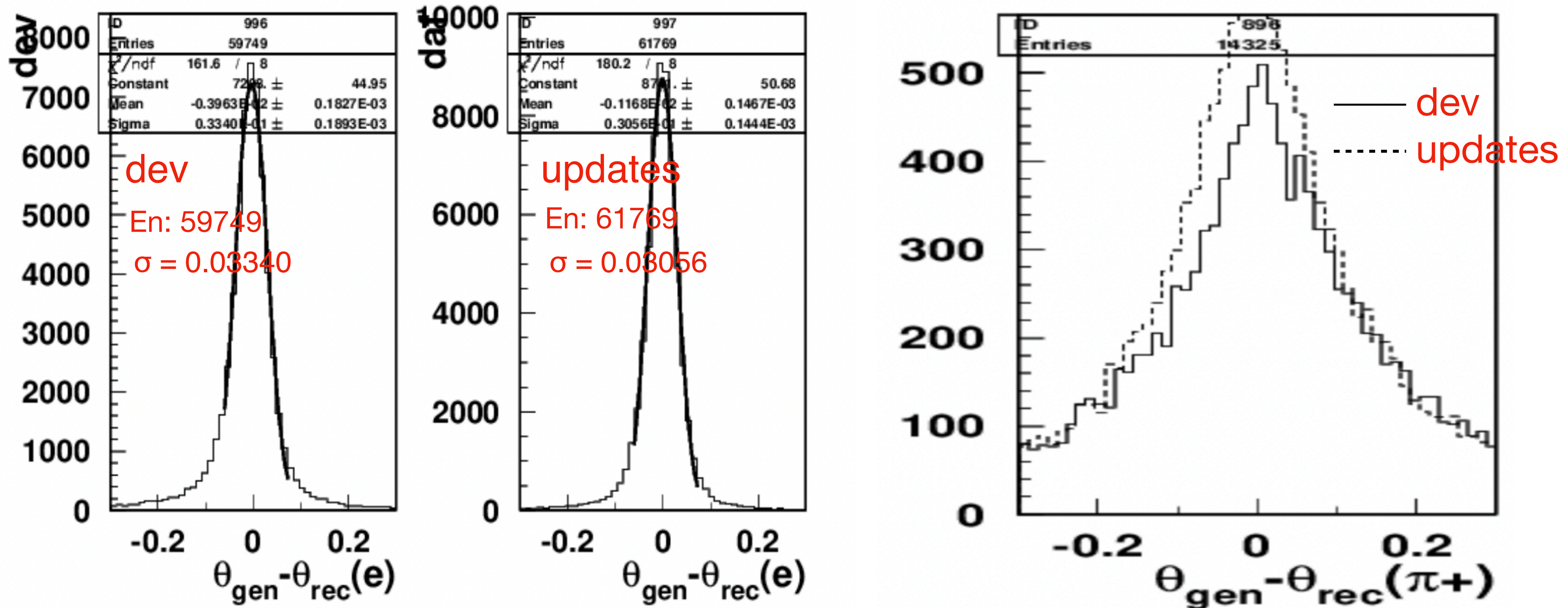


Resolution better ~42%



# RGA-SIDIS MC Validation by Harut

## Angle Resolution and Reconstruction Efficiency for $e\pi^+$ Channel

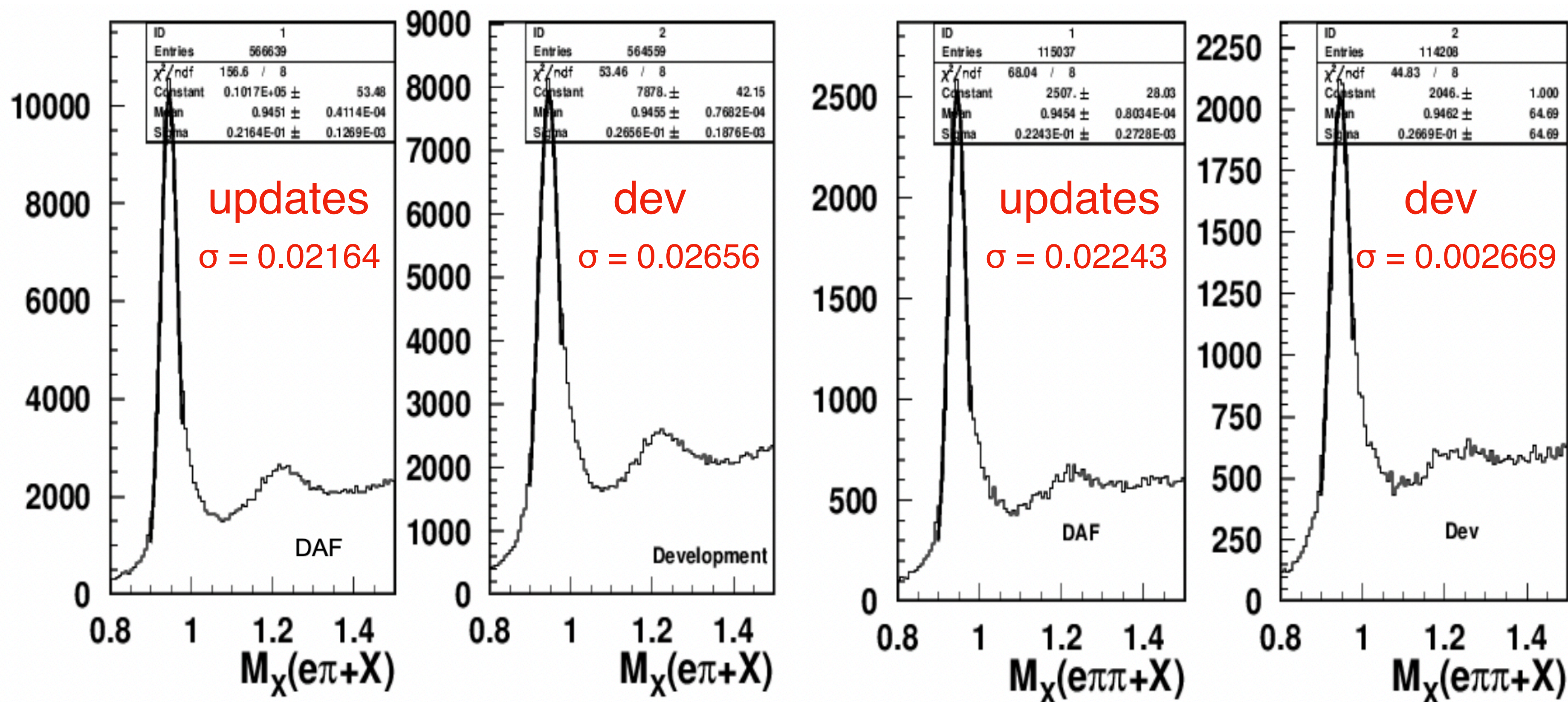


- Resolution better  $\sim 10\%$
- Reconstruction efficiency better  $\sim 3.4\%$

More  $e\pi^+$  events with better resolution



# RGK Validation by Harut



Resolution better ~23%

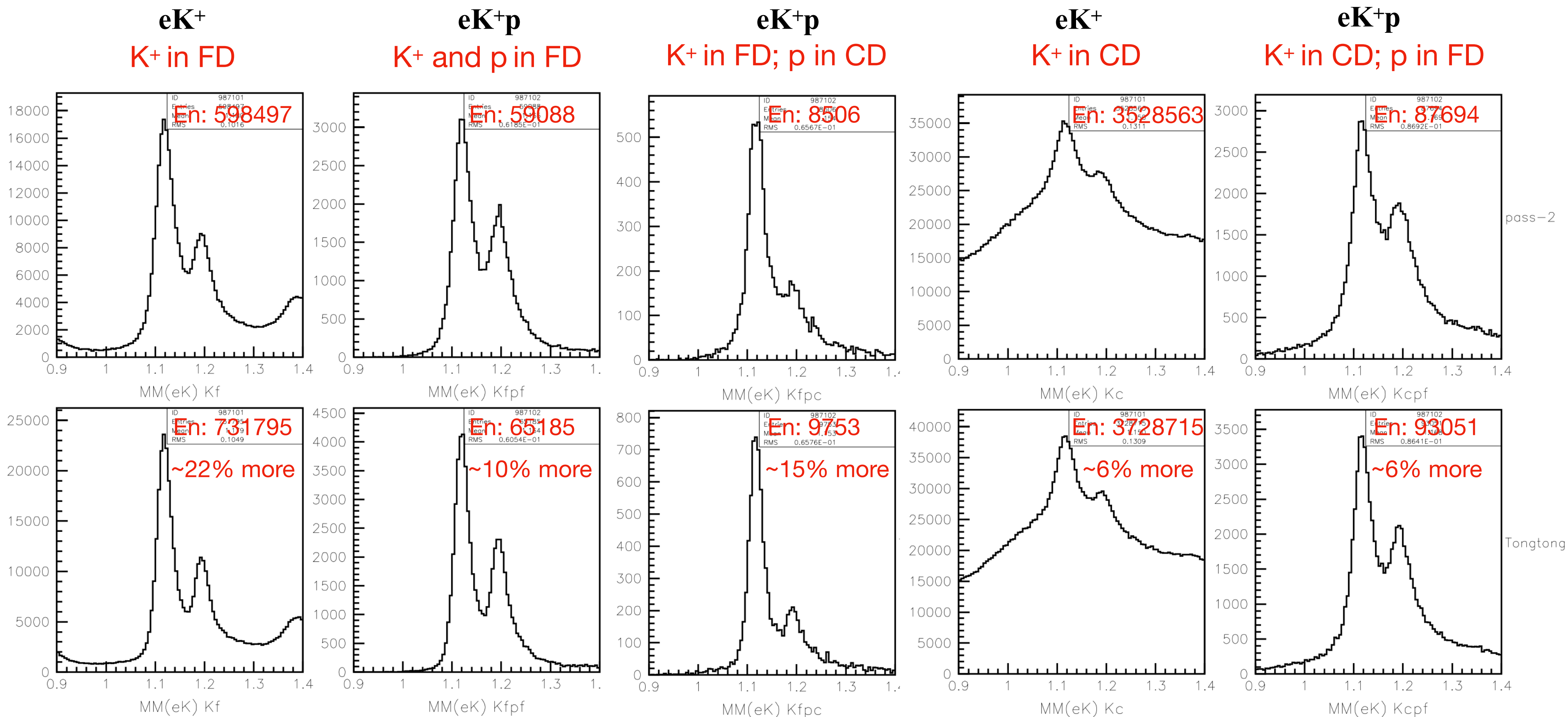
Resolution better ~12%

# RGK Validation by Daniel

## MM(eK<sup>+</sup>)

pass2

updates

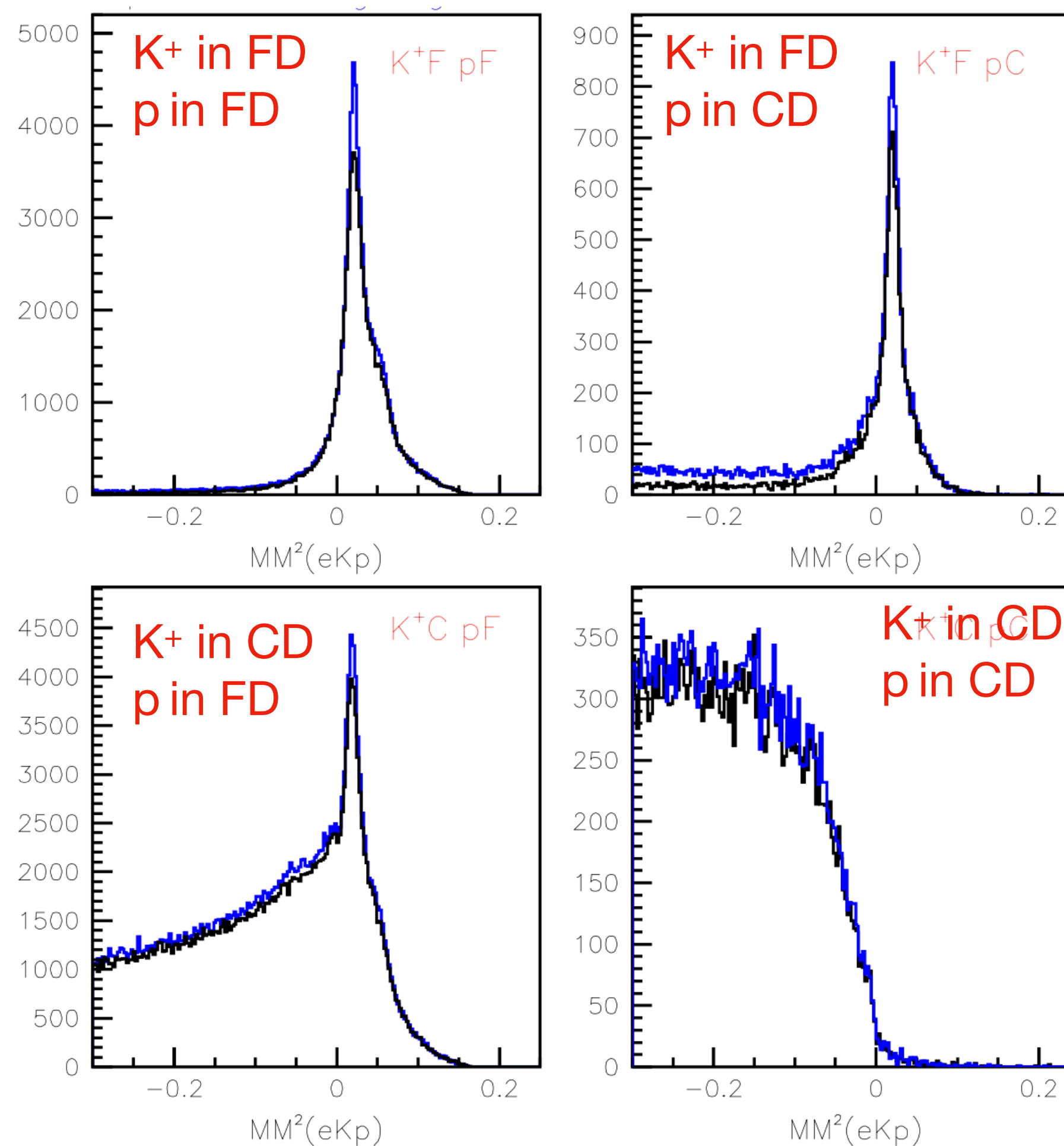


Better for both resolution and reconstruction efficiency



# RGK Validation by Daniel

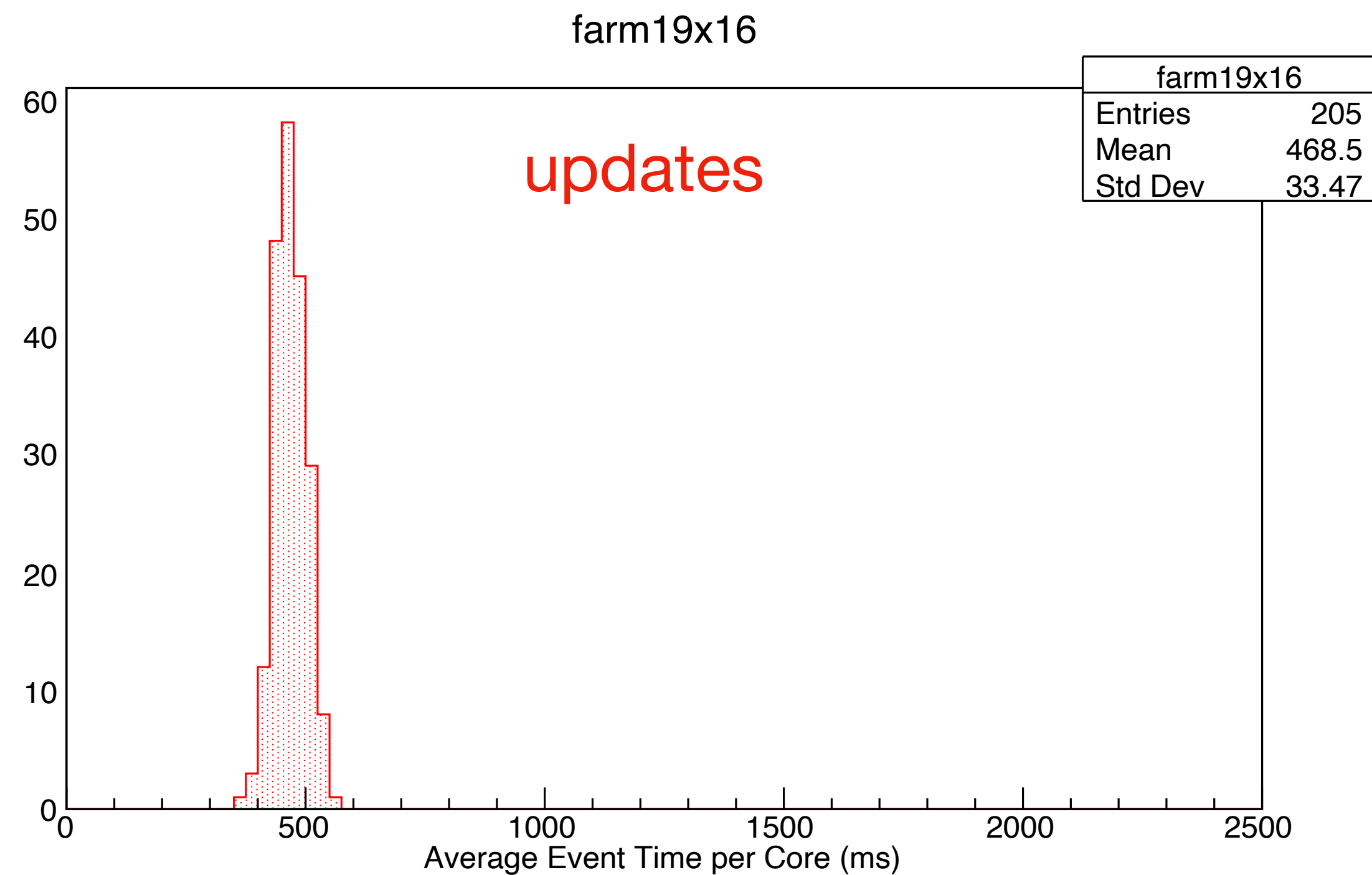
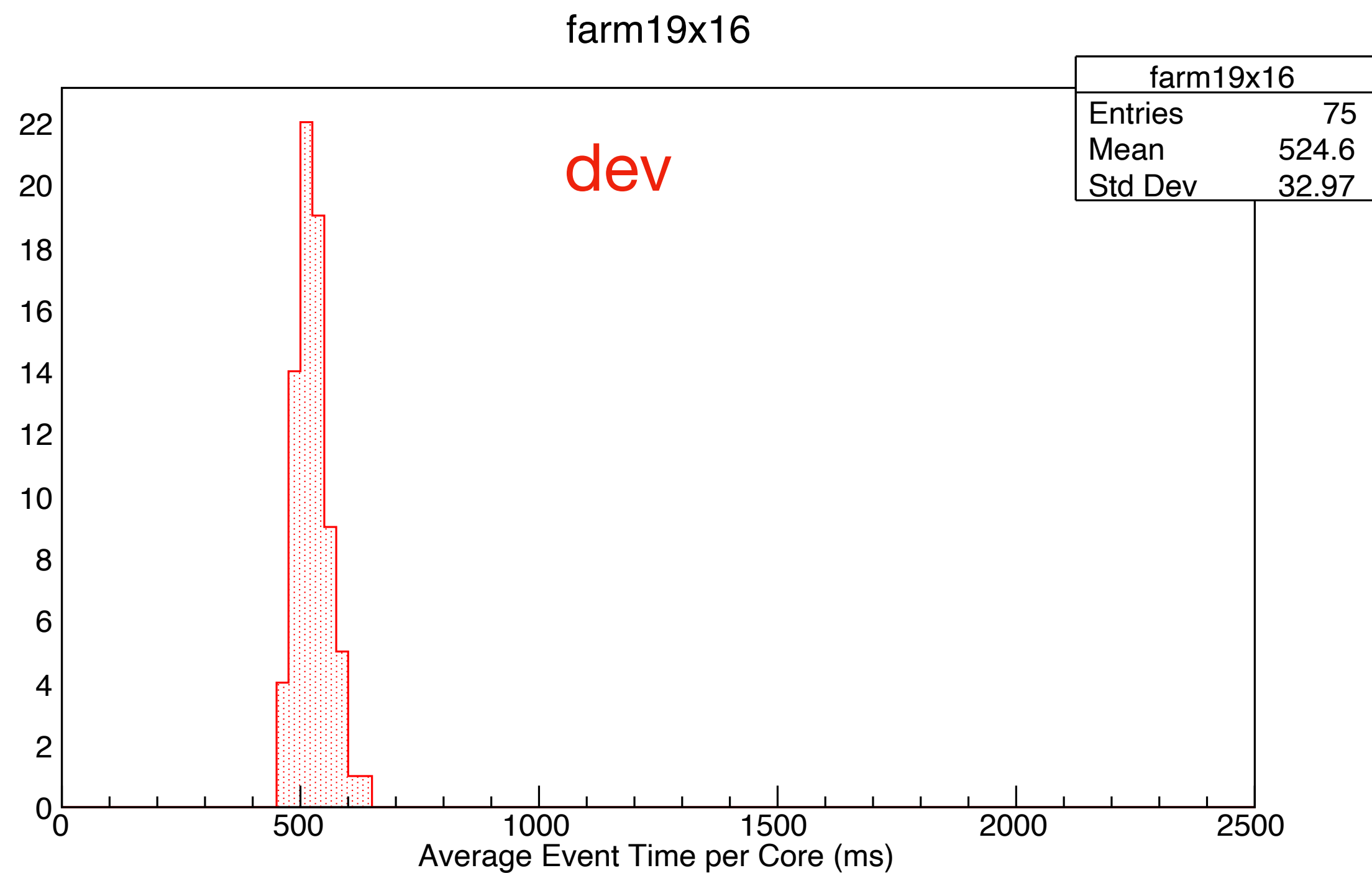
## MM(eK<sup>+</sup>p)



- pass2
- updates

Better for both resolution and reconstruction efficiency

# CPU Efficiency



CPU efficiency ~12% better

# Summary and Next

- With FD tracking software updates, tracking & reconstruction efficiency, resolution and CPU efficiency are comprehensively improved.
- DAF parameters will be tuned to optimize tracking quality after some calibrations are done, such as update of time-to-doca table, update of DC-hit-error function, etc.
- Thank Raffaella, Harut and Daniel for efforts on validations, and thank the software group for supports.
- It will be appreciated that anyone contributes on more validations.

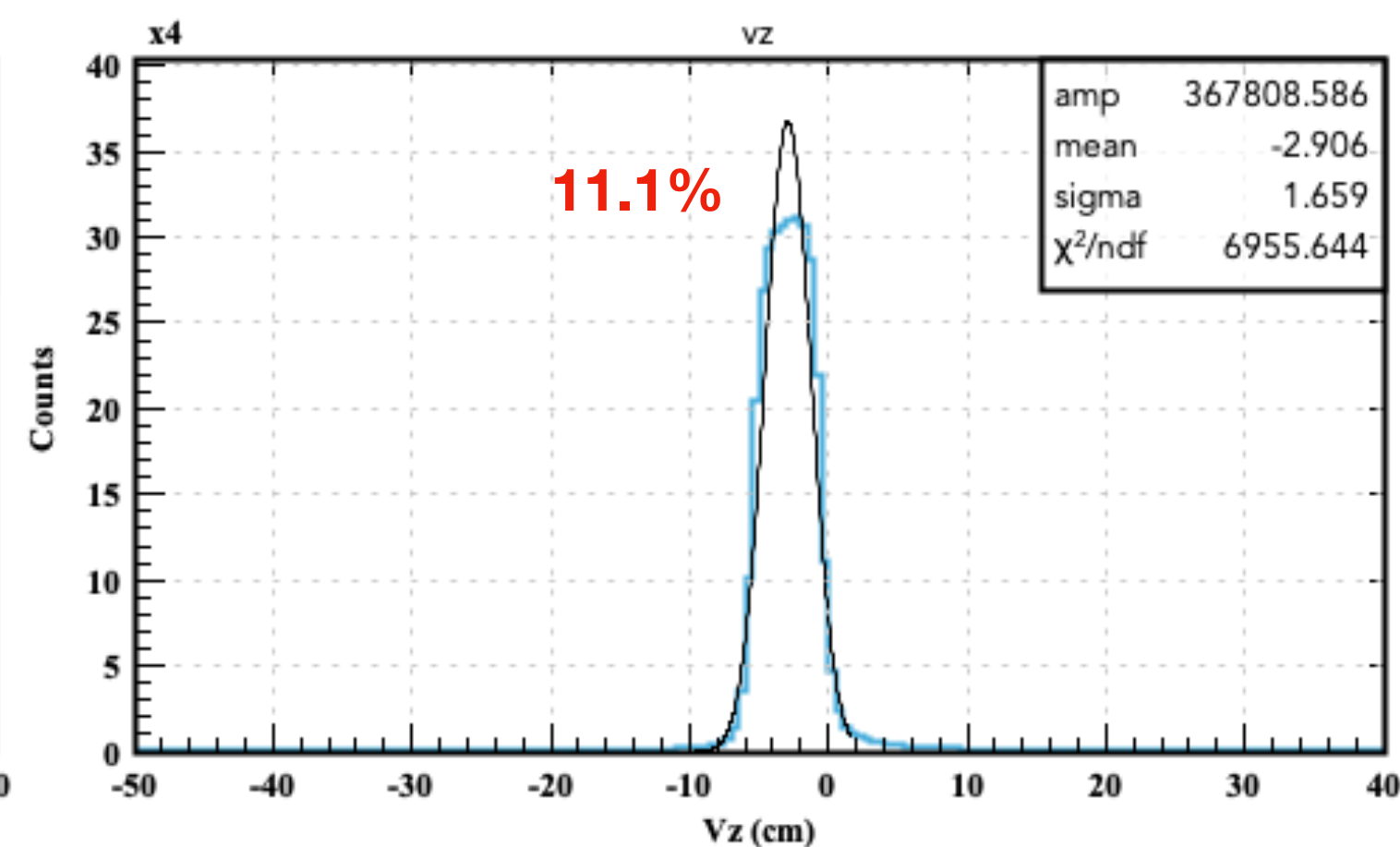
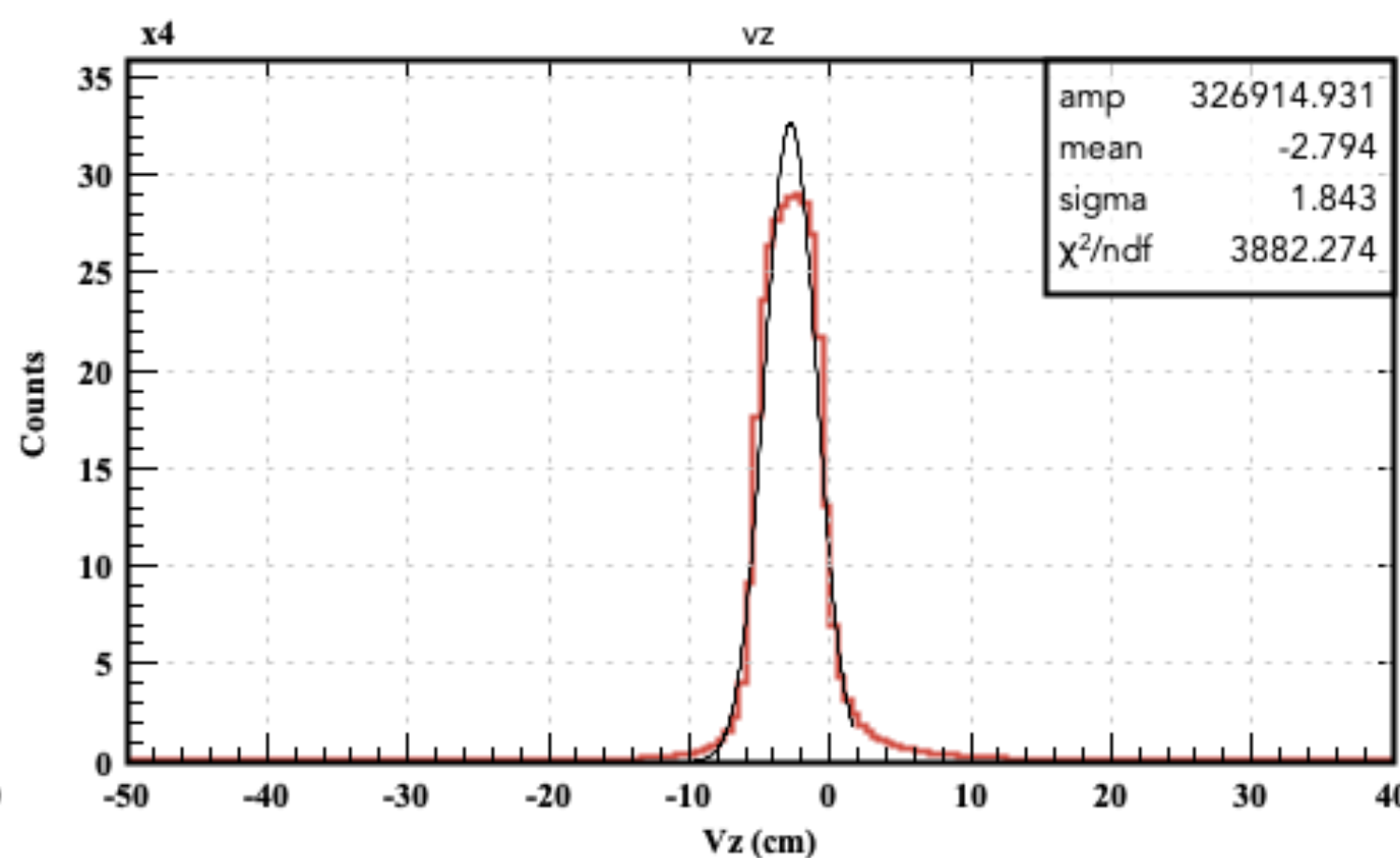
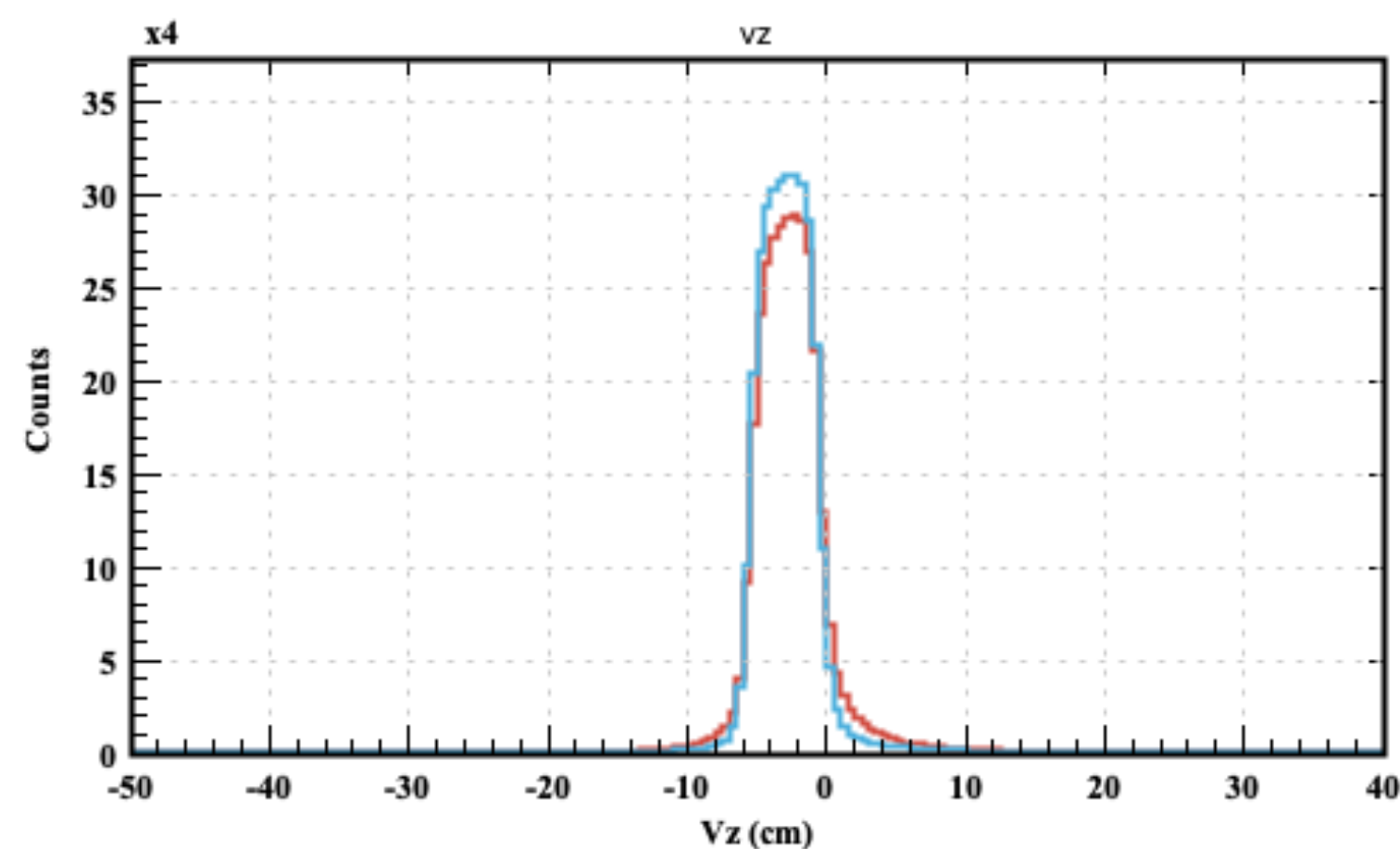


# Backup Slides

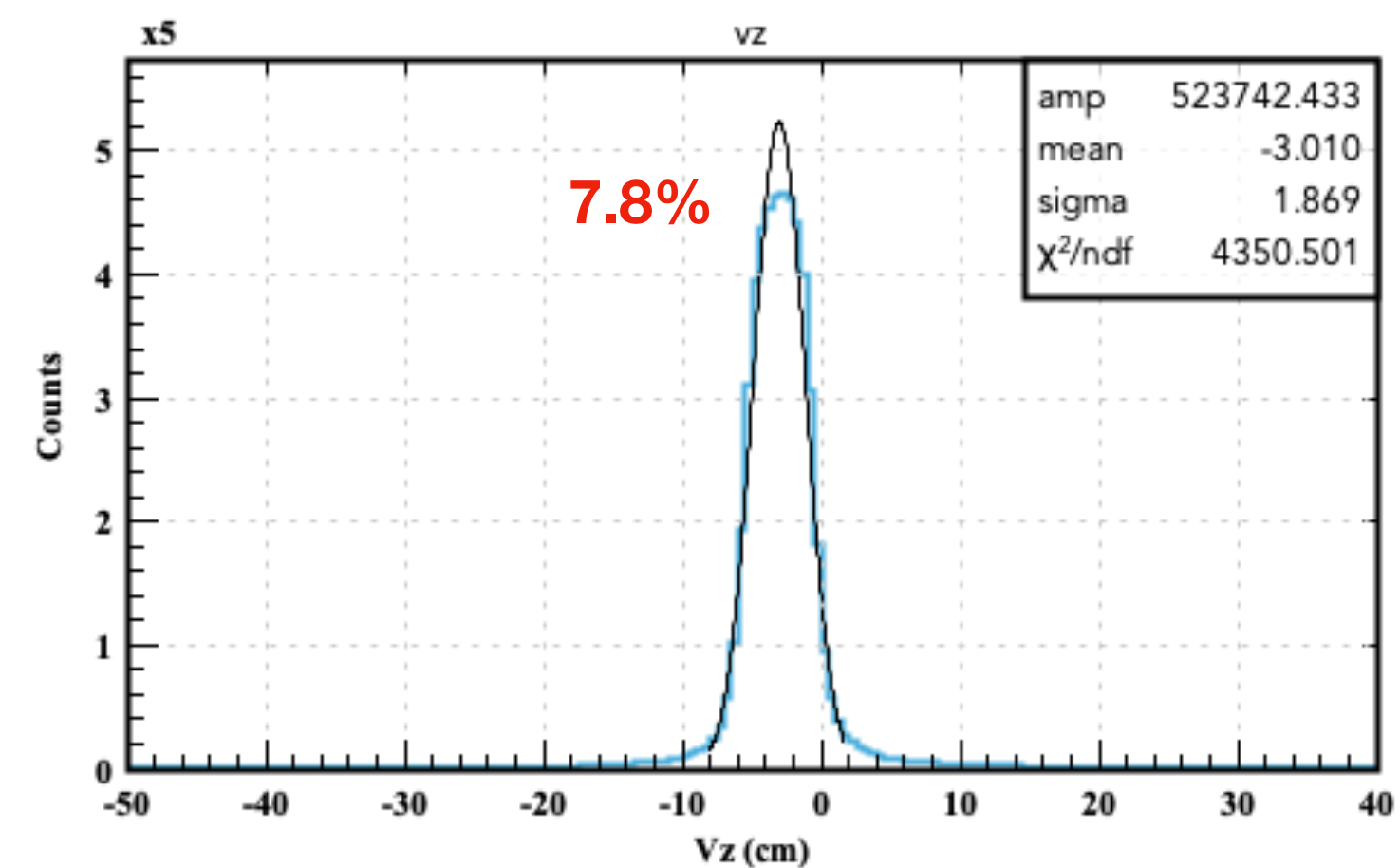
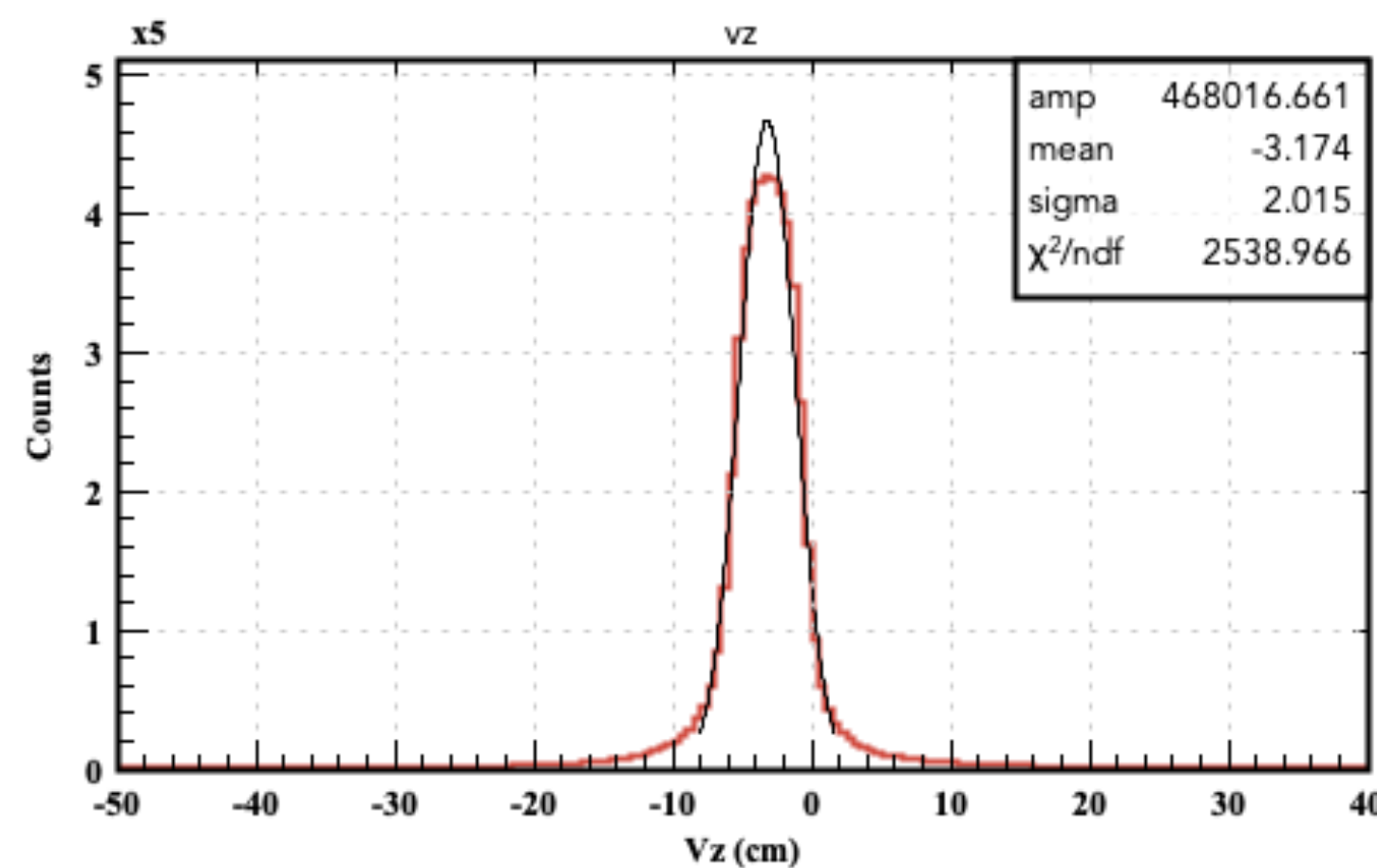
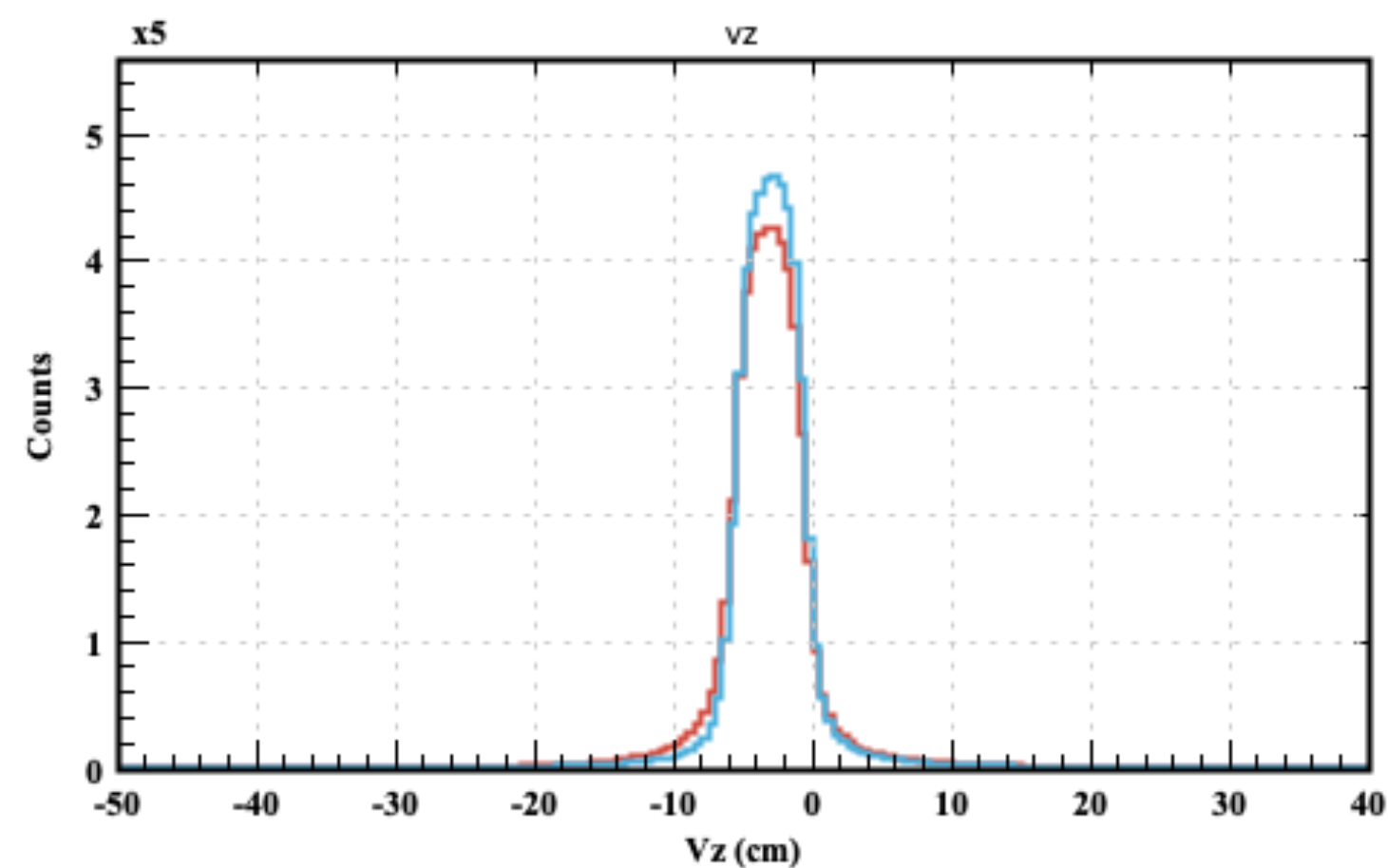
# Resolution: Vertex Z

- Red: ai/dev  
- Blue: ai/updates

Neg. Tracks



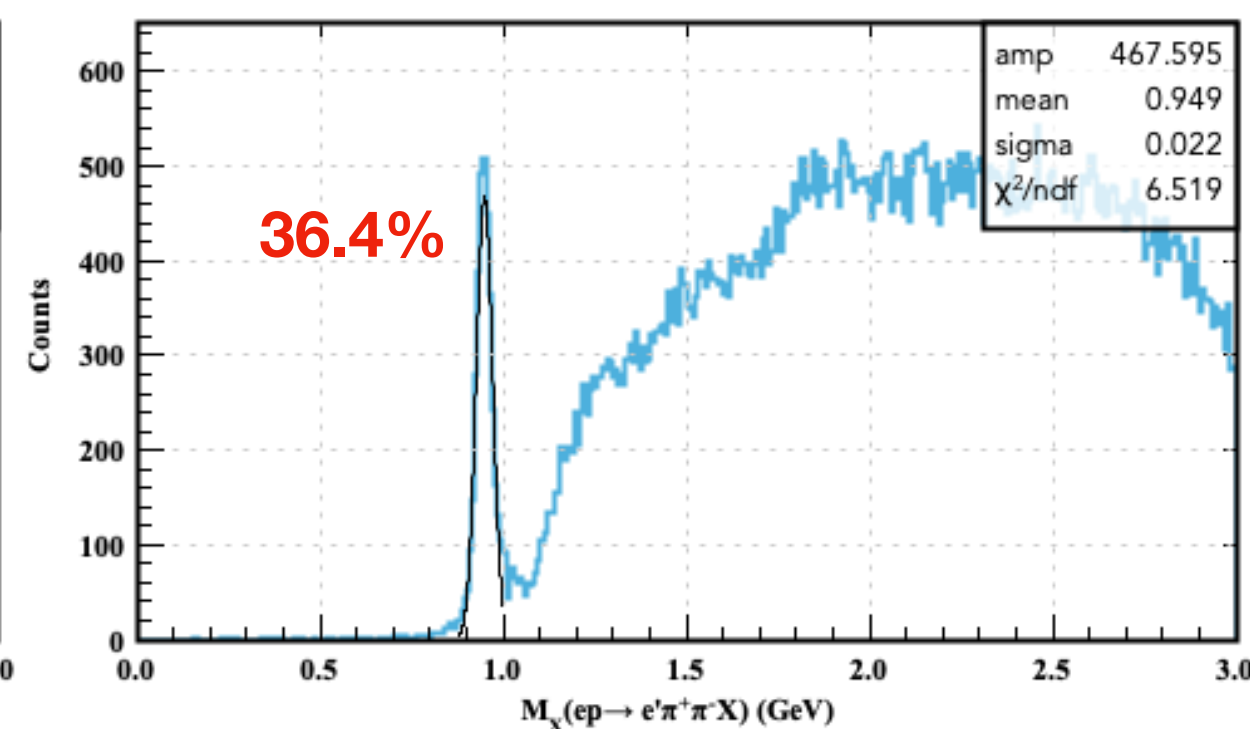
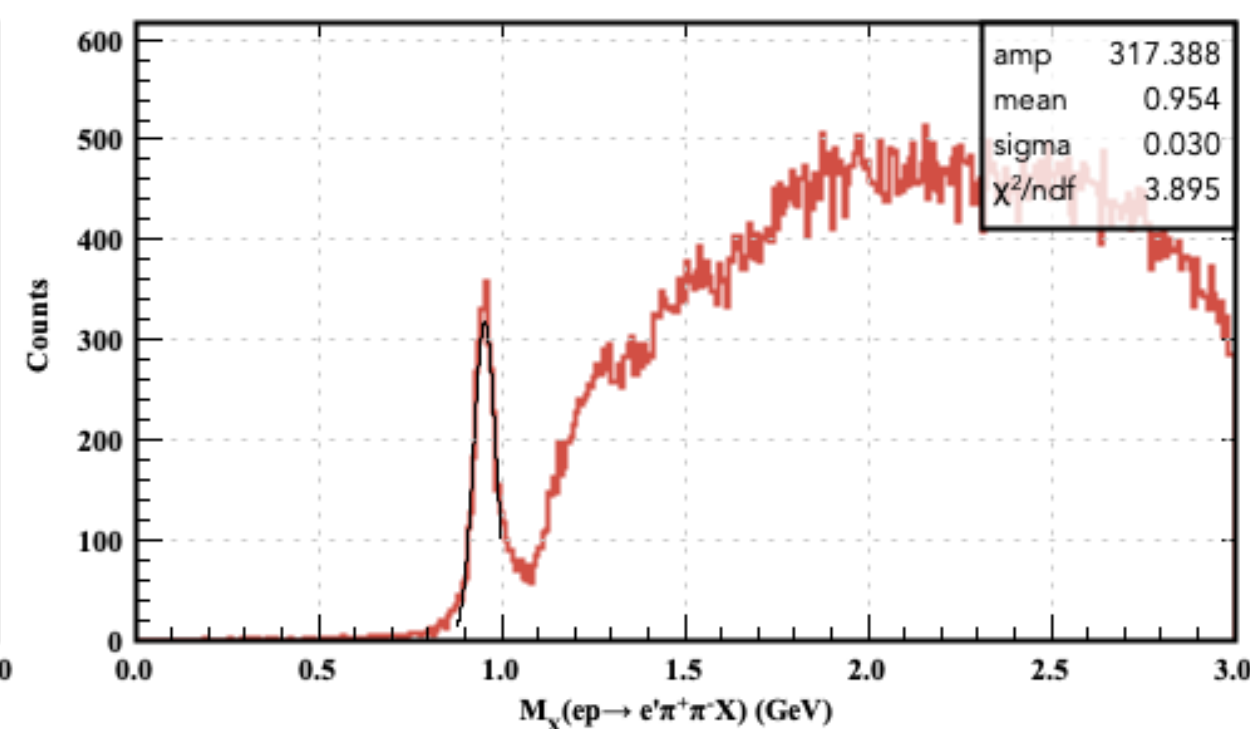
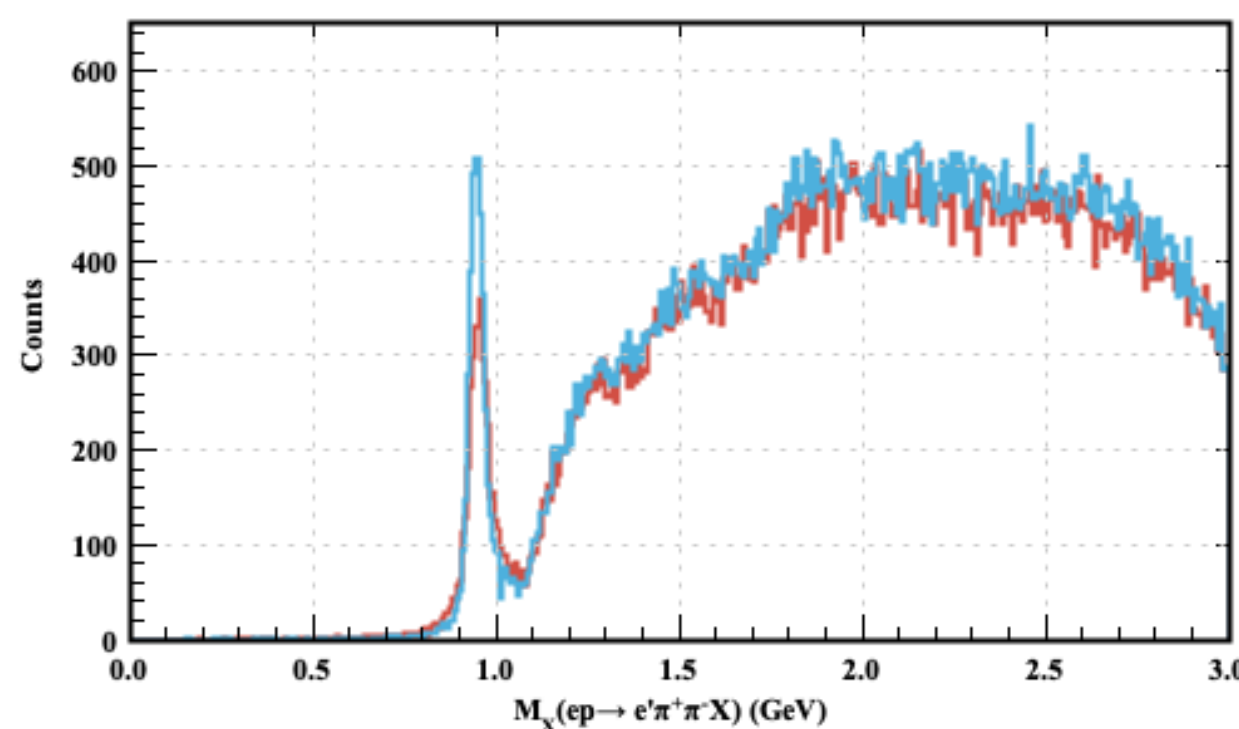
Pos. Tracks



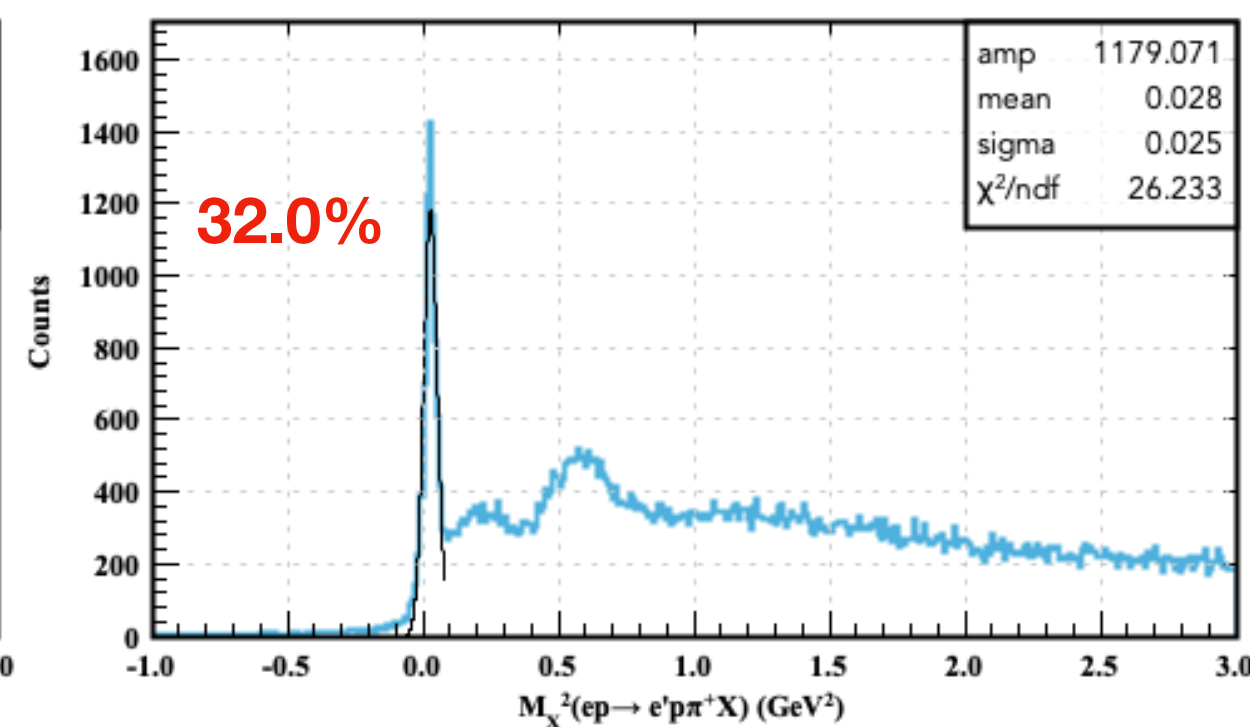
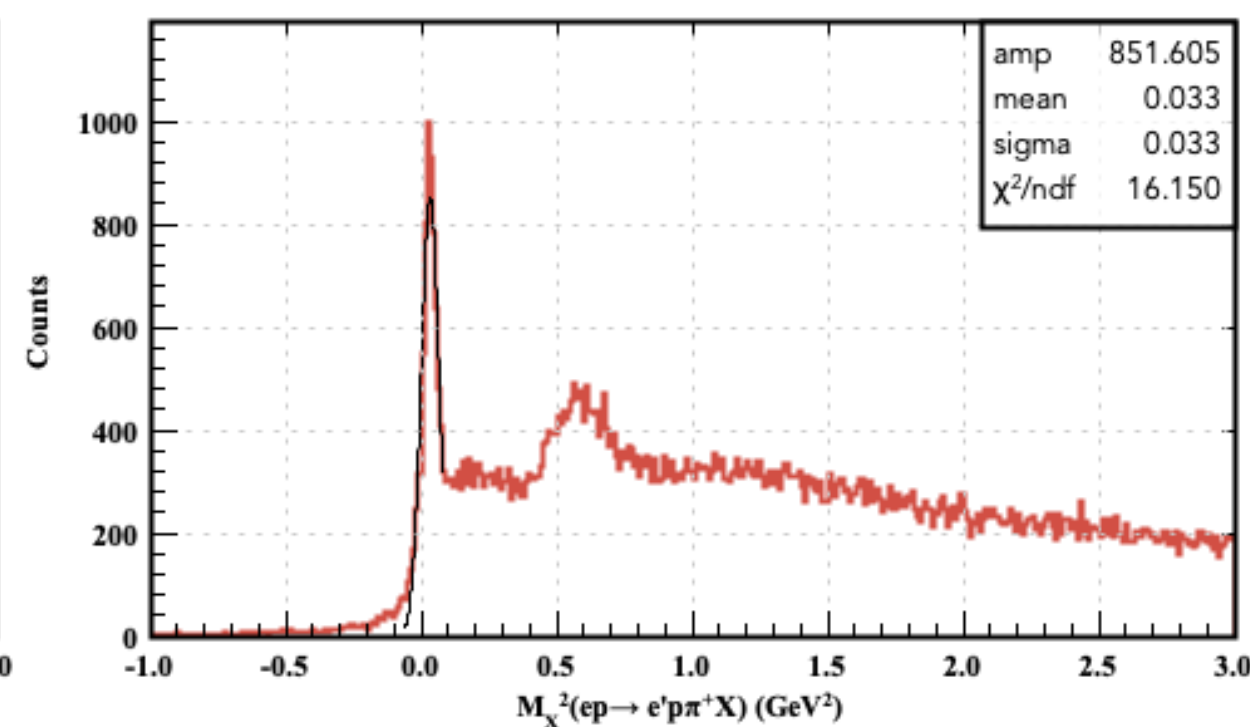
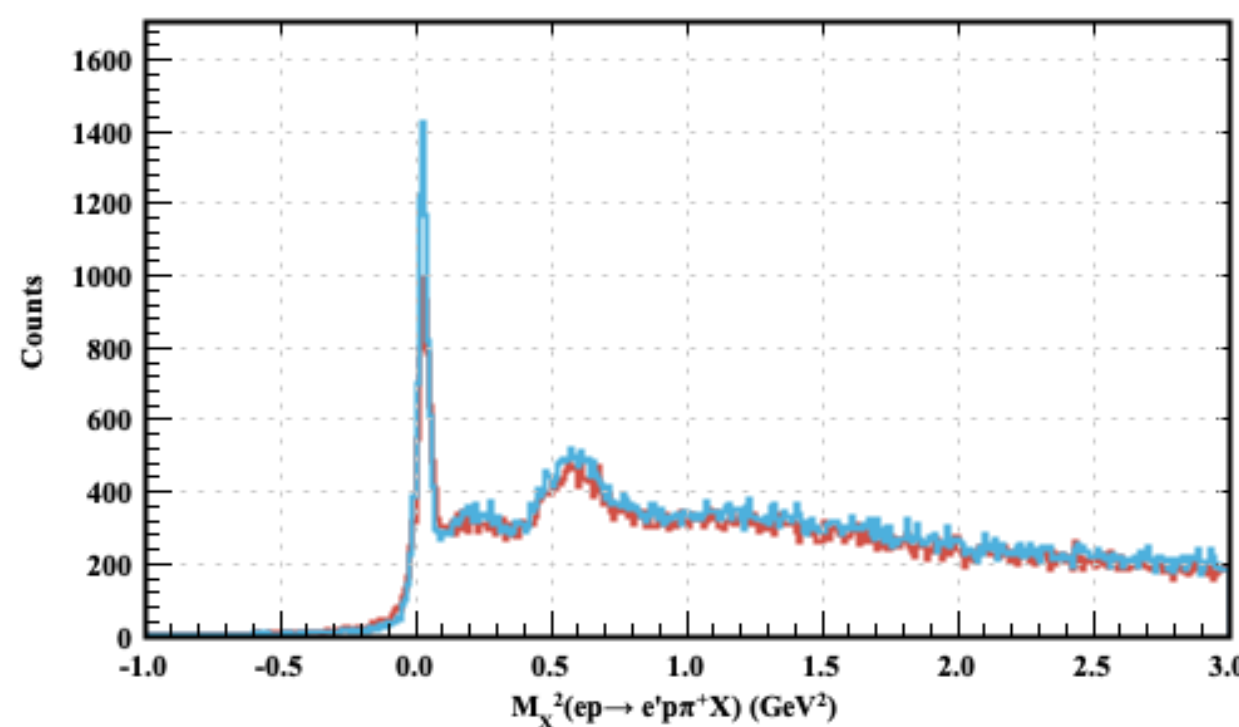
# Resolution: MM for 3-FSP Channels

- Red: ai/dev  
- Blue: ai/updates

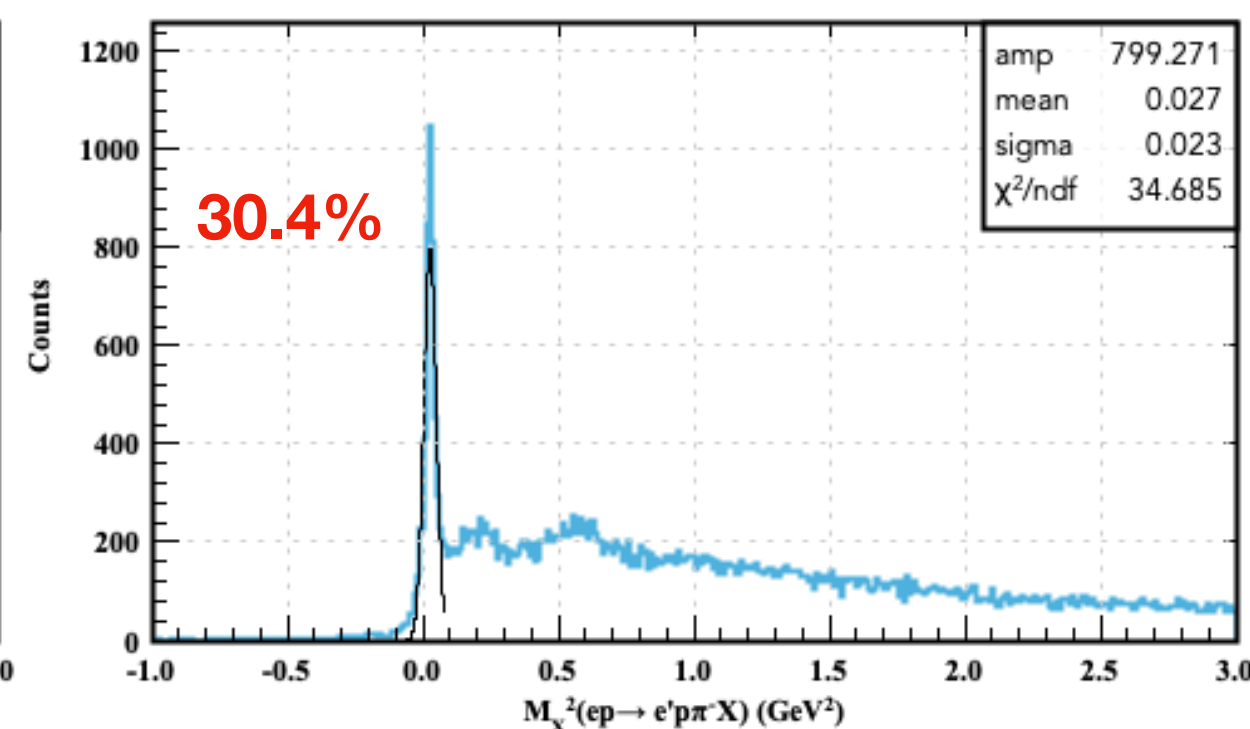
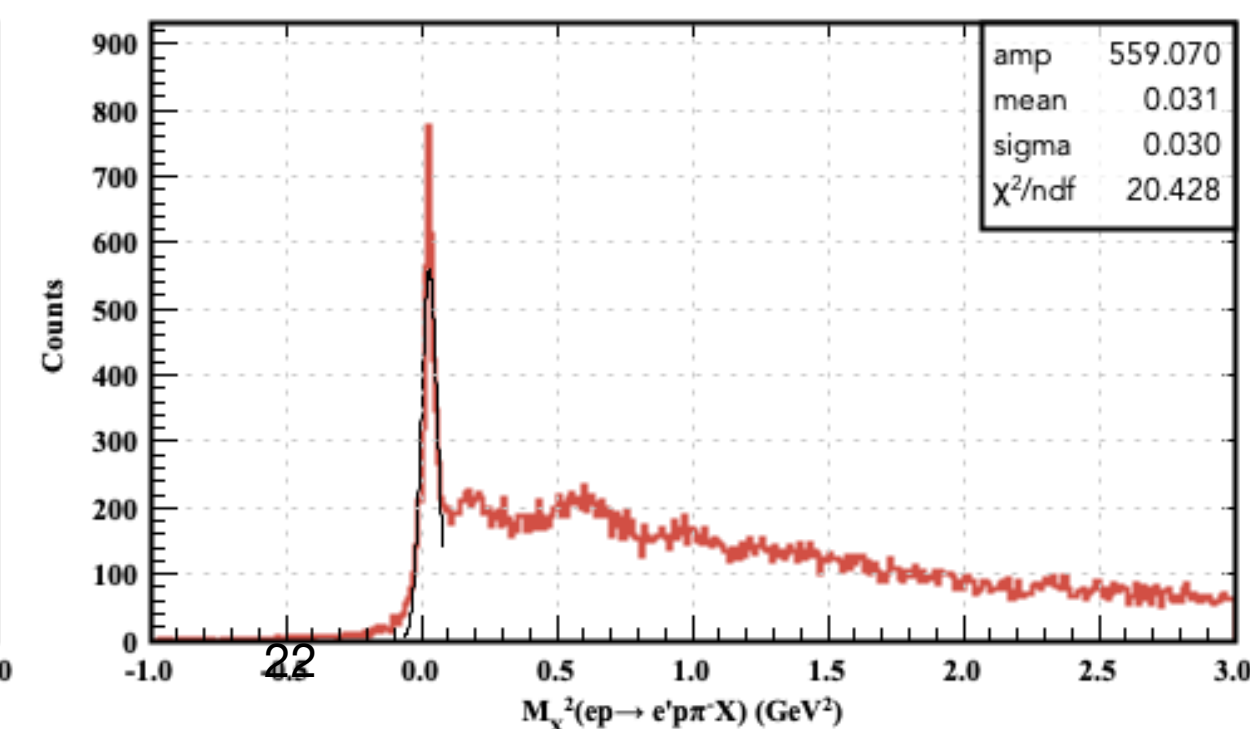
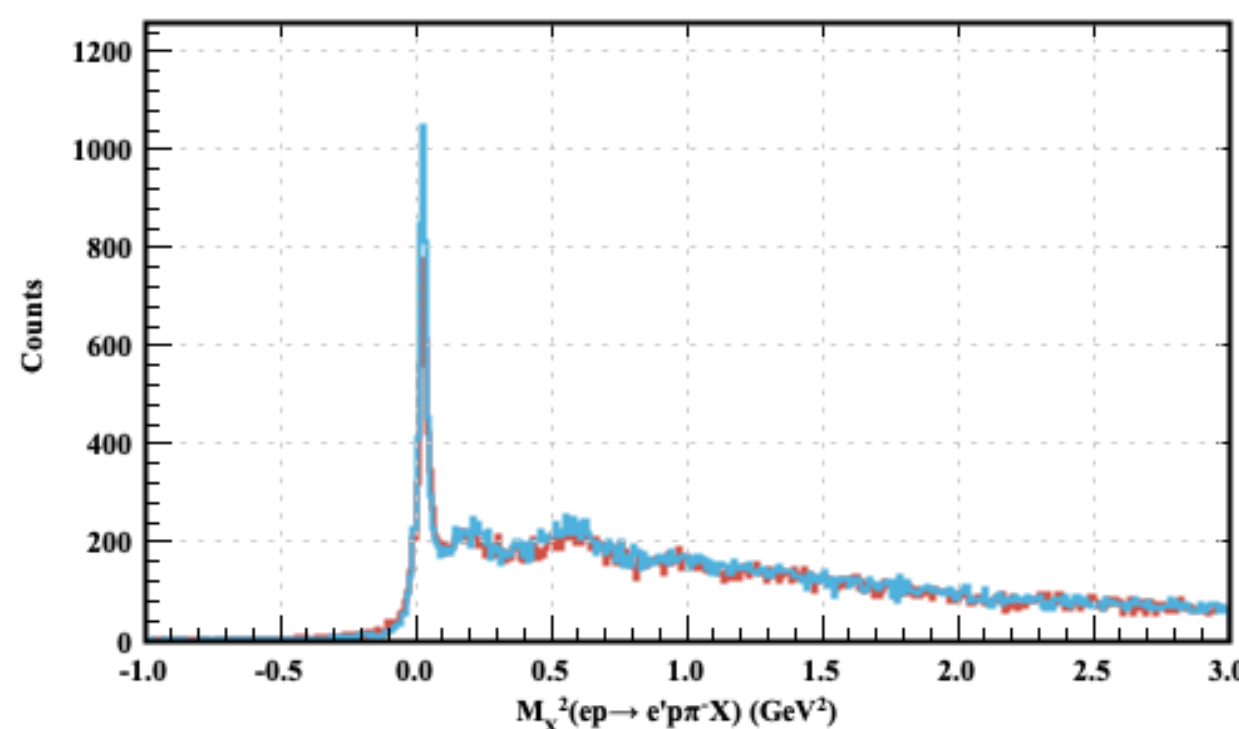
$$ep \rightarrow e' \pi^+ \pi^- X$$



$$ep \rightarrow e' p \pi^+ X$$



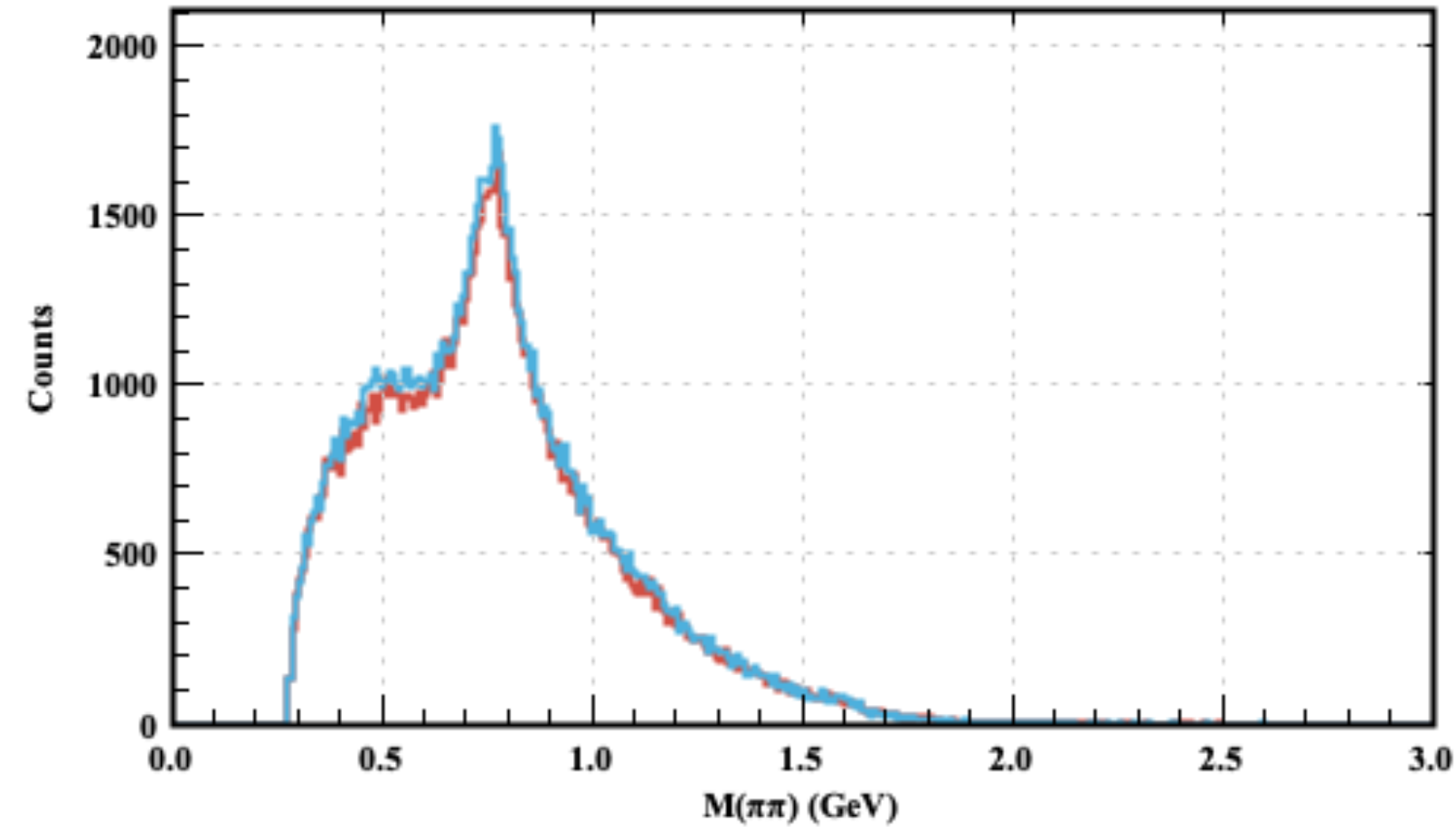
$$ep \rightarrow e' p \pi^- X$$



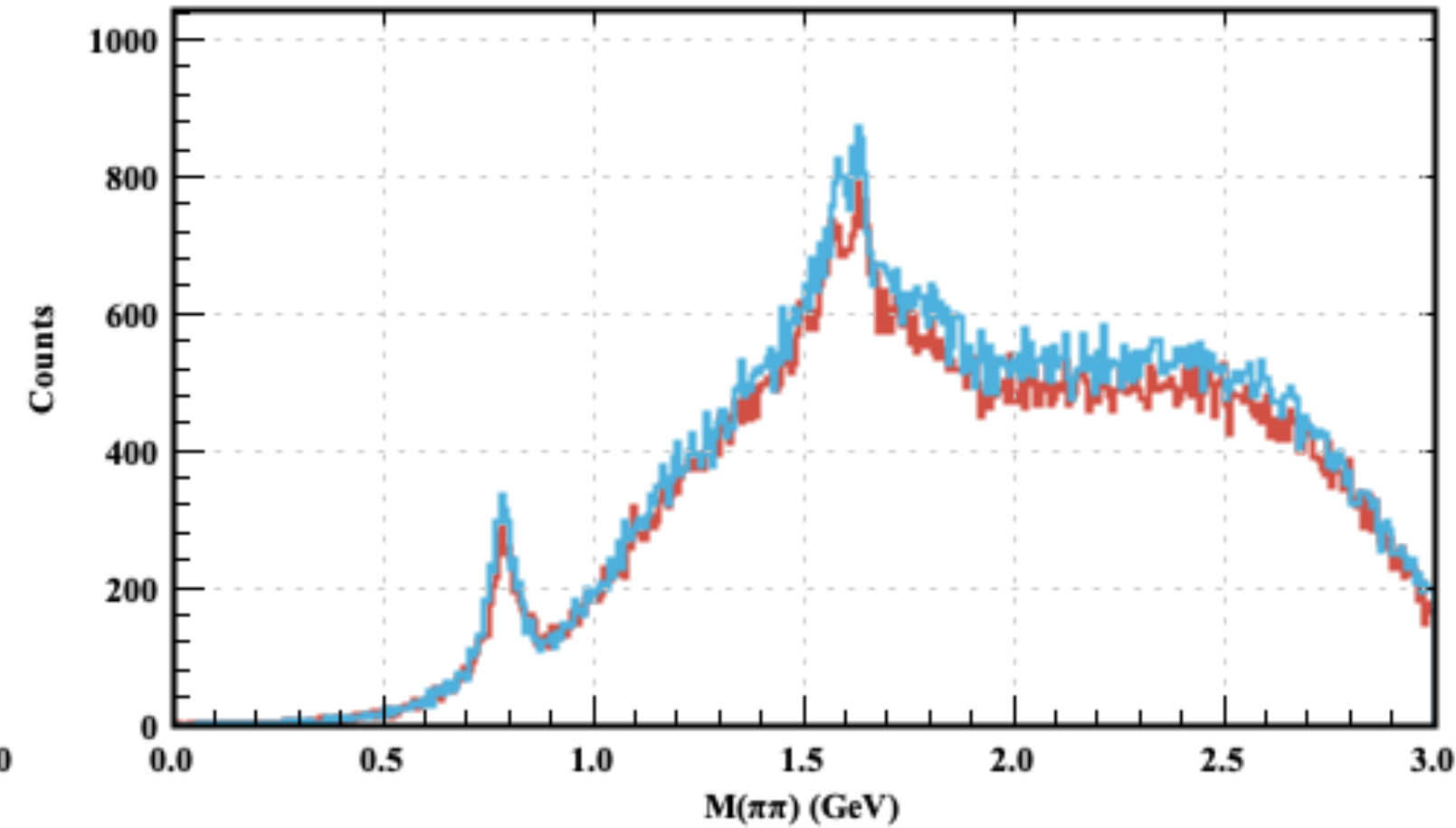
# Resolution: $M(\pi^+\pi^-)$ for 3-FSP Channels

- Red: ai/dev  
- Blue: ai/updates

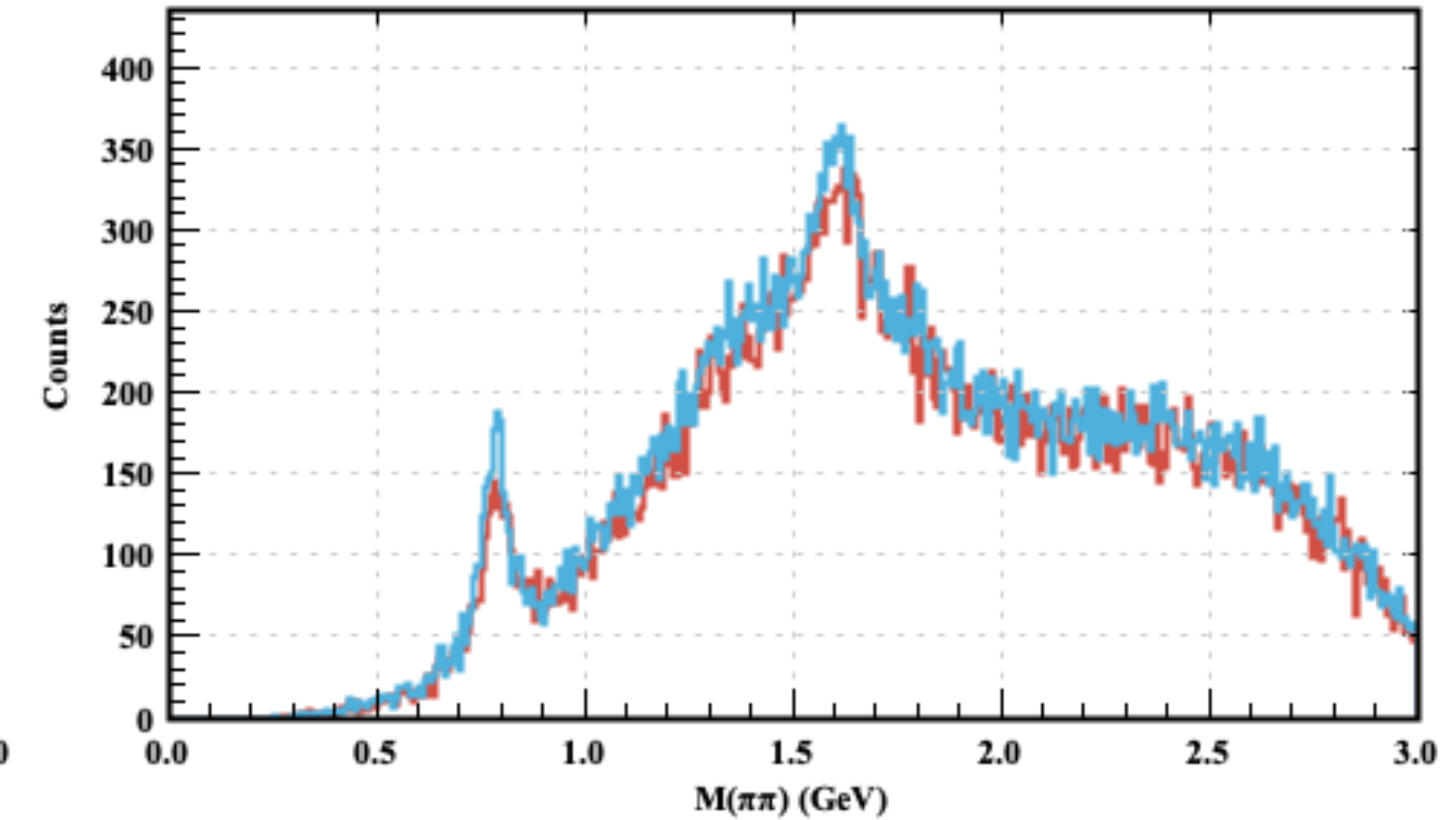
$$ep \rightarrow e'\pi^+\pi^- X$$



$$ep \rightarrow e'p\pi^+ X$$



$$ep \rightarrow e'p\pi^- X$$

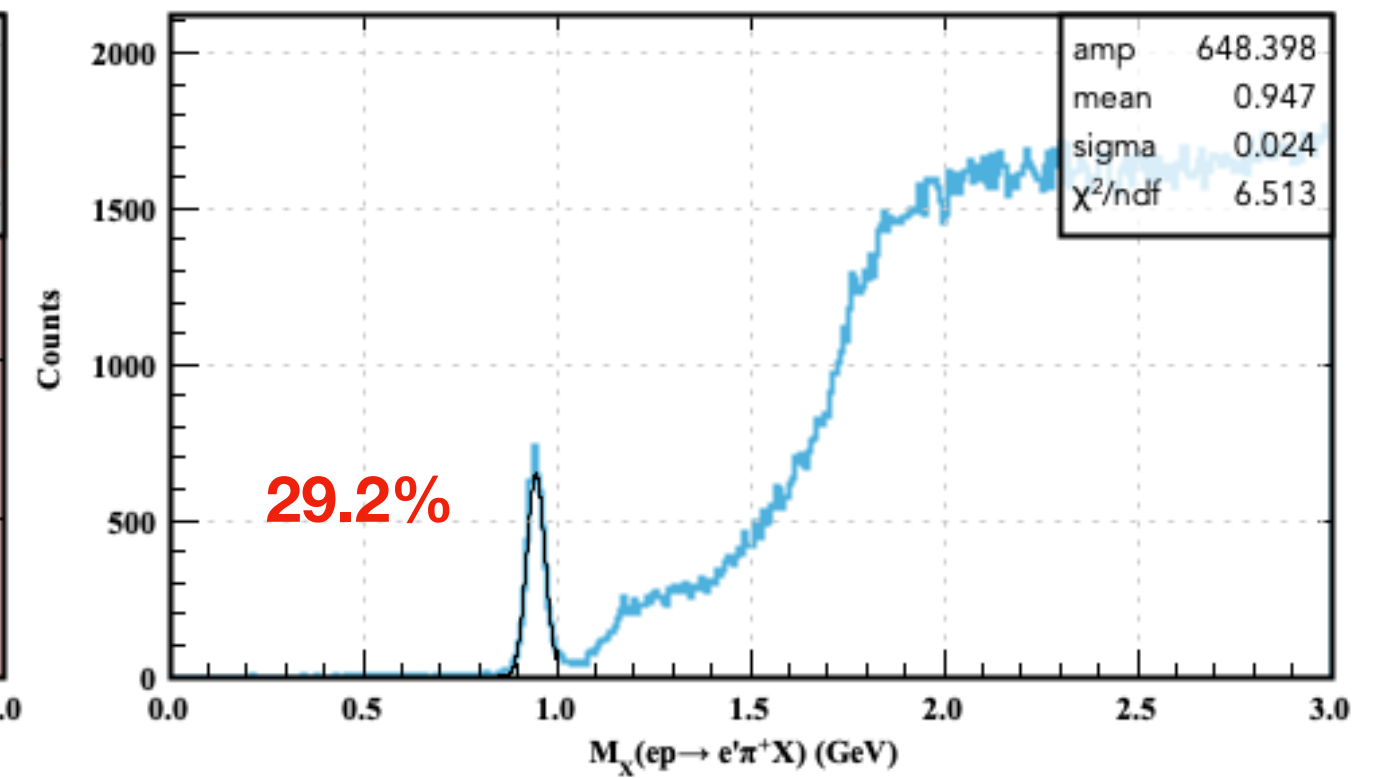
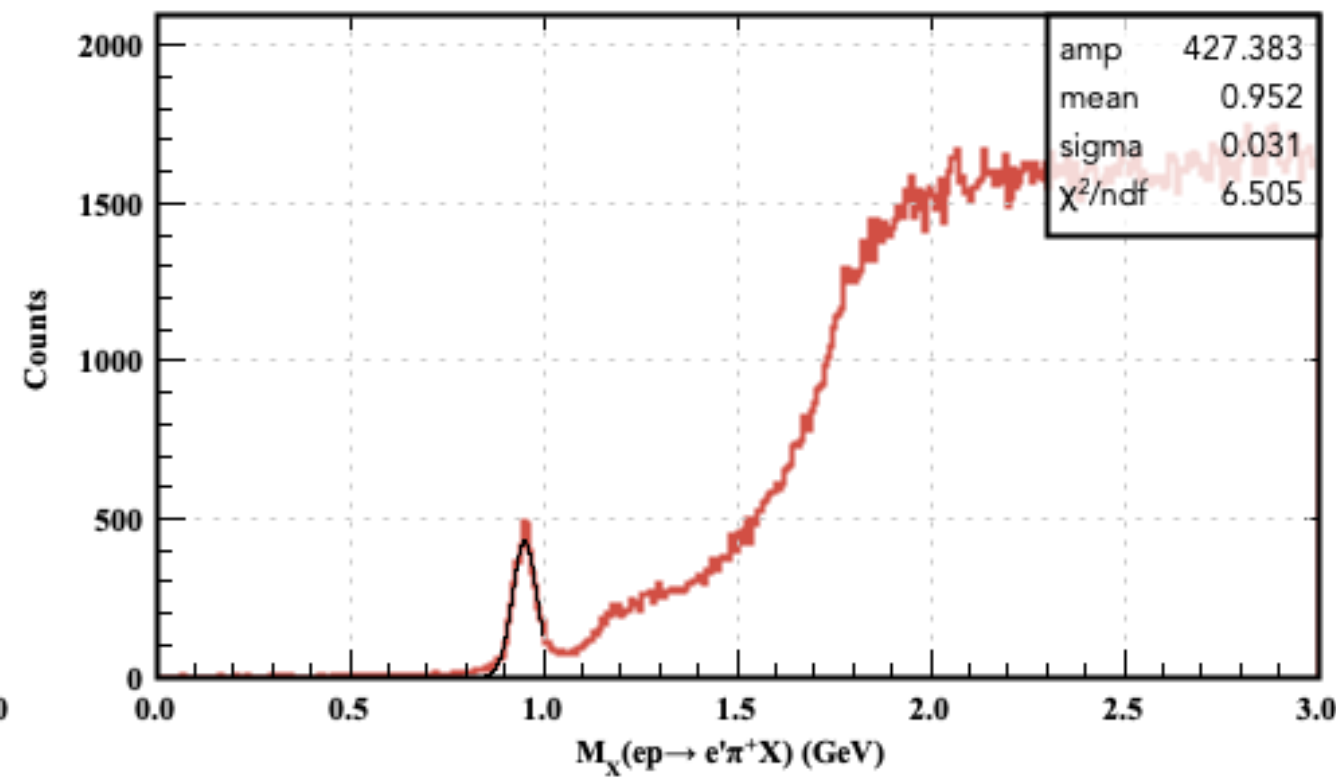
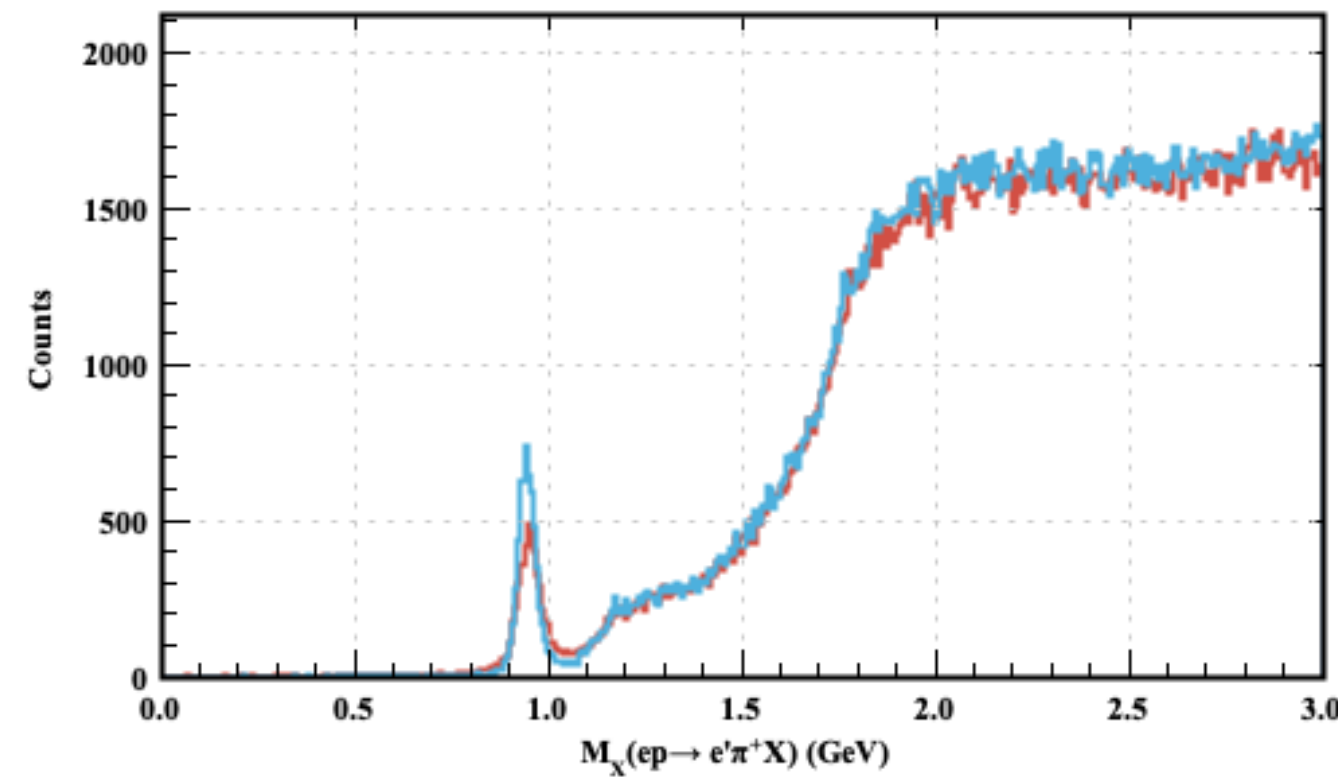




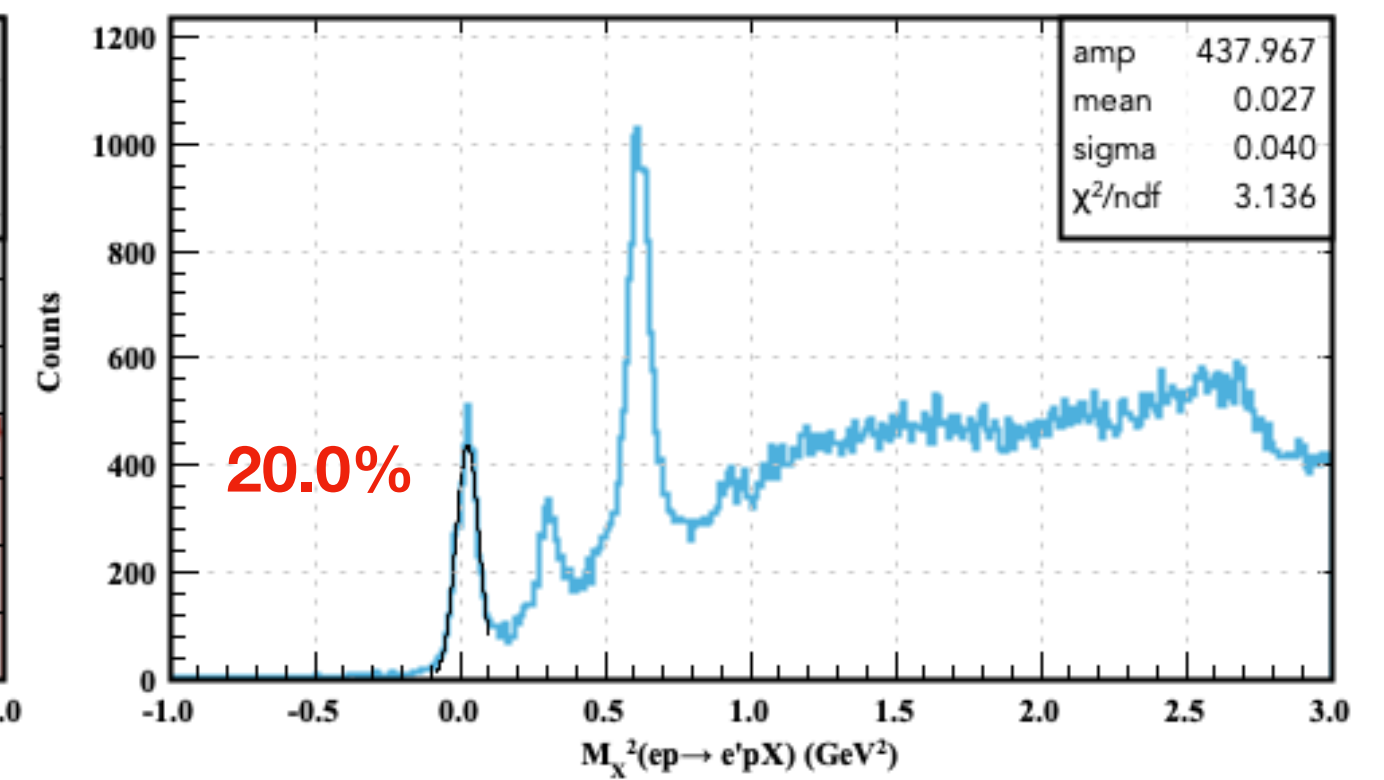
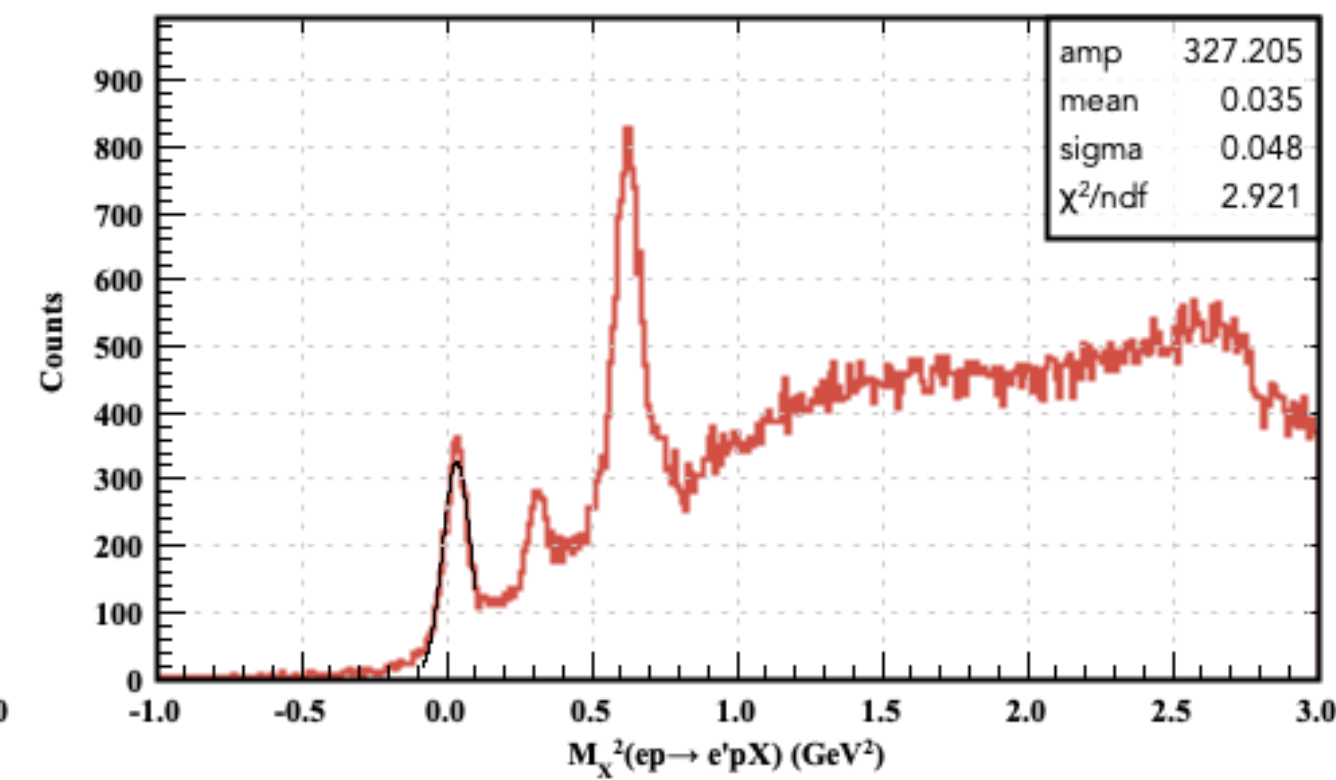
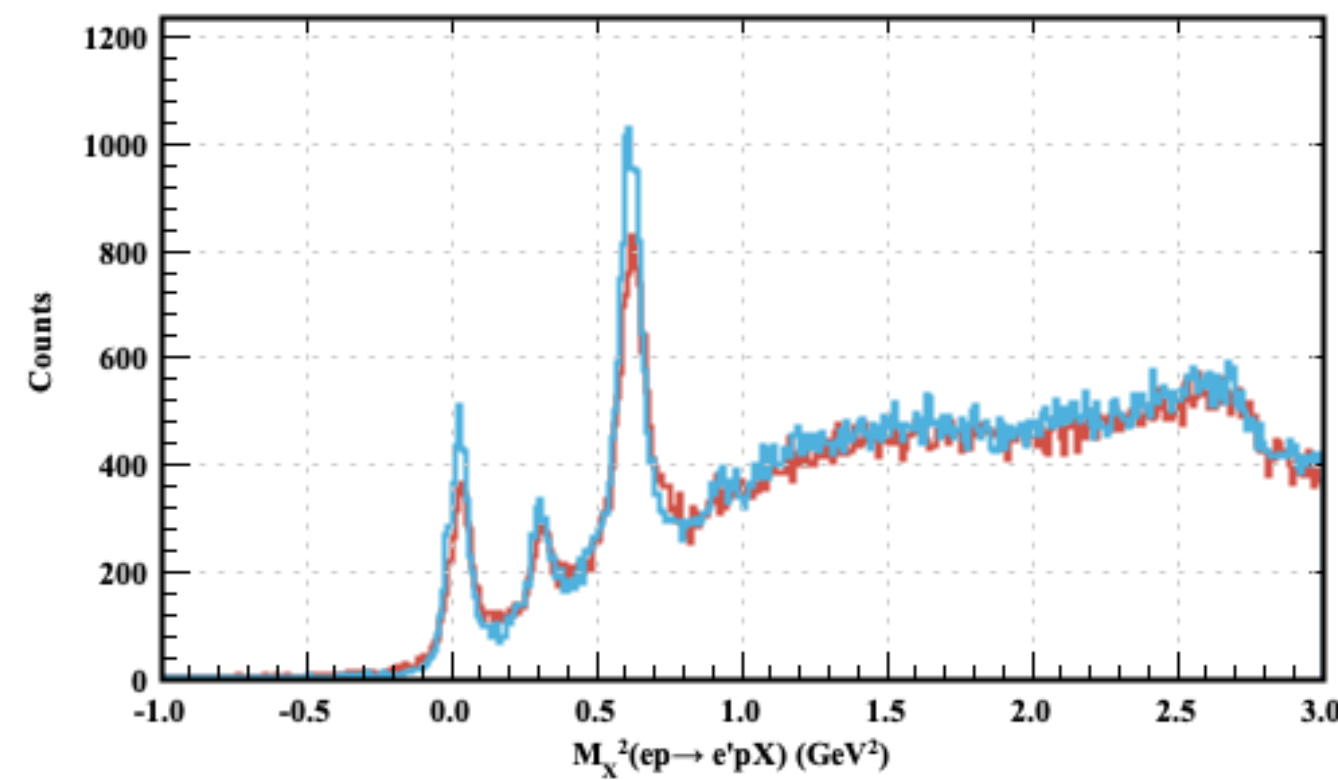
# Resolution: MM for 2-FSP Channels

- Red: ai/dev  
- Blue: ai/updates

$$ep \rightarrow e' \pi^+ X$$



$$ep \rightarrow e' p X$$

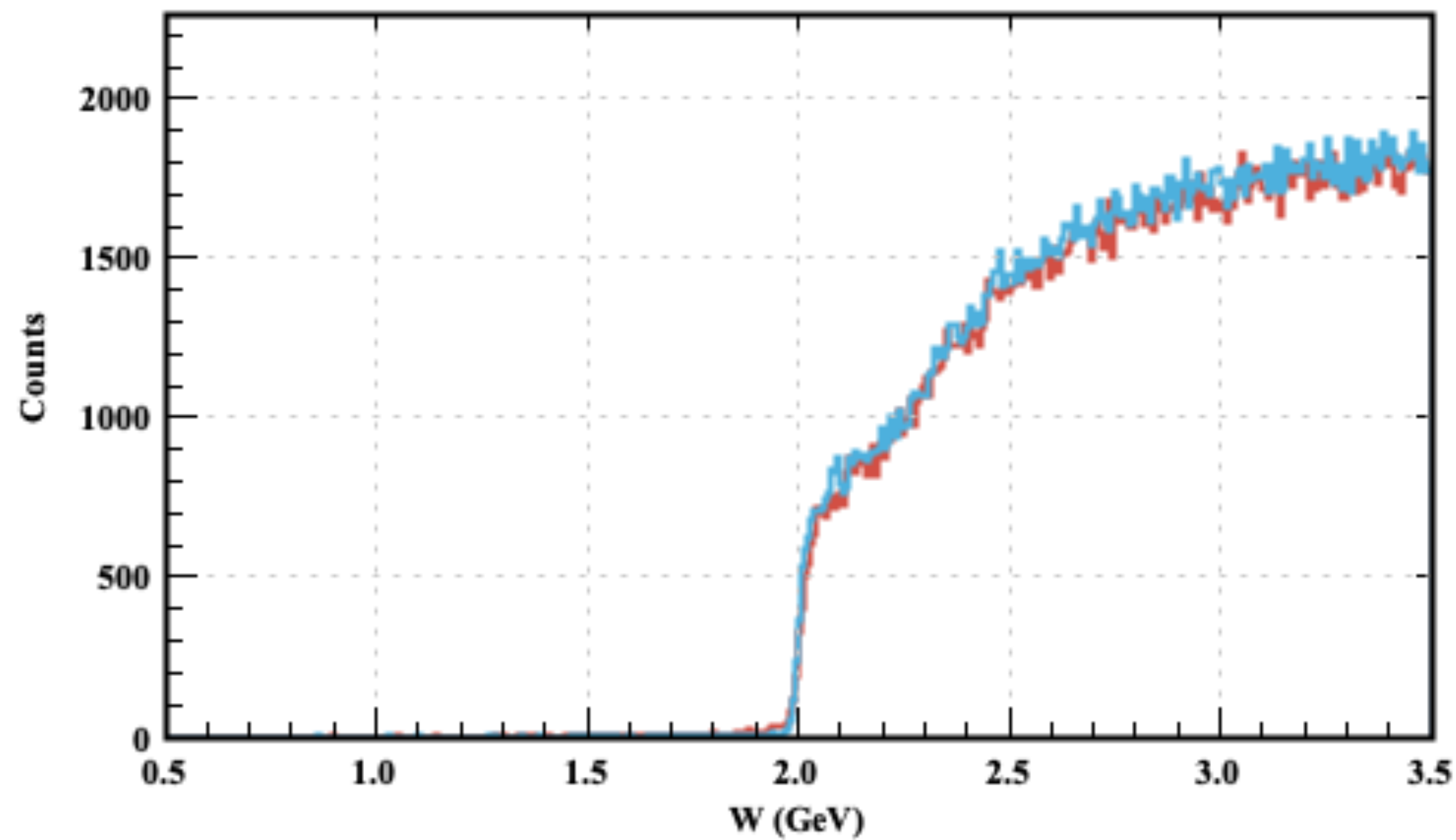




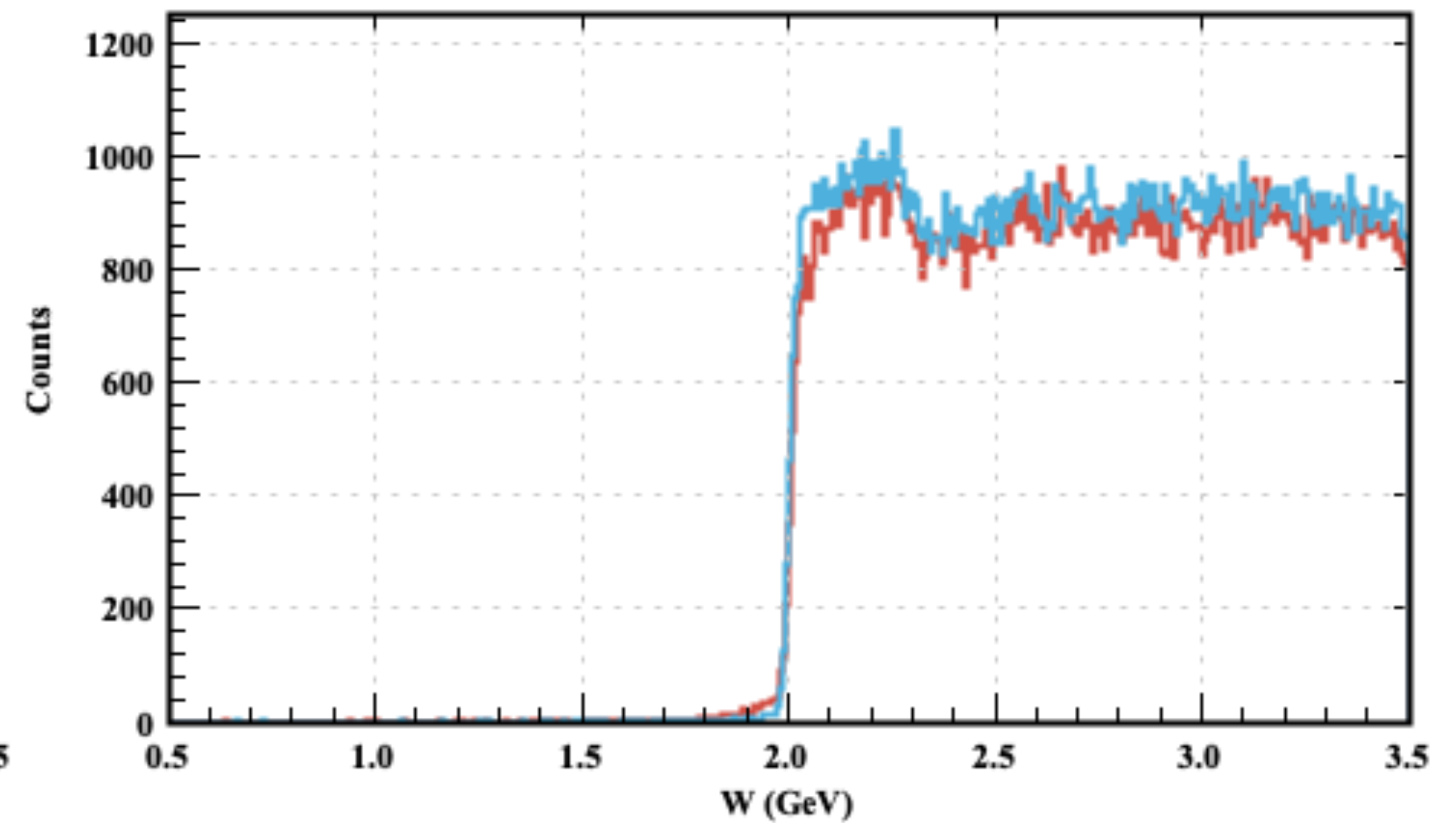
# Resolution: $W$ ( $M_x$ of $ep \rightarrow e'X$ ) for 2-FSP Channels

- Red: ai/dev  
- Blue: ai/updates

$$ep \rightarrow e'\pi^+ X$$

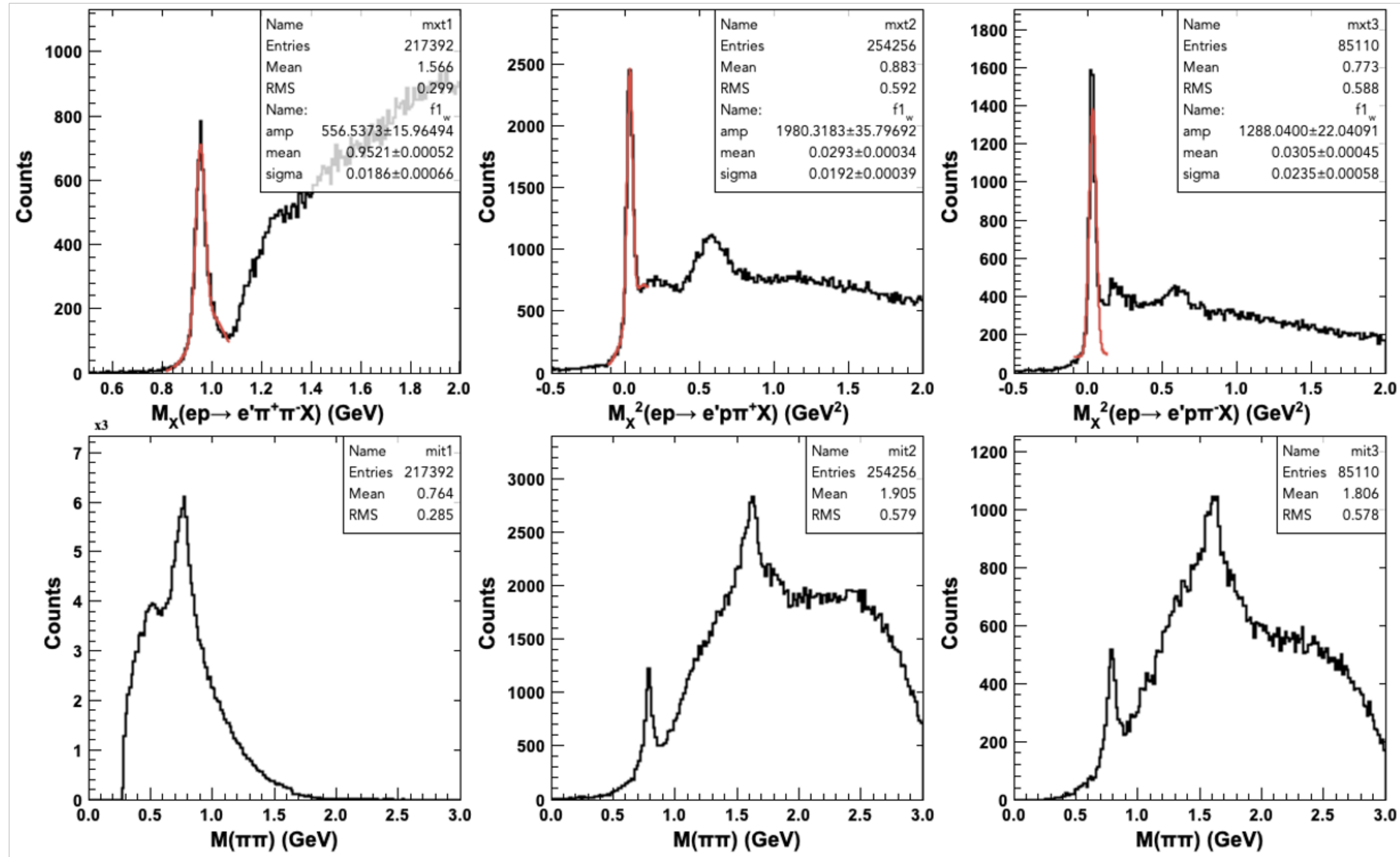


$$ep \rightarrow e'pX$$



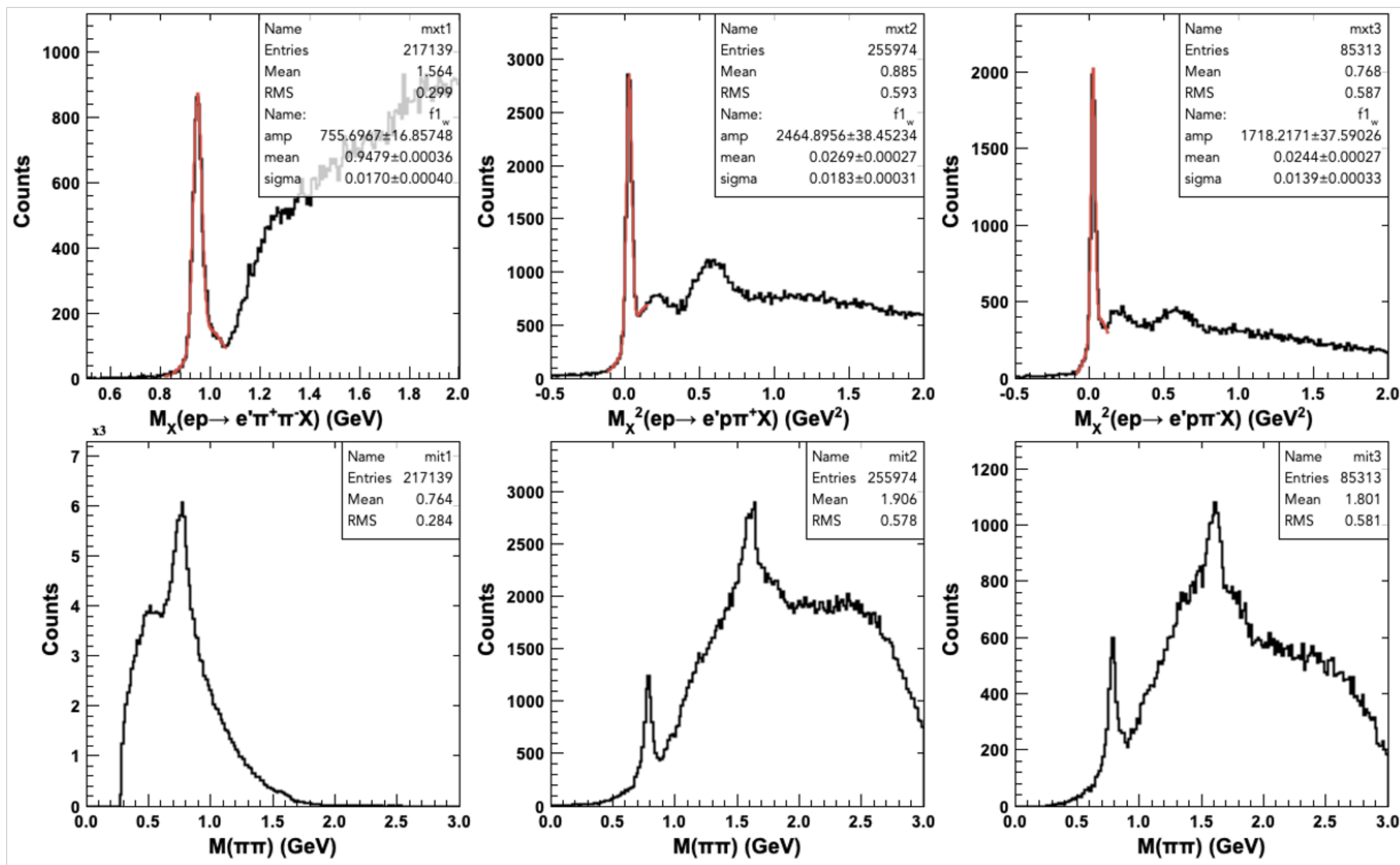
# Validation for RGA-SIDIS MC by Raffaella

No background; 3-FSP Channels; dev



# Validation for RGA-SIDIS MC by Raffaella

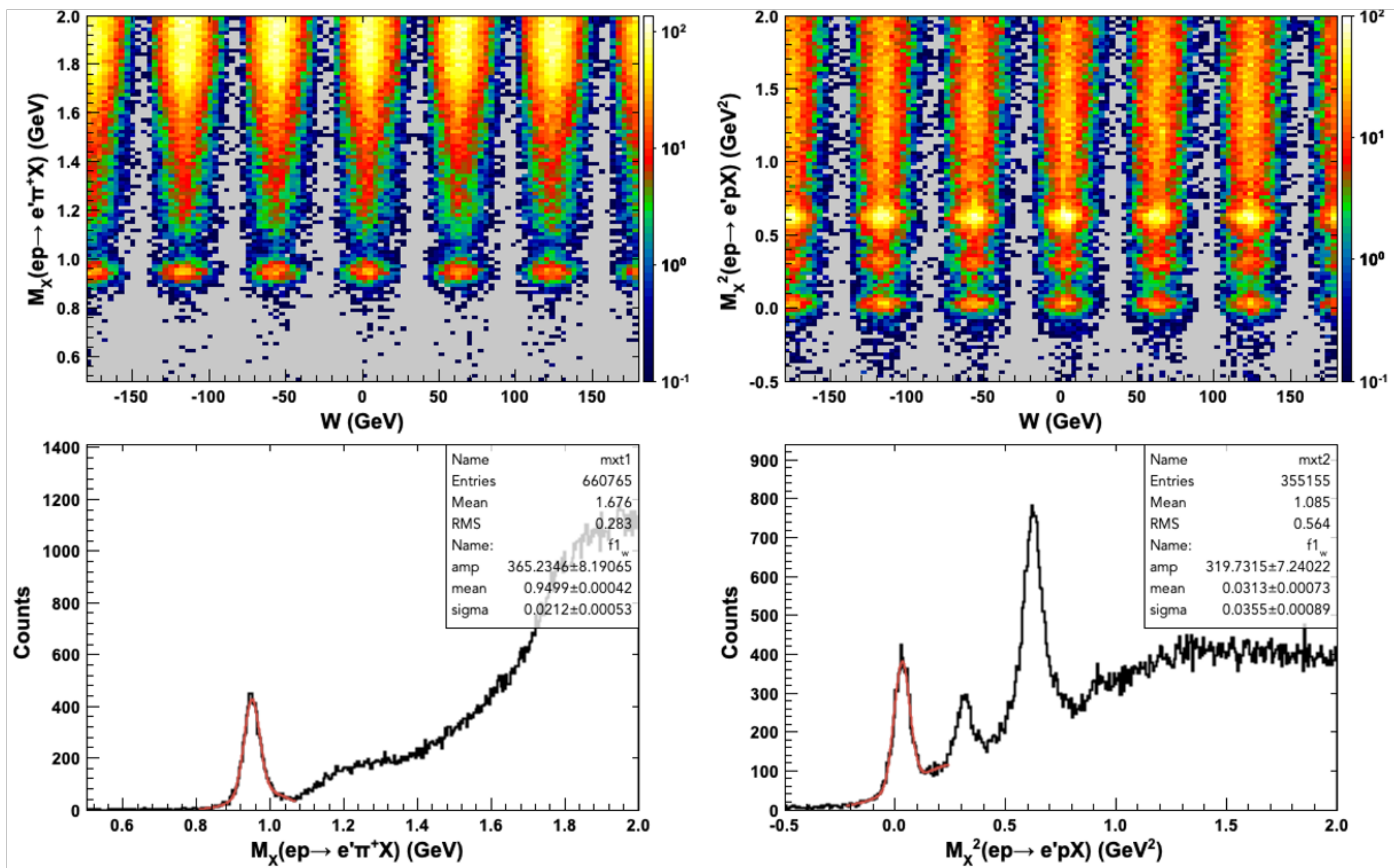
No background; 3-FSP Channels; updates





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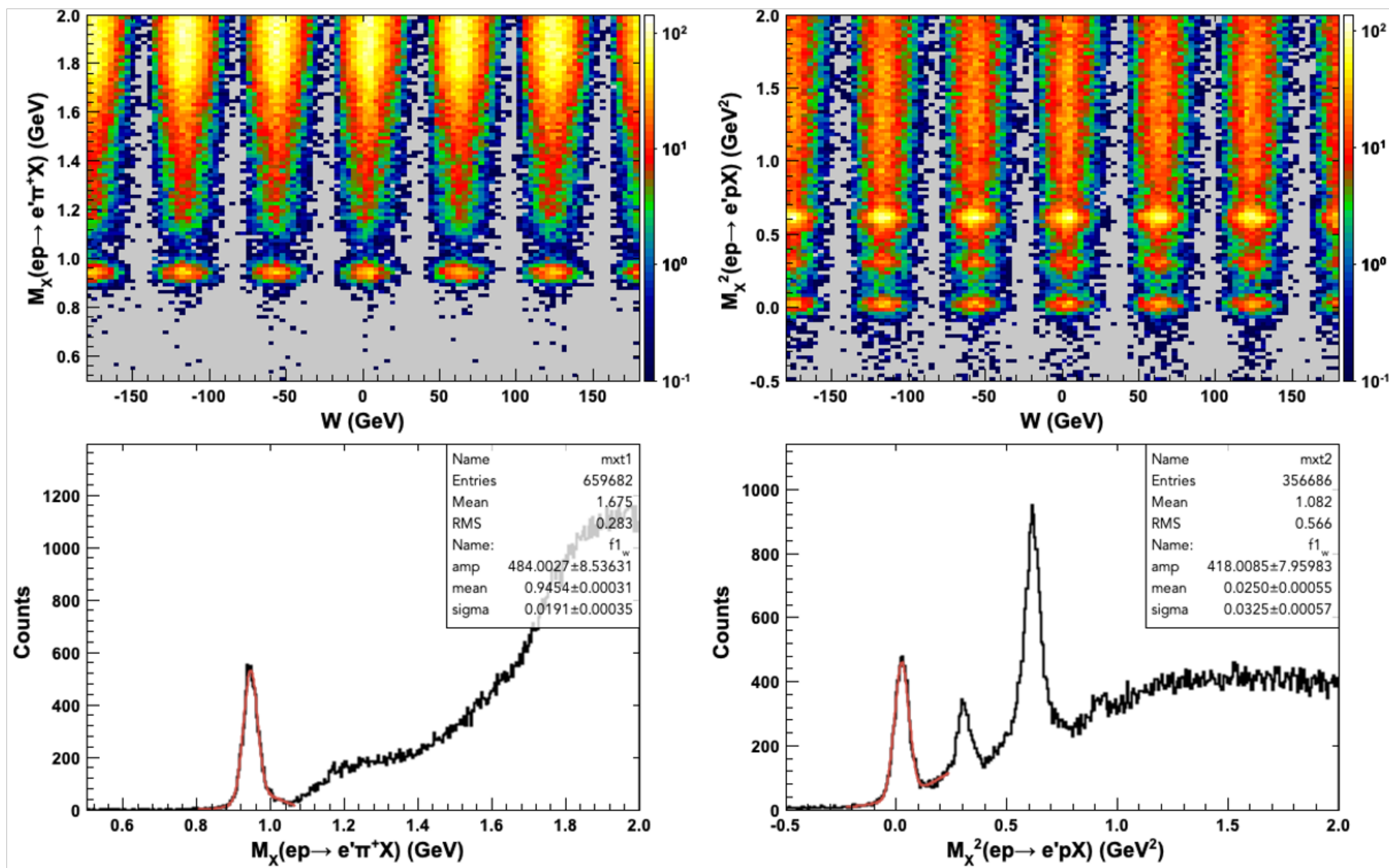
No background; 2-FSP Channels; dev





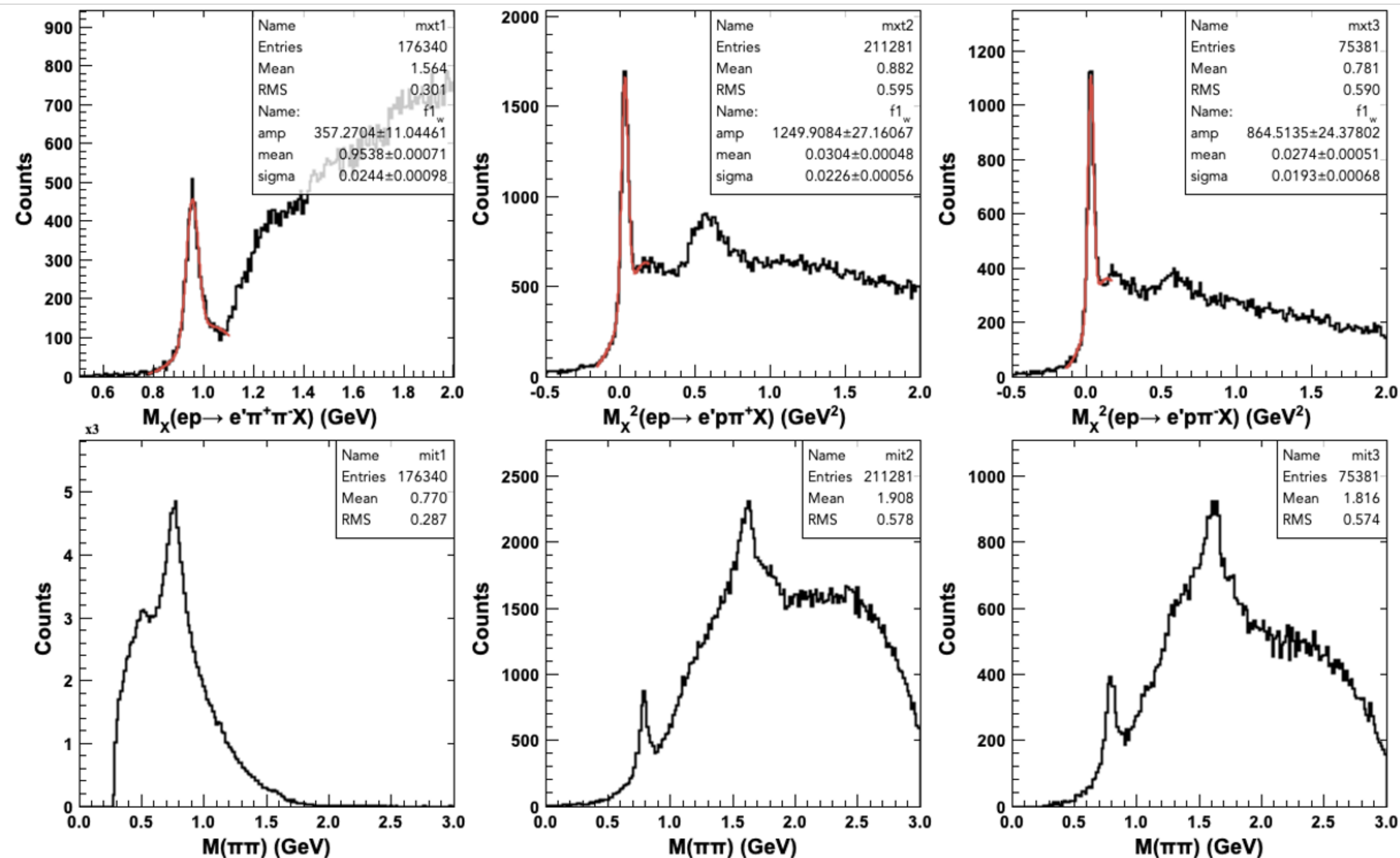
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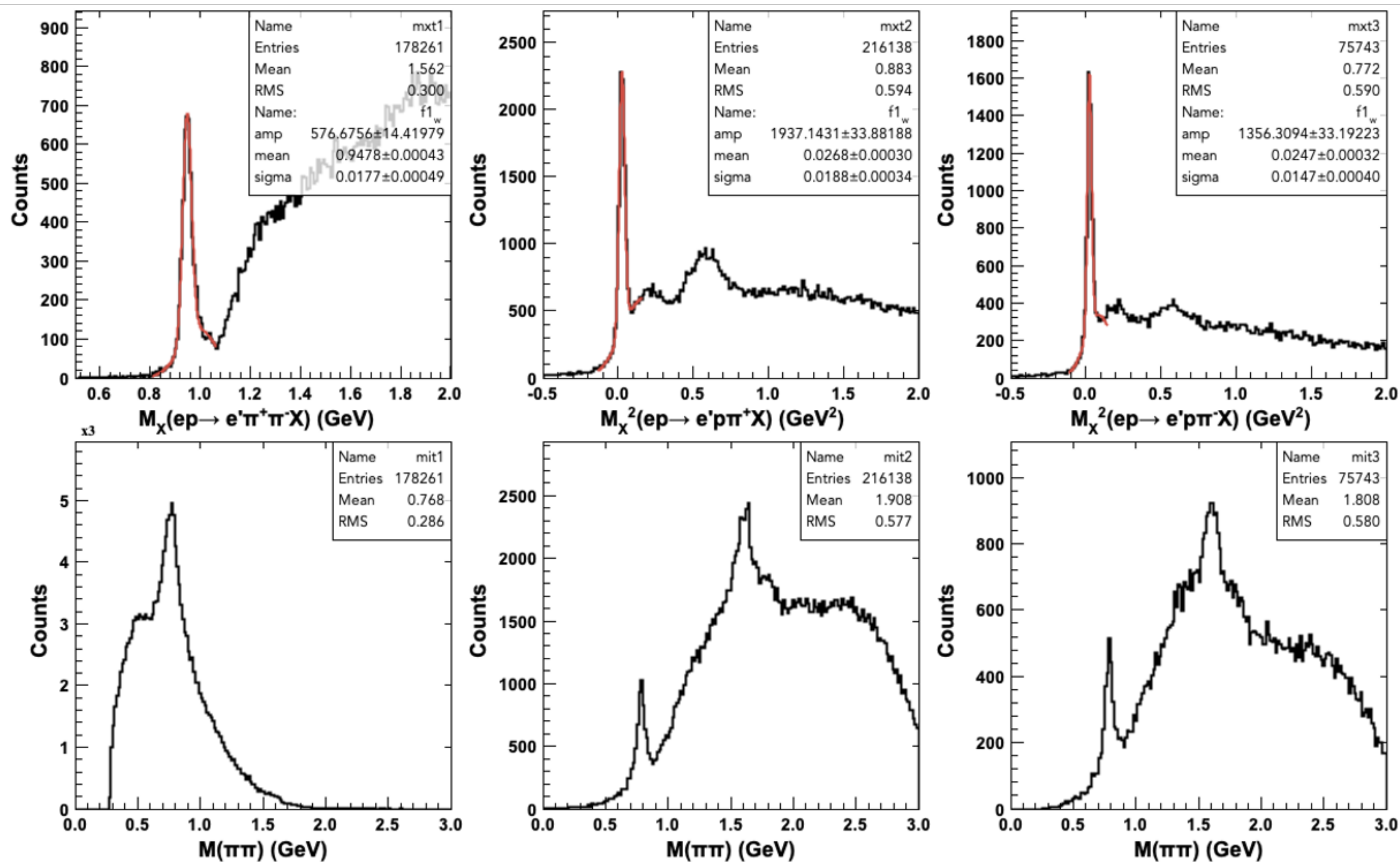
Background; 3-FSP Channels; dev





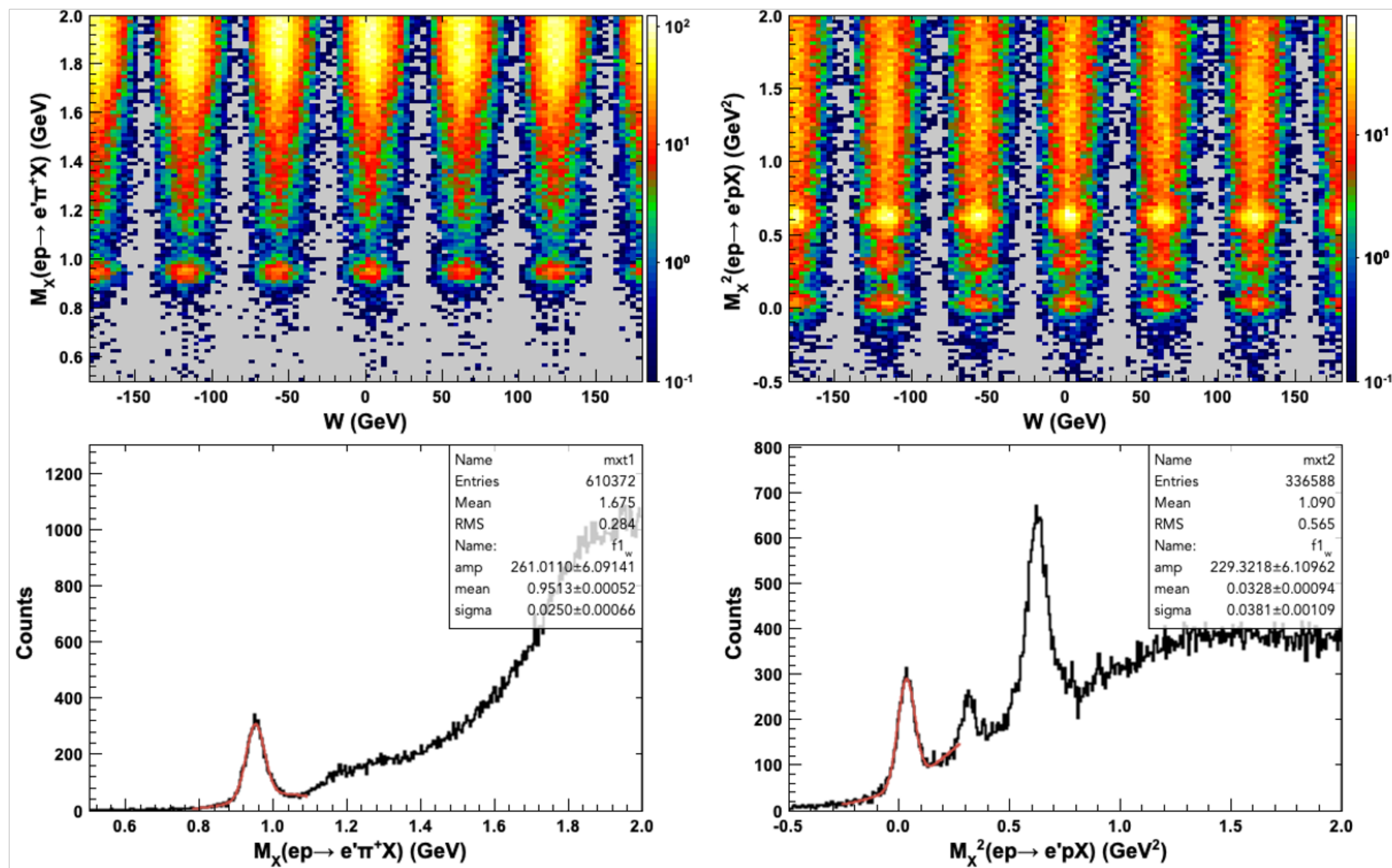
# Validation for RGA-SIDIS MC by Raffaella

## Background; 3-FSP Channels; updates



# Validation for RGA-SIDIS MC by Raffaella

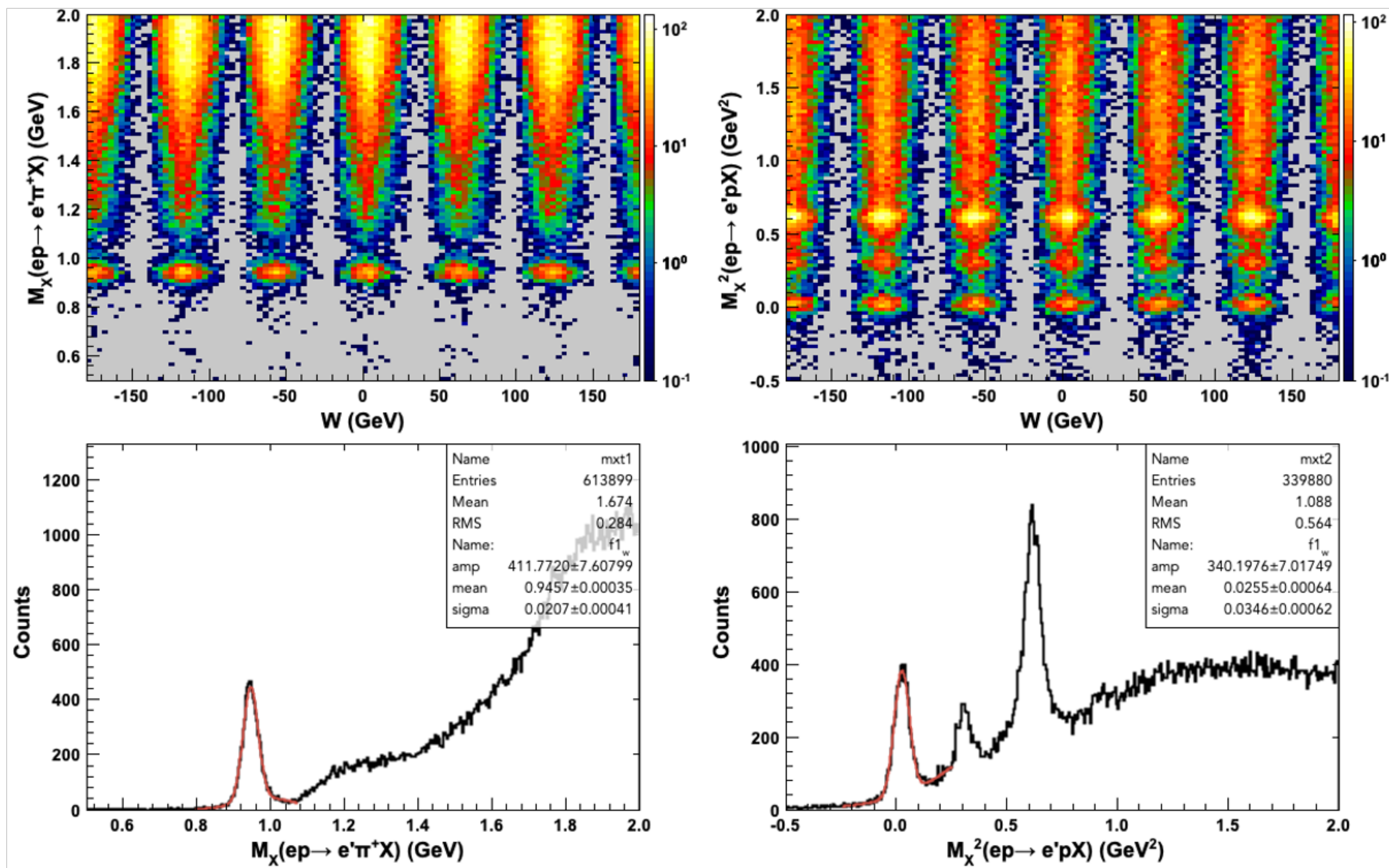
Background; 2-FSP Channels; dev





# Validation for RGA-SIDIS MC by Raffaella

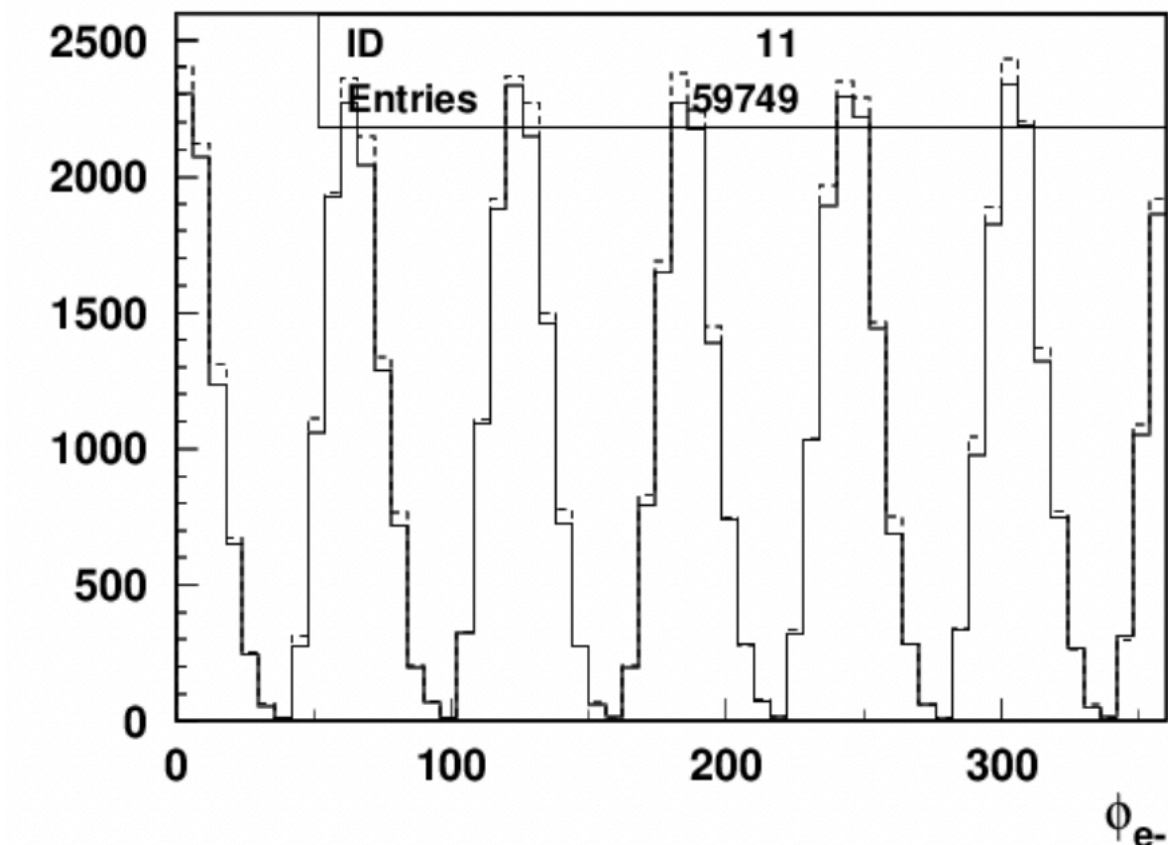
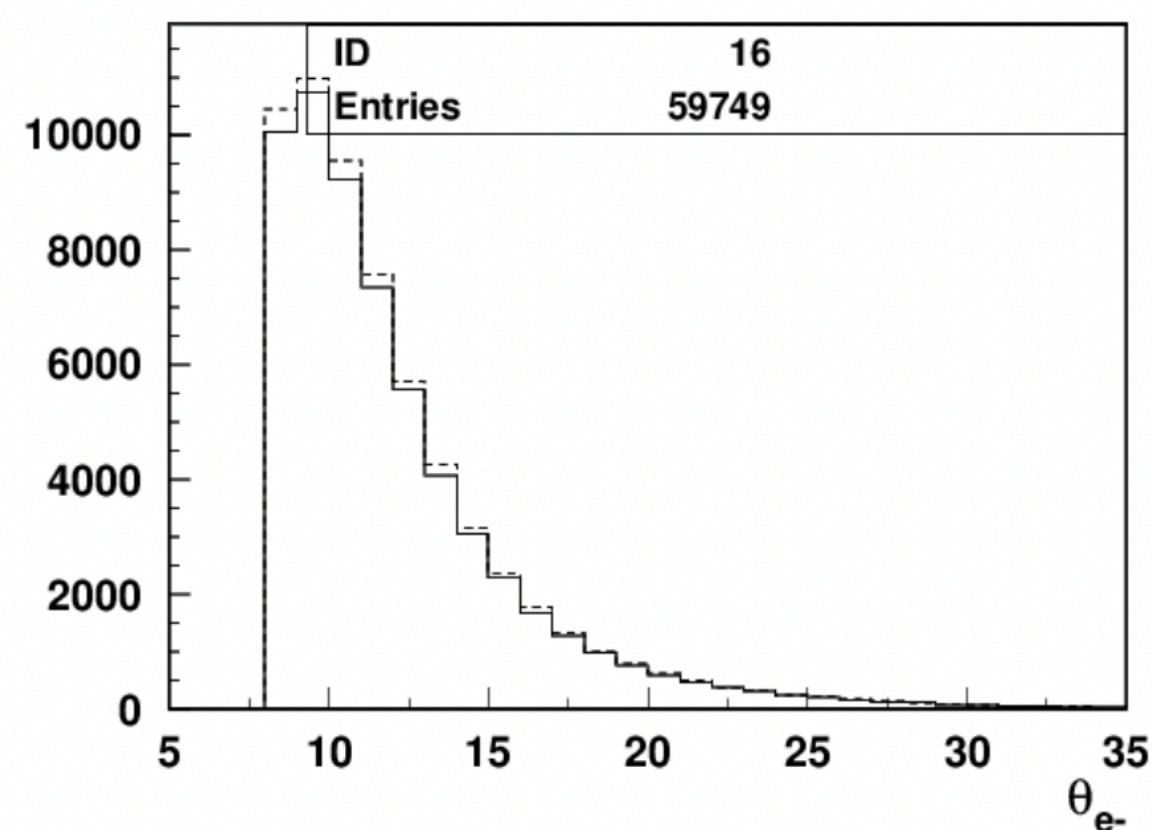
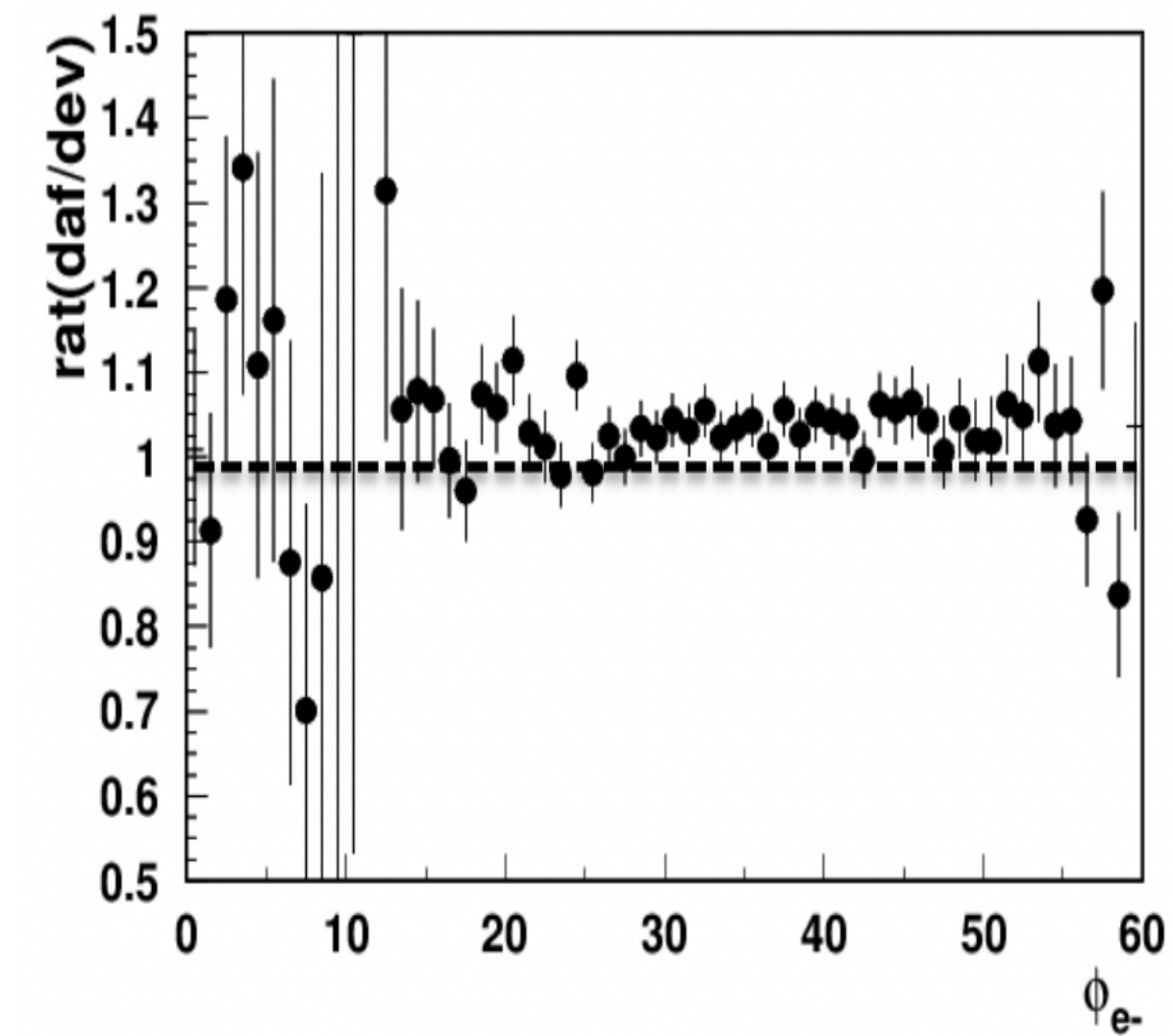
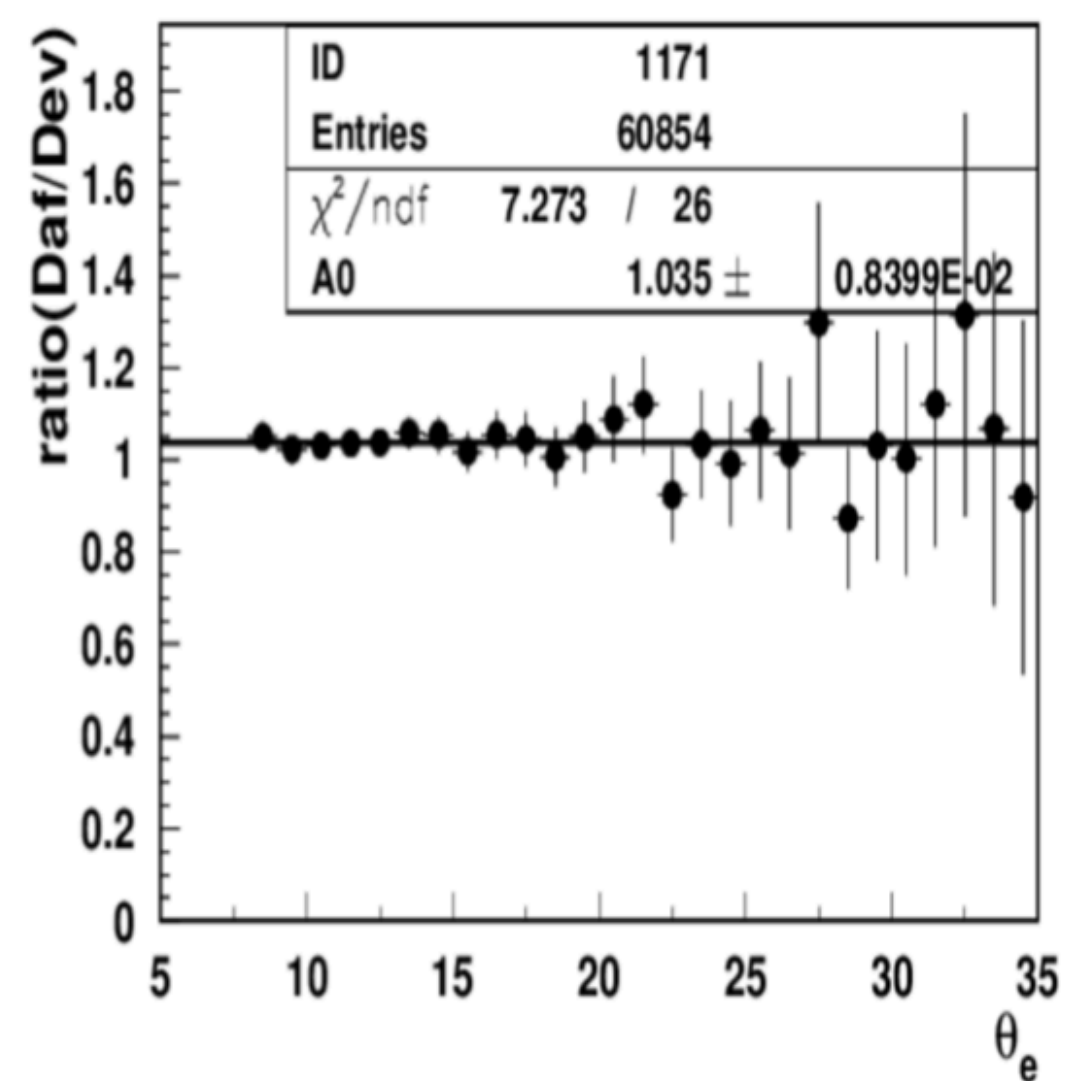
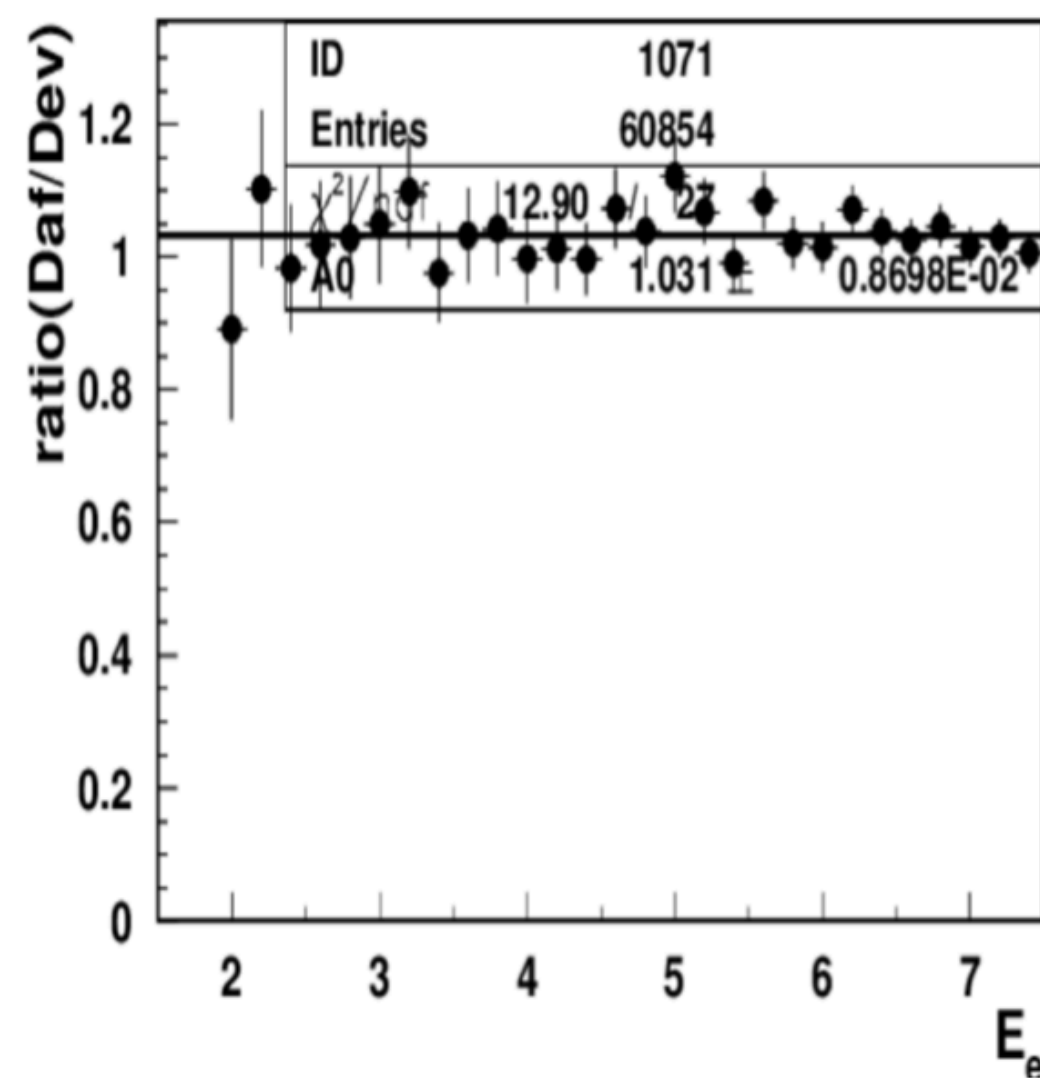
Background; 2-FSP Channels; updates





# RGA-SIDIS MC Validation by Harut

## Reconstruction Efficiency

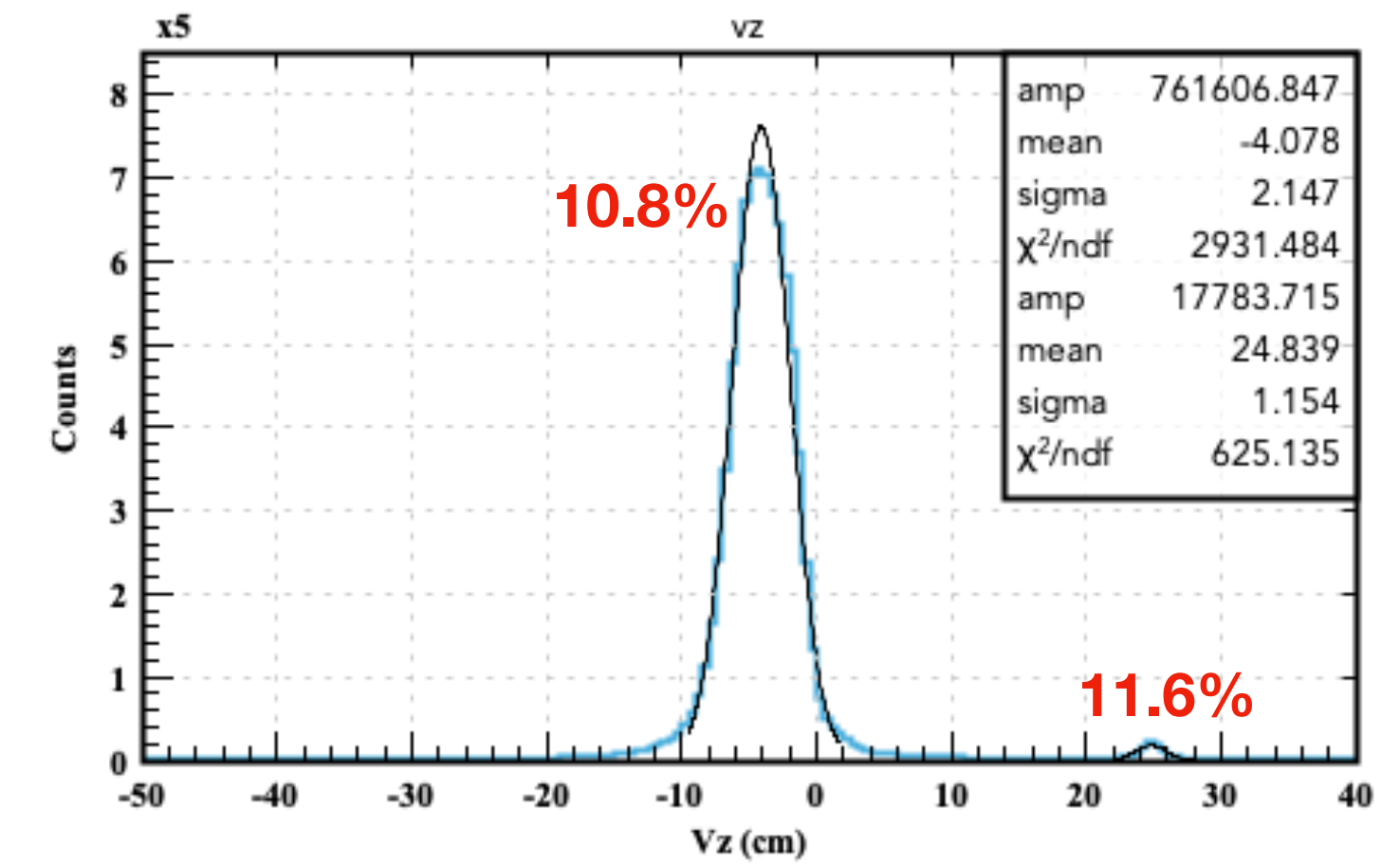
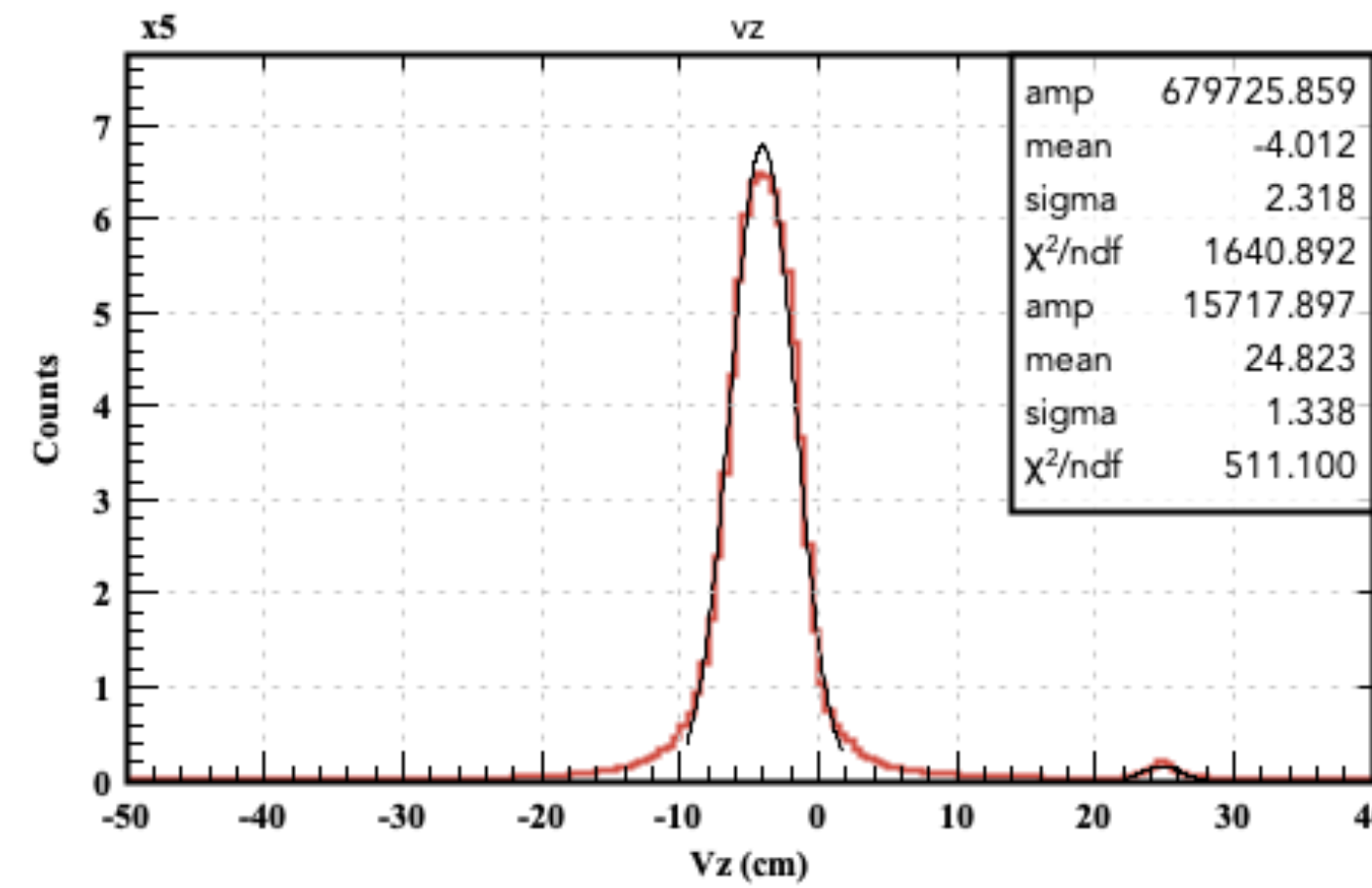
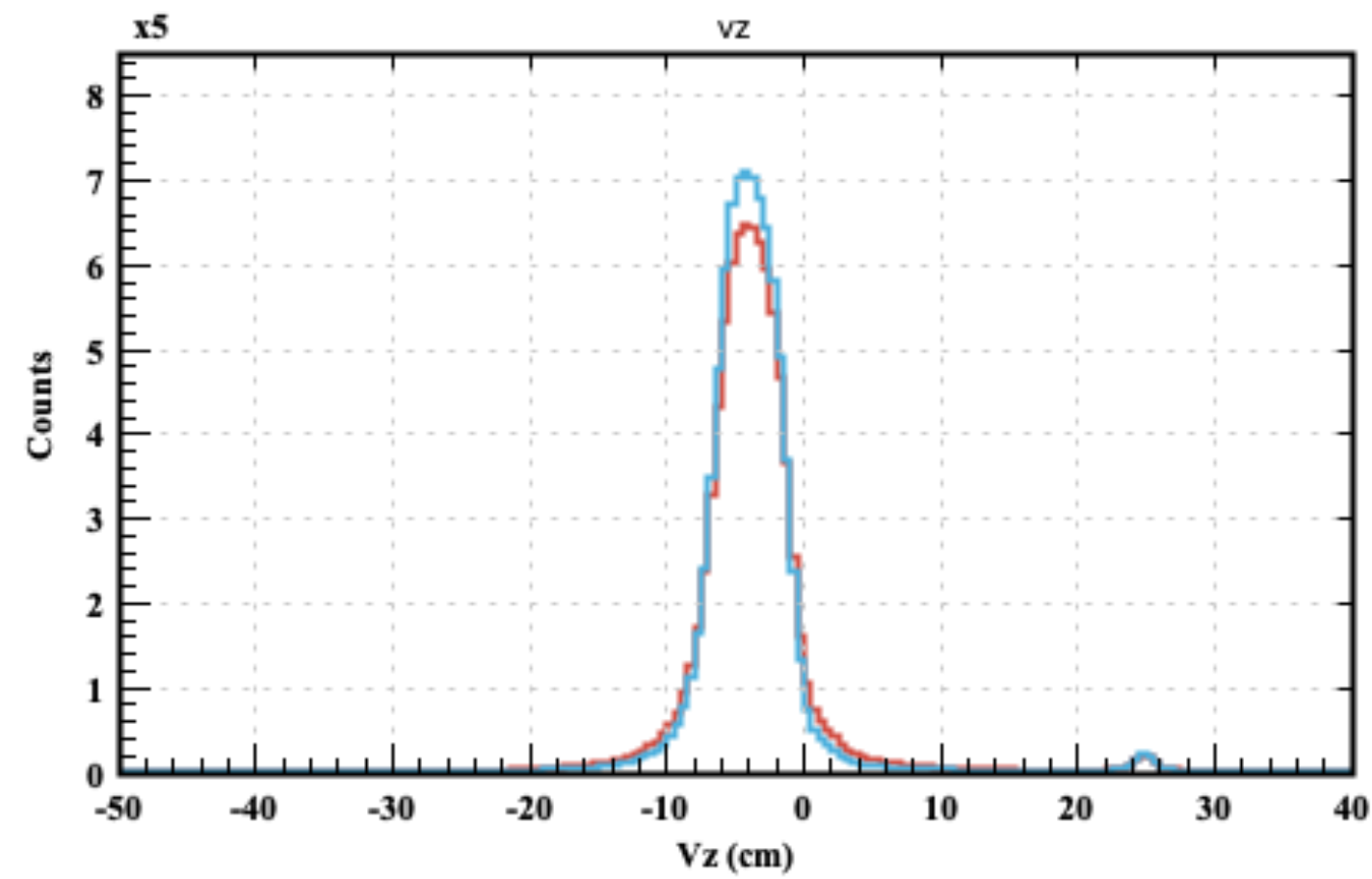


Reconstructed events more ~3%

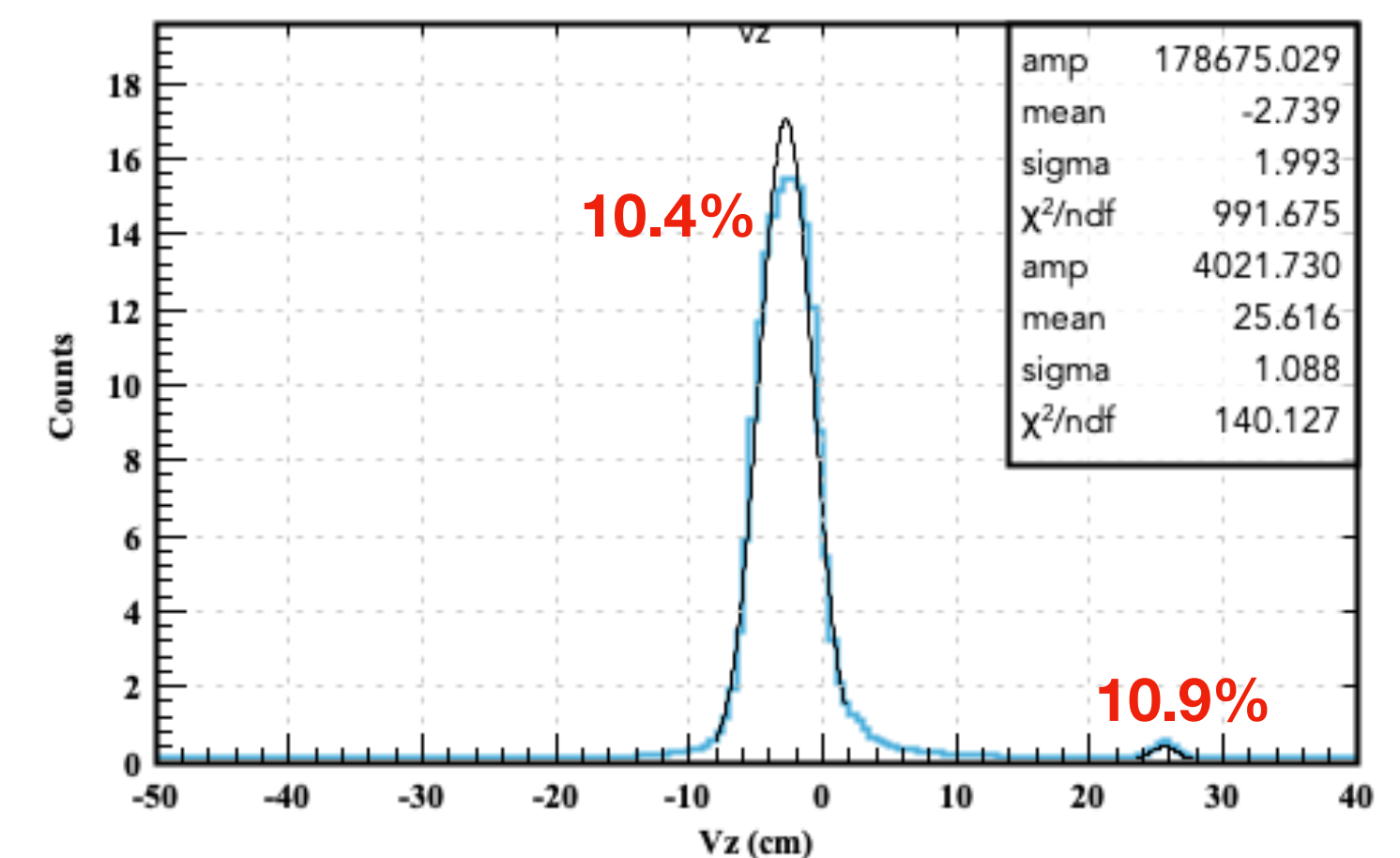
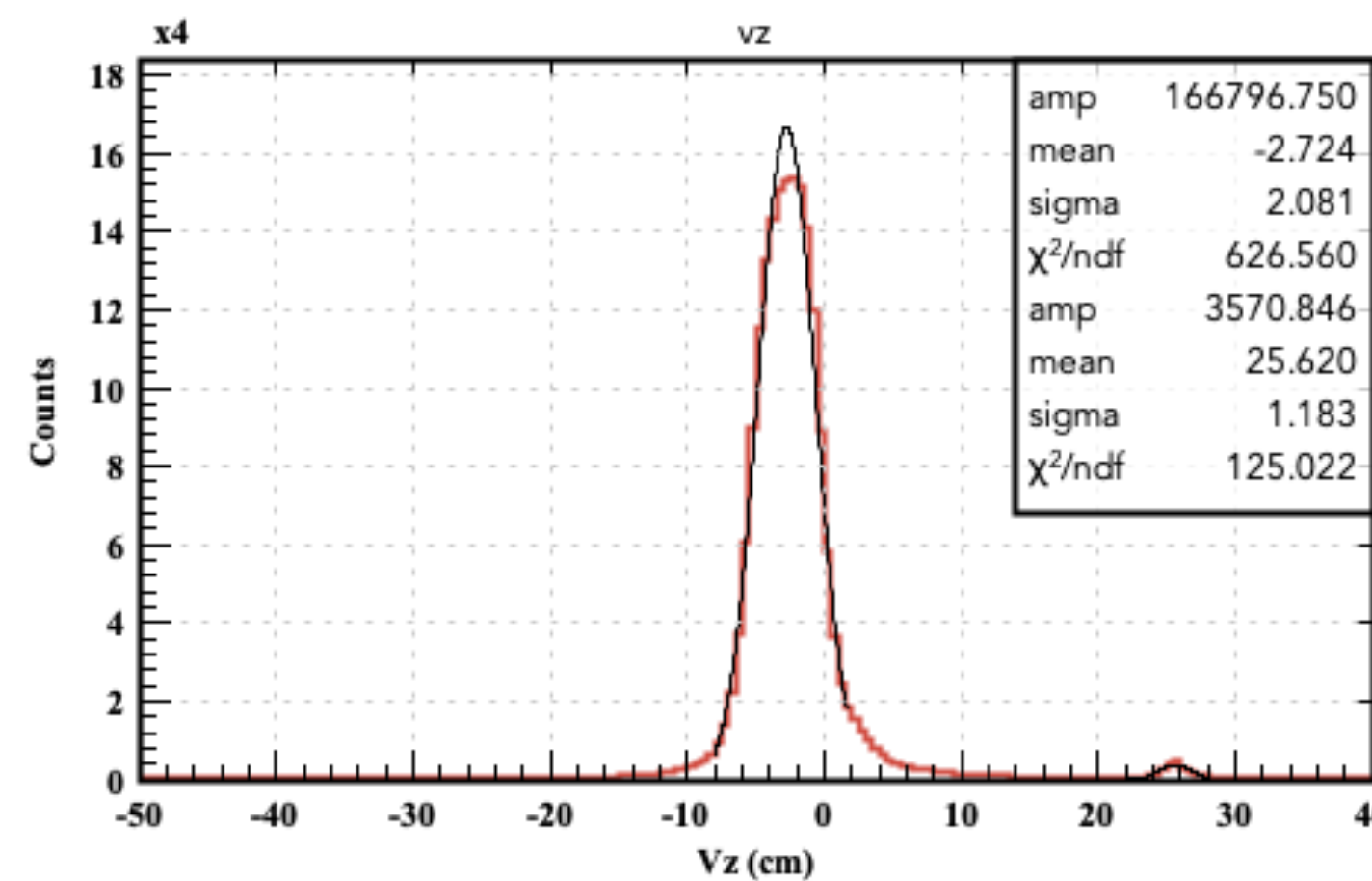
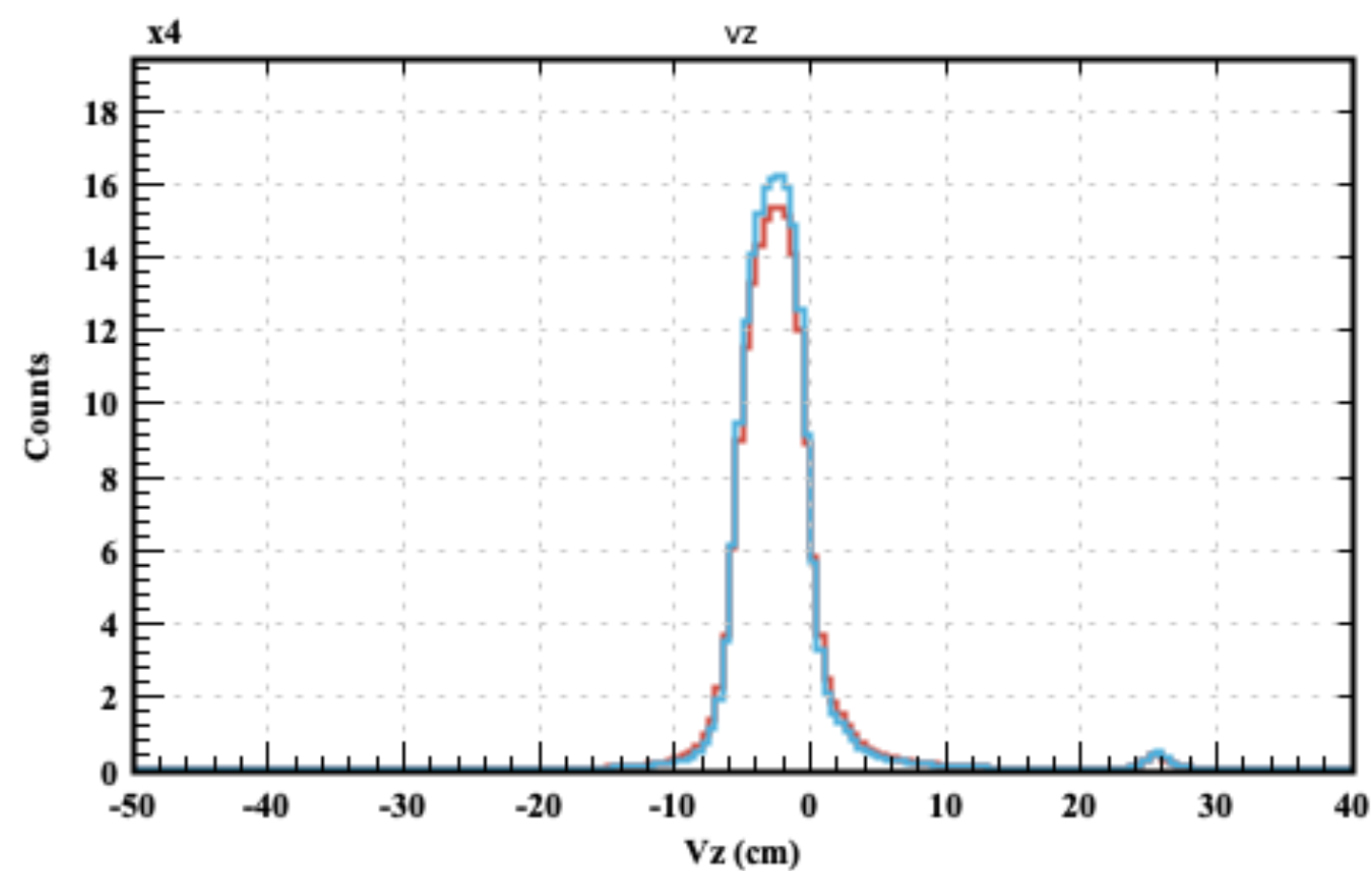
# Resolution: Vertex Z

- Red: dev  
- Blue: updates

Neg. Tracks



Pos. Tracks

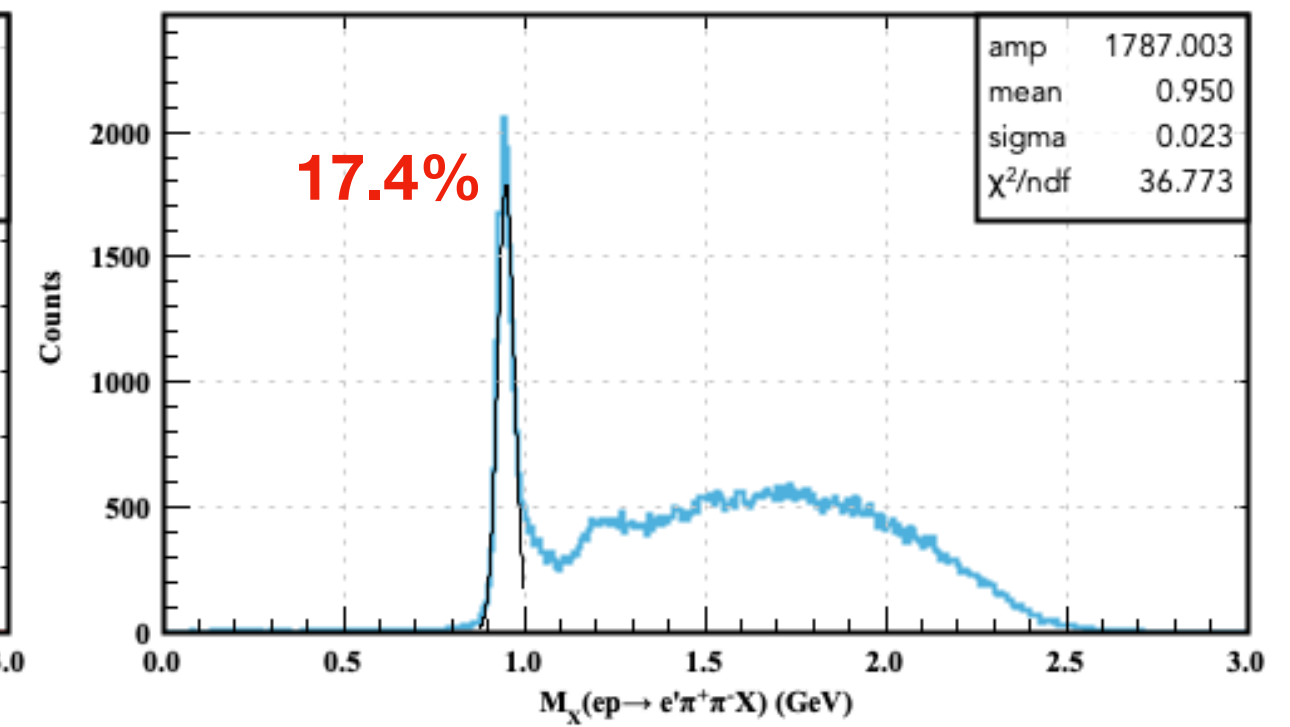
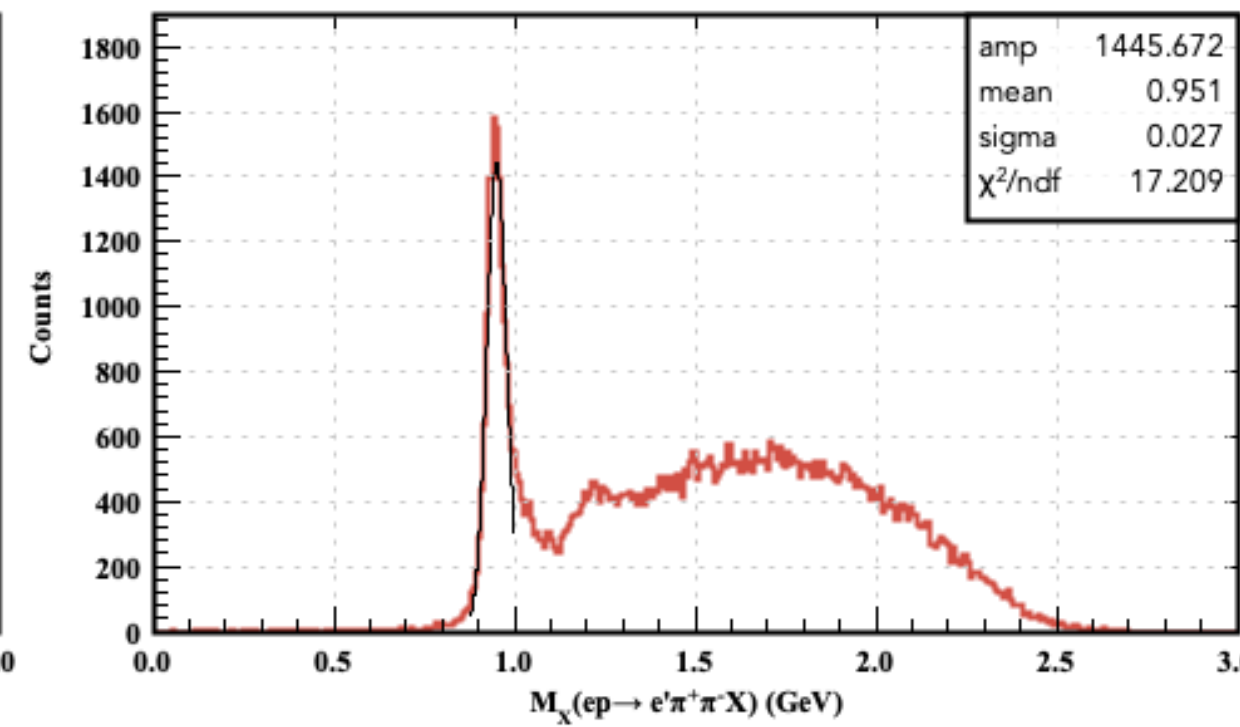
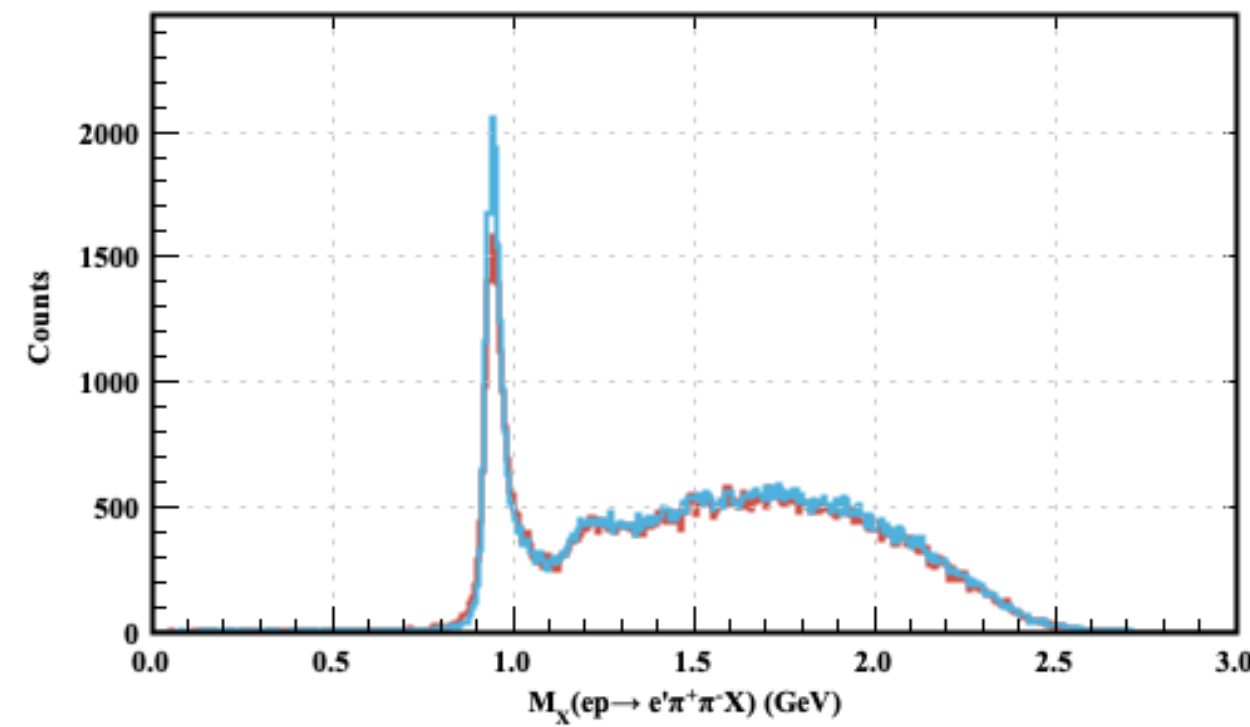




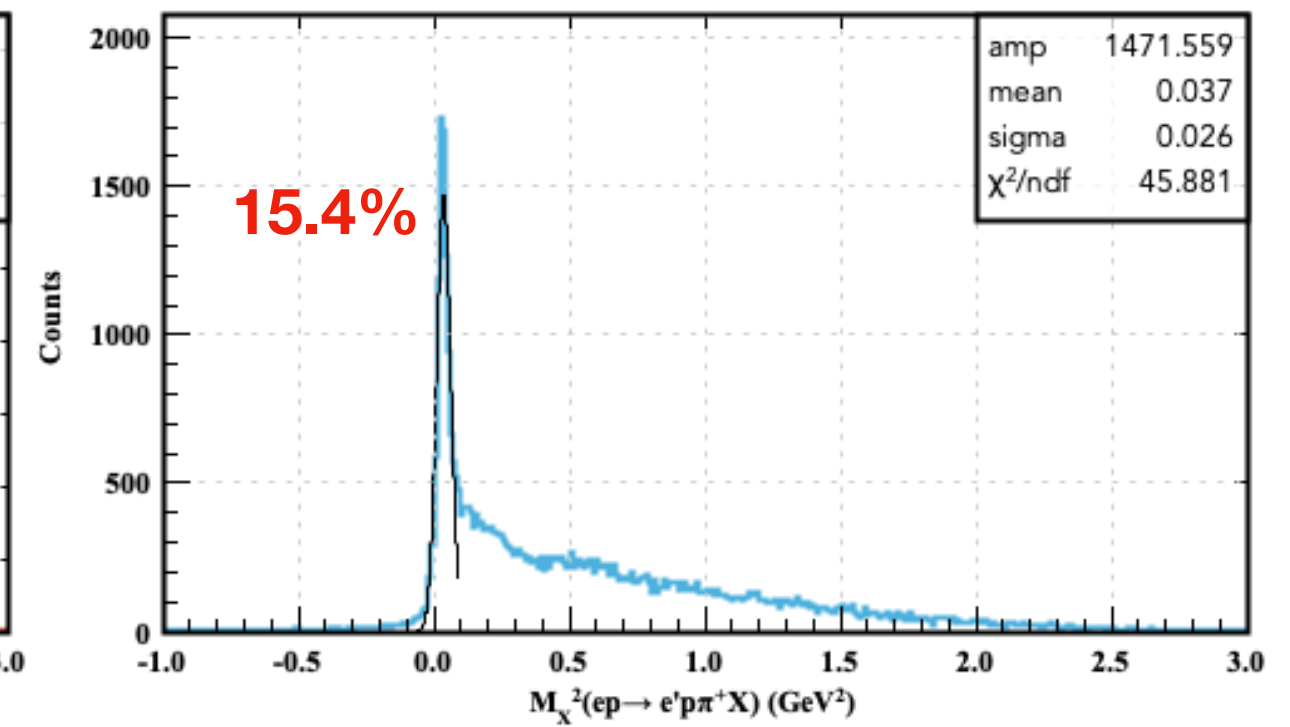
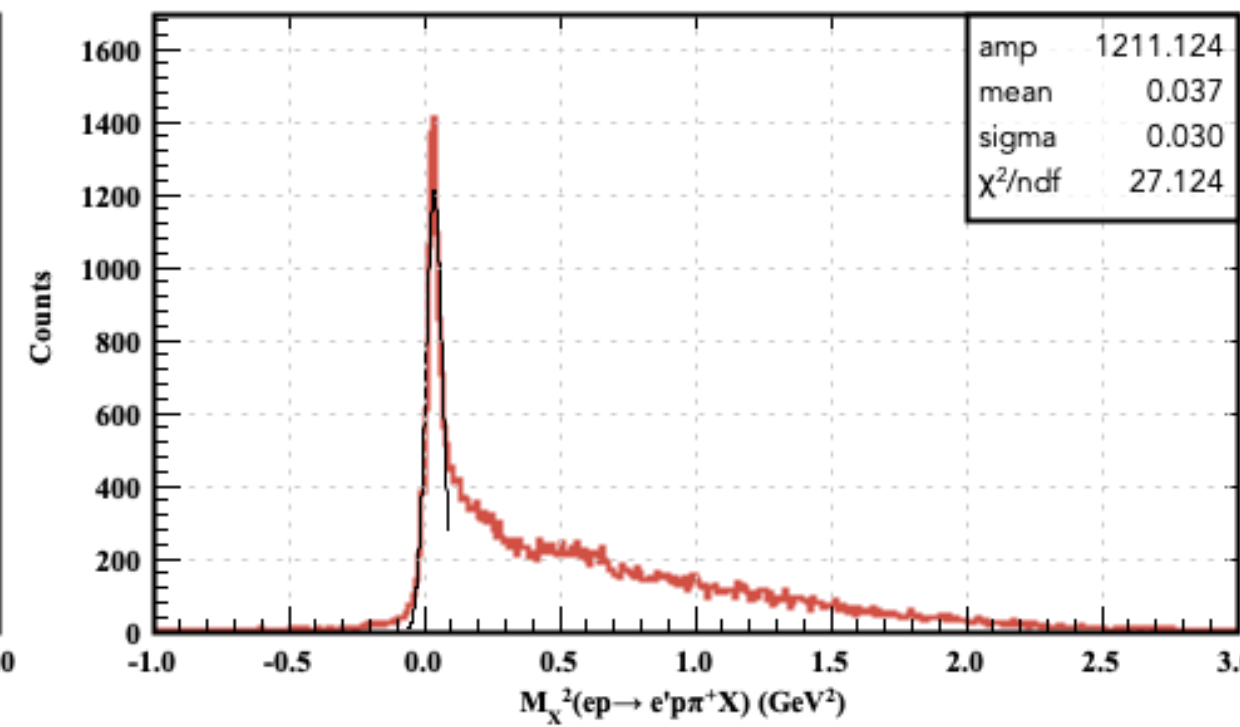
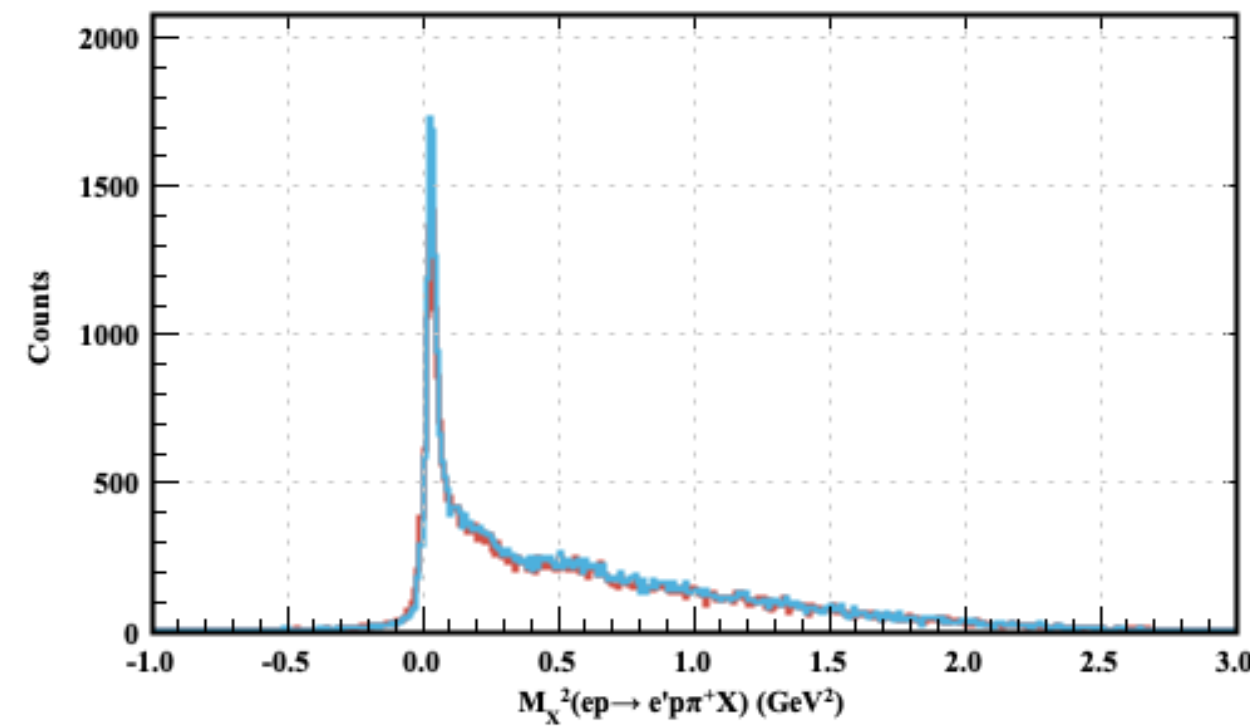
# Resolution: MM for 3-FSP Channels

- Red: dev  
- Blue: updates

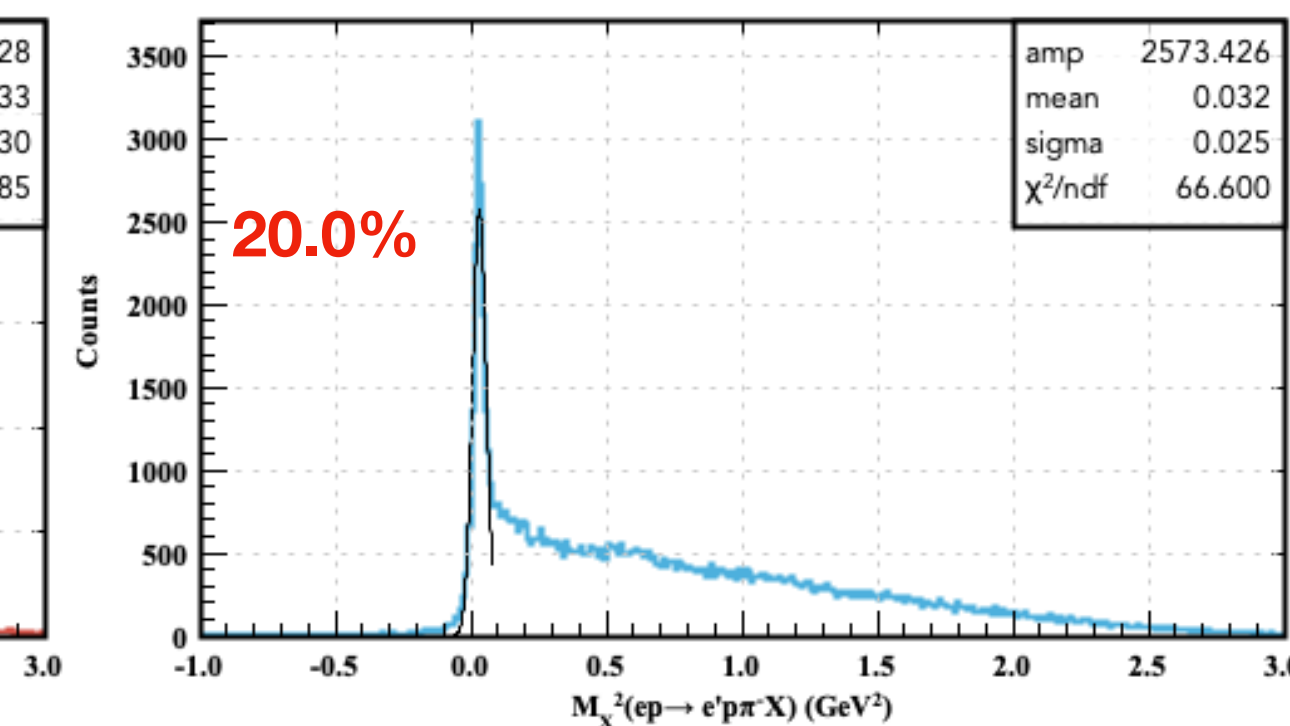
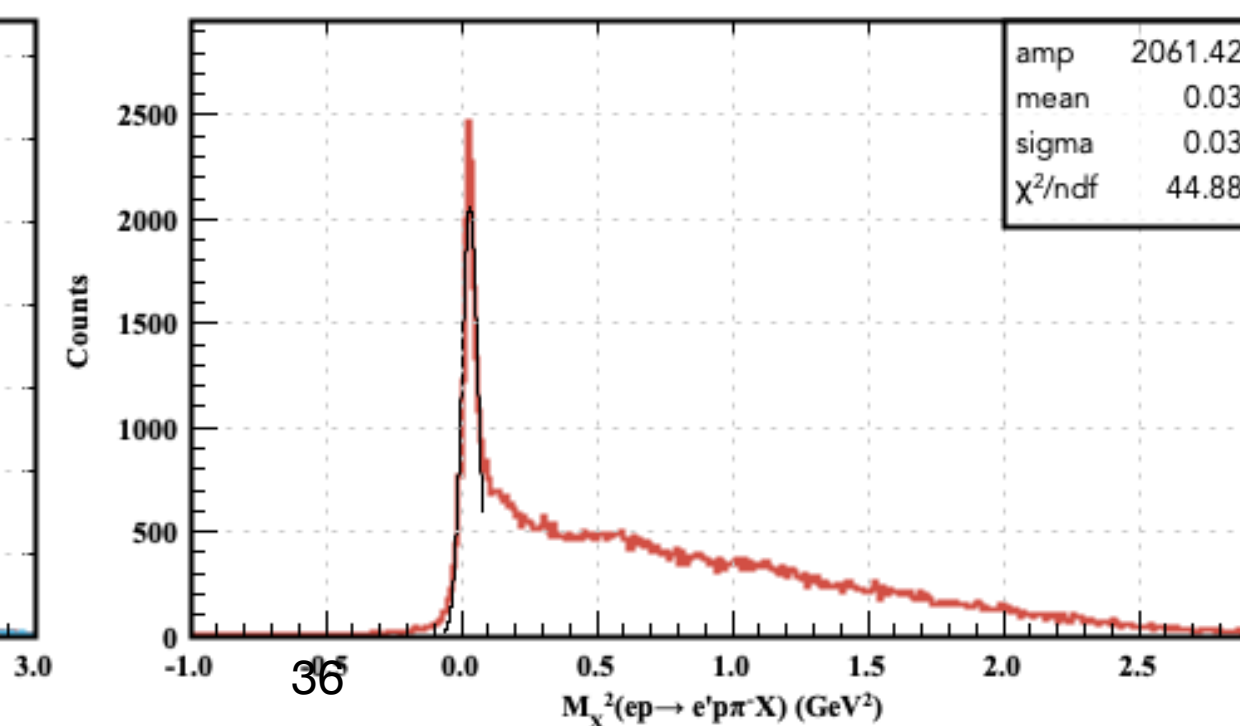
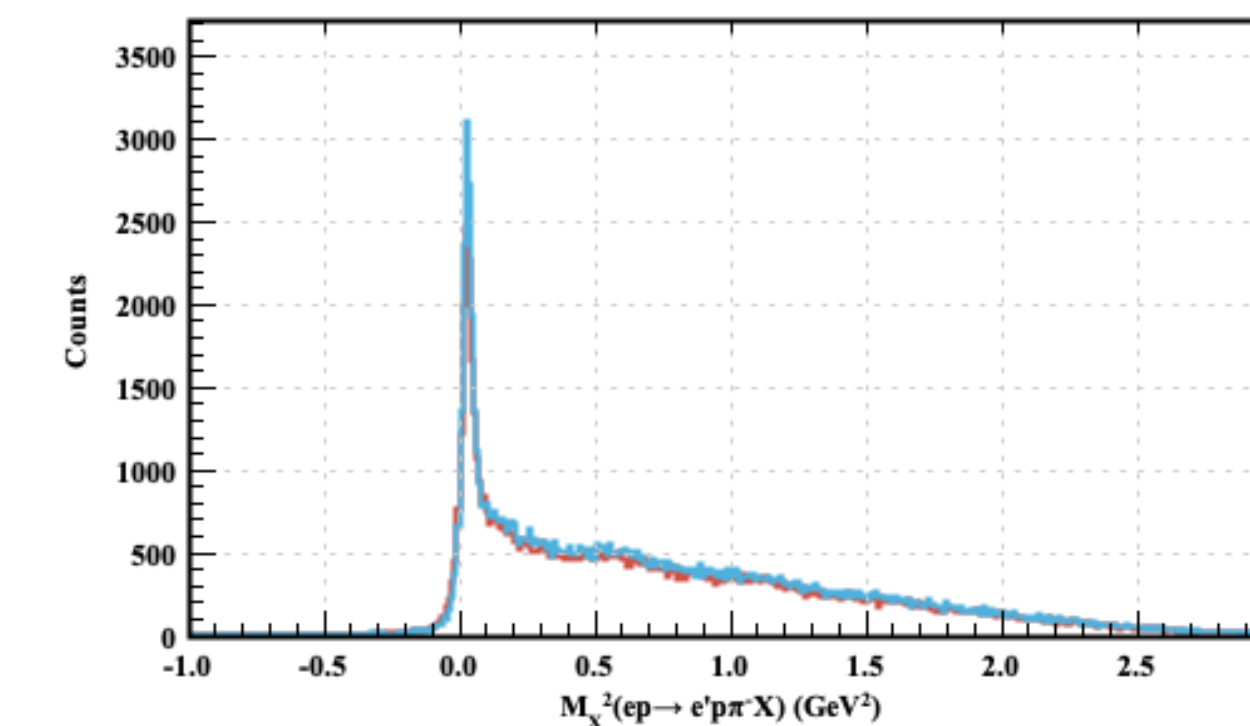
$$ep \rightarrow e' \pi^+ \pi^- X$$



$$ep \rightarrow e' p \pi^+ X$$



$$ep \rightarrow e' p \pi^- X$$

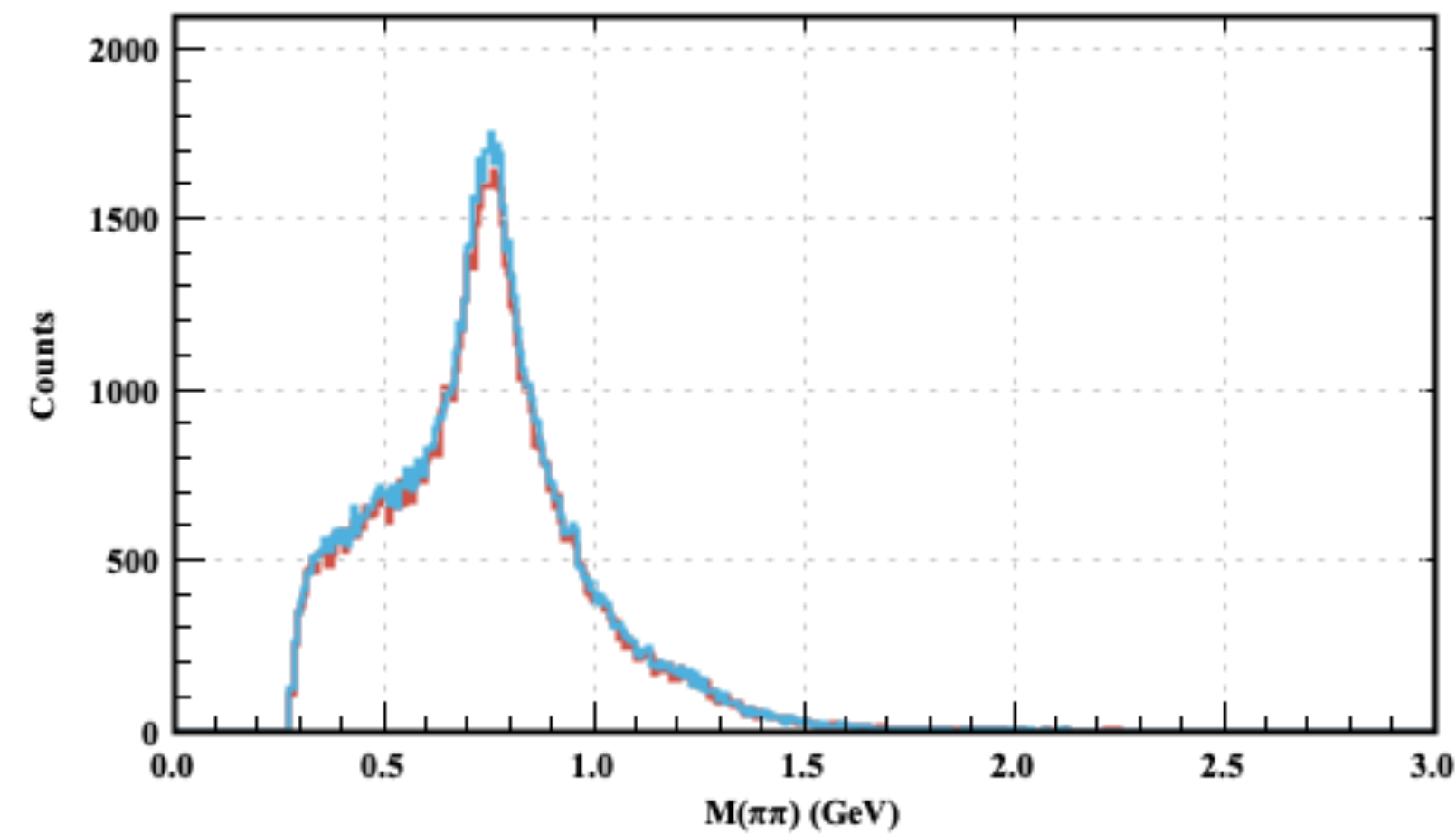




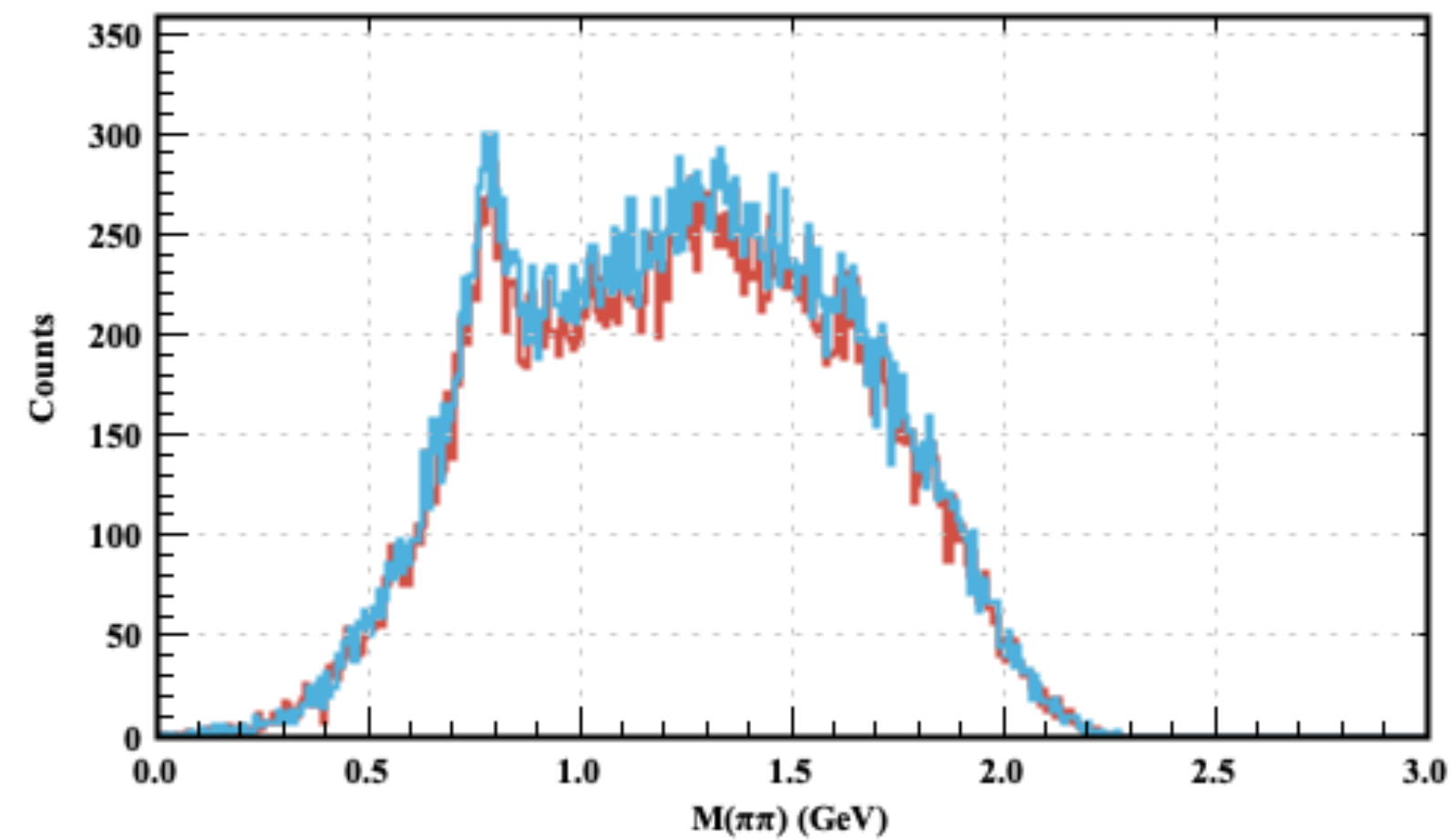
# Resolution: $M(\pi^+\pi^-)$ for 3-FSP Channels

- Red: dev  
- Blue: updates

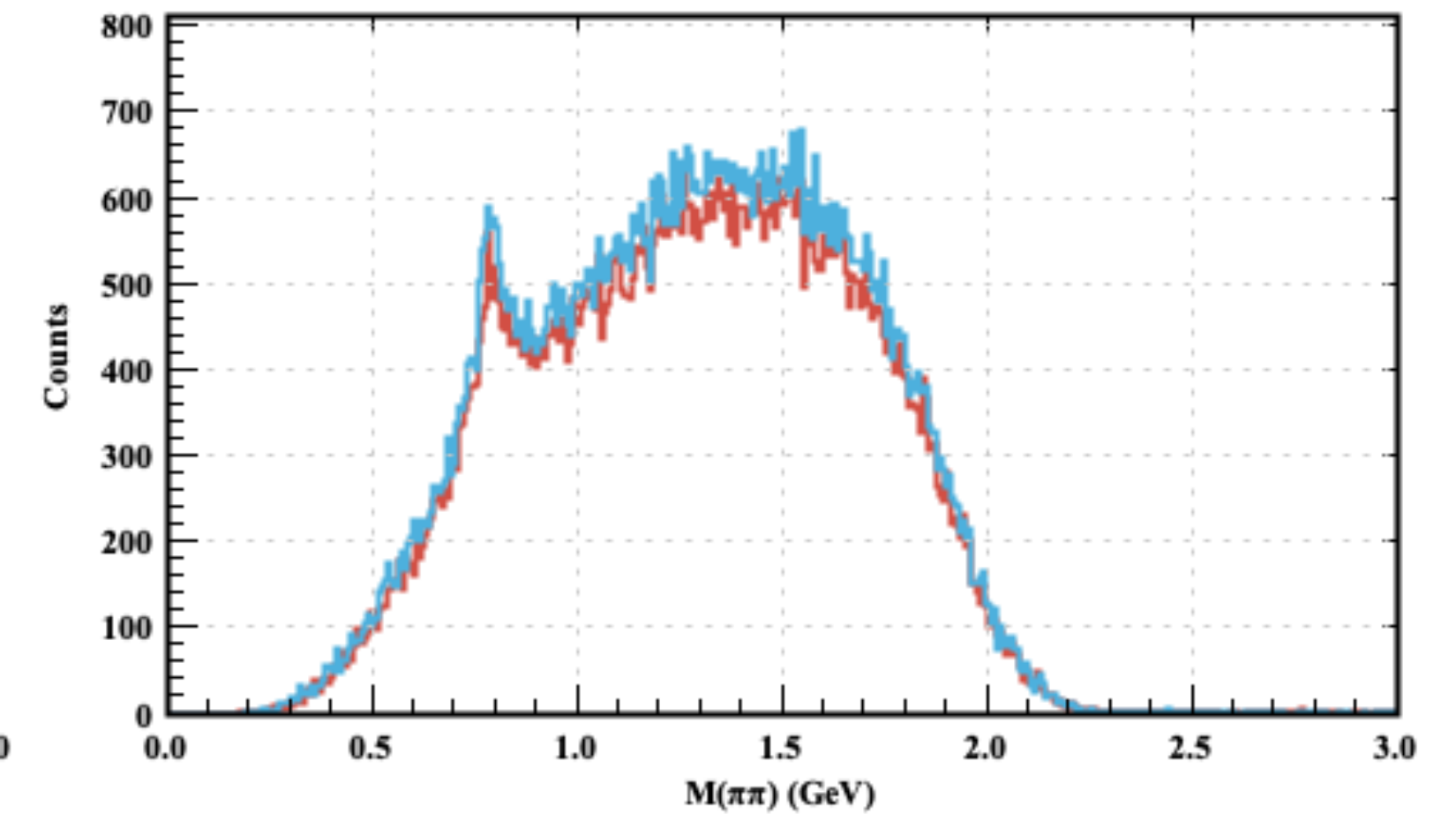
$$ep \rightarrow e' \pi^+ \pi^- X$$



$$ep \rightarrow e' p \pi^+ X$$

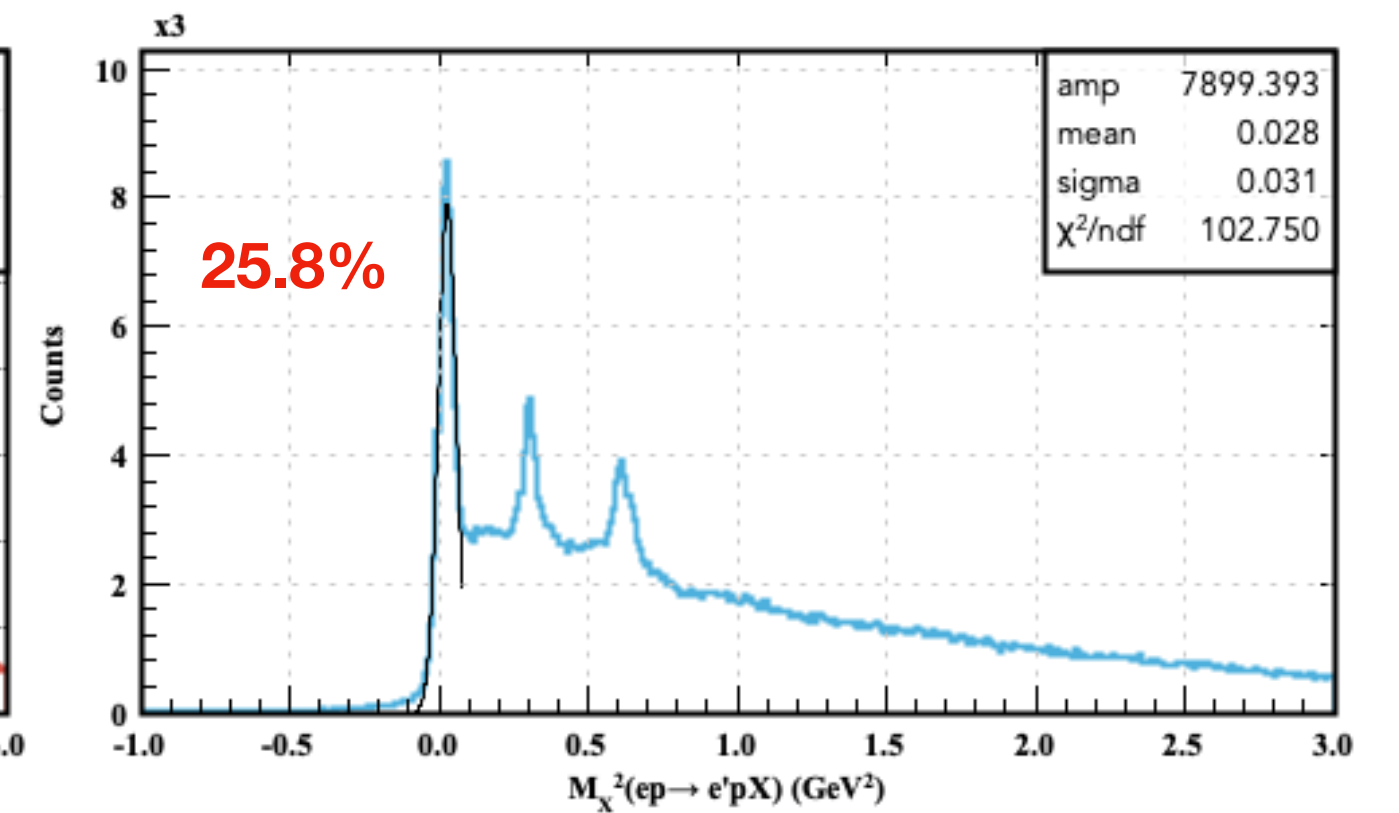
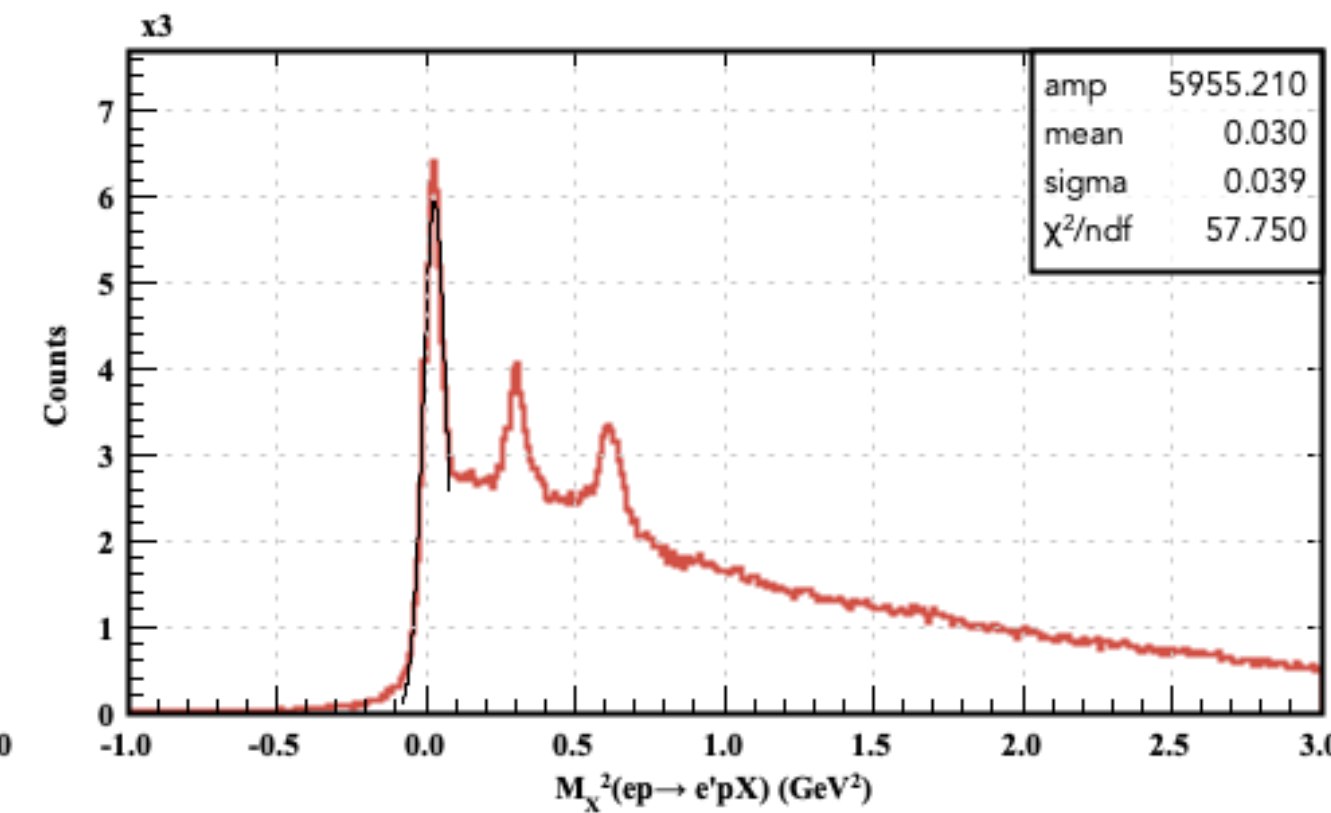
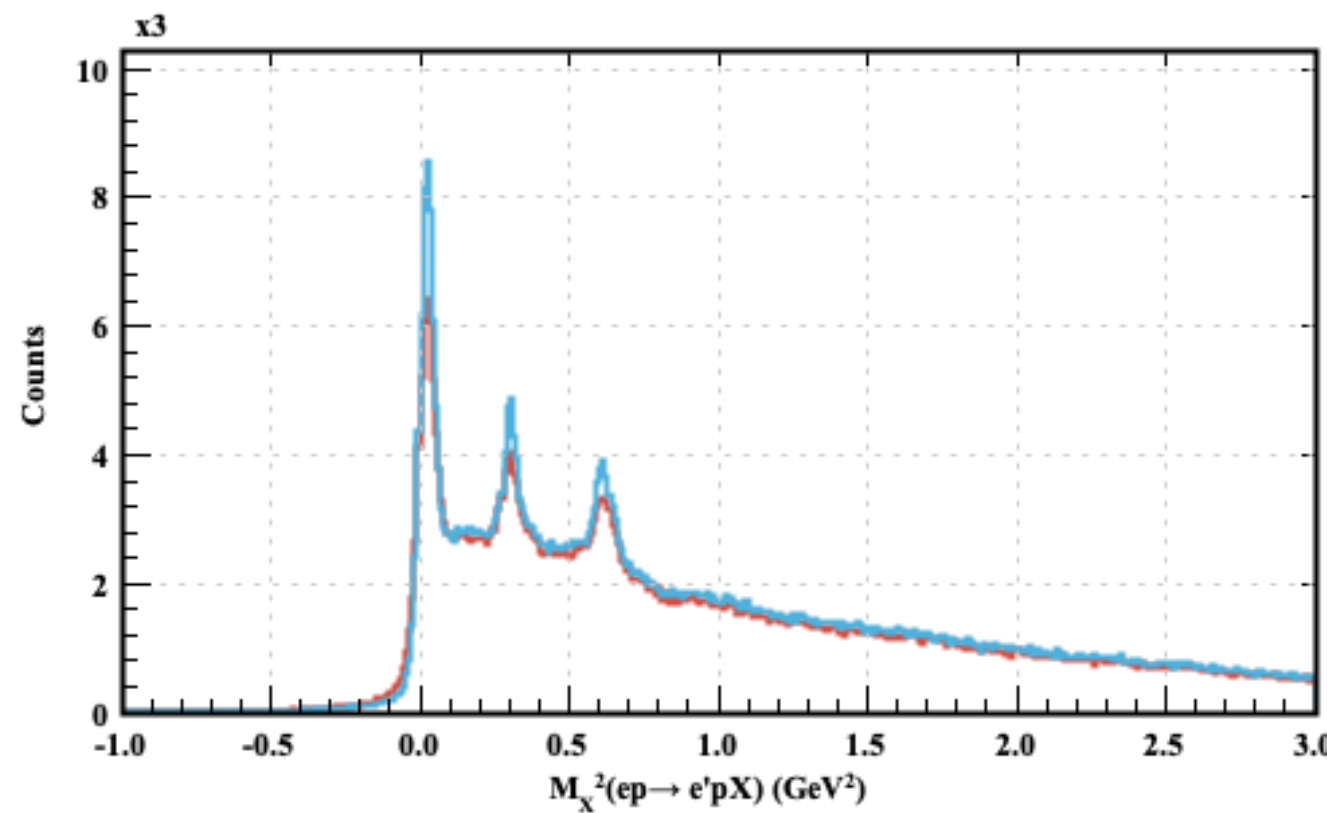
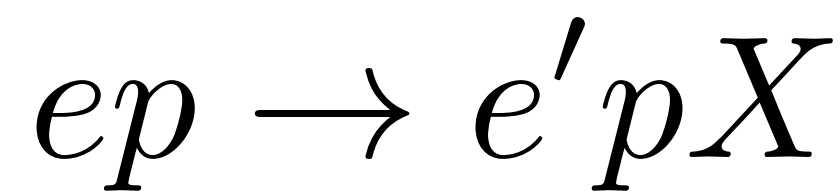
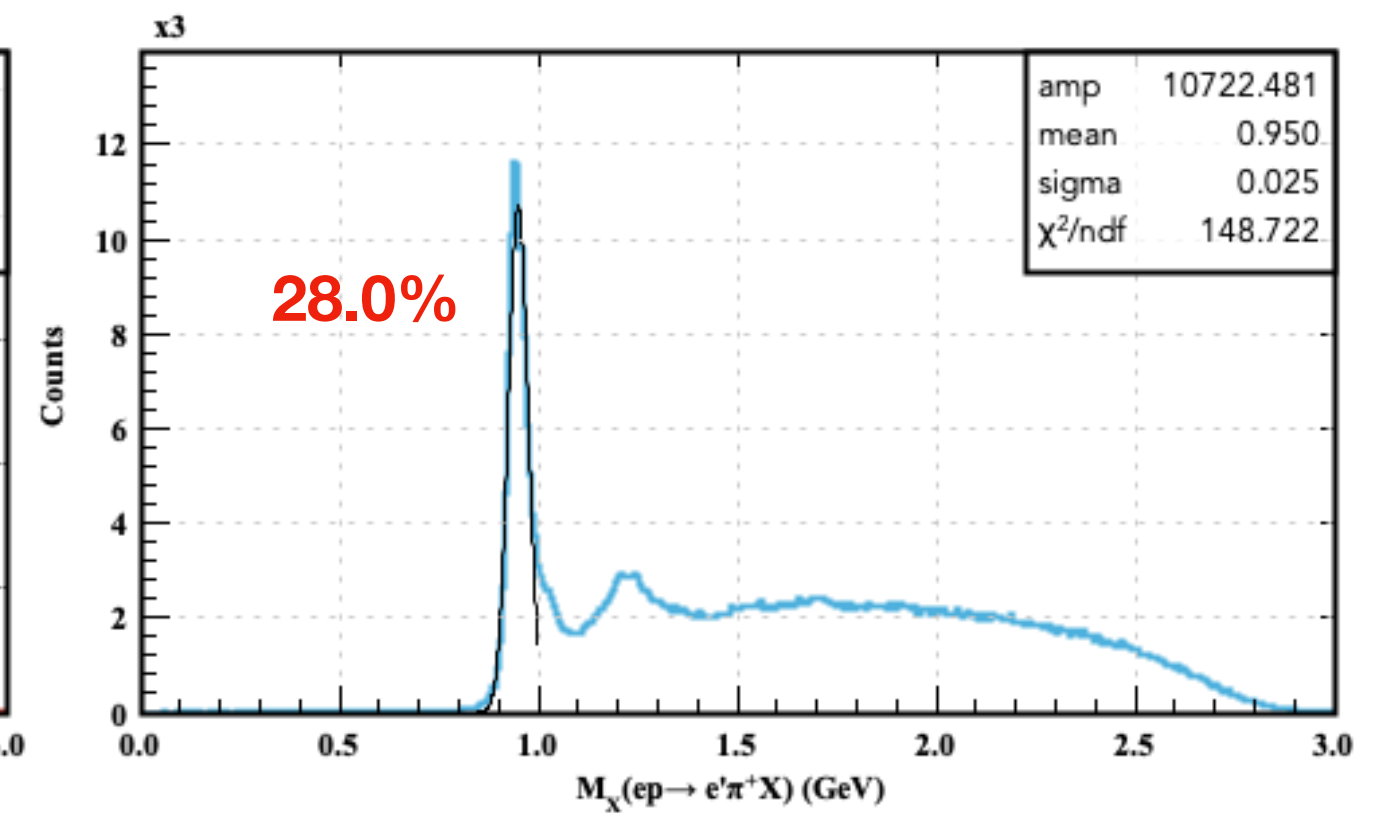
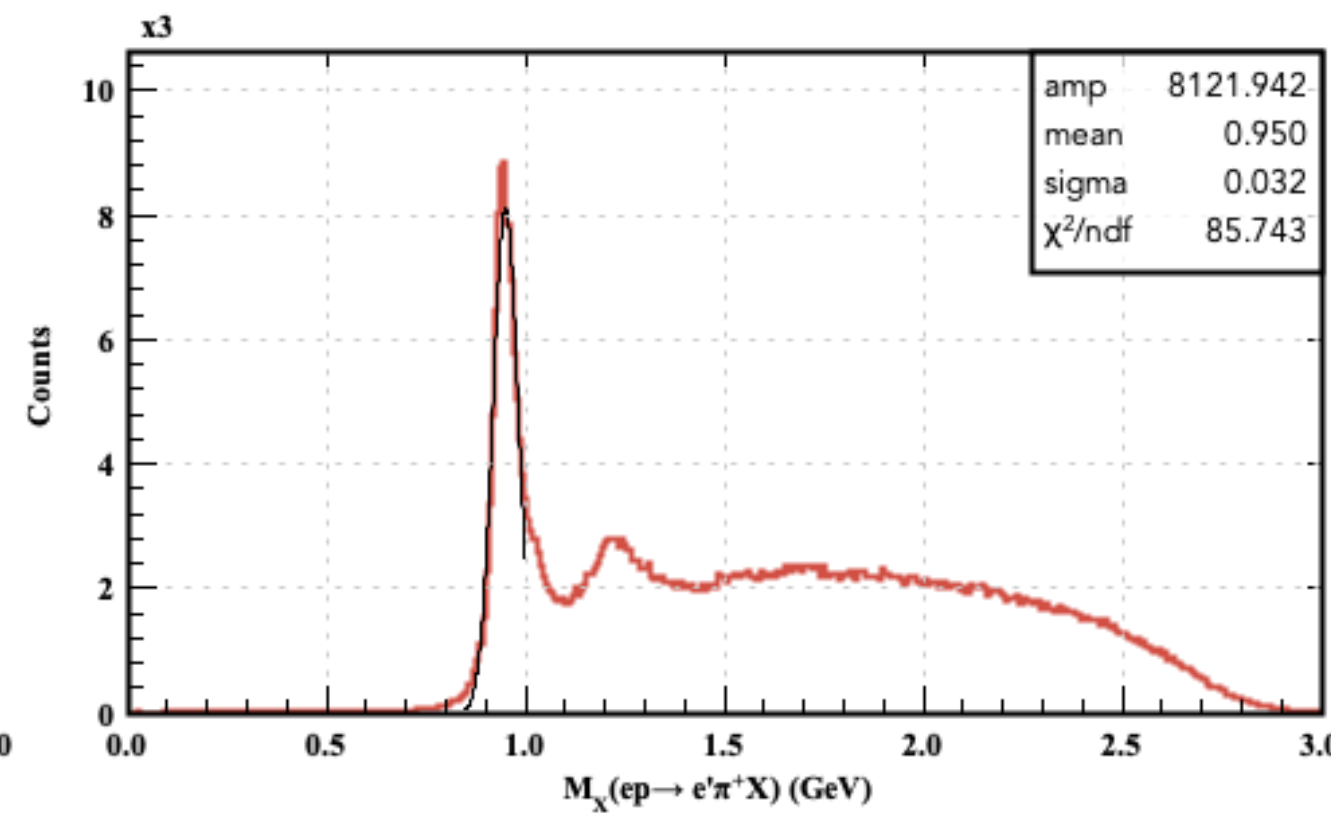
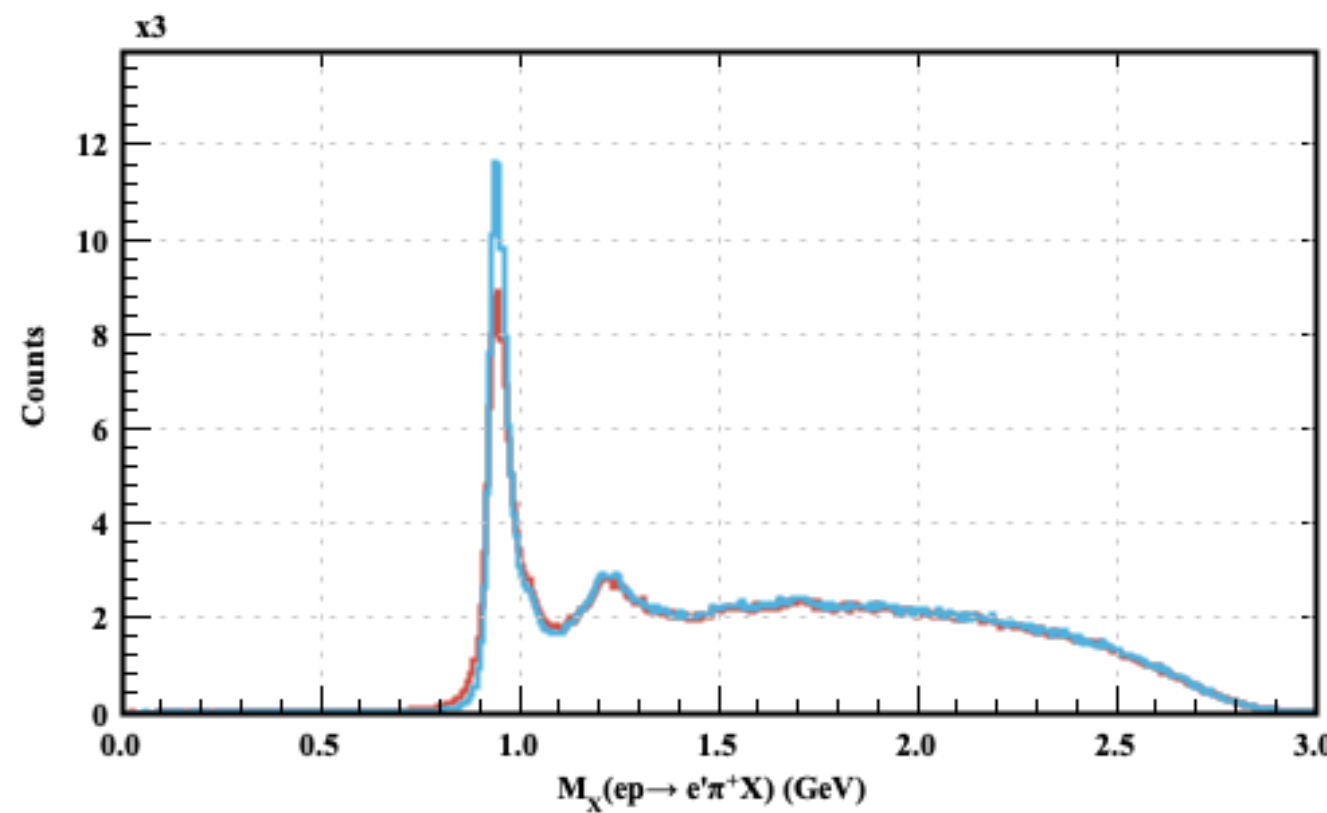
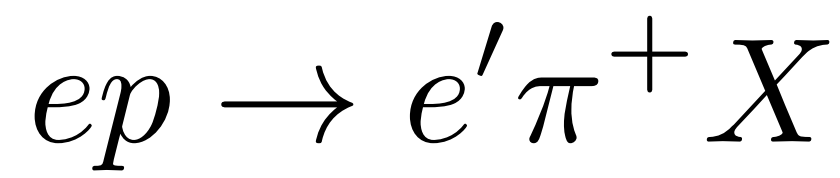


$$ep \rightarrow e' p \pi^- X$$



# Resolution: MM for 2-FSP Channels

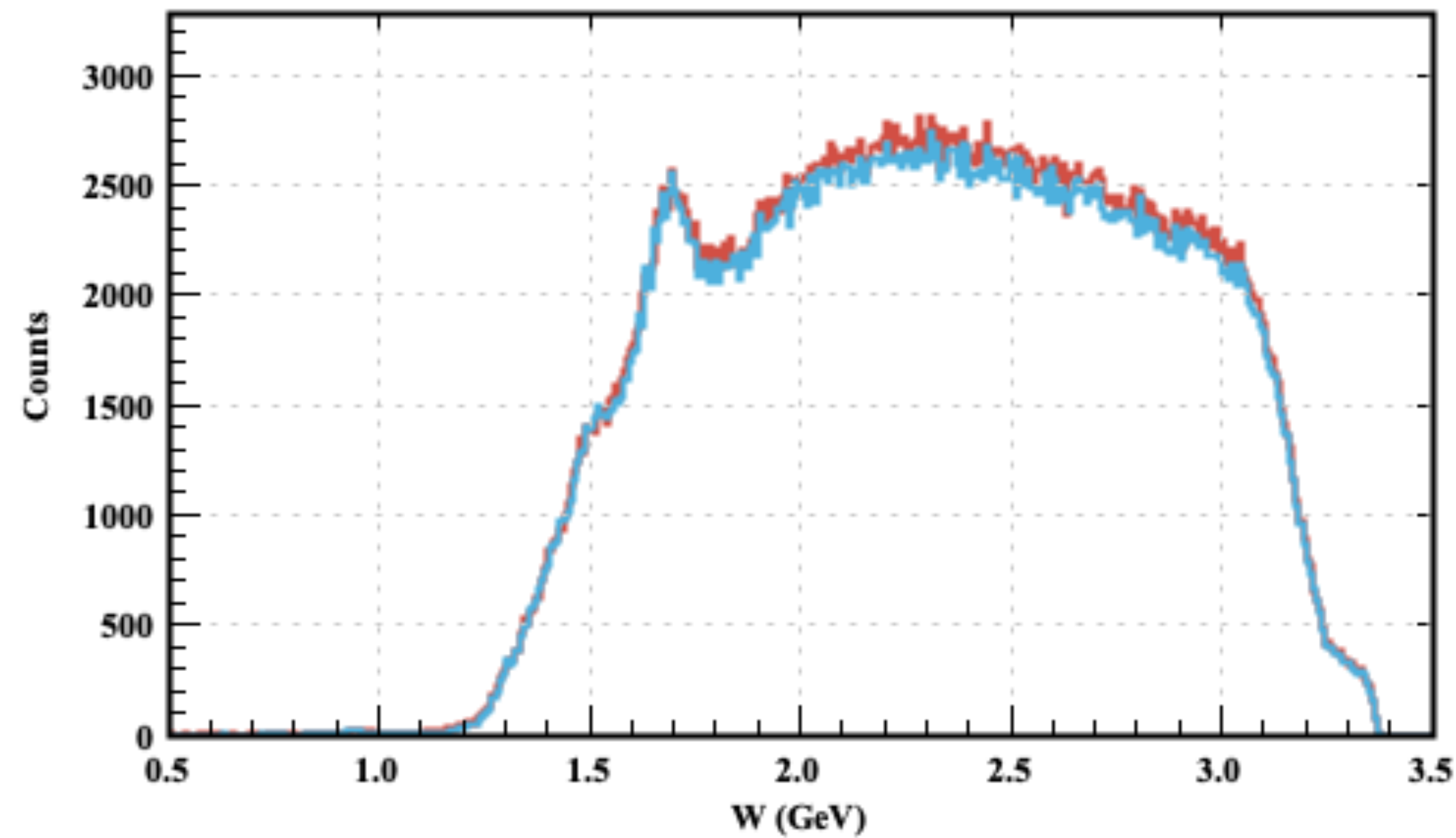
- Red: dev  
- Blue: updates



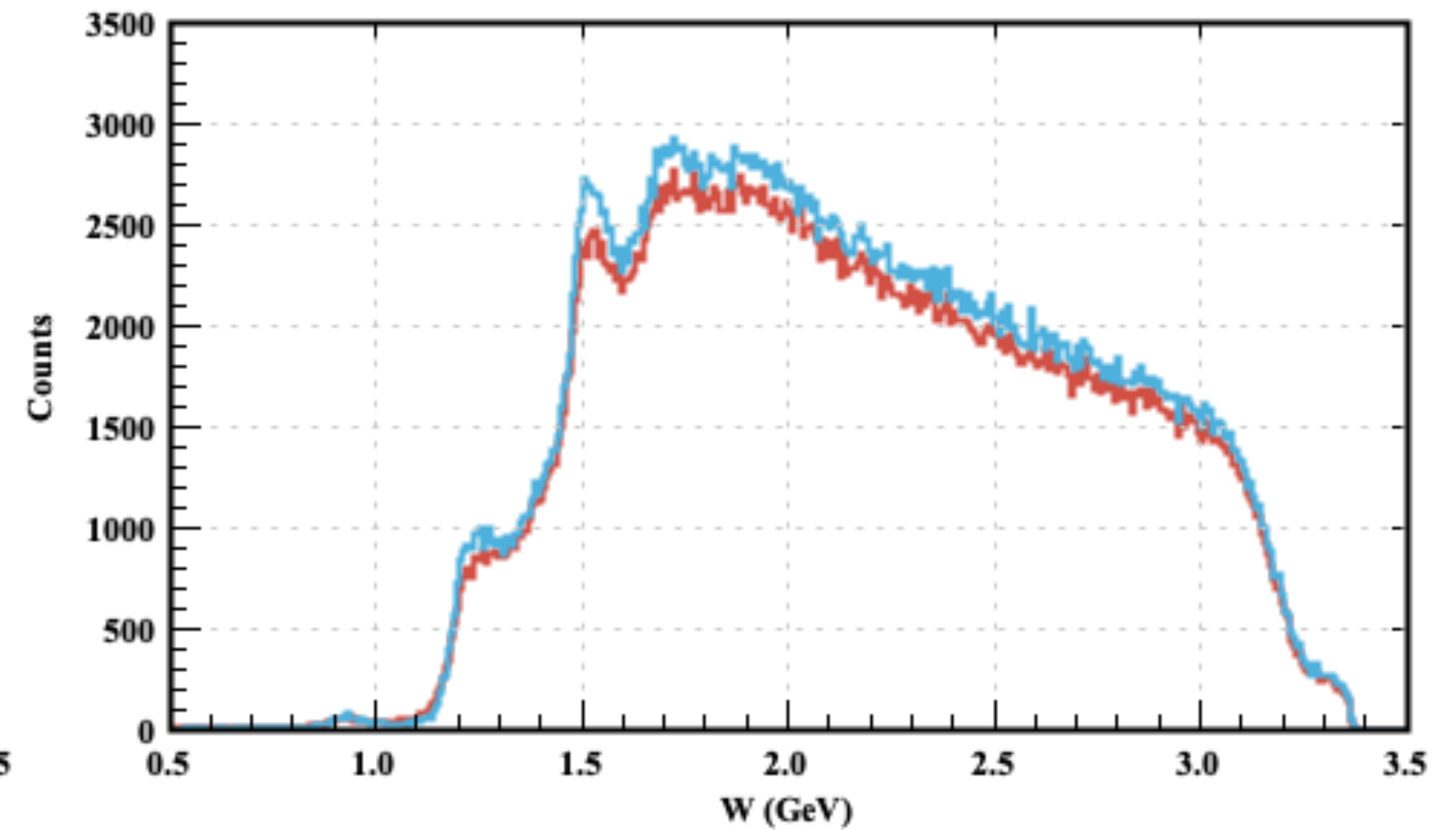
# Resolution: $W$ ( $M_x$ of $ep \rightarrow e' X$ ) for 2-FSP Channels

- Red: dev  
- Blue: updates

$$ep \rightarrow e' \pi^+ X$$



$$ep \rightarrow e' p X$$





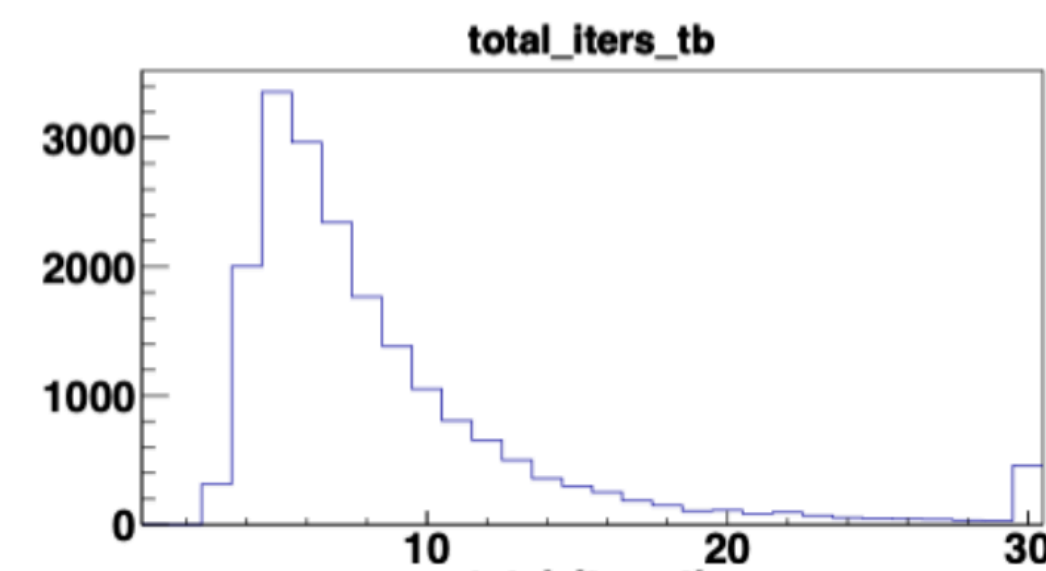
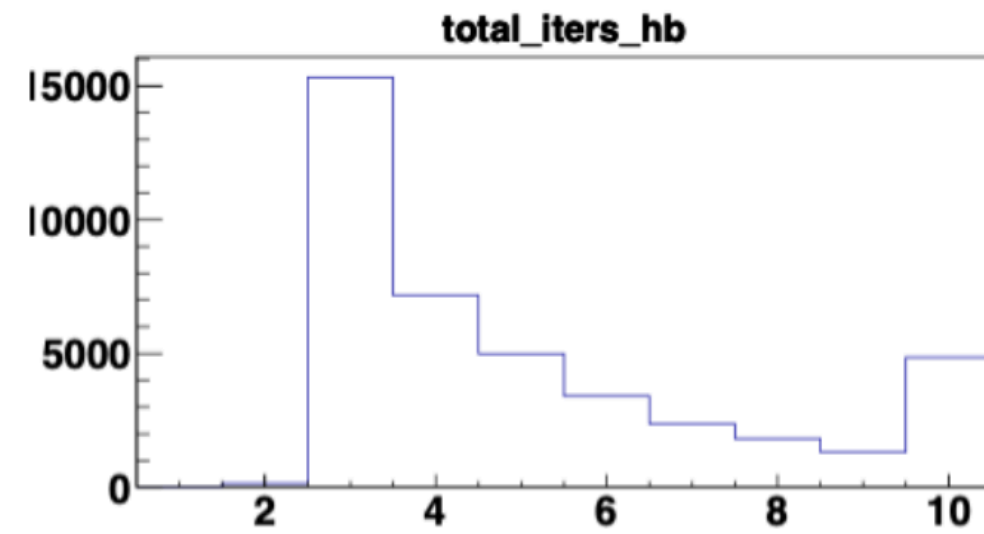
# CPU Efficiency

**HB**

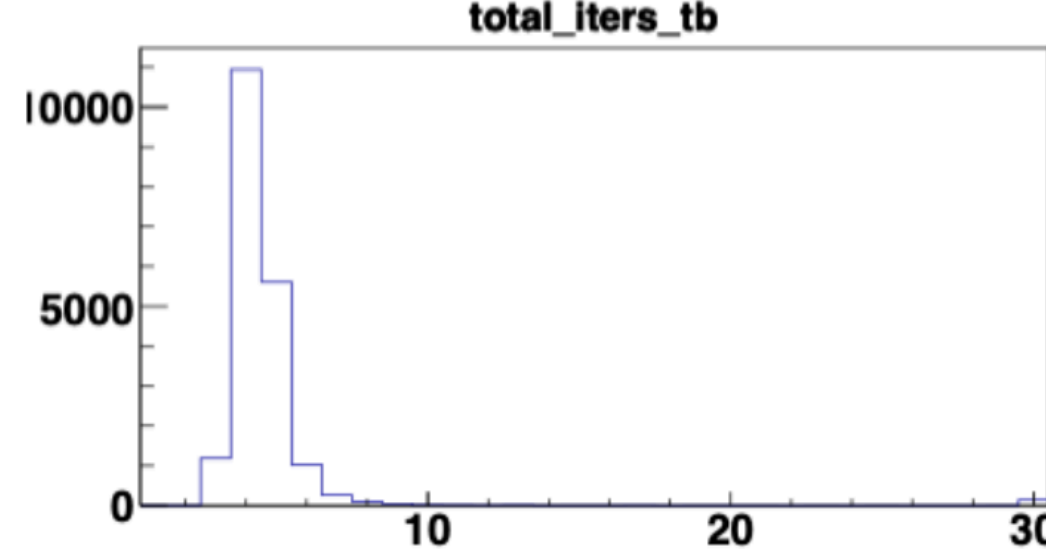
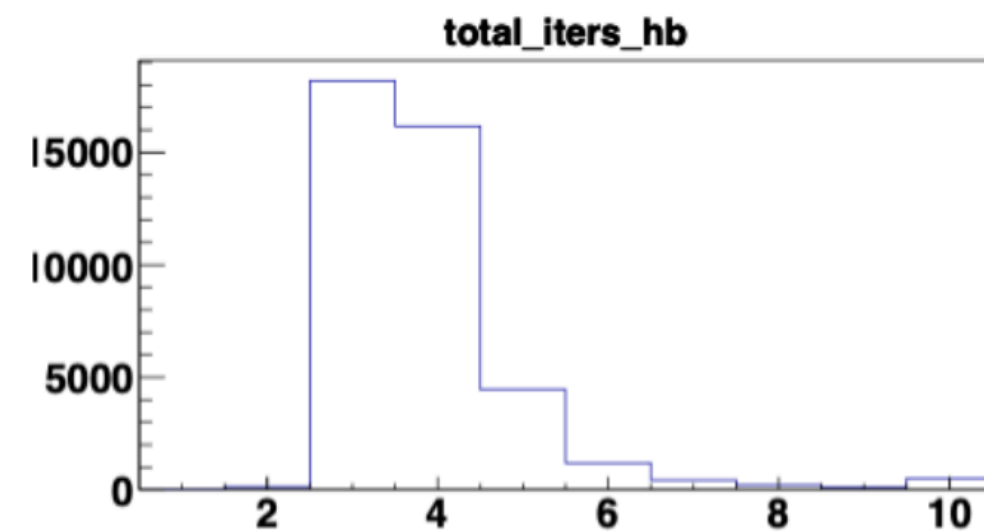
**TB**

RGB run 6299 (50 nA)

**Old**

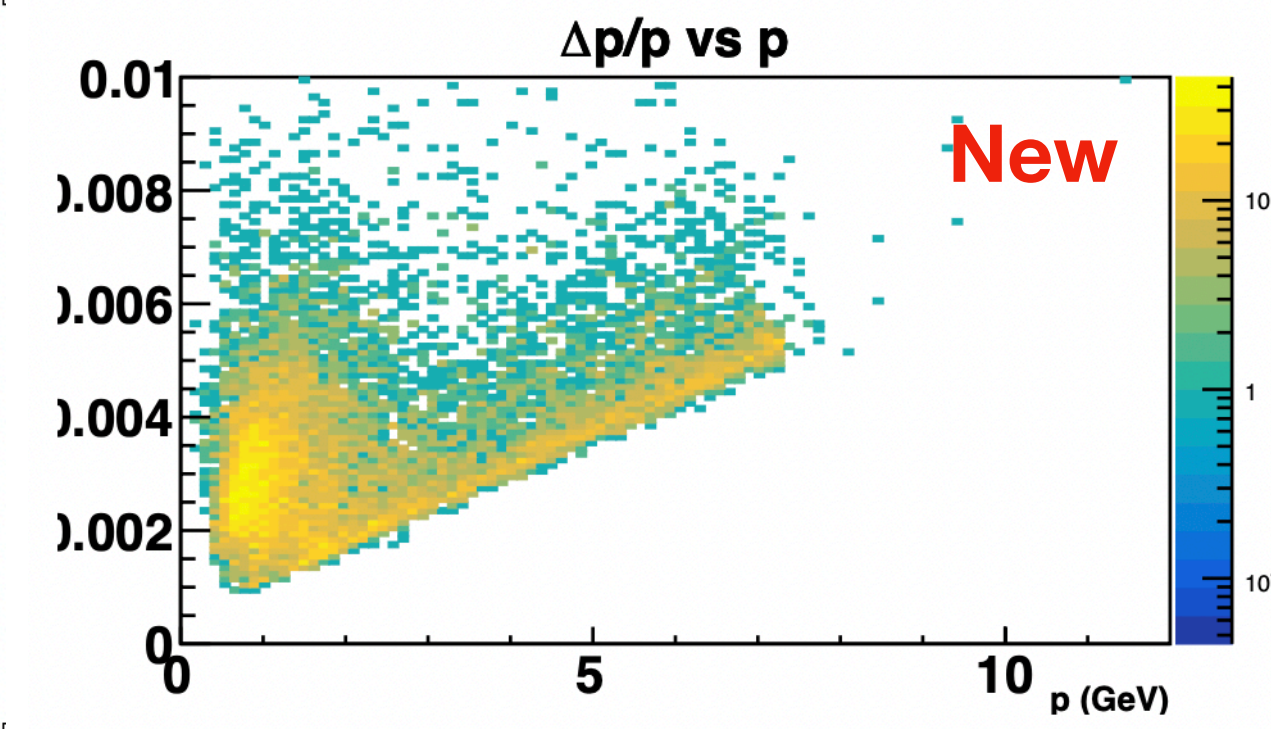
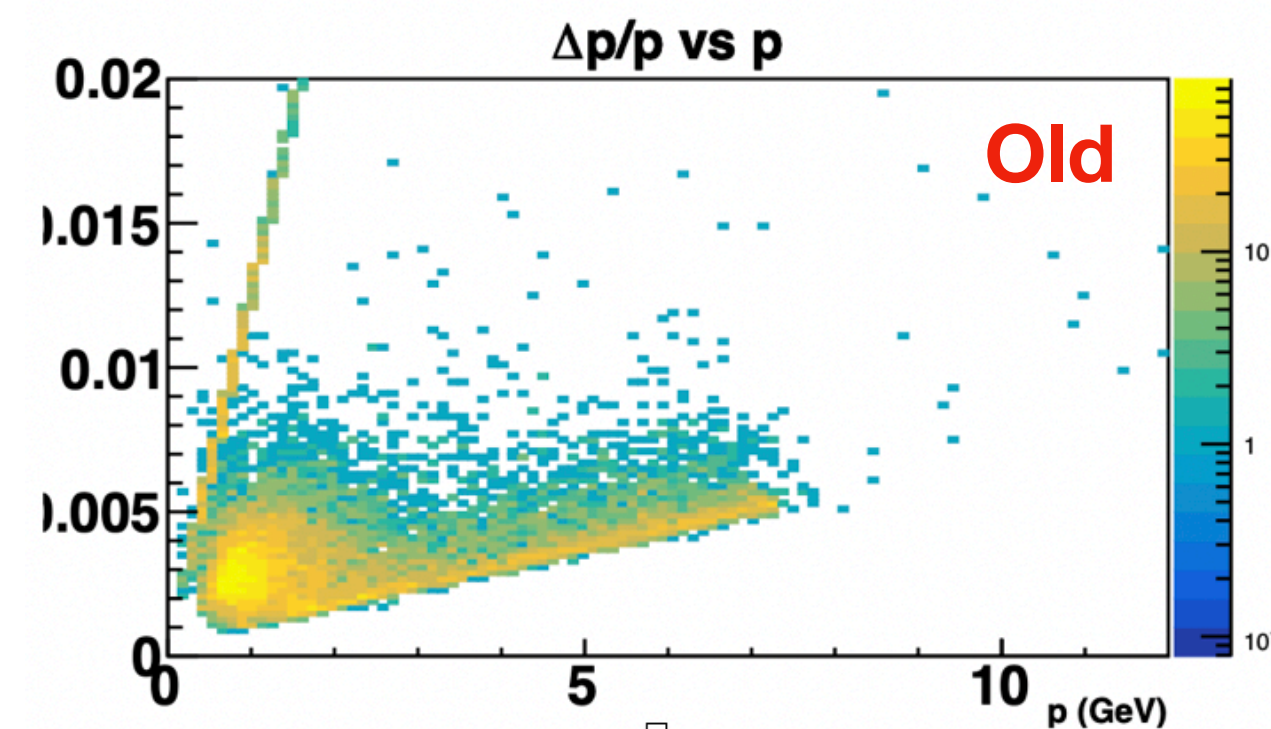


**New**



Denoising	ai/dev	ai/updates	Improvement
<b>HBAI (ms/event)</b>	23.90	20.76	15%
<b>TBAI (ms/event)</b>	74.01	61.85	20%

- Significant contribution on CPU efficiency improvement from resetting conditions for tracking iteration termination is not counted here, since it has been applied for pass2.
- Besides, more successful tracks are reconstructed by the updated tracking package, while tracking for most of these tracks is failed and terminated at the first iteration. These tracks are the main contribution on improvement of statistics.



# Summary and Next

- With FD tracking software updates, tracking efficiency, statistics, resolution and CPU efficiency are comprehensively improved.
- Appreciate that anyone contributes on more validations.
- Some projects for further improvement of forward tracking quality include:
  - DAF parameters will be tuned to optimize tracking efficiency and resolution.
  - A straight tracking package with four track parameters  $(x, y, t_x, t_y)$  will be developed. It will help studies of alignment and calibration.
  - With account of trackers' local rotation, development for a non-straight tracking package with six track parameters  $(x, y, z, \theta, \varphi, q/p)$  is in plan.
  - More AI-technique applications are in discussion.