

# Momentum Corrections for charged particles in Forward Detector from pass-1 RGA dataset

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on behalf of Momentum Corrections group

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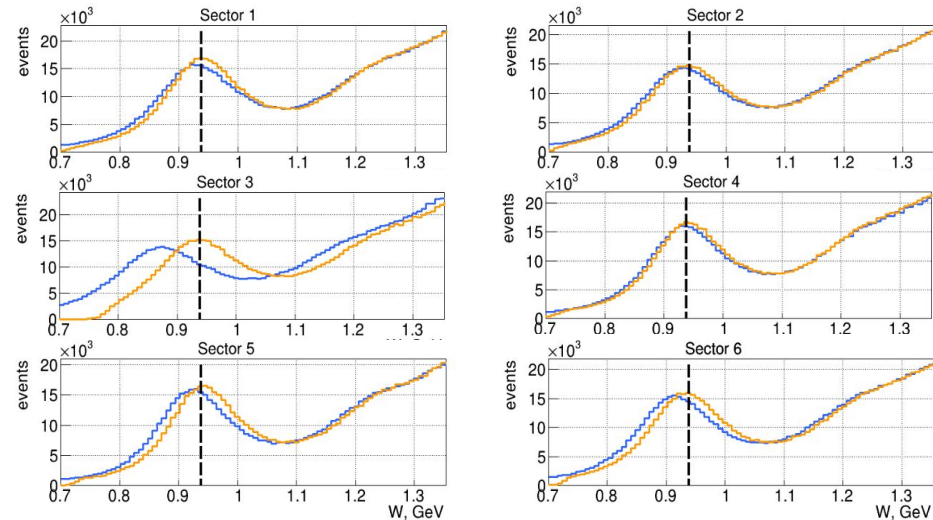
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Sources of momentum reconstruction inaccuracies:

- Magnetic field map
- Detectors alignment
- Passive material budget
- Others

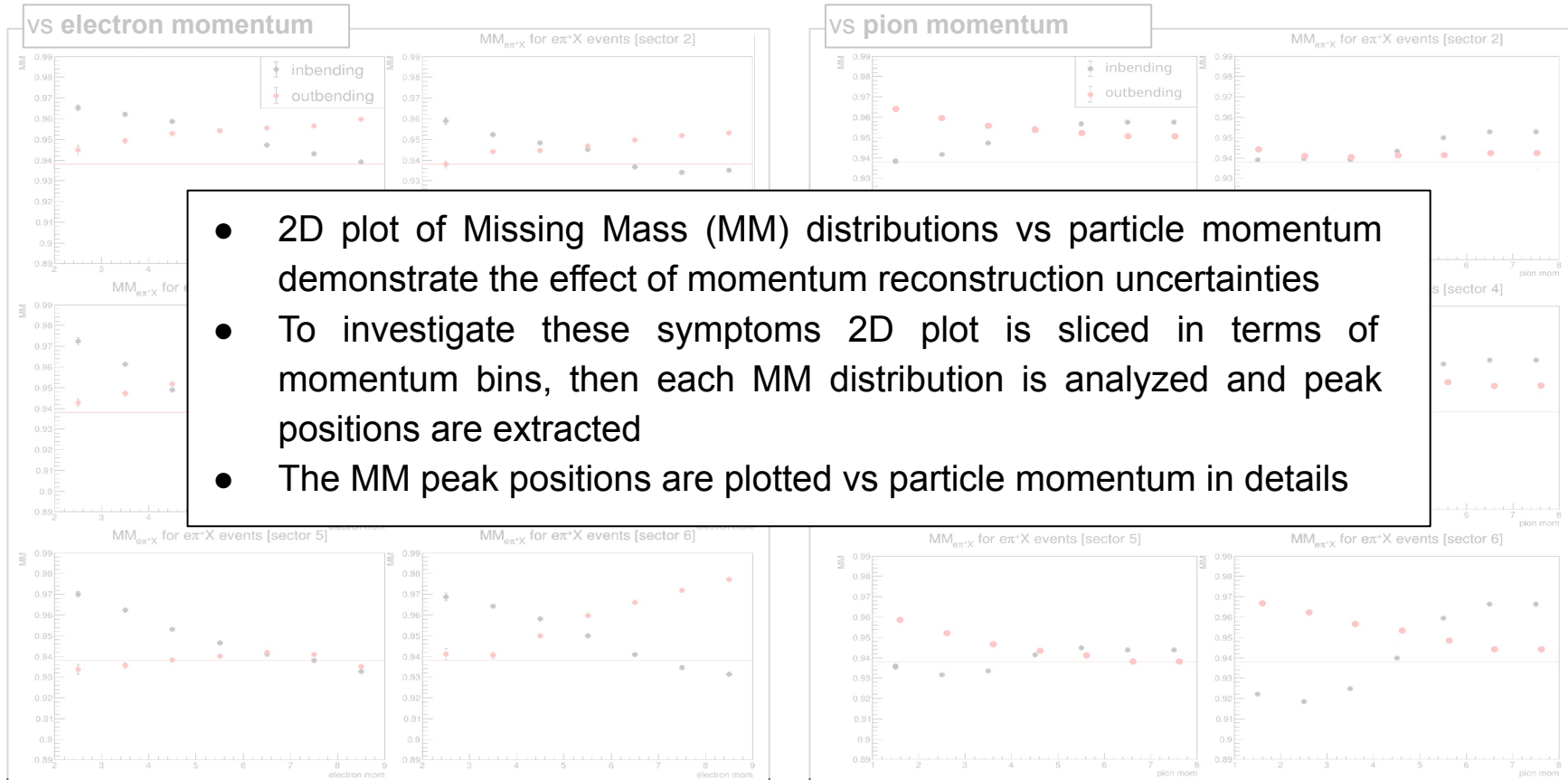
Symptoms:

- Elastic peak positions
- Shift of missing mass peak positions in exclusive channels



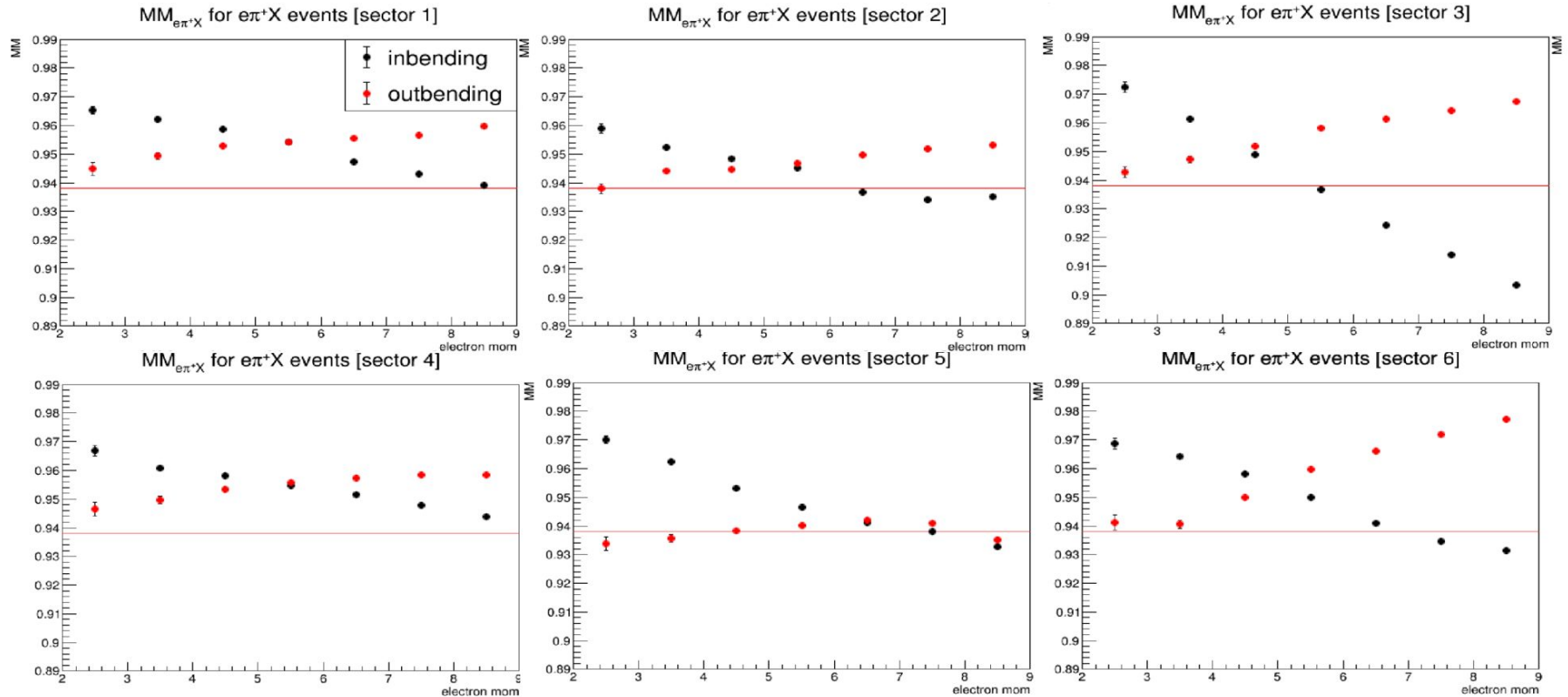
Elastic peak positions

# Motivation: $MM(e\pi^+X)$ for $e\pi \rightarrow e\pi^+(N)$



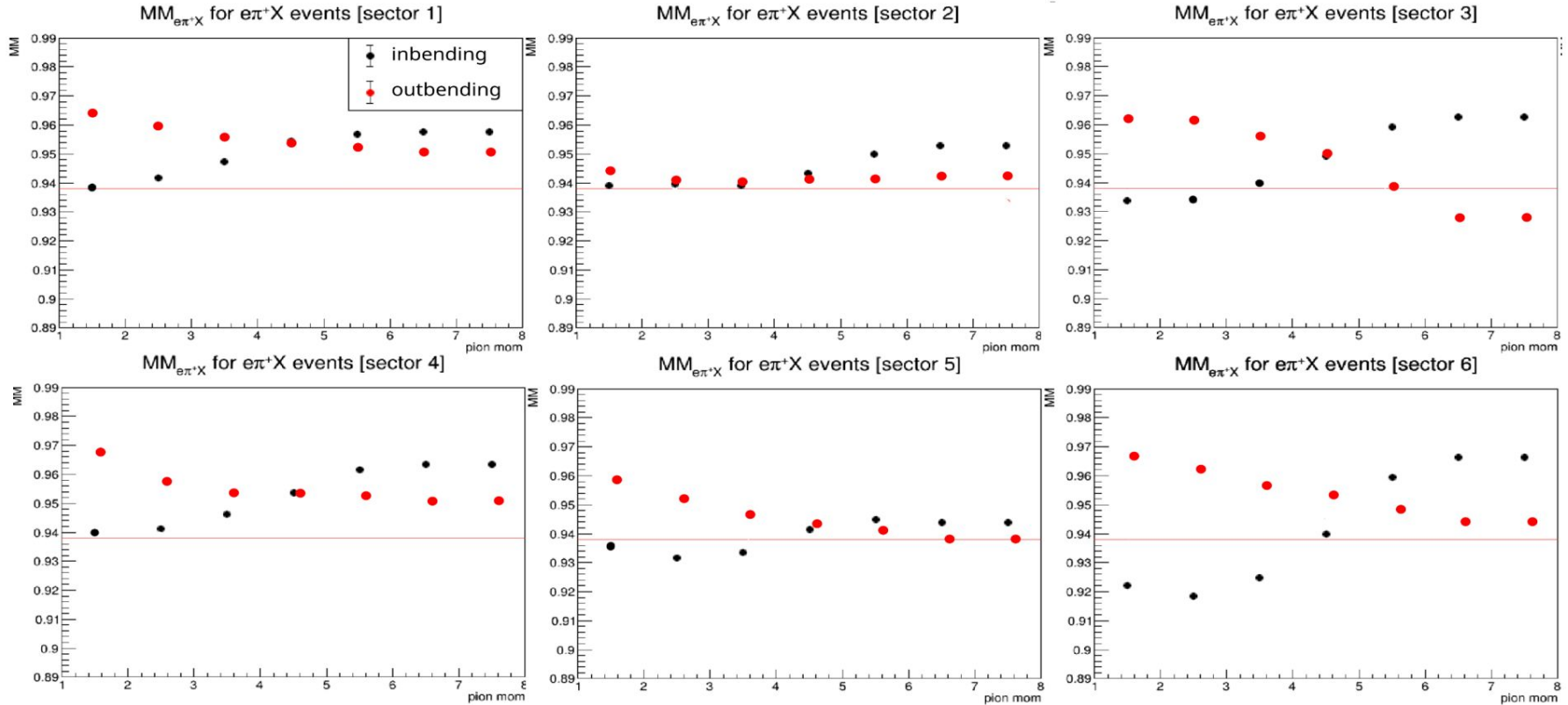
# Motivation: $MM(e\pi^+X)$ for $ep \rightarrow e\pi^+(N)$

vs electron momentum



# Motivation: $MM(e\pi^+X)$ for $e\pi^+(N)$

vs pion momentum

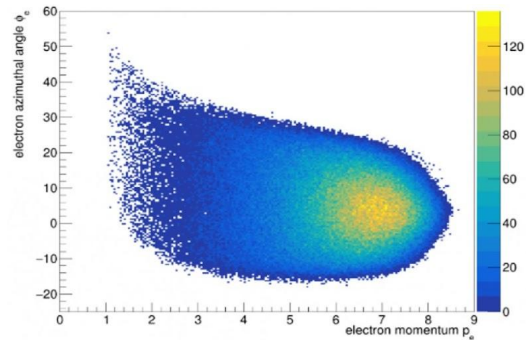


- In addition to momentum dependence we look at **the azimuthal  $\varphi$  dependence** inside each sector
  - **The deviations of the missing mass values from nominal become even more evident**
- For the next slides we will look at:
  - MM peak position as a function of momentum for 3 individual azimuthal  $\varphi$  bins for each sector and each particle type

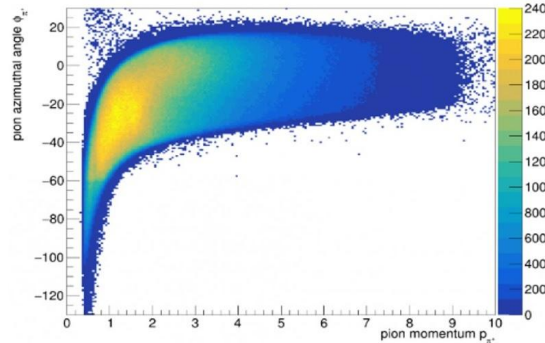
# Introduction of $\varphi$ dependence: $\varphi$ kick due to solenoid field

sector  $\varphi$  angle

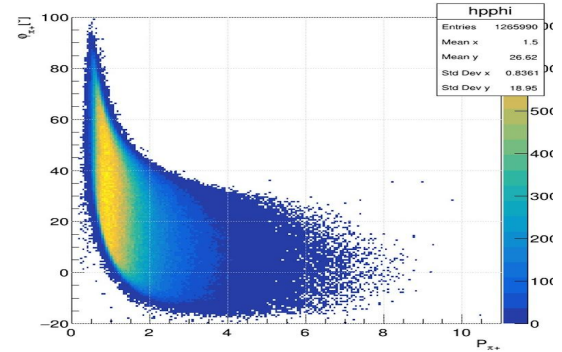
ELECTRON



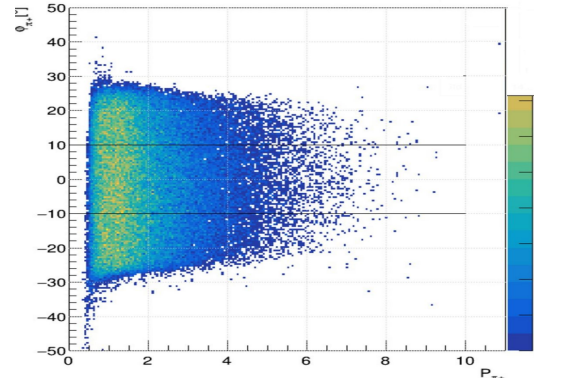
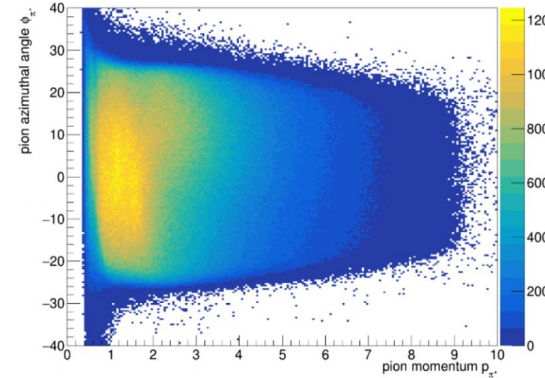
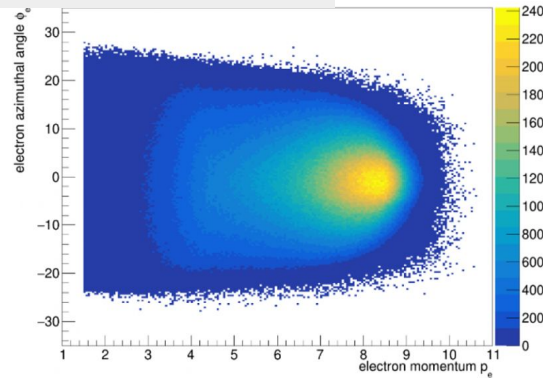
$\pi^+$

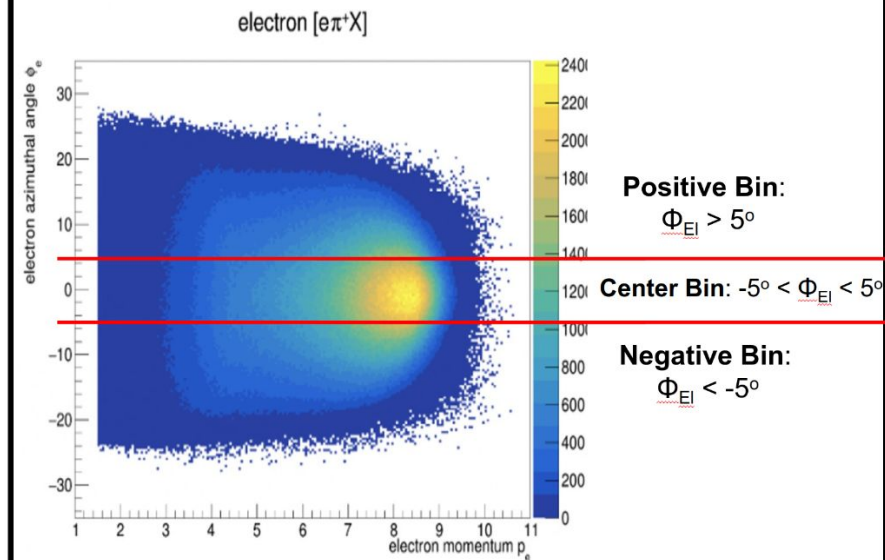
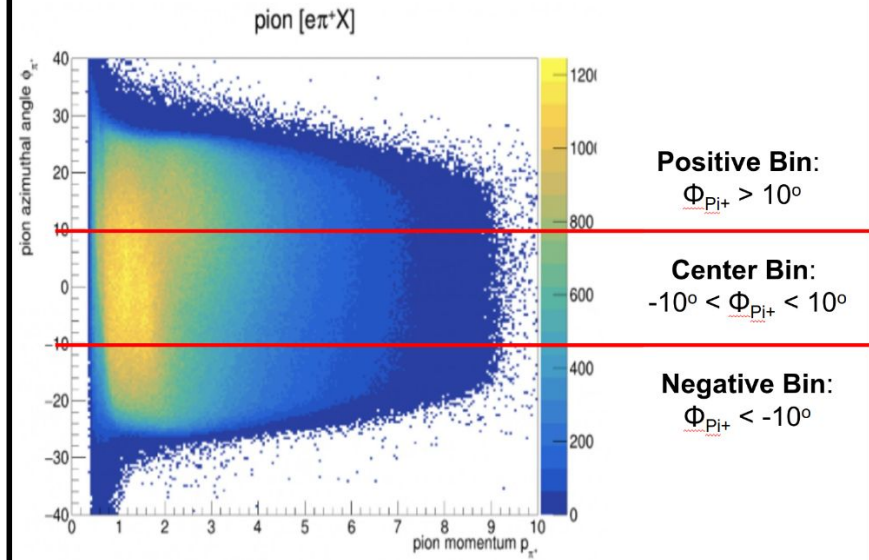


$\pi^-$



shifted sector  $\varphi$  angle

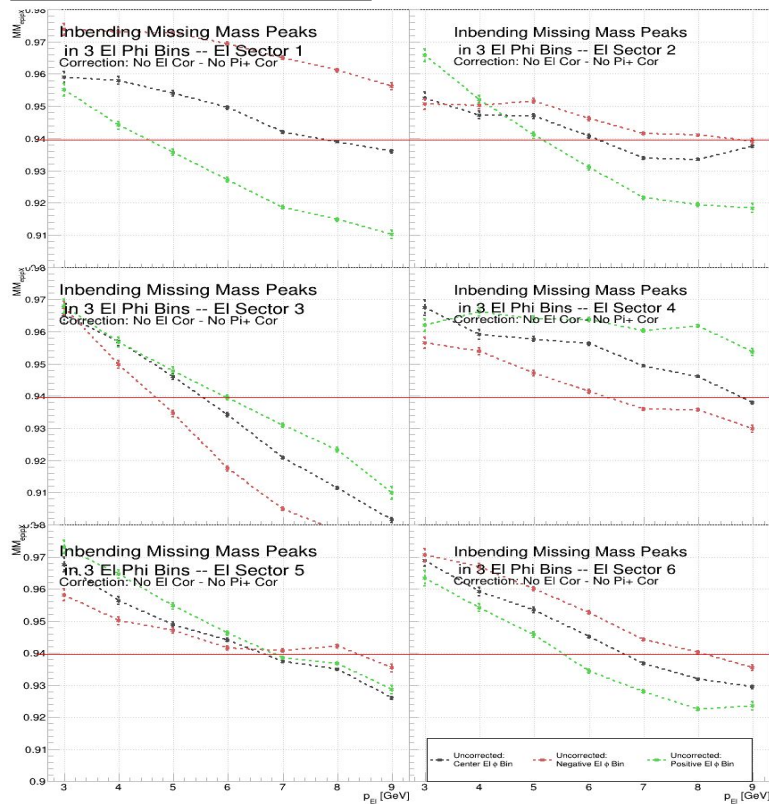


Electron Phi Bins:Pi+ Phi Bins:

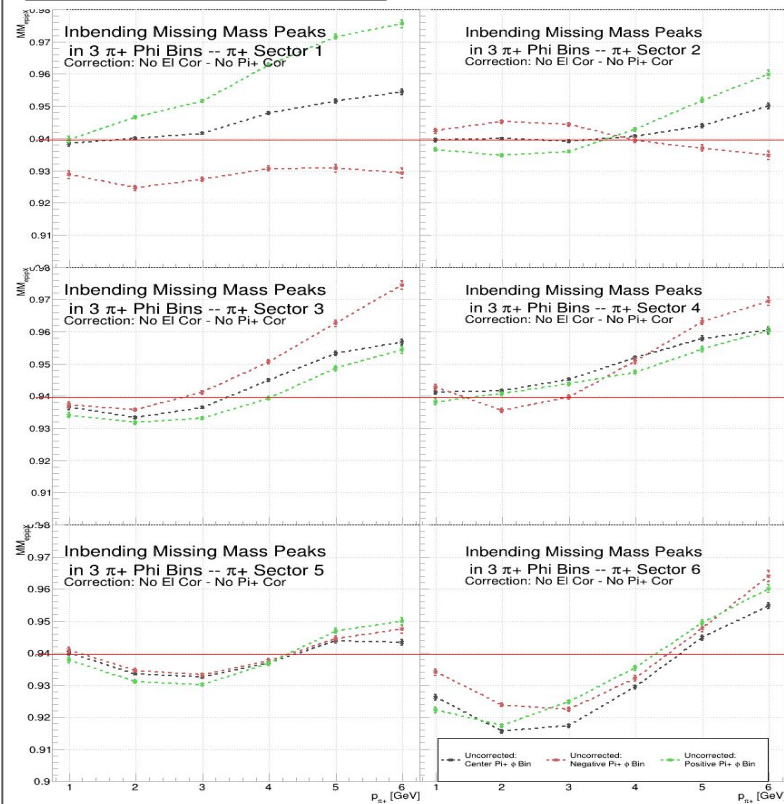


---  $\varphi$  bin 1  
 ---  $\varphi$  bin 2  
 ---  $\varphi$  bin 3

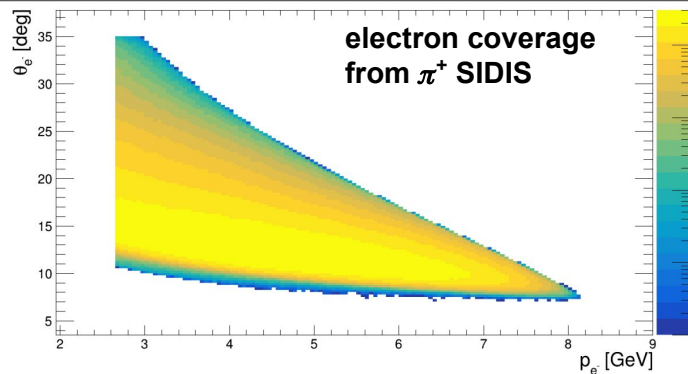
## vs electron momentum



## vs pion momentum



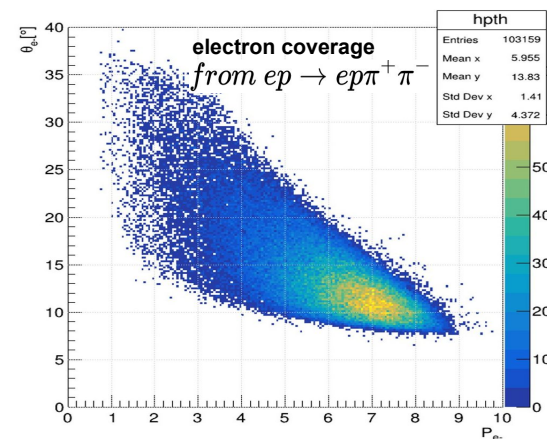
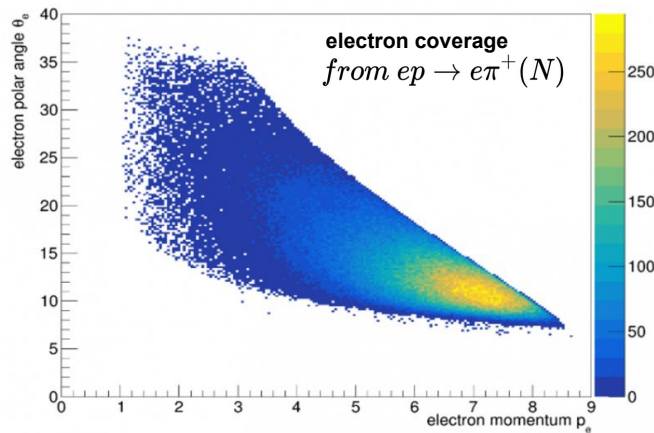
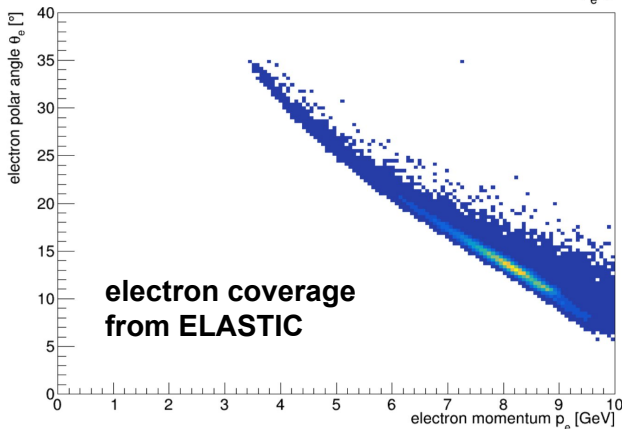
# Kinematic coverages - electron coverage



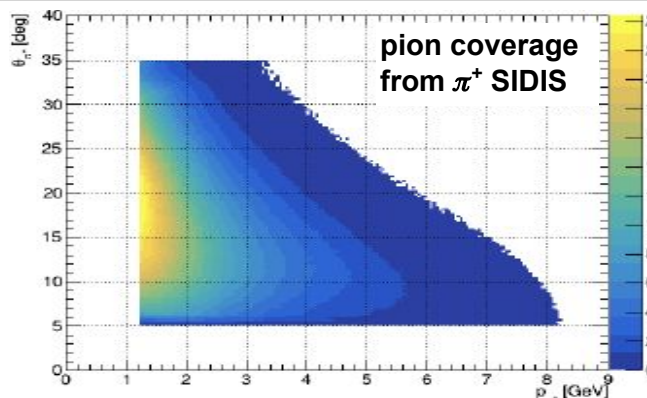
Electron momentum (P) vs polar angle ( $\theta$ ) coverages:

- Elastic - cleanest way, but very narrow kinematic coverage
- Single pion channel
- Double pions channel

Exclusive  $\pi^+$  and  $\pi^+\pi^-$  channels offer **wider kinematic coverages**



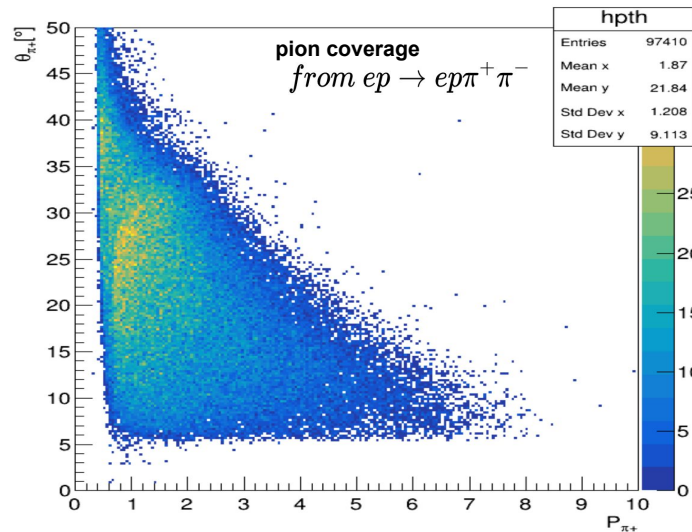
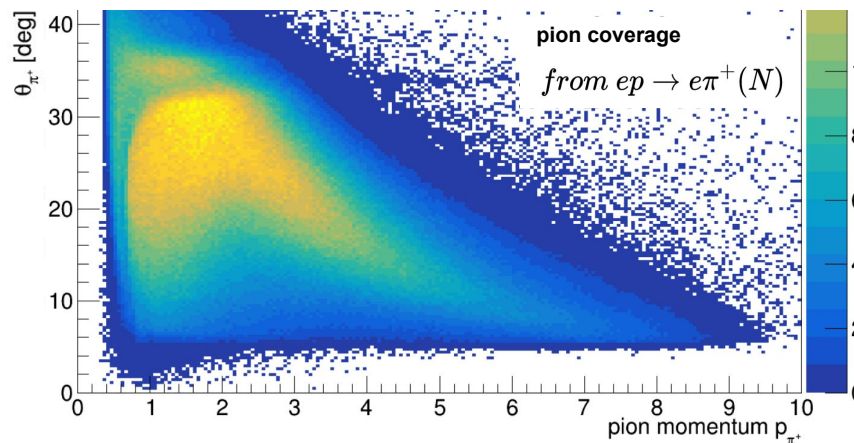
# Kinematic coverages - $\pi^+$ coverage



$\pi^+$  momentum (P) vs polar angle ( $\theta$ ) coverages:

- $\pi^+$  SIDIS
- Single pion channel - to extract  $\pi^+$  correction
- Double pions channel - use  $\pi^+$  correction and extract  $\pi^-$  and **proton** correction

Exclusive  $\pi^+$  and  $\pi^+\pi^-$  channels offer **wide kinematic coverages**



## Combined approach

- Using single channel for momentum correction extraction does not yield universal correction due to limited kinematic coverage of each individual exclusive channel
- Combined approach is using both  $e\pi^+\pi^-p$  and  $e\pi^+N$  channels to extract momentum corrections: ( $MM_{e\pi^+\pi^-X}$  from  $e\pi^+\pi^-p$ ) and ( $MM_{e\pi^+X}$  from  $e\pi^+N$ ) events
- Independent correction functions are applied to each of three particles on event by event basis, and absolute shift of missing mass from nominal value is calculated for the whole dataset
- **this absolute shift is used as minimization criteria for finding the corrections**

$$\chi^2 = \sum_{i < nEvents} \left( MM_i^{e\pi^+\pi^-X} - M_p \right)^2 + \sum_{i < nEvents} \left( MM_i^{e\pi^+X} - M_n \right)^2$$

- Reiterate electron corrections using single pion channel
  - introduce  $\varphi$  dependence
- Reiterate  $\pi^+$  corrections using single pion channel
  - introduce  $\varphi$  dependence
- Reiterate electron corrections again using single pion channel
- Reiterate  $\pi^-$  corrections using 2 pions channel

$$\Delta p = (\alpha_a \phi^2 + \beta_a \phi + \gamma_a) p^2 + (\alpha_b \phi^2 + \beta_b \phi + \gamma_b) p + (\alpha_c \phi^2 + \beta_c \phi + \gamma_c)$$

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- Each correction has  $3 \times 3 = 9$  parameters:
  - quadratic dependence on momentum of the particle
  - quadratic dependence on azimuthal angle of the particle
- The correction is uniquely defined for each particle type and for each sector
  - particle types (e.g. electron,  $\pi^+$ ,  $\pi^-$ )  $\times$  6 sectors

Total:  $3 \times 3 \times 6 = 54$  correction parameters for each particle

$$e \pi^+ (N)$$

## $\pi^+$ correction iteration: calculation of $\pi^+$ momentum and its correction $\Delta P$

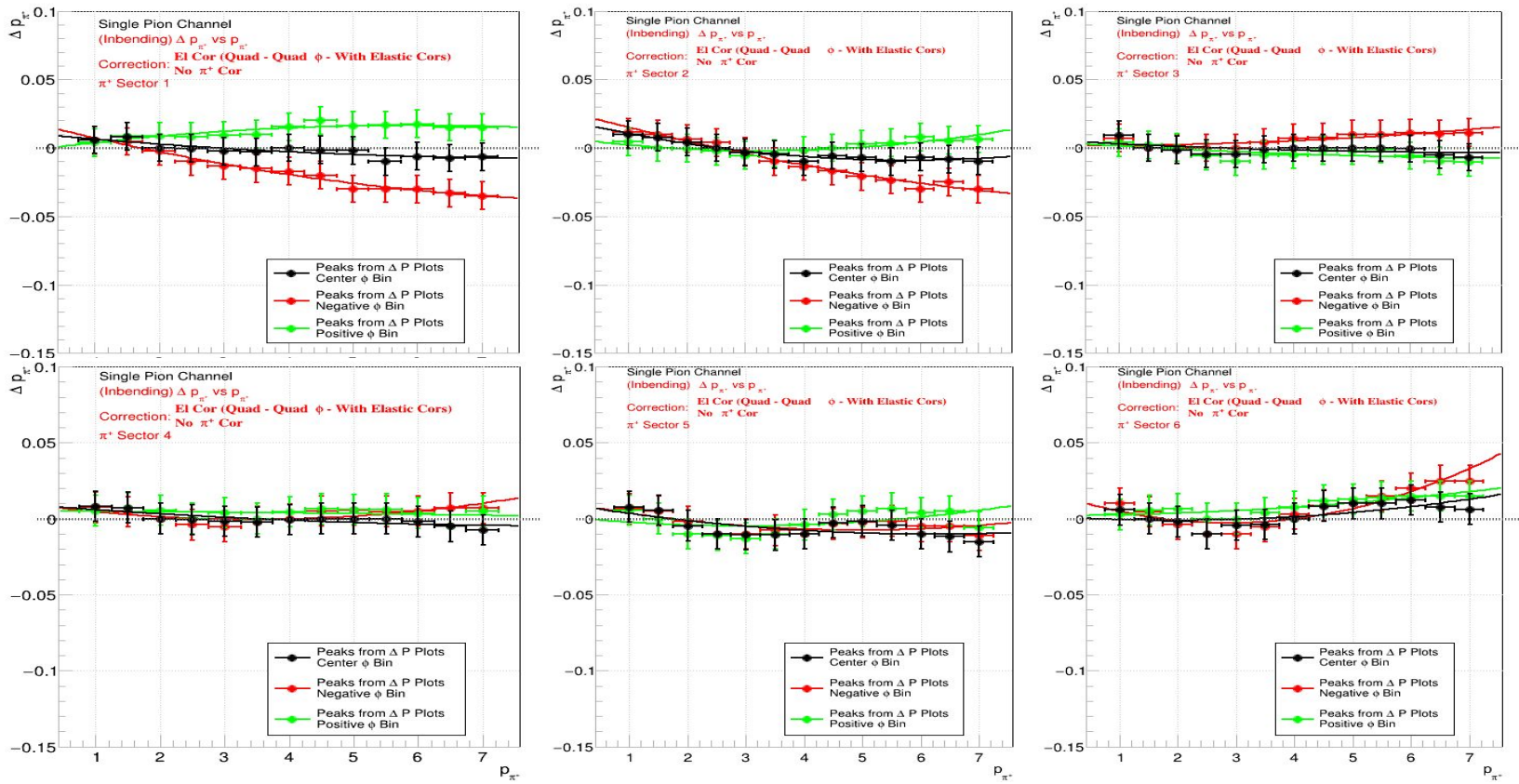
- Trusting electron corrected momentum, we can calculate  $\pi^+$  momentum from the following equation:  $(e + p - e' - \pi^+)^2 = M_N^2$
- The calculated correction for the  $\pi^+$  momentum:  $\Delta p = p_{calc} - p_{rec}$
- The determined correction is plotted vs  $\pi^+$  momentum and fitted with pol2 function in 3 individual  $\varphi$  bins for each of 6 sectors
- Each of the parameters is then plotted vs  $\varphi$  value and fitted with pol2 function

$$\Delta p = (\alpha_a \phi^2 + \beta_a \phi + \gamma_a) p^2 + (\alpha_b \phi^2 + \beta_b \phi + \gamma_b) p + (\alpha_c \phi^2 + \beta_c \phi + \gamma_c)$$

- The electron correction is iterated in similar procedure after the  $\pi^+$  momentum correction is defined using the procedure above

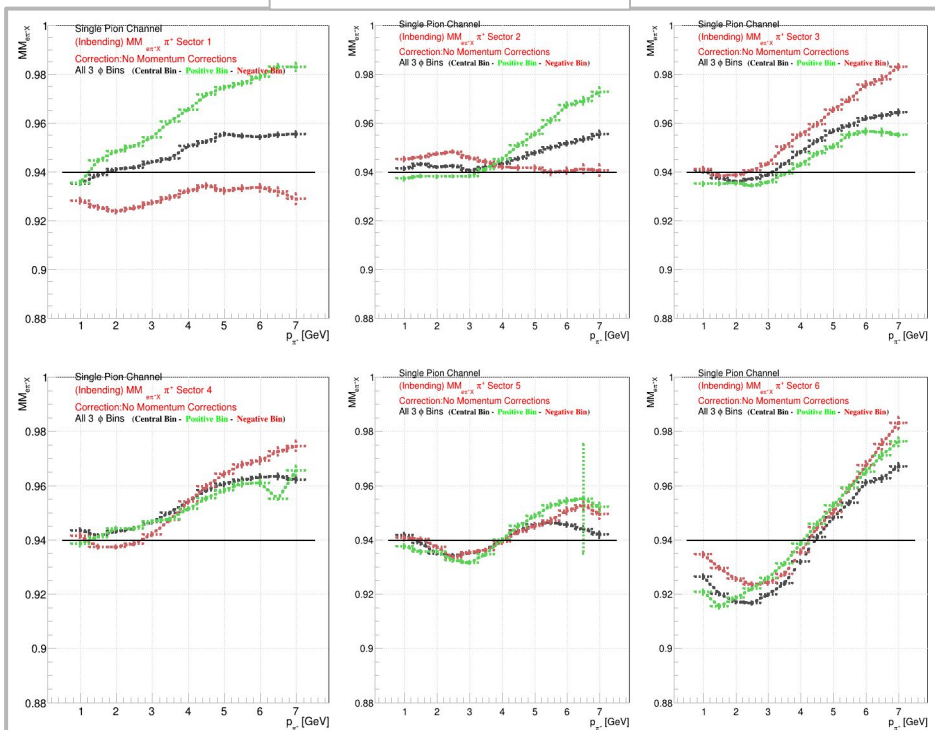


# $\Delta P$ vs $P$ : for $\pi^+$ , after electron momentum is corrected

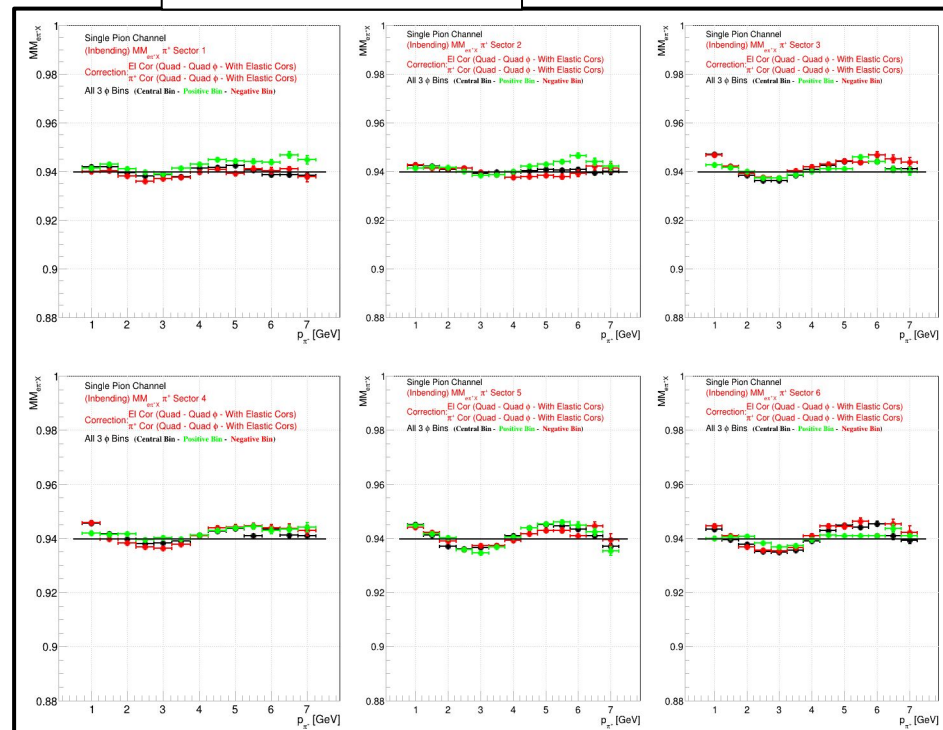


# Inbending: MM for $e\pi^+X$ system before/after electron and $\pi^+$ corrections

## Before corrections



## After corrections



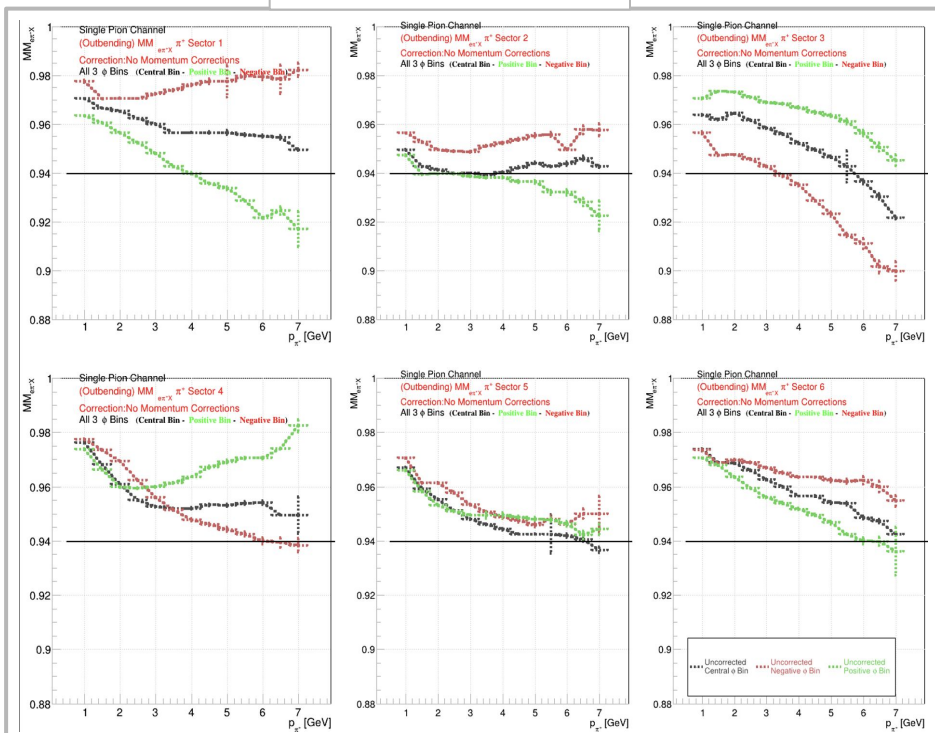
◆  $\phi$  bin 1

◆  $\phi$  bin 2

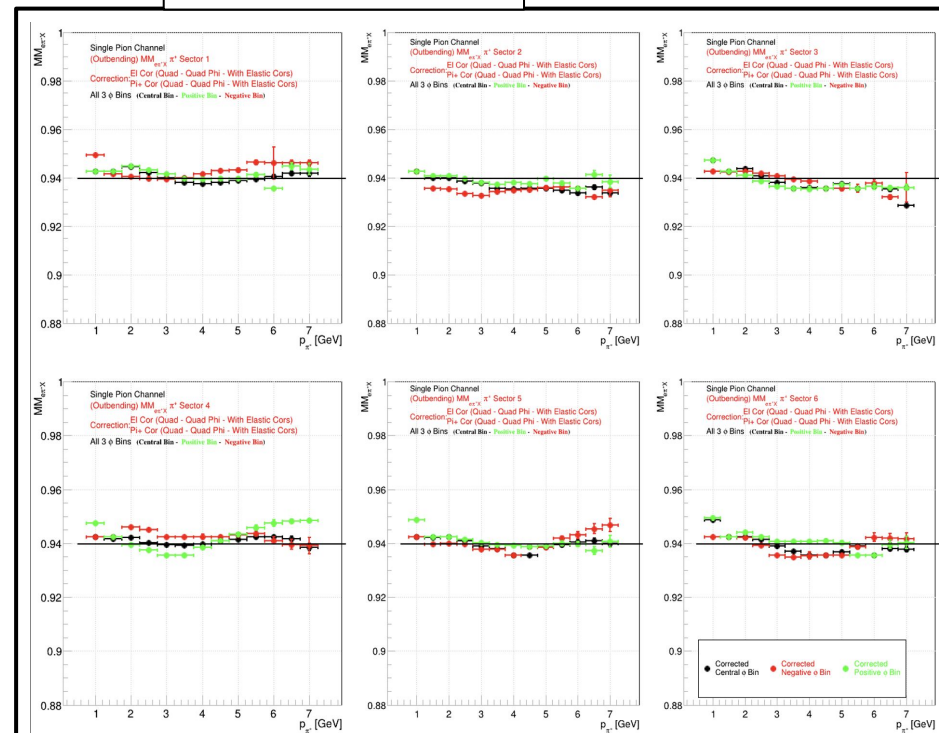
◆  $\phi$  bin 3

# Outbending: MM for $e\pi^+X$ system before/after electron and $\pi^+$ corrections

## Before corrections



## After corrections



●  $\phi$  bin 1

●  $\phi$  bin 2

●  $\phi$  bin 3

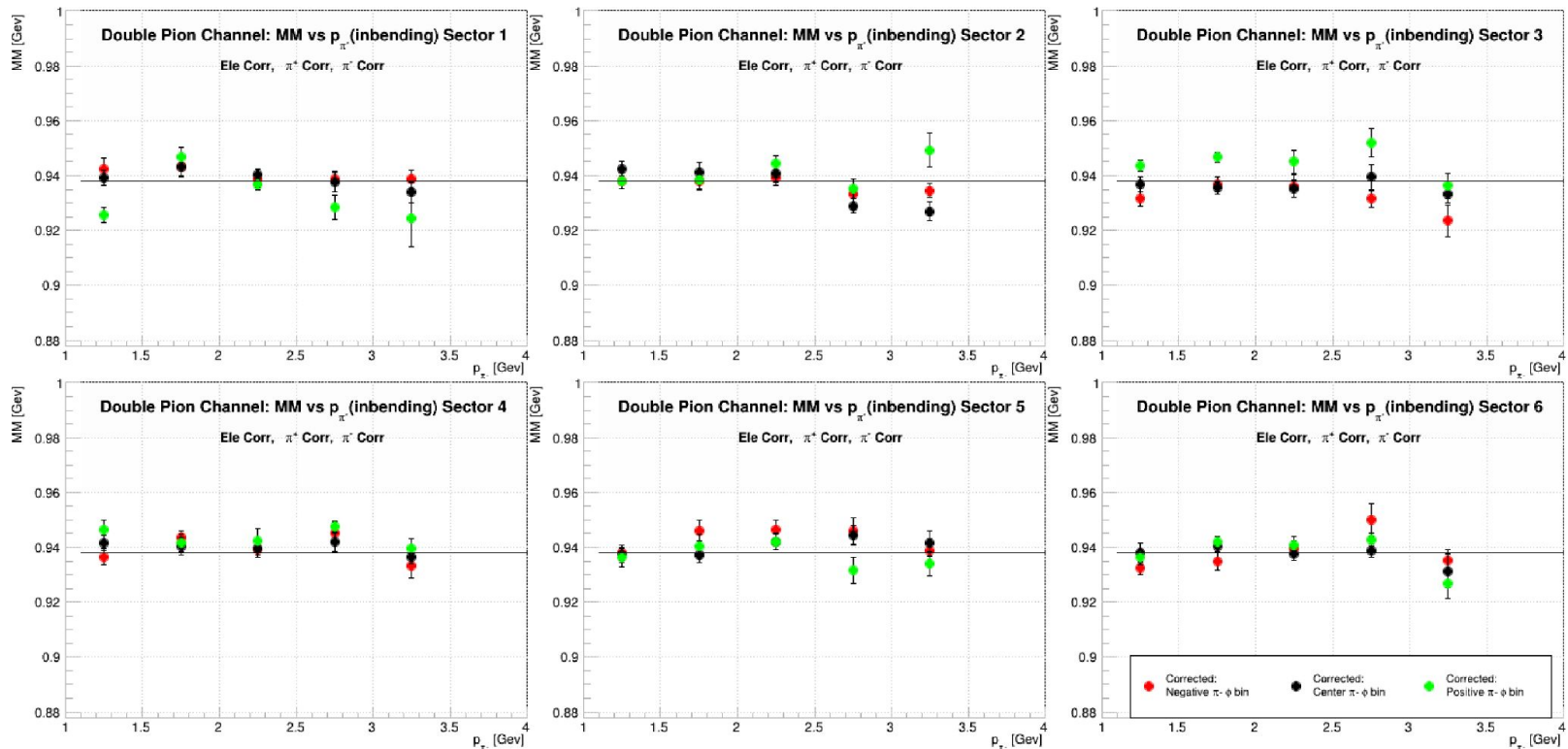
$\pi^-$  corrections:  
 $e \pi^+ \pi^- (P)$

## $\pi^-$ correction iteration: calculation of $\pi^-$ momentum and its correction $\Delta P$

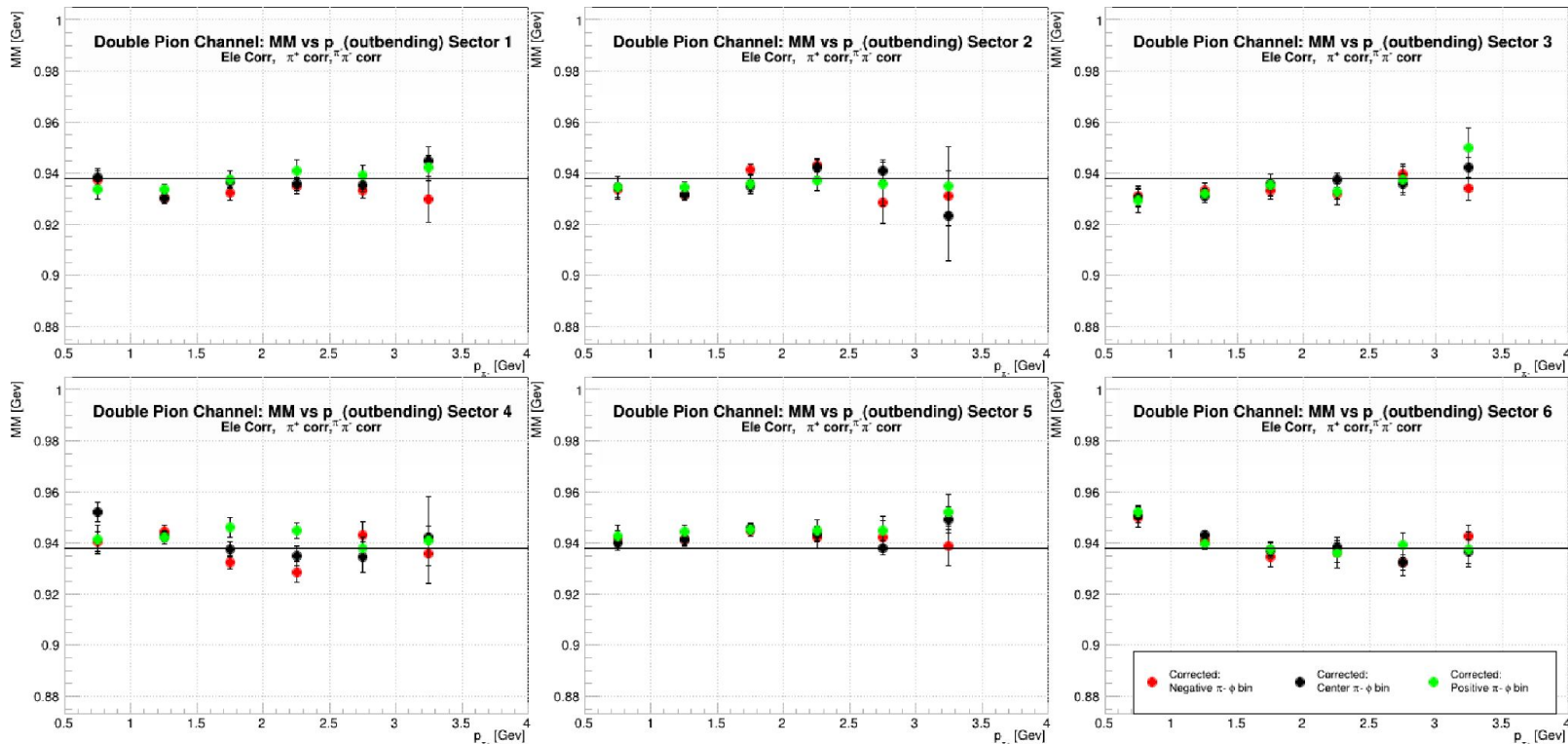
similarly to  $\pi^+$  procedure

- Trusting electron and  $\pi^+$  corrected momentum, we can calculate  $\pi^-$  momentum from the following equation:  $(e + p - e' - \pi^+ - \pi^-)^2 = M_p^2$
- The calculated correction for the  $\pi^-$  momentum:  $\Delta p = p_{calc} - p_{rec}$
- The determined correction is plotted vs  $\pi^-$  momentum and fitted with pol2 function in 3 individual  $\varphi$  bins for each of 6 sectors
- Each of the parameters is then plotted vs  $\varphi$  value and fitted with pol2 function

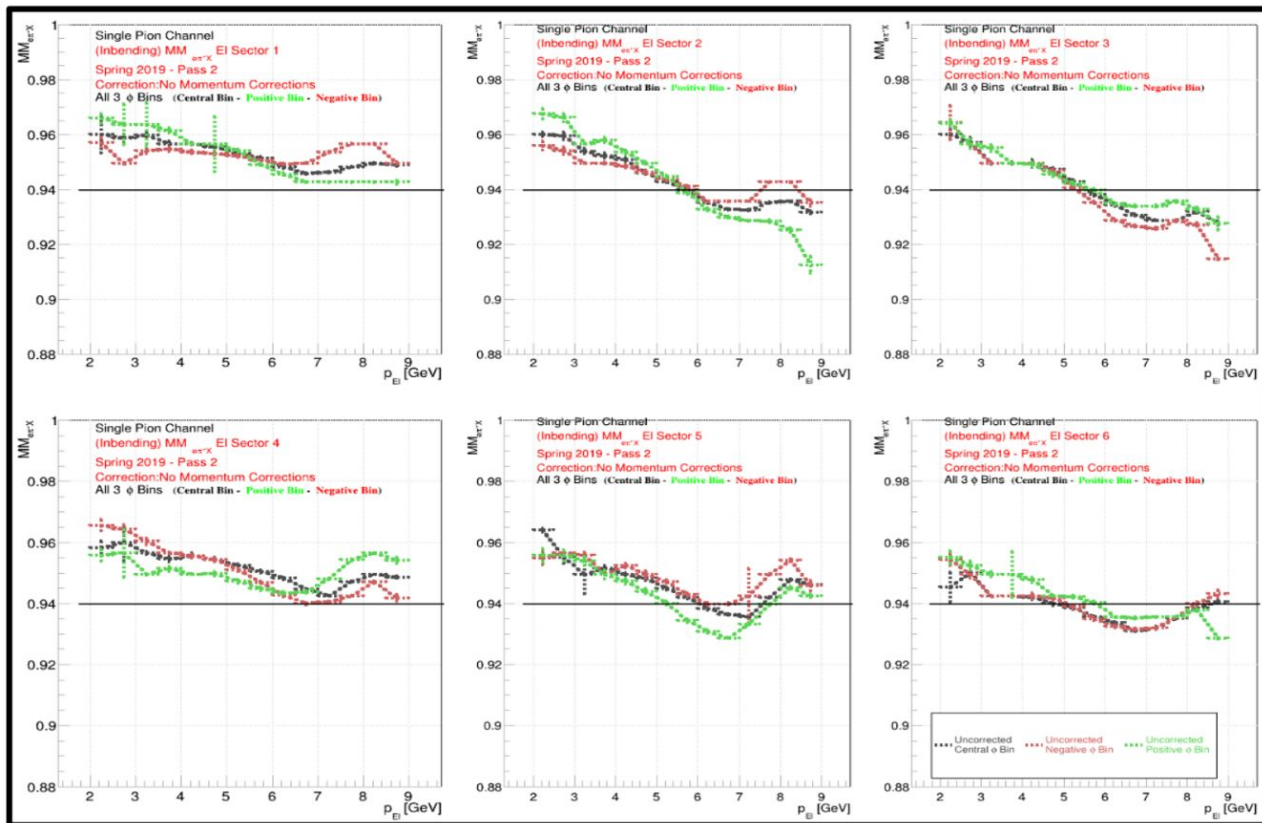
# Inbending: MM for $e\pi^+\pi^-X$ system before/after corrections



# Outbending: MM for $e\pi^+\pi^-X$ system before/after corrections



# Future plans: pass-2 data



## SPRING 2019 PASS 2



**NO CORRECTIONS**



- The momentum corrections for electron,  $\pi^+$  and  $\pi^-$  for pass-1 RGA inbending and outbending datasets are finalized
- The developed corrections for each particle work within the kinematic range of the used reactions, and **cannot be extrapolated outside the available momentum range**
- We plan to develop momentum corrections for pass-2 data using the same technique

THANK YOU