

# DarkLight Experiment and Visualization of Madgraph generated events

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# Outline

- What is DarkLight Experiment?
- Madgraph event generator
- Kinematics
- Kinematic correlations
- Conclusion & Future work

# What is darklight experiment?

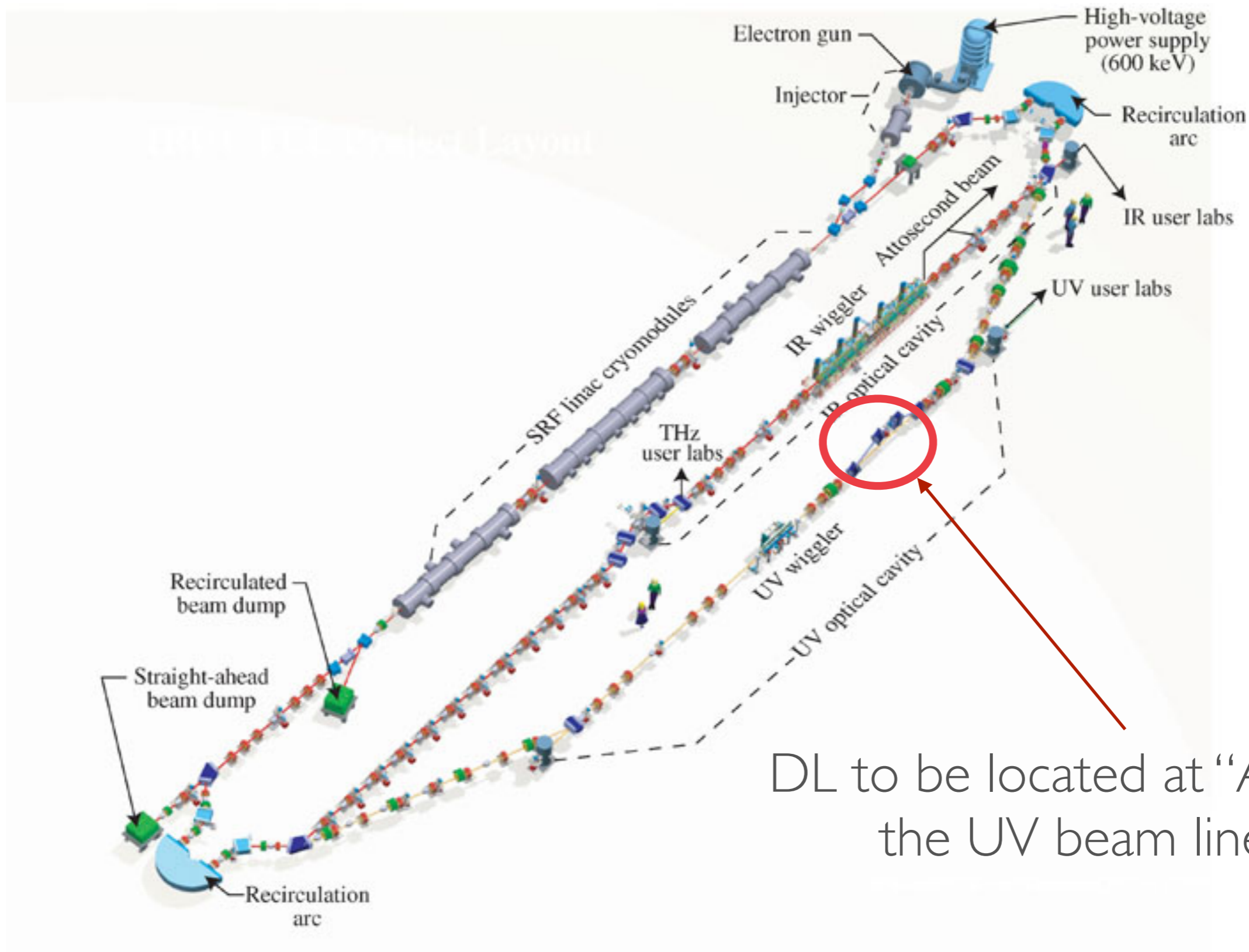


- Detecting **A** Resonance **K**inematically with **e**lectrons **I**ncident on a **G**aseous **H**ydrogen **T**arget.
- There are indications for a dark photon in the mass range below 1 GeV, while there has been intensive searching with existing experiments, no  $A'$  has been found.
- DarkLight is designed to search for such a dark photon in the mass range 10-100 MeV with a new experimental technique with increased sensitivity  $\sim 5\sigma$

# Motivation

- Search for a new light boson  $A'$  using Jlab's ERL (formerly known as FEL)
  - will explore the  $A'$  mass region 10-100MeV and coupling as low as  $10^{-9}$
- Study the process of  $e^- + p \longrightarrow e^- + p + e^- + e^+$  below pion threshold.
- A force particle would show up as a narrow resonance in the radiated  $e^-e^+$  system.
  - At the  $A'$  mass
- Possibilities of other measurements
  - Proton charge radius measurements
  - Electroweak measurements
  - $A'$  invisible decay

# Jefferson Lab Energy Recovery Linac



DL to be located at "A1" on the UV beam line.

# Experimental Considerations

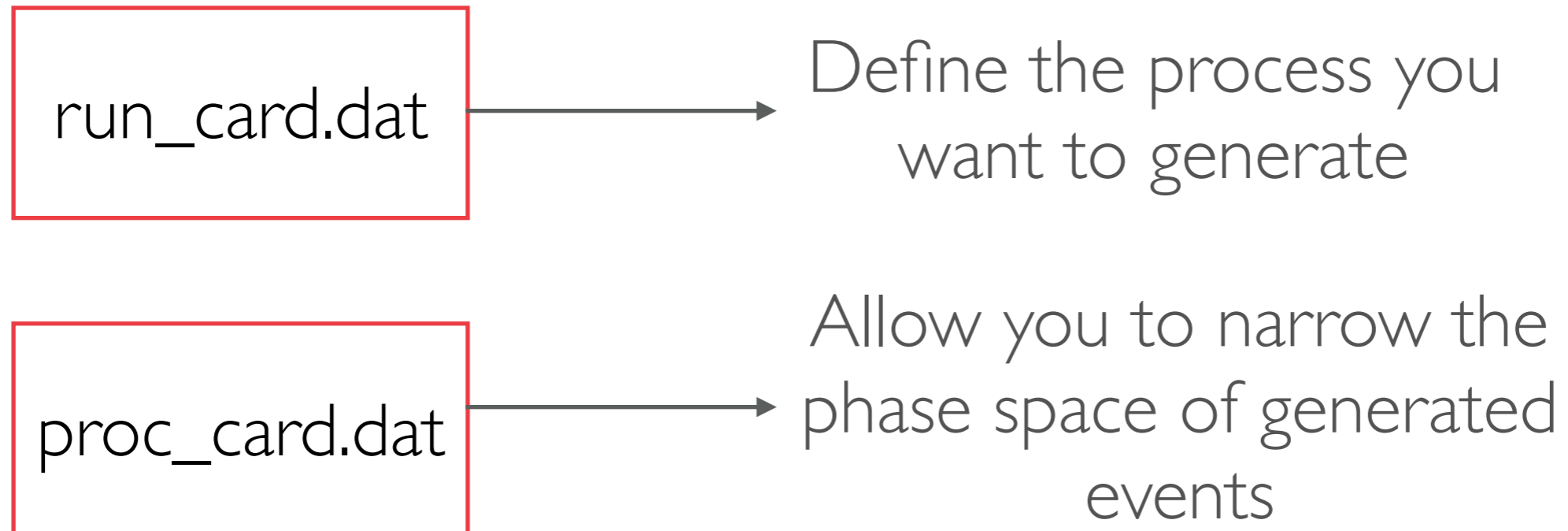
- JLab free electron laser electron Beam
  - energy 100MeV
  - current 10mA
  - power 1MW
- Gaseous hydrogen target
  - Gas jet target provides point-like electron-proton interaction.
  - $10^{19} \text{ cm}^{-2}$  target density
- Target and tracker components are in 0.5 T solenoidal magnetic field.

# DarkLight Phases and Schedule

- Phase I - Visible search
  - Prepare and run in Summer 2016 - Fall 2016
  - Contribution from HU - 10x10 GEM detectors
- Phase II - Invisible search
  - run in Summer 2017-Fall 2017
  - Contribution from HU - 24x40? GEM detectors & Photon veto detector

# Madgraph

- An event generator



- Outputs a root file



# Madgraph Event Generator

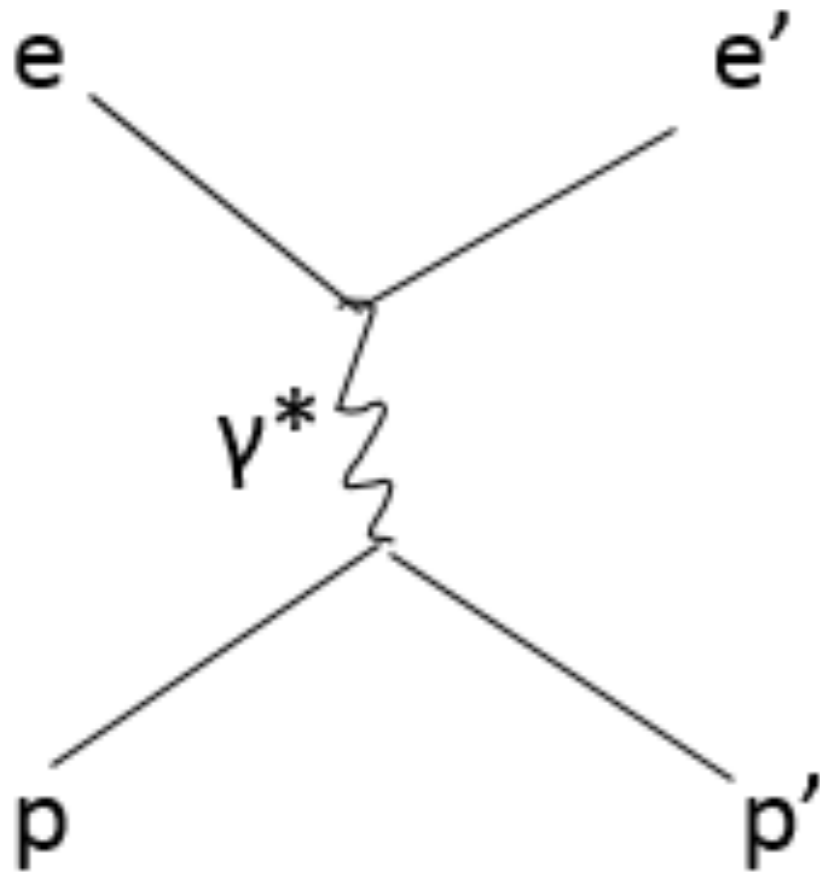
Elastic process

- $ep \rightarrow ep$

Inelastic processes

- $ep \rightarrow epa$  (one radiated photon)
- $ep \rightarrow epaa$  (two radiated photons)
- $ep \rightarrow epA'$  (darklight photon with invariant mass of 20MeV)

# Kinematics



$$\gamma^* = e - e'$$

$$(\gamma^* p) = e - e' + p$$

$$\text{4-momentum transfer squared } -Q^2 = (\gamma^*)^2$$

$$\text{Invariant mass } W = \sqrt{(\gamma^* p)^2}$$

$$(\gamma^*)^2 = \omega^2 - \vec{q}^2$$

$$(\gamma^* p)^2 = (\omega + M_p)^2 - \vec{q}^2$$

$$E' = \frac{2M_p E - W^2 - M_p^2}{2M_p + 4E \sin^2 \frac{\theta}{2}}$$

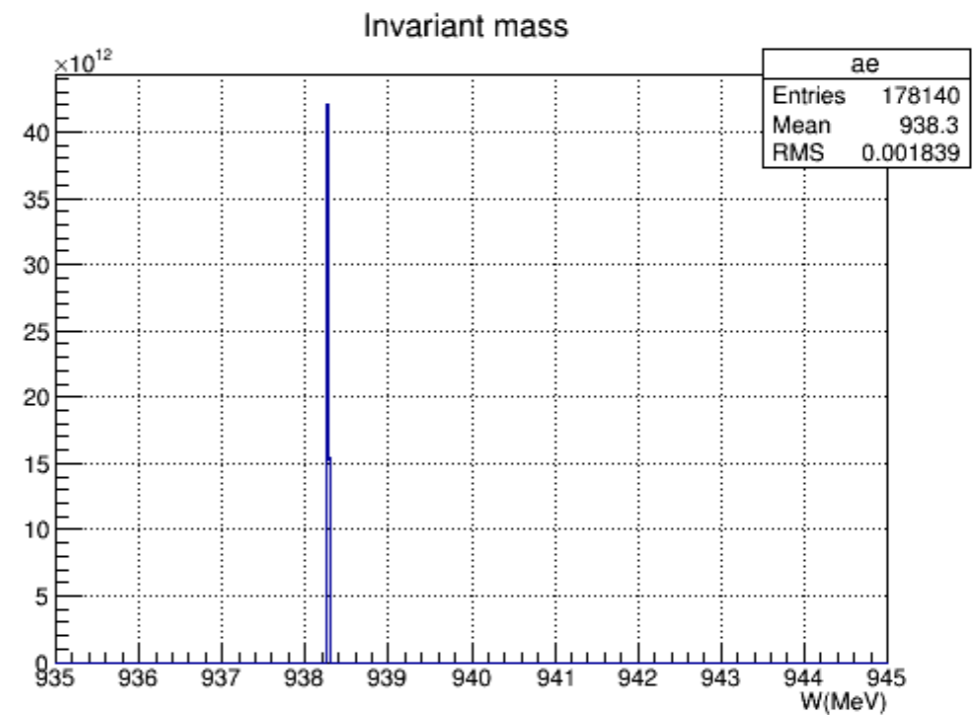
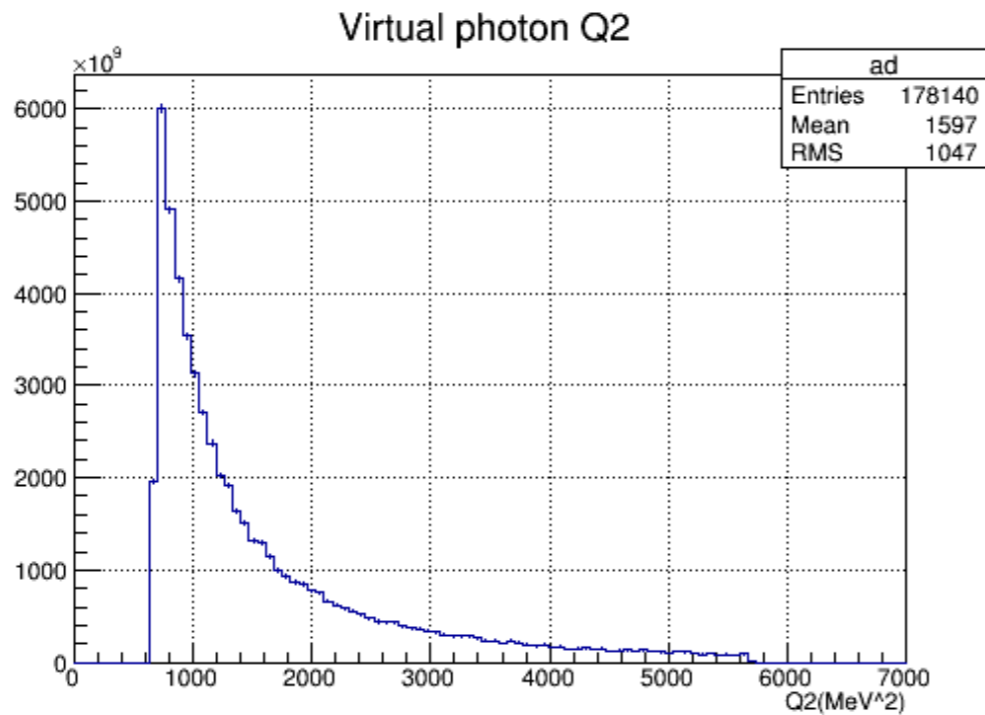
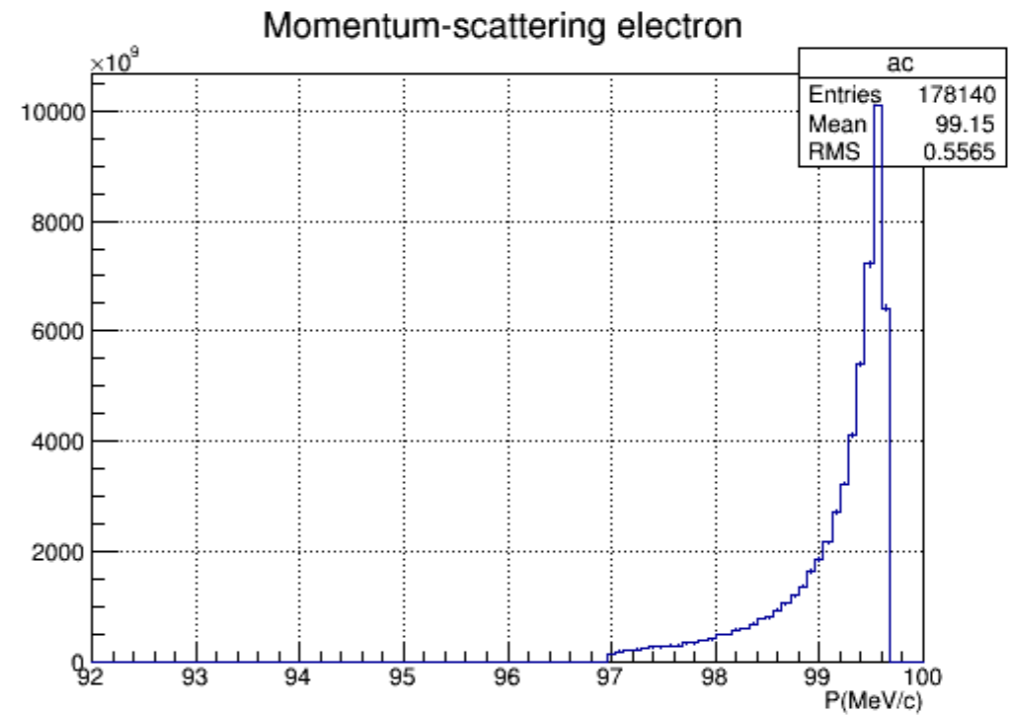
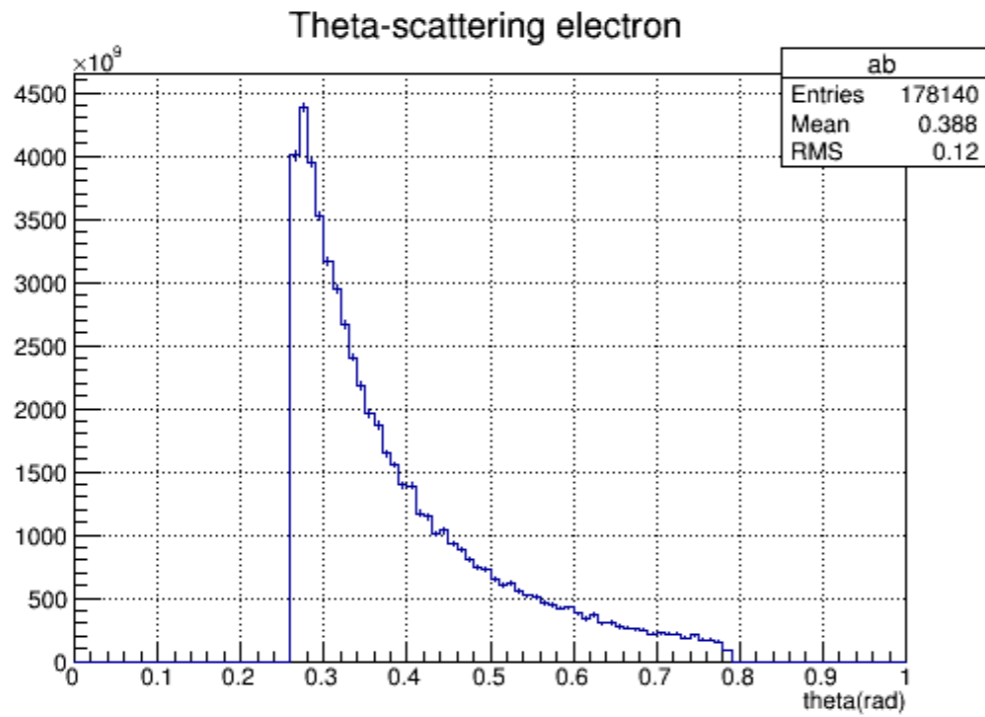
e - incoming electron

e' - scattered electron

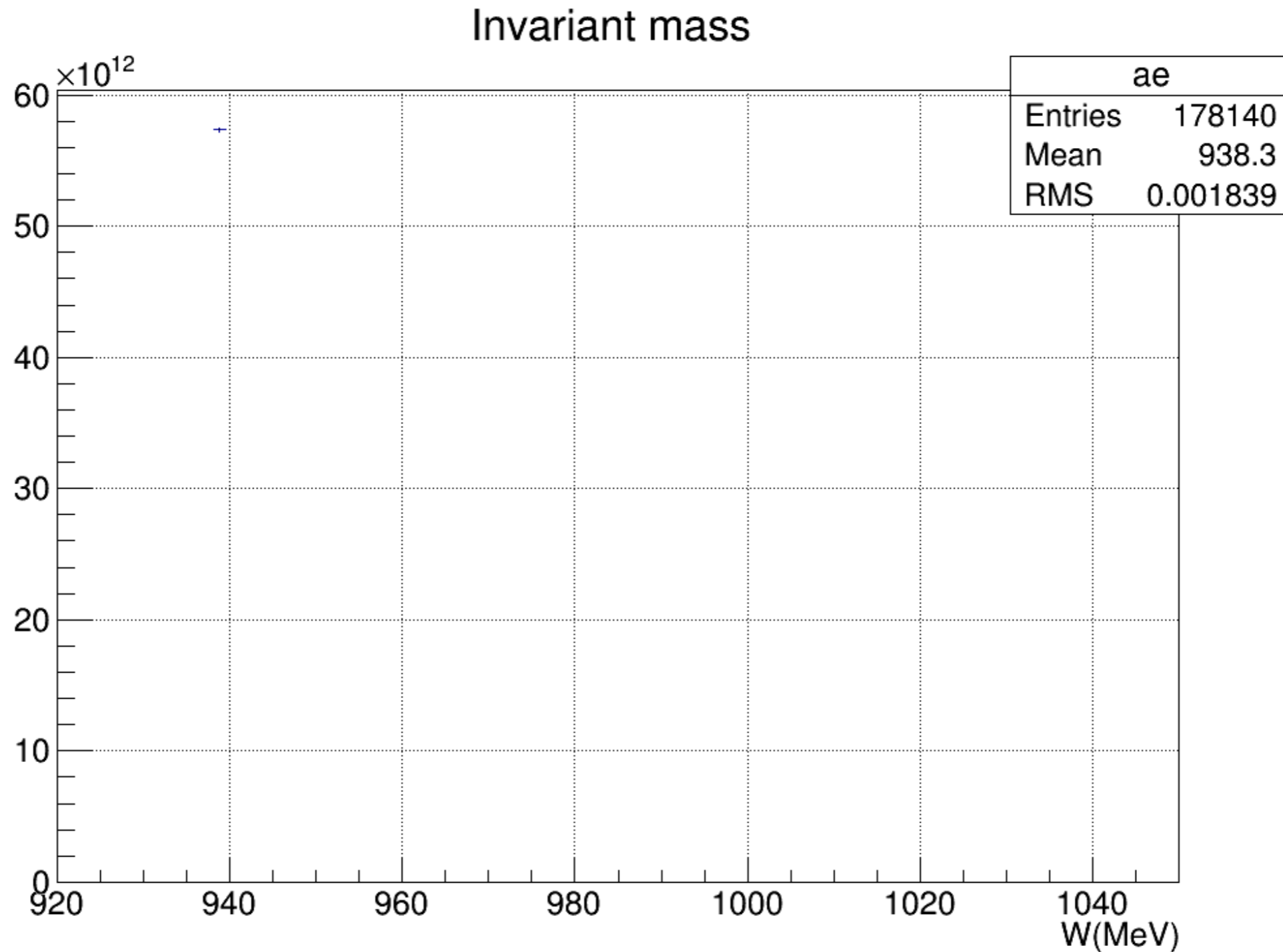
p - proton at rest

p' - recoiling proton

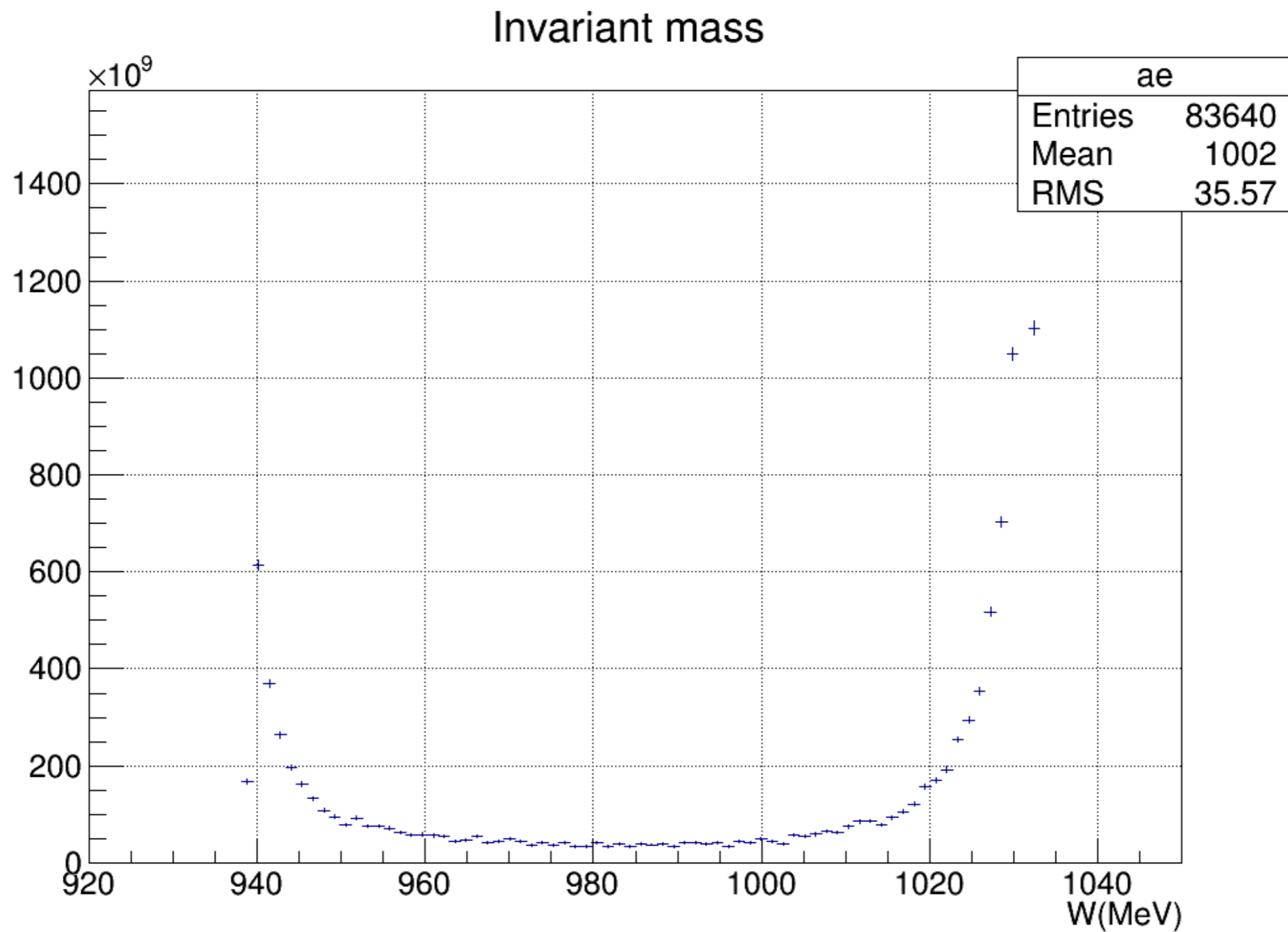
# ID histograms for elastic process



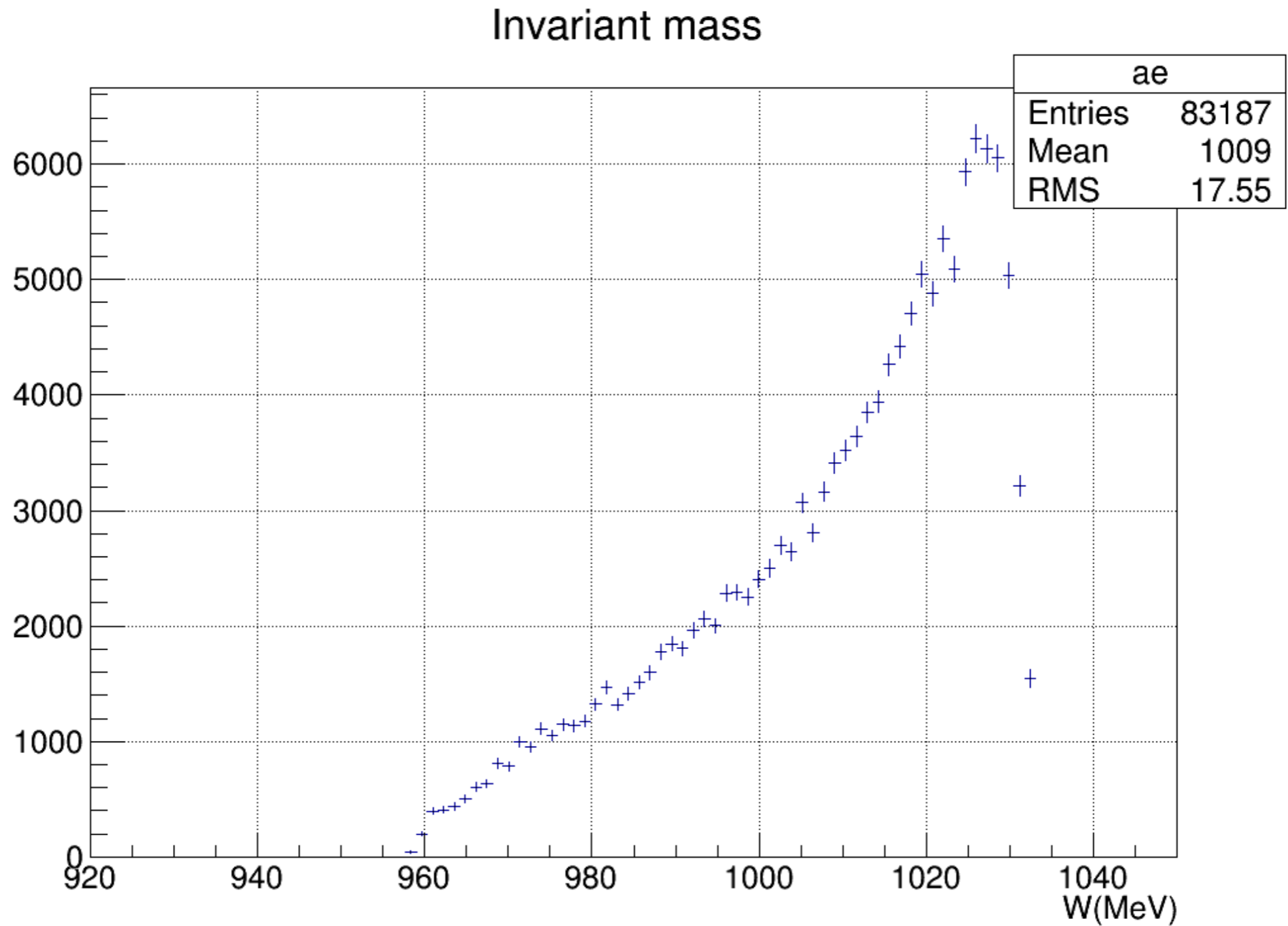
# Invariant mass distribution - (elastic process)



# Invariant mass distribution - ( $ep \rightarrow epa$ )

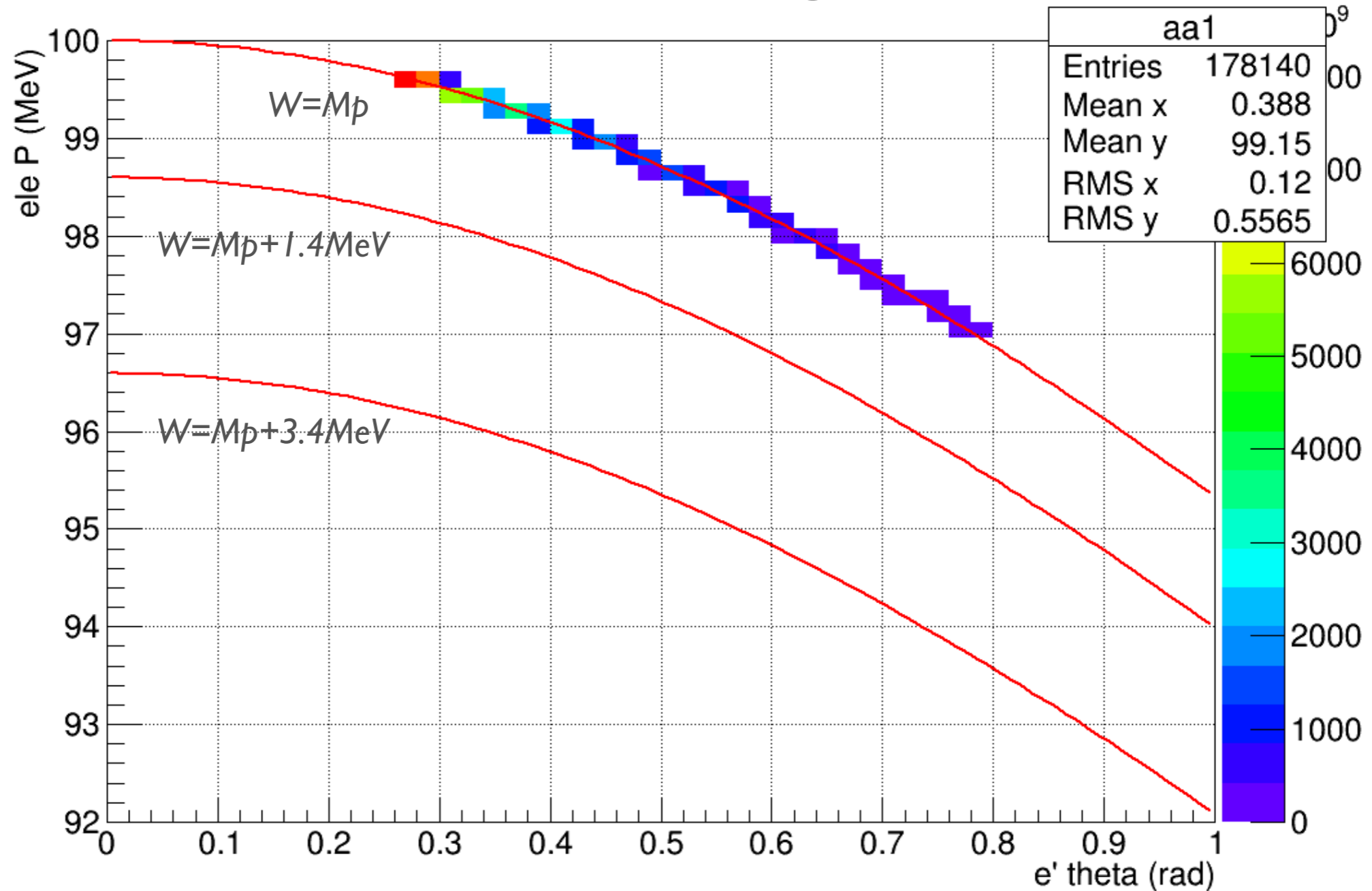


# Invariant mass distribution - ( $ep \rightarrow epA'$ )



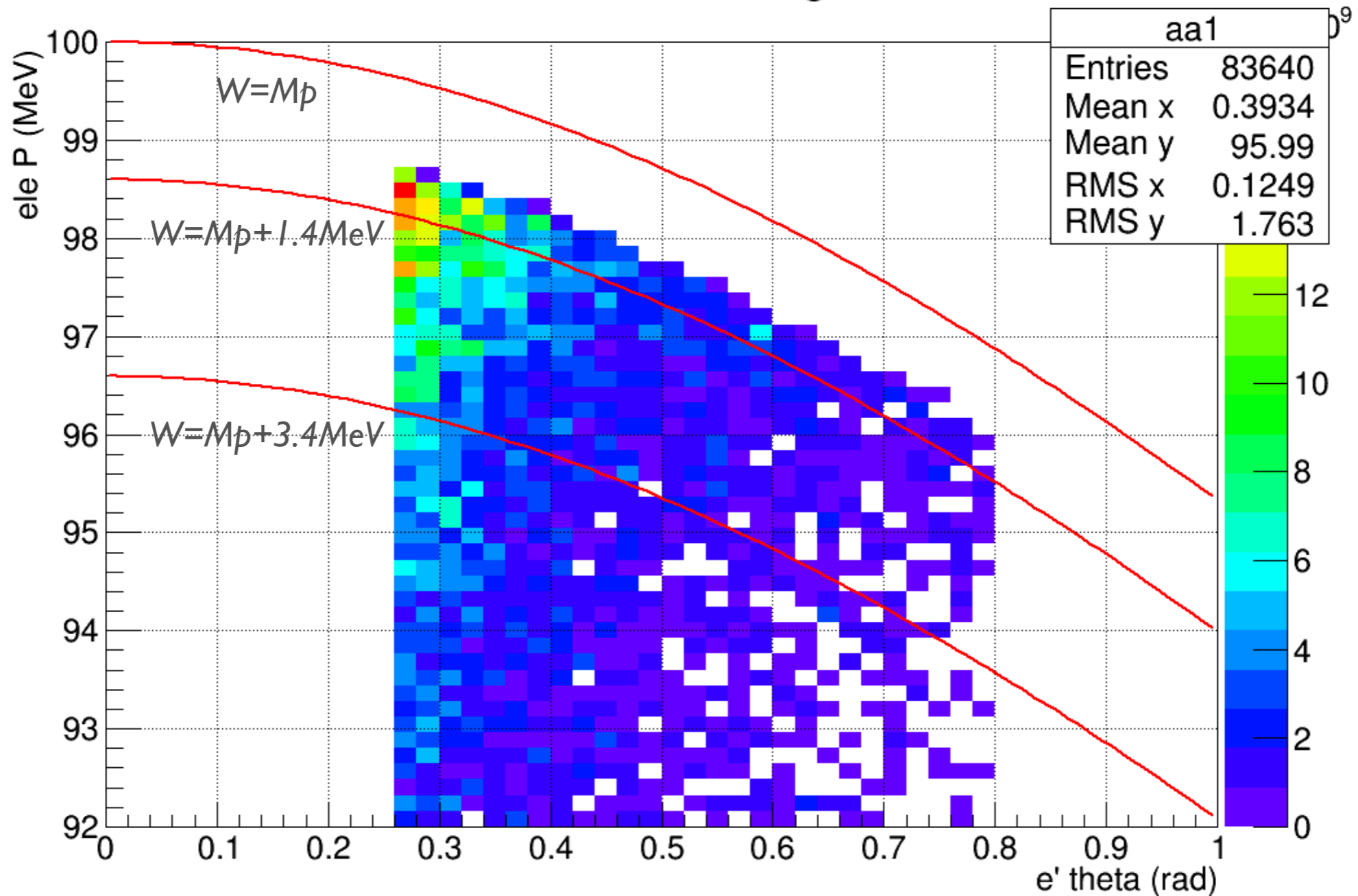
# Kinematic Correlations - Elastic process

P Vs. theta for scattering electron



# Kinematic Correlations - ( $ep \rightarrow epa$ )

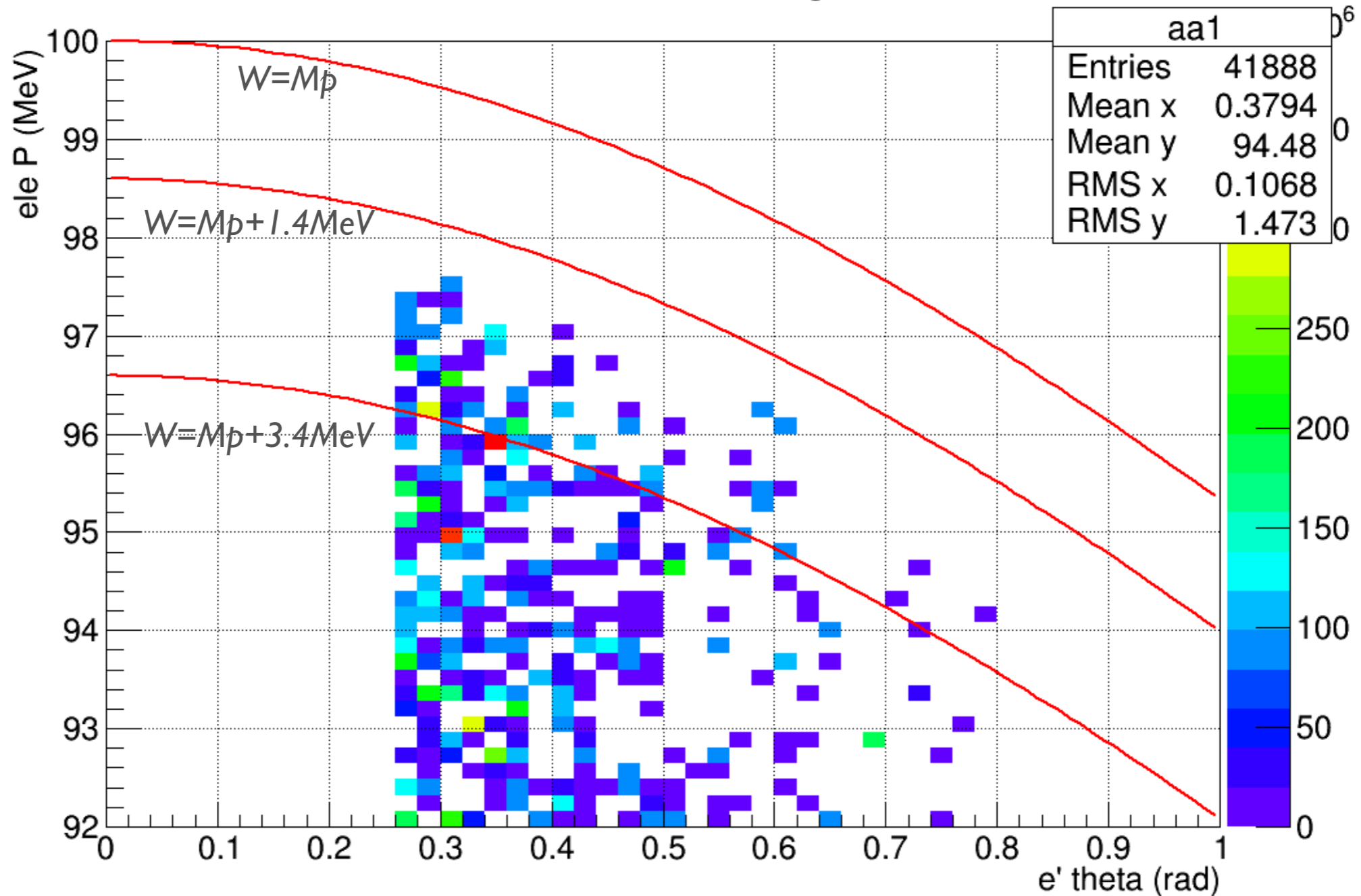
P Vs. theta for scattering electron





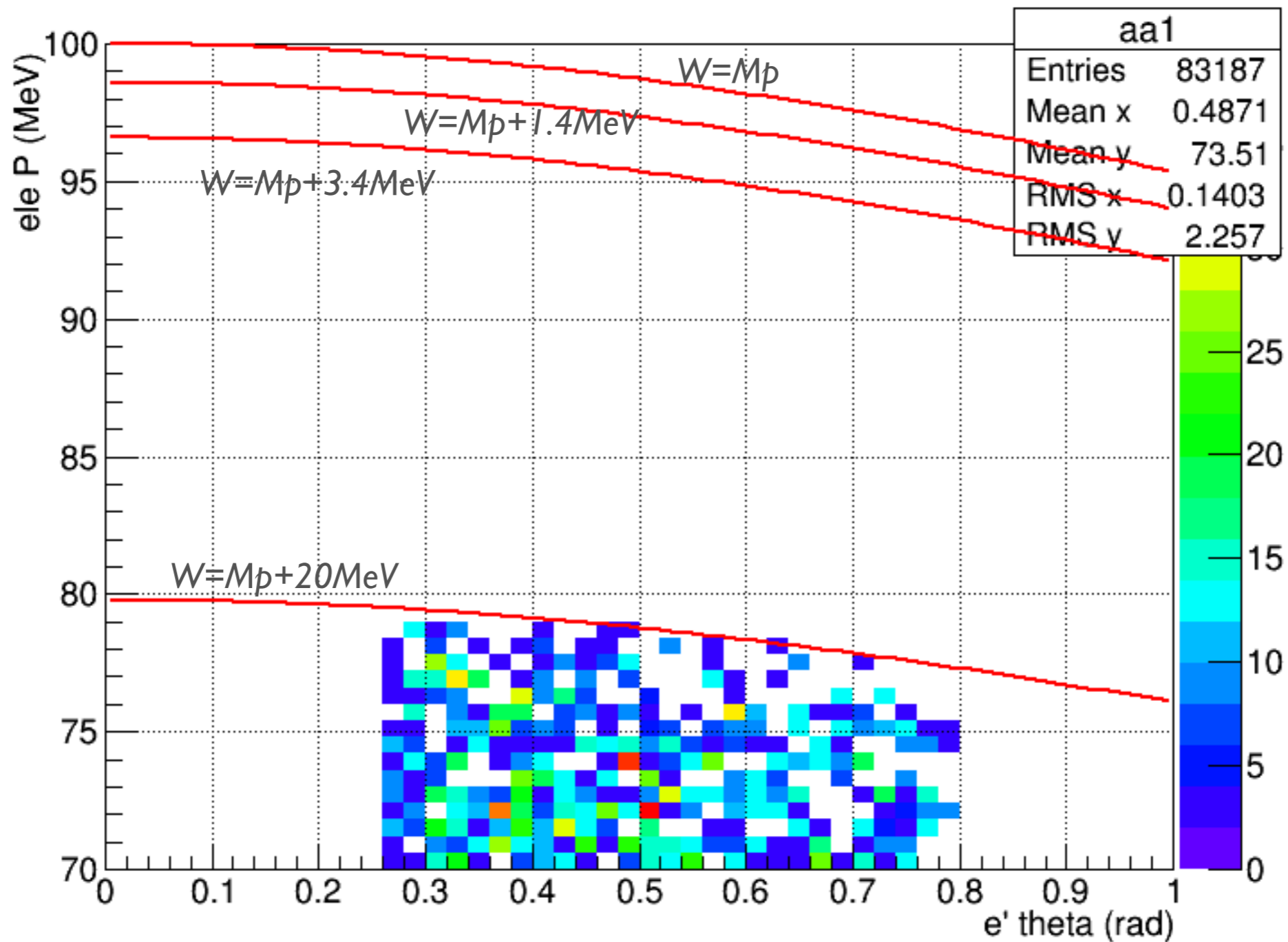
# Kinematic Correlations - ( $ep \rightarrow epaa$ )

P Vs. theta for scattering electron

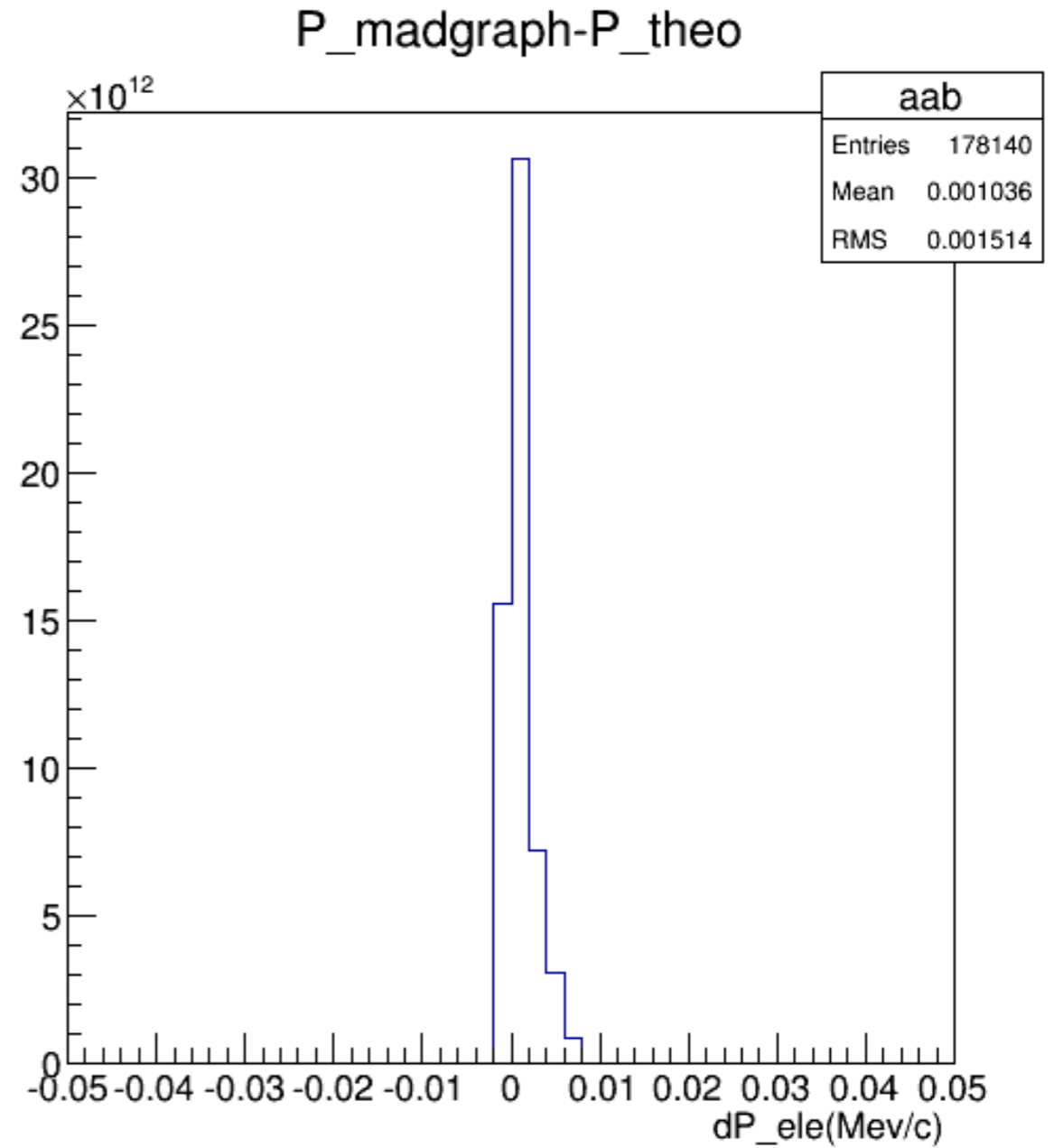
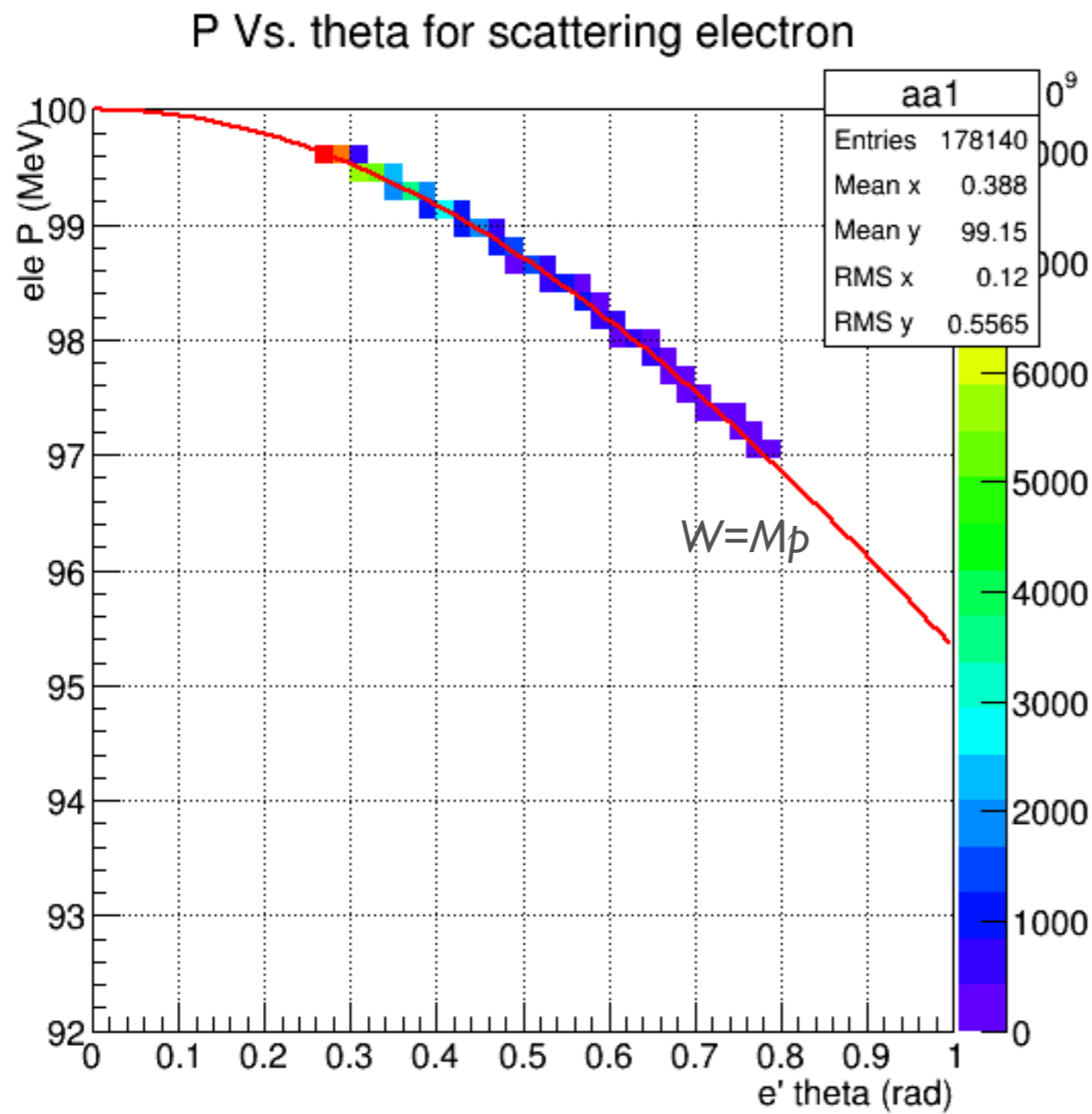


# Kinematic Correlations - ( $ep \rightarrow epA'$ )

P Vs. theta for scattering electron

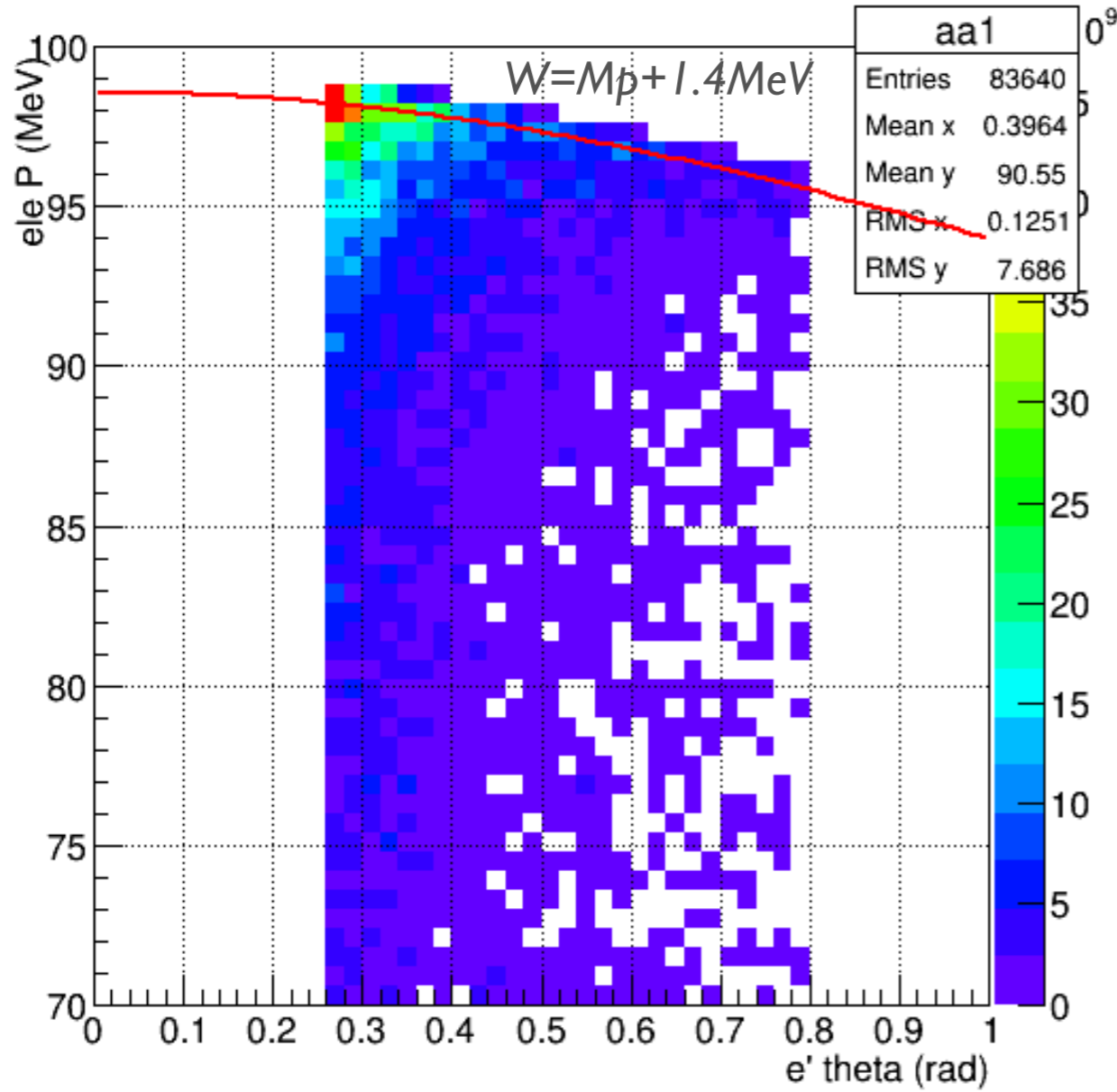


# Kinematic Correlations - Elastic process

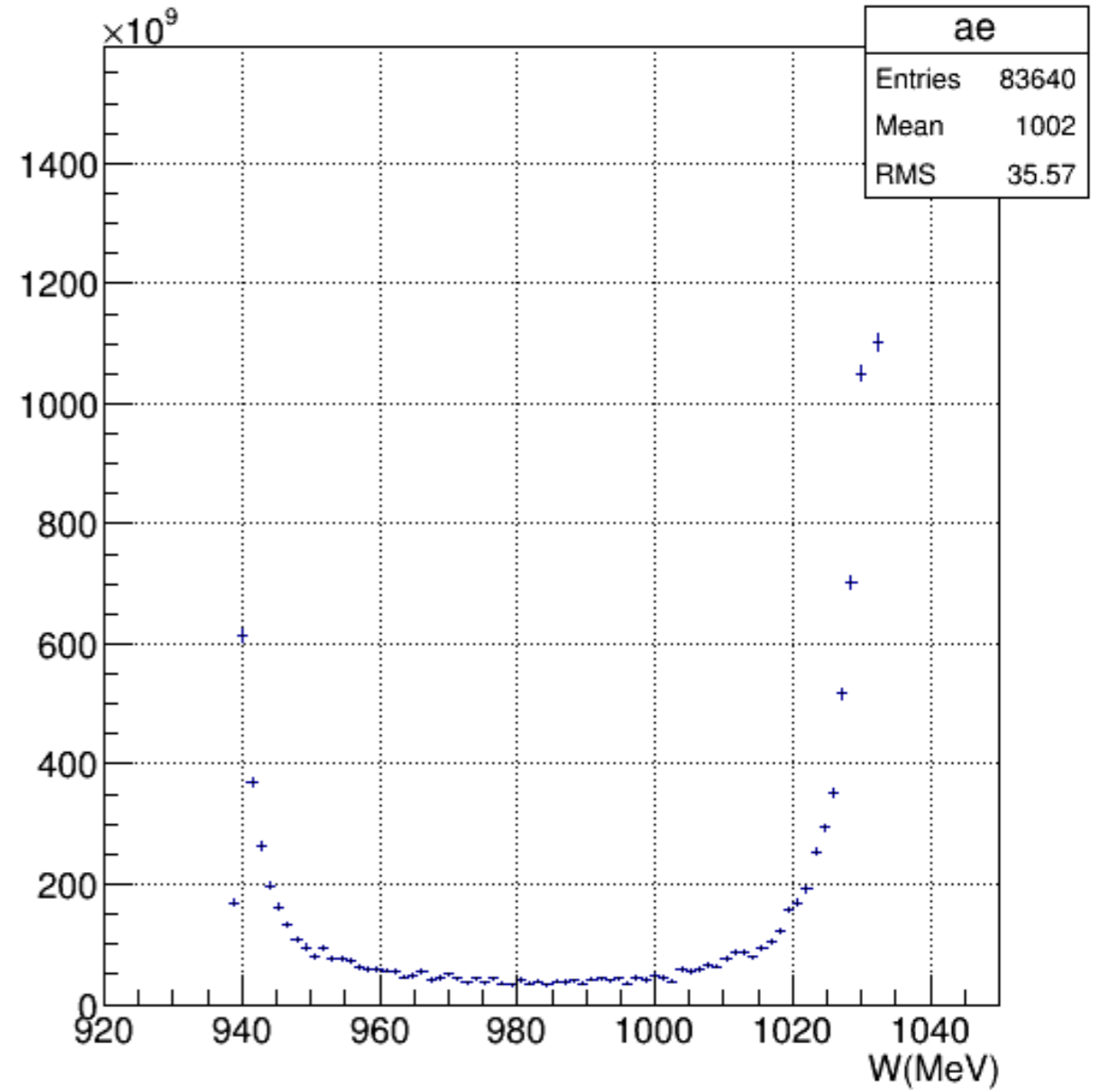


# Kinematic Correlations - ( $ep \rightarrow epa$ )

P Vs. theta for scattering electron

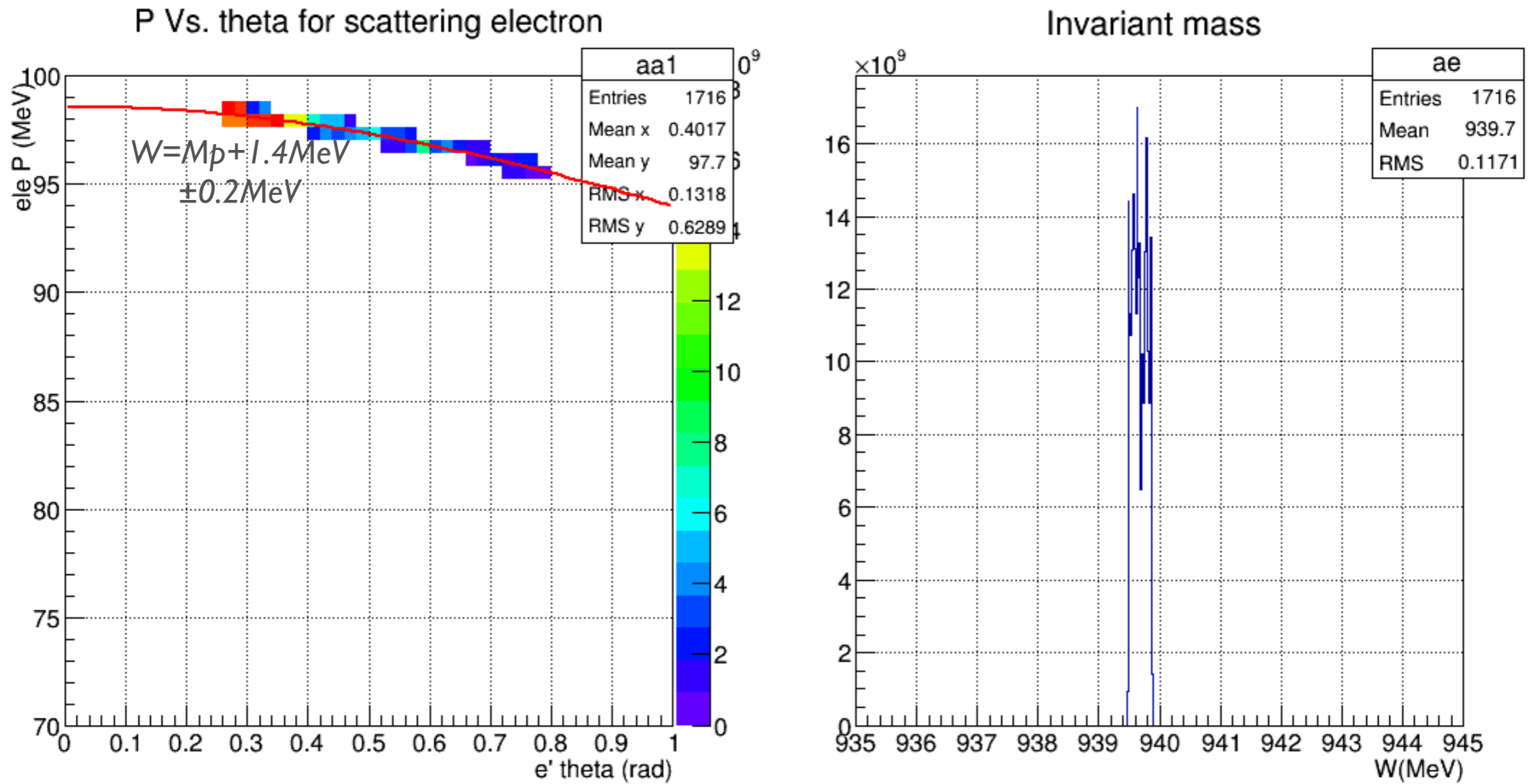


Invariant mass



# Kinematic Correlations - ( $ep \rightarrow epa$ )

with  $W = M_p + (1.4 \pm 0.20) \text{ MeV}$



# Conclusion & Future work

- Missing mass

$$e+p \rightarrow e'+p'+X$$

$$M_x^2 = (e - e' + p - p')^2$$

- Geant4

THANK YOU!