

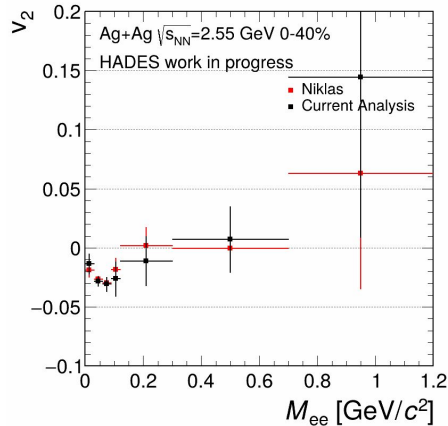


# **Progress towards the azimuthal anisotropy of dileptons in the HADES beam energy scan**

Henrik Flörsheimer  
(TU Darmstadt)

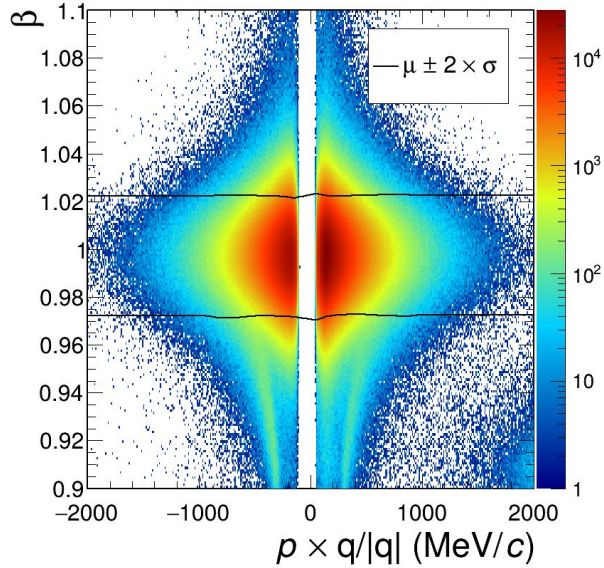
# Current Goals and Overview of the Hard Cuts Analysis Steps

- Obtain Flow for the Feb24/Apr25 Beam energy scan
  - Start off by reproducing Niklas results for Mar19
- Increase statistics using machine learning



# Velocity comparison in RPC

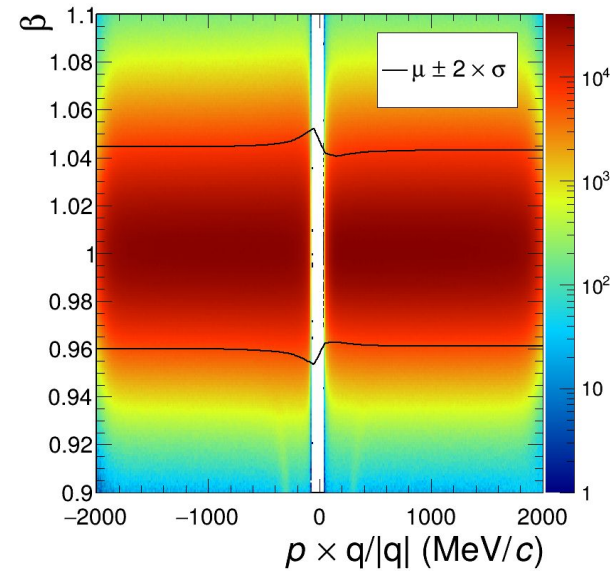
Gen6 Data



$$Ag + Ag \sqrt{S_{NN}} = 2.55 \text{ GeV}$$

HADES Performance

White leptons embedded to  
real data



$$Ag + Ag \sqrt{S_{NN}} = 2.55 \text{ GeV}$$

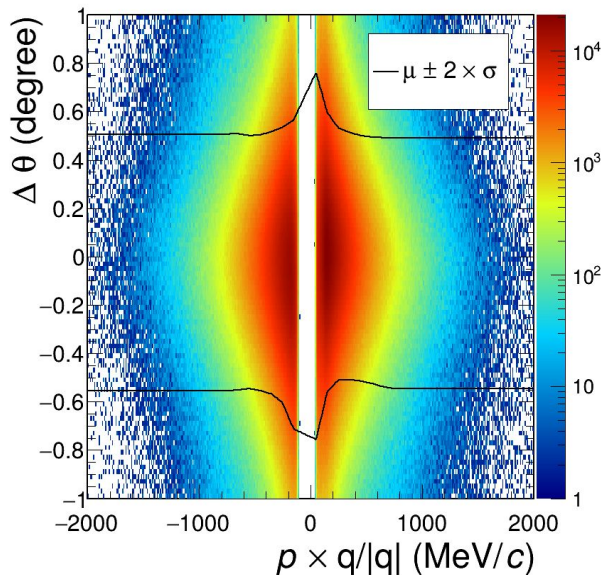
# Spatial correlations of track to RICH ring center



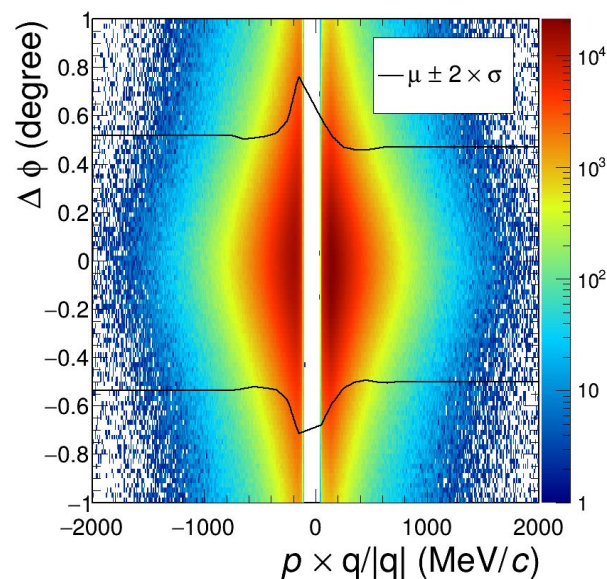
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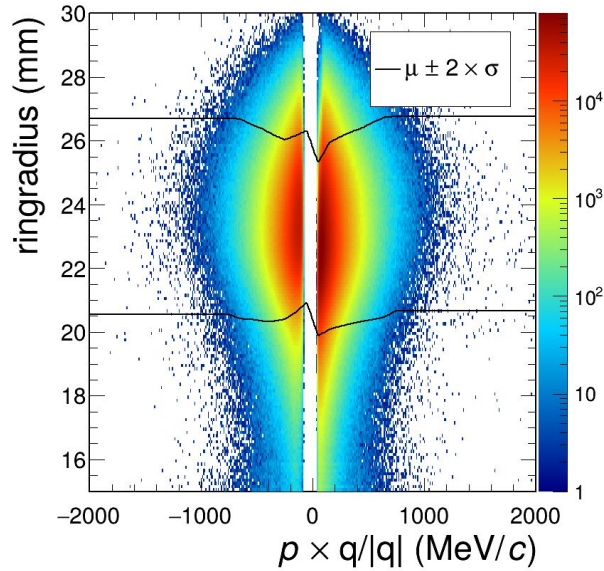
# Cuts on the Ring Radius for both RICH planes



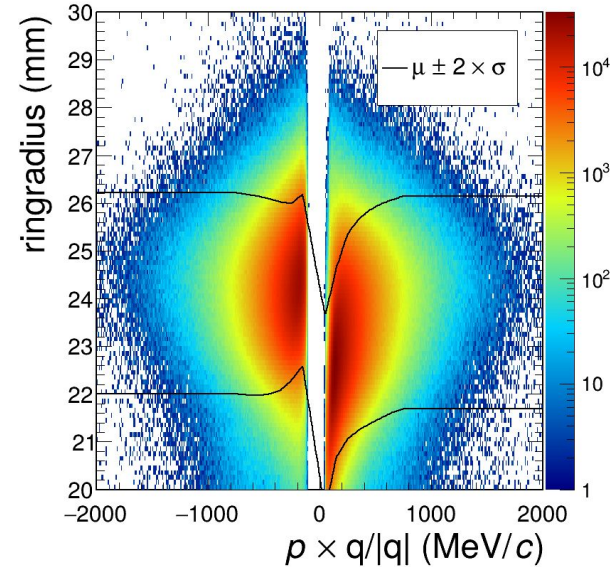
Gen6 Data

HADES Performance

White leptons embedded to  
real data

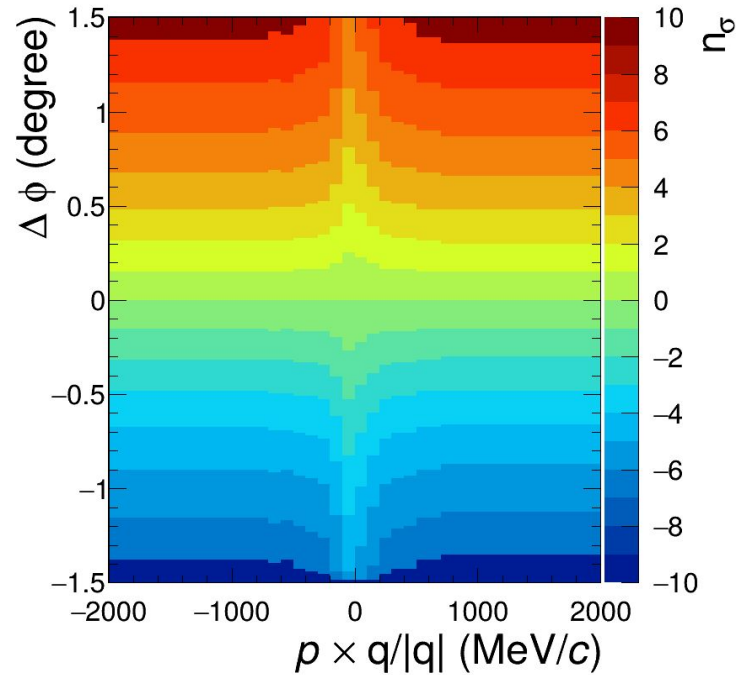


$$Ag + Ag \sqrt{S_{NN}} = 2.55 \text{ GeV}$$



$$Ag + Ag \sqrt{S_{NN}} = 2.55 \text{ GeV}$$

# Cutting based on the quantiles of the fit function



$$Ag + Ag \sqrt{S_{NN}} = 2.55 \text{ GeV}$$

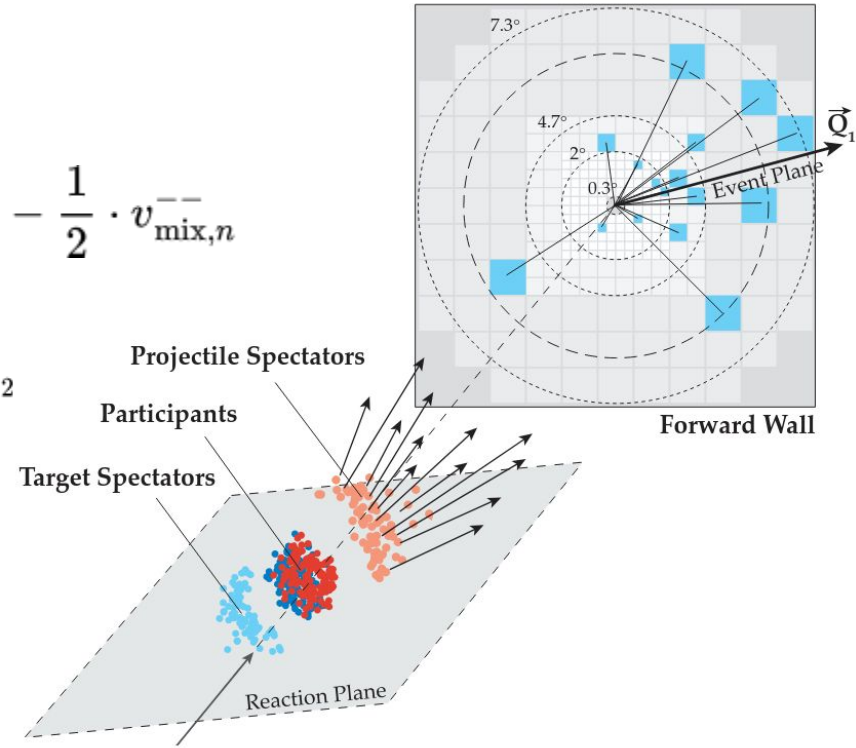
# How to calculate the Flow

$$v_n^{\text{obs}} = v_n \cdot \mathcal{R}_n$$

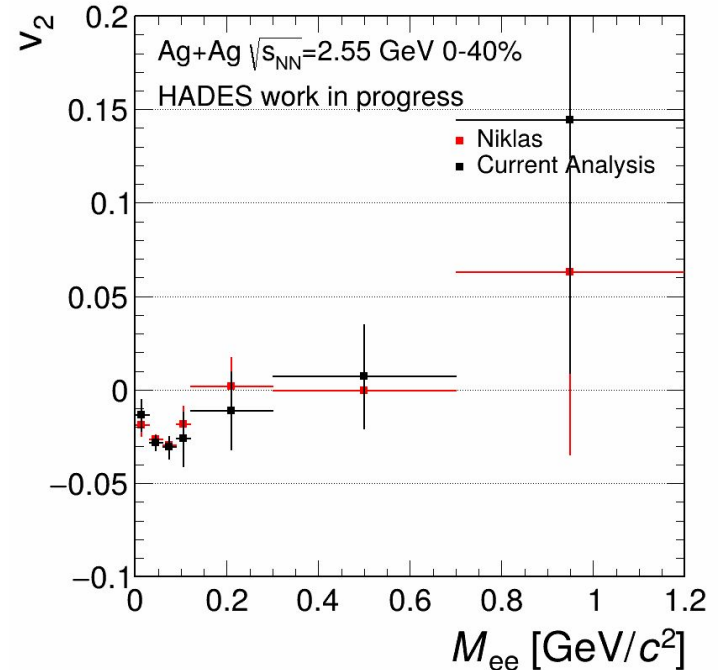
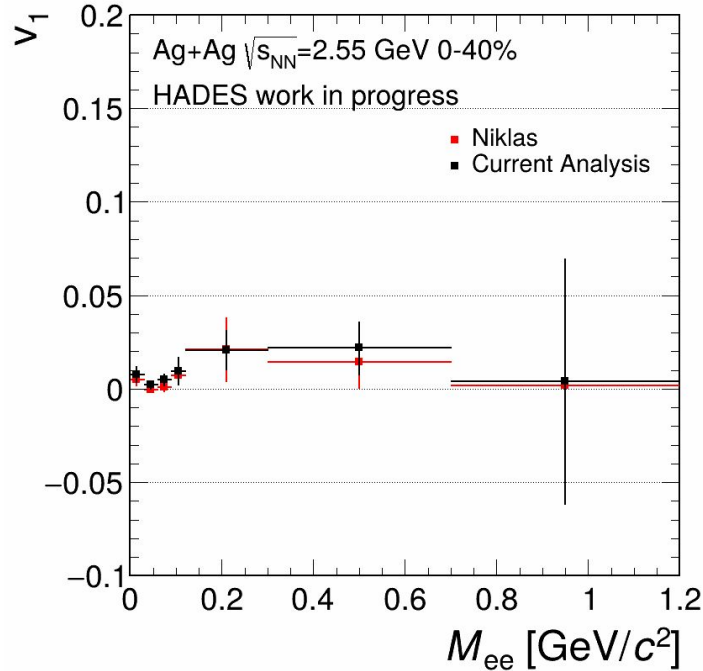
$$v_{n,SE}^B = v_{\text{mix},n}^{+-} + \frac{1}{2} \cdot v_{SE,n}^{++} + \frac{1}{2} \cdot v_{SE,n}^{--} - \frac{1}{2} \cdot v_{\text{mix},n}^{++} - \frac{1}{2} \cdot v_{\text{mix},n}^{--}$$

$$N^B = (N_{\text{mix}}^{+-})^1 \cdot (N_{SE}^{++})^{1/2} \cdot (N_{SE}^{--})^{1/2} \cdot (N_{\text{mix}}^{++})^{-1/2} \cdot (N_{\text{mix}}^{--})^{-1/2}$$

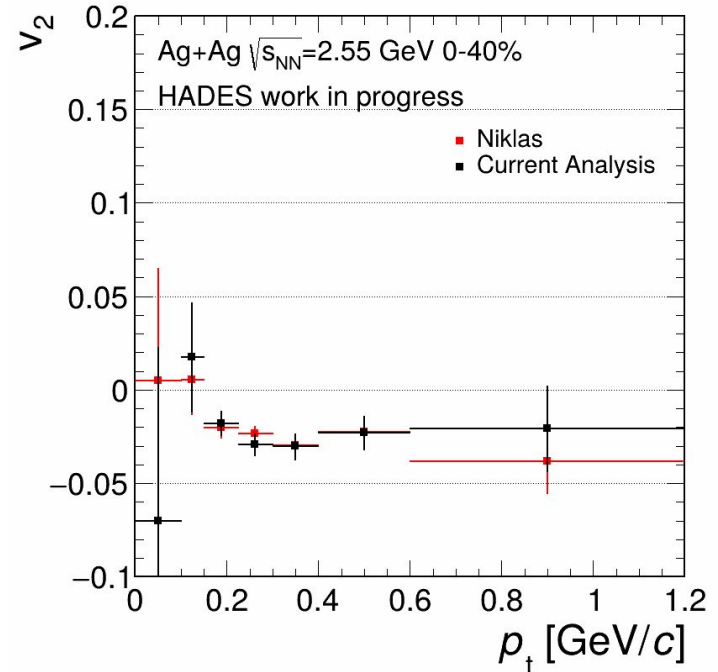
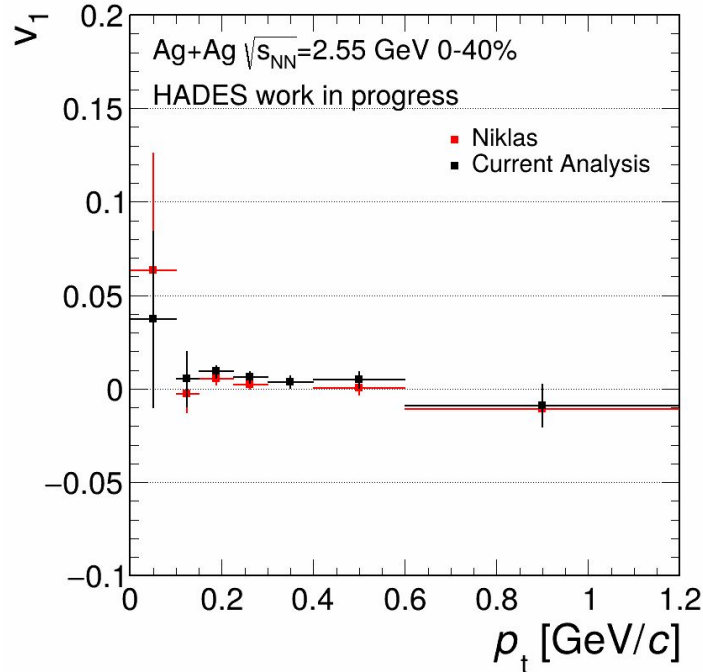
$$v_n^S = \left( 1 + \frac{N^B}{NS} \right) \cdot v_{n,SE}^{+-} - \frac{N^B}{NS} \cdot v_{n,SE}^B$$



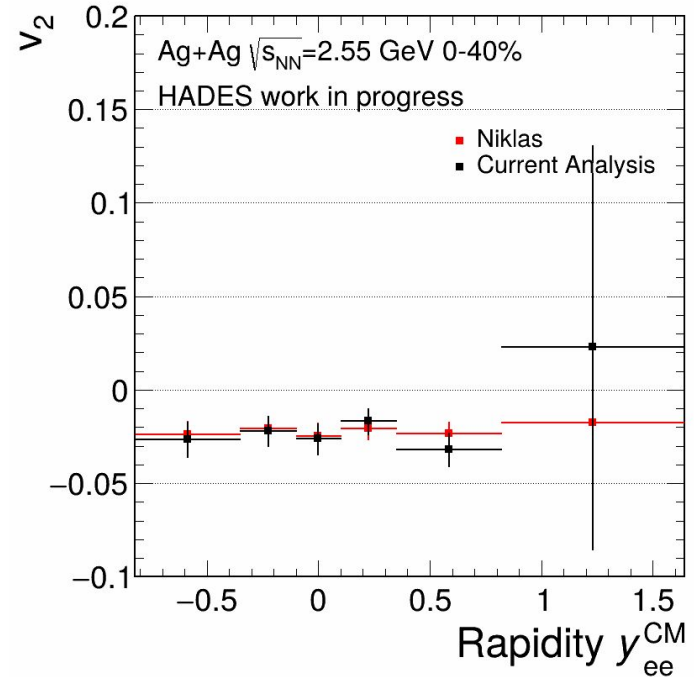
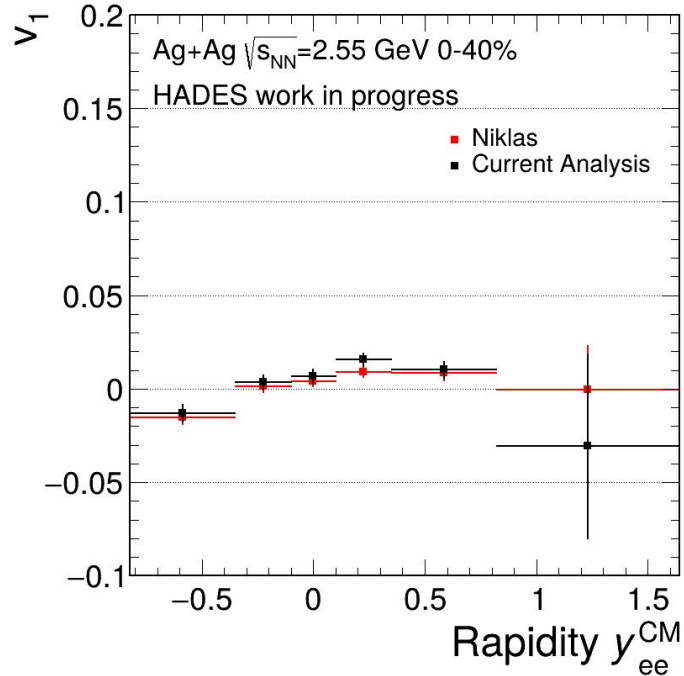
# Comparison of uncorrected Flow as a function of invariant mass



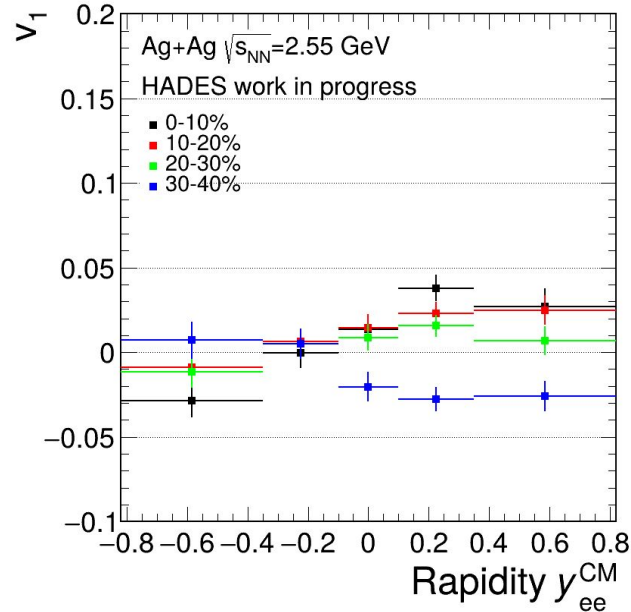
# Comparison of uncorrected Flow over Transverse Momentum



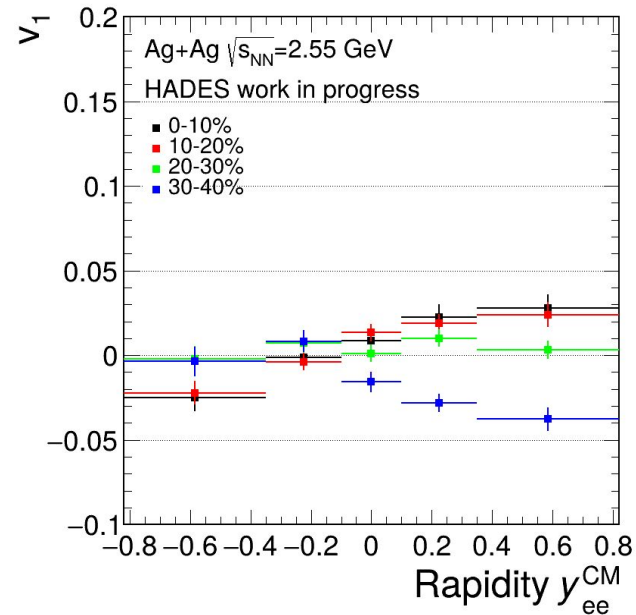
# Comparison of uncorrected Flow over Rapidity



# Comparison of uncorrected Flow over Rapidity for different centralities



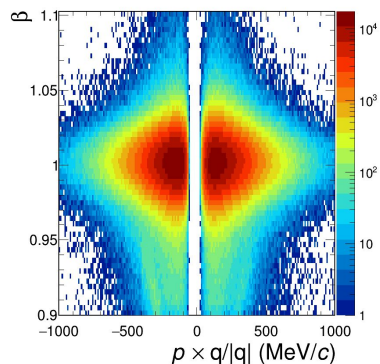
Current Analysis



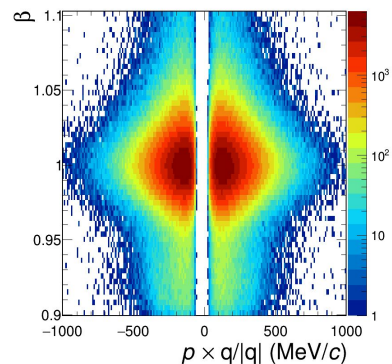
Niklas

# Velocity comparison for RPC for the Apr25 Beam Energy Scan

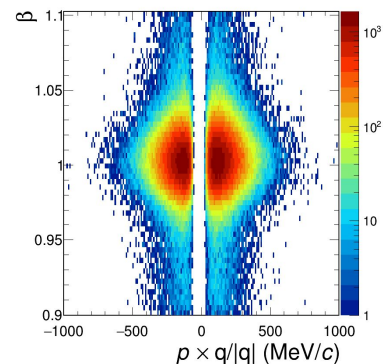
## HADES Performance



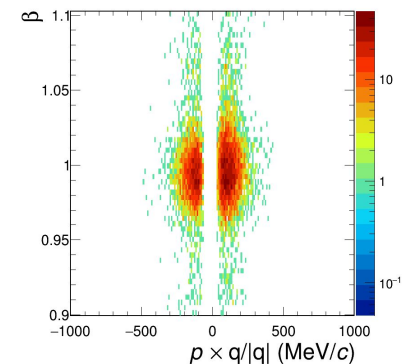
$\text{Au+Au}\sqrt{s_{\text{NN}}} = 2.23 \text{ GeV}$



$\text{Au+Au}\sqrt{s_{\text{NN}}} = 2.14 \text{ GeV}$



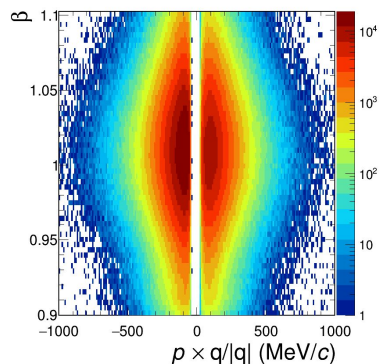
$\text{Au+Au}\sqrt{s_{\text{NN}}} = 2.05 \text{ GeV}$



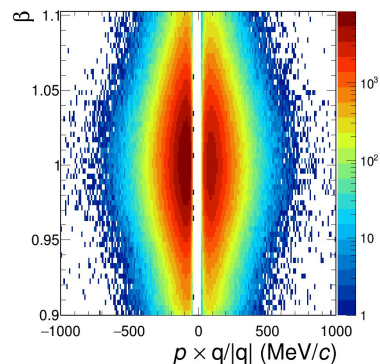
$\text{Au+Au}\sqrt{s_{\text{NN}}} = 1.96 \text{ GeV}$

# Velocity comparison in TOF for the Apr25 Beam Energy Scan

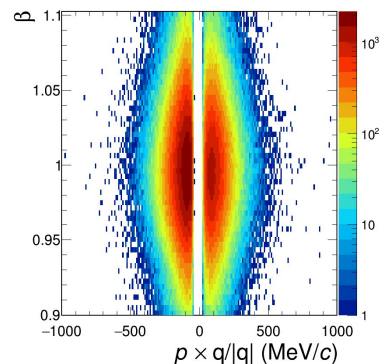
## HADES Performance



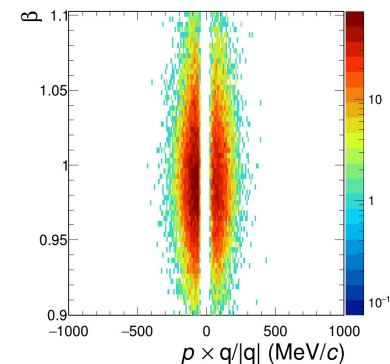
$$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.23 \text{ GeV}$$



$$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.14 \text{ GeV}$$



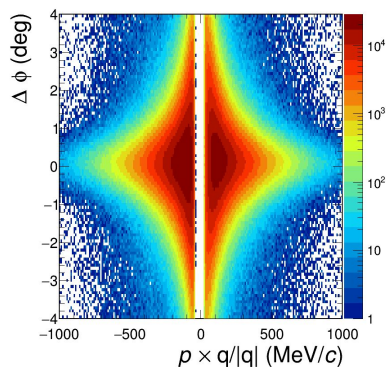
$$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.05 \text{ GeV}$$



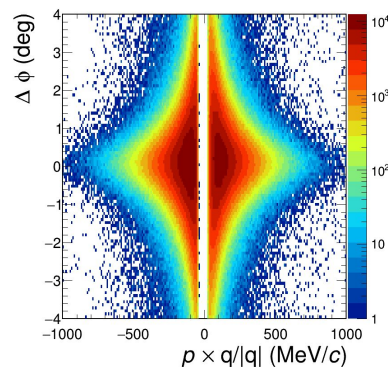
$$\text{Au+Au}\sqrt{S_{\text{NN}}} = 1.96 \text{ GeV}$$

# Spatial correlations of track to RICH ring center: $\Delta\phi \cdot \sin\theta$

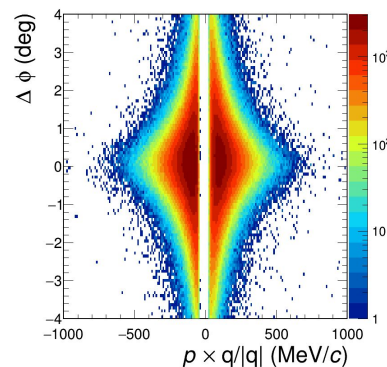
## HADES Performance



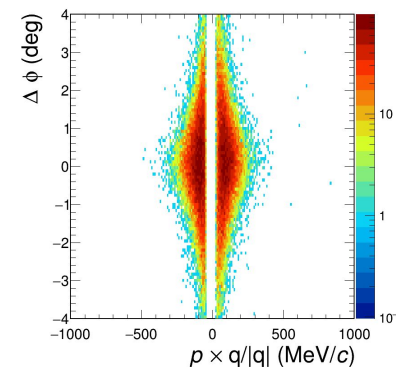
$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.23 \text{ GeV}$



$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.14 \text{ GeV}$



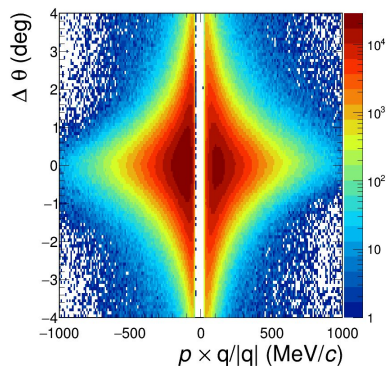
$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.05 \text{ GeV}$



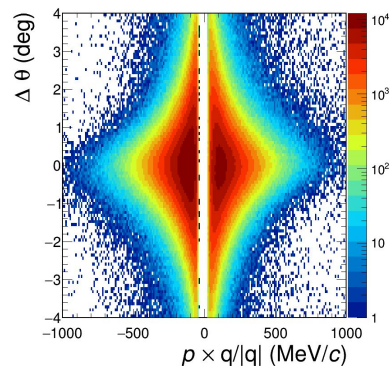
$\text{Au+Au}\sqrt{S_{\text{NN}}} = 1.96 \text{ GeV}$

# Spatial correlations of track to RICH ring center: $\Delta\theta$

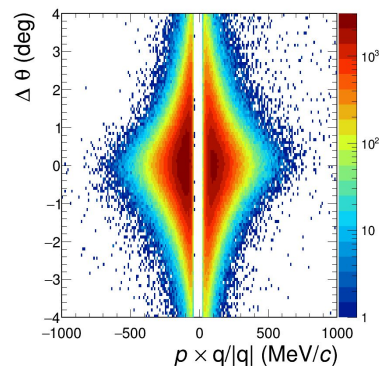
## HADES Performance



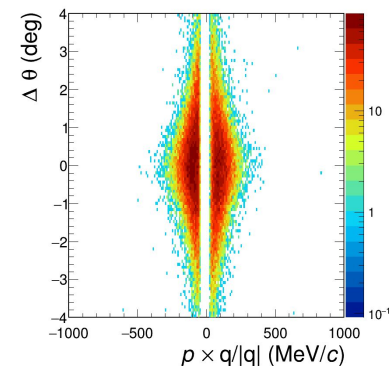
$$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.23 \text{ GeV}$$



$$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.14 \text{ GeV}$$

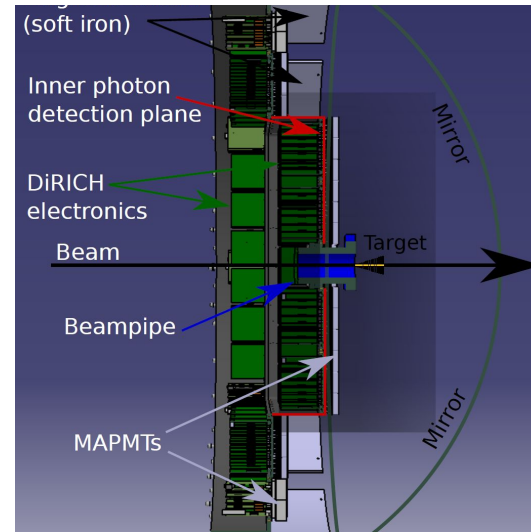
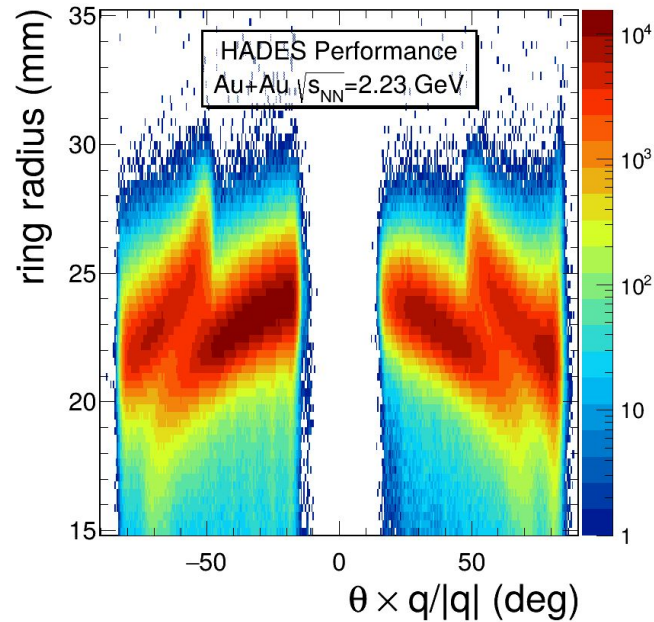


$$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.05 \text{ GeV}$$

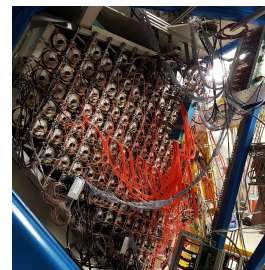


$$\text{Au+Au}\sqrt{S_{\text{NN}}} = 1.96 \text{ GeV}$$

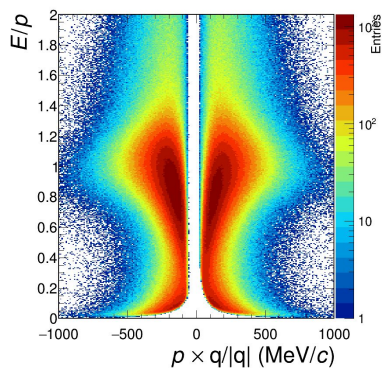
# Ring Radius Comparison in the Inner and Outer Plane of the RICH



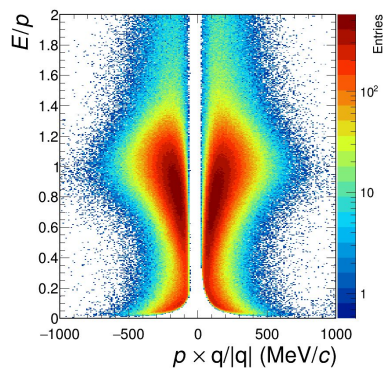
# Energy loss in the Electromagnetic calorimeter



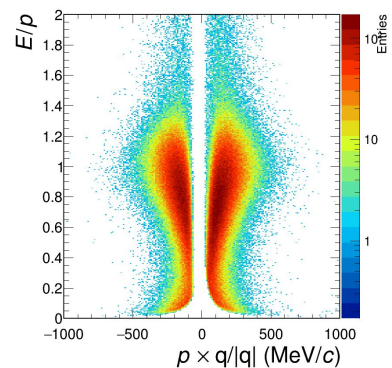
HADES Performance



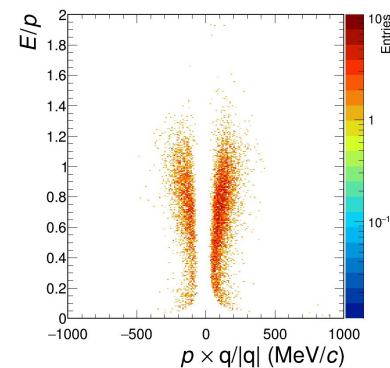
$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.23 \text{ GeV}$



$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.14 \text{ GeV}$



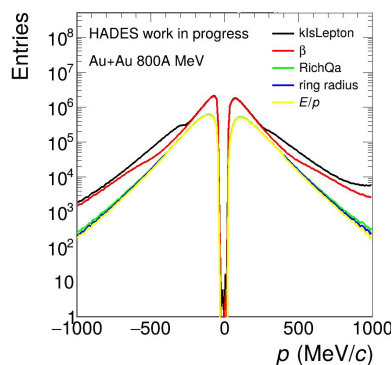
$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.05 \text{ GeV}$



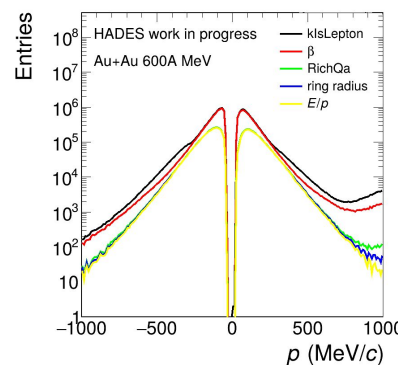
$\text{Au+Au}\sqrt{S_{\text{NN}}} = 1.96 \text{ GeV}$

# Cut by Cut Distributions of Lepton Candidates for the Apr25 Beam Energy Scan

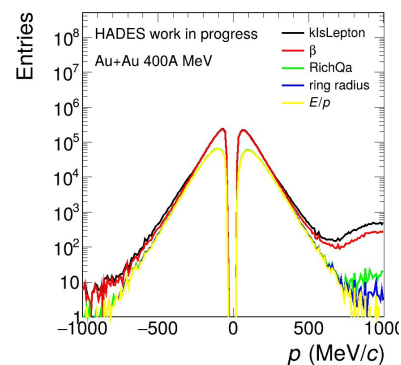
## HADES Performance



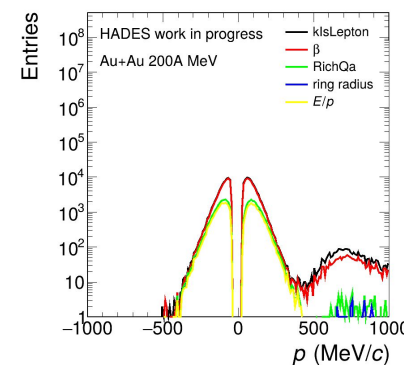
$$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.23 \text{ GeV}$$



$$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.14 \text{ GeV}$$



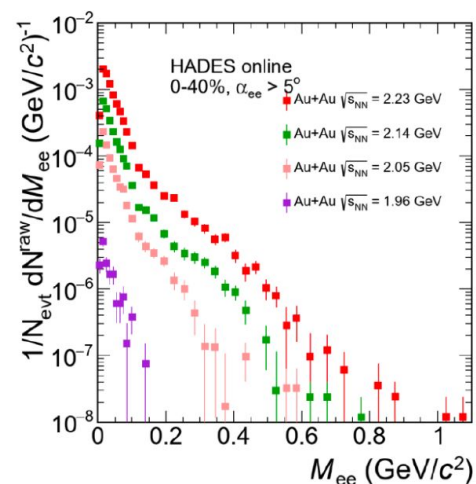
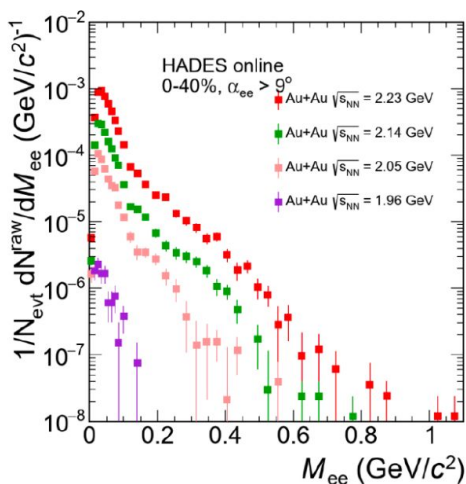
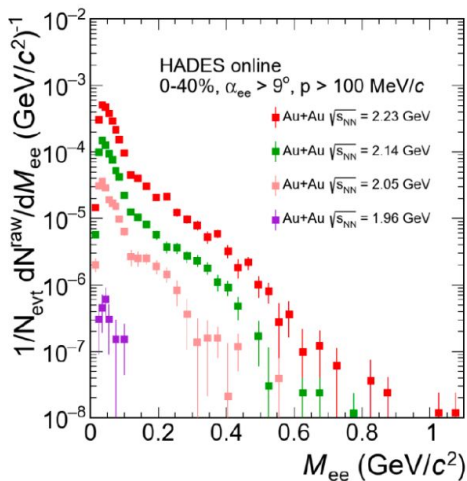
$$\text{Au+Au}\sqrt{S_{\text{NN}}} = 2.05 \text{ GeV}$$



$$\text{Au+Au}\sqrt{S_{\text{NN}}} = 1.96 \text{ GeV}$$

# Invariant mass distribution of Raw signal for the Apr25 Beam Energy Scan

- Data collected at  $E_{\text{kin}} = 0.8, 0.6, 0.4, \text{ and } 0.2A \text{ GeV}$  ( $\sqrt{s_{NN}} = 2.23, 2.14, 2.05, 1.96 \text{ GeV}$ )
  - Lowest energy below  $\pi^0$  production threshold in elementary collisions  
→ potentially no “physics background”
- In addition, dedicated run at  $E_{\text{kin}} = 0.8A \text{ GeV}$  with low magnetic field  
→ field reduced from 50% to 5% of max. field

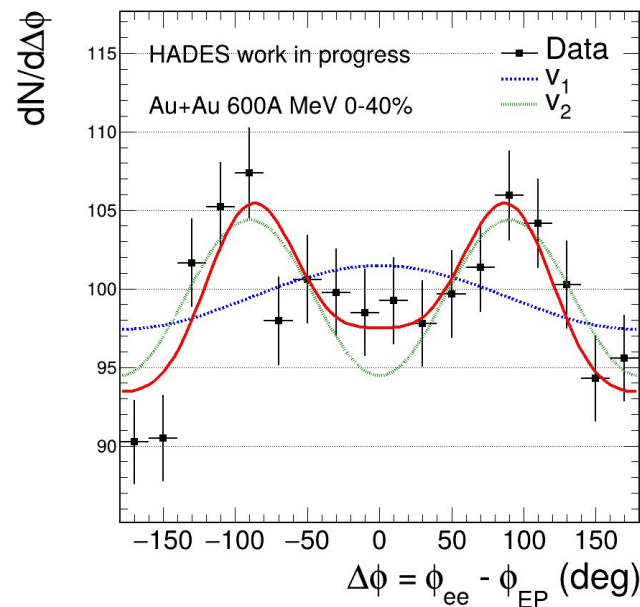
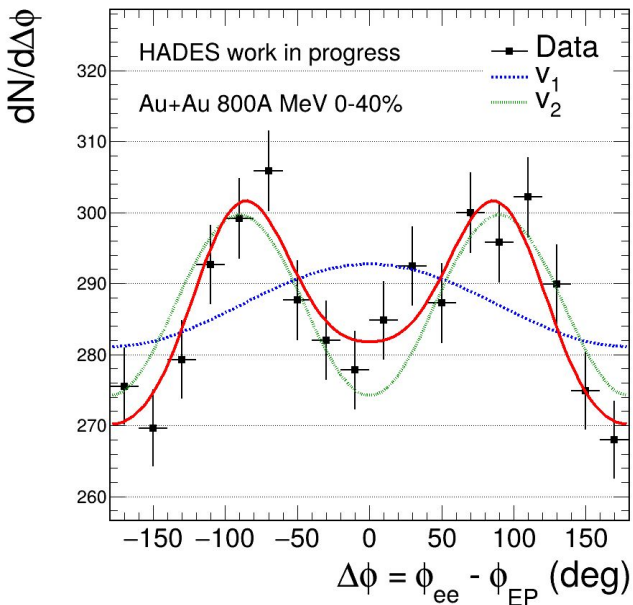


# First Look Into Flow for the Apr25 Beam Energy Scan



Precise event plane determination achieved  
using Forward wall

$$\frac{dN}{d\Delta\phi} \propto 1 + 2 \sum_{n=1}^{\infty} v_n \cos n(\phi - \Psi_{RP})$$



# Summary and Outlook

- Uncorrected Flow for Mar19 successfully reproduced
- Next:
  - Reproduce efficiency and occupancy corrected flow for Mar19
  - Improve the whole analysis using Machine Learning for Mar19
  - Obtain flow for the Feb24/Apr25 Beam energy scan

