Preliminary results on the transverse flow of light mesons from Ag+Ag collisions registered by the HADES experiment

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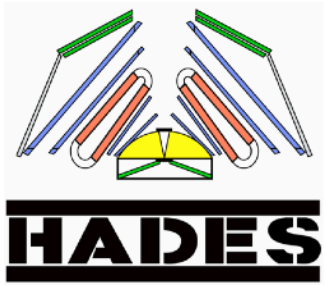

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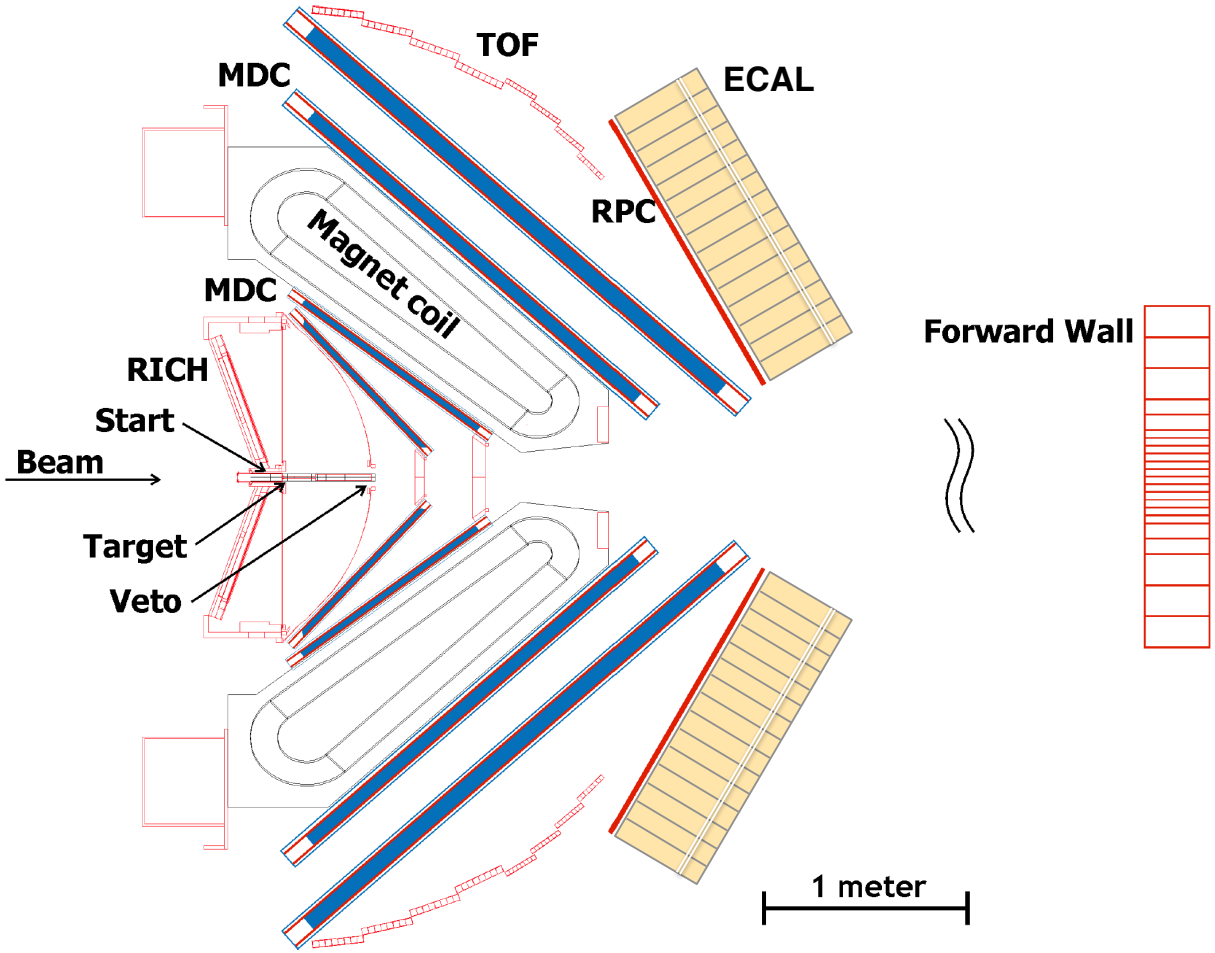
Overview

1. The HADES experiment
2. Azimuthal anisotropies (transverse flow)
3. Preliminary $p_T : y$ distribution of K^+ mesons
4. Preliminary flow patterns of K^+ mesons
5. Summary and outlook

High **A**cceptance **D**i-**E**lectron **S**pectrometer

- Installed at the SIS18 accelerator at GSI (Darmstadt, Germany)
- Measures products of *A*+*A* as well as *p*+*A*, *p*+*p* and π+*A* collisions
- 0.2 - 4.5 GeV/nucleon beam energy regime;
- In close cooperation with the future CBM experiment at SIS100.



G. Agakichiev et al. (HADES Collaboration), Eur. Phys. J. A 41, 243 (2009)

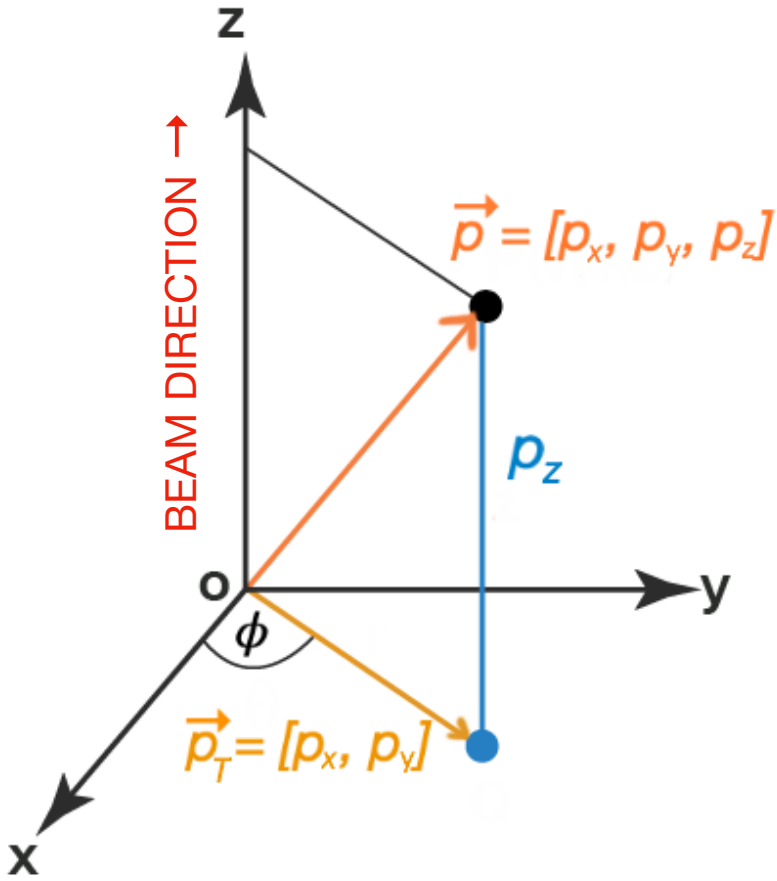
The relativistic momentum phase space

- Rapidity $y_i \equiv \operatorname{atanh}(\beta_i)$, where $\beta_i = \dfrac{v_i}{c}$

- "Usual" description of spectra is two-dimensional:

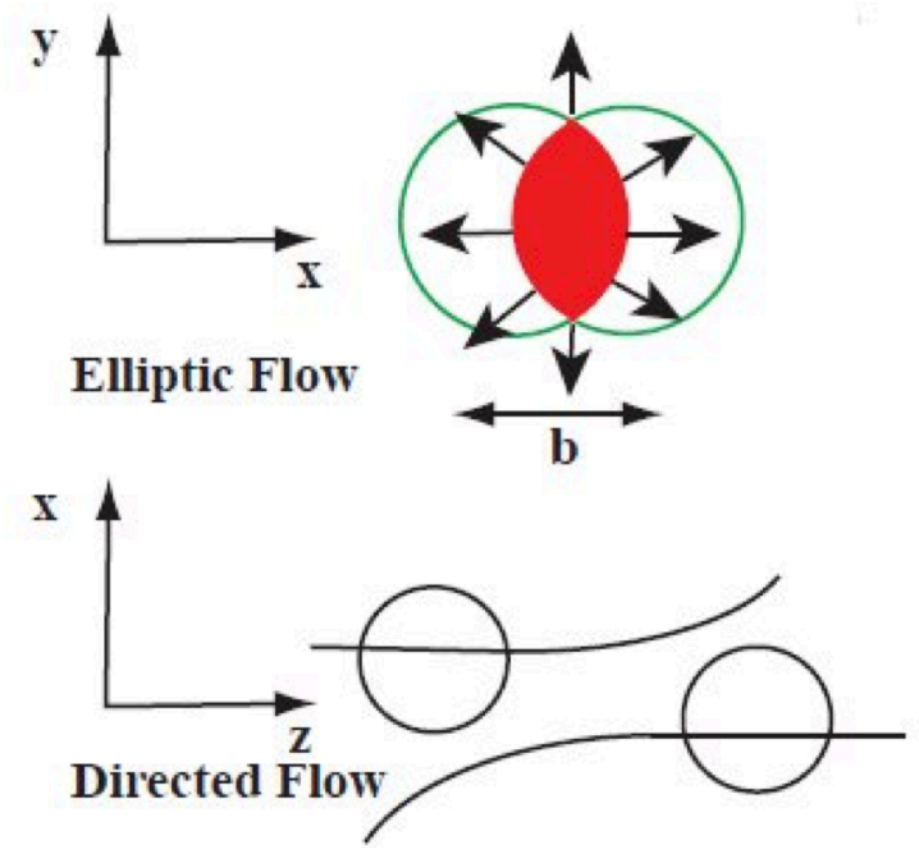
$$p_T \equiv |\vec{p_T}|$$
$$y \equiv y_Z \qquad y_0 = \frac{y - y_{CM}}{y_{CM}}$$

- Notice! We collapse 3D → 2D. Information about the ϕ angle is lost in such an approach.



The ϕ azimuthal angle in heavy-ion collisions

- The azimuthal angle matters in describing momenta of particles emitted from heavy ion collisions
- The distributions in this angle are not isotropic!
- Anisotropies of these distributions are called the **transverse flow**
- Caused by non-spherical geometry of the collision and other more intricate effects

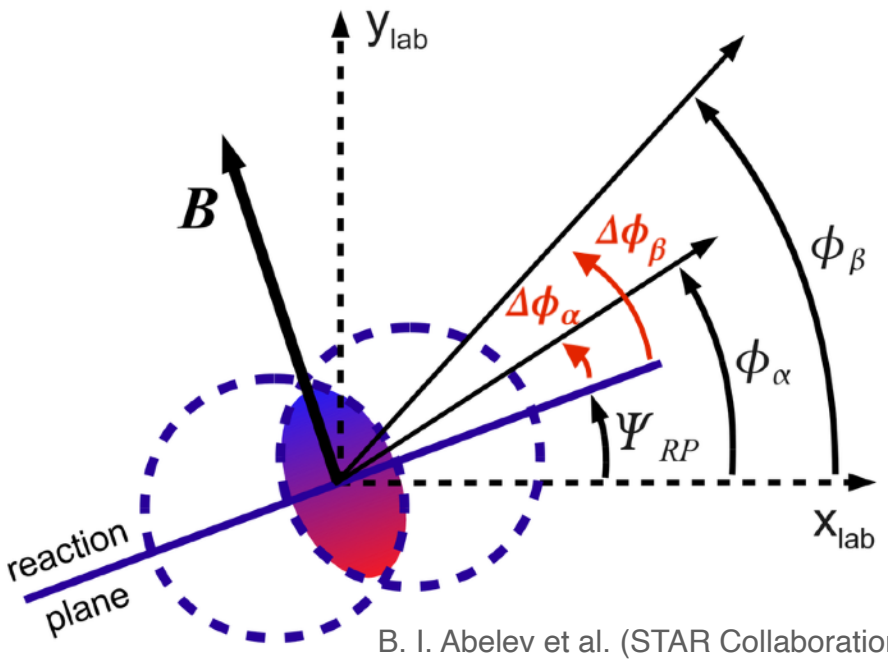


A. Poskanzer et al., arXiv:08090409 [nucl-ex] (2002)

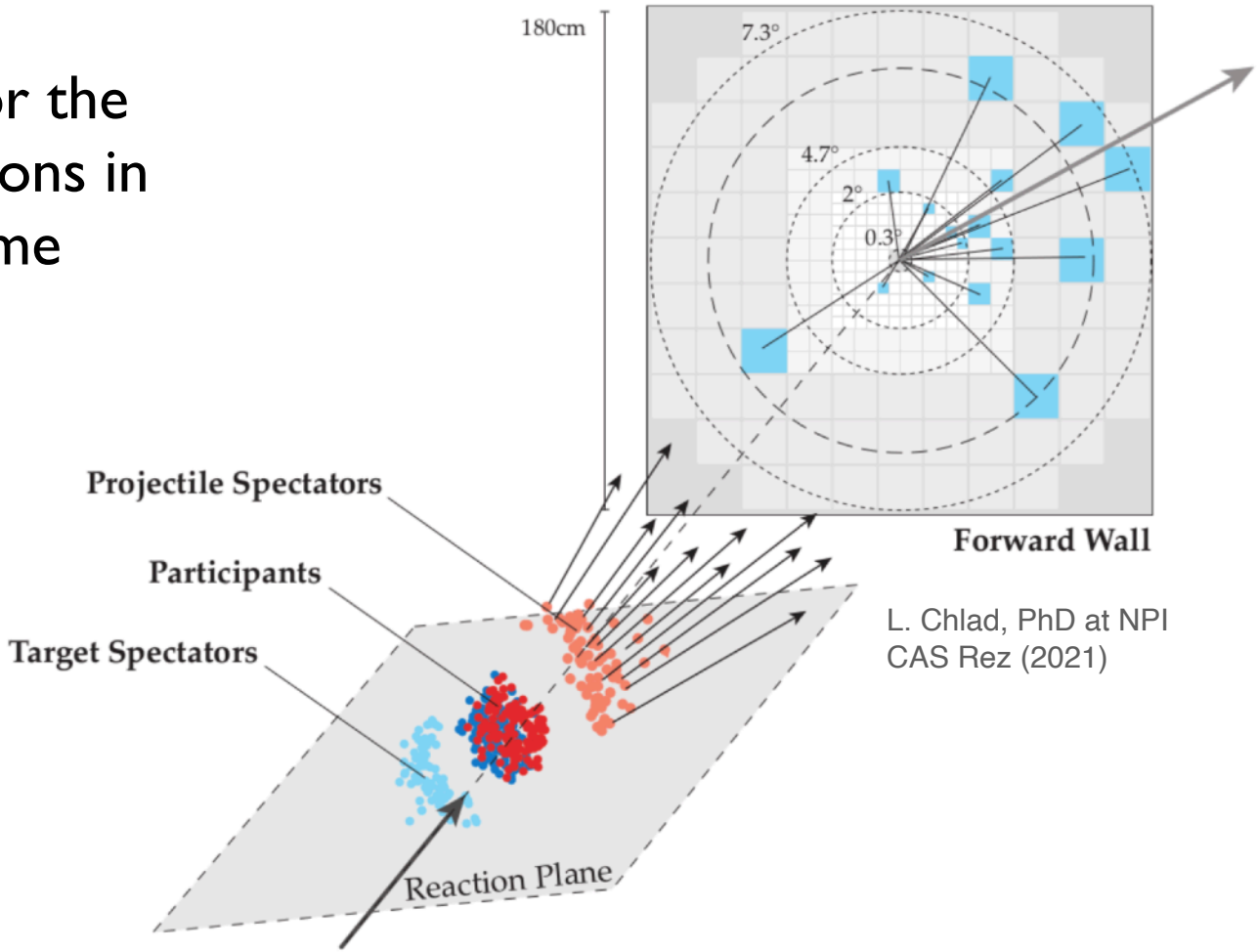
Orientation of collisions is random in the Lab

- The azimuthal angle is only meaningful if we correct it for the random orientation of collisions in the laboratory reference frame

- We obtain $\Delta\phi = \phi - \Psi_{RP}$



B. I. Abelev et al. (STAR Collaboration), Phys. Rev. Lett. 103(25):251601 (2009)



L. Chlad, PhD at NPI CAS Rez (2021)

Measurement of flow

- The azimuthal angle distribution can be described with a Fourier series:

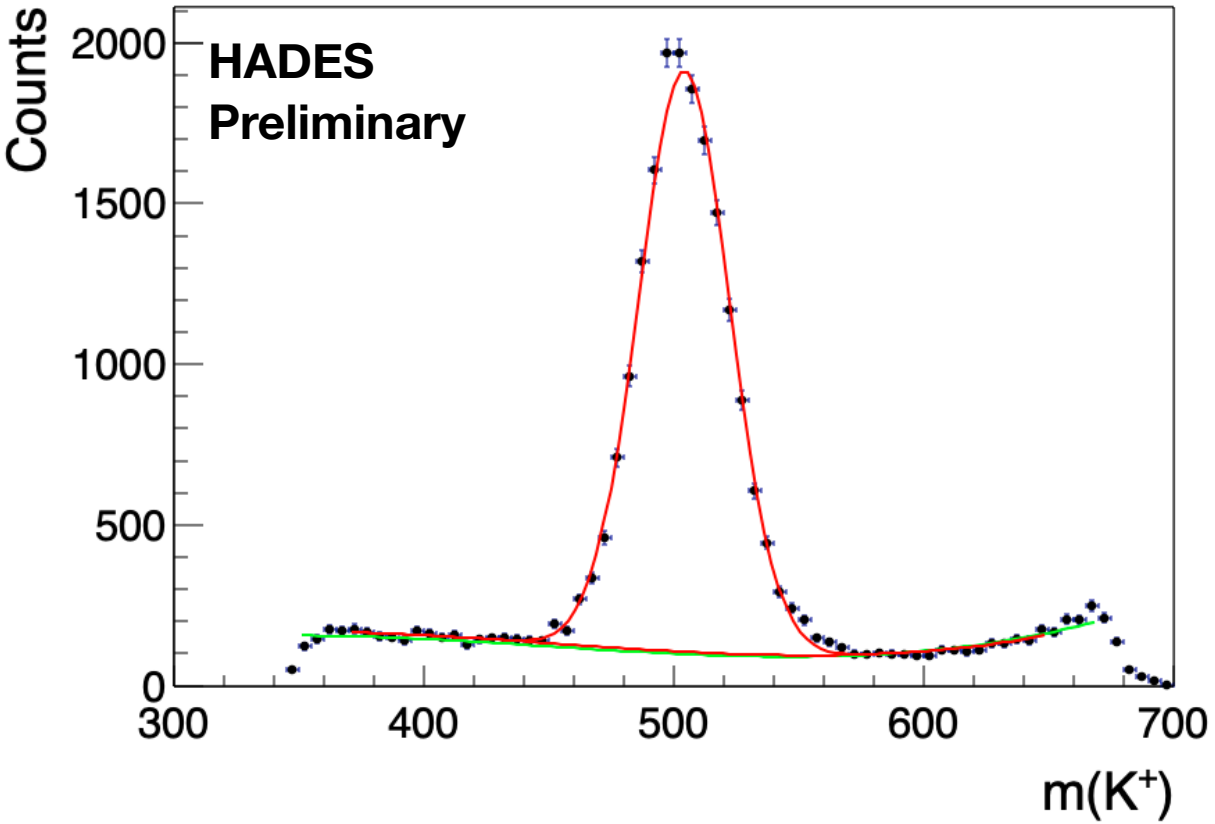
$$\frac{dN}{d\Delta\phi} = \mathcal{N}\left(1 + 2\sum_{n} v_n \cos(n\Delta\phi)\right)$$

- The goal of flow analysis is to obtain maps of $v_{1,2,\ldots}(p_T, y)$

- Such maps are sensitive to many exciting features of nuclear matter:
  - the nuclear Equation of State (EoS)
  - in-medium effects on particles masses

Identification of K^+ emitted from Ag+Ag collisions at beam kinetic energy of 1.58 GeV/nucleon

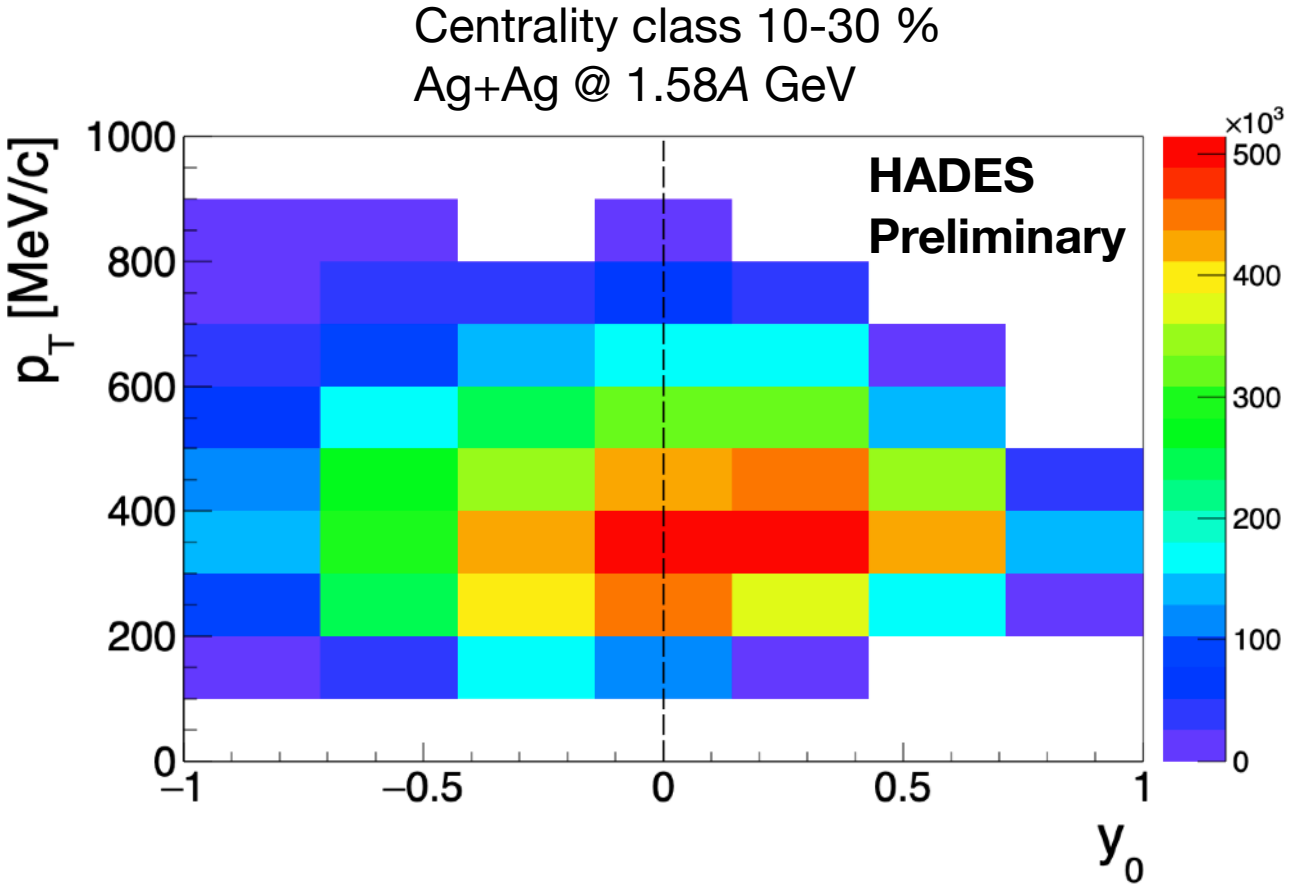
- Mass spectrum in given $p_T - y$ intervals shows Gaussian peak around K^+ mass
- Background modeled with polynomial of 3rd degree
- Independent fits in p_T , y_0 and $\Delta\phi$ bins yield a 3D distribution of K^+ mesons



- This plot: example for $400 < p_T$ [MeV/c] < 500 and $-0{,}71 < y_0 < -0{,}43$.

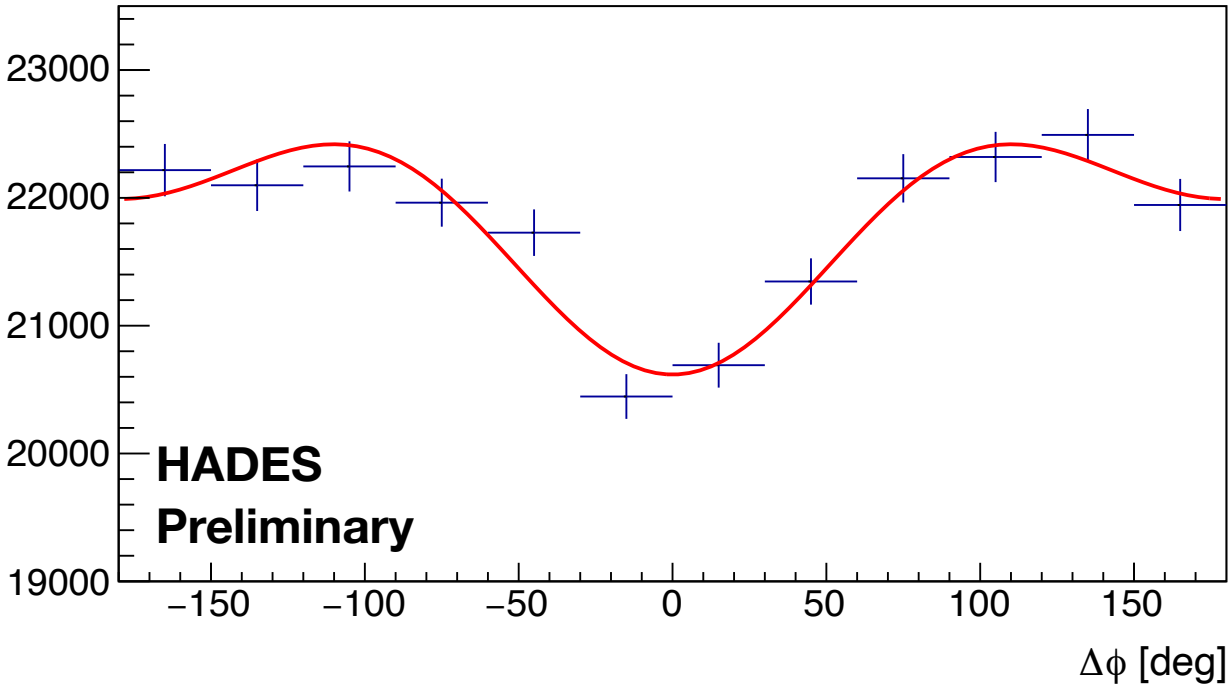
$p_T : y$ distribution of K^+

- 8.6 millions of K^+ reconstructed
- Presented distribution is not corrected for efficiency
- Such distribution (after correction) can be used to:
  - compare transport models to data
  - extrapolate outside of the acceptance and obtain total kaon yield



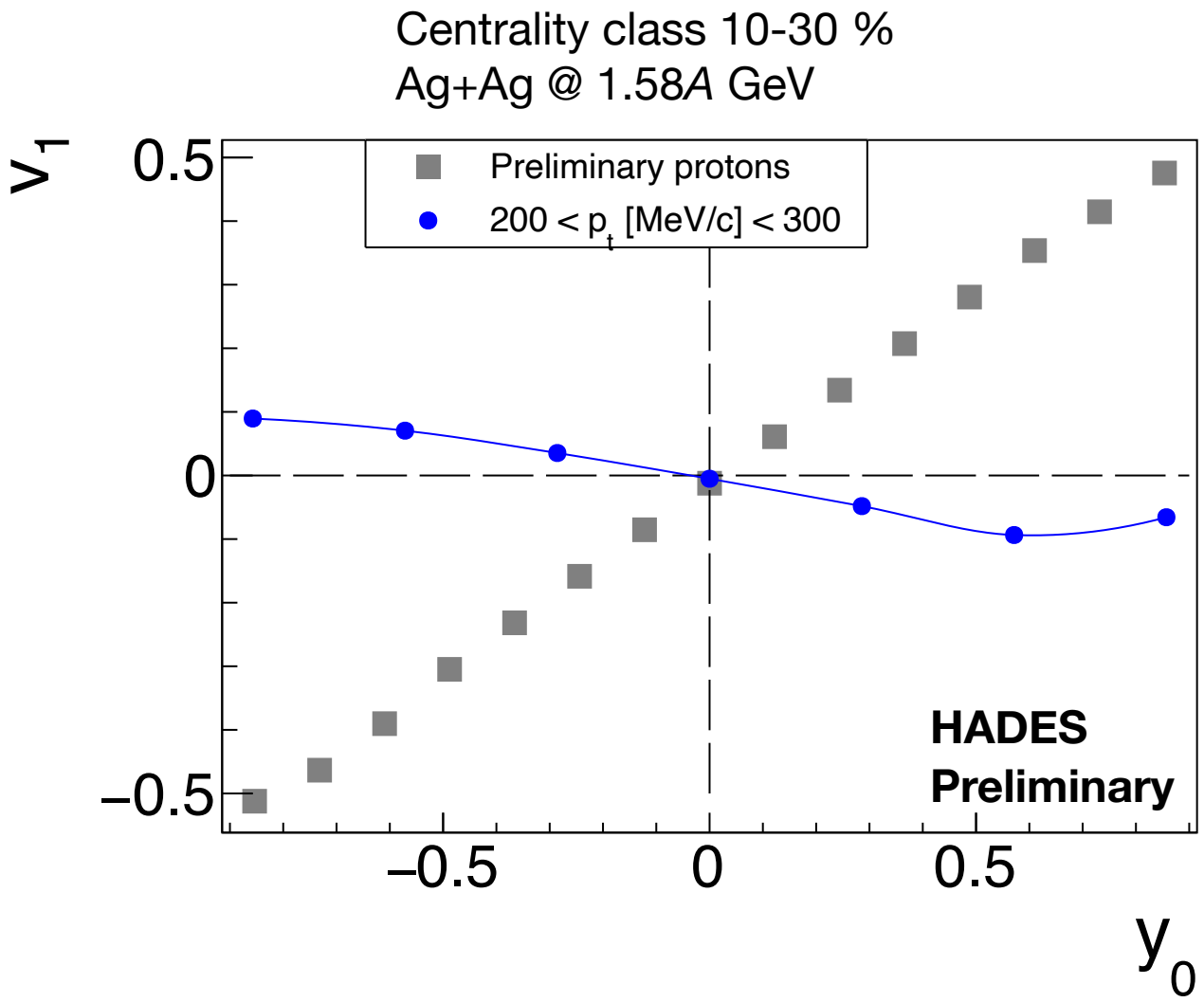
Fourier analysis

- $\Delta\phi$ distribution for given $p_T - y$ interval, is fitted with a Fourier series to extract harmonics



- This plot: example for $400 < p_T$ [MeV/c] < 500 and $-0{,}71 < y_0 < -0{,}43$.
- For this cell, $\frac{\mathrm{d}N}{\mathrm{d}\Delta\phi}$ can be described with $v_1 = -0.016$ and $v_2 = -0.011$.

Directed flow (v_1) of K^+ as function of p_T and y_0



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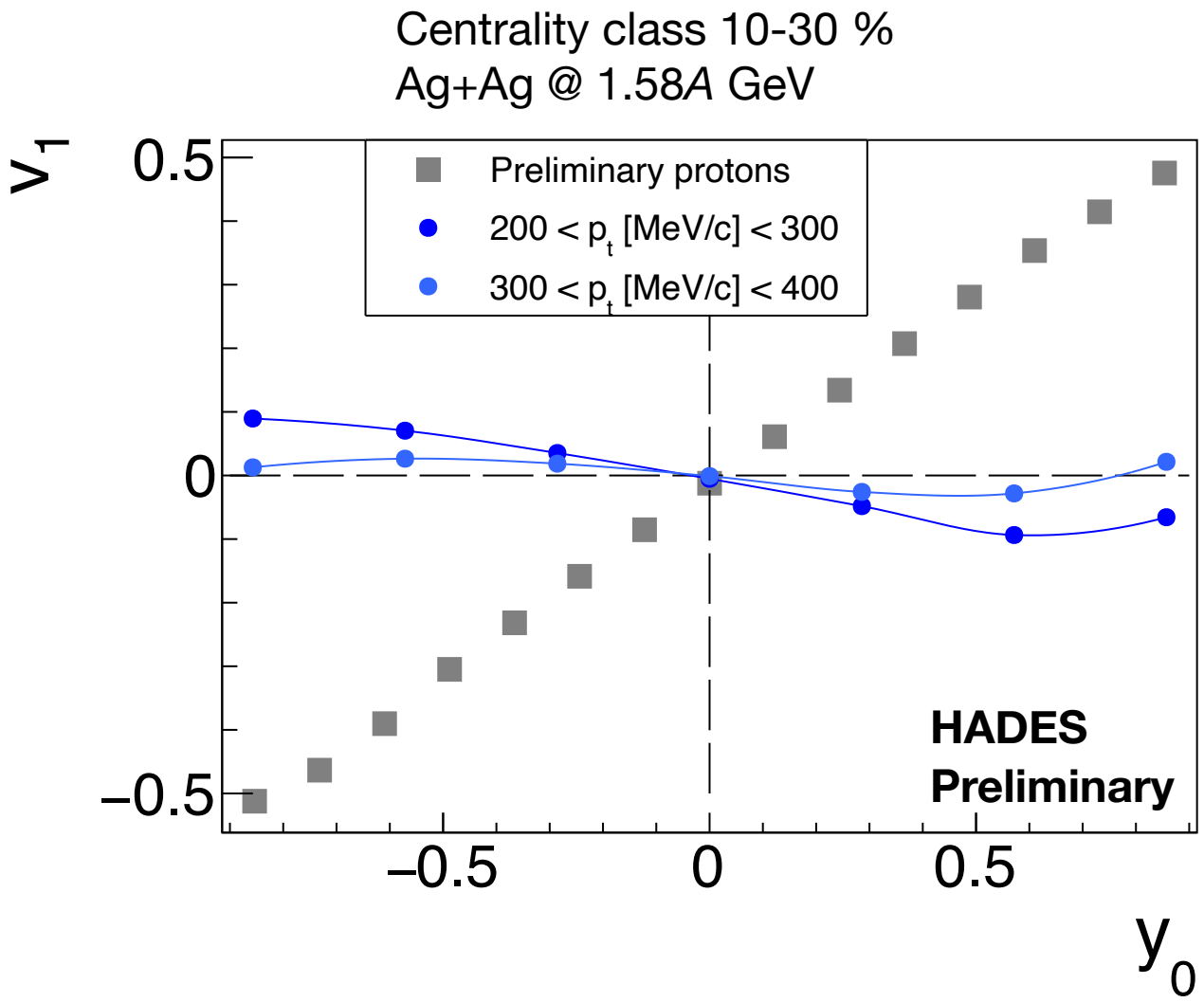

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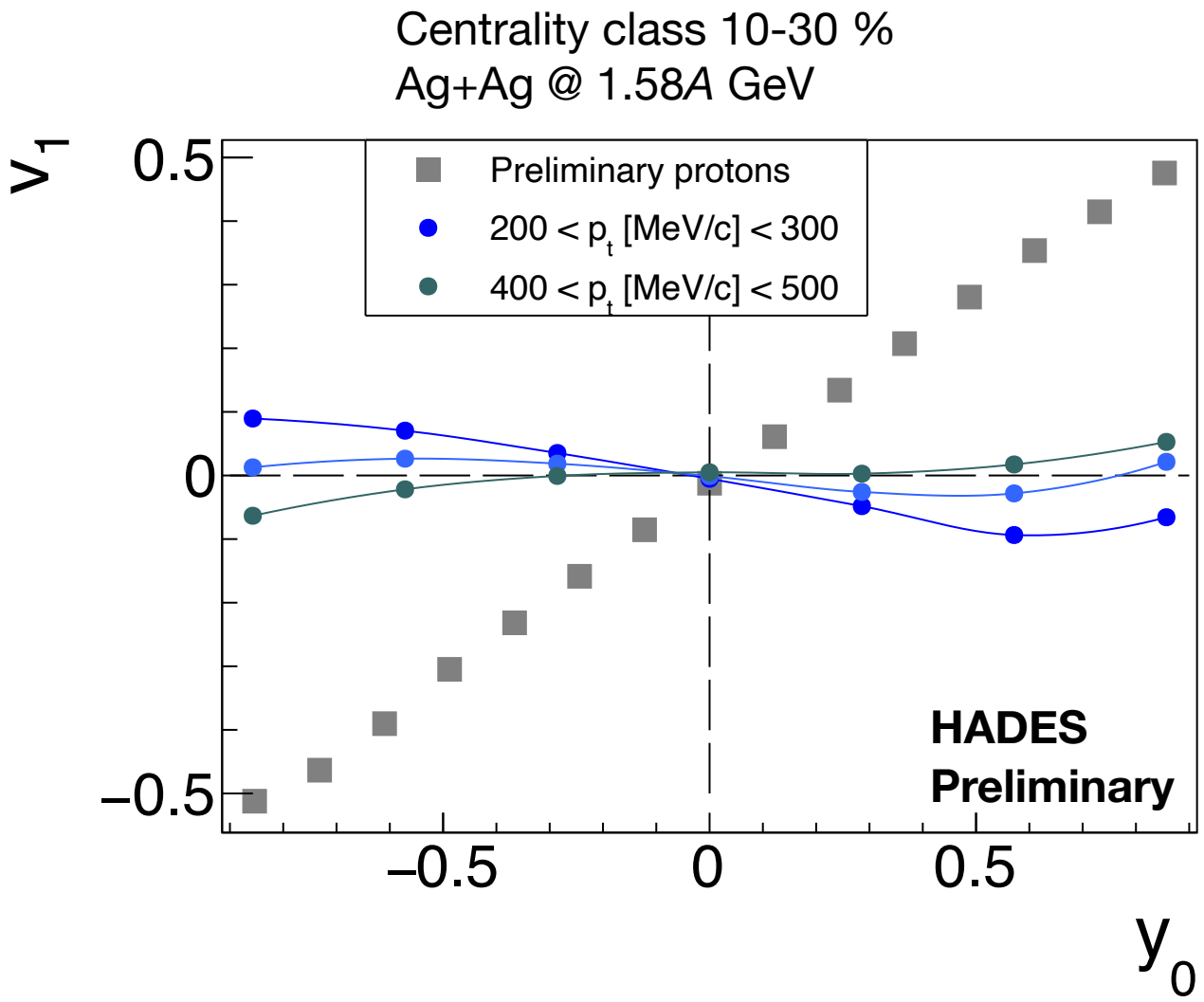

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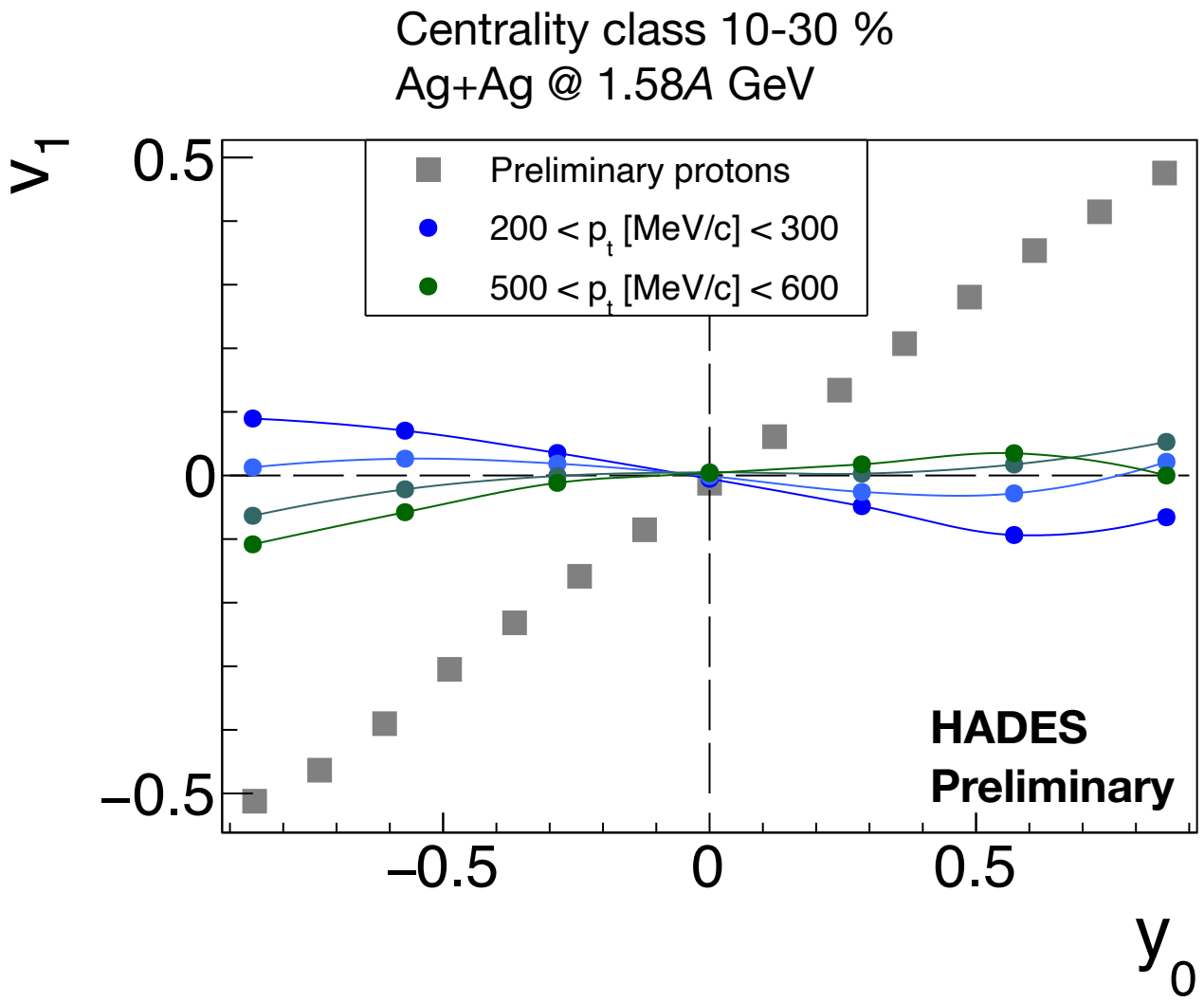

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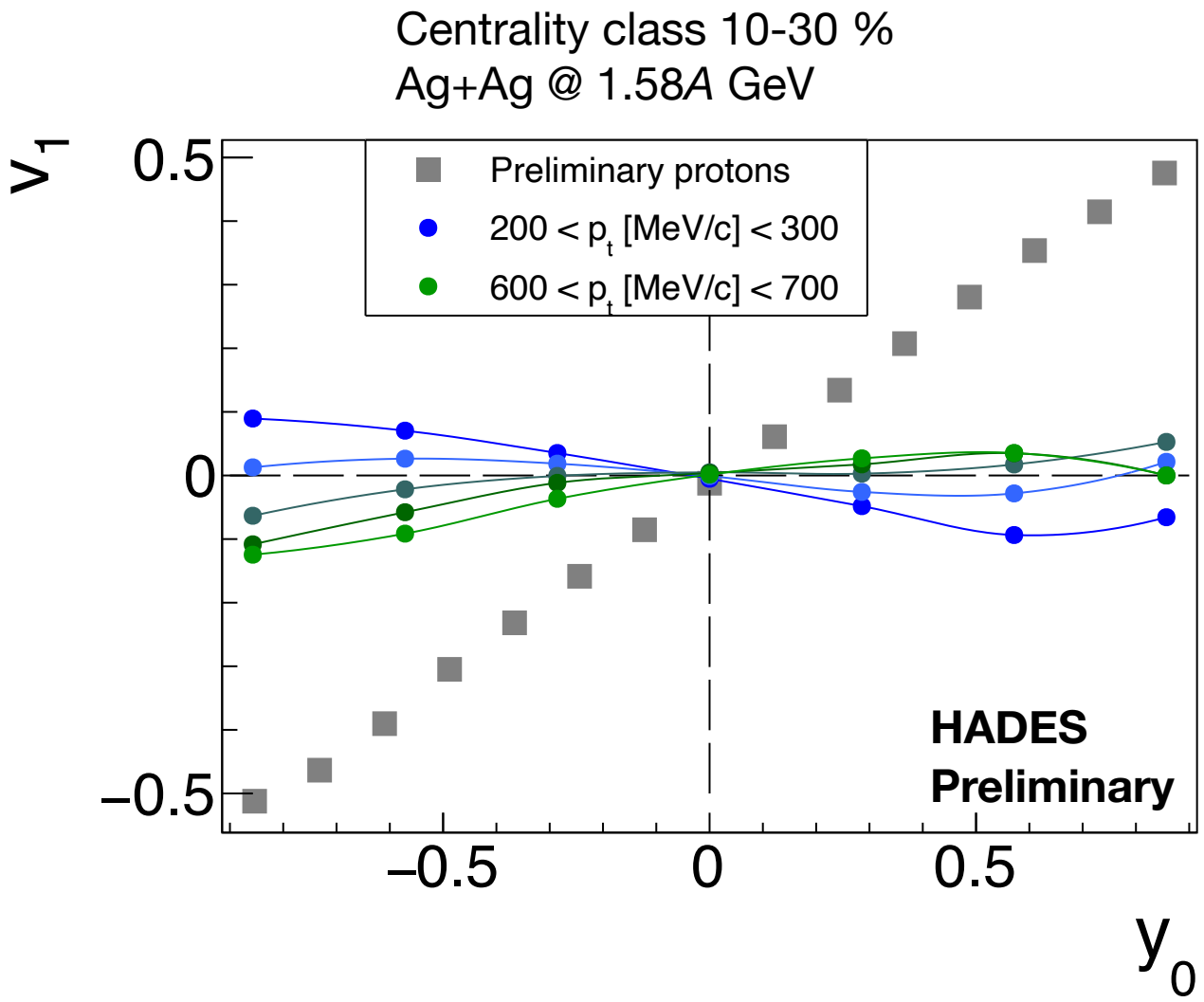

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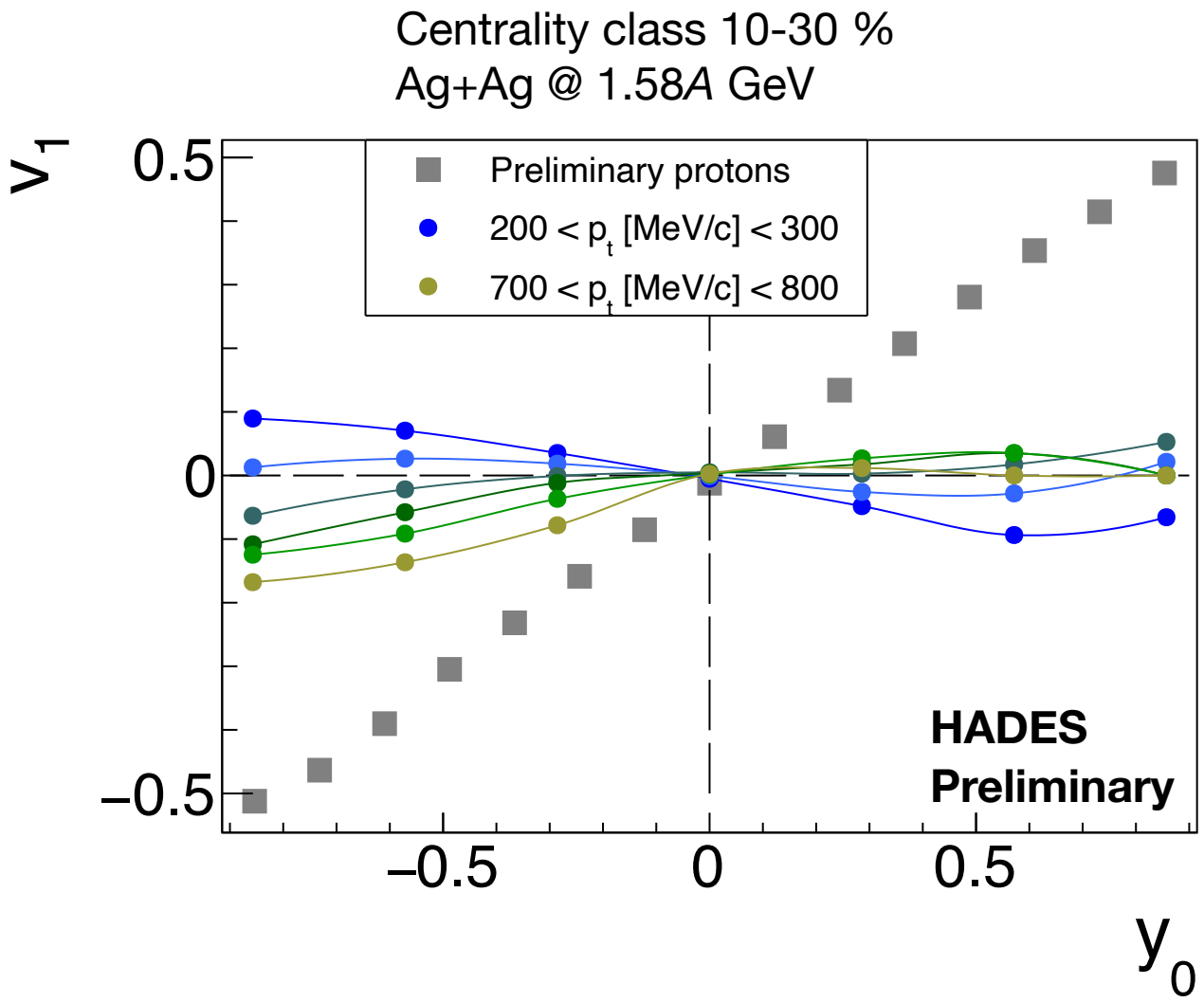
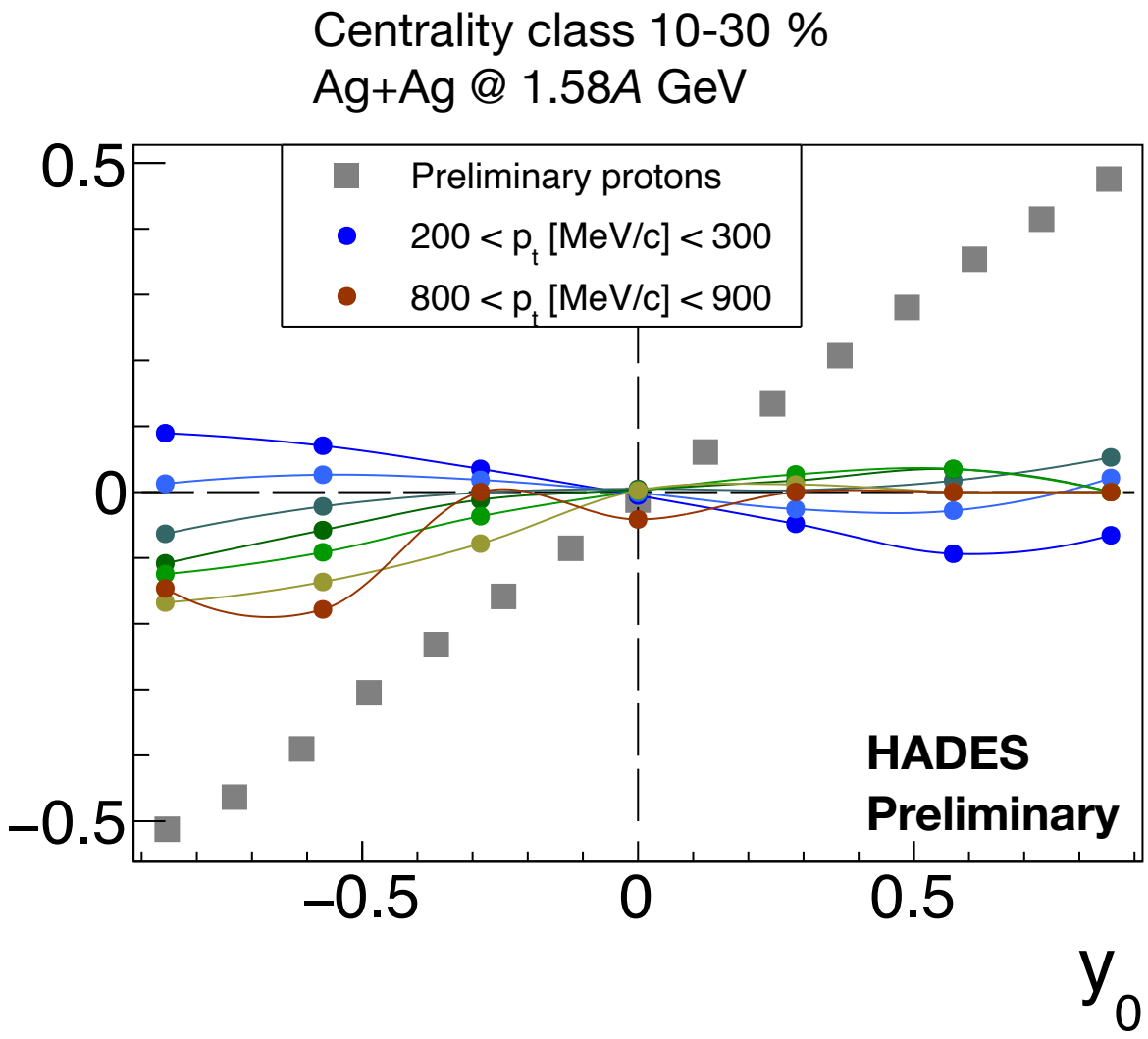
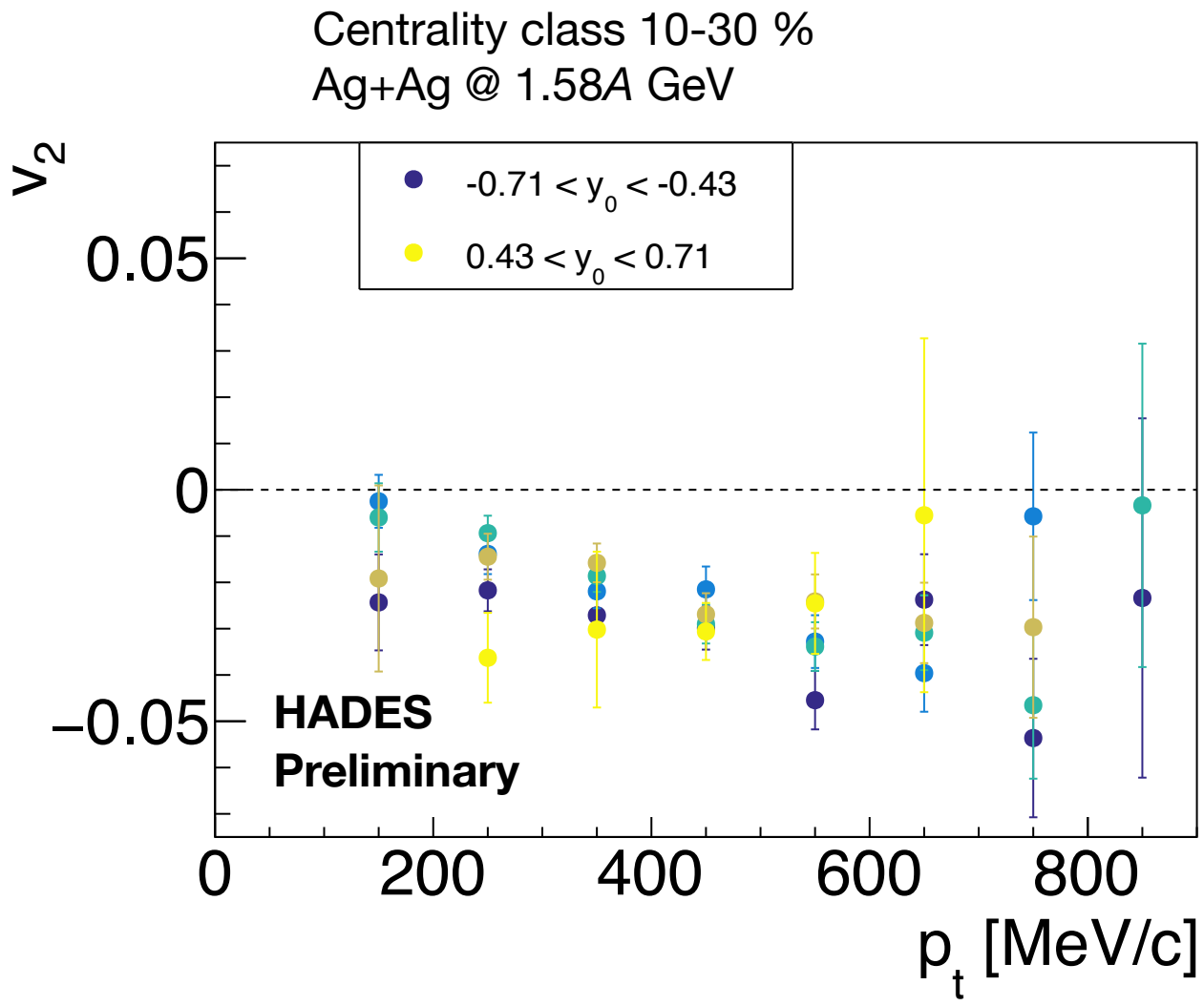


Directed flow (v_1) of K^+ as function of p_T and y_0

- 'Antiflow' effect observed!
- For low p_t , K^+ mesons have inverse flow patterns w.r.t. protons (bulk matter)
- For higher momenta the effect is not visible
- Possible indication of kaon-nucleon interaction?
- Results lack efficiency analysis and systematic err's



Elliptic flow (v_2) of K^+ as function of p_T and y_0



Summary and outlook

- Kinematic distribution of K^+ mesons was studied in three dimensions
- The azimuthal angle ($\Delta\phi$) distribution is the focus of reported analysis and gives access to the flow observables
- $v_1(y)$ for K^+ mesons with low transverse momenta shows strong 'antiflow' compared to protons - result of kaon-nucleon potential?
- PhD project in progress:
  - improve flow reconstruction method and evaluate systematic errors
  - extend analysis to other strange hadrons ($K^{-,0}$, Λ, ϕ)

Thank you for your attention!