Strangeness flow in Au+Au collisions at 1.23 AGeV measured with HADES

Lukáš Chlad
for HADES collaboration

GSI

FAIR

EUROPEAN UNION
European Structural and Investment Funds
Operational Programme Research,
Development and Education

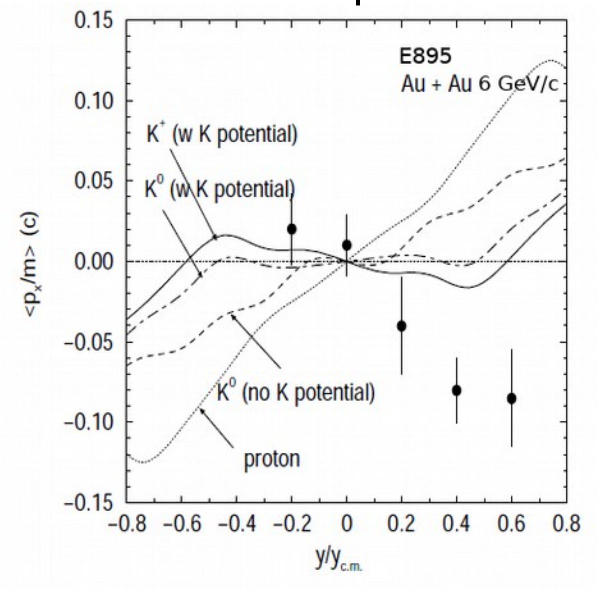
MINISTRY OF EDUCATION,
YOUTH AND SPORTS

ÚJF

Strange Quark Matter 2019
13. 6. 2019

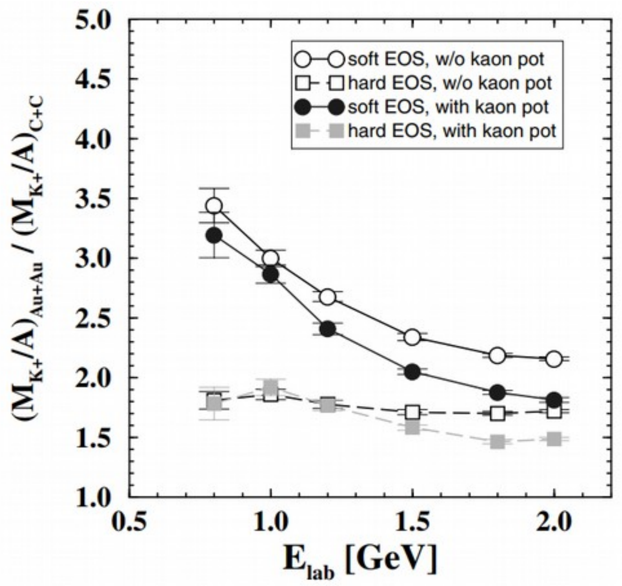
Why is it interesting to study strangeness flow?

Kaon flow is very sensitive on KN potential



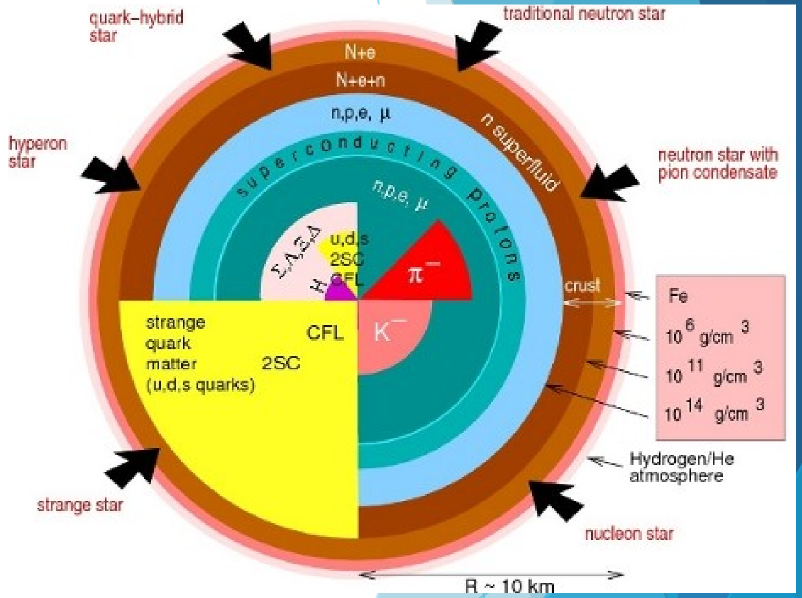
J.Phys. G26 (2000) 1665-1670

Kaons are good probe of EOS



Phys.Rev.Lett. 86, 1974-1977, 2001

Kaons might exist inside neutron stars



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Kaon propagation and production in nuclear medium is affected by kaon-nucleon potential

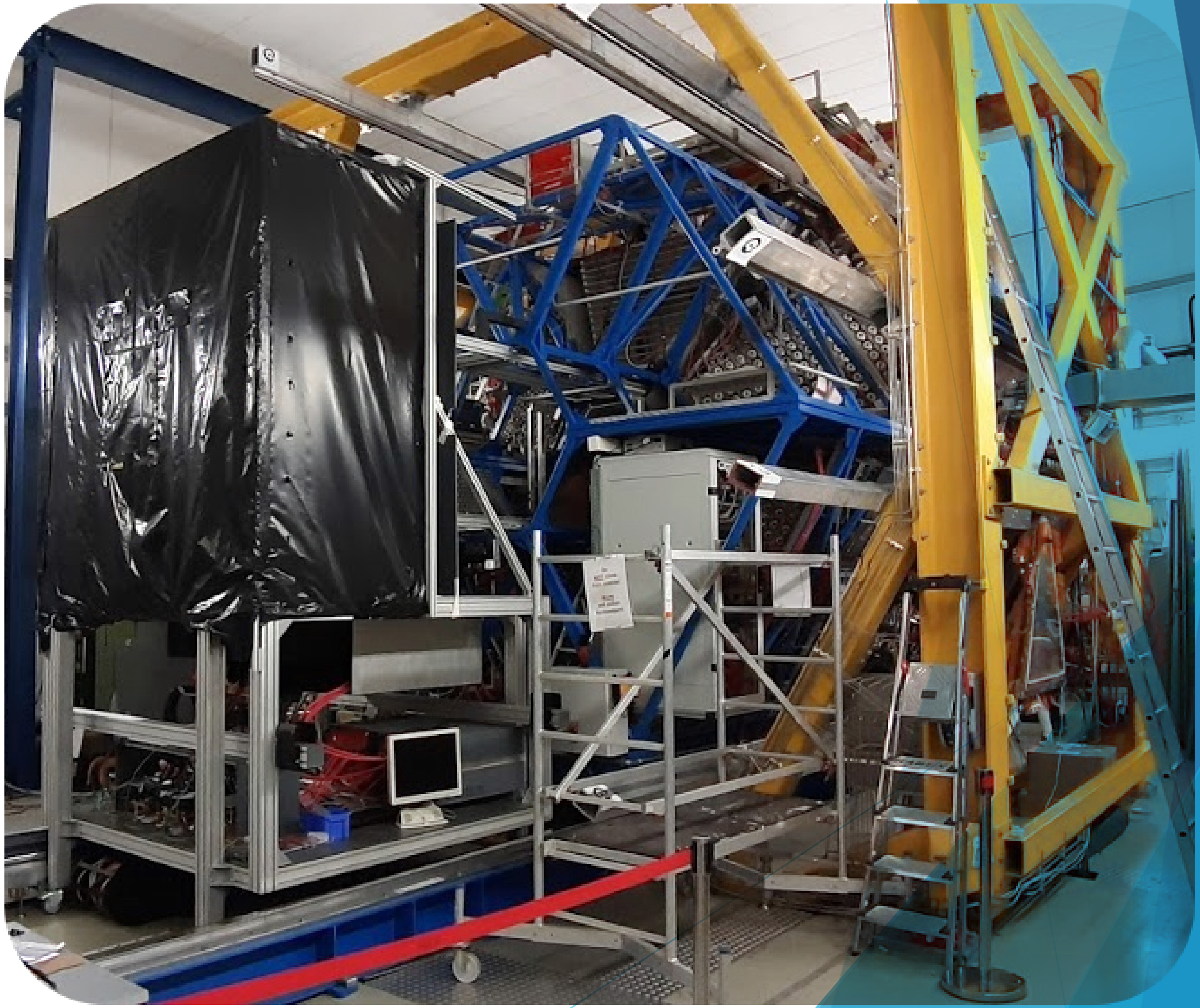
Kaon flow is important test for models like HSD, IQMD, BUU...

Hight **A**cceptace **D**i-**E**lectron **S**pectrometer

Fixed target experiment
Toroidal magnetic field
=> Six sector design provides
Full azimuthal coverage
18°-85° polar coverage

Very precise time and position measurement
=> Great hadron detector (as well as lepton – new ECAL)

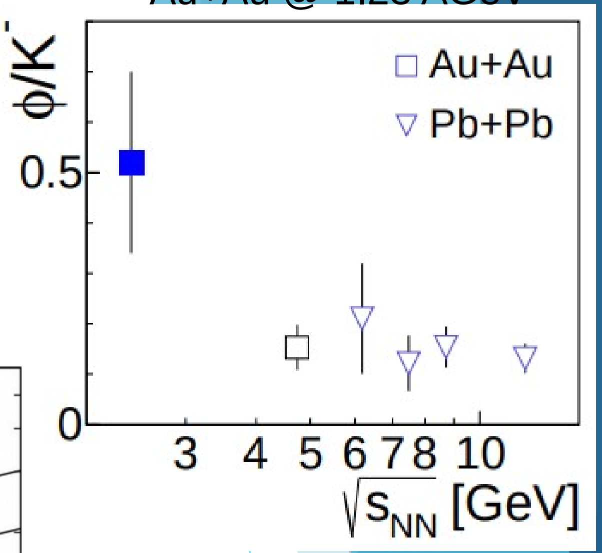
Superfast DAQ (above 10kHz HIC)



HADES strangeness program

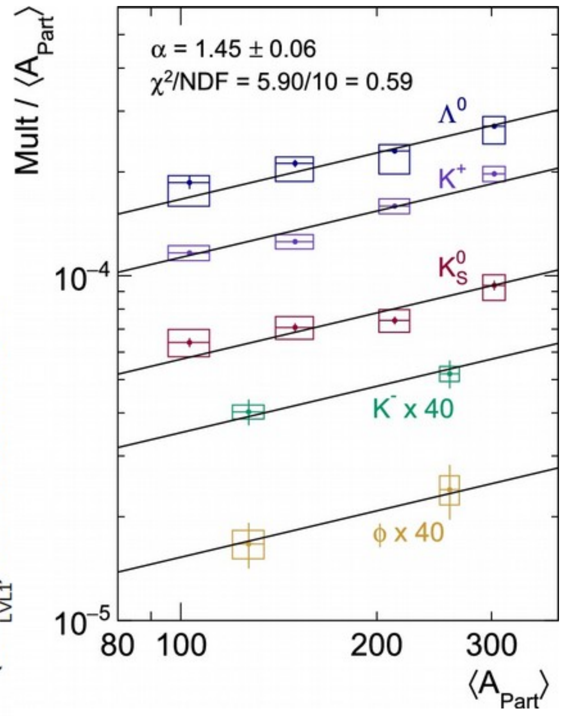
At low energy HIC rise of K^-/Φ - ratio
Universal $\langle A_{part} \rangle$ dependence of strangeness production (different thresholds)
Suppresion of K^- w.r.t K^+ in π+A
More details in presentation
M. Lorenz on Monday 10.6.

Au+Au @ 1.23 AGeV



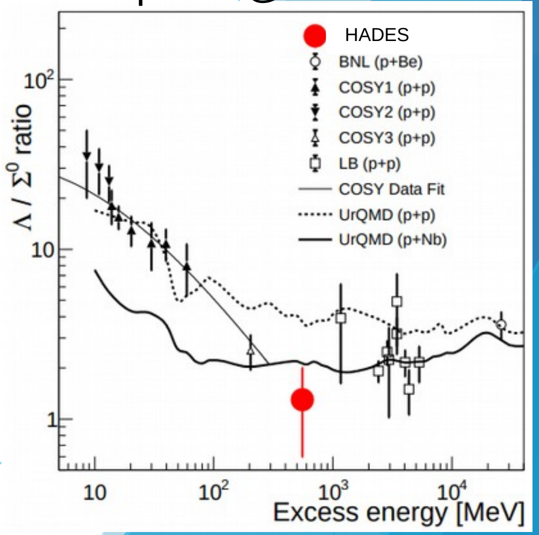
Phys.Lett. B778 (2018) 403-407

Au+Au @ 1.23 AGeV



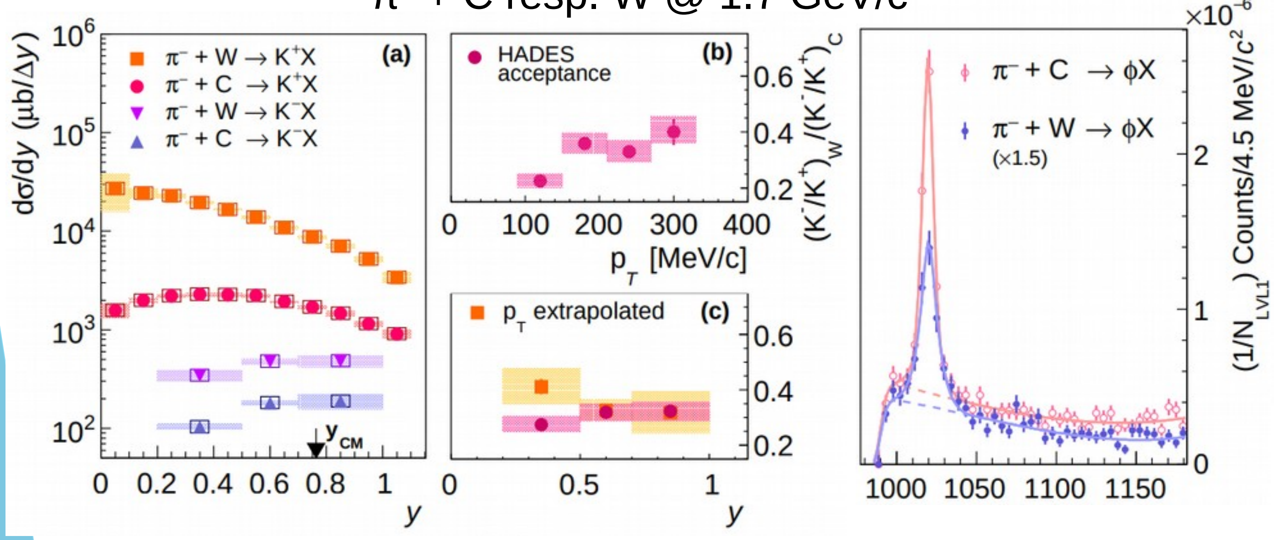
Phys.Lett. B793 (2019) 457-463

p+Nb @ 3.5 GeV/c



Phys.Lett. B781 (2018) 735-740

π- + C resp. W @ 1.7 GeV/c

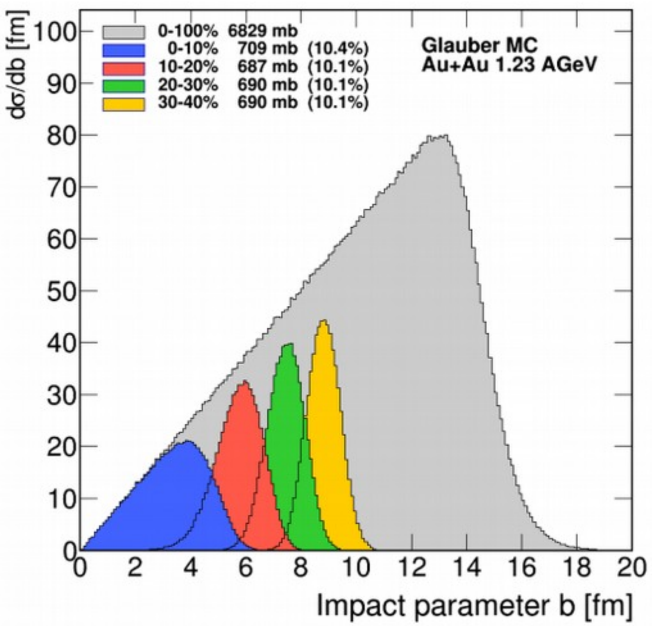


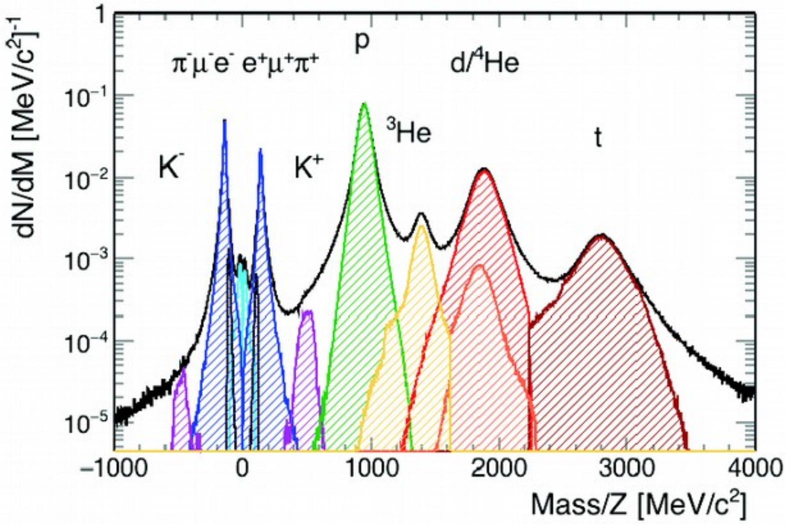
arXiv:1812.03728
(accepted by PRL)

Au+Au at 1.23 AGeV

Centrality Determination:

Eur. Phys. J. A (2018) 54: 85





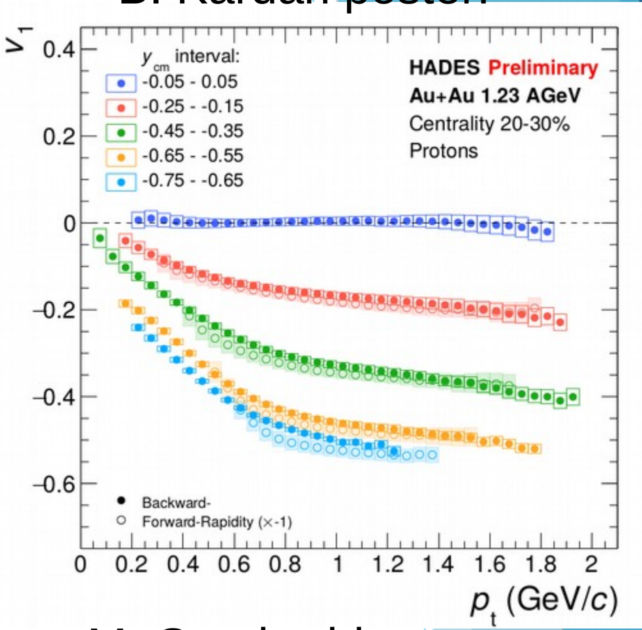
Selected 0-40%
most central collisions

After additional event
quality cuts => 2.1 billion
Events

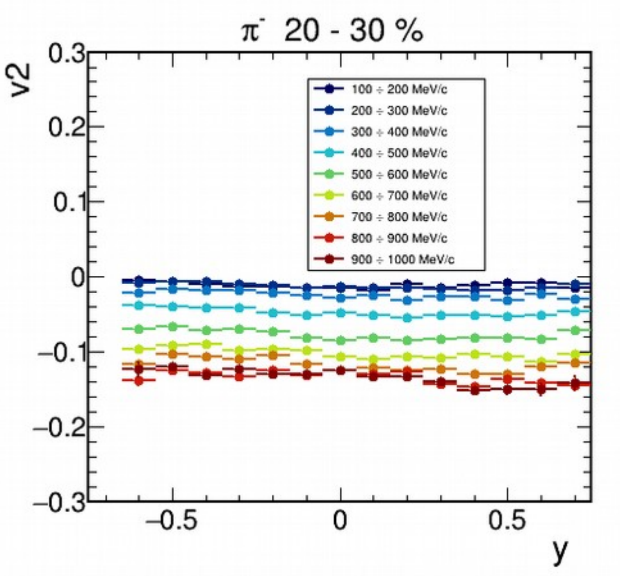
Excellent particle
identification

This opens possibilities
for very challenging
analysis

B. Kardan poster:

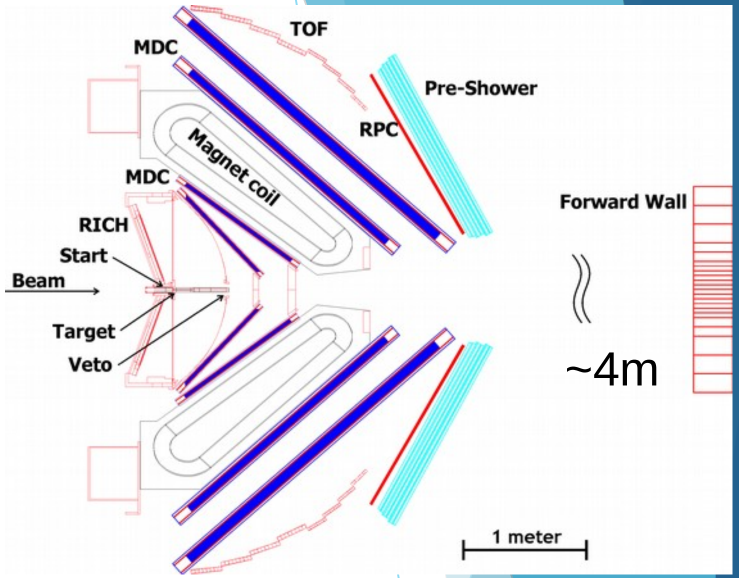


M. Gumberidze poster:

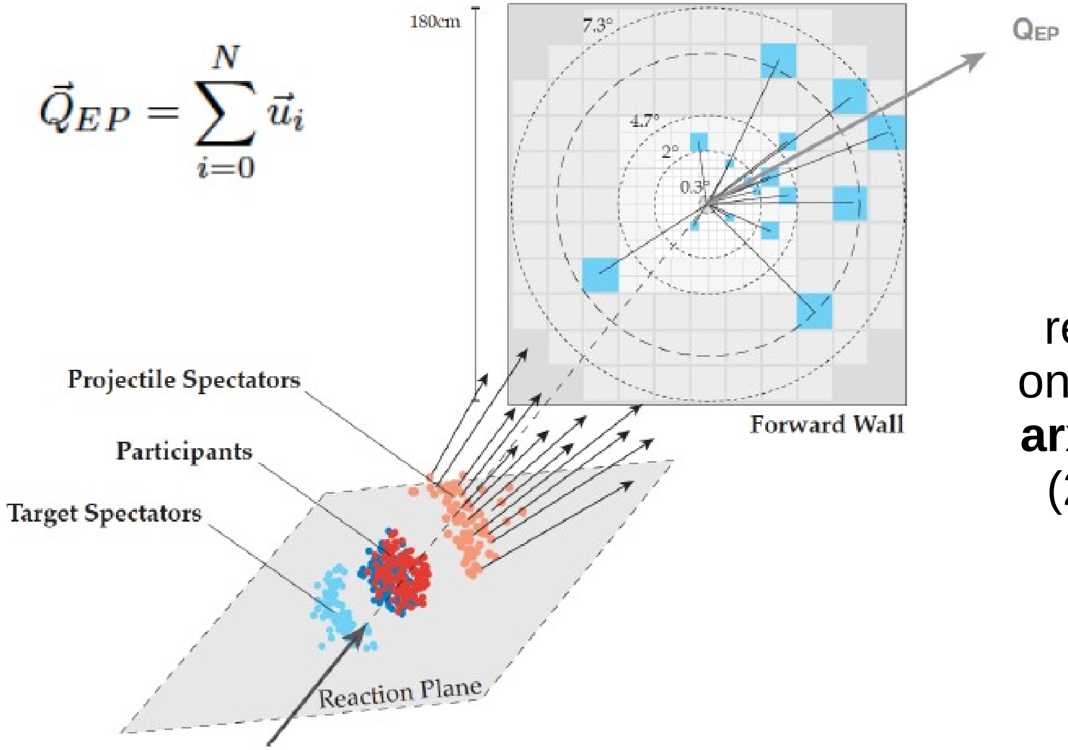


Event Plane reconstruction and resolution

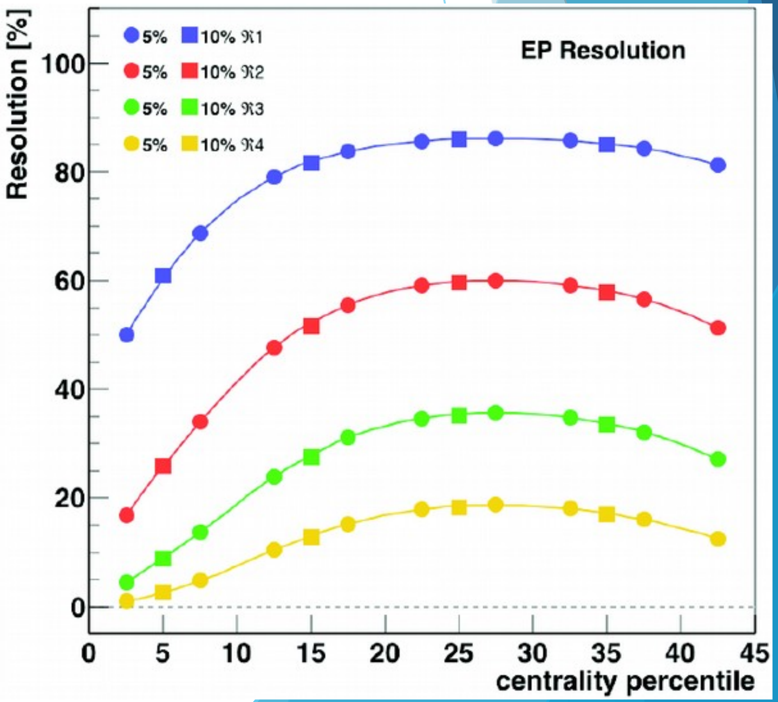
Event Plane is reconstructed from hits of charged projectile spectators registered in Forward Wall (big rapidity gap between FW and rest of HADES)



$$\vec{Q}_{EP} = \sum_{i=0}^{N} \vec{u}_i$$



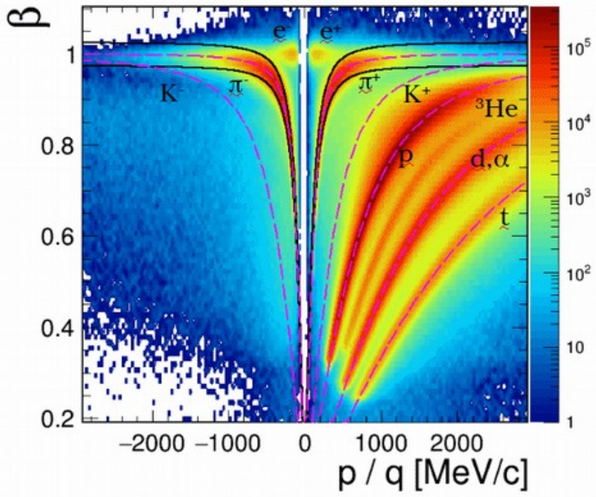
Resolution of EP reconstruction based on method described in **arxiv:nucl-ex/9711003** (2 subevent method)



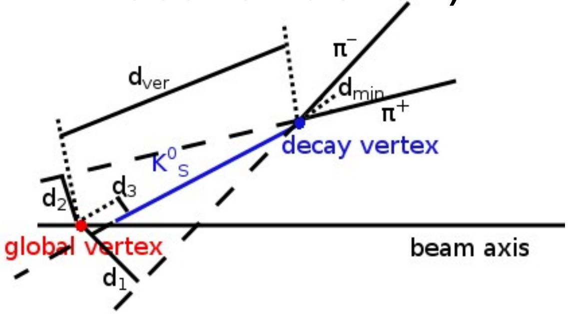
Kaon identification

K^0_s

Charged pions identification

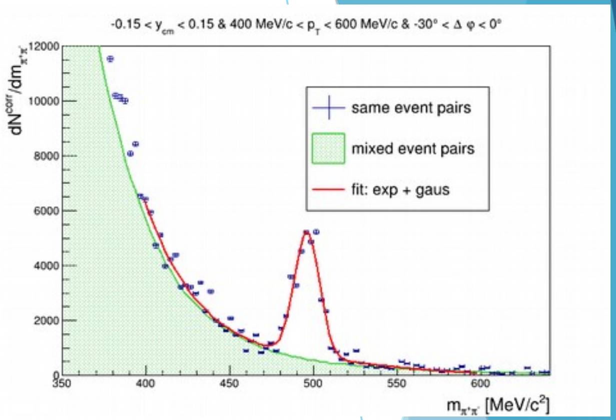


Topologycal cuts (secondary vertex reconstruction)



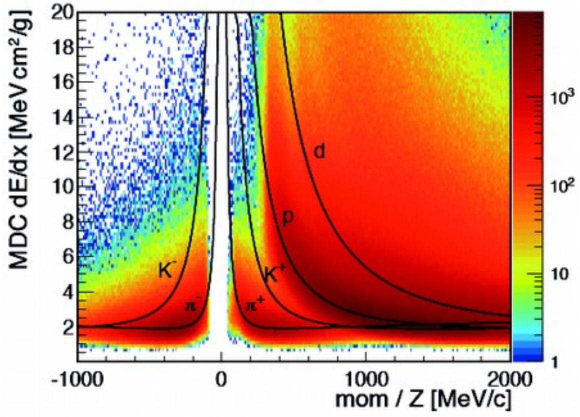
$K^0_s \rightarrow \pi^- + \pi^+$

Background subtraction (mixed event technique)

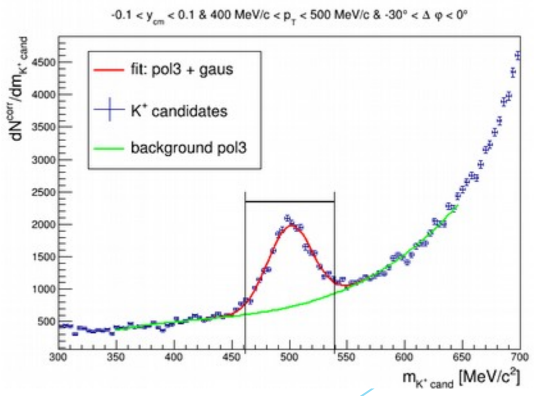


K^+

Energy losses in MDC and TOF

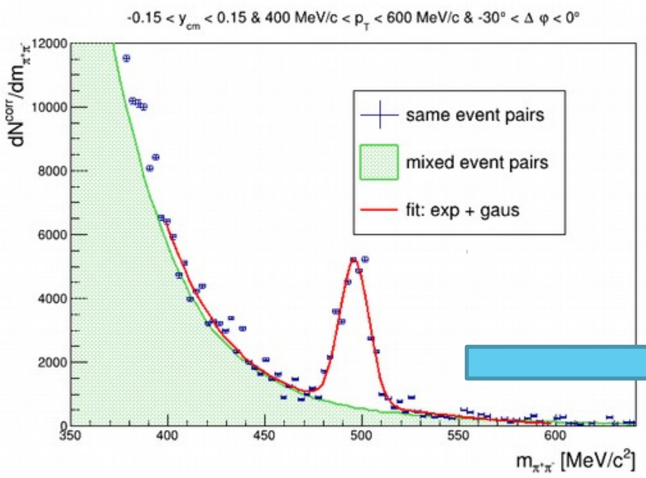


Background subtraction

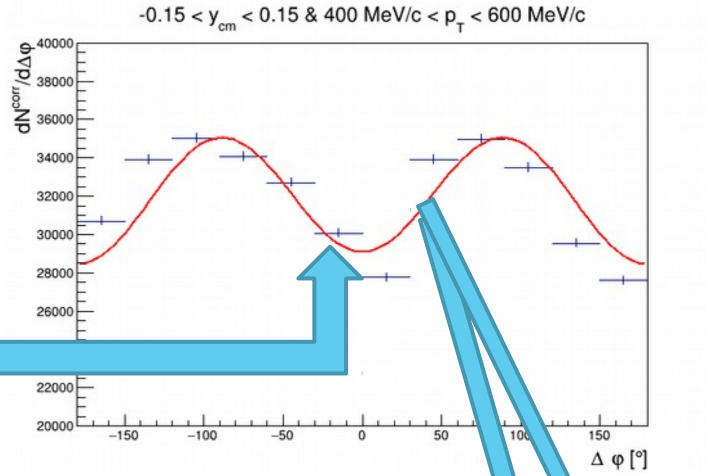


Two methods of flow analysis

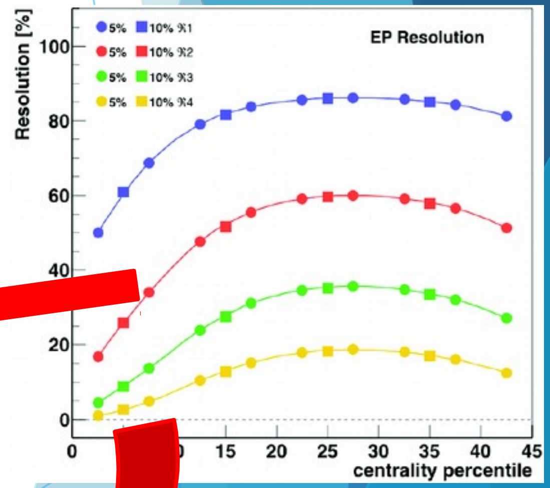
Get number of kaons



Fill azimuthal distribution and fit with Fourier expansion

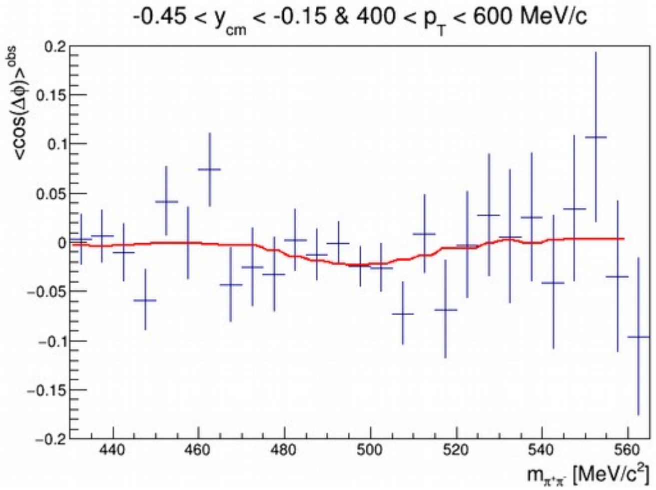


Use event plane resolution correction



Fit invariant mass spectra

$$\langle\cos(n\Delta\phi)\rangle^{\rm obs} = \frac{S}{S+B}(M_{\rm inv})\,\langle\cos(n\Delta\phi)\rangle^{\rm sig} \cdot \frac{B}{S+B}(M_{\rm inv})\,\langle\cos(n\Delta\phi)\rangle^{\rm bckg}$$

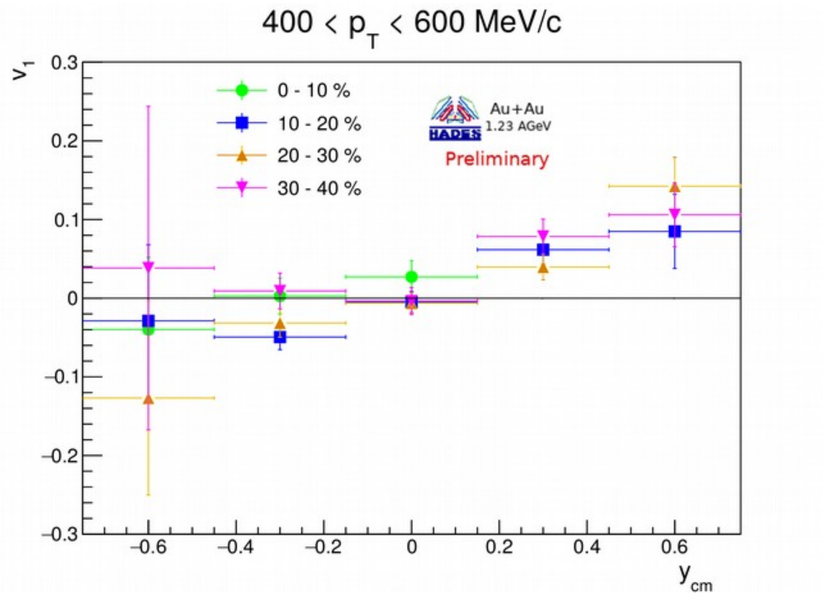


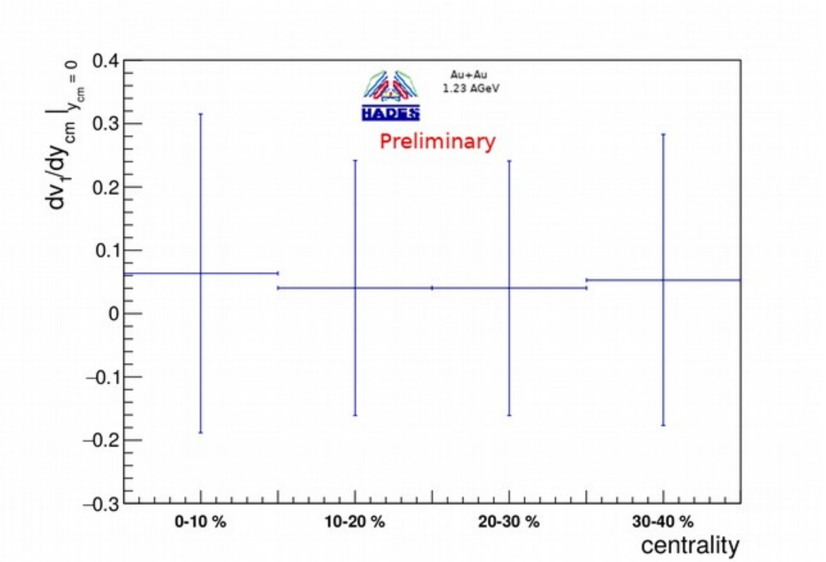
$$\langle\cos(n\Delta\phi)\rangle^{\rm bckg} = c_0 + c_1 M_{\rm inv} + c_2 M_{\rm inv}^2 + c_3 M_{\rm inv}^3$$

V_1 V_2

Based on work:
Phys. Rev. C 88, 014902

K^0_s directed and elliptic flow



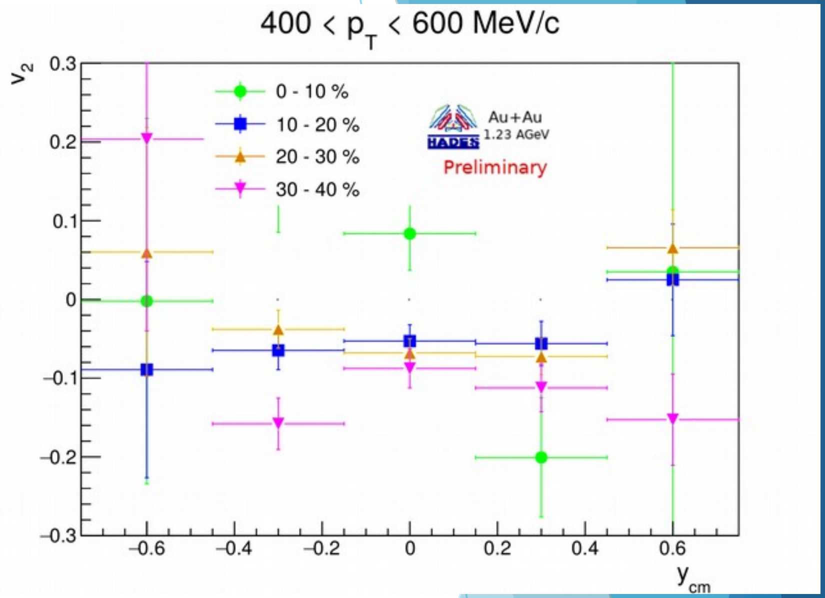


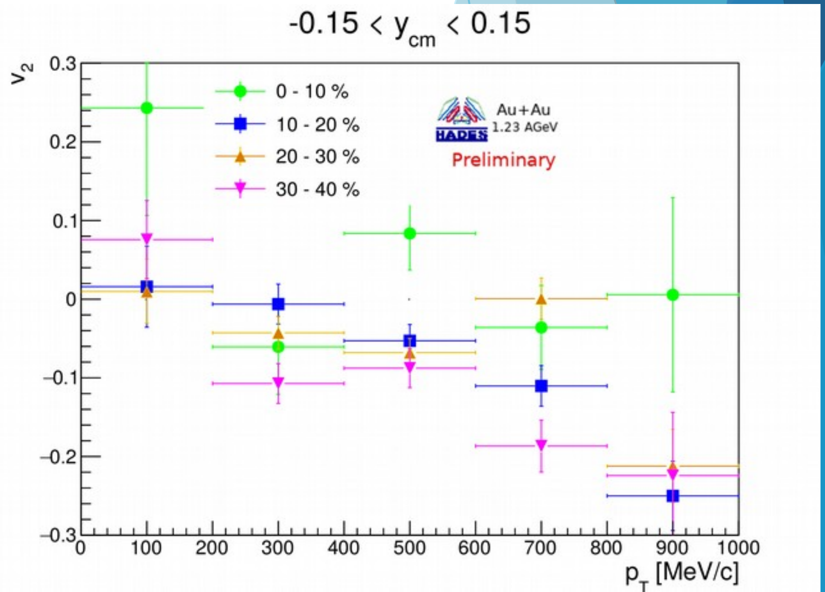
v_1 is slowly rising with rapidity (towards forward rap.)

No strong dependency of v_1 with centrality

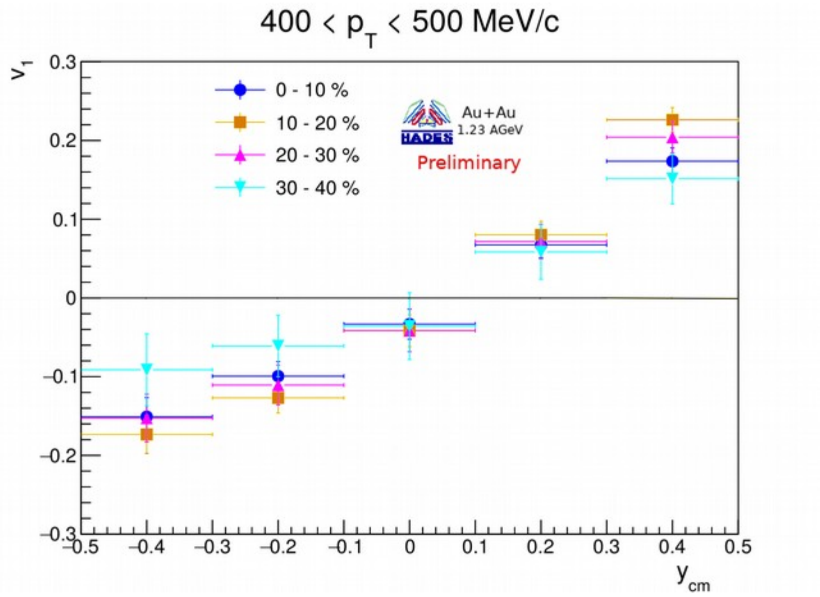
Slope of v_1 at midrapidity is positive (big errors)

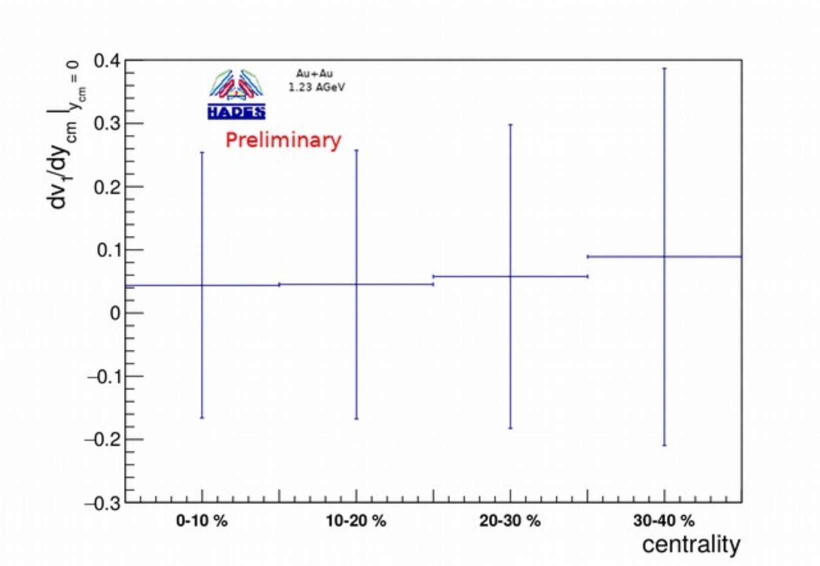
v_2 is negative (out-of-plane) similar to pions





K^+ directed and elliptic flow





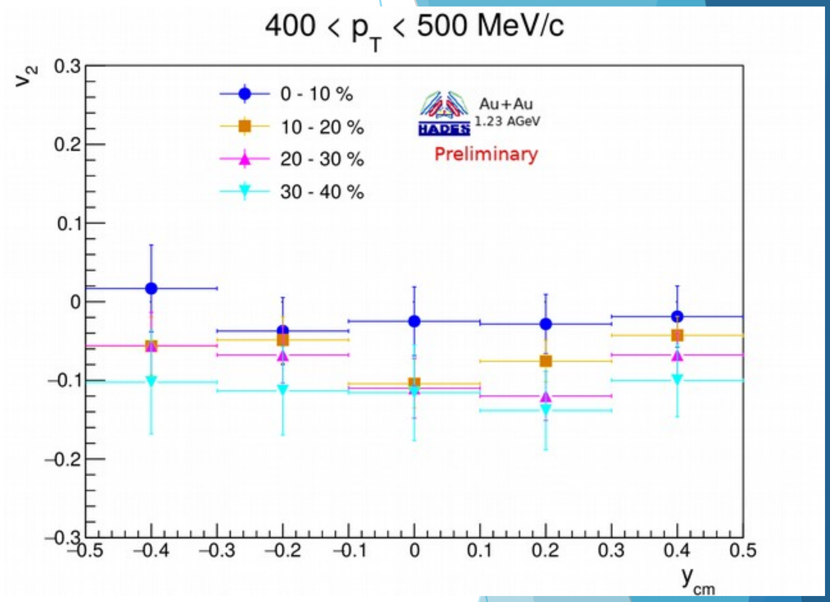
v_1 is slowly rising with rapidity (towards forward rap.)

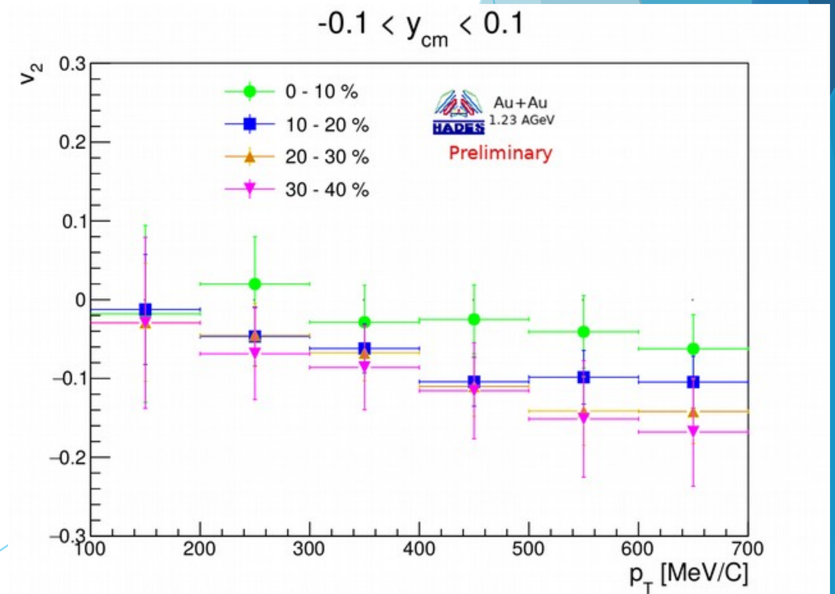
No strong dependency of v_1 with centrality

Slope of v_1 at midrapidity is positive (big errors)

v_2 is negative (out-of-plane) similar to pions

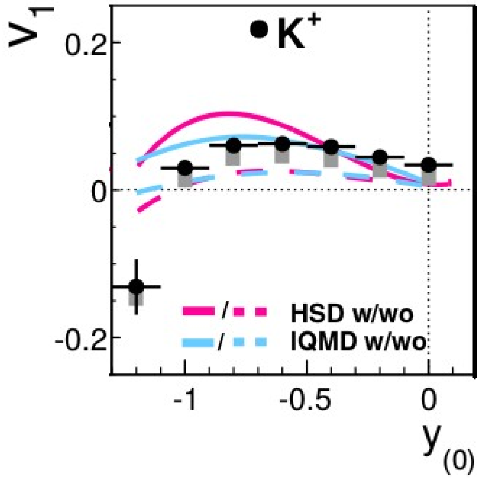
v_2 independent of rapidity and decreases with transverse momentum

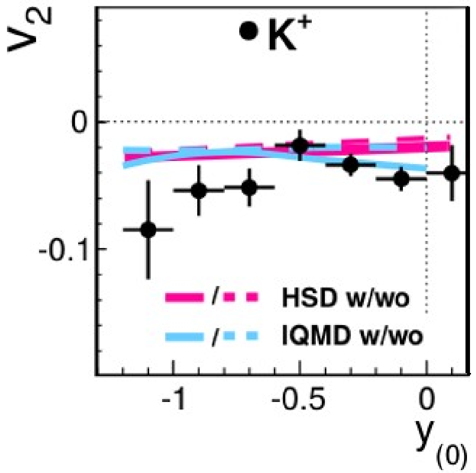




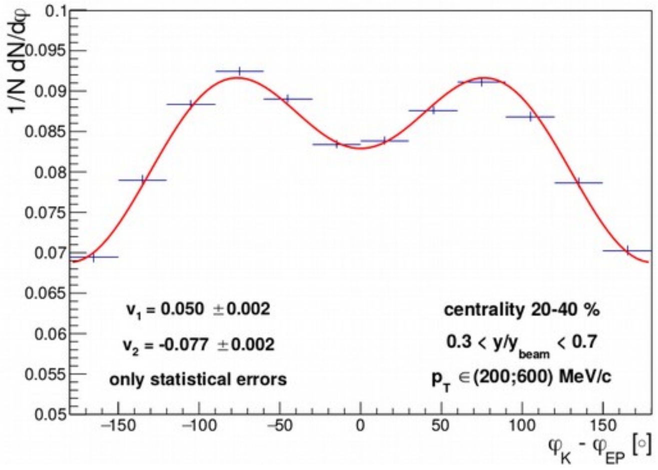
Comparison to world results and models

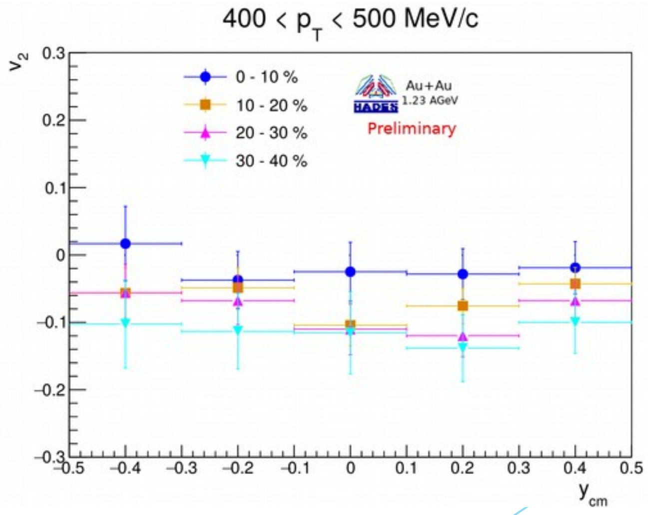
FOPI (Phys. Rev. C 90, 025210, 2014)
Ni+Ni @ 1.91 AGeV



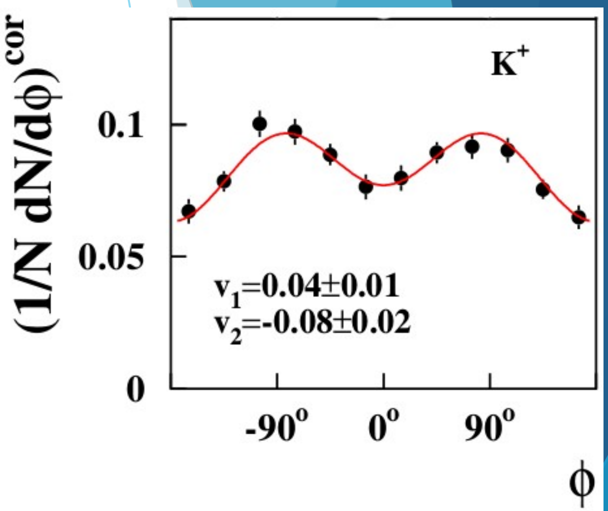


HADES preliminary
Au+Au @ 1.23 AGeV



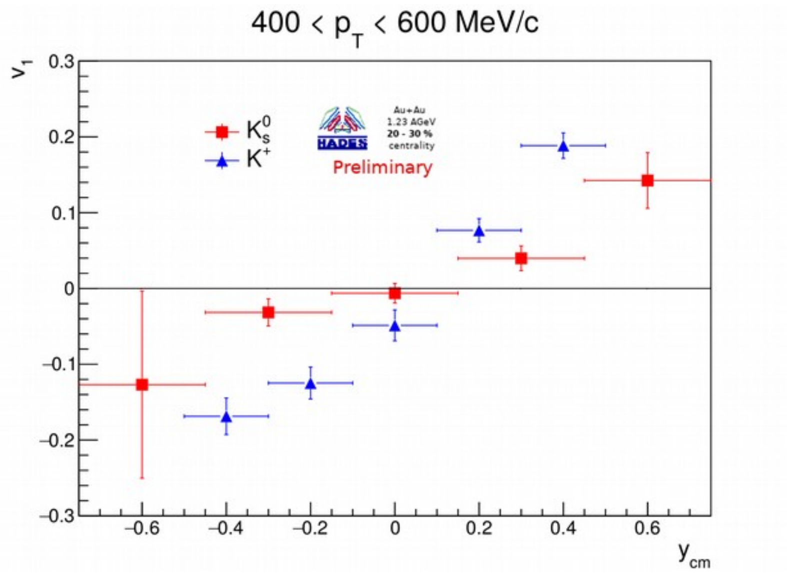


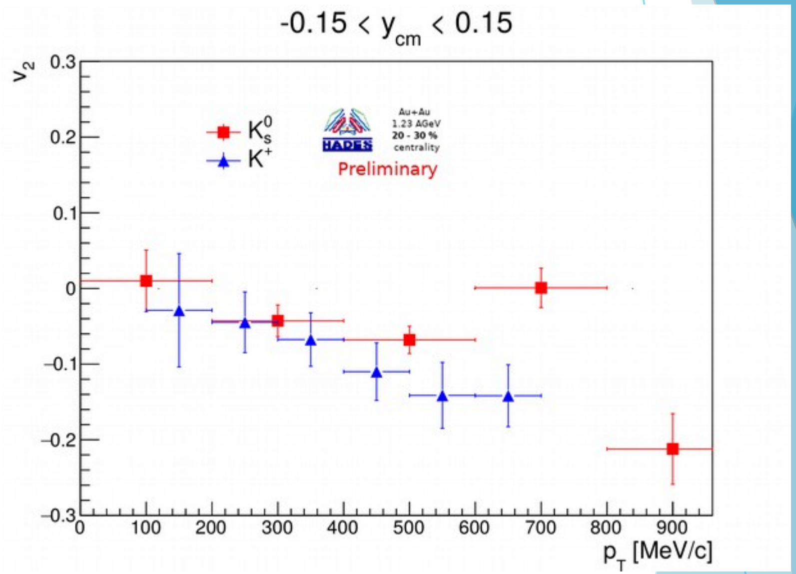
KaoS (J.Phys. G31 (2005) no.6, S693-700)
Au+Au @ 1.5 AGeV



Summary and Outlook

Differential analysis of kaon flow was presented
Comparison with FOPI and KaoS data shows a good agreement
Comparison between K^0_s and K^+ shows good agreement



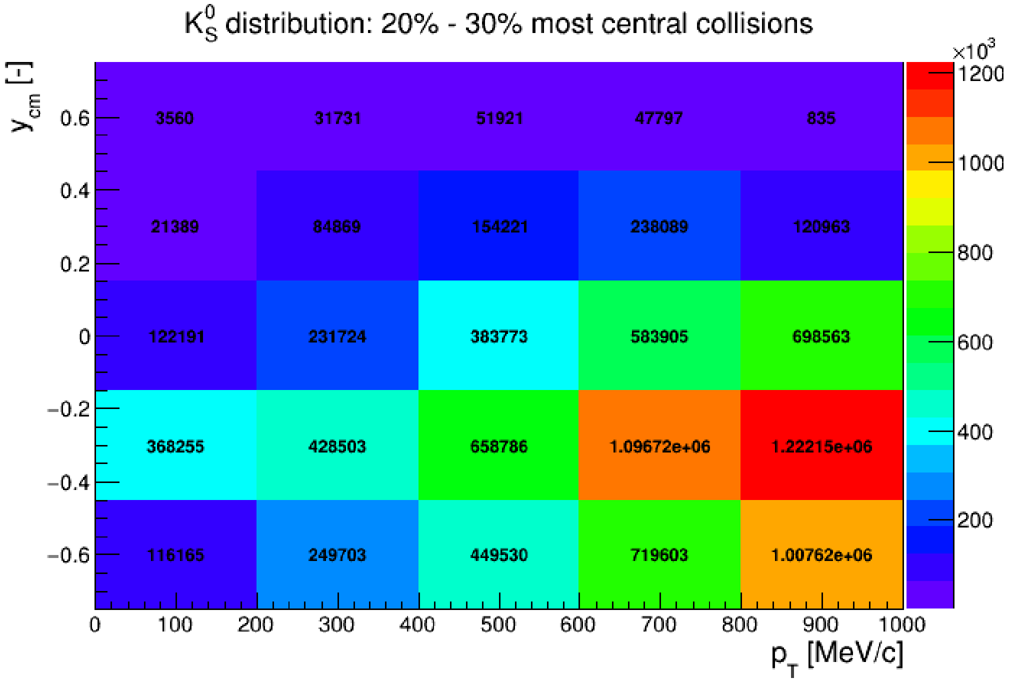


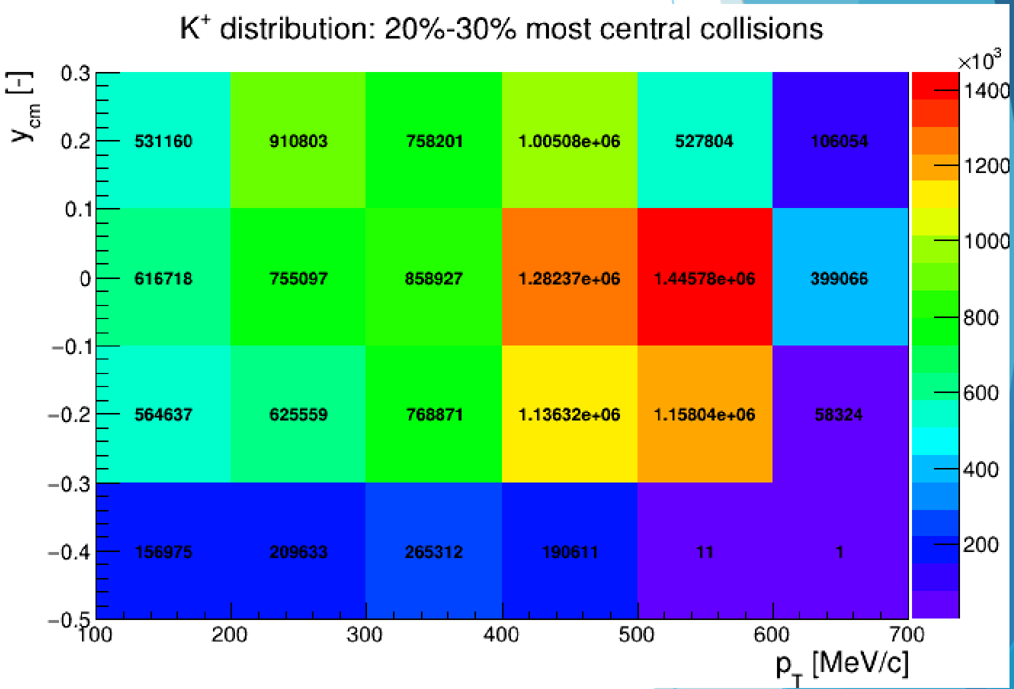
Study systematic uncertainty
Detailed comparison with different models

NEW data from Ag+Ag @ 1.58 AGeV (FAIR-0 phase)

BACKUP

Acceptance and Reconstruction corrected phase-space distribution of kaons





We obtained similar number of both kaons (similar threshold)
However the correction factors
for neutral kaons are >100
and for positive kaons ~4