Proton/Pion ratios in $\Delta\varphi$ wrt a jet in $\sqrt{S_{NN}}$ = 200 GeV Au+Au collisions at STAR

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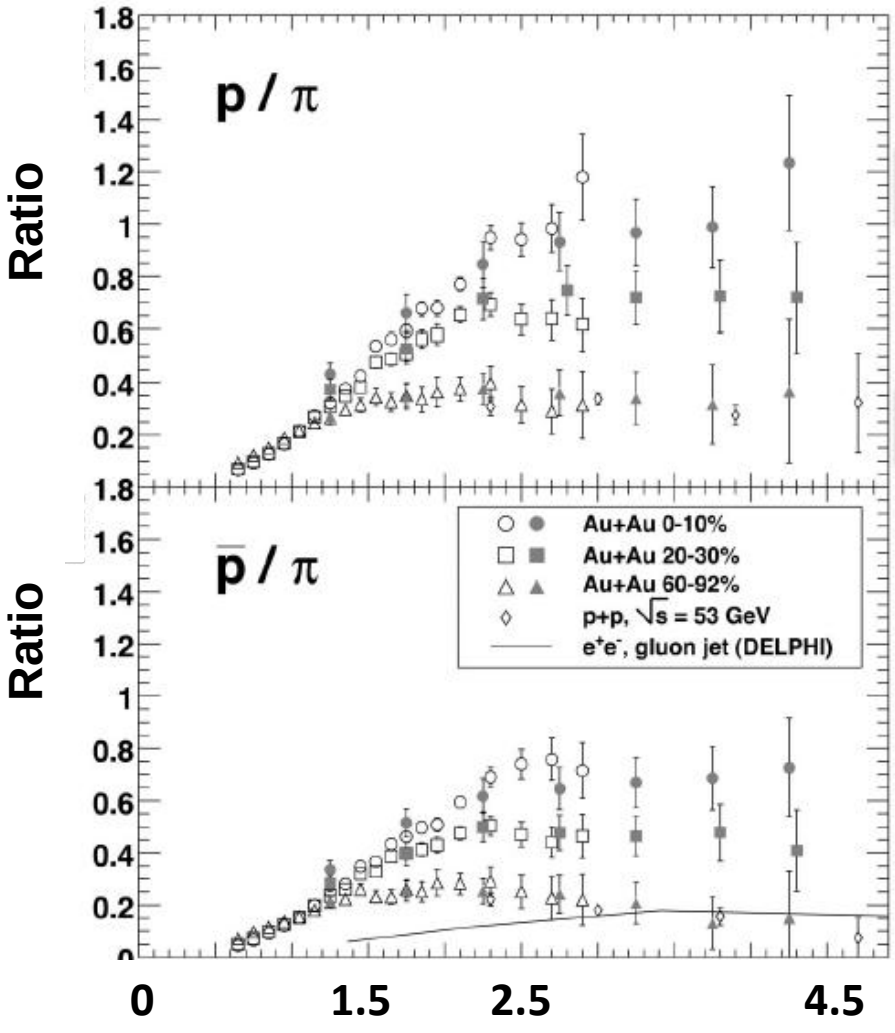
Hard Probes 2012, May,28,2012

Outline

- p/π enhancement in HI collisions
- STAR detector
- PID at STAR using Time of Flight and Time Projection Chamber detectors
- Analysis methodology
- Jet – PID hadrons Δϕ correlations
- Conclusions

P/π enhancement in HI collisions



Au+Au 200 GeV
p_T and centrality dependence

0-10% Au+Au

60-92% Au+Au, p+p

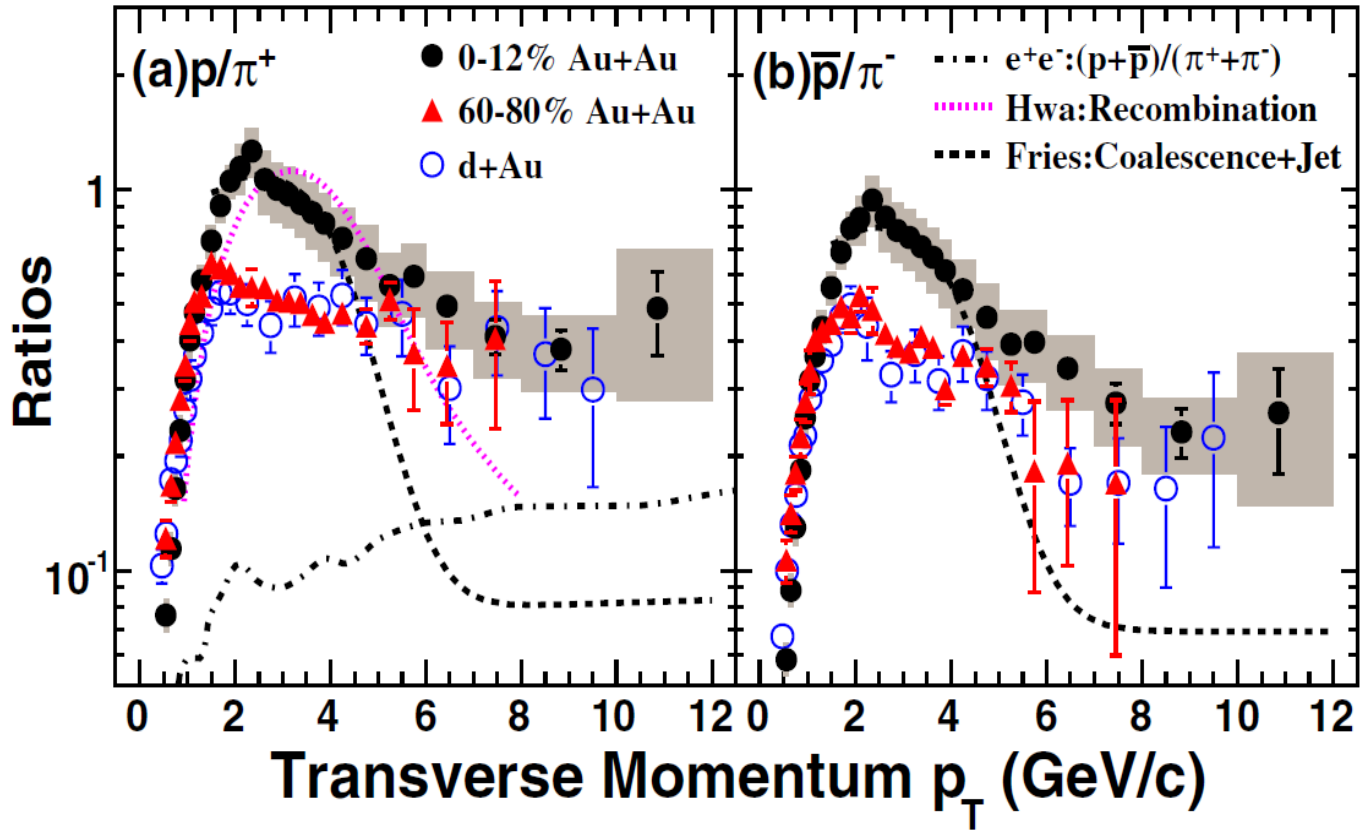
- First observation: Au+Au 130 GeV
- Protons less suppressed than pions at mid p_T
- Centrality dependence p_T >1.5 GeV/c
- R_{CP} Protons ~ 1.0
  @ 2.0 GeV/c < p_T < 3.0 GeV/c

PHYSICAL REVIEW C 69, 034909 (2004)

P/π enhancement in HI collisions

Au+Au 200 GeV
p_T and centrality dependence

- p/π ratio at high p_T : d+Au ~ Au+Au ~ p+p

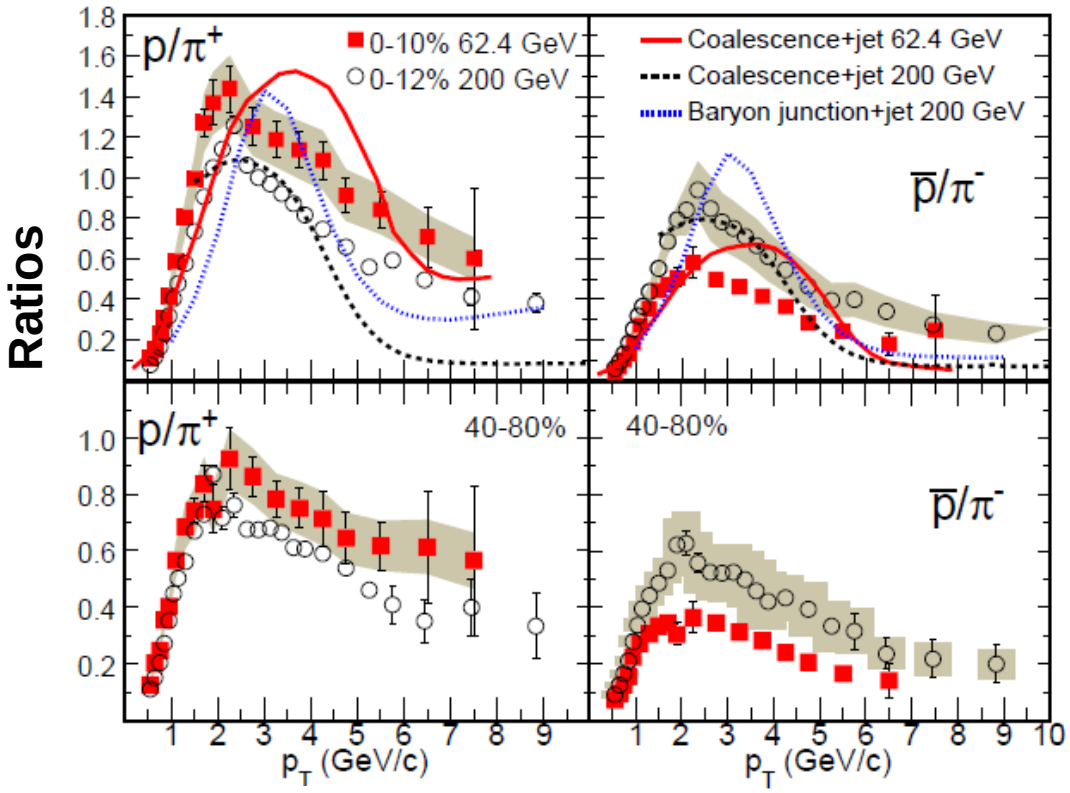


PRL 97, 152301 (2006)

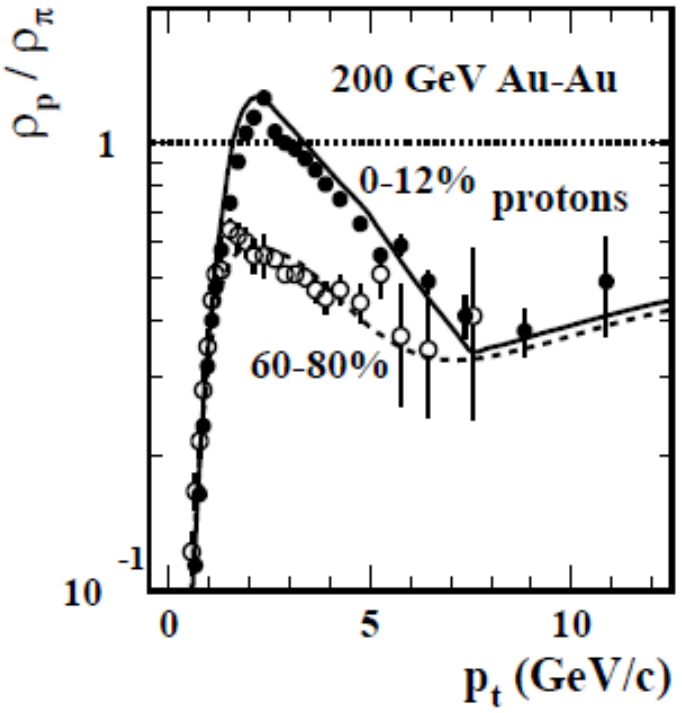
PHYSICAL REVIEW C 69, 034909 (2004)

P/π enhancement in HI collisions

- Attempts to describe it: Recombination, Coalescence, modified parton fragmentation,…
- Non perturbative processes dominate at mid-p_T?



Phys. Lett. B 655 (2007) 104



http://arxiv.org/abs/1011.6351v1

STAR Detector

Charged particles from the TPC (protons, pions, kaons, electrons, muons)
Neutral particles from BEMC (π^0 , gamma)
No K_L^0 , neutrons, detected

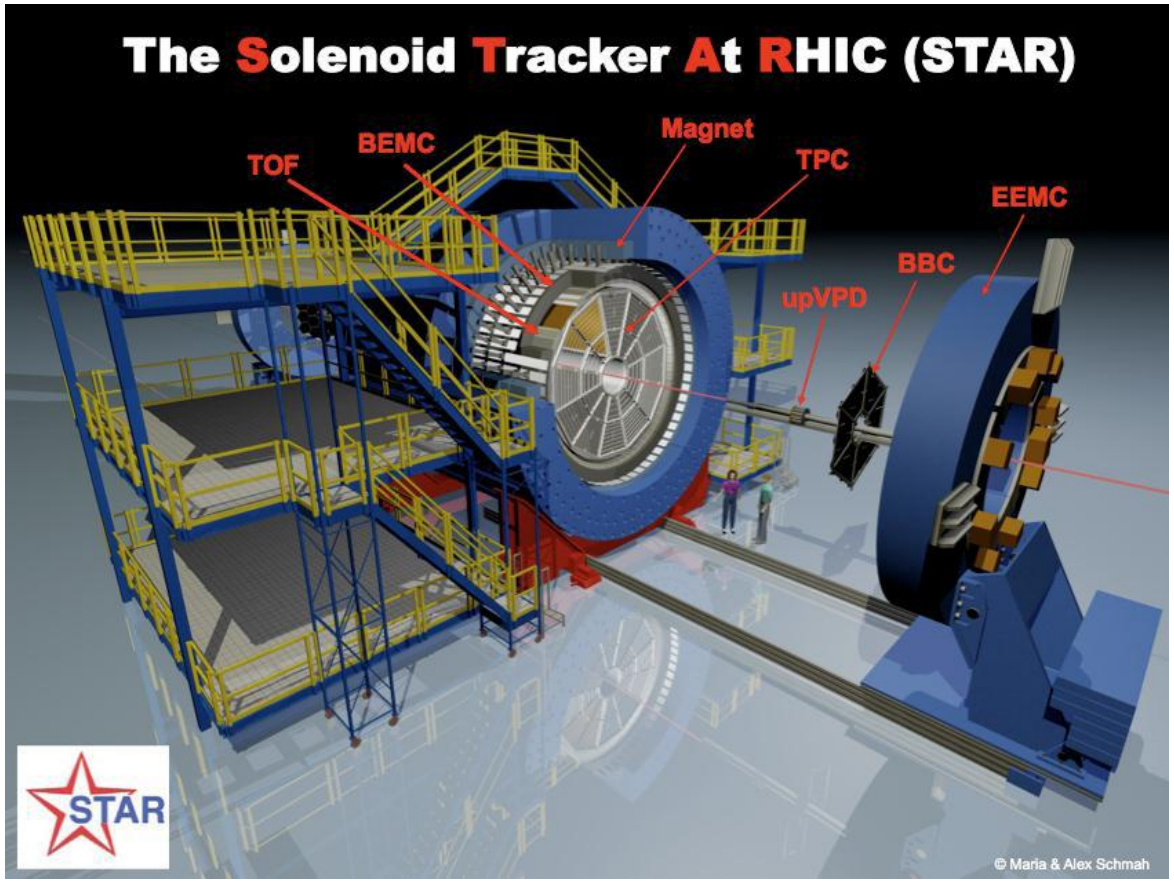
Triggers used

High Tower $0.05 \times 0.05 (\Delta\eta, \Delta\varphi)$

$E_T > 4.3 GeV$

Towers' matched tracks are subtracted to avoid double counting

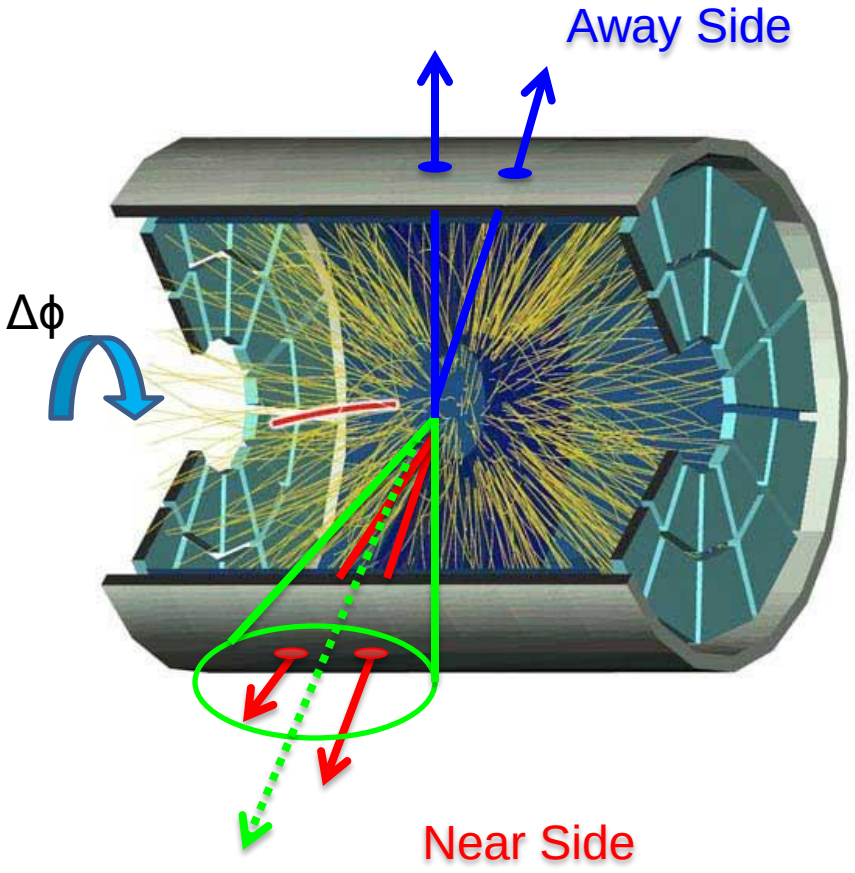
|z Vertex| < 30 cm
|DCA| <1.5 cm
Run 10 Au+Au data



Jet Trigger

Isolate the azimuth direction of a parton coming from a hard scattering

- JFA: AntiKt, R=0.4
- Track (Tower) p_T (E_T) cut of 3.0 GeV/c (GeV)
- 5 GeV High Tower in Jet
- High p_T Jet $8 < p_T^{Jet} \leq 20$ GeV/c



Biased towards non-interacting jets

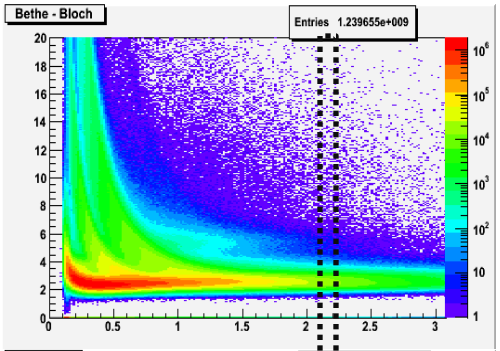
Reconstructed Jet p_T not necessarily equal to hard scattered parton p_T

PID

- TOF + TPC : PID up to ~ 2.8 GeV/c
- Track probability (Pion, Kaon or Proton) : $\Delta\beta^{-1}/\beta^{-1}$ vs $n\sigma$

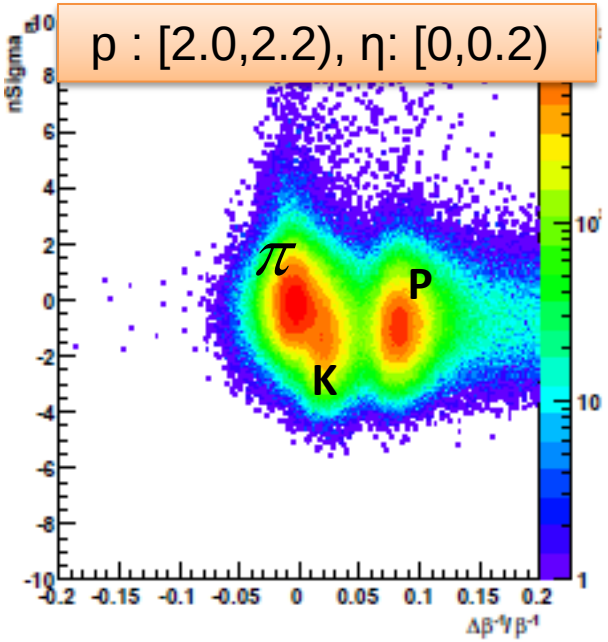
dE/dx (KeV/cm) (TPC)

β^{-1} **(TOF)**



0 0.5 1 1.5 2 2.5 3 p (GeV/c)

p : [2.0,2.2), η: [0,0.2)



$$\beta_{TPC}(m,p) = \frac{1}{\sqrt{1+\left(m^2/p^2\right)}}$$

$$\beta_{TOF} = \frac{L}{ct}$$

$$\Delta\beta^{-1}/\beta^{-1} = \frac{\beta_{TOF}^{-1} - \beta_{TPC}^{-1}}{\beta_{TOF}^{-1}}$$

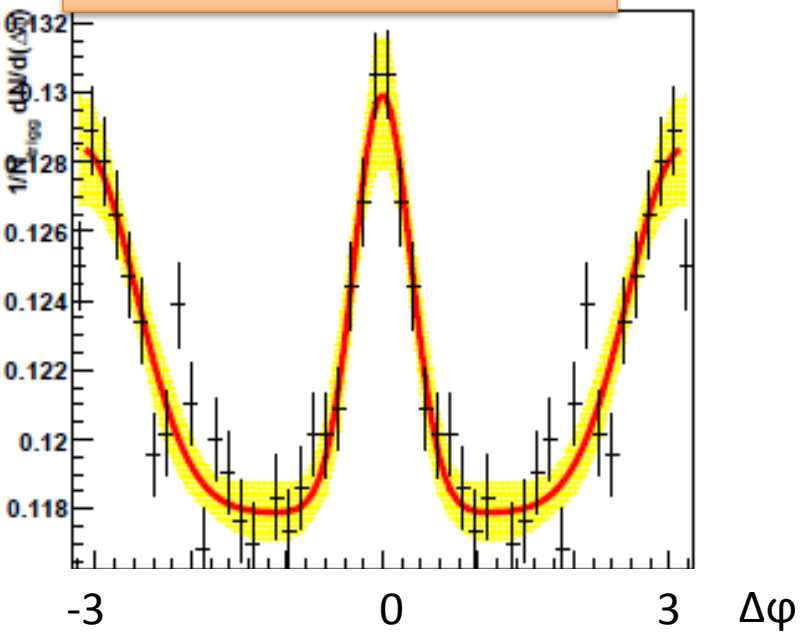
Δϕ correlation

Correlation after mix event correction
Normalized to have sibling yield and 1/NumTriggers

Au+Au 200 GeV
0-20% Centrality

$$\frac{1}{N_{TriggJet}}\frac{dN}{d\Delta\varphi}$$

Proton p_T : [2.0,2.8)



STAR
Preliminary

χ^2 /df: 66.45/43
p : 0.01239
B : 0.1179±0.0004
a_{NS} : 0.01209±0.00081
σ_{NS} : 0.2966±0.0293
a_{AS} : 0.01051±0.00062
σ_{AS} : 0.5654±0.0524

No efficiency correction

Statistical errors only

$$f(\Delta\varphi) = B + a_{NS}e^{-\frac{1}{2}\left(\frac{\Delta\varphi}{\sigma_{NS}}\right)^2} + a_{AS}e^{-\frac{1}{2}\left(\frac{\Delta\varphi-\pi}{\sigma_{AS}}\right)^2}$$

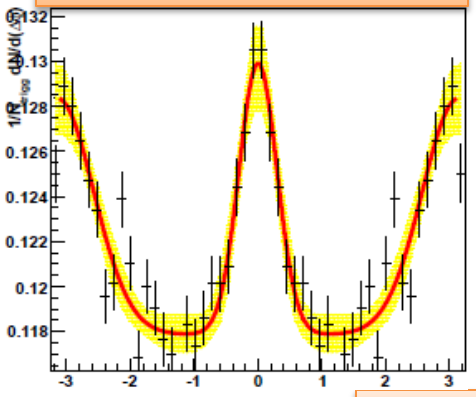
Δϕ dependent particle ratios

Au+Au 200 GeV
0-20% Centrality

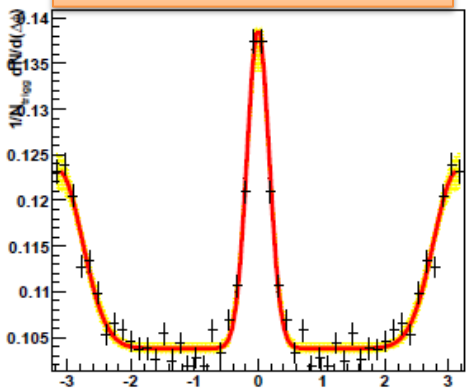
p/π ratios smaller than bulk in both near and away side jet regions

All Charged

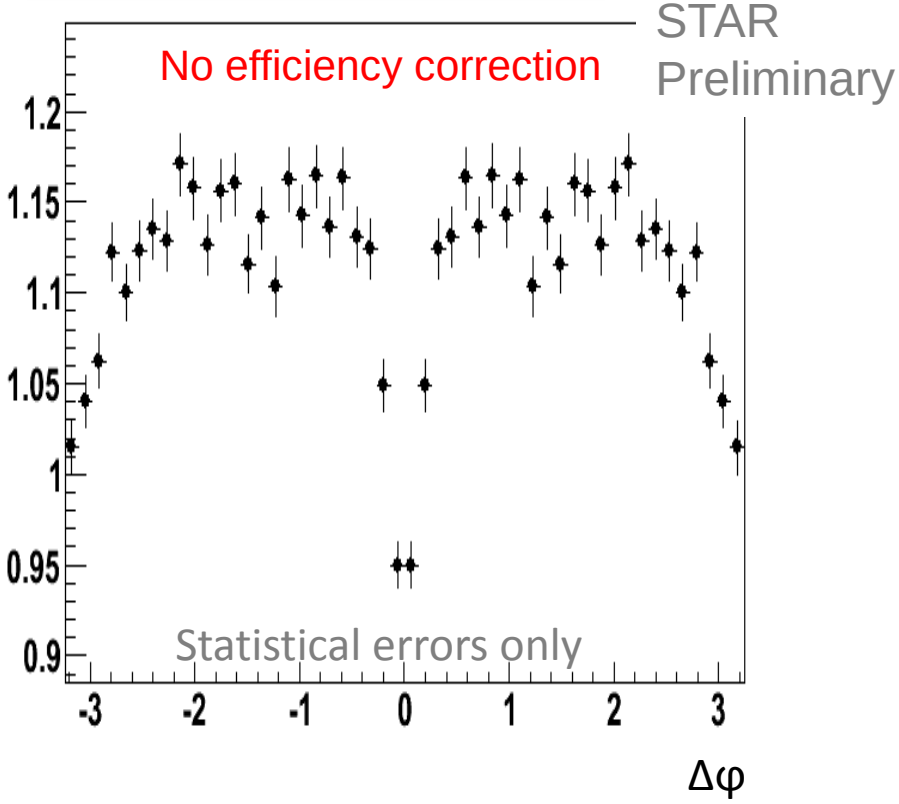
Proton Δϕ p_T [2.0, 2.8)



Pion Δϕ p_T [2.0, 2.8)



Proton/Pion Δϕ p_T [2.0, 2.8)



Proton / Pion Δϕ dependence

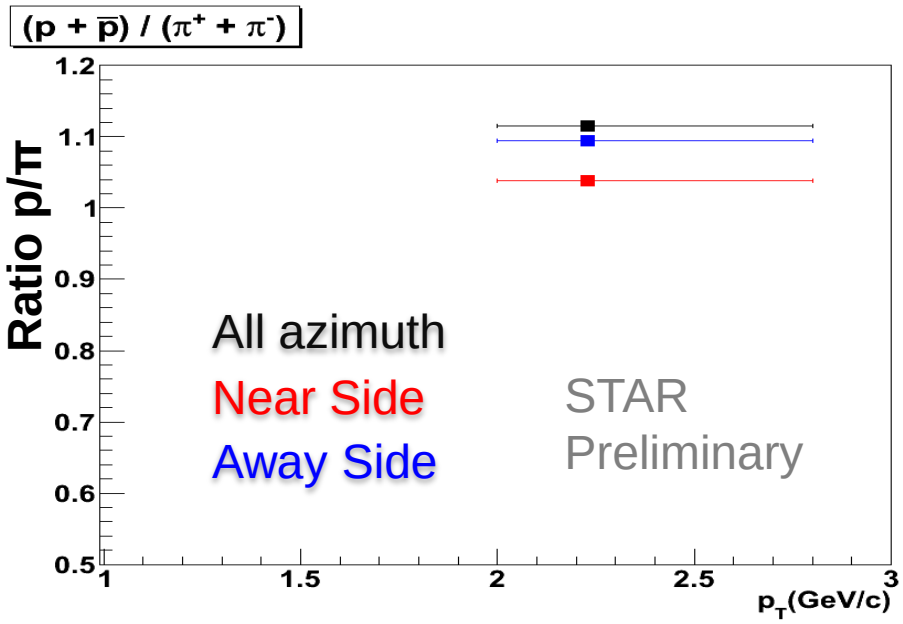
Au+Au 200 GeV
0-20% Centrality

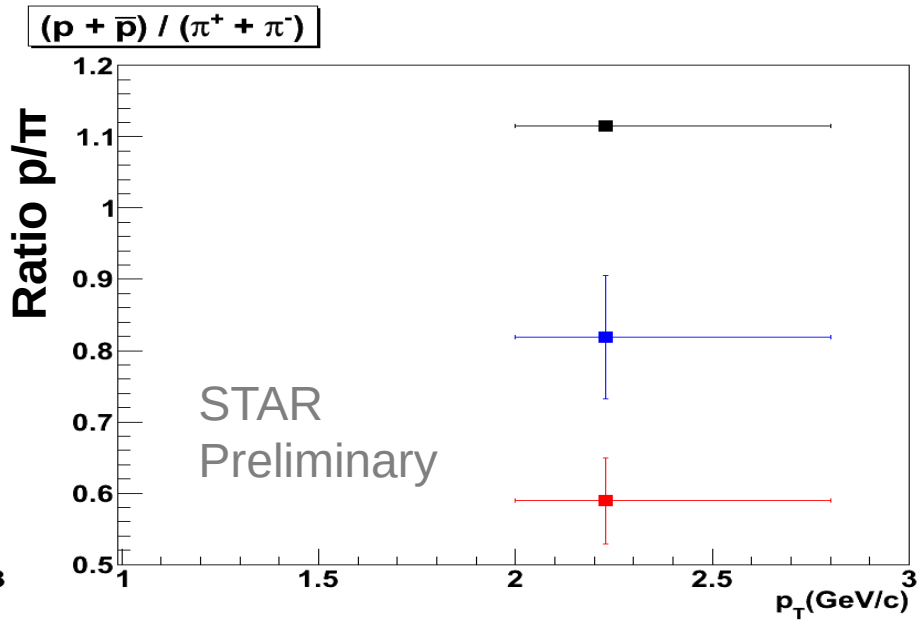
No efficiency correction

Statistical errors only

All tracks and hard quadrants cuts

Background subtracted Yields





The background subtraction **enhances** the difference in ratios compared to using hard quadrant cuts and all tracks in a given Δφ region

Proton / Pion Δϕ dependence

Au+Au 200 GeV
0-20% Centrality

Using different but similar signal models gives small discrepancies.

p/π (all azimuth) > p/π (away)
p/π (away) > p/π (near)

(pp + jet trigger comparison in progress)

Statistical errors only
(all azimuth, same/away side)

No efficiency correction

Gauss fit

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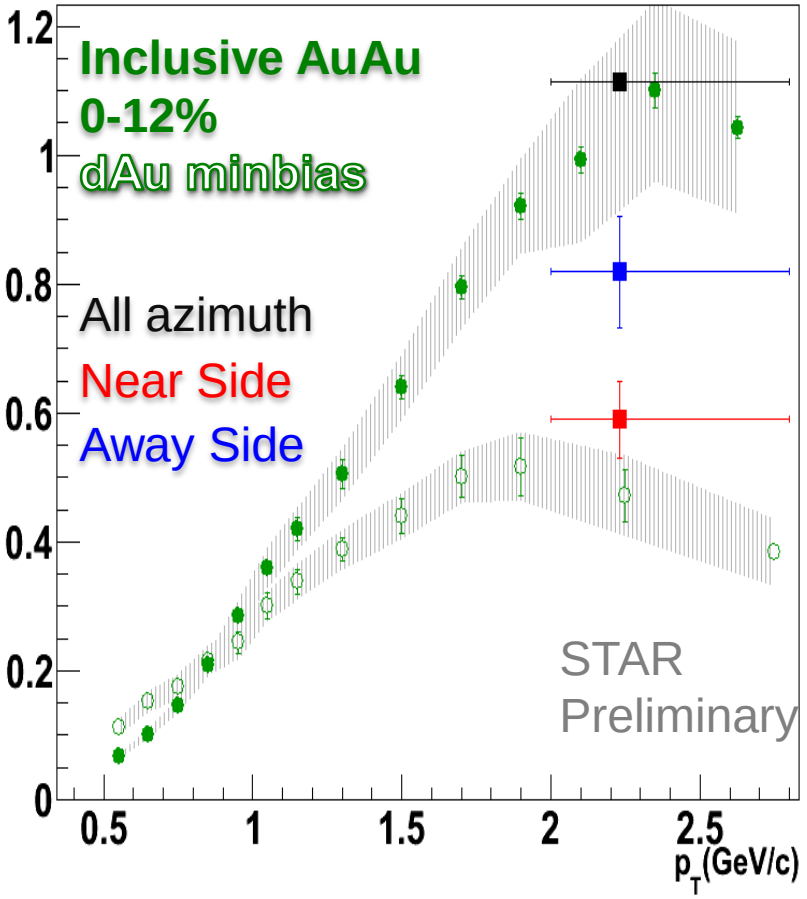
$(p + \bar{p}) / (\pi^+ + \pi^-)$



Conclusions

- The p/π ratios at intermediate p_T correlated with a jet trigger (p_T ~ 8-10 GeV/c) in the 20% most central 200 GeV Au+Au collisions are analyzed
- The near side p/π ratio is significantly lower than bulk → reflecting near side jet property
- The away side p/π ratio is larger than near side and seems smaller than bulk → away side jet – medium interaction?

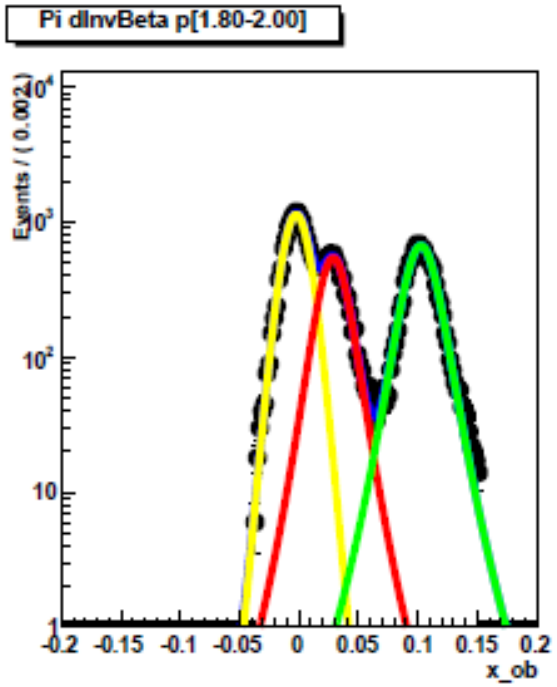
To do

- Complete analysis with peripheral Au+Au and p+p 200 GeV data (trigger bias + vacuum fragmentation assumptions)
- Systematic uncertainties and efficiency corrections pending → study p_T dependency of ratios at lower momentum
- Systematic study of the PID identification (probability, purity cuts)

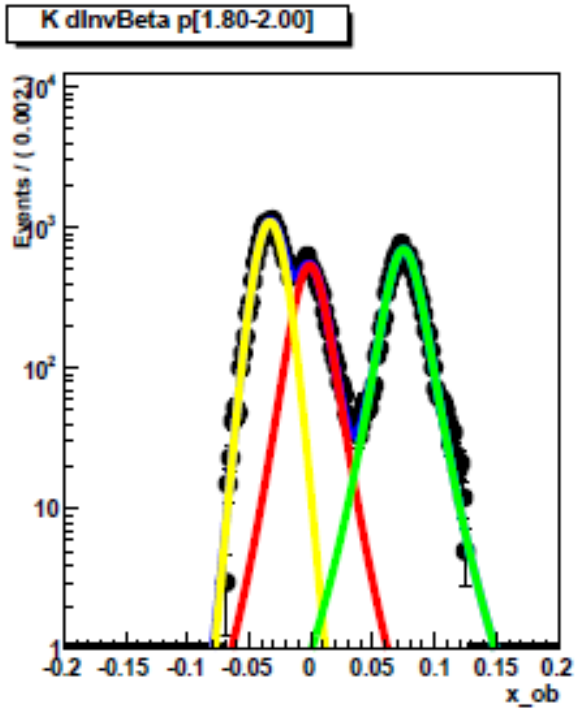
Back Up

The weight for 3 particle fits

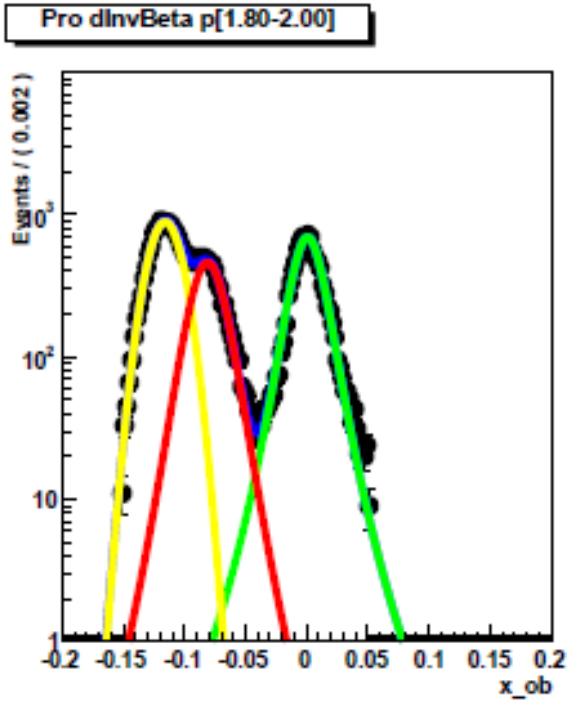
Pion Mass Assumption



Kaon Mass Assumption



Proton Mass Assumption



$$W\big|_{\pi} = frac\big|_{\pi} P(\pi,..) \Big/ \sum_{i} frac\big|_{i} P(i,..)$$

Δφ Correlation

Mix 30 events with |zVertex1 – zVertex2| < 5 cm

Used 14 zVertex bins

$$\frac{dN}{d(\Delta\varphi)} = \left\{ \frac{\sum_{\Delta\varphi} n^{mix}_{\Delta z,\Delta\varphi}}{\sum_{\Delta z,\Delta\varphi} n^{mix}_{\Delta z,\Delta\varphi}} \left[\frac{n^{sib}_{\Delta z,\Delta\varphi}}{n^{mix}_{\Delta z,\Delta\varphi}} \frac{N^{mix}_{\Delta z}}{N^{sib}_{\Delta z}} \right] \right\} \qquad N^{mix}_{\Delta z} = \sum_{\Delta\varphi} n^{mix}_{\Delta z,\Delta\varphi}$$

After step above:

normalize by the integral of the sibling raw correlation

divide by the number of jet triggers

Fit Functions

$$f(\Delta\varphi) = B + \frac{a_{NS}}{\left(1+\frac{1}{2n_{NS}}\left(\frac{\Delta\varphi}{\sigma_{NS}}\right)^2\right)^{n_{NS}}} + \frac{a_{AS}}{\left(1+\frac{1}{2n_{AS}}\left(\frac{\Delta\varphi-\pi}{\sigma_{AS}}\right)^2\right)^{n_{AS}}}$$

$$f(\Delta\varphi) = B + a_{NS}e^{-\frac{1}{2}\left(\frac{\Delta\varphi}{\sigma_{NS}}\right)^2} + a_{AS}e^{-\frac{1}{2}\left(\frac{\Delta\varphi-\pi}{\sigma_{AS}}\right)^2}$$