Measuring Away-Side Jet Modifications in Au+Au Collisions at RHIC

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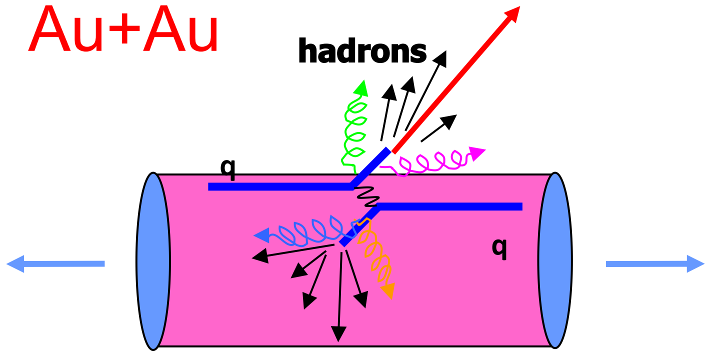
Outline

- Motivations
- Methodology
- Correct for detector efficiency/acceptance
- Systematic error study
- Results and discussion
- Summary

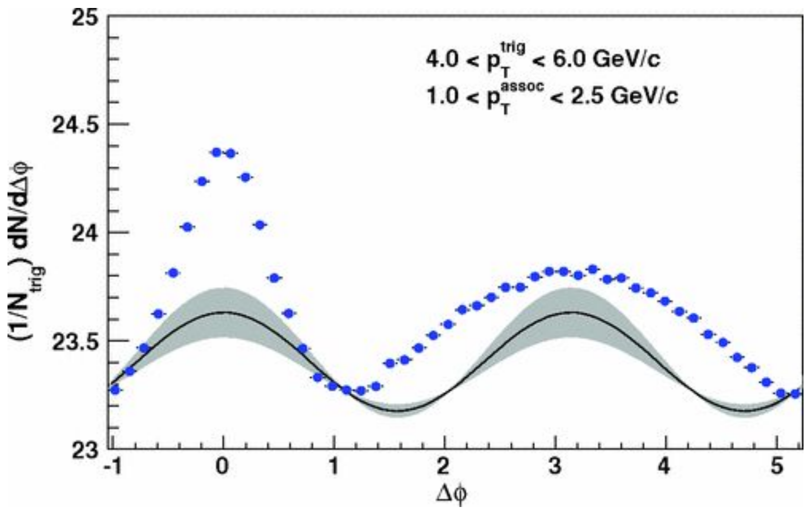
Motivation

- Energetic partons are predicted to lose energy due to interactions in the dense medium

Au+Au

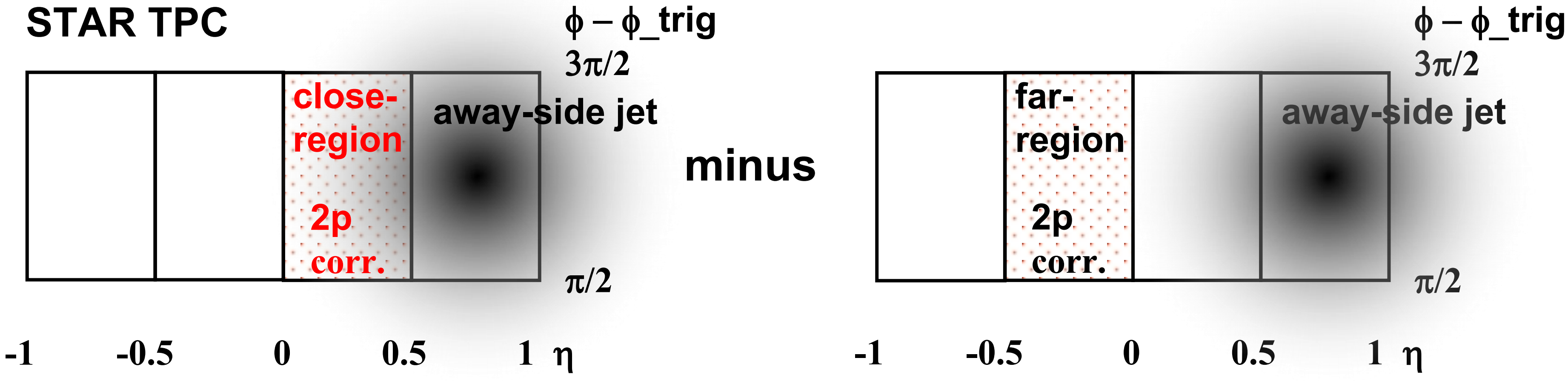


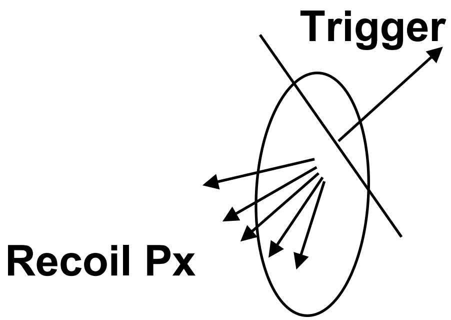
PRC 82 (2010) 024912



- Measurements of medium modifications of jets have so far been obscured by the large anisotropic flow background. Flow shape and amplitude are not precisely known.
- We devise a method to subtract flow background using data itself

Methodology





close-region 2p corr.
= flow + near-side jet + away-side jet ∗ fraction_close

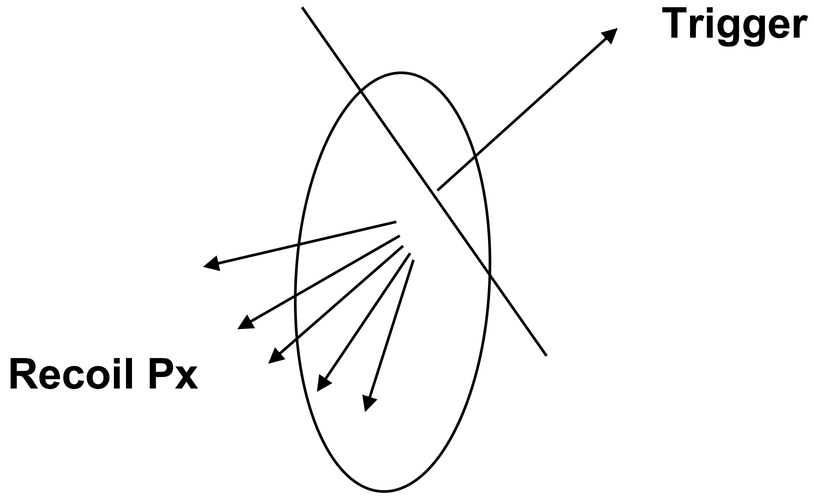
far-region 2p corr.
= flow + near-side jet + away-side jet ∗ fraction_far

- Select events with a large recoil Px from a high-pT trigger particle within a given eta window (0.5 - 1 or -1 - -0.5) to enhance away-side jet population
- Analyze di-hadron correlations in close-region and far-region respectively
- Flow contributions to close-region and far-region are equal!!

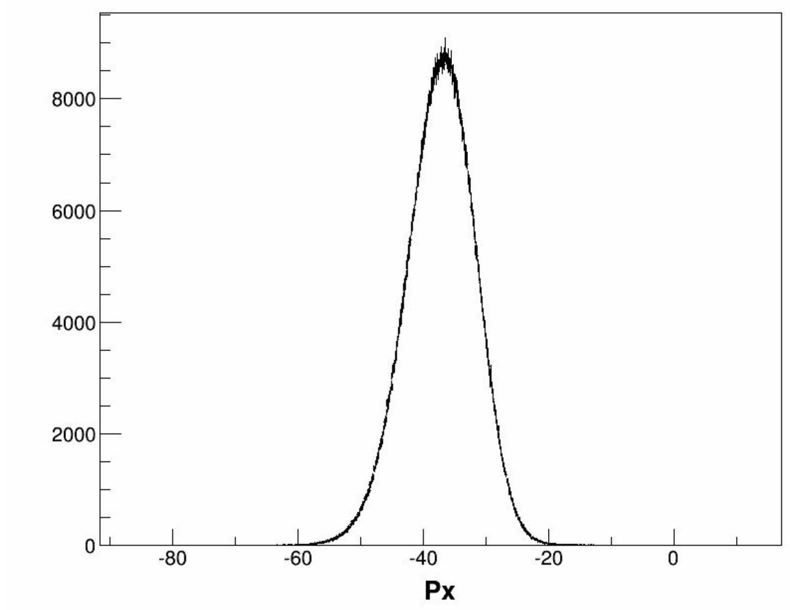
"Px" calculation

- Recoil Px from a high-pT trigger particle:

$$P_x\,|_{\eta_1 \le \eta \le \eta_2} = \sum_{assoc} pT_{assoc} \cdot \cos(\phi_{assoc} - \phi_{trig})$$

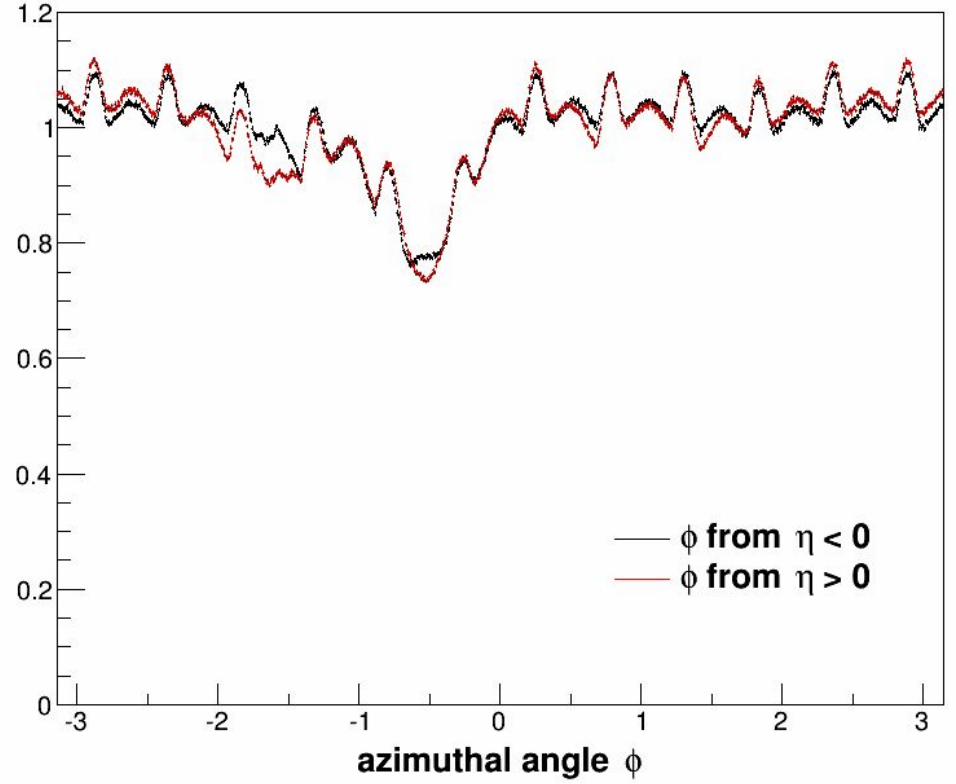


tranverse plane (-1 < η < -0.5 or 0.5 < η < 1)



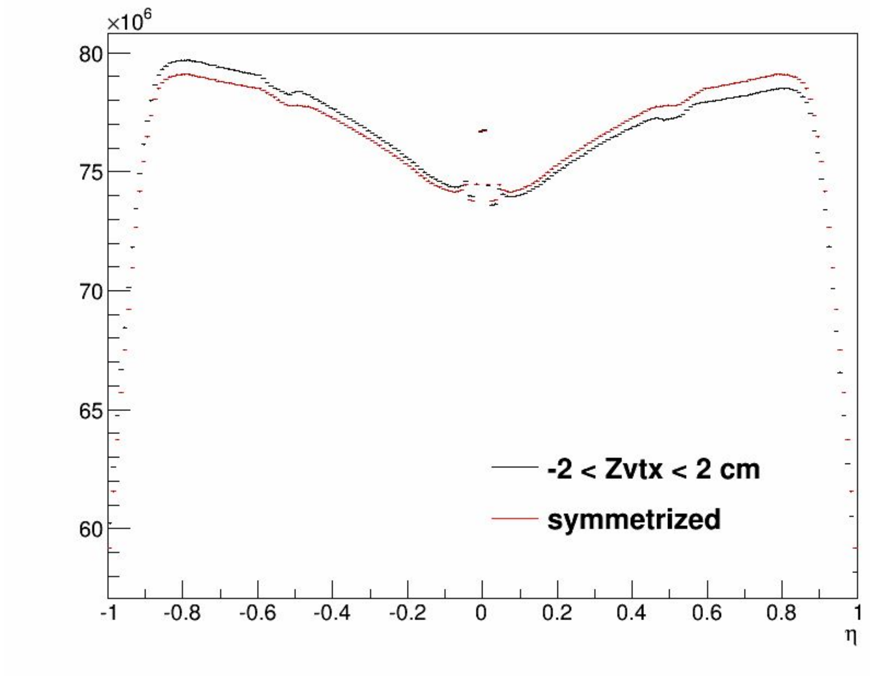
- For each centrality, cut on the left tail of the distribution (fraction of events) to enhance away-side jet population

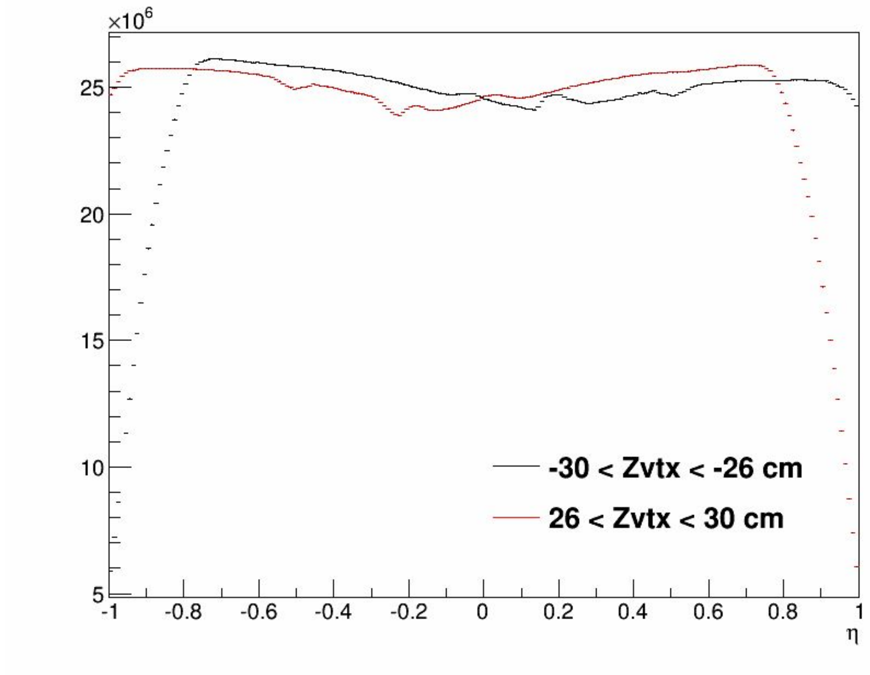
Correct for ϕ-dependent efficiency ∗ acceptance



- Normalize the single particle phi distribution to average unity. The inverse of that will be the phi-dependent efficiency
- Done run-by-run (and runs with same efficiency grouped together)
- Corrections are done as a function of centralities
- Apply phi-dependent efficiency correction for Px calculation

Correct for η-dependent efficiency ∗ acceptance



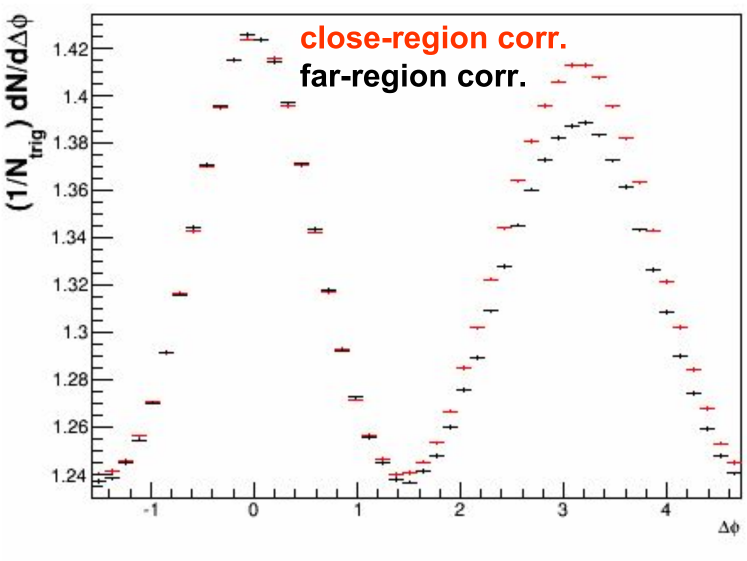


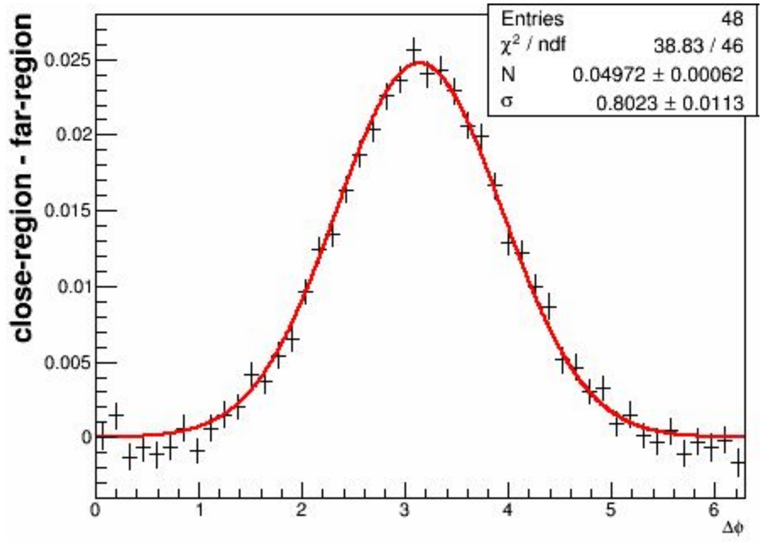
- Use the -2<zvtx<2 cm distribution and make it symmetric by taking the average of the two sides. Treat the symmetrized dN/deta as "truth"
- Take the ratio of the dN/deta in each zvtx bin to this "truth". Use the inverse of the ratio as the eta- and zvtx-dependent correction
- Apply eta-dependent efficiency correction for Px calculation and di-hadron correlations

STAR Run11 AuAu 200 GeV

trigger particle: pT > 3 GeV, associated particle: 1<pT<2 GeV, minbias

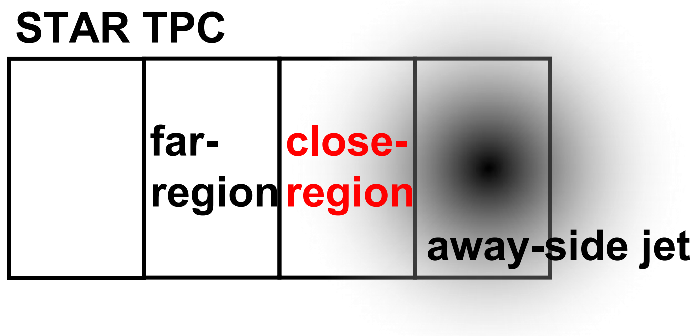
Near-side almost equal as expected





close-region 2p corr.
= flow + near-side jet + away-side jet ∗ fraction_close

far-region 2p corr.
= flow + near-side jet + away-side jet ∗ fraction_far



Fit away-side jet shape with a Gaussian

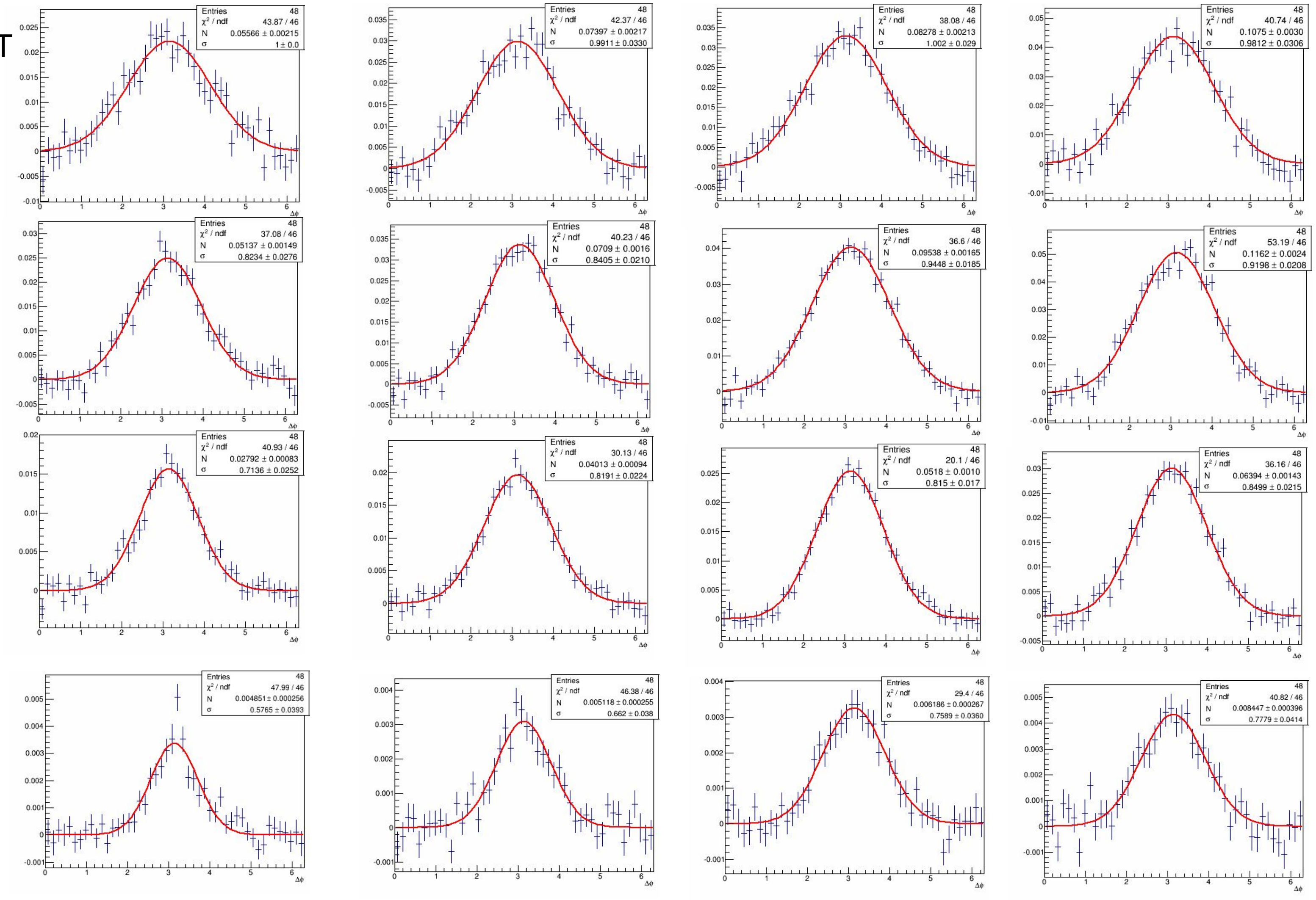
associate pT

0.15 - 0.5 GeV

0.5 - 1 GeV

1 - 2 GeV

2 - 3 GeV

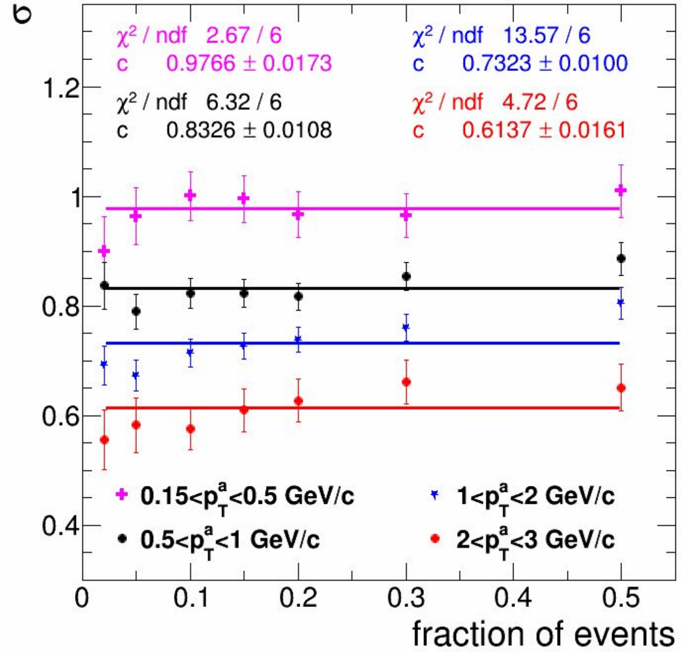


50-80% 30-50% 10-30% 0-10%

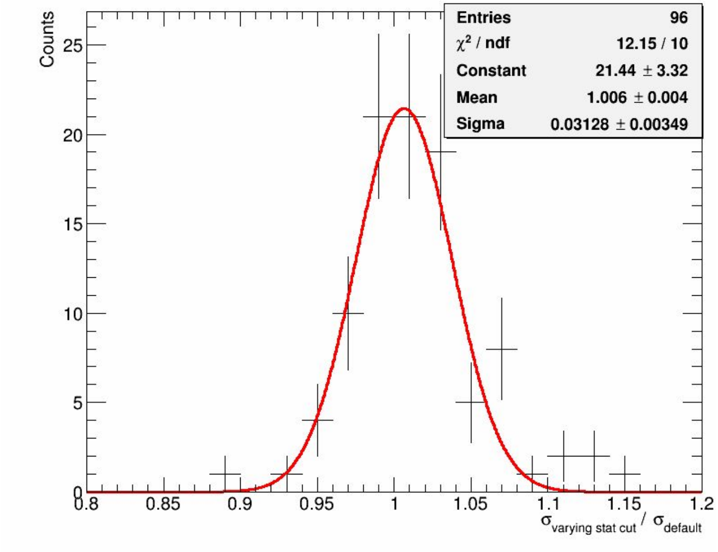
Systematic study: Varying "Px" cut

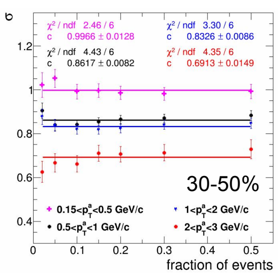
varying Px cut percentage: 2%, 5%, 10% (default), 15%, 20%, 30%, 50%

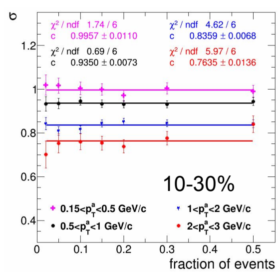
In principle: σ should not change with Px cut, only jet fraction (or amplitude) changes

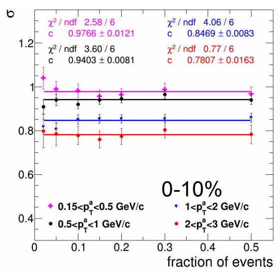


50-80%



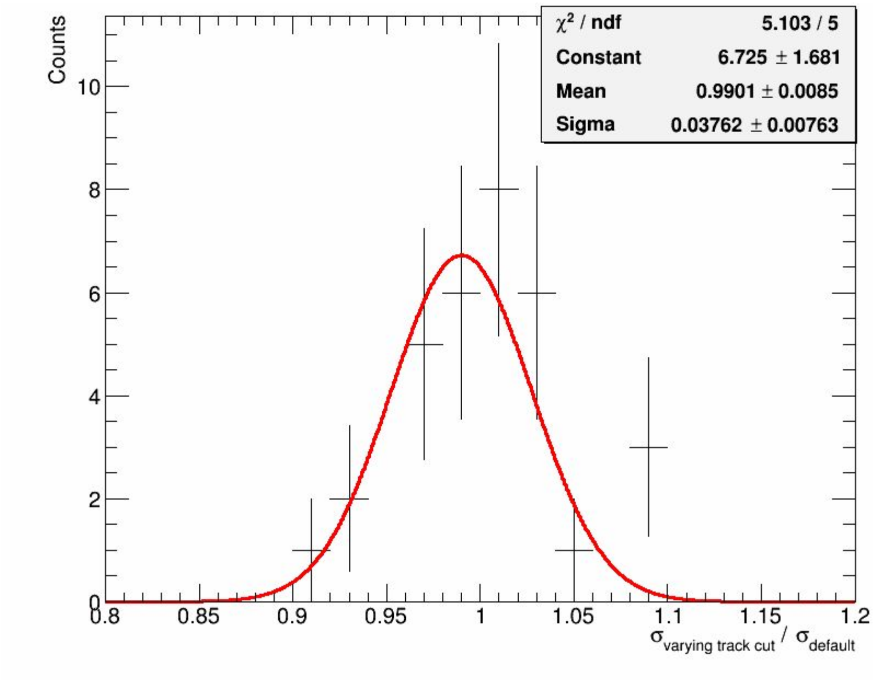






- Take the ratio of the σ under other "Px" cut to σ under default cut
- The Sigma of the distribution gives a systematic error of 3.1% from "Px" cut

Systematic study: Varying track quality cuts



Default: dca <= 2 nHitsFit >= 20

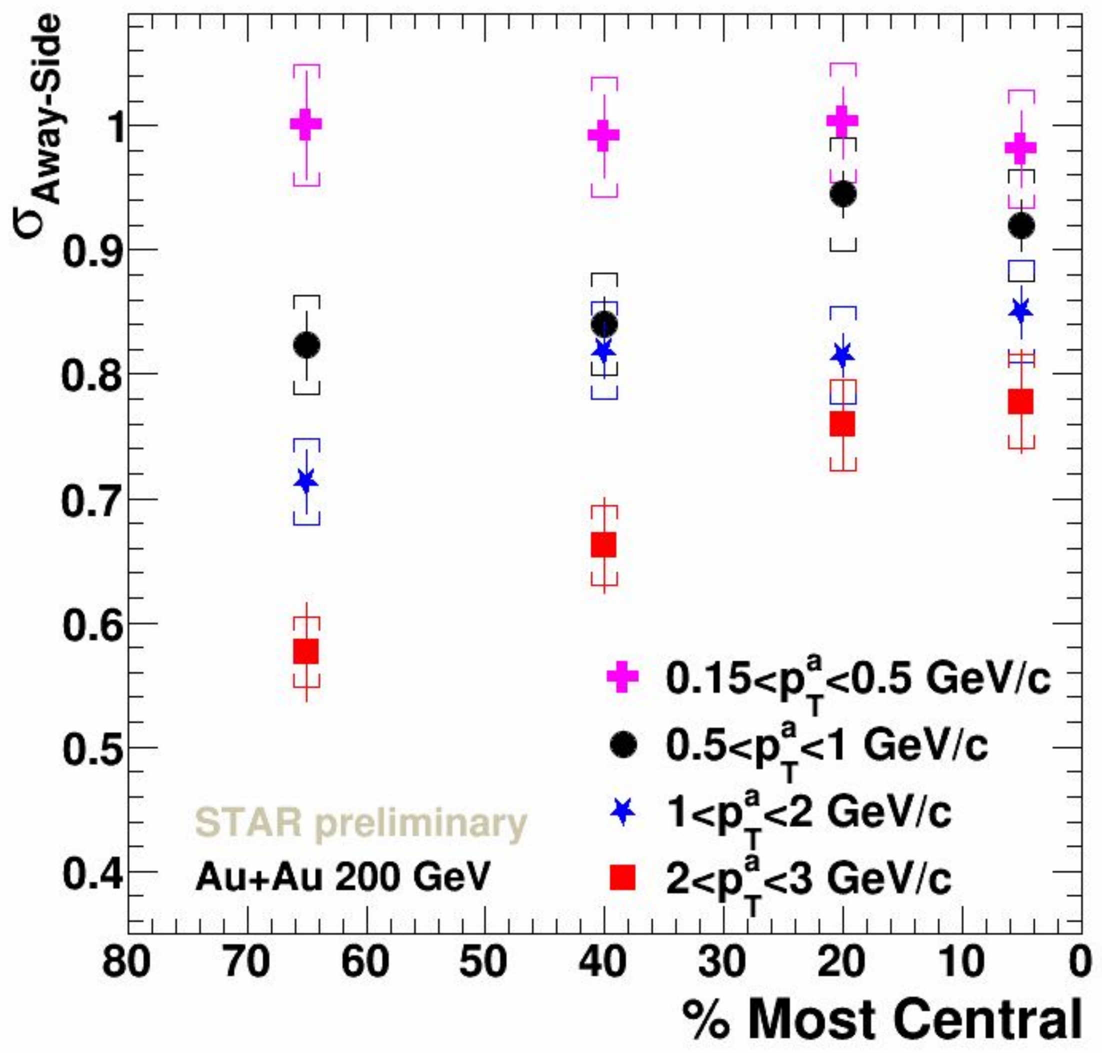
Loose cut: dca <= 3 nHitsFit >= 15

Tight cut: dca <= 1 nHitsFit >= 25

dca: distance of closest approach to the collision vertex
nHitsFit: number of hits in the TPC

- Take the ratio of the σ under other track quality cuts to σ under default track quality cuts
- The Sigma of the distribution gives a systematic error of 3.8% from track quality cuts

Result: the width of the away-side jet

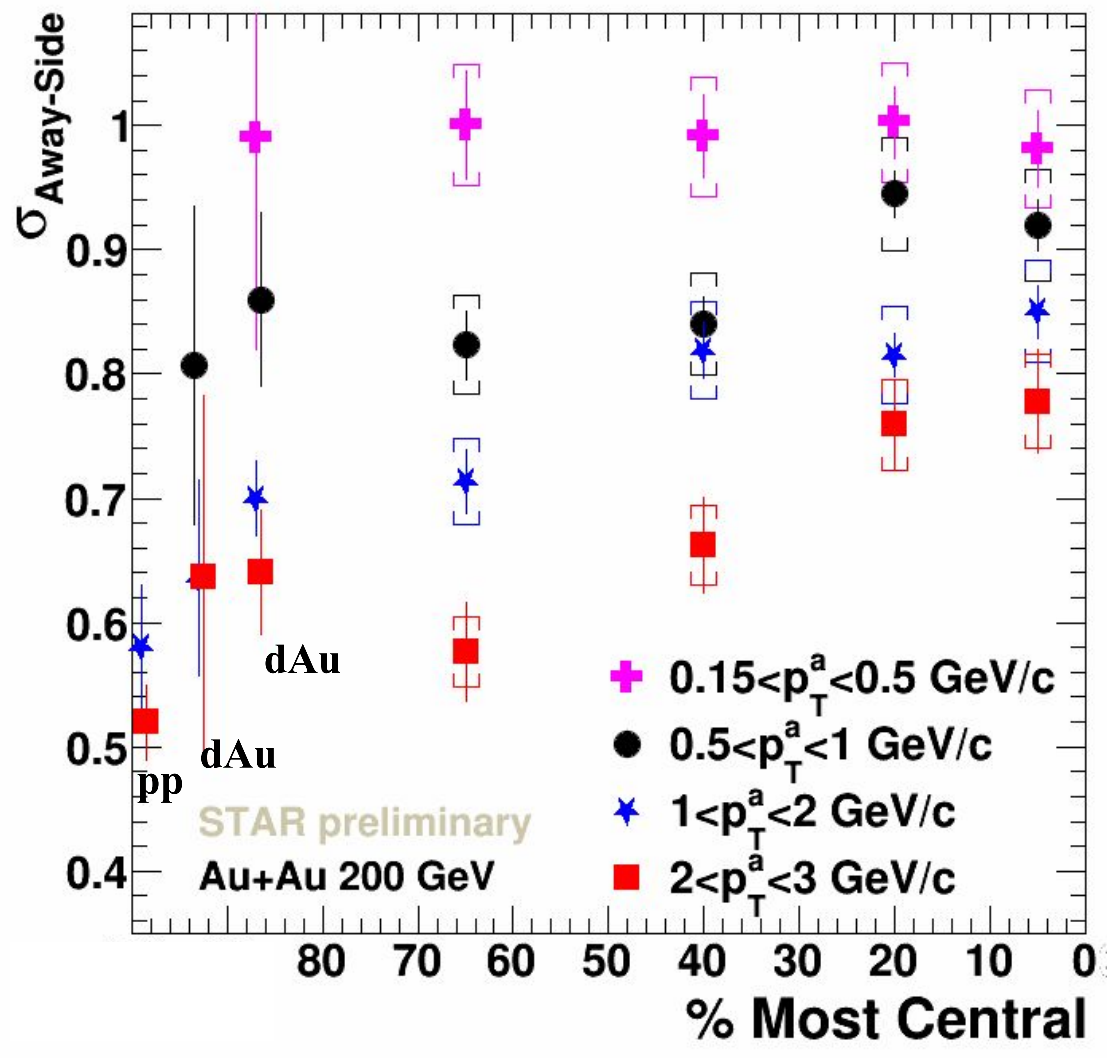


The horizontal caps indicate the systematic error

Away-side jets are modified:

- Moderate to high pT associated particles: broaden with increasing centrality
- Low pT associated particles: no change
- In central collisions, particles of all pT tending towards same distribution

Result: the width of the away-side jet



The leftmost 3 sets of data are for
PHENIX p+p
PHENIX d+Au
STAR d+Au minbias

PRD 74 (2006) 072002
PRC 73 (2006) 054903

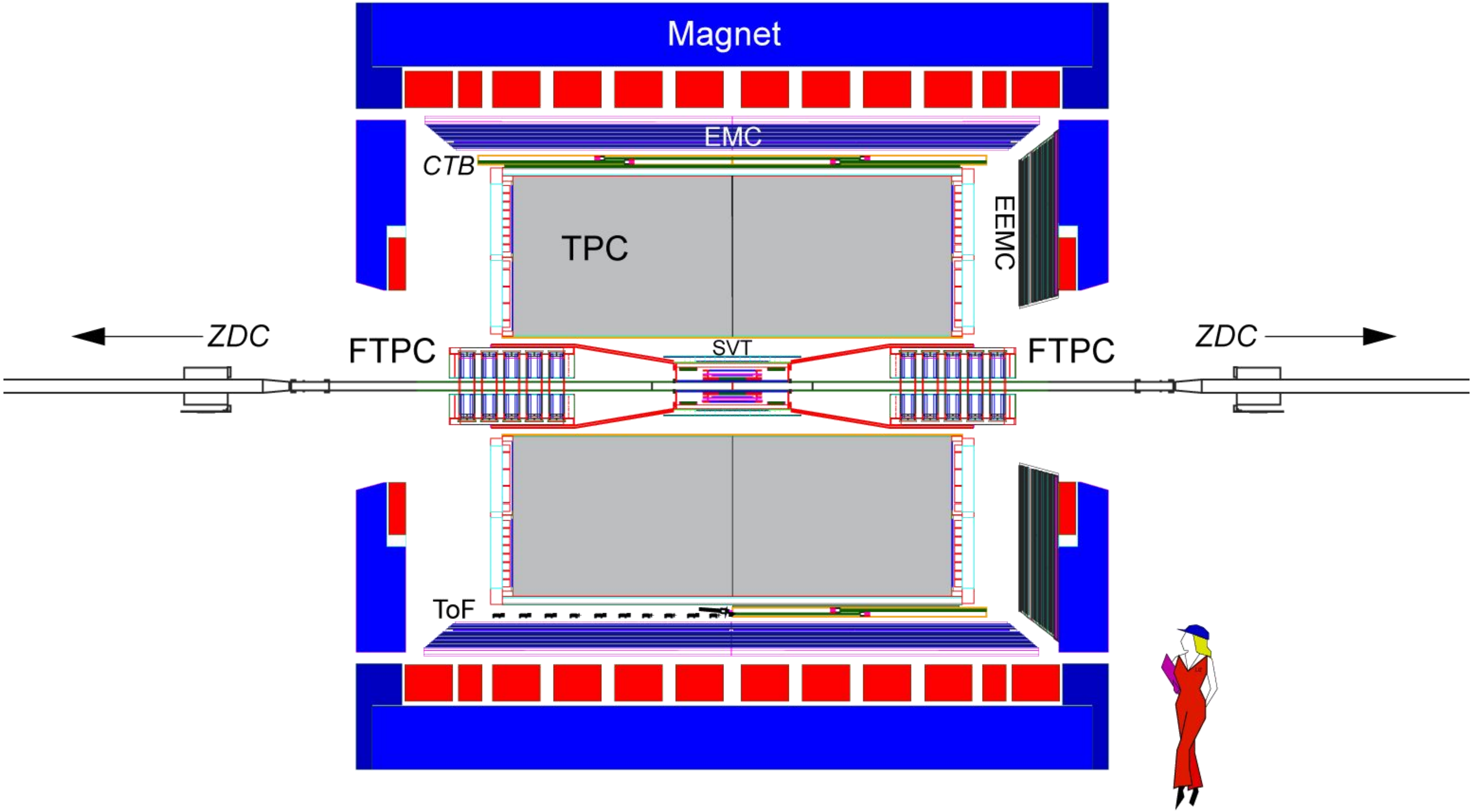
- Peripheral data are consistent with pp/dAu

Summary

- A novel method was devised to measure away-side jet modifications with clean, robust flow subtraction
- Away-side jets are modified:
  - Moderate to high pT associated particles: broaden with increasing centrality
  - Low pT associated particles: no change
  - In central collisions, particles of all pT tending towards same distribution
- Potentially powerful method to study jet modification in medium

Backup slides

STAR detector

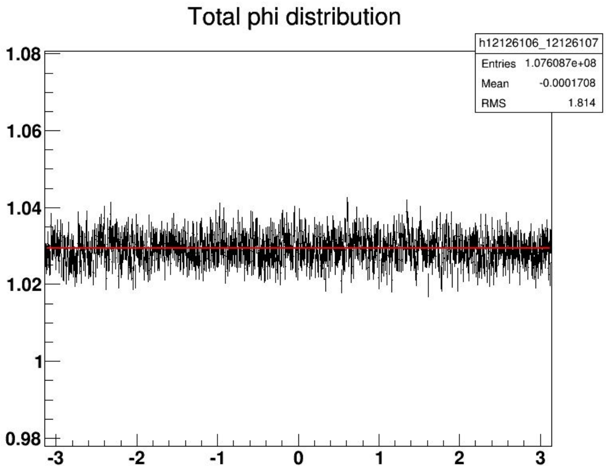


Data sets and cuts

- Data sets
  - Au+Au@200 GeV run11

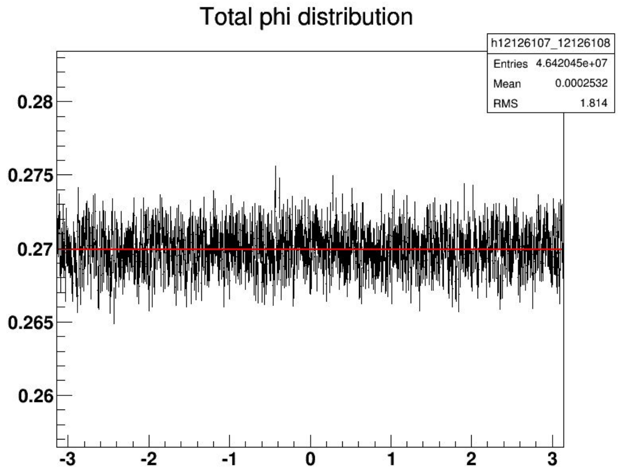
- Event and track cuts
  - $|Vz| < 30$ cm
  - $Vr < 3$ cm
  - track quality cut > 0.52
  - nHitsFit > 20
  - dca < 2 cm

Run by run phi-dependent efficiency correction



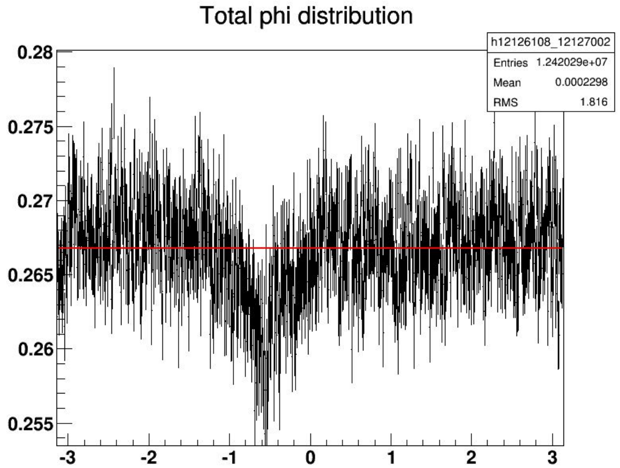
run12126107 / run12126106

chi2 / ndf = 1.04



run12126108 / run12126107

chi2 / ndf = 0.98

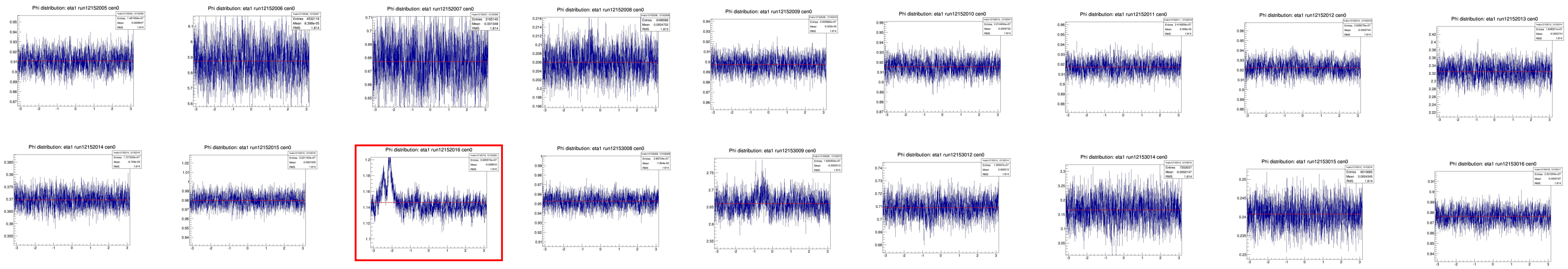


run12127002 / run12126108

chi2 / ndf = 1.59

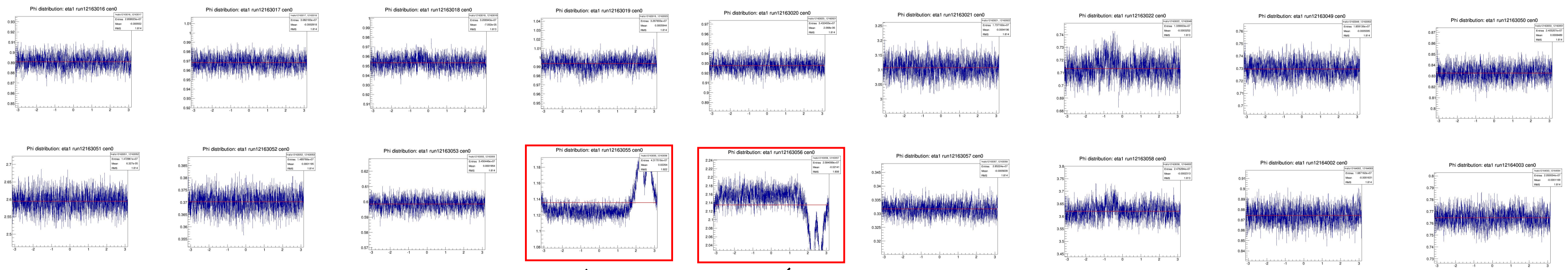
- Histogram single particle phi distribution in one run
- Take a ratio between adjacent runs and fit by a constant
- Combine runs with same detector efficiency into one run block

#1

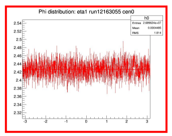


a jump in efficiency, grouped into 2 groups

#2



single bad run

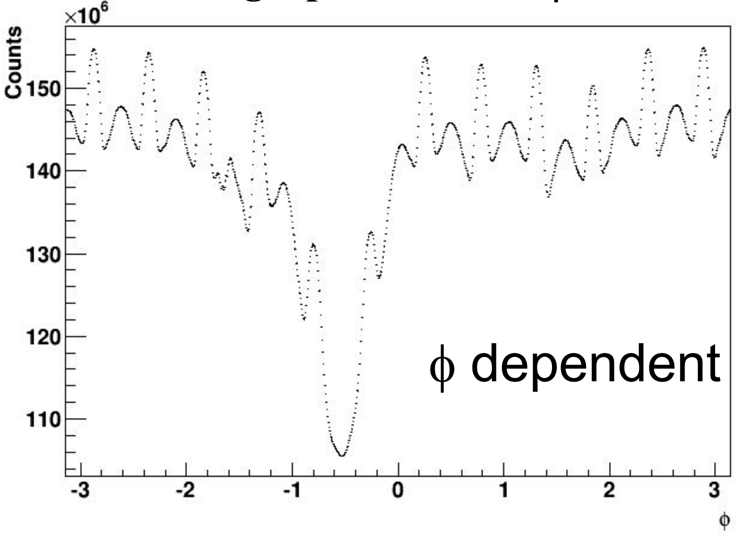


two groups can be catenated

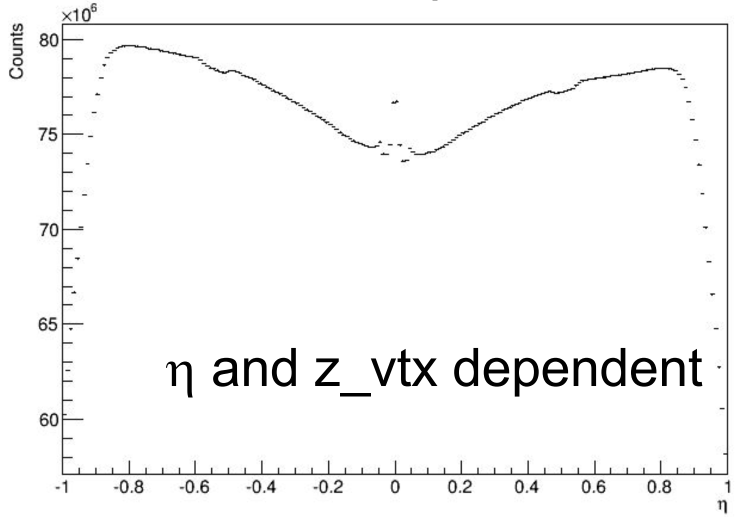
- Total 1297 runs in Run11. Grouped into 144 groups
- Exclude 134 single bad buns

Correct for detector inefficiency

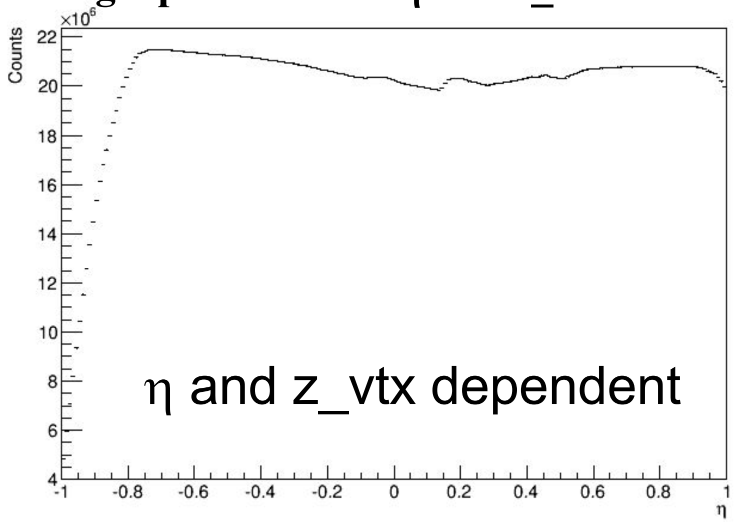
single particle dN/dϕ



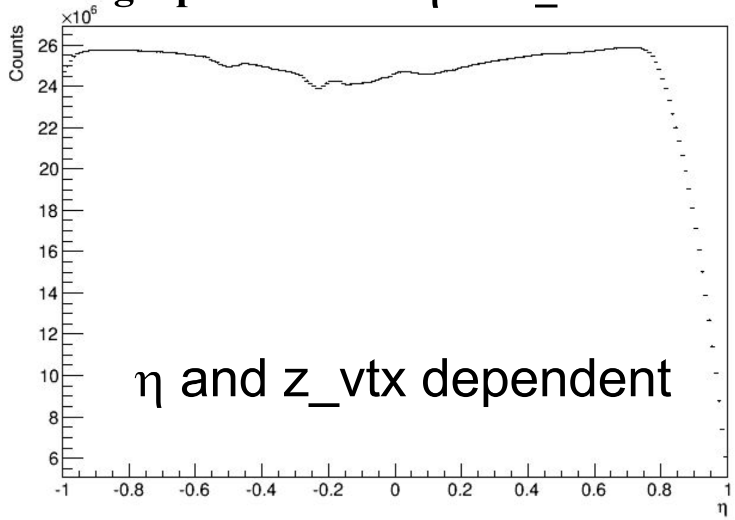
single particle dN/dη -2<z_vtx<2 cm



single particle dN/dη -30<z_vtx<–26 cm



single particle dN/dη 26<z_vtx<30 cm

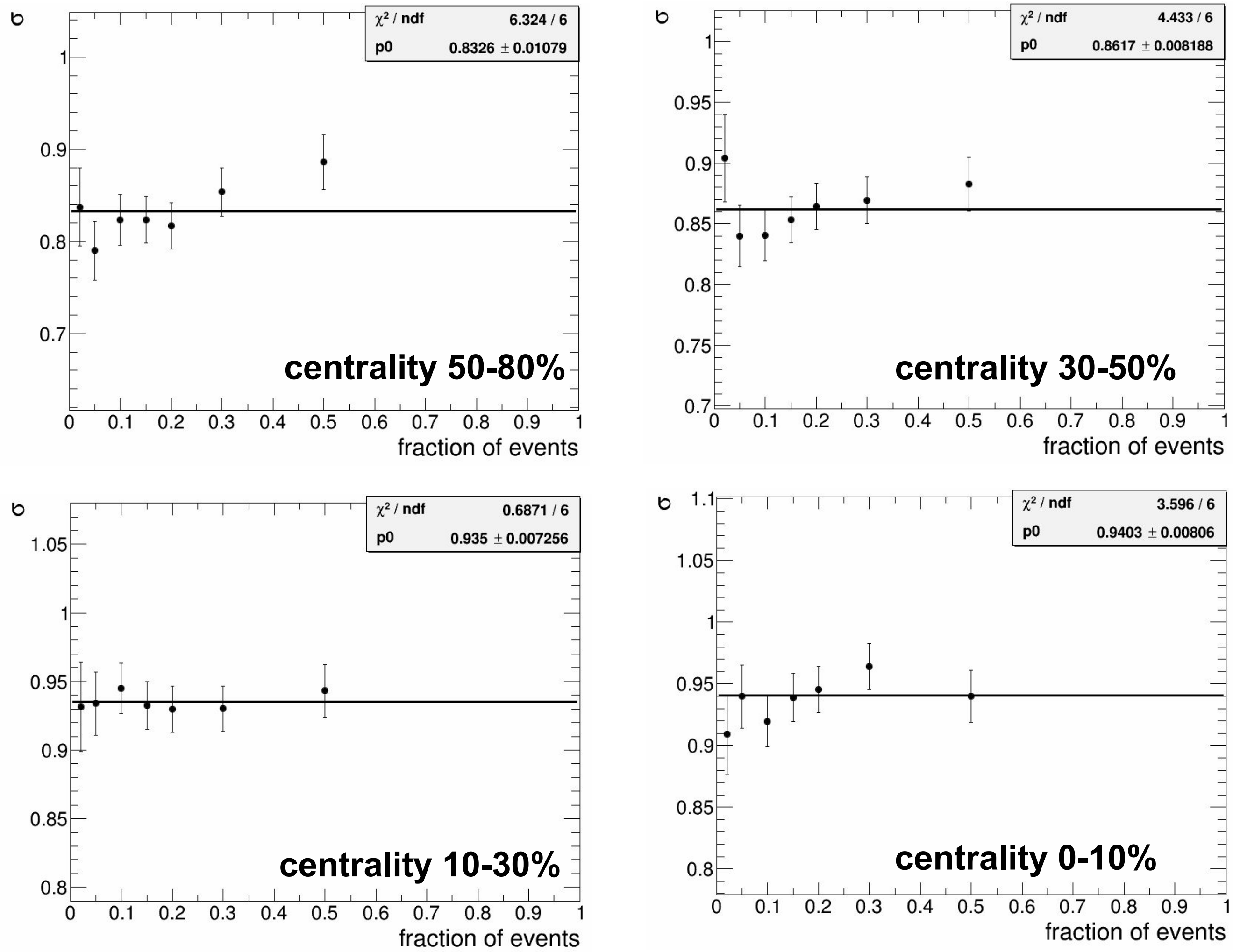


Varying "Px" cut

study sigma vs Px cut percentage: 2%, 5%, 10%, 15%, 20%, 30%, 50%

default "Px" cut
10%

associate pT
0.5 - 1 GeV

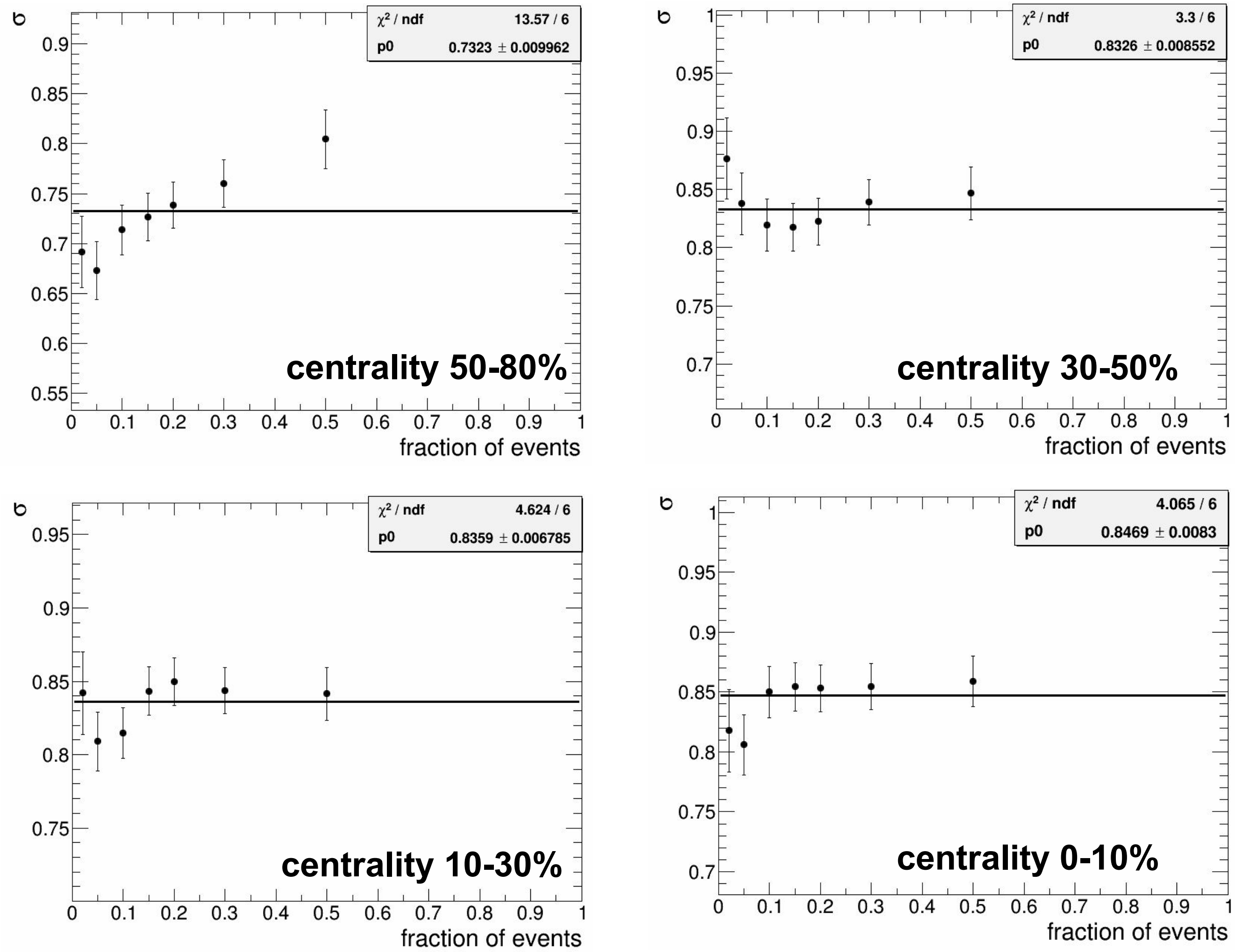


Varying "Px" cut

study sigma vs Px cut percentage: 2%, 5%, 10%, 15%, 20%, 30%, 50%

default "Px" cut
10%

associate pT
1 - 2 GeV

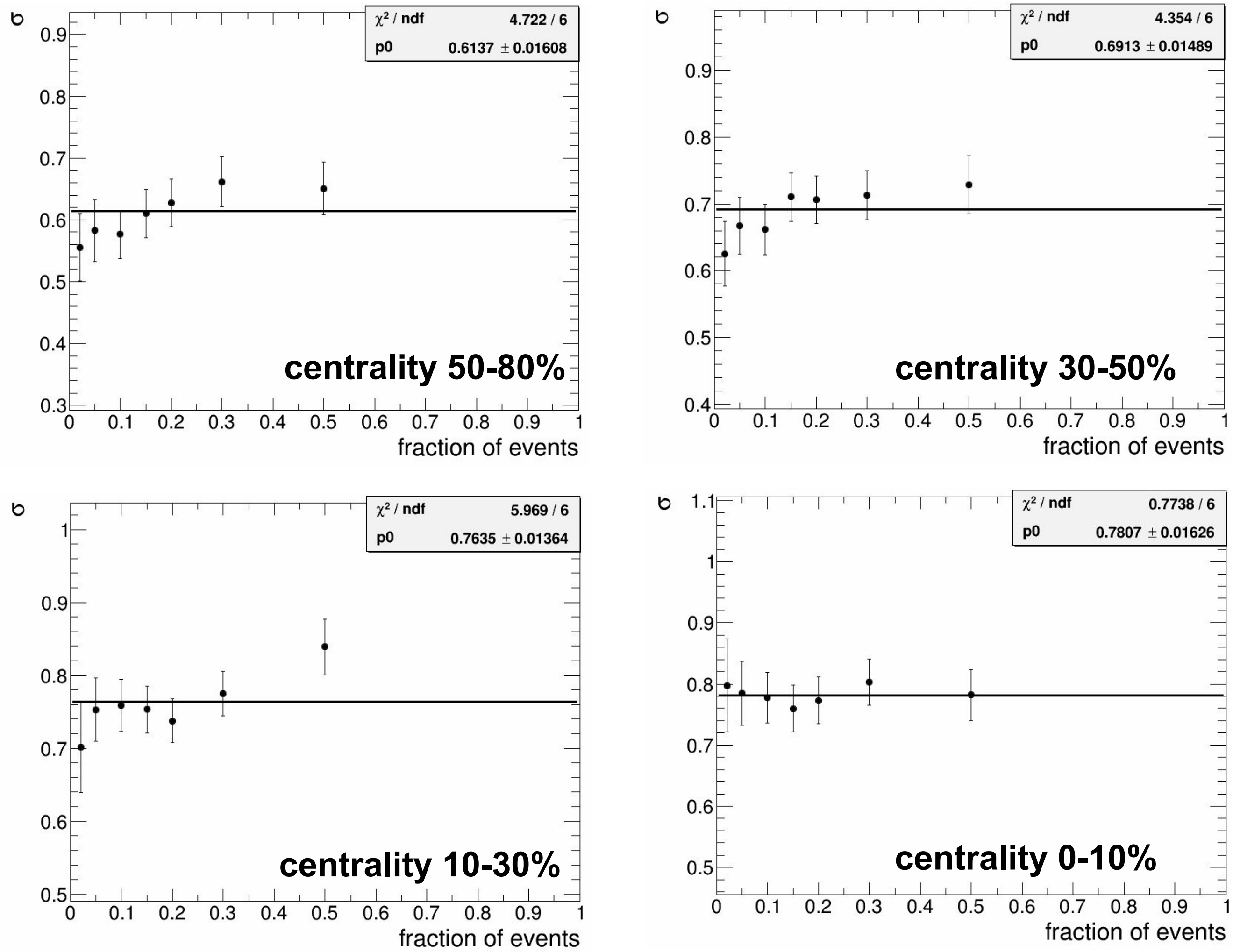


Varying "Px" cut

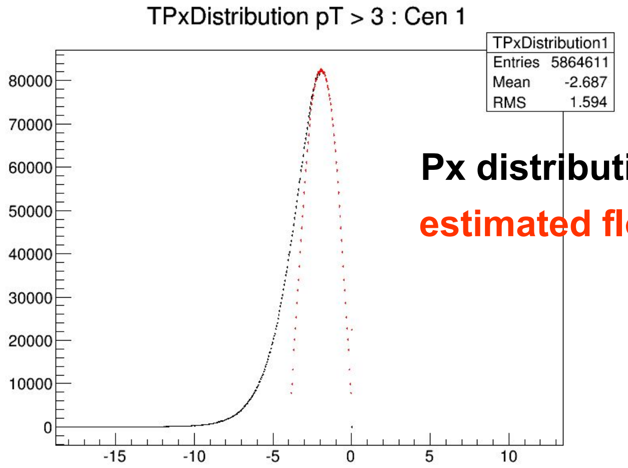
study sigma vs Px cut percentage: 2%, 5%, 10%, 15%, 20%, 30%, 50%

default "Px" cut
10%

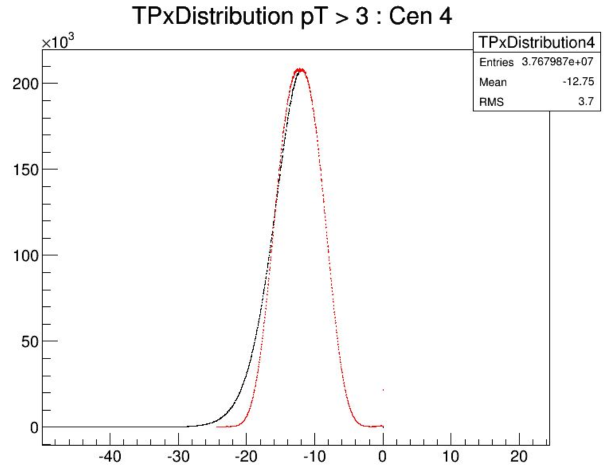
associate pT
2 - 3 GeV



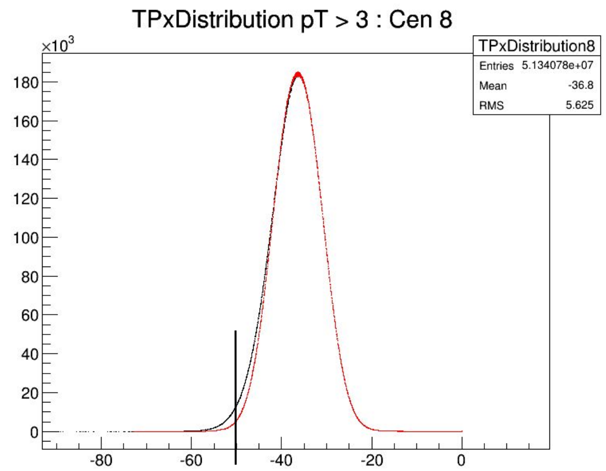
Px distritbutions



peripheral 60-70%



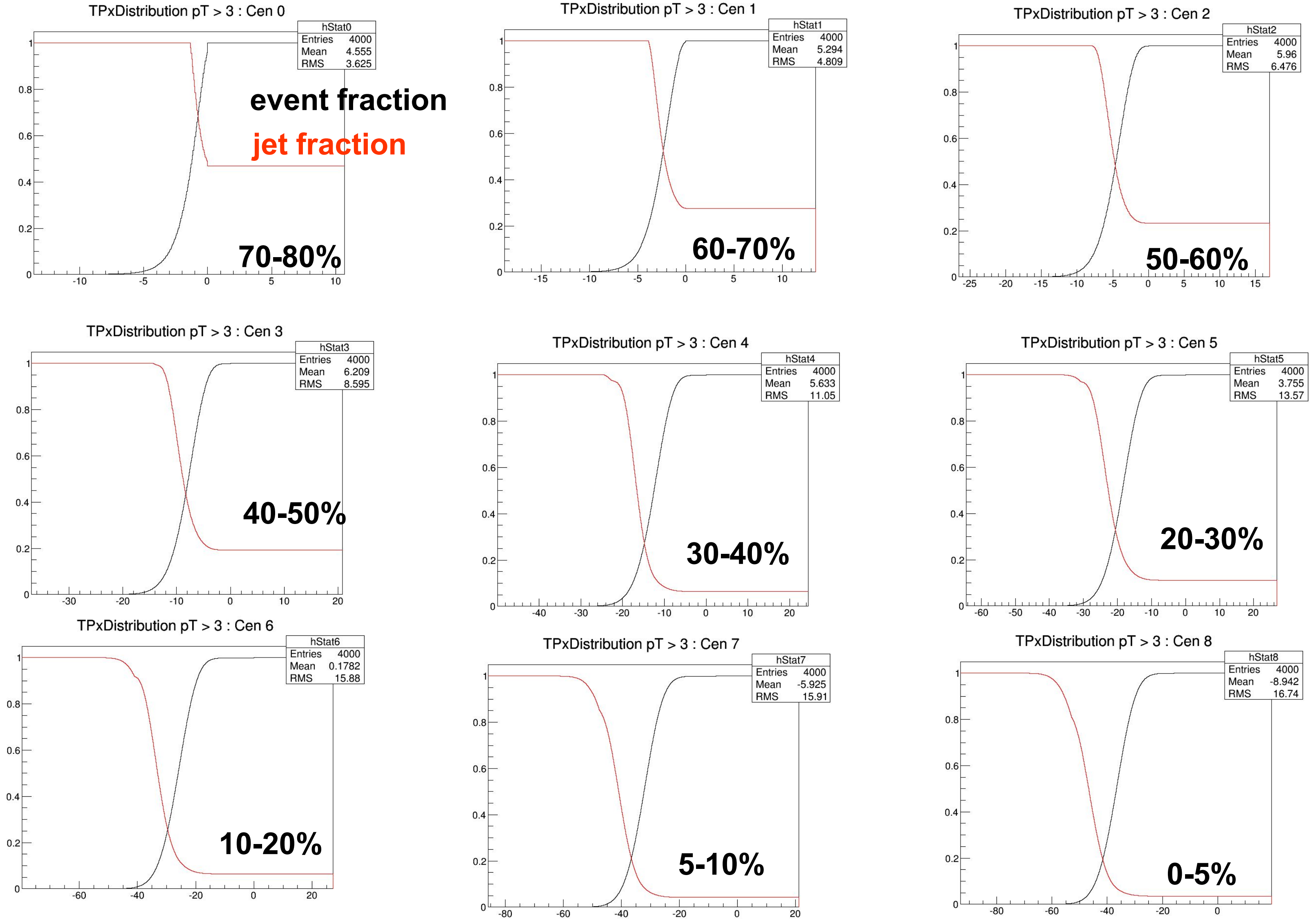
midcentral 30-40%



central 0-5%

- •recoil Px is a convolution of away-side jet and flow
- • assume that flow has a symmetric distribution, small px are almost from flow contribution
- • flip the histogram on the right of the maximum bin to the left to estimate the flow contribution

Jet fractions



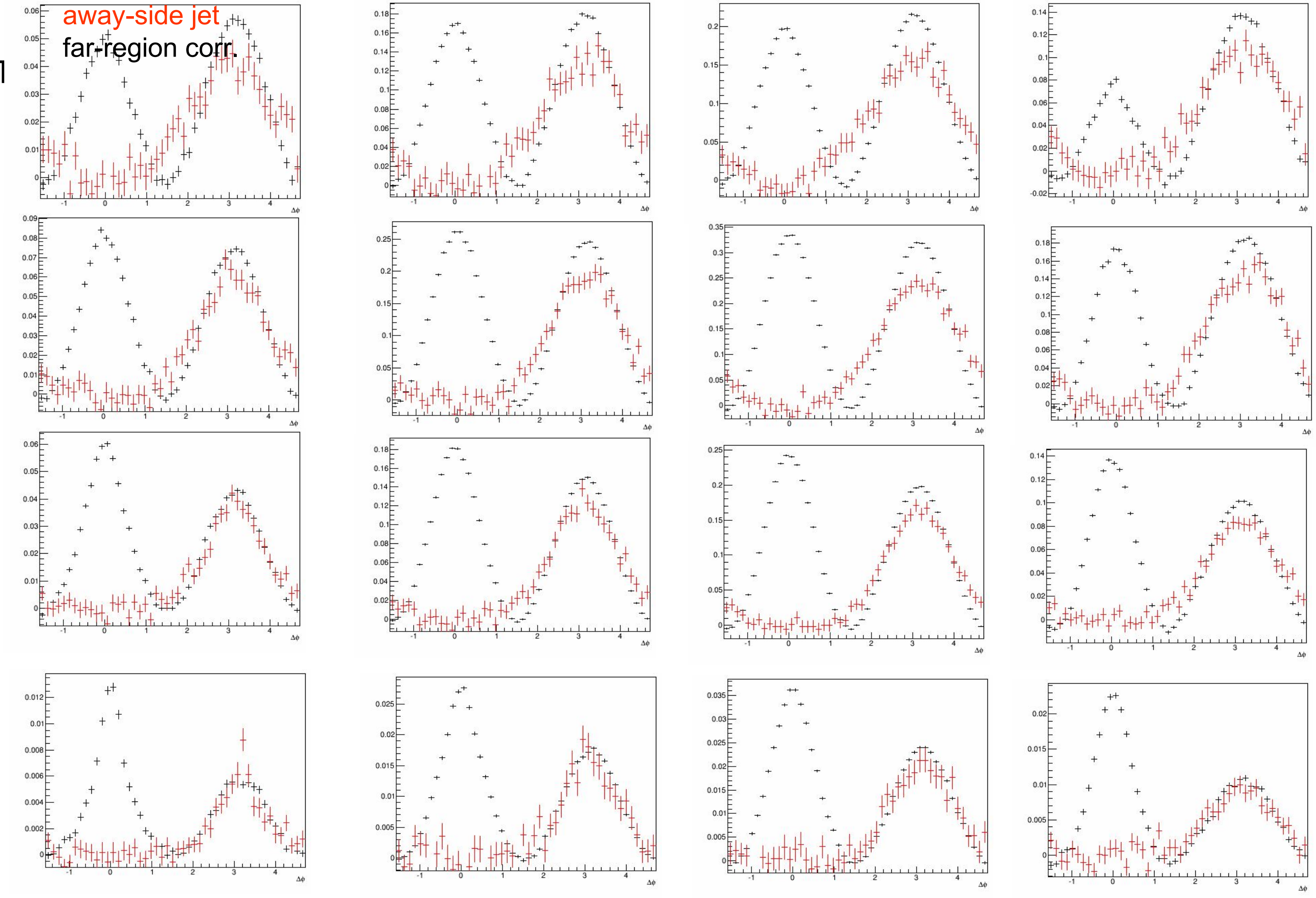
shape comparison: jet and far-region corr.

associate pT
0.15 - 0.5 GeV

0.5 - 1 GeV

1 - 2 GeV

2 - 3 GeV



50-80% 30-50% 10-30% 0-10%

- For far-region corr, low pT is dominated by flow. High pT is dominated by jet, so it has same shape as jet.