ZYAM Alternative: The Absolute Background Normalization

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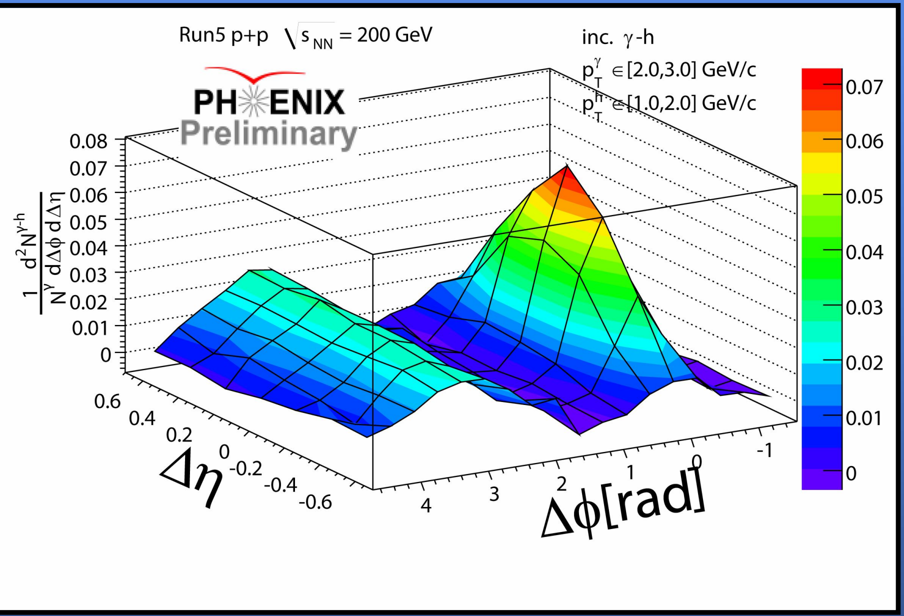
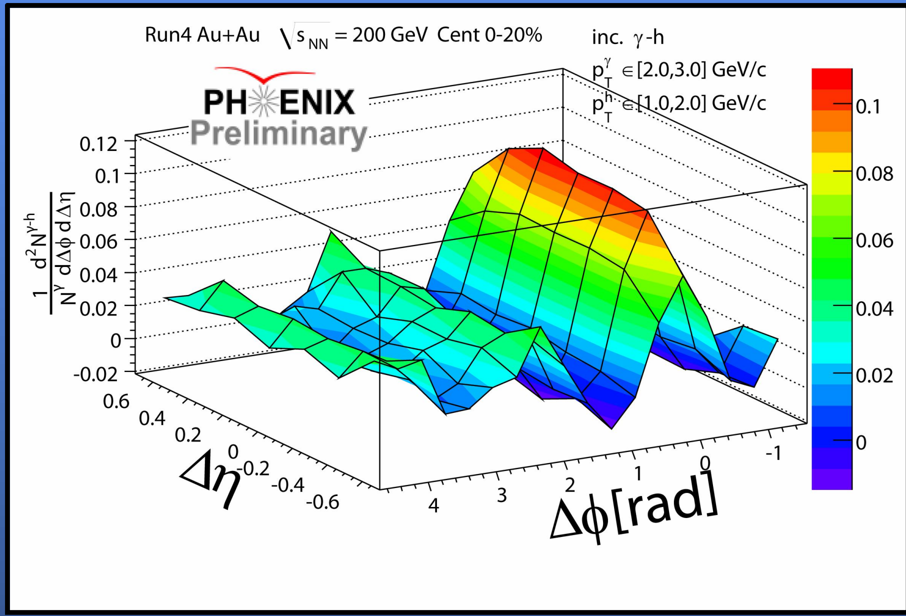
Medium Response

p+p, peripheral Au+Au



central Au+Au



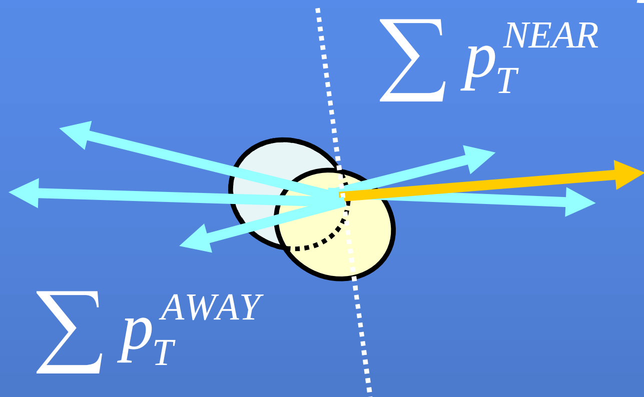
PHENIX poster (Chin-Hao Chen)

Typical:
- Near-side Jet
- Away-side Jet – "Head"

New:
- Near-side Modification – "Ridge"
- Away-side Modification – "Shoulder"

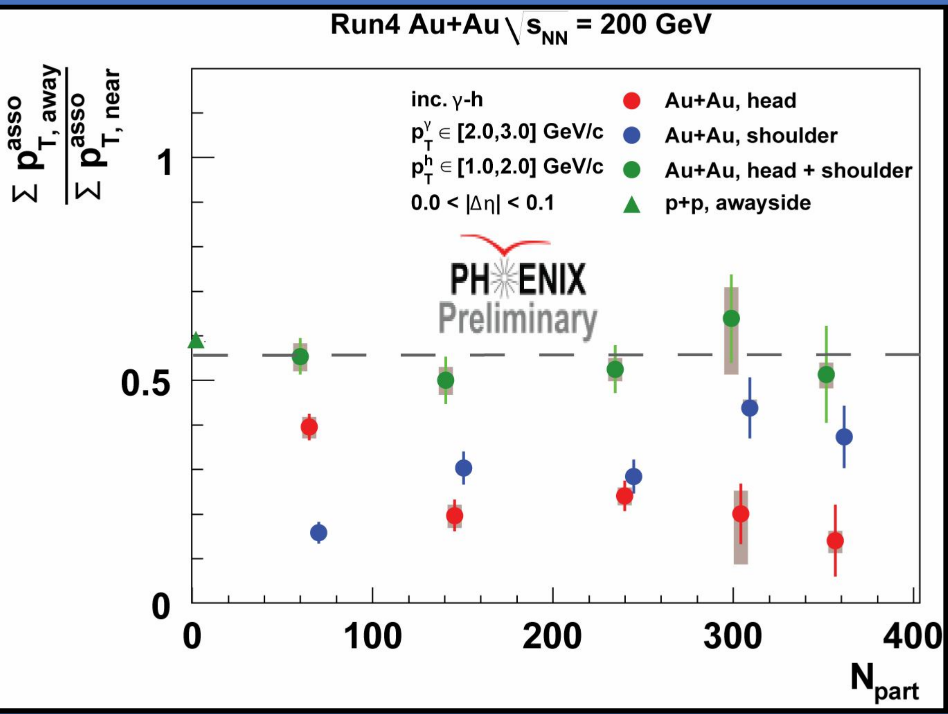
Near-side Ridge theories: Boosted Excess, Backsplash, Local Heating,…
Away-side Shoulder theories: Mach, Jet Survival + Recom, Scattering,…

p_T Balance

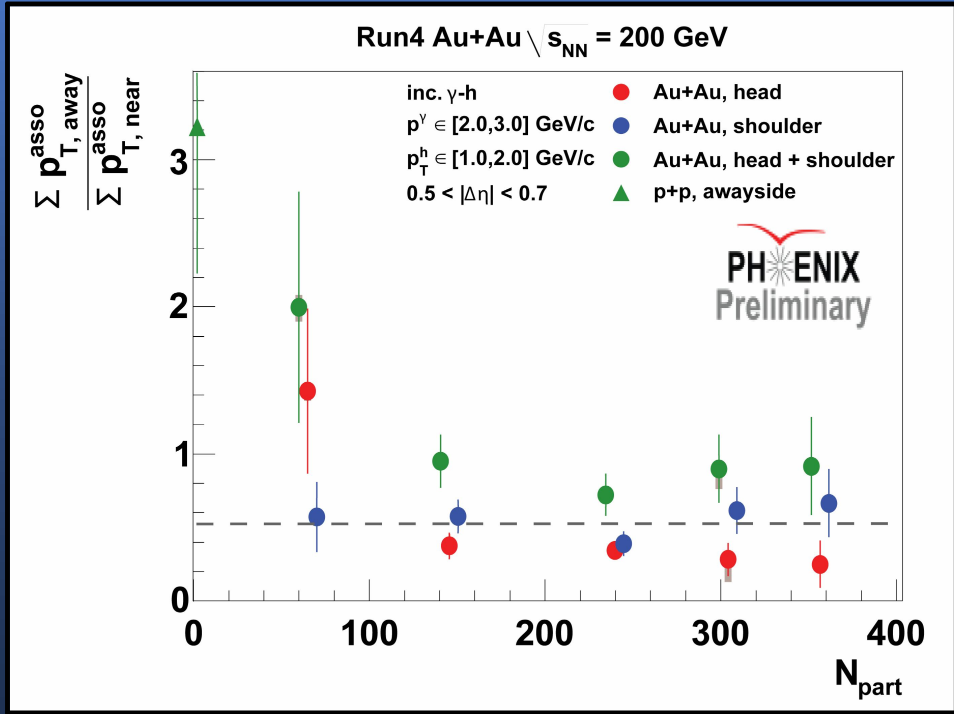


- Jet & Ridge balances Shoulder & Head
- Ridge & Shoulder balance separately!

0.0 < |Δη| < 0.1



0.5 < |Δη| < 0.7



Background Basics

ZYAM makes non-trivial assumptions about jet behavior in heavy ion collisions

Reliance on any untested jet-shape assumption would be improper without a detailed supporting theory or other supporting evidence

Independent estimations of background level are required to test the validity of the ZYAM assumptions

Requires a greater understanding of background multiplicities in heavy ion events

Intro. Jet Mathematics

Two Source Model:

$$\frac{1}{n^A}\frac{dn_{jet}^{AB}}{d\Delta\varphi} = \frac{1}{n^A}\frac{dn_{inc}^{AB}}{d\Delta\varphi} - \frac{1}{n^A}\frac{dn_{comb}^{AB}}{d\Delta\varphi}$$

Pairs correlate in two ways:

direct interactions (jet)

global event properties (comb)

Correlation and
Jet Function Framework:

$$\frac{1}{n^A}\frac{dn_{jet}^{AB}}{d\Delta\varphi} = \frac{1}{\varepsilon^B\kappa}\frac{n_{real}^{AB}}{n^A\int d\Delta\varphi}J(\Delta\varphi)$$

$$C(\Delta\varphi) = \frac{\frac{dn_{real}^{AB}}{d\Delta\varphi}}{\frac{dn_{mix}^{AB}}{d\Delta\varphi}}\frac{\int\frac{dn_{mix}^{AB}}{d\Delta\varphi}d\Delta\varphi}{\int\frac{dn_{real}^{AB}}{d\Delta\varphi}d\Delta\varphi}$$

$$J(\Delta\varphi) = C(\Delta\varphi) - b_0\left(1 + 2c_2^{AB}\cos(2\Delta\varphi) + \ldots\right)$$

b_0 sets the background normalization

Assumptions

Foreground combinatorial pairs-per-event given by corrected mixed-event pairs-per-event

$$n_{comb}^{AB} = n_{mix}^{AB}\xi \qquad b_0 = \frac{n_{mix}^{AB}\xi}{n_{real}^{AB}}$$

Reliance on stochastic hard scattering production

Example of failure scenario:

Every event has 1 and only 1 hard scattering and no other particle production

Absolute Normalization

There are two equivalent methodologies to set b_0

Mixed Event Method:

Count average pair multiplicity in mixed events

Correct for centrality binning

$$n_{comb}^{AB} = n_{mix}^{AB}\xi \qquad b_0 = \frac{n_{mix}^{AB}\xi}{n_{real}^{AB}}$$

Mean-Seeds Mean-Partners Method:

Count singles

Count pair-cut loss in mixed event

Calculate average pair multiplicity in mixed events

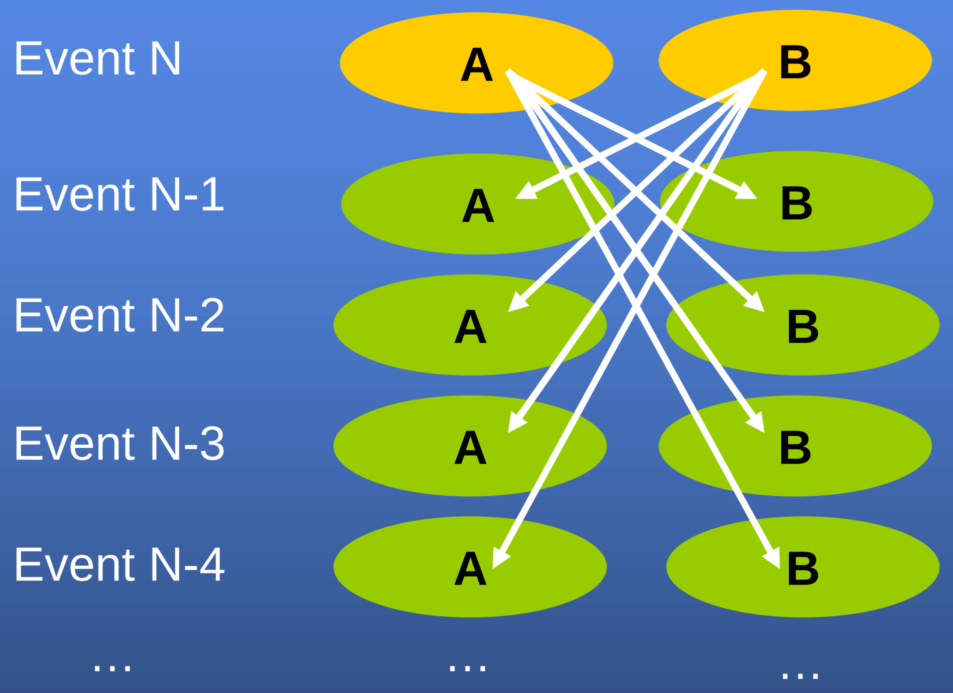
Correct for centrality binning

$$n_{comb}^{AB} = n^{A} n^{B} \kappa\xi \qquad b_0 = \frac{n^{A} n^{B} \kappa\xi}{n_{real}^{AB}}$$

Mixed Events

Rolling buffer mixing technique

Pooled by Event type:
  5cm zvertex
  5% centrality

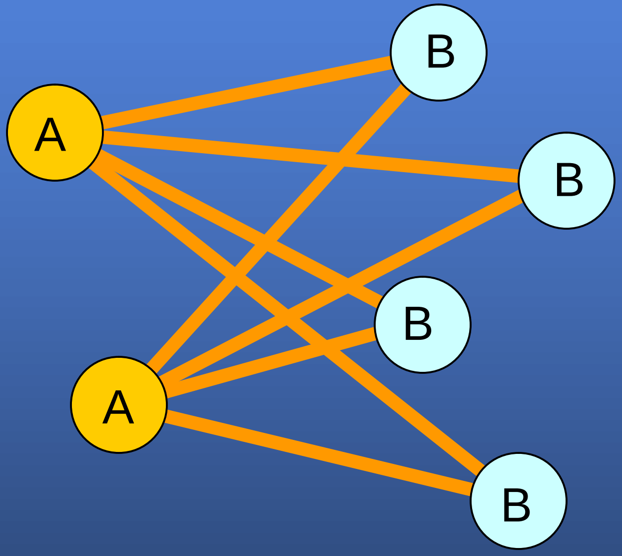


Mixing produces two products:

- Acceptance Correction
- Mixed Event Pair Multiplicity

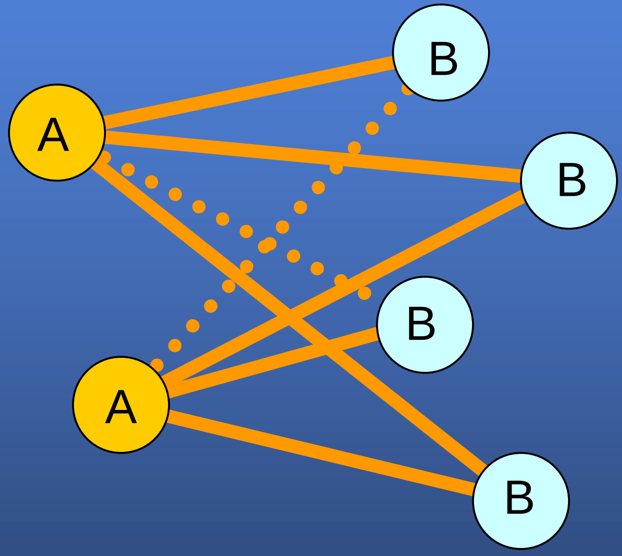
Pair Cut Correction, κ

Calculation without pair cut correction



$$n_{mix}^{AB} \neq n^A n^B$$

Calculation with pair cut correction

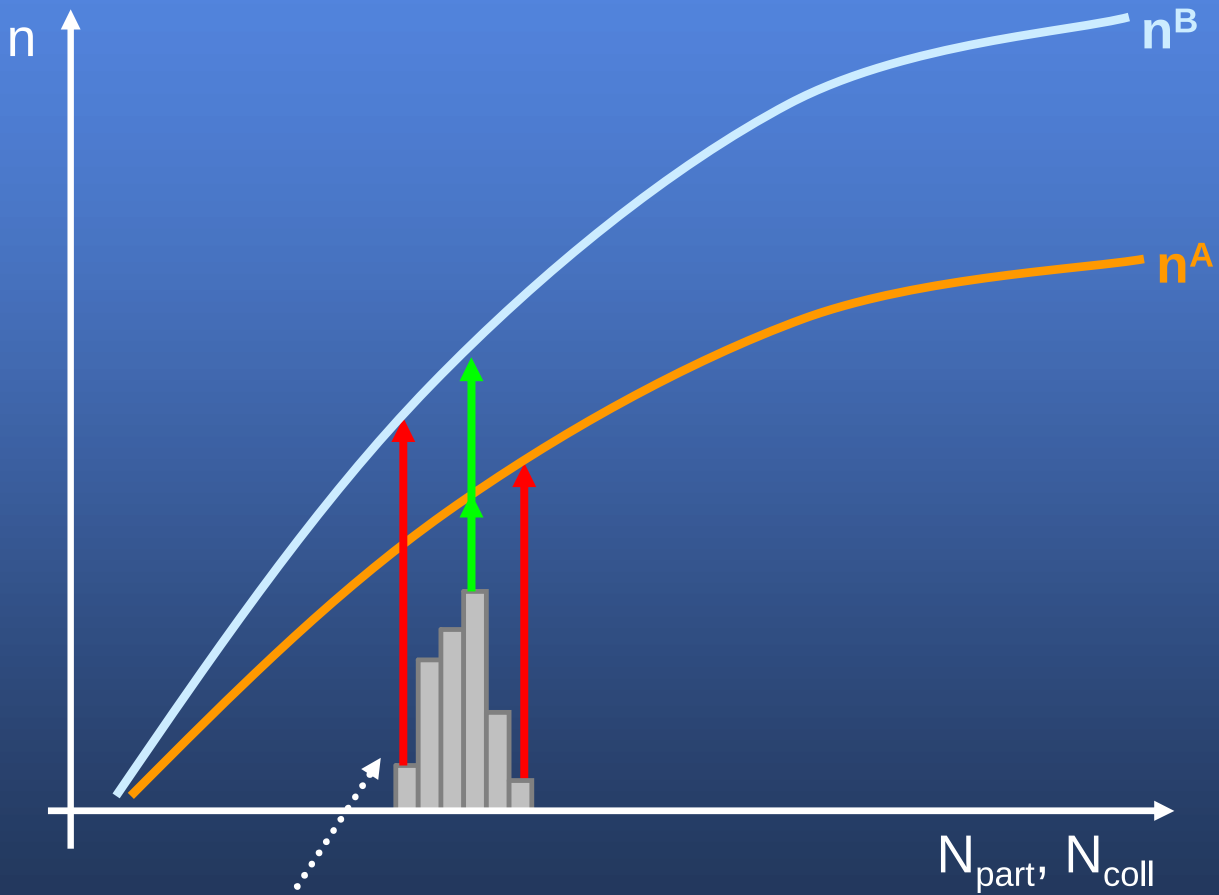


$$n_{mix}^{AB} = n^A n^B \kappa$$

κ, the survival probability, is typically ~99.3% and can be estimated in mixed events

Centrality-Multiplicity Correlations

Calculating (or mixing) for backgrounds in a centrality bin requires a correction for the multiplicity dependence across the bin



Event distribution in a centrality bin, w

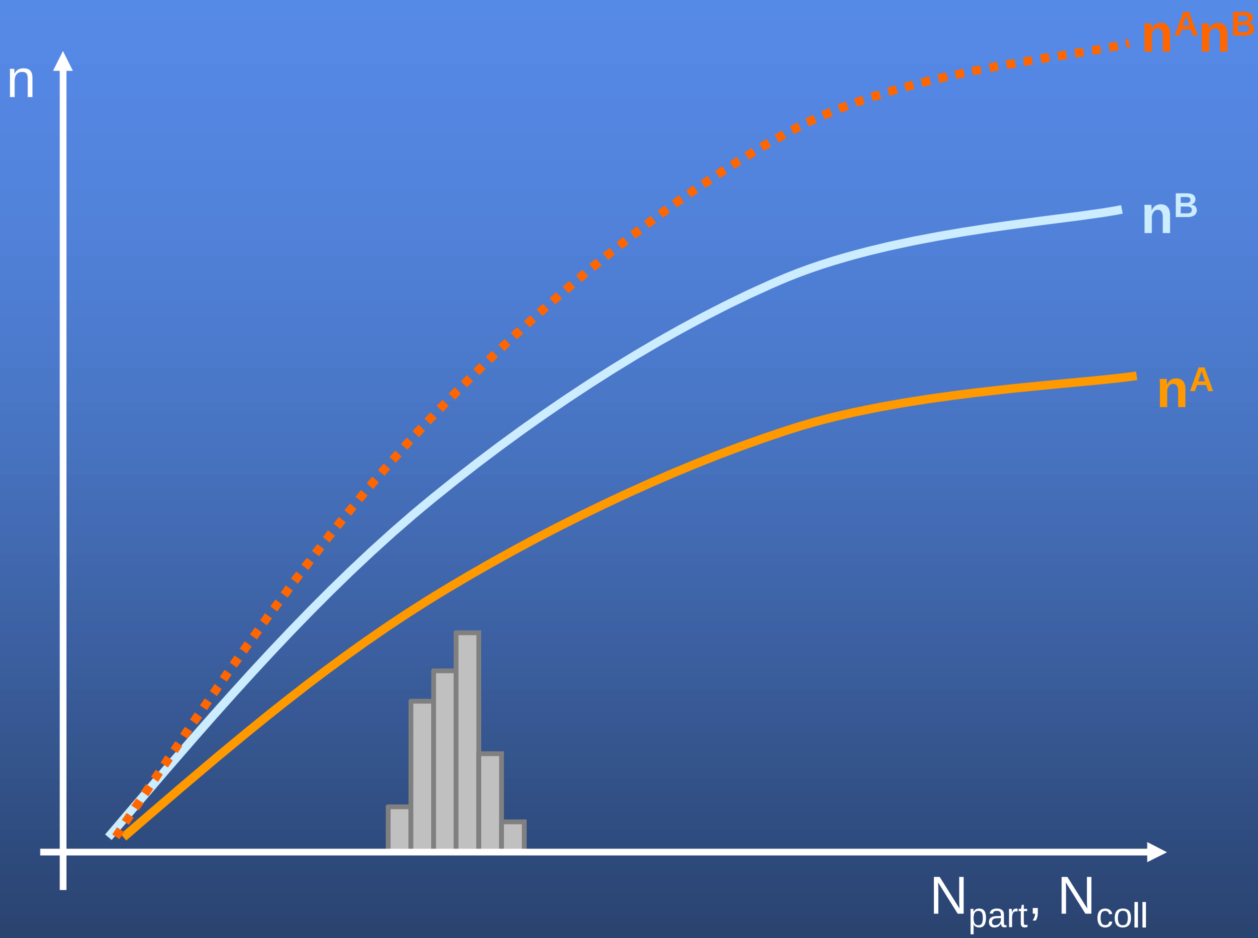
Foreground Events:

Sample particle multiplicities from the same event

Mixed Events:

Sample particles from different multiplicities

ξ Correction

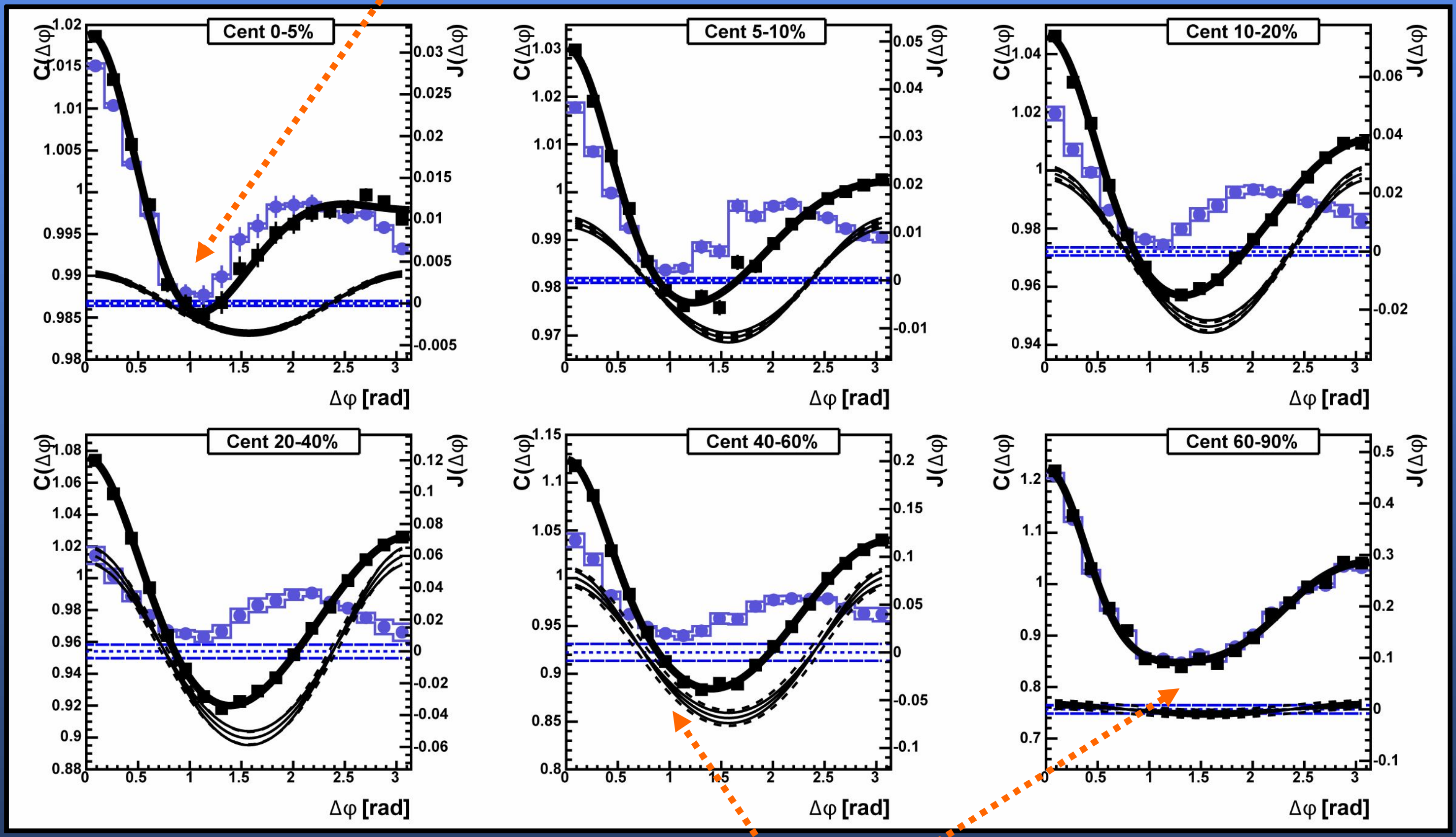


$$\xi \equiv \frac{\langle n^A \cdot n^B \rangle}{\langle n^A \rangle \langle n^B \rangle} = \frac{\sum n^A n^B w}{\sum n^A w \sum n^B w} \sum w$$

Cent(%)	ξ
0-5	1.0011(4)
5-10	1.0025(6)
10-15	1.0044(9)
15-20	1.007(1)
20-25	1.010(3)
25-30	1.014(4)
30-35	1.019(7)
35-40	1.025(9)
40-45	1.03(1)
45-50	1.05(1)
50-55	1.06(3)
55-60	1.10(6)
60-65	1.15(9)
65-70	1.3(2)
70-75	1.4(3)
75-80	1.5(4)
80+	1.6(5)

Absolute Normalization Results

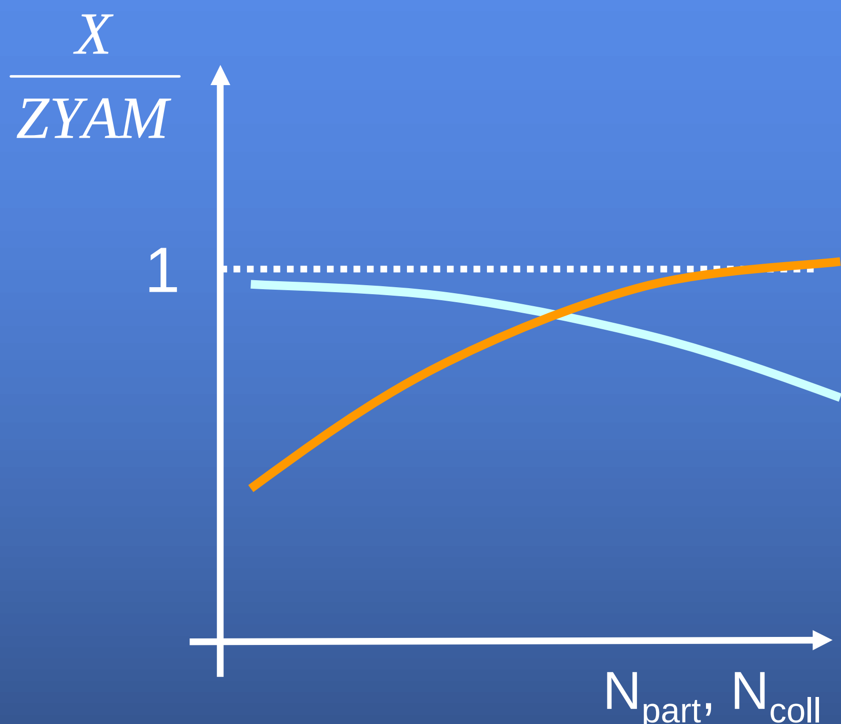
Confirmation of ZYAM procedure in most central



Peripheral shows pedestal yield

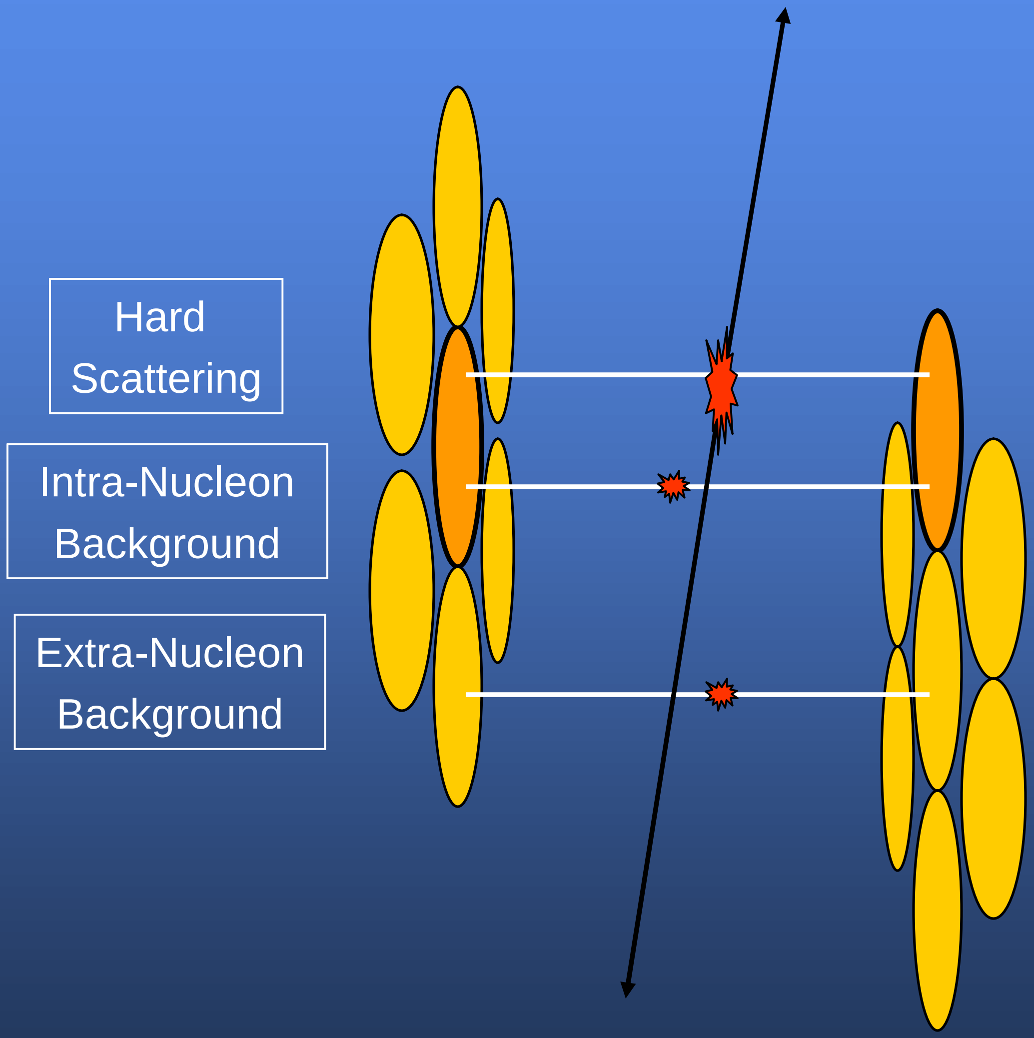
Comparison to Others

	b_0		
Cent (%)	Absolute	ZYAM	Fit
0-5	**0.989**	0.988	0.966
5-10	**0.982**	0.982	0.947
10-20	**0.973**	0.971	0.943
20-40	**0.956**	0.960	0.954
40-60	**0.929**	0.942	0.939
60-90	**0.775**	0.861	0.858



Fit normalization assumes an underlying double away-side Gaussian profile, evidence rules against this assumption

Intra- and Extra-Nucleon Background

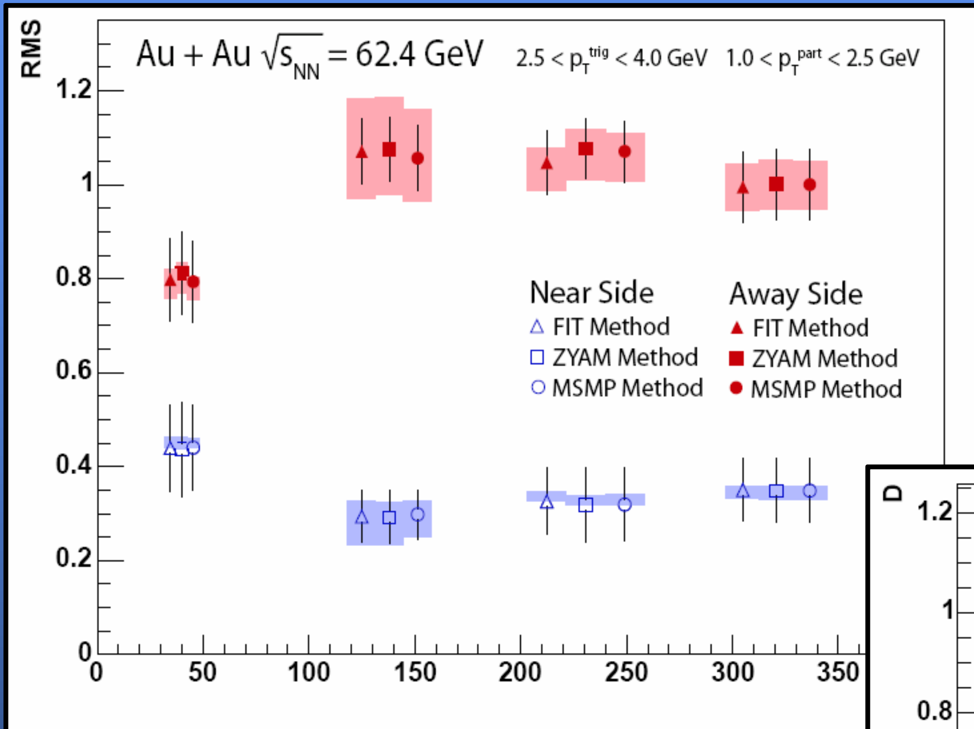


Two Sources of Background:
- Scatterings within the hard-scattering's nucleons or from other nucleon-nucleon collisions

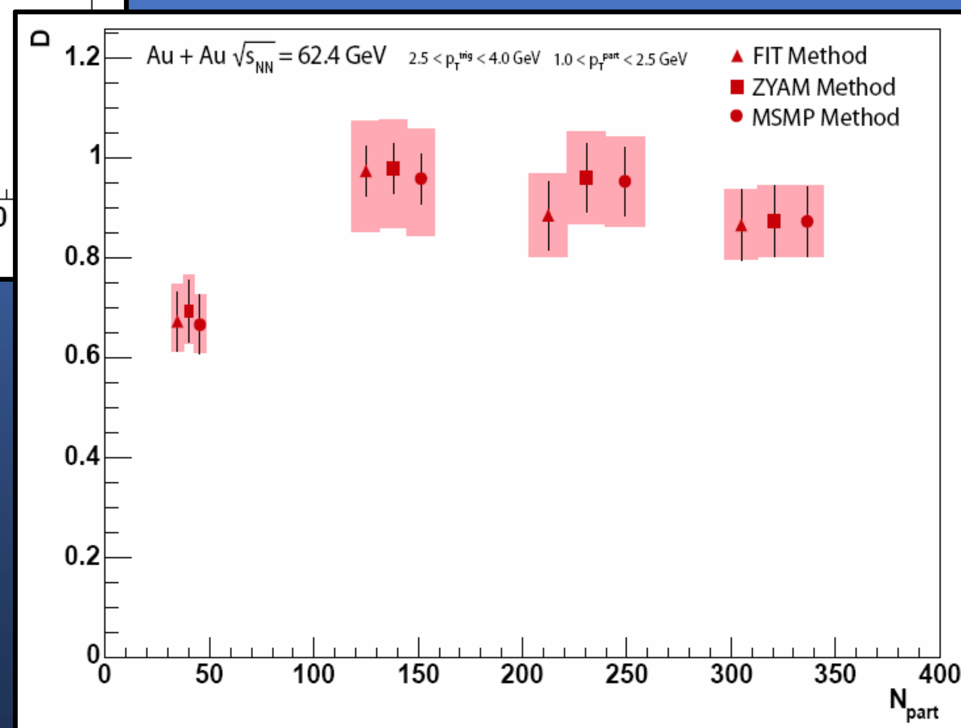
ξ estimations correct for only the extra-nucleon component

Resulting subtractions in peripheral collisions should look like un-subtracted p-p

Effects on Jet Shape



Shape metrics in three background normalization methods



"Small" differences in background level result in smaller differences on shape than those from the v_2 systematics

Summary

Absolute and ZYAM match in most central collisions where concern about how to subtract are maximized by the S/B ratio

Current difference in the peripheral is possibly due to differing philosophies on what constitutes background

No significant difference in final jet shapes

Pair correlations are still an active subject