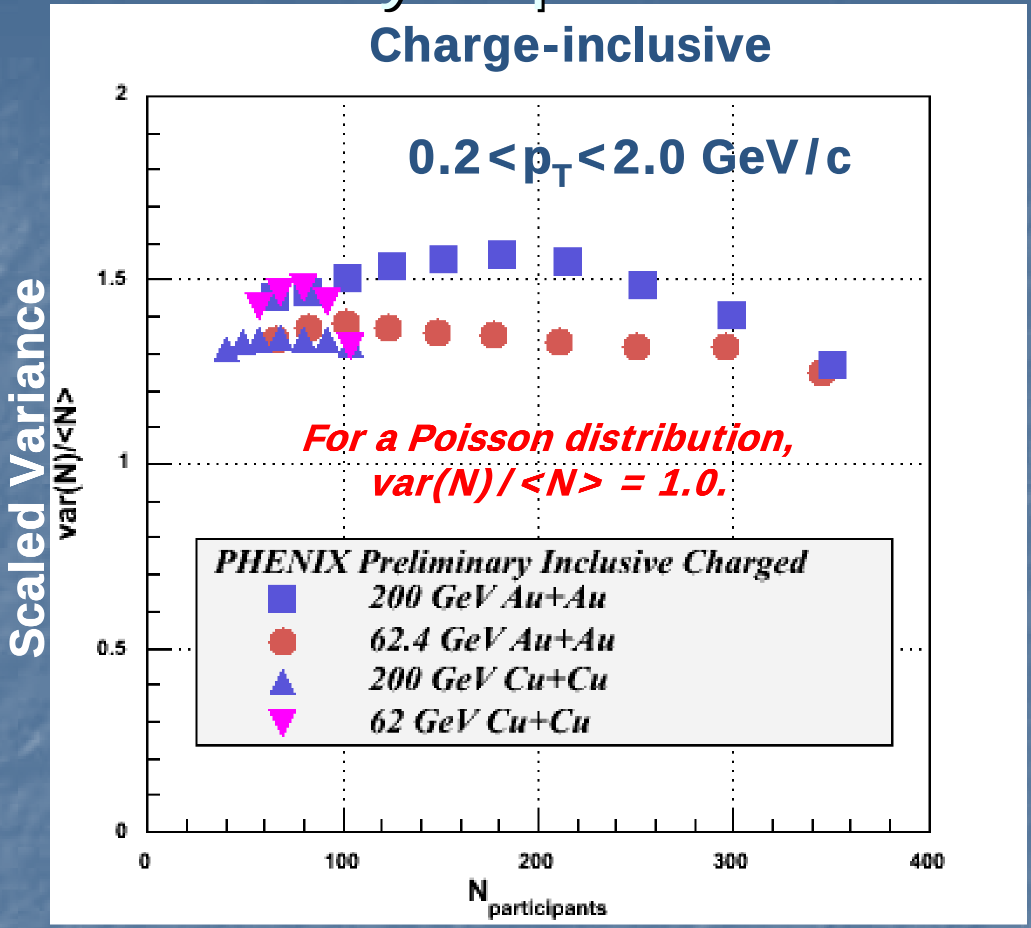
A Survey of Multiplicity Fluctuations in PHENIX

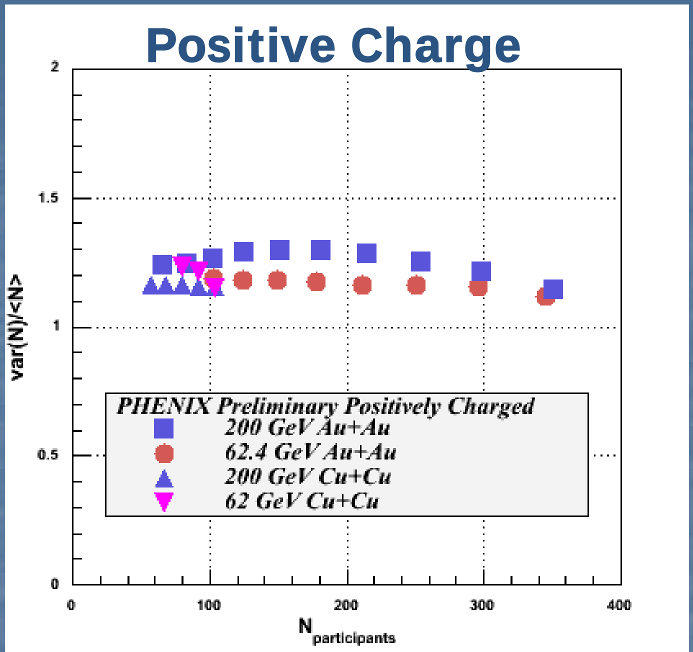
Quark Matter 2005
Jeffery T. Mitchell
(Brookhaven National Laboratory)
for the PHENIX Collaboration

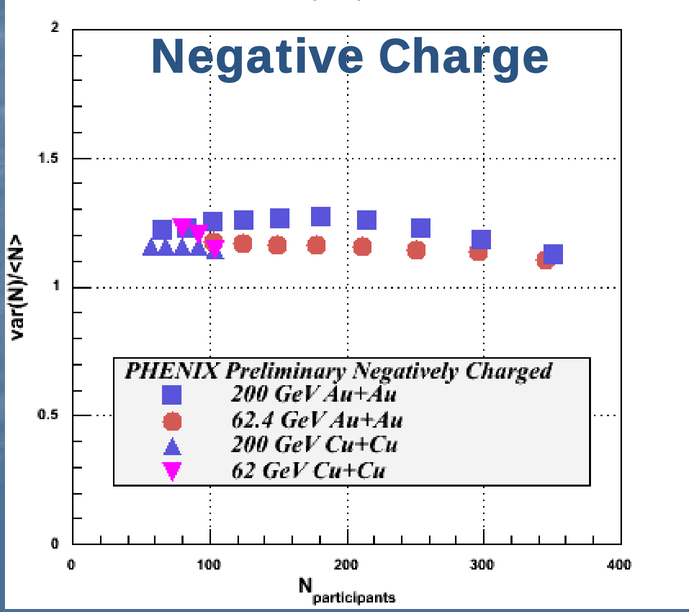
OUTLINE

- **Scaled Variance vs. Centrality**
- **Negative Binomial Distribution Fits: k Parameter vs. Centrality**
- **HIJING comparisons**
- **Scaled Variance vs. Transverse Momentum Range**
- **N.B.D. k Parameter vs. Transverse Momentum Range**

Centrality Dependence of Multiplicity Fluctuations

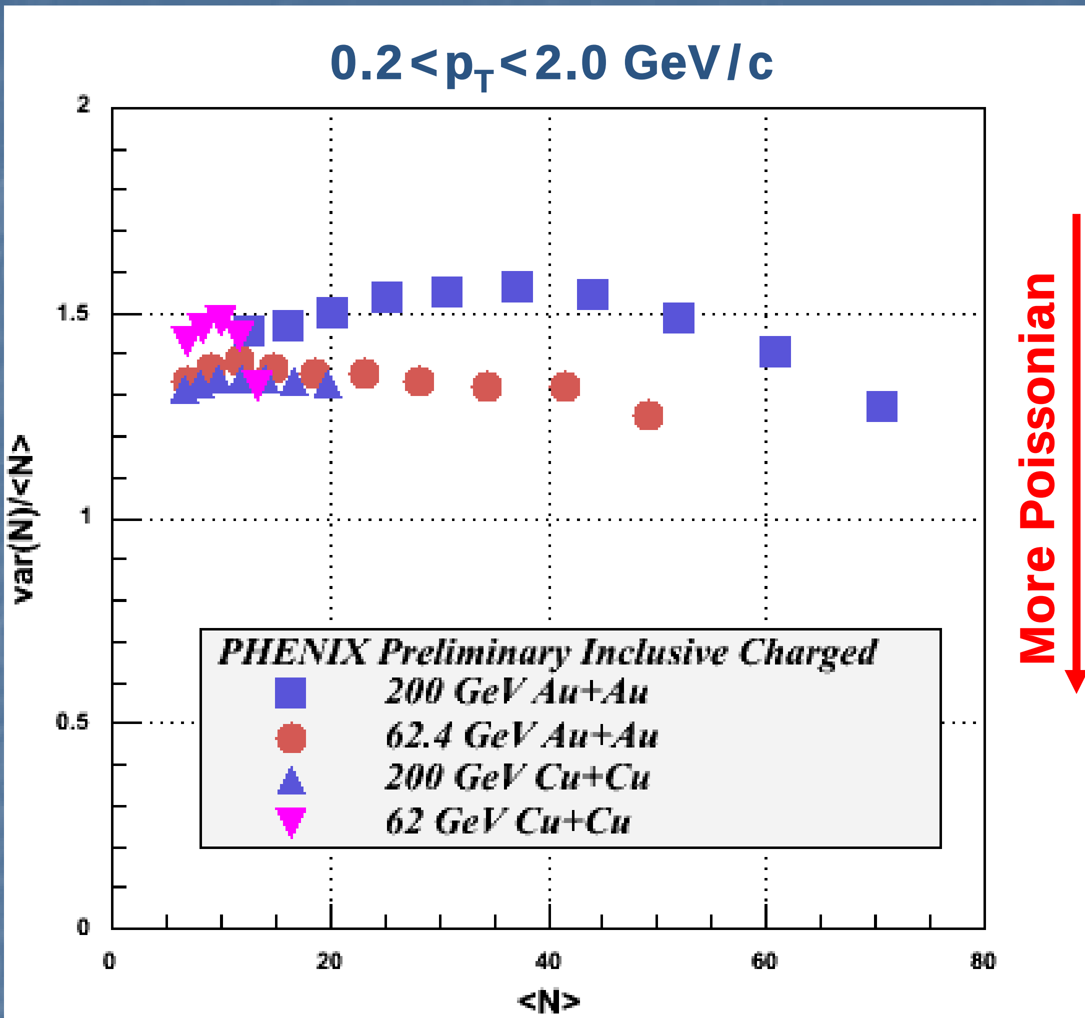


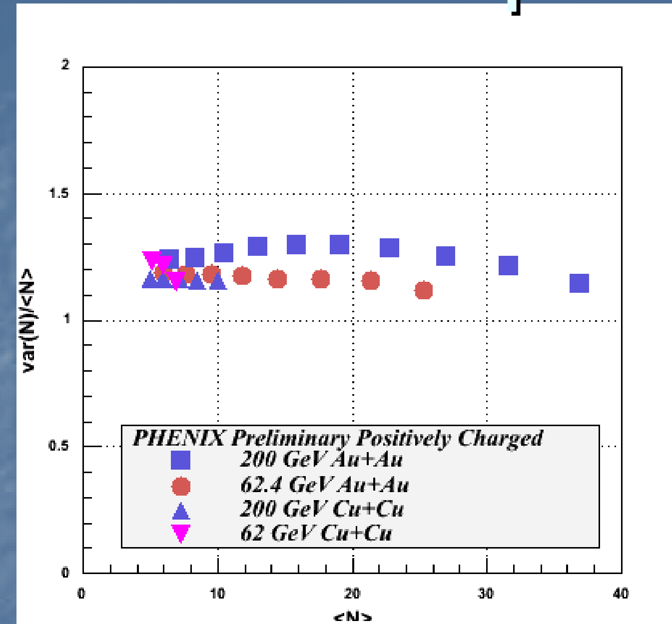


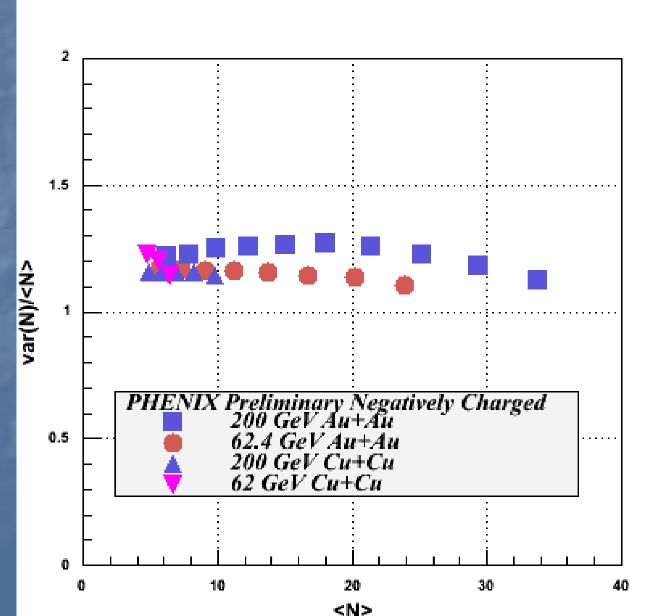


- 200 GeV Au+Au fluctuations have a centrality-dependent structure while the 62 GeV Au+Au fluctuations are relatively flat with centrality.
- Fluctuations increase from 200 GeV to 62 GeV Cu+Cu collisions. 62 GeV Cu+Cu distribution qualitatively similar to NA49 results.
- No significant charge dependence is observed.

Multiplicity Fluctuations vs. Mean Multiplicity







Fluctuations binned in 5% centrality bins.

The centrality-dependent fluctuations do not scale with the mean, <N>.

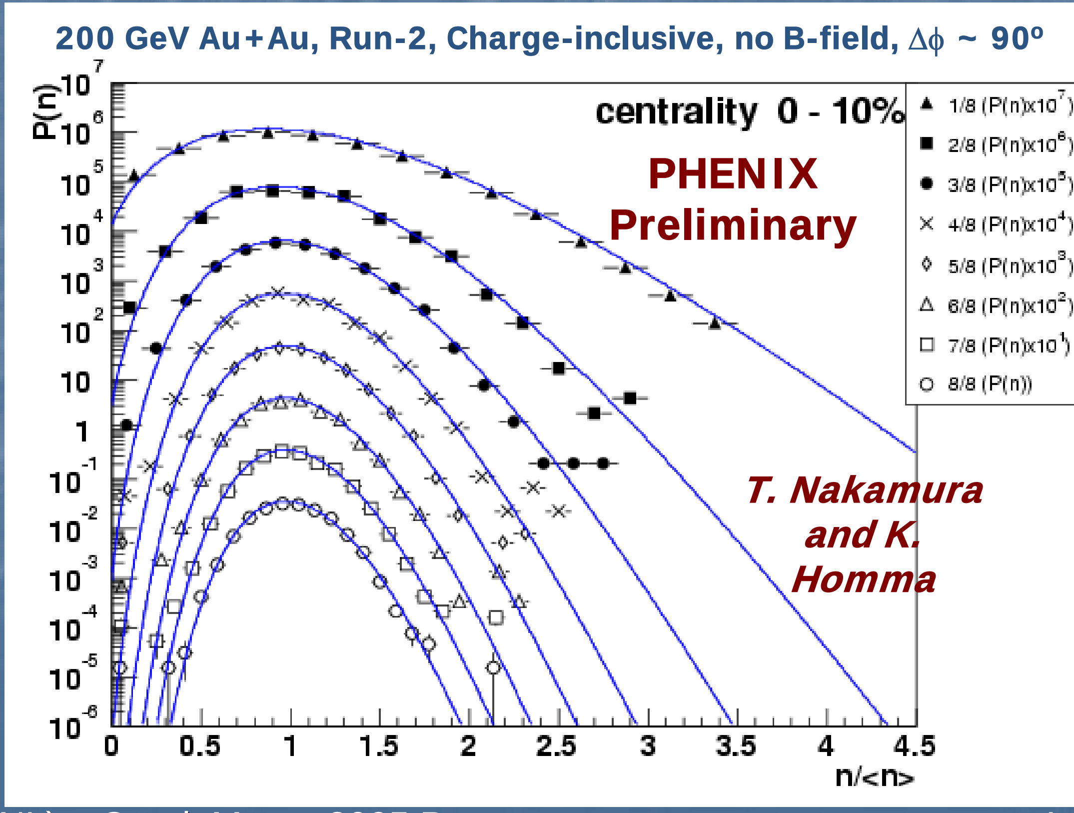
Multiplicity Distributions and Negative Binomial Distributions: k

We know that multiplicity distributions from high energy p+p and 14.6 GeV/A Au+Au (E802) collisions can be described by the Negative Binomial Distribution (N.B.D.). This has been confirmed for all centralities by fitting them to an N.B.D. distribution. The magnitude of k describes the deviation from a Poisson distribution – higher k means more Poissonian. k from the fit and from the formula below agree within errors for all centralities and p_T ranges.

$$P(m) = \frac{(m+k-1)!}{m!(k-1)!}\frac{\left(\mu/k\right)^m}{\left(1+\mu/k\right)^{m+k}}$$

$$\frac{1}{k} = \frac{\sigma^2}{\mu^2} - \frac{1}{\mu}$$

δη= 0.09 (1/8) : P(n) x 10^7
δη= 0.18 (2/8) : P(n) x 10^6
δη= 0.35 (3/8) : P(n) x 10^5
δη= 0.26 (4/8) : P(n) x 10^4
δη= 0.44 (5/8) : P(n) x 10^3
δη= 0.53 (6/8) : P(n) x 10^2
δη= 0.61 (7/8) : P(n) x 10^1
δη= 0.70 (8/8) : P(n)



Multiplicity Fluctuations vs. Centrality: N.B.D. k

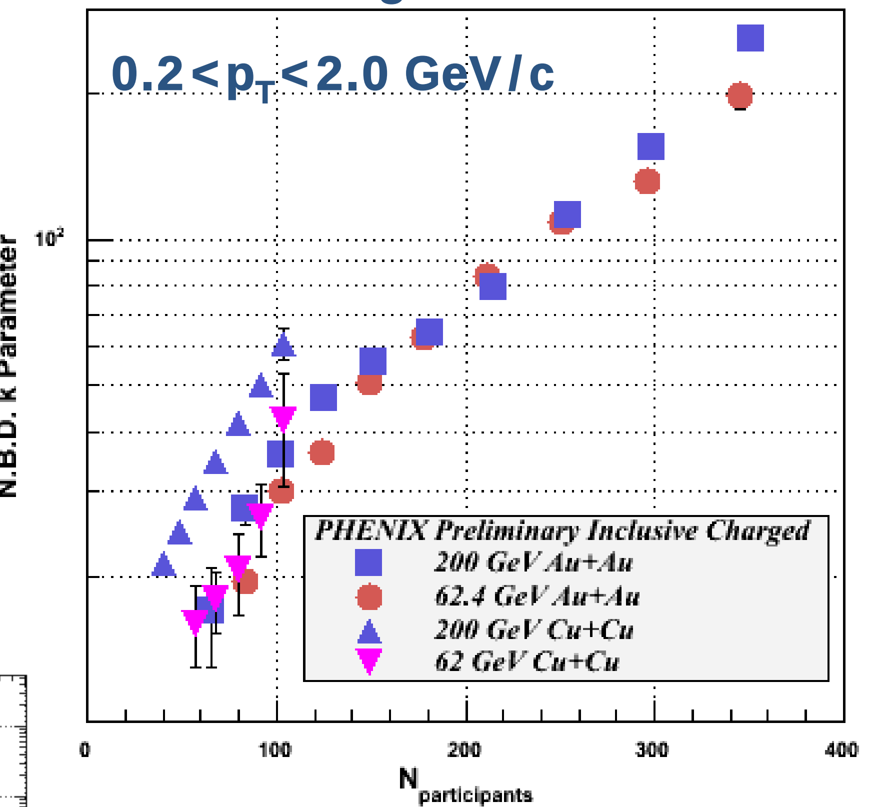
k from the fit and from the bottom formula below agree within errors for all centralities and p_T ranges.

$$P(m) = \frac{(m+k-1)!}{m!(k-1)!} \frac{\left(\mu/k\right)^m}{\left(1+\mu/k\right)^{m+k}}$$

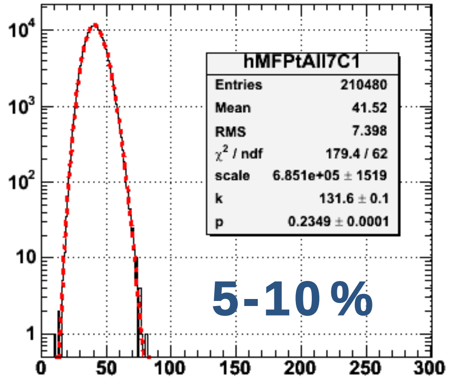
$$\frac{1}{k} = \frac{\sigma^2}{\mu^2} - \frac{1}{\mu}$$

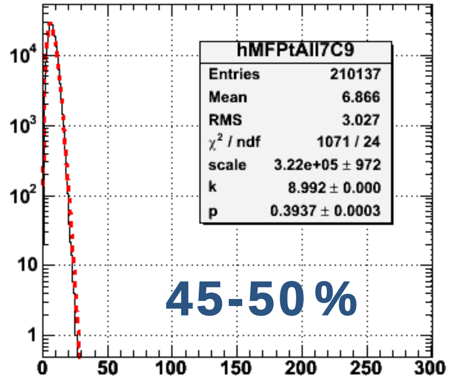
More Poissonian

Charge-inclusive



PHENIX Preliminary

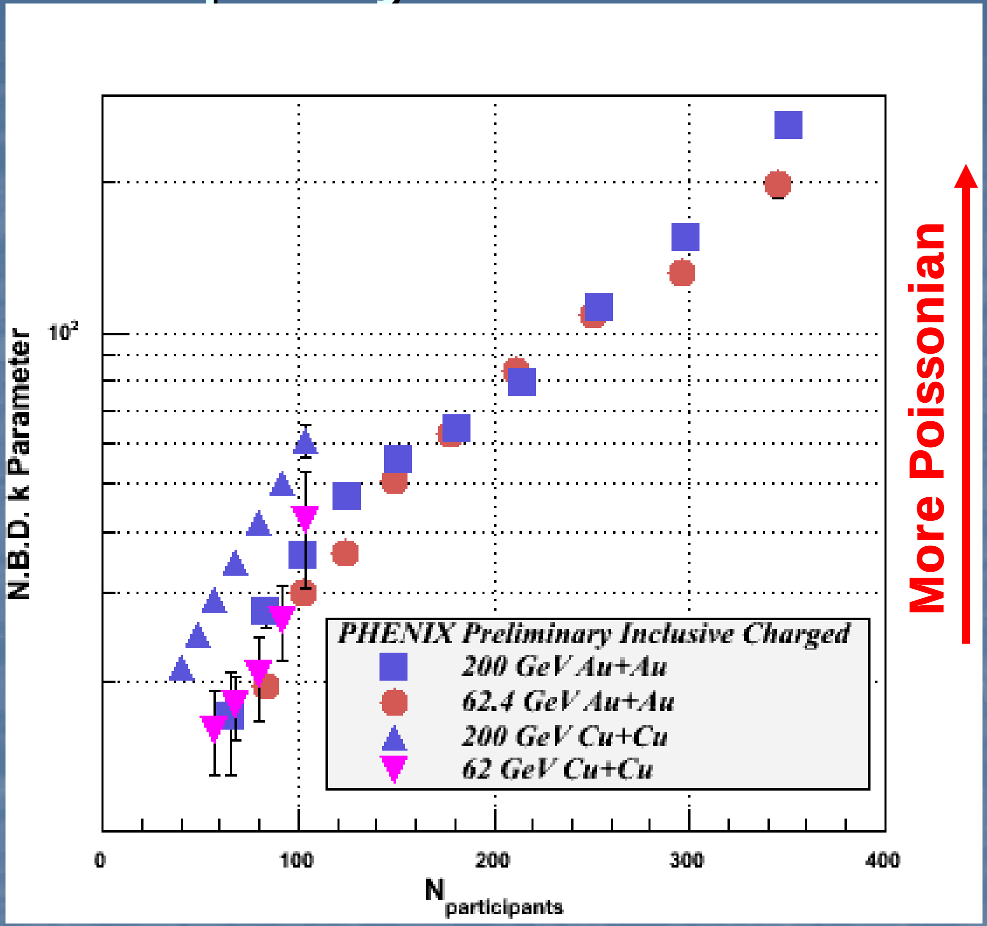


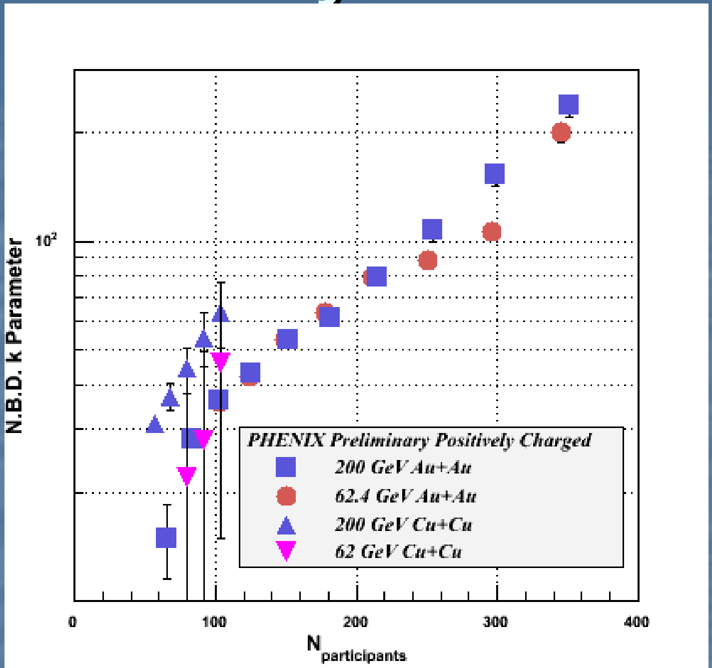


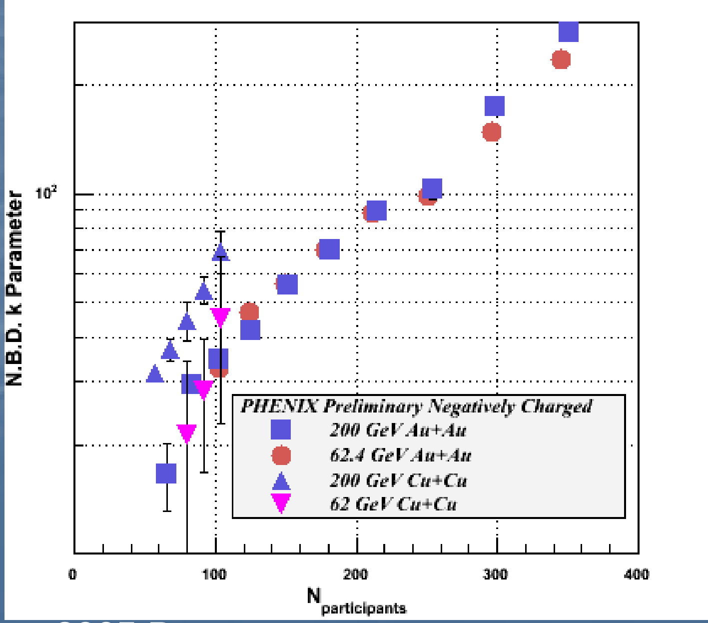
Examples of Negative Binomial Fits: 62 GeV Au+Au

The N.B.D. distribution becomes a Poisson distribution in the limit $k \rightarrow \infty$

Multiplicity Fluctuations vs. Centrality: N.B.D. k

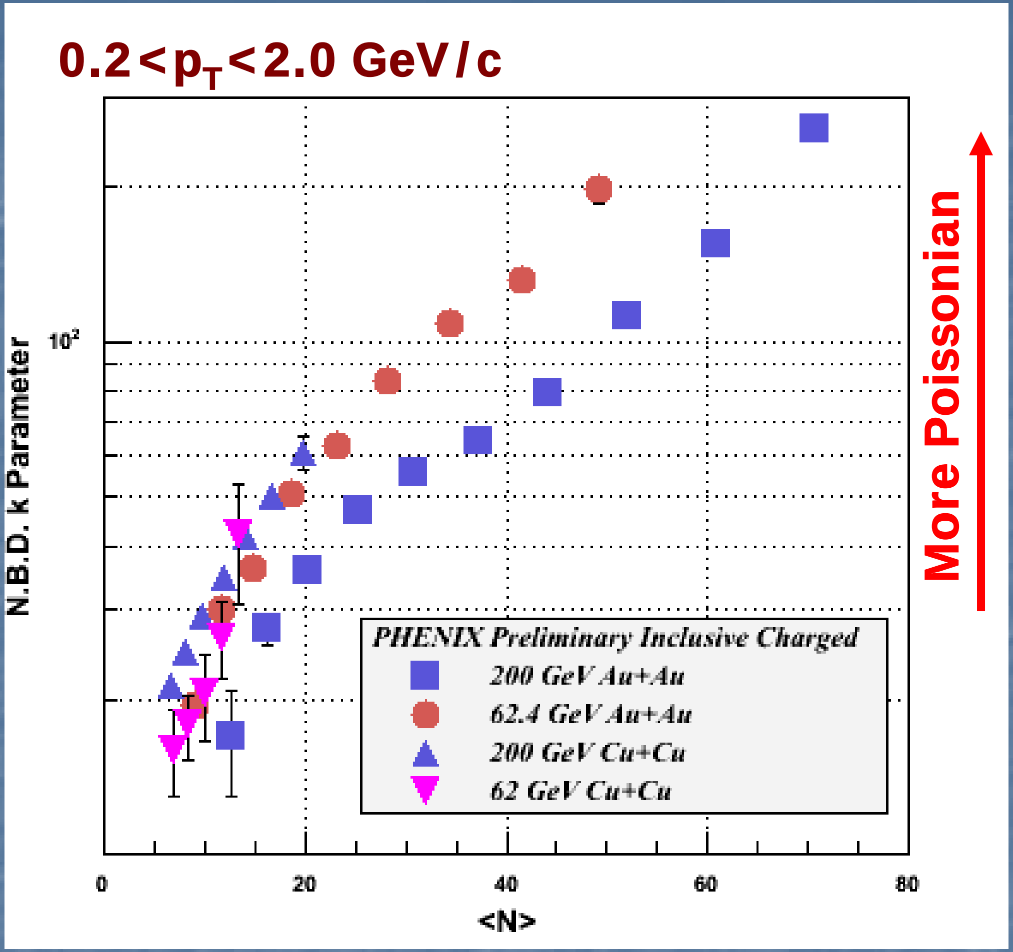


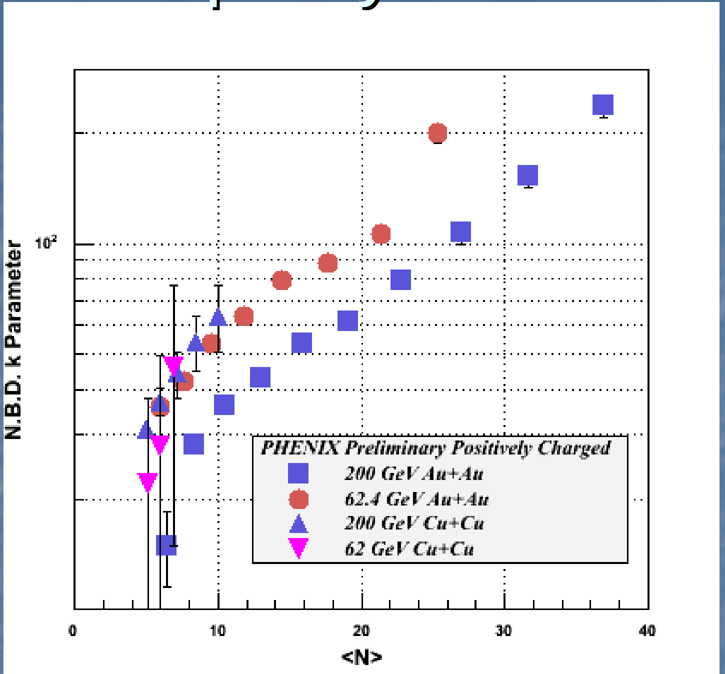


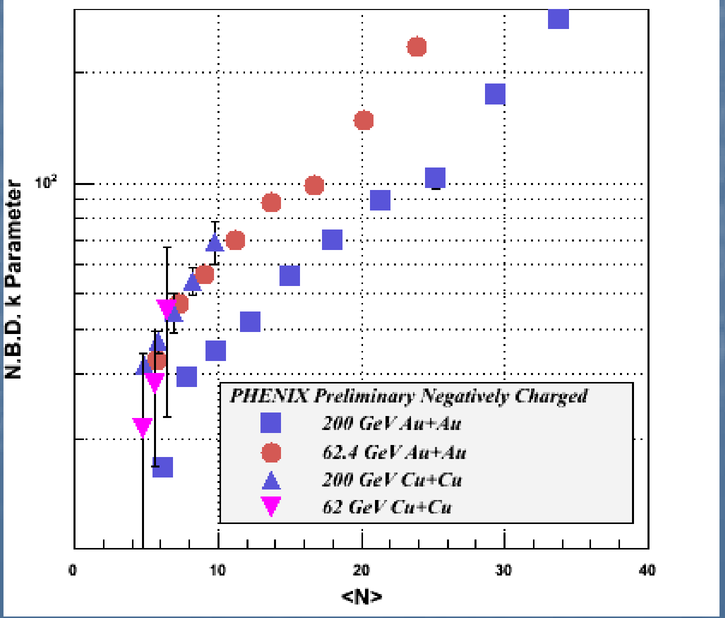


- 62 and 200 GeV Au+Au k parameters increase roughly exponentially with Nparticipants and are consistent with each other over a wide centrality range. The value of k increases sharply for the most central collisions.
- 62 GeV Cu+Cu distributions are less Poissonian than 200 GeV Cu+Cu collisions.
- No significant charge dependence is observed.

Multiplicity Fluctuations vs. Mean Multiplicity: N.B.D. k



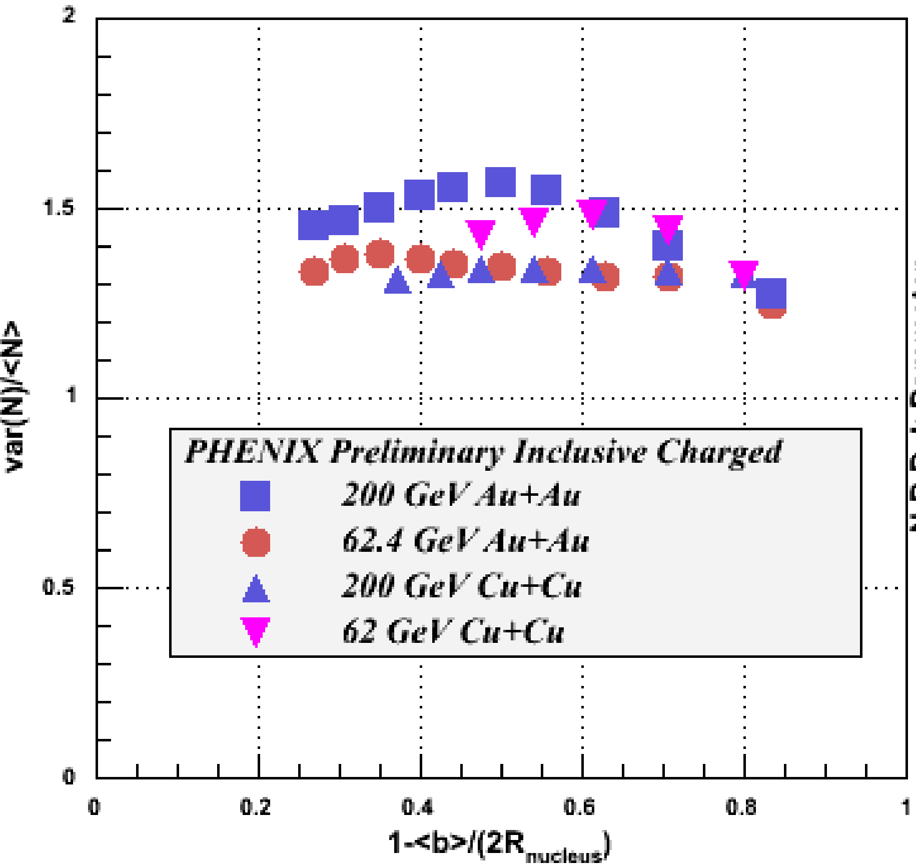


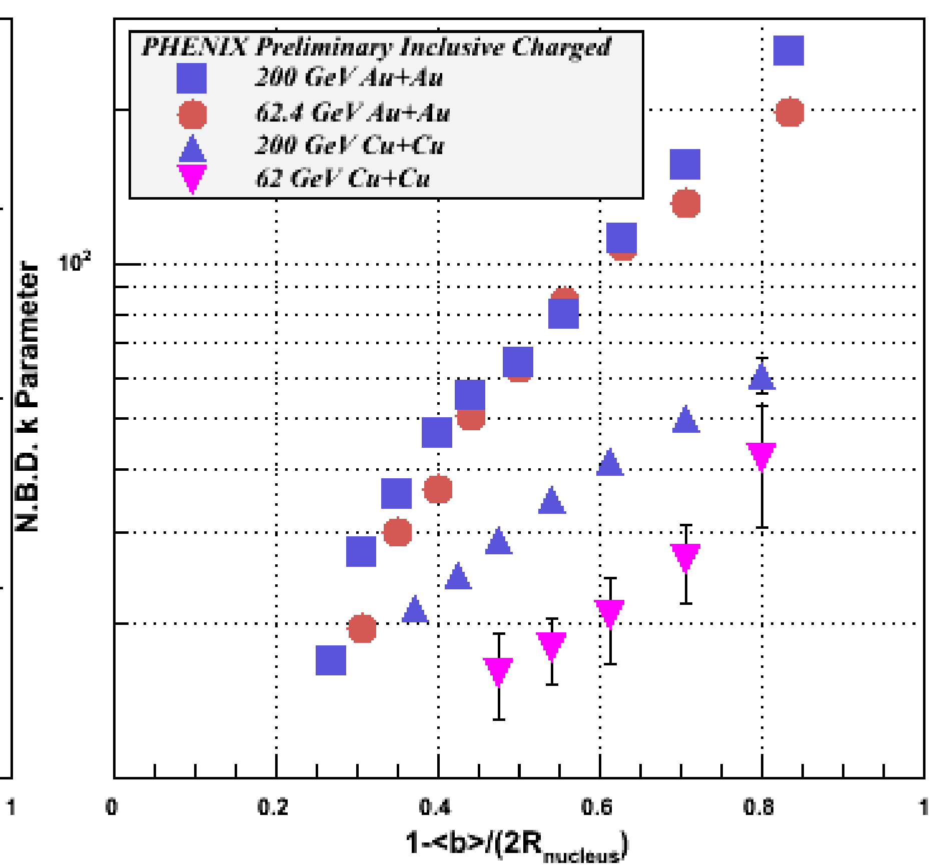


The value of the NBD k parameter does not scale with <N>. Universality of 62 GeV and 200 GeV Au+Au data appears to be geometry-driven, not multiplicity-driven.

Multiplicity Fluctuations as a Function of Collision Overlap Geometry

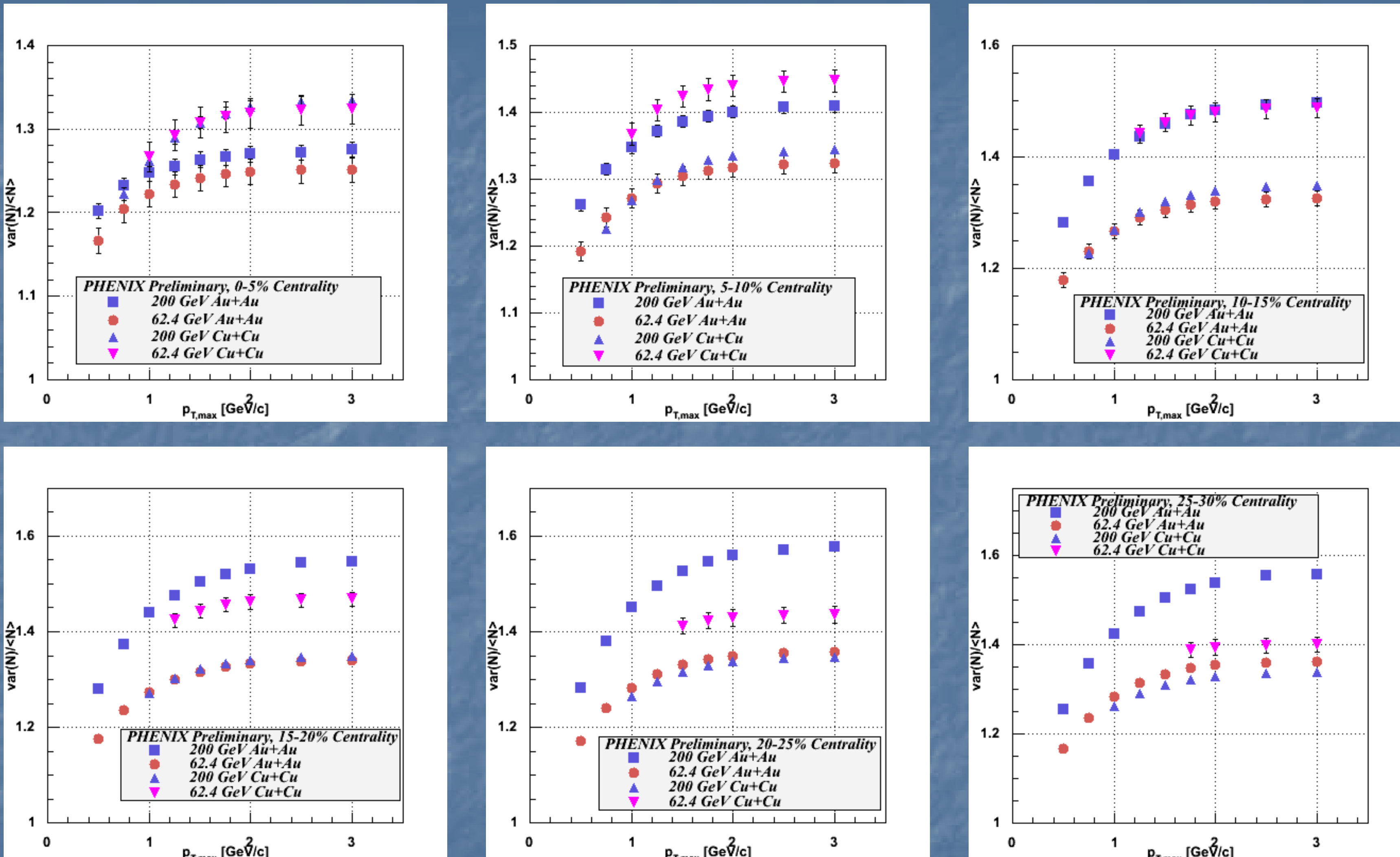
When plotted as a function of a measure of the collision overlap geometry (fractional impact parameter divided by the nuclear diameter - so a b=0 collision has a value of 1.0), the 62 GeV Cu+Cu fluctuations from the N.B.D. fit are the least Poissonian for all centralities.





Scaled Variance vs. p_T

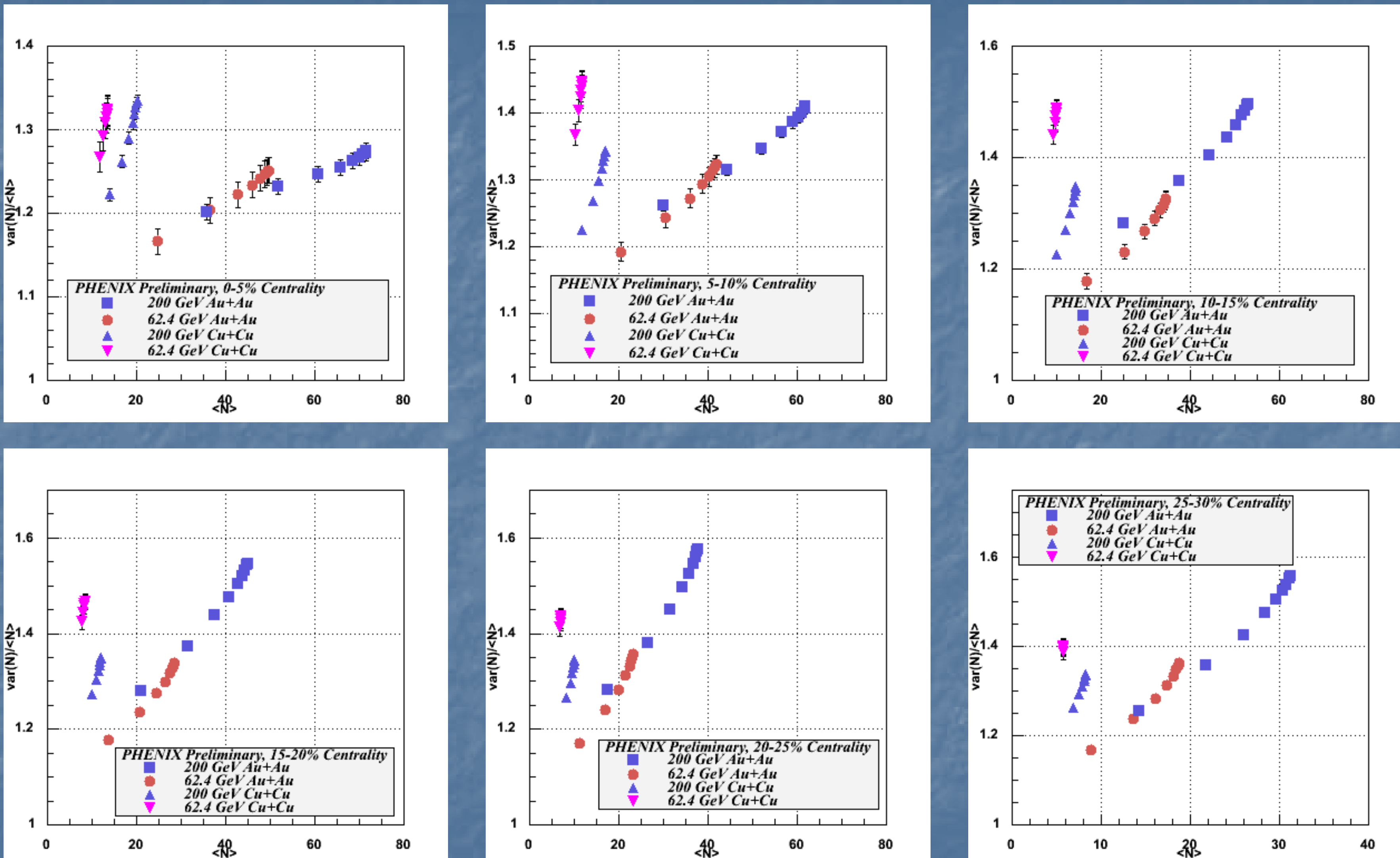
$0.2\ GeV/c < p_T < p_{T,max}$



The fluctuations increase (become less Poissonian) as the maximum p_T in the p_T range is increased. This may be due to the addition of a non-Poissonian hard processes component.

Scaled Variance vs. p_T

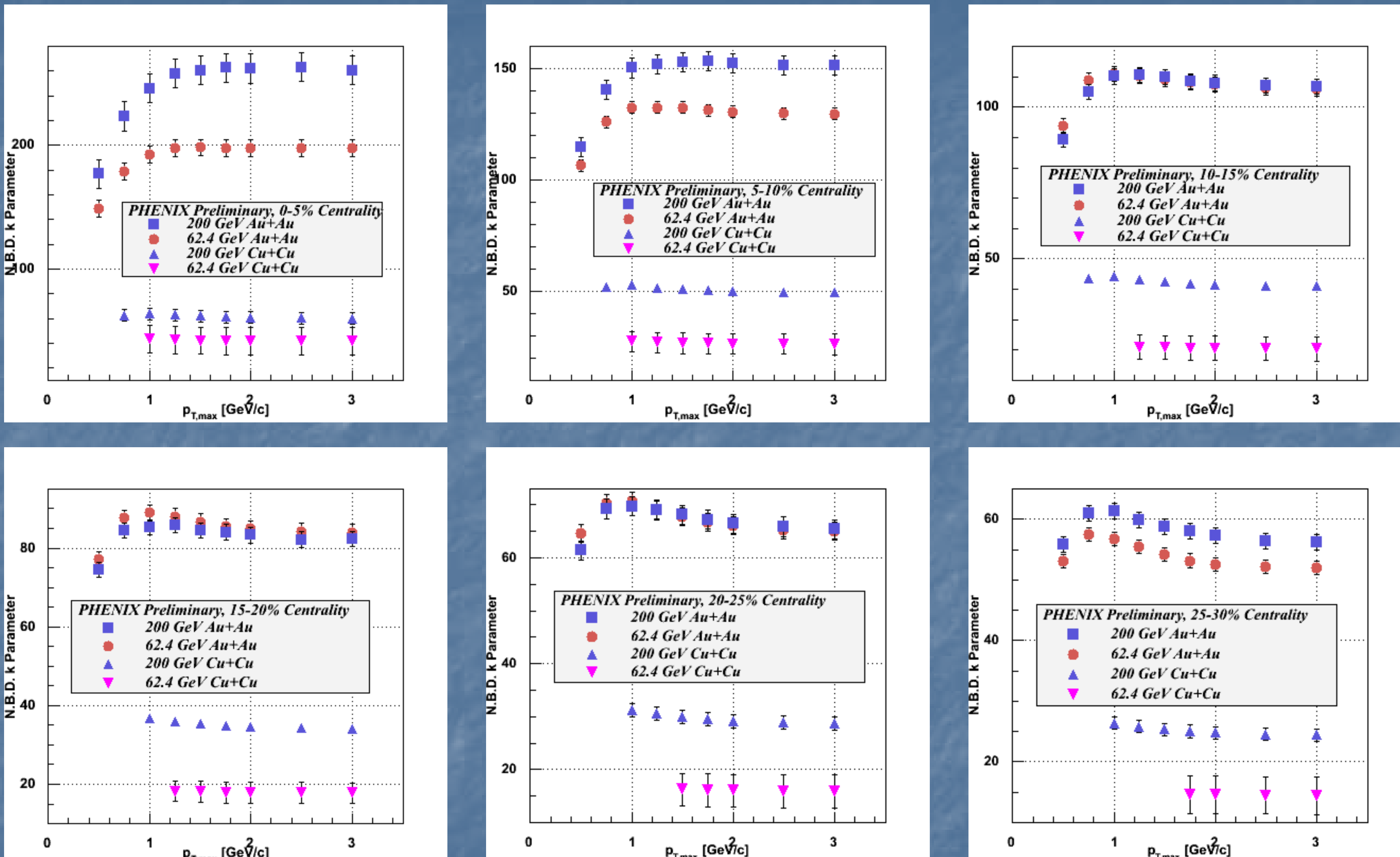
$0.2\ GeV/c < p_T < p_{T,max}$



In the most central collisions, the fluctuations do not scale linearly with the mean multiplicity as a function of p_T range..

N.B.D. k vs. p_T

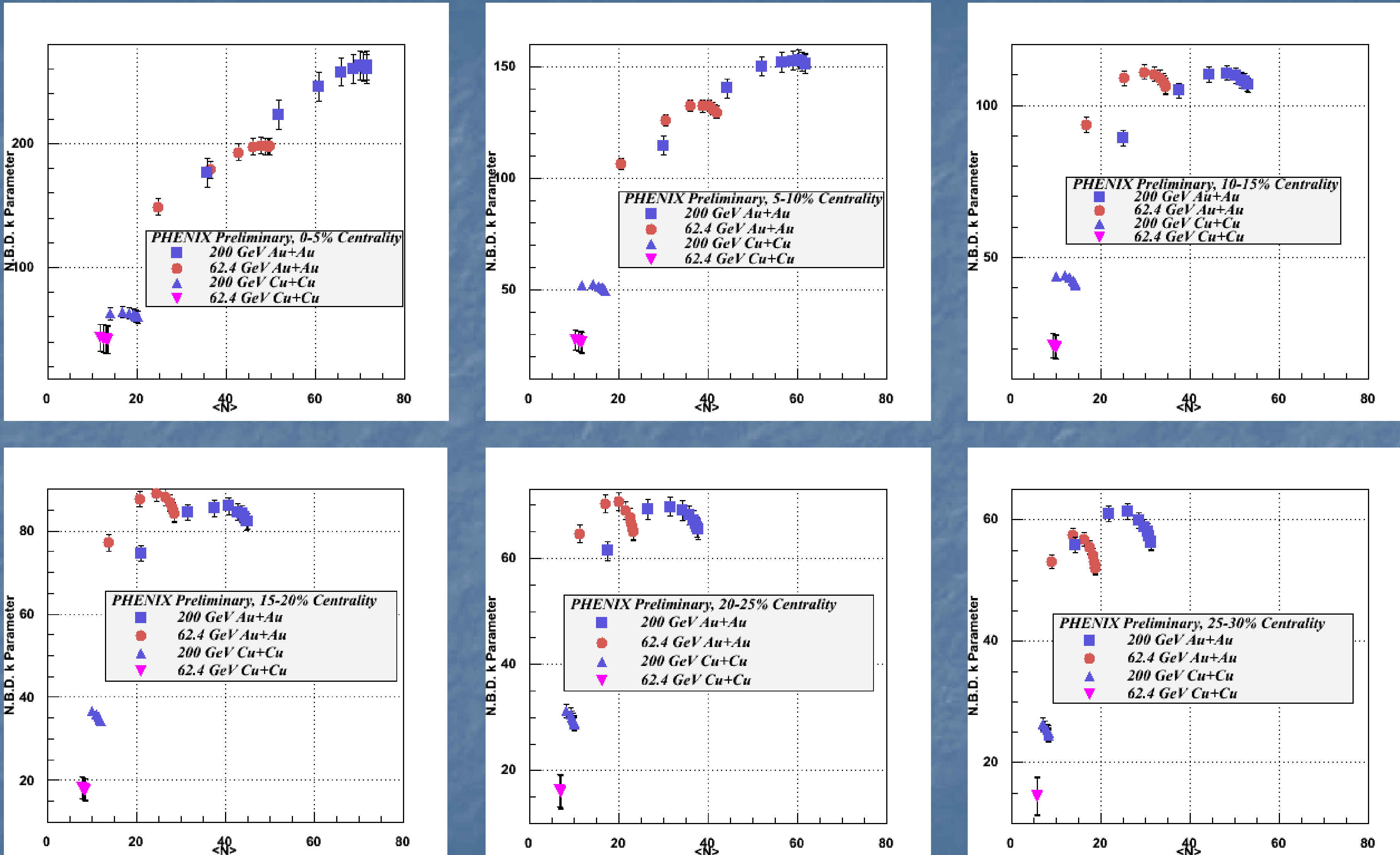
$0.2\ \mathrm{GeV}/c < p_T < p_{T,max}$



There is a change of shape in the p_T-dependent trend of the N.B.D. k parameter between central and mid-central collisions. This is consistent with a scenario where jet suppression in central collisions effectively removes or dilutes a fraction of the non-Poissonian hard component of the multiplicity distribution.

N.B.D. k vs. p_T

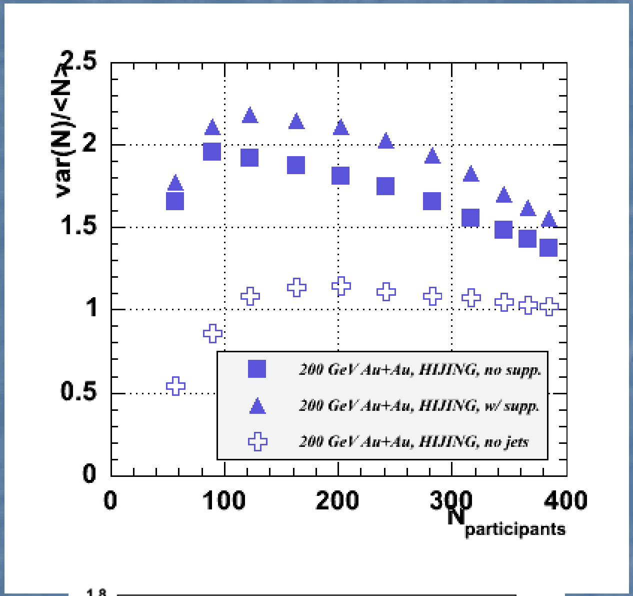
$0.2\ GeV/c < p_T < p_{T,max}$

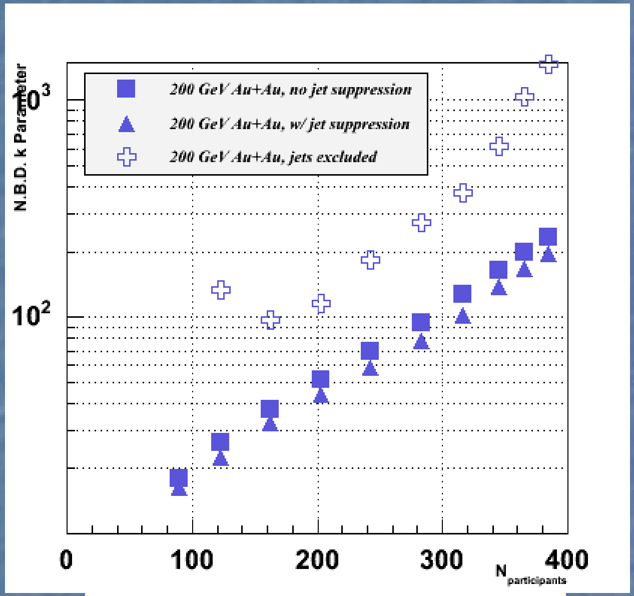


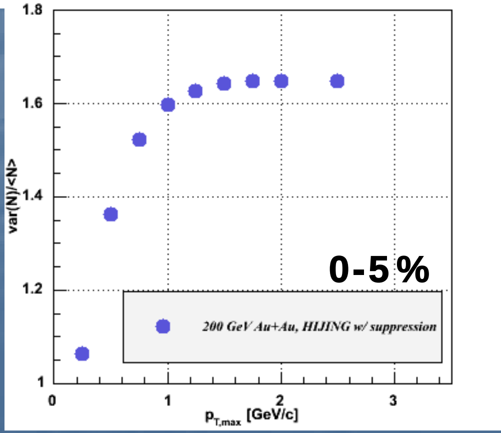
Multiplicity fluctuations expressed in terms of N.B.D. k do not scale linearly with the mean multiplicity as a function of p_T range.

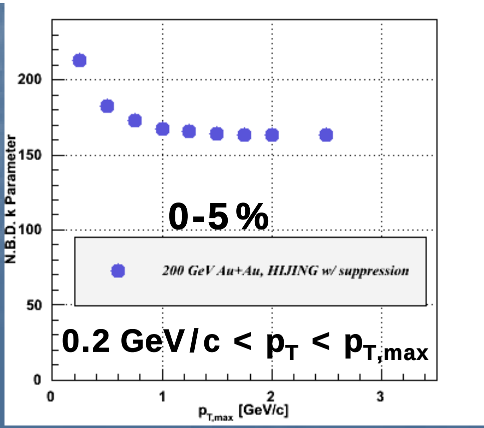
200 GeV Au+Au Multiplicity Fluctuations: HIJING 1.35

HIJING 1.35, 200 GeV Au+Au, filtered through the PHENIX acceptance. The centrality-dependent structure apparent in the 200 GeV Au+Au data may be due to hard processes, which are non-Poissonian. The flat structure of the 62 GeV Au+Au data may be due to a much lower cross section for hard processes, although this does not explain the structure in the 62 GeV Cu+Cu data. Further studies with HIJING are planned.









Conclusions

- Multiplicity Fluctuations for 62 and 200 GeV Au+Au and Cu+Cu collisions are presented as a function of centrality and transverse momentum range.
- When fit to a Negative Binomial Distribution, multiplicity fluctuations become more Poissonian for central collisions (k increases).
- Fluctuations for 62 GeV Au+Au collisions are more Poissonian than in 200 GeV Au+Au collisions. However, 62 GeV Cu+Cu collisions are less Poissonian than 200 GeV Cu+Cu collisions.
- The centrality-dependent structure of the scaled variance for 62 GeV collisions is qualitatively similar to that measured by NA49 at SPS energies.
- The p_T dependence of the fluctuations fit to a Negative Binomial Distrubution changes in Au+Au collisions when comparing 0-5% centrality to 25-30% centrality.