Event By Event Fluctuation in K/π ratio at RHIC

Supriya Das †
VECC, Kolkata
(for **STAR** Collaboration)

† *Financially assisted by CSIR, India*

Disclaimer

many of the results I will present here are from
"works in very active progress"

Outline

- Physics Motivation
- Possibility at STAR
- Analysis Methods and results
- Future Plan
- Summary

Physics Motivation

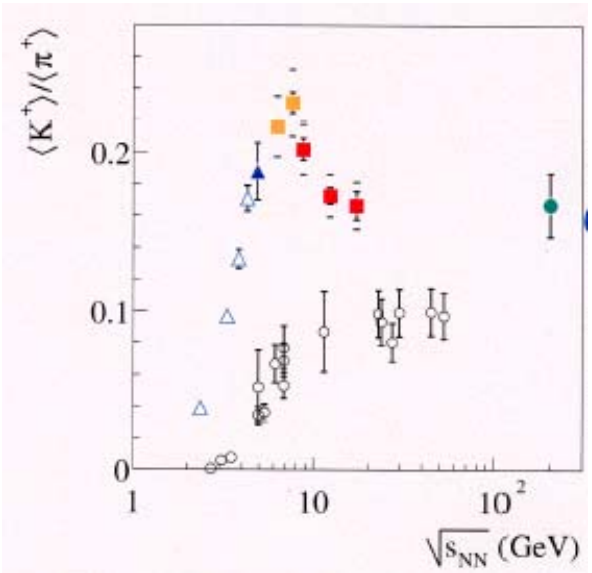
Statistical fluctuations:

Arise due to the measurement process itself such as finite number statistics.

Dynamical fluctuations:

Reflect the dynamics and responses of the system (density fluctuations *etc.*).

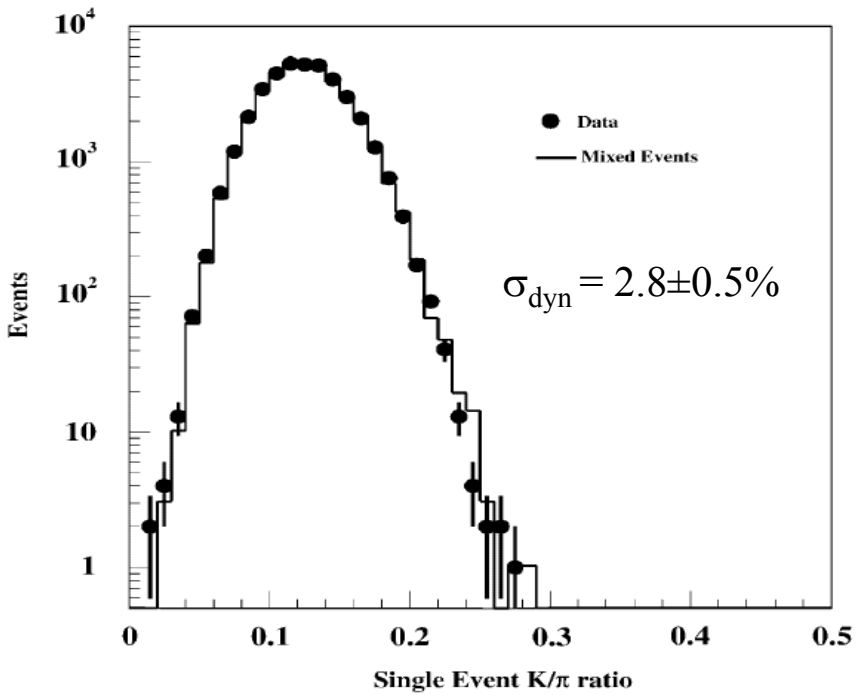
Why K/π ?



- K/π ratio shows interesting behavior as function of collision energy.
- It would be interesting to see what happens to the fluctuation of the ratio.

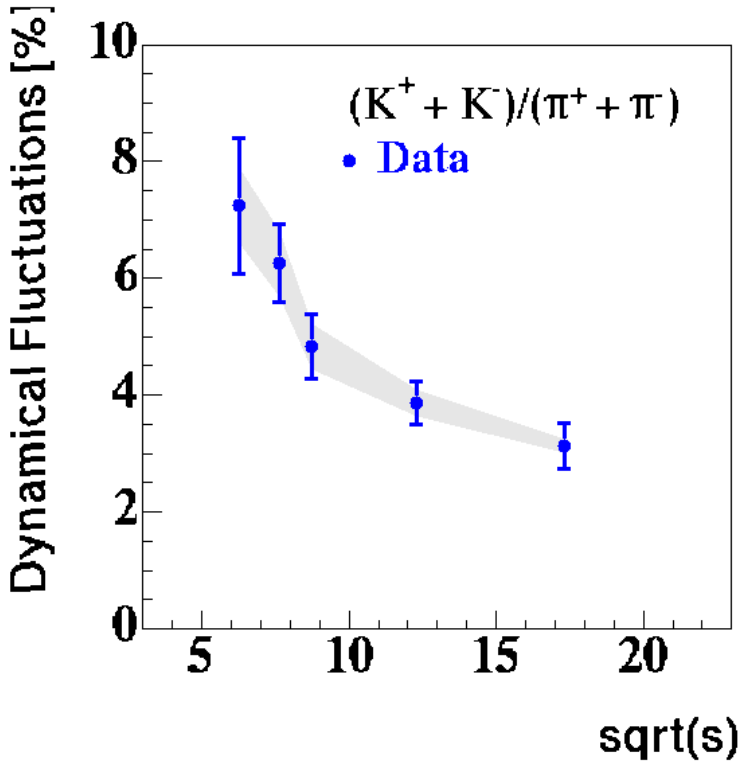
Similar work at SPS

Pb+Pb at 158 A GeV (top 5% central)



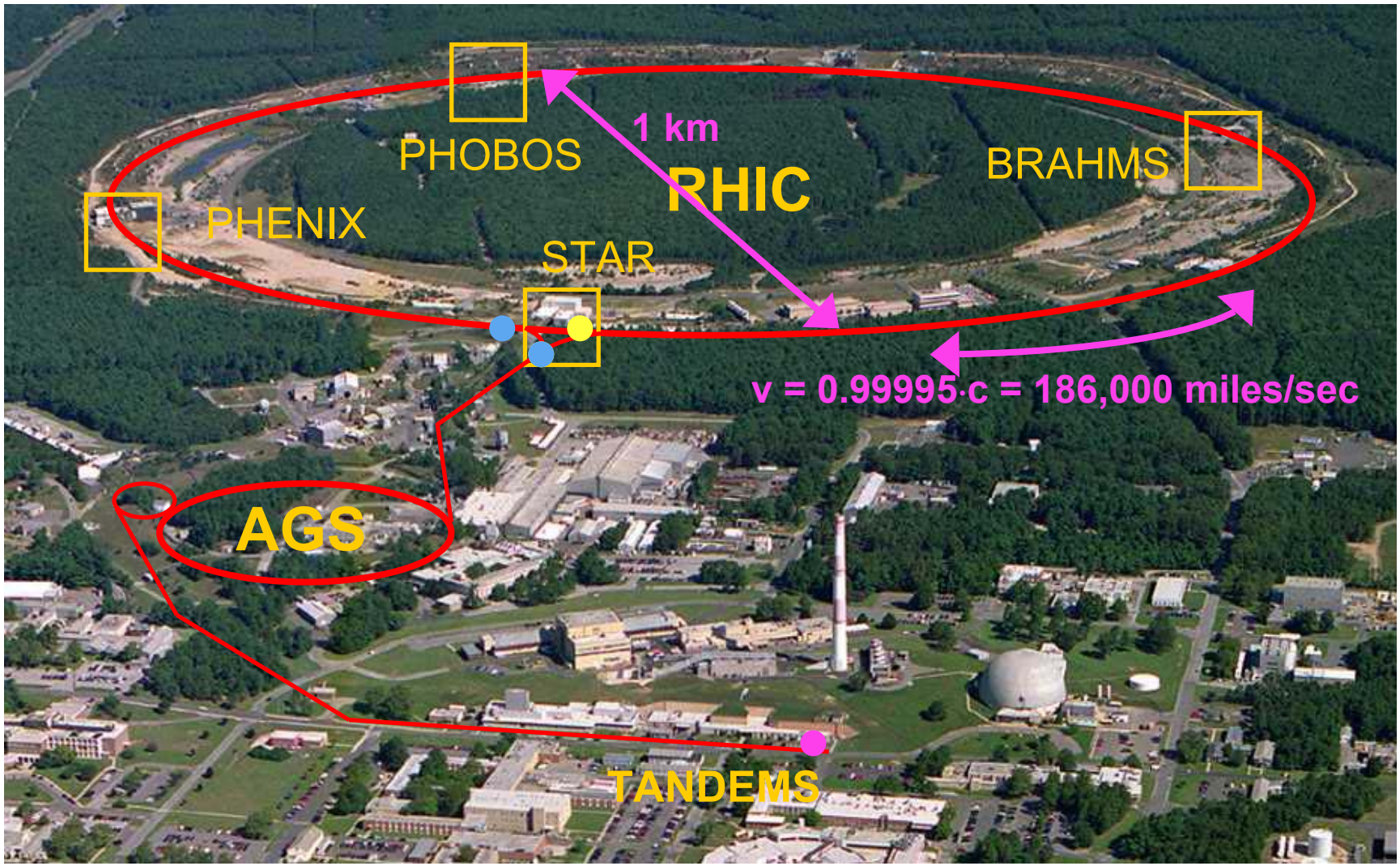
S. V. Afanasiev *et al.* for NA 49 Collaboration
PRL 86 (2001)

Pb+Pb at 20, 30, 40, 80, 158 A GeV



C. Roland QM 2004

Relativistic Heavy Ion Collider



Solenoidal Tracker At RHIC

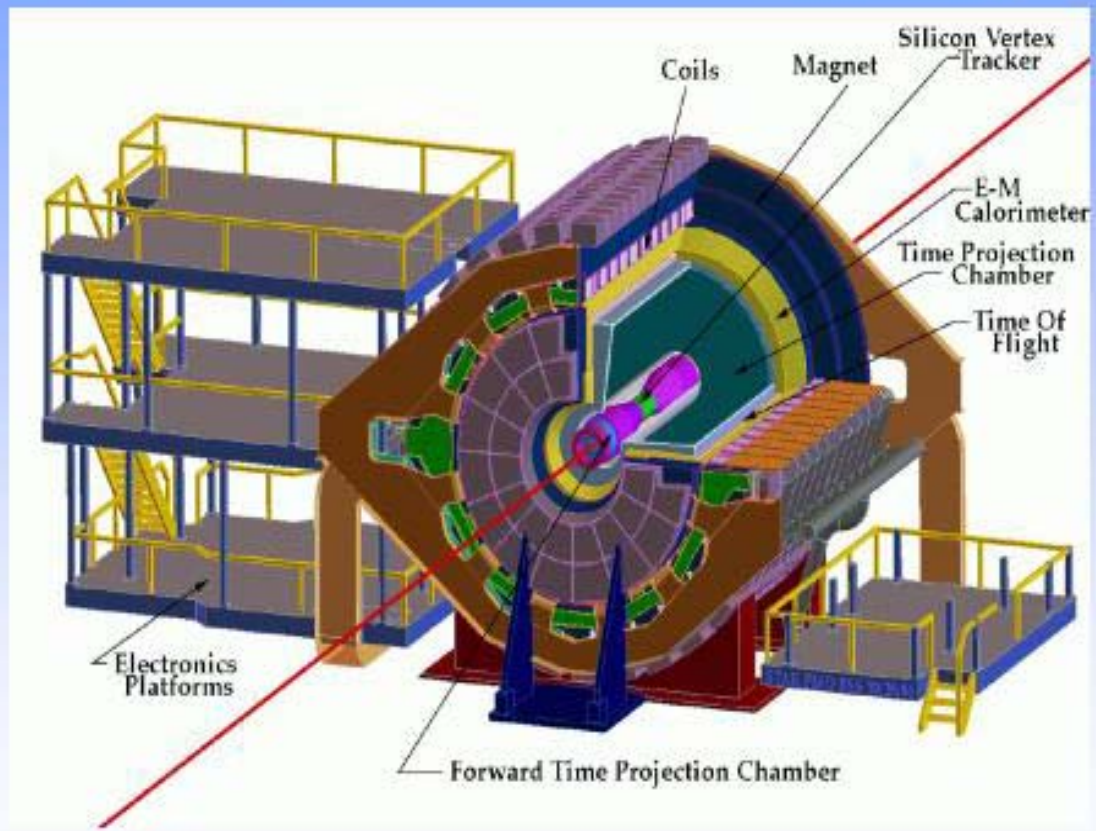
Conceptual Overview

Tracking Detectors:
TPC, FTPC, SVT

Calorimeters:
BEMC, EEMC, ZDC

Trigger Detectors:
CTB, BBC, MWPC

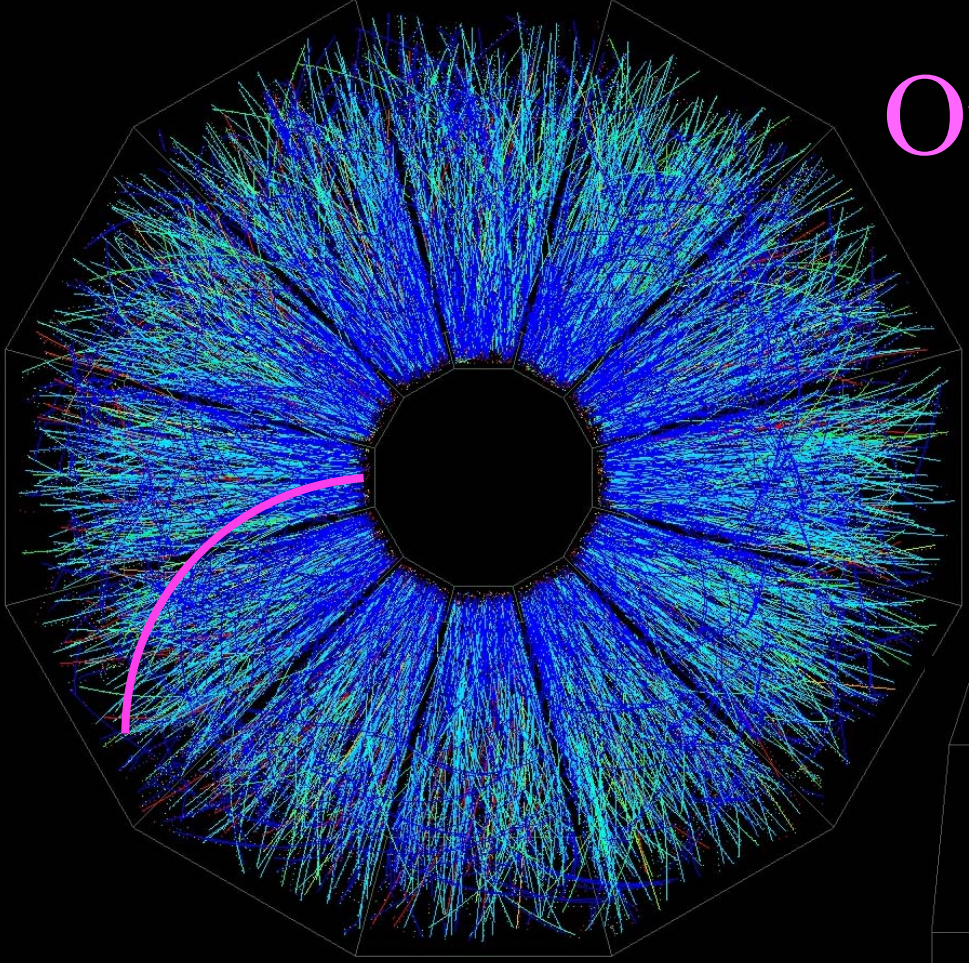
Photon Detector:
PMD



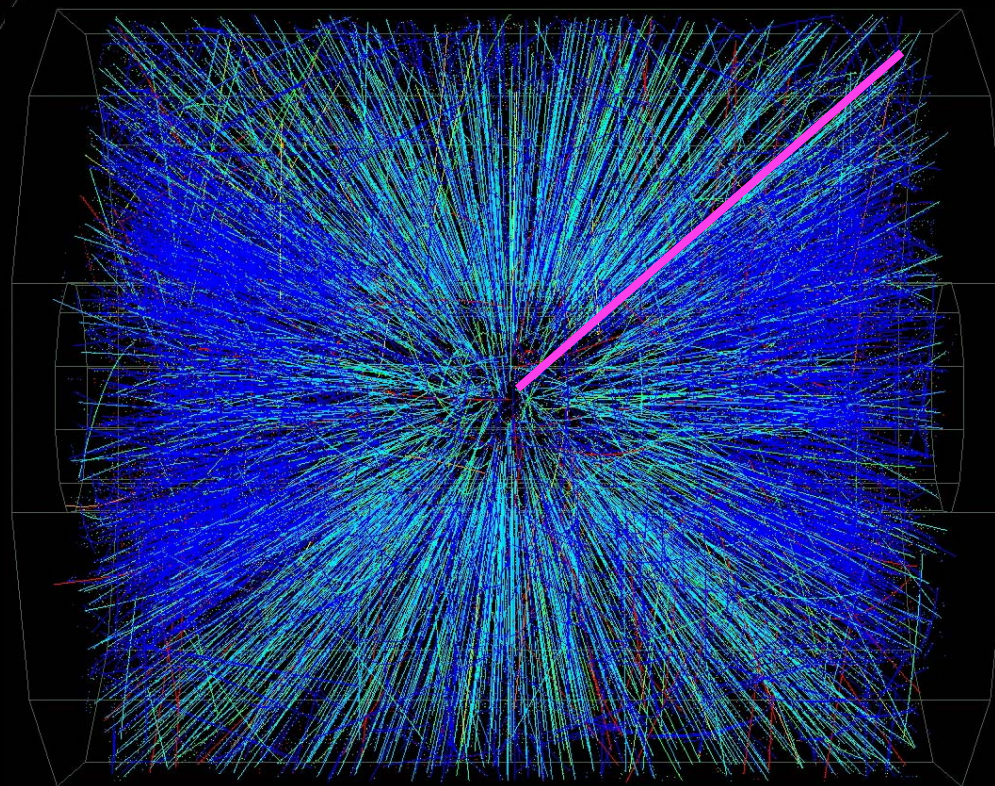
Others: TOF, FPD

Goal : *to track all the hadrons (and photons) in each collision*

One collision seen by STAR TPC



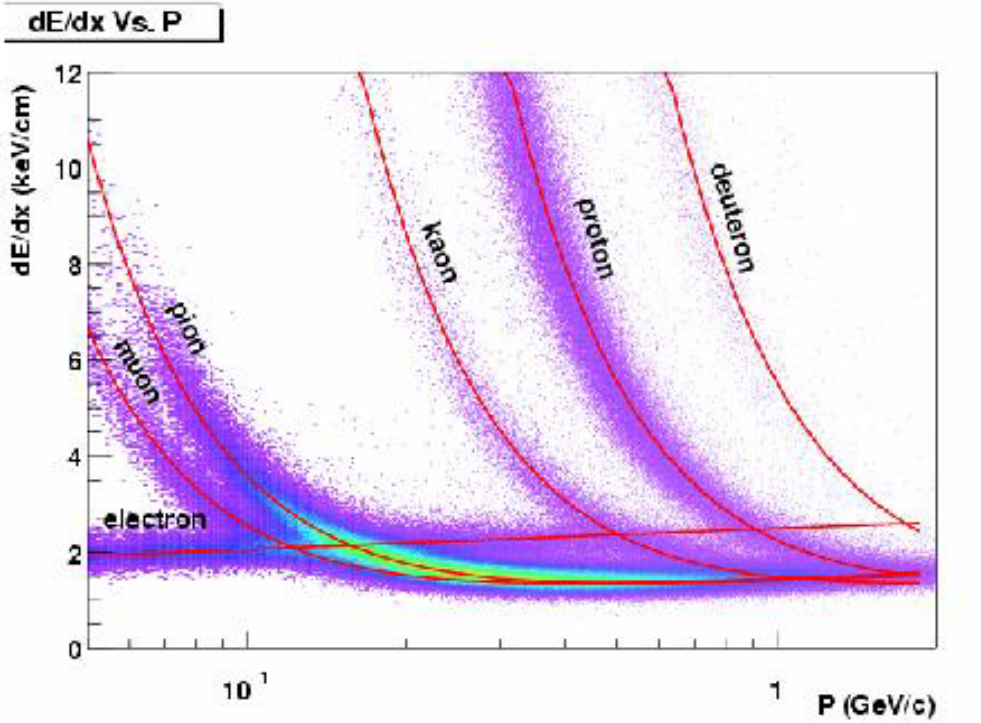
Momentum determined by track curvature in magnetic field…



…and by direction relative to beam

Possibility at STAR

- Large acceptance detector (2 units of η with full ϕ symmetry)
- Good Kaon to Pion separation (for a wide momentum range) from Time Projection Chamber



M. Anderson et al. for STAR Collaboration, NIMA499 (2003)

Analysis Method I

σ_{dyn}

- Kaons and Pions are counted event by event and the ratio is plotted for a large number of events.
- Same ratio from mixed events and distribution of that is obtained.
- Width of the distribution (σ) is the measure of fluctuation.
- Dynamical fluctuation, σ_{dyn} is calculated as

$$\sigma_{dyn} = \sqrt{(\sigma_{data}^2 - \sigma_{mixed}^2)}$$

Statistical fluctuation

Analysis Method I (contd…)

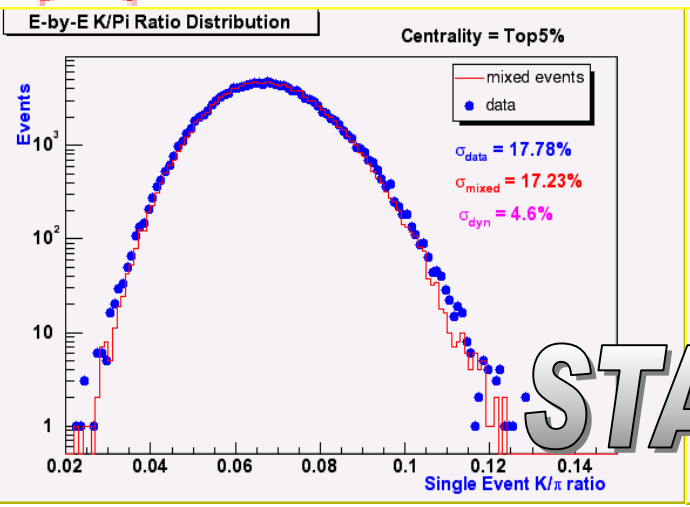
Mixed Event :

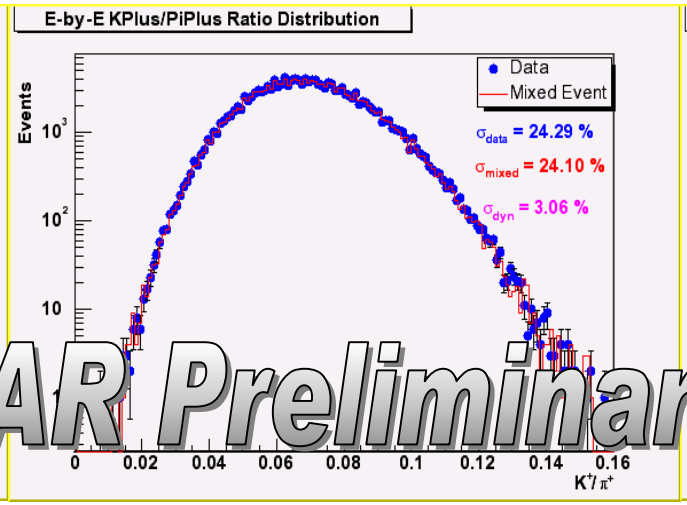
To get the measure of the **statistical fluctuation** from

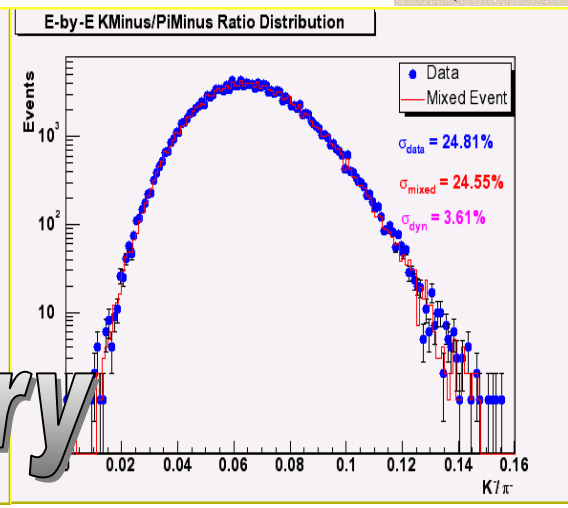
- Finite number statistics
- Experimental resolution
- Correlations if any

- Mixed track pool constructed by randomly picking up one track from each event.
- Same cuts applied on the mixed tracks before applying the particle identification.

Results (Method I)







STAR Preliminary

Experiment	Ratio type	σ_{data}	σ_{mixed}	σ_{dyn}
NA49	K/π	23.27%	23.1%	2.8%±0.5
STAR	K/π	17.78%	17.23%	4.6%±0.025
STAR	K^+/π^+	24.29%	24.10%	3.06%±0.066
STAR	K^-/π^-	24.81%	24.55%	3.61%±0.055

Analysis Method II

$\nu_{dynamic}$

First proposed by Pruneau, Gavin and Voloshin PRC 66 (2002)
Used in STAR Net Charge fluctuation paper – PRC 68 (2003)

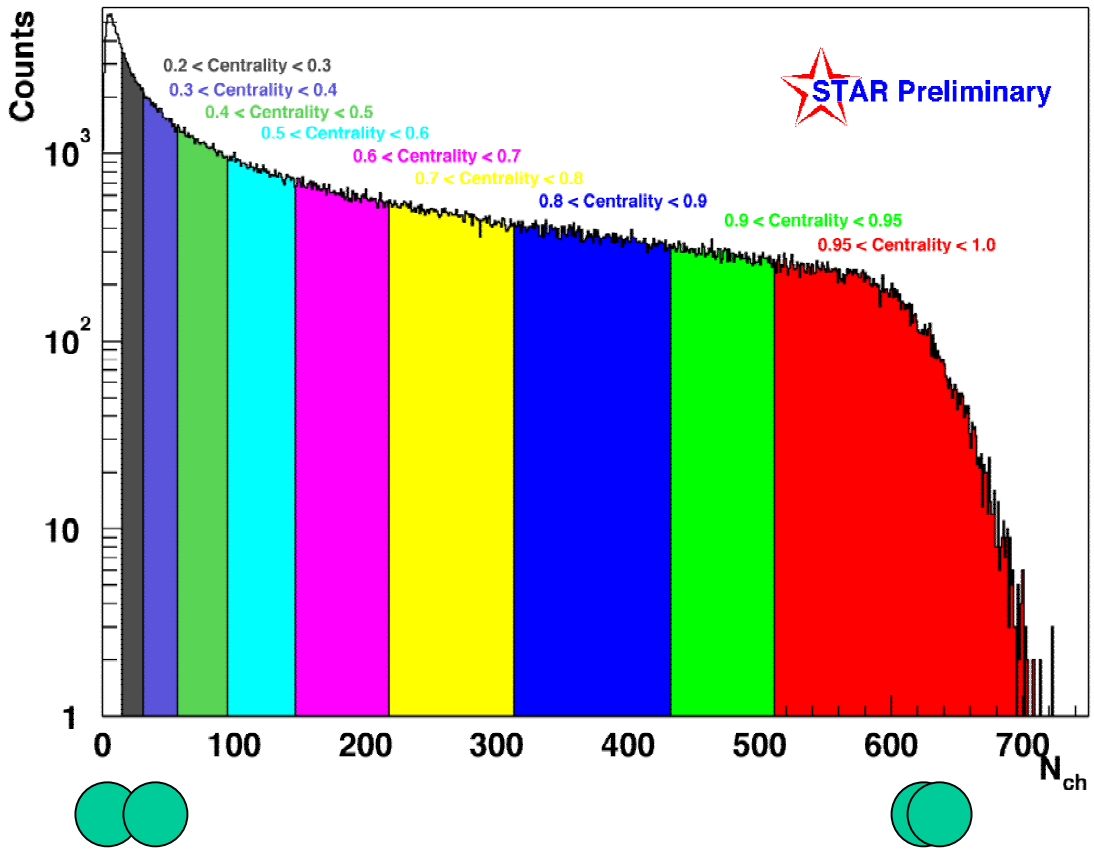
Independent of detection efficiency

$$\nu_{K\pi,dyn}(M) = \frac{\langle N_K(N_K - 1)\rangle_M}{\langle N_K\rangle_M^2} + \frac{\langle N_\pi(N_\pi - 1)\rangle_M}{\langle N_\pi\rangle_M^2} - 2\frac{\langle N_K N_\pi\rangle_M}{\langle N_K\rangle_M \langle N_\pi\rangle_M}$$

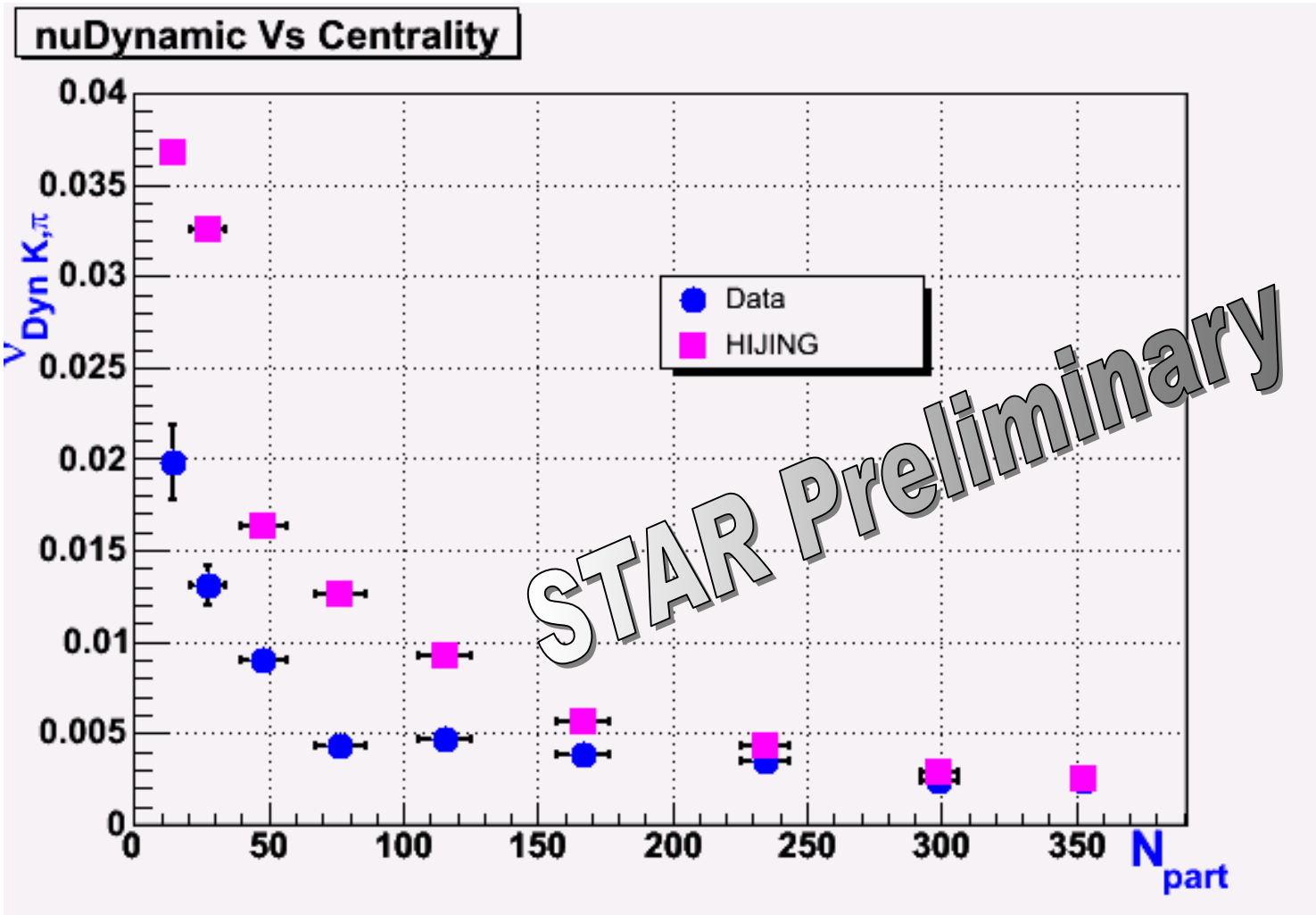
M is the multiplicity in a particular centrality bin

Determination of collision centrality

Based on multiplicity of charged particles in the STAR TPC ($|\eta|<0.5$)



Results (Method II)



Summary

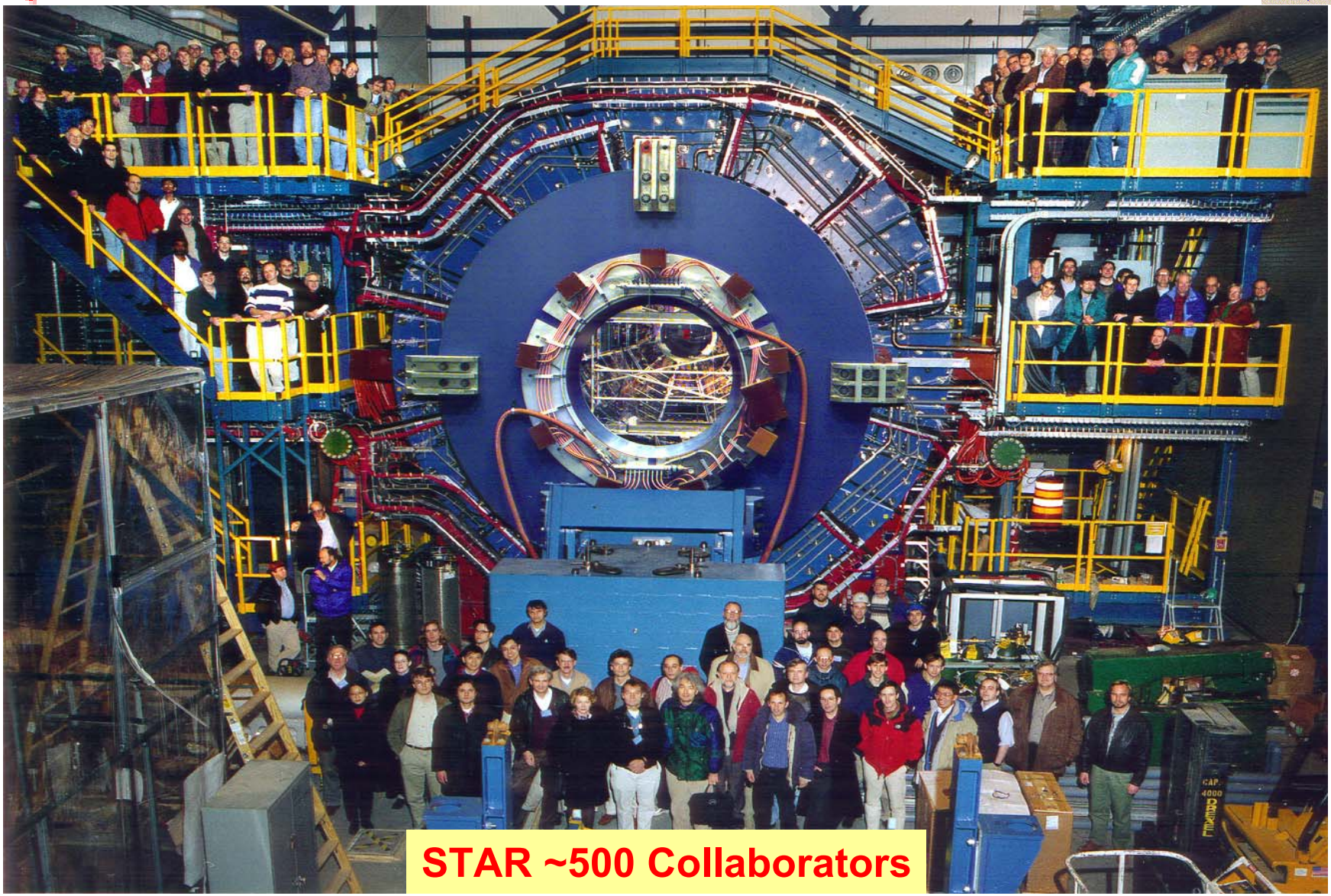
- The event by event fluctuation in strange to non-strange ratio has been studied for Au+Au collisions at $\sqrt{s}$ = 200 GeV.
- The σ_{dyn} needs to be studied for varying CM energies.
- The ν_{dyn} shows a 1/M dependence with more and more resonance production giving rise to the correlated term in the central events.

Future Plan

Carry out analysis for different CM energies available at RHIC.

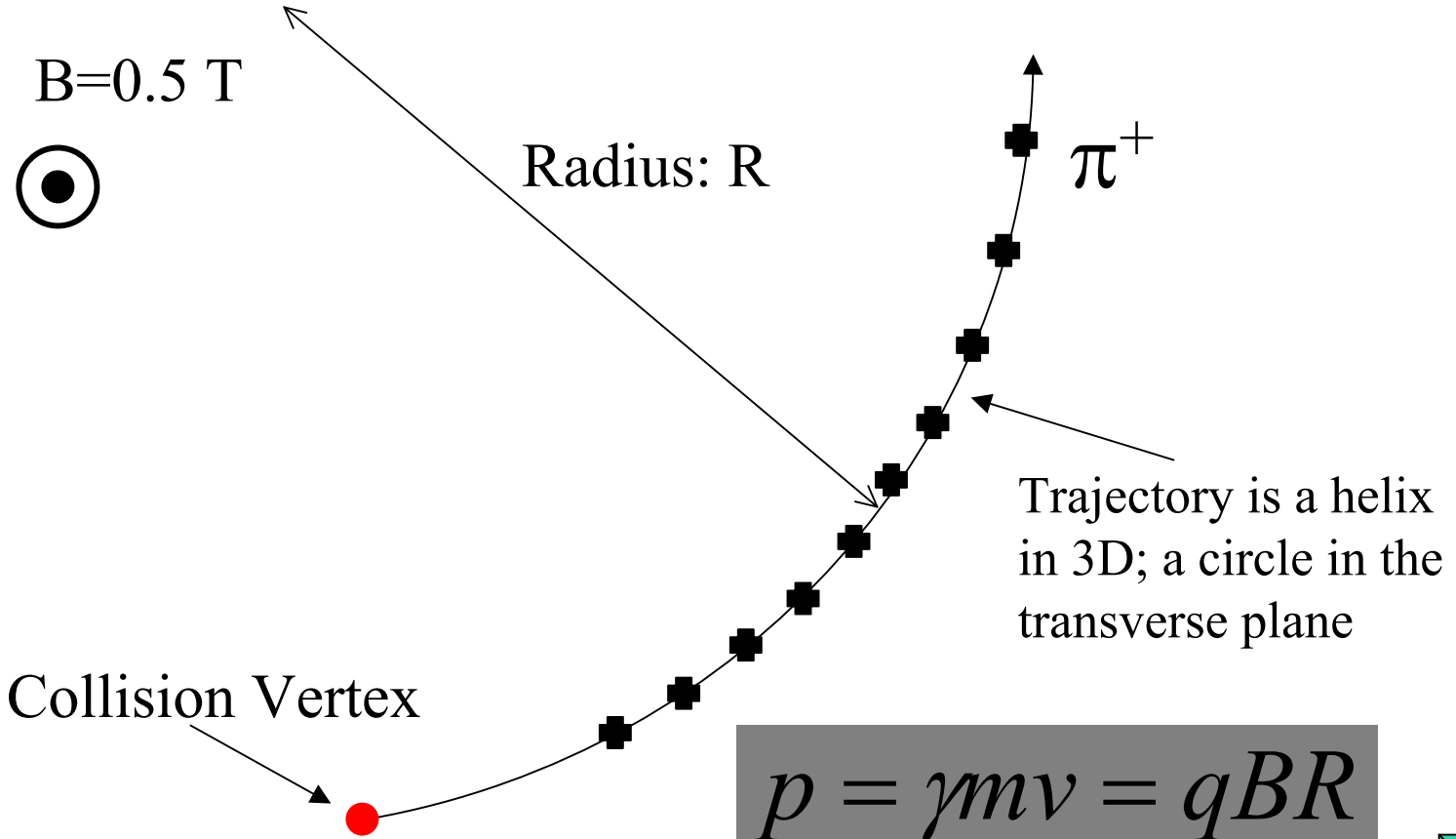
Analysis in progress…

STAR Collaboration



Back Up

Momentum Measurement



$$p = \gamma m v = qBR$$

Physics Motivation

The strange to non-strange particle ratio for same multiplicity is expected to give large fluctuation as a signal of phase transition.

This fluctuation in strangeness is expected to survive through the mixed phase.

Dynamical fluctuation in strangeness production

To study the fluctuation with

Variation with centrality

Variation with CM energy

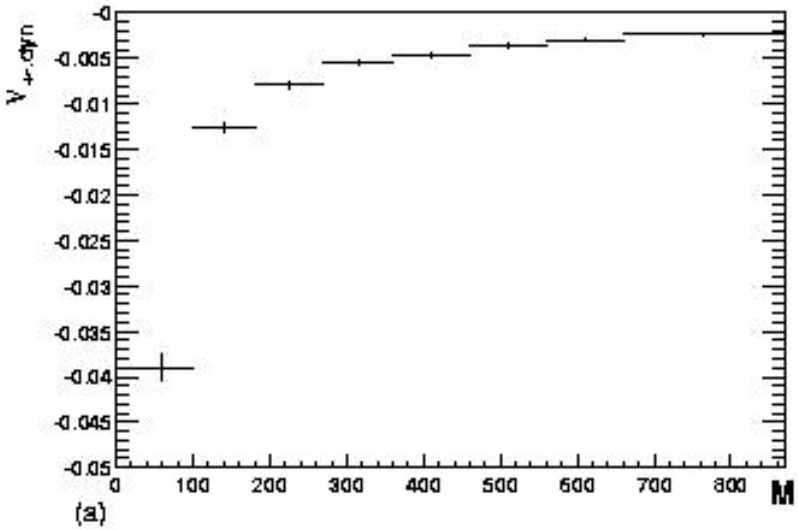
This analysis has been presented in EbyE PWG

Event, Track selection and Particle Identification

Au+Au data at 200 GeV (prod => P02gd)

1. Events selected with -25 cm < z-vertex < 25 cm
2. Primary tracks taken from MuDST, the following cuts have been applied,
   i. DCA_z < 3 cm
   ii. Nhits < 15 (for both Kaons and Pions)
   iii. $-1 < \eta < 1$
   iv. 100 MeV < P_t < 600 MeV
3. Particle identification applied based on nSigma cut i.e.
   Kaons: nSigmaKaon < 2 && nSigmaPion > 2
   Pions: nSigmaPion < 2 && nSigmaKaon > 2

Results (Method II)

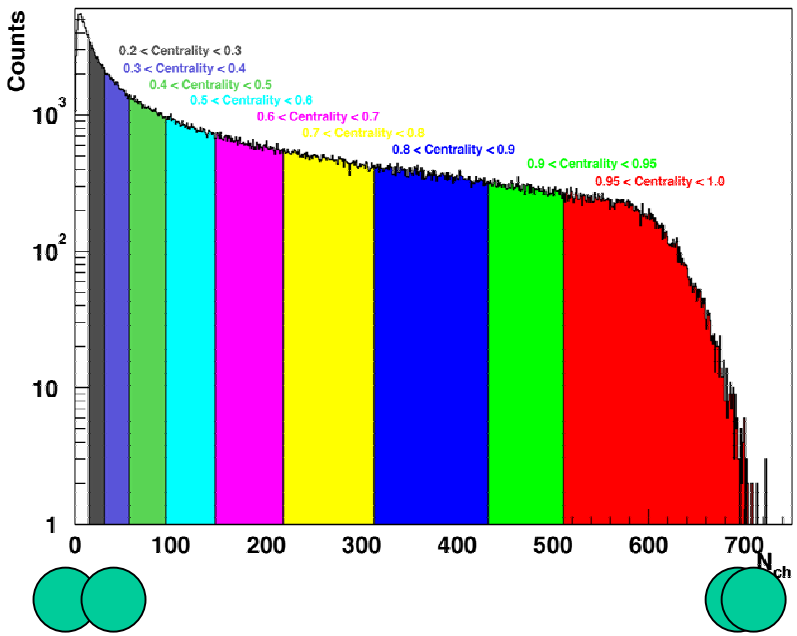


J. Adams *et al*. for STAR collaboration PRC 68 (2003)

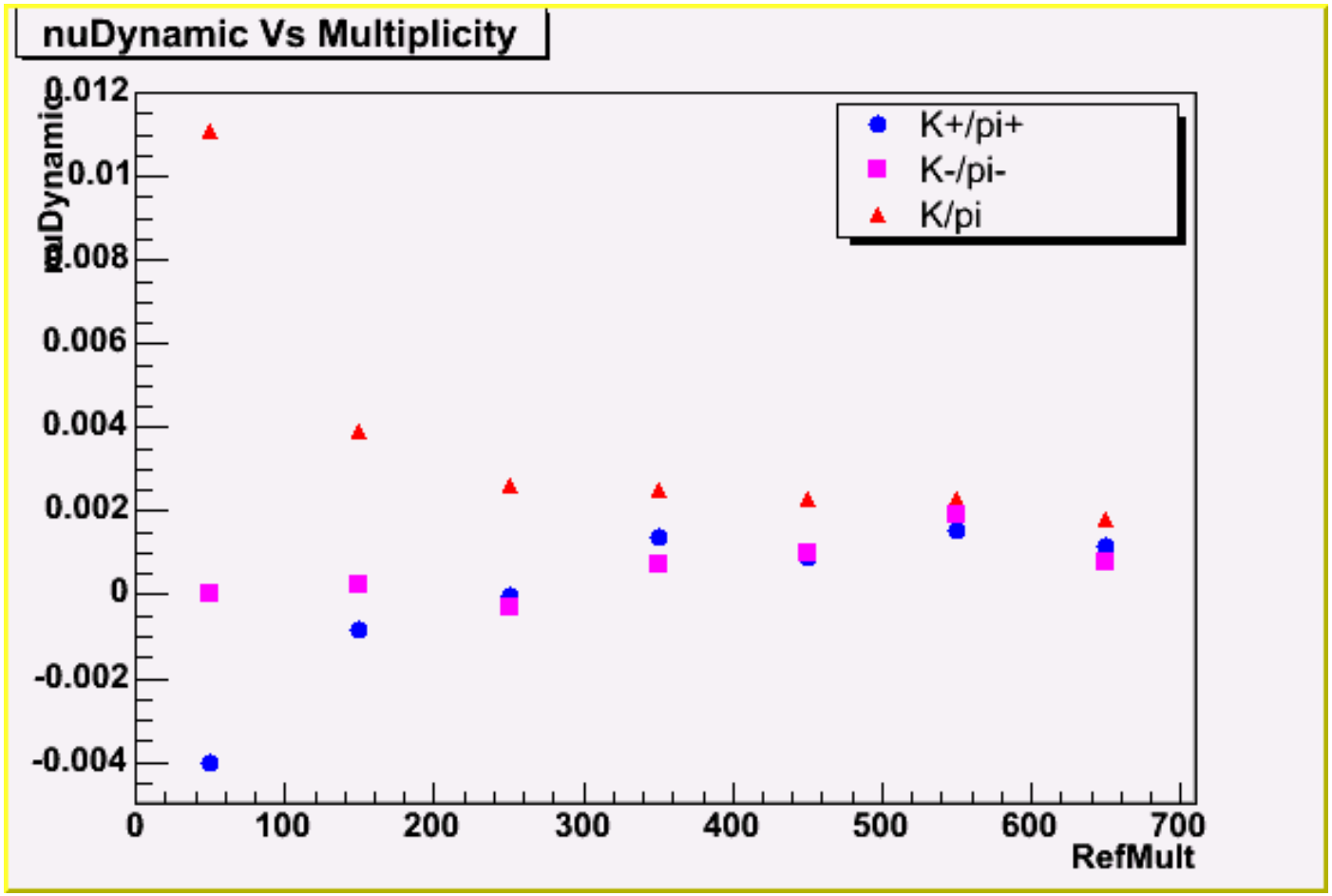
- Magnitude of $\nu_{dynamic}$ decreases monotonically with increasing centrality

Strength of dynamical fluctuation

Centrality at STAR



Results (Method II)



Dynamical Net charge Fluctuations

$$\nu_{+-} = \left\langle \left(\frac{N_+}{\langle N_+ \rangle} - \frac{N_-}{\langle N_- \rangle} \right)^2 \right\rangle$$

- Sensitive to net charge
- Insensitive to volume fluctuations

$$\nu_{+-,stat} = \frac{1}{\langle N_+ \rangle} + \frac{1}{\langle N_- \rangle}$$

- Statistical Limit – Independent particle production.

$$\nu_{+-,dyn} = \nu_{+-} - \nu_{+-,stat}$$

- **Dynamical Fluctuations.**

$$\nu_{+-,dyn} = \frac{\langle N_+(N_+ - 1)\rangle}{\langle N_+\rangle^2} + \frac{\langle N_-(N_- - 1)\rangle}{\langle N_-\rangle^2} - 2\frac{\langle N_+ N_-\rangle}{\langle N_+\rangle\langle N_-\rangle}$$

Measured Quantity