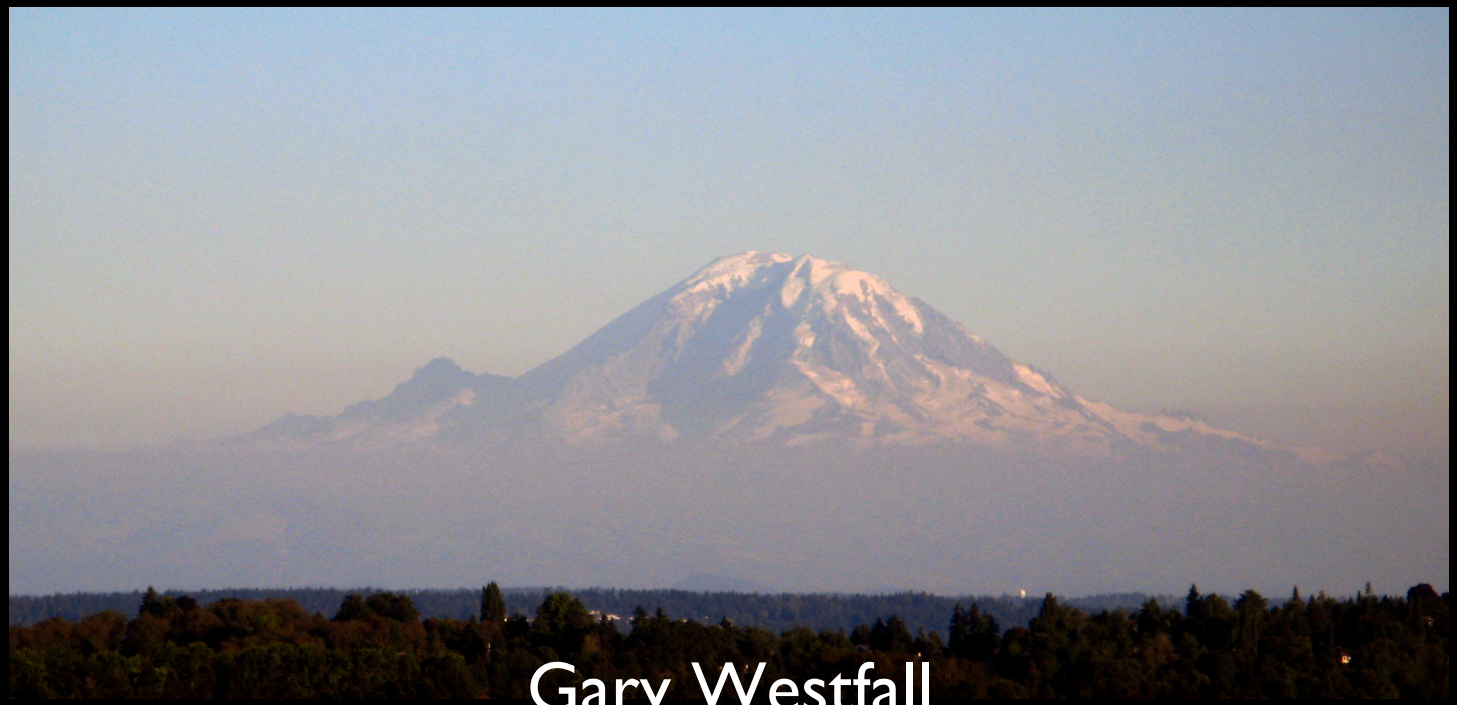
K/π Fluctuations and the Balance Function



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INT Workshop on the QCD Critical Point
August 12, 2008

Fluctuations in the K/π Ratio

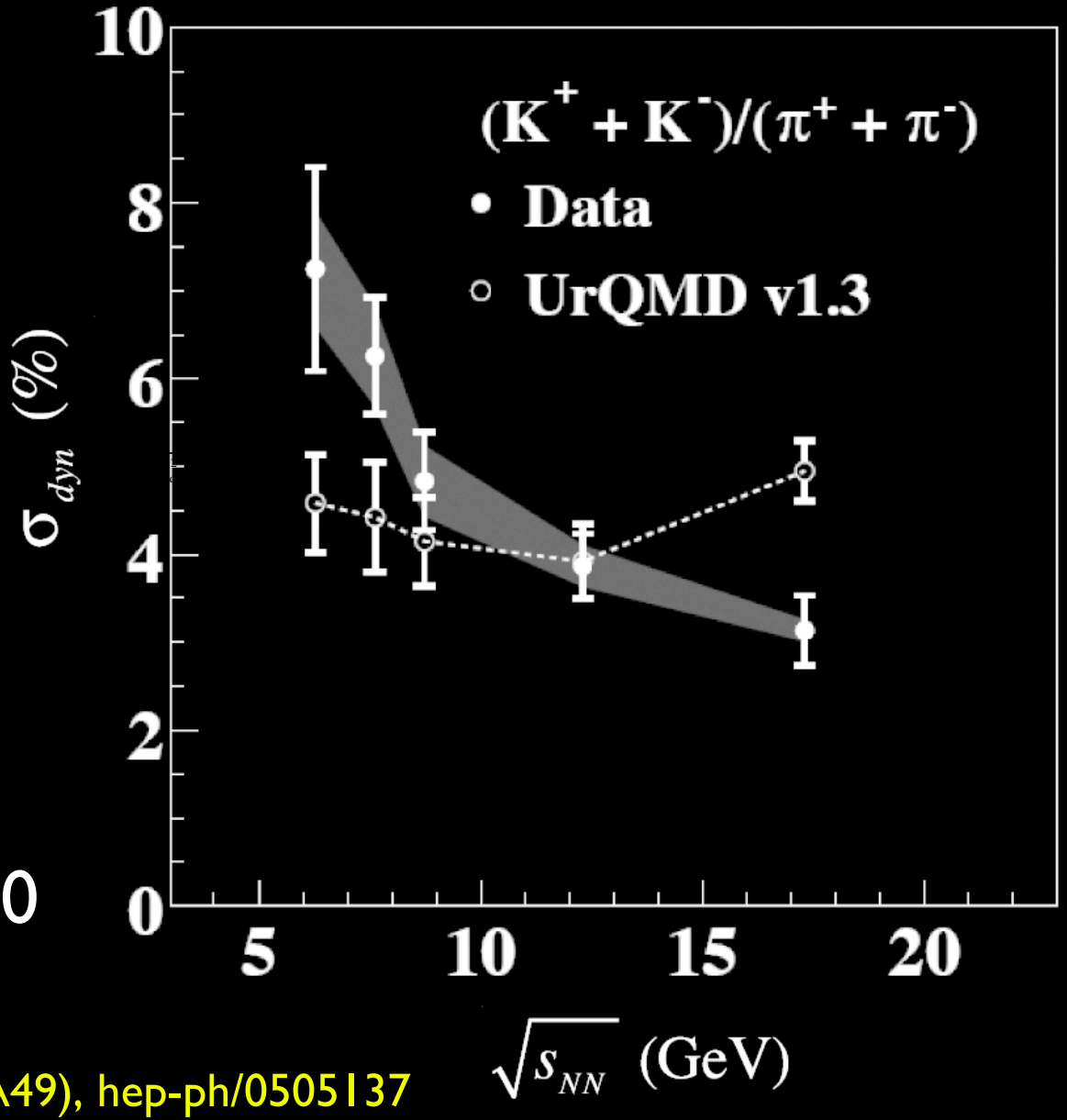
- Event-by-event fluctuations in K/π may give insight into the QCD critical point
- NA49 measured the fluctuations of K/π as a function of incident energy for central Pb+Pb collisions from $s_{NN}^{1/2}$ = 6 to 17 GeV using the observable σ_{dyn}
  - measure the K/π ratio event-by-event
    - $K = K^+ + K^-$
    - $\pi = \pi^+ + \pi^-$
  - produce histogram of the K/π ratio
  - extract the width of K/π histogram to get σ_{data}
  - do the same for mixed event to get σ_{mixed}

K/π Fluctuations at the SPS

- Define the dynamical fluctuations in terms of σ_{dyn}

$$\sigma_{\mathrm{dyn}} = \sqrt{\sigma^2_{\mathrm{data}} - \sigma^2_{\mathrm{mixed}}}$$

  - Divide by the mean and multiplity by 100 to get %

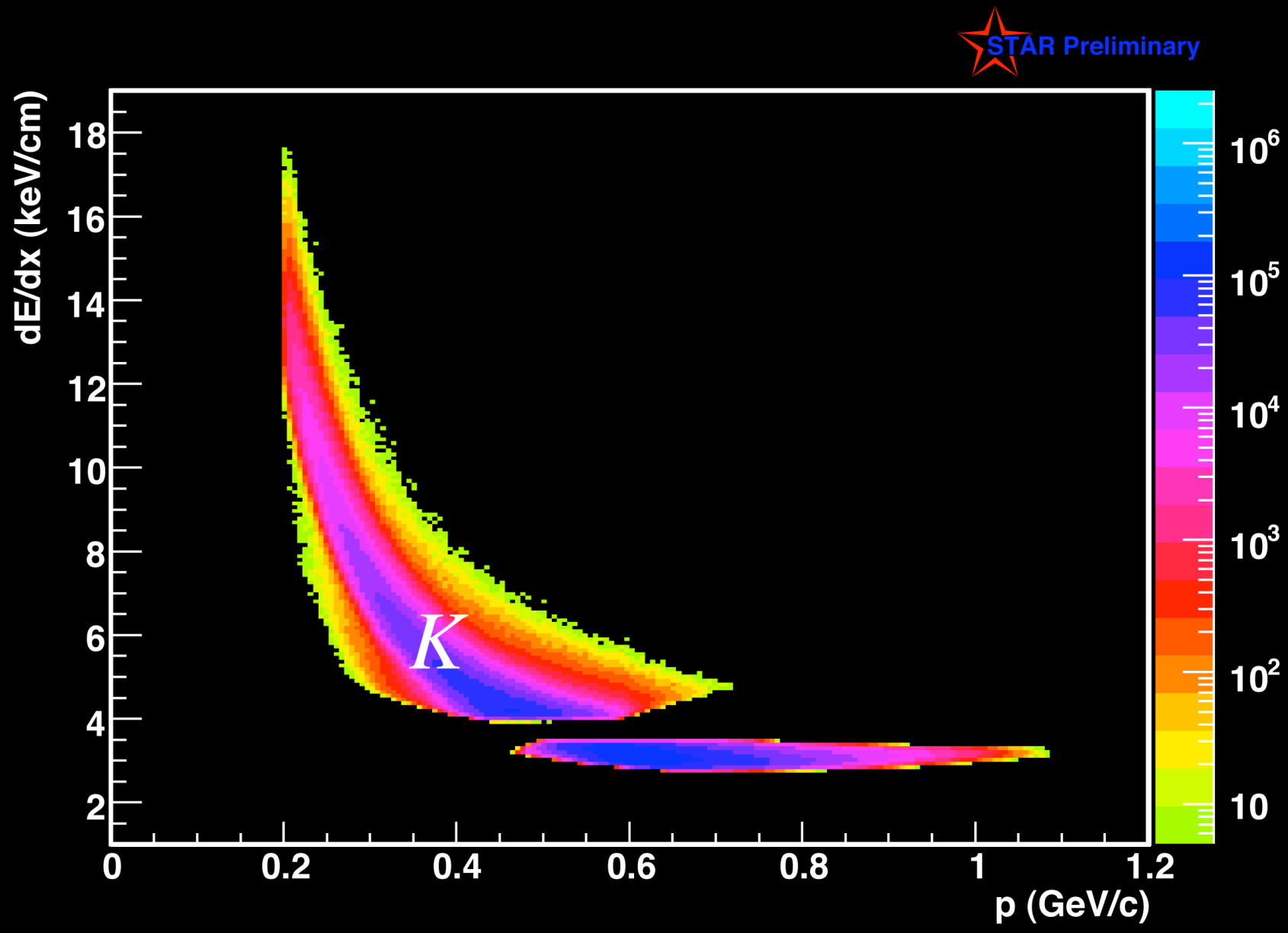


C. Blume (NA49), hep-ph/0505137

K/π Fluctuations in STAR

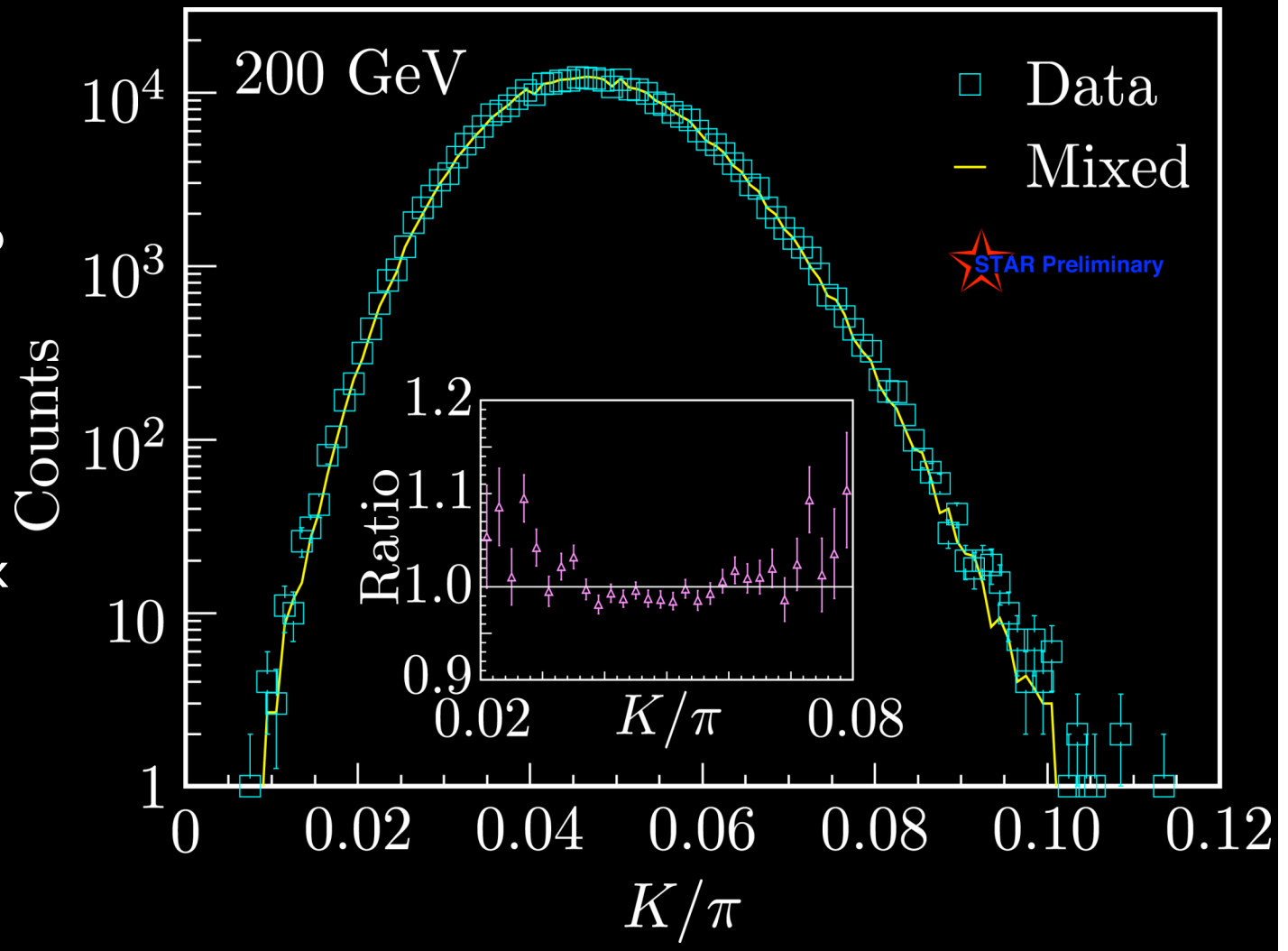
- Study Au+Au collisions at $s_{NN}^{1/2}$ = 20, 62, 130 and 200 GeV
- Extract the number of $K^+ + K^-$ and $\pi^+ + \pi^-$ event-by-event using energy loss and curvature in the STAR TPC
- Take kaons and pions with $0.2 < p_t < 0.6$ GeV/c and $|\eta| < 1.0$
  - kaons: $N_{\sigma,K} < 2$, $N_{\sigma,\pi} > 2$
  - pions: $N_{\sigma,\pi} < 2$, $N_{\sigma,K} > 2$
  - electrons are suppressed with $N_{\sigma,e} > 1$

K and π Identification in STAR



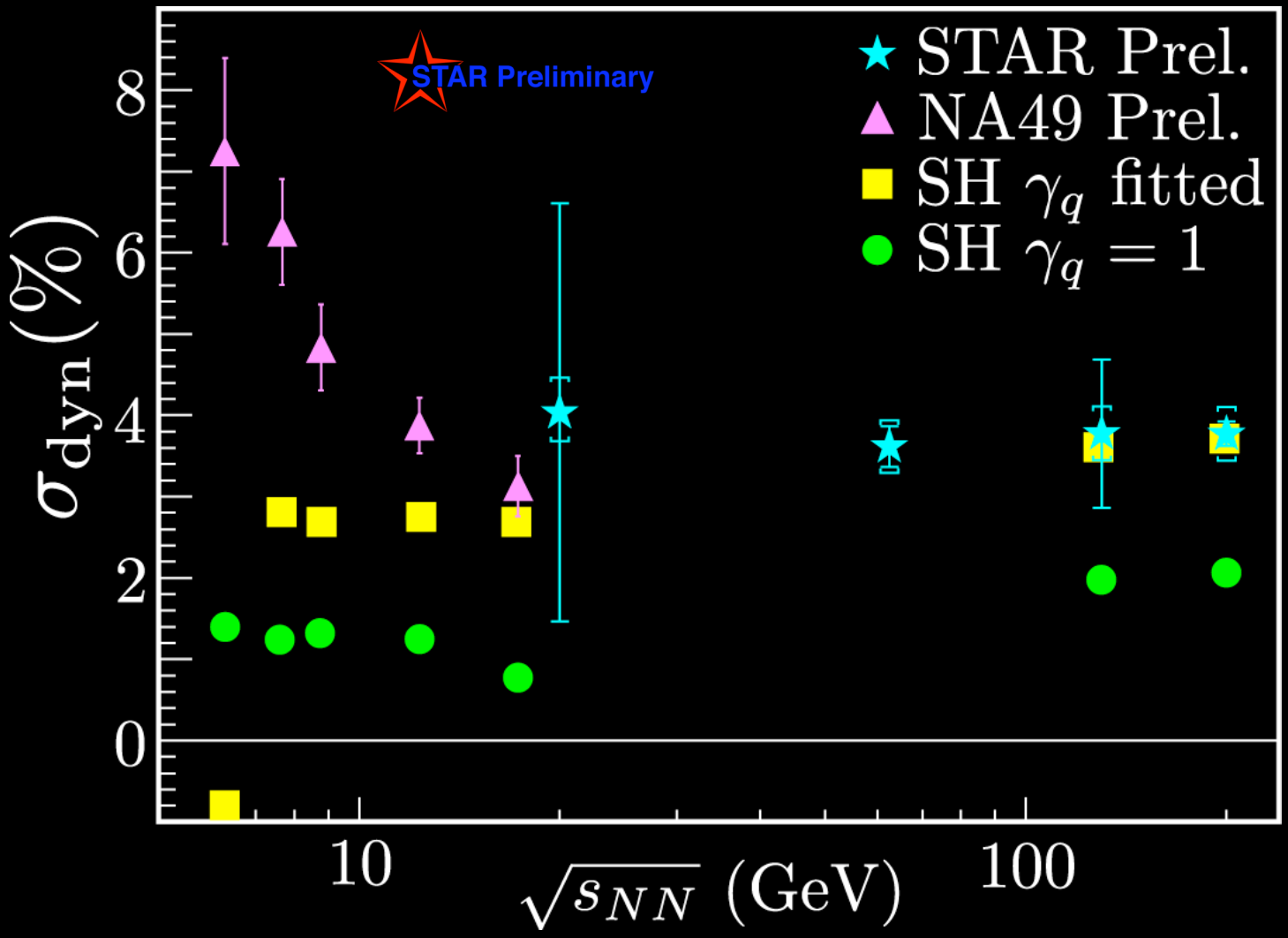
K/π Histograms for Au+Au Collisions

- Mixed events are created by taking one track from different events to produce new events that have no correlations
- Mixed events are produced using 10 bins in centrality and 5 bins in vertex position
- The K/π distributions are wider for real events than for mixed events



Excitation Function for σ_{dyn}

- Compare STAR results for central Au+Au collisions with SPS results for central Pb+Pb collisions



Excitation Function for σ_{dyn} (2)

- STAR results for σ_{dyn} are similar to those at the top SPS energies
- The statistical hadronization model (SH) of Torrieri [nucl-th/0702062 (2007)] for the light quark phase space density $\gamma_q = 1$ (equilibrium) under-predicts σ_{dyn} at all energies
- The statistical hadronization model for a fitted γ_q (non-equilibrium) explains the STAR results but under-predicts the SPS measurements

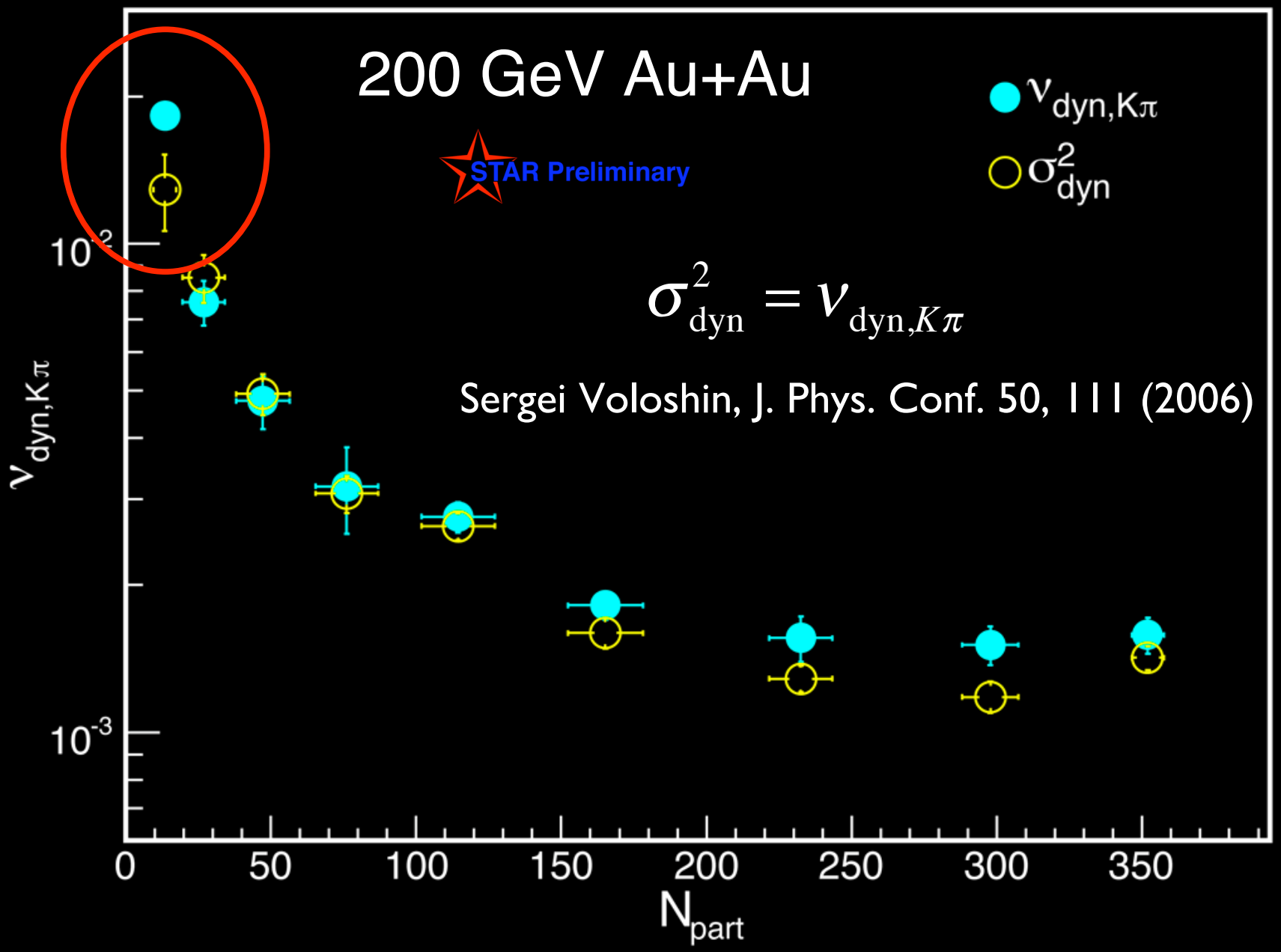
Different Fluctuations Measure

- The use of σ_{dyn} is problematic for low multiplicities
- A better measure is $\nu_{dyn,K\pi}$

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

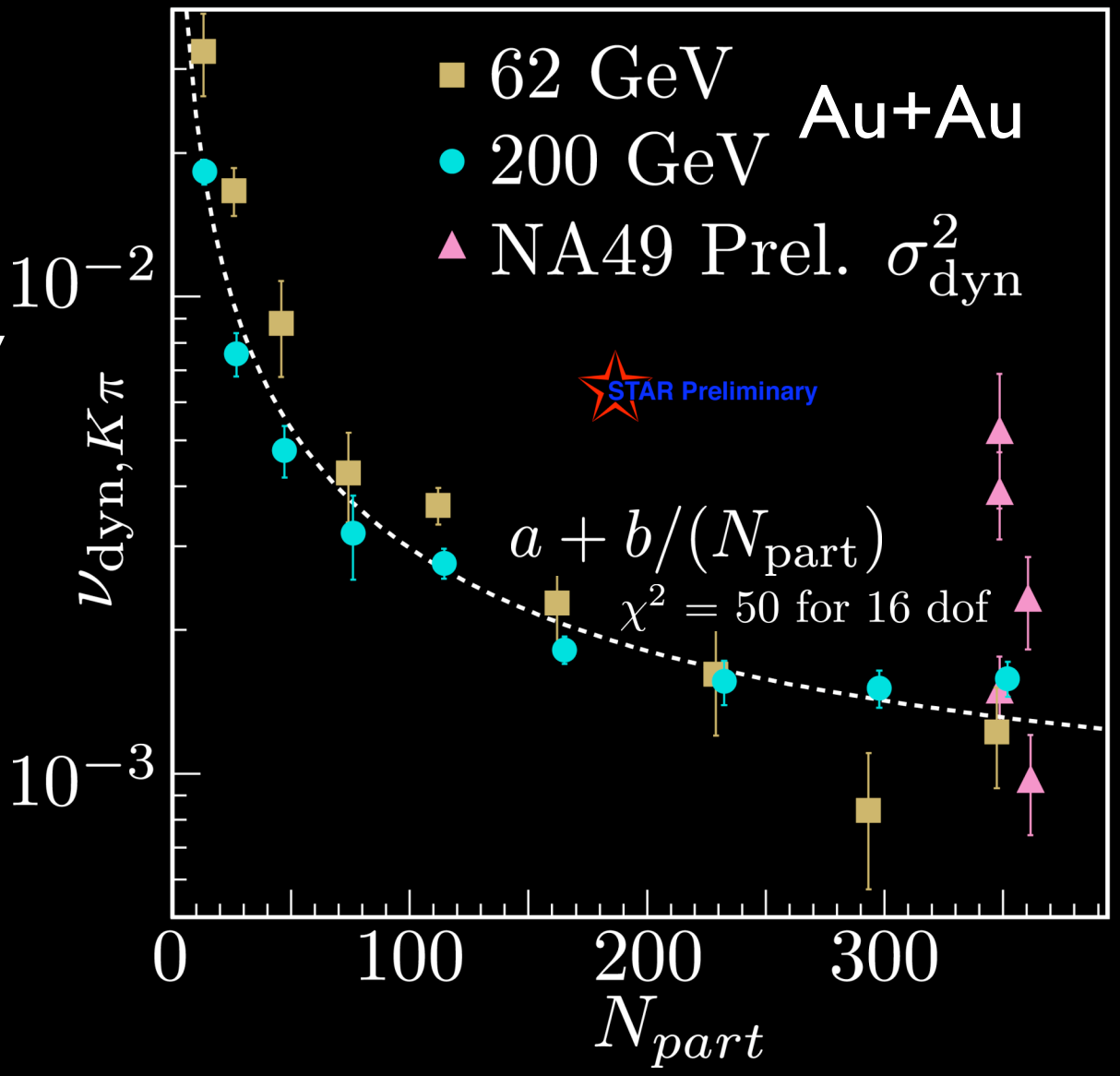
- ν_{dyn} was introduced to study net charge fluctuations (PRC 68, 044905 [2003])
- $\nu_{dyn,K\pi}$ is insensitive to efficiency
- $\nu_{dyn,K\pi}$ deals well with low multiplicities and does not require mixed events

Are σ_{dyn} and $\nu_{dyn,K\pi}$ Different?



$\nu_{dyn,K\pi}$ for Au+Au at 62 and 200 GeV

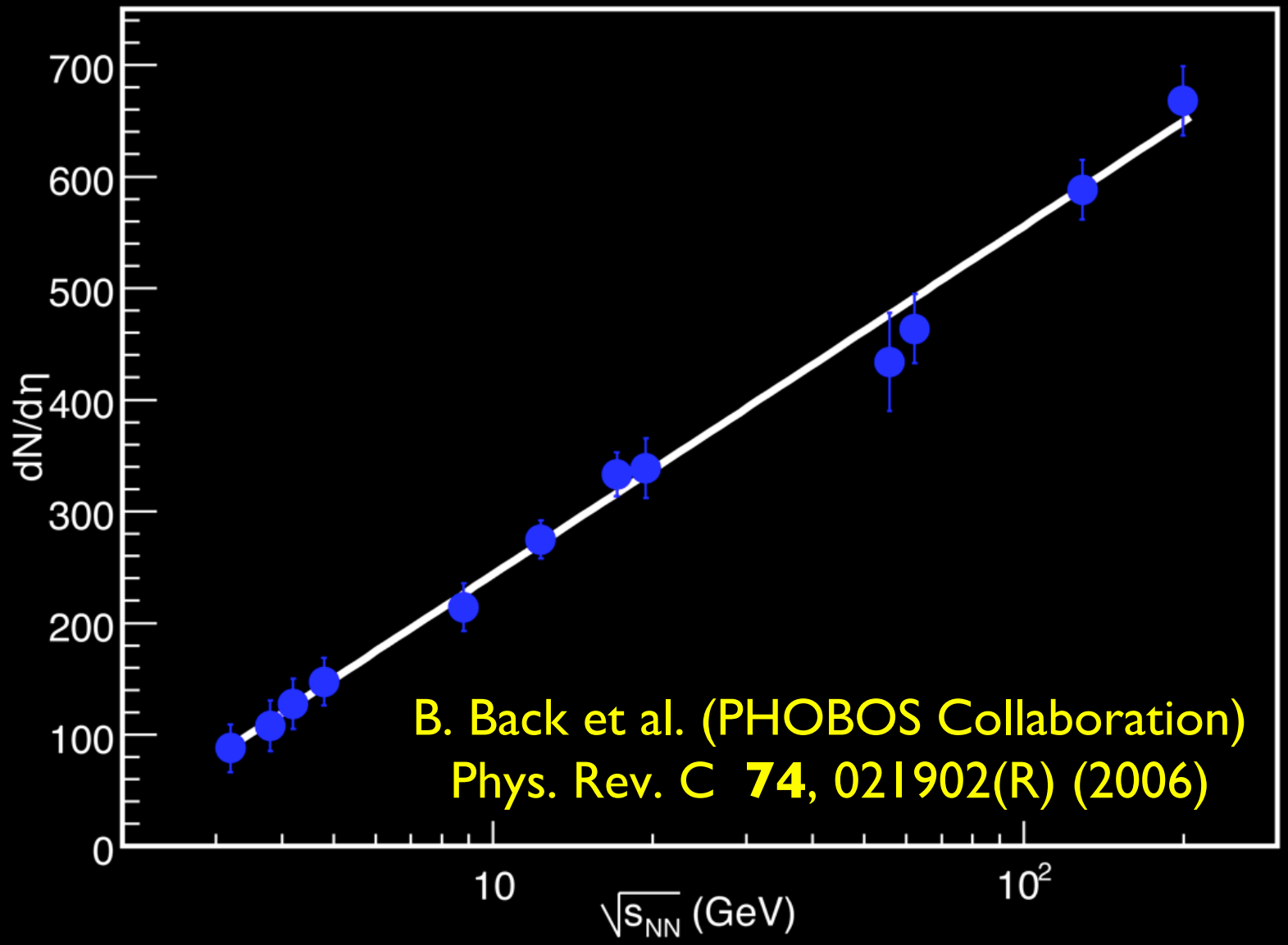
- Centrality dependence of K/π fluctuations
  - Inverse multiplicity dependence
  - Relatively poor fit versus $1/N_{part}$
- NA49 results are all central Pb+Pb collisions
  - Similar N_{part}



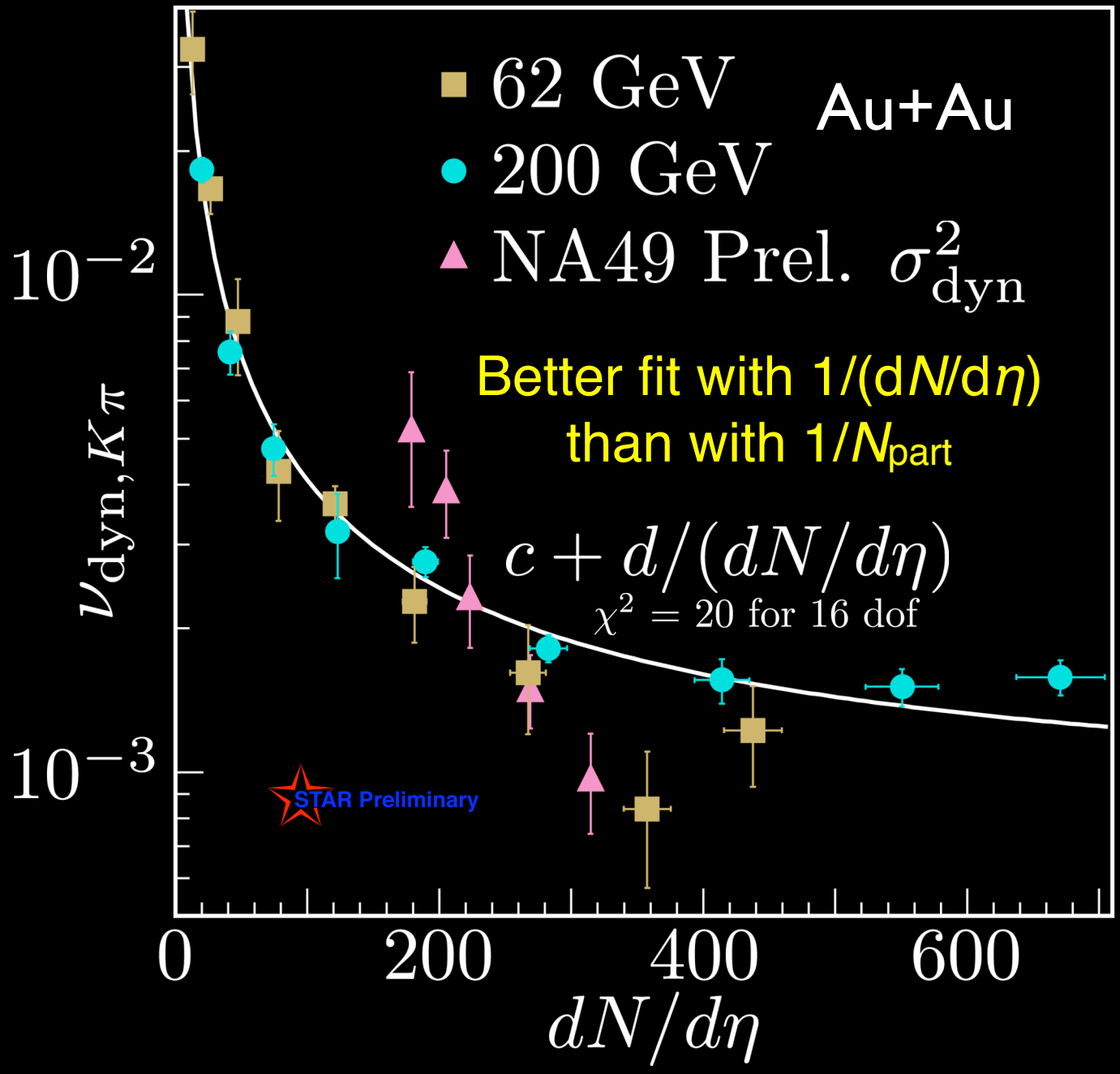
Compare with NA49 using dN/dη

- We can compare the results for the centrality dependence of $\nu_{dyn,K\pi}$ to the incident energy dependence of σ_{dyn} in central collisions using the following method
  - Use PHOBOS systematics for dN/dη versus $s_{NN}^{1/2}$
  - Use the identity $\sigma_{dyn}^2 = \nu_{dyn,K\pi}$

PHOBOS Systematics for d*N*/dη in Central Collisions

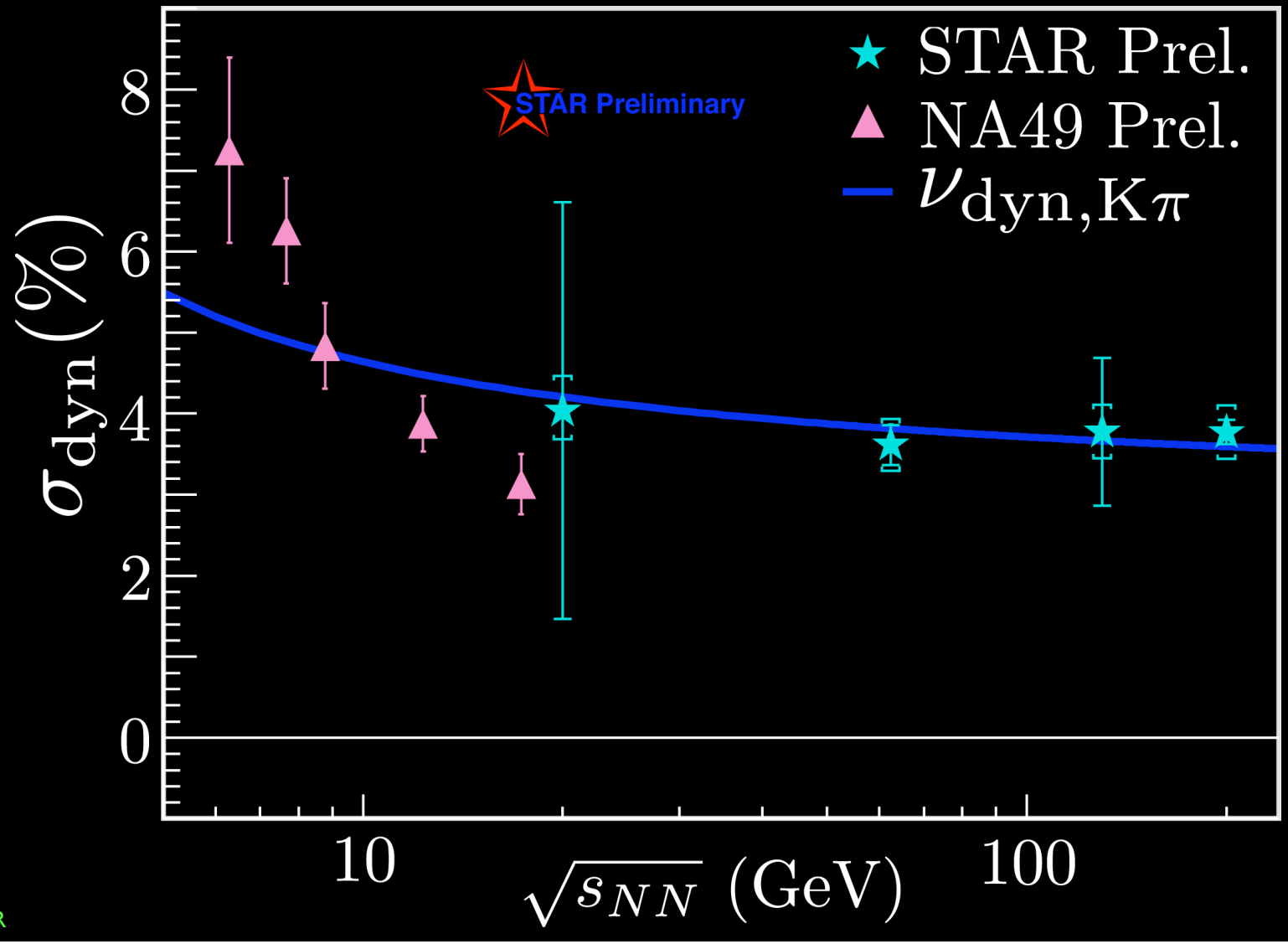


$\nu_{dyn,K\pi}$ Plotted versus dN/dη



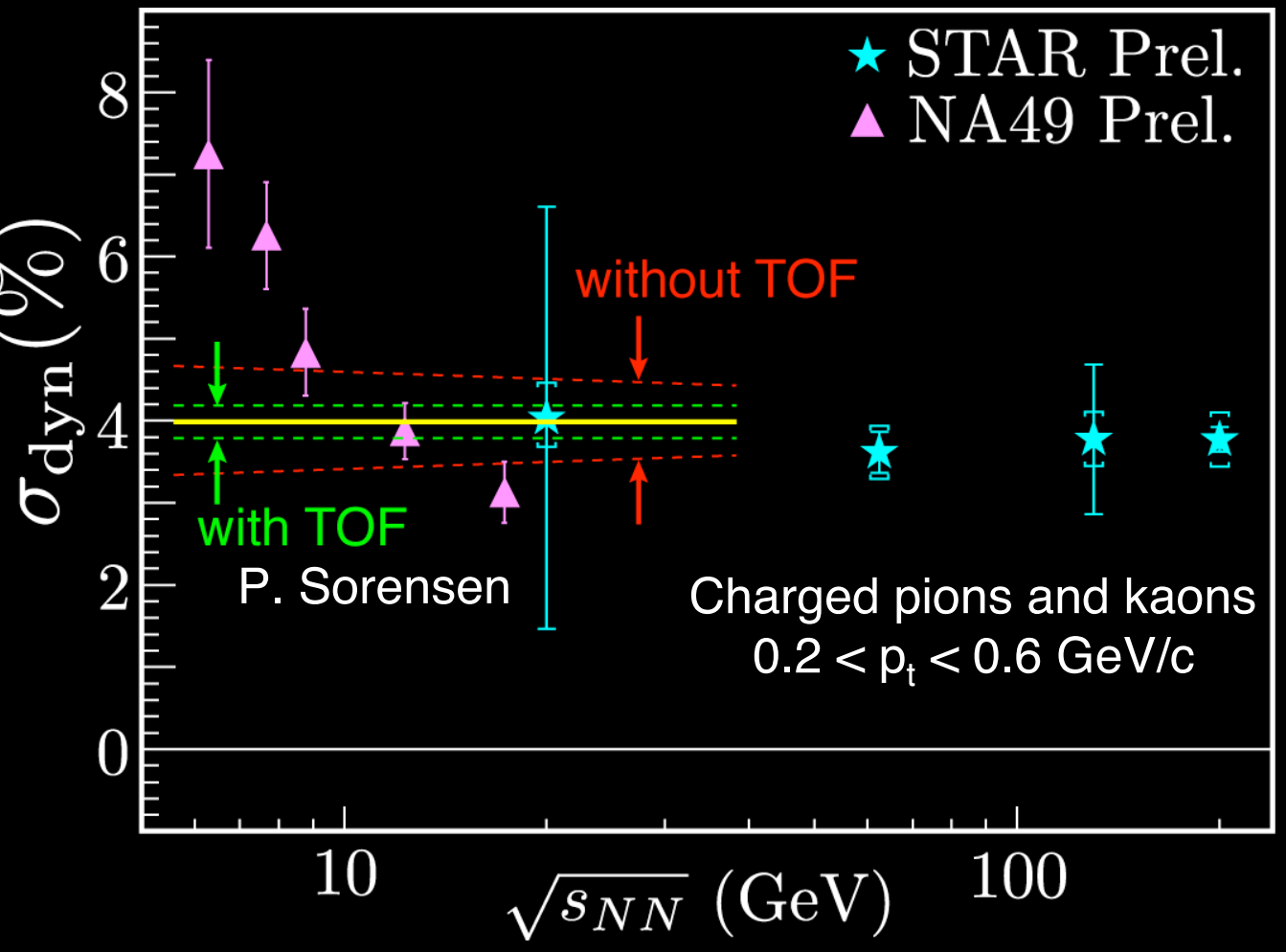
Excitation Function for σ_{dyn}

- Scale centrality dependence of $\nu_{dyn,K\pi}$ to compare with excitation function of σ_{dyn} in central collisions

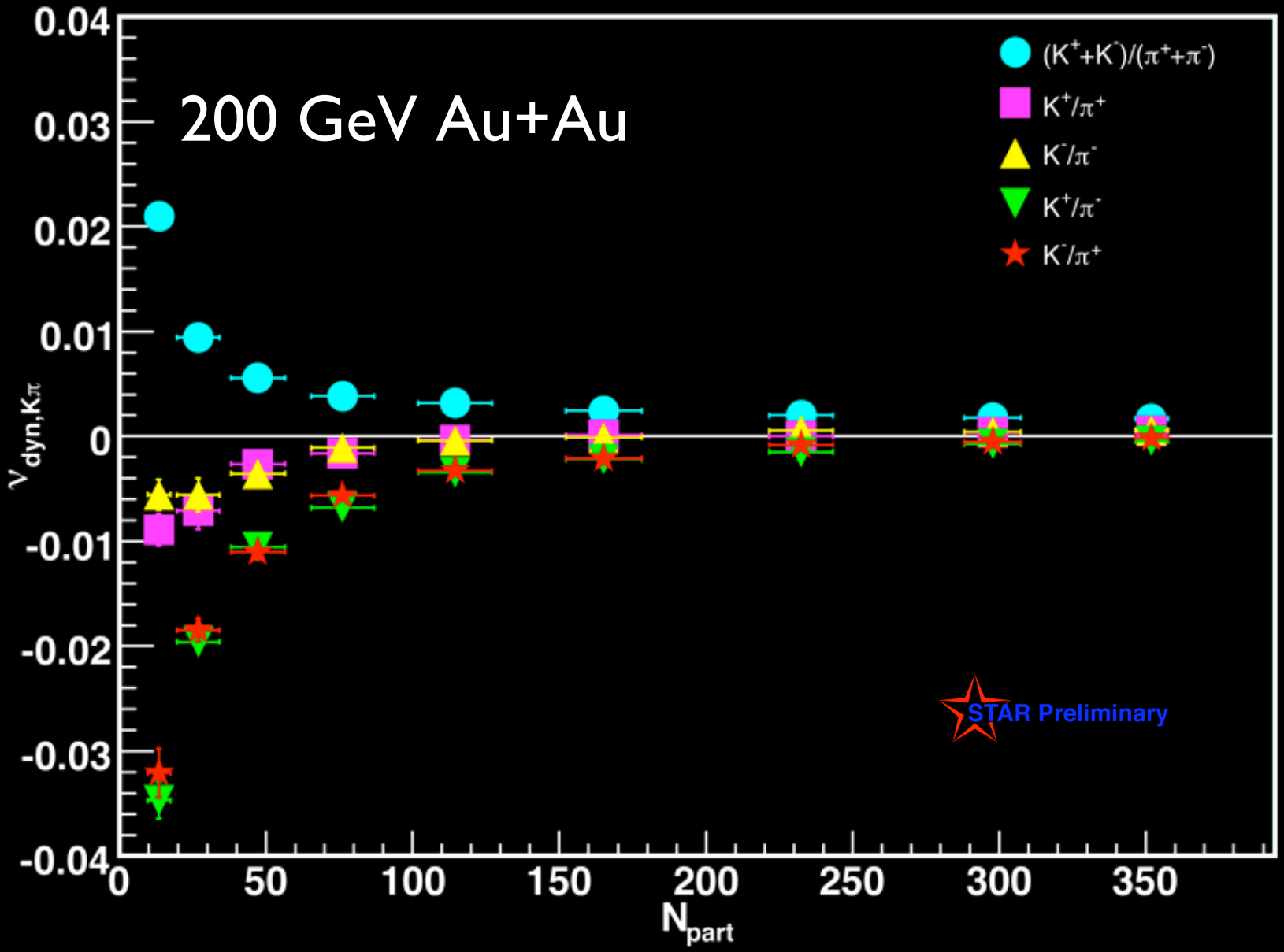


Addition of TOF to STAR

- STAR will add TOF for Run 10
- The TOF will provide excellent particle identification for π, K, and p for a large fraction of the measured particles event-by-event
- Improved K/π fluctuation measurements
- Improved balance functions with identified π, K, and p



Look at Charges Separately



HIJING Predictions - Separated Charges