First results from STAR experiment at RHIC

- Soft hadron physics -

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for the STAR collaboration

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Focus on

- Hadrons
  - Measured : h^-, $\pi^\pm$, $K^\pm$, K^0_s, K^{*0}, $\bar{K}^{*0}$, p, $\bar{p}$, $\bar{d}$, ^3He, $^3\bar{He}$, t, Λ, $\bar{\Lambda}$, Ξ^-, $\bar{\Xi}^+$,
  - In future : π^0, ϕ, $\Omega^-+\bar{\Omega}^-$, ρ, ω, η, η', Δ, $\Lambda(1520)$, $\Sigma(1385)$, J/ψ and more
- Freeze-out conditions of low momentum hadrons by
  - Spectra/Ratios
    - Thermal/Chemical Freeze-out
  - Particle correlations
    - Size parameters, Phase space density
  - Event anisotropy
    - v_2

Spectra

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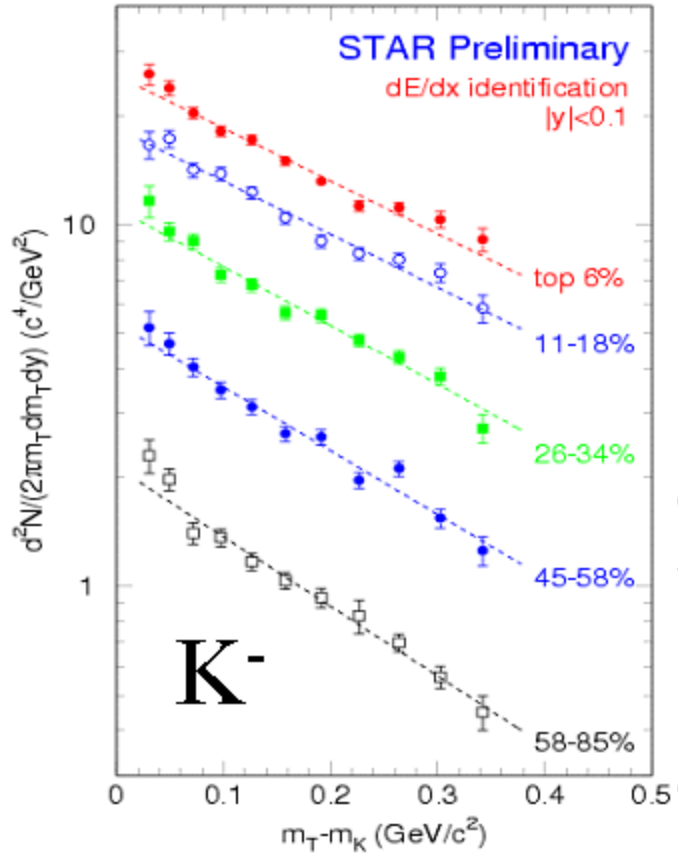
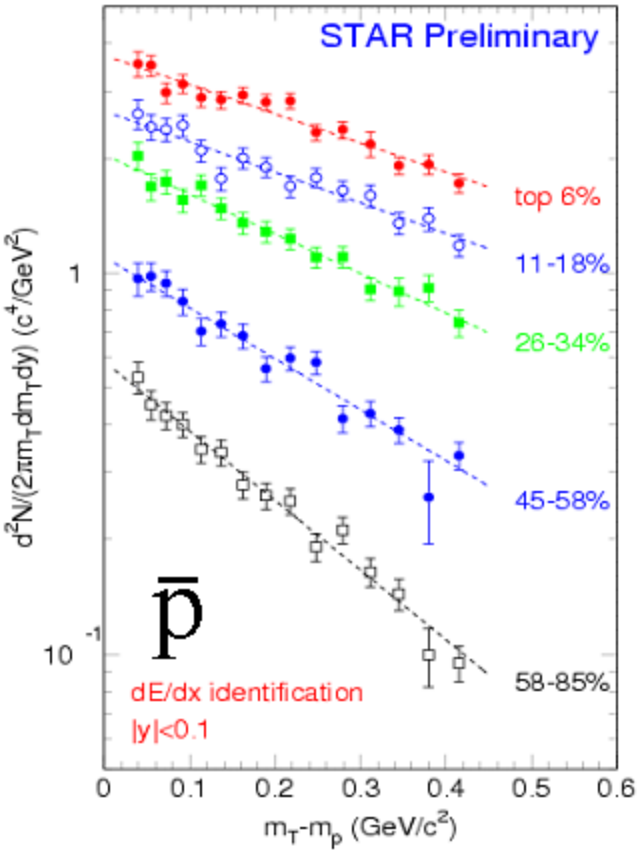
Spectra

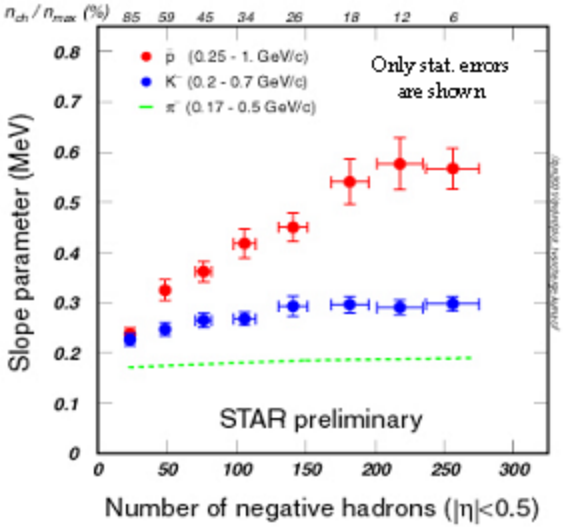
- Momentum distributions
  - Information of thermal (kinetic) freeze-out
  - The inverse slope parameter of m_T distribution reflects temperature and radial flow

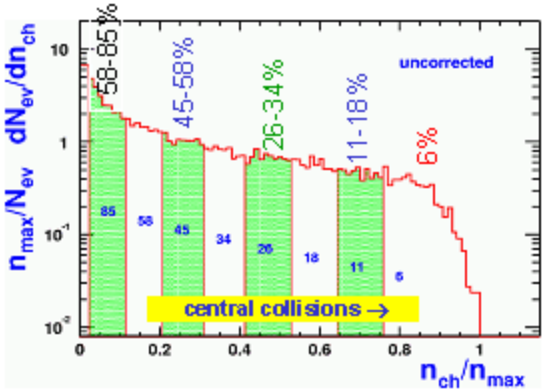
Identified particle spectra



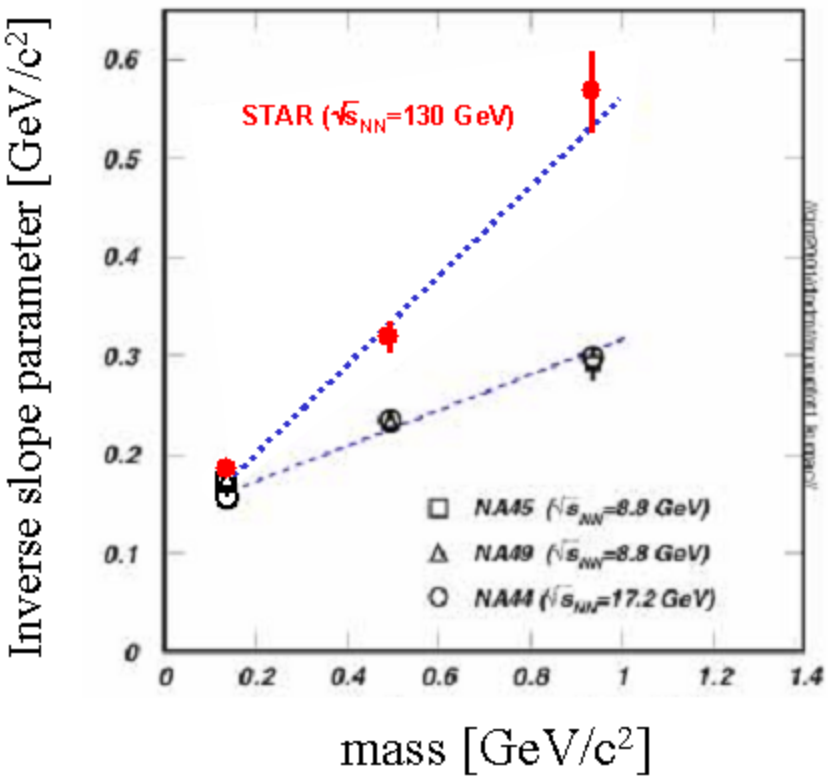


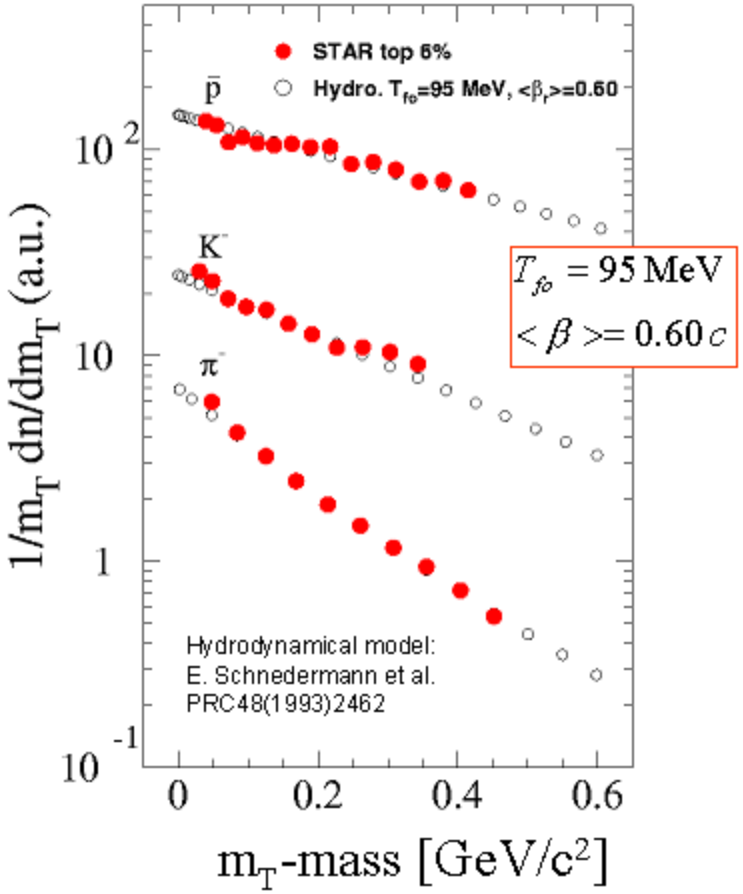
Au + Au at $\sqrt{s_{NN}}$ = 130 (GeV)





Thermal(Kinetic) freeze-out





- Thermal freeze-out at RHIC
  - Temperature is similar at SPS
  - Larger radial flow than at SPS

Ratios

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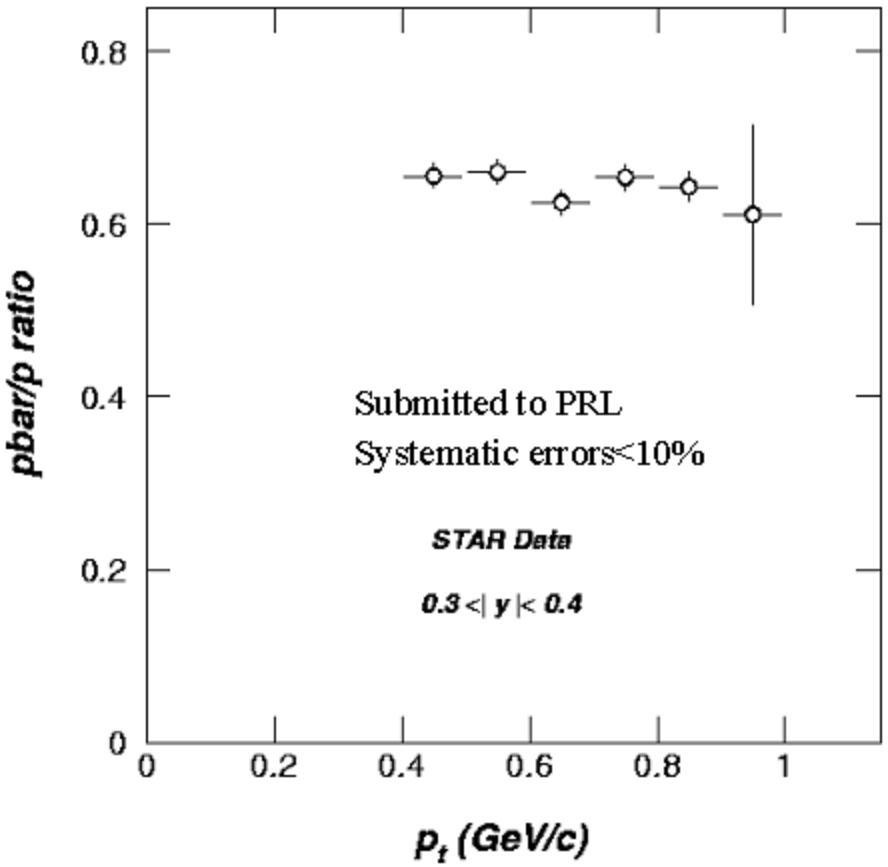
Ratios

- p_T dependence anti-particle/particle
  - Test slope for particle and anti-particle
- Anti-baryon/baryon ratio
  - Stopping or transparent?
- Particle ratios from hadrons
  - Chemical freeze-out parameters

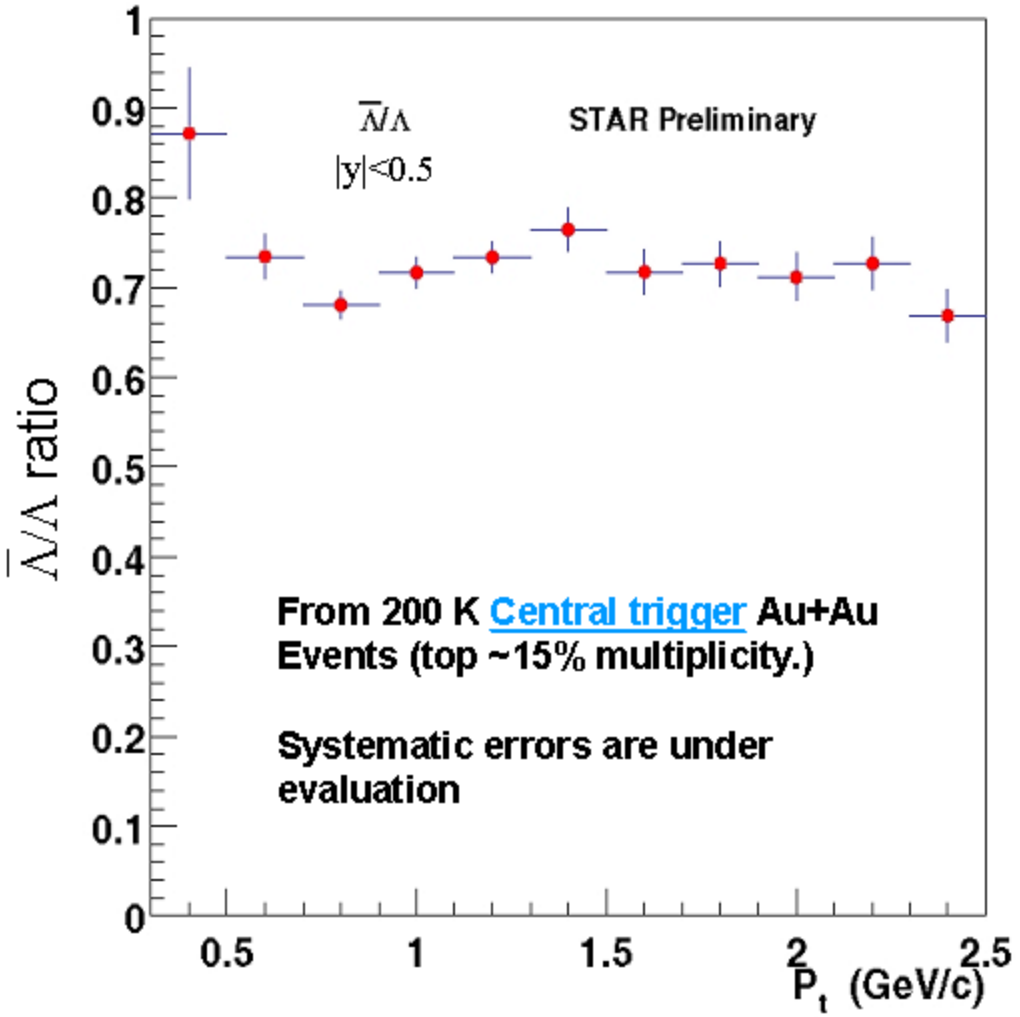
$\bar{p}/p$ ratio

- Minimum bias data
- No or weak p_T dependence

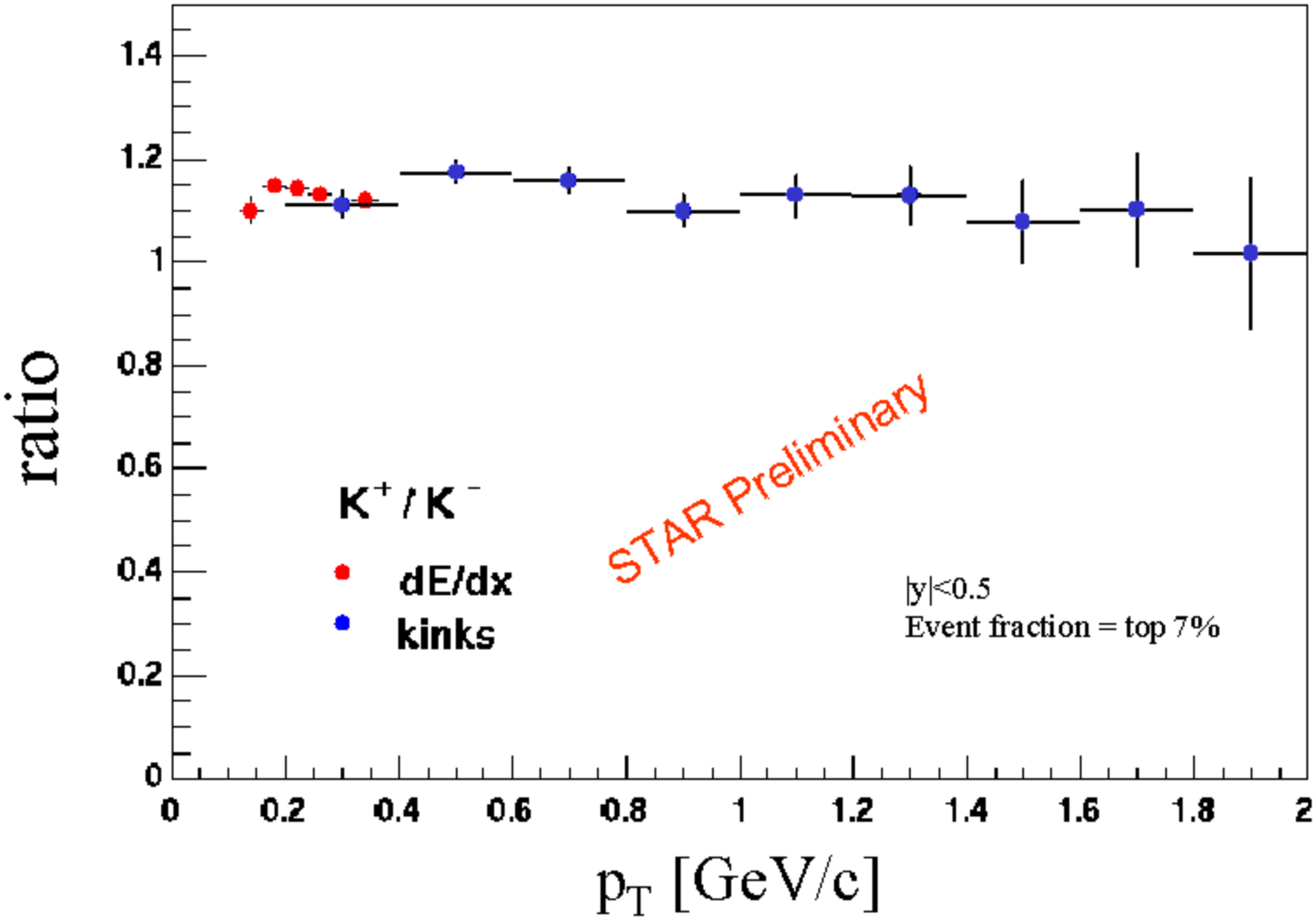


$\bar{\Lambda}/\Lambda$ ratio

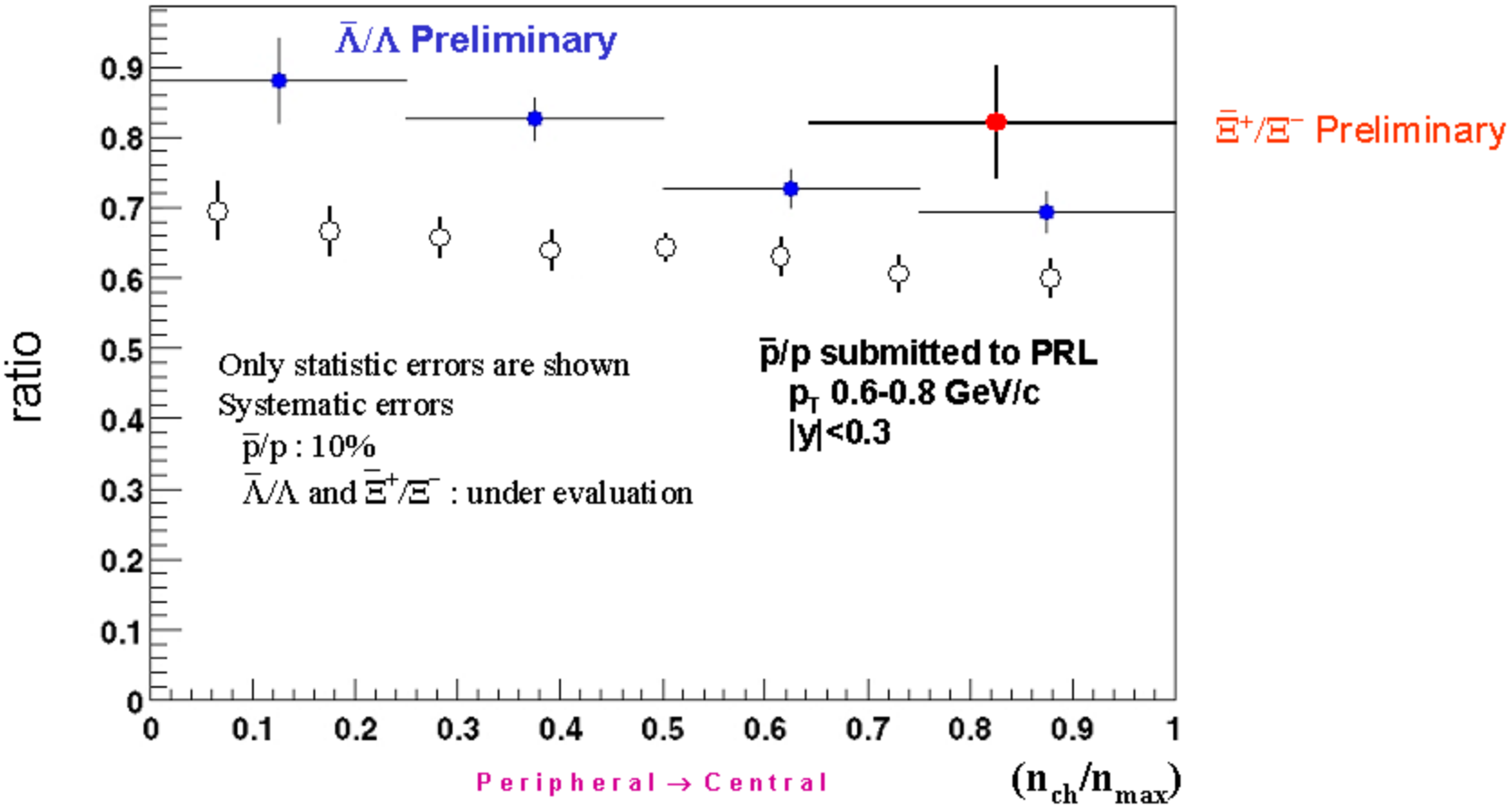
- No significant p_T dependence in the ratio
- The mean ratio = 0.72±0.04



K^+/K^- ratio

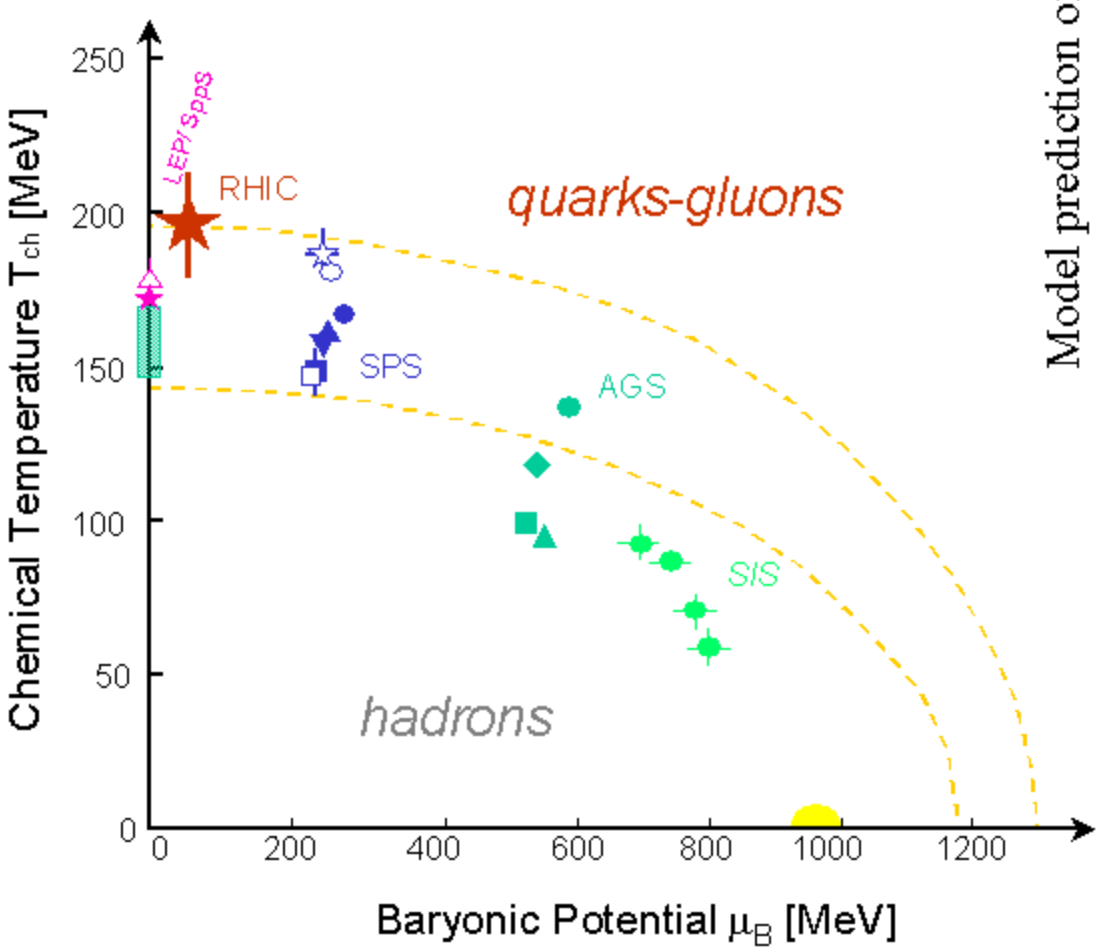

ratio
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
p_T [GeV/c]
K^+ / K^-
dE/dx
kinks
STAR Preliminary
|y|<0.5
Event fraction = top 7%

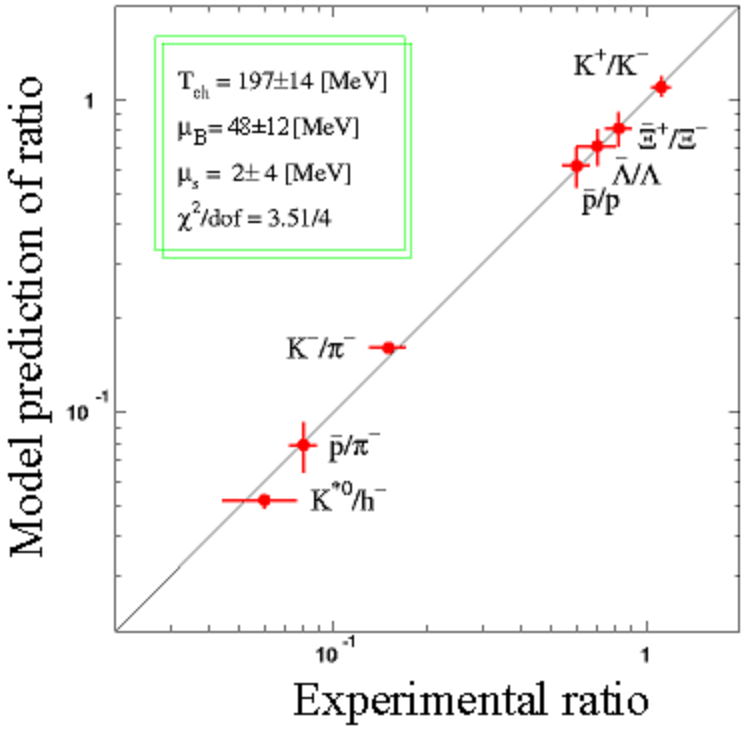
Multiplicity dependence of ratios



- Not baryon free at mid-rapidity
- An effect of anti-baryon absorption in central collisions?

Chemical freeze-out





HBT

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HBT

Many topics in STAR measurement

- Pion HBT
  - Centrality
  - Transverse momentum
  - The HBT excitation function

Focus in this talk

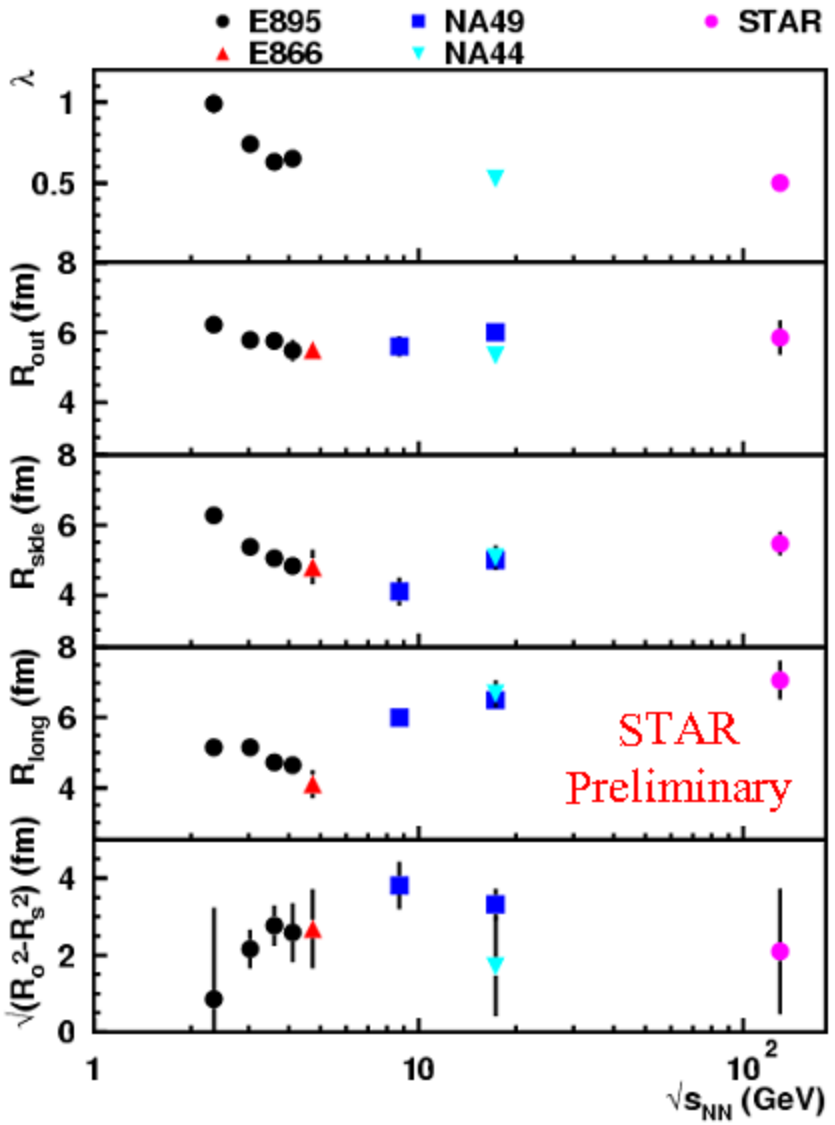
- Phase space density
- Event-by-Event HBT
- $K^0_s K^0_s$, $\Lambda\Lambda$
- pp, $\bar{p}\bar{p}$
- $\pi\pi\pi$ correlations
- Non-identical particles

The HBT excitation function

- Compilation 3D $\pi\pi$-HBT parameters as a function of $\sqrt{s}$

  - ~10% Central Au+Au(Pb+Pb) events
  - $y \sim 0$
  - $k_T \approx 0.17$ GeV/c

- No significant jump from SPS to RHIC
- We need energy scan between both energy



Event Anisotropy

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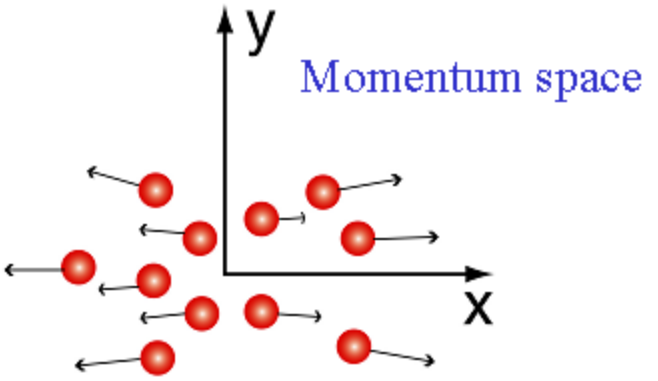
Event anisotropy

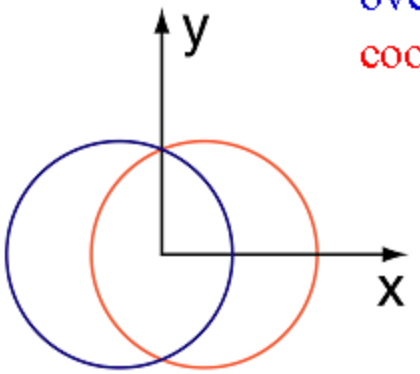
- In momentum space
  - Anisotropy measured as second harmonic parameter v_2

$$v_2 = \langle \cos 2\phi \rangle \qquad \phi = \operatorname{atan} \frac{p_y}{p_x}$$



- v_2 will be scale to initial shape parameter ε,
  if the source has a hydrodynamical expansion

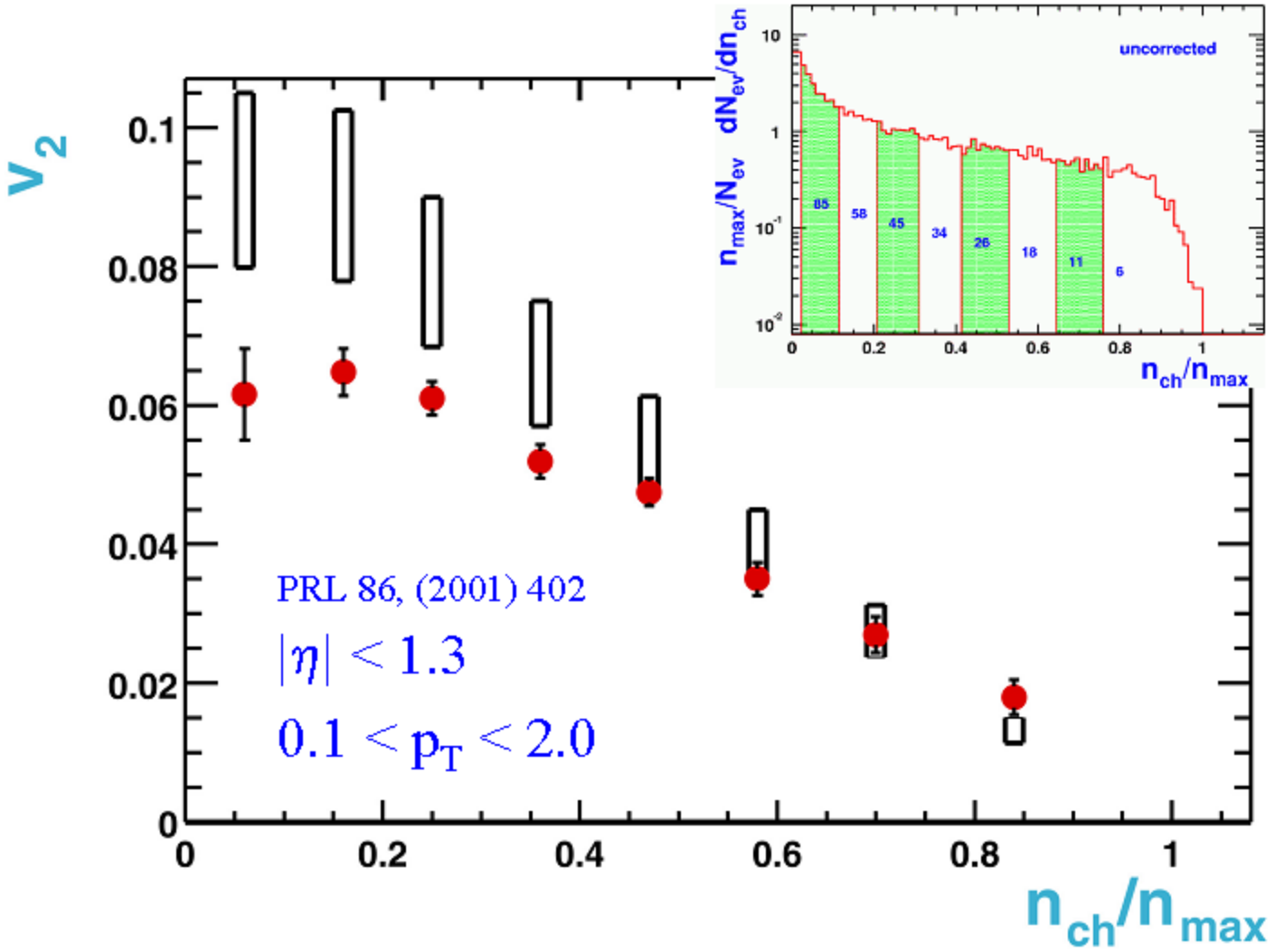
Almond shape overlap region in coordinate space



$$\varepsilon = \frac{\langle y^2 - x^2 \rangle}{\langle y^2 + x^2 \rangle}$$

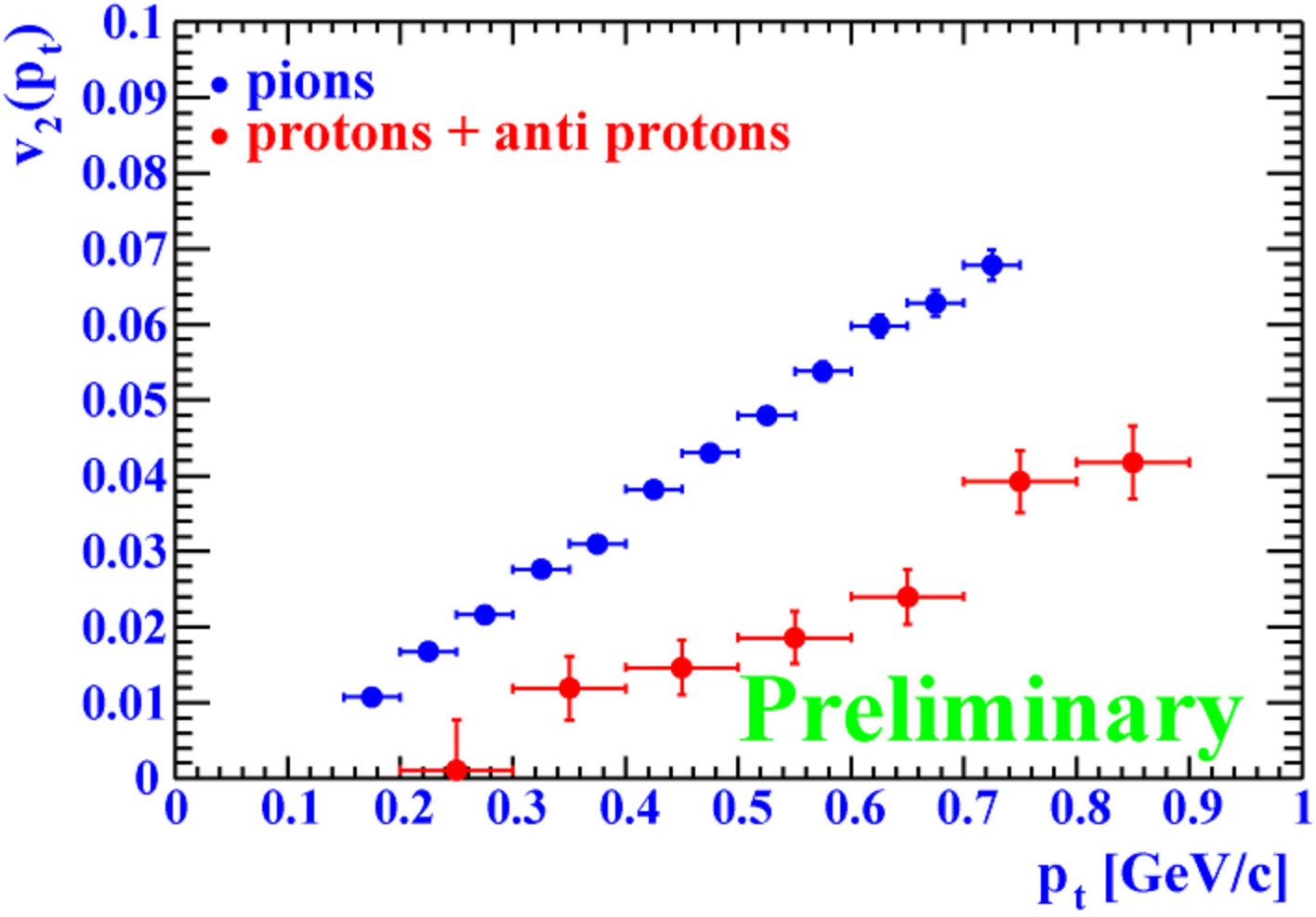
Charged particle v_2 versus Multiplicity

- Boxes show "initial spatial anisotropy" ε scaled by 0.19-0.25



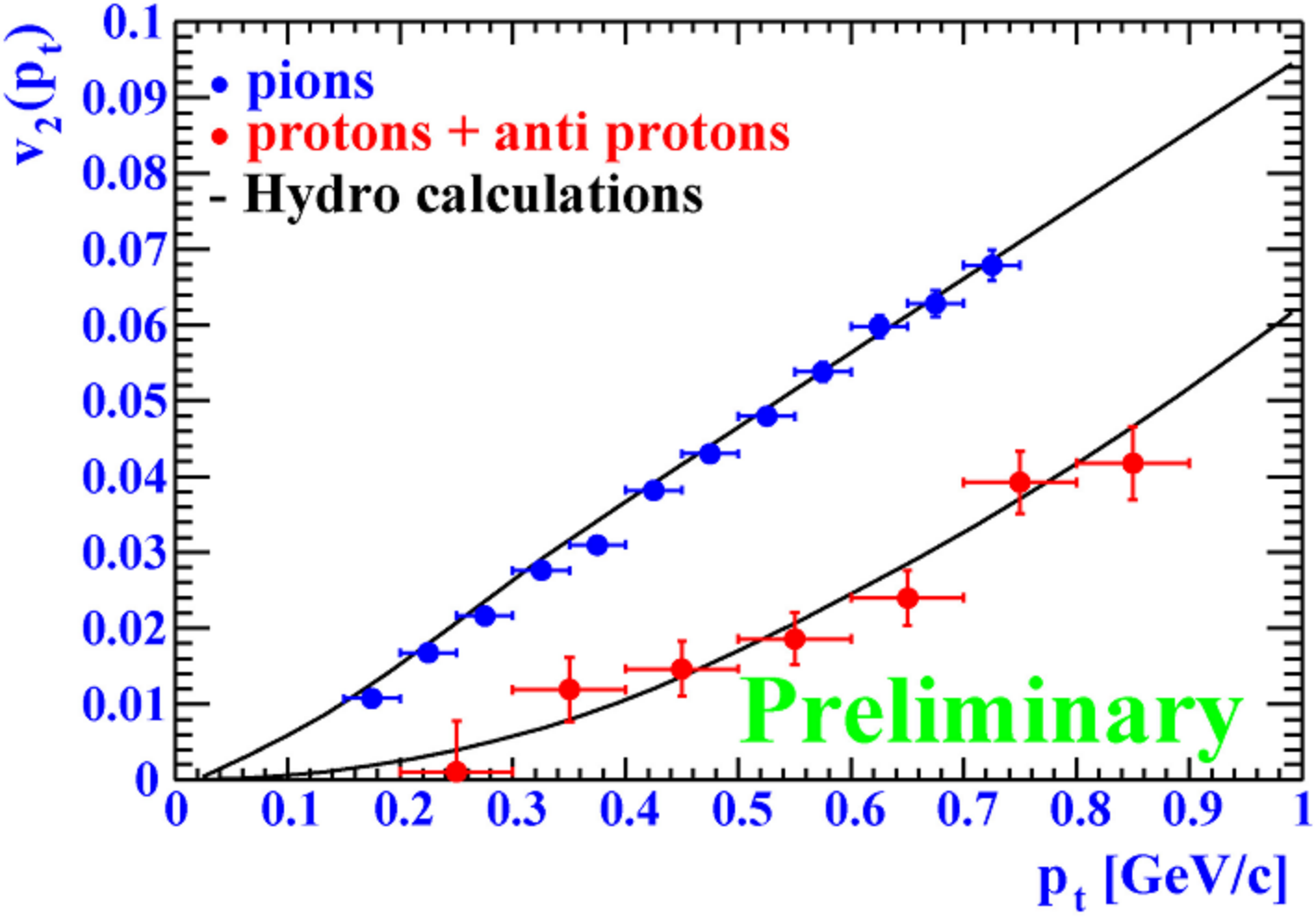
n_{ch} = primary tracks in $|\eta| < 0.75$

Charged π and $\bar{p}$+p, $v_2(p_T)$ (M.B.)



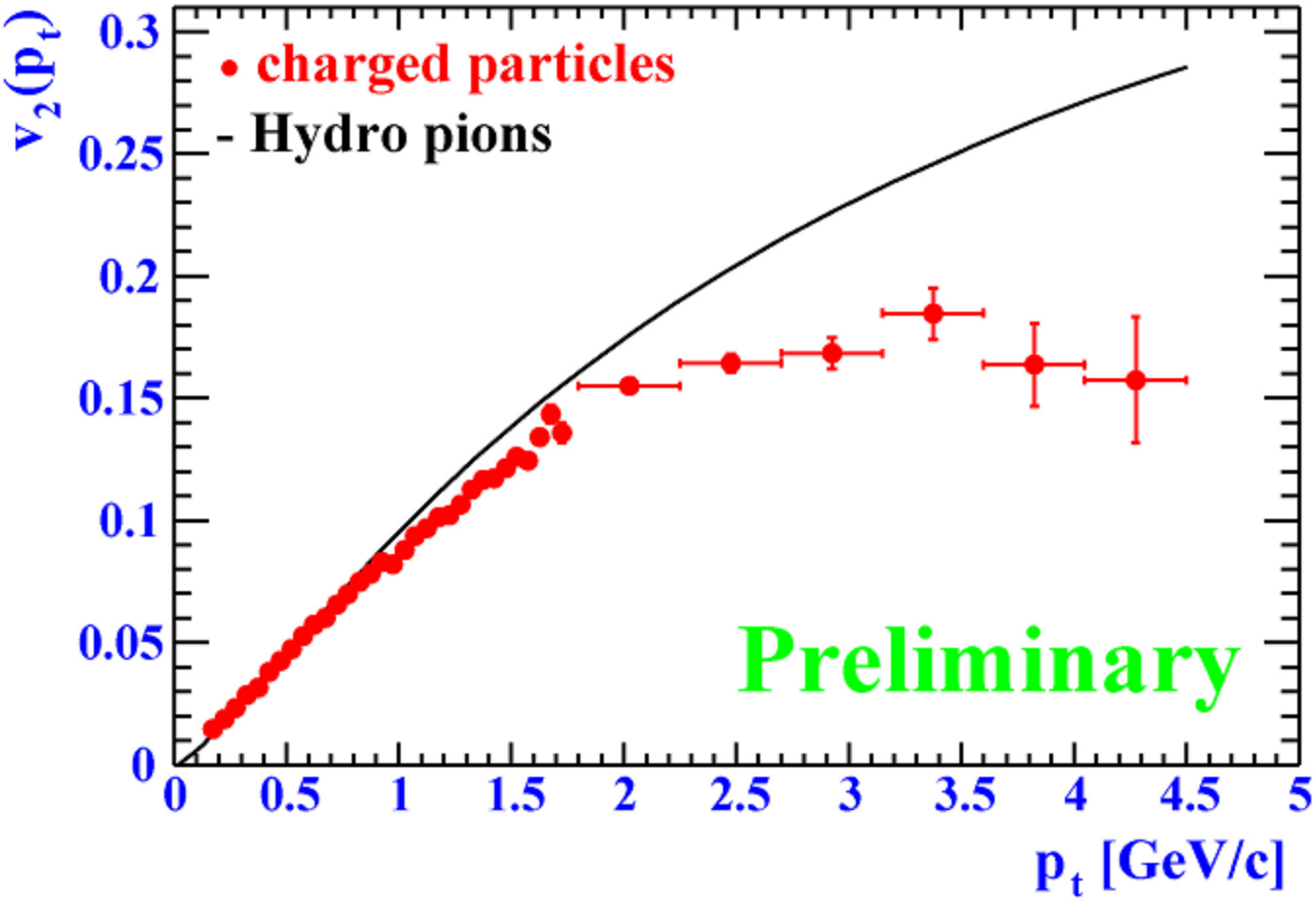
Comparison with a hydrodynamical model

- Hydrodynamical calculations: Huovinen, Kolb and Heinz



Charged particle anisotropy $0<p_T<4.5$ GeV/c

- Minimum bias data
- Only statistical errors
- Systematic error 10% - 20% for $p_t = 2 - 4.5$ GeV/c



Summary

- Net-baryon ≠ 0 at mid-rapidity
  - Anti-baryon/baryon ratios are toward 1, but still <1
- Chemical Freeze-out
  - T_{ch} : same or higher than at SPS
  - μ_B : smaller than at SPS
- HBT parameters
  - Similar to SPS
- Large anisotropic flow
  - From mid-central to central data,
    Hydrodynamical model can describe v_2 at low p_T (<2GeV/c)
- Thermal Freeze-out
  - T_{fo} : similar to SPS/AGS
  - Large radial flow
- We need energy scan between SPS and RHIC!

Future plans

- TOF
  - PID up to 2GeV/c of p_T
- SVT
  - Increasing momentum resolution
  - More strangeness baryons
- EMC
  - Electron measurement
- Full fields
  - Higher p_T measurement
  - Increasing momentum resolution
- With high statistics
  - Physics of γ, π^0, and resonances

γ and π^0

- The e^+e^- pair from γ conversion is measured
- Large γ acceptance
  - p_T = 50 MeV/c to ~4 GeV/c, $|\eta|<1.8$