# *Current Measurements of Baryon Stopping and Radial Flow*

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- Introduction
  - What and why of baryon stopping
  - Baryon stopping and related measurements
  - Understanding the mechanism of stopping
- Baryon Rapidity Distributions
  - System size dependence
  - Energy dependence
- Particle Production
  - Wounded nucleon scaling at the SPS
- Transverse Spectra
  - Flow vs. initial state scattering
- Summary + capabilities at RHIC

# Introduction

- What and why of baryon stopping

  - ❑ Baryon stopping = transport of net baryon number from target and proj region to center of mass

  - ❑ Sets initial conditions of evolution -

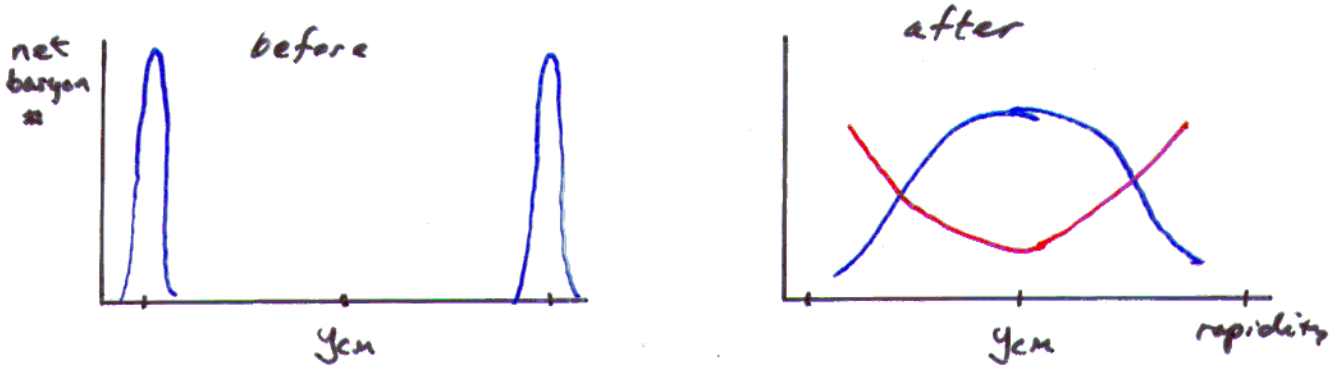
    - energy for particle production and expansion

    - sets baryon density at cm -

      - ◆ determines conditions of phase transition

      - ◆ influences ratios of produced particles

  - ❑ Interested in single inclusive rapidity distribution of net baryon number




  - ❑ What will happen at RHIC?

    - expectations based on lower energy data

- Baryon stopping measurements

  - Measured by single inclusive rapidity distributions of

    - net protons ($p$-$\bar{p}$) -

      - central collision of light->heavy nuclei
      - b selected collisions of heavy nuclei

  - Also important, but won't discuss

    - pA collisions (with some b selection)
    - net hyperons

- Understanding the mechanism of stopping

  - ❑ What carries baryon number?

    - Valence quarks vs gluon junction

  - ❑ What are experimental signatures?

    - Energy dependence

      - ◆ Is net baryon number moved to mid-rapidity in high energy systems (RHIC, LHC, HERA)?

    - Correlations in light systems

      - ◆ Does charge (valence quark) stay with baryon number in ep, pp, pA

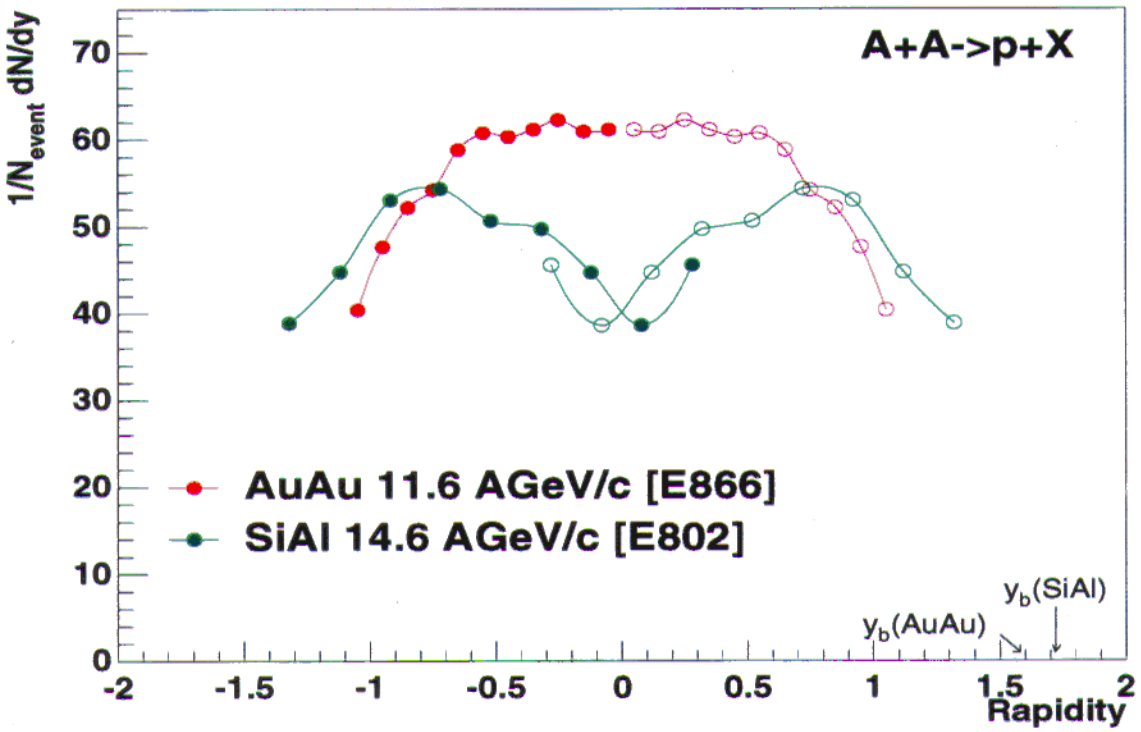
    - Hyperon production [see Vance]

    - A-A measurements at SPS?

      stopping vs. b

      $\Lambda$/p vs. b

# Stopping
# Size dependence at AGS

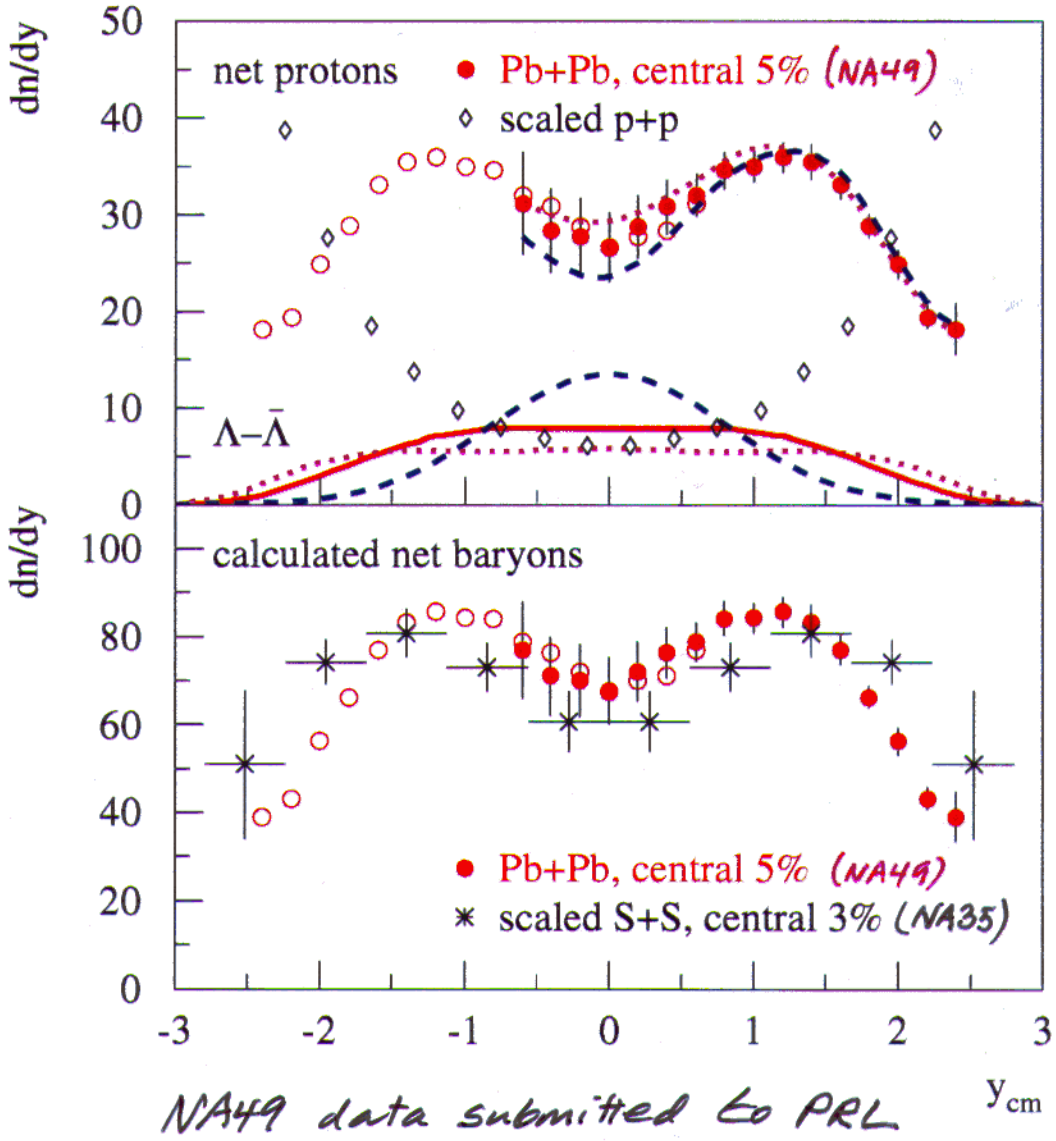



Increased stopping for larger system

Protons piled up at mid-rapidity for heavy system

Heavy systems at AGS exhibit large baryon density

# Stopping
# Size dependence at SPS



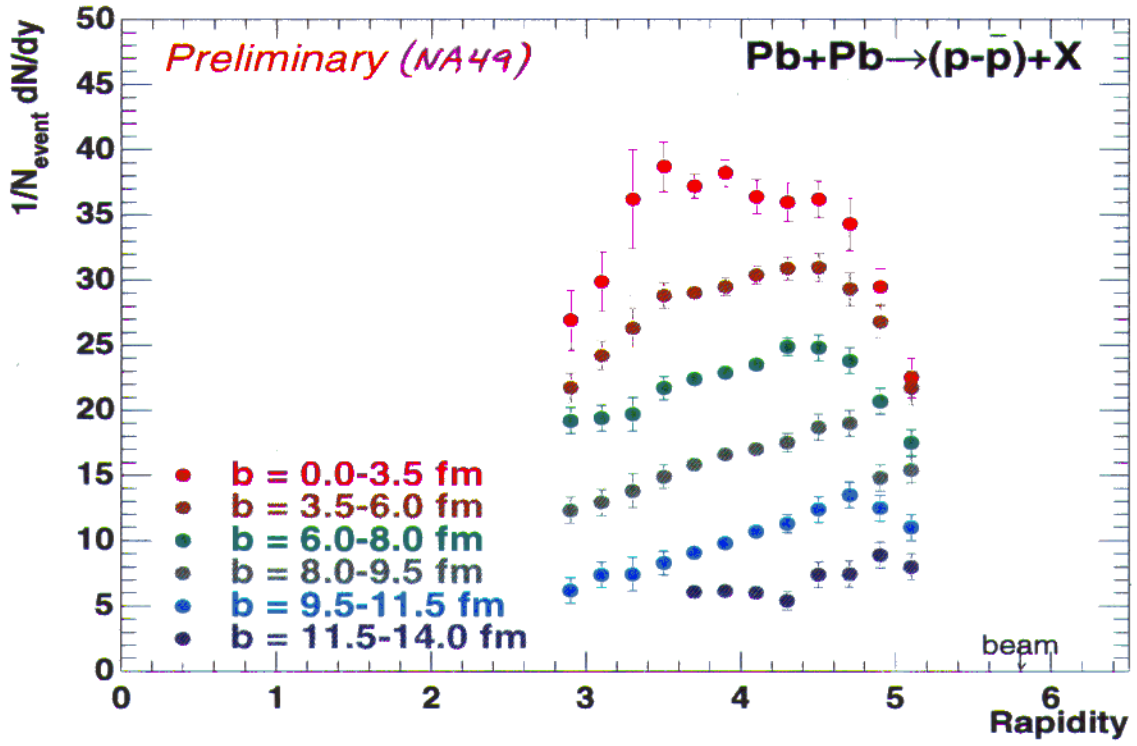

NA49 data submitted to PRL

Increased stopping for largest system

Largest system no longer fully stopped
- some transparency observed

Less difference between light and heavy than at AGS

# Stopping
# Centrality dependence at SPS




Centrality selected Pb+Pb data are preliminary, not bkgd corr.

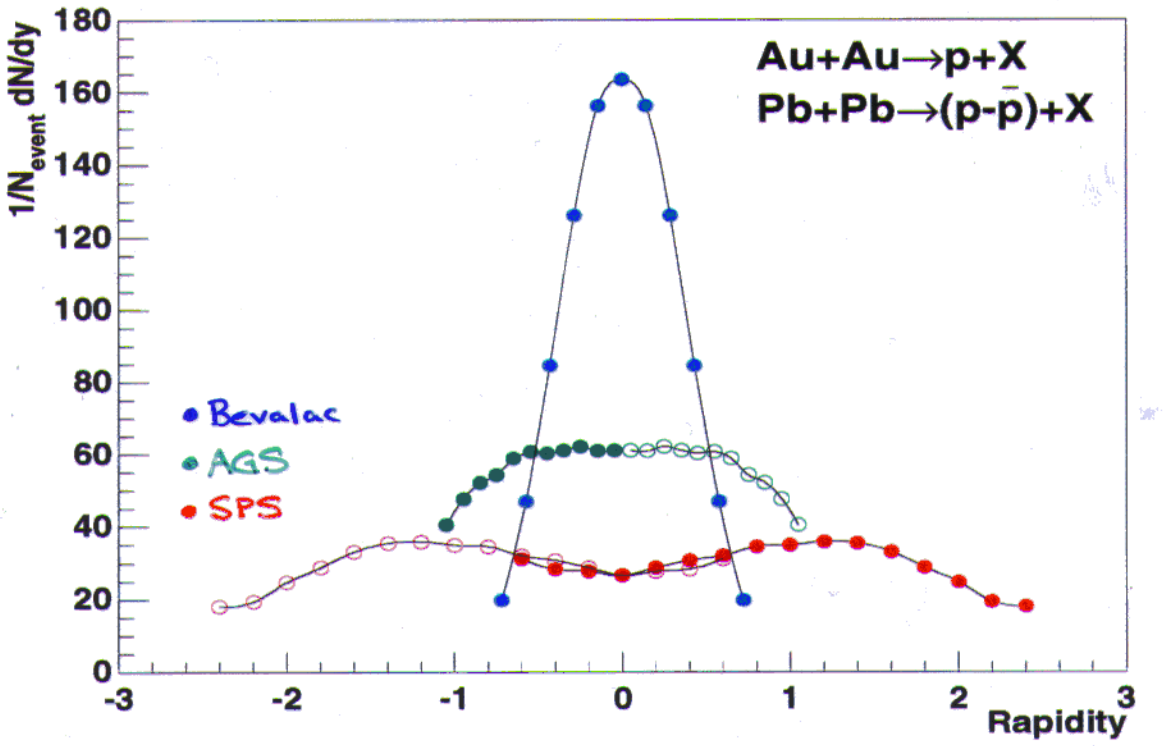
Increased stopping with increasing centrality

Dip appears starting at mid-central collisions

Increase in hyperon production?

Mid-rapidity $\Lambda/p$ ratio vs centrality should be interesting

# Stopping
# Energy dependence in Heavy Systems



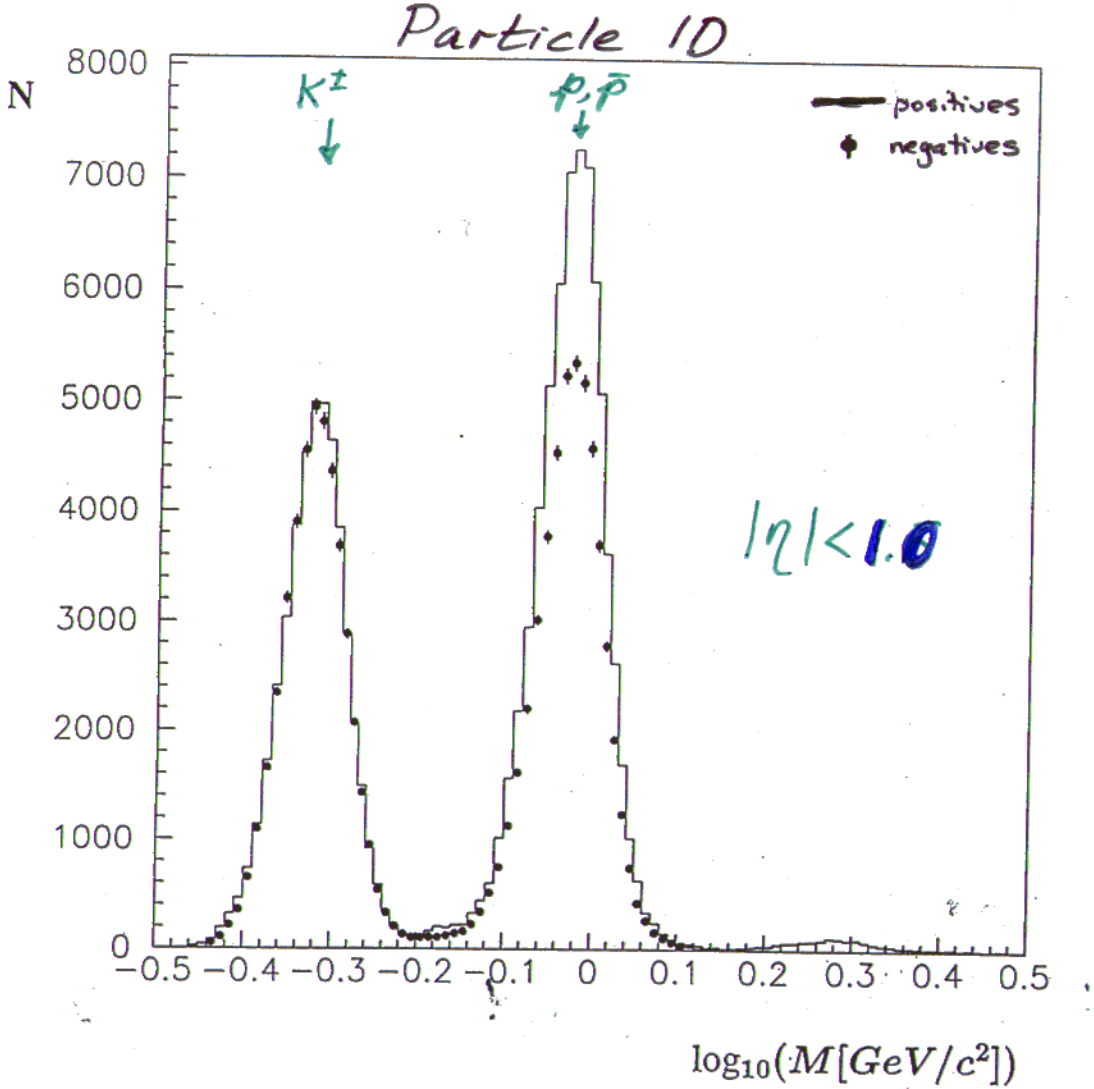

Central collisions of heavy systems

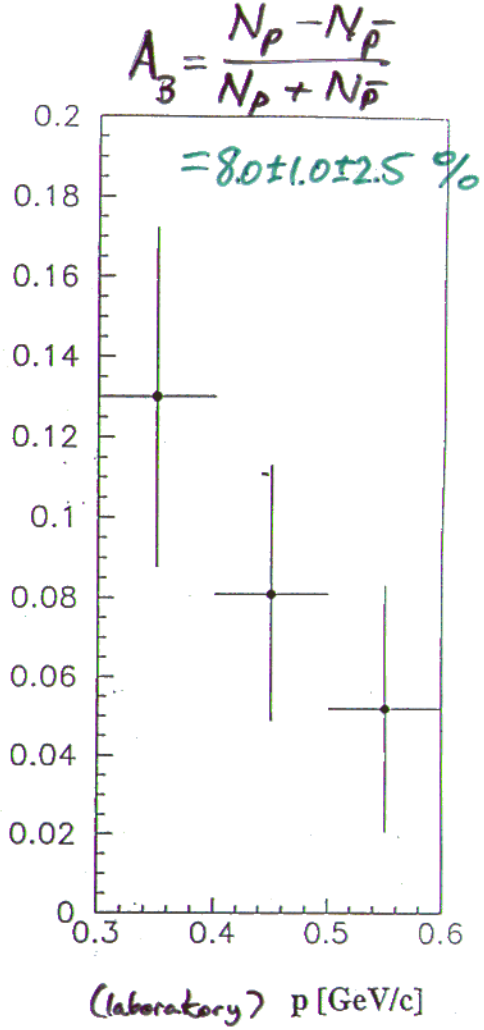
Full stopping to partial transparency for Bevalac->SPS

Spatial baryon density decreases with increasing energy

# ep collisions at HERA
## [H1 Preliminary, ICHEP98]

## Net Proton Production at $\Delta y_{beam} \simeq 7$




- charge asymmetry for baryons
- no charge asymmetry for mesons

} It's not the valence quarks!

# Particle Production and Wounded Nucleon Scaling

Scaling of Soft vs. Hard production process -

$$(A, N_{part})^{\alpha}$$

Soft - $\alpha = 1$ - wounded nucleon scaling

independent particle fragmentation

Hard - $\alpha = 4/3$ (central), $1 < \alpha < 4/3$ (non-central)

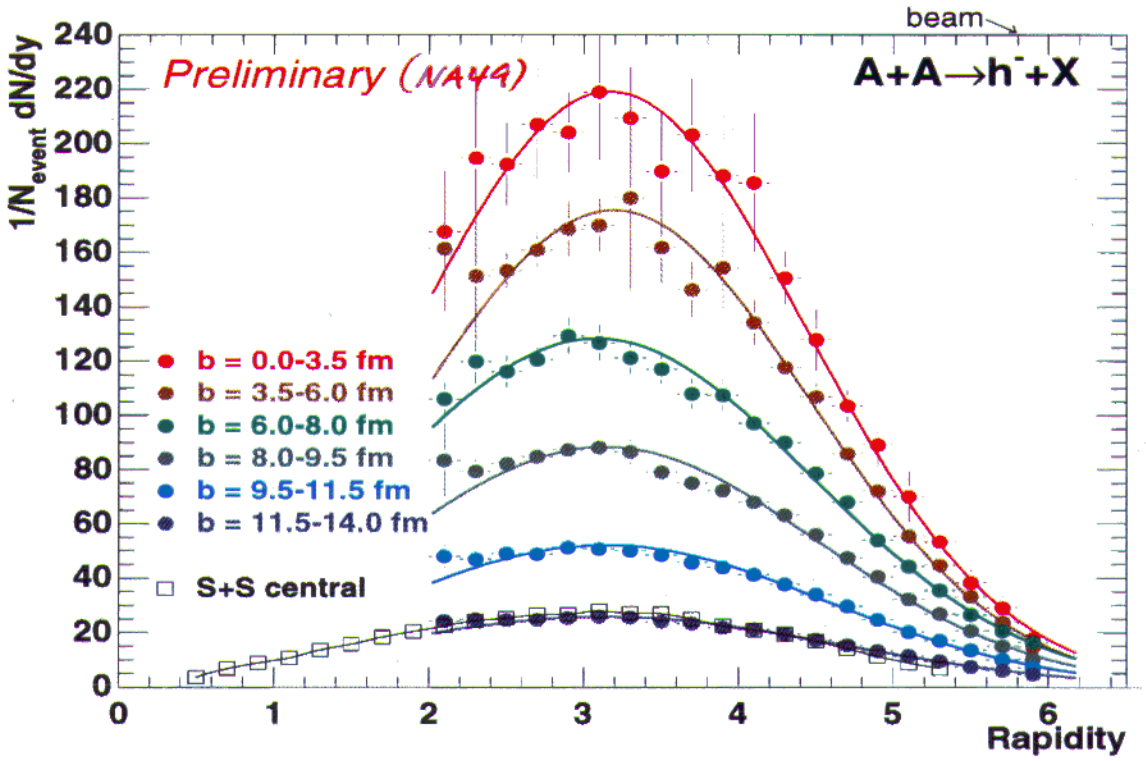
scaling with # of nucleon-nucleon collisions

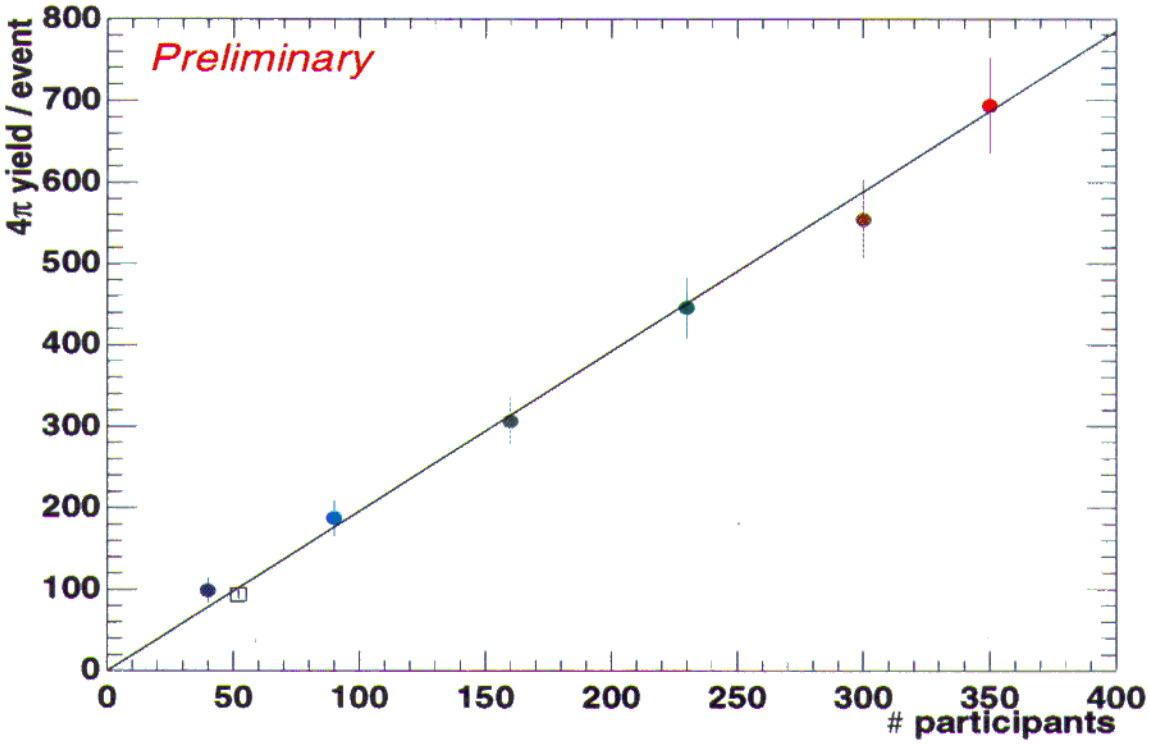
Expectations at RHIC -

HIJING central - $\frac{dN}{dy} \propto A^{1.1}$ at $\sqrt{s_{NN}} = 200 GeV$

At RHIC, a mix of soft and hard

# Particle Production
# System size dependence at SPS



## Contradiction to WN scaling from WA98?

[PRL 81, 4087 (1998)]

$\pi^0$ $p_t$ distributions for $0.4<p_T<3$ GeV/c

$\alpha = 4/3$

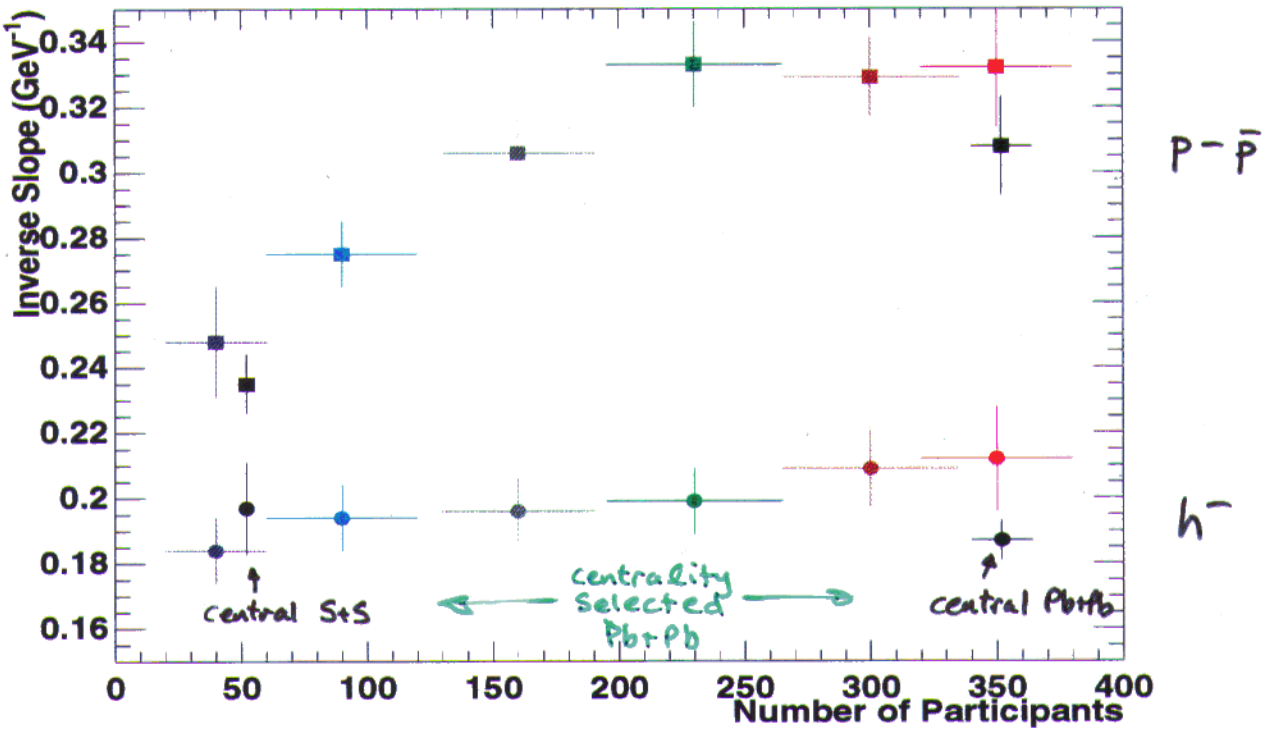
Caveats -

1) data most reliable above 0.5 GeV/c
   (less than half of yield)
2) reassement of $N_{part}$ calculation ongoing

Work to be done by NA49 and WA98

# Transverse Spectra at SPS
# Mass dependence vs system size

Mid-rapidity Transverse Slope Parameter




Pb+Pb centrality selected data are preliminary

No change in mass dependence of spectra slopes out to mid-central collisions

- Can this be understood in initial state scattering scenario?

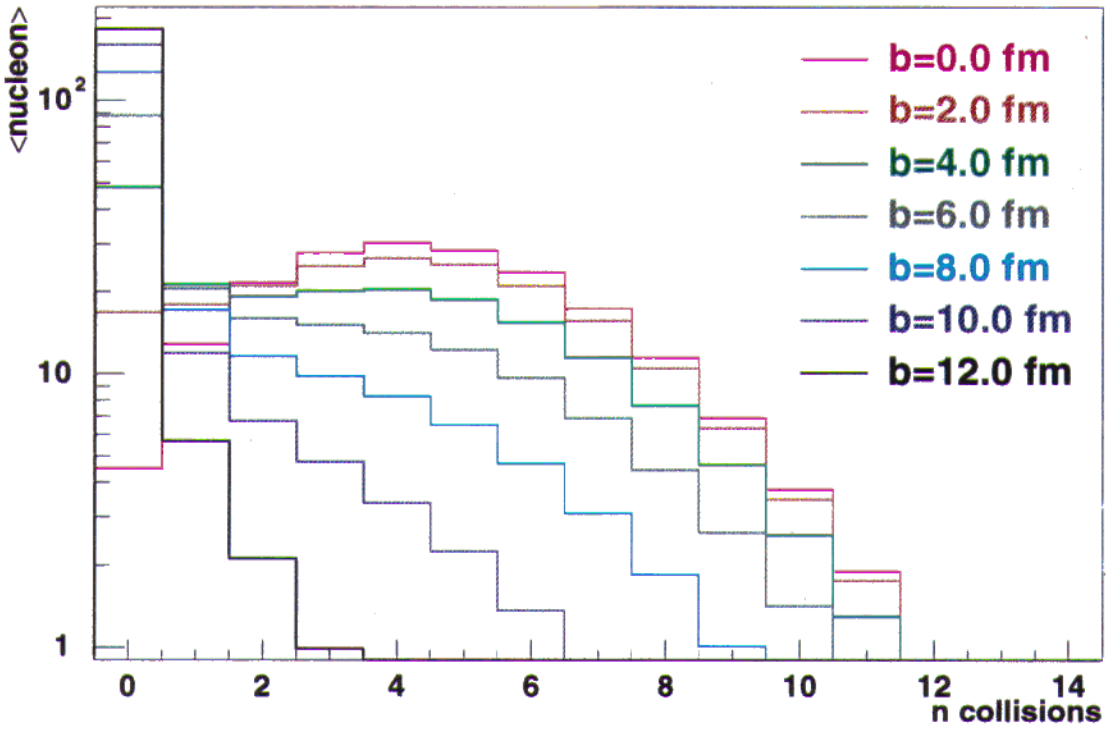
- Mid-rapidity spectra - which baryons end up at mid-rapidity?

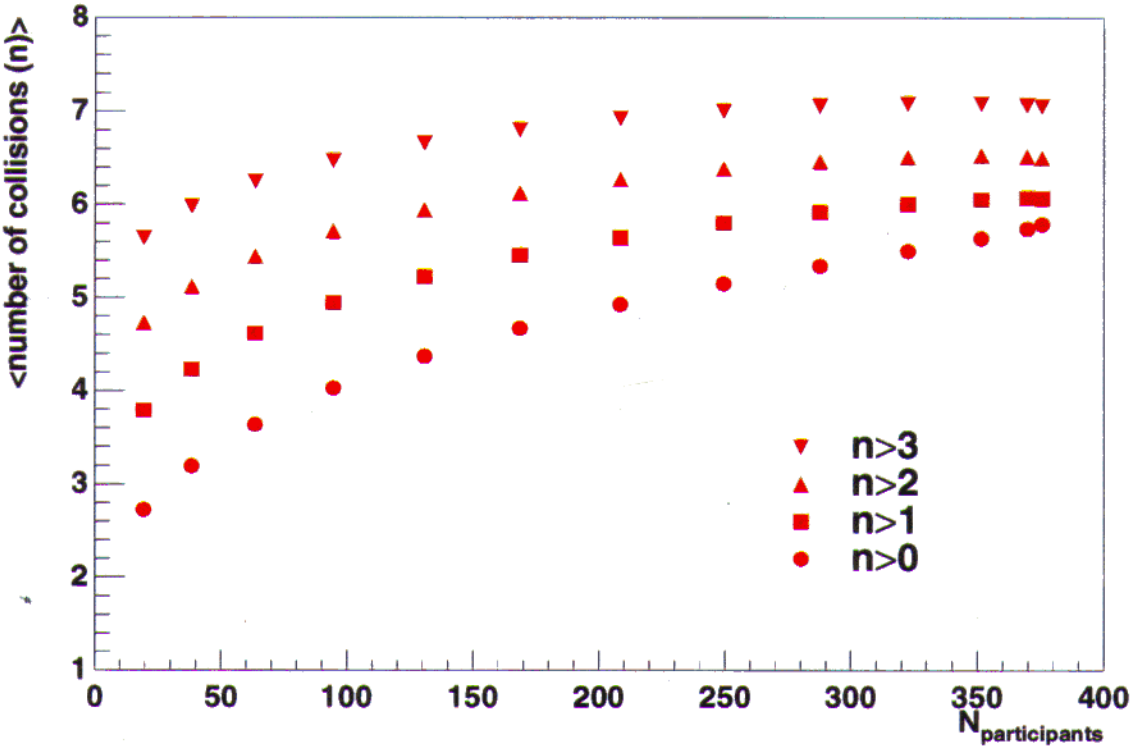
- Compare to Glauber - distributions of collisions # vs. b

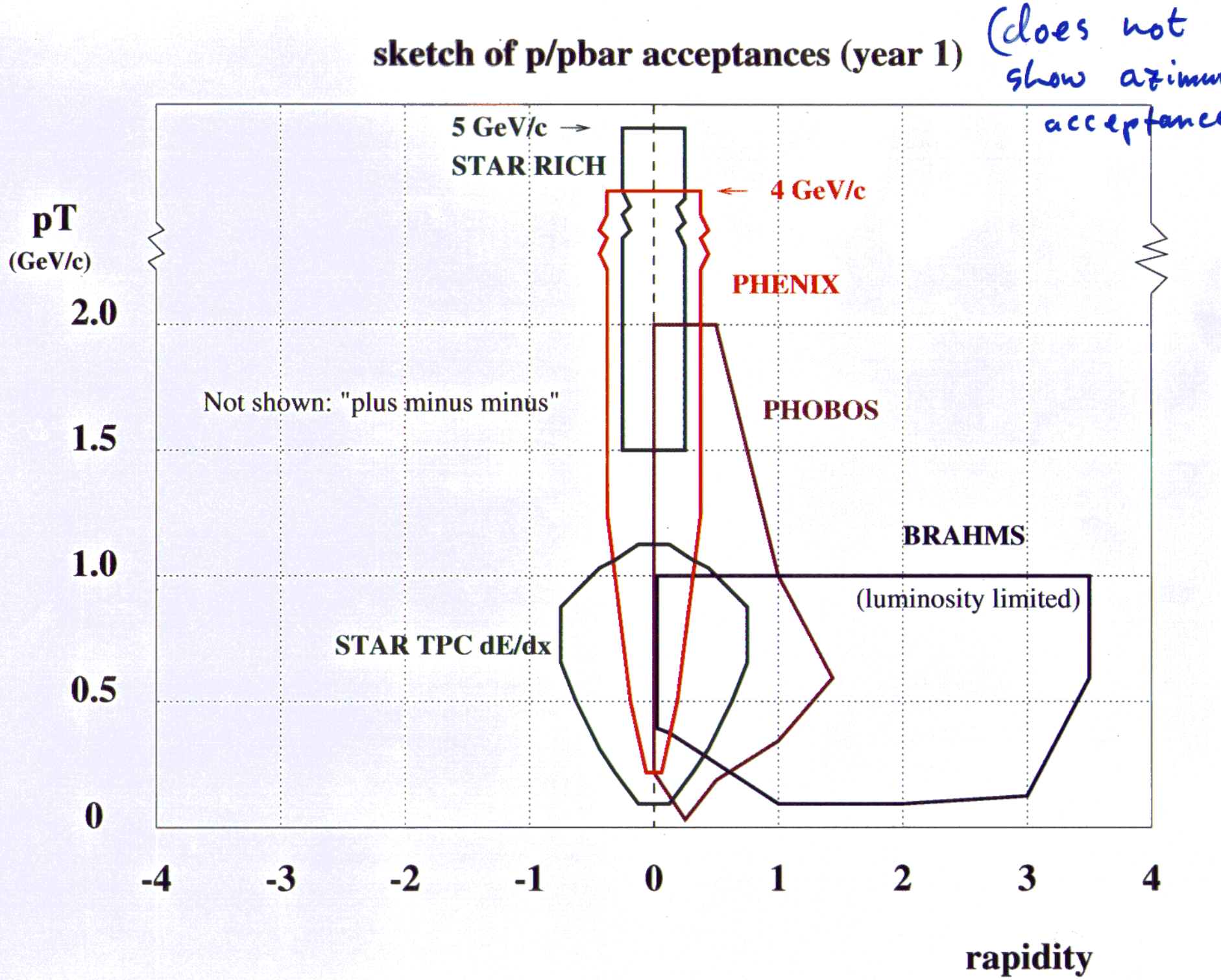
- Longitudinal vs transverse flow
  [Ollitrault, Phys.Lett.B273:32,1991]
  + other evidence for some rescattering

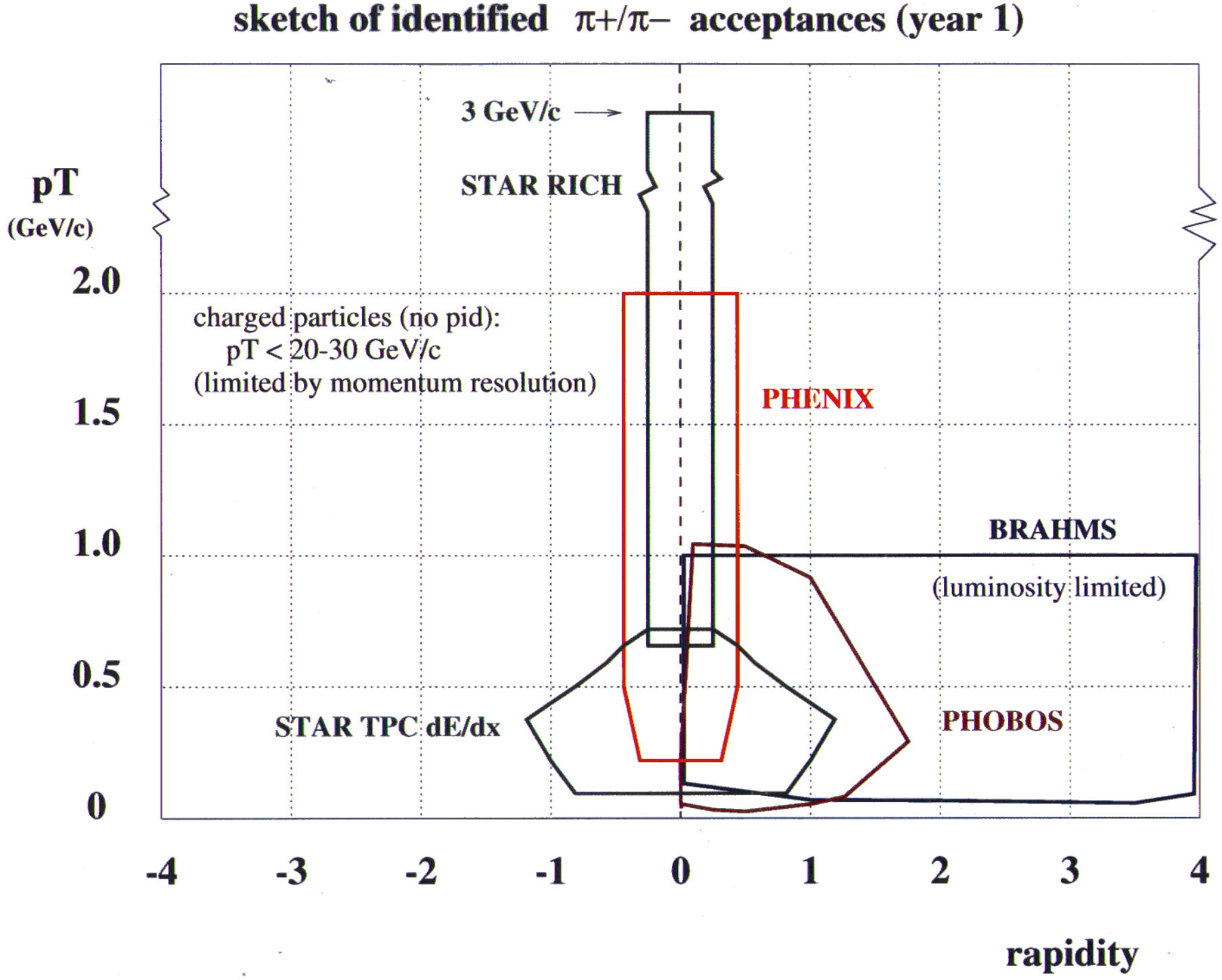
# Number of Collisions vs Centrality

[Pb+Pb, $\sigma_{in}$=30mb]




sketch of p/pbar acceptances (year 1)
(does not show azimu
acceptanc
5 GeV/c →
STAR RICH
← 4 GeV/c
PHENIX
PHOBOS
BRAHMS
(luminosity limited)
Not shown: "plus minus minus"
STAR TPC dE/dx
pT
(GeV/c)
2.0
1.5
1.0
0.5
0
-4
-3
-2
-1
0
1
2
3
4
rapidity


sketch of identified π+/π− acceptances (year 1)
3 GeV/c
STAR RICH
pT
(GeV/c)
2.0
1.5
1.0
0.5
0
charged particles (no pid):
pT < 20-30 GeV/c
(limited by momentum resolution)
PHENIX
BRAHMS
(luminosity limited)
STAR TPC dE/dx
PHOBOS
-4
-3
-2
-1
0
1
2
3
4
rapidity

# Summary

- At AGS, heaviest systems stopped.
- At SPS, limited stopped (transparency) is just starting to appear
- RHIC will be a new regime where transparency is dominant

- Interplay between number of collisions a baryon suffers, its rapidity loss, and transverse momentum generation -
  - Do data from impact parameter selected collisions reopen the debate over initial state scattering versus buildup of radial flow?

- Clear evidence from H1 for mechanism for enhanced stopping.
  - There will be a baryon asymmetry at mid-rapidity for RHIC and LHC (but probably small)!

- Complementary Detectors at RHIC will measure stopping well.