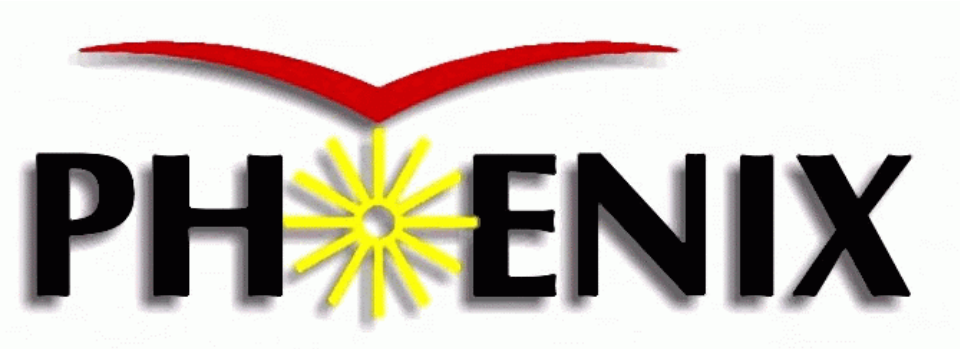

Charged Particle Multiplicity and Transverse Energy in $\sqrt{s_{nn}}$ = 130 GeV Au+Au Collisions

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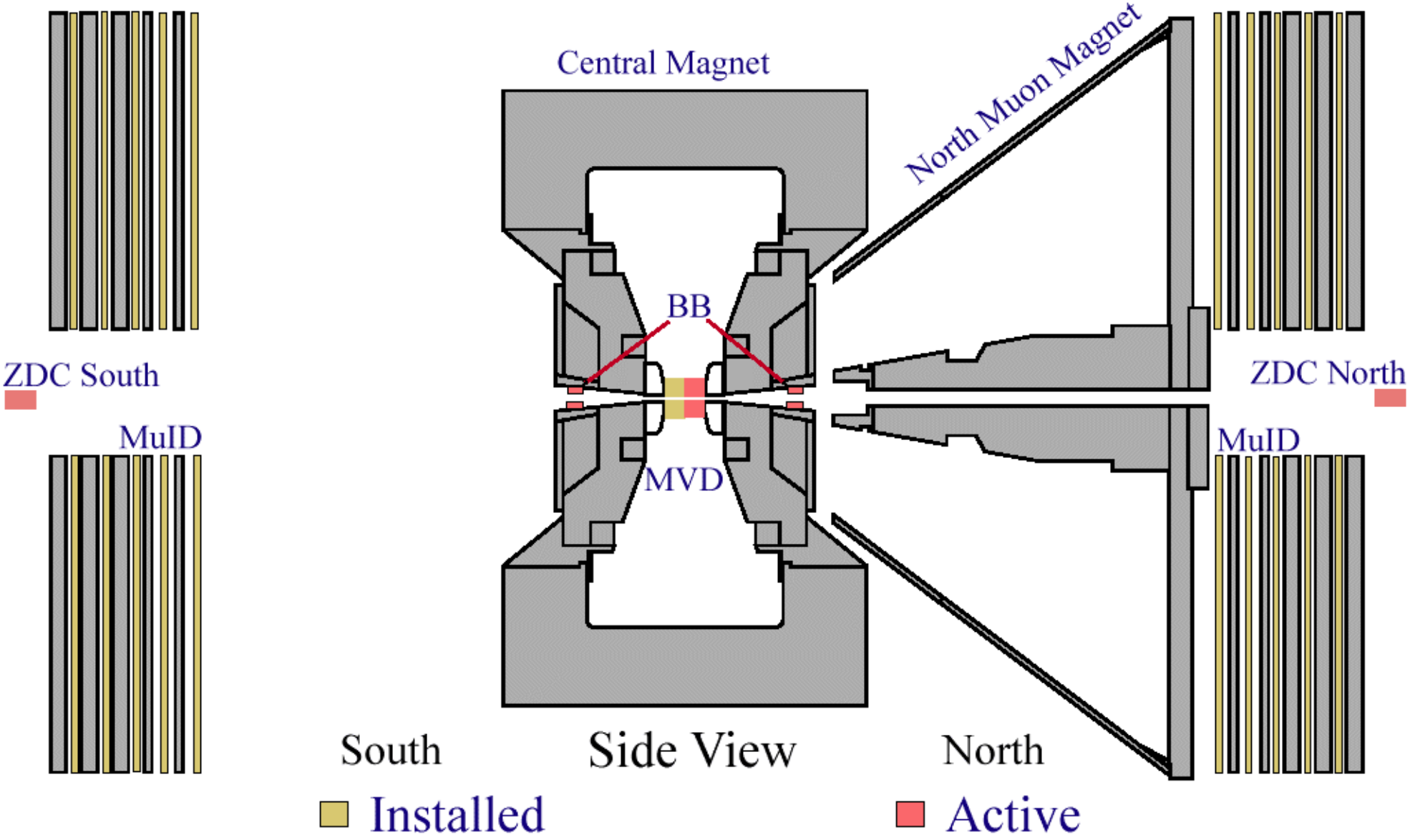
for the PHENIX Collaboration

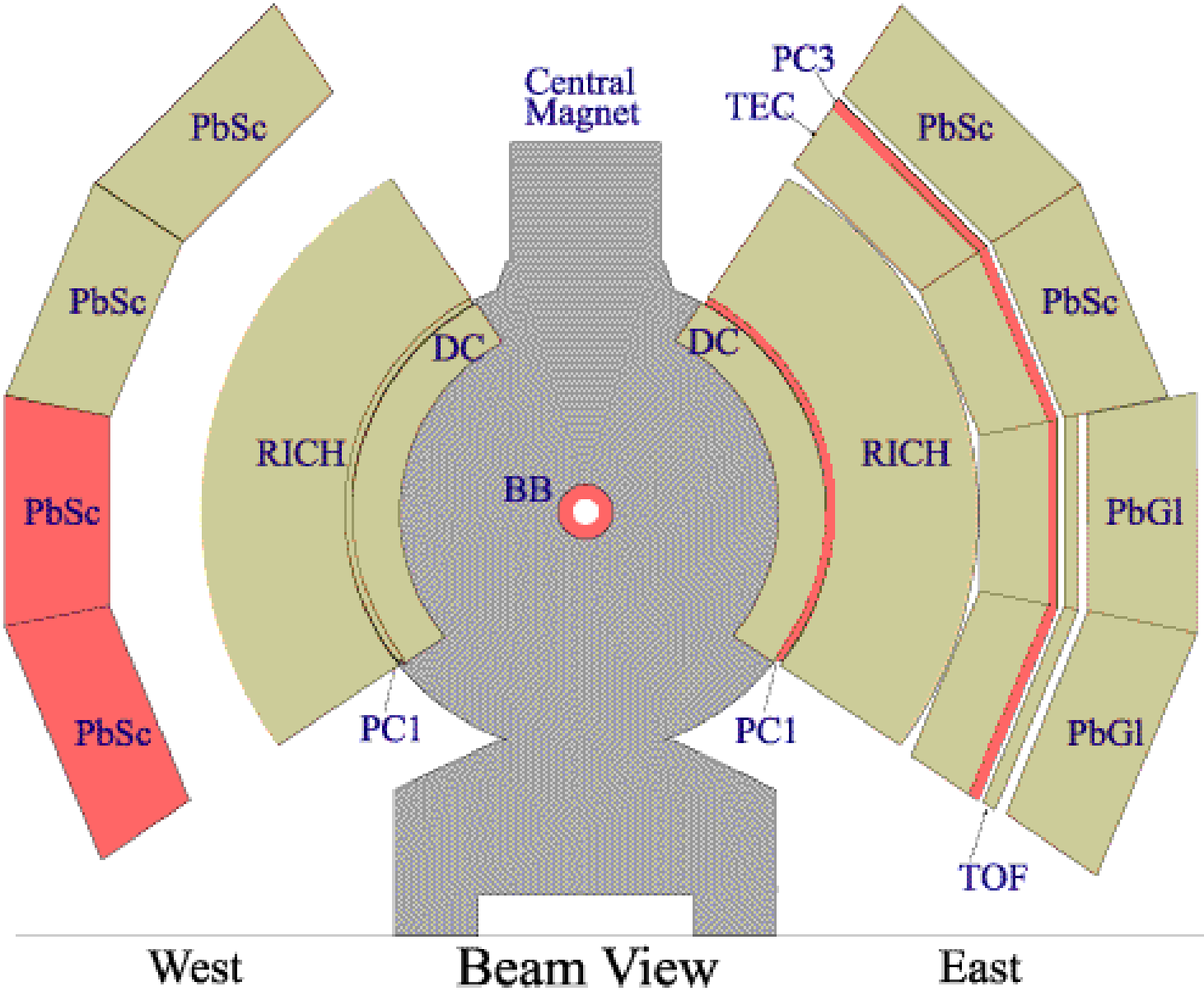
Gobal Variables: N_{ch} and E_T

- Fundamental question: Particle and E_T production proportional to N_{part} or N_{coll} ?
- Constraints for models of particle production
  - centrality dependence
  - $\sqrt{s}$ dependence
- Information about initial conditions in heavy ion collisions:
  - Energy density
  - Gluon saturation ?
  - Longitudinal p dV work in plasma phase ?
- Different behavior compared to $\sqrt{s_{nn}}$ = 17.2 GeV Pb+Pb collisions at CERN SPS ?

PHENIX-Setup: Side View



PHENIX-Setup: Beam-View



Detectors used in N_{ch} and E_T Measurement

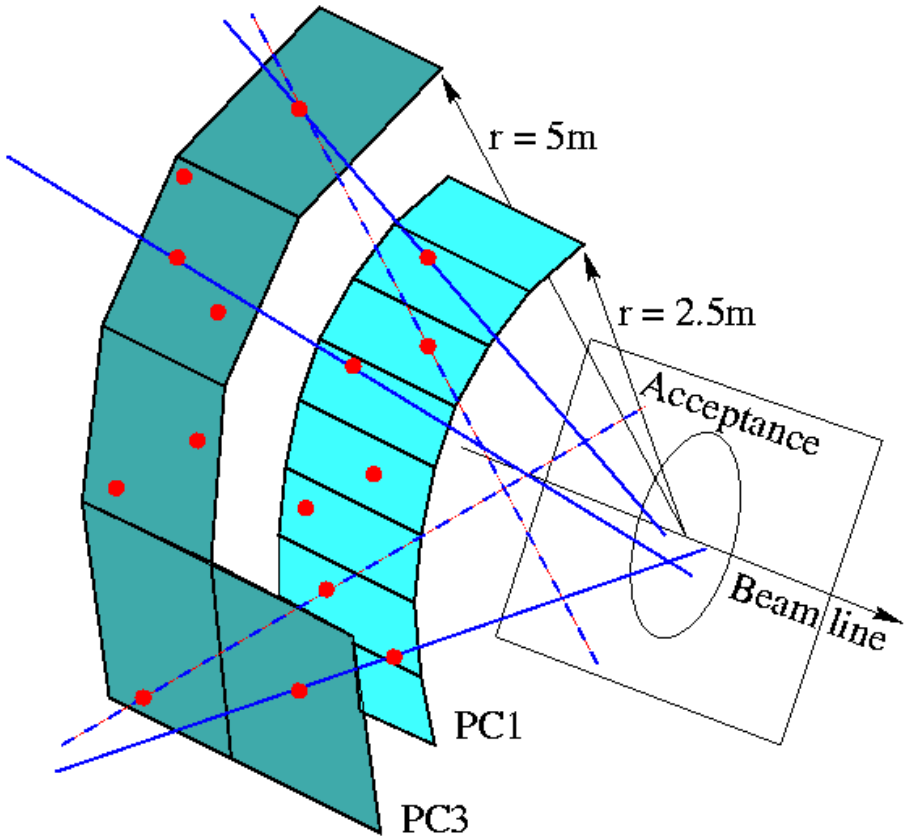
- Pad Chambers (PC)
  - Two layers (PC1, PC3) with radial distance of 2.49 m and 4.98 m to interaction region
  - Each layer consists of 8 wire chambers with cathode pad readout
  - Intrinsic efficiency for charged particles > 99%
  - Acceptance:
    $|\eta| < 0.35$, $\Delta\Phi = 90°$

- Lead Scintillator Calorimeter (PbSc)
  - Two sectors, each with 2592 individual towers
  - Towers:
    - Alternating lead and scintillator tiles
    - Depth: 18 radiation length (X_0)
    - Cross section: 5.54 x 5.54 cm^2
  - Energy resolution
    $$\sigma_E / E = 8.2\% / \sqrt{E(\mathrm{GeV})} \oplus 1.9\%$$
  - Acceptance:
    $|\eta| < 0.38$, $\Delta\Phi = 44.4°$

N_{ch} Measurement

- Strategy:
  count tracks in PC1/PC3 on statistical basis, no explicit track reconstruction

- Analysis steps:
  - Reconstruct vertex (with lines formed by all possible PC1/PC3 hit combinations)
  - Count lines that fall in a window around the reconstructed vertex
  - Determine combinatorial background lines by event mixing



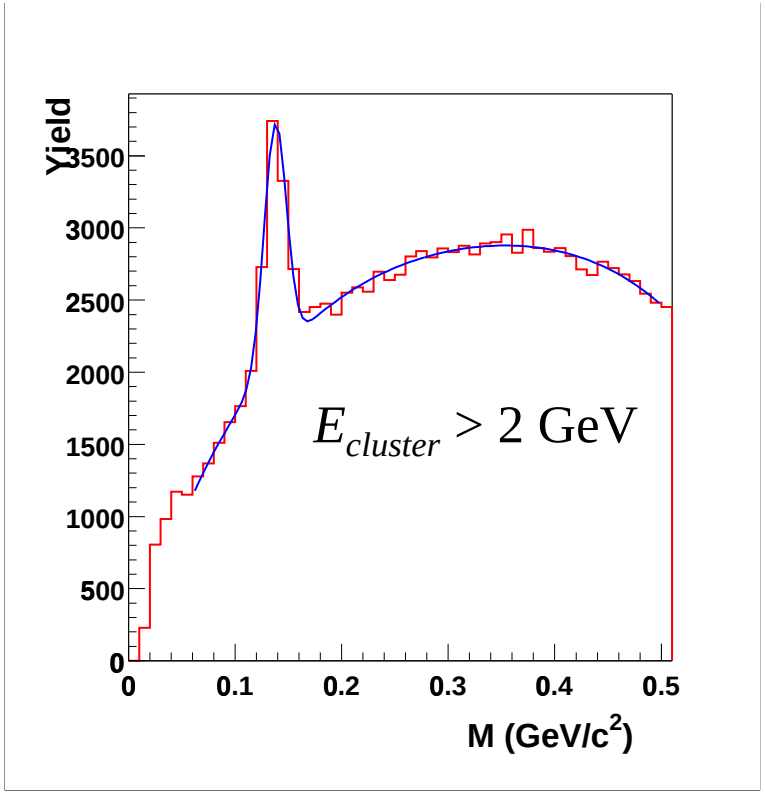
Measurement without magnetic field!

E_T Measurement

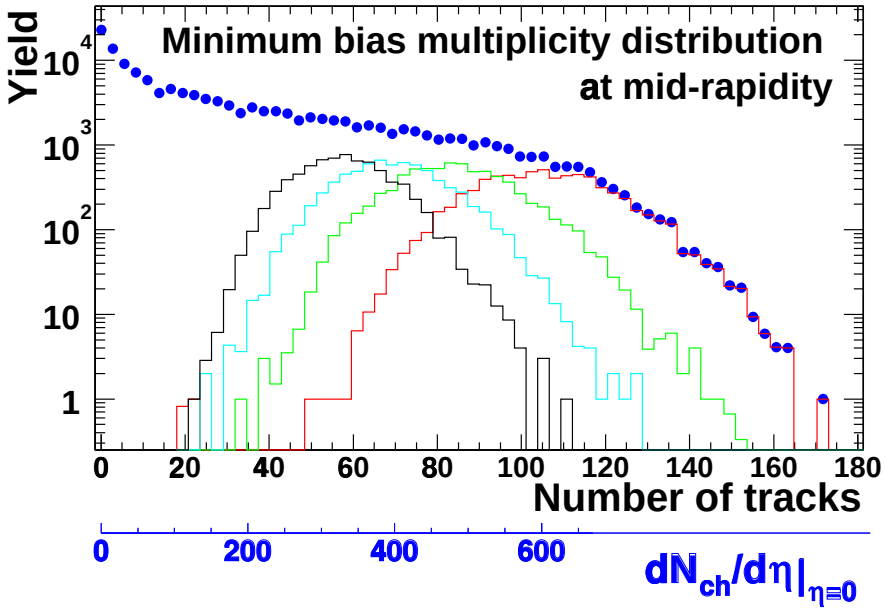
- Definition
  - $E_T = \sum_i E_i \sin\vartheta_i$
  - Convention
    - Nucleons: E_i = kinetic energy
    - All other particles: E_i = total energy
- PbSc acts as thin hadronic calorimeter:
  p_T threshold for complete stopping
  - Charged pions: 0.35 GeV/c
  - Kaons: 0.64 GeV/c
  - Protons: 0.94 GeV/c
- Correction factor from Hijing + Geant simulation

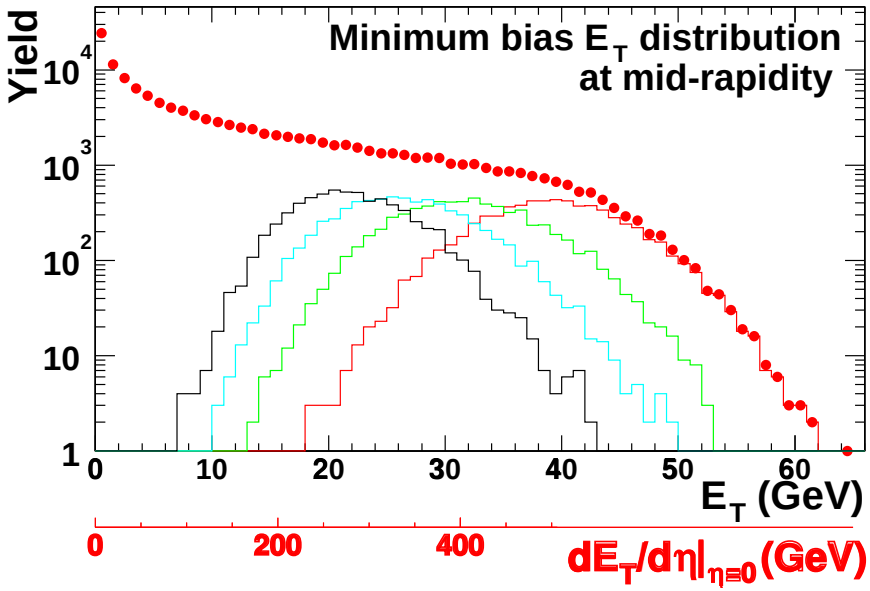
$$E_T^{true} / E_T^{PbSc} = 1.17 \pm 0.01$$

- Systematic error of PbSc energy scale less than 1.5%
  $\rightarrow$ estimated from π^0-peak position measured with PbSc



N_{ch} and E_T Distribution

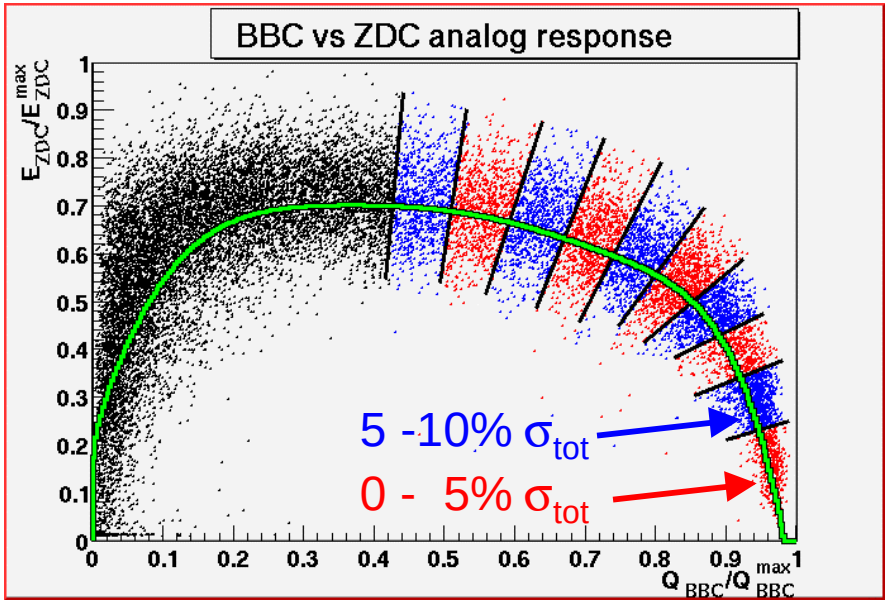




- Shape of N_{ch} and E_T distribution dominated by nuclear geometry
- Shape above the ´knee´ depends on detector aperture

Centrality Selection

- Centrality classes defined with BBC and ZDC
- Trigger: BBC coincidence
  → accepts 92% of total inel. Au+Au cross-section (σ_{tot} = 7.2 b)



- Calculation of N_{part} and N_{coll}
  - Glauber Monte-Carlo approach: geometrical picture of a A+A reaction
    - Straight line nucleon trajectories
    - Nucleon-nucleon collision takes place if

$$d < \sqrt{\sigma_{nn,inel}/\pi}$$

    - Fluctuations: simple sim. of ZDC and BBC detector response
  - Parameters
    - Woods-Saxon Nuclear Density distribution with

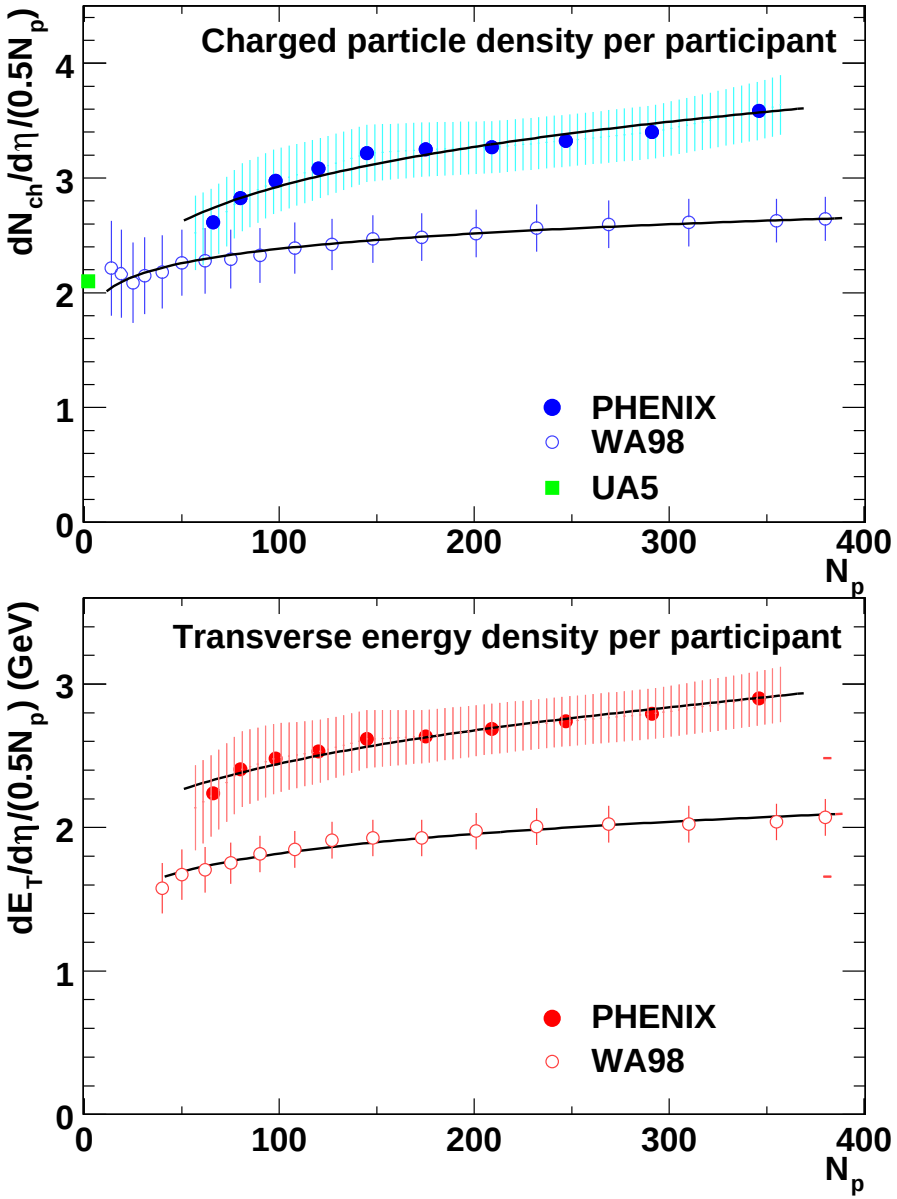
$$R = 1.19A^{1/3} - 1.61A^{-1/3} = 6.65 \text{ fm}$$

$$d = 0.54 \text{ fm}$$

    - Nucleon-nucelon inel. Cross section

$$\sigma_{nn,inel} = 40 \text{ mb}$$

Centrality Dependence



- Comparison to CERN SPS results (Pb+Pb at $\sqrt{s_{nn}}$ = 17.2 GeV)

$$dX / d\eta = c \cdot N_{part}^{\alpha}$$

α-value	$dN_{ch}/d\eta$	$dE_T/d\eta$
PHENIX	1.16 ± 0.04	1.13 ± 0.05
WA98	1.07 ± 0.04	1.08 ± 0.06

- $dE_T/dy \approx 690$ GeV (central Au+Au):

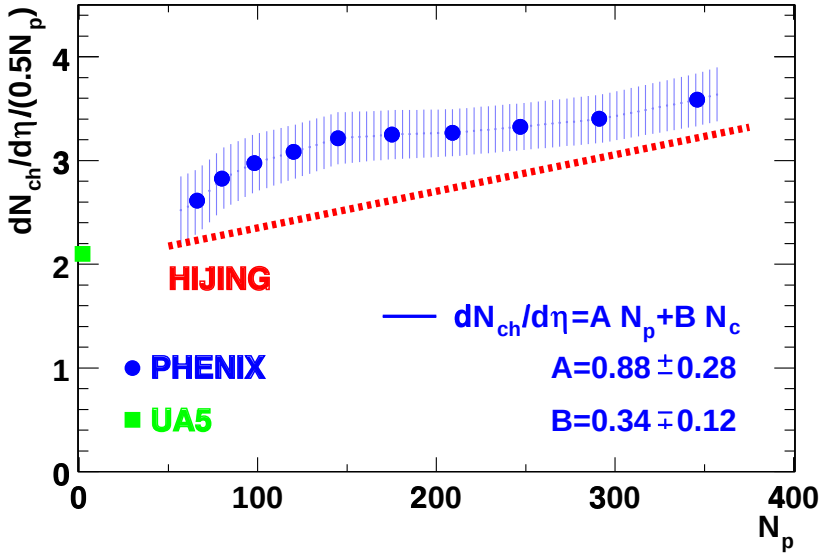
  Energy density from Bjorken formula

$$\varepsilon \approx 5.0 \text{ GeV / fm}^3$$

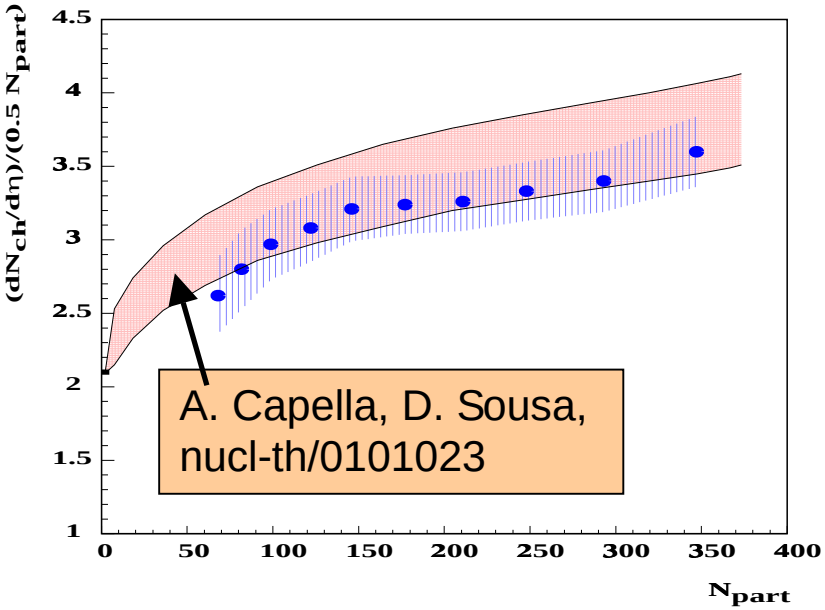
  70% larger than at CERN SPS

Interpretation of Centrality Dependence

- Hijing:
  - soft particle production + pQCD mini-jet production above transverse momentum p_0 = 2 GeV
  - $dN_{ch} / d\eta = A \cdot N_{part} + B \cdot N_{coll}$
  - Exp. result B/A = 0.38 ± 0.19 indicates contribution of hard component

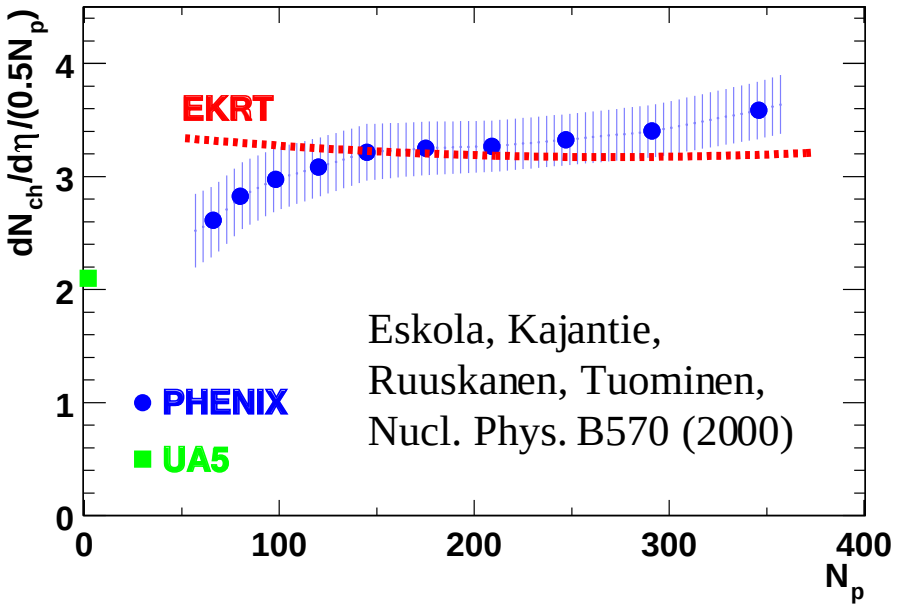


- Dual Parton Model
  - No hard component
  - But: Soft component that scales with N_{coll} (contribution from $q_{sea} - \bar{q}_{sea}$ strings)

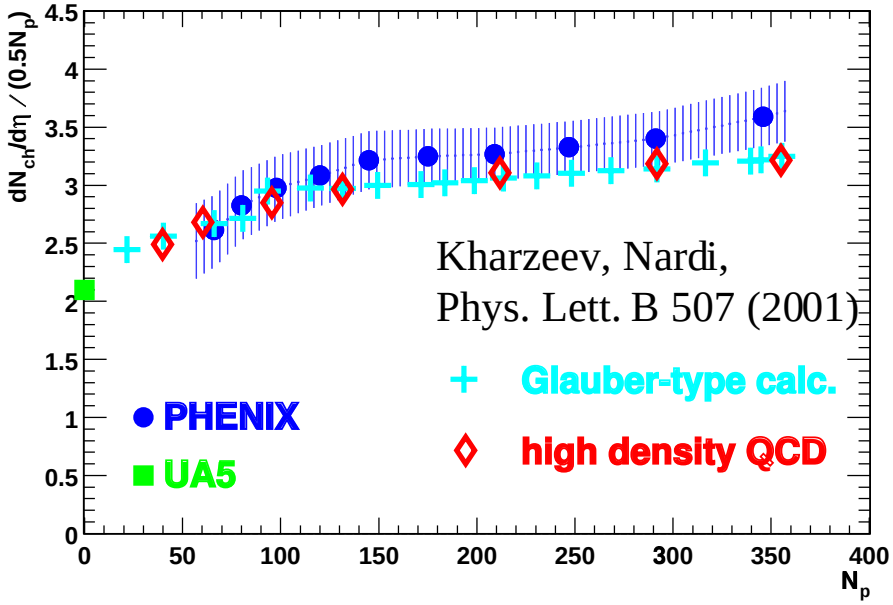


Comparison to Saturation Models

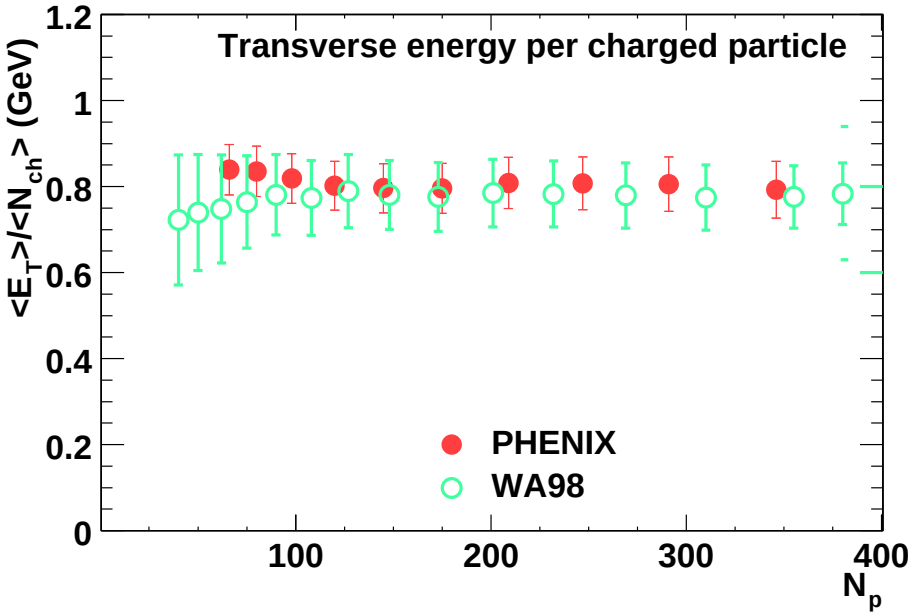
- EKRT saturation model
  - Phase space density of gluons saturates below some transverse momentum scale $p_0 < p_{sat}$ ($gg \rightarrow g$ recombinations)
  - Predicted N_{ch} in reasonable agreement with data
  - Predicted centrality dependence not observed

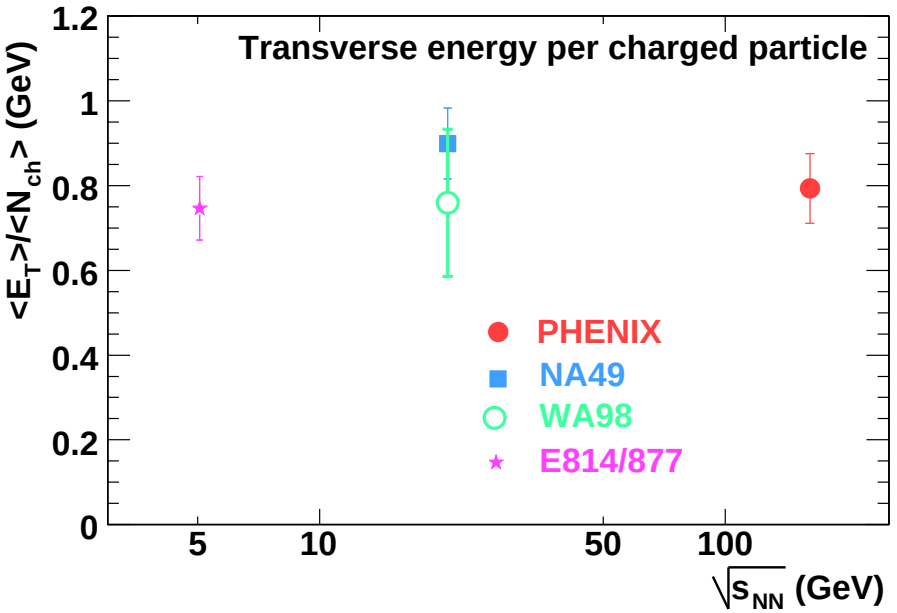


- Kharzeev, Nardi saturation model
  - N_{ch} normalized to data for central Au+Au reactions
  - Centrality dependence agrees with data
  - Simple Glauber-type calculation gives similar results



E_T per N_{ch}





- E_T / N_{ch} independent of centrality
- Similar E_T / N_{ch} values as in heavy ion collisions at SPS and AGS energies
- E_T or E_T / N_{ch} :
  - Probe of the longitudinal pressure in the plasma phase
  - EKRT prediction: final, measureable E_T much smaller than initially produced E_T due to longitudinal p dV work

Summary

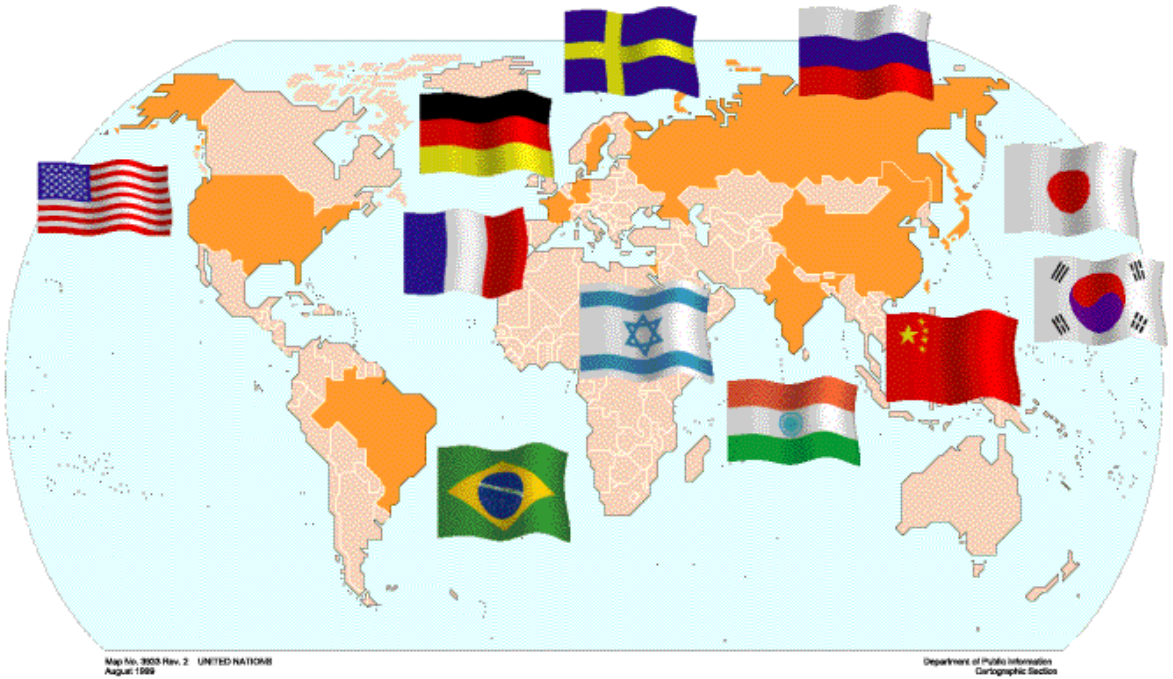
- dN_{ch}/dy and dE_T/dy in central Au+Au collisions at $\sqrt{s_{nn}}$ = 130 GeV approx. 70-80% higher than $\sqrt{s_{nn}}$ = 17.2 GeV Pb+Pb results at CERN SPS

- Stronger increase of dN_{ch}/dy and dE_T/dy with N_{part} than observed at CERN SPS

- Interpretation of centrality dependence model dependent

- Within models like Hijing: Indication of contribution from hard processes to N_{ch}
  - ≈ 30% in semi-central reactions
  - ≈ 50% in central reactions

PHENIX



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