Charge Particle Multiplicity and Transverse Energy Measurements in Au-Au collisions in PHENIX at RHIC

QM2002, July 18, 2002

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PHENIX Setup, Year-2

Charged Multiplicity

Pad Chambers:

R_{PC1} = 2.5 m

R_{PC3} = 5.0 m

$|\eta|<0.35$, $\Delta\varphi=\pi$

Transverse Energy

Lead-Scintillator EMCal:

R_{EMC} = 5.0 m

$|\eta|<0.38$, $\Delta\varphi = (5/8)\pi$

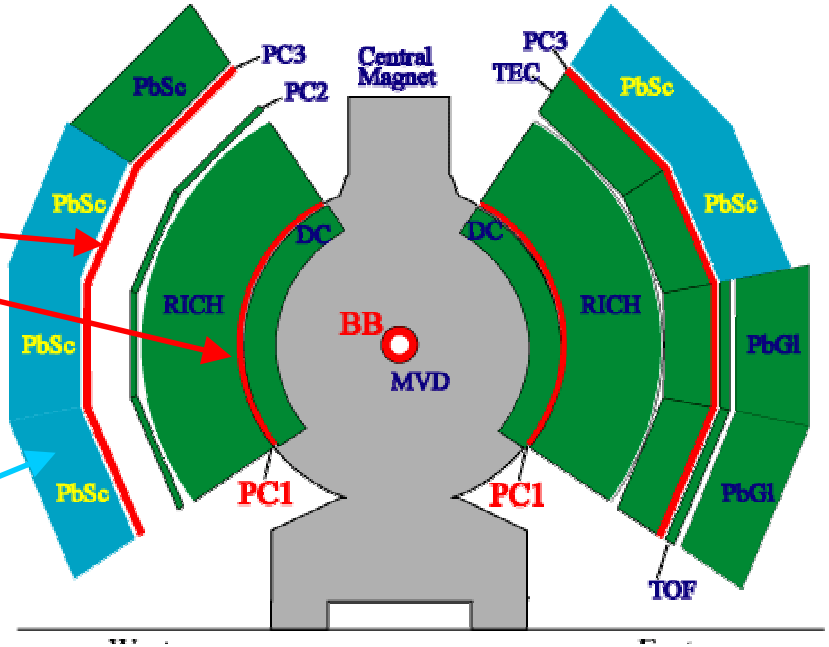
Trigger

Beam-Beam Counters:

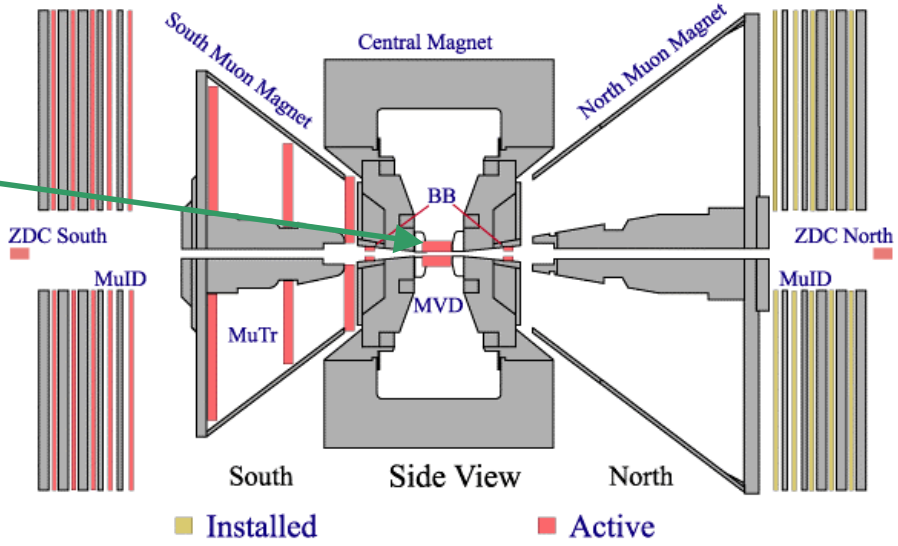
$3.0<|\eta|<3.9$, $\Delta\varphi = 2\pi$

Zero-Degree Calorimeters:

$|\eta| > 6$, $|Z|=18.25$ m



PHENIX Detector - Second Year Physics Run



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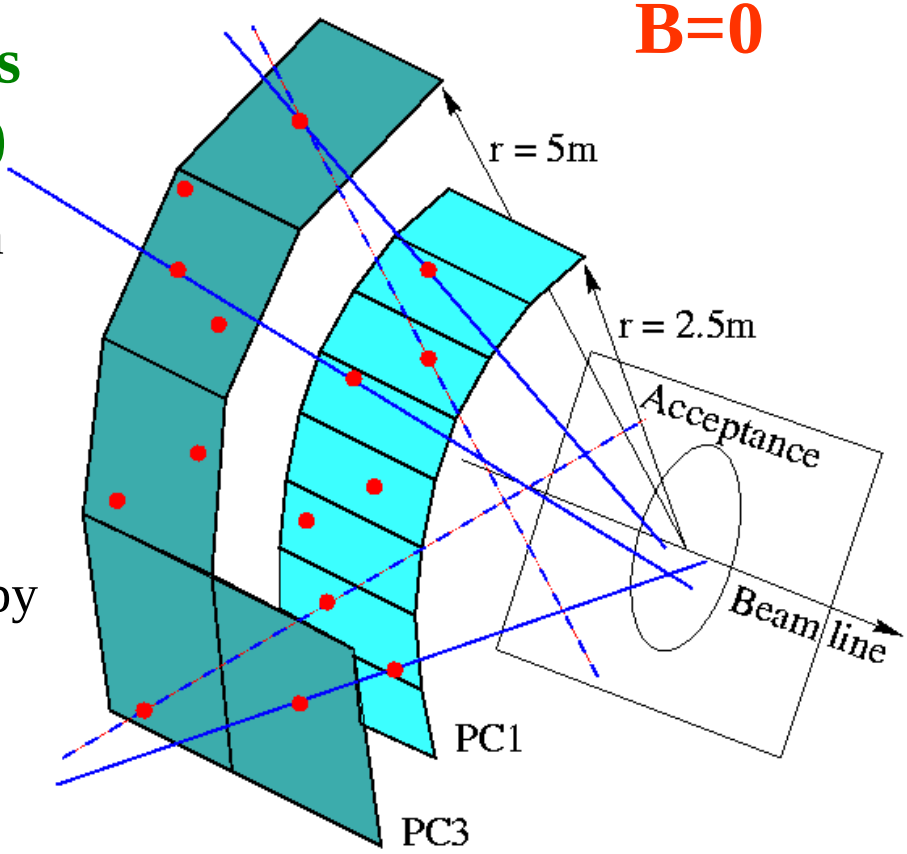
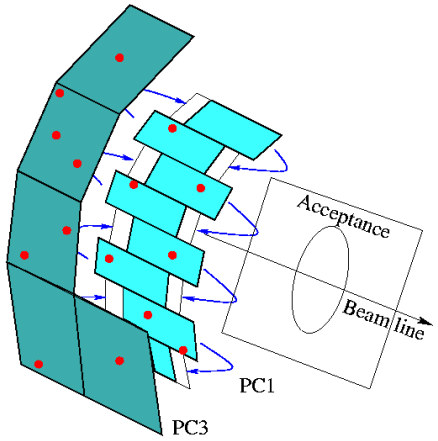
Charged Multiplicity Measurements

Count tracks on a statistical basis (no explicit track reconstruction)

- Combine all hits in PC3 with all hits in PC1.
- Project resulting lines onto a plane through the beam line.
- Count tracks within a given radius.
- Determine combinatorial background by event mixing





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Transverse Energy Measurements

Convention: $E_T = \sum_i E_i \sin\theta_i$

$E_i = E_i^{tot} - m_N$ for baryons

$E_i = E_i^{tot} + m_N$ for antibaryons

$E_i = E_i^{tot}$ for others

Different from publication, prefer this.

EMCal is "almost" hadronic calorimeter:

$E_{EMC} = 1.0 \cdot E_{tot}$ for γ, π^0

$E_{EMC} = 0.7 \cdot E_{tot}$ for $\pi^{\pm}$

$E_T^{EMC} \rightarrow E_T$ transformation:

$E_T = 1.23 \cdot E_T^{EMC}$

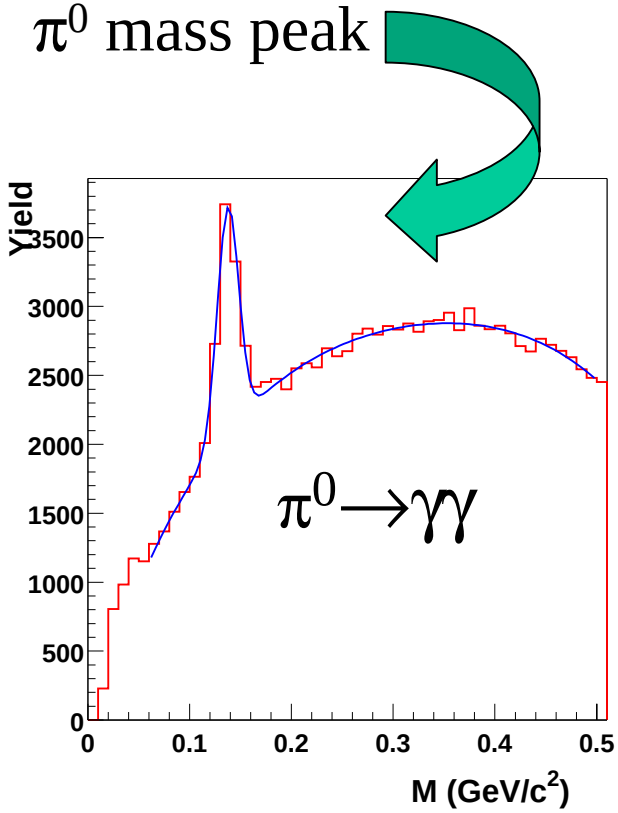
Inflow, losses
Response to hadrons

EMCal absolute energy calibration

MIP (min. ioniz. part.) peak

E/p matching peak for $e^{\pm}$

π^0 mass peak



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Corrections

Charged particle multiplicity

Tracks outside acceptance window	4%
Inactive regions	~10%
Double hit resolution: hit losses	~15% (most central)
background subtraction	3.6%
In-flight particles decay	0.2%
Geometrical acceptance	×2.89

Transverse energy

Inactive regions	~1%
Inflow	24%
Losses	18%
Response (to hadrons)	0.83
Geometrical acceptance	×4.18

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Improved Year-1 ($\sqrt{s_{NN}}$ = 130 GeV) analysis

Trigger:

- Improved event selection
- Trigger efficiency definition in Year-1 data relative to Year-2 data for better comparison of $\sqrt{s_{NN}}$ = 130 GeV and 200 GeV results

Transverse Energy:

- New definition explicitly accounting for nucleon masses (4% increase)
- Correction based on measured particle ratios instead of HIJING

Charged Particle Multiplicity:

- In-flight decay correction based on measured particle ratios and pt instead of HIJING

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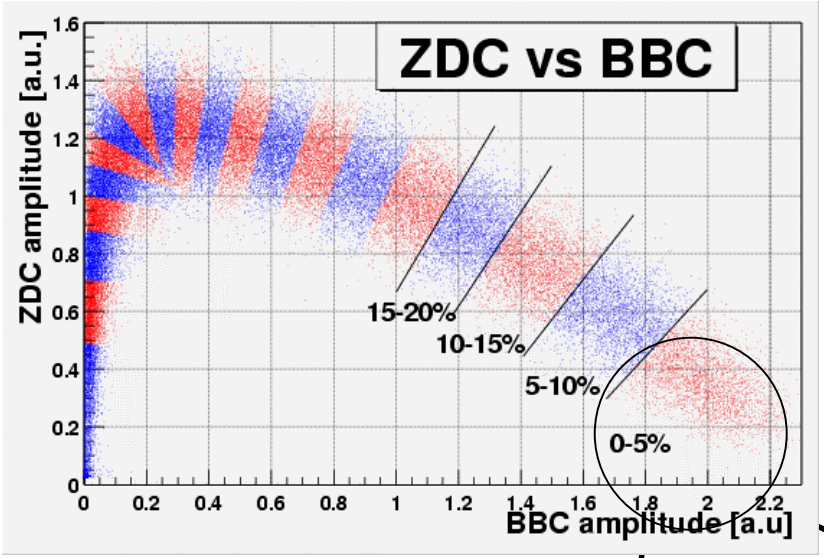
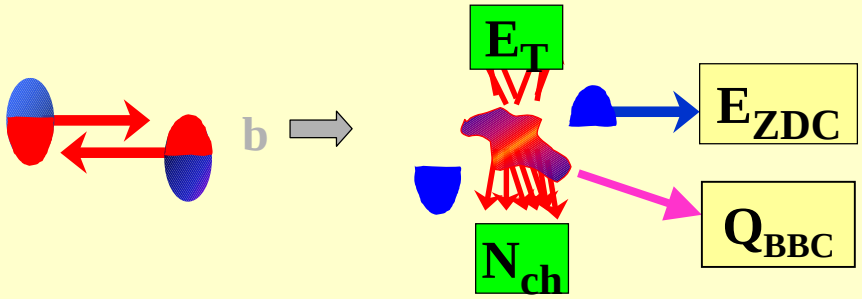
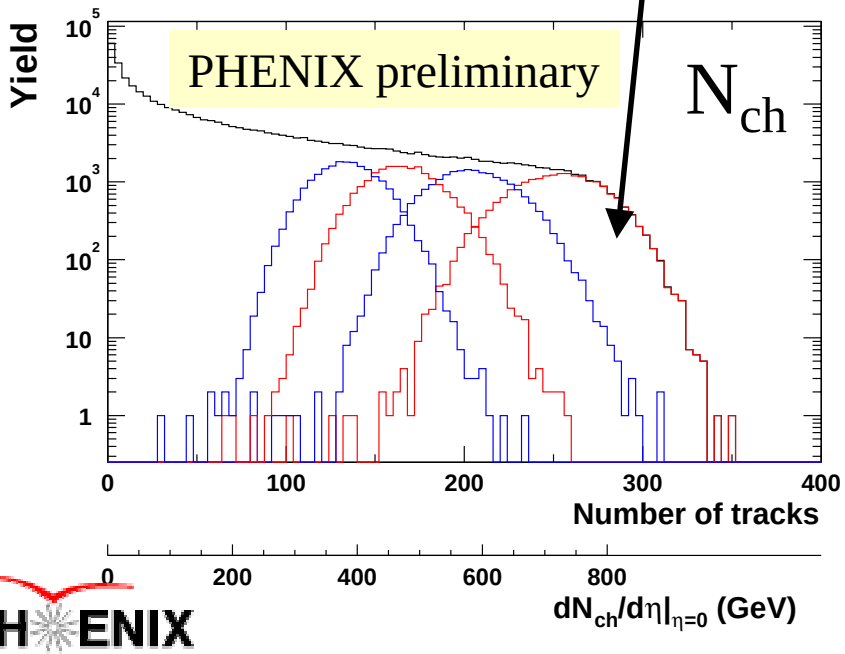
Centrality Selection

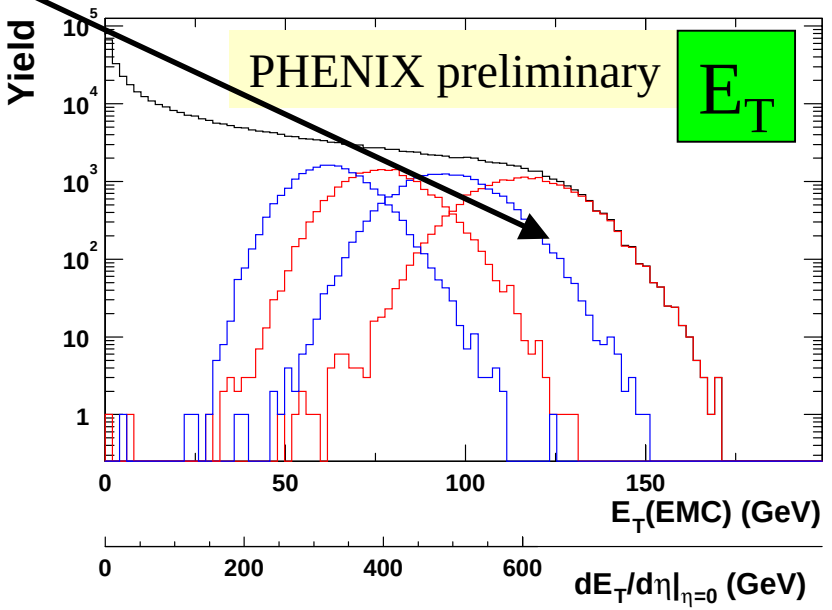


Define centrality classes: ZDC vs BBC



Extract N participants: Glauber model





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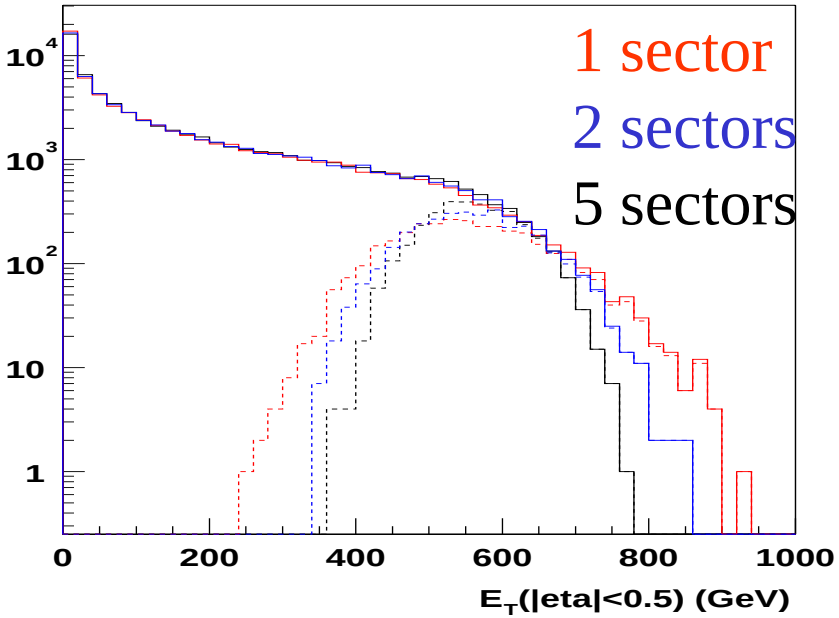
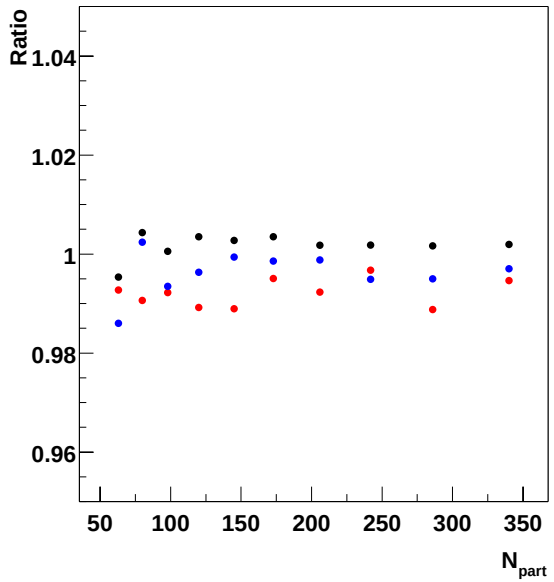
Crosscheck:
different acceptance



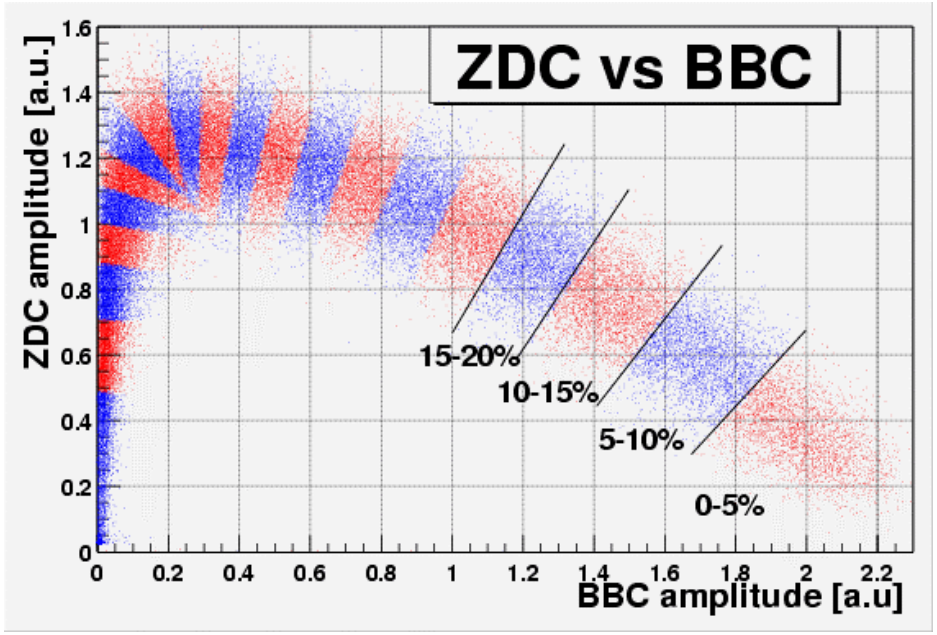


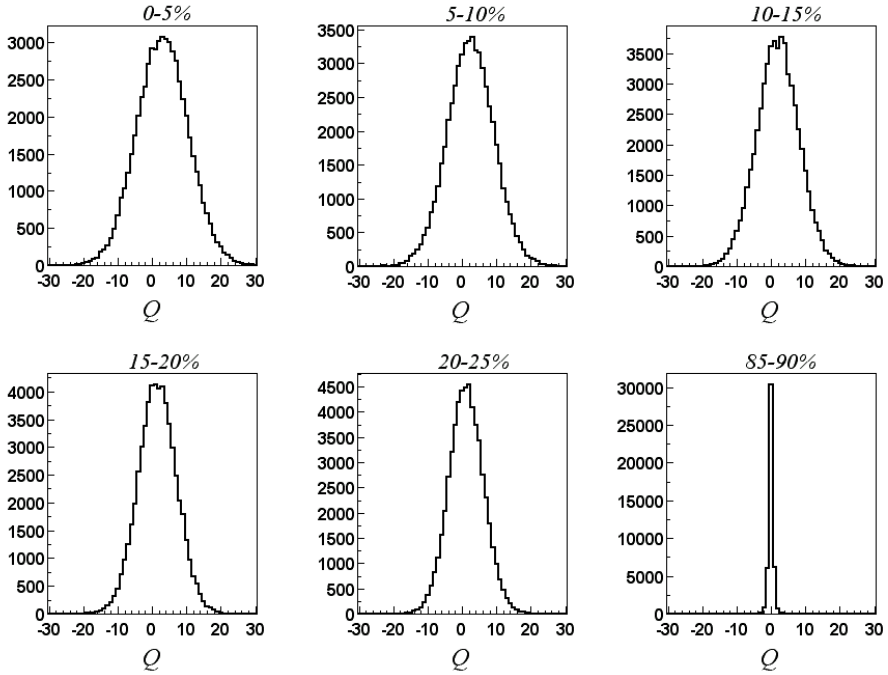
All measurements consistent within 1%

Centrality Selection

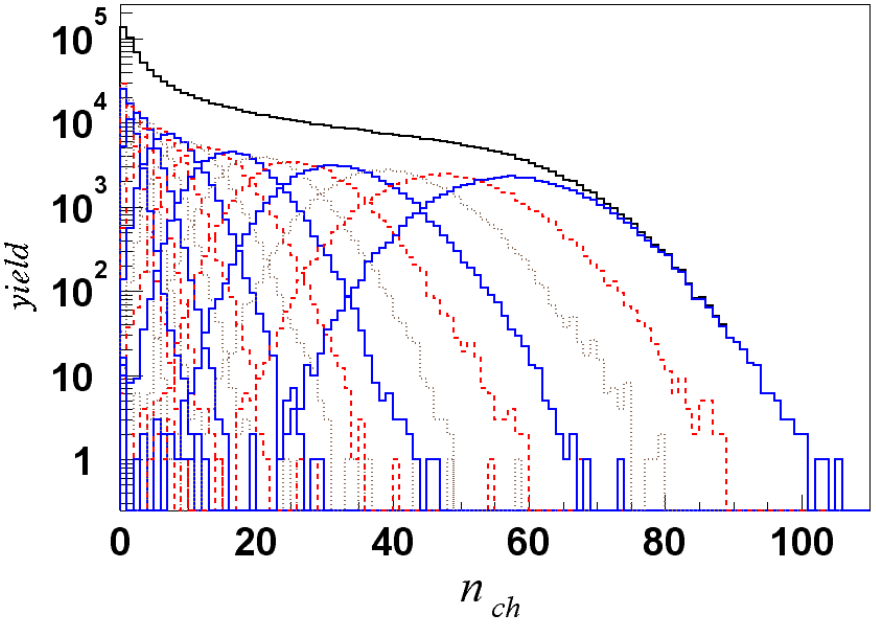
Select events based on ZDC and BBC information.

n_{ch} and Q distributions for centrality classes (5% bins).

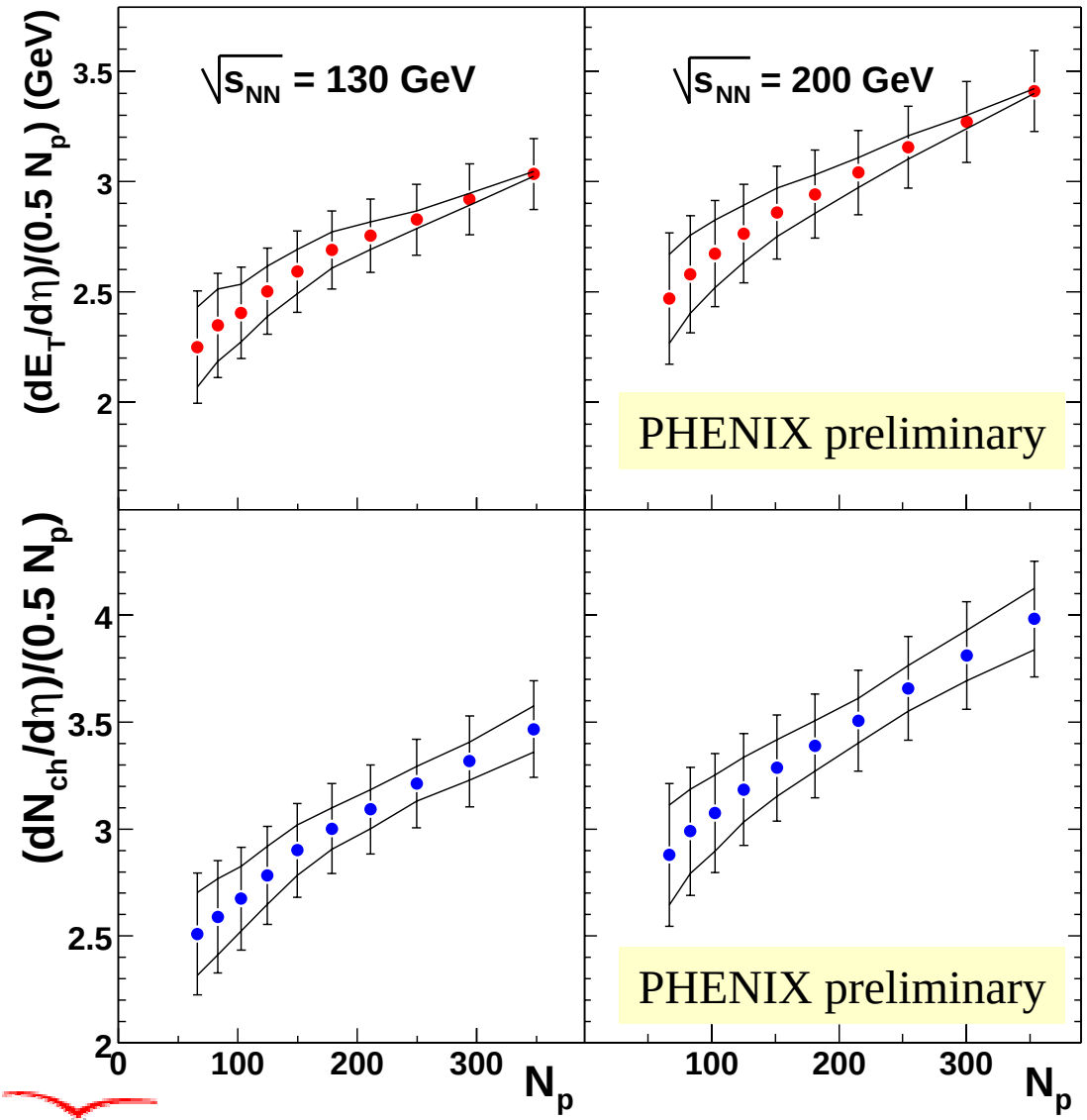




$\Delta\Phi=\pi/2 \quad \Delta\eta=0.7$



Centrality dependence



E_T and N_{ch} exhibit consistent behavior at $\sqrt{s_{NN}}$=130 GeV and 200 GeV

Stat. errors

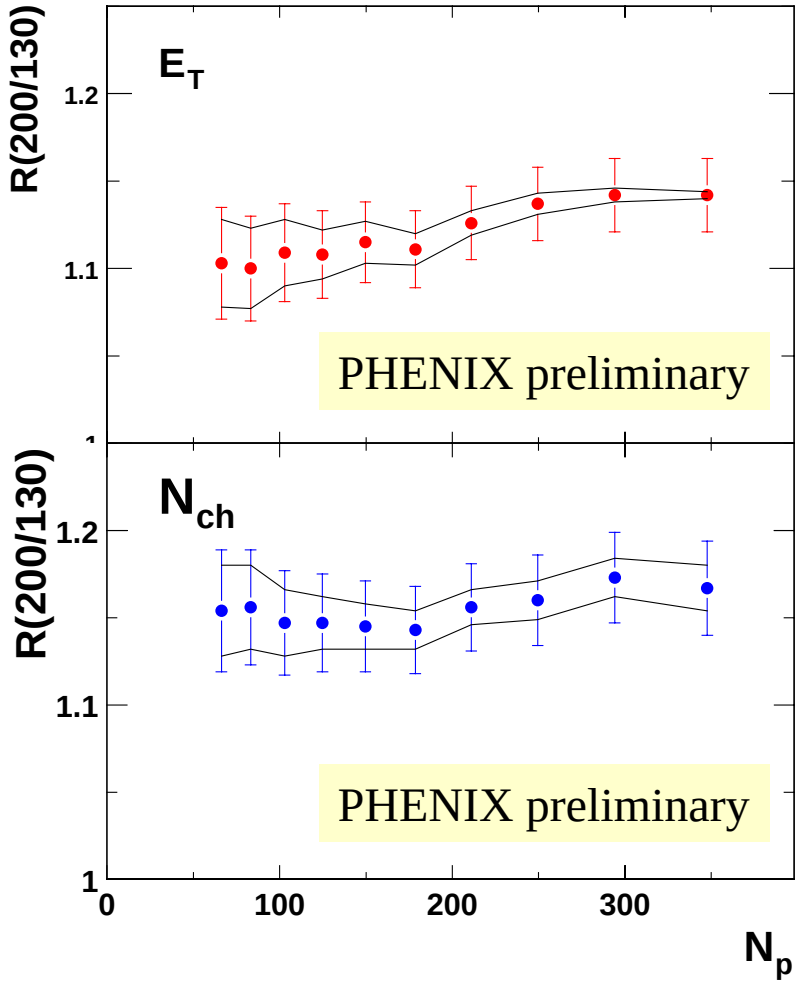
Negligible

Syst. errors

Band: possible common tilt

Bars: total syst. error

200 GeV / 130 GeV



For the most central collisions:

$$\frac{E_T(200\,GeV)}{E_T(130\,GeV)} = 1.14 \pm 0.02$$

$$\frac{N_{ch}(200\,GeV)}{N_{ch}(130\,GeV)} = 1.17 \pm 0.03$$

Constant scaling within syst. errors

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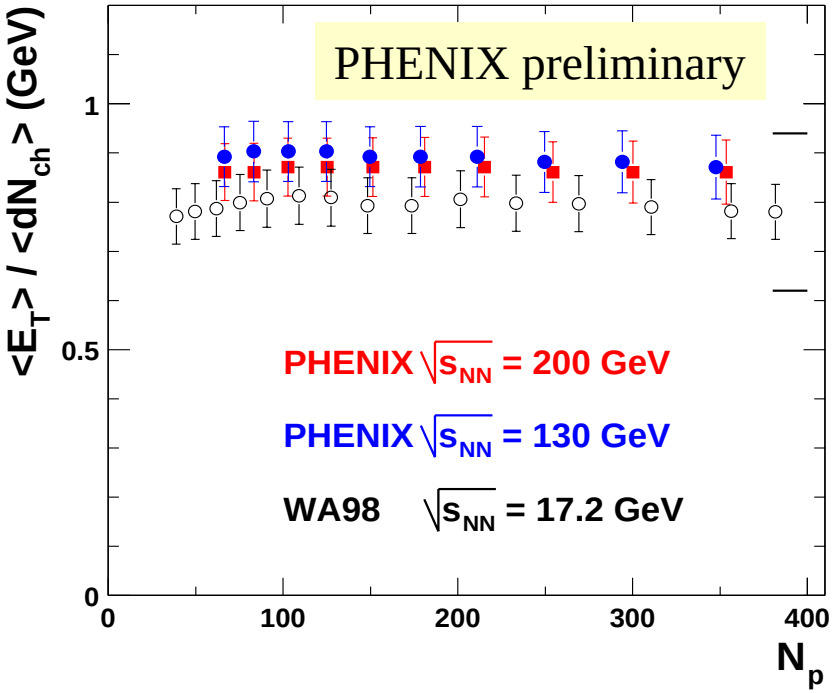
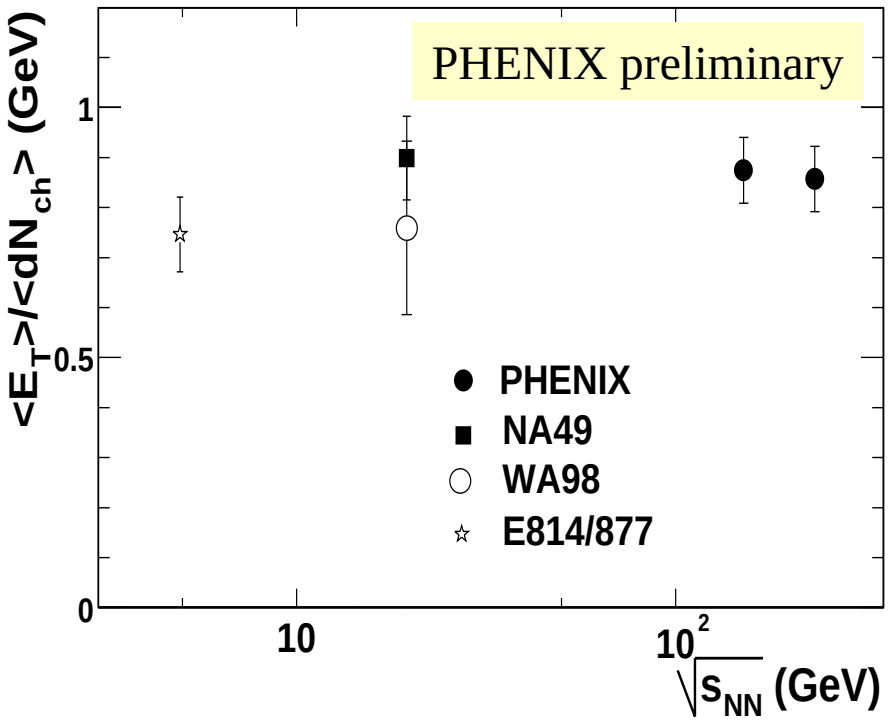
$\langle E_T \rangle / \langle N_{ch} \rangle$





Independent from centrality

Independent from energy

Star prelim at QM2002 also ~0.8 GeV

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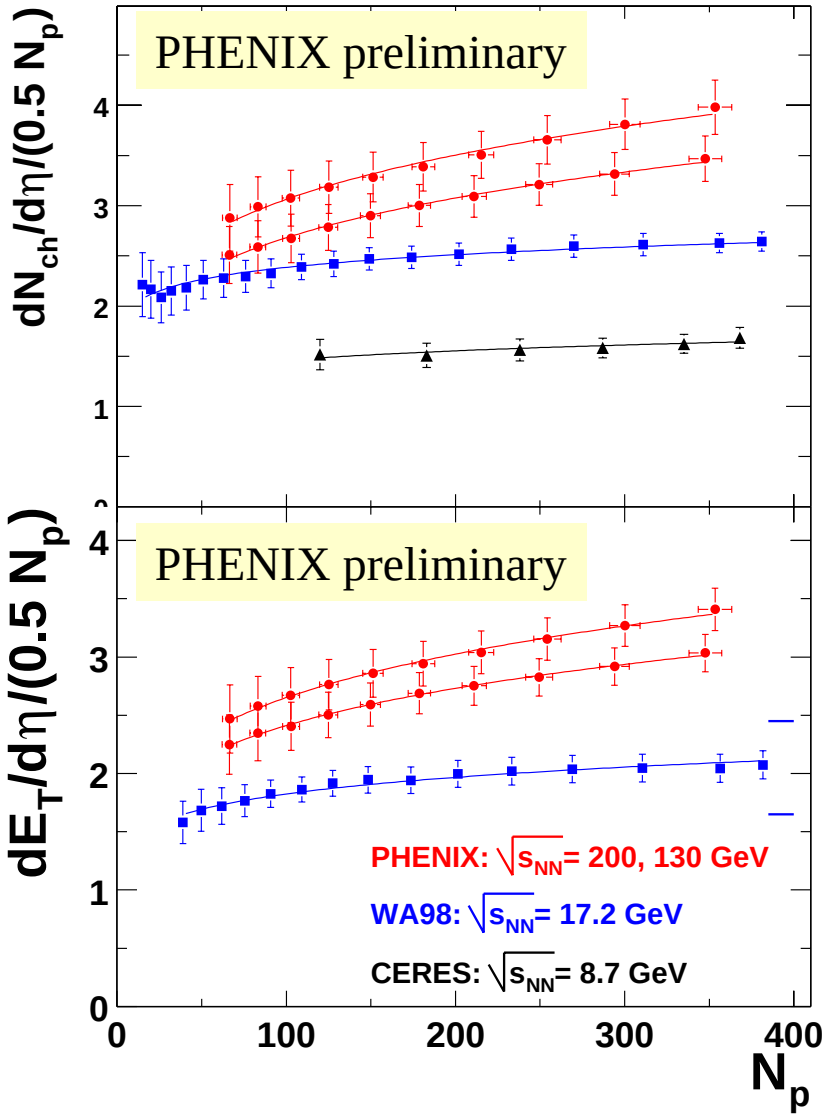
Centrality dependence vs $\sqrt{s_{NN}}$



Fit: $dX/d\eta \propto N_{part}^{\alpha}$:

CERES ($\sqrt{s_{NN}}$=8.7 GeV)

$dN_{ch}/d\eta$: α=1.09

WA98 ($\sqrt{s_{NN}}$=17.2 GeV)

$dN_{ch}/d\eta$: α=1.07±0.04

$dE_T/d\eta$: α=1.08±0.06

PHENIX ($\sqrt{s_{NN}}$=130 GeV)

$dN_{ch}/d\eta$: α=1.20±0.05

$dE_T/d\eta$: α=1.18±0.05

PHENIX ($\sqrt{s_{NN}}$=200 GeV)

$dN_{ch}/d\eta$: α=1.19±0.05

$dE_T/d\eta$: α=1.19±0.05

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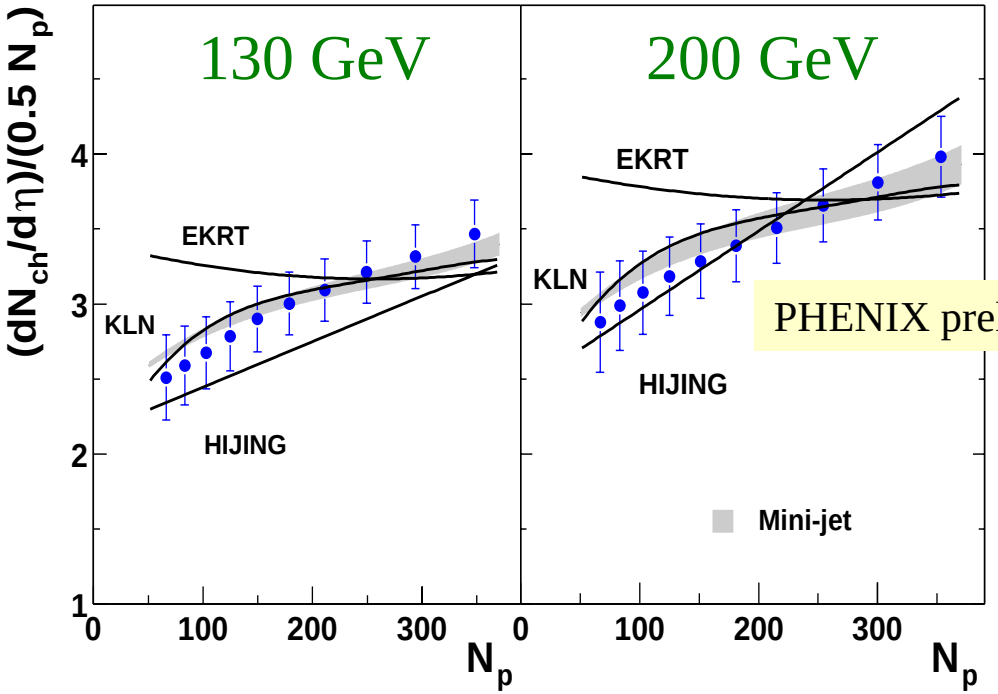
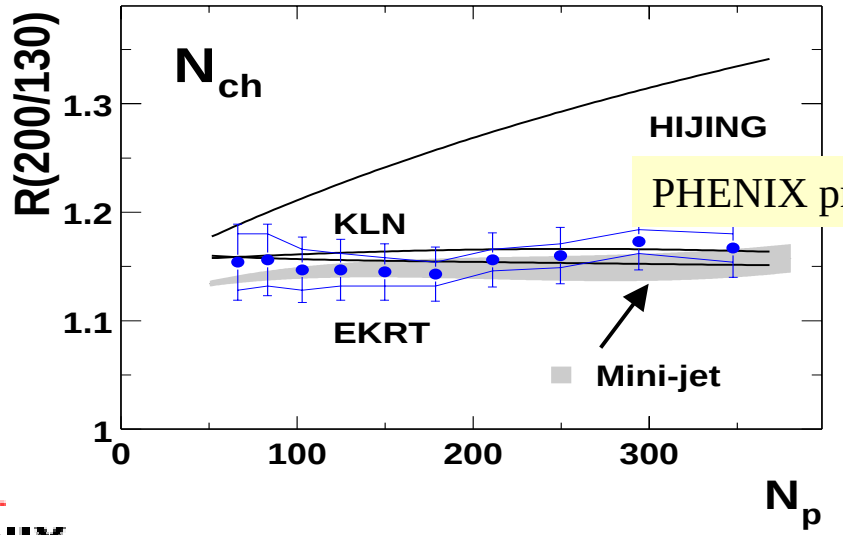
Comparison to theory



PHENIX preliminary



PHENIX preliminary

HIJING X

X.N.Wang and M.Gyulassy,
PRL 86, 3498 (2001)

Mini-jet

S.Li and X.N.Wang
Phys.Lett.B527:85-91 (2002)

EKRT X

K.J.Eskola et al,
Nucl Phys. B570, 379 and
Phys.Lett. B 497, 39 (2001)

KLN

D.Kharzeev and M. Nardi,
Phys.Lett. B503, 121 (2001)
D.Kharzeev and E.Levin,
Phys.Lett. B523, 79 (2001)

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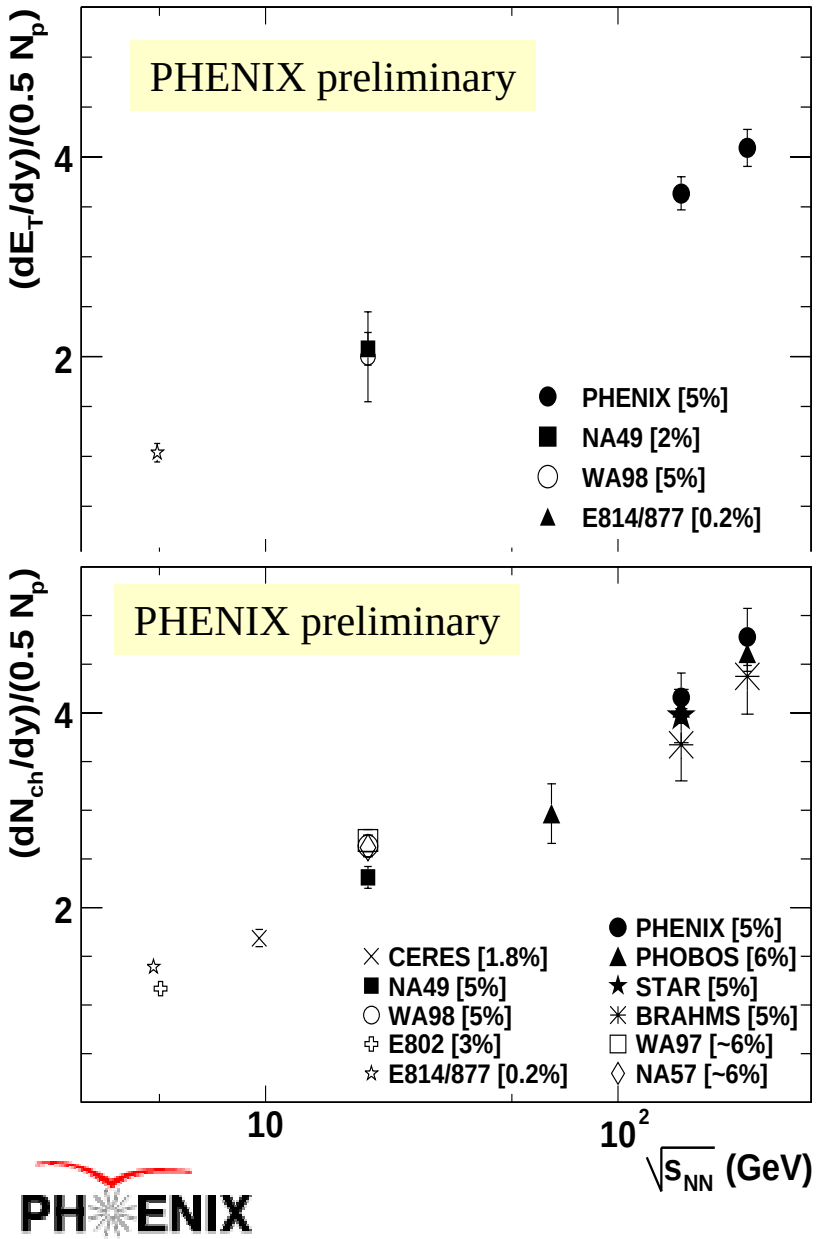
Energy Dependence



Assumptions:

in Lab $\quad \frac{dX}{dy} \approx \frac{dX}{d\eta}$

in C.M. $\quad \frac{dX}{dy} \approx 1.2\frac{dX}{d\eta}$

Energy density (Bjorken):

$$\varepsilon = \frac{1}{\pi R^2 \tau}\frac{dE_t}{dy} \qquad R = 1.18\,fm \cdot A^{1/3} \qquad \tau = 1\,fm/c$$

2% most central at $\sqrt{s_{NN}}$=200 GeV:

$\varepsilon \approx 5.5$ GeV/fm^3

From AGS, SPS to RHIC:

Transverse energy and charged particle multiplicity densities per participant consistent with logarithmic behaviour

Summary

- **Centrality dependence of particle $dN_{ch}/d\eta$ and $dE_T/d\eta$ have been measured at $\sqrt{s_{NN}}$ = 130 GeV and 200 GeV in Au+Au collisions**
- **$\langle dE_T \rangle / \langle dN_{ch} \rangle$ is near independent of centrality and of $\sqrt{s_{NN}}$**
- **The ratio R(200/130) consistent with constant scaling vs N_p**
- **Both $dN_{ch}/d\eta$ and $dE_t/d\eta$ per participant increase with centrality:**
  - ✓ the increase is stronger than at SPS
  - ✓ data well described by KLN and Mini-jet model predictions

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