

Measurement of energy density in Cu+Cu Collisions at RHIC-PHENIX

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for the PHENIX collaboration



Motivation

Understanding quantitative QCD phase diagram is important.

From the initially energy density and temperature, It is possible to determine basis of temperature on QCD phase diagram.

It is important to know the scaling of the $dE_T/d\eta$ with the atomic mass, Number of participant and center-of-mass collision energy.

It is possible to test whether color glass like behavior arise in the initial collision.

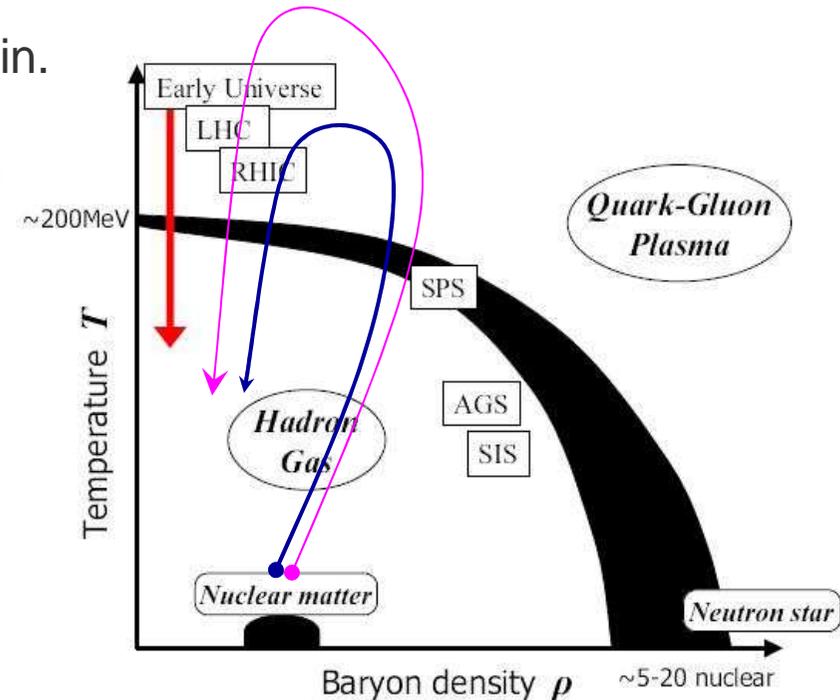
Reference : Dmitri Kharzeev and Kirill Tuchin.
arXiv:hep-ph/0501234 v2

Look whether initial temperature depend on color glass condensate.

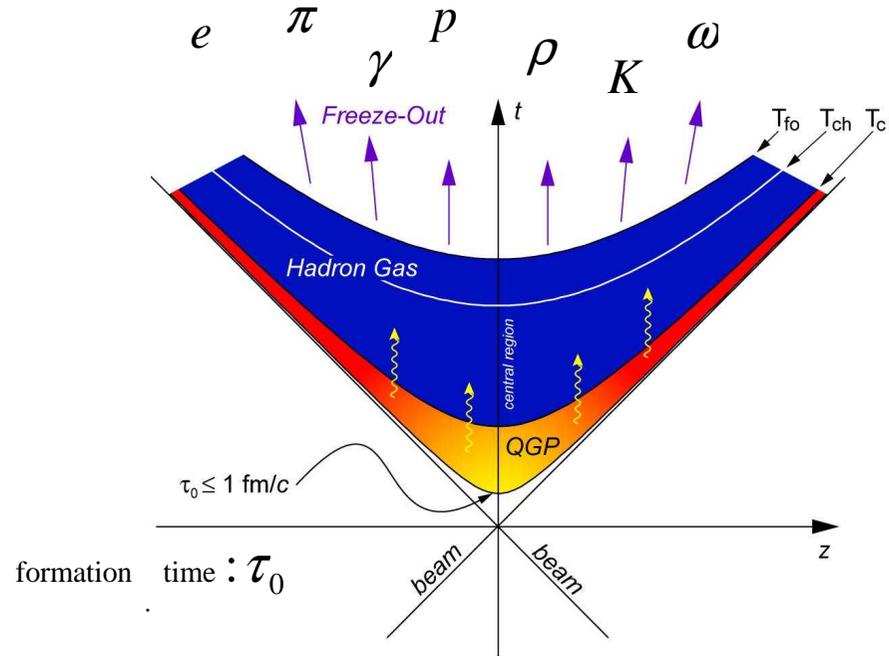
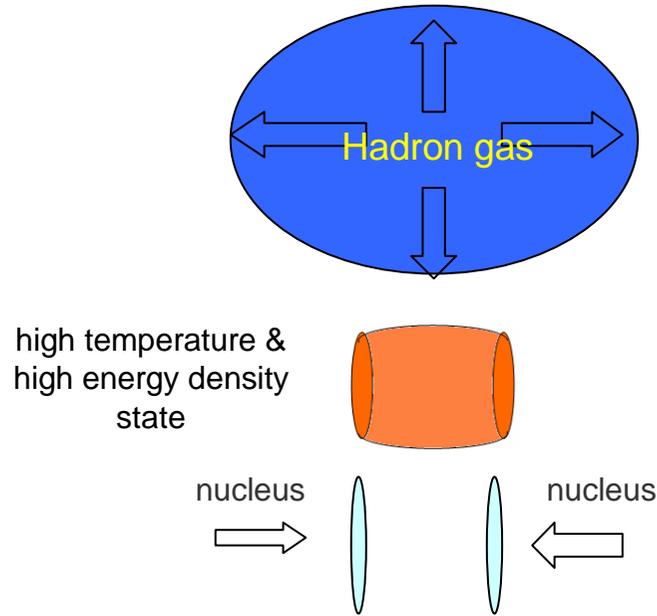
$$T = \frac{Q_s}{2\pi} \propto Q_s \propto A^{\frac{1}{6}} \sqrt{S}^{0.15}$$

Q_s : saturation · scale

A : Atomic · number



Buck ground :time evolution and energy density



energy density

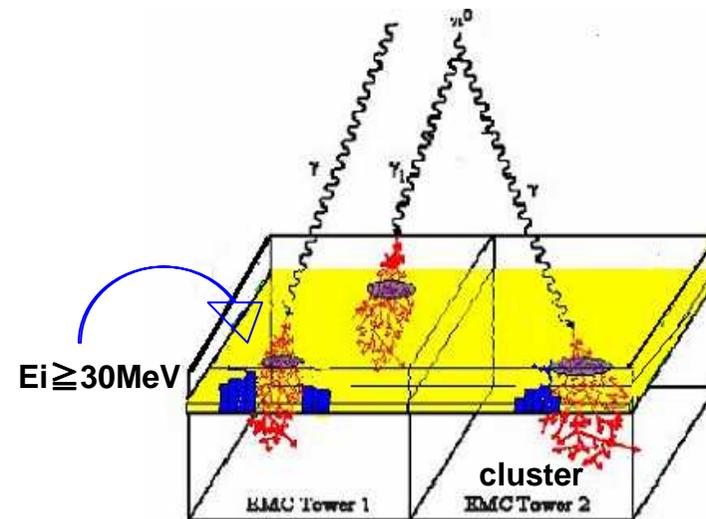
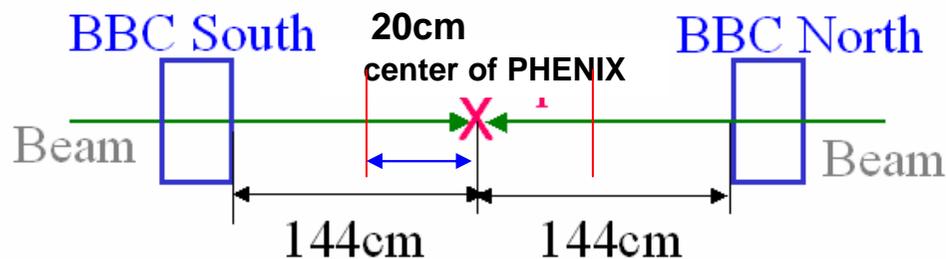
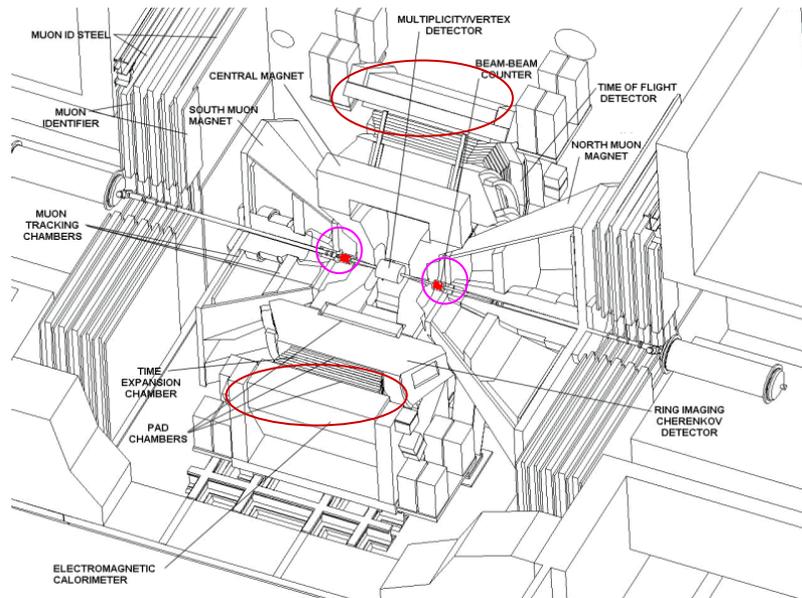
$$\mathcal{E}_0 = \frac{1}{\tau_0 \pi R^2} \frac{dE_T}{dy} \propto \frac{1}{\tau_0 \pi R^2} \frac{dE_T}{d\eta} \iff \left. \frac{dE_T(\eta)}{d\eta} \right|_{\eta=0} = E_T \times \left(\text{correction} \cdot \text{factor} \right)$$

E_T : measurement presented was performed using the PbSc³EMCa1

Analysis : measurement of transverse energy

- The sum is taken over all particles emitted into a fixed solid angle in an event.
- π^\pm : ~40%. photon:~40%.
decaying μ particle ~20%:
kmeson, proton, etc

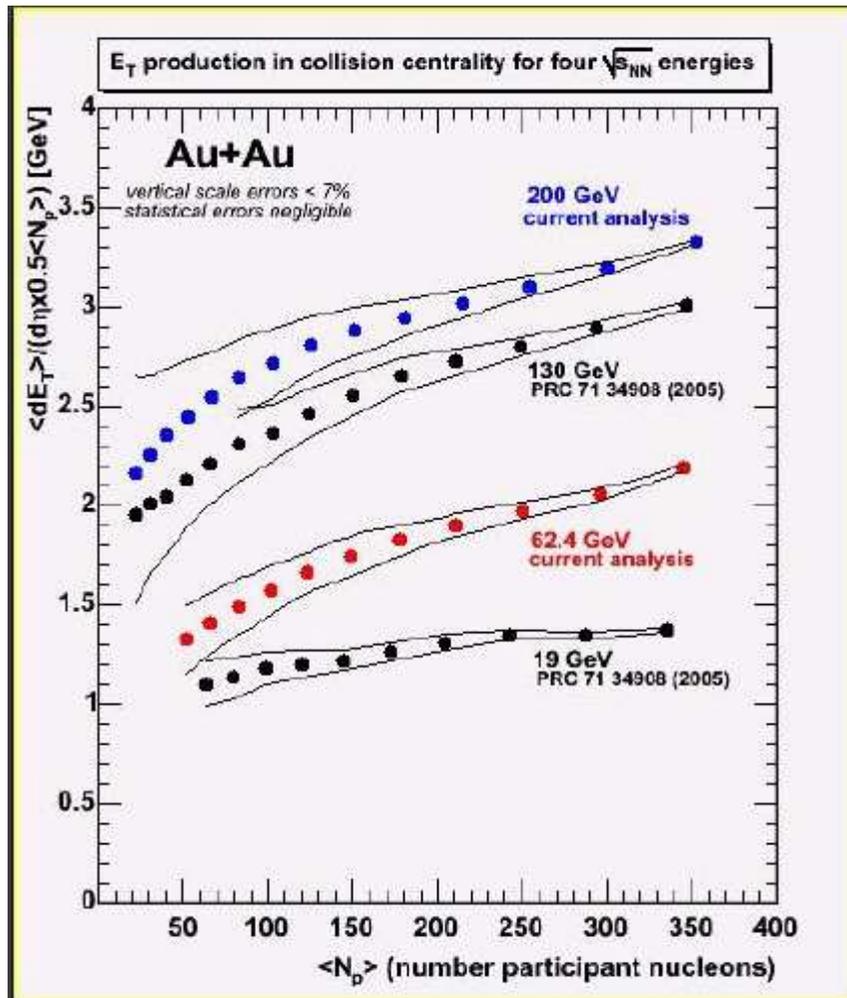
- using Minimum Bias trigger data
- $\langle Z_{\text{vertex}} \rangle$
- $|B_{bc}Z_{\text{vertex}}| < 20\text{cm}$
- EMCal cluster energy thresholds $\geq 30\text{MeV}$
- using EMCal Sector
- W0,W1,W2,E2,E3 (5sector)



A. A. P. Kulkarni

past PHENIX analysis (Au+Au)

Au+Au E_T analysis were done !



<goal>

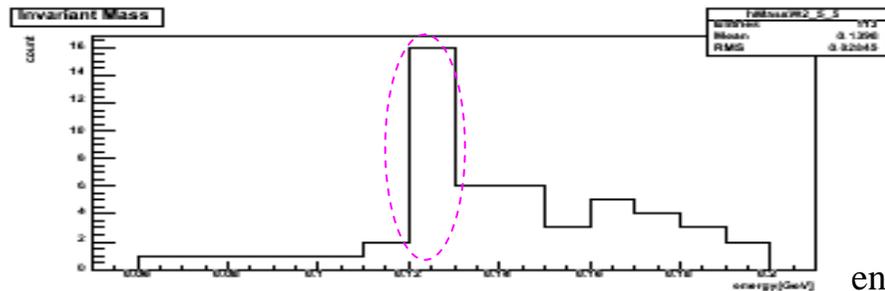
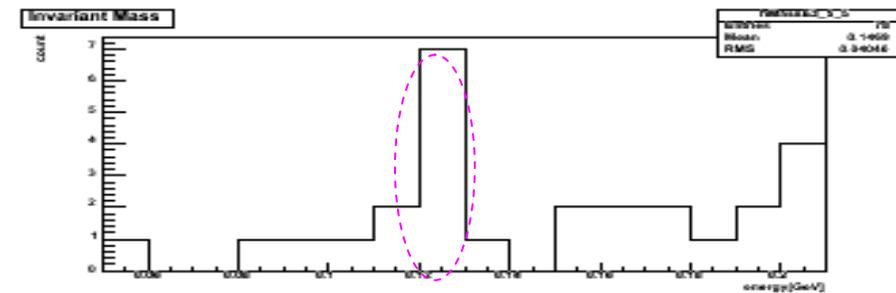
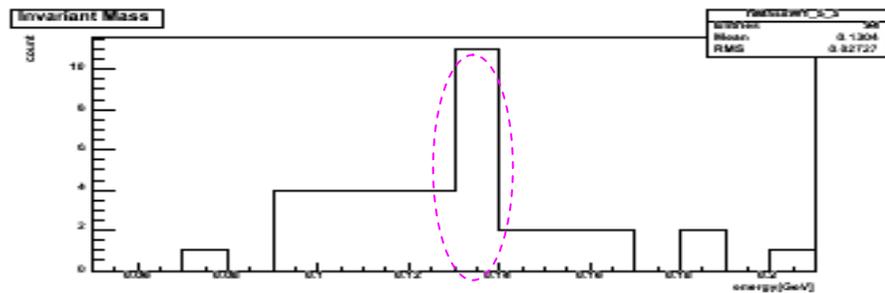
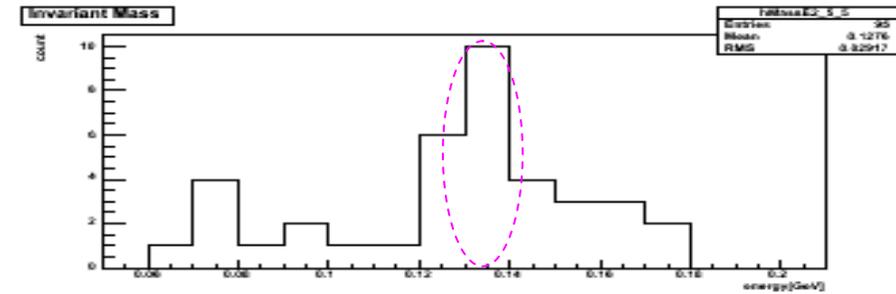
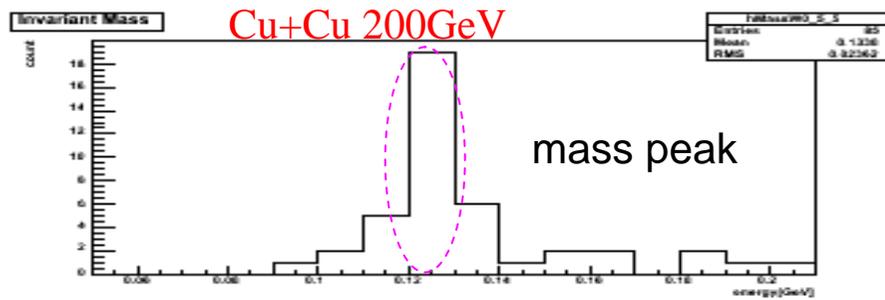
evaluate new transverse energy with Cu+Cu data with different atomic number and know the position of these Au+Au.

look whether transverse energy with another nucleus collision or center-of-mass collision do scaling as a function of Number of participant.

check of Run5(Cu+Cu) by sector EMCal energy calibration.

check of doing reconstruction of π^0 invariant mass (135MeV). $\pi^0 \rightarrow \gamma + \gamma$

- $\langle Z_{\text{vertex}} \rangle$ -collision point: $|Bbc Z_{\text{vertex}}| < 20\text{cm}$
- Time of flight = 1.2ns
- asymmetry cut < 0.8 ● invariant mass: $E^2 = 2E_1E_2(1 - \cos\theta)$
- EMCal cluster thresholds $\geq 300\text{MeV}$ (photon)



energy [GeV]

W0,W1,W2 & E2,E3
each 5sector

energy [GeV]

<corrections>

- ☆EMCal geometrical acceptance correction
- ☆EMCal disable channel correction
- ☆situational correction

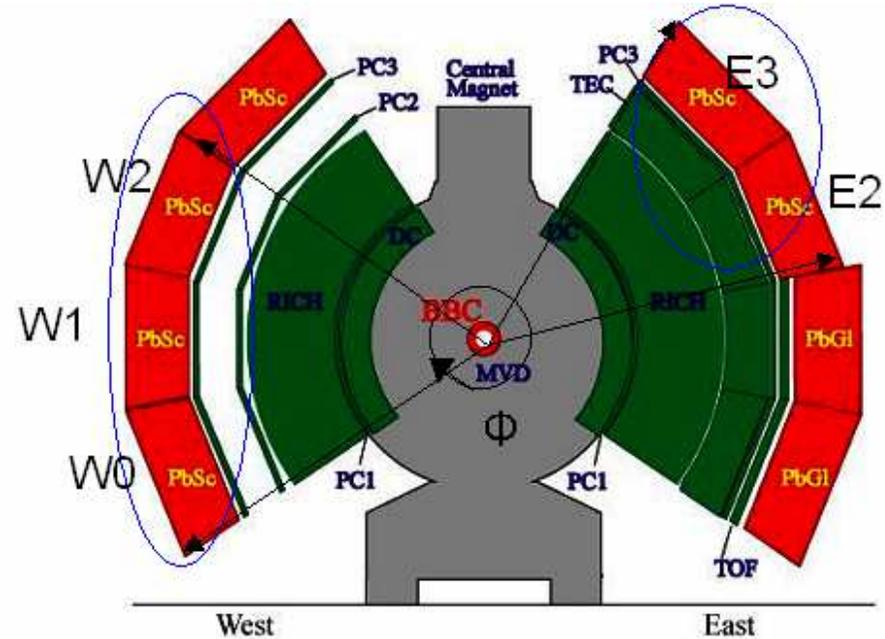
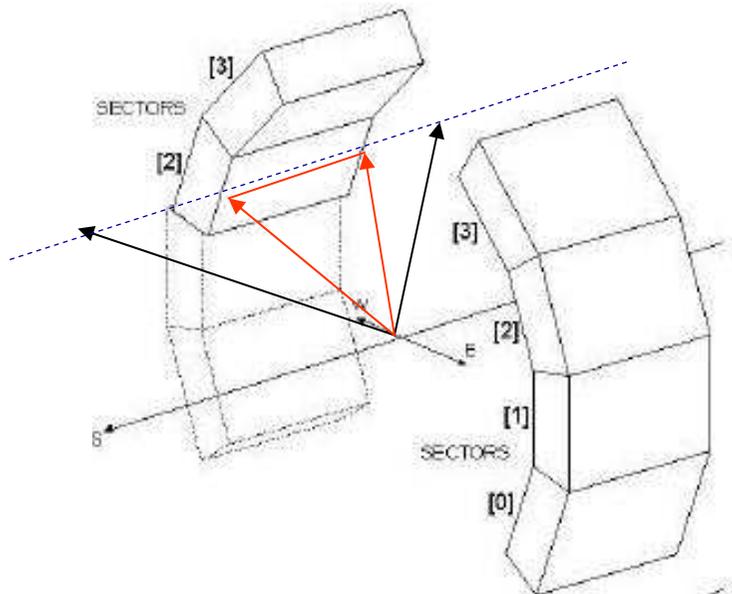
(rapidity) × (azimuthal): correction

EMCal : $|\eta| < 0.38$, $E_T : |\eta| < 0.5$

$$\left(\frac{1}{0.76}\right) \times \left(\frac{360}{112}\right) = 4.21$$

transverse energy : $\left. \frac{dE_T(\eta)}{d\eta} \right|_{\eta=0} = E_T \times \left(\text{correction factor} \right)$

$\Delta \Phi = 5 \times 22.5^\circ$



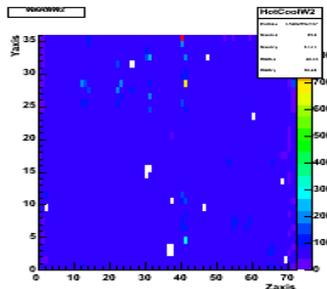
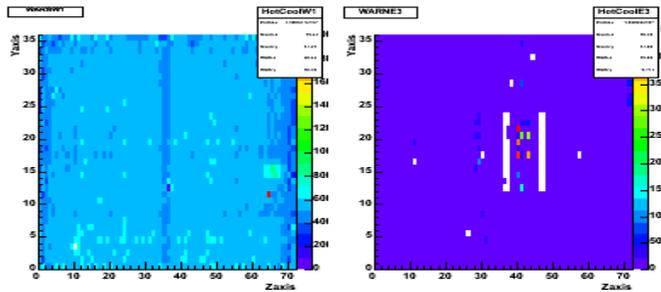
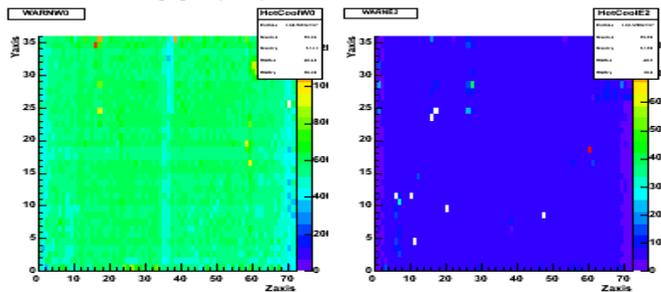
Correction of disable EMCAL channels

$$\text{correction factor} = \frac{5 \text{ sec} \times 2592 \text{ tower}}{(5 \text{ sec} \times 2592 \text{ tower}) - (5 \text{ sec} \text{ disable tower})}$$

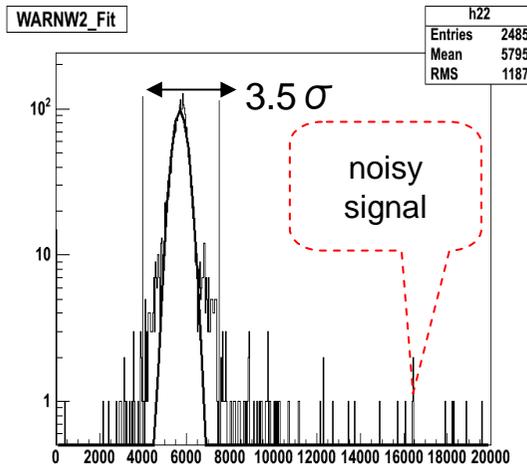
hit maps: seen head on sectors

After removed disable tower maps

72 x 36 tower

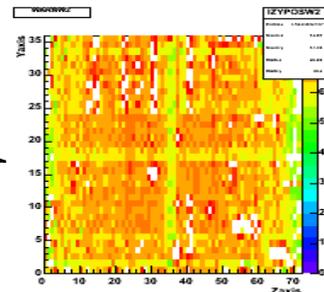
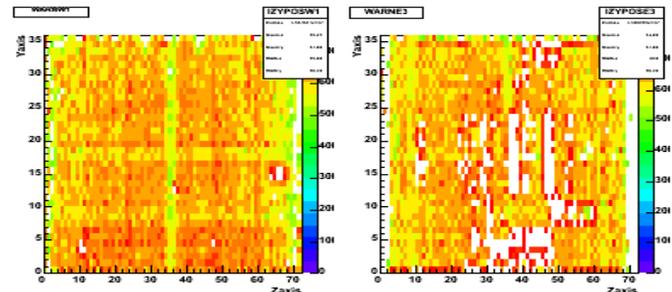
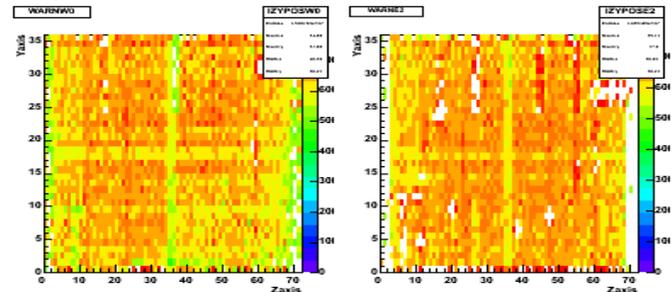


Tower number

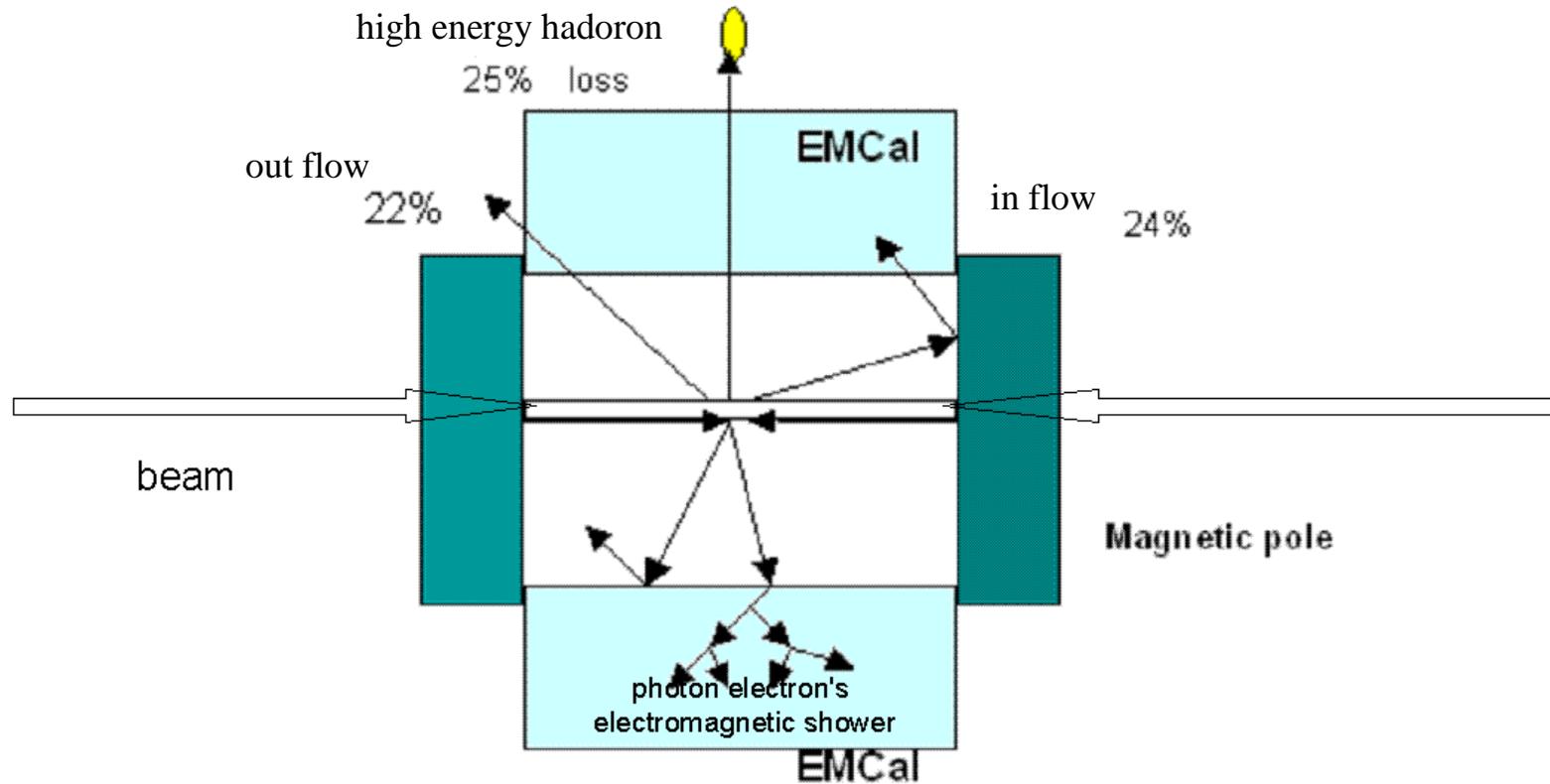


hit number

After removal disable channel



correction of EMCAL response, in-flow-out-flow particle (result of simulation)

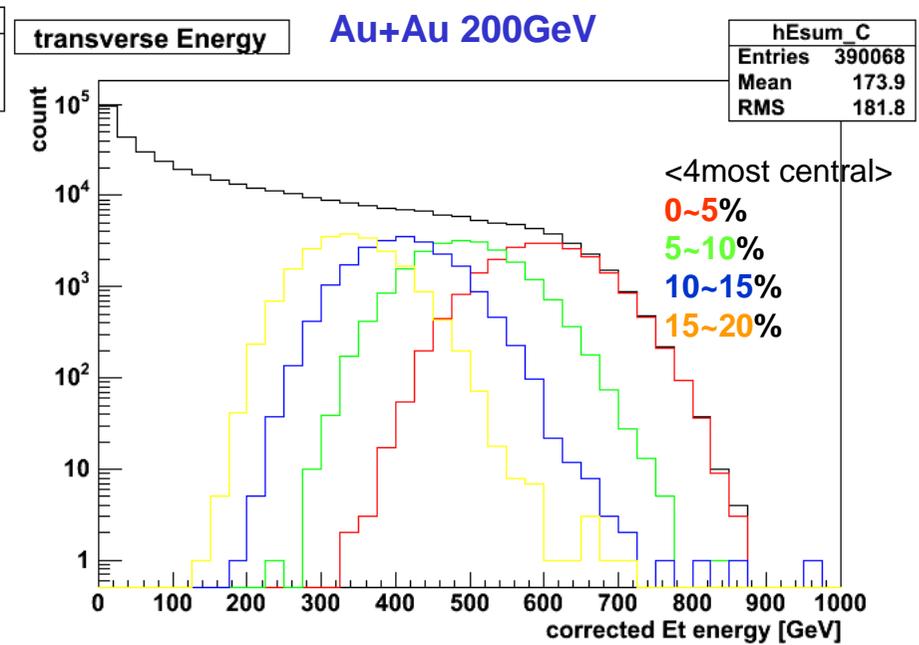
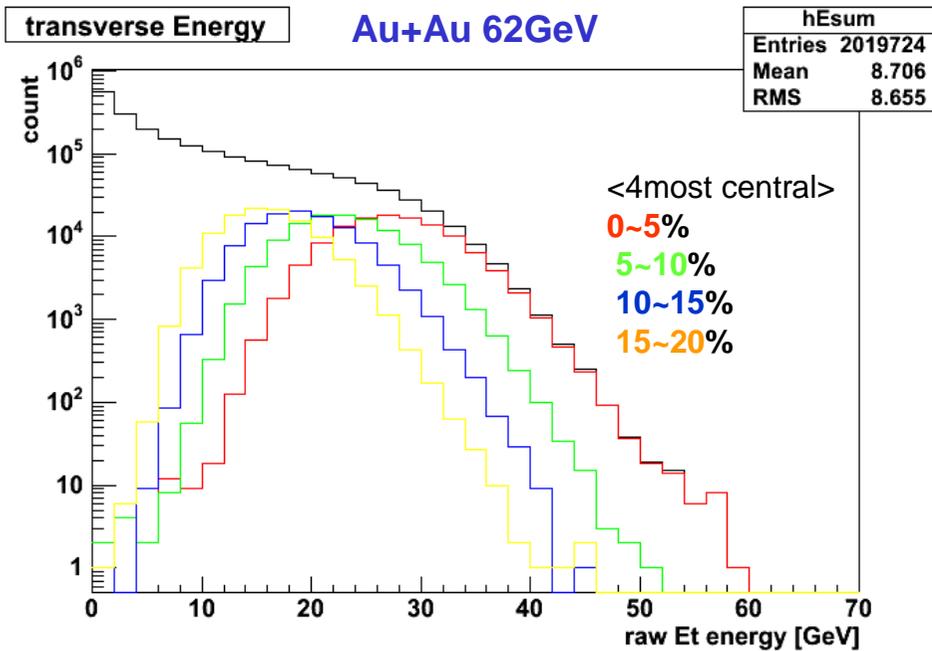
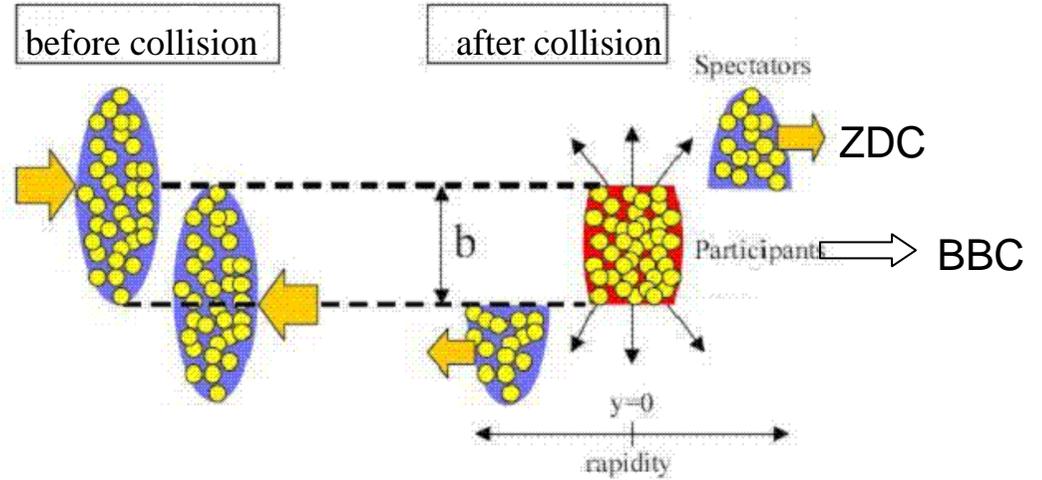
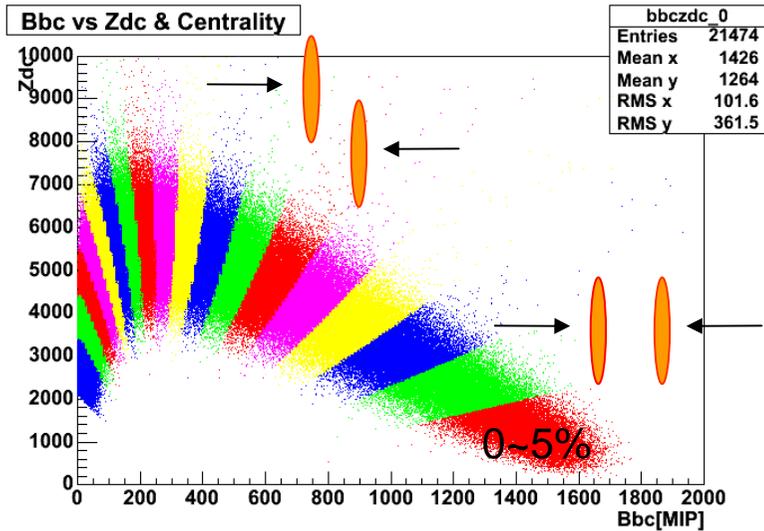


correction factor =

$$\frac{1 - \text{in-flow component}(24\%)}{[\text{EMCal response}(75\%)] \times [1 - \text{out-flow component}(22\%)]} = 1.3$$

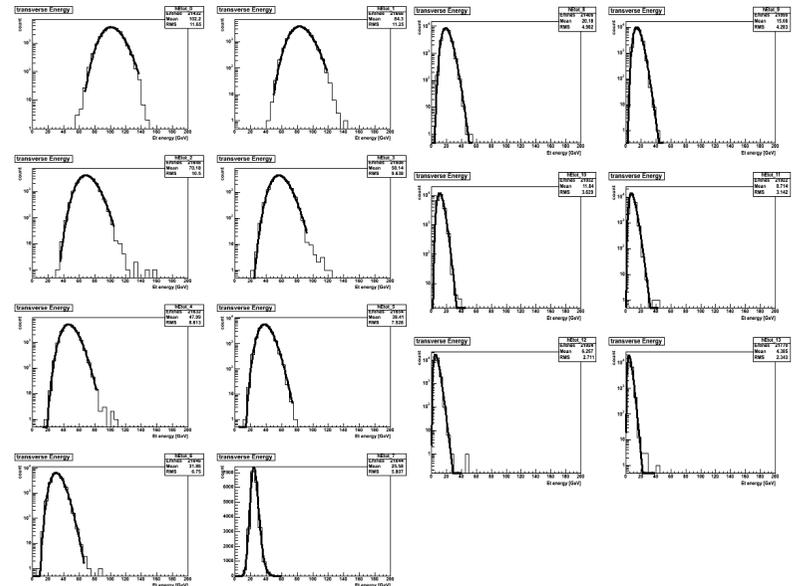
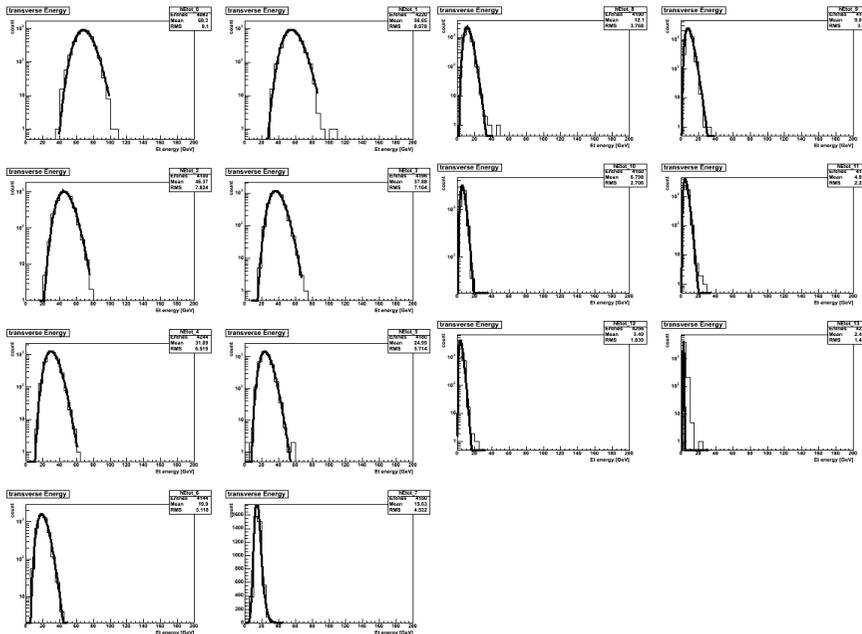
$$k = \frac{E}{E_{EMCal}}$$

results: measurement of Au+Au 200GeV,62GeV transverse energy(reproduction)

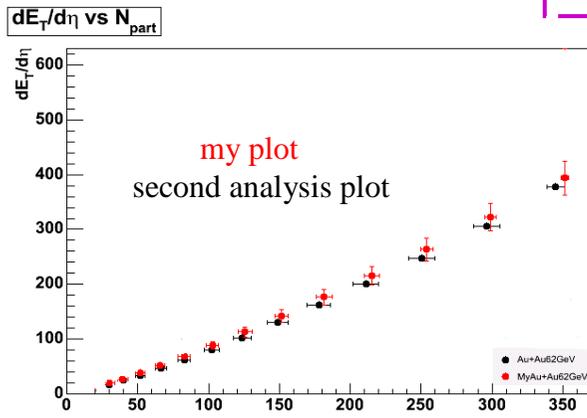


Results: Au+Au 200GeV, 62GeV transverse energy vs Number of participant (reproduction)

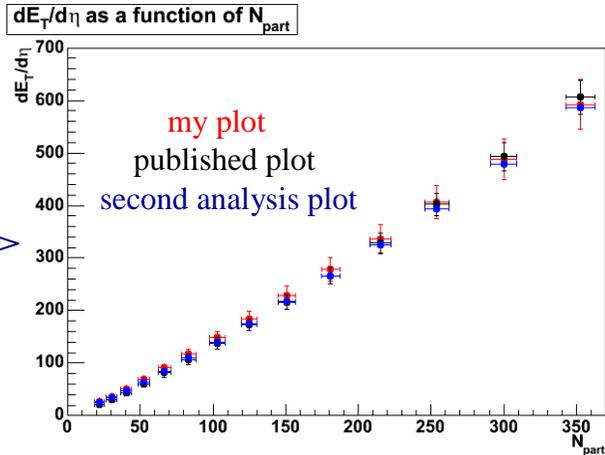
•Fit Et distribution with Gamma Function and get mean.



•Et mean plot with Npart.

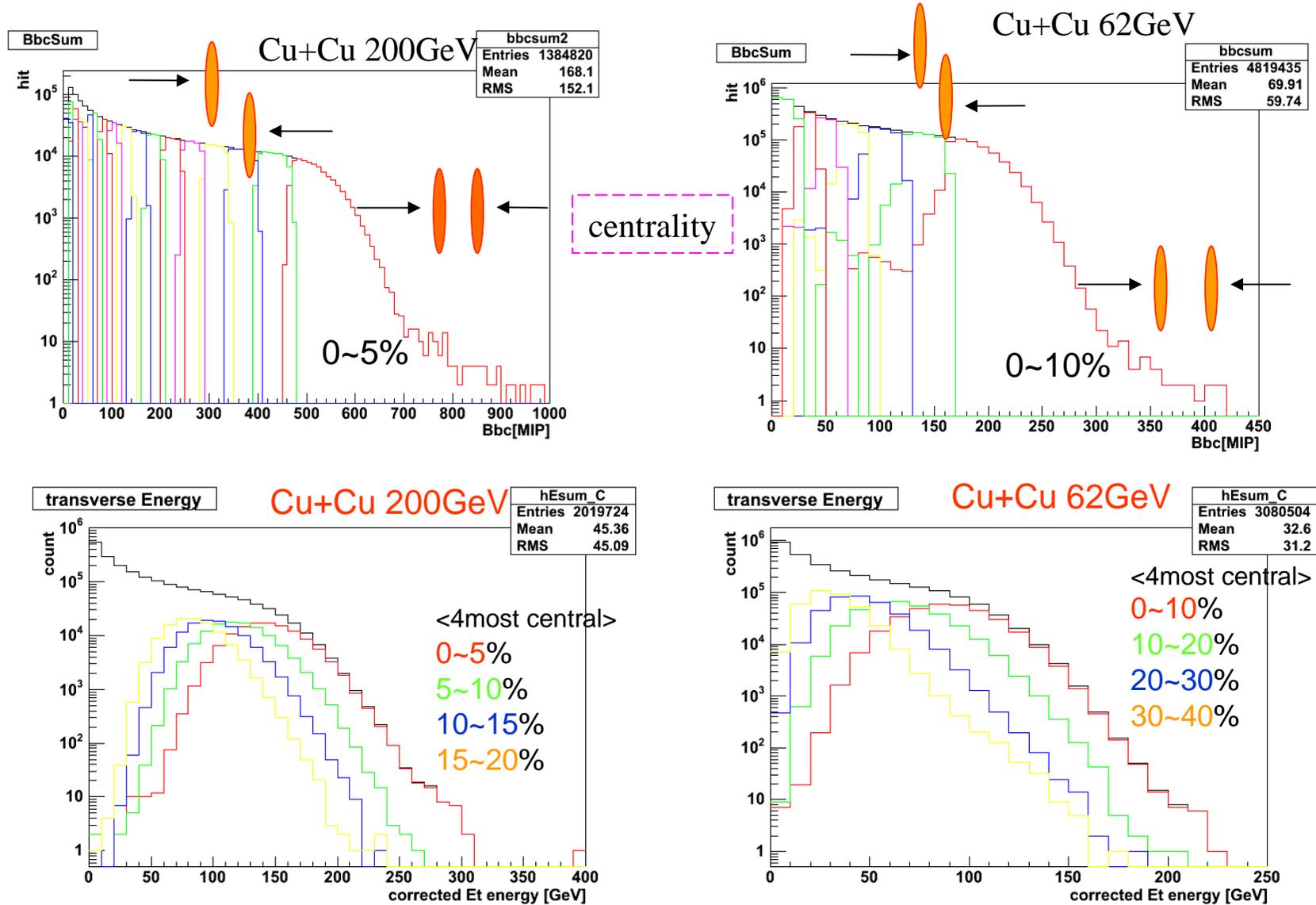


my Au+Au analysis correspond with past analysis



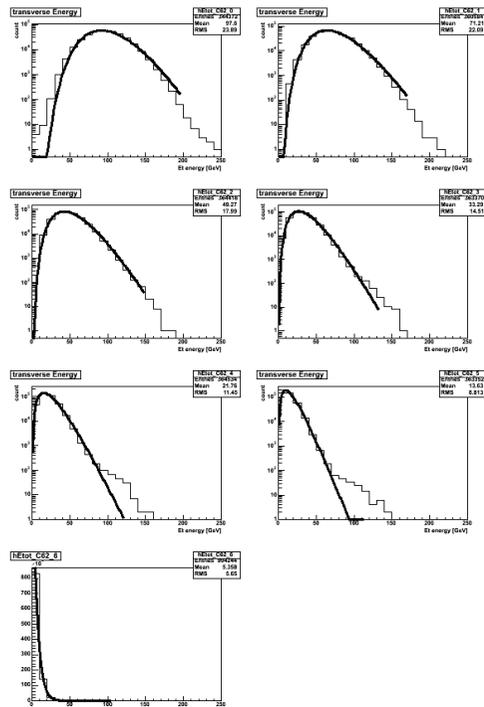
results: Cu+Cu transverse energy

- Cu+Cu 200GeV centrality (0~100%) each 5% bin, Cu+Cu 62GeV each 10% bin

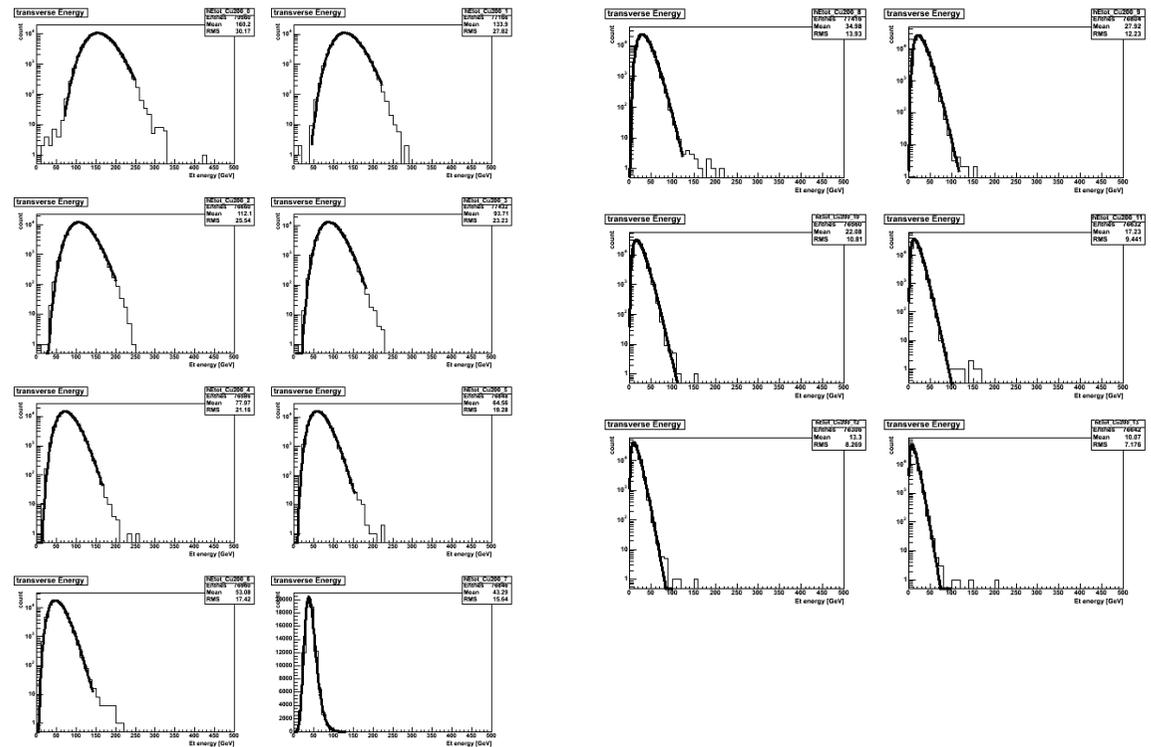


results: Cu+Cu transverse energy distribution with Gamma Fit.

•Cu+Cu 62GeV



•Cu+Cu 200GeV



•I could get mean of Et distribution, and I can get energy density.
 but I can't show these value any more ,because of No PHENIX preliminary.

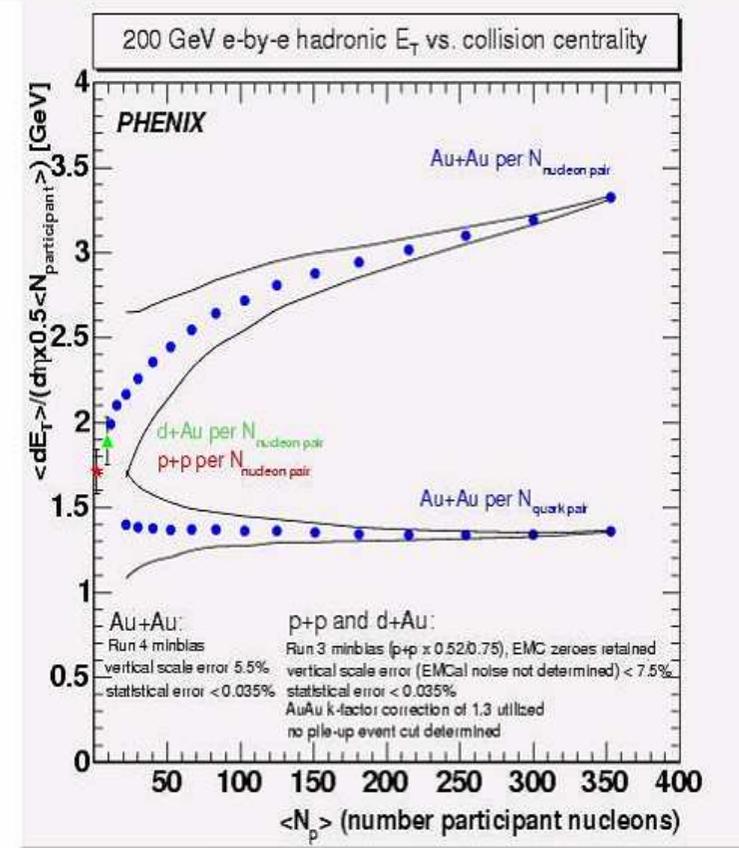
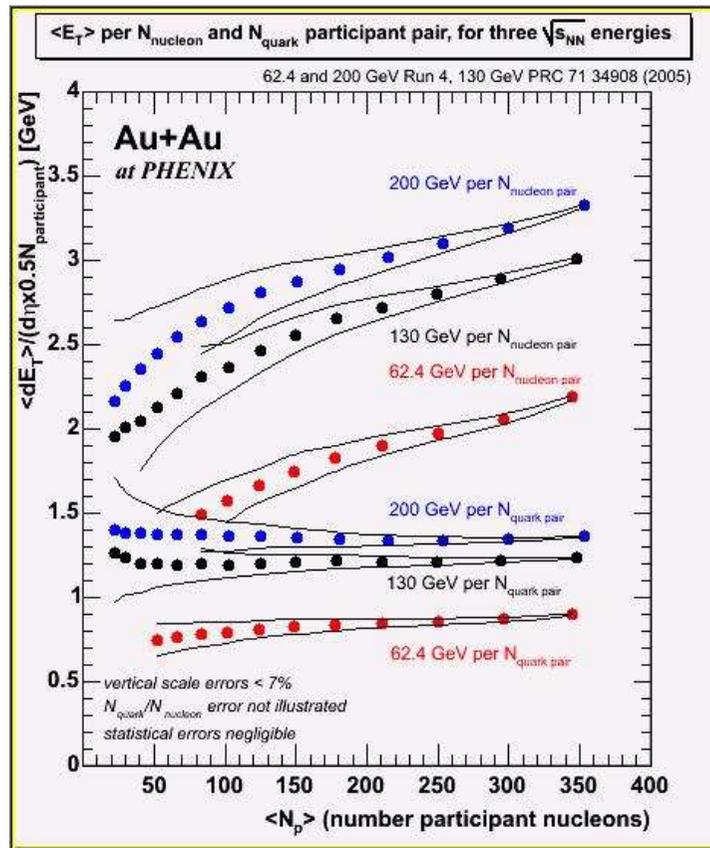
Summary & prospect

- Measuring transverse energy at Au+Au 200GeV & 62GeV, my result matched published data (200GeV) or second analysis (200GeV & 62GeV).
⇒ my analysis are correct.
- transverse energy at Cu+Cu 200GeV & 62GeV were taken as well.

<next>

- The scaling of the with Number of participant and with colliding energy will be discussed.
- Since the energy density is proportional to temperatures in the thermal zed system, I will get initial temperature.
- as a function of temperature, R_{AA} , flow, fluctuation and etc behavior are looked.

expansivity



•normalize to quark participants.