$\Delta\eta$ dependence of net-charge fluctuations in Au+Au collisions from the Beam Energy Scan at the STAR experiment

JPS fall meeting at Miyazaki

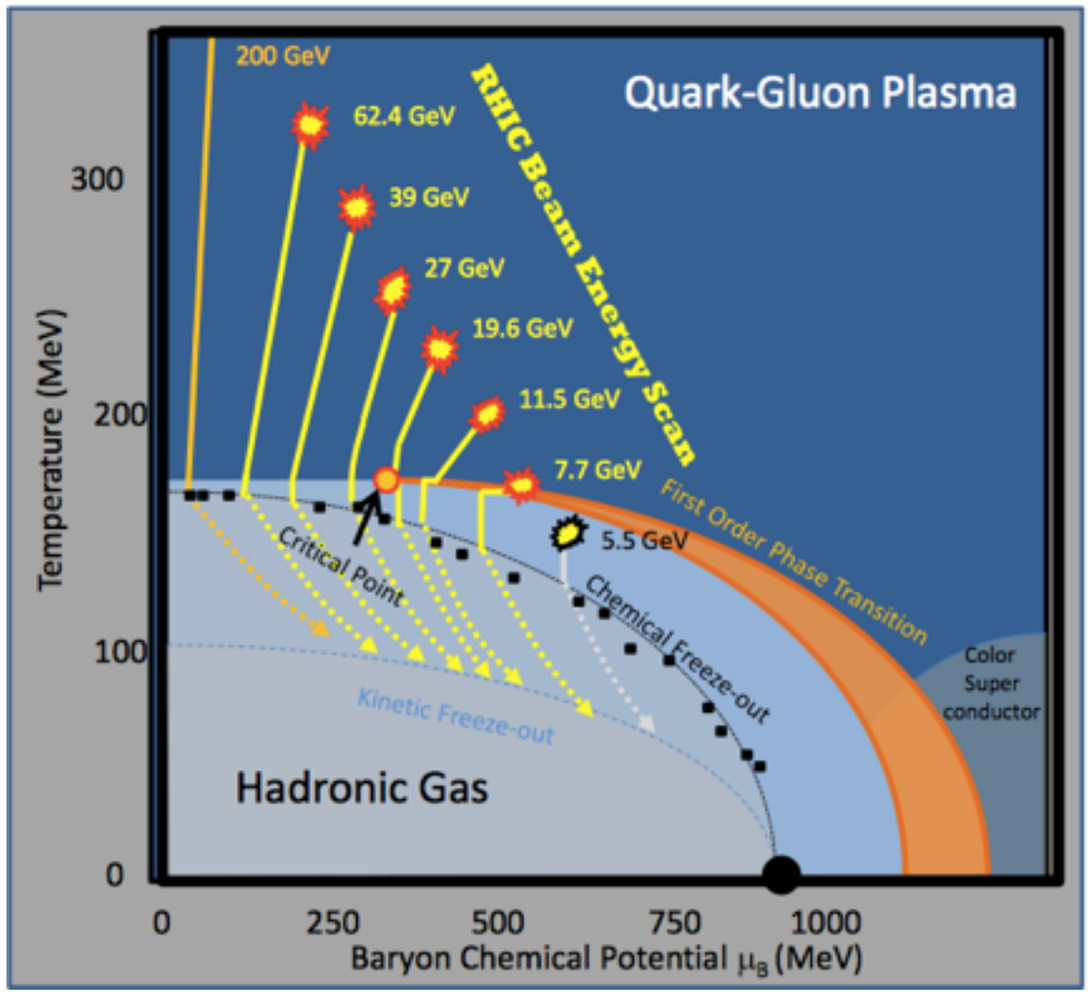
Tetsuro Sugiura

for the STAR collaboration

筑波大学
University of Tsukuba

Beam Energy Scan (BES Ⅰ) 2010-2014

Major goals : Explore the QCD phase diagram,
and searching critical point



QCD phase diagram

Varying the center of mass energy
$\sqrt{s_{NN}}$ =7.7, 11.5, 14.5 19.6, 39, 62.4,
and 200GeV

We can “scan”
QCD phase diagram

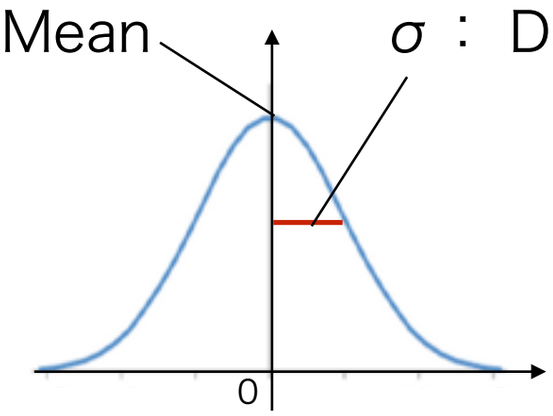
(μ value is observed to
increase with decreasing $\sqrt{s_{NN}}$)

Event by Event fluctuation

Event by Event fluctuation is powerful tools to explore the QCD phase diagram

N : net charge ⋯ $N_+ - N_-$

M： Mean　　σ： Deviation



r-th non-central moment is defined by

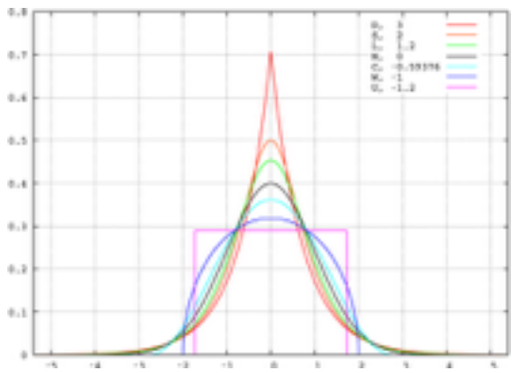
$$\mu_r{}' = \langle N^r \rangle$$

n-th order cumulant is written as

$$c_n = \mu'_n - \sum_{m=1}^{n-1} {}_{n-1}C_{m-1} c_m \mu'_{n-m}$$

S： Asymmetry

κ： Peakedness



$$\hat{M} = \hat{C}_{1,N}, \hat{\sigma}^2 = \hat{C}_{2,N}, \hat{S} = \frac{\hat{C}_{3,N}}{(\hat{C}_{2,N})^{3/2}}, \hat{\kappa} = \frac{\hat{C}_{4,N}}{(\hat{C}_{2,N})^2}$$

D-measure

D-measure is defined by 2 formula

D-measure1…

$$D = 4\frac{\langle \delta Q^2 \rangle}{\langle N_{ch} \rangle}$$

$$N_{ch} = N^+ + N^-$$
$$Q = N^+ - N^-$$

D-measure2…

$$D' = \langle N_{ch} \rangle \nu_{(+-,dyn)}$$

$$\begin{aligned} \nu_{+-,\mathrm{dyn}} &= \nu_{+-} - \nu_{+-,stat} \\ &= \frac{\langle N_+(N_+-1)\rangle}{\langle N_+\rangle^2} + \frac{\langle N_-(N_--1)\rangle}{\langle N_-\rangle^2} \\ &\quad -2\frac{\langle N_+N_-\rangle}{\langle N_-\rangle\langle N_+\rangle} \end{aligned}$$

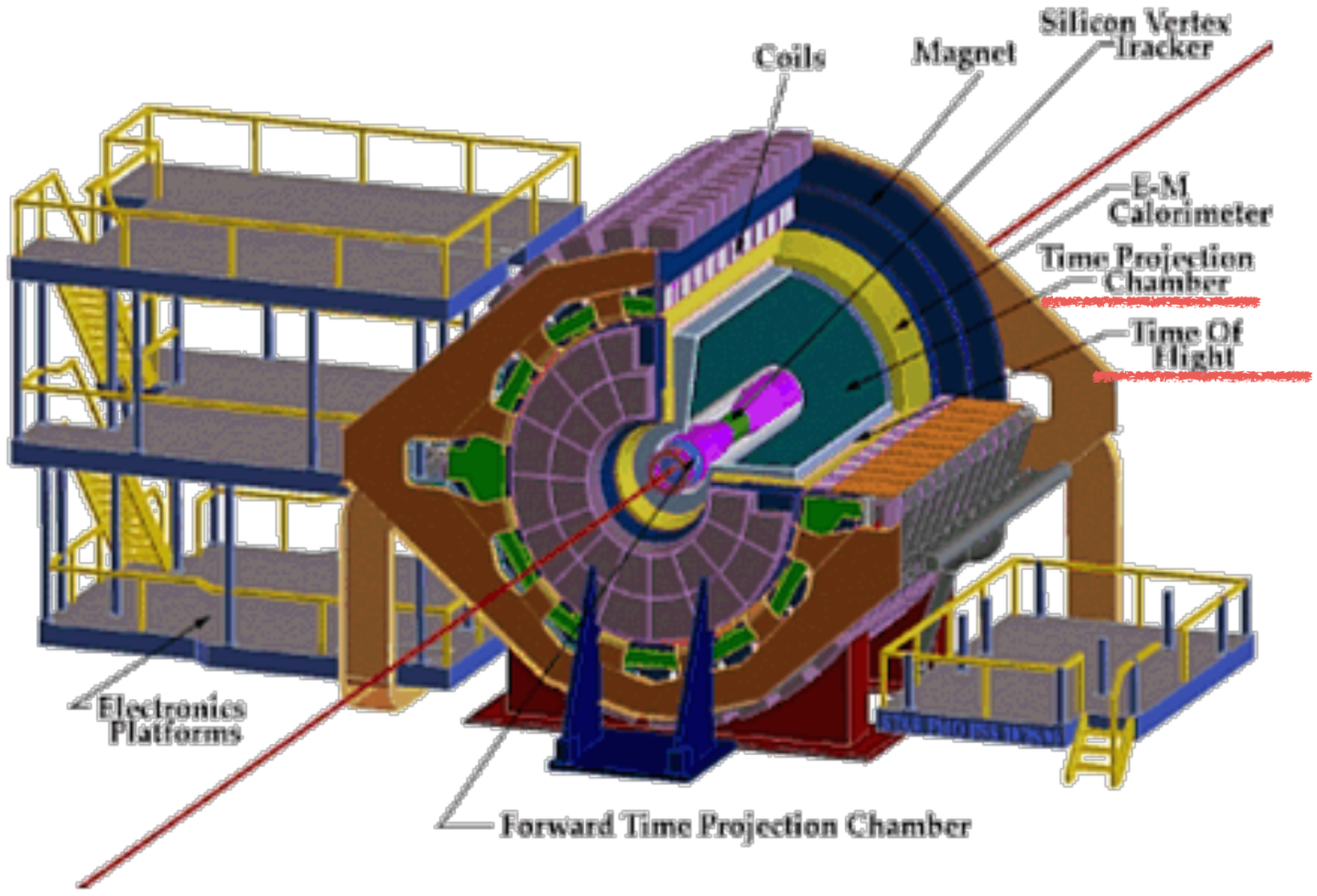
$$D' \sim D - 4$$

Theoretically, it is expected that

QGP fluctuation : D =1-1.5

Hadron fluctuation : D= 3-4

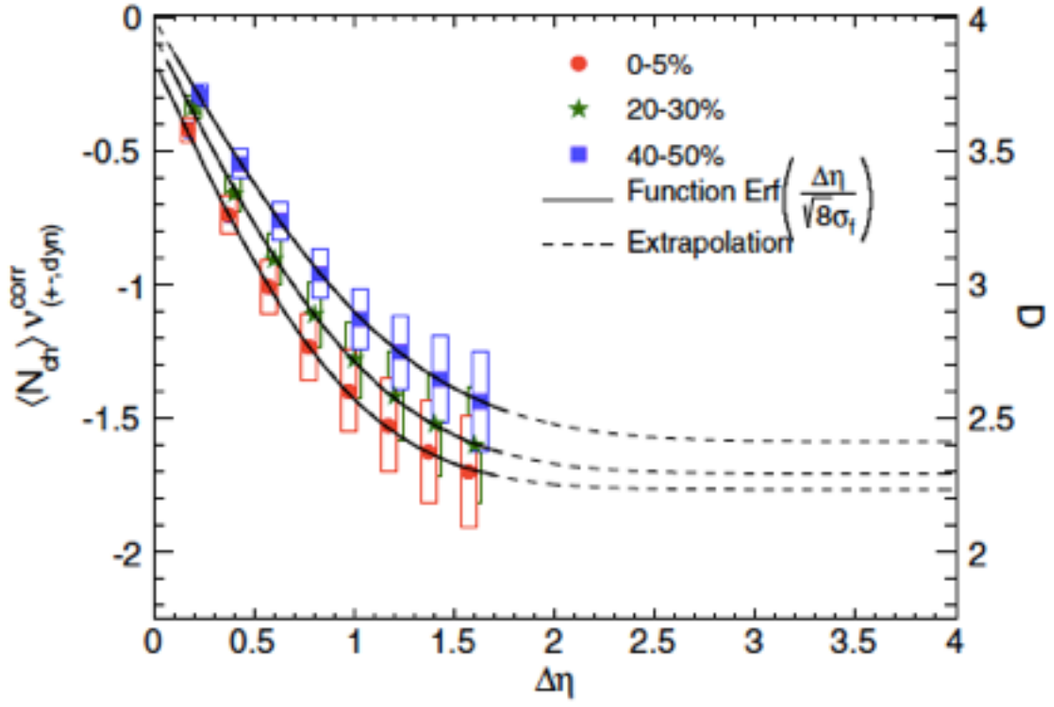
STAR Detector



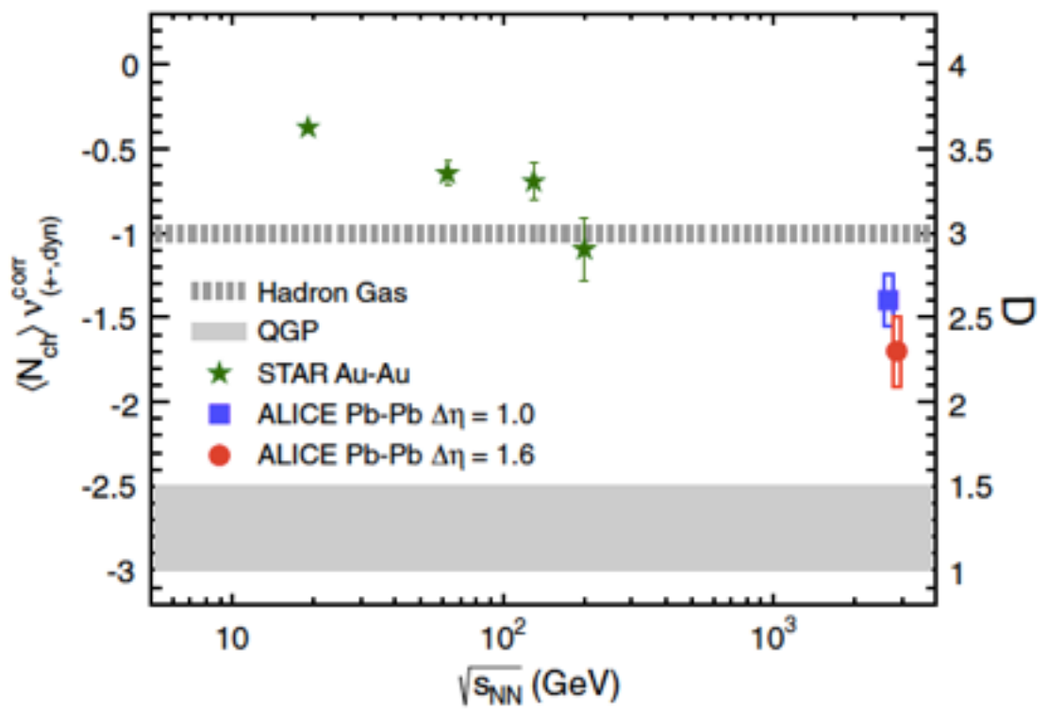
- TPC is used to decide particle trajectory and p_T
- TOF detector is used to remove pile up event in this analysis

ALICE and STAR results

Pb Pb ALICE(2.76TeV Pb+Pb)



PRL 110, 152301 (2013)



- As centrality become central, D-measure become small.
- As energy become large, D-measure become small

Expanding $\Delta\eta$ ⋯ we can see the signal of QGP fluctuation?

Correction method

- Remove Autocorrelation effect $\begin{cases} 0.5 < |\eta| < 1 & \cdots\text{determine centrality} \\ |\eta| < 0.5 & \cdots\text{used for analysis} \end{cases}$
- Centrality Bin Width Correction
- Efficiency Correction
- Charge conservation correction (D-measure)

Charge conservation correction have done to avoid effect of charge conservation and system size.

$$D \quad \Rightarrow \quad D + 4\frac{\langle N_{ch} \rangle}{\langle N_{total} \rangle}$$

Charged multiplicity in measured acceptance

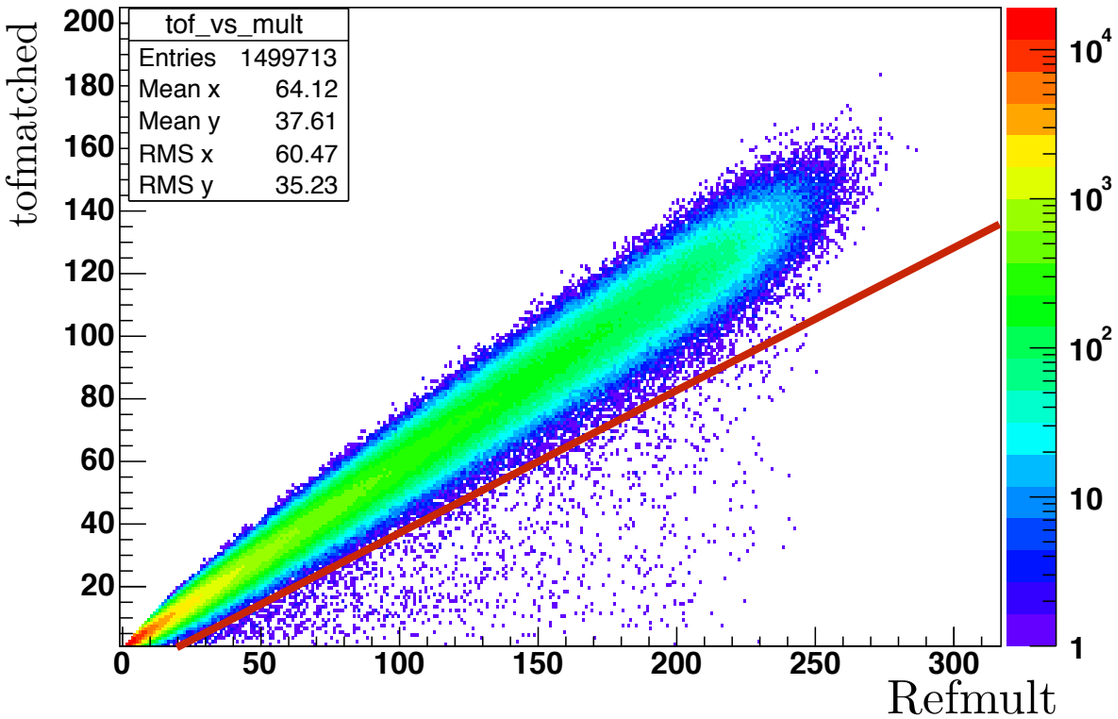
Total charged multiplicity in all acceptance

If this correction are applied,
D-measure become large.

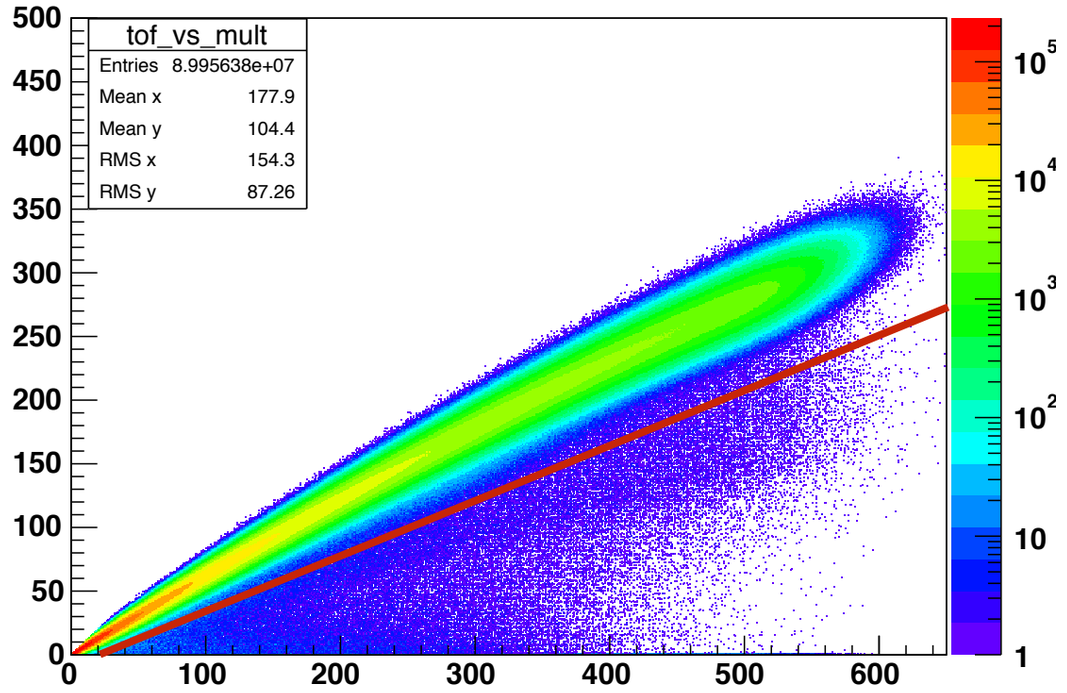
QA plot

Hits of TOF

7.7GeV



200GeV

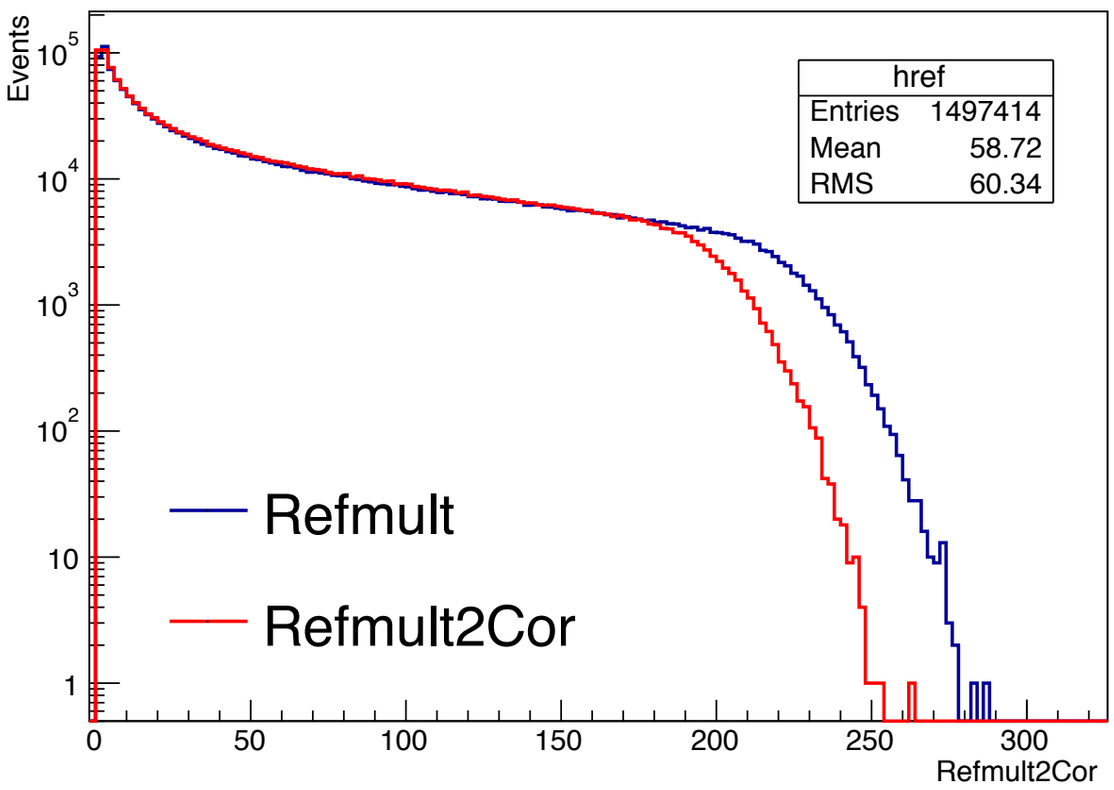


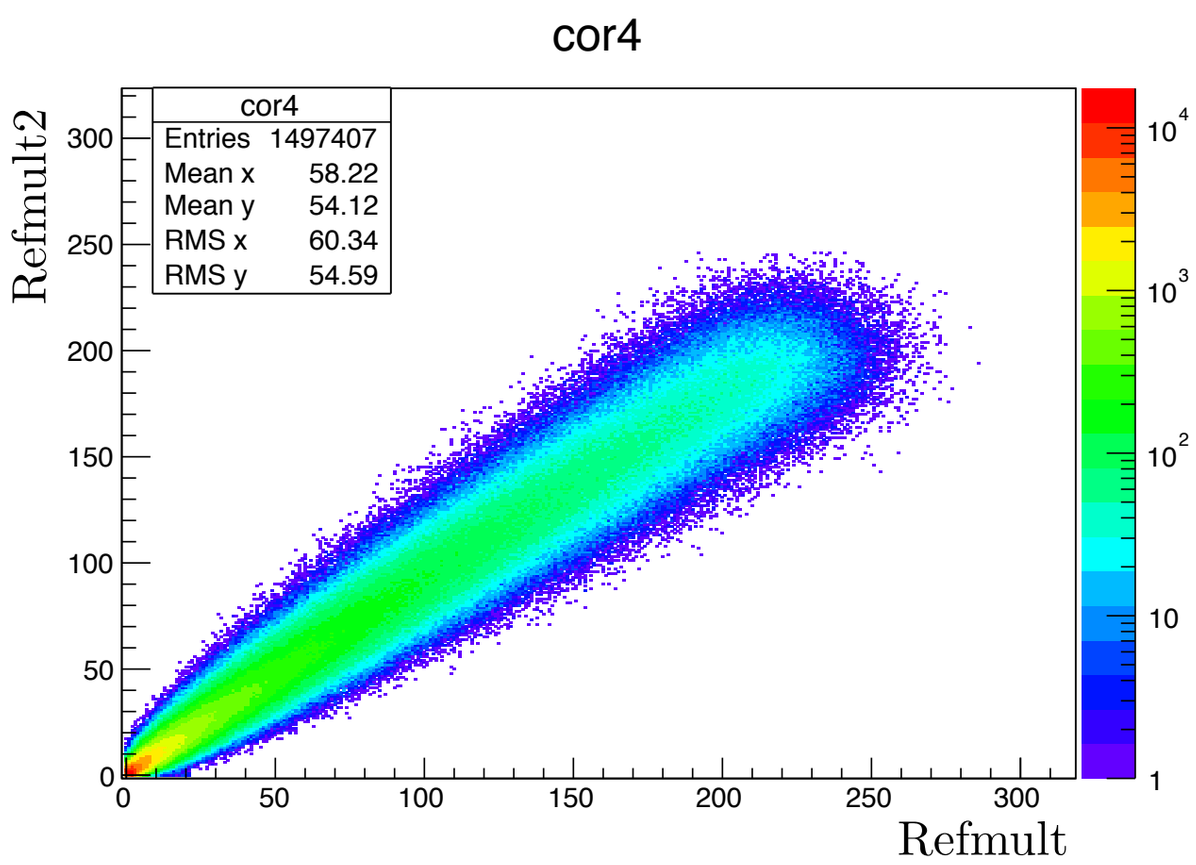
Hits of TPC

Pile up event has been removed.

(cut under red line)

Centrality Determination



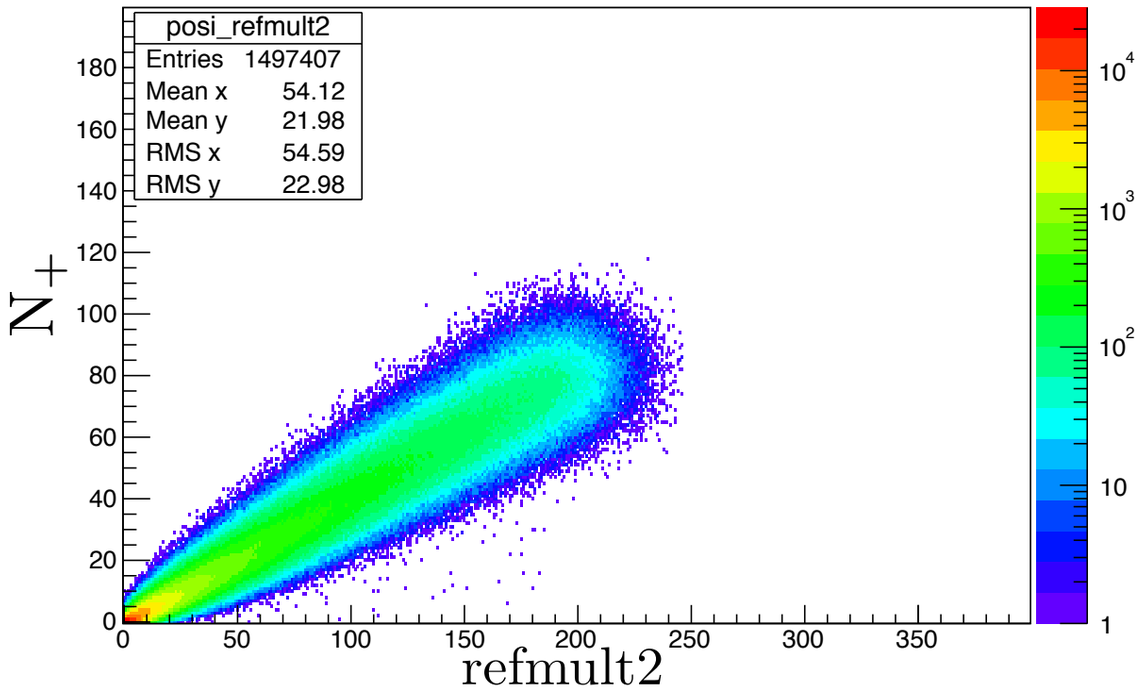


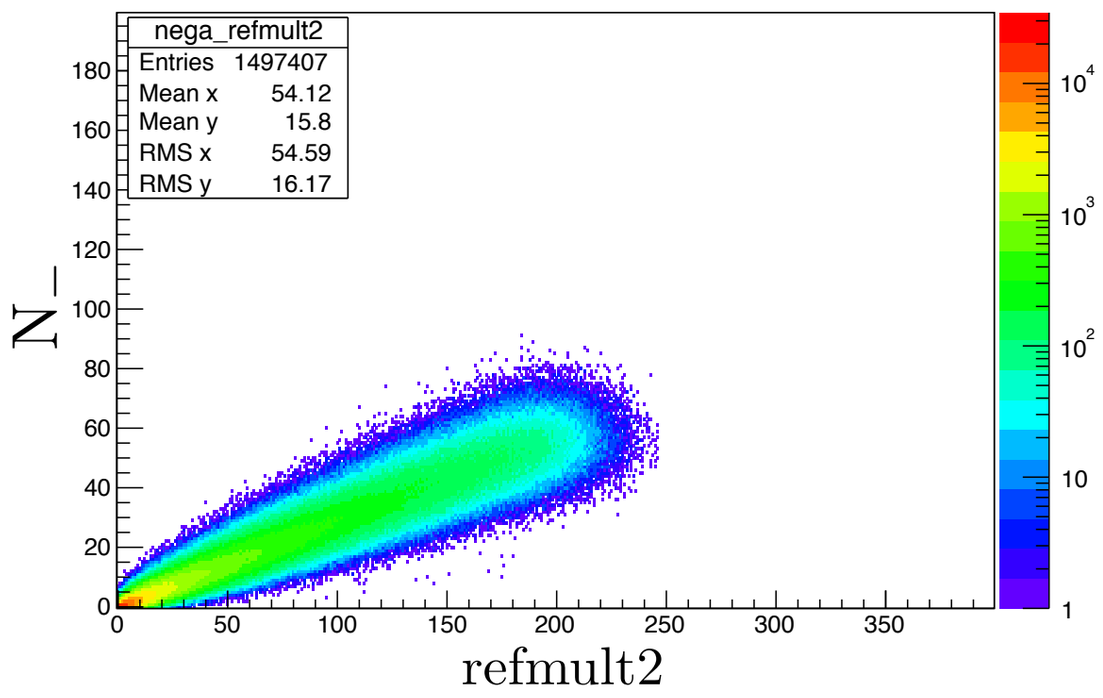
Refmult…charged multiplicity in $|\eta| < 0.5$

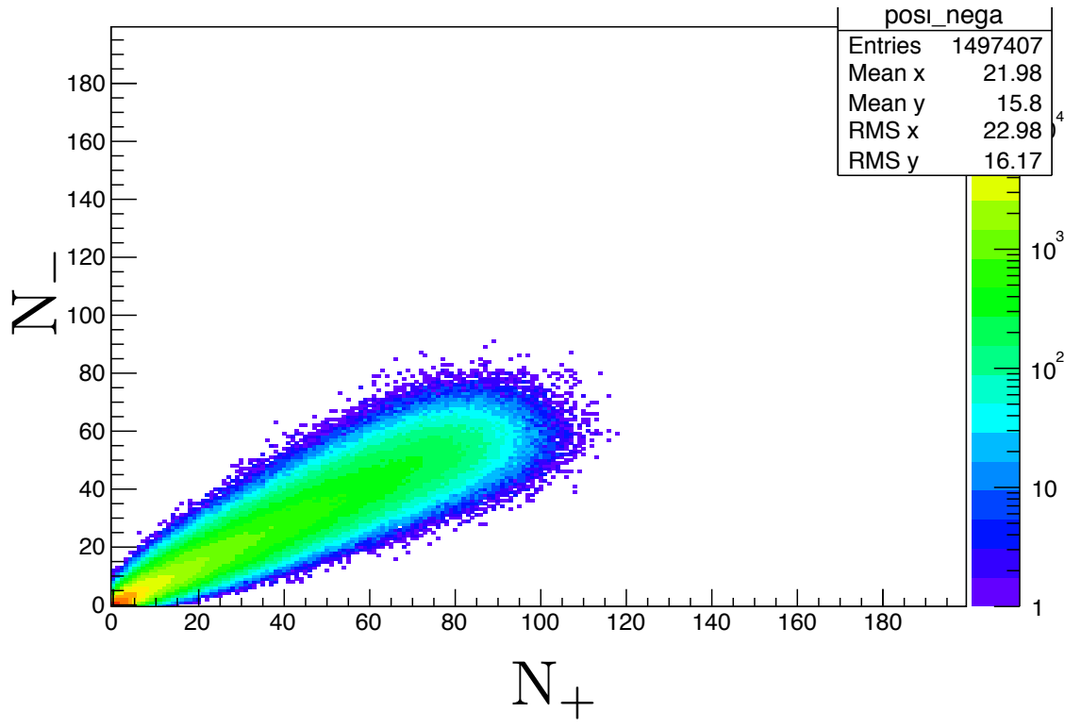
Refmult2…charged multiplicity in $0.5 < |\eta| < 1$

Refmult2 is used for centrality determination to remove autocorrelation effects

Scatter plot of N+, N- (7.7GeV)

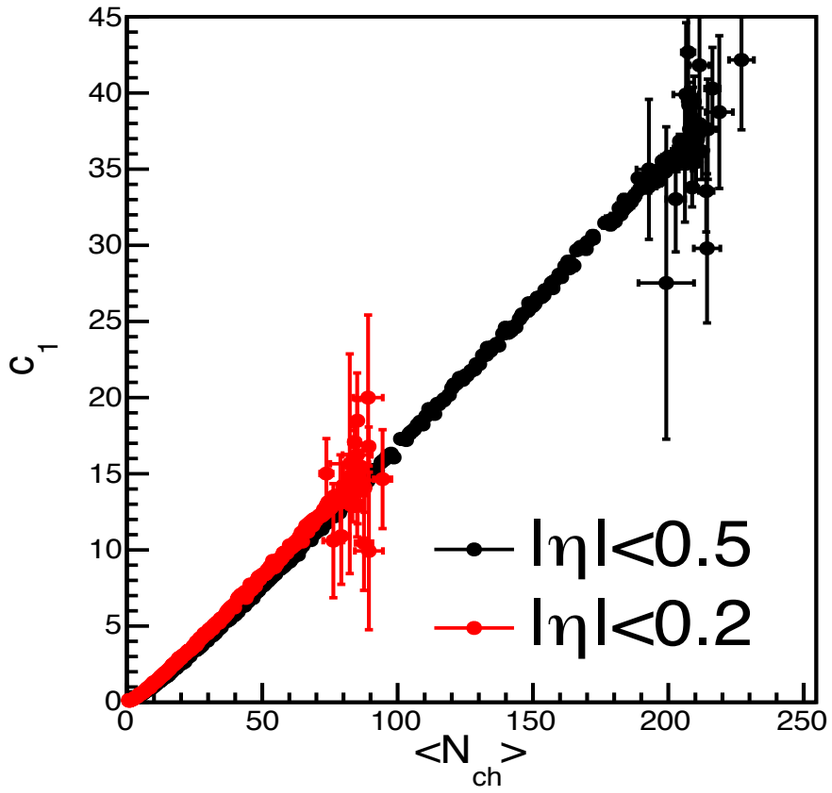


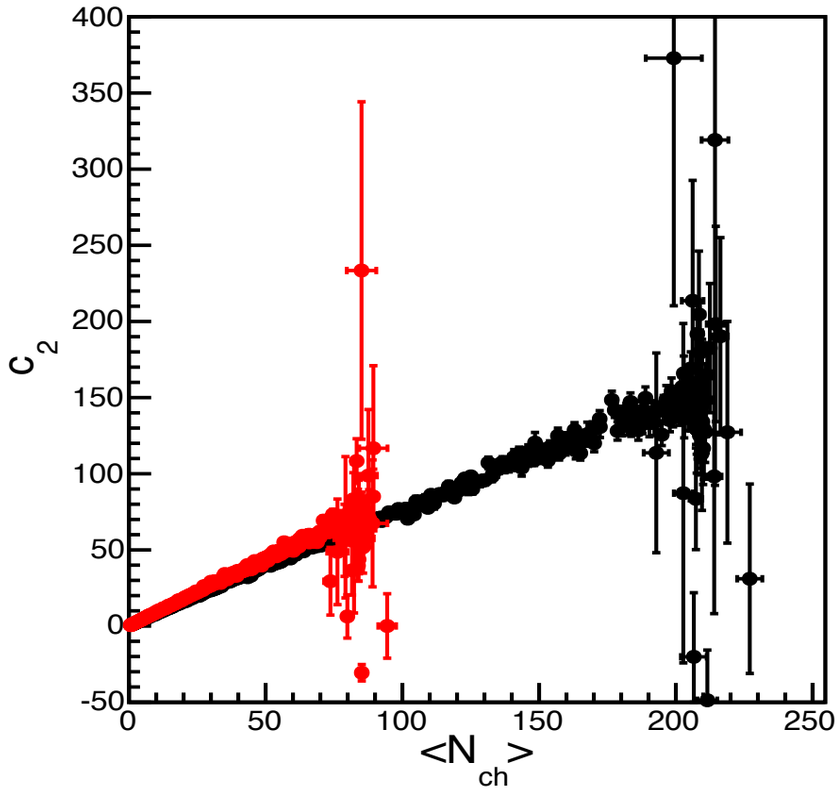


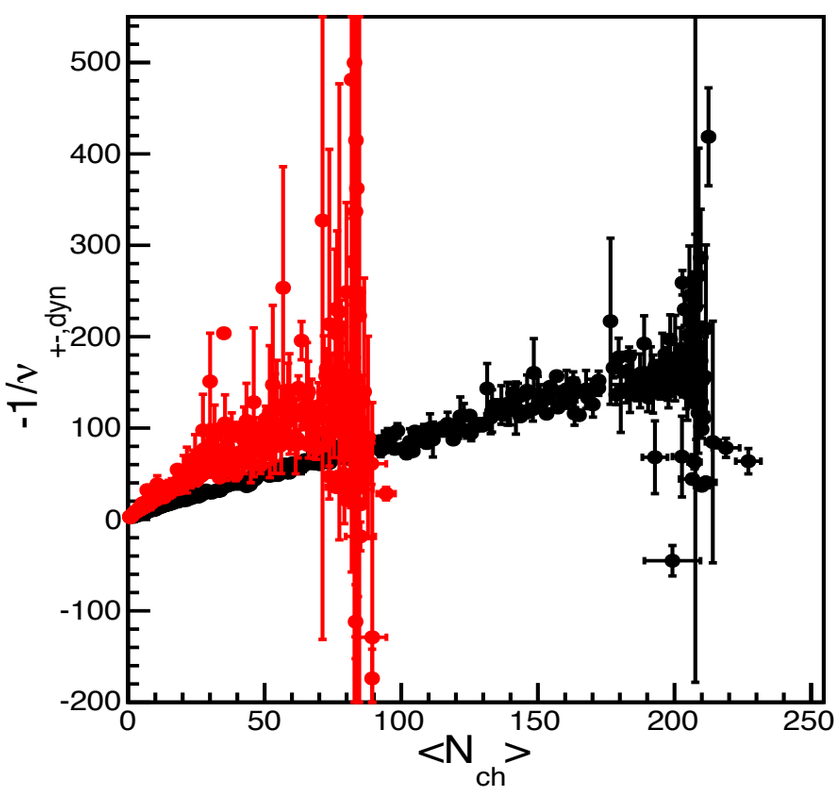


Linear correlation is seen in N+ v.s. N-

Correlation (7.7GeV)







- c1, c2 and -1/ν_{dyn} seems proportional to <Nch>
- c2/<Nch> of $|\eta|$<0.2 seems smaller than that of $|\eta|$<0.2

Summary

- We report correlations for 1st to 2nd order cumulants of net-charge, Nch, and ν_{dyn} at different eta region at $\sqrt{s_{NN}}$ = 7.7 GeV Au+Au collisions at RHIC.

- We confirmed c1, c2 and -1/ν_{dyn} are approximately proportional to <Nch> because of volume effect.

- c2/<Nch> of $|\eta|$<0.5 seems smaller than that of $|\eta|$<0.2

Next

- Calculate delta eta dependence of D-measure and cumulant ratios from 7.7GeV to 200GeV and consistency check with publish results.

back up

Data set

RHIC STAR experiment, Beam Energy Scan

Au+Au 7.7GeV, 11.5GeV, 19.6GeV, 27GeV, 39.5GeV, 62GeV, 200GeV

$0.5 < |\eta| < 1$ …used to define centrality

$$\begin{cases} |\eta| < 0.5 \\ 0.2 < p_T < 2.0 \end{cases}$$ …used to net-charge analysis

Run selection

…using Nihar's good run list and Hiroshi's bad run list

Event selection

	Nihar(published)	My analysis
|Vz|	<30	same
|Vr|	<2	same
|VpdVz-Vz|	<4 (39-200GeV only)	same
Pile up event cut	Tof matched>0.46*(Refmult)-10	same

Track cut

Analysis

	Nihar(published)	My analysis
p_T	0.2 to 2 (GeV)	same
η	-0.5 to 0.5	same
nFitPoints	>20	same
DCA	<1cm	same
Track Quality Cut	>0.52	same
nhitsdedx	>10	same
spallation proton cut	nSigmaProton < 2	same

Centrality

	Nihar(published)	My analysis
$\|\eta\|$	0.5 to 1	same
z-vertex correction	done	same
DCA	<3cm	same
nFitPoint	>10	same