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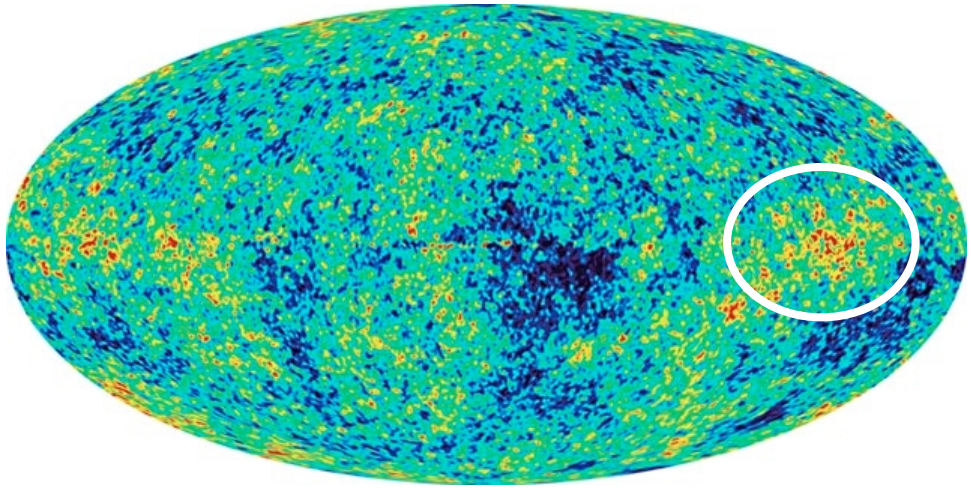
PHENIX

Measurement of Fluctuations in Event-by-Event N_{ch}-N_{γ} Balance

Tomoaki Nakamura and Kensuke Homma
for the PHENIX collaboration
Hiroshima University

What we measure is **inhomogeneity** of fluctuations **PER EVENT**



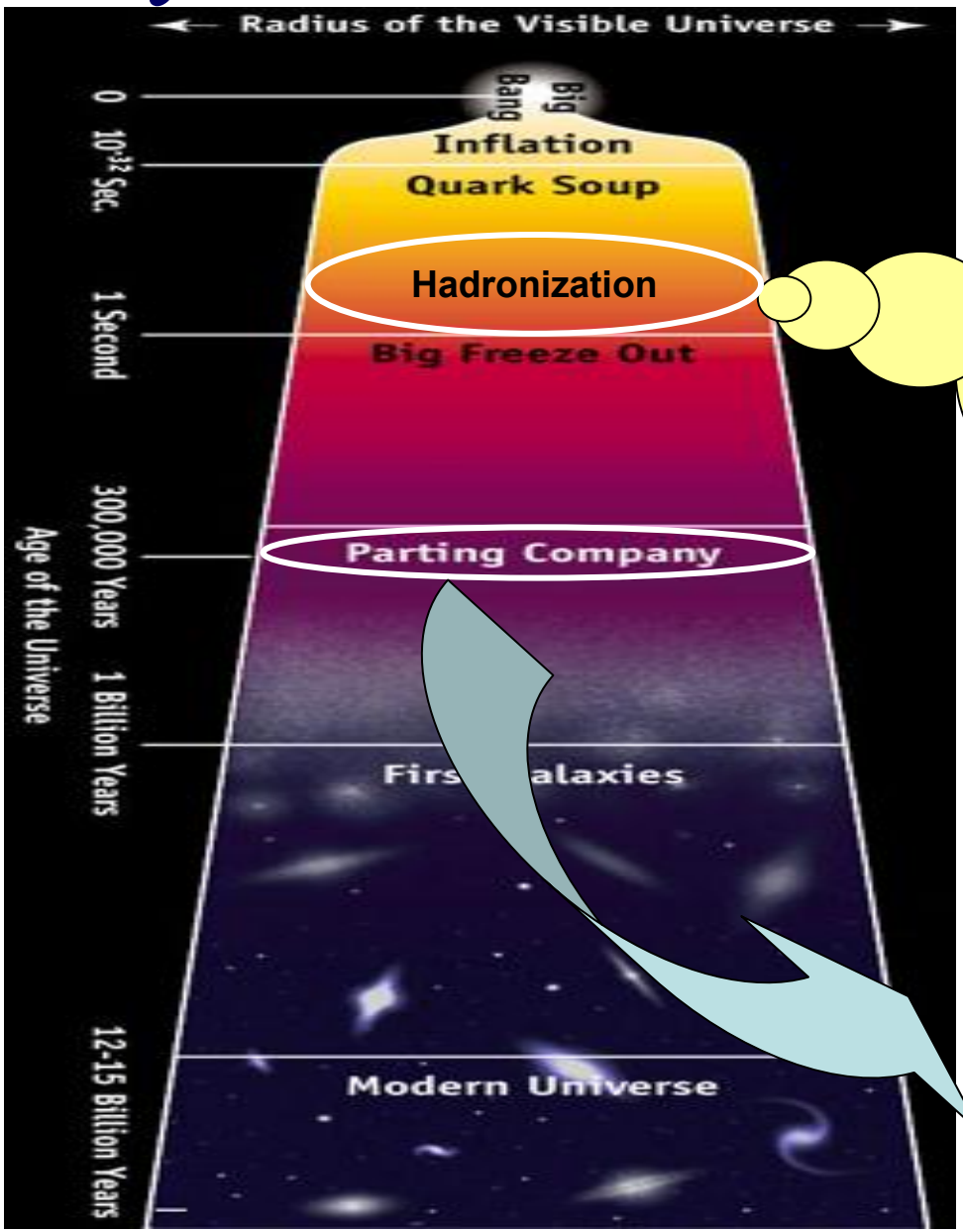
The Microwave Sky image from the WMAP Mission
http://map.gsfc.nasa.gov/m_mm.html

Measure a maximum deviation on balances between Nch and Nγ as a function of search region size PER EVENT !

- Fluctuations carries information at early universe in cosmology despite of the only single Big-Bang event.
- Why don't we use the genuine event-by-event information by getting all phase space information to study evolution of dynamical system in heavy Ion collisions ?

We can firmly search for interesting fluctuations with more than million times of mini Big-Bangs.

Physics motivation



Fluctuation of the balance between charged and neutral π is a possible probe to extract information at the chiral phase transition.

(DCC scenario)

Fluctuations of CMB inherited from early universe is observed at the later stage of the evolution.

Observables

balance

$$B(x) \equiv N_{\pi^{\pm}}(x) - 2N_{\pi^0}(x)$$

$$\approx N_{ch}(x) - N_{\gamma}(x)$$

$$where, x \equiv (\eta / 2^{j_\eta}, \phi / 2^{j_\phi})$$

$$\langle B(x) \rangle \equiv \langle N_{ch}(x) \rangle - \langle N_{\gamma}(x) \rangle$$

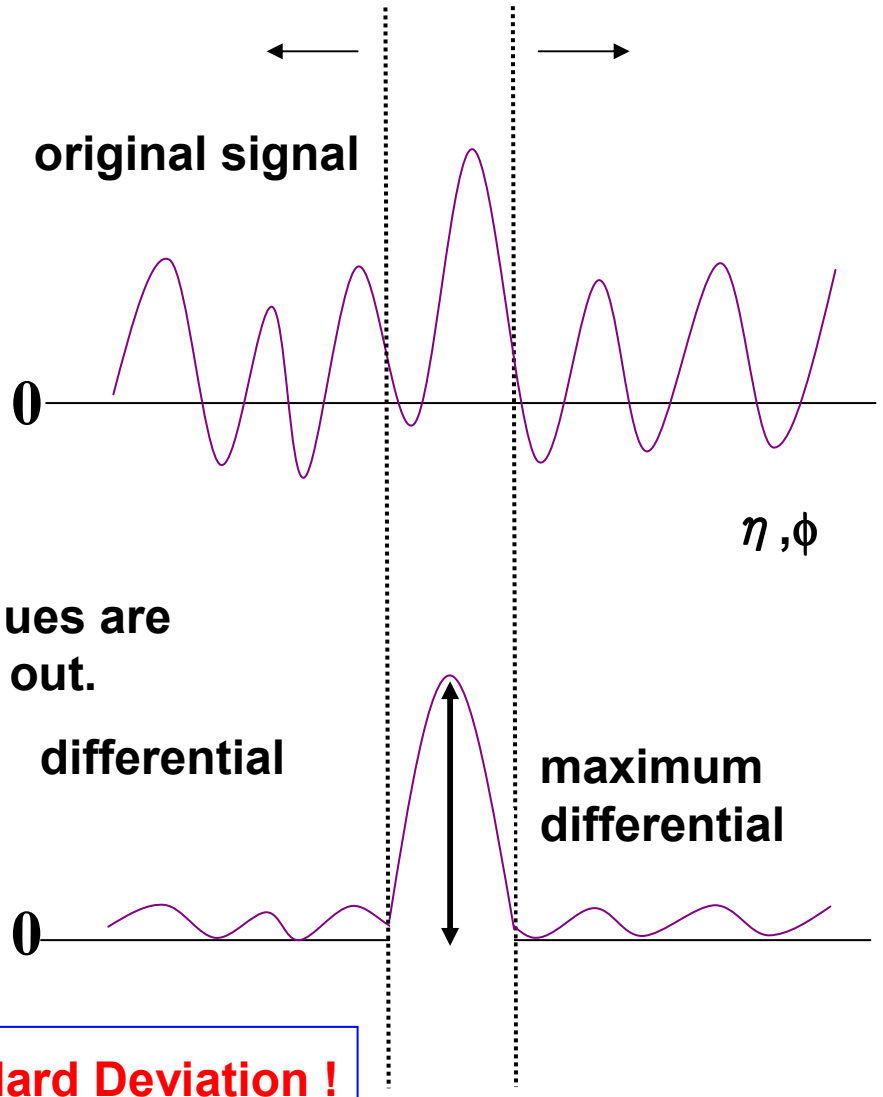
differential balance

←Offset values are canceled out.

$$\delta B(x) \equiv \frac{B(x+dx) - B(x)}{\sigma_{\langle B(x) \rangle}}$$

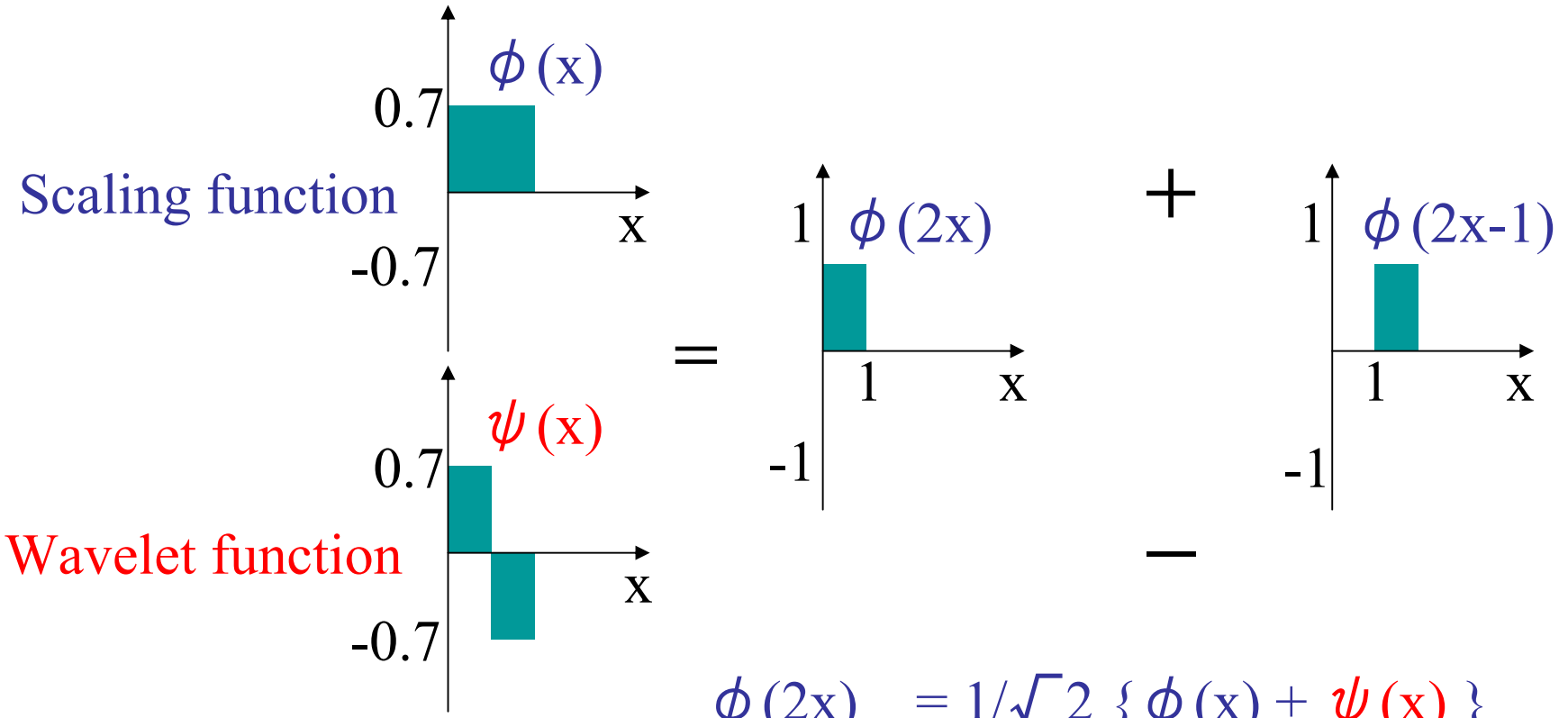
$$\sigma_{\langle B(x) \rangle} \equiv \sqrt{\delta \langle N_{ch}(x) \rangle^2 + \delta \langle N_{\gamma}(x) \rangle^2}$$

$$\delta B_{\max} \equiv \max |\delta B(x)|$$ **Unit is Standard Deviation !**



Wavelet algorism (two scale relation)

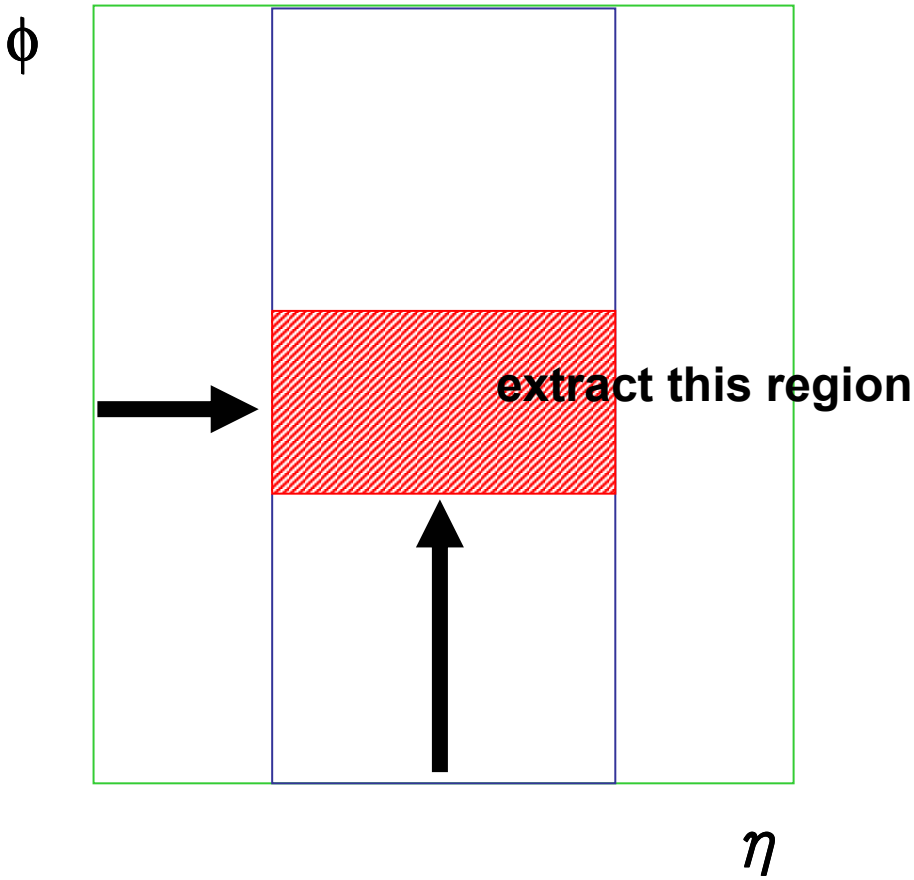
Level j-1 : 2^{j-1} bins Level j : 2^{j} bins



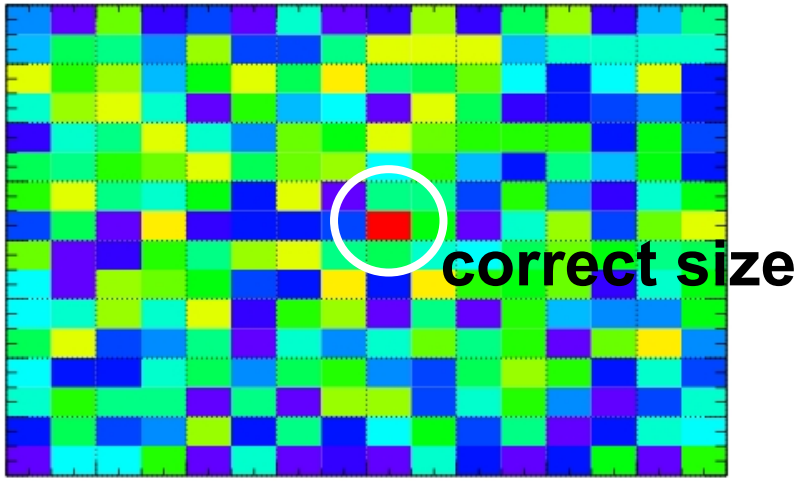
$$\phi(2x) = 1/\sqrt{2}\,\{\phi(x) + \psi(x)\}$$
$$\phi(2x-1) = 1/\sqrt{2}\,\{\phi(x) - \psi(x)\}$$

How to extract region?

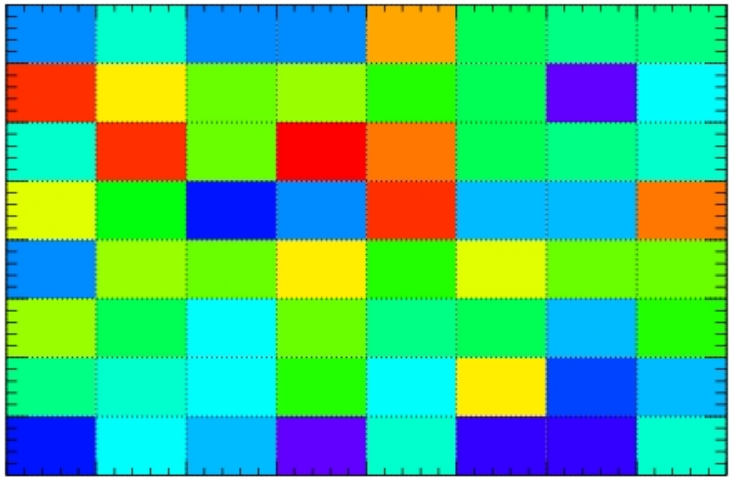
Assuming only square shape
(no diagonal components)



High resolution

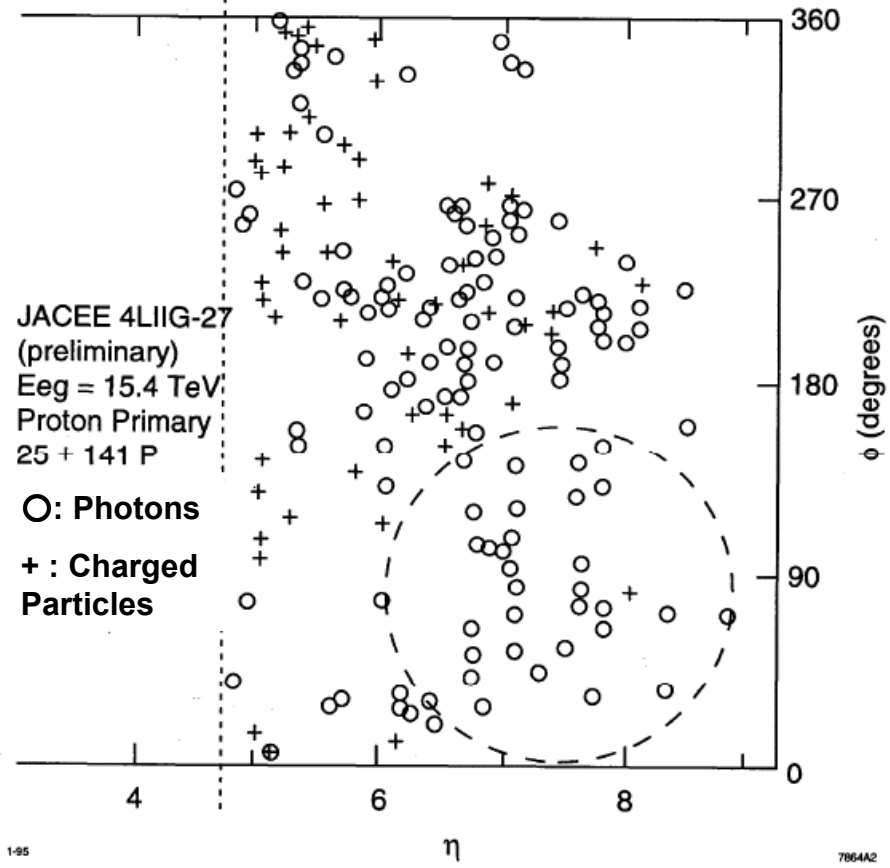


Low resolution



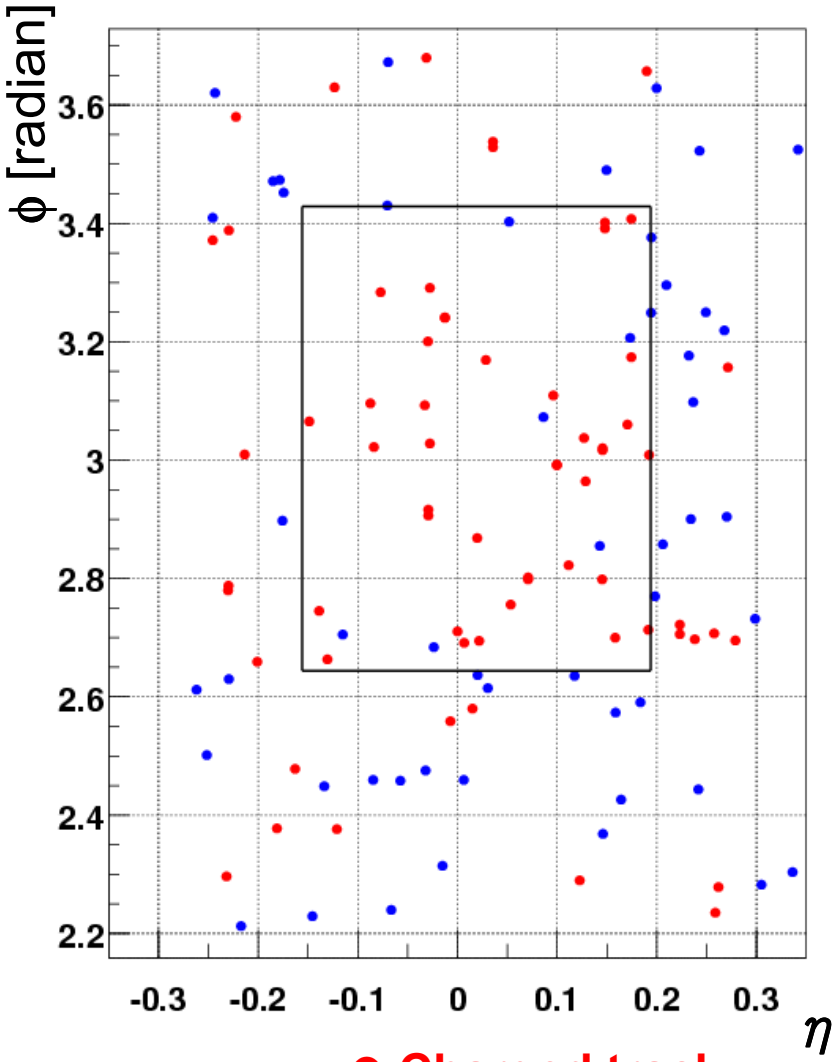
High energy cosmic ray experiment and PHENIX

Can DCC scenario explain these events or something else?



J. J. Lord and J. Iwai. Int. Conference on High Energy Physics, TX, 1992

PHENIX 7.26 standard deviation

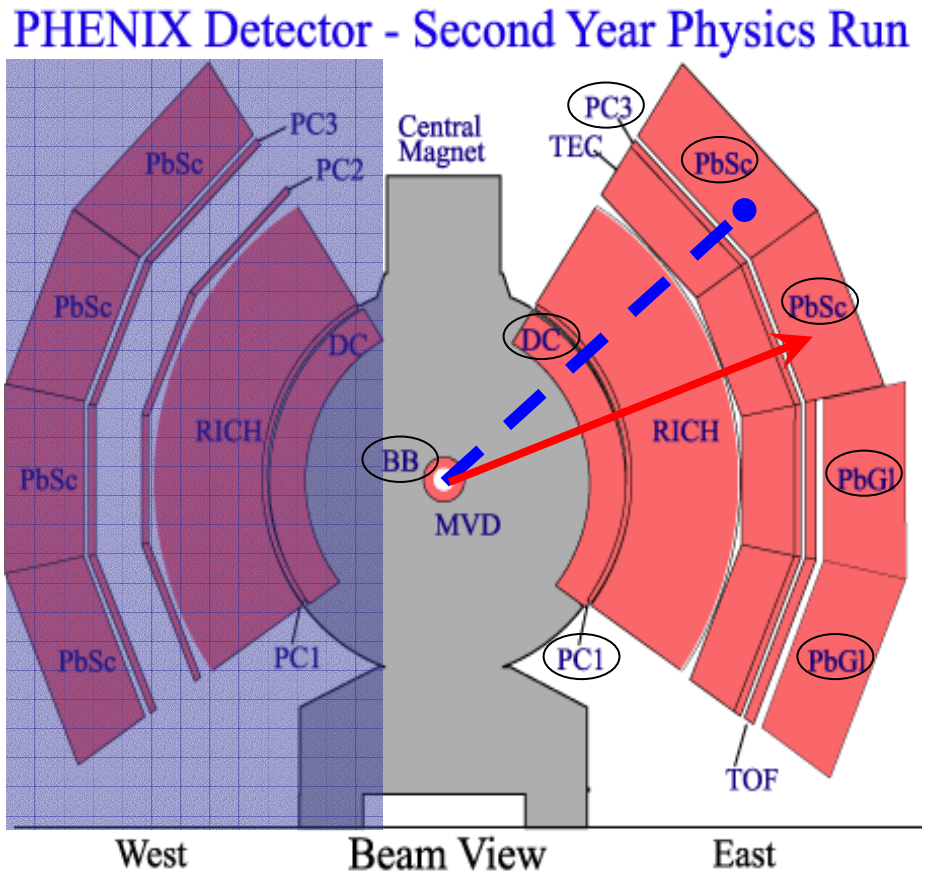


● **Charged track**

● **Photon cluster**

Au+Au $\sqrt{s_{NN}}$ = 200GeV at PHENIX

- **Using magnetic field-off**
- **Charged Track**
  Tracking detectors
  - Drift chamber
  - Pad chamber 1, 3
  - BBC vertex
- **Photon Cluster**
  Electro-magnetic calorimeter
  - Cluster shower shape
  - Time of flight
  - Charged particle veto by track
  - Charged particle veto by PC3
- **Rigorous data quality assurance was necessary to guarantee detector stabilities**

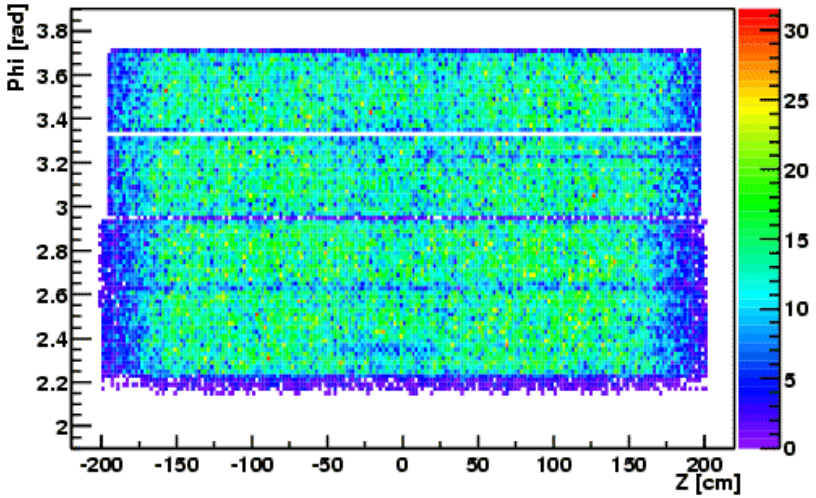


$$|\eta| < 0.35$$

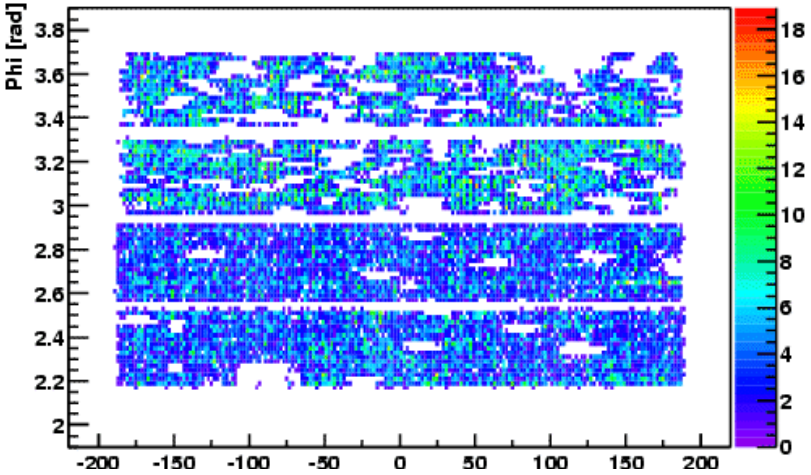
$$\Delta\phi < 1/2\pi$$

Event sample and a normal event

Charged tracks

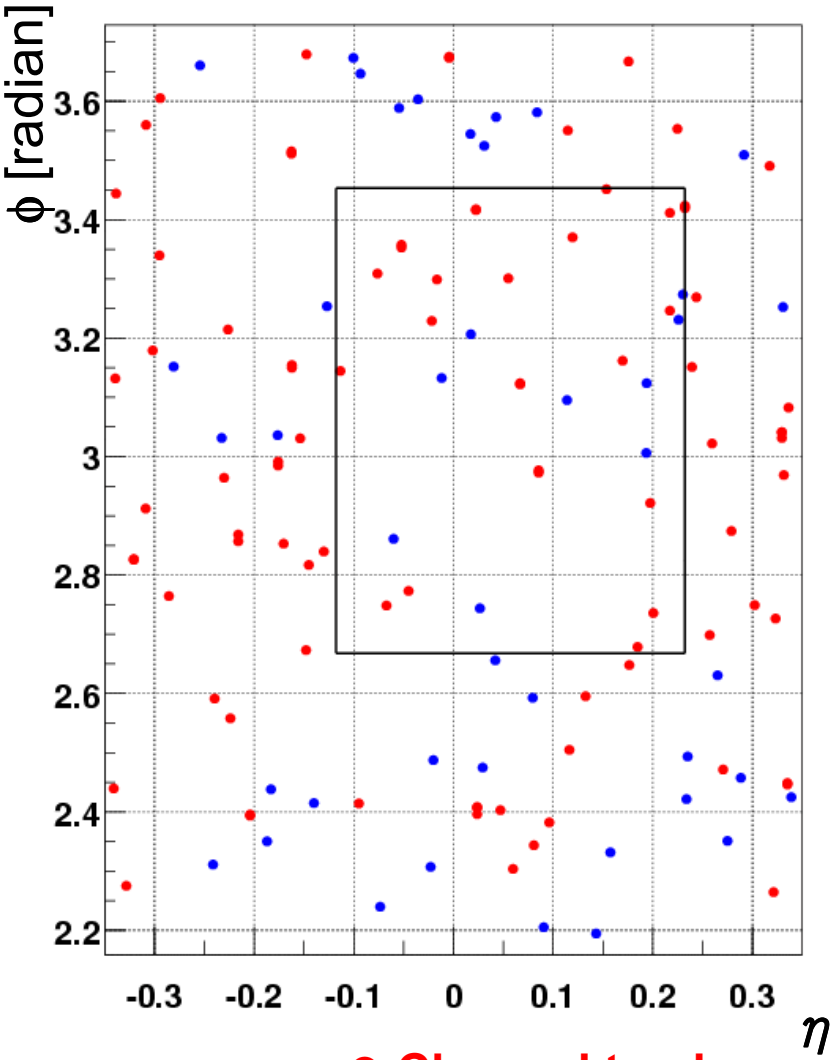


Photon clusters

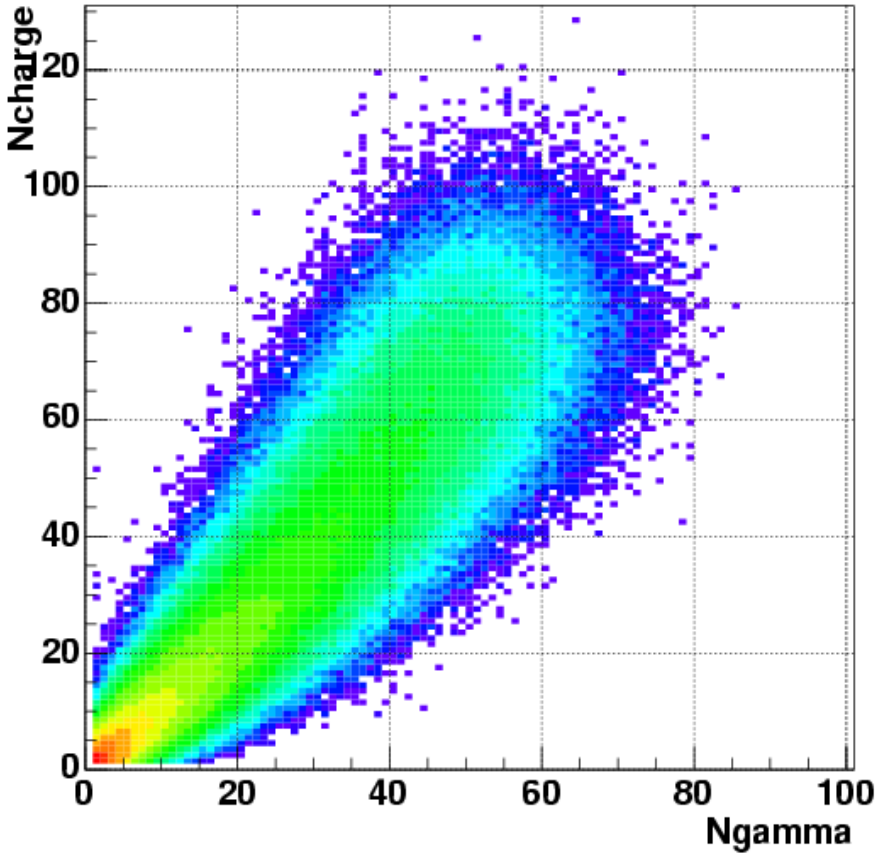


~3,000 events accumulated

2.4 standard deviation

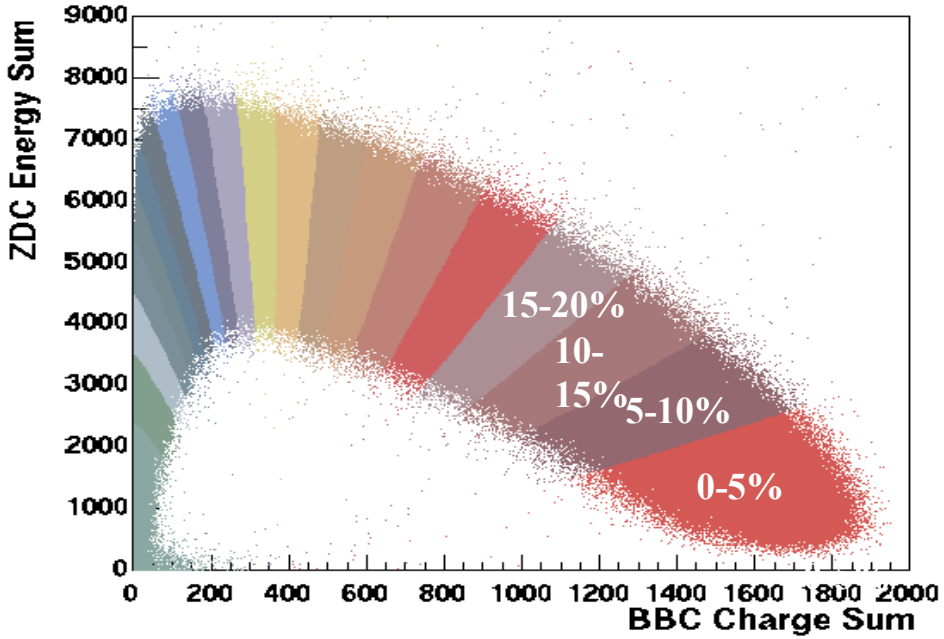


Selected event samples



Correlation between N_{ch} and N_{γ} measured by PHENIX central arm

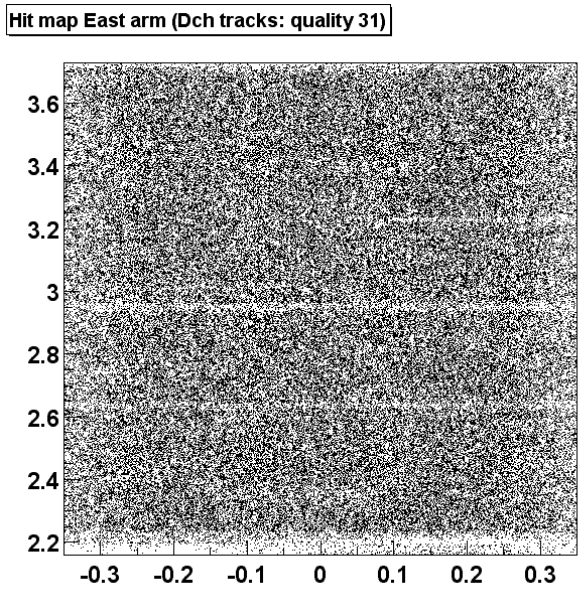
Centrality was measured by Beam-Beam Counter and Zero Degree Calorimeter



Baseline fluctuations

Binomial sample

- Produce hit maps (2^8 x 2^8 bins in η–ϕ) from the accumulated positions of γ clusters and charged tracks respectively in real data to reproduce inefficient area of the detector as realistic as possible.

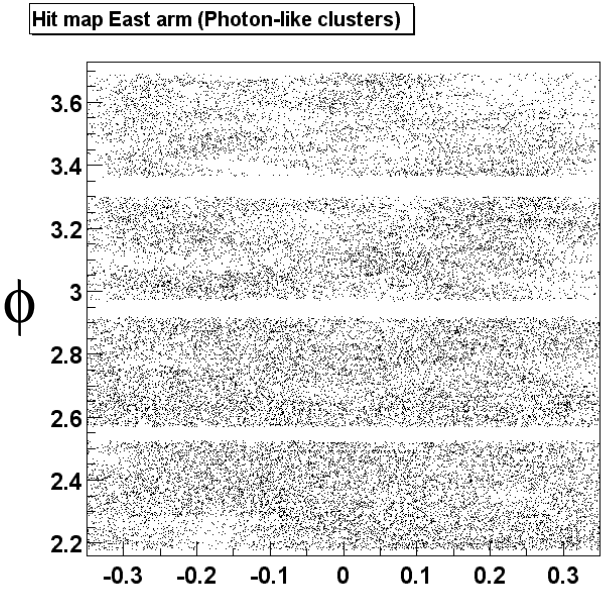


ϕ

η

Map for charged tracks

- Randomly distribute γ clusters and charged tracks to all η–ϕ space, but if there is no entry in the hit map, discard the cluster or track until # of accepted clusters and tracks coincide with those observed in a given real event.



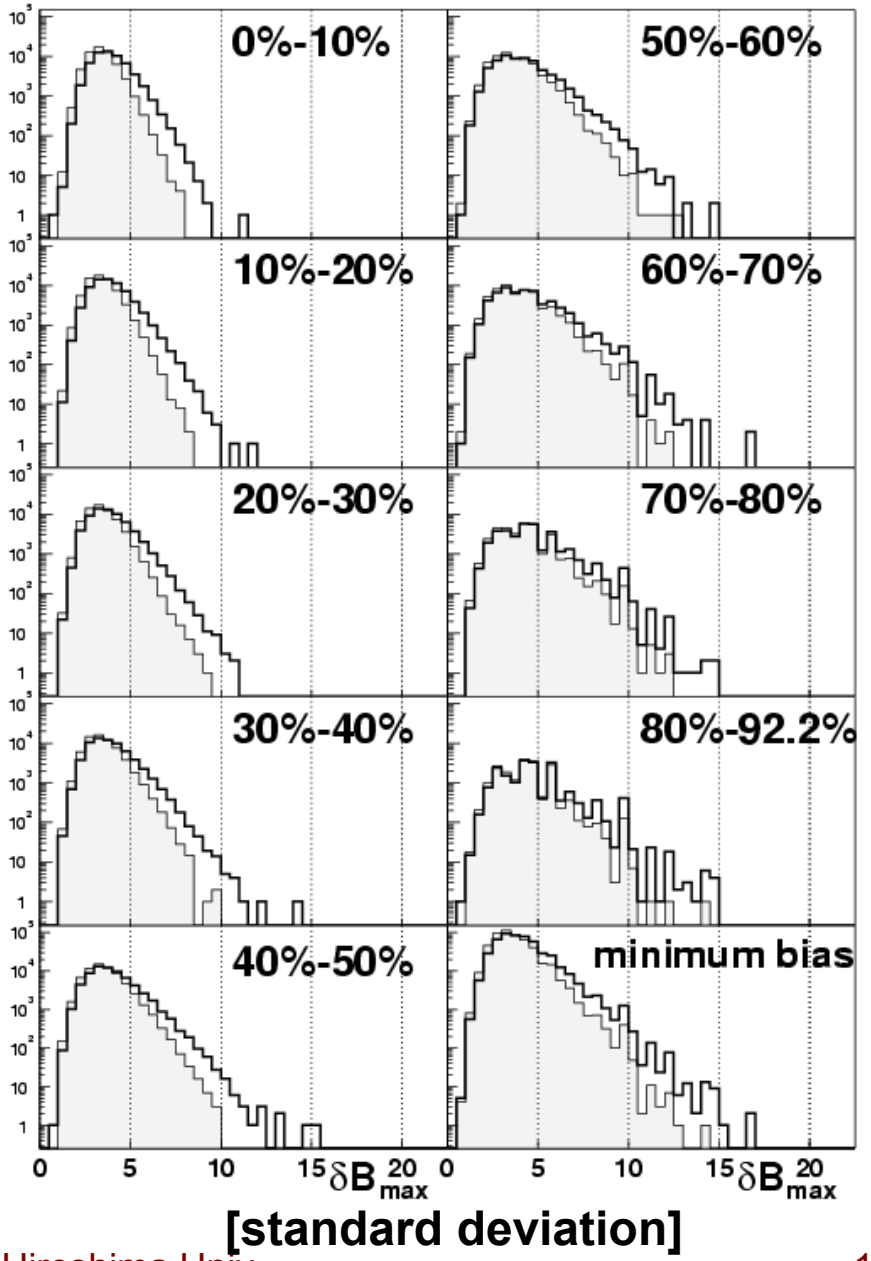
ϕ

η

Map for γ clusters

Comparison with baseline fluctuation

- Comparison of δB_{max} distribution between real data and binomial samples for each centrality.
  - black : real data
  - shaded : baseline fluctuation of binomial made by hit map



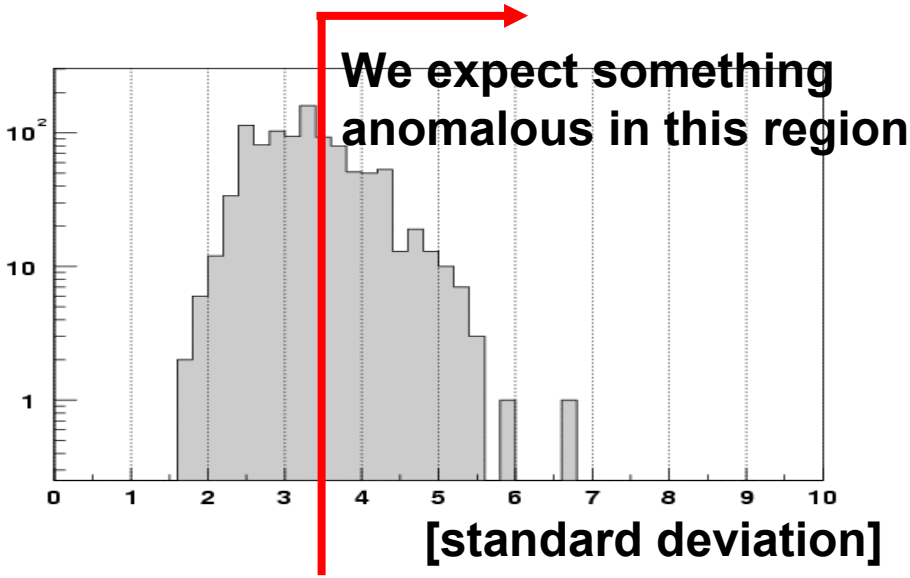
Determination of 5 % significance level

Significance level defines degree of anomaly of an event compared to the corresponding binomial fluctuations. Analogy to background levels to invariant mass spectra.

- 5% significance level was not determined from evens belonging to one centrality bin, but from event-by-event multiplicity set of N_{ch} and N_{γ} .
- 5% significance level is to exclude 95% binomial fluctuation, which is made by hit map of real charged tracks and photon cluster position in the η -ϕ space.

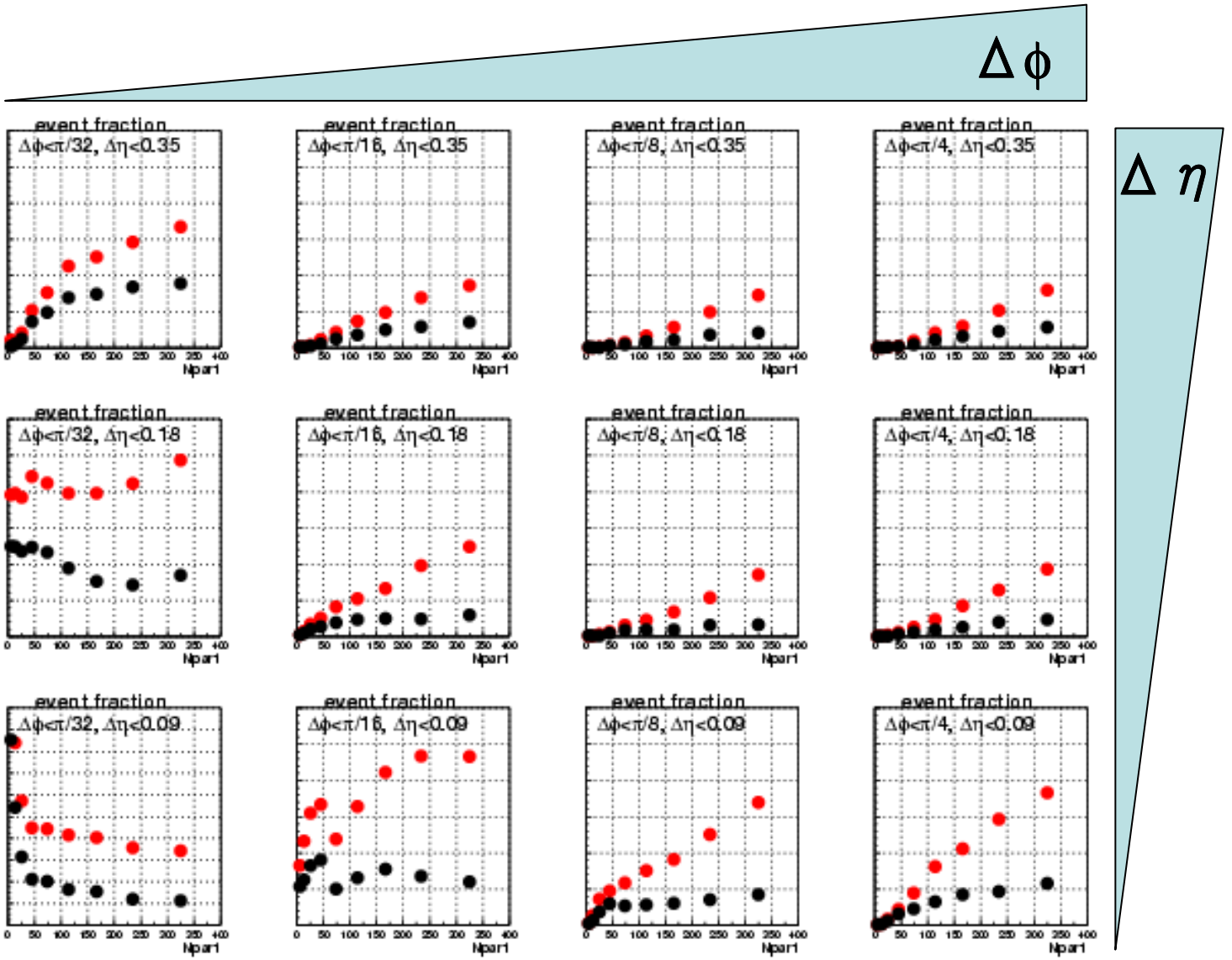
δB_{max} distribution of 1000 binomial events for an observed event of

$(N_{ch}, N_{\gamma}) = (50,50)$.



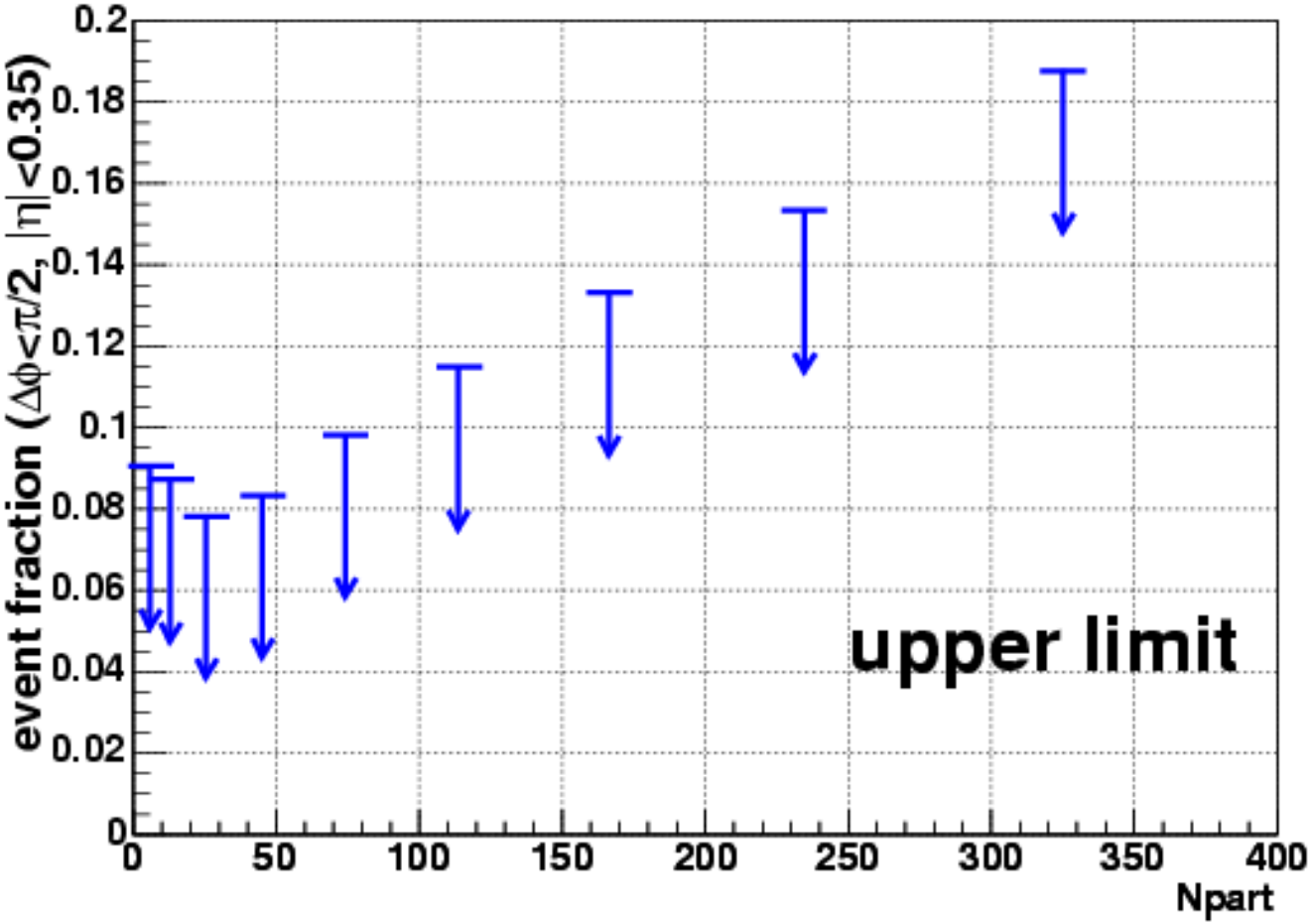
Subtraction of baseline fluctuation in each subdivided area

- **data**
- **baseline**



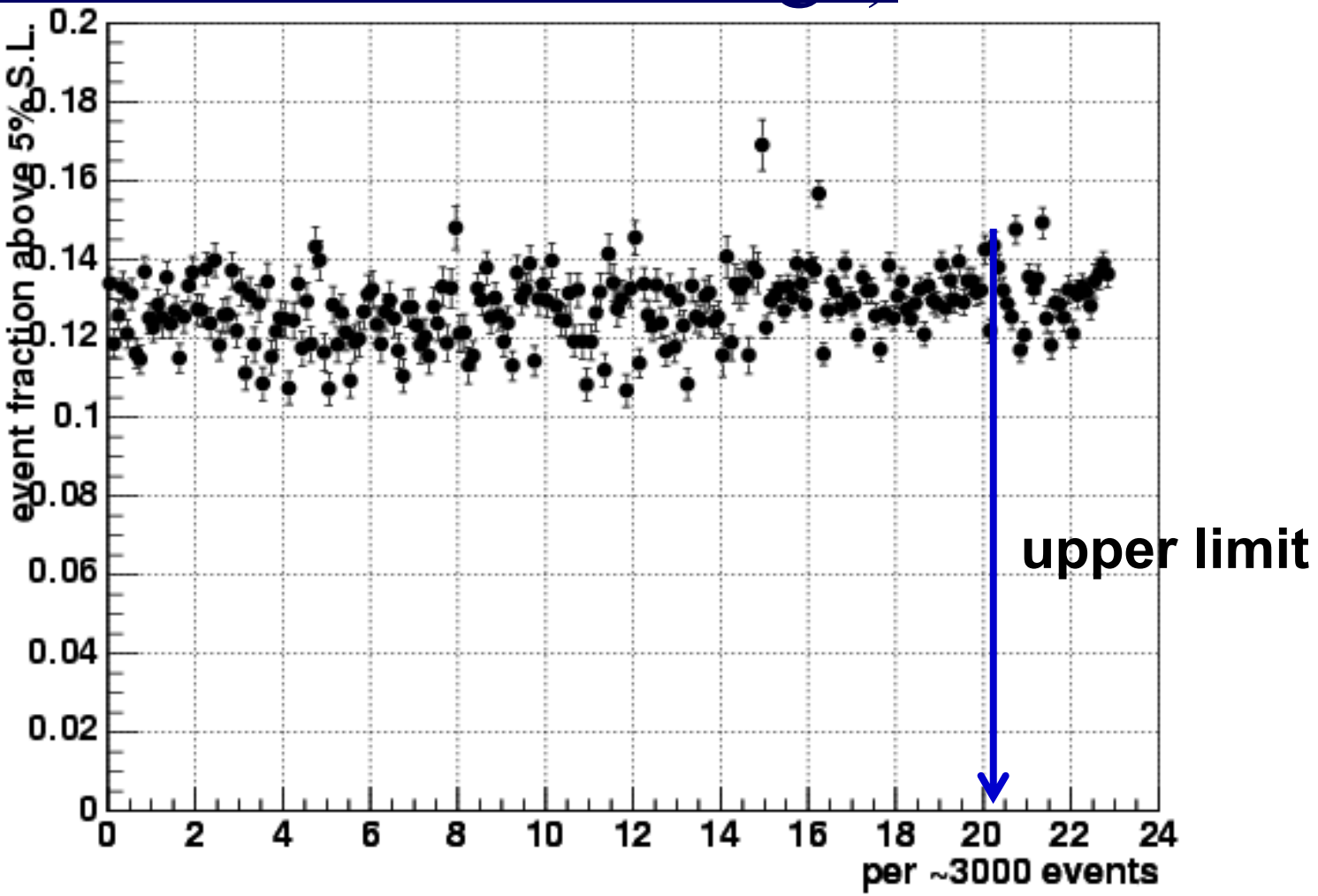
Npart dependence of event fraction

Event fraction corresponds to a probability that anomalous events occur and detected by our acceptance. Similar to a X-section of rare events.



$$\text{Event fraction} = \frac{\text{The number of events above 5\% significance level on } \delta B_{max}}{\text{The number of events per centrality bin}}$$

Event fraction above 5% significance level (per ~3000 events run range)



Summary

- We have developed a novel method to measure the inhomogeneity on the charge and neutral balance in the event-by-event basis.
- Detector stabilities are now guaranteed.
- The event fraction above 5% significance level as its upper limit shows monotonic raise as a function of Npart. However, the detector originated fluctuations might be still contained.
- After complete understanding of the detector bias, elliptic flows, jets and Bose-Einstein effects in the event fraction will be evaluated in order to search for more exciting effects such as DCC.