Study of Fluctuations on Isospin Symmetry in Au+Au Collisions at RHIC-PHENIX

Tomoaki Nakamura / Kensuke Homma

Hiroshima Univ.

for the PHENIX Collaboration

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Centauro Type Event

(High Energy Cosmic Ray Experiment)

- **(Brazil-Japan collaboration in Bolivia) Y.Fujimoto and S.Hasegawa, Phys. Rep. 65, 151 (1980)**
- **(JACEE) J.J.Lord and Iwai, Paper No. 515, International Conference on High Energy Physics, Dallas (1992)**

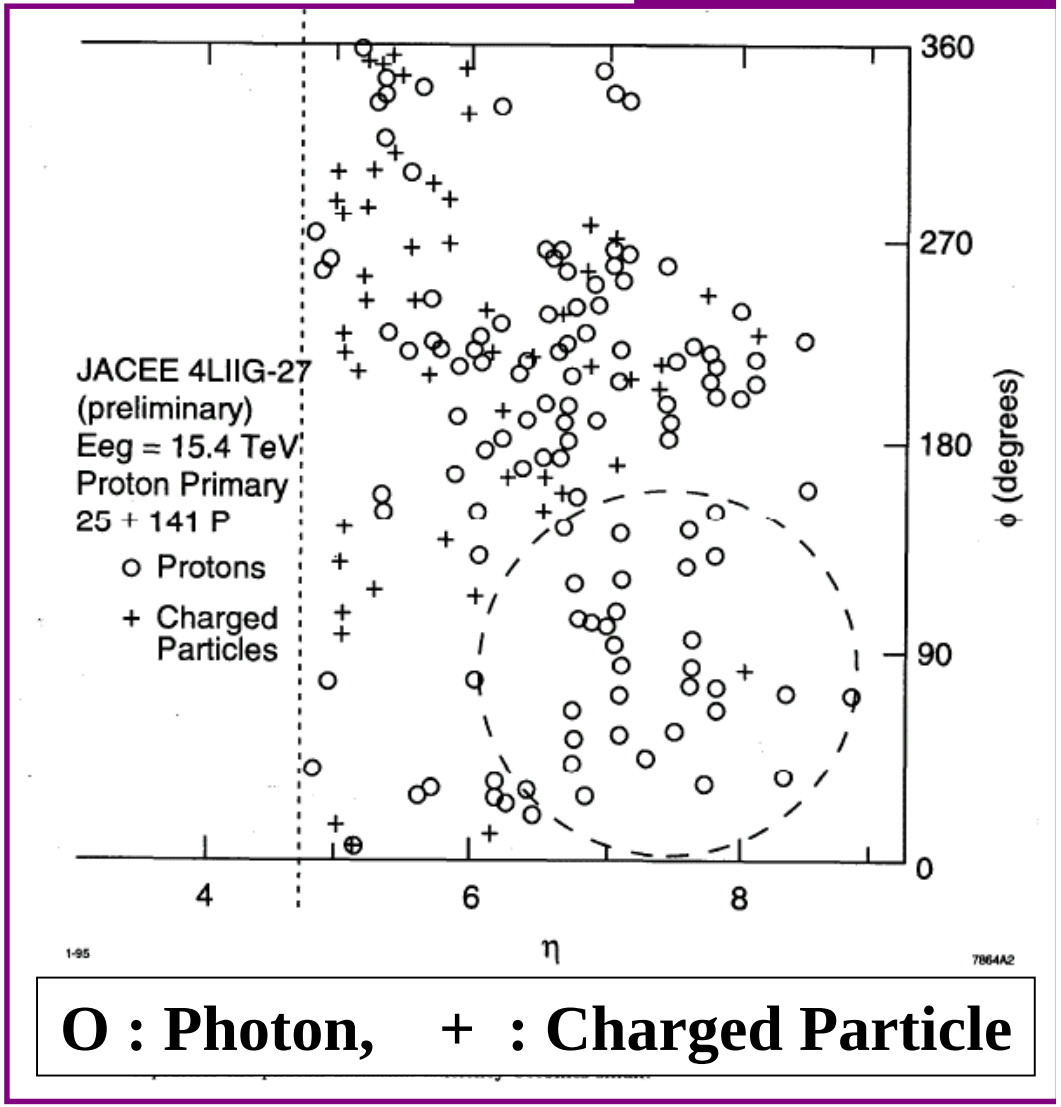
(High Energy Accerarator Experiment)

- **(UA5) K. Alpgard rt al., Phys. Lett. 115B, 71 (1982)**
- **(CDF) P.L.Melese for the CDF Collaboration XIth Topical Workshop on ppbar Collider Physics (1996)**
- **(MINIMAX) T.C.Brooks et al., Phys. Rev. D 55, 5667 (1997)**

(High Energy Heavy Ion Experiment)

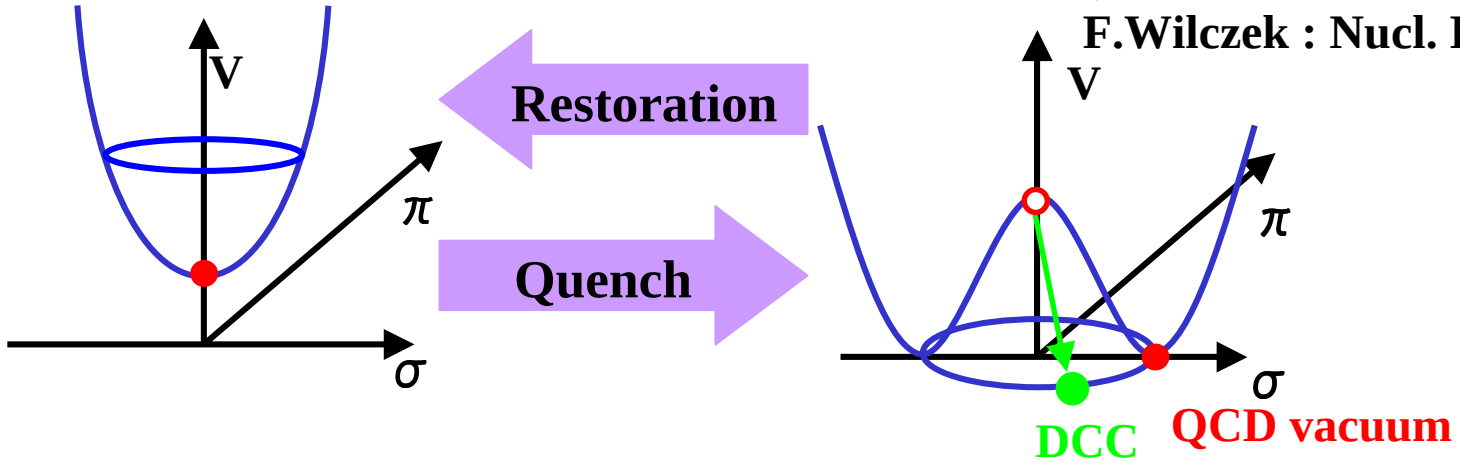
- **(WA98) Tapan K. Nayak et al., Nucl.Phys.A663:745-748, (2000)**

Anti Centauro



O : Photon, + : Charged Particle

Disoriented Chiral Condensate



(Quench Mechanism) K.Rajagopal and F.Wilczek : Nucl. Phys. B379, 395 (1993)

Chiral Transformation

$$\begin{pmatrix} u \\ d \end{pmatrix} \rightarrow e^{i\gamma^5 \tau \cdot \theta} \begin{pmatrix} u \\ d \end{pmatrix}$$

Linear sigma model

$$L = \frac{1}{2}\partial_\mu \phi_i \partial^\mu \phi_i - \frac{1}{4}\left(\phi^2 - v^2\right)^2 + H\sigma$$

Fluctuation of Asymmetry as a function of pseudo rapidity

$$\delta A_{I_3}(\eta) \equiv \frac{N_{\pi^\pm}(\eta) - 2N_{\pi^0}(\eta)}{\sqrt{N_{\pi^\pm} + 4N_{\pi^0}}}$$

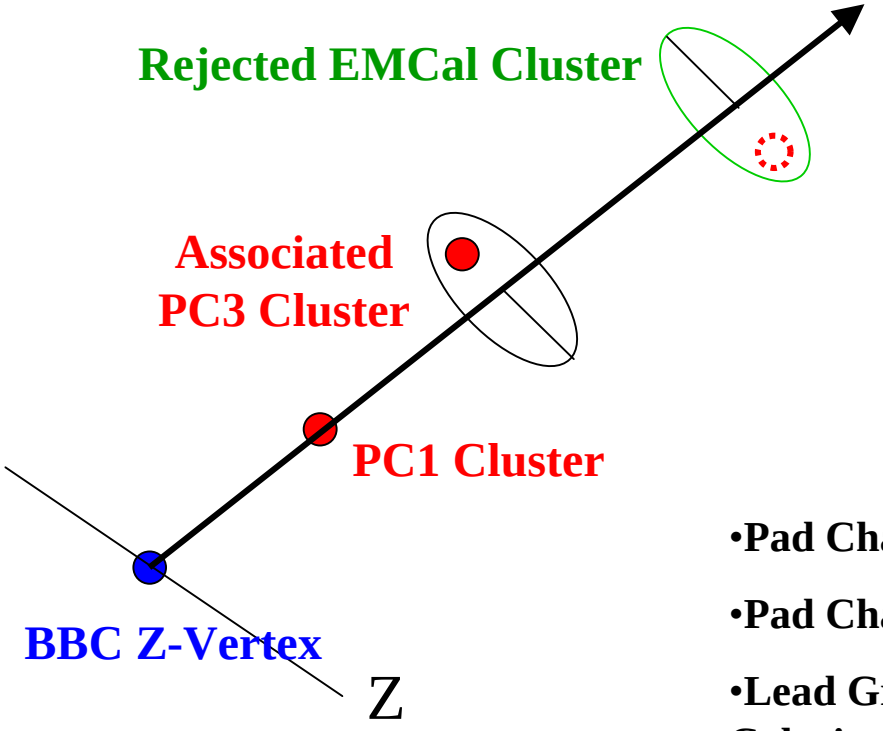
$$\approx \frac{N_{\pi^\pm}(\eta) - N_\gamma(\eta)}{\sqrt{N_{\pi^\pm} + N_\gamma}}$$

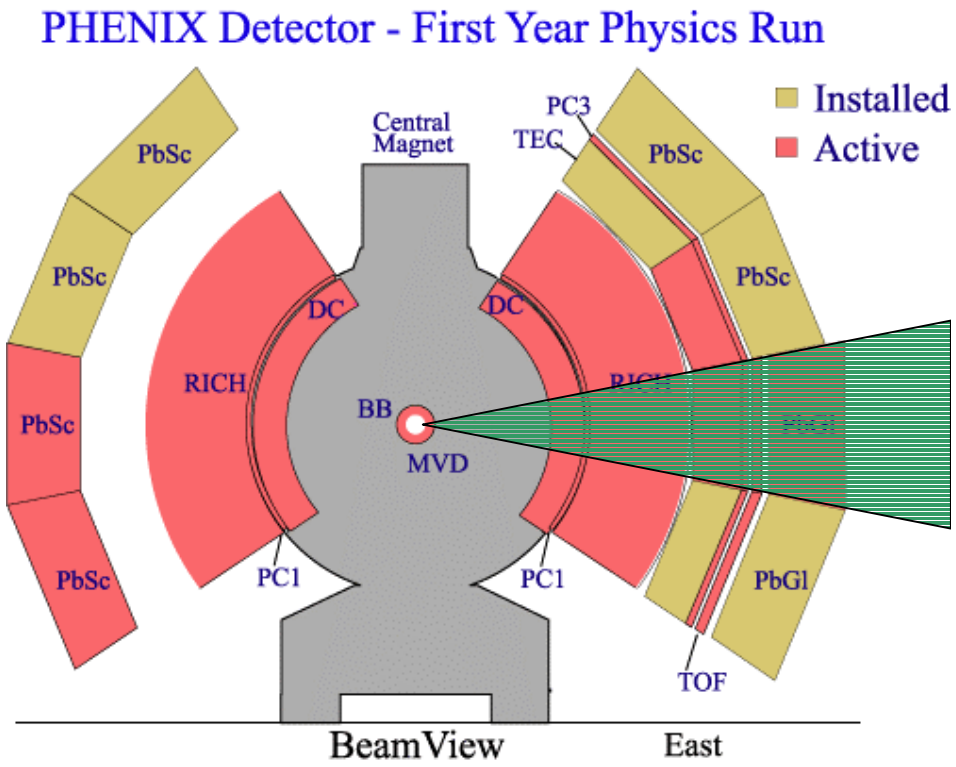
PHENIX Experiment at $\sqrt{s_{NN}} = 130\ GeV$

Using Magnetic Field-off data

Gamma like Cluster (EMC)

Charged Track (PC1, PC3)





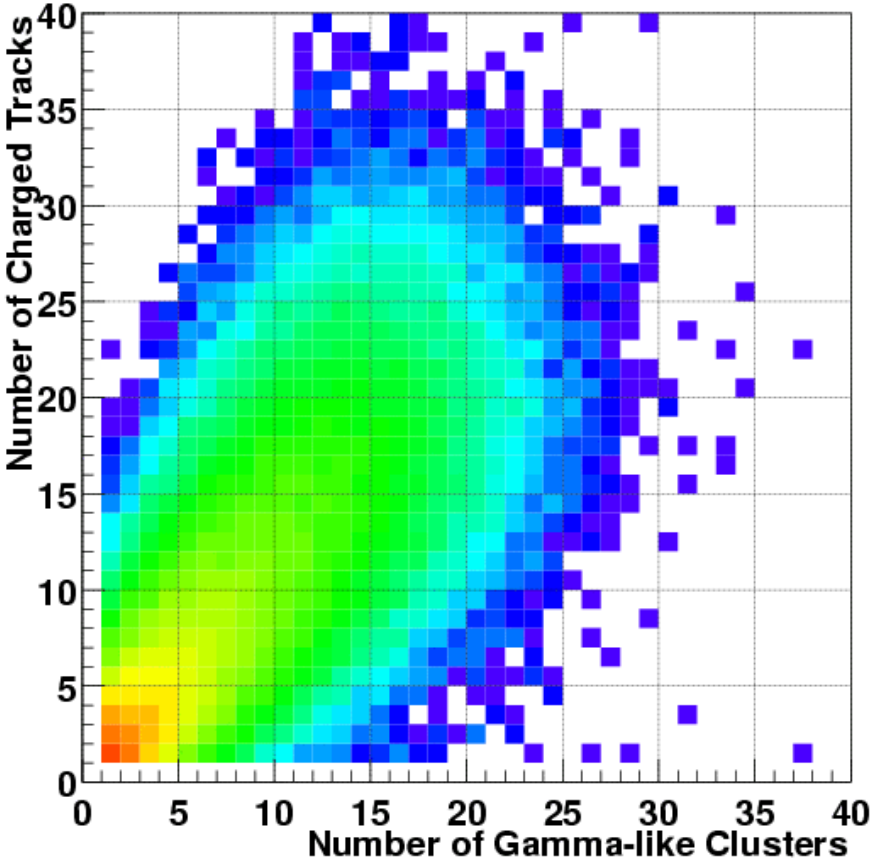
- **Pad Chamber 1 (PC1)**
- **Pad Chamber 2 (PC2)**
- **Lead Grass Electro-Magnetic Calorimeter (EMC)**

$$-0.35 < \eta < 0.35$$

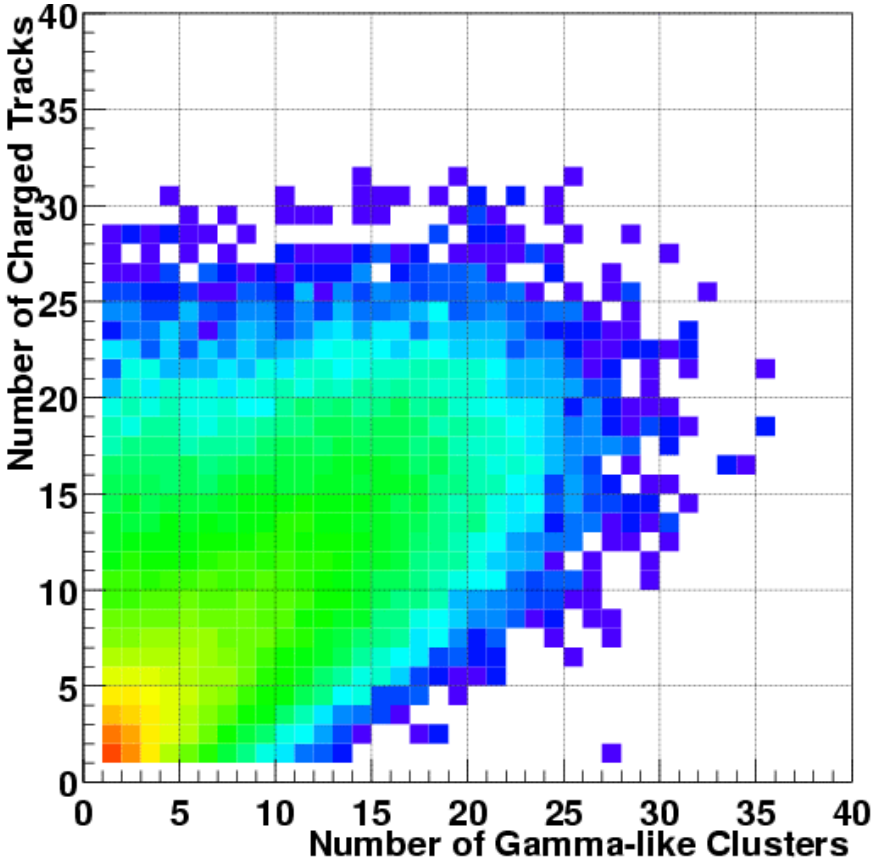
$$0 < \phi < 22.5^{o}$$

Correlation between Charged Tracks and Gamma like Clusters

(Real Data)

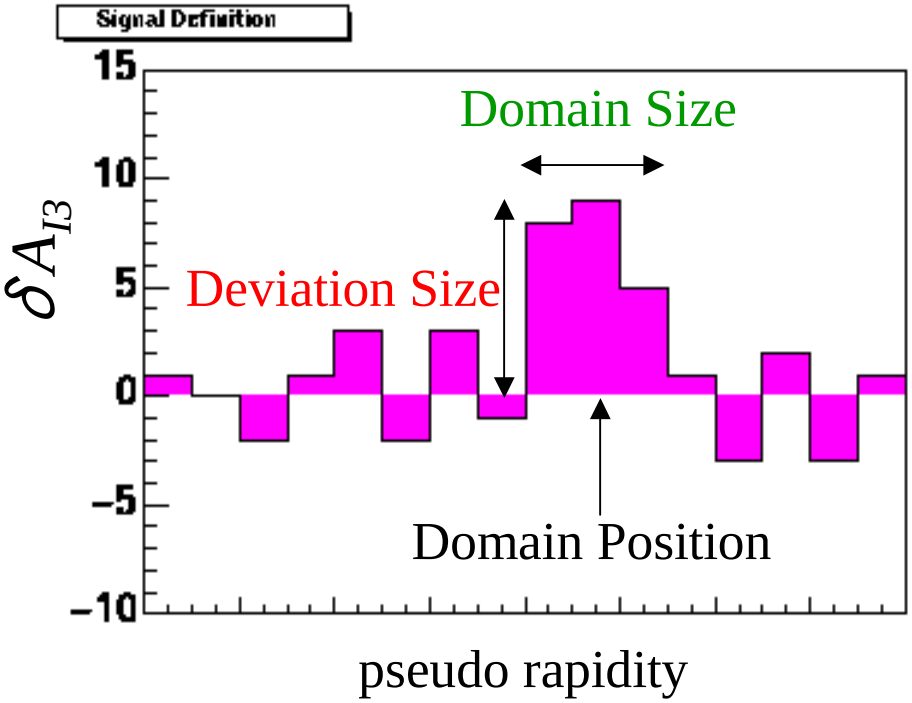


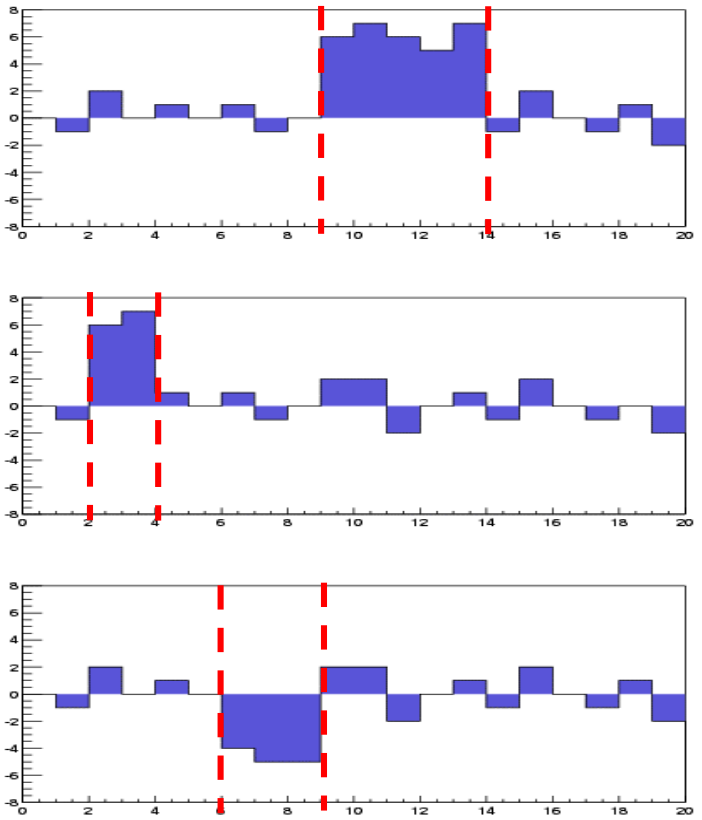
(MC with Full Reconstruction)



Isospin Asymmetry

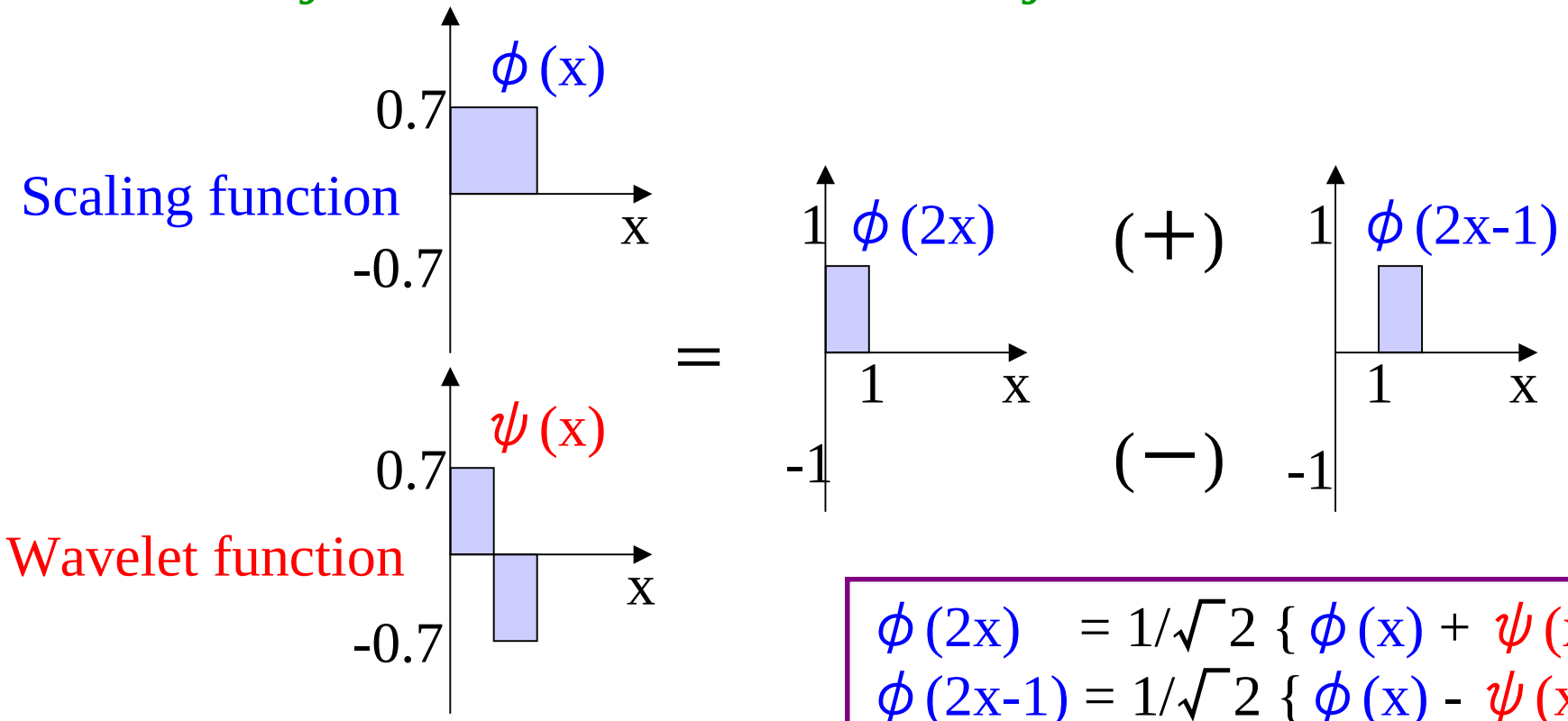
$$\delta A_{I_3}(\eta) \equiv \frac{N_{\pi^{\pm}}(\eta) - N_{\gamma}(\eta)}{\sqrt{N_{\pi^{\pm}} + N_{\gamma}}} \approx \frac{N_{PC\,track}(\eta) - N_{\gamma-like\,cluster}(\eta)}{\sqrt{N_{PC\,track} + N_{\gamma-like\,cluster}}}$$





Multi Resolution Analysis (MRA)

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



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

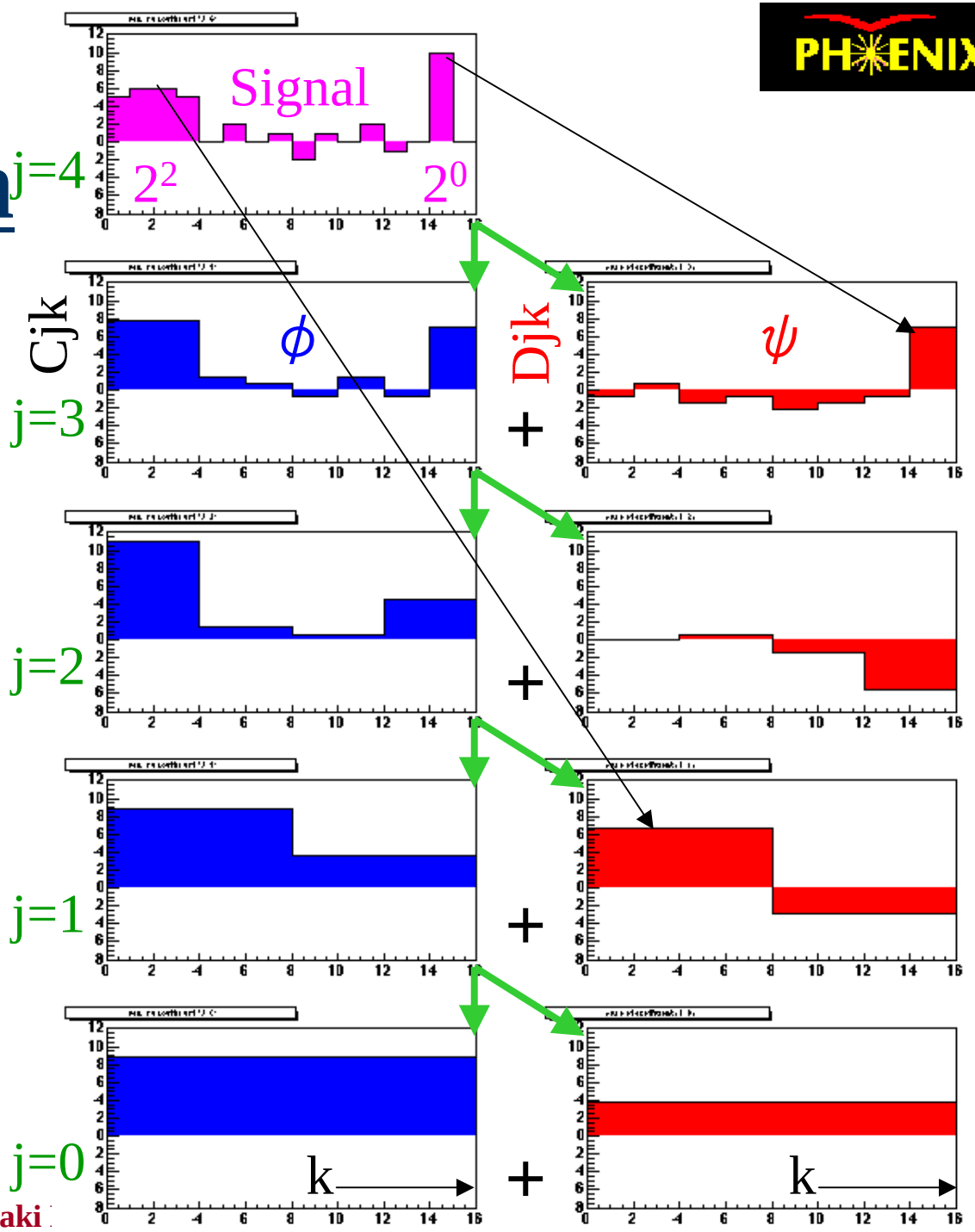
Signal Decomposition

j : resolution level
k : k-th bin in pseudo rapidity
Cjk : coefficients of ϕ
Djk : coefficients of ψ

j → Domain Size

k → Phase Space Position

Djk → Deviation Size



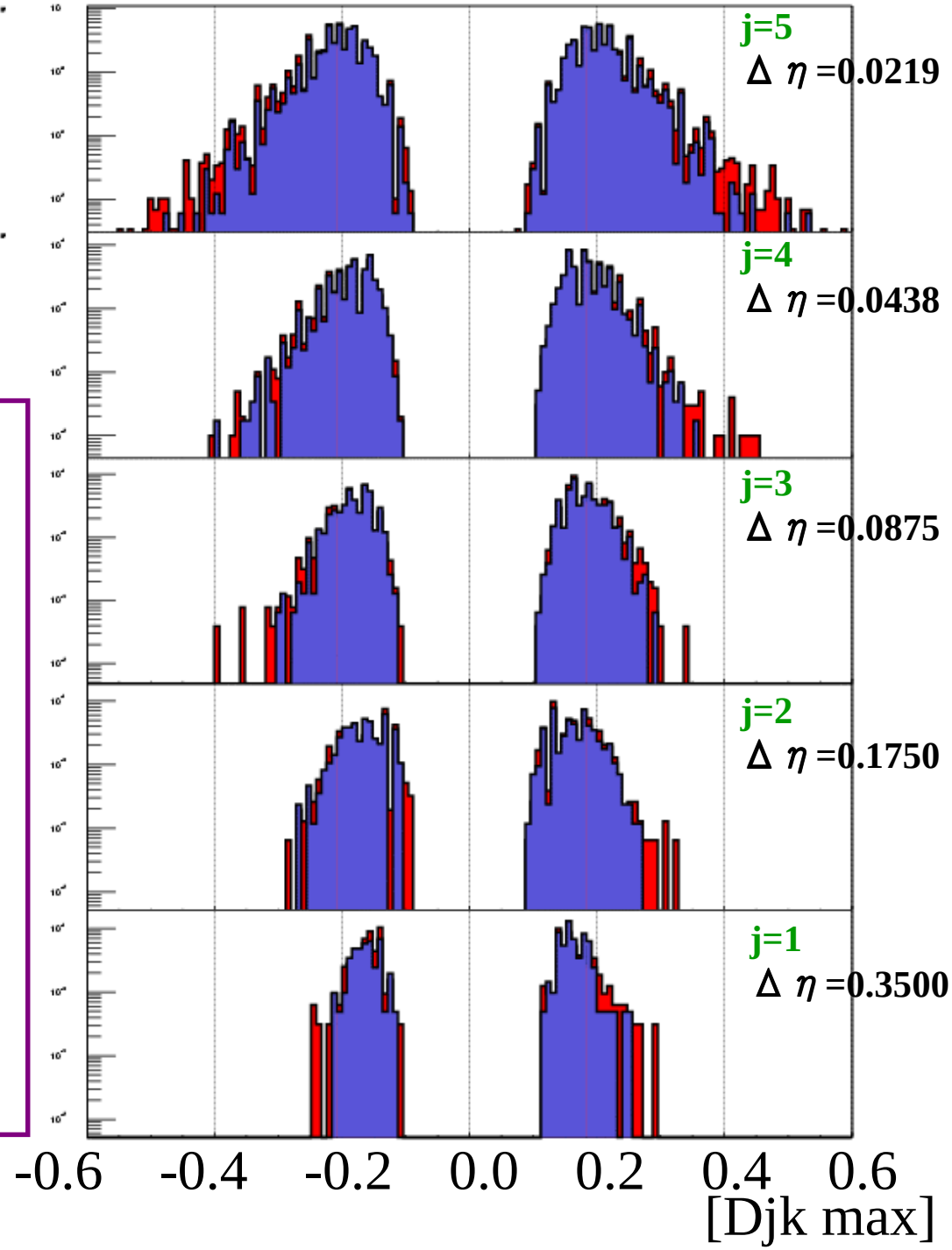
Djk Max distribution

- **Red : Real Data**

PHENIX B-field off data
√sNN =130GeV
Selected 44,180 events from minimum bias 700k events.

- **Blue : MC with Full reconstruction**

HIJING
√sNN =130GeV
Selected 25,281 events from minimum bias 200k events



Probability of Large Djk Max Event

Binomial Distribution

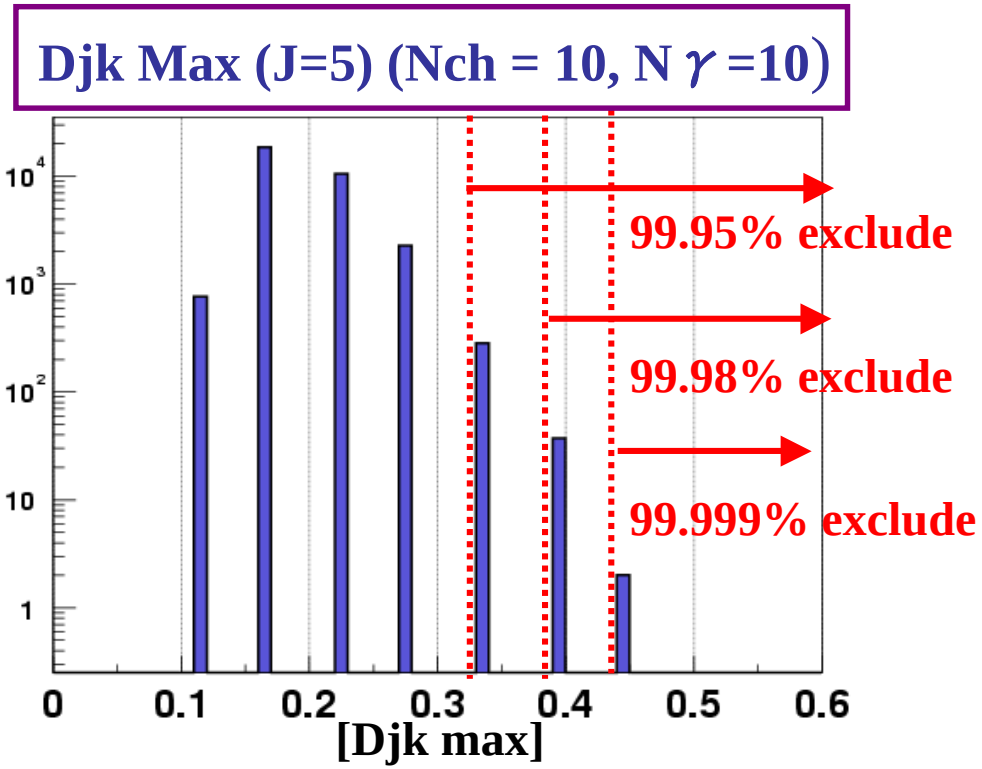
$$B^{j}_{N_{ch}}(k) = {}_{N_{ch}}C_{k}\,(P^{j})^{k}(1-P^{j})^{N_{ch}-k}$$

$$P^{j} = 2^{-j}$$

$$(B^{j}_{ch}(k), B^{j}_{\gamma}(k'))$$

$$\Leftrightarrow \delta A^{(j)} = \frac{k-k'}{\sqrt{N_{ch}+N_{\gamma}}}$$

$$\Leftrightarrow DjkMAX$$

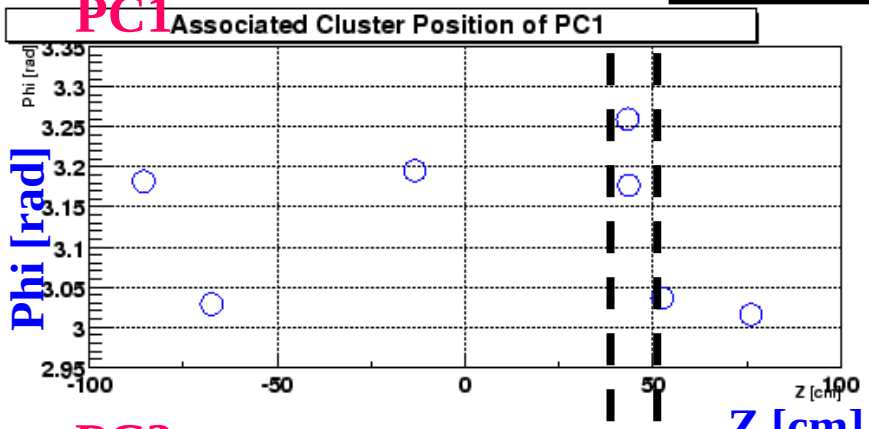


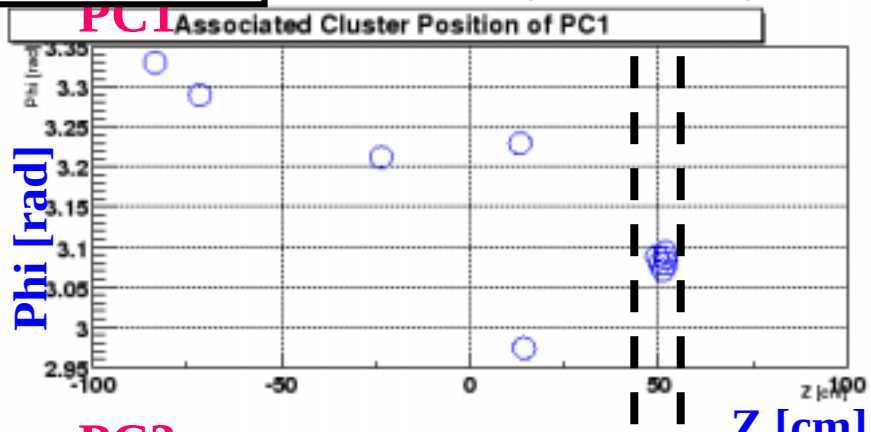
Asymmetry (-)

j=5 $\Delta\eta$ =0.0219

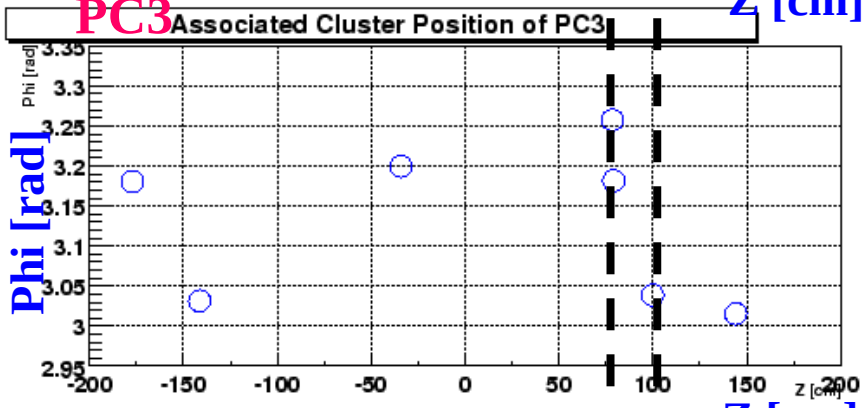
Asymmetry (+)

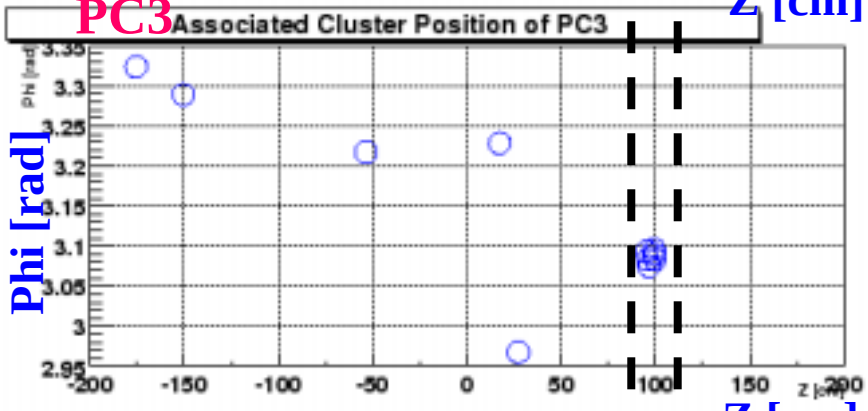
PC1



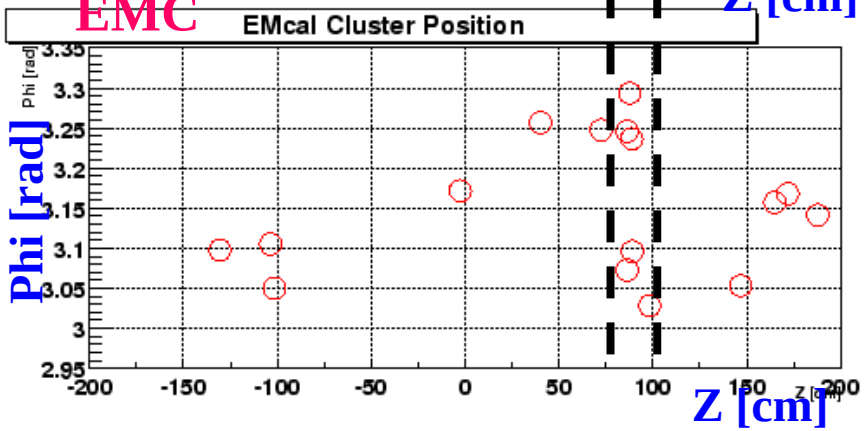


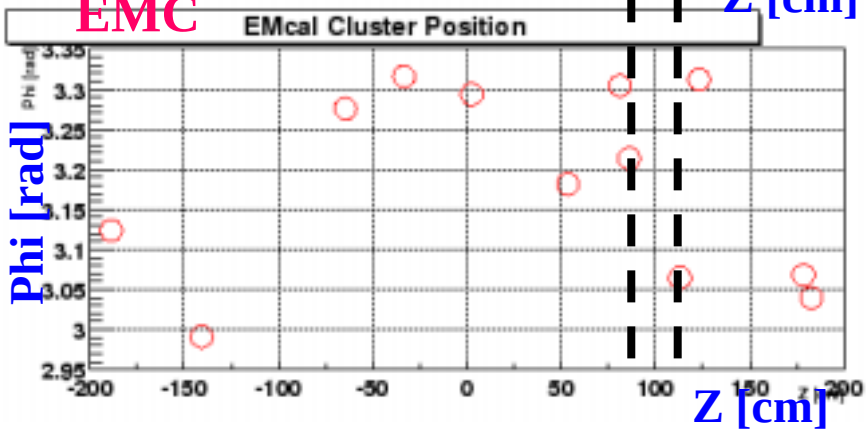
PC3





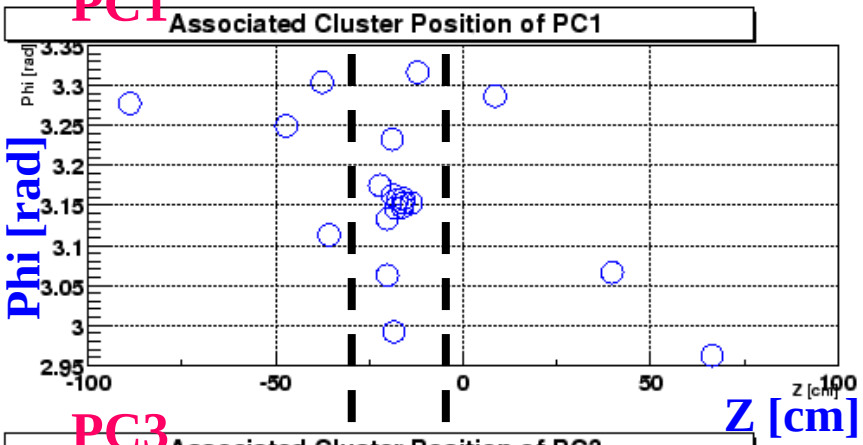
EMC



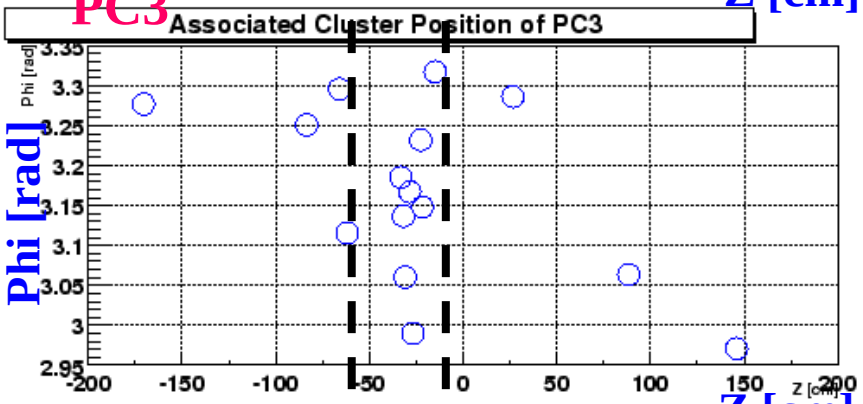


j=4 $\Delta\eta$ =0.0438

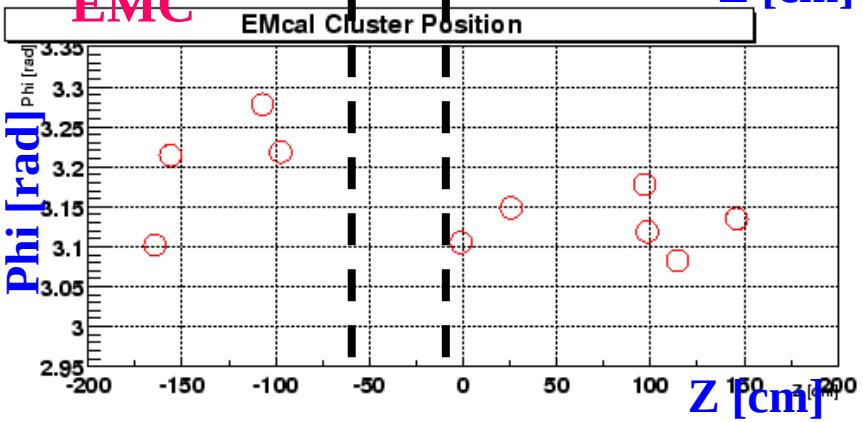
PC1



PC3

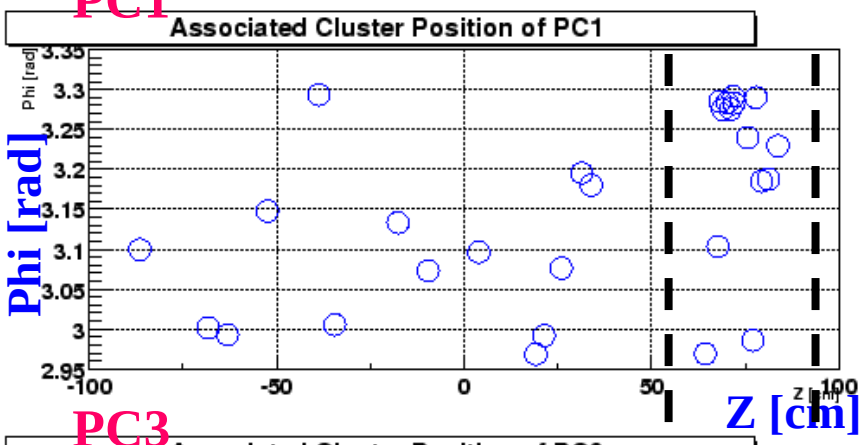


EMC

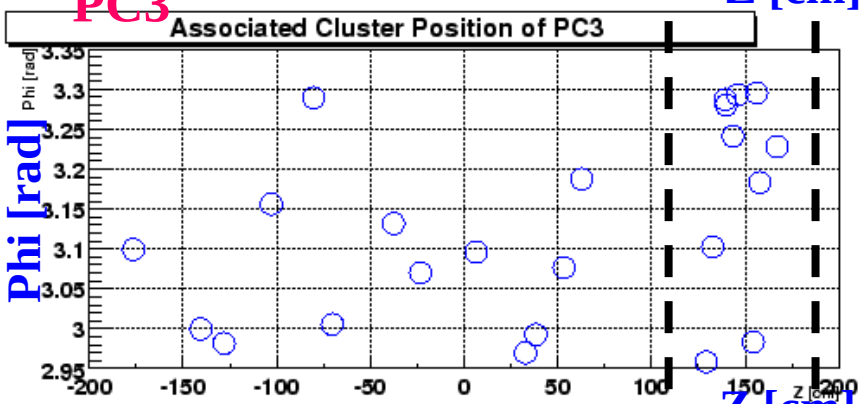


j=3 $\Delta\eta$ =0.0875

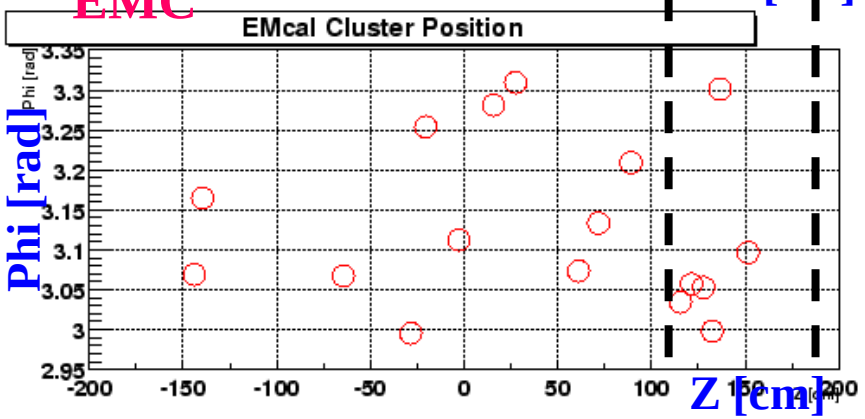
PC1



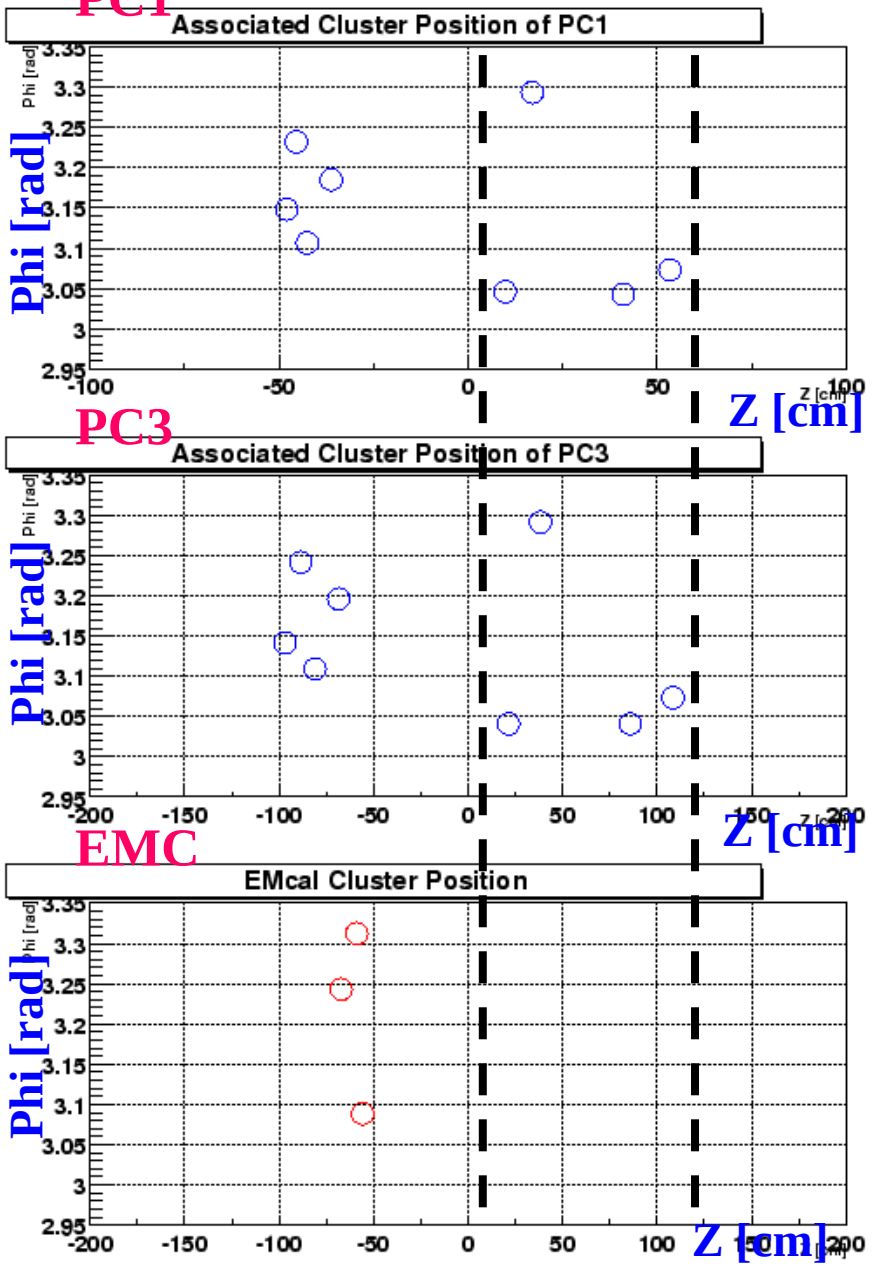
PC3



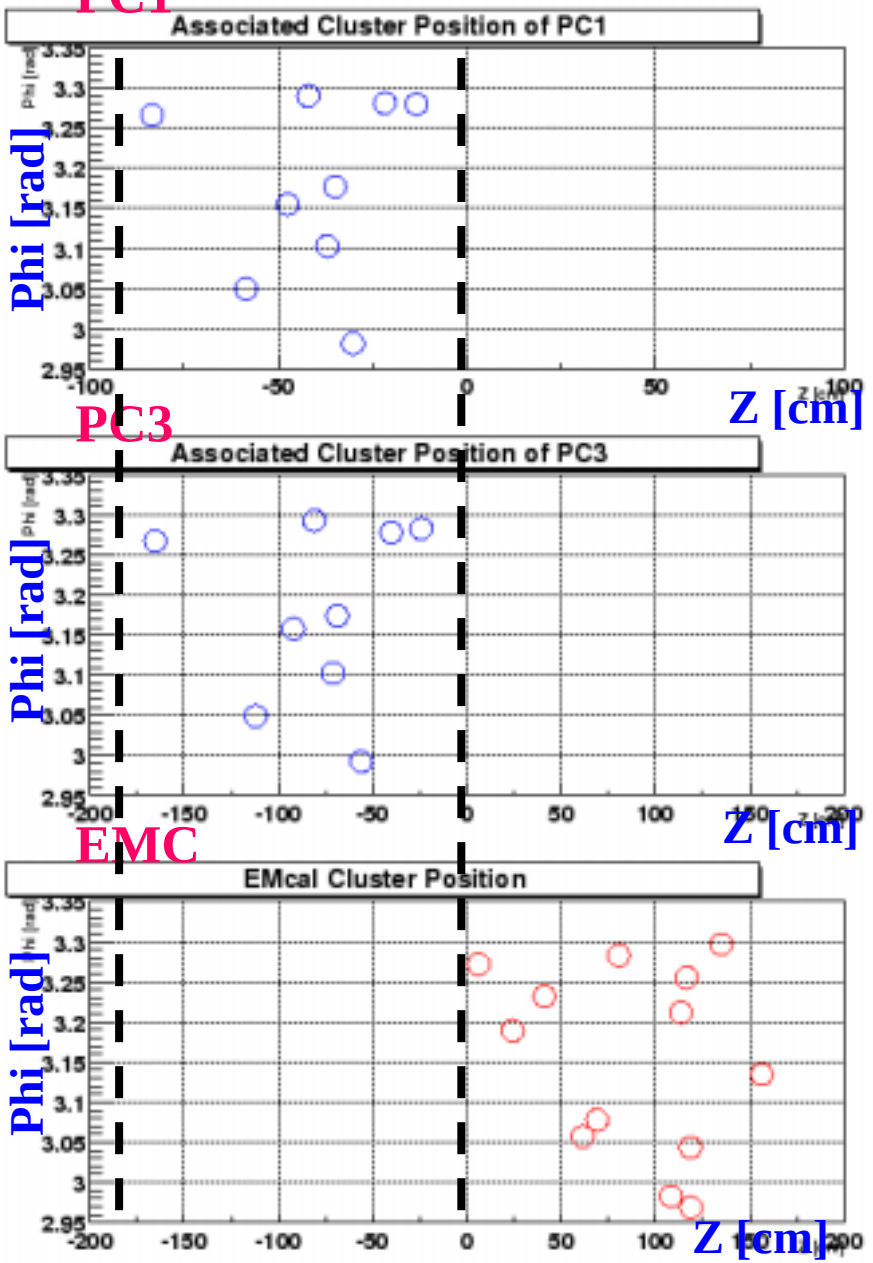
EMC



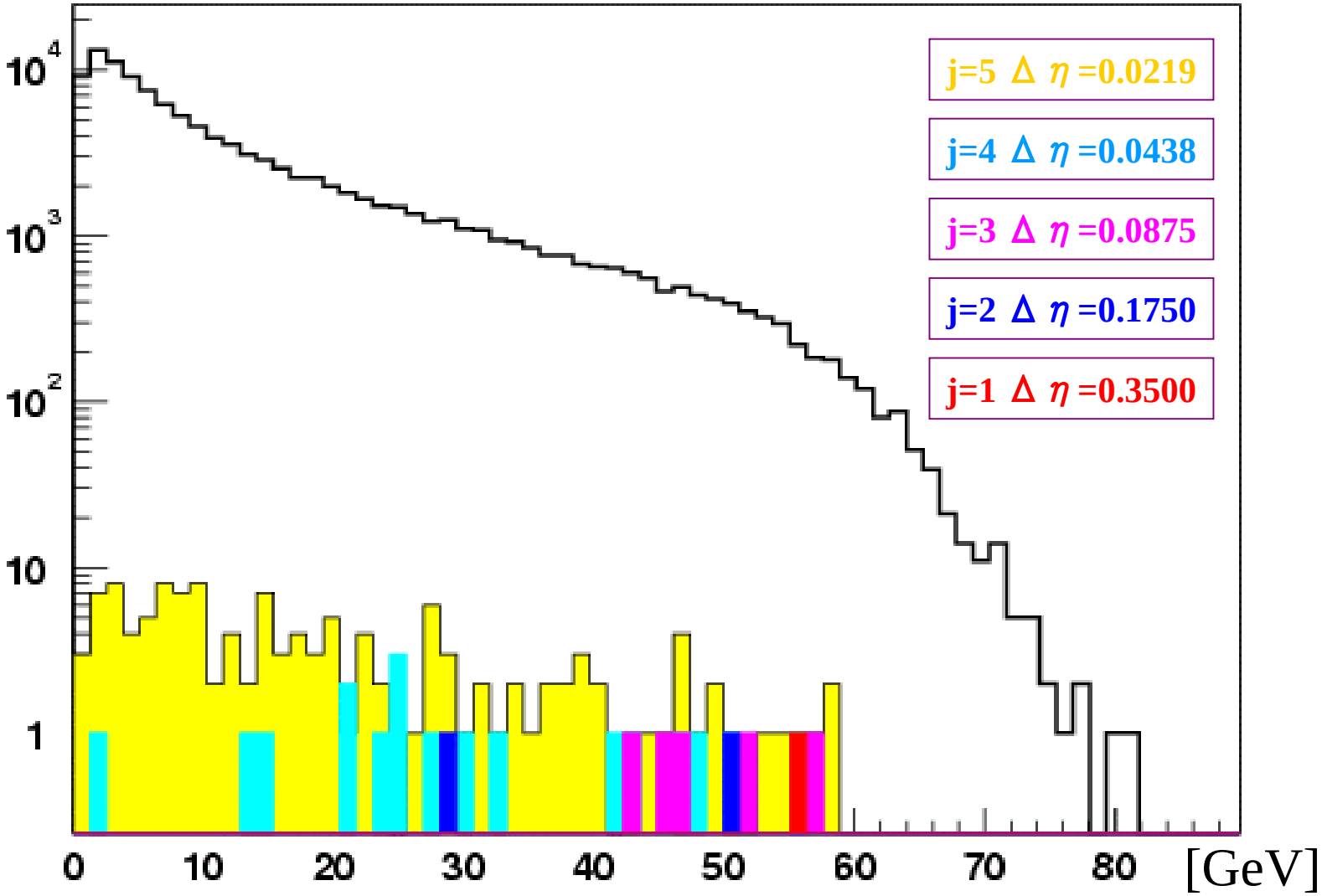
j=2 $\Delta\eta$ =0.1750



j=1 $\Delta\eta$ =0.3500



Total Energy (Centrality)



Total Energy of Electro-Magnetic Calorimeter

Summary

- **The total 155 anomalous events are found by MRA. The definition of "anomalous events" is the events above thresholds which exclude 99.999% of normal events, if those normal events are based on combination of the binominal distributions.**

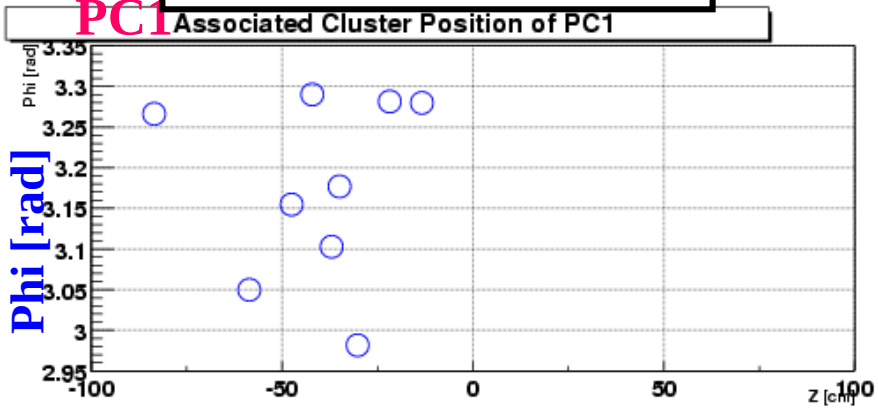
(# of anomalous events) / (selected total # of events) : 153 / 44,180					
Level	**j=5 $\Delta\eta$ =0.0219**	**j=4 $\Delta\eta$ =0.0438**	**j=3 $\Delta\eta$ =0.0875**	**j=2 $\Delta\eta$ =0.1750**	**j=1 $\Delta\eta$ =0.3500**
Number of Events	129	18	5	2	1

- **We are investigating the nature of the events with large deviation from binomial, whether those are coming from PHYSICS or detector.**

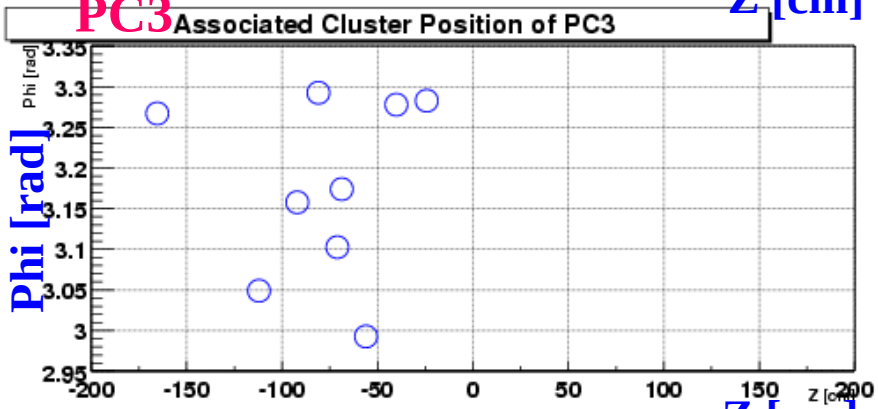
Backup Slide

j=1 $\Delta\eta$ =0.3500

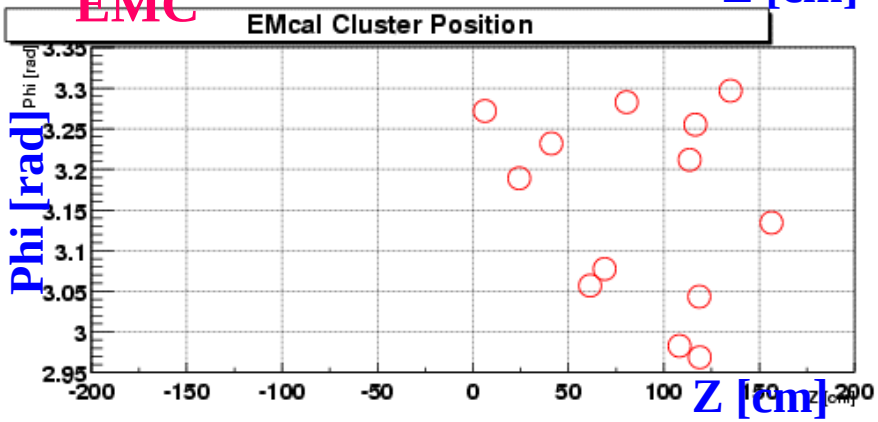
PC1



PC3

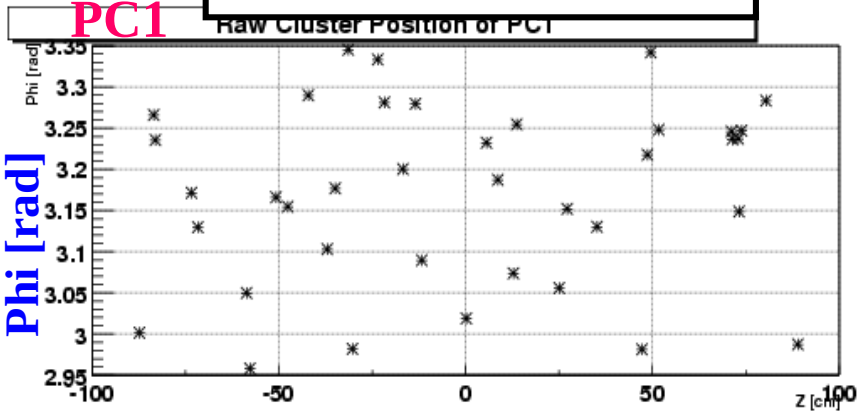


EMC

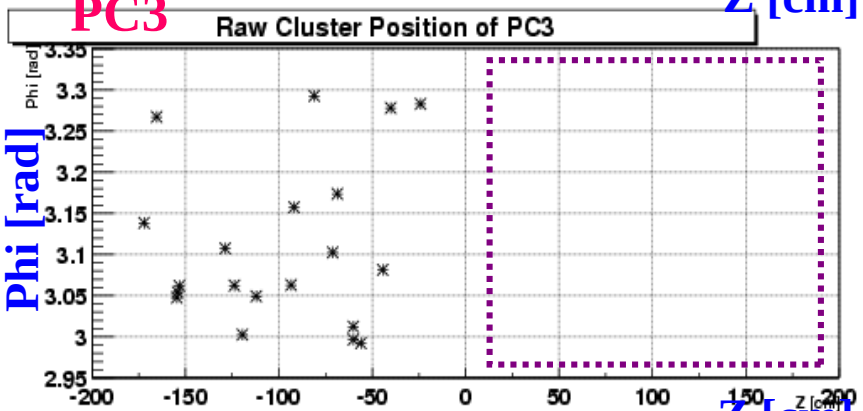


Raw Cluster

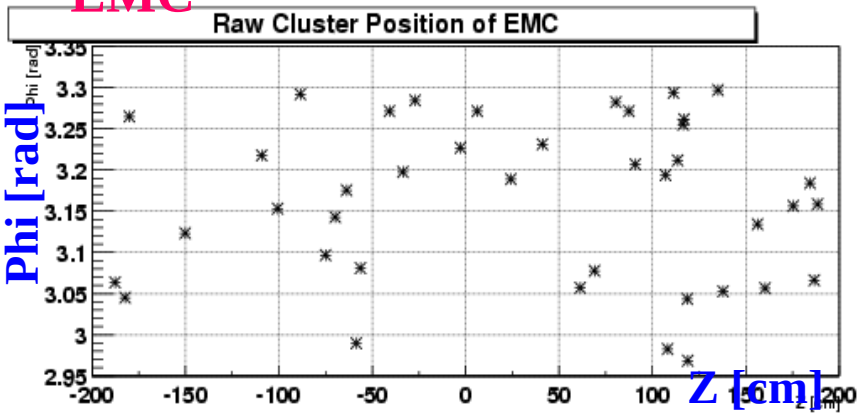
PC1



PC3

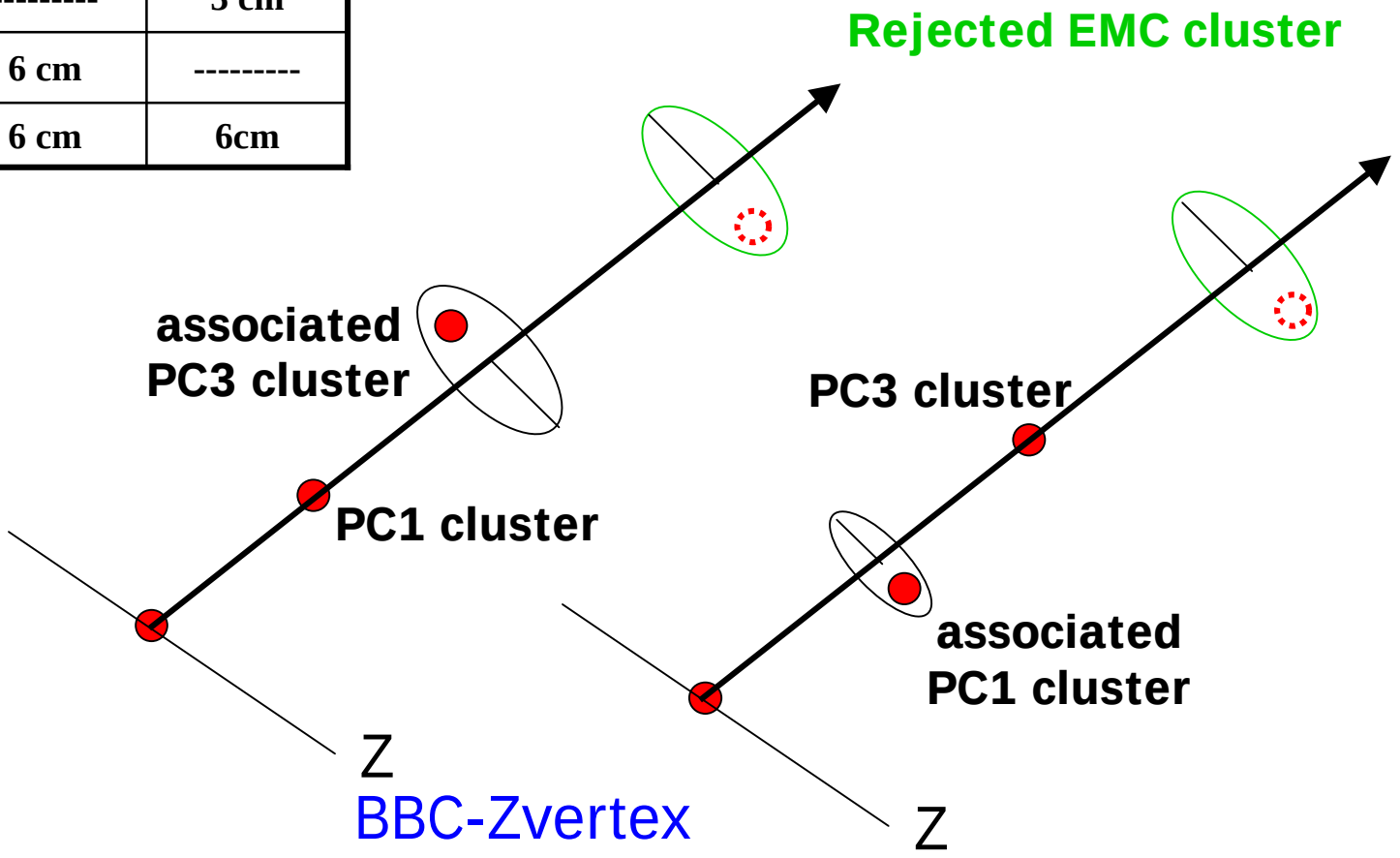


EMC



Rejection of Asymmetric dense Cluster

	TrackA	TrackB
PC1 association cut	---------	3 cm
PC3 association cut	6 cm	---------
EMC rejection cut	6 cm	6cm

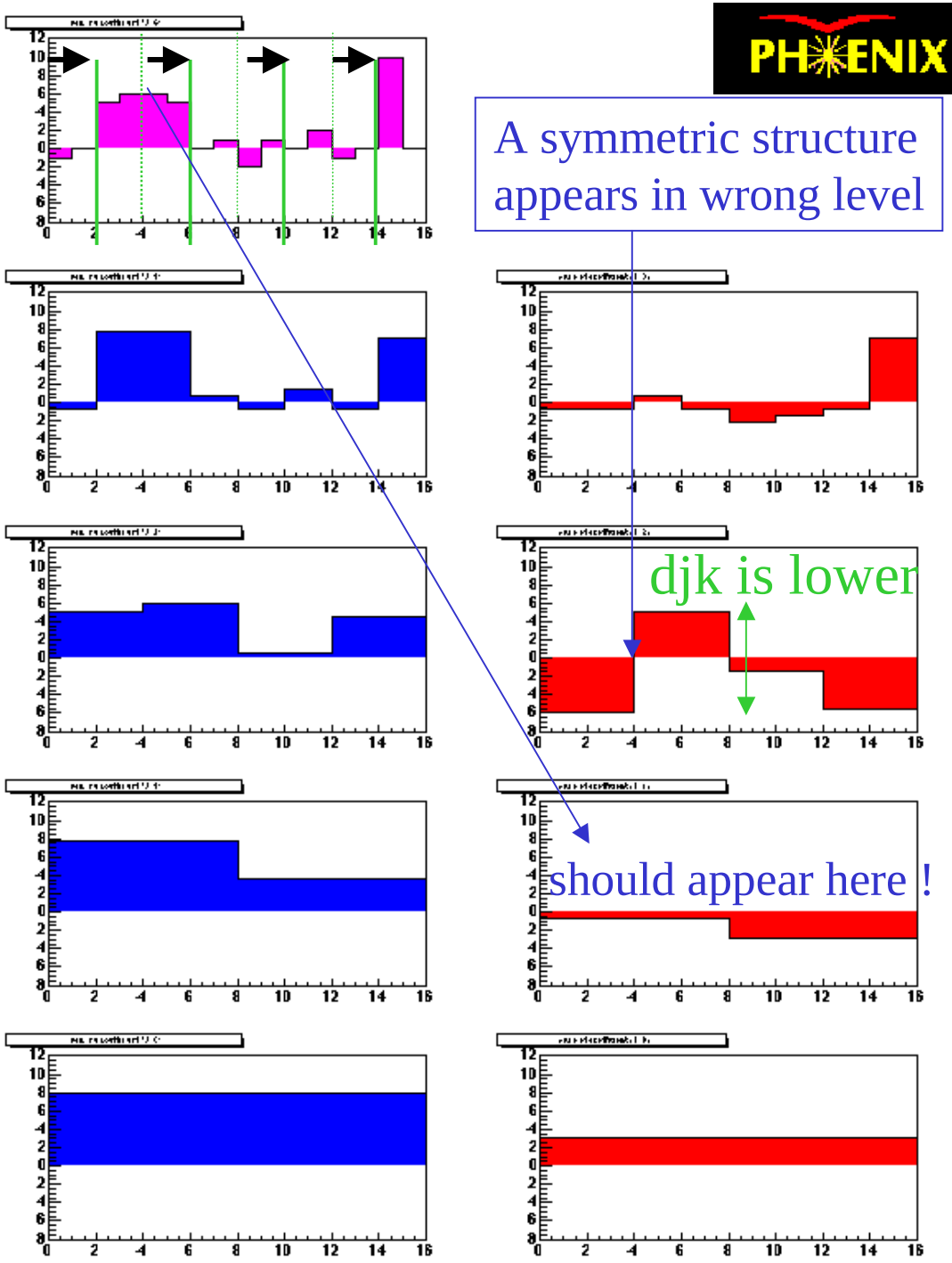


Window shift method

Shift the start bin at each resolution level.

Find djk max among all of leve

This can determine the level (domain size) with the largest deviation size.



Performance of window shift method

Success probability that a correct domain size is found

Domain size of $2^8 / 2^j$

j=1
j=2
j=3
j=4
j=5
j=6
j=7