Charged-Neutral Fluctuations In Pb-Pb At $\sqrt{s_{NN}}$ = 2.76 TeV In ALICE At LHC

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Outline

- Introduction and Motivation
- Analysis Details -> Data-set & Event selection cuts
- Simulation study -> PMD Efficiency (E) and Purity (P) calculation
- Results
- Future Plans and Summary

Physics Motivation

Study of fluctuations provides the evidence for the production of QGP (Quark Gluon Plasma) and nature of the QGP matter in relativistic heavy ion collisions.

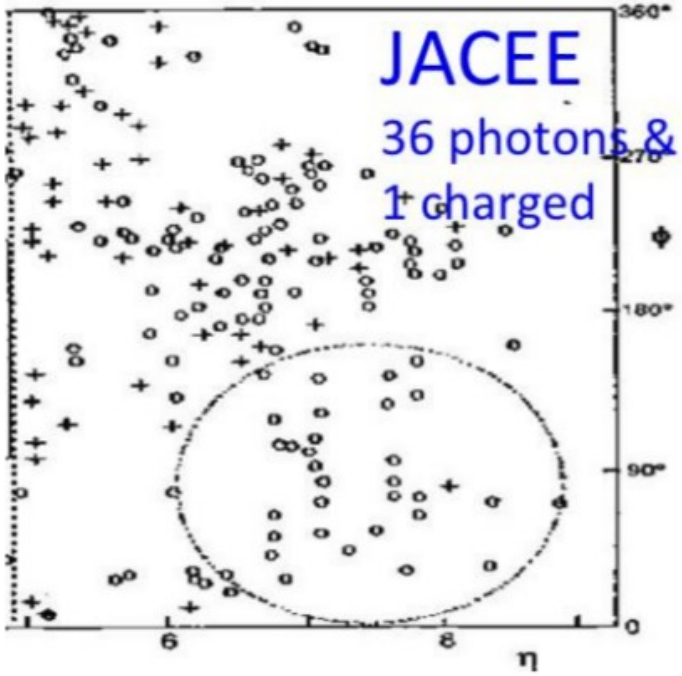
Formation of QCD matter and the transition from QGP to hadronic state can give informations about the physical observables which vary event to event.

- Net Charge Fluctuations
- Fluctuations in Particle ratio
- Disoriented chiral condensates
- Temperature Fluctuations

All these phenomenas have gained attention on event-by-event basis.

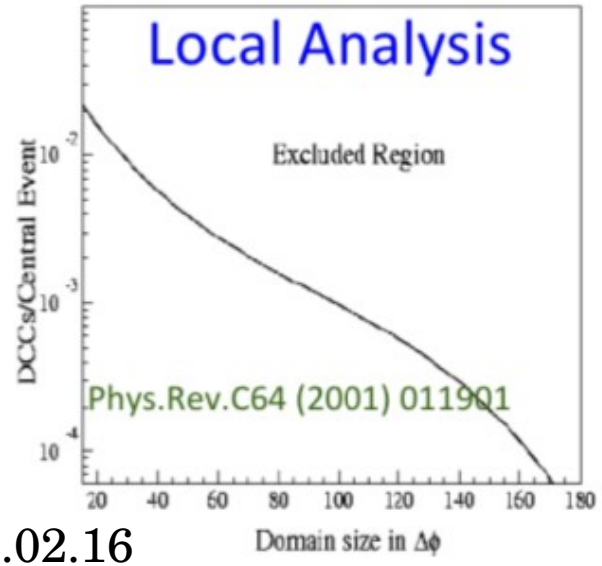
Physics Motivation

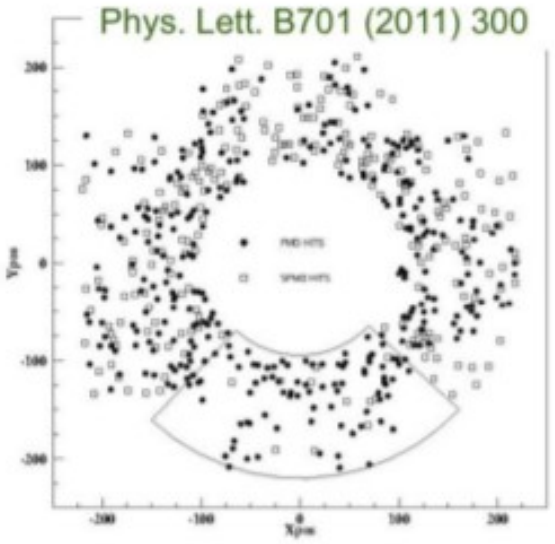
Spatial overlap region between two heavy ions colliding at relativistic high energies may provide physical conditions necessary for charged-neutral fluctuations observed by ***JACEE Cosmic ray experiment.***



Events with large charged-neutral fluctuations, called
Centauro ($N_{ch} >> N_{\gamma}$) and
Anti-centauro ($N_{\gamma} >> N_{ch}$) events.
First reported in JACEE cosmic ray experiment, C.M.G Latters et.al., Phys. Rep. 65 (1980)151.

WA 98 Experiment

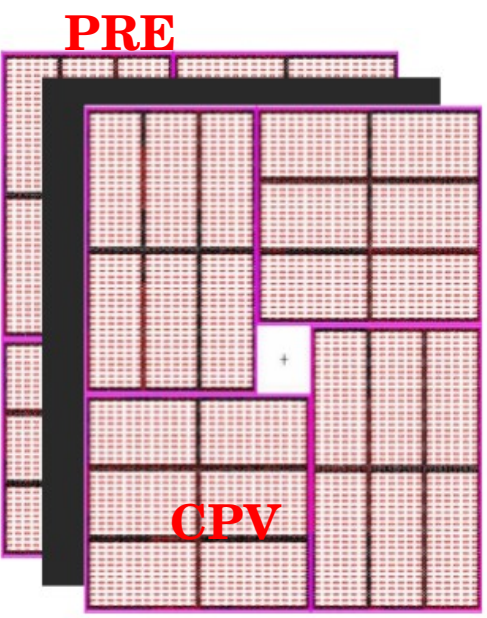


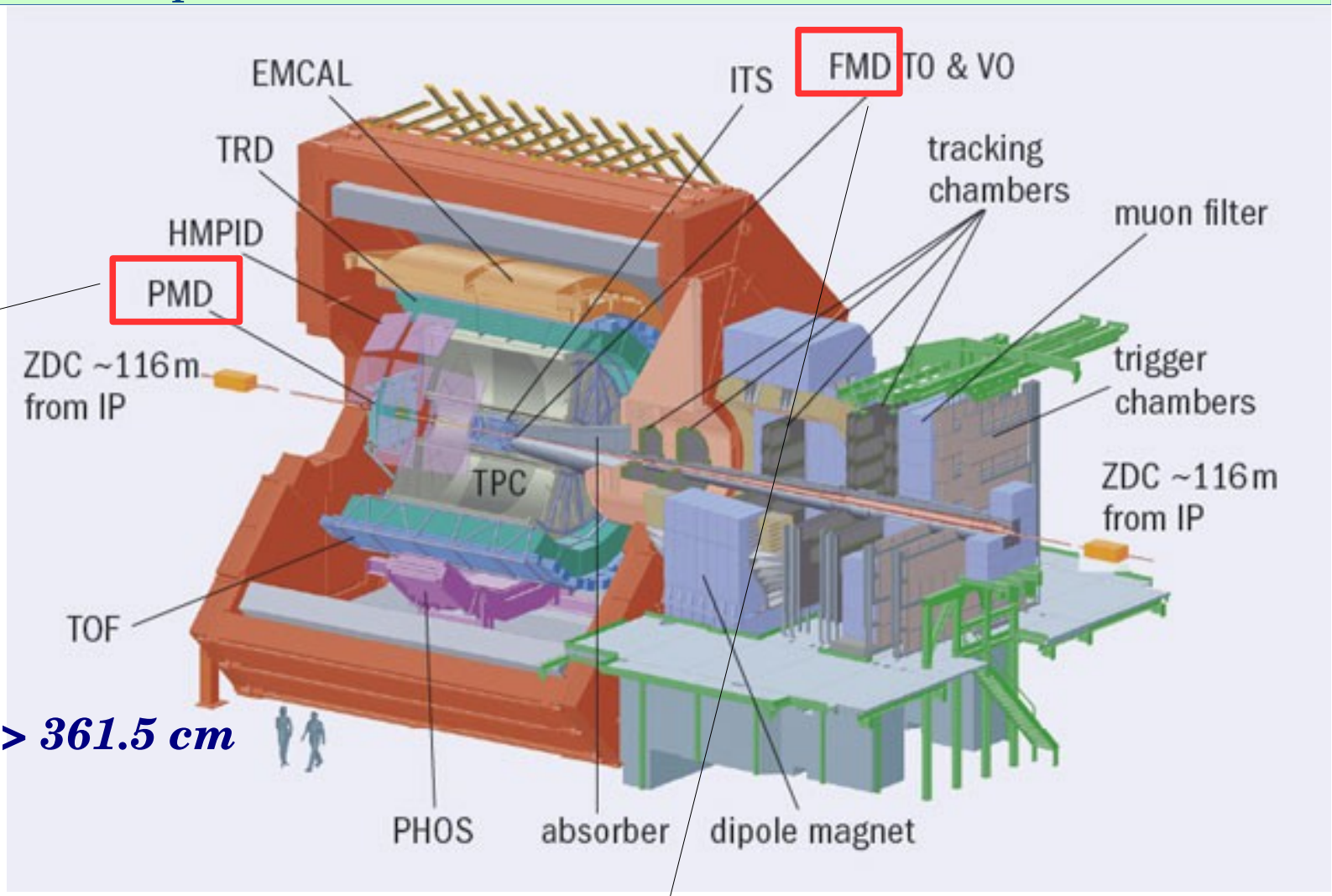


References:

Phys. Lett. B 459(1999) 679
Phys. Lett. B 420(1998) 169

ALICE – Experimental Setup





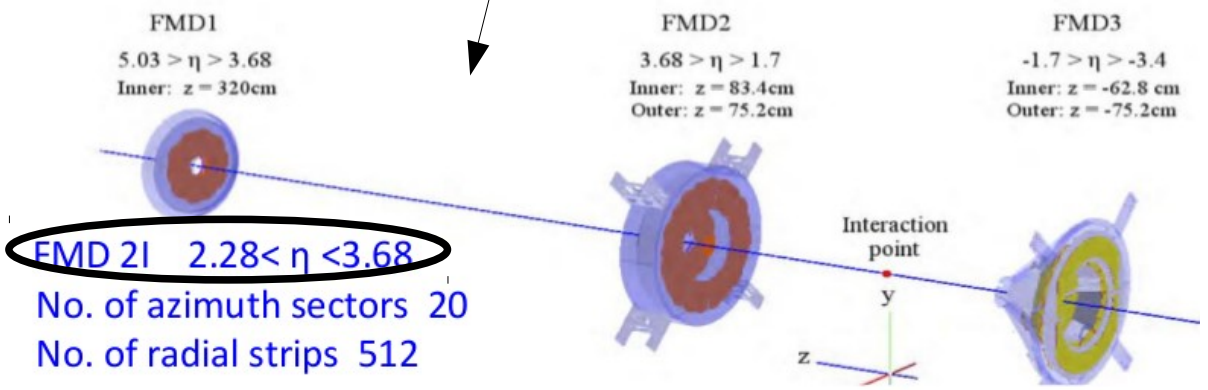
2.3 < η < 3.9

Distance from IP -> 361.5 cm

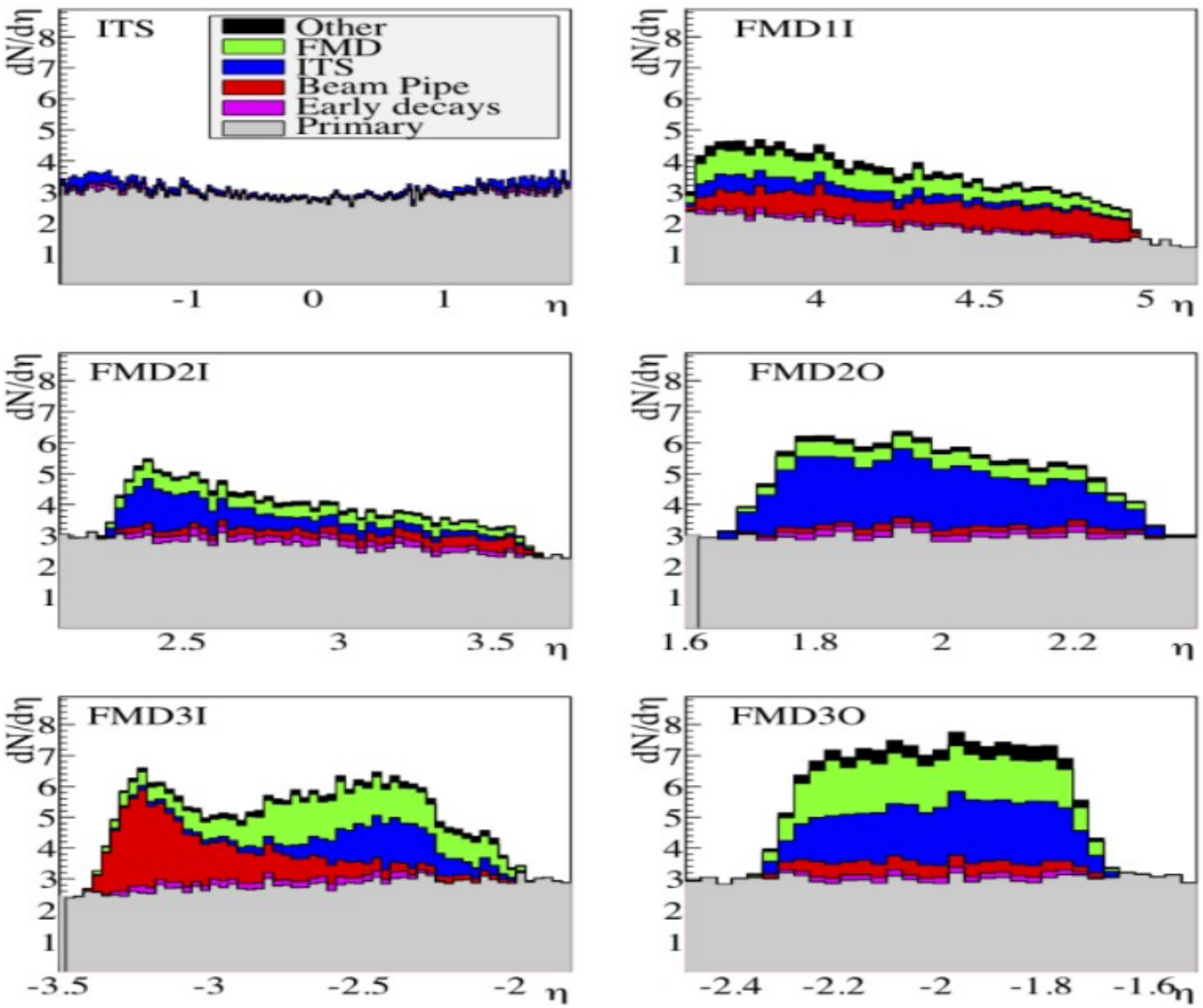
Forward Detectors:

PMD (Photon Multiplicity Detector)

FMD (Forward Multiplicity Detector)



Energy deposition by primary & secondary particles in FMD



FMD 2I Data Analyzed in pseudo-rapidity region $2.8 < \eta < 3.6$ has less background and leaving sectors 16 and 17 which are not good.

Analysis Details

Data used for the analysis from : Photon Multiplicity Detector (PMD)
Forward Multiplicity Detector (FMD)

Data Set : LHC10h Pb-Pb (ESD pass2)

MC Sample : LHC11a10a_bis

Event Selection:

Vertex cut: -10 < Vz < +10 cm

Trigger : AliVEvent :: kMB

Pseudorapidity: 2.8 < η < 3.6

Centrality Estimator : V0M

Number of events analyzed (MC) = 32 lac

Number of events analyzed (Data) = 8M

No. of charged particles (N_{ch}) from FMD with strip :

0.3 < multiplicity < 1 taken as one

multiplicity > 1 taken as two

$N_{\gamma\text{-like}}$ Hits with signal > 432 (**6*MIP**)

PMD detector's Efficiency / Purity

In selected pseudorapidity window $2.8 < \eta < 3.6$

$$Efficiency = \frac{\gamma_{true}}{\gamma_{inc}}$$

$$Purity = \frac{\gamma_{true}}{\gamma_{like}}$$

γ_{like} = the number of clusters in Pre-shower plane above threshold (ADC > 432 & nCell > 2)

γ_{true} = the number of clusters in Pre-shower plane above threshold and with the Track pid = = 22

γ_{inc} = the number of Incident Photons

$$N_{clus}\,(ADC > 6\ MIP\ ) = N_{\gamma\text{-}like}$$

MIP in ADC can be changed including N_{cell} cut

$$N_{\gamma like} = N_{\gamma}^{true} + N_{\gamma}^{split} + N_{\gamma\,like}^{others}$$

Efficiency, $\varepsilon = \dfrac{N_{\gamma}^{true}}{N_{\gamma}^{inc}}$

Purity, $p = \dfrac{N_{\gamma}^{true}}{N_{\gamma}^{like}}$

Detected (true) photons

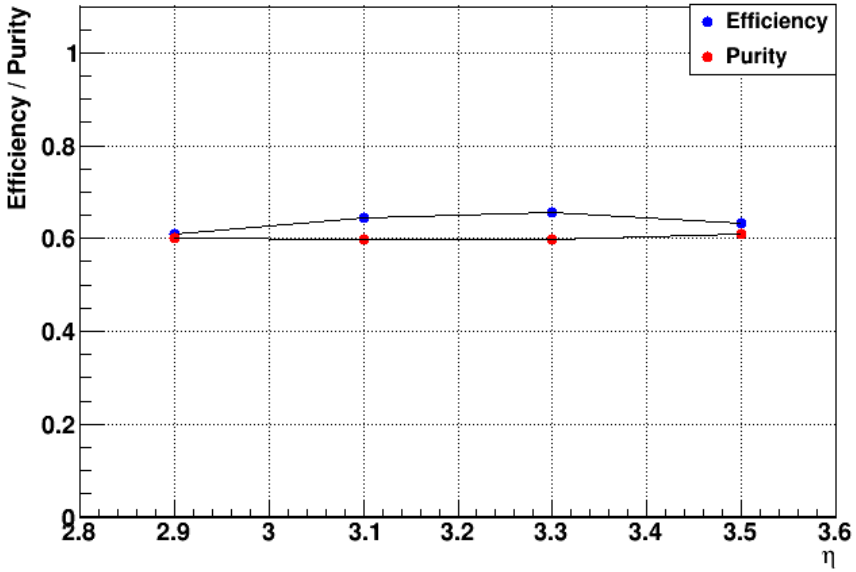
Total photons

$$N_{\gamma}^{inc} = \frac{p}{\varepsilon} * N_{\gamma}^{like}$$

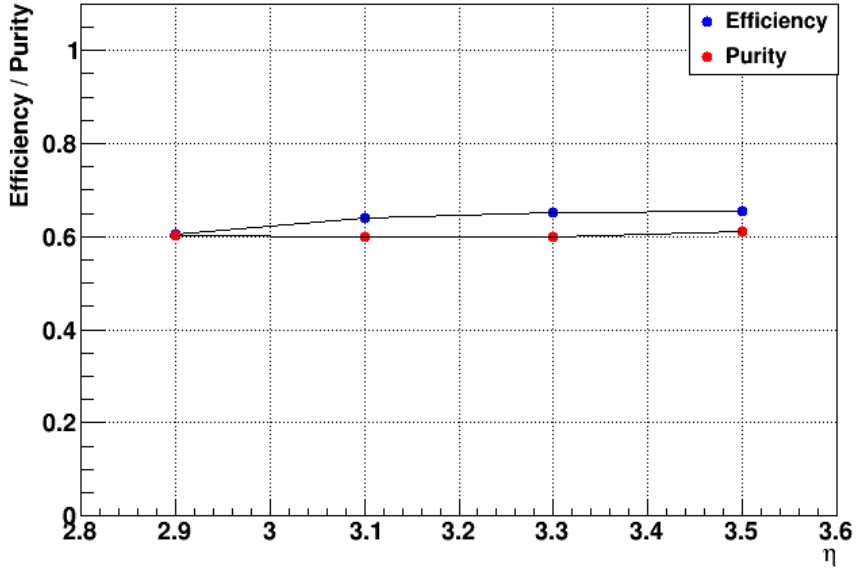
Incident photons

Eff / Purity (adc > 432 (6 * MIP) and ncell > 0, 1 and 2)

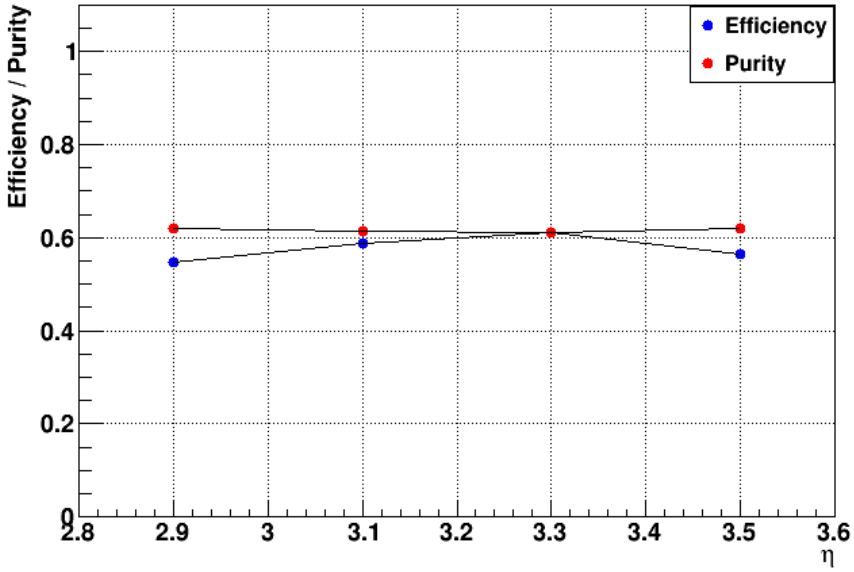
ncell > 0



ncell > 1

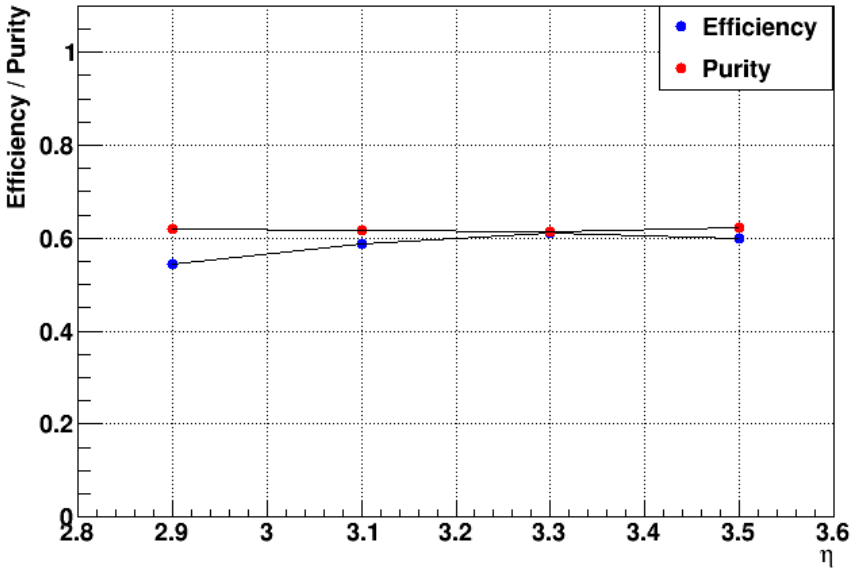


ncell > 2

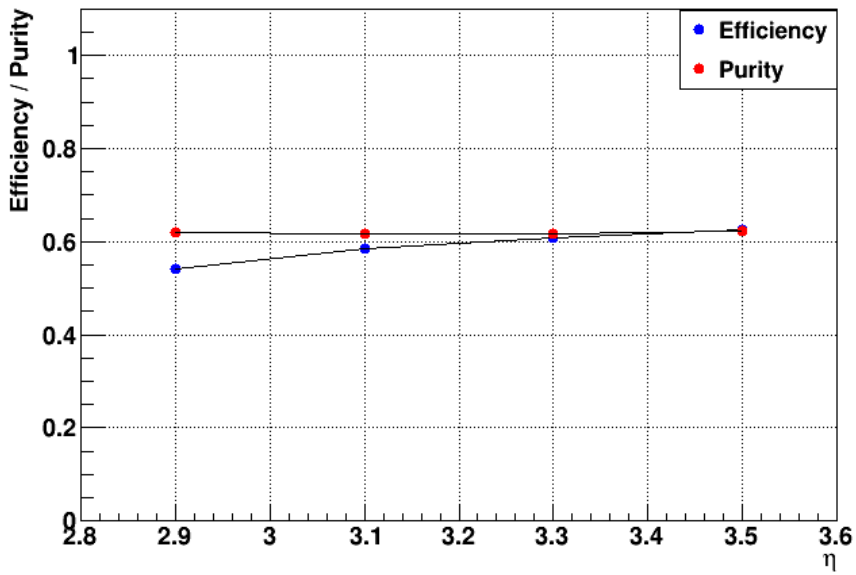


Eff / Purity (adc > 600 (~8 * MIP) and ncell > 0, 1 and 2)

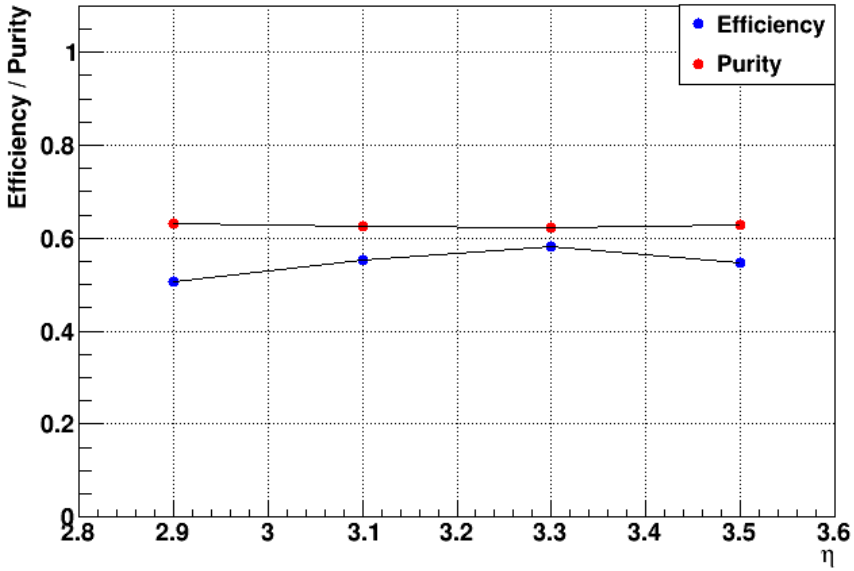
ncell > 0



ncell > 1



ncell > 2



Eff & purity for different adc and ncell cuts listed below:

Sr. No.	eta (η)	adc	ncell	Efficiency (%)	Purity (%)
1.	2.8, 3.6	> 432	> 0	0.616366	0.600889
2.			> 1	0.621936	0.602005
3.			> 2	0.576022	0.614482
4.	2.8, 3.6	> 600	> 0	0.576504	0.616707
5.			> 1	0.573785	0.617482
6.			> 2	0.545421	0.625812

Analysis Method:

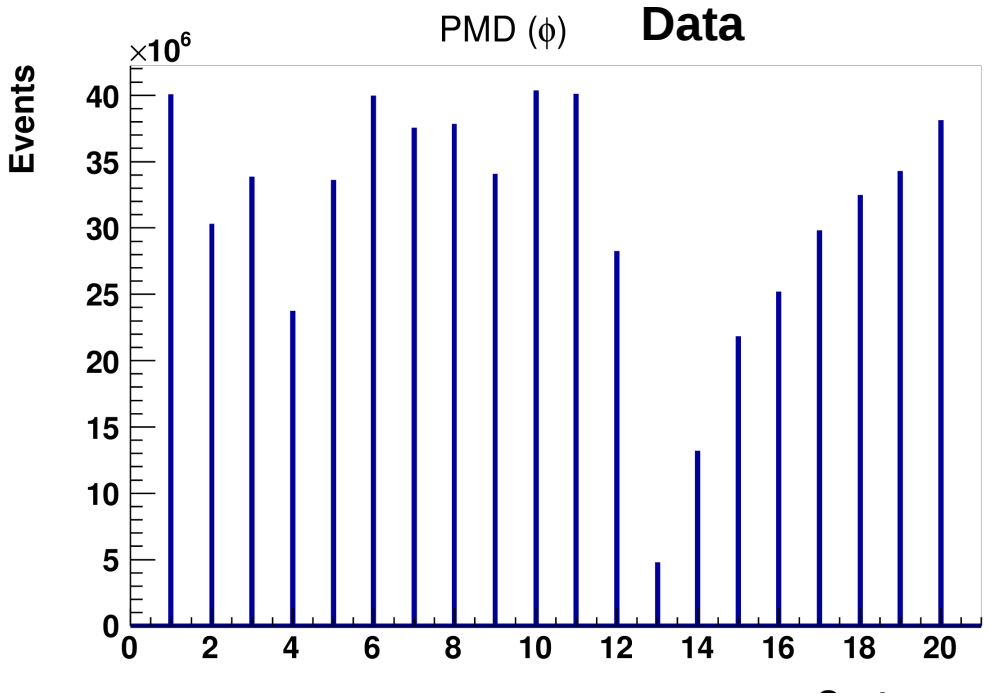
Localized Event Analysis

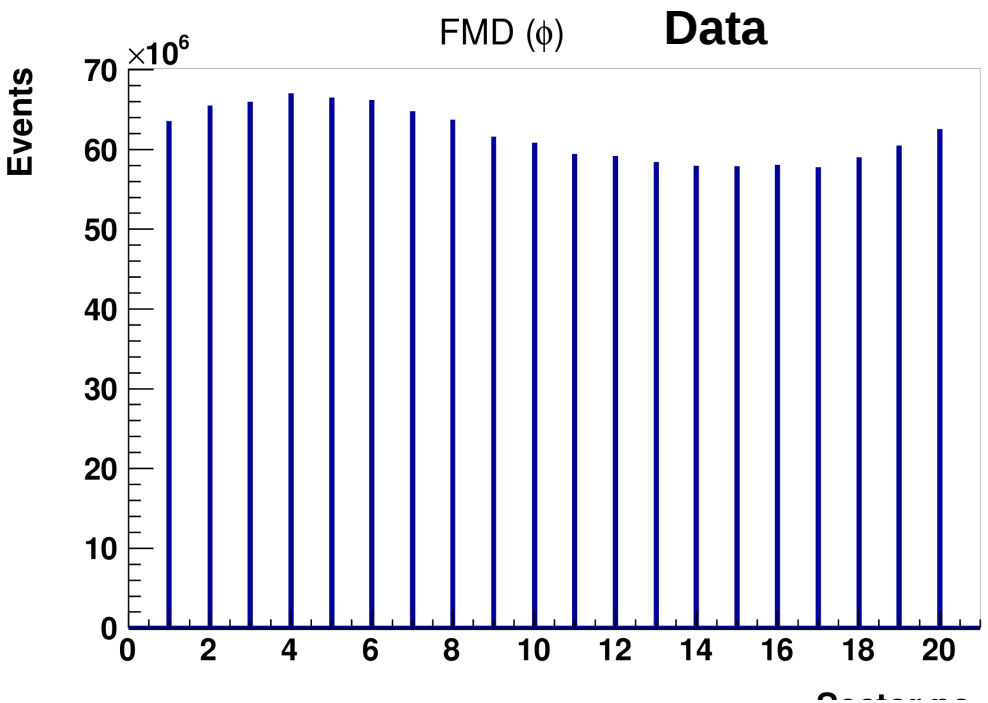
Sliding Window Method

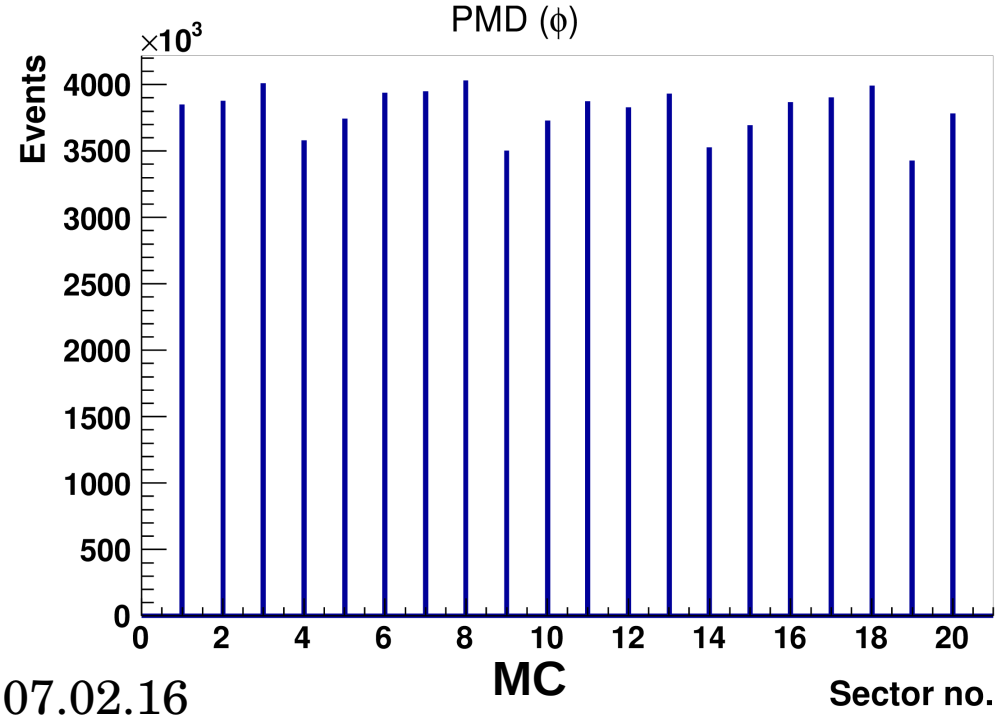
Calculated the ratio f for each $\Delta\Phi = 18^0$, 36^0 and 54^0 region to extract the maximum and minimum values of f in each event, which represents the photon and charge excess respectively.

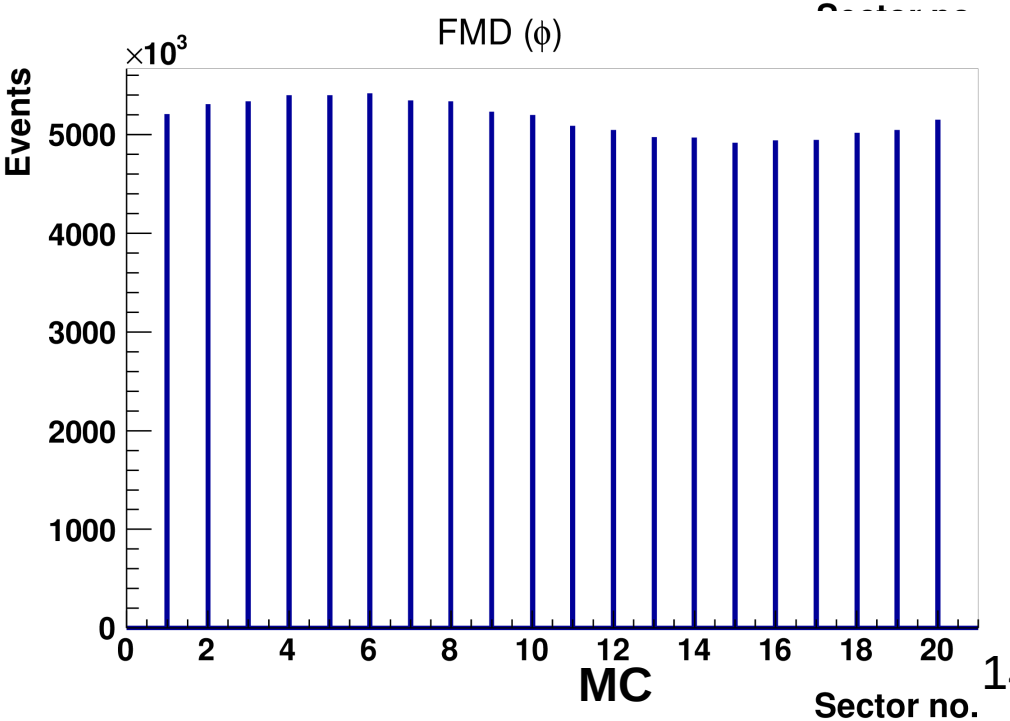
$$\mathbf{f = N_{\gamma\text{-like}} / N_{ch}}$$

Data analyzed in the overlap region of FMD & PMD i.e., $2.8 < \eta < 3.6$ and sectors 1 to 12 ($0^0 < \varphi < 216^0$) , 19 and 20 ($334^0 < \varphi < 360^0$)









For Azimuth window size $\Delta\Phi = 18^0$

Data

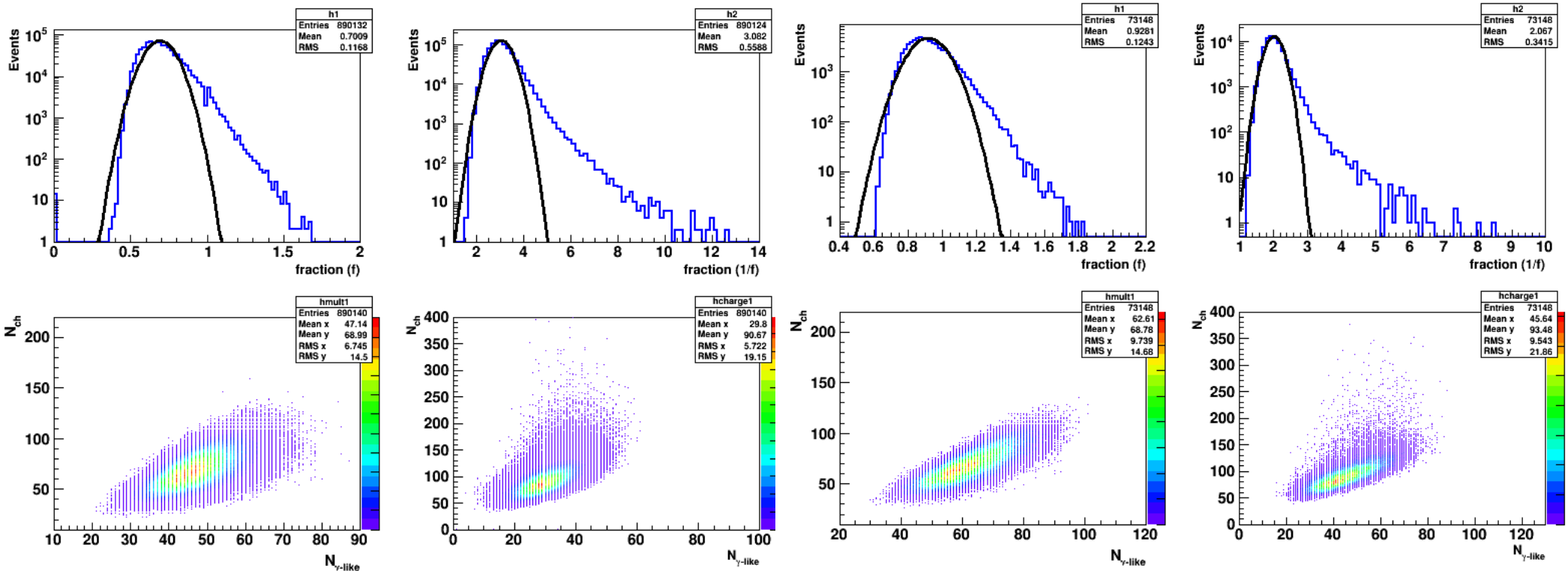
Monte carlo

photon excess

charge excess

photon excess

charge excess

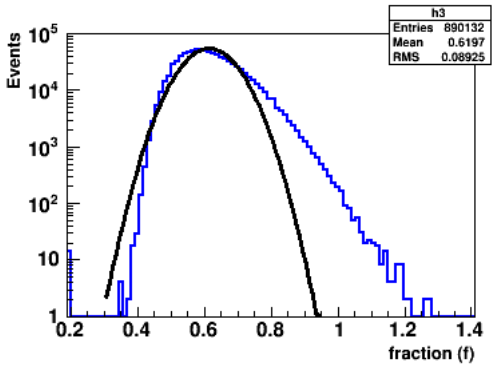


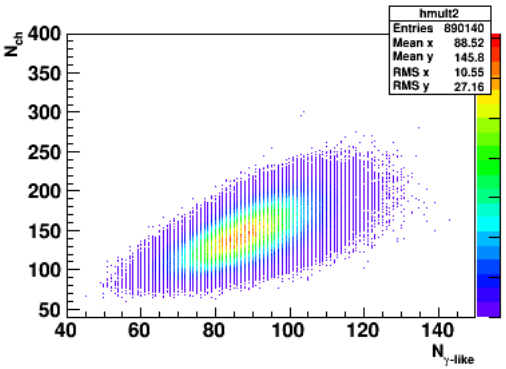
upper plot shows the variation of fraction (f) and (1/f) which is > 1 in both cases representing gamma excess and charge excess regions respectively. And in bottom plots correlation between the number of charged (N_{ch}) & gamma like ($N_{\gamma\text{-like}}$) particles for both γ-excess and ch-excess resp.

For Azimuth window size $\Delta\Phi = 36^0$

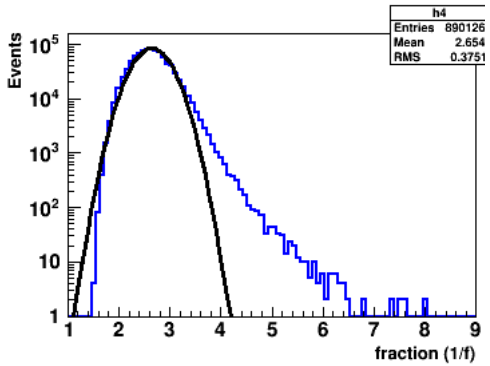
Data

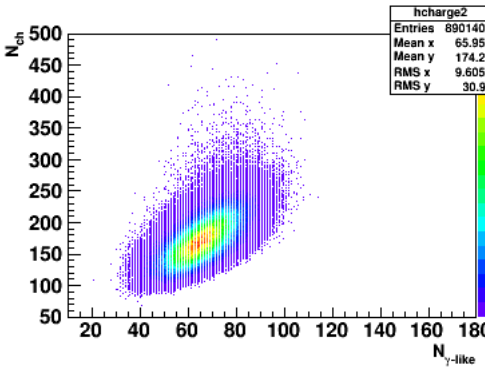
photon excess





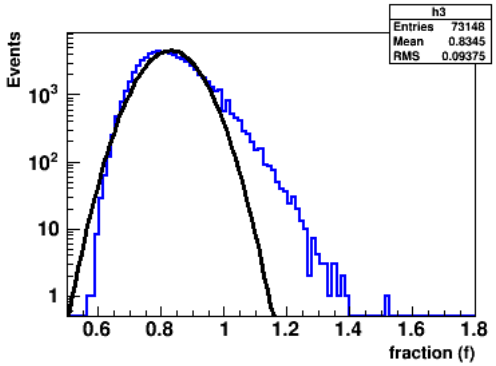
charge excess

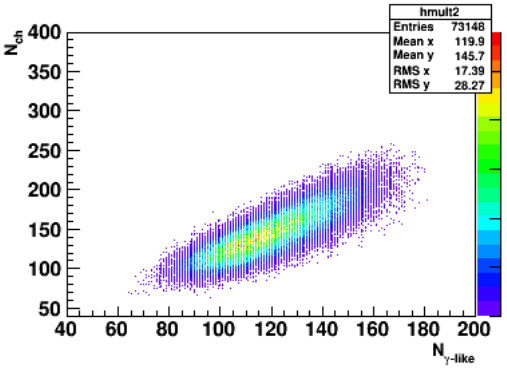




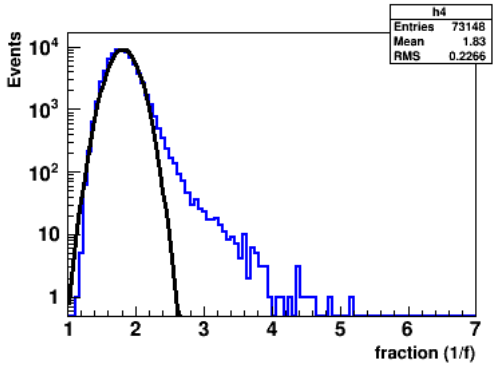
Monte carlo

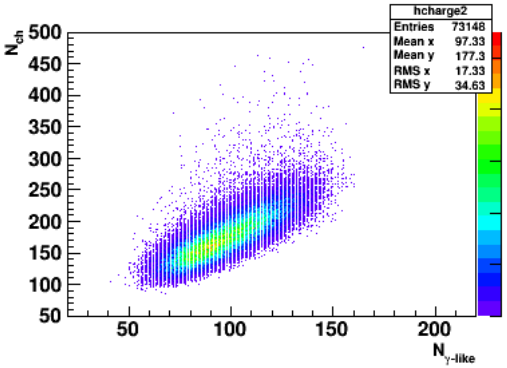
photon excess





charge excess

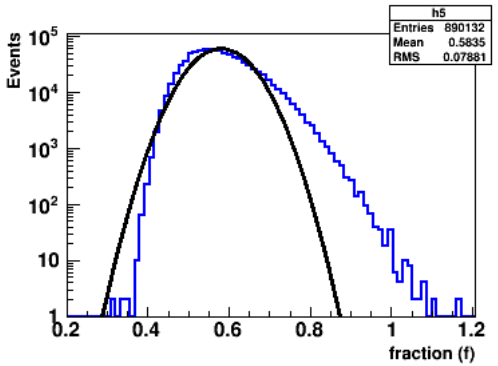


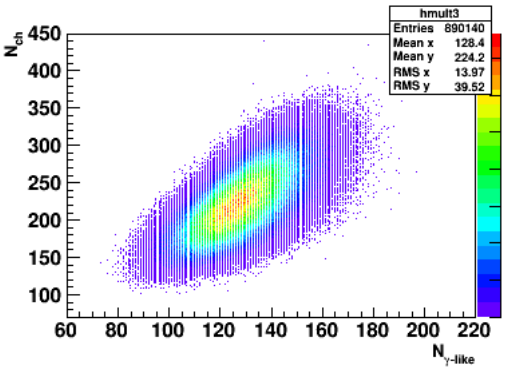


For Azimuth window size $\Delta\Phi = 54^0$

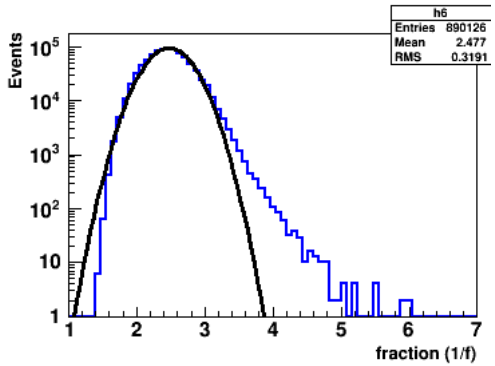
Data

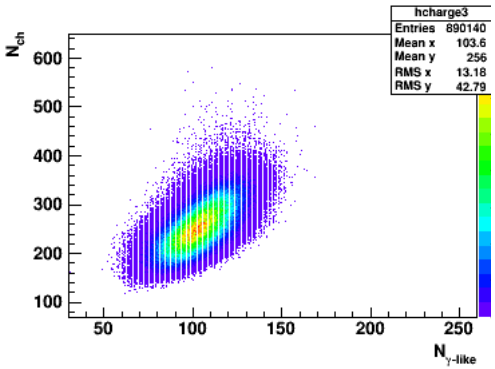
photon excess





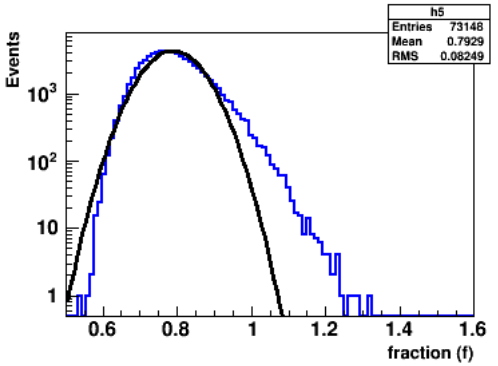
charge excess

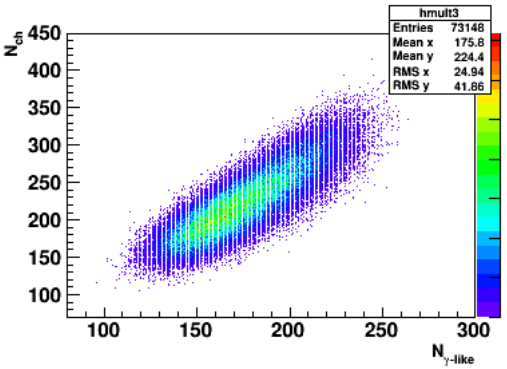




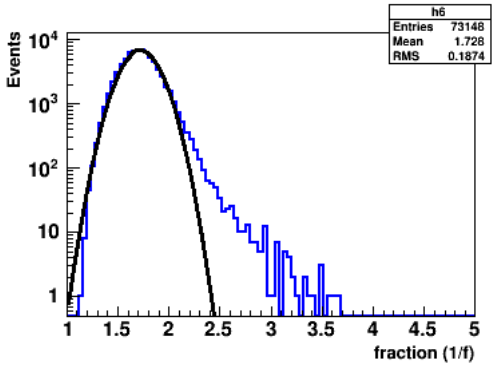
Monte carlo

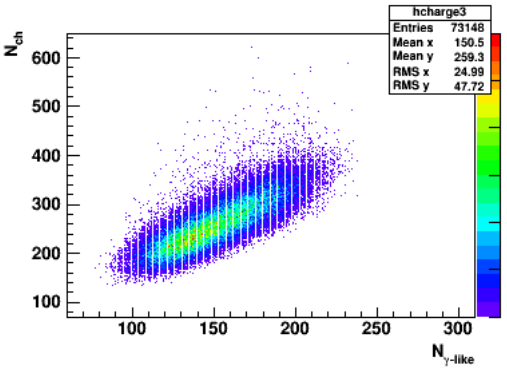
photon excess





charge excess

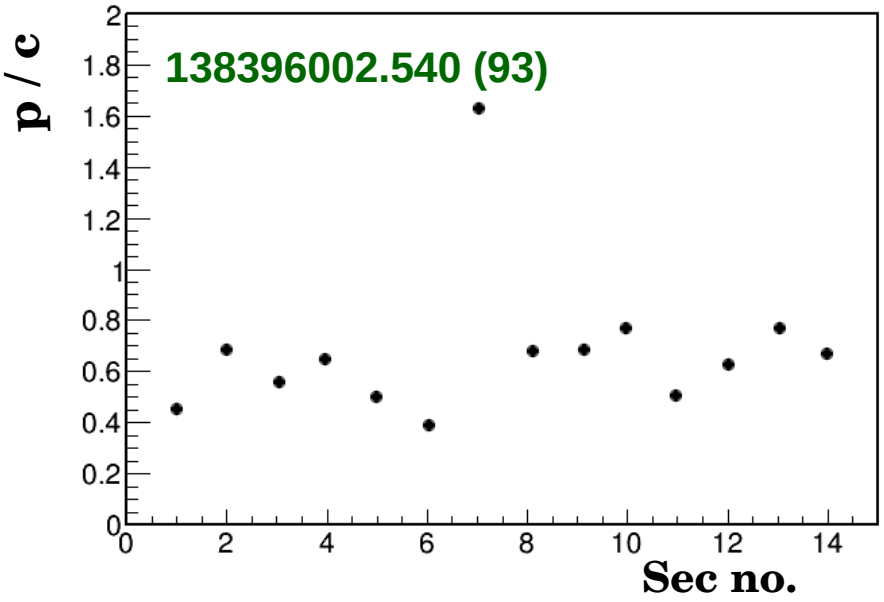


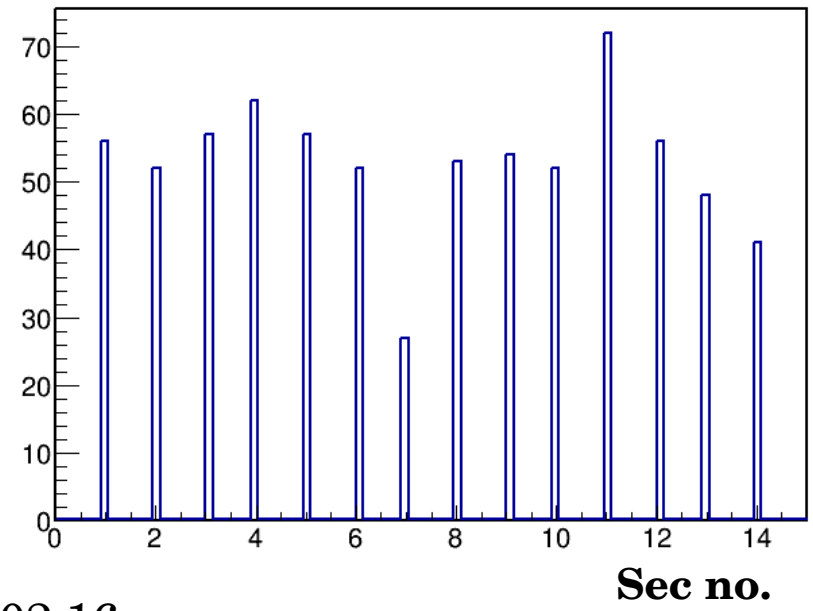


As increasing the window size from 18^0 onwards, the gamma excess and charge excess decreases. Also the events with charge excess are more.

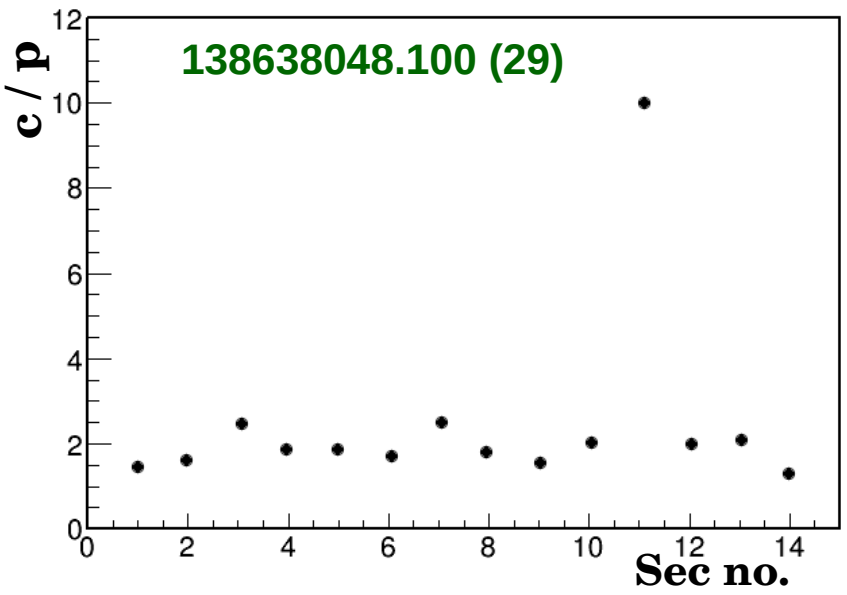
Unusual events analyzed from data for Azimuth window size $\Delta\Phi = 18^0$

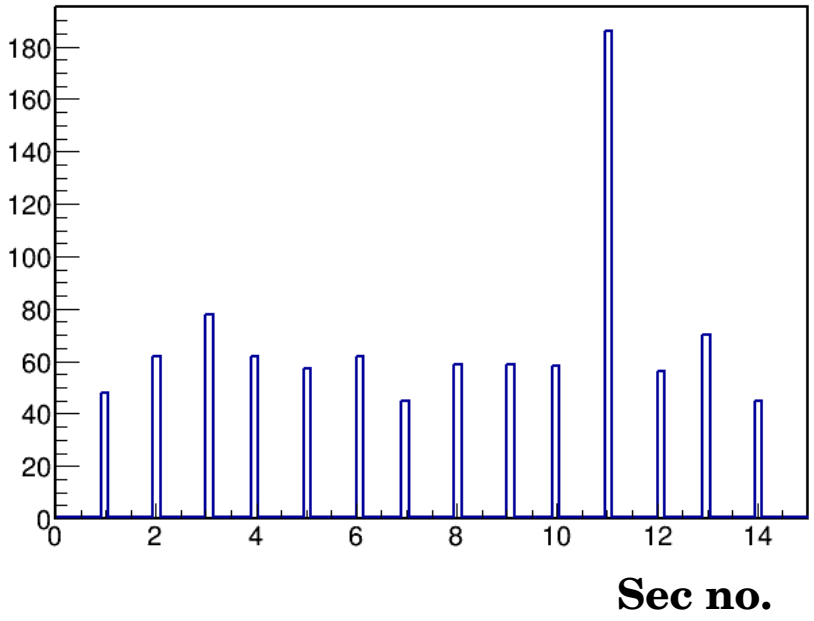
photon excess





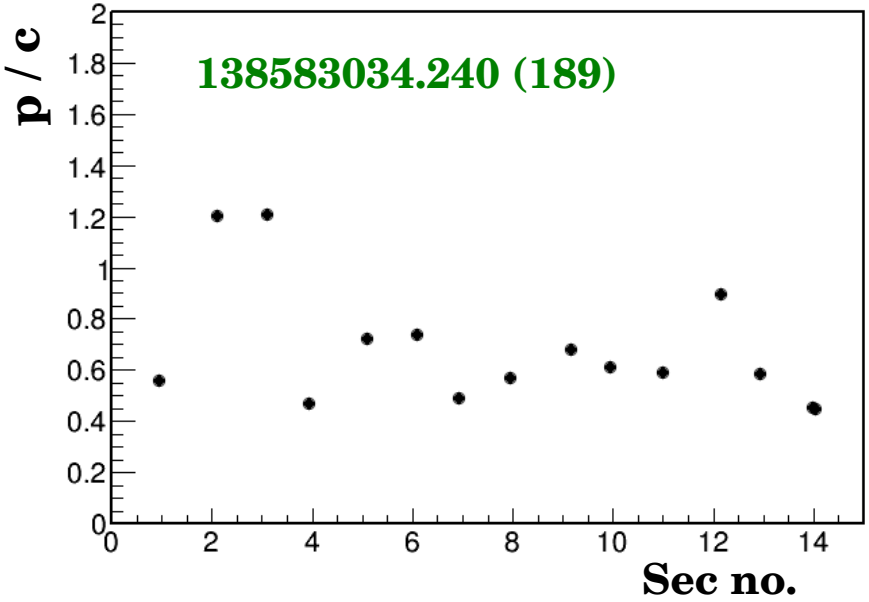
charge excess



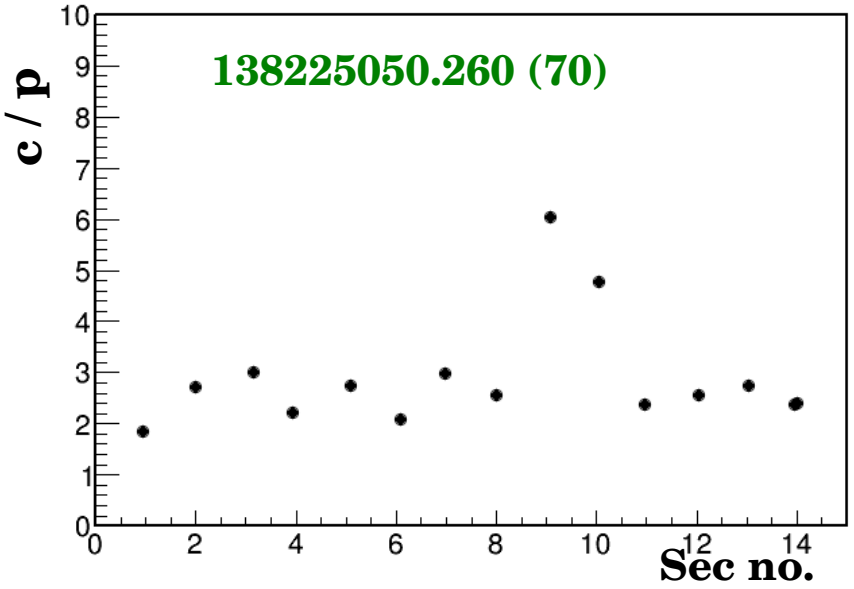


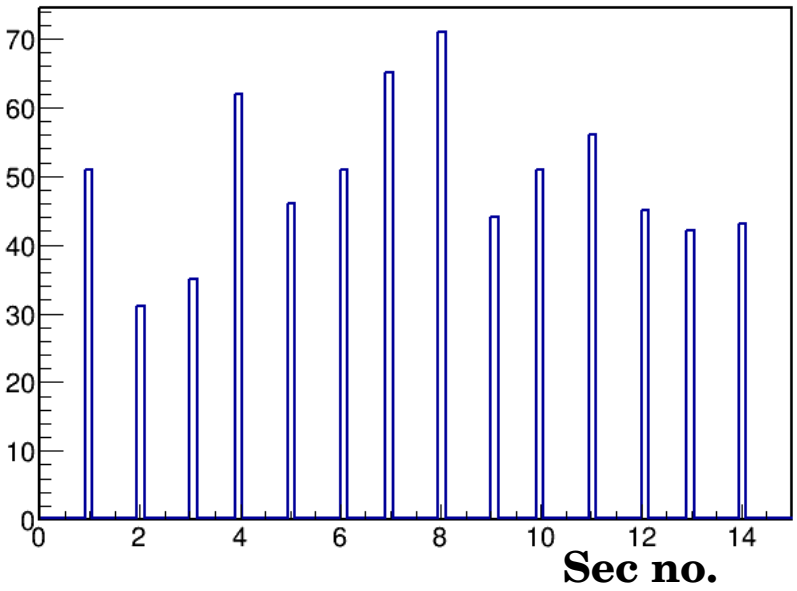
For Azimuth window size $\Delta\Phi = 36^0$

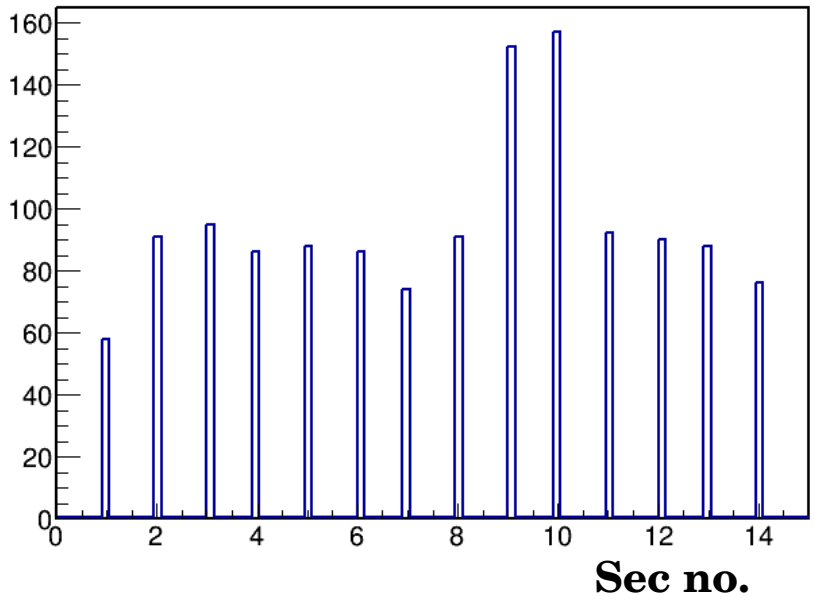
photon excess



charge excess

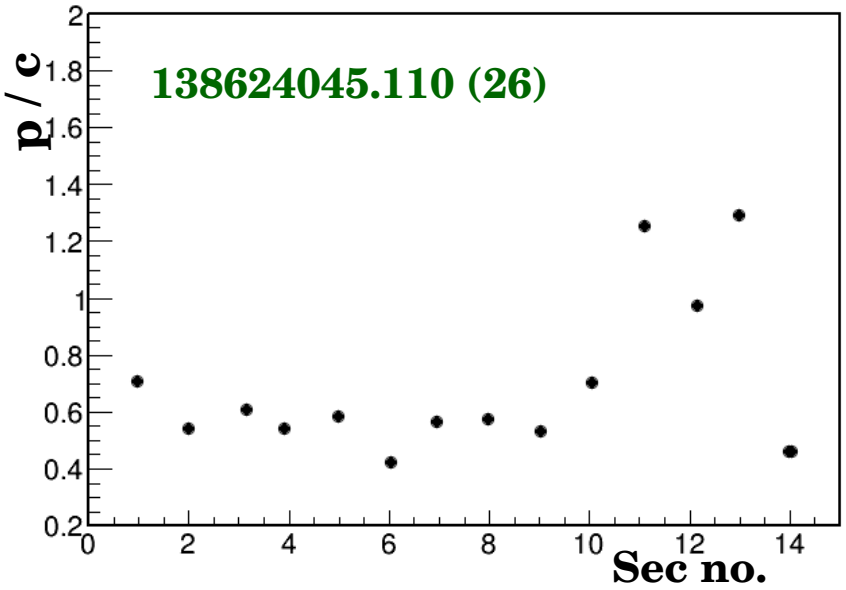


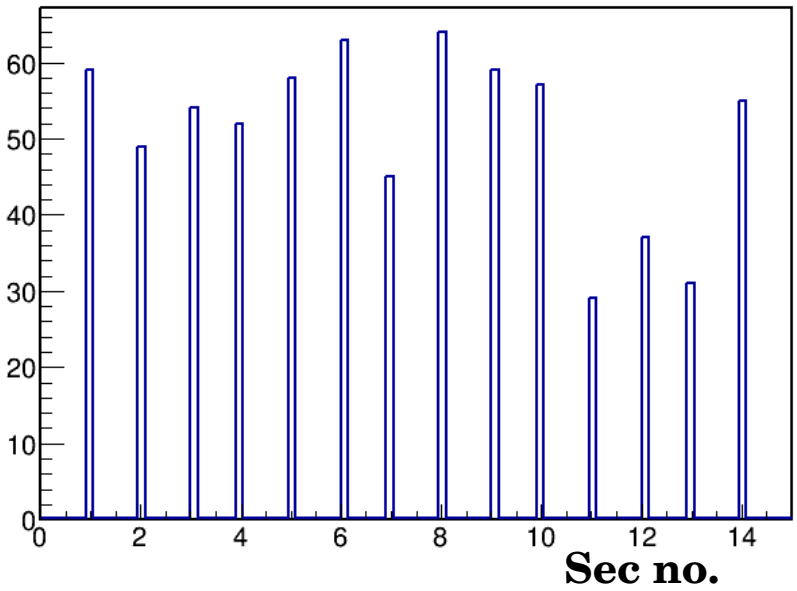




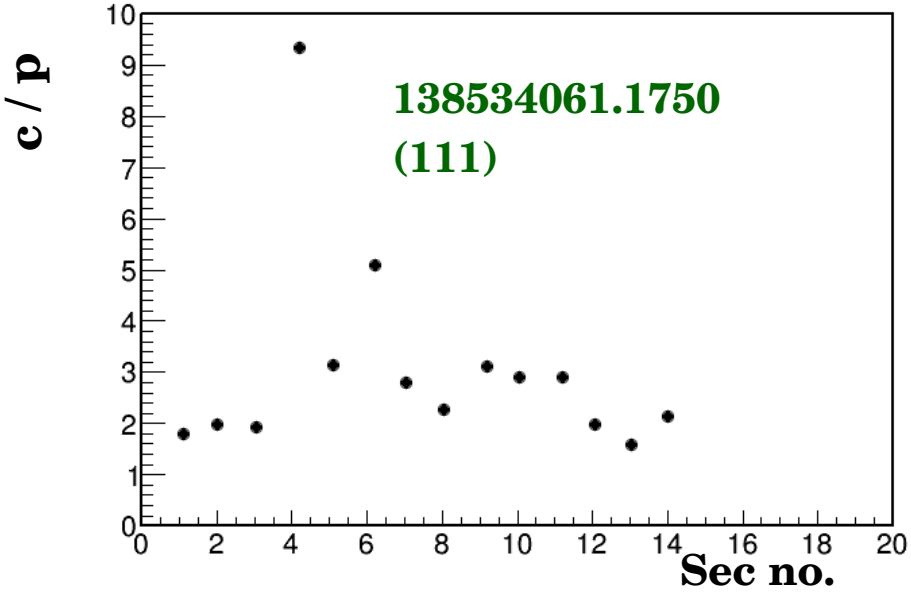
For Azimuth window size $\Delta\Phi = 54^0$

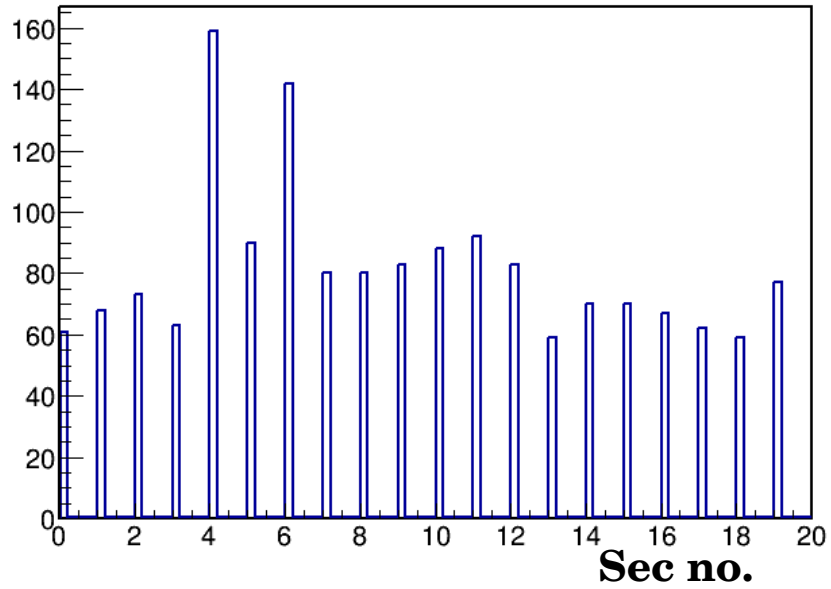
photon excess





charge excess





Measure of charged-neutral fluctuations: Global Event Analysis

1) Dynamic Variable

$$\nu_{dyn} = \frac{\langle N_\gamma (N_\gamma - 1)\rangle}{\langle N_\gamma \rangle^2} + \frac{\langle N_{ch}(N_{ch}-1)\rangle}{\langle N_{ch}\rangle^2} - 2\frac{\langle N_\gamma N_{ch}\rangle}{\langle N_\gamma\rangle\langle N_{ch}\rangle}$$

2) Normalized factorial moments

$$F_m = \langle N(N-1)\ldots(N-m+1)\rangle / \langle N\rangle^m$$

Expand to bivariate distributions by the Minimax

$$F_{m,j} = \frac{\langle n_{ch}(n_{ch}-1)....(n_{ch}-m+1)n_\gamma(n_\gamma-1)\ldots(n_\gamma-j+1)\rangle}{\langle n_{ch}\rangle^m \langle n_\gamma\rangle^j}$$

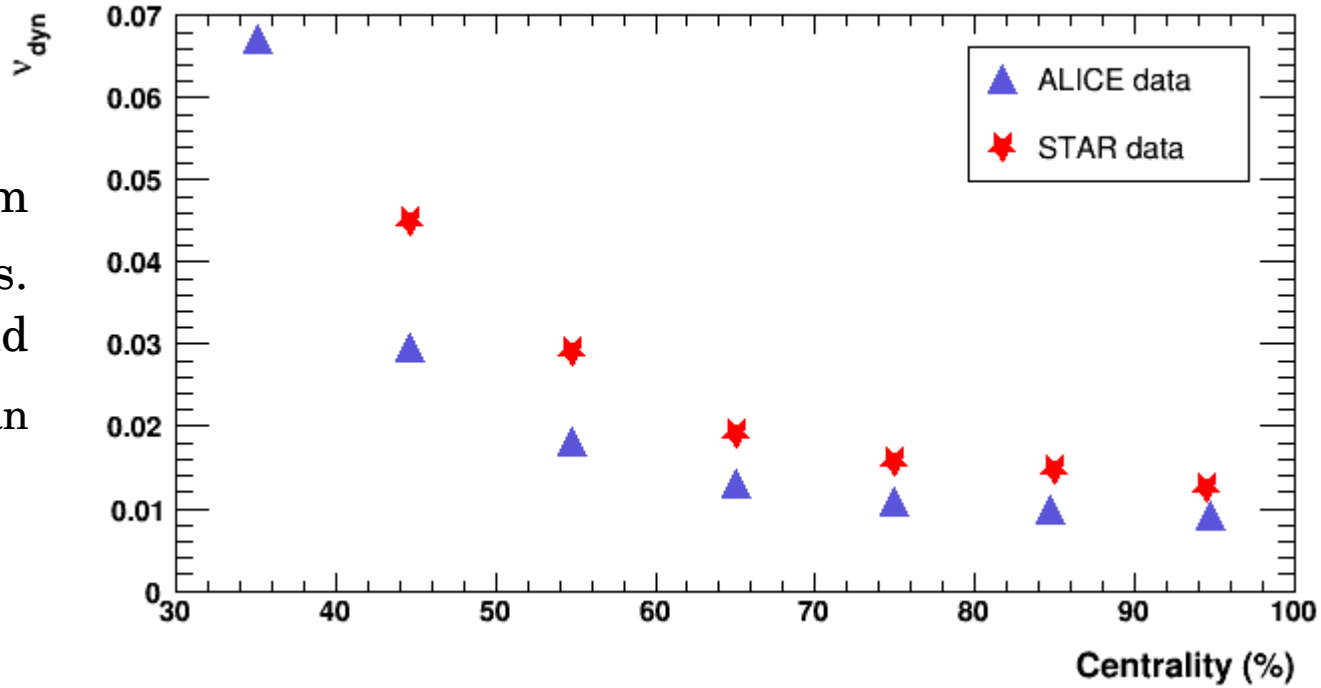
$$r_{m,1} = \frac{F_{m,1}}{F_{m+1,0}}$$

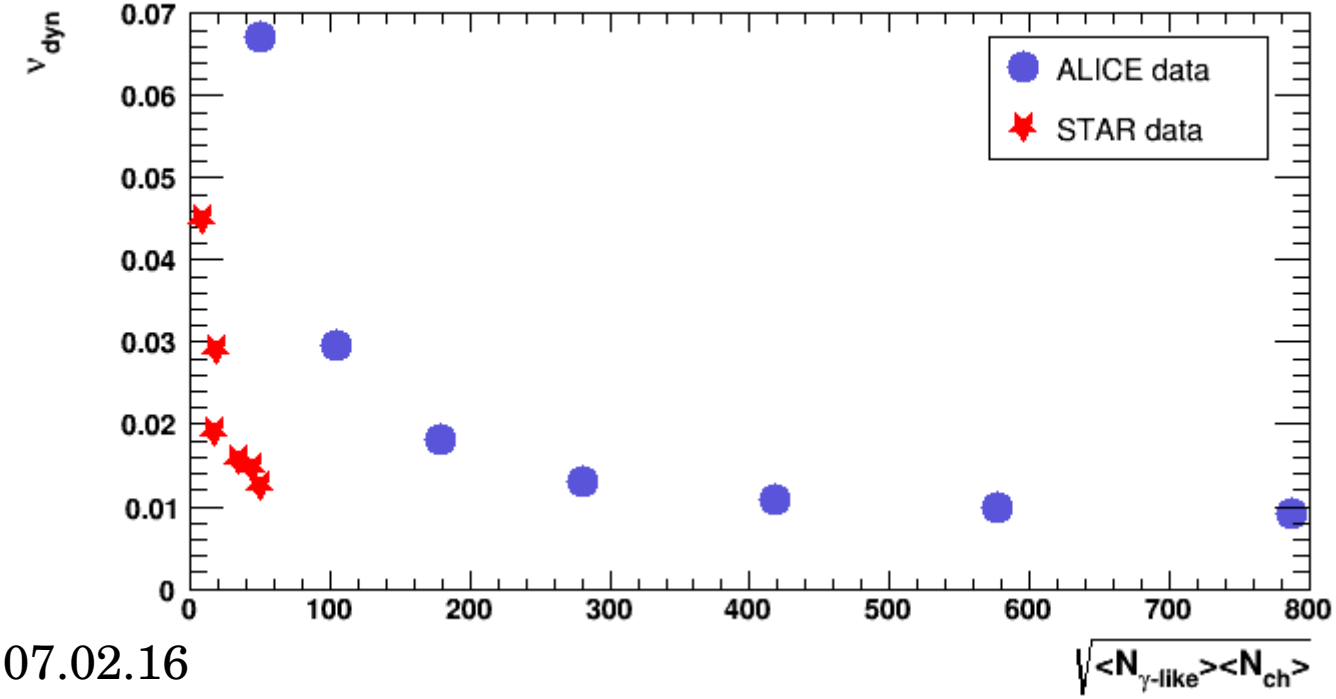
$$r_{m,1}^{\gamma-ch} = \frac{\langle N_{ch}(N_{ch}-1)\ldots(N_{ch}-m+1)N_\gamma\rangle\langle N_{ch}\rangle}{\langle N_{ch}(N_{ch}-1)\ldots(N_{ch}-m)\rangle\langle N_\gamma\rangle}$$

$r_{m,1}$ (generic) =1, $r_{m,1}$ (DCC) =1 / (m+1)

ν_{dyn} as a Function of Centrality

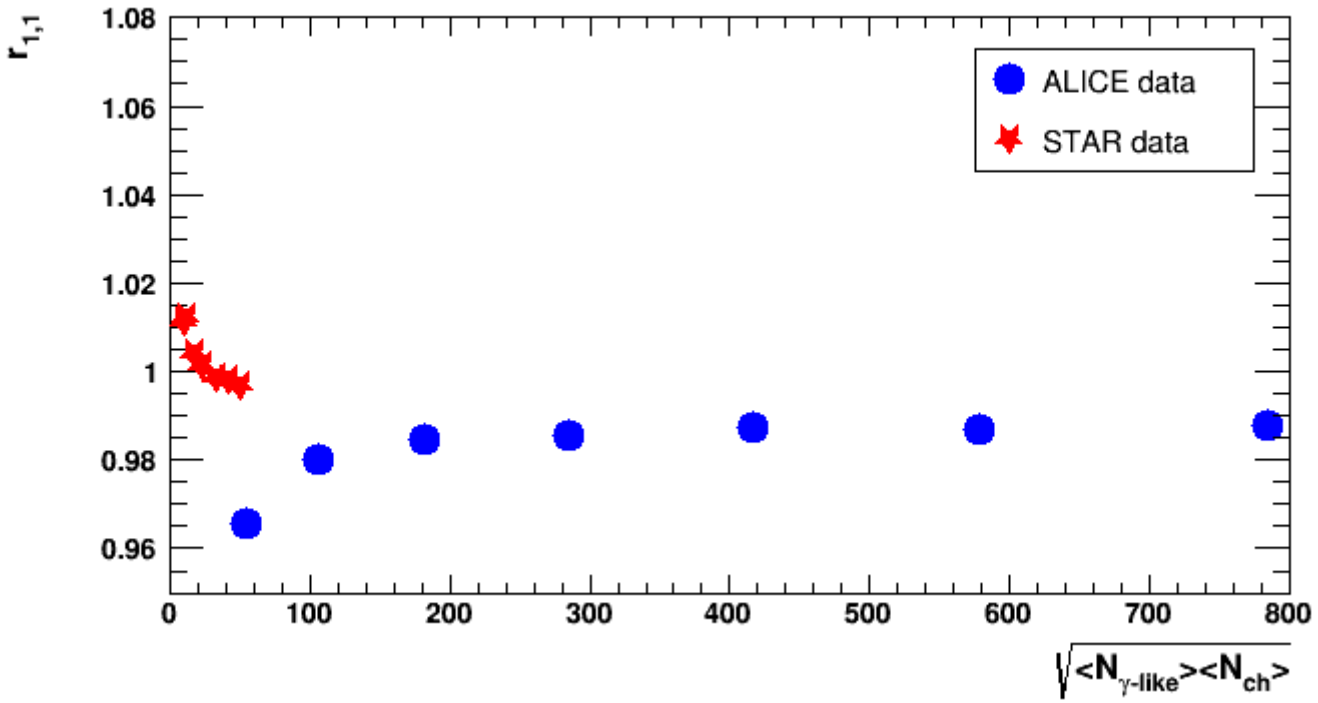
ν_{dyn} values decreases from peripheral to central collisions. Also STAR has the same trend but higher values of ν_{dyn} than ALICE.





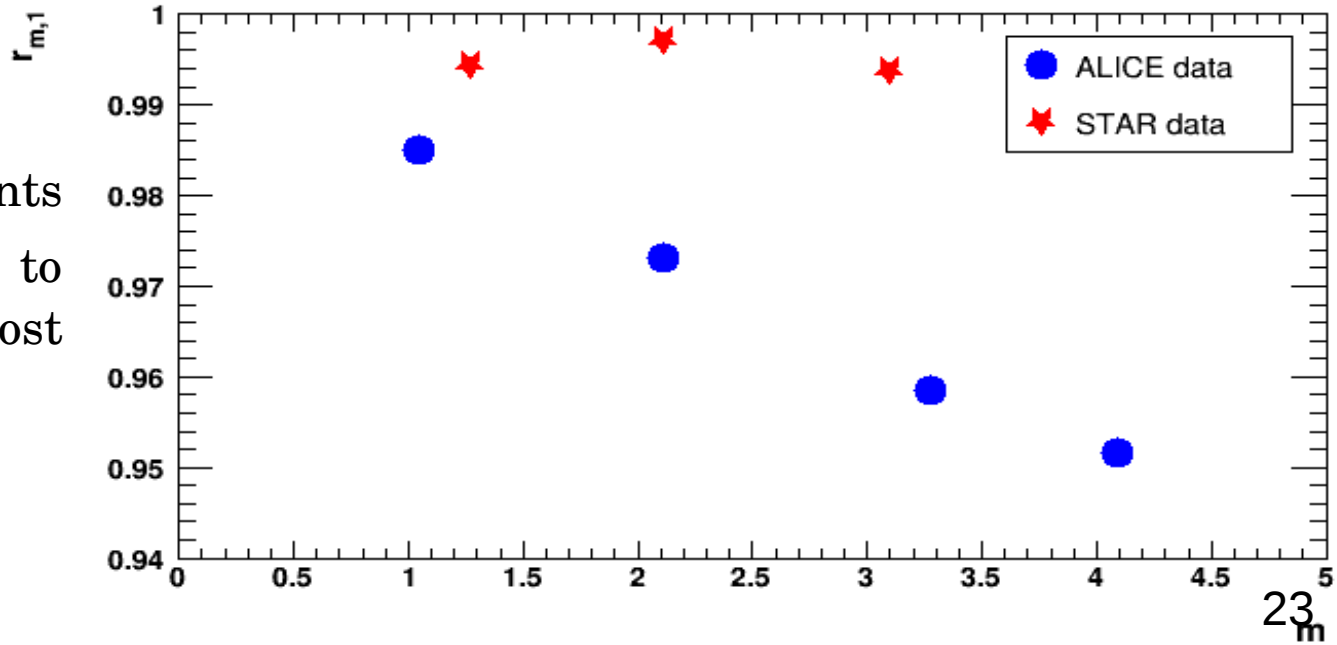
ν_{dyn} values are plotted as function of average multiplicity.
ALICE data points have more smaller values than STAR and gets fltattened afetr 300.

Factorial moment method



$r_{1,1}$ increases with increase in average multiplicity but it gets saturate at 200. STAR values decreases.

$r_{m,1}$ values for ALICE data points decreases faster as compared to STAR, which are almost constant.



Summary

- Studied efficiency / purity for the PMD detector with different combinations of adc and ncell, and adc > 432 & ncell > 1 has the better value of efficiency and purity from all of the six combinations.
- In data, some events found having photon excess and charge excess. In MC study, same effect has been observed but because of low statistics we have not concluded anything.
- ν_{dyn} has been studied as a function of average multiplicity and compared the results with STAR Experimental values both are positive but ALICE gets flattened after 300.
- $r_{1,1}$ increases with increase in average multiplicity and gets saturate at 200 whereas STAR $r_{1,1}$ decreases.
- ALICE $r_{m,1}$ decreases much faster than STAR values.

To do:

Prepared AOD of PMD using ESD along with the FMD AOD. So now data will be analyzed with AOD of PMD-FMD.

Study of charged-neutral fluctuations in the overlap pseudorapidity coverage of Vzero and PMD is started.

Thank you !!