Multiplicity Distribution of Photons at Forward Pseudorapidity in p + p Collisions at $\sqrt{s}$ = 7 TeV

Sidharth Kumar Prasad
Variable Energy Cyclotron Centre, Kolkata, INDIA
for ALICE Collaboration

Outline :

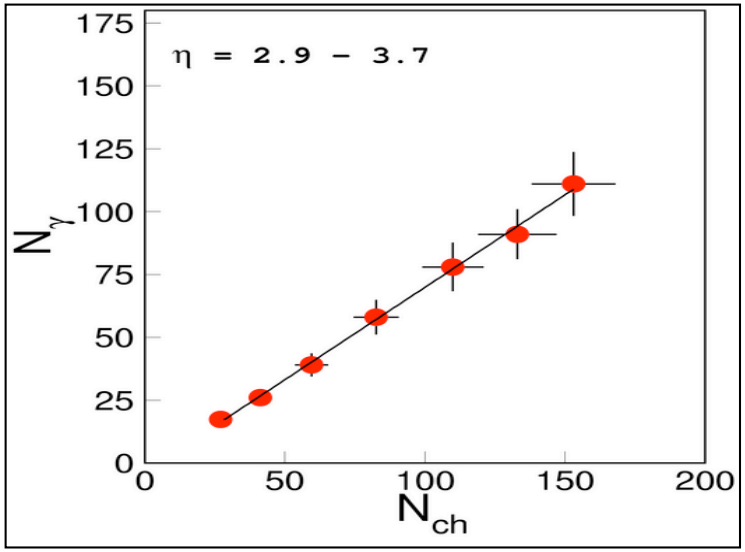
- *Physics motivation*
- *PMD : Data analysis (pp collisions at $\sqrt{s}$ = 7 TeV)*
- *Photon multiplicity distribution*
- *Summary*

Physics motivation: Photon multiplicity measurement in forward rapidity

❖ *Photon measurement is complementary to the charged particle measurement.*

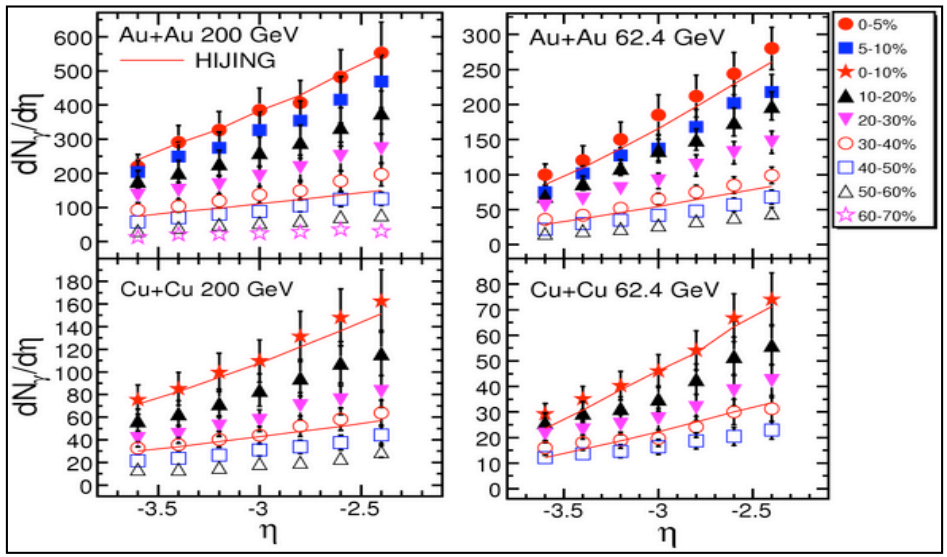
❖ *Photon measurement in the forward rapidity gives important Physics input for:*

- *Limiting Fragmentation (LF)*
- *Multiplicity Fluctuation*
- *Photon-Charge Correlation*
- *Elliptic Flow*

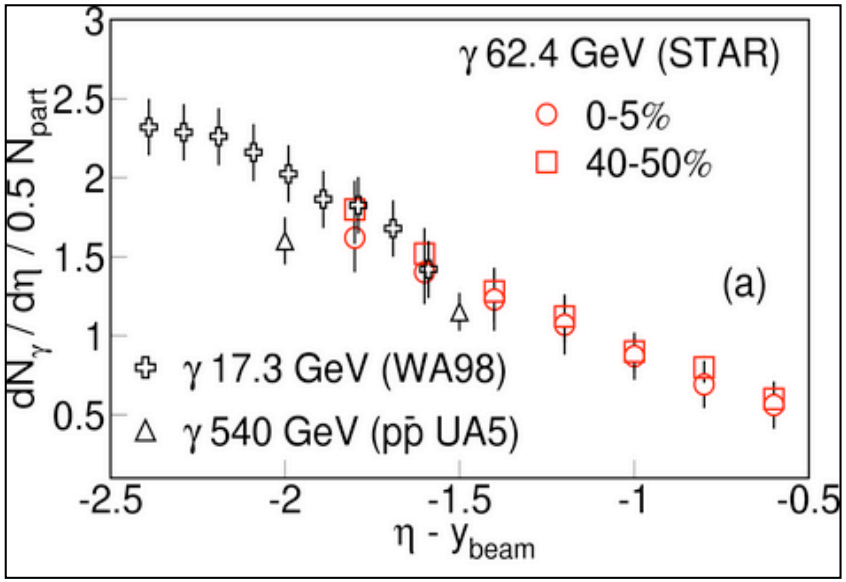


N_γ-N_{ch} correlation (PRC73 (2006))

Results from STAR-PMD from Nucleus-Nucleus collisions



$dN_\gamma/d\eta$ (NuclPhys A832 (2010))



LF behavior (PRL95(2005))

Physics motivation: Photon multiplicity measurement in forward rapidity

❖ *Measurements in pp collisions act as reference for A+A collisions*

❖ *Collectivity (Elliptic flow): High density matter is expected to be formed in high multiplicity pp events and collective effects like 'elliptic flow' can be observed.*

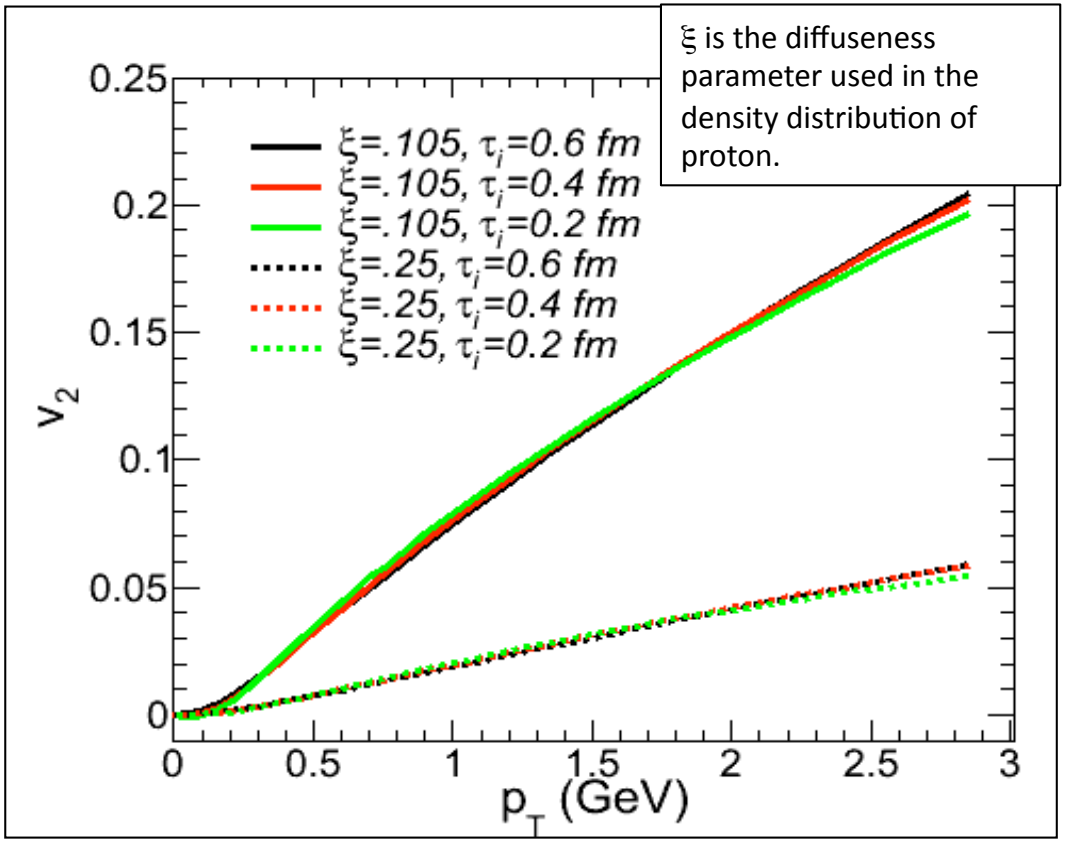
❖ H. von Gersdorff, L. McLerran, M. Kataja, and P. V. Ruuskanen, Phys. Rev. D **34**, 794 (1986).

❖ D. d'Enterria *et al.*, Eur. Phys. J C **66**, 173 (2010) **(v_2 : 3%).**

❖ S. K. Prasad *et al.*, Phys. Rev. C **82**, 024909 (2010).

❖ J. Casalderrey-Solana, U. A. Wiedemann, Phys. Rev. Lett. **104**, 102301 (2010).

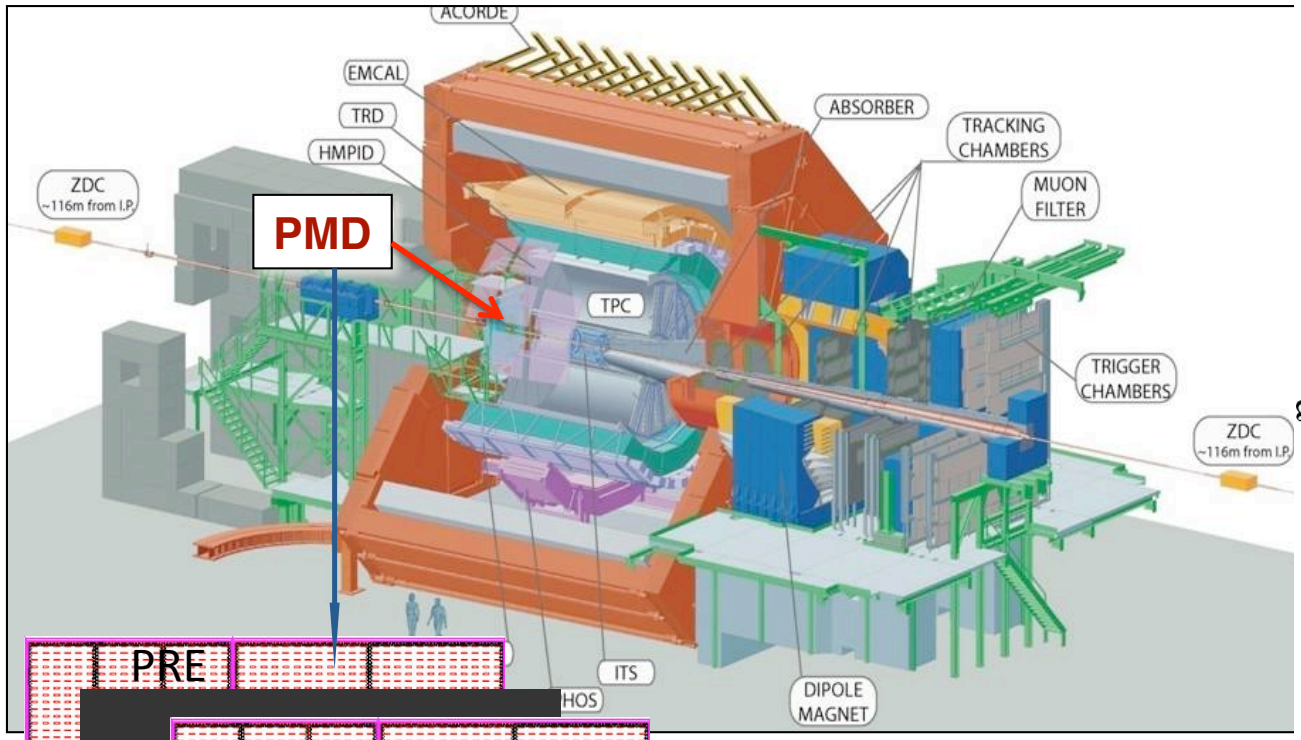
❖ P. Bozek, Acta Phys. Pol. B, **41,** 837 (2010).

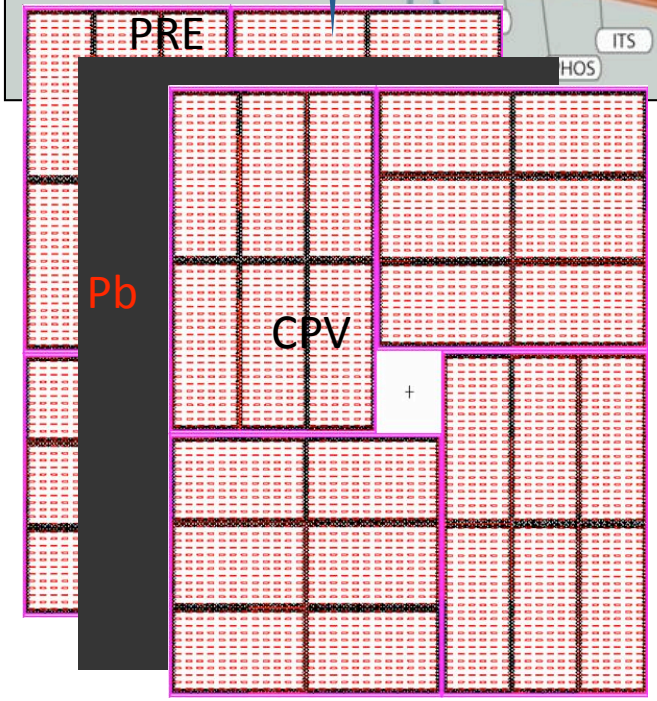


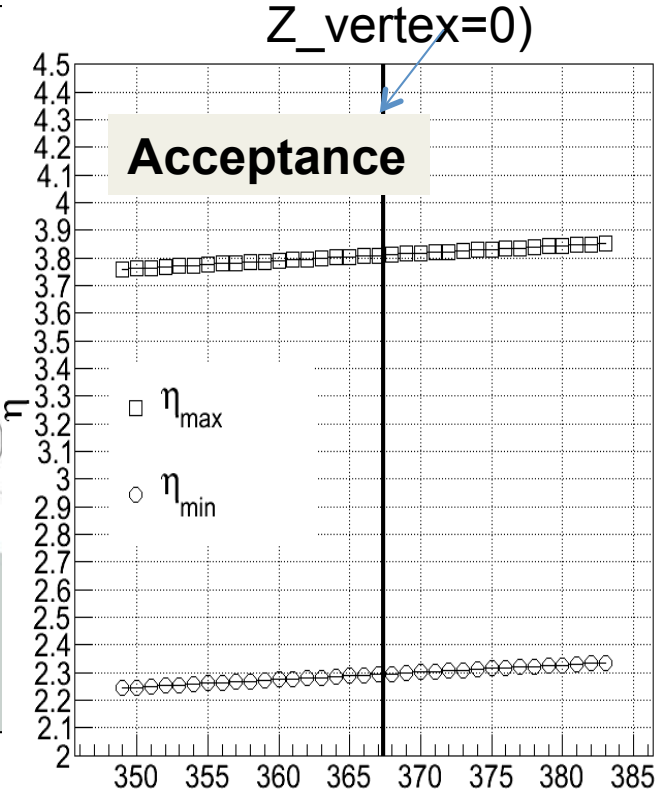
ξ is the diffuseness parameter used in the density distribution of proton.

Phys. Rev. C82:024909 (2010)

Photon Multiplicity Detector (PMD) in ALICE





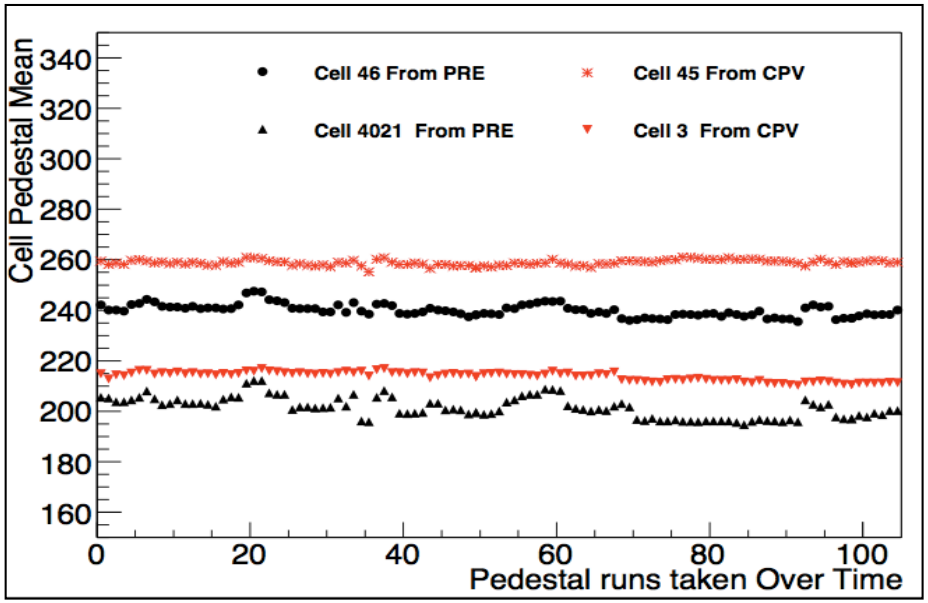


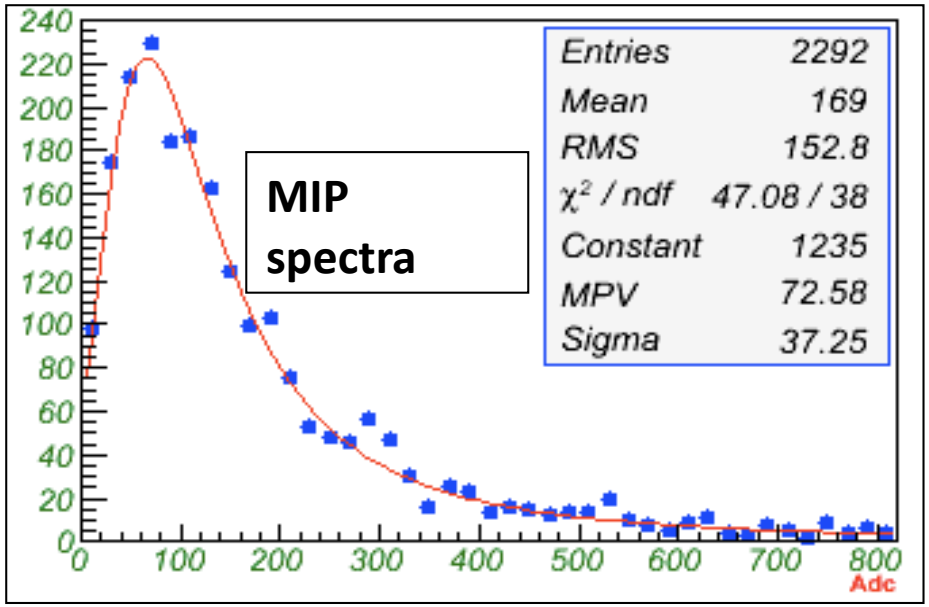
- Cell depth : 0.5 cm
- Cell cross-section : 0.23 cm^2
- Total no. of cells : 76800×2 (as installed)
- Distance from IP : 367.5 cm (as installed)
- Coverage : 2.3 to 3.9 in η
- Sensitive medium : Gas (Ar+CO_2 in the ratio 70:30)

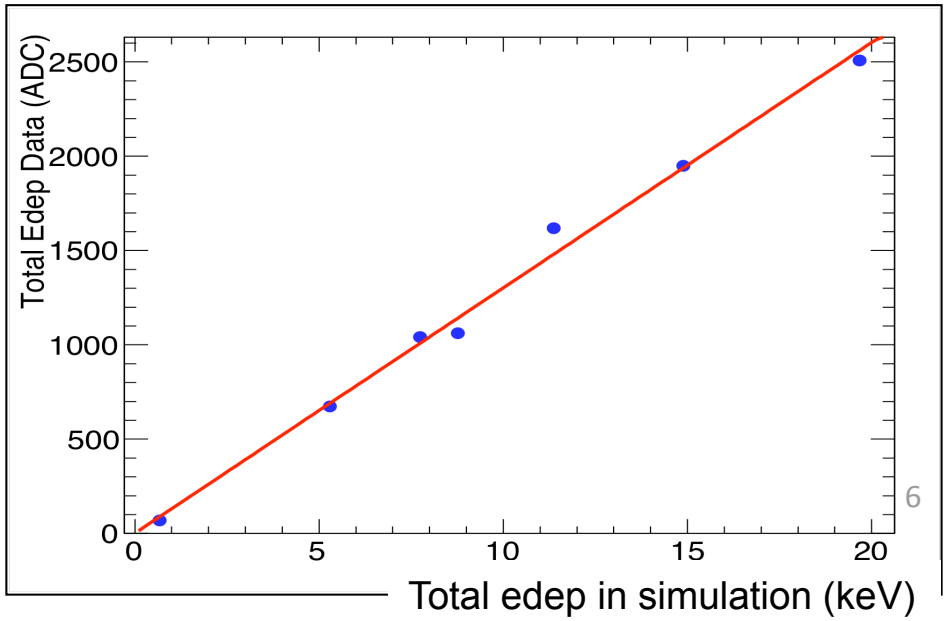
Testing modules with π^- and e^- beams

Test beam results:
- *Pedestal*
- *Pulse height spectra*
- *keV-ADC calibration*

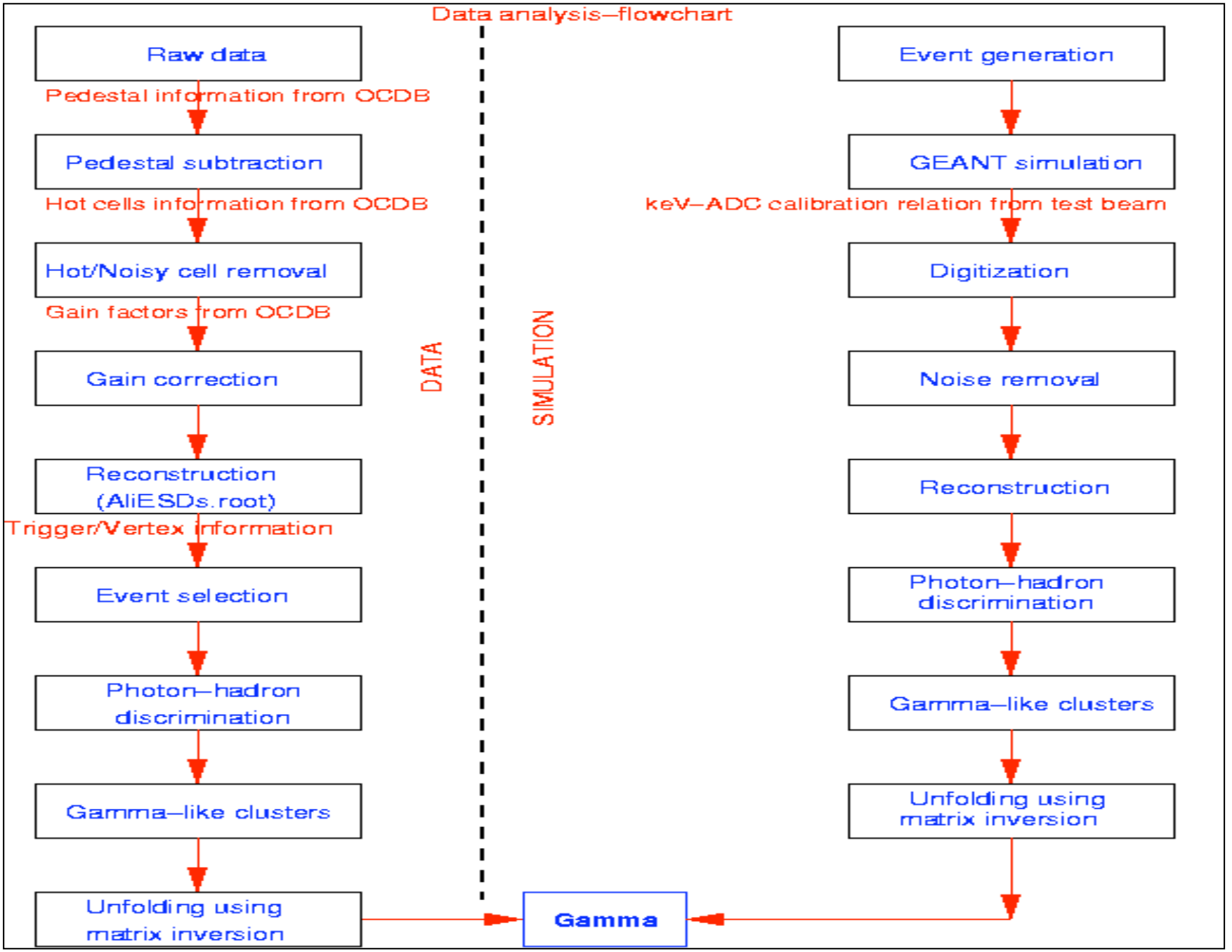
Pion beam energy: 3 GeV
Electron beam energies: 1-4 GeV







Data analysis – flowchart

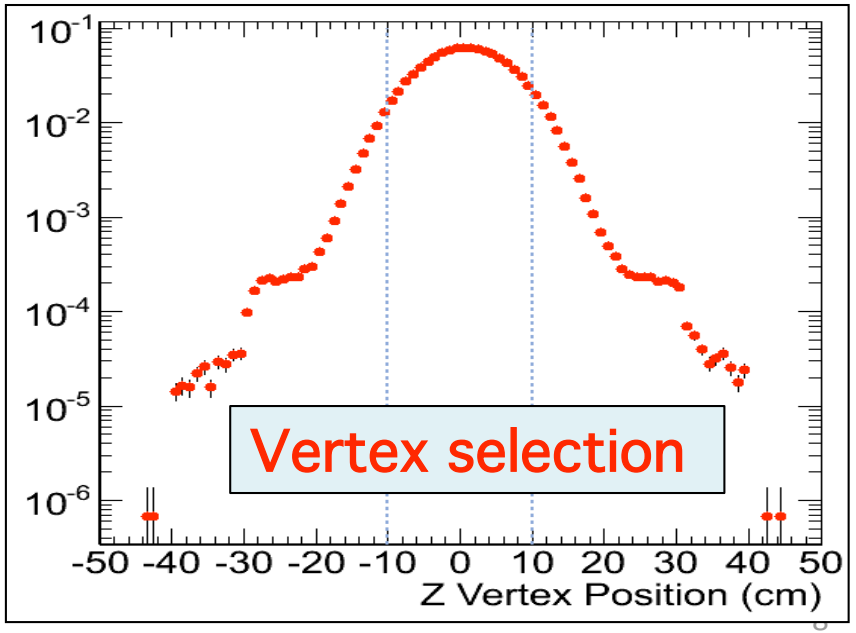


Event selection

9	CMUS1WU-E-NOPF-ALL	1							0
10	CBEAMB-B-NOPF-ALLNOTRD	2							18 864
11	CINT1-B-NOPF-ALLNOTRD	2							1 036 843
12	CINT1-AC-NOPF-ALLNOTRD	2							8 202
13	CINT1-E-NOPF-ALLNOTRD	2							324
14	CMUS1-B-NOPF-ALLNOTRD	2							99 081
15	CMUS1-AC-NOPF-ALLNOTRD	2							483
16	CMUS1-E-NOPF-ALLNOTRD	2							0
17	CSH1-B-NOPF-ALLNOTRD	2							53 453
18	CSH1-AC-NOPF-ALLNOTRD	2							2 506
19	CSH1-E-NOPF-ALLNOTRD	2							3

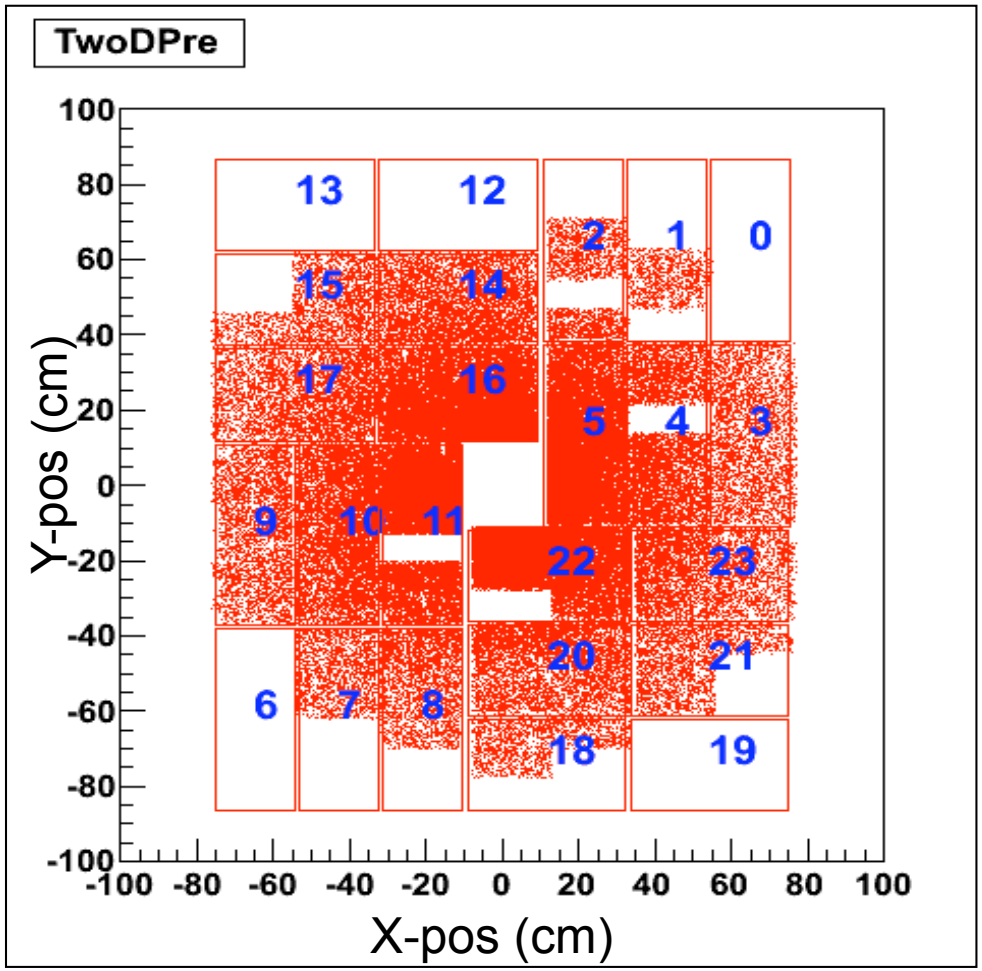
Selected Trigger Class

- Data sets used for analysis:
  LHC10e, Run#127935
- Data sets used for simulation:
  LHC10f6 (Phojet)
- Total number of events analyzed:
  390 416
- Trigger selected:
  CINT1-B-NOPF-ALLNOTRD
  (SPD+V0)
- Z vertex selection:
  $|V_Z| < 10$ and $V_z \neq 0$

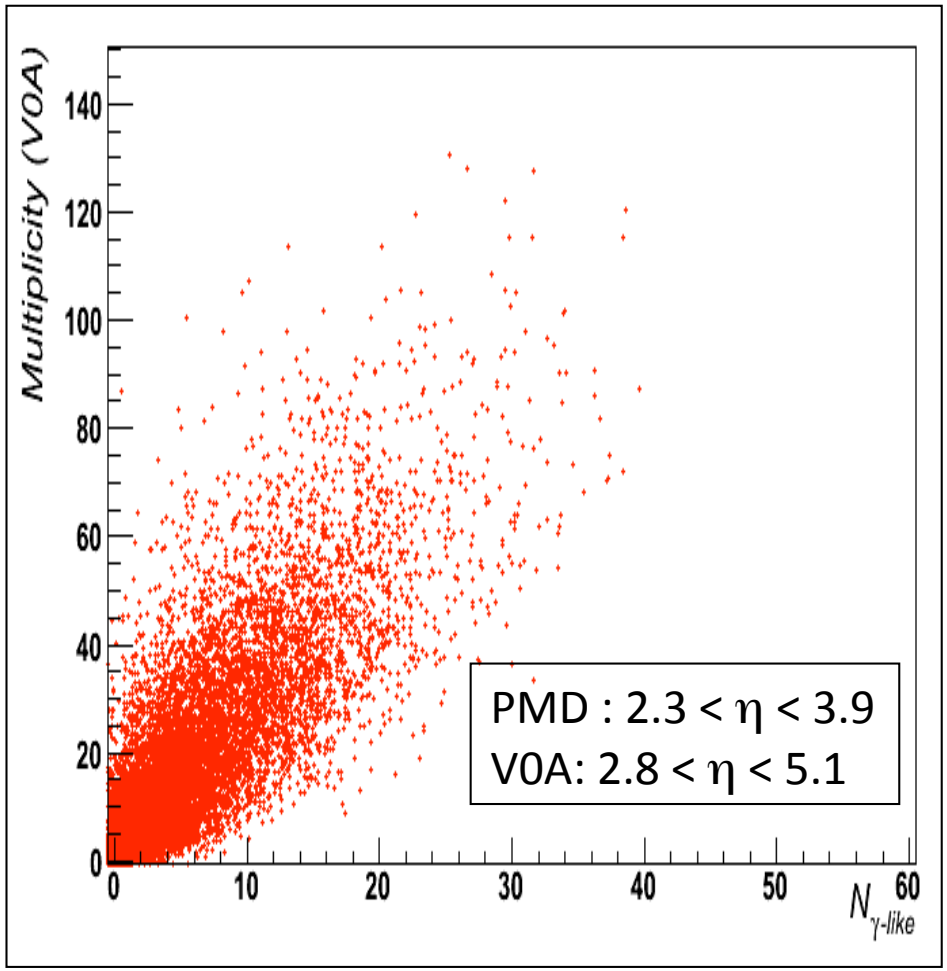


Quality Assurance plots

PMD coverage (Preshower plane) @ 7 TeV



PMD Vs V0A correlation



Unfolding method: Performance

Calculating the Detector Response Matrix (*A*) and unfolding the measured distribution *g*

$$g = Af \quad \Rightarrow \quad f = A^{-1}g$$

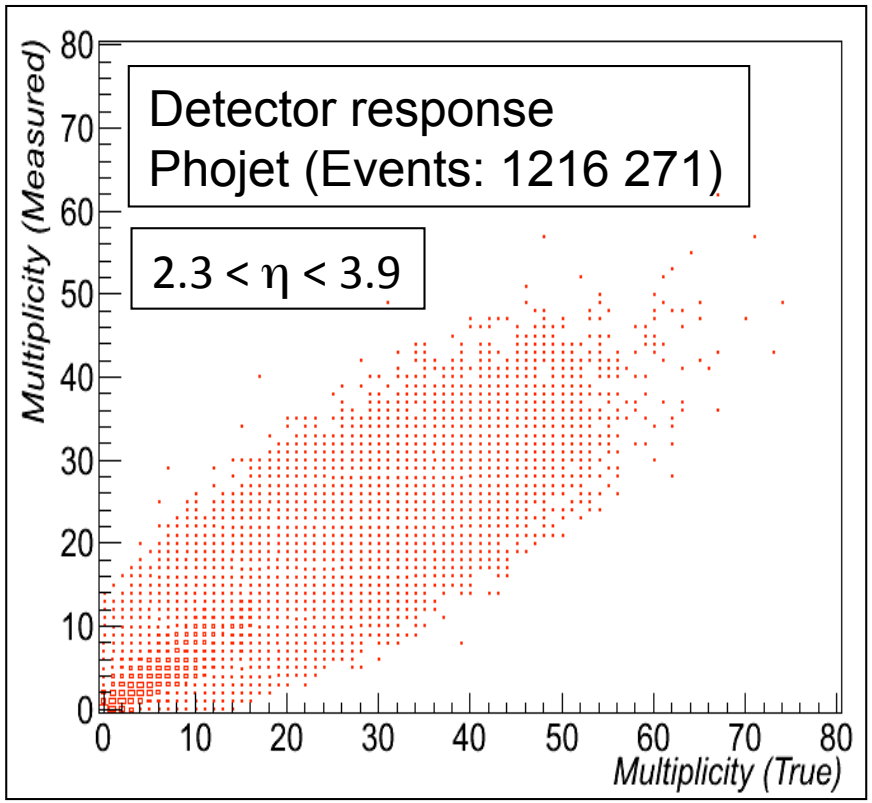
Determination of the true distribution '*f* ' from the measured distribution 'g' is called Unfolding. Using minimization of a χ^2-function given as:

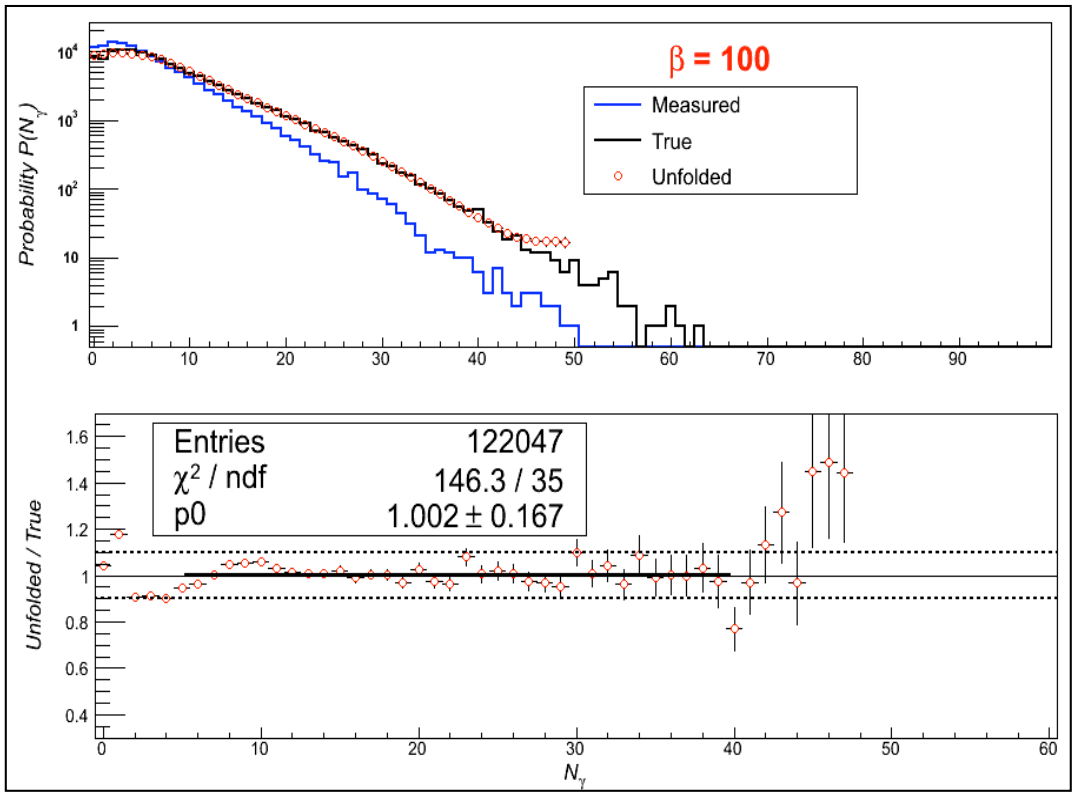
$$\hat{\chi}^2 = \sum_i \left(\frac{g_i - \sum_j A_{ij} f_j}{e_i}\right)^2$$

where '*e*' is the error in measurement, and adding a regularization term P, $\chi^2 = \hat{\chi}^2 + \beta P$

Where β is weight factor, the oscillations in the solutions are removed.

Measured multiplicity (Phojet:122K events)



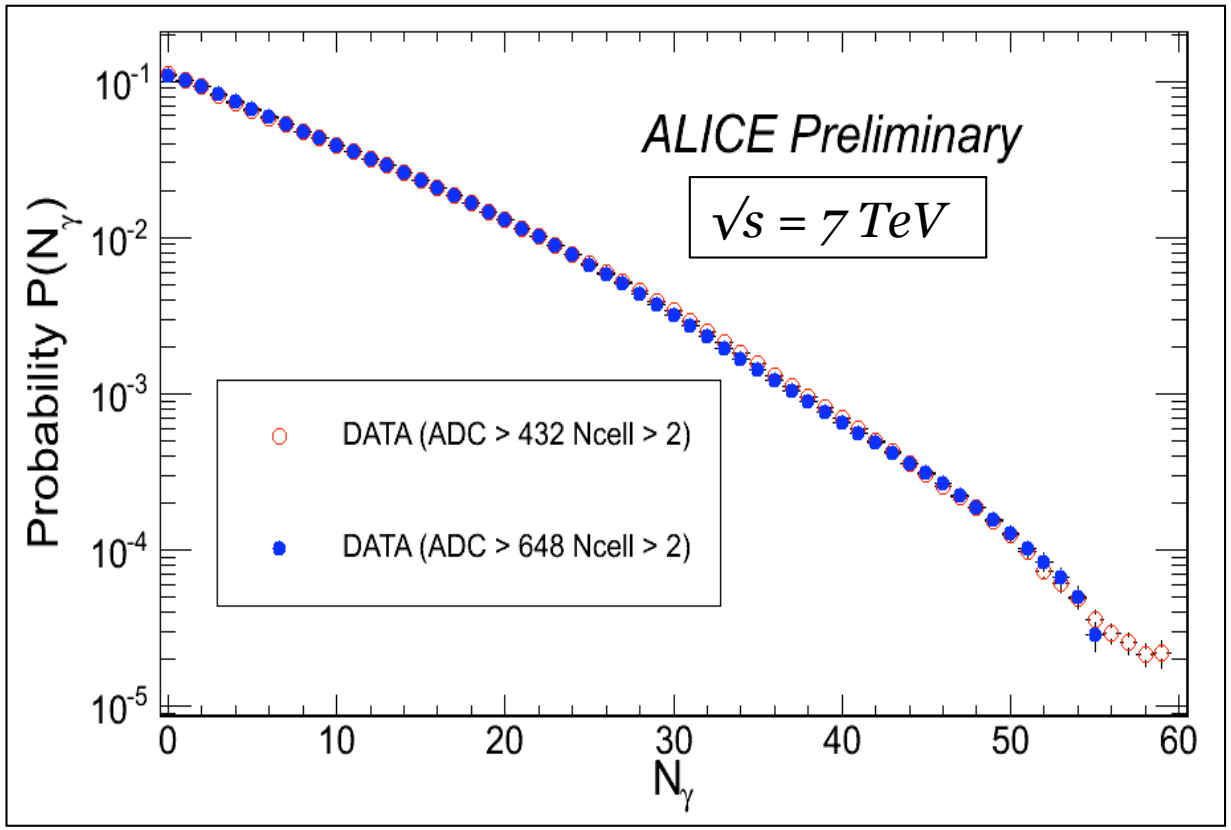


Results

Results and discussion

- *Thresholds applied for photon-hadron discrimination:*
  - *Cluster ADC > 432 and cluster ncell > 2*
  - *Cluster ADC > 648 and cluster ncell > 2*
- *Detector response is reconstructed using Phojet event generator*

Photon multiplicity within 2.3 < η < 3.9 (data from preshower plane of PMD)



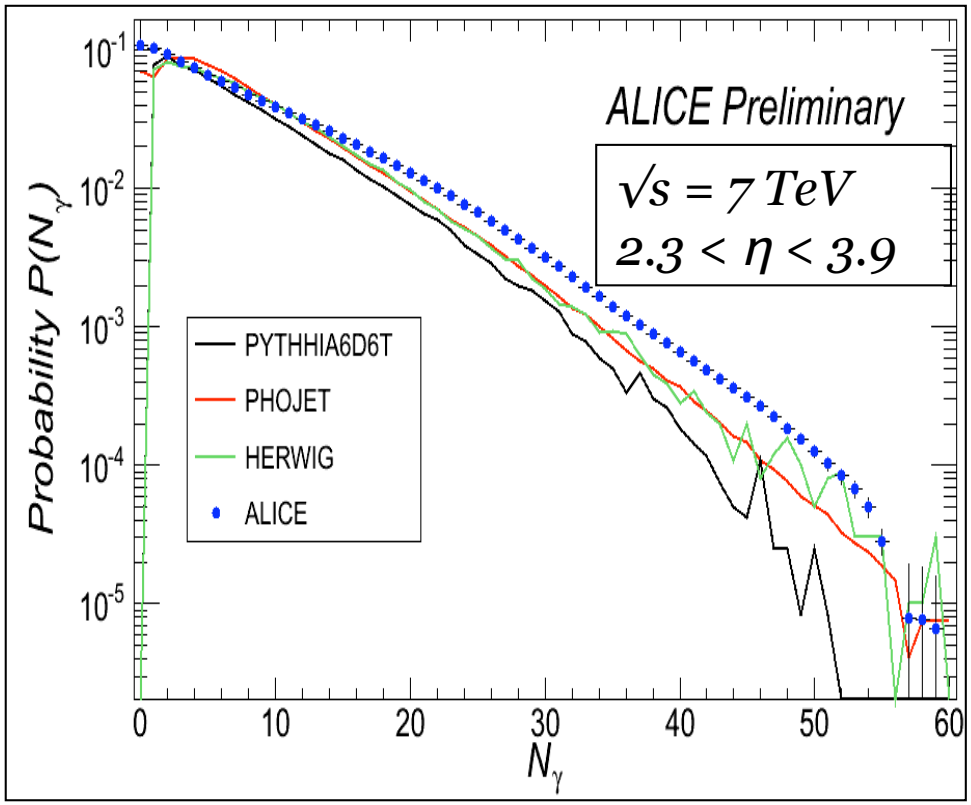
*432 ADC ≅ 6 MPV**
*648 ADC ≅ 9 MPV**

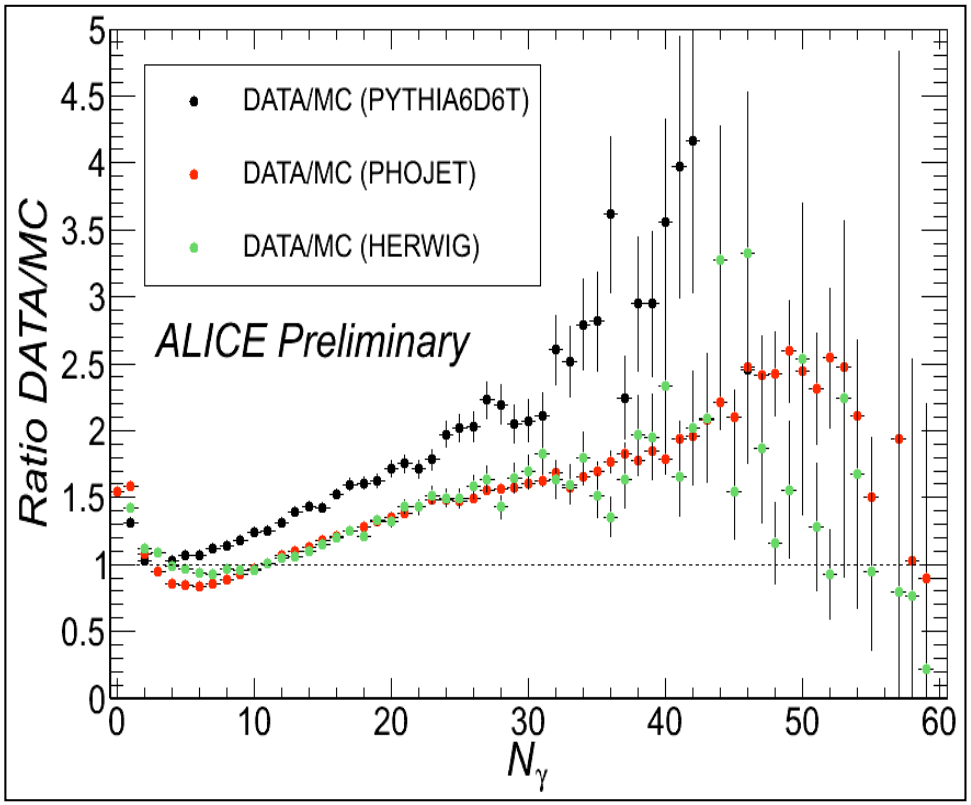
Unfolded distribution is same for different threshold at cluster level.

Systematic errors to be estimated

**Most probable value of the MIP spectra*

Photon multiplicity distribution

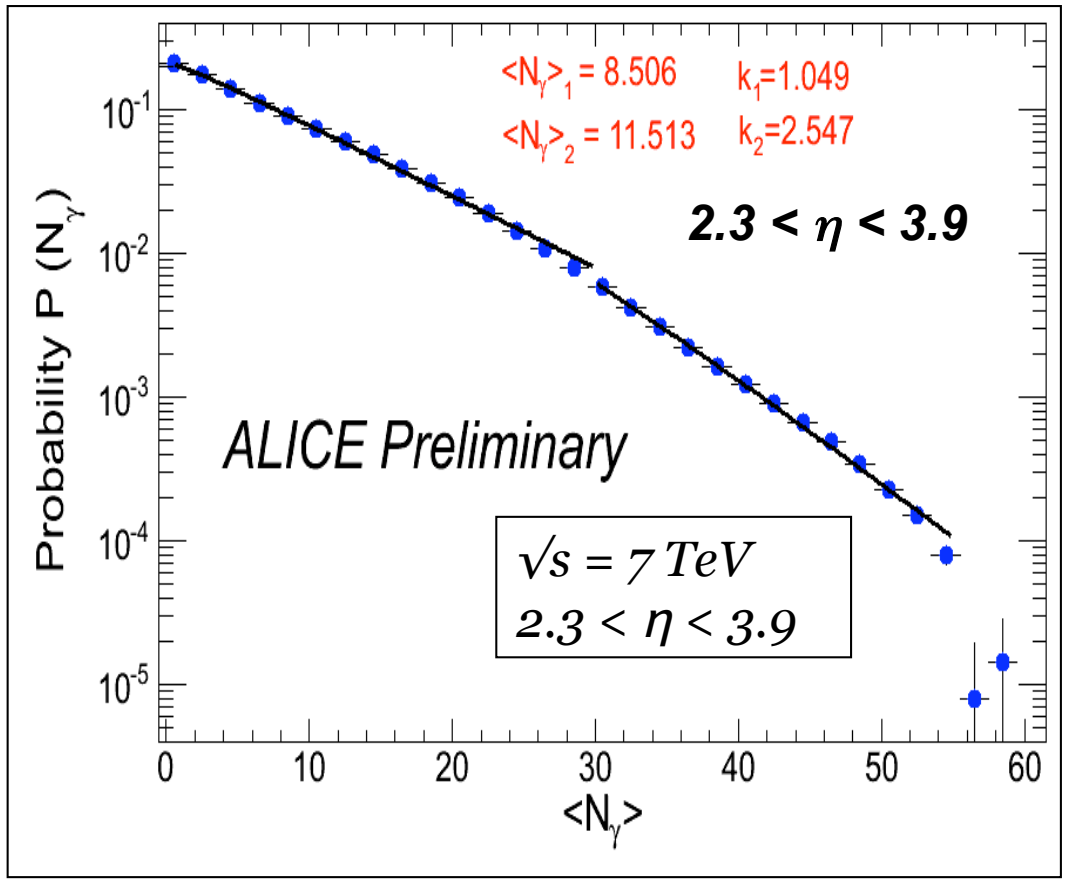




Multiplicity distribution compared to three models: Pythia, Phojet, and Herwig.

All the models under predict the photon multiplicity at high multiplicity at forward rapidities in pp collisions at LHC energy.

Multiplicity distribution and NBD



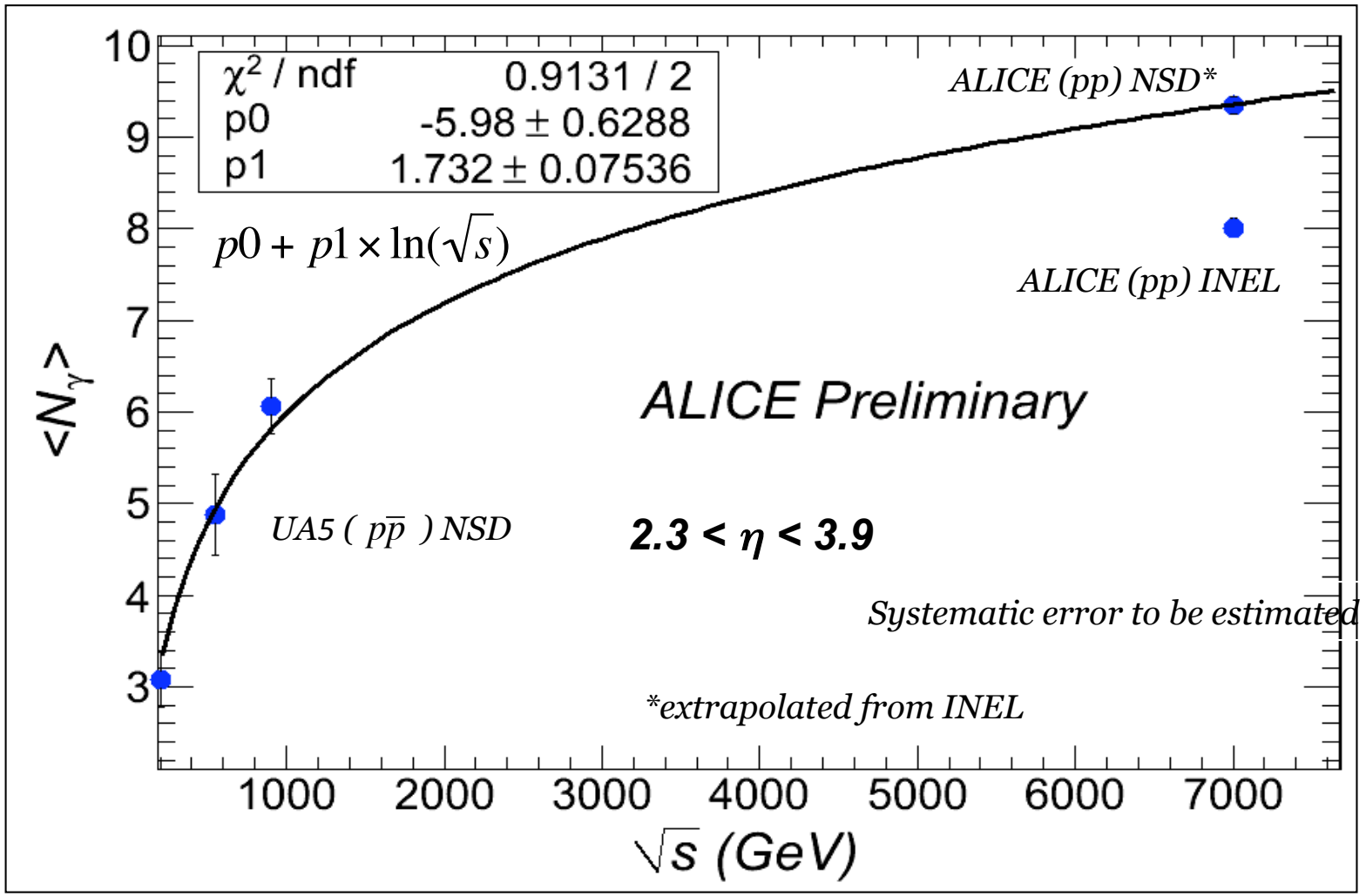
Multiplicity distribution described by a double NBD function

1/k =>0: Poissionian distribution
k=>1: Geometric distribution

Systematic error to be estimated

$$P_{NBD}(< N_\gamma >, k; n) = \frac{\Gamma(n+k)}{\Gamma(n+1)\Gamma(k)} \times \frac{(< N_\gamma > / k)^n}{(< N_\gamma > / k + 1)^{n+k}}$$

Energy dependence of photon multiplicity at forward rapidity



Average photon multiplicity in pp collisions for 2.3 < η < 3.9, increases with increase in √s as ln(√s).

Summary

◆ *First measurement of photon multiplicity distribution at forward rapidities in pp collisions for √s = 7 TeV presented.*

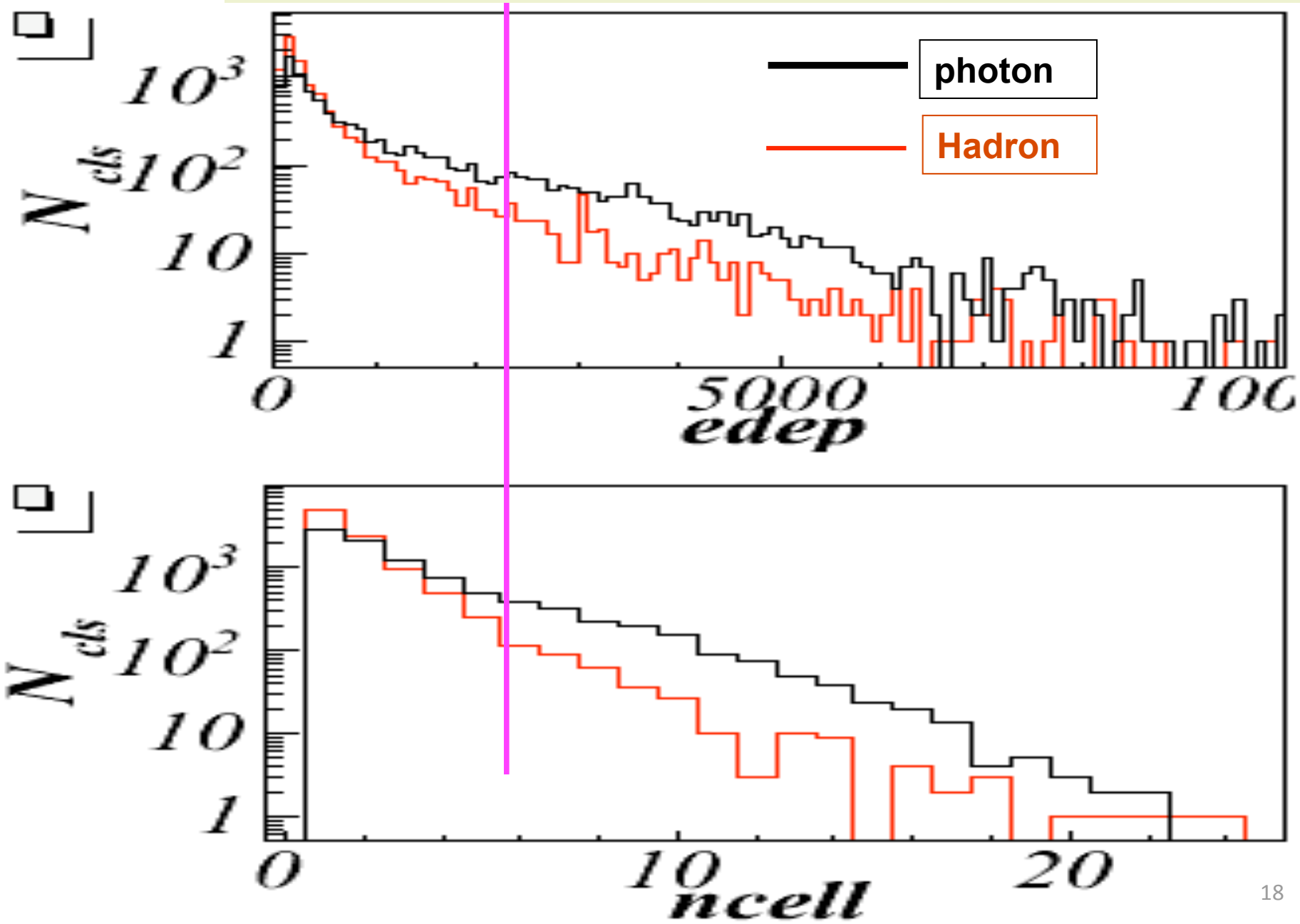
◆ *Multiplicity distributions are compared to various models for particle production: Pythia, Phojet, and Herwig. All models under predict the multiplicity distribution at higher multiplicity.*

◆*Multiplicity distribution is reasonably well described by a double NBD.*

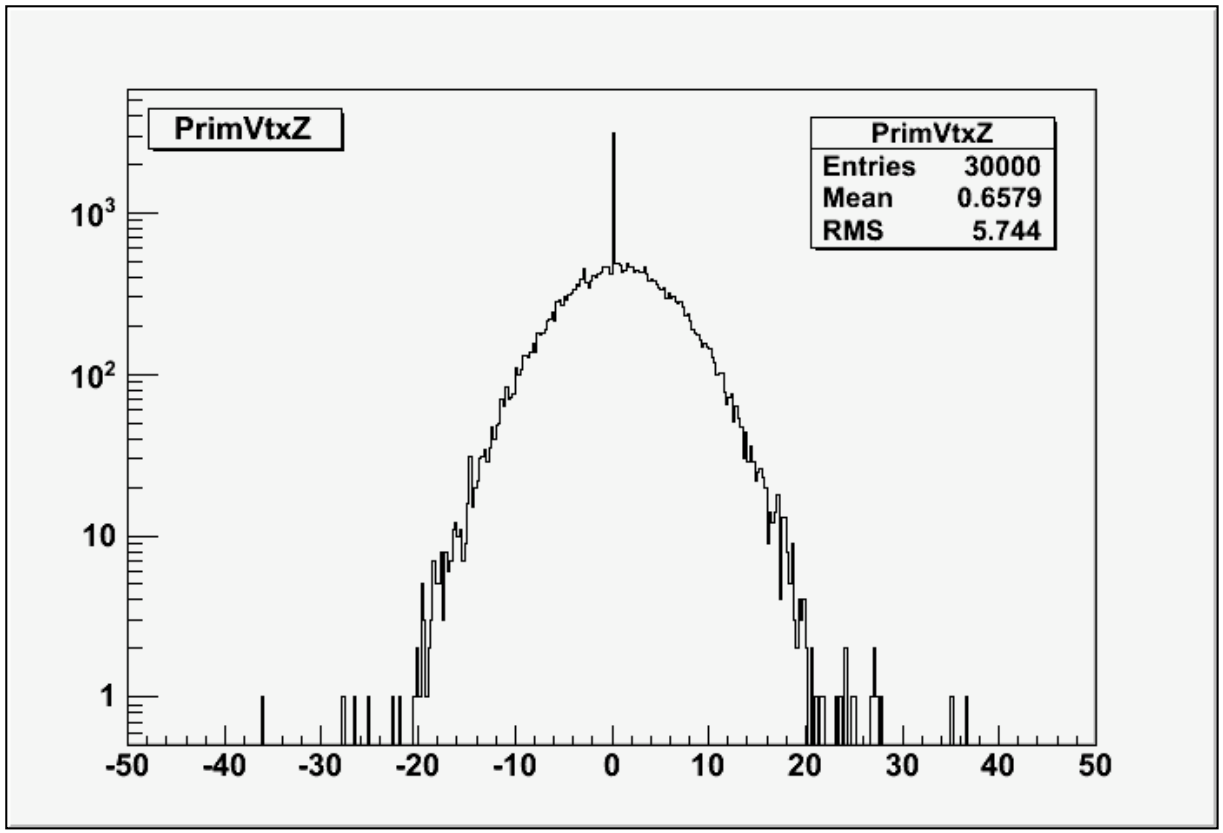
◆ *Average photon multiplicity is observed to increase, with increase in √s as ln(√s) at forward rapidity (2.3 < η < 3.9).*

Backup slides

Photon and hadron clusters has **significantly** different adc and no of cells



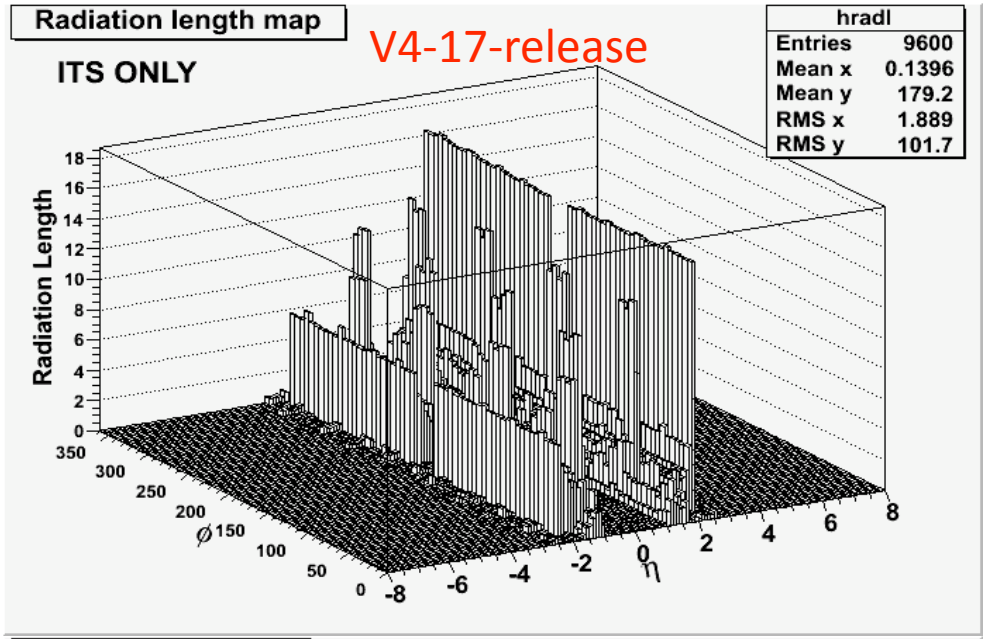
Vertex-Z distribution

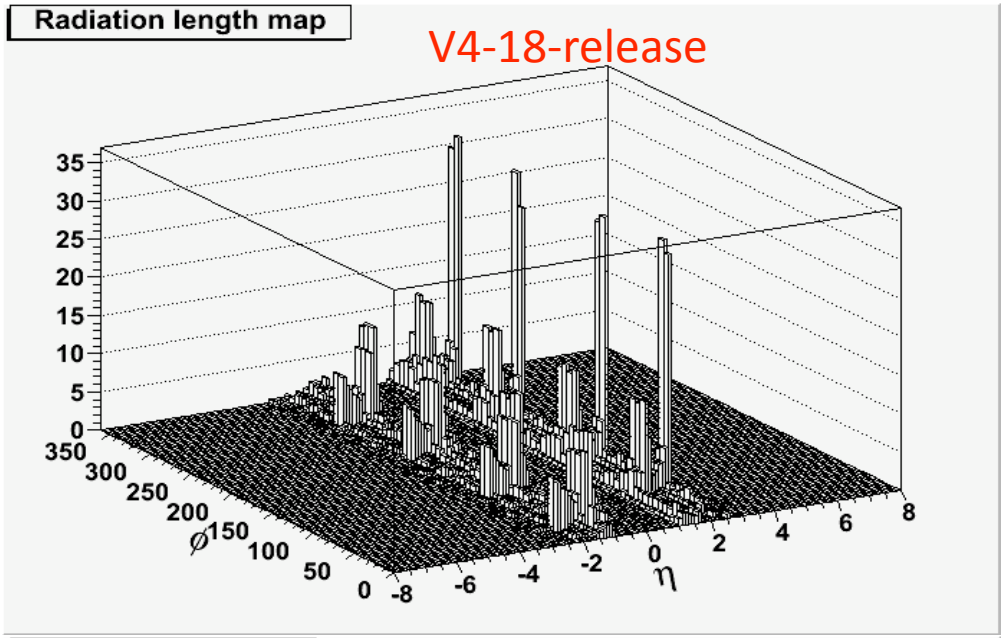


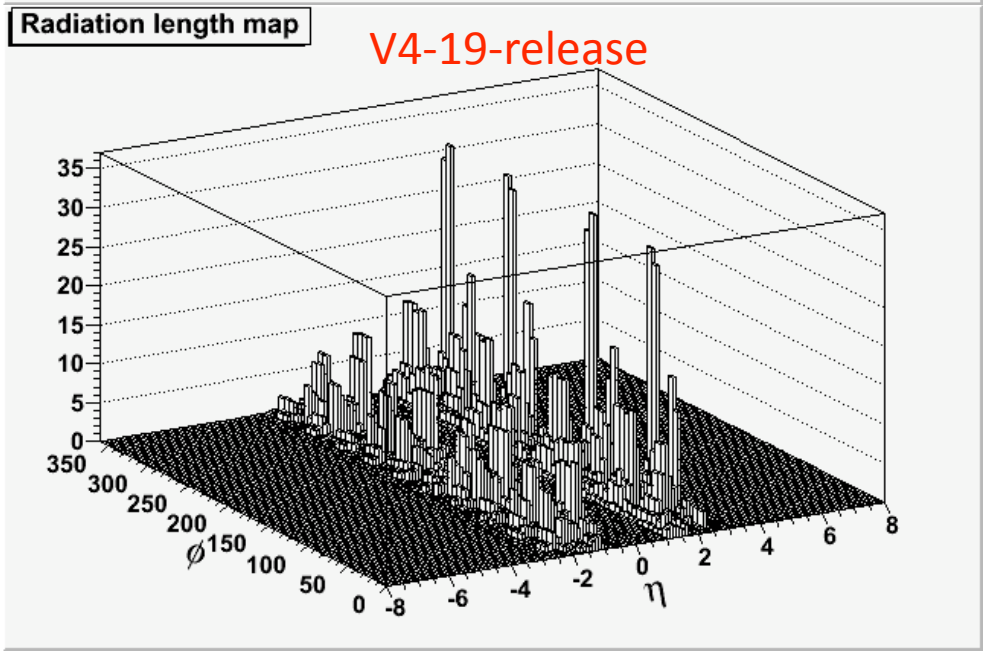
Upstream material

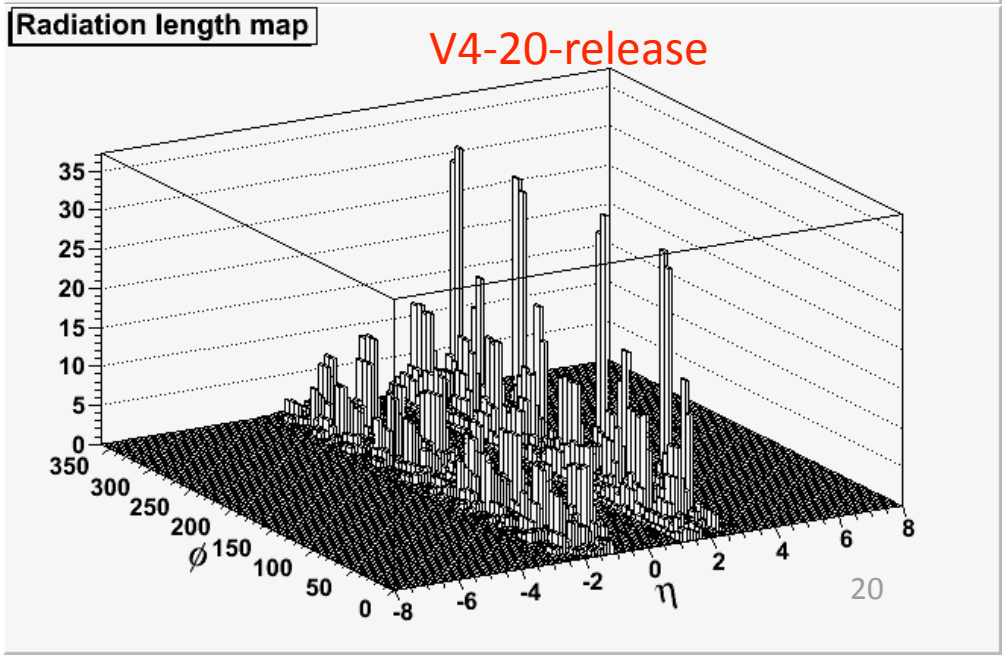
η bin = 0.1
Φ bin = 6 degree
Z = 320 cm

ITS only

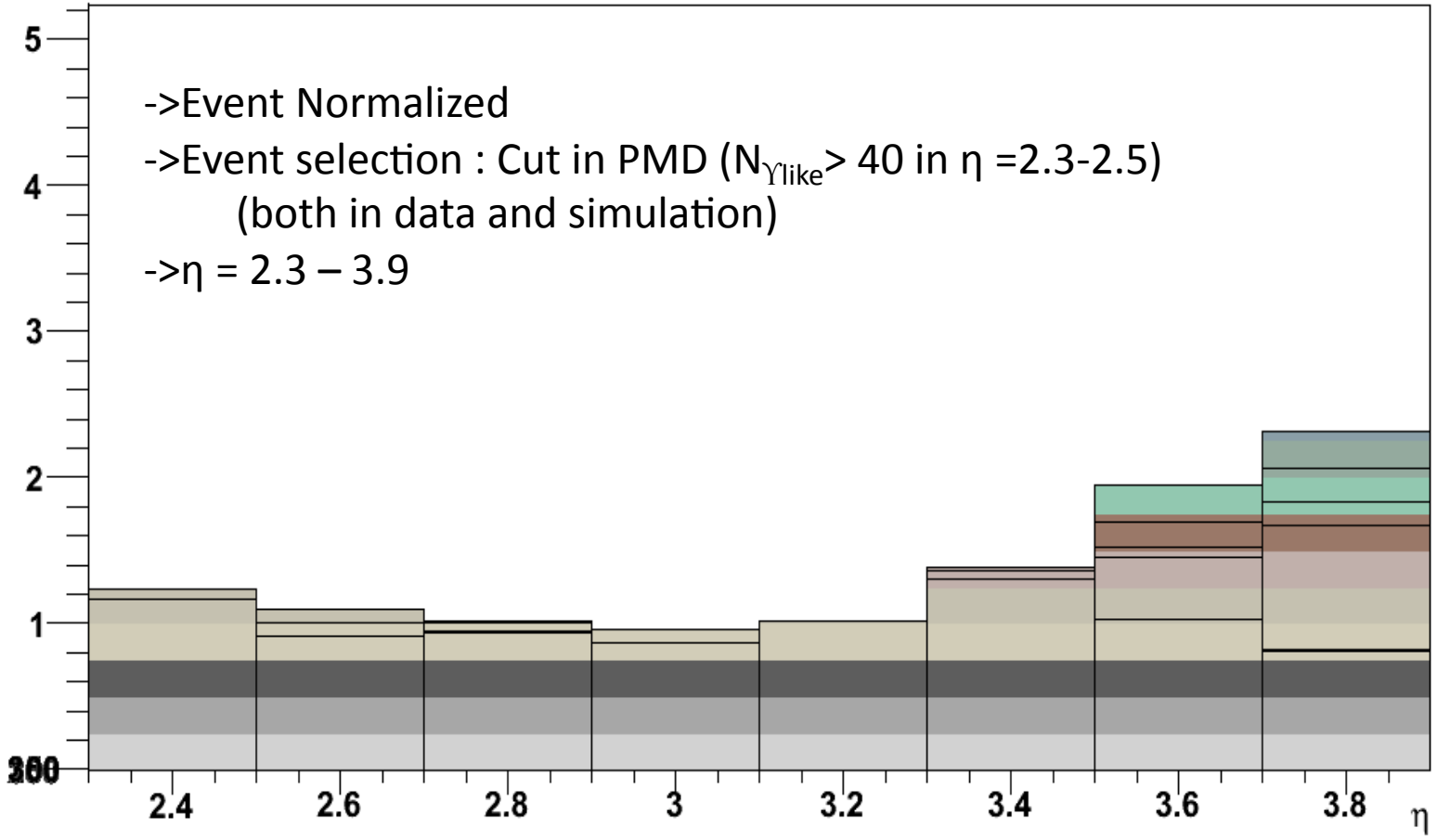




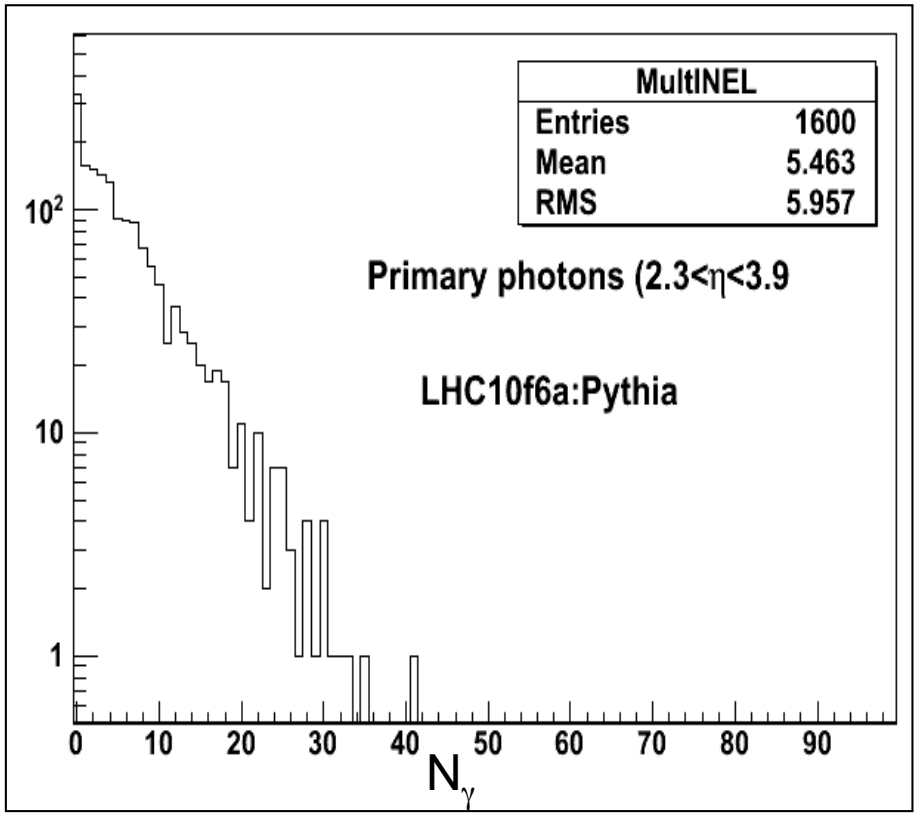


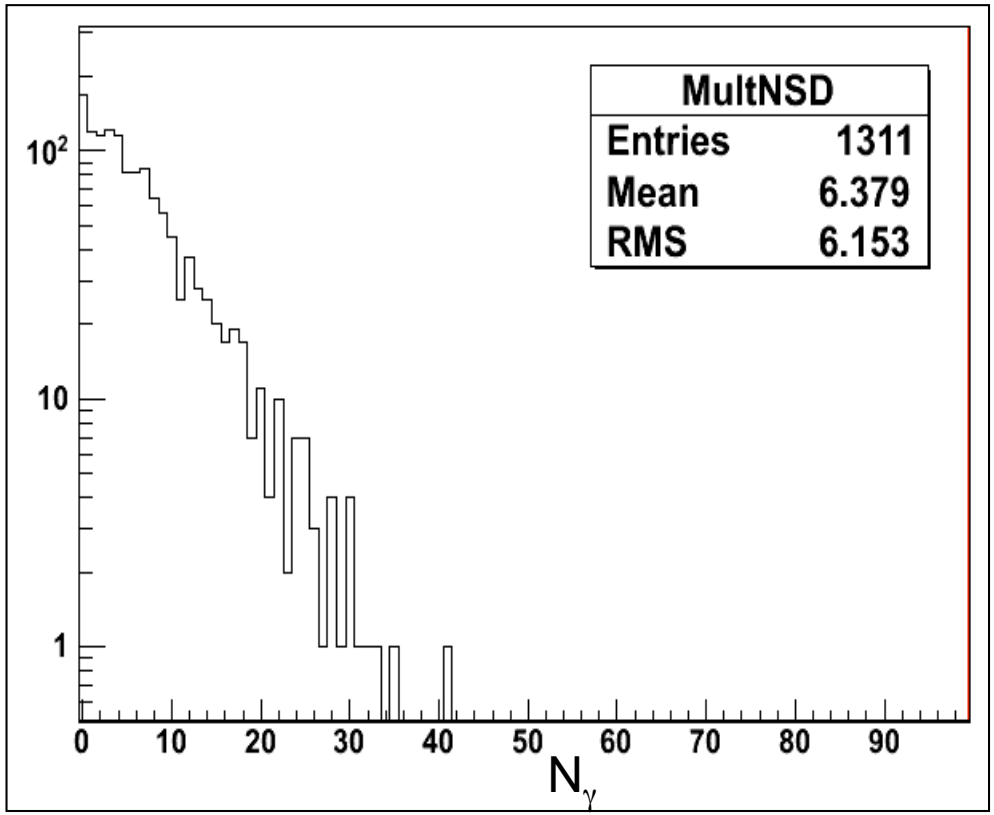


Occupancy-Data/Occupancy-MC

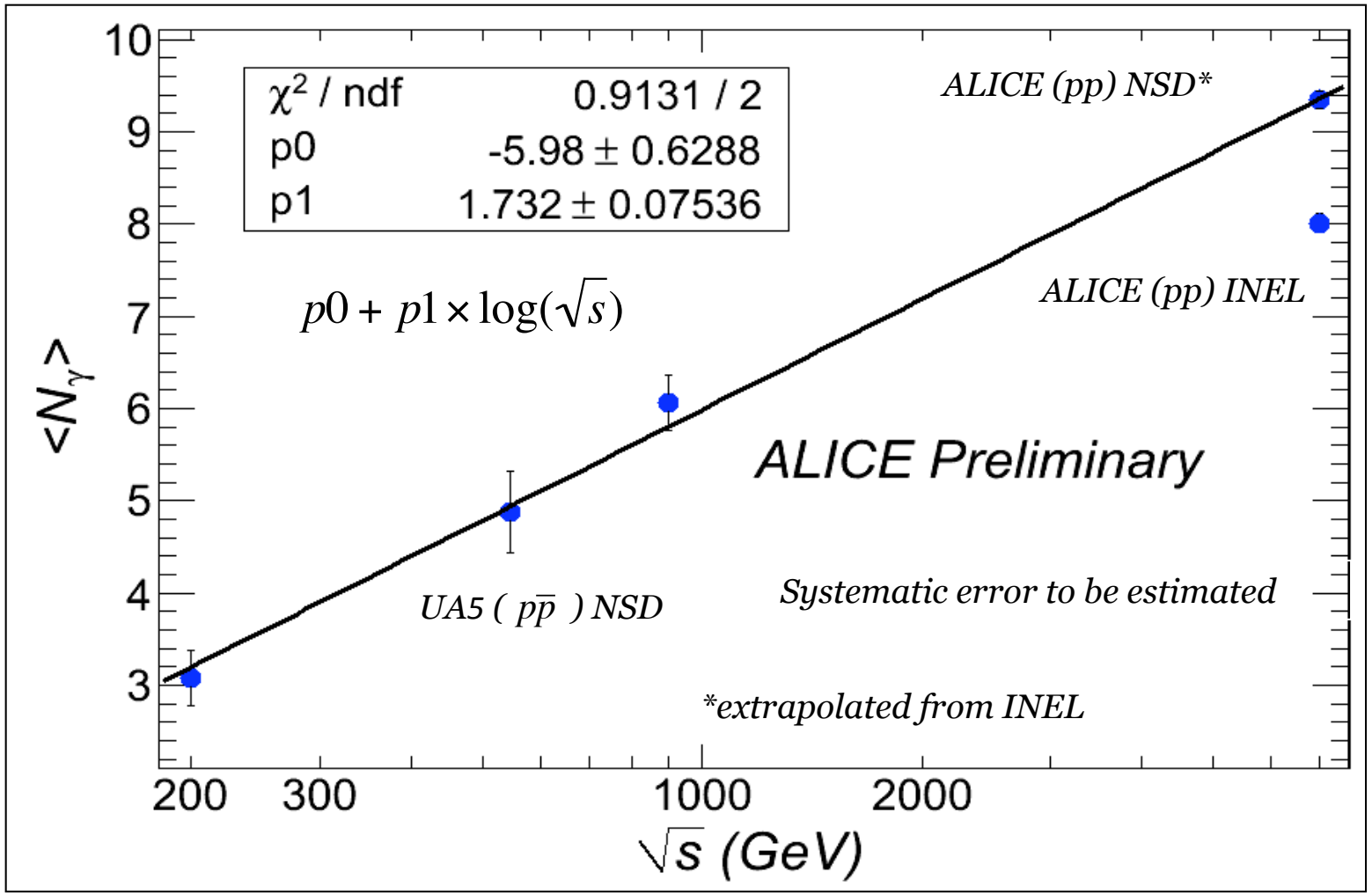


Primary photons from INEL and NSD (2.3 < η < 3.6)



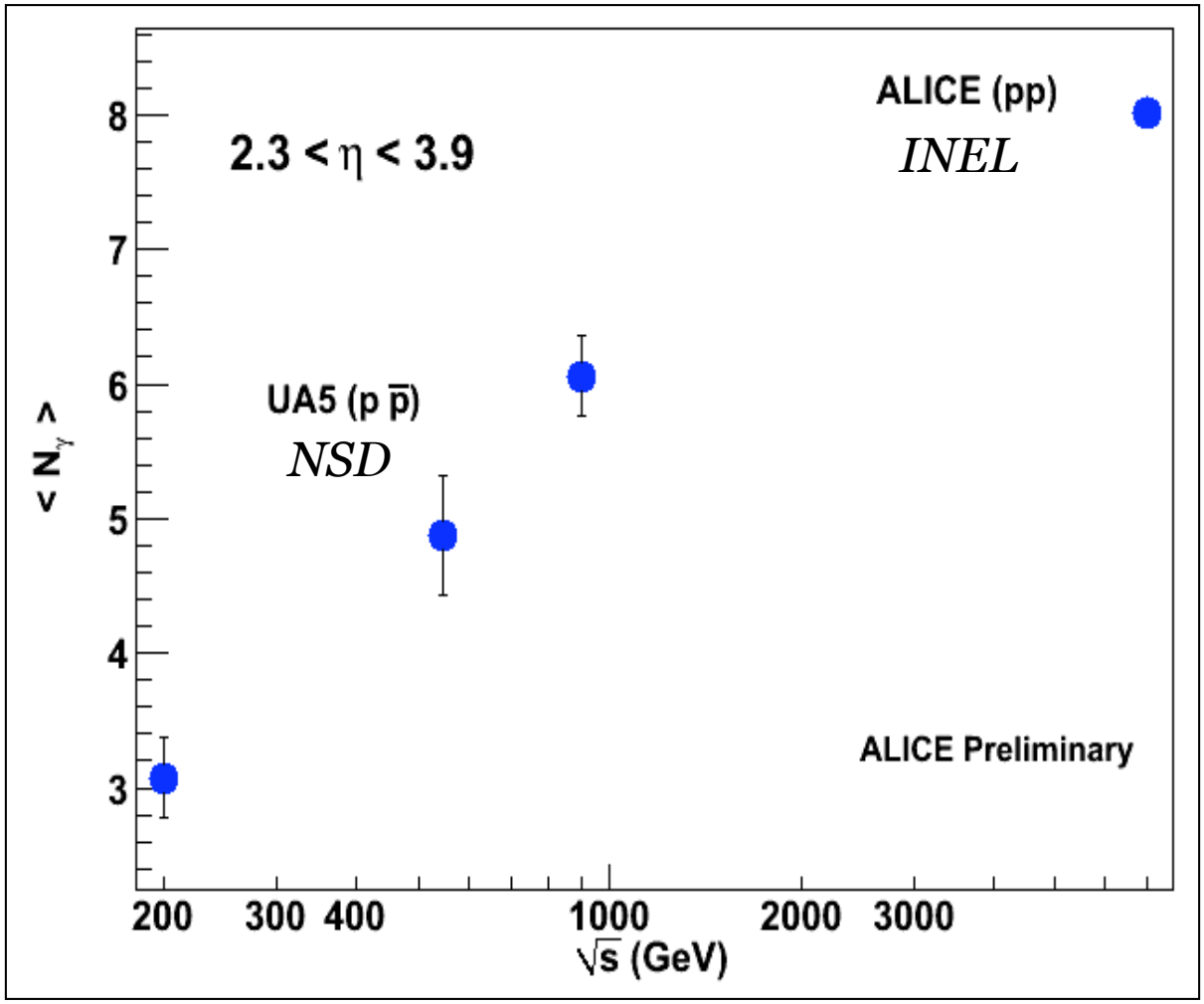


Energy dependence of photon multiplicity at forward rapidity



Average photon multiplicity in pp collisions for 2.3 < η < 3.9, increases with increase in √s as 'a+b×ln(√s)'.

Energy dependence of photon multiplicity at forward rapidity



Average photon multiplicity in pp collisions for $2.3 < \eta < 3.9$ increases with increase in $\sqrt{s}$

Systematic error to be estimated