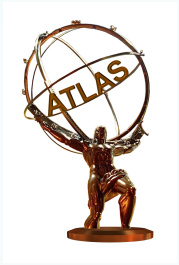


Charged particle multiplicity and correlations in heavy ion collisions in the ATLAS experiment

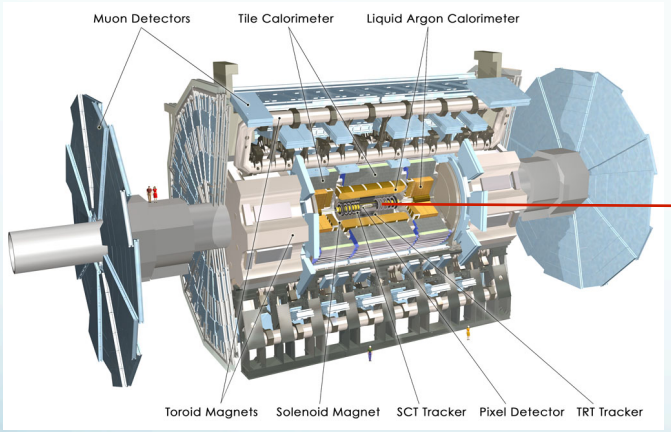
B.Żabiński IFJ PAN, Kraków
for the ATLAS Collaboration

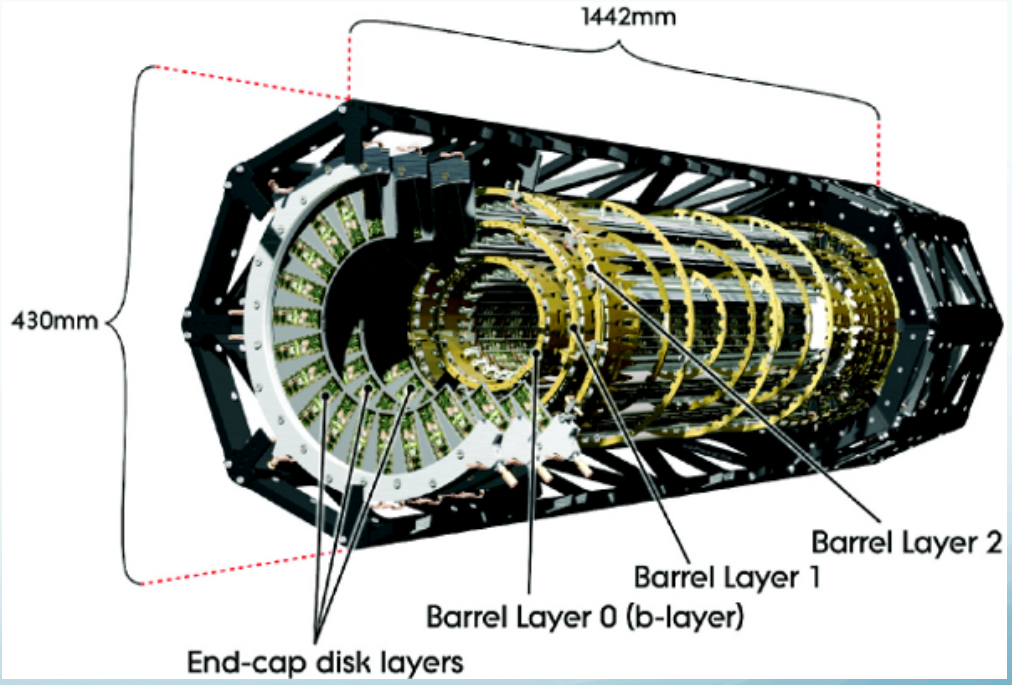
Outline:

- Charged particle multiplicity in PbPb collisions
- Azimuthal correlations in pPb collisions
- Summary

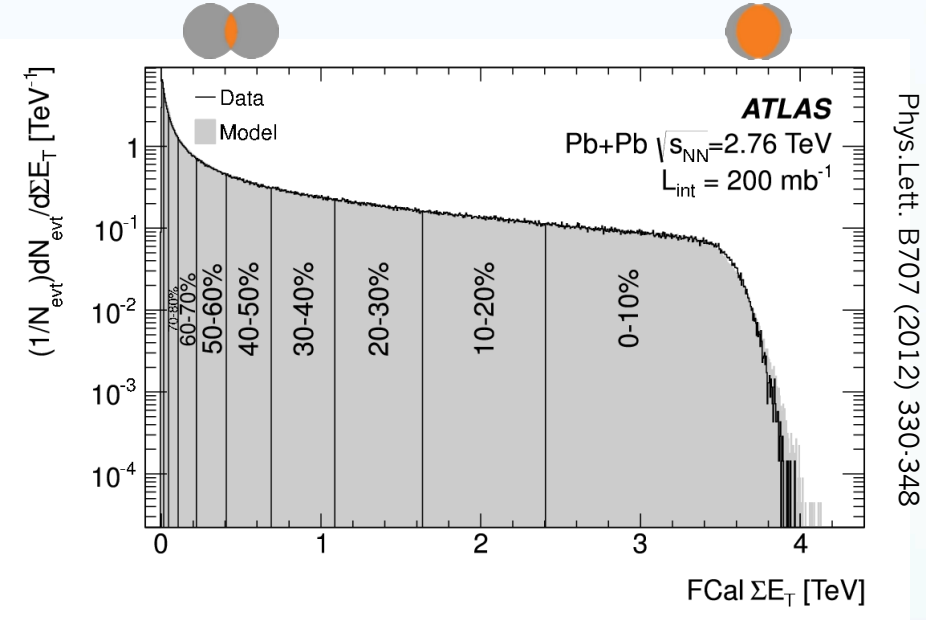
Pixel Detector

1. Tracking device, very close to the beam pipe (50.5 mm)
2. Consist of 3 layers in barrel and 6 disk in end caps
3. 1744 modules with over $80*10^{6}$ pixels (one pixel has 50x 400 μm^2)
4. 2T magnetic field





Centrality of PbPb collisions

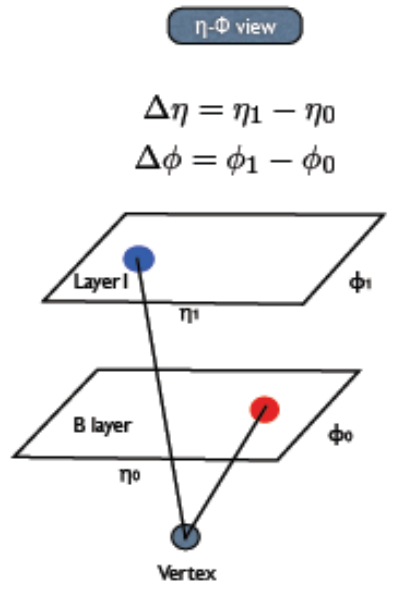


Centrality determination from deposit energy in Forward Calorimeter (FCal) covering $3.2<|\eta|<4.9$ - outside of tracking devices acceptance.

Multiplicity reconstruction

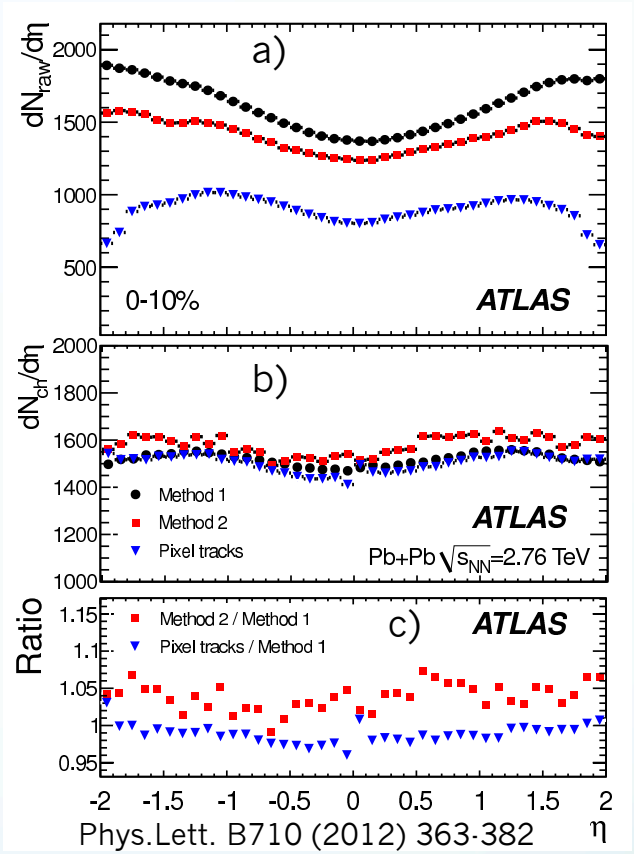
Tracklet – with to hits:
- 1st in the innermost layer (B layer)
- 2nd in one of the following layers

compatible with the event vertex.



$$\sqrt{\left(\frac{\Delta\eta}{\sigma_{\Delta\eta}}\right)^2 + \left(\frac{\Delta\phi}{\sigma_{\Delta\phi}}\right)^2} < 3 * \sqrt{2}$$

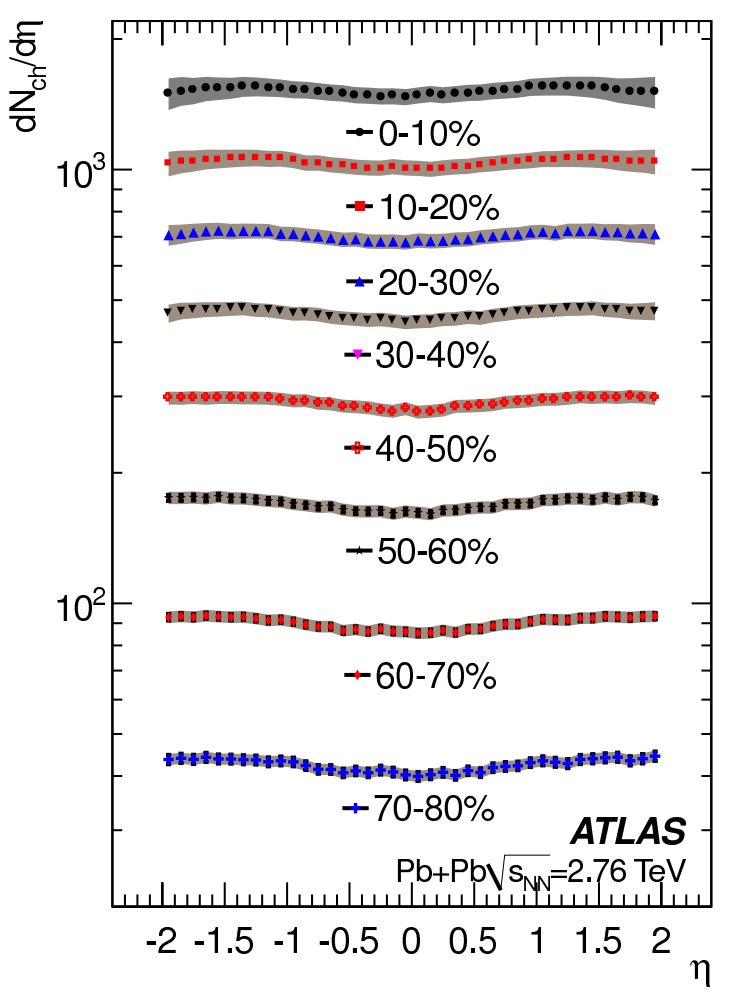
No magnetic field in this analysis
Minimal p_T = 30 MeV



Pixel tracks – standard method to reconstruct track, restricted to the pixel detector

a) Uncorrected charged particle density as a function of η in most centrality region.
b) Corrected charged particle density.
c) Ratio of tracklet method 1 to method 2 and pixel track method to method 1 of tracklets.

Multiplicity in PbPb collisions

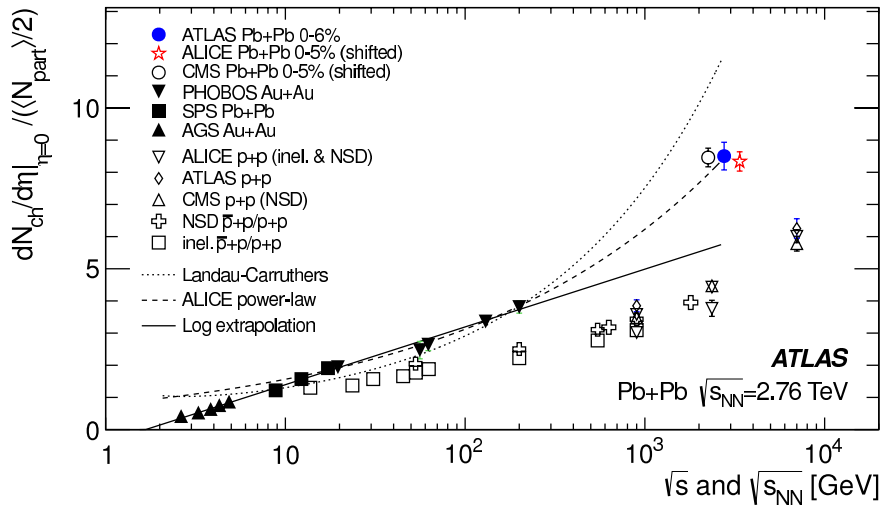


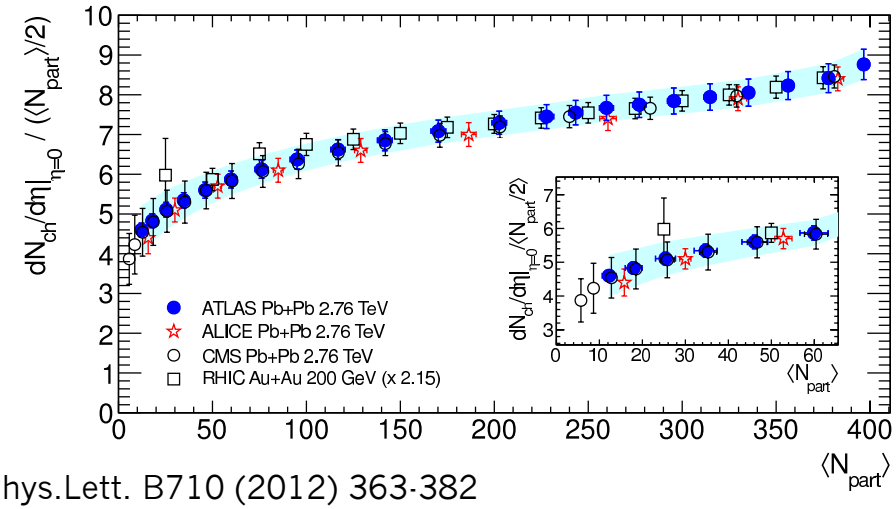
Corrected charged particle multiplicity as a function of η for eight centrality classes.

- Approximately flat in pseudorapidity
- Increase with centrality
- Maximal charged particle density for central events = 1746 ($|\eta|<0.5$)

Phys.Lett. B710 (2012) 363-382

Multiplicity in PbPb collisions





Phys.Lett. B710 (2012) 363-382

Charged particle multiplicity per a pair of participants at $\eta = 0$ as a function of center of mass energy per nucleons.

Increase of multiplicity faster than logarithmic

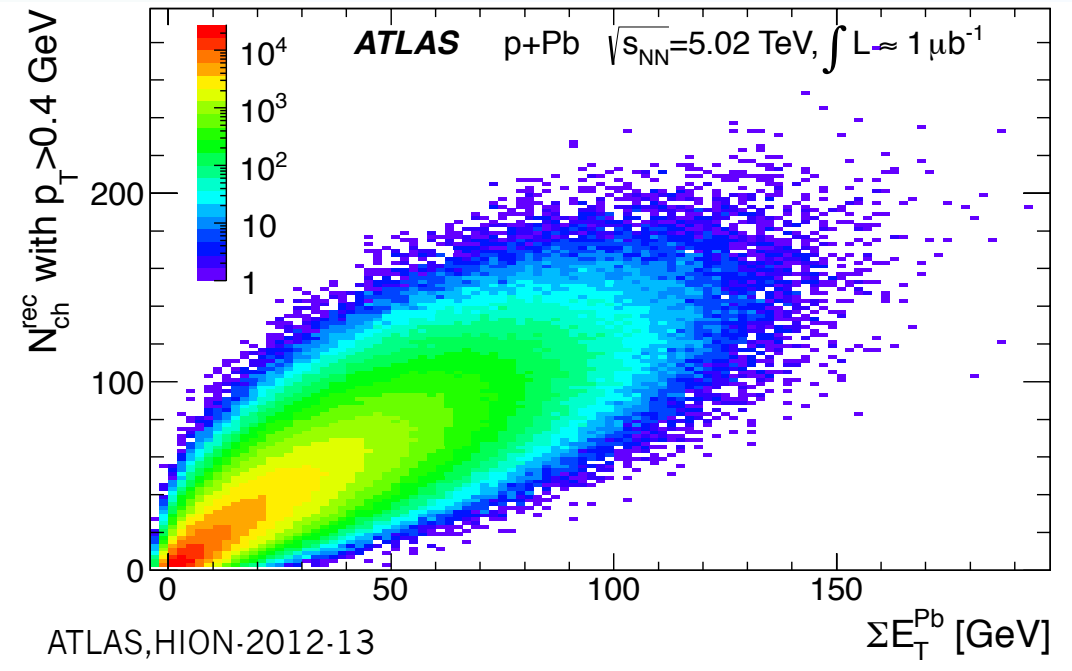
Charged particle pseudorapidity density per a pair of number participants as a function $\langle N_{part} \rangle$.

Centrality dependence consistent with scaled RHIC results.

New results for pPb collisions

In September 2012 LHC was colliding proton with lead nuclei at $\sqrt{s_{NN}} = 5.02$ TeV with low pileup (below 0.1%). ATLAS has collected about 2 milions good events.

Centrality in pPb

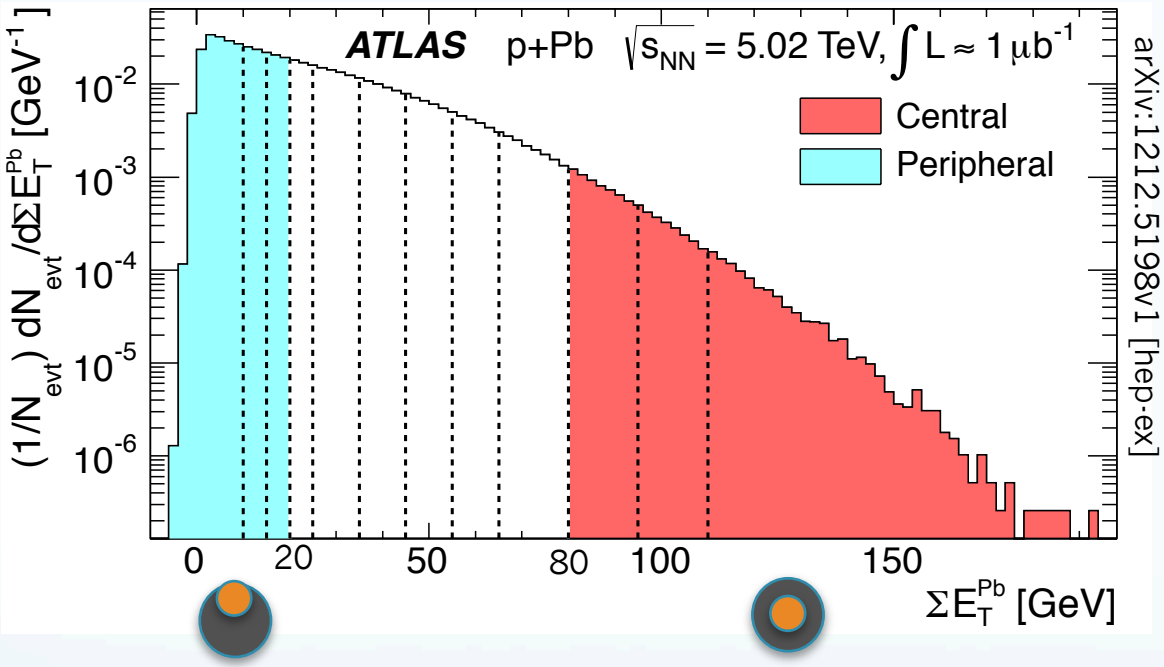


CMS, ALICE – selection of events according to multiplicity.

ATLAS – selection based on $\sum E_T^{Pb}$

Centrality selection is based on FCal energy on Pb side, which is correlated with number of measured particles. Direct systematic effects appear when the same tracks are used in correlations studies.

Centrality in pPb

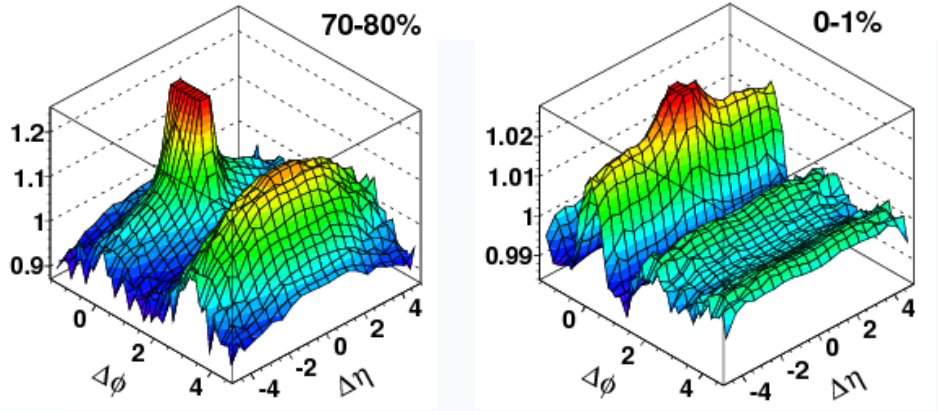


Distribution of E_T measured in the Forward Calorimeter on Pb side ($3.1 < \eta < 4.9$)

Two particle correlations in pPb collisions

PbPb

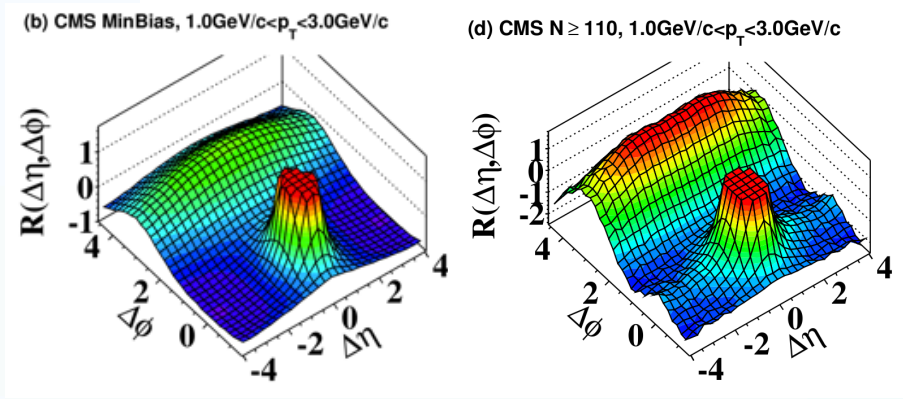
complicated correlations interpreted as flow



arxiv 1212.2001v1 [nucl-ex]

pp

long-range correlations - "ridge"



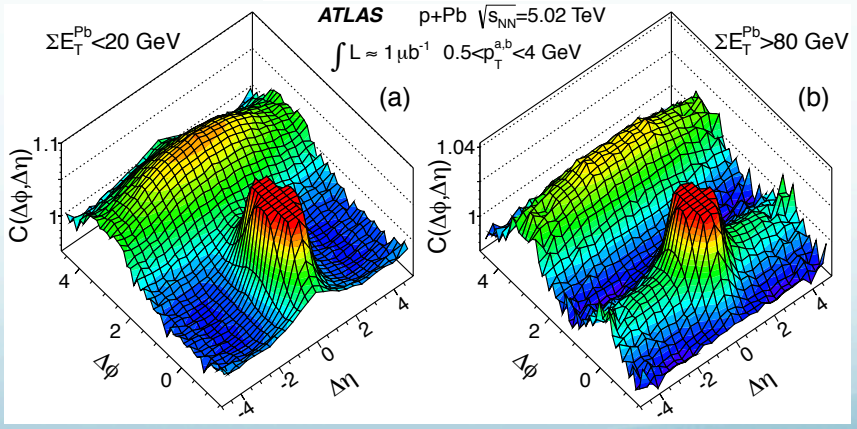
CMS, JHEP09 (2012) 091

$$C(\Delta\phi,\Delta\eta) = \frac{S(\Delta\phi,\Delta\eta)}{B(\Delta\phi,\Delta\eta)}$$

Signal: pairs from one event

Background: pairs from different events

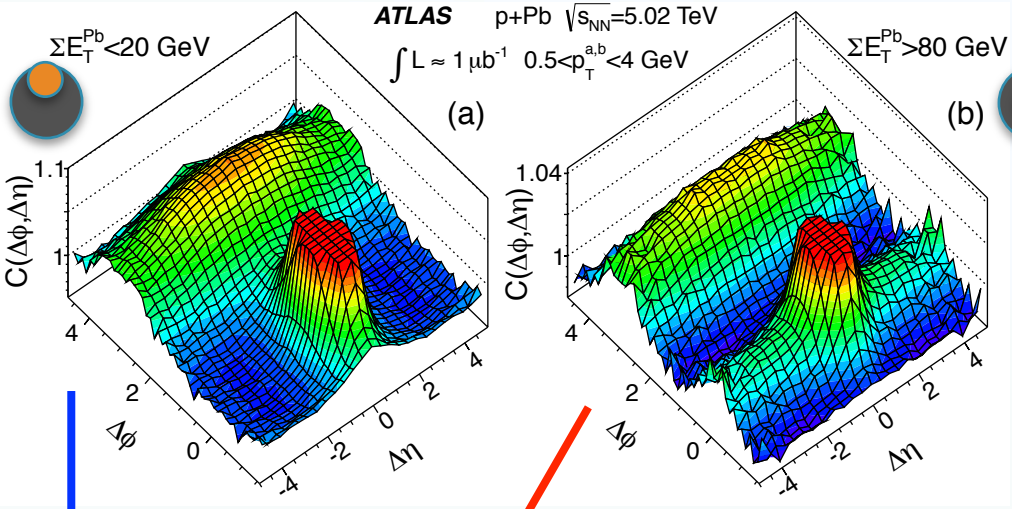
pPb

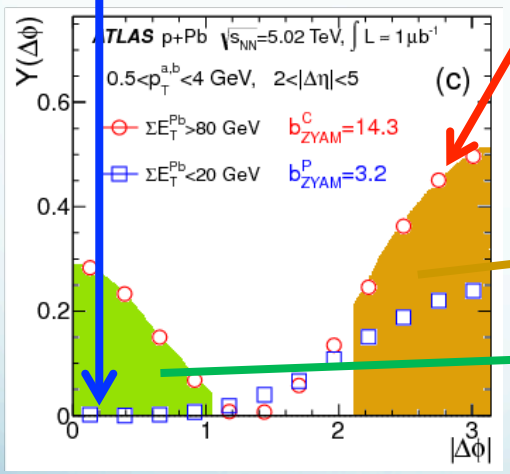


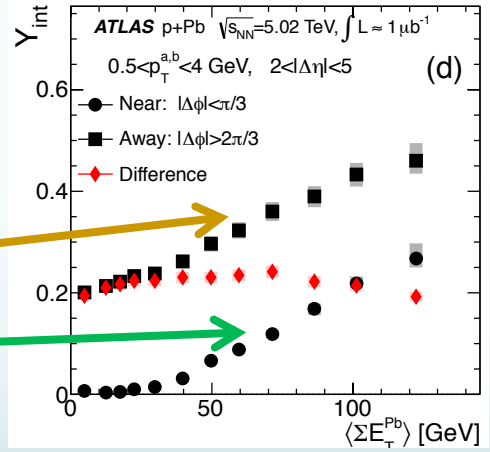
arXiv:1212.5198v2 [hep-ex]

in central pPb collisions ridge is also present new analysis of the ridge components

Two particle correlations in pPb collisions







arXiv:1212.5198v1 [hep-ex]

Integrated Y in near and away range as a function of $\sum E_T$

per-trigger yield

$$Y(\Delta\phi) = \left(\frac{\int B(\Delta\phi) d\Delta\phi}{\pi N_a} \right) C(\Delta\phi) - b_{ZYAM}$$

N_a – total number of trigger particles
b_{ZYAM} – determinated by zero-yield-at-minimum method

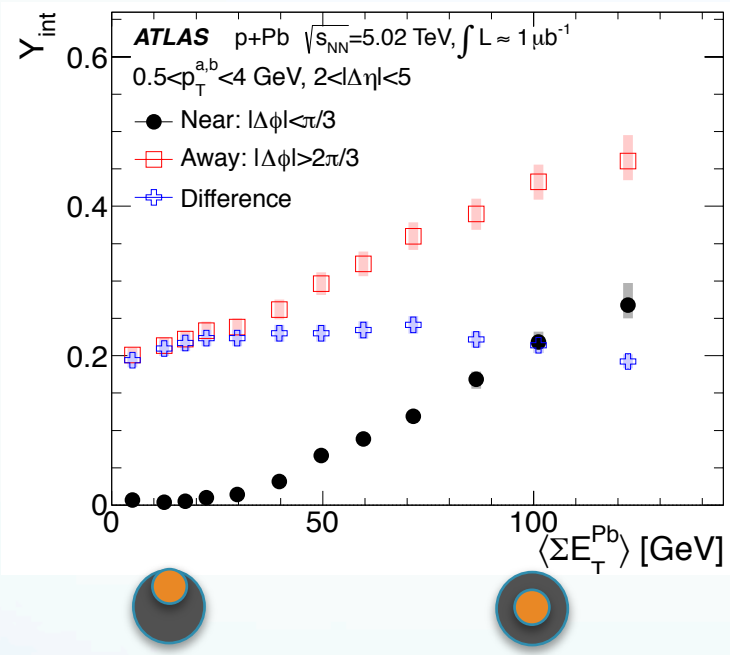
$$Y_{\text{int}} = \int Y(\Delta\phi) d(\Delta\phi)$$

Y_{int} increase in similar way with centrality

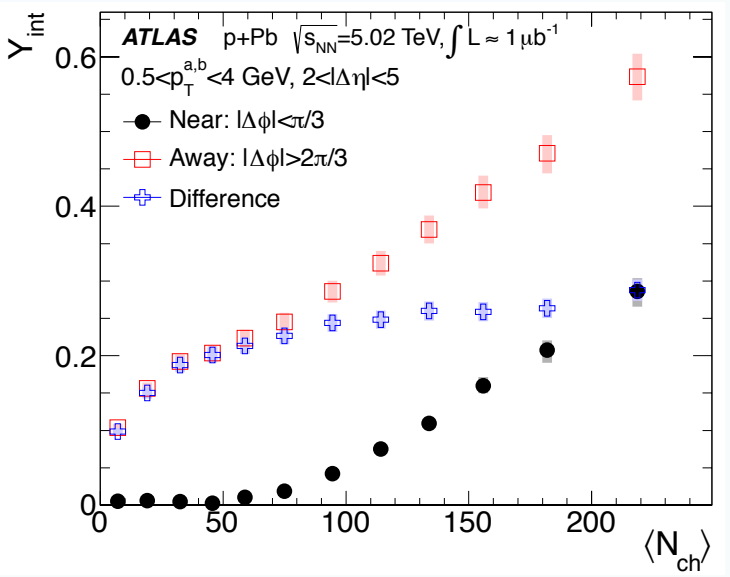
Difference is approximately constant.

Two particle correlations in pPb collisions

FCal signal dependence



Multiplicity dependence

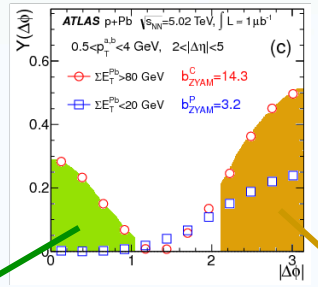


ATLAS,HION-2012-13

Integrated per-trigger yield as a function of FCal energy (left) and as o function charged particle multiplicity (right).

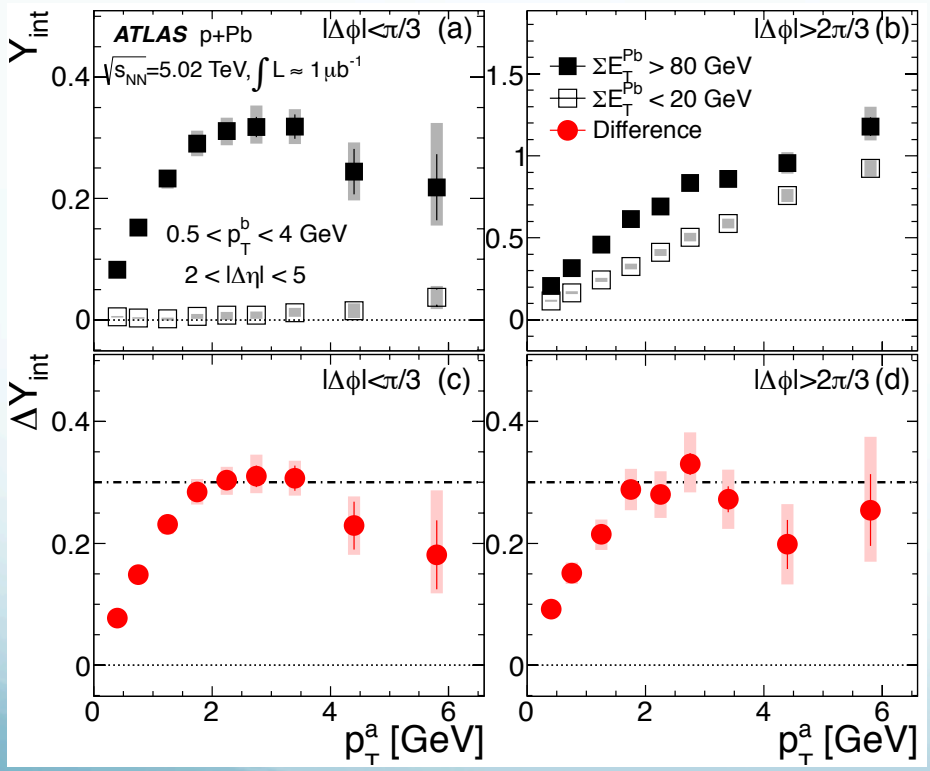
Centrality defined using FCal energy allows to avoid systematic effects present in the samples with fixed multiplicity.

Two particle correlations in pPb collisions



Near side

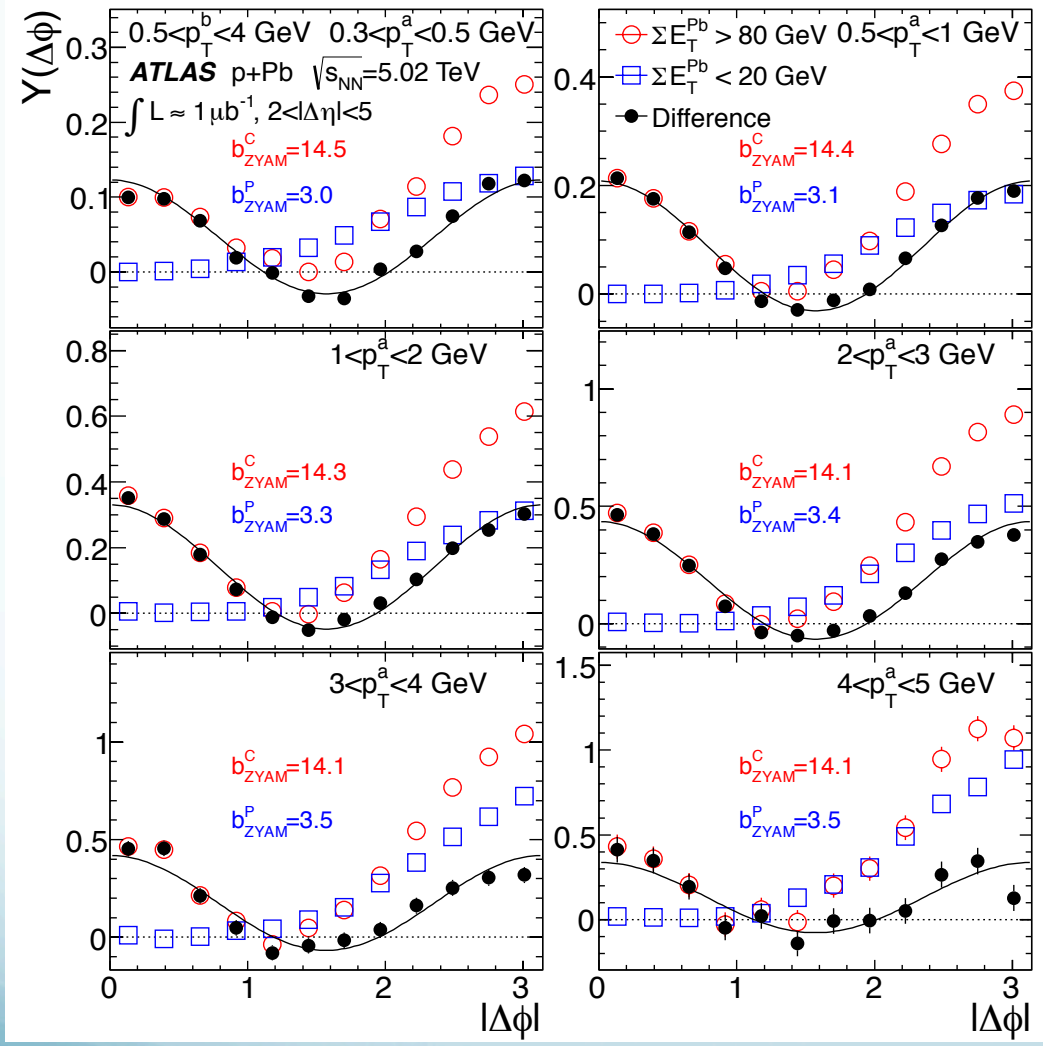
Away side



Differences between yields for central and peripheral events in near side and away side are very similar.

arXiv:1212.5198v1 [hep-ex]

Two particle correlations in pPb collisions



arXiv:1212.5198v1 [hep-ex]

Per-trigger yield in several p_T ranges. The difference between yields for central and peripheral events is consistent with $\cos(2\Delta\phi)$ modulation:

$$a_0 + 2a_2 \cos 2\Delta\phi$$

where:

$$a_0 = \langle \Delta Y(\Delta\phi) \rangle$$

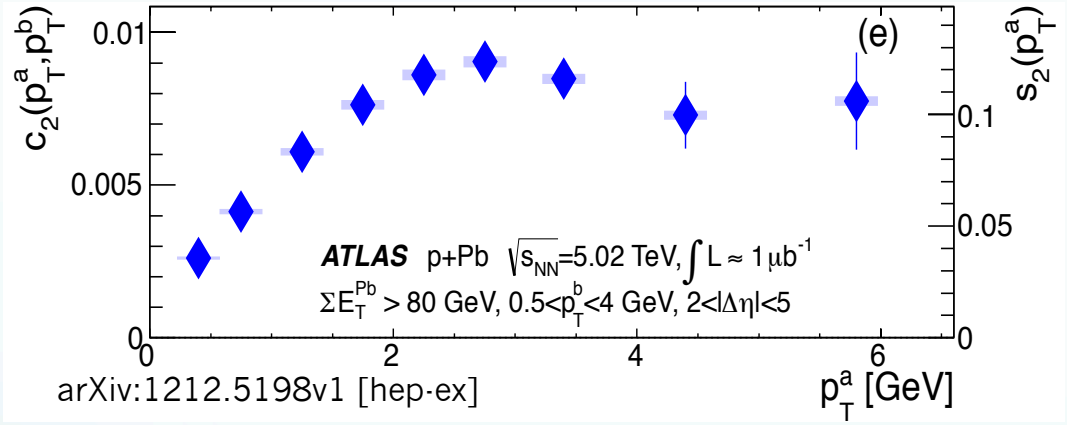
$$a_2 = \langle \Delta Y(\Delta\phi) \cos 2\Delta\phi \rangle$$

The same type of modulation in all p_T intervals.

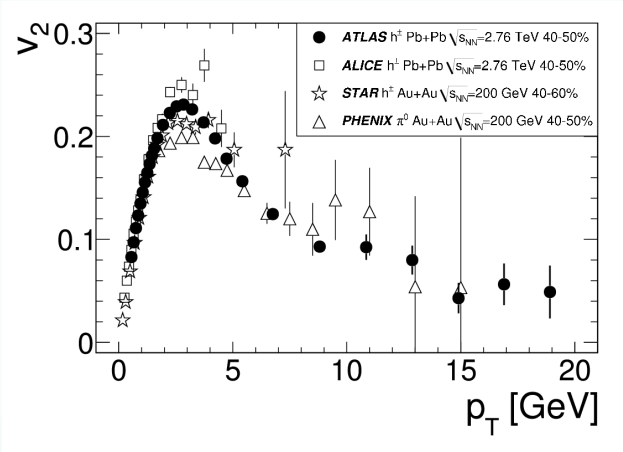
Two particle correlations in pPb collisions

Normalized amplitude of the $\cos(2\Delta\phi)$ modulation of $\Delta Y(\Delta\phi)$: $c_2 = \frac{a_2}{b_{ZYAM}}$

single particle $\cos 2\Delta\phi$ modulation s_2: $s_2\left(p_T^a\right) = c_2(p_T^a, p_T^b) / \sqrt{c_2(p_T^b, p_T^b)}$



Calculated c_2 (left axis) and s_2(right axis) values as a function p_T^a. s_2 differs from the c_2 only by a multiplicative factor $1/\sqrt{5.4 \cdot 10^{-3}}$.



ATLAS, Phys. Lett. B707 (2012) 330

The s_2 modulation parameter has similar p_T dependence as elliptic flow in PbPb collisions

Summary

Charged particle multiplicity:

- Measured in a wide pseudorapidity range $|\Delta\eta|<2$ and for particles reconstructed down to very low momenta ($p_T > 30$ MeV)

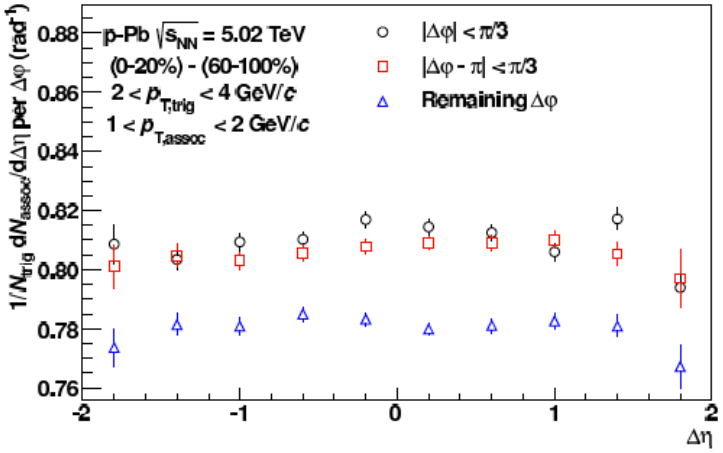
New pPb results:

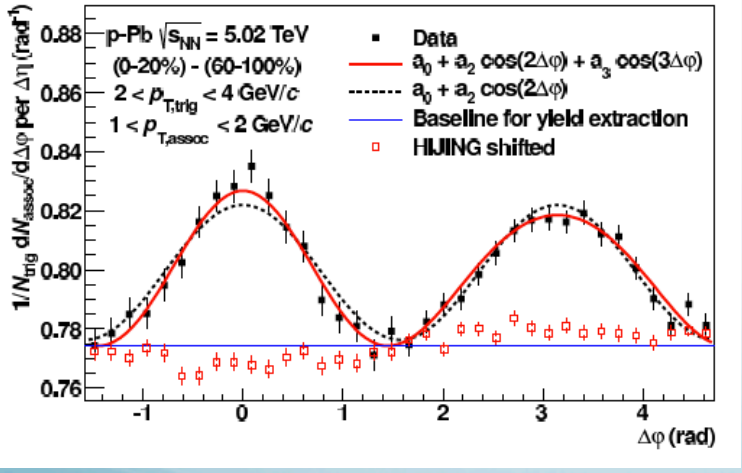
- "ridge" in the central pPb collisions
- $\cos(2\Delta\phi)$ modulation visible after subtracting per-trigger yields for central and peripheral collisions

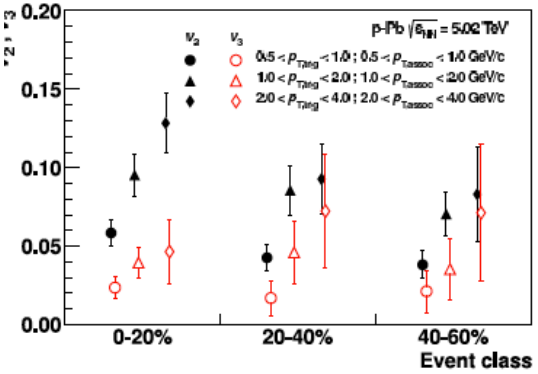
Thank You

BACKUP

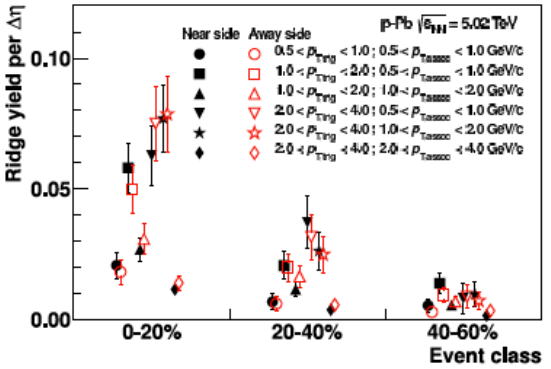
Particle correlations in ALICE experiment







arxiv_1212.2001v1



Correction factors

Final results has been obtained using Monte Carlo correction C(O, η). Correction depend on centrality and pseudorapidity, applied to reconstructed tracks.

For pixel tracking:

$$C_{pt}(\eta) = \frac{1 - b_{pt}^{backg}(\eta)}{\varepsilon_{pt}(\eta)}$$

$$\varepsilon_{pt}(\eta) = \frac{N_{pr}^{match}(\eta)}{N_{pr}(\eta)} \qquad b_{pt}(\eta) = \frac{N_{pt}^{backg}(\eta)}{N_{pt}(\eta)}$$

Tracklet:

$$C_{2pt}(\eta) = \frac{N_{pr}(\eta)}{N_{2pt}(\eta)}$$

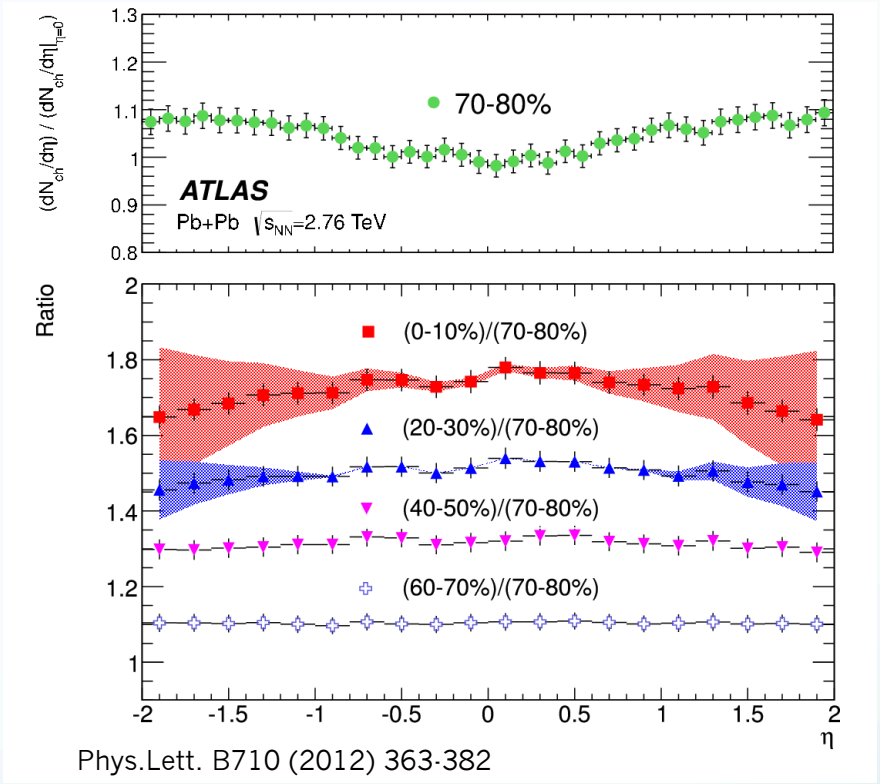
N_{pt} – number of pixel tracks
N_{pr} – number of primary particles
N_{2pt} – number of tracklets

Systematic uncertainties

Source	Uncertainty (0-10%)	(70-80%)
Detector stability	2%	2%
MC detector description	0.4%	0.4%
Extra material	2%	2%
$\Delta\mathcal{R}$ cut	1%	1%
p_T re-weighting	0.5%	0.5%
Hadron flavor composition	1%	1%
Enhanced K_s, Λ.	1%	1%
HYDJET	0.5-7.5% vs. η	0%
Analysis Method	3.5%	1%
Combined ($\eta = 0$)	5%	4%
Combined ($\eta = 2$)	9%	4%

Charged particle multiplicity (method 1) scaled by $dN/d\eta \mid_{\eta=0}$ as a function of η for the 70 -80 % centrality region. Bars are present statistical errors.

Picture presents four plots for $dN/d\eta$ /<$N_{part}/2$> In centrality region 0%-10%, 20%-30%,40%-50%, 60% -70 %. Divided by peripheral measurement 0 % - 80%. Systematically errors are presented by shaded bands and statistical errors are shown by bars.



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