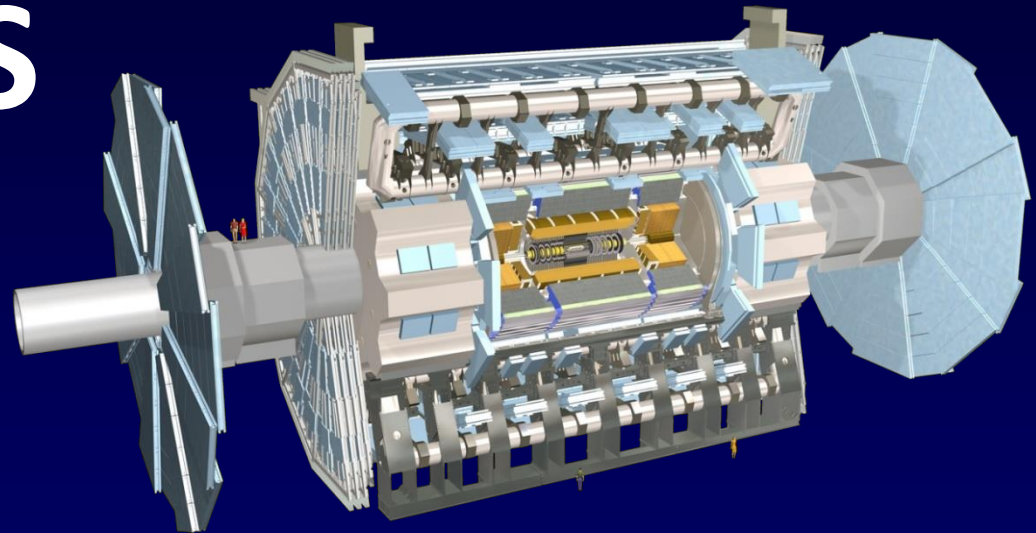


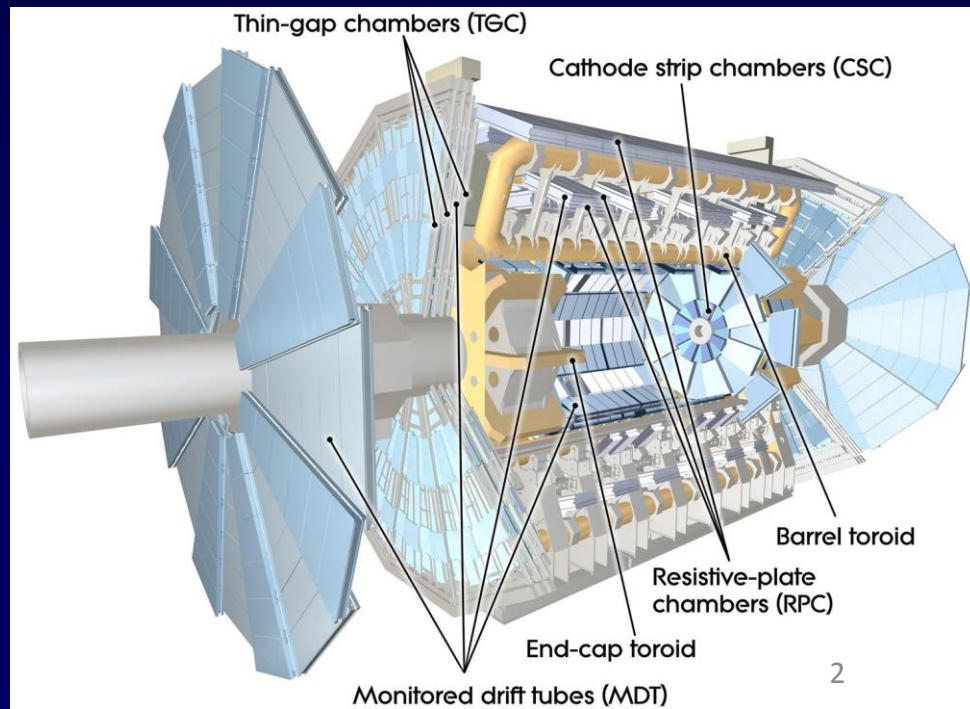
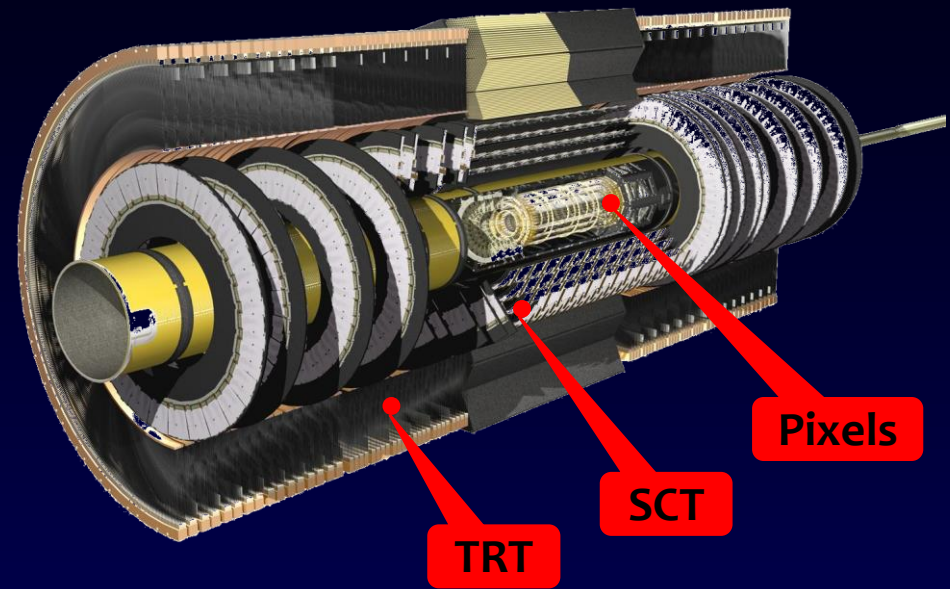
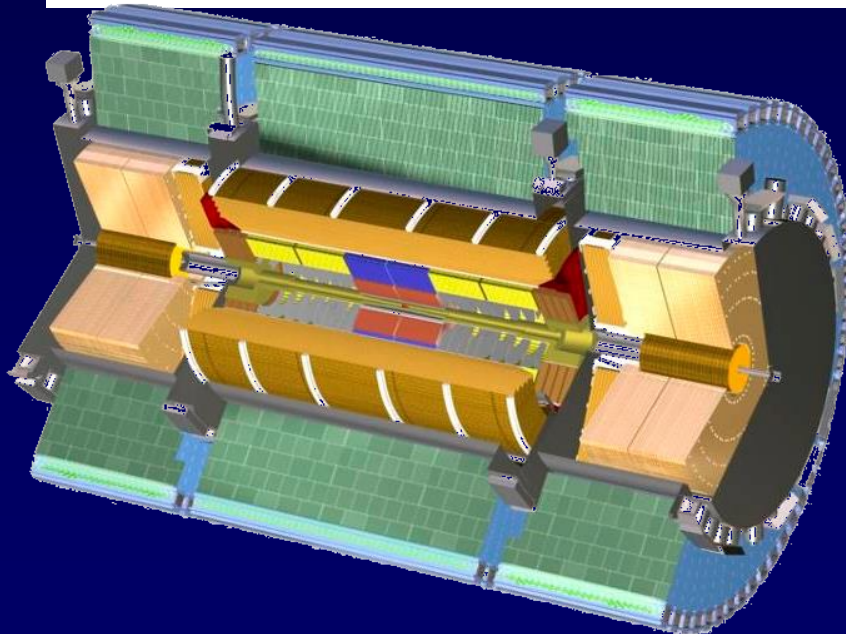
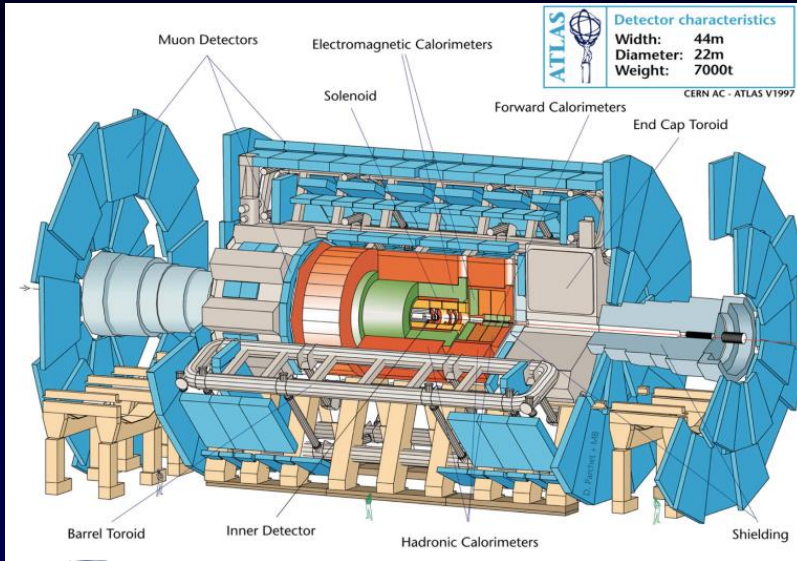
Results from the heavy ion runs from ATLAS



Jiří Dolejší,
Charles University Prague,
for ATLAS collaboration

Low x meeting, Yukawa Institute, Kyoto, June 2014

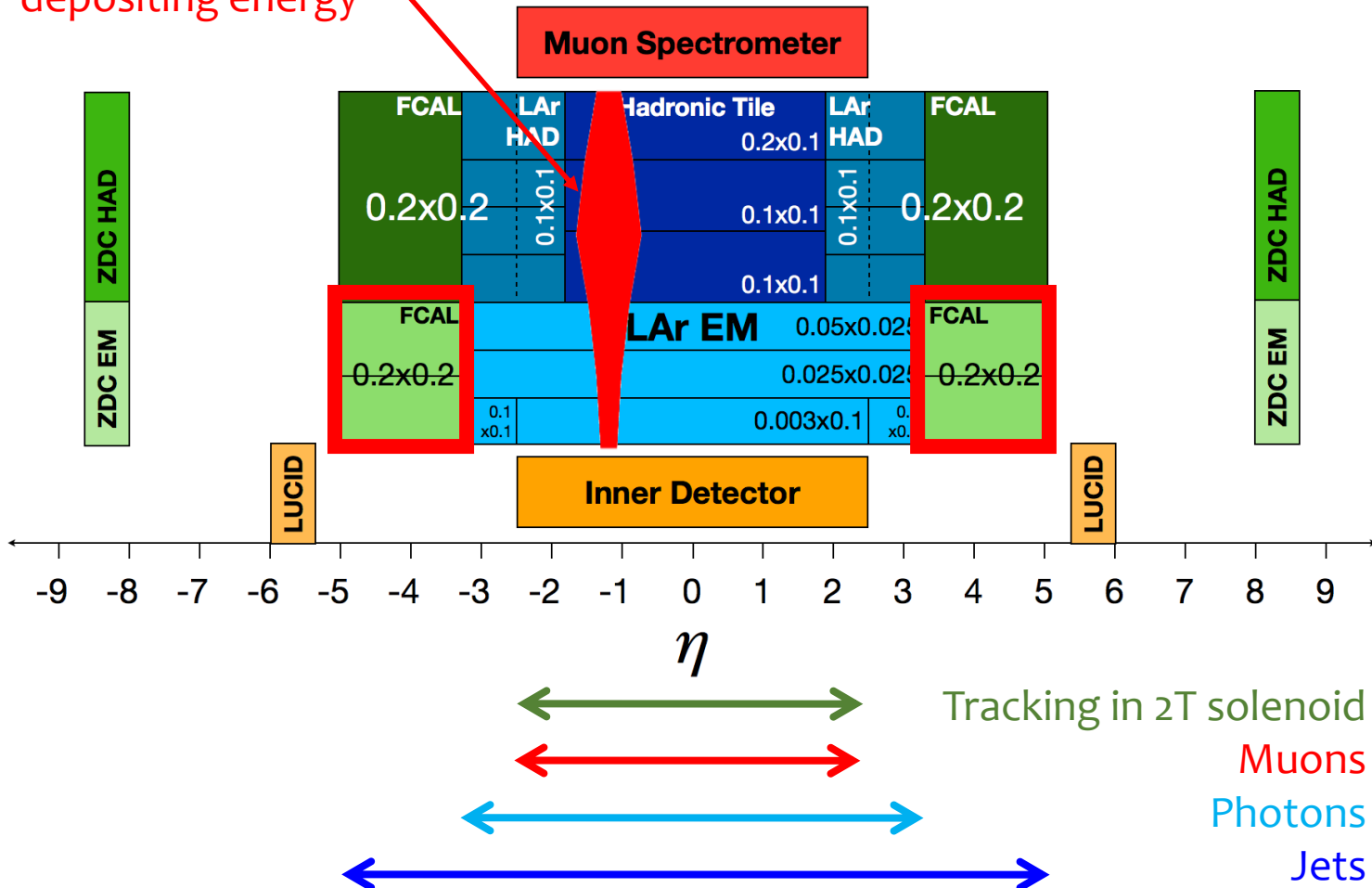
ATLAS detector



ATLAS detector

100 GeV jet
depositing energy

ATLAS calorimetry - full azimuthal acceptance

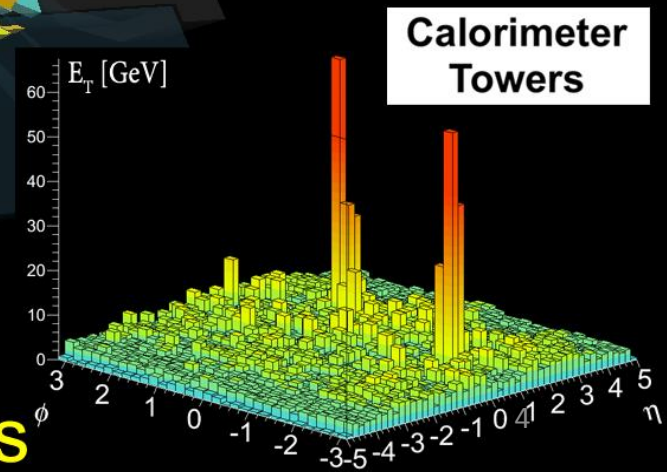
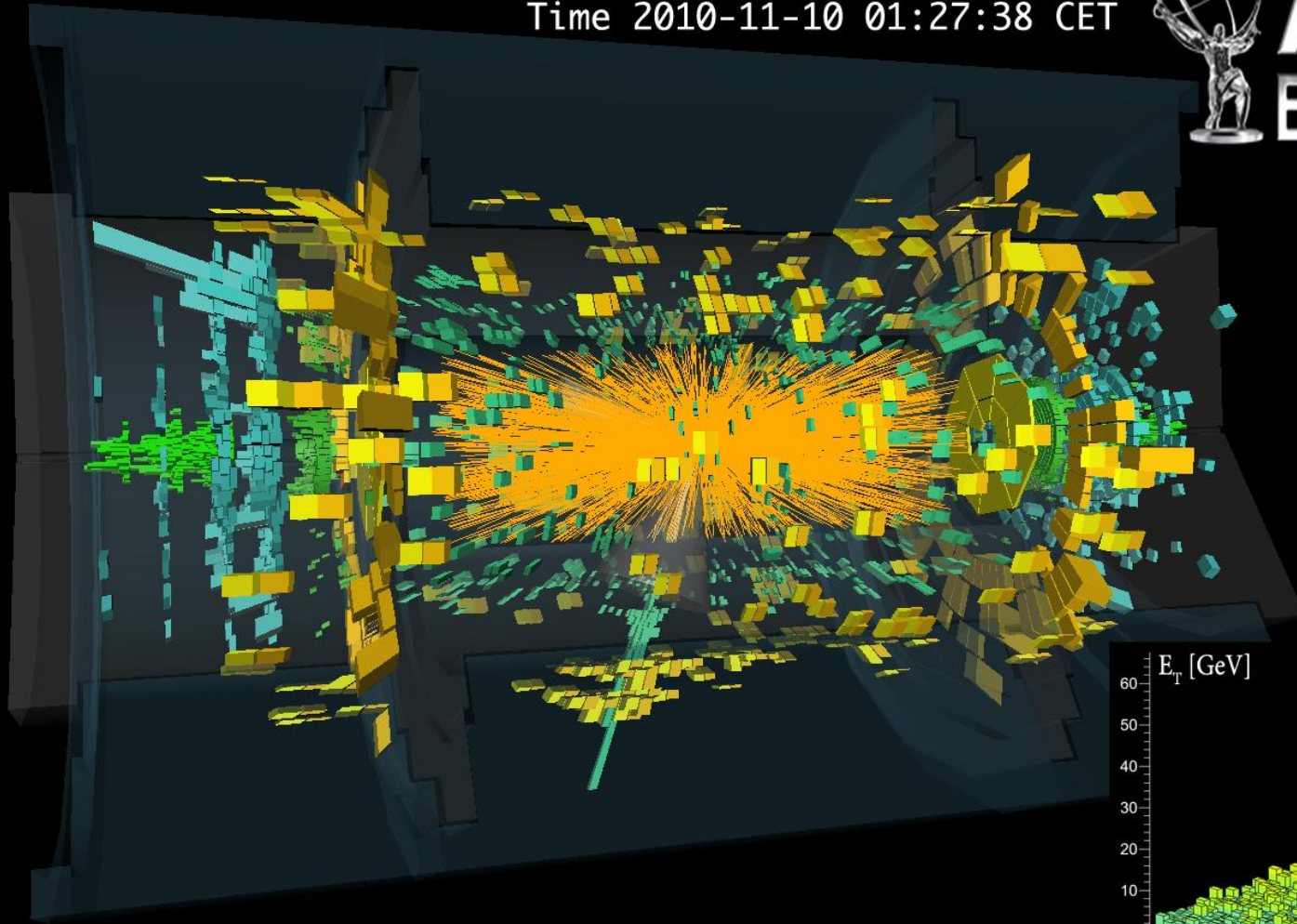


Global view of LHC Heavy ion events

Run 168875, Event 1577540
Time 2010-11-10 01:27:38 CET



ATLAS EXPERIMENT



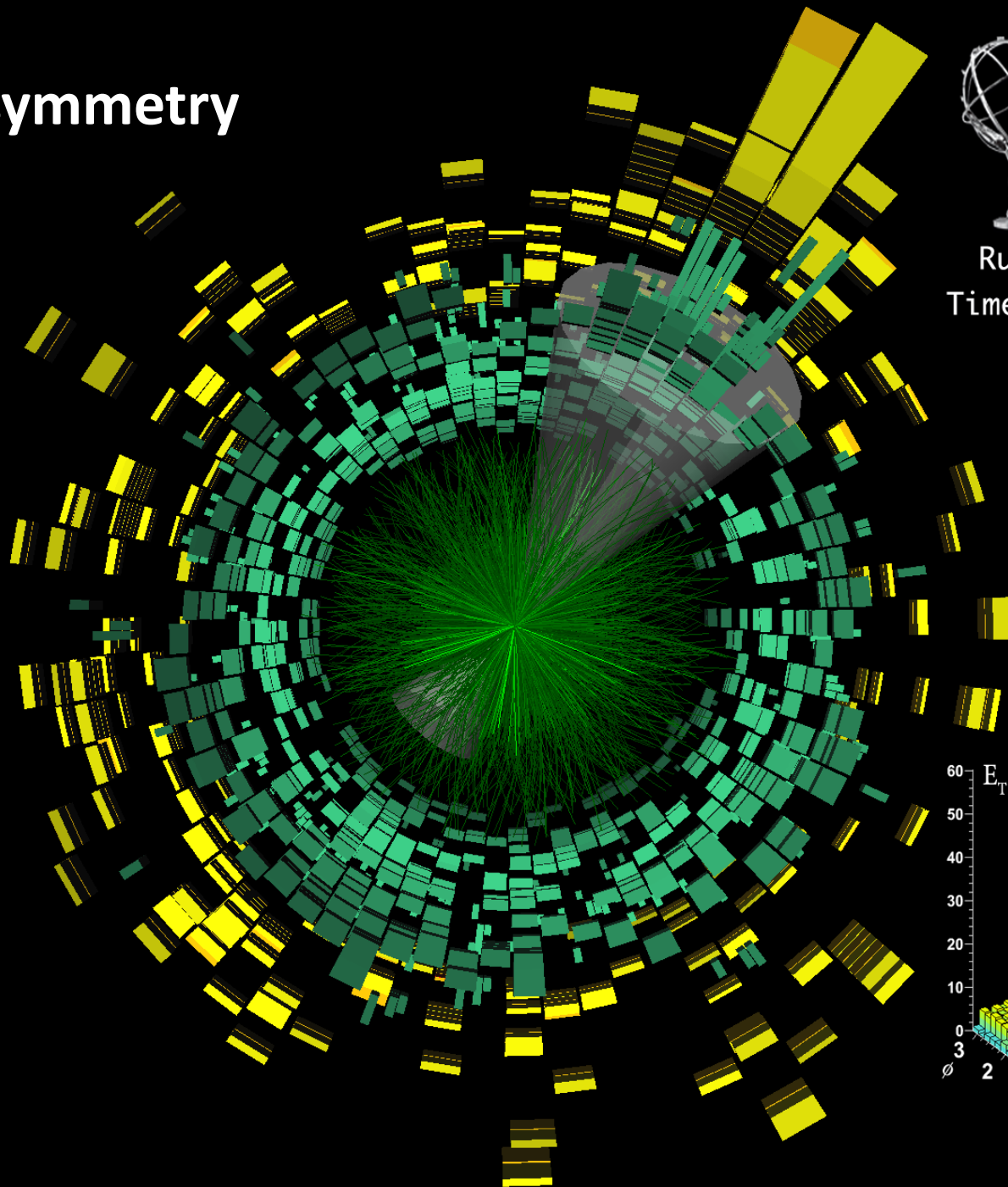
Heavy Ion Collision Event with 2 Jets

Asymmetry

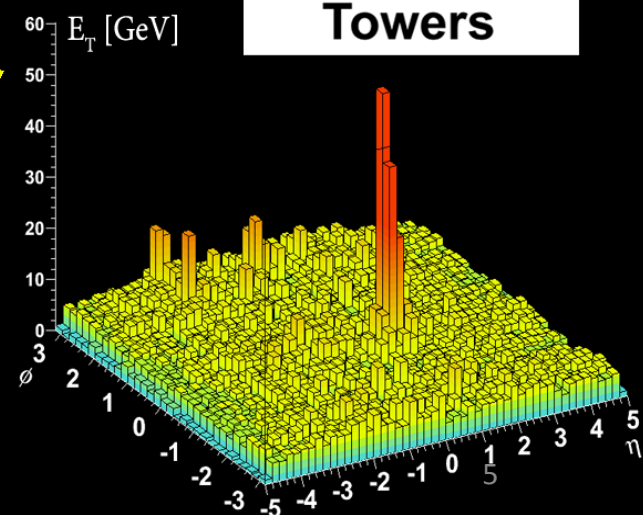


ATLAS EXPERIMENT

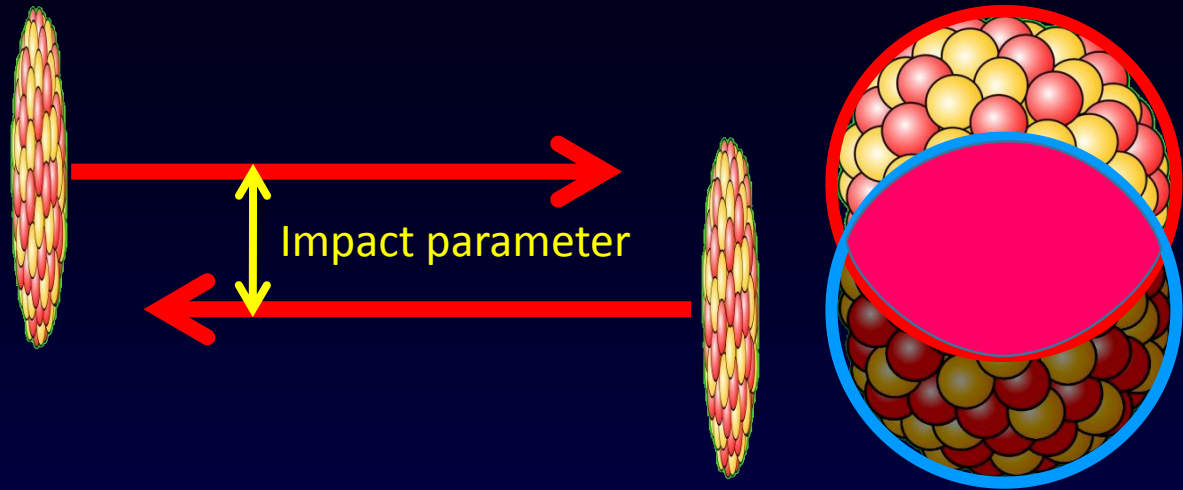
Run 168795, Event 7578342
Time 2010-11-09 08:55:48 CET



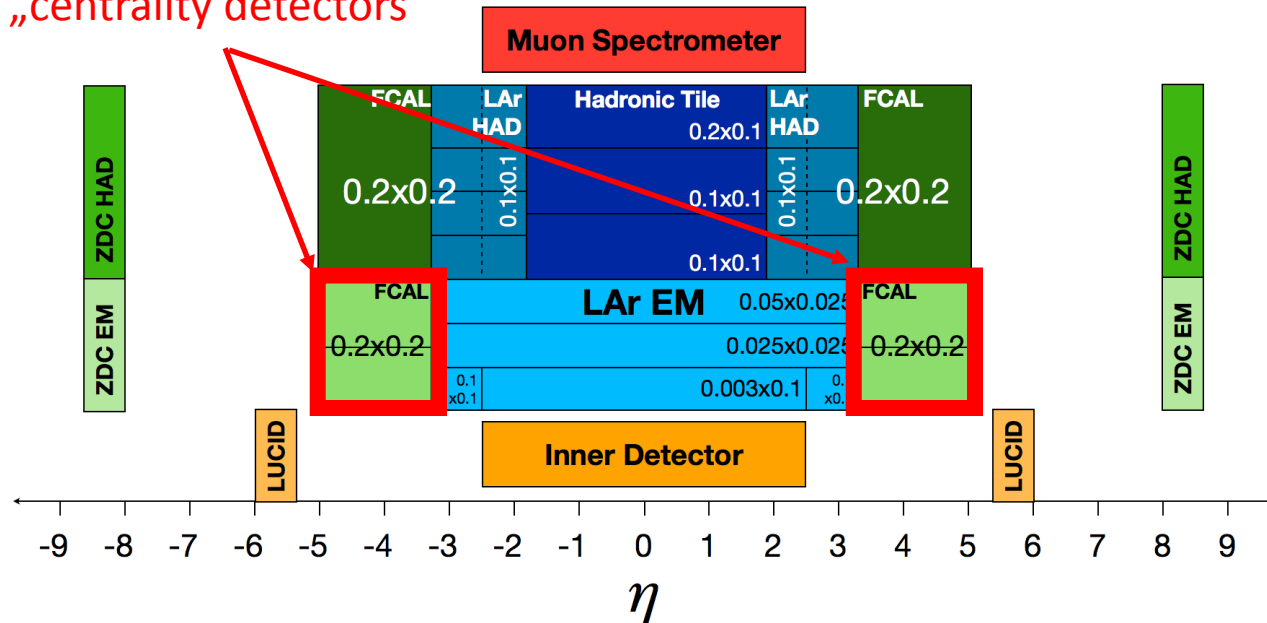
**Calorimeter
Towers**



Centrality



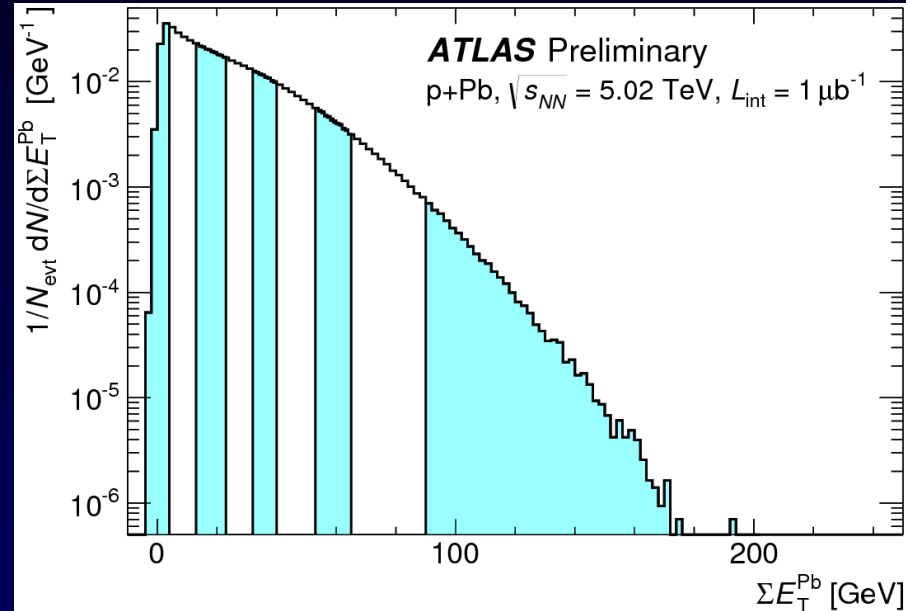
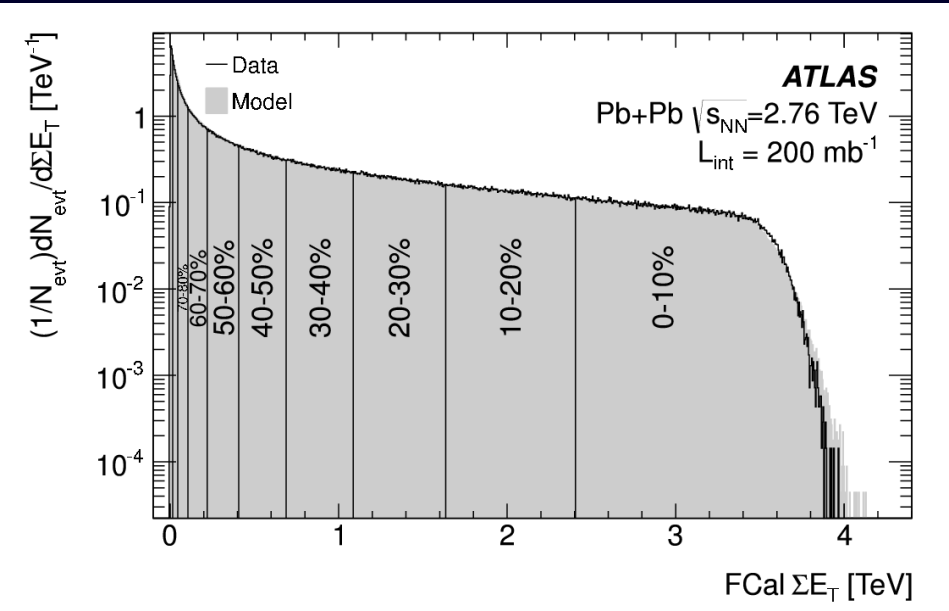
Forward calorimeters –
„centrality detectors“



Centrality in Pb+Pb, p+Pb

$$3.2 < |\eta| < 4.9$$

$$-4.9 < \eta < -3.2 \text{ (in direction of Pb)}$$



Model = Glauber MC, also Glauber-Gribov for p+Pb (with fluctuations of σ_{NN})

Number of
participating
nucleons N_{part}

$$N_{part}(\vec{b}) = \int T_A(\vec{s})(1 - e^{-T_B(\vec{s}-\vec{b})\sigma_{inel}^{NN}}) d^2s + \\ + \int T_B(\vec{s})(1 - e^{-T_A(\vec{s}-\vec{b})\sigma_{inel}^{NN}}) d^2s, \quad T(\vec{b}) = \int_{-\infty}^{\infty} \rho(\vec{b}, z) dz$$

Physics goals of heavy ion studies

- Collective responses to asymmetric initial conditions
- Effects of the hot and dense environment (QGP) in Pb+Pb (jet quenching)
- Effects of the cold nuclear environment in p+Pb as a reference

Basic tool:

- comparison of Pb+Pb to p+Pb and p+p,
- comparison of central events to peripheral ones

Basic task:

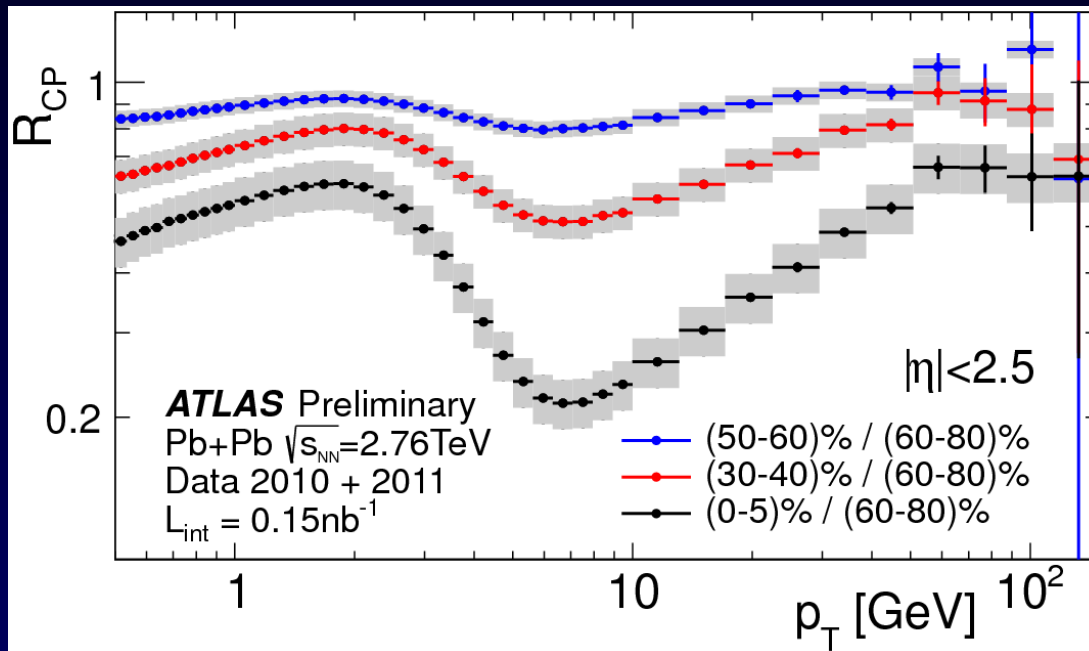
- Cope with the underlying event

My goal here:

- present some „particle“ observables;
- Just mention v_2

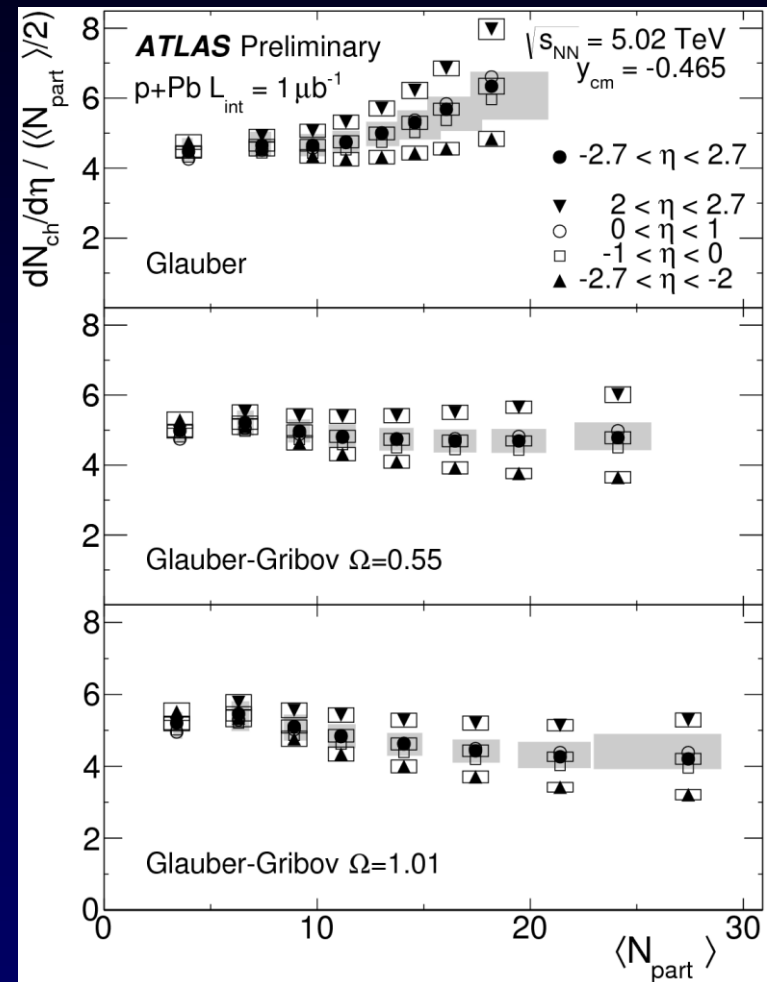
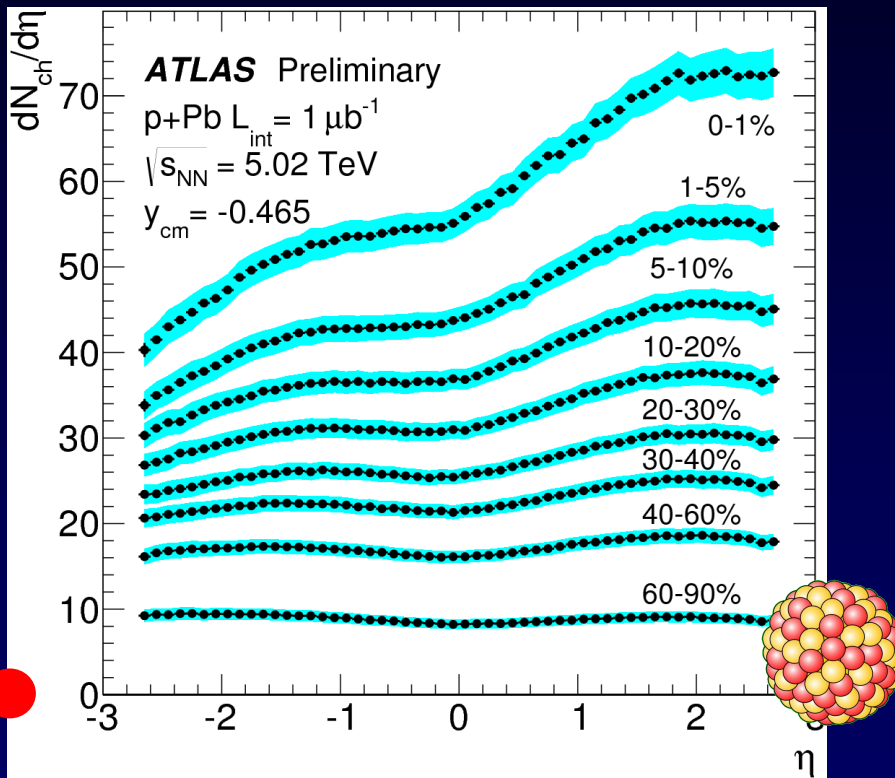
Charged particle spectra in Pb+Pb at $\sqrt{s_{NN}}=2.76$ TeV

(ATLAS-CONF-2012-120)



R_{CP} measured in $|\eta| < 2.5$ in three centrality combinations:
with 0-5%, 30-40% and 50-60% as numerators and a
common peripheral sample 60-80% as denominator.

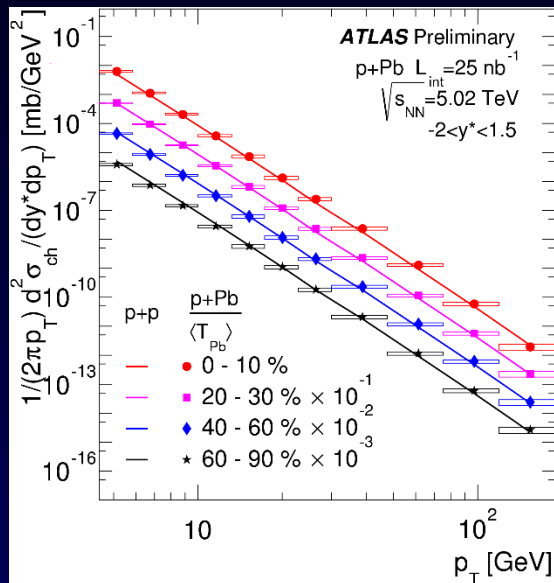
Charged particle multiplicity distribution in p+Pb collision at $\sqrt{s_{NN}}=5.02$ TeV (ATLAS-CONF-2013-096)



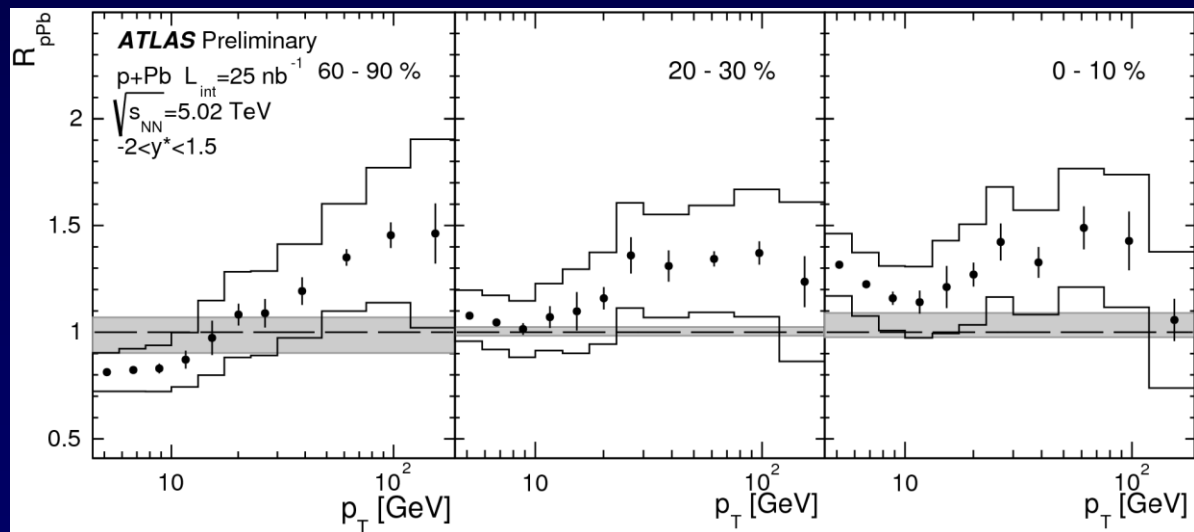
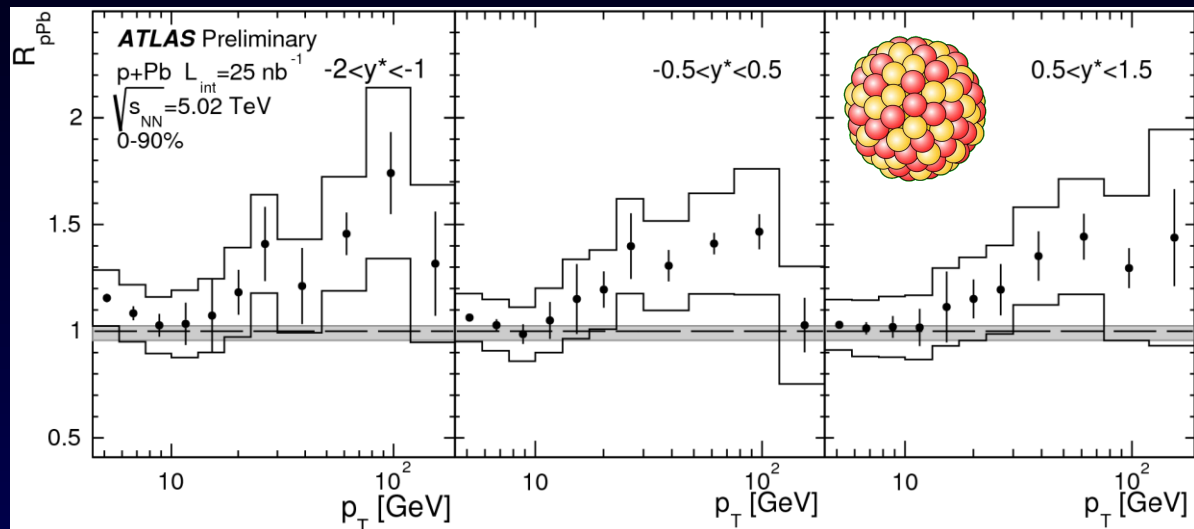
$dN/d\eta$ ($<N_{part}>/2$) as a function of $<N_{part}>$ in several η -regions for the three implementations of the Glauber model: the standard Glauber model (top panel), the Glauber-Gribov model with $\Omega=0.55$ (middle panel) and the Glauber-Gribov model with $\Omega=1.01$ (bottom panel).

Charged hadron production in p+Pb at $\sqrt{s_{NN}}=5.02$ TeV

(ATLAS-CONF-2014-029)



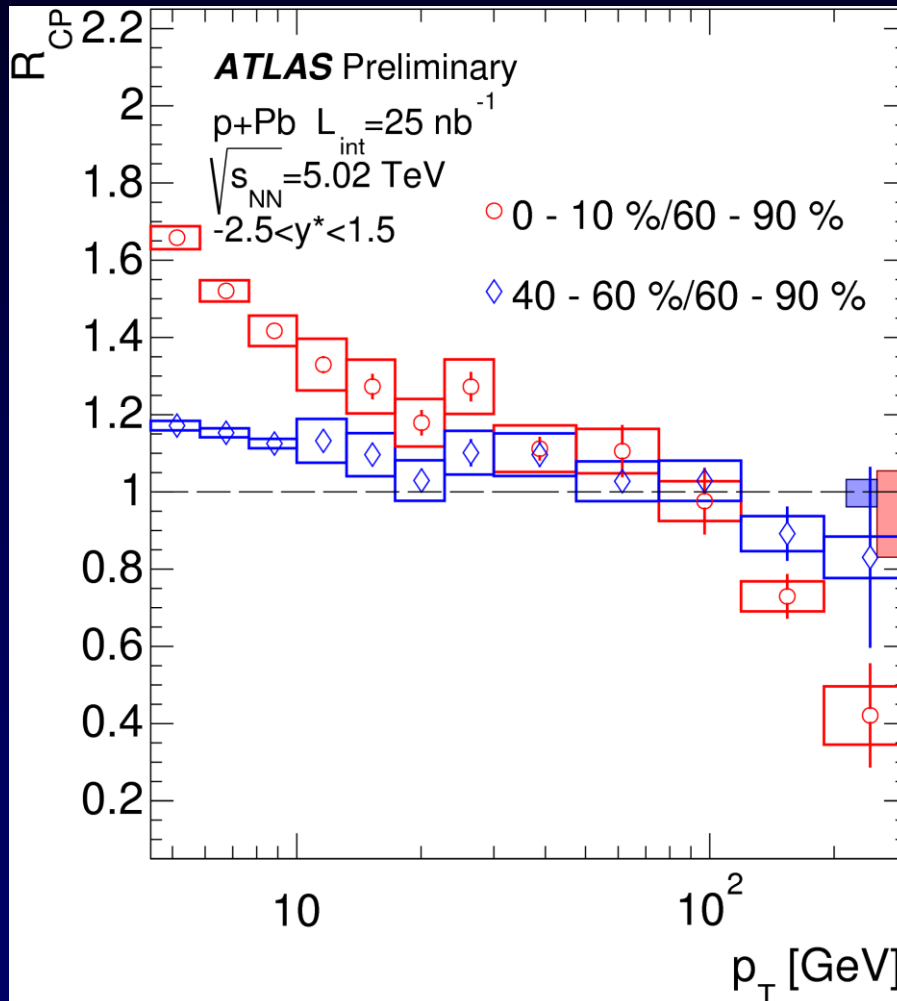
Differential yields of charged particles in four centrality classes averaged over $-2 < y^* < 1.5$



The R_{pPb} as a function of p_T measured for the 0-90% centrality class in three rapidity ranges (upper) and for the $-2 < y^* < 1.5$ rapidity range for three centrality classes.

Charged hadron production in p+Pb at $\sqrt{s_{NN}}=5.02$ TeV

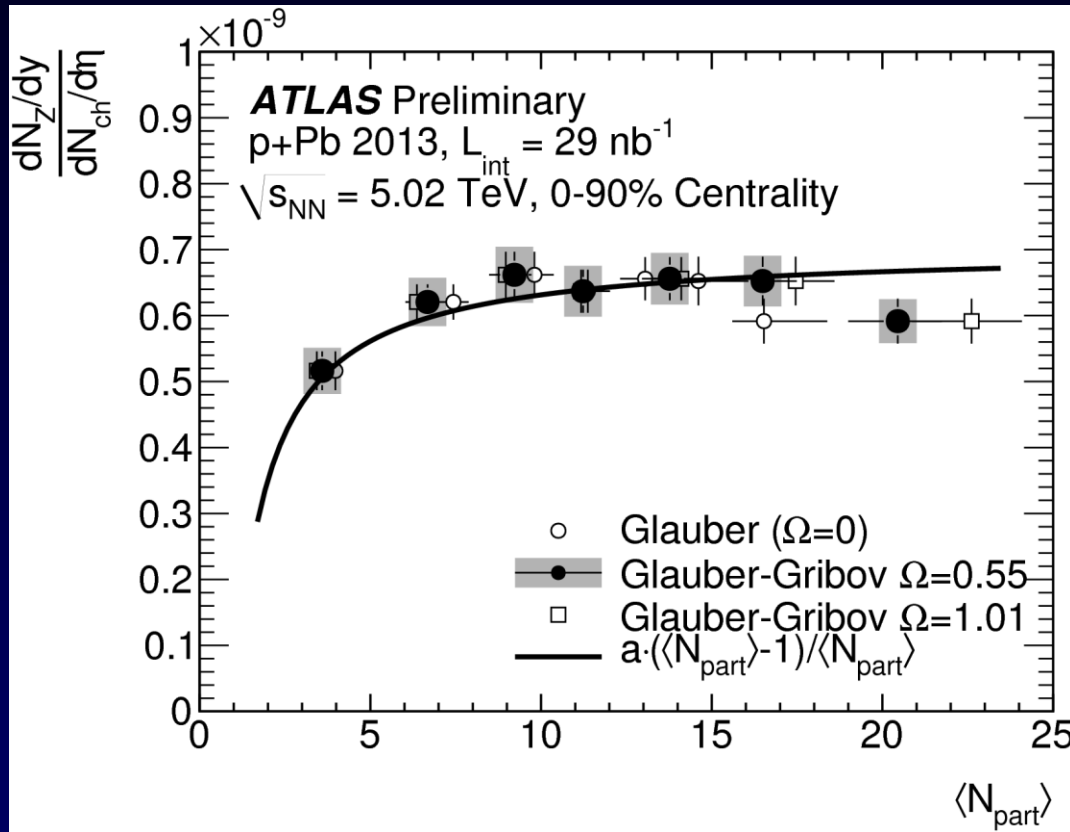
(ATLAS-CONF-2014-029)



The R_{CP} as a function of p_T measured for the $-2.5 < y^* < 1.5$ rapidity range for 0-10% and 40-60% centrality class using 60-90% as normalisation.

Z production in p+Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

(ATLAS-CONF-2014-020)

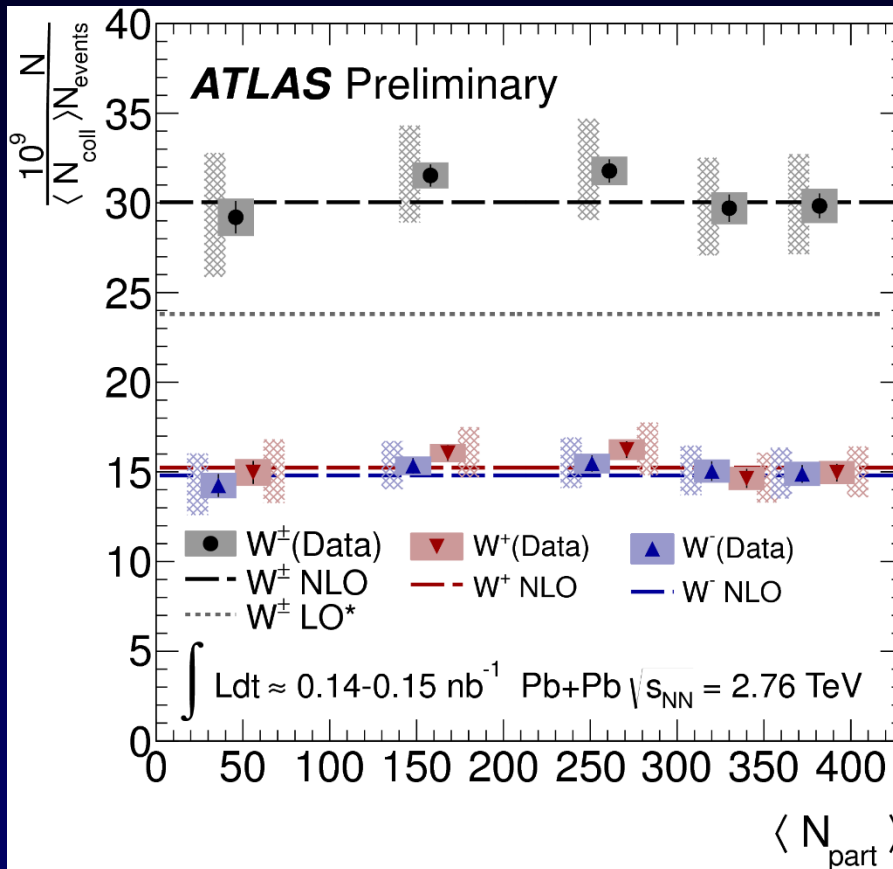


The ratio $(dN_Z/dy)/(dN_{ch}/d\eta)$ (for $|y^Z| < 2.5$) as a function of $\langle N_{part} \rangle$.

The values of the ratio themselves are wholly independent of the definition of $\langle N_{part} \rangle$, but each point is plotted three times on the x-axis corresponding to the three different Glauber implementations.

The charged particle yield is expected to scale with $\langle N_{part} \rangle$ and the Z boson yield with $\langle N_{coll} \rangle = \langle N_{part} \rangle - 1$, and so the ratio is fit to a function of the form $a \cdot \langle N_{coll} \rangle / \langle N_{part} \rangle = a \cdot (\langle N_{part} \rangle - 1) / \langle N_{part} \rangle$ which describes the data well.

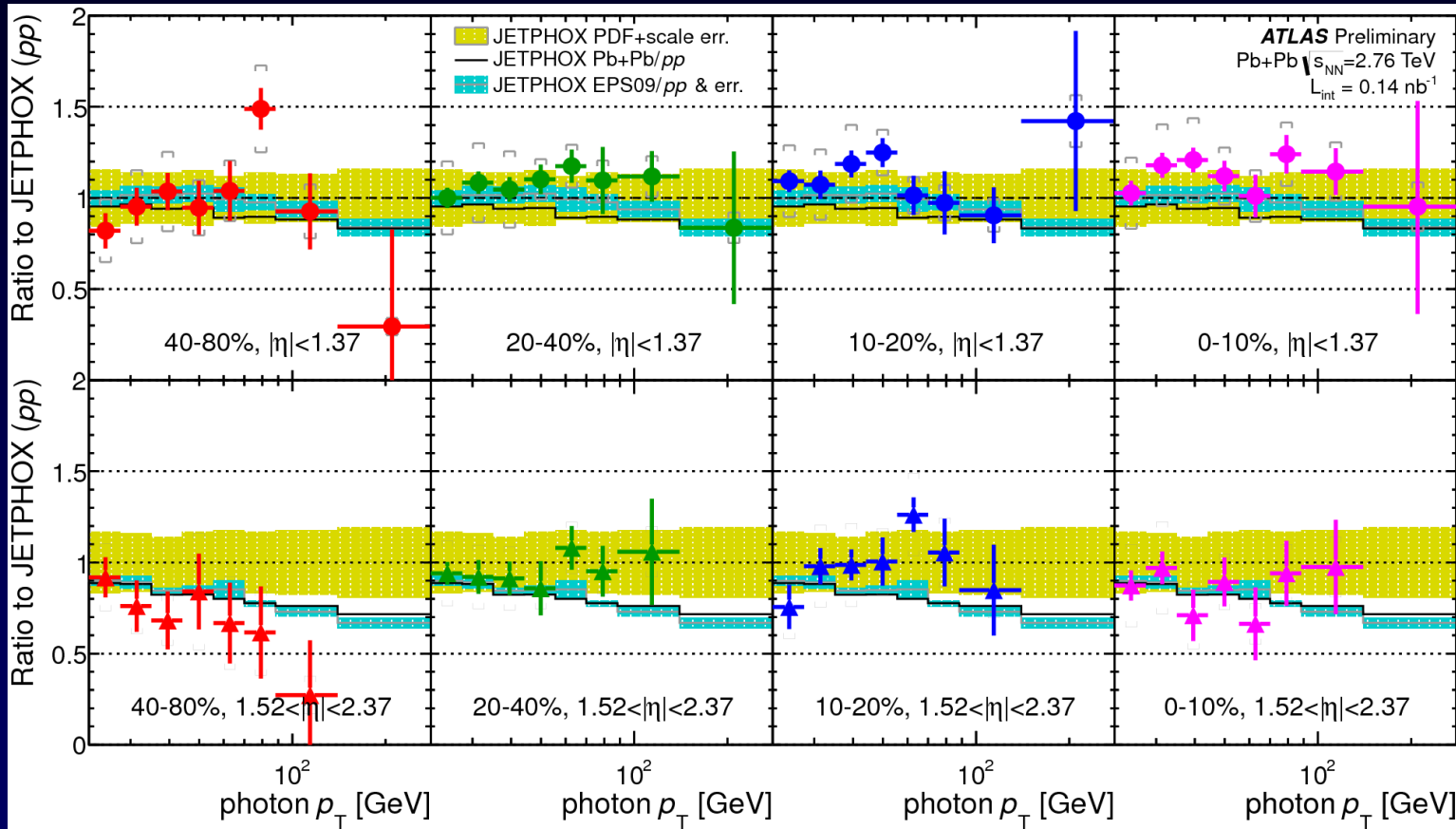
Measurement of W boson production in PbPb collisions at $\sqrt{s_{NN}}=2.76$ TeV (ATLAS-CONF-2014-023)



W boson production yield per binary collision as a function of the mean number of participants $\langle N_{\text{part}} \rangle$ for W^+ , W^- , and $W^{+/-}$ bosons for combined muon and electron channels.

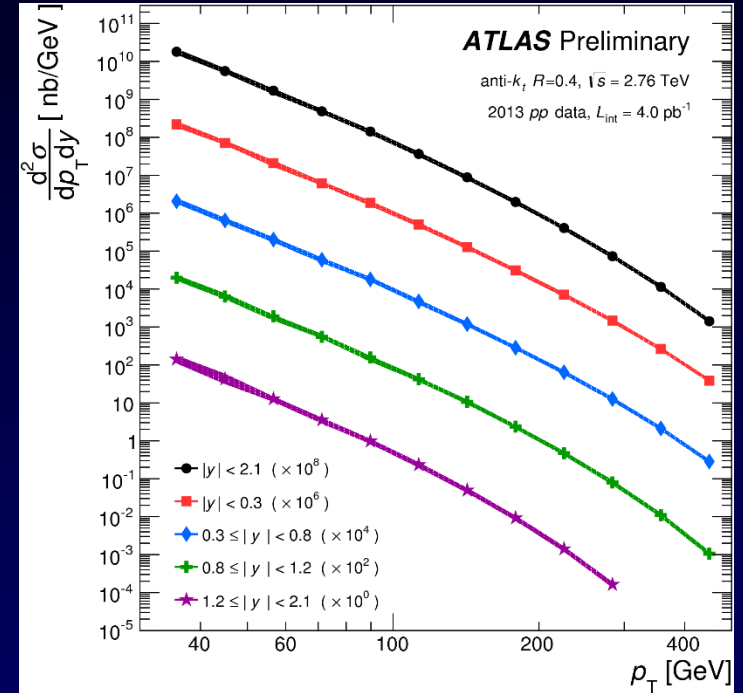
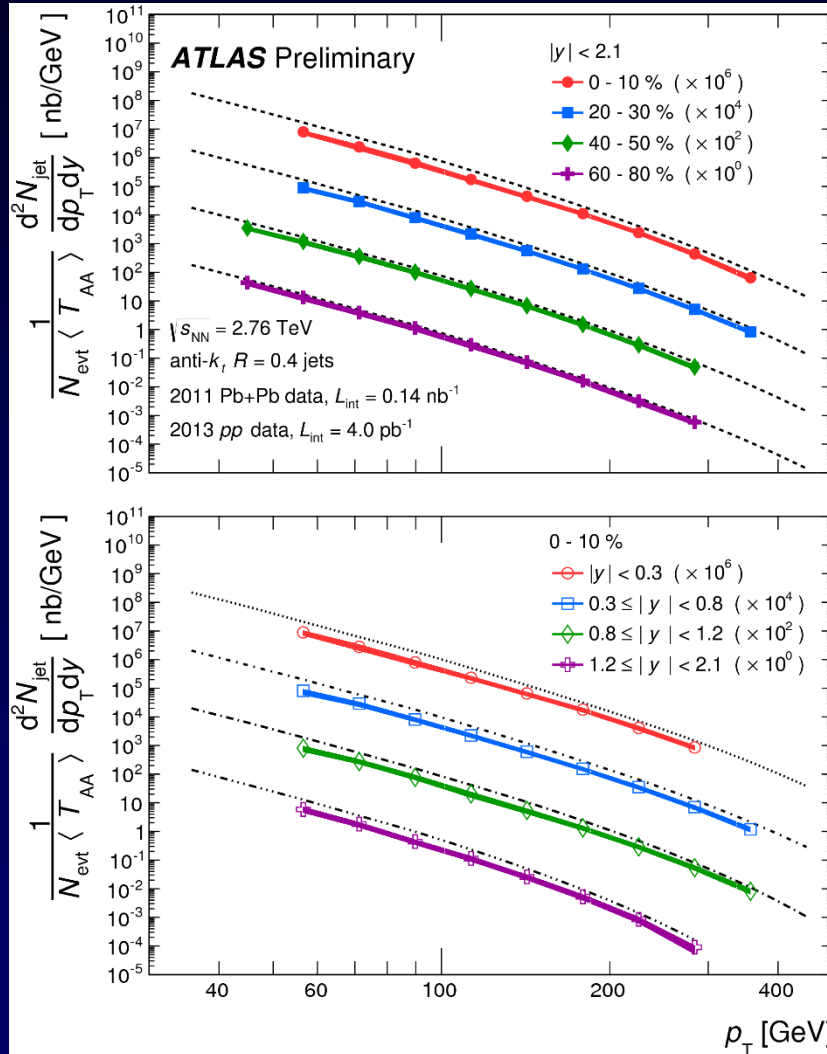
Statistical errors are shown as black bars, whereas uncorrelated systematic and statistical uncertainties added in quadrature are shown as the filled error box. Correlated scaling uncertainties are shown as the hatched boxes and are offset for clarity. These include uncertainties from N_{coll} .

Centrality, rapidity and p_T dependence of isolated prompt photon production in Pb+Pb at $\sqrt{s_{NN}} = 2.76$ TeV



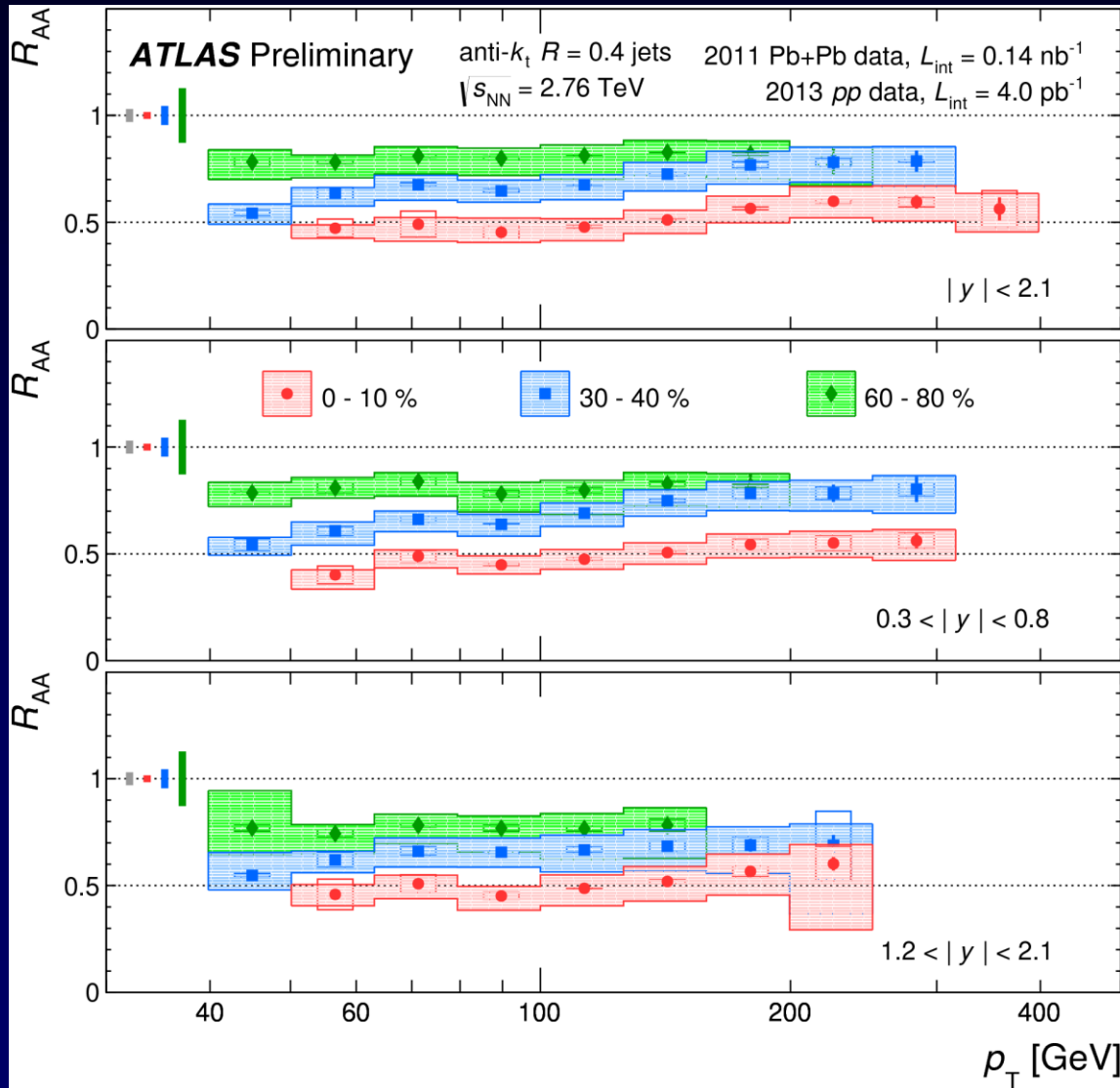
Fully corrected yields of prompt photons as a function of p_T in $|\eta| < 1.37$ and $1.52 < |\eta| < 2.37$ using tight photon selection, isolation cone radius $R_{iso} = 0.3$ and isolation energy of 6 GeV, divided by T(pb) scaled JETPHOX predictions for pp collisions, which implement the same isolation selection (ATLAS-CONF-2014-026)

The nuclear modification factor for **jets** in Pb+Pb collisions at $\sqrt{s}_{NN} = 2.76$ TeV (ATLAS-CONF-2014-025)



The double differential jet cross section in pp collisions (top) and the jet yield in Pb+Pb collisions (left)

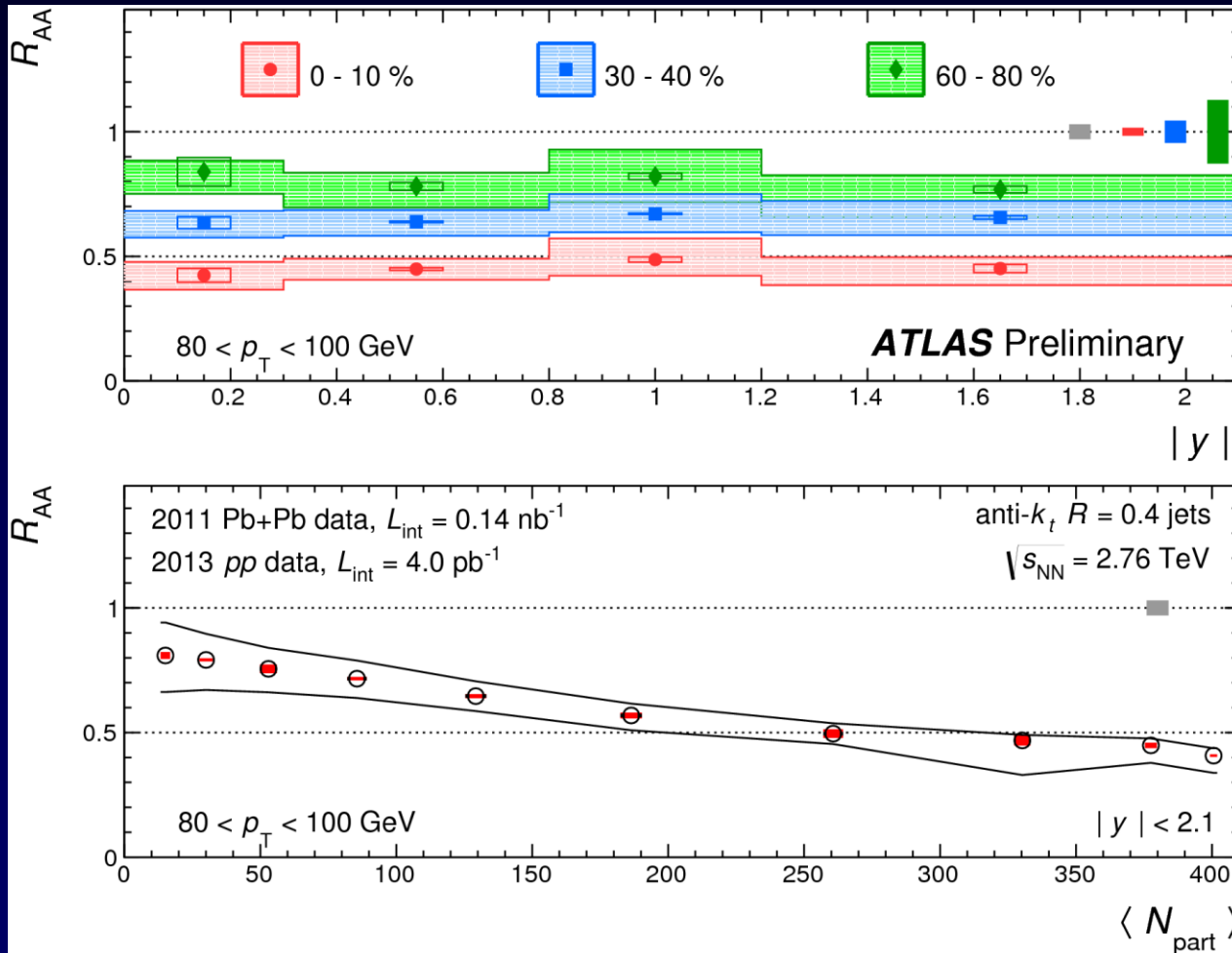
The nuclear modification factor for **jets** in Pb+Pb collisions at $\sqrt{s}_{\text{NN}} = 2.76$ TeV (ATLAS-CONF-2014-025)



Jet R_{AA} as a function of p_{T} for three centrality bins and different rapidity intervals.

Jets are suppressed by factor of about 2 in central collisions

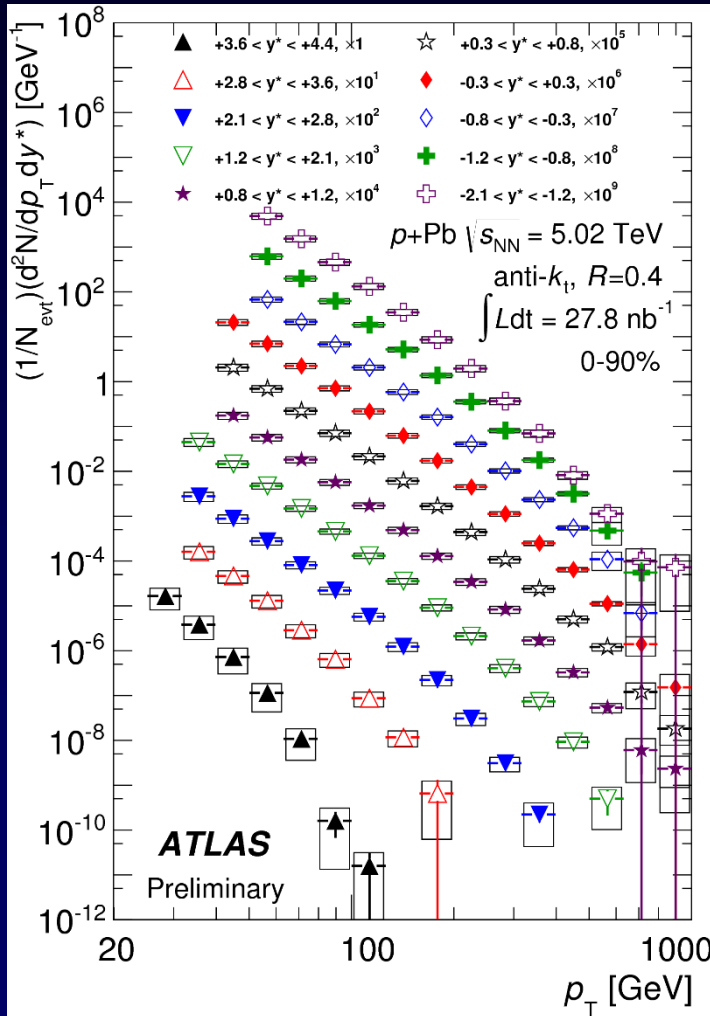
The nuclear modification factor for **jets** in Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV (ATLAS-CONF-2014-025)



The R_{AA} for jets with $80 < p_T < 100$ GeV is shown as a function of $|y|$ for three centrality bins (top). **NO rapidity dependence**

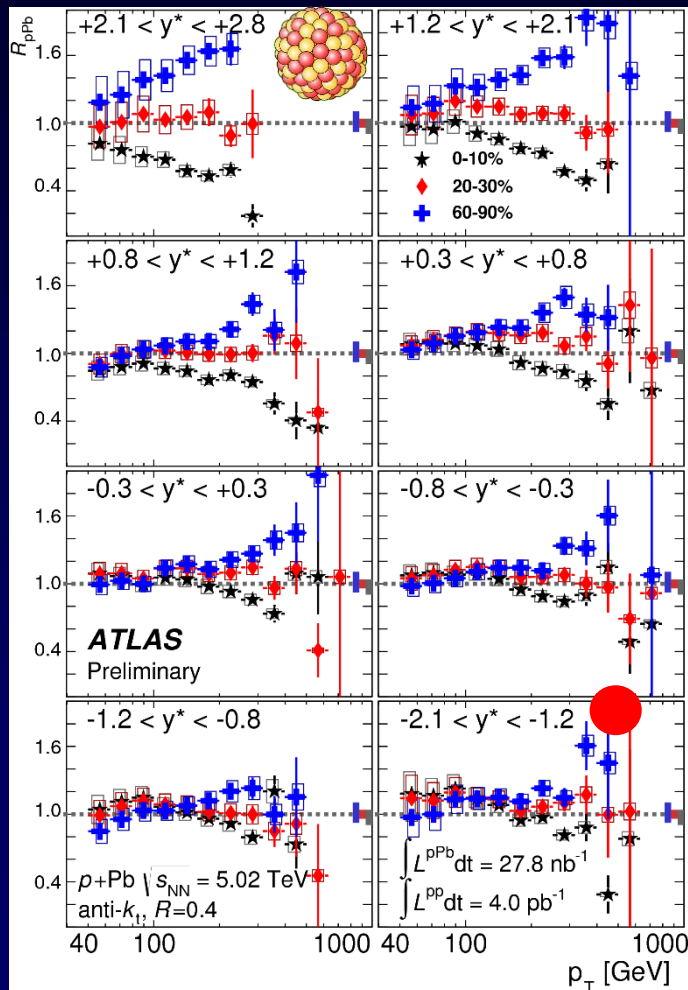
The R_{AA} for jets with $80 < p_T < 100$ GeV and $|y| < 2.1$ as a function of $\langle N_{part} \rangle$ (bottom) **Monotonous decrease with $\langle N_{part} \rangle$**

Centrality and rapidity dependence of inclusive jet production in $\sqrt{s_{NN}} = 5.02$ TeV p+Pb (ATLAS-CONF-2014-024)

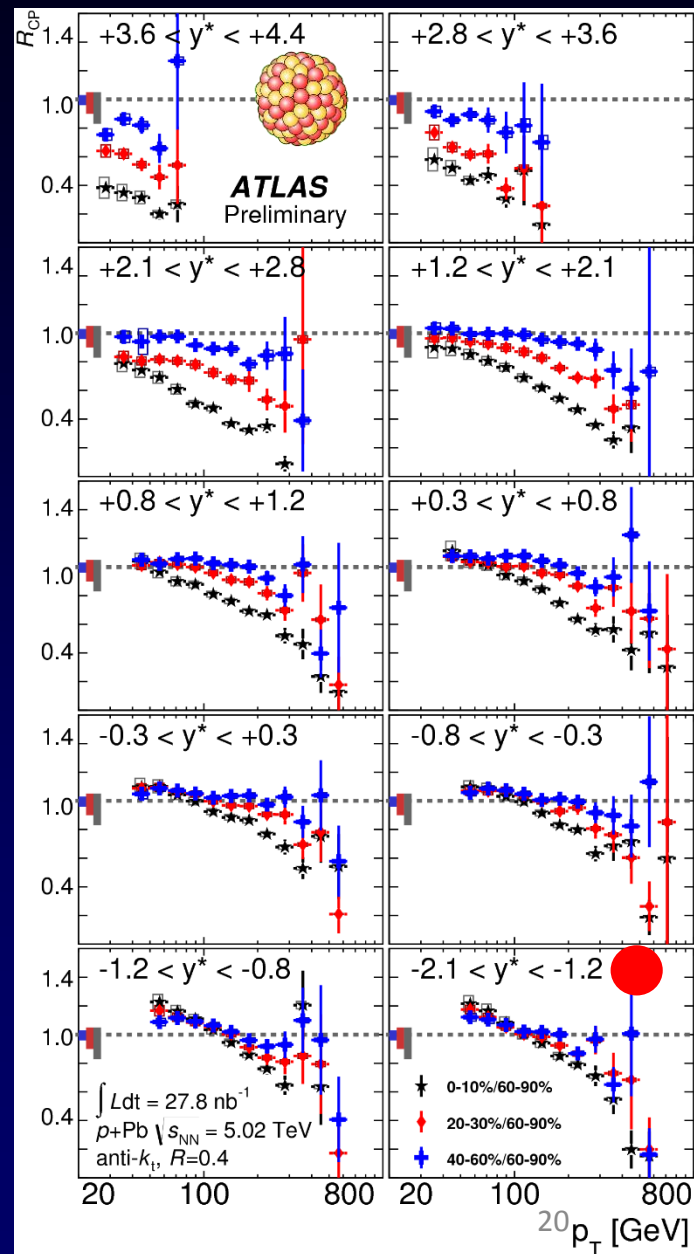


Inclusive double differential per-event jet yield in 0-90% p+Pb collisions as a function of jet p_T in different y^* bins.

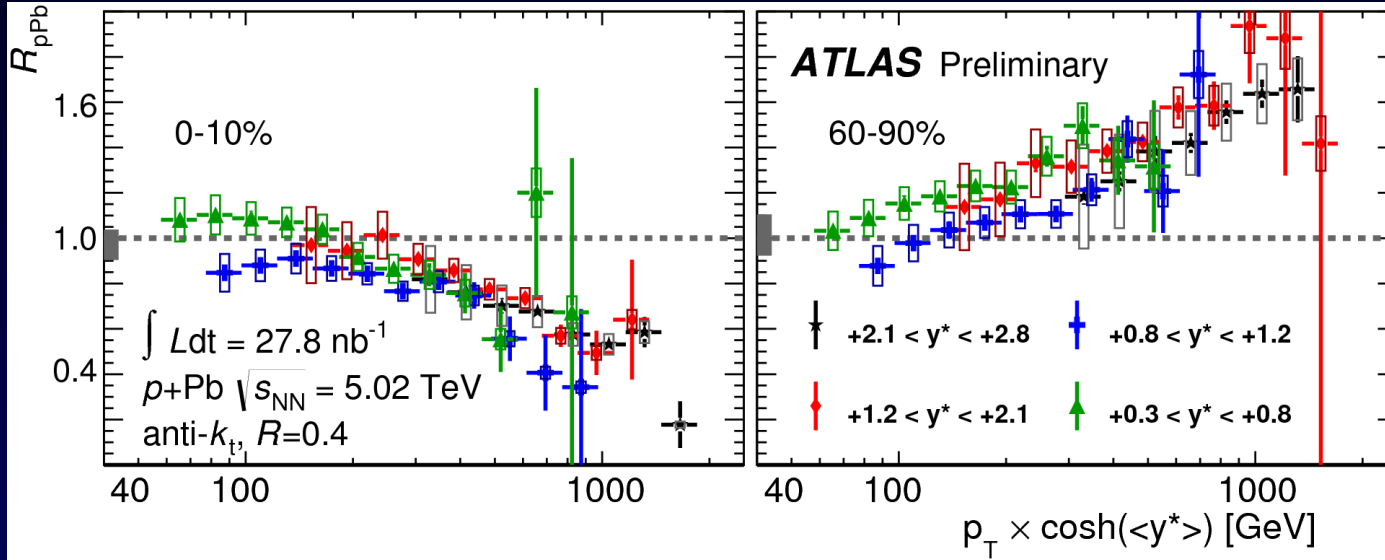
Centrality and rapidity dependence of inclusive jet production in $\sqrt{s_{NN}} = 5.02$ TeV p+Pb (ATLAS-CONF-2014-024)



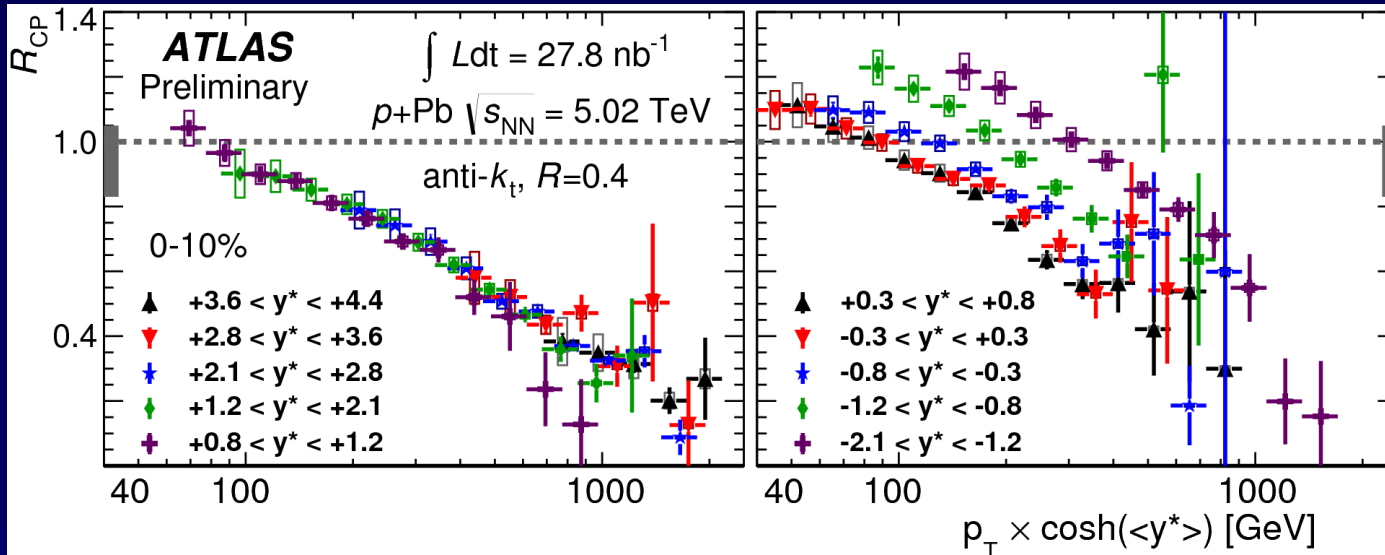
R_{ppb} (left) and R_{CP} (right) for $R=0.4$ jets in $\sqrt{s_{NN}} = 5.02$ TeV p+Pb collisions in central (black), mid-central (red) and peripheral (blue) events.



Centrality and rapidity dependence of inclusive jet production in $\sqrt{s_{NN}} = 5.02$ TeV p+Pb (ATLAS-CONF-2014-024)

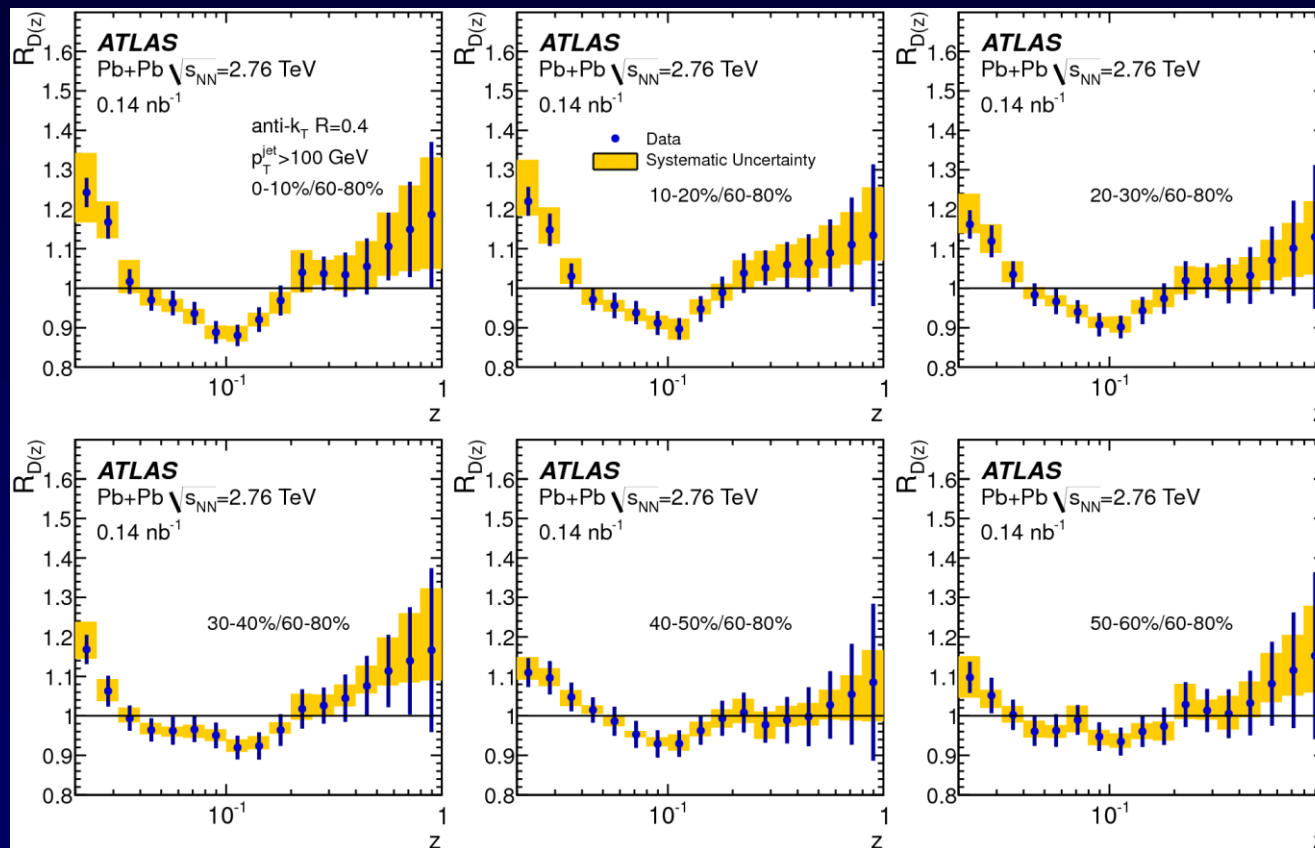


← Jet energy



Inclusive jet charged particle fragmentation functions in Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV (arXiv:1406.2979 [hep-ex])

New paper submitted to PLB just before the conference – 11. 6. 2014

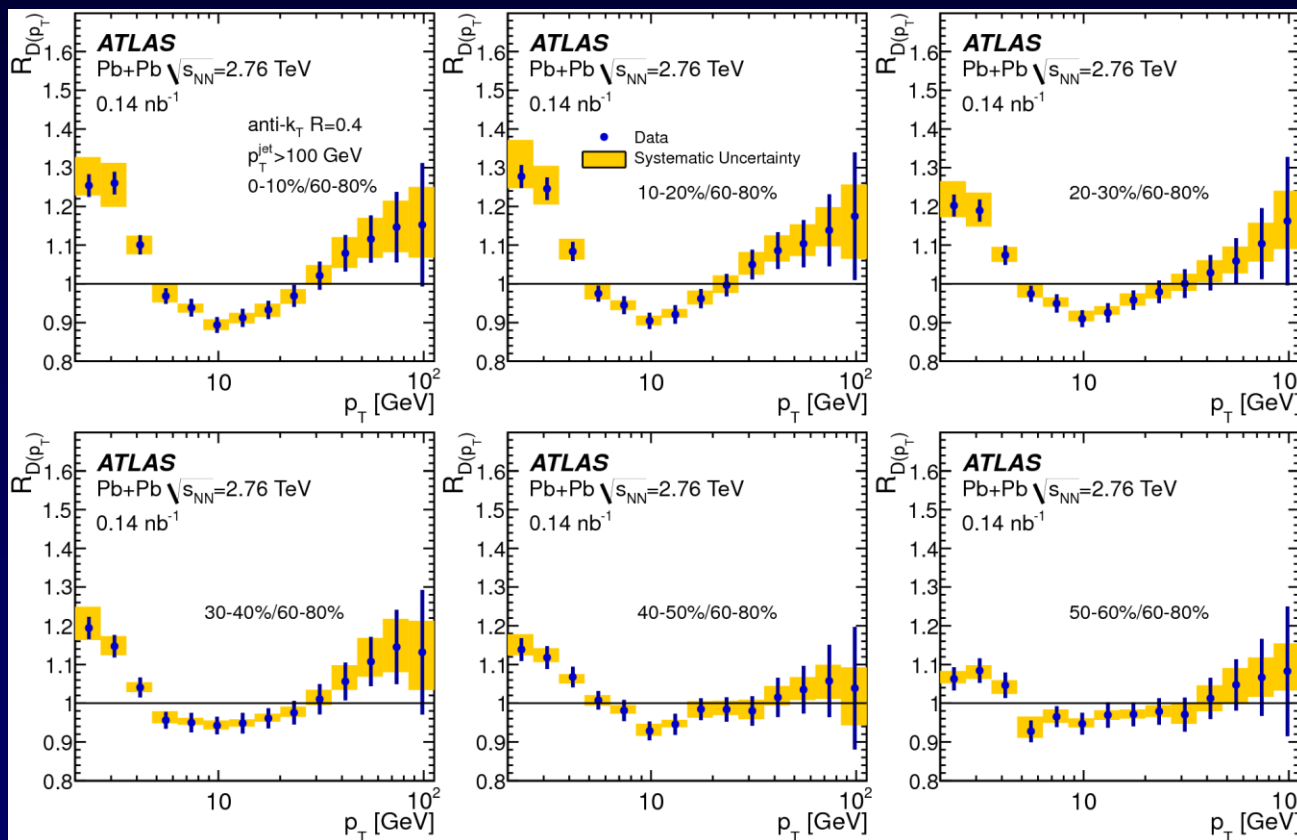


Ratios of $D(z)$ for six bins in collision centrality to those in peripheral (60-80%) collisions, for $R=0.4$ jets.

The error bars indicate statistical uncertainties while the yellow shaded bands indicate systematic uncertainties.

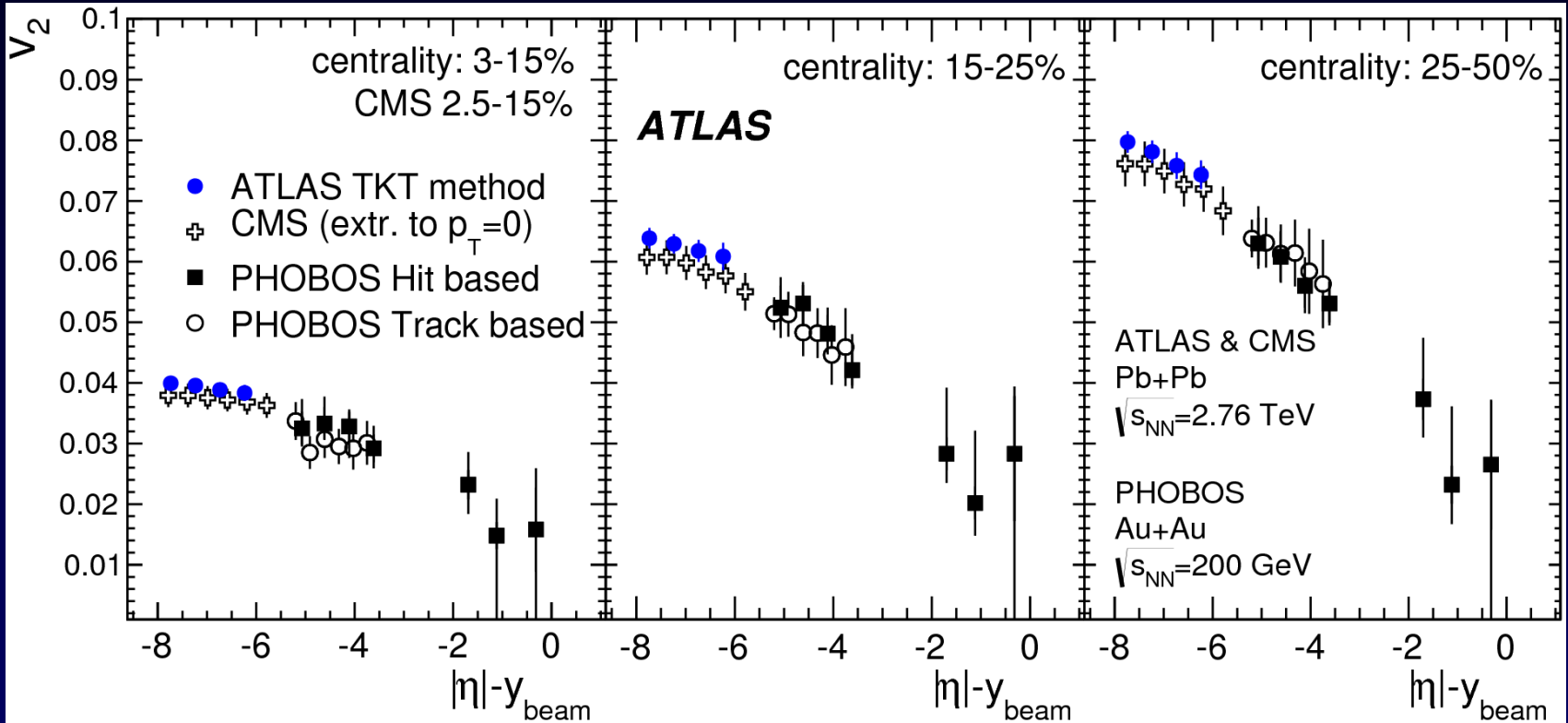
Inclusive jet charged particle fragmentation functions in Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV

New paper submitted to PLB just before the conference – 11. 6. 2014



Ratios of unfolded $D(p_T)$ distributions for six bins in collision centrality to those in peripheral ({60-80%}) collisions, for $R=0.4$ jets. The error bars indicate statistical uncertainties while the yellow shaded bands indicate systematic uncertainties.

Centrality and pseudorapidity dependence of the integrated elliptic flow in Pb+Pb at $\sqrt{s_{NN}} = 2.76$ GeV



Integrated elliptic flow, v_2 , as a function of $|\eta| - y_{\text{beam}}$ for three centrality intervals indicated in the legend, measured by the ATLAS and CMS experiments for Pb+Pb collisions at 2.76 TeV and by the PHOBOS experiment for Au+Au collisions at 200 GeV. The CMS result is obtained by averaging the $v_2(p_T)$ with the charged particle spectra over the range $0 < p_T < 3$ GeV.

Summary

- W, Z, hard photons behave as expected
- jets are strongly suppressed in central Pb+Pb
- jets are strongly modified in central Pb+Pb
- jets and hadrons in P+Pb not completely trivial
- detailed analyses gradually appear, stay tuned!

Last ATLAS Heavy-ion conf notes I.

Charged particle production in proton-lead collisions measured by the ATLAS detector
ATLAS-CONF-2014-029 29-May-2014

Angular correlations of jets in lead-lead collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS detector
ATLAS-CONF-2014-028 20-May-2014

Collective flow with higher-order cumulants in lead-lead collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS detector at the LHC
ATLAS-CONF-2014-027 20-May-2014

Centrality, rapidity and pT dependence of isolated prompt photon production in lead-lead collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS detector at the LHC
ATLAS-CONF-2014-026 19-May-2014

Measurements of the nuclear modification factor for jets in Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS detector
ATLAS-CONF-2014-025 19-May-2014

Centrality and rapidity dependence of inclusive jet production in $\sqrt{s_{NN}} = 5.02$ TeV proton-lead collisions with the ATLAS detector
ATLAS-CONF-2014-024 19-May-2014

Last ATLAS Heavy-ion conf notes II.

Measurement of W boson production and the lepton charge asymmetry in Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS detector ATLAS-CONF-2014-023 18-May-2014

Elucidating the event-shape fluctuations via flow correlations and jet tomography studies in 2.76 TeV Pb+Pb collisions using the ATLAS detector ATLAS-CONF-2014-022 17-May-2014

Measurement of the long-range pseudorapidity correlations and associated Fourier harmonics in $\sqrt{s_{NN}} = 5.02$ TeV proton-lead collisions with the ATLAS detector ATLAS-CONF-2014-021 17-May-2014

Measurement of the Z-boson production in pPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV with the ATLAS detector ATLAS-CONF-2014-020 17-May-2014

Transverse momentum, rapidity, and centrality dependence of inclusive charged-particle production in $\sqrt{s_{NN}} = 5.02$ TeV p+Pb collisions measured by the ATLAS experiment ATLAS-CONF-2013-107 05-Nov-2013

Last ATLAS Heavy-ion conf notes III.

Measurement of the $W \rightarrow \mu\nu$ charge asymmetry and centrality dependence in Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS detector ATLAS-CONF-2013-106 04-Nov-2013

Measurement of the centrality-dependence of inclusive jet production in p+Pb data at $\sqrt{s_{NN}} = 5.02$ TeV with the ATLAS detector ATLAS-CONF-2013-105 04-Nov-2013

Performance of the ATLAS Minimum Bias and Forward Detector Triggers in pA collisions ATLAS-CONF-2013-104 01-Nov-2013

Measurement of the charged particle multiplicity distribution in p+Pb collision at $\sqrt{s_{NN}} = 5$ TeV with the ATLAS detector at LHC ATLAS-CONF-2013-096 12-Sep-2013

To be found at: ATLAS Public Results

<https://twiki.cern.ch/twiki/bin/view/AtlasPublic>