ATLAS results from Pb-Pb collisions at 2.76 TeV

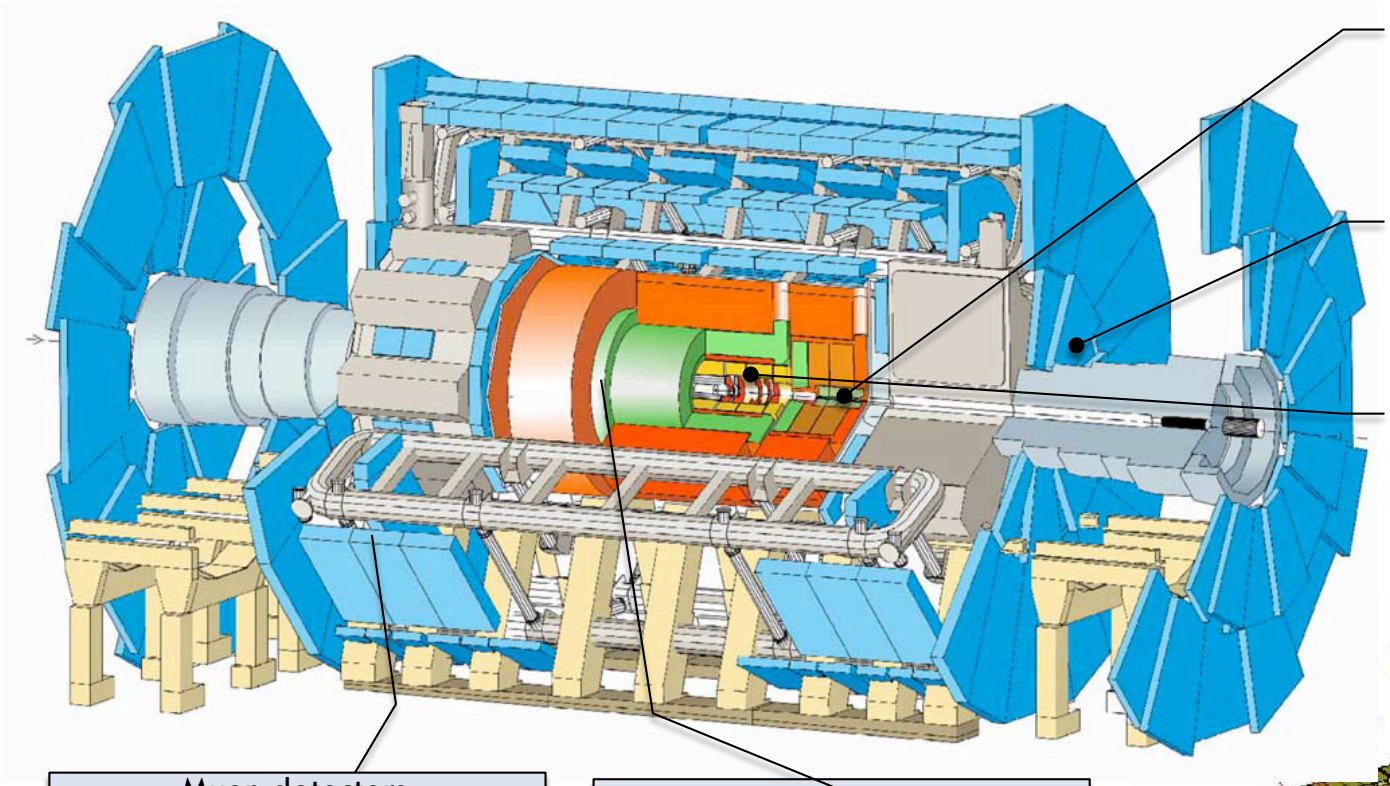
On behalf of ATLAS Collaboration

Tomasz Bold

UC Irvine, AGH-UST Krakow

PLHC 2011, Perugia

The ATLAS Detector



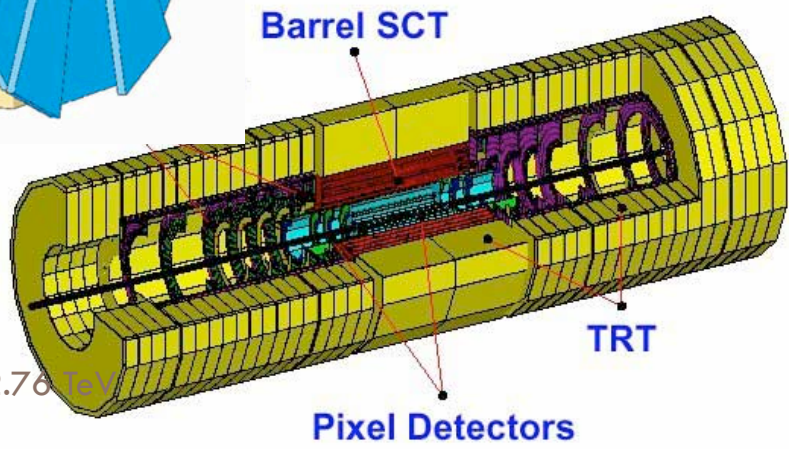
Forward calorimeters
$3.2 < |\eta| < 4.9$
centrality,
reaction plane

MBTS (Min-bias Trigger Scintillators):
$2.1 < |\eta| < 3.8$
For triggering

Inner Detector:
Pixel, SCT, TRT
$|\eta| < 2.5$

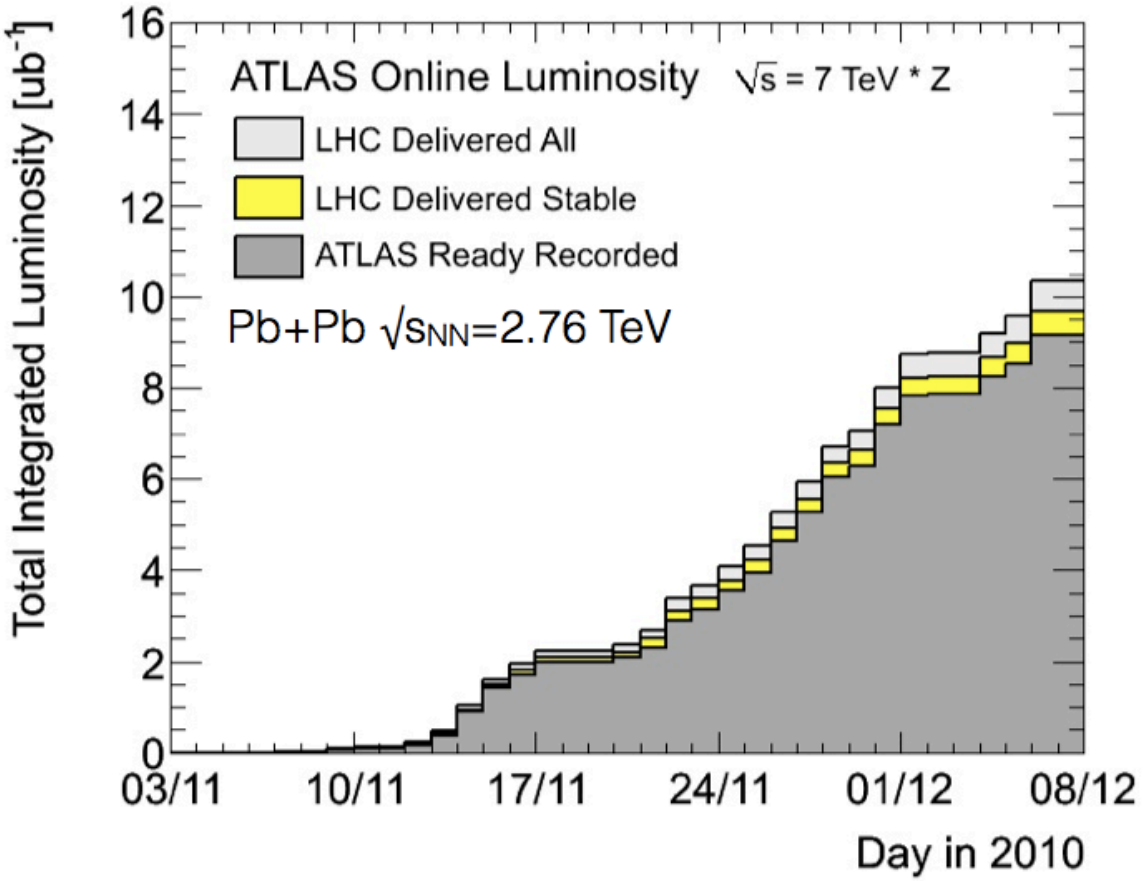
Muon detectors:
barrel RPC, MDT;
forward: TGC, CSC
$|\eta| < 2.5$

Calorimeters:
LAr, Tile
$|\eta| < 3.2$



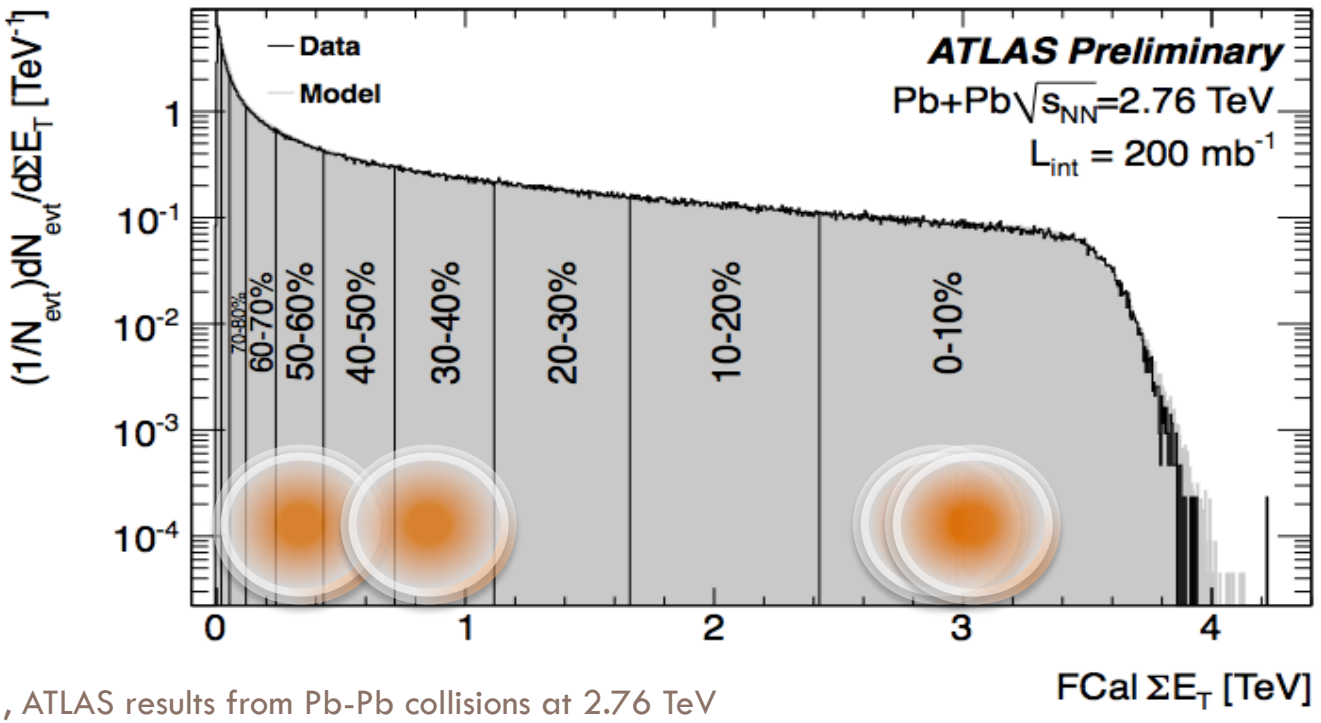
Recorded luminosity

- Delivered: 10 μ b^{-1}
- Recorded: 9 μ b^{-1}
  - 8 μ b^{-1} with solenoid on
- Only minimum-bias trigger used:
  - Zero Degree Calorimeter, MBTS
  - No high p_T triggers used to select the events



Centrality

- Measured FCal $\sum E_T$ ($3.2 < |\eta| < 4.9$) and compared to Glauber MC & pp data → scale of centrality errors - 2%
- Whole range split into percentiles of FCal $\sum E_T$ distribution
- $\langle N_{part} \rangle$
  $\langle N_{coll} \rangle$
  from centrality bin

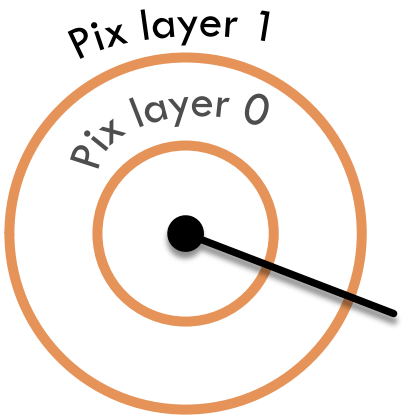


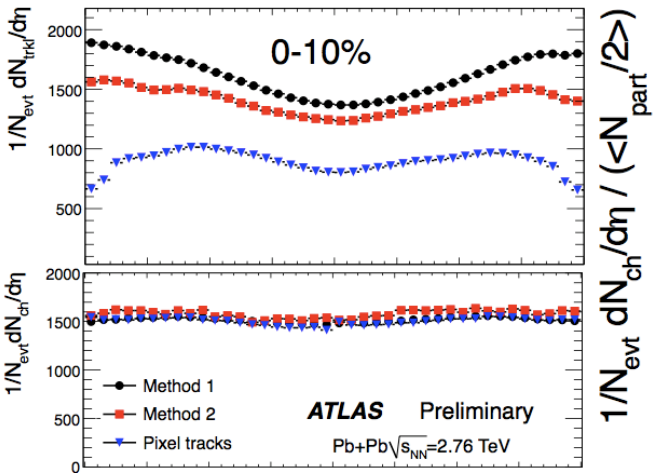
Charged particles yields and spectra

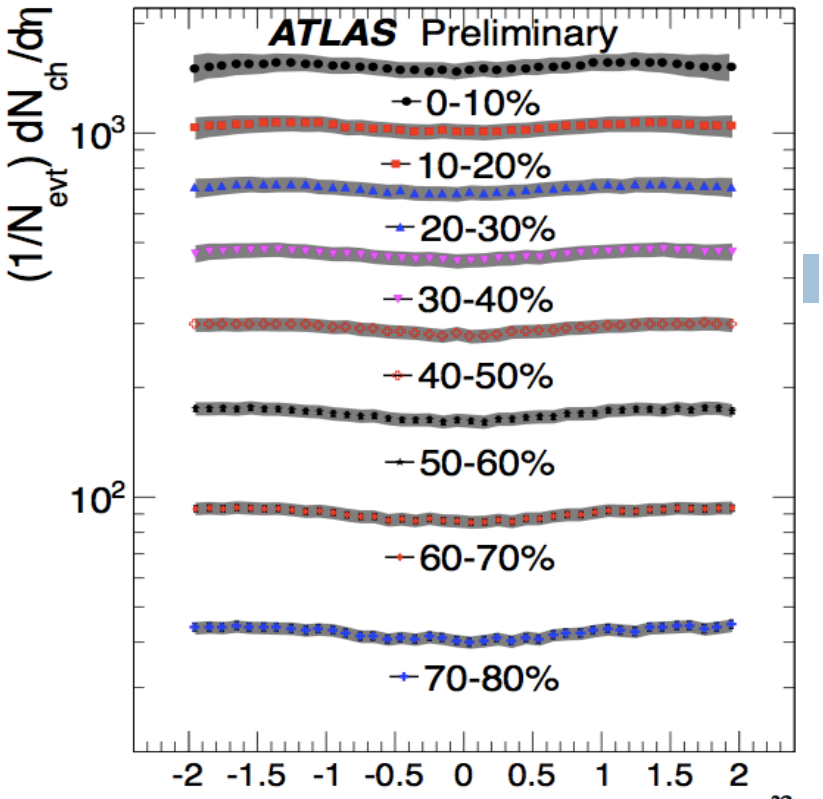
Total multiplicities

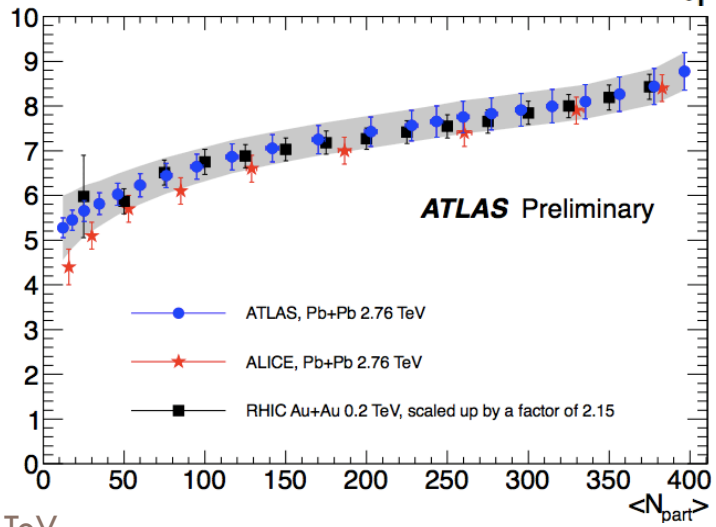
low p_T, mid-centrality

- Run w/o solenoid field → low p_T
  - Tracklet method – straight "track" from vertex through clusters in pixel layer 0 and 1
  - Also pixel tracks used
  - Efficiencies & fake ratios corrected from MC (and data)



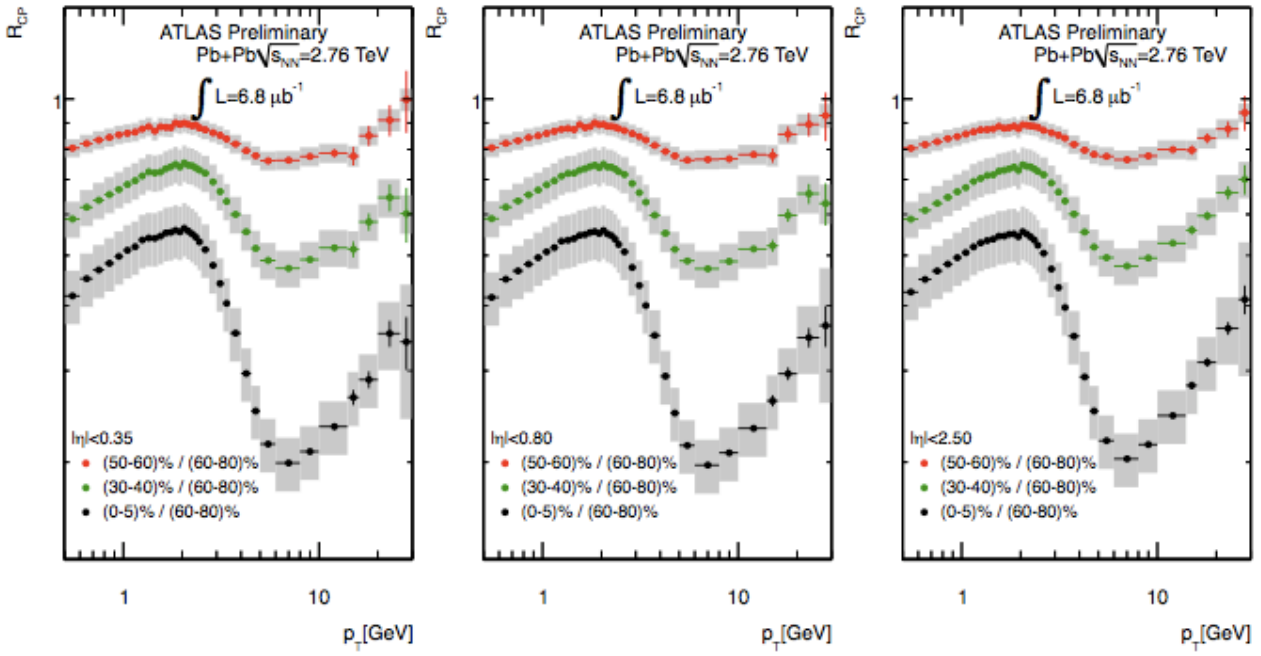






Spectrum

- Tracks (Pixel+SCT) $|\eta| < 2.5$
- R_{AA} modification better seen via:

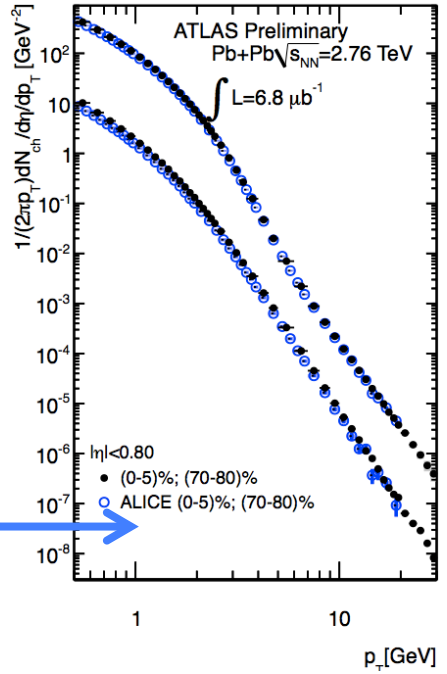


$$R_{CP} = \frac{N^C_{coll}}{N^P_{coll}} \frac{N^P_{evt}}{N^C_{evt}} \frac{d^2N^C/d\eta dp_T}{d^2N^P/d\eta dp_T}$$

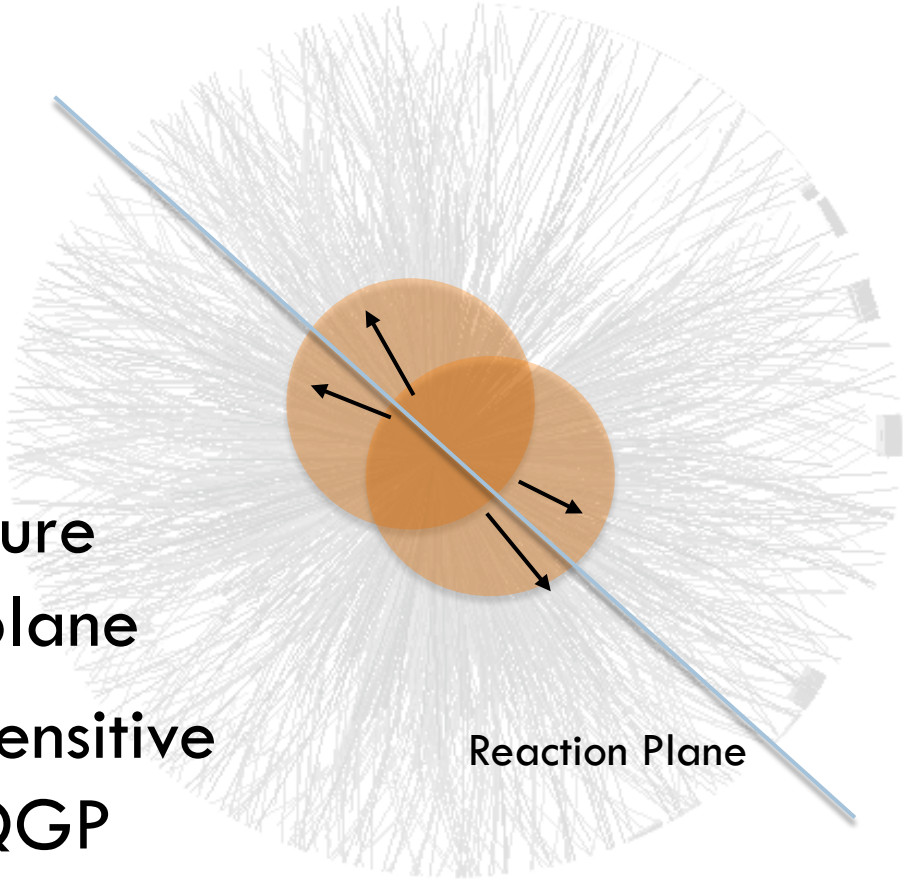
Minima around 7 GeV, no η dependence.

Weak η dependence.

Agrees with Alice.



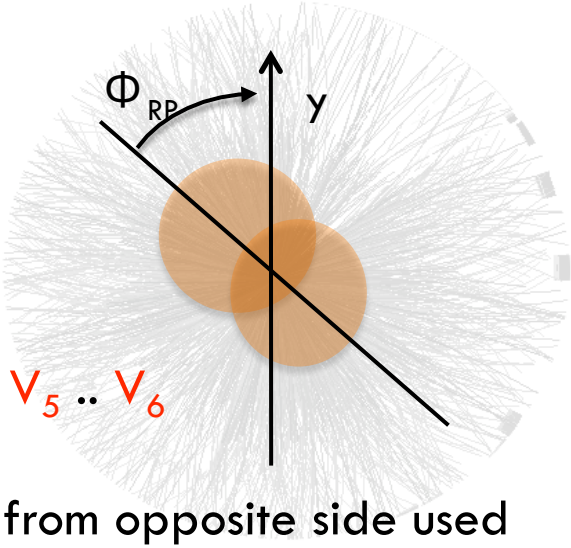
Azimuthal event shapes



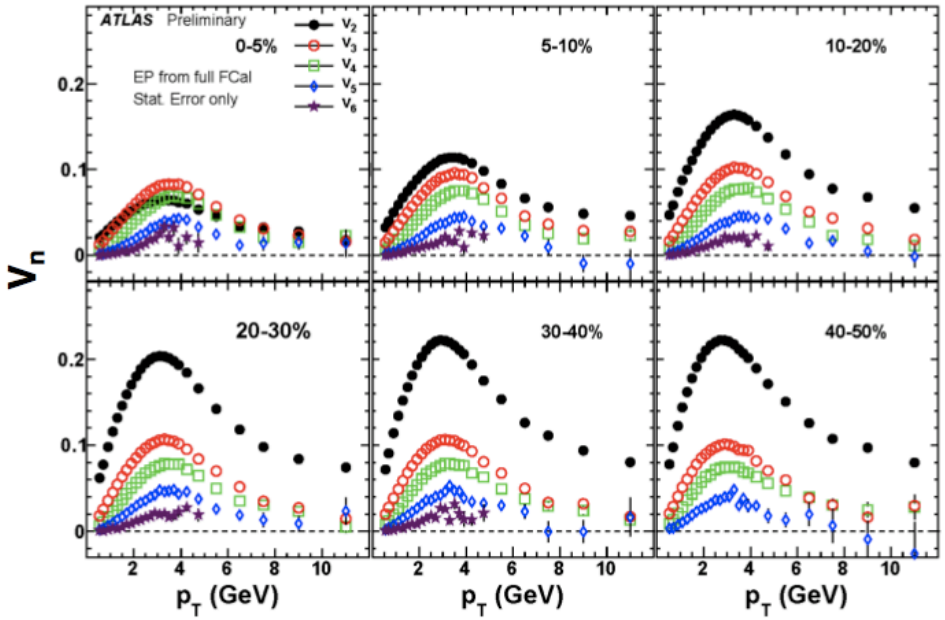
- Elliptic flow results from pressure gradient along the reaction plane
- Higher order flows possibly sensitive to viscous hydrodynamics in QGP
  - Alternative explanations are jet-medium interactions i.e. “mach cone”

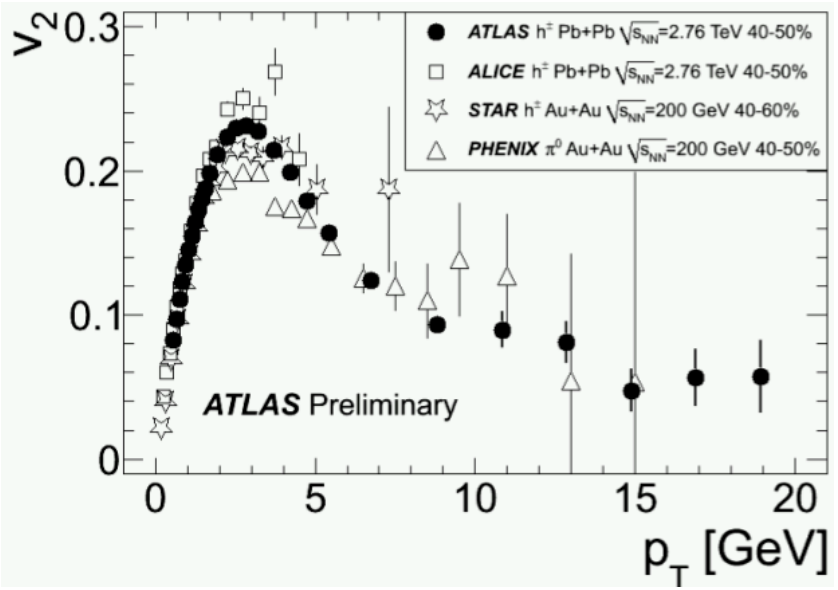
Flow

Event Plane method



- $dN/d(\phi - \Phi_{RP}) = N_0 (1 + 2v_1 \cos(\phi - \Phi_{RP}) + 2v_2 \cos(2(\phi - \Phi_{RP})) + 2v_3 \cos(3(\phi - \Phi_{RP})) + .. V_4 .. V_5 .. V_6$
- Φ_{RP} not measured → estimate Ψ_{EP} using FCal, independently for A and C sides of ATLAS → tracks from opposite side used (η -gap to avoid flow enhancement by di-jets & resonances decays)
- → new input for hydro models

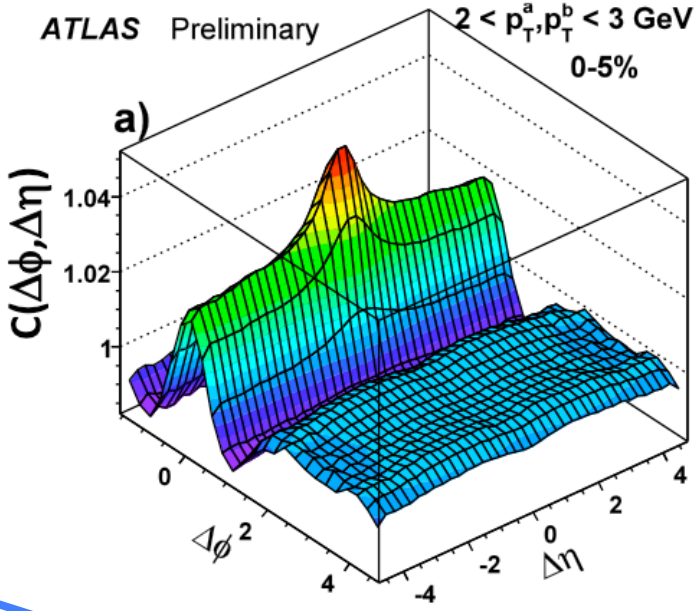


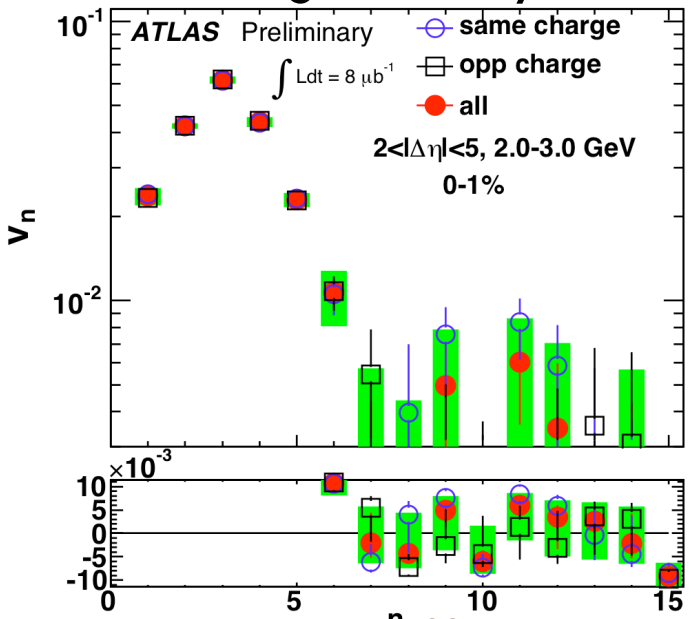


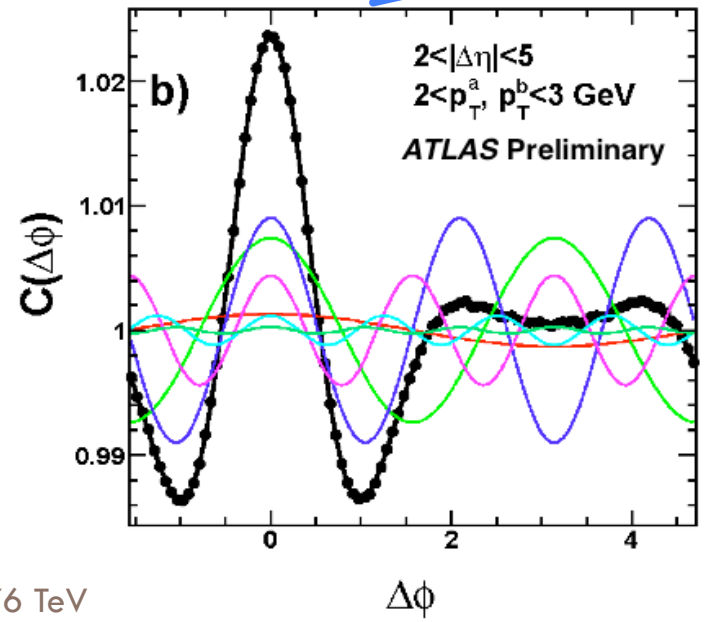
Flow

2-particle correlation

- $C(\Delta\phi, \Delta\eta) = N_{same}(\Delta\phi, \Delta\eta) / N_{mixed}(\Delta\phi, \Delta\eta)$
  - Projected/sliced into η and DFT
  - Range of p_T studied
- Results agree very well with Event Plane method.





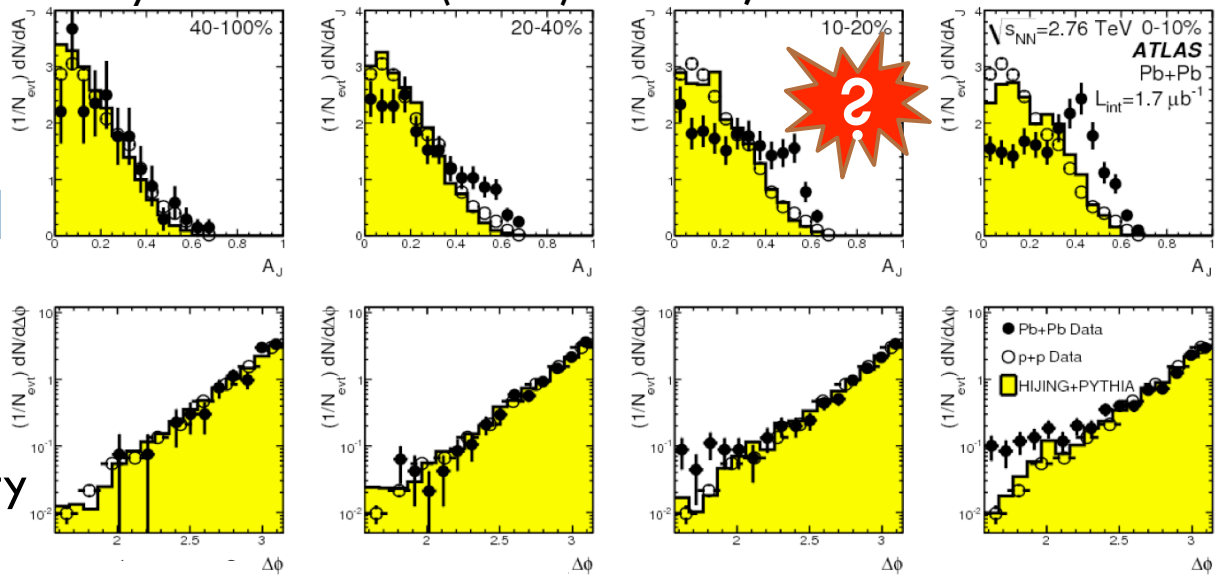


Hard probes

Jets

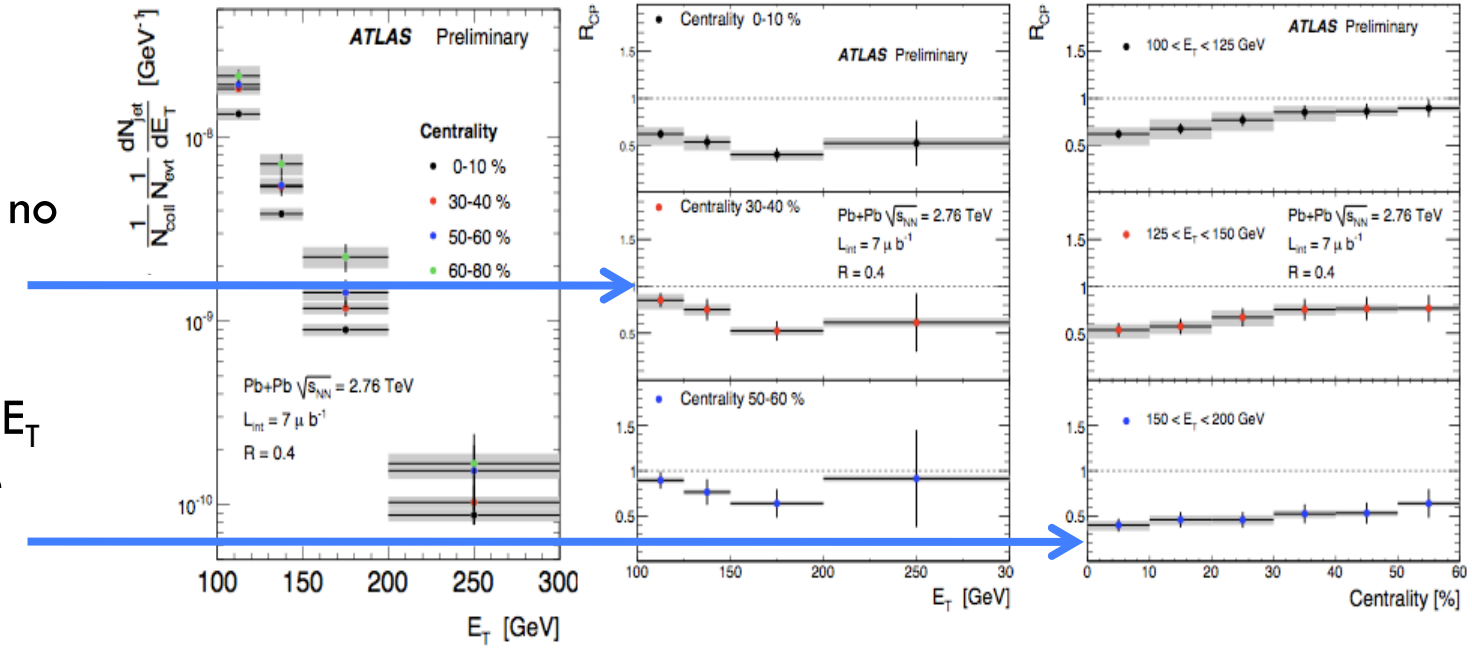
Assymetry & inclusive spectra

Phys. Rev. Let. 105(2010) 252303, arXiv: 1011.6182v2



- Measured quantity jet asymmetry $A_j = \frac{E_T^1 - E_T^2}{E_T^1 + E_T^2}$
- Observed enhancement of suppression with centrality

- Inclusive spectra
- R_{CP} vs E_T / in centrality bins → no dependence
- R_{CP} vs Centrality dependence / in E_T bins → moderate dependence

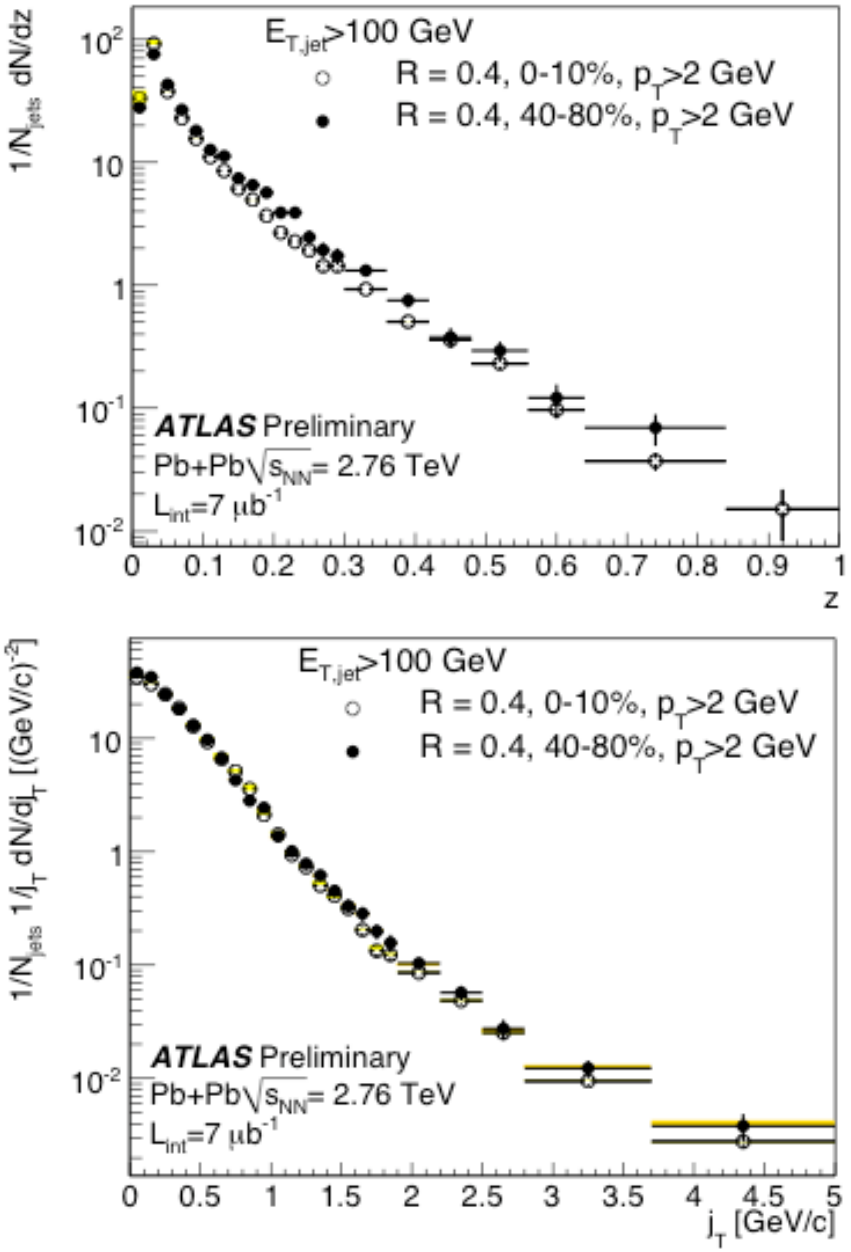


PLHC 2011, ATLAS results from Pb-Pb collisions at 2.76 TeV

Jets

Fragmentation functions

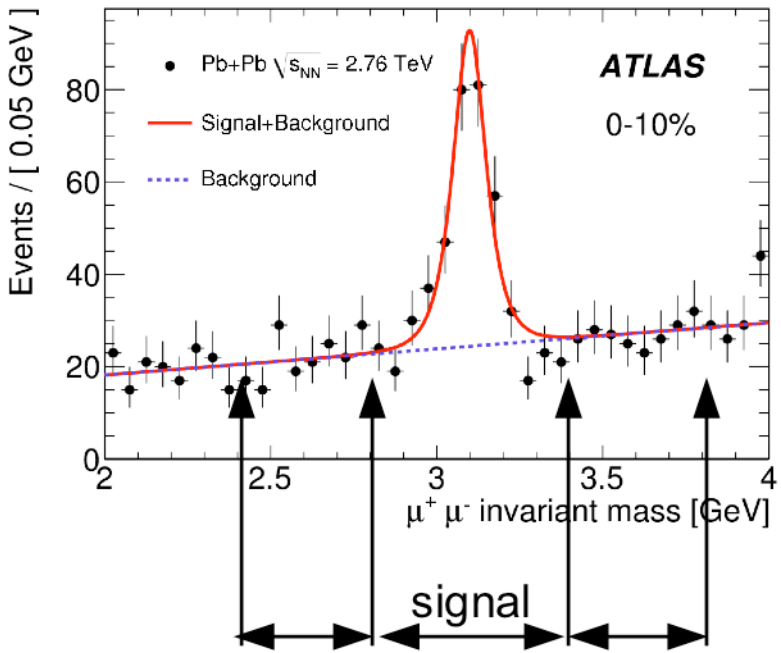
- Jet fragmentation functions
  - Longitudinal $z = \frac{p_T^{part}}{E_T^{part}} \cos\Delta R$
  - Transverse $j_T = p_T^{part} \sin\Delta R$
- No substantial change between central and peripheral despite large change in the yield

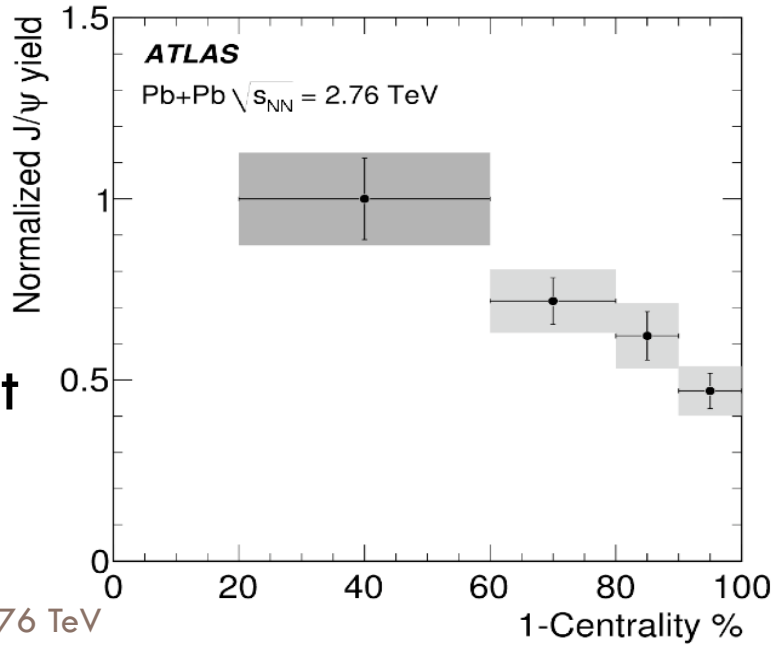


J/ψ suppression

- Color screening prevents formation of cc-bar states in QGP
  - This was seen by Phenix and NA50
  - And confirmed by ATLAS in the first study:
    $J/\psi \rightarrow \mu\ \mu$
    - $p_{T\,\mu} > 3$GeV, $|\eta_{\mu}| < 2.5$
  - Plan to look into prompt/non-prompt

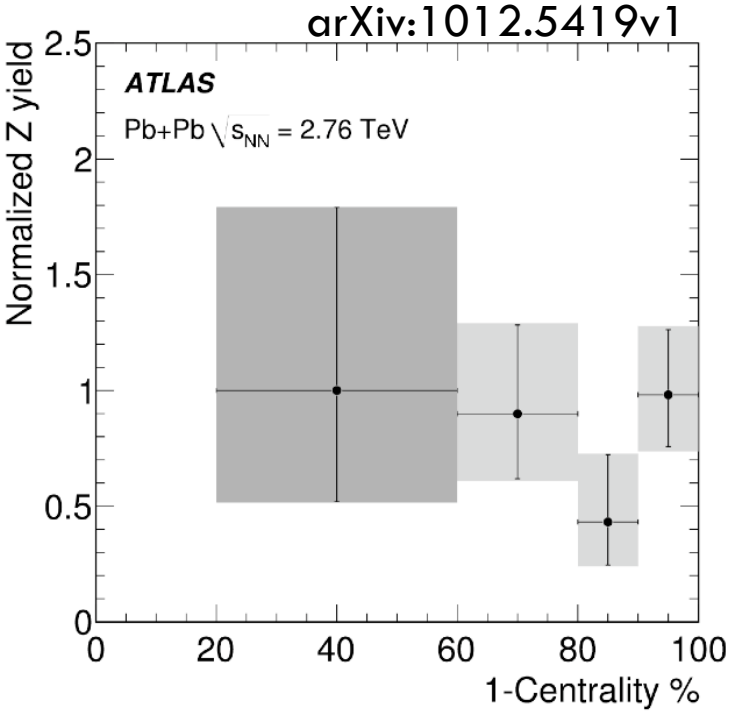
arXiv:1012.5419v1

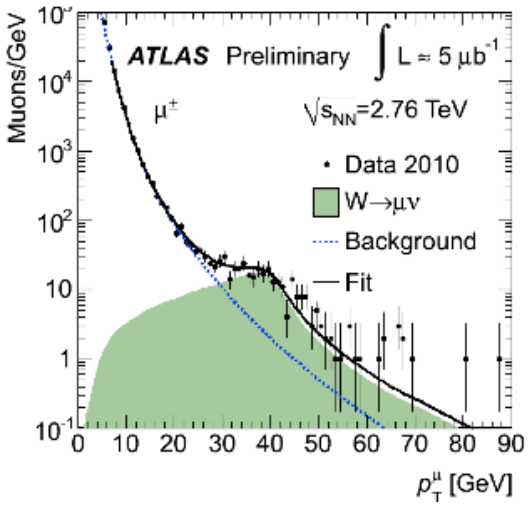


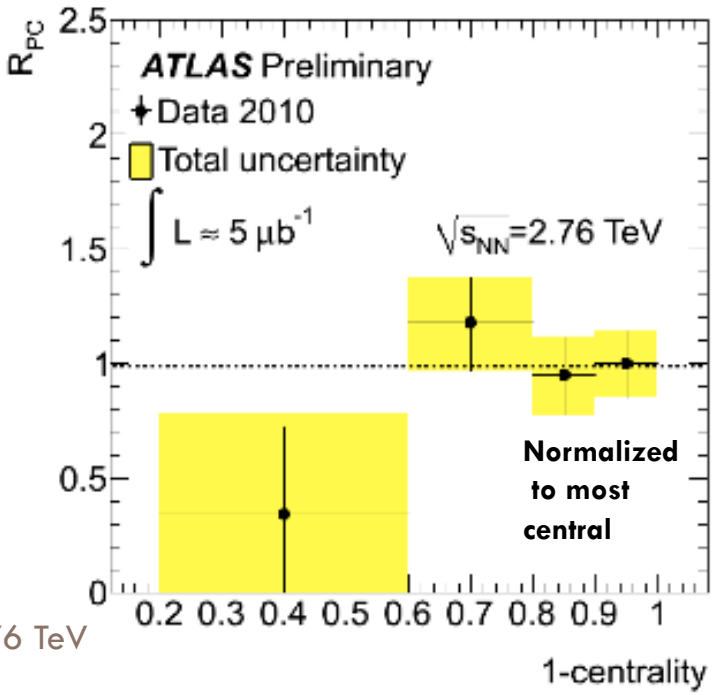


W and Z bosons

- No suppression should be seen for W and Z
  - Z → μ μ used to test this hypothesis
  - W → μ ν
    - E_t^{miss} impossible, use fit to MC templates
- No conclusion can be drawn about Z suppression
- W R_{CP} consistent with no-suppression
  - Measured $R_{W/Z} = 10.5 \pm 2.2$





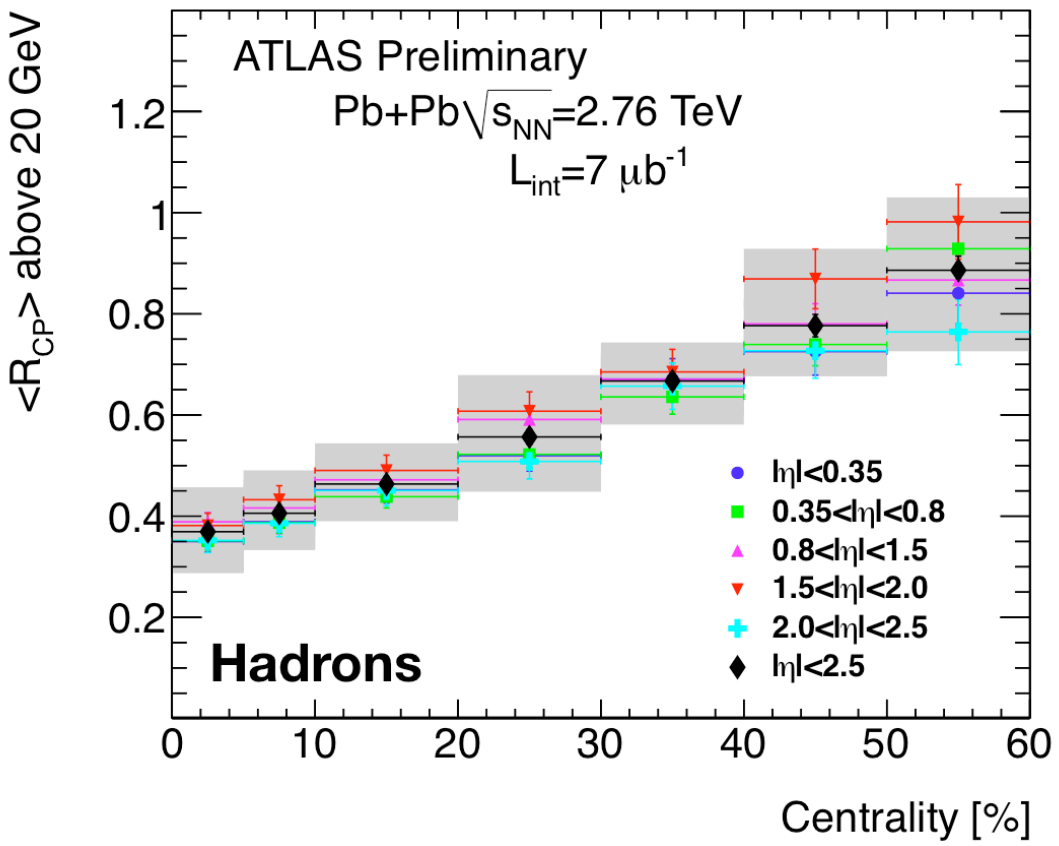


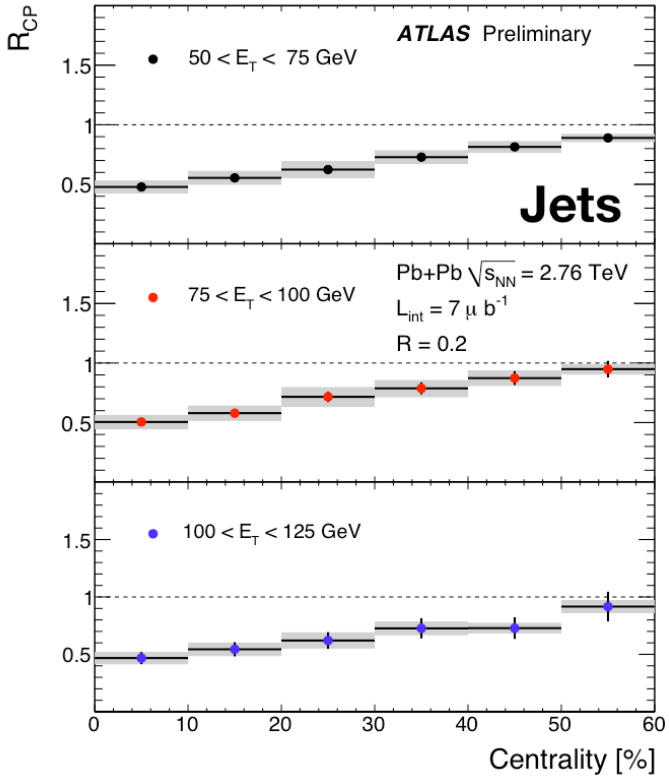
Summary

- ATLAS advances HI program:
  - Measured multiplicities of charged particles → comparable with other LHC experiments, raise by factor ~2 w.r.t. the RHIC
  - R_{CP} for charged particles has minimum around 7GeV and raises for higher p_T
  - Elliptic flow and higher modes studied in details → harmonics up to 6 measurable, challenges jet-medium explanation
  - Jet fragmentation functions unmodified going from central to peripheral
  - J/psi at mid-η suppressed, no W suppression, to low stat. for Z to conclude
- More analyses ongoing

Backup

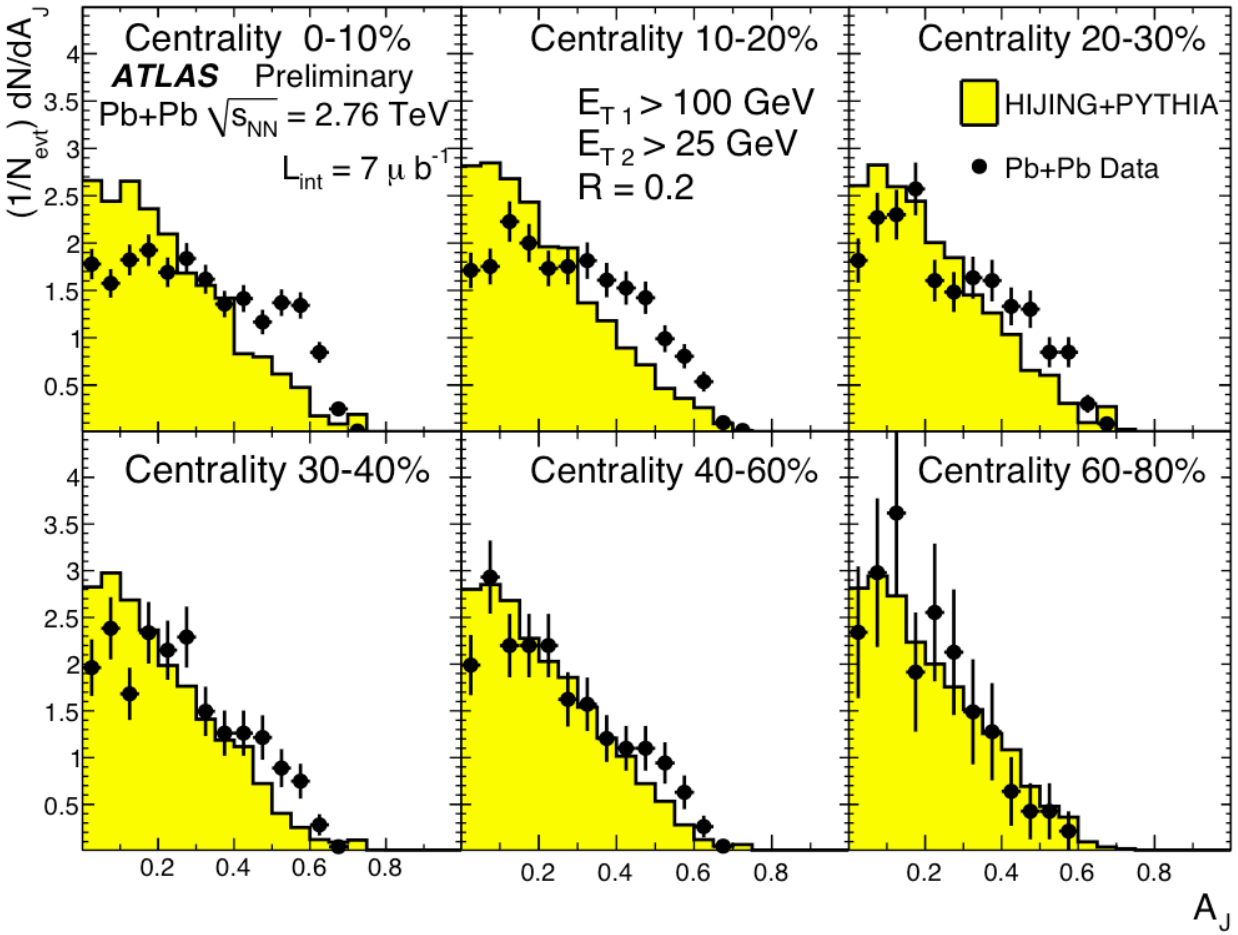
Jets & N_{ch}





PLHC 2011, ATLAS results from Pb-Pb collisions at 2.76 TeV

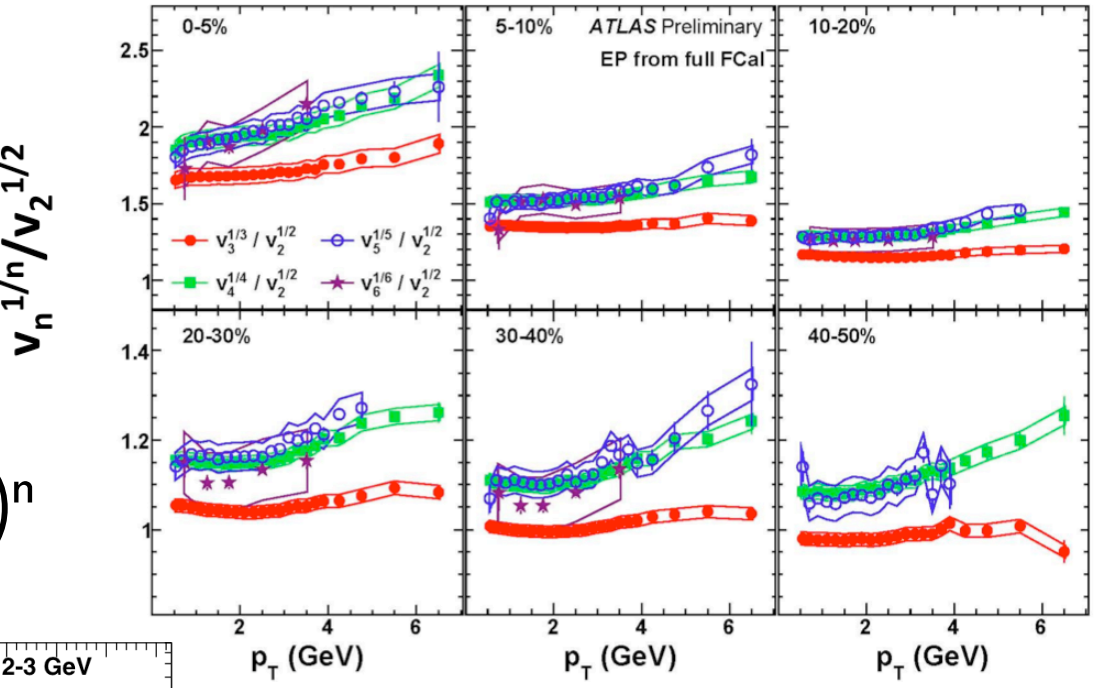
Narrow (R-0.2) jets

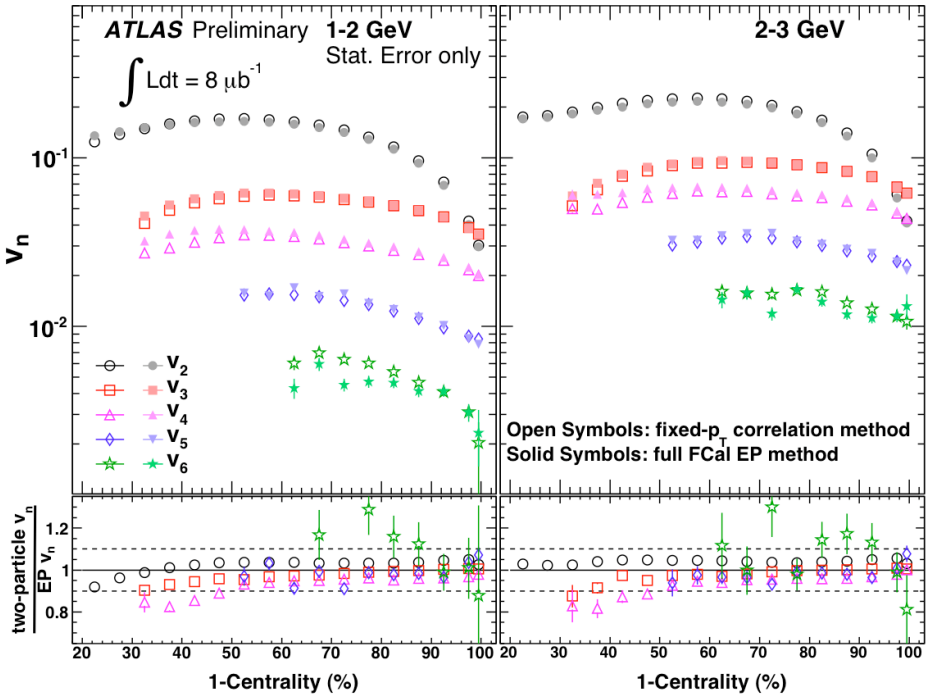


PLHC 2011, ATLAS results from Pb-Pb collisions at 2.76 TeV

Flows

- Hydro: $V_n^n \sim$ (expansion velocity)^n

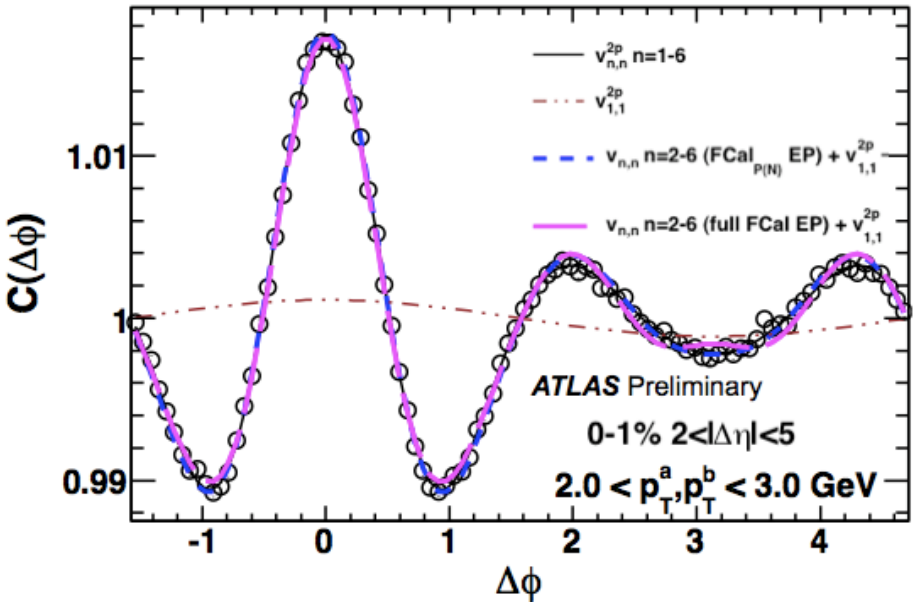


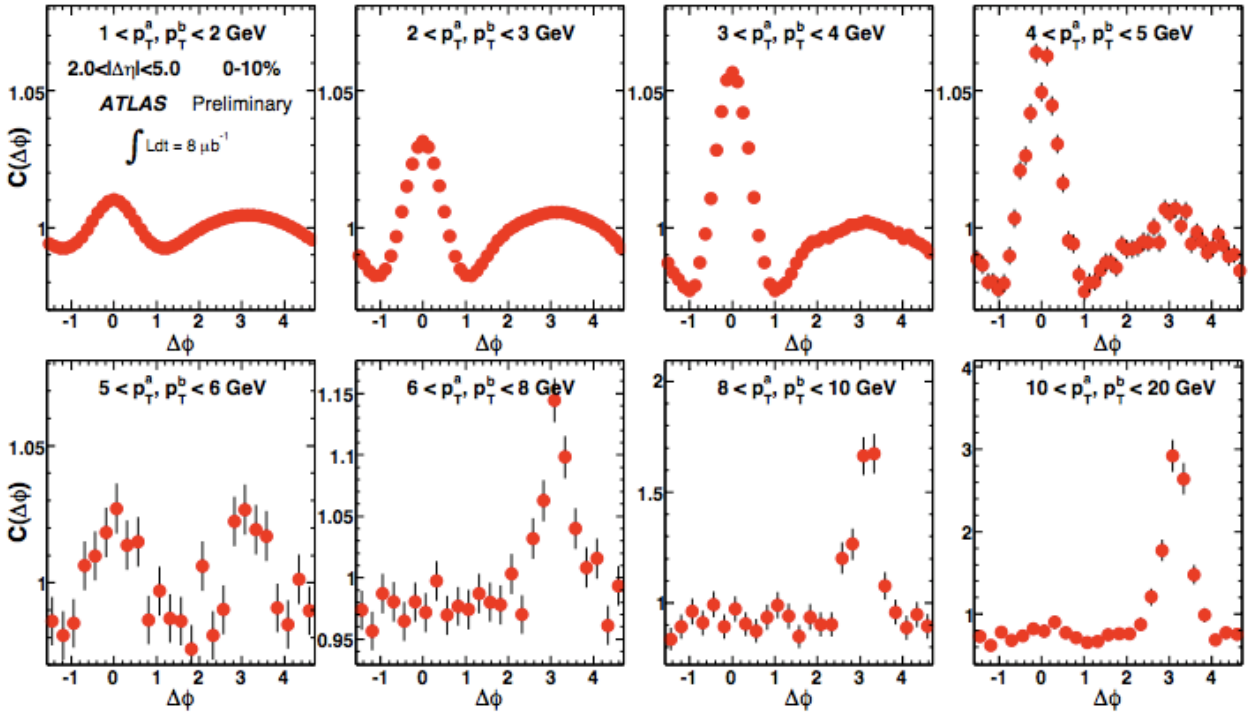


- EP and 2P methods comparison
  - Note dominant v_3 over v_2 at high centralities

Flow

- EP and 2P match





- High pt recovers second peak from di-jet

Tracklets details

- Fake tracklets counts estimated from MC
  - In "Method 2" used also trick with flipped pixel hits