

Charged particle spectra and nuclear modification factor in lead-lead collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS detector at the LHC

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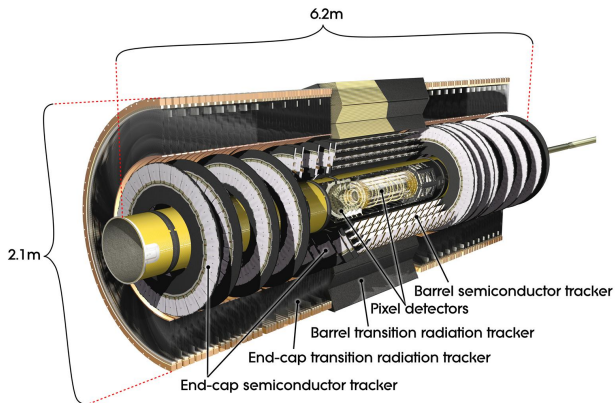
- why to study charged particle spectra?
 - ▶ to understand properties of hot dense matter created in HI collisions
 - ▶ to understand the mechanism of energy loss of partons
- study ratio of central (C) and peripheral (P) spectra:

$$R_{CP} = \frac{\frac{1}{N_{\text{coll}}(C) \cdot N_{\text{events},C}} d^2 N_C / d\eta d p_T}{\frac{1}{N_{\text{coll}}(P) \cdot N_{\text{events},P}} d^2 N_P / d\eta d p_T}$$

- as a peripheral bin we take 60–80%
- previously measured R_{CP} and spectra up to 30 GeV
- high luminosity collected by ATLAS in 2011 allow us to extend previous measurements

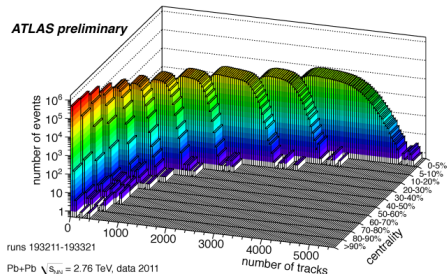
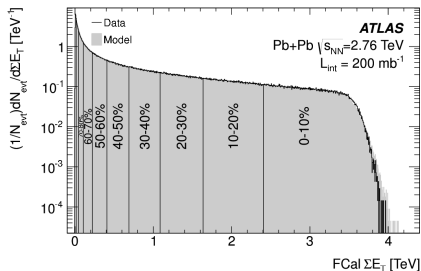
ATLAS detector – Inner detector

- $p_T > 0.5 \text{ GeV}$
- $|\eta| < 2.5$
- full ϕ coverage



determination of centrality

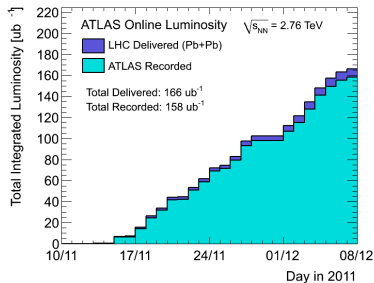
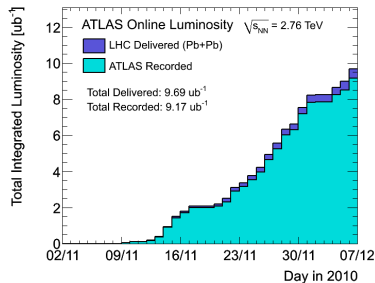
- centrality based on energy deposited in Forward Calorimeter – $3.1 < |\eta| < 4.9$
- model – based on Glauber calculation convoluted with p+p data



event selection

used data 2010 and 2011:

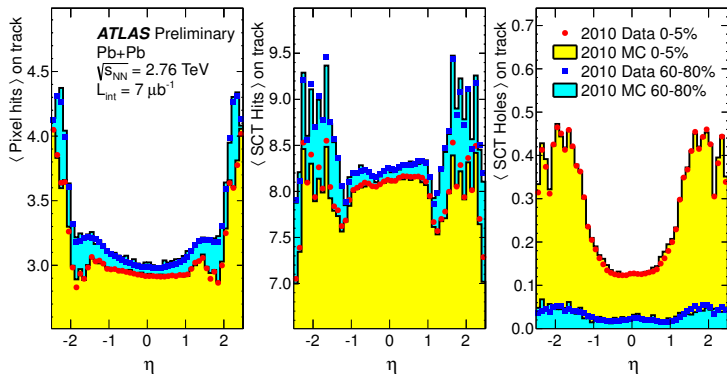
- minimum bias 2010 – $7 \mu\text{b}^{-1}$, 50.7M events
 - ▶ MBTS *or* ZDC
- minimum bias 2011 – $7 \mu\text{b}^{-1}$, 50.7M events
 - ▶ total energy $> 50 \text{ GeV}$
 - ▶ *or* signal from ZDC+track
- hard probes 2011 – 0.14 nb^{-1} , 998M sampled events
 - ▶ unrescaled jet trigger; anti- k_T , $E_T > 20 \text{ GeV}$



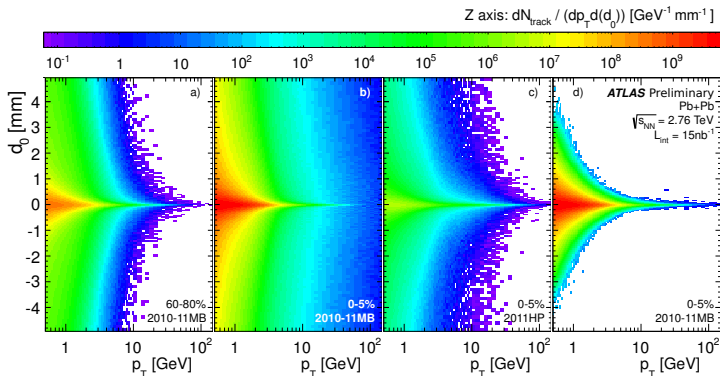
track selection

each track is required to have:

- at least 2 Pixel hits, one in the innermost layer
- at least 7 SCT hits
- no Pixel or SCT holes

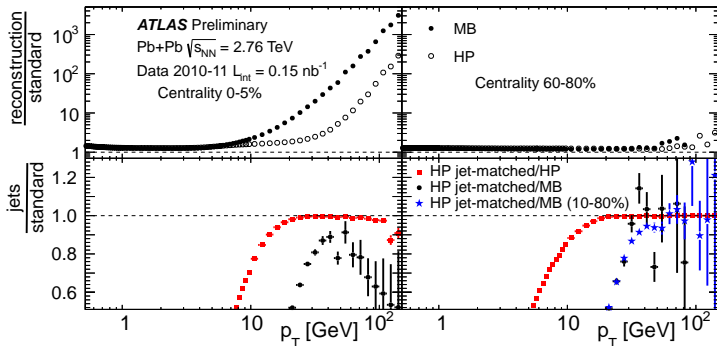


track selection



- Pixel measure d_0 and $z_0 \sin \theta$ precisely
- due to high occupancy, SCT measure p_T of some tracks incorrectly
- this caused populating area of high p_T and high d_0
- significance cuts on d_0 and $z_0 \sin \theta$ solve this problem

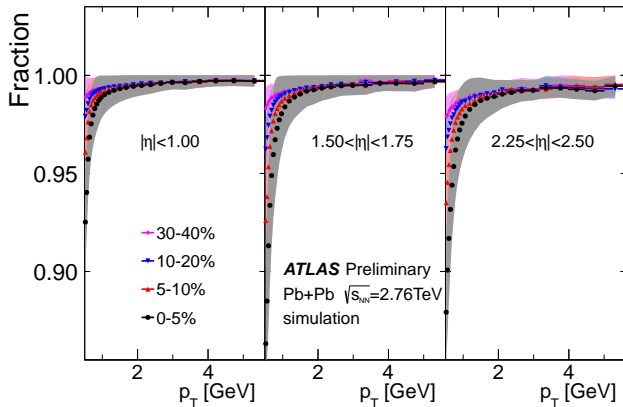
raw spectra



- tracking cuts able to deal with signal/background up to 1/100
 - need matching to jets from ~ 60 GeV
-
- for spectra and R_{CP} , muon and electrons (and positrons) are subtracted – these are μ^\pm and e^\pm from W decay

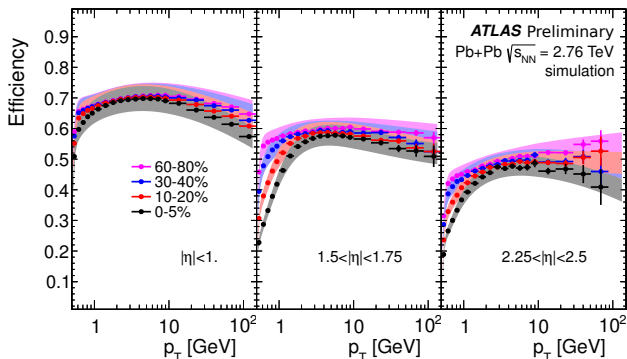
fakes and secondaries correction

- low- p_T tracks are corrected for fakes and secondary particle
- based on PYTHIA events embedded into HIJING



efficiency correction

- efficiency estimated with PYTHIA events embedded into HIJING (2010) or data (2011)
- evaluate efficiencies in 7 η bins and 9 centrality bins
- used bin-by-bin unfolding to correct spectra for momentum resolution
- we use iterative approach - once fully corrected spectra are obtained, MC spectrum is reweighed to follow data

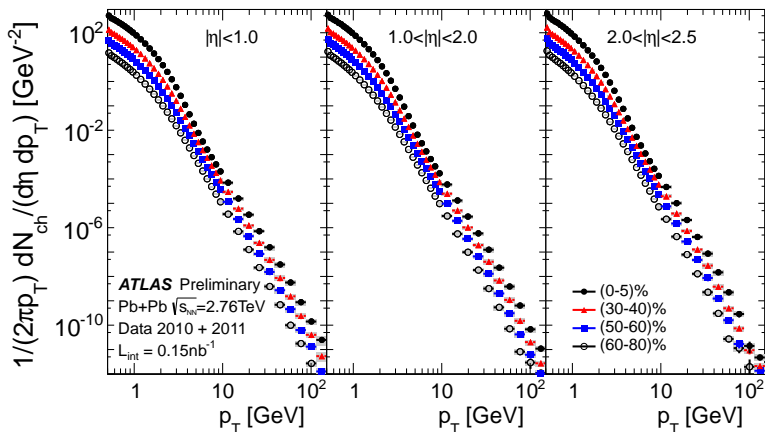


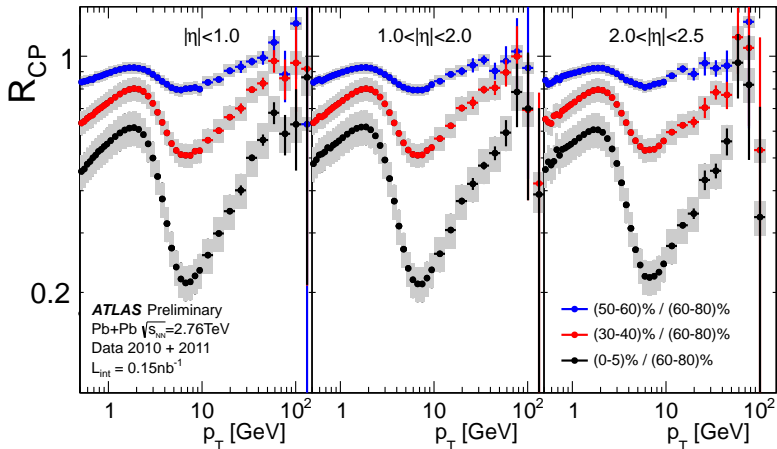
systematic uncertainties

Source	Spectra	R_{CP}
Tracking cuts	4%	3%
PV pointing cuts	1-4%	1-3%
Truth association	1%	2%
Efficiency	3-20%	5%
Feed down	0-3%	–
Material budget	2-5%	–
Momentum scale	0-6%	–
Trigger efficiency	2%	1%
Electroweak decays	1%	1%
N_{coll} ratios	–	3.8-11.7%

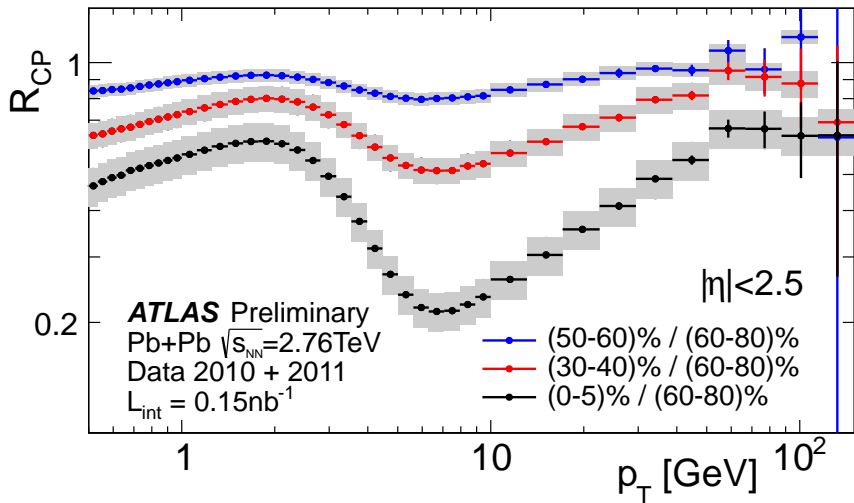
- in uncertainty of efficiency is hidden all unfolding uncertainties

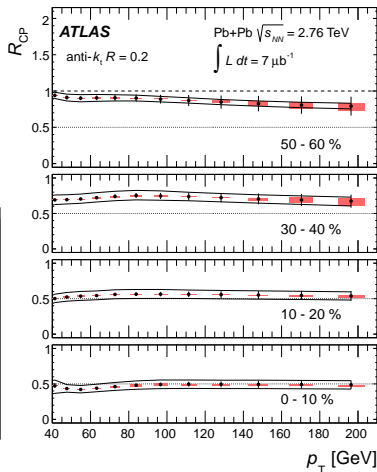
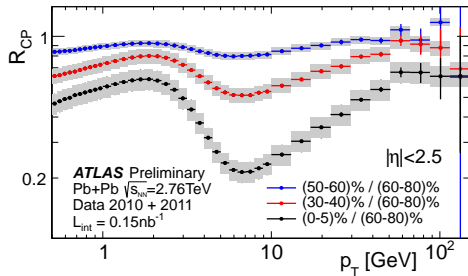
- use minimum bias events for $p_T < 30$ GeV and hard probes events for $p_T > 30$ GeV



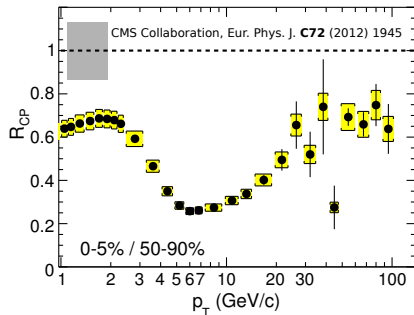
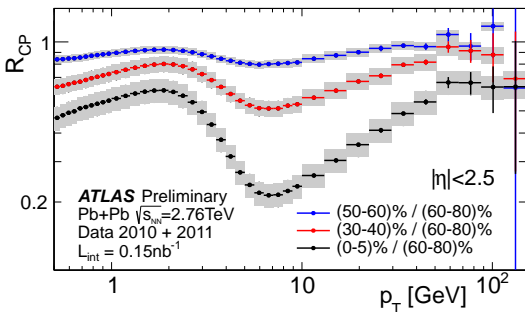


- R_{CP} has no η dependency



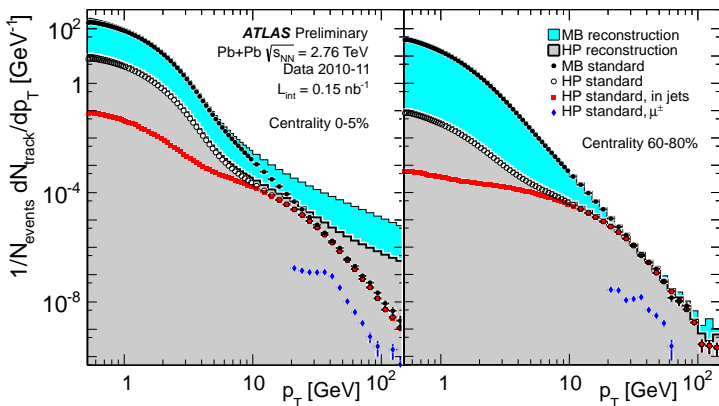


- compatible with jet measurement



- CMS has different peripheral bin
- ATLAS used lower threshold for jet trigger
 → better statistics at high p_T

- measured spectra and R_{CP} within $|\eta| < 2.5$ and $0.5 \text{ GeV} < p_{\text{T}} < 150 \text{ GeV}$
- minimum seen at around 7 GeV; above show rise up to high p_{T}
- very good statistics up to $\sim 70 \text{ GeV}$; higher p_{T} limited by statistics of peripheral bin
- compatible with level of suppression measured in jets



- good agreement between MB and HP at high p_T