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Measurements of particle production, Bose-Einstein correlations and Underlying Event properties with the ATLAS detector

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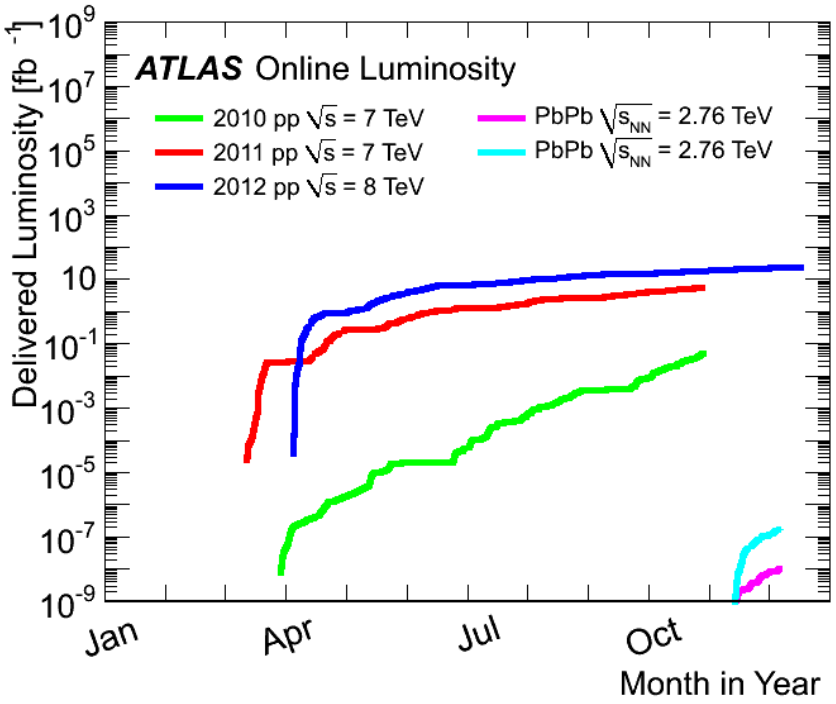
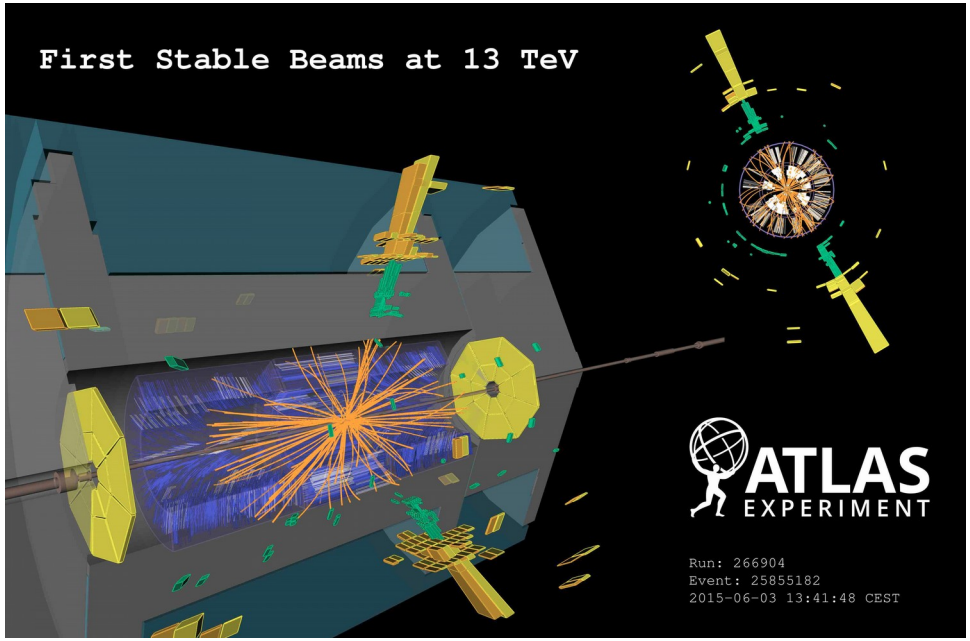
On behalf of the ATLAS collaboration

HELMHOLTZ GEMEINSCHAFT

DESY

Introduction





- Tracking system ideal for the measurement of track based particles properties
- Multi purpose detector:
  - Can measure events with different detector technologies
  - Possibility to measure soft-QCD with complementary methods
  - First comparisons with 13 TeV data will be shown in the talk

Publications

- New 7 TeV results for Bose Einstein Correlations and Lamda polarisation:
  - Two-particle Bose-Einstein correlations in pp collisions at √s= 0.9 and 7 TeV measured with the ATLAS detector (arXiv:1502.07947, submitted to EPJC)
  - Measurement of the transverse polarization of Λ and anti-Λ hyperons produced in proton-proton collisions at √s=7 TeV using the ATLAS detector (arXiv:1412.1692; submitted to PRD)
- 7 TeV underlying event results:
  - Measurement of distributions sensitive to the underlying event in inclusive Z-boson production in pp collisions at √s = 7 TeV with the ATLAS detector (Eur.Phys.J. C74 (2014) 2965)
  - Measurement of the underlying event in jet events from √s=7 TeV proton–proton collisions with the ATLAS detector (Eur.Phys.J. C74 (2014) 2965)
  - Underlying event characteristics and their dependence on jet size of charged-particle jet events in pp collisions at √s = 7 TeV with the ATLAS detector (Phys. Rev. D 86 (2012) 072004)
  - Measurements of underlying-event properties using neutral and charged particles in pp collisions at √s = 900 GeV and √s = 7 TeV with the ATLAS detector at the LHC (Eur.Phys.J. C71 (2011) 1636)
  - Measurement of underlying event characteristics using charged particles in pp collisions at √s = 900 GeV and 7 TeV with the ATLAS detector (Phys. Rev. D83 (2011) 112001)
- Brand new: 13 TeV comparisons for underlying-event using charged particles
  - Detector Level plots for UE with leading track: PUB-STDM-2015-03

Bose Einstein Correlations (BEC)

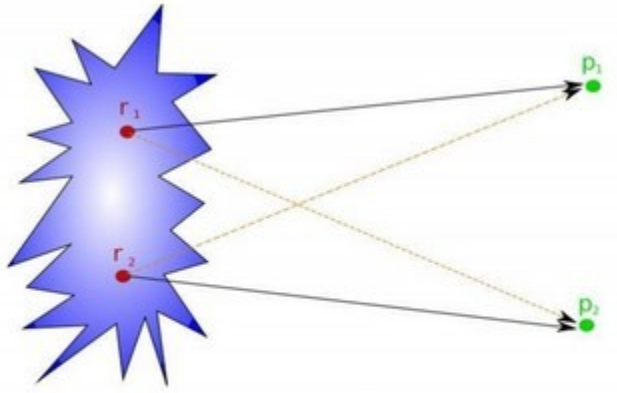
- BEC: higher emission probability of two mesons with very similar momentum
- Two particle correlation C_2 of same sign particles:

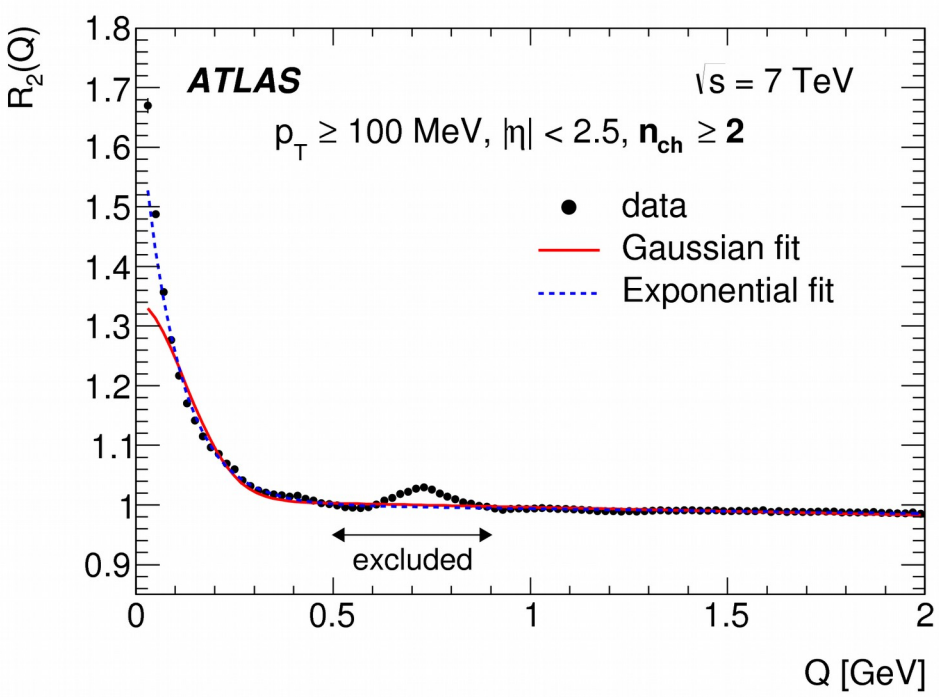
$C_2(Q^2)=\rho(++,--)/\rho(+-)$ with $Q^2= -(P_1-P_2)^2$

$R_2(Q^2) = C_2(Q^2)_{data}/C_2(Q^2)_{MC}$

MC := MC without BEC

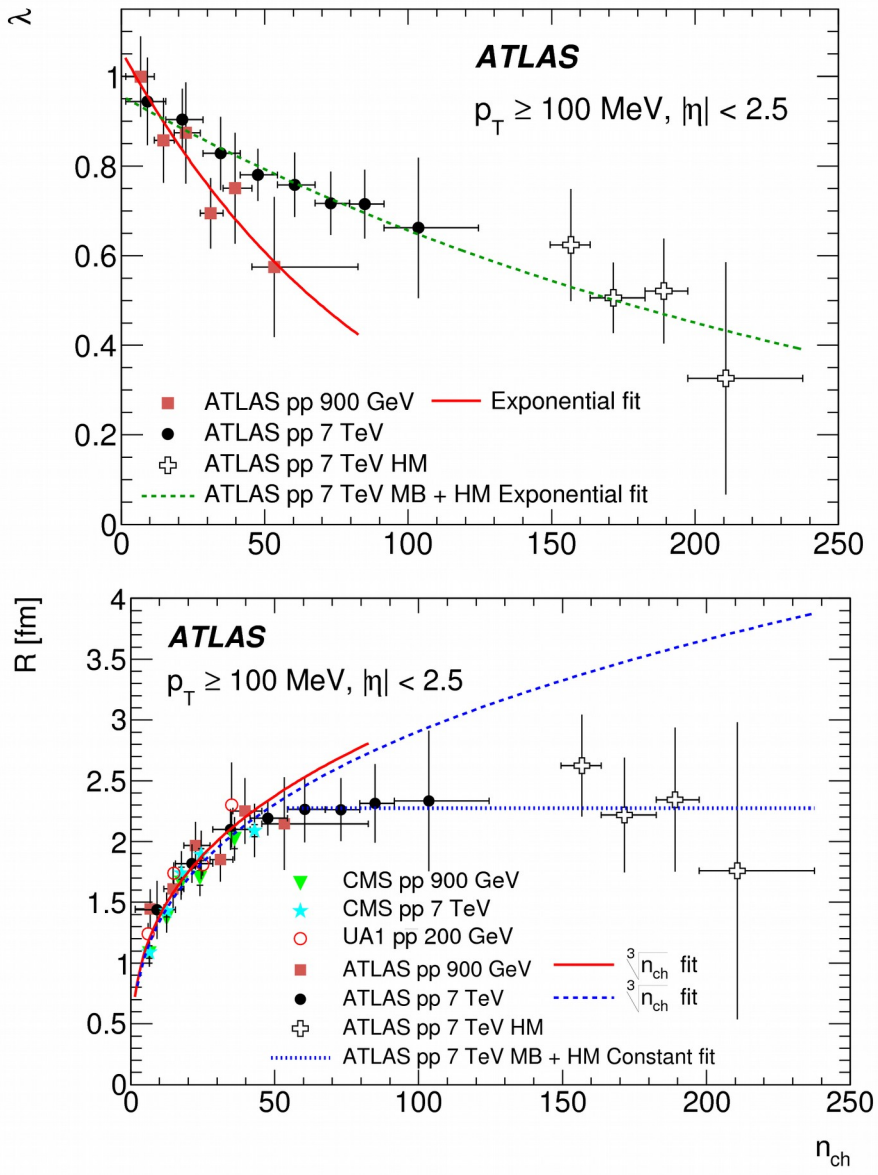
- Fit to extract BEC, two possible parametrisations:
  - $\lambda \cdot \exp(-R^2Q^2)$, gauss
  - $\lambda \cdot \exp(-RQ)$, exponential
  - λ:= strength of BEC
  - R: effective radius





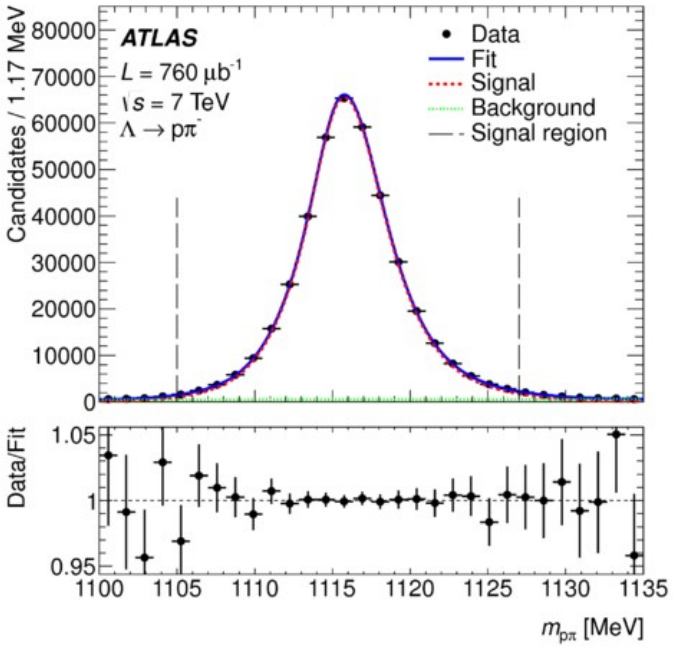
Bose Einstein Correlations

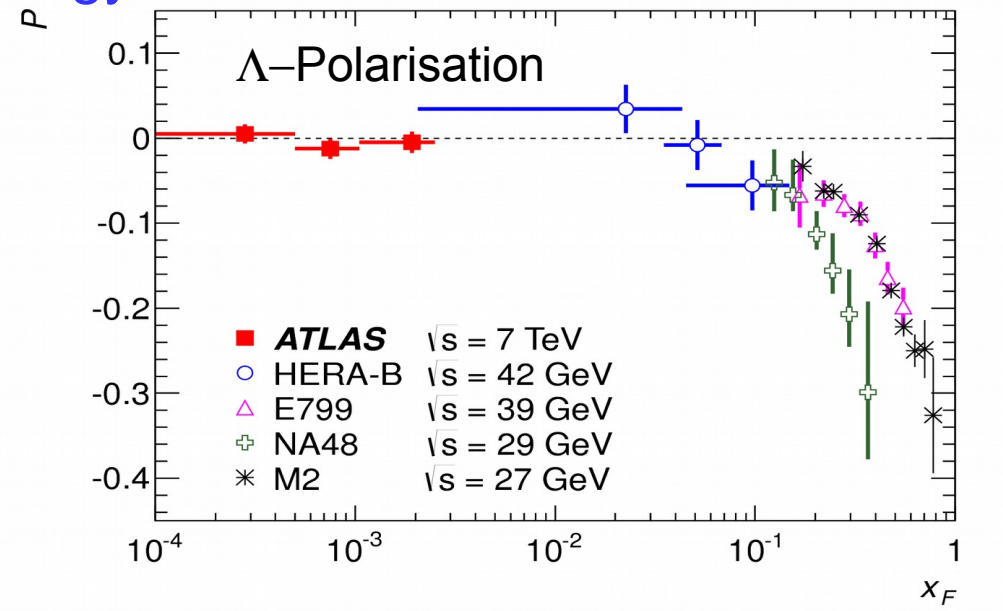
- λ:= strength
  - 0 → fully correlated, 1 → chaotic
  - Depends on centre of mass energy and charged multiplicity n_{ch}
- R := effective radius of the BEC
  - Saturation at n_{ch}~70
  - proton overlap, expect for a decreases at very high n_{ch}



Lambda Polarisation in the transverse plane

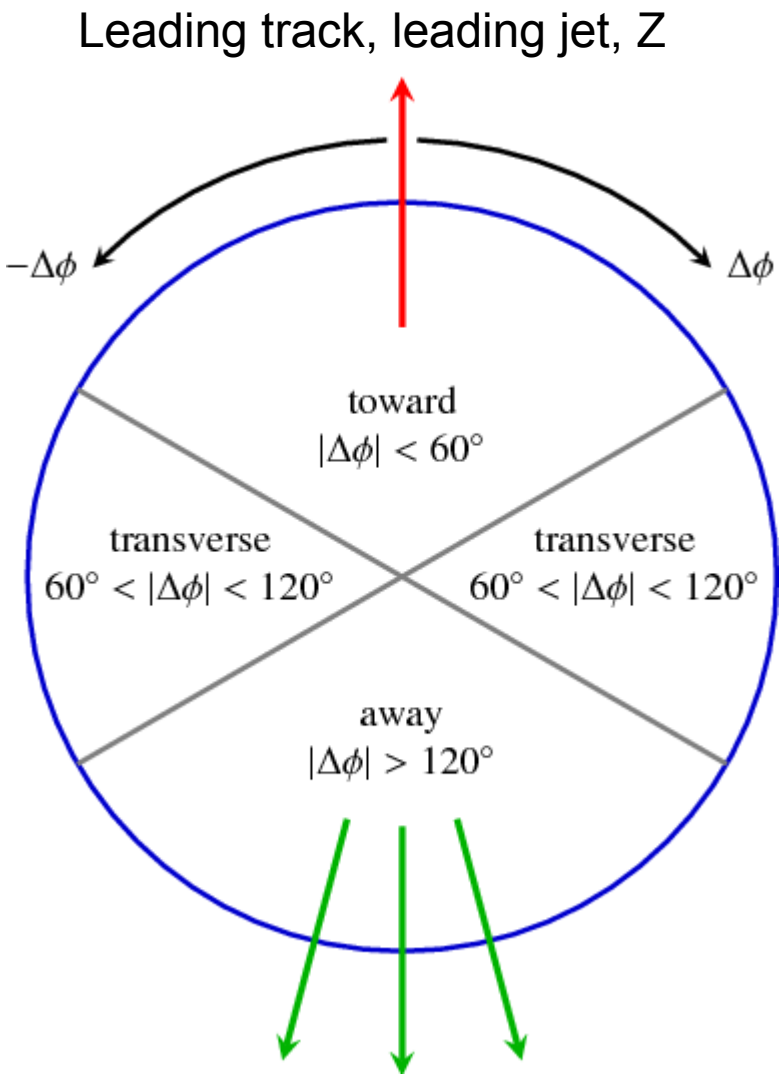
- Huge Λ sample allows to measure Λ polarisation P by measuring the decay angle $\cos\theta^*$ between the decay proton and Λ flight directions
  - $P(\Lambda) = (1 + \alpha P \cos\theta^*)$; Decay asymmetry : $\alpha = 0.642 \pm 0.013$
- Results:
  - $P(\Lambda) = -0.010 \pm 0.005(\text{stat}) \pm 0.004(\text{syst})$
  - $P(\overline{\Lambda}) = \ 0.002 \pm 0.006\ (\text{stat}) \pm 0.004(\text{syst})$
- Consistent to previous measurement which expect a degradation of the Λ polarisation at high energy





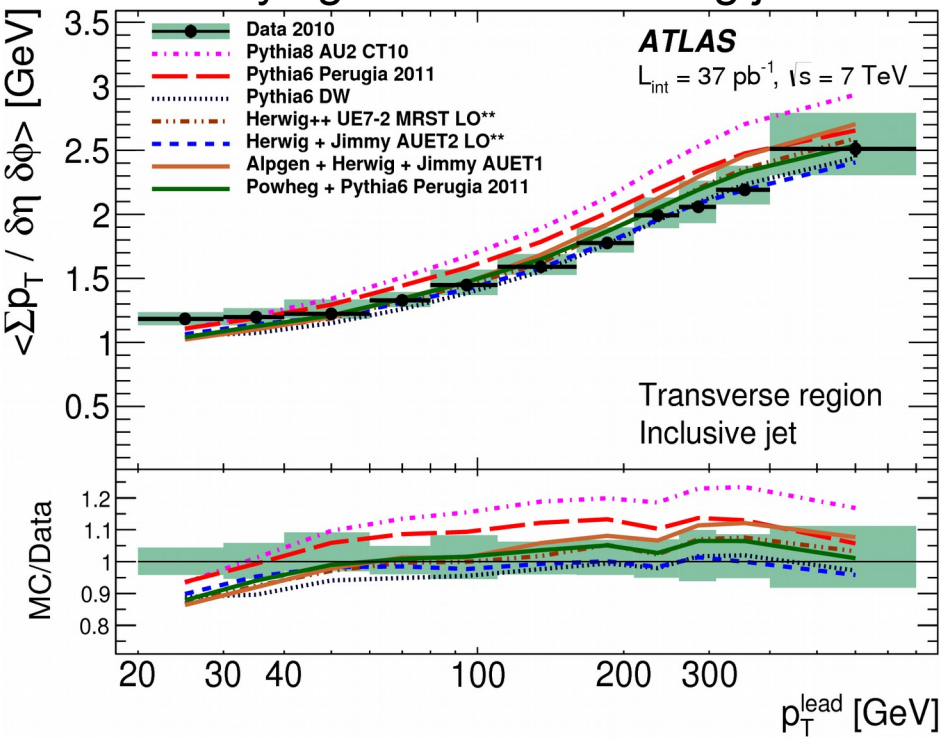
Underlying event

- Looking for activity in a event in addition of the hard interaction:
  - Initial/final state radiation
  - Multi parton interactions
- These soft interaction cannot be calculated:
  - Free parameters to be tuned using data
- Usual approach, split event in three regions:
  - Towards region: close to leading object
  - Transverse region: sensitive to UE and MPI
  - Away region: recoil of the leading object
- Leading object can defined variously:
  - Leading jet
  - Z - p_T
  - Leading track in Minimum Bias like events

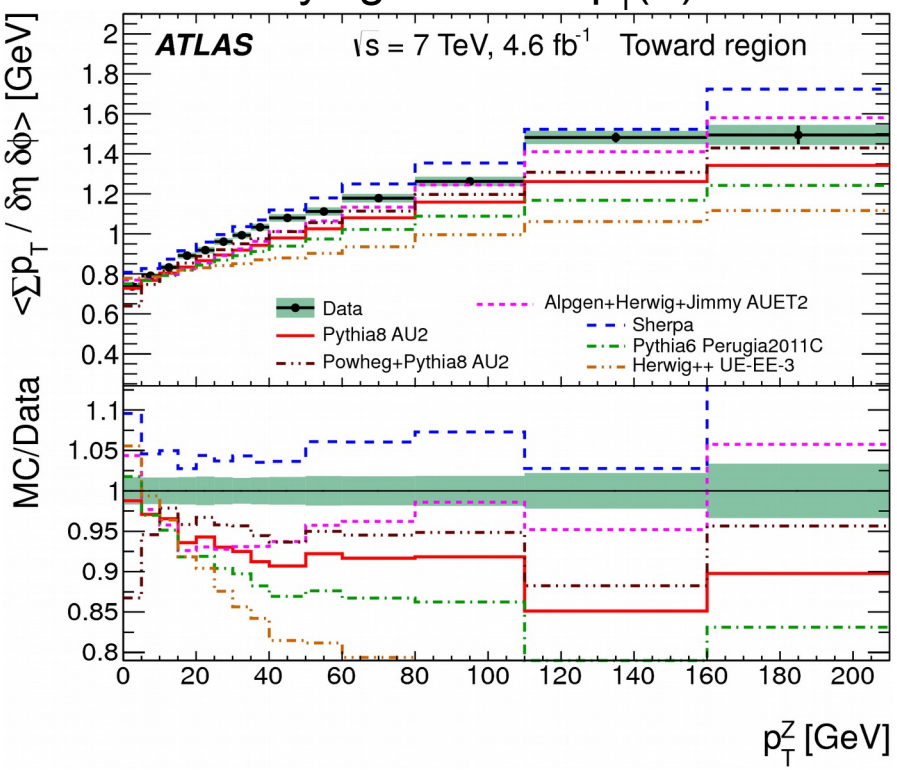


Underlying events with jets / Z : Σp_T

Underlying event with leading jet

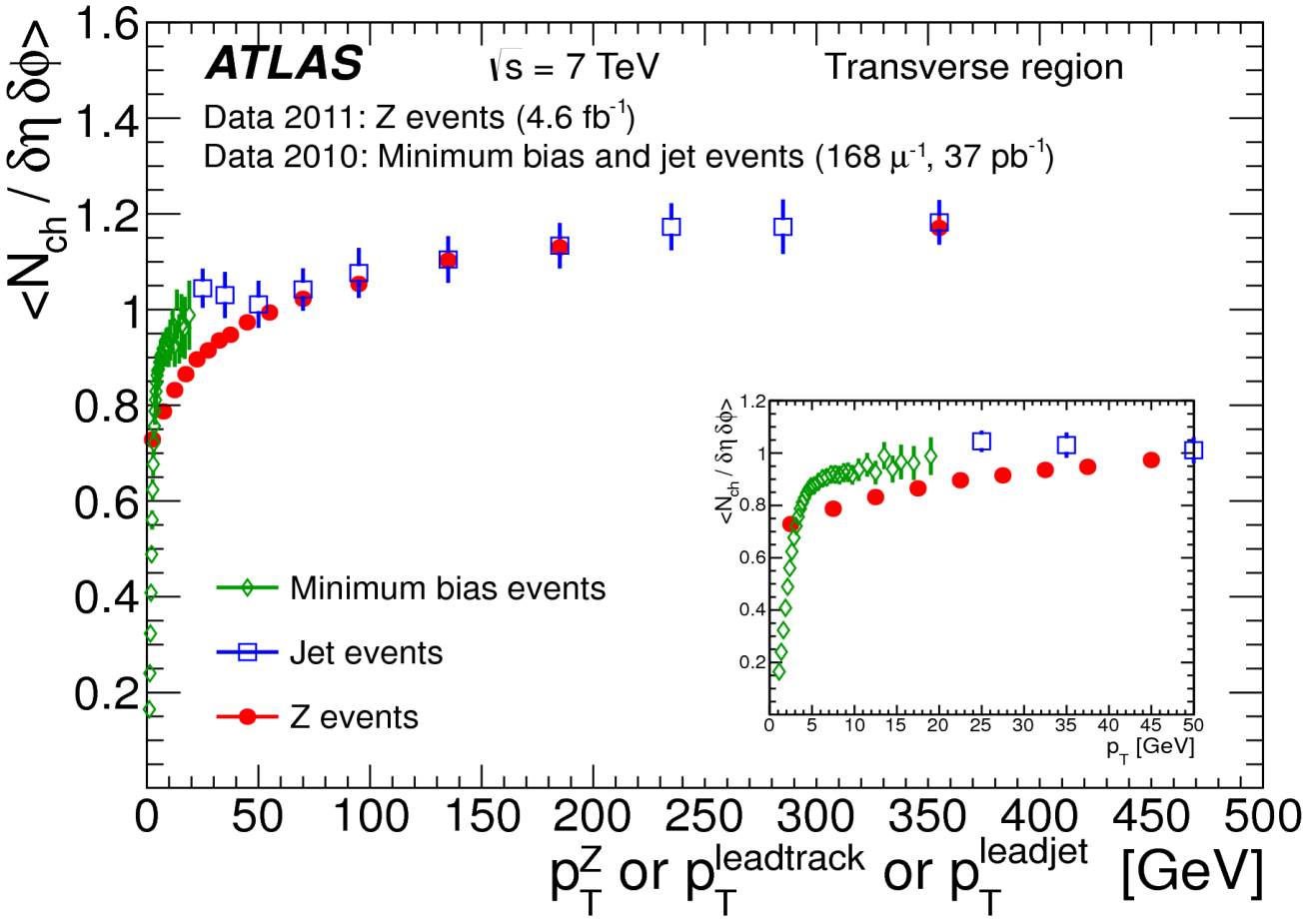


Underlying event vs $p_T(Z)$



- Sum p_T for UE vs leading jet and $p_T(Z)$:
  - Agreement is in the 10% level but different for both analyses
  - LO vs NLO Matrix element: Powheg+Pythia looks different than Pythia

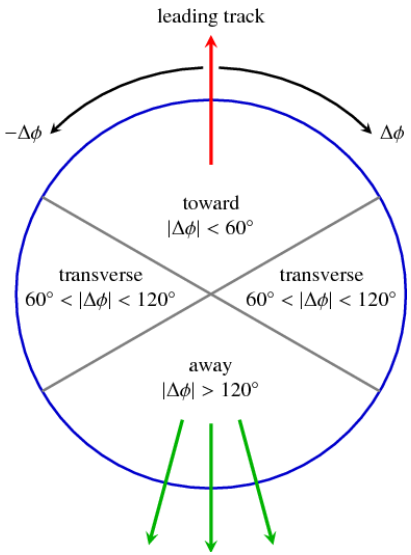
Compatibility of the different analyses

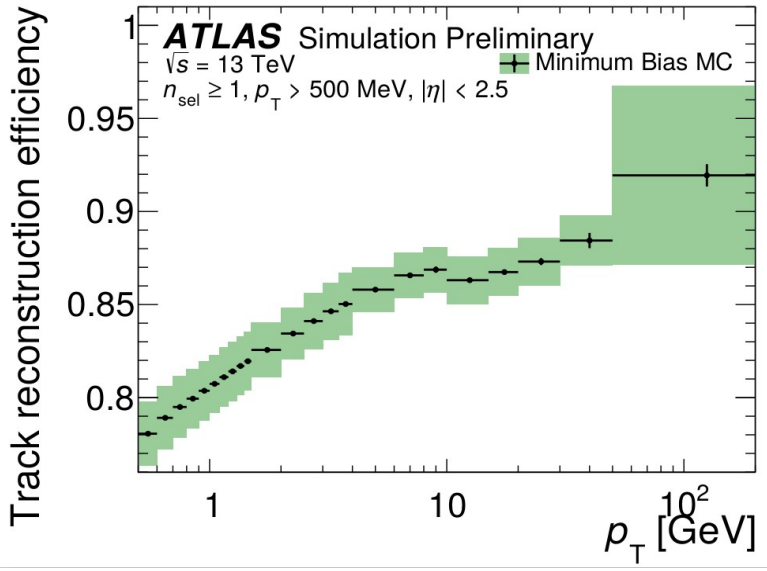


- Track density for different leading objects:
  - Data are compatible between the different definitions
  - Transition between leading track and jet
  - Z and jet agree well at high p_T (selection bias in the Z at low p_T)

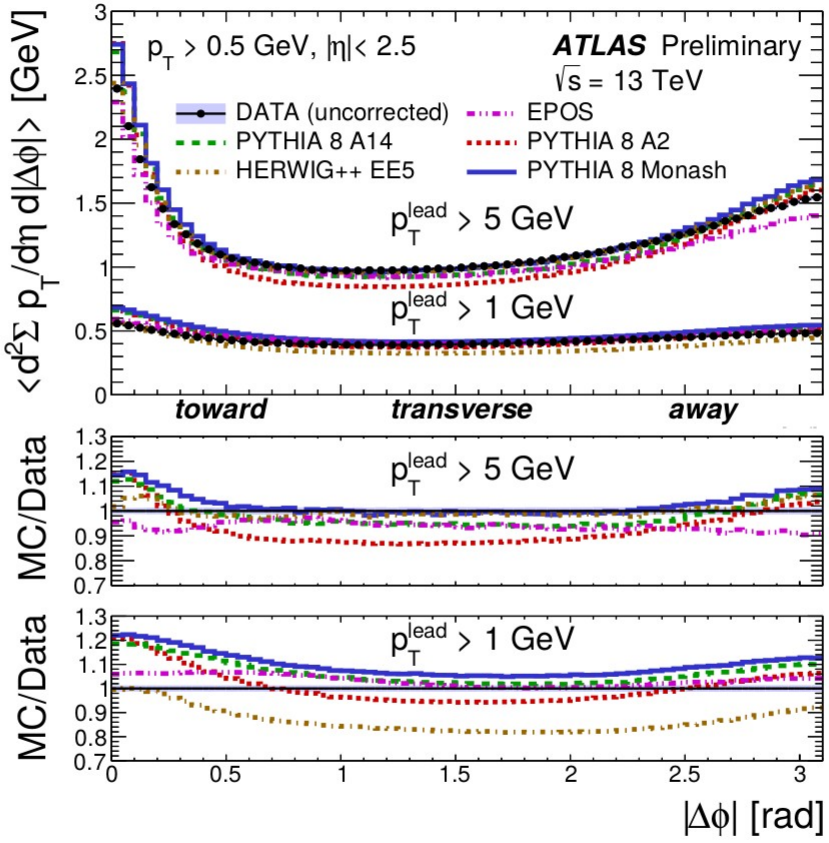
Underlying events comparisons at 13 TeV

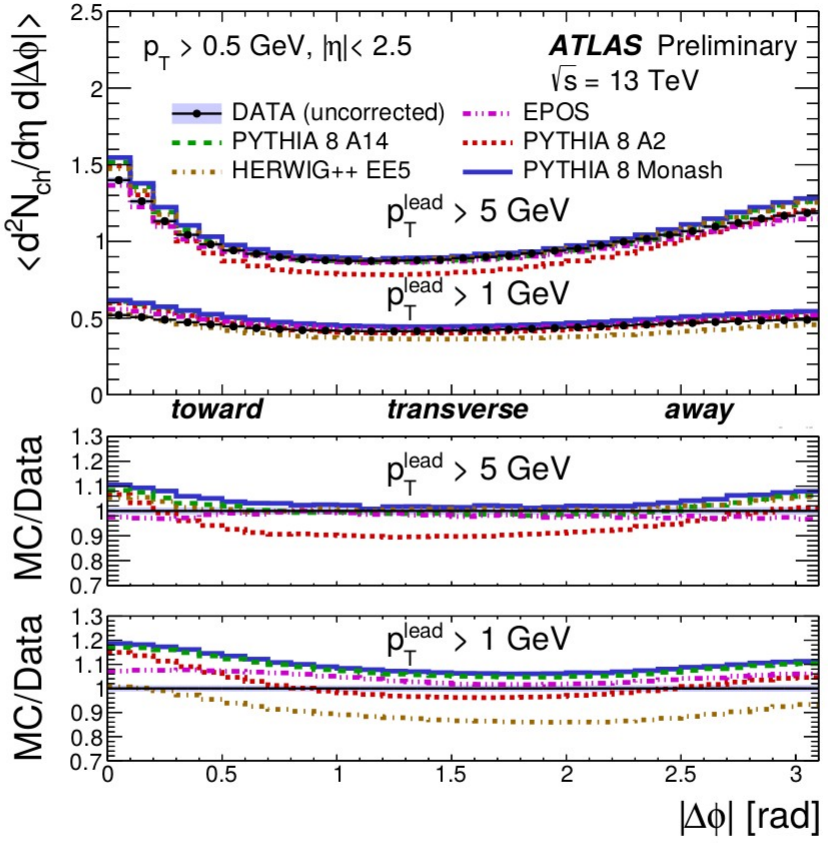
- Underlying events with leading track with $p_T > 1$ GeV
- Spin off of Minimum Bias analyses (15:30, Anthony Morley):
  - Minimum Bias scintillator trigger
  - Pile up veto
  - Track $p_T > 500$ MeV and $|\eta| < 2.5$
  - Event selection is ~99.5% efficient for at least 2 selected tracks
- Uncorrected performance plots:
  - Systematic shown is for tracking efficiency using Monte Carlo
- Comparisons to:
  - Pythia8 Monash (Author tune)
  - Pythia8 A2 (Atlas MinBias tune)
  - Pythia8 A14 (Atlas UE tune)
  - Herwig++ UEEE5 (Author tune)
  - EPOS (Astrop. physics model)



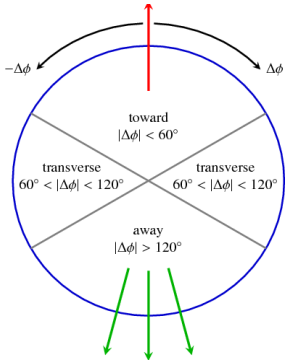


Σp_T vs $\Delta\phi$ and N_{ch} vs $\Delta\phi$

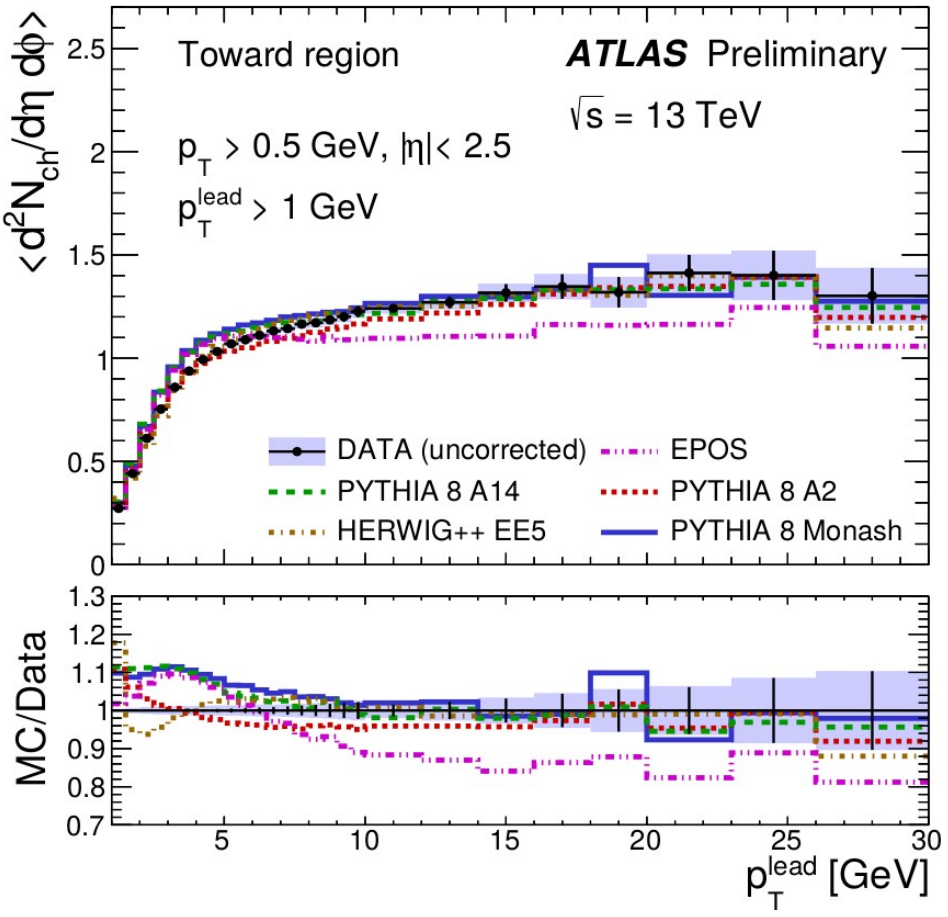


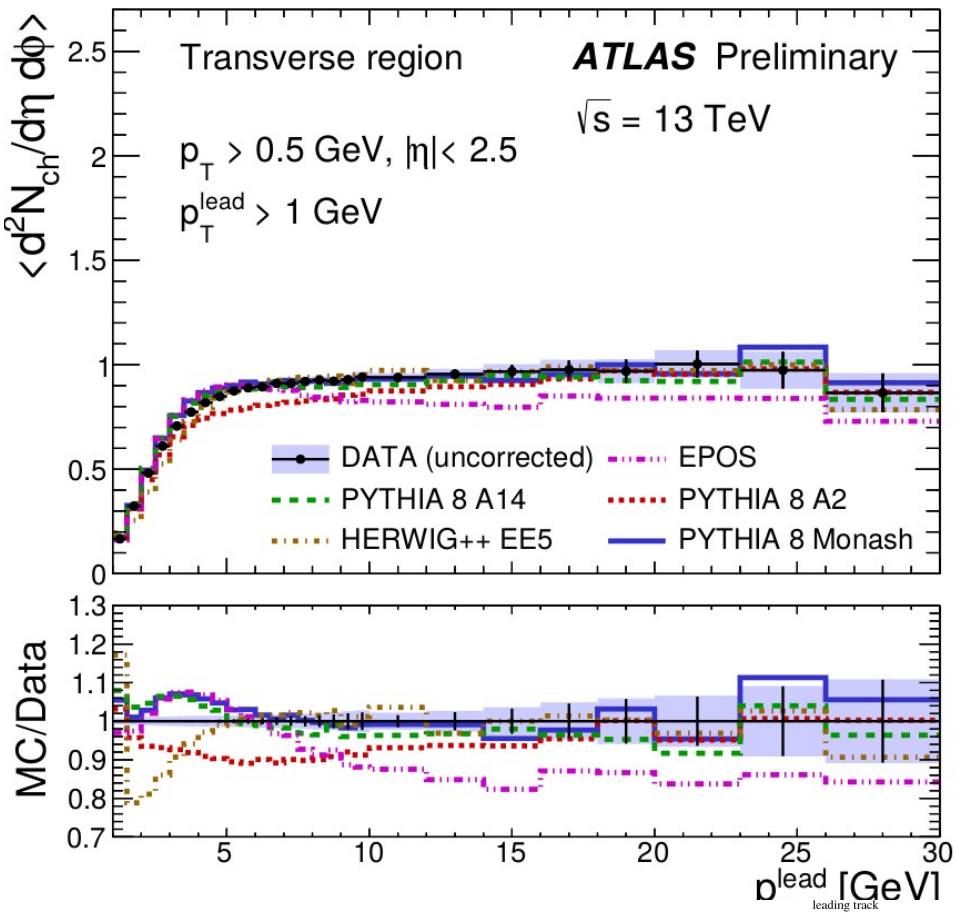


- MinBias Tune (A2) agrees well at p_T-lead > 1 GeV
- Underlying event Tunes (Herwig++, Monash, A14) better at p_T-lead > 5 GeV

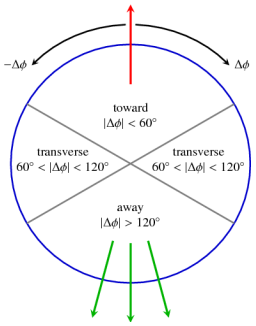


N_{ch} vs p_T - lead

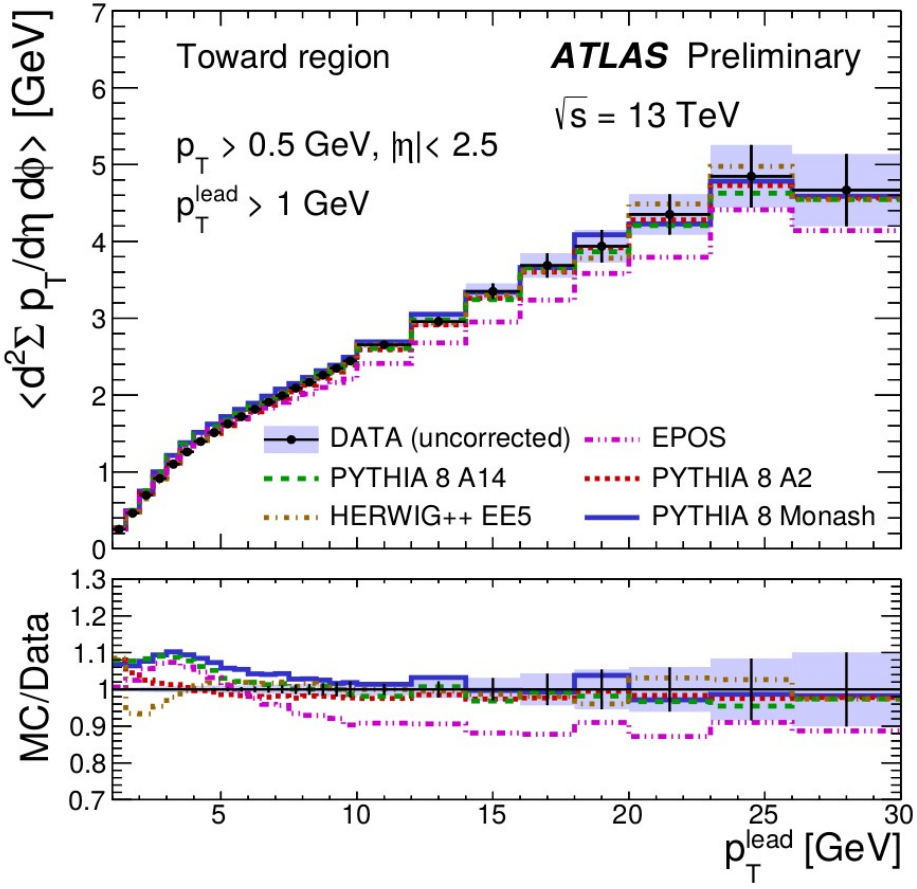


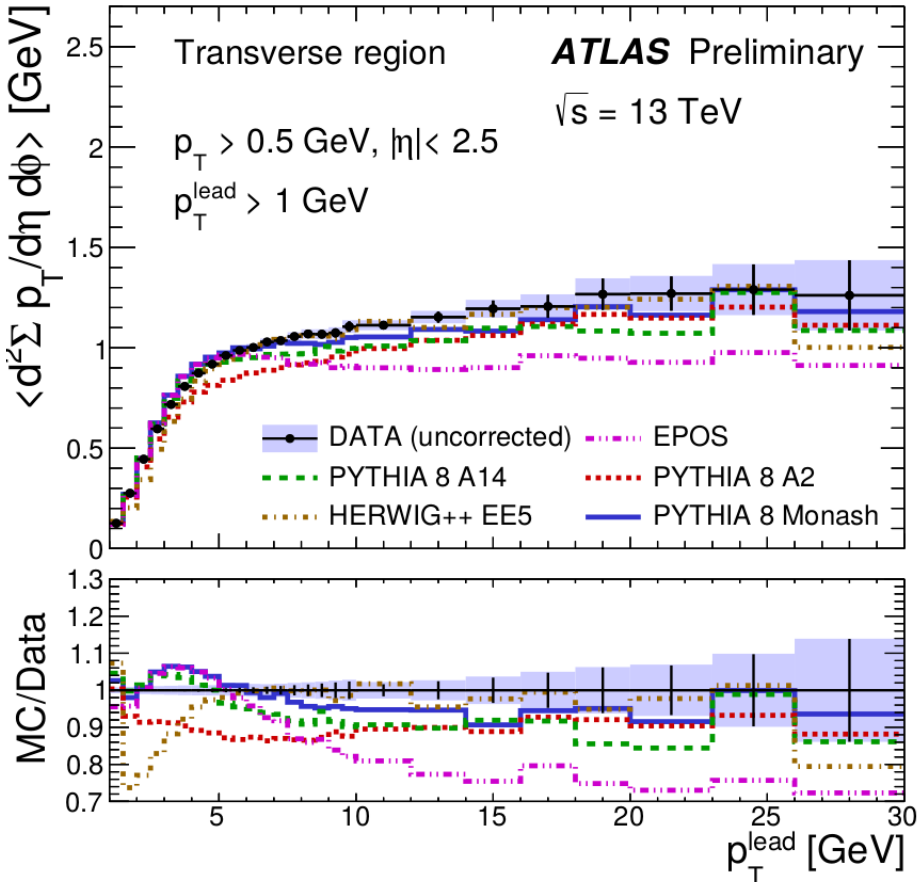


- From 10 GeV decent description for the UE Tunes
- A2 describes only toward region well
- EPOS 15% off in the plateau



Σp_T vs p_T - lead





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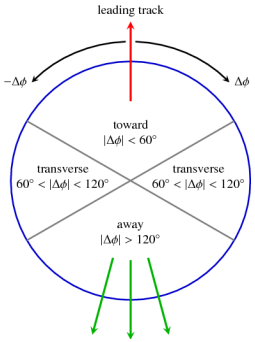
- Underlying event Tunes better at p_T-lead > 5 GeV
- Epos off in the Plateau



Summary

- Atlas is a good place to study soft-QCD
- Particle production studies:
  - Bose Einstein-Correlations correlation of same sign particles
    - saturation effect in the effective radius observed for large n_{ch}
  - Lambda polarisation:
    - no polarisation for Λ and $\overline{\Lambda}$ at high energies
- Underlying event analysis:
  - Needed for tuning of the soft part of Monte Carlo simulation
  - Diverse studies done at 7 TeV: leading track, leading jet and Z
- New comparisons for Underlying Event with 13 TeV data are shown:
  - Reasonable agreement of tunes used in Atlas Monte Carlo with new data

  → looking forward to future unfolded results