Charged-particle distributions in $\sqrt{s} = 13$ TeV pp interactions with ATLAS at the LHC

Valentina Cairo

University of Calabria & CERN

2016 Lake Louise Winter Institute - February 7-13, 2016

arXiv:1602.01633 [hep-ex]
• Inclusive charged-particle measurements in \( pp \) collisions provide insight into the strong interaction in the low energy, non-perturbative QCD region

• Inelastic pp collisions have different compositions

<table>
<thead>
<tr>
<th>Non-diffractive</th>
<th>Single-diffractive</th>
<th>Double-diffractive</th>
</tr>
</thead>
</table>

• Main source of background when more than one interaction per bunch crossing

• Perturbative QCD can not be used for peripheral interactions
  • ND described by QCD-inspired phenomenological models (tunable)
  • SD and DD hardly described and little data available

Goal:

Measure spectra of unfolded primary charged particles

• Three different phase-spaces studied at 13 TeV:
  • Nominal: \( p_T > 500 \text{ MeV}, |\eta|< 2.5 \) (Presented today)
  • Reduced: \( p_T > 500 \text{ MeV}, |\eta|< 0.8 \) (For comparison to the various detectors)
  • Extended: \( p_T > 100 \text{ MeV}, |\eta|< 2.5 \) (To investigate the low \( p_T \) region)

• Many different phase-spaces (including high multiplicity) studied at 8 TeV! (just published)
• Accepted on single-arm Minimum Bias Trigger Scintillator (MBTS)
• Primary vertex (2 tracks with $p_T > 100$ MeV)
• Reject pile up with veto on any additional vertices with $\geq 4$ tracks
• At least one selected track:
  • $p_T > 500$ MeV and $|\eta| < 2.5$
    (note track reconstruction runs with 100 MeV)
  • At least 1 Pixel hit
  • At least 6 SCT hits
  • IBL or BL hit required (if expected)
  • $|d_0^{BL}| < 1.5$ mm (transverse impact parameter w.r.t beam line)
  • $|\Delta z_0 \sin \theta| < 1.5$ mm ($\Delta z_0$ is the difference between track $z_0$ and vertex $z$ position)
  • Reject fakes with track fit $\chi^2$ probability $> 0.01$ for tracks with $p_T > 10$ GeV

Using the two 13 TeV low mu ($<\mu> \sim 0.005$) runs:

$168 \mu b^{-1}$

$8,870,790$ events selected, with $106,353,390$ selected tracks!

February 7-13, 2016
V. Cairo
Strange Baryons

- Particles with lifetime $30 \text{ ps} < \tau < 300 \text{ ps}$ (strange baryons) are no longer considered primary particles in the analysis, decay products are treated like secondary particles.

- Low reconstruction efficiency (<0.1%) and large variations in predicted rates lead to a model dependence.

- Final results produced with and without the strange baryons to allow comparison with previous measurements.

Data-Driven correction to tracking efficiency

- The track reconstruction efficiency is corrected by using a method that compares the efficiency to extend a track reconstructed in the pixel detector into the SCT (SCT Extension Efficiency Method) in data and simulation.

February 7-13th 2016
V. Cairo
Some Models/Tunes give remarkably good predictions:
- **Pythia8-A2** (used as baseline) shows nice agreement with data
- **Epos-LHC** is performing even better!

Models differ mainly in normalisation, shape similar

Measurement spans 10 orders of magnitude

Low $n_{ch}$ not well modelled by any MC; large contribution from diffraction;
Models without colour reconnection (QGSJET) fail to model scaling with $n_{ch}$ very well
Final Results

Mean number of primary charged particles increases by a factor of 2.2 when $\sqrt{s}$ increases by a factor of about 14 from 0.9 TeV to 13 TeV!
Mean number of primary charged particles increases by a factor of 2.2 when √s increases by a factor of about 14 from 0.9 TeV to 13 TeV!