First Physics measurements with ALICE: $dN_{ch}/d\eta$

with the silicon pixel detector

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Contents

- Introduction
  - the ALICE experiment at LHC

- First physics with ALICE
  - charged-particle multiplicity and pseudorapidity density
  - first physics papers in preparation within the First Physics group

- Charged-particle pseudorapidity density
  - role of the pixels for first data
  - reconstruction procedure: the "tracklet" algorithm
  - analysis procedure: from measured to physical distribution
  - results on official Monte Carlo samples

- Summary and outlook

1) Charged-particle pseudorapidity density in proton-proton collisions at $\sqrt{s} = 900$ GeV/7 TeV with ALICE at LHC
2) Charged-particle multiplicity distribution in proton-proton collisions at $\sqrt{s} = 900$ GeV/7 TeV with ALICE at LHC
Goals:

- study phase transition to Quark Gluon Plasma
  (Pb-Pb collisions @ $\sqrt{s_{NN}} = 5.5$ TeV + p-p as baseline)
- p-p physics programme (good acceptance for $p_t$ down to 100MeV/c)

The ALICE apparatus

- central barrel detectors (tracking, PID)
- forward rapidity detectors (trigger, muon detectors)
  Silicon Pixel Detector (SPD)
Charged-particle multiplicity and pseudorapidity density:

- first measurements (in p-p collisions) → first physics papers
- global event characterization:
  - collisions at 900 GeV → comparison with existing measurements, sistematics
  - collisions at 7/10/14 TeV → MC configuration, energy dependence

Detectors for “First Physics”:
- ITS, TPC, V0

Data is from:
Advantages (over ITS+TPC full track reconstruction)

- larger acceptance in $\eta$ and $p_T$ (down to $\sim 30$ MeV/c)
- simpler and faster alignment and calibration procedures

First results with $\sim 10^4$-$10^5$ collisions
- after few days of data taking at 900 GeV
- after few hours of data taking at 7/14 TeV!

The Silicon Pixel Detector (SPD) will allow to

- reconstruct points produced by charged particle crossing the detector
- use them to find the interaction vertex position
- use both reconstructed points and vertex to reconstruct charged primary tracks produced in the collision (next slide)
- contribute to event selection with the FastOr

(however triggering on bunch crossing is assumed for first collisions)
“Tracklet” reconstruction algorithm

- looks for pairs of clusters (inner/outer layer) aligned with the reconstructed primary vertex within fiducial windows in $\theta$ and $\phi$
- iterative procedure

Measured quantities

- multiplicity = number of tracklets
- pseudorapidity $\eta \rightarrow \theta$ angle cluster inner layer

Applied cuts

- need to optimize them (both in p-p and Pb-Pb) wrt
  - efficiency
  - background contamination
Definition:

\[ \frac{dN_{ch}}{d\eta} = \langle \text{charged primaries per event} \rangle \]

Corrections needed to get all the charged primaries in the SPD acceptance from the reconstructed tracklets:

- background from secondaries
- tracklet algorithm and detector inefficiency
- detector acceptance
- particles not reaching the sensitive layers
- vertex reconstruction inefficiency
- minimum bias trigger inefficiency

both at track and at event level

Charged primaries:
- particles produced in the collision
- products of strong and em decays

60k p-p events @ 7 TeV B=0.5 T (PYTHIA)

Generated MC distribution

Reconstructed distribution (SPD tracklets)
What do we need to identify?
- among the generated primary particles:
  - **Reconstructed** → particle having a tracklet associated
  - **Reconstructable** → particle producing a signal on both layers
  - **Detectable** → particle crossing both SPD layers

What do we need to calculate corrections?
- from reconstruction
  - tracklet $\eta$ and labels
  - tracklet multiplicity
  - reconstructed vertex
- from Monte Carlo
  - MC particles
  - track references
  - MC vertex
  - process type
**Track level**

- **Background**
  - primReconstructed

- **Algorithm and SPD ineff.**
  - primReconstructed
  - primReconstructable

- **SPD acceptance**
  - primReconstructable
  - primDetectable

- **Disappeared particles**
  - primDetectable

- **Vertex and trigger ineff.**

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**Formulas**

- **Background**
  \[
  BkgCorrW(\eta, z_v) = \frac{\sum_{iEv} \# \text{prim Reconstructed}(\eta_{MC}, z_{MC})}{\sum_{iEv} \# \text{tracklets}(\eta_{rec}, z_{rec})}
  \]

- **Efficiency**
  \[
  EffCorrW(\eta, z_v) = \frac{\sum_{iEv} \# \text{prim Reconstructable}(\eta_{MC}, z_{MC})}{\sum_{iEv} \# \text{prim Reconstructed}(\eta_{MC}, z_{MC})}
  \]

- **Acceptance**
  \[
  AccCorr(\eta, z_v) = \frac{\sum_{iEv} \# \text{prim Reconstructable}(\eta_{MC}, z_{MC})}{\sum_{iEv} \# \text{prim Detectable}(\eta_{MC}, z_{MC})}
  \]

- **Disappearance correction**
  \[
  DisPartCorrW(\eta, z_v) = \frac{\sum_{iEv} \# \text{prim}(\eta_{MC}, z_{MC})}{\sum_{iEv} \# \text{prim Detectable}(\eta_{MC}, z_{MC})}
  \]

- **Trigger vertex correction**
  \[
  TriggVtxCorrW(\eta, z_v) = \frac{\sum_{allEvts} \# \text{prim}(\eta_{MC}, z_{MC})}{\sum_{trigg \& \text{recVtxEvts}} \# \text{prim}(\eta_{MC}, z_{MC})}
  \]
**Event level**

- **Vertex inefficiency**

\[ \text{CorrW}(\text{multSPD}, z_v) = \frac{\sum_{\text{triggEvts}} \#\text{events}(\text{multSPD}, z_{MC})}{\sum_{\text{trigg & vtxEvts}} \#\text{events}(\text{multSPD}, z_{MC})} \]

- **MB trigger inefficiency**

\[ \text{CorrW}(\text{multSPD}, z_v) = \frac{\sum_{\text{allEvts}} \#\text{events}(\text{multSPD}, z_{MC})}{\sum_{\text{triggEvts}} \#\text{events}(\text{multSPD}, z_{MC})} \]

All events generated for a certain event class
Background correction

\[
BkgCorrW(\eta, z_v) = \frac{\sum_{iEv} \# \text{prim Reconstructed}(\eta_{MC}, z_{MC})}{\sum_{iEv} \# \text{tracklets}(\eta_{rec}, z_{rec})}
\]

Overall bkg fraction (SS tracklets+comb): 5%
Efficiency correction

Detector + reconstruction algorithm inefficiency

\[
\text{EffCorr}_W(\eta, z_v) = \frac{\sum_{iEv} \# \text{ prim Reconstructable}(\eta_{MC}, z_{MC})}{\sum_{iEv} \# \text{ prim Reconstructed}(\eta_{MC}, z_{MC})}
\]

Overall algorithm inefficiency: 2%
Detector inefficiency: 13% (15 fully dead modules assumed to test the analysis tools)
\[ \text{AccCorr}(\eta, z_v) = \frac{\sum_{iEv} \# \text{ prim Reconstructable}(\eta_{MC}, z_{MC})}{\sum_{iEv} \# \text{ prim Detectable}(\eta_{MC}, z_{MC})} \]
Applying corrections to data

d$N_{\text{ch}}$/d$\eta$ in triggered events with vertex reconstructed

Adding particle disappeared before reaching the SPD (decays and secondary Interactions)

Applying acceptance correction

Applying efficiency correction

Background subtraction

Data matrices $\rightarrow$ PYTHIA
Corr. matrices $\rightarrow$ PYTHIA
Vertex

Events used in the analysis to fill data matrices: triggered events with vertex in $|z_{\text{recVtx}}| < 10 \text{ cm}$ and at least one tracklet reconstructed.

Trigger

**Two different event classes considered:** Inelastic (INEL) and Non Single Diffractive (NSD)

Event level corrections

Assumed trigger condition: (pixels or V0 detector) and beam-gas veto.
Applying corrections

Final $dN_{ch}/d\eta$ distribution

Triggered events with vertex

Triggered events

Final distribution

Data matrices $\rightarrow$ PYTHIA
Corr. matrices $\rightarrow$ PYTHIA
Applying corrections

Final \( dN_{\text{ch}} / d\eta \) distribution

Data matrices → PYTHIA
Corr. matrices → PYTHIA
Summary and outlook

- dN_{ch}/d\eta measurement with pixels:
  - available with very first data using pixel detector
  - status of reconstruction and analysis tools:
    - fully developed within the First Physics Task Force
    - tested on MC official productions on the CERN Analysis Facility
    - added to the official “analysis train” for the organized analysis

- Outlook:
  - apply the correction chain to the first data
  - complete first physics papers (and try to be first at LHC...)
  - extend the analysis tools to the first heavy ion data (ongoing)
Applying corrections

Final $dN_{ch}/d\eta$ distribution

<table>
<thead>
<tr>
<th>7 TeV</th>
<th>NSD</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>PYTHIA</td>
<td>0.809</td>
<td>0.191</td>
</tr>
<tr>
<td>PhoJet</td>
<td>0.860</td>
<td>0.140</td>
</tr>
</tbody>
</table>

Data matrices $\rightarrow$ PhoJet
Corr. matrices $\rightarrow$ PYTHIA