Measurement of identified charged hadron spectra in p-p collisions using the Inner Tracking System of the ALICE experiment at the LHC

Quark Confinment and the Hadron Spectrum IX
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on behalf of the ALICE collaboration
detectors
- ALICE experiment and the PID detectors
- Inner Tracking System

ITS analysis
- particle identification
- efficiency

results
- inclusive spectra
- Lévy function fit
the following systems have been used for this analysis:
- Time of Flight detector (TOF) → see Y. Foka’s talk for details
- Time Projection Chamber (TPC) → see Y. Foka’s talk for details
- Inner Tracking System (ITS)
Inner Tracking System (ITS)

Silicon detectors:
- **pixel** (SPD) → 240 volumes
- **drift** (SDD) → 260 volumes
- **strip double-side** (SSD) 1698 volumes

- dE/dx information in the SSD and SDD for particle identification

- dE/dx range from 0 to 8 MIP ($\lesssim$ maximum value for particle tracked in ITS)

- total material budget $\approx 0.07 \ X_0$

<table>
<thead>
<tr>
<th></th>
<th>res. on $x_{loc}$ [$\mu m$]</th>
<th>res. on $z_{loc}$ [$\mu m$]</th>
<th>occupancy [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPD</td>
<td>12</td>
<td>70</td>
<td>1.5 - 0.4</td>
</tr>
<tr>
<td>SDD</td>
<td>38</td>
<td>28</td>
<td>2.5 - 1.0</td>
</tr>
<tr>
<td>SSD</td>
<td>20</td>
<td>830</td>
<td>4.0 - 3.3</td>
</tr>
</tbody>
</table>
ITS in Particle Identification: TWO analyses

ITS+TPC tracks
- better resolution in pt
- important for the matching with TPC points
- cross check for global analysis

ITS standalone tracks
- not using of TPC or TOF information
- low momentum reached
- recovering the tracks lost by the TPC
tracking for the standalone ITS

1. group clusters in the same $\theta, \varphi$ windows on the 6 layers
   - starting point (seed): tracklet built with the primary vertex and a cluster in one of the inner layers (1,2,3)
   - extrapolation to the next layer taking into account trajectory curvature

2. N loop iterations on the clusters, increasing at each step the $\theta, \varphi$ window size
   - small windows (first iteration steps) $\rightarrow$ high $p_t$ particles
   - larger windows (subsequent iterations) $\rightarrow$ lower $p_t$ particles

3. track fitted with the Kalman-filter method

tracking efficiency $\rightarrow$
ITS charge calibration performed using p-p data

- ADC to keV conversion factor fine tuned to have the Most Probable Value of the charge at 84 MeV with a tolerance of 5%

- correction for the drift time dependence applied (for the SDD)

- correction for the track length (depending on the crossing angle) applied

- zero suppression algorithm enabled
ITS analysis
dE/dx calculation

\( dE/dx \) given by the truncated mean of the SSD/SDD signals:
- on 4 clusters: cut the 2 highest values
- on 3 clusters: cut the highest value, put a weight of 0.5 to the middle one, 1 to the lowest one

Distribution directly in pt bins of

\[ \log(\frac{dE}{dx})_{\text{calculated}} - \log(\frac{dE}{dx})_{\text{expected}} \]

where expected is the value calculated by the BetheBloch formula, using an ad hoc parametrization:

\[
\frac{dE}{dX}(\beta \gamma) = p_0 \frac{p_1 + 2 \log \gamma - \beta^2}{\beta^2} \xi \tag{1}
\]

with

\[
\xi = \begin{cases} 
  p_4 + (\beta \gamma - p_3)^2 & \text{for } \beta \gamma < p_2 \\
  p_4 + (p_2 - p_3)^2 & \text{for } \beta \gamma > p_2
\end{cases} \tag{2}
\]

with different parameters for the two samples of tracks (standalone/global).
3 Gaussian method

- **Event selection**
  - All tracks

- **General cuts on tracks**

- **Assuming mass**

- **Cuts for DCA \& \gamma**

  Calculating \( \log(dE/dx) \cdot \log(dE/dx_{BB}) \) in pt bins for each particle type

Area below peak center in zero is a yield which we are looking for.

Other peaks are background.
ITS fit to dE/dx distributions

different fit procedures for the two analyses, to take into account differences in resolution and contamination

(negative kaons in two $p_T$ bins)
the efficiency takes into account all the effects to correct via Monte Carlo simulation:

- geometric acceptance
- dead channels
- tracking efficiency
- decay of K
results
the results obtained by the 4 independent analyses are consistent and allow to cover the whole momentum range from 90 MeV to 2.5 GeV
the spectra have been combined weighting for the uncorrelated systematic errors and fitted using the Lévy function which gives the best description and can be used to extract the total yields and the $\langle p_t \rangle$
mean transverse momentum, extracted from the Lévy fit, has been compared with the STAR@RHIC results.
About the ALICE performance

- ITS provided spectra corrected using two sample of tracks and reaching a very low momentum (90 MeV/c for pions)
- the points taken from three different detectors are coherent, so it is possible to cover a large pt range (0.09 - 2.4 GeV/c)

About the results:

- the first identified hadron pt spectra from pp collisions at 900 GeV have been analyzed
- the whole analysis framework has been tuned in order to repeat the study for the pp collisions at 7 TeV (analysis presently ongoing)
- the first ALICE article about this topic is ready and will be published in next month

that’s all, thanks for the attention
backup slides
**ITS standalone**

On the events

1. Physics selection + Background rejection
2. SPD vertex with at least 1 contributor
3. Z vertex position $< 10$ cm
4. Dispersion on Z vertex $< 0.03$ cm

On the tracks

1. $k_{\text{ITS refit}}$ & $k_{\text{ITSpureSA}}$
2. Pseudo-rapidity range: $[-0.9,0.9]$
3. Rapidity range: $[-0.5,0.5]$
4. At least one point in the pixel layers
5. At least 3 points in strip or drift layers
6. $\chi^2/($# ITS clusters$) < 1$

**ITS + TPC**

On the events

1. Physics selection + Background rejection
2. SPD vertex with at least 1 contributor
3. Z vertex position $< 10$ cm

On the tracks

1. $k_{\text{ITS refit}}$ & $k_{\text{TPC refit}}$
2. No kink daughters
3. Rapidity range: $[-0.5,0.5]$
4. At least one point in the pixel layers
5. At least 3 points in strip or drift layers
6. Minimum # TPC clusters $= 70$
7. $\chi^2/($# TPC clusters$) < 4$
8. ITS cluster charge $> 50$ keV (under investigation)
SDD: correction for zero suppression

p-p events simulation

correction extracted from simulation
↓
applied to data
↓
no dependence on drift time

cosmic data in Turin

p-p data @ 900 GeV

\[
\text{slope} = -0.00377 \pm 0.00002
\]

\[
\begin{align*}
\text{constant fit: } \chi^2 = 1.370 \\
\text{linear fit: } \chi^2 = 1.129
\end{align*}
\]
momentum range covered by 3 detectors

**ALICE Performance**

\[ p_{\text{p}} \text{ at } \sqrt{s} = 900 \text{ GeV (2009 data)} \]

**TOF**
- \( \pi: 0.5 - 2 \)
- \( K: 0.5 - 2 \)
- \( p: 0.5 - 2.5 \)

**TPC**
- \( \pi: 0.2 - 0.7 \)
- \( K: 0.2 - 0.4 \)
- \( p: 0.5 - 1 \)

**ITS**
- \( \pi: 0.1 - 1 \)
- \( K: 0.2 - 0.4 \)
- \( p: 0.3 - 1 \)