Results from particle identification in pp collisions measured with ALICE at the LHC

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(on behalf of ALICE Collaboration)

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The plan of the talk is to show results on particle identification (light flavour) in proton-proton collisions.

- Description of ALICE experiment.
- Particle Identification in ALICE.
- Charged pions, (anti)protons and kaons at low-$p_t$. Prospects for high-$p_t$.
- Neutral pion production.
- Strange ($K^0_s, \Lambda$) and multi-strange ($\Xi, \Omega$) particle production.
- Light vector meson production.
- Light nuclei and anti-nuclei production.
- Outlook.
Light charged hadrons ($\pi^\pm, K^\pm, p, \text{anti-} p$): $100 \text{ MeV} < p < 5 \text{ GeV}$ (several 10 GeV) 
dE/dx in silicon (ITS) and gas (TPC) + time-of-flight (TOF) + Cherenkov (HMPID)

Invariant mass and decay topologies ($K_s^0, \Lambda, \Omega^\pm, \Xi^\pm$, open charm, resonances, ...)
TPC+ITS+TOF

Leptons ($e, \mu$), photons, $\pi^0$, $\eta$.
electrons TRD: $p > 1 \text{ GeV}$, muons: $p > 4 \text{ GeV}$ (light vector mesons), $\pi^0$ in PHOS, EMCAL: $1 < p < 80 \text{ GeV}$
Low $p_t$ $p$, $K$ and $\pi$ spectra, $pp$ at $\sqrt{s}=0.9$ TeV

Results from different analyses

**ITS standalone**

**TPC**

**TOF**


Low $p_t$ $p$, $K$ and $\pi$ spectra, pp at $\sqrt{s}=7$ TeV

Important test of pQCD and NLO calculations.

Important tool to constrain the fragmentation functions in the non-perturbative domain.

With the TPC, the separation of $p$, $K$, $\pi$ can be done on statistical basis in the $dE/dx$ relativistic rise ($\beta\gamma \sim 3.6-1000$).
Preliminary results for pions at high-$p_t$

See talk of Paul Kuijer
Test pQCD, probe PDF and FF at low x and low z values.
Constrain the gluon to pion fragmentation: at LHC energies, ~75% of pions are produced from gluon fragmentation.


Measurement via the two-photon decay channel.

- PHOS (Photon Spectrometer)
- ITS+TPC (Photon Conversion Method)

At 2.76 and 7 TeV, most NLO calculations overestimate the cross sections, better agreement at 0.9 TeV.
pp, $\sqrt{s}=0.9$ TeV

Ratios from integrated yields extracted from Lévy fits.

pp, $\sqrt{s}=0.9$ TeV.

<table>
<thead>
<tr>
<th>Particles</th>
<th>Charged decay</th>
<th>B.R. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesons $K^0_S$</td>
<td>$K^0_S \rightarrow \pi^+ + \pi^-$</td>
<td>69.2</td>
</tr>
<tr>
<td>$\phi$ (ss)</td>
<td>$\phi \rightarrow K^+ + K^-$</td>
<td>49.2</td>
</tr>
<tr>
<td>Baryons $\Lambda$ (u/d/s) and $\bar{\Lambda}$ (u/d/s)</td>
<td>$\Lambda \rightarrow p + \pi^-$ and $\bar{\Lambda} \rightarrow \bar{p} + \pi^+$</td>
<td>63.9</td>
</tr>
<tr>
<td>$\Xi^-$ (dss) and $\Xi^+$ (dss)</td>
<td>$\Xi^- \rightarrow \Lambda + \pi^-$ and $\Xi^+ \rightarrow \bar{\Lambda} + \pi^+$</td>
<td>99.9</td>
</tr>
</tbody>
</table>

Strange particle production

$pp, \sqrt{s}=0.9$ TeV.

Multi-strange baryon production

pp, $\sqrt{s}=7$ TeV.

BR

- $\Xi^- \rightarrow \Lambda^0 + \pi^- \rightarrow p^+ + \pi^- + \pi^-$: 99.9%
- $\bar{\Xi}^+ \rightarrow \bar{\Lambda}^0 + \pi^+ \rightarrow \bar{p}^- + \pi^+ + \pi^+$: 67.8%
- $\Omega^- \rightarrow \Lambda^0 + K^- \rightarrow p^+ + \pi^- + K^-$
- $\bar{\Omega}^+ \rightarrow \bar{\Lambda}^0 + K^+ \rightarrow \bar{p}^- + \pi^+ + K^+$

Multi-strange baryon production

Studying the possible saturation of the s-quark production with respect to non-strange quark production ...
Mass dependence of mean $p_t$

STAR: Central collisions 0-10%
Measurement in the dimuon decay channel
(2.5 < y < 4, 1 < p_T < 5 GeV/c),

<table>
<thead>
<tr>
<th></th>
<th>σ_φ (mb)</th>
<th>σ_ω (mb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALICE μμ measurement</td>
<td>0.940 ± 0.084 ± 0.076</td>
<td>5.28 ± 0.54 ± 0.49</td>
</tr>
<tr>
<td>PYTHIA/Perugia-0</td>
<td>0.50</td>
<td>5.60</td>
</tr>
<tr>
<td>PYTHIA/Perugia-11</td>
<td>0.62</td>
<td>7.81</td>
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<tr>
<td>PYTHIA/ATLAS-CSC</td>
<td>0.91</td>
<td>6.50</td>
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<tr>
<td>PYTHIA/D6T</td>
<td>1.12</td>
<td>9.15</td>
</tr>
<tr>
<td>PHOJET</td>
<td>0.87</td>
<td>6.89</td>
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</table>

pp at √s = 7 TeV

Light vector meson production


The identification is done using dE/dx in the TPC.

The good statistics in pp @ 7 TeV (~380 M events) gives a nice sample of light nuclei and anti-nuclei.

The measurements allow one to study the production mechanisms.
• Several measurements on particle identification using different techniques, results at 0.9, 2.76 and 7 TeV shown.
• Transverse momentum spectra for protons, anti-protons, charged kaons and pions have been measured in a wide range of $p_t$, we expect to reach $p_t=20$ GeV/c very soon.
• Neutral pion spectra show disagreements with NLO calculations, especially at 7 TeV.
• Multi-strange baryon production has been measured, the $p_t$ reach of the data to model comparison is the highest ever achieved. Huge differences with MC models were found, even with recent Pythia tunes (e.g. Perugia-2011).
• ALICE is studying light nuclei and anti-nuclei production, final results on deuteron, Tritons, Helium3 and Helium4 soon.
Backup
Longitudinal FF

\( \frac{P(qq)}{P(q)} \), the suppression of diquark-antidiquark pair production in the colour field, compared with quark-antiquark production.

\( \frac{P(s)}{P(u)} \), the suppression of s quark pair production in the field compared with u or d pair production.

\( \frac{P(us)}{P(ud)} \) \( \times \) \( \frac{P(s)}{P(d)} \), the extra suppression of strange diquark production compared with the normal suppression of strange quarks.

\( \frac{1}{3} \frac{P(ud_1)}{P(ud_0)} \), the suppression of spin 1 diquarks compared with spin 0 ones (excluding the factor 3 coming from spin counting).

extra suppression for having a s anti-s pair shared by the B and anti-B of a BM anti-B situation.

extra suppression for having a strange meson M in a BM anti-B configuration.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Perugia 0</th>
<th>Perugia 2011 (All)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSTP(5)</td>
<td>310</td>
<td>350 — 359</td>
</tr>
<tr>
<td>MSTJ(11)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>PARJ(1)</td>
<td>0.073</td>
<td>0.087</td>
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<tr>
<td>PARJ(2)</td>
<td>0.2</td>
<td>0.19</td>
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<tr>
<td>PARJ(3)</td>
<td>0.94</td>
<td>0.95</td>
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<tr>
<td>PARJ(4)</td>
<td>0.032</td>
<td>0.043</td>
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<td>PARJ(6)</td>
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<td>1.0</td>
</tr>
<tr>
<td>PARJ(7)</td>
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<td>1.0</td>
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<tr>
<td>PARJ(11)</td>
<td>0.31</td>
<td>0.35</td>
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<tr>
<td>PARJ(12)</td>
<td>0.4</td>
<td>0.40</td>
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<td>PARJ(13)</td>
<td>0.54</td>
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<tr>
<td>PARJ(21)</td>
<td>0.313</td>
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<tr>
<td>PARJ(25)</td>
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<tr>
<td>PARJ(26)</td>
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<tr>
<td>PARJ(41)</td>
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<tr>
<td>PARJ(42)</td>
<td>1.2</td>
<td>0.80</td>
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<td>PARJ(45)</td>
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<td>PARJ(46)</td>
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<td>1.0</td>
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<tr>
<td>PARJ(47)</td>
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