Quarkonium detection in ALICE

G.M for the ALICE collaboration
Dielectron channel: $|\eta|<0.9$

Dimuon channel: $-4.0<\eta<-2.5$

Central Barrel tracking: ITS-TPC-TRD

Electron ID: dE/dx, TR, EMCAL-tracking, ...

Muon trigger

Muon tracking
Time Projection Chamber

...largest ever built, calibrated in 2008-09 with cosmic rays, laser and Kr

- 90 m³ active volume
- 500 million “pixels”
- 100 μs drift time
- on-line (digital) signal processing
- 5.5% dE/dx resolution
Transition Radiation Detector

electron identification and fast (6.5 \( \mu \)s) trigger for high-momenta (e)

- 27 m\(^3\) Xe
- 35 million “pixels”
- 2 \( \mu \)s drift time
- 540 chambers (700 m\(^2\))
Muon Spectrometer
Muon Spectrometer

First Dimuon event observed in p+p @ 900 GeV
Alice Running conditions

In proton-proton collisions, luminosity is limited by the number of pile-up events in TPC to $3.10^{30} \text{ cm}^{-2}\text{s}^{-1}$ ($\sim 240$ kHz interaction rates)
Quarkonium acceptances

For Full-TRD acceptance.
First run with 7/18 TRD modules
Factor 7 acceptance reduction for J/psi

Down to \( p_T = 0 \) for \( J/\psi \) & \( \Upsilon \).
Two \( \eta \) domains

\[ \begin{align*}
\text{Electron channel, } |y| < 0.9; \\
\text{Muon channel, } 2.5 < |y| < 4.0;
\end{align*} \]
Dielectron performances in pp

- 7/18 TRD configuration
- pp first run (10^9 MB events): ~400 J/ψ;
- Nominal pp run with electron trigger: 10^6 J/ψ, 10^4 ϒ;
- Gain of a factor ~7 with full TRD configuration

Graph:
- |y| < 0.9
- dN/dM_{e^e} (counts per 10 MeV/c^2)
- S/B = 1.3
- S/√S+B = 16
- 10^9 minB pp at \( \sqrt{s} = 10 \) TeV
- Invariant Mass M_{e^e} (GeV/c^2)
Secondary dielectron J/$\psi$ from B

J/$\psi$ from a displaced vertex ($c\tau \sim 500 \mu$m);
CDF approach: simultaneous fit of inv mass and the pseudo-proper decay time:

$$x = L_{xy}(J/\psi) \cdot \frac{M_{J/\psi}}{p_T(J/\psi)}$$

$$L_{xy}(J/\psi) = \frac{\vec{L} \cdot \vec{p_T}(J/\psi)}{|\vec{p_T}(J/\psi)|}$$

$$\vec{L} = \vec{r}^{sec}_{vtx} - \vec{r}^{prim}_{vtx}$$

4 $10^9$ pp Mb events in 7/18 TRD configuration.
\( \chi_c \) in the *tetra-electron* channel

\[
\chi_{c1,2} \xrightarrow{36.0\%} J/\psi + \gamma \xrightarrow{8.3\%} e^+ e^- \text{ (conversion)} \quad e^+ e^-
\]

J/\( \psi \) invariant mass resolution removed in:
\[
\Delta M = M(e^+e^-\gamma) - M(e^+e^-)
\]

Nominal p+p 14 TeV,
10\(^7\) s at \( L = 3 \cdot 10^{30} \text{ cm}^{-2}\text{s}^{-1} \).
7200 \( \chi_c \) (perfect trigger)
Realistic background to be evaluated (under progress)
Dimuon performances in pp

It will be possible to study $J/\psi$ $p_T$ differential distribution with reasonable statistics up to 20 GeV/c.
The large $\Upsilon$ statistics will allow a study of its differential distributions.

First run (~10 months): ~50000 $J/\psi$, ~1000 $\psi'$, and ~350 $\Upsilon$(1S)

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<tr>
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<th>$S \times 10^3$</th>
<th>$S/B$</th>
<th>$S/\sqrt{S+B}$</th>
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<tr>
<td>$J/\psi$</td>
<td>2807</td>
<td>12</td>
<td>1610</td>
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<tr>
<td>$\psi'$</td>
<td>75</td>
<td>0.6</td>
<td>170</td>
</tr>
<tr>
<td>$\Upsilon$</td>
<td>27</td>
<td>10.4</td>
<td>157</td>
</tr>
<tr>
<td>$\Upsilon'$</td>
<td>6.8</td>
<td>3.4</td>
<td>73</td>
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<tr>
<td>$\Upsilon''$</td>
<td>4.2</td>
<td>2.4</td>
<td>55</td>
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Polarization in dimuon channel

\( J/\psi \)

Bias on the evaluation of the \( J/\psi \) polarization due to the background is not very large (as expected)

with 200K \( J/\psi \), the error on \( \alpha_{J/\psi} \) is < 0.02

\( \Upsilon \)

with the available \( \Upsilon \) statistics we can evaluate the polarization with a statistical error between 0.05 – 0.11;

statistical errors, for the \( p_T \) dependence of the polarization, vary between 0.03 -0.2;
Smaller error at high \( p_T \) because the \( \cos(\theta) \) coverage is wider.
More exotic studies foreseen

• Quarkonia+muon azimuthal and invariant mass correlations;
• Quarkonia+hadron azimuthal correlations;
• Quarkonia production in high multiplicity events;
• ...
Conclusions

• ALICE will measure $J/\psi$, $\psi'$, $\Upsilon(1S)$, $\Upsilon(2S)$, $\Upsilon(3S)$ in pp at LHC (with B and higher resonances feed down);
• In two rapidity ranges:
  – $|y|<0.9$ and $-4.0<y<-2.5$;
• Down to $p_T=0$;
• $J/\psi$ from B via secondary high precision vertexing in $|y|<0.9$;
• $\chi_c$ detection in $|y|<0.9$ (under progress);
• Polarisation of $J/\psi$ ($\Upsilon(1S)$). In $-4.0<y<-2.5$ precision below 5 (10)%;
• Quarkonium correlation studies foreseen;
### Further References

<table>
<thead>
<tr>
<th>Reference</th>
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