Measurements of quarkonia production in jets at LHCb

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Strangeness in Quark Matter 2022

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- **Hard production** Non-Relativistic QCD (NRQCD) predicts:
  - Differential production cross section consistent with measurement.
  - J/ψ produced largely isolated.
  - Large transverse polarisation, minimal observed.

![Graph showing differential production cross section](image)

- Colour singlet
  - Low \( p_T \)
  - Longitudinal pol.

- Colour octet
  - High \( p_T \)
  - Transverse pol.

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Shower production analytic resummation NRQCD predicts:
- Lack of polarisation
- $J/\psi$ rarely produced in isolation

Two pictures of quarkonia production distinguished by studying radiation associated with them → JETS

Instead of measuring cross section wrt $p_T(J/\psi)$, take into account surrounding radiation with $z \equiv p_T(J/\psi)/p_T(\text{jet})$.

Procedure:
- Build Quarkonia $(Q) \rightarrow \mu^+\mu^-$ candidates in jets
- Determine $Q$ signal yield with mass fits
Separate prompt (direct) from displaced (eg. b decays) yields with pseudo-lifetime fits, \[ t \equiv x_z - x_z(PV)m_Q/p_z \]

Measure \( d\sigma/\sigma \) verses \( z \equiv p_T(Q)/p_T(jet) \), to probe DPS.

Obtain different \( z \) distributions for different \( Q \) with unfolding and efficiency corrections: \( J/\psi, \psi(2S), \Upsilon(1S), \Upsilon(2S), \Upsilon(3S) \) and \( X(3872) \).
Unfolding $p_T$(jet) from reconstruction to truth level is done to correct for jet energy resolution effects, using RooUnfold.
• Presented here results for $z(J/\psi)$.
• Analyses for $\psi(2S)$, $\Upsilon(1S)$, $\Upsilon(2S)$, $\Upsilon(3S)$ and $X(3872)$ are in progress.
• Predictions for the $z(Q)$ distributions are shown below, where $\Upsilon$’s are predicted to be more isolated than $\psi(2S)$ and $X(3872)$.