54. Quarkonia production in p-Pb collisions at LHCb

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Presented at The Second Annual Conference on Large Hadron Collider Physics (LHCP 2014)

Physics motivation

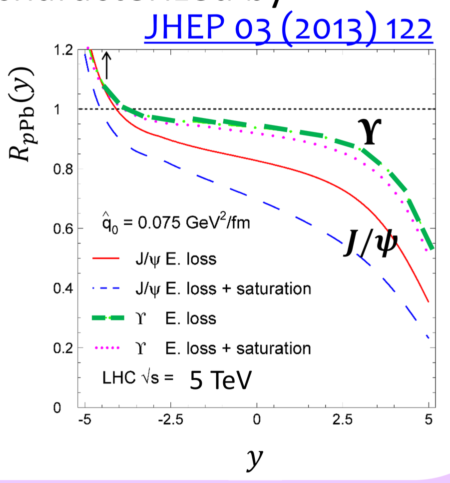
- pA collisions are important to study cold nuclear matter effects
- Heavy quarkonia production is strongly suppressed in pA collisions at large rapidity
- Cold nulcear matter effects characterized by JHEP 03 (2013) 122

Nuclear modification factor:

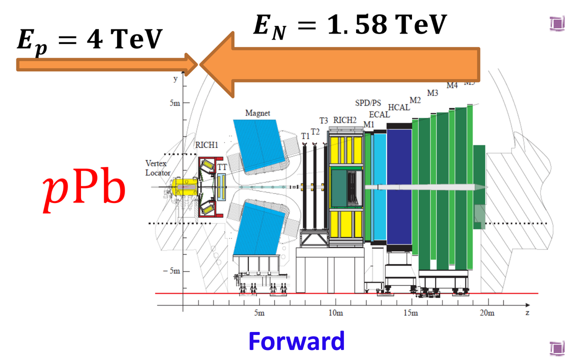
$$R_{pA}(y,\sqrt{s_{NN}}) = \frac{1}{A}\cdot\frac{\frac{d\sigma_{pA}}{dy}(y,\sqrt{s_{NN}})}{\frac{d\sigma_{pp}}{dy}(y,\sqrt{s_{NN}})}$$

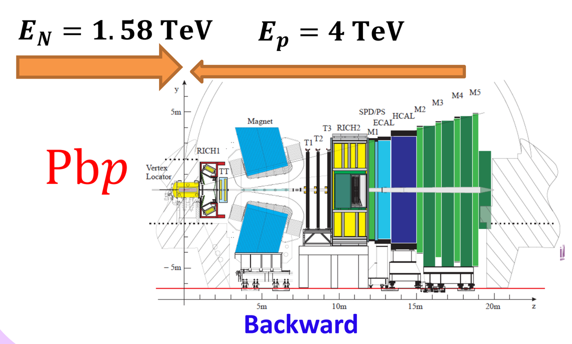
Forward-backward production ratio:

$$R_{FB}(y,\sqrt{s_{NN}}) = \frac{\sigma_{pA}(+|y|,\sqrt{s_{NN}})}{\sigma_{pA}(-|y|,\sqrt{s_{NN}})}$$

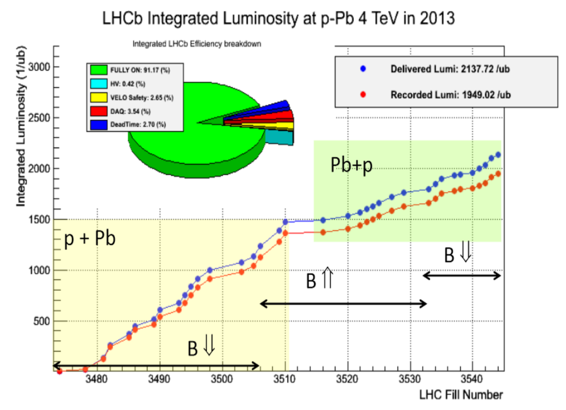


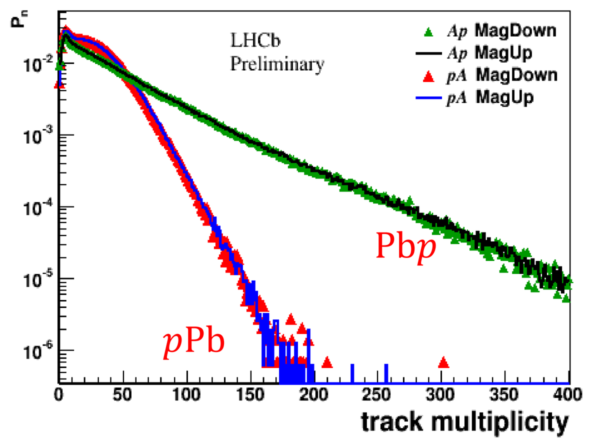
LHCb detector and data-taking in 2013





- Asymmetric beam energy
  - $E_p = 4$ TeV
  - $E_N = 1.58$ TeV for Pb beam
  - $\sqrt{s_{NN}} = 5$ TeV
  - $y_{c.m.s.} - y_{lab} = \pm 0.465$
- Rapidity coverage (in NN c.m.s.)
  - Forward direction (pPb) $1.5 < y < 4.0$
  - Backward direction (Pbp) $-5.0 < y < -2.5$
  - Common coverage $2.5 < |y| < 4.0$





- Low pile-up
- Integrated $\mathcal{L}$:
  Forward : 1.1 nb^{-1}
  Backward : 0.5 nb^{-1}
- Higher multiplicity in Pbp as expected

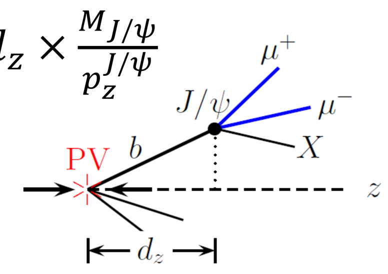
J/ψ production and cold nuclear matter effects in pPb collisions at $\sqrt{s_{NN}}$ = 5 TeV

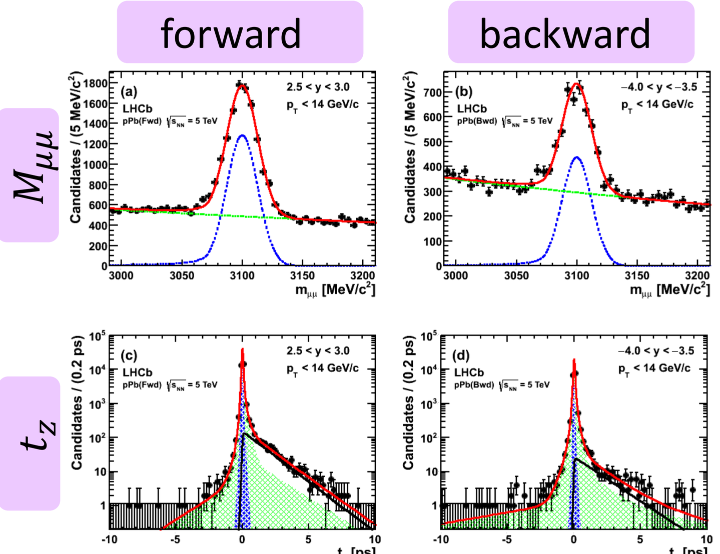
JHEP 02 (2014) 072

J/ψ signal extraction

- Reconstructed using $J/\psi \to \mu^+\mu^-$ decay
- Measurement performed in bins of p_T and y
- Three sources of J/ψ at hadron colliders
  - Prompt J/ψ
    - Direct J/ψ
    - Feed-down from heavier $c\bar{c}$ states
  - J/ψ from b-hadron decays
- Prompt J/ψ and J/ψ from b separated by pseudo proper time $t_z = d_z \times \frac{M_{J/\psi}}{p_z^{J/\psi}}$

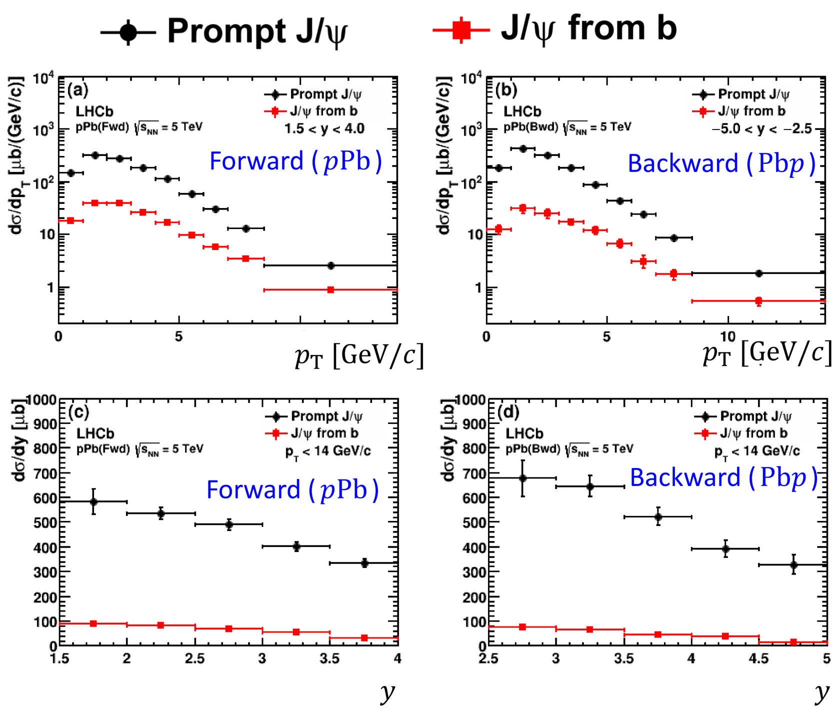
Cold nuclear matter effects on J/ψ from b reflect those on b hadrons!





Signal yield	Forward	Backward
Prompt J/ψ	25280 ± 240	8830 ± 160
J/ψ from b	3720 ± 80	890 ± 40

J/ψ cross-sections



- Integrated cross-section (p_T < 14 GeV)
  - Prompt J/ψ:

$$\sigma(+1.5 < y < +4.0) = 1168 \pm 15 \pm 54\,\mu b$$
$$\sigma(-5.0 < y < -2.5) = 1293 \pm 42 \pm 75\,\mu b$$

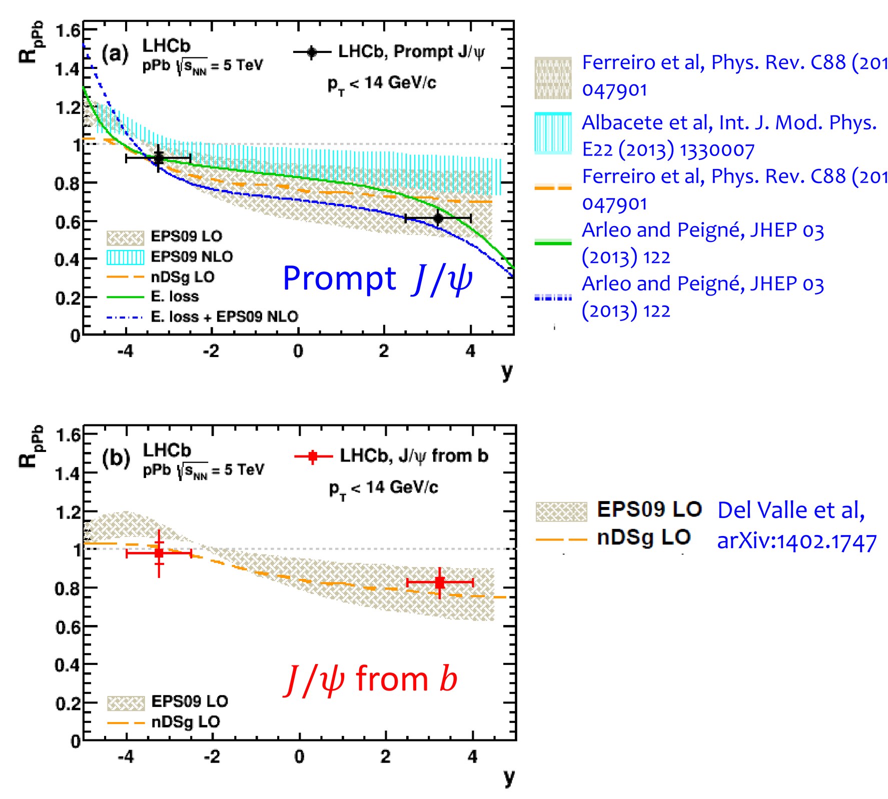
  - J/ψ from b:

$$\sigma(+1.5 < y < +4.0) = 166.0 \pm 4.1 \pm 8.2\,\mu b$$
$$\sigma(-5.0 < y < -2.5) = 118.2 \pm 6.8 \pm 11.7\,\mu b$$

- Where systematic uncertainties are dominated by:
  - Fit model
  - Luminosity
  - Data-MC discrepancy

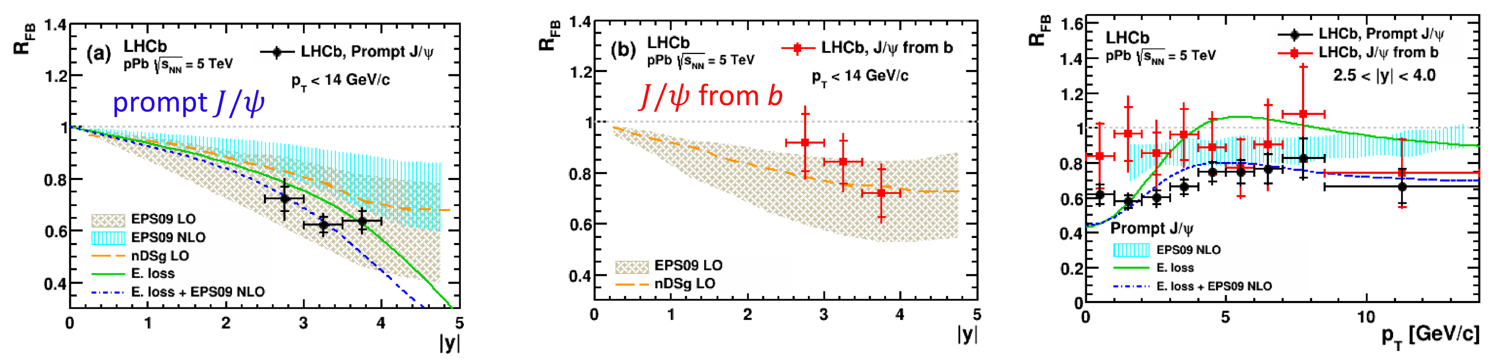
Nuclear modification factor R_{pPb}

- Reference σ_{pp} at $\sqrt{s}$ = 5 TeV interpolated from measurements at 2.76 TeV, 7 TeV and 8 TeV.
- Strong dependence on rapidity
- J/ψ from b less suppressed in forward region than prompt J/ψ $\Rightarrow$ b hadrons less affected by cold nuclear matter effects
- Agreement with predictions, yet the precision is insufficient to distinguish different models



Forward - backward production ratio R_{FB}

- Part of experimental and theoretical uncertainties cancel
- Clear difference between prompt J/ψ and J/ψ from b

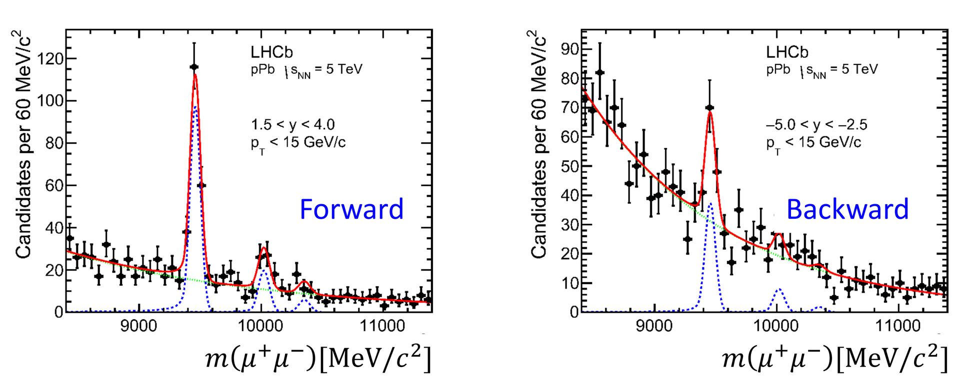


Υ production and cold nuclear matter effects in pPb collisions at $\sqrt{s_{NN}}$ = 5 TeV

arXiv: 1405.5152

Υ production

- Reconstructed using $\Upsilon(nS) \to \mu^+\mu^-$



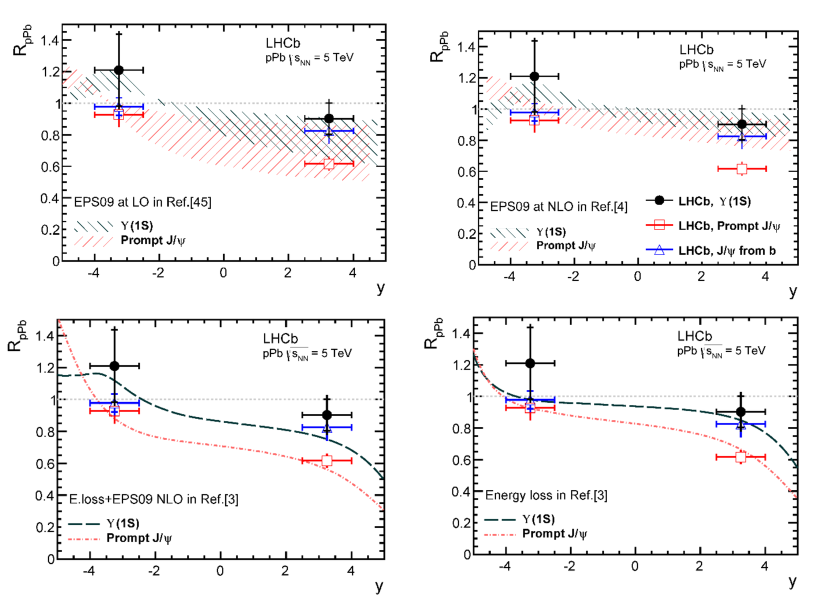
- Total cross-section with p_T < 15 GeV measured
- Systematic uncertainty dominated by mass fit model, data-MC discrepancy and trigger
- Production ratios $R^{nS/1S} \equiv \frac{\sigma(\Upsilon(nS))\times Br(\Upsilon(nS)\to\mu^+\mu^-)}{\sigma(\Upsilon(1S))\times Br(\Upsilon(1S)\to\mu^+\mu^-)}$

$$R^{2S/1S}(-5.0 < y < -2.5) = 0.28 \pm 0.14 \pm 0.05$$
$$R^{3S/1S}(-5.0 < y < -2.5) = 0.02 \pm 0.09 \pm 0.02$$
$$R^{2S/1S}(1.5 < y < 4.0) = 0.20 \pm 0.05 \pm 0.01$$
$$R^{3S/1S}(1.5 < y < 4.0) = 0.07 \pm 0.04 \pm 0.01$$

consistent with pp results but limited by statistics
$R^{2S/1S}(pp) \sim 0.24$
$R^{3S/1S}(pp) \sim 0.12$

R_{pPb} for $\Upsilon(1S)$

- Reference pp cross-section interpolated as done for J/ψ
- Forward region: suppression smaller than prompt J/ψ, and compatible with b hadrons
- Backward region: indication of antishadowing effect
- Consistent with different theoretical models with large uncertainty



- LHCb, Υ(1S)
- LHCb, Prompt J/ψ
- LHCb, J/ψ from b

Theoretical predictions:

EPS09 LO: Ferreiro et al, EPJC 73 (2011) 2427
EPS09 NLO: Albacete et al, IJMP E22 (2013) 1330007
E. loss: Arleo and Peigné, JHEP 03 (2013) 122

R_{FB} for $\Upsilon(1S)$

- Part of experimental and theoretical uncertainties cancel
- Agreement with different theoretical models, but statistical uncertainty large