UNIVERSIDAD TECNICA FEDERICO SANTA MARIA

ATLAS EXPERIMENT

J/ψ and ψ(2S) production in pp and PbPb collisions at 5.02 TeV with ATLAS

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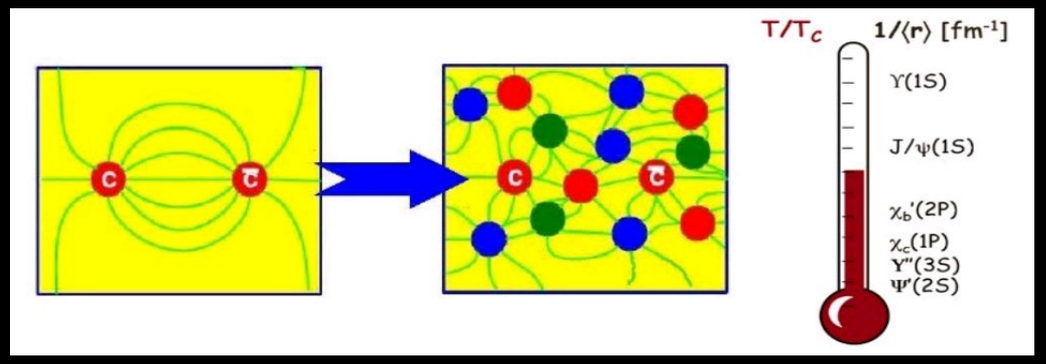
8th International Conference on Hard and Electromagnetic Probes of High-Energy Nuclear Collisions

Why measure the Quarkonia:

Charmonia bound states of c and $\bar{c}$ quarks, could be a unique probe to study the hot, dense system created in nucleus-nucleus (A+A) collisions.

T. Matsui and H. Satz PLB 178 (1986) 416



However, the full picture is much more complicated

- Color-Screening: melting
- Color-exchange: absorption
- Medium induced energy loss
- Regeneration via statistical recombination
- Feed-Down of excited charmonium states and B-hadrons

Method

Reconstructed dimuons in Invariant Mass $2.6 < M_{\mu\mu} < 4.2$ GeV

Trigger PbPb

- L1 Trigger: Single MU4 (PbPb)
- High Level Trigger: 2 muons, $p_T > 4$ GeV

Trigger pp

- L1 Trigger: Double MU4
- High Level Trigger: 2 muons, $p_T > 4$ GeV

Measurements of prompt and non-prompt J/ψ and ψ(2S)

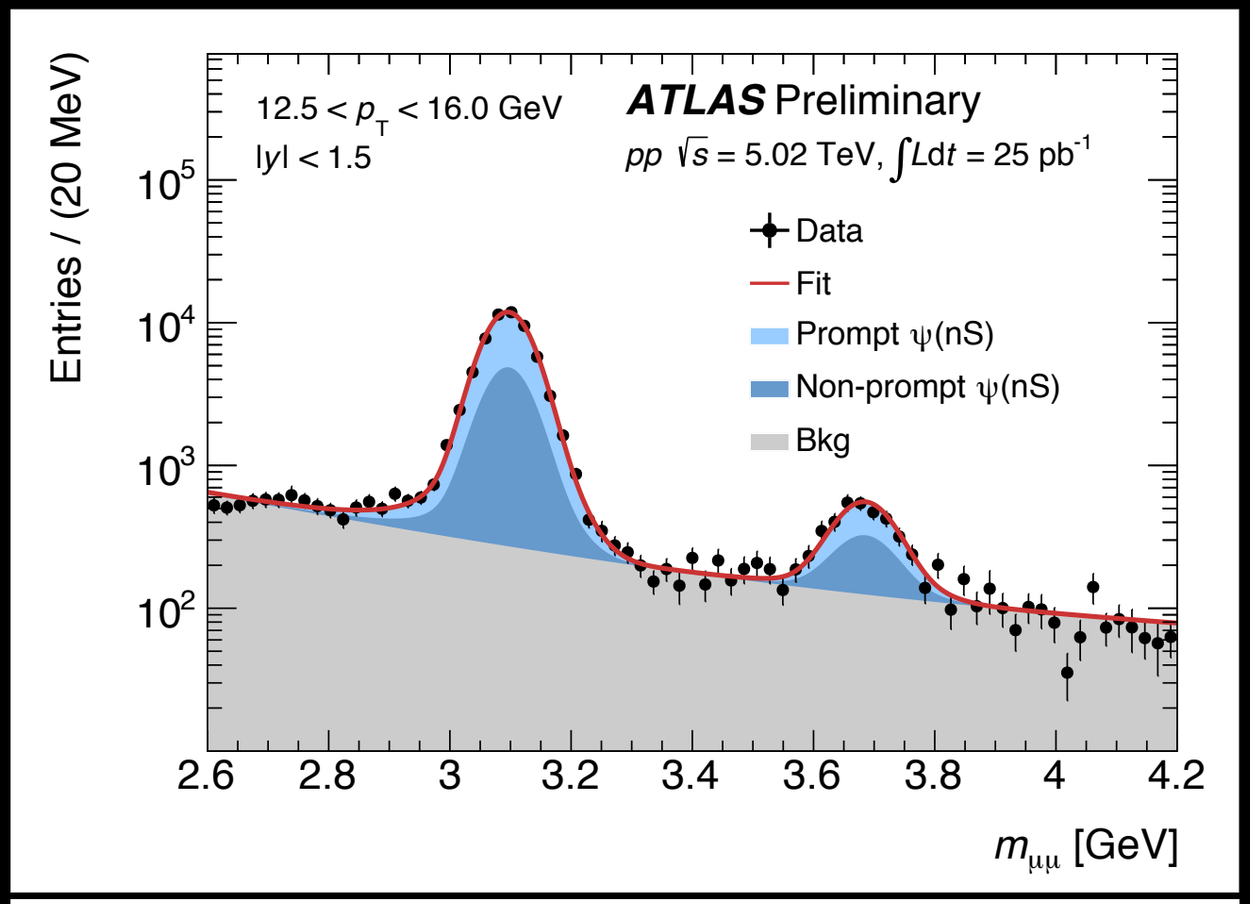
Kinematic Range: $9 < p_T < 40$ GeV and $|y| < 2$, centrality 0-80%

Perform weighted 2D unbinned maximum likelihood fit

- dimuon Invariant mass and lifetime
- Per-dimuon weight: trigger and reconstruction efficiency; acceptance
- Parametrize signal, background and non-prompt fraction

Simultaneous Fit Method

pp projections

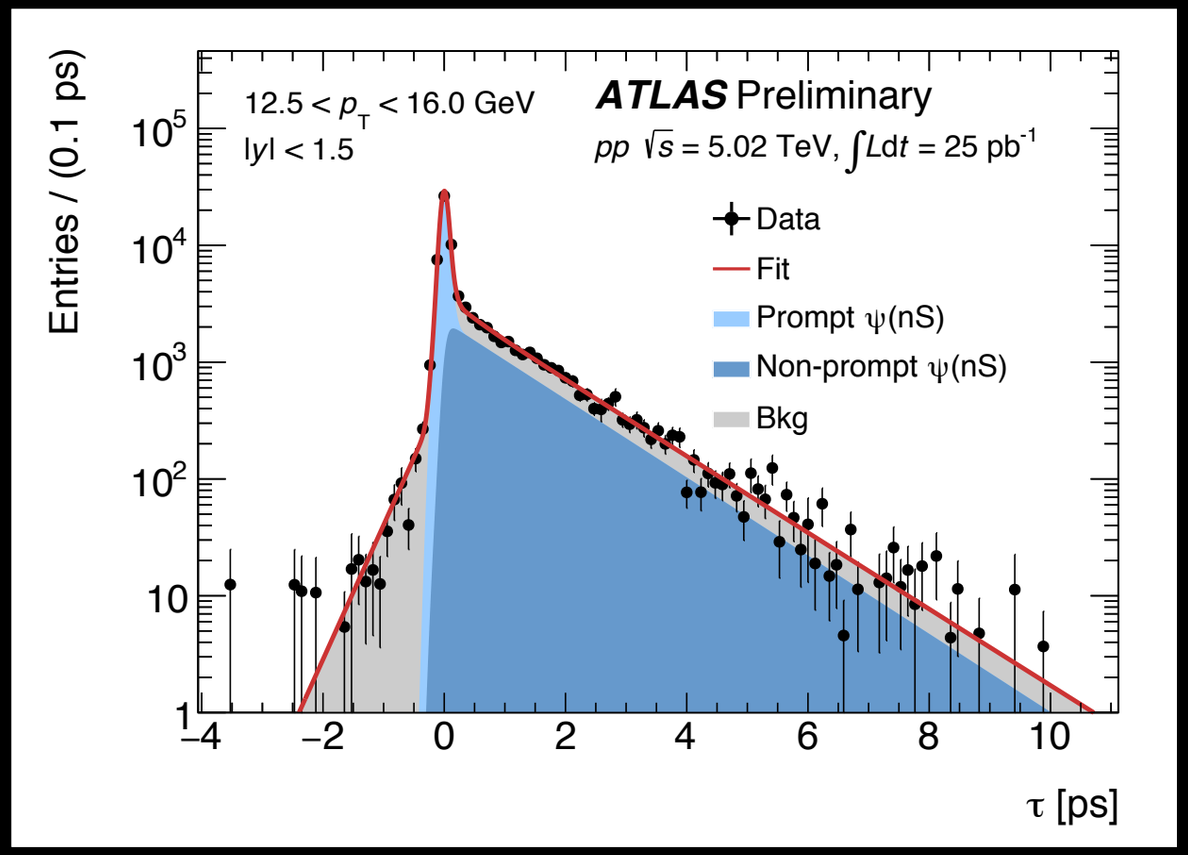


i	Type	Source	$f_i(m)$	$h_i(\tau)$
1	J/ψ S	P	$\omega_i \mathrm{CB}_1(m) + (1-\omega_i)\mathrm{G}_1(m)$	$\delta(\tau)$
2	J/ψ S	NP	$\omega_i \mathrm{CB}_1(m) + (1-\omega_i)\mathrm{G}_1(m)$	$\mathrm{E}_1(\tau)$
3	$\psi(2S)$ S	P	$\omega_i \mathrm{CB}_2(m) + (1-\omega_i)\mathrm{G}_2(m)$	$\delta(\tau)$
4	$\psi(2S)$ S	NP	$\omega_i \mathrm{CB}_2(m) + (1-\omega_i)\mathrm{G}_2(m)$	$\mathrm{E}_2(\tau)$
5	Bkg	P	flat	$\delta(\tau)$
6	Bkg	NP	$\mathrm{E}_3(m)$	$\mathrm{E}_4(\tau)$
7	Bkg	NP	$\mathrm{E}_5(m)$	$\mathrm{E}_6(\lvert\tau\rvert)$

pseudo-proper decay time

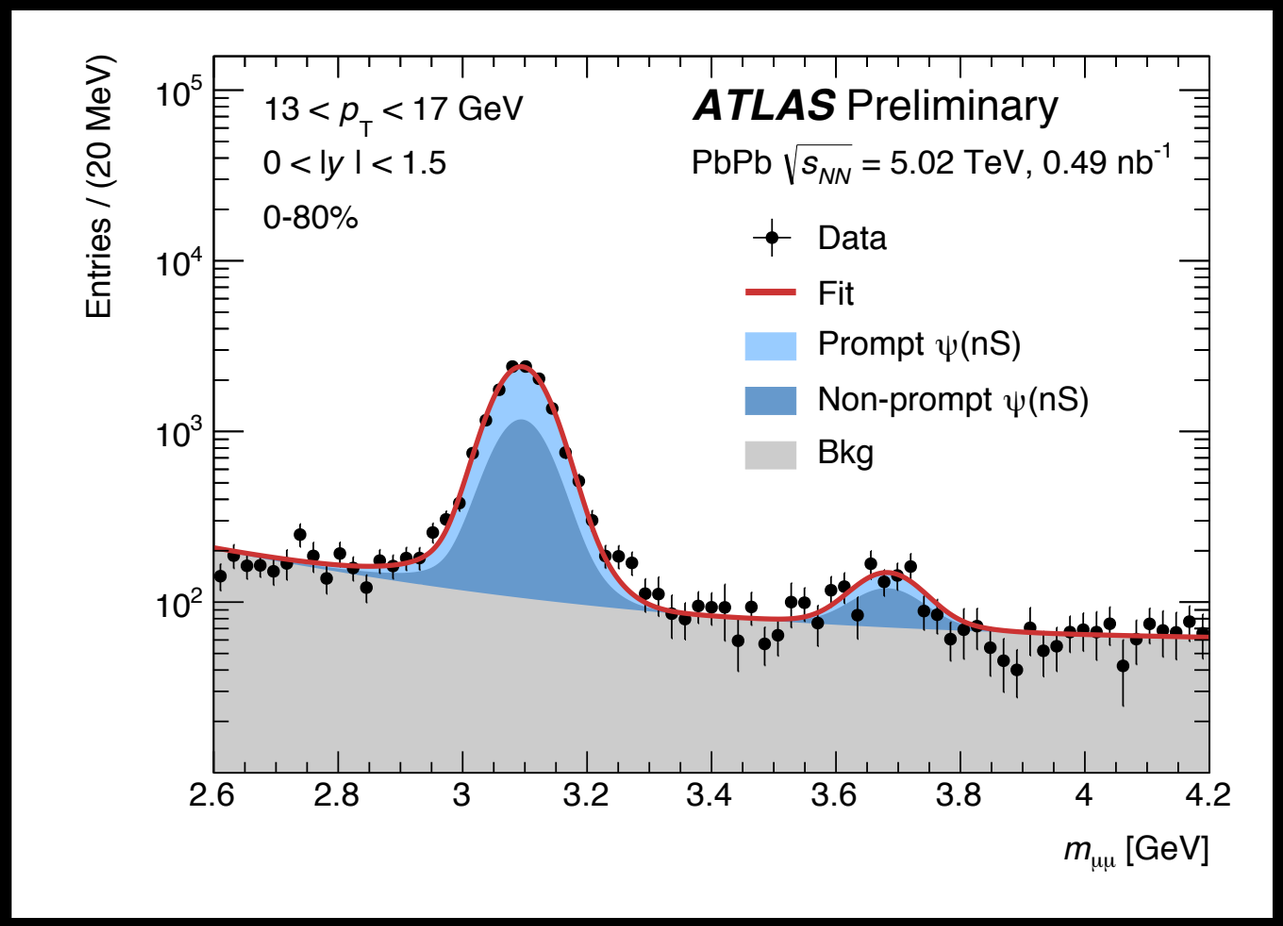
$$\tau = \frac{L_{xy} m_{\mu\mu}}{p_T^{\mu\mu}}$$

L_{XY} = projection of decay length on the transverse plane

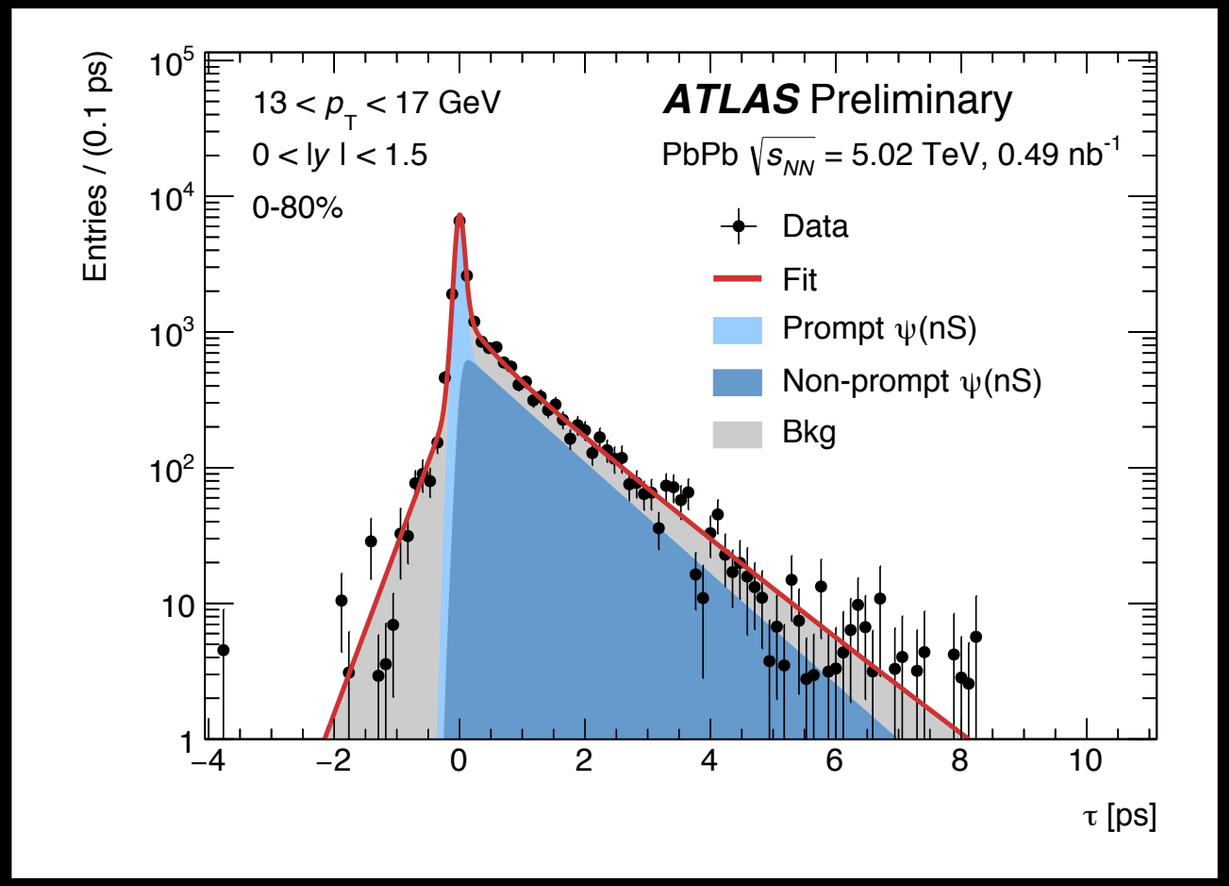


Simultaneous Fit Method

PbPb projections



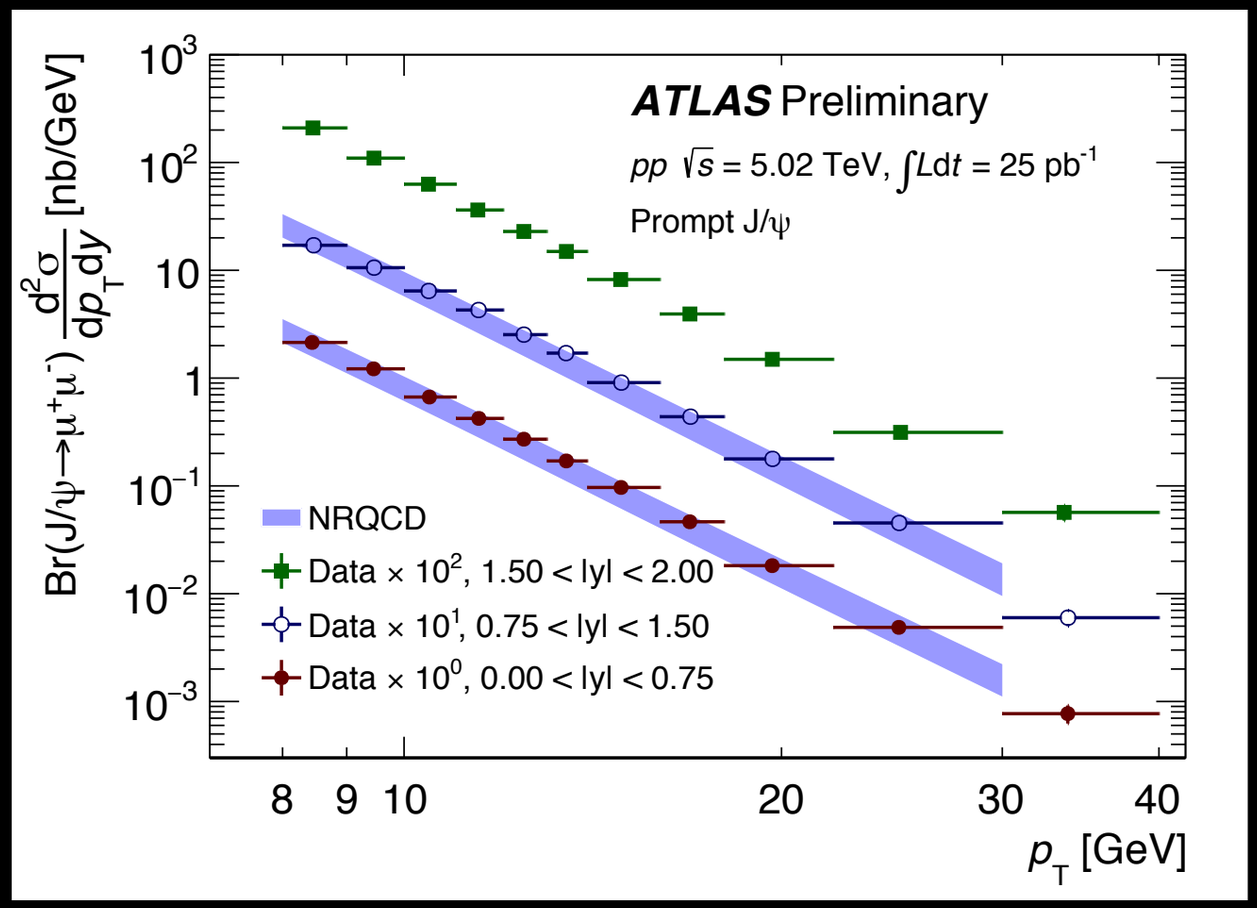
Invariant dimuon mass and lifetime

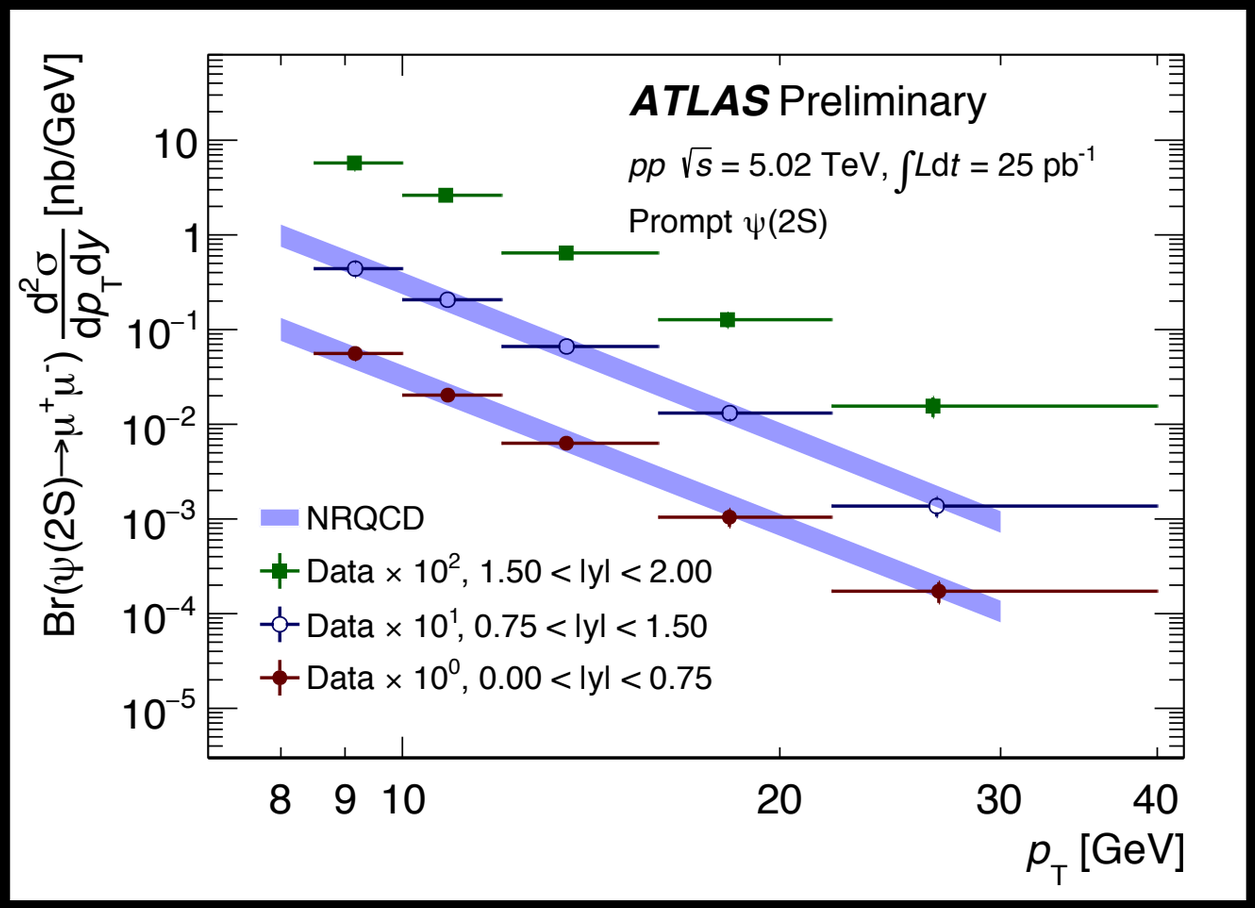


Weights: Acceptance, trigger and reconstruction efficiency

Differential production Cross Section Prompt

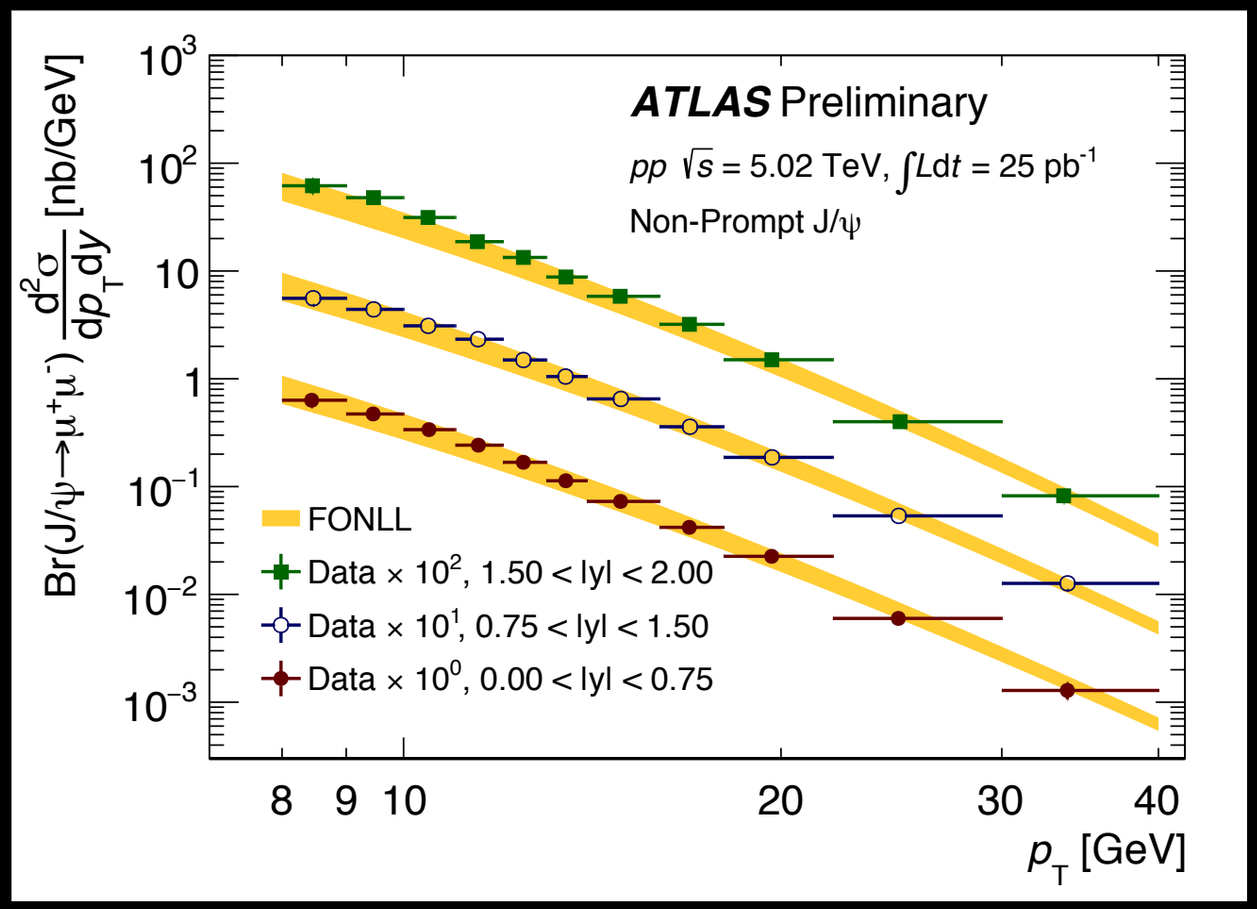
J/ψ and ψ(2S) 5.02 TeV pp

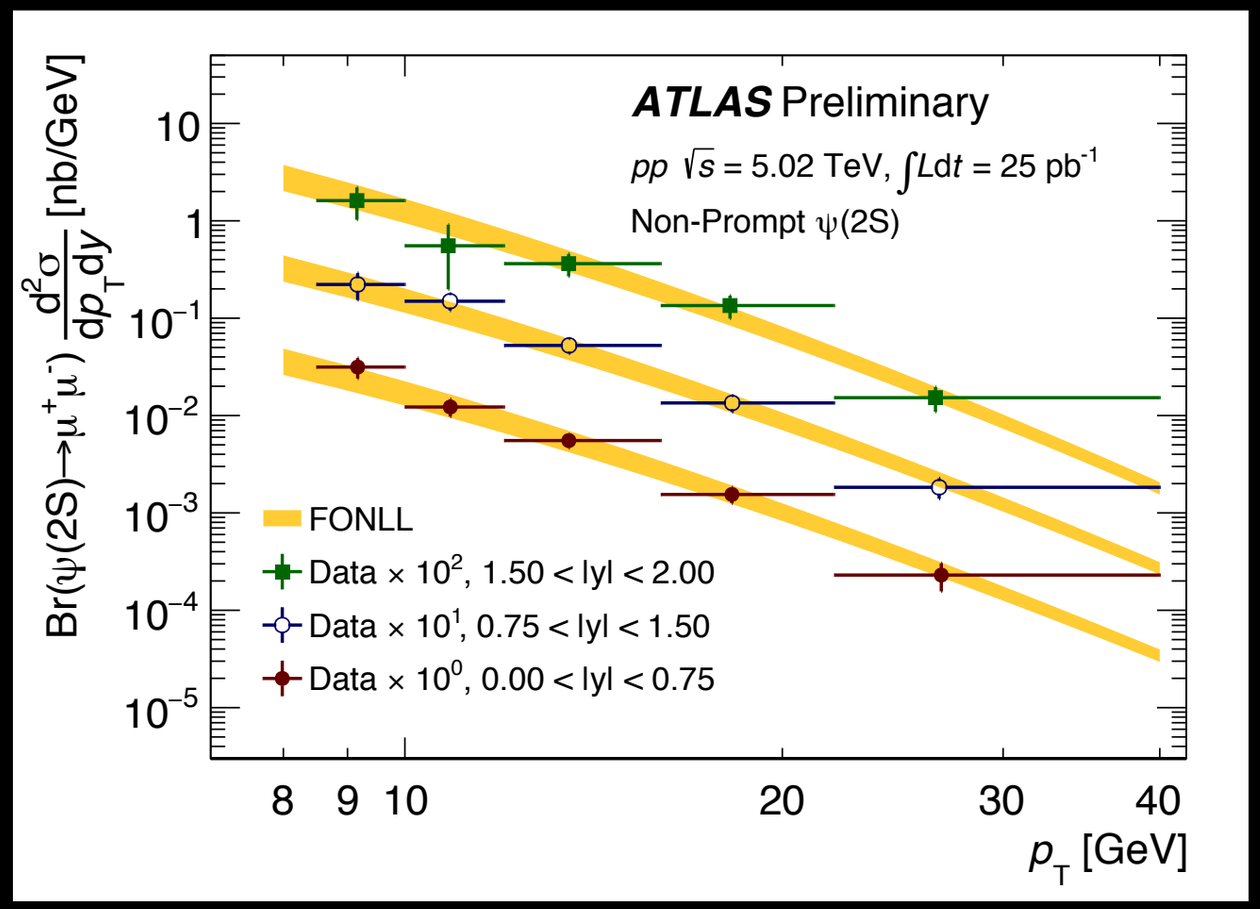




As can be seen, the data are in very good agreement with the theoretical prediction within the uncertainties.

Differential production Cross Section non-Prompt J/ψ and ψ(2S) 5.02 TeV pp

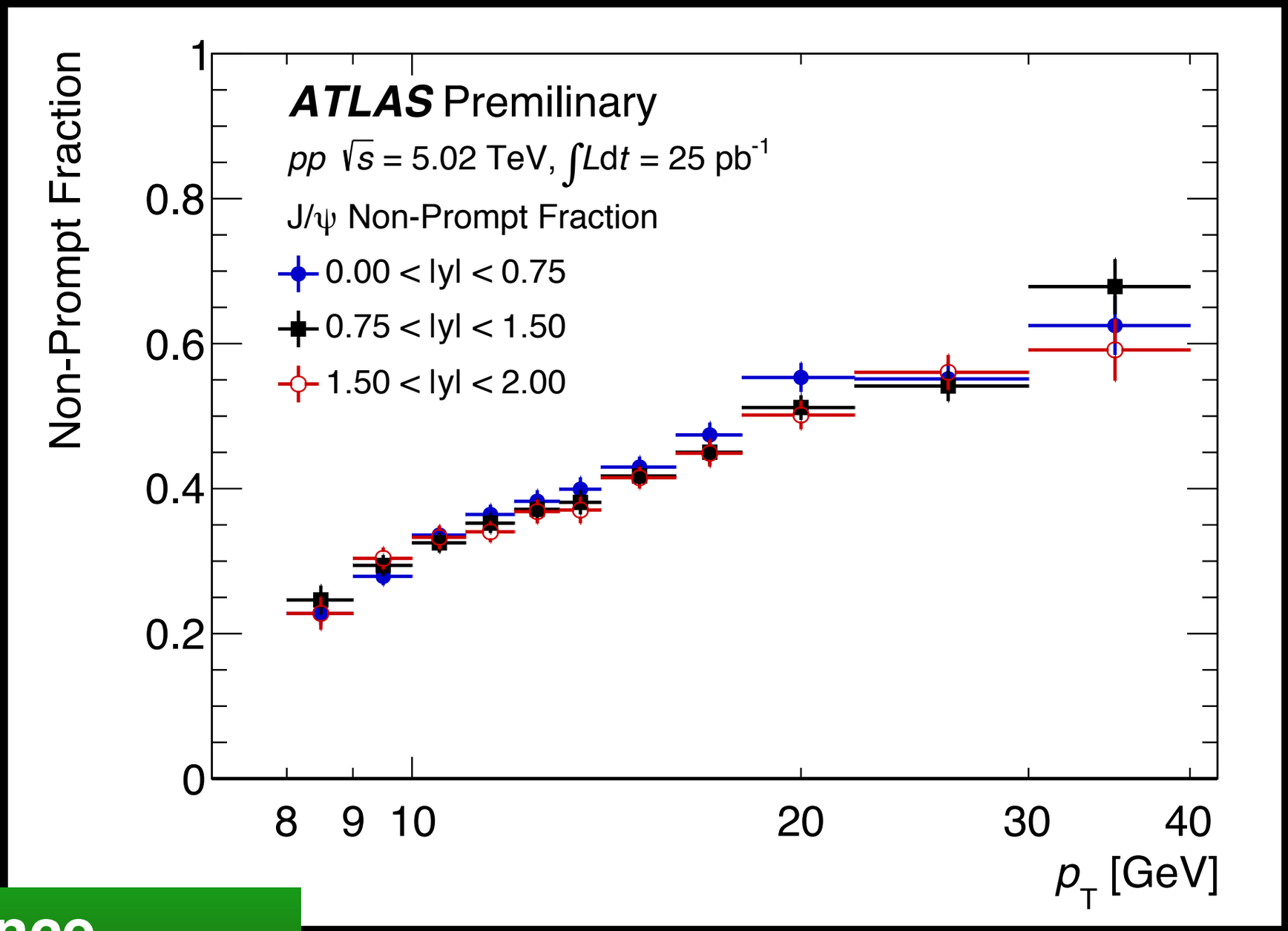




As can be seen, the data are in very good agreement with the theoretical prediction within the uncertainties.

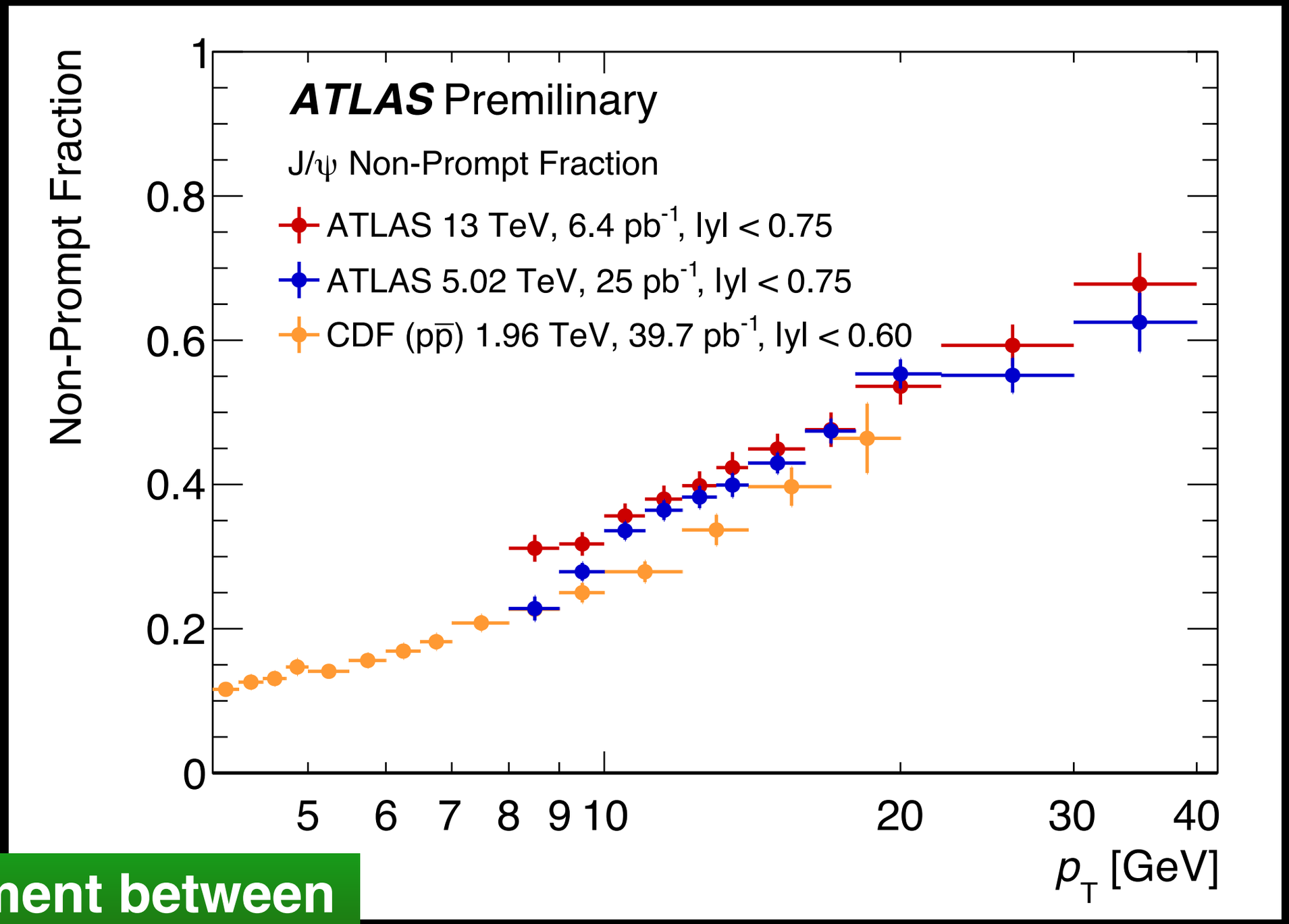
Non-prompt fraction of J/ψ in pp 5.02 TeV vs. p_T for |y| slices

$$f_{\mathrm{NP}}^{\psi(nS)} = \frac{N_{\mathrm{NP}}^{\psi(nS)}}{N_{\mathrm{NP}}^{\psi(nS)} + N_{\mathrm{P}}^{\psi(nS)}}$$



Strong pT dependence
No significant |y| dependence

Non-prompt fraction of J/ψ in pp 5.02 TeV, 13 TeV and 1.96 TeV



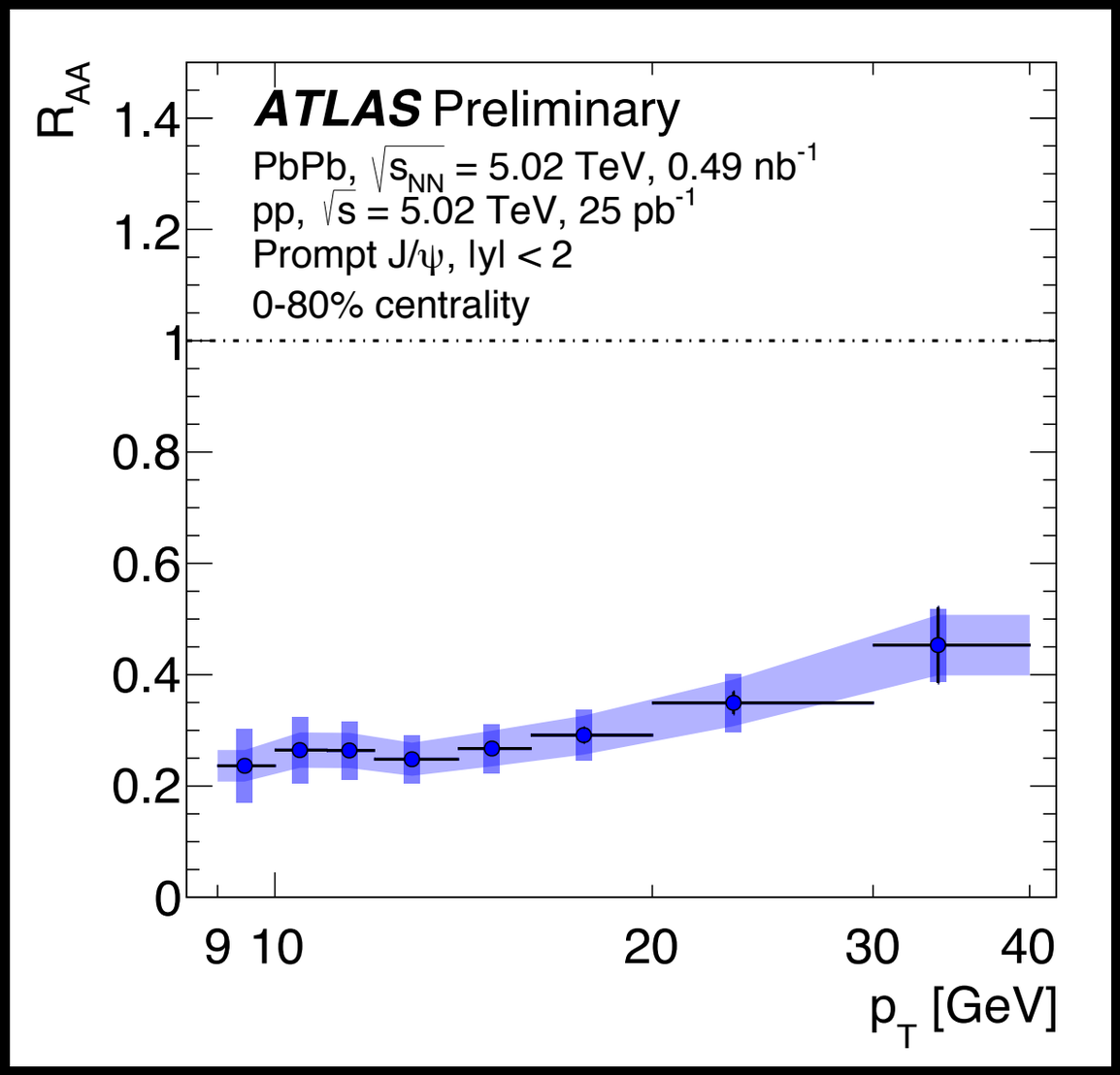
Good agreement between the different energies

R_{AA} vs. p_T

Integrated y and centrality

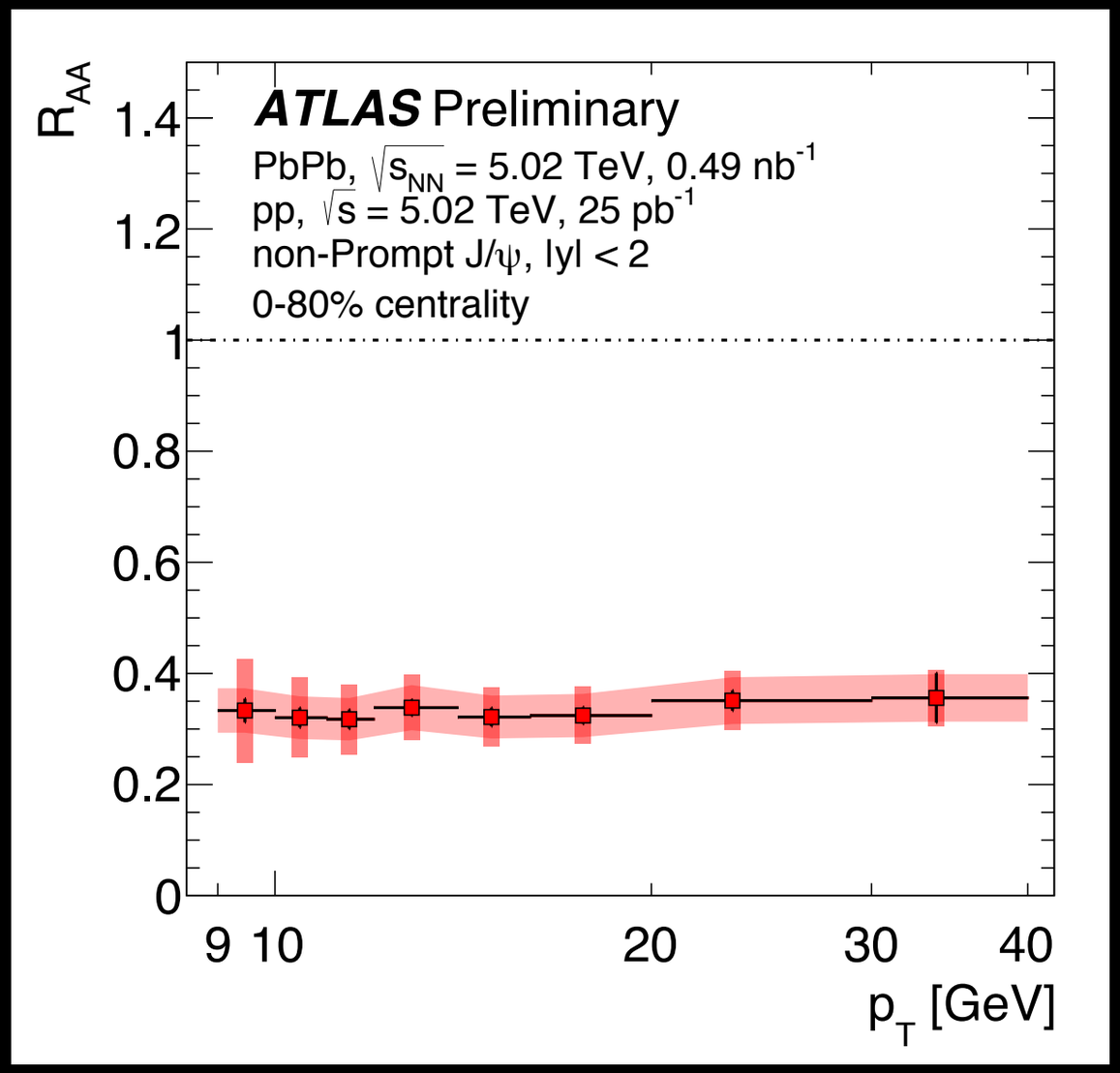
$$R_{\mathrm{AA}} = \frac{N_{\mathrm{AA}}}{\langle T_{\mathrm{AA}} \rangle \sigma^{pp}}$$

Prompt



Increasing R_{AA} as a function of pT

non-Prompt

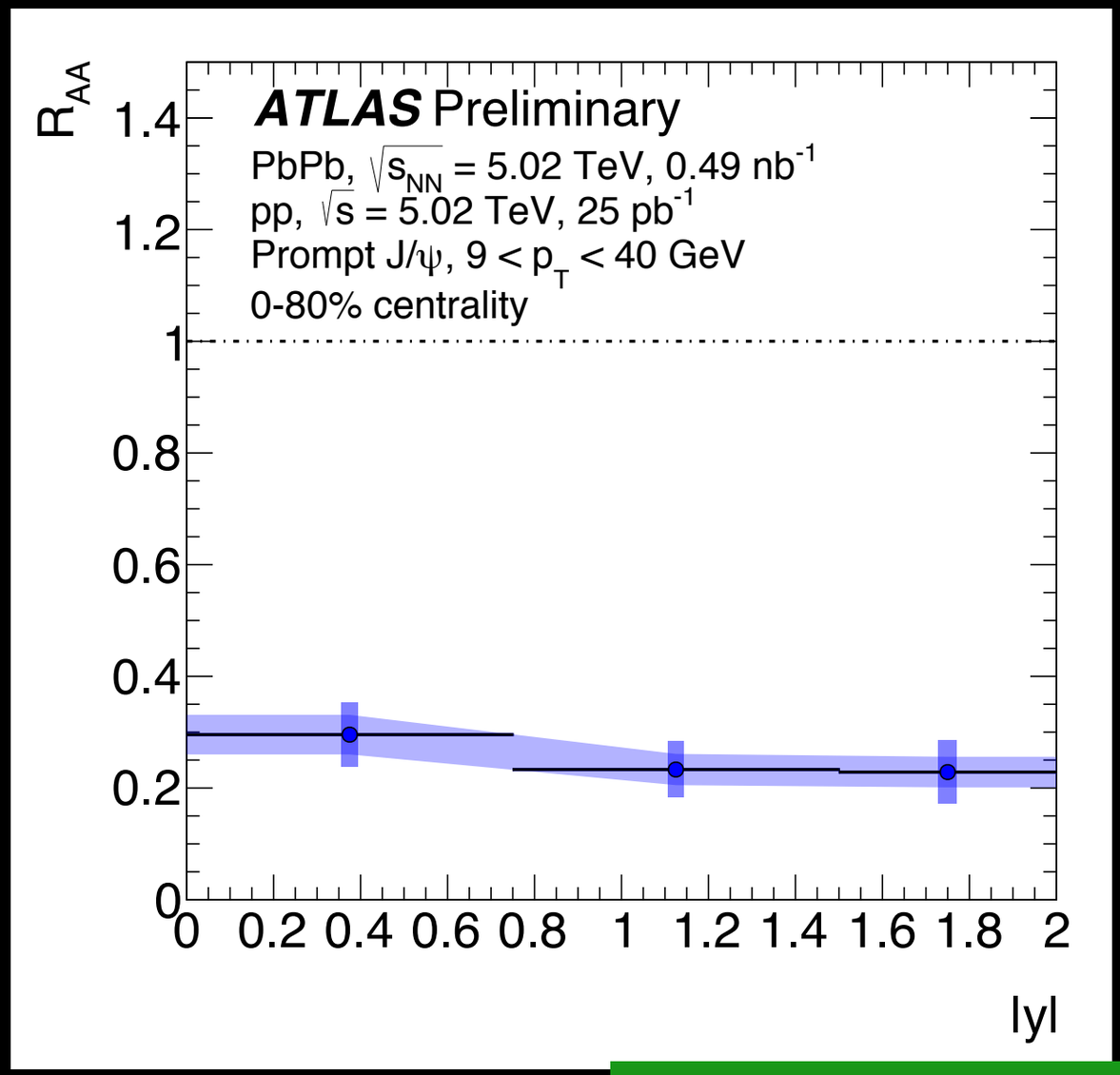


Flat along the pT range

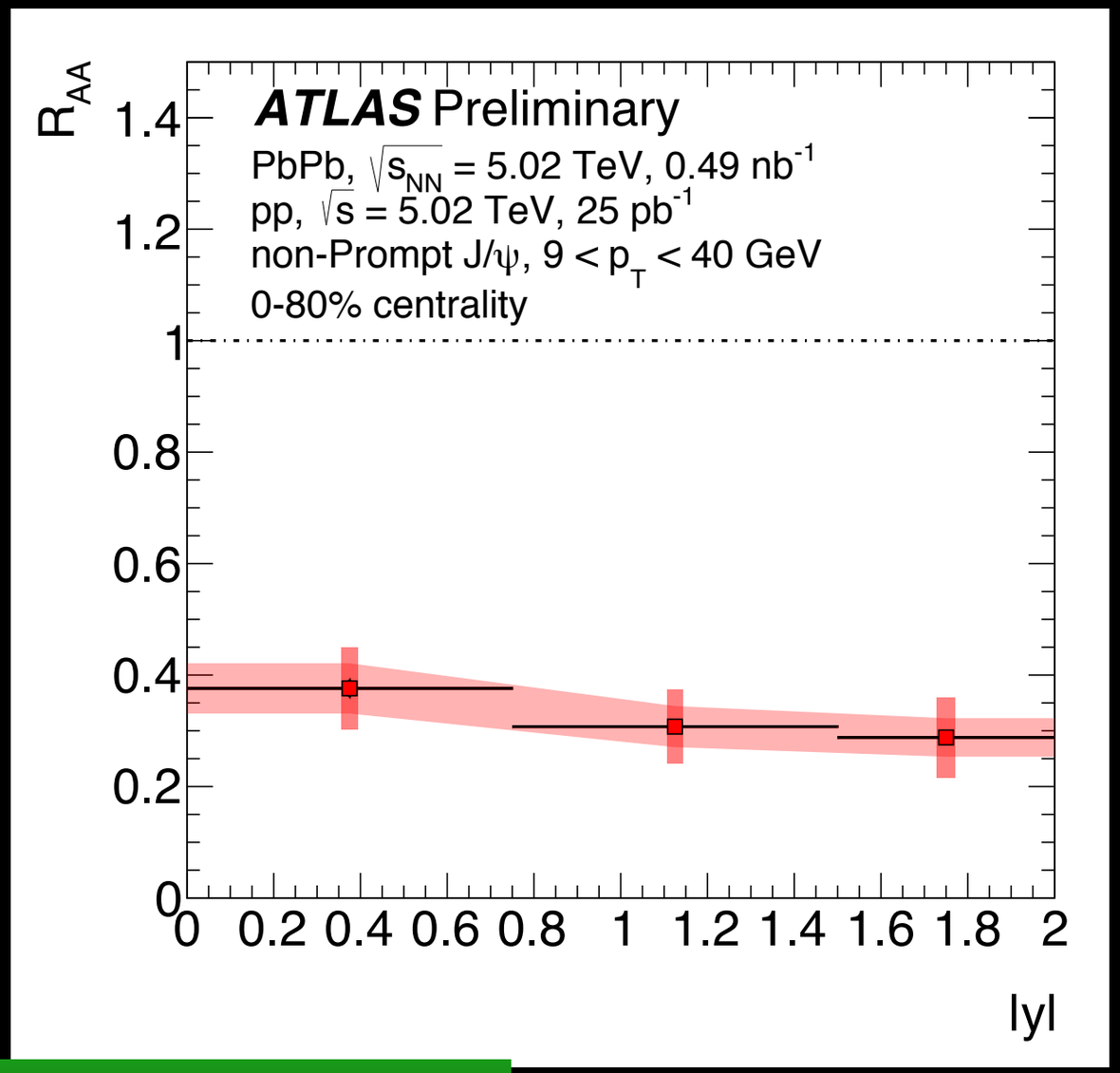
R_{AA} vs. |y|

Integrated pT and centrality

Prompt



non-Prompt



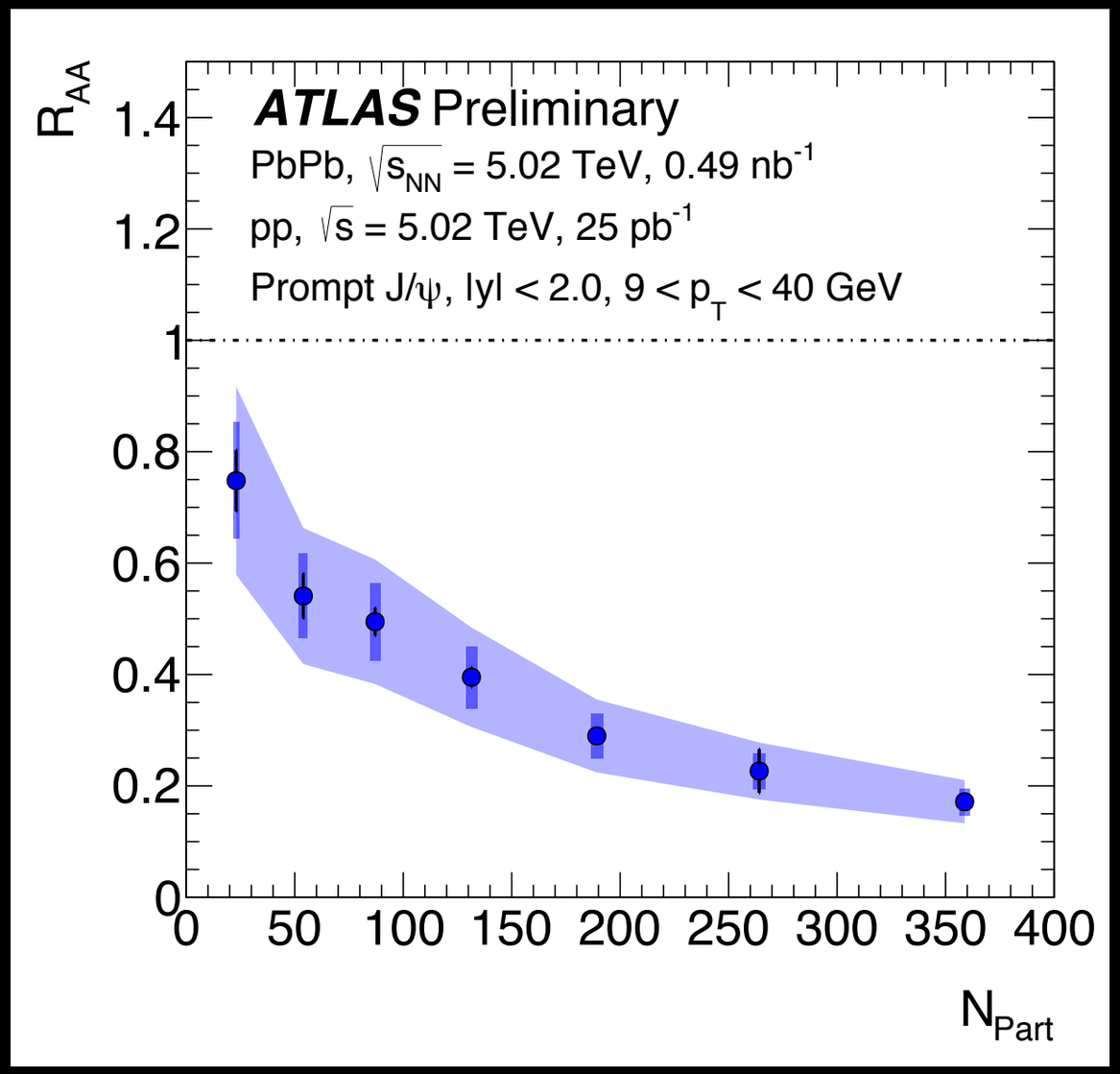
No significant |y| dependence

R_{AA} vs. N_{part}

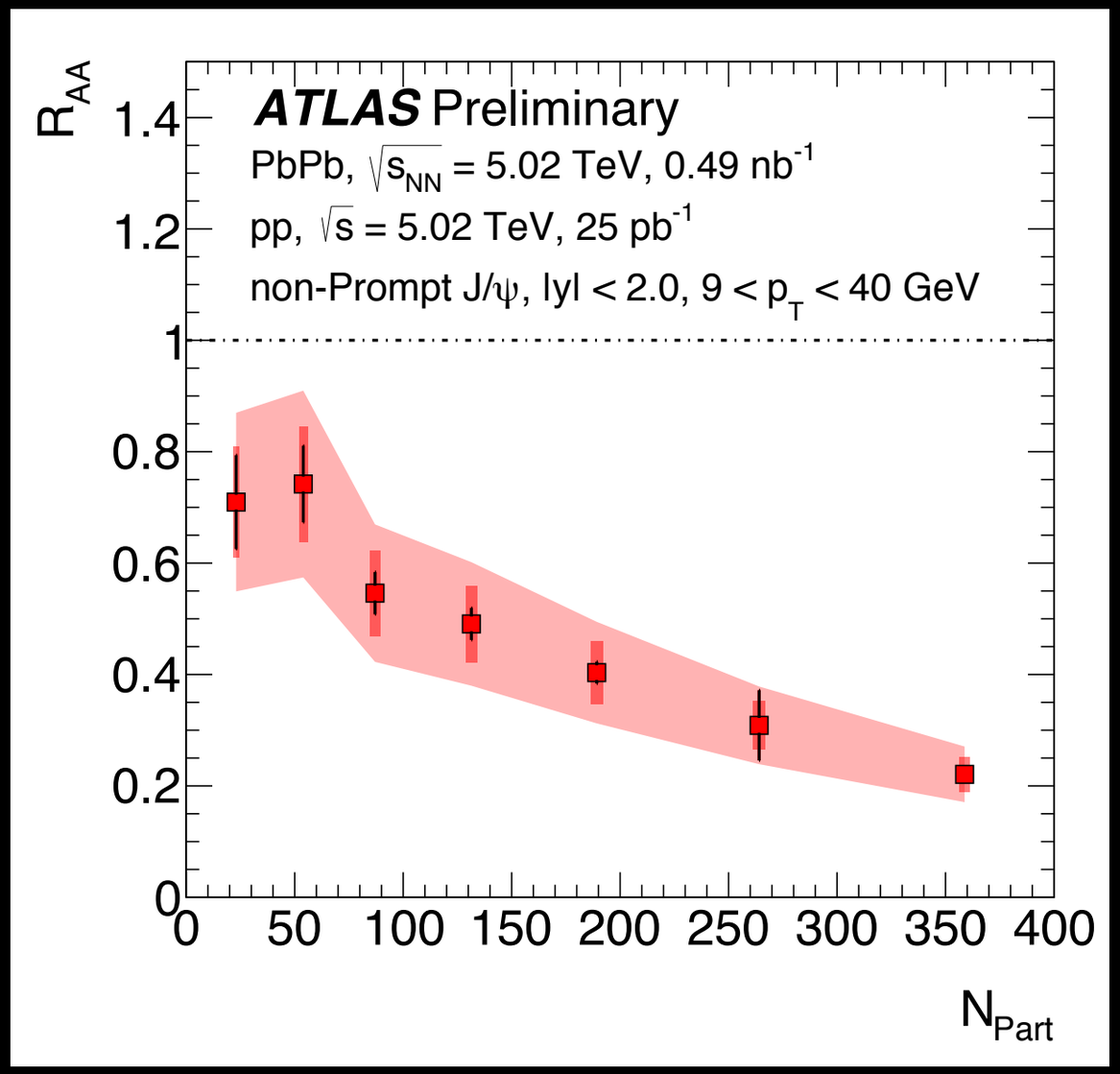
Integrated pT and |y|

N_{part}: mean number of participant

Prompt



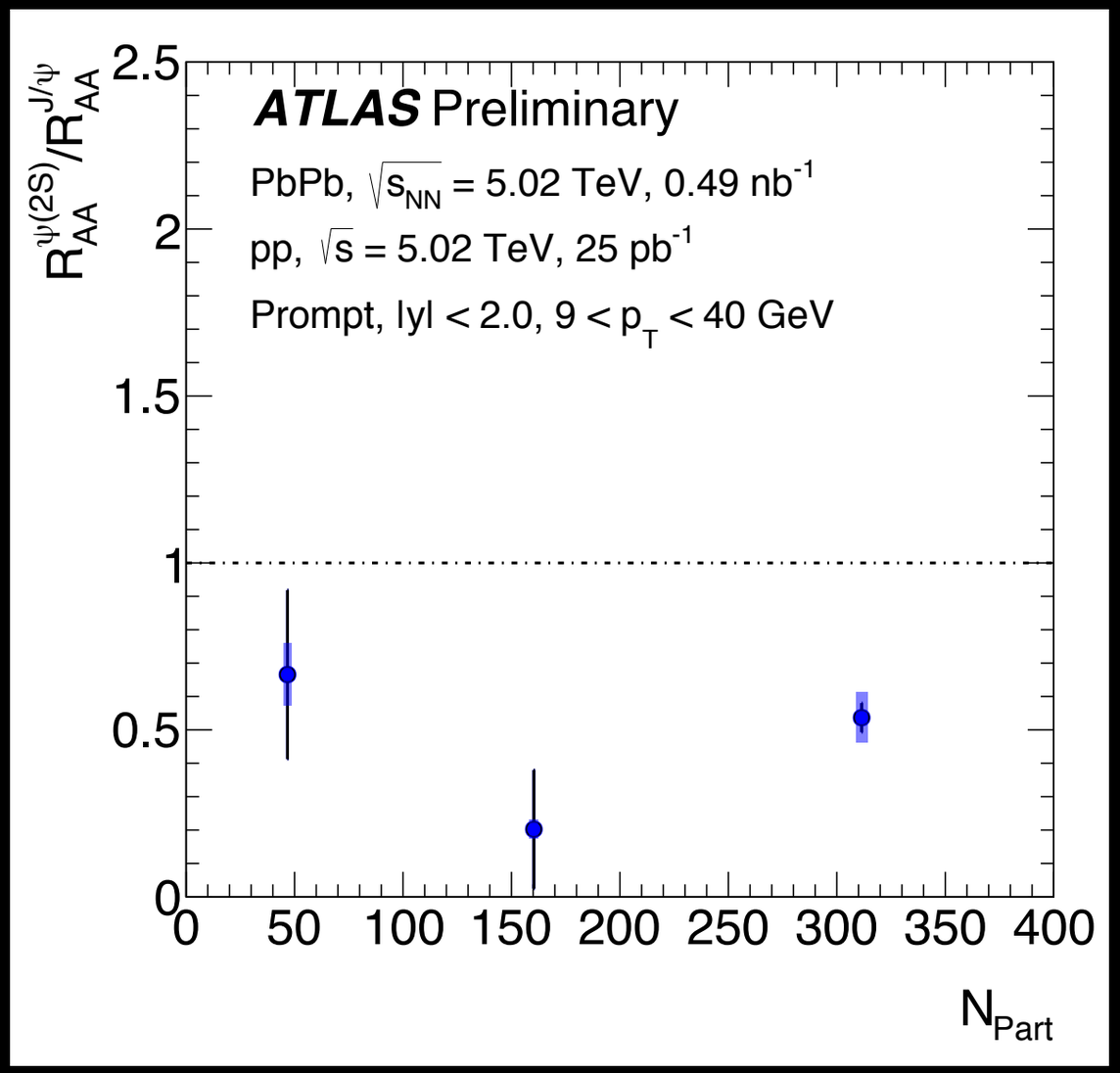
non-Prompt



J/ψ is strongly suppressed in most central collisions

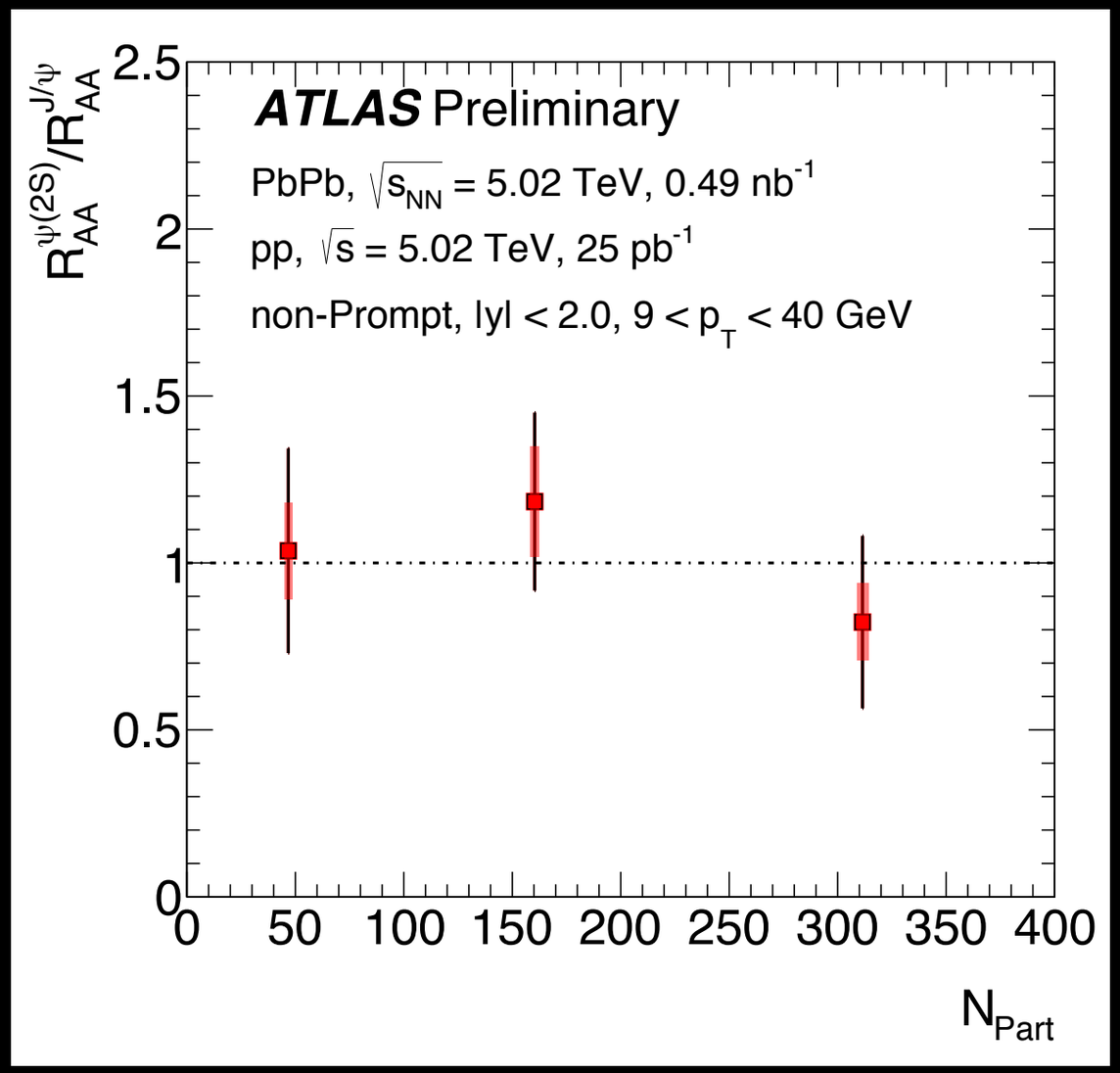
Suppression of ψ(2S) to J/ψ vs N_{part}

Prompt



Stronger suppression of ψ(2S) with respected to the J/ψ

non-Prompt



Consistent with 1

Conclusions

pp collision

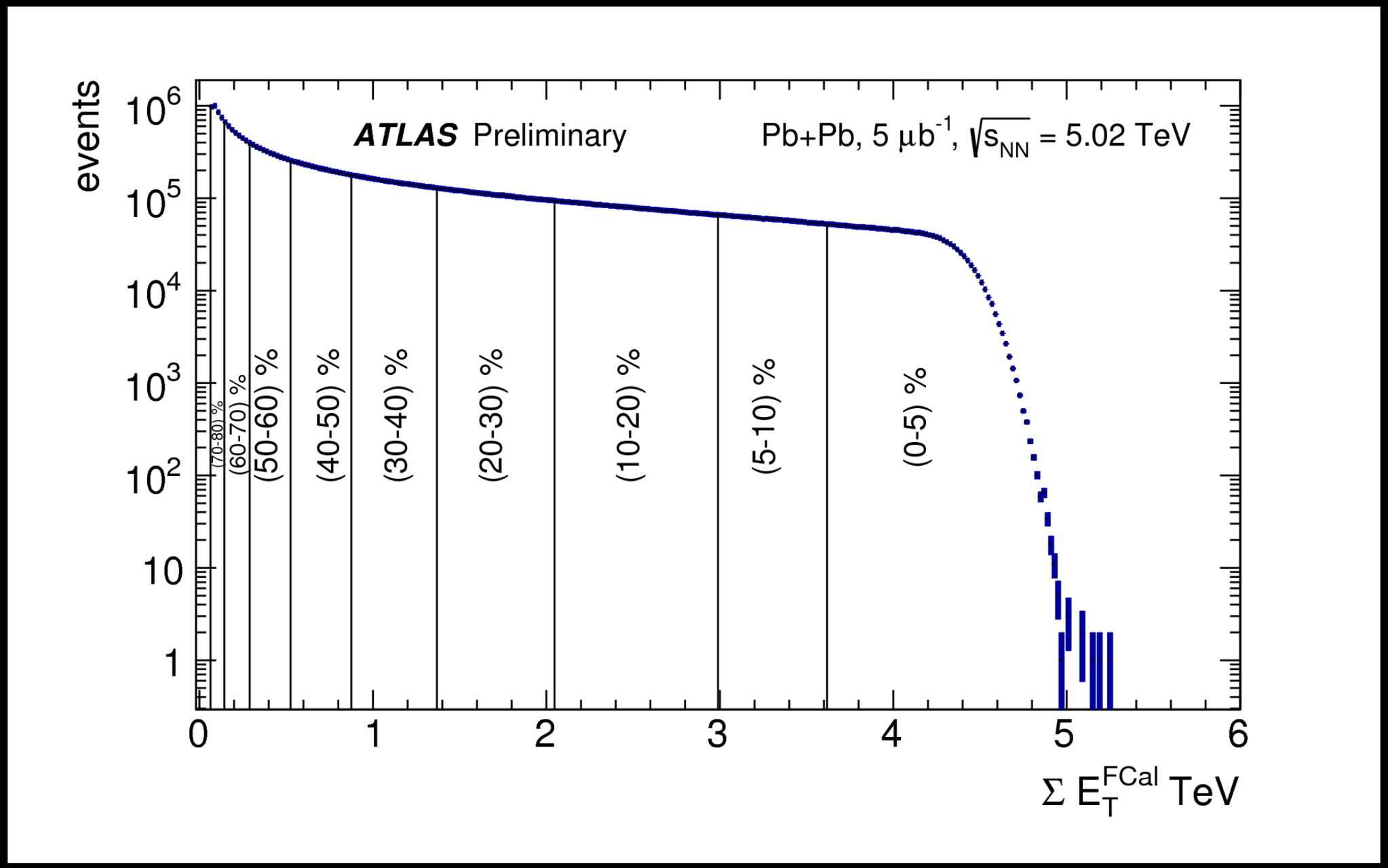
- Measurement of the J/ψ and ψ(2S) production Cross Section for prompt and non-prompt component.
- Measurement of non-prompt fraction.

First measurement of quarkonia production in PbPb with ATLAS

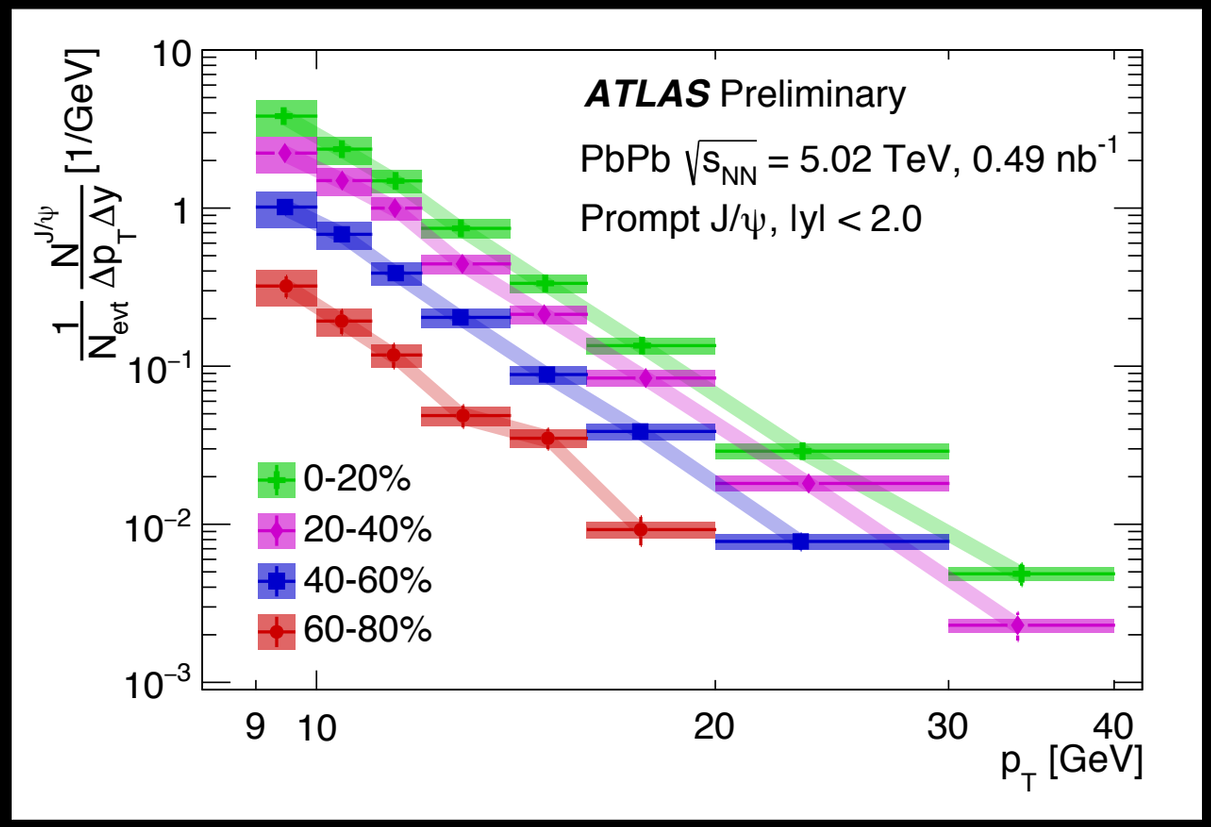
- Per-event Yields of prompt and non-prompt production of J/ψ for different centrality classes.
- non-prompt fraction for different centrality classes.
- **J/ψ R_{AA}** as a function of p_T, |y| and N_{Part}. For prompt and non-prompt component.
- ψ(2S) to J/ψ double ratio as a function of N_{Part}. For prompt and non-prompt component.

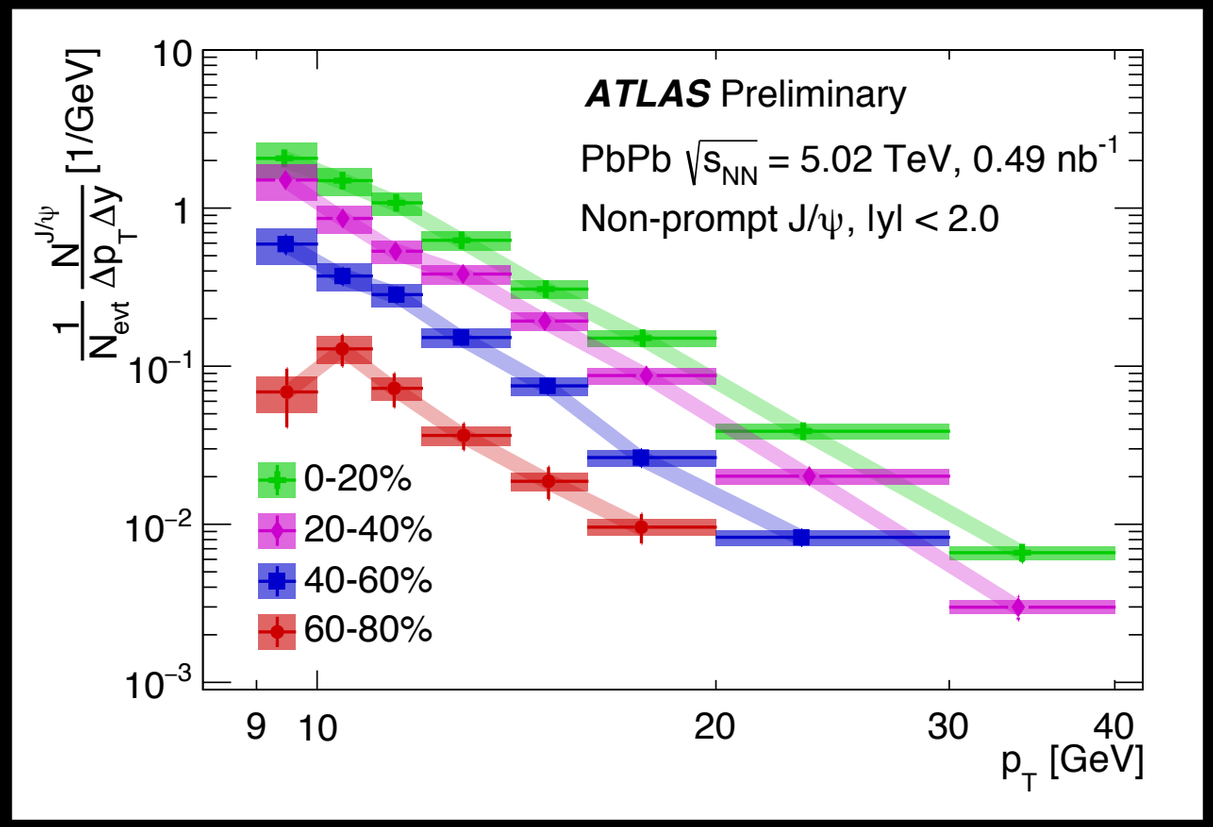
Additional Slides

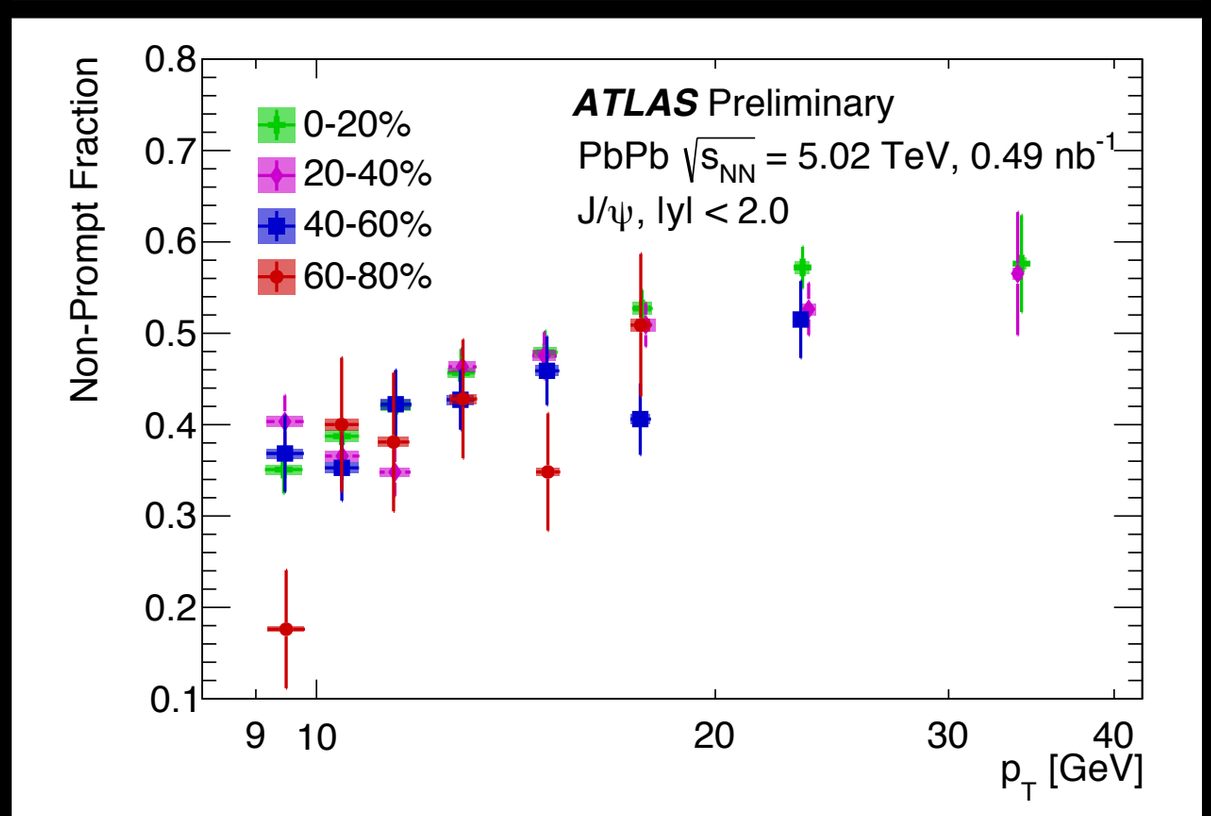
Centrality vs. Fcal



Per-event-yields prompt and non-prompt J/ψ







Poster by Jorge

Simultaneous Fit Method

$$\mathrm{PDF}(m,\tau) = \sum_{i=1}^{7} \kappa_i f_i(m) \cdot h_i(\tau) \otimes g(\tau),$$

The composite PDF terms are defined as follows:

- CB - Crystal Ball;
- G - Gaussian;
- E - Exponential;
- Resolution function $g(\tau)$ is a double Gaussian function;
- δ - delta function.