Charmonium suppression in PbPb collisions with CMS

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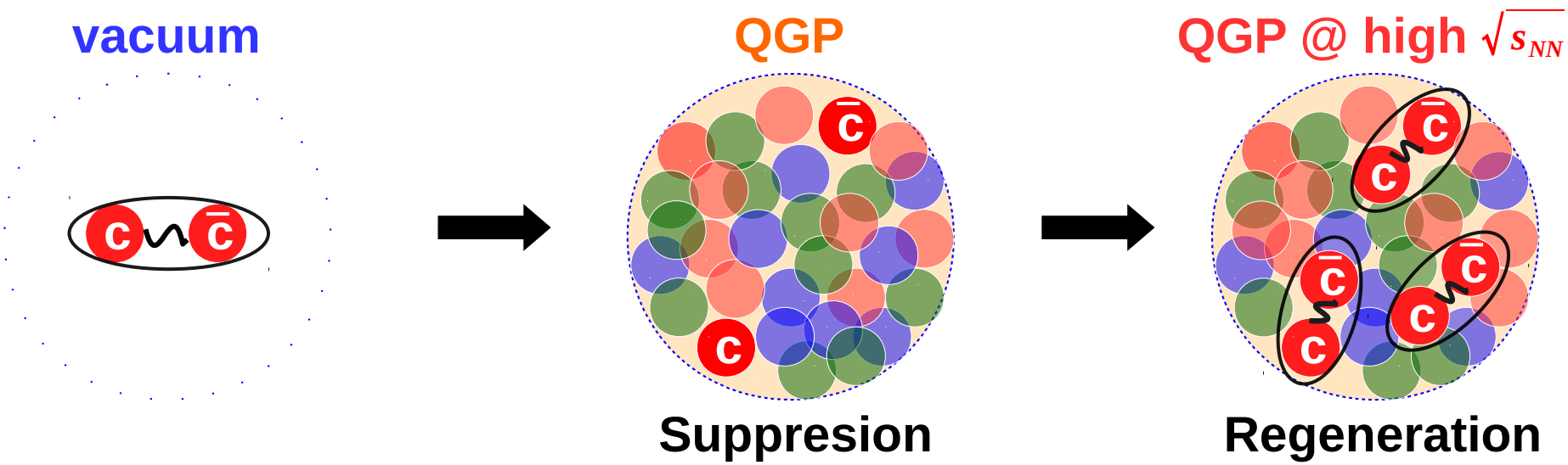
Charmonia in Pb-Pb Collisions

Charmonia ($c\bar{c}$ mesons) are produced in the early stages of the collision

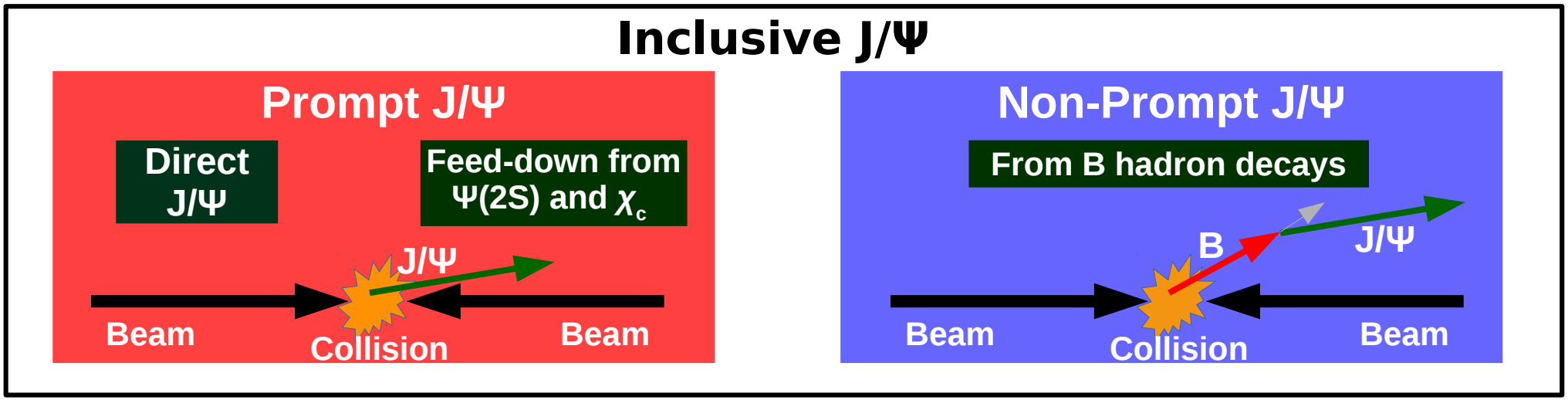
$$\tau^{Charmonia}_{formation} \lesssim \tau^{QGP}_{formation} < \tau^{QGP}_{lifetime} < \tau^{Charmonia}_{decay}$$

The Quark-Gluon Plasma is expected to modify the charmonia production



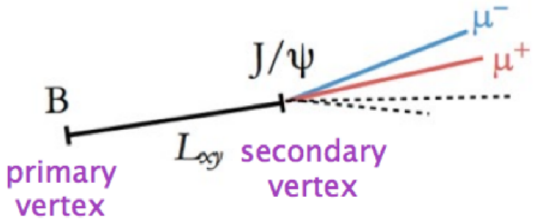
Charmonia are good probes of the medium evolution

Prompt and Non-Prompt Charmonia



- **Prompt Charmonia:**
  Directly affected by the QGP
- **Non-Prompt Charmonia:**
  Reflects energy loss of b quarks in the QGP

Separation based on **pseudo-proper decay length** ($\ell_{J/\psi}$)



LHC Runs: Recorded by CMS

Run 1 (2011-2013)		
p-p	$\sqrt{s_{NN}}$ = 2.76 TeV	L = 5 pb^{-1}
Pb-Pb	$\sqrt{s_{NN}}$ = 2.76 TeV	L = 150 μb^{-1}

Run 1

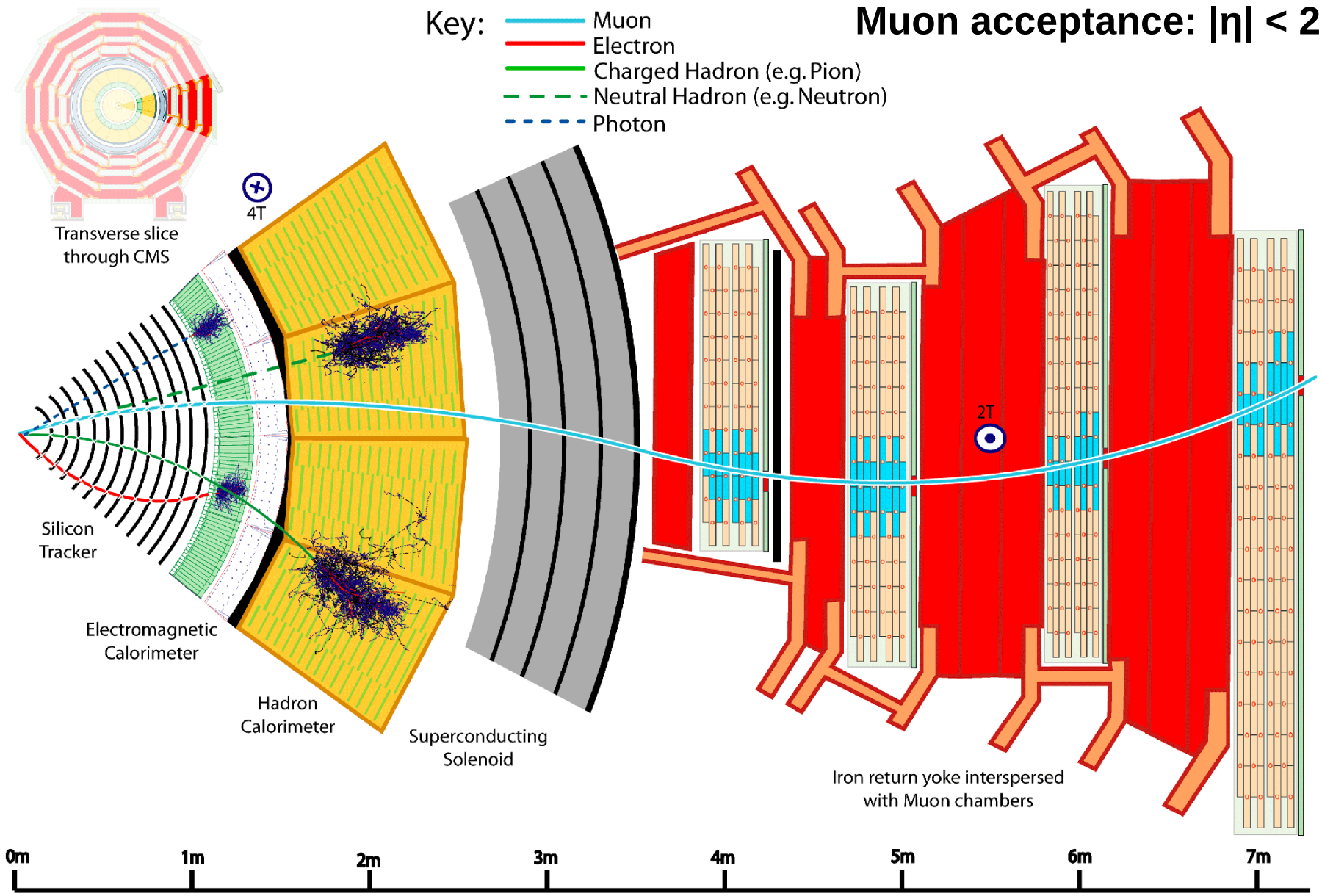
↓

Run 2

Run 2 (2015)		
p-p	$\sqrt{s_{NN}}$ = 5.02 TeV	L = 28 pb^{-1}
Pb-Pb	$\sqrt{s_{NN}}$ = 5.02 TeV	L = 460 μb^{-1}

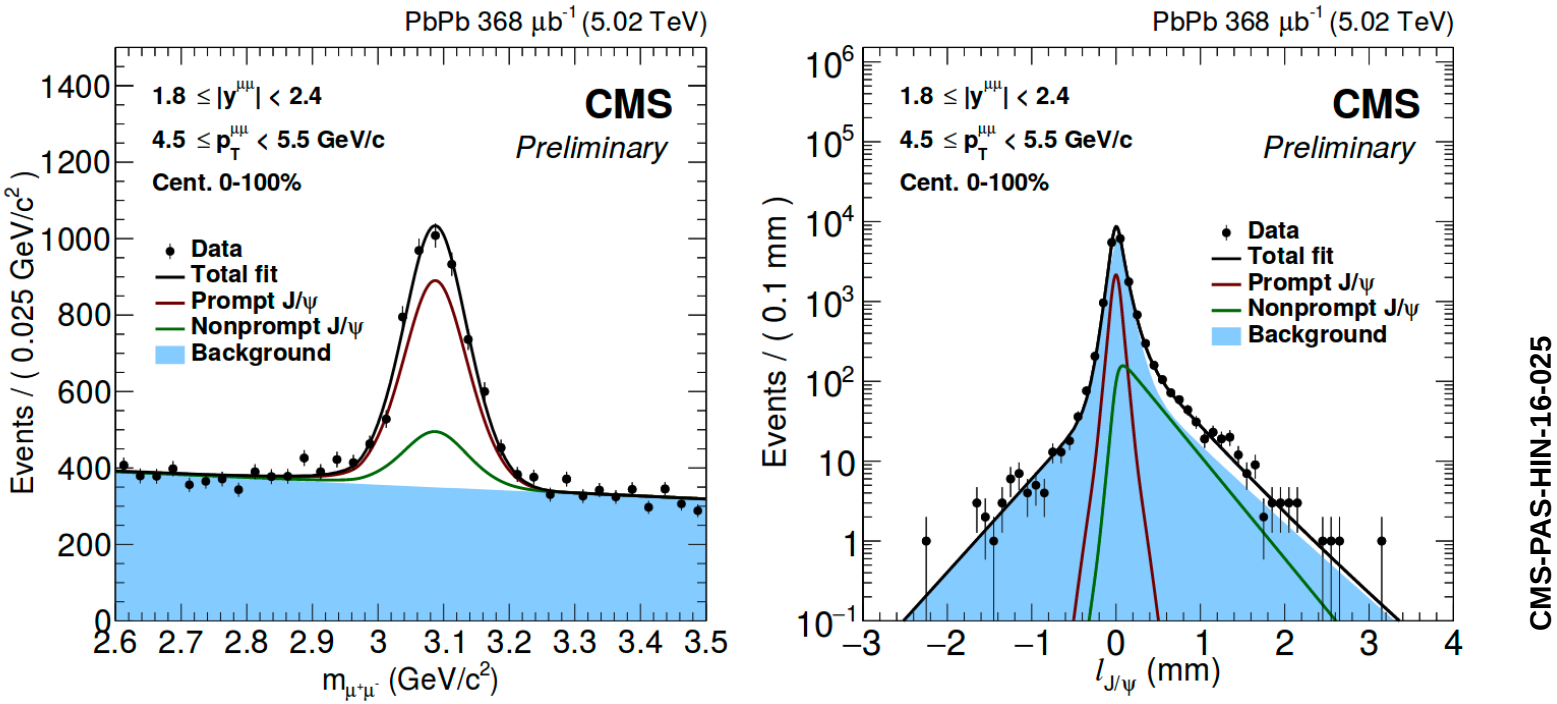
- ~2x increase in Energy
- ~3x increase in Pb-Pb Luminosity

CMS Detector



Prompt and Non-Prompt Charmonia

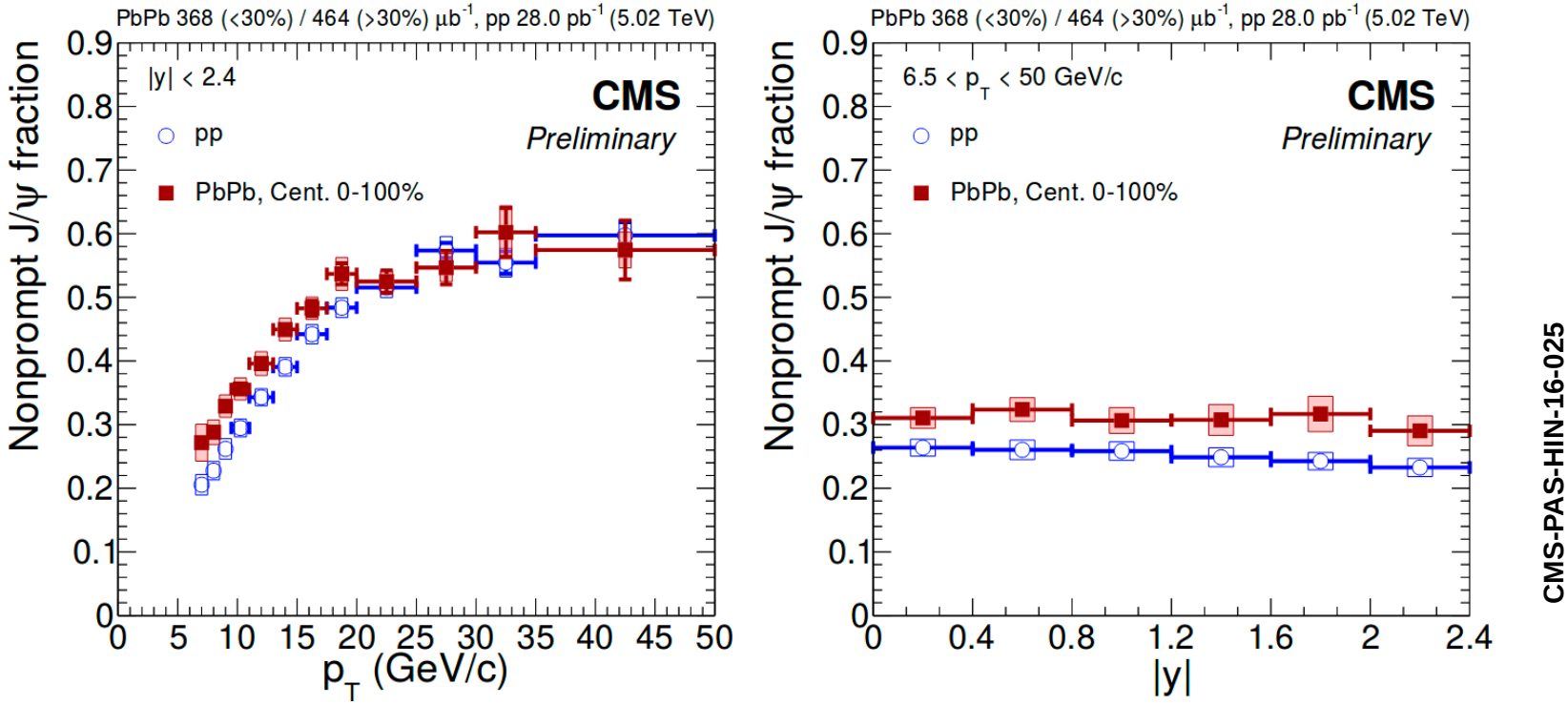
2D fits of the dimuon mass and pseudo-proper decay length



- Signal:
  - Mass: Two Crystal Ball Functions (Guassian with power like tail)
  - Decay Length: Exponential Function
- Background:
  - Mass: Polynomial function (between order 1-3)
  - Decay Length: 3 Exponential Functions

Prompt and Non-Prompt Charmonia

2D fits of the dimuon mass and pseudo-proper decay length



- From the fits we get:
  - Inclusive J/ψ Yields
  - Nonprompt J/ψ fraction (also called b fraction)

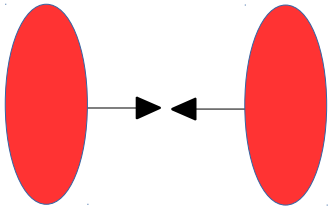
- Combining the inclusive yields and the b-fractions, we extract the Prompt and Nonprompt J/ψ yields

Outline:

"Measurement of prompt and nonprompt charmonium suppression in PbPb collisions at 5.02 TeV"

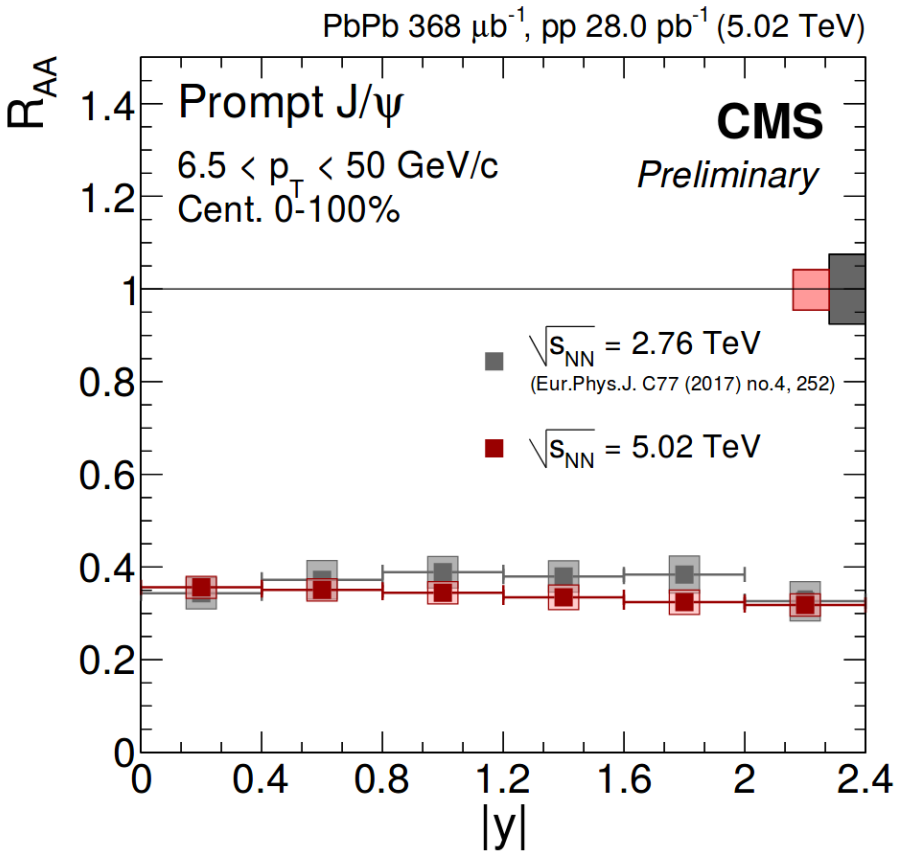
CMS-PAS-HIN-16-025

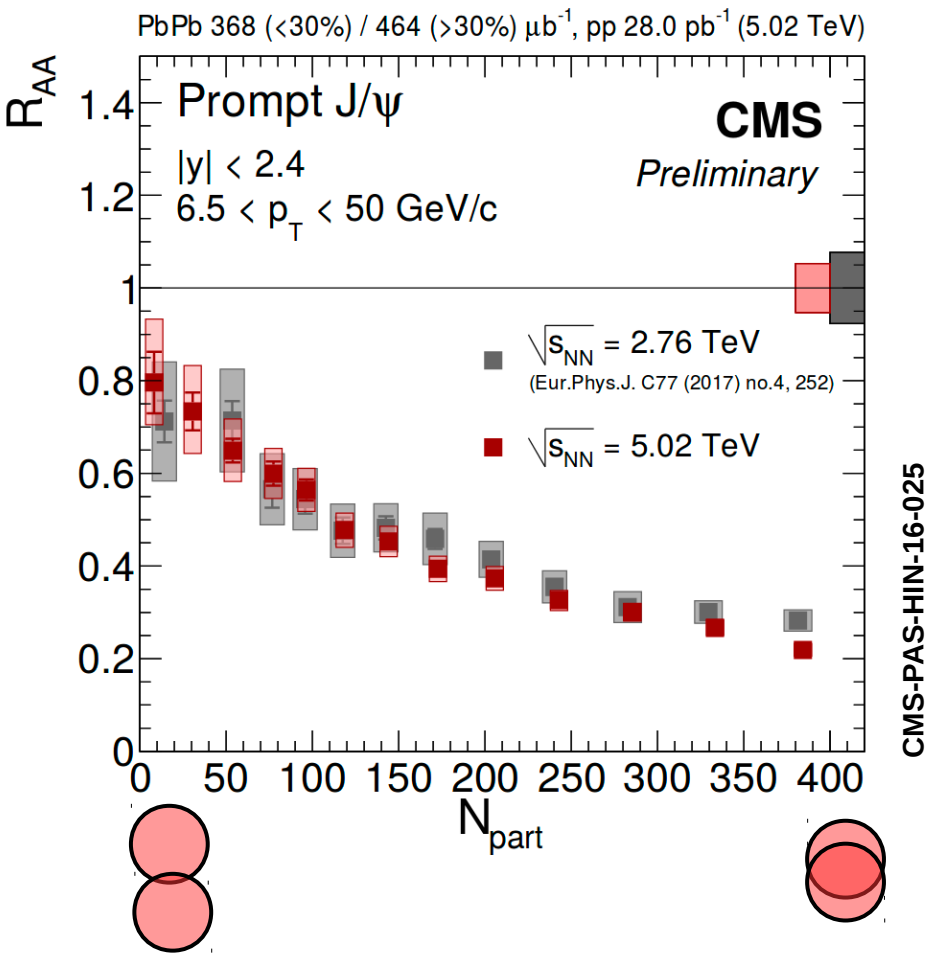
- Prompt J/ψ in PbPb at 5.02 TeV
- Prompt ψ(2S) PbPb at 5.02 TeV
- Nonprompt J/ψ in PbPb at 5.02 TeV



Prompt J/ψ in PbPb at 5 TeV

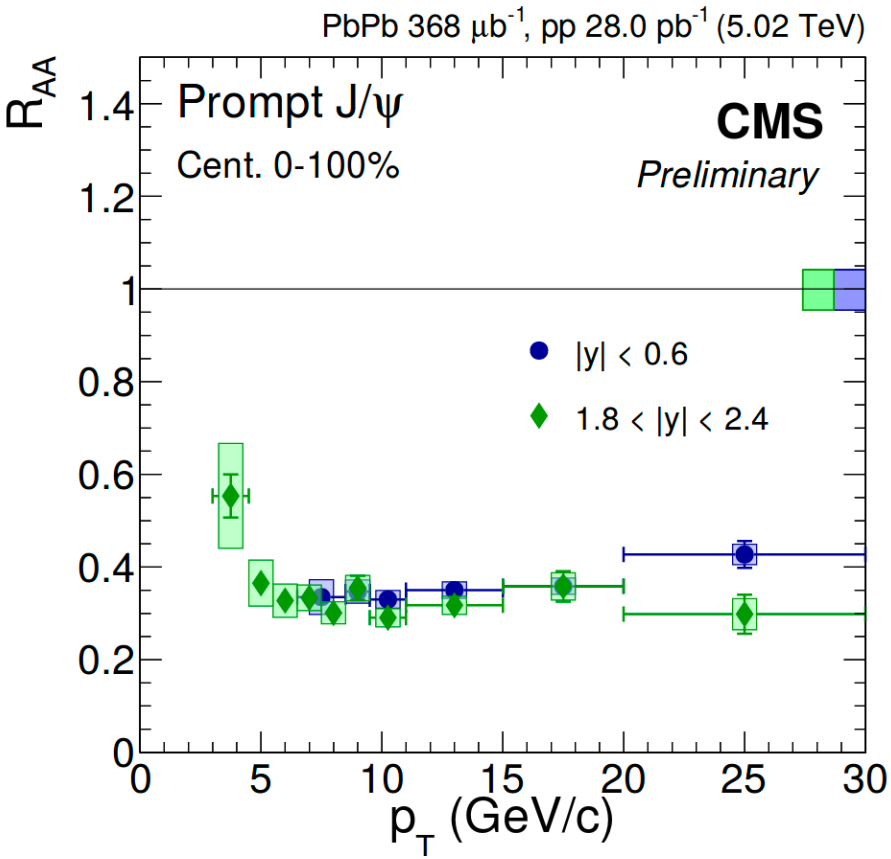
Prompt J/ψ R_{AA}

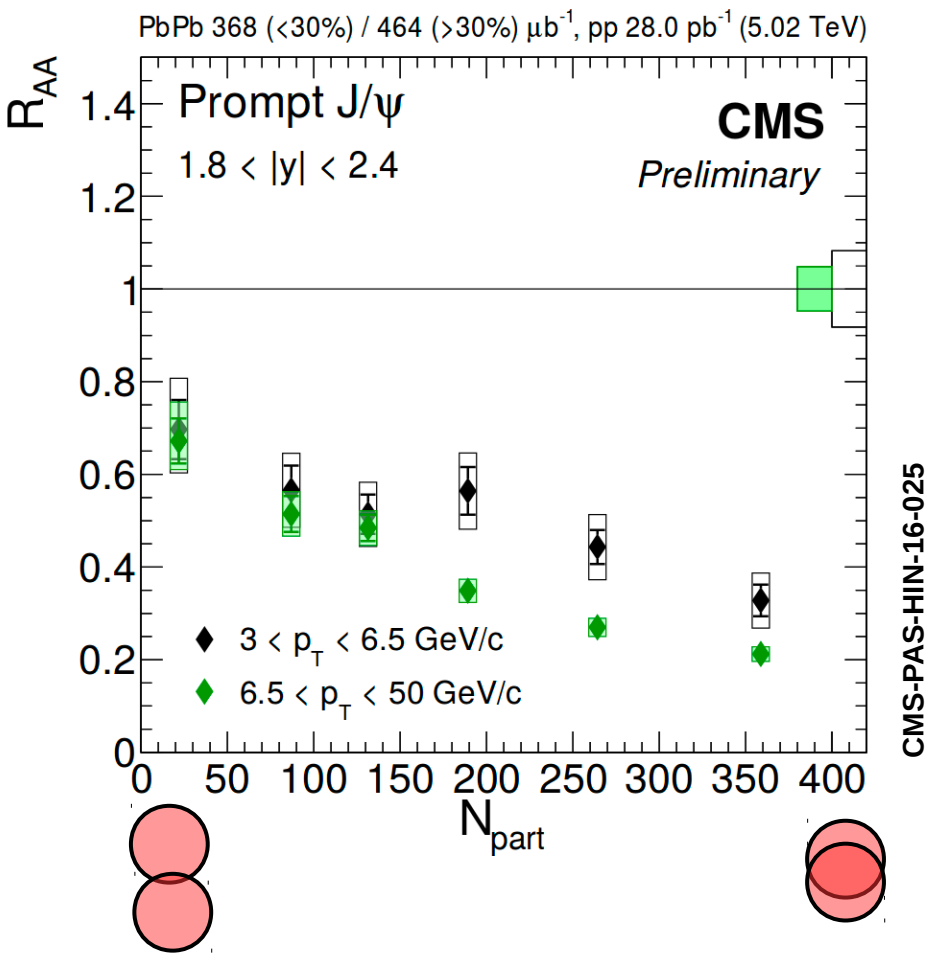




- Similar suppression between 5.02 TeV and 2.76 TeV
- No strong rapidity dependence
- Suppression increases when going to more central events

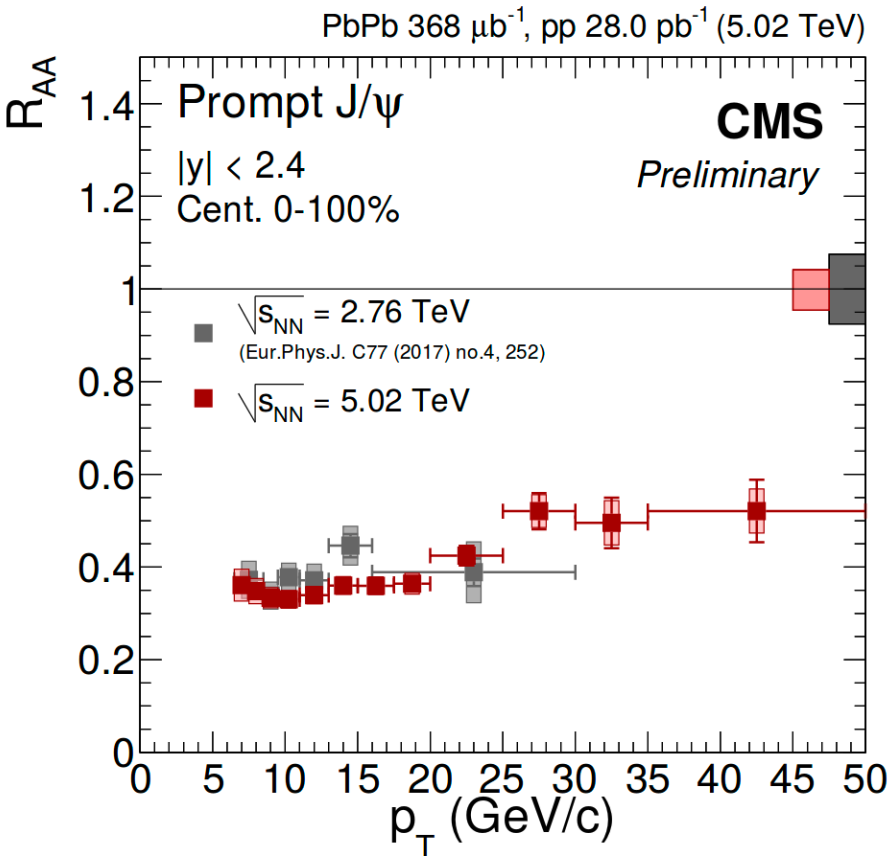
Prompt J/ψ R_{AA}: Low p_T

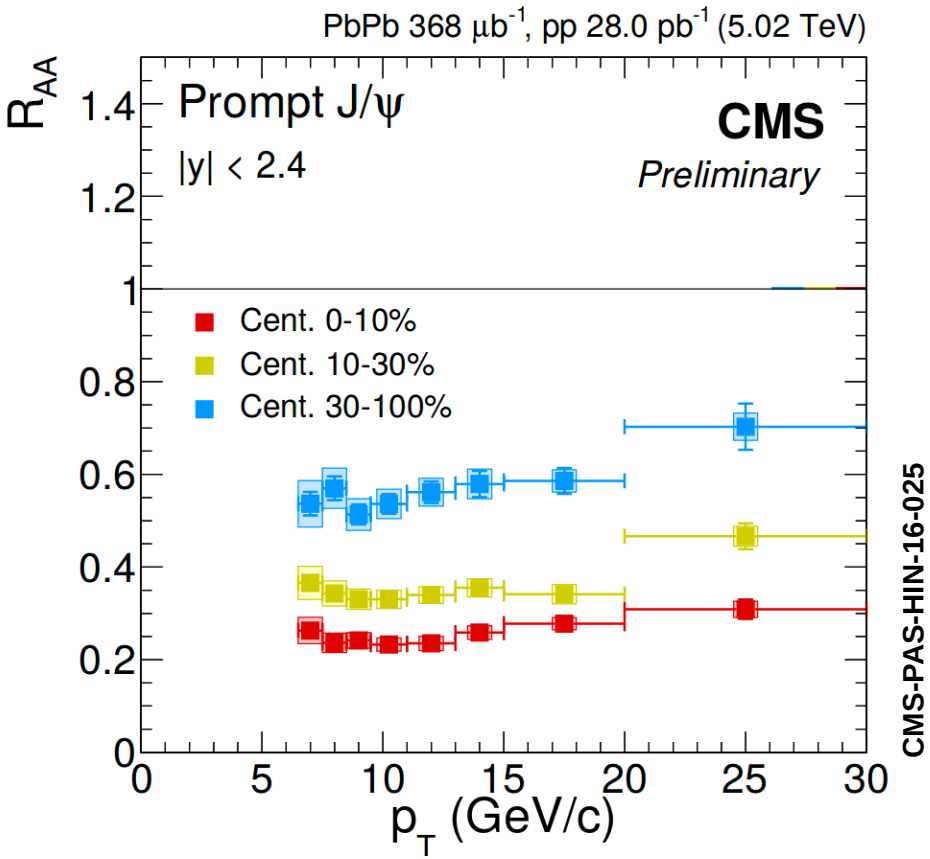




- Similar p_T trend for different rapidities bins
- Less suppression at lowest p_T
- Less suppression at lowest p_T for the most central events (cent < 30%)

Prompt J/ψ R_{AA}: High p_T

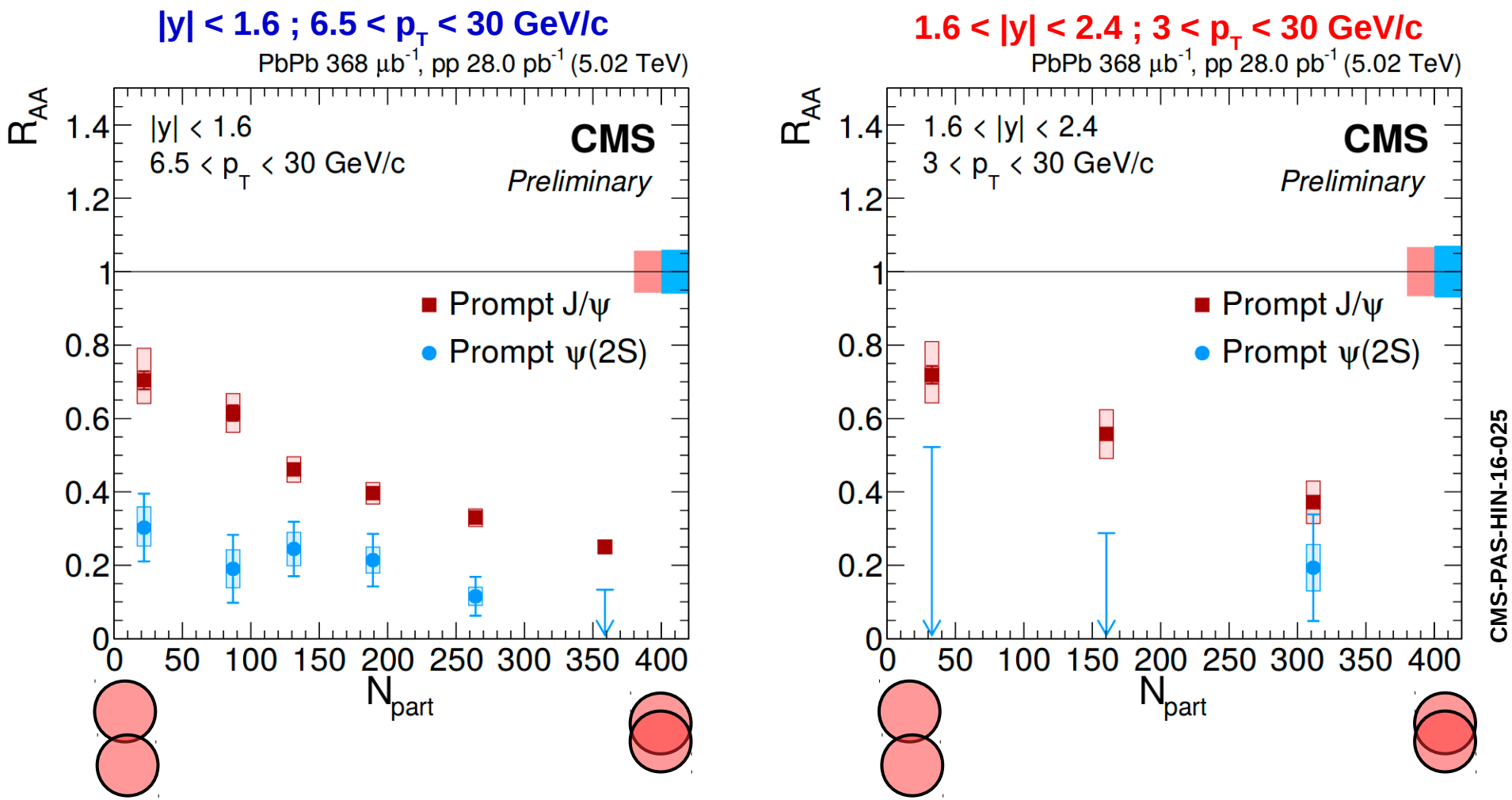




- Less suppression at high p_T
- Similar p_T trend between different centrality bins

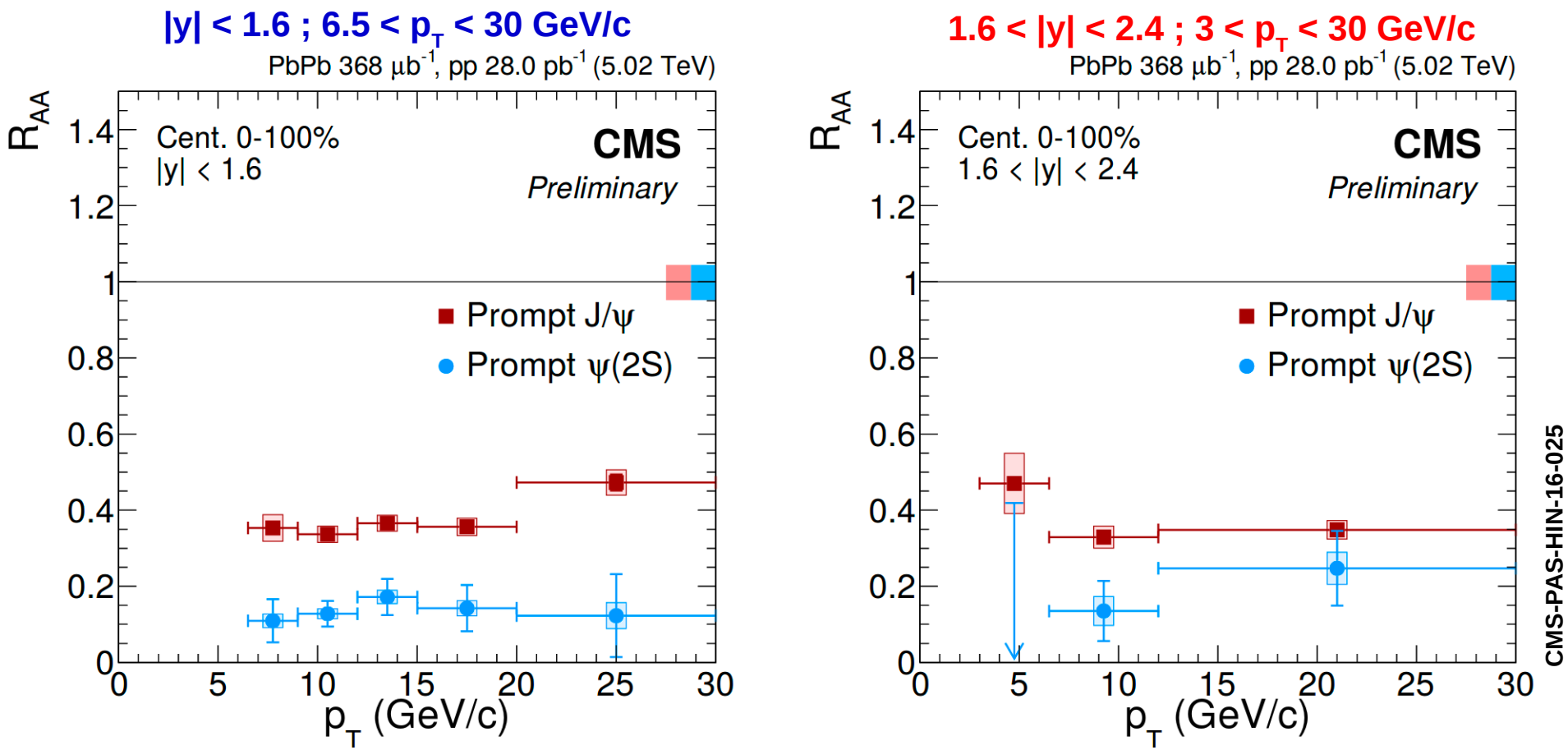
Prompt ψ(2S) in PbPb at 5 TeV

Prompt ψ(2S) R_{AA}



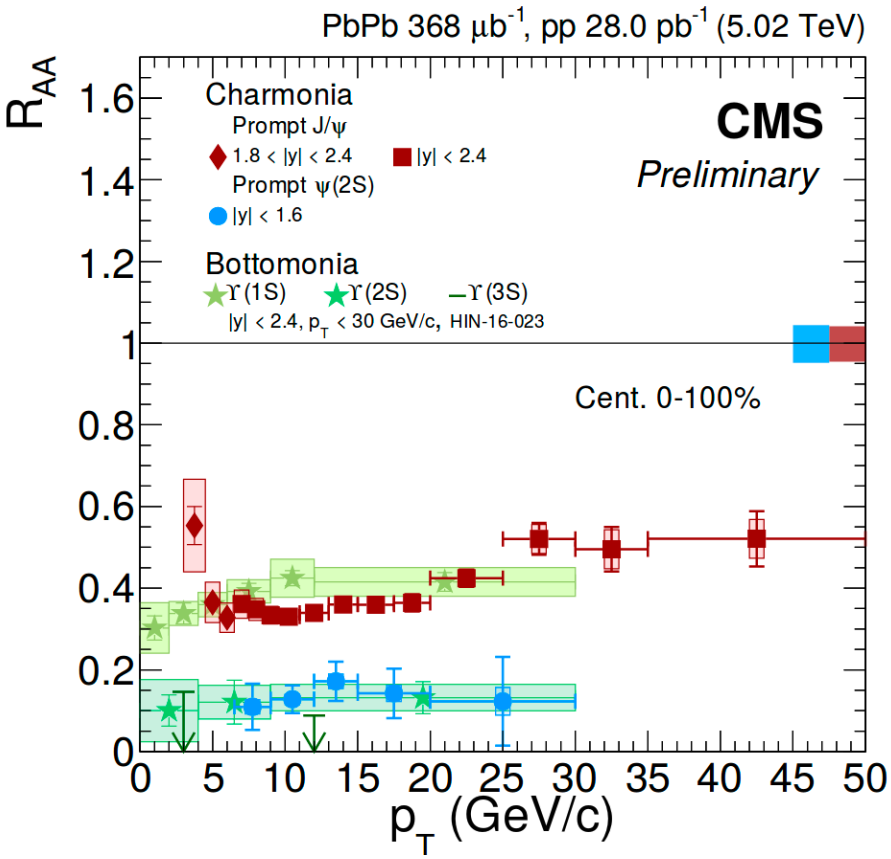
- Increasing suppression of ψ(2S) towards more central events at high p_T
- Stronger suppression of ψ(2S) than J/ψ in all centrality bins

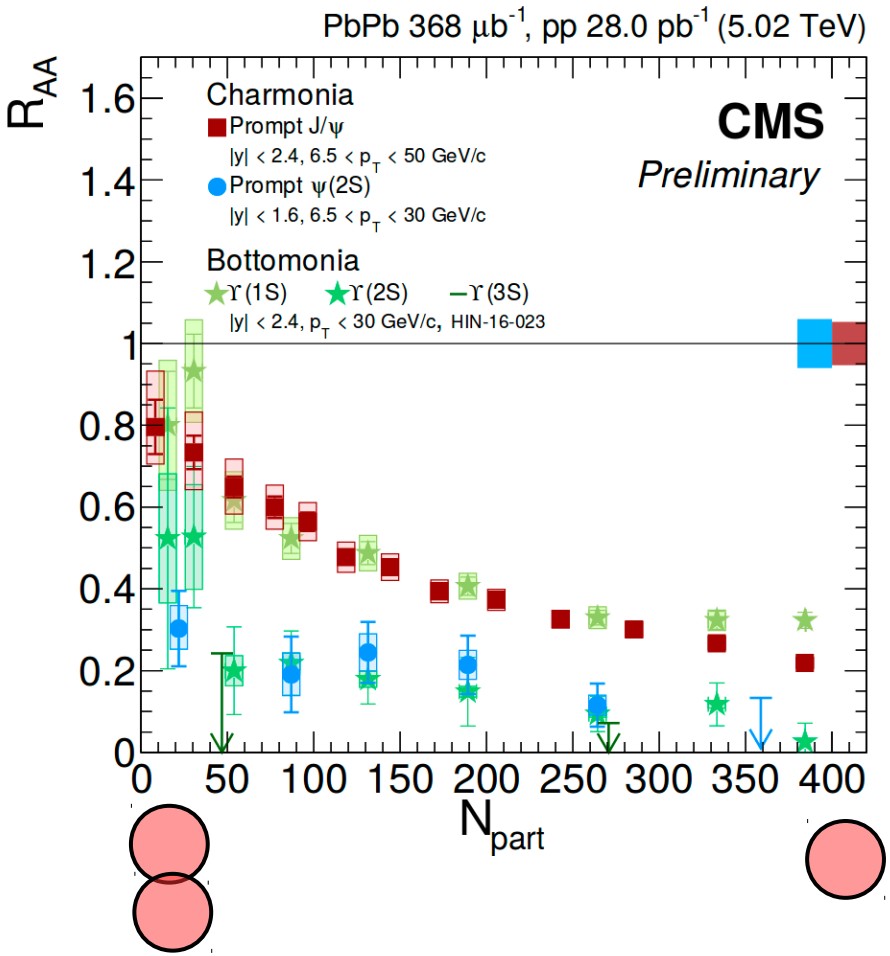
Prompt ψ(2S) R_{AA}



- No strong p_T dependence of ψ(2S) suppression
- Stronger suppression of ψ(2S) than J/ψ in all p_T bins

Charmonium vs Bottomonium





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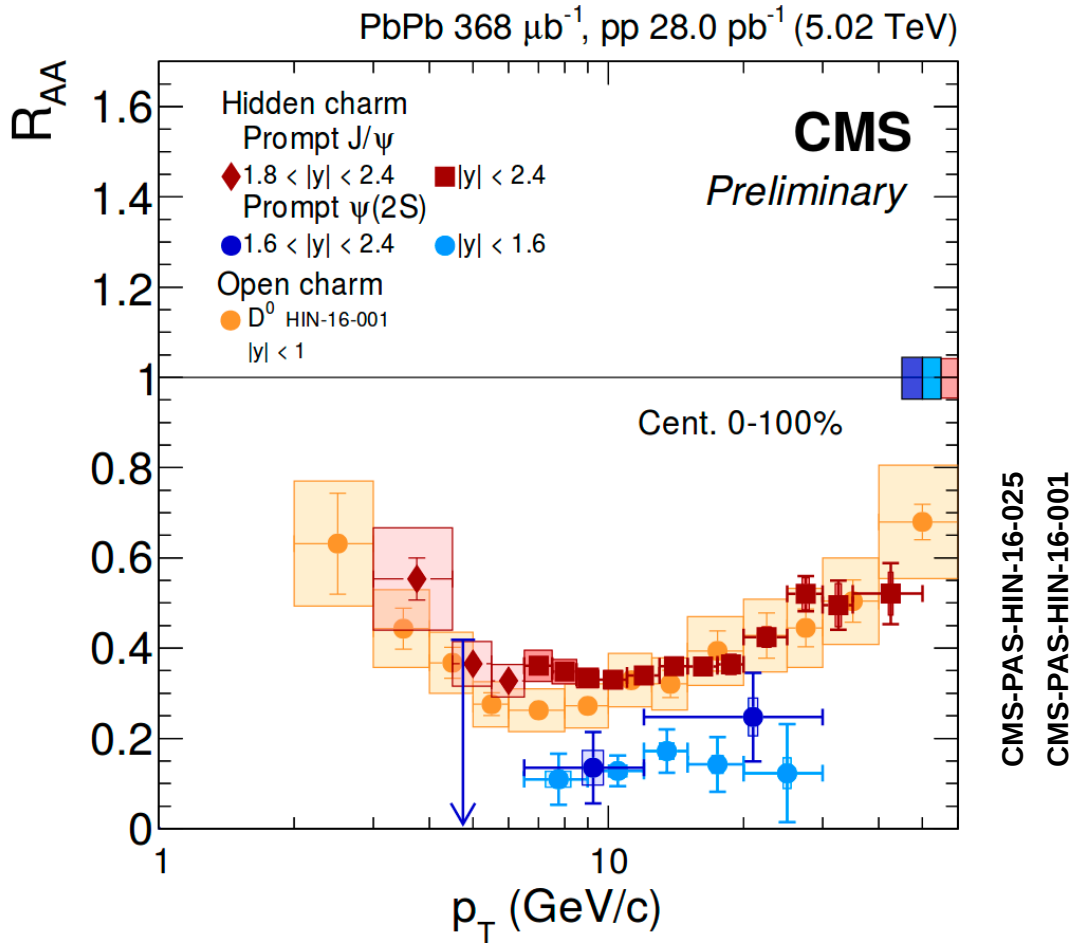
- Similar suppression between ψ(2S) and Υ(2S), versus p_T and centrality
- Hint of less suppression of J/ψ compared to Υ(1S) at lowest p_T

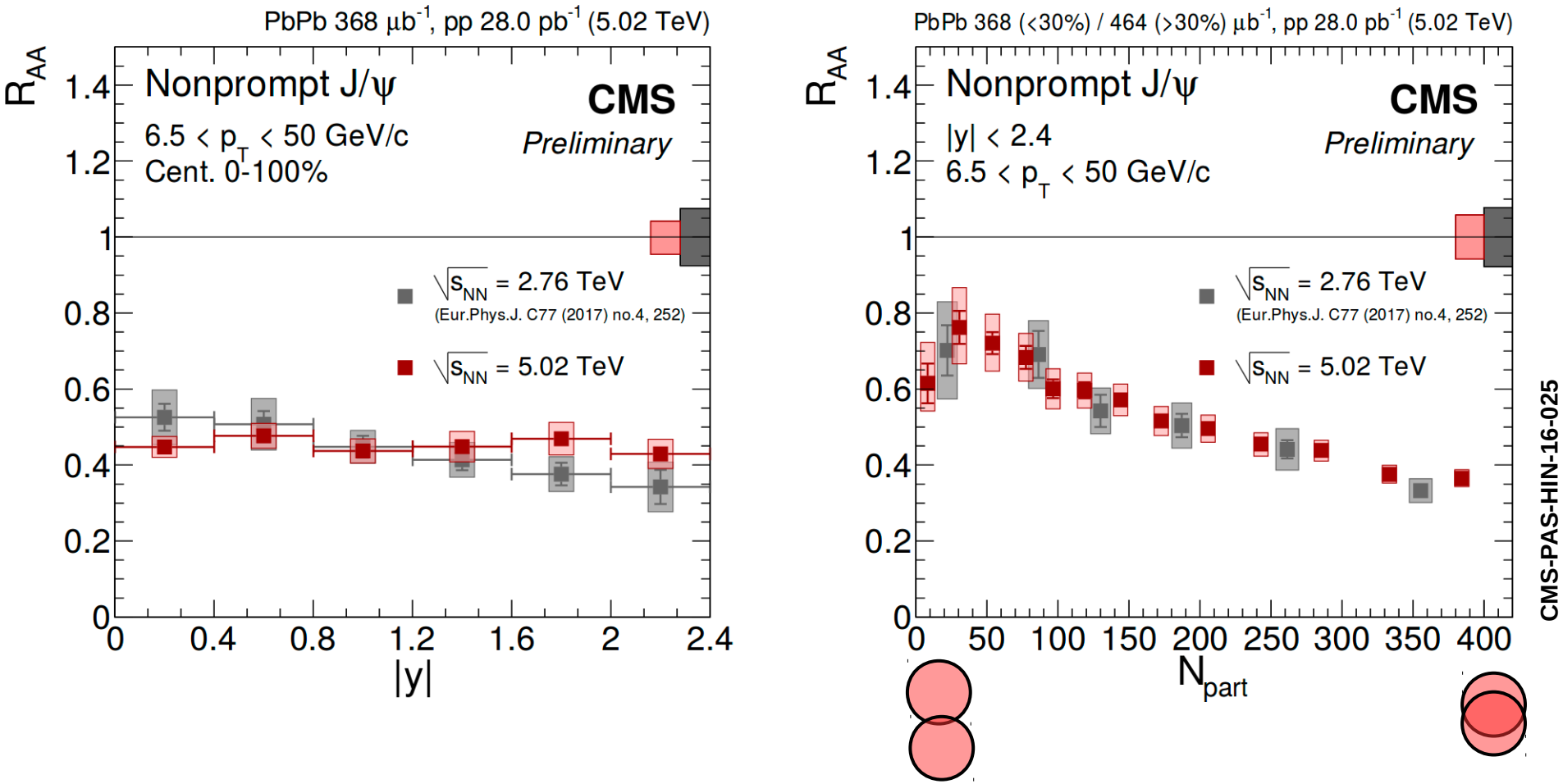
Open vs Hidden Charm



- Similar R_{AA} trend between prompt J/ψ and D^0 R_{AA}
  - E_{loss} contribution to charmonium suppression?
- ψ(2S) still more suppressed up to p_T = 30 GeV/c

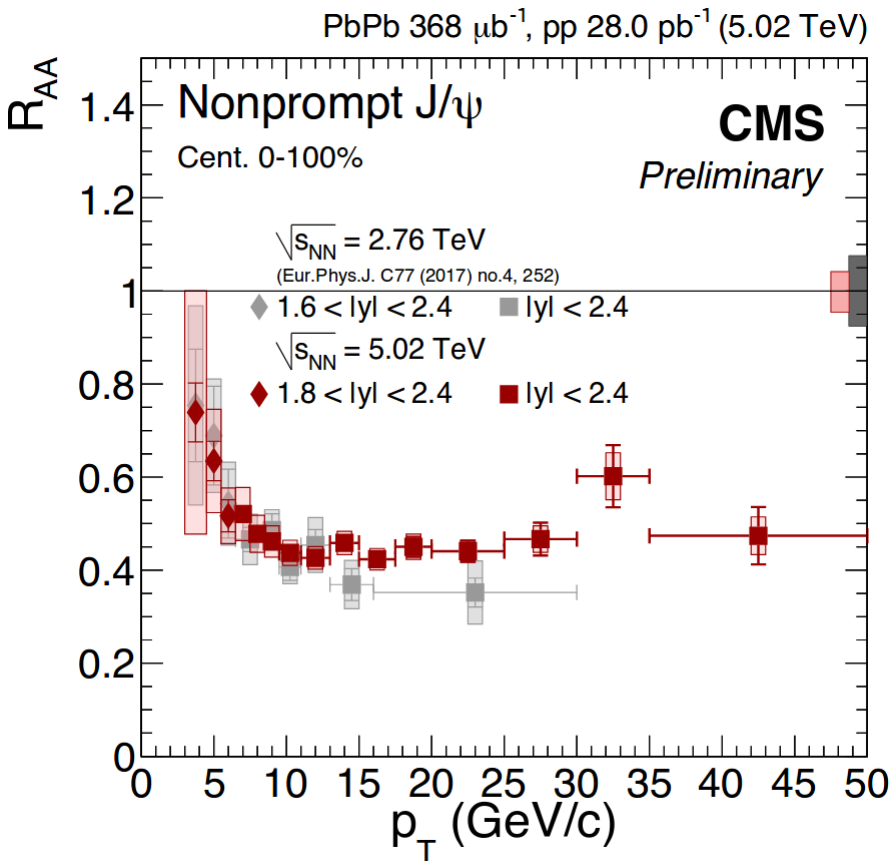
Nonprompt J/ψ in PbPb at 5 TeV

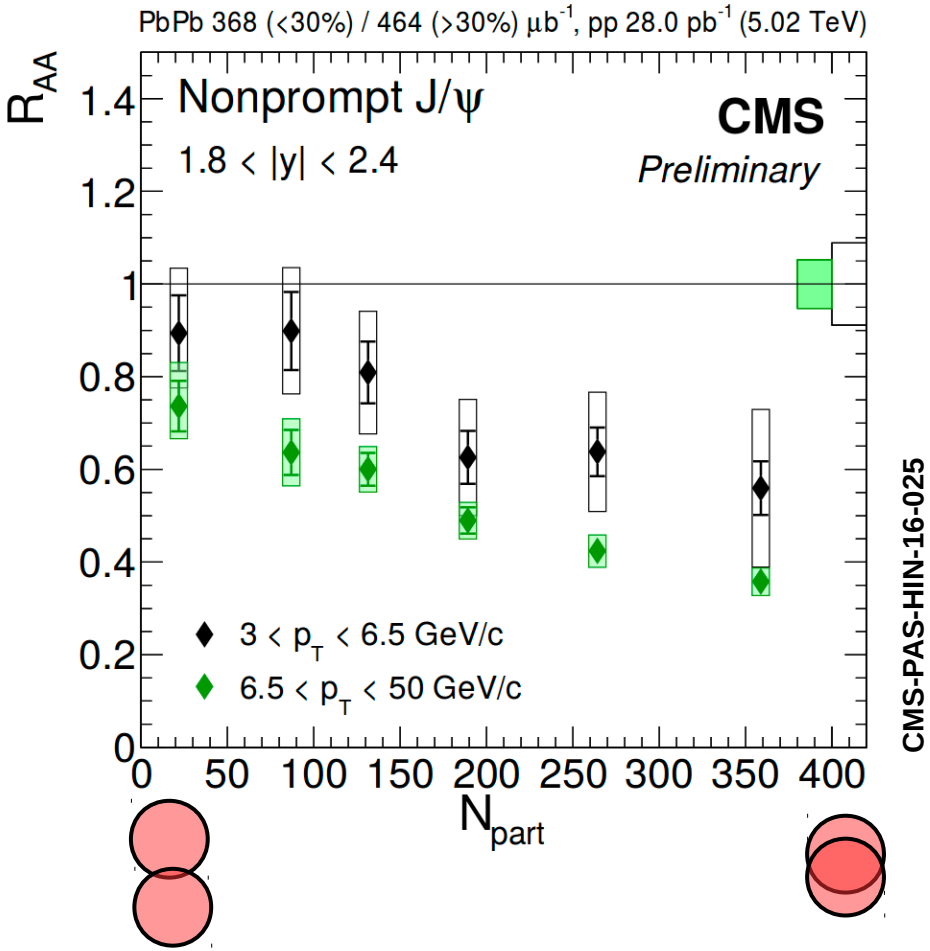
Nonprompt J/ψ R_{AA}



- Similar suppression between 2.76 TeV and 5.02 TeV
- No strong rapidity dependence at 5.02 TeV
- Increasing suppression towards more central events

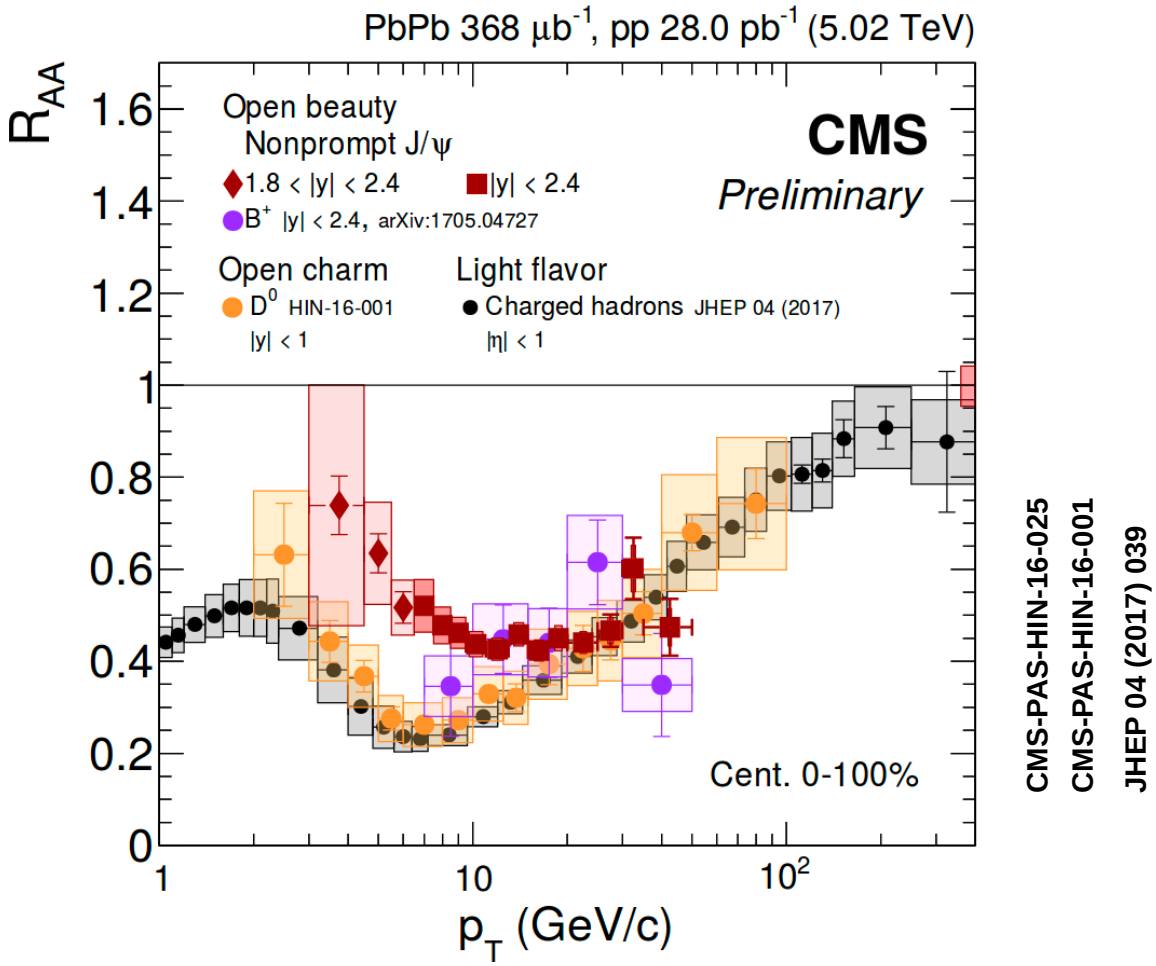
Nonprompt J/ψ R_{AA}





- Similar suppression between 2.76 TeV and 5.02 TeV
- Hint of less suppression at lowest p_T , while no clear p_T dependence at high p_T
- Slight less suppression at the lowest p_T in all centrality bins

Flavour Dependence of E_{loss}

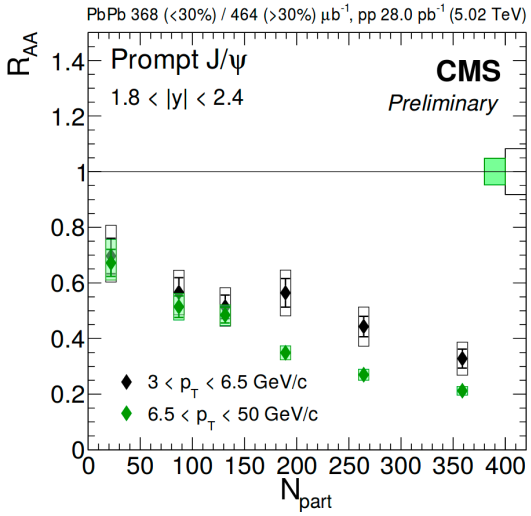


- **High p_T**: Similar suppression between D^0, light hadrons and nonprompt J/ψ
  - **Universal trend of E_{loss} at high p_T?**
- **Low p_T**: hints of $R_{AA}(B \rightarrow J/\psi) > R_{AA}(D^0) \sim R_{AA}$(light hadrons)
  - **Smaller E_{loss} of b quarks at low p_T?**

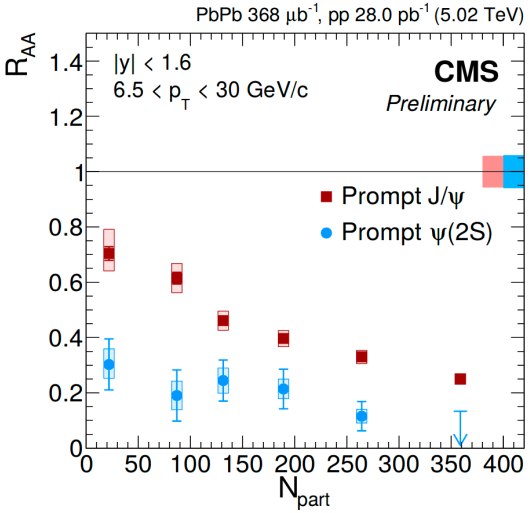
SUMMARY

Probing Hot Nuclear Matter Effects:

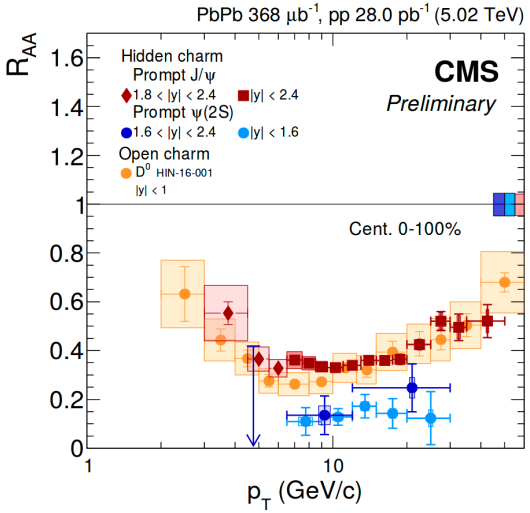
Less prompt J/ψ suppression at lowest p_T



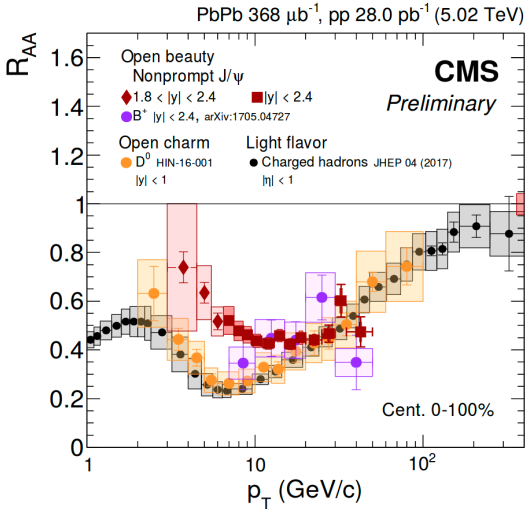
Prompt ψ(2S) more suppressed than J/ψ



E_{loss} in charmonium suppression?



Flavour dependence of E_{loss}?

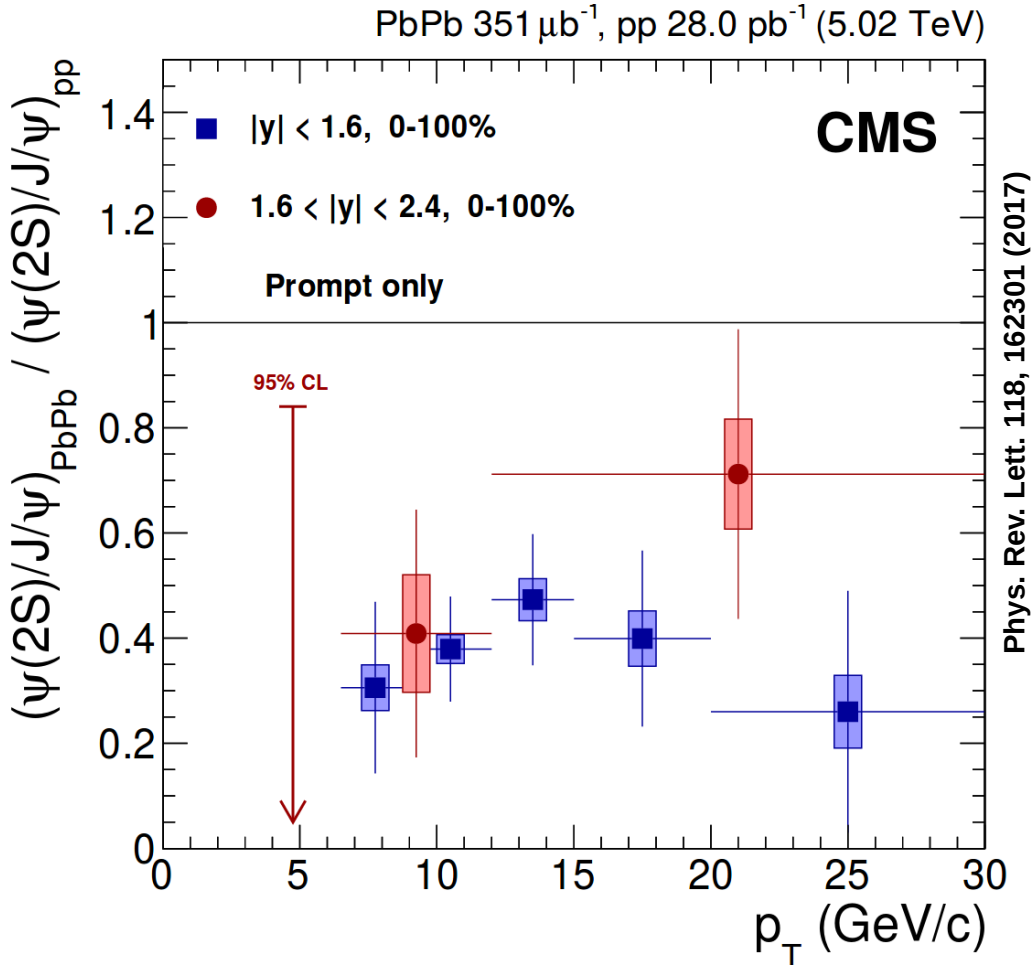


Stay tuned for more future CMS results!

Thank you for your attention!

BACKUP

Ratio of ψ(2S) / J/ψ R_{AA} vs p_T

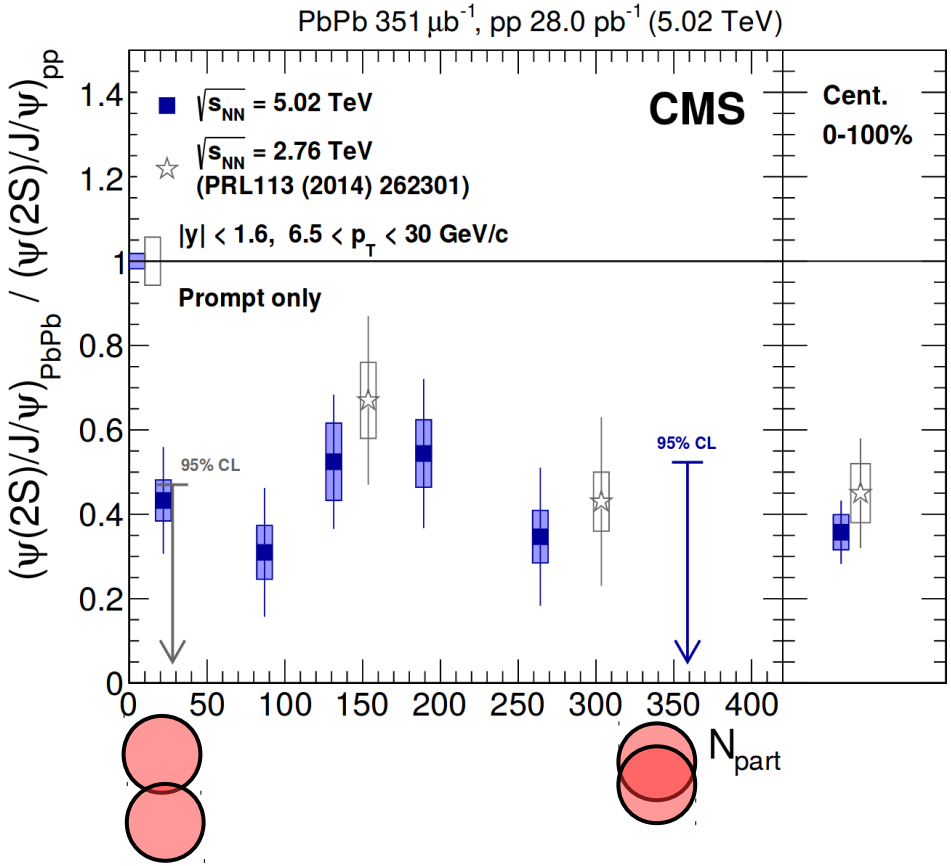


- $R_{AA}(\psi(2S)) / R_{AA}(J/\psi) < 1$ in all bins → **ψ(2S) is more suppressed than J/ψ**
- No p_T dependence within uncertainties

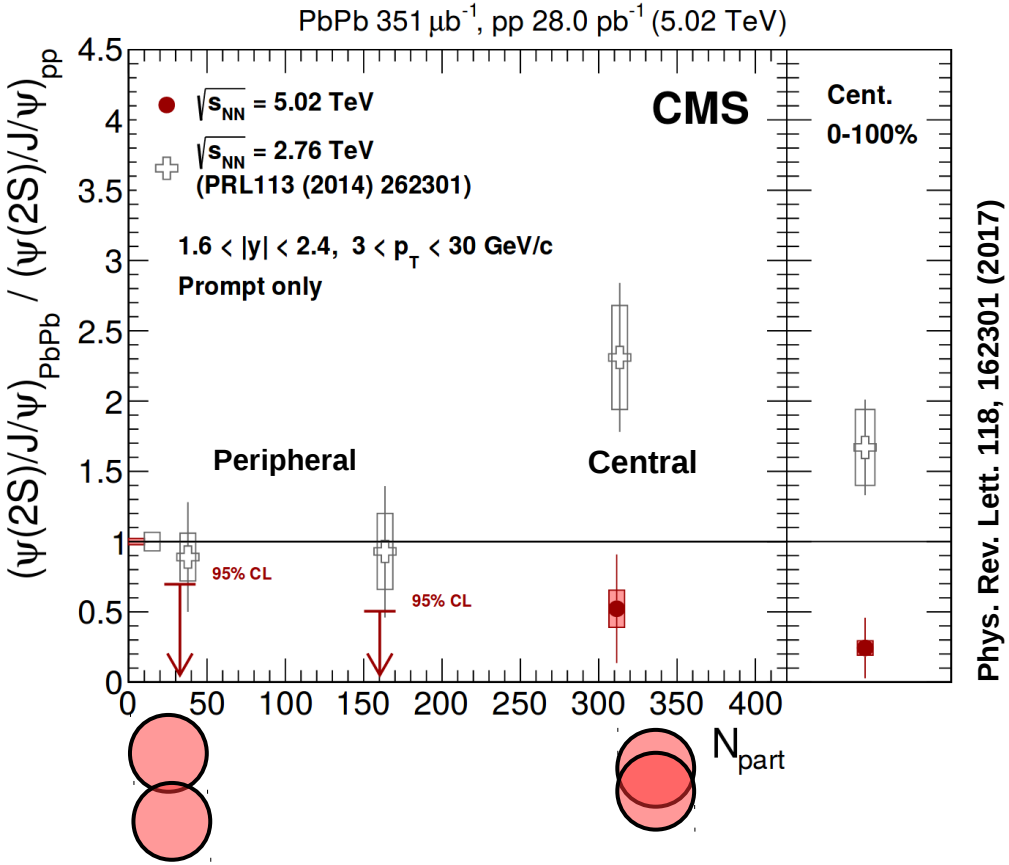
ψ(2S) / J/ψ vs Centrality

2.76 vs. 5.02 TeV

|y| < 1.6 ; 6.5 < p_T < 30 GeV/c



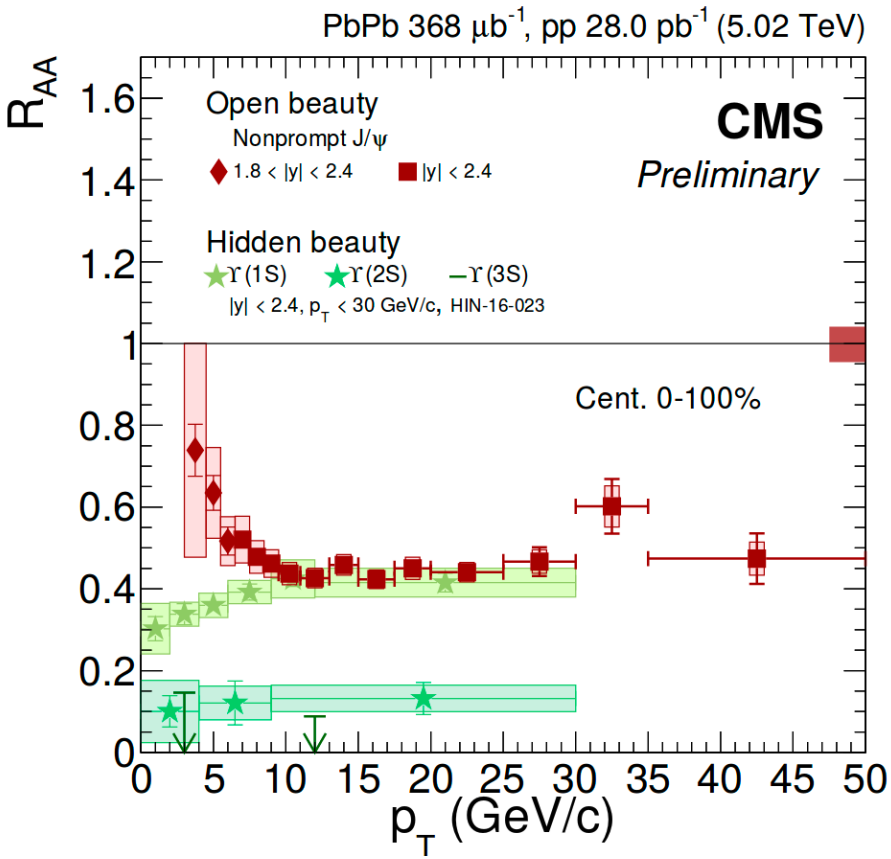
1.6 < |y| < 2.4 ; 3 < p_T < 30 GeV/c

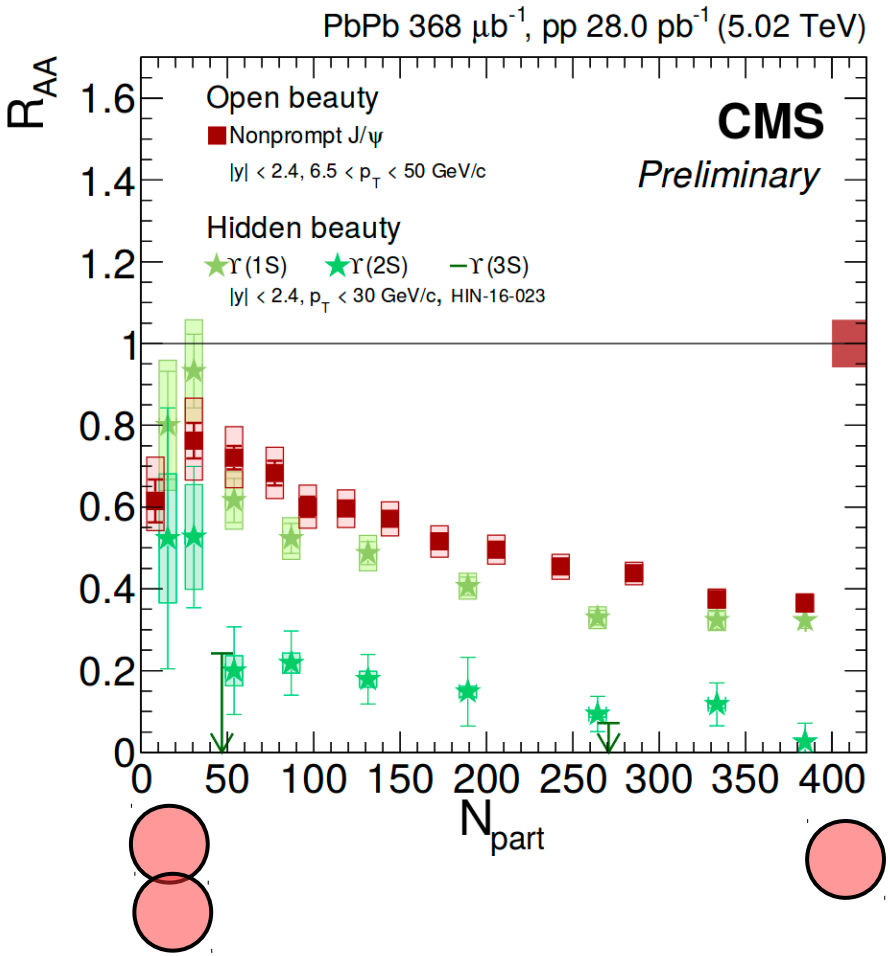


Phys. Rev. Lett. 118, 162301 (2017)

- **ψ(2S) is more suppressed than J/ψ** at 5.02 TeV
- No strong N_{part} dependence at 5.02 TeV
- Double ratio at 5.02 TeV consistently lower than at 2.76 TeV in 1.6 < y < 2.4, 3 < p_T < 30 GeV/c, especially for most central collisions (~3 s.d. in 0-100%)

Open vs Hidden Beauty





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