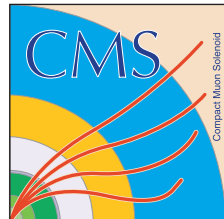


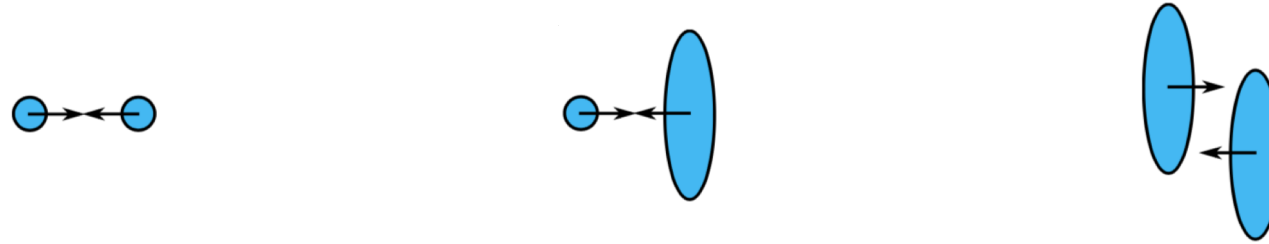
Beyond nPDFs effects : Prompt J/ψ and $\psi(2S)$ production in pPb and pp collisions



Geonhee Oh
On Behalf of the CMS Collaboration
Chonnam National University (KOREA)



Introduction



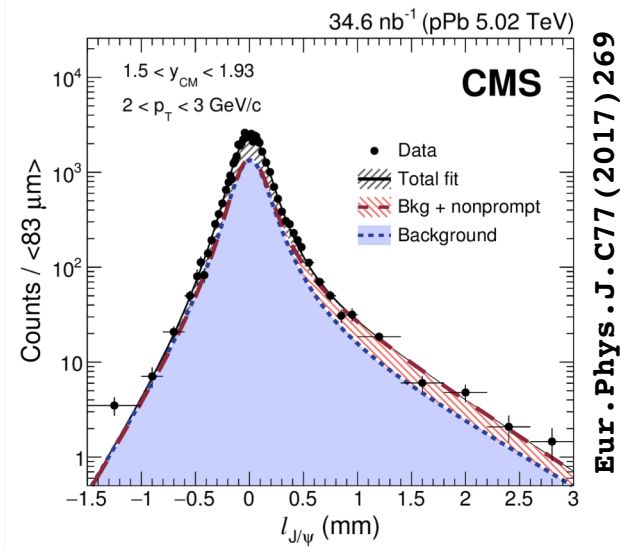
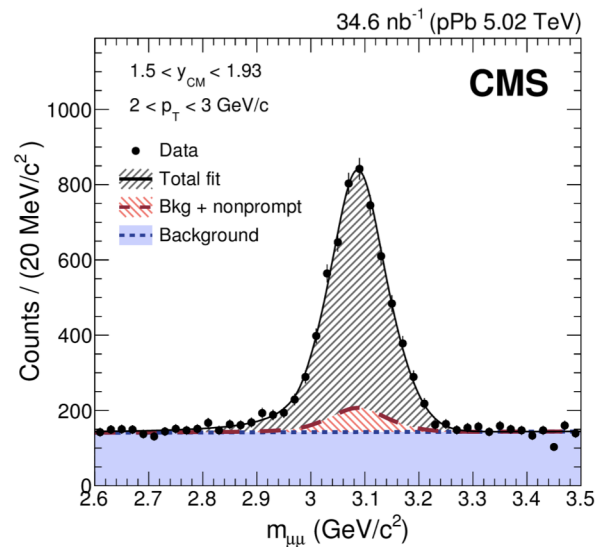
- **J/ψ and ψ(2S) production in PbPb**
 - **QGP** effects
 - **CNM** effects
 - **Fundamental phenomena**

- **Beyond nPDFs effects**
 - **Probing Cold Nuclear Matter(CNM) effects**
 - J/ψ and ψ(2S) production in pPb
 - Elliptic flow of J/ψ in high multiplicity pPb
 - **Probing NO nuclear effects: production mechanism**
 - J/ψ production in jets in pp(pure scattering)

Prompt and Nonprompt Charmonia

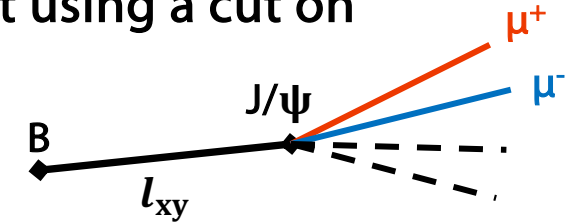
- Two techniques to separate components:

1. 2D fit to dimuon mass and decay length

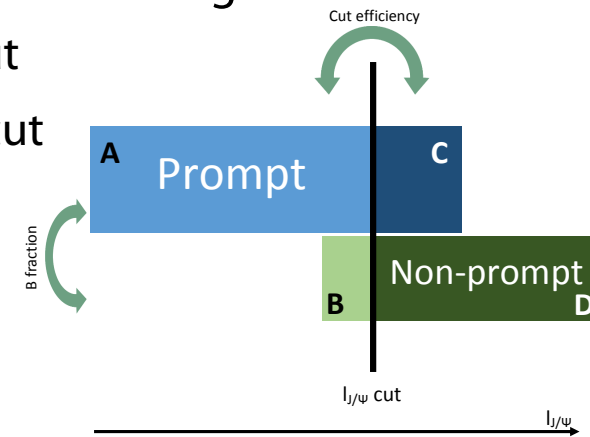


2. Rejecting non-prompt using a cut on

$$l_{J/\psi}^{2D} = l_{xy} * m/p_T$$



- Can be used with low stats : ψ(2S) and J(ψ) v₂ analysis
- Correction to account for remaining contamination :
 - Using reverted l_{J/ψ} cut
 - MC efficiency of l_{J/ψ} cut

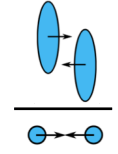


Focus of this talk: prompt charmonia

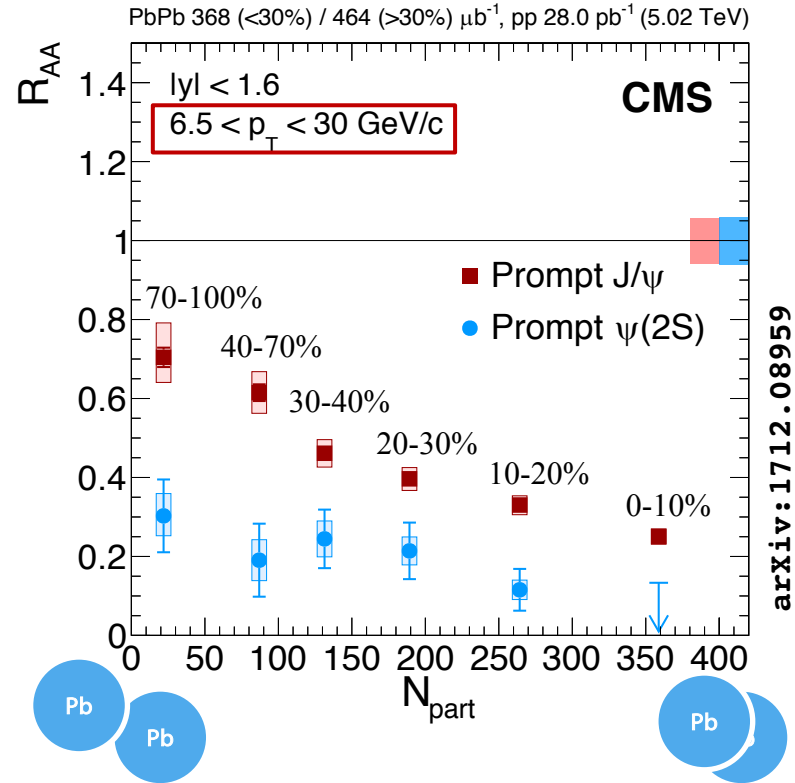
Prompt J/ψ and Prompt $\psi(2S)$ R_{AA}



Emilien Chapon's
Poster: QRK-02



Probing **QGP** effects :



- $R_{AA}(2S) < R_{AA}(1S)$
- $R_{AA}(1S)$ is suppressed even for most peripheral events(70-100%)
- Enhanced nuclear modification for increasing N_{part}

What causes the suppression?

QGP effects, but also **pPb** effects





- Prompt J/ψ in pPb at 5.02 TeV (ground state)
 - Eur. Phys. J. C 77 (2017) 269



- Prompt $\psi(2S)$ in pPb at 5.02 TeV (excited state)
 - arXiv : 1805.02248



- Prompt J/ψ v_2 in pPb at 8.16 TeV
 - CMS PAS HIN-18-010



- Prompt J/ψ in Jets in pp at 5.02 TeV
 - CMS PAS HIN-18-012

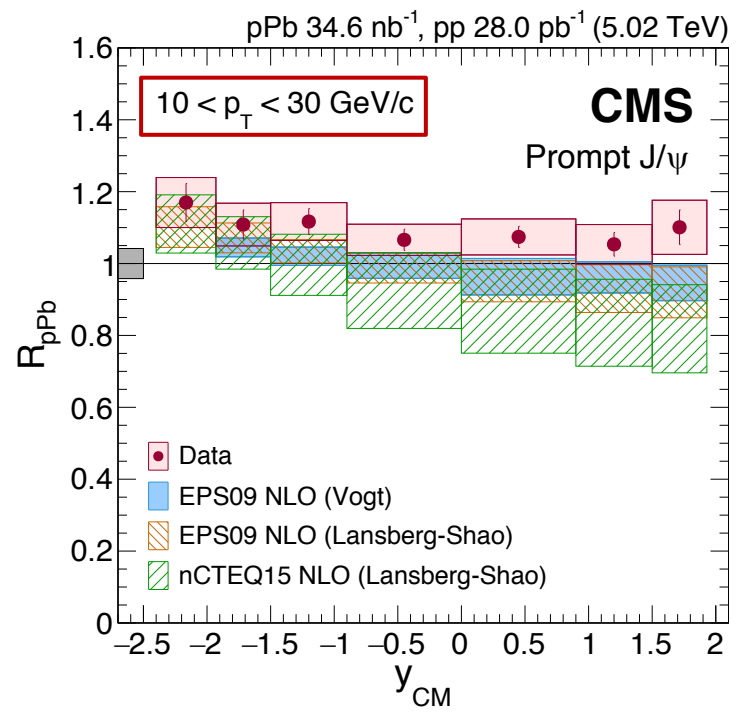
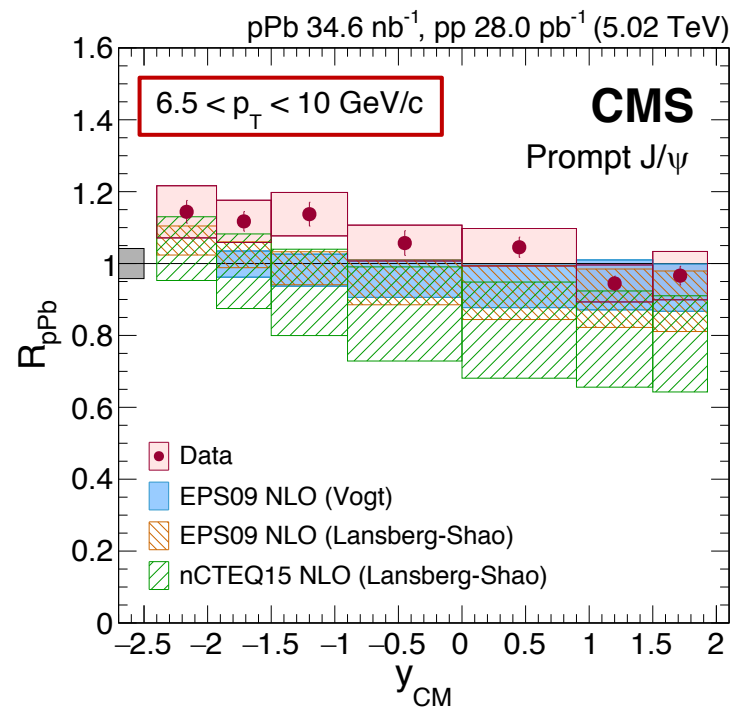
Batoul Diab's
Poster:QRK-06

- Summary

Prompt J/ψ R_{pPb}



Low p_T \longrightarrow High p_T



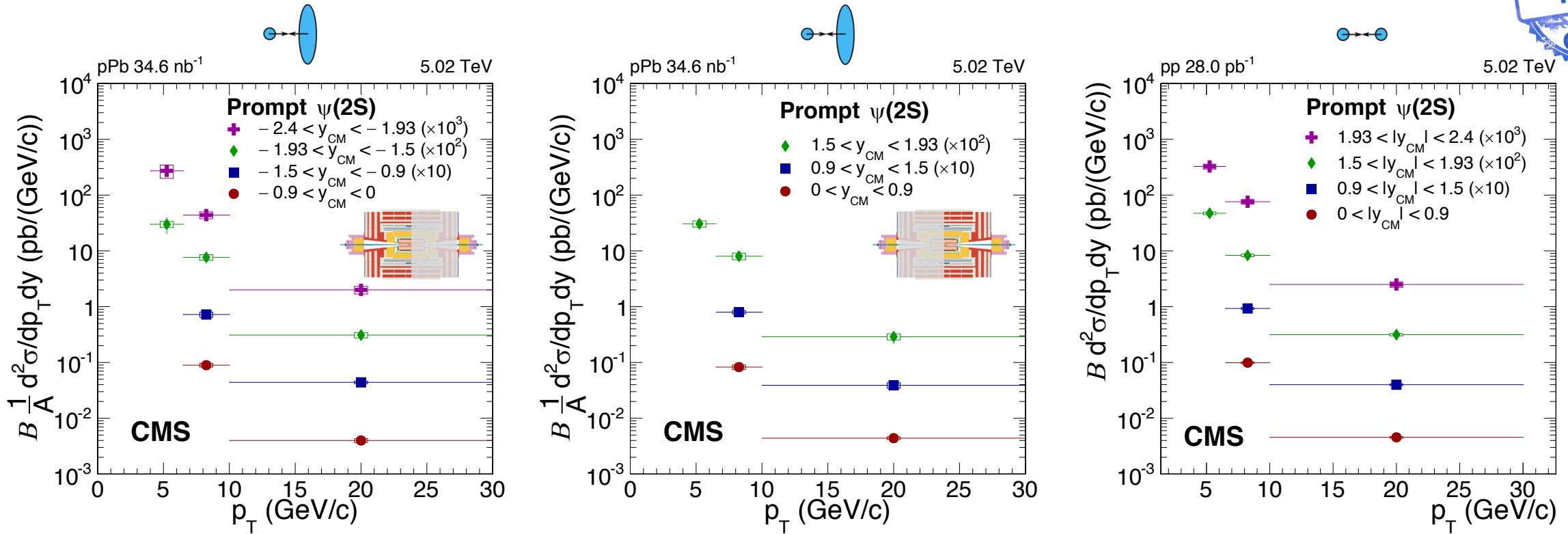
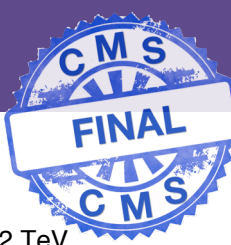
Eur. Phys. J. C77 (2017) 269

- Decreasing of R_{pPb} for increasing y_{CM}
- R_{pPb} above unity for the whole y_{CM} range
- Models predict lower R_{pPb} , but describe the y_{CM} trend

What happens to the excited state?



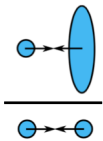
Cross section of Prompt $\psi(2S)$ in pPb and pp



arXiv:1805.02248

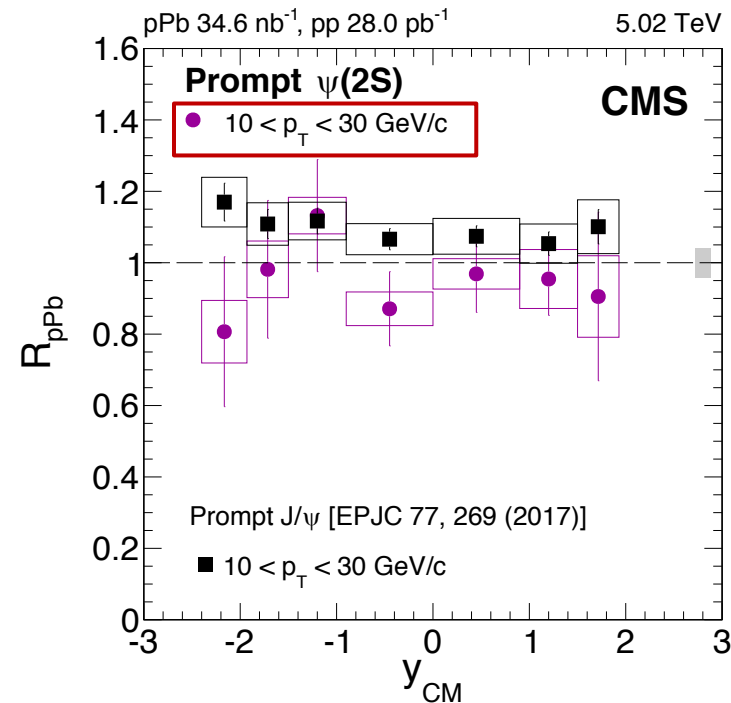
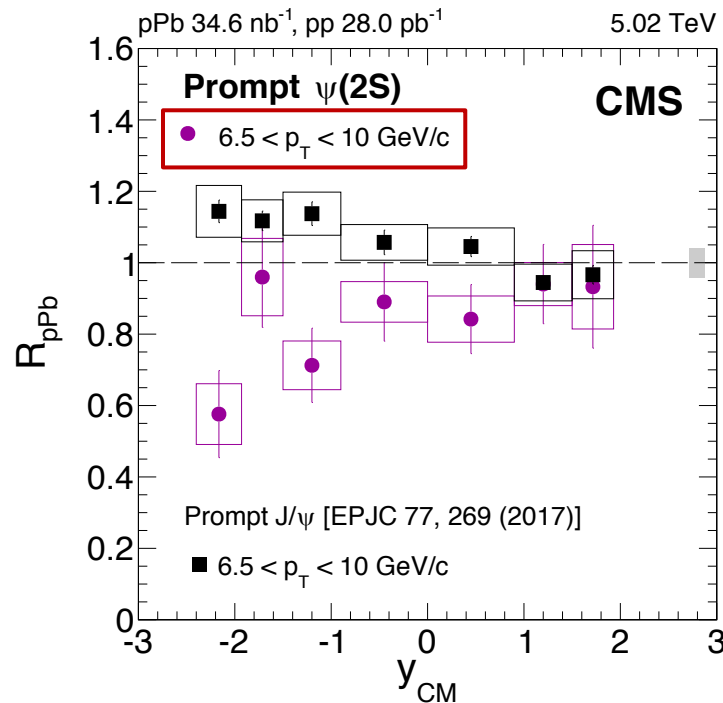
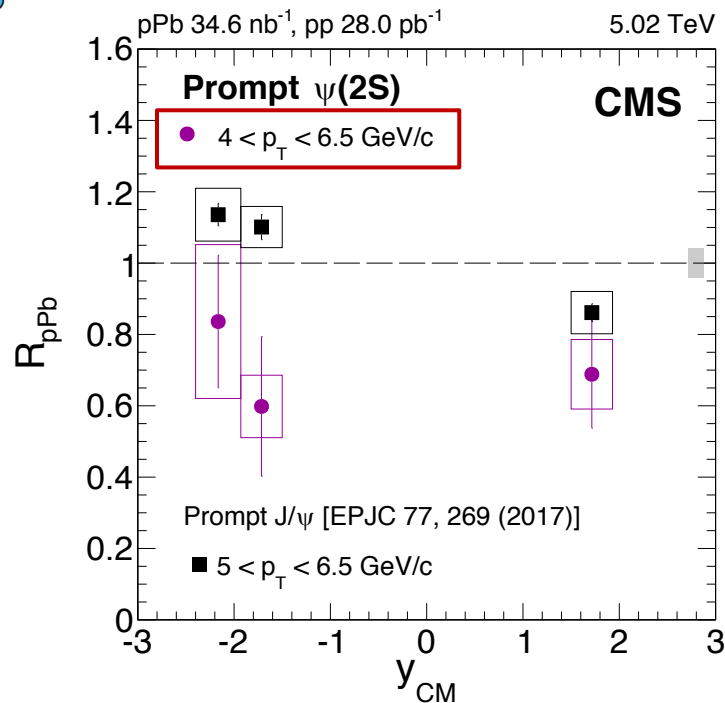
- Differential cross sections of Prompt $\psi(2S)$ in pPb and pp collisions at 5TeV
 - $p_T > 4$ GeV/c, $-2.4 < y_{CM} < 1.93$ in pPb
- Prompt $\psi(2S)$ from b-hadron decay is extracted using a cut on $l_{J/\psi}$
- The cross sections in pPb collisions are normalized by $A = 208$

Prompt $\psi(2S)$ R_{pPb}



Low p_T

High p_T



arXiv:1805.02248

- $R_{pPb}(2S) / R_{pPb}(1S) < 1$ in all measured bins
- $\psi(2S)$ is suppressed strongly
- Suppression of excited state continues in higher p_T (the same is seen in PbPb)

Indication of final state effect: suppression by interactions with co-movers?

Outline



- Prompt J/ψ in pPb at 5.02 TeV (ground state)
 - Eur. Phys. J. C 77 (2017) 269



- Prompt $\psi(2S)$ in pPb at 5.02 TeV (excited state)
 - arXiv : 1805.02248



- **Prompt J/ψ v_2 in pPb at 8.16 TeV**
 - CMS PAS HIN-18-010



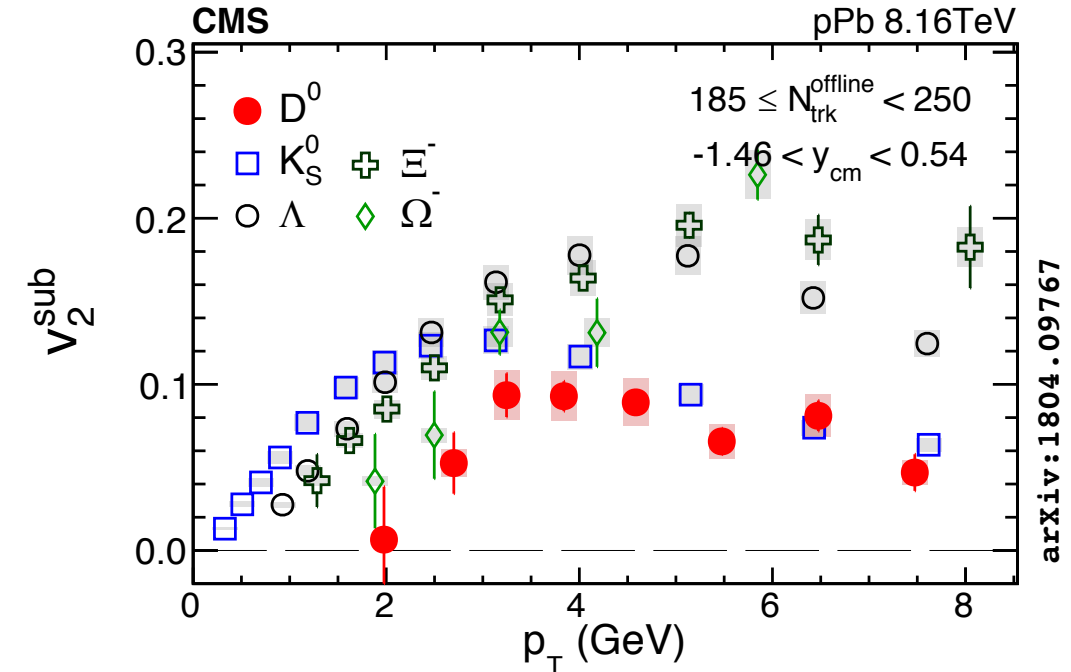
- Prompt J/ψ in Jets in pp at 5.02 TeV
 - CMS PAS HIN-18-012

- Summary

J/ ψ v_2 : Physics motivation



- Collectivity of heavy quarks in small system?
 - Early thermalization -> system coupling strength
 - Evidence for hard probe -> medium interaction
 - Evidence of charm flow from D^0 v_2
 - D^0 -> charm quark + light quark
 - Flow from u or c quark?



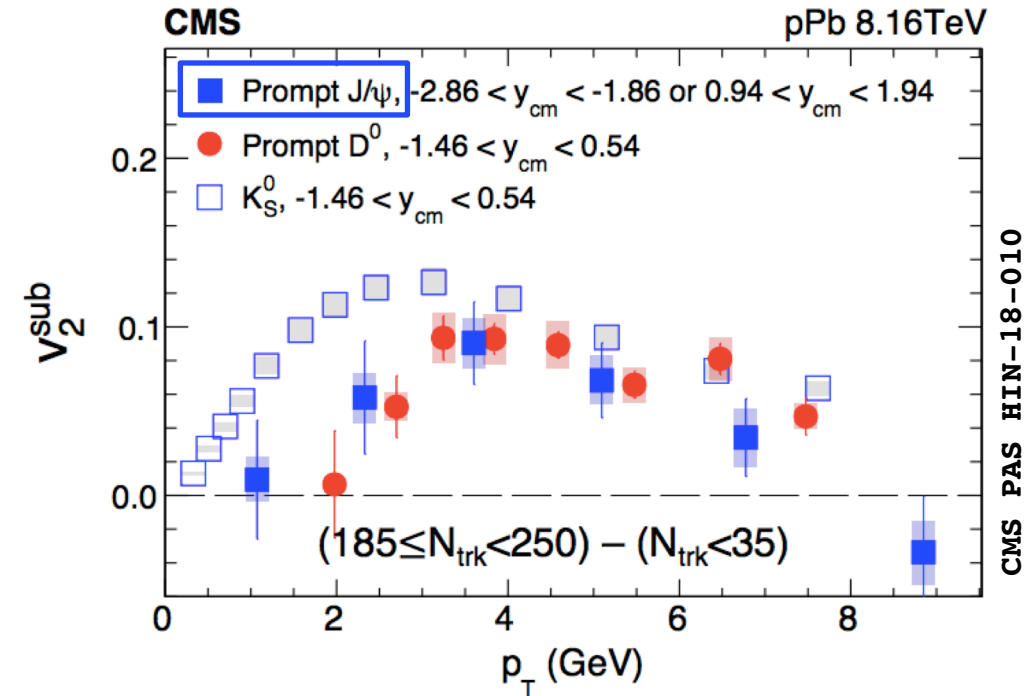
- Low p_T : follow mass ordering
- High p_T : similar to K_S^0

J/ ψ v_2 to complete the picture of charm dynamics

Prompt J/ψ v_2 in pPb



- Clear observation of Prompt J/ψ v_2 in pPb collisions
 - Direct evidence of charm collectivity
- Direct comparison with light and open heavy flavors mesons
 - Confirms v_2 between charm and light



D^0 and J/ψ : Strong constraints to charm dynamics in pPb
QGP can be formed in high multiplicity pPb collisions?

- Significant positive J/ψ v_2 observed
- $v_2(K_S^0) > v_2(J/\psi) \rightarrow v_2(\text{light}) > v_2(\text{charm})$

Outline



- Prompt J/ψ in pPb at 5.02 TeV (ground state)
 - Eur. Phys. J. C 77 (2017) 269



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- Prompt J/ψ v_2 in pPb at 8.16 TeV
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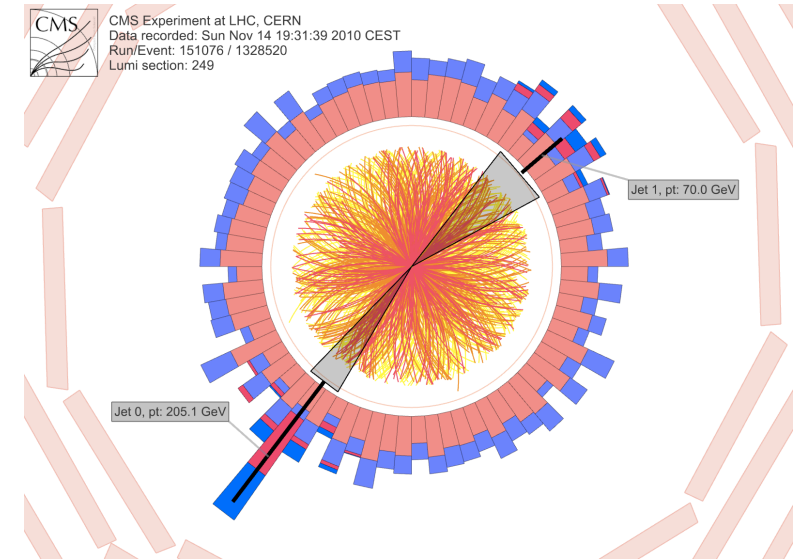


- **Prompt J/ψ in Jets in pp at 5.02 TeV**
 - CMS PAS HIN-18-012

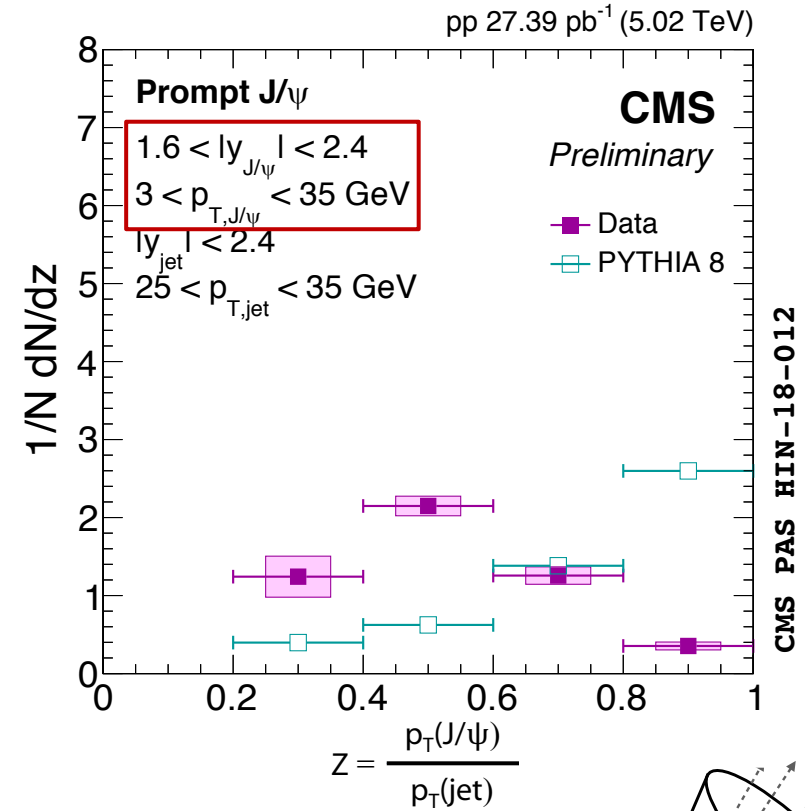
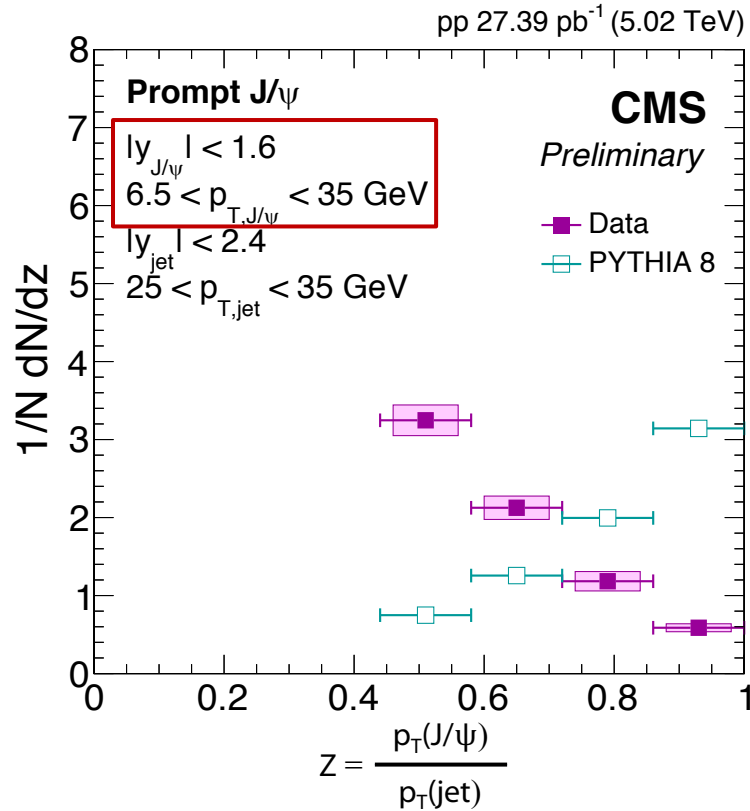
- Summary

J/ ψ in jets : Physics motivation

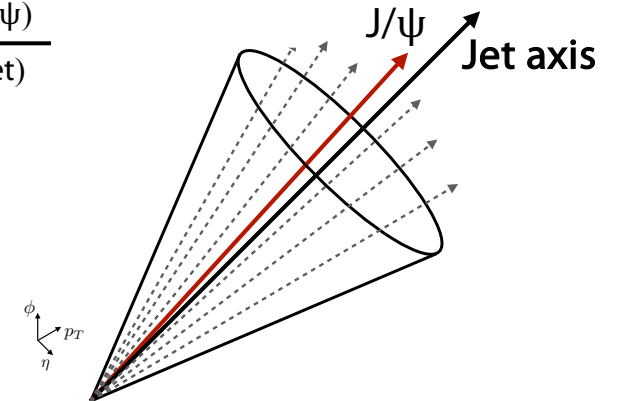
- J/ ψ is used as a probe for QCD phenomena
 - **QGP** in PbPb collisions
 - **Cold nuclear matter** in pPb collisions
- The J/ ψ production is not fully understood
 - Influence of the initial state
 - How much it is isolated?
- Study production of J/ ψ in jets in pp(pure scattering)
 - Fragmentation pattern
 - Fraction of J/ ψ in jets



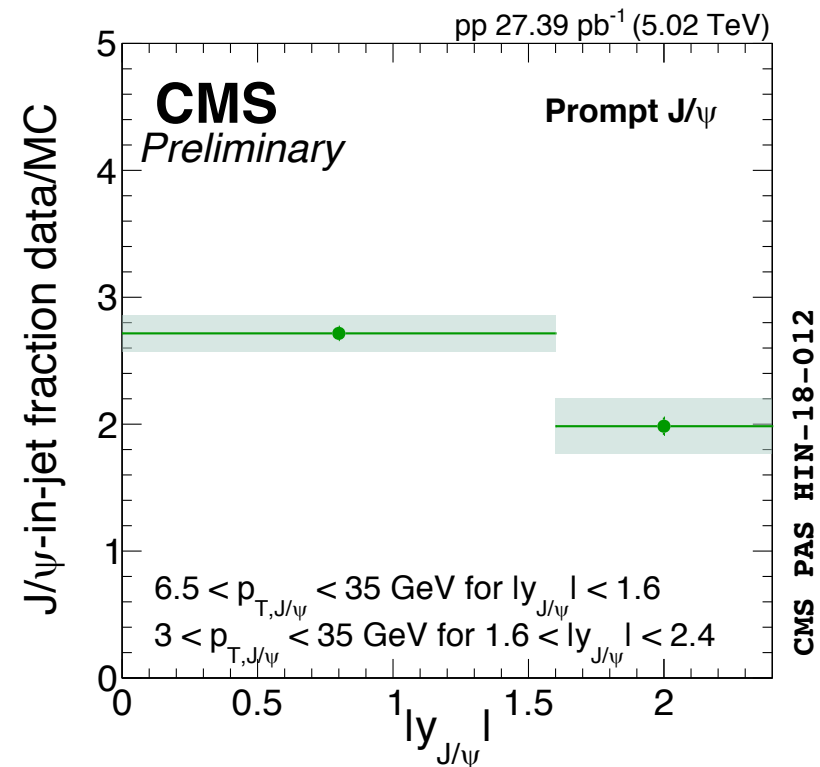
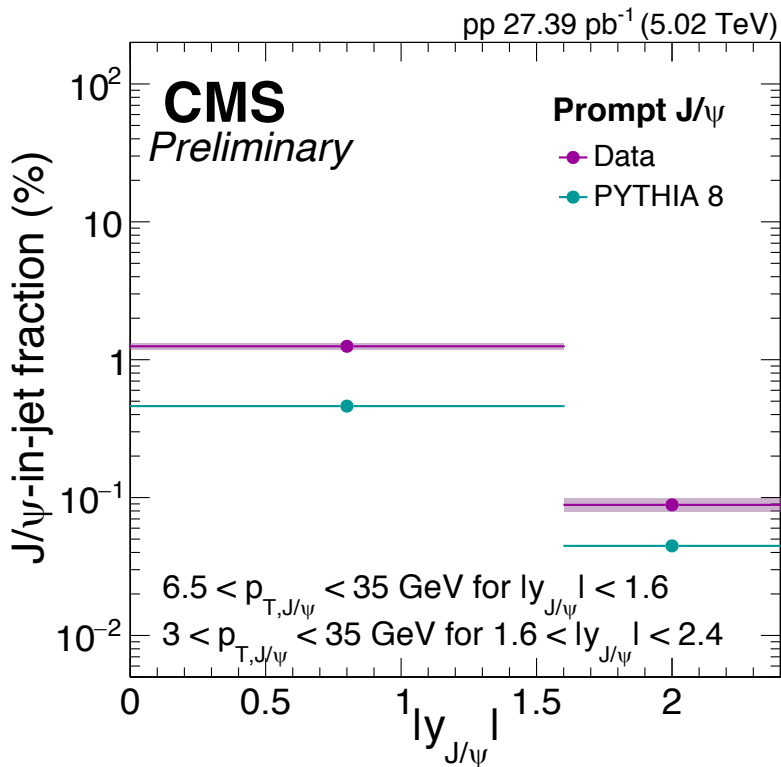
Prompt J/ψ in jets in pp



- Prompt J/ψ in jets is measured in mid-rapidity and forward rapidity
- **PYTHIA 8 does not describe the prompt J/ψ production in pp**
 - J/ψ are much less isolated in data than in MC



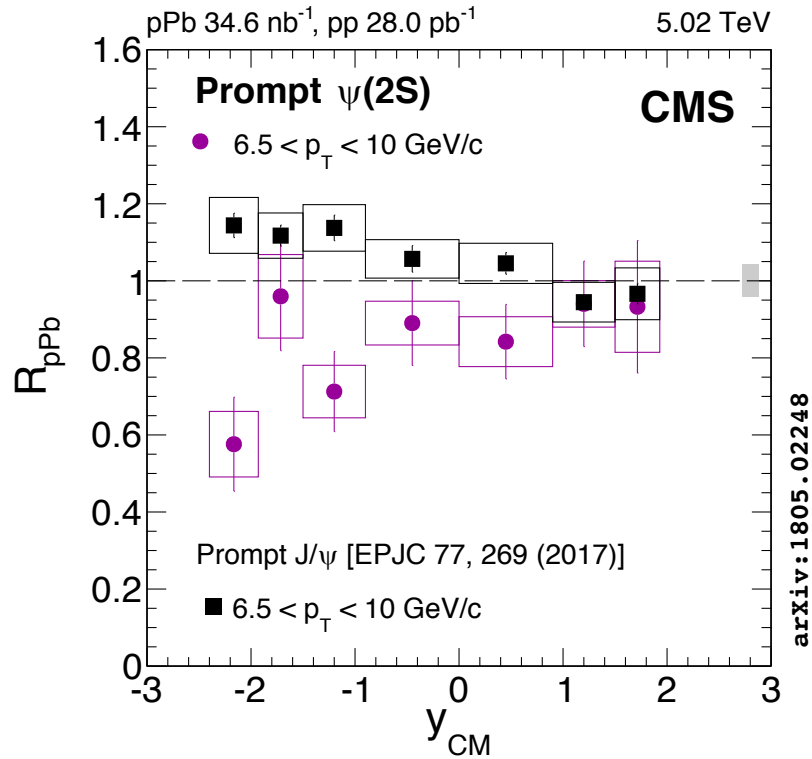
Prompt J/ψ in jets fraction



- The fraction of prompt J/ψ is less than ~1%
- Higher fraction of prompt J/ψ in jets in data than MC
- In PbPb: jet quenching might play a role in J/ψ production

Summary

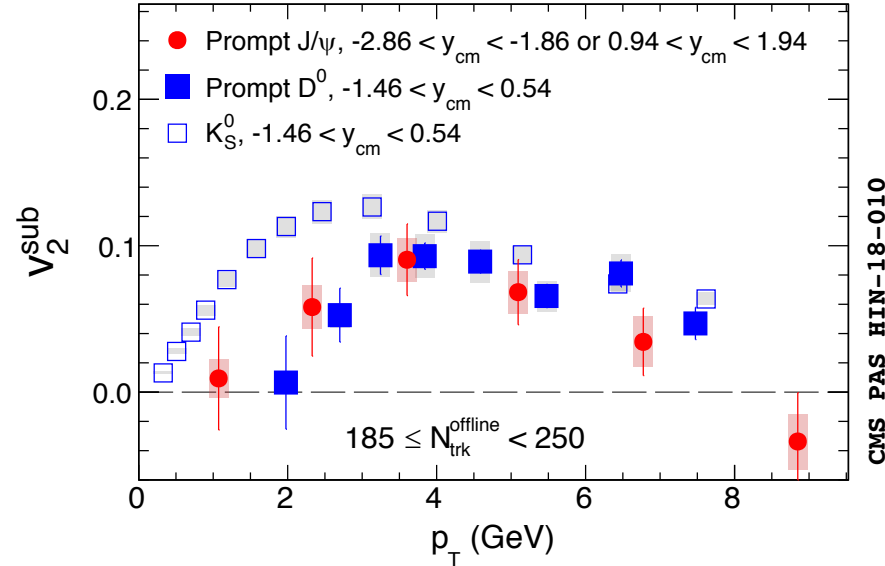
Probing **Cold Nuclear Matter** effects :



Ground state:
No strong modification

Excited state:
Affected by final state effects

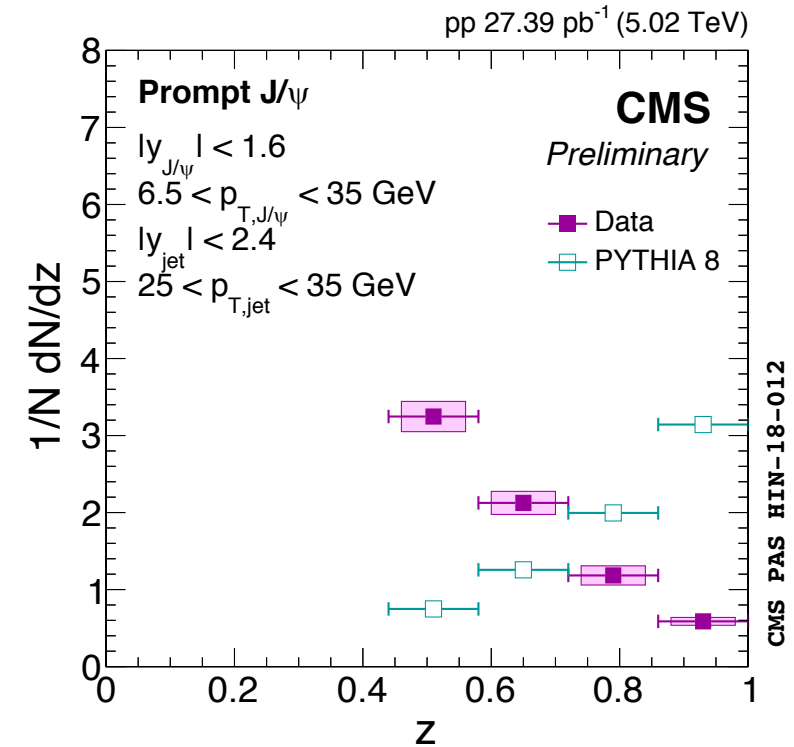
CMS pPb 8.16 TeV



Significant v_2 of J/ψ in pPb

Strong constraints
to charm dynamics in pPb

Probing **NO nuclear effects** :



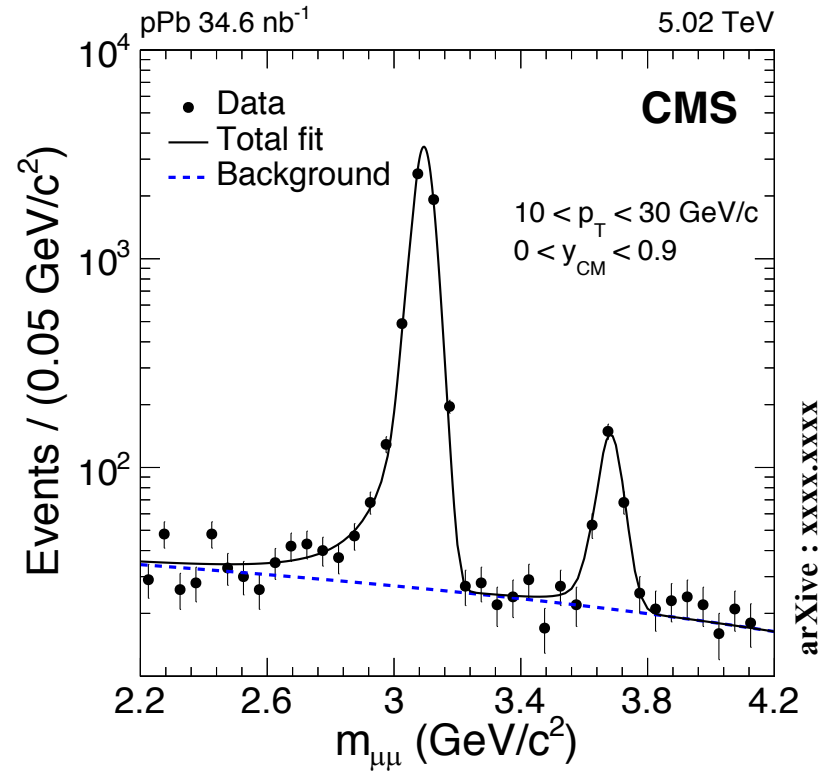
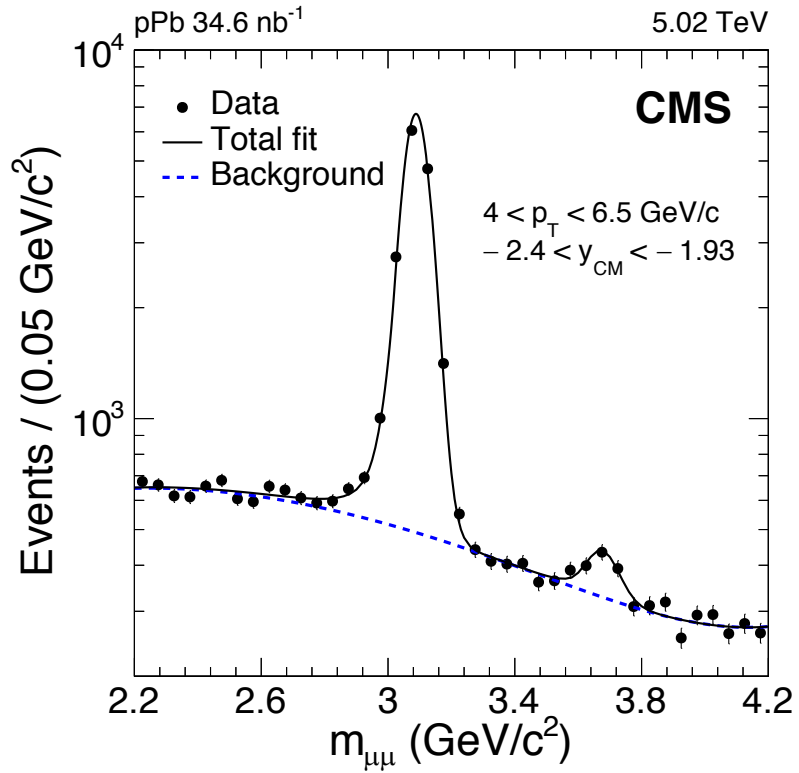
Prompt J/ψ is much jettier
than predicted

In PbPb: jet quenching
might play a role
in J/ψ production

THANK YOU FOR YOUR ATTENTION!

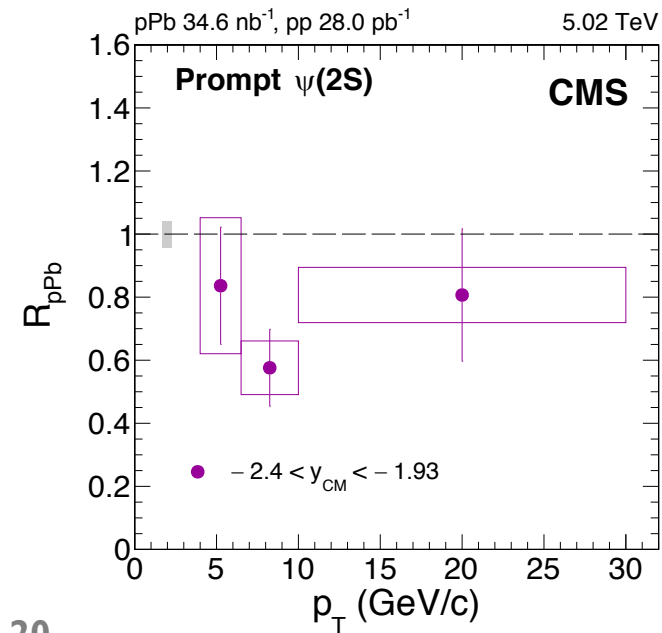
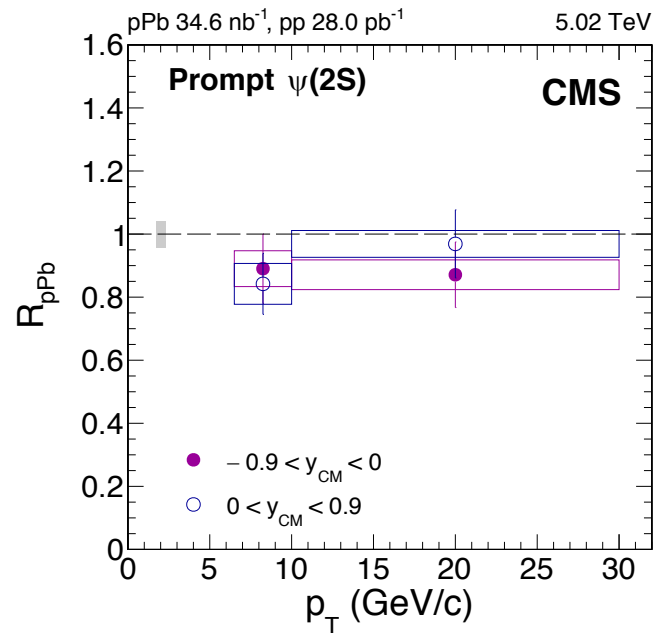
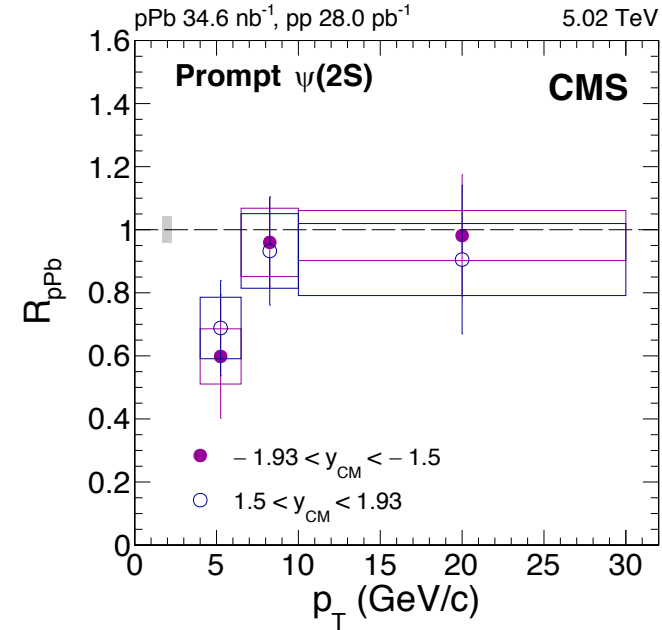
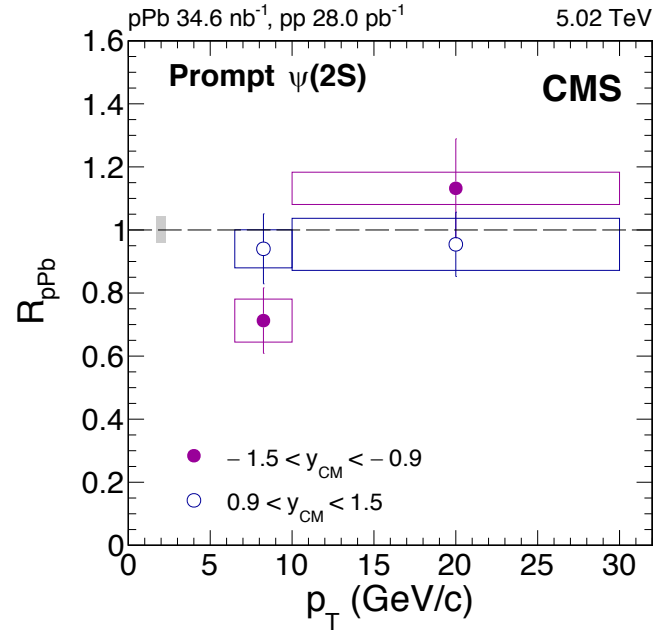
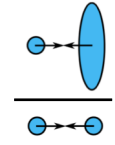
Back Up

Prompt J/ψ and $\psi(2S)$

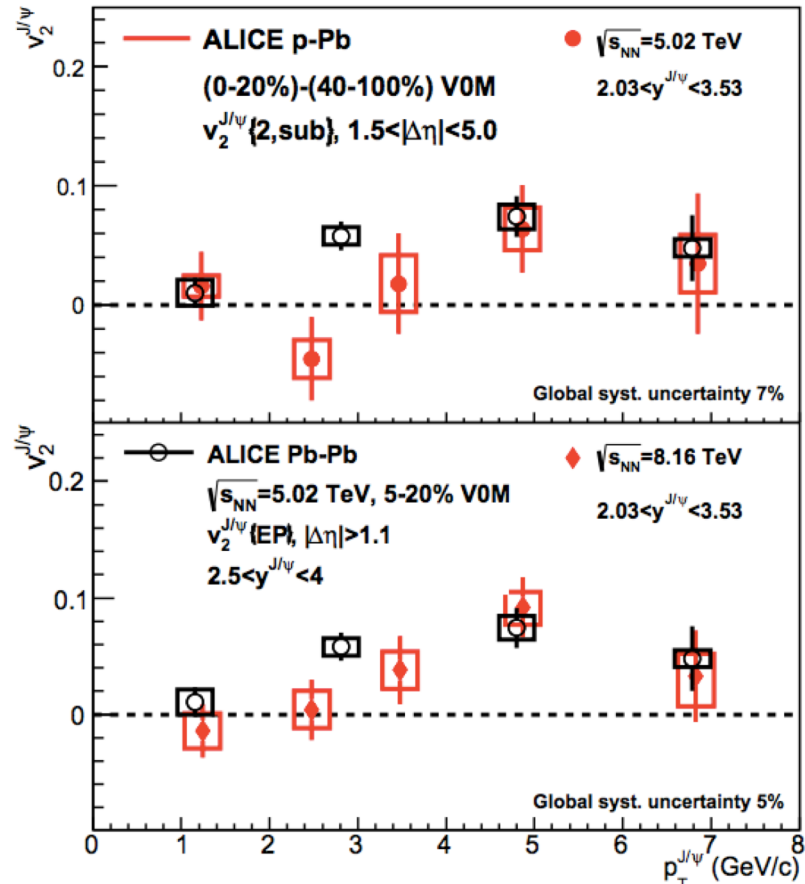


- Dimuon invariant mass distribution : J/ψ and $\psi(2S)$ applied $l_{J/\psi}$ selection
(rejecting nonprompt charmonia ; b hadron decays)
- The signal model is **Crystal Ball** and a **Gaussian**
- The background is modeled by **Chebyshev polynomials**
- Log-Likelihood Ratio (LLR) tests were applied to choose the degree of the Chebyshev

Prompt $\psi(2S)$ R_{pPb}

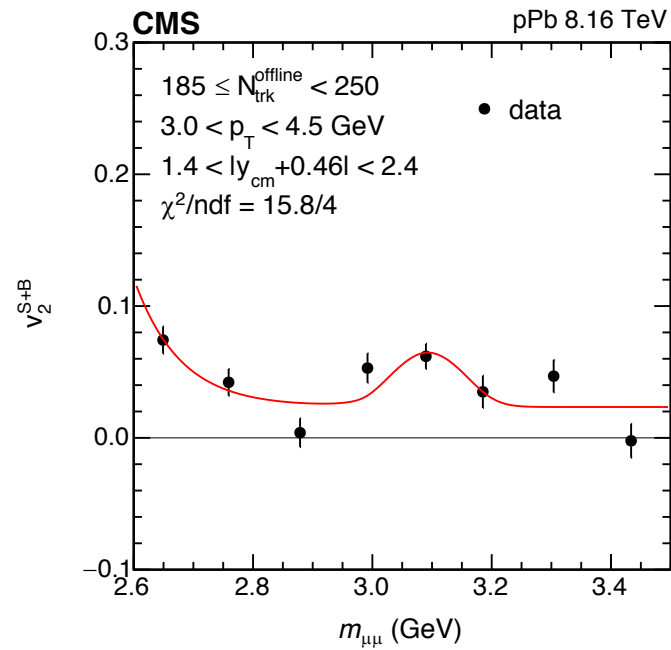
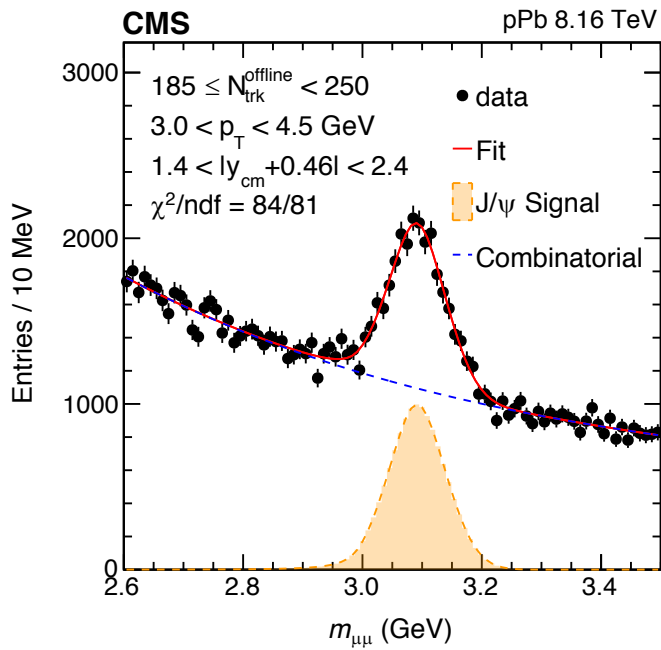


J/ψ v₂ in pPb & PbPb In ALICE

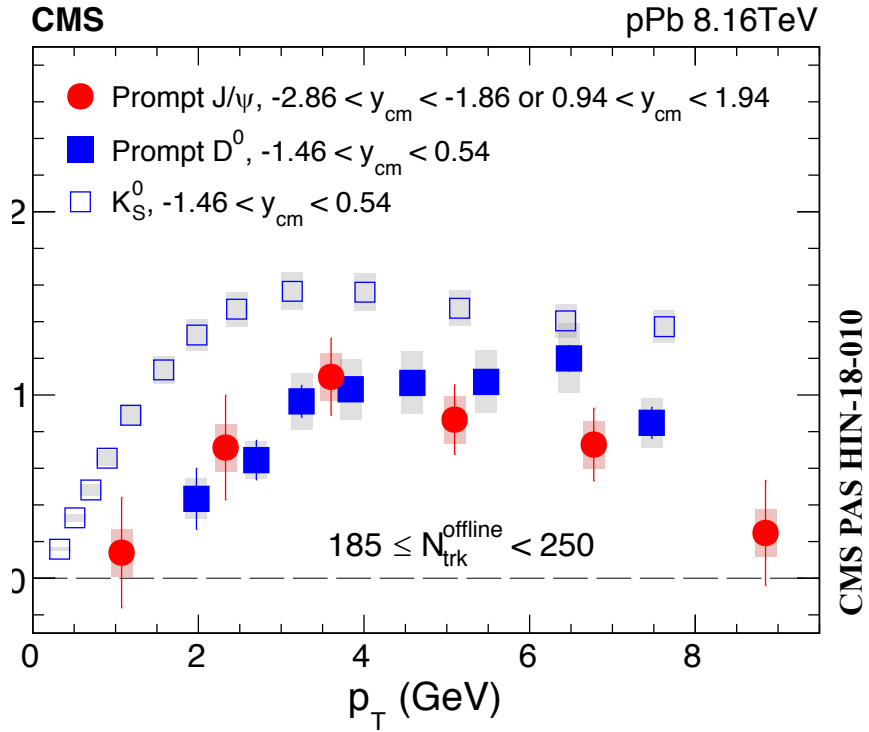
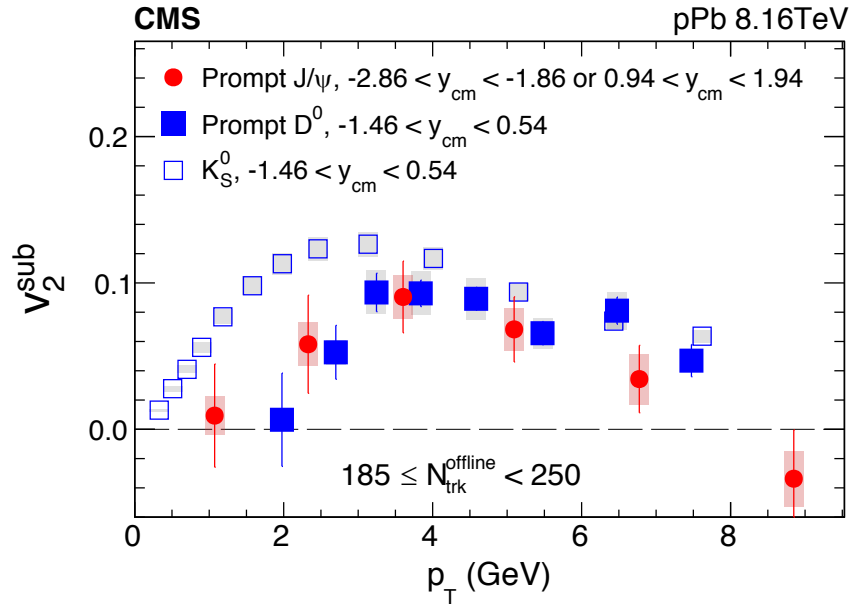


- Indication of positive v_2 for inclusive J/ψ
- What do we see in CMS?
 - High-multiplicity triggers
 - Limited low p_T reach

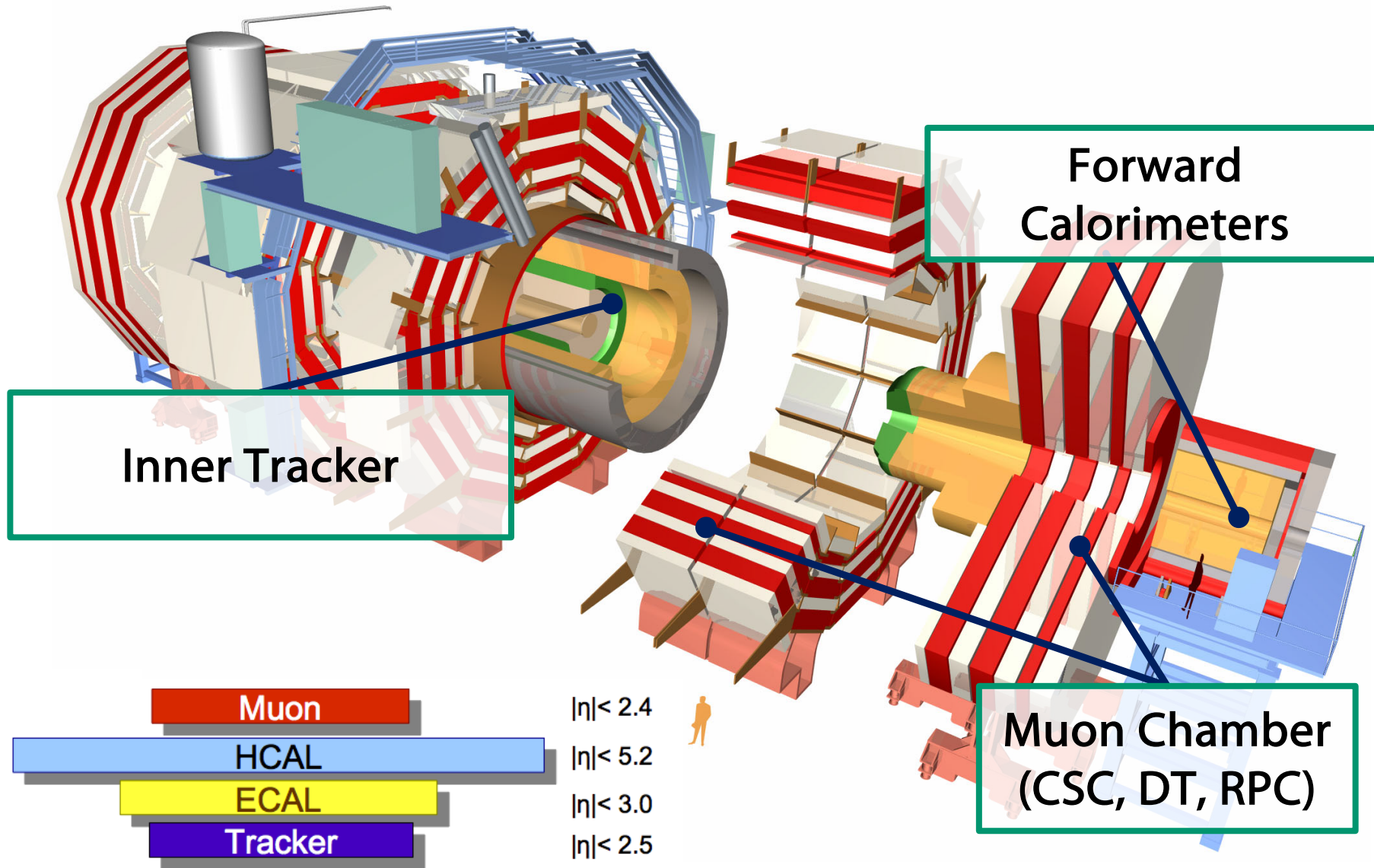
Fitting in J/ψ v_2



Prompt J/ψ v_2 in pPb with LM



CMS Detector



Muon reconstruction

