Detailed measurements of charmonium suppression in PbPb collisions at 2.76 TeV with CMS

Dong Ho Moon
(Korea University)
for the CMS Collaboration

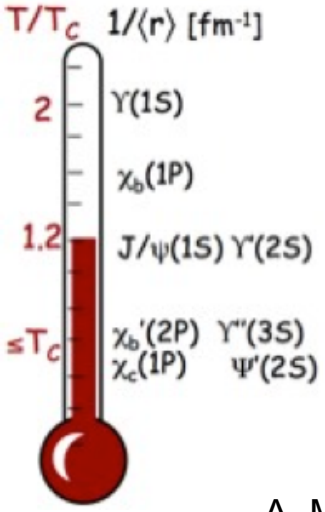
Quark Matter conference, Washington DC
14th August, 2012

J/ψ in heavy-ion collisions

- One of the most powerful tools to understand the QGP
  - Heavy quarks created at the early stage and with a large momentum transfer in gluon-gluon fusion.
  - Sequential melting
    - By Debye screening.
    - Can play a role to quantify medium properties (as thermometer).

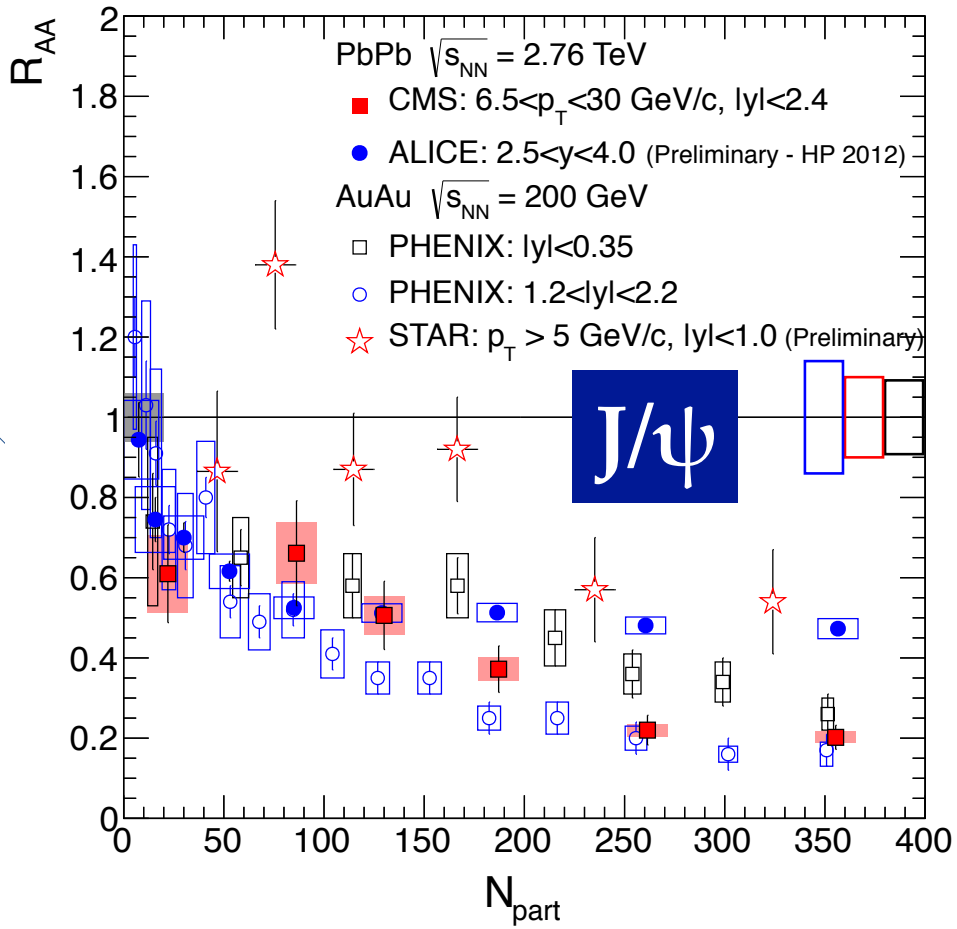
State	J/ψ (1S)	χ_c (1P)	ψ' (2S)
m (GeV/c^2)	3.10	3.53	3.68
r_0 (fm)	0.50	0.72	0.90

Υ (1S)	χ_b (1P)	Υ' (2S)	χ_b' (2P)	Υ'' (3S)
9.46	9.99	10.02	10.26	10.36
0.28	0.44	0.56	0.68	0.78



A. Mocsy
Eur.Phys.J.C61,2009

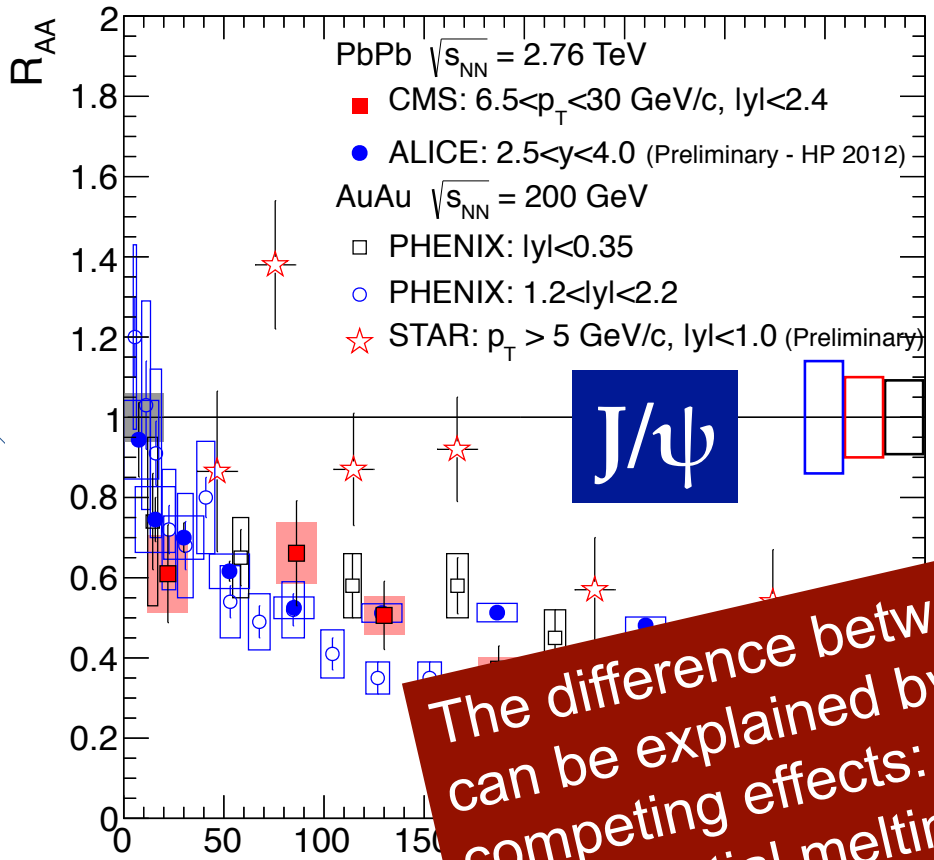
J/ψ in heavy-ion collisions



Phys. Rev. Lett. 98 (2007) 232301,
arXiv:1107.0532,
arXiv:1202.1383

- At lower p_T
  - **PHENIX** observed less suppression at mid-rapidity than at forward rapidity
  - **ALICE** observed less suppression than **PHENIX**
- At higher p_T
  - **CMS** measured more suppression than **STAR**
- At LHC
  - **CMS** measured more suppression at higher p_T than **ALICE** at lower p_T

J/ψ in heavy-ion collisions



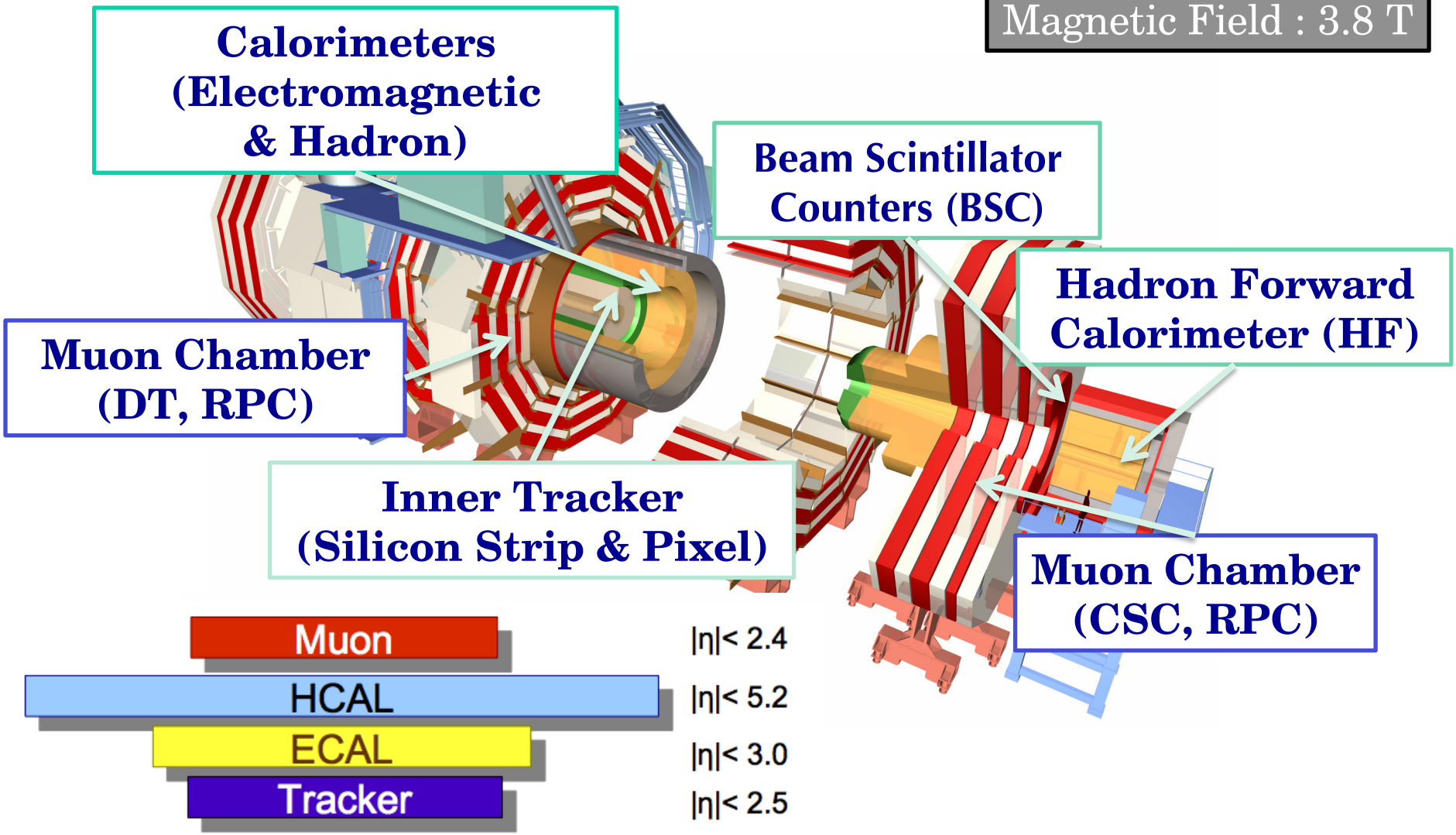
Phys. Rev. Lett. 98 (2007) 2323
arXiv:1107.0532,
arXiv:1202.1383

- At lower p_T
  - **PHENIX** observed less suppression at mid-rapidity than at forward rapidity
  - **ALICE** observed less suppression than **PHENIX**
- At higher p
  - more
  - n **STAR**
  - ore
  - gher p_T than
  - 2 at lower p_T

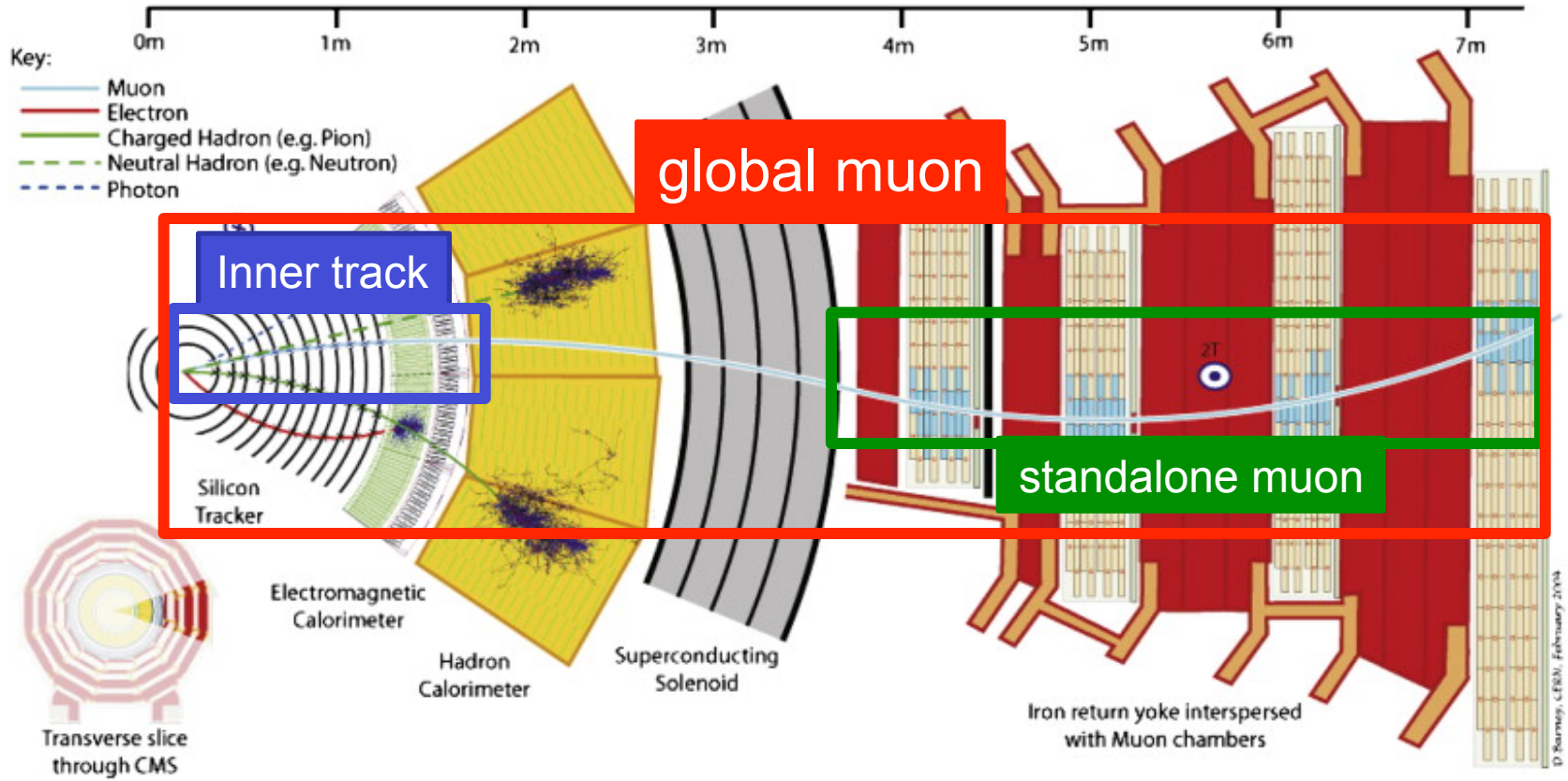
The difference between these results can be explained by various mixes of competing effects:
- Sequential melting
- Shadowing or saturation
- Regeneration

CMS detector

Magnetic Field : 3.8 T

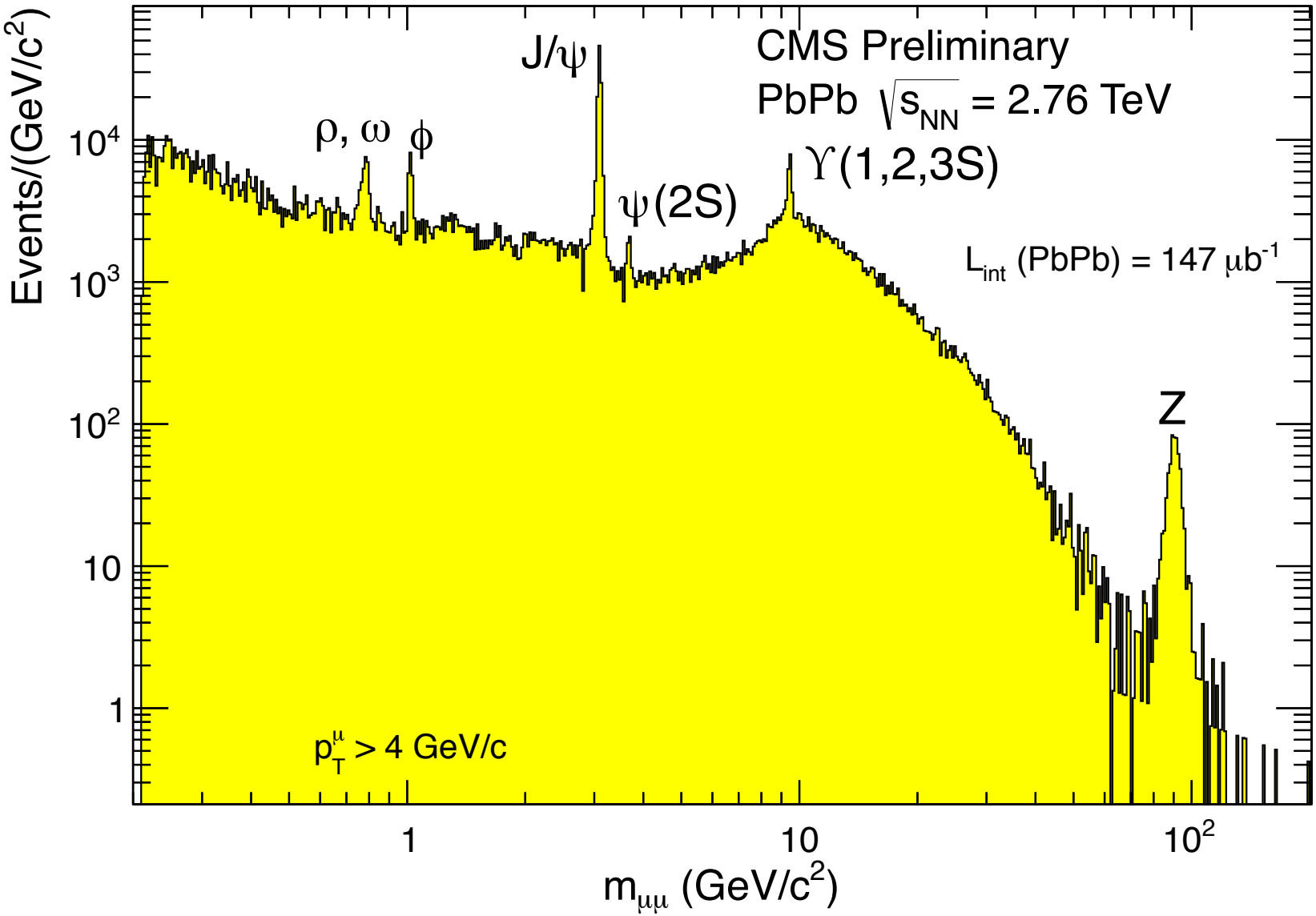


Muon reconstruction

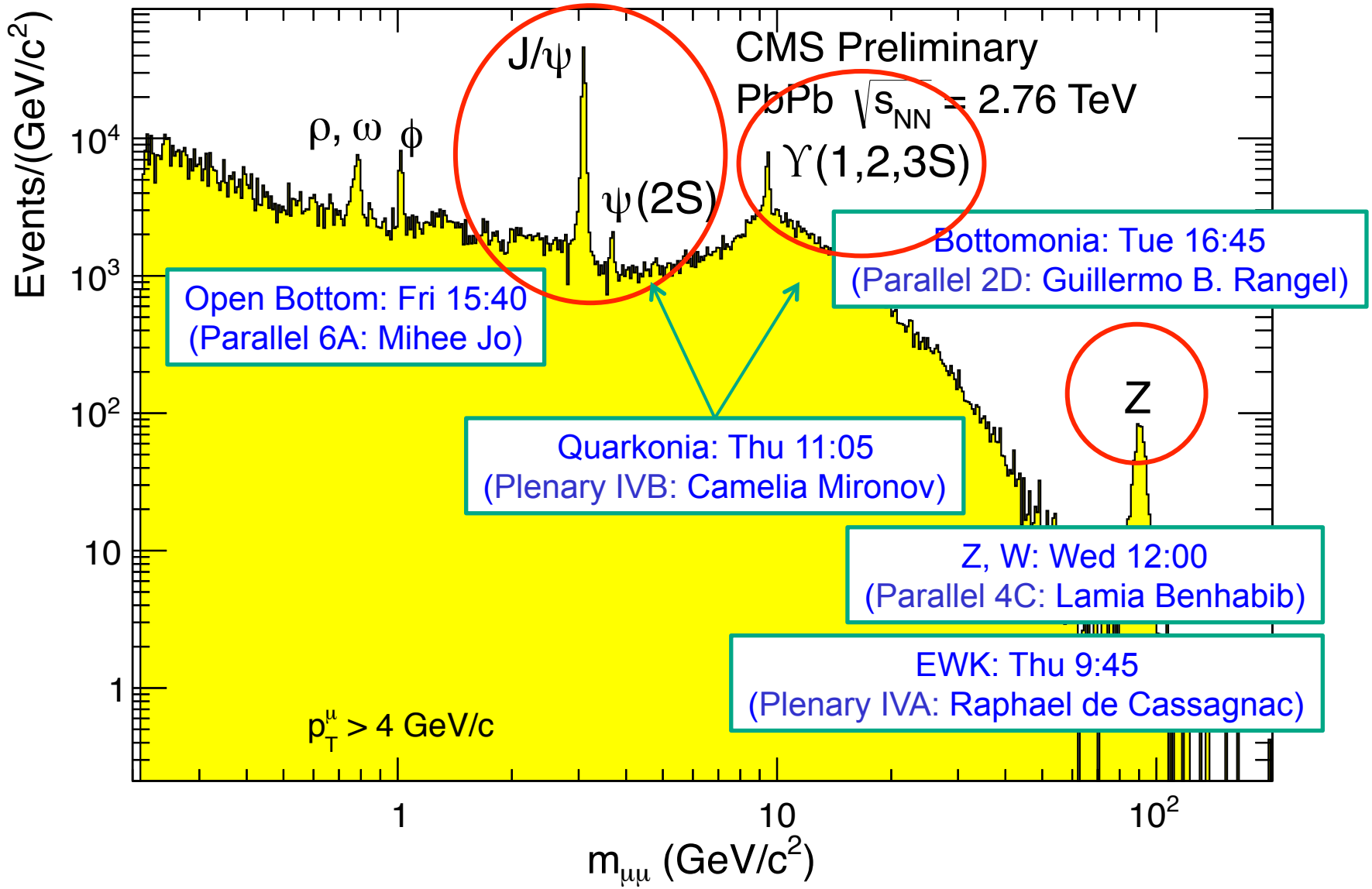


- Excellent muon identification & triggering in muon system.
- Excellent momentum resolution of tracking system.
  - Overall resolution: 1~2 %

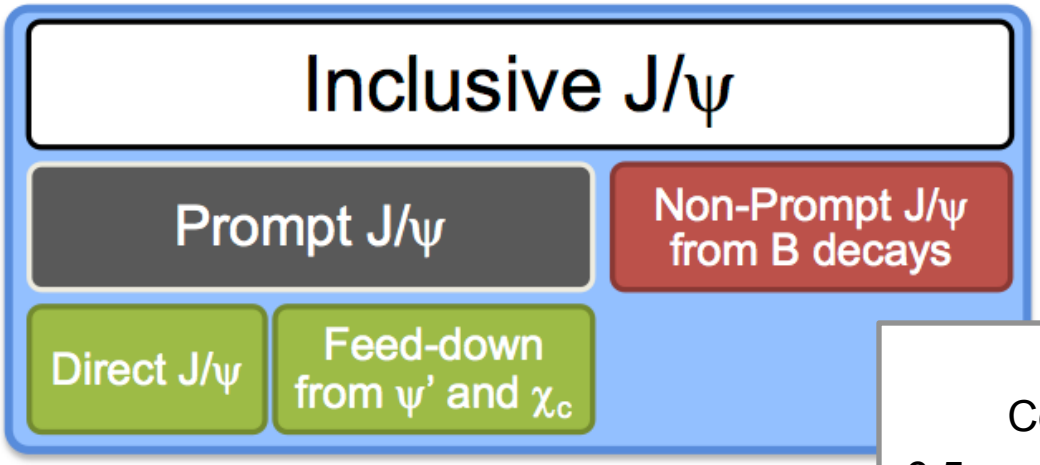
Dimuon spectrum in 2011 PbPb



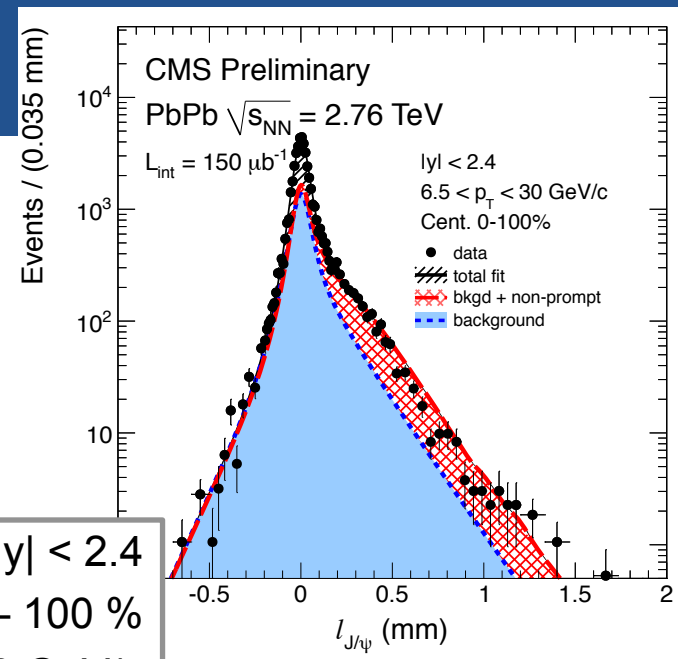
Dimuon spectrum in 2011 PbPb



Prompt/non-prompt J/ψ

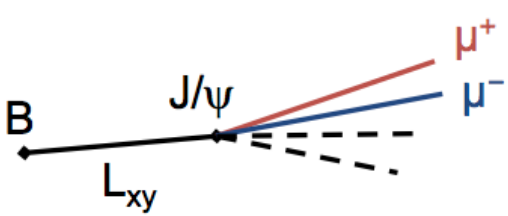


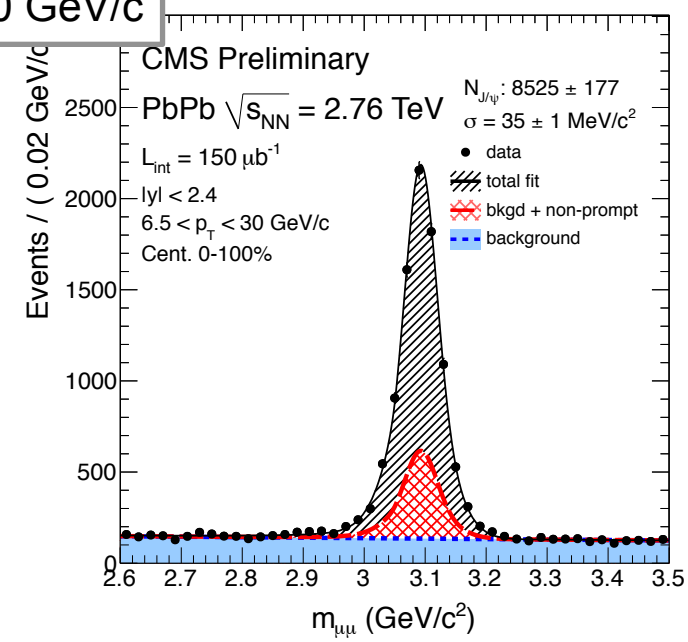
|y| < 2.4
Cent. 0 – 100 %
6.5 < < p_T < 30 GeV/c



- Reconstruct opposite sign muon vertex
- 2-D unbinned maximum likelihood fit of dimuon mass and pseudo-proper decay length ($l_{J/\psi}$)

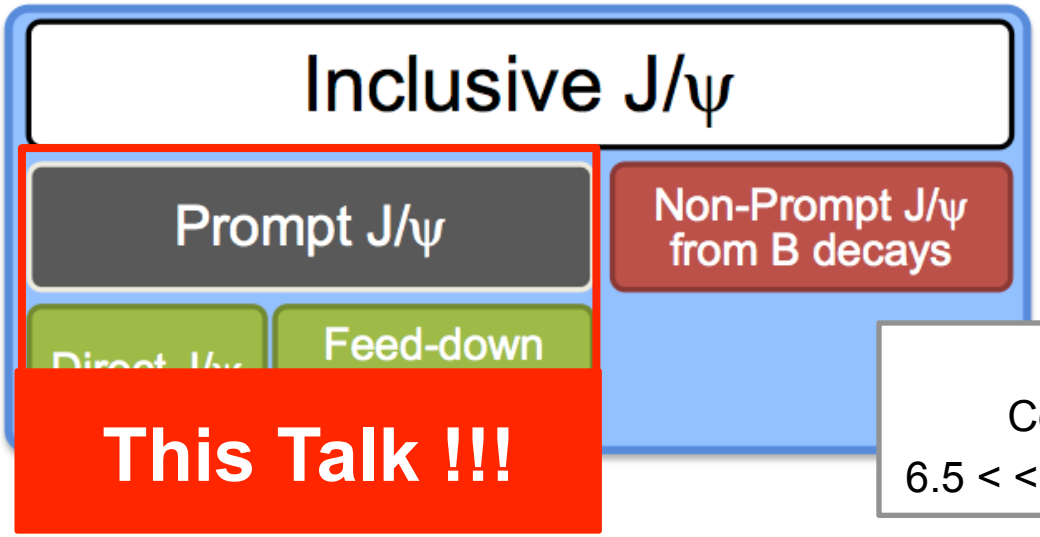
$$\ell_{J/\psi} = L_{xy}\frac{m_{J/\psi}}{p_T}$$



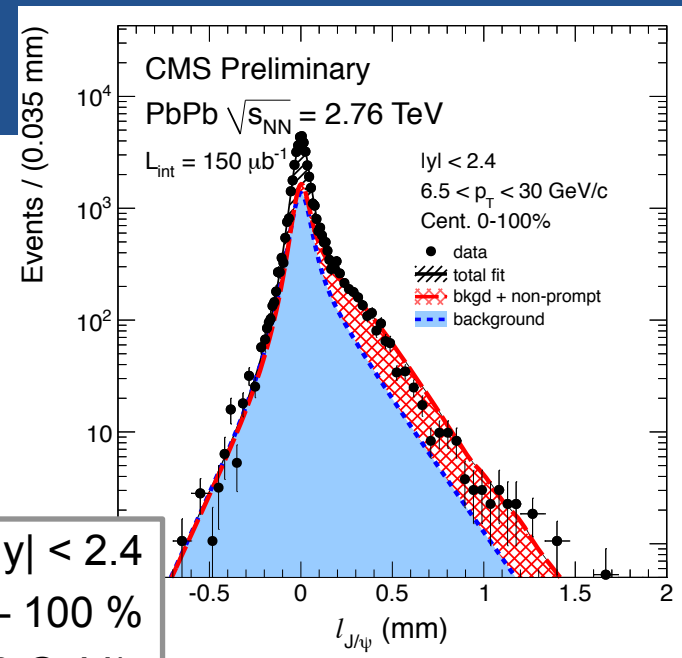


PAS CMS-HIN-12-014

Prompt/non-prompt J/ψ

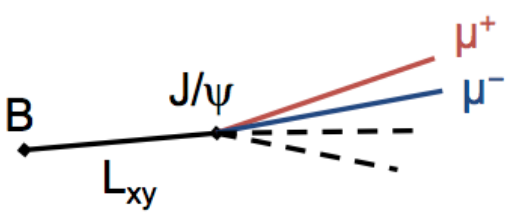


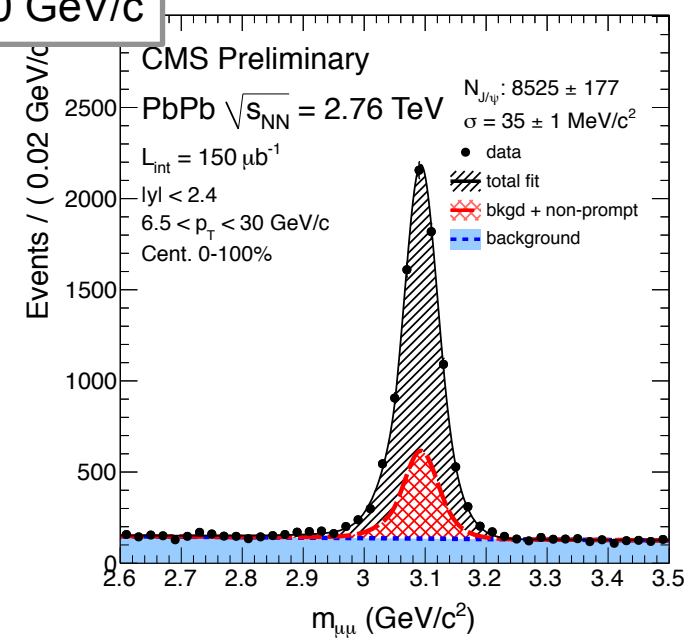
|y| < 2.4
Cent. 0 – 100 %
6.5 < < p_T < 30 GeV/c



- Reconstruct opposite sign muon vertex
- 2-D unbinned maximum likelihood fit of dimuon mass and pseudo-proper decay length ($l_{J/\psi}$)

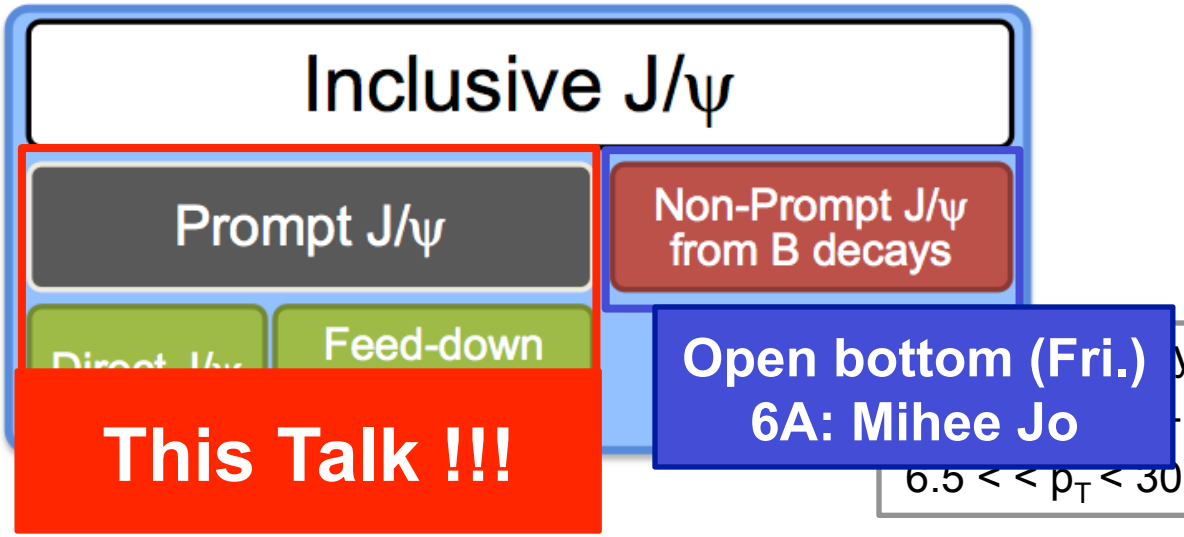
$$\ell_{J/\psi} = L_{xy}\frac{m_{J/\psi}}{p_T}$$

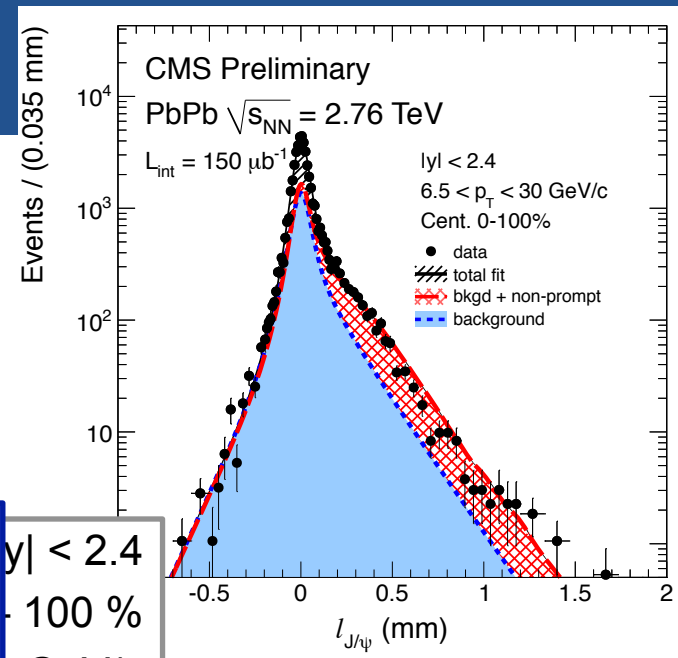




PAS CMS-HIN-12-014

Prompt/non-prompt J/ψ

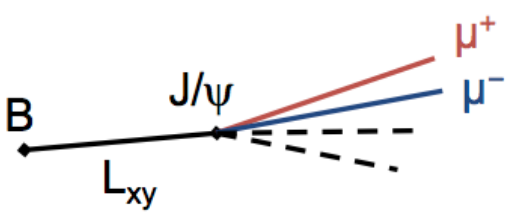


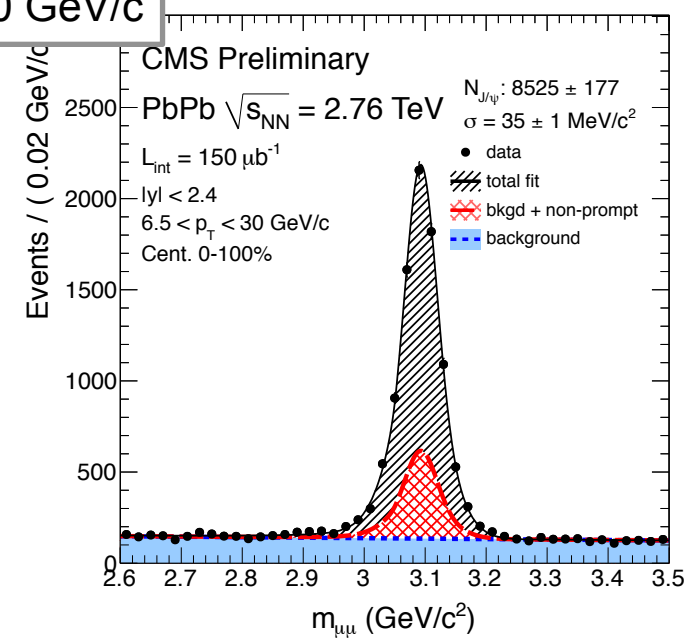


|y| < 2.4
- 100 %
6.5 < < p_T < 30 GeV/c

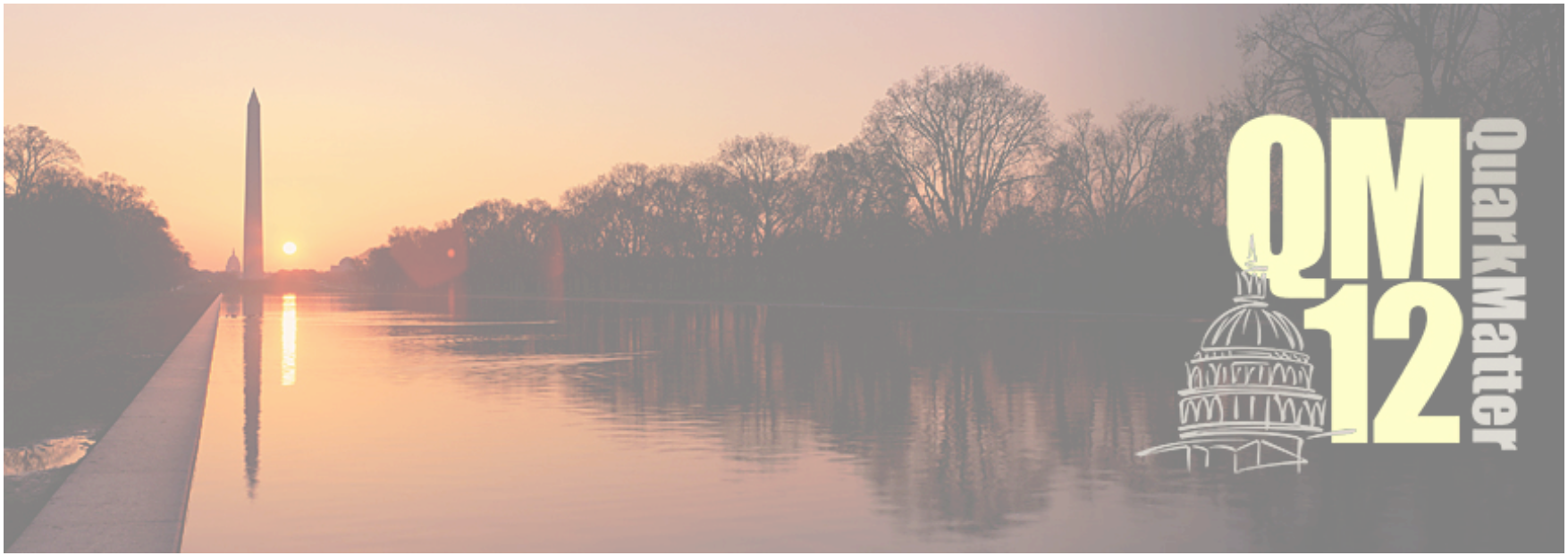
- Reconstruct opposite sign muon vertex
- 2-D unbinned maximum likelihood fit of dimuon mass and pseudo-proper decay length ($l_{J/\psi}$)

$$\ell_{J/\psi} = L_{xy}\frac{m_{J/\psi}}{p_T}$$





PAS CMS-HIN-12-014

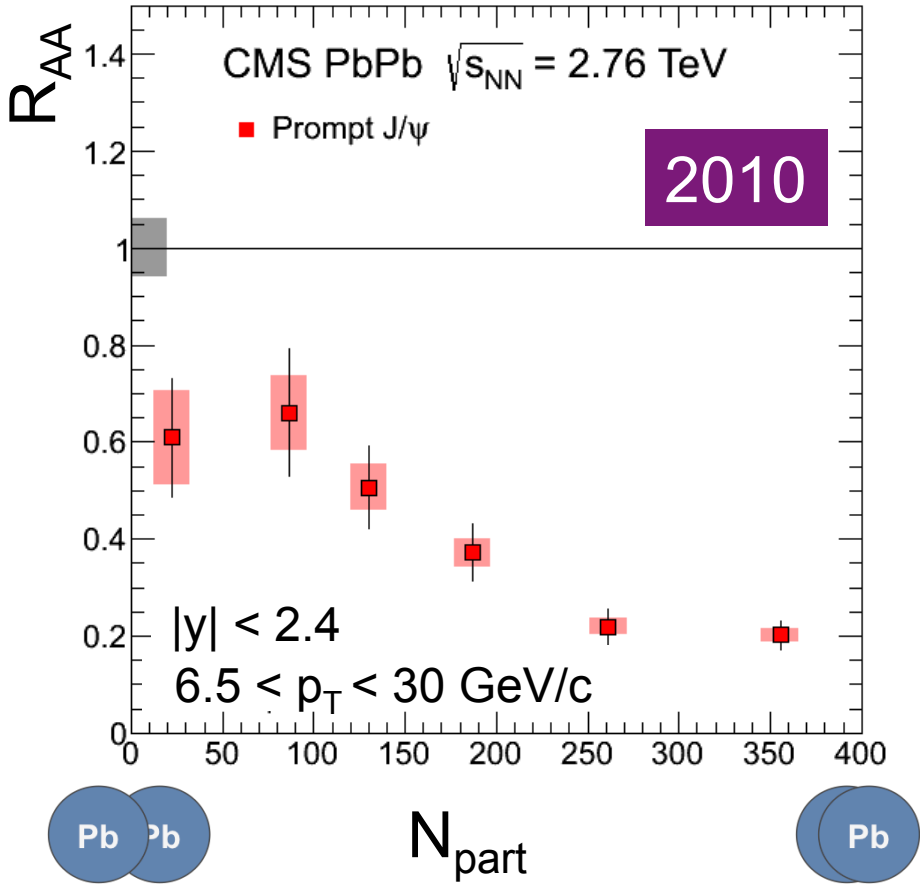


2011 prompt J/ψ results

R_{AA} of prompt J/ψ vs N_{part}

$$R_{AA} = \frac{\mathcal{L}_{pp}}{T_{AA} N_{\mathrm{MB}}} \frac{N_{\mathrm{PbPb}}(J/\psi)}{N_{pp}(J/\psi)} \frac{\varepsilon_{pp}}{\varepsilon_{\mathrm{PbPb}}(\mathrm{cent})}$$

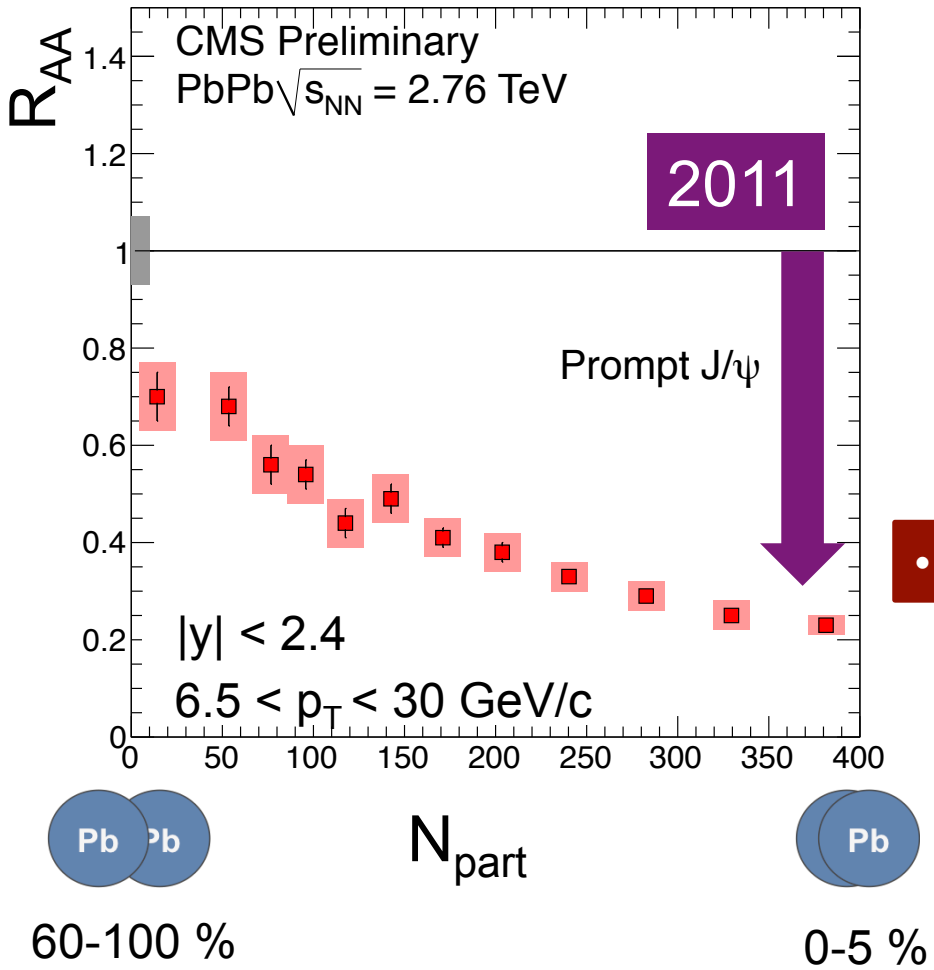
JHEP 1205 (2012) 063



R_{AA} of prompt J/ψ vs N_{part}

$$R_{AA} = \frac{\mathcal{L}_{pp}}{T_{AA} N_{\mathrm{MB}}} \frac{N_{\mathrm{PbPb}}(J/\psi)}{N_{pp}(J/\psi)} \frac{\varepsilon_{pp}}{\varepsilon_{\mathrm{PbPb}}(\mathrm{cent})}$$

PAS CMS-HIN-12-014

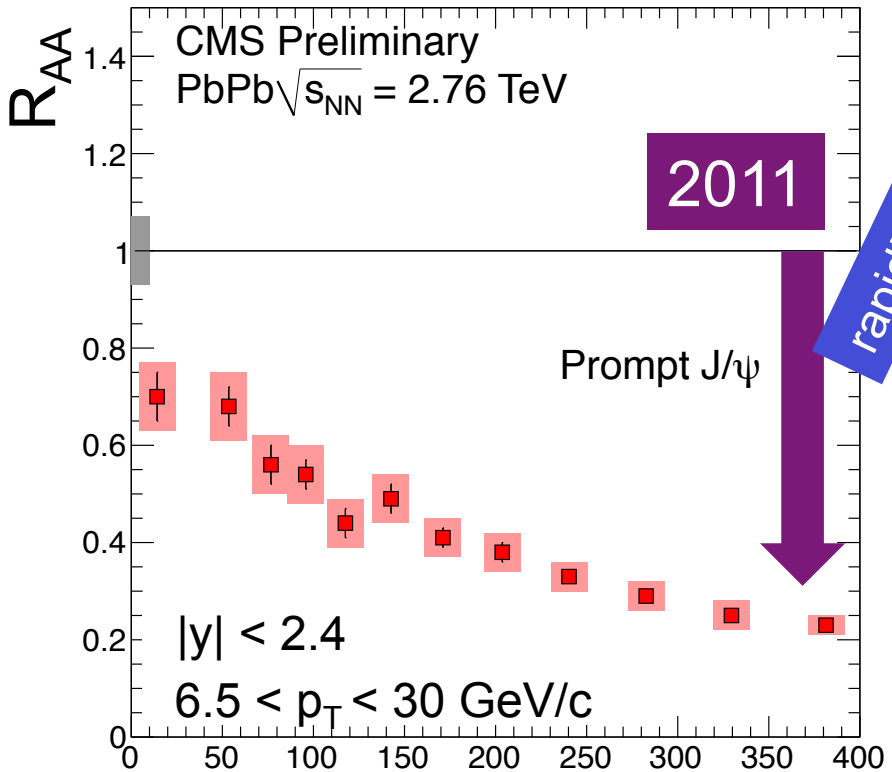


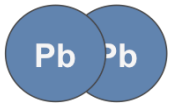
- Suppressed by factor 5 in most central

R_{AA} of prompt J/ψ vs N_{part}

$$R_{AA} = \frac{\mathcal{L}_{pp}}{T_{AA} N_{\mathrm{MB}}} \frac{N_{\mathrm{PbPb}}(J/\psi)}{N_{pp}(J/\psi)} \frac{\varepsilon_{pp}}{\varepsilon_{\mathrm{PbPb}}(\mathrm{cent})}$$

PAS CMS-HIN-12-014

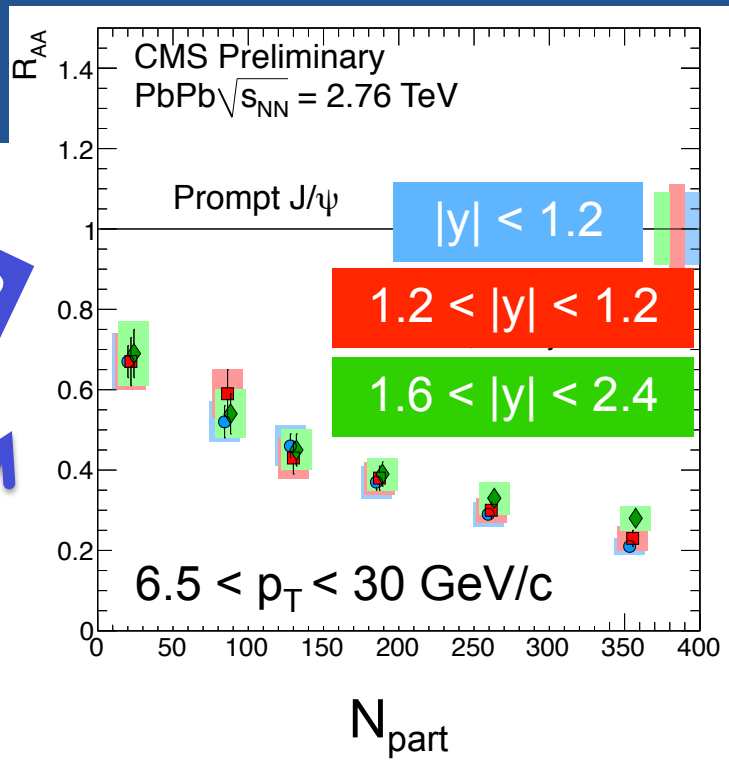




60-100 %

0-5 %

rapidity dependence

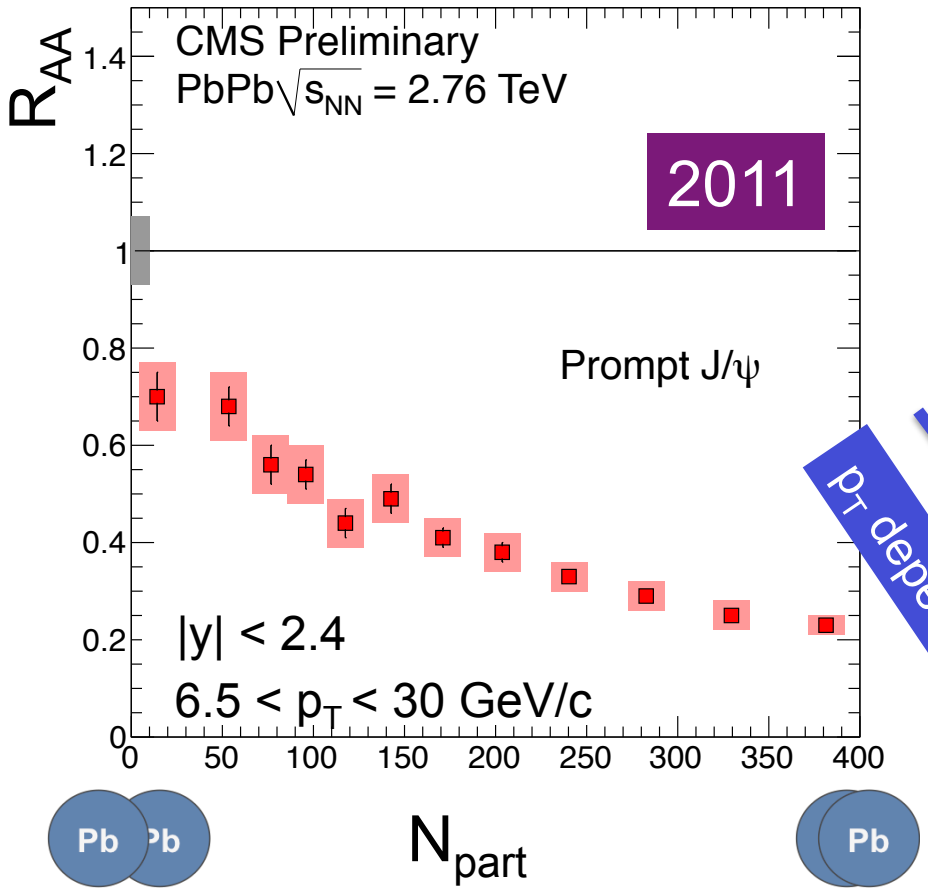


- No strong dependence on rapidity

R_{AA} of prompt J/ψ vs N_{part}

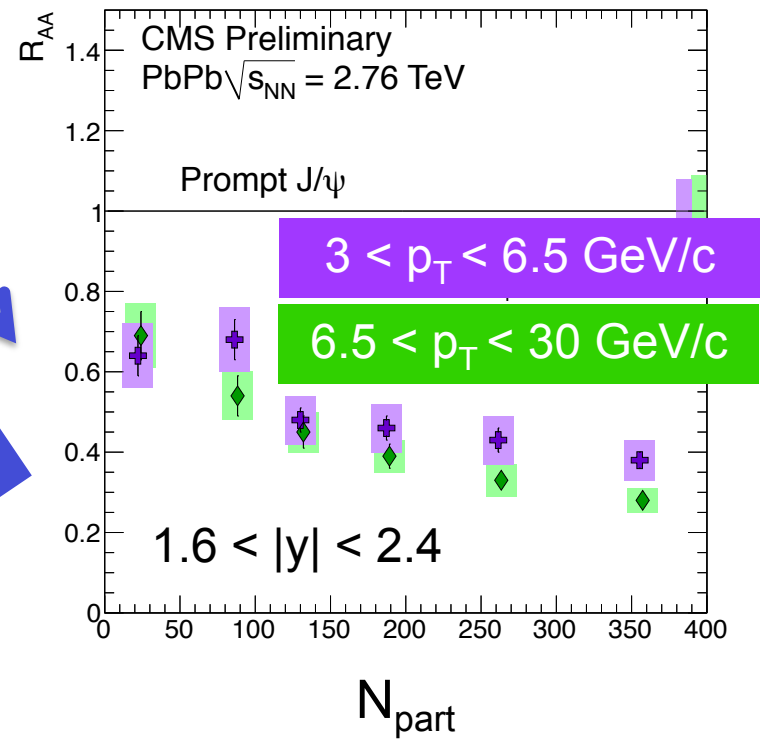
$$R_{AA} = \frac{\mathcal{L}_{pp}}{T_{AA} N_{\mathrm{MB}}} \frac{N_{\mathrm{PbPb}}(J/\psi)}{N_{pp}(J/\psi)} \frac{\varepsilon_{pp}}{\varepsilon_{\mathrm{PbPb}}(\mathrm{cent})}$$

PAS CMS-HIN-12-014



- Hint of less suppression at lower p_T

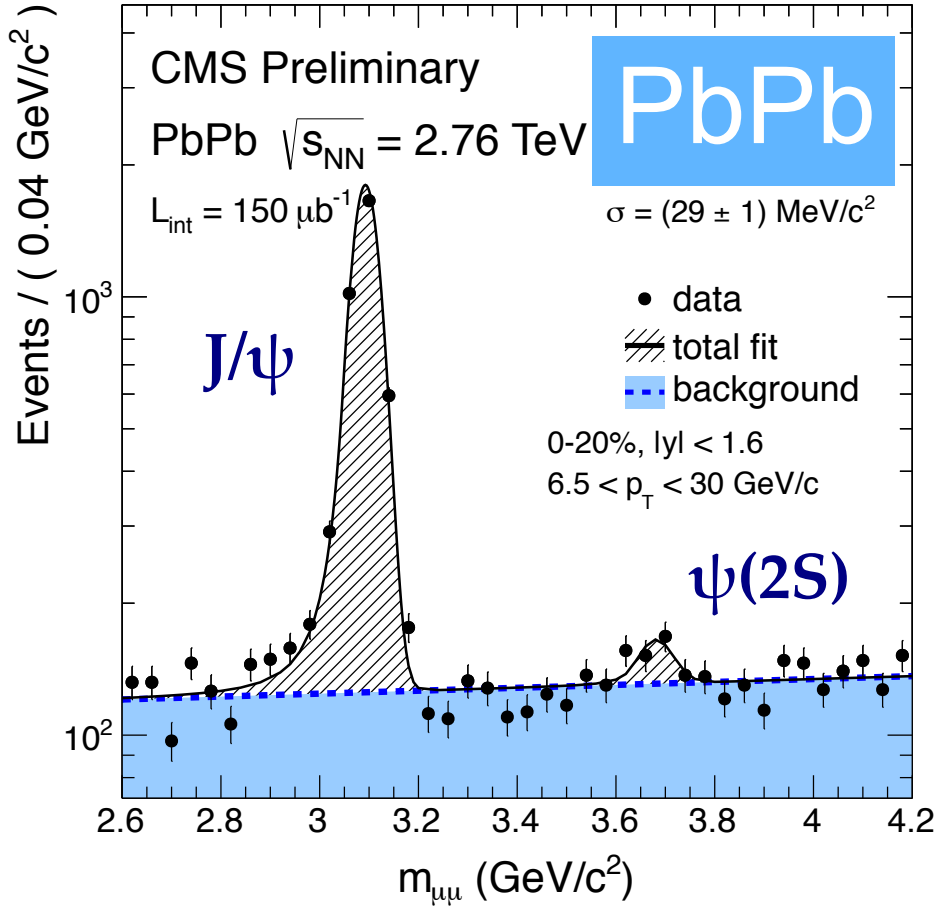
p_T dependence

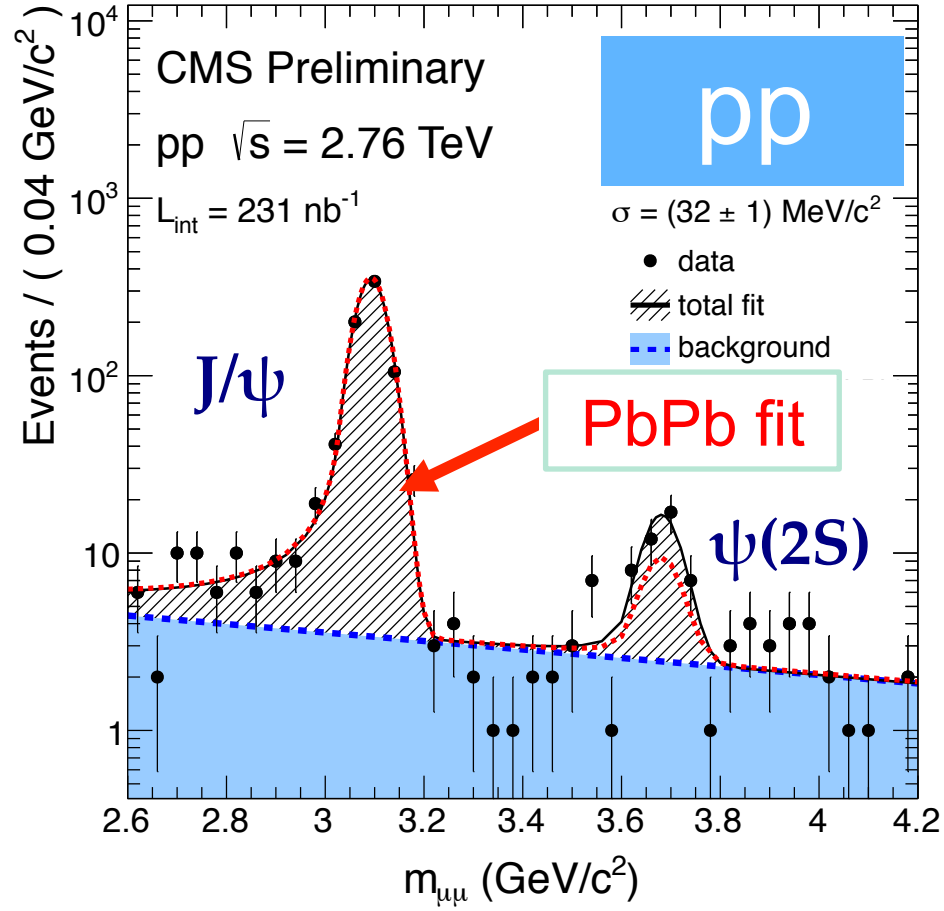


2011 ψ(2S) results

ψ(2S) PbPb and pp

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



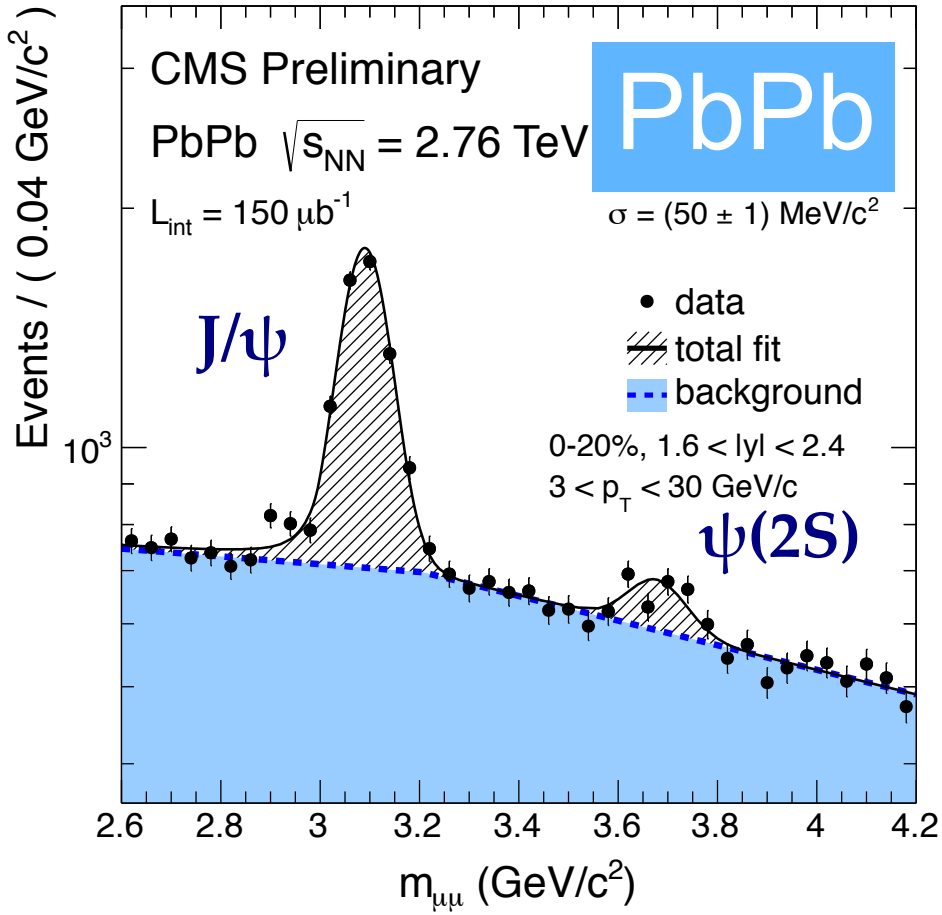


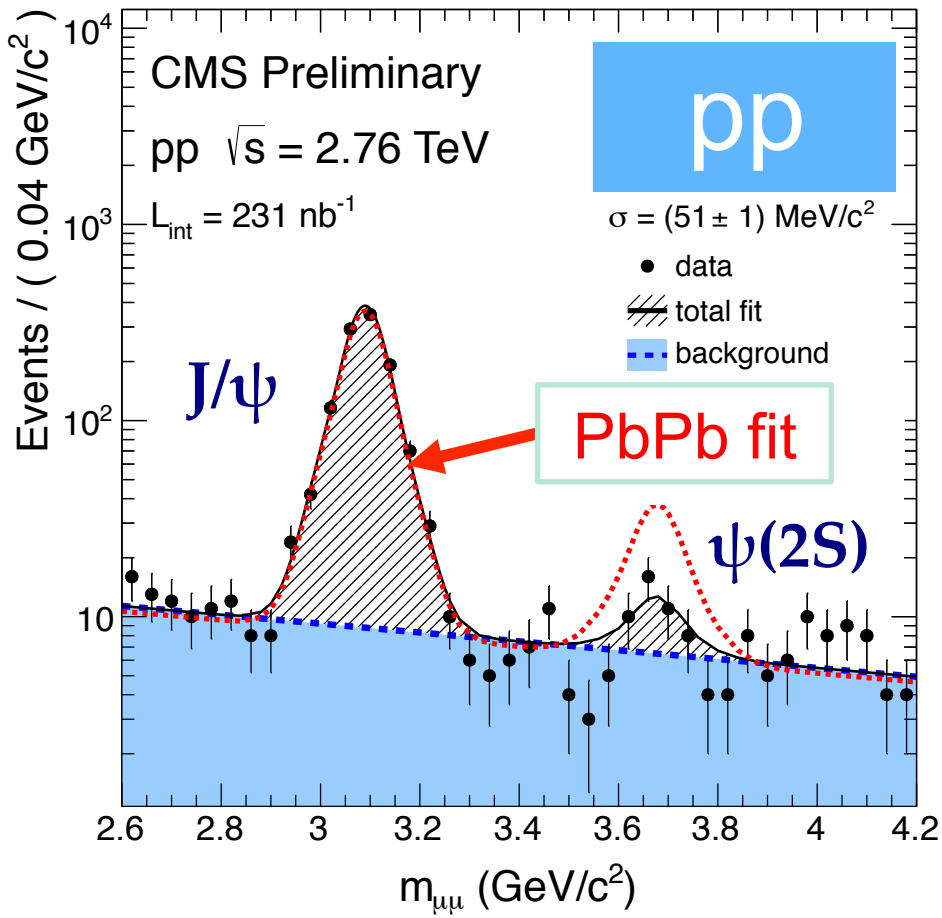
Raw yields ratio (**ψ(2S) / J/ψ**) in PbPb is ~2 times smaller than pp.

PAS CMS-HIN-12-007

ψ(2S) PbPb and pp

$1.6 < |y| < 2.4$ and $3 < p_T < 30$ GeV/c





Raw ratio (**ψ(2S) / J/ψ**) in PbPb is ~5 times larger than pp.

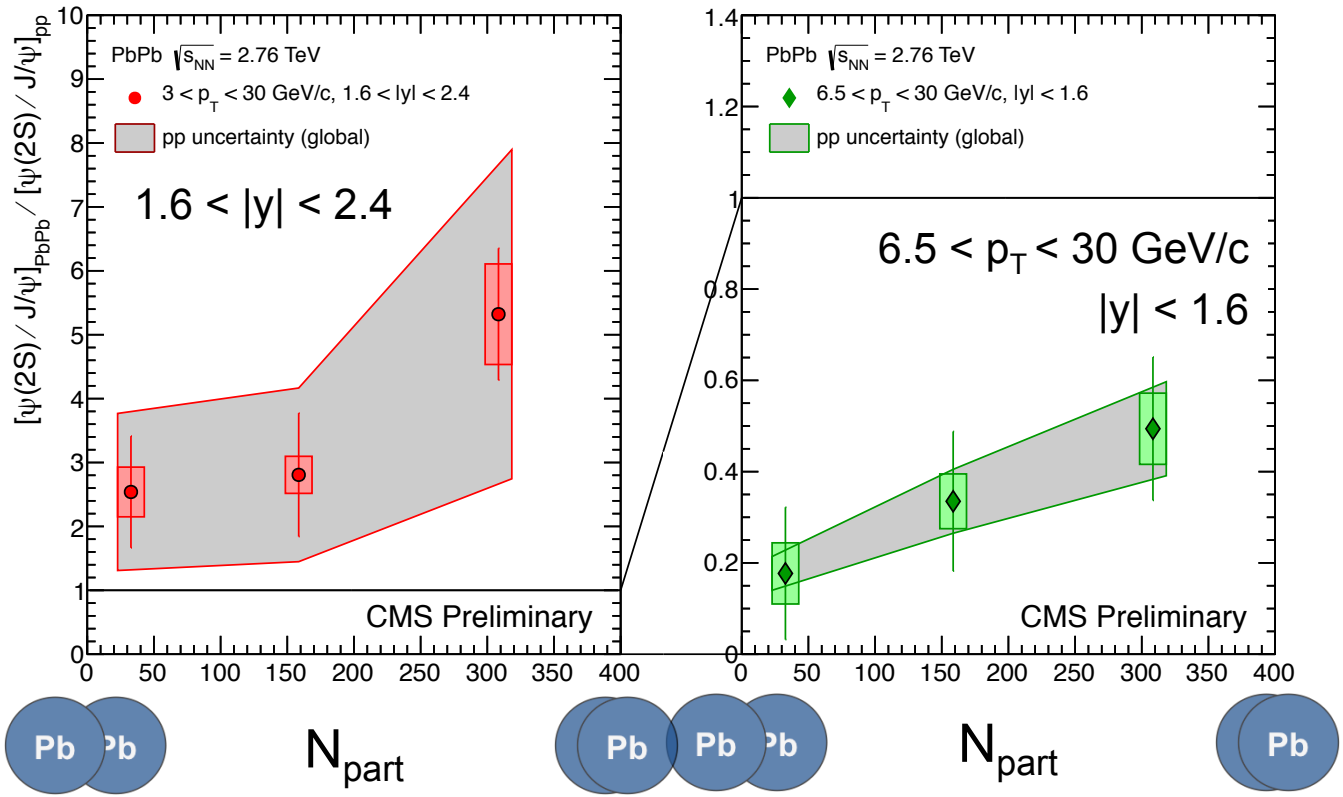
PAS CMS-HIN-12-007

Double ratio of ψ(2S) & J/ψ

$3 < p_T < 30$ GeV/c

$$\frac{R^{\mathrm{PbPb}}_{\psi(2S)}}{R^{\mathrm{pp}}_{\psi(2S)}} = \left[\frac{N_{\psi(2S)}}{N_{J/\psi}}\right]_{\mathrm{PbPb}} \Bigg/ \left[\frac{N_{\psi(2S)}}{N_{J/\psi}}\right]_{\mathrm{pp}}$$

PAS CMS-HIN-12-007



For $p_T > 6.5$ GeV/c, ψ(2S) are more suppressed than J/ψ.
Indication that ψ(2S) less suppressed than J/ψ for $p_T > 3$ GeV/c.
(not more than 2σ significance, limited by pp statistics)

Summary

- Prompt J/ψ
  - R_{AA} measured in finer bins than 2010 results
  - Significant suppression observed
  - No strong dependence on p_T and rapidity

- ψ(2S)
  - More suppressed than J/ψ at high p_T and mid-rapidity
  - Less suppressed than J/ψ at lower p_T and forward rapidity (but not more than 2σ significance)

https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsHIN

Back up