Quarkonia with CMS

*[session: **Quark-Gluon Plasma** II]*

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ERC grant "QuarkGluonPlasmaCMS"

Quarkonia with CMS

[Quark-Gluon Plasma]

Introduction to QGP *et al.*

How do quarkonia behave under the QGP assumption?

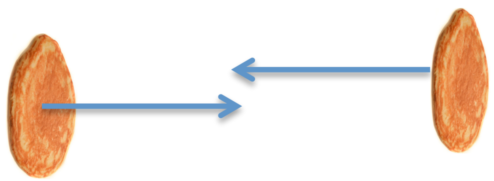
Quick overview of the detector

↓

Observations from PbPb collisions
Charmonia [J/ψ, ψ(2S)]
Bottomonia [Υ(1S,2S,3S)]

Quark-Gluon Plasma

the lead-pancake collision



Before colliding: Lorentz-contracted ultra-relativistic Pb nuclei

The LHC performed PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV

Early stage of the collision: open the QGP 'can of worms'

Large amount of initial hard collisions at $\sqrt{s_{NN}}$ = 2.76 TeV

Deconfinement of quarks and gluons

Production of heavy flavours ($c,\bar{c},b,\bar{b}$) is NOW

Medium temperature = ?

QGP expansion and freeze-out

(QCD aspects addressed in previous introductory talks)

Quarkonia as Probes of the QGP

Quarkonium 'ordinary life':

- Formation of a heavy quark-antiquark pair
- Fall into a given state in the spectroscopy
- Possible decay to lesser excited state (called "feed-down")
- Decay in lighter elements > final state.

Covered in HF's Friday morning session

In medium production: additional complexities (think of QGP degrees of freedom...)

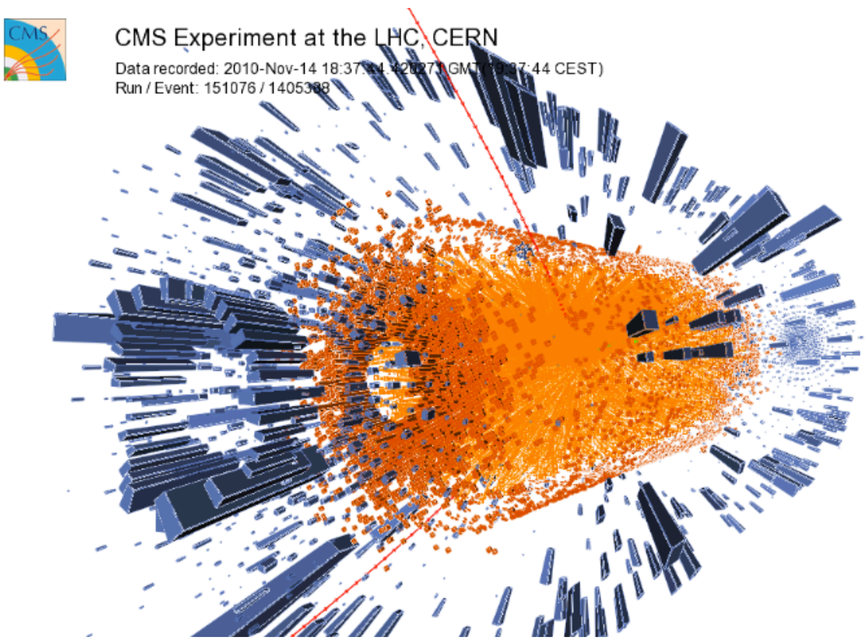
- Colour charge screening: "melting" of pairs
- Binding energy: is melting sequential?
- is statistical regeneration possible?

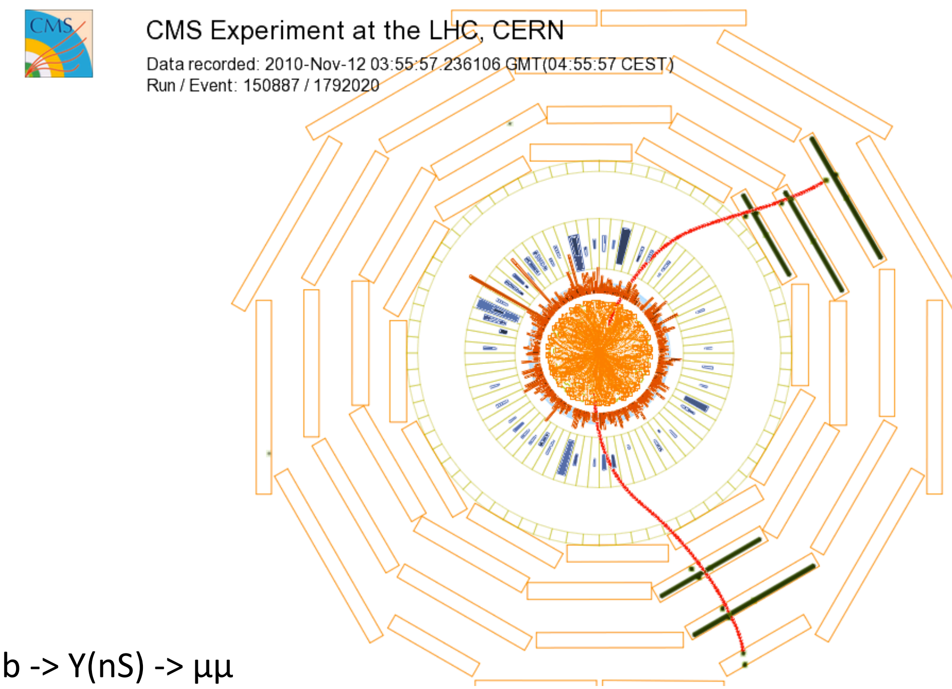
Compare yields in PbPb and pp
(*nuclear modification factor*) →

$$R_{AA} = \frac{1}{< N_{coll} >} \frac{Y_{AA}}{Y_{pp}}$$

The CMS detector
our perception of things

Di-muon reconstruction:
"Global" muons (i.e. high quality hits in the muon stations matched to tracks)
Resolution in p_T goes down to 1~2 % up to 100 GeV/c
Large acceptance coverage: allow different interesting measurements.





PbPb -> Υ(nS) -> μμ
event displays

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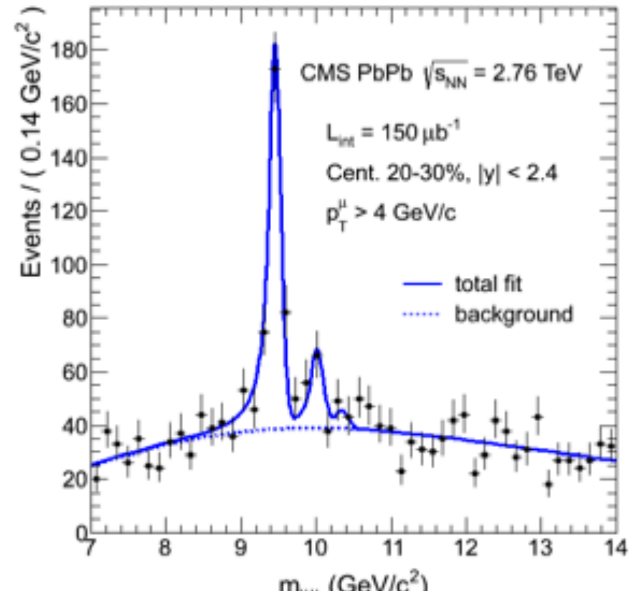
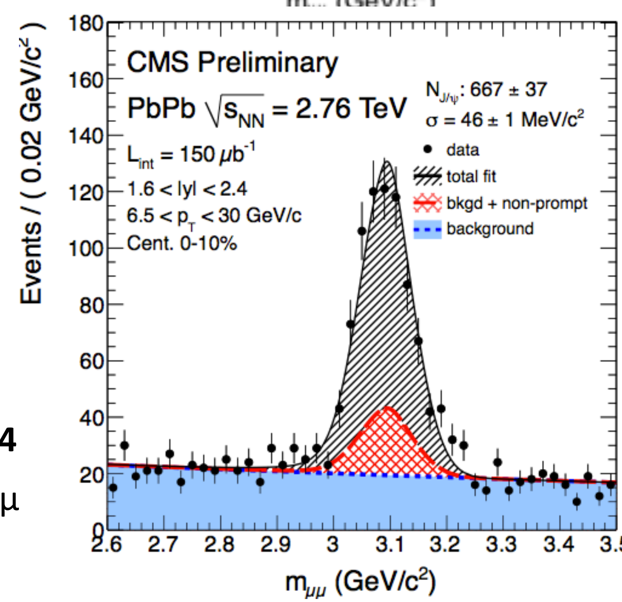
Υ(1S,2S,3S) -> μμ



Separation of μμ states

- CMS measures modification of 3 Υ(nS) states

→ Possibility for Υ's R_{AA}



Displaced tracks and secondary vertices

- non-prompt J/ψ suppression in HI was measured

→ access b-quark energy loss
Secondary vertices in HI (!)

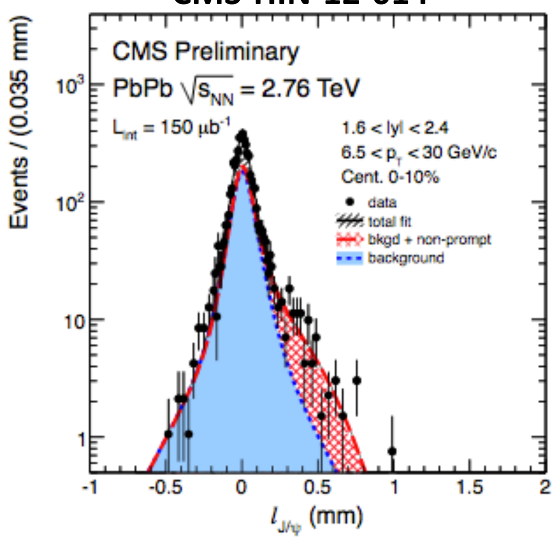
CMS-HIN-12-014

J/Ψ -> μμ

PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV

non-prompt J/ψ : b-quark energy loss

CMS-HIN-12-014



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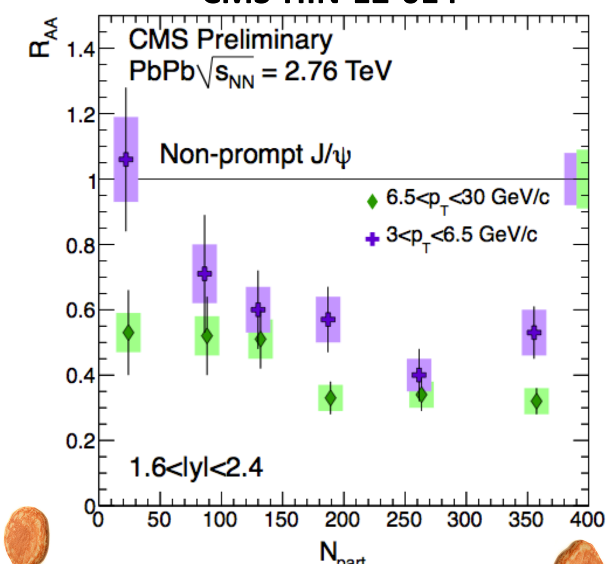

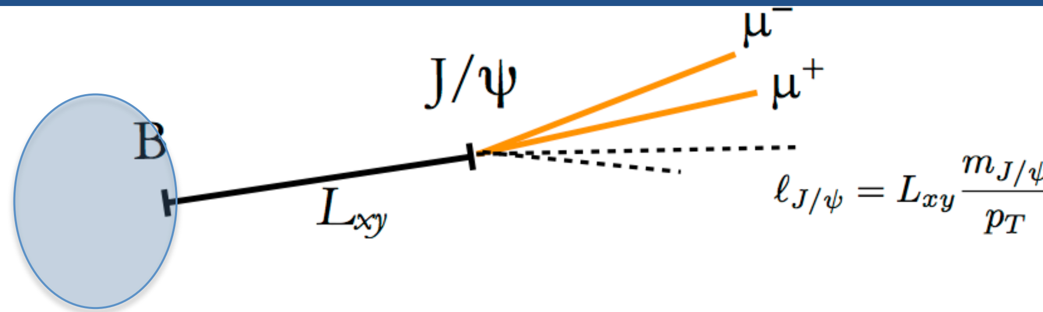

Pseudo-proper decay length of dimuon distribution:
non-prompt in the tail

Centrality dependent suppression of non-prompt J/Ψ

At forward y, CMS can measure down to pT > 3 GeV/C
slightly less suppression is observed

b quark energy loss in the medium.
Non-prompt J/Psi are modified.
What about prompt charmonia?

PbPb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV

A look at prompt J/ψ: suppression !

Two outstanding facts:

- strong centrality-dependent suppression of J/ψ,

- At low-pT (forward region in CMS, 3 GeV/c threshold)
  less suppression from ALICE (stats down to pT = 0)
  possible interplay of suppression and regeneration

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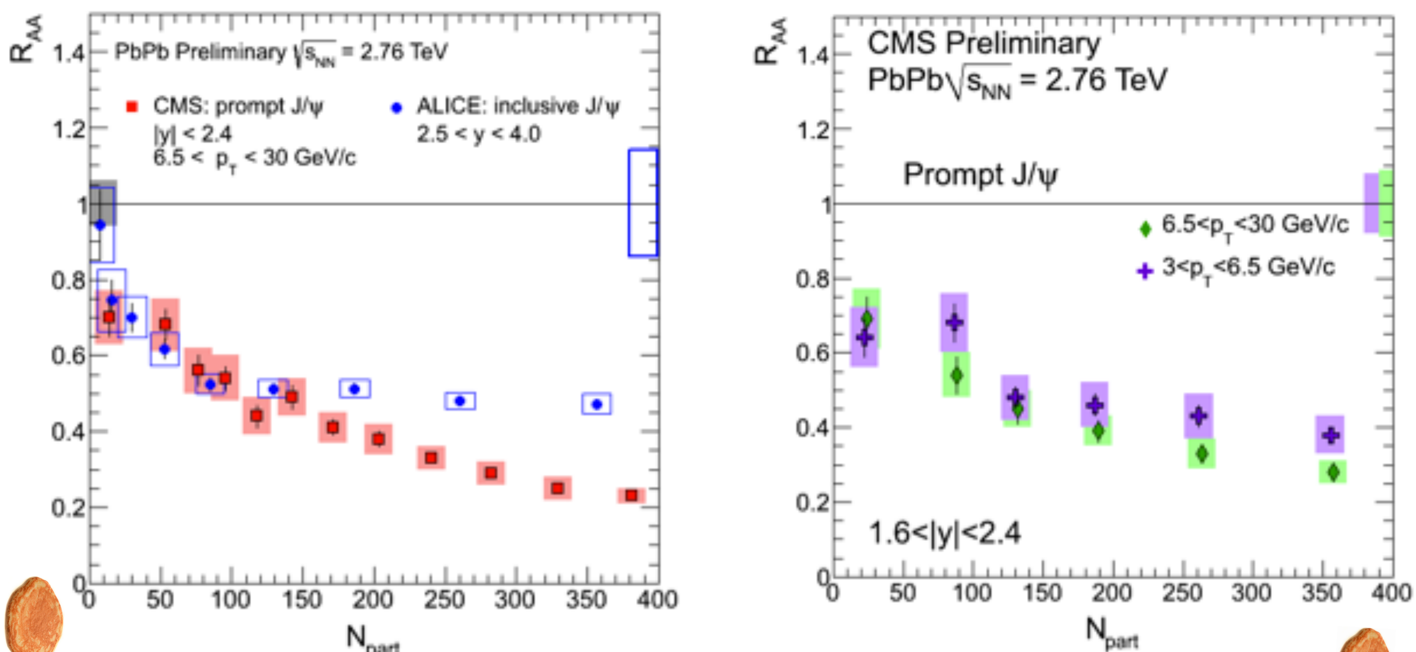

Υ(nS) suppression in *PbPb* collisions at $\sqrt{s_{NN}}$ = 2.76 TeV

Mission : Measure $R_{AA}^{\Upsilon(1S)}$,$R_{AA}^{\Upsilon(2S)}$, $R_{AA}^{\Upsilon(3S)}$

$R_{AA}^{\Upsilon(3S)} < R_{AA}^{\Upsilon(2S)} < R_{AA}^{\Upsilon(1S)}$: sequential suppression expected for looser (excited) bound states

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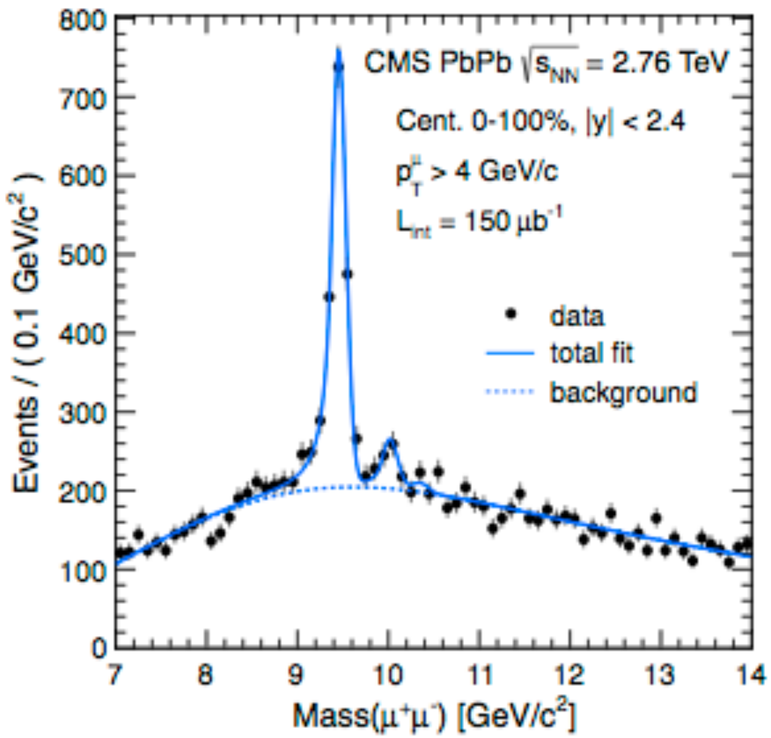

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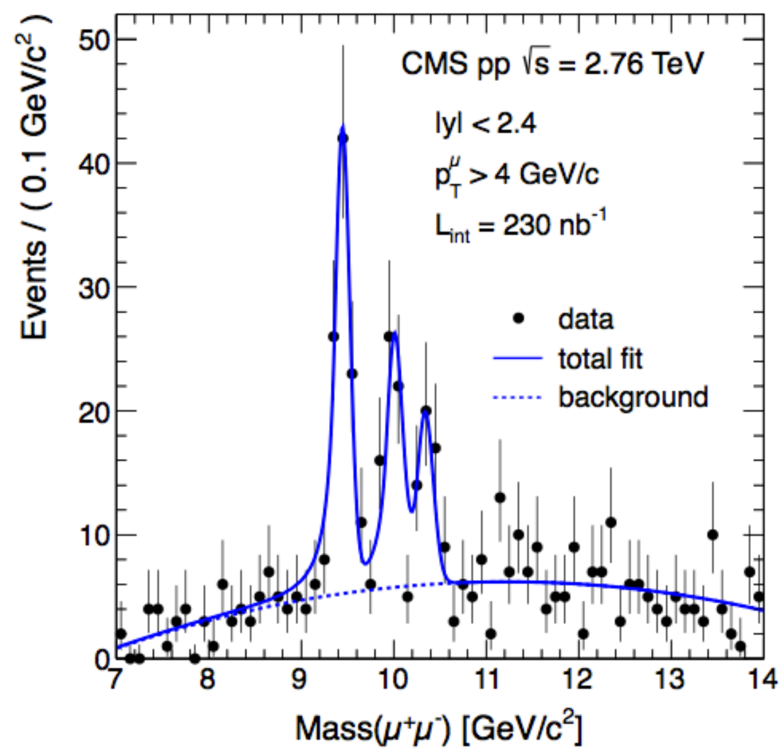

(!) Bottomonia have a complex spectroscopy. (Υ(nS), $\chi_{b,n}$)
Feed-down fractions (e.g. from 1P to 1S states) aren't well known
→ too early for a conclusion on direct Υ(1S) yield...

Υ(nS) suppression in *PbPb* collisions at $\sqrt{s_{NN}}$ = 2.76 TeV

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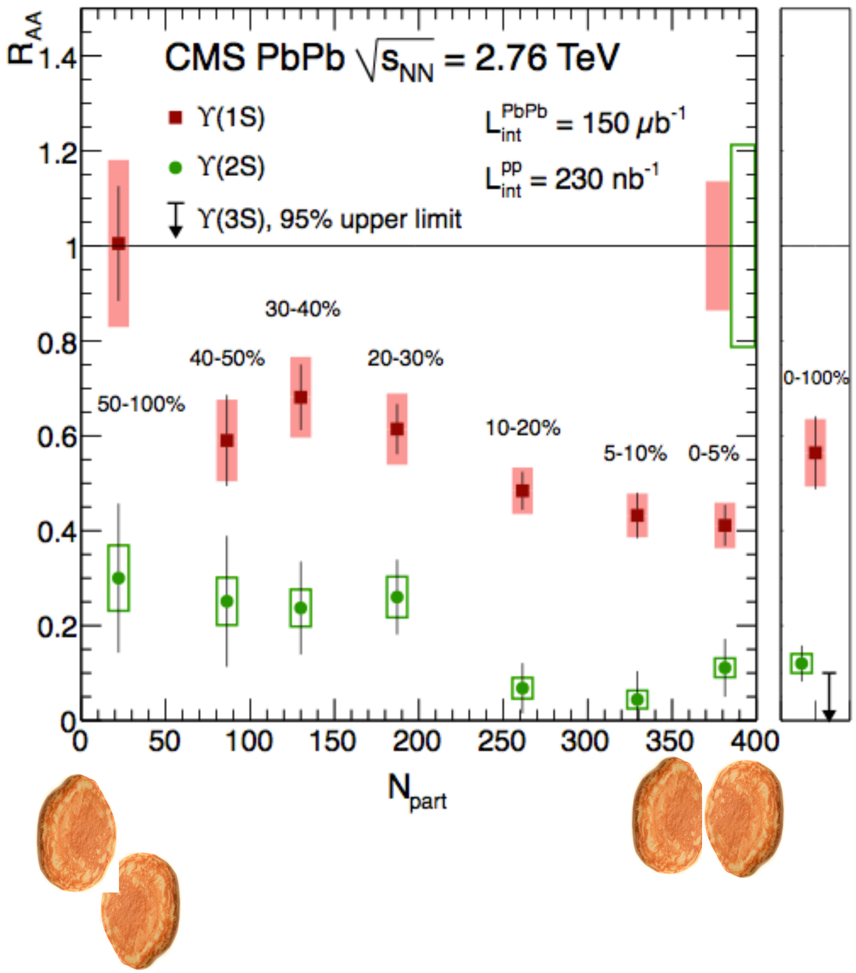


ϒ(1S): clear modification

ϒ(2S): strong suppression

ϒ(3S), we can

(make an minimum bias R_{AA} upper limit)

$$R_{AA}(\Upsilon(1S)) = 0.56 \pm 0.08(\text{stat}) \pm 0.07(\text{syst}),$$
$$R_{AA}(\Upsilon(2S)) = 0.12 \pm 0.04(\text{stat}) \pm 0.02(\text{syst}),$$
$$R_{AA}(\Upsilon(3S)) = 0.03 \pm 0.04(\text{stat}) \pm 0.01(\text{syst})$$
$$< 0.10(95\%\text{CL}).$$

Thank you

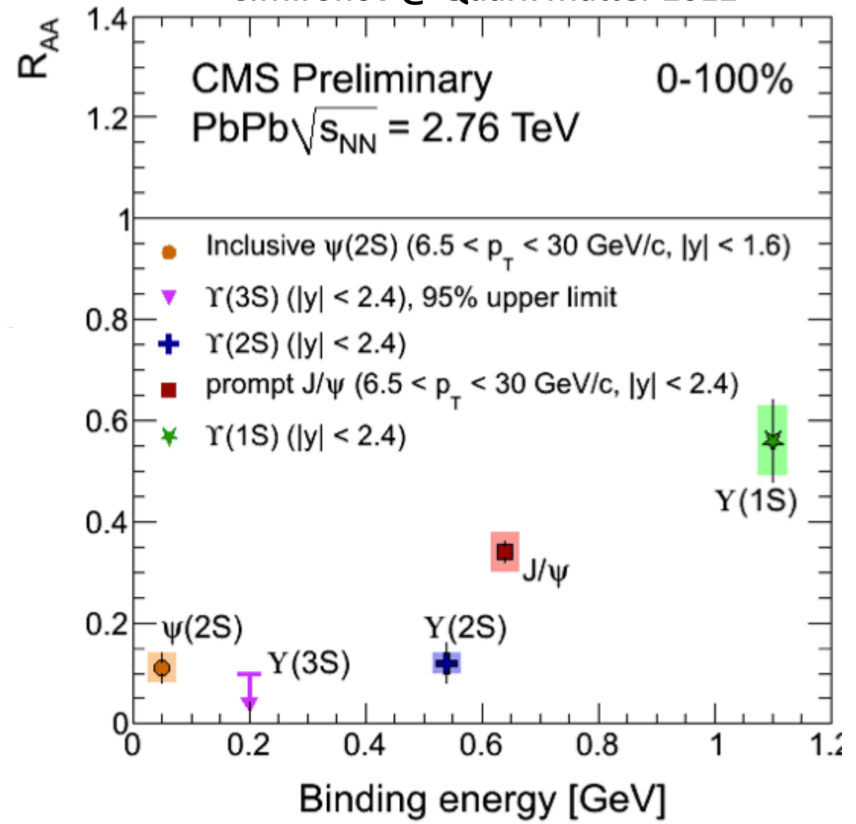
Summary:

- Suppression of heavy quarkonium states happens sequentially when using the ratio PbPb/pp to quantify effects (R_{AA}< 1)
- J/Ψ, Ψ(2S) measured (Preliminary) at high transverse momenta fall into the same picture

The road goes on:

- A new set of pp data (2.76 TeV, 5.3/pb) has been recorded in February, 2013
- Hot topic: pPb data from Jan./Feb. 2013. Great expectations on the 'cold' nuclear matter side

CMS-HIN-12-014
C.Mironov @ Quark Matter 2012



Thank you for listening
Merci de votre attention