Observation of sequential Υ suppression in PbPb collisions

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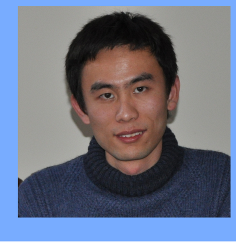
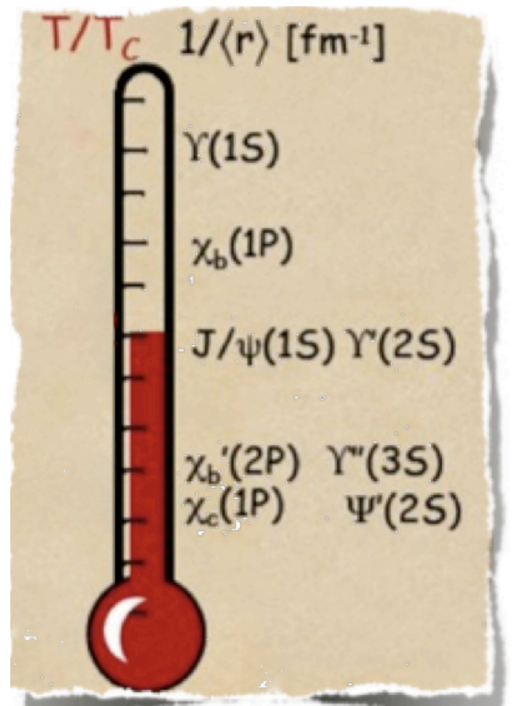


Introduction



EPJC 61:705-710,2009

In our universe today, quarks are always bound by gluons to form the "composite" particles. The Quark-Gluon Plasma (QGP) is a hot, dense state where the quarks and gluons move freely and unbound. This is thought to be the situation a few millionths of a second after the Big Bang.

A smoking gun signature of the QGP is that its high temperature causes the sequential melting of quarkonia, which manifests itself as the suppression excited Υ states in heavy-ion collisions, compared to the number of quarkonia produced in pp collisions.

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

→ decreasing binding energy

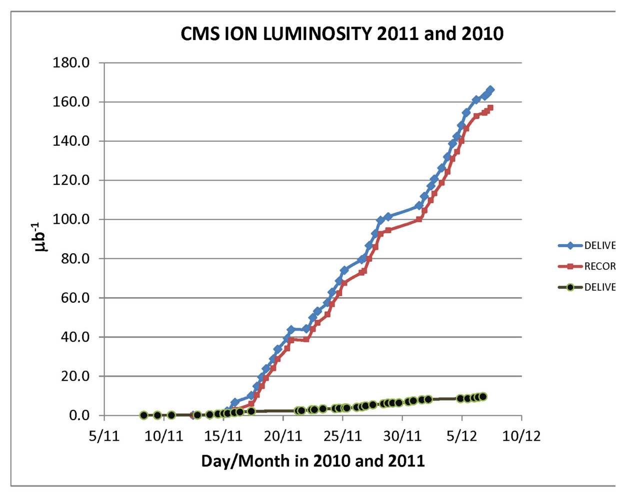
J.Phys.G32:R25,2006

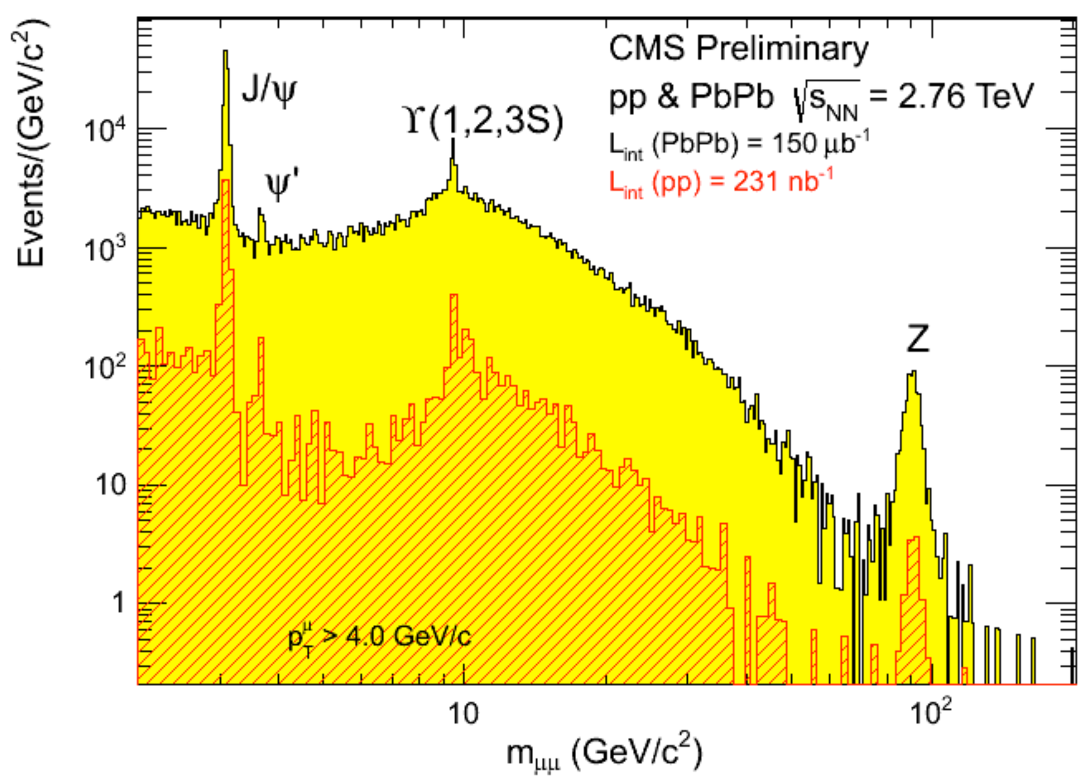
C. Mironov, QM2012

Quarkonia in CMS

PbPb run 2011 @ $\sqrt{s_{NN}}$ = 2.76 TeV (L_{int} = 7.28 μb⁻¹)

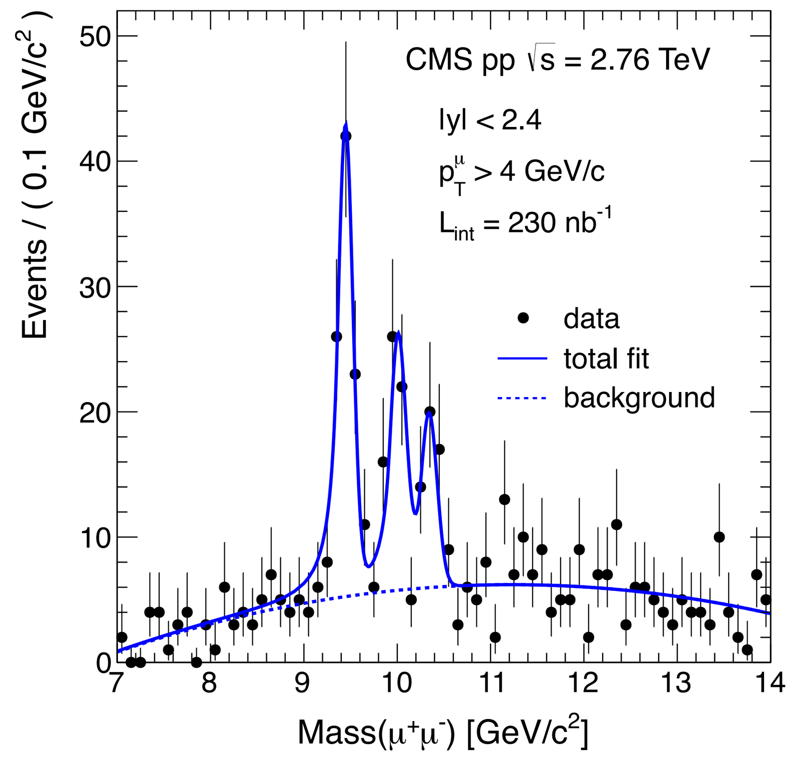
pp run 2011 @ $\sqrt{s}$ = 2.76 TeV (L_{int} = 230 nb⁻¹)

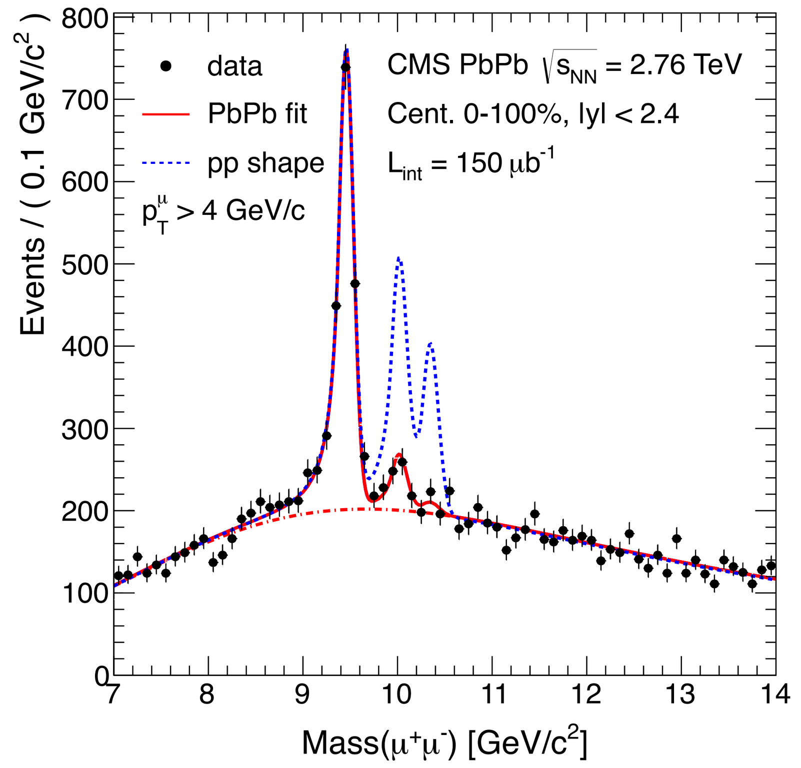




Suppression of Excited Υ States

- Measure the fraction of excited states Υ(2S+3S) relative to Υ(1S)
- Fraction extracted directly from the simultaneous fit to the PbPb and pp data sample (both at 2.76 TeV)





Extended unbinned maximum likelihood fit

Signal

- Core Gaussian with power law tail for final state radiation
- Float Resolution and FSR (fixed in 2010 data analysis)
- Peak separation fixed to PDG

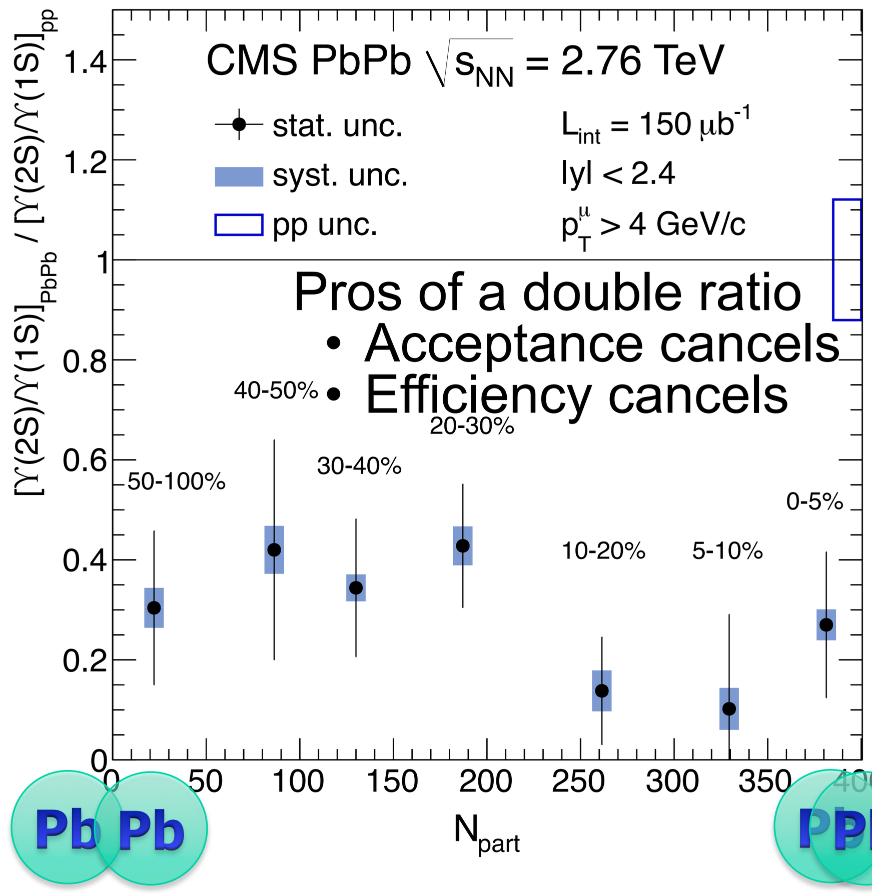
Background

- Second order polynomial for pp sample
- Error function * exponential for PbPb sample

$$\frac{\Upsilon(2S)/\Upsilon(1S)|_{PbPb}}{\Upsilon(2S)/\Upsilon(1S)|_{pp}} = 0.21 \pm 0.07(stat) \pm 0.02(syst)$$

$$\frac{\Upsilon(3S)/\Upsilon(1S)|_{PbPb}}{\Upsilon(3S)/\Upsilon(1S)|_{pp}} < 0.17 \quad (95\% \text{ confidence level})$$

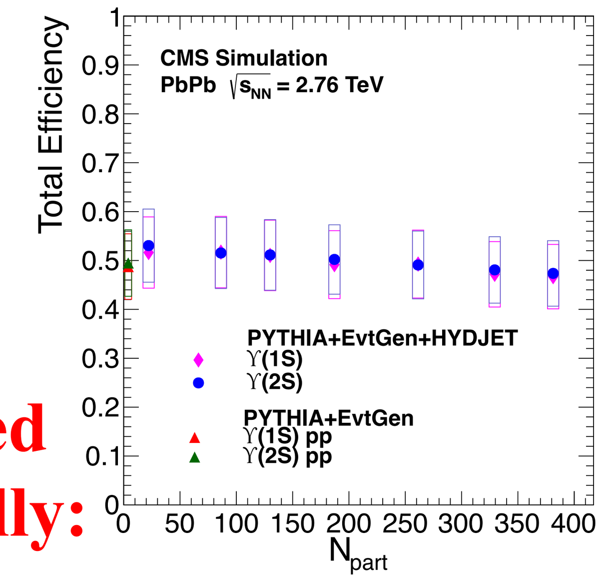
The Υ(2S+3S) resonances are suppressed with respect to the Υ(1S) state, with a significance exceeding 5 σ.

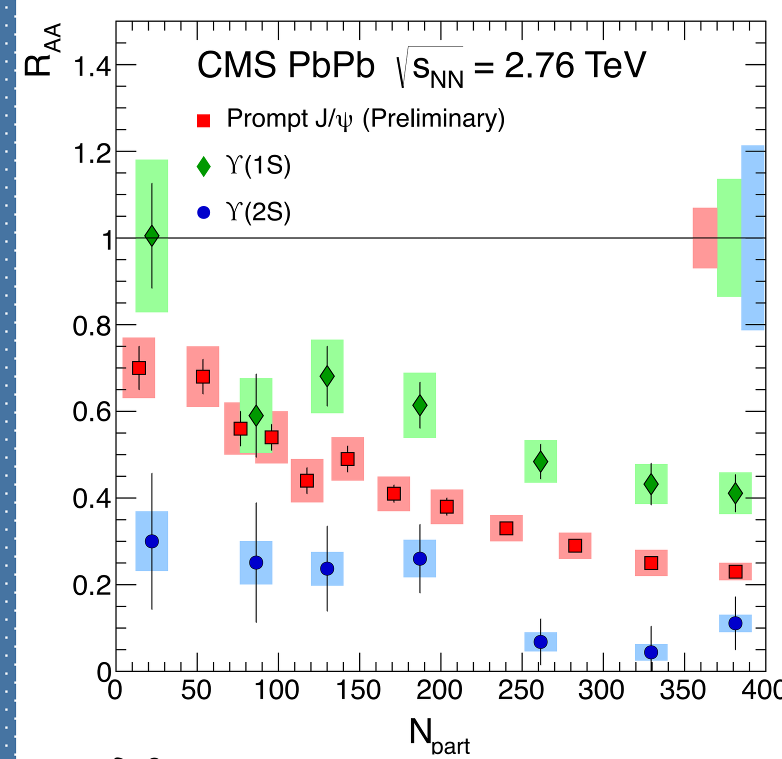


In absence (by cancellation) of cold nuclear matter effects, Υ(1S) and Υ(2S) show no obvious centrality dependence, within uncertainties, of the remaining hot nuclear matter induced effects

Nuclear Modification Factor

$$R_{AA} = \frac{\mathcal{L}_{pp}}{T_{AA} N_{MB}} \frac{\Upsilon(nS)|_{PbPb}}{\Upsilon(nS)|_{pp}} \frac{\varepsilon_{pp}}{\varepsilon_{PbPb}}$$





Suppressed sequentially:

$R_{AA}^{\Upsilon(1S)} = 0.56 \pm 0.08(stat) \pm 0.07(syst)$

$R_{AA}^{\Upsilon(2S)} = 0.12 \pm 0.04(stat) \pm 0.02(syst)$

$R_{AA}^{\Upsilon(3S)} = 0.03 \pm 0.04(stat) \pm 0.01(syst)$

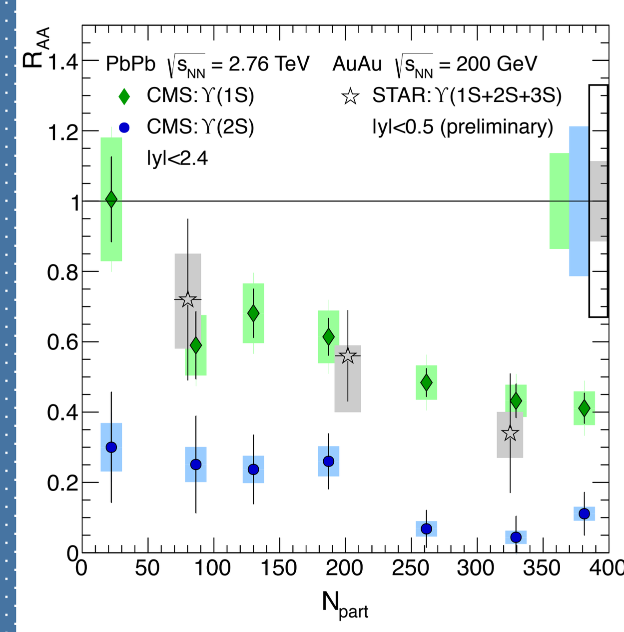
< 0.10 (95% C.L.)

Υ(2S) more suppressed than Υ(1S)

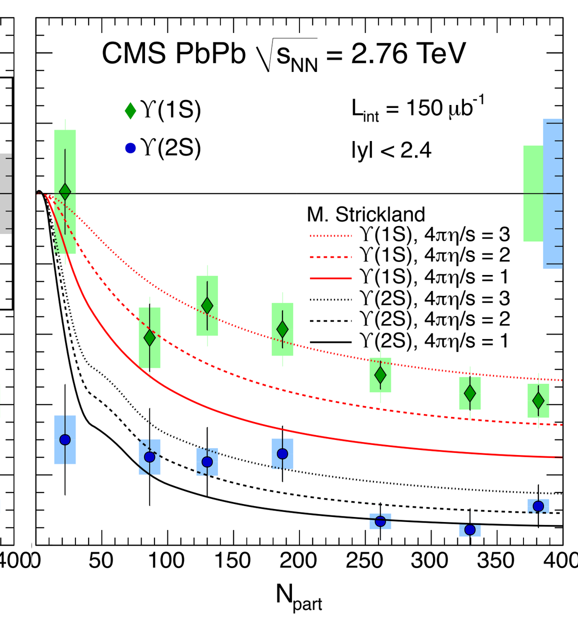
- Υ(1S): 0.41±0.05±0.04 (0-5%)→ 1.01±0.18±0.12 (50-100%)
- Υ(2S): 0.11±0.02±0.06 (0-5%)→ 0.30±0.07±0.16 (50-100%)

Systematic

- Fitting model: Υ(1S) (4-9%), Υ(2S) (10-40%) and Υ(3S) 14%
- T_{AA}: 4-15% from central to peripheral collisions
- L_{pp} : 6%
- MC efficiency ratio: < 7%
- Data and MC simulations: 3%



arXiv:1109.3891



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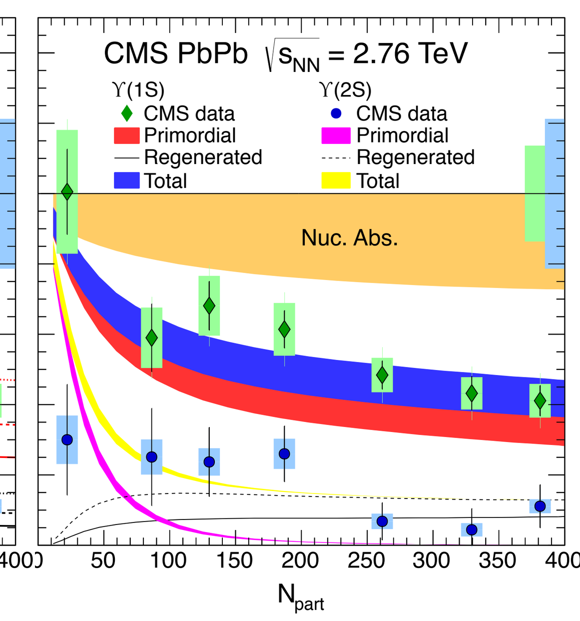

arXiv:1111.6537

References

[1] "Indications of Suppression of Excited Υ States in Pb-Pb Collisions at $\sqrt{s_{NN}}$ = 2.76 TeV", PRL **107**, 052302(2011)

[2] "Observation of sequential Upsilon suppression in PbPb collisions", https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsHIN11011, arXiv:1208.2826, submitted to PRL