

Quarkonia chapter

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- Do we understand the **different ingredients for quarkonium suppression**?
 - contribution from feed-down
 - cold nuclear matter effects
 - low p_T : transport vs statistical models
 - high p_T : energy loss, importance of gluon fragmentation
- **Ground vs excited states** in pp, pPb, PbPb?
- What is the **impact of multiplicity**? Does polarisation depend on multiplicity?
- What is the R_{AA} in **very peripheral PbPb**? Importance of **EM production**?
- Pursue the study of the **flow of heavy quarks** (c, b). Is it implying their complete thermalisation?



- Do we understand the different ingredients for quarkonium suppression?
 - contribution from feed-down \rightarrow pp (not WG5)
 - cold nuclear matter effects \rightarrow pPb
 - low p_T : transport vs statistical models \rightarrow PbPb
 - high p_T : energy loss, importance of gluon fragmentation \rightarrow PbPb
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Proposing to structure the chapter by flavour

- ① Introduction
- ② Charmonia
 - R_{AA}
 - v_2
 - excited states
- ③ Bottomonia
 - R_{AA}
 - v_2
 - excited states

NB: need to synchronise pPb with small systems and nPDF/small-x chapters.

Experiment

- $J/\psi + \psi(2S)$ yields and R_{AA} from CMS (projection) and ALICE (ee, $\mu\mu$)
- $R_{AA}(\psi(2S))/R_{AA}(J/\psi)$ vs centrality, from ALICE (ee, $\mu\mu$)
- $J/\psi v_2$ vs p_T , from ALICE (ee, $\mu\mu$; pPb and PbPb)

plus published results also from all 4 LHC experiments, cf also [overview slides](#) at the first HL-LHC workshop

Missing: maximum p_T reachable by ATLAS and CMS

Theory

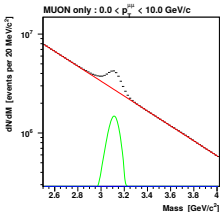
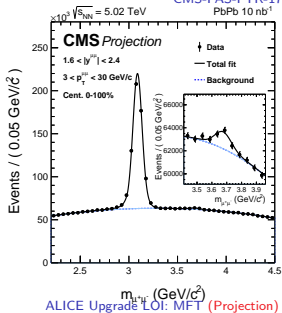
Wishlist:

- J/ψ , $\psi(2S)$ in-medium spectral function (Lattice QCD)
- J/ψ and $\psi(2S)$ R_{AA} vs p_T , y , centrality (transport + statistical models – R. Rapp, A. Andronic)
- J/ψ and $\psi(2S)$ v_2 vs y and p_T , several centrality classes (transport + statistical models – R. Rapp)

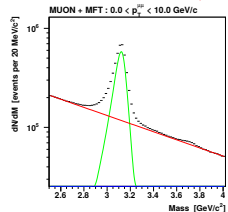


Charmonia: some existing projections

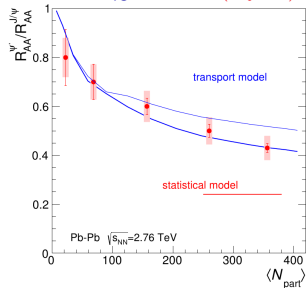
CMS-PAS-FTR-17-002



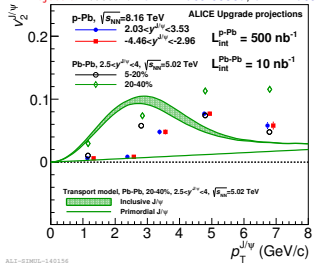
ALICE Upgrade LOI: MFT (Projections)



ALICE Upgrade LOI: MFT (Projection)



Projection based on arXiv:1709.06807, arXiv:1709.05260



ALICE-CHARM-140138



Experiment

- $R_{AA}(\Upsilon(nS))$ vs centrality, from CMS (projection)
- (coming soon) $R_{AA}(\Upsilon(nS))$ vs centrality, from LHCb (full simulation)
- (coming soon) $R_{AA}(\Upsilon(nS))$ vs y , from ALICE (full simulation)

plus published results also from ATLAS, ALICE and CMS, cf also [overview slides](#) at the first HL-LHC workshop

Missing: maximum p_T reachable by ATLAS and CMS

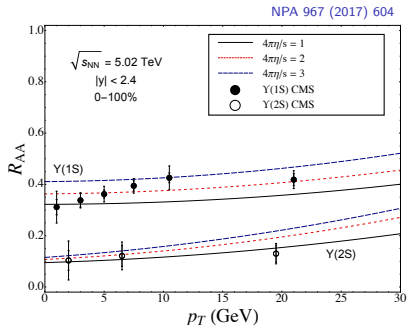
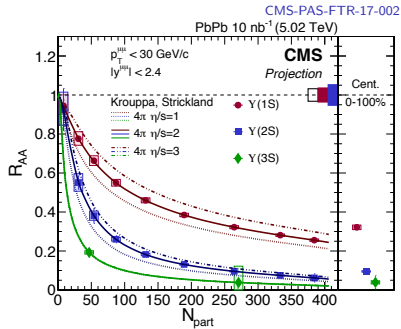
Theory

Wishlist:

- $\Upsilon(nS)$ in-medium spectral functions (Lattice QCD)
- $\Upsilon(nS)$ R_{AA} vs p_T , y , centrality (transport or hydro – R. Rapp, M. Strickland)
- $\Upsilon(nS)$ v_2 vs y and p_T , several centrality classes (transport or hydro – R. Rapp, M. Strickland)

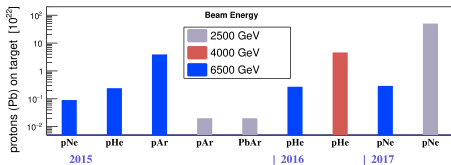
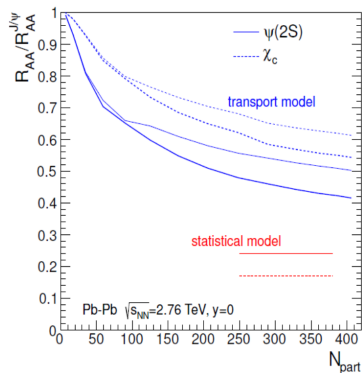


Bottomonia: some existing studies



Possible additional studies

- “Exotic” quarkonium states
 - χ_c : available predictions from transport + statistical models
 - $X(3872)$, B_c ?
- Maximum p_T reach on J/ψ and $\Upsilon(1S)$ from ATLAS and CMS
- Possibility to combine $B \rightarrow J/\psi$ and Υ results to constrain beauty in PbPb
- Fixed target physics with SMOG in LHCb: pAr, pHe, pNe



- Organisation and contents of the chapter:
 - focus on PbPb
 - J/ψ : R_{AA} at low and high p_T , precision v_2 in pPb and PbPb
 - $\Upsilon(nS)$: R_{AA} , v_2 ?
 - large gain for ψ and Υ : limited precision in Run 1+2
 - experiment-combined figures? (eg y dependence for $\Upsilon(nS)$)
- Theorists contacted: R. Rapp (transport model), M. Strickland (hydro), I. Vitev (transport), R. Venugopalan (CGC)
 - Need to agree on a $c\bar{c}$ and $b\bar{b}$ uncertainty (with uncertainty)
 - PbPb projections: 5.02 TeV?

Next meeting planned on April 9, and at Quark Matter

