

HONEX-COMB kick-off: Quarkonium measurements

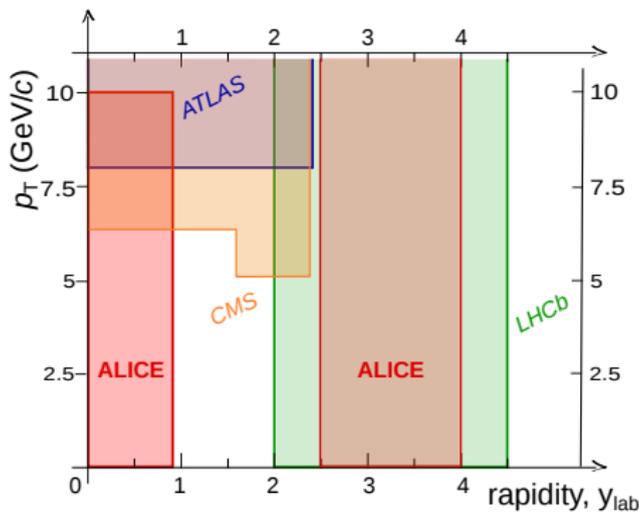
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Introduction



example acceptance for J/ψ in pPb Run1. for Υ all measure down to 9 , upper bound luminosity dependent.

- ▶ Quarkonium measurements at the LHC:
one of the few physics areas with a large number and a large variety of important contributions from all four collaborations
- ▶ thanks to:
vector states in dilepton decays: simple signatures
the complementary acceptance & instrumentation
a variety of cross section and Branching sizes: $O(10 \mu\text{barn})$ ($J\psi$)
used in: flavour physics (calibration), tests of perturbative QCD, nuclear modifications in pA, QGP physics
- ▶ combinations interesting in overlapping acceptance or for full phase space integration

Multi-experiment measurements in quarkonium

Primary scope:

- ▶ combine results in same acceptance: consistency checks and reduced combined uncertainty
- ▶ combine results between different acceptances: provide integrated results or dependencies over larger kinematic lever arm in homogeneous way
- ▶ combine results for derived quantities: total beauty cross section (from J/ψ from B), feed-down fractions

Secondary scope:

- ▶ resolve discrepancies
- ▶ harmonized methodology & interpretation exploiting not only experiment, but full community inputs
- ▶ promote common output platforms (HEP-DATA, RIVET)
- ▶ progress in uncertainty treatment
- ▶ forum for priorities for future measurements

→ partially, work fully within this group; partially, the experiment to be "mobilized" a lot

→ do not underestimate the latencies, inertia, requires permanent wake-up calls

First primary goal: combination in same acceptance

Prerequisites

- ▶ define common acceptances in rapidity/pair pt: additional work for larger acceptance exp.
→ leaves only ground state measurements with sufficient statistics for pA and AA
- ▶ discuss possible exceptions: "first observations" combining different acceptances
→ at the moment, complicated
- ▶ ideally: start with fiducial cross sections with same daughter cuts
- ▶ ideally: combination as early as possible in analysis chain

2nd primary goal: combination between different acceptance

- ▶ requirement: results "matching"
- ▶ need to agree how much guidance or no guidance via phenomenology
- ▶ derived quantities like σ_{bb} from non-prompt jpsi could be an interesting target as well

Quarkonium: pp

Measurement of the $\eta_c(1S)$ production cross-section in proton-proton collisions via the decay $\eta_c(1S) \rightarrow p\bar{p}$

by LHCb and the theory rebound:

η_c production at the LHC challenges nonrelativistic-QCD factorization

Mathias Bauerhain, Zhu-Guo He, Bernd A. Knieff (University of, Inst. Theor. Phys. B)

Nov 20, 2014 - 5 pages

Phys.Rev.Lett. 114 (2015) no.9, 092004

(2015-03-04)

DOI: 10.1103/PhysRevLett.114.092004

arXiv:1411.2218

e-Print: [arXiv:1411.2218](https://arxiv.org/abs/1411.2218) [hep-ph] | PDF

η_c production at LHC and indications on the understanding of J/ψ production

Hao Han (Peking U. & Peking U. SOAIPP), Yan-Qing Ma (Dalian U. & Peking U., CERN), Guo-Ming Pei (Peking U. & Peking U. SOAIPP), Hai-Sheng Shao (CERN & Peking U. & Peking U.), Shi-Li Wang, Kuang-Ta Chou (National Sun Yat-Sen U., CERN & Peking U., SOAIPP)

Nov 10, 2014 - 5 pages

Phys.Rev.Lett. 114 (2015) no.9, 092005

(2015-03-06)

DOI: 10.1103/PhysRevLett.114.092005

arXiv:1411.1750

e-Print: [arXiv:1411.1750](https://arxiv.org/abs/1411.1750) [hep-ph] | PDF

Impact of η_c hadroproduction data on charmonium production and polarization within NRQCD framework

Hong-Pei Zhang (Tsinghua University, Institute of Physics, Tsinghua University), Chen-Sun Chen (Tsinghua University), Wen-Liang Song (Tsinghua University, Institute of Physics, Tsinghua University), Hong Li (Institute of Physics, Tsinghua University)

Dec 1, 2014 - 5 pages

Phys.Rev.Lett. 114 (2015) no.9, 092006

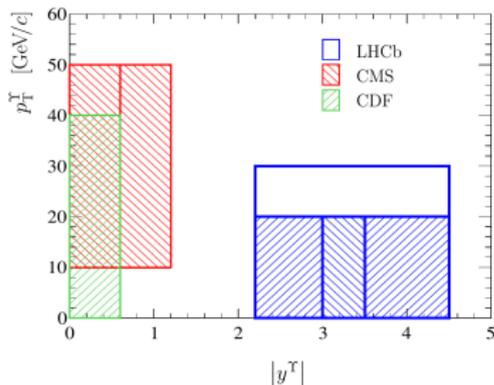
(2015-03-06)

DOI: 10.1103/PhysRevLett.114.092006

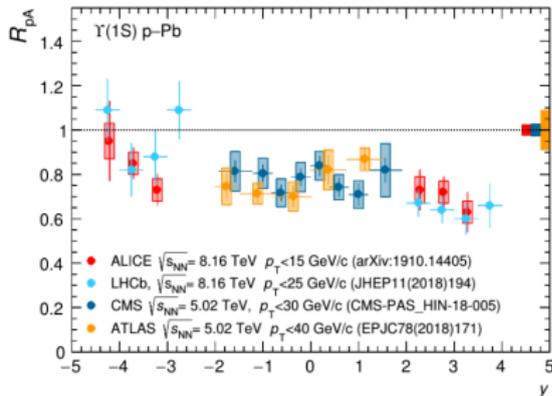
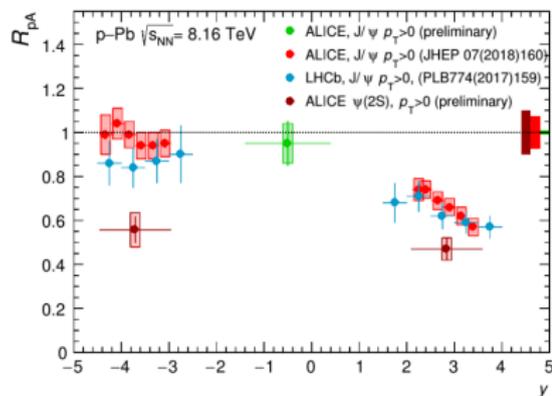
arXiv:1411.0500

e-Print: [arXiv:1411.0500](https://arxiv.org/abs/1411.0500) [hep-ph] | PDF

- ▶ Example highlights: η_c at hadron collider, cross section/polarisation for vector states, precision p-wave state measurements, exotica measurements
- ▶ measurements where all experiments have results: bread and butter J/ψ cross sections
→ in my view not first combination priority unless: reference for pA/AA AND/OR large discrepancies to be resolved, maybe total $b\bar{b}$ could be interesting
- ▶ multiplicity dependences: not yet ready due to lack of particle level correction

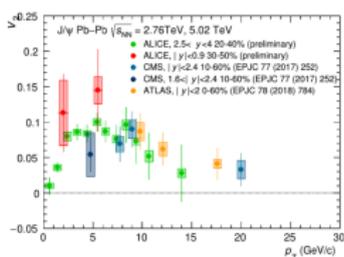
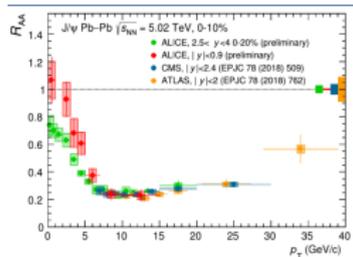
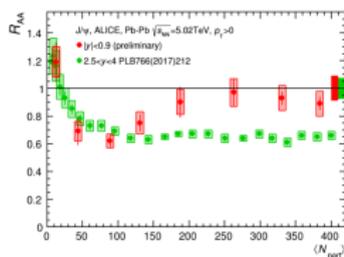


Quarkonium highlights: pPb



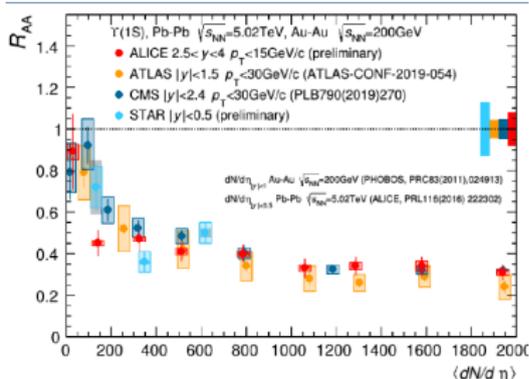
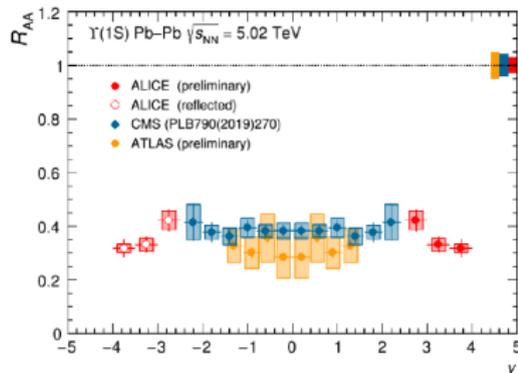
- ▶ precision ground vector state measurements
- ▶ excited state suppression measured by several experiments for different states
- ▶ ground state combination could be interesting to do in common acceptance as well in combination for full phase space (*of course* also as a function of p_T)
- ▶ non-prompt J/ψ could be used for total $b\bar{b}$ cross section estimate

Charmonium highlights: PbPb



- ▶ regeneration including v_2
- ▶ combination of J/ψ yields/RAA as function of p_T/y
 → gain precision for model testing via combination ?

Bottomonium highlights: PbPb



- ▶ suppression patterns pioneered by CMS, now by ATLAS/CMS/ALICE
- ▶ so far only for 1S good candidate for combinations due to difference in performance
- ▶ y-dependence could be fairly well constrained
- ▶ should do comparison/combination also on the level of yields, RAA

A few comments

- ▶ "old" results (Run 1) could be difficult to get a handle on
- ▶ could focus first on high statistics measurements: ground states references, pA, AA
- ▶ uncertainty treatment to be discussed: quite heterogeneous, mostly no correlation matrices available before clarification, combination may see difficulties
- ▶ Shall we have a forum like the "LHC forward physics/top/EWK" one in the LHC physics center and put the "HONEX-COMB" activity there?

Proposal

- ▶ identify Run 2 recent/ongoing measurements that could be combined
 - define common acceptance, precise input observable for ground states
 - propagate to analysers and convenors as soon as possible
- ▶ agree upon a strategy for uncertainty combination and homogenisation
- ▶ organisation-wise:
worthwhile to think whether a LHC Physics working group "heavy-ion physics" makes sense combining with inter-experiment activities [lpcc-link](#)
- ▶ combination between exclusive acceptances: could be rather fast, but model dependent;
total $b\bar{b}$ could be a nice target
- ▶ combination with overlap: will require more work and time

Combination candidates

cross section/yields:

- ▶ total charm/beauty yields in pp/pA potentially AA
- ▶ midrapidity prompt/non-prompt J/ψ in pp (5+13 TeV), pPb (8.16 TeV), PbPb (5 TeV) by ATLAS/CMS/ALICE
- ▶ midrapidity Upsilon measurements in pp and PbPb (5 TeV): ATLAS/CMS
- ▶ forward rapidity inclusive J/ψ ALICE/LHCb in pp and pPb: not sure how useful, since ALICE no prompt/nonprompt separation
- ▶ forward rapidity Upsilon measurement by ALICE/LHCb in pp (5, 13), pPb (8.16 TeV) and PbPb (5 TeV)
- ▶ Jpsi flow measurements in PbPb/pPb: CMS/ALICE where overlap (bin redefinitions), requires assessment of method choice
- ▶ rapidity combinations of the above
- ▶ Jpsi in jets: combination of different experiments in different y difficult even assuming jet-universality: different q/g -partitions

Multiplicity differential measurements requires unfolding on particle level in common acceptance between detectors

Polarisation measurements may also be of interest, at the moment low priority