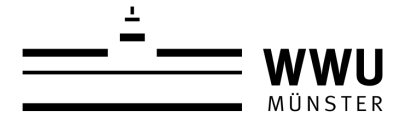


Multiplicity dependence of quarkonium production in pp collisions from ALICE

A. Andronic – University of Münster



on behalf of the ALICE Collaboration





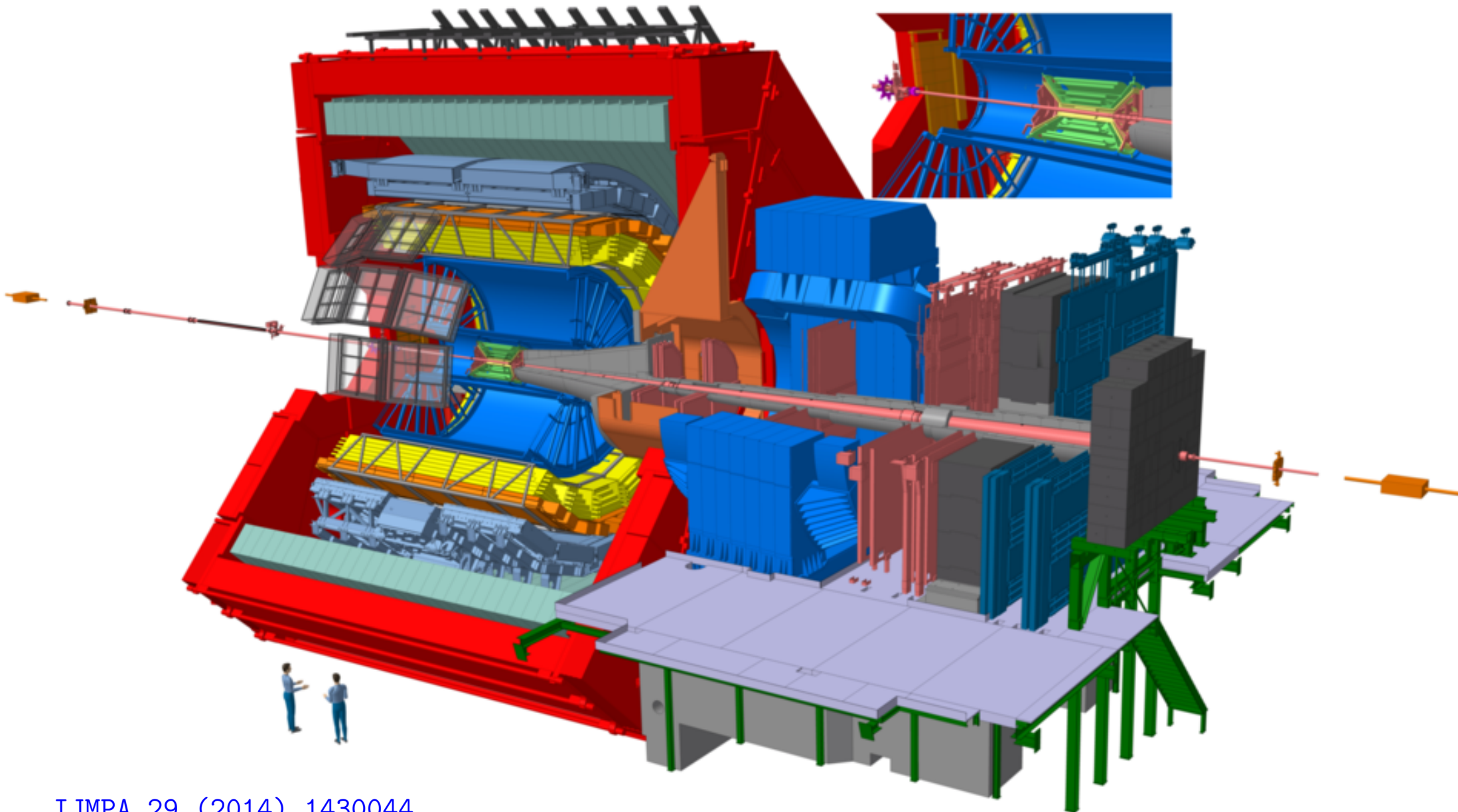
Production as a function of event charged-particle multiplicity of inclusive (prompt and non-prompt):

- J/ψ ($|y| < 0.9$, $2.5 < y < 4$), [PLB 810 \(2020\) 135758](#), [JHEP 06 \(2022\) 015](#)
- $\psi(2S)$ ($2.5 < y < 4$), [arXiv:2204.10253](#) (p-Pb in appendix)
- Υ ($2.5 < y < 4$), [arXiv:2209.04241](#)

...and compare to models (refs. in our papers and in appendix)

...some don't alter quarkonium production mechanism vs. event multiplicity

ALICE setup (Run 2)

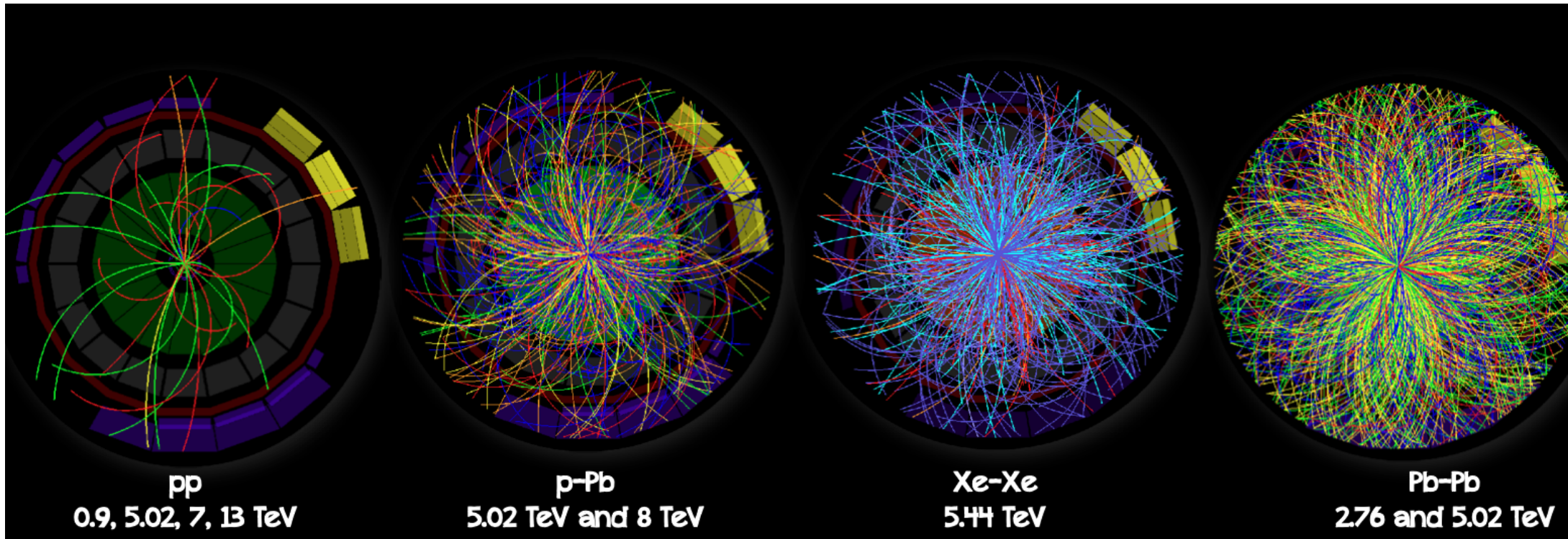


A pictorial summary of collisions at the LHC



A.Andronic **ALICE**

4



©ALICE/CERN

ALICE speciality:

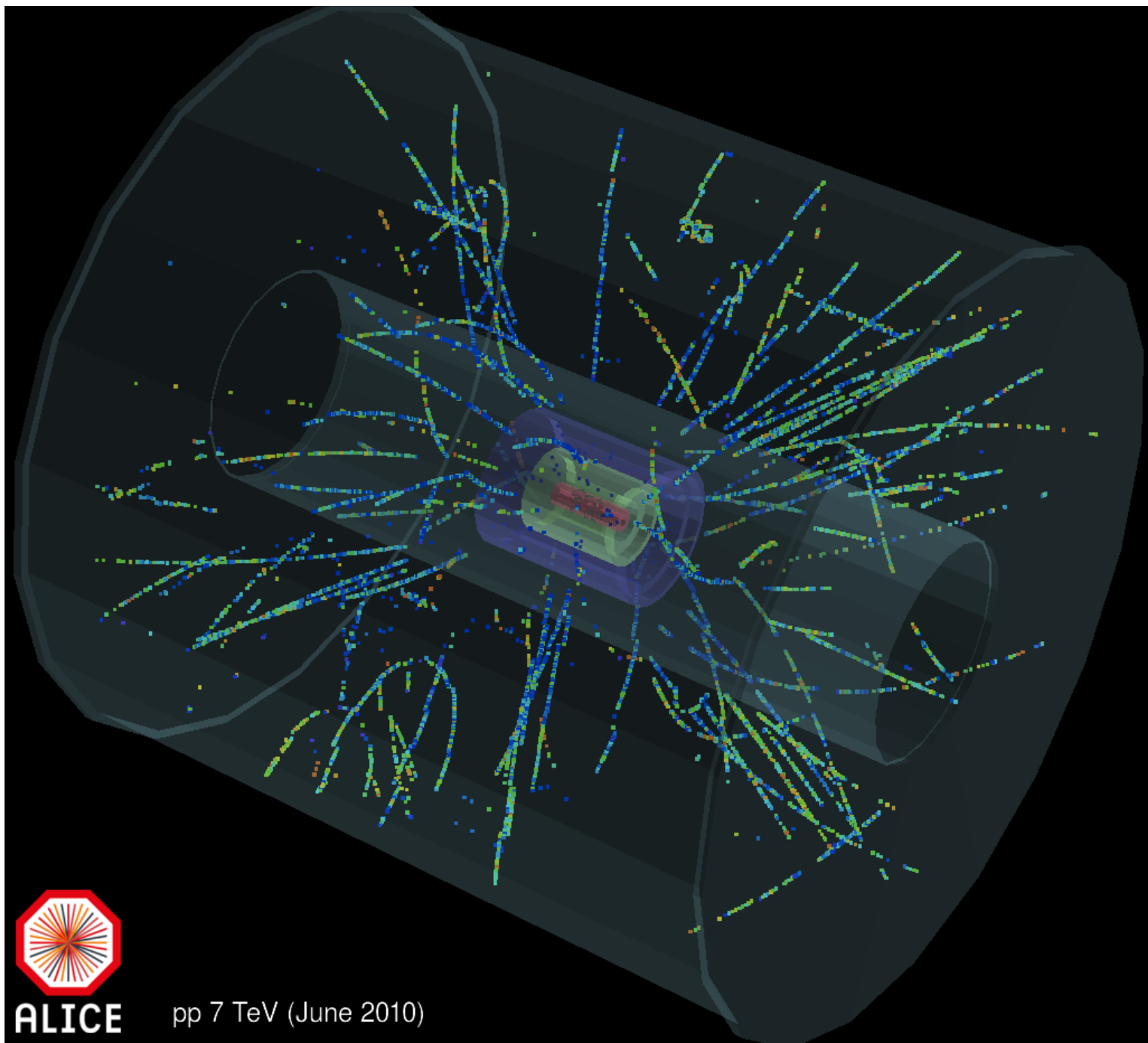
tracking and particle identification down to very low p_T (0.15 GeV/c) at $|y| < 0.9$

pp collisions at the LHC



A.Andronic **ALICE**

5



ALICE

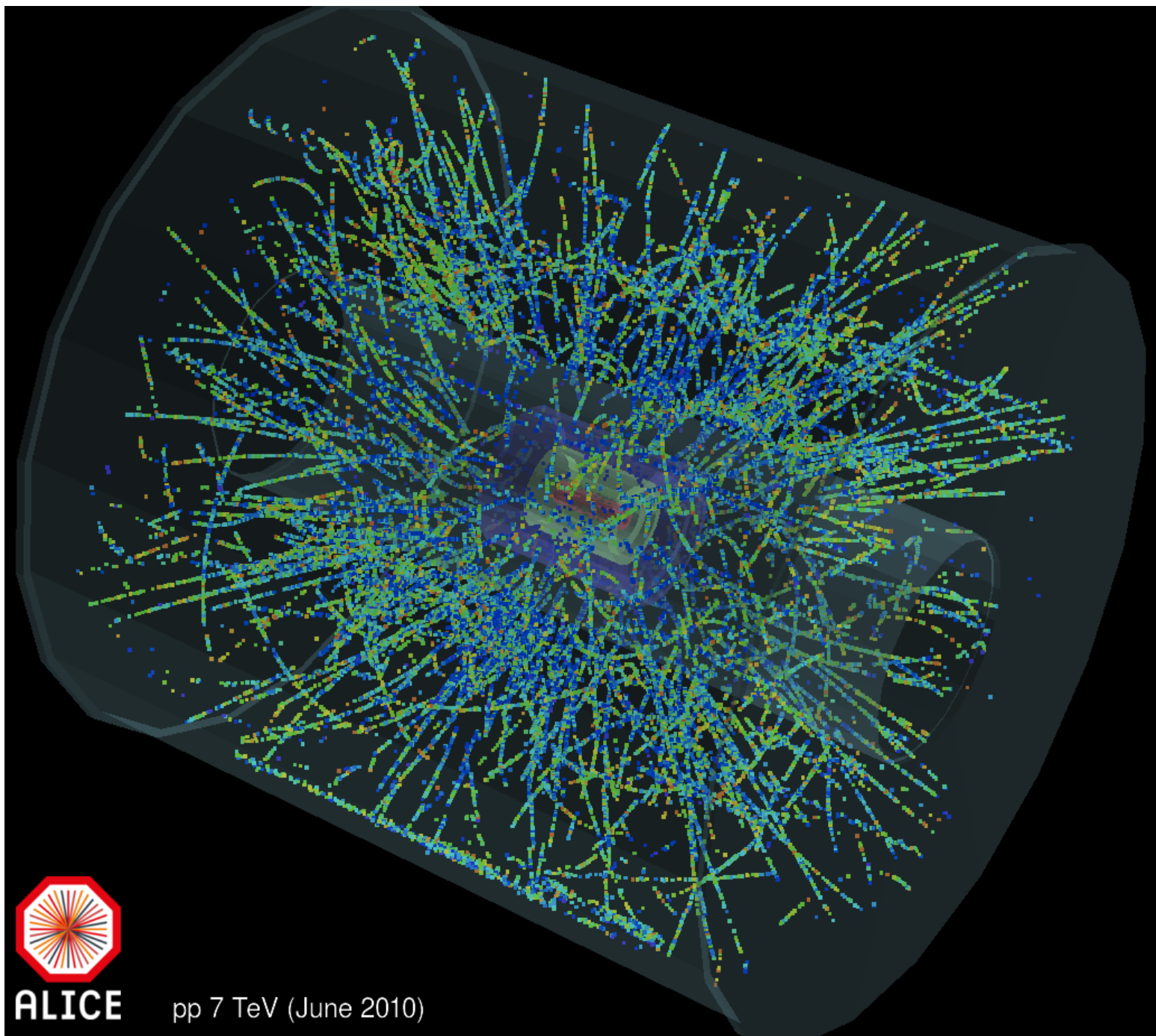
pp 7 TeV (June 2010)

pp collisions at the LHC



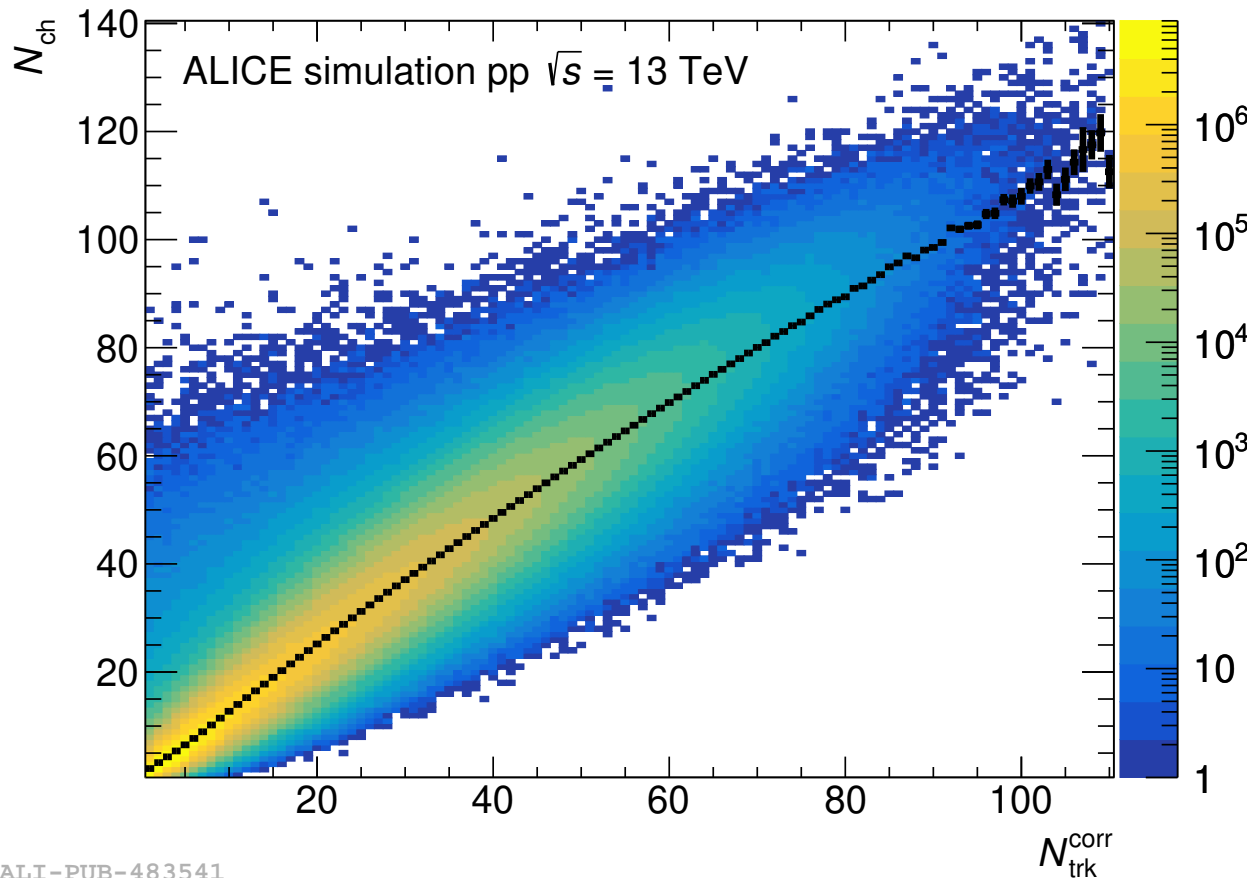
A.Andronic **ALICE**

6



ALICE

pp 7 TeV (June 2010)



ALI-PUB-483541

[PLB 810 \(2020\) 135758](#)

Monte Carlo, $|\eta| < 1.0$

N_{ch} true multiplicity

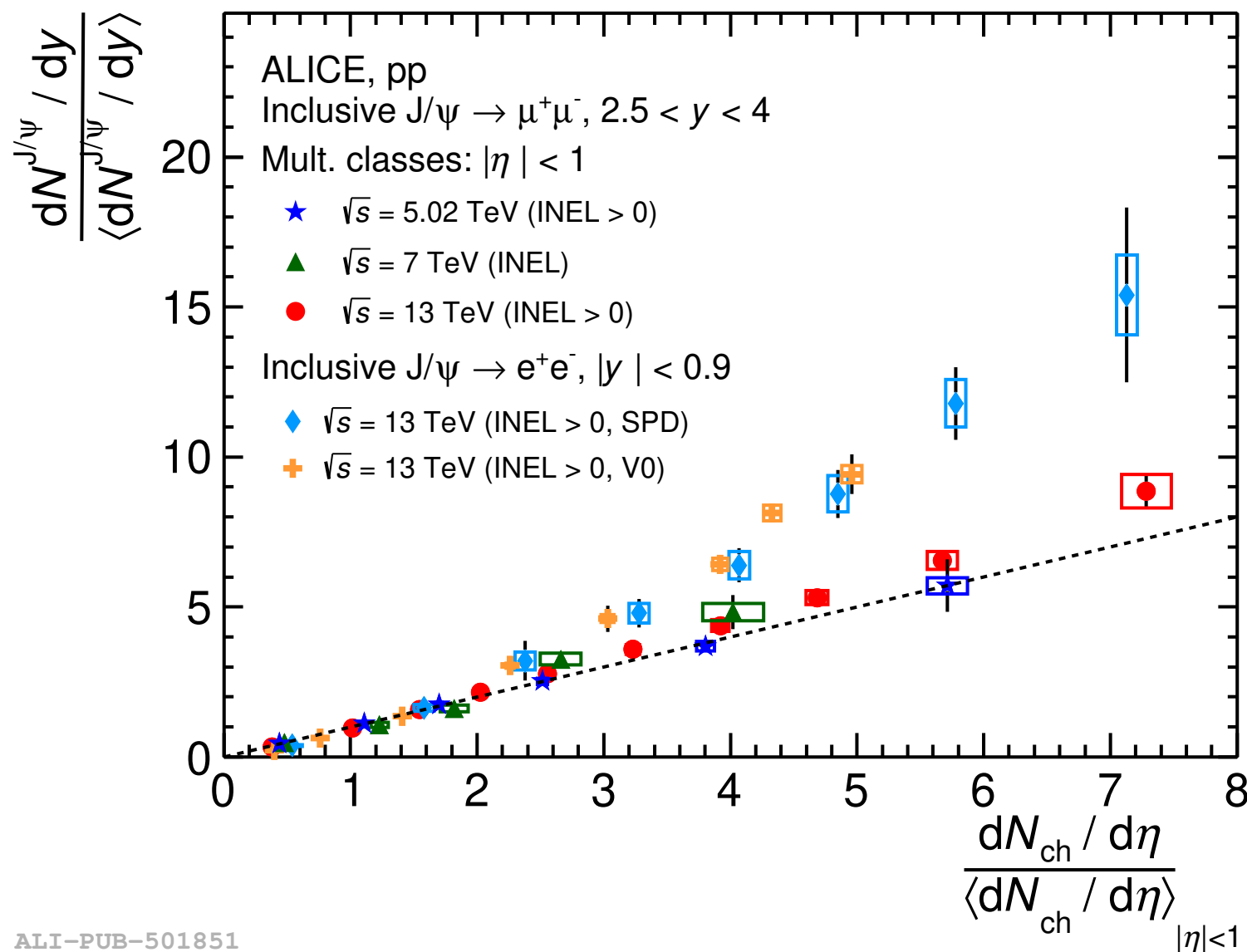
N_{trk}^{corr} measured

tracklets in SPD, $|\eta| < 1.0$,
corrected for efficiency

also: amplitude in V0 detector
 $-3.7 < \eta < -1.7$ and
 $2.8 < \eta < 5.1$

Inclusive quarkonium measured at $|y| < 0.9$, high-multiplicity trigger
and forward rapidity, $2.5 < y < 4$ (pp), dimuon-trigger

Results shown as normalized yields to minBias events (INEL > 0)

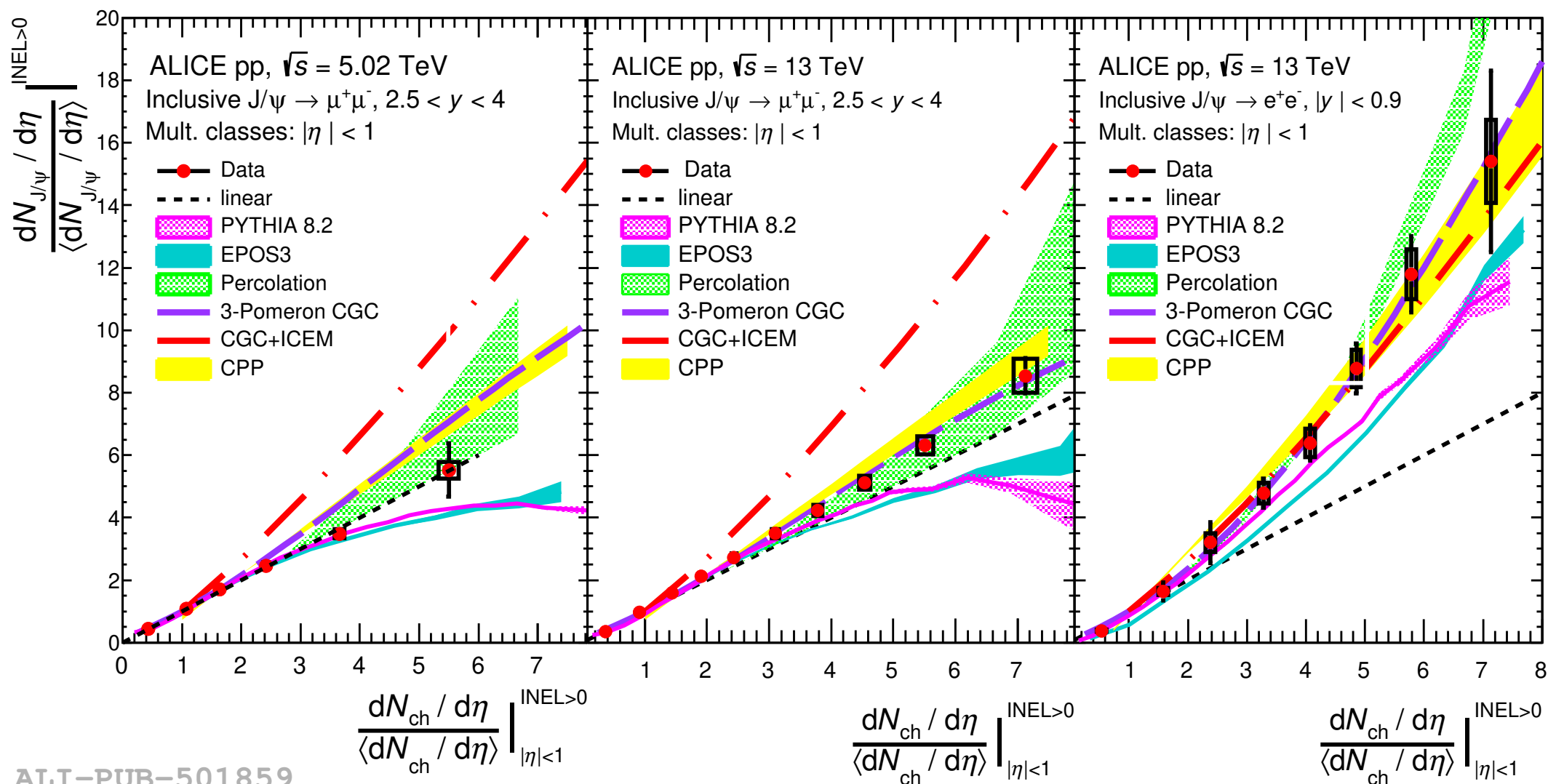


ALI-PUB-501851

PLB 810 (2020) 135758, JHEP 06 (2022) 015

Linear and faster-than-linear dependence for forward y and midrapidity J/ψ

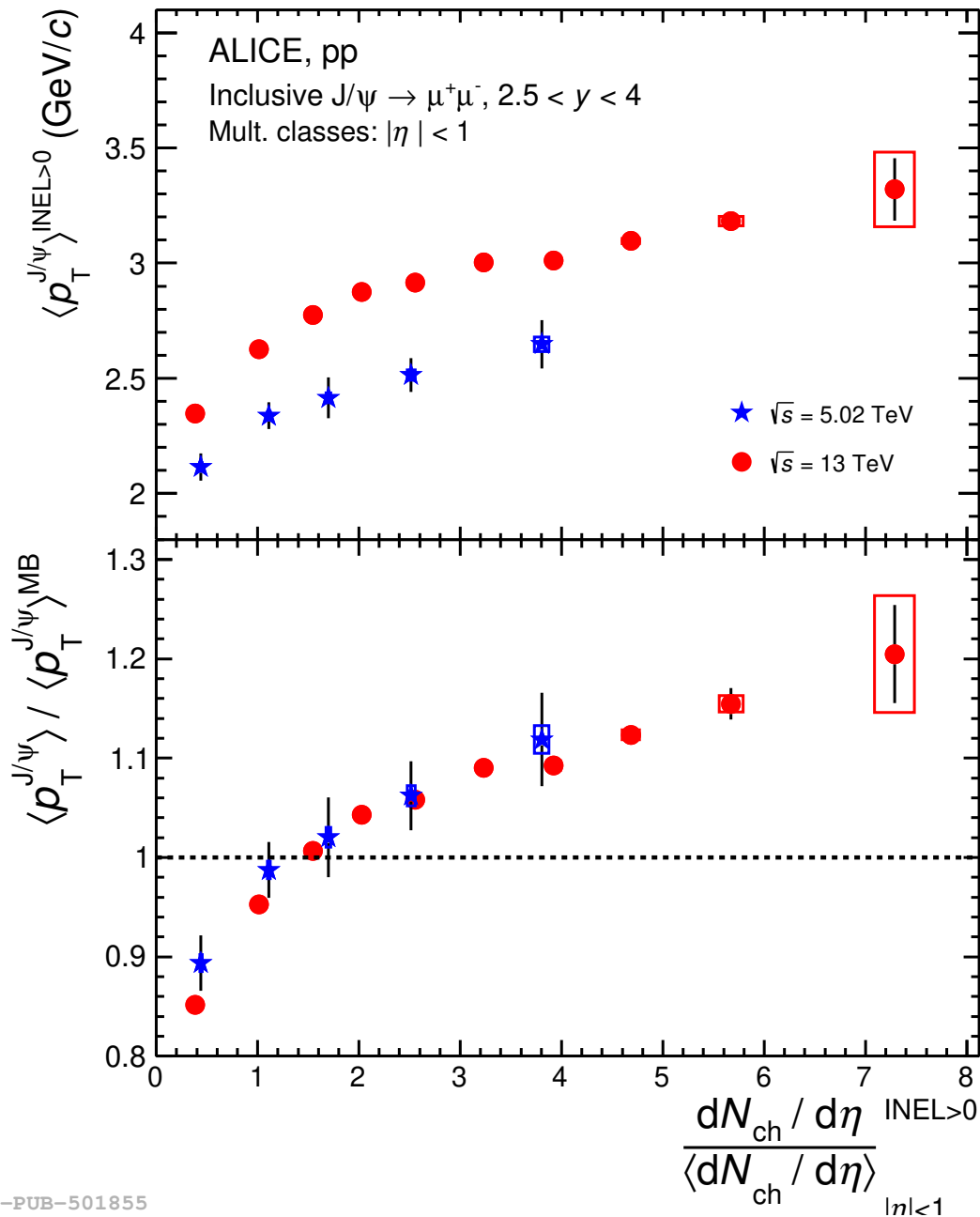
J/ψ production: data and models



PLB 810 (2020) 135758, JHEP 06 (2022) 015

The models describe the features of the data (with various degrees of success)

J/ψ production: mean p_T



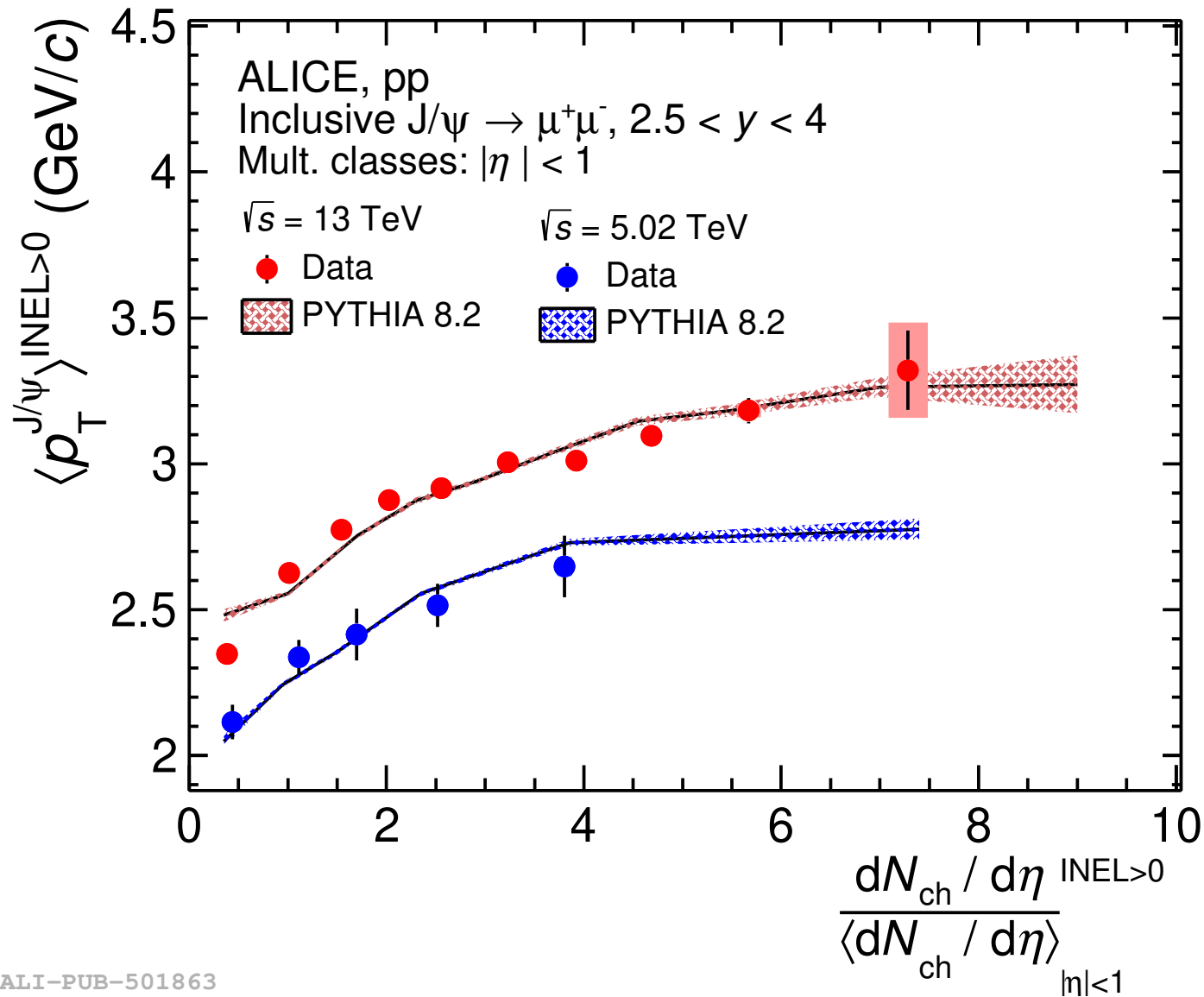
schematically 2 regimes:

- (medium) soft events
faster increase

- (very) high-multiplicity
saturation ?

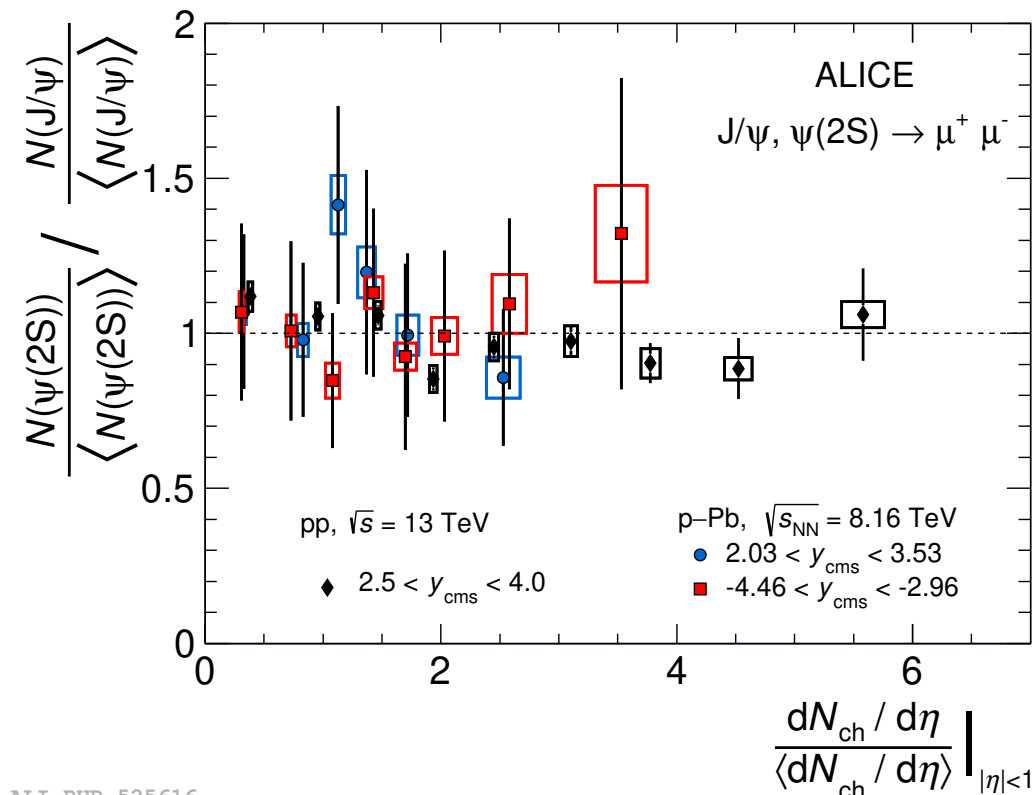
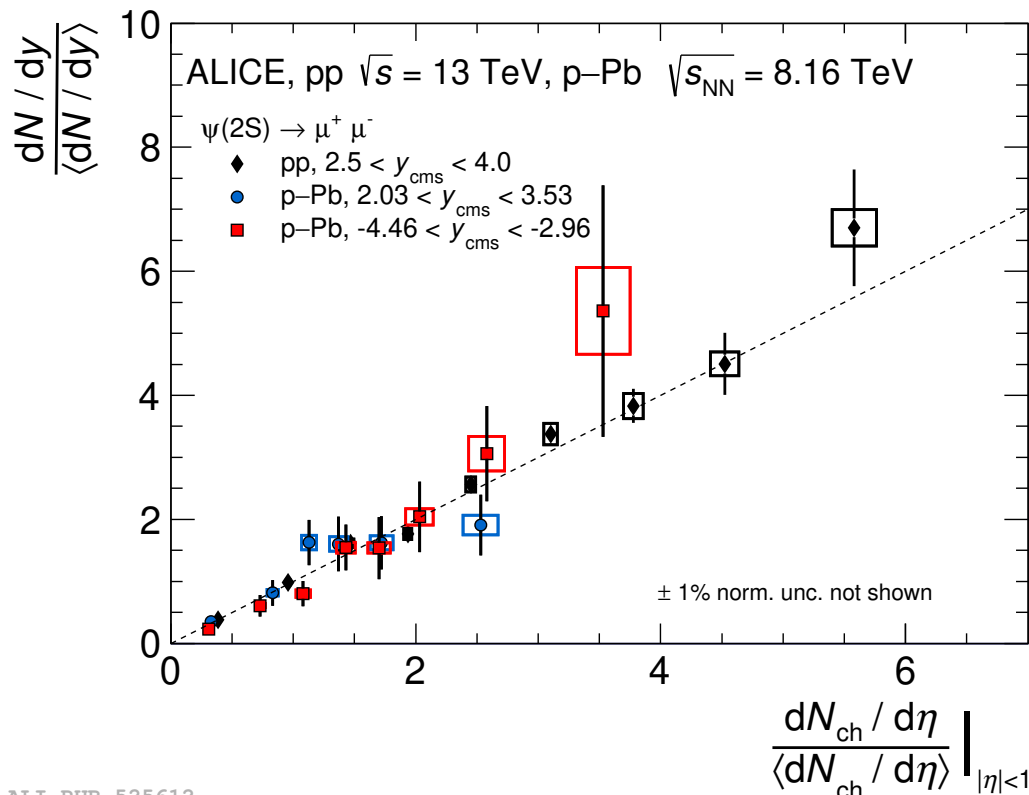
JHEP 06 (2022) 015

J/ ψ production: mean p_T , data and PYTHIA8



ALI-PUB-501863

$\psi(2S)$ production at forward rapidity



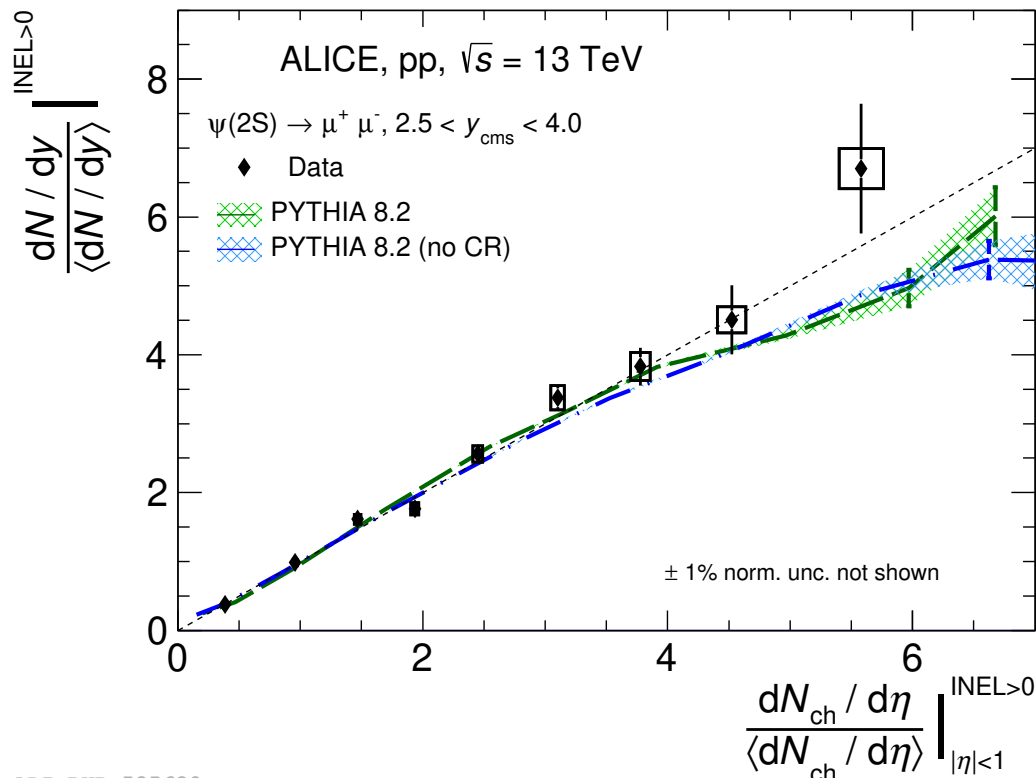
ALI-PUB-525612

ALI-PUB-525616

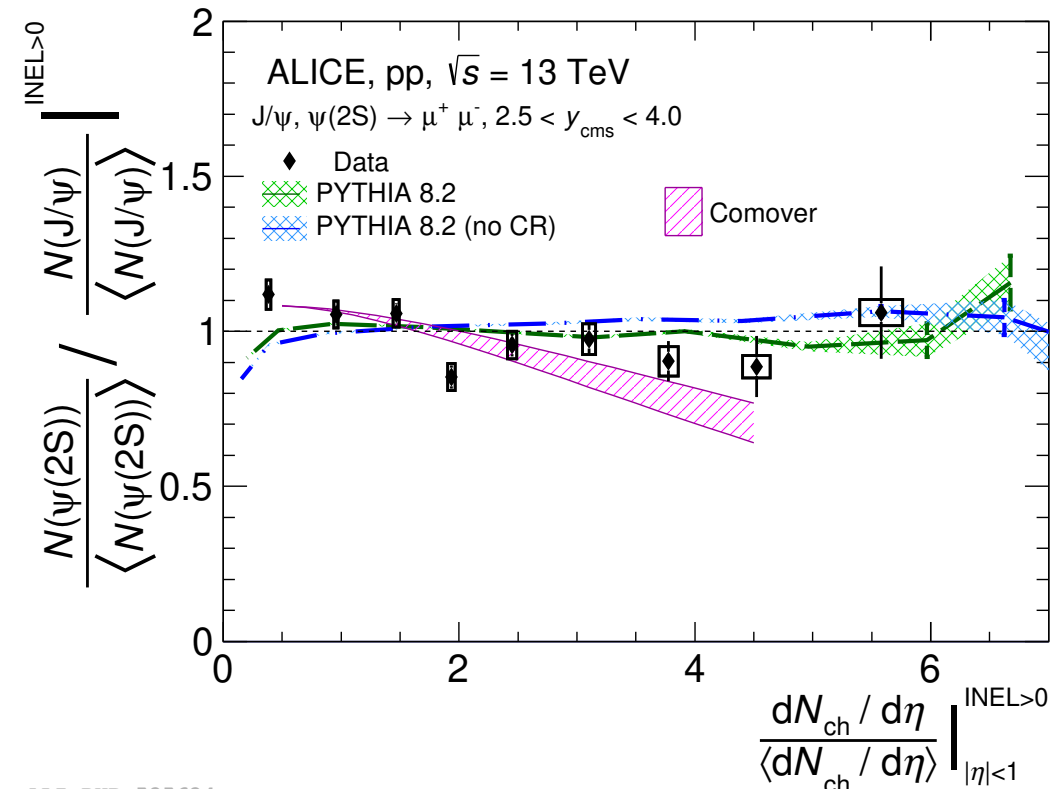
[arXiv:2204.10253](https://arxiv.org/abs/2204.10253)

$\psi(2S)$ production exhibits similar features as J/ψ , both in pp and p-Pb

$\psi(2S)$ production: data vs. models



ALI-PUB-525620



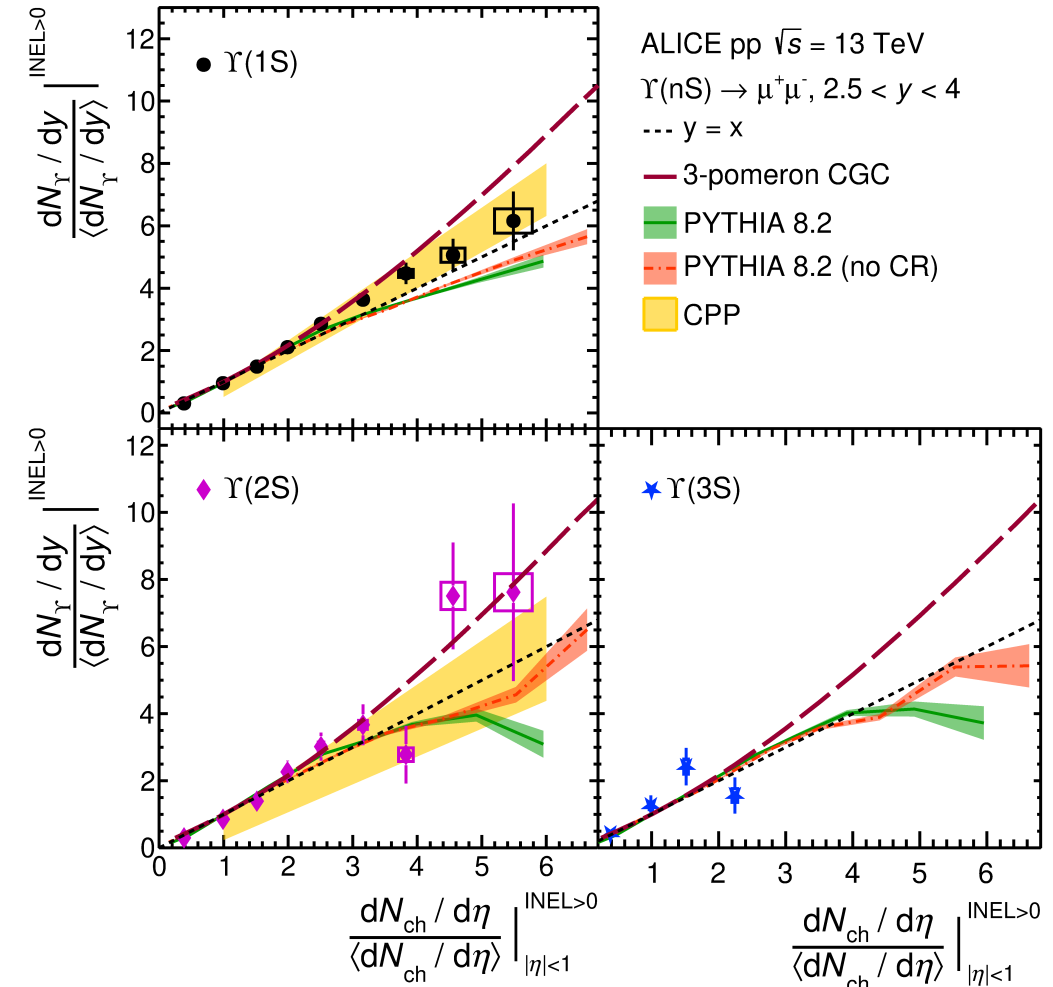
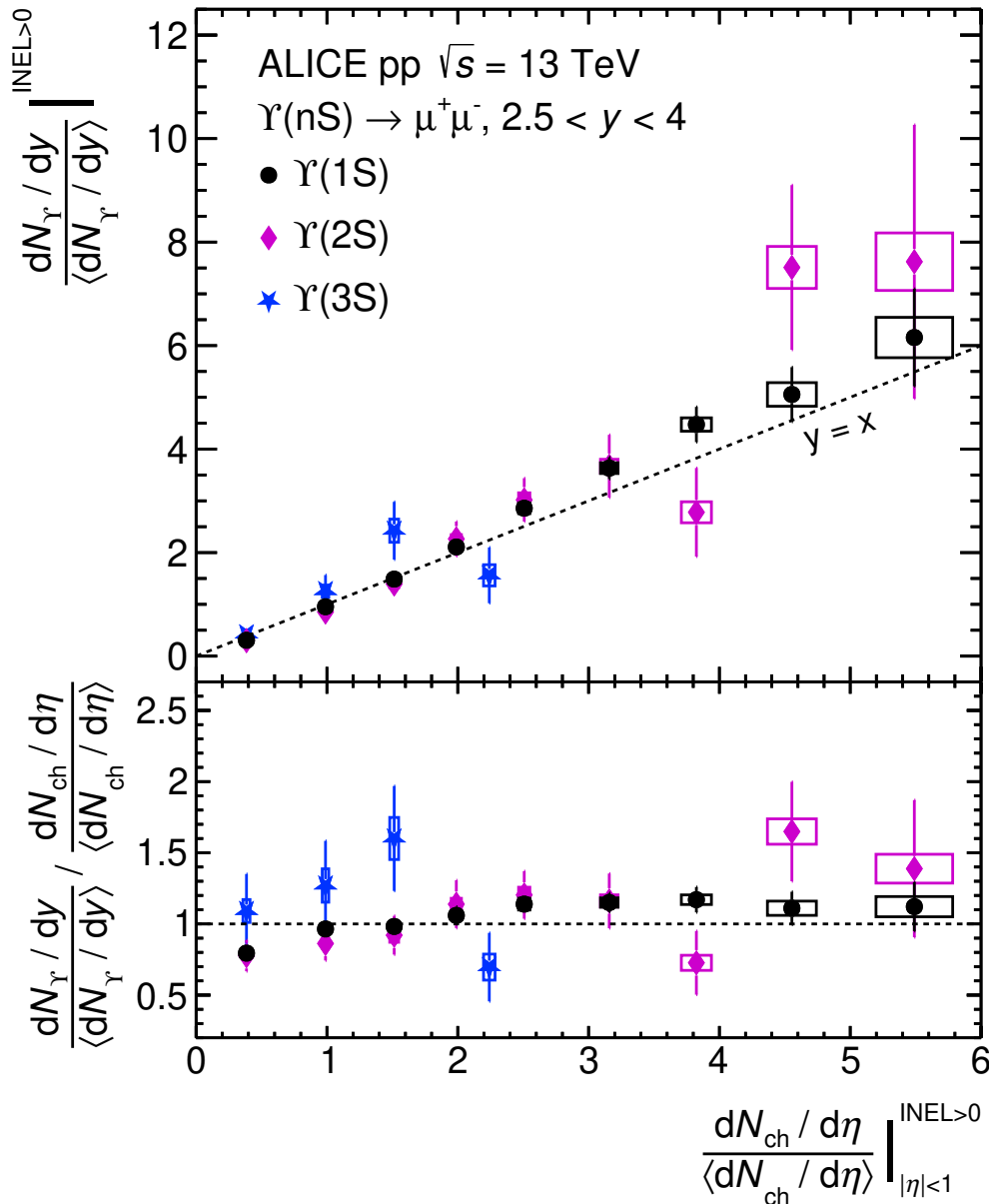
ALI-PUB-525624

[arXiv:2204.10253](https://arxiv.org/abs/2204.10253)

Again, PYTHIA 8 reproduces data well, underpredicting $\psi(2S)$ similar to J/ψ

The comover model predicts a $\psi(2S)$ suppression trend wrt J/ψ

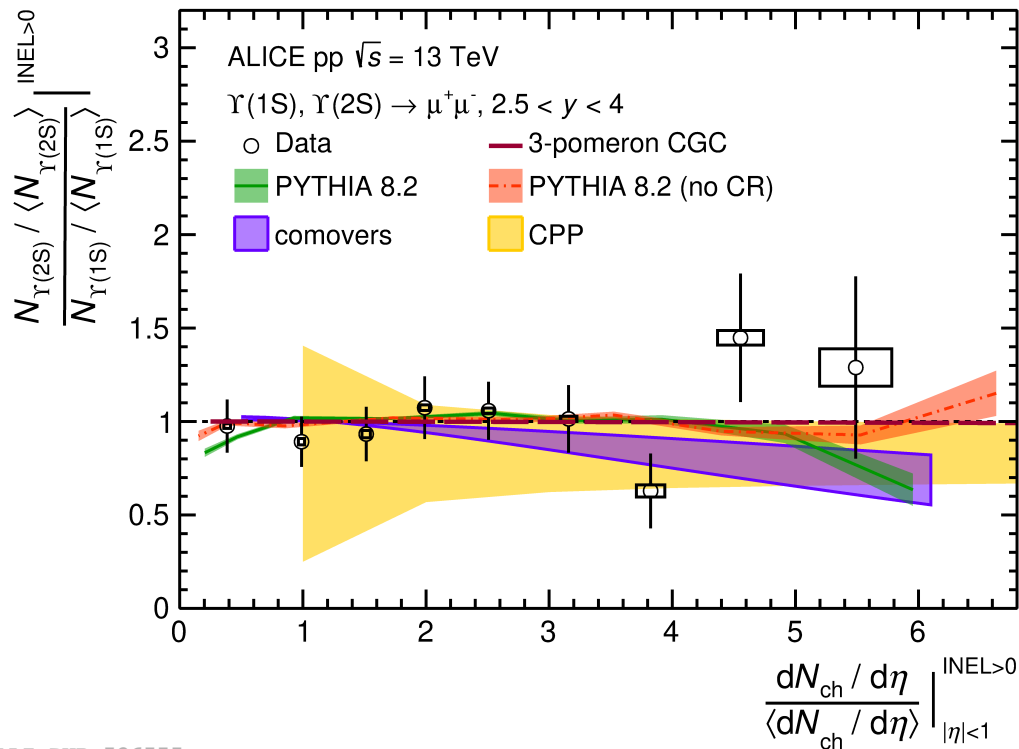
Υ production: overview



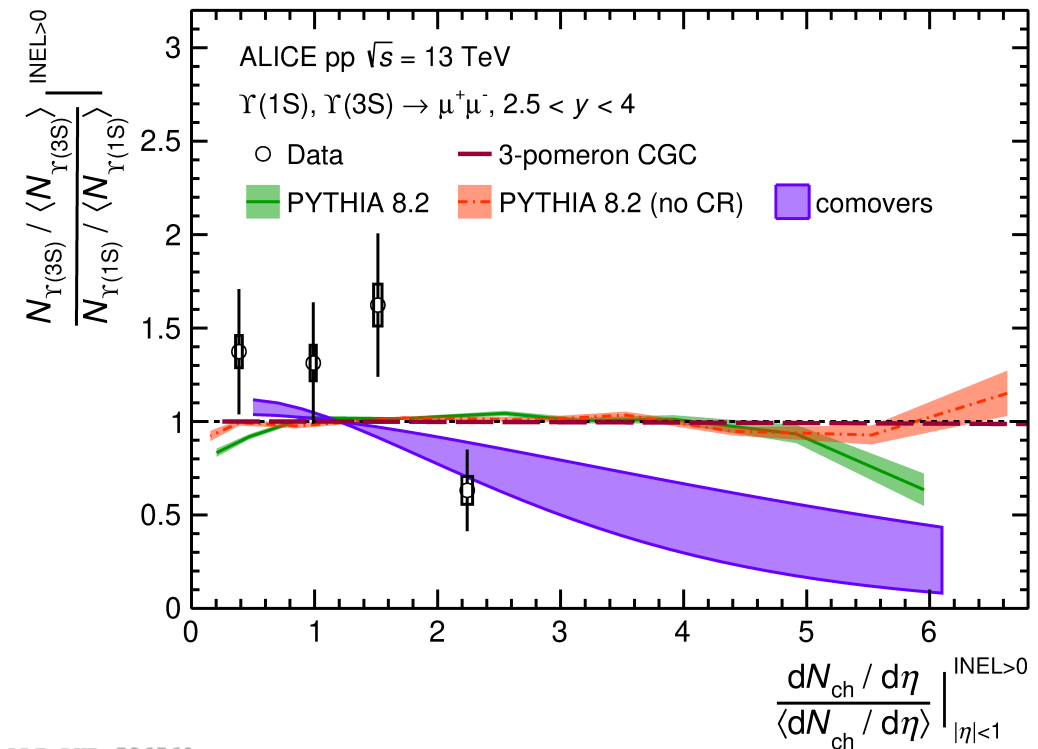
ALI-PUB-526545

ALI-PUB-526550

Υ production: a closer look vs. state



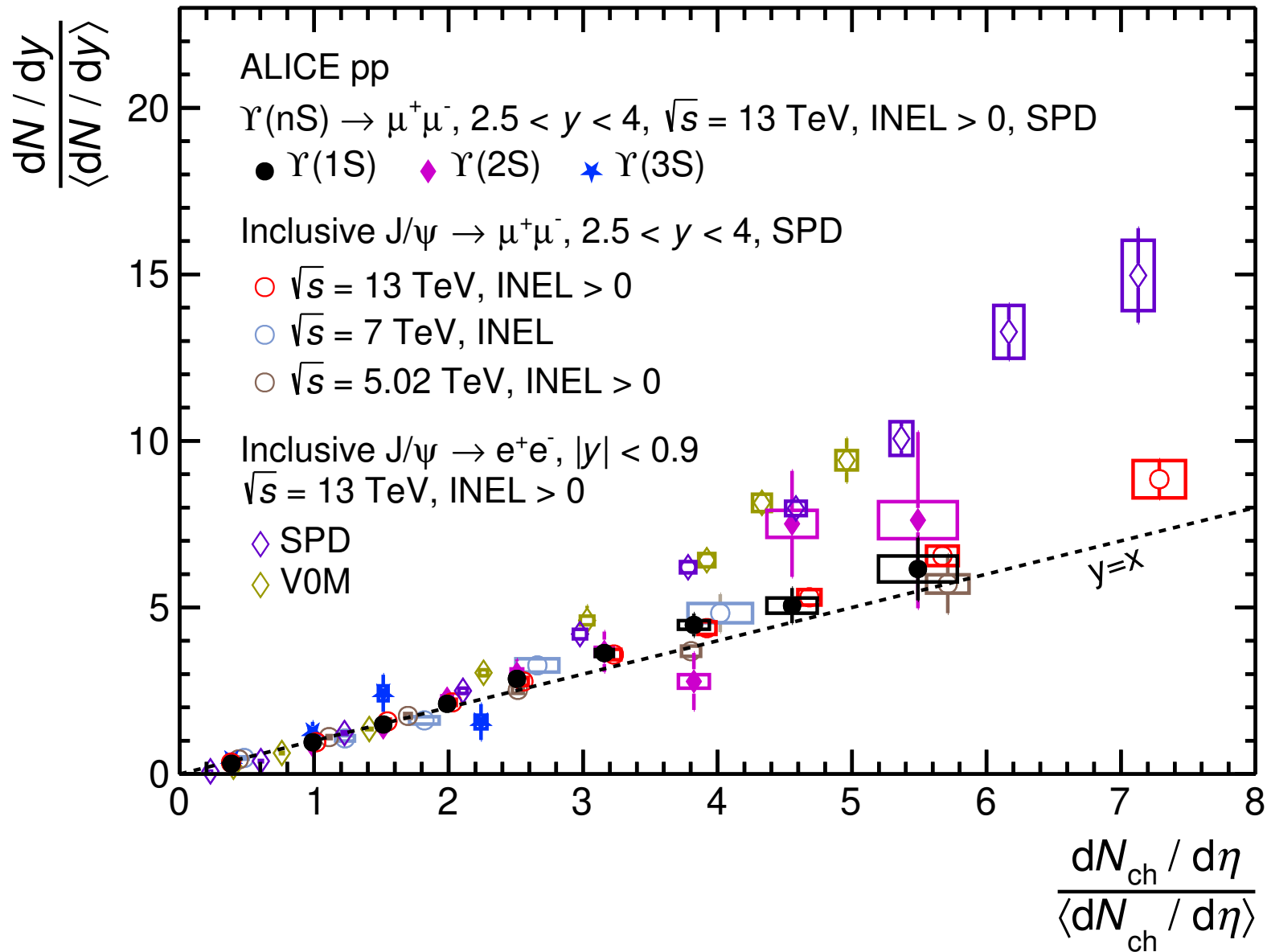
ALI-PUB-526555



ALI-PUB-526560

[arXiv:2209.04241](https://arxiv.org/abs/2209.04241)

All models reproduce the data well ...most models predicting no state-dep. effects
 ...but the comover model predicts a $\Upsilon(2S, 3S)$ suppression trend wrt $\Upsilon(1S)$





- ALICE performed a comprehensive set of measurements on quarkonium production (inclusive) as a function of multiplicity (normalized)
 - The data are in their main features described by models
...some don't alter quarkonium production mechanism vs. event multiplicity (quarkonium as reference for soft-QCD effects (gluon saturation) in high-multiplicity events ...should not be the whole story, we think/hope)
 - Next steps:
 - separate prompt and non-prompt (for Run 2 data only at $|y| < 0.9$)
 - dependence on multiplicity in azimuthal regions wrt quarkonium direction (better selectivity to quarkonium production mechanisms?)
- any suggestion on what else we could provide is much welcome

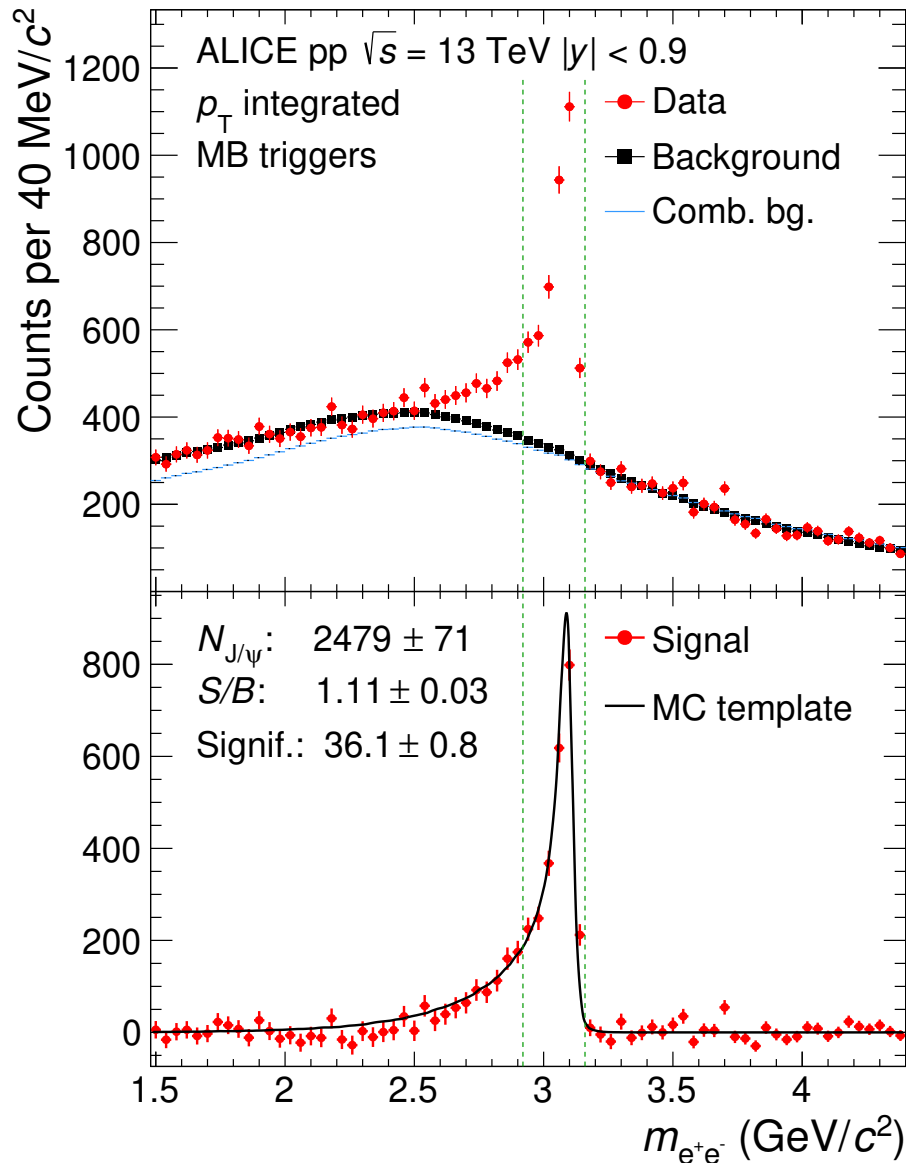
Supplementary material



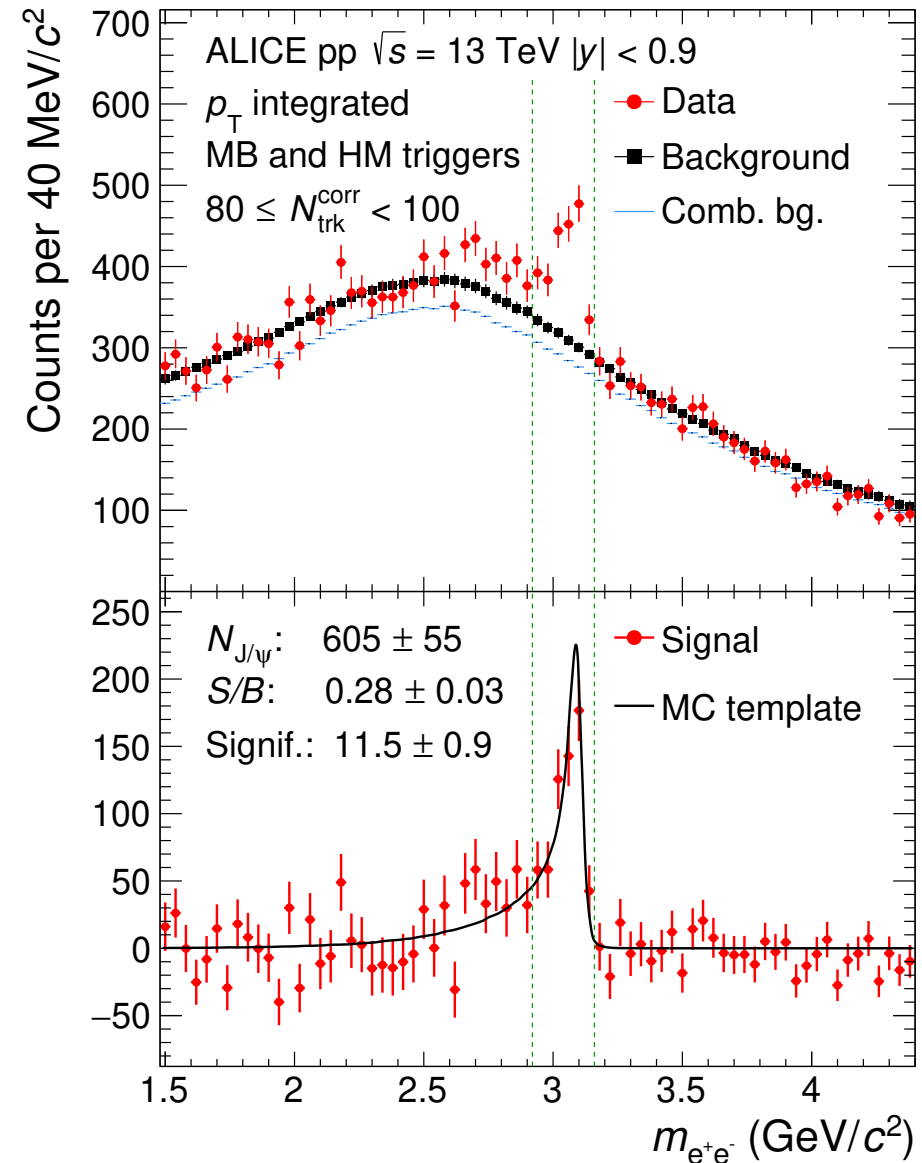


- **PYTHIA 8.2**
- **EPOS3**
- **Percolation** - E.G. Ferreiro, C. Pajares,
High multiplicity pp events and J/ψ production at LHC
- **3-Pomeron CGC** - E. Levin et al.,
Multiplicity dependence of quarkonia production in the CGC approach
- **CGC+ICEM** - Y.-Q. Ma et al.,
Event engineering studies for heavy flavor production and hadronization in high multiplicity hadron-hadron and hadron-nucleus collisions
- **CPP** - B.Z. Kopeliovich et al.,
Heavy quarkonium in the saturated environment of high-multiplicity pp collisions

J/ψ measurement, $|y| < 0.9$

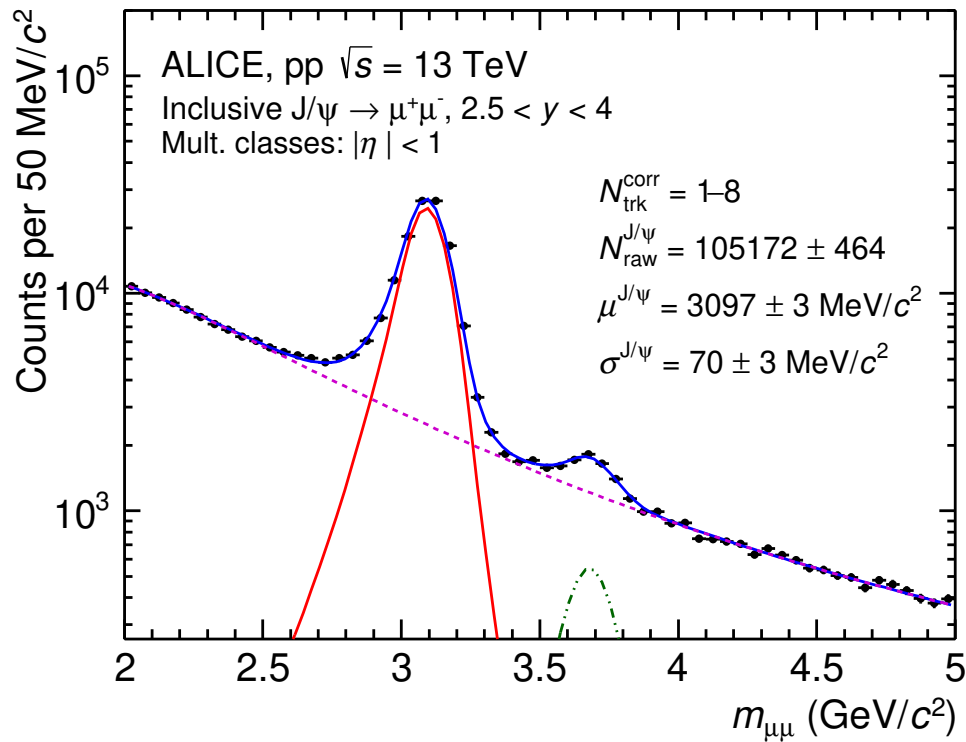


ALI-PUB-527797

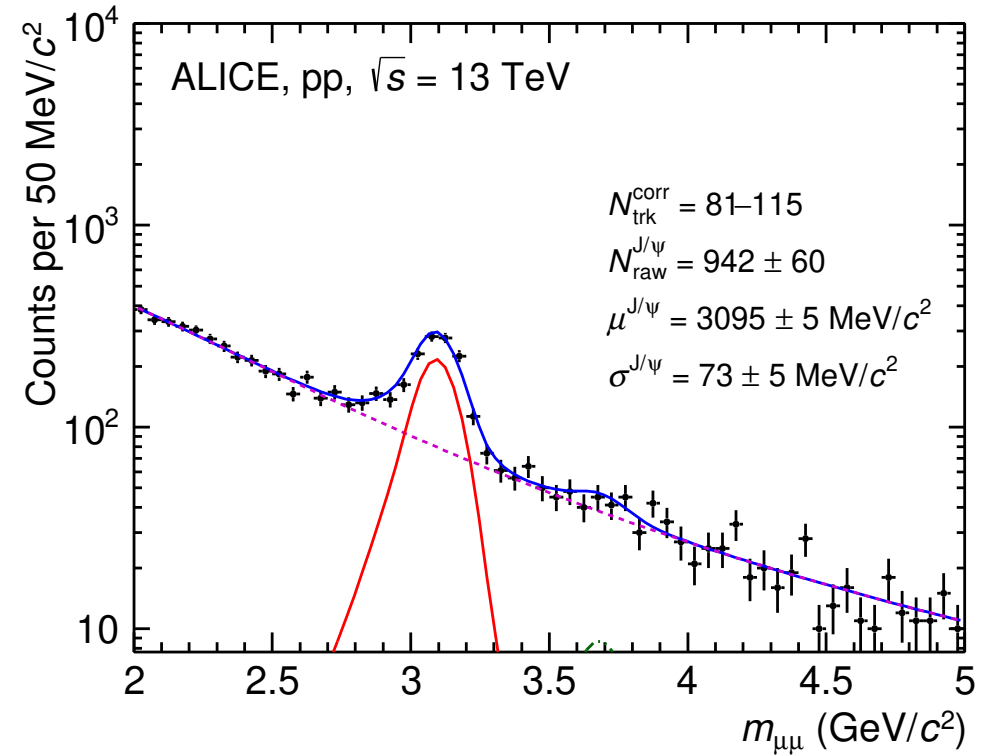


ALI-PUB-527801

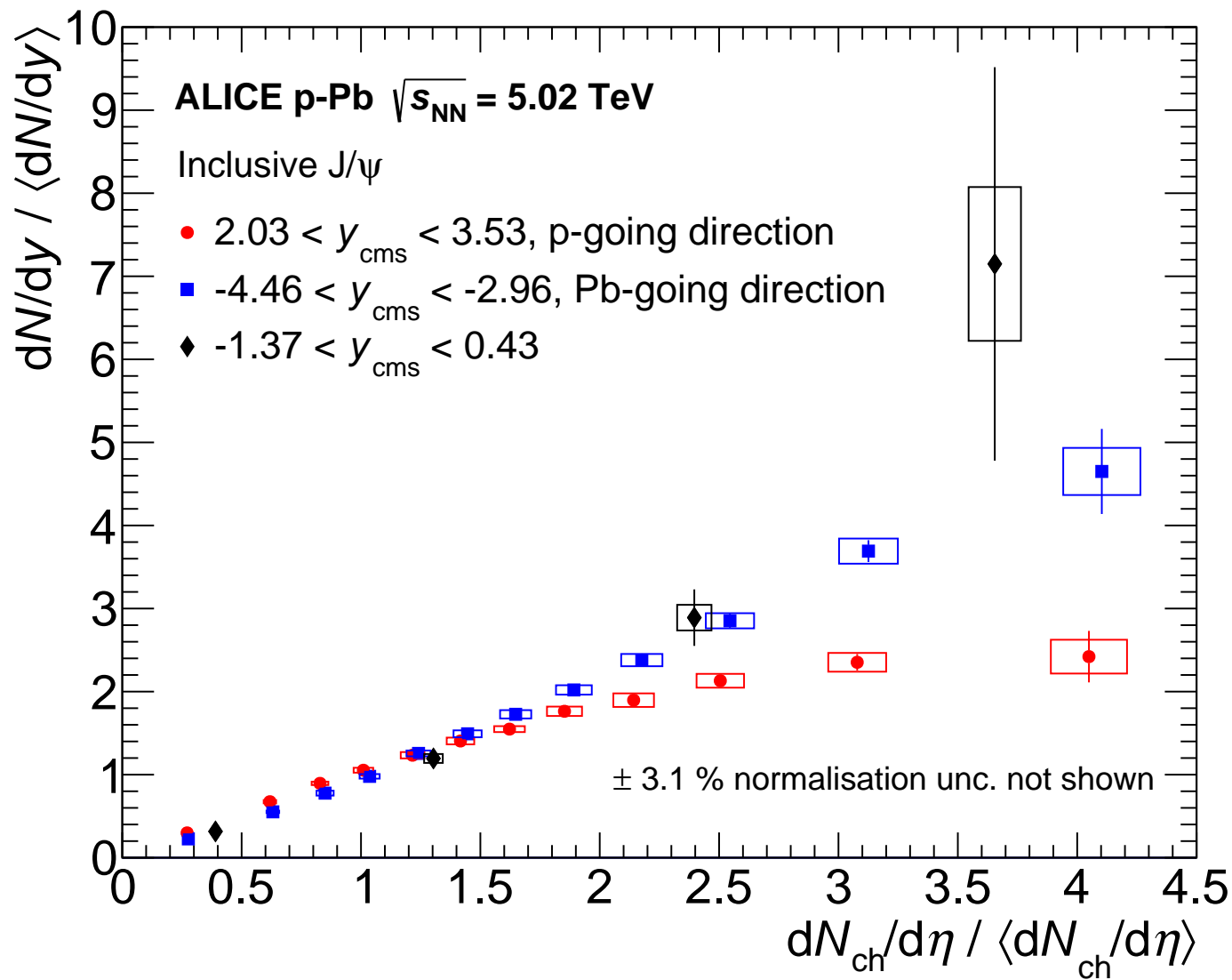
J/ ψ , $\psi(2S)$ measurement, forward y



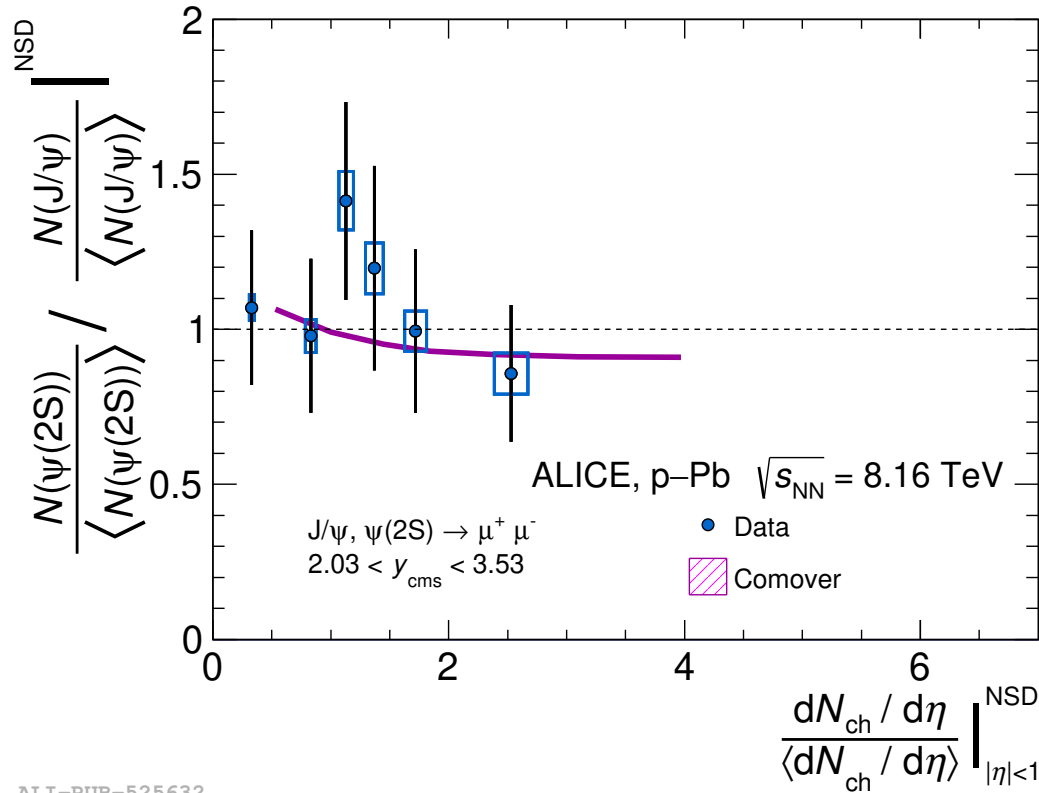
ALI-PUB-501819



ALI-PUB-501827

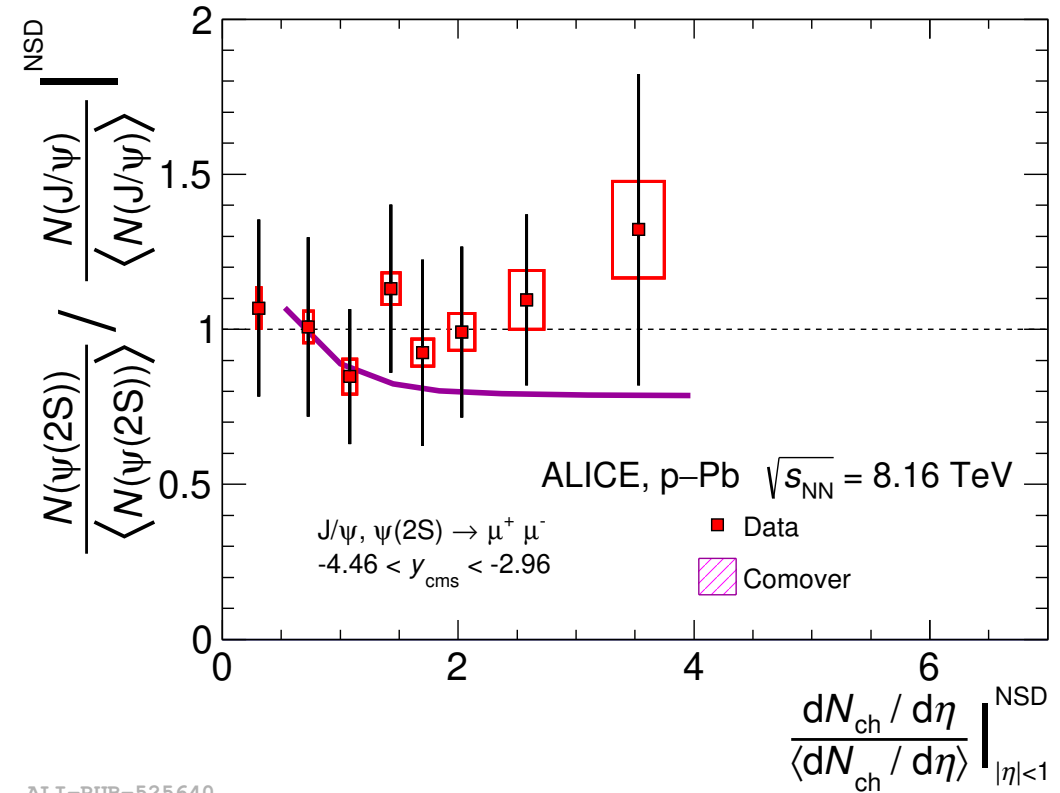


$\psi(2S)$ production in p-Pb



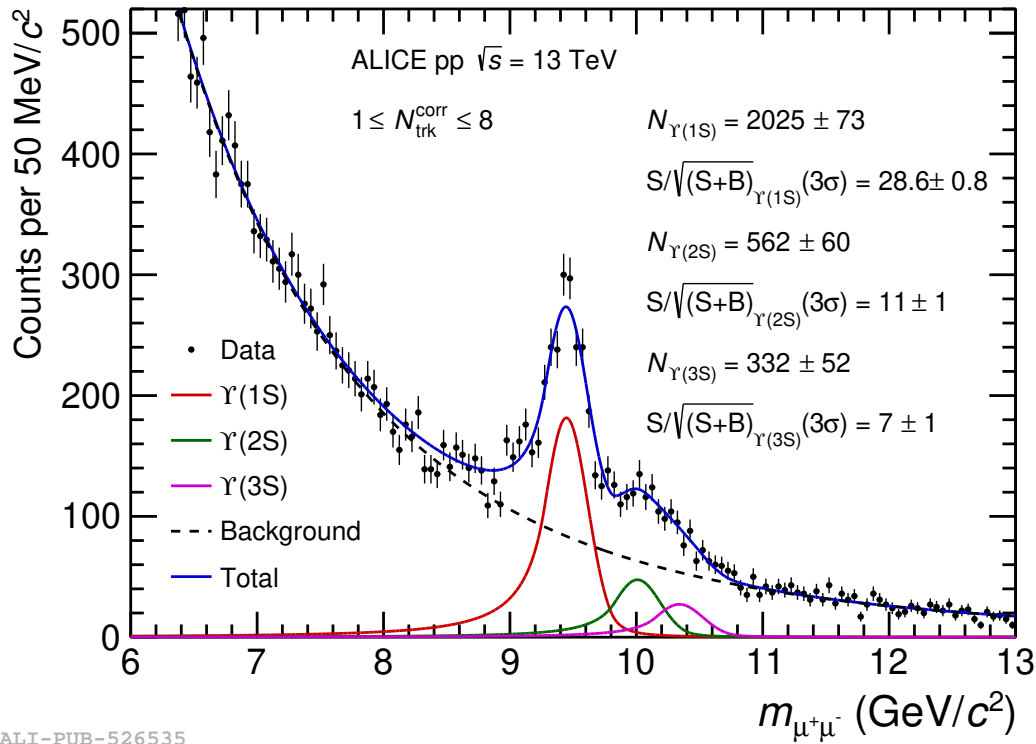
ALI-PUB-525632

[arXiv:2204.10253](https://arxiv.org/abs/2204.10253)

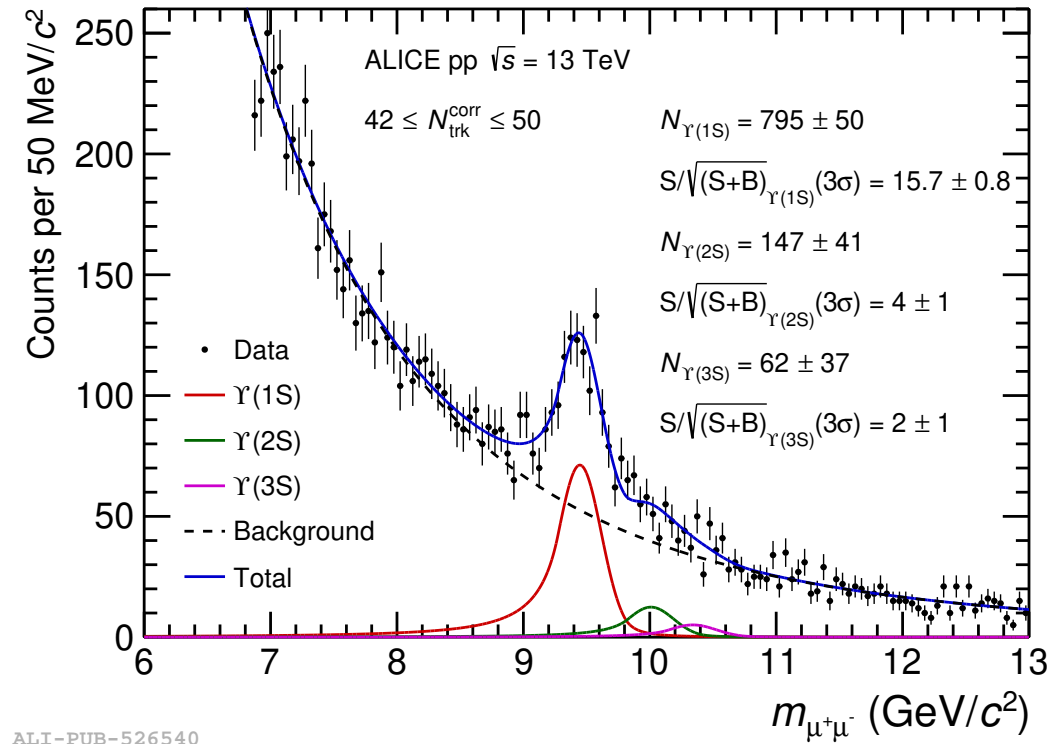


ALI-PUB-525640

Υ measurement



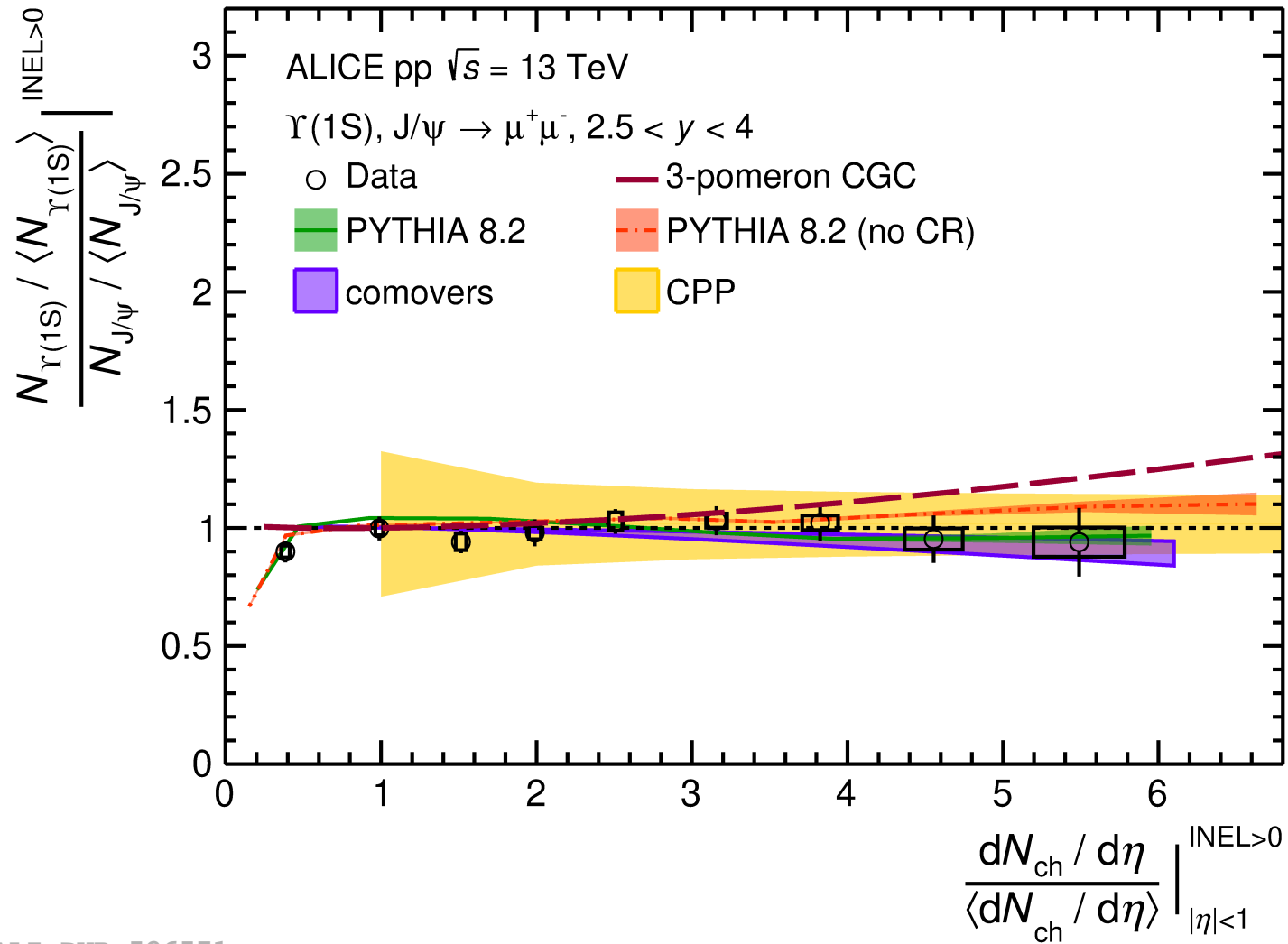
ALI-PUB-526535



ALI-PUB-526540

[arXiv:2209.04241](https://arxiv.org/abs/2209.04241)

$\Upsilon(1S)$ vs. J/ψ production



ALI-PUB-526571