m_T – scaling of mesons at LHC energies

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Why?

Transverse momentum - `m_T – scaling' is a tool to understand the relative production of different particles

We use it to understand what is going on with Y(nS) production in *pp* at the LHC:

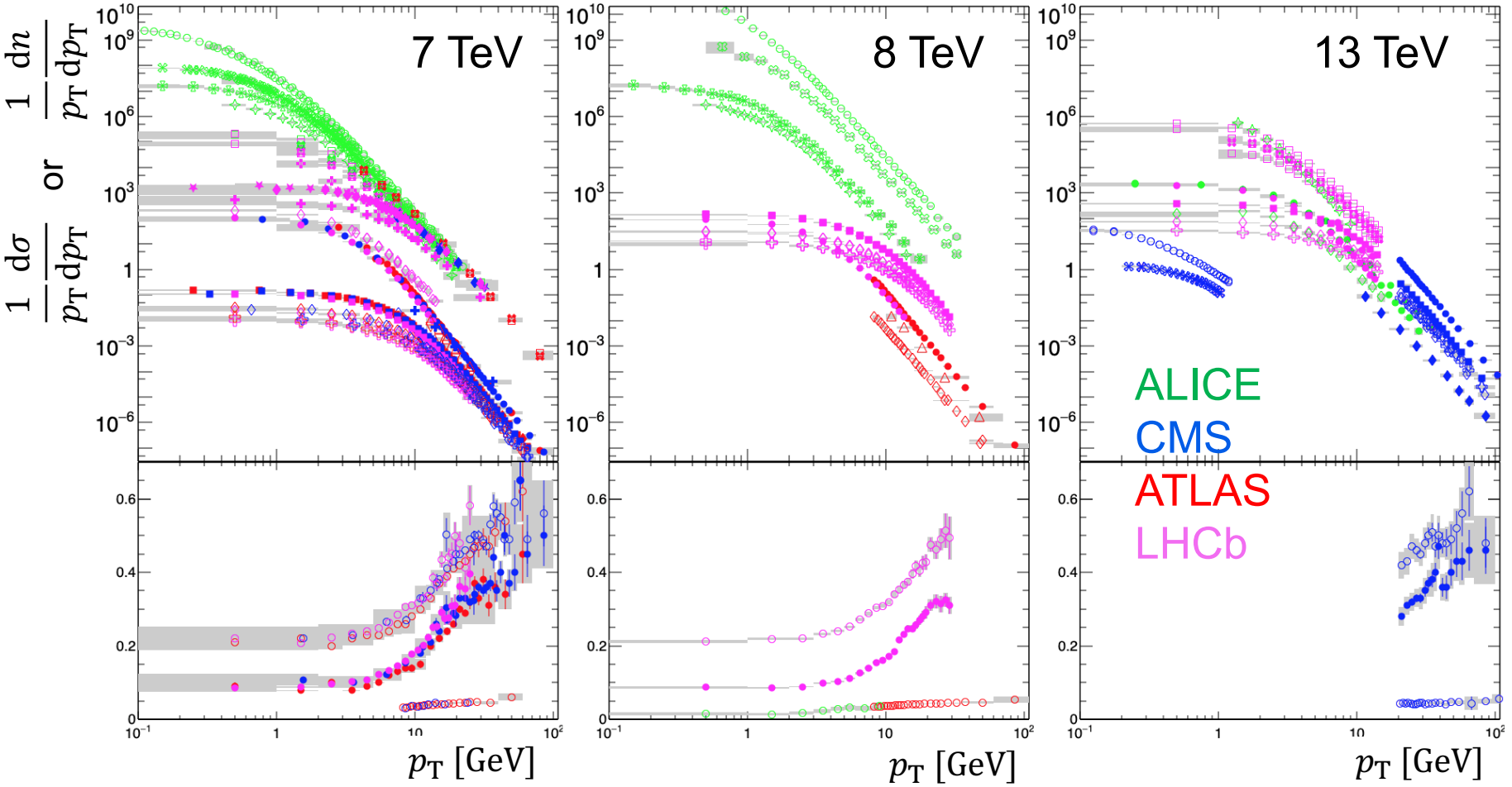
CMS JHEP 04 (2014) 103,
CMS JHEP 11 (2020) 001,
ATLAS ATLAS-CONF-2022-023

Experiments observe fewer n_{ch} in higher Y(nS) events than in Y(1S)

These can be explained by **suppression of higher Y(nS) in *pp***

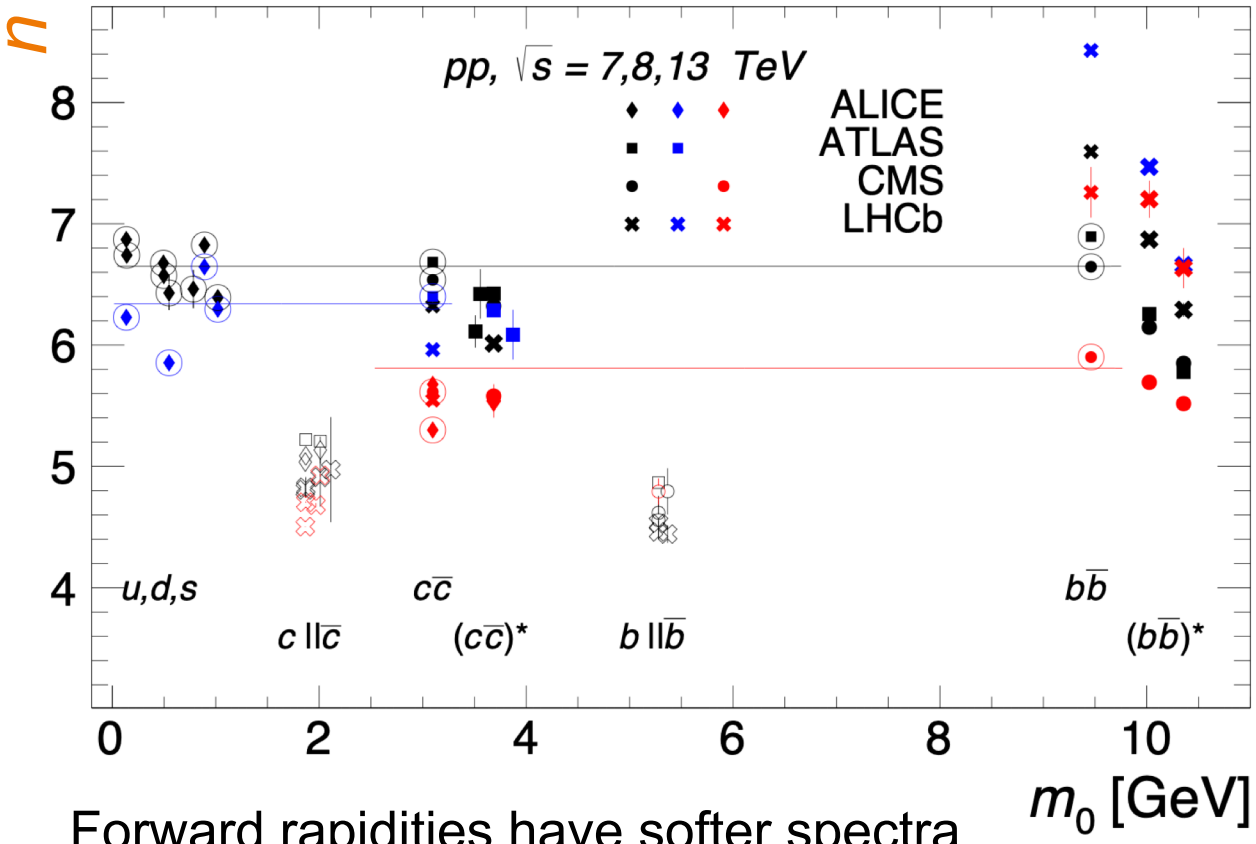
Here we look for this phenomenon from a very different angle and try to give a baseline for relative suppression

What?



4 LHC experiments, all meson measurements at 7, 8 and 13 TeV
18 different particles species and their isospin partners
72 data samples with 1509 experimental data points
15 measurements of particle ratios with 327 data points

How?



$$\frac{\mathrm{d}\sigma}{\mathrm{d}p_{\mathrm{T}}} \propto \left[1 + \frac{m_{\mathrm{T}}}{nT}\right]^{-n}$$

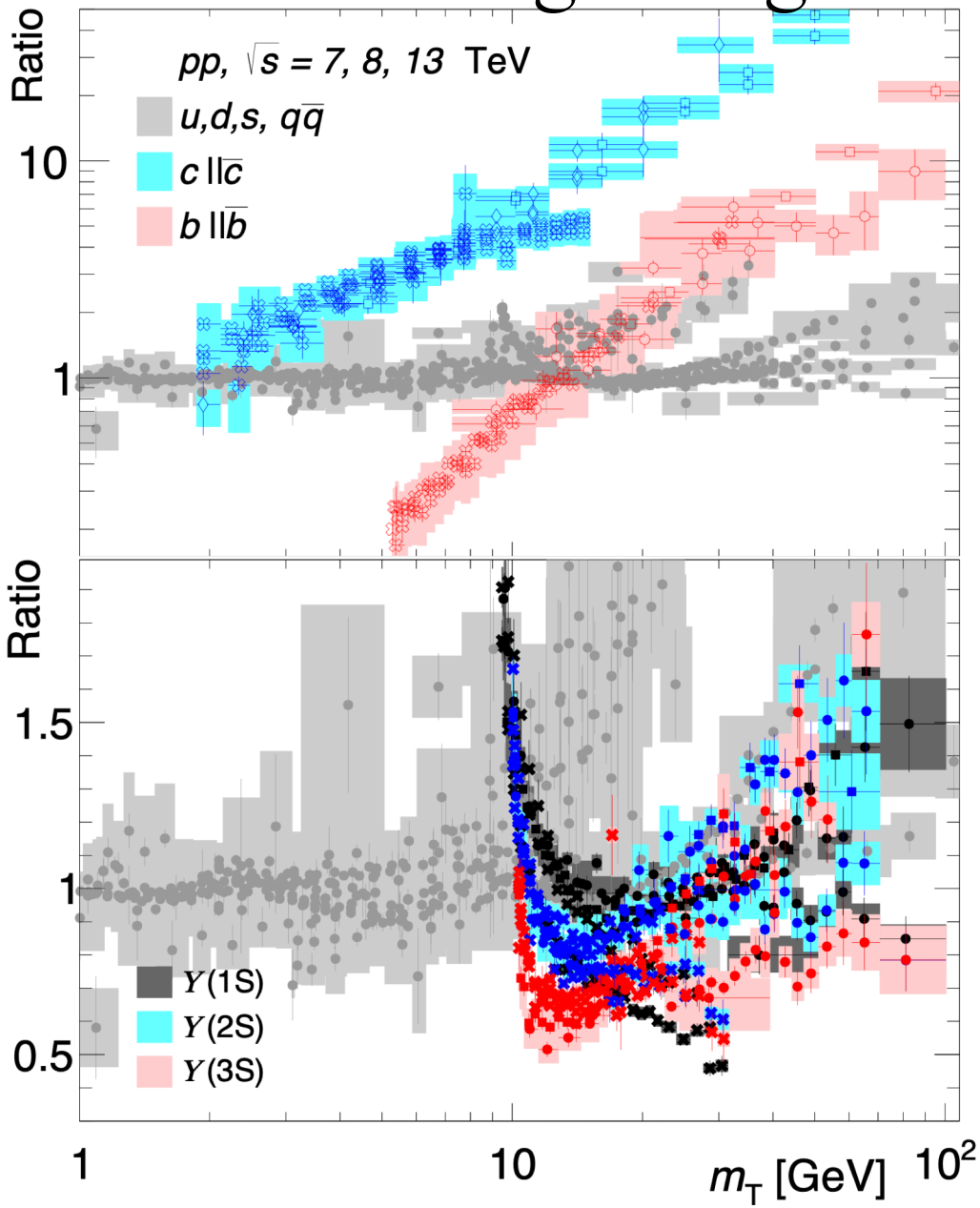
$T = 254\ MeV$

Lower *n* = harder spectra
Higher *n* = softer spectra

Smaller *n* @ higher $\sqrt{s}$
→ Spectra get harder

Forward rapidities have softer spectra
Open flavor has harder spectra than other particles
Open-*b* is harder than open-*c*
Excited quarkonia is harder than the ground-state
Use light species and ground state quarkonia in common fit
for each collision energy: *n*(7, 8, 13 TeV) = 6.65, 6.34, 5.44

Beginning - Common fit



Common fit is not perfect (small experimental differences across measurements) but works

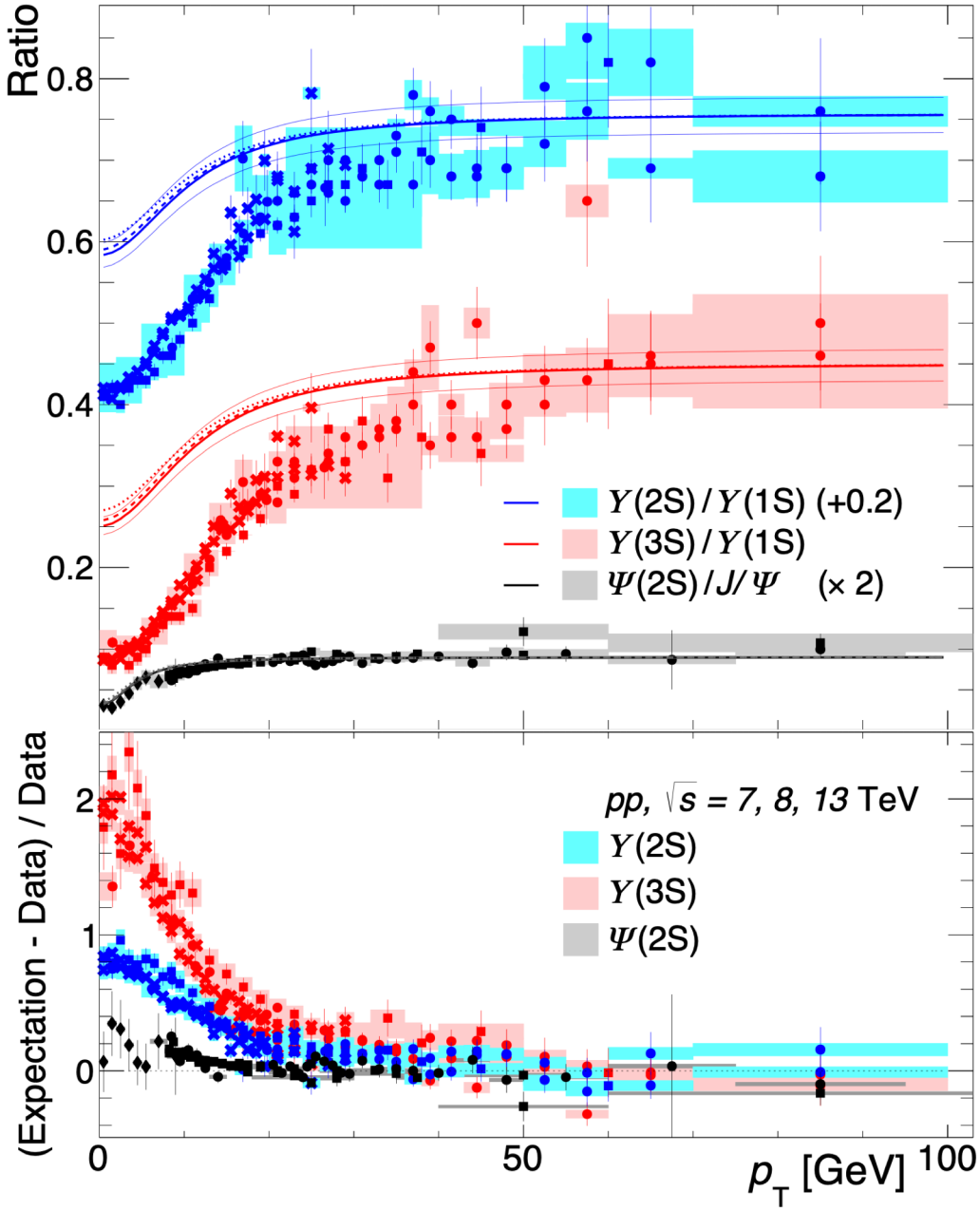
Open-*b* is harder than open-*c*

Spike at low p_T of Y(nS) likely due to non-prompt component from χ_b decays

χ_b feed-downs are ~same into all Y(nS)

It is clear, that lower *n* for excited quarkonia is due to a deficit at low and intermediate p_T

Middle - Predictions vs. measured ratios



Lines matched to data > 50 GeV

Significant discrepancies for excited bottomonia

Surprising for particles with close m_0 = 9.46, 10.02, 10.36 GeV

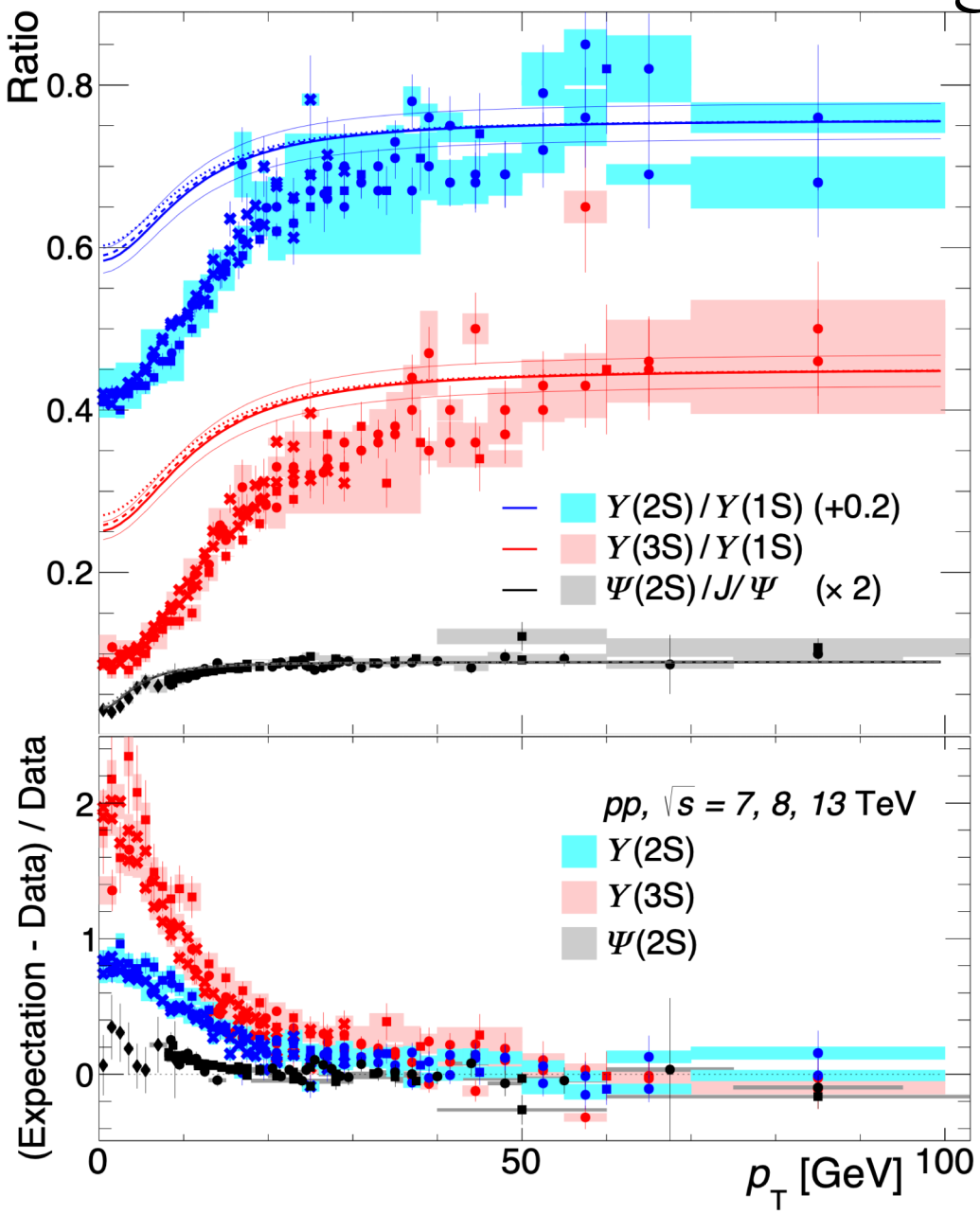
$$\text{missing} = \frac{\text{expected} - \text{measured}}{\text{measured}}$$

Weighted by the p_T spectra, scaling expects:

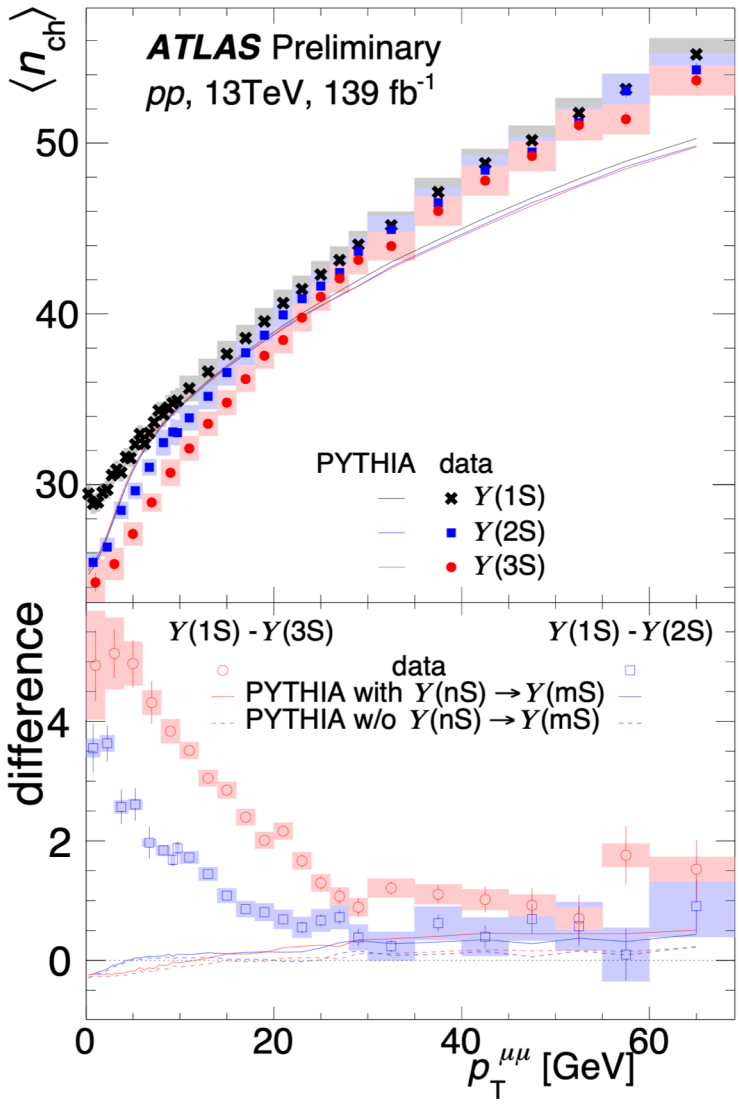
Y(2S) to be x1.6 the measured
Y(3S) to be x2.4 the measured

Ψ(2S) unclear at present statistics

End? - Striking similarity



ATLAS-CONF-2022-023



Summary

m_T - scaling works for light mesons and ground-state quarkonia at LHC-$\sqrt{s}$

Open flavor has harder spectra than other particles

Open-*b* is harder than open-*c*

Significant difference between m_T - scaling expectations and measured Y(nS) / Y(1S) ratios

Scaling expects Y(2S) to be 1.6 times larger than measured
Scaling expects Y(3S) to be 2.4 times larger than measured

Missing fraction looks like the number of missing tracks in ATLAS analysis

Are we seeing interaction of Y(nS) with the underlying event in *pp*?