Υ production as a function of charged-particle multiplicity in pp collisions at 13 TeV with ALICE

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PhD Day

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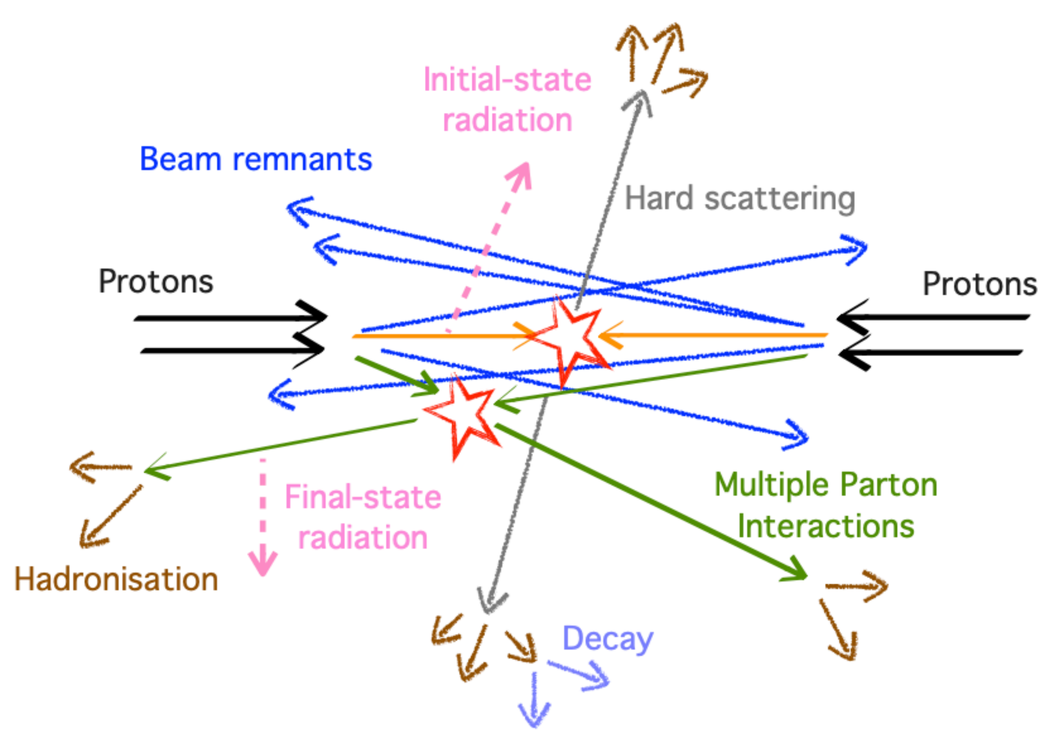
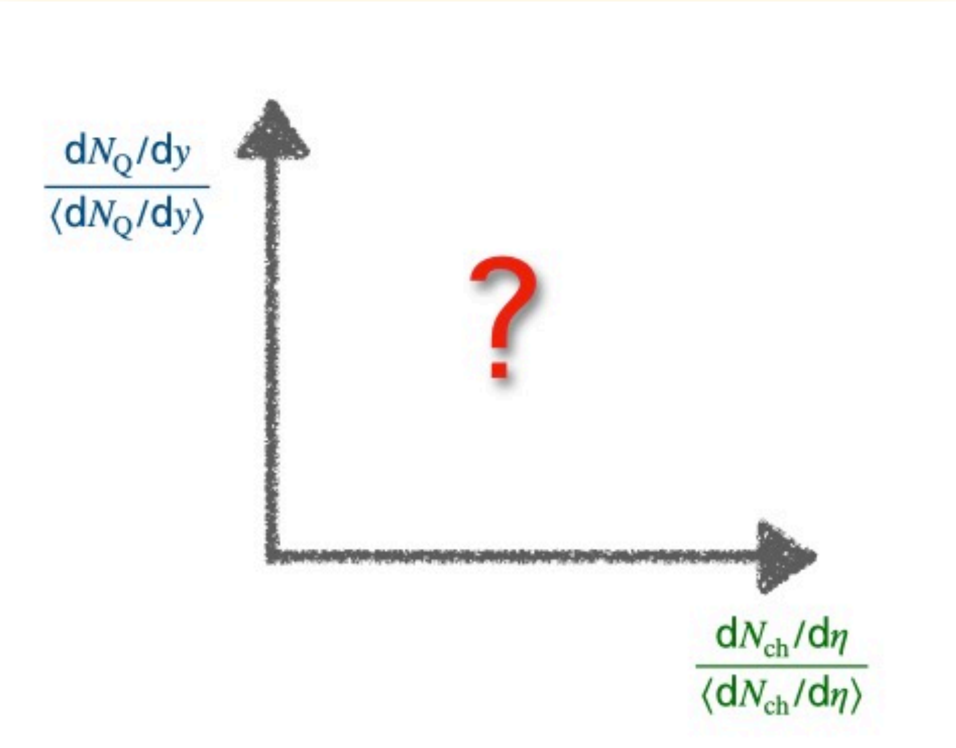
Introduction

Quarkonium(Q): bound states of a $c\bar{c}$ pair [J/Ψ, $\Psi(2S)$ ...] or a $b\bar{b}$ pair [$\Upsilon(1S)$, $\Upsilon(2S)$,$\Upsilon(3S)$ ...]

Charged-particle multiplicity(ch) dependence on quarkonium production in pp collisions:

- ➡ Understand particle production mechanisms (such as Multiple Parton Interactions (MPI))
- ➡ Provide insight into the interplay between soft and hard processes





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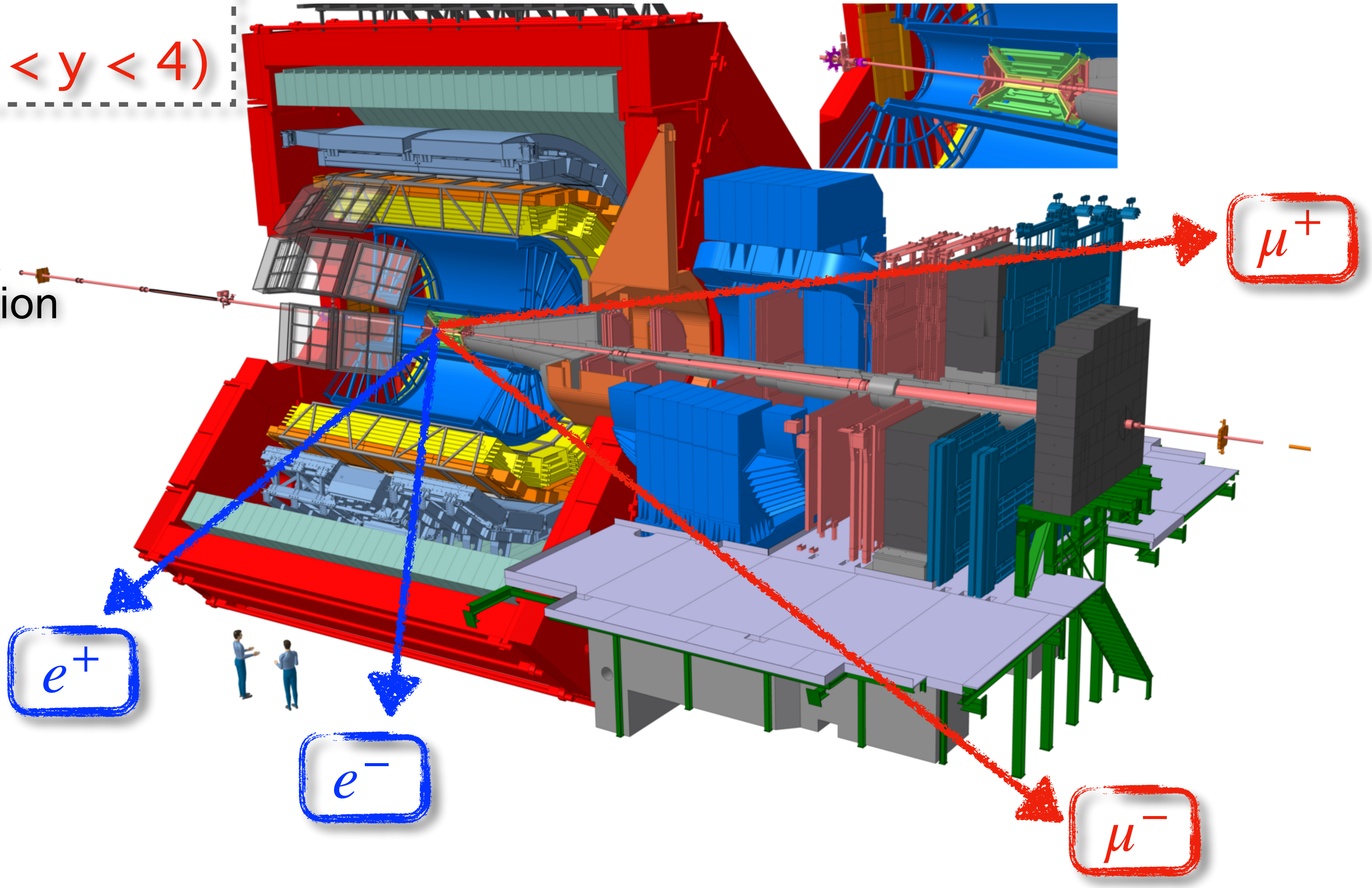
The ALICE detector

$J/\Psi \rightarrow e^{+}e^{-}$, $\mathrm{HF} \rightarrow \mathrm{e}$ ($|y| < 0.9$)

$J/\Psi, \Psi(2S), \Upsilon(nS) \rightarrow \mu^{+}\mu^{-}$, $\mathrm{HF} \rightarrow \mu$ ($2.5 < y < 4$)



Inner Tracking System

- Tracking, vertexing and multiplicity estimation

Time Projection Chamber

- Tracking and PID

Time-of-Flight detector

- PID

Electromagnetic Calorimeter

- Trigger and PID

V0 detectors

- Trigger and event characterisation

Muon spectrometer

- Muon tracking and muon triggering
- Heavy flavours, W/Z bosons and low mass resonance measurement

Analysis strategy

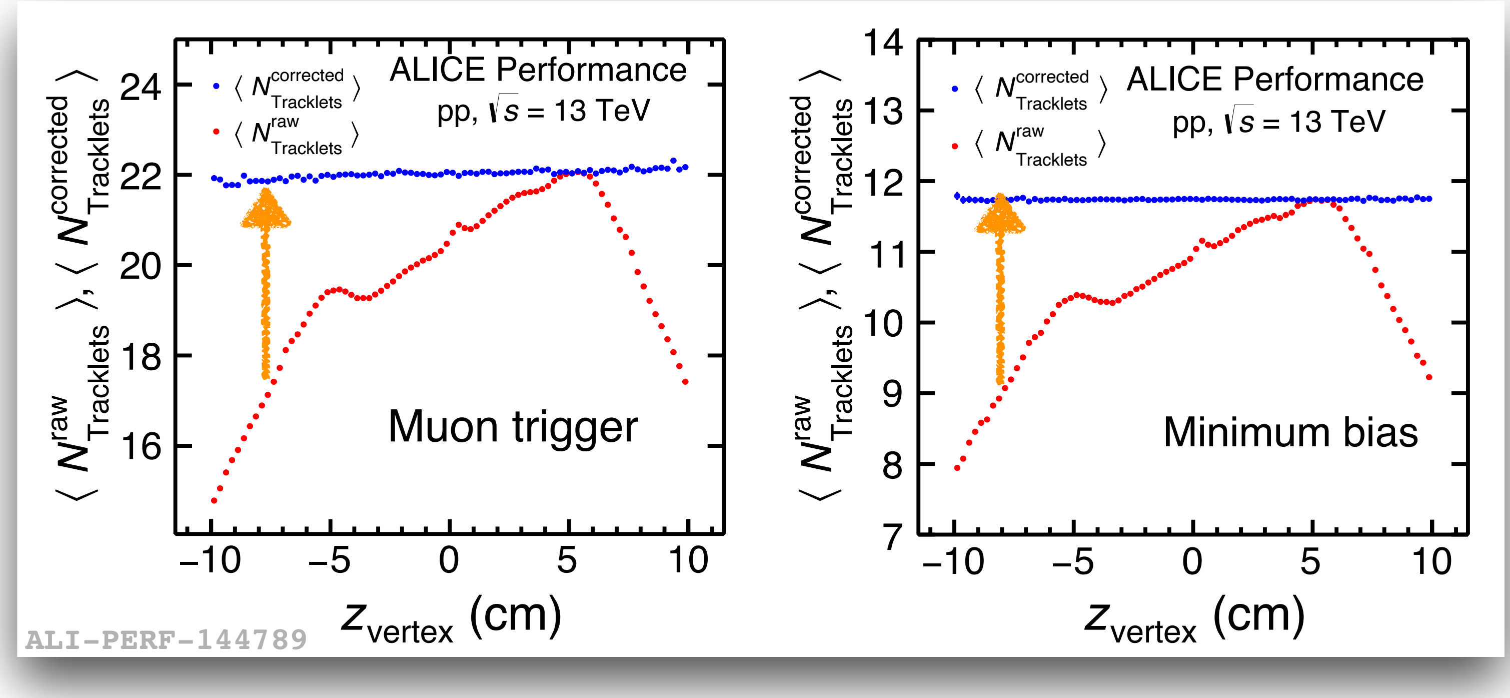
Multiplicity estimation — SPD tracklets (the two innermost ITS layers)

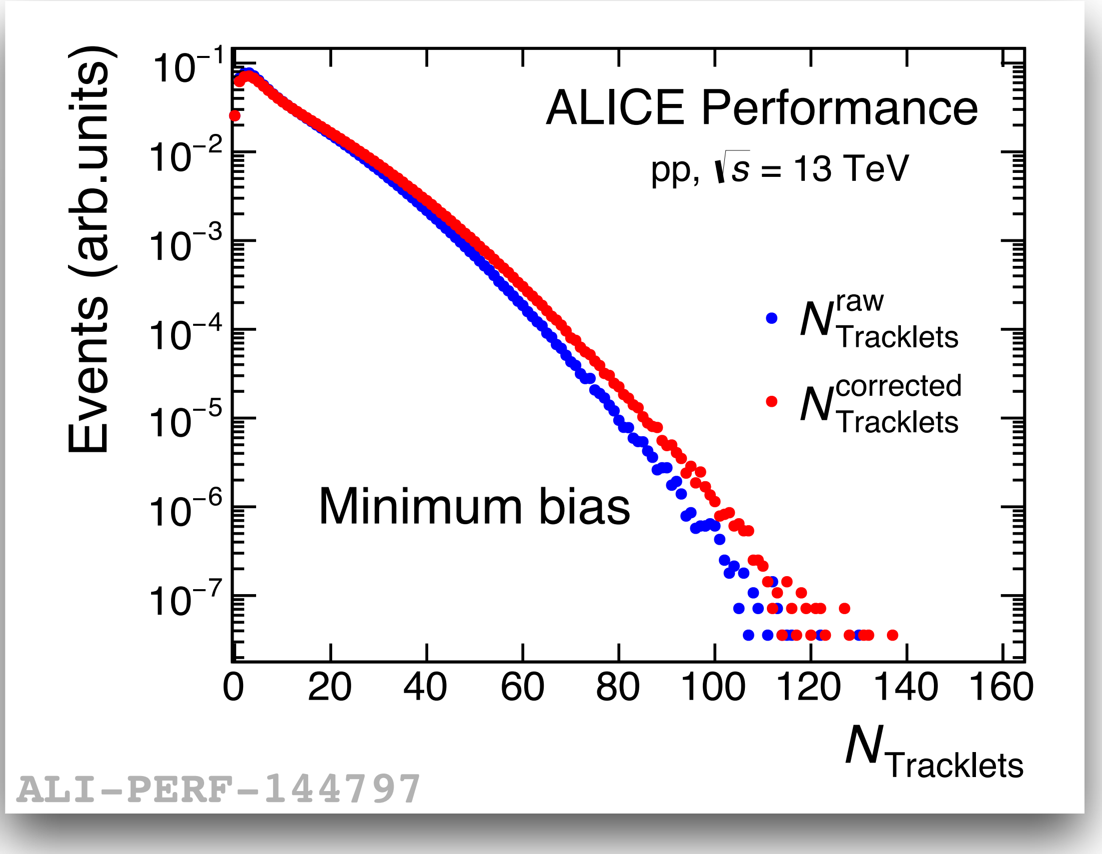
1) $N_{\mathrm{trk}} \rightarrow N_{\mathrm{trk}}^{\mathrm{corr}}$

- The multiplicity estimation is affected by the detector inefficiency: strong effect as a function of primary vertex z position
- Correct for the detector inefficiency

(Un)corrected N_{trk} distribution

(Un)corrected $< N_{\mathrm{trk}} >$ vs. z_{vertex}



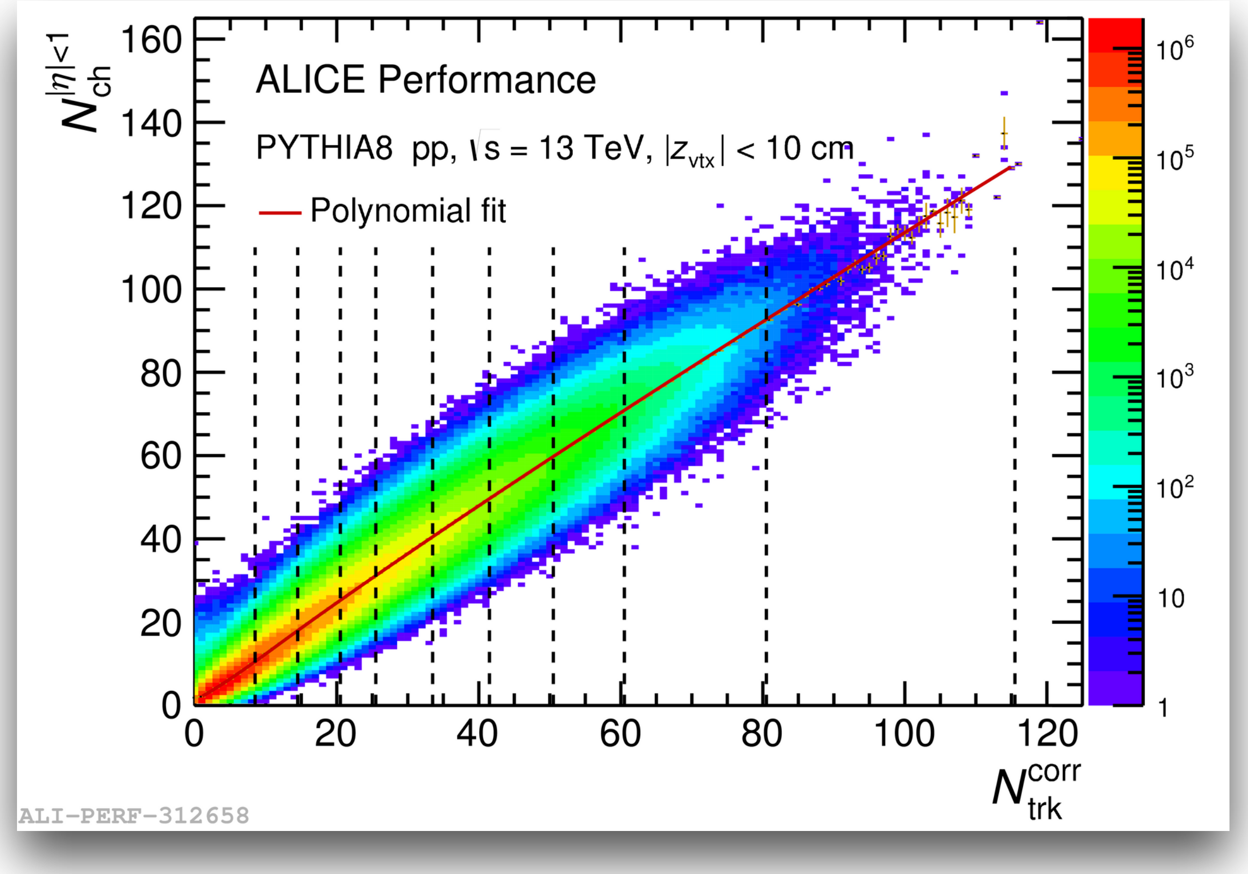


Analysis strategy

Multiplicity estimation — SPD tracklets (the two innermost ITS layers)

2) $N_{\mathrm{trk}}^{\mathrm{corr}} \rightarrow N_{\mathrm{ch}}$

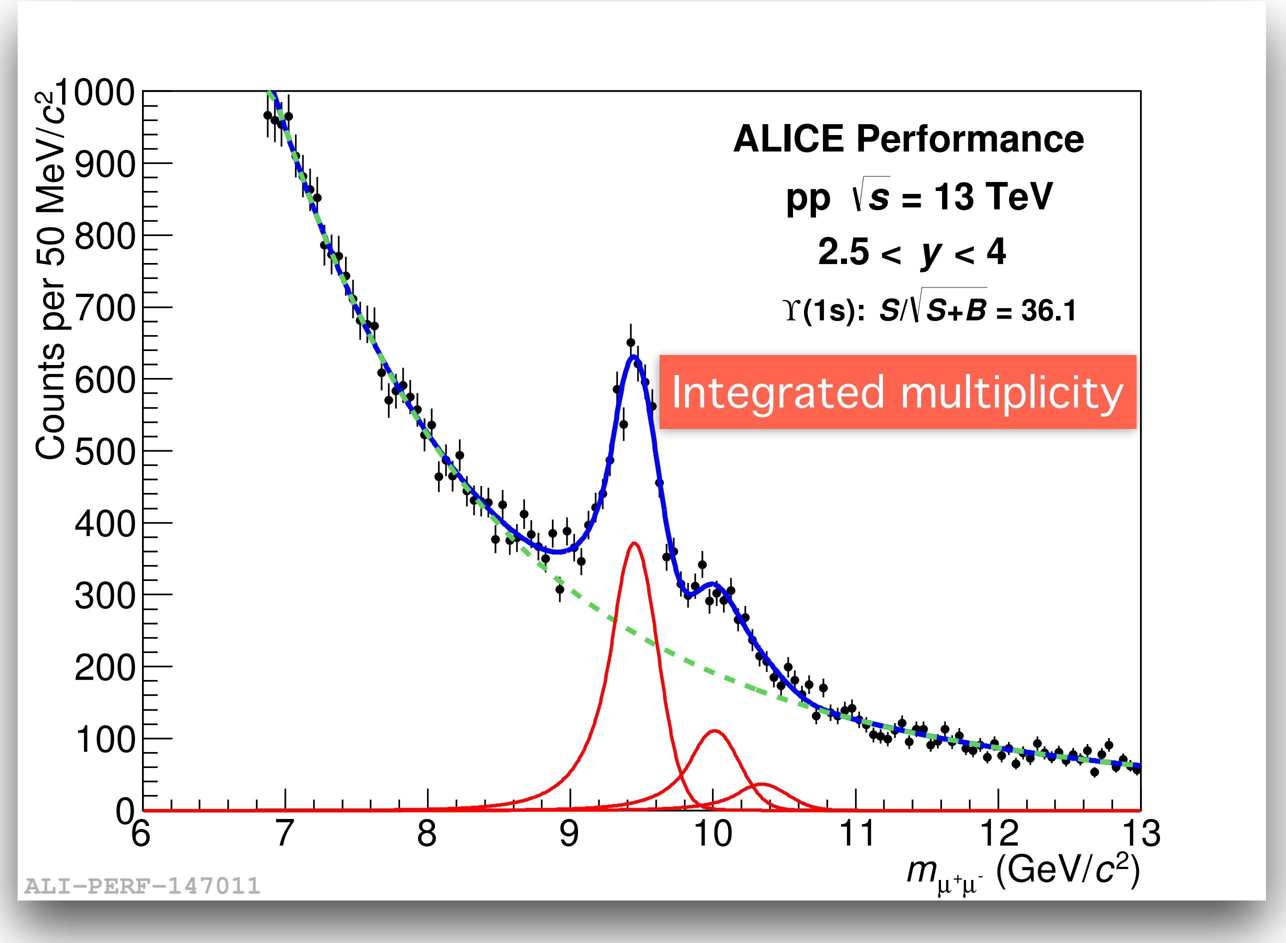
- Tracklet-to-charged particle conversion: $\langle N_{\mathrm{ch}} \rangle = f(\langle N_{\mathrm{trk}}^{\mathrm{corr}} \rangle)$



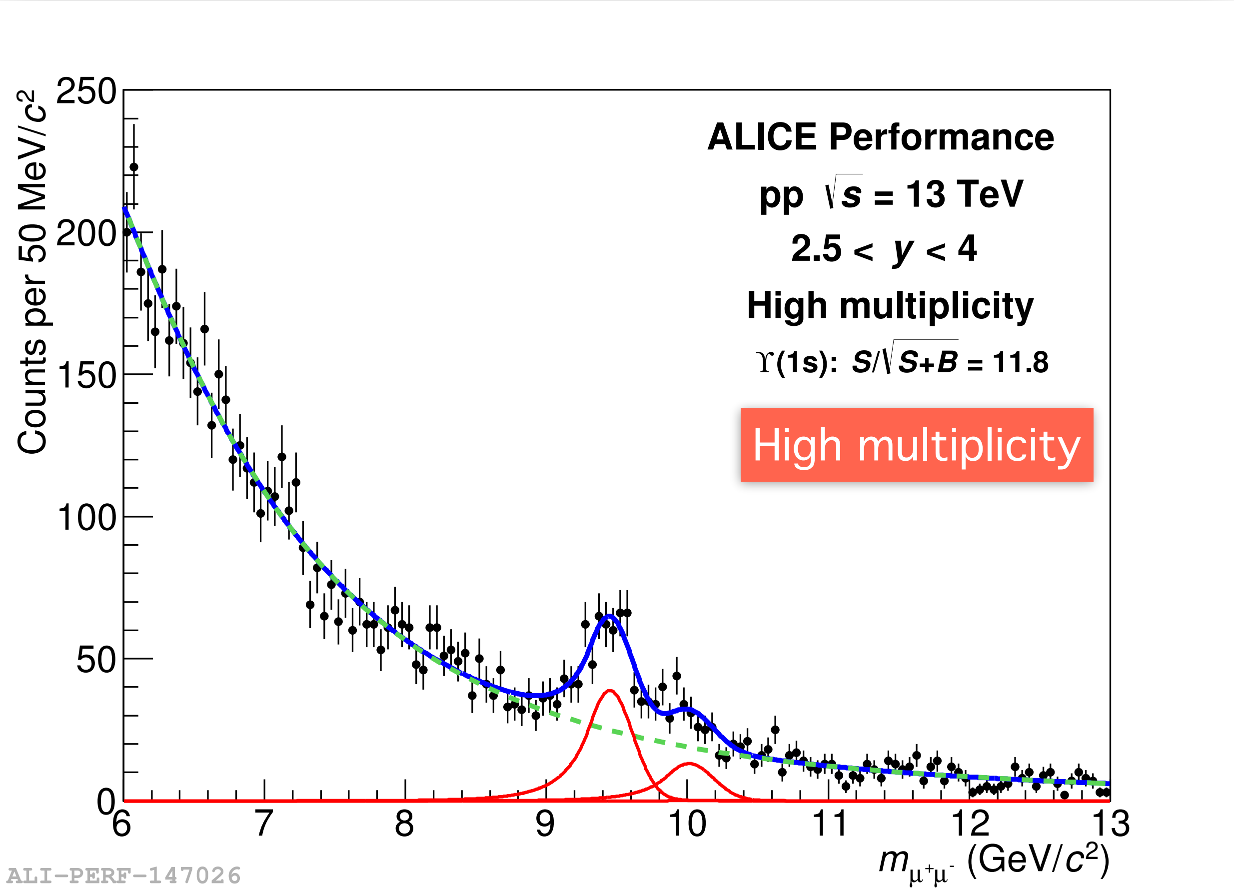
➡ The correlation between the corrected tracklet multiplicity $N_{\mathrm{trk}}^{\mathrm{corr}}$, and the number of primary charged particles N_{ch} is determined via a Monte Carlo simulation based on the PYTHIA8 generator

Analysis strategy

Signal extraction



Integrated multiplicity



High multiplicity

- ➡ Clear Υ(nS) signal peaks are observed at forward rapidity in the dimuon invariant mass distribution
- ➡ A combined fit is applied to disentangle signals and background

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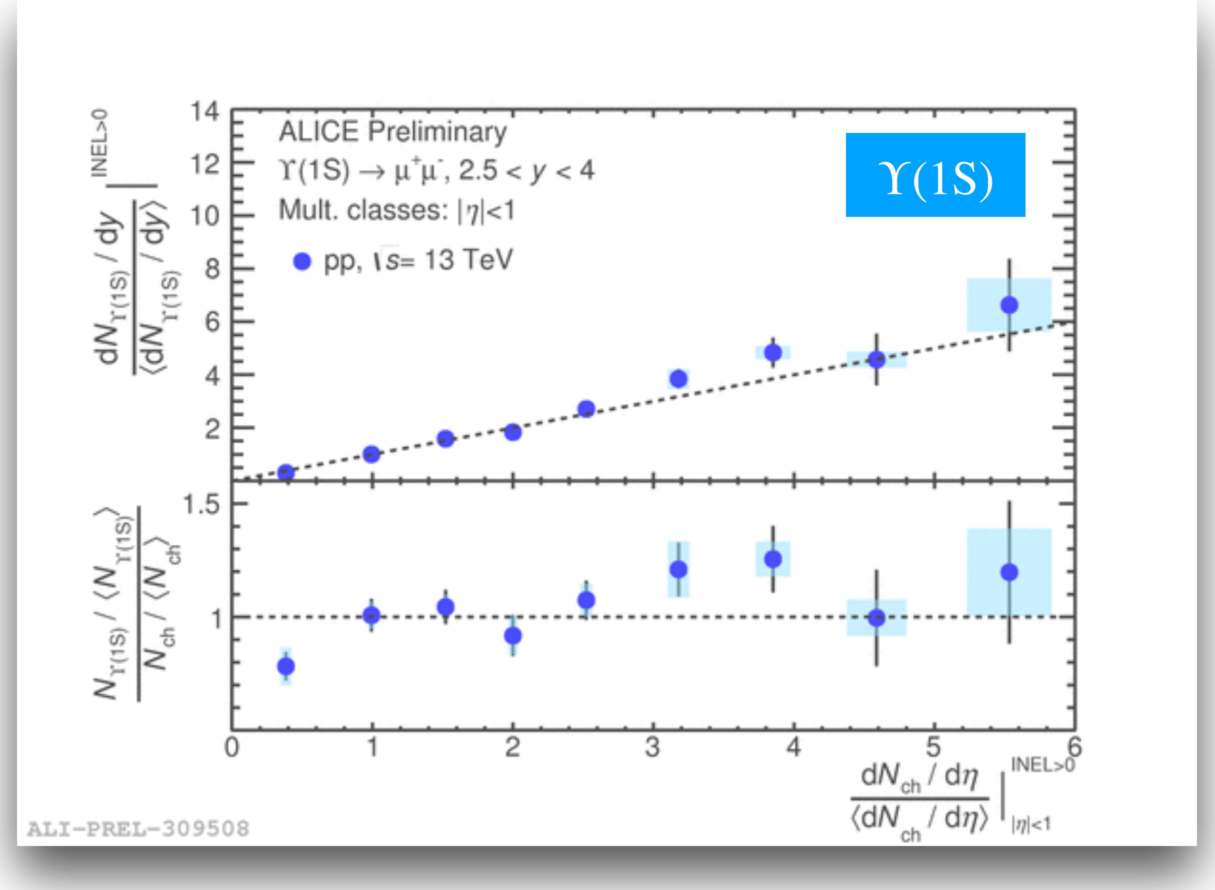
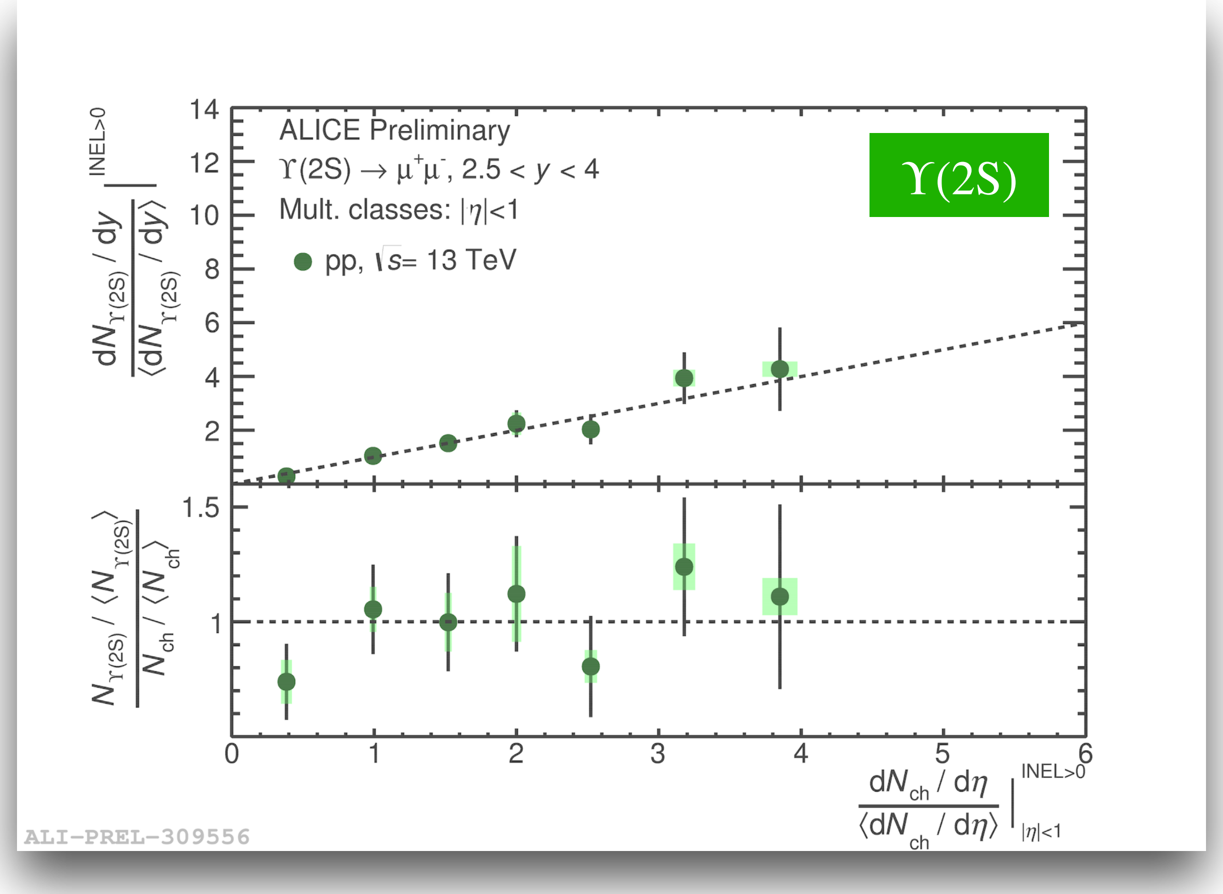
$\Upsilon(1S)$ and $\Upsilon(2S)$ production vs. multiplicity

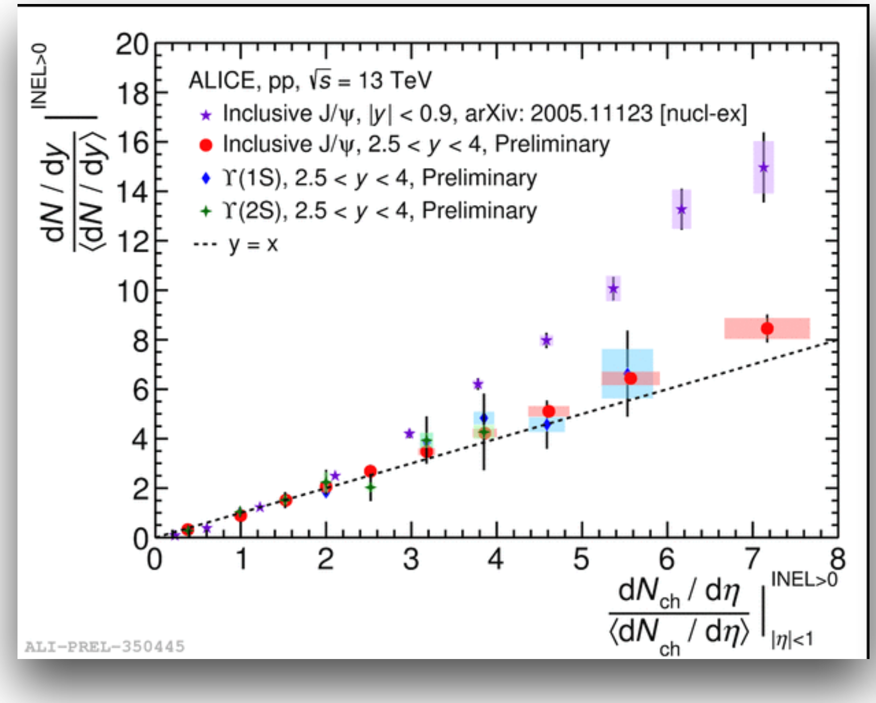


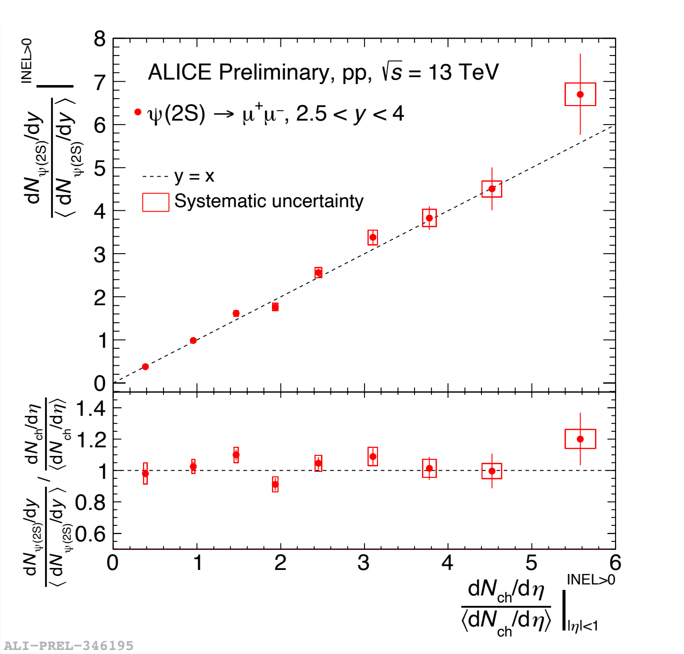


- ➡ Self-normalised yield of $\Upsilon(1S)$ and $\Upsilon(2S)$ at forward rapidity (only 2016 data sample): compatible with linear dependence on multiplicity with uncertainties
- ➡ Full LHC RUN2 $\Upsilon(nS)$ (including 3S state) results coming soon

Multiplicity dependent quarkonium measurements

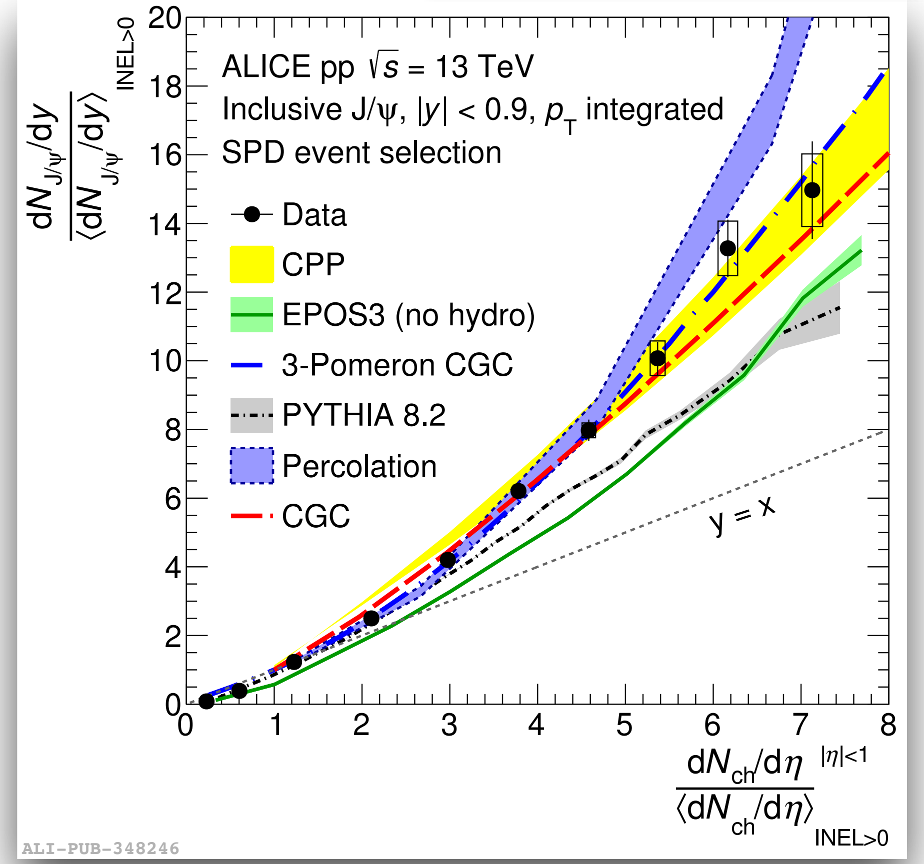
Multiplicity: measured at mid-rapidity $(|\eta| < 1)$





- ➡ J/Ψ and Ψ(2S) self-normalised yield at forward rapidity: compatible with linear dependence on multiplicity within uncertainties (consistent with bottomonium)

Phys. Lett. B (2020) 135758



- ➡ J/Ψ self-normalised yield at mid-rapidity: stronger than linear with multiplicity
- ➡ The trend of data is fairly described by model predictions
- ➡ Good agreement with CPP, CGC and 3-Pomeron CGC models

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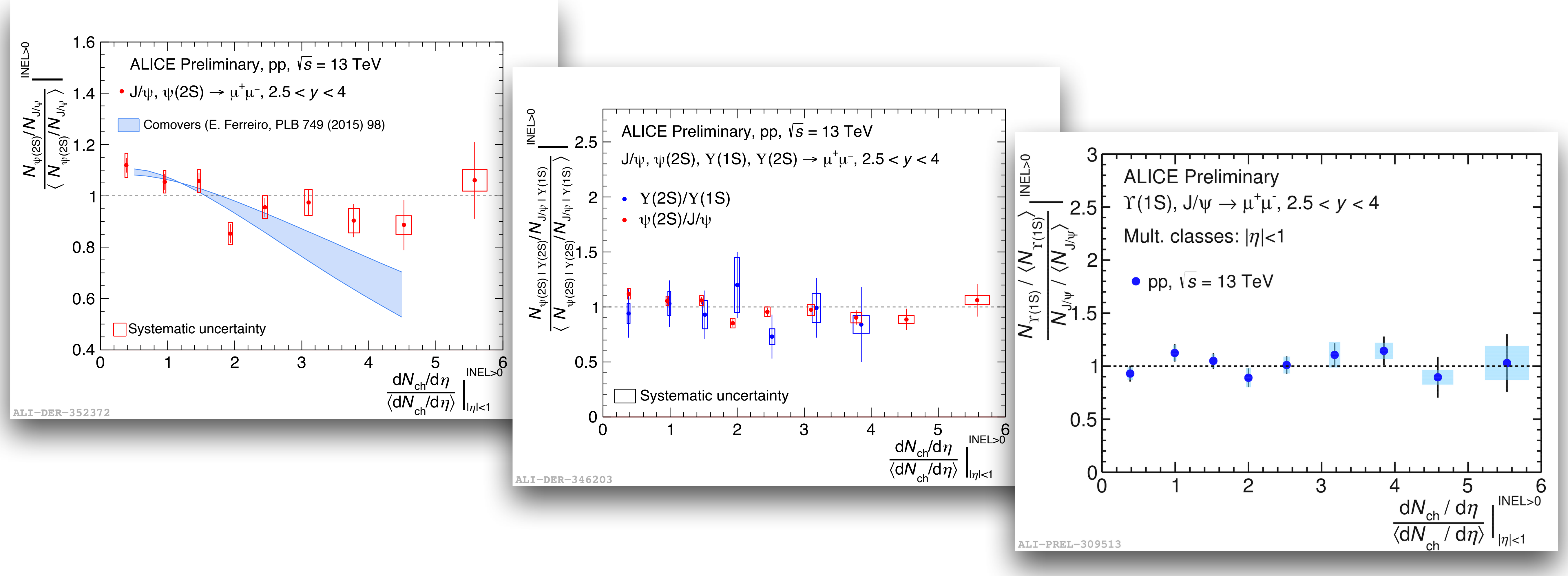
Self-normalised yield ratio vs. multiplicity



- ➡ $\Psi(2S)/J/\Psi$: maximum deviation from unity is around 2.2σ related to the first multiplicity bin
- ➡ The suppression is stronger in comover approach than in data at high multiplicity
- ➡ $\Upsilon(2S)/\Upsilon(1S)$ and $\Upsilon(1S)/J/\Psi$: compatible with unity within uncertainties (indicating no dependence on resonance mass and quark component)

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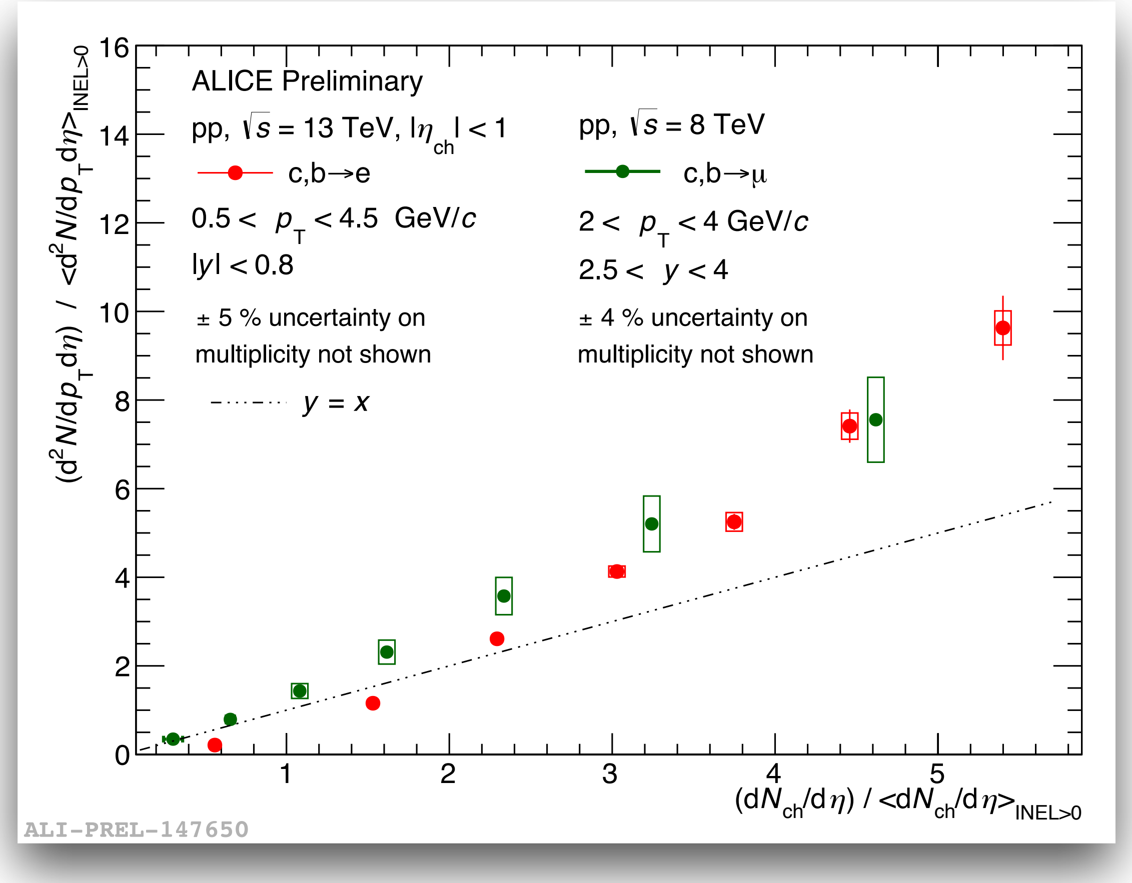
HFe and $\mathrm{HF}\mu$ production vs. multiplicity

Multiplicity: measured at mid-rapidity ($|\eta| < 1$)



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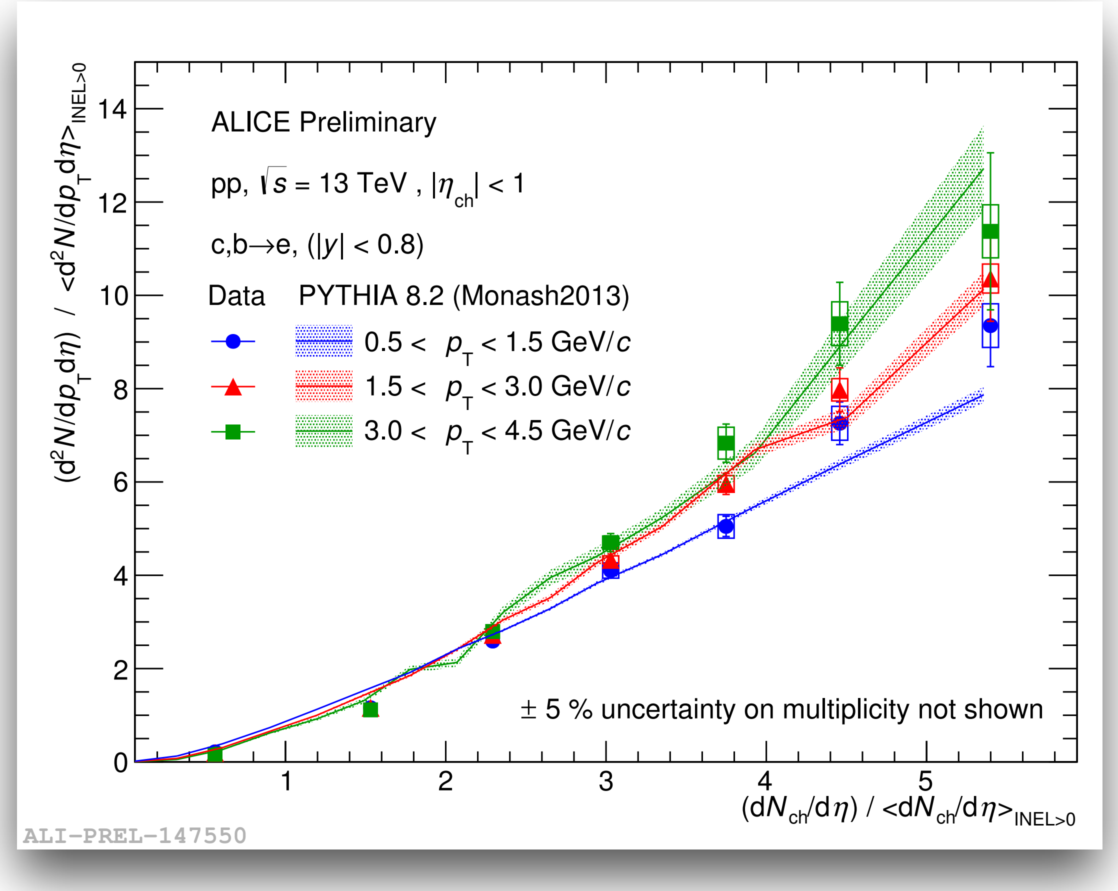
- ➡ Stronger than linear increase of open heavy-flavour hadrons decay leptons [$\mathrm{HF} \rightarrow \mathrm{e}$ (mid-rapidity), $\mathrm{HF} \rightarrow \mu$ (forward rapidity)]
- ➡ Unlike J/Ψ measurement

$\mathrm{HF} \rightarrow \mathrm{e}$

- ➡ A steeper increase at high p_{T}
- ➡ PYTHIA 8.2 including MPI effects well reproduces ALICE data in all p_{T} intervals



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Summary

Multiplicity dependence on quarkonia production:

- Rapidity dependence for J/Ψ production
- Compatible behaviour between charmonium and bottomonium at forward rapidity

Multiplicity dependence of excited state suppression:

- Predictions based on comovers approach tend to overestimate the $\Psi(2S)$ at high multiplicity
- Incoming more significant $\Upsilon(nS)$ results will improve the charmonium/bottomonium comparison

Multiplicity dependence on open heavy flavours production:

- Stronger than linear enhancement with charged-particle multiplicity

Υ production as a function of charged-particle multiplicity in pp collisions at 13 TeV

- Full LHC RUN 2 data sample is analysed
- Paper proposal has been accepted
- Paper will be published this year

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THANK YOU!