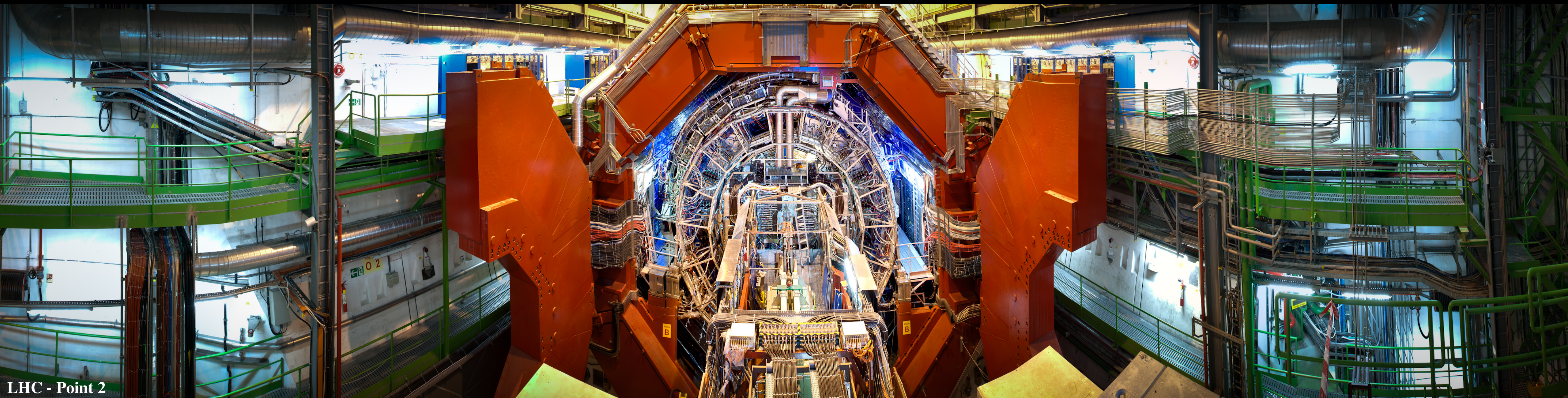


ALICE running at full pp energy - run 3 and 4

$J/\psi \rightarrow ee$ inputs for discussion



LHC - Point 2

Antoine Lardeux, Ionut Arsene
(University of Oslo)

Recall of the context

Presentation by Maximiliano Puccio at the last ALICE Physics Week in Prague ([link](#))

- Large ALICE upgrades during LS2
- Use of an Event Processing Nodes **farm to select interesting events** (LHCb-like)
 - Farm size tunes for an interaction rate of 50 kHz in Pb-Pb (all events recorded)
 - Equivalent to an interaction rate of 4.5 MHz in pp
 - But we cannot afford to write everything on tape
 - Interaction rate **inspectable in pp** → **Baseline 1 MHz**
 - ✓ Run event selection algorithms (online triggers)
 - ➔ **Reduce the rate to tape down to 100 Hz - 1 kHz (rejection factor of 10 000 - 1 000)**

Dedicated session for discussion at the next ALICE week ([link](#)): Tuesday 27th - 16:15

Foreseen scenario

Precision measurement of rare observables relying on an **integrated luminosity of 200 pb⁻¹**

- Investigate extreme pp collisions with multiplicities up to peripheral Pb-Pb
 - ✓ **Record all high multiplicity events** equivalent to 0.01% of Minimum Bias events (rf = 10 000)
- Any possible online triggers based on physics cases and respective achievable statistics
 - ✓ Input request from Physics Coordination:
 - **trigger estimates with a rejection factor RF = 10 000**
 - **Perspectives for physics observables**

Looking for the ψ

Nevents: $\sim 1.3 \times 10^9$ kINT7 events

J/psi counts: 2150

All ee OS and LS pairs within the mass range 2.6-3.2 GeV: ~ 15000

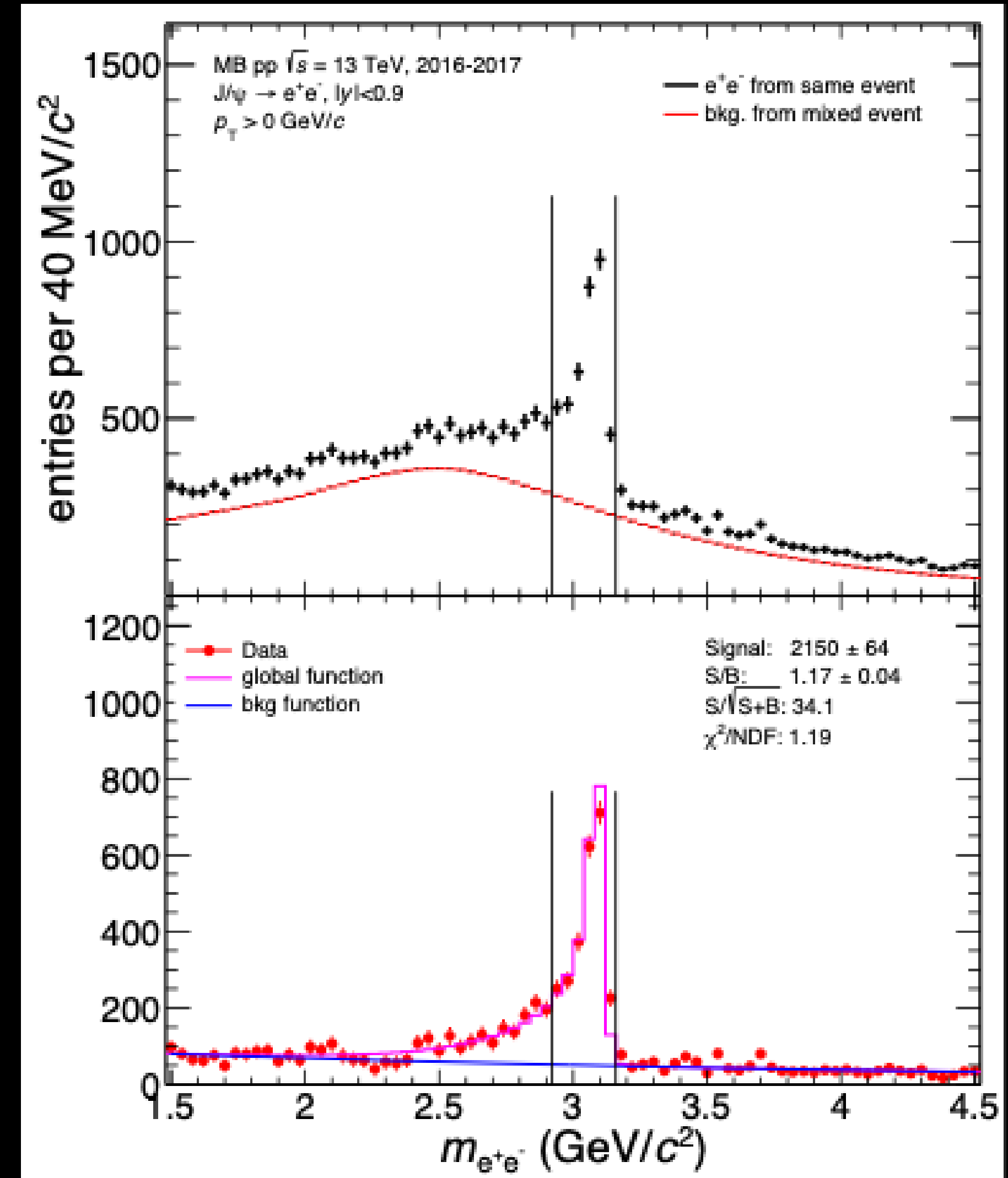
Rejection factor: $\sim 1.0 \times 10^5$!!

All ee OS and LS pairs in the mass range 3.2-3.8 GeV psi(2S): ~ 6000

Rejection factor: $\sim 2.0 \times 10^5$!!

Upsilon estimations ongoing

Ingrid



Charmonium physics: online trigger strategy

Using the farm and relying on:

- ▶ ITS vertexing
- ▶ Full TPC reconstruction
- ▶ **TPC PID evaluation** → online calibration using V0s (processing a small fraction of events)
 - PID calibration with V0 could be either something specific to this filtering, or could be done in a dedicated task

Event cuts :

- ▶ kINT7 (Physics Selection)
- ▶ Vertex: $-10 < z < 10$ cm ; at least one contributor
- ▶ Pile-up rejection
- ▶ **At least 2 tracks fulfilling the track cuts**

Track cuts :

- ▶ $-1 < \text{DCA}_{xy} < 1$ cm ; $-3 < \text{DCA}_z < 3$ cm ;
- ▶ $-0.9 < \text{eta} < 0.9$; $p > 1$ GeV/c ;
- ▶ ITS and TPC refit ; $N_{\text{cls}}^{\text{TPC}} > 70$; ITS $\chi^2 < 36$; TPC $\chi^2 < 4$
- ▶ **PID** (varied for RF estimates)

Pair cuts :

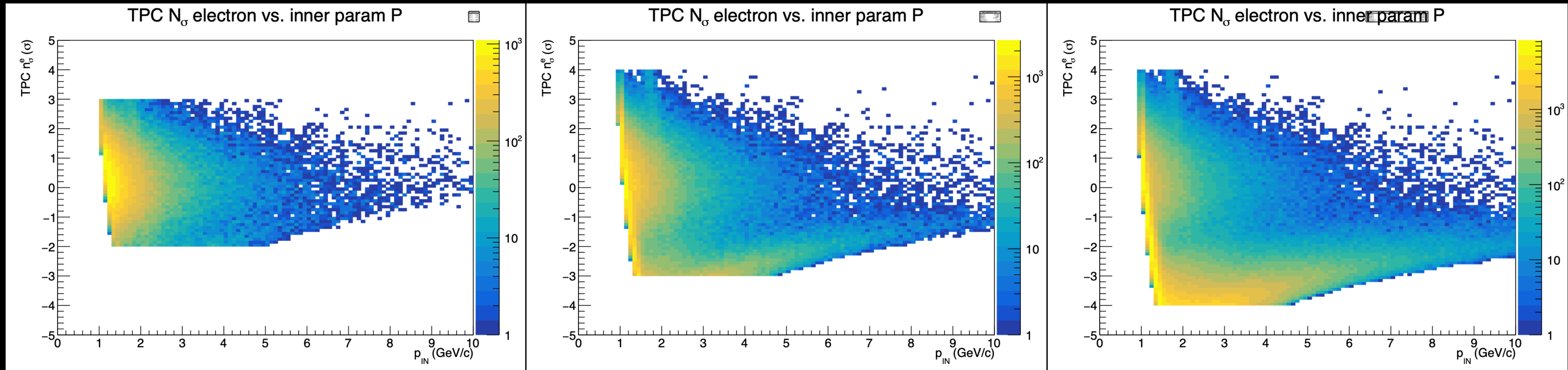
- ▶ $-0.9 < y < 0.9$
- ▶ **Invariant mass**
- ▶ p_T (might be used for larger RF)

Rejection factor estimates

Investigating in pp data at 13 TeV: run 288908 from LHC18i → **25.5 10⁶ kINT7 events**

► Estimates for:

- **J/ψ** state: invariant mass range cut **[2.6 ; 3.2] GeV/c²** (first look → to be tuned)
- **Different sets of PID selection to simulate different calibration conditions**



Looser cuts

Rejection factor estimates

Investigating in pp data at 13 TeV: run 288908 from LHC18i → **25.5 10⁶ kINT7 events**

► Estimates for:

► **J/ψ** state: invariant mass range cut **[2.6 ; 3.2]** GeV/c² (first look → to be tuned)

► **Different sets of PID**

└ inclusion band for electrons and exclusion for protons and pions

	PID sets	N_{evt} after cuts	Rejection Factor
Looser cuts ↓	$-2 < n_{\sigma}(e) < +3$, $n_{\sigma}(p) > 3$, $n_{\sigma}(\pi) > 3$	460	55 000
	$-3 < n_{\sigma}(e) < +4$, $n_{\sigma}(p) > 2$, $n_{\sigma}(\pi) > 2$	$1.06 \cdot 10^3$	24 000
	$-4 < n_{\sigma}(e) < +4$, $n_{\sigma}(p) > 1$, $n_{\sigma}(\pi) > 1$	$11.8 \cdot 10^3$	2 000
	$-5 < n_{\sigma}(e) < +5$, no p and π rejection	$0.45 \cdot 10^6$	57
	no PID selection at all	$5.15 \cdot 10^6$	5

the RFs are given for all pairs (LS and OS)

Rejection factor estimates

Investigating in pp data at 13 TeV: run 288908 from LHC18i → **25.5 10⁶ kINT7 events**

► Estimates for:

► **J/ψ** state: invariant mass range cut **[2.6 ; 3.2]** GeV/c² (first look → to be tuned)

► **Different sets of PID**

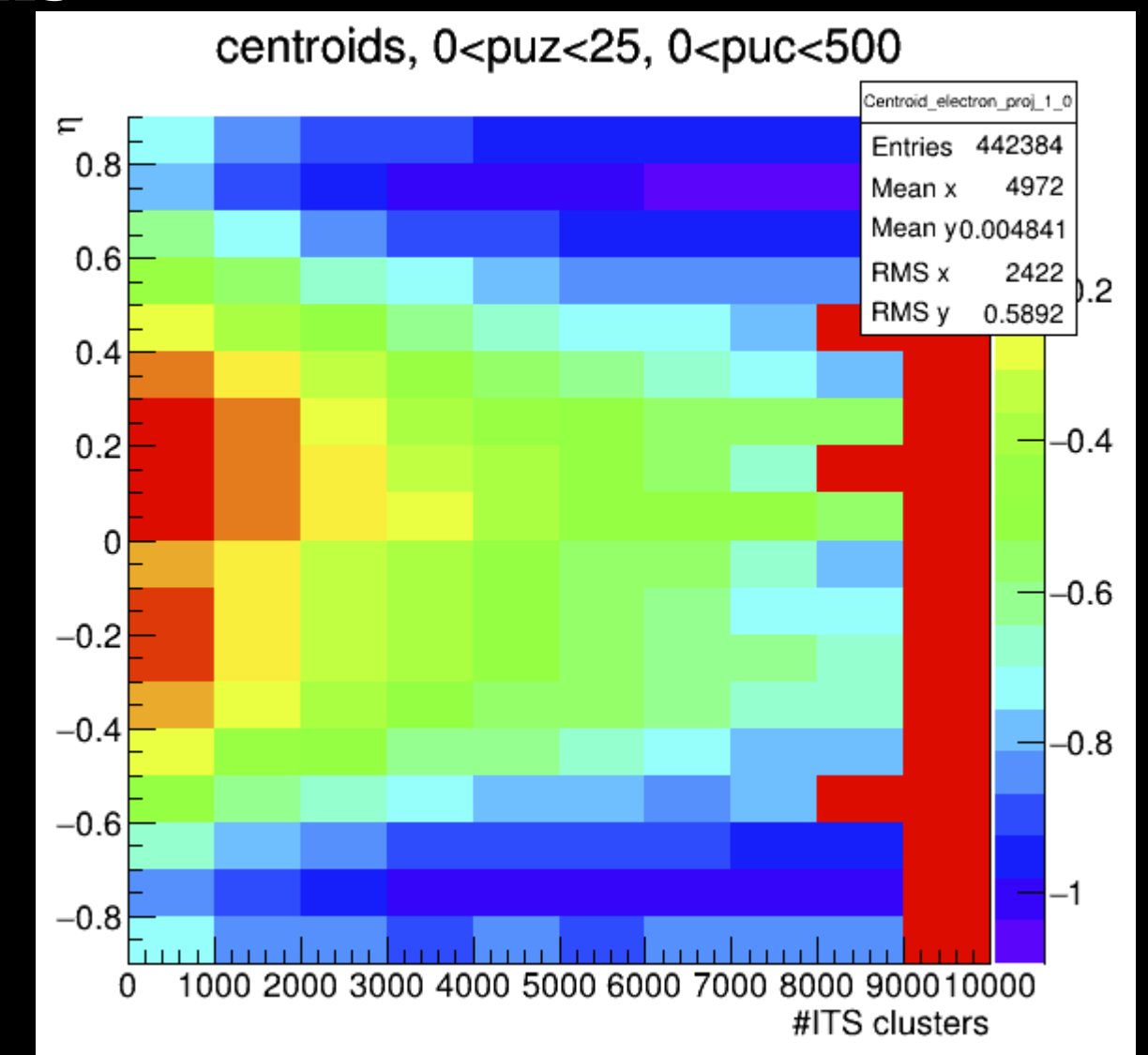
└─ inclusion band for electrons and exclusion for protons and pions

• In case of insufficient PID calibration:

- High pt cuts (drawback: lose competitiveness)
- Downscaling (drawback: less inspected lumi)
- Both of the above

• Relatively accurate TPC online PID crucial for “triggers” at low pt !!

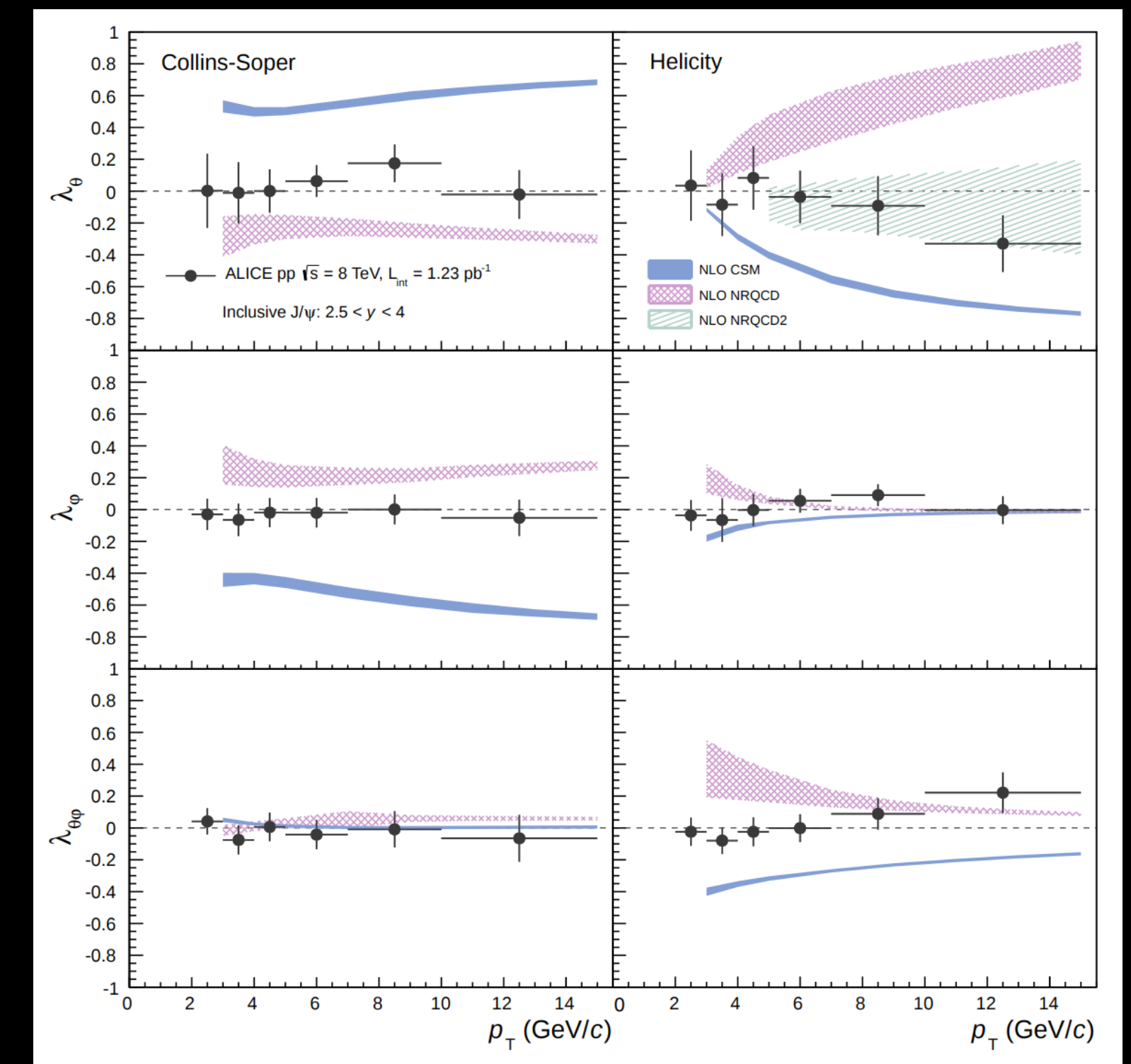
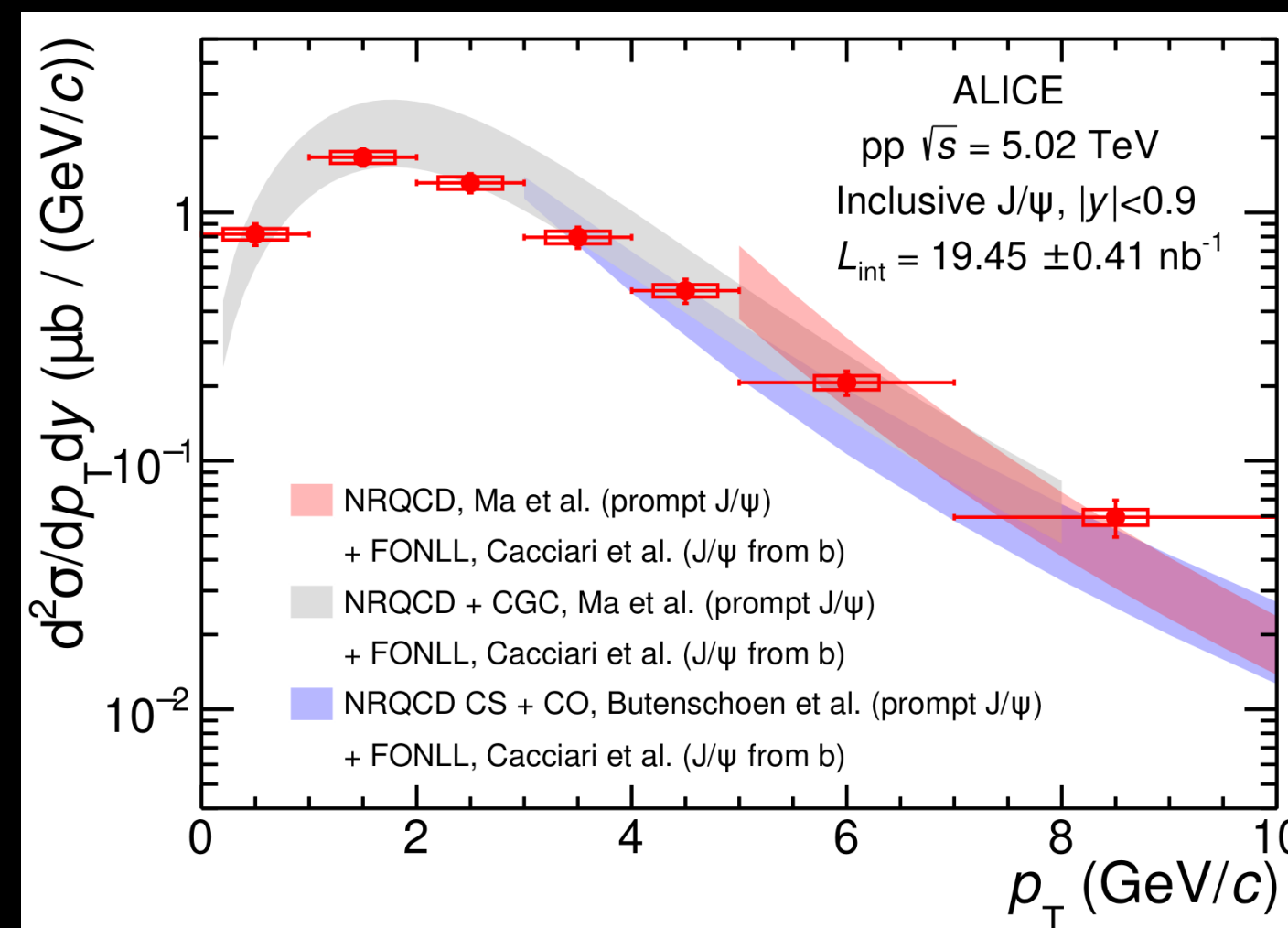
- Our group has experience in “post-calibrating” the TPC pid using conversion, K0s and Lambda topologies



Perspectives for physics observables

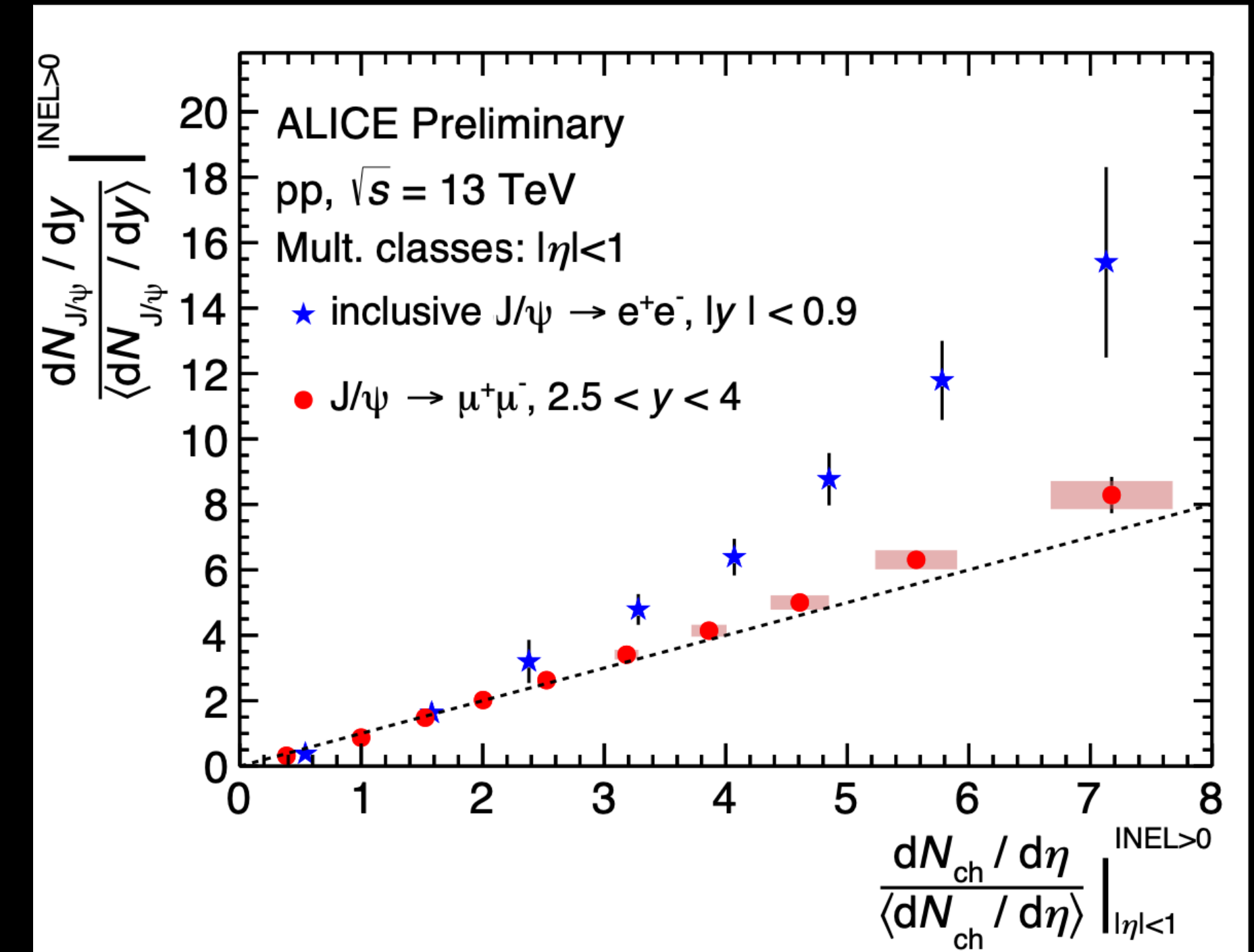
- The inspection of all of the 200 pb^{-1} would provide **$\sim 2.0 \times 10^7$ observed J/psi counts** and **$\sim 2.0 \times 10^5 \text{ psi}(2S)$**
 - “Infinite” statistics for looking into charmonium production mechanisms:
 - **prompt and non-prompt** measurements
 - **Polarization**
 - **J/psi - hadron (near-side) correlations**
 - **Associated J/psi production with jets, open heavy flavour,**
 - **Double J/psi production**
 - **Higher mass charmonia** decaying via J/psi (e.g. $\chi_c \rightarrow \text{J/psi} + \gamma$)
 - **Beauty physics** ($B^+ \rightarrow \text{J/psi} + K^+$)
 - **Exotics** (e.g. $X(3872) \rightarrow \text{J/psi} + \text{pions}$)
 - **Bottomonium measurements** at mid-rapidity

ALICE, EPJC78(2018)562



Perspectives for physics observables

- **Quarkonium production as a function of multiplicity**
 - Extension of current J/psi measurements in both multiplicity and pT
 - Prompt / non-prompt separation



- **Study of final state effects as a function of event multiplicity:**
 - Excited to ground state ratios vs multiplicity: e.g. psi(2S) / psi(1S)
 - J/psi - hadron flow-like correlations