Update on Υ(nS) cross section in pp @ 13TeV

Recap:

1. Υ(1S,2S) p_T (< 15 GeV/c) and y differential yields were approved during HP2023 approvals
2. Υ(3S) was not approved at all
3. Link to AN:https://alice-notes.web.cern.ch/node/1371 (to be updated)

Focus of this talk:

1.Υ(3S) cross sections
2. Plan for convergence to paper

Subikash Choudhury, SINP

Physics Motivation and Analysis details

Physics Motivation

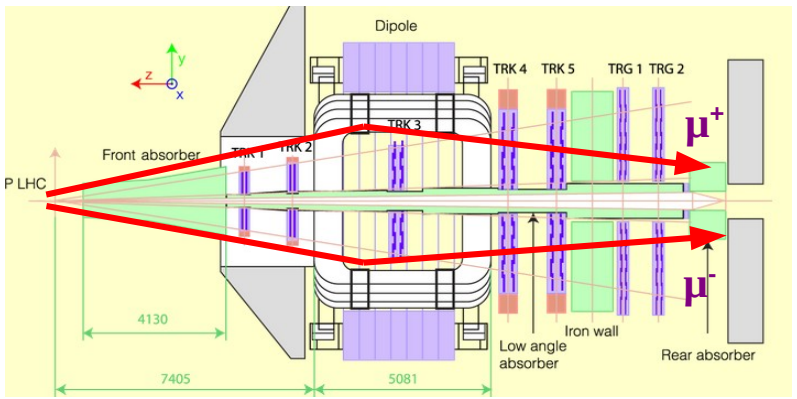
➢ Highest statistics data set for Run 2 facilitates finner and precise measurements of upsilon production cross-sections

➢ Larger statistics will allow measurements of Y(2S) and Y(3S) differential cross-section in more granular p_T and y bins for the first time in ALICE

➢ Measurement of ratios of Y(2S)/Y(1S) and Y(3S)/Y(1S) cross-sections as a function of p_T and y bins will be done for the first time in ALICE

➢ Facilitate more stringent test QCD, in particular pQCD

➢ Benchmark for RUN3 analyses that has undergone paradigm change in hardware and data-taking and complementary to LHCb



Trigger selection : CMUL7-NOPF-MUFAST

Physics selection : kMuonUnlikePt7 (LHC17 and LHC18) or kMUU7 (LHC16)

Total Analysed Events: ~647 M

Single muon track selection

1. Muon tracking-trigger matching.
2. $-4.0 < \eta_\mu < -2.5$
3. $17.6 < R_{abs} < 89$ cm
4. pDCA cuts

Muon pair selection

1. $2.5 < y^{\mu+\mu-} < 4$
2. Opposite sign charges
3. $0 < p_T < 30$ GeV/c

Signal Extraction

1. Obtain di-muon invariant mass spectra
2. MC and Data driven tail parameter extraction
3. Fit mass-spectra with fixed tails and obtain parameters of interest
4. Acceptance and Efficiency corrections

Basics Signal Extraction

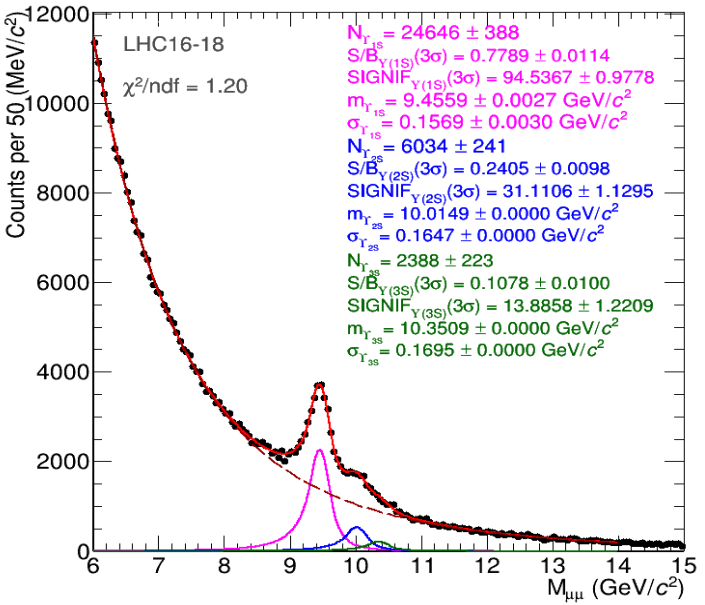
Fitting function:

- **Signal: Crystal Ball (An exponetial tail + Gaussian core)**
- **Background: DE, DP, VWG (Pl. See back up)**
- **Fitting Range: [6.0,14.0] (typical)**

Parameter initialization and constrains:

- **Mass of Υ_{1s} is kept free**
- **Sigma of Υ_{1s} is kept free**

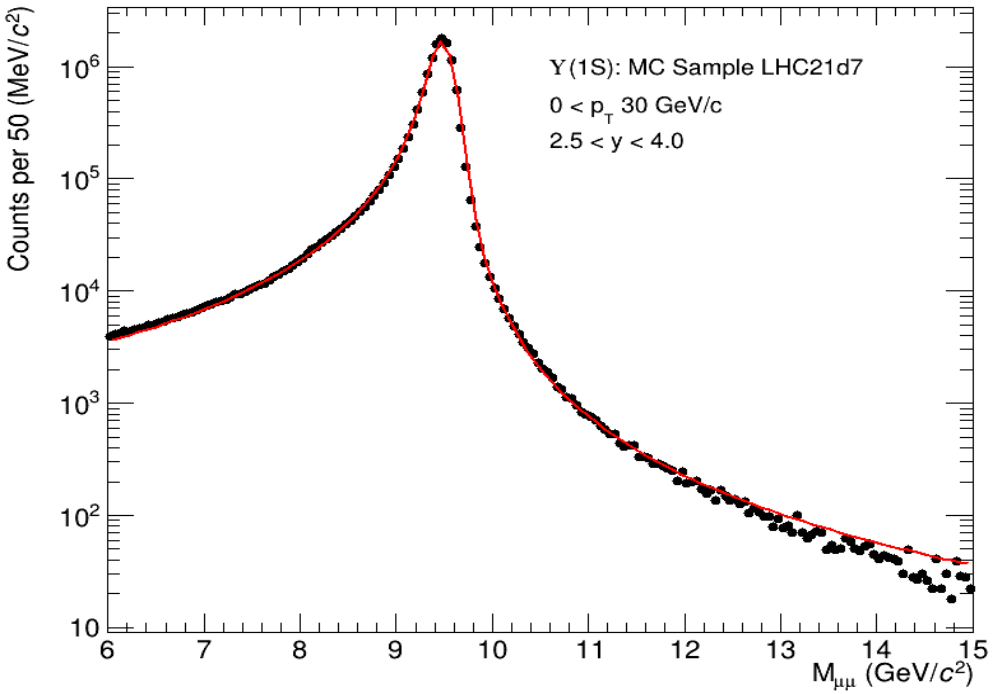
$$m_{\Upsilon(nS)} = m_{\Upsilon(1S)} + \left(m^{\mathrm{PDG}}_{\Upsilon(nS)} - m^{\mathrm{PDG}}_{\Upsilon(1S)}\right), \quad \sigma_{\Upsilon(nS)} = \sigma_{\Upsilon(1S)} \times \frac{\sigma^{\mathrm{MC}}_{\Upsilon(nS)}}{\sigma^{\mathrm{MC}}_{\Upsilon(1S)}}$$



Tail Extraction from MC[LHC21d7]

-Invarient mass distribution is -fitted with CB
-No background
-p_T and rapidity inclusive

α_L	1.016
n_L	2.035
α_R	2.063
n_R	2.247



Tail Extraction from data (systematics)

Data driven

1.A bkg function is fitted excluding at least ±5σ around Υ_{1s} mass peak

2.Bkg+Gaus is fitted excluding Υ_{2S} and Υ_{3S}

3.Bkg+1CB2 taking mass and σ of 1s from step2, excluding 2s and 3s, and bkg params are fixed

4.Bkg + 2CB2 excluding 3s, bkg params fixed

5. Bkg + 3CB2, bkg params fixed

6. Mass and sigma of Υ_{1s} and, tail parameters are always kept free

Systematics are done repeating 1-5 for following conditions

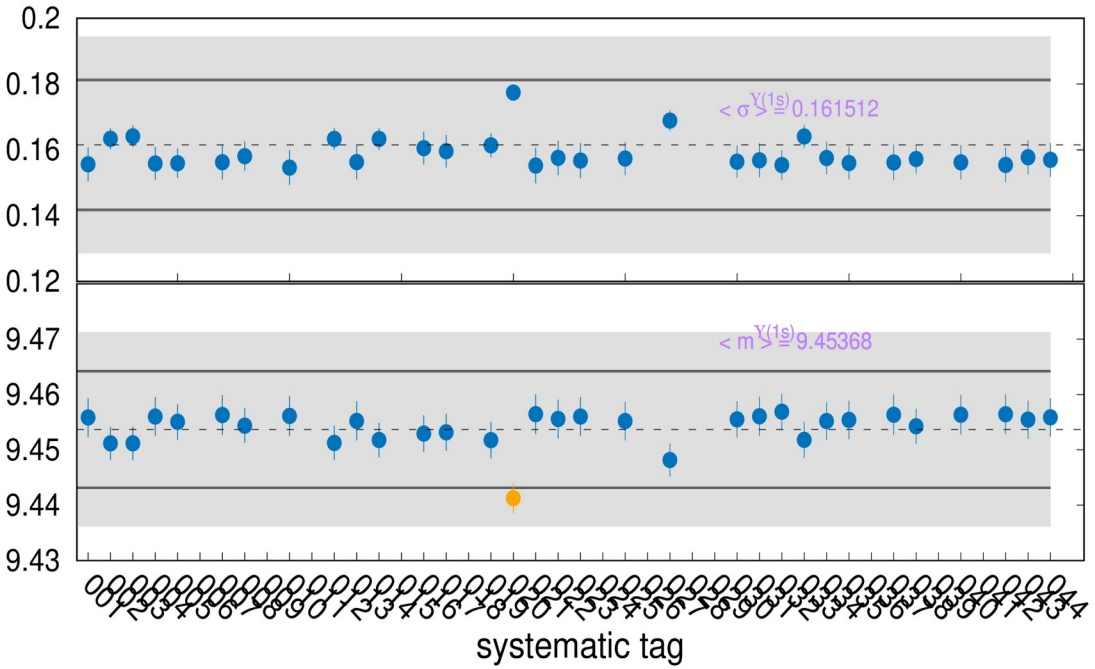
Bkg Functions	1. Double Exponential 2. Sum of two power law 3. Variable Width Gaussian
Fit ranges	6-13, 5-14, 7-12, 7-14, 5-12
Exclusion region around Υ_{1s} mass peak	±5σ, ±6σ, ±8σ

Tail Parameters (data summary)

Data driven tail parameters are extracte
averaging over those fits with:
Fit status = 0 and cov. matrix status =3

α_L	0.807
n_L	3.369
α_R	1.228
n_R	3.738

No explicit cut over χ^2/ndf is applied

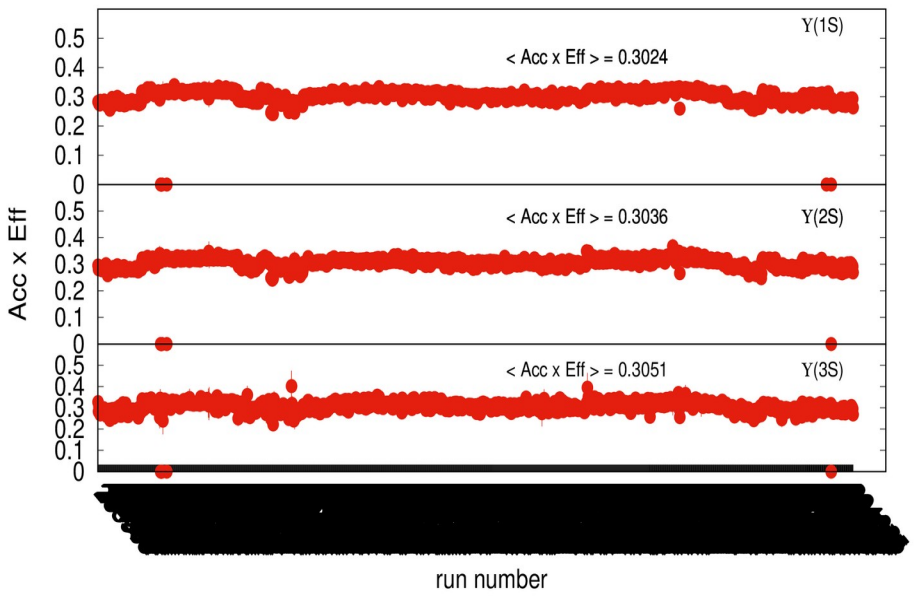


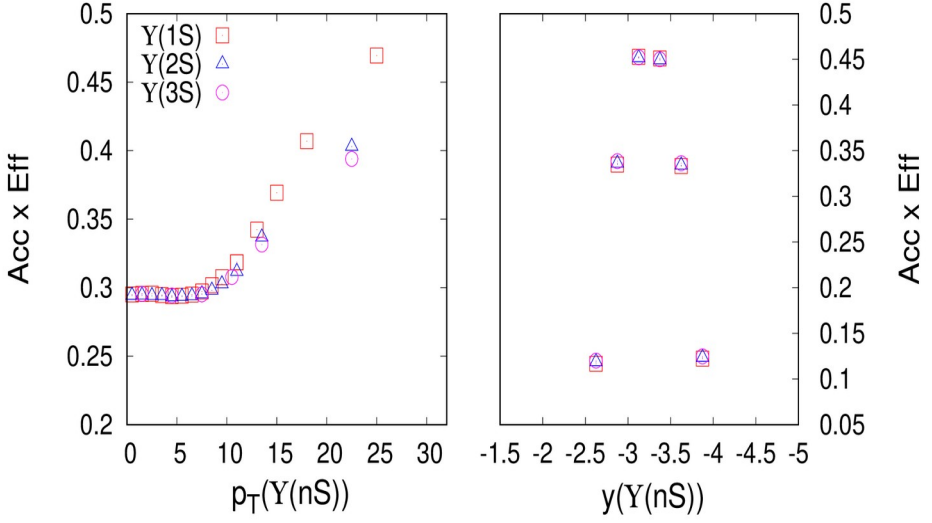
Mass and σ of Υ_{1s} of corresponding fits

Acceptance and Efficiency corrections (Υ_{ns})

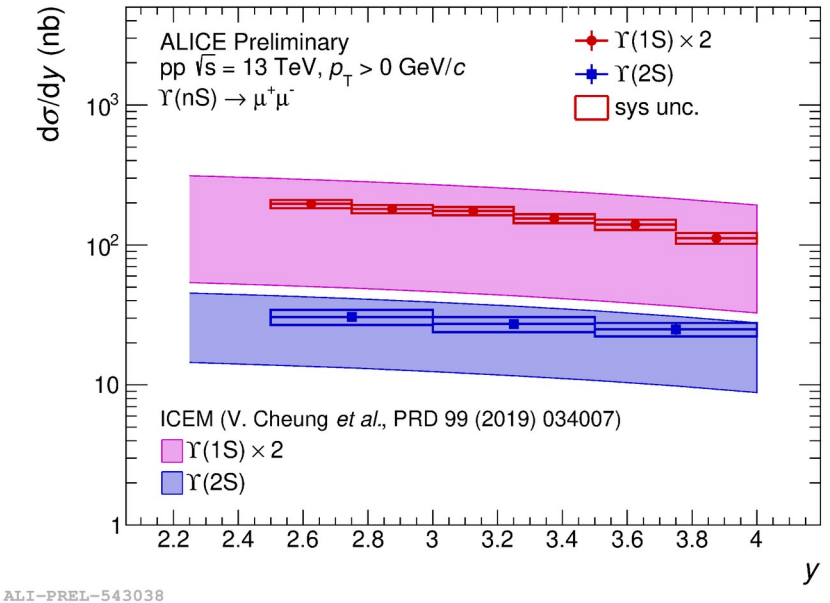
MC sample:
tuned on LHCb data @ 13TeV
LHC21d7
LHC22d4

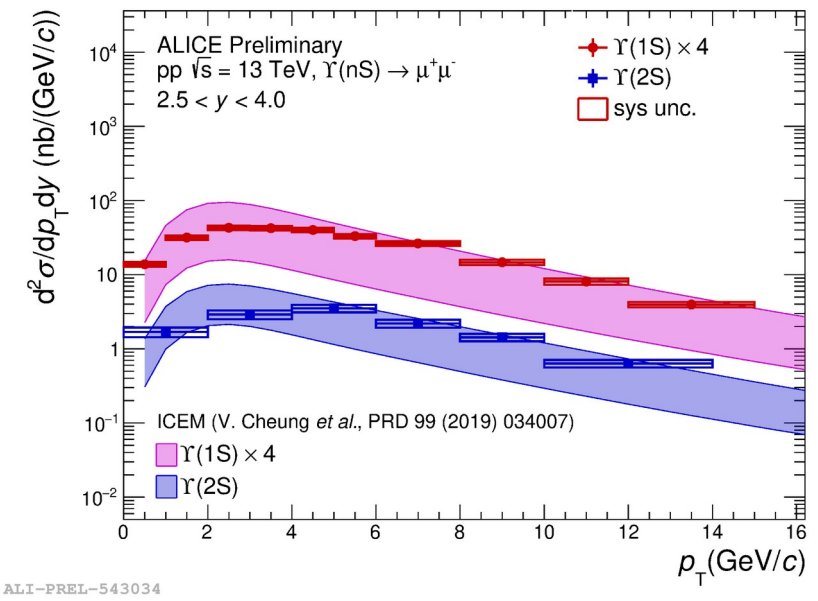
$$< A\varepsilon >= \frac{N_{\text{reconstructed}}}{N_{\text{generated}}}$$





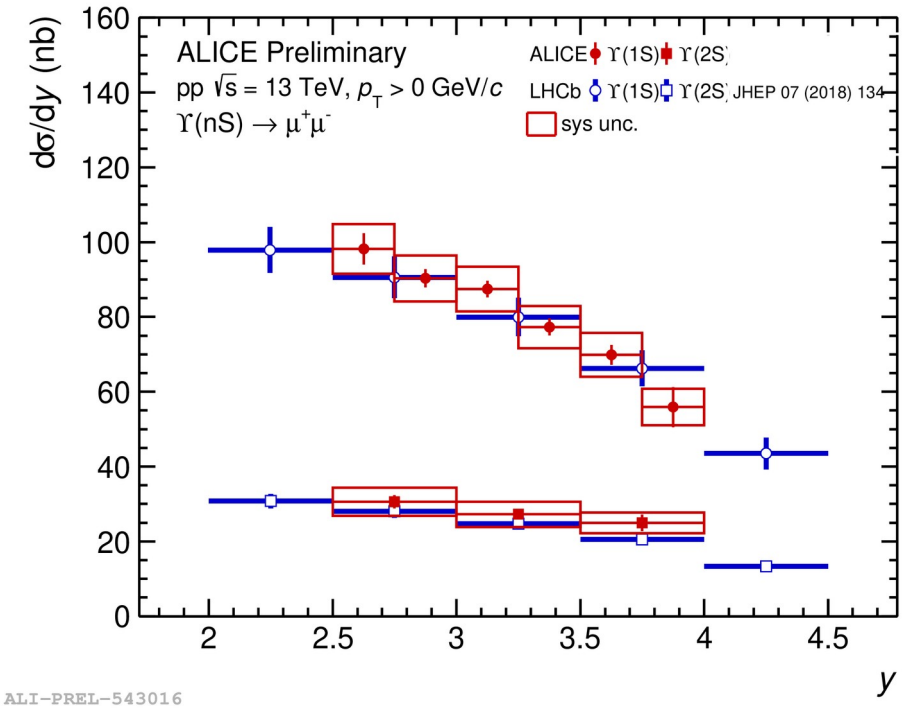
Preliminaries

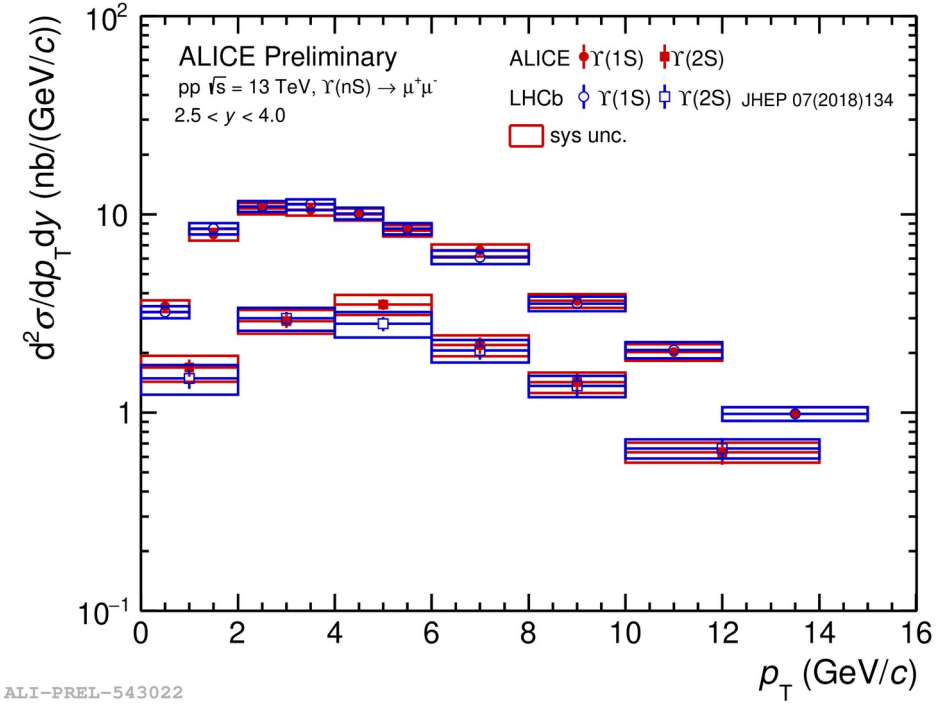




p_T and y differential cross sections are consistent with ICEM calculations within errors

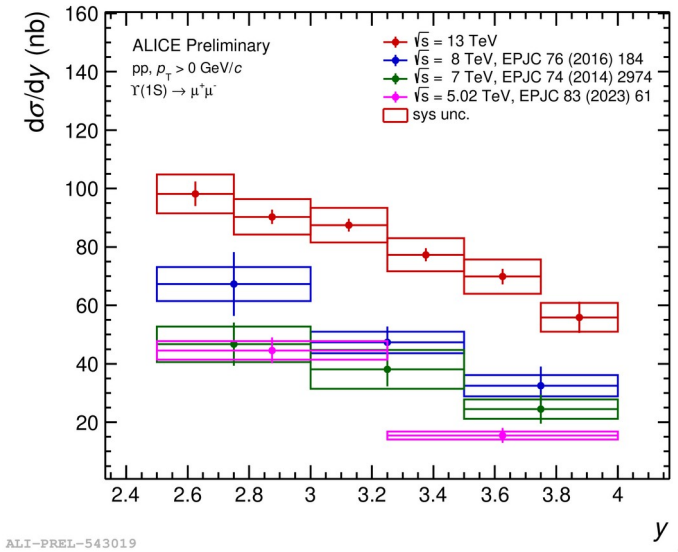
Preliminaries

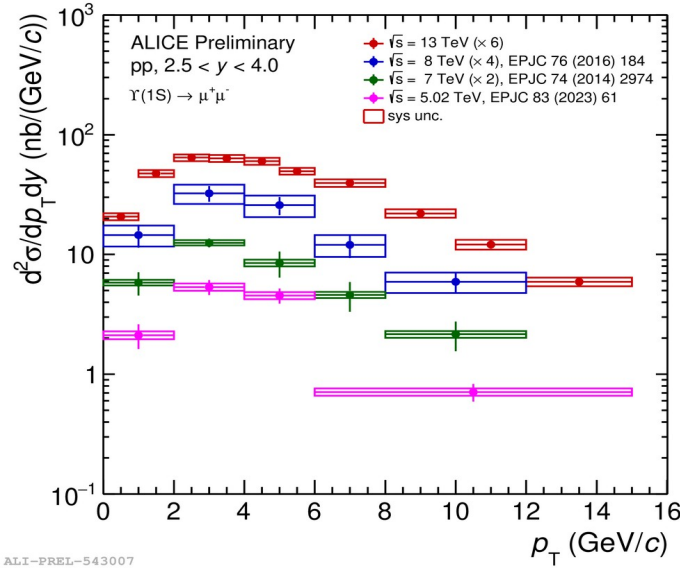


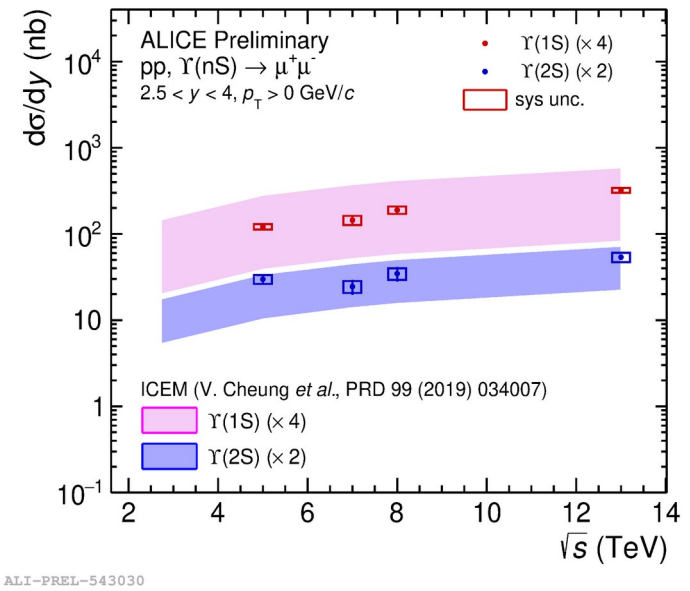


p_T and y differential cross sections are consistent with LHCb results within errors

Preliminaries







Integrated and (p_T , y) differential cross sections vary smoothly with √s

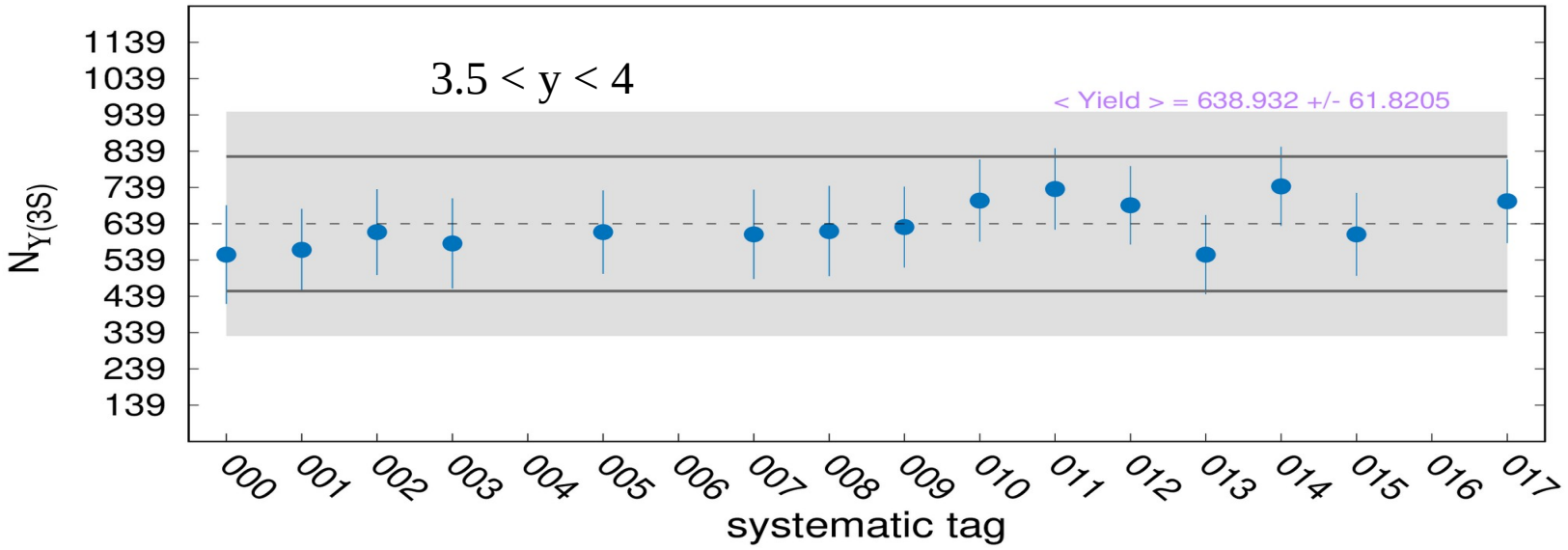
Exctraction of p_T and y differential yields for Υ (3S)

Systematic tags

Bkg. Func	Fit Range	Tail type	Tag
DE	6-14	data	000
	7-12		001
	5-14		002
DP	6-14	data	003
	7-12		004
	5-14		005
VWG	6-14	data	006
	7-12		007
	5-14		008

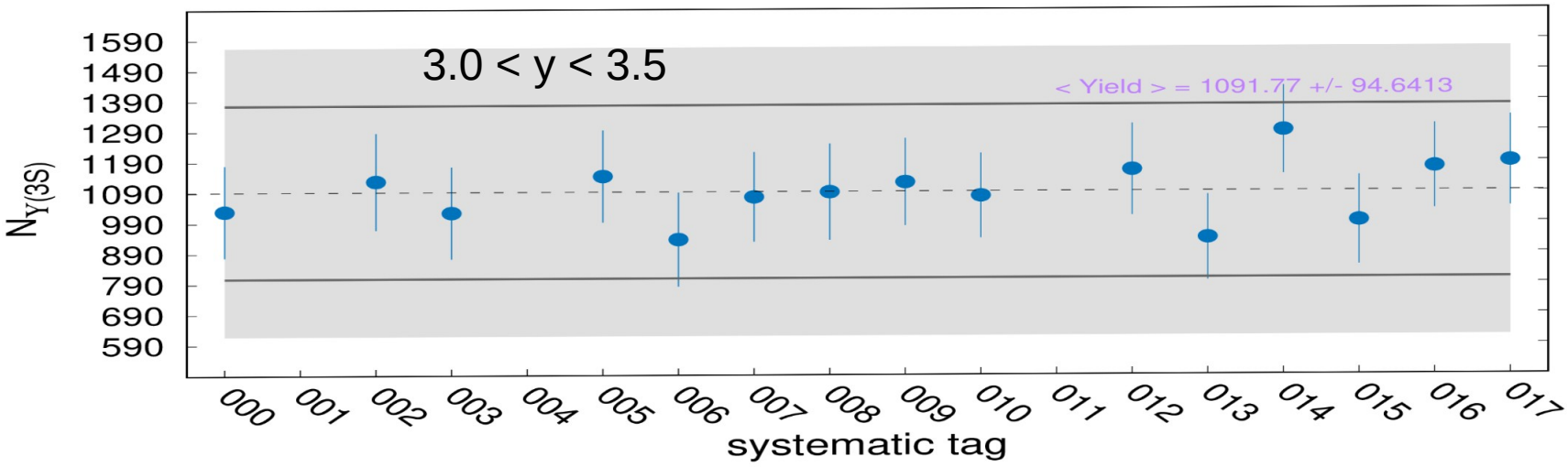
Bkg. Func	Fit Range	Tail type	Tag
DE	6-14	MC	009
	7-12		010
	5-14		011
DP	6-14	MC	012
	7-12		013
	5-14		014
VWG	6-14	MC	015
	7-12		016
	5-14		017

Υ(3S) *y*-differential yield



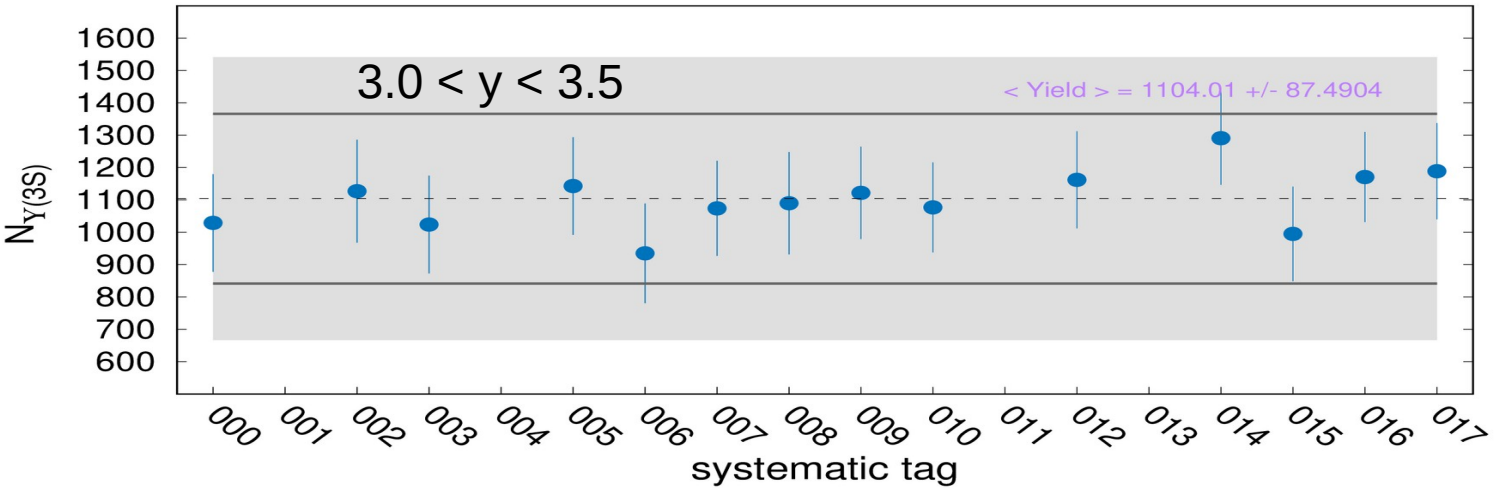
Sys tag	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
Significance	6.8	6.9	7.5	7.2		7.6	7.0	7.5	7.6	7.5	8.3	8.8	8.2	6.5	8.8	7.4		8.5
ChiSq/ndf	1.04	1.13	1.04	1.17		1.2	1.06	1.07	1.07	1.06	1.13	1.02	1.2	2.4	1.2	1.09		1.13

$\Upsilon(3S)$ *y*-differential yield



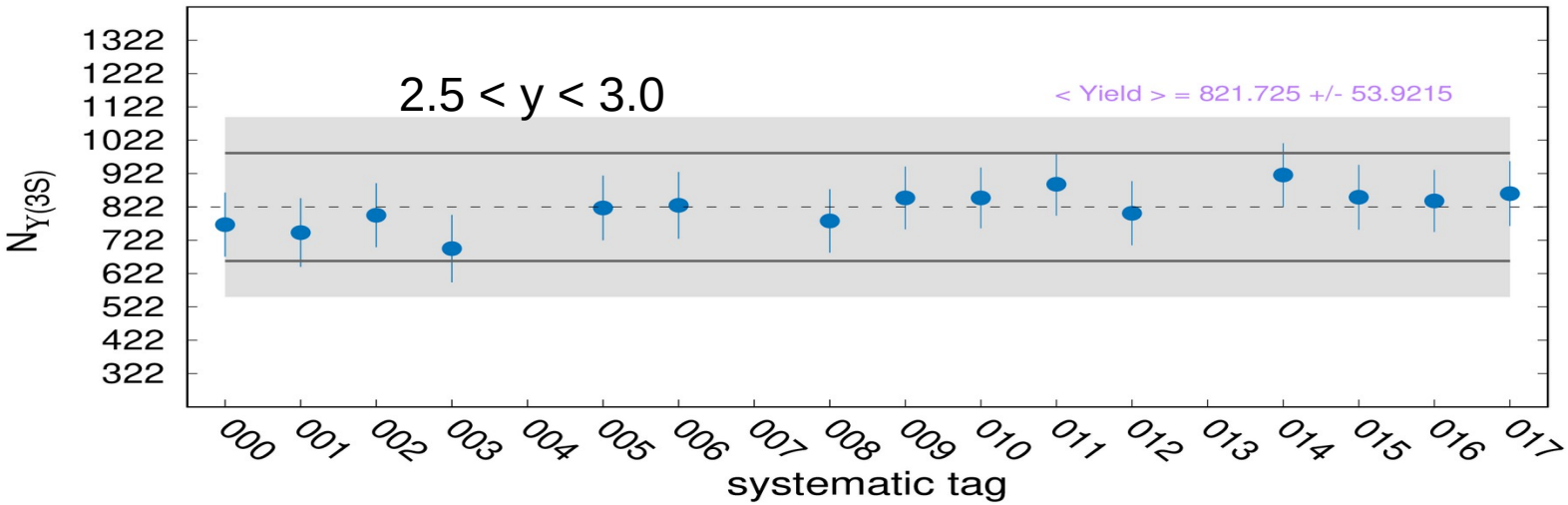
Sys tag	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
Significance	8.2	8.17	9.05	8.2		9.1	7.5	8.6	8.8	8.7	8.4	8.8	9.0	7.2	9.9	9.19		9.3
ChiSq/ndf	0.83	0.85	0.86	0.86		0.85	0.76	0.81	0.8	0.85	0.87	1.02	0.86	3.03	1.57	0.82		0.84

$\Upsilon(3S)$ *y*-differential yield



Sys tag	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
Significance	8.2		9.05	8.2		9.1	7.5	8.6	8.8	8.7	8.4		9.0	7.2	9.9	9.19		9.3
ChiSq/ndf	0.83		0.86	0.86		0.85	0.76	0.81	0.8	0.85	0.87		0.86	3.03	1.57	0.82		0.84

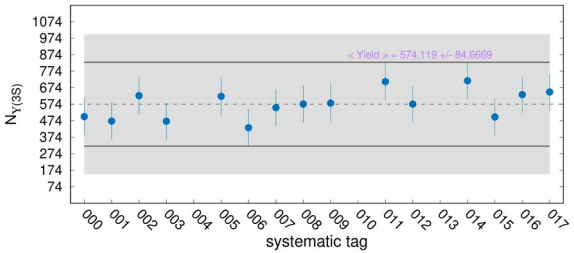
$\Upsilon(3S)$ *y*-differential yield



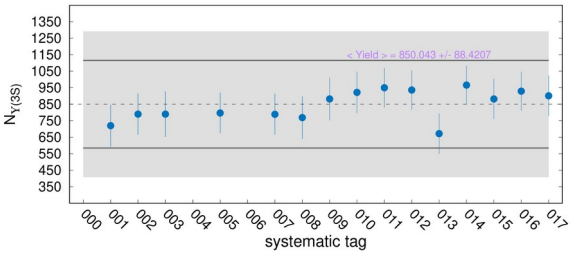
Sys tag	000	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017
Significance	8.8	8.4	9.1	8.0		9.3	9.4	8.7	8.9	9.3	9.2	9.7	8.7	6.5	9.9	9.3	9.2	9.5
ChiSq/ndf	1.04	1.78	1.45	1.4		1.4	1.2	1.2	1.2	1.5	1.8	1.5	1.5	2.4	1.5	1.3	1.3	1.3

$\Upsilon(3S)$ p_T-differential yield

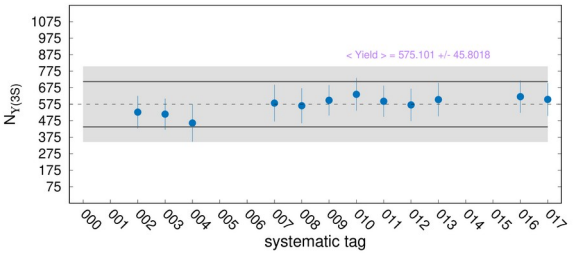
$0 < p_T < 4$



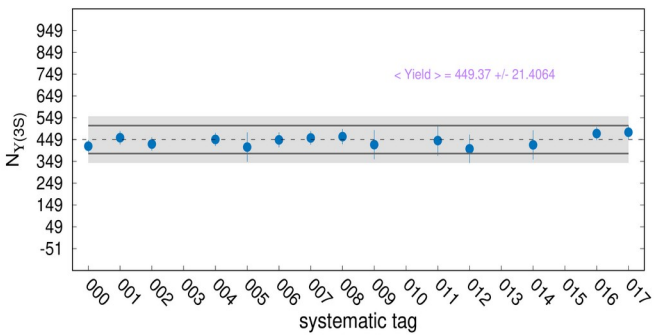
$4 < p_T < 8$



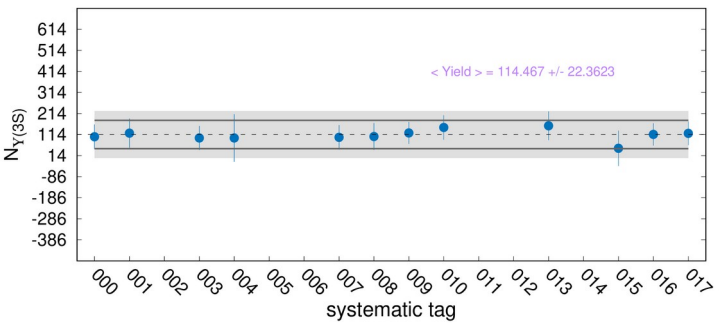
$8 < p_T < 12$



$12 < p_T < 18$

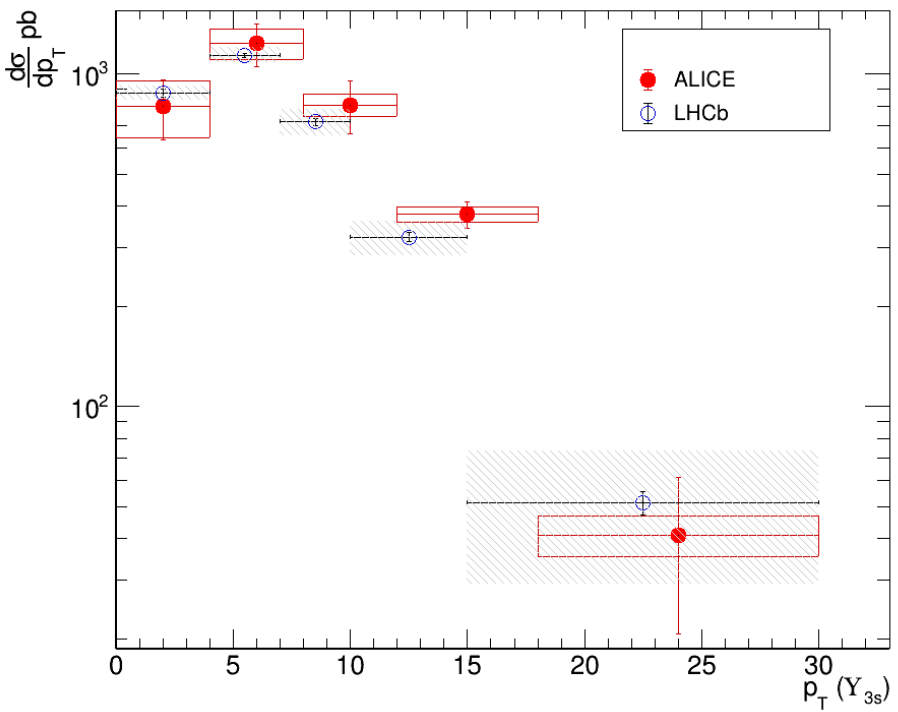


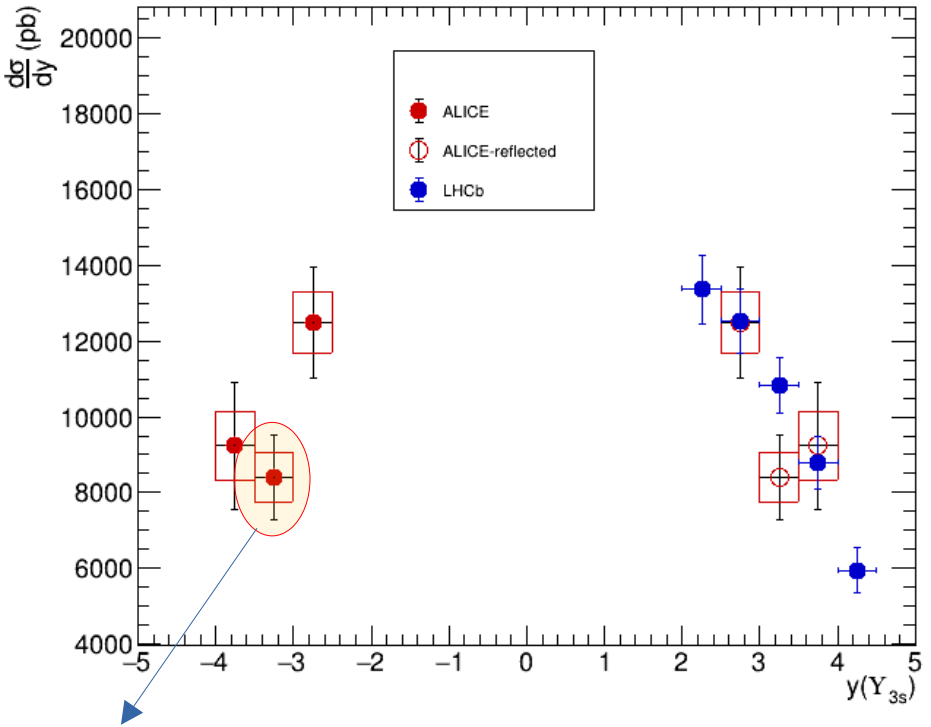
$18 < p_T < 30$



Bin-to-bin systematic of p_T-differential yield

p_T and y differential yield Υ(3S)





Unusual drop in yield, not yet understood to me

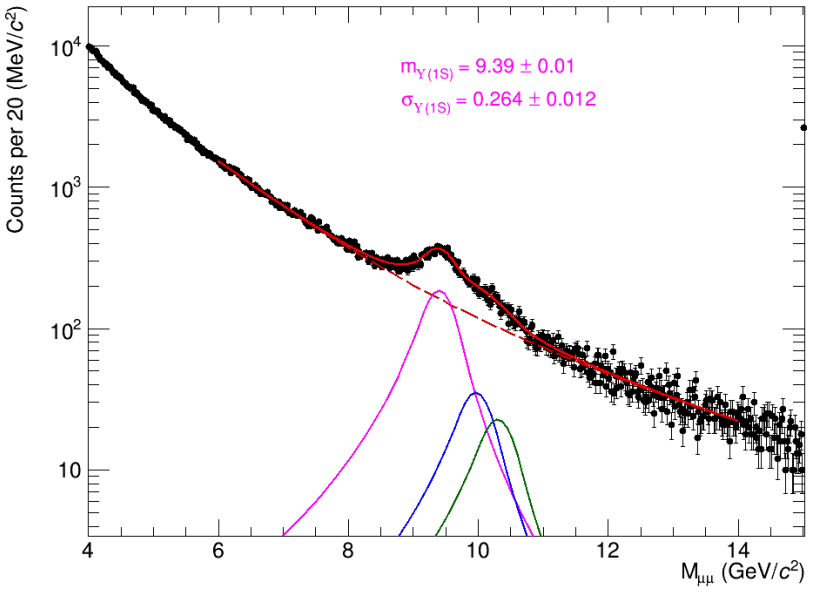
Summary

1. Υ(3S) yield calculated as a function of p_T and y
2. Yields are compared to LHCb, discrepencies are found in some bins

Remaining task:
1. Extraction of yield for Υ(1S,2S) for $p_T > 15$ GeV
2. Obtain corrections related to track and trigger matching
3. Proceed for paper proposal (Idea and suggestions)
   a) There is suggestion to merge THIS analysis with Υ(1S) polarization (Yanchun)
   b) Yanchun and myself (including Husnud and Wadnut) have agreed to this proposal

Thank you

A quick look to RUN3 pp Υ(nS)



Using data available in the hyperloop corressponding to:
https://alice-notes.web.cern.ch/node/1478

For now, I am using tail parameters same as this analysis