Ξ_c^0 via semileptonic decay in pPb at 5.02 TeV

July 3rd 2020

D2H meeting

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Contents

- Dataset
- Analysis procedure
- Result (w/o systematic uncertainty)

Dataset

- pPb 5.02 TeV
- Data Period : LHC16q(31 runs), LHC16t(4 runs)
  - FAST, CENT_woSDD
- Run numbers
  - https://twiki.cern.ch/twiki/pub/ALICE/AliDPGRunList16q/LHC16qpass1runlistv2.pdf
    - HadronPID, ElectronPID are same.
  - 16q : 265525, 265521, 265501, 265500, 265499, 265435, 265427, 265426, 265425, 265424, 265422, 265421, 265420, 265419, 265388, 265387, 265385, 265384, 265383, 265381, 265378, 265377, 265344, 265343, 265342, 265339, 265338, 265336, 265334, 265332, 265309
  - 16t : 267166, 267165, 267164, 267163
- Event selection
  - Trigger Class: kINT7
  - Pileup rejection only for the real data (AliESDtrackCuts::kSPD, AliESDtrackCuts::kBoth)
  - Primary vertices reconstructed from ITS+TPC tracks are within ±10 cm
- Event numbers
  - 516M after event selection, AliNormalizationCounter
  - Grid job
- MC
  - Period : LHC17d2b_fast_new
  - Event numbers : 16M

Analysis Procedure

- Following pp 5TeV, 13TeV which followed 7TeV (PLB 781 (2018) 8–19)
  - Based on the code
    - vertexingHF/AliAnalysisTaskSEXic0Semileptonic.cxx
    - macros/AddTaskXic0Semileptonic.C
  - Previous analysis note for pp 5,13TeV
    - https://alice-notes.web.cern.ch/system/files/notes/analysis/990
  - Using the same cut, procedure at this moment.
- Procedure

$$\Xi_c^0 \to e^+\Xi^-\nu \to e^+(\pi^-\Lambda)\nu \to e(\pi p\pi)\nu + c.c.$$

  - Select e and Ξ
  - Make Right-Sign (RS) pairs (e+ Ξ− , e− Ξ+) and Wrong-Sign (WS) pairs (e− Ξ− , e+ Ξ+)
  - Signal extraction by subtracting the WS spectra from the RS spectra
  - Prefilter correction
  - Convert p_T(eΞ pair) into $p_T(\Xi_c^0)$ using unfolding technique
  - Efficiency correction
  - Calculate BR*dσ/dp_T
  - Calculate R_{pPb}
  - (Systematic Uncertainty)

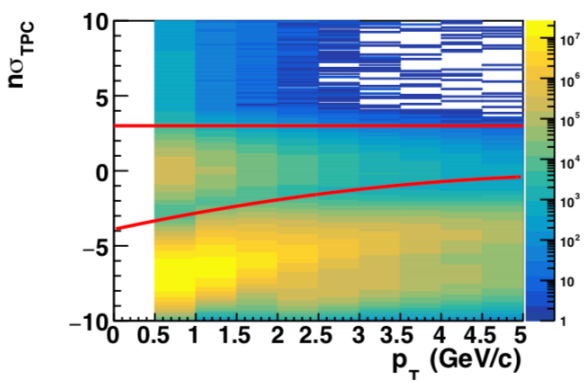
Analysis detail : electron PID

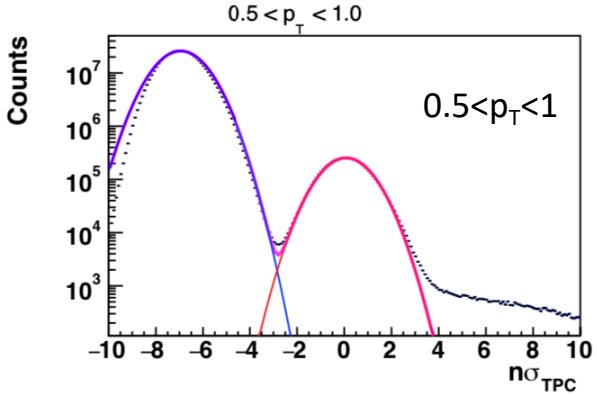
- Electron PID cuts: following 5TeV, 13TeV analysis

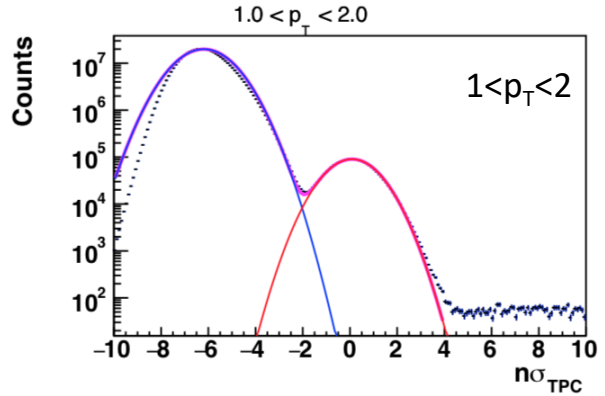
Cuts vairbales	cuts
AOD Filter Bit	4(Standard cuts with very loose DCA)
Number of crossed rows	>70
Number of crossed rows over TPC findable cluster	>0.8
Number of TPC PID clusters	>50
Ratio of findable clusters	>0.6
ITS/TPC refit	TRUE
Number of ITS cluster	≥ 3
p_T(GeV/c)	>0.5
η	<0.8
SPD hit	both
$\lvert n\sigma_{TOF}\rvert$	<3
$\lvert n\sigma_{TPC}\rvert$	$>-3.9+1.17\cdot x-0.094\cdot x^2$
prefilter cut	$m_{e^+e^-}$ <0.05 GeV/c^2

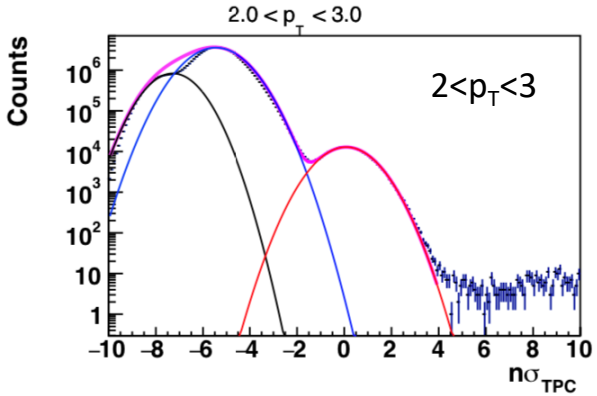
Analysis Detail : $n\sigma_{TPC}$ cut

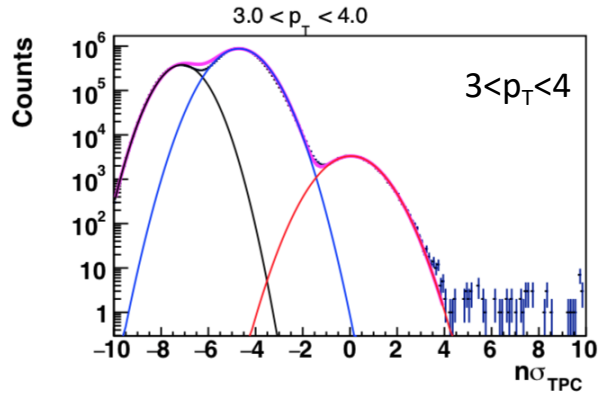
- $n\sigma_{TPC}$ distribution for
  - p_T between 0.5, 1.0, 2.0, 3.0, 4.0, 5.0
- p_T dependent cut will be used
  - $-3.9 + 1.17*x - 0.094*x*x < n\sigma_{TPC} < 3.0$

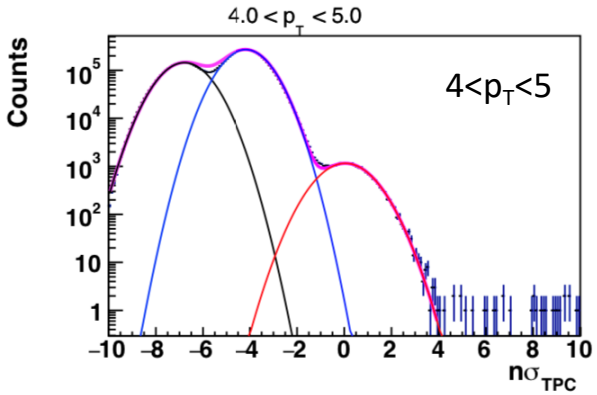






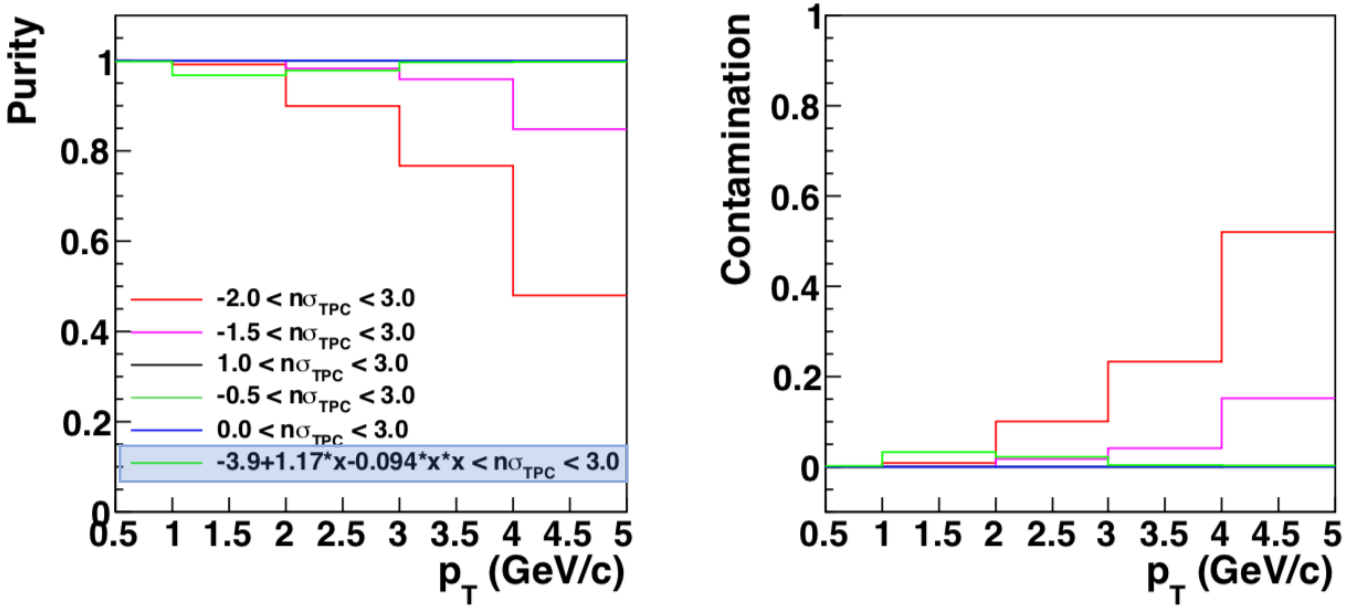






Electron purity, contamination by $n\sigma_{TPC}$ cut

- p_T-dependent cut will be used : $-3.9 + 1.17*x - 0.094*x*x < n\sigma_{TPC} < 3.0$
  - Used in pp 7,5,13 TeV analyses
- Purity = N(elec)/N(all).
- Contamination = N(others)/N(all)
- Purity is high enough to use this cut



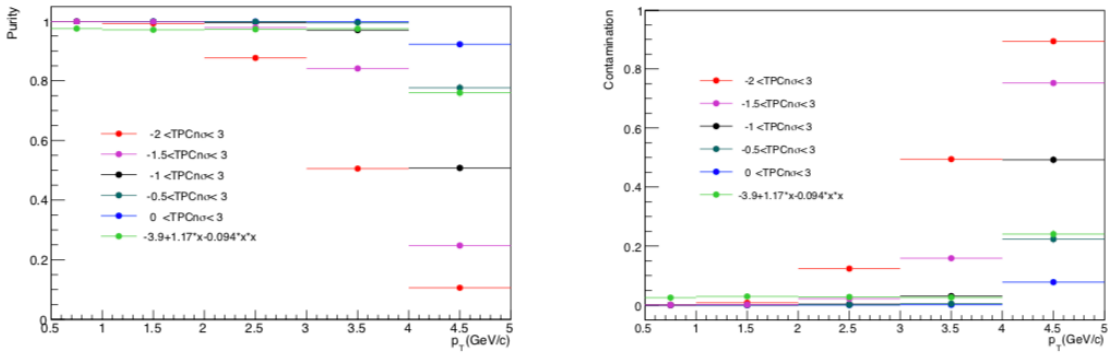


Fig. 3: The purity of electron(left) and the contamination of electron(right) at $\sqrt{s} = 5.02$ TeV

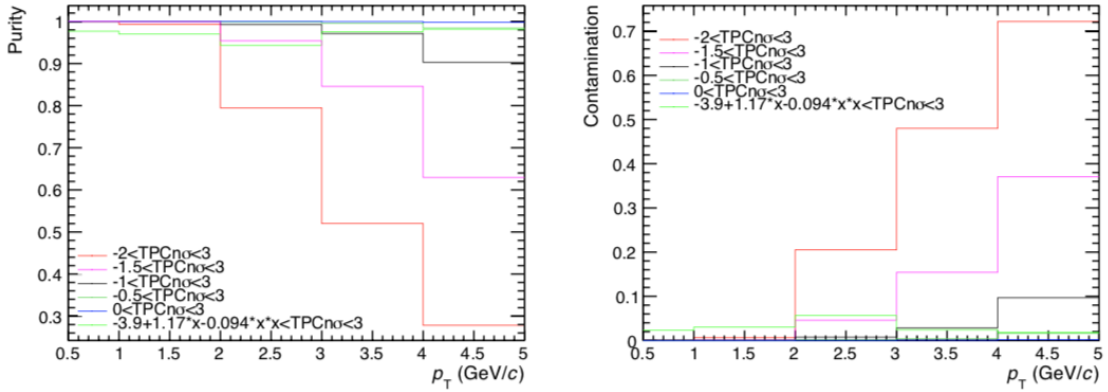
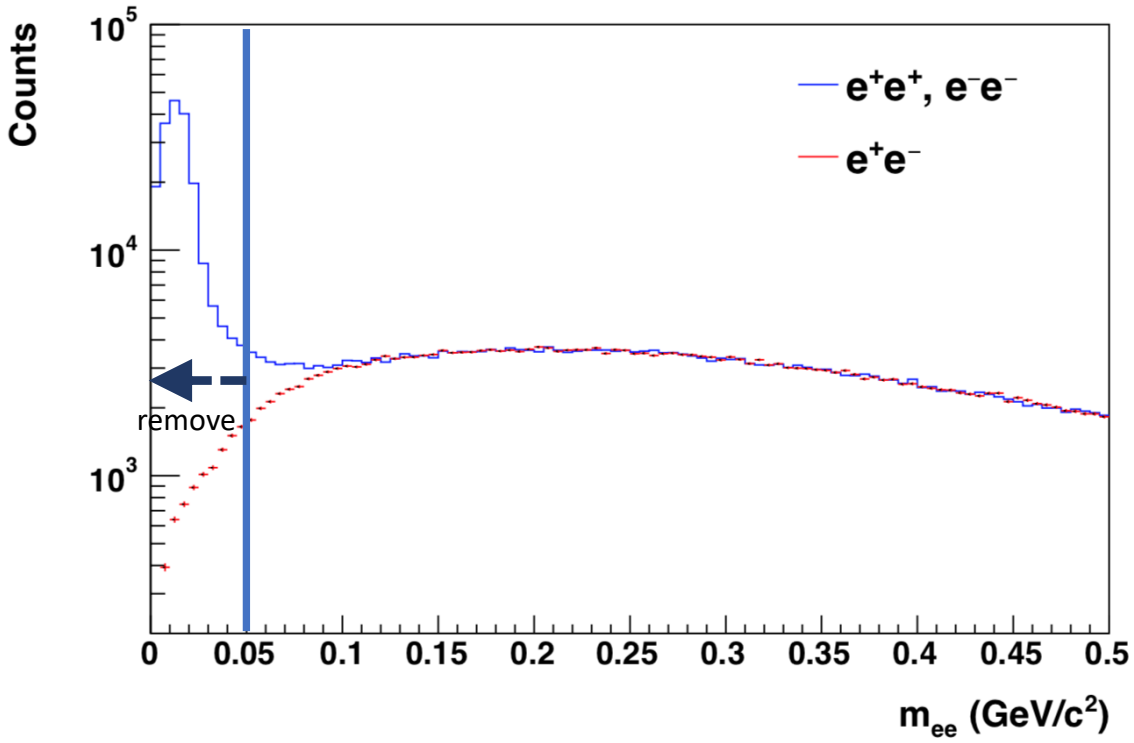


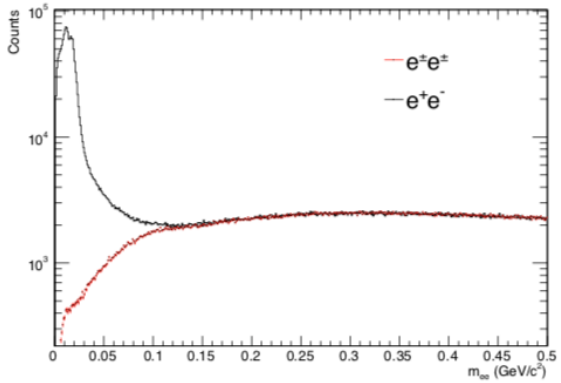
Fig. 4: The purity of electron(left) and the contamination of electron(right) at $\sqrt{s} = 13$ TeV

Electron PID : prefilter cut

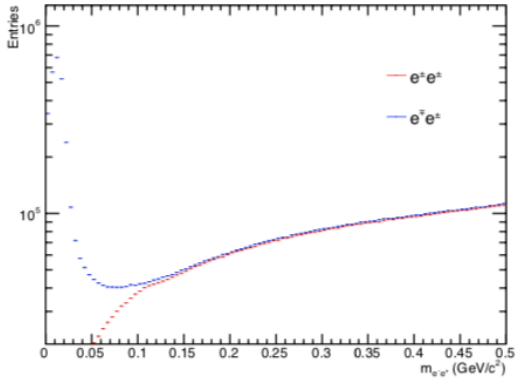
- Prefilter cut to reject photonic electron
  - M(e+e- pair) > 0.05
  - M(ee)~0 : π^0 Dalitz decays, γ conversions.



pp 5TeV, 13TeV



(a) $\sqrt{s} = 5.02$ TeV



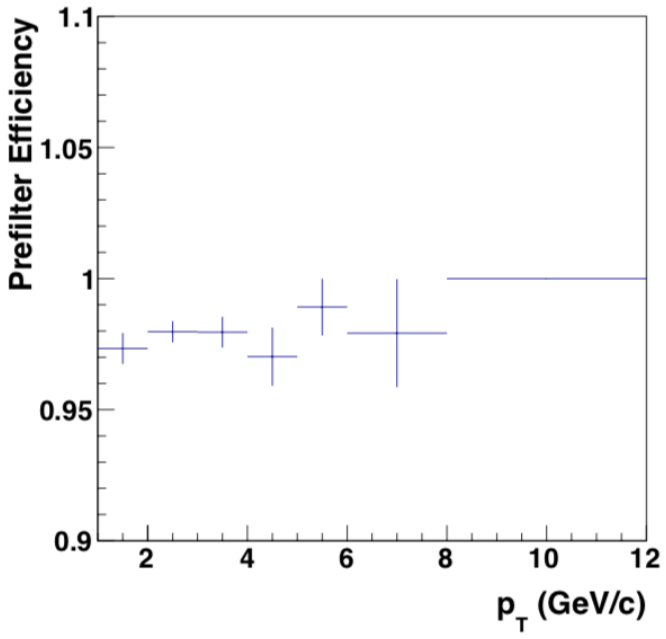
(b) $\sqrt{s} = 13$ TeV

prefilter efficiency

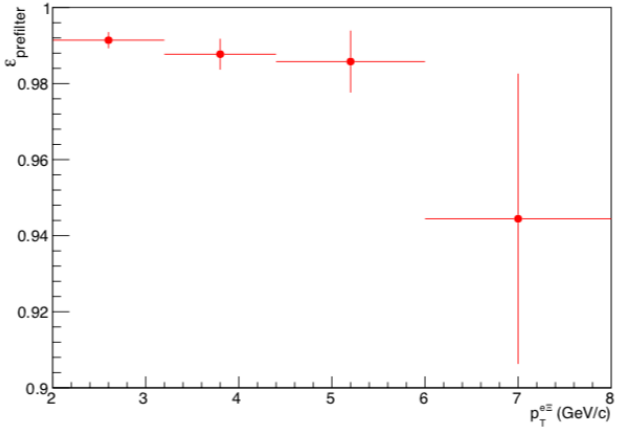
- M(ee pair) > 0.05
- Prefilter efficiency ~ 0.98, close to pp

$$\varepsilon_{prefilter} = \frac{N_{e\Xi}(same-sign\ prefilter\ on)}{N_{e\Xi}(prefilter\ off)}$$

pPb 5TeV

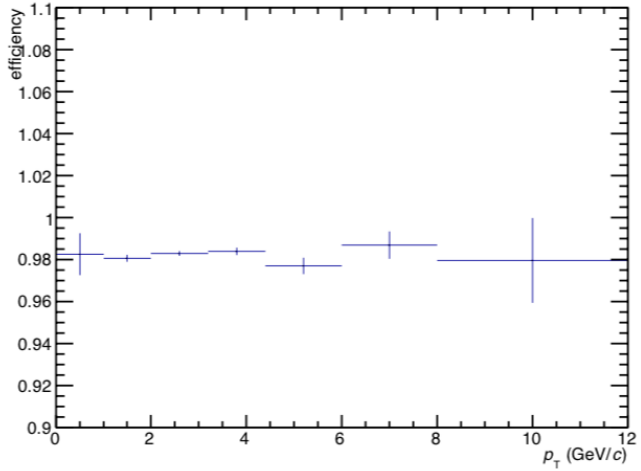


pp 5TeV



(a) $\sqrt{s} = 5.02$ TeV

pp 13TeV



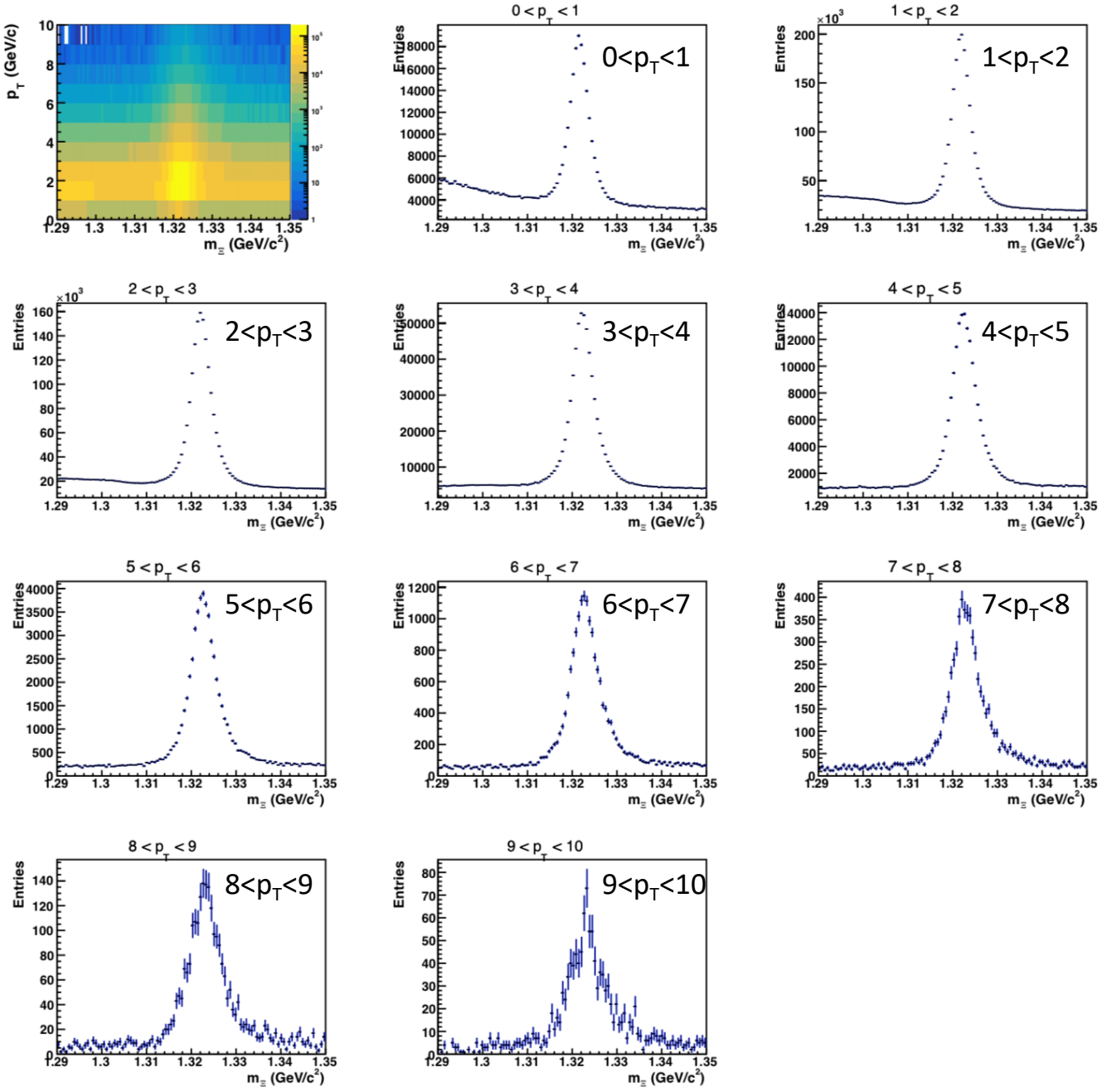
(b) $\sqrt{s} = 13$ TeV

Ξ selection

- Invariant mass distribution of Ξ as a function of *p*T.
- Cuts for Ξ are listed

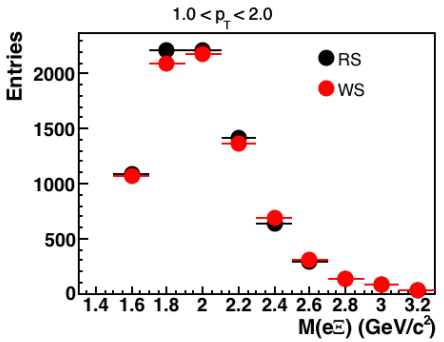
Particle	Quarks	S	$I(J^P)$	Mass(MeV/c^2)	Decay particles	B.R.(%)	$c\tau$
$\Xi^-(\overline{\Xi}^+)$	dss($\overline{dss}$)	-2 (+2)	$\frac{1}{2}(\frac{1}{2}^+)$	1321.71	$\Lambda\pi^-(\overline{\Lambda}\pi^+)$	99.9	4.91

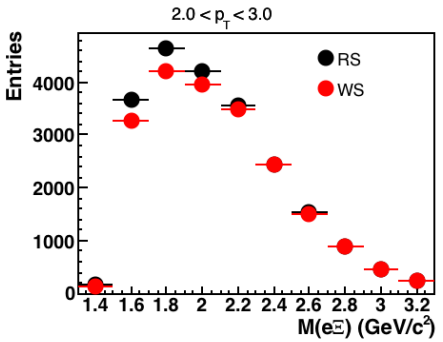
Cuts variables	cuts
Number of TPC clusters	>80
Λ Mass tolerance (MeV/c^2)	7.5
Ξ Mass tolerance (MeV/c^2)	8
DCA of V0 to PV (cm)	>0.03
DCA of V0 daughters to PV (cm)	>0.073
V0 cosine of pointing angle to Ξ vertex	>0.983
Ξ cosine of pointing angle to PV	>0.983
DCA of bachelor track to PV (cm)	>0.0204
V0 decay length (cm)	>2.67
Ξ decay length (cm)	>0.38
$\lvert n\sigma_{TPC}\rvert$ (*proton*)	<4
$\lvert n\sigma_{TPC}\rvert$ (*pion*)	<4

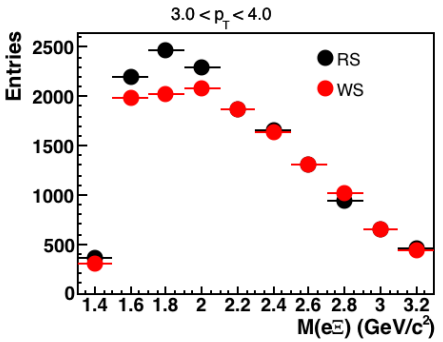


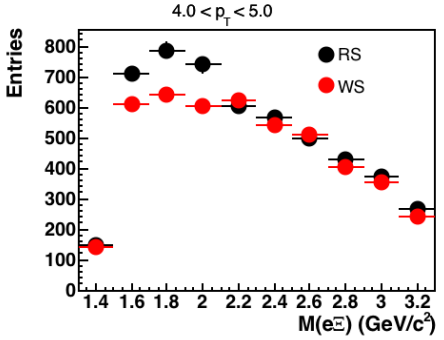
RS and WS

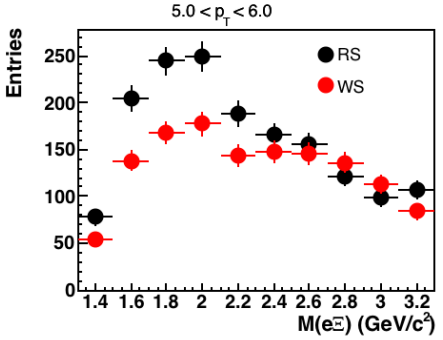
- RS (Right-Sign) : e+Ξ−, e−Ξ+
  - Includes signal
- WS (Wrong-sign) : e−Ξ−, e+Ξ+
  - Background estimation
- most of the background sources contribute equally to WS and RS pairs.
  - → estimate background with WS
  - → signal = RS − WS
- Due to the missing momentum of the neutrino, the M(eΞ pair) doesn't have a peak at the Ξ_c^0 mass. (2470.85+0.28 MeV/c^2)
- eΞ pair cuts
  - M(eΞ) < 2.5 GeV/c^2
  - Opening angle < 90°

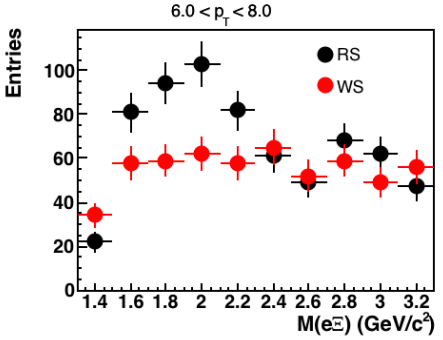


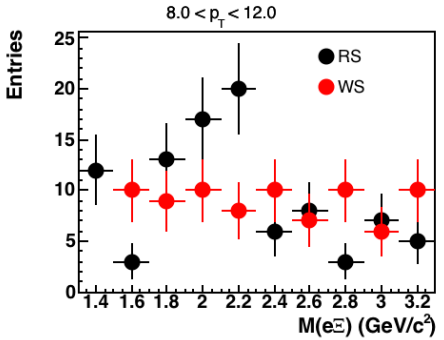








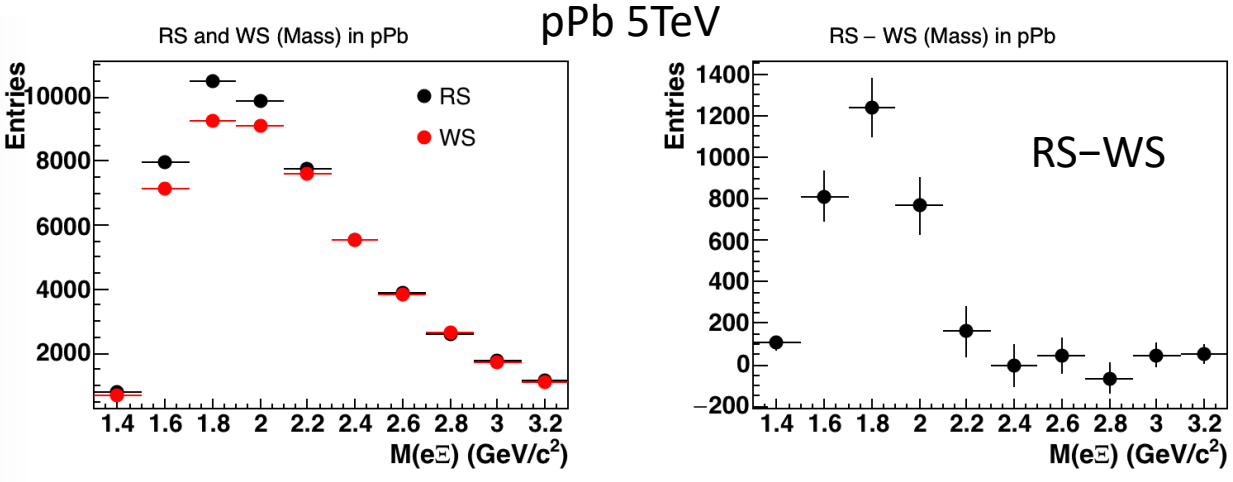




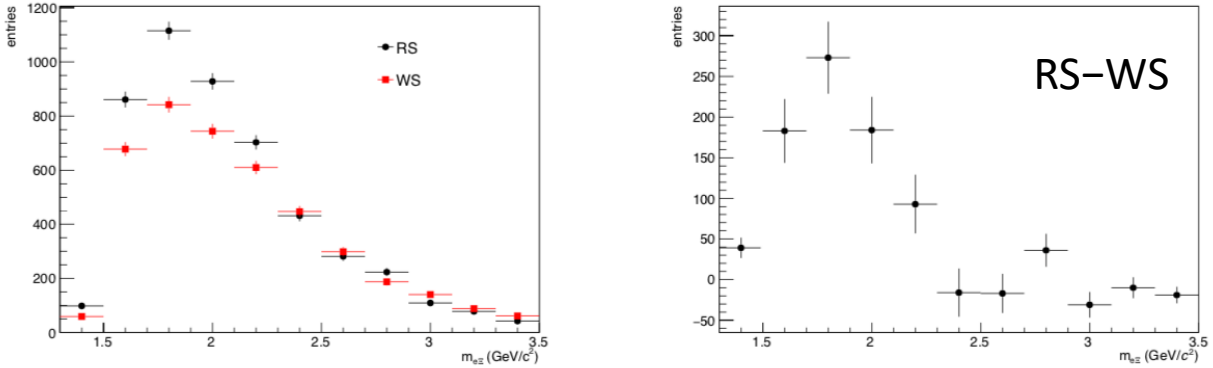
Subtract WS from RS spectra

- RS and WS, RS-WS in Mass

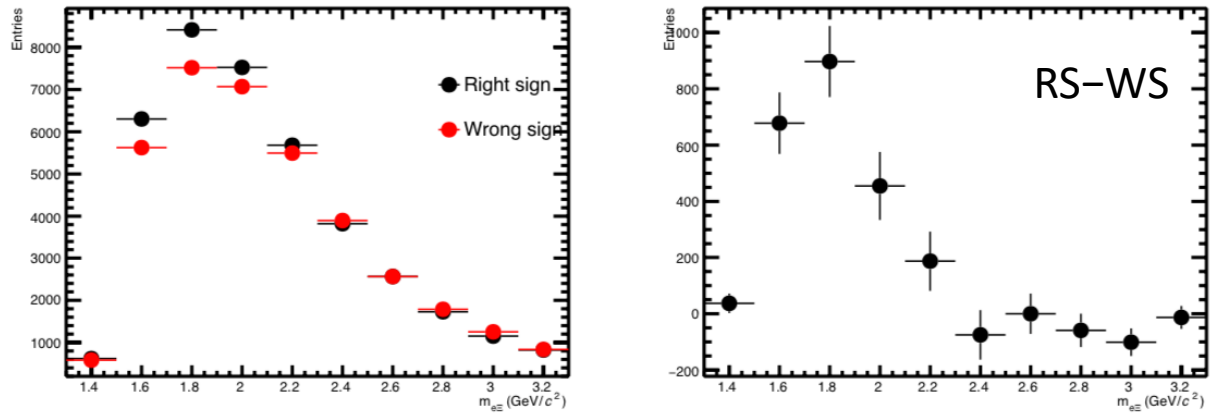
pPb 5TeV



pp 5TeV

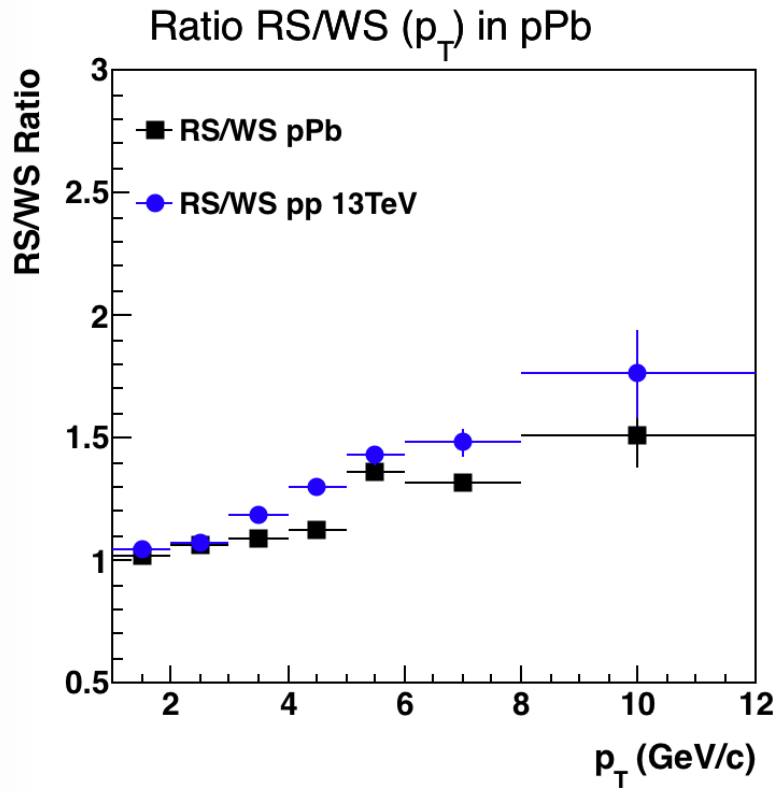


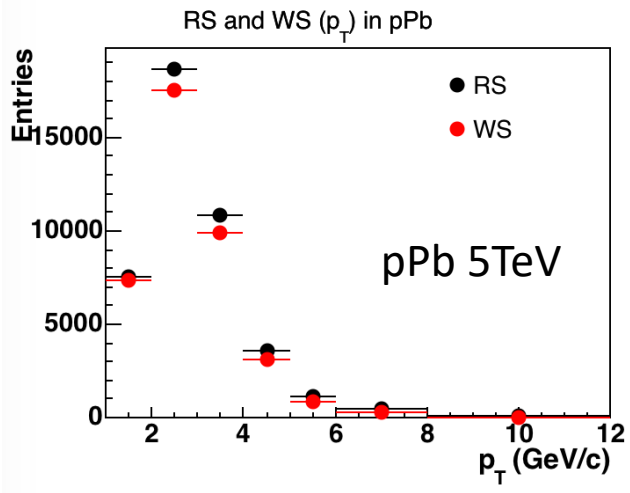
pp 13TeV

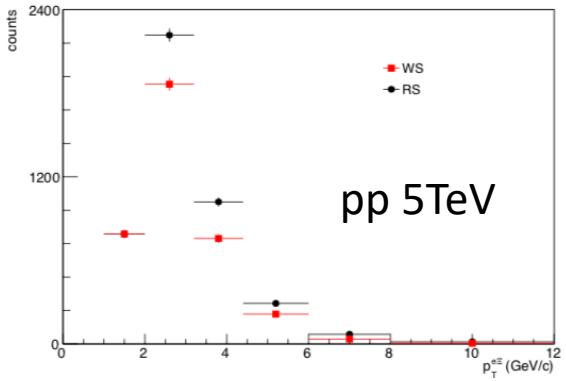


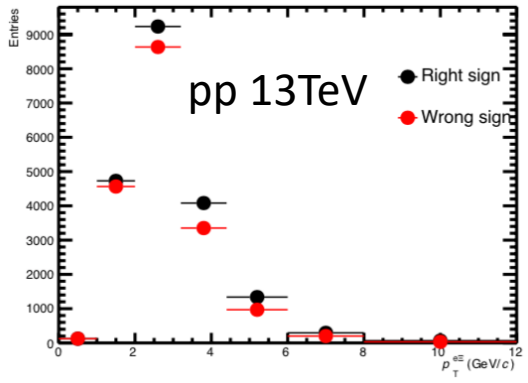
RS and WS in p_T bin, RS/WS

- RS and WS in p_T bin
- Different binning in the analysis note
- Right side : comparison of RS/WS in pPb and pp 13TeV with new binning
  - RS/WS in pPb is smaller than pp 13TeV



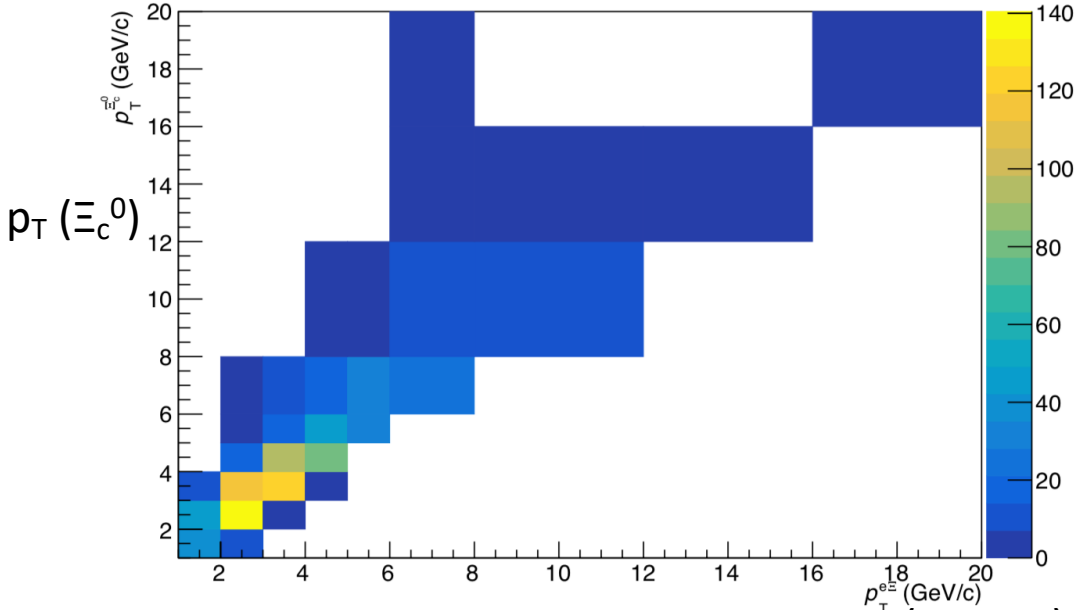




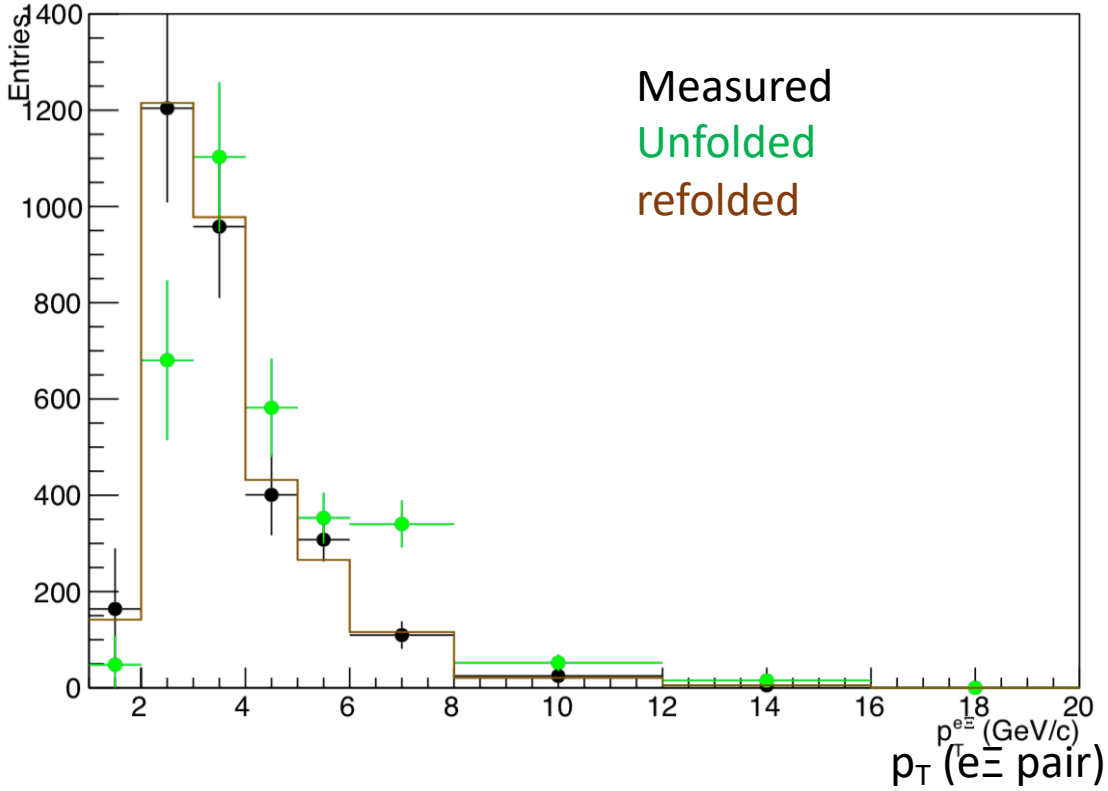


Unfolding

- Following pp 5, 13 TeV analysis
- Using RooUnfold - Bayesian unfolding , 3 iterations.
- Response matrix from MC
- Check unfolding by comparing measured spectra and refolded spectra
  - 'Refolded' is consistent with 'Measured' within uncertainty
- Systematic uncertainty will be studied very soon
- Unweighted spectra (weighting factor next page)

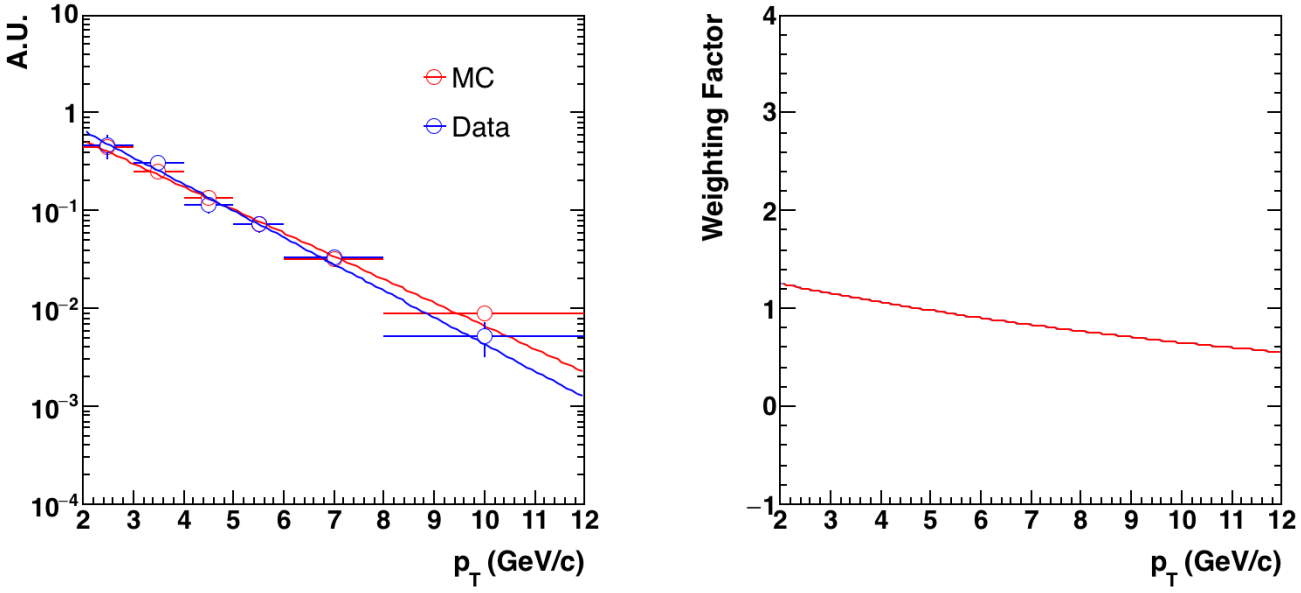


Response matrix



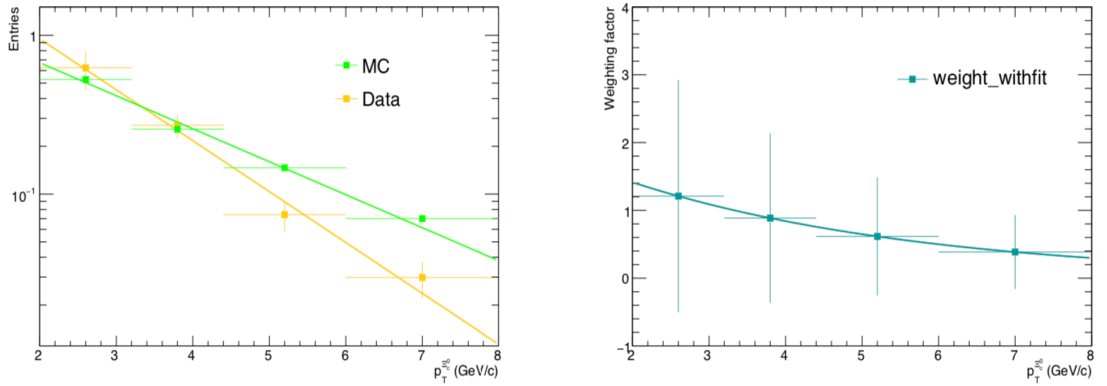
Weighting factor

- Match shape of MC and unfolded (unweighted) spectra in 2<pT<12
  - Normalize within 2<pT<12, fit with exponential, then get the ratio between two functions → weighting factor



pPb 5TeV

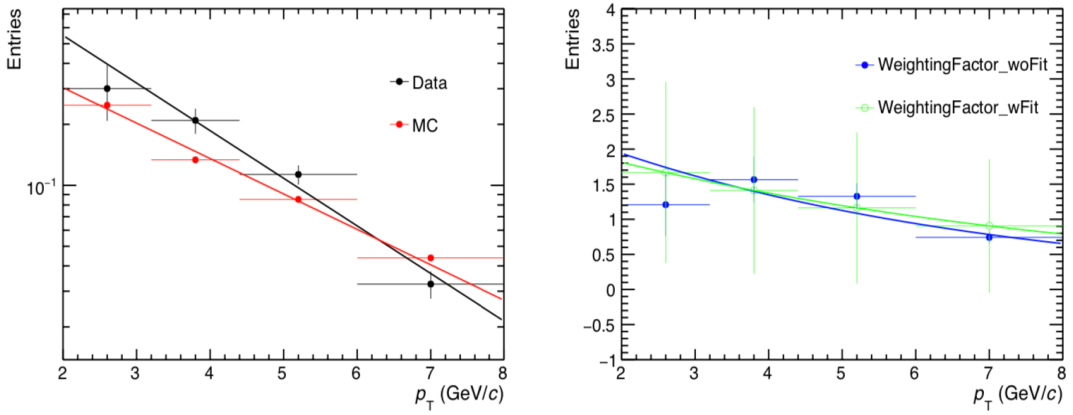
pp 5TeV



(a) Distribution of p_T: data and Gen-MC (b) Weights compared with 2 cases

Fig. 16: Weight process at $\sqrt{s} = 5.02$ TeV .

pp 13TeV



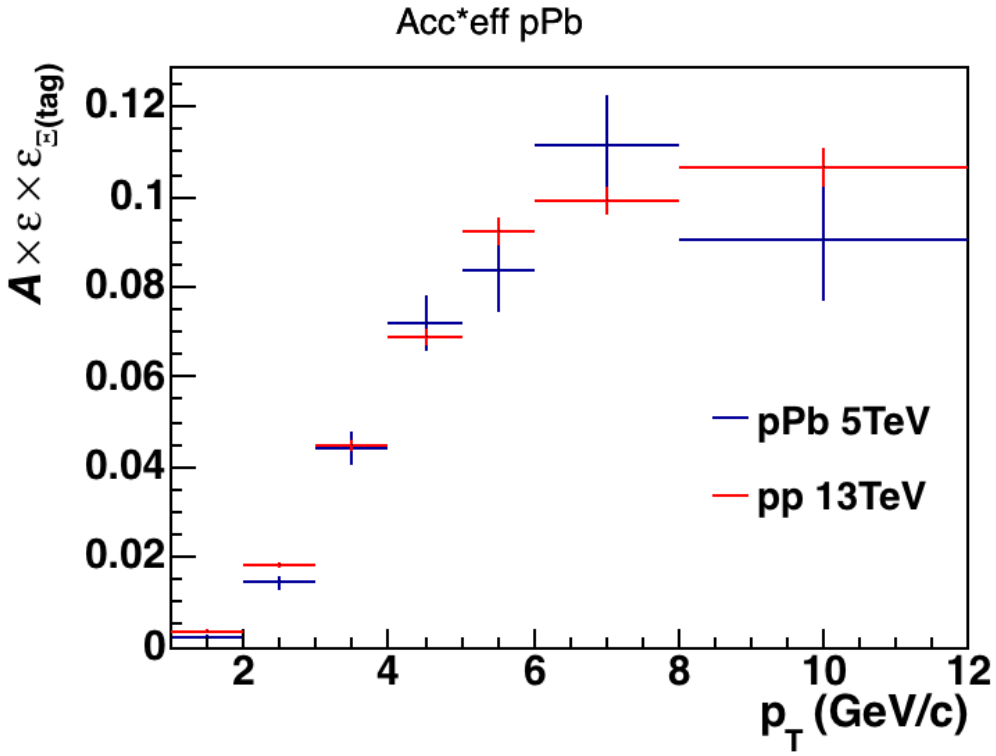
(a) Distribution of p_T: data and Gen-MC (b) Weights compared with 2 cases

Fig. 17: Weight process at $\sqrt{s} = 13$ TeV .

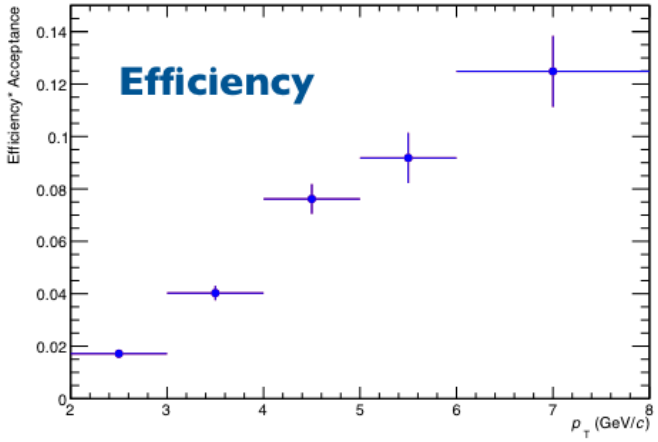
Acc*Eff

- Acc*eff is consistent with pp 5TeV, 13TeV

$$(Acc \times \varepsilon \times \varepsilon_{\Xi} tag) = \frac{N^{\Xi_c^0}_{MC,reco}}{N^{0}_{MC,gen}}$$

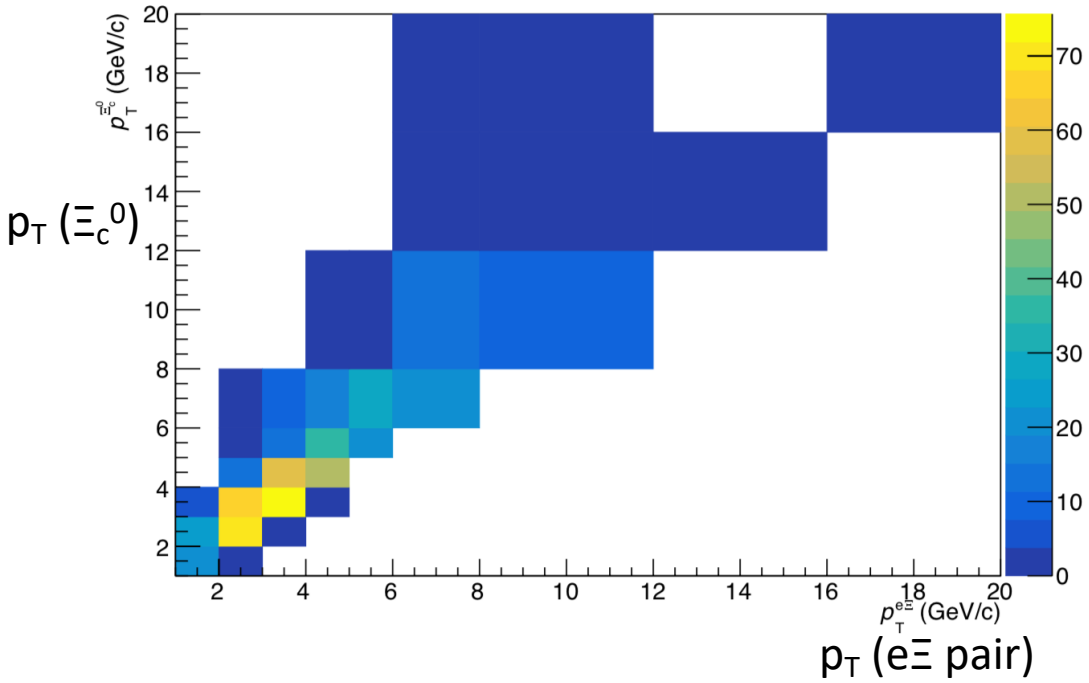


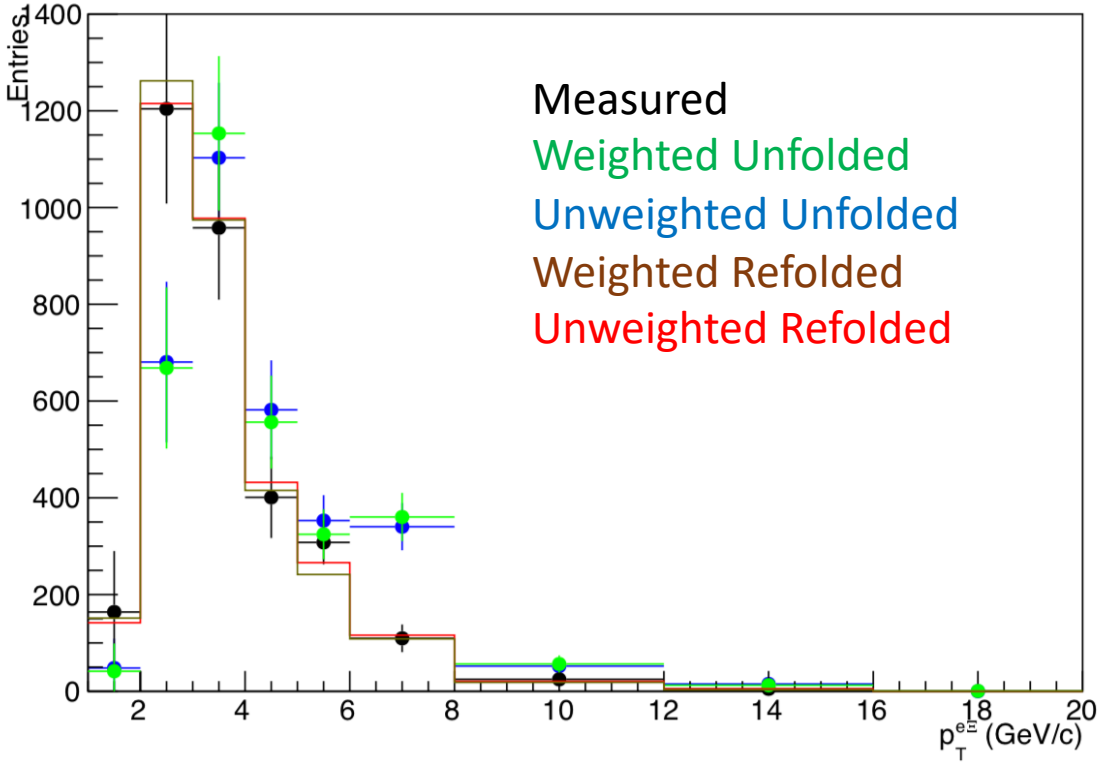
pp 5 TeV



Unfolding (weighted)

- Refolded is consistent with ‘measured’
- Weighted unfolded is close to unweighted unfolded one



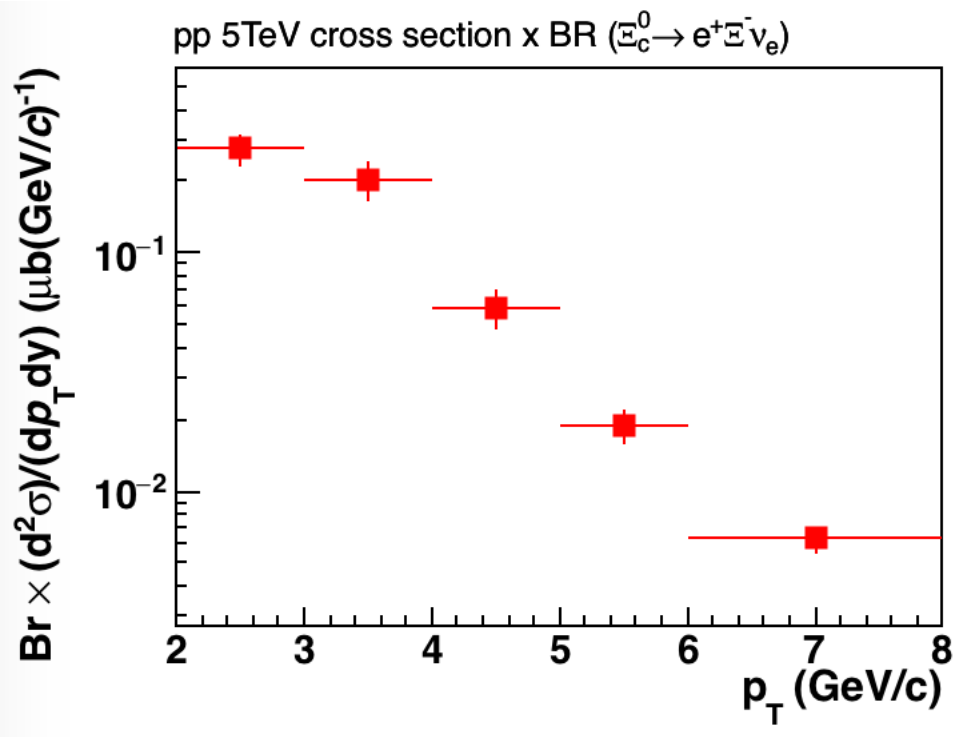


Result : cross section (xBR)

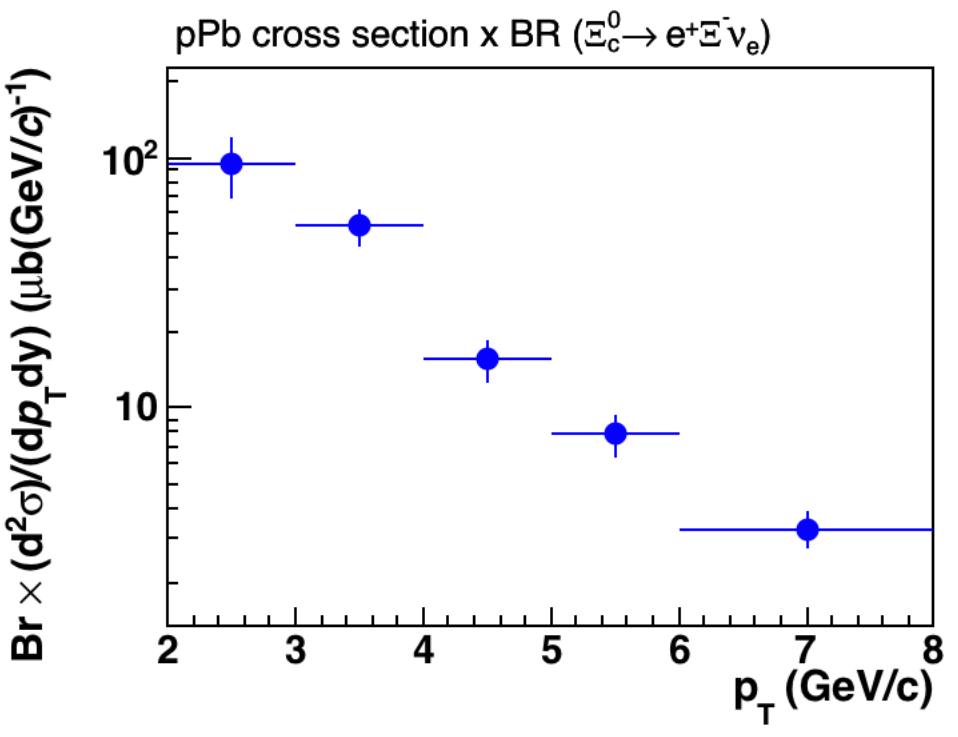
$$BR \cdot \frac{d\sigma^{\Xi_c^0}}{dp_T dy} = \frac{N_{\Xi_c^0}}{2 \cdot \Delta p_T \Delta y \cdot (A \times \varepsilon \times \varepsilon_{\Xi tag}) \cdot L_{int}}$$

$$L_{int} = \frac{N_{evt}}{\sigma_{pp}^{MBAND}}$$

- N_{evt}(pPb) = 5.15708e+08.
- Visible cross section (pPb) = 2.09e+06 μb
  - arxiv:1412.6828 page 6
  - pp 13TeV : 57mb pp 5TeV : 50.87mb



pp 5.02 TeV in recent presentation with same binning by Tiantian



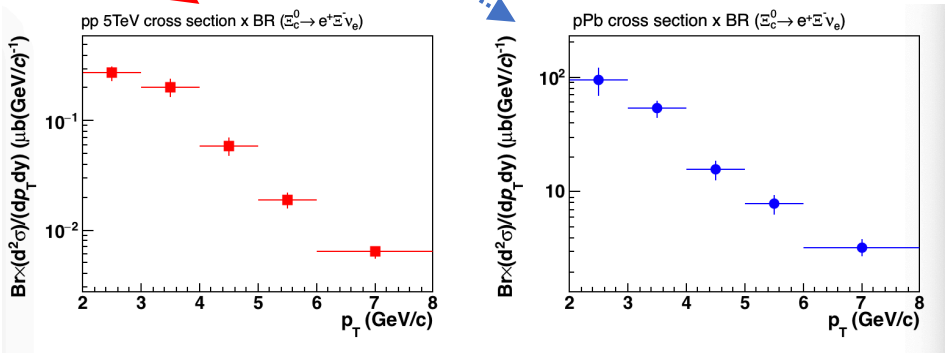
pPb 5.02 TeV

calculating R_{pPb}

$$R_{\mathrm{pPb}} = \frac{1}{\langle N_{\mathrm{coll}} \rangle} \frac{dN_{\mathrm{pPb}}/dp_T dy}{dN_{\mathrm{pp}}/dp_T dy}$$

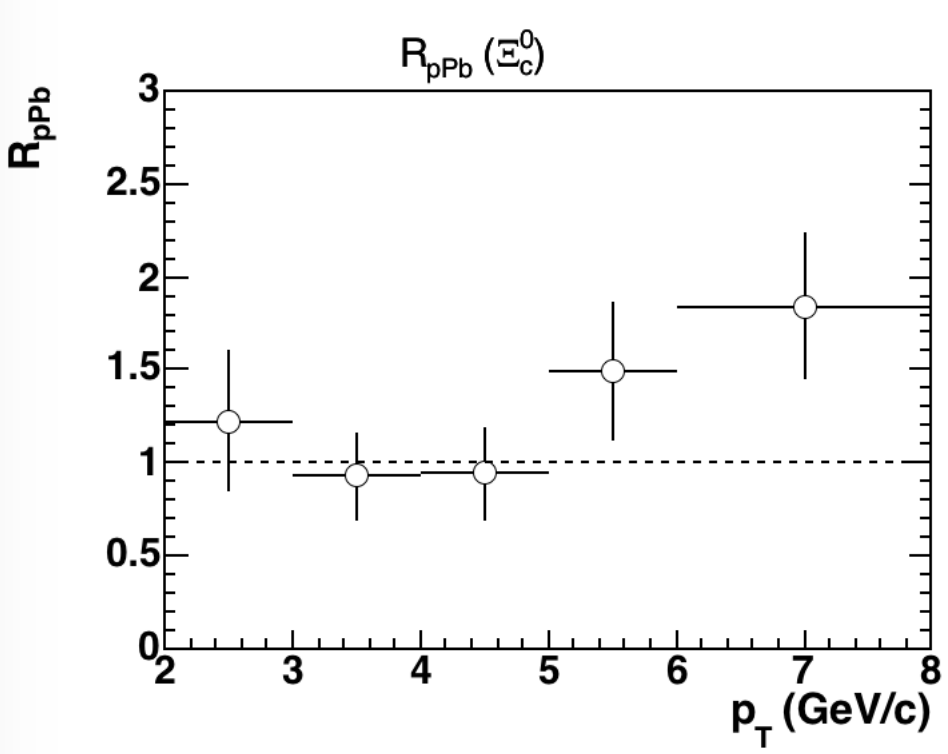
$$= \frac{1}{\langle N_{\mathrm{coll}} \rangle} \frac{Br \times (d\sigma^2_{\mathrm{pPb}}/dp_T dy)/\sigma^{\mathrm{MBAND}}_{\mathrm{pPb}}}{Br \times (d\sigma^2_{\mathrm{pp}}/dp_T dy)/\sigma^{\mathrm{MBAND}}_{\mathrm{pp}}}$$

- $\langle N_{coll} \rangle$ (pPb 5.02 TeV)= 6.87
  - https://arxiv.org/pdf/1412.6828.pdf
- Visible cross section
  - σ_{pPb}^{MBAND} = 2.09e+06 μb
    - arxiv:1412.6828 page 6
  - σ_{pp}^{MBAND} = 50.87 ± 0.04 (stat.) mb = 50.87*1000 μb
    - http://cds.cern.ch/record/2648933 page 5
- R_{pPb} = {BR x ($d\sigma/dp_T$)/σ_{pPb}^{MBAND}} / {BR x ($d\sigma/dp_T$)/σ_{pPb}^{MBAND}}



BR x ($d\sigma/dp_T$)
Shown in previous page

$R_{pPb}(\Xi_c^0)$ at 5.02 TeV



- Not far from 1 as expected
- Outlook
  - Systematic study

Thank you

Backup Slides

Backup : pp cross section

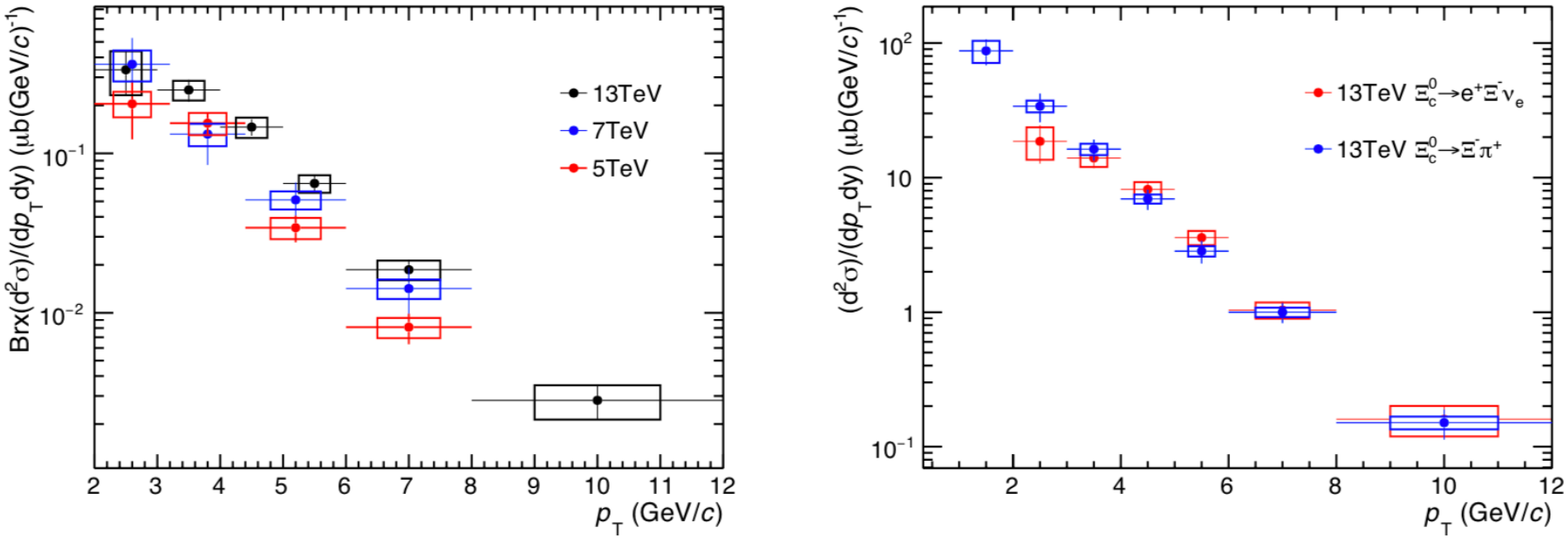
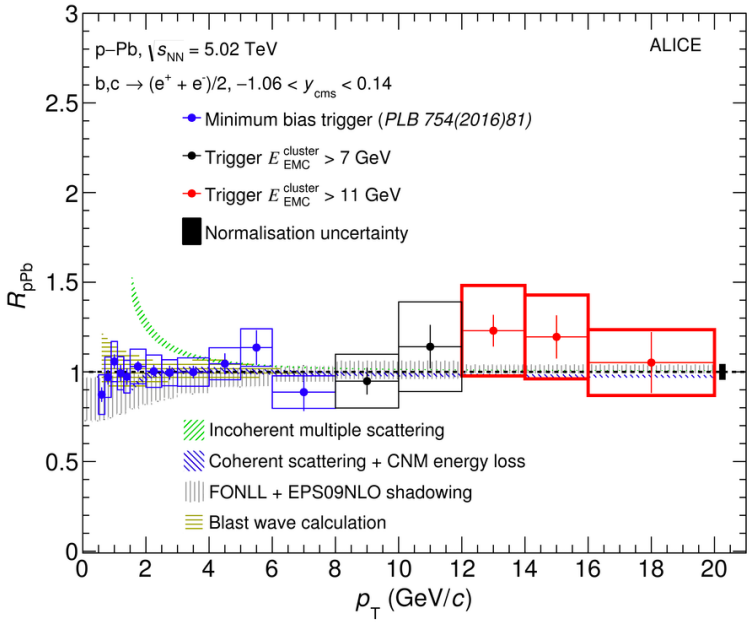


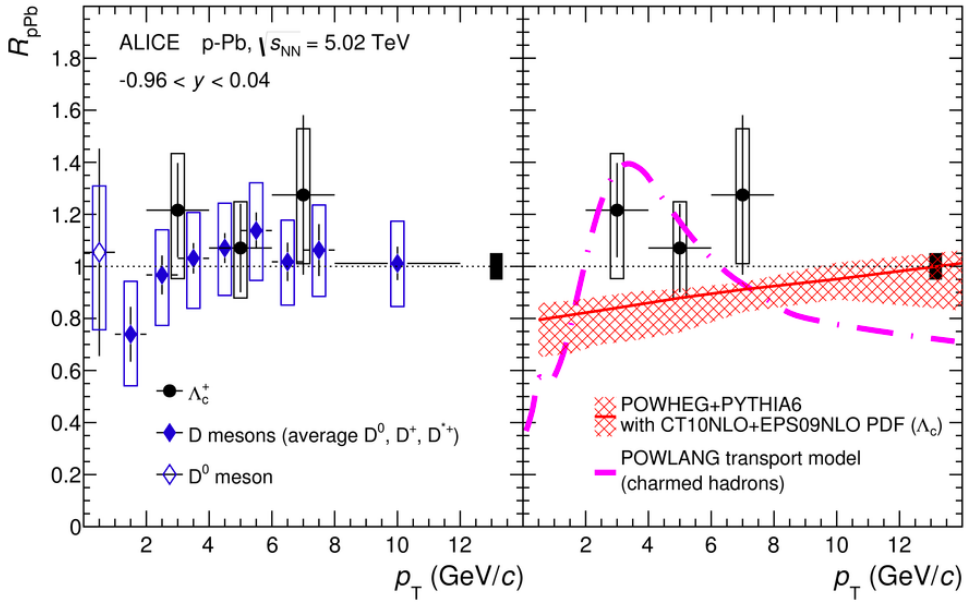
Fig. 46: Left Ξ_c^0 p_T spectra for different energy. (Right) The comparison of Ξ_c^0 in pp collisions at $\sqrt{s} = 13$ TeV .

Backup : some R_{pPb} results

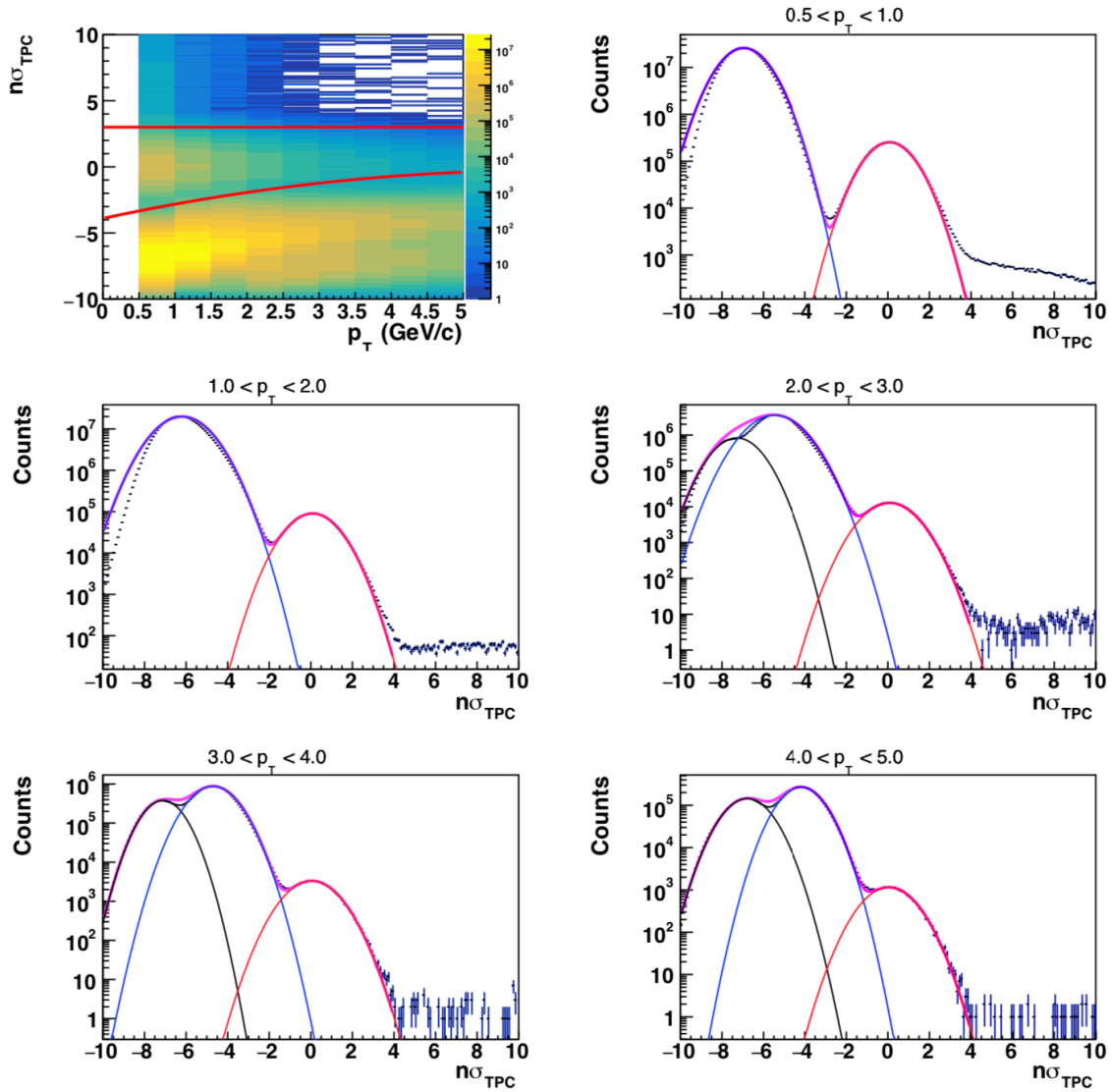
- Hfe pPb
  - http://alice-publications.web.cern.ch/node/5647
  - arXiv:1910.14399



- Lambda_c+
  - http://alice-publications.web.cern.ch/node/4141
  - arXiv:1712.09581



TPC nsigma pPb vs pp 13 TeV



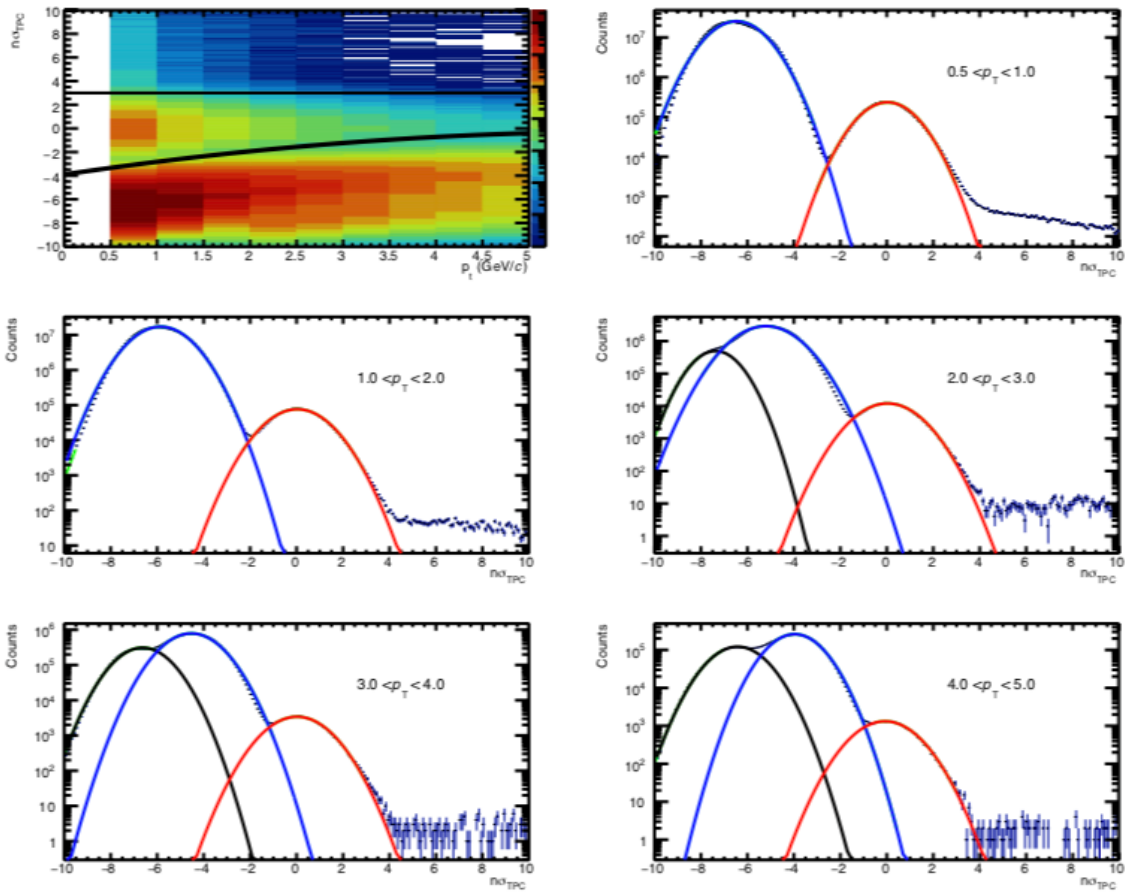
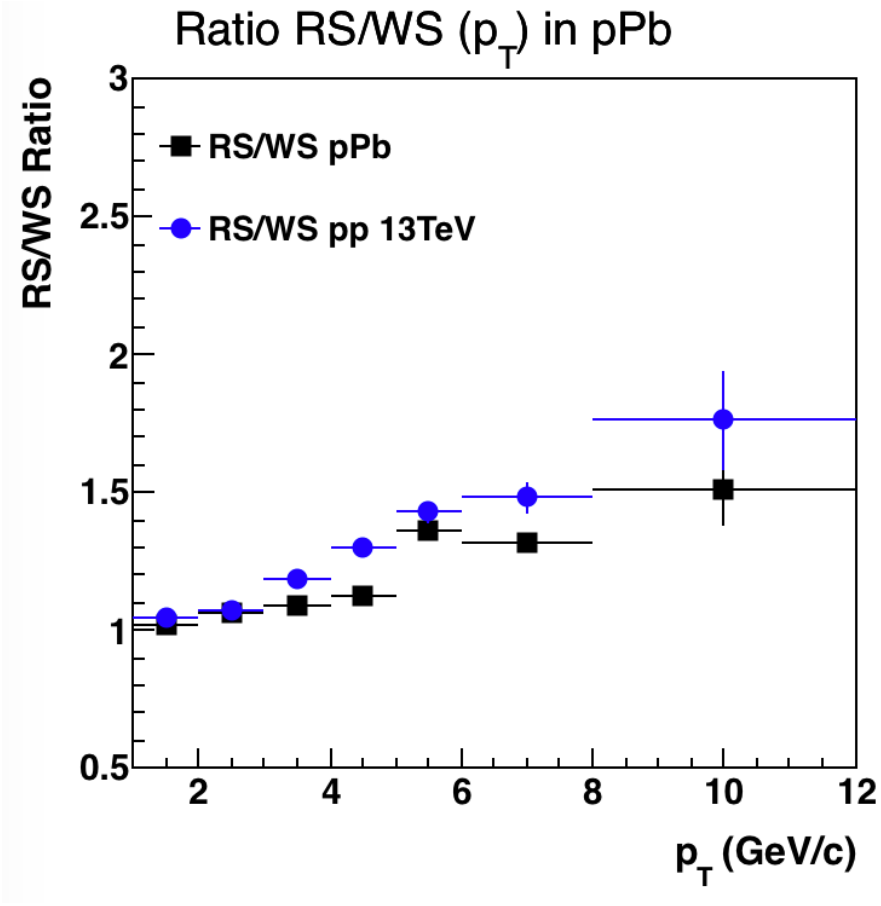
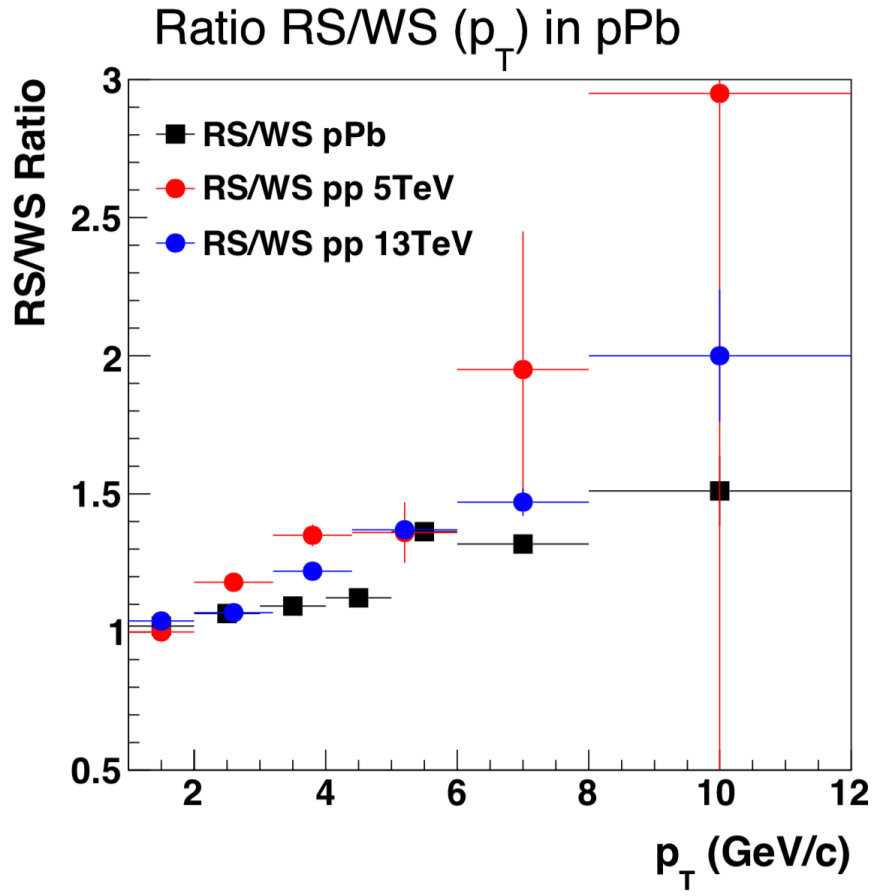


Fig. 2: The distribution of σ_{TPC} for different p_T at $\sqrt{s} = 13$ TeV.

RS/WS comparison

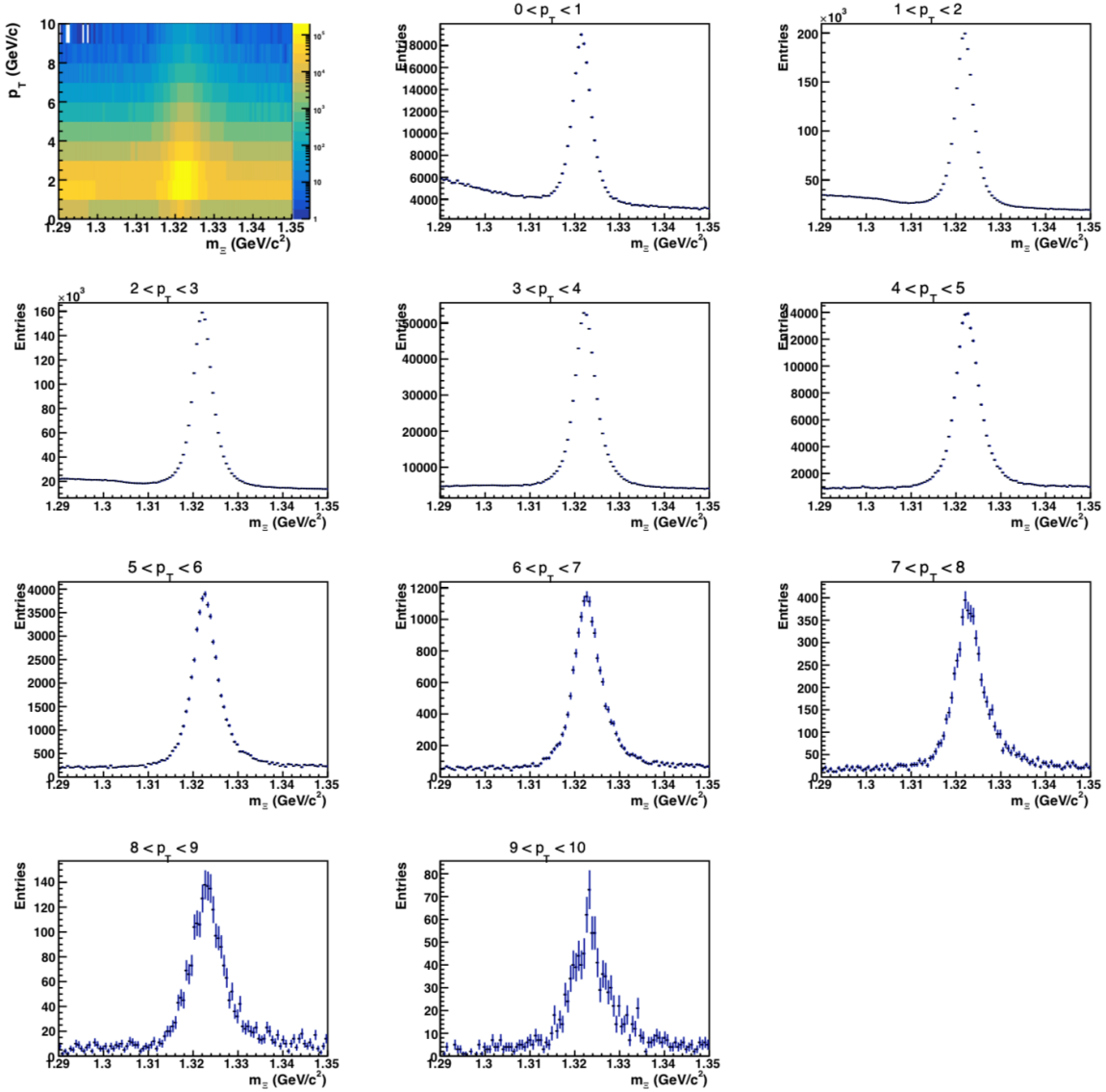
- RS/WS in pPb, pp5TeV, pp13TeV but on the right side,
- Right side : Different binning, extracted from plots in the analysis note
  - Left side : new binning, comparison with pp 13TeV
- RS/WS in pPb looks smaller than pp



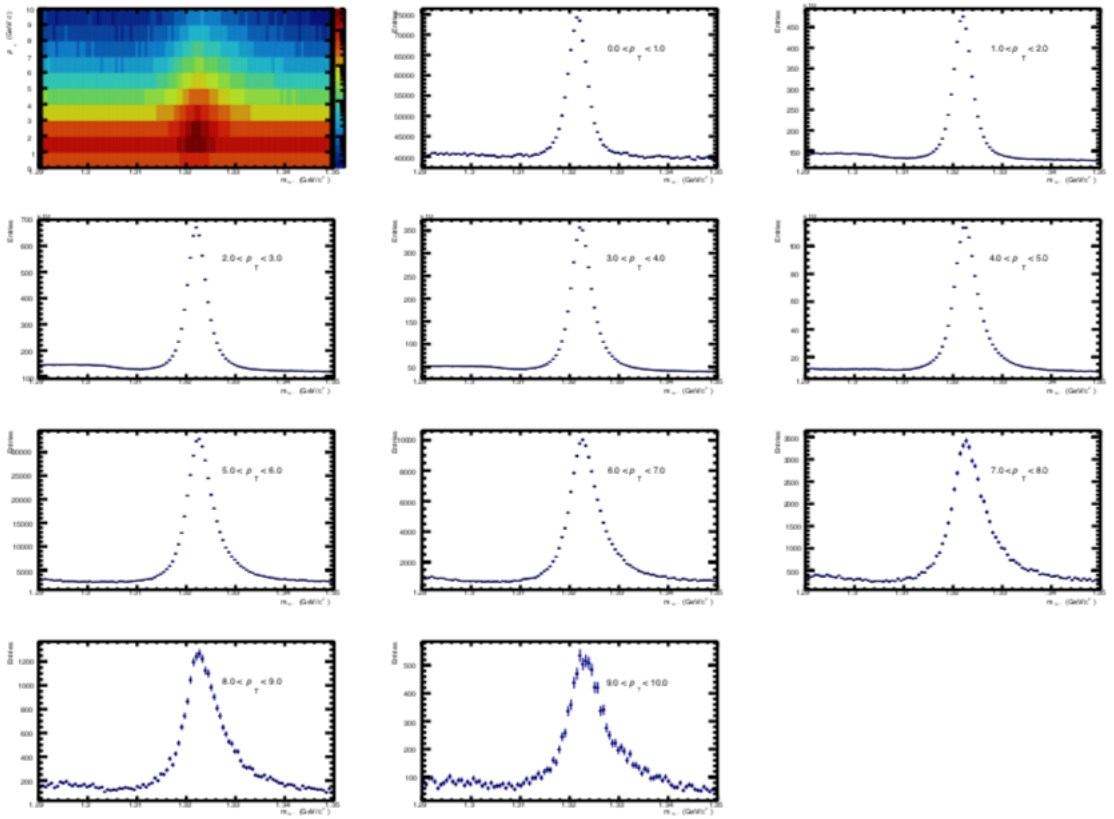


Xi mass (1321.71)

- pPb

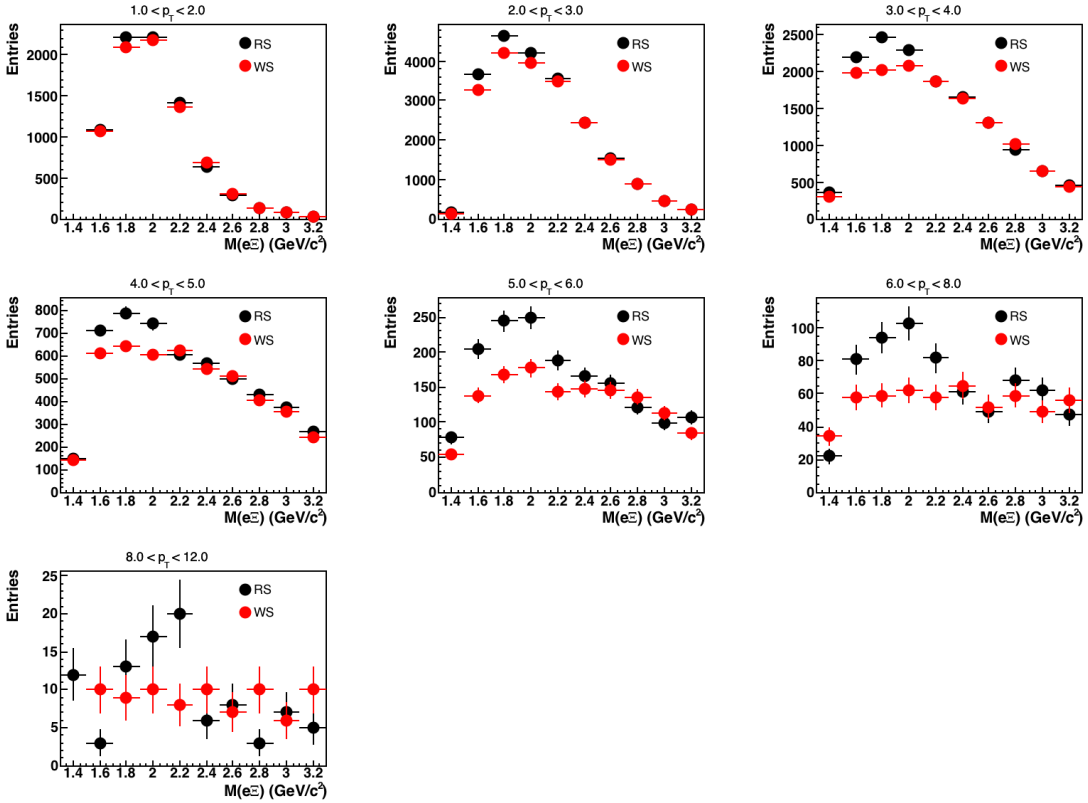


pp 13TeV



RS, WS ptbin

- pPb, pp 5TeV



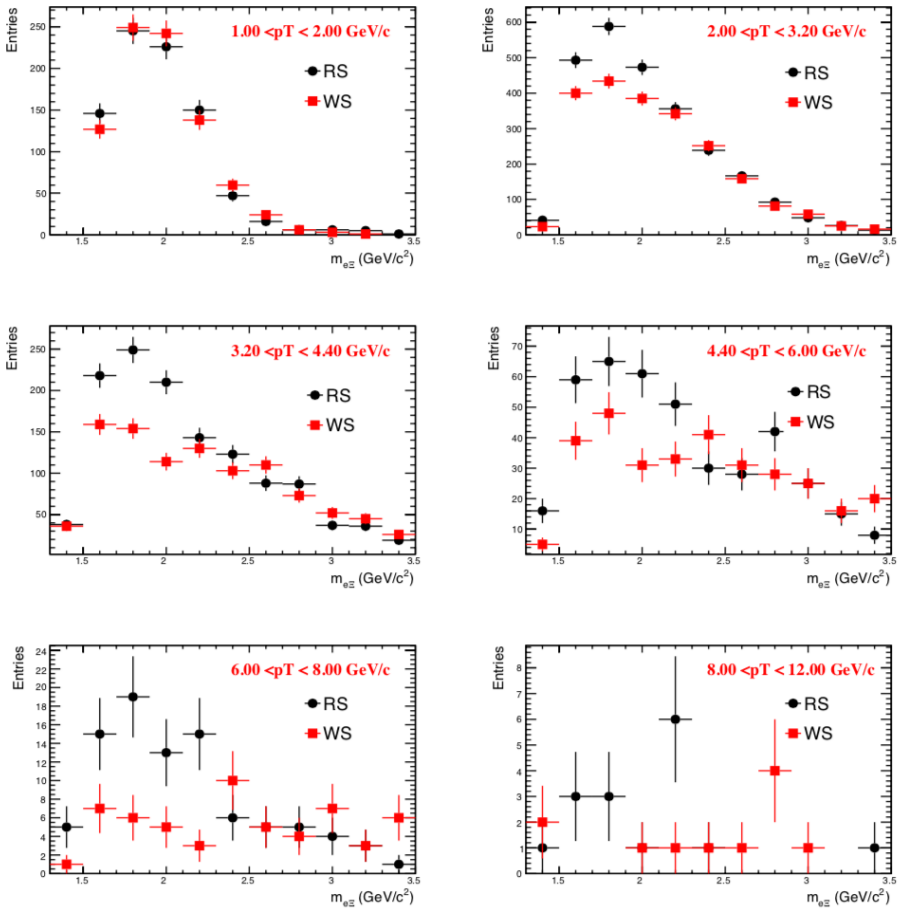
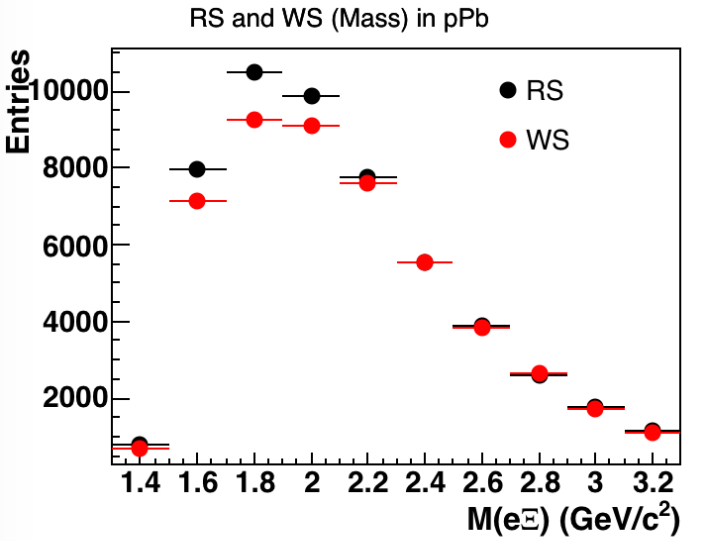
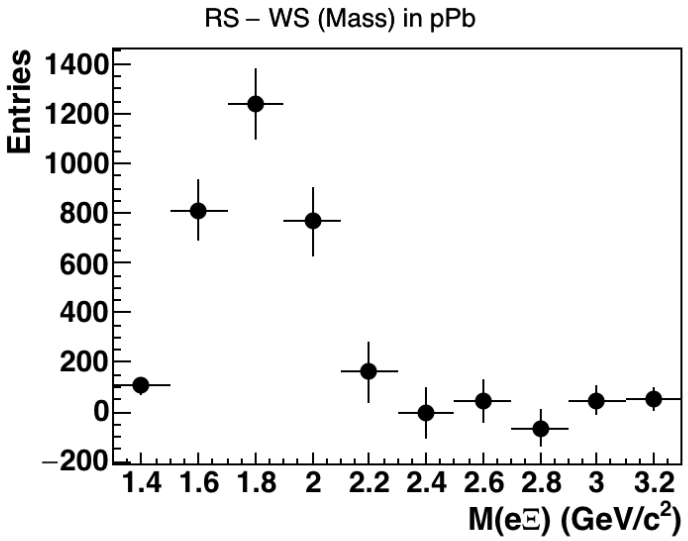


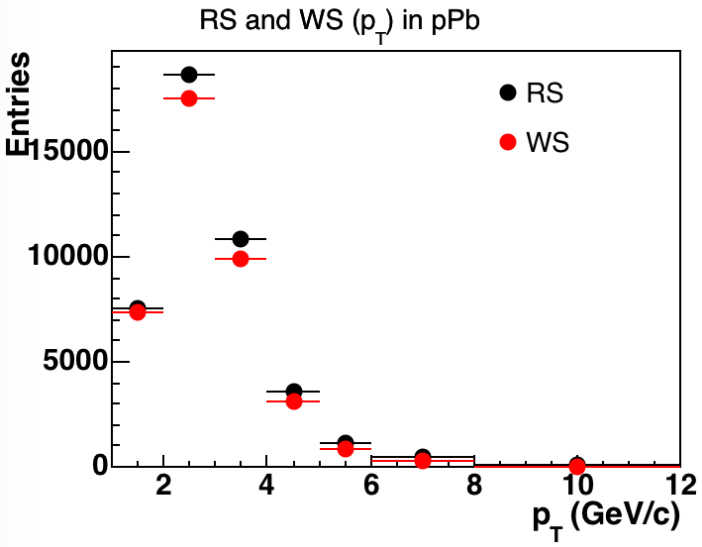
Fig. 9: The invariant mass distribution of RS and WS $e\Xi$ pairs at $\sqrt{s} = 5.02$ TeV.

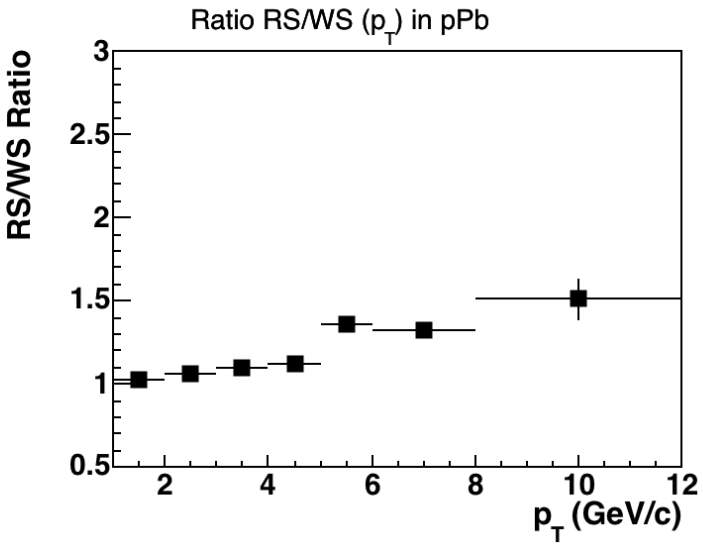
RS and WS

- pPb 5 TeV

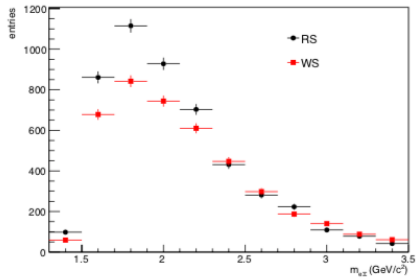


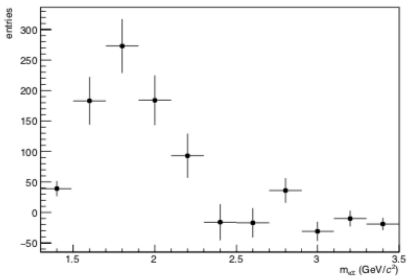




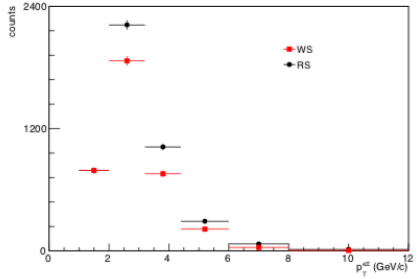


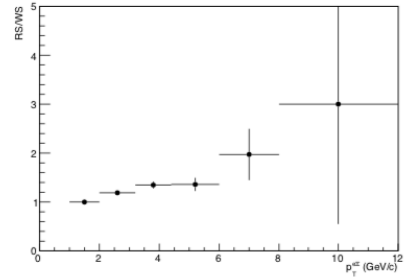
RS/ WS ratio close to pp

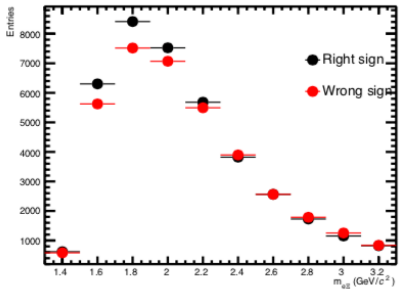


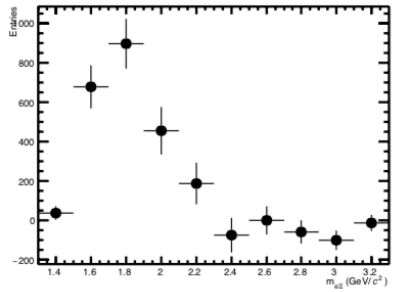


pp 5 TeV

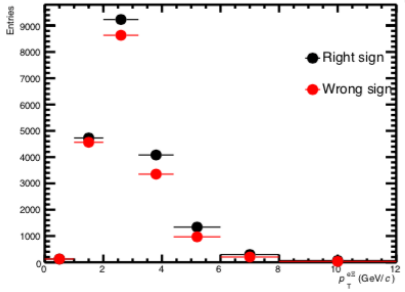


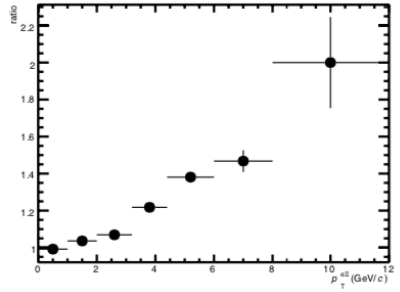






pp 13 TeV





RS and WS in MC