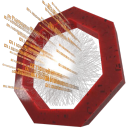




ALICE



**RUN3**

# Production of $\Lambda(1520)$ Resonance in pp Collision at LHC Energies Using $O^2$ Physics Framework

**Hirak Kumar Koley**

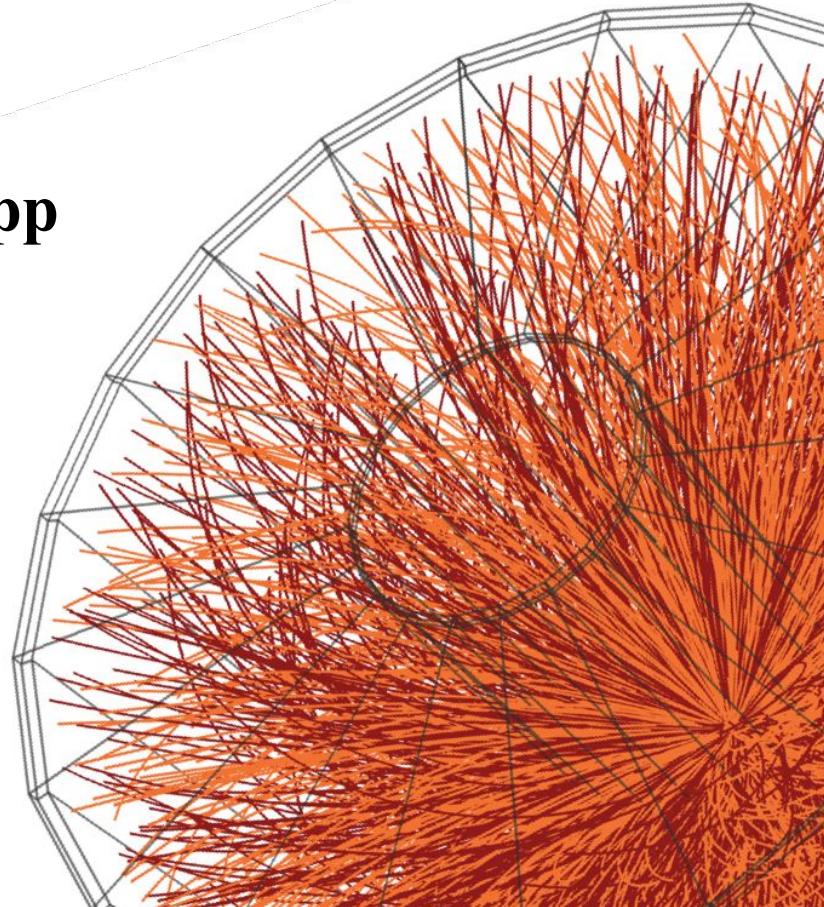
Jadavpur University

[hirak.koley@cern.ch](mailto:hirak.koley@cern.ch)

**Supervisor: Prof. Mitali Mondal**

ALICE-STAR India Collaboration Meeting, **2023**

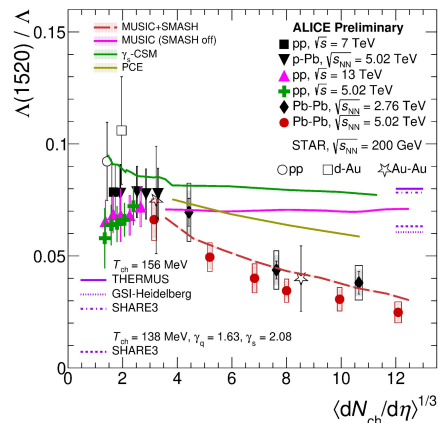
21 November 2023



# Outline

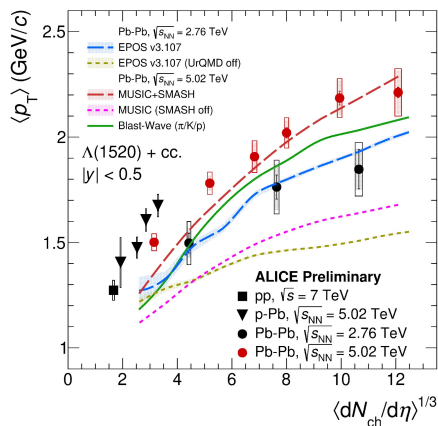
- Motivation
- Analysis Method
  - Data samples and event selection
  - Track selection and PID selection
  - Signal extraction (inv. mass, fit, fit parameters)
  - Correction: Acceptance x Efficiency
  - Systematic uncertainty
- Corrected Spectra
- Results
- Summary and Outlook

# Motivation



- **900 GeV: Lowest multiplicity region**
  - First measurements of  $\Lambda(1520)$  in this energy scale
- **13.6 TeV: Largest data sample available**
  - Enables differential resonance studies (eg. resonance flow)
  - Yield measurements as initial confirmation for the analysis framework

ALI-PREL-516662

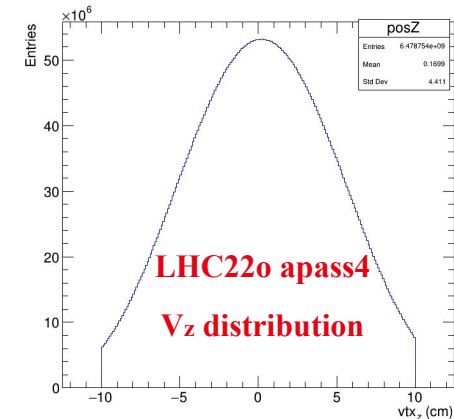
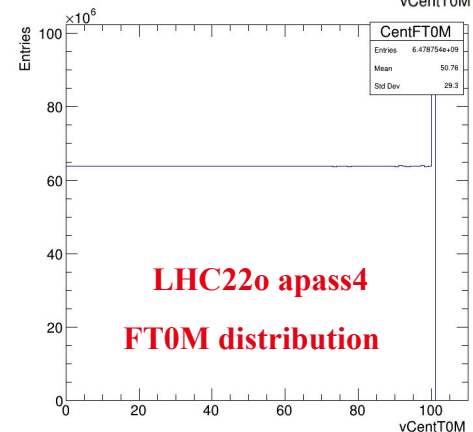
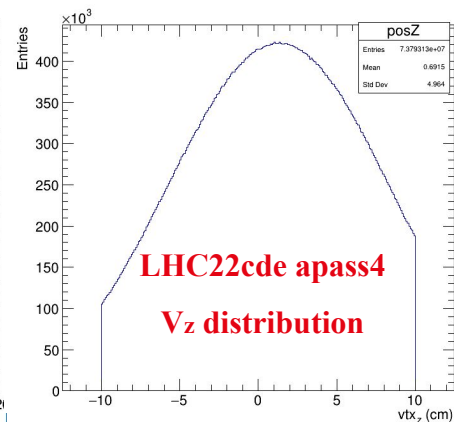
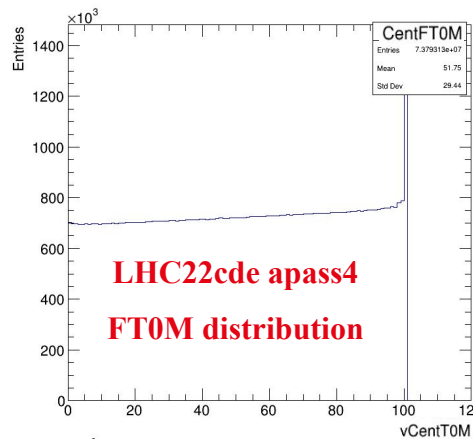


ALI-PREL-516652

# Data Samples and Event Selection






- **pp 900 GeV**
  - **Data set:** LHC22[c+d+e]\_pass4  
**Accepted events:** ~73M
  - **MC:** LHC23f3a  
~390k events (unanchored resonance injected MC)
  - Anchored reproduction: [Ongoing](#)
- **pp 13.6 TeV**
  - **Data set:** LHC22o\_pass4  
**Accepted events:** ~6.5B
  - **MC:** LHC23f3b  
~400k events (unanchored resonance injected MC)
  - Anchored reproduction: [Ongoing](#)
- **Event selection:** sel8(),  $|v_z| < 10$  cm

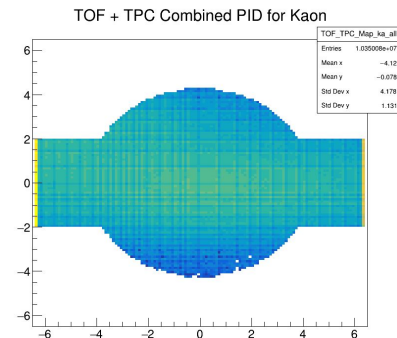
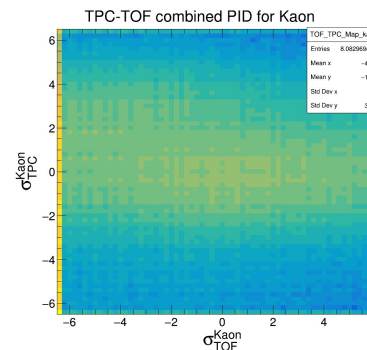
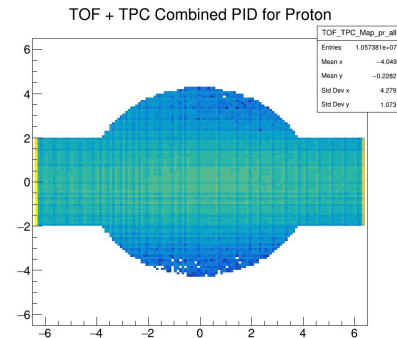
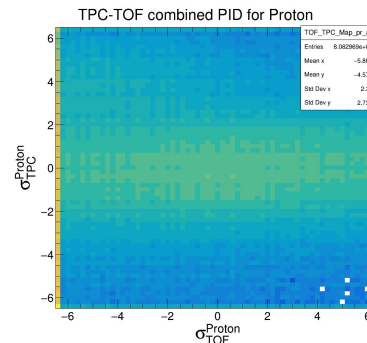


# Track Selection and PID Selection

- Track and PID selections

TPC-TOF  $n\sigma$  map of  $\Lambda(1520)$  daughters

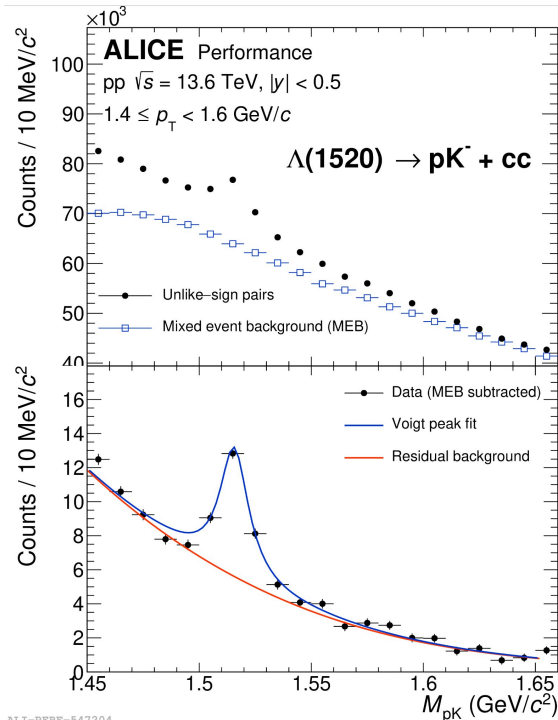
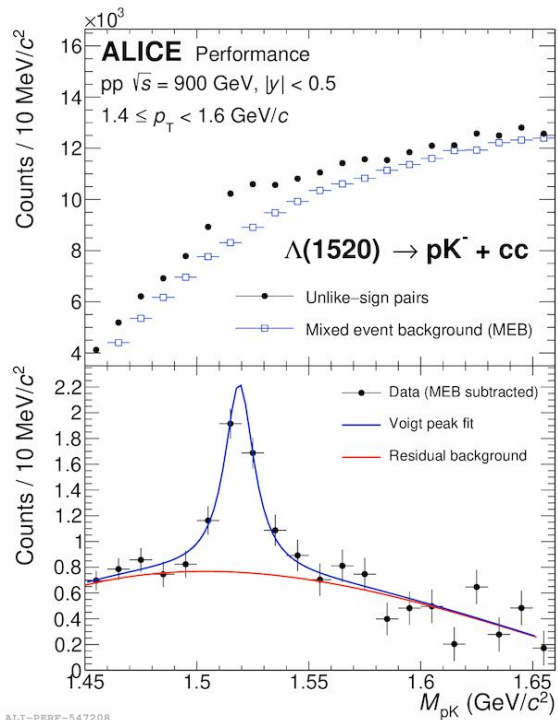
Selection Criteria	$\Lambda(1520)$
isGlobalTrackWoDCA()	
isPVContributor()	
isGlobalTrack()	
$ DCA_{xy} $	$< 0.15$ cm
$ DCA_z $	$< 2.0$ cm
$p_T > 0.15$ GeV/c	
$ \eta  < 0.8$	
$ \sigma_{TPC} $	$< 2.0$
$ \sigma_{TPC}^2 + \sigma_{TOF}^2 $	$< 2*2^2$ (veto)



# | Analysis Details

- **Invariant mass distribution** from **p+K** unlike-sign pair.
- **Background:**
  - Mixed-event
- **$p_T$  intervals:**
  - [0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0]
- **Fit:**
  - Voigtian + 3rd order polynomial
- **Mixed-event bkg.:**
  - Number of Event mixing = 5, Difference in  $|Vz| < 1$  cm, in FT0M Multiplicity bin  $< 10\%$

# Signal Extraction: Invariant Mass Distribution

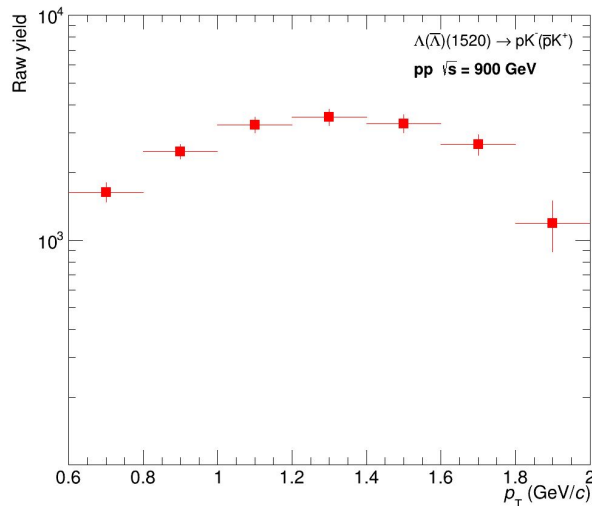
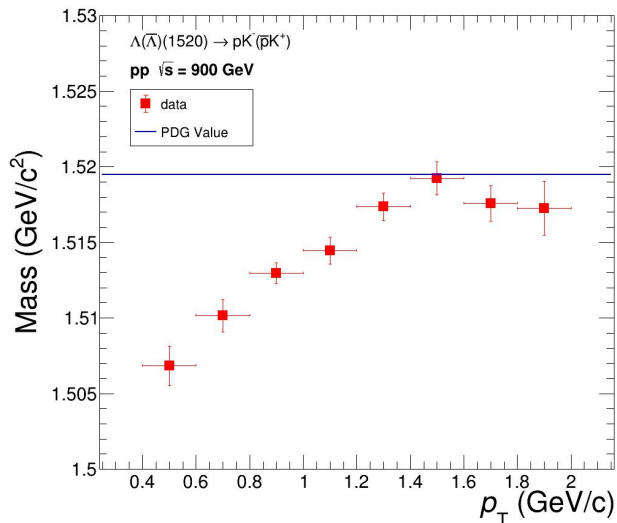


- Examples of invariant mass distribution
- Fit with fixed signal widths (PDG value)
  - Voigtian + 3rd order polynomial

| pp 900 GeV

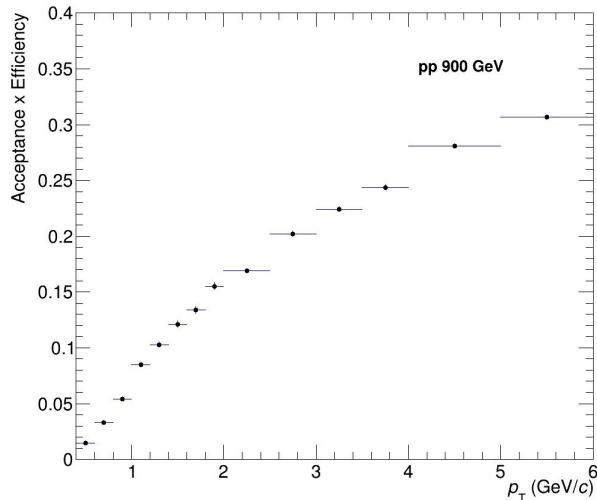


# Signal Extraction: Fit Parameters



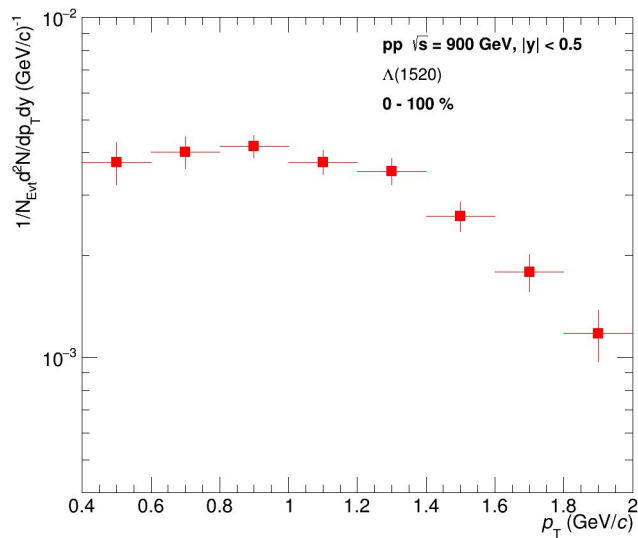
- **Fit mean:** at lowest  $p_T$  bin shifted: Similar behaviour with the Run 2
  - **Line:** PDG value
  - Significant shift on the **first  $p_T$  bin:** possibly reconstruction effect
- **Raw yields:**
  - Extracted from the bin counting method.
  - Fit width is fixed to the PDG value.

# Reconstruction Efficiency



- **Acceptance x Efficiency** = Number of reconstructed  $\Lambda(1520)$  decays to  $p+K$  using analysis acceptance and cut / Number of generated  $\Lambda(1520)$  in  $|y| < 0.5$
- **Used MC:**
  - Resonance injected MC (LHC23f3a)

# Corrected $p_T$ Spectra (MB)



- Corrected spectra: 
$$\frac{1}{N_{evt}} \frac{d^2N}{dp_T dy} = \frac{1}{N_{evt}} \frac{Y_{raw}}{dp_T dy \epsilon_{rec.B.R.}}$$

# Systematic Study: Strategy

- **Group - 1: Track Selection**

GlobalTrackwoDCA (def) vs GlobalTrack vs GlobalTrack with PVContributor

- **Group - 2: DCA Variations**

Default vs  $DCA_{xy}$  tight vs  $DCA_z$  tight vs  $DCA_{both}$  tight

- **Group - 3: TPC-TOF PID variations**




$2\sigma$  (def) vs  $2.5\sigma$  vs  $1.5\sigma$

- **Group - 4: Background & Fit Functions**

Voigtian with pol3 (default) vs Briet-Wigner with pol3 vs Voigtian with pol2

- **Group - 5: Signal Extraction**

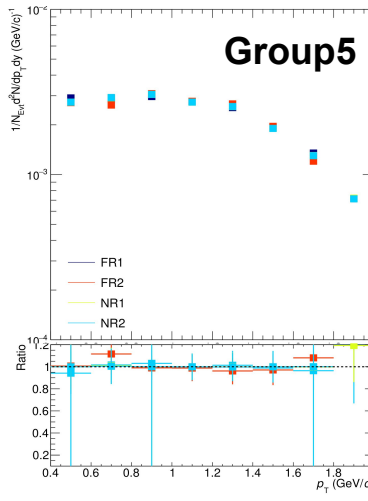
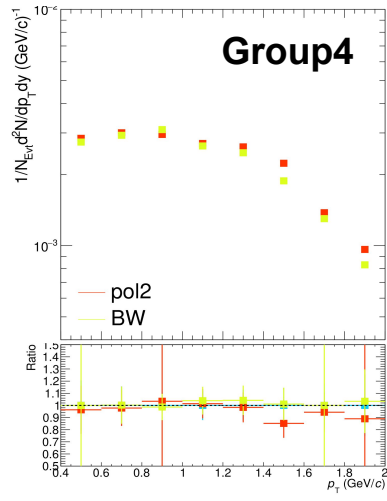
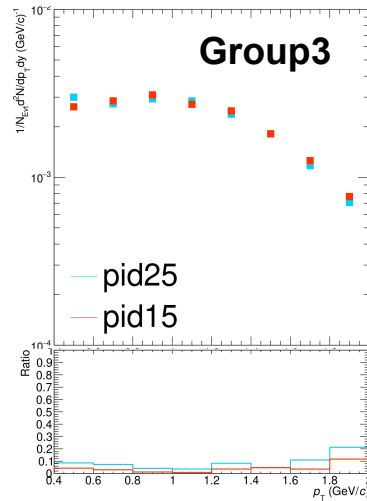
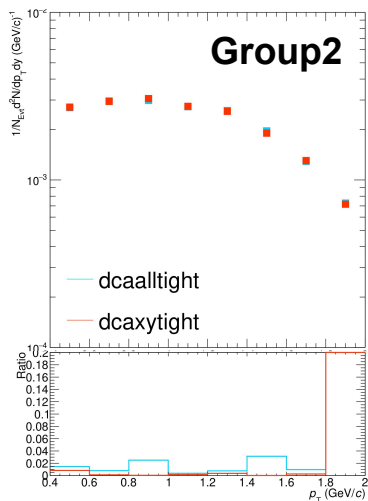
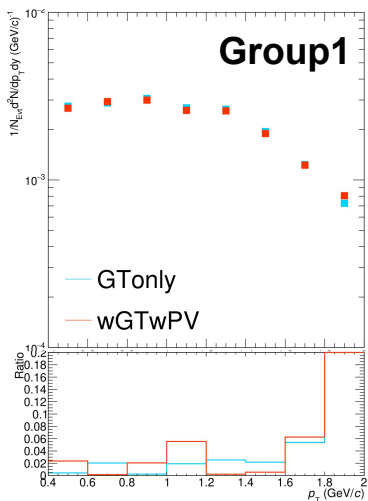
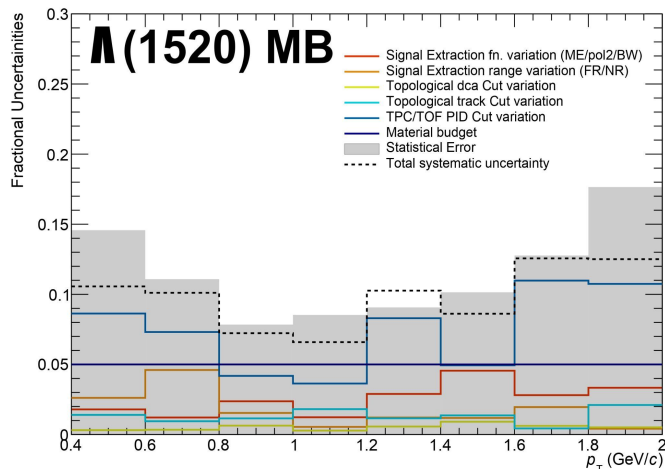
Fit range, Normalisation range

Selection Criteria	Default
isGlobalTrackWoDCA()	
isPVContributor()	
isGlobalTrack()	
$ DCA_{xy} $	< 0.15 cm
$ DCA_z $	< 2 cm
$p_T > 0.15$ GeV/c	
$ \eta  < 0.8$	
$ \sigma_{TPC} $	< 2.0
$ \sigma_{TPC}^2 + \sigma_{TOF}^2 $	< $2 \cdot 2^2$ (veto)

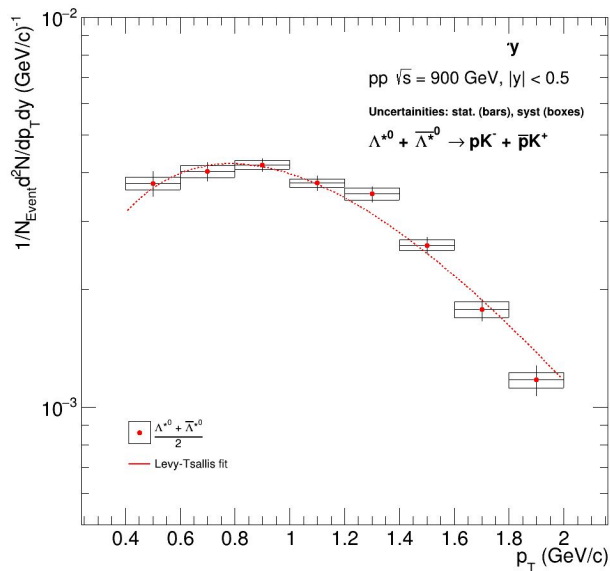
Selection criteria

# Systematic Study

- Basic systematic checks are done
- Smoothing procedure applied
- Large contribution: TPC/TOF PID variation and Signal Extraction



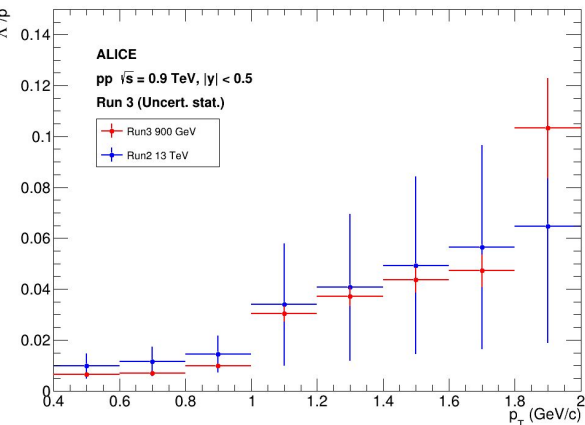
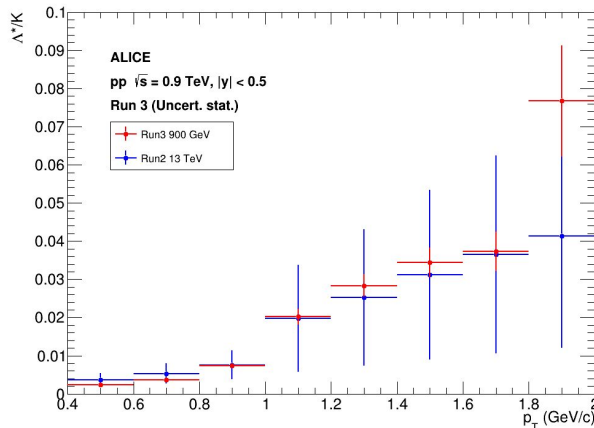
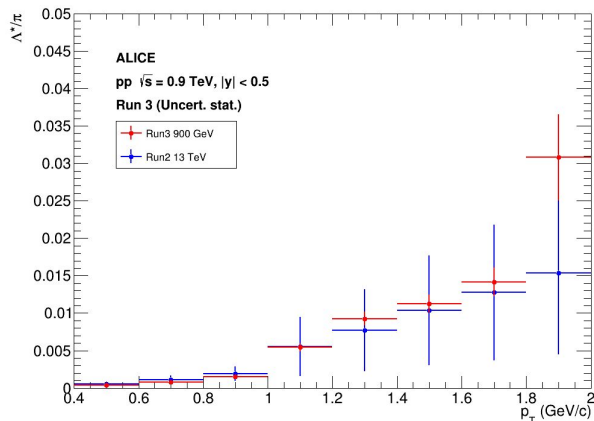
# Corrected $p_T$ Spectra (MB)



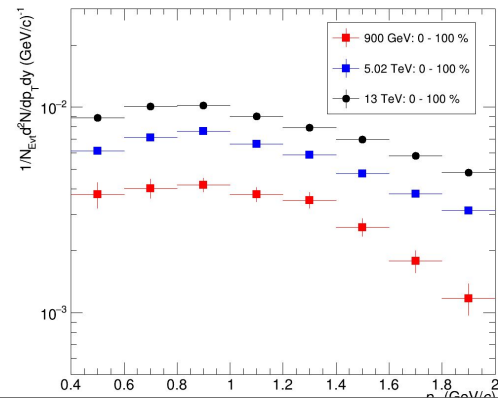
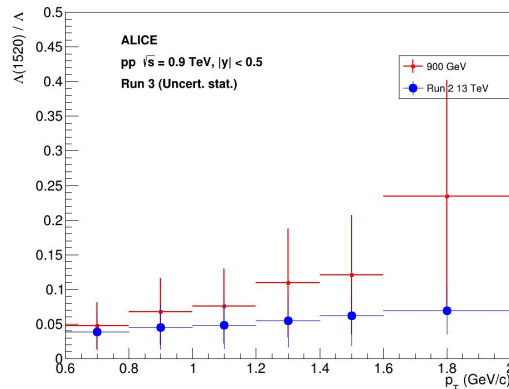
Corrected spectra with systematic uncertainty

# | Results

# $p_T$ -differential Particle Ratios

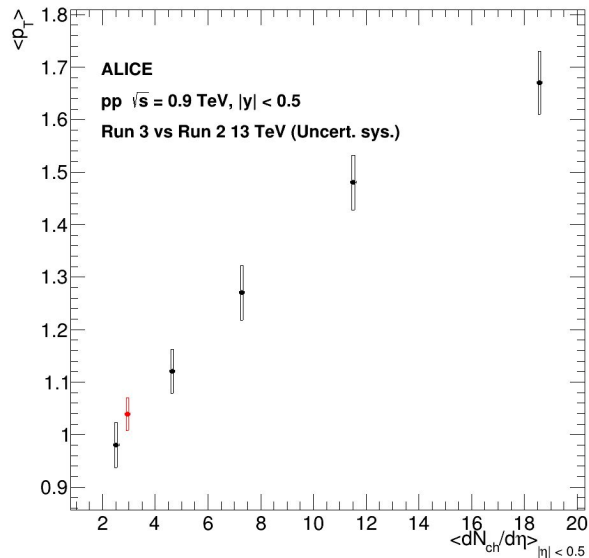
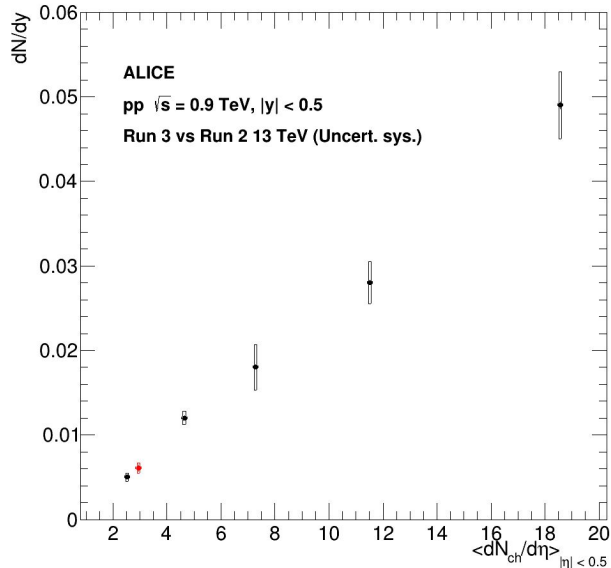


- Ratio to the RUN3  $p_T$  spectra ( $\pi$ , K, p,  $\Lambda$ )
- Blue point: pp 13 TeV, Run2 study
- Red point: pp 900 GeV, this study
- $\Lambda$  (G.S.): [1012.3257](https://arxiv.org/abs/1012.3257)
- They are reasonably consistent within the uncertainty.





# Yields, Mean $p_T$



**Black points:** pp 13 TeV [Run 2 Study](#)

**Red point:** pp 900 GeV, **this study**

**MB multiplicity:**  $2.94 \pm 0.11$  ([arXiv:1509.07541](#))

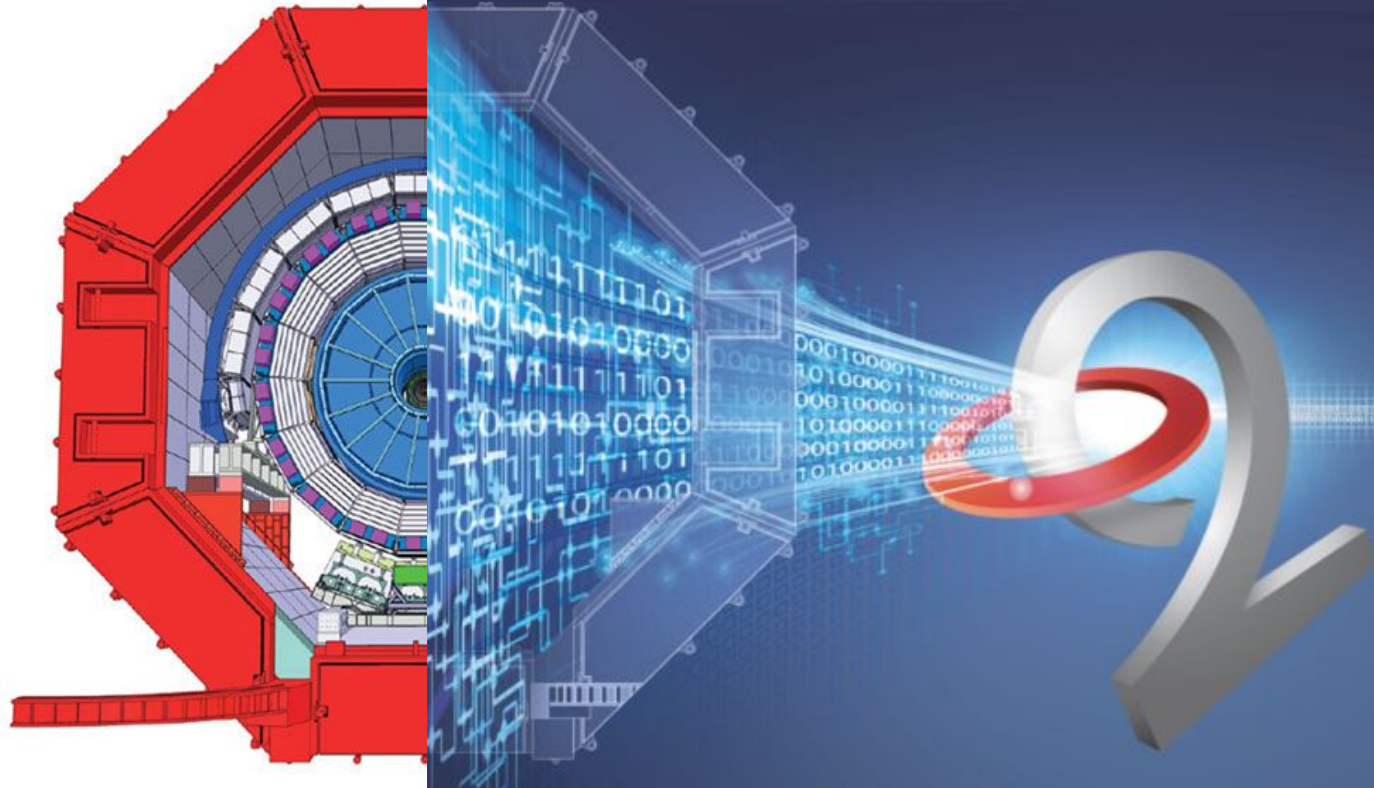
- $dN/dy = 0.006079 \pm 0.0001519(\text{stat.}) \pm 0.0005882(\text{sys.})$
- $\langle p_T \rangle = 1.03868 \pm 0.0186624(\text{stat.}) \pm 0.0308112(\text{sys.})$

# | Summary and Outlook

- Summary:
  - Signal Extraction has been done - [Performance plots](#) are approved for both the energies.
  - MB study on 900 GeV has been done.
  - Basic framework has been developed for both energies.

Analysis Note: <https://alice-notes.web.cern.ch/node/1449>

- Outlook:
  - Finalisation of anchored MC production
  - Wrap up the study of both energies for preliminary.



*Thank you for your attention*

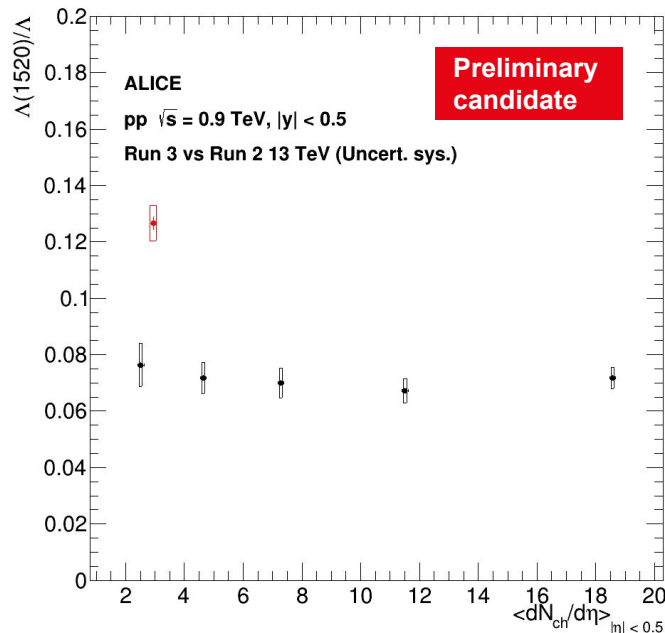
Back up

# | Normalisation

$$\text{eff}_{\text{INEL,MC}} = N_{\text{event,TVX MC}} / N_{\text{event,genMC}} = 597093/907500 \text{ or } 575202/ =$$

$$L_{\text{INEL}} = (N_{\text{event,TVXData}} / \sigma_{\text{INEL}} \text{eff}_{\text{INEL,MC}}) P_{\mu} =$$

# $\Lambda(1520)$ Particle ratios



**Black points:** pp 13 TeV [Run 2 Study](#)

**Red point:** pp 900 GeV, this study, syst. err. is underestimated.

**MB multiplicity:**  $2.94 \pm 0.11$  ([arXiv:1509.07541](#)), **RUN1  $\Lambda$  yields** ([arXiv:1012.3257](#)) -> Different y range



# | Run lists



## **LHC22c apass4:**

517619 517620 517623 517677 517678 517679 517685 517690 517693 517737 517748 517751  
517753 517758 517767

## **LHC22d apass4:**

518541 518543 518546 518547

## **LHC22c apass4:**

519041 519043 519045 519497 519498 519502 519503 519504 519507 519903 519904 519905  
519906

## **LHC22o apass4 small:**

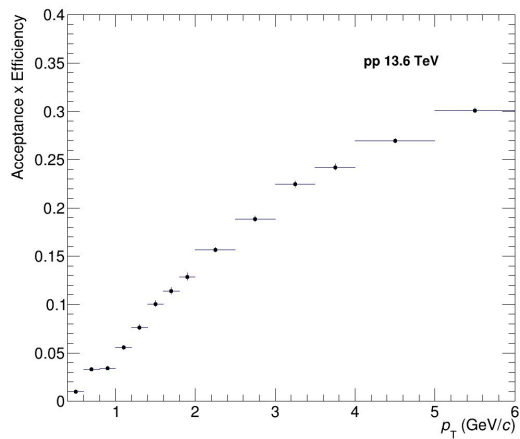
528531



| pp 13.6 TeV

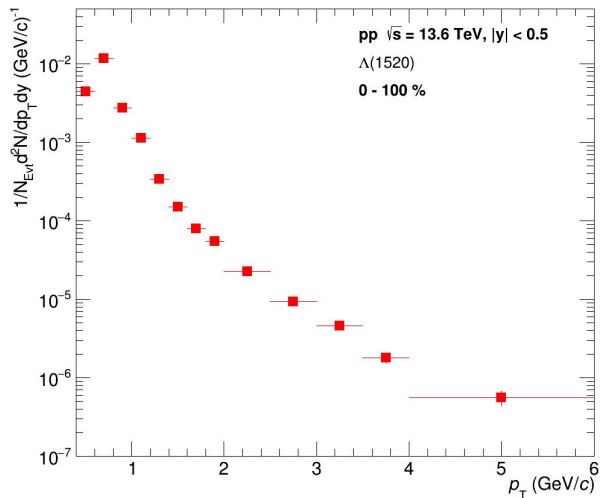


# Reconstruction Efficiency



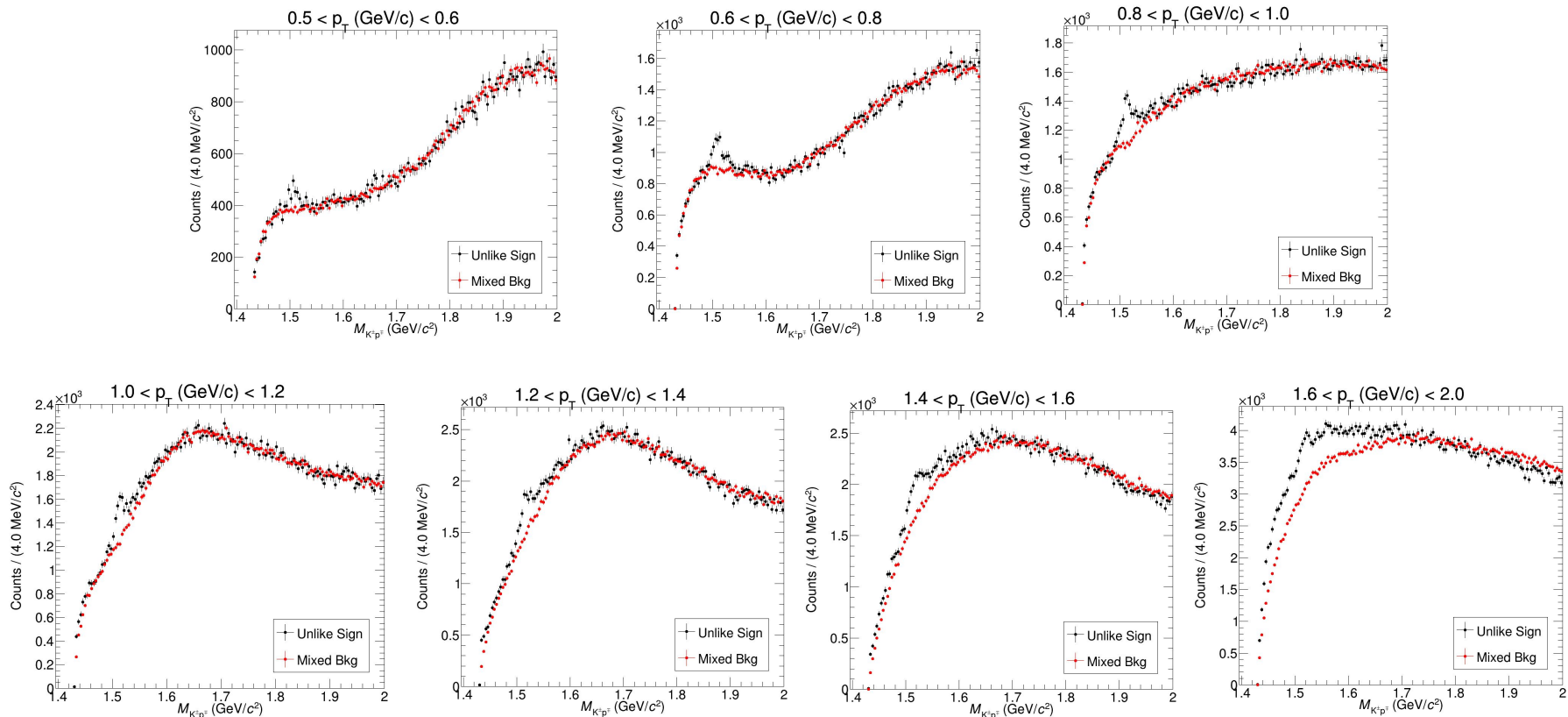
- **Acceptance X Efficiency** = Number of reconstructed  $\Lambda(1520)$  decays to  $p+K$  using analysis acceptance and cut / Number of generated  $\Lambda(1520)$  in  $|y| < 0.5$
- **Used MC:**
  - $\Lambda(1520)$ : Resonance injected MC (LHC23f3a)

# Corrected $p_T$ spectra (MB)



- under preparation

# $\Lambda(1520)$ Signal Extraction (pp 900 GeV) - MB #1



# $\Lambda(1520)$ Signal Extraction (pp 900 GeV) - MB #2

