Multi-Strange particle production in Run 3 pp collisions at 900 GeV

ALICE-STAR INDIA Collaboration Meeting
21-24 Nov 2023

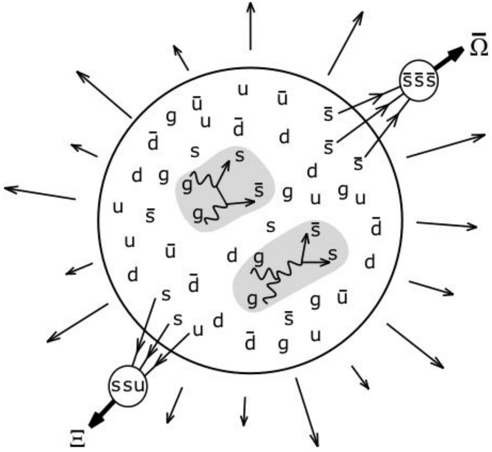
Upasana Sharma
Supervisor: Prof. Anju Bhasin
Department of Physics
University of Jammu

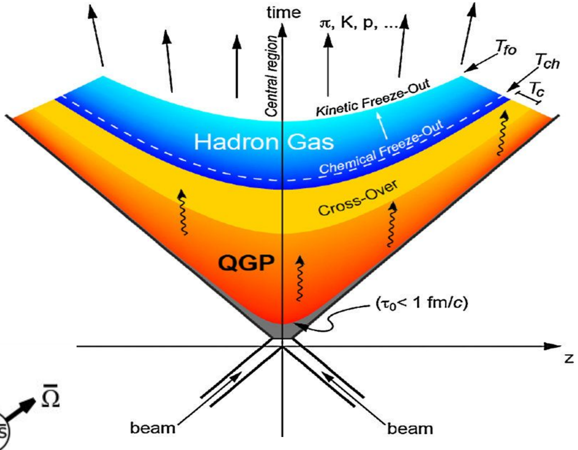
Outline

- Motivation
- Data Sample
- Task Used
- Topological and Kinematical Selections
- Signal Extraction
- Corrections used
- Results
- Summary

Motivation

- The hot, dense state of matter at sufficiently high temperature and high energy density i.e (QGP) Quark Gluon Plasma.
- The temperature of QGP formation close to the mass of s-quark allows for thermal production of *s*trange and Anti-strange quark pairs through the annihilation of gluon pairs.
- Thus, lead to an **enhancement of multi-strange** hadrons.





This **Strangeness Enhancement** was proposed as the first signature of QGP.

Physics motivation

Extend the studies of **strangeness enhancement in small collision systems** (pp collisions) characterised by **higher multiplicity.**

Ω production at low multiplicity

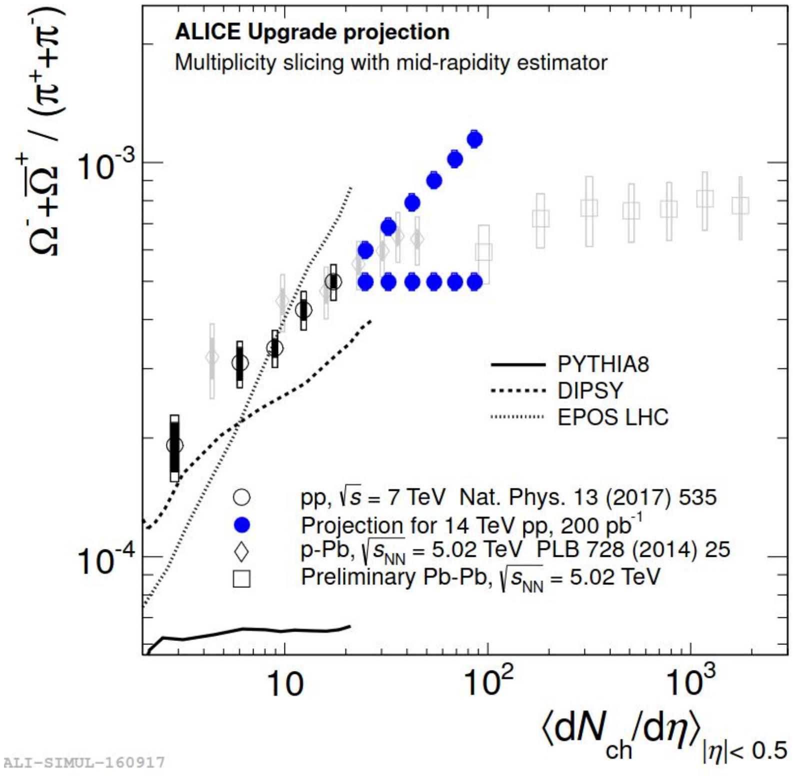
➔ exploiting Run 3 pp at 900 GeV collisions

(not feasible with Run 1 data!)

Ω production at high multiplicity

→ Does Ω/π ratio in high multiplicity pp collisions saturate, smoothly connecting with Pb-Pb results (thermal limit)?

→ Or does it exceed the low multiplicity Pb-Pb?



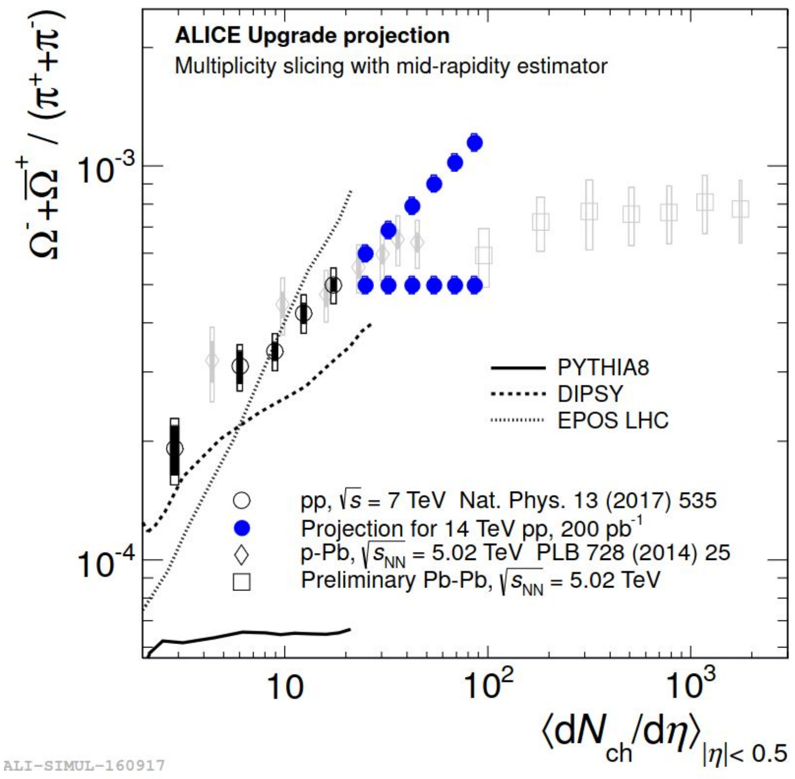
Physics motivation

Extend the studies of **strangeness enhancement in small collision systems** to pp collisions characterised by **higher multiplicity.**

Ω production at low multiplicity

exploiting Run 3 pp at 900 GeV collisions

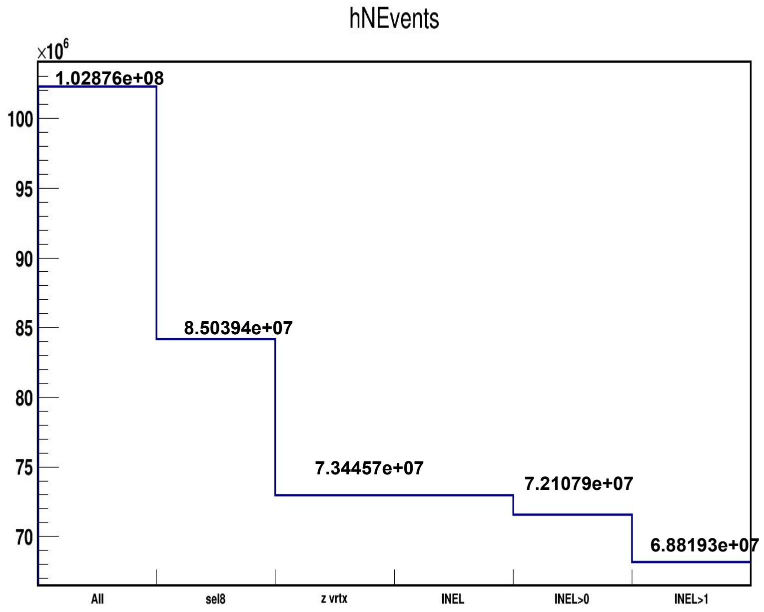
(not feasible with Run 1 data!)



Data sample

Dataset → Pilot Beam Data
LHC22cde_pass4 (72x 10^6 events).

MC used: MC Gap-Triggered (produced internally*) and General Purpose MC Anchored to 900 GeV Data LHC22cde_pass4 (**LHC22h1c1**).



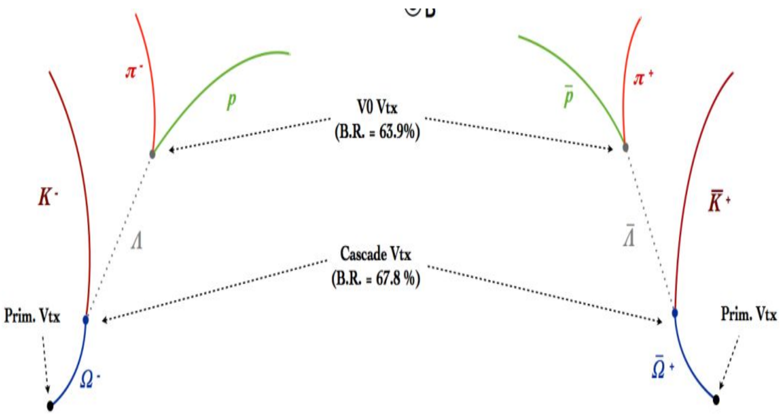
Tasks used for the analysis

https://github.com/AliceO2Group/O2Physics/blob/master/PWGLF/Tasks/cascqaanalysis.cxx
→ produces **a derived data table** which stores topological and kinematic variables of cascade candidates

https://github.com/AliceO2Group/O2Physics/blob/master/PWGLF/Tasks/cascpostprocessing.cxx
→ produces **invariant mass** vs p_T vs multiplicity **histograms** after applying custom selections to topological and kinematic variables
→ can be run locally or on the hyperloop on larger datasets

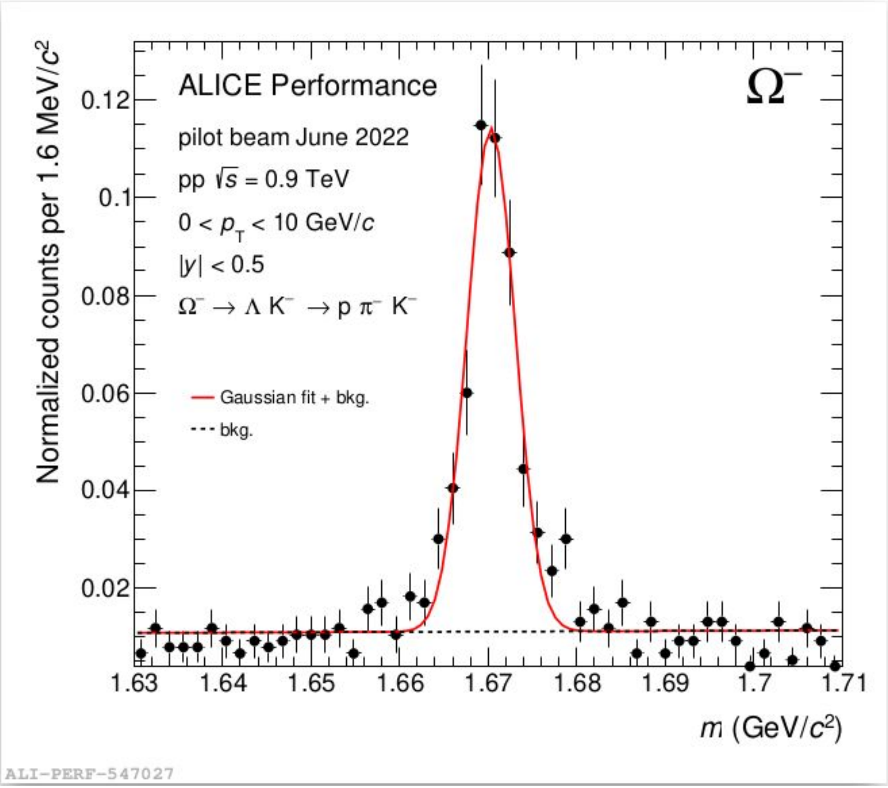
Topological and kinematic selections for Ω identification

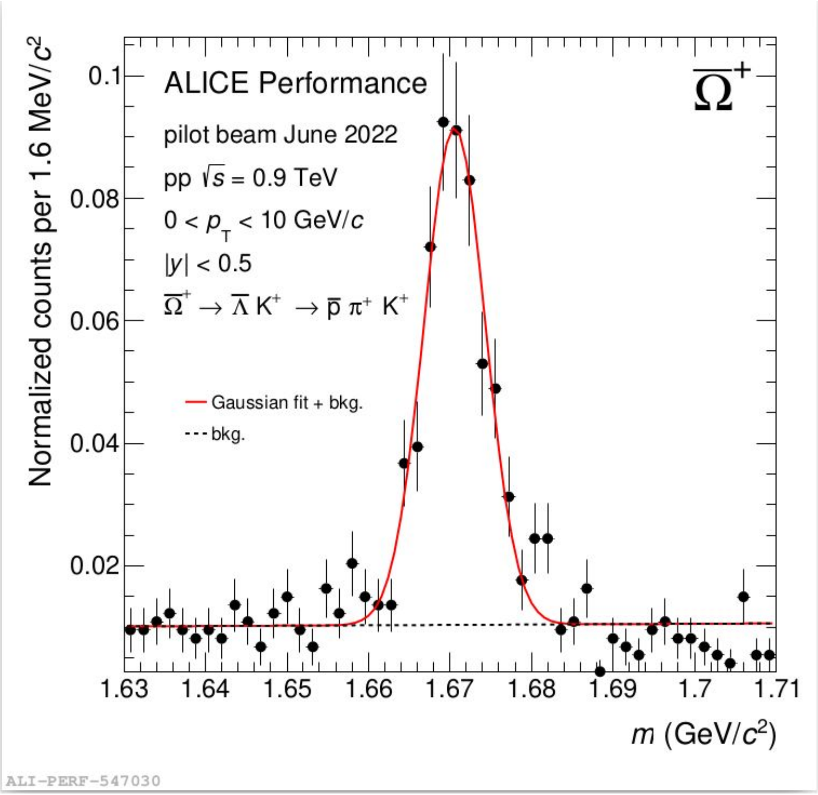
Number of TPC crossed pad rows	> 50
DCA meson daughter to primary vertex	> 0 cm
DCA baryon daughter to primary vertex	> 0 cm
DCA bachelor to primary vertex	> 0.04 cm
DCA between daughter tracks of the V0s	< 0.4 cm
Casc CosPA	> 0.95
V0CosPA	> 0.99
DCA between bachelor and V0s	< 0.8 cm
DCA V0s to primary vertex	>0.03 cm
V0s decay radius	> 1.2 cm
Cascade decay radius	> 0.5 cm
Rapidity$_{\|y\|}$	< 0.5



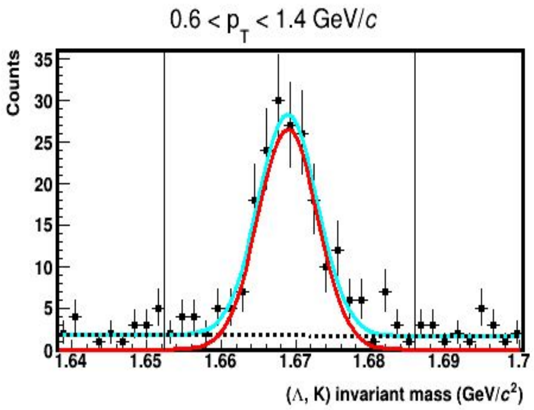
$$M^2_{experimental}(\Omega^-) = \left(\sqrt{m^2_\Lambda + \vec{p}^{\,2}_{V0}} + \sqrt{m^2_{K^-} + \vec{p}^{\,2}_{bach}}\right)^2 - (\vec{p}_{V0} + \vec{p}_{bach})^2$$

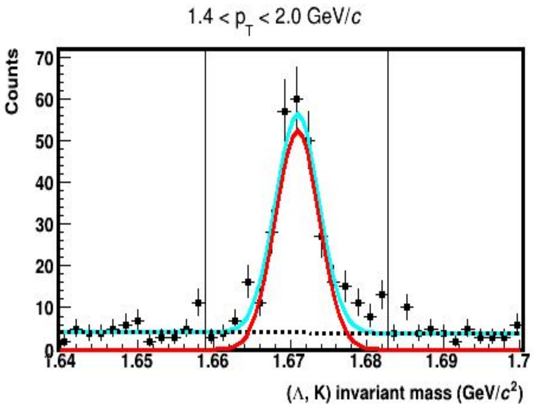
Signal Extraction

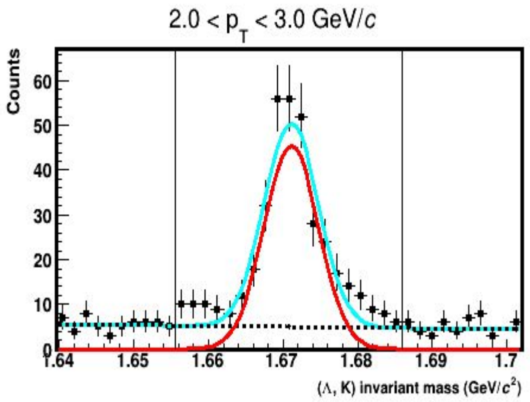




Signal extraction of Ω in FT0M (0-100)Multiplicity Class







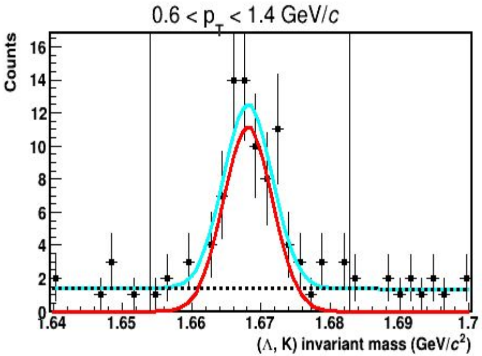
- Fit with gaussian + pol1

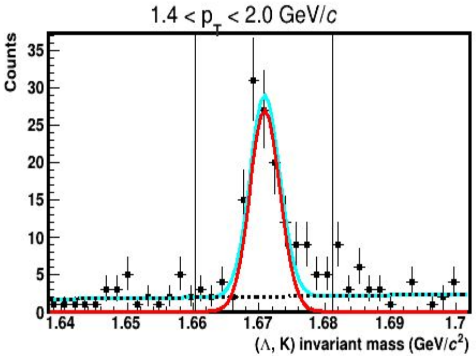
Background B = integral of fit function

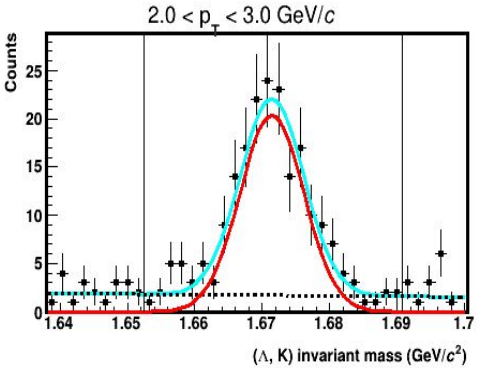
Signal S = (S+B) - B

Signal extraction of Ω in FT0M Multiplicity Classes

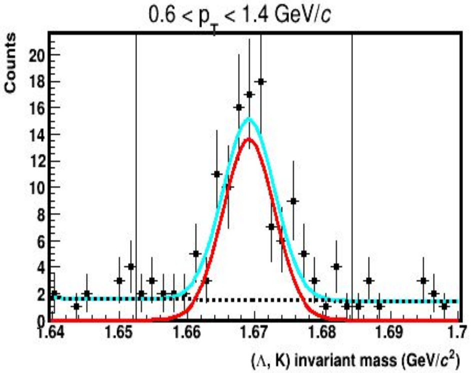
(0-30)%

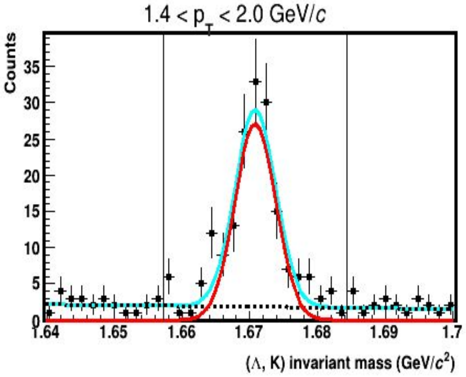


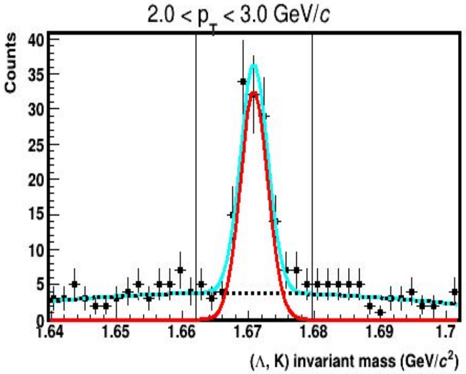




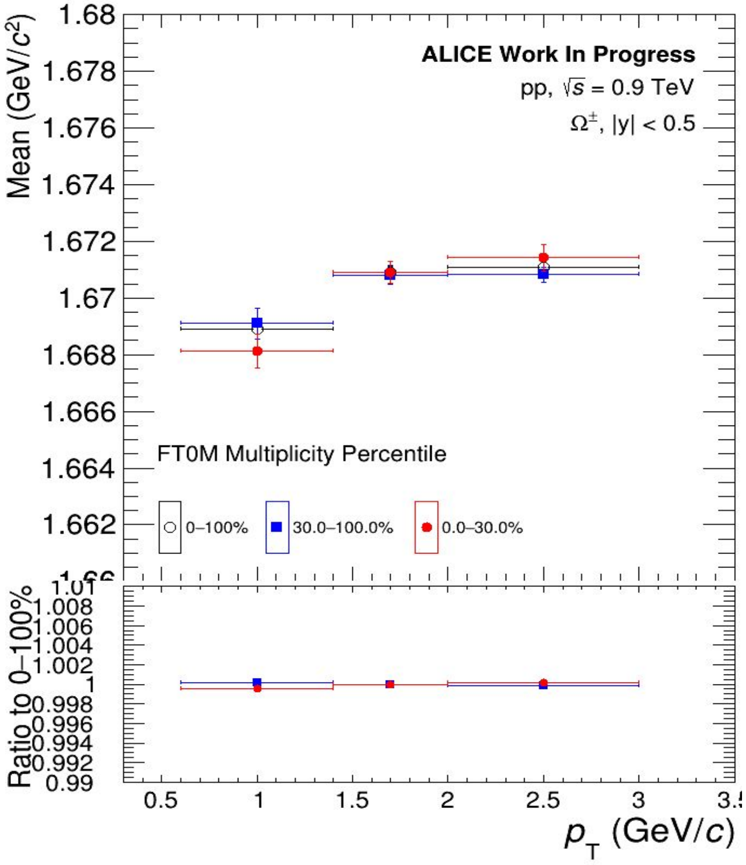
(30-100)%

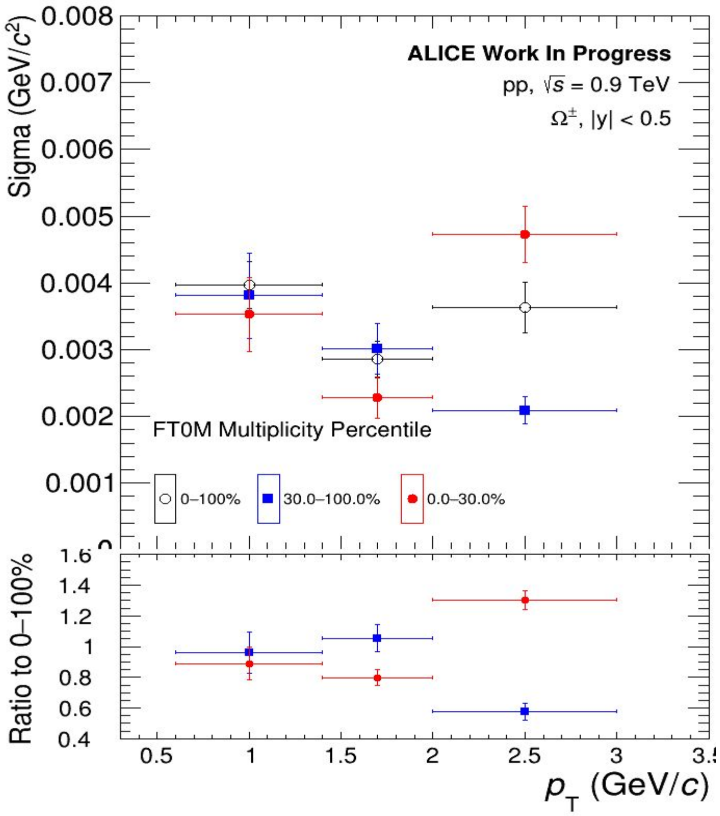




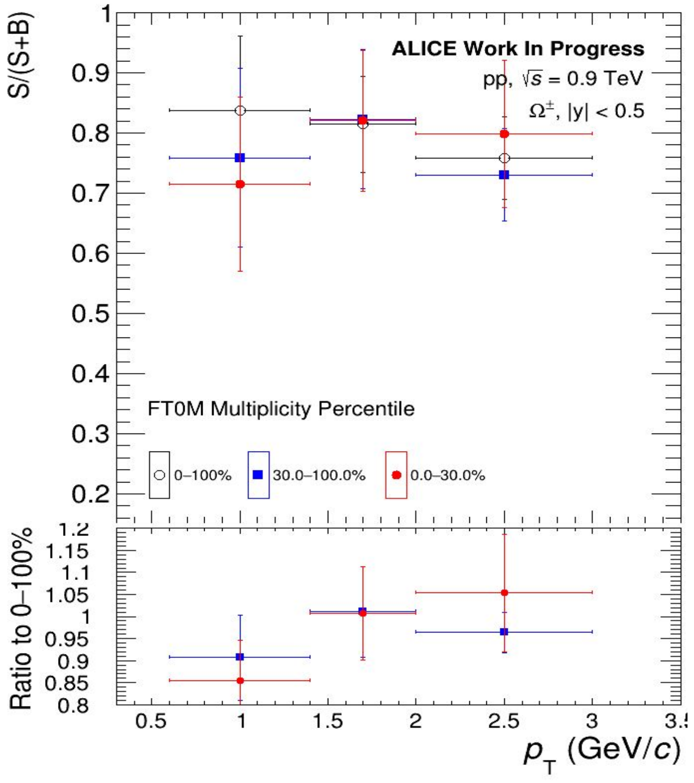


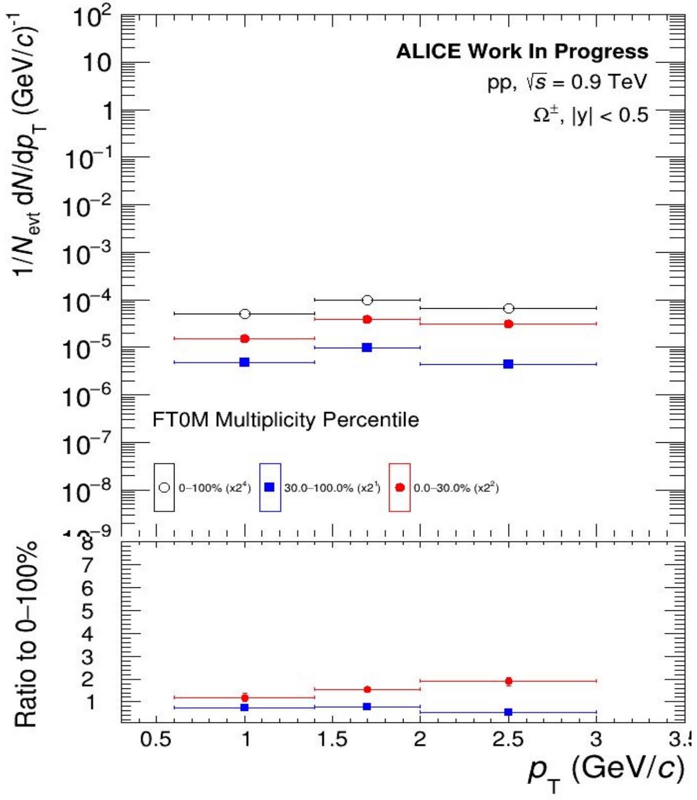
Mean (μ) and Sigma (σ) in FT0M Classes





Purity and Raw Yield in FT0M Classes

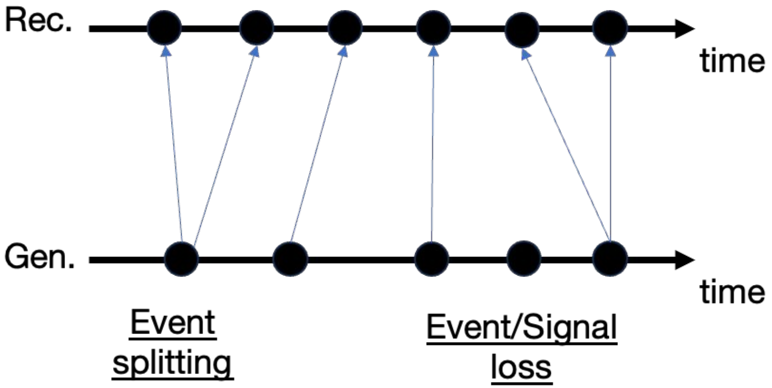




Event and Signal loss corrections in Run 3

$$\frac{1}{N_{\text{events}}^{\text{true INEL}>0}(\%)}\frac{dN}{dp_{\text{T}}} = Y_{\text{corr}}(\Delta p_{\text{T}}, \%) =$$

$$= \frac{S(\Delta p_{\text{T}}, \%)}{N_{\text{events}}^{\text{acc INEL}>0}(\%)} \cdot \frac{1}{\varepsilon_{\text{eff.x acc.}}(\Delta p_{\text{T}})} \cdot \frac{1}{\Delta p_{\text{T}}} \cdot \frac{\varepsilon_{\text{event loss}}(\%)}{\varepsilon_{\text{signal}}(\Delta p_{\text{T}}, \%) \cdot \varepsilon_{\text{event splitting}}(\%)}$$



$$\varepsilon_{\text{event loss}}(\%) = \frac{N_{\text{gen events with at least 1 rec.event}}(\%)}{N_{\text{gen}}(\%)}$$

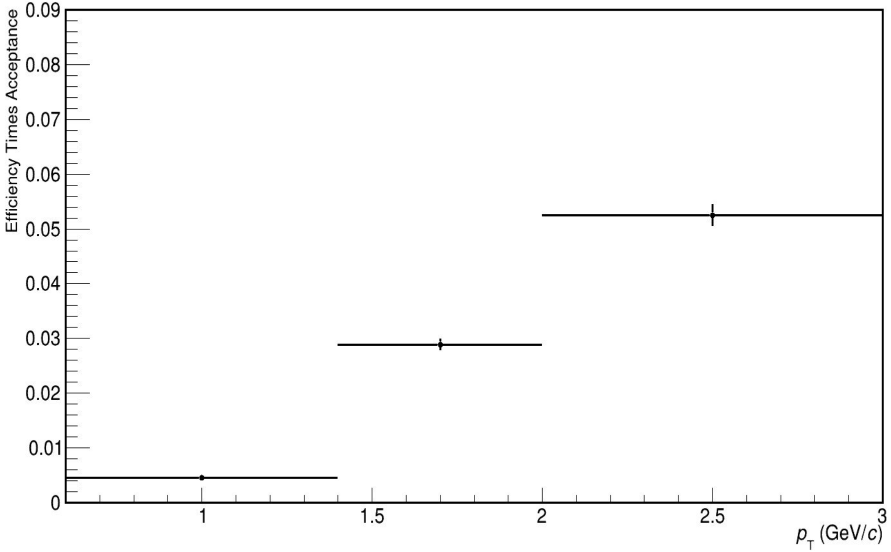
$$\varepsilon_{\text{event splitting}}(\%) = \frac{N_{\text{gen events with at least 1 rec.event}}(\%)}{N_{\text{rec}}(\%)}$$

These two factors will cancel out in the particle ratios (e.g. Ω/π)

$$\varepsilon_{\text{signal}}(\Delta p_{\text{T}}, \%) = \frac{N_{\text{gen cascades, at least 1rec. event}}(\Delta p_{\text{T}}, \%)}{N_{\text{gen cascades}}(\Delta p_{\text{T}}, \%)}$$

Efficiency x Acceptance correction

$$\varepsilon_{\text{eff. } x \text{ acc.}}\left(\Delta p_{\mathrm{T}}\right)=\frac{N_{\text{rec casc.}}\left(\Delta p_{\mathrm{T}}\right)}{N_{\text{gen casc., at least 1 rec.event}}\left(\Delta p_{\mathrm{T}}\right)}$$



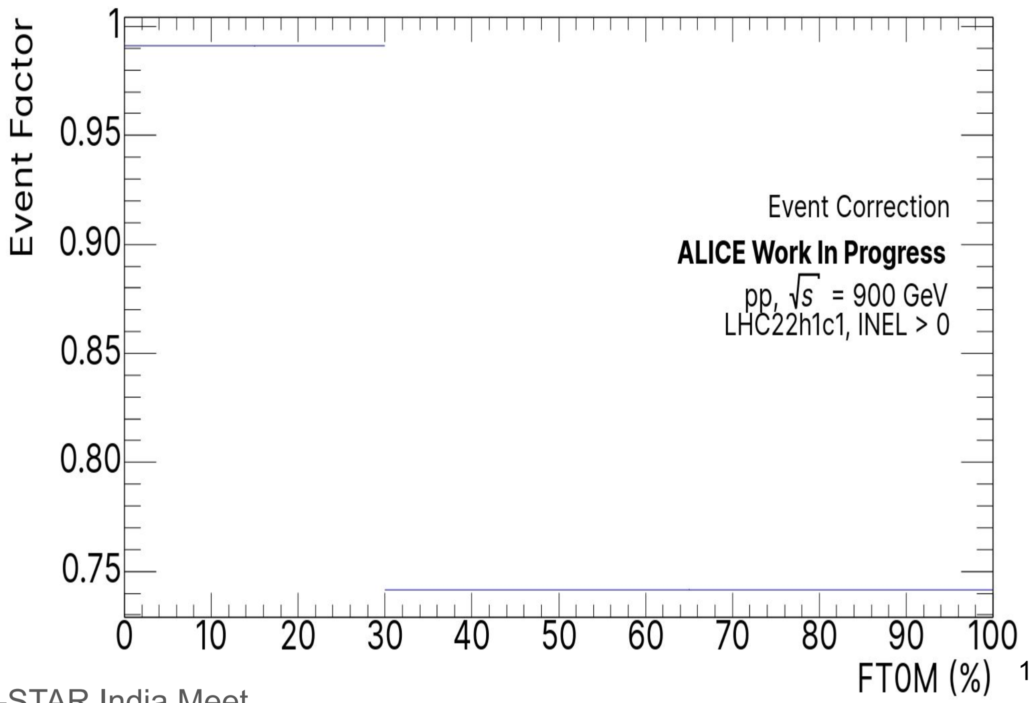
- Efficiency x Acceptance is calculated by using the **Gap-Triggered** MC (produced internally) **Anchored** to Data .

Event loss correction

$$\frac{\varepsilon_{\text{event loss}}(\%)}{\varepsilon_{\text{event splitting}}(\%)} = \frac{N_{\text{rec}}(\%)}{N_{\text{gen}}(\%)}$$

First calculation of event loss in multiplicity classes in 900 GeV

Calculated by using the General purpose MC anchored to LHC22c,d,e



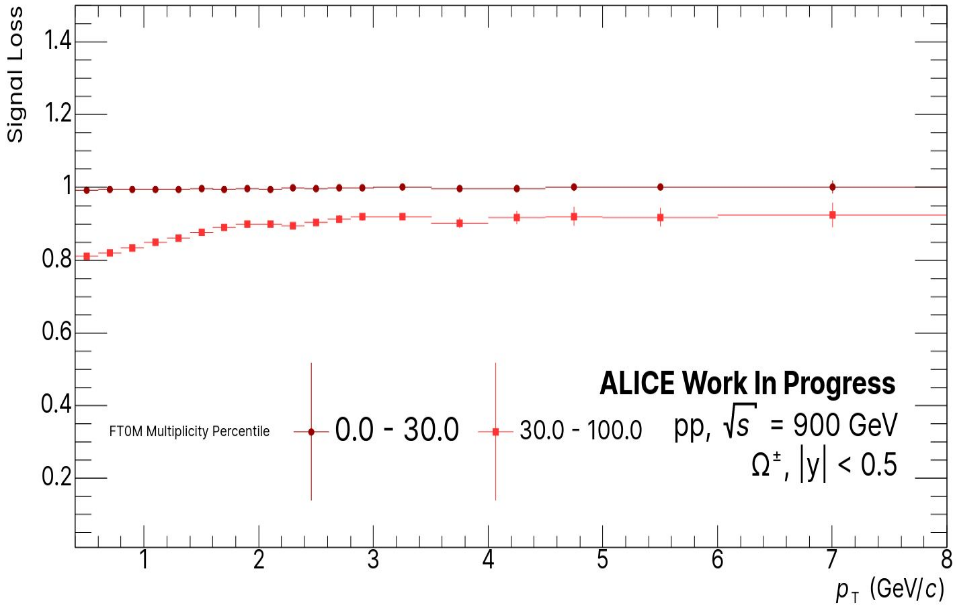
Signal loss correction

$$\varepsilon_{\text{signal}}\ (\Delta p_{\text{T}}, \%) = \frac{N_{\text{gen cascades, at least 1rec. event}}\ (\Delta p_{\text{T}}, \%)}{N_{\text{gen cascades}}\ (\Delta p_{\text{T}}, \%)}$$

First calculation of Ω signal loss in multiplicity classes and p_T intervals

Signal Loss is calculated by using the Gap-Triggered MC (produced internally) anchored to data

- As expected significant only for the lower mult classes



p_T spectra in multiplicity classes

First Ω spectra in multiplicity classes in pp at 900 GeV

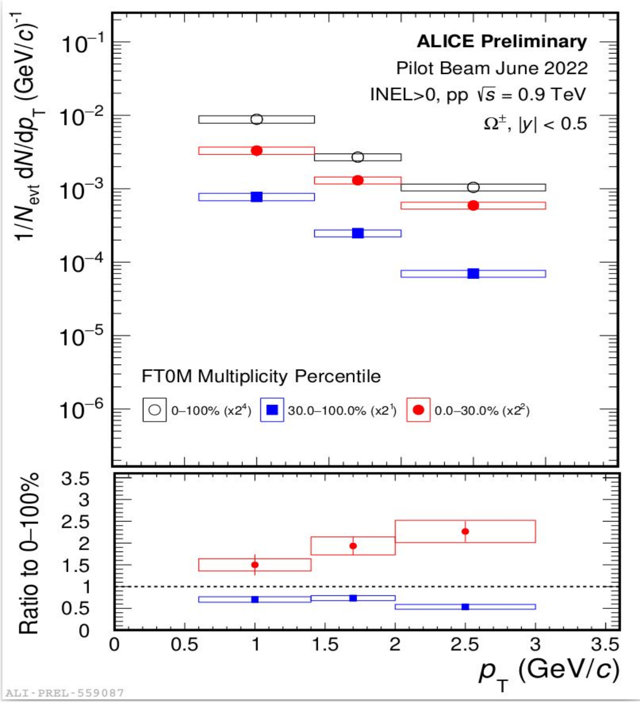
Hardening of the spectra in p_T observed for increasing multiplicity

-**Gap-Triggered** + anchored to 900 GeV Data (produced internally) to calculate the Efficiency X Acceptance and Signal Loss Correction.

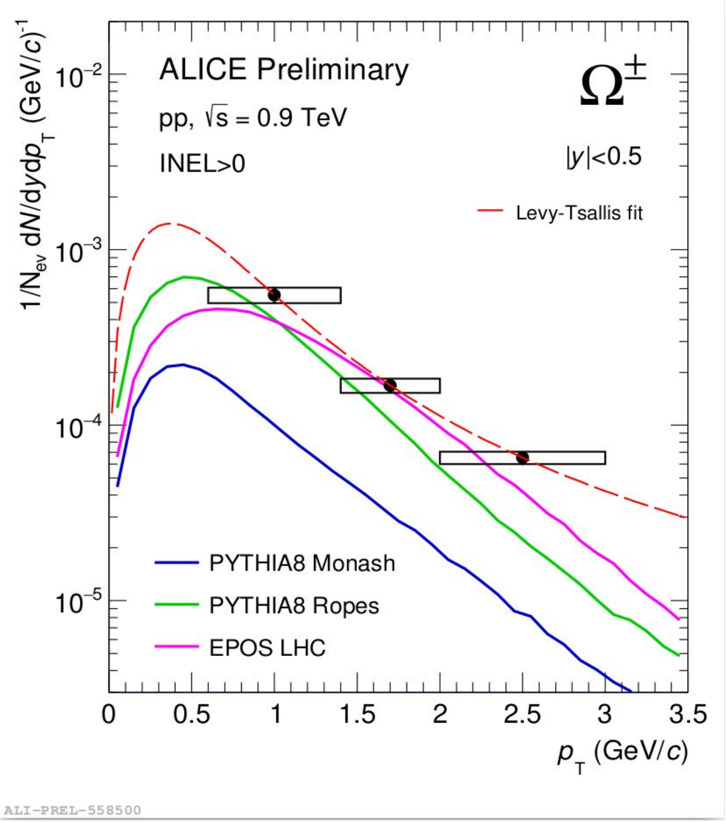
-MC General Purpose anchored to LHC22c,d,e (LHC22h1c1) (produced centrally) to calculate the event loss correction

Most of the systematic uncertainties are inherited from 13.6 TeV analysis

Multiplicity spectra



MB p_T spectrum



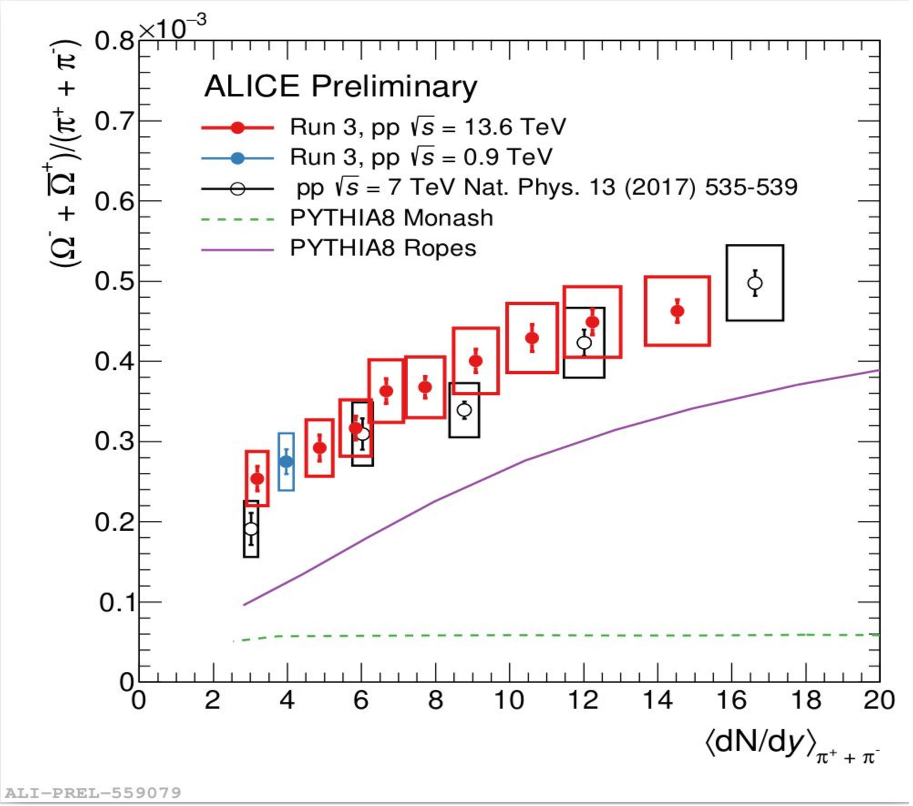
First Ω spectrum in pp at 900 GeV

-**Gap-Triggered** MC anchored to 900 GeV data (produced internally) to calculate the Efficiency X Acceptance and Signal Loss Correction.

-MC General Purpose anchored to LHC22c,d,e (LHC22hc1)(produced centrally) to calculate the event loss correction

Comparison with model predictions for Pythia Monash and with color ropes and EPOS-LHC

Ω/π Ratio



First Ω/π ratio in pp at 900 GeV

Comparison with model predictions for Pythia8 Monash and with color ropes

Summary and Outlook

- Invariant Mass Distribution of $\mathbf{\Omega^{\pm}}$.
- Mean, Sigma, Purity and Raw Yield in FT0M Classes.
- Efficiency X Acceptance Correction, Event Loss Correction, Signal Loss Correction.
- Corrected Spectra in FT0M Classes.
- MB p_T Spectrum and Comparison with models.
- Omega-Pion Ratio **(Ω/π)**.

Summary

- Invariant Mass Distribution of $\boldsymbol{\Omega}^{\pm}$.
- Mean, Sigma, Purity and Raw Yield in FT0M Classes.
- Efficiency X Acceptance Correction, Event Loss Correction, Signal Loss Correction.
- Corrected Spectra in FT0M Classes.
- MB p_T Spectrum and Comparison with models.
- Omega-Pion Ratio **($\boldsymbol{\Omega/\pi}$)**.

THANK YOU