Production of Σ(1385)± and Ξ(1530)0 measured by ALICE in pp, p-Pb and Pb-Pb collisions at the LHC

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1. Motivation

Pb-Pb collisions

- **Hadronic resonances** are used to study the properties and the evolution of the hadronic medium produced in ultra-relativistic heavy-ion collisions

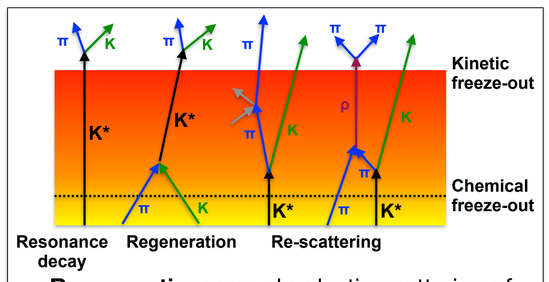
- Due to their **short lifetimes**, resonances are a good tool to probe the interplay of particle **re-scattering** and **regeneration** in the hadronic phase

p-Pb collisions

- Helps to disentangle cold nuclear matter effects from genuine hot medium effects
- Contribute to the study of the system size dependence of re-scattering

pp collisions

- Serve as reference measurements
- Help tune QCD-inspired event generators



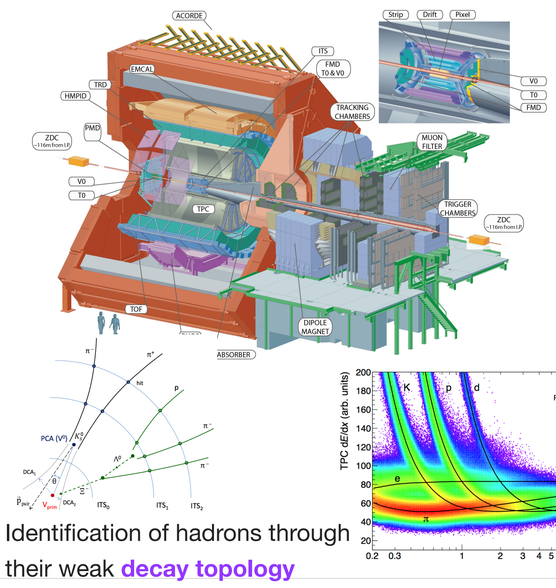
Regeneration: pseudo-elastic scattering of decay products

Re-scattering: resonance decay products undergo elastic scattering or pseudo-elastic scattering through a different resonance

→ Not reconstructed through invariant mass

	Quark content	Mass [Mev/c^2]	Width [Mev/c^2]	Lifetime [fm]	Branching ratio [%]
Σ*±	uus,dds	1382.80±0.3	36.0±0.7	5.48	55.6±1.1
Ξ*0	uss	1531.80±0.3	9.1±0.5	22	42.6±0.3

2. A Large Ion Collider Experiment [1]



Identification of hadrons through their weak **decay topology**

ALICE detector central barrel

- $|\eta| < 0.9$
- $p_T \gtrsim 0.15$ GeV/c

V0 scintillator detectors

- centrality definition in Pb-Pb (V0A & V0C)
- multiplicity event classes in p-Pb (V0A)

Inner Tracking System (ITS)

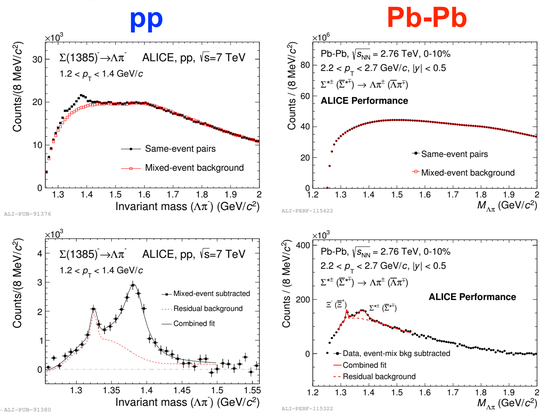
- tracking and vertex determination
- radii between 3.9 cm and 43.0 cm

Time Projection Chamber (TPC)

- tracking and PID via energy-loss measurement
- active volume extends over the range 85 < r < 247 cm and -250 < z < 250 cm

3. Signal extraction

pp **Pb-Pb**



Signal: Unlike-sign pairs from the same event

Background: Unlike-sign pairs from mixed events

Breit-Wigner (BW) function for Σ*±

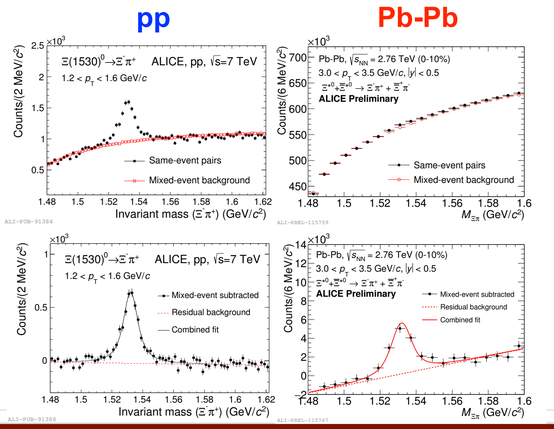
$$\frac{dN}{dm} = \frac{Y}{2\pi}\frac{\Gamma}{(m-m')^2+\frac{\Gamma^2}{4}}$$

Voigtian (BW⊗Gaussian) function for Ξ*0

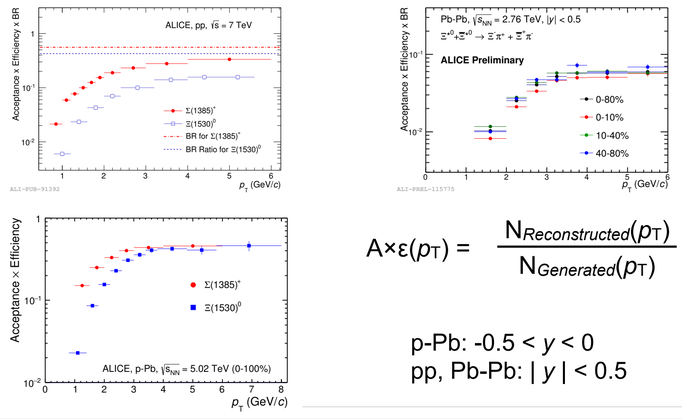
$$\frac{dN}{dm} = \frac{Y}{2\pi}\int \frac{\Gamma}{(m-m')^2+\Gamma^2/4}\frac{e^{-(m'-m_0)^2/2\sigma^2}}{\sigma\sqrt{2\pi}}dm'$$

Γ: intrinsic width, σ: detector resolution

pp **Pb-Pb**



4. Acceptance × Efficiency × BR

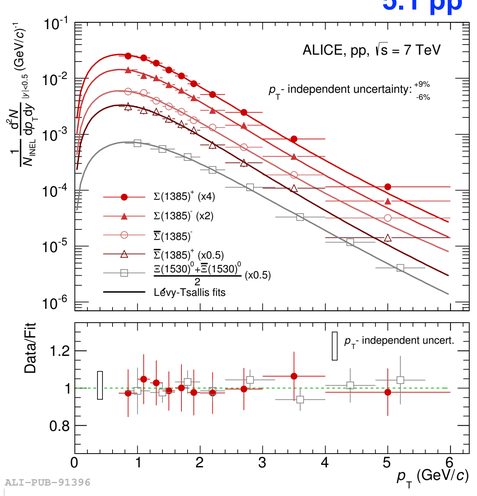


$$A\times\varepsilon(p_T) = \frac{N_{Reconstructed}(p_T)}{N_{Generated}(p_T)}$$

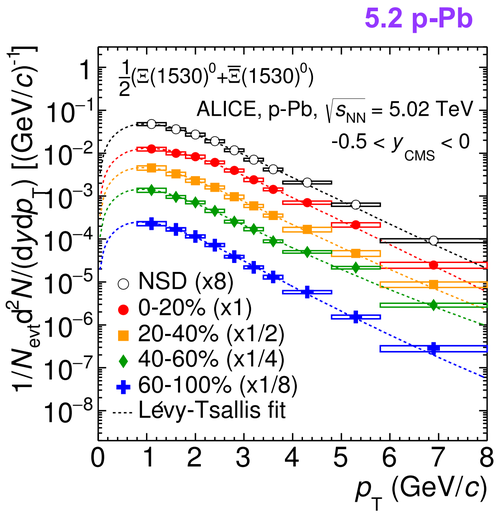
p-Pb: -0.5 < y < 0
pp, Pb-Pb: | y | < 0.5

5. p_T-spectra

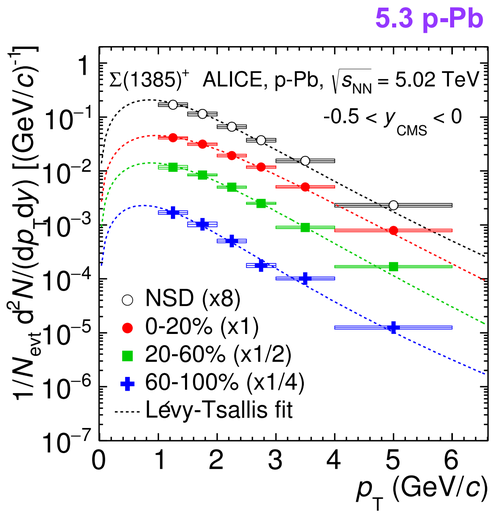
5.1 pp



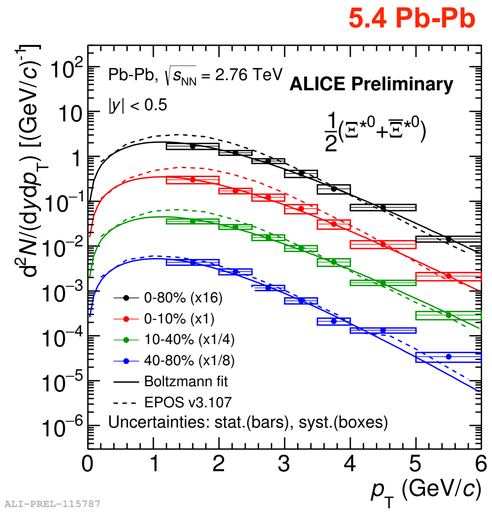
5.2 p-Pb



5.3 p-Pb



5.4 Pb-Pb



Transverse momentum spectrum d²N/(dp_Tdy) of

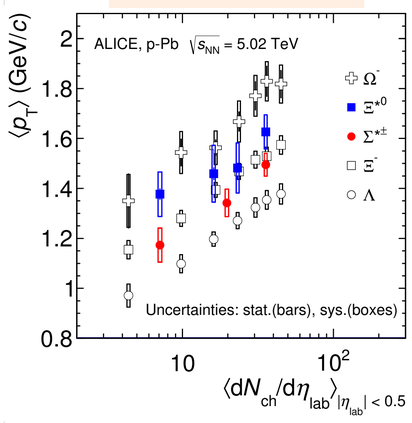
1. Σ*± & Ξ*0 measured in the rapidity range |y| < 0.5 in inelastic **pp** collisions [2]

2.&3. Σ*± & Ξ*0 measured in the rapidity range -0.5 < y < 0 in non-single diffractive (NSD) **p-Pb** collisions and different V0A event multiplicity classes [3]

4. Ξ*0 measured in the rapidity range |y| < 0.5 in **Pb-Pb** collisions in different centrality classes

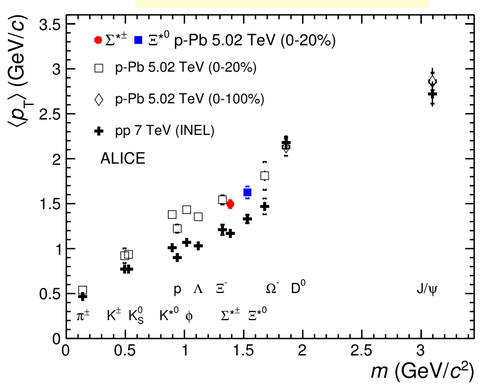
6. Mean transverse momentum

6.1 ⟨p_T⟩ vs. <dN/dη>



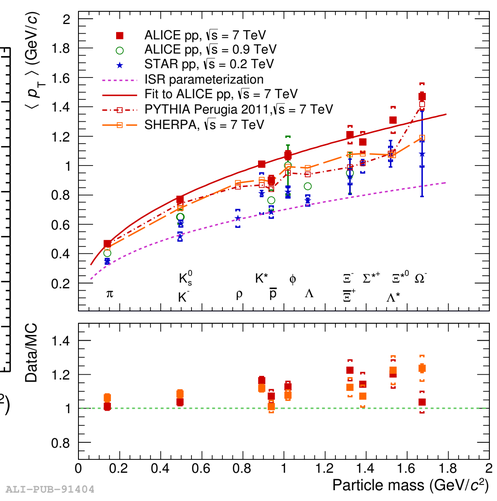
6.2 ⟨p_T⟩ vs. Mass

- system dependence



6.3 ⟨p_T⟩ vs. Mass

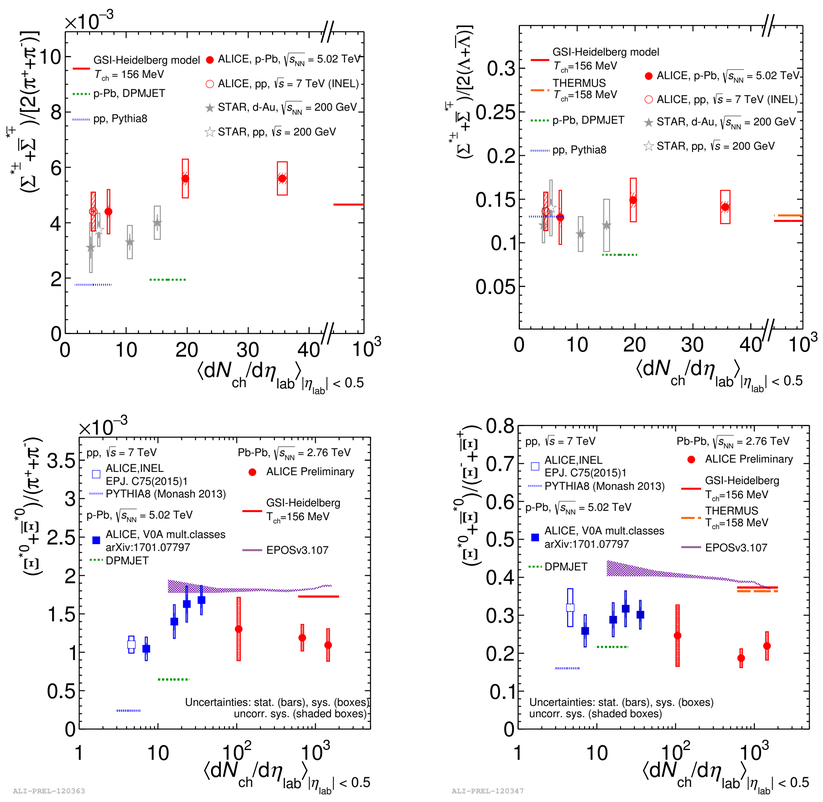
- Energy dependence



- ⟨p_T⟩ vs. <dN/dη>
  - ⟨p_T⟩ of Σ*± & Ξ*0 are compared with those of other hyperons
  - Increasing trends from low to high multiplicity are observed
- ⟨p_T⟩ vs. Mass
  - Mass ordering is observed in pp and Pb-Pb collisions
    ⟨p_T⟩$_\Lambda$ < ⟨p_T⟩$_{\Xi^-}$ ≃ ⟨p_T⟩$_{\Sigma^{*\pm}}$ < ⟨p_T⟩$_{\Xi^{*0}}$ < ⟨p_T⟩$_{\Omega^-}$
  - Trend with mass is similar in pp and high multiplicity p-Pb collisions

- ⟨p_T⟩ of Σ*± & Ξ*0 are compared with other particles reconstructed in pp collisions at different energies
- ISR parameterisation fail to describe ALICE data while for STAR data it works relatively well for lower mass particles up to ~1 GeV/c^2
- PYTHIA and SHERPA predictions are ~20% lower than data for Σ*± & Ξ*0

7. Ratio of particle yields



- Integrated particle yield **ratios of excited hyperons to pions (Σ*±/π, Ξ*0/π)**
  - relative strangeness production increases with multiplicity in p-Pb
  - **enhancement of hyperons** is due to their **strangeness content** in p-Pb
  - ratios are observed to increase gradually and approach thermal model prediction and EPOS [4] for the highest multiplicity in p-Pb collisions
  - **Ξ*0/π** is observed to be smaller than thermal model prediction in central Pb-Pb

- Integrated particle yield **ratios of excited to ground-state hyperons** with **same strangeness content**
  - **Σ*±/Λ**: consistent with the values predicted by PYTHIA8; DPMJET prediction is lower than experimental data
  - **Ξ*0/Ξ**: higher than PYTHIA8 [5] and DPMJET [6] but lower than thermal model despite the much larger lifetime with respect to K*0; observed to be multiplicity independent in p-Pb and decrease in Pb-Pb

8. Summary

- Baryonic resonances Σ*± & Ξ*0 have been measured in pp, p-Pb and Pb-Pb collisions at different energies
- Mean transverse momentum studies
  - ⟨p_T⟩ is observed to increase with multiplicity
  - ⟨p_T⟩ follows the mass ordering for (multi) strange baryons
- Integrated yield ratios
  - hyperon-to-pion ratios show increasing trend with multiplicity in p-Pb and decreases in Pb-Pb
  - excited to stable hyperon ratios show flat behaviour in p-Pb and decrease in Pb-Pb

References
[1] ALICE, Int. J. Mod. Phys. A 29 (2014) 1430044
[2] Eur. Phys. J. C (2015) 75:1
[3] arXiv:1701.07797
[4] Phys.Rev. C 93 (2016) 014911
[5] *Comput. Phys. Comm.* 178 (2008) 852–867, arXiv:0710.3820
[6] Conference Proceedings, MC2000, Lisbon, Portugal, October 23-26 (2000) 1033–1038