32nd Winter Workshop on Nuclear Dynamics 2016

Guadaloupe - 28Feb-5Mar 2016

Livio Bianchi

University of Houston

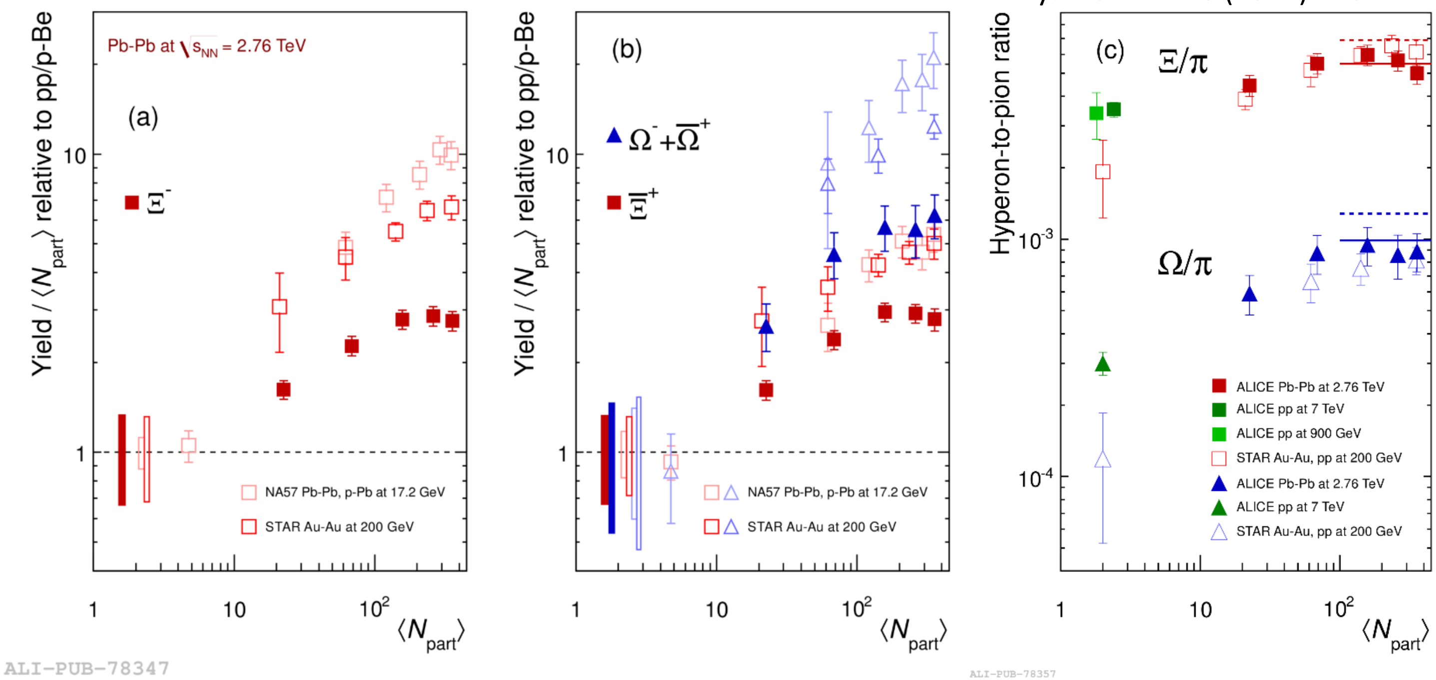
On behalf of the ALICE Collaboration

Strangeness production as a function of charged particle multiplicity in pp and p-Pb collisions in ALICE

Introduction

Strangeness: from A-A to small systems

Phys. Lett. B 728 (2014) 216–227



Strange particle yields extensively studied in A-A:

- Strangeness enhancement
- More pronounced at lower energy
- Canonical suppression in pp

Strangeness: from A-A to small systems

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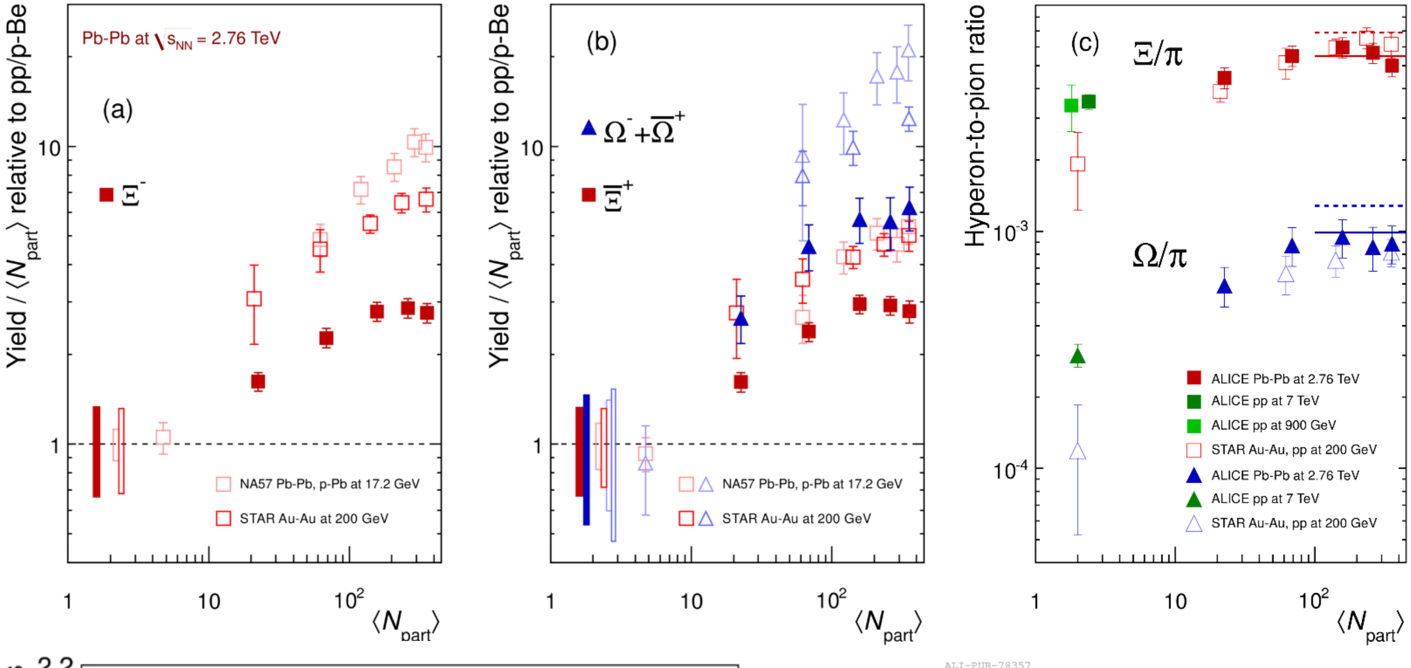

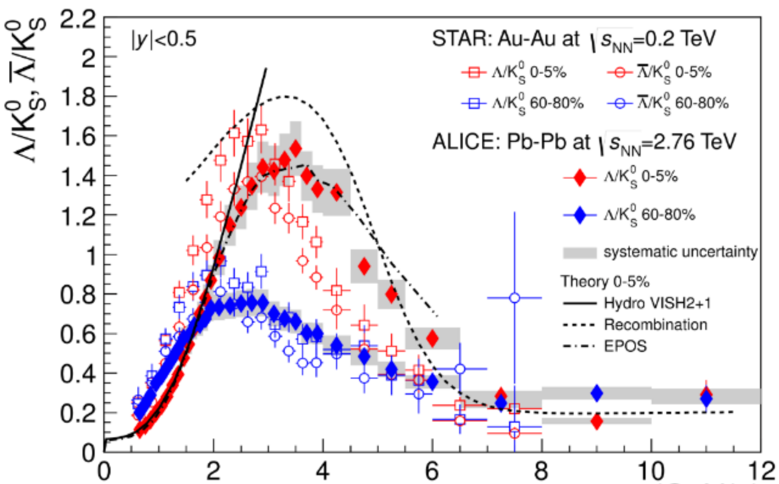

Phys. Rev. Lett. 111 (2013) 222301

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Λ/K^0_S ratio versus p_T

- Intermediate- p_T enhancement interpreted as hydrodynamical radial flow

Strangeness: from A-A to small systems

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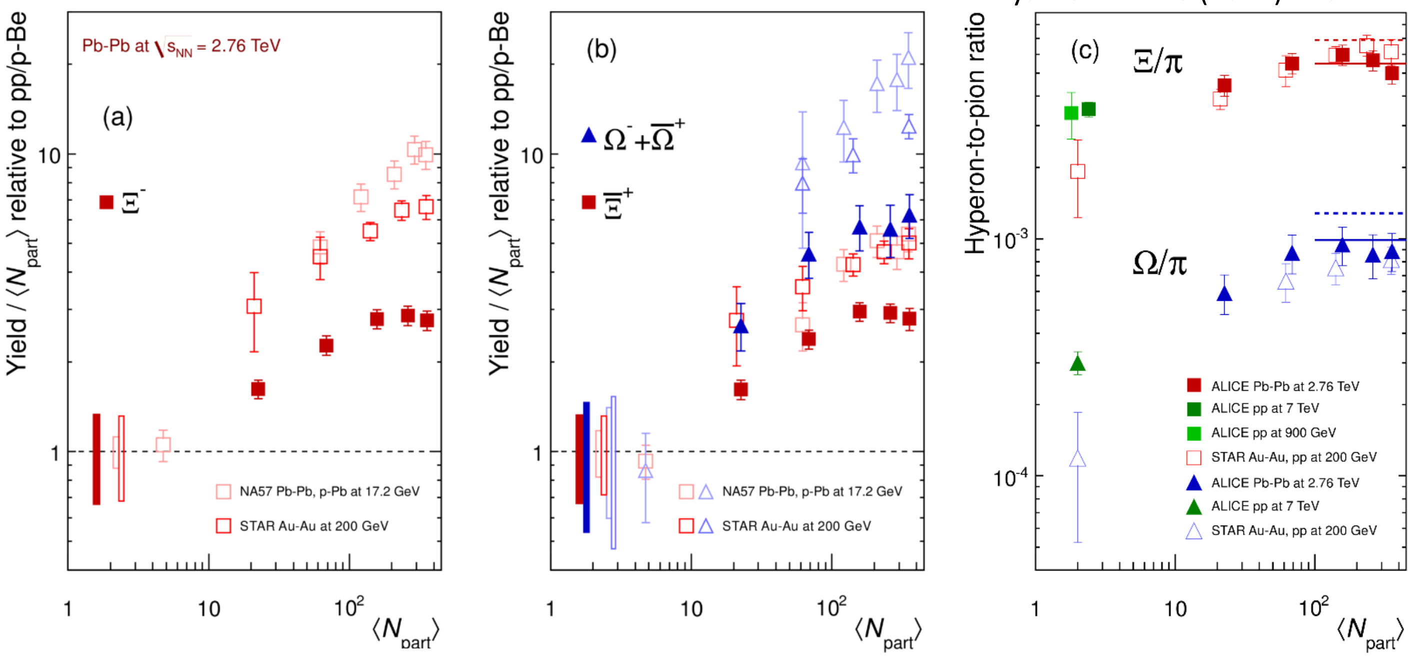
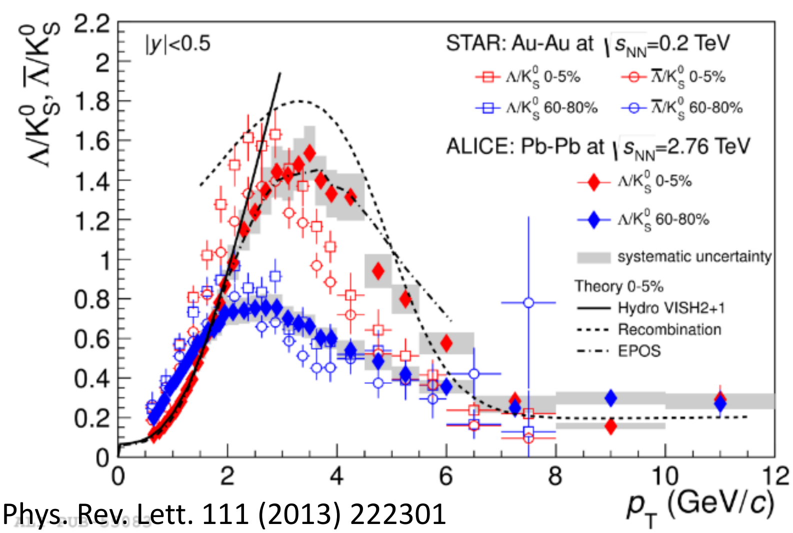


What happens in smaller systems?

Is there an evolution with multiplicity?



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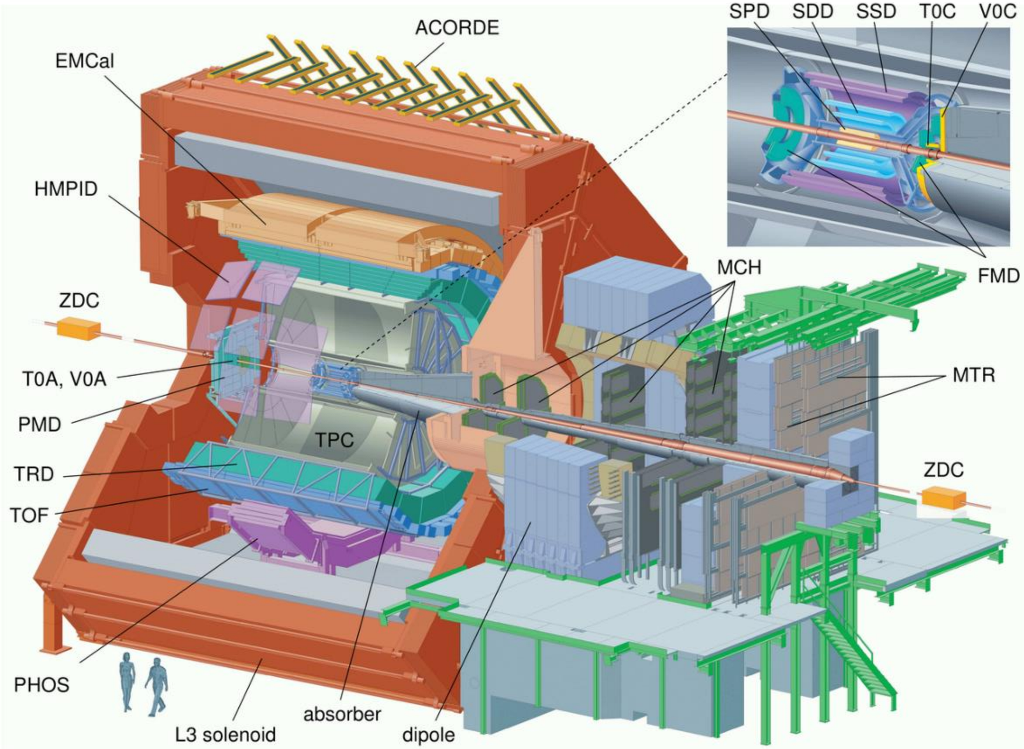
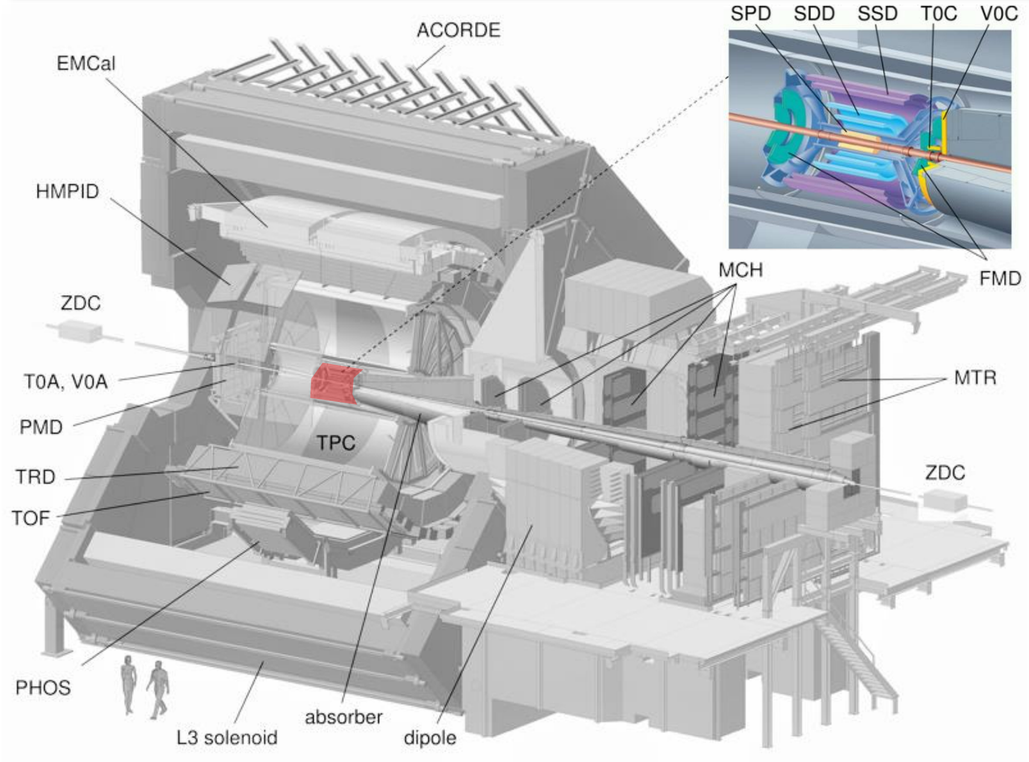
Detecting strange particles in ALICE

A Large Ion Collider Experiment



DETECTORS USED IN THIS ANALYSIS:

A Large Ion Collider Experiment

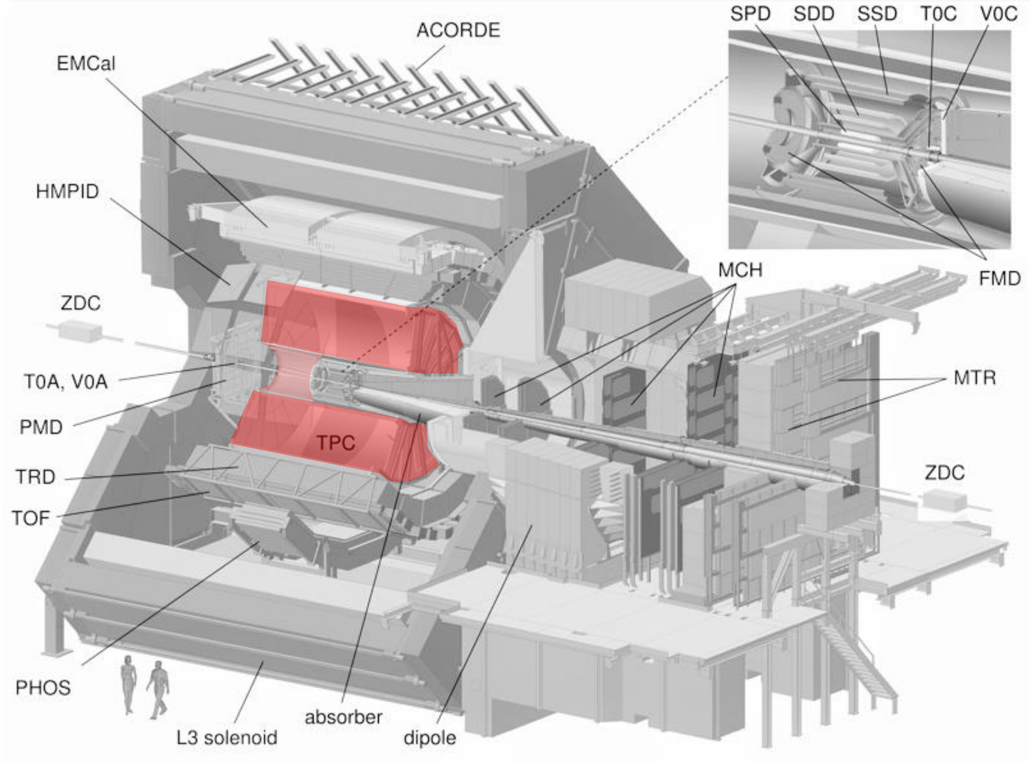


DETECTORS USED IN THIS ANALYSIS:

ITS ($|\eta| < 0.9$)

6 layers of silicon detectors:

trigger, tracking, vertex, PID (d*E*/d*x*)



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TPC ($|\eta| < 0.9$)

Gas-filled ionization detector:

tracking, PID (dE/dx)

A Large Ion Collider Experiment

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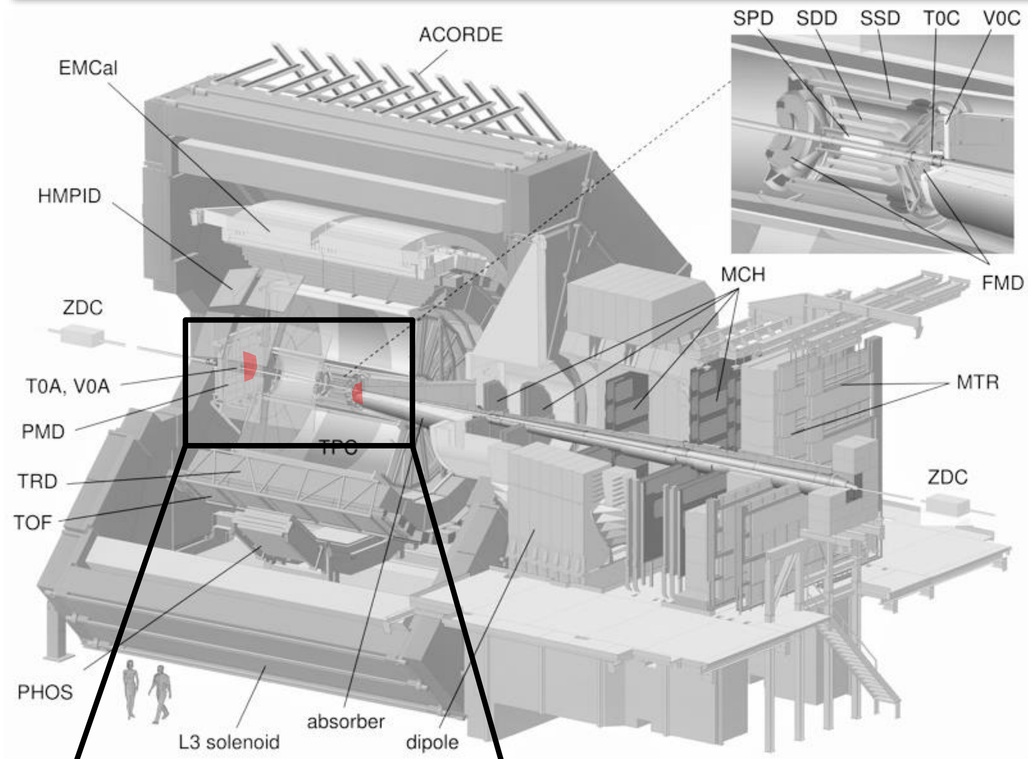

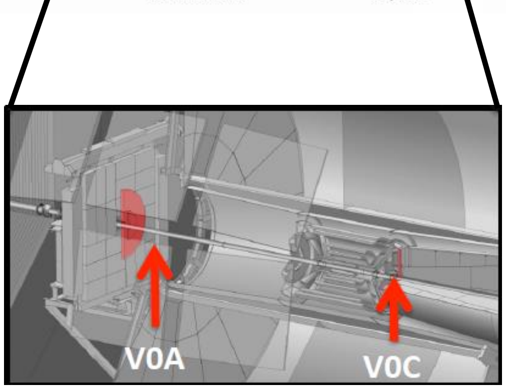

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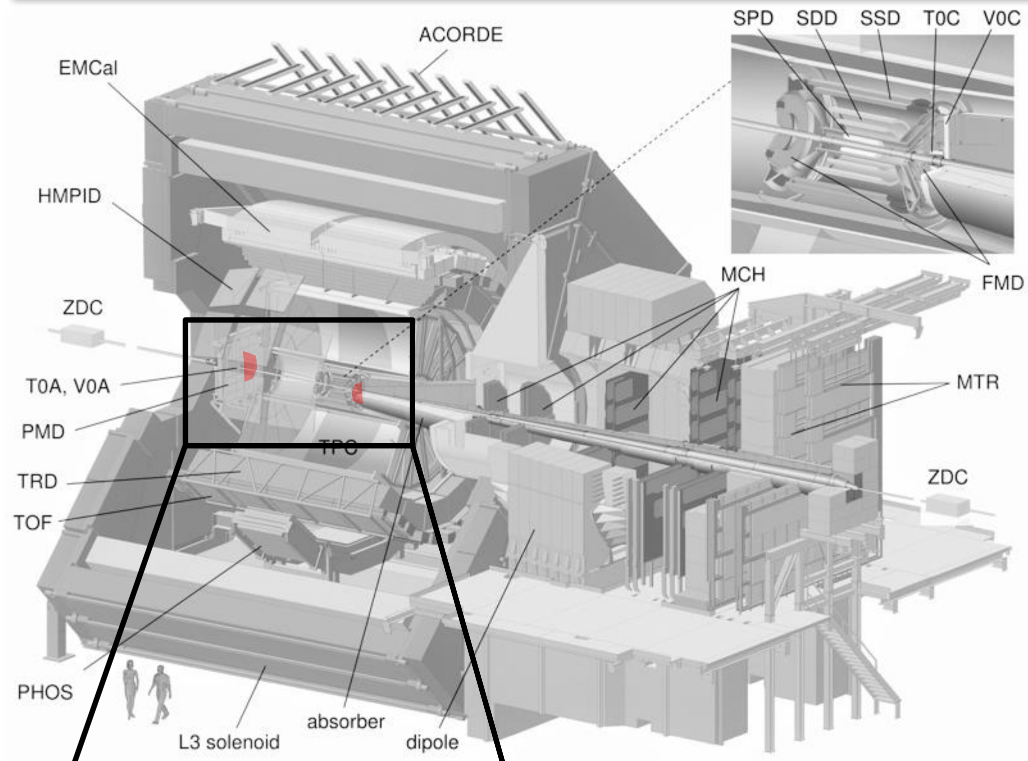
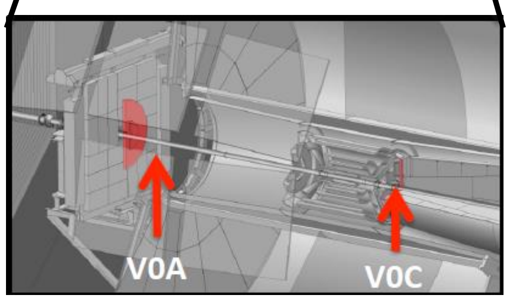
V0 ($2.8 < \eta < 5.1$ (V0A) &
$-3.7 < \eta < -1.7$ (V0C))
Forward arrays of scintillators:
trigger, beam gas rejection,
multiplicity estimation

A Large Ion Collider Experiment





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Forward arrays of scintillators:
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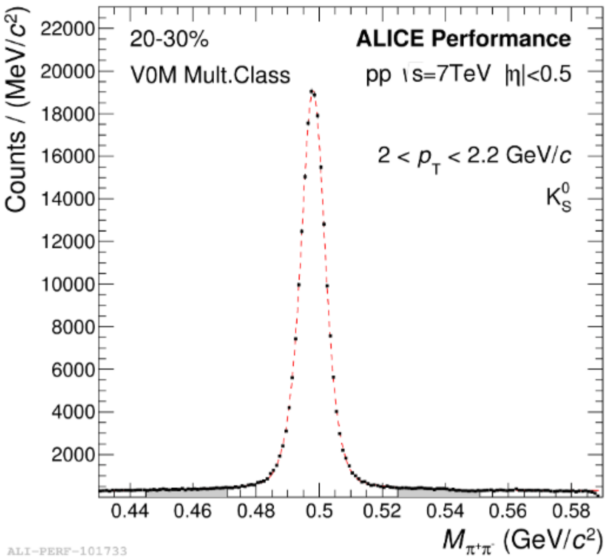
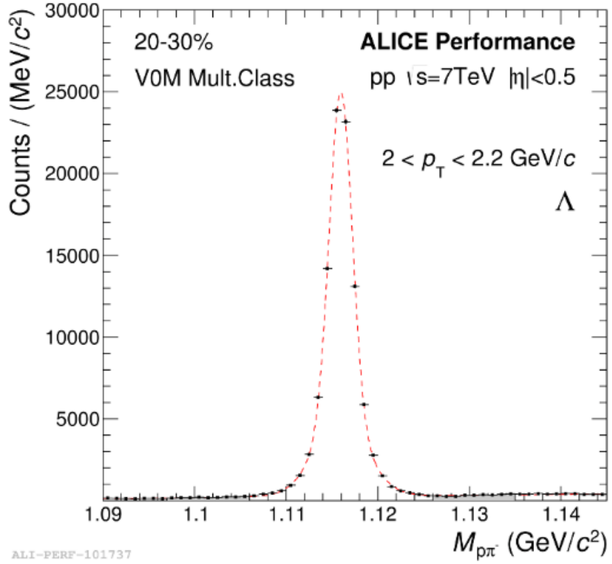
multiplicity estimation

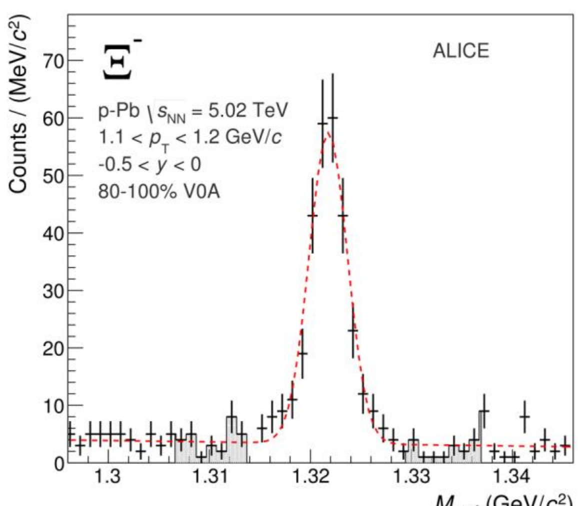
HOW DO WE ESTIMATE MULTIPLICITY:

- Use forward rapidity estimator V0
- For each V0 multiplicity class we take the average of the distribution of charged tracks in $|\eta| < 0.5$:
$\langle dN_{ch}/d\eta \rangle$

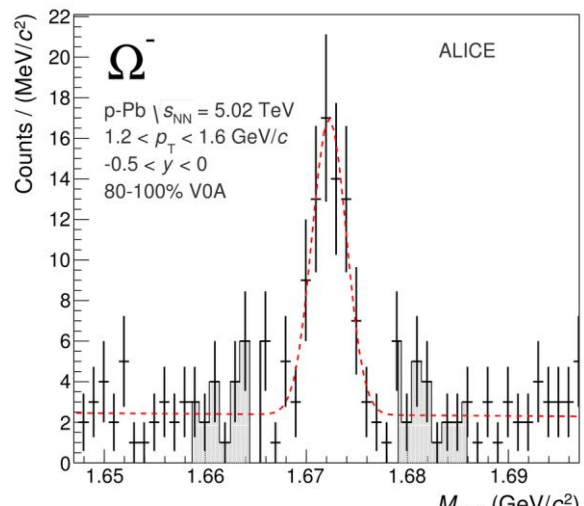
Strange particle signal







arXiv:1512.07227



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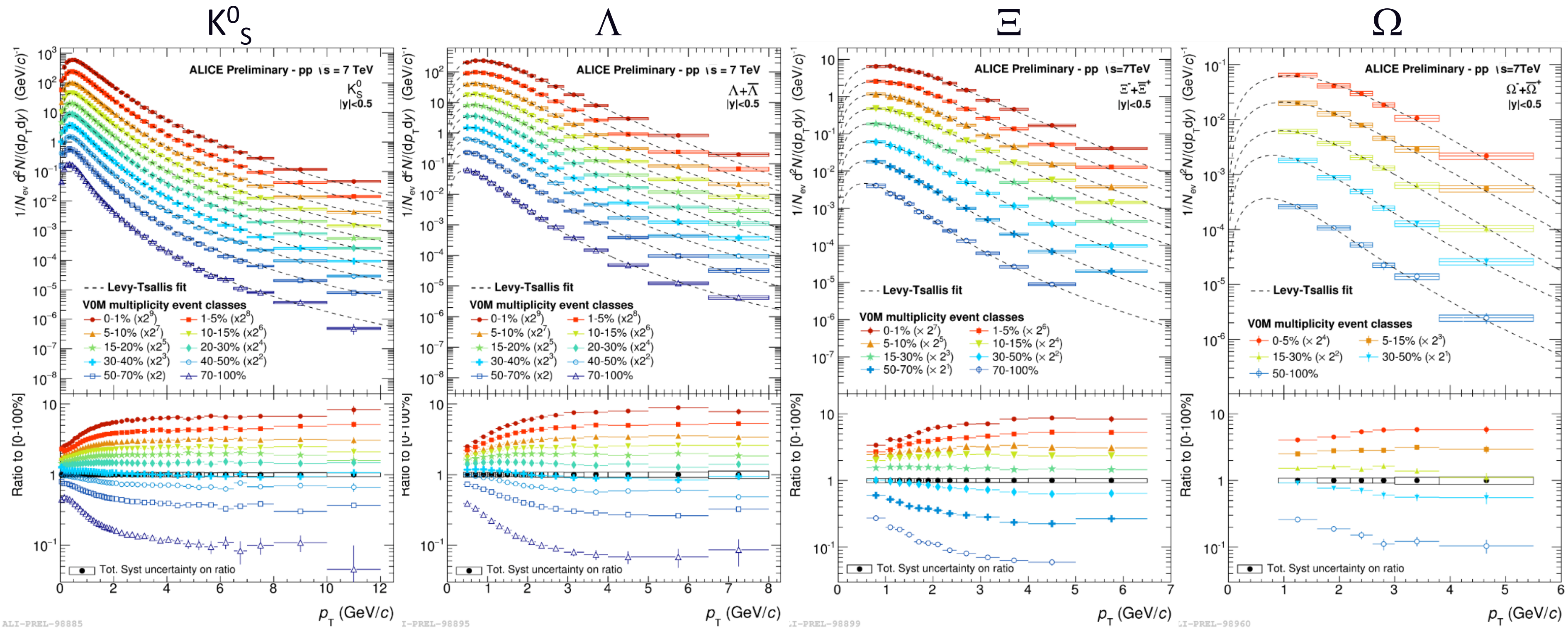
Several topological selections tuned in order to perform reliable signal extraction

PID performed with TPC for all the 2(3) V0(cascade) decay products

Bin-counting technique applied to extract yields

Results

Transverse momentum spectra: pp



Spectra get harder for higher multiplicity

Ratio
SPECTRA$^{\text{bin-i}}$ / SPECTRA$^{\text{INEL}}$
constant for $p_T \gtrsim 3$ GeV/c

Lévy-Tsallis fits performed in order to extract yields (low-p_T extrapolation)

Transverse momentum spectra: p-Pb

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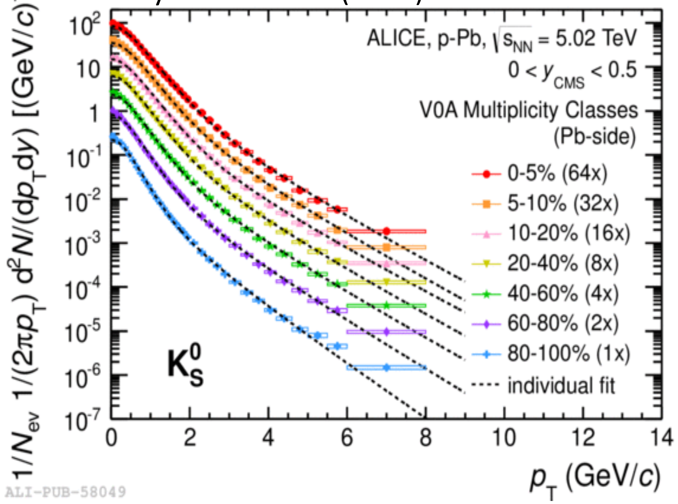
Phys. Lett. B 728 (2014) 25-38



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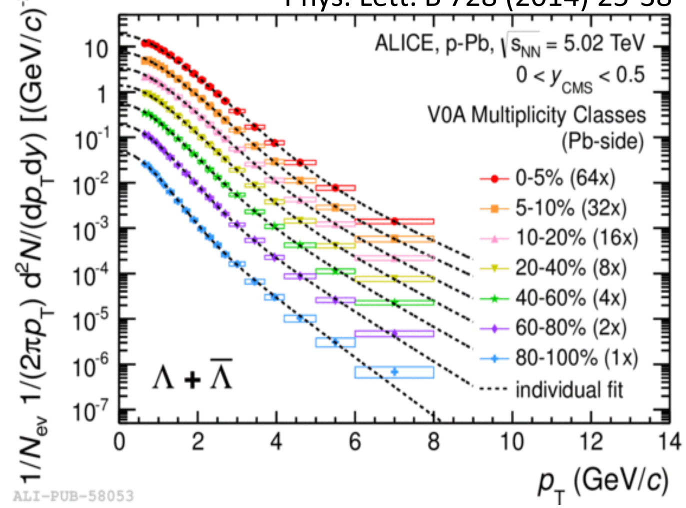

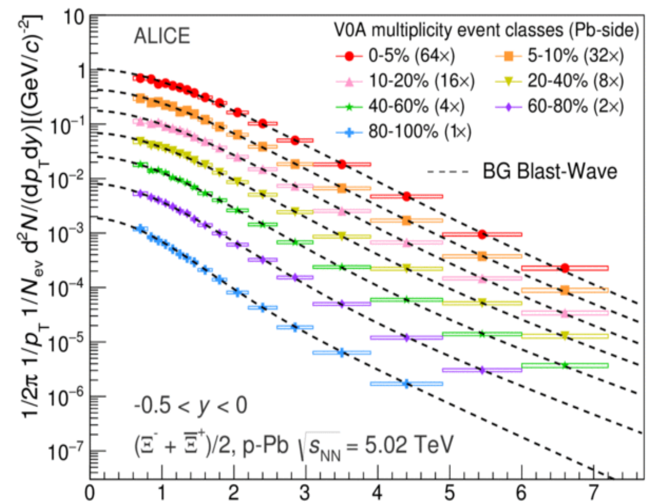

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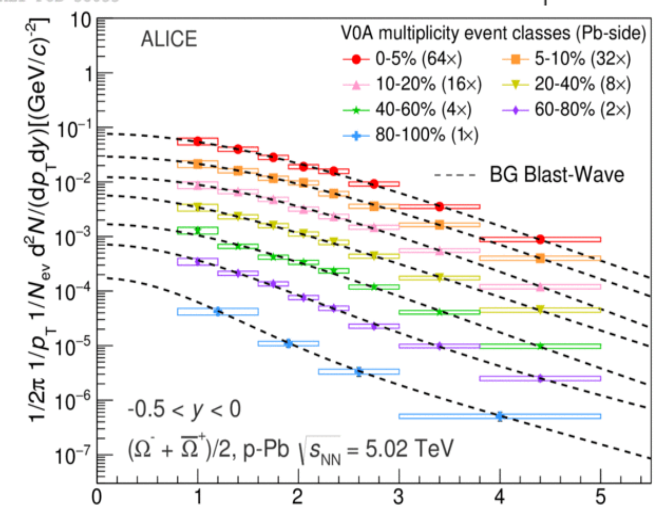

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Same hardening with multiplicity observed in p-Pb collisions

Blast-Wave fit: p-Pb

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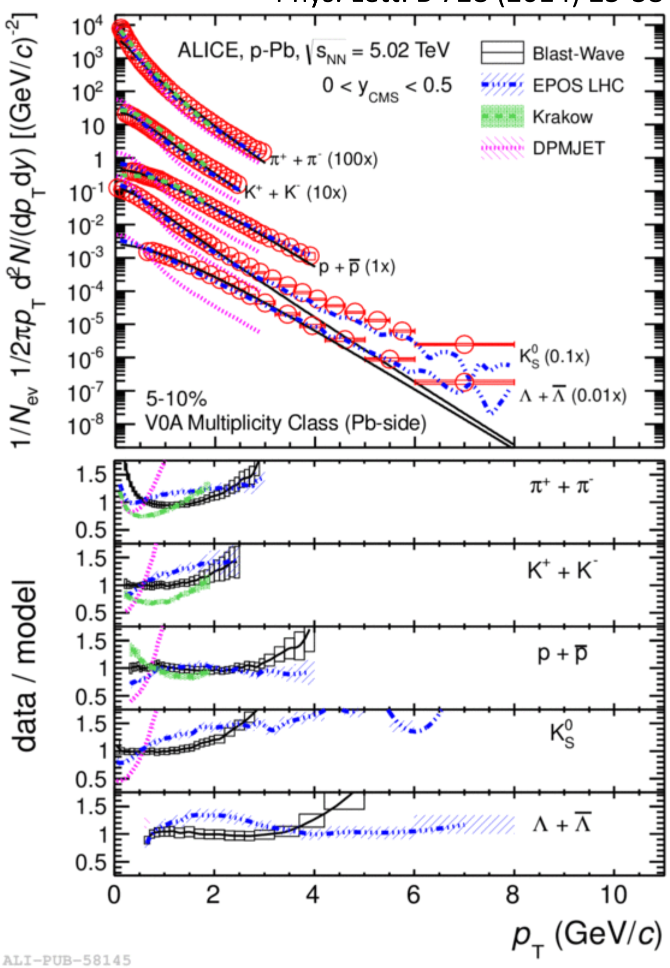
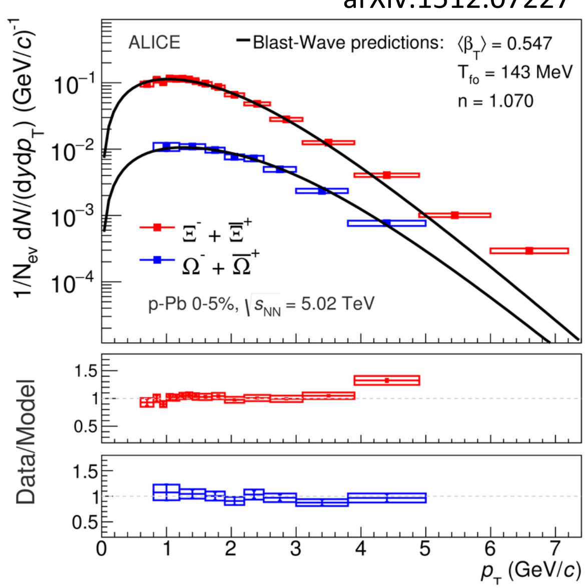


Combined Blast-Wave fit performed on π, K, p K^0_S and Λ (in each multiplicity bin)

Used to predict Ξ and Ω spectra in the same multiplicity bins

Strange and multi-strange particles seem to follow a common radial expansion with all other particles

arXiv:1512.07227



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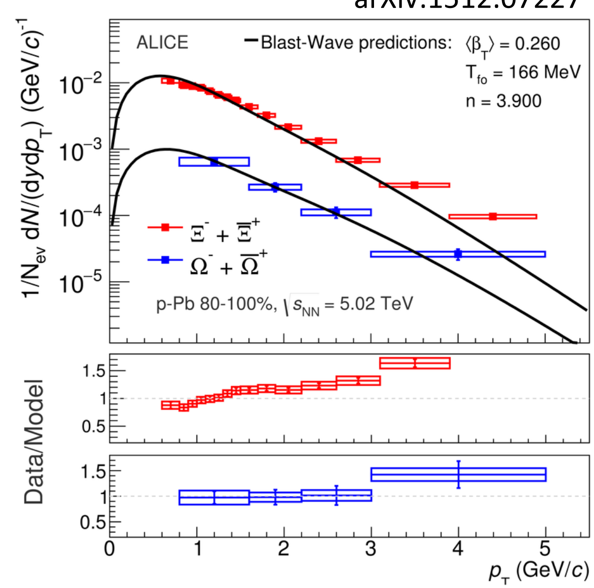
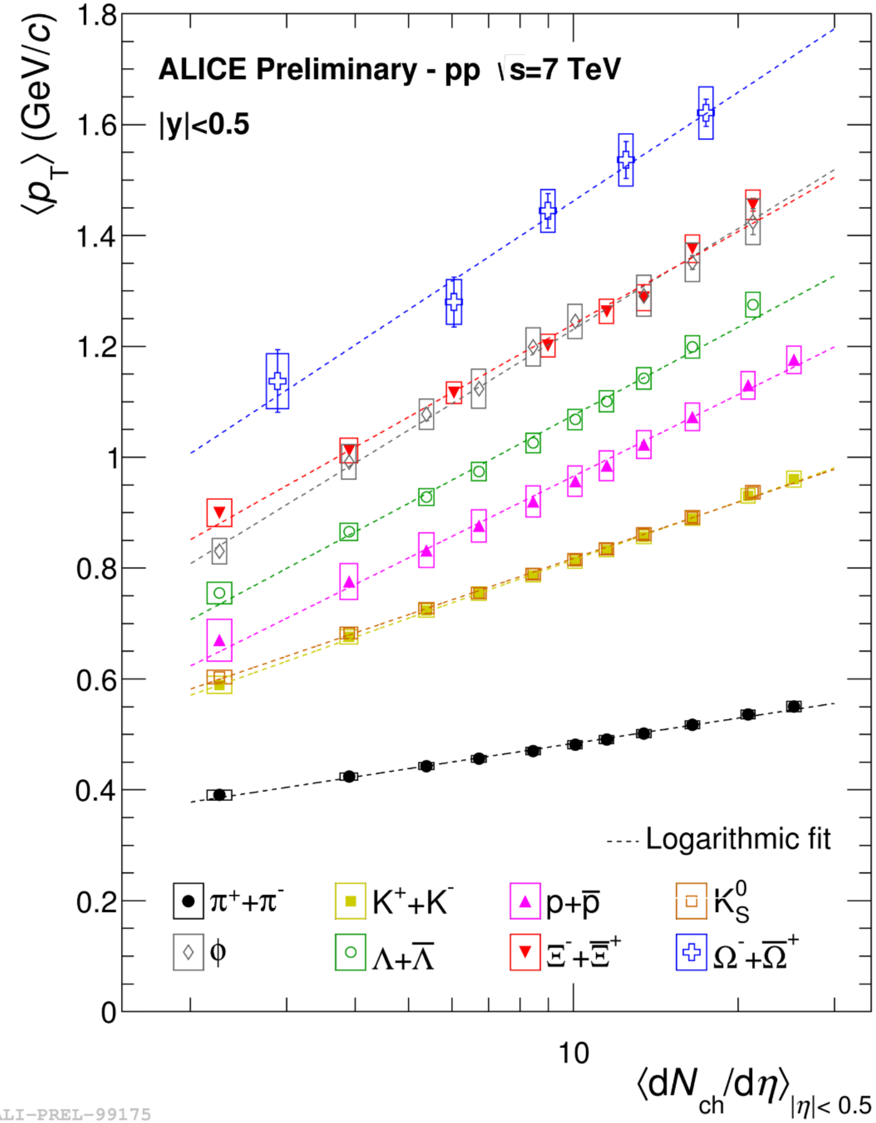
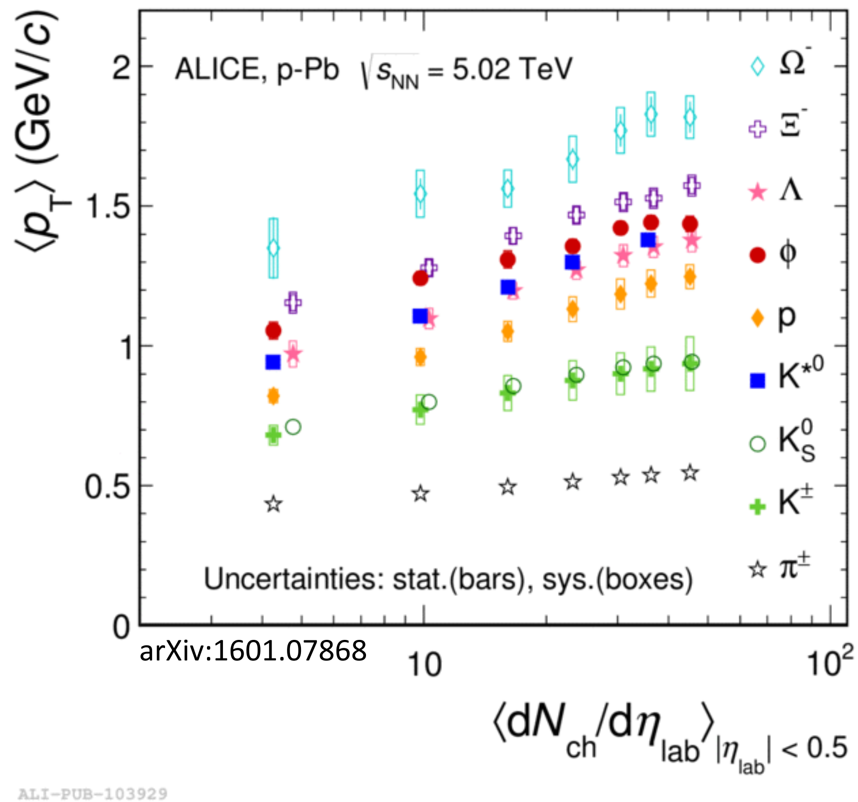




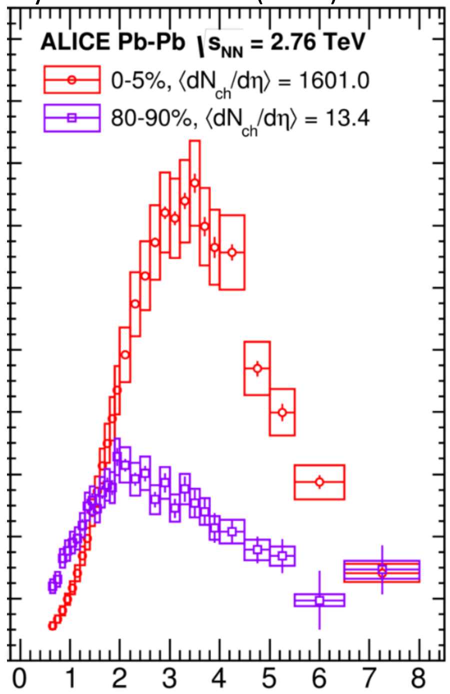


arXiv:1601.07868

Rising trend of $\langle p_T \rangle$ with multiplicity for all identified particles in pp and p-Pb

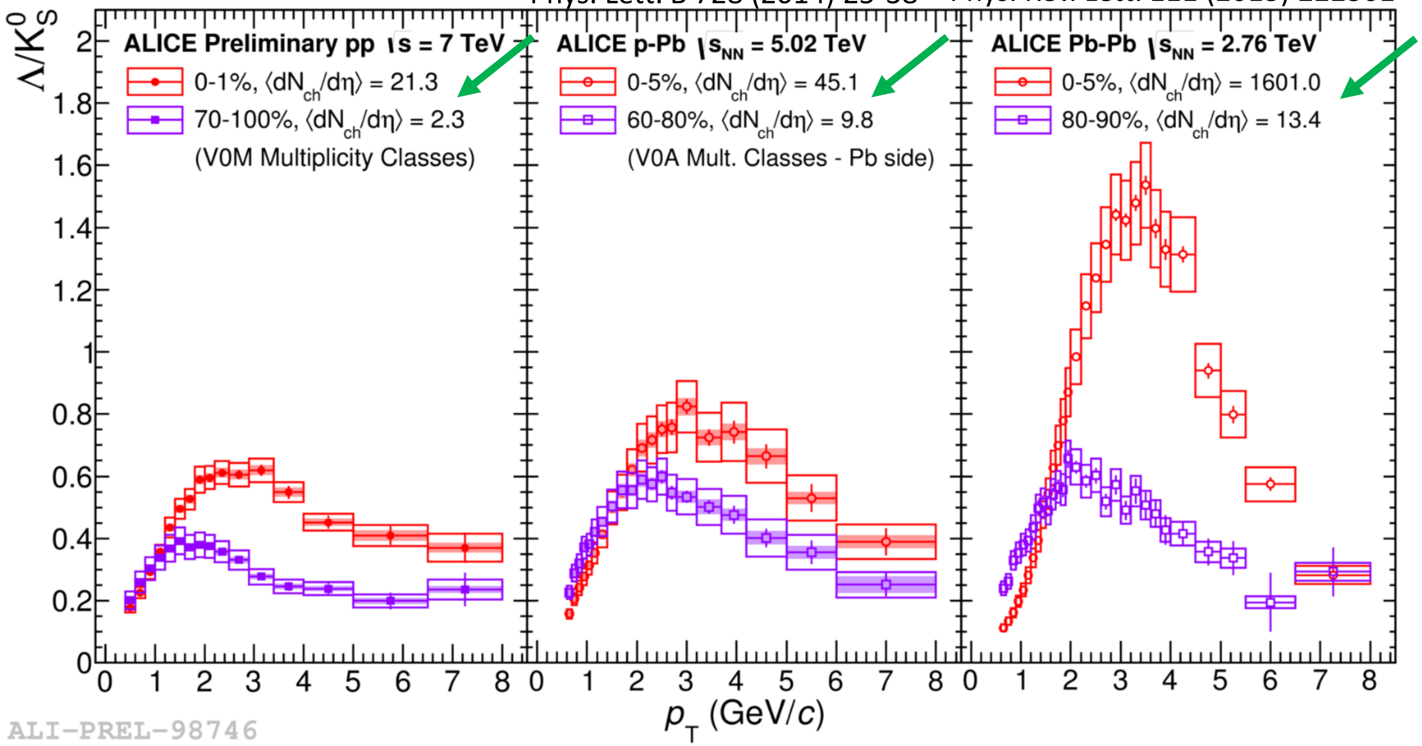
Λ/K^0_S

Phys. Rev. Lett. 111 (2013) 222301



Λ/K^0_S

Phys. Lett. B 728 (2014) 25-38 Phys. Rev. Lett. 111 (2013) 222301



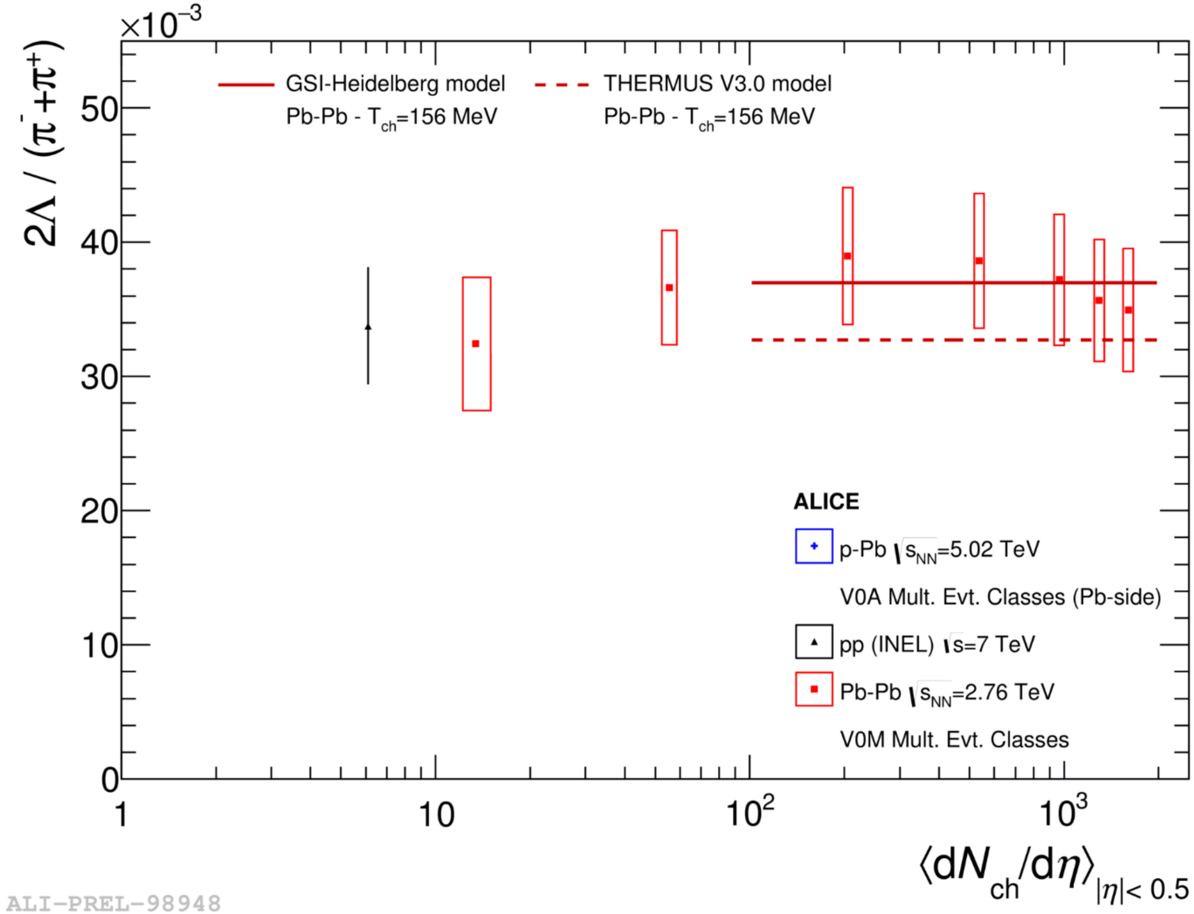
The ratio depends on the event multiplicity

in a **qualitatively similar** way **in pp, p-Pb and Pb-Pb**

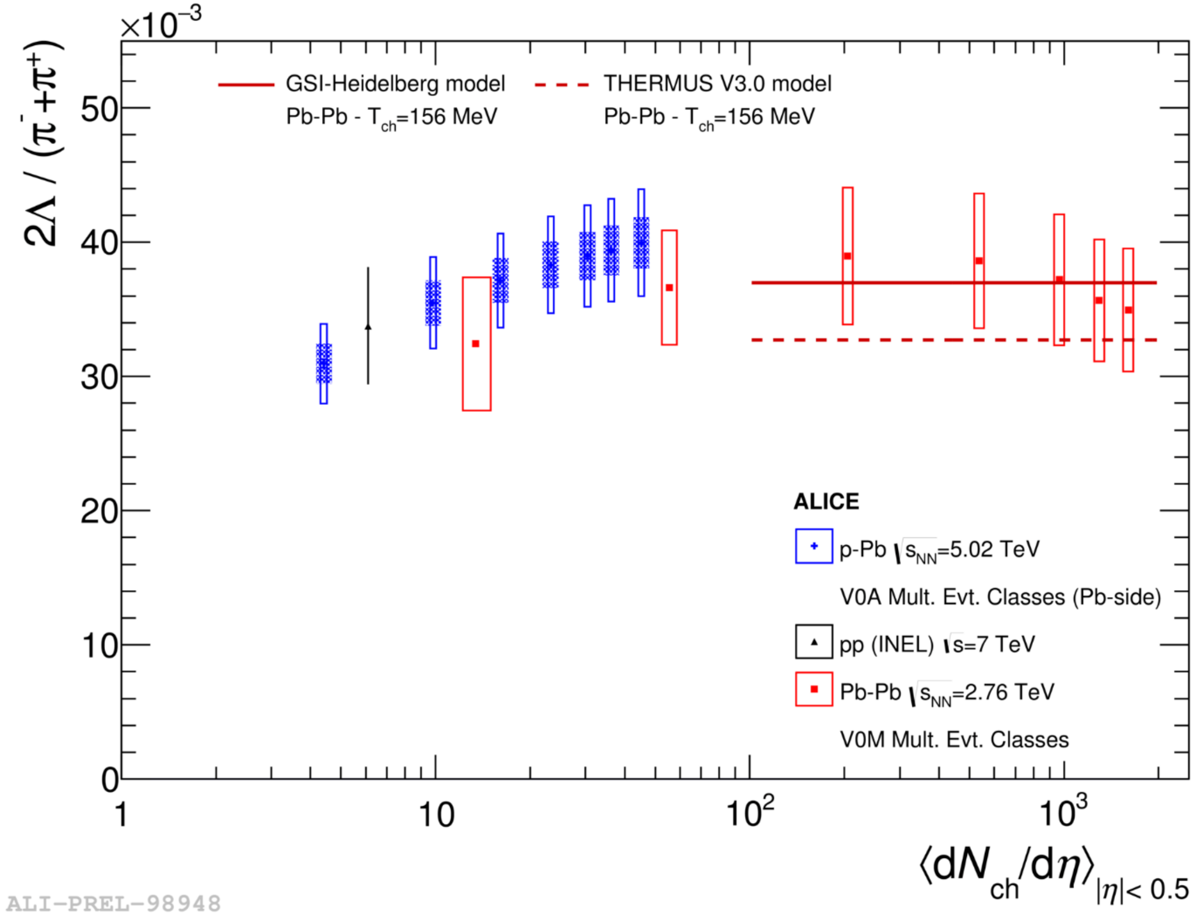
The magnitude is smaller in pp with respect to p-Pb and Pb-Pb,

but note that for similar percentiles $\langle dN_{ch}/d\eta \rangle$ is dramatically different among the three systems

Λ/π


$\times 10^{-3}$
$2\Lambda / (\pi^- + \pi^+)$
GSI-Heidelberg model
Pb-Pb - T_{ch}=156 MeV
THERMUS V3.0 model
Pb-Pb - T_{ch}=156 MeV
ALICE
p-Pb $\sqrt{s_{NN}}$=5.02 TeV
V0A Mult. Evt. Classes (Pb-side)
pp (INEL) $\sqrt{s}$=7 TeV
Pb-Pb $\sqrt{s_{NN}}$=2.76 TeV
V0M Mult. Evt. Classes
$\langle dN_{ch}/d\eta \rangle_{|\eta|<0.5}$
ALI-PREL-98948

Λ/π

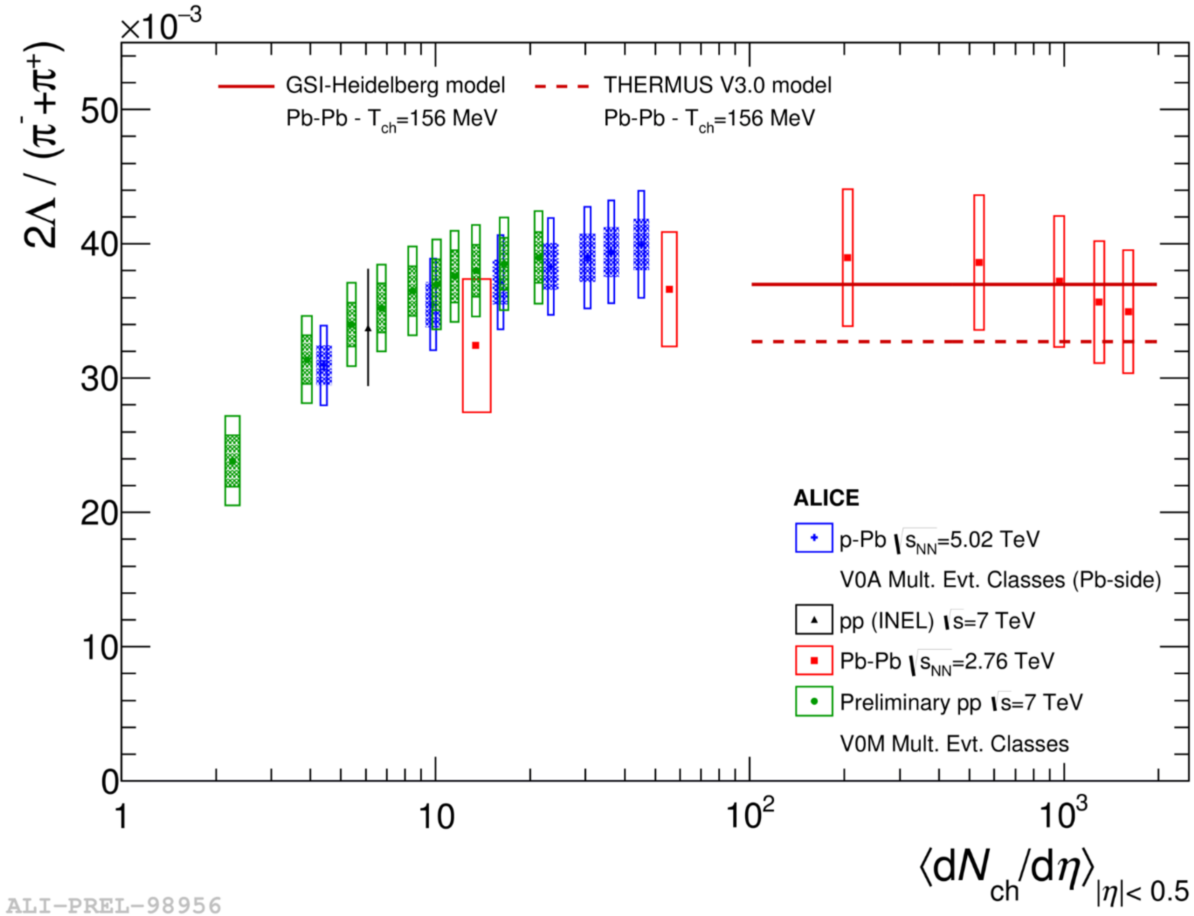


Shaded boxes: uncorrelated systematics across multiplicity

p-Pb:

- Rising trend as a function of multiplicity
- Good agreement with inclusive pp (low multiplicity) and Pb-Pb (high multiplicity)

Λ/π



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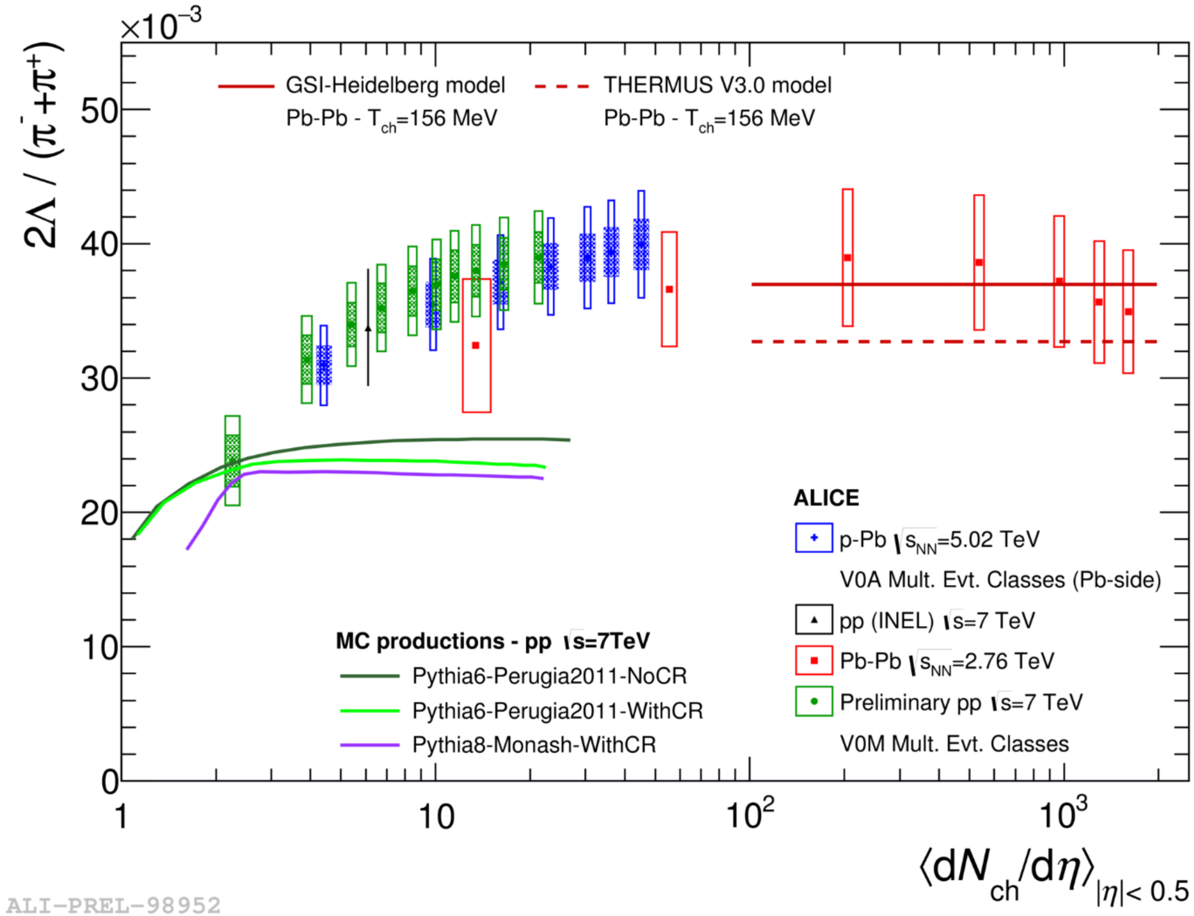
pp:

- Rising trend as a function of multiplicity
- Perfect agreement with p-Pb

Λ/π



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pp:

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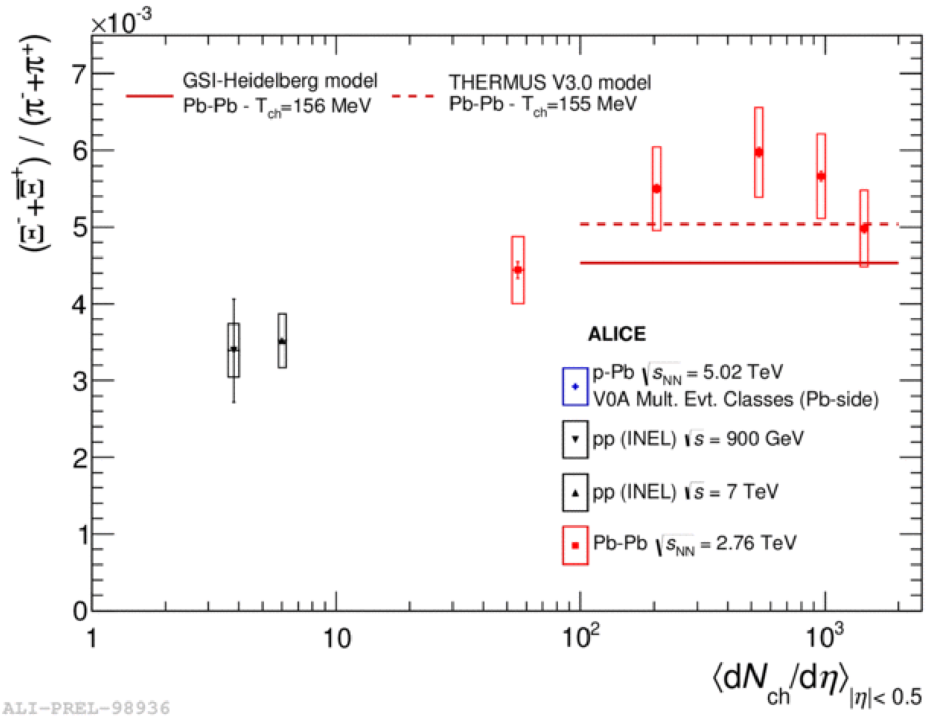
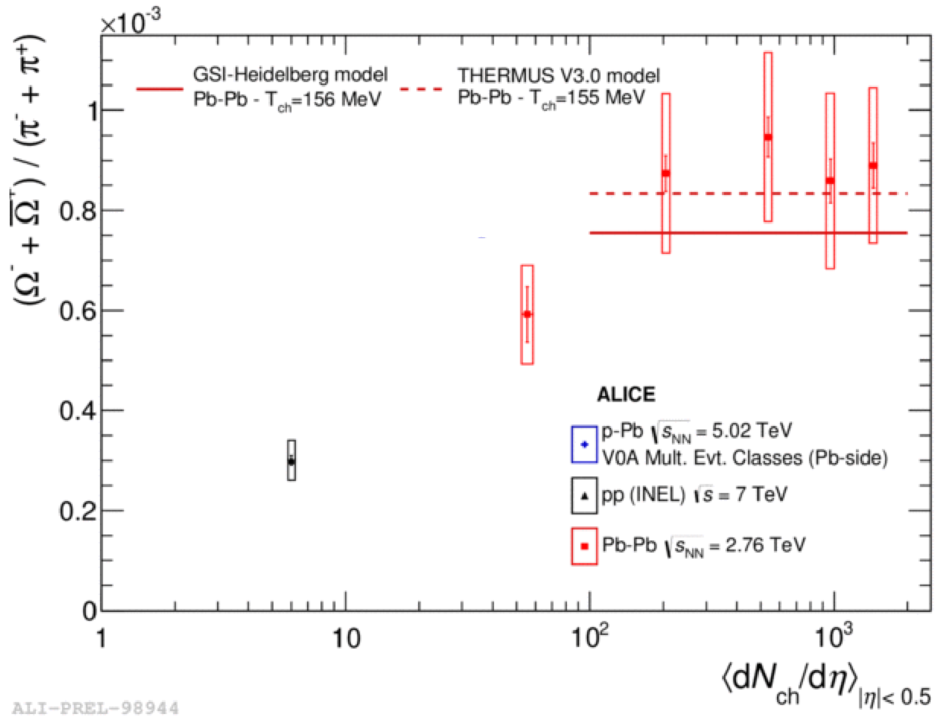
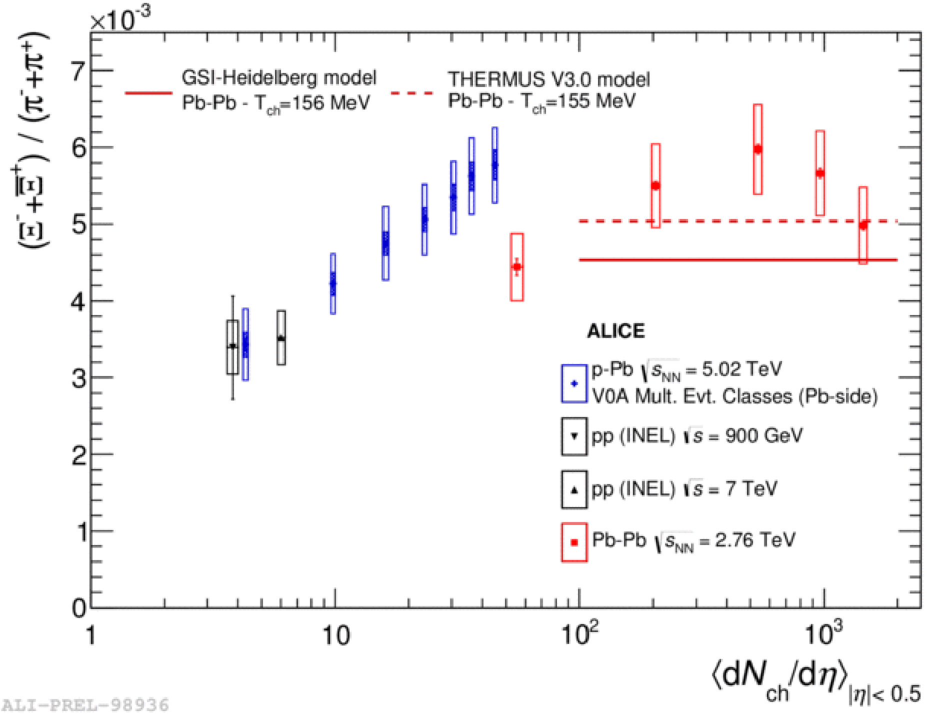
Pythia6 and 8 with several tunes considered: **strong disagreement** with observed trend in pp

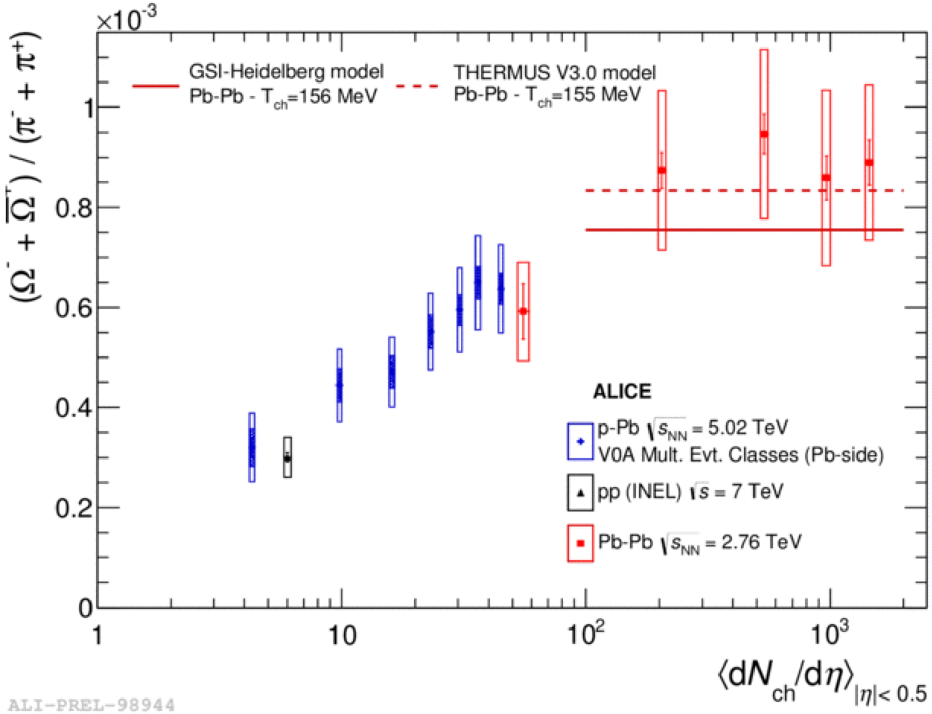
Ξ/π and Ω/π





Ξ/π and Ω/π

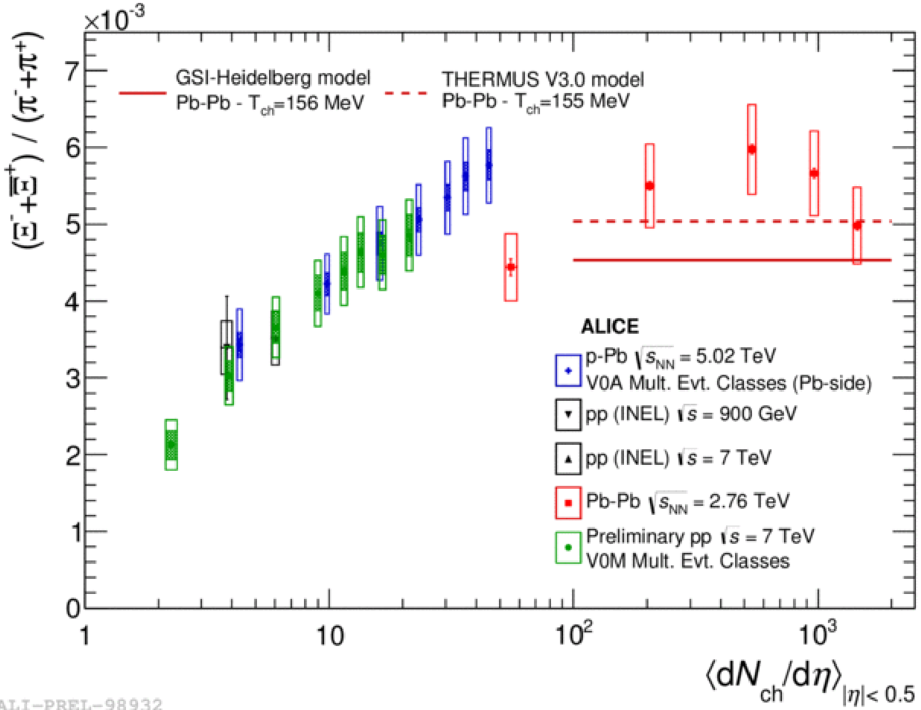


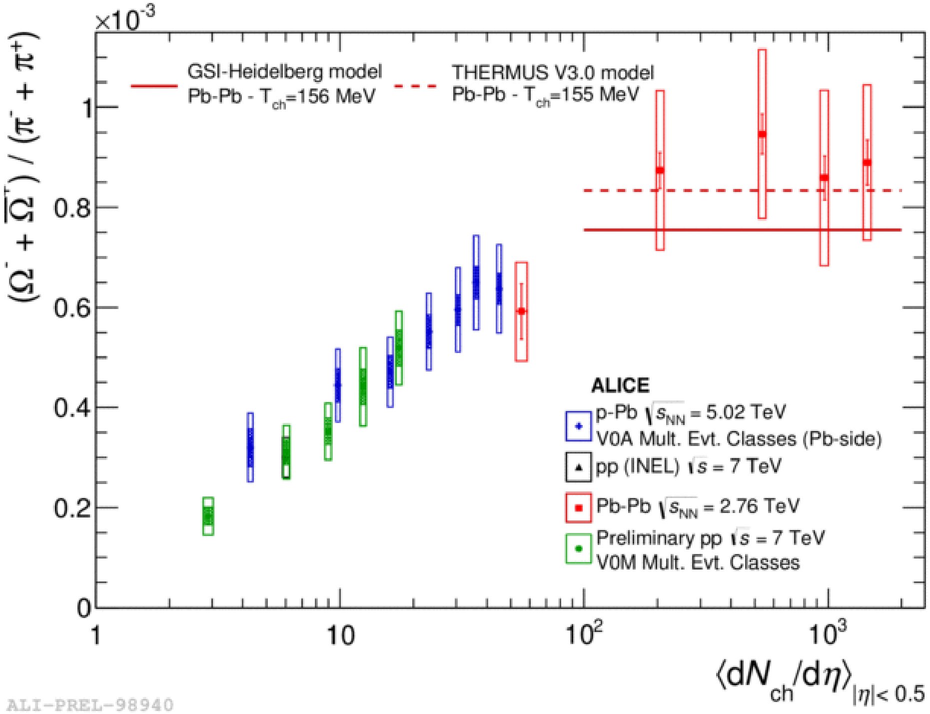


p-Pb:

- Rising trend as a function of multiplicity
- Values bridge the inclusive pp result and the lowest multiplicity probed in Pb-Pb
- Reaches GC saturation value (THERMUS and GSI-Heidelberg models) in the case of Ξ, while staying below in the case of Ω

Ξ/π and Ω/π





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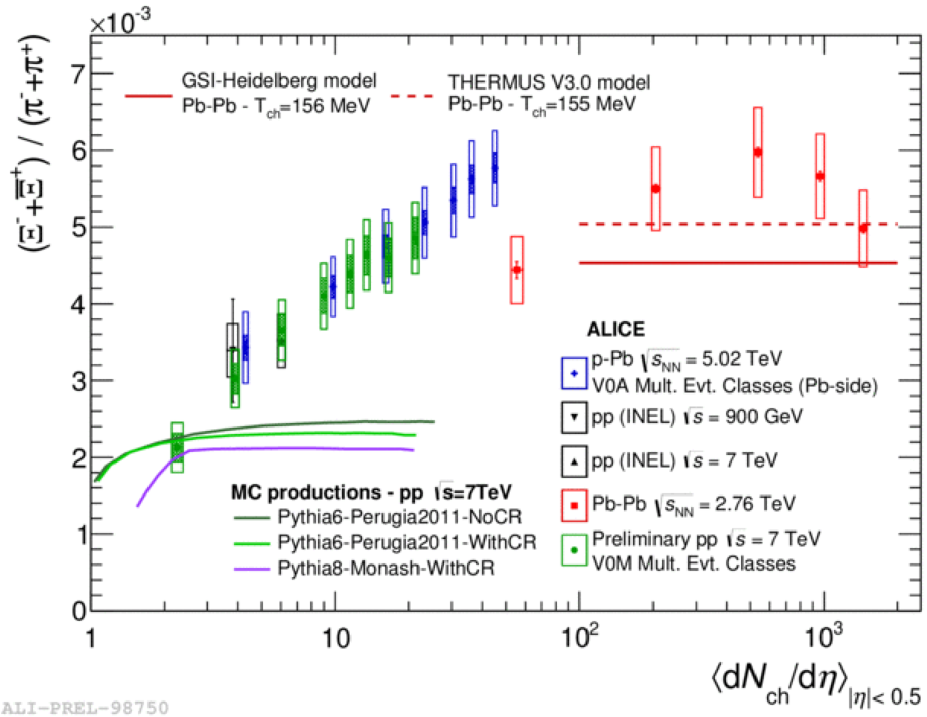
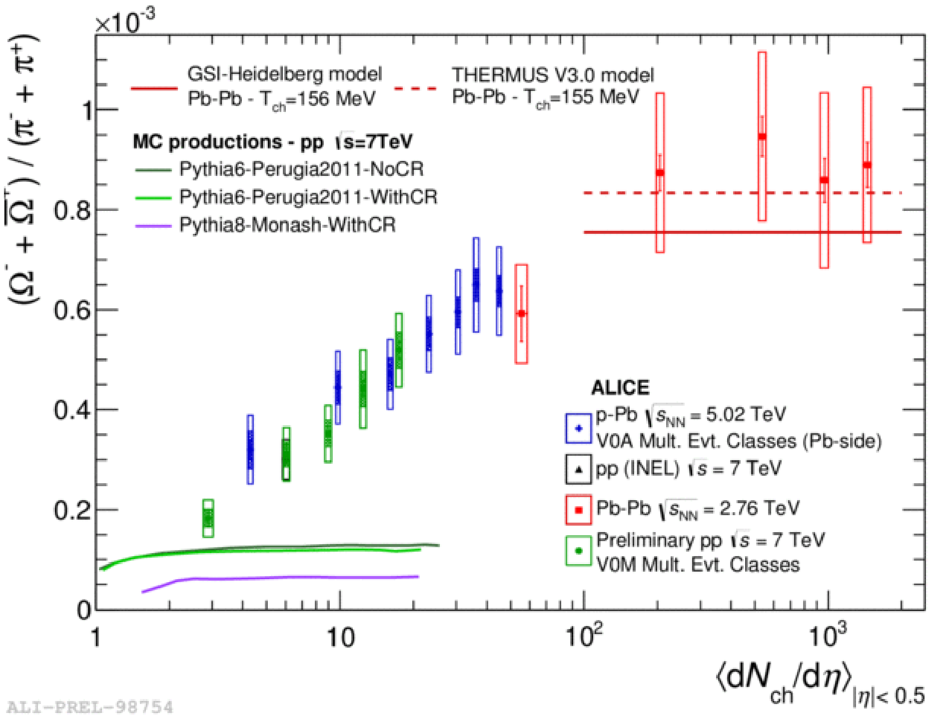
p-p:

- Remarkably similar trend as in p-Pb
- **Same mechanism at play from very low multiplicity and for the three systems?**

Ξ/π and Ω/π





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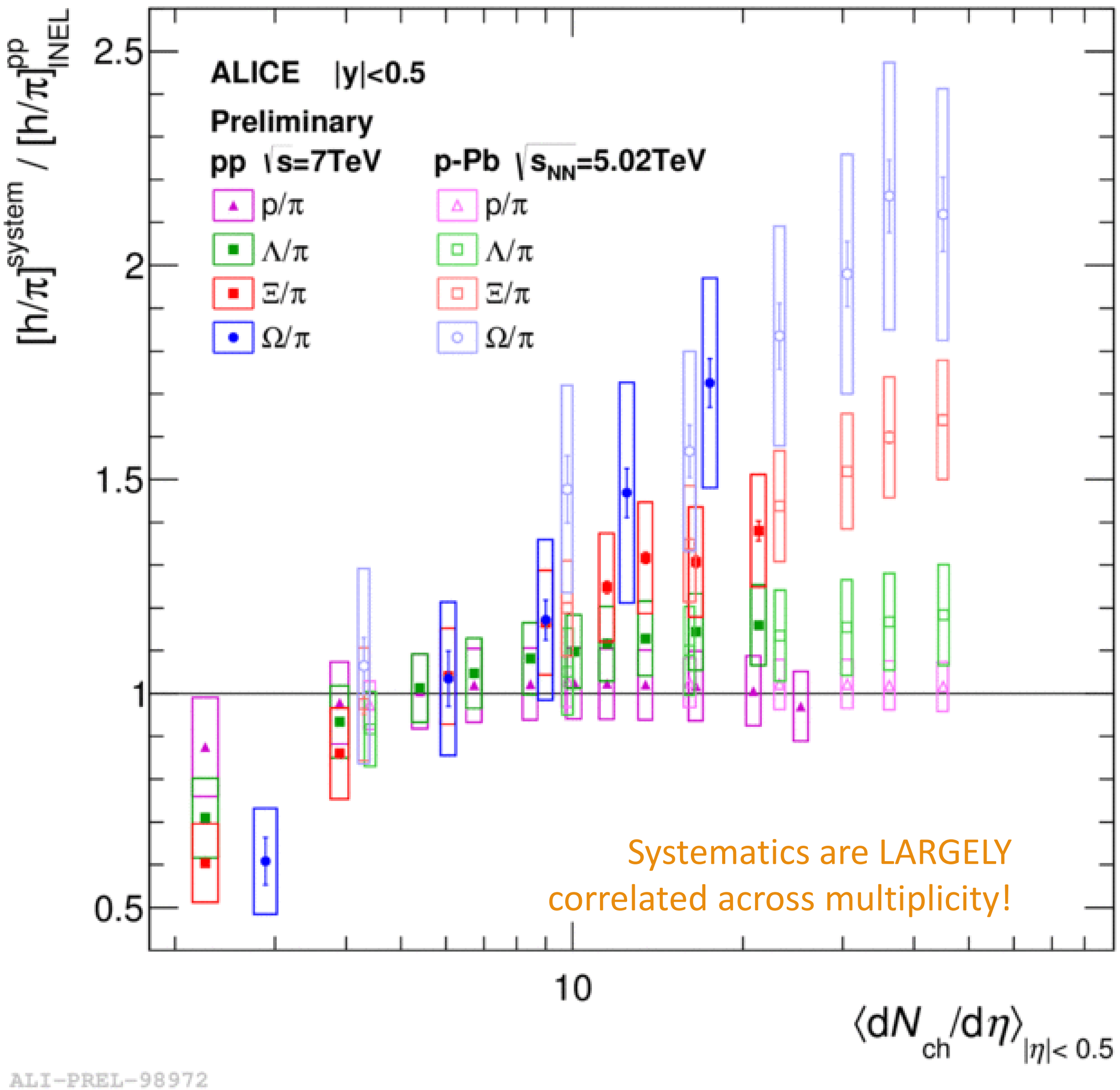
Pythia6 and 8 with several tunes considered: **strong disagreement** with observed trend in pp

pp and p-Pb normalized to pp_{INEL}



How fast does the h/π ratio increase for the different species?

We plot

$[h/\pi]^{system} / [h/\pi]^{pp}_{INEL}$

The relative increase with multiplicity is more pronounced for baryons with higher strangeness content

The increase is **strangeness-related and not baryon-related**, since for protons the ratio remains constant from $\langle N_{ch} \rangle^{INEL}$ up to highest $\langle N_{ch} \rangle$ probed

Conclusions

The ALICE Collaboration reported on the study of strange particle production as a function of multiplicity in pp and p-Pb collisions at the LHC

p_T spectra:

- hardening as a function of $\langle dN_{ch}/d\eta \rangle$ reflected in a logarithmic increase of the $\langle p_T \rangle$
- In p-Pb global Blast-Wave fit describes spectra reasonably from π up to Ω

Λ/π, Ξ/π and Ω/π ratios:

- increase as a function of $\langle dN_{ch}/d\eta \rangle$ with the same trend in pp and p-Pb
- baryons with higher strangeness content exhibit larger increase with multiplicity
- Pythia6 and Pythia8(Monash) do not reproduce the observed trend in pp collisions

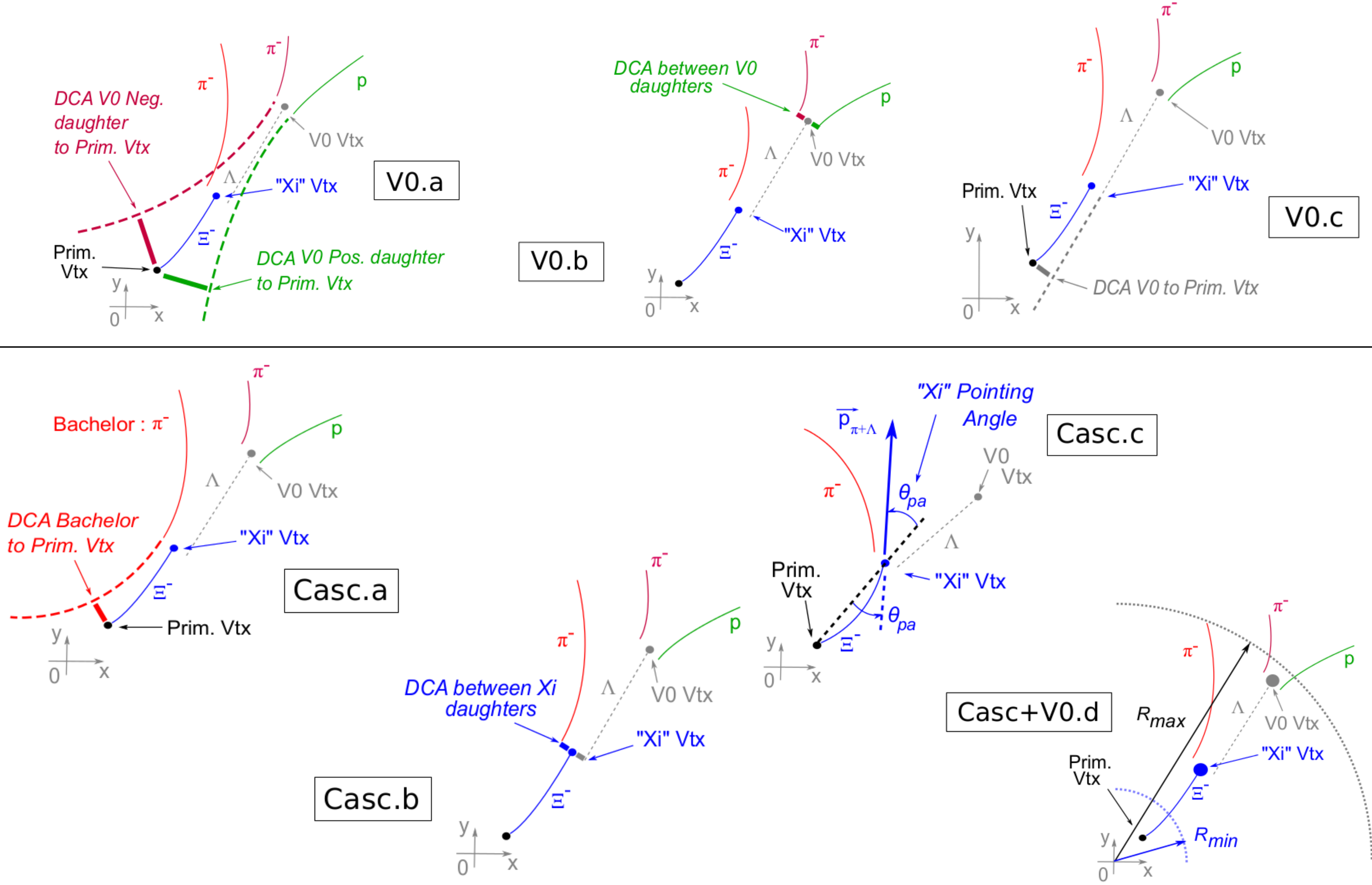
Λ/K^0_S ratio as a function of p_T:

- shows a qualitatively similar trend as the same quantity measured in p-Pb and Pb-Pb

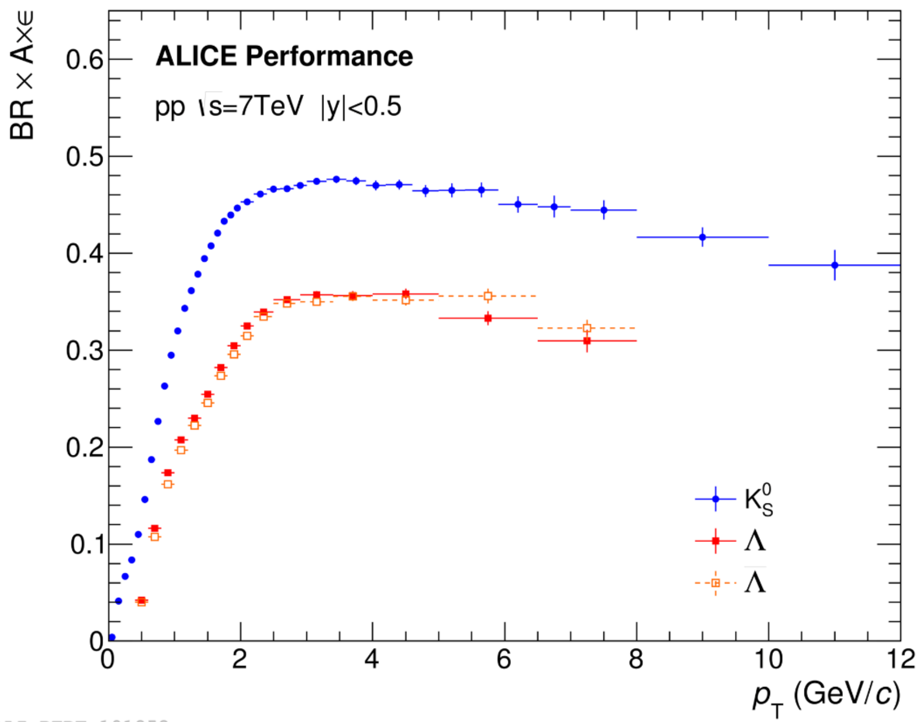
Thank you

Backup

Topological cuts



Acceptance × efficiency correction



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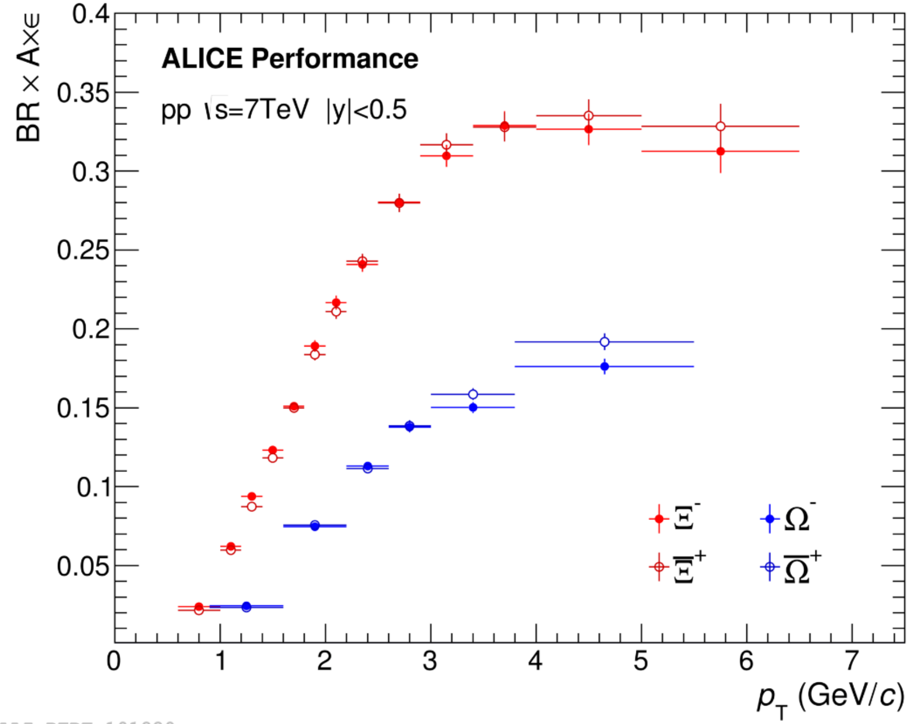


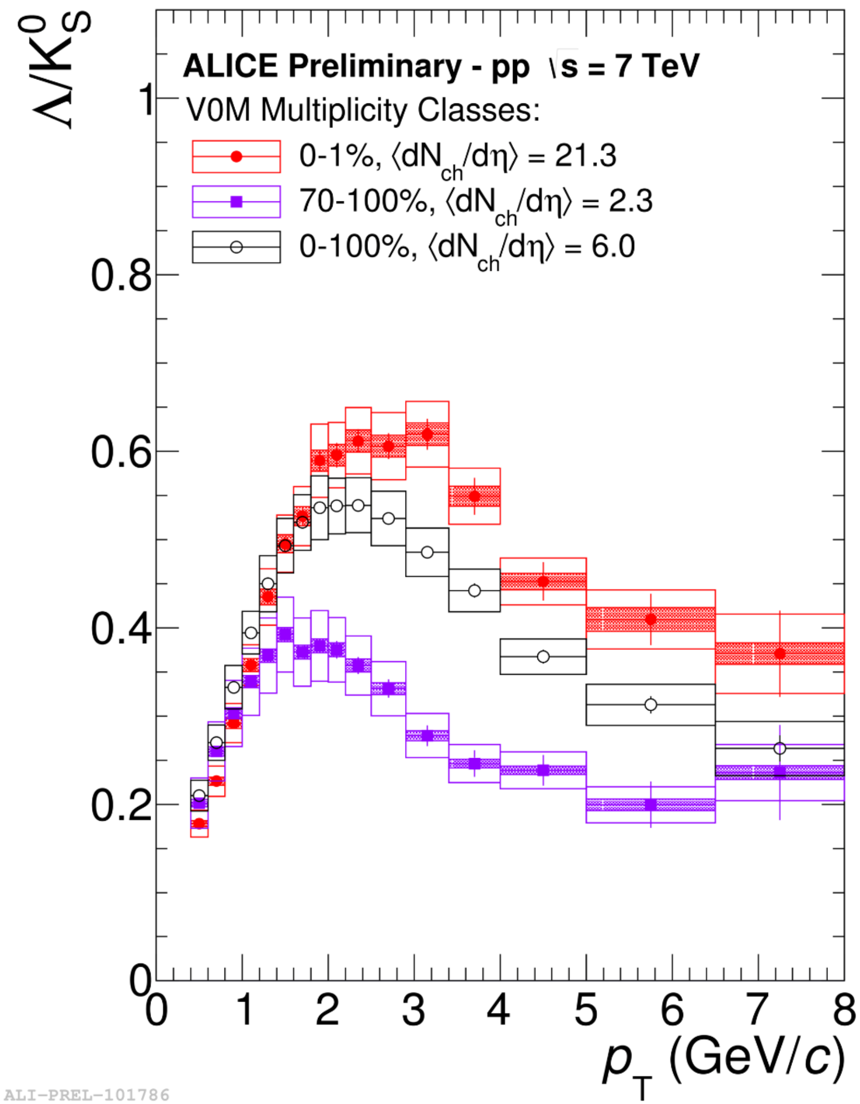
ALI-PERF-101820

Acceptance × efficiency (A×ε) estimated estimated with a Monte Carlo simulation based on the PYTHIA Perugia-0 event generator and full ALICE geometry modeled in Geant3

Ξ and Ω corrections were obtained using a Monte Carlo sample with enriched cascade content

A×ε verified to be independent of charged particle multiplicity

Λ/K^0_S compared to INEL



Ratio Λ/K^0_S for the lowest and highest multiplicity bins probed, compared to the same ratio evaluated for 0-100% multiplicity

The multiplicity-integrated trend is more similar to the one observed at high multiplicity rather than to the one observed at low multiplicity