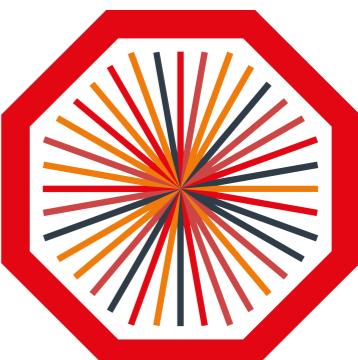


Strangeness and hadronic resonance production in pp, p-Pb and Pb-Pb collisions measured by **ALICE** at the LHC



Jihye Song
for the ALICE collaboration
Pusan National University, Korea

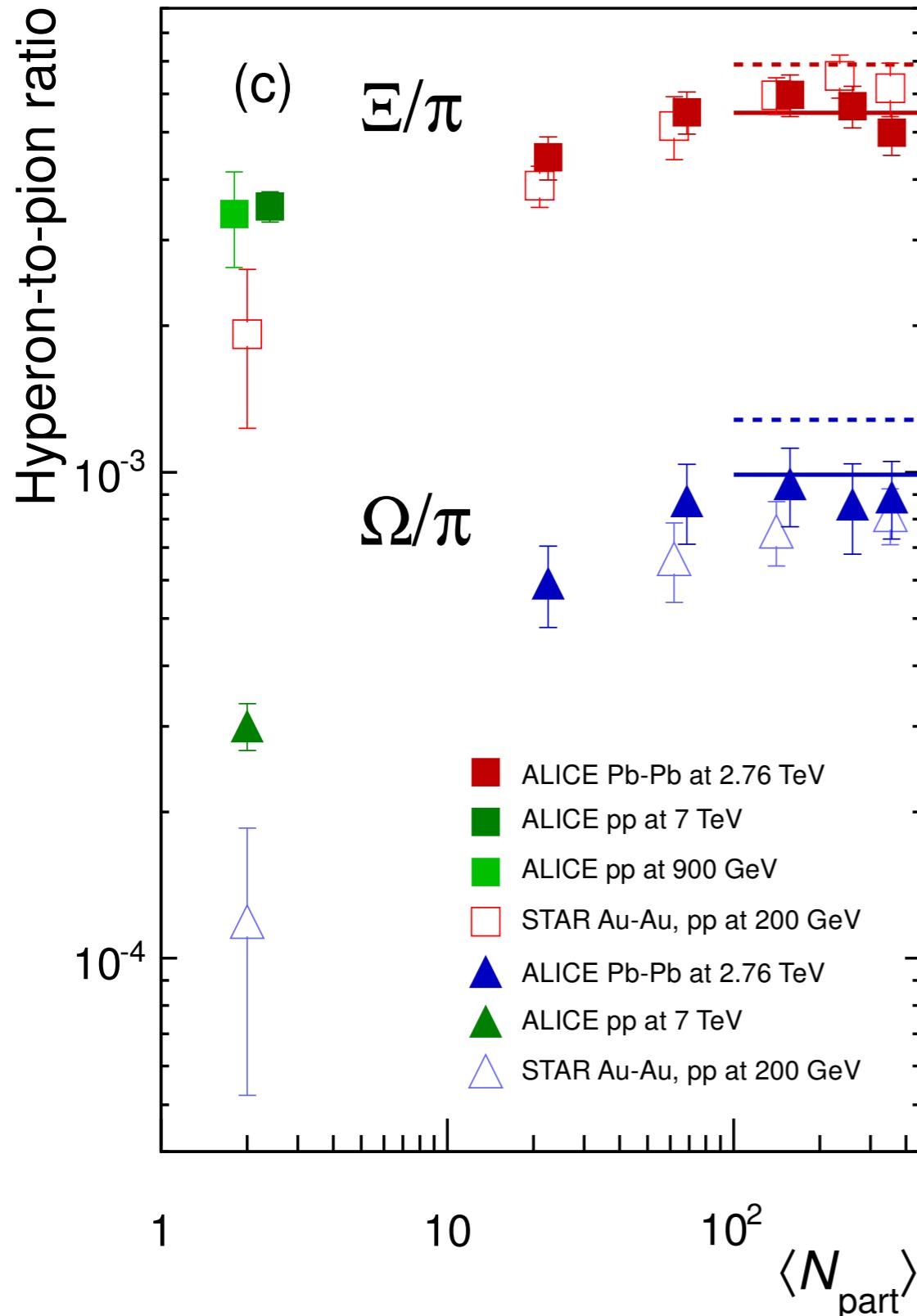


— ALICE

Outline

- Physics motivation
- **ALICE** detector
- Multiplicity-dependent **strangeness** production
- Measurement of mesonic and baryonic **resonances**
- Summary

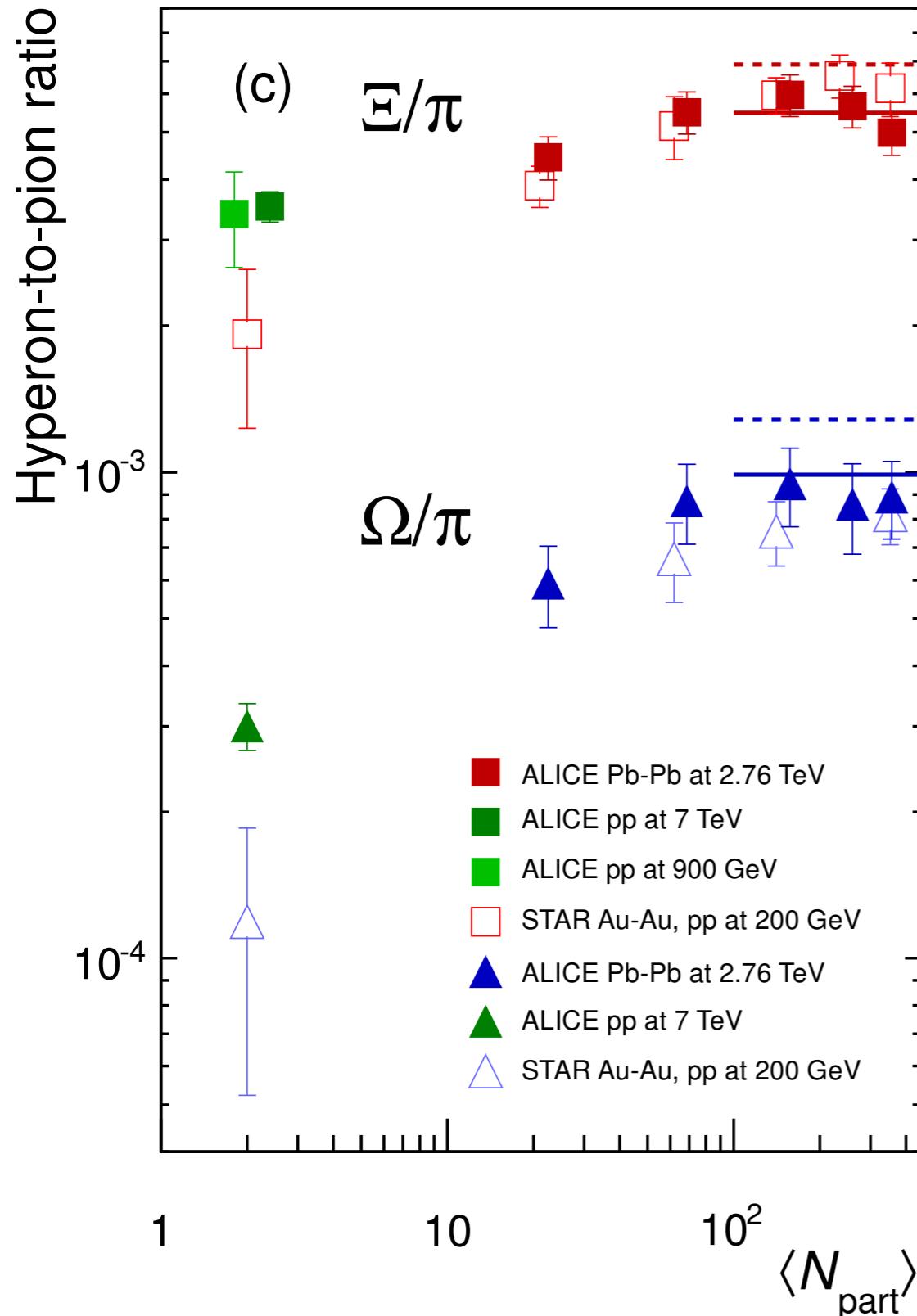
Strangeness enhancement



- Enhanced production of strangeness particles in AA w.r.t. pp

	Mass[GeV/c ²]	quark contents
Ξ	1.321	dss
Ω	1.672	sss

Strangeness enhancement

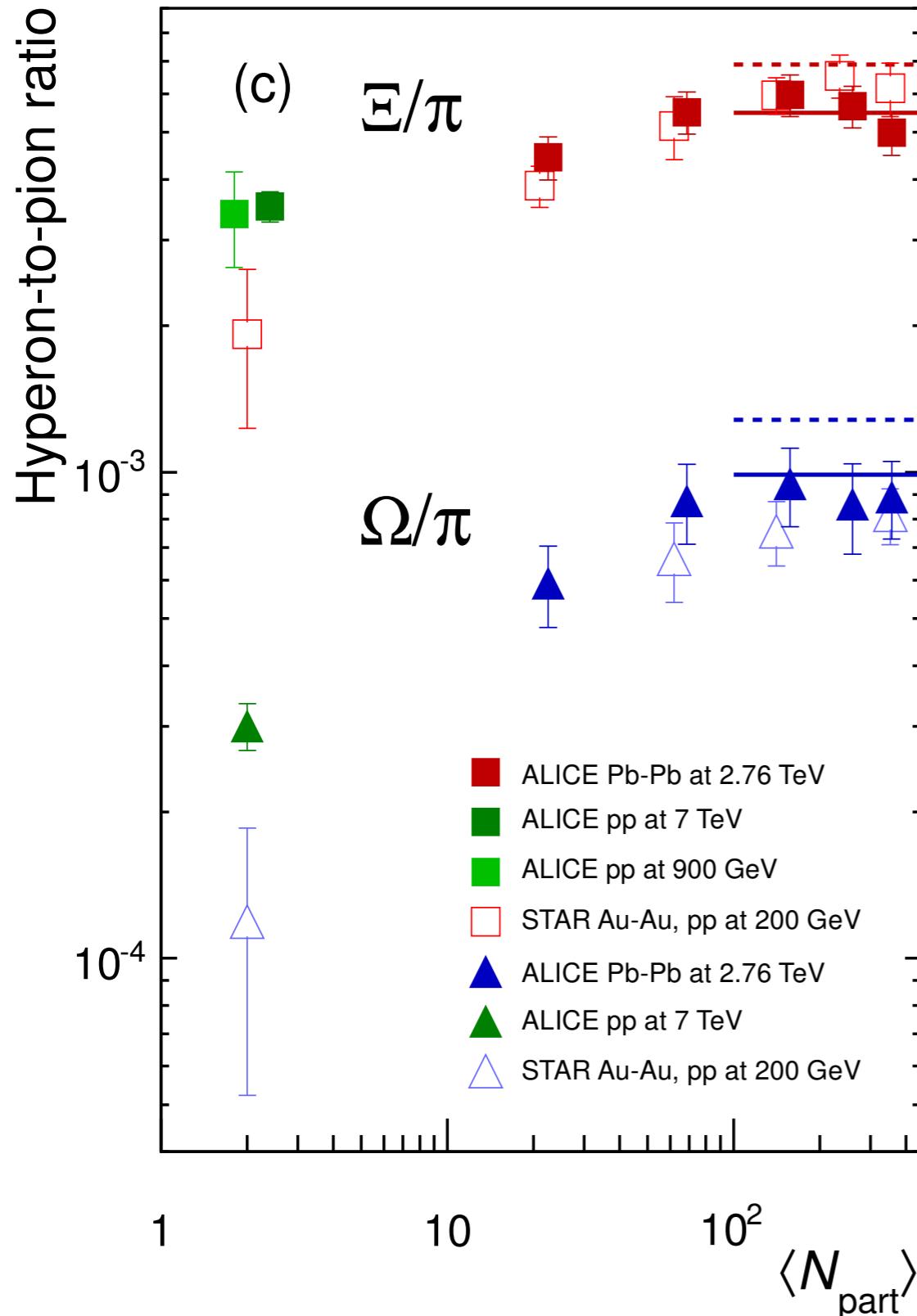


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What are the latest results on strangeness production in different colliding systems at the top LHC energy?

Strangeness enhancement



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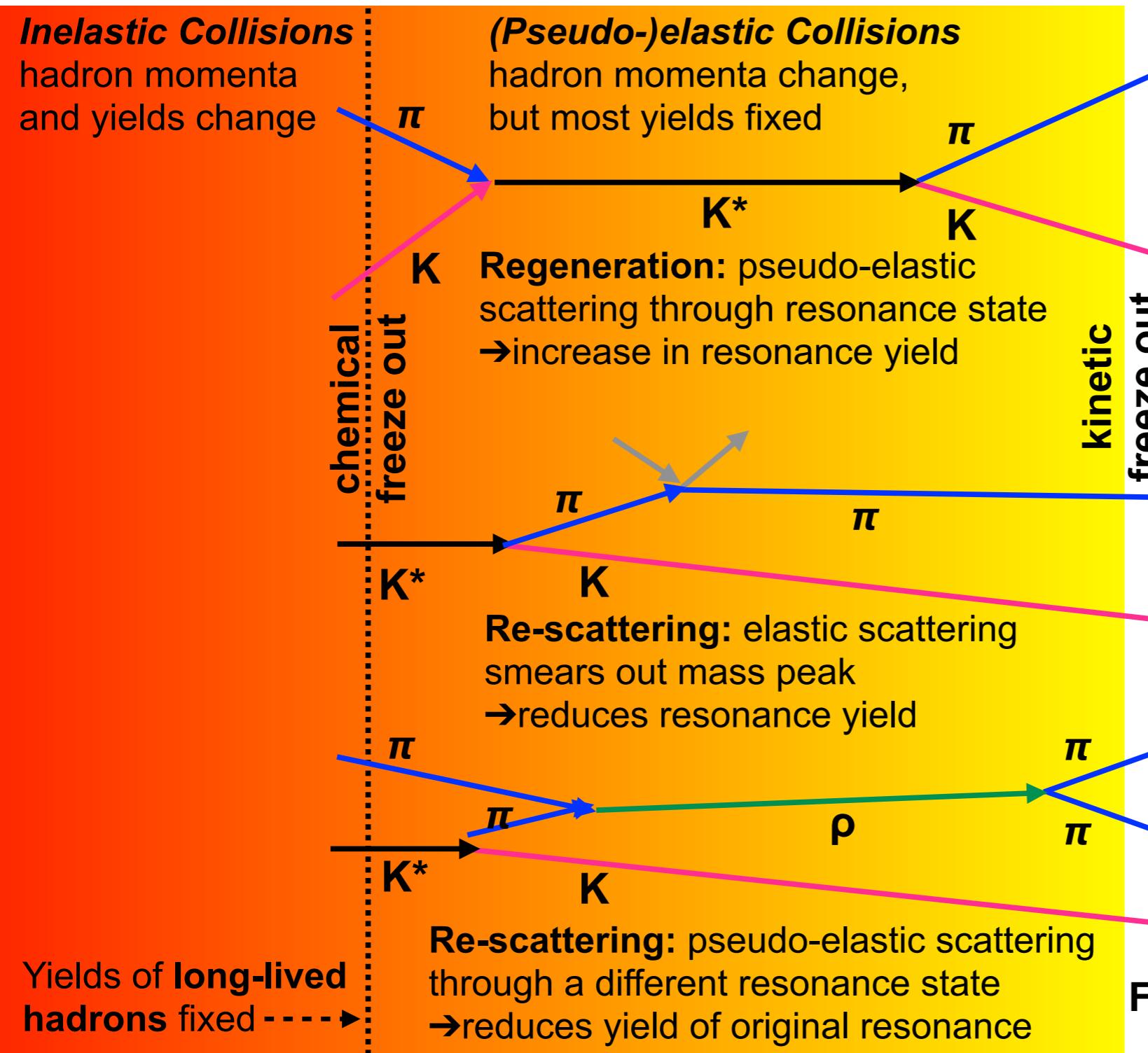
What are the latest results on strangeness production in different colliding systems at the top LHC energy?

What causes the enhancement?



ALICE

Probing the hadronic phase

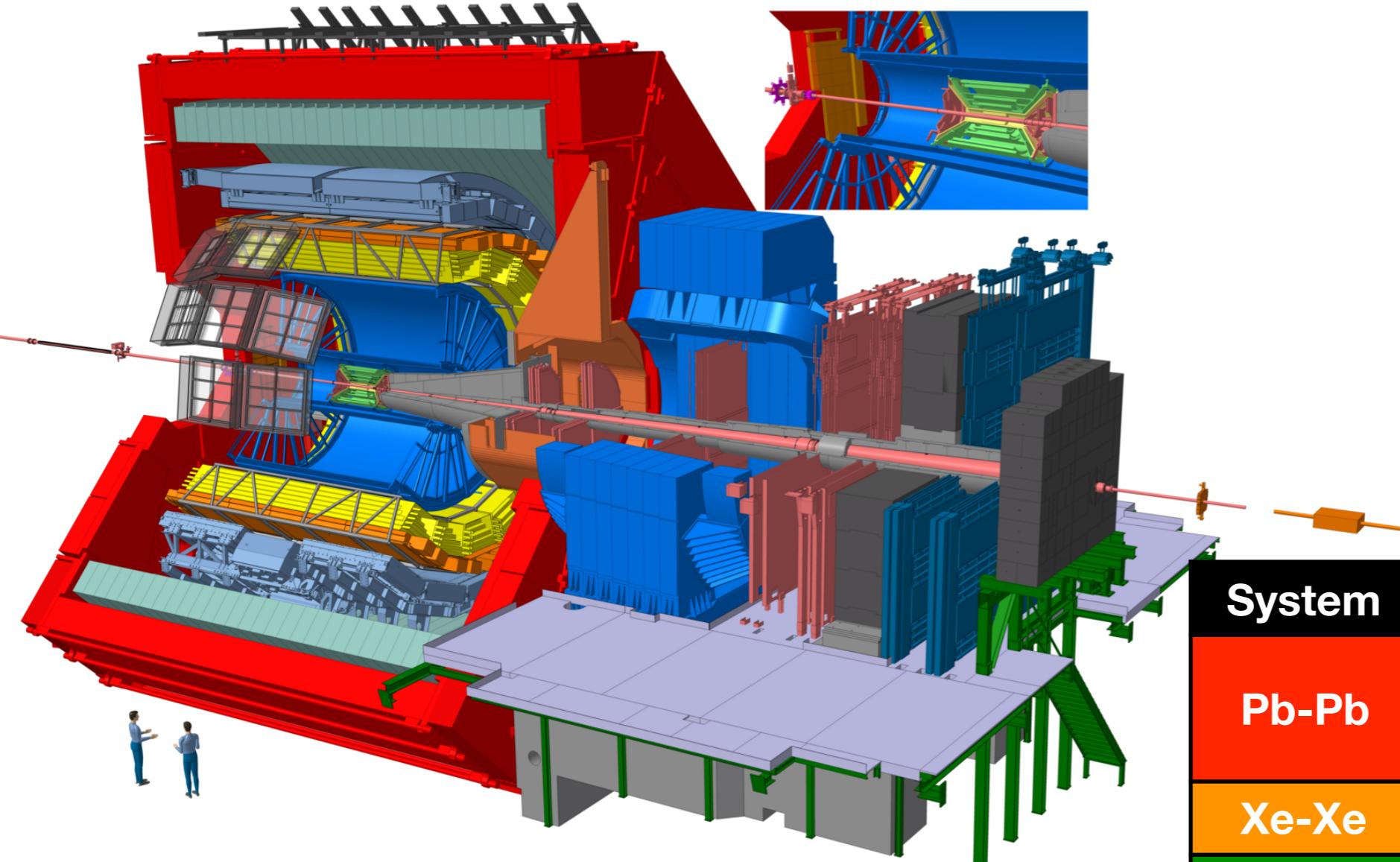


Resonances have

- Different short lifetimes
 - allow to study properties of hadronic phase in terms of **re-scattering and regeneration effects**

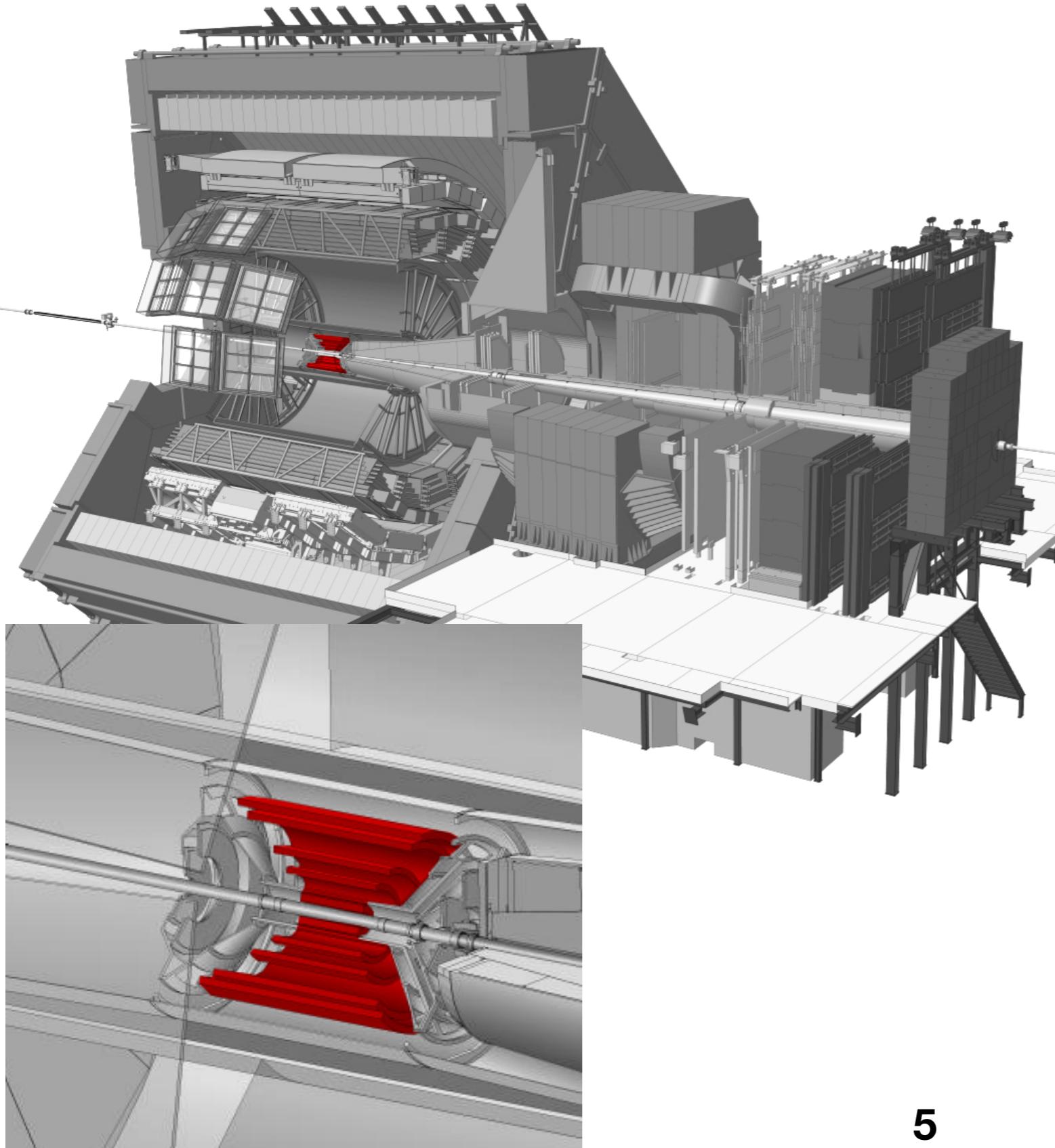
	Lifetime [fm/c]
ρ	1.3
K^{*0}	4.2
Λ^*	12.6
Ξ^{*0}	21.7
ϕ	46.2

The ALICE detector

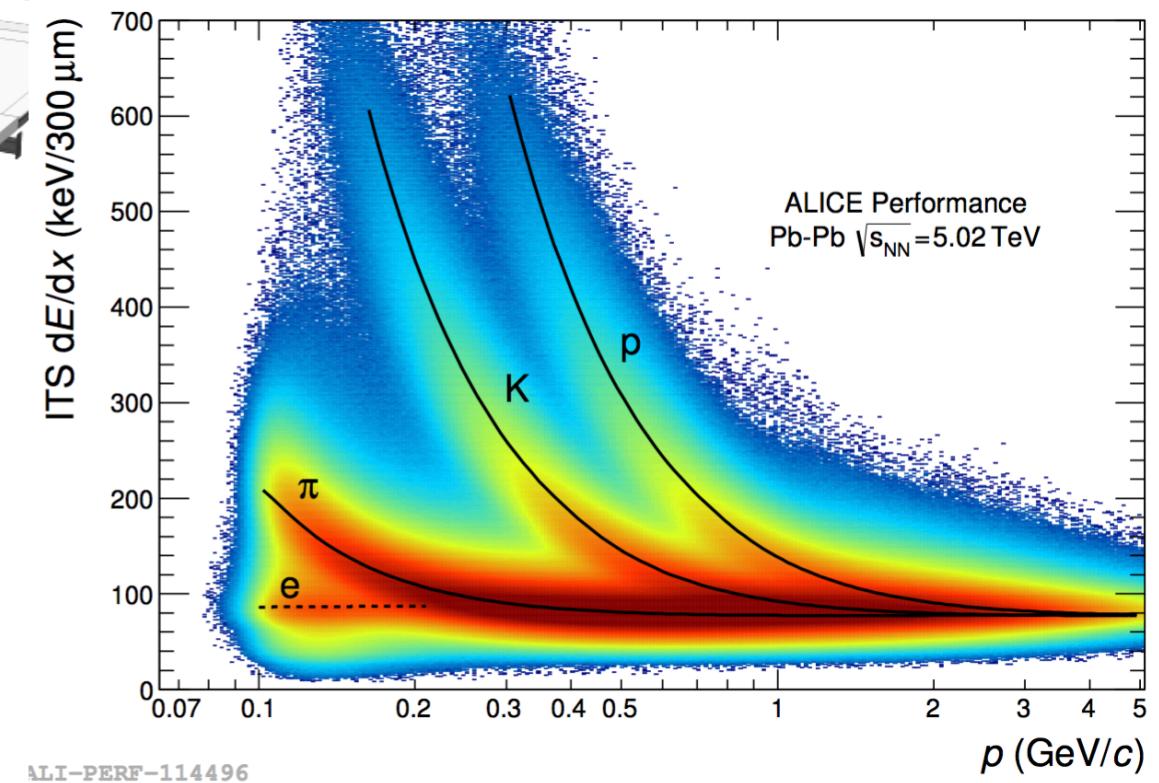


System	Year(s)	$\sqrt{s_{\text{NN}}}$ [TeV]
Pb-Pb	2010-2011	2.76
Xe-Xe	2015	5.02
p-Pb	2017	5.44
pp	2013	5.02
p-Pb	2016	5.02, 8.16
pp	2009-2013	0.9, 2.76, 7, 8
pp	2015, 2017	5.02, 13

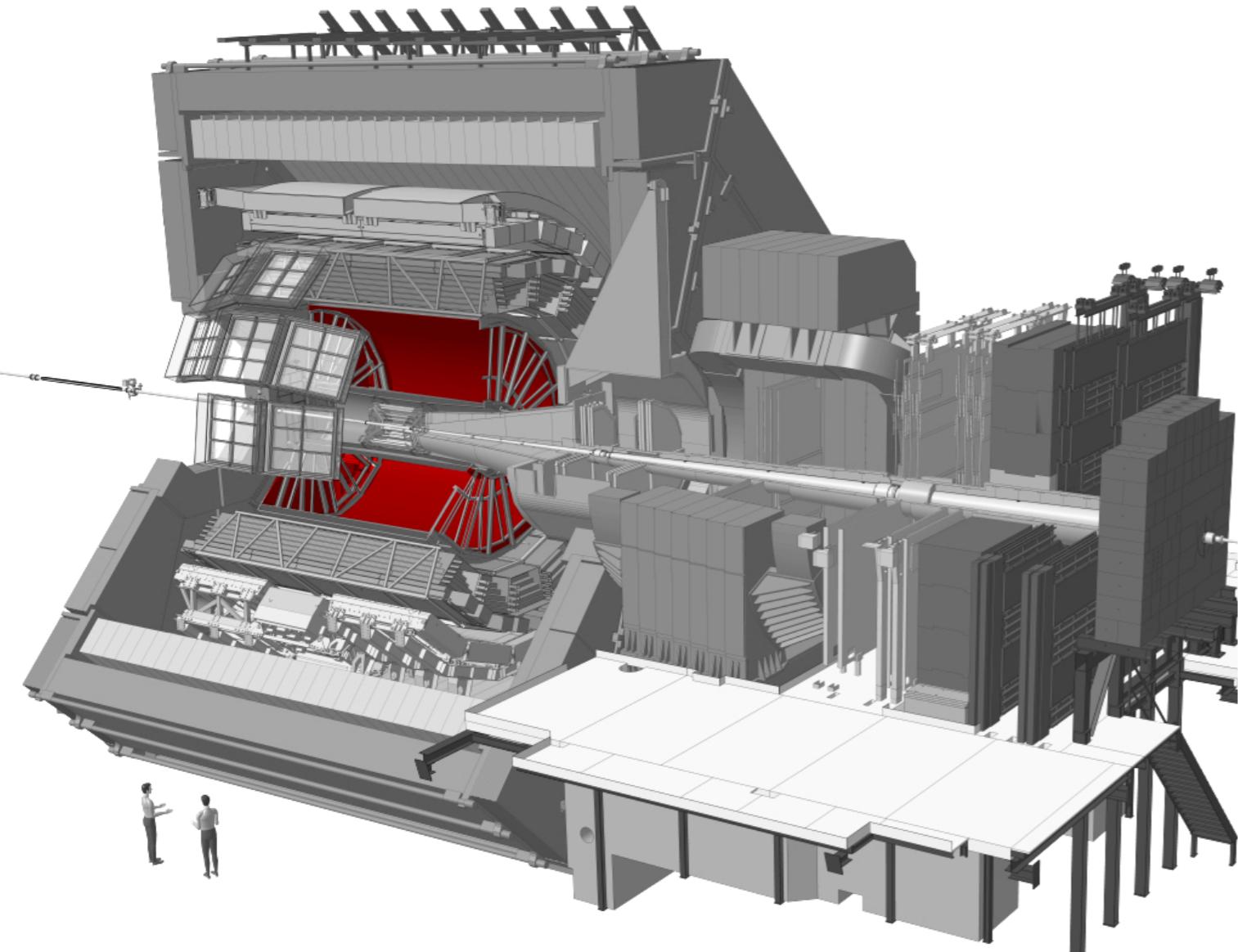
The ALICE detector



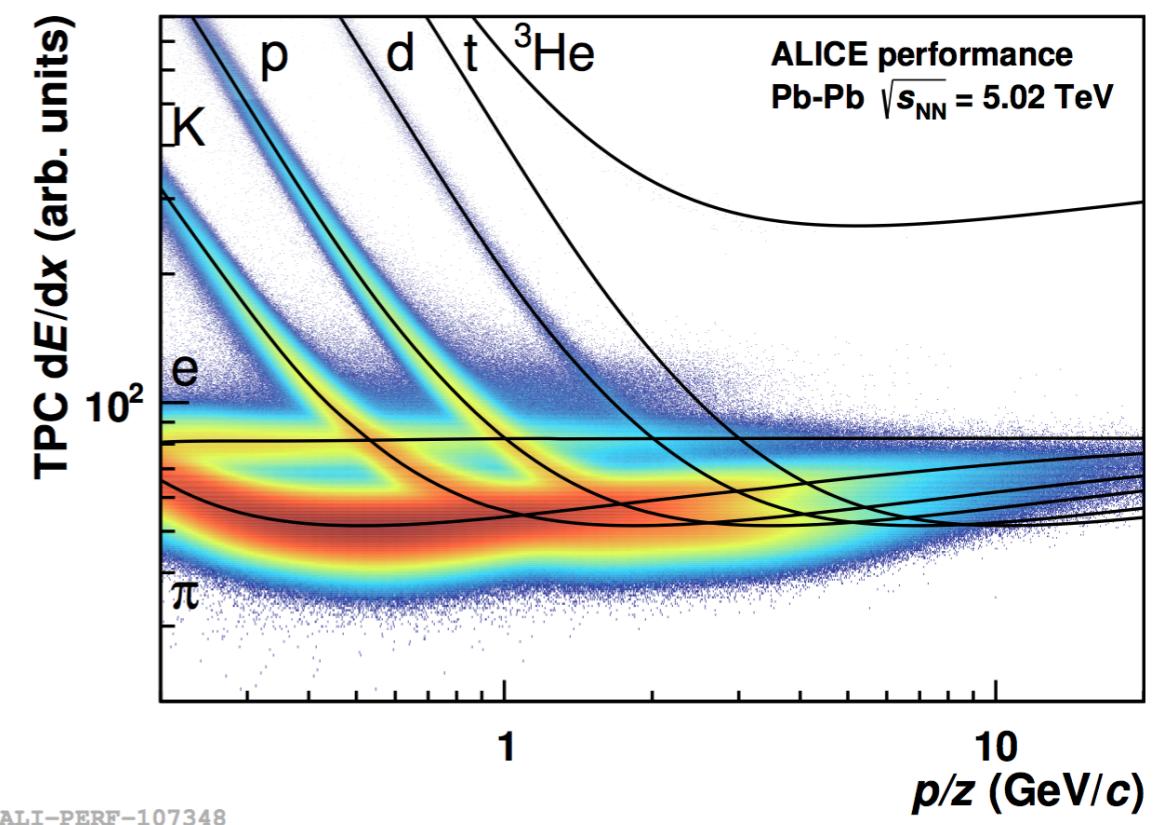
- **Inner Tracking System (ITS)**
 - SPD, SDD, SSD
 - Trigger, tracking, vertex, PID (dE/dx)



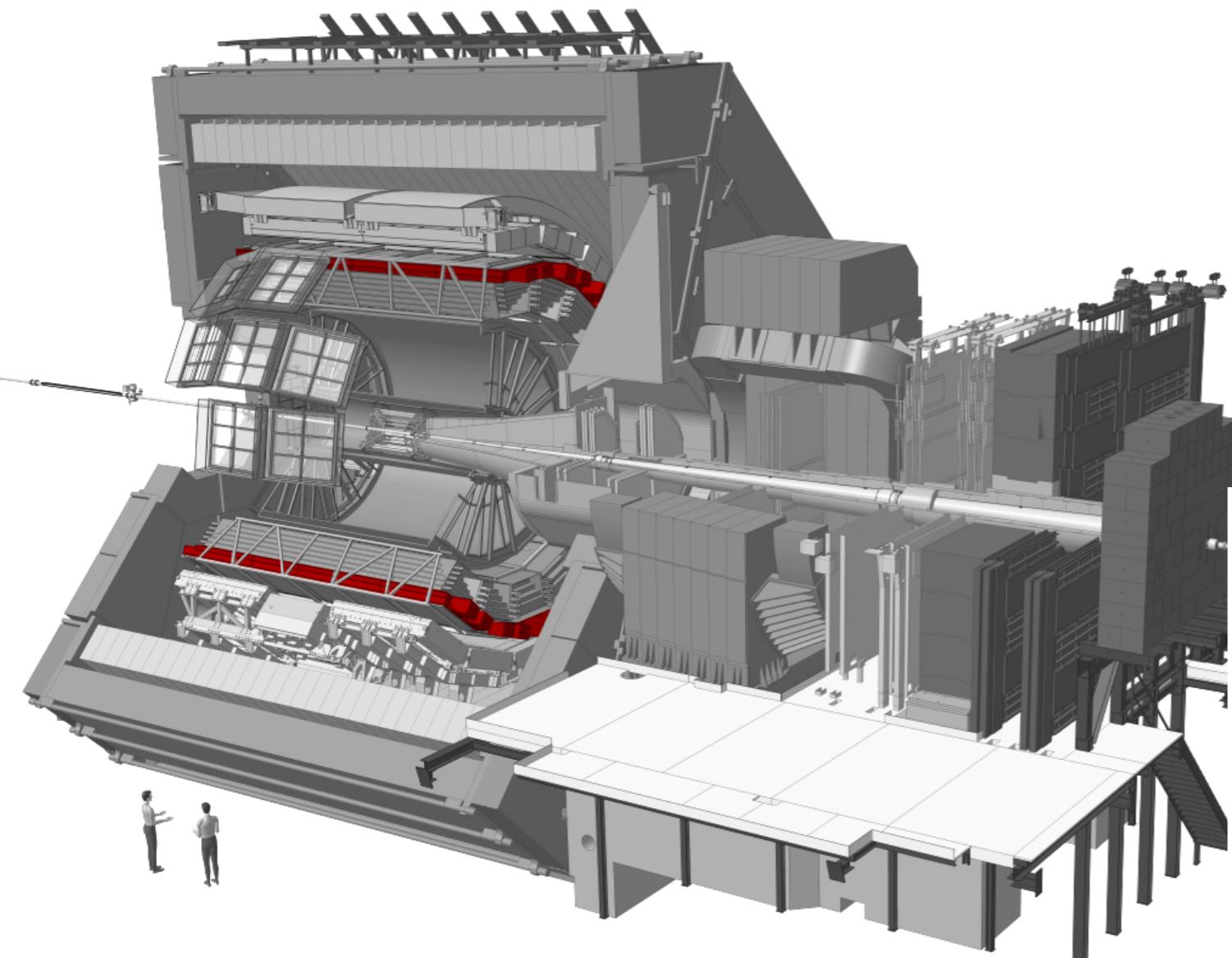
The ALICE detector



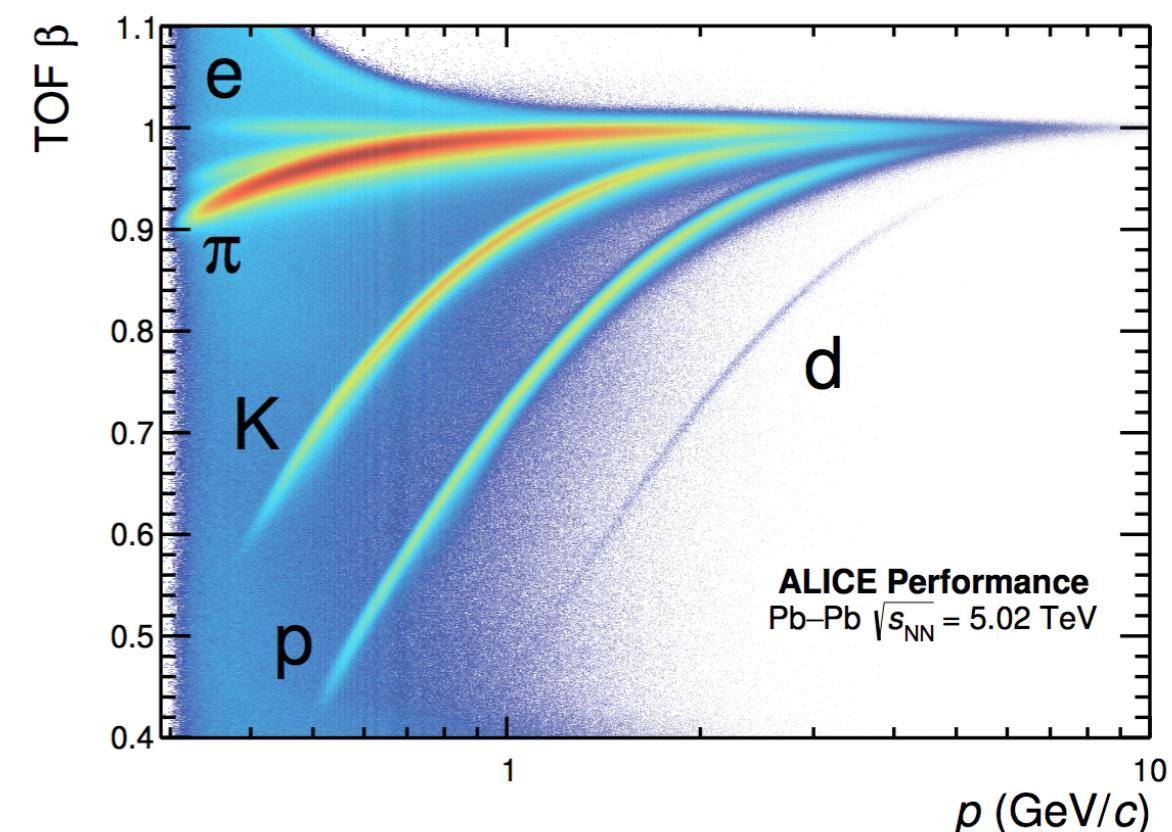
- **Time Projection Chamber (TPC)**
 - Gas-filled ionization detector
 - Tracking, vertex, PID, (dE/dx)



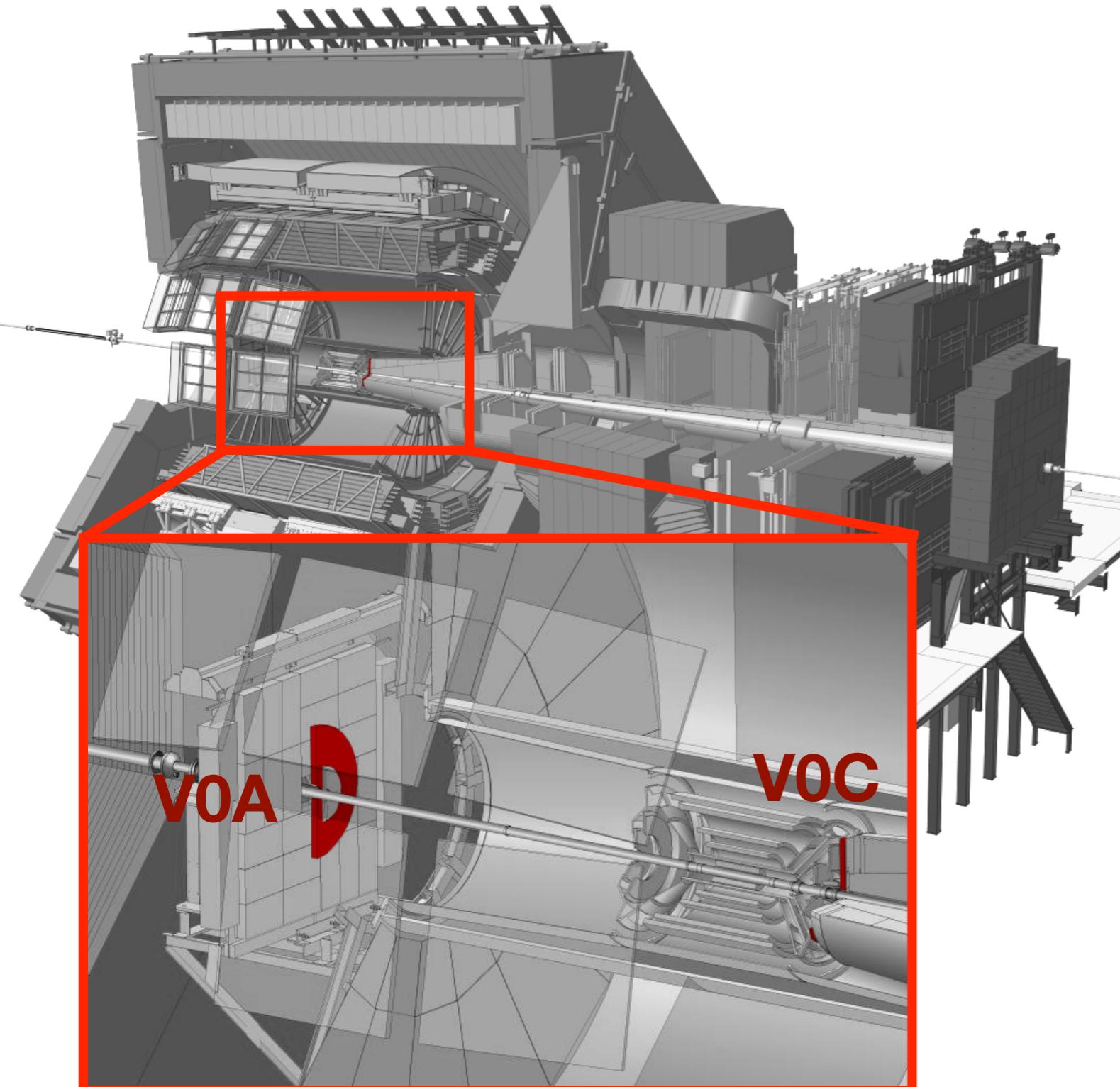
The ALICE detector



- **Time Of Flight (TOF)**
 - PID through particle time of flight



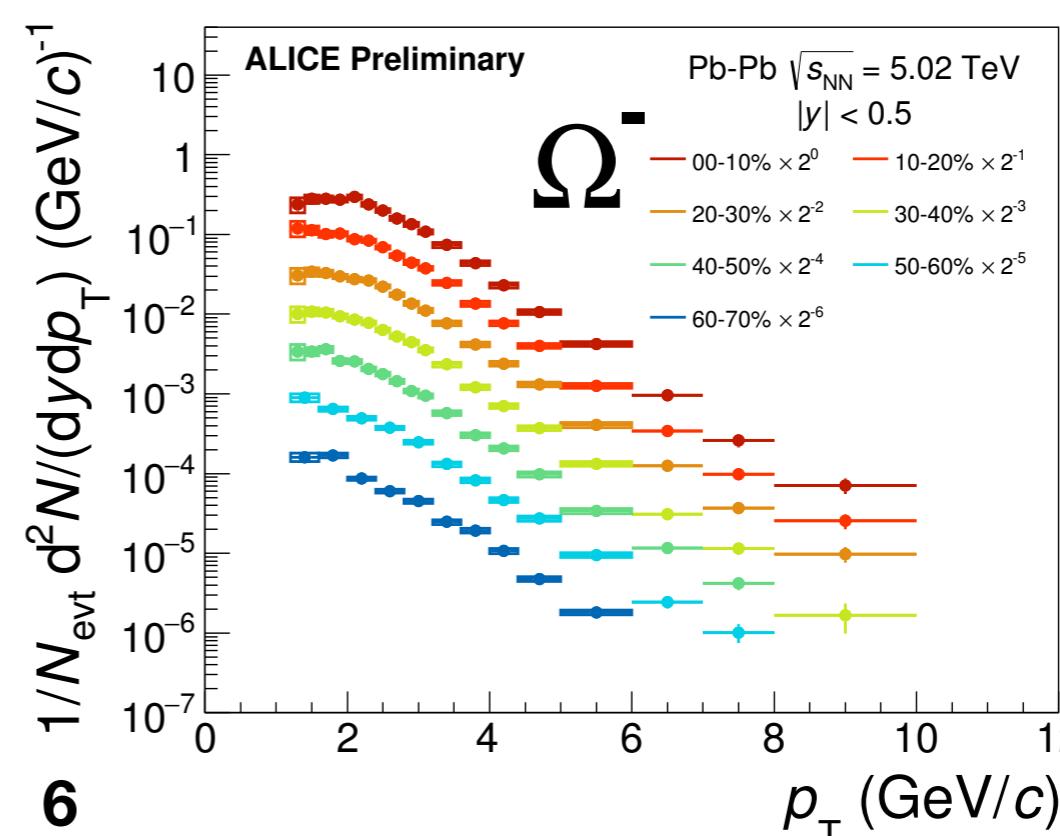
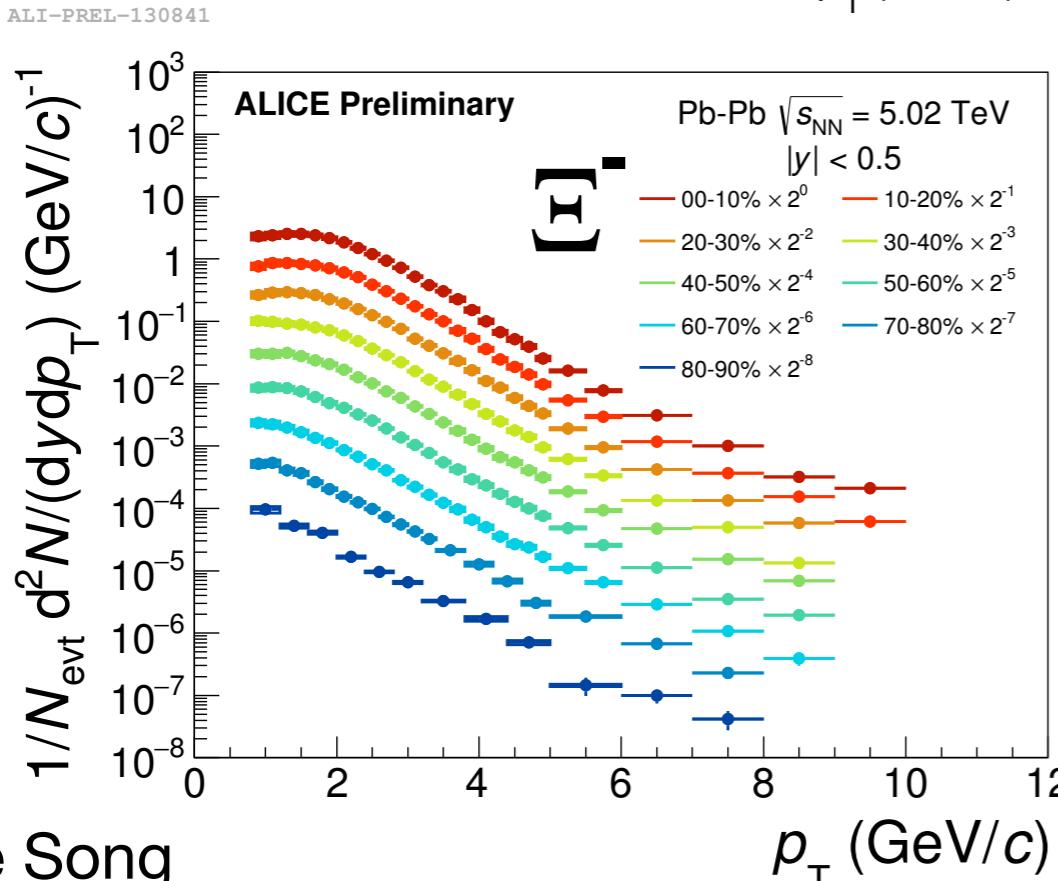
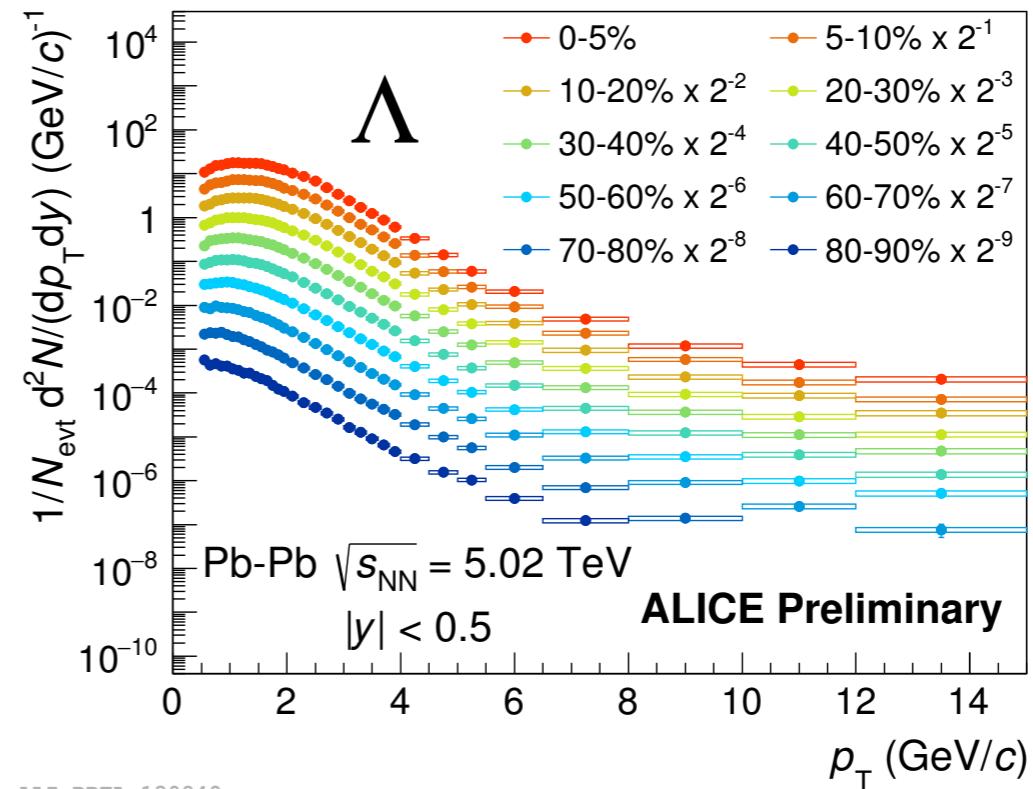
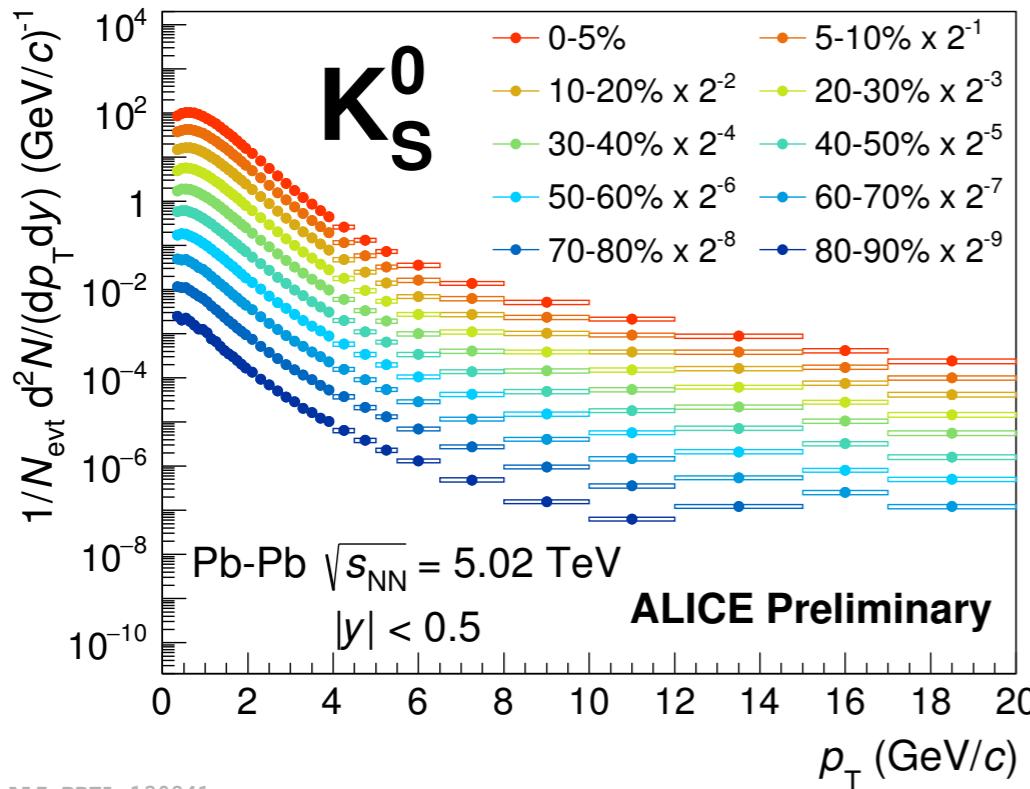
The ALICE detector



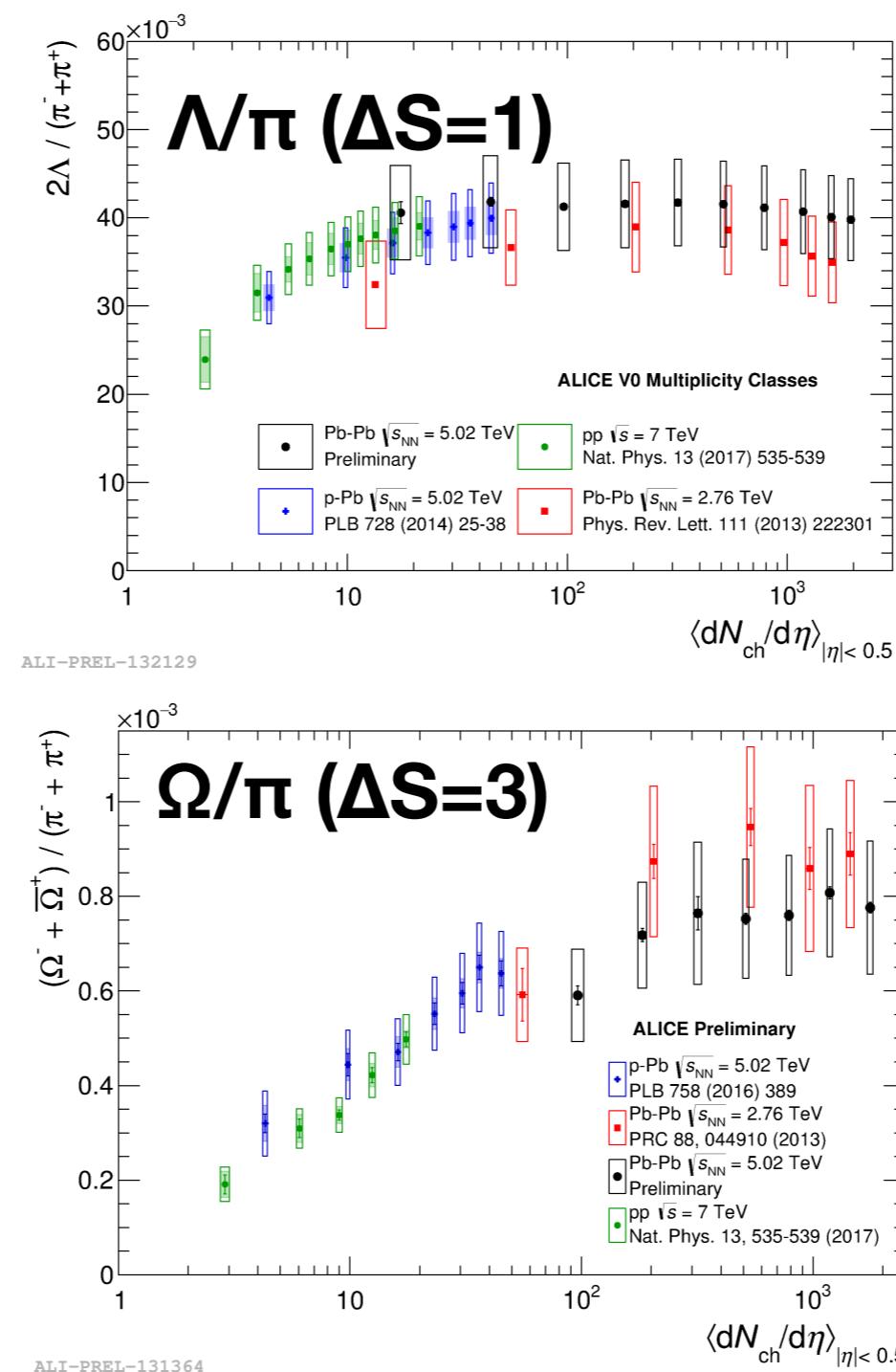
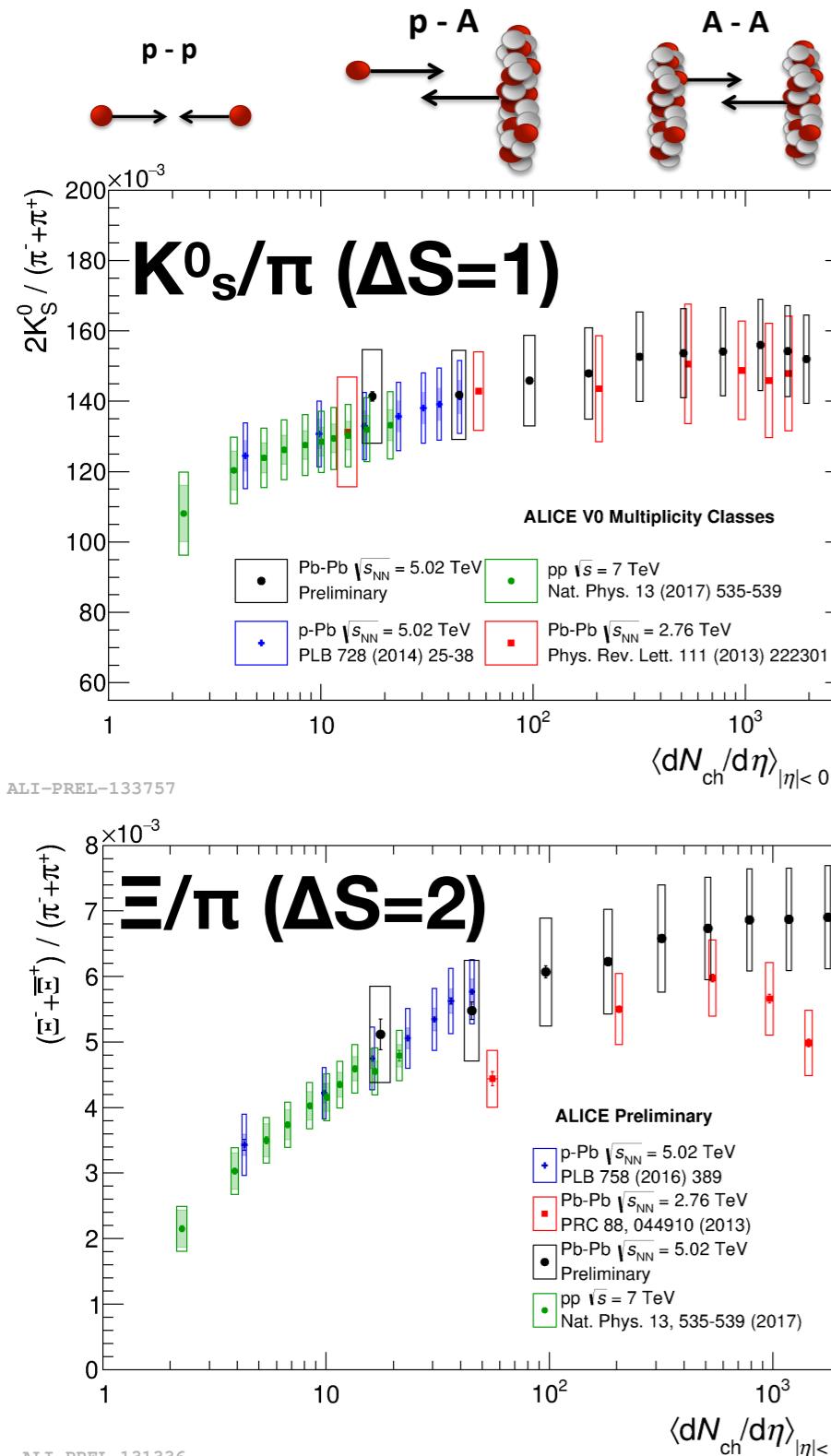
- **VOA and VOC**
 - Trigger, centrality/multiplicity estimator

Strangeness particle p_T -spectra in Pb-Pb

at $\sqrt{s_{NN}} = 5.02 \text{ TeV}$

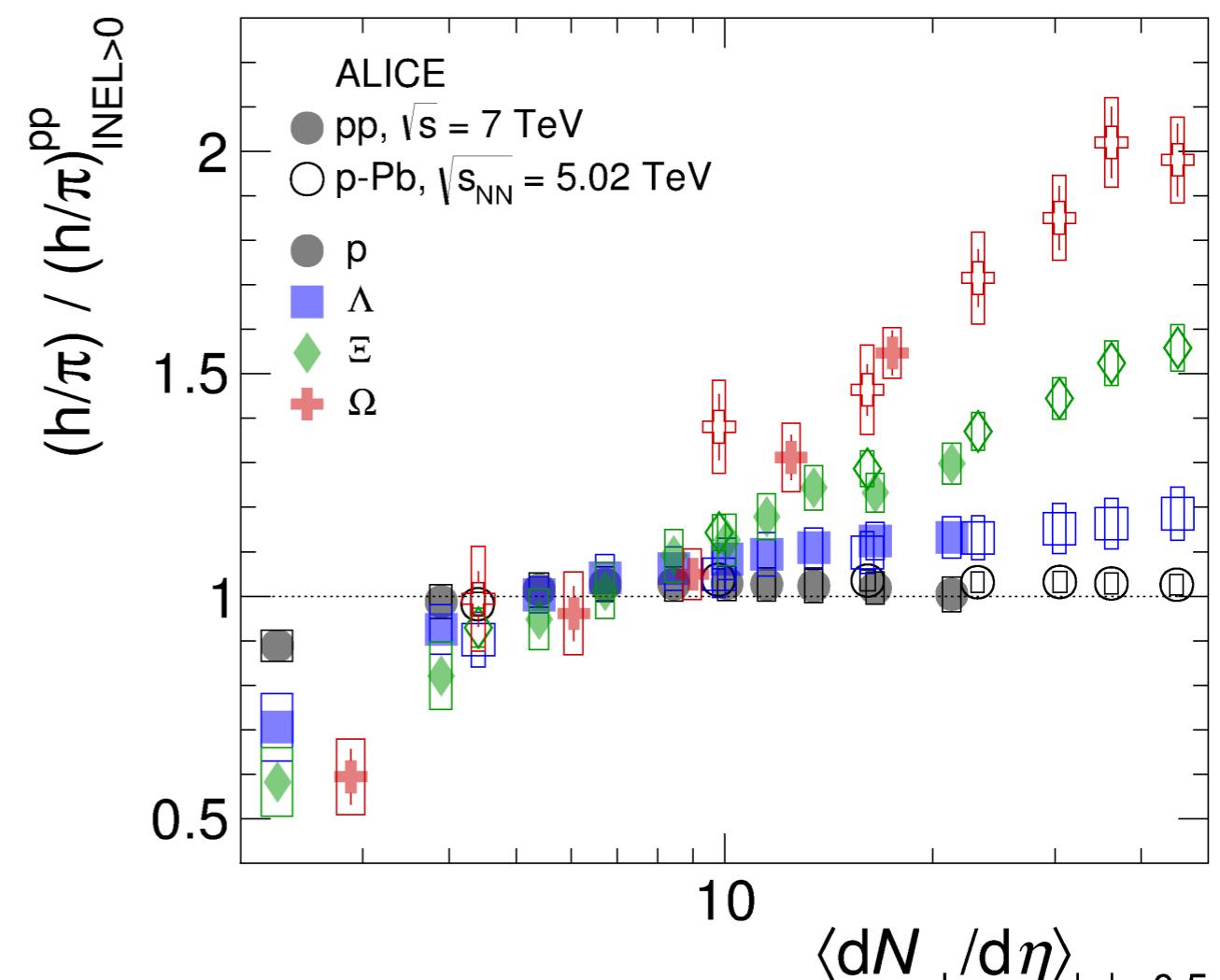
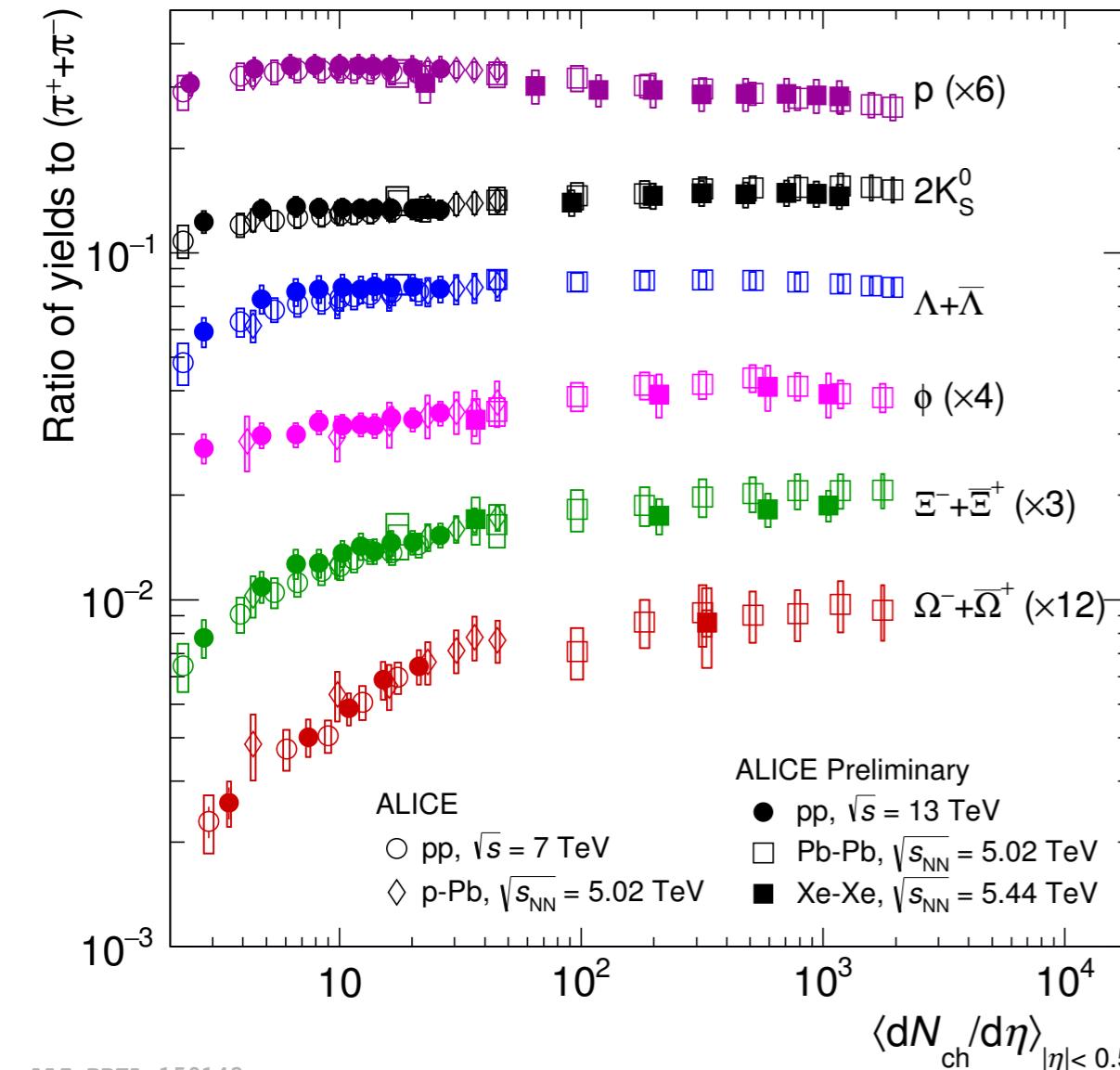


Yields to π ratio as a function of multiplicity



- Smooth evolution from pp to Pb-Pb collisions
- At similar multiplicity, no dependence with system nor energy is observed

Relative strangeness production

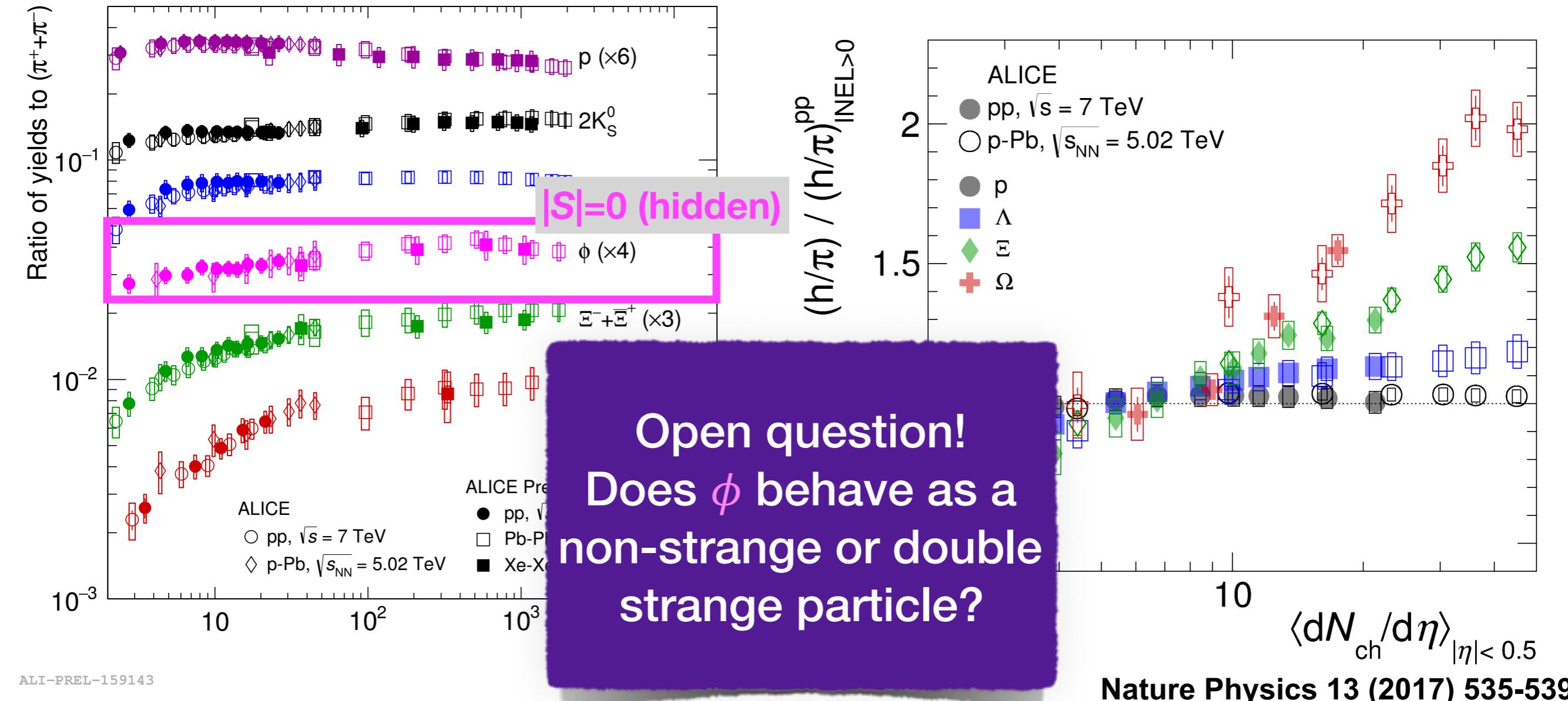


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Nature Physics 13 (2017) 535-539

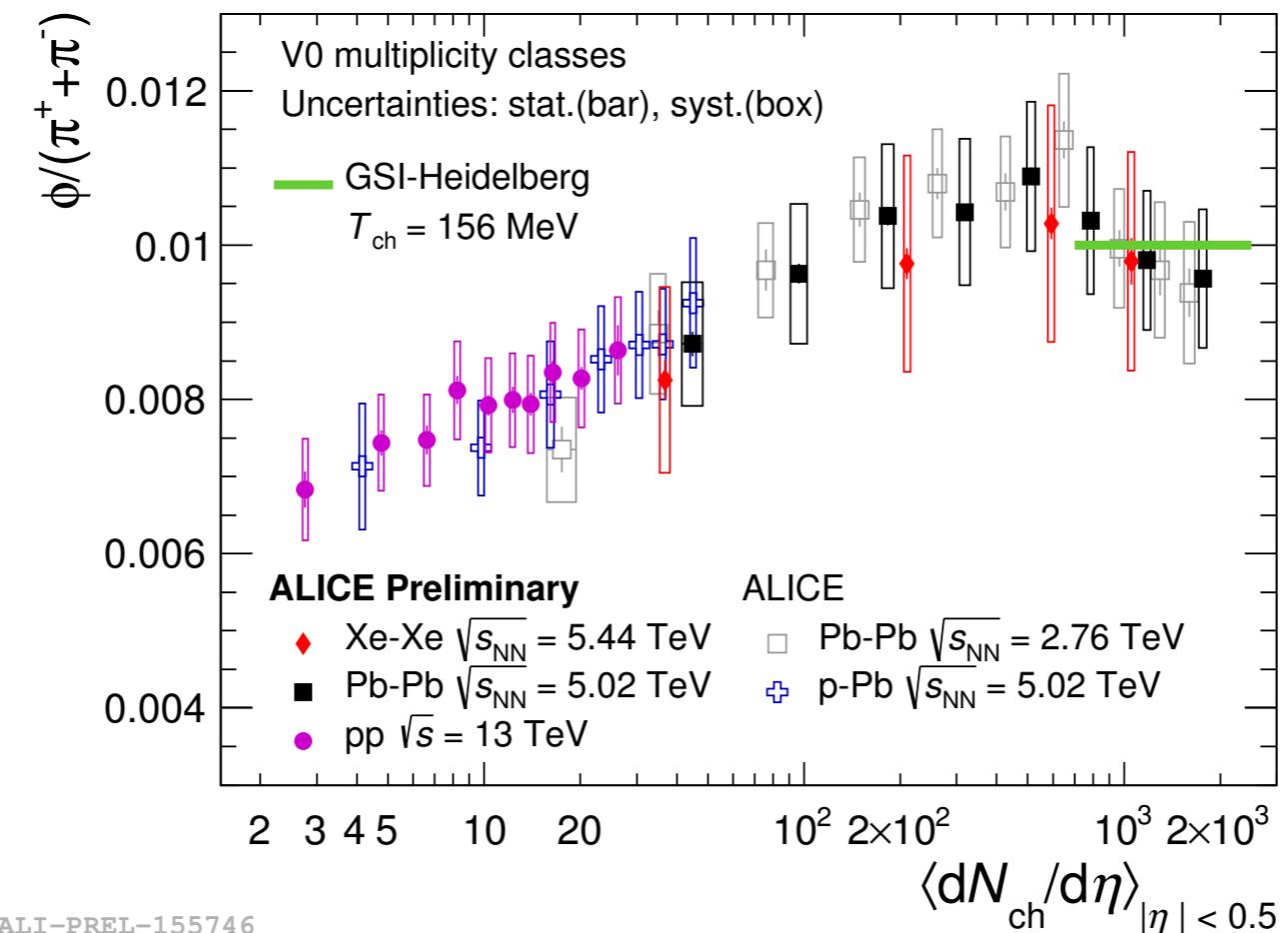
- Enhancement for small systems, saturation for large system
 - strangeness enhancement increases with **strange-quark** content

Relative strangeness production



- Enhancement for small systems, saturation for large system
 - strangeness enhancement increases with **strange-quark** content

Hidden & Open strangeness



$\phi/\pi: (|S|=0)/(|S|=0)$

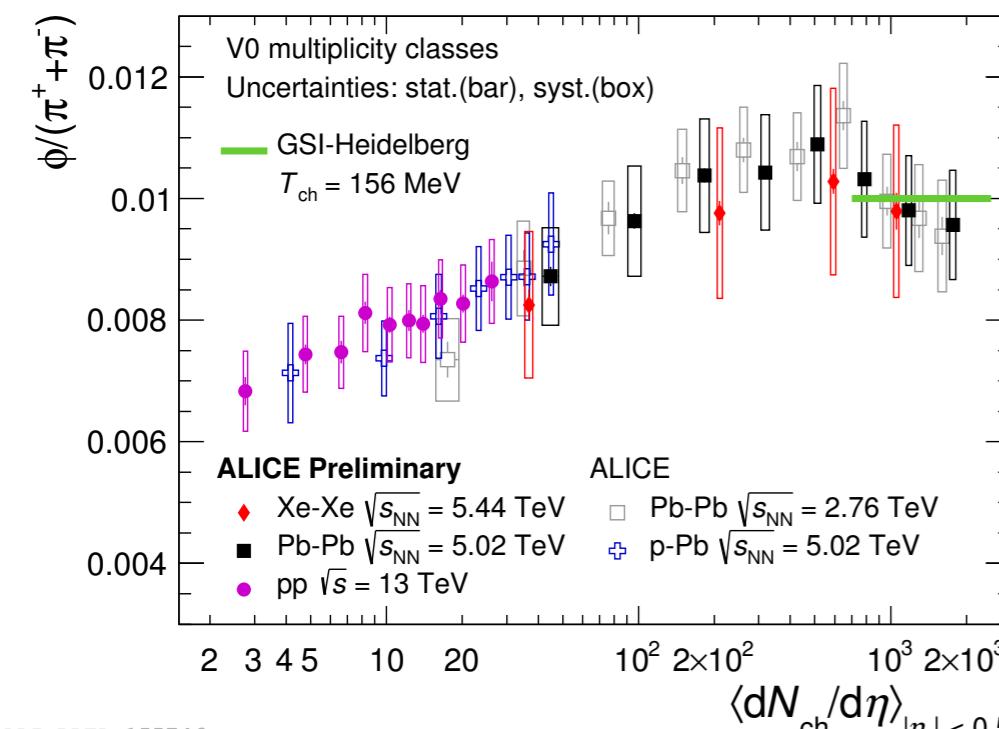
- Ratio ϕ/π
 - large systems: described by thermal model
 - small systems: increase with multiplicity



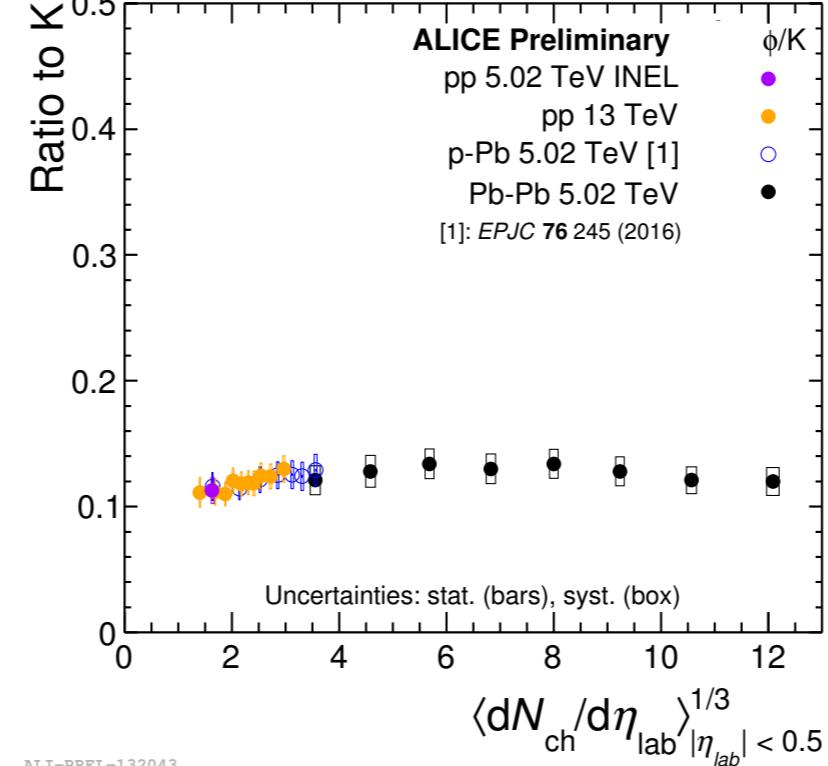
ALICE

Hidden & Open strangeness

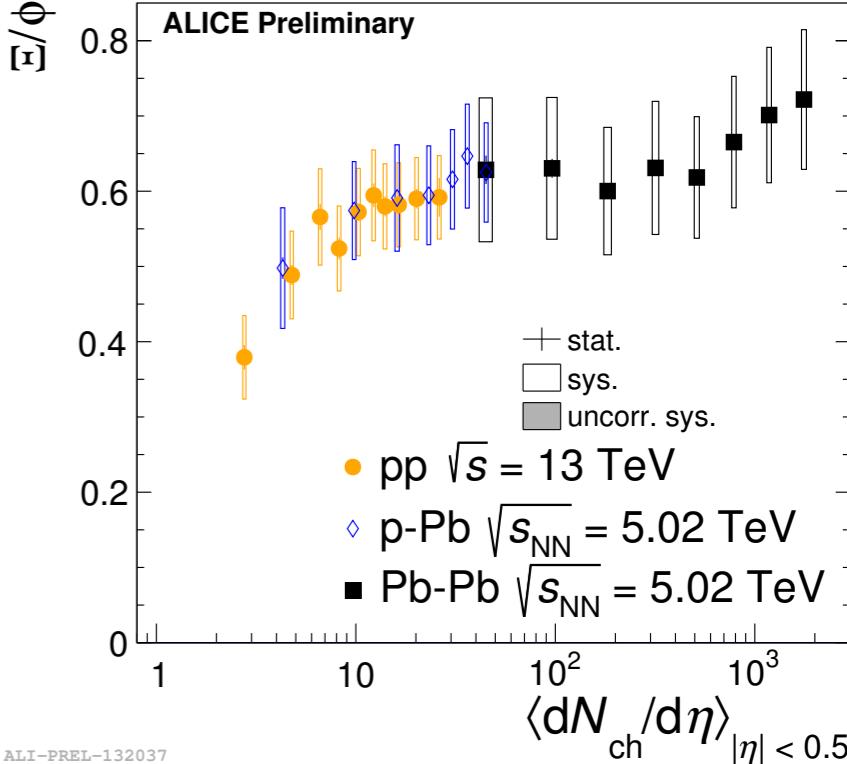
$\phi/\pi: (|S|=0)/(|S|=0)$



$\phi/K: (|S|=0)/(|S|=1)$

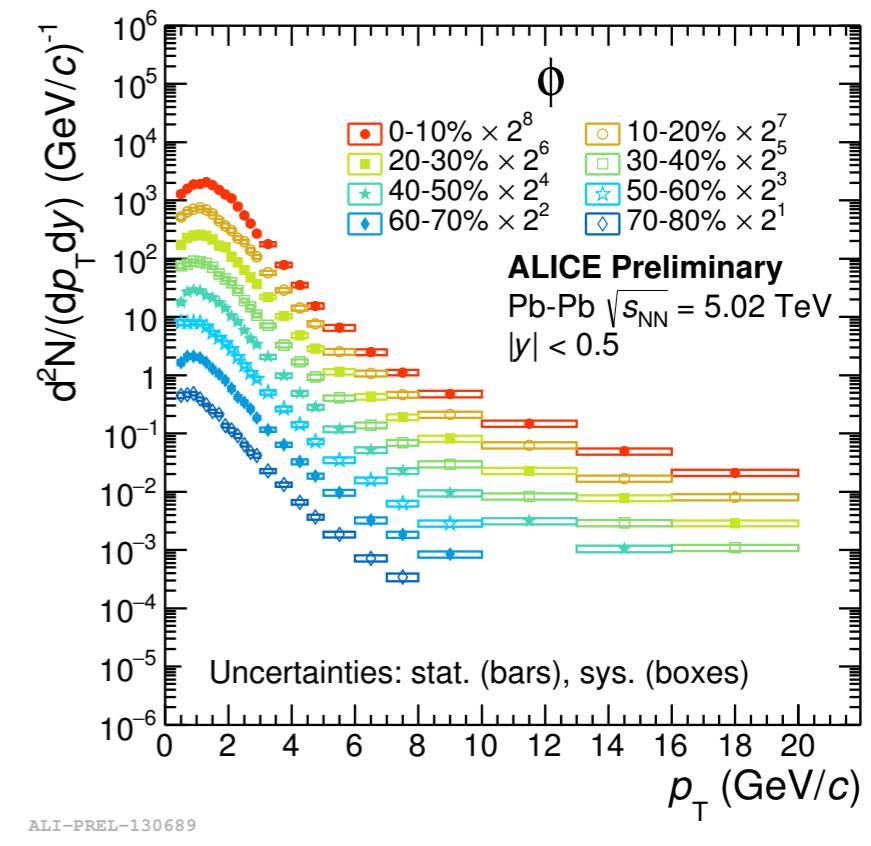
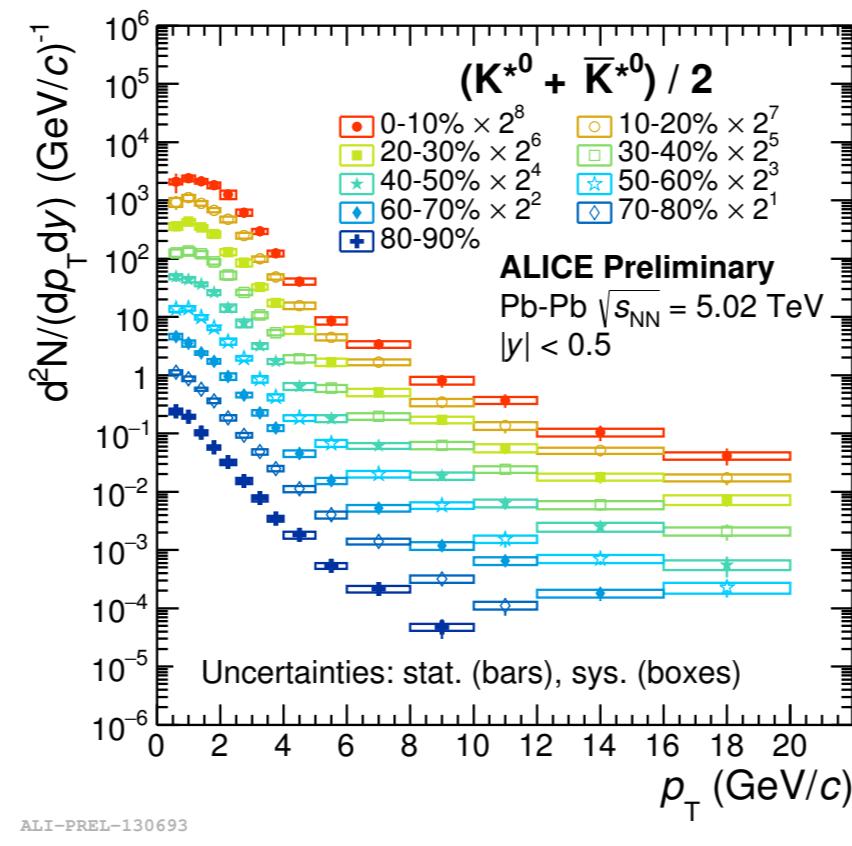
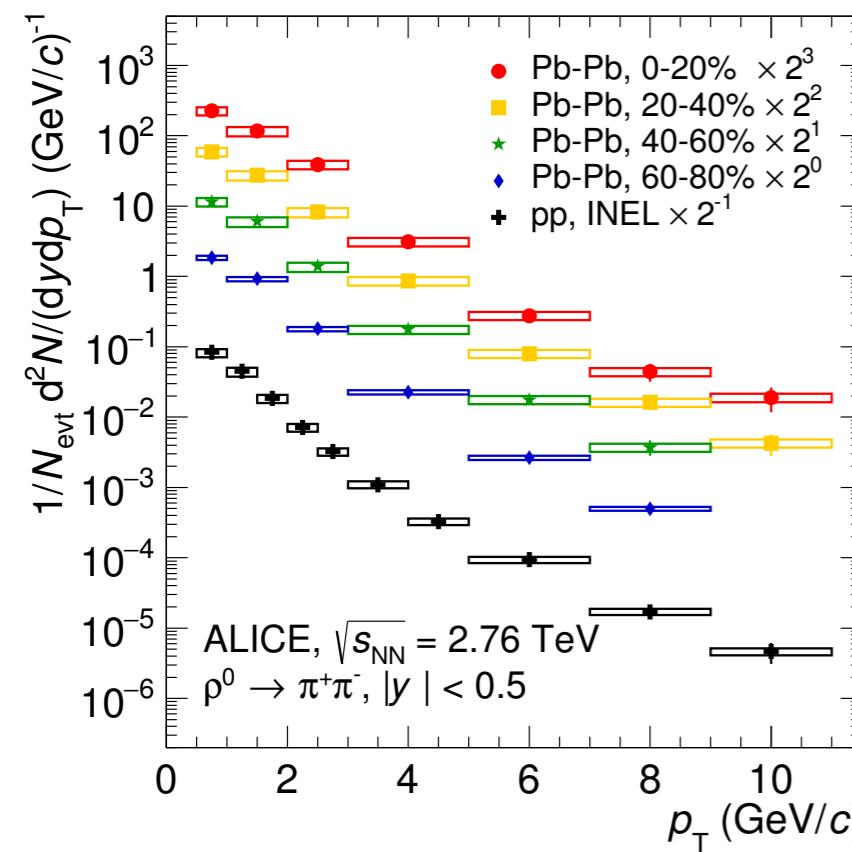


$\Xi/\phi: (|S|=2)/(|S|=0)$



- Ratio ϕ/π
 - large systems: described by thermal model
 - small systems: increase with multiplicity
- Ratios ϕ/K and Ξ/ϕ fairly flat across wide multiplicity range
 - The ϕ has “effective strangeness” of 1-2 units

Resonances p_T -spectra in Pb-Pb



ALI-PUB-161346

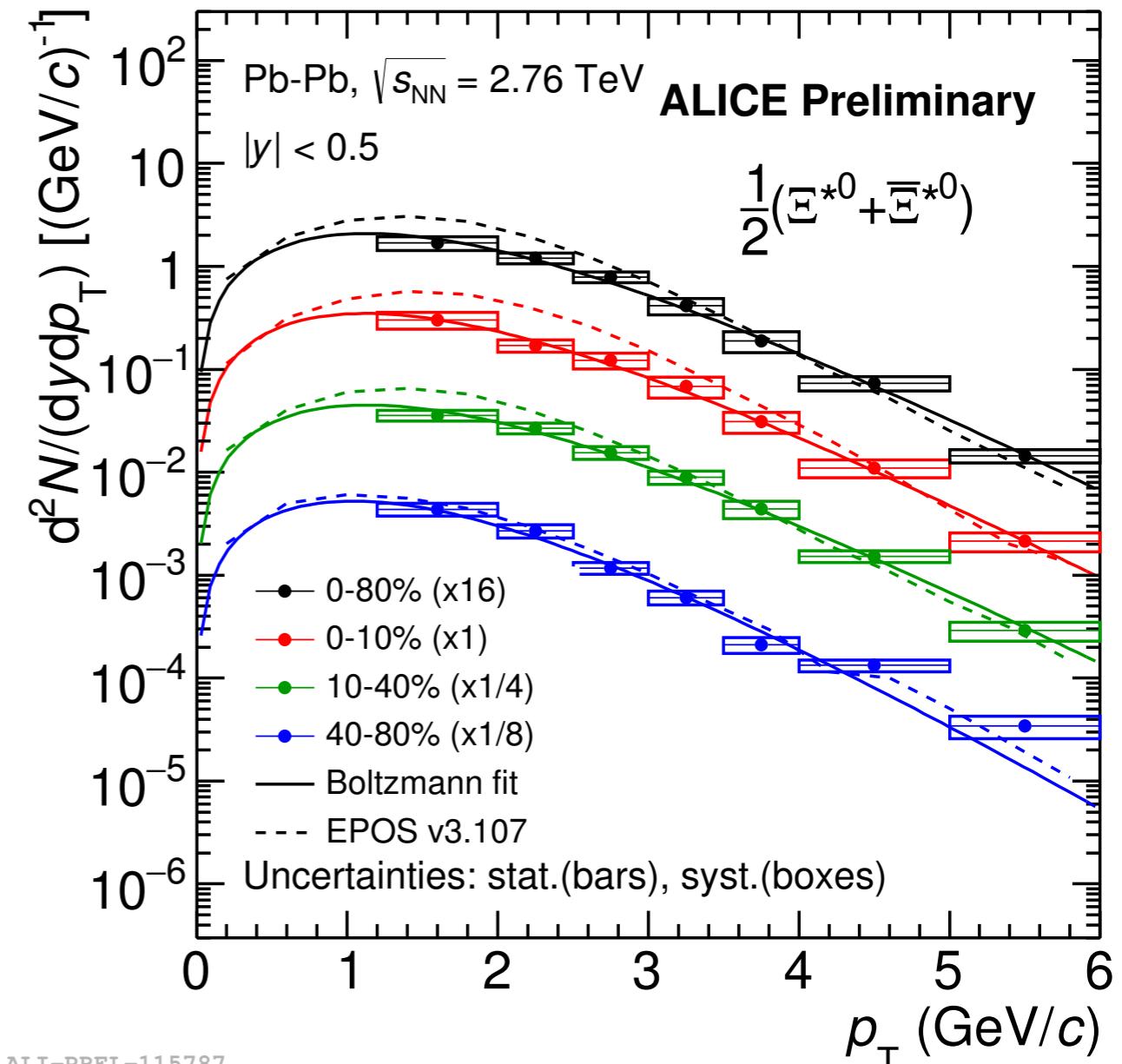
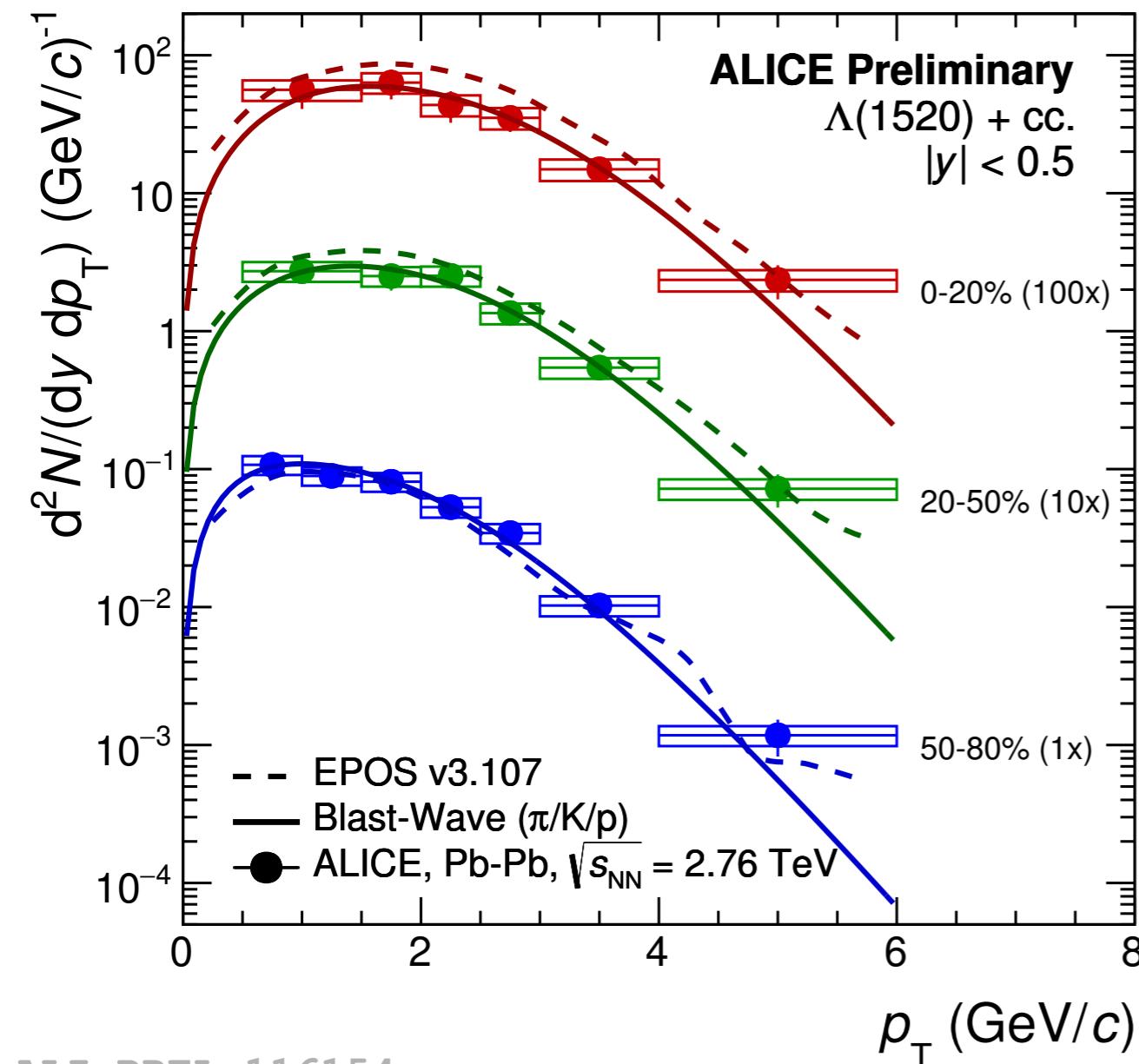
<https://arxiv.org/abs/1805.04365>

Lifetime(fm/c): $\tau_\rho(1.3) < \tau_{K^*}(4.2) < \tau_{\Lambda^*}(12.6) < \tau_{\Xi^*}(21.7) < \tau_\Phi(46.2)$

Resonances p_T -spectra in Pb-Pb



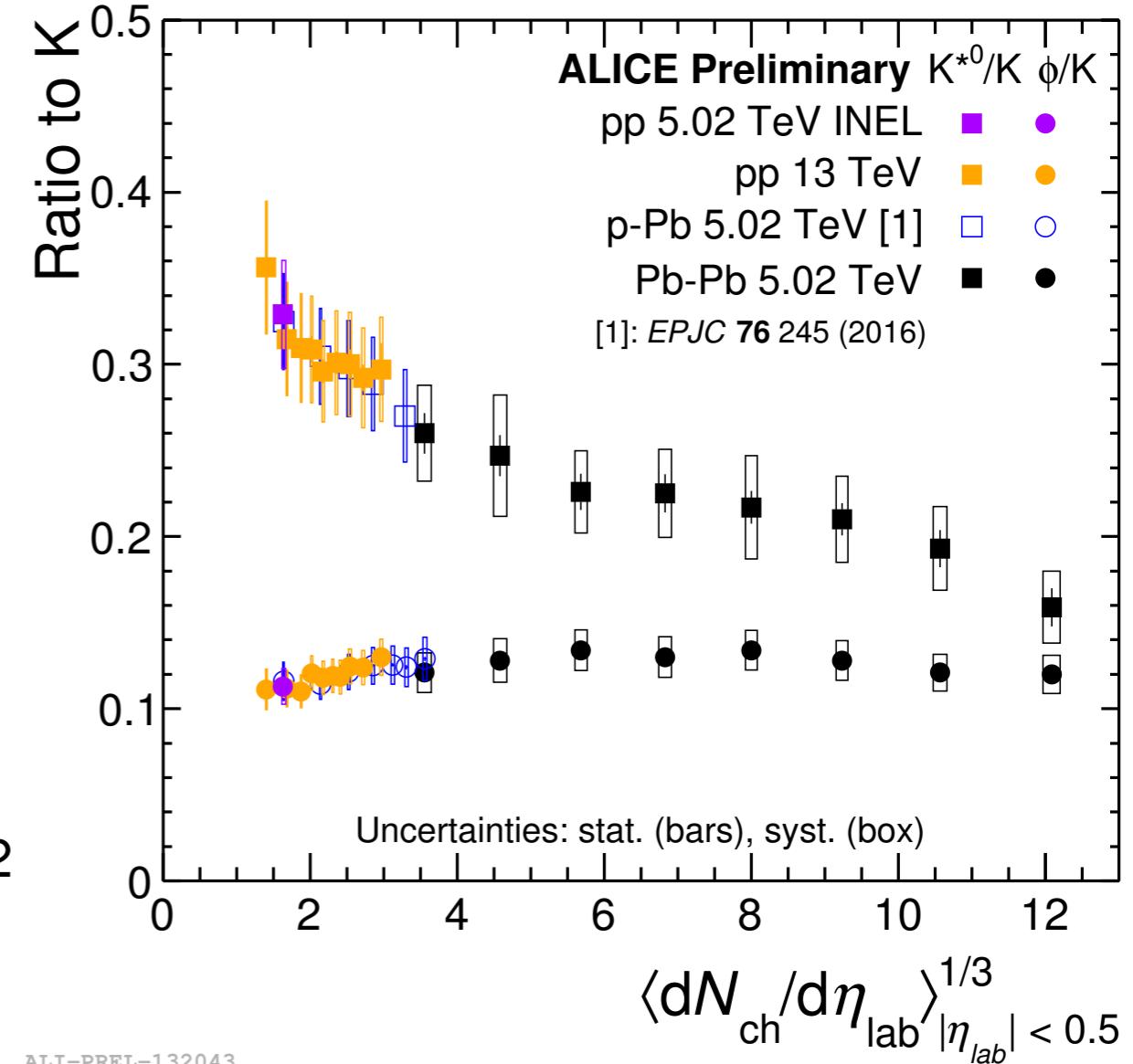
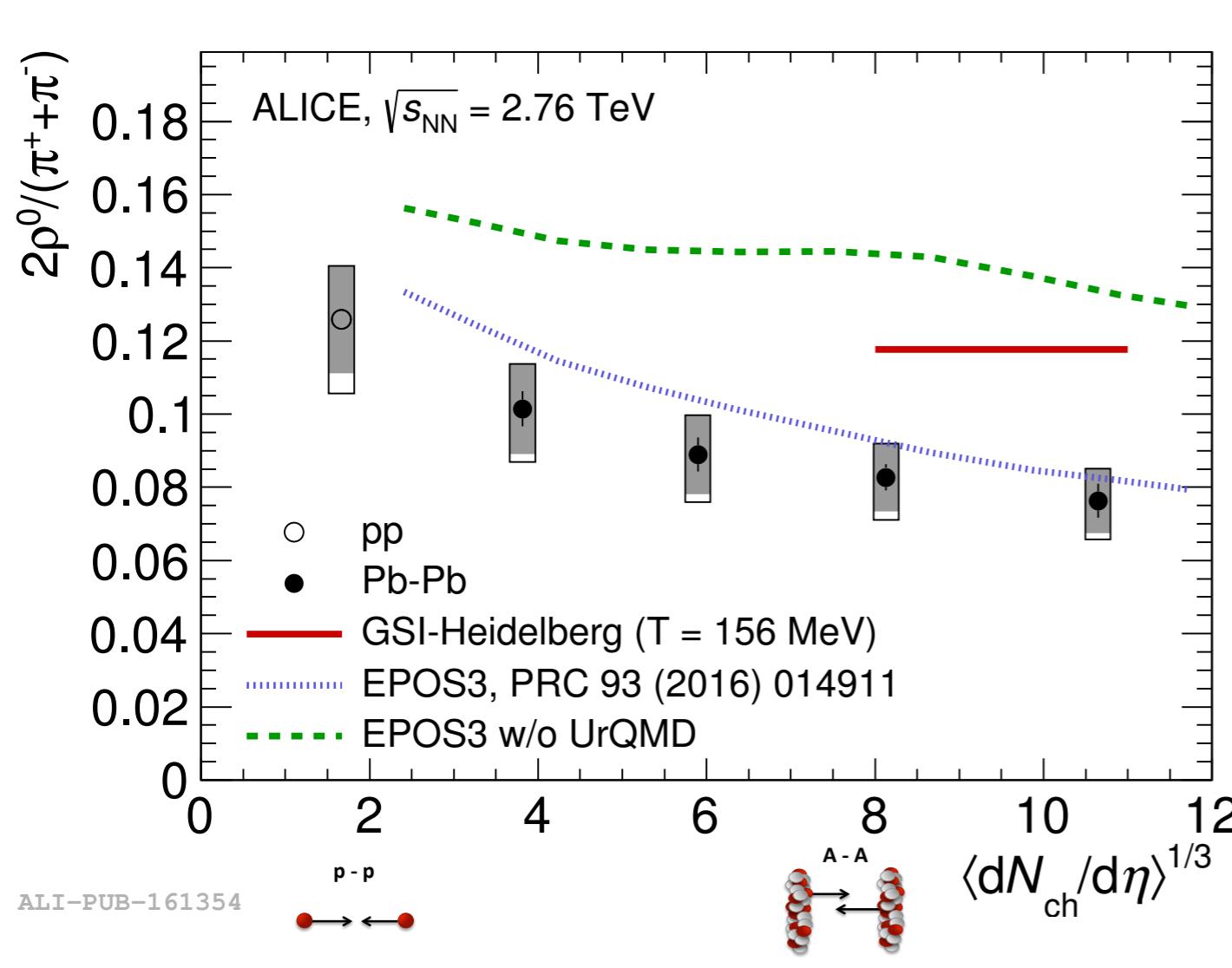
ALICE



<https://arxiv.org/abs/1805.04361>

Lifetime(fm/c): $\tau_\rho(1.3) < \tau_{K^*}(4.2) < \tau_{\Lambda^*}(12.6) < \tau_{\Xi^*}(21.7) < \tau_\Phi(46.2)$

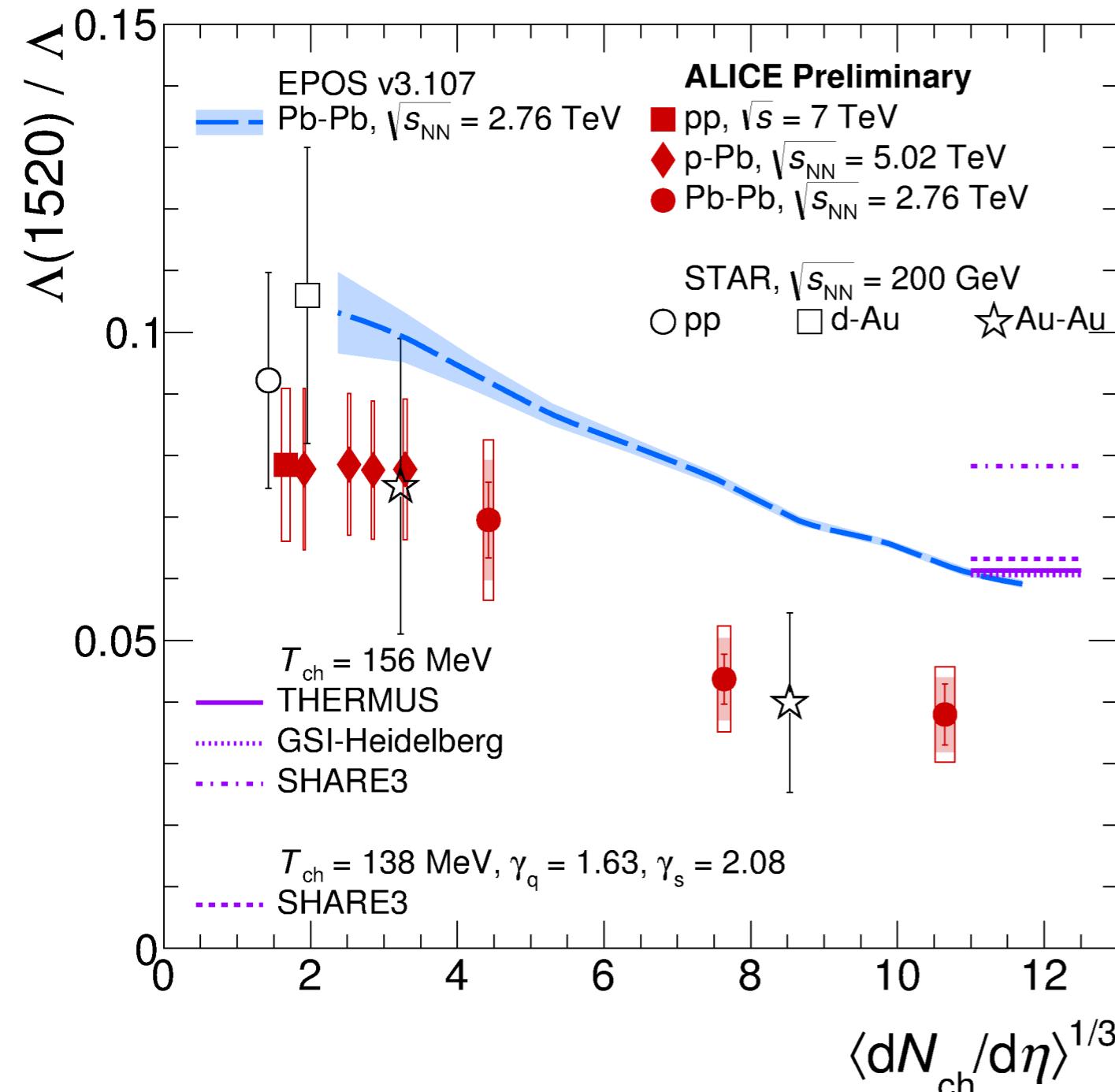
Resonance to long-lived particle ratio



- Suppression of p^0/π and K^*/K ratios in central Pb-Pb w.r.t. smaller system such as peripheral Pb-Pb, p-Pb and pp
- Suggests **re-scattering** is dominant over regeneration for short-lived resonances
- No suppression ϕ/K due to larger lifetime

Lifetime(fm/c): $\tau_p(1.3) < \tau_{K^*}(4.2) < \tau_{\Lambda^*}(12.6) < \tau_{\Xi^*}(21.7) < \tau_\phi(46.2)$

Resonance to long-lived particle ratio

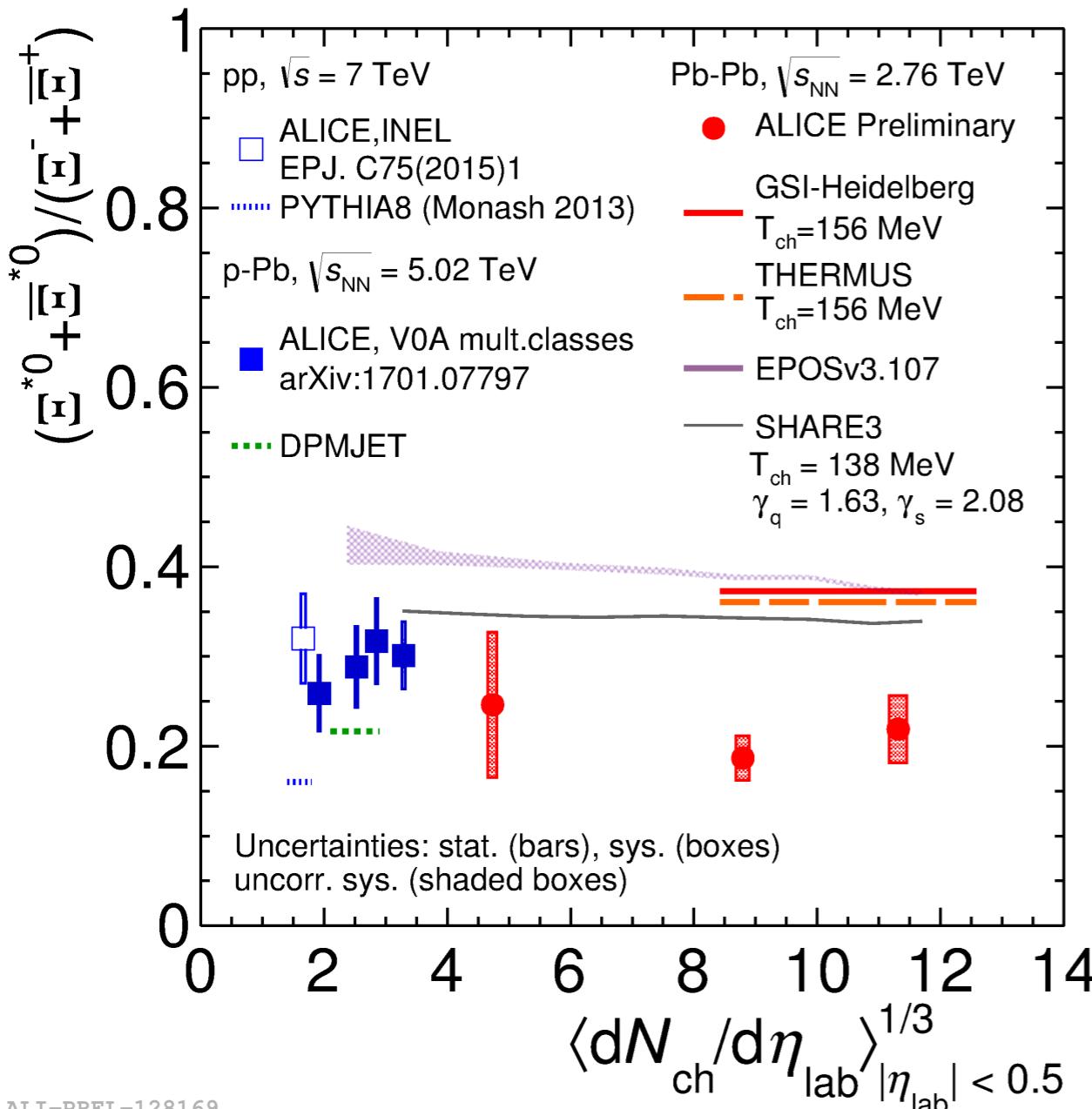


- Suppression of Λ^*/Λ in most central Pb-Pb (0-20%) wrt. pp, p-Pb (d-Au), peripheral Pb-Pb (Au-Au)
- Thermal models overestimate the data in Pb-Pb
- Qualitatively described by EPOS with UrQMD
 - overestimates the ratio

ALI-PREL-129193

Lifetime(fm/c): $\tau_\rho(1.3) < \tau_{\kappa^*}(4.2) < \tau_{\Lambda^*}(12.6) < \tau_{\Xi^*}(21.7) < \tau_\Phi(46.2)$

Resonance to long-lived particle ratio



- Ξ^*/Ξ in **pp** and **p-Pb**
 - No clear multiplicity dependence
 - higher than pQCD-inspired models
- In **Pb-Pb**
 - No significant centrality dependence
 - lower in (semi-)central Pb-Pb than pp and p-Pb
 - lower than thermal model predictions
 - possible weak suppression

Lifetime(fm/c): $\tau_\rho(1.3) < \tau_{K^*}(4.2) < \tau_{\Lambda^*}(12.6) < \tau_{\Xi^*}(21.7) < \tau_\Phi(46.2)$

Summary

- ALICE has measured comprehensive set of identified particles
- We presented latest results on **multiplicity-dependent strangeness** production in all the available colliding systems at the top LHC energy
 - **smooth enhancement** has been observed with multiplicity
 - the enhancement increases with **strangeness content**
 - at similar multiplicity, no dependence with system nor energy is observed
 - ϕ has **effective strangeness of 1-2 units**
- Measurements of mesonic and baryonic **resonances** were presented
 - **suppression of short-lived resonances**, ρ^0 , K^{*0} , Λ^{*0} , has been observed in most central collisions w.r.t. small collision systems
 - **re-scattering is dominant over regeneration**
 - there is **no suppression of long-lived resonances**, ϕ