Hadrochemistry of Particle Production in Small Systems with ALICE at the LHC

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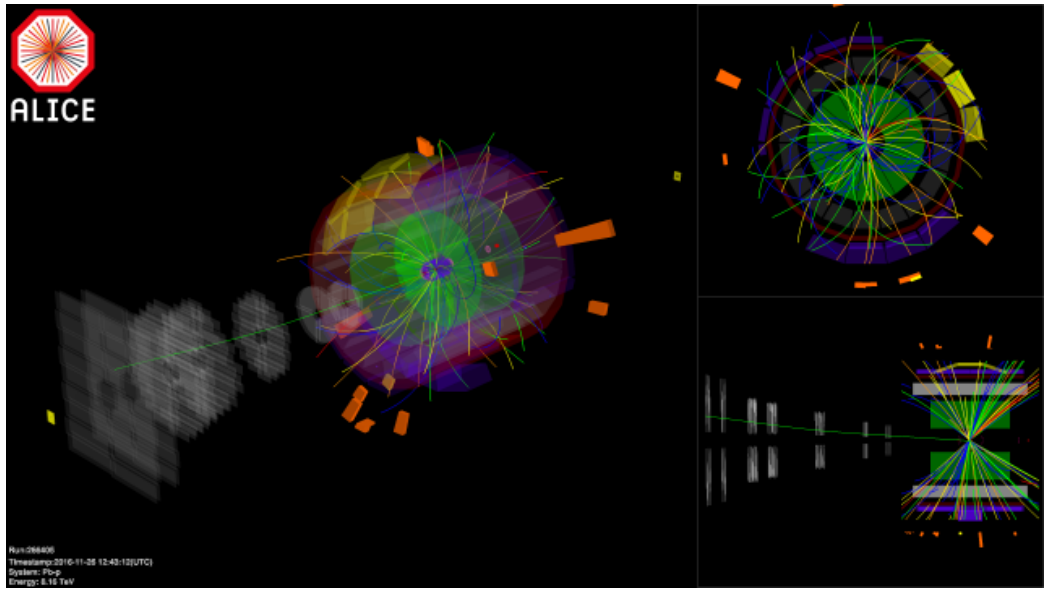
for the ALICE collaboration
11/06/2019

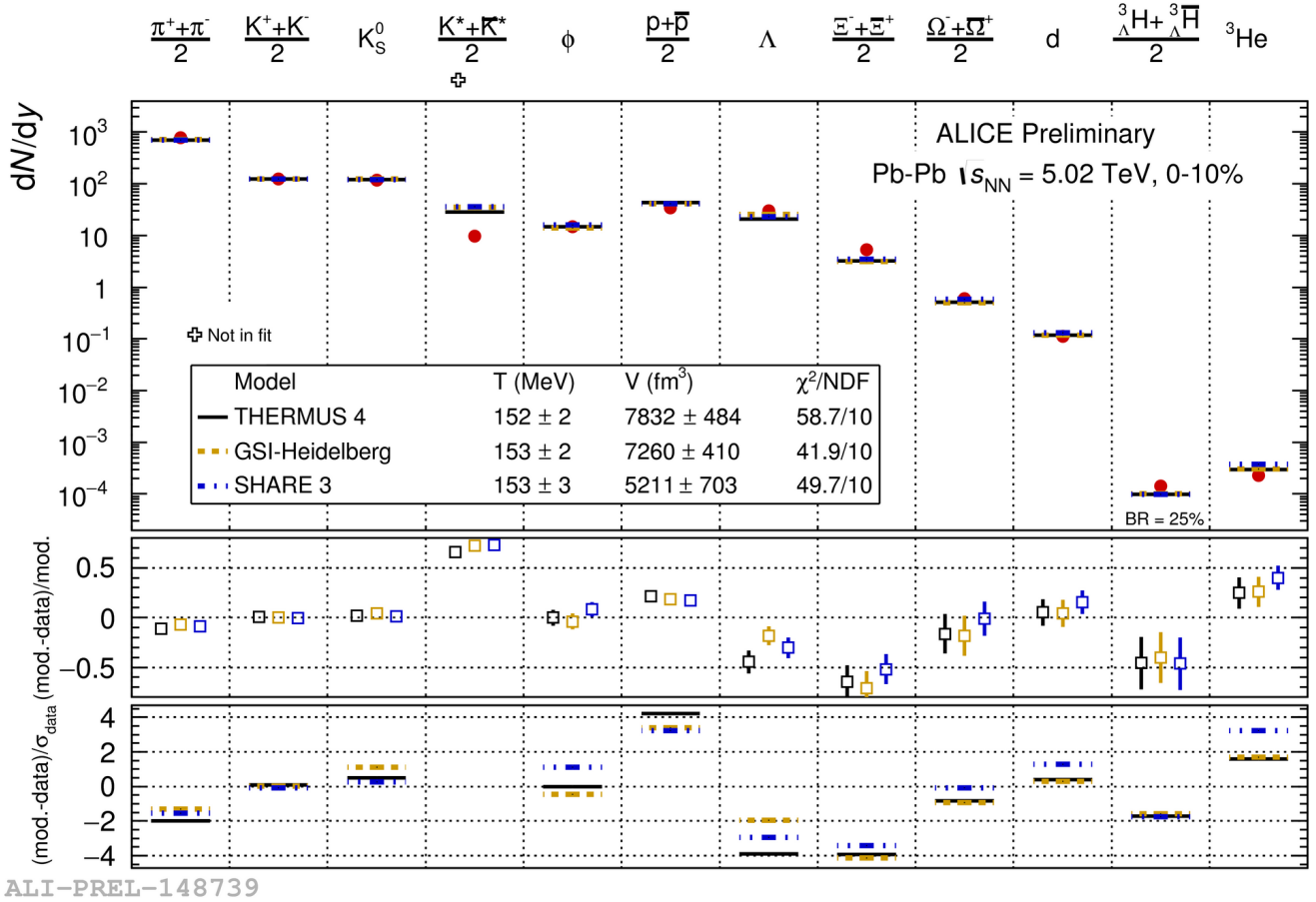
Outline

- Hadrochemistry
- Detecting Strange Particles with ALICE
- Results in Small Systems
- New Results from p-Pb collisions at 8.16 TeV



Hadrochemistry

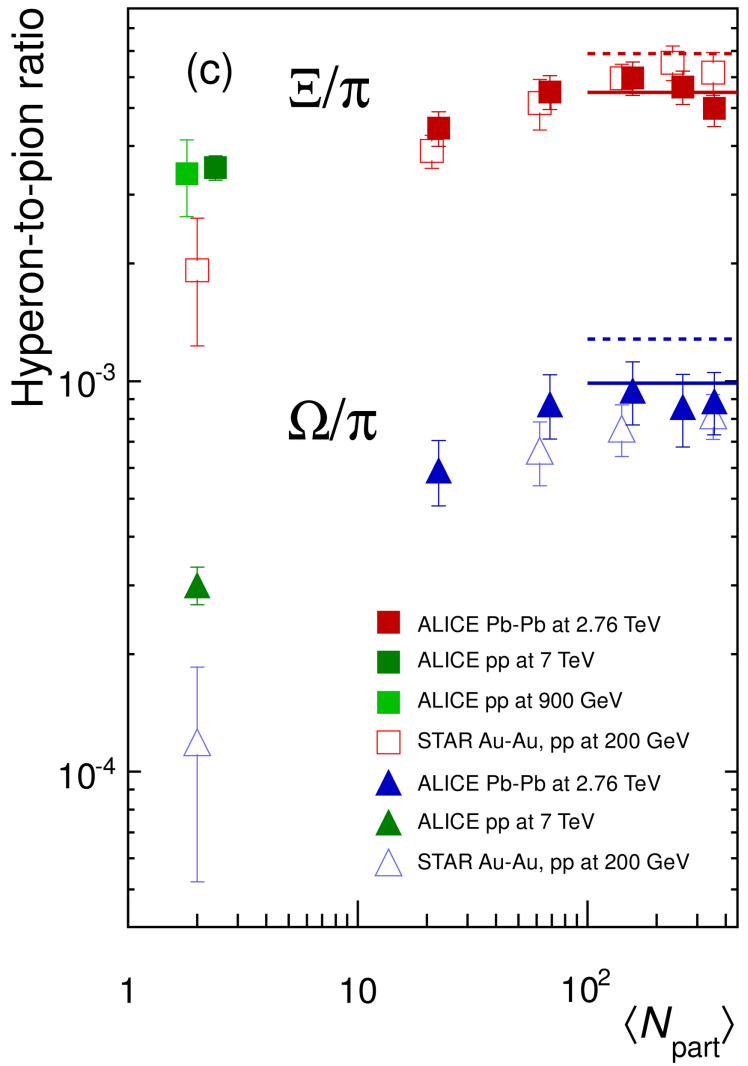
- Hadrochemistry: A measurement of relative abundances of different particle species
- Yields described by statistical-thermal models with common chemical freeze-out temperature, T ~ 153 MeV



Hadrochemistry

- Hadrochemistry: A measurement of relative abundances of different particle species
- Yields described by statistical-thermal models with common chemical freeze-out temperature, T ~ 153 MeV
- Enhanced yields of strange particles was one of the earliest proposed signatures of QGP formation

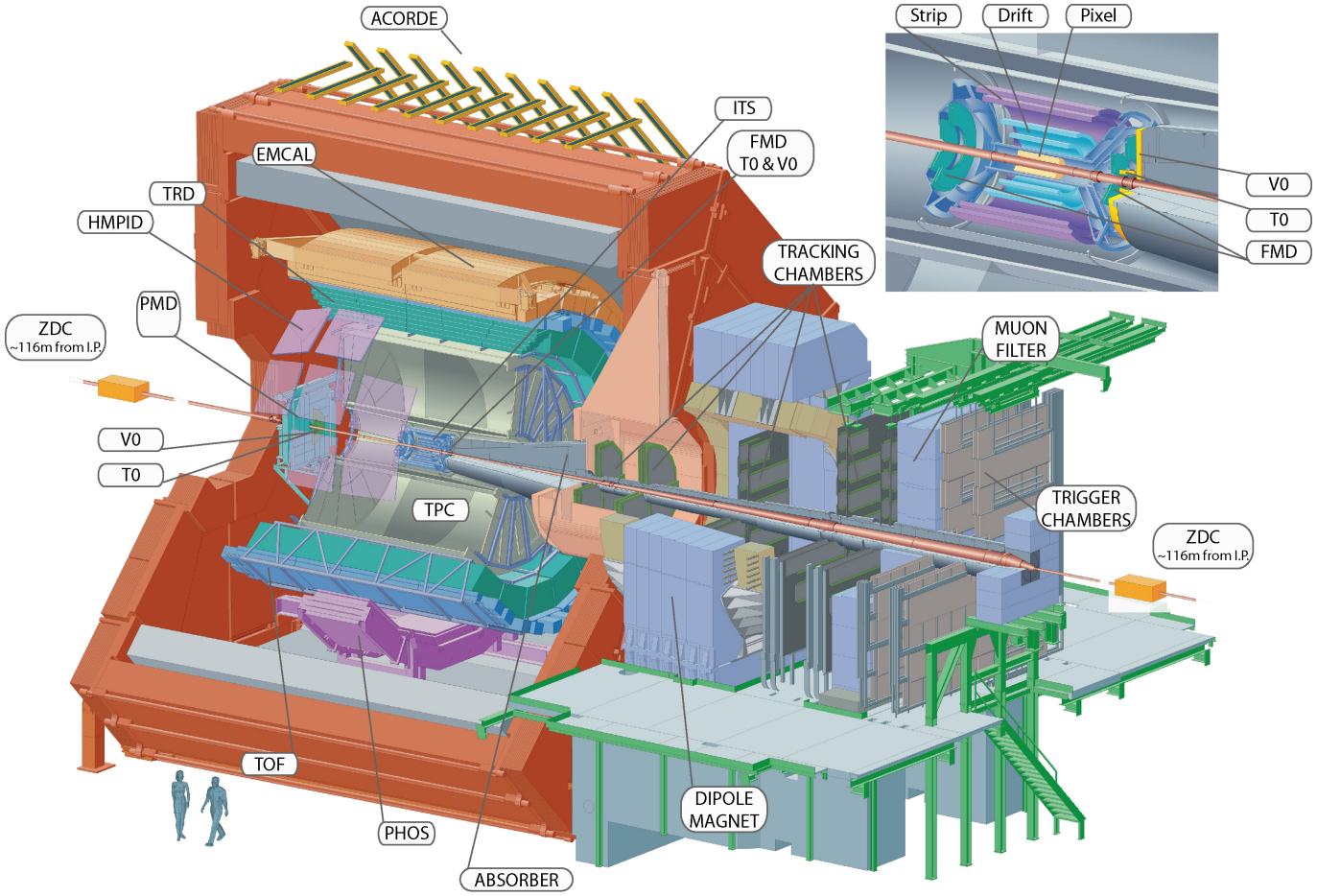
  J. Rafelski and B. Müller, PRL 48, 1066 (1982)
- In ALICE, strange particle yields in A-A collisions with respect to non-strange particles higher than in pp



Phys. Lett. B 728 (2014) 216–227

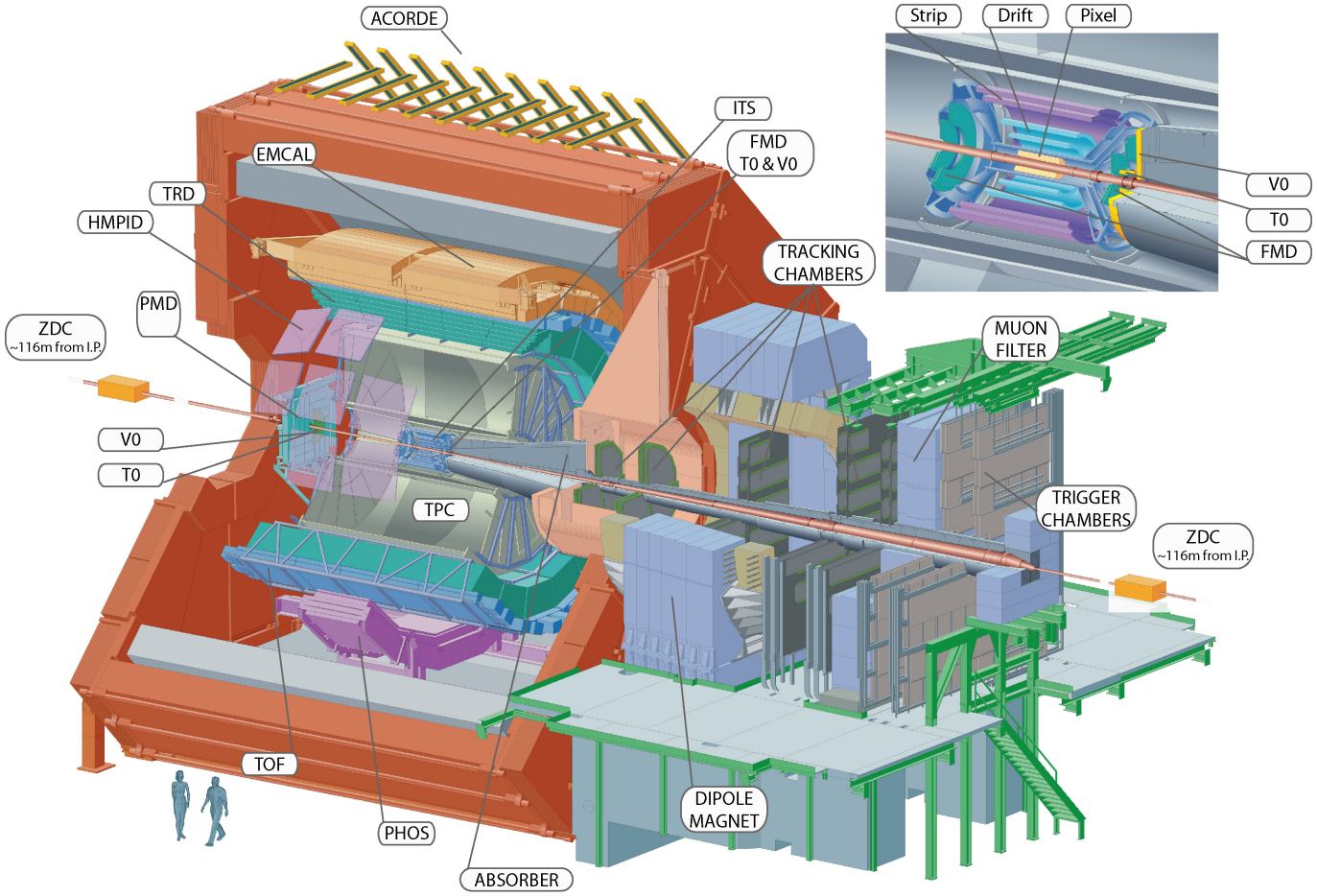
Detecting Strange Particles in ALICE

ALICE



- A Large Ion Colliding Experiment
- Detectors used in this analysis are:

ALICE



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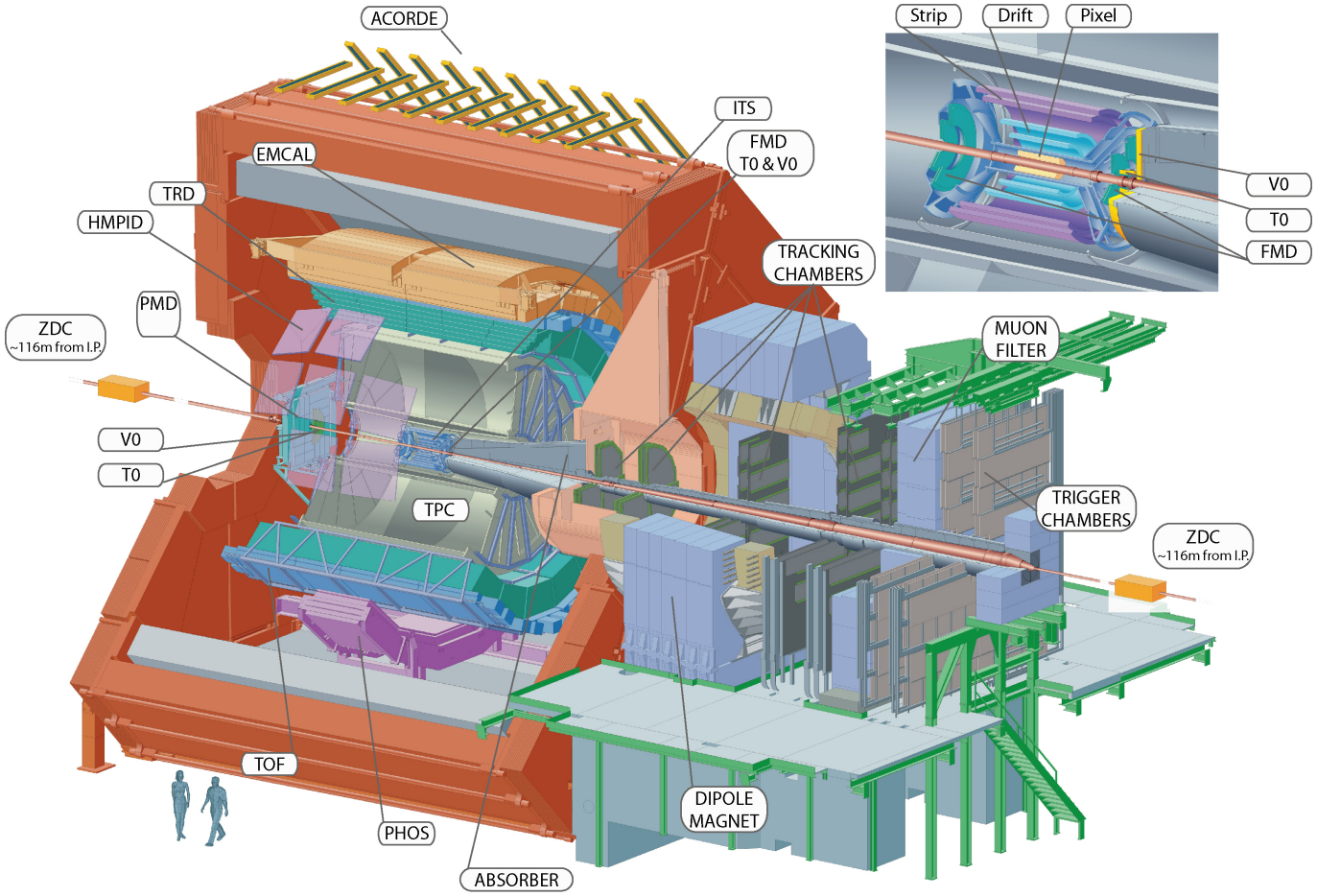
- Detectors used in this analysis are:
- ITS ($|\eta|$<0.9)
  - 6 layers of silicon detectors
  - Used for trigger, tracking, vertexing, PID (dE/dx)

ALICE



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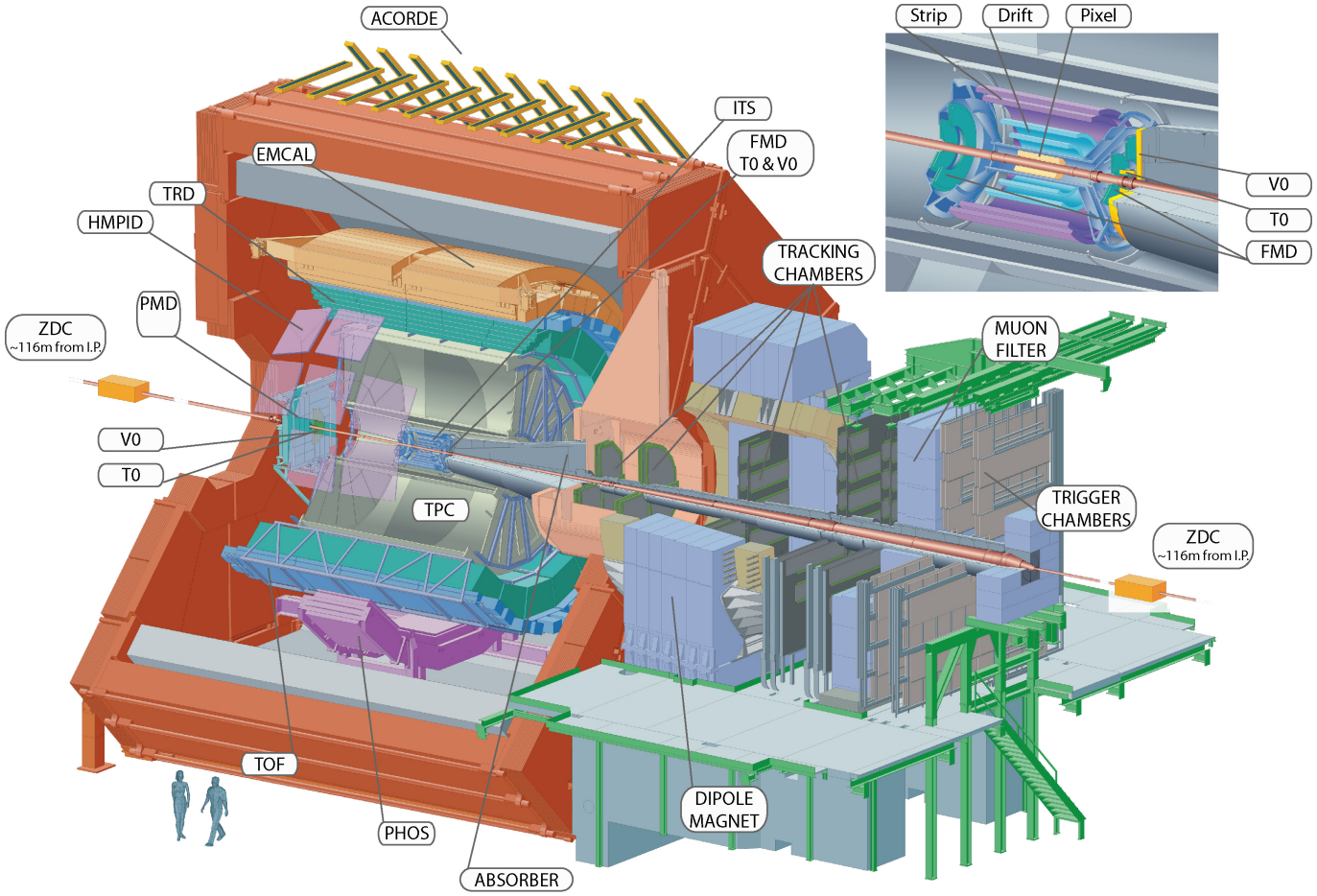
ALICE



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- TPC ($|\eta|<0.9$)
  - Gas-filled ionisation chamber
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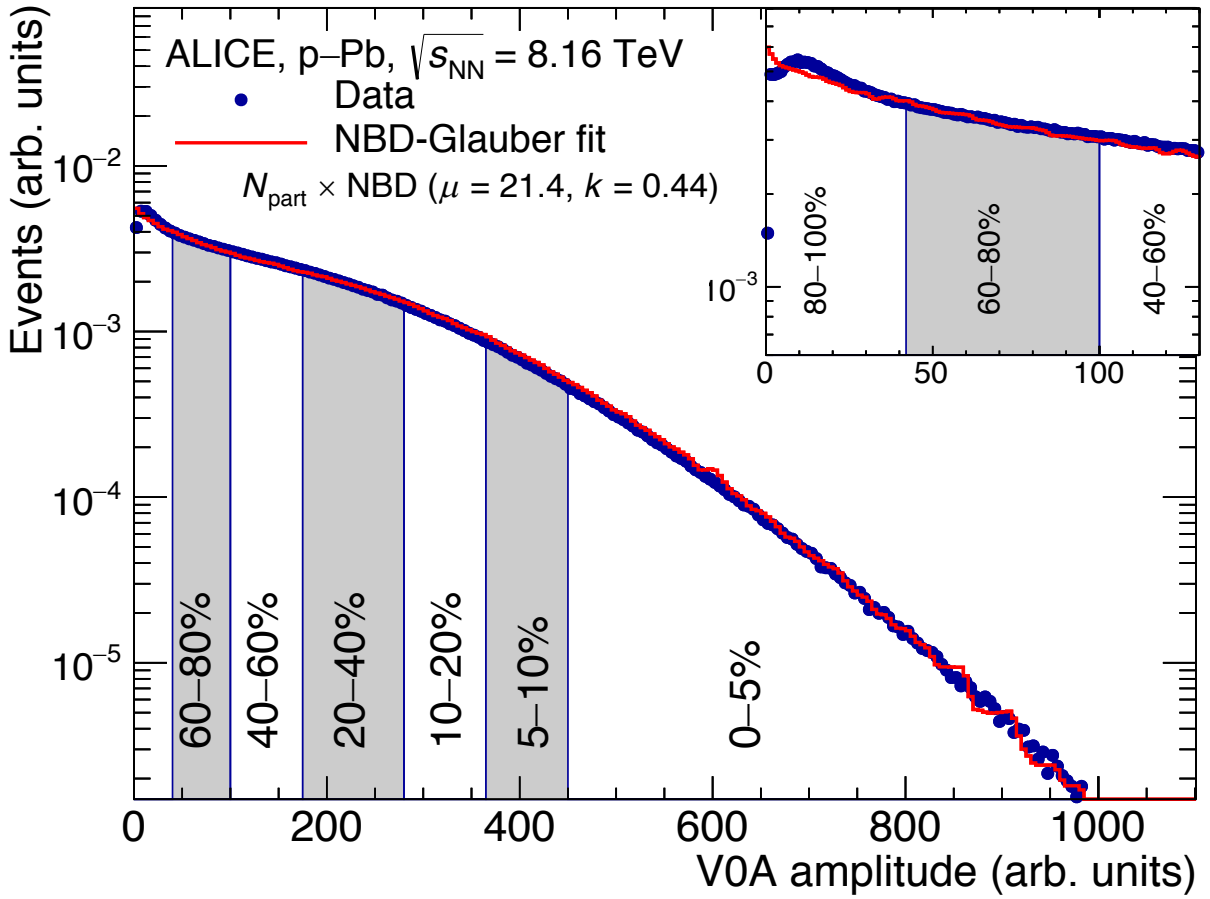
- V0A ($2.8< \eta <5.1$ Pb-going direction)
  - Forward scintillator arrays
  - Used for trigger and multiplicity estimation

Multiplicity Estimation

- Multiplicity can be defined as the number of charged particles per event
- Event activity is measured by ALICE at forward rapidity by V0A detector
- Multiplicity classes defined as percentile intervals of cross-section



Eur. Phys. J. C (2019) 79-307

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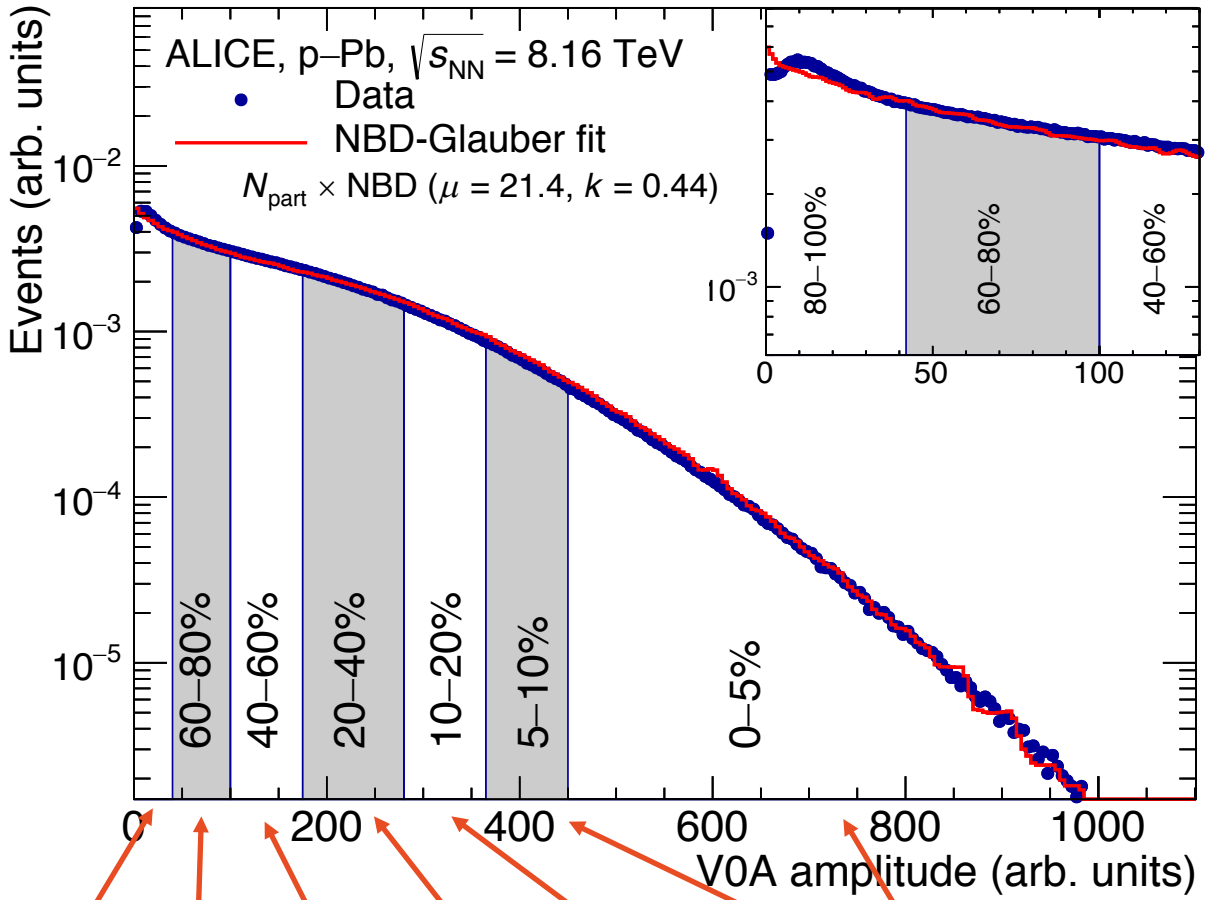

$<\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta>_{\eta<0.5}$:

4.47 ±0.14	10.97 ±0.29	18.39 ±0.48	26.89 ±0.7	35.49 ±0.92	42.40 ±1.1	53.22 ±1.38

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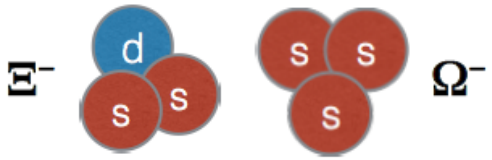
Signal Extraction

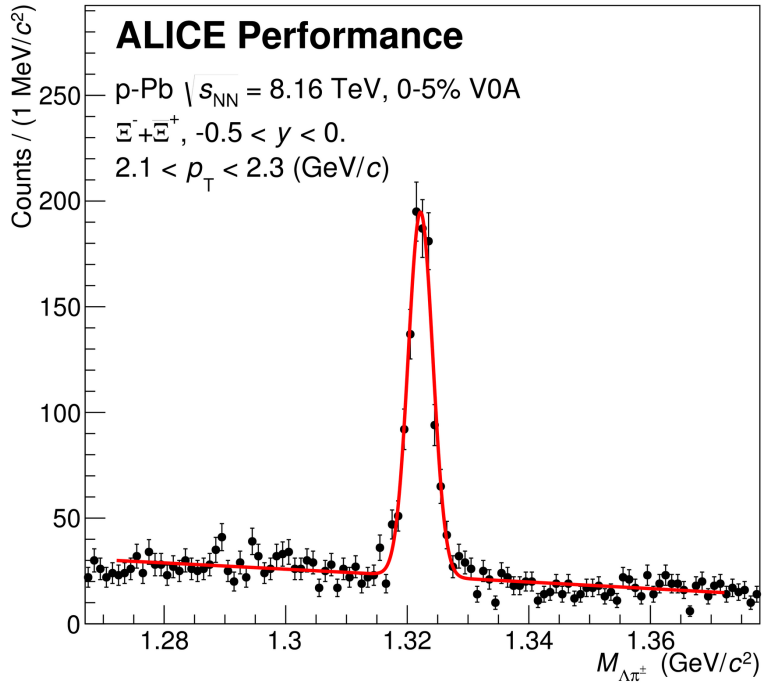
- Detect strange particles from the topology of their weak decays
- Plot invariant mass in p_{T} and multiplicity bins and extract yields

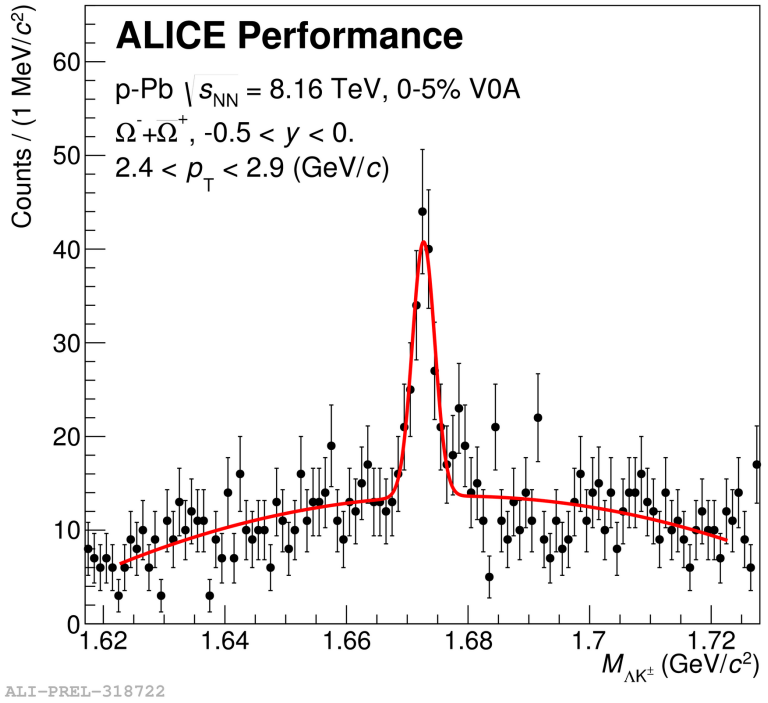


$\boldsymbol{\Xi^- \rightarrow \Lambda\pi^-}$ **BR: 99.9%**

$\boldsymbol{\Omega^- \rightarrow \Lambda K^-}$ **BR: 67.8%**

$\Lambda \rightarrow p\pi^-$ BR: 63.9%

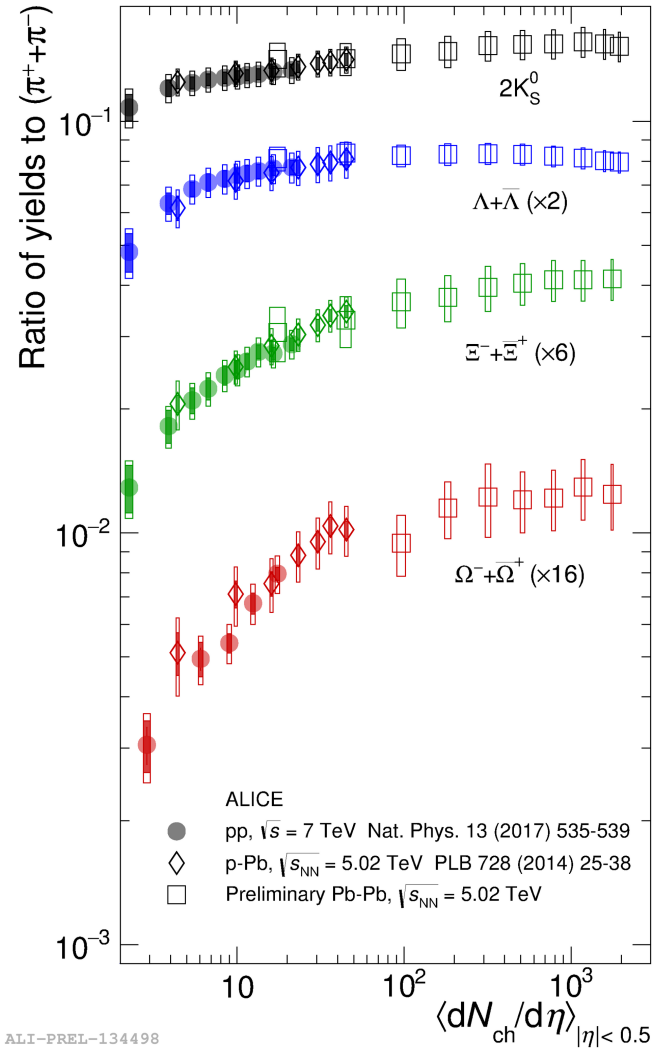




Results from Small Systems

Strangeness Enhancement in Small Systems

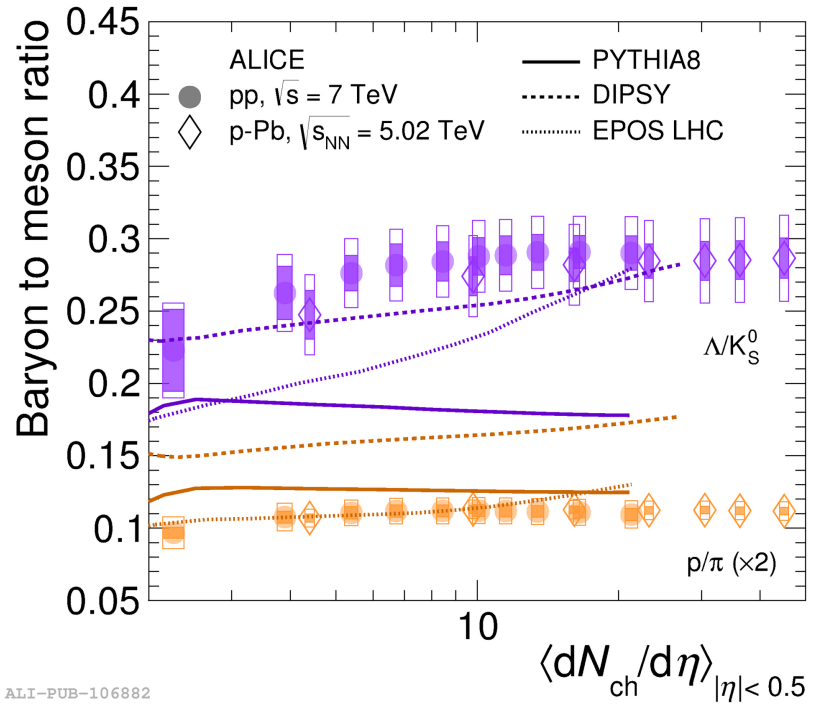
- Enhancement of ratio of strange particle yields to pions observed in small collision systems (pp and p-Pb)
- Significant enhancement in pp with $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$
- pp and p-Pb in strong agreement at same $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$
- Smooth evolution from low $\mathrm{d}N_{\mathrm{ch}}$ pp to high $\mathrm{d}N_{\mathrm{ch}}$ p-Pb which reaches levels in Pb-Pb

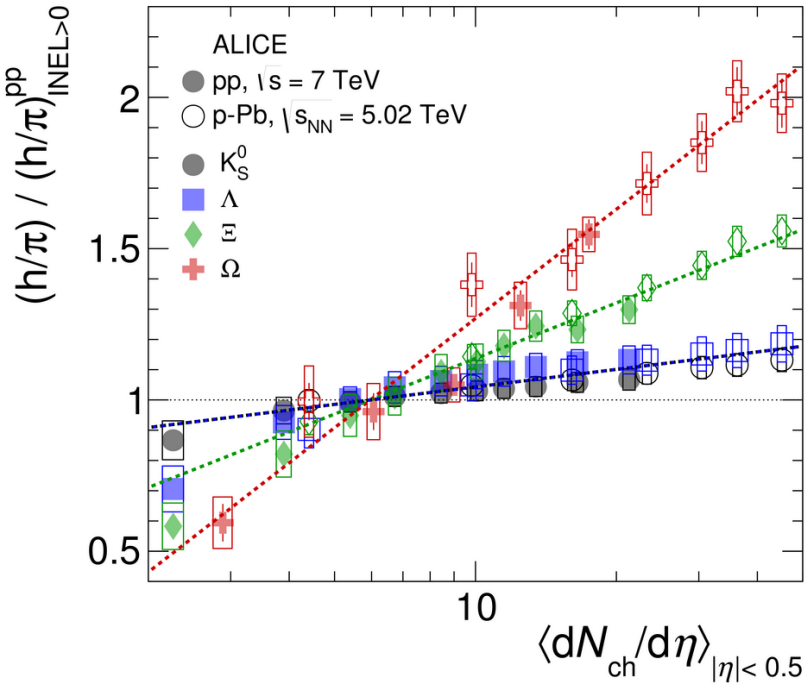


Nat. Phys. 13, (2017) 535–539
PLB 728 (2014) 25-38
Phys. Rev. C 99 (2019) 024906

Strangeness Enhancement in Small Systems

- Plot Baryon to Meson ratio
  - Observed enhancement is related to strangeness not mass
- Plot $(h/\pi)/(h/\pi)^{pp}_{INEL>0}$
  - Hierarchy - strength of enhancement depends on strangeness content of baryon





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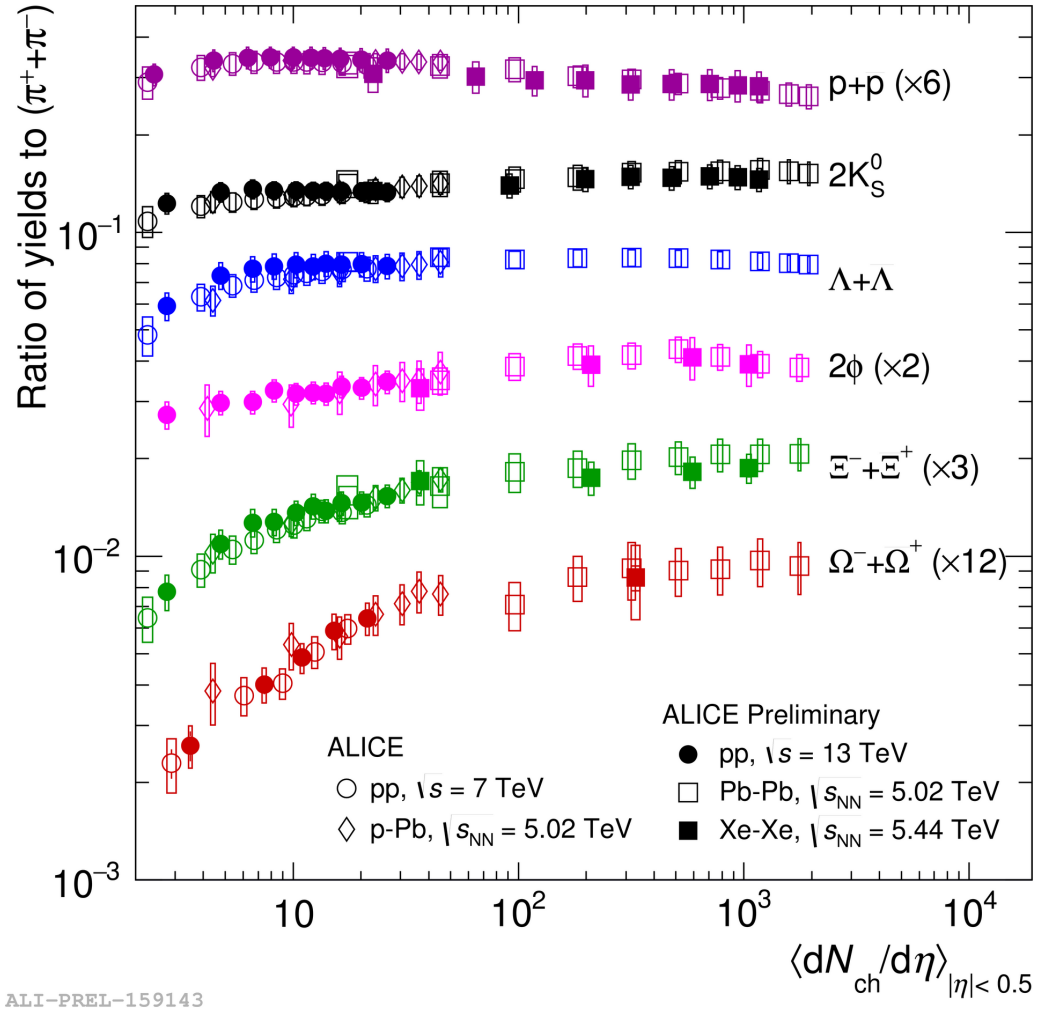
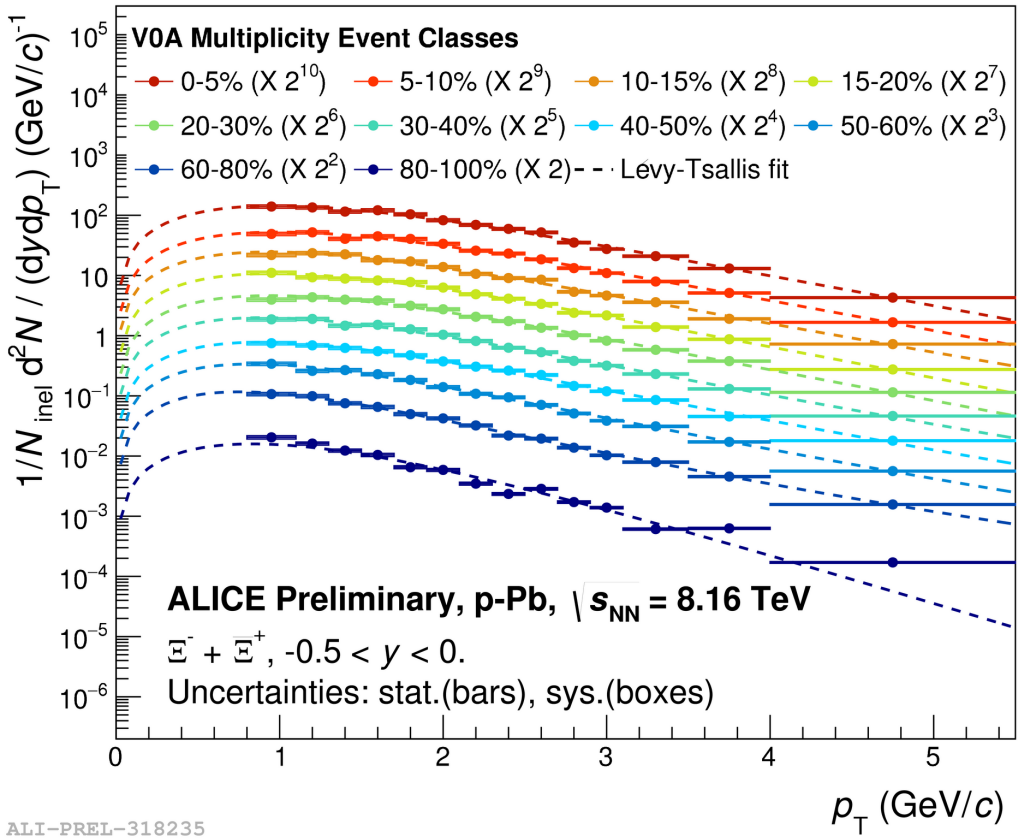
Strangeness Enhancement in Small Systems

- Charged particle multiplicity is biggest driver of strangeness enhancement
- Results consistent for different colliding energies and collision systems measured by ALICE (pp, p-Pb, Pb-Pb, Xe-Xe)
- Strangeness production increases until saturation levels are reached

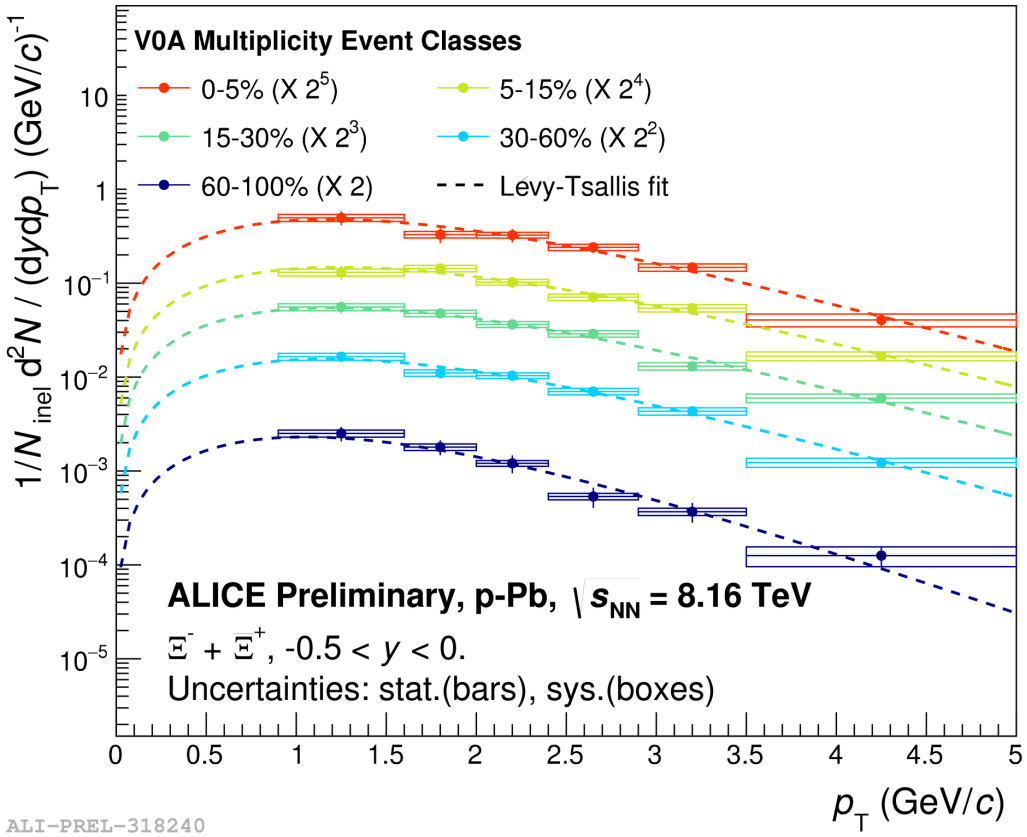


New Results from p-Pb Collisions at 8.16 TeV

p_{T} Spectra



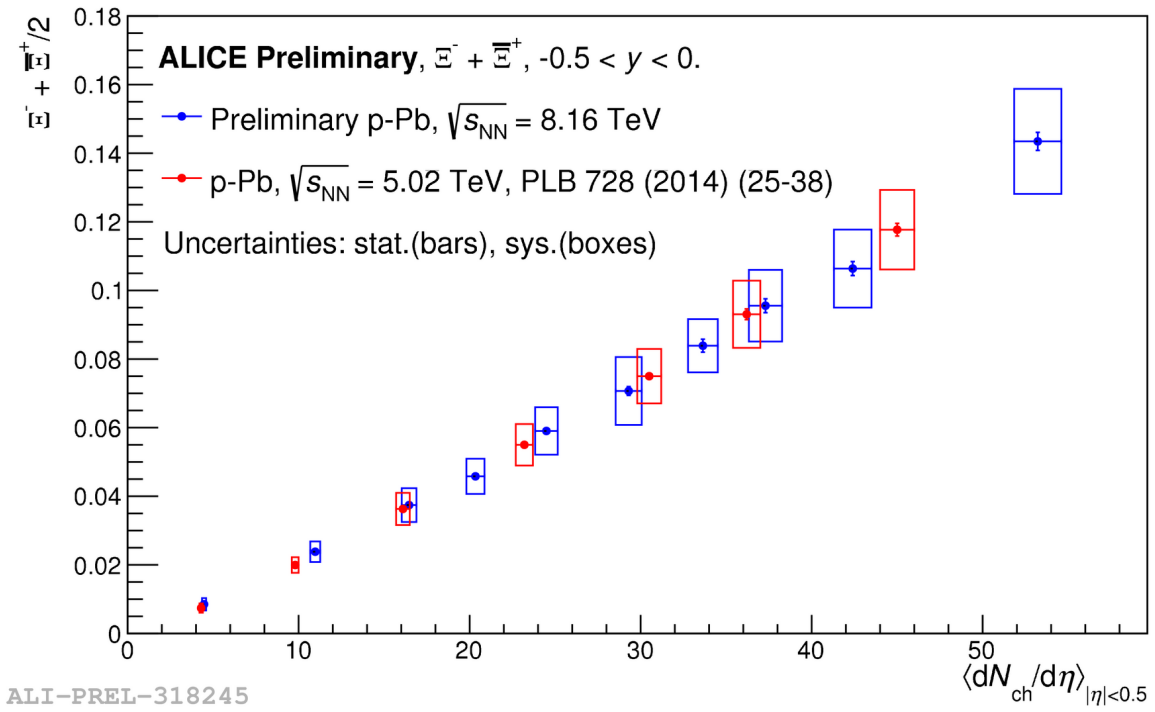
ALI-PREL-318235

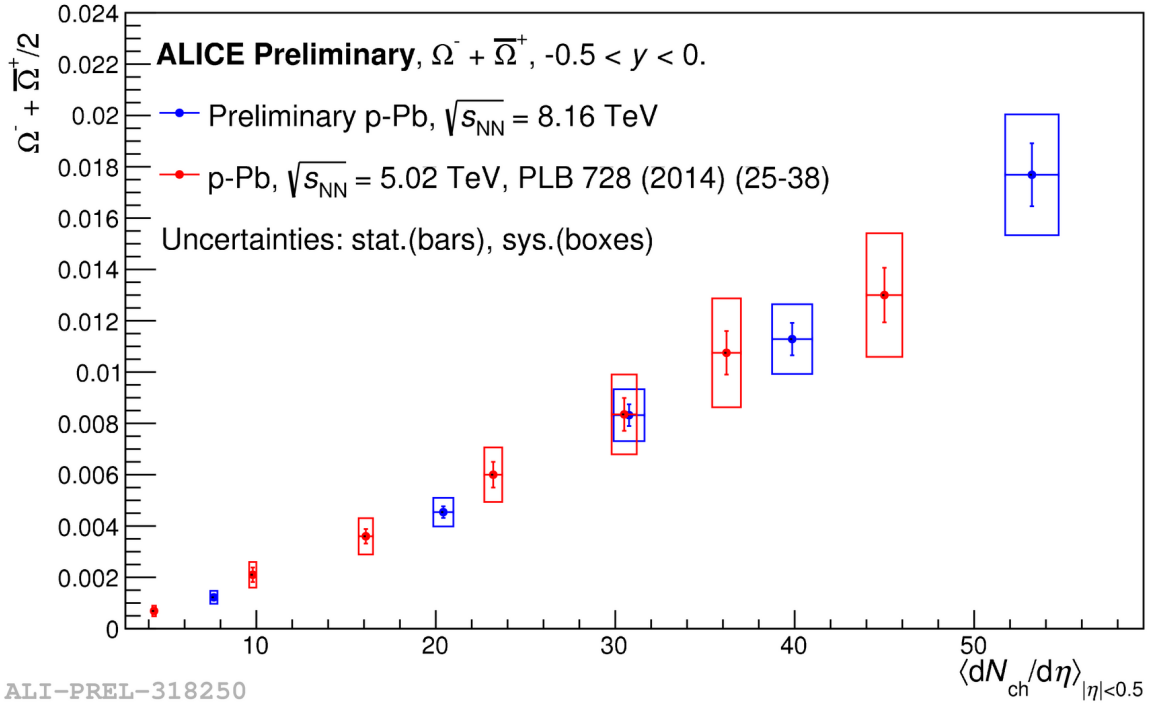


ALI-PREL-318240

- New Results in p-Pb at 8.16 TeV
- Spectra fitted with a Lévy-Tsallis function

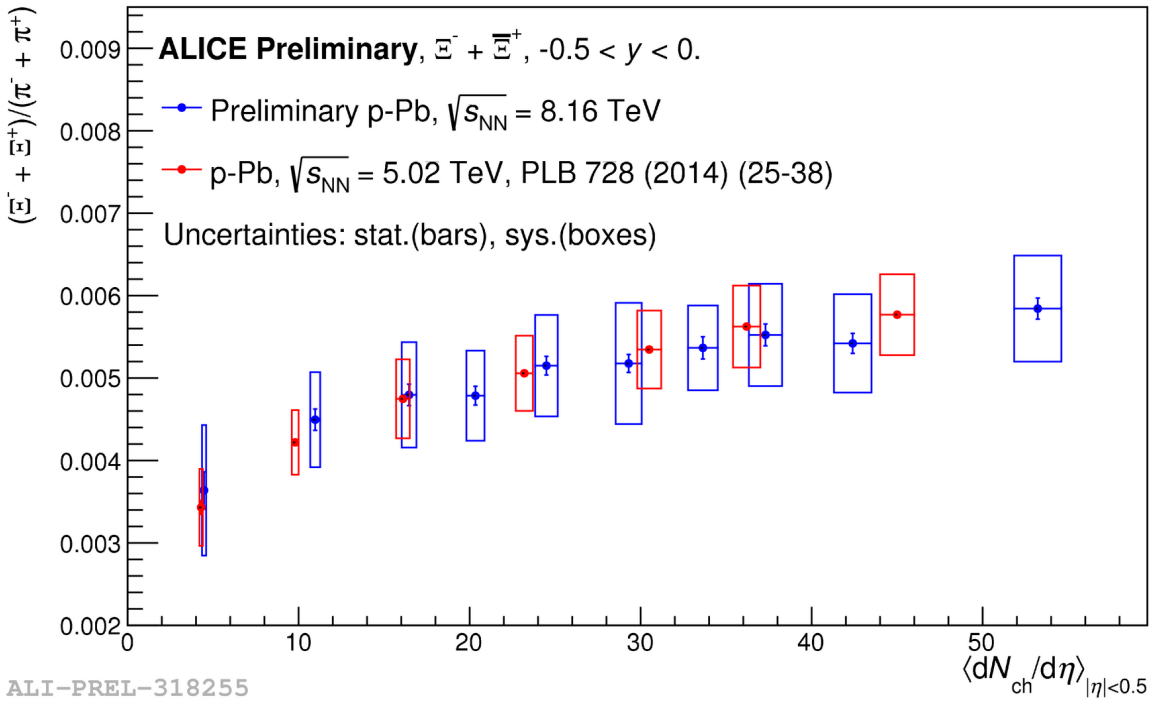
Particle Yields

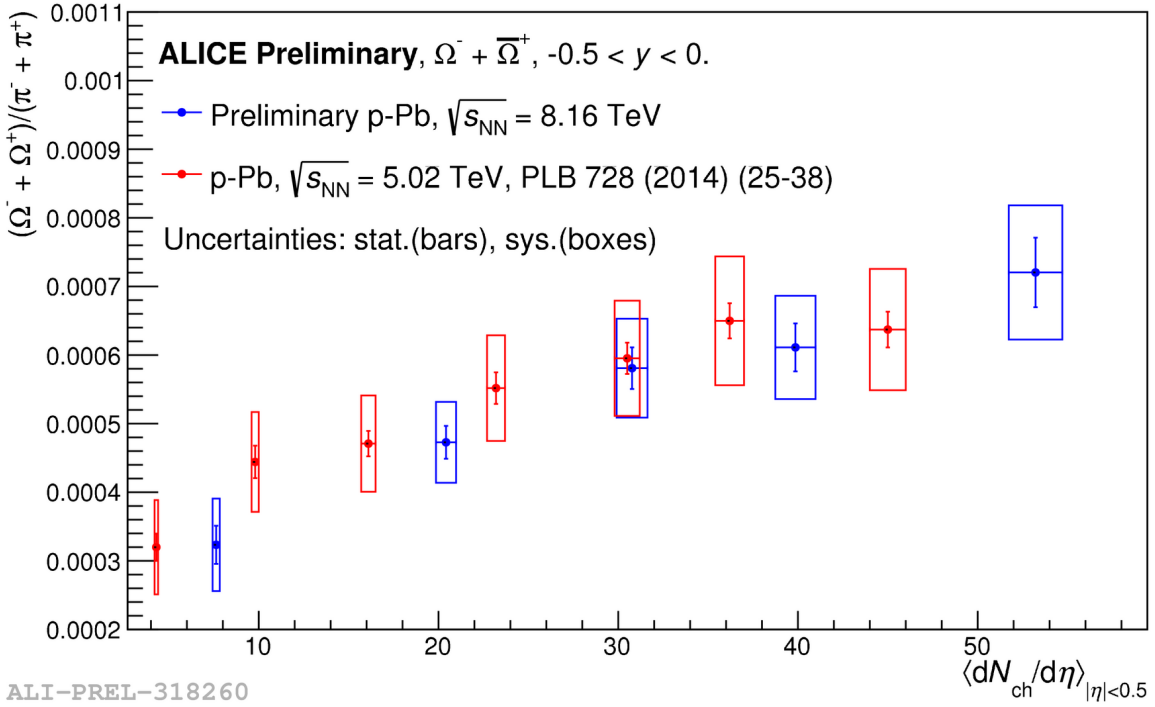




- New Results in p-Pb at 8.16 TeV
- Results in agreement with 5.02 TeV p-Pb results → $dN_{ch}/d\eta$ dependence is independent of collision energy
- Trend increases at higher values of $dN_{ch}/d\eta$

Cascade to Pion Ratios

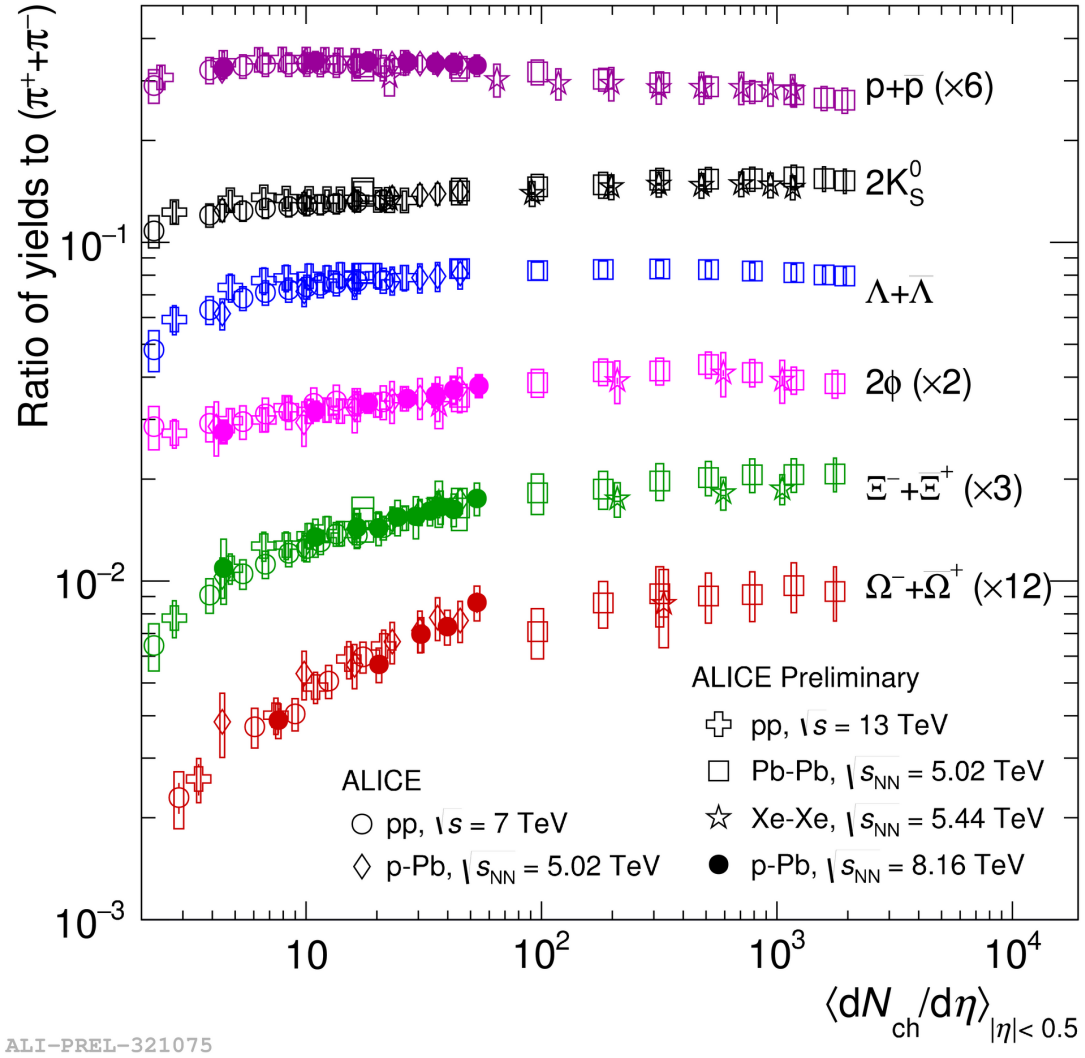




- New Results in p-Pb at 8.16 TeV
- New higher energy results are in agreement with lower energy measurements
- New measurements extend multiplicity reach of p-Pb data

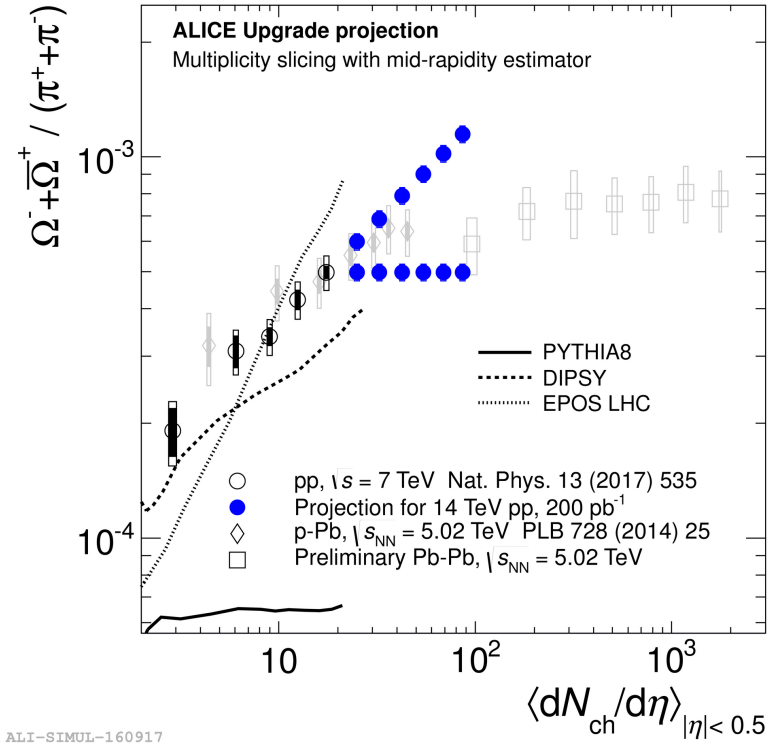
Cascade to Pion Ratios

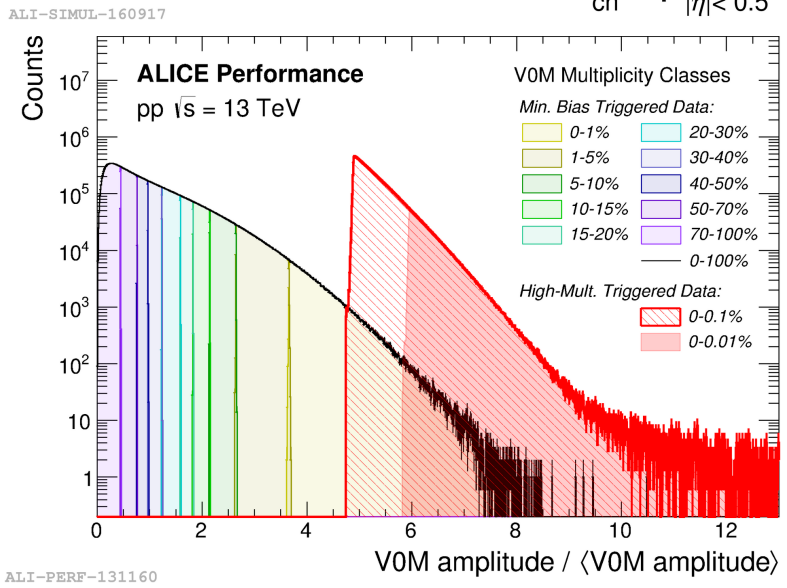
- New Results in p-Pb at 8.16 TeV now included
- New p-Pb results are consistent with the smooth evolution between collision systems



Summary

- ALICE has reported on the study of strange particle production as a function of multiplicity from pp to A-A collisions at the LHC
- New results from p-Pb collisions at 8.16 TeV have been presented
- Cascade to pion ratios show an increase as a function of $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$ across collision systems
- Results are not dependent on collision energy
- Future studies of p-Pb will be extended to higher $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$ using a dedicated high-multiplicity trigger → explore p-Pb/Pb-Pb crossover region
- Run 3+4 measurements will extend pp data into the Pb-Pb region as well

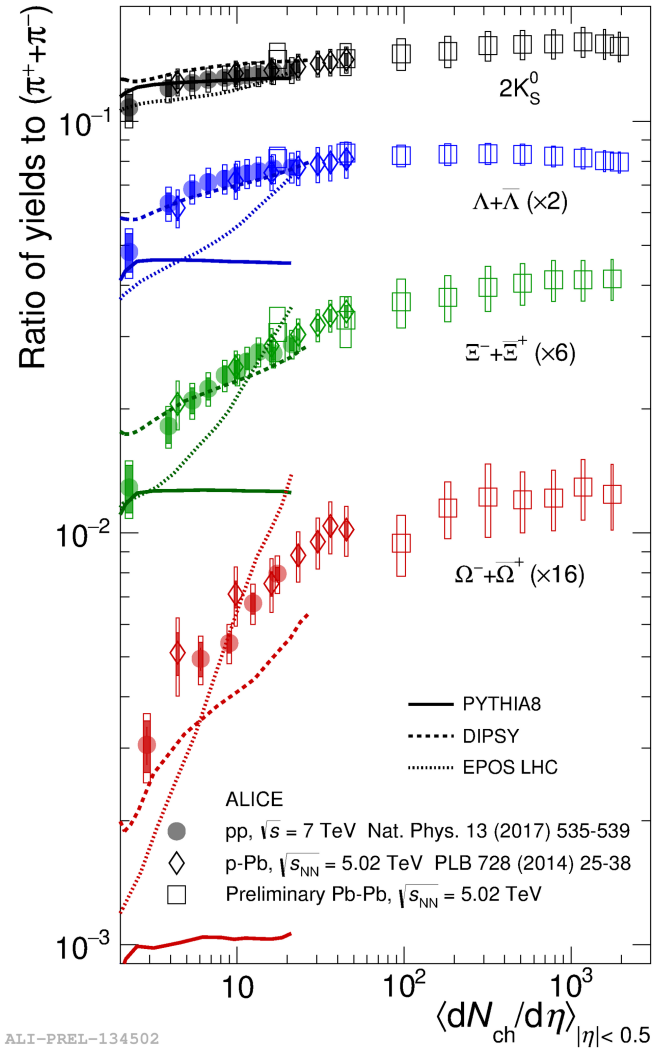




Thank you!

Strangeness Enhancement in Small Systems

- pp data can be compared to different event generators
  - PYTHIA8 (Lund String model) – poor reproduction with/without colour reconnection
  - DIPSY (colour ropes) – qualitatively describes increase
  - EPOS-LHC (core-corona) – ok qualitative description of trend
- Results for strange to non-strange yield ratios are not reproduced well by microscopic models



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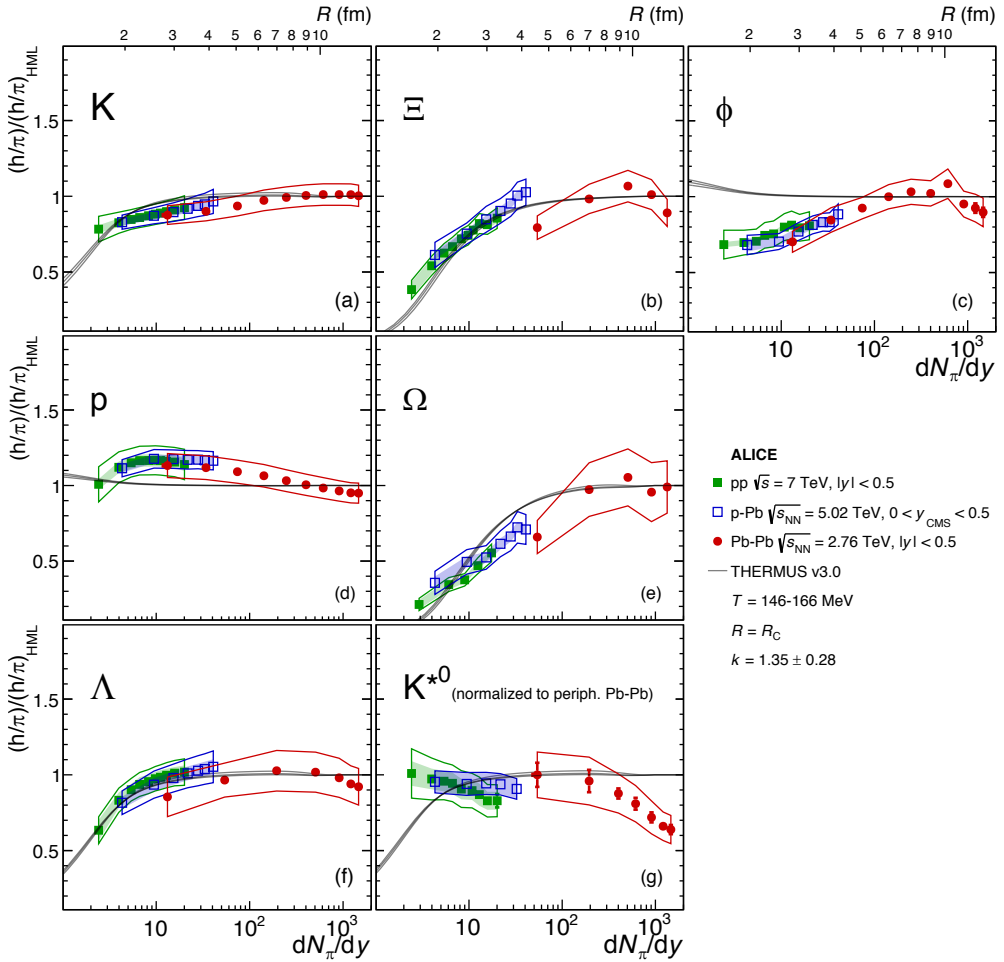
Strangeness Enhancement in Small Systems

- In macroscopic statistical hadronisation models, strange hadron production in small systems is supressed due to conservation of strangeness quantum number (Canonical Supression)
- Magnitude of suppression dependent on strangeness content
- Model describes data well except ϕ meson



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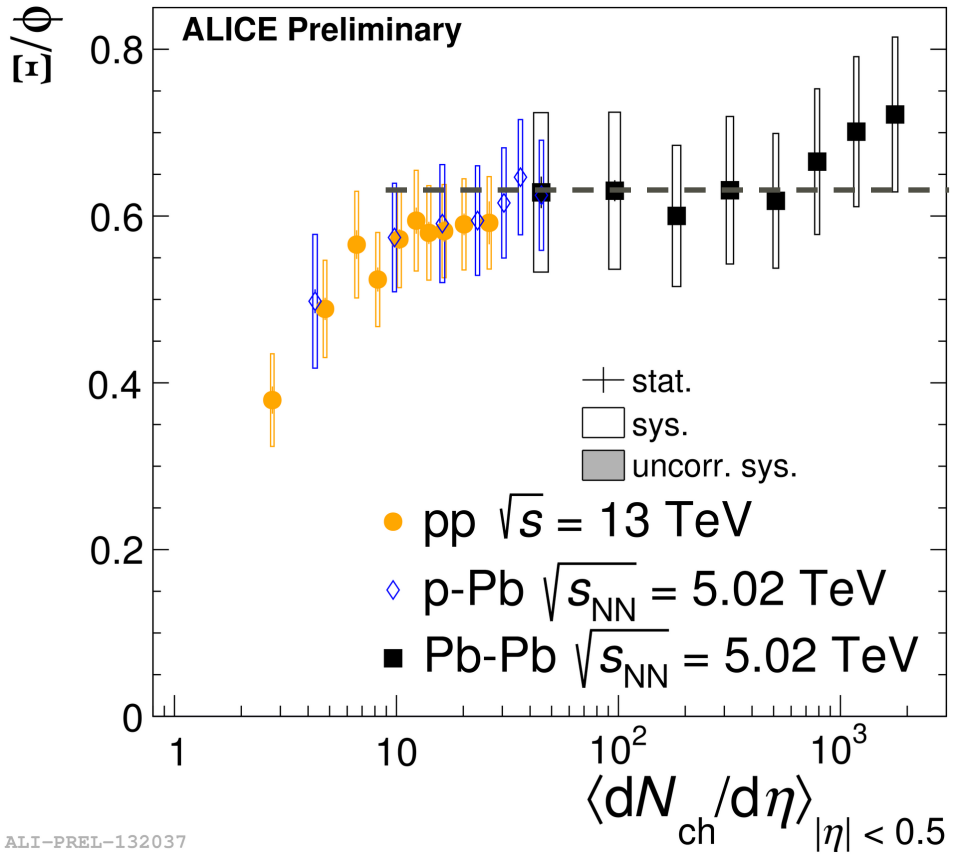
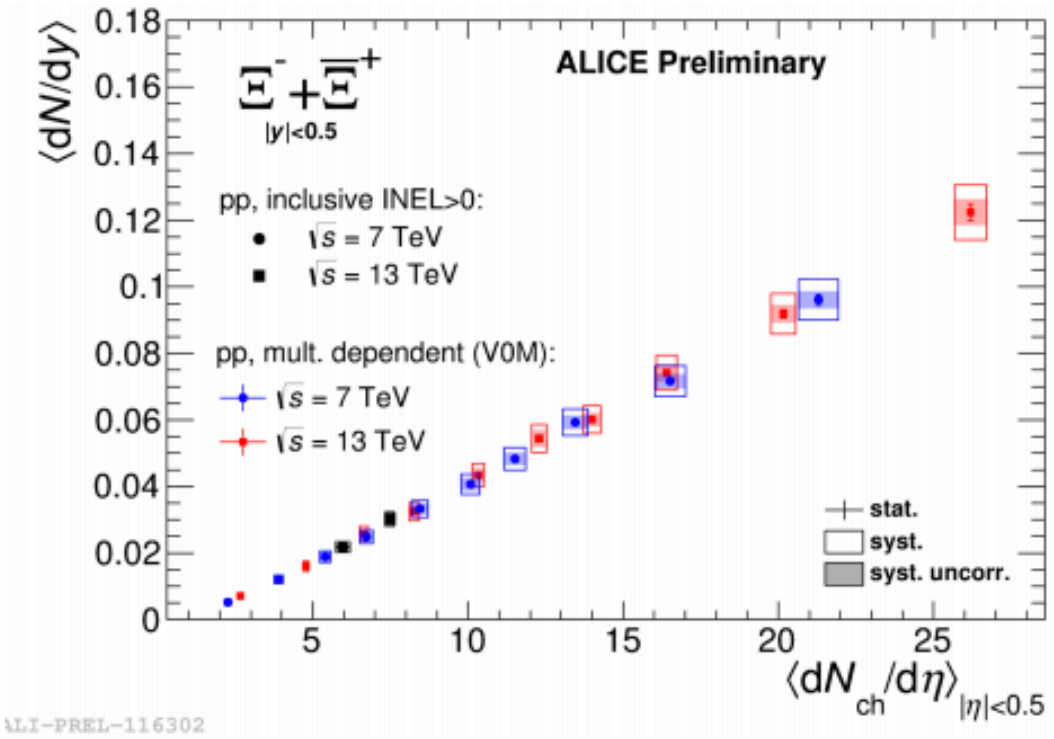
Strangeness Enhancement in Small Systems

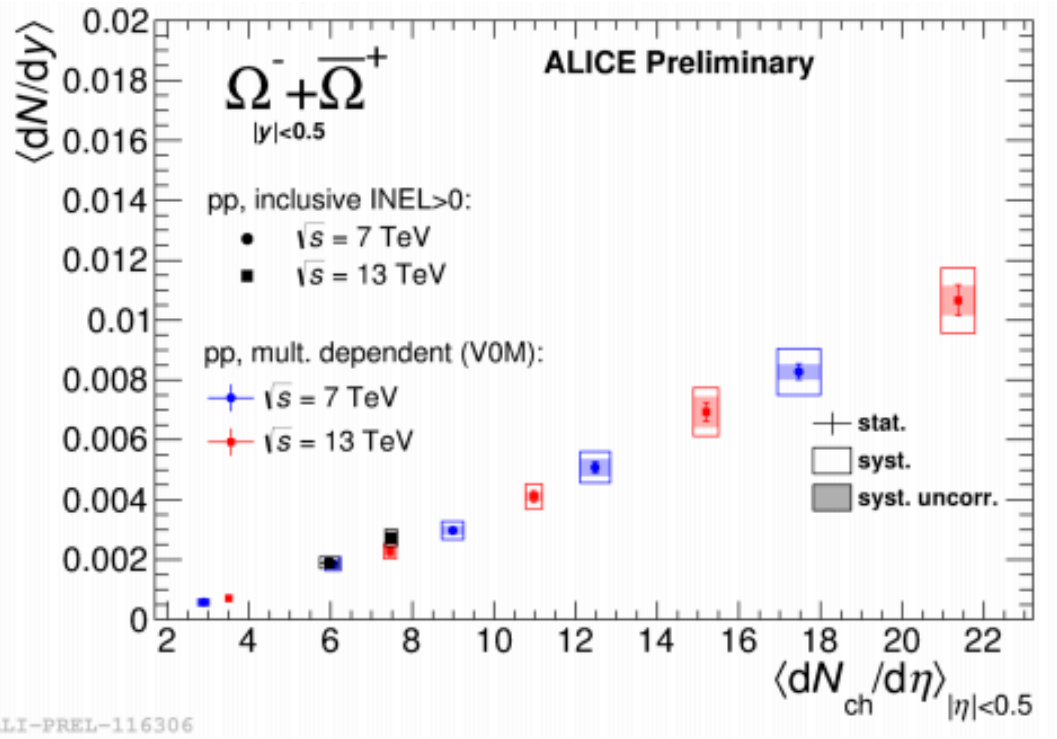
- ϕ does not behave liked hadron with strangeness quantum number 0
- ϕ shows enhancement with $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$
- Ξ(S=2)/ϕ(S=0) ratio is constant within uncertainties for $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$ >10
- ϕ meson behaves like particle with two strange quarks S=2



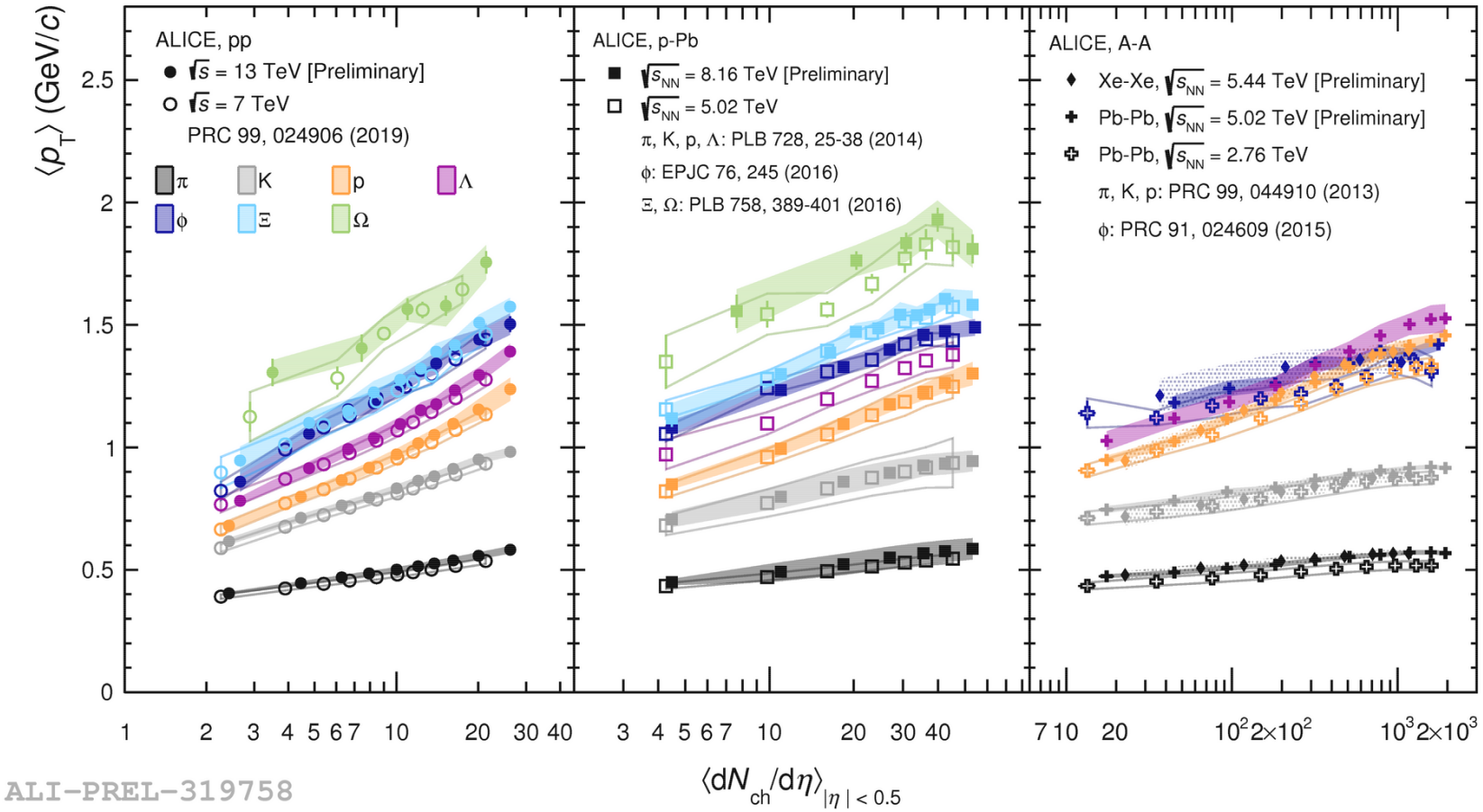
Strangeness Enhancement in Small Systems

- Same scaling for strangeness production with $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$ observed
- Hadrochemistry driven by event activity not collision energy





Mean p_{T}



ALI-PREL-319758

- New Results in p-Pb at 8.16 TeV included
- Rising trend of <p_{T}> for all particles

Signal Extraction