STRANGENESS WITH ALICE:

from pp to Pb-Pb

BETTY ABELEV

LAWRENCE LIVERMORE NATIONAL LAB

on behalf of the ALICE Collaboration

WHY THE STRANGE QUARK?

- **Production in the collision:**

  all strange hadrons produced during the collision

  → handle on particle production mechanisms

  $q+\bar{q} \rightarrow s+\bar{s}$ $g+g \rightarrow s+\bar{s}$: $E_{threshold}$ ~200 MeV ~ T_{QCD}

  → freely produced in the plasma

- **A handle on the chemistry of the system: density, viscosity, temperature of the system**

A long-standing signature of QGP:

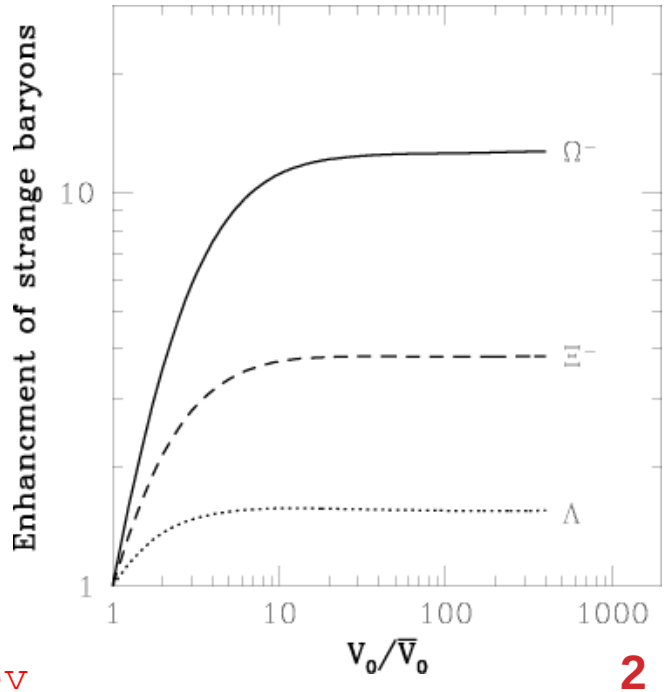
enhancement at large volumes;

the "stranger" the particle, the larger the enhancement:

particular importance of *multistrange baryons:*

$\Omega(sss)$ & $\Xi(dss)$

Hamieh et al.: Phys. Lett. B486 (2000) 61



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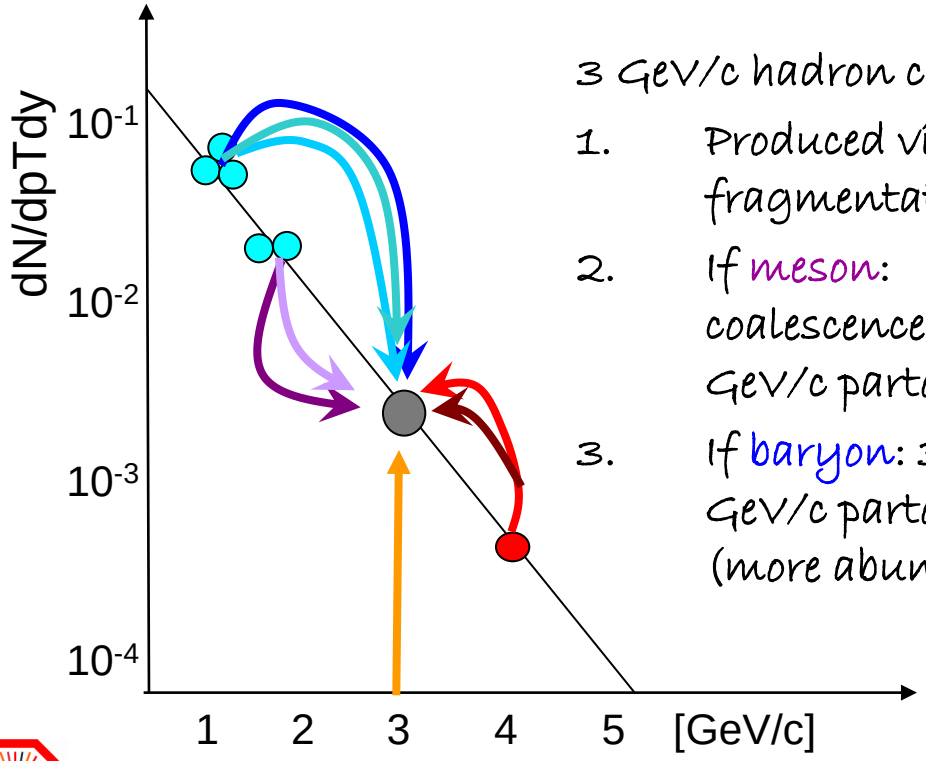
PARTICLE PRODUCTION

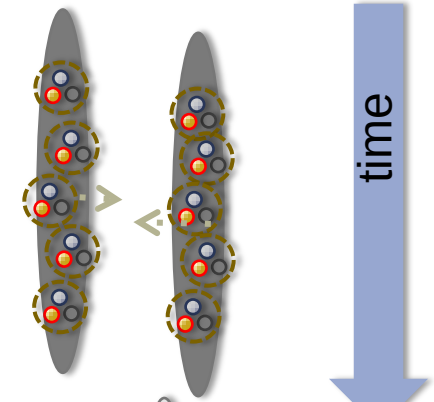
in pp and Pb-Pb: an interplay between hard and soft processes

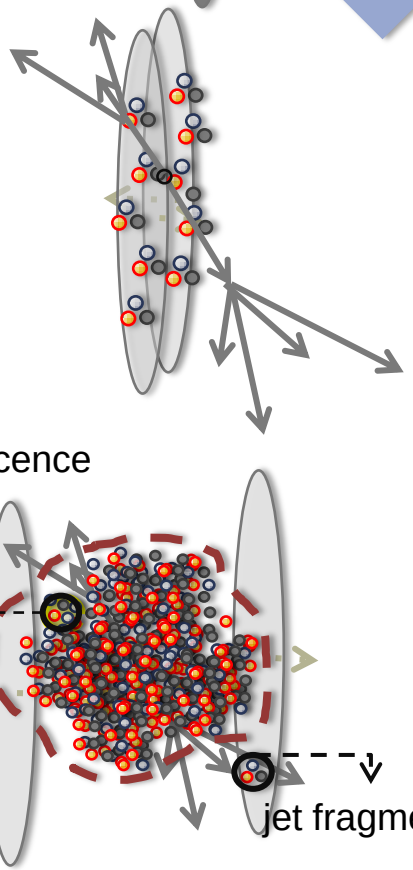
Pb-Pb: production through initial hard scattering & in plasma



3 GeV/c hadron can be

1. Produced via fragmentation
2. If meson: coalescence of 2 1.5 GeV/c partons
3. If baryon: 3 1 GeV/c partons (more abundant!)



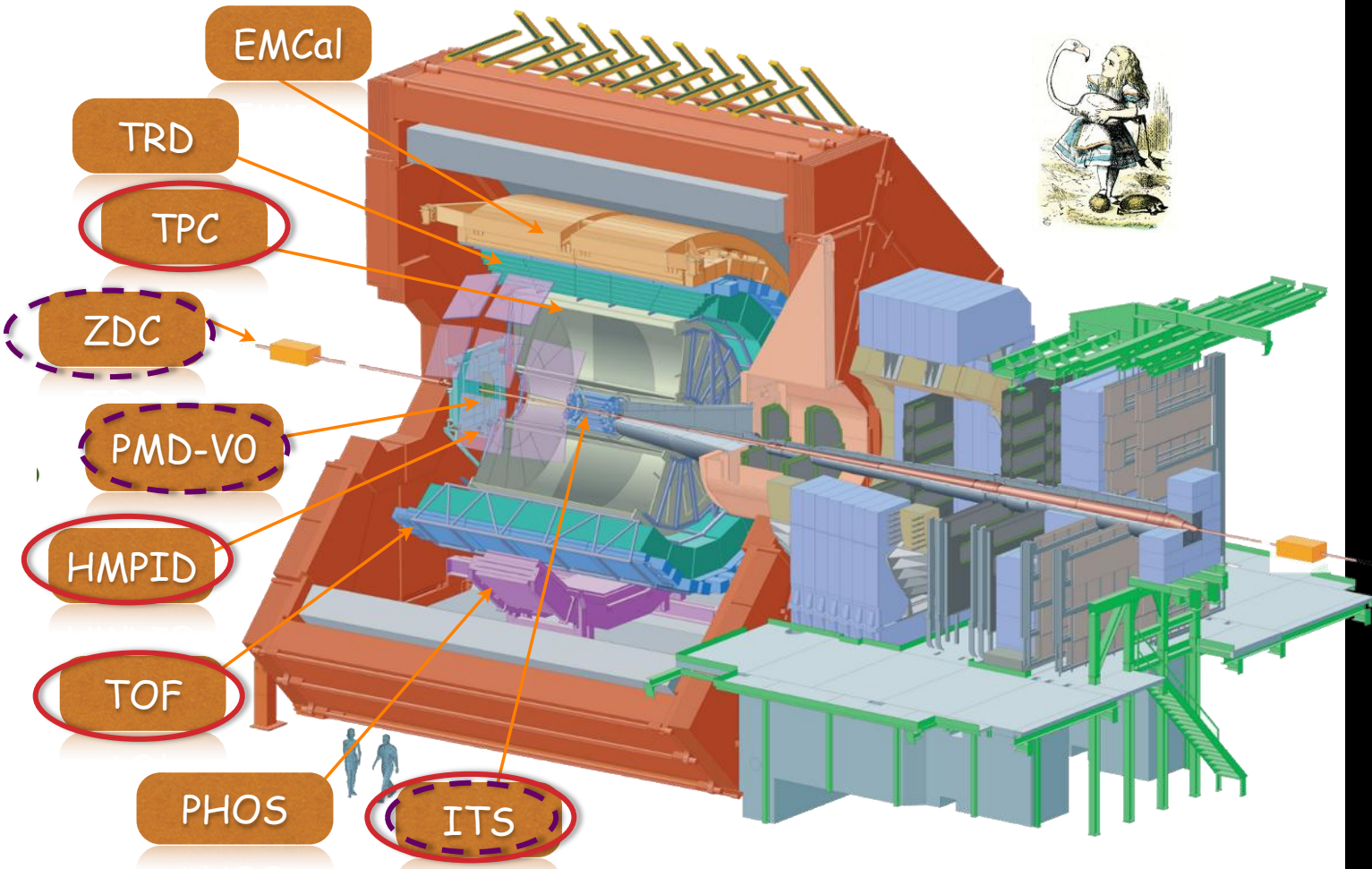


ALICE:

PERFECT FOR STRANGENESS MEASUREMENTS

Triggering detectors:

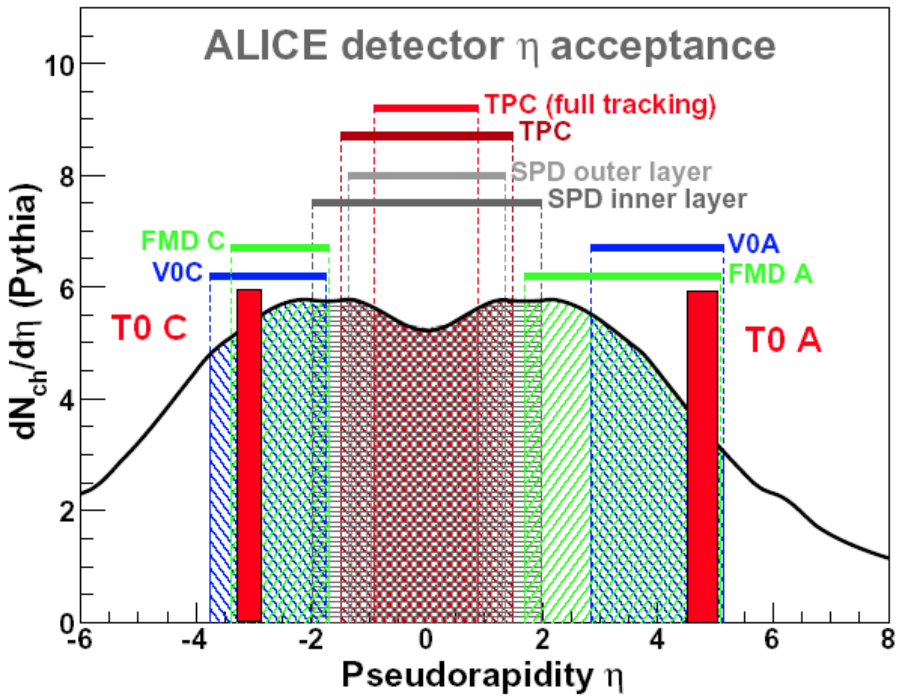
- V0
- Silicon Pixel Detector (two layers of ITS closest to beam)
- ZDC



ALICE TRACKING

Tracking and PID detectors

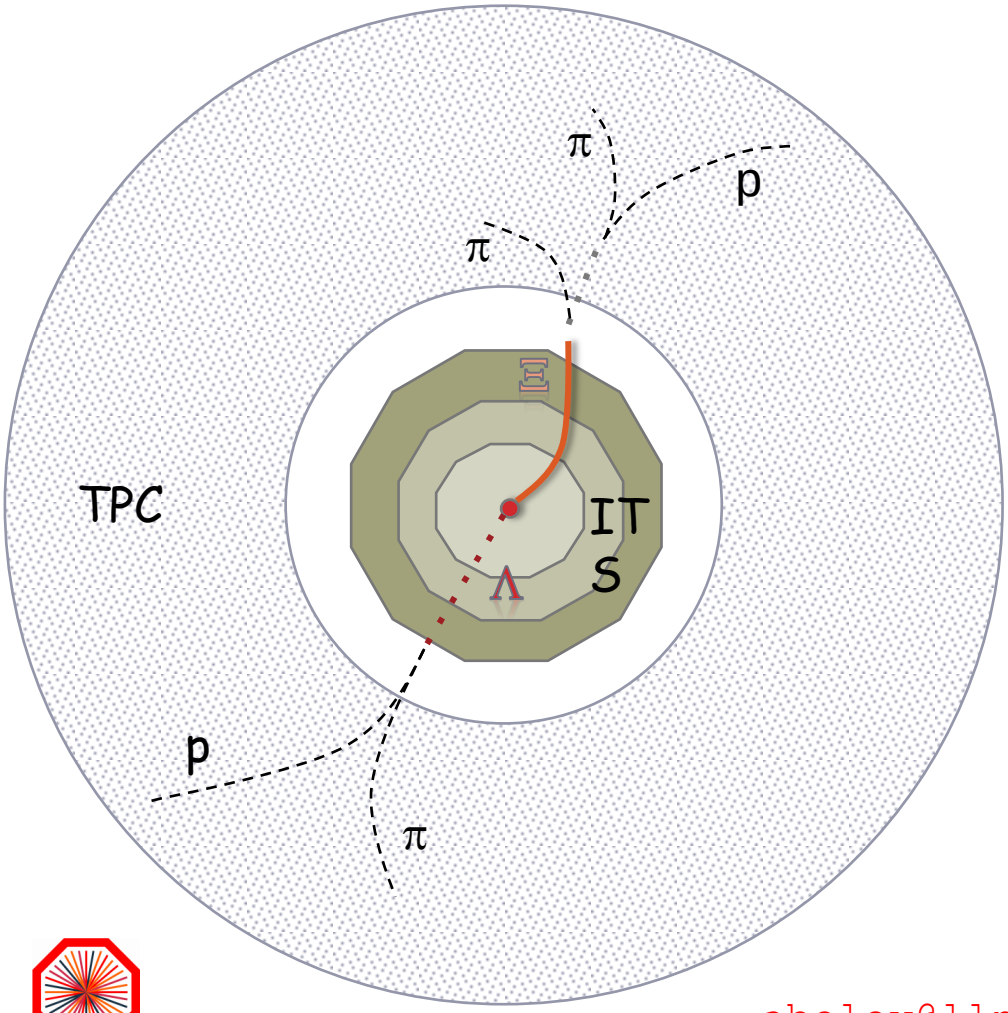
- TPC
- ITS (SPD, SDD, SSD)
- HMPID (RICH)
- TOF



Analysis volume for strange particles: $0<\phi<2\pi$

in pp: $|y|<0.5$
in Pb-Pb: $|y|<0.75$

STRANGENESS RECONSTRUCTION: TOPOLOGY



Reconstructing strange particles using ITS and TPC tracks

: characteristic decay topology

$\Lambda(uds) \rightarrow p^{\pm} + \pi^{\pm}$ (64% BR)

$K^0_S(ds) \rightarrow \pi^+ + \pi^-$ (69% BR)

$\Xi^{\pm}(dss) \rightarrow \Lambda + \pi^{\pm} \rightarrow p + \pi^{\pm} + \pi^{\pm}$ (99% BR)

$\Omega^{\pm}(sss) \rightarrow \Lambda + K^{\pm} \rightarrow p^{\pm} + \pi^{\pm} + K^{\pm}$ (68% BR)

7 TeV pp: SPECTRA

Mid- and High p_T regions are now accessible for multi-strange particles

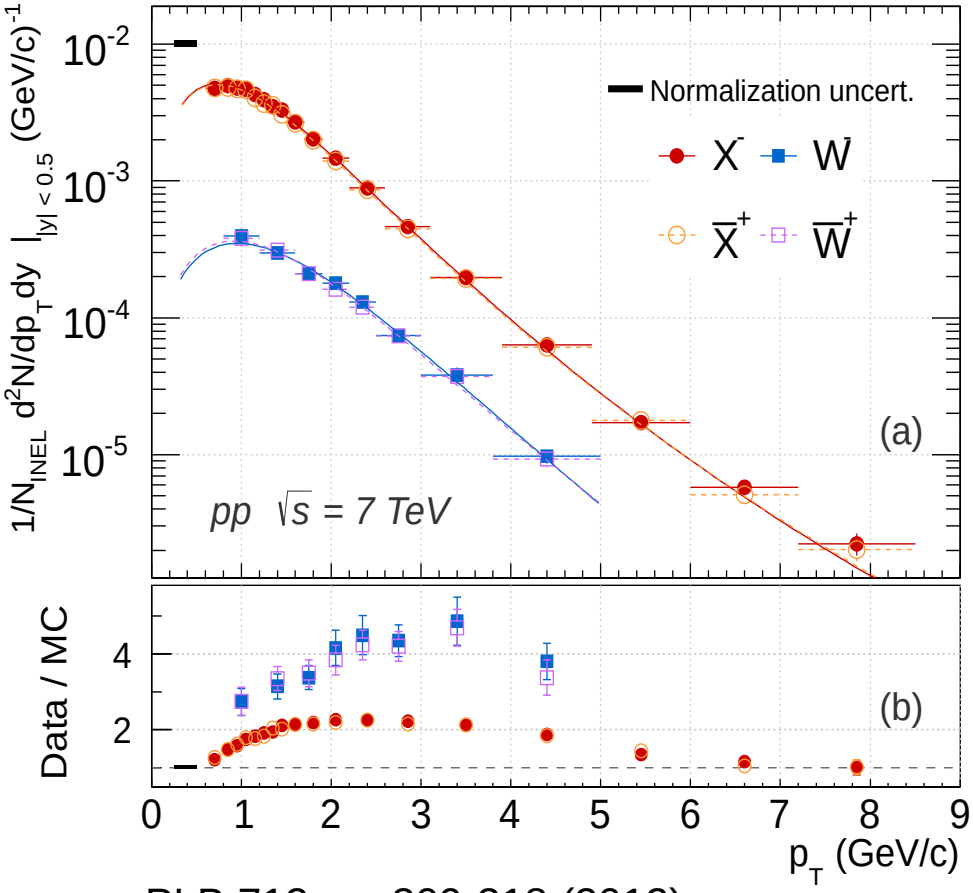
Better modeling

PYTHIA Perugia-2011:

pop-corn off;

adjust strange vs. non-strange di-quark rate

Other tunes: Perugia-0, Z1, Z2: magnitude x3-x10 off



PLB 712 pp. 309-318 (2012)

N_{ch} reproduced for all PYTHIA tunes tested

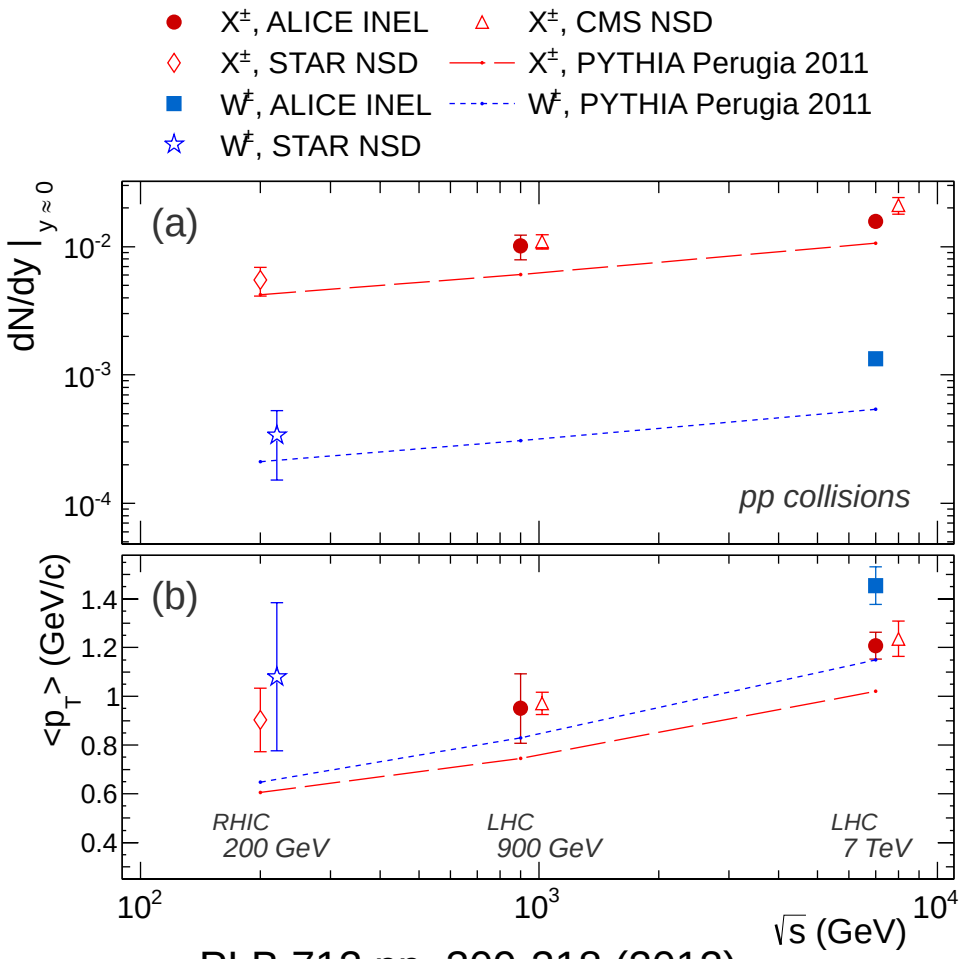
pp: COMPARISON TO LOWER ENERGIES

Multistrange baryons

- Power-law increase in yields

  $\sim s^{0.25}$ (PYTHIA, too!)

- Indication of a linear increase in $\langle p_T \rangle$
- PYTHIA underestimates yields and $\langle p_T \rangle$



PLB 712 pp. 309-318 (2012)

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STRANGE QUARK/NON-STRANGE QUARK RATIO

Ω(sss)/Ξ(dss) ratio

m_T-m_0: remove mass effect to look at *d*- vs. *s*-quark

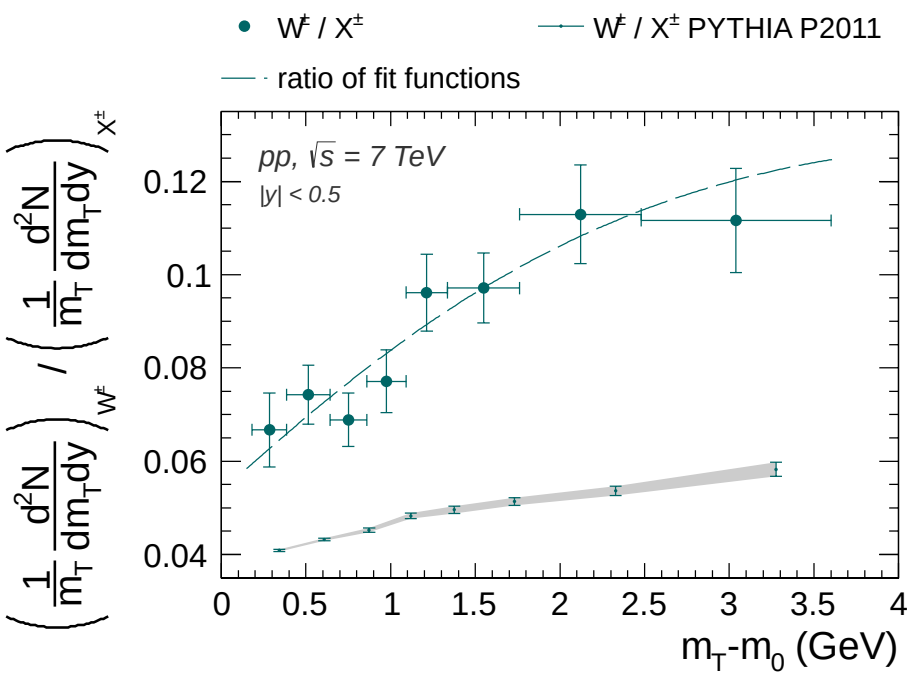
Easier to produce an *s*-quark at higher momentum?

PYTHIA Perugia-2011

reproduces shape

magnitude off

No evidence of *s*-quark saturation



PLB 712 pp. 309-318 (2012)

HIGHLIGHTS FROM THE Pb-Pb COLLISIONS

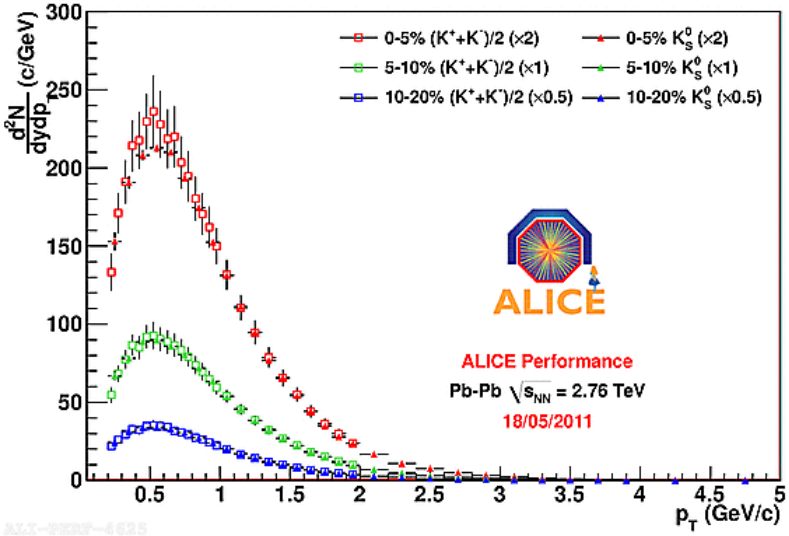
Density

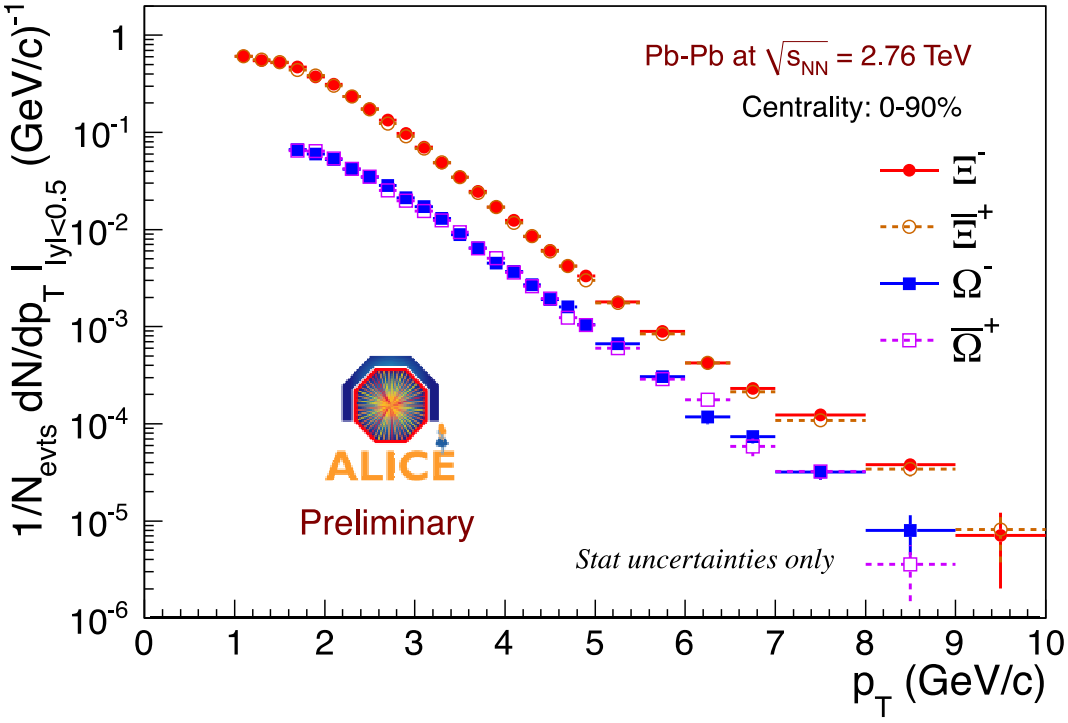
Quark Gluon Plasma

Dialing up the number of participants

- Data from Nov. 2010
- $\sqrt{s_{NN}}$ =2.76 TeV
- 30M MinBias collected
- 20M used for analysis

SPECTRA





Excellent agreement between spectra using different analysis methods;

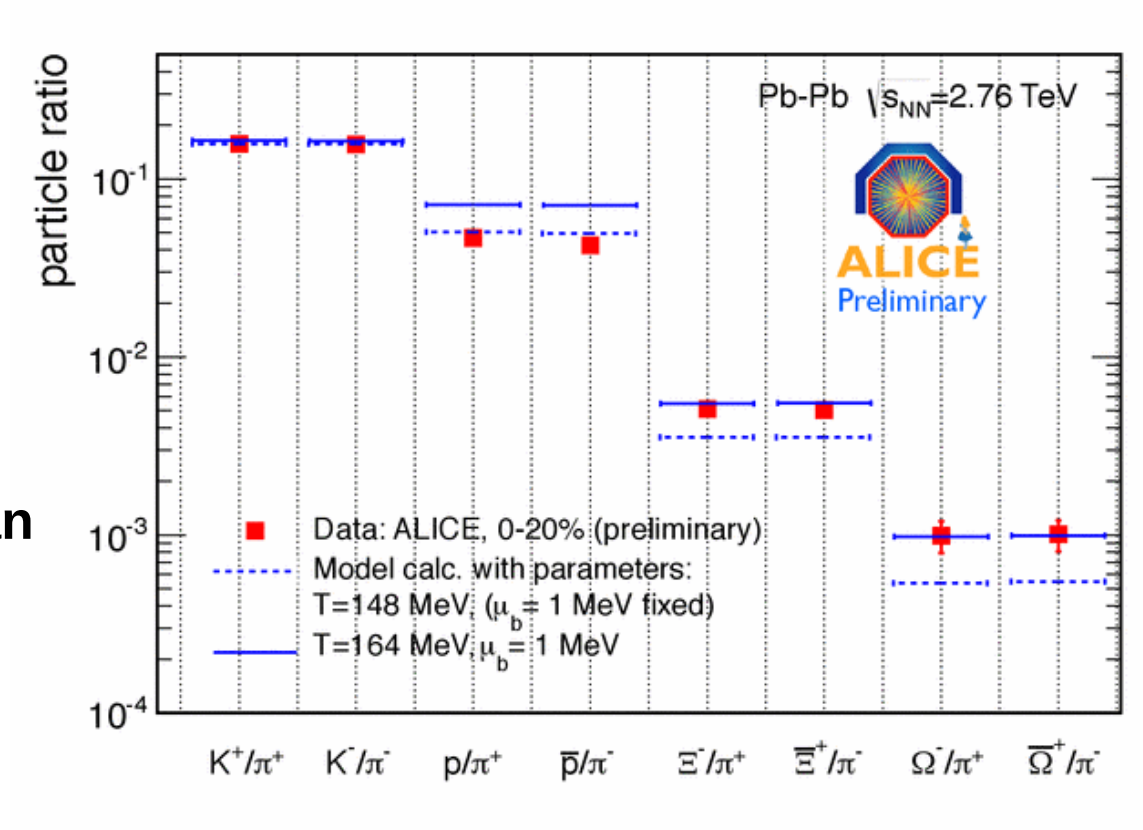
Measurements: from K± to multi-strange baryons

BULK: THERMAL MODEL COMPARISON

All ratios other than p/π are predicted accurately

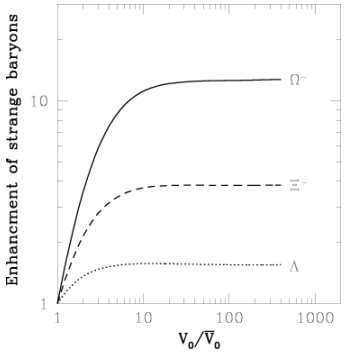
$\gamma_s=1$

Protons: different T_{ch} than strange/multi-strange? Model may yet improve?



A. Andronic et al, PLB 673: 142-145 (2009)

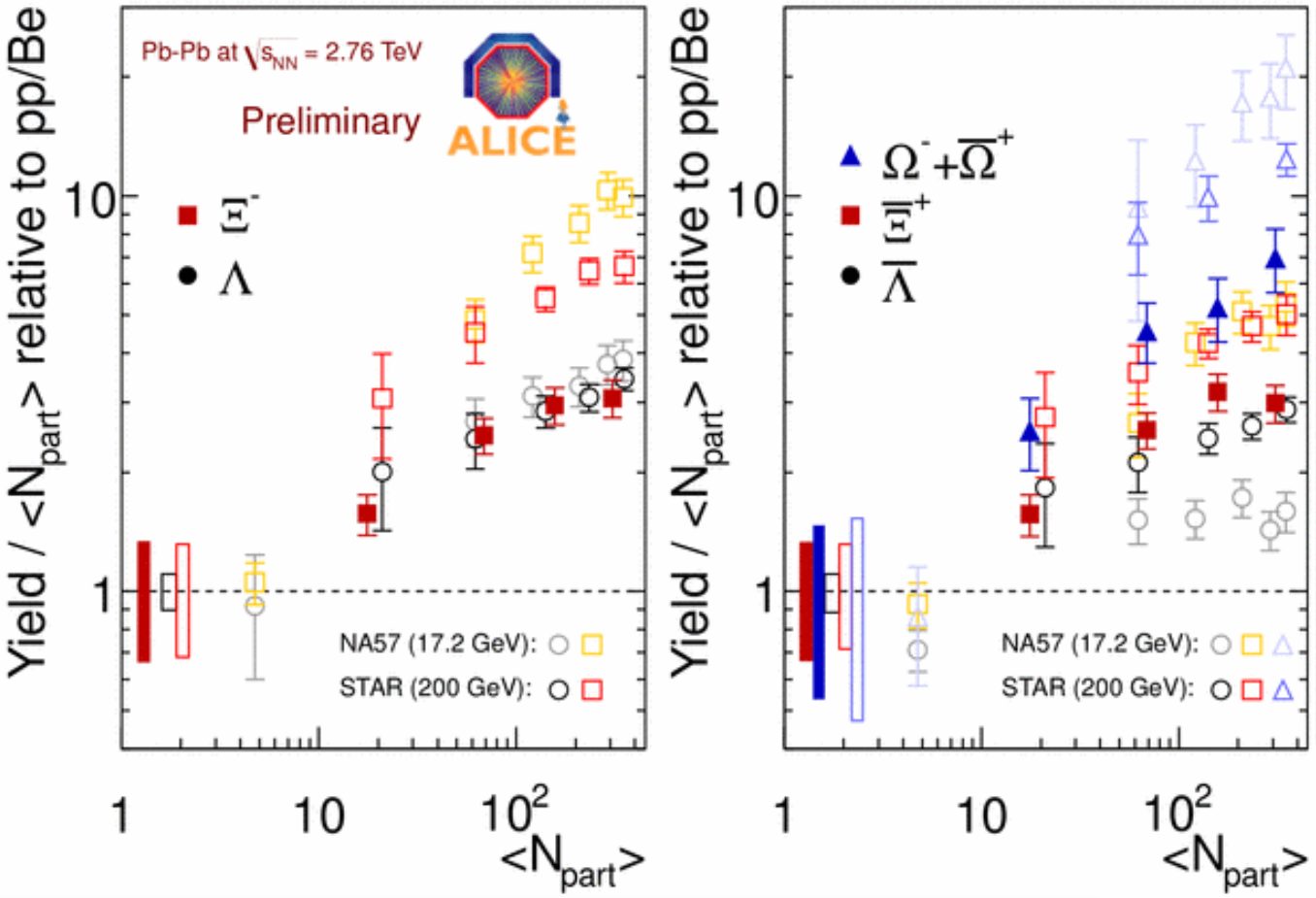
ENHANCEMENT



LHC: Pb-Pb collisions with pp reference

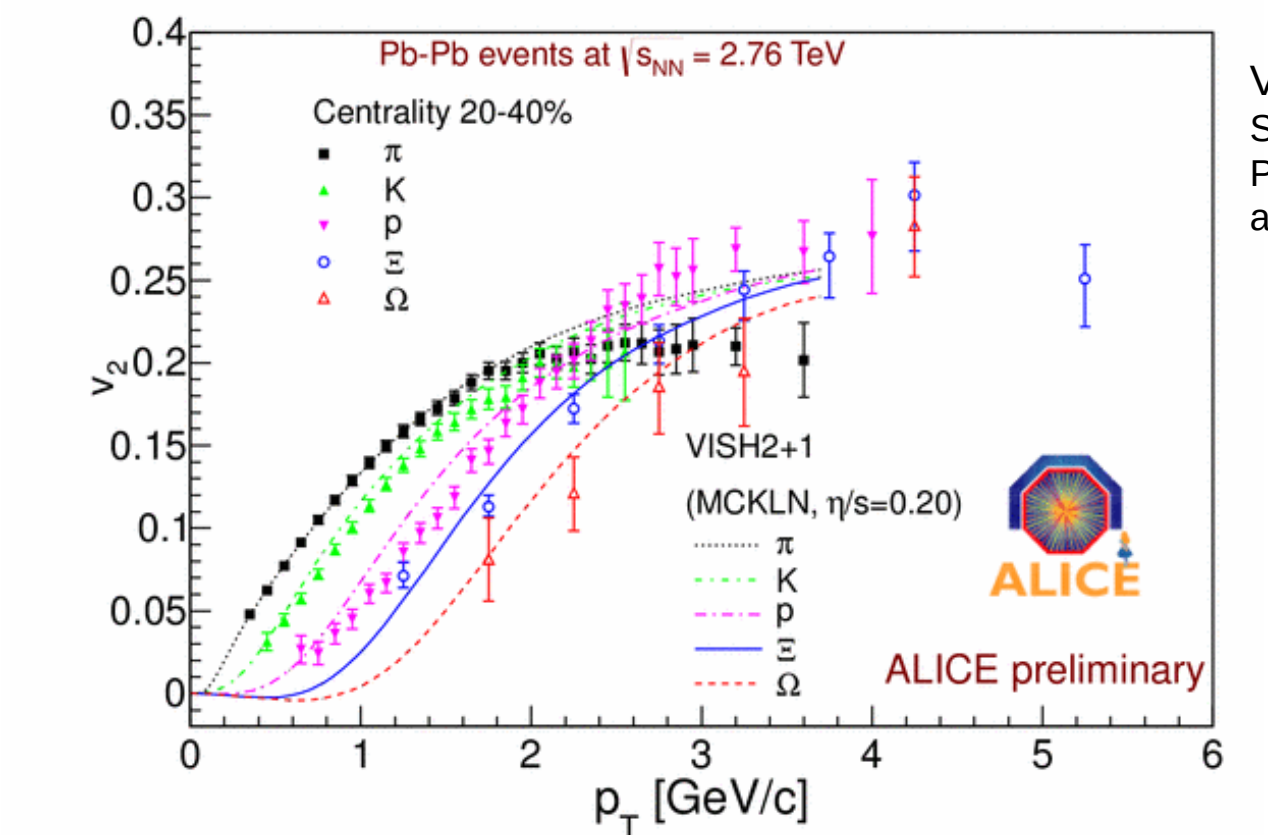
Step down in energy to RHIC (Au-Au collisions, reference: pp)

Lower in energy yet: SPS (Pb-Pb collisions, Be reference)



Enhancement weakens with increased energy

COLLECTIVITY: ELLIPTIC FLOW

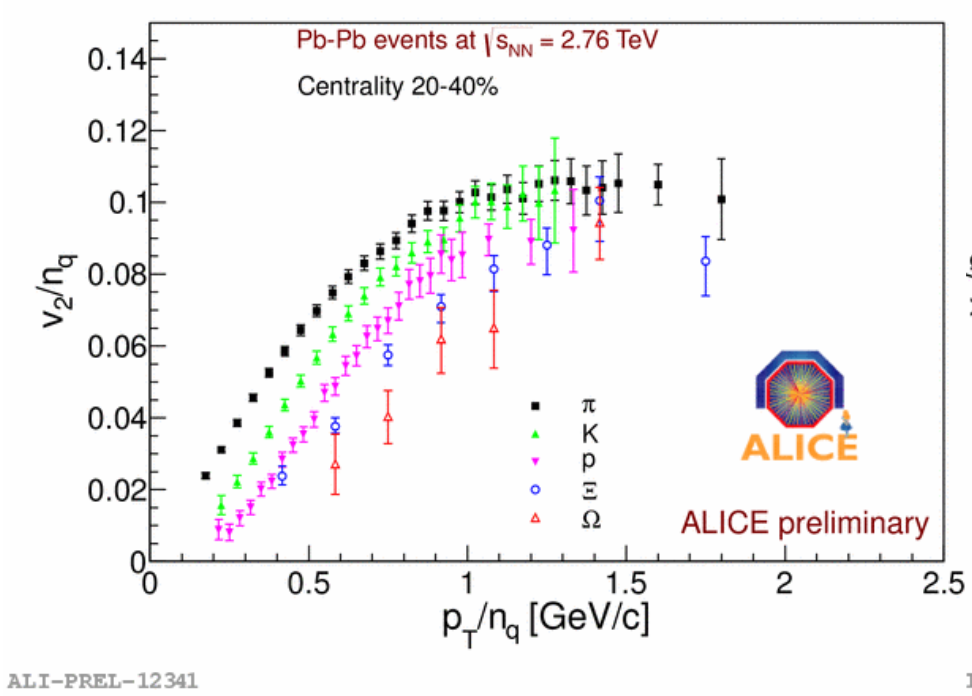


VISH2+1:
Shen et al
PRC 84 (2011) 044903
arXiv:1105.3226

Good agreement between data and VISH2+1: viscous hydro, low viscosity (η/s=0.2)

(but deviates by ~20% for K and p)

QUARK SCALING



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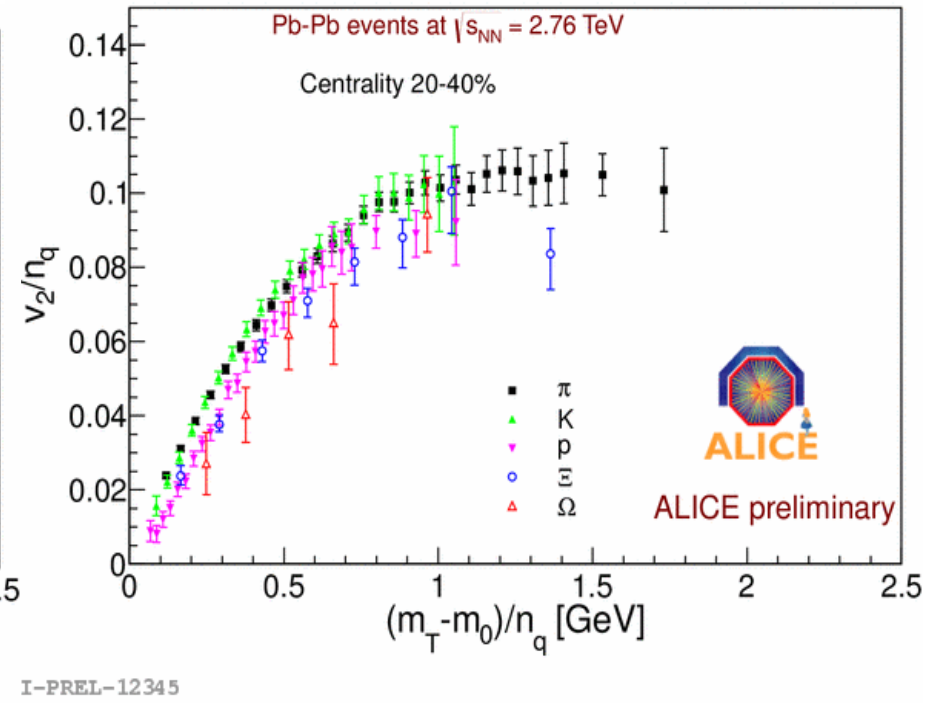
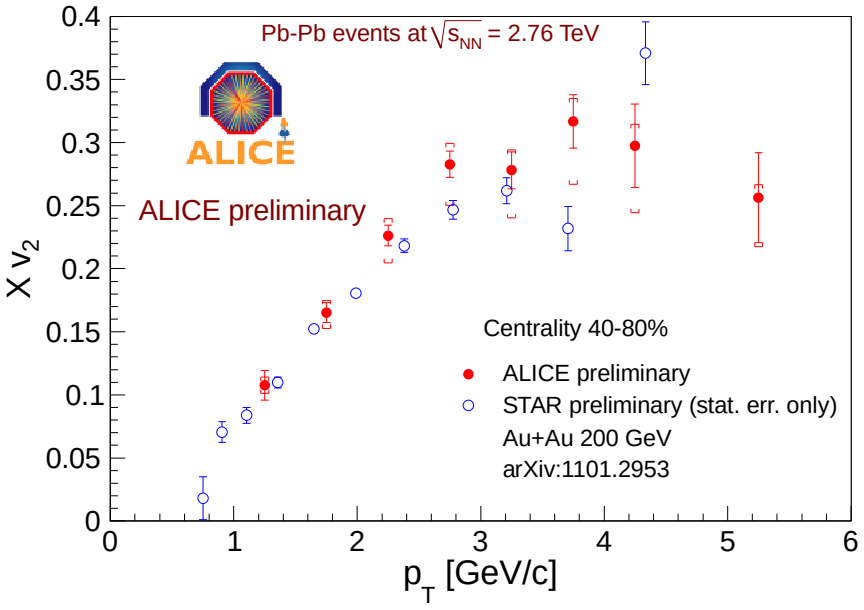


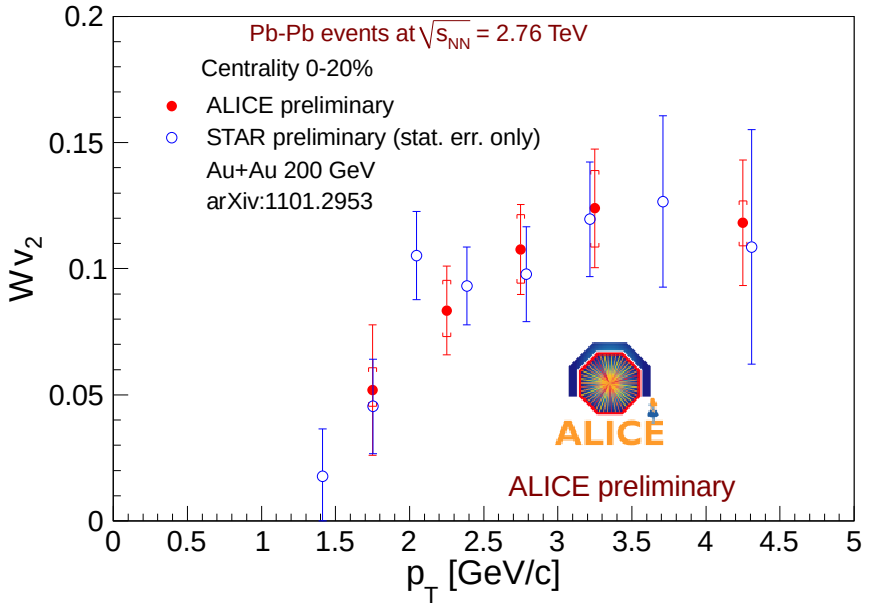
I-PREL-12345

Mesons and baryons seem to scale differently; no single scaling for all particles

Scaling works better as a function of transverse energy, but also breaks down

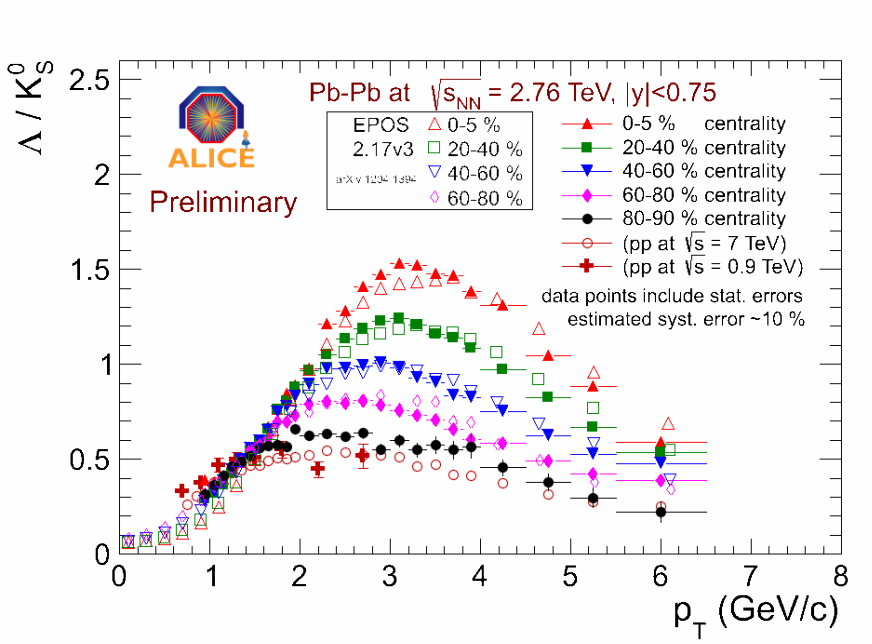
COLLECTIVITY: COMPARISON TO RHIC

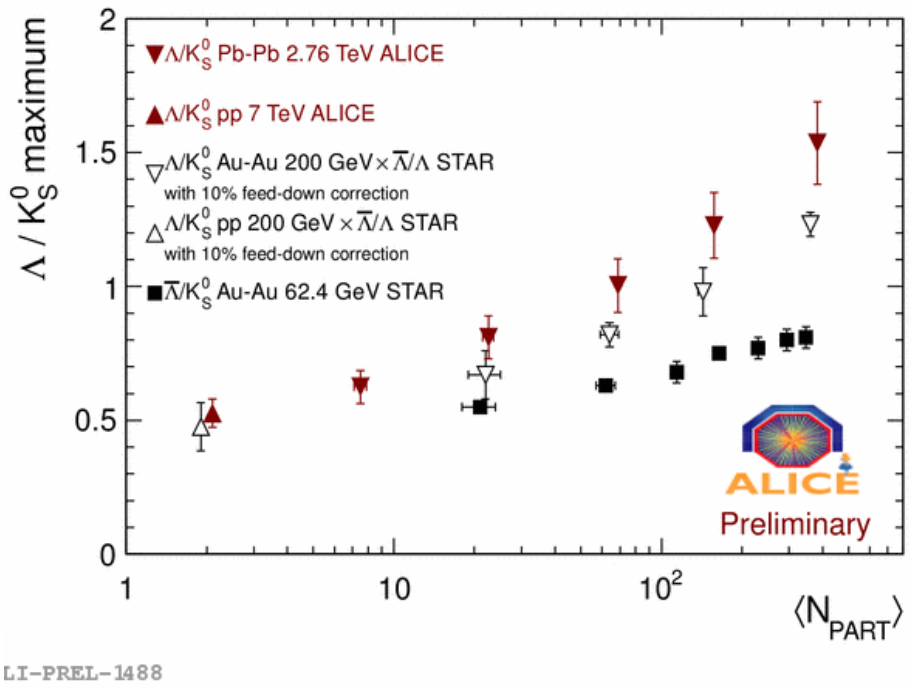




Central and mid-central elliptic flow for multi-strange baryons is similar to RHIC

MID-p_T: Λ/K^0_S



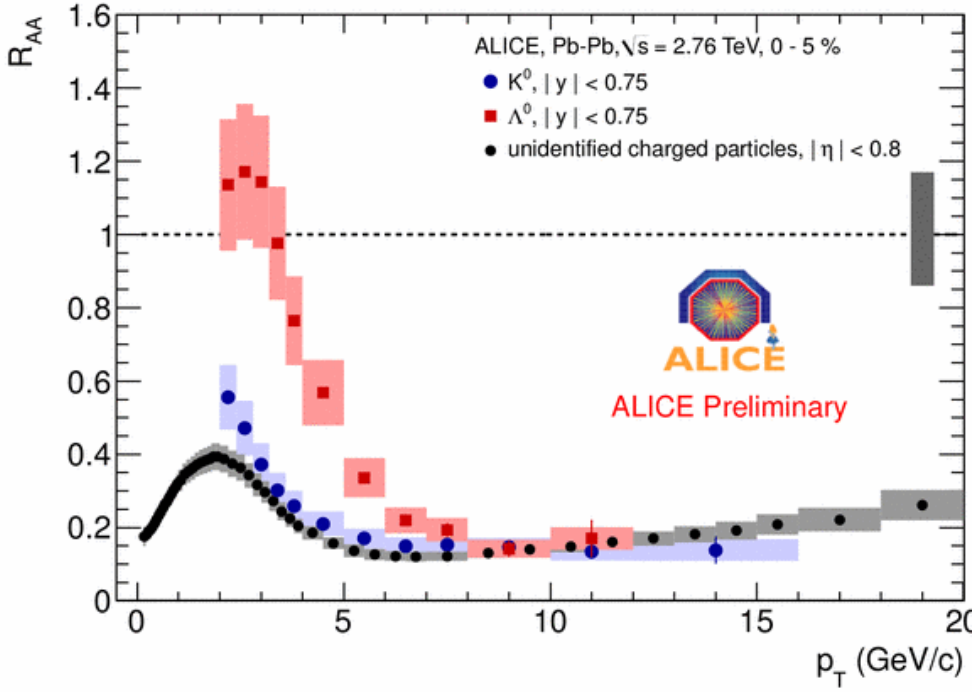


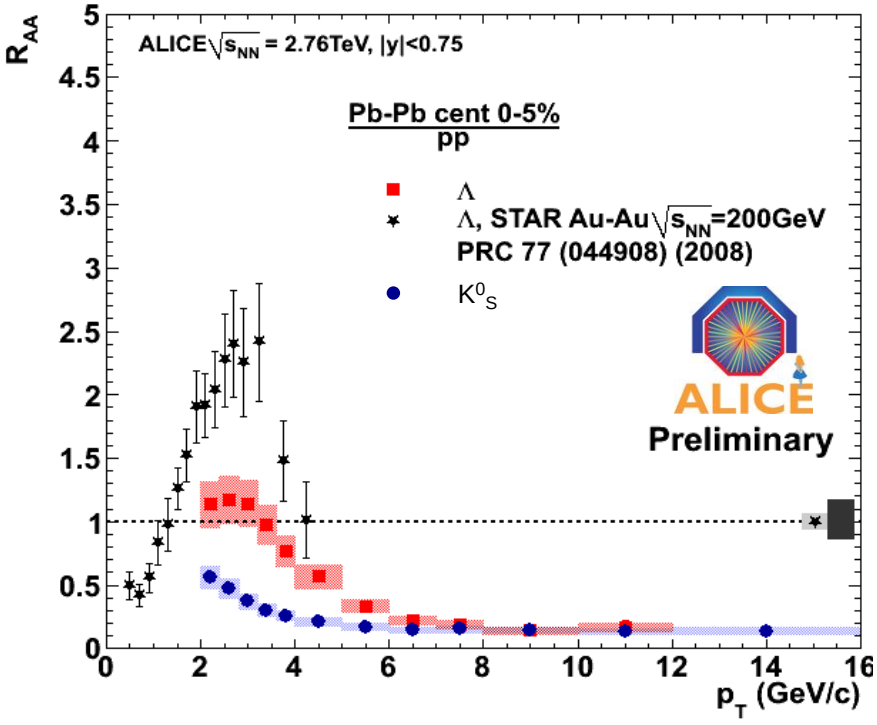
Mid-p_T region: 2 <p_T <5 GeV/c

Ratio >1 for spectra in 0-40% central collisions

Maxima similar to 200 GeV RHIC at low N_{part}; possibly above RHIC at N_{part}>30

HIGH p_T: NUCLEAR MODIFICATION fn, R_{AA}





Central Collisions: no strong flavor or meson/baryon dependence at high p_T

Approaches the RHIC result at p_T~4 GeV/c

CONCLUSIONS

ALICE: a wide range of strangeness measurements at low, mid, and high p_T: an important probe;

PYTHIA: significantly closer to reproducing 7 TeV pp multi-strange, but room for improvement yet;

THERMAL MODEL: works well in Pb-Pb with γ_s=1 and all strange particles included, work needed on protons;

Elliptic flow: consistent with a viscous system with a low η/s; quark scaling doesn't work as well as at RHIC;

Enhancement: decreases with energy;

Mid p_T: Λ/K^0_S ratio: shows the same trend as at RHIC, but exceeds unity in most central collisions;

High p_T: behavior similar to non-strange particles, same suppression rate;

THANK YOU, ALICE!