The energy density representation of the strangeness enhancement from p+p to Pb+Pb

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- ArXiv:1608.02101

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Outline

✔Motivation
(production of strangeness on different systems)

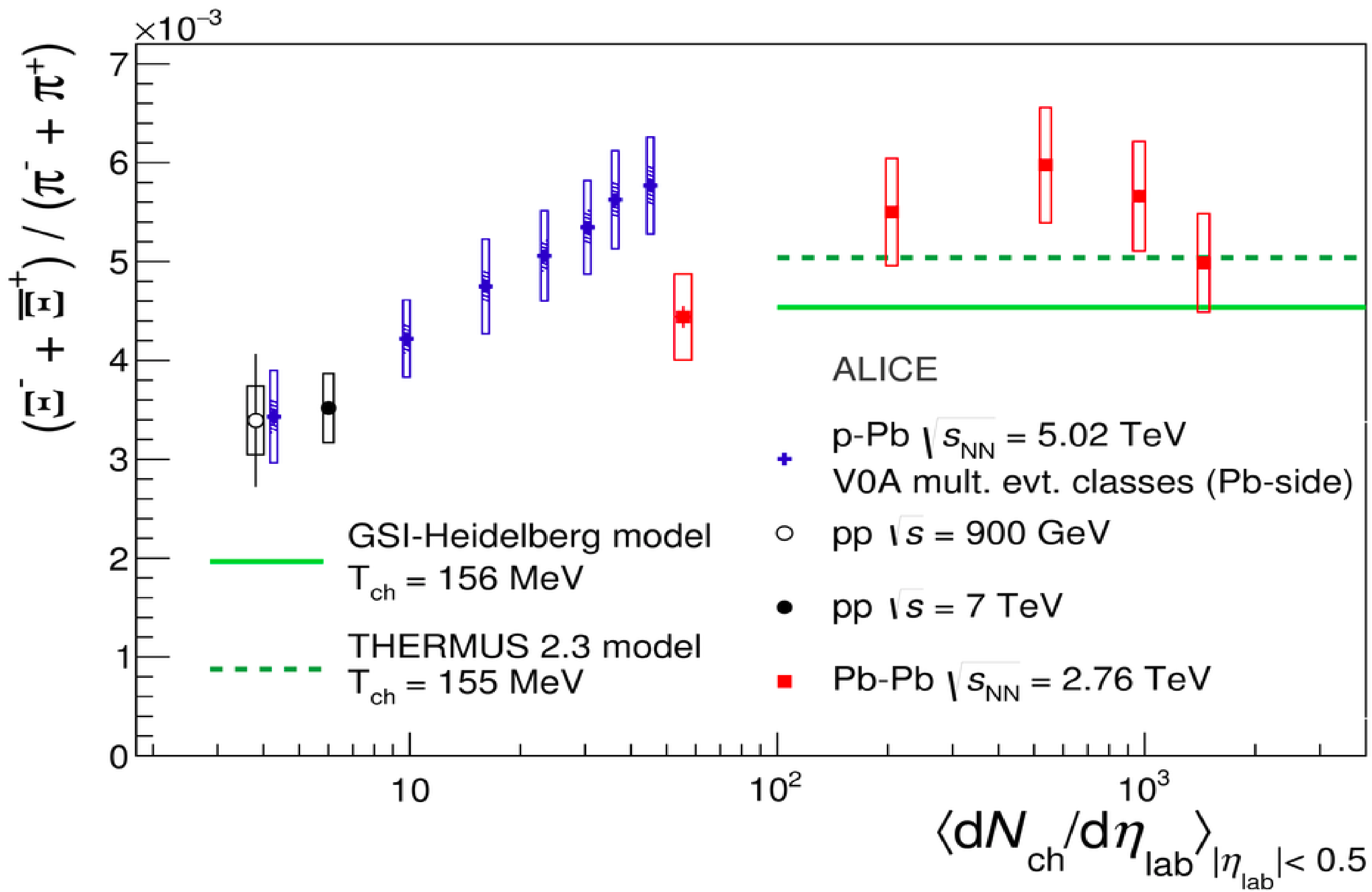
✔Density of charged hadron production and energy

✔Ratios multi-strangeness baryons to pion
- On pt bins vs charged hadron density
- On integrated pt vs energy density

✔Conclusions

Production of multistrange baryons vs dN/dη

p+Pb: PLB 758(2016) 389; Pb+Pb: PLB 728 (2014) 216



- The p-p and p-pb seems to follow the same trend.
  But what about pb-pb? Does the Thermal model describe data?
- Is it possible to compare ratios using dN/dη, from different systems?
- Strangeness production is not described by Pythia

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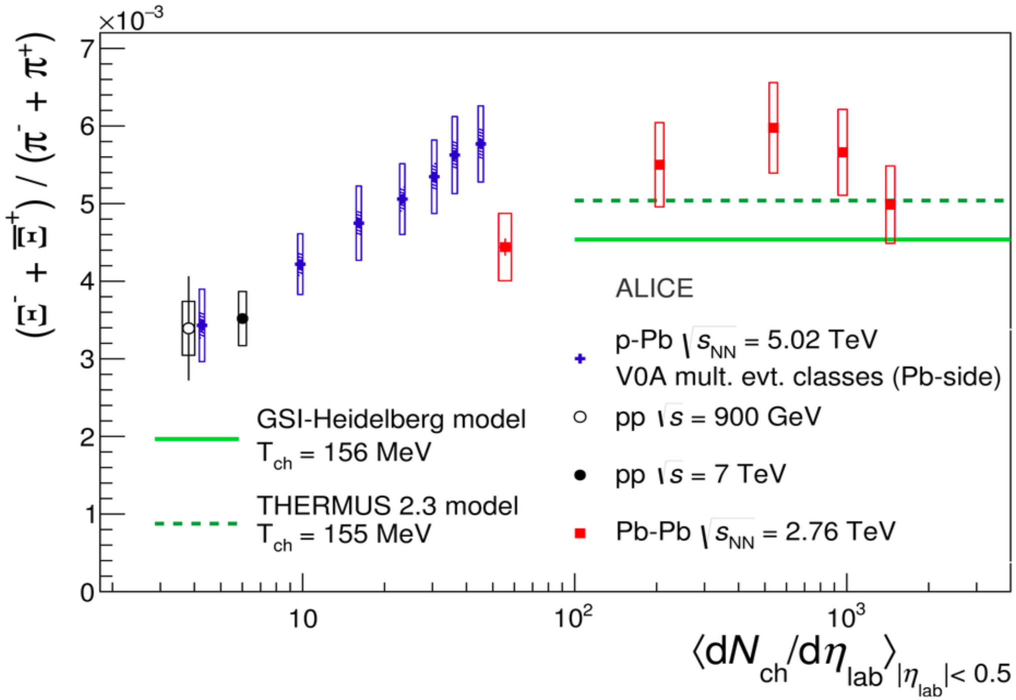
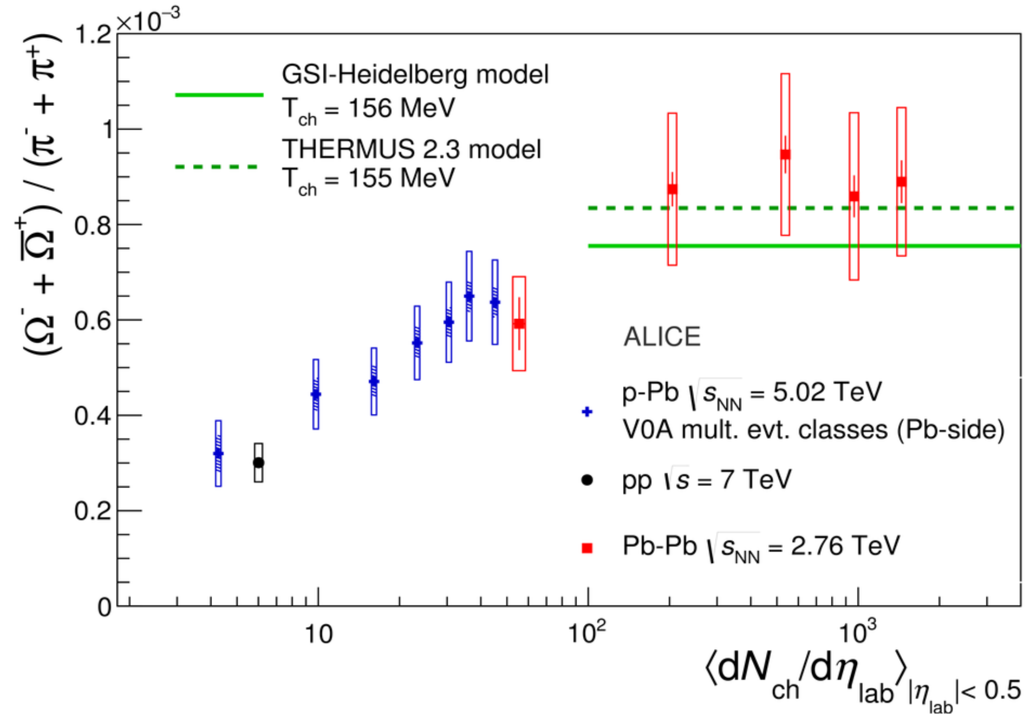
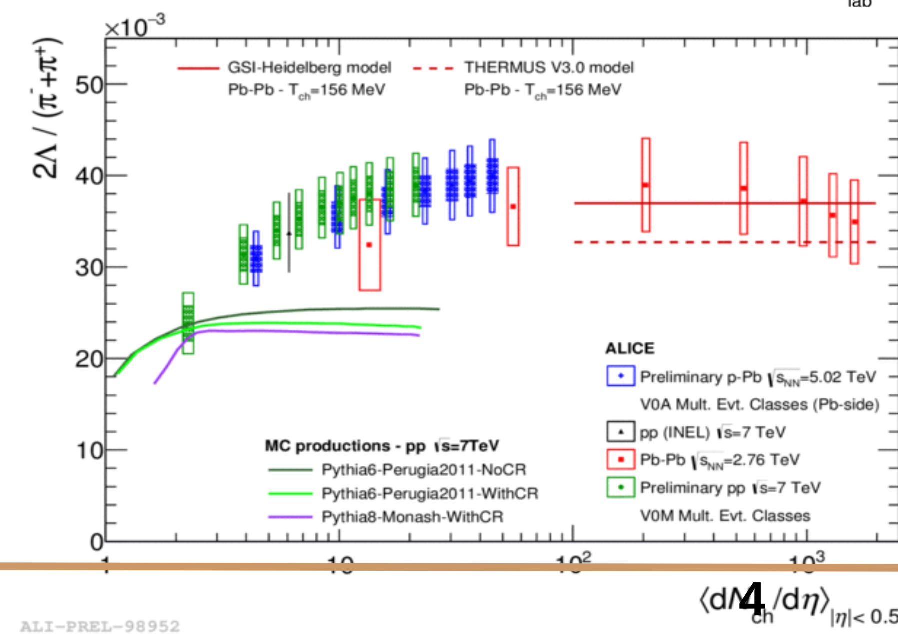
Multistrange/pion vs <dN/d>

ALICE: ArXiv: 1512.07227

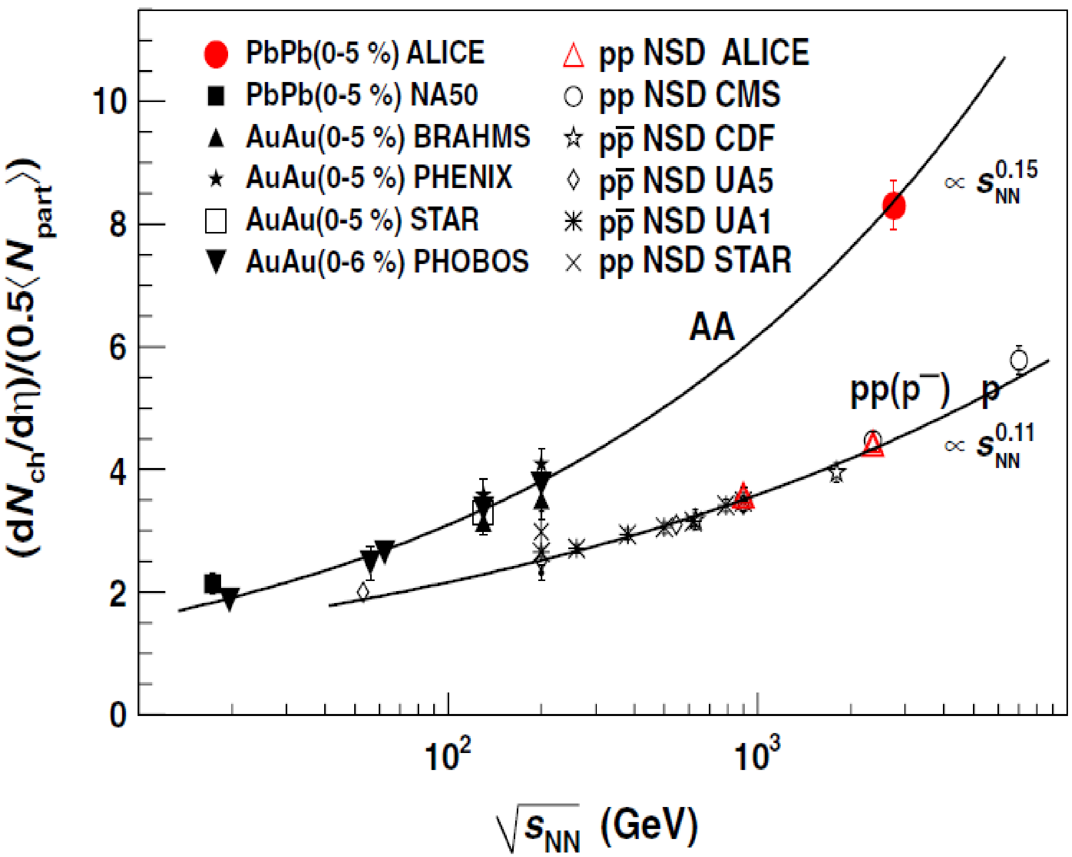




- ✔ Λ/π, Ξ/π Ω/π approaching Grand Canonical saturation limit in a similar way.
- ✔ Pythia do not describe the data. Usually this MC fail to reproduce strangeness productions



Charged hadron and energy density



Phys. Rev. Lett. 105, 252301 (2010).

At 2.76 TeV vs 0.2 TeV

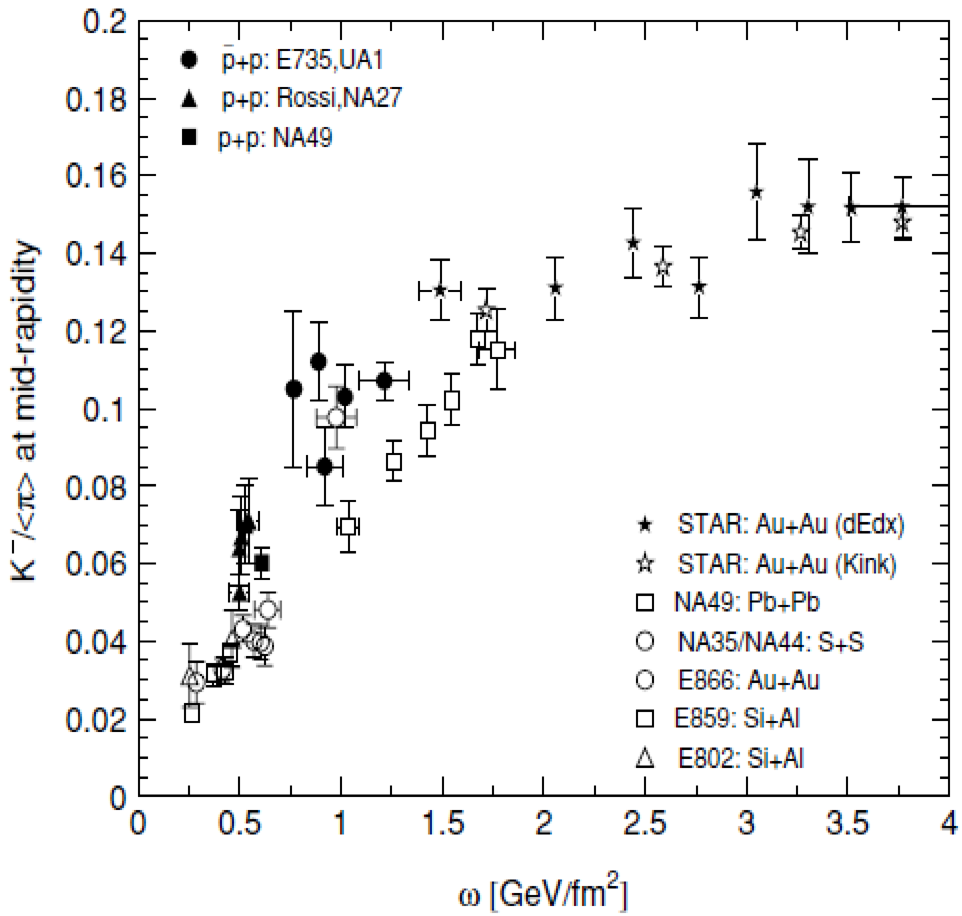
- Power law dependence fits well.
- Faster rise in Pb-Pb, ≈ $s^{0.15}$, than in pp, ≈ $s^{0.11}$.

- $N_{ch}^{LHC} \approx 2XN_{ch}^{RHIC}$
- $\varepsilon_{LHC} \approx 3\varepsilon_{RHIC}$.
- Similar centrality dependence.

K-/π versus energy density in diff. collision systems

- ✔ **K-/π in A+A, p+p, p+$\bar{p}$ follow interesting systematics in *ω*.**
- ✔ **The systematic indicate that *ω* might be the relevant variable underlying *K-/π* .**
- ✔ **At high energy, the ω variable is related to gluon saturation scale in high density QCD or perhaps to the initial density in the Bjorken picture.**

$$\omega \approx \langle m_T \rangle \frac{3\, dN_\pi / dy}{\pi R^2} \propto Q_s^3$$



- *J. Phy. G: Nucl. Part. Phys. 28 (2002)2102*

Fuquiang Wang:

$$\omega \approx \langle m_T \rangle \frac{3\left(dN_\pi / dy\right)_{cent}}{\pi R^2} \left[\frac{dN_\pi / dy}{\left(dN_\pi / dy\right)_{cent}} \right]^{1/3}$$

Charge particle density (dN/dη) and Bjorken Energy

Bjorken Energy density approach
PRD27, 140 (1983)

$$\epsilon \sim \frac{dE_T/dy}{\pi R^2 \tau_0}$$

Scaling dN/dη from pp to central PbPb collisions:

$$\epsilon \sim \frac{dE_T^{p+p}/d\eta}{\pi R_{p+p}^2 \tau_0} \sim \frac{\langle p_T^{p+p} \rangle}{A^{p+p}} \frac{dN^{p+p}}{d\eta} = \frac{\langle p_T^{pb+pb} \rangle}{A^{pb+pb}} \frac{dN^{pb+pb}}{d\eta}$$

?

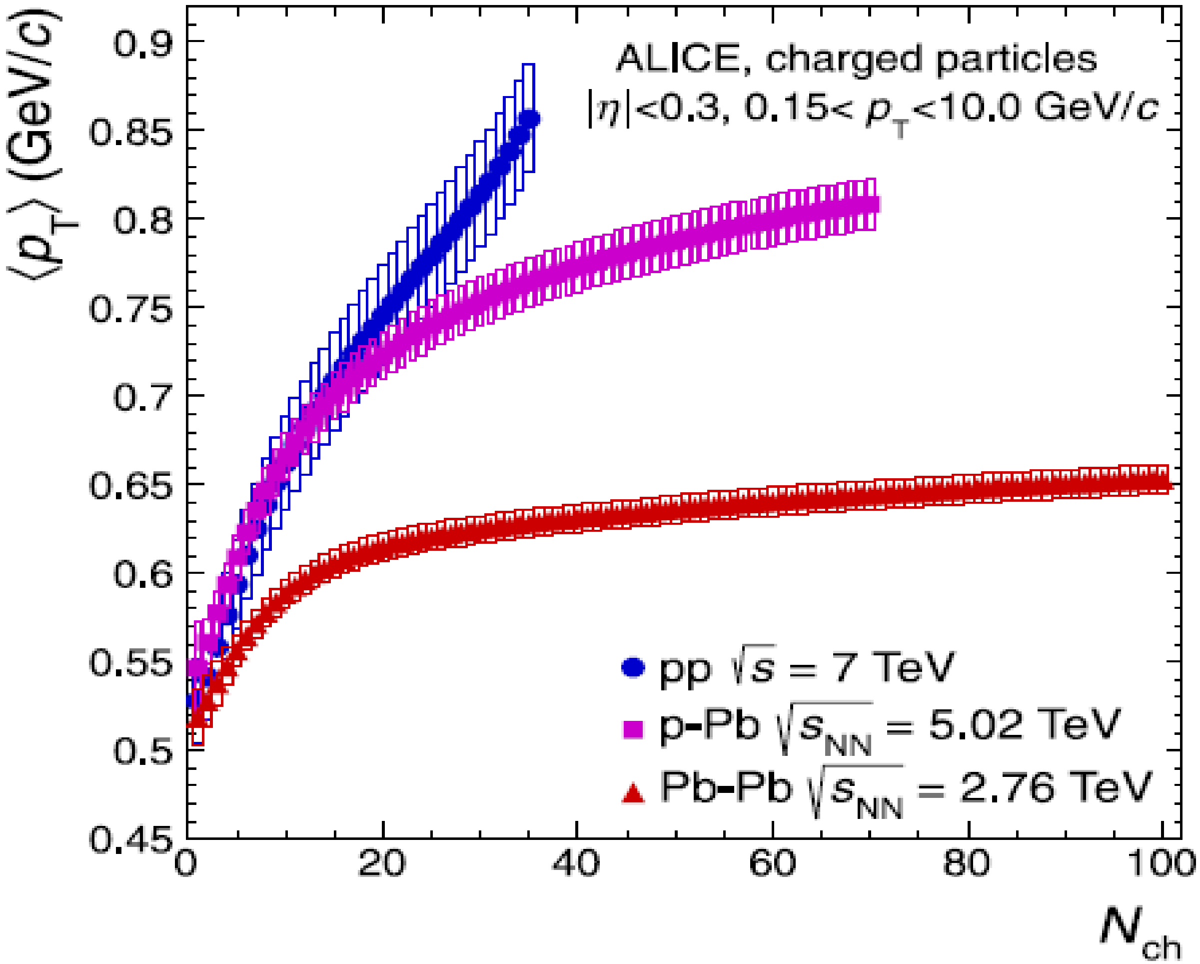
?

➔A is the overlap area between hadron/nucleus colliding

➔τ is the hadronization time

Average transverse momentum of charged particles

ALICE: PLB727, 371 (2013)



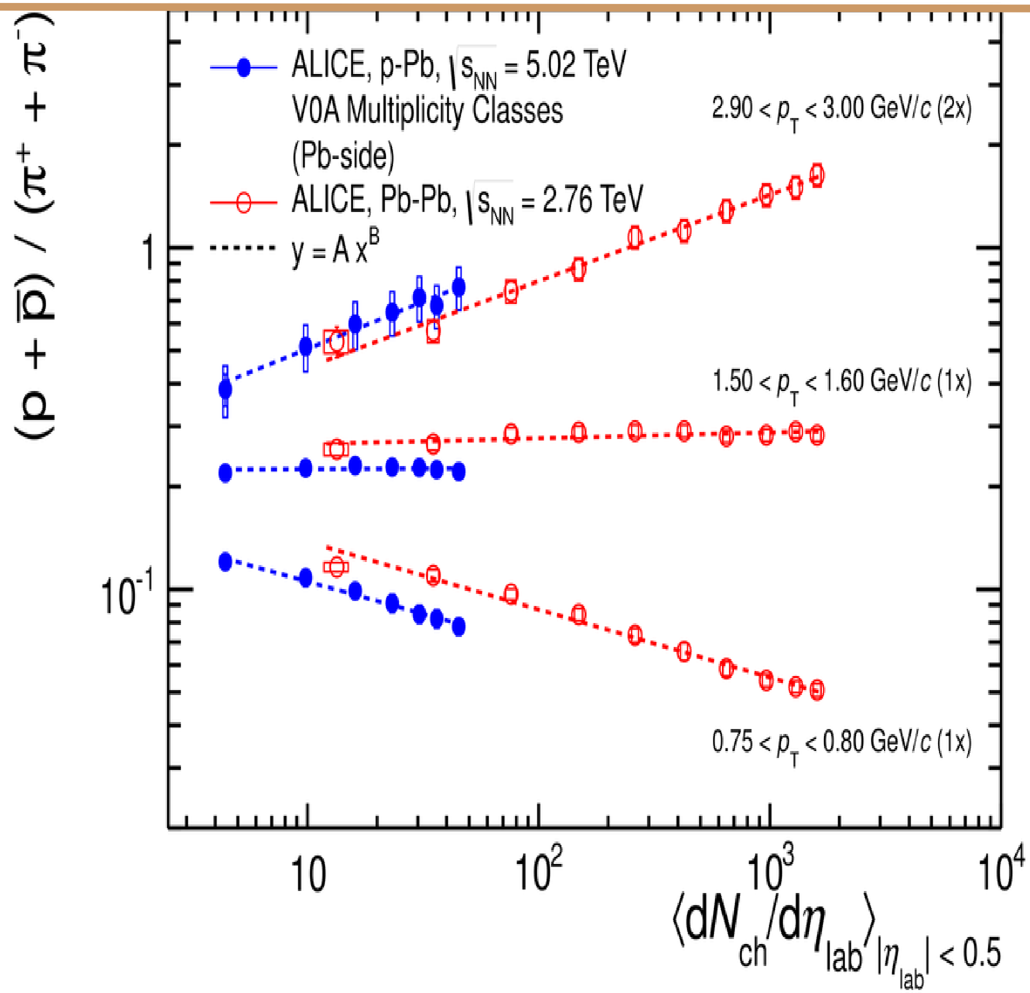
- <pT> seems to be function of the energy and the colliding system
- <pT> from p+p system is higher respect to those values from p+pb. pb+pb
- p-p is described by CR
- P-Pb qualitatively described by EPOS
- Pb-pb there is not model to describe it.

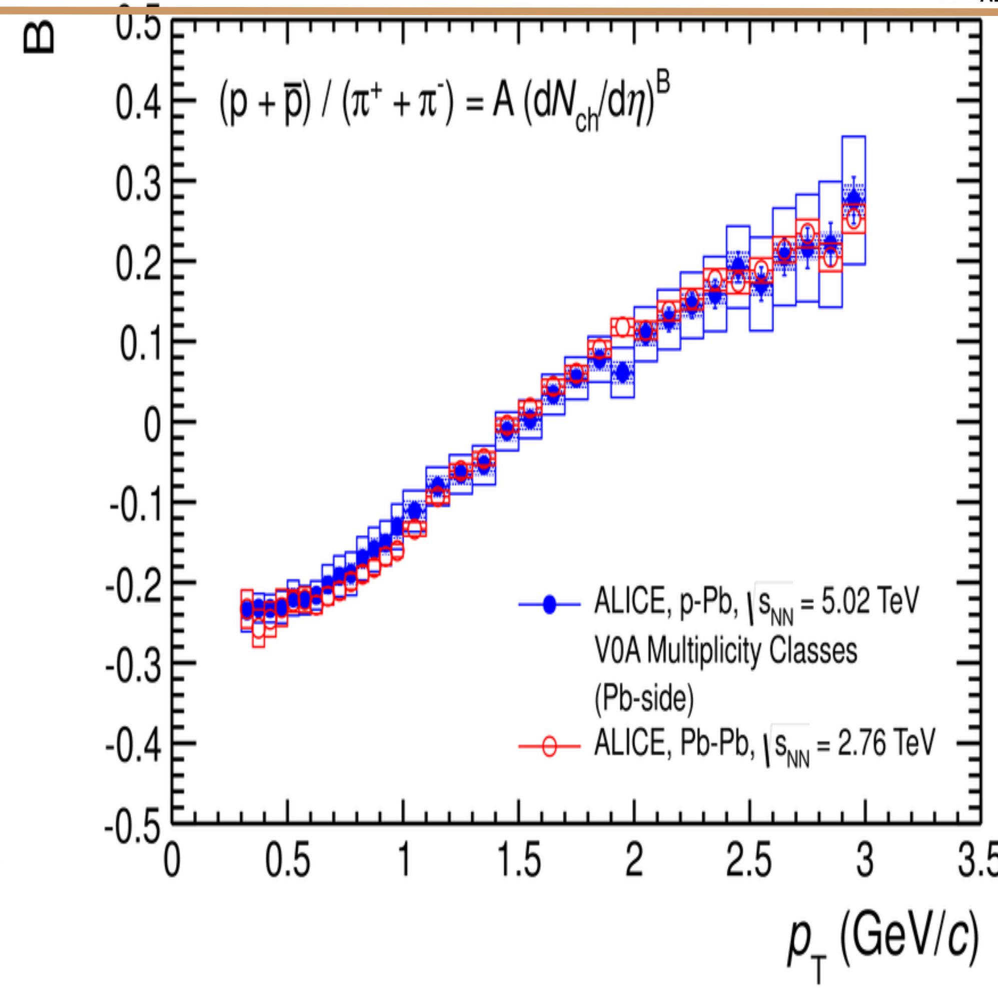
Scale variables to describe baryon to meson ratio:

$$\left(\frac{dN_{ch}}{d\eta}\right), \qquad p_T, \qquad \varepsilon$$

Probably combination of some variables

p/π Ratio vs dNch/dη & p_T



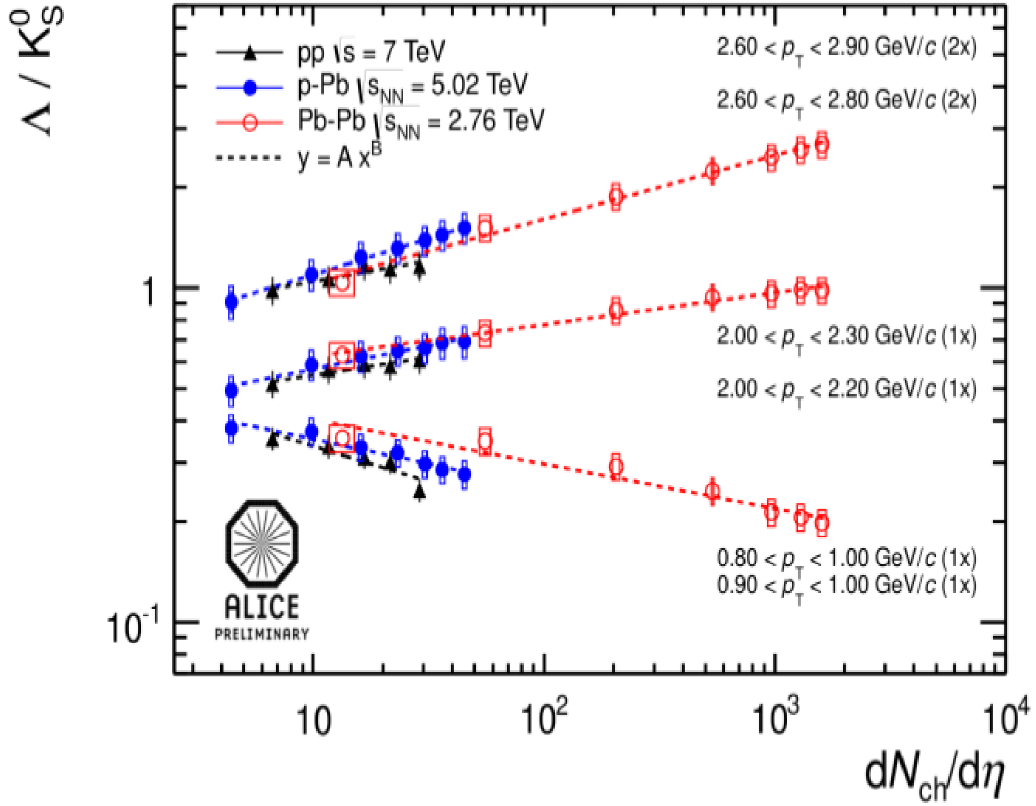


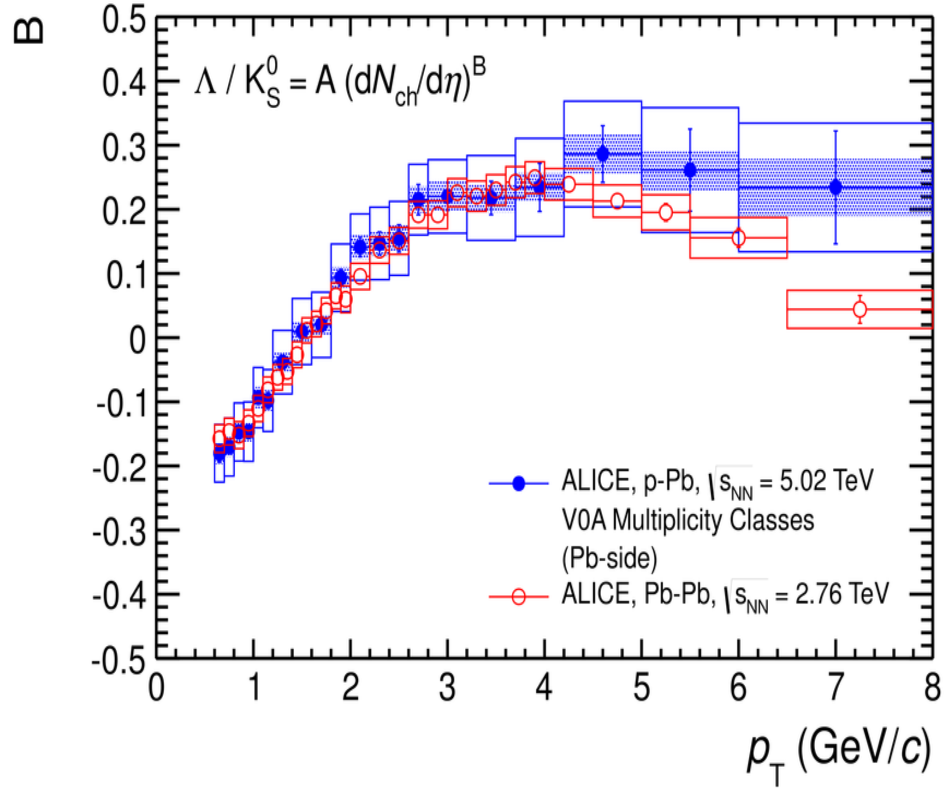
p/π ratio follows power law behavior with dNch/dη. **This Evolution is identical in p-Pb as in Pb-Pb!**
ALICE: LB728, 25 (2014)

What does this behavior is telling us?

$$\frac{p}{\pi}(p_T) = A(p_T)\left(\frac{dN_{ch}}{d\eta}\right)^{B(p_T)}$$

Λ/K ratio vs dNch/dη & p_T





- ~ **Same B values for pp, p-Pb, Pb-Pb!**
- **Is there a common mechanism for the ratio evolution in pp, p-Pb, Pb-Pb???**
- **Similar physics?**
- **Across systems, sizes/geometries, energies?**

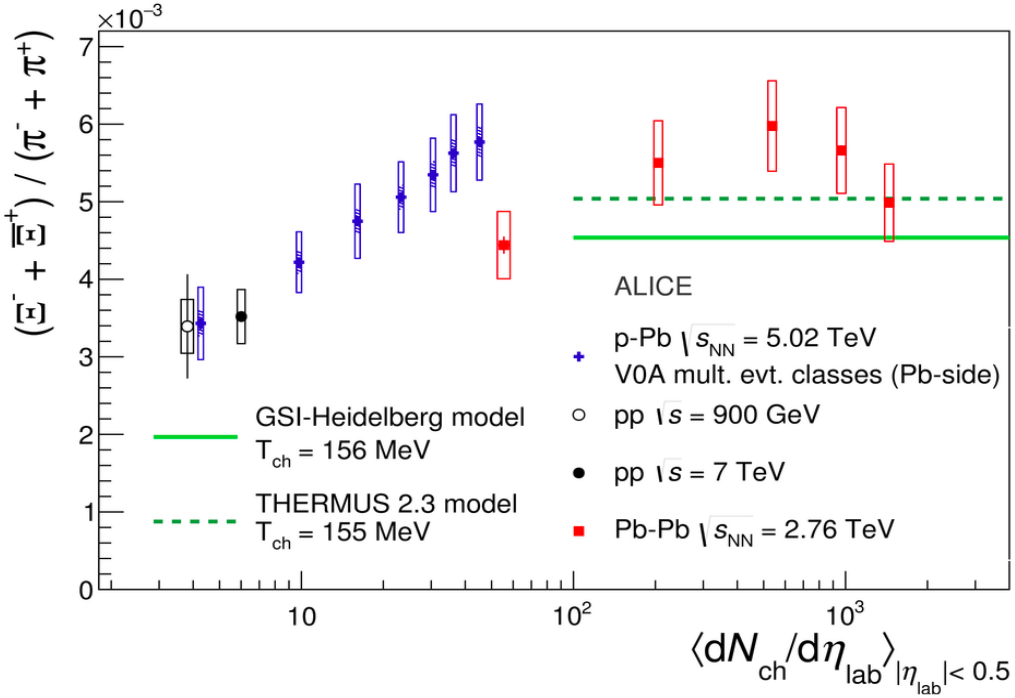
Extended p_T range

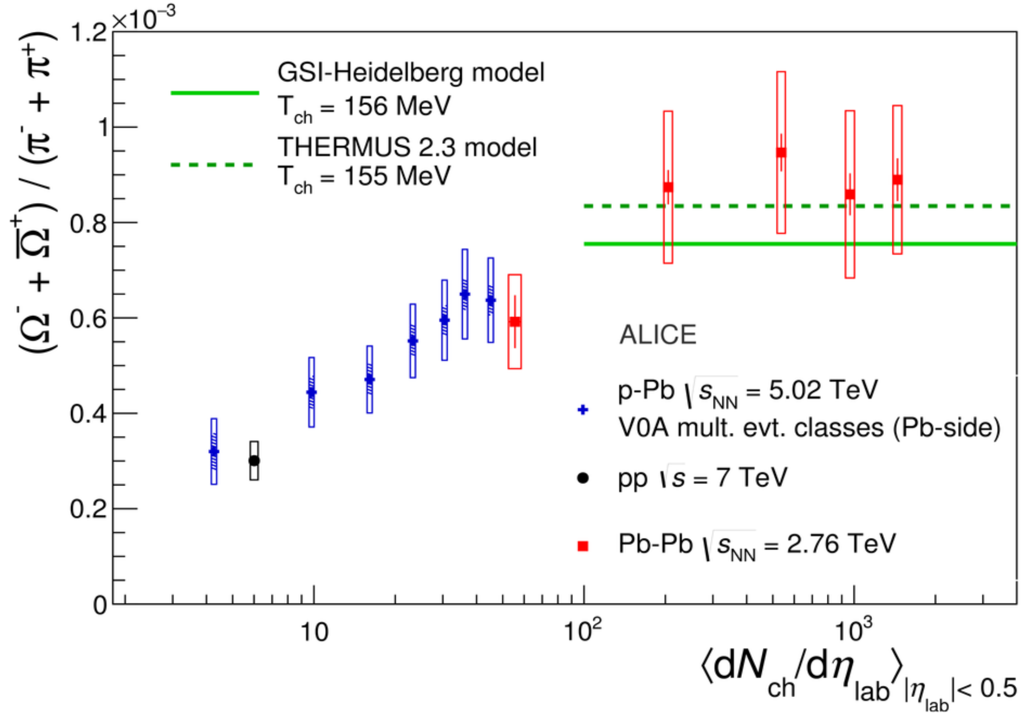
$$\frac{\Lambda}{K}(p_T) = A(p_T)\left(\frac{dN_{ch}}{d\eta}\right)^{B(p_T)}$$

Strangeness production as function of energy density (τε)

Multi- strange hadron to pion ratios vs energy density

ALICE: ArXiv: 1512.07227





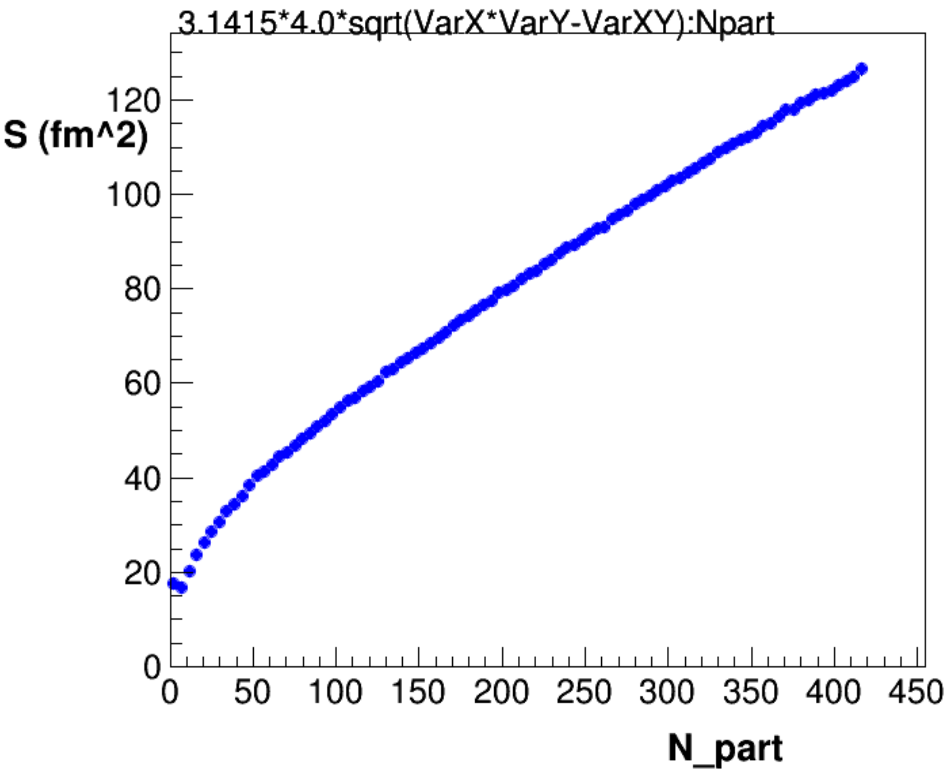
$$\epsilon \sim \frac{dE_T^{p+p}/d\eta}{\pi R^2_{p+p}\tau_o} \sim \frac{\langle p_T^{p+p}\rangle}{A^{p+p}}\frac{dN^{p+p}}{d\eta} = \frac{\langle p_T^{pb+pb}\rangle}{A^{pb+pb}}\frac{dN^{pb+pb}}{d\eta}$$

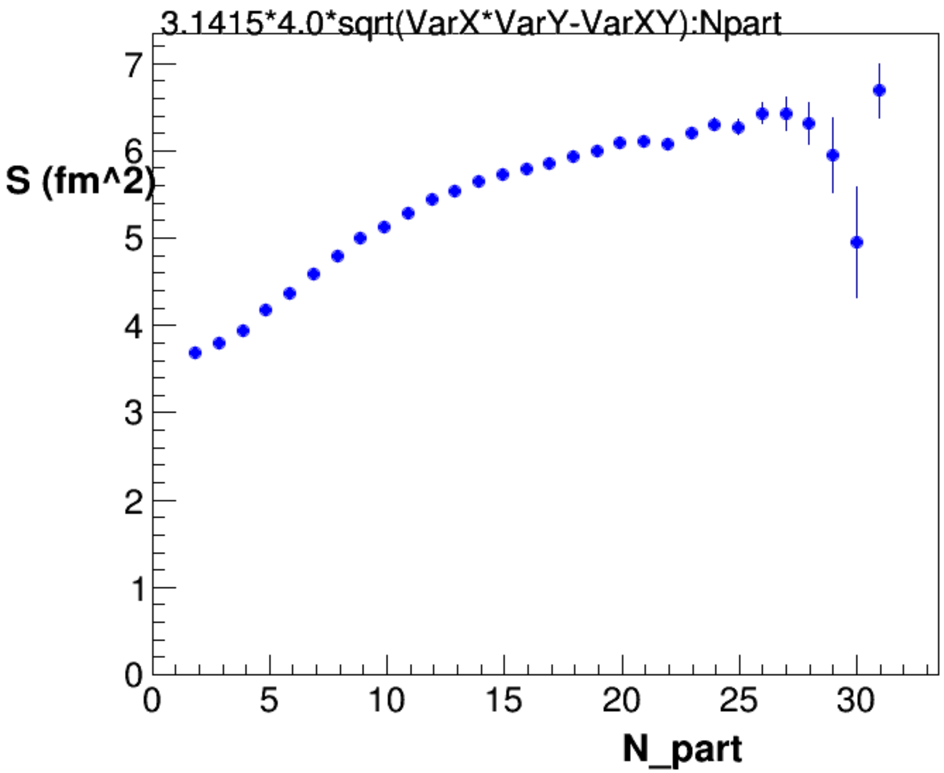
?

?

Overlap area by Glauber model

From centrality bins and the number of participants we get area

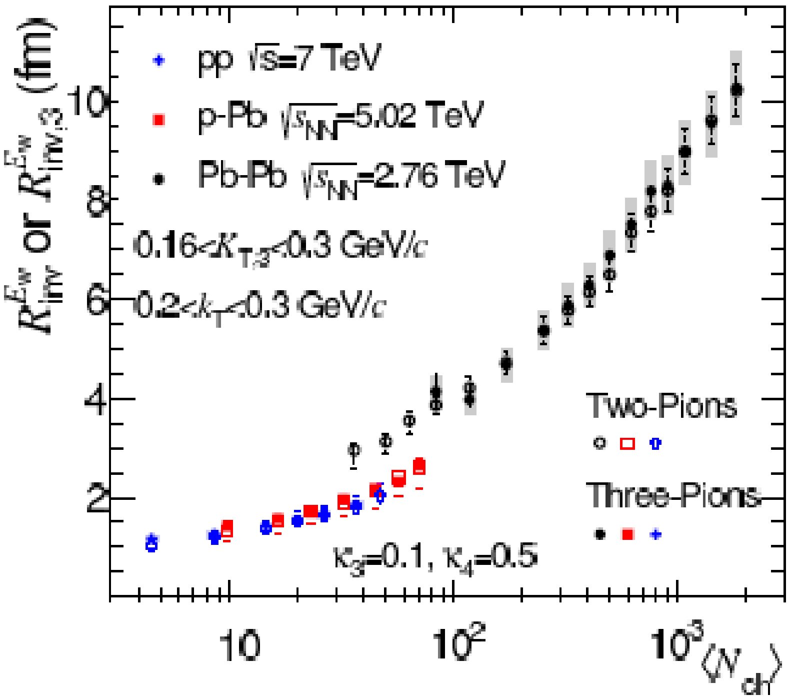




Overlap area calculated for Pb+Pb
The number of participants is uded to get the centrality and multiplicity.

Overlap area calculated for p+Pb
The number of participants is uded to get the centrality and multiplicity.

Experimental Invariant Radii from momentum correlations



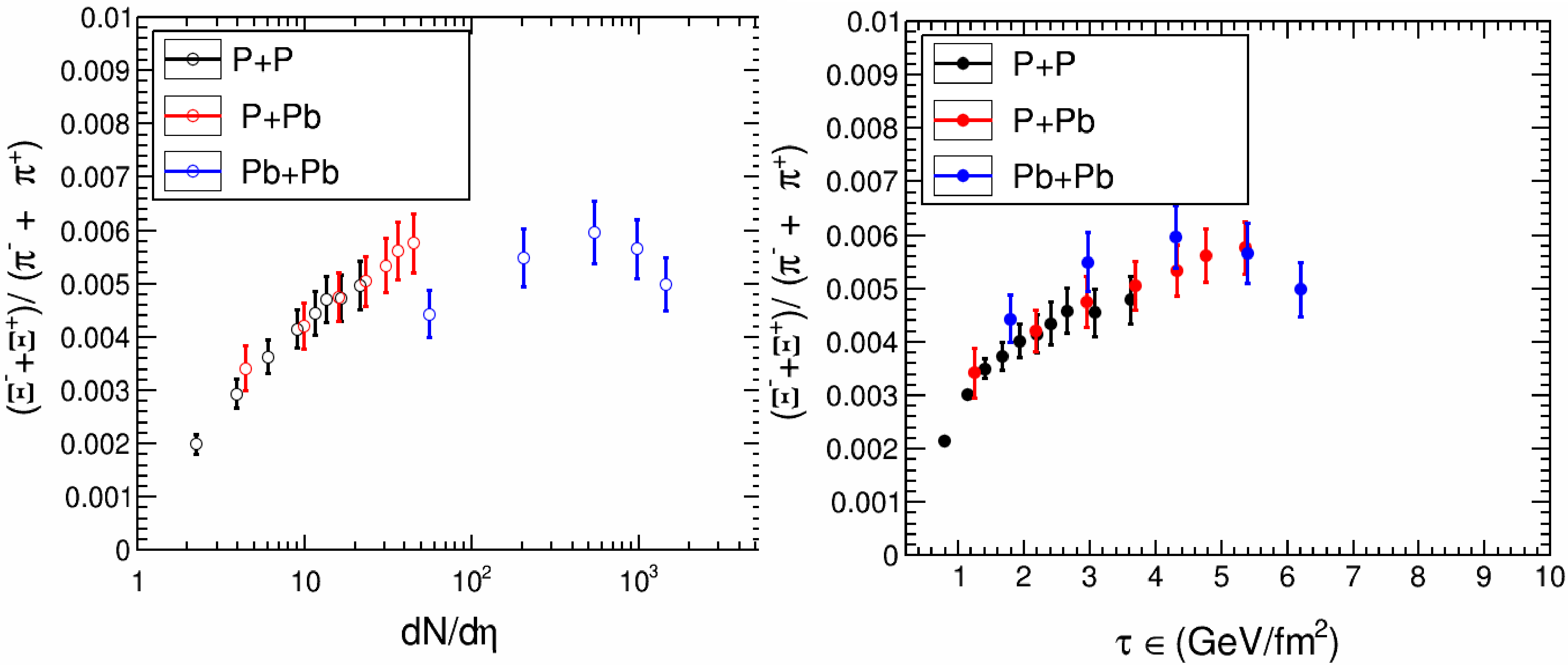
PLB739 (2014)139

- **Radii depend on the multiplicity, the transverse momentum of the pairs.**
- **The radii for p+p and p+Pb seems to be the same**

$$R_{p+p}(N_i) = 0.405 \frac{dN_i^{1/3}}{d\eta} + 0.332$$

$$R_{Pb+Pb}(N_i) = 0.772 \frac{dN_i^{1/3}}{d\eta} + 0.049$$

Ξ/π ratio vs dN/dη, & τε

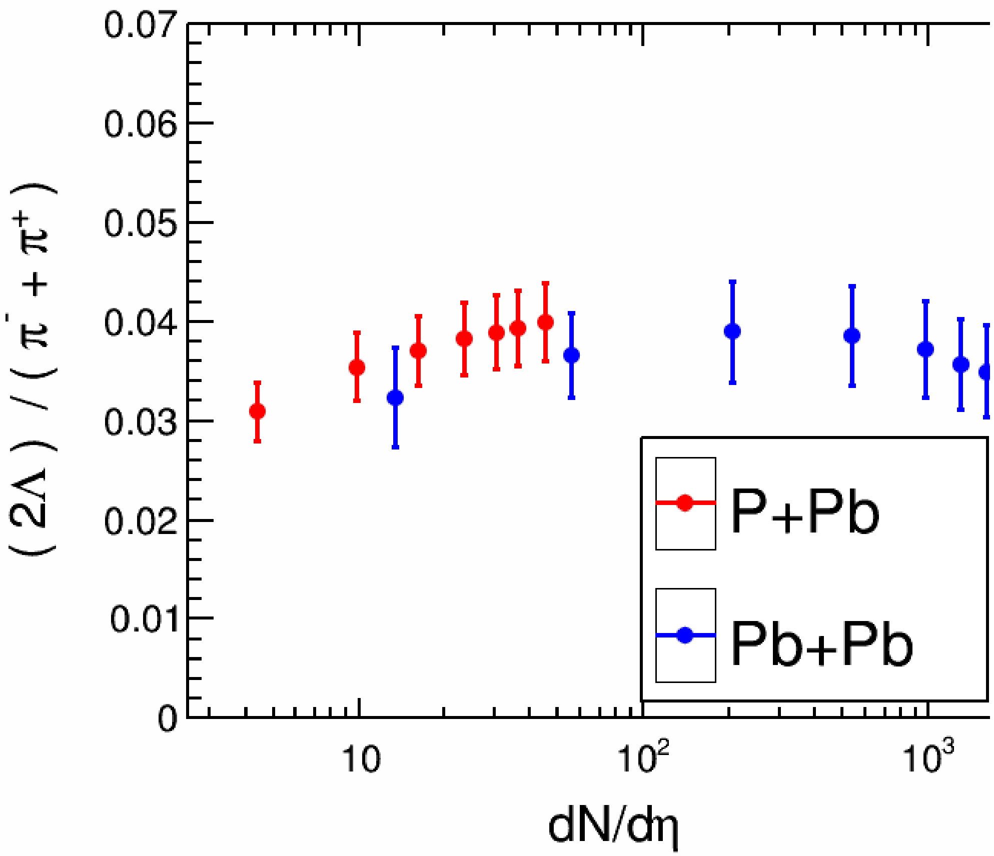


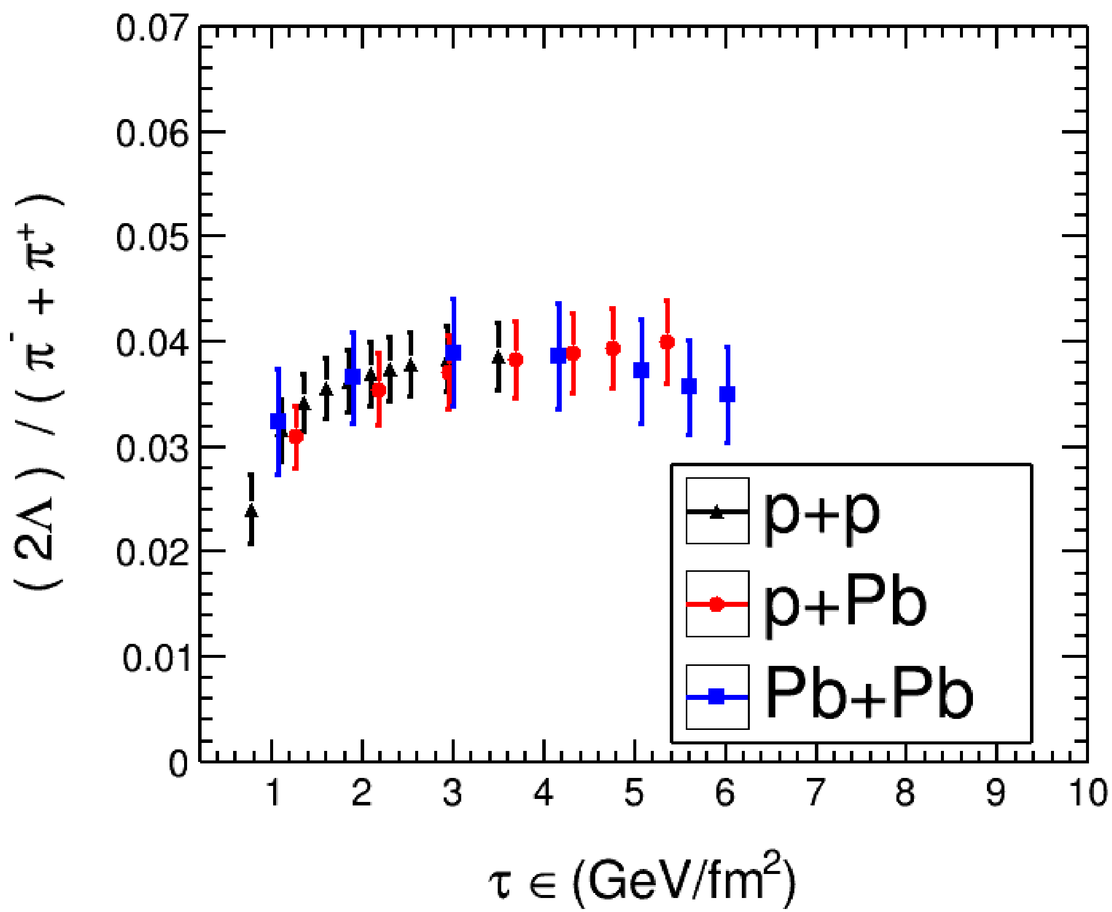
Ξ/π ratio vs dN/dη could not be the best variable to describe the ratio

The energy density (ε) seems to be the better, at least for the Ξ/π.

How important is to reach higher multiplicity in p-p instead of pb-pb?

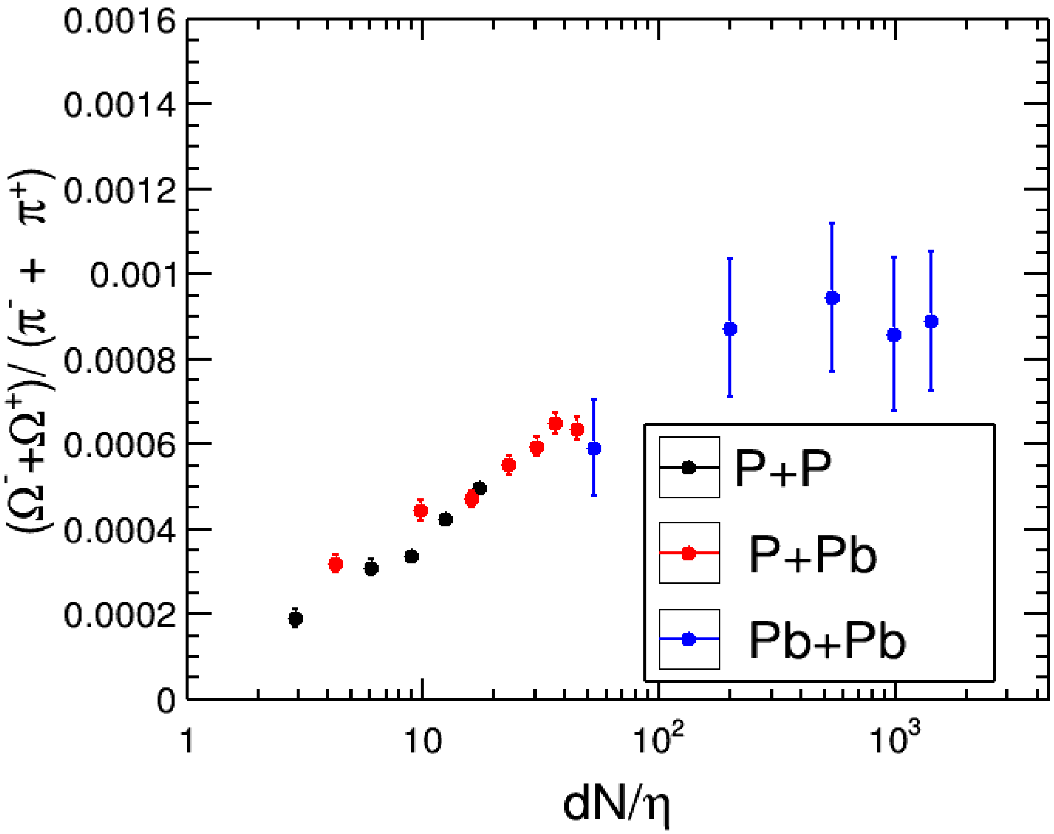
Λ/π ratio vs dN/dη & τε

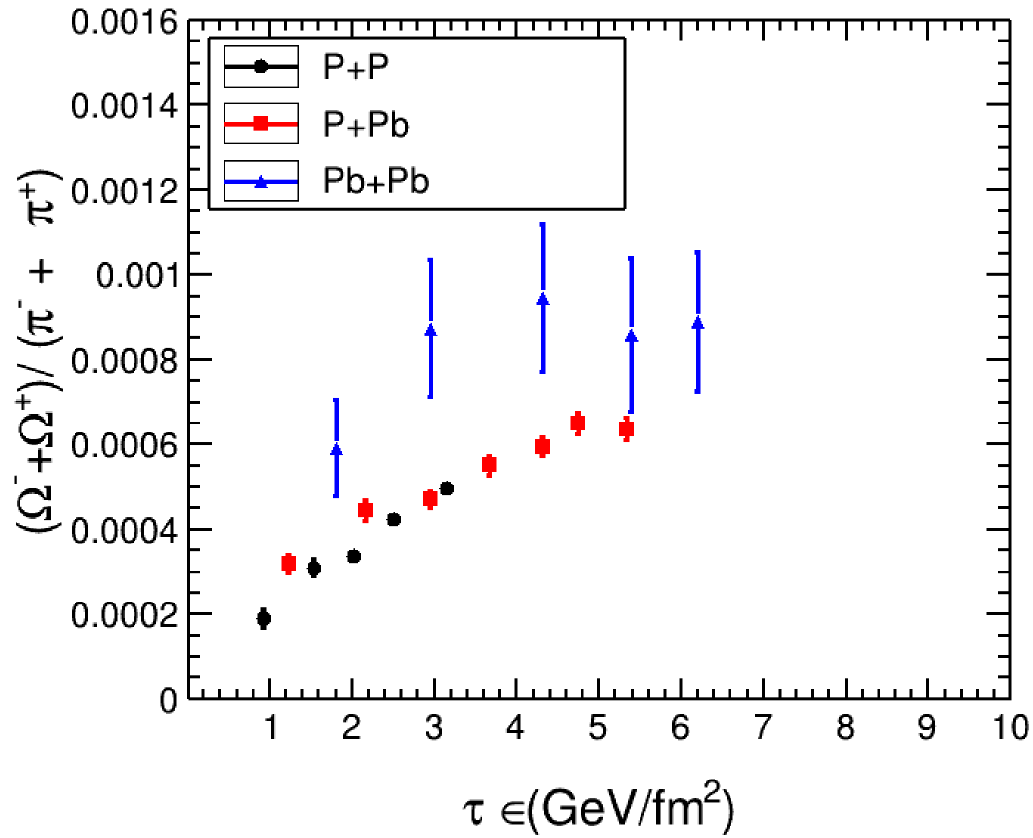




- ***Λ/π vs dN/dη could not be the best variable to describe the ratio***
- ***The energy density (tε) seems to be the better, at least for the Λ/π.***

Ω/π ratio vs dN/dη & τε





- **Ω/π ratio vs dN/dη could not be the best variable to describe the ratio**
- **The energy density (ε) seems to be the better, at least for the Ω/π.**
- **At the same ε the strangenes is enhancement in heaviest systems!**

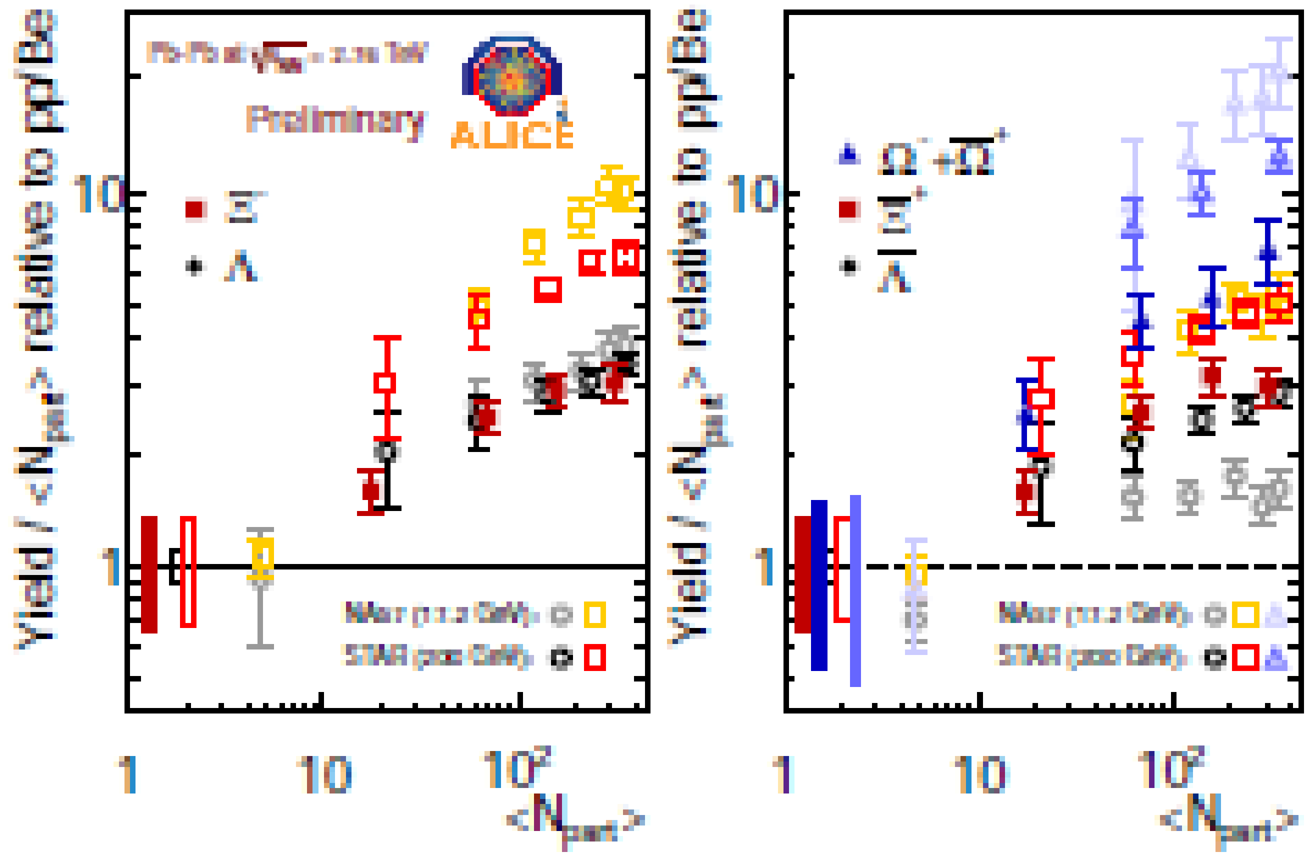
Conclusions

✔ The multiplicity could not be the best variable to describe baryons to meson ratios (may be on pt intervals?)

✔The Ξ/π (Λ/π) ratio presents a scaling with the Bjorken energy density.

✔The observed scaling does not indicate saturation of the ratio hyperon to pions as proposed by the thermal model

✔Does the highest multiplicity in p+p events provides more information than the Pb+Pb at the same multiplicity?

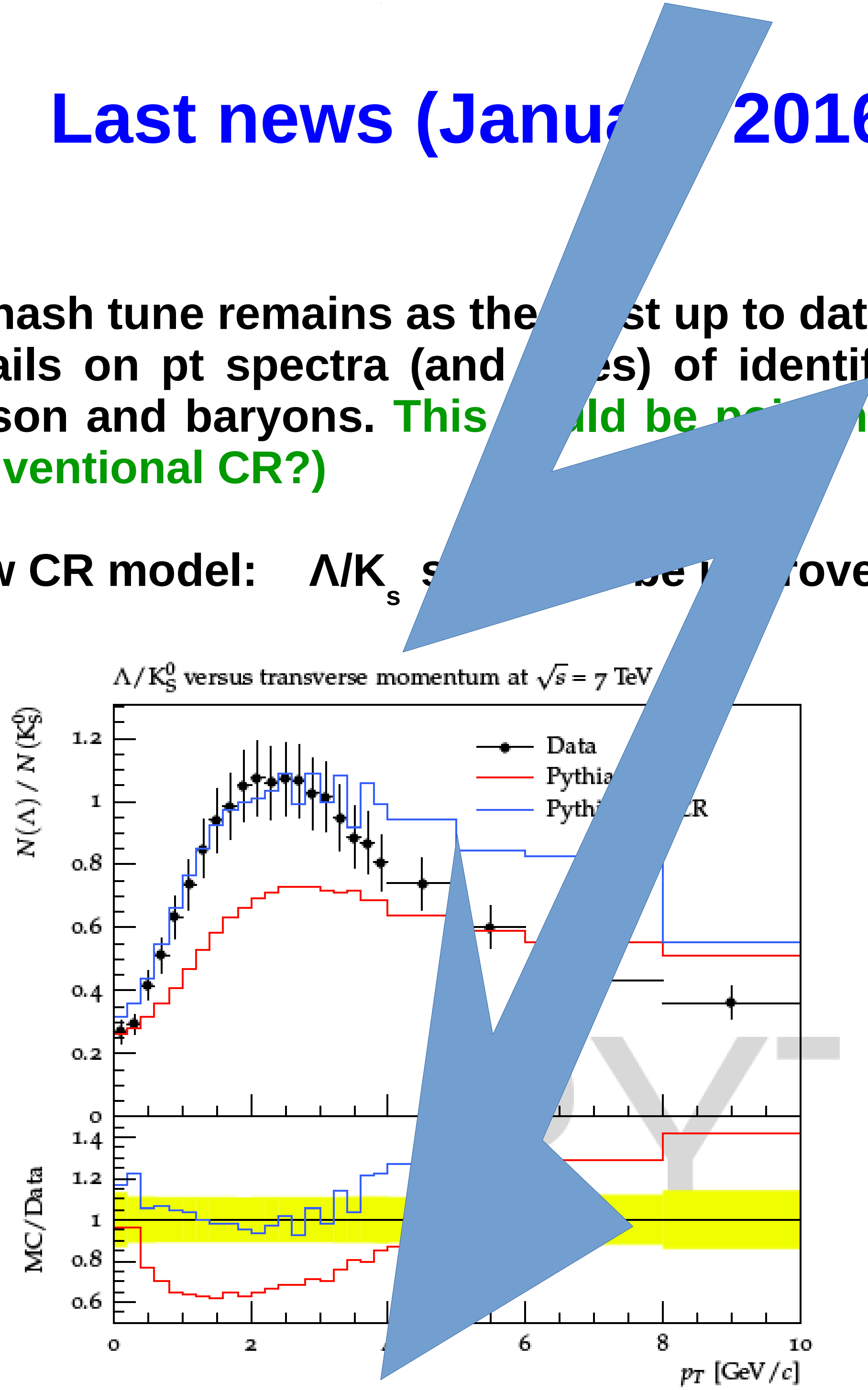


Preliminary
ALICE
10
1
Yield / <N_part> relative to pp/Be
1
10
10^2
<N_part>

Last news (Janua 2016) on Pythia 8

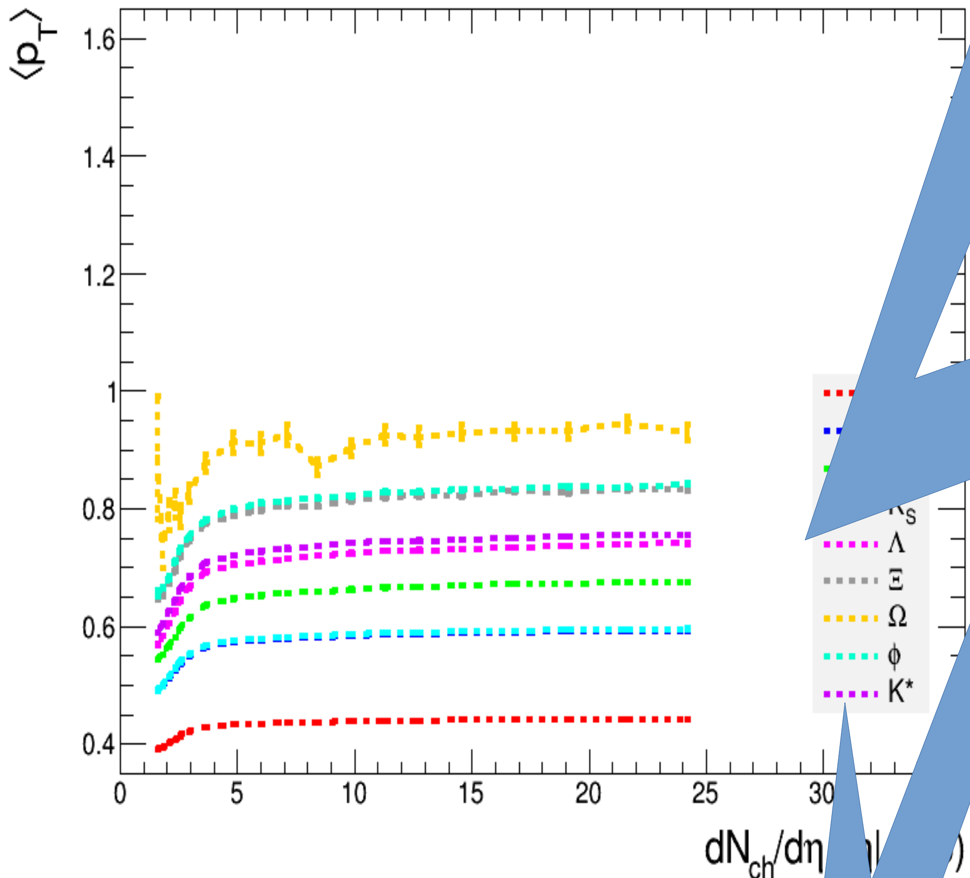
Monash tune remains as the st up to date one:
It fails on pt spectra (and es) of identified particles, especially strange meson and baryons. This ld be p ig to interesting physics (beyond conventional CR?)

New CR model: Λ/K_s s be roved but Ξ/Λ remain the same

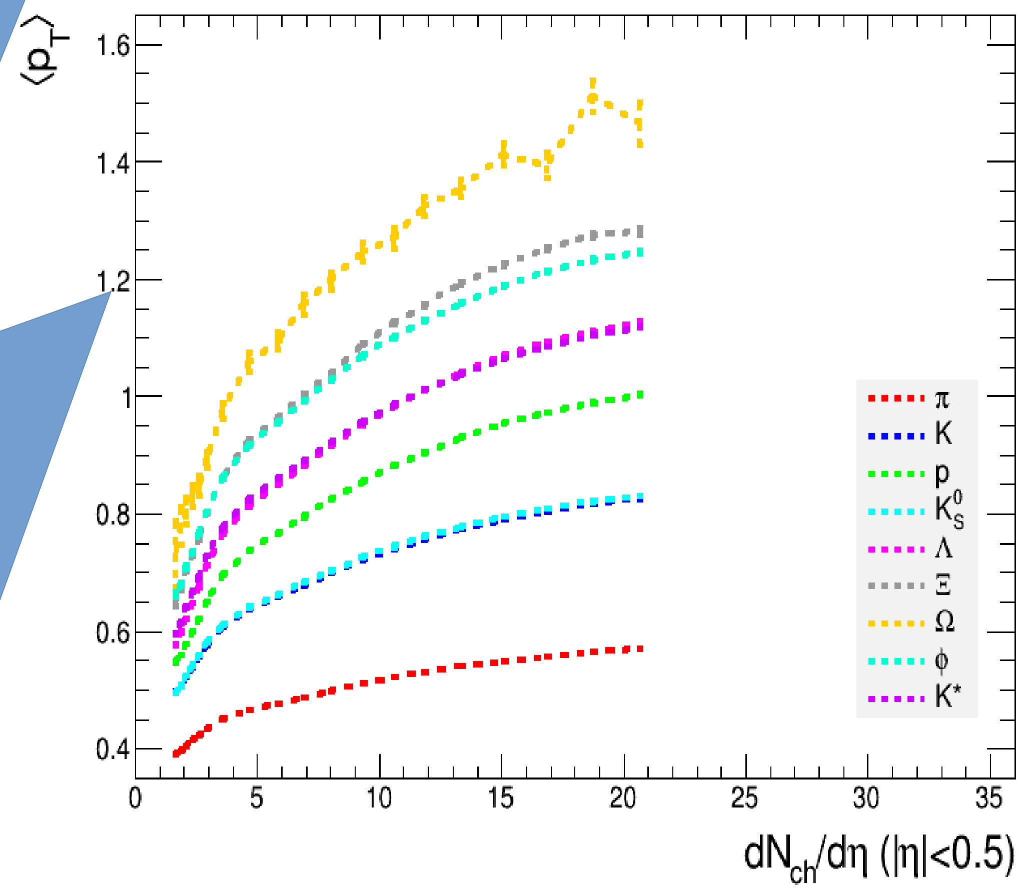


Pythia Status Report,
Stephen Mrenna,
January 11, 2016

$<p_T>$ on Strangeness from Pythia 8



Pythia Monash w/o

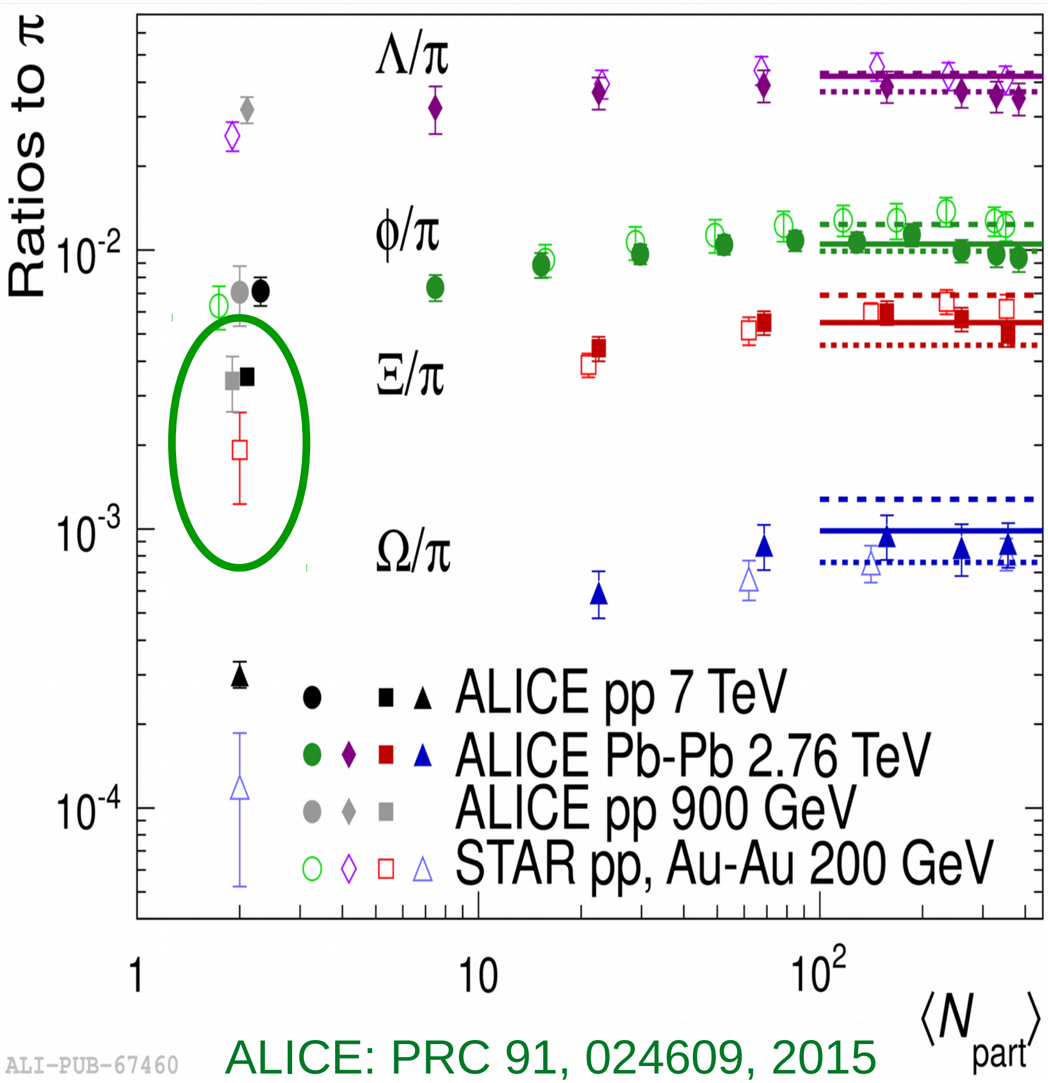


Pythia Monash CR

Is well known that Pythia eproduce many of the data, but fail to reproduce the Strangeness production. CR help to improve the results but still we need more precisión

Strangeness production vs N_{part}, $dN/d\eta$

Strangeness to pion ratios



Ratios of strange particle to pion at different energies as function of number of participants.

Does the ratio saturate as N_part increase?

The lines show ratios given by grand-canonical thermal models with temperatures of

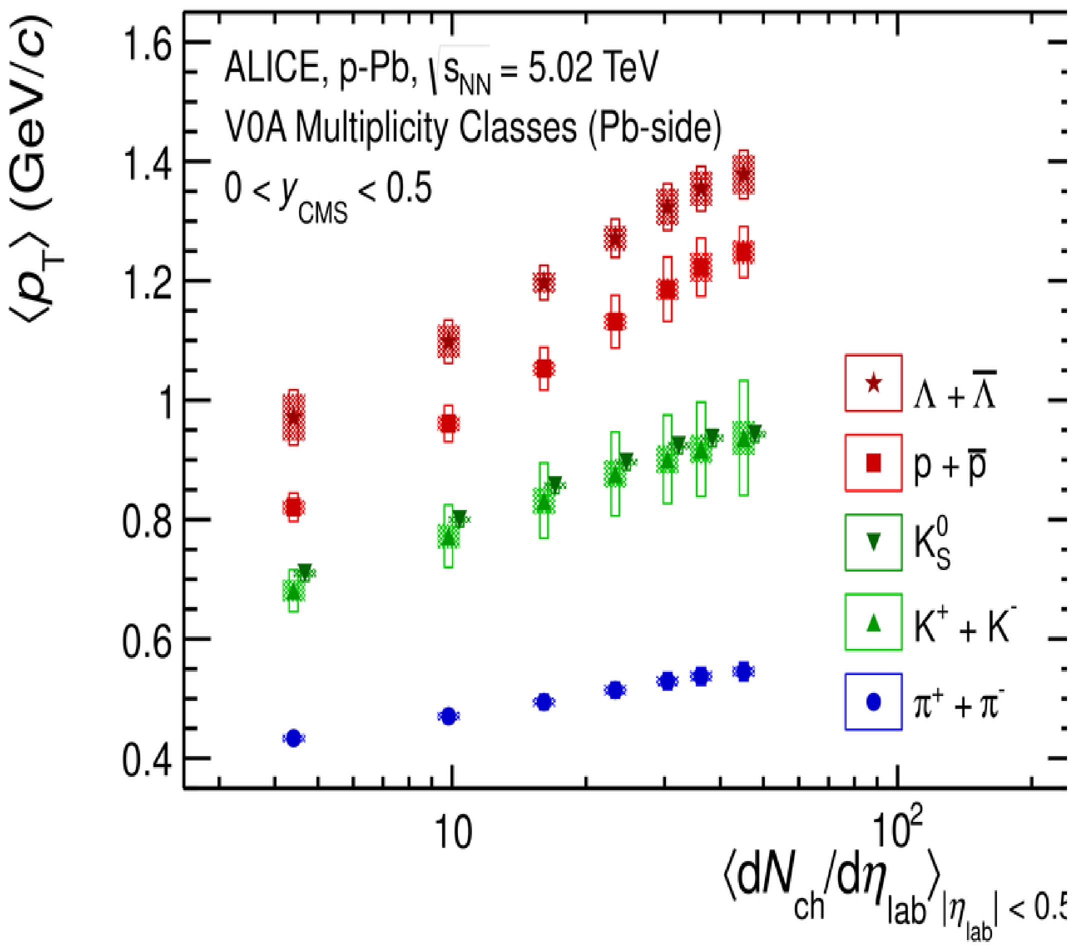
170 MeV (upper dashed lines),

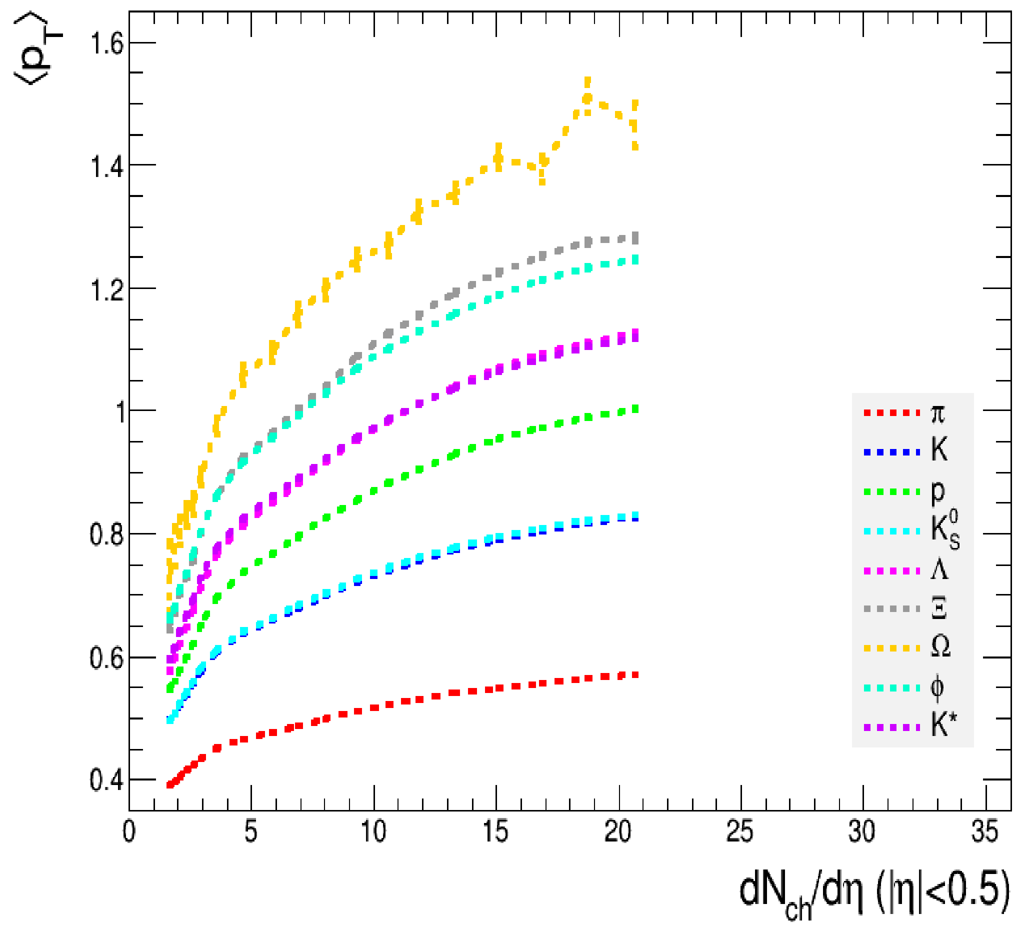
164 MeV (solid lines),

156 MeV (lower dashed lines).

The multi-strange hadrons to pion ratio seems to follow certain scale

<p_T> vs multiplicity for strangeness, experimental vs Pythia





- Raising trend of <pT> for all species
- Mass and strangeness content ordered

- The same behavior is observed for pp at 7 TeV

ALICE: PLB 728, 25 (2014)

Pythia; pp simulations with CR, The results present the same trend as the data.