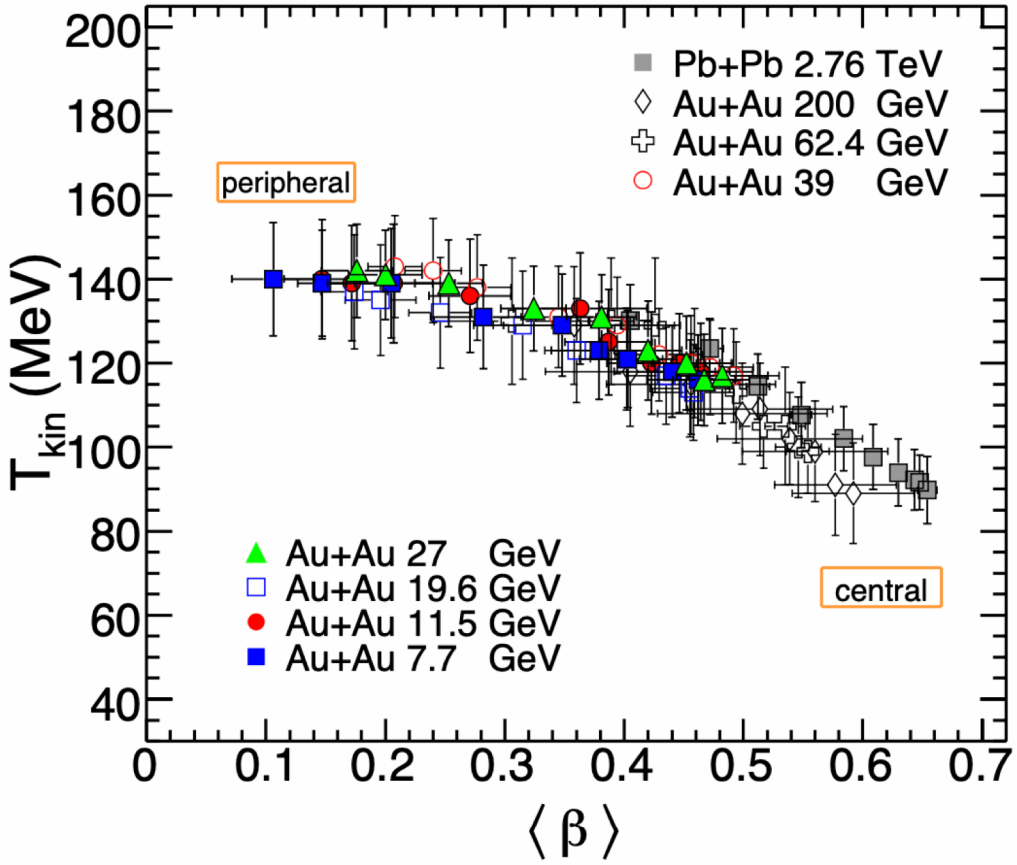
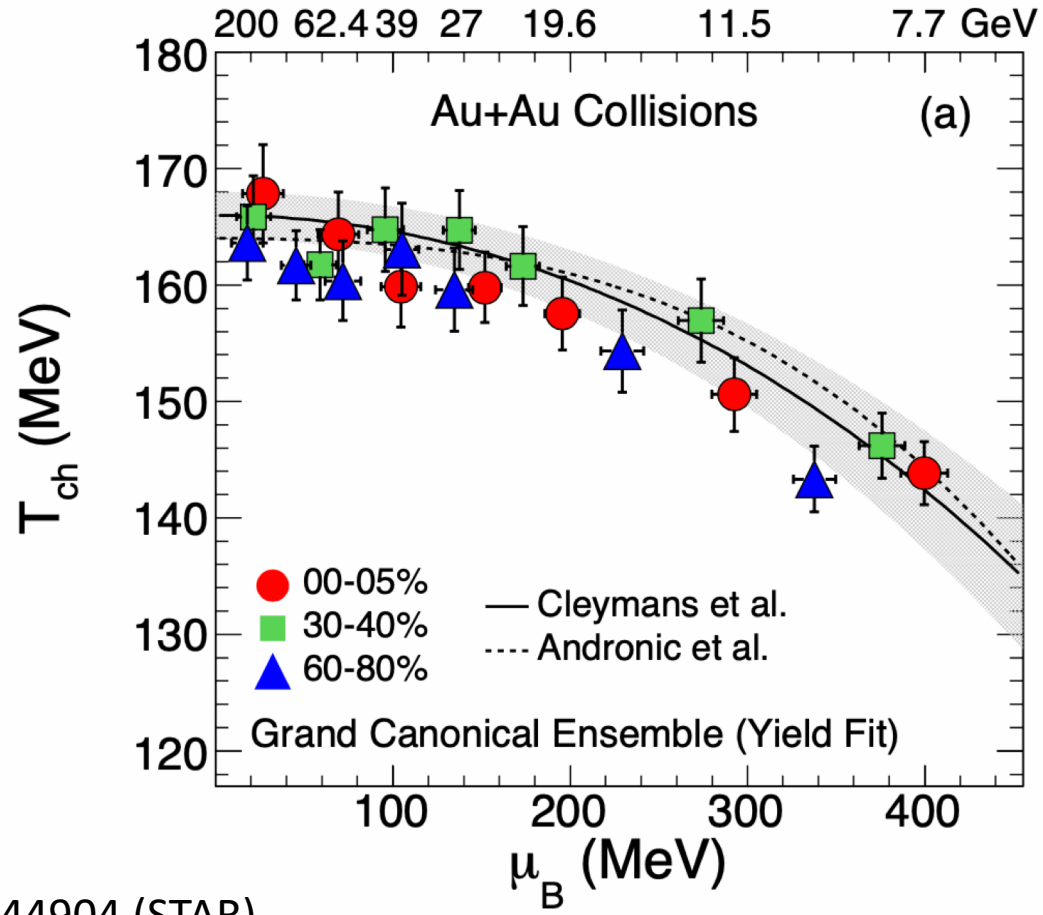
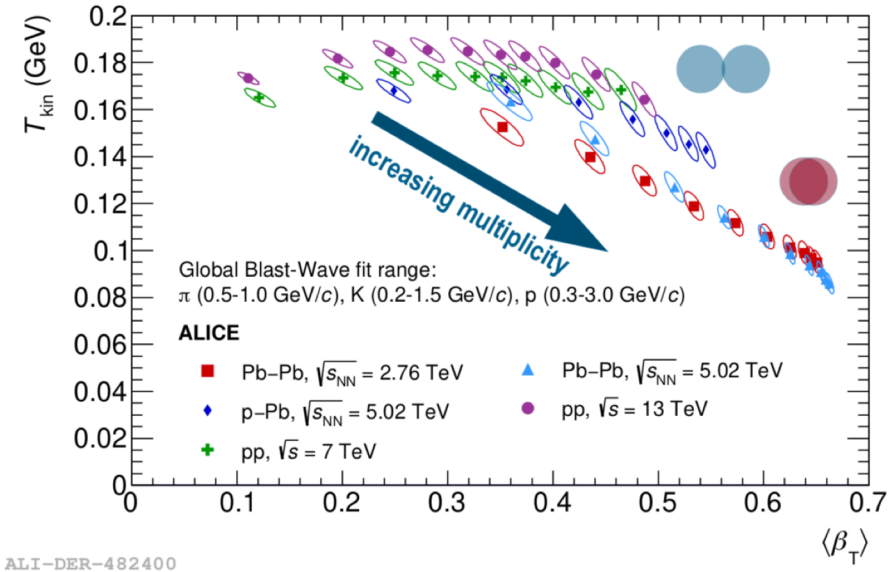
T_{kin} vs β_T at kinetic freeze-out
with Blast wave model fitting

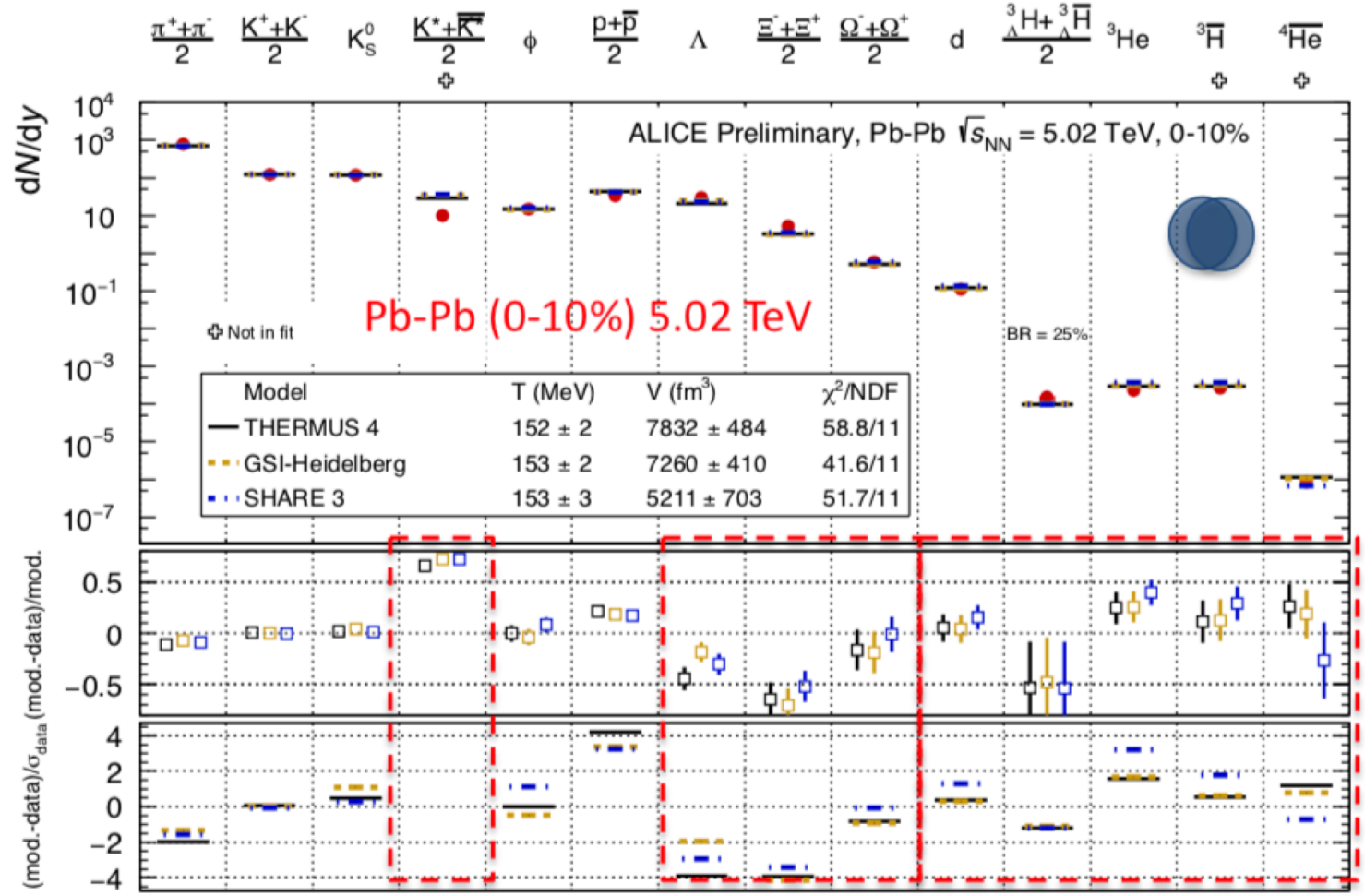


T_{ch} vs μ_B at chemical freeze-out
by fitting yields and ratios of hadrons

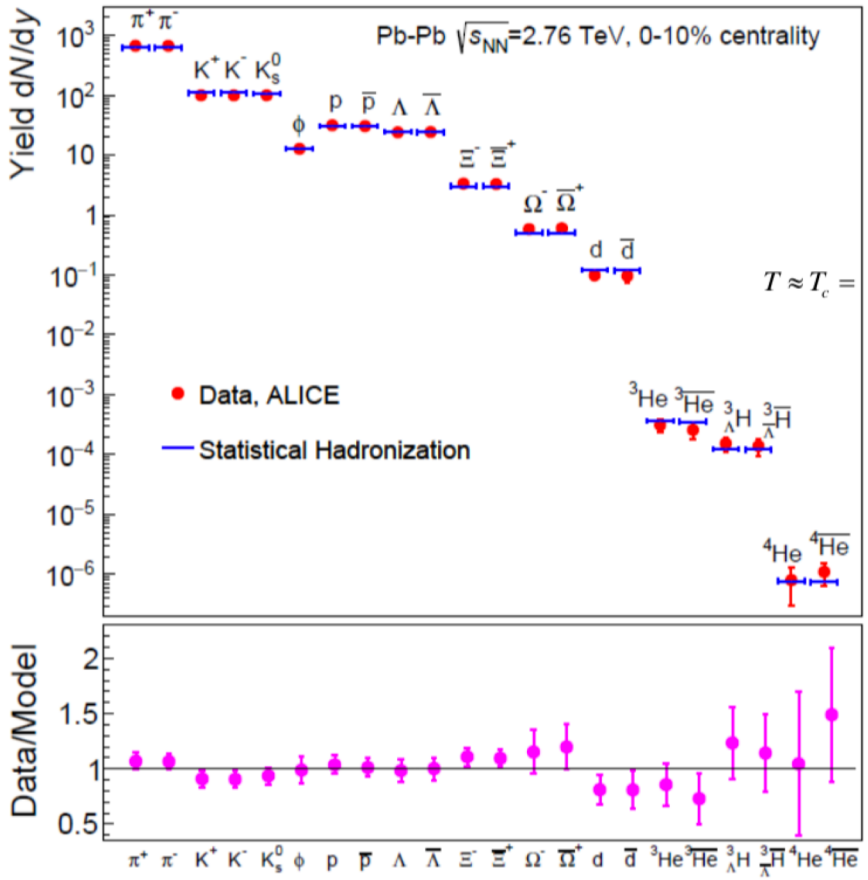


PRC **96** (2017) 44904 (STAR)


T_{kin} (GeV)
$\langle\beta_T\rangle$
increasing multiplicity
Global Blast-Wave fit range:
π (0.5-1.0 GeV/c), K (0.2-1.5 GeV/c), p (0.3-3.0 GeV/c)
ALICE
Pb–Pb, $\sqrt{s_{NN}}$ = 2.76 TeV
Pb–Pb, $\sqrt{s_{NN}}$ = 5.02 TeV
p–Pb, $\sqrt{s_{NN}}$ = 5.02 TeV
pp, $\sqrt{s}$ = 13 TeV
pp, $\sqrt{s}$ = 7 TeV
ALI-DER-482400


ALICE Preliminary, Pb-Pb $\sqrt{s_{NN}}$ = 5.02 TeV, 0-10%
Pb-Pb (0-10%) 5.02 TeV
dN/dy
Not in fit
BR = 25%
Model | T (MeV) | V (fm³) | χ²/NDF
THERMUS 4 | 152 ± 2 | 7832 ± 484 | 58.8/11
GSI-Heidelberg | 153 ± 2 | 7260 ± 410 | 41.6/11
SHARE 3 | 153 ± 3 | 5211 ± 703 | 51.7/11
(mod.-data)/mod.
(mod.-data)/σdata
ALI-PREL-332406

S-matrix HRG and particle yields in Pb-Pb collisions at the LHC



$$P^{regular}(T,\vec{\mu}) \approx \sum_H P_H^{id} + \sum_R P_R^i$$

The S-matrix HRG model formulated in GC ensemble that incudes empirical information on pion-nucleon interactions provides a very good description of LHC yields data

- Measured yields reproduced at

$T = 156.6 \pm 1.7 \text{MeV}$

$\mu = 0.7 \pm 3.8 \text{ MeV}$

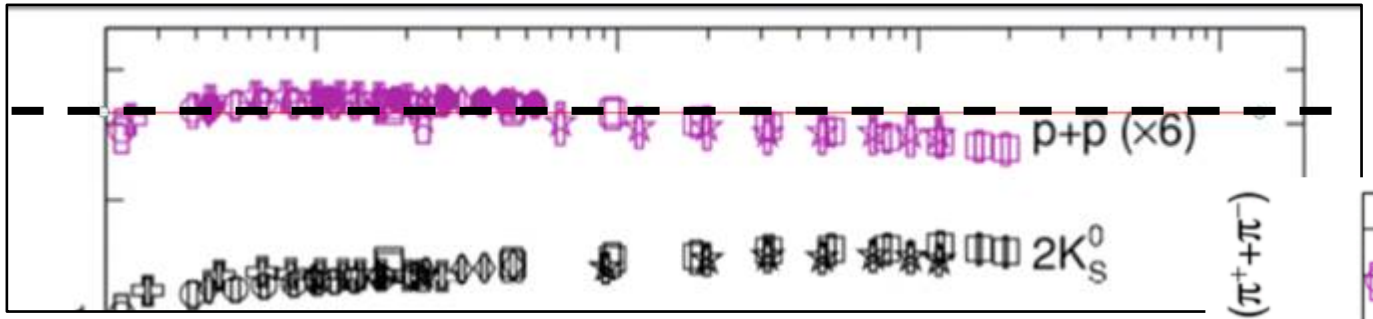
$V_{\Delta y=1} = 4175 \pm 380 \text{ fm}^3$

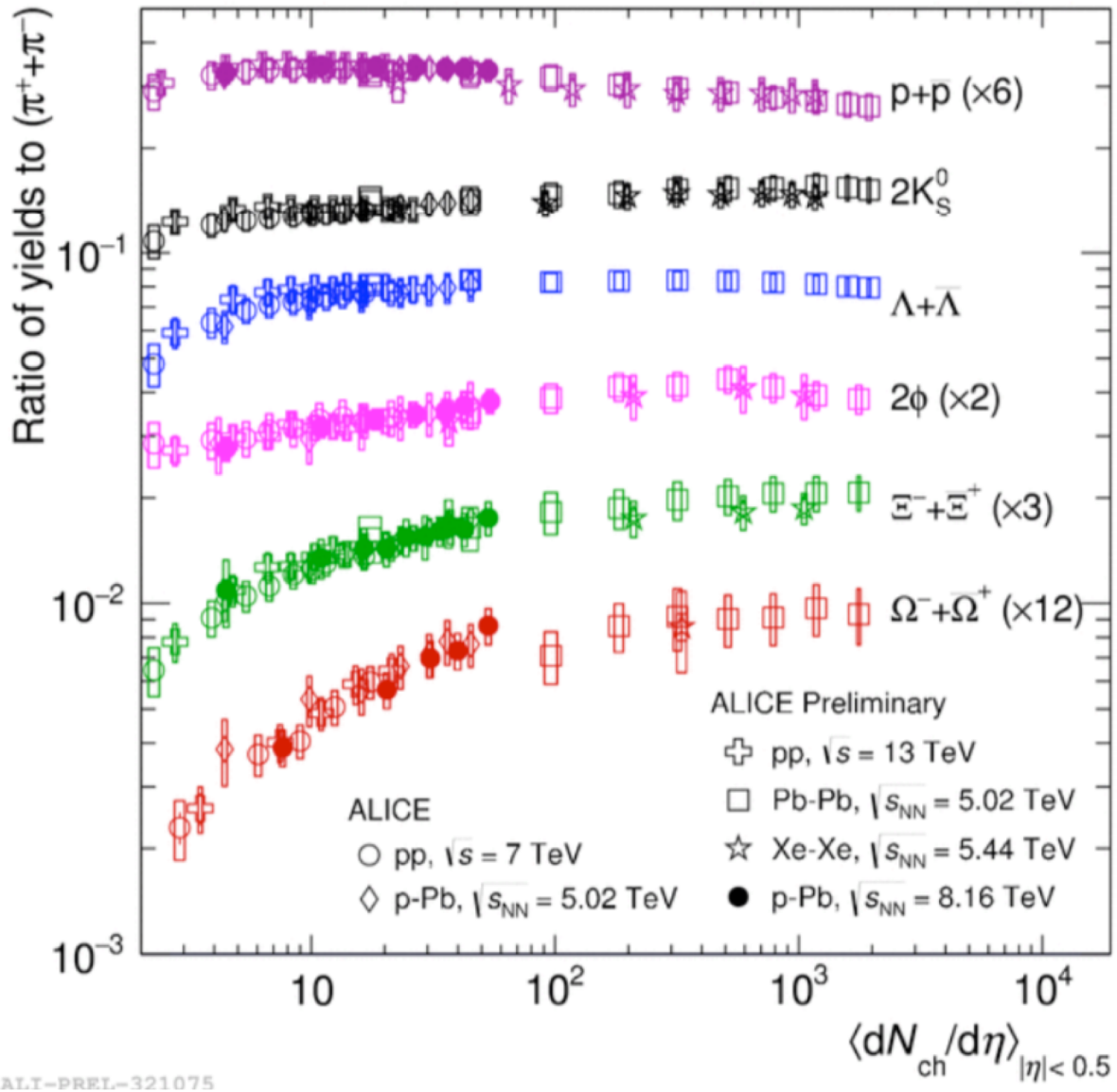
$\chi^2 / dof = 16.7/19$

- A fireball in central Pb-Pb collisions is matter at the QCD phase boundary

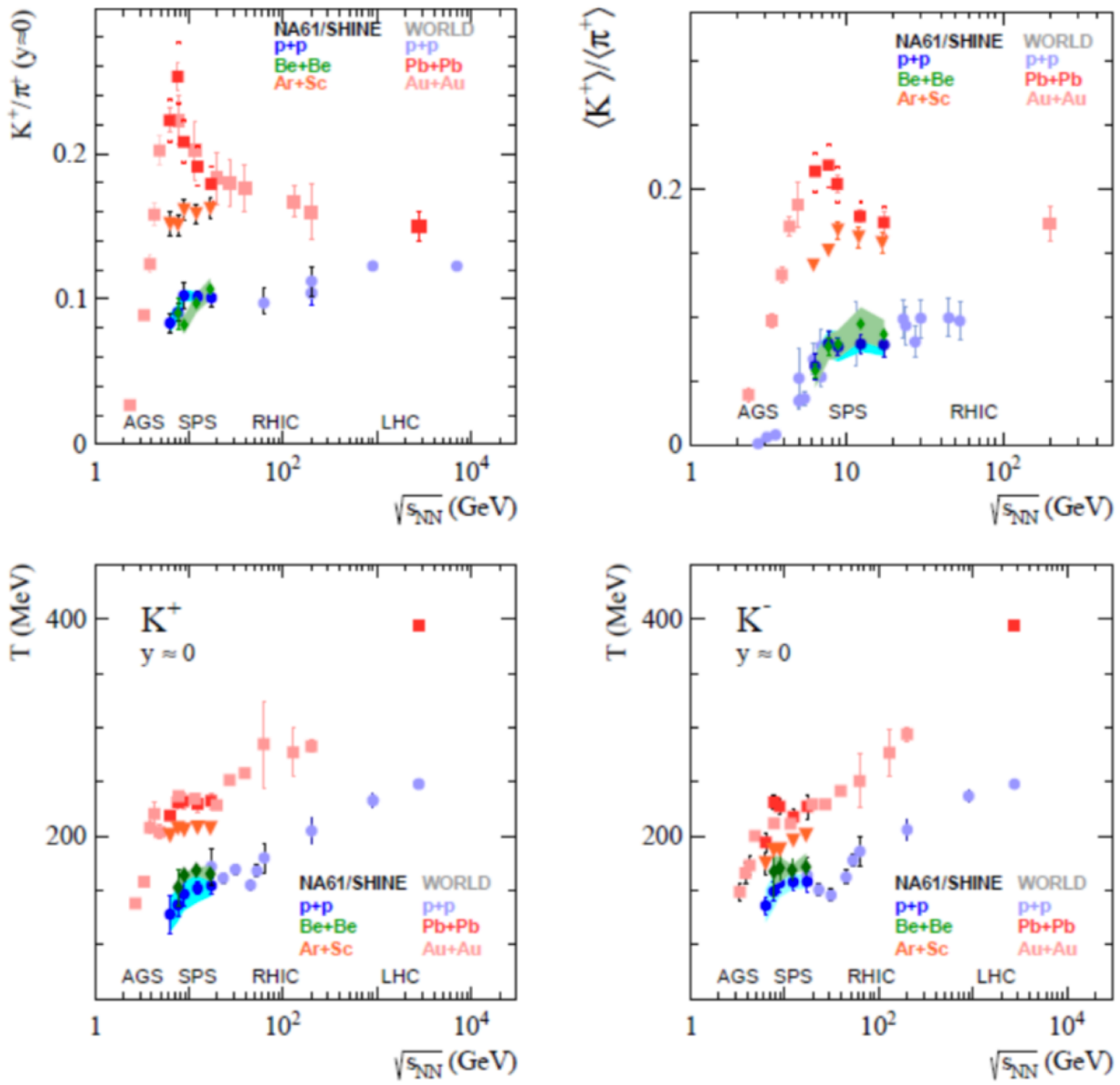
A. Andronic, P. Braun-Munzinger, Pok Man Lo, B. Friman, J. Stachel & K.R Phys. Lett. B 792, 304 (2019)

A. Andronic, P. Braun-Munzinger, J. Stachel & K.R., Nature 561, 302 (2018)





- What functional shape of p_T spectra were used to integrate/get the yield (in 4π or dN/dy?)
- How the flow/jet quenching could affect this, that is known to change the spectra shape significantly.
- How the rapidity distribution changes with centrality/multiplicity?



$$p + p \approx Be + Be \neq Ar + Sc \leq Pb + Pb$$

Thanks to the discussion with Jurgen S.

The discussion was about the "p/π" puzzle, i.e. is the proton yield

1) Lower than predicted in the thermal model
2) does it depend on N_{ch} (or sqrt(s), beyond the expected dependence on μ_B)

The answer to 1) given by Peter: One can improve the thermal model to give a good fit to central PbPb, and this has been shown in the talk of Redlich's slide 4. Protons now are spot on. To me this improvement makes sense (it does not introduce any new physics, but it makes a better approximation to the hadron phase space which is relevant for the stat model) and therefore for me is part of the solution (and here to stay, unless improved even further).

However, there is still some indication that the p/pi ratio is not constant with N_{ch} (see the expanded plot below). Difficult to judge the significance (depends on how much the syst. errors are correlated), but clearly suggestive. And not (easy) accommodated in the thermal model (unless T_{ch} changes) for $dN_{ch}/d\eta > 100$ (i.e. grand canonical). So that could be annihilation.

I think it would help to have a highly accurate (small sys. errors) result from RHIC as function of N_{ch}. The decrease in the ALICE data from N_{ch}=100 to N_{ch}= 2000 is about 15-20%, so to get a significant result you want to have a **total error** of ideally close to 5-7%. I am not sure this accuracy is possible when using the thermal model to correct. So in theory the correction procedure is OK, but in practice its presumably not good enough. In any case, what one wants to test the N_{ch} dependence of p/π is an independent confirmation from RHIC, which needs a p/π ratio with a total error (< 10%). In the end I don't mind how its done, if it can be done..

Why the F.O. temperature or so different at RHIC (165 MeV) and LHC (156 MeV). I guess the answer to that is known (but I actually don't know it). I assume the ratios are compatible but the thermal fits are different…