Identified particles in pp and Pb-Pb collisions at LHC energies with the ALICE Detector

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CERN, Geneva, Switzerland

26/05/2011 – Quark Matter 2011

What I will cover

- Low to intermediate p_T
- Spectra and Yields
- Cascades
- Resonances

More on identified particles

- High P_T PID (Raa)

  See H. Appelshaeuser (25 May)

- Anisotropic flow PID

  See R. Snellings (24 May)

- Brief reminder: PID in ALICE
- Results in pp collsions at $\sqrt{s}$ = 900 GeV and 7 TeV
- Results in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV
- Outlook

Inner tracking system
- Low p_T standalone tracker
- PID: dE/dx in the silicon (up to 4 samples)

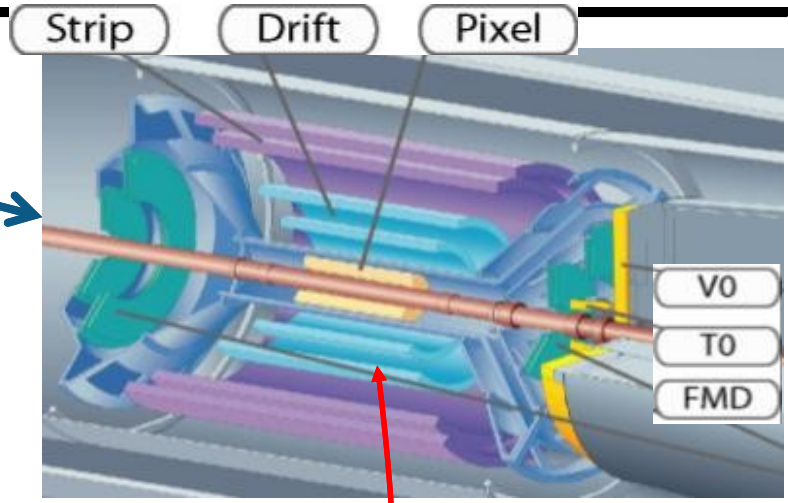
TPC
- Standalone and global (+ITS) tracks
- PID: dE/dx in the gas (up to 159 samples)

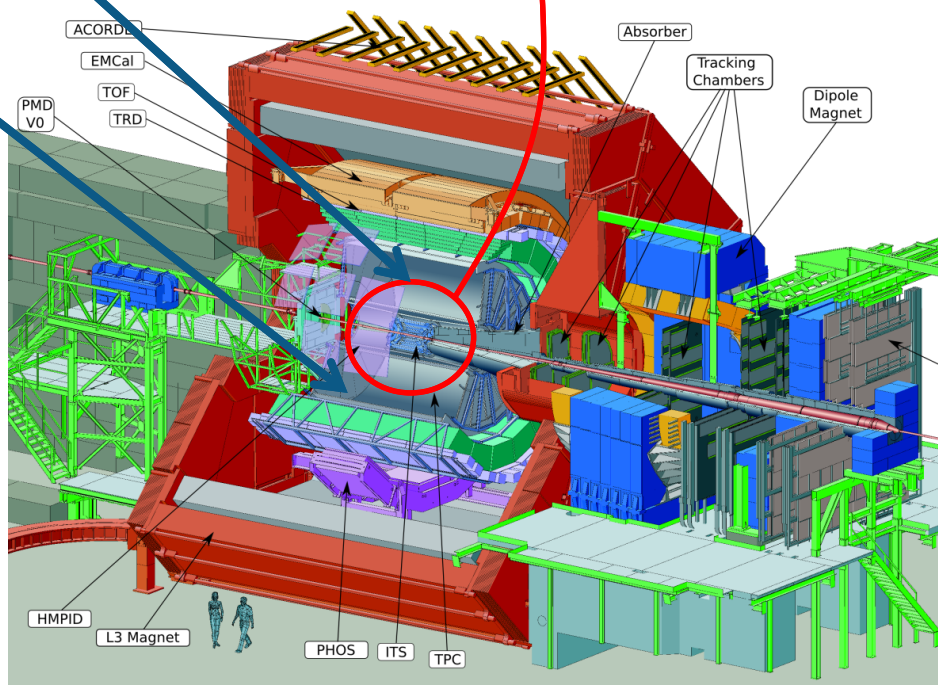
Time of Flight
- Matching of tracks extrapolated from TPC
- PID: TOF, σ_{TOT} ~ 85 ps (PbPb) – 120 ps (pp)

Topological ID + Invariant Mass
- Resonances, Cascades, V0s, Kinks
- PID: indirect cuts to improve S/B

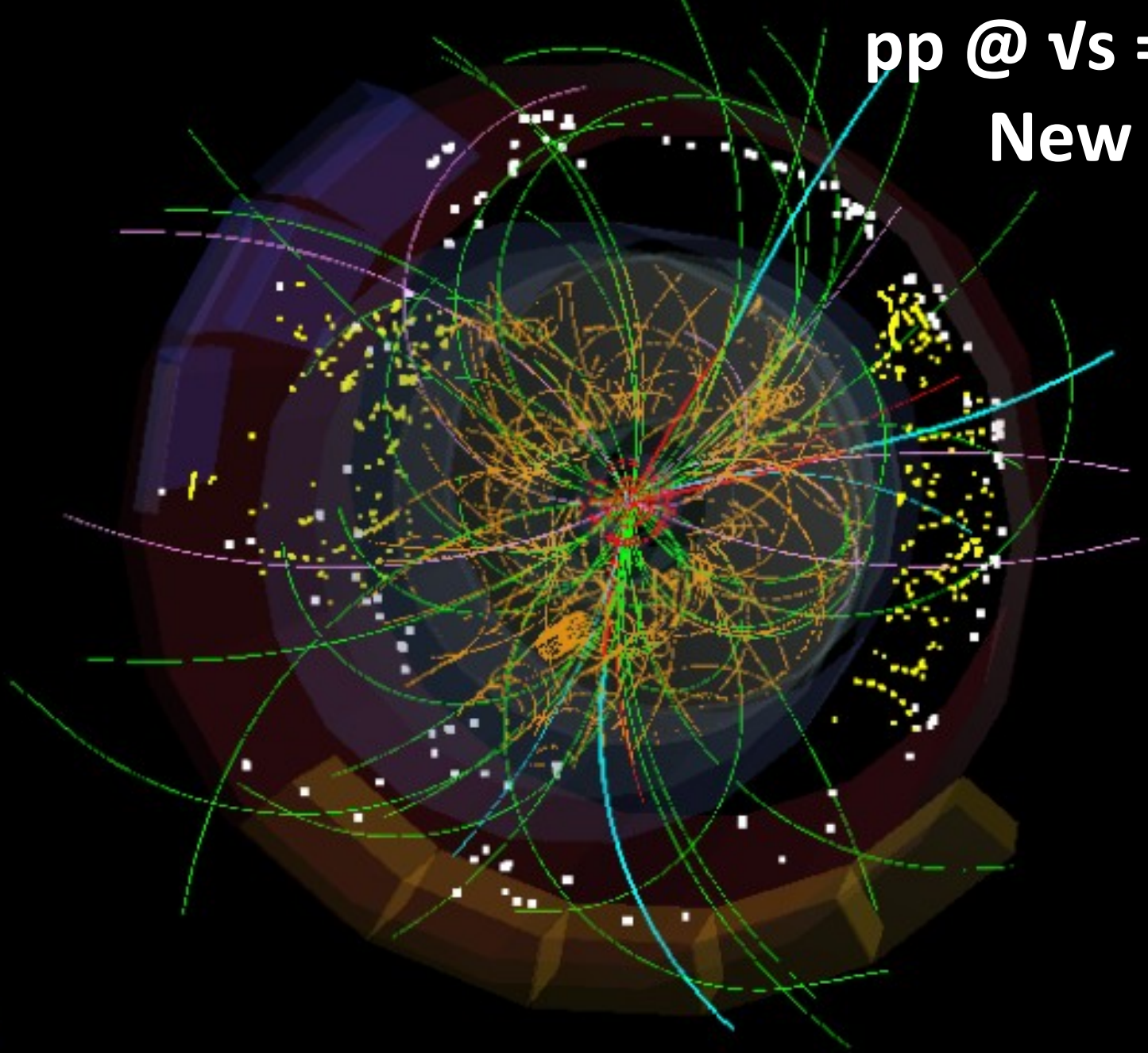
See A. **Kalweit** (23 May)

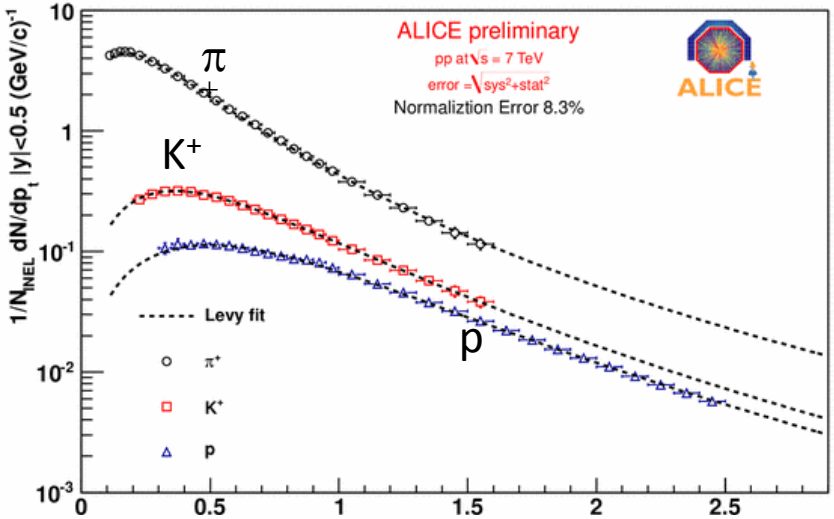
See L. **Milano** (Poster)





pp @ √s = 7 TeV
New Results

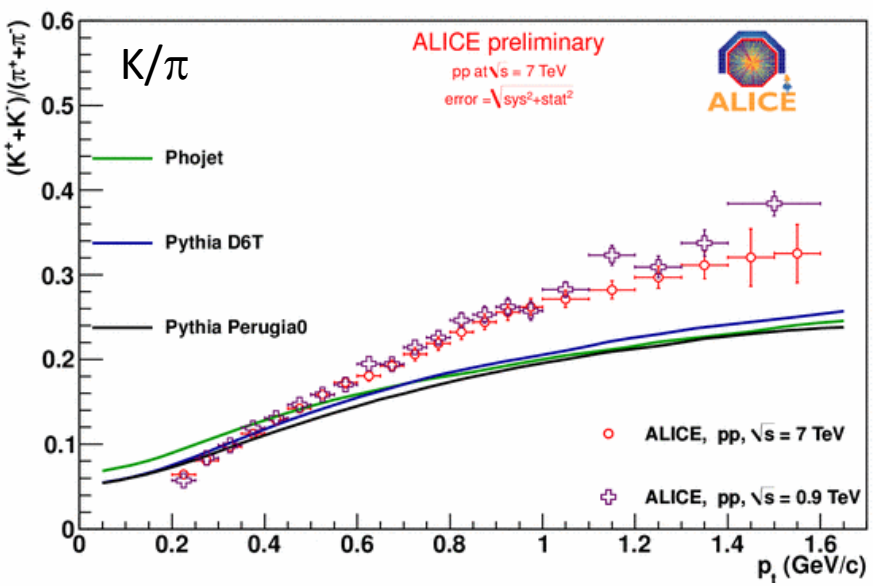


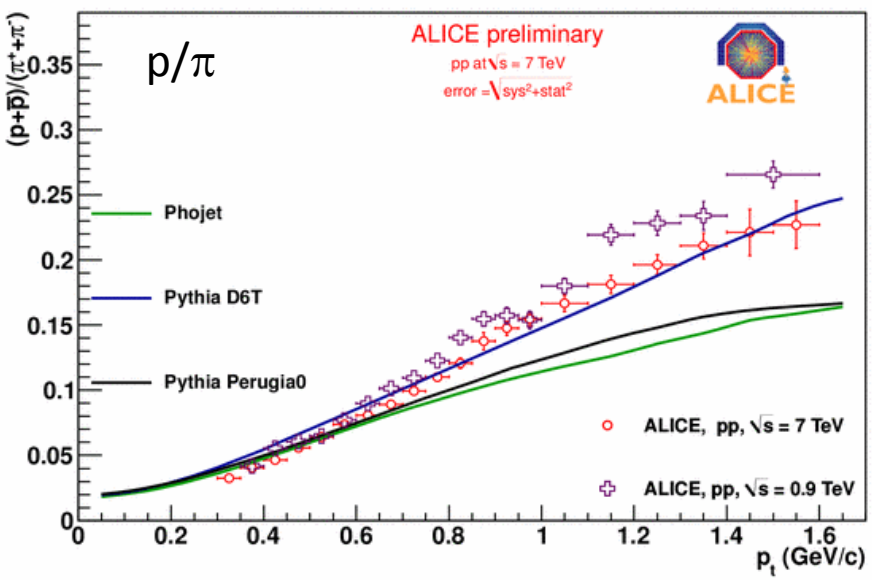


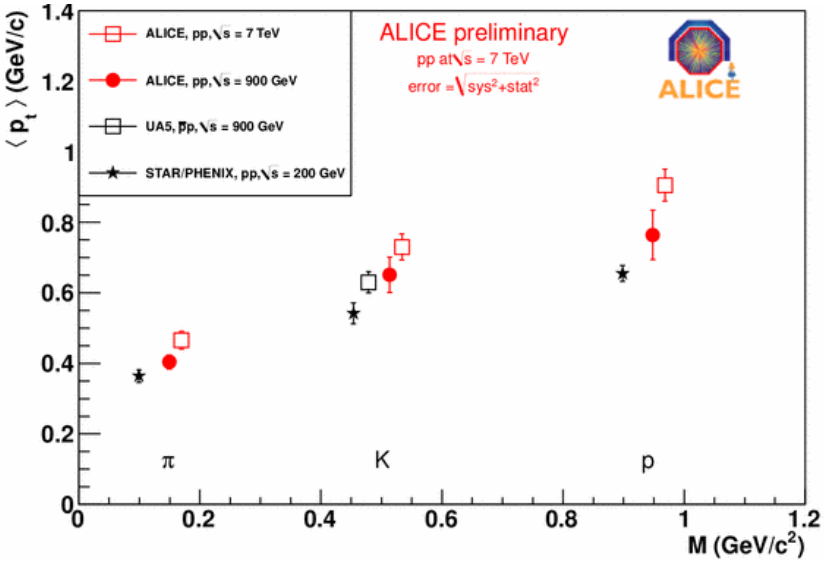
Different techniques used

Minimum p_T = 0.1 / 0.2 / 0.3 GeV/c for π/K/p
(small extrapolation for yields and $\langle p_T \rangle$ calculation)

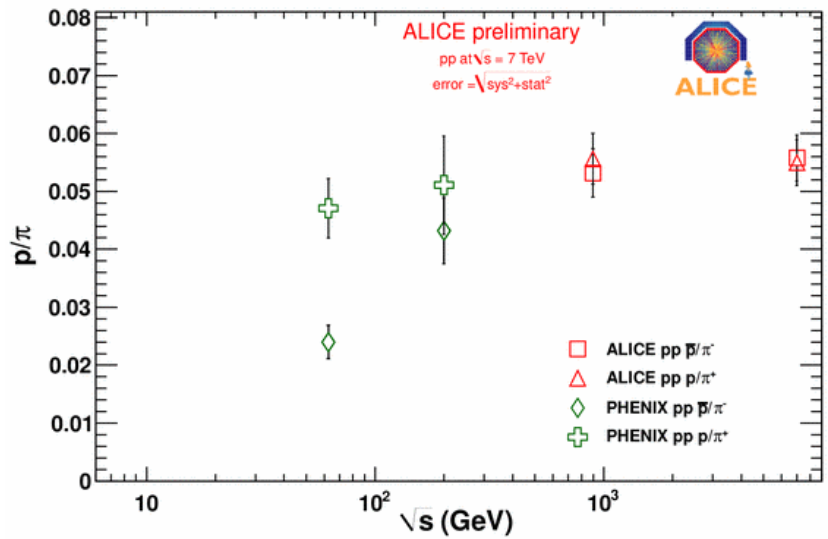
MC models: poor description of data
Ratios similar at different energies







ALI-PREL-2133



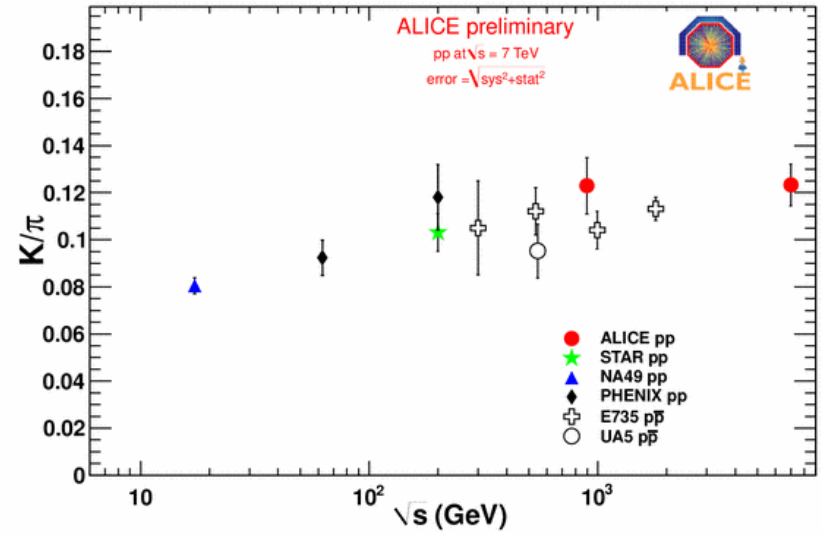
ALI-PREL-5416

Modest increase of $<p_T>$

➔ Harder spectra

Integrated and p_T differential particle ratios ~ independent of energy between 0.9 and 7 TeV

See M **Chojnacki** (23 May)



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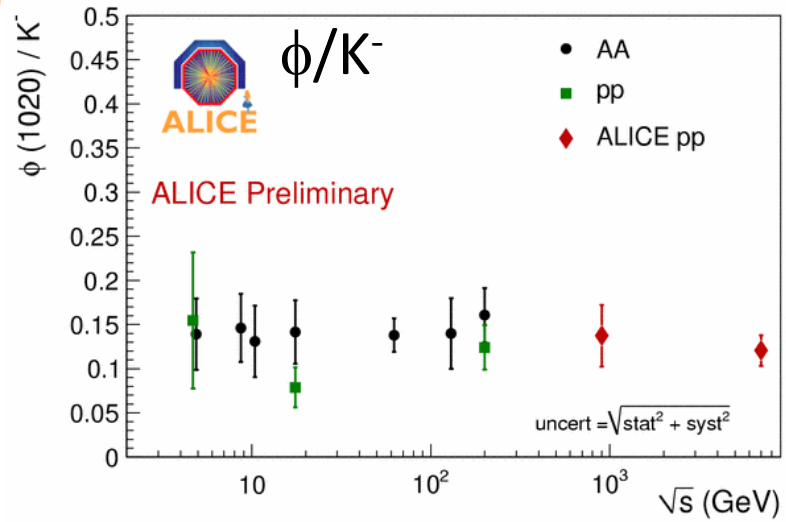
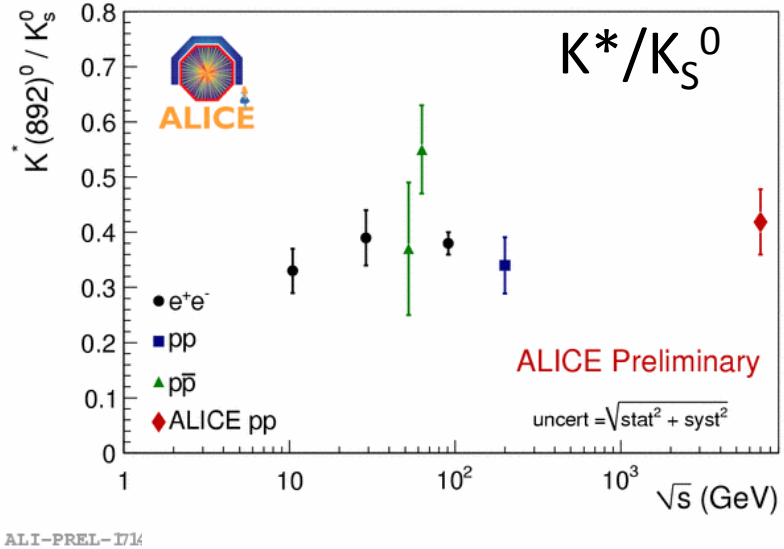




$K^*(892)^0 \rightarrow K\pi$
$\phi\ (1020) \rightarrow KK$
$\Xi^*(1530) \rightarrow \Xi\pi$

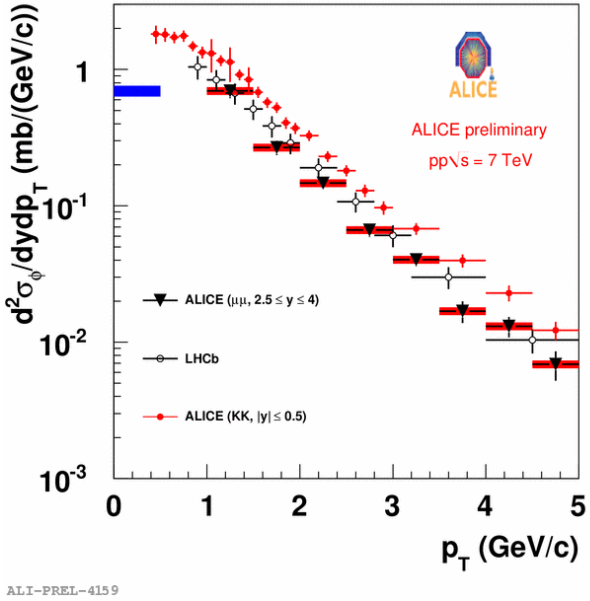
Invariant mass studies
Ratios ~ constant vs √s

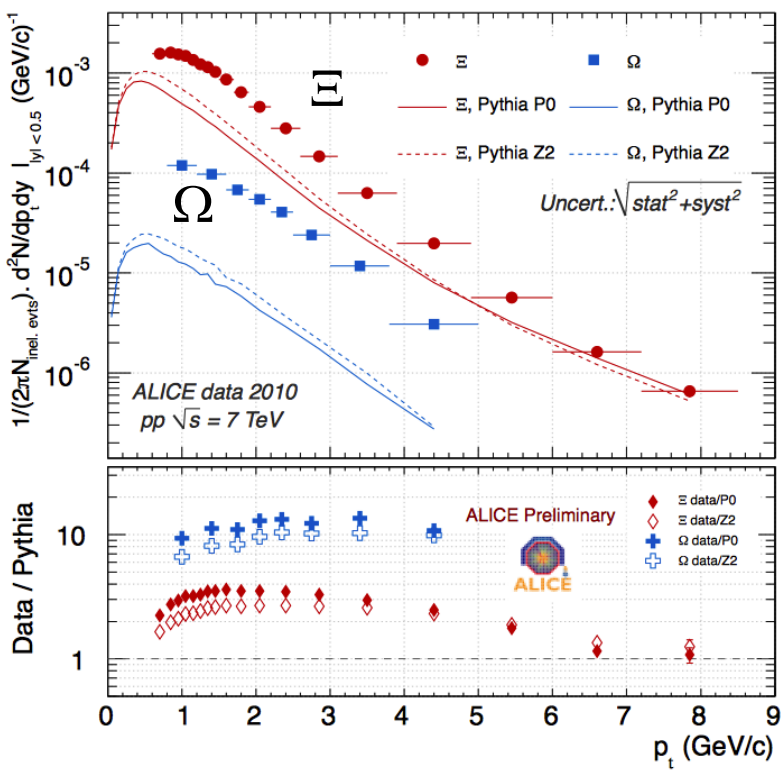
See A **Pulvirenti** (23 May)

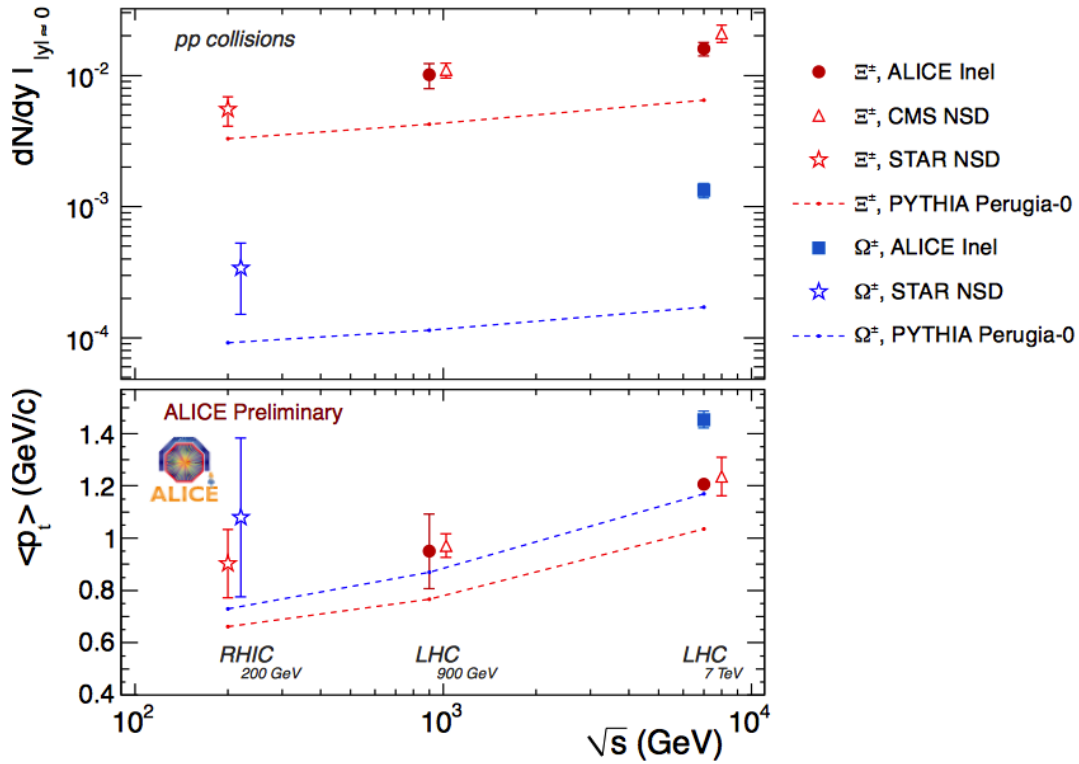
$\phi\ (1020) \rightarrow \mu\mu$
(fwd rapidity)

Slope consistent with $\phi \rightarrow KK$

See A **De Falco**(23 May)





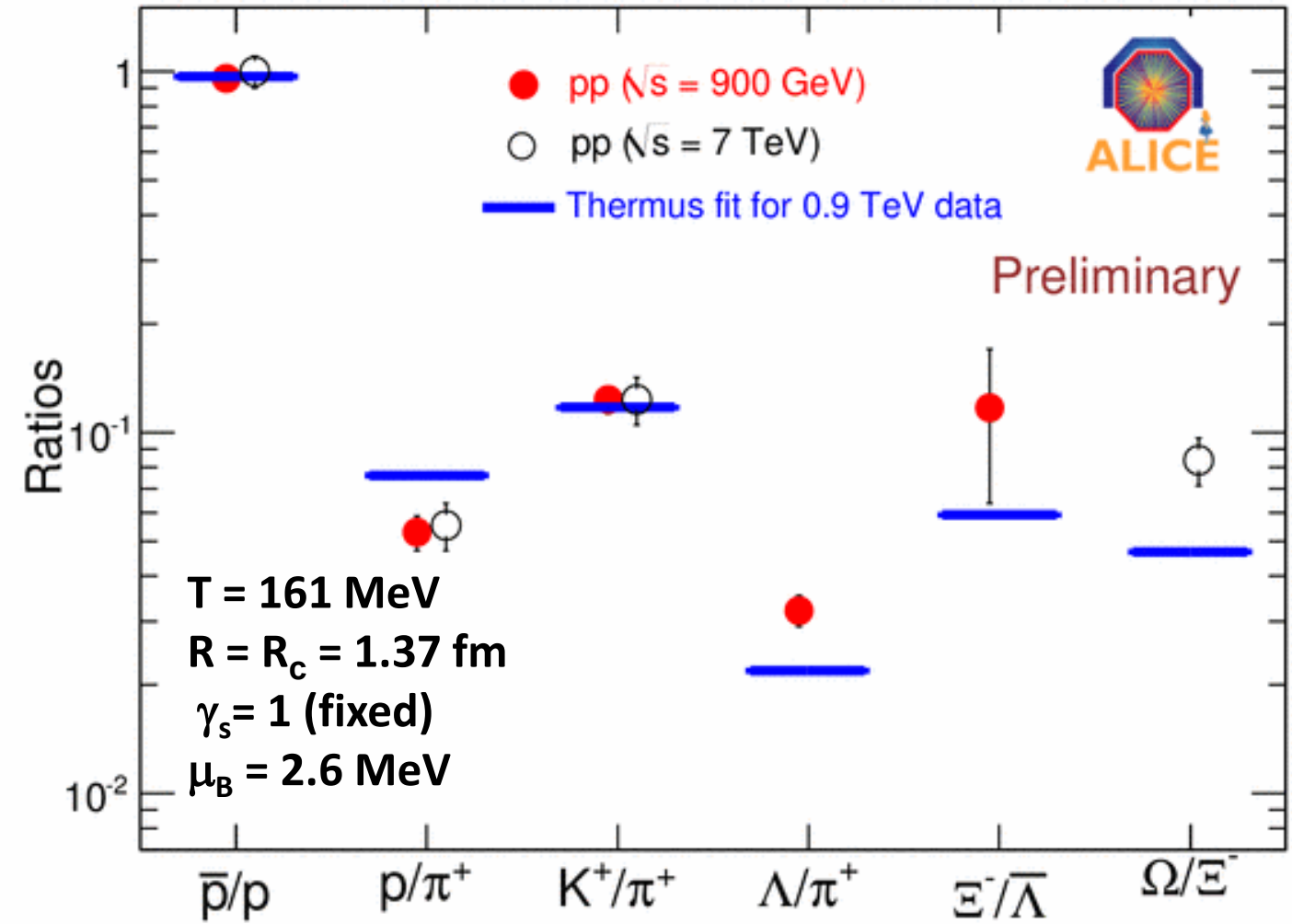


Measured via topological identification

- MC models underestimate strangeness production (factor 10 for the Ω in the measured range)
- Ξ: ALICE and CMS agree (taking into account NSD/INEL)

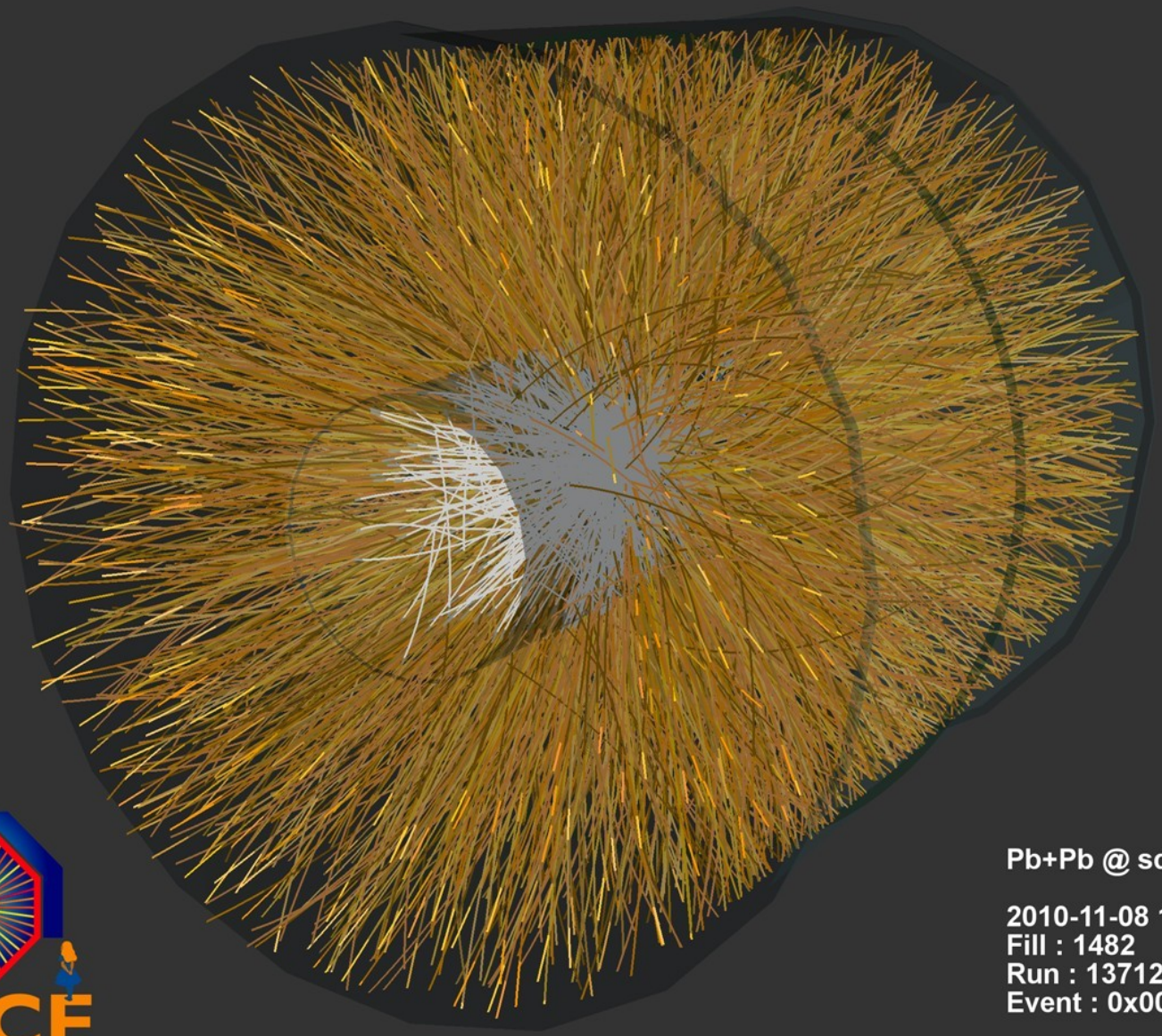
See DD **Chinellato** (23 May)

Fit to 900 GeV data (arXiv:1102.2745)



THERMUS: Comput. Phys. Commun 180, 84, 2009

PbPb Results
√s = 2.76 TeV

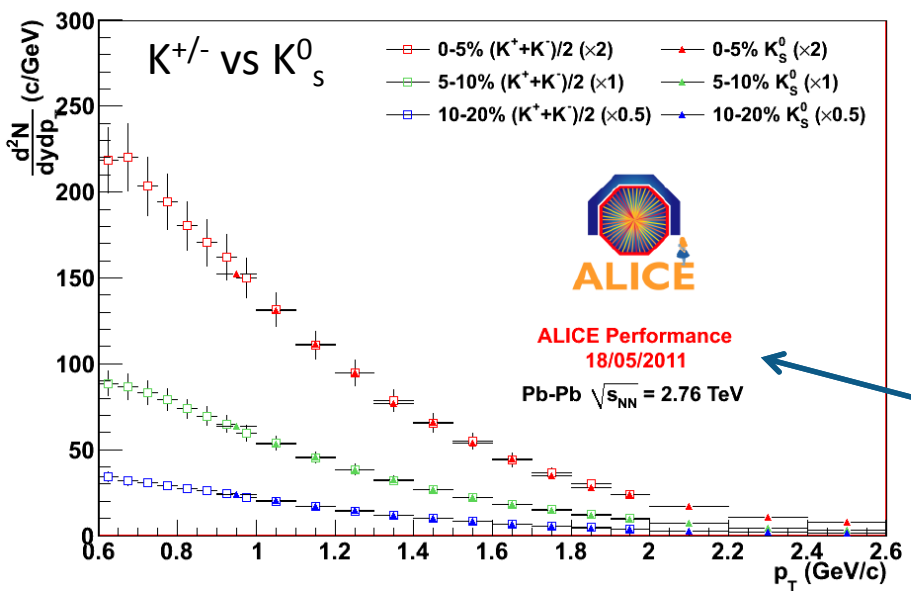


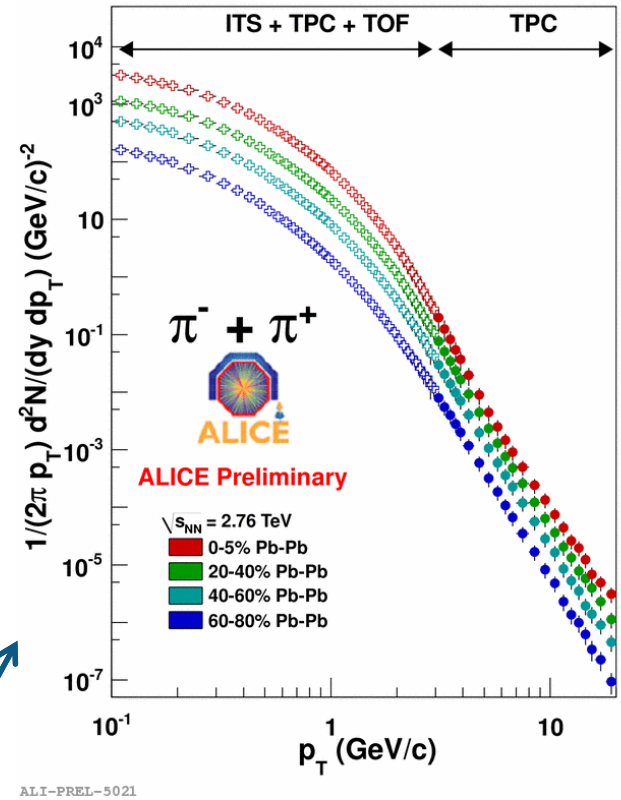
ALICE

Centrality bins:

Centrality	$dN_{ch}/d\eta$	$\langle N_{part}\rangle$	$(dN_{ch}/d\eta)/(\langle N_{part}\rangle/2)$
0%–5%	1601 ± 60	382.8 ± 3.1	8.4 ± 0.3
5%–10%	1294 ± 49	329.7 ± 4.6	7.9 ± 0.3
10%–20%	966 ± 37	260.5 ± 4.4	7.4 ± 0.3
20%–30%	649 ± 23	186.4 ± 3.9	7.0 ± 0.3
30%–40%	426 ± 15	128.9 ± 3.3	6.6 ± 0.3
40%–50%	261 ± 9	85.0 ± 2.6	6.1 ± 0.3
50%–60%	149 ± 6	52.8 ± 2.0	5.7 ± 0.3
60%–70%	76 ± 4	30.0 ± 1.3	5.1 ± 0.3

See A. **Toia** (24 May)

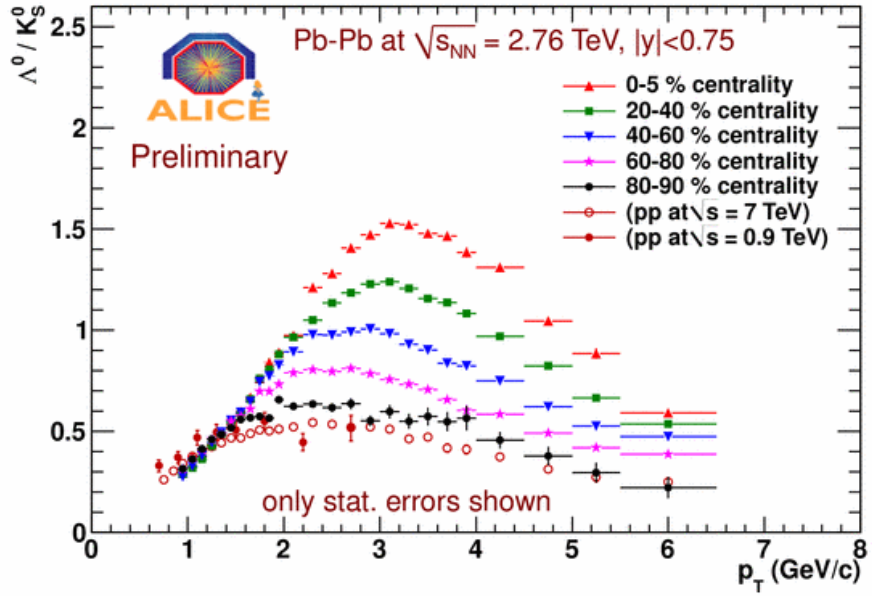




π in the relativistic rise: nice continuation of low p_T analysis

Agreement of charged kaons and K^0_S

See A. **Kalweit** (23 May)



Baryons produced more easily at intermediate p_T

Baryon/meson ratio increases with centrality

→ Recombination?

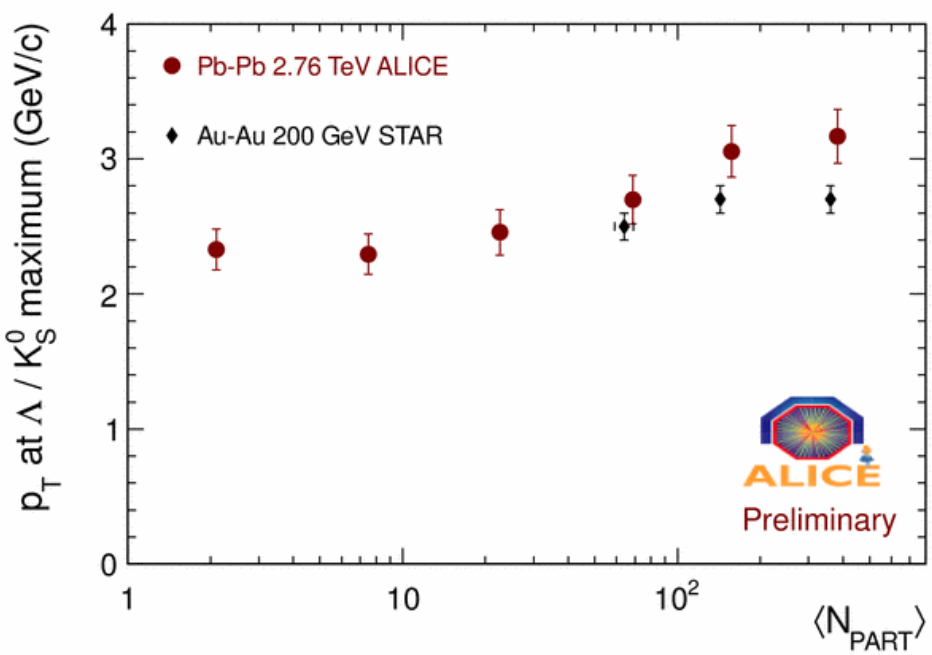
Enhancement stronger that at RHIC

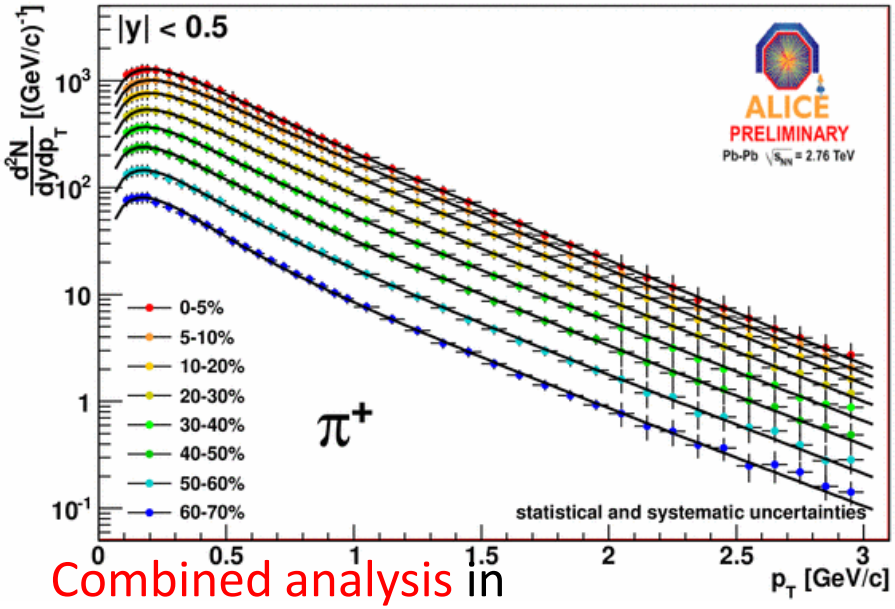
(Λ feed down corrected in this study)

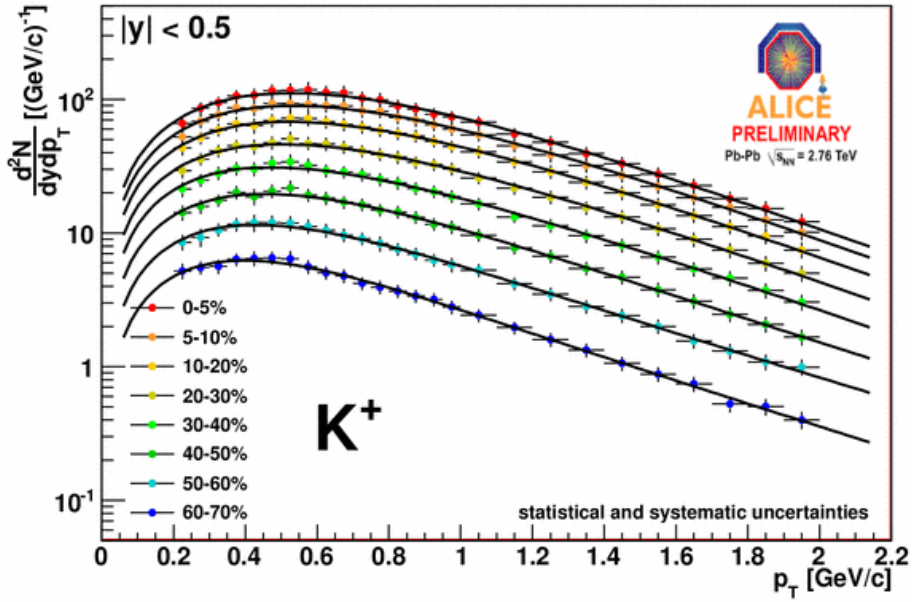
Maximum of Λ/K slightly pushed towards higher p_T than at RHIC: higher radial flow?

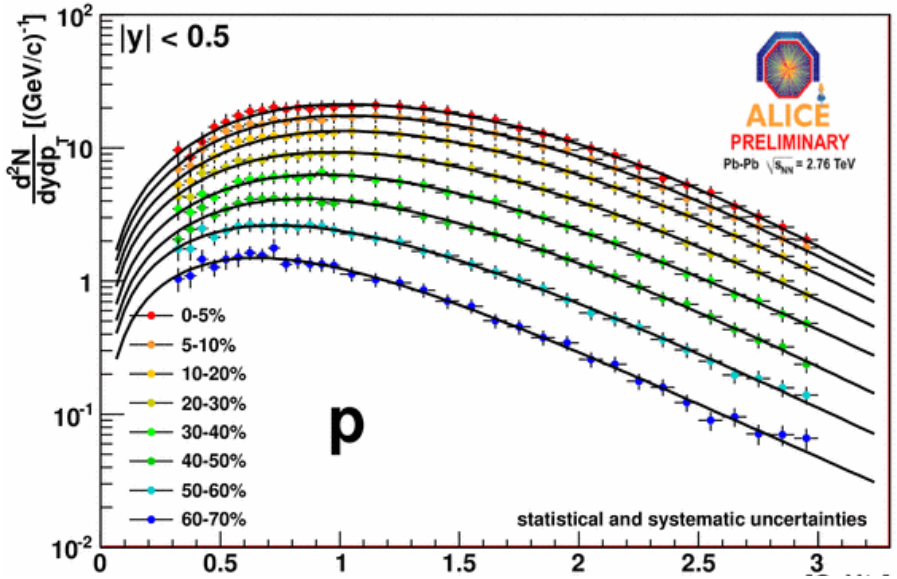
Dramatic shift of baryon enhancement, O(1-2) GeV predicted by some models (e.g. EPJC C34, s279, 2004) not seen

See J **Belikov** (23 May)









Combined analysis in

- Inner Tracking System
- Time Projection Chamber
- TOF

p_T Range:

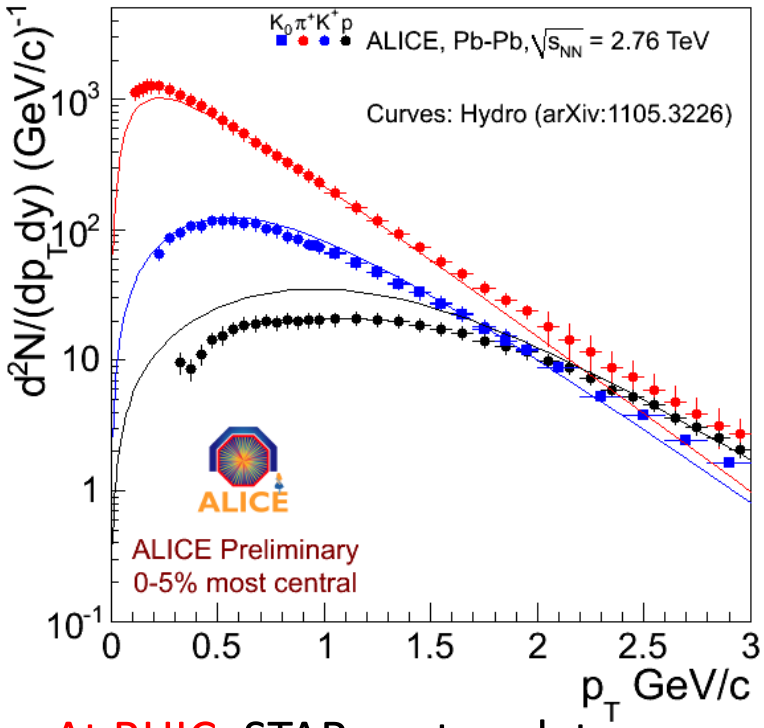
0.1 – 3 GeV/c (π)

0.2 – 2 GeV/c (K)

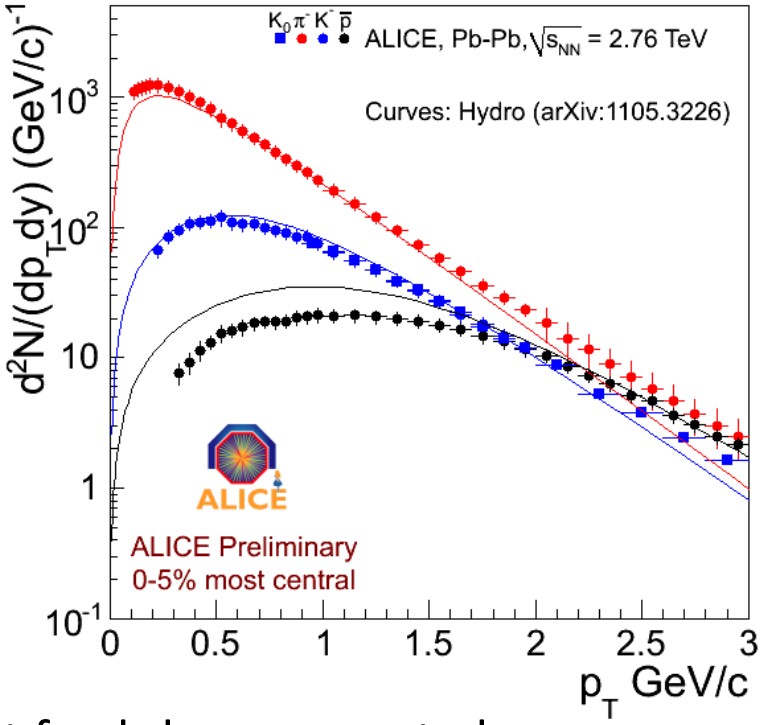
0.3 – 3 GeV/c (p)

Blast wave fits to individual particles to extract yields

positive



negative



At RHIC: STAR proton data generally not feed-down corrected.

Large feed down correction

➔ Consistent picture with feed-down corrected spectra

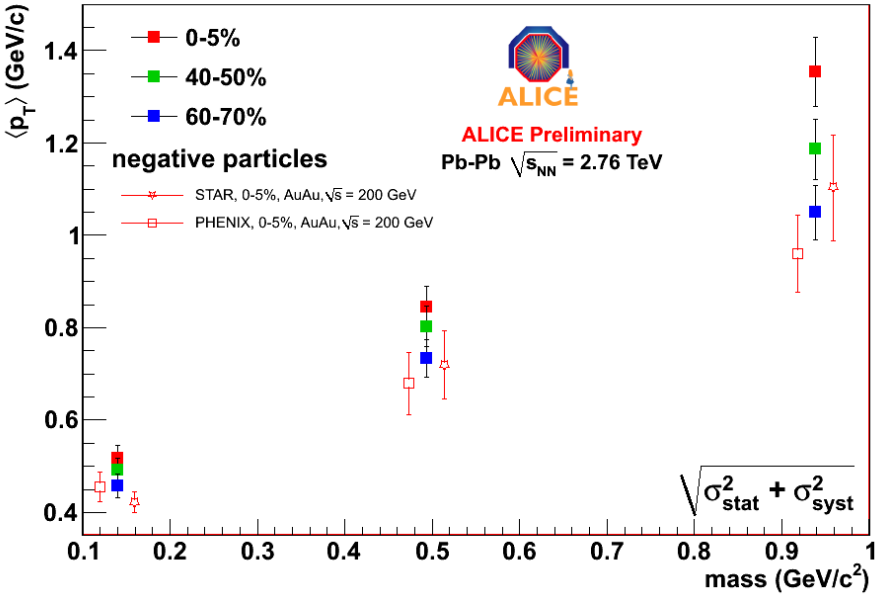
At LHC: ALICE spectra are feed-down corrected

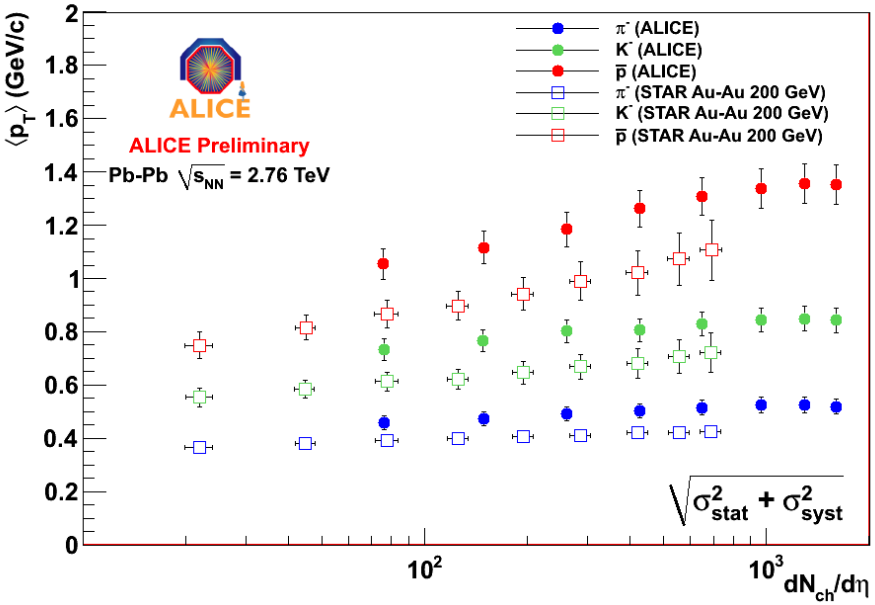
- Harder spectra, flatter p at low pt
- Strong push on the p due to radial flow?

STAR, PRL97, 152301 (2006)

STAR, PRC 79 , 034909 (2009)

PHENIX, PRC69, 03409 (2004)



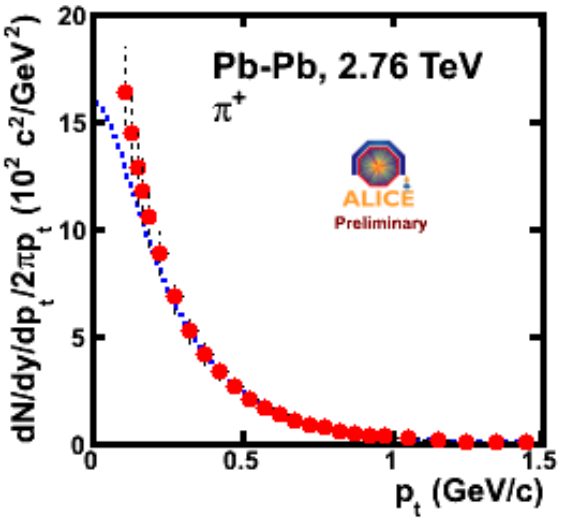


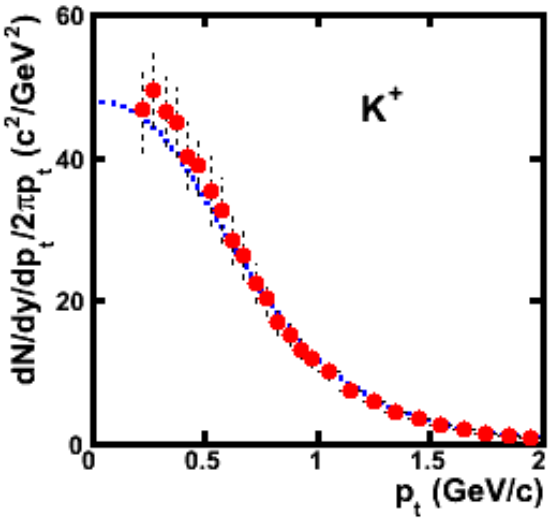
Mean p_T increases linearly with mass

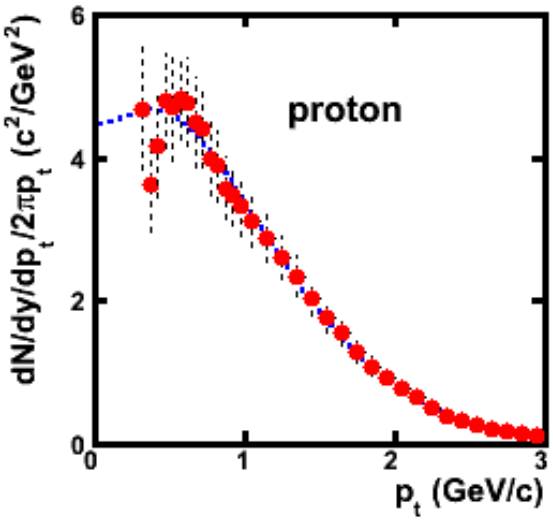
Higher than at RHIC (harder spectra, more flow?)

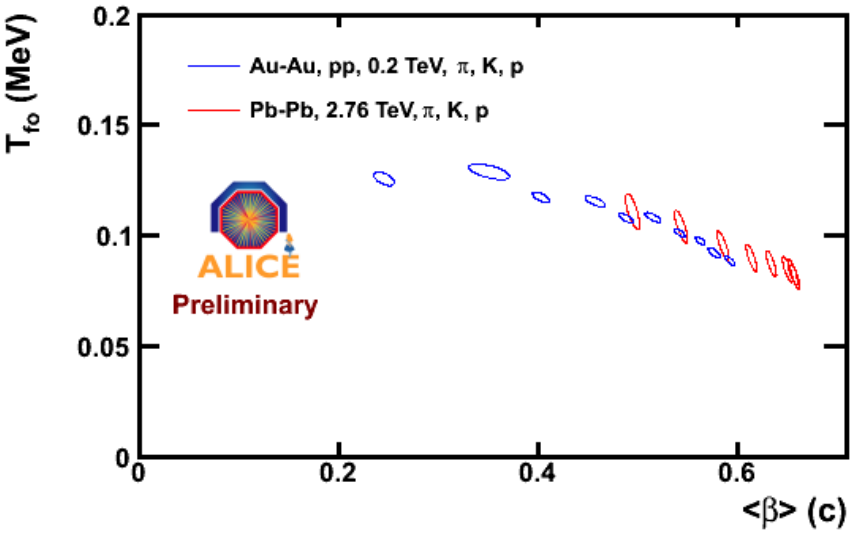
For the same dN/dη higher mean p_T than at RHIC

PRC48, 2462 (1993).







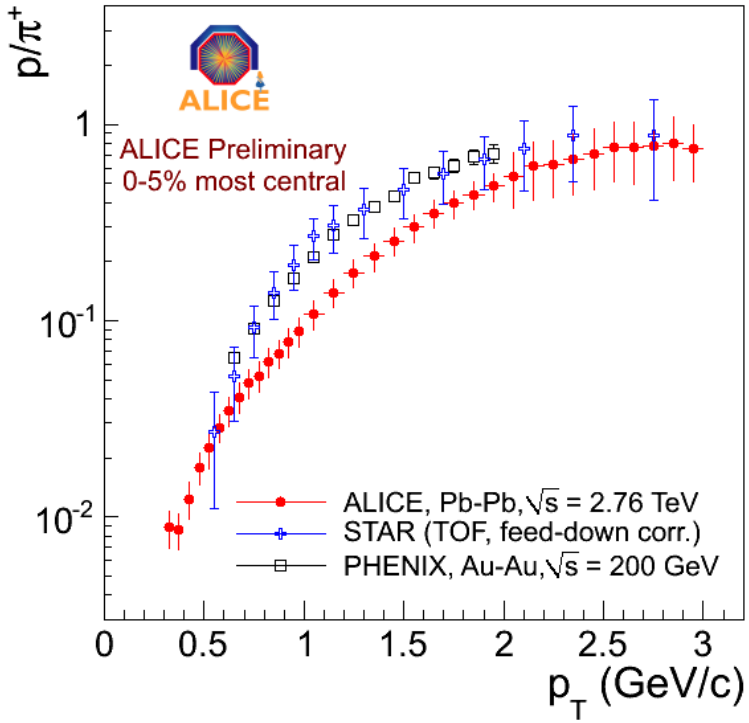


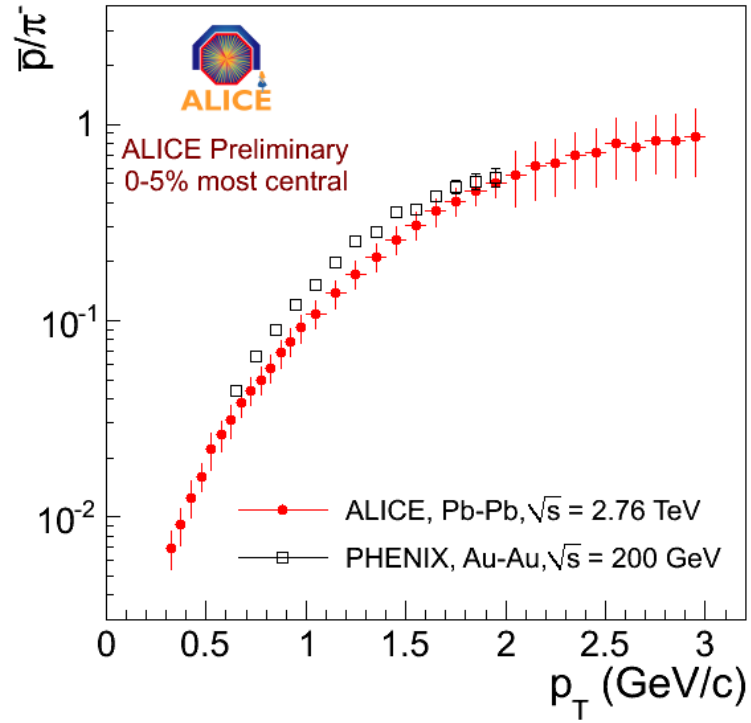
Blast wave fits → radial flow ~ 10% higher than at RHIC

Fit Range:

- pions 0.3 – 1 GeV
- kaons 0.2 – 1.5 GeV
- protons 0.3 – 3 GeV

T depends on the pions and fit-range (effect of resonances to be investigated)





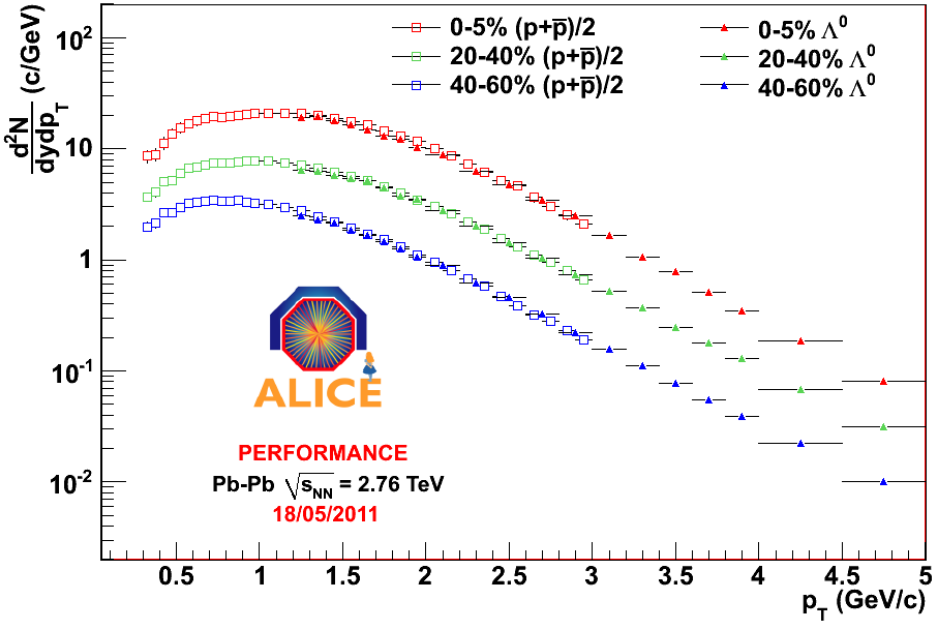
p/π: similar trend at RHIC

Saturates at higher p_T than at RHIC → similar to Λ/K_0

Stronger push from radial flow?

STAR, PRC 79 , 034909 (2009)

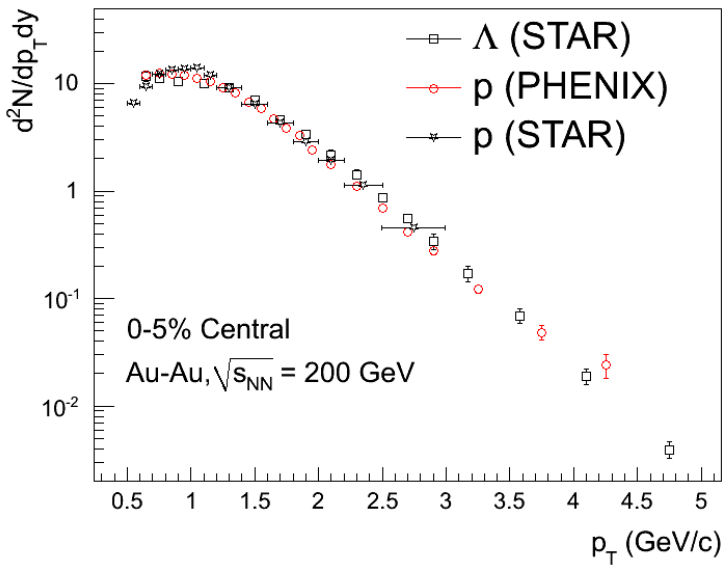
PHENIX, PRC69, 03409 (2004)



Lambda very similar to protons in shape and yield

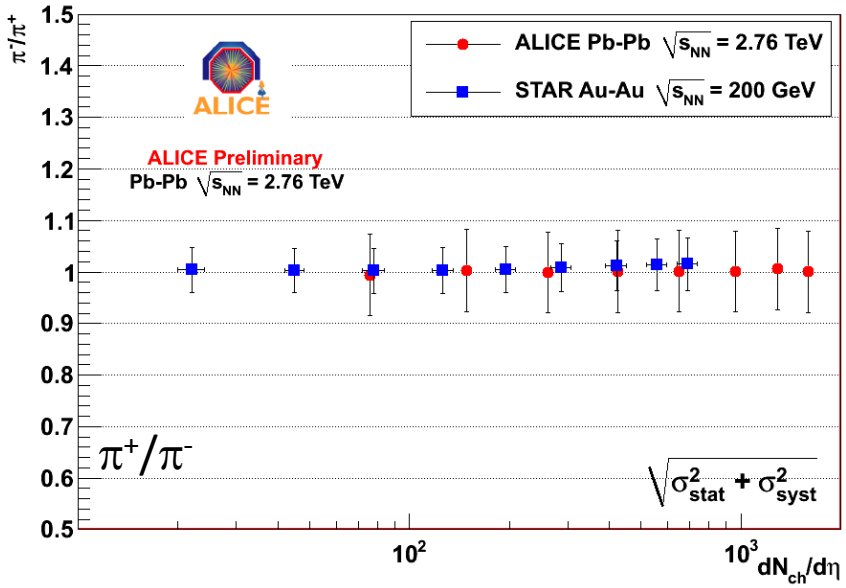
Feed-down correction:

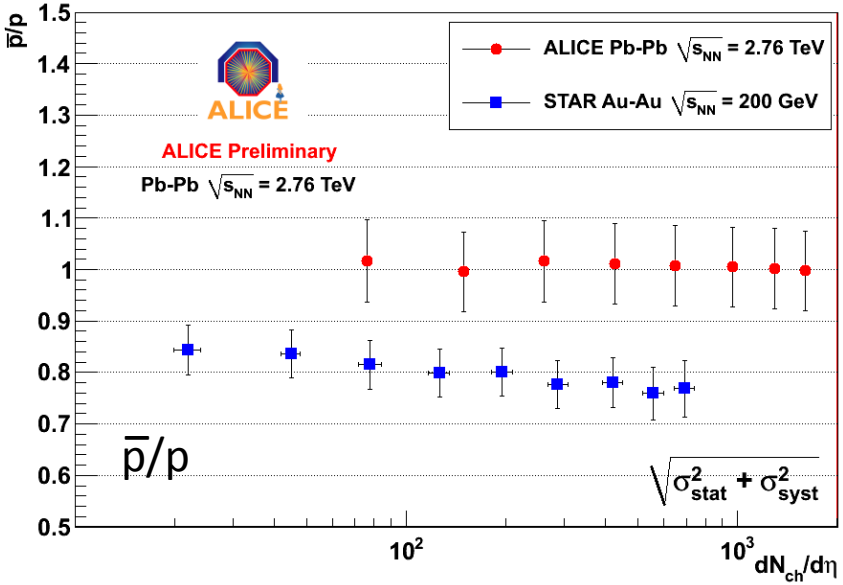
- p corrected for weak decays
- Λ corrected for f.d. from the Ξ

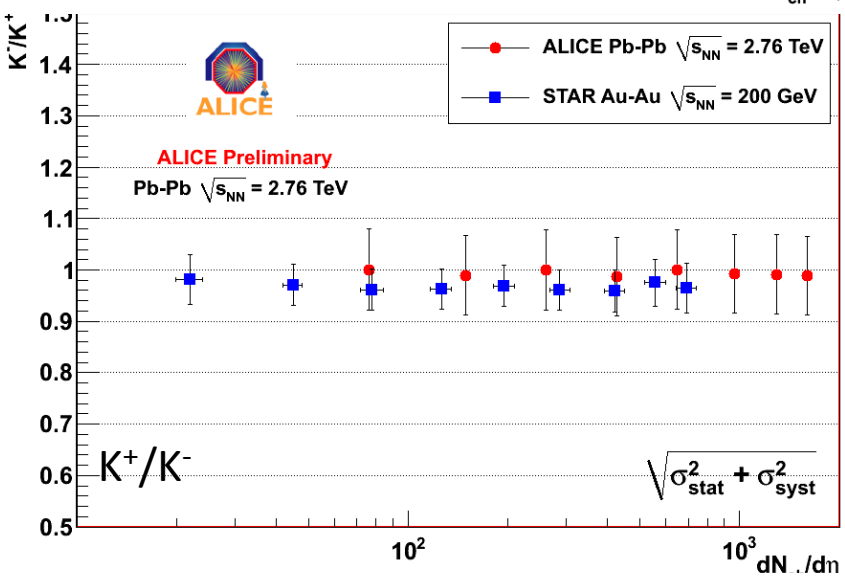


... this was similar at RHIC, if one compares feed-down corrected spectra

STAR, PRL98, 062301 (2007)
PHENIX, PRC69, 03409 (2004)

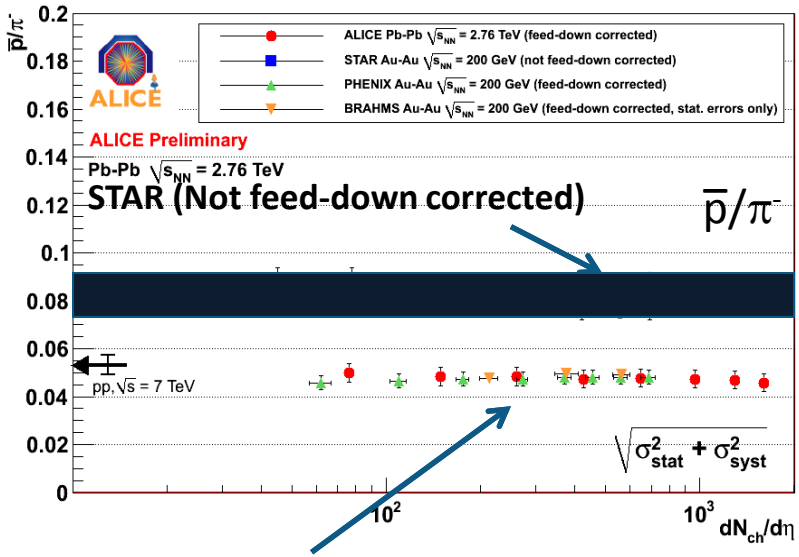




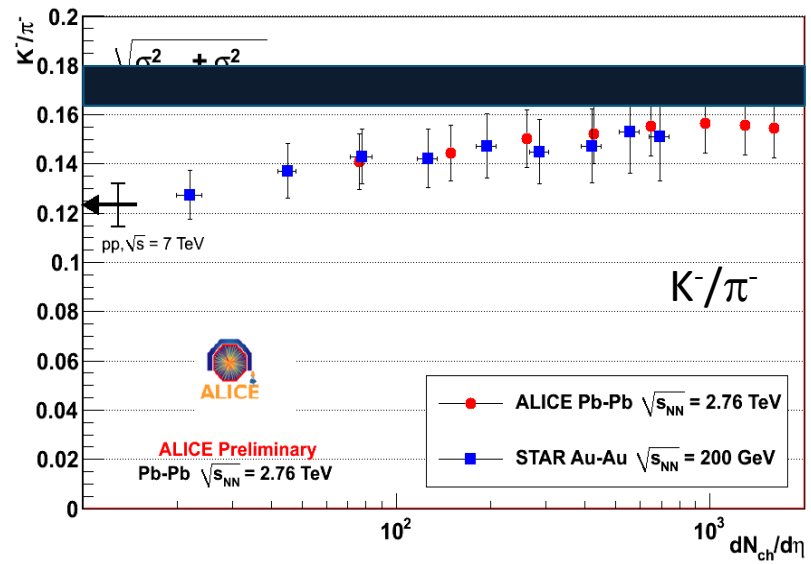


All +/- ratios are compatible with 1 at all centralities, as expected at LHC energies

STAR, PRC 79 , 034909 (2009)



ALICE, BRAHMS, PHENIX (feed-down corrected)



STAR, PRC 79 , 034909 (2009
PHENIX, PRC69, 03409 (2004
BRAHMS, PRC72, 014908 (2005

Predictions for the LHC

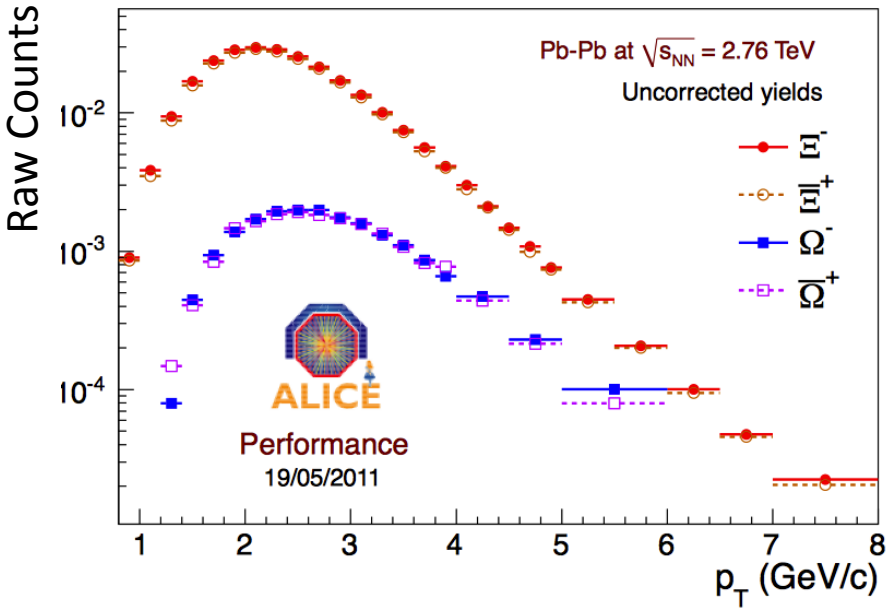
Ratio	Data	(1)	(2)
p/π^+	0.0454+-0.0036	0.072	0.090
p/π^-	0.0458+-0.0036	0.071	0.091+0.009-0.007
K/π^+	0.156 +- 0.012	0.164	0.180+0.001-0.001
K/π^-	0.154 +- 0.012	0.163	0.179+0.001-0.001

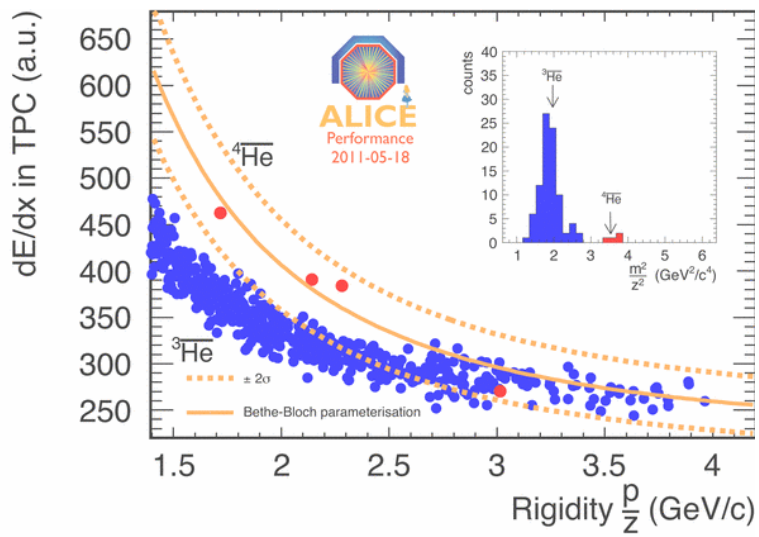
(1) A. *Andronic et al, Nucl. Phys. A772 167 (2006)* **(2) *J. Cleymans et al, PRC74, 034903 (2006)***

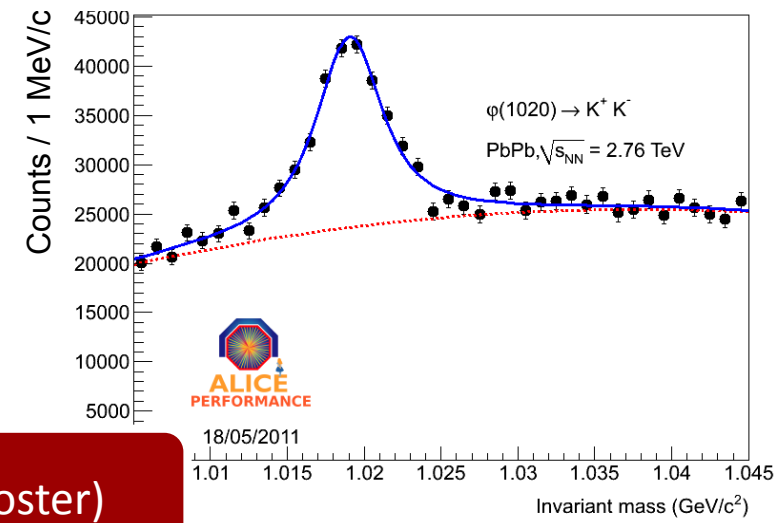
T = 164 MeV, μ_B = 1 MeV

T = (170±5) MeV and μ_B =1+4 MeV

- Strangeness
- Resonances
- Anti- and Hyper-Nuclei
- …







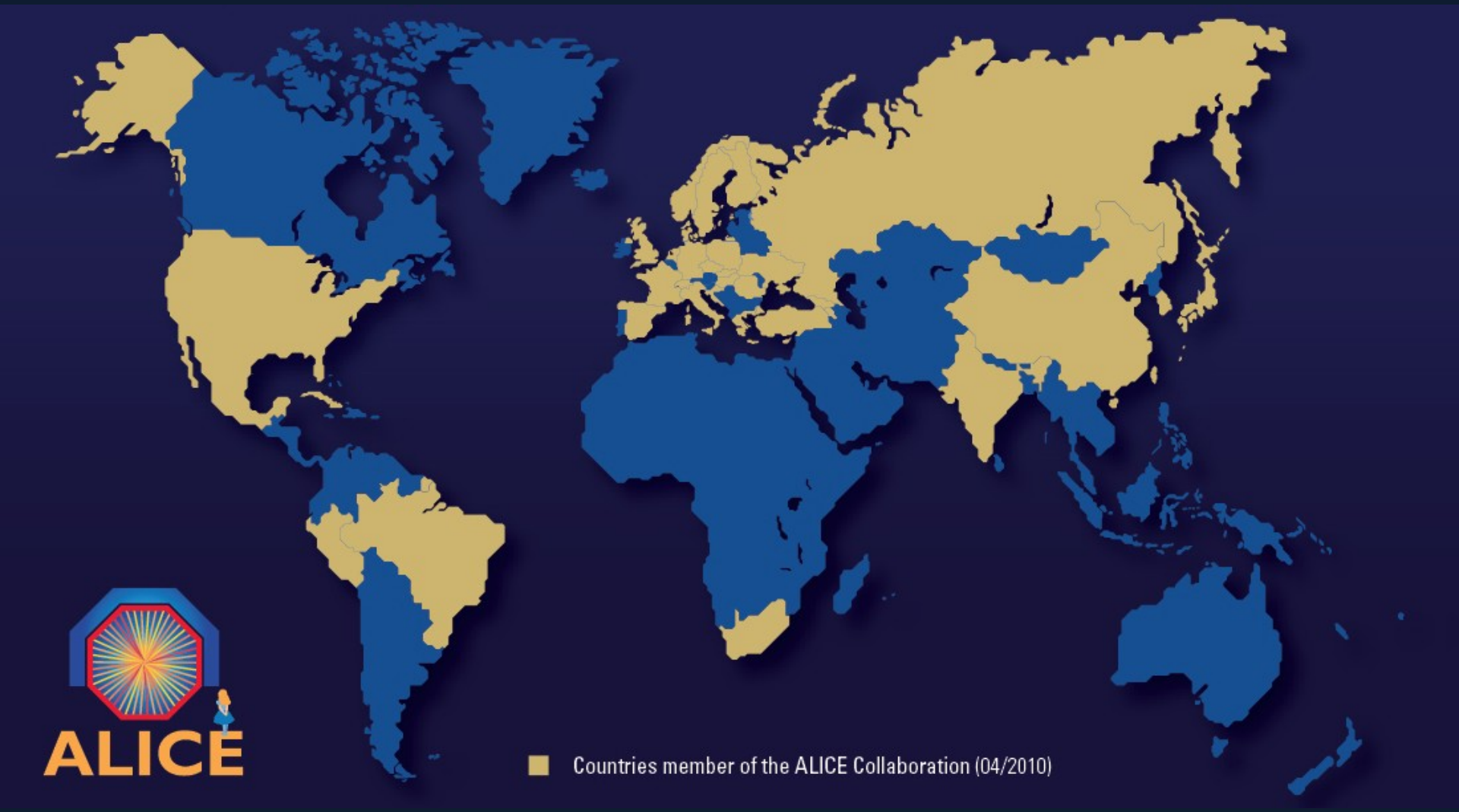
See N **Sharma** (Poster)

See B **Doenigus** (Poster)

- ALICE has very good capabilities for the measurement of identified particles
- pp Collisions
  - Measurements at $\sqrt{s}$ = 900 GeV and 7 TeV
  - Particle ratios independent of energy
- PbPb Collision
  - Spectral shapes show much stronger radial flow than at RHIC
  - Baryon/meson anomaly: enhancement slightly higher and pushed to higher p_T than at RHIC
- $p/\pi \approx 0.05$ in pp and PbPb collisions
  - Difficult to understand in a thermal model prediction with T = 160-170 MeV

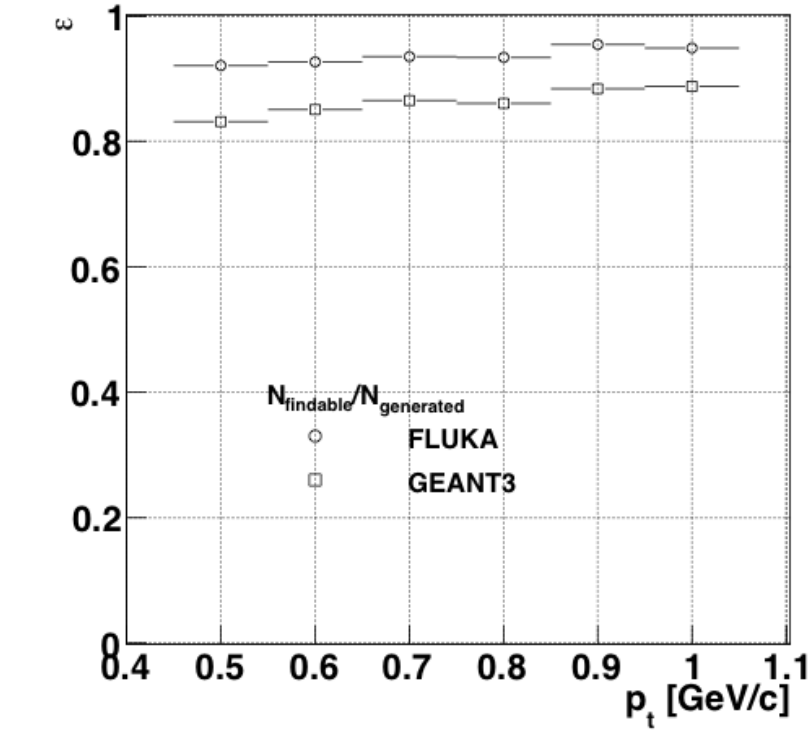
The ALICE Collaboration

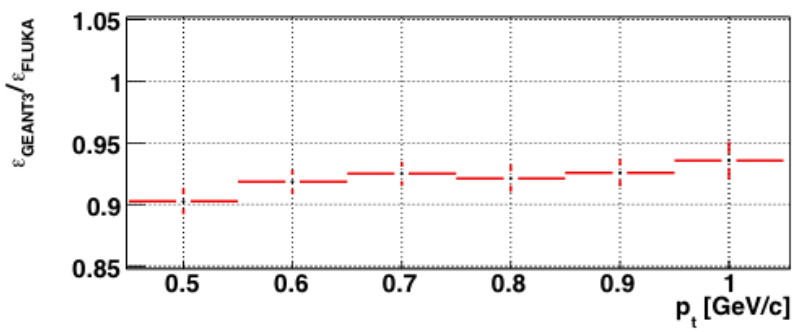
33 countries, 116 institutes, 1000 members



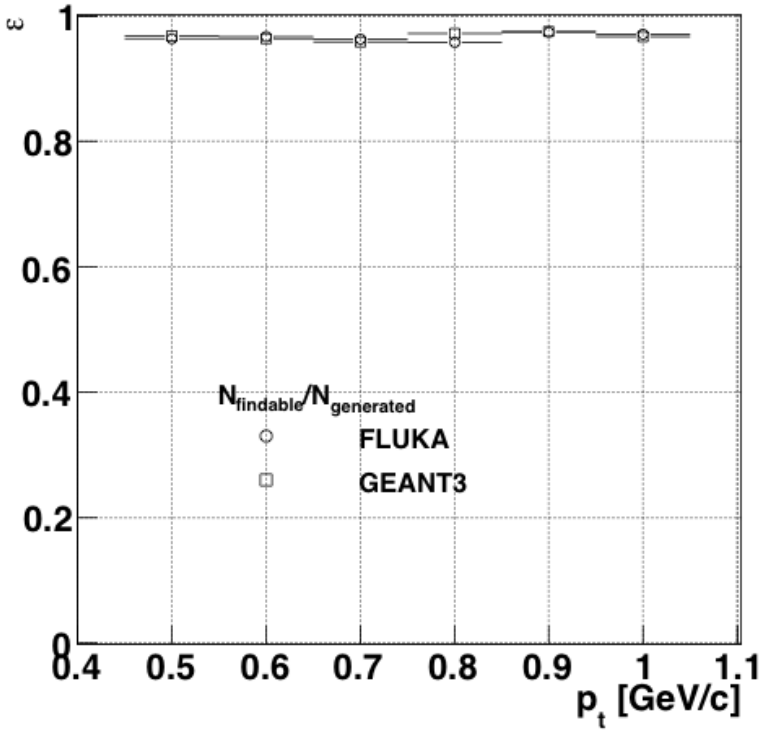
http://aliweb.cern.ch

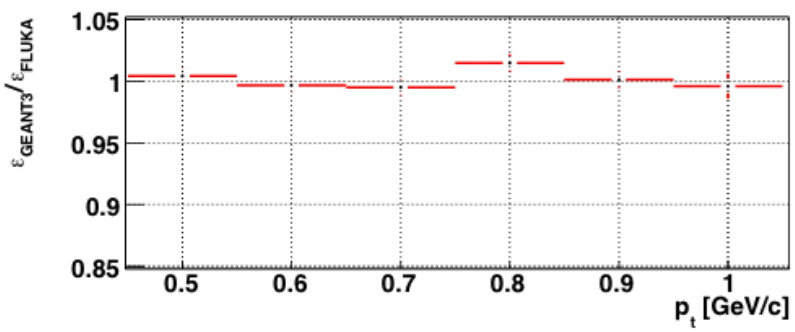
Efficiency: $\bar{p}$

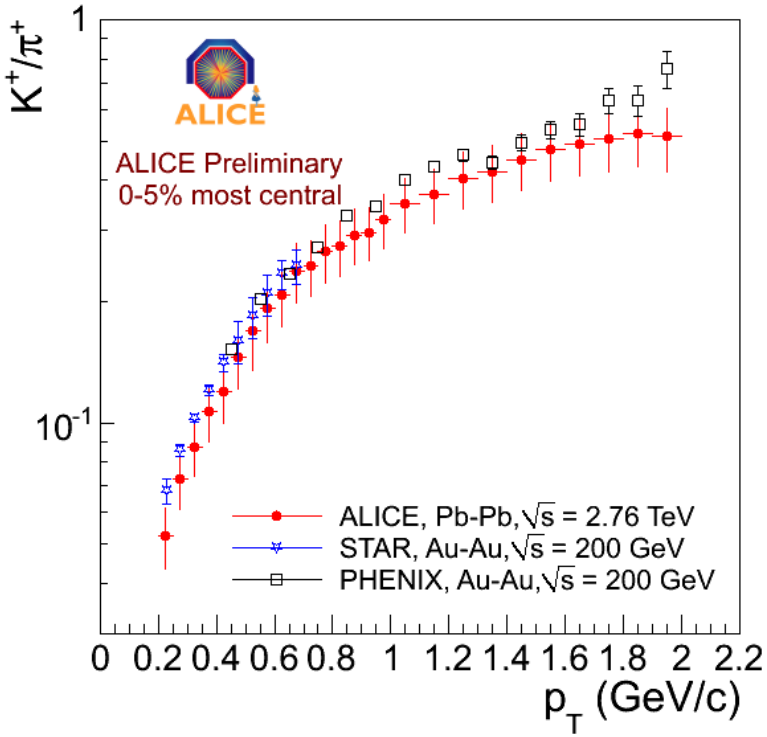


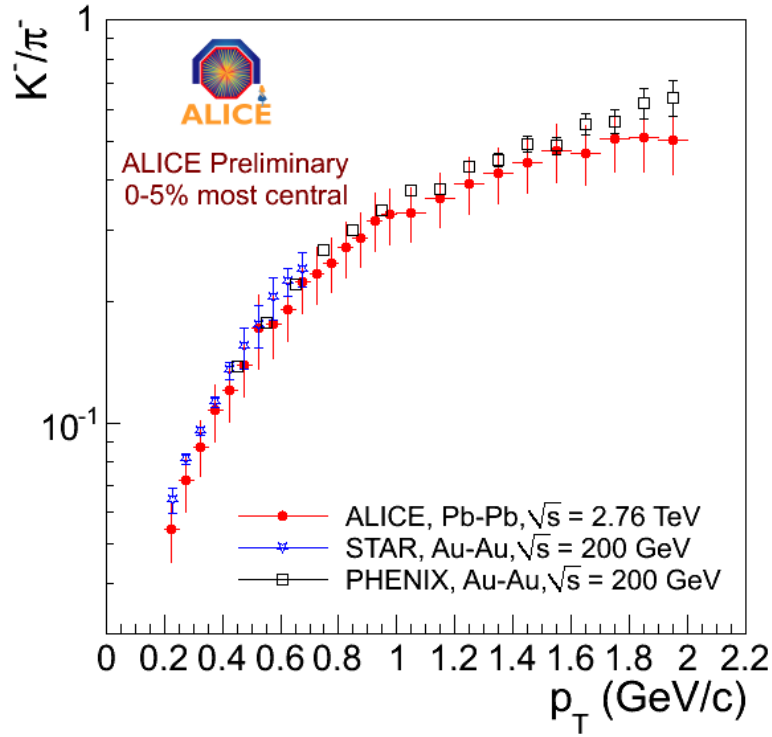


Efficiency: p





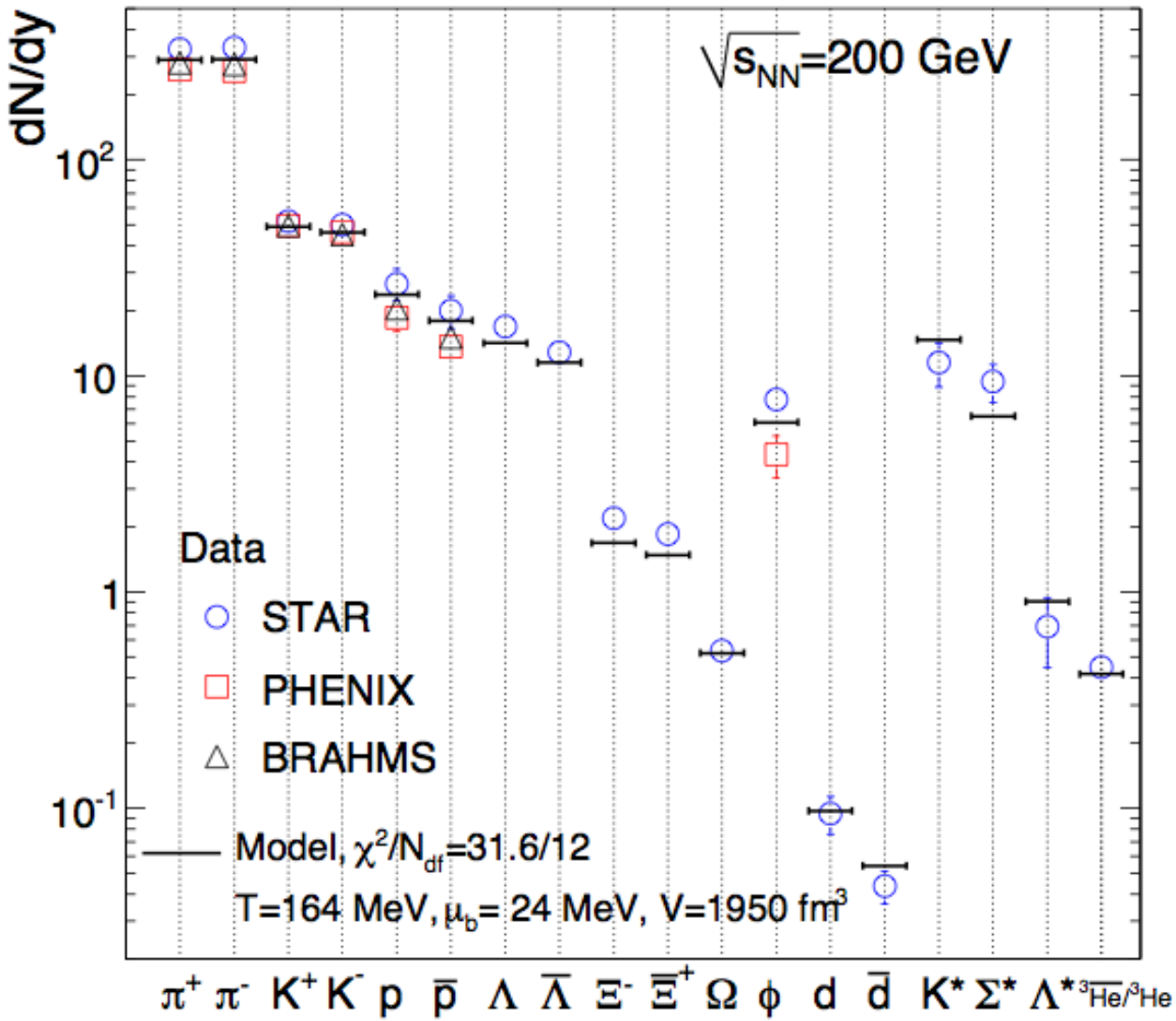




K/p ratio vs p_T is very similar at RHIC and LHC energies

STAR, PRC 79 , 034909 (2009)
PHENIX, PRC69, 03409 (2004)

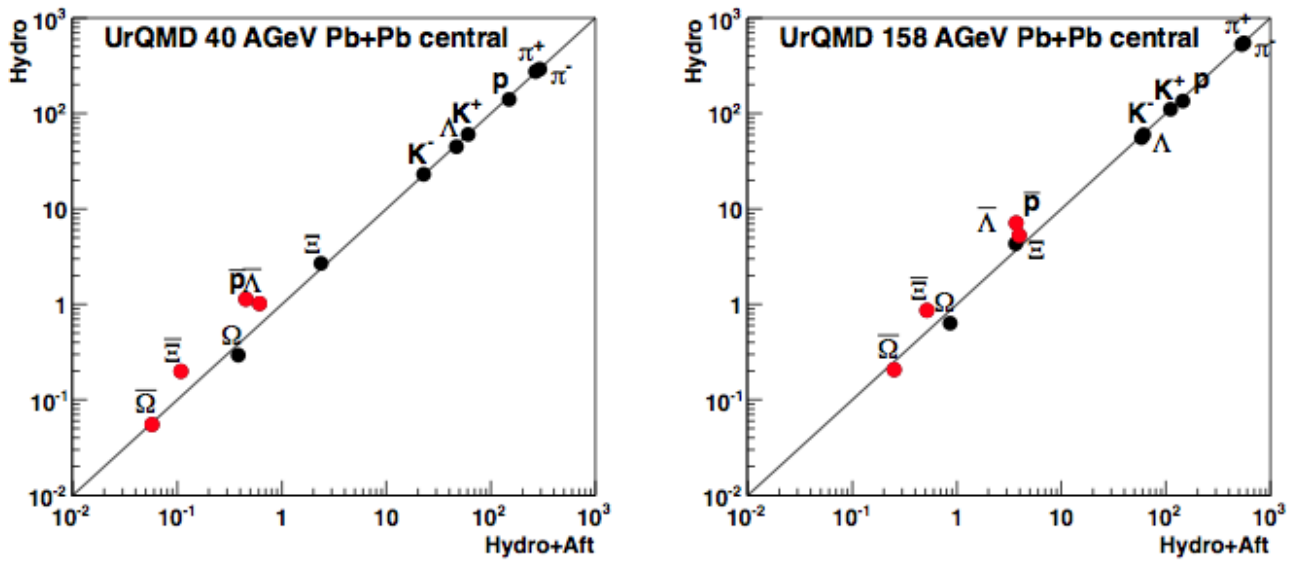
A. Andronic,
(Mon 23)



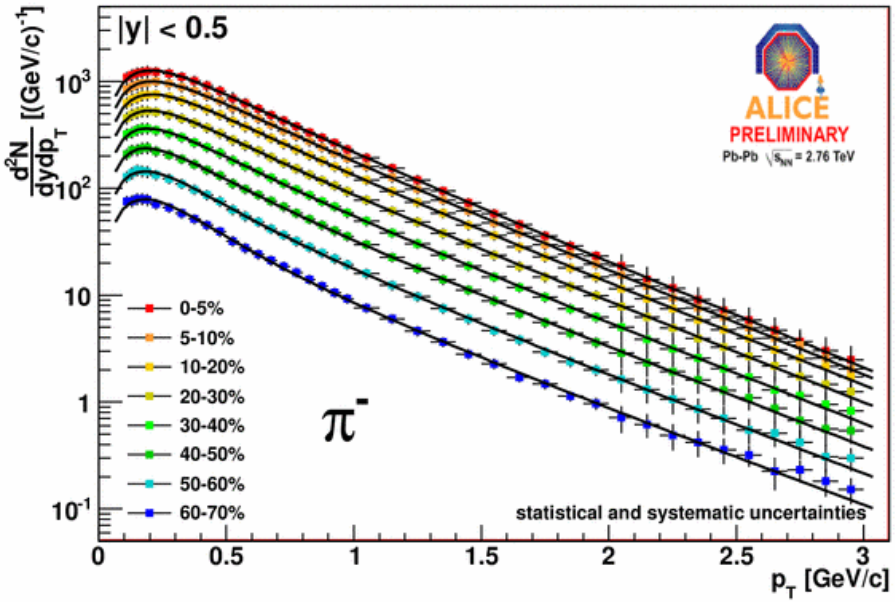
R. Stock
May 23

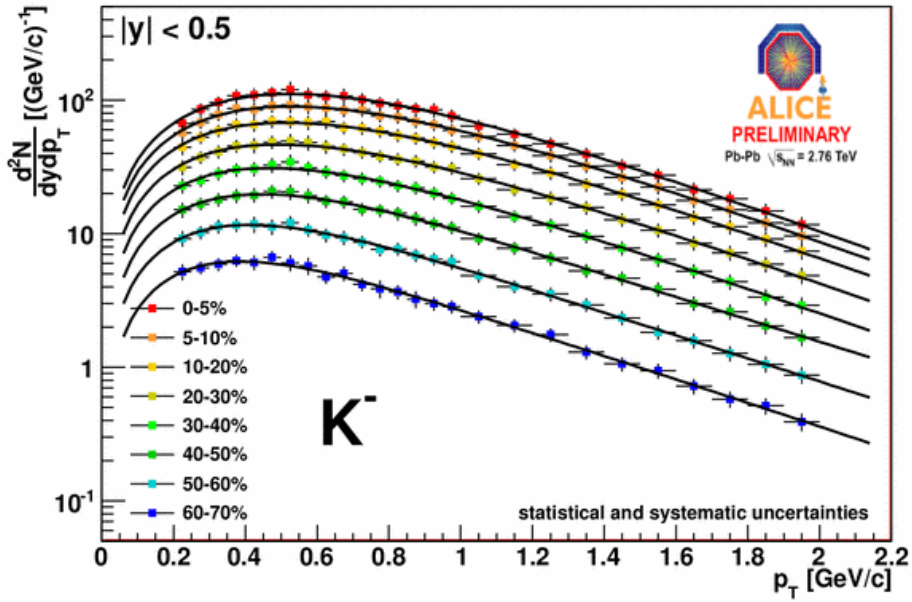
UrQMD Hybrid Model:

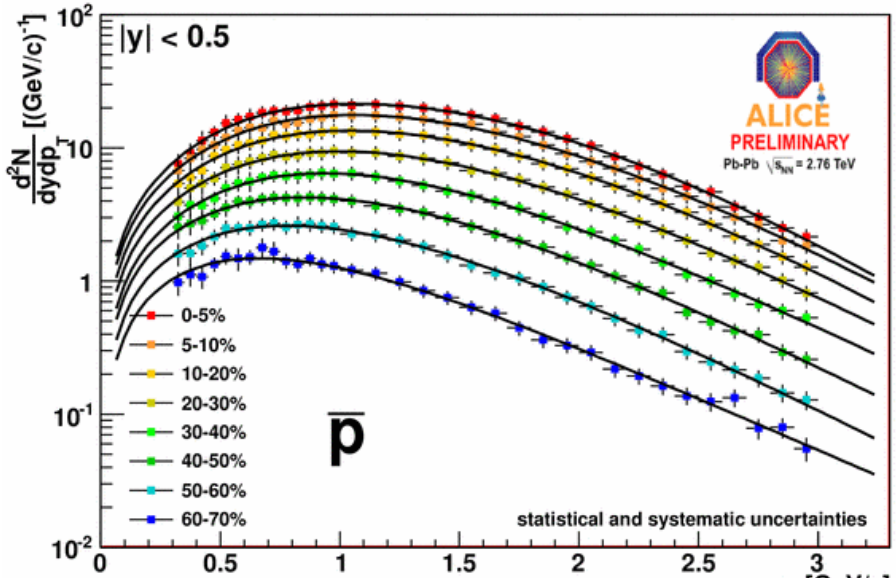
Comparison Hydro vs. Hydro+Afterburner at 40 and 158A GeV

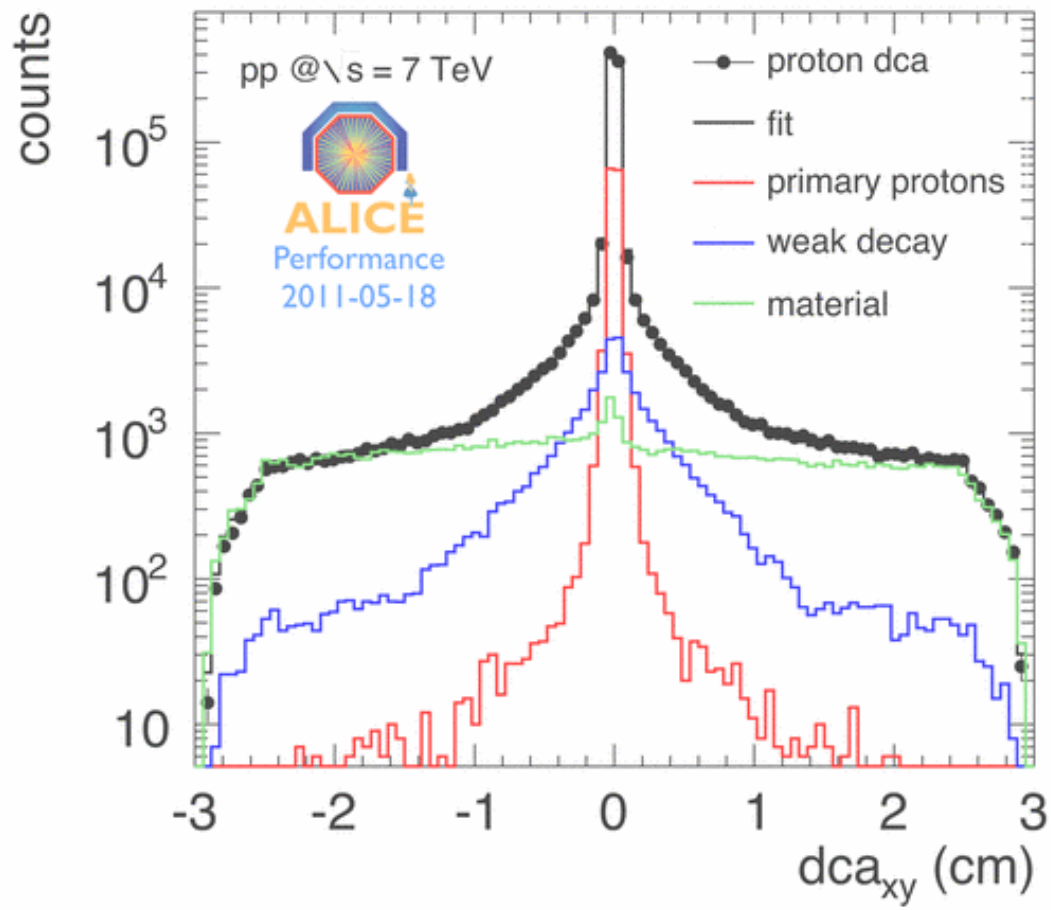


→ Hadronic cascade "afterburner" removes antibaryons except anti-Omega!


|y| < 0.5
ALICE
PRELIMINARY
Pb-Pb √s_NN = 2.76 TeV
0-5%
5-10%
10-20%
20-30%
30-40%
40-50%
50-60%
60-70%
π-
statistical and systematic uncertainties
p_T [GeV/c]
d²N/dydp_T [(GeV/c)⁻¹]


|y| < 0.5
ALICE
PRELIMINARY
Pb-Pb √s_NN = 2.76 TeV
0-5%
5-10%
10-20%
20-30%
30-40%
40-50%
50-60%
60-70%
K-
statistical and systematic uncertainties
p_T [GeV/c]
d²N/dydp_T [(GeV/c)⁻¹]


|y| < 0.5
ALICE
PRELIMINARY
Pb-Pb √s_NN = 2.76 TeV
0-5%
5-10%
10-20%
20-30%
30-40%
40-50%
50-60%
60-70%
p̄
statistical and systematic uncertainties
d²N/dydp_T [(GeV/c)⁻¹]



Distance of closest approach fitted with MC templates

ALI-PERF-6111

$$E\frac{d^3N}{dp^3} \propto \int_{\sigma} e^{-(u^{\mu}p_{\mu})/T_{fo}}\, p\, d\sigma_{\mu} \Rightarrow$$

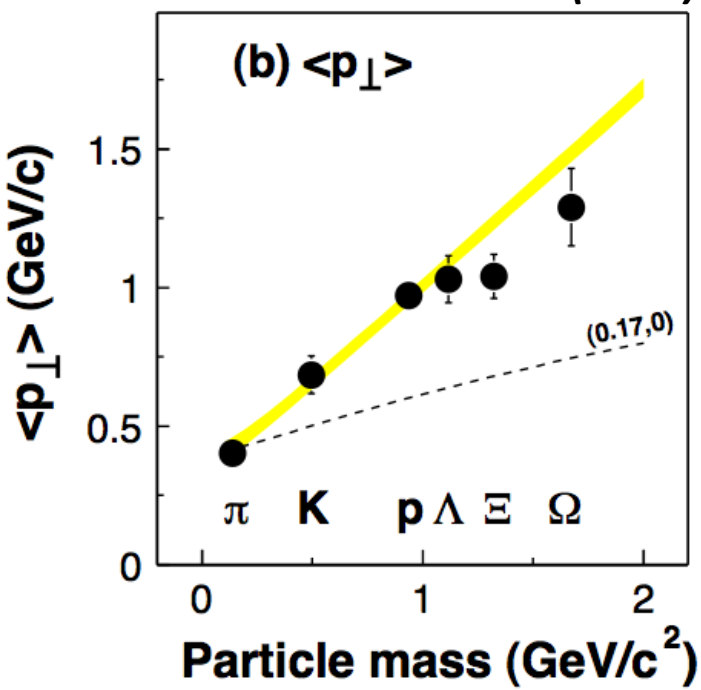
$$\frac{dN}{m_T dm_T} \propto \int_0^R r dr m_T K_1\left(\frac{m_T \cosh\rho}{T_{fo}}\right) I_0\left(\frac{p_T \sinh\rho}{T_{fo}}\right)$$

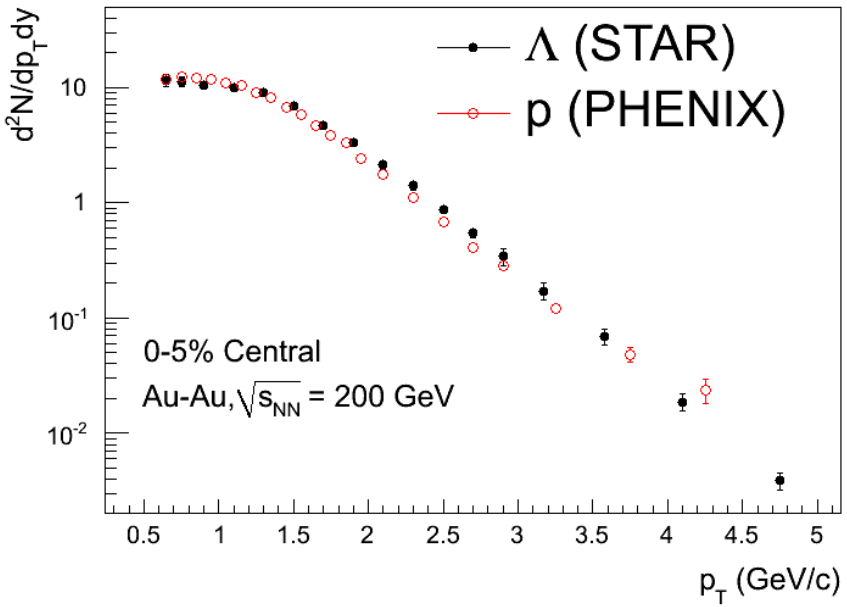
$$\rho = \tanh^{-1}\beta_T \qquad \beta_T = \beta_S\left(\frac{r}{R}\right)^{\alpha} \qquad \alpha = 0.5,\ 1,\ 2$$

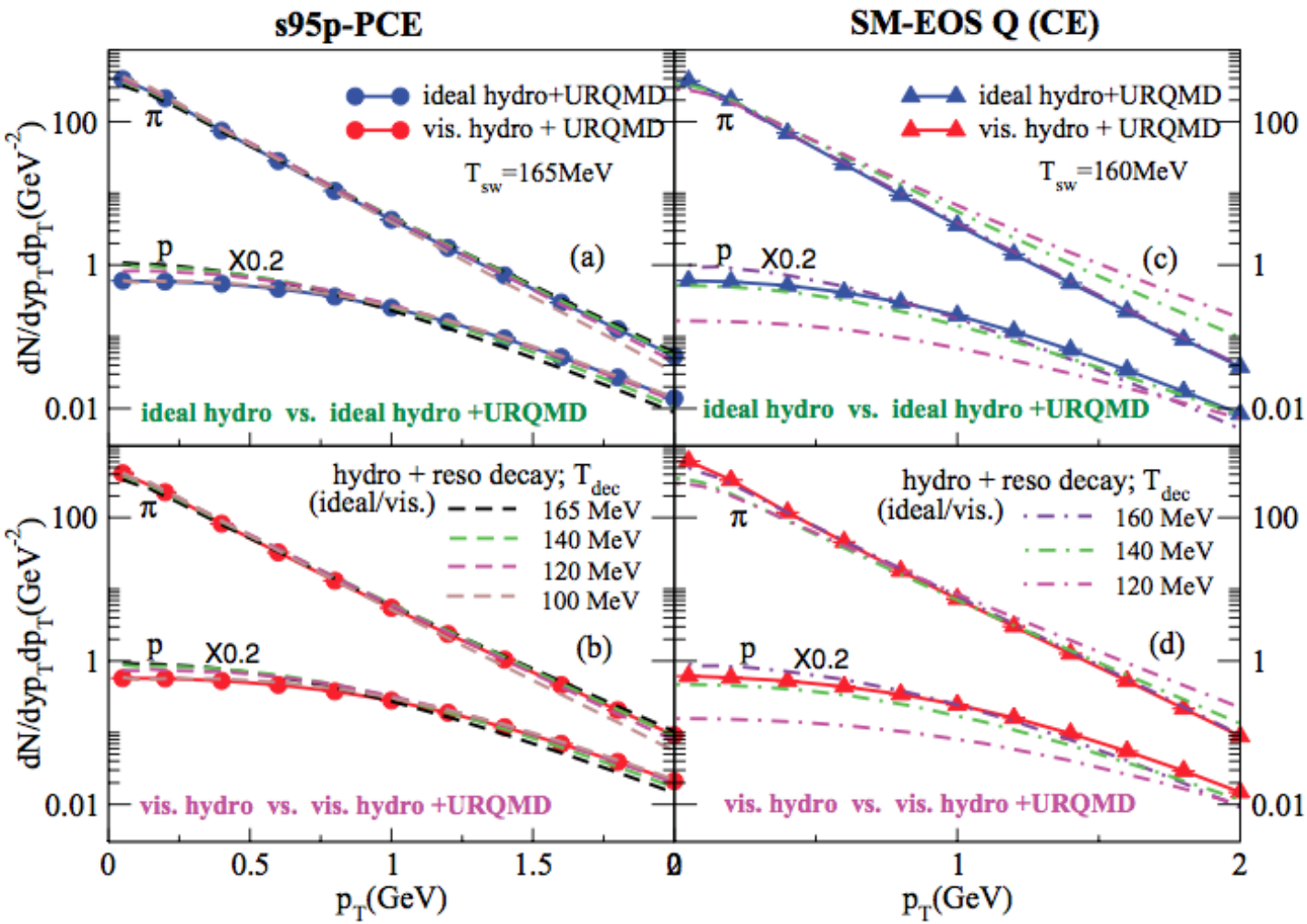
Free parameters: T_{fo}, β, α

E.Schnedermann, J.Sollfrank, and U.Heinz, Phys. Rev. C48, 2462(1993).

PRL92 182301 (2004)







VISHNU: PRC 83, 024912 (2011)

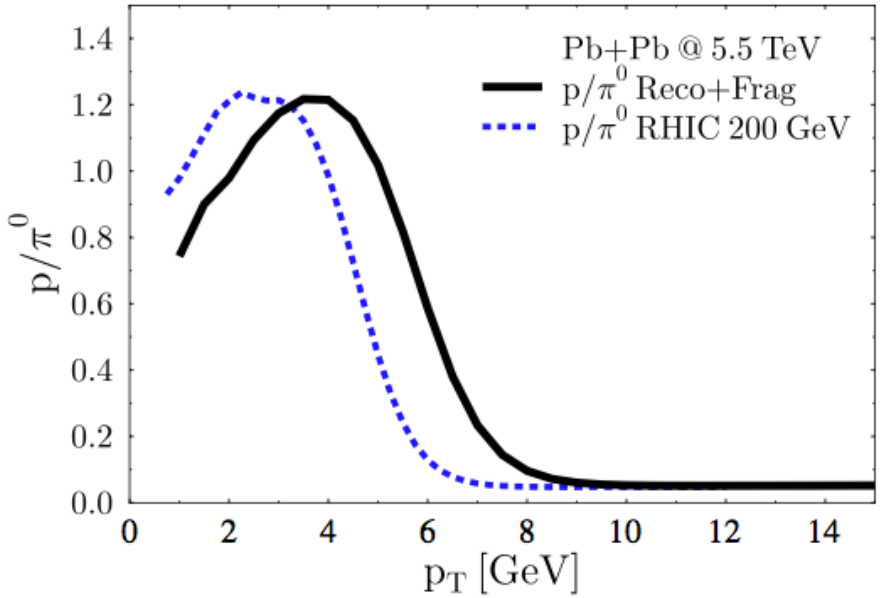


Fig. 7. The p/π^0 ratio for Pb+Pb at LHC (*solid*) and for Au+Au at RHIC (*dashed line*) as predicted by a calculation using recombination and pQCD. The baryon enhancement is pushed to higher P_T for LHC

R.J.Fries and B.Muller, Eur. Phys. J C34, s279–s285 (2004)

See R. Snellings
(24 May)