Strange particle production in pp collisions with ALICE at LHC

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Motivations and subsequent measurements

MOTIVATIONS:

Main goal of the ALICE experiment:
Study the properties of strongly interacting matter (QGP)
created in HE nucleus-nucleus collisions

→ Necessity of the hadronic reference for all observables for HI

→ Understanding the particle production in elementary pp collisions over the largest possible energy domain by systematic comparisons with models

→ Strange particles provide a particularly sensitive test to all models (p-QCD inspired models as well as statistical models)

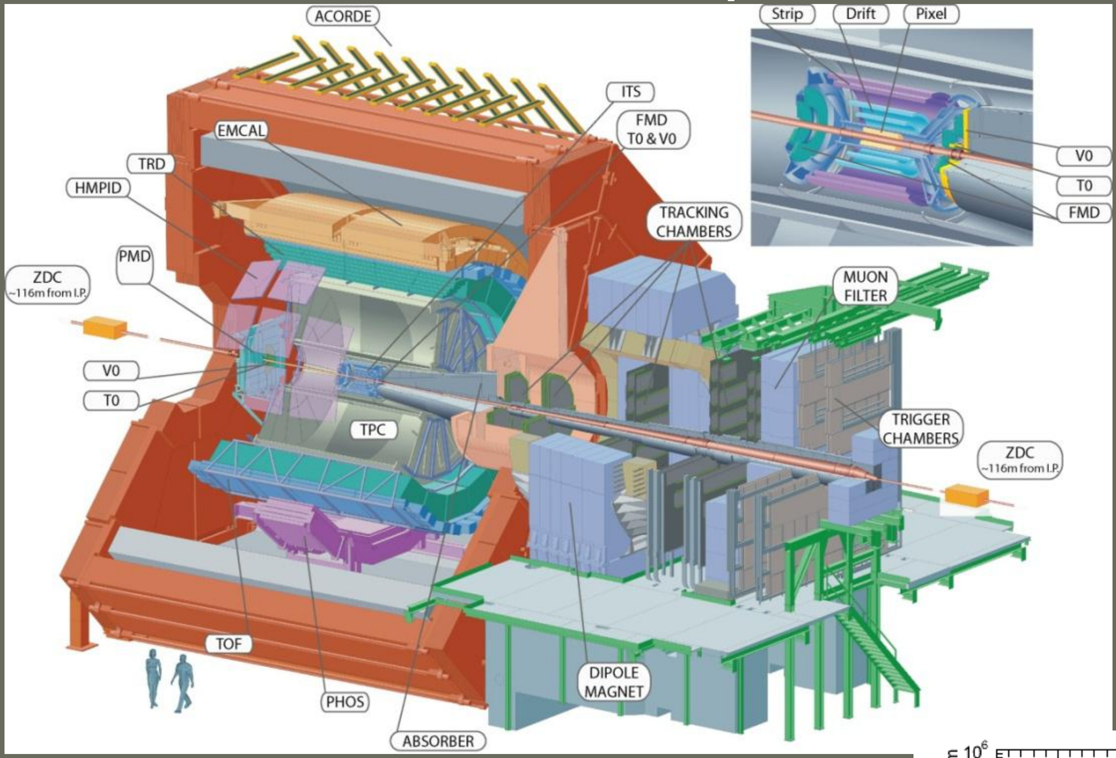
MEASUREMENTS:

Transverse momentum spectra and yields
at central rapidity for various strange particle species:

- Strange weak decaying hadrons (K^0_S, Λ, Ξ)
- Resonances (ϕ)
- Stable kaons (K^+, K^-)

Comparison with previous data and with models

Detector set-up and event selection strategy



Strange particle reconstruction needs high precision **vertexing, tracking and PID in the central barrel**, i.e., 3 main detectors: TPC, ITS and TOF + proper trigger detectors

Minimum Bias trigger:

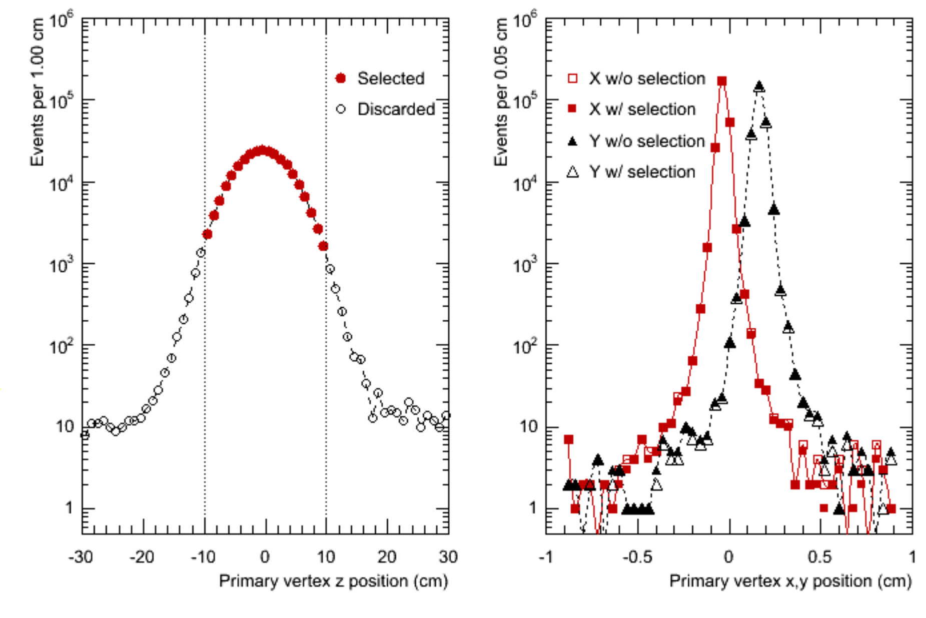
- LHC bunch crossing signal in coincidence with the BPTX beam pickup counters
- At least one charged particle in SPD or in one of the VZERO counters (V0A or V0C)

Event Classes (offline):

INEL: MBOR (SPD or VZEROA or VZEROC) and offline background suppression

NSD: MBAND (VZEROA and VZEROC) and offline background suppression

Vs = 900 GeV:
About 250 K events selected after offline cuts (less than 10 cm between the primary vertex position and the centre of the experiment, …)



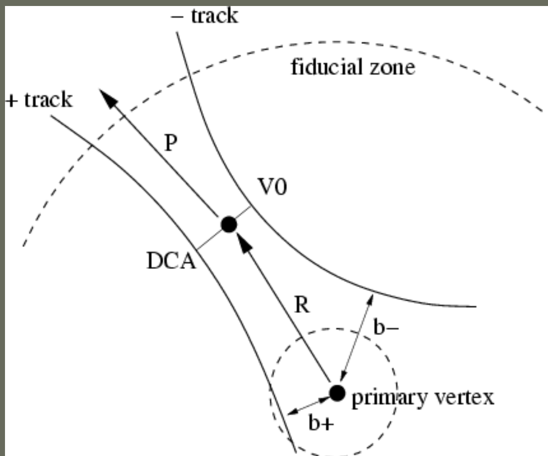
Topological reconstruction of K^0_s, Λ and Ξ

After further track selection (TPC clusters ≥ 80 , p_T > 160 MeV/c, |y| < 0.75, …), the association between daughter particles is made:

V0 (K^0_s, Λ) reconstruction

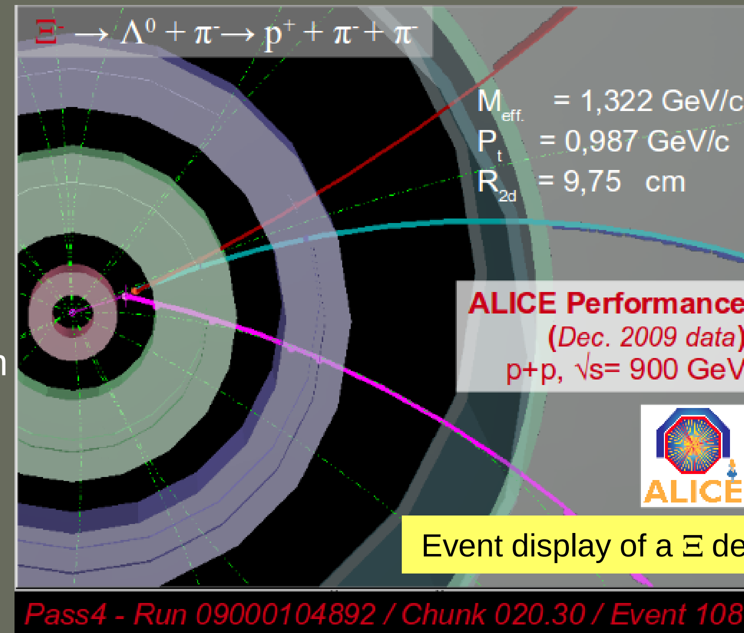
$K^0_s \rightarrow \pi^+\pi^-$

$\Lambda \rightarrow p\ \pi$



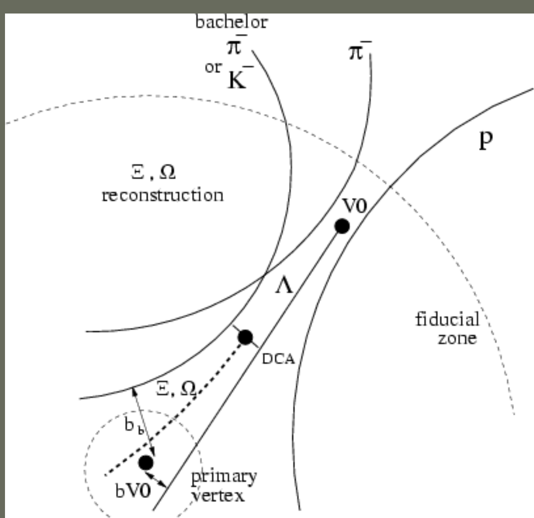
– Select secondary tracks from DCA to primary vertex

– Select secondary vertex by DCA of secondary tracks to possible vertex

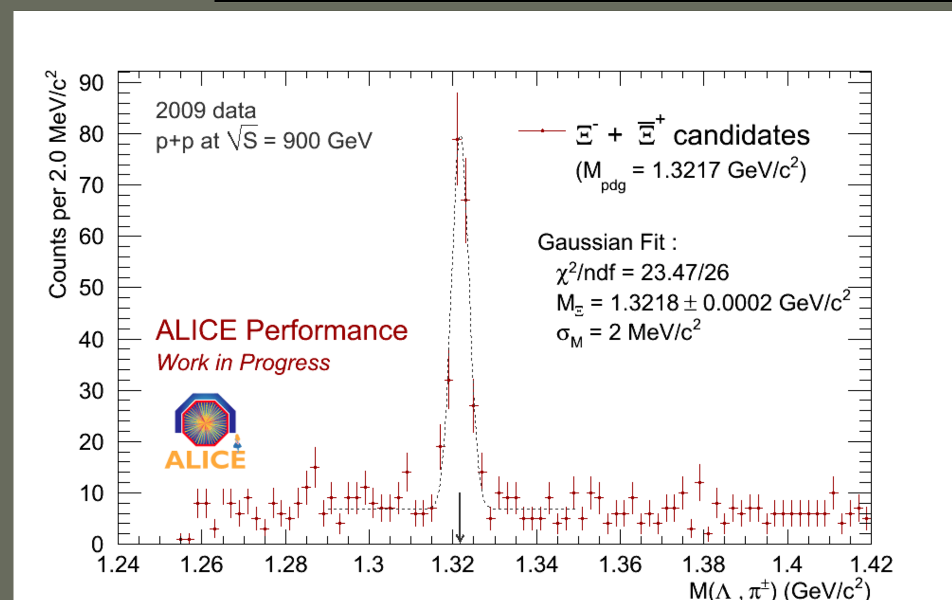


Event display of a Ξ decay

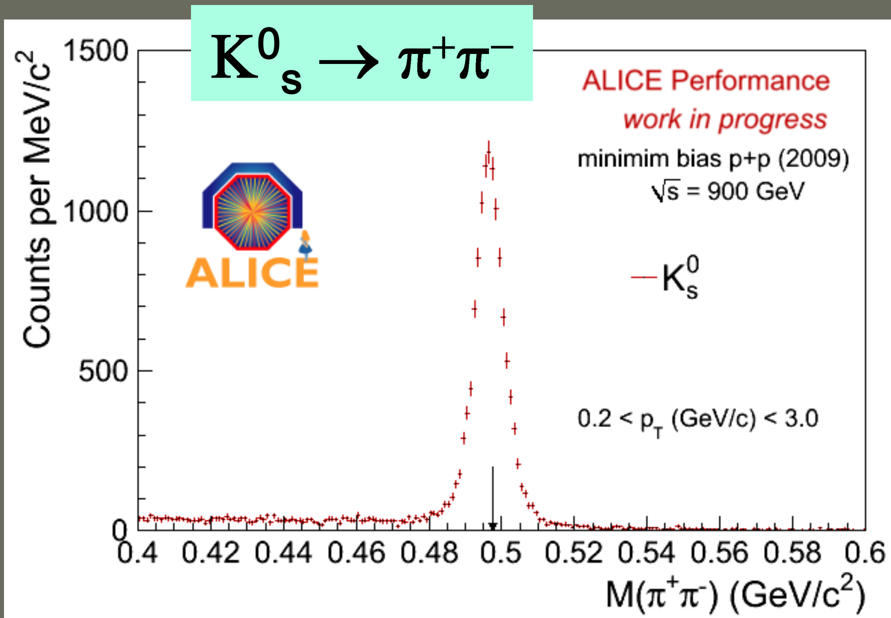
Cascade (Ξ) or (Ω) reconstruction

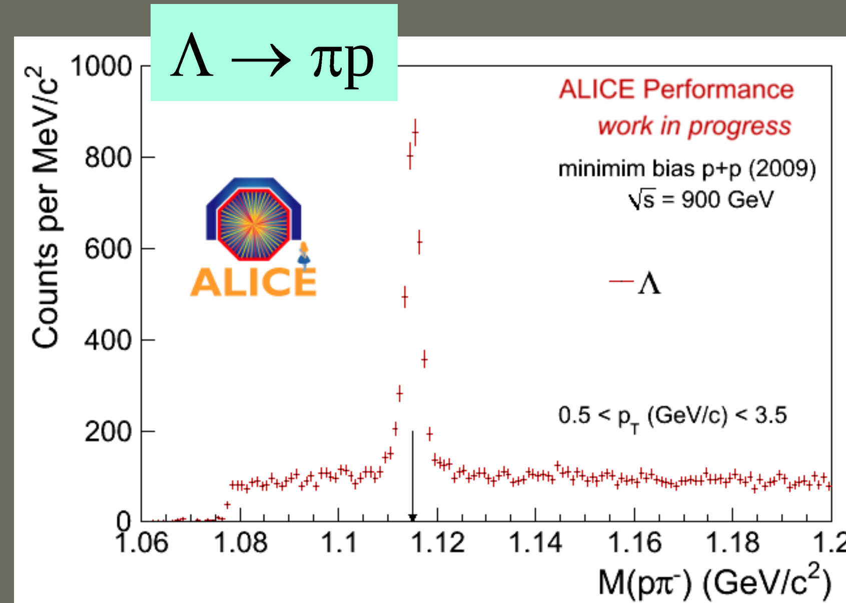


$\Xi / \overline{\Xi} \rightarrow \Lambda\ \pi$

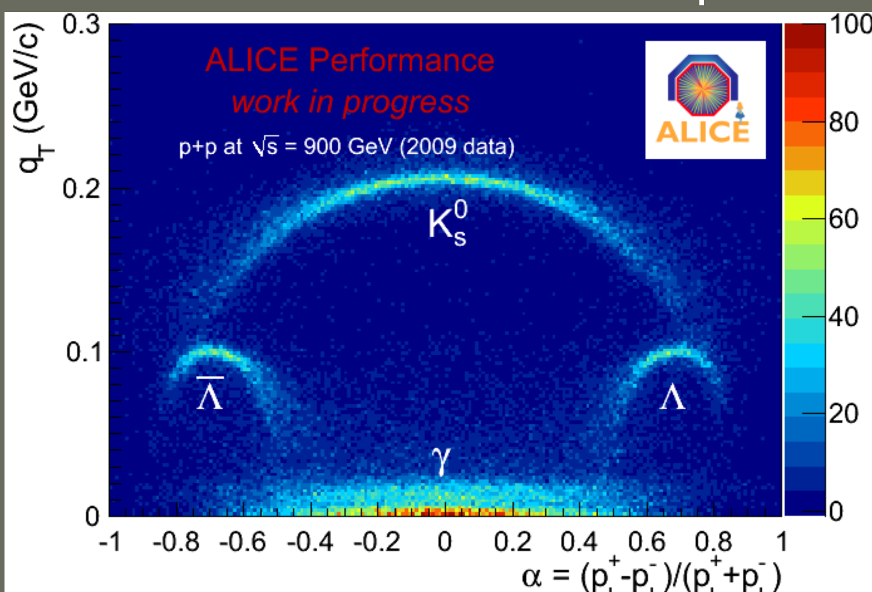


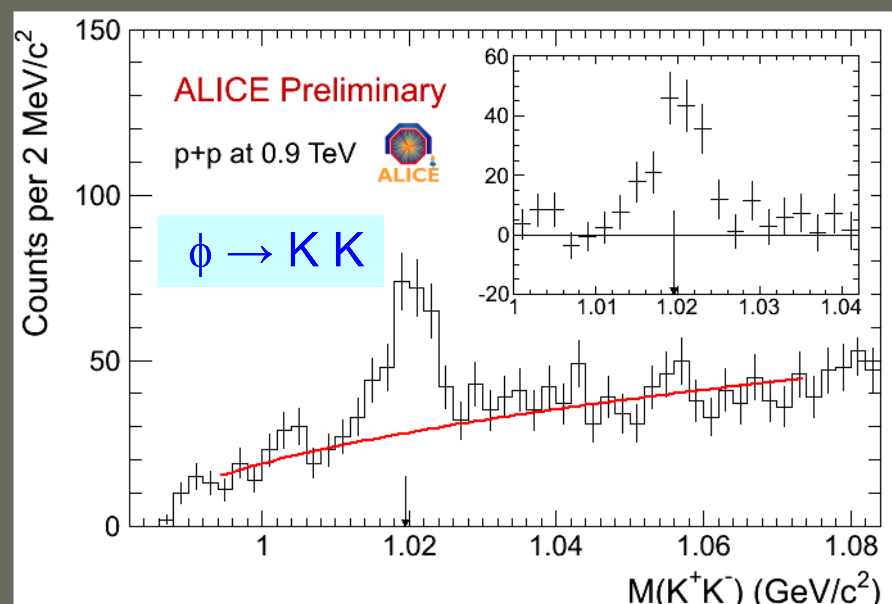
Invariant mass spectra of K^0_s, Λ, anti-Λ and ϕ





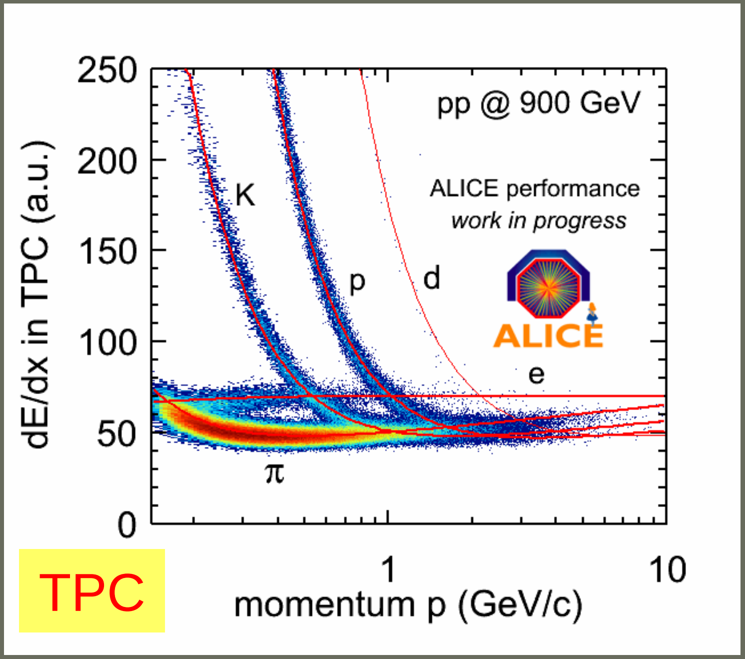
Armenteros-Podolanski plot

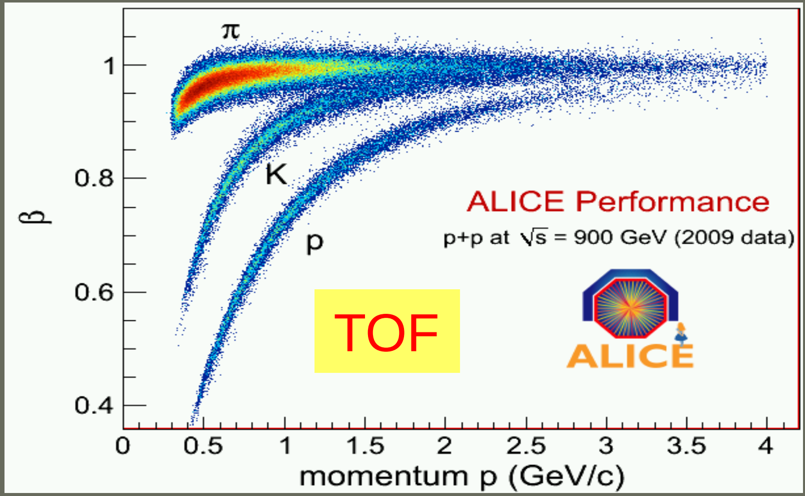




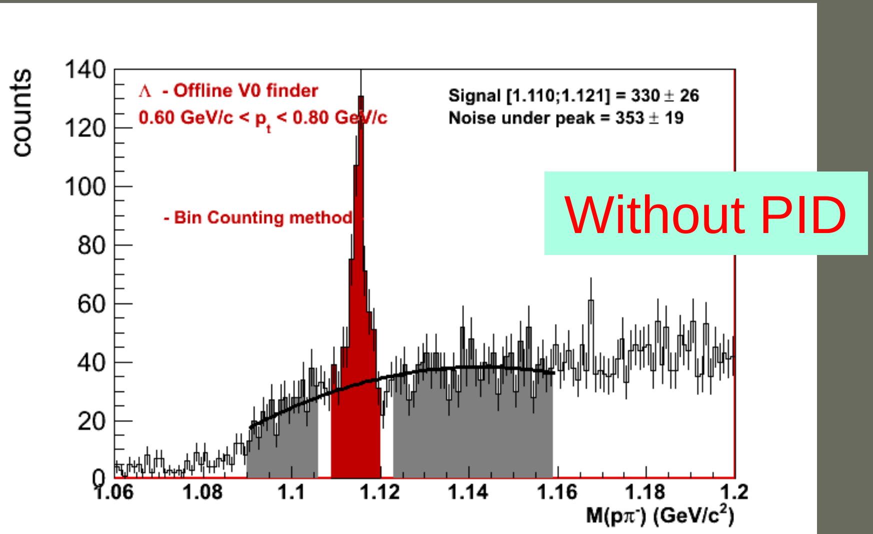
Improvement of signal over background ratio using Particle IDentification

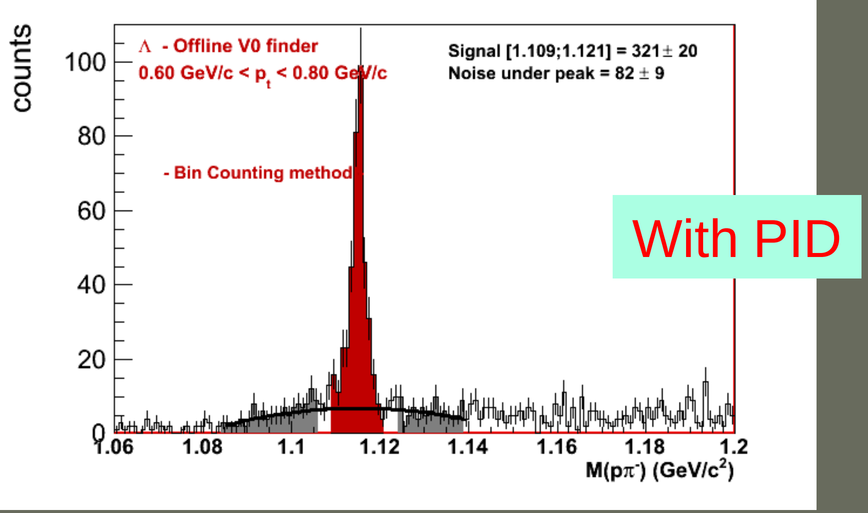
Especially for Λ and ϕ





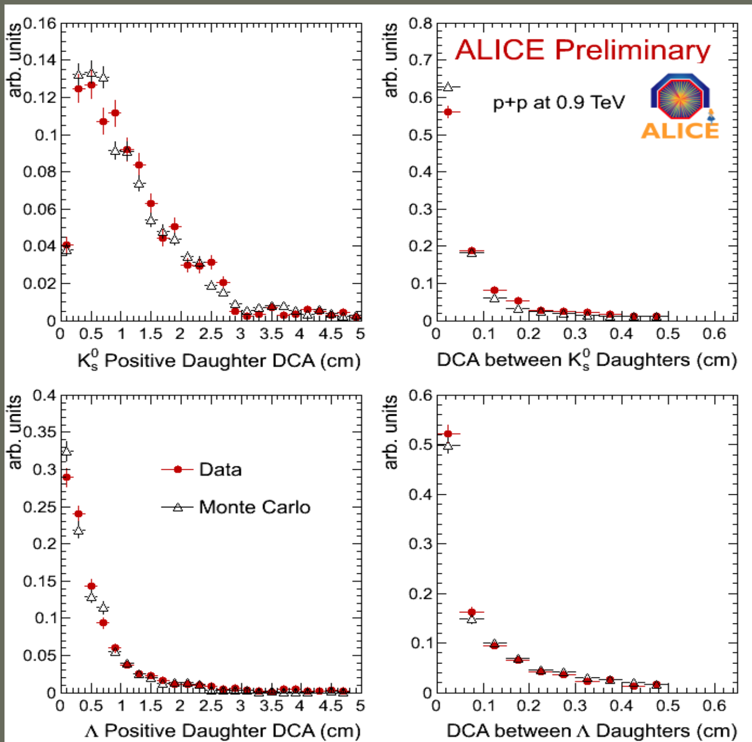
Bin counting after background fitting





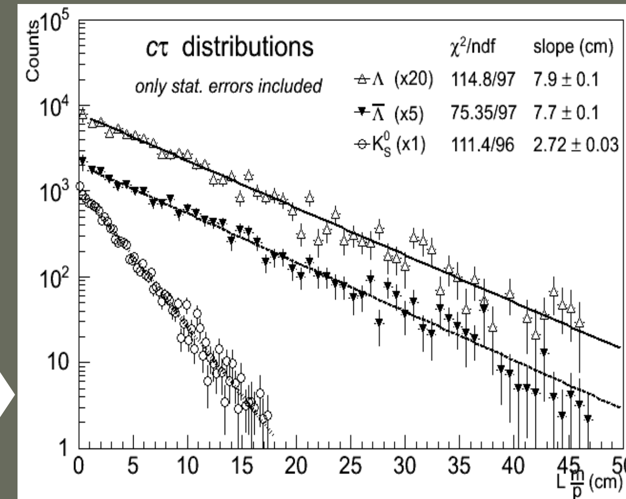
Different PID combinations (using TPC, TOF and ITS) depending on the particle type

From quality checks & efficiency determination to final spectra

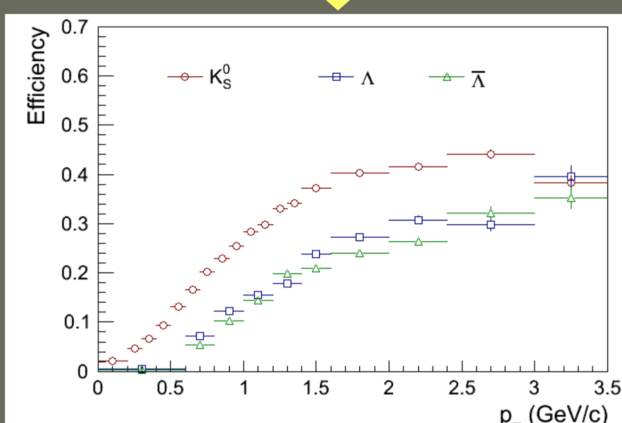


Topological cut distributions from Data and MC: very reasonable agreement

$c\tau$:
Excellent agreement with PDG values

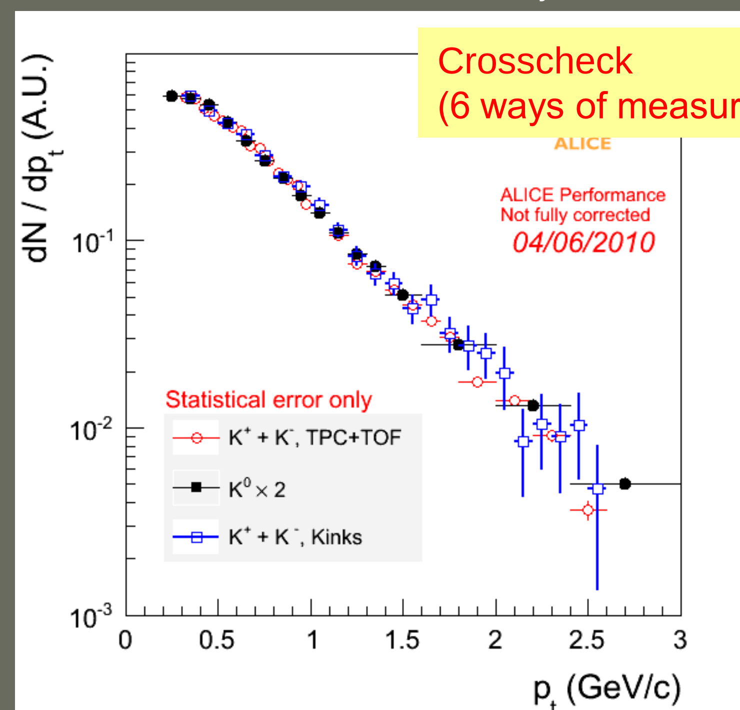


Efficiency from MC



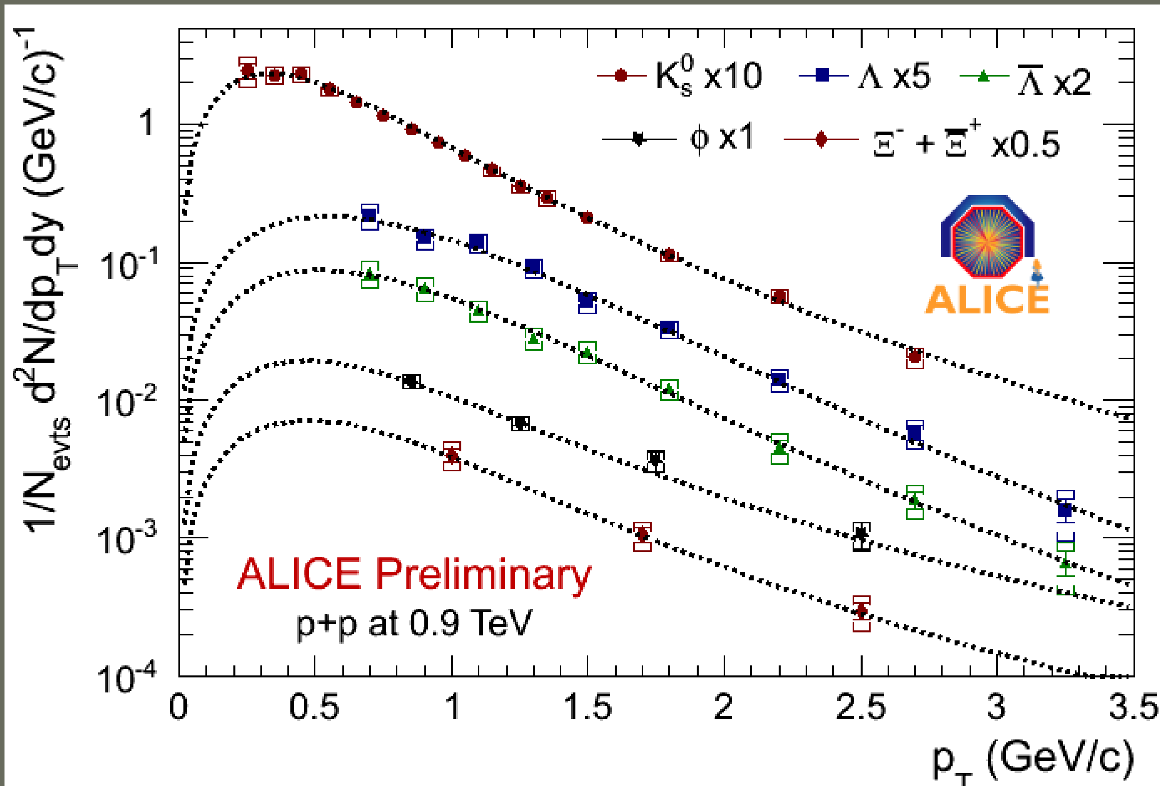
Corrected spectra

Comparison of corrected K0s with charged Kaons measured via dE/dx in TPC and by TOF



Crosscheck
(6 ways of measuring K's)

Transverse momentum spectra and yields at $\sqrt{s}$ = 900 GeV



Corrected and normalized (INEL collisions)

K^0_s (|y|<0.75) Stat. Syst.
dN/dy = 0.184 ± 0.002 ± 0.006

Λ (|y|<0.75)
dN/dy = 0.048 ± 0.001 ± 0.004

$\bar{\Lambda}$ (|y|<0.75)
dN/dy = 0.047 ± 0.002 ± 0.005

ϕ (|y|<0.6)
dN/dy = 0.021 ± 0.004 ± 0.003

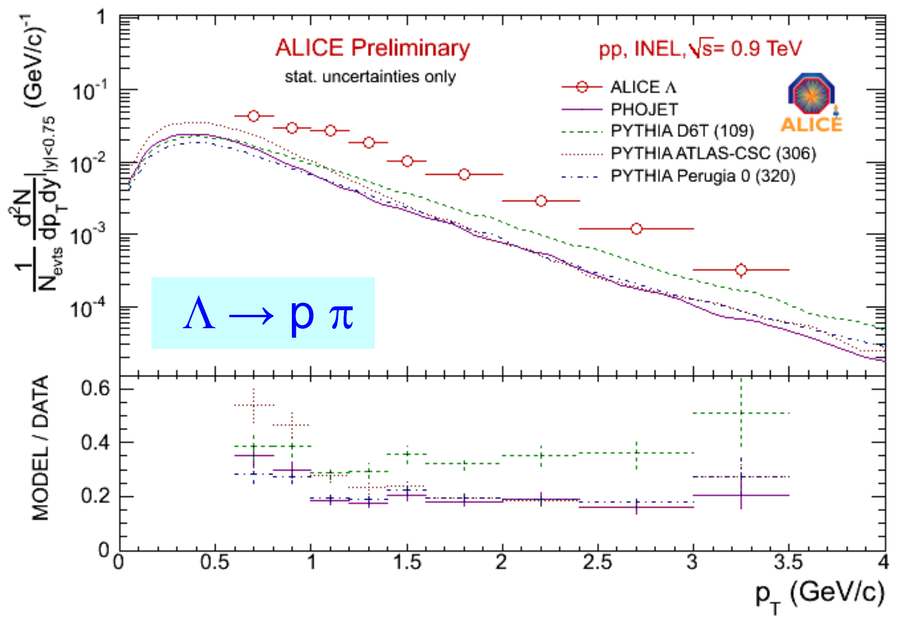
$\Xi + \bar{\Xi}$ (|y|<0.8)
dN/dy = 0.015 ± 0.003 ± 0.004

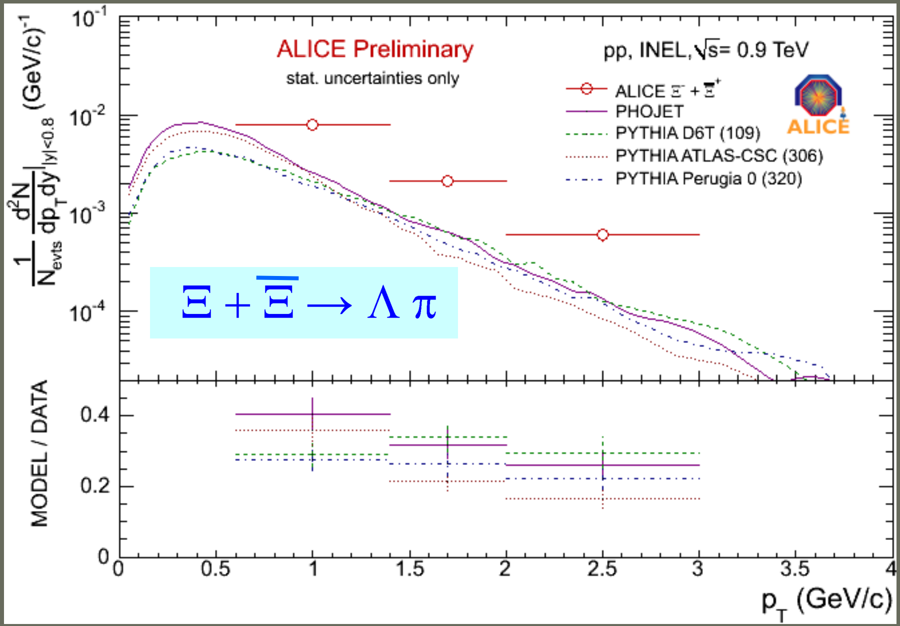
Main systematic errors:
1) Track, topological selections and signal counting
2) Material budget and absorption X-sections
3) Feed down from cascades

dN/dy extracted using a Lévy functional form

$$\frac{dN}{dp_t} \propto p_t \left(1+\frac{\sqrt{m^2+p_t^2}-m}{nT}\right)^{-n}$$

Comparison with p-QCD inspired models
What do we learn from strange baryons?

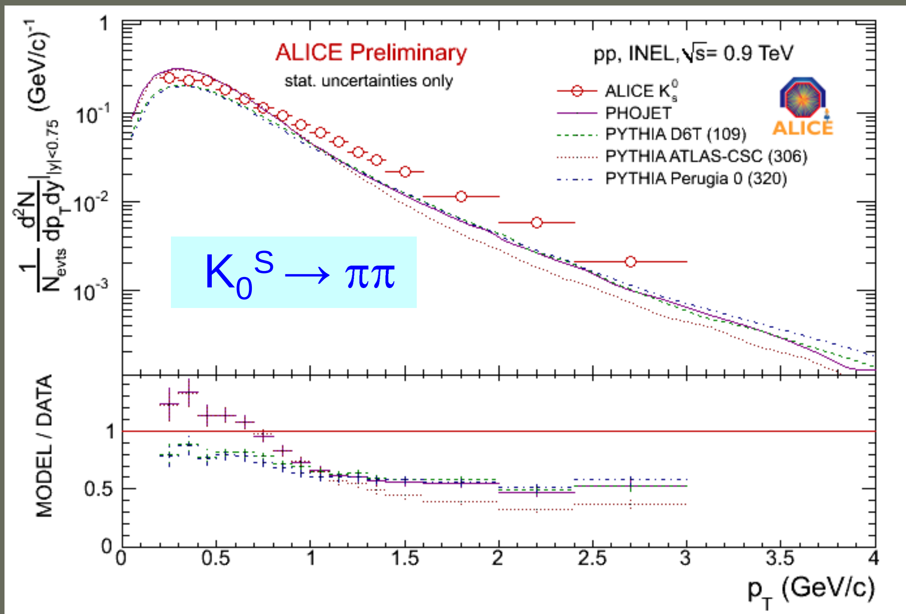




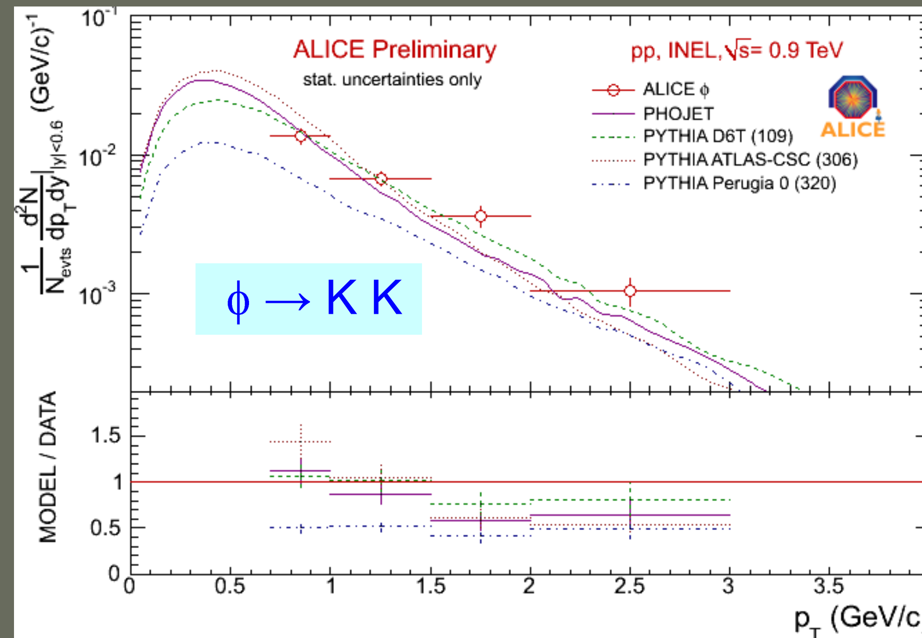
Pythia and Phojet:
pQCD (for the hard component of the interactions)
+ phenomenological description of the soft component and of the underlying event

All models or tunes, even those with new treatments of processes involving gluon baryon string junctions or multi-parton interactions, strongly underestimate strange baryon production

Comparison with p-QCD inspired models
What do we learn from strange mesons?



Not perfect for K^0_s …



Somewhat better for ϕ …

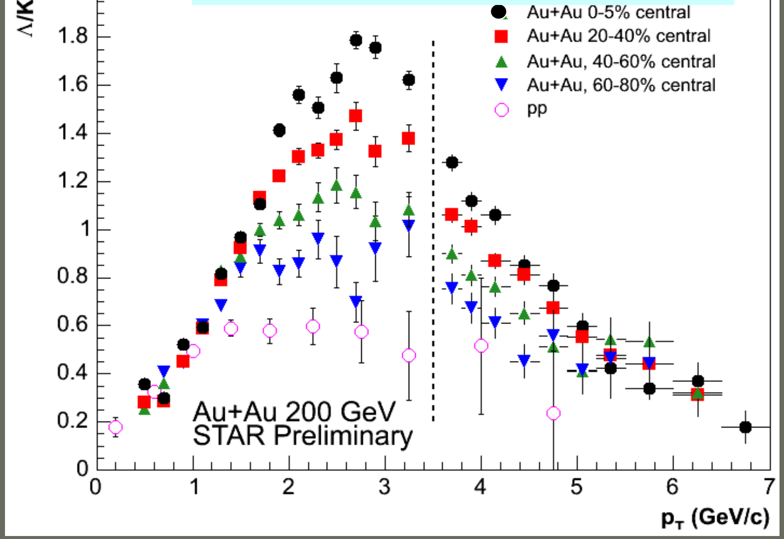
A lot of work for models if we want to understand (or at least reproduce) hadron production in pp and its excitation function. Moreover, it is crucial as a reference for HI (extrapolation of the yields to the PbPb energies)

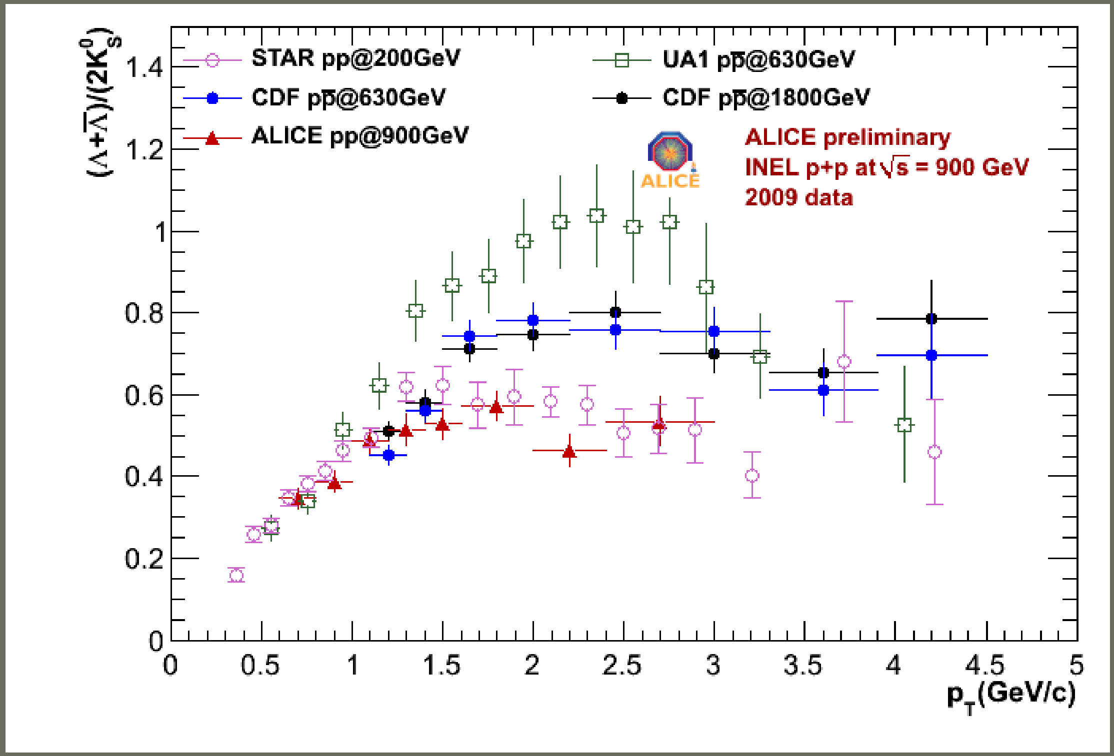
The question of the Λ/K^0_s ratio

At RHIC: large Baryon/Meson ratio: parton coalescence from QGP ?

Ratio at mid-p_T already surprisingly high in previous pp data at high energies

Λ/K^0_S Ratio in Au+Au at RHIC



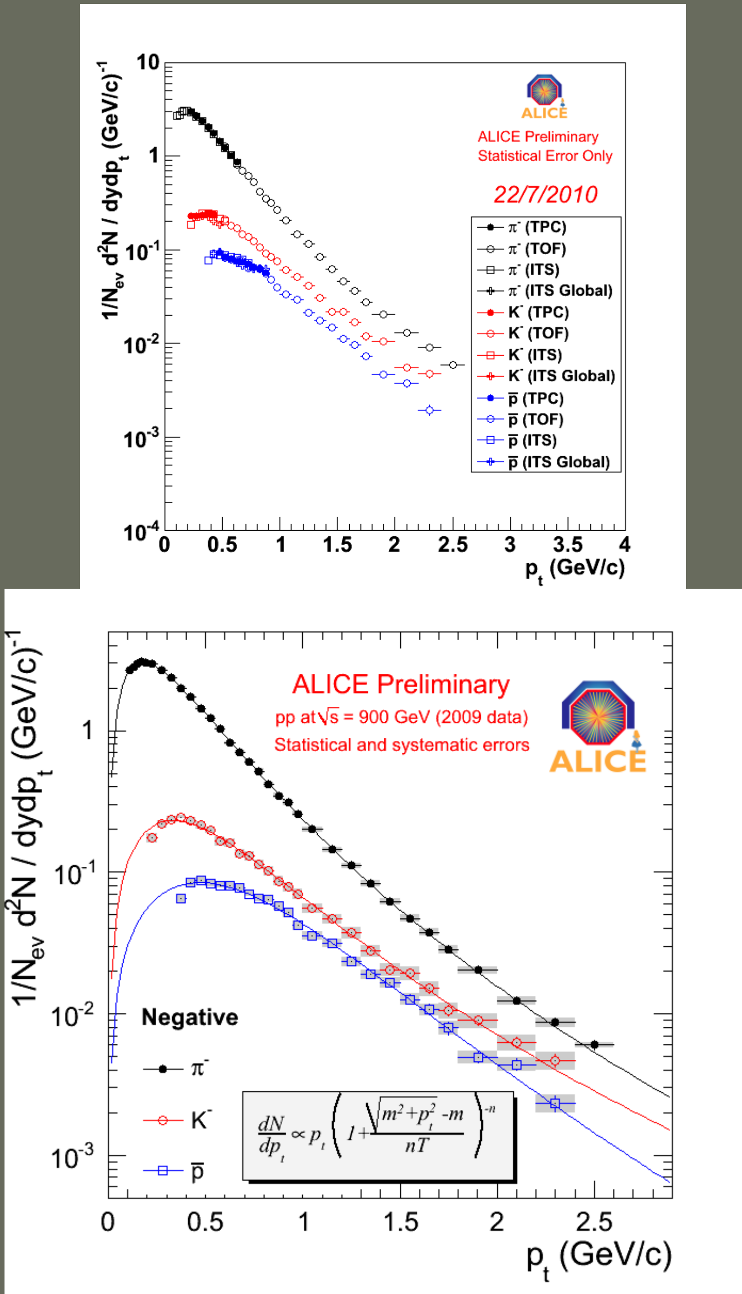


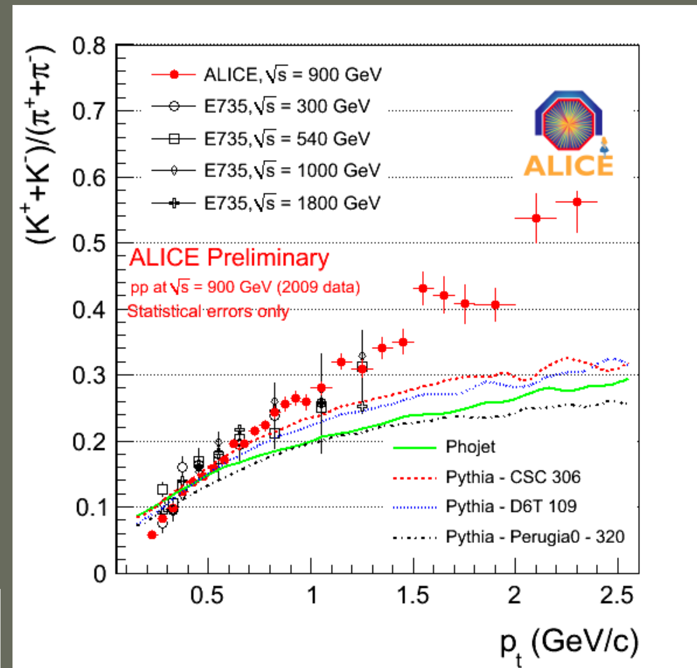
Very good agreement between STAR (200 GeV) and ALICE (900 GeV) (both feed-down corrected: 12 to 15 % correction)

Very different from CDF (630/1800) and UA1 (630) for p_T > 1.5 GeV (not feed-down corrected)

To be further investigated (different triggers, acceptance, feed-down correction?)

Spectra of π, K, p identified via dE/dx in TPC & ITS and by the TOF

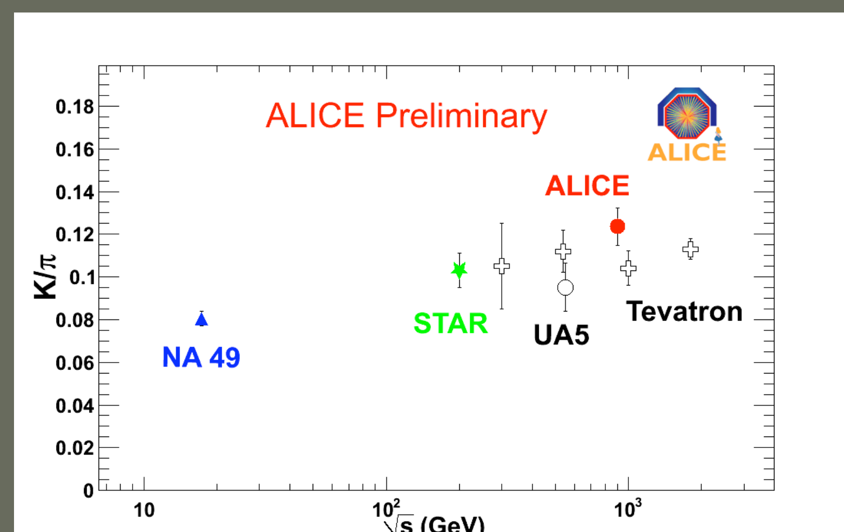




K/π

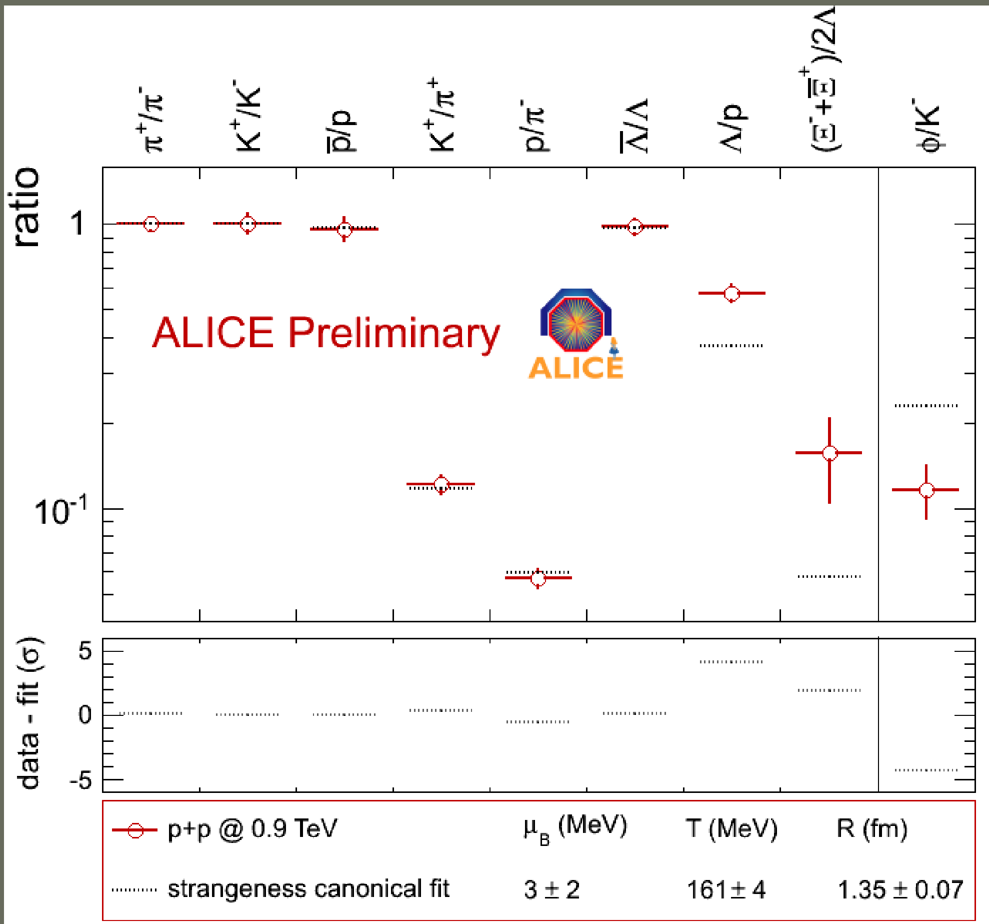
A good agreement with E735 at various energies but again a substantial discrepancy with Pythia and Phojet (increasing with pt)

Slow rise with √s?: 7TeV point important

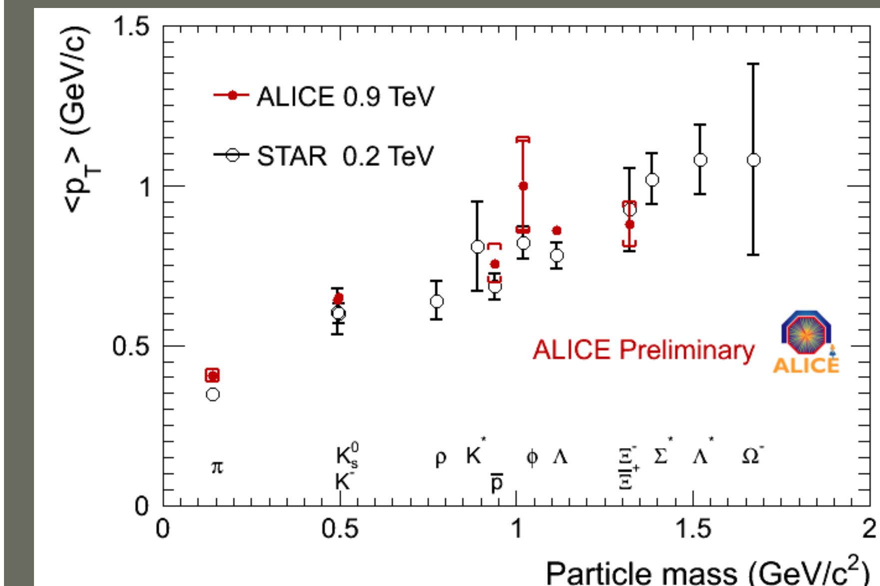


All species and ratios together …

Comparison of yield ratios to fits with the THERMUS statistical model
(S. Wheaton, J. Cleymans and M. Hauer)



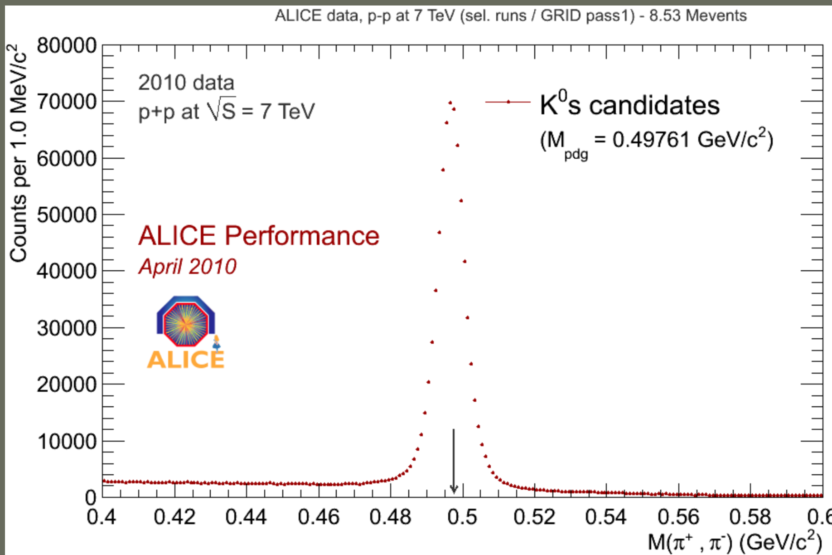
$\langle p_T \rangle$ as function of particle mass

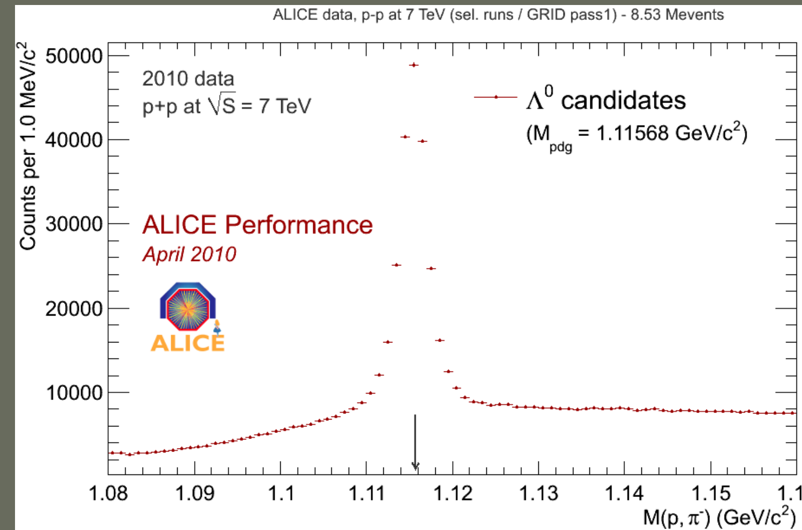


Same trend as in STAR in 200 GeV pp collisions

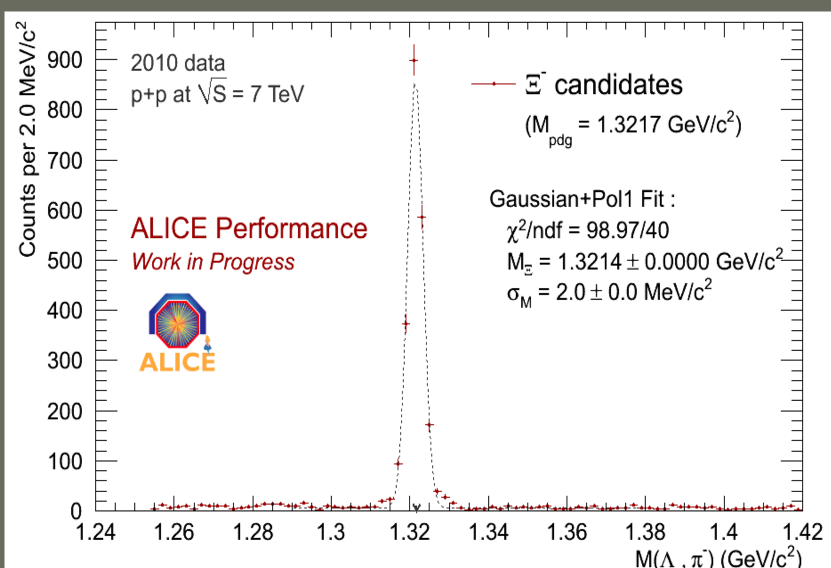
T=161 ± 4 MeV; μ_B = 3 ± 2 MeV

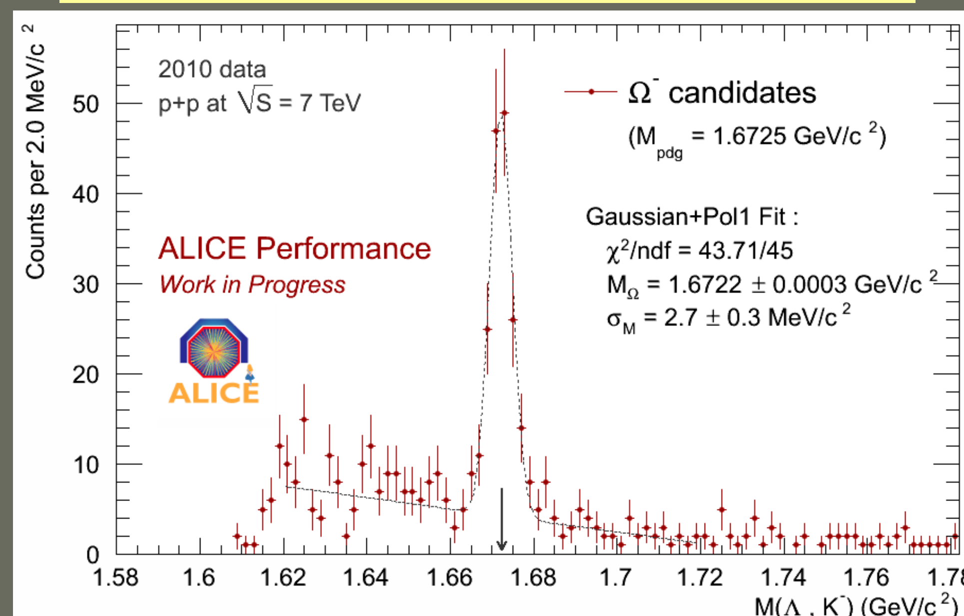
Next steps: K^0_s and Hyperons at 7 TeV with 4000 times more statistics!



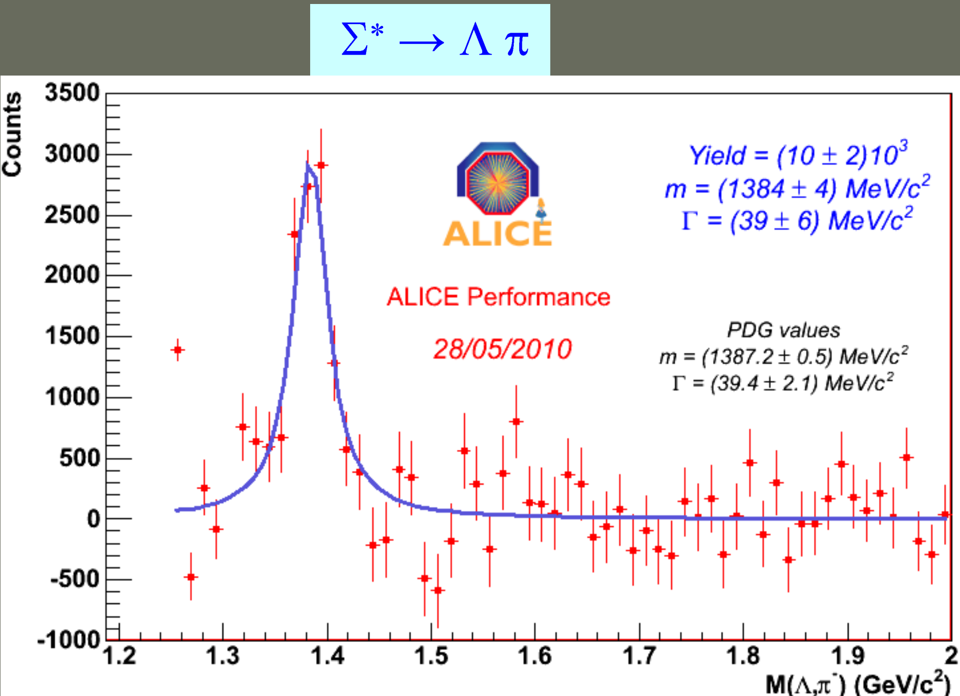


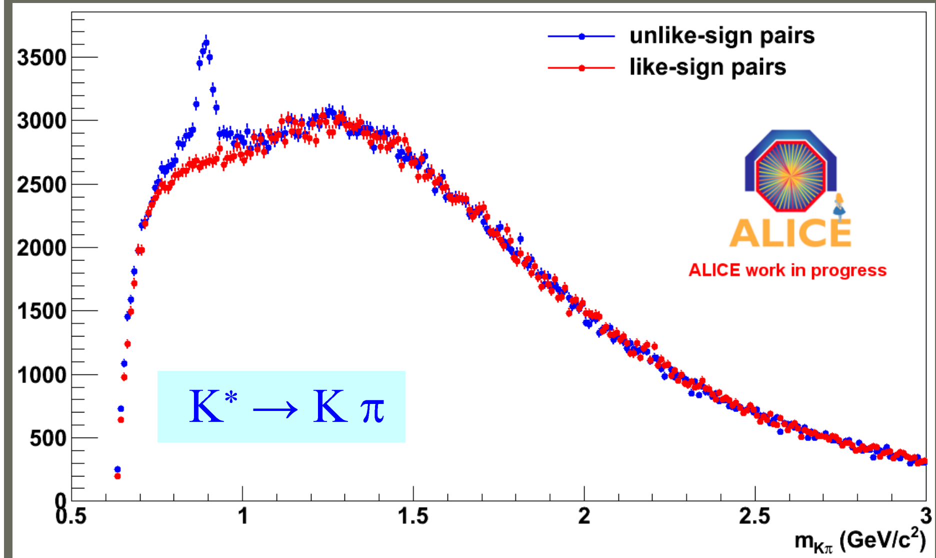
An additional particle in the game!



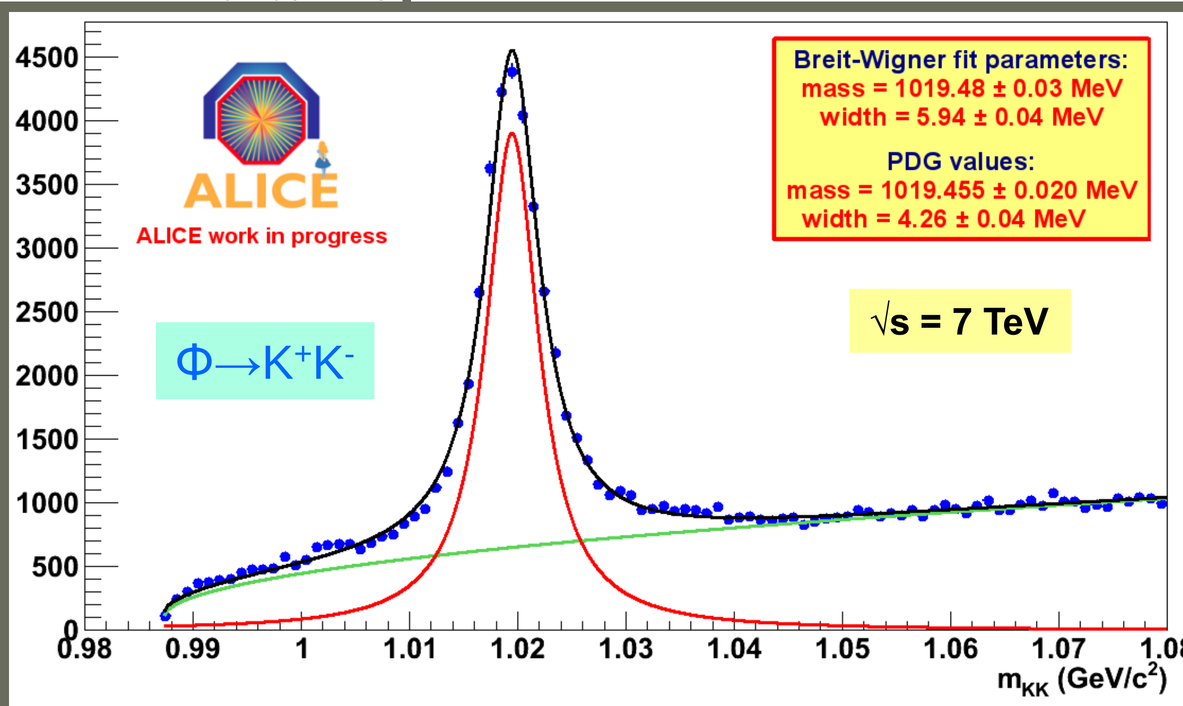


and resonances at 7 TeV





Here also, a few new players!



CONCLUSION

- Detailed study of strange mesons and baryons produced in pp at 900 GeV, making use of ALICE PID capability
- Surprisingly poor description of the data by PYTHIA and PHOJET
- High statistics 7 TeV data under study will provide many more details
- Important for comparisons with heavy ion data