Lambda and K^0_S in LHC pp collisions

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Strasbourg, June 2009

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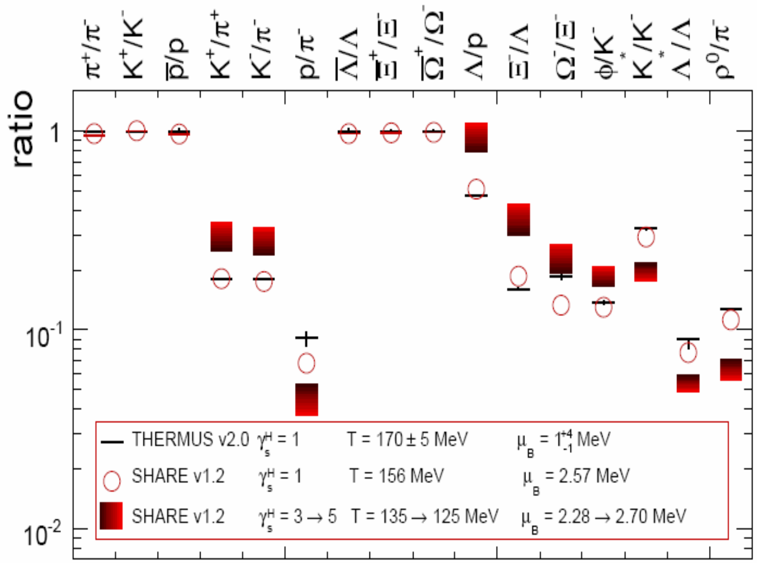
Why Λ and K^0_S will be interesting at LHC ?

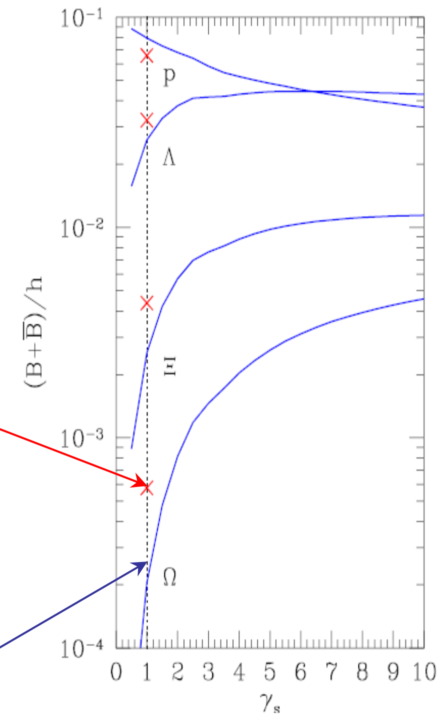
➢ Measurements of strange particles ratio can help to constrain the **statistical models** (and to distinguish between the different existing models…)



Eur.Phys.J.C49:121-124,2007

Strangeness saturation (equilibrium)

Strangeness oversaturation (non equilibrium)



➢ Strange particles spectra can help to understand the dynamics of the system and the hadronisation mechanisms in the **intermediate p_t region.**

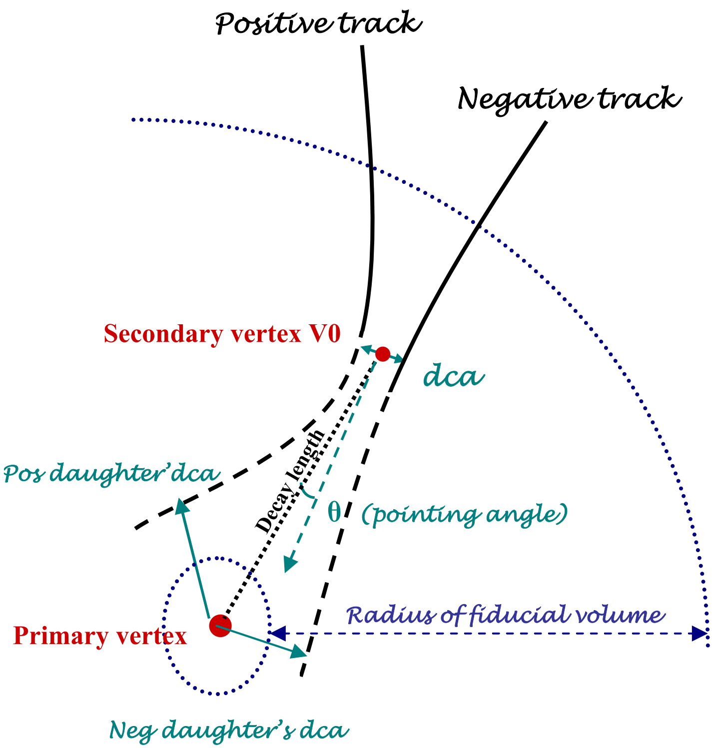
Important to check the behaviour in pp !!

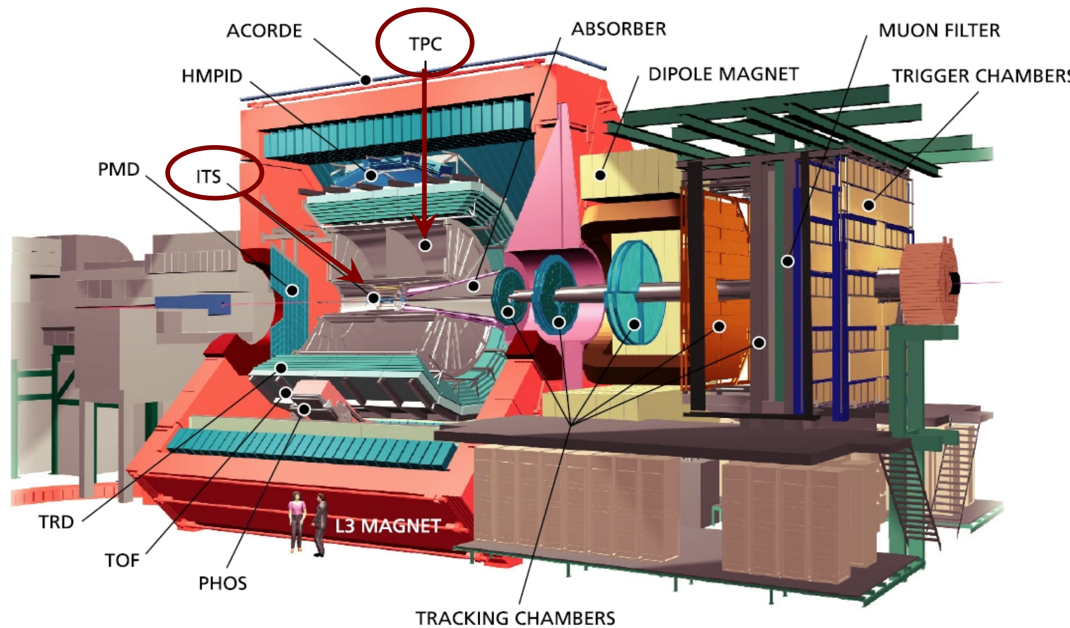
Why Lambda and K^0_S ?

Λ and K^0_S are identified through topological cuts → identification over a large p_t range

Reconstruction of Λ and K^0_S with ALICE

V0s vertex are reconstructed with the help of only two detectors in the central barrel:
TPC & ITS





particle	Decay products	Branching ratio	cτ (cm)
Λ	$p + \pi^-$	63.9 %	7.89
$\overline{\Lambda}$	$\overline{p} + \pi^+$	63.9 %	7.89
K^0_s	$\pi^- + \pi^+$	68.6 %	2.68

Reconstruction algorithms

Two tracking strategies for V0 reconstruction have been developed:

On-the-fly V0 finder: During tracking

- Check the likelihood of having a V0 while adding cluster to the tracks.

↓

The local characteristics of the helix describing the trajectory of the particle are available

This algorithm needs the clusters.

Offline V0 finder: After full tracking

- Selection of secondary tracks depending on their dca to primary vertex;
- Association of two opposite charged secondary tracks + topological cuts.

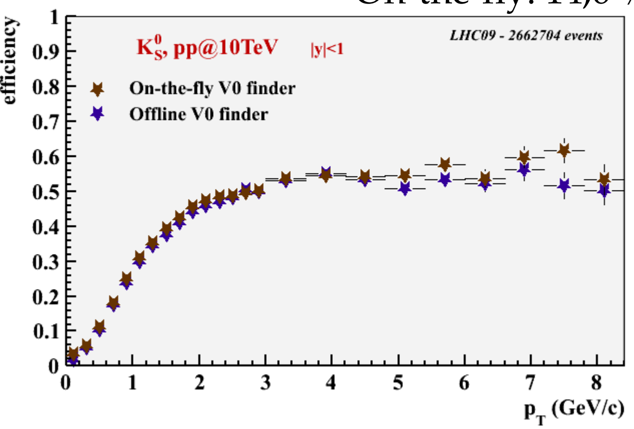
↓

Only the parameters at the dca to primary vertex are available.

Algorithm more independent of the tracking.

Comparison of the two V0 finders

K^0_S total efficiency : Offline: 13,8 %
On-the-fly: 14,6 %



The performances are slightly better for the On-the-fly finder. Because it can access the local characteristics of the helix describing the trajectory, it can define the V0 vertex with a better precision.

However:

The On-the-fly finder depends strongly on the quality of the parameterisation of the detector geometry and the correction of the energy loss.

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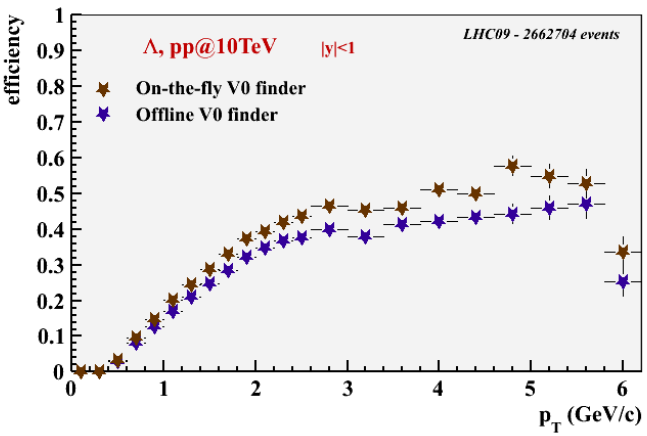
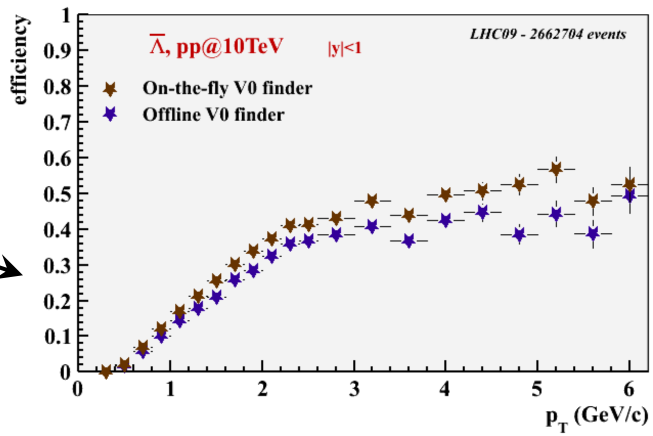
The clusters are needed : impossible to re-run the On-the fly finder once the general tracking is done.

If in pp collision the behaviour of both finders are similar, this might change in the high multiplicity environment such as Pb-Pb collisions…



Λ total efficiency:
Offline: 9,2%
On-the-fly: 10,7 %

$\overline{\Lambda}$ total efficiency:
Offline: 7,7%
On-the-fly: 9,0 %



Analysis codes are ready for the first data !

Three Tasks for Λ and K^0_S analysis:

- AliAnalysisTaskCheckV0: QA task
- AliAnalysisTaskStrange: Advanced QA task

They are available in $ALICE_ROOT/PWG2/SPECTRA.
They have been tested locally, on the Grid and on CAF and run fine within train (official GSI train).

- AliAnalysisTaskStrangeMC: Analysis code – Access to MC info

→ Task to calculate the reconstruction efficiency
Will be committed soon.

All of them can run over ESD & AOD

Analysis Strategy

Raw p_t spectra

~ 2 M events are enough to access interesting physics with Λ and K^0_S

Feed-down correction

(See next slide)

Signal extraction in each p_t bins:

-Bin couting

- fits (gaussian, Breit-Wigner…)

✓ Have been evaluated

Codes ready !

Efficiency correction

1/ based on PYTHIA simulations

✓ Code ready !

2/ Embedding:

Environment more realist to calculate the efficiency

But it modifies the multiplicity of the event !

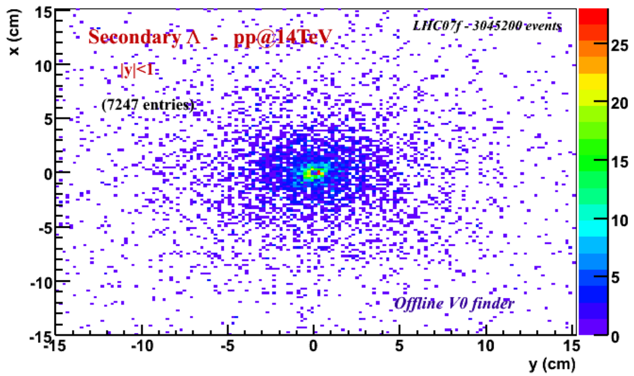
Interesting analysis in LHC pp data:

-Extract the yield to compare statistical models;

-Fit the p_t spectra with Blaste-Wave fit with Tsallis function. Such a study has been done very recently on RHIC data and give interesting results (**arXiv:0812.1609v2[nucl-ex]**)

- Study the ratio Λ/K^0_S versus p_t

Feed down correction strategies :



Secondary Λ = ~18% of the total number of Λ

Secondary Λ come mainly from decay of others particles (Ξ, Ω,…): *feed-down*

(PYTHIA simulations: baryon production is not fully reliable → proportion of secondary Λ is likely to change in real data.)

Reconstruction efficiency of secondary Λ not negligible.

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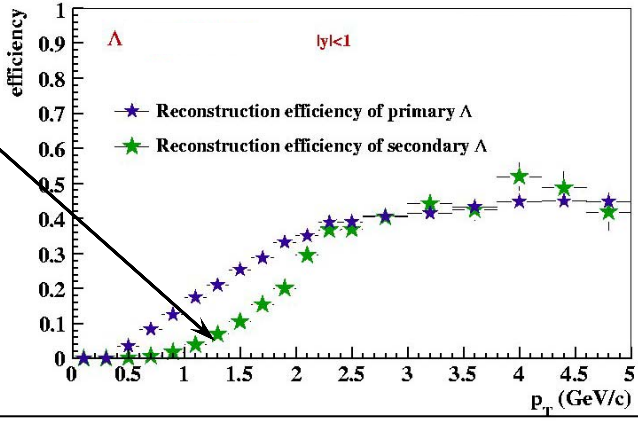
Reconstruction efficiency of secondary Λ ≠ Reconstruction efficiency of primary Λ.



It is needed to do the feed-down correction before applying the efficiency correction factors.
→ 2 possible strategies:

1/ One can estimate the contamination when knowing:
- the p_t distributions for every particles that decay in Λ;
- the branching ratio;
- the reconstruction efficiency of secondary Λ.

2/ - Statistical model can provide an estimation of the number of particles that decay in Λ (N_{th})

- By comparing the spectra obtained with analysis cuts and the inclusive spectra one can estimate the fraction of secondary Λ that hasn't been reconstructed (N_{missed})

- Contamination due to secondary Λ in the spectra = $N_{th} - N_{missed}$

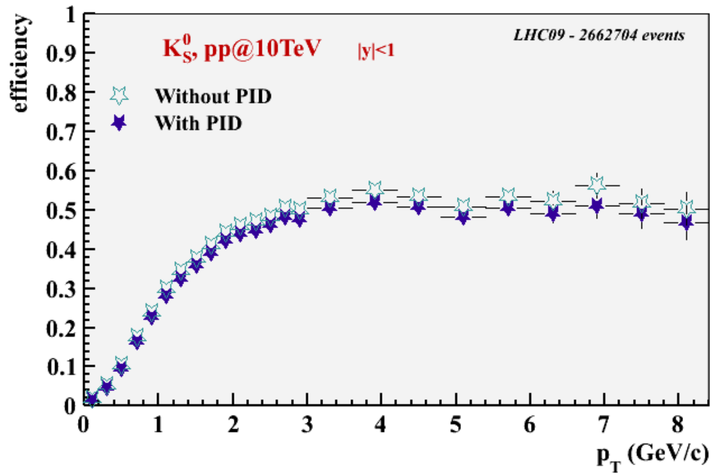
Use of PID in Λ and K^0_S analysis

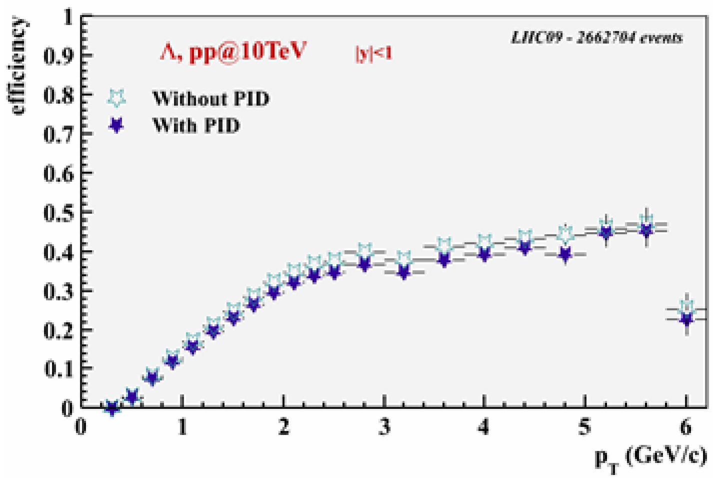
Use of TPC PID (3σ band, see Alexander's talk) to better identify V0s daughters

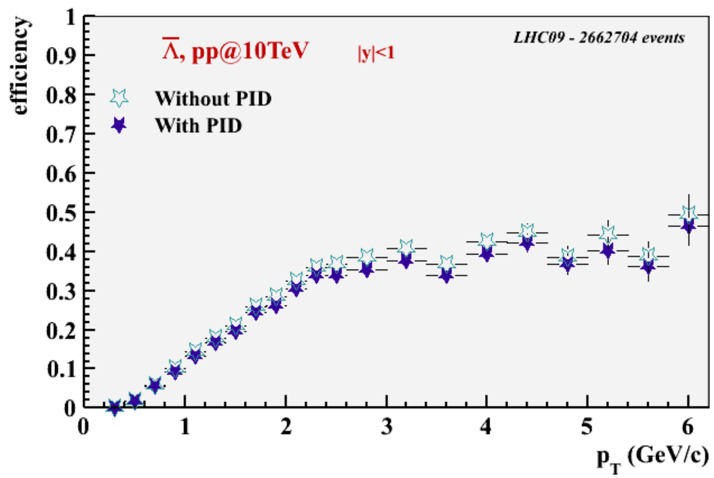
Reconstruction efficiency:

	With PID	Without PID
K^0_S	12.8 % 13.6 %	13.8 % 14.6 %
Λ	8.5 % 9.9 %	9.2 % 10.7 %
$\overline{\Lambda}$	7.1 % 8.4 %	7.7 % 9.0 %

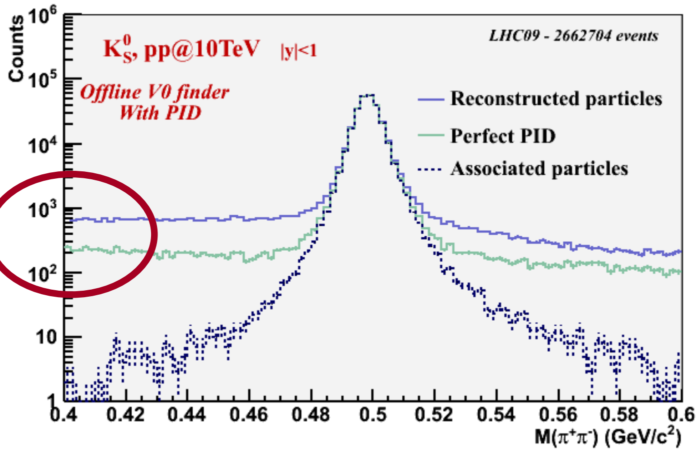
Offline finder / On-the-fly finder

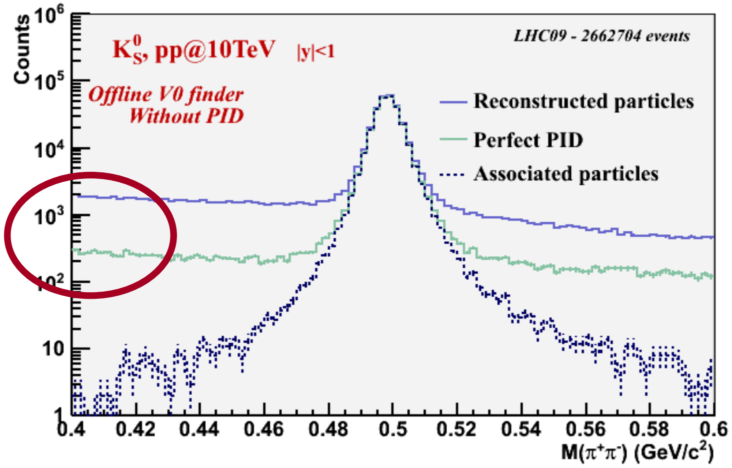


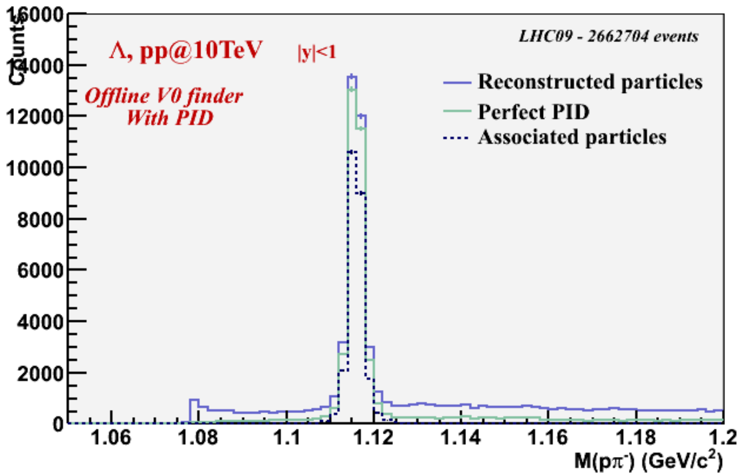


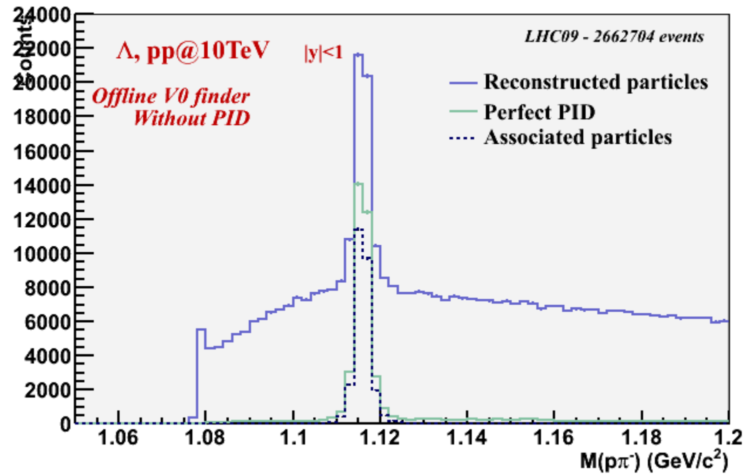


Use of PID in Λ and K^0_S analysis









Use of PID in Λ and K^0_S analysis

❖ Use of PID does not change to much the efficiency (though there is a small decrease, to be investigated and understood...)

❖ But it clearly increases the purity, especially for Lambda and Antilambda. Purity improvement for K^0_S as well but smaller (the majority of the particles are π so the misidentification of the K^0_S daughters is not that high).

❖ However it is possible to fit the invariant mass spectra and so extract the signal even without PID. But for some analysis is more important to have a very pure sample than a higher efficeny (flow)

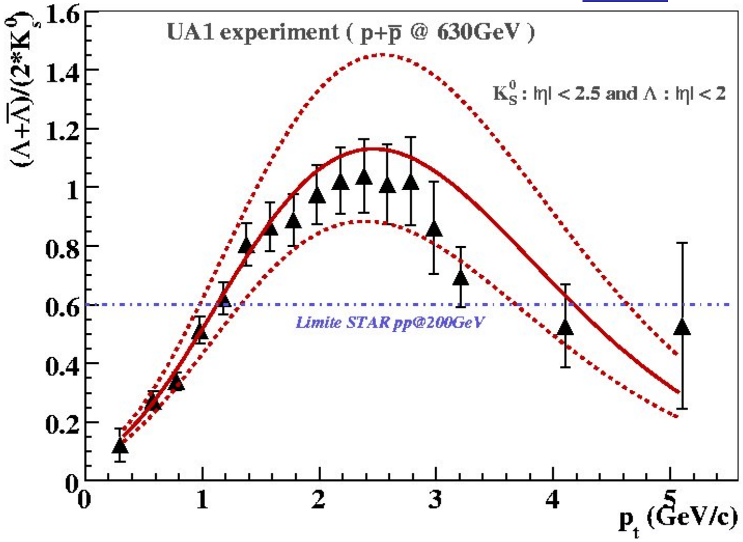
❖ Inconvenient of using PID: makes the K^0_S and Λ analysis more dependent on the TPC calibration...

❖ K^0_S and Λ analysis can extend the PID capabilities of ALICE: Λ can be identified until a quite high p_t so a pure sample of Λ can give identified proton at higher p_t than the one identified thanks to dE/dx.

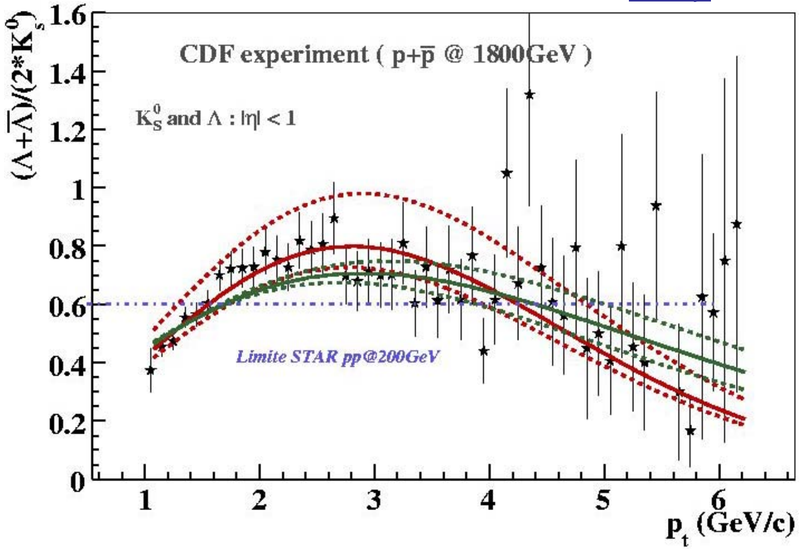
Ratio Λ/K^0_S in pp collisions

Why it will be interesting in LHC pp data…

UA1



CDF



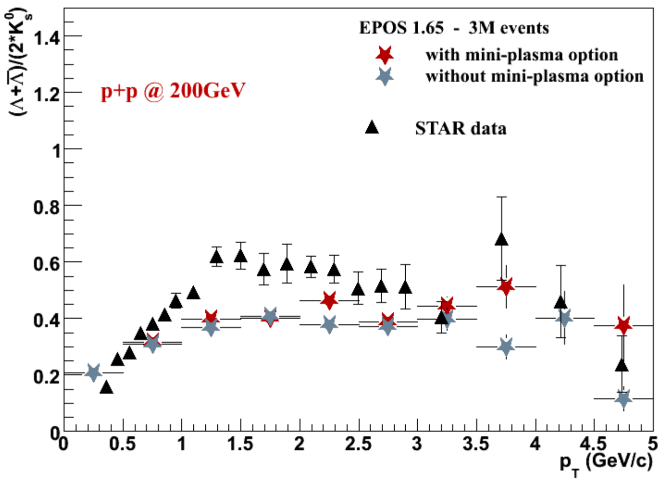
In pp collisions at √s=200 GeV (STAR), the Λ/K^0_S ratio is flat in the intermediate p_t region and remained below unity.

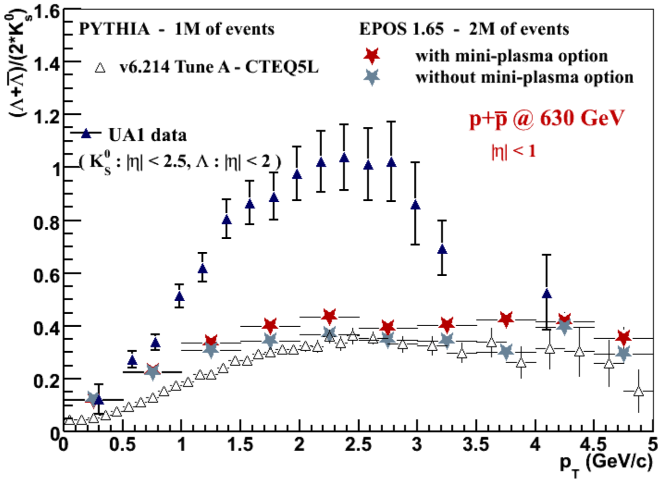
However with increasing energy (630 GeV in UA1 and 1.8 TeV in CDF) the behaviour changes: the amplitude is around unity…

How can we explain the hadron production in this region ?
What can we expected at the very high LHC energy ??

Study of two models: PYTHIA and EPOS

Comparison data with EPOS and PYTHIA



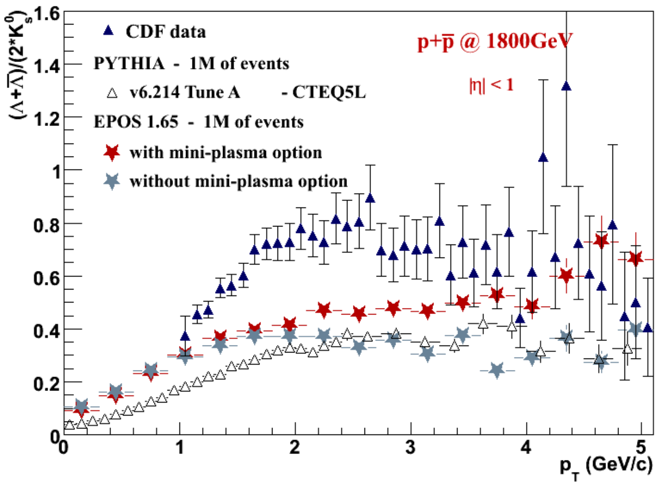


At intermediate p_t: EPOS ~ PYTHIA

<u>Use of mini-plasma option (mP):</u>

- No influence at $\sqrt{s}$= 200 GeV

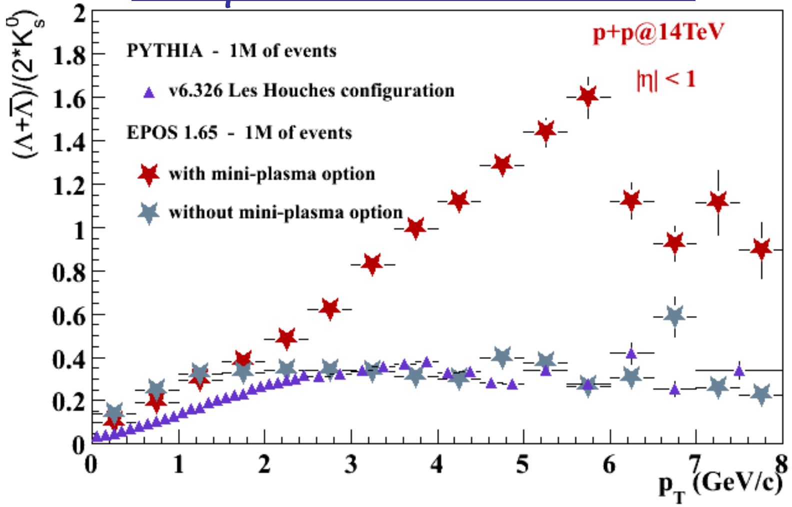
- With increasing energy, mP option seems to have an effect : the ratio baryon/meson increases at intermediate p_t approaching experimental data.



Collective phenomena ?

EPOS and PYTHIA predictions at LHC energy

Comparison PYTHIA - EPOS

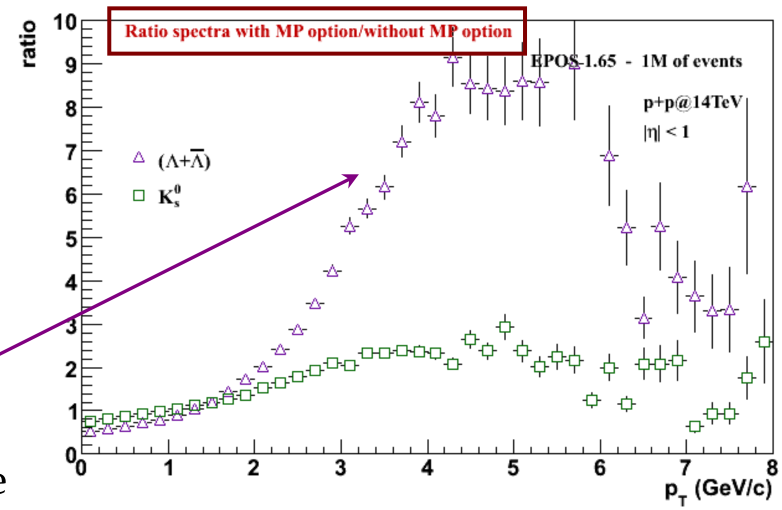


EPOS without mini-plasma option

≈

PYTHIA at intermediate pt.

EPOS



EPOS with mini-plasma option:

- ➢ very strong increase of baryon production;
- ➢ for 2 GeV/c < p_t < 7 GeV/c
- ➢ maximum of the amplitude of the baryon/meson ratio at p_t~6 GeV/c

If the data will show such an increase of baryon production, then according to EPOS that could be interpreted as the manifestation of collective phenomena:

→ Are p-p collisions elementary ? Baseline for heavy ion collisions …??

→ Perspective of a new physics in p-p !

Conclusion

Λ and K^0_S analysis is one of the first physics that will be accessible with the first LHC data.

Only about 2or 3 M of events re needed to make really interesting analysis with Λ and K^0_S :

→ Extract the production yields to characterize the medium created the collision trough the statistical models.

→ Study the behaviour of Λ / K^0_S ratio vs p_t to investigate some domains of Physics that are not yet fully understood: hadronisation mechanisms.

→ Study the ratio Λ / K^0_S and the shape of the p_t spectra by fitting them to extract information related to the nature of the pp collisions:
collective phenomena ? Elementary collision ?