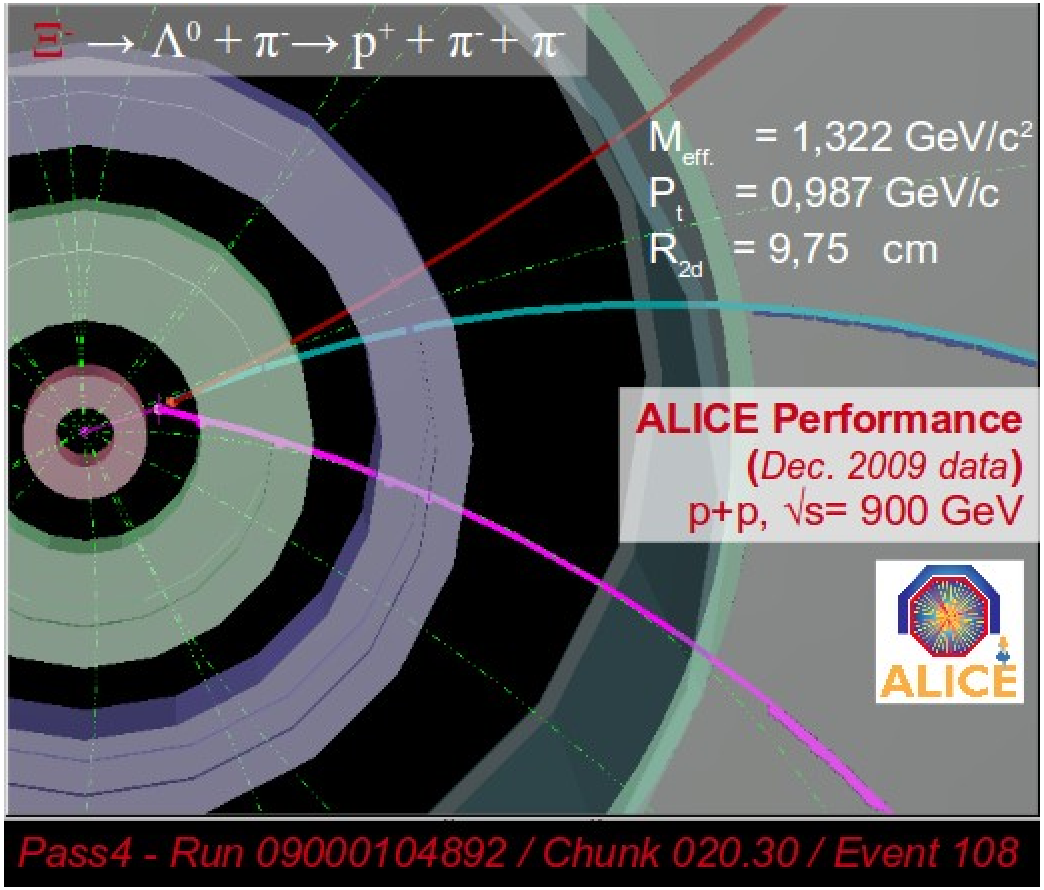
First measurements of strange baryons and anti-baryons with the ALICE experiment in pp collisions at LHC

[… and a few words on mesons]



The IX International Conference on Hyperons, Charm and Beauty Hadrons

- Perugia, 21^{st} - 26^{th} June 2010 -

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for the ALICE collaboration

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Outline

- Why study strange particle production?
- The tools ALICE offers to search for strange particles
- The data
- Secondary vertex reconstruction techniques
- Strange and multi-strange particle measurements in pp at $\sqrt{s}$=900 GeV and 7 TeV
- Summary

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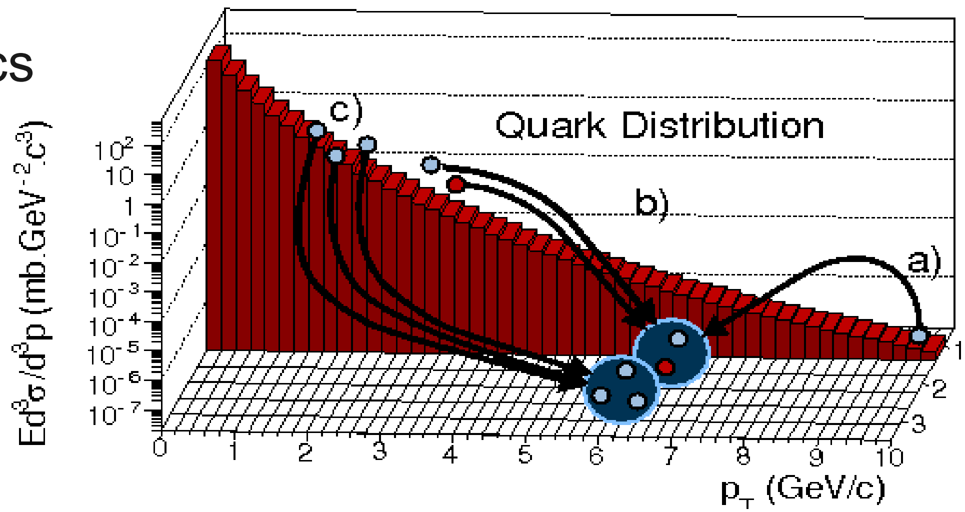
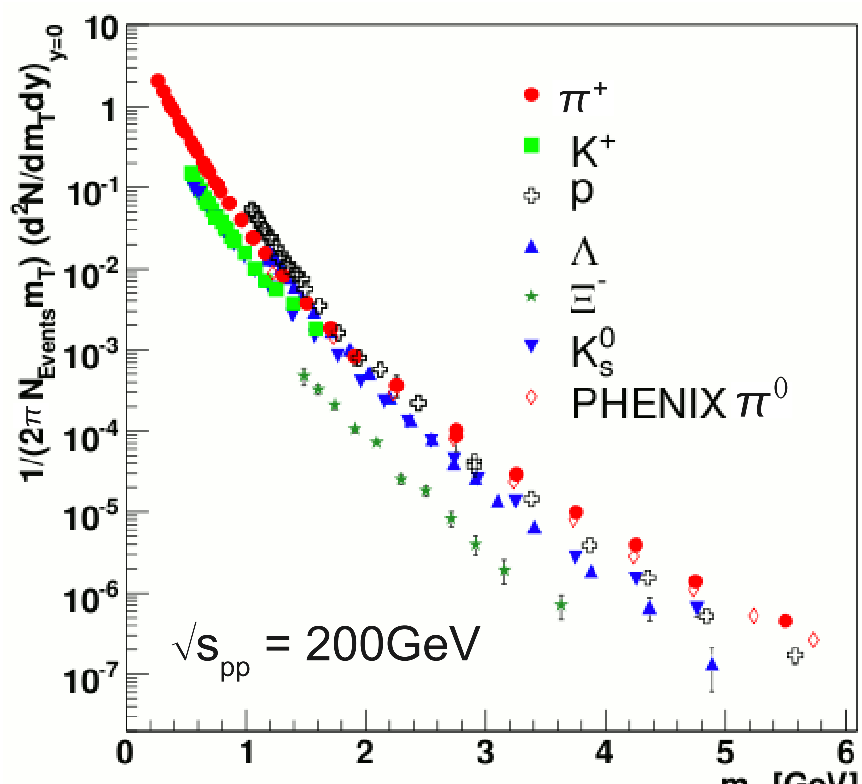
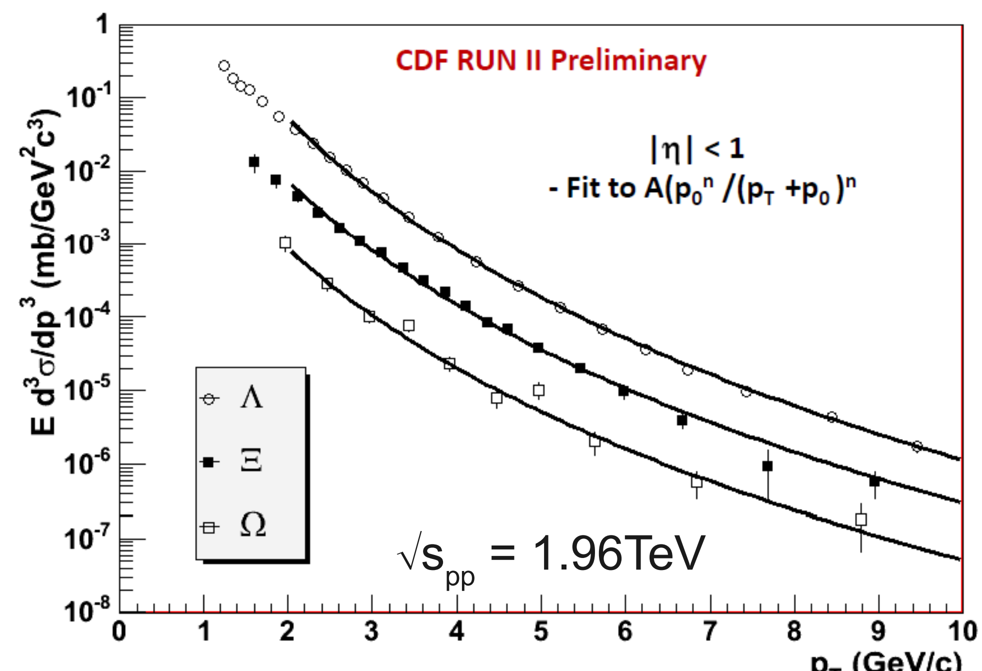
Why study strangeness production?

- Very powerful probe in heavy-ion physics
  - Degree of equilibration of the system
  - Quark recombination phenomena
- Why pp ?
  - Essential reference system for HI studies
  - Genuine pp physics !





STAR : Phys.Rev.C75:064901,2007



Varelas, Physics at LHC 2010

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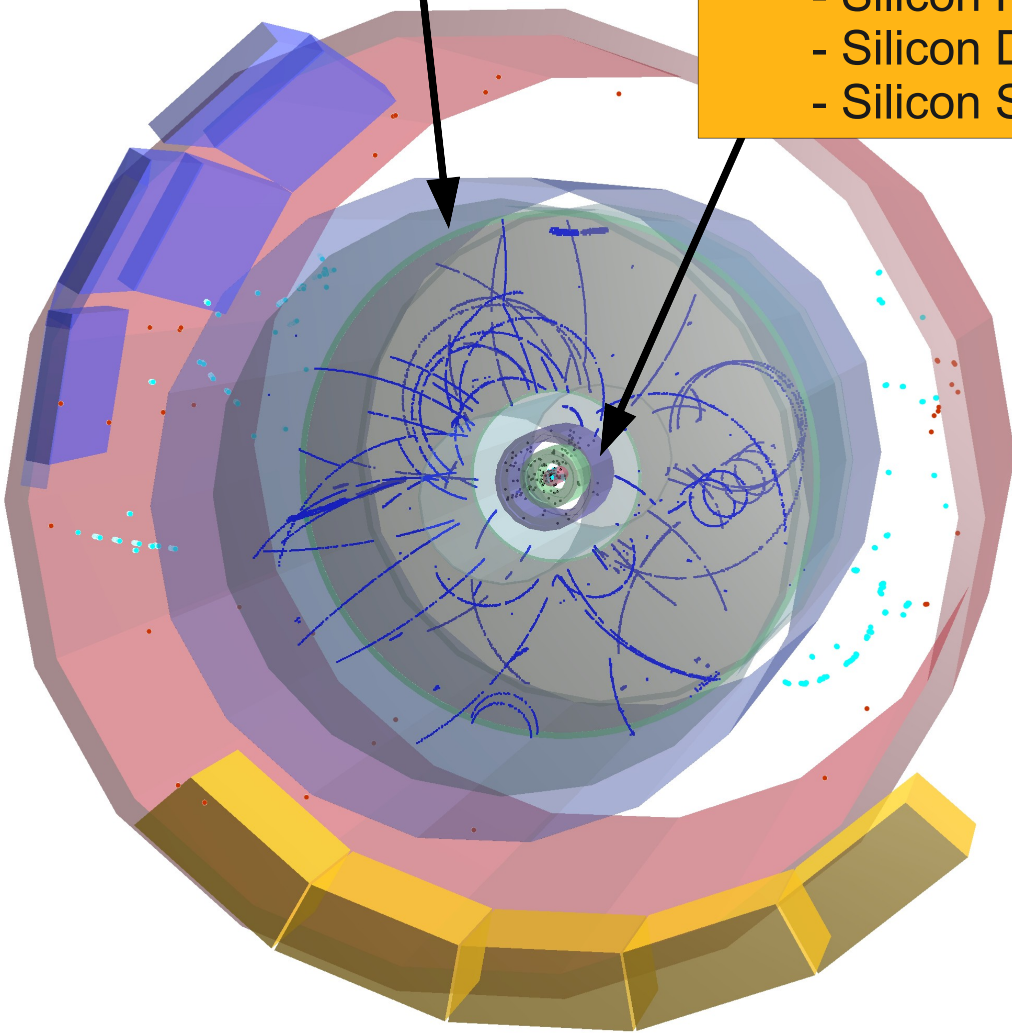
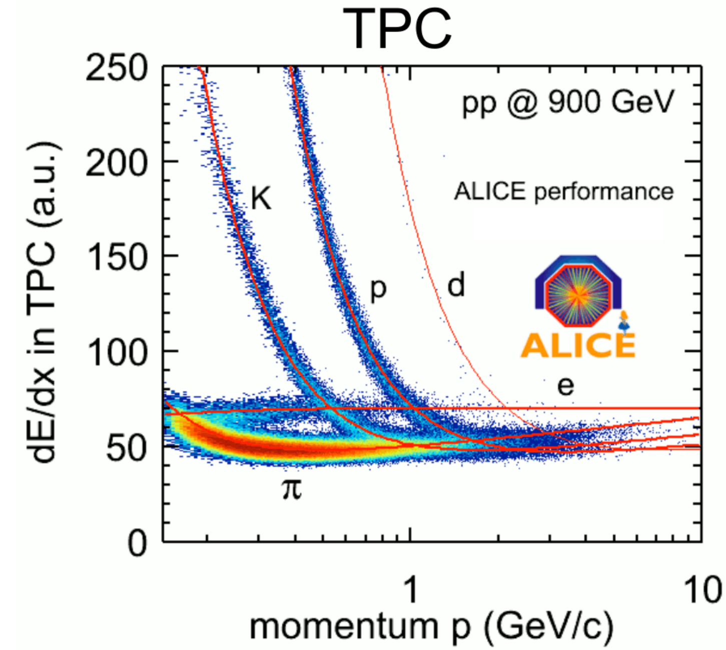
ALICE tools for strangeness

Time Projection Chamber

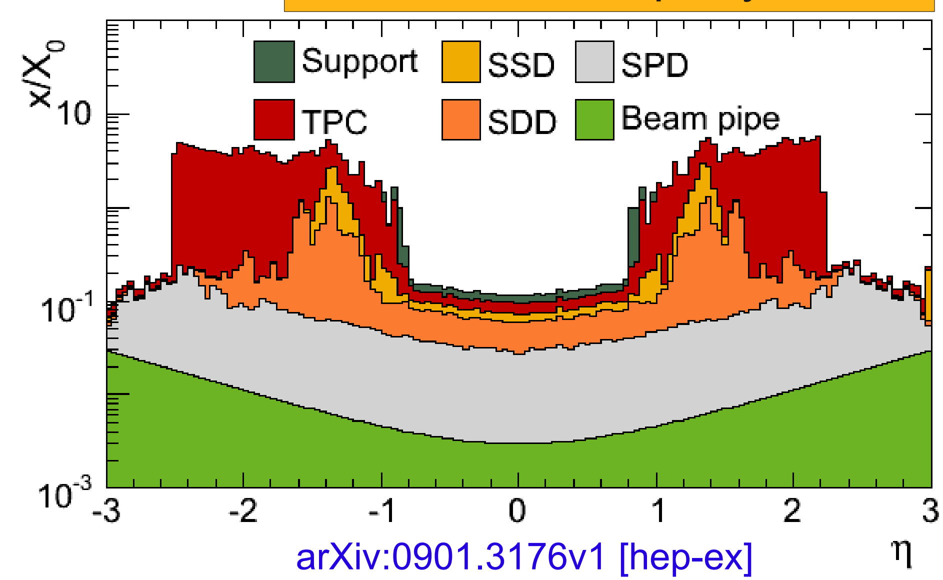
ITS (close to the beam)
- Silicon Pixel Detector
- Silicon Drift Detector
- Silicon Strip Detector





PID =
ITS+**TPC**+TOF+TRD+RICH

Low material budget at central rapidity



arXiv:0901.3176v1 [hep-ex]

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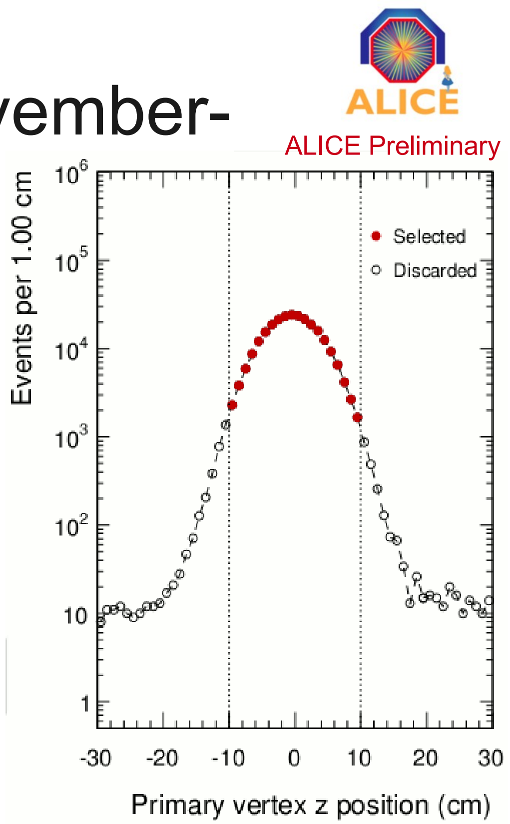
The data

- ALICE took pp data at √s=900 GeV in November-December 2009, the first LHC runs
  - ~300k Minimum Bias events kept for analysis
    - more 900 GeV taken later on in 2010
  - Selection on primary vertex
    - Vertex quality (SPD + tracks)
    - Vertex is kept within +/- 10cm along the beam axis
- Since March 2010, √s=7 TeV
  - > 100M Min. Bias events !!
- Simulation
  - 1.8M events, pp 900 GeV, Pythia tune D6T
  - Particle transport with GEANT3



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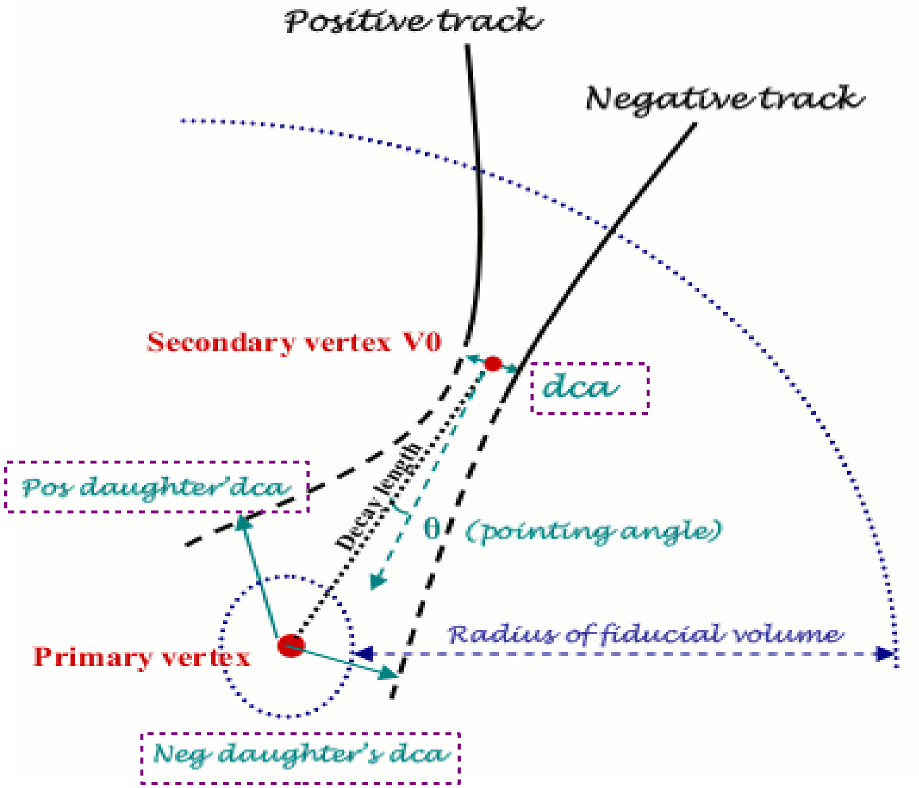
Secondary vertex reconstruction

- K^0_S and hyperons (Λ, Ξ, Ω) have a $c\tau$ ~ few cm
  - Charged decay modes
  - Can be identified via topological methods
    - → momentum range limited by statistics only
  - PID not mandatory

"V^0" (K^0_S, Λ) — "cascade" (Ξ, Ω)

	K^0_S	Λ	Ξ	Ω
	$d\bar{s}$	*uds*	*dss*	*sss*
$c\tau$ (cm)	2.68	7.89	4.91	2.46
decay	$\pi\pi$	$p\pi$	$\Lambda\pi$	ΛK
BR (%)	69.2	63.9	99.9	67.8



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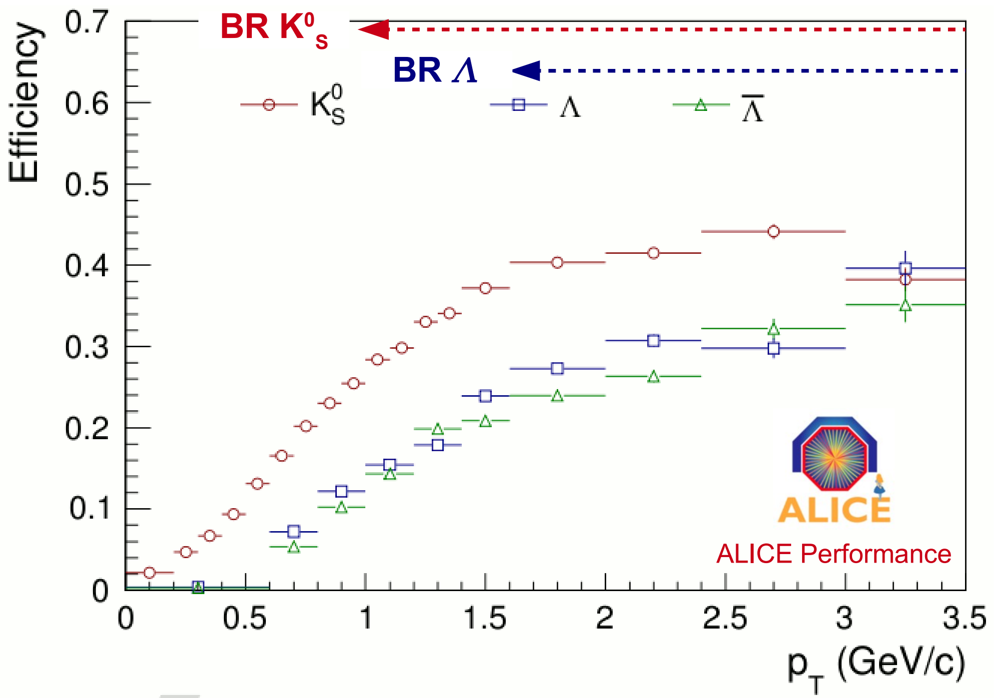
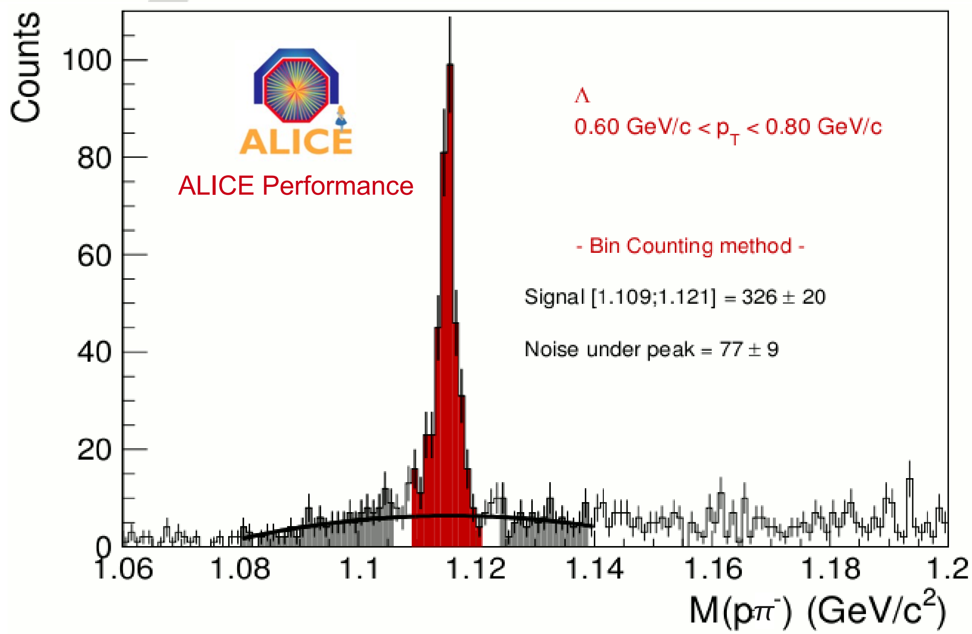
K^0_s and (anti-)Λ performance

- Efficiency at low p_t limited due to
  - Acceptance and tracking efficiency
  - Branching ratios : ~69% (K) and 64% (Λ)
- Anti-Λ below Λ because of anti-p absorption
  - eff(anti-Λ)/eff(Λ) ~ 0.85 ± 0.03 in average



- Raw yields extracted from invariant mas spectrum
  - $|y|<0.75$
  - Fit $\rightarrow$ mass m^0,σ^0
  - Signal obtained by bin counting around $m^0 \pm 4\sigma^0$
  - Background estimated with polynomial fit (gray area)
- PID used for (anti-) protons
  - dE/dX in TPC :
  - Cut at 5σ if p<0.7 GeV/c , 3σ otherwise



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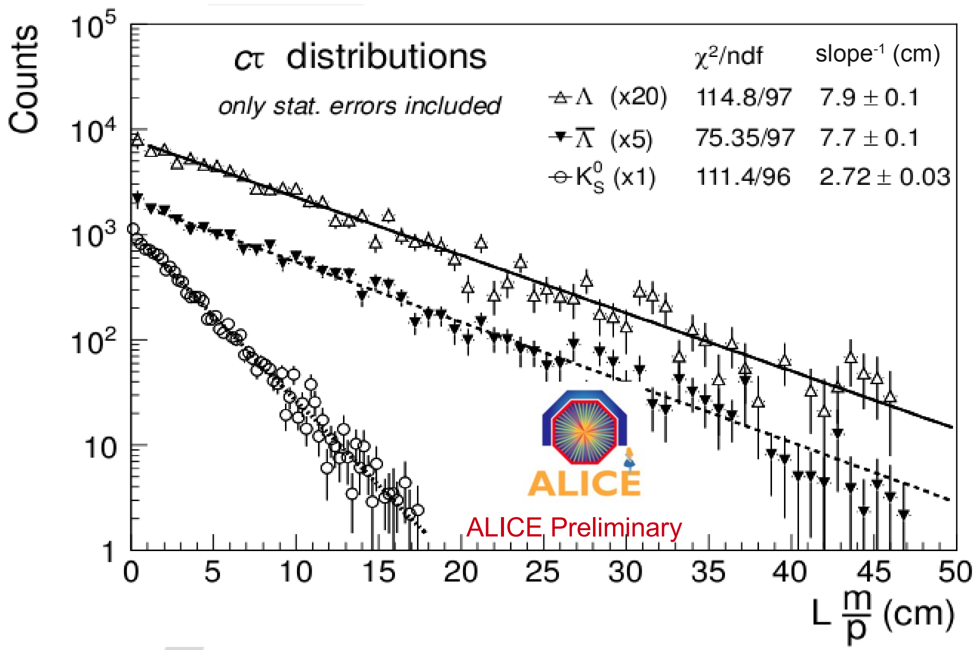
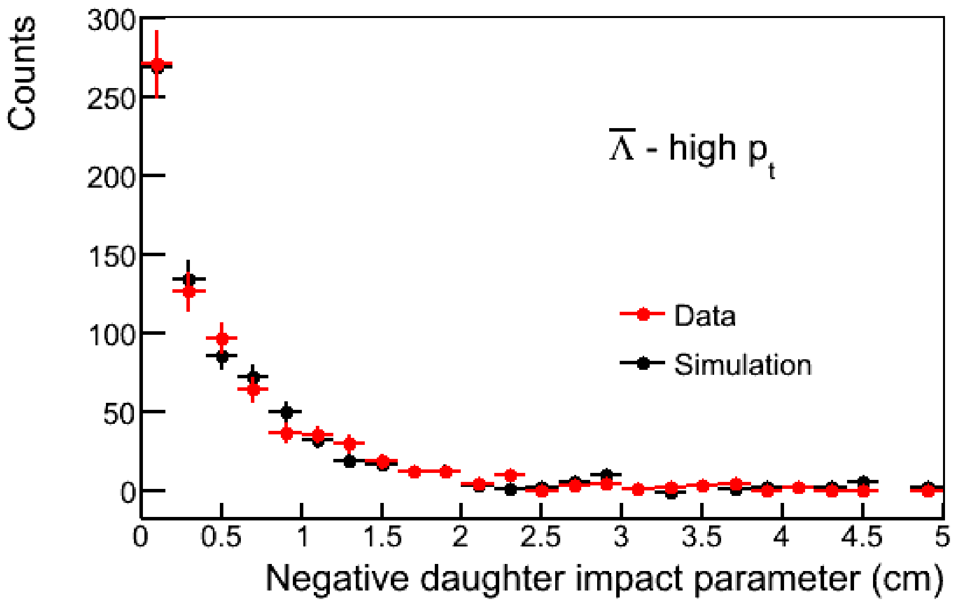
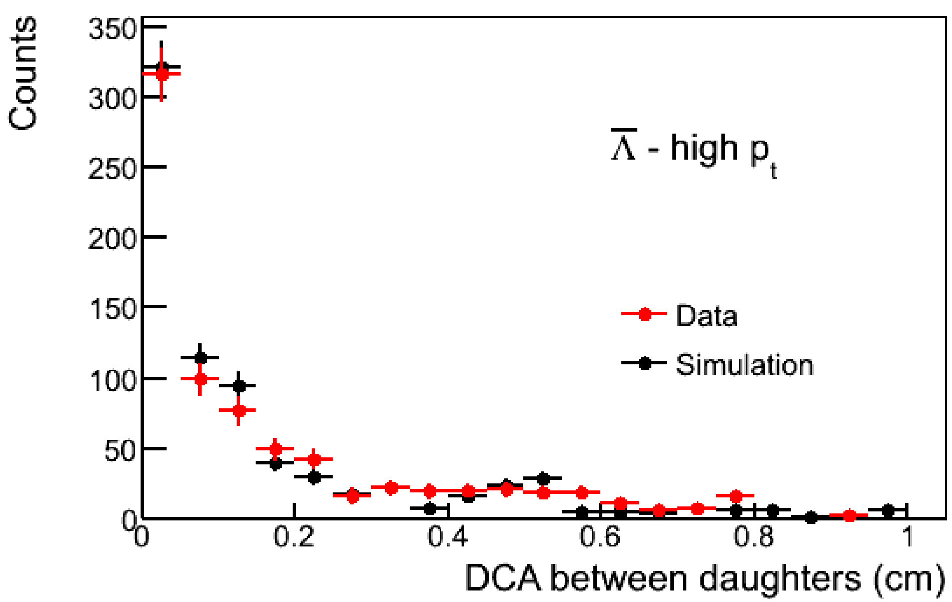
Data quality

- Measured $c\tau$ in agreement with PDG
- Cut distribution of signal particles in real data are described by simulations reasonably well







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Feed-down correction for Λ

what we measure

$\Lambda = \Lambda_{primary} + \Lambda_{from\ \Xi's\ decay} + \Lambda_{others}$

what we want !

How to evaluate $\Lambda_{from\ \Xi's\ decay}$ in the data ?

In Monte-Carlo:

$r = \Xi_{MC\ reconstructed} / \Lambda_{MC\ from\ \Xi}$

In real data:

$\Lambda_{Data\ from\ \Xi} = \Xi_{Data\ reconstructed} / r$

which is ~13±2% of all Λ candidates

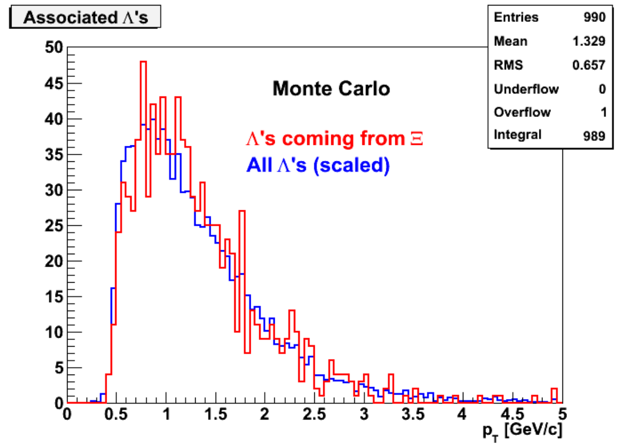
- **Current estimate for this correction for Λ: 13±2%.**
  neglecting the Λ's re-generated in material (~2%, in MC).
- **The same for anti-Λ is 12±2%.**
  neglecting the anti- Λ's re-generated in material (~0.3%, in MC).

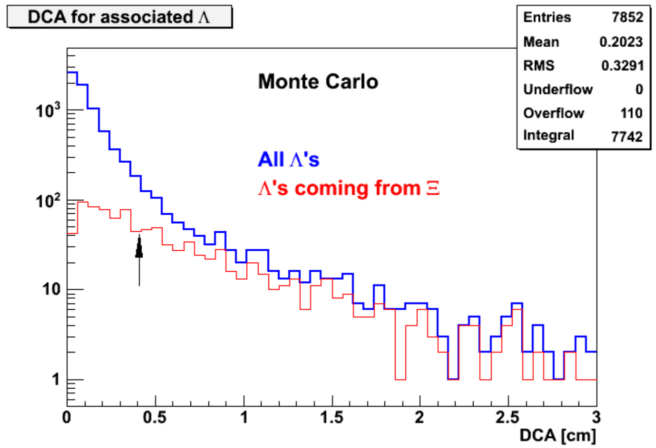
Pt spectra: same shape for associated Λ and for secondary Λ → **This opens the possibility to apply just a global correction to the final spectra.**

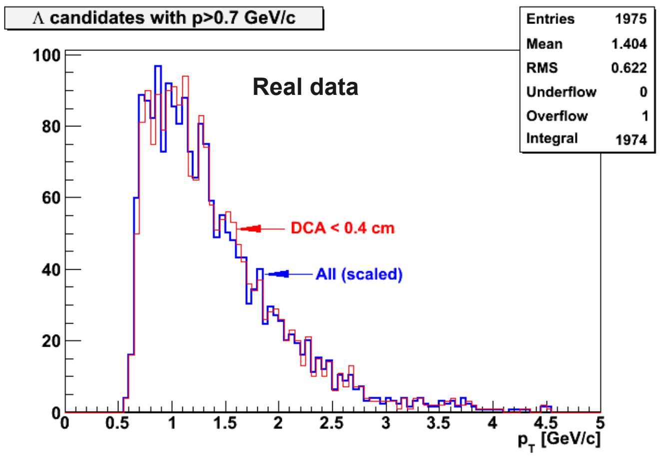
Does the p_t spectra of $\Lambda_{primary}$ differ from the $\Lambda_{from\ \Xi's\ decay}$'s spectra ?

In Monte-Carlo simulation:

Use the dca to Primary Vertex distribution to distinguish between primary and secondary Λ







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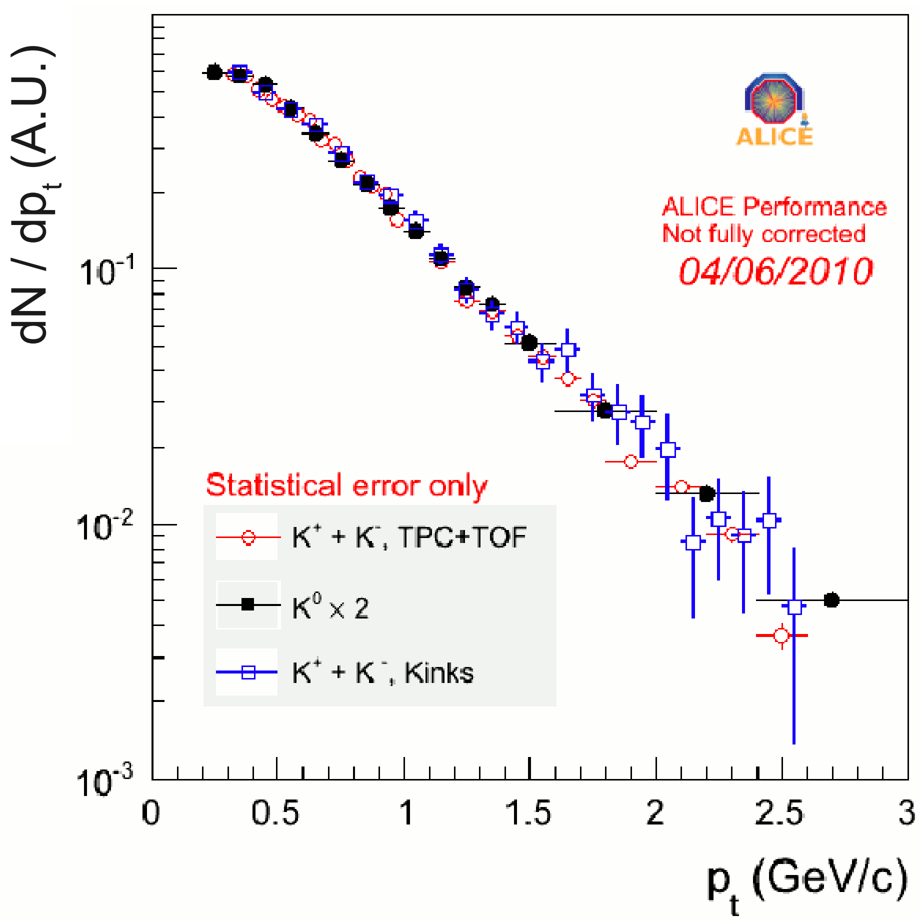
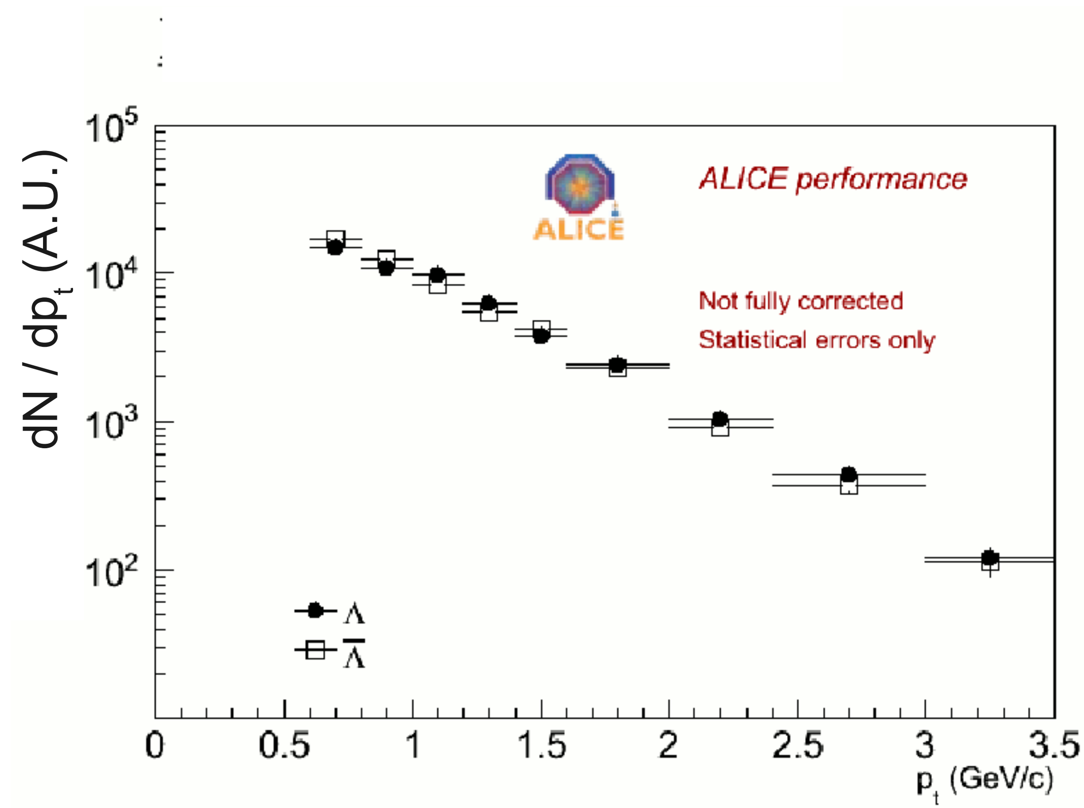
K^0_S and (anti-)Λ spectra





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Systematics on corrected spectra

- Errors are partly due to the choice of the cut value for V^0s
  - How much? How does it compare to stat. error?
- Two contributions
  - 1/ discrepancies on the cut variable distributions between MC and real data
    - This error can be extracted from those distributions → **< 5%**
  - 2/ different resolutions on cut variables between MC and real data
    - Estimated by making the cuts vary around their nominal values
    - → see if the corrected spectra change **< 1%**

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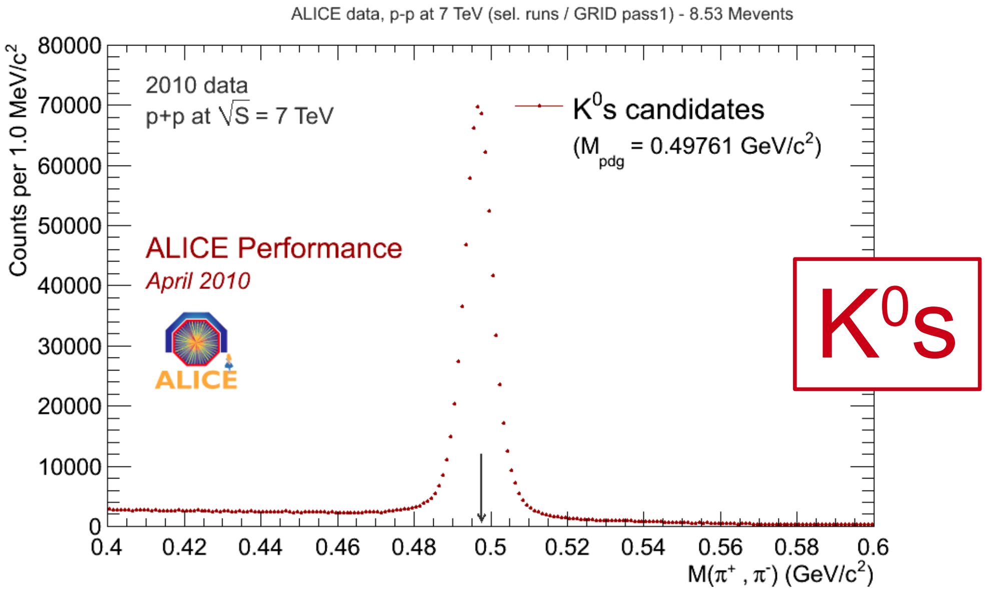
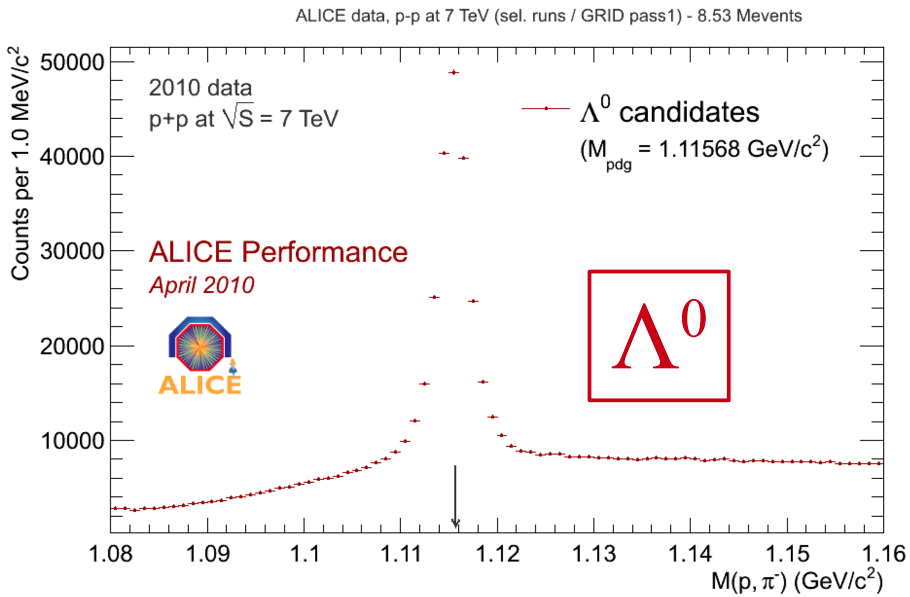
K^0_s and Λ at 7 TeV

- 8.5 Mevents analysed
- No PID used





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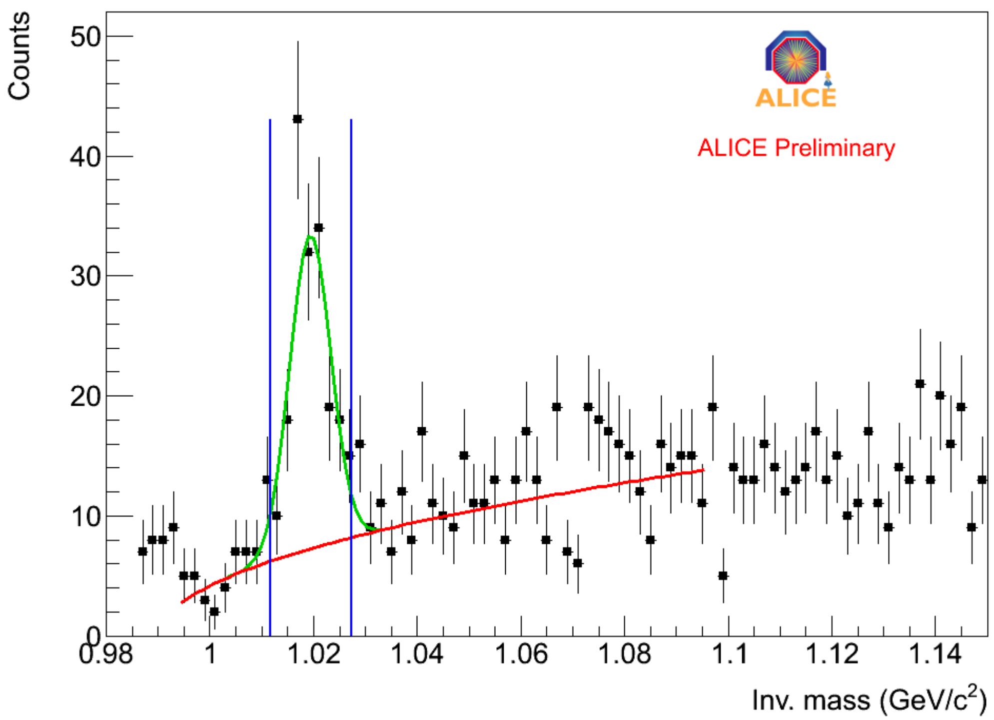
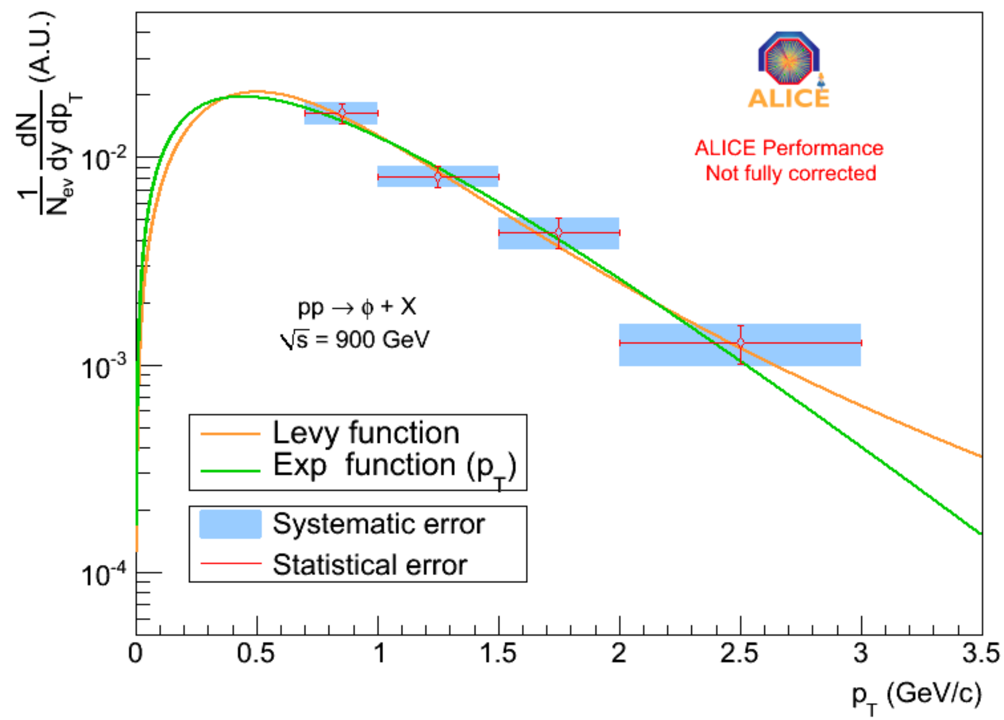
$\phi \rightarrow$ KK @ 900 GeV

$$\frac{1}{p_T}\frac{dN}{dp_T} \propto \frac{(n-1)(n-2)}{2\pi T\left[nT + m_0(n-2)\right]} \cdot \left[1 + \frac{m_T - m_0}{nT}\right]^{-n}$$





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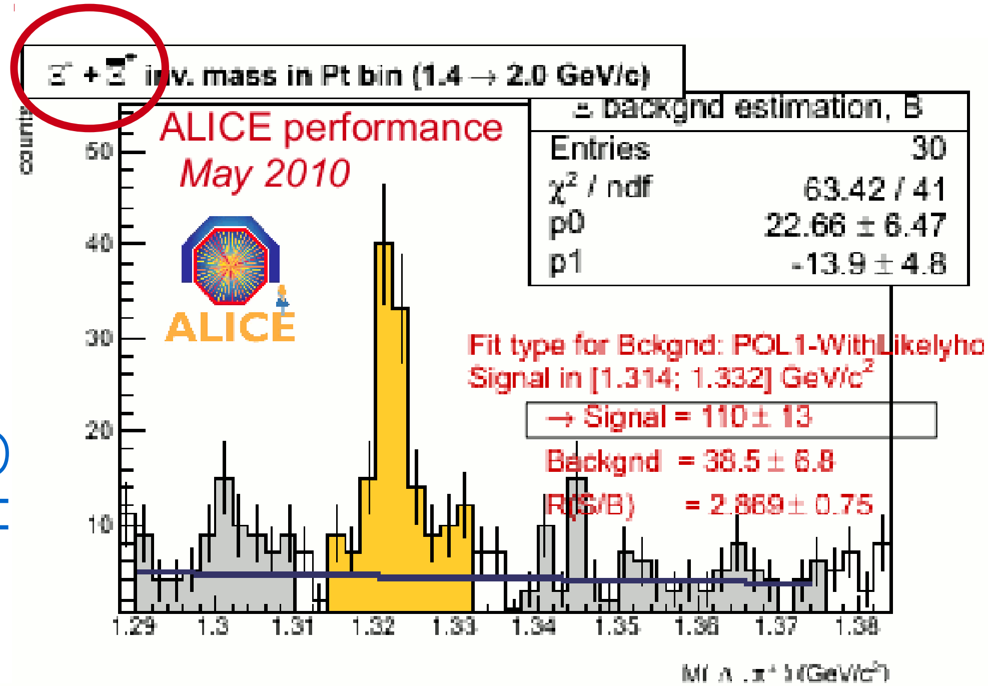
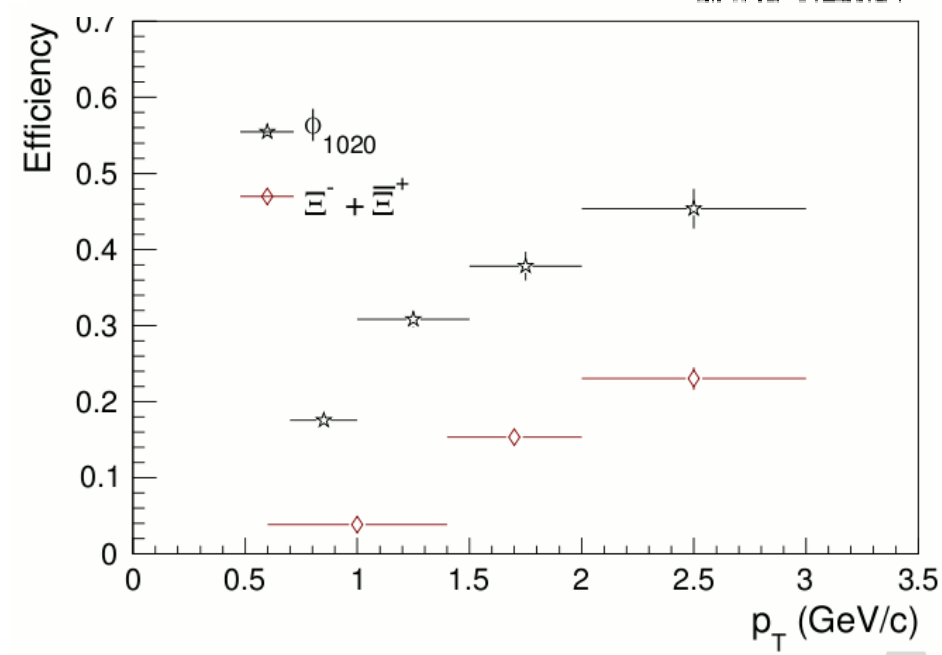
Multi-strange at 900 GeV

- low statistics, but Ξ peak visible !
  - |y|<0.8
- PID used on all 3 daughters
  - $\Xi \rightarrow \Lambda\pi \rightarrow p\pi\pi$
  - Selection from d*E*/d*X* in TPC
    - Cut at 4σ from BB curve
- We have got three points to draw the Ξ corrected p_t spectra

pp@900GeV data





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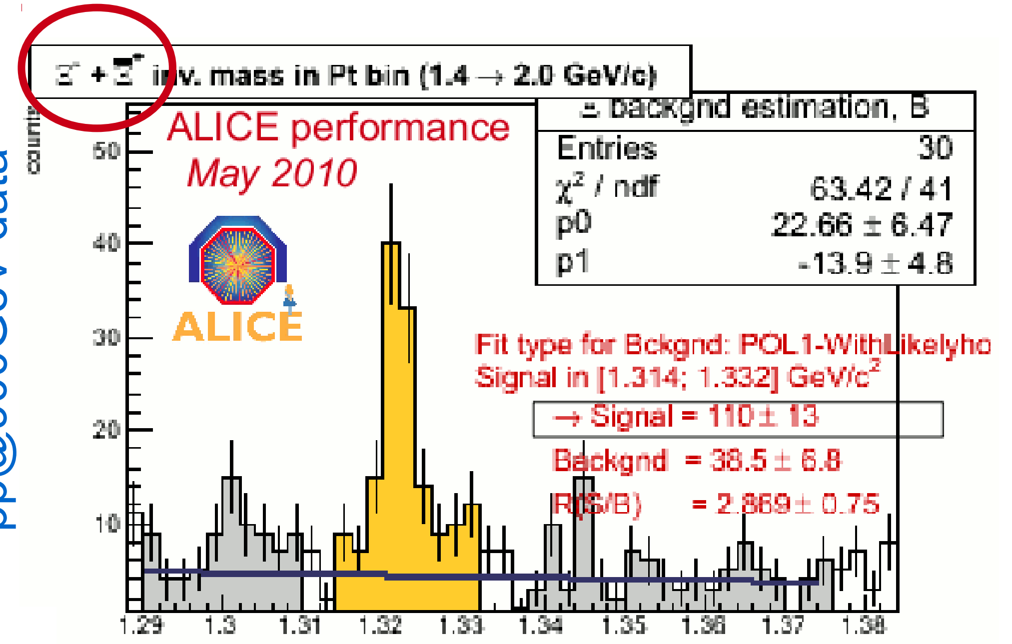

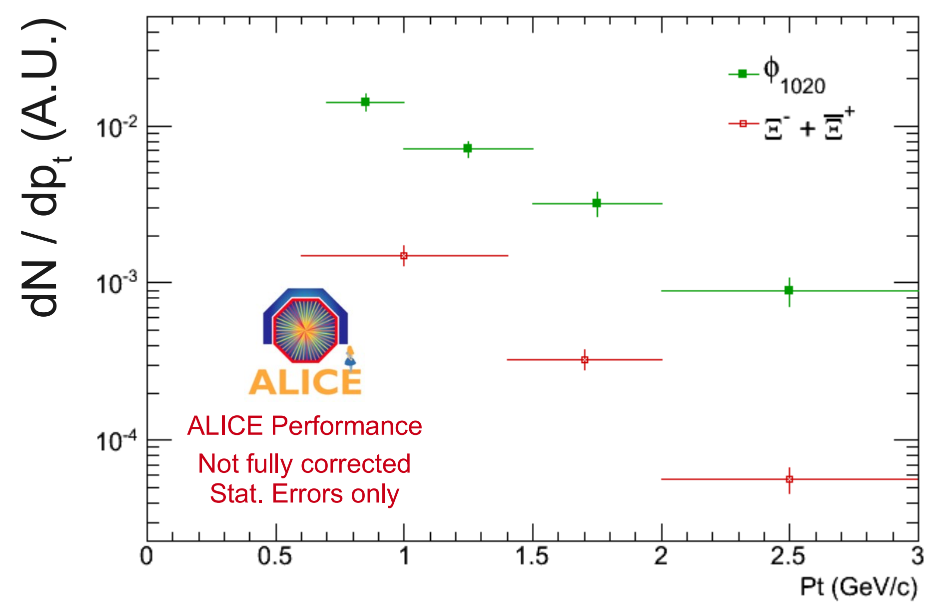

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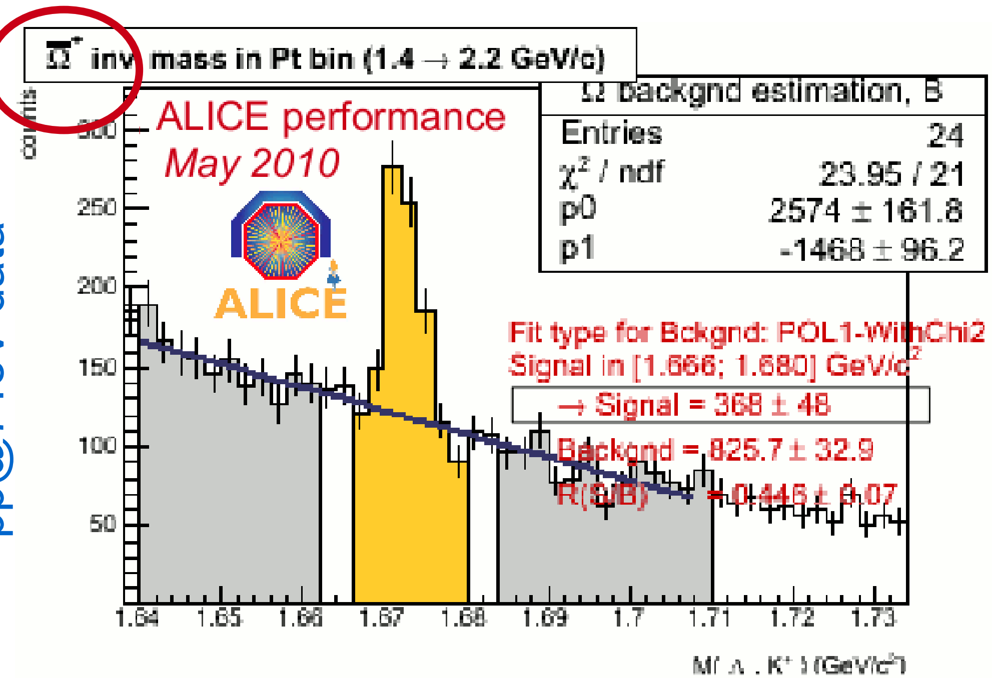
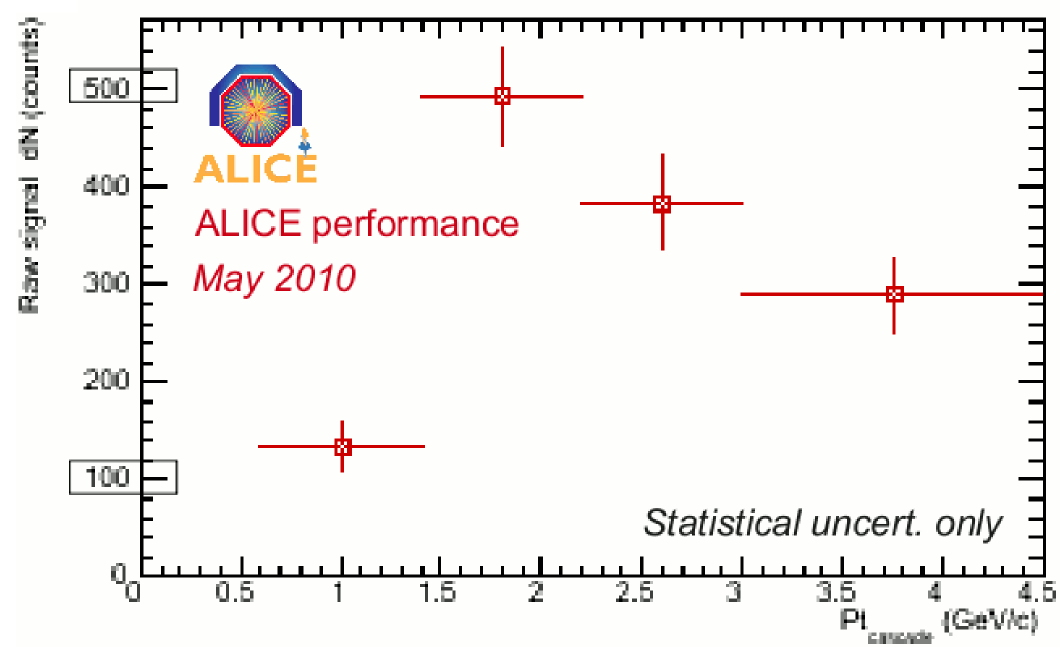
Multi-strange at 7 TeV

- The statistics at 7 TeV makes the Ω measurable
  - |y|<0.8
  - 24M Min Bias events
  - S/B ~ 0.4

pp@7TeV data



- Four points in raw p_t spectrum



- Analysis of 7 TeV data makes the full set of secondary vertex hyperons measurable

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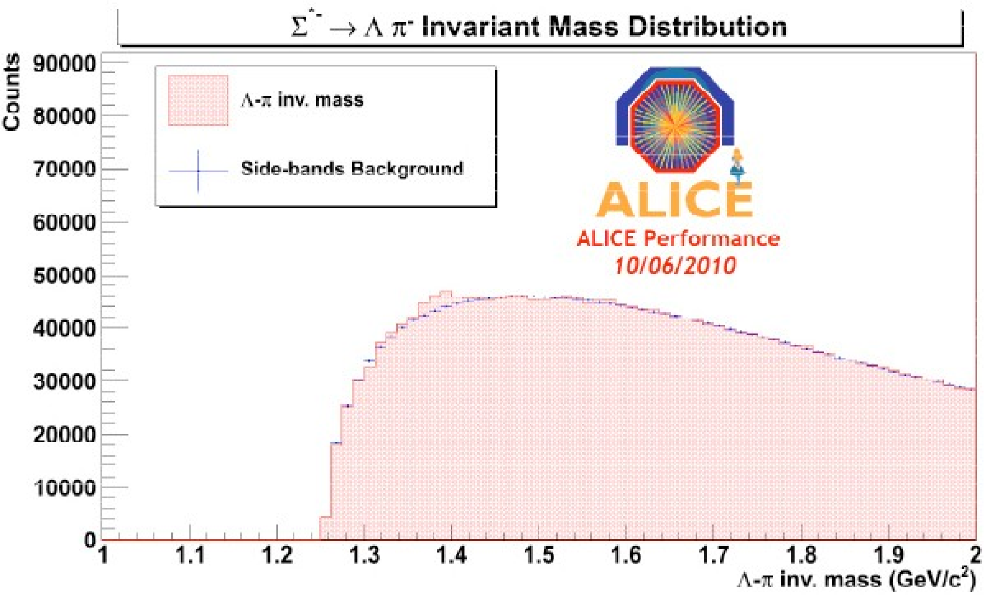
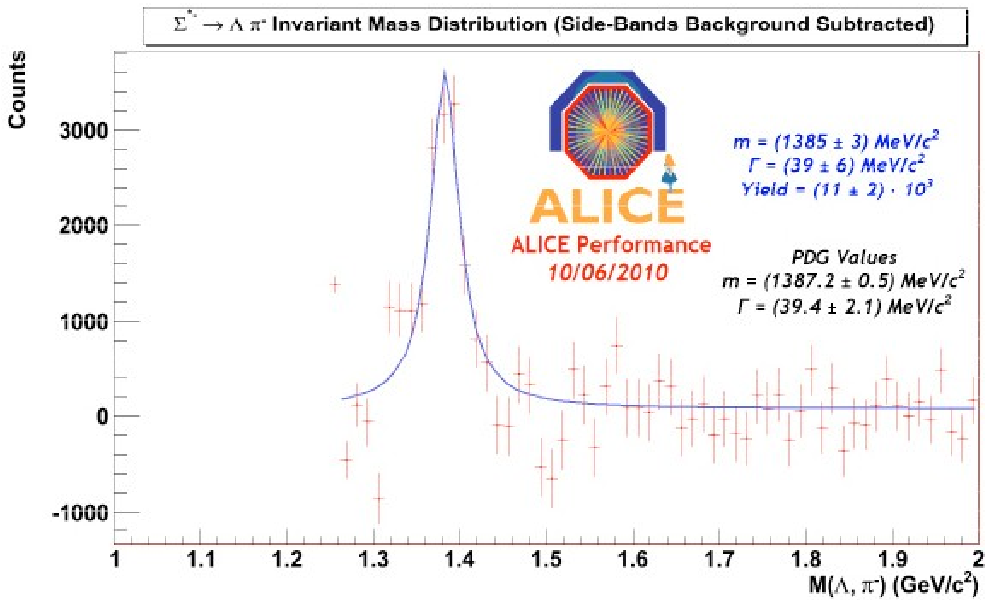
Σ^* at 7 TeV

- Strong decay $\Sigma^* \rightarrow \Lambda\pi$
- $\rightarrow$ can probe fireball evolution in HI collisions
  - time-span between chemical and thermal freeze-outs
  - pp reference needed





Venaruzzo, INPC2010, poster

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Summary

- Measurement of hyperons (Λ,Ξ,Ω) -and strange particles ($K^{\pm}$, K^0_S, ϕ) in general- has been a success from the very first LHC pp data
  - Small samples at 900 GeV already made us
    - draw the first corrected p_t spectra of identified particles
    - understand our detector
    - fine-tune our analysis cuts
- Very final correction of p_t spectra has to be done
- 7 TeV data already very promising (lots of events!)
  - New physics at such energy
  - Statistics will help us understand better the systematics

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