



# Identified charged hadrons and strange particle production in 900 GeV p-p collisions with the ALICE experiment

*André Mischke for the ALICE Collaboration*

ERC-Starting Independent Research Group  
*QGP - Utrecht*



**Universiteit Utrecht**

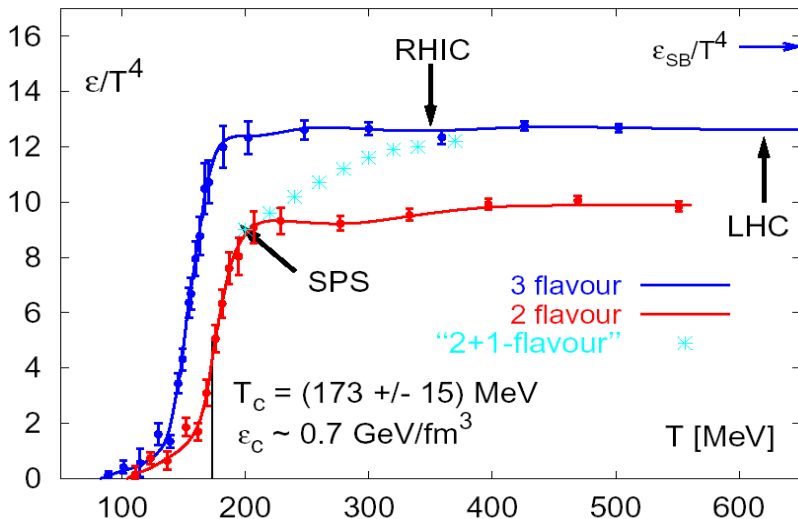
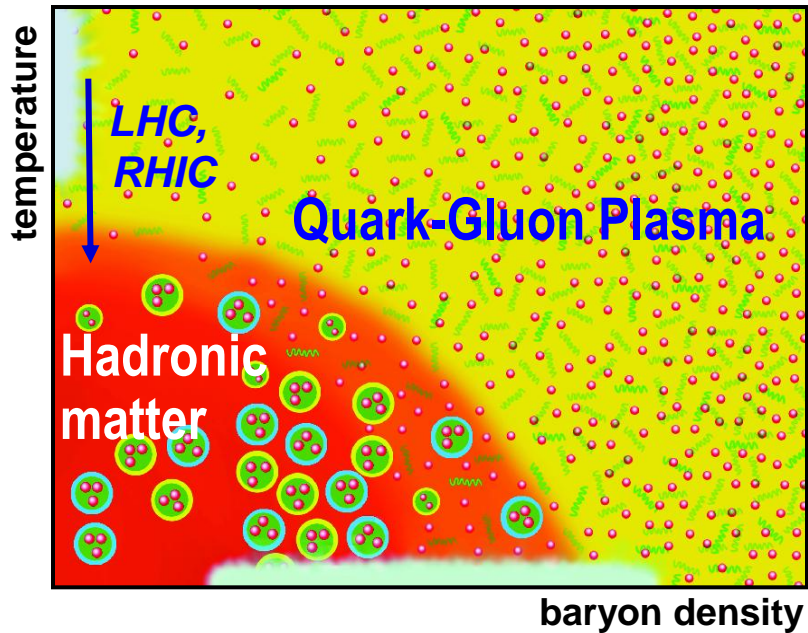


# Outline

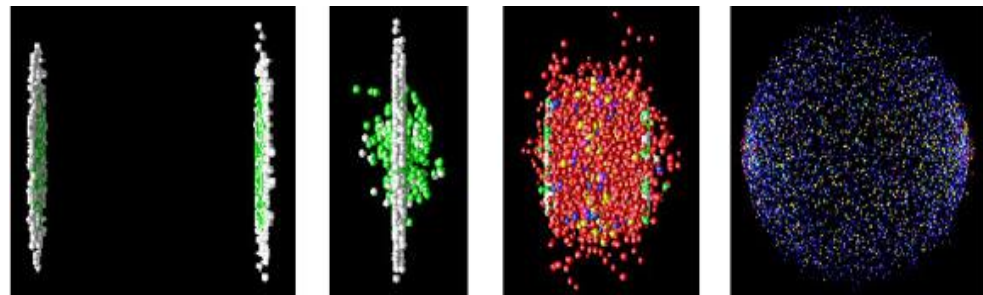
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- Introduction
- ALICE detector setup
- Trigger and data sample
- Results from 900 GeV p-p collisions
  - identified charged hadrons
  - strange particle production
- Summary

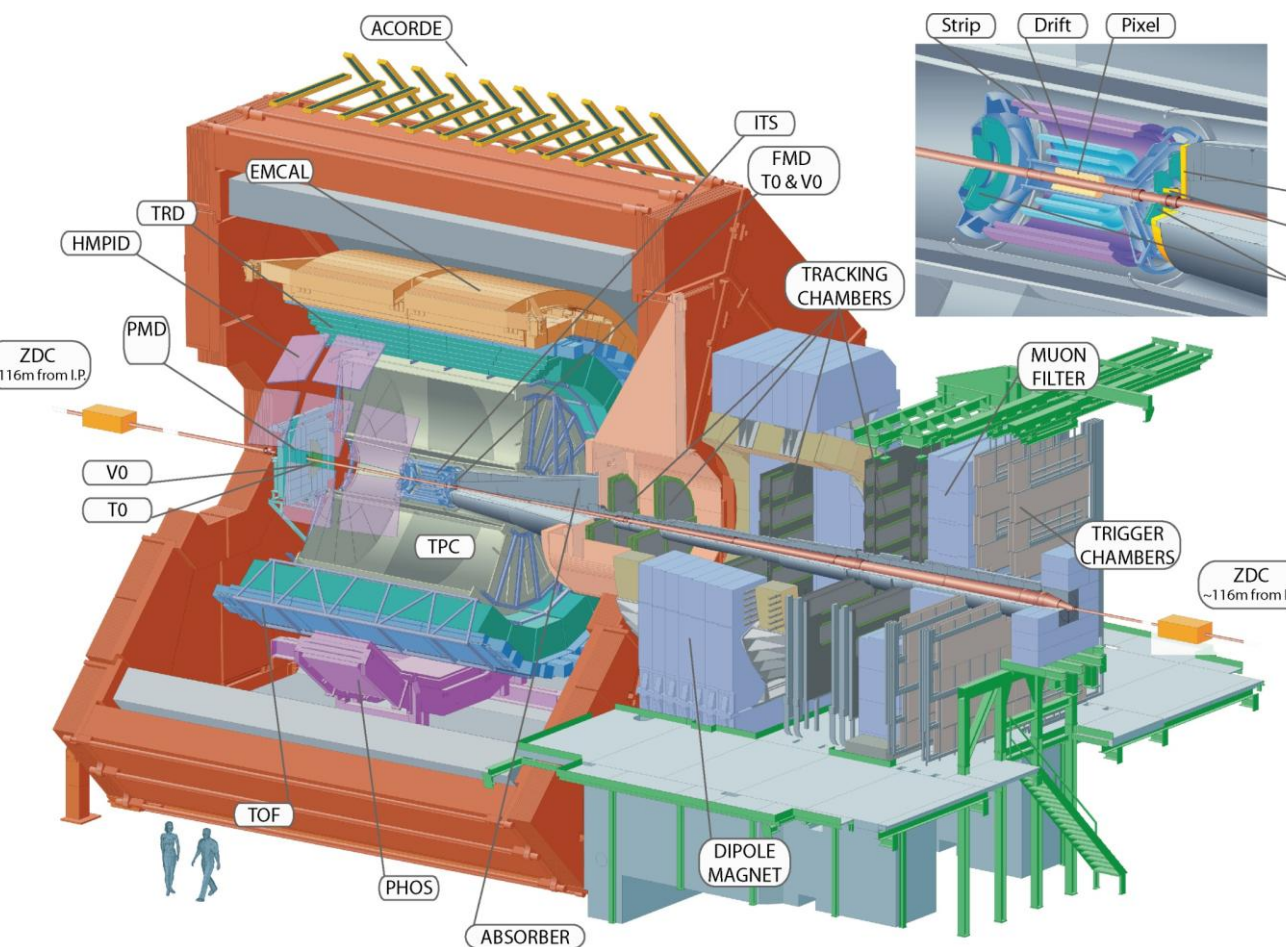
# Matter in extremes: the QGP



- Study strongly interacting matter under extreme conditions: high temperature and high density
- Lattice QCD predicts a phase transition from hadronic matter to a deconfined state, the **Quark-Gluon Plasma**
- Experimental access via high energy heavy-ion collisions



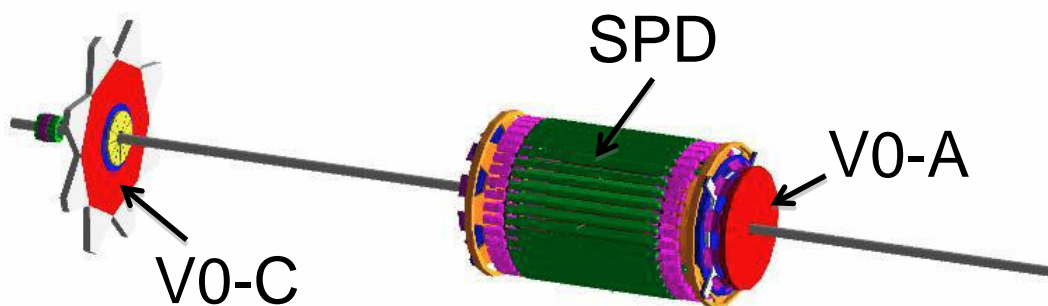
# ALICE detector



- PID from  $\sim 100$  MeV/c to above 30 GeV/c
- Large acceptance in azimuth
- Mid-rapidity coverage ( $|\eta| < 0.9$ ) and  $-4 < \eta < -2.5$  in forward region

- **ITS**
  - material budget  $\sim 8\% X_0$
  - impact parameter res.  $< 50\mu\text{m}$  for  $p_T > 1.5$  GeV/c
- **TPC**
  - $\Delta p/p = 5\%$  at 100 GeV/c
  - $\sigma_{dE/dx}/dE_{dx} < 6\%$
- **HMPID, MUON, T0, V0, FMD, PMD, ZDC**
- **TRD (7/18)**
- **TOF**
  - 90 ps
- **EMCal (4/12)**
  - $dE/E < 10\%/\sqrt{E}$
- **PHOS (3/5)**

# Trigger and data sample

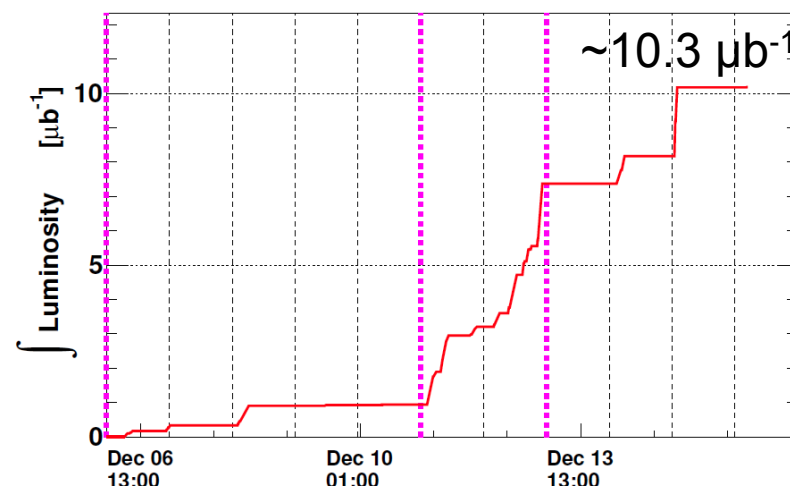


“Minimum bias”, based on interaction trigger

- SPD or V0-A or V0-C
  - at least one charged particle in 8  $\eta$  units
- read out all ALICE

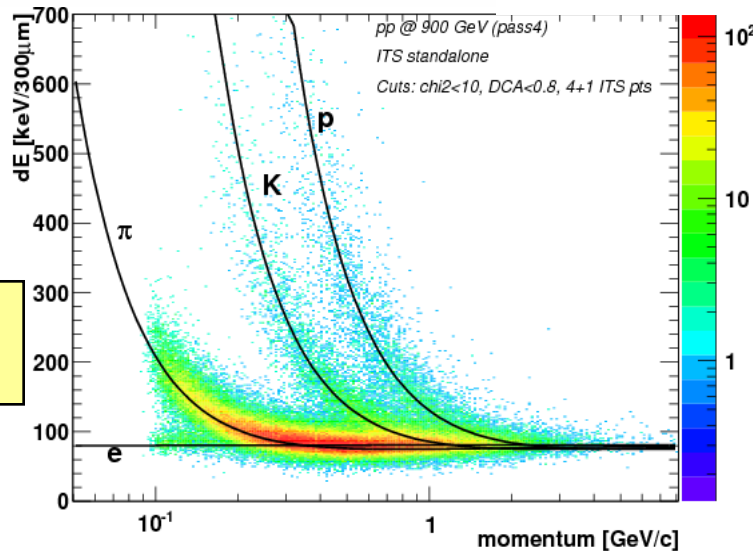
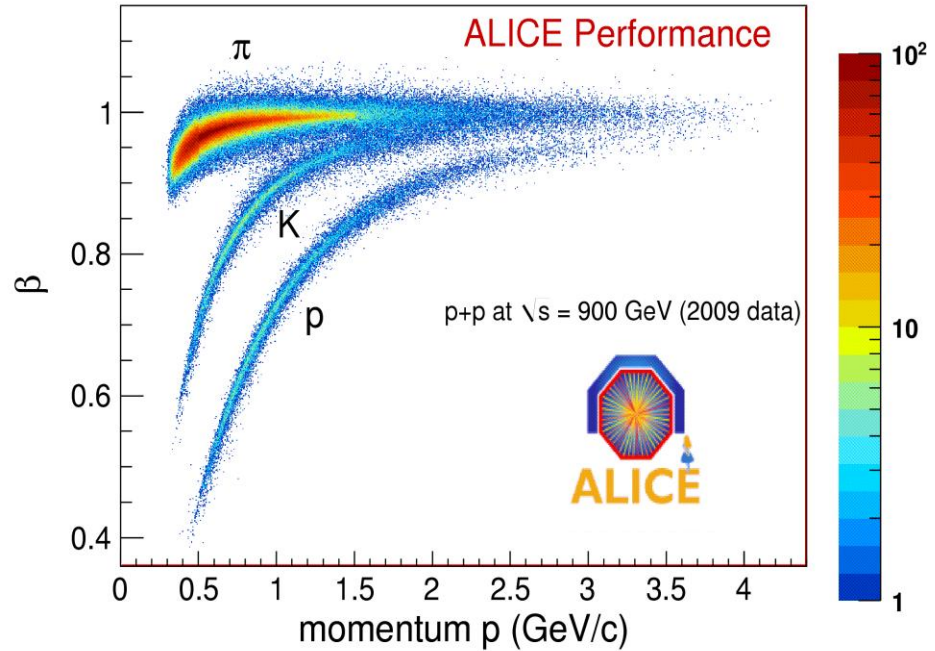
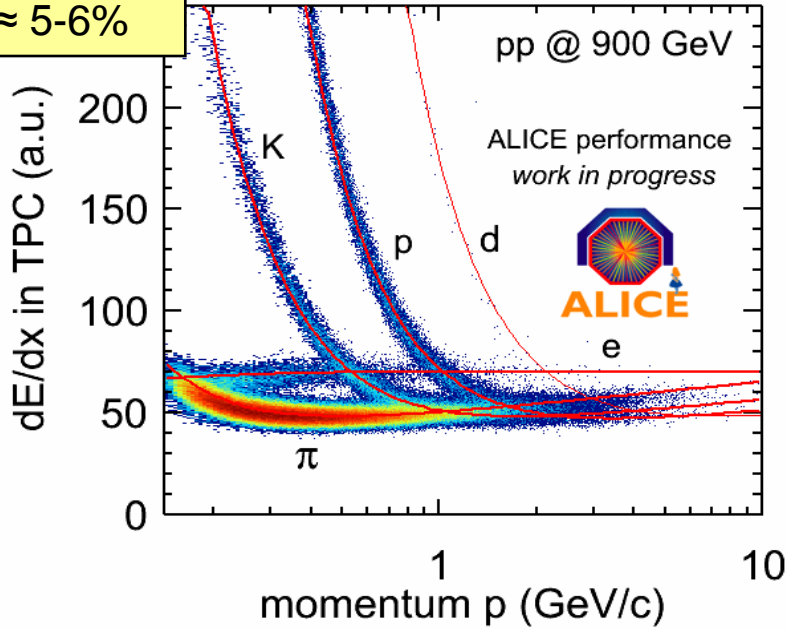
## 900 GeV proton-proton data

- December 2009      500k events
- April 2010          4M events



# PID with TPC, ITS and TOF

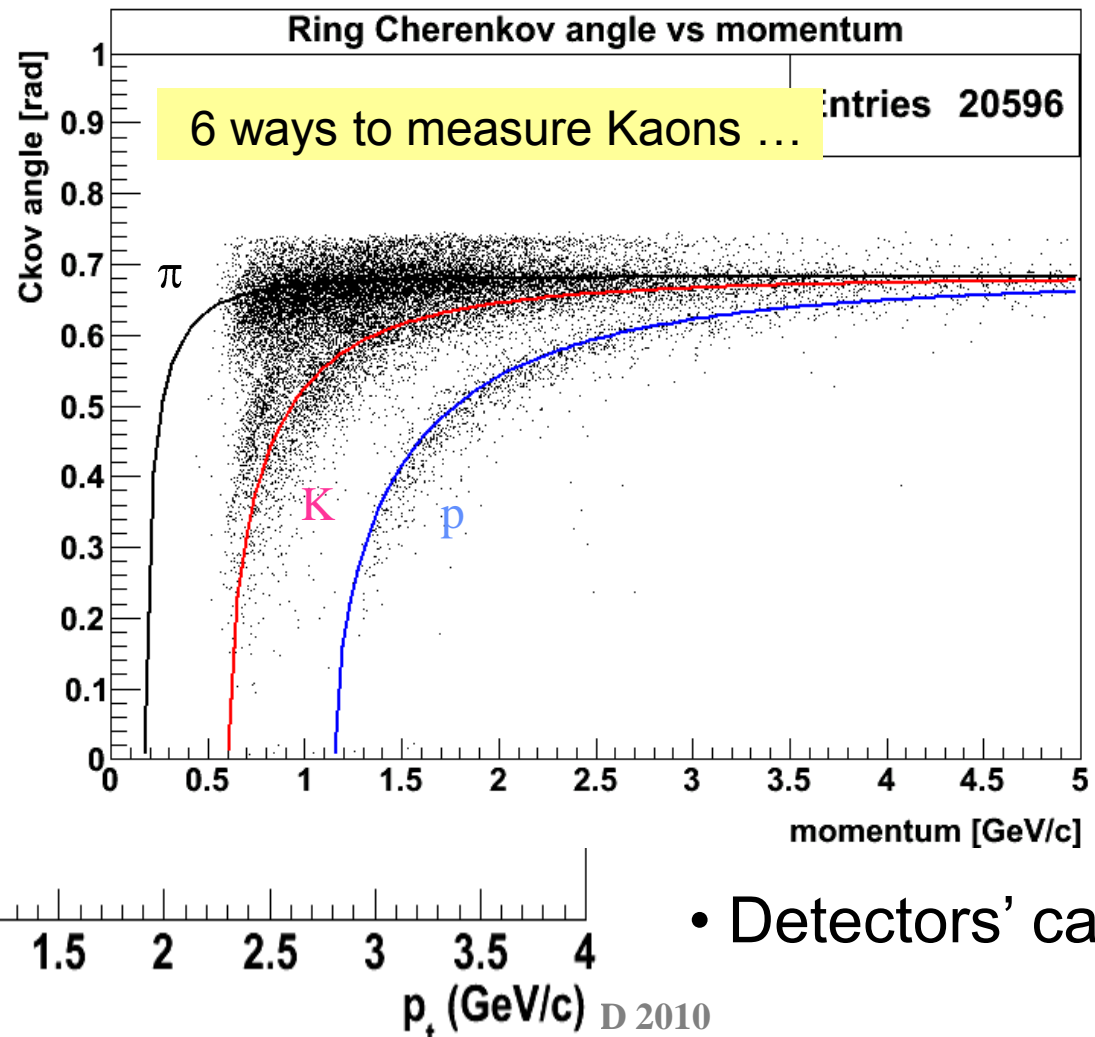
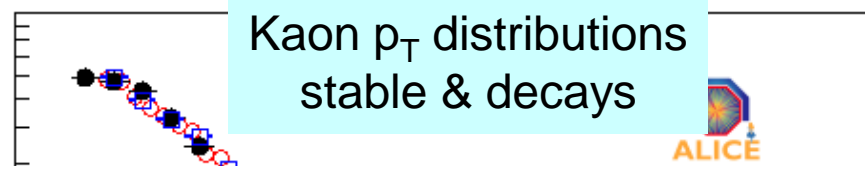
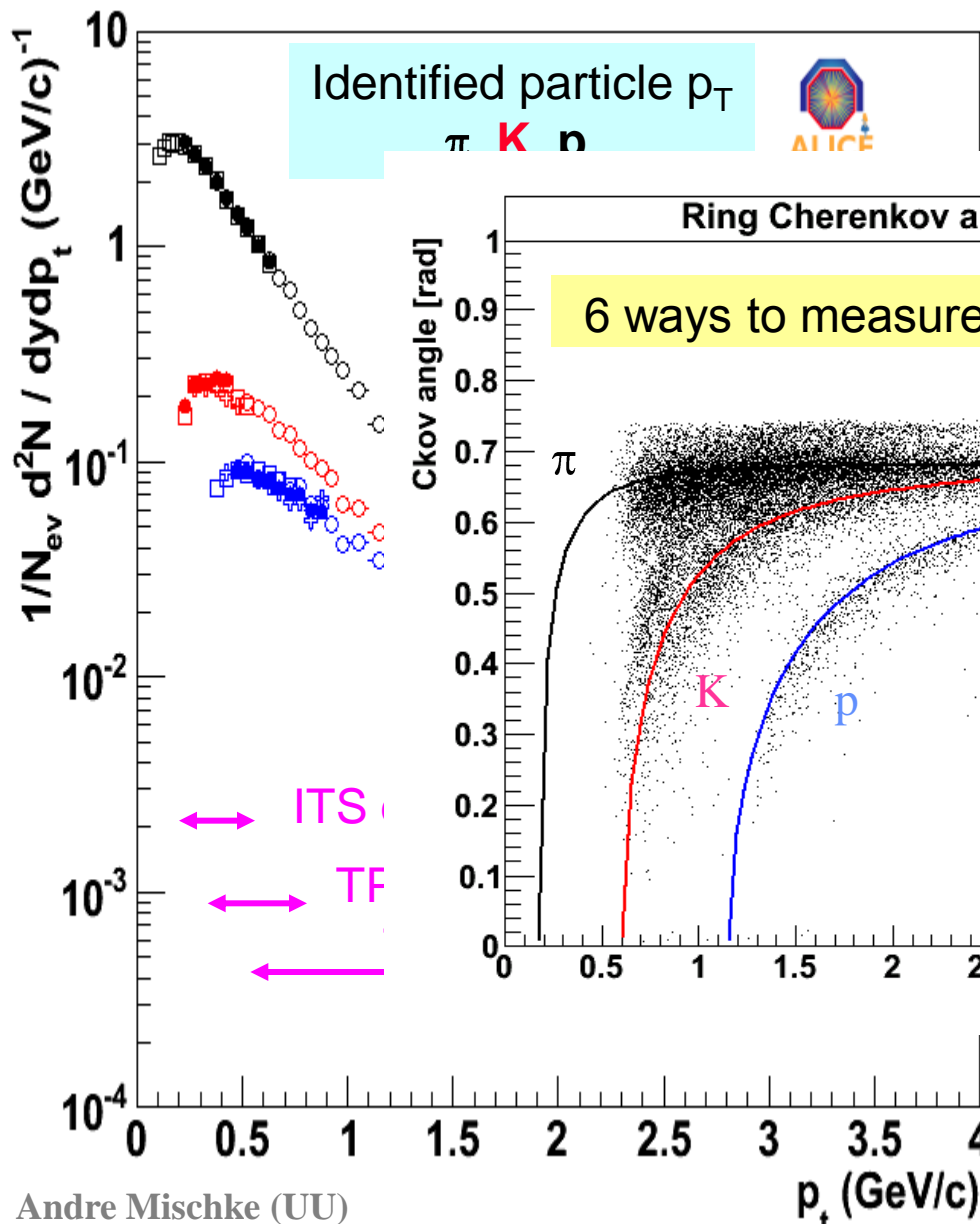
TPC  $dE/dx$   
 $\sigma \approx 5-6\%$



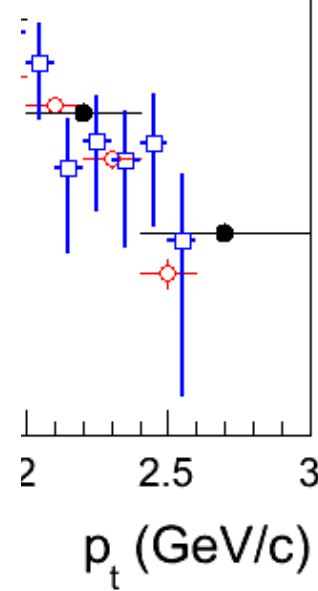
TOF (150k channels)  
 $\sigma \approx 90$  ps

Vertex detector  
 $p_T(\text{min}) < 100$  MeV/c

# Identified charged hadrons

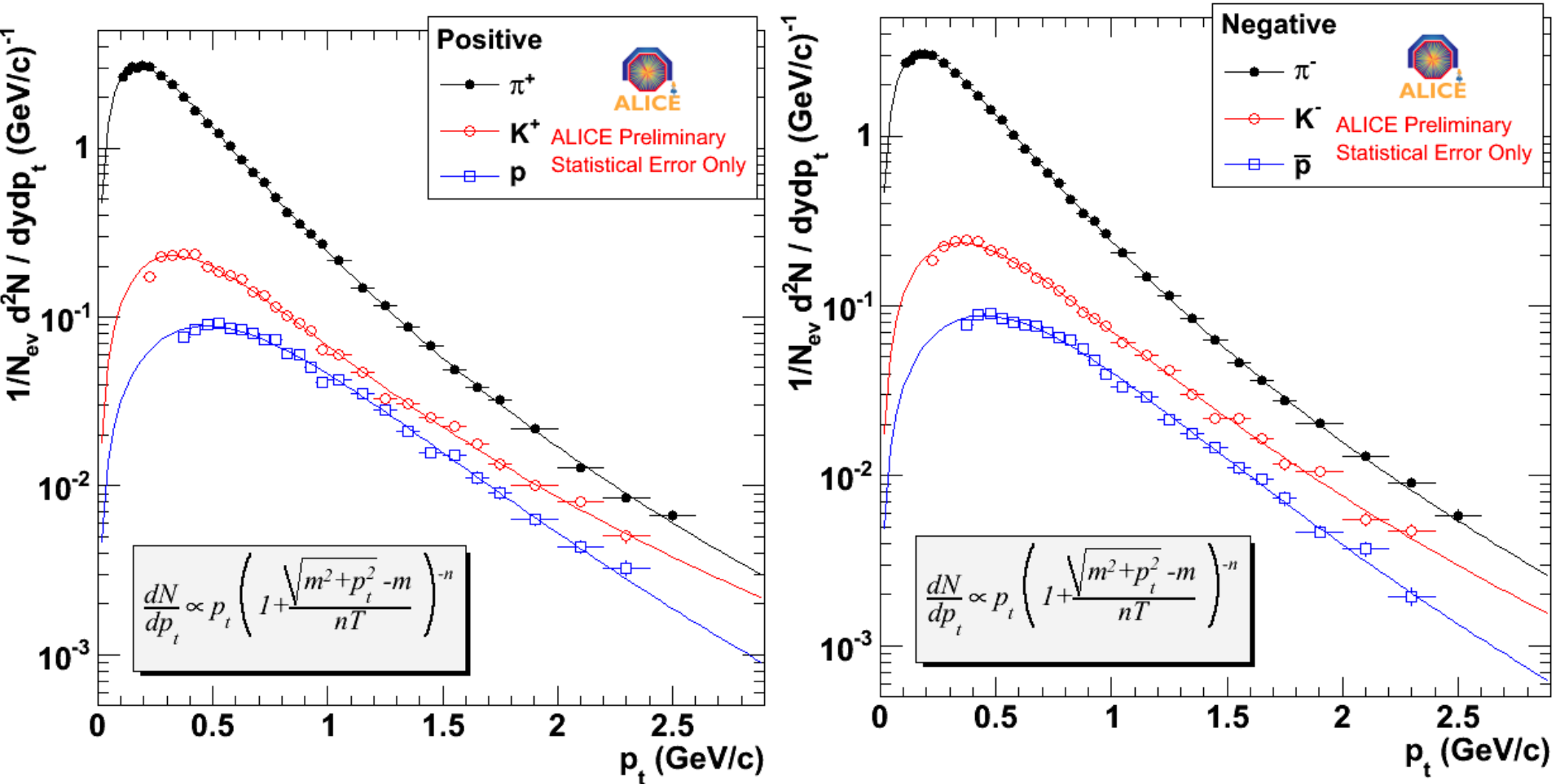


ALICE Performance  
 Not fully corrected  
 04/06/2010



• Detectors' calibration ok

# Stable particle $p_T$ spectra



Lévy (Tsallis) fits describe data well in the measured  $p_T$  range



# Strange particle reconstruction

➤ Analysis based on decay topology (weak decay) and invariant mass technique

➤ Excellent PID

- $K_s^0(498) \rightarrow \pi\pi$

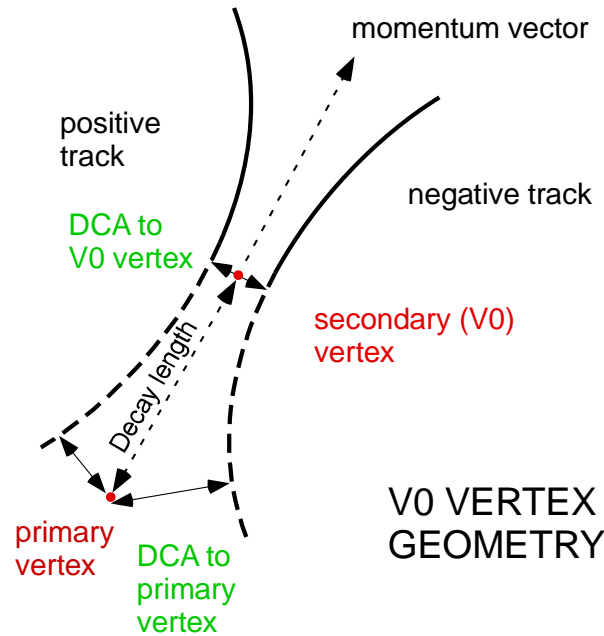
- $\Lambda(1116) \rightarrow p\pi$

- $\Xi(1321) \rightarrow \Lambda\pi \rightarrow p\pi\pi$

- $\Omega^-(1672) \rightarrow \Lambda K^- \rightarrow \pi^- p^+ K^-$

- $\phi(1020) \rightarrow K^+K^-$

# V0 detection



V0 VERTEX GEOMETRY

**Primary vertex:**  $|z| < 10$  cm

**Tracks:**

$p_T > 160$  MeV/c

TPC clusters  $> 80$

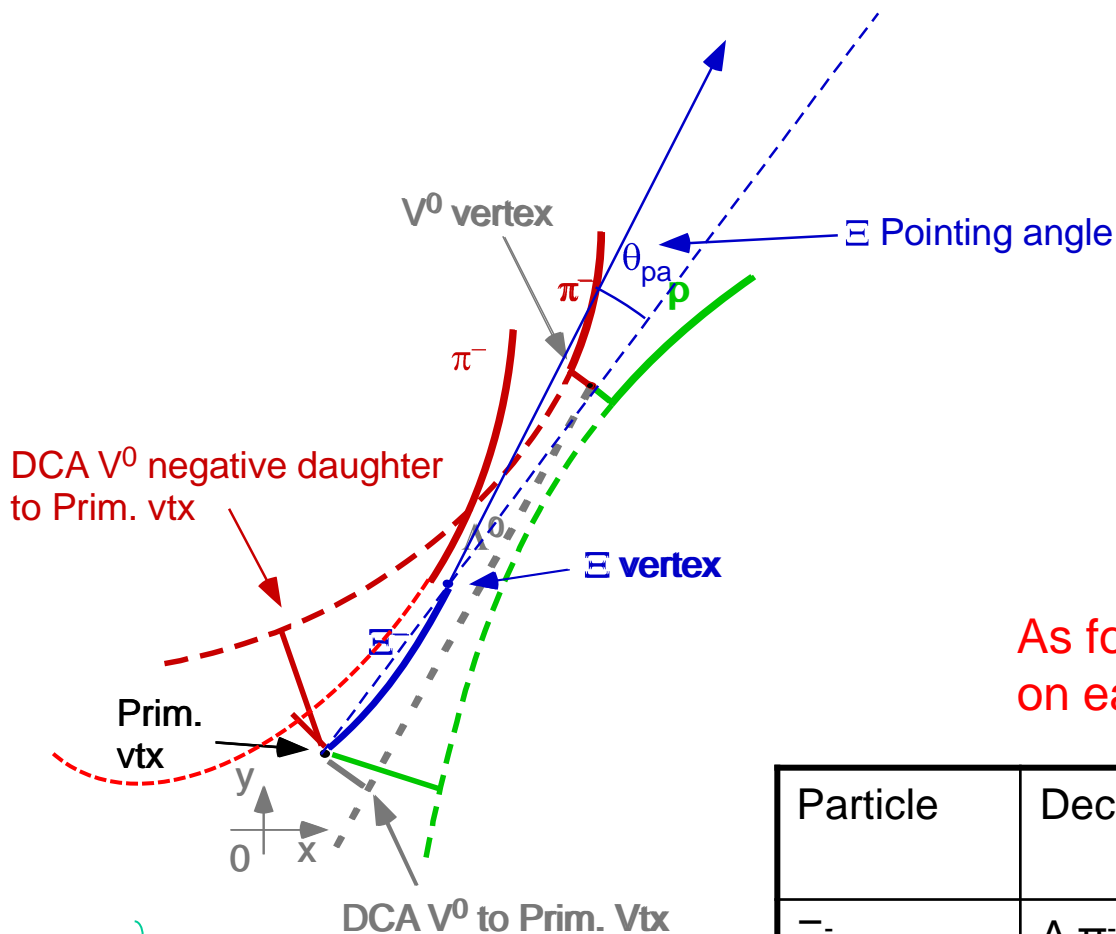
**V0**  $|y| < 0.75$

Select secondary tracks from DCA to primary vertex

Select secondary vertex by DCA of secondary tracks to possible vertex

| Particle        | Decay           | Branching ratio | $c\tau$ (cm) | $q_T$ (MeV/c) |
|-----------------|-----------------|-----------------|--------------|---------------|
| $\Lambda$       | $p \pi^-$       | 63.9%           | 7.89         | 101           |
| $\bar{\Lambda}$ | $\bar{p} \pi^+$ | 63.9%           | 7.89         | 101           |
| $K_s^0$         | $\pi^+\pi^-$    | 69.2%           | 2.68         | 206           |

# Cascade reconstruction



**Primary vertex:**  $|z| < 10$  cm

**Tracks:**

TPC clusters  $> 80$

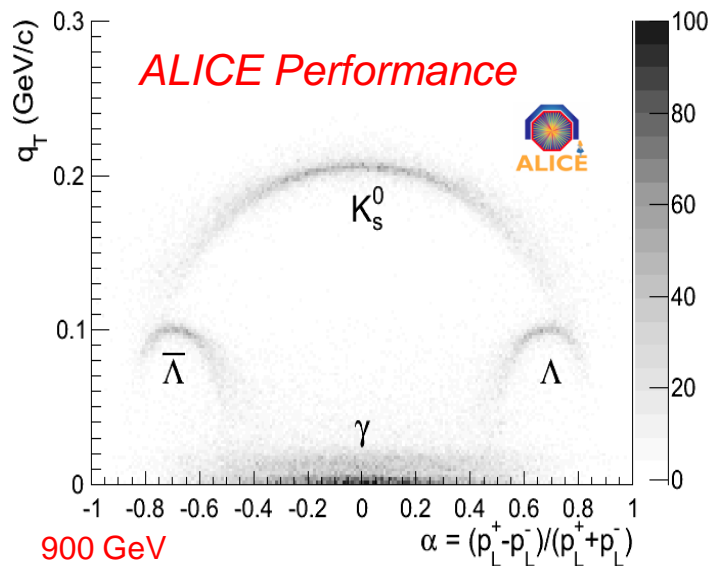
**$V^0$**   $|y| < 0.8$

As for  $V^0$ , but also check TPC PID on each daughter

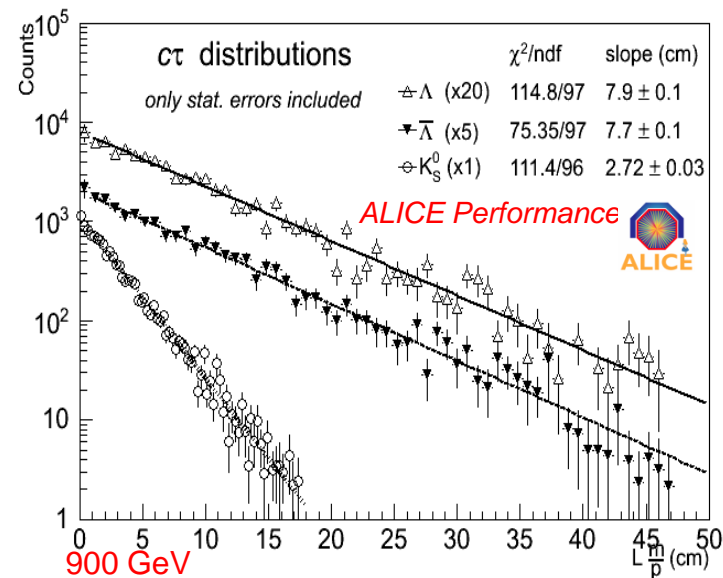
| Particle   | Decay           | Branching ratio | $c\tau$ (cm) | $q_T$ (MeV/c) |
|------------|-----------------|-----------------|--------------|---------------|
| $\Xi^-$    | $\Lambda \pi^-$ | 100%            | 4.91         | 140           |
| $\Omega^-$ | $\Lambda K^-$   | 67.8%           | 2.46         | 211           |

# V0 quality

Armenteros-Podolanski plot



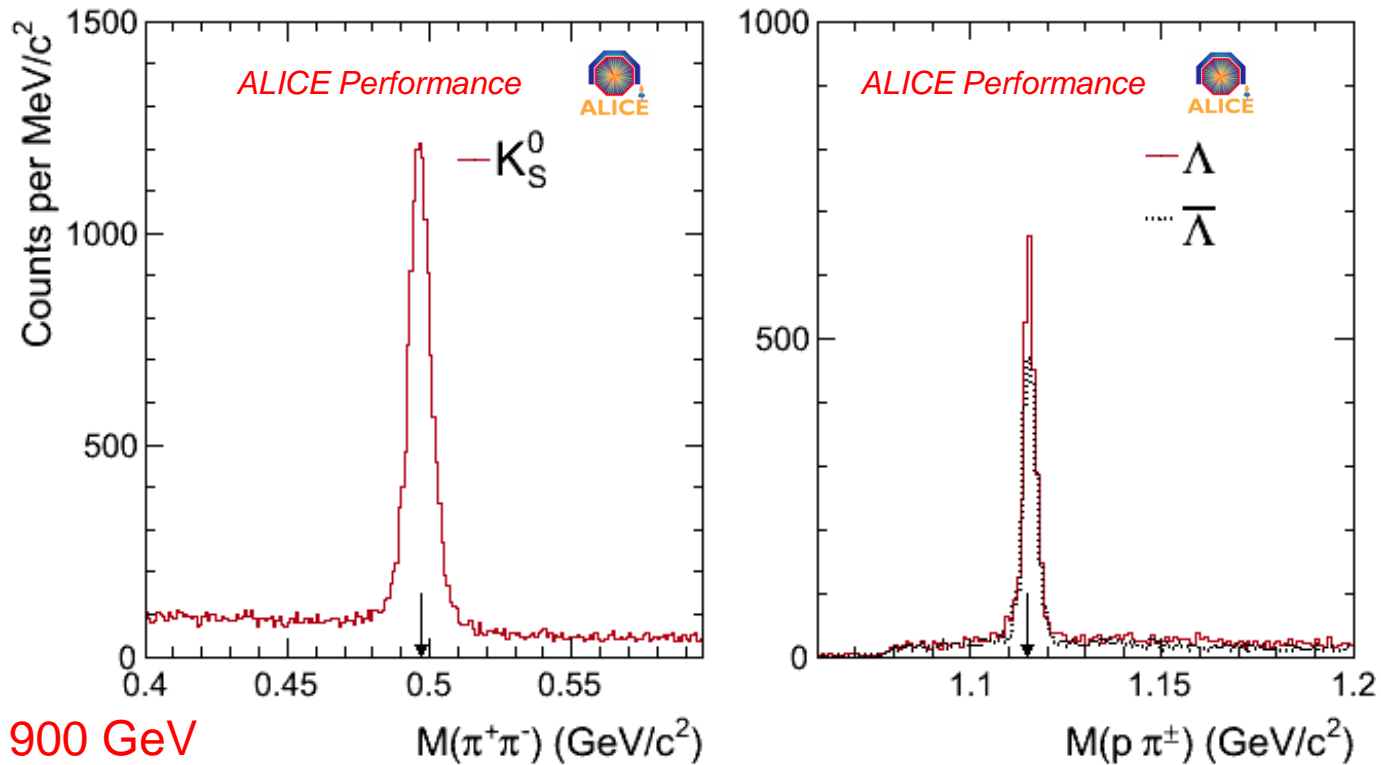
Lifetime



V0 decay kinematics and lifetime distributions seems ok

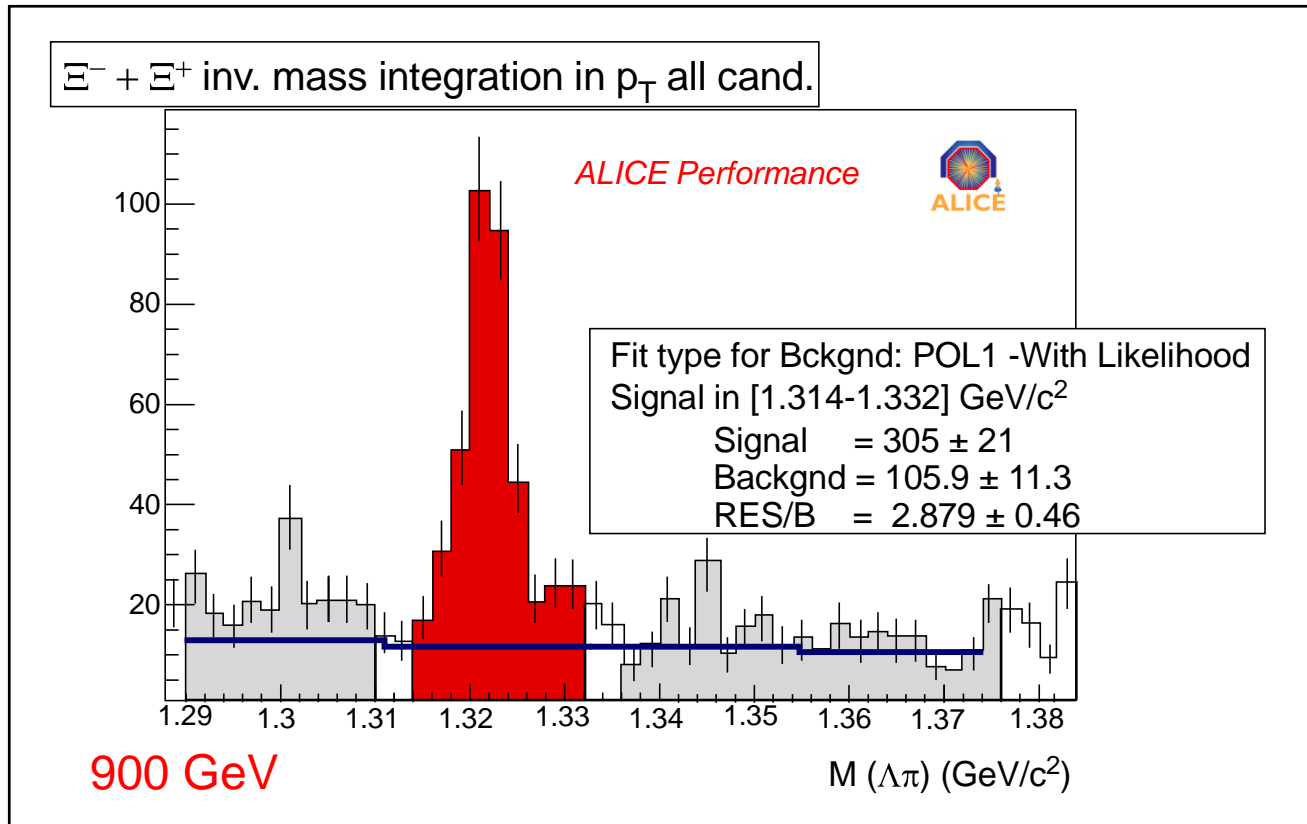
| particle        | decay         | $c\tau$ (meas.) (cm) | $c\tau$ (PDG) (cm) | $q_T$ (MeV/c) |
|-----------------|---------------|----------------------|--------------------|---------------|
| $\Lambda$       | $p \pi^-$     | $7.9 \pm 0.1$        | 7.89               | 101           |
| $\bar{\Lambda}$ | $p \pi^+$     | $7.7 \pm 0.1$        | 7.89               | 101           |
| $K_s^0$         | $\pi^+ \pi^-$ | $2.72 \pm 0.03$      | 2.68               | 206           |

# V0 signals



| Particle        | Mass (PDG) [ $\text{MeV}/c^2$ ] | $\mu$ [ $\text{MeV}/c^2$ ] |
|-----------------|---------------------------------|----------------------------|
| $K_S^0$         | 497.61                          | $498.66 \pm 0.04$          |
| $\Lambda$       | 1115.683                        | $1115.2 \pm 0.4$           |
| $\bar{\Lambda}$ | 1115.683                        | $1115.3 \pm 0.4$           |

# Cascade signal



# Reconstruction of $\phi$ mesons

**Primary vertex:**  $|z| < 10$  cm

**Tracks:**

$p_T > 160$  MeV/c  
TPC clusters  $> 80$

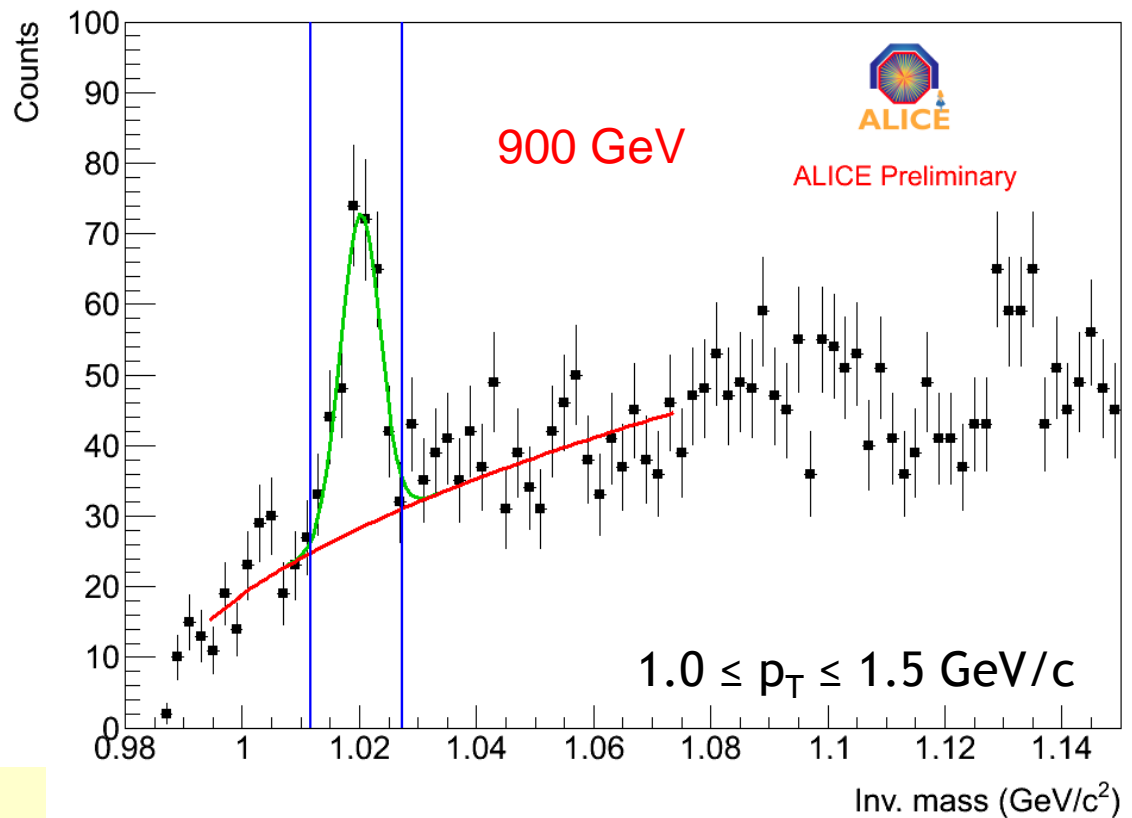
**DCA**

Transverse  $< 0.5$  cm  
Longitudinal  $< 3.0$  cm

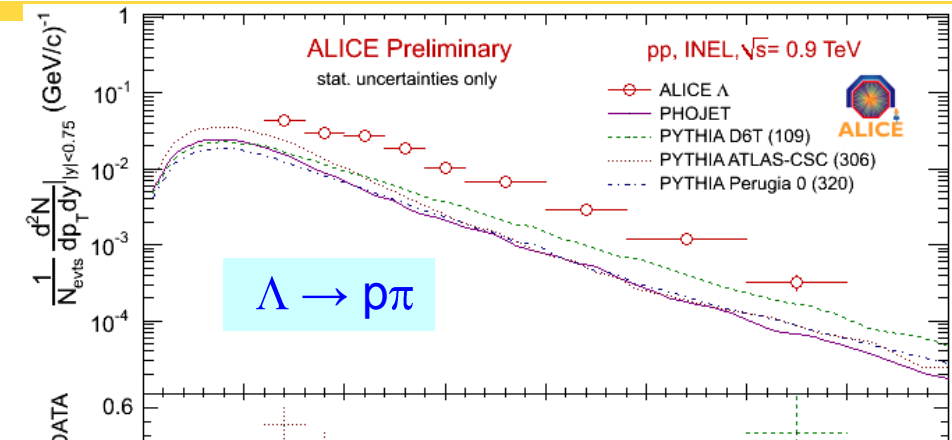
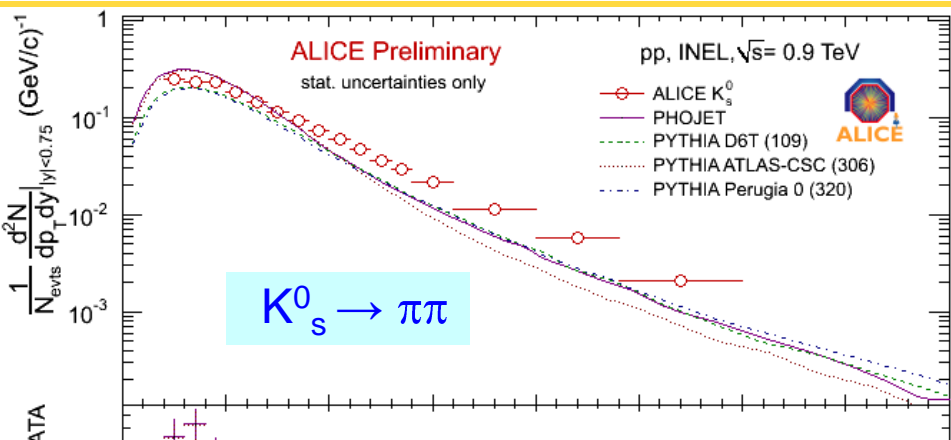
**PID**

TPC-identified kaon

TOF-identified when appropriate

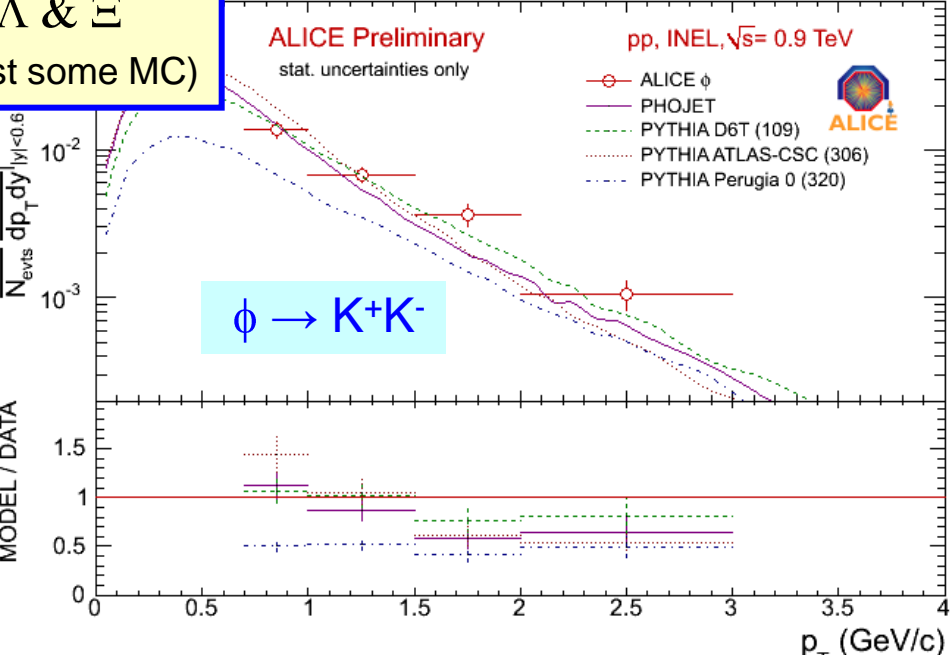
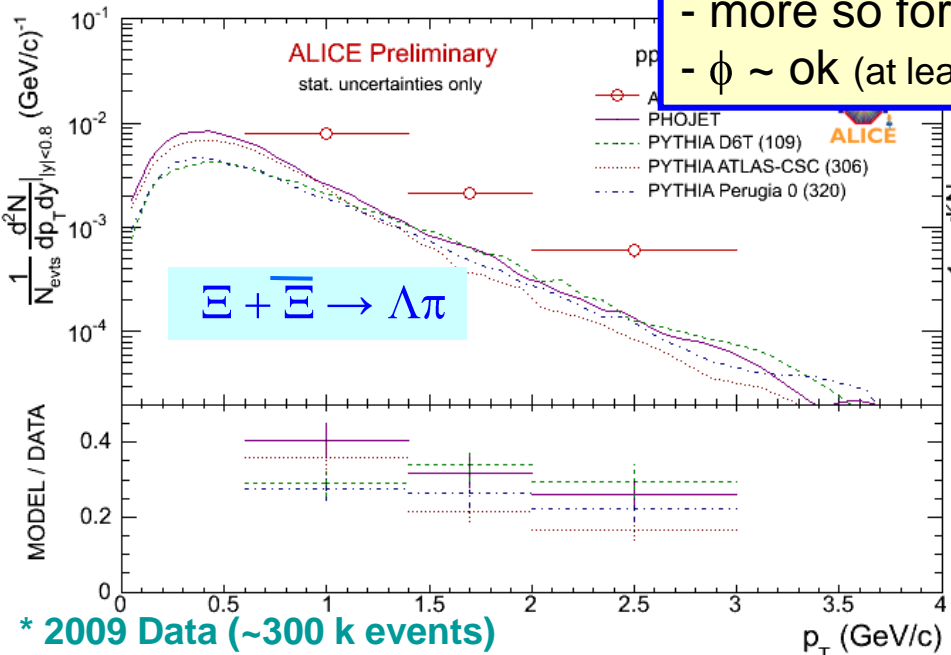


# Hyperon spectra in 900 GeV p-p collisions



**Preliminary results**

- MC well below data
- more so at high  $p_T$
- more so for  $\Lambda$  &  $\Xi$
- $\phi \sim \text{ok}$  (at least some MC)

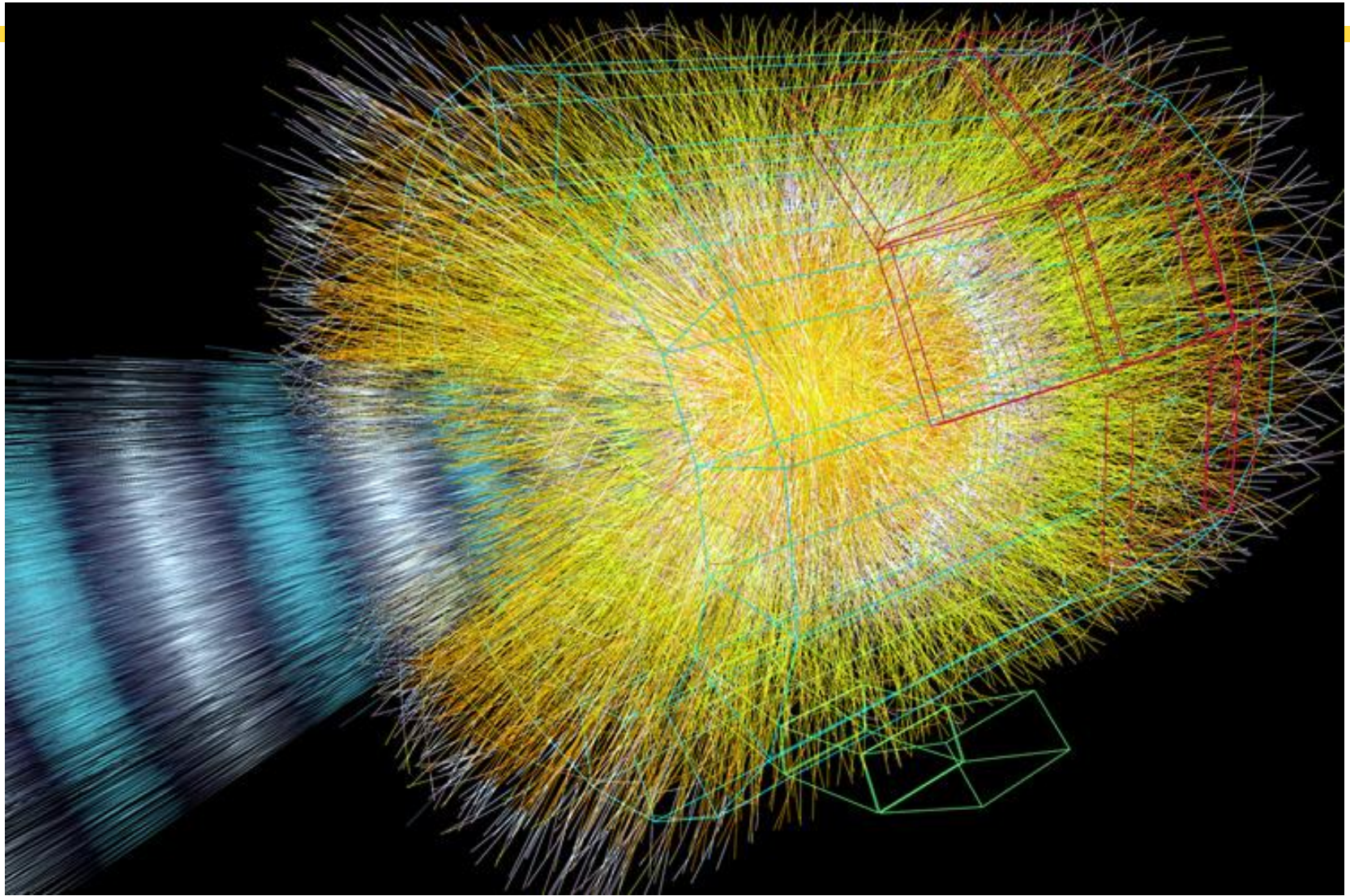


\* 2009 Data (~300 k events)



# Summary

- Stable particles well identified from 100 MeV/c up to 2.6 GeV/c
- Signals studied for  $K_s^0$ ,  $\Lambda$ ,  $\Xi$  and  $\phi$  in p-p at 900 GeV
- Papers in the pipeline
- 7 TeV data on tape (aim for 1000M events)
- First lead-lead collisions at  $\sqrt{s_{NN}} = 2.76$  TeV anticipated for November 2010
- Exciting times ahead of us...

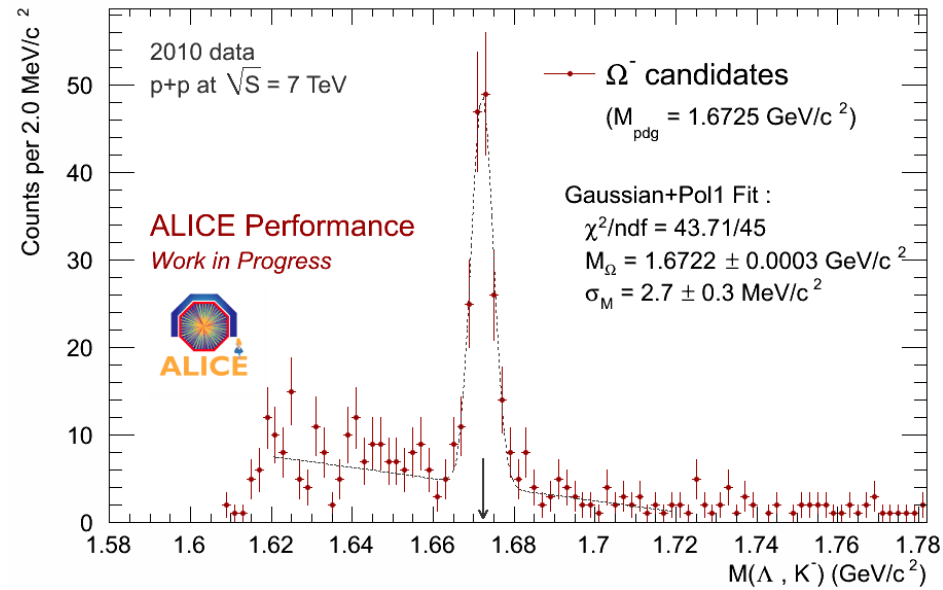
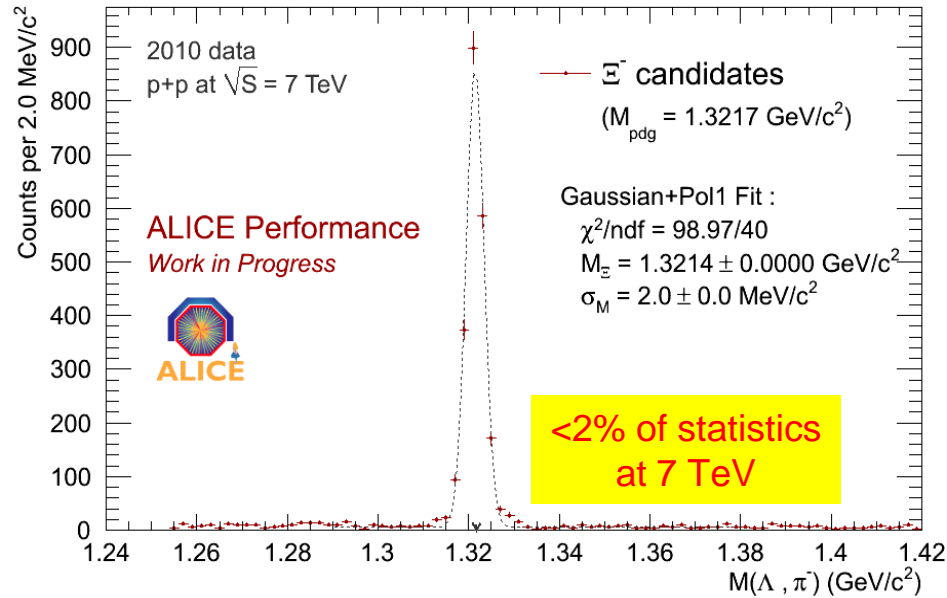


Monte Carlo simulation of a Pb-Pb collision at 5.5 TeV

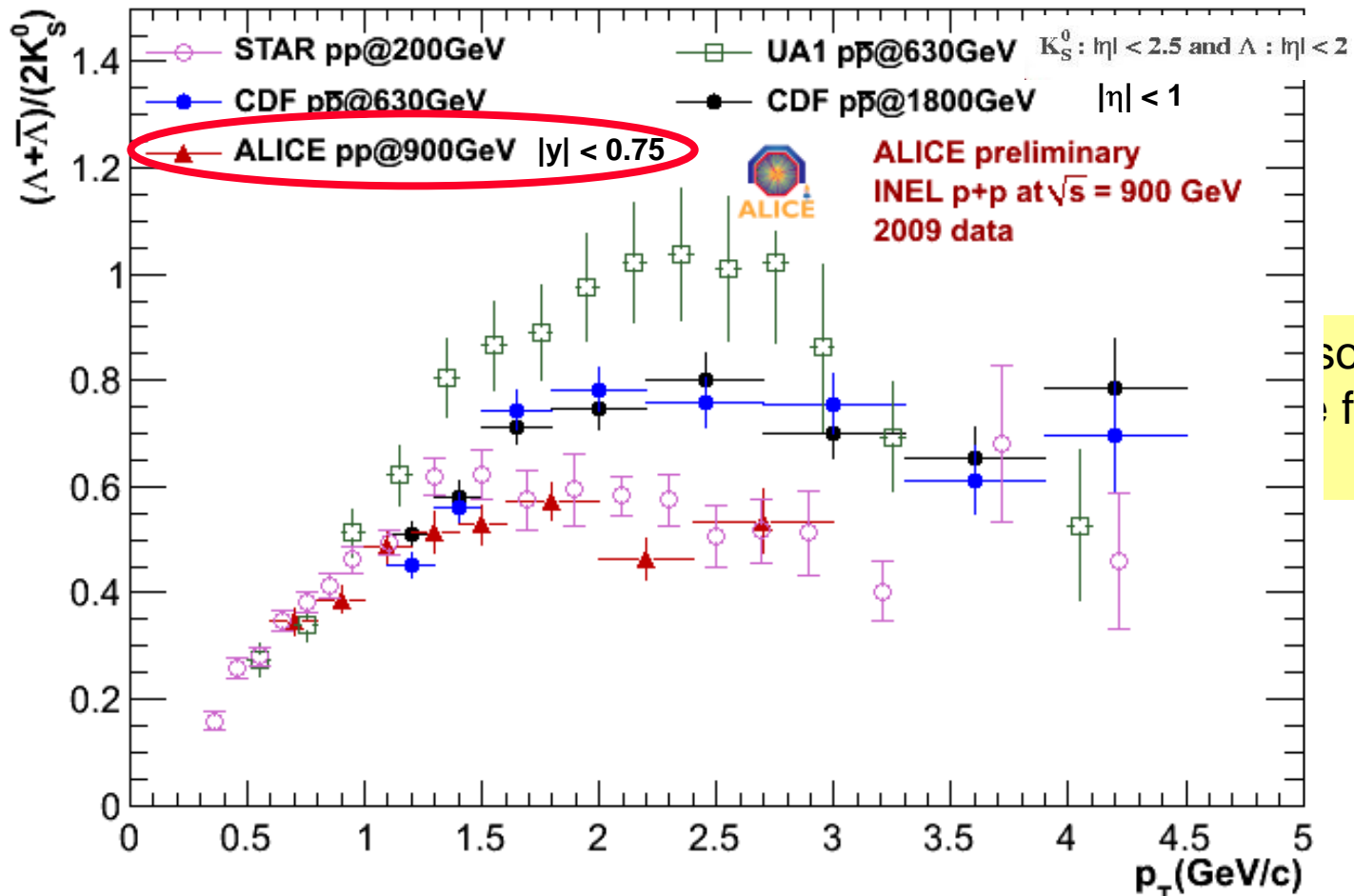
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# Backup

# Strange particles in 7 TeV p-p collisions



# $\Lambda/K_S^0$ ratio in p-p at 900 GeV



- very **good agreement** between **STAR** (200 GeV) and **ALICE** (900 GeV)
  - very **different** from **CDF** (630/1800) and **UA1** (630) for  $p_T > 1.5$  GeV/c
  - UA1(630) and CDF(630) don't agree either ...
- to be further investigated (different triggers, feed-down correction)