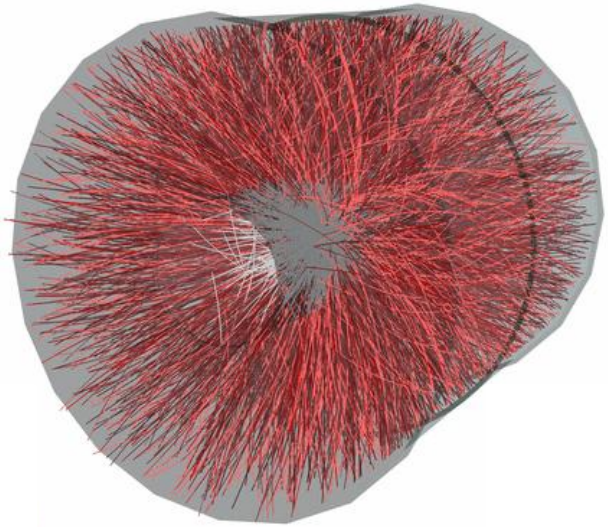
Resonance production and search for exotica with ALICE at the LHC



Benjamin Dönigus

for the ALICE collaboration

RBRC workshop on Hyperon-Hyperon interactions/BNL

29.02.2012

H-QM | Helmholtz Research School Quark Matter Studies

ALICE

GSI

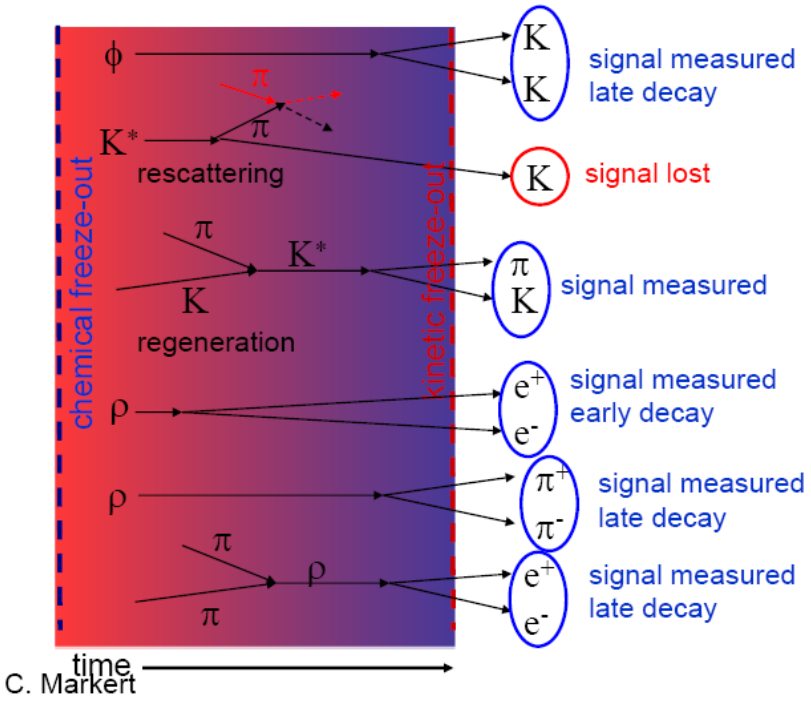
Content

- Motivation
- ALICE setup and running conditions
- Hyperon production
- Resonance production
- Search for exotica

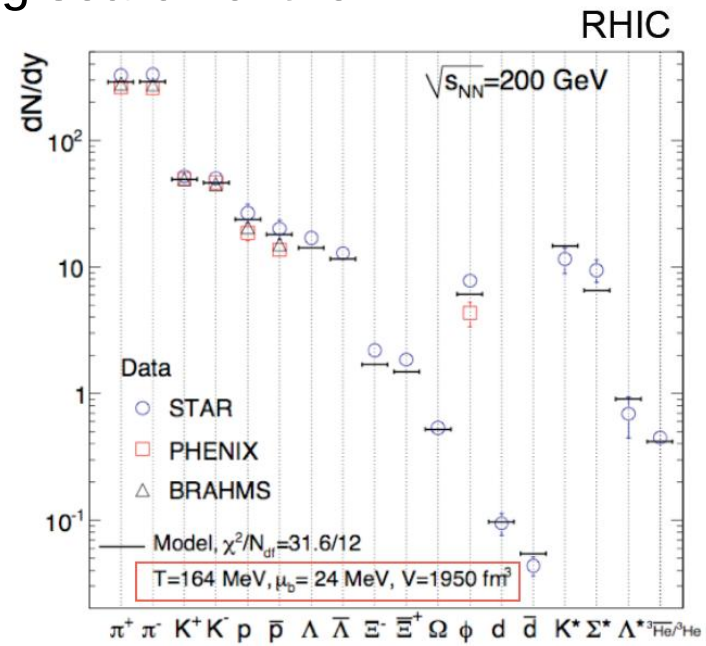
Motivation

- Test of (p)QCD
- Chiral symmetry restoration:

  Measure mass and width in pp and compare to PbPb
- Disentangle different phases of the fireball evolution, since resonances are short-lived (~1.5-50 fm/c)
- Production mechanisms: Test thermal model(s)
- Exclude/give evidence on the long ongoing search of the H^0



C. Markert

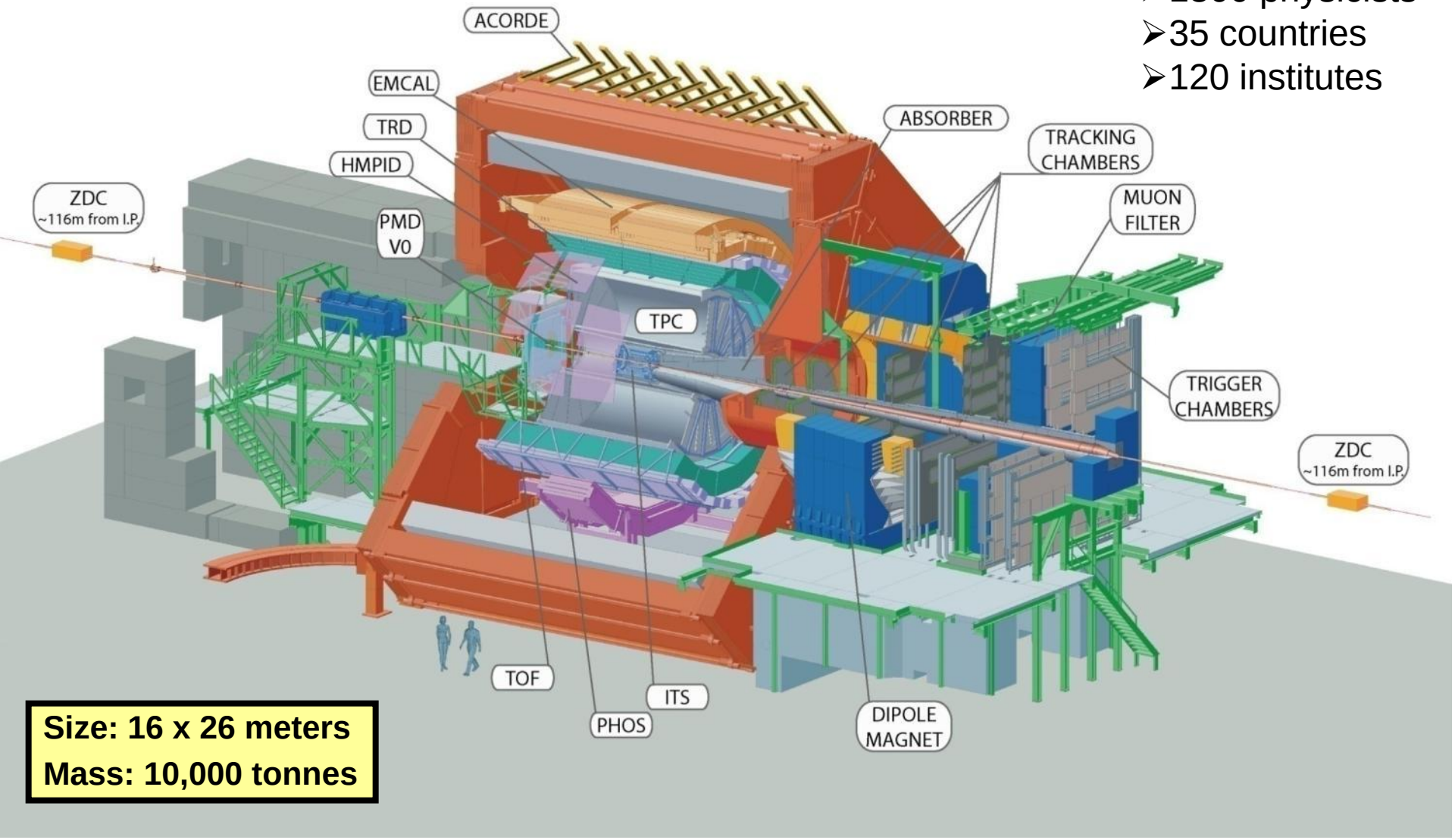


A. Andronic et al., Phys.Lett.B 673 (2009) 142

ALICE

A Large Ion Collider Experiment

- 1300 physicists
- 35 countries
- 120 institutes



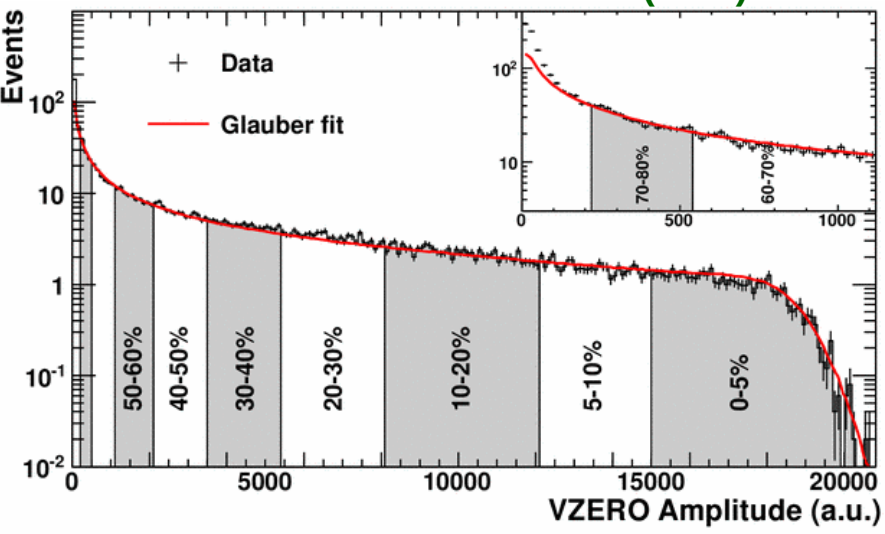
Size: 16 x 26 meters
Mass: 10,000 tonnes

Data taking and analysis input

- 2009:
  - pp 900 GeV
- 2010:
  - pp 900 GeV
  - pp 2.36 GeV
  - pp 7 TeV
  - Pb-Pb 2.76 TeV
- 2011:
  - pp 2.76 TeV
  - pp 7 TeV
  - Pb-Pb 2.76 TeV

System	Energy (TeV)	Trigger	Analyzed events
pp	7	MB	365 M
pp	2.76	MB	65 M
Pb-Pb	2.76	MB	22 M

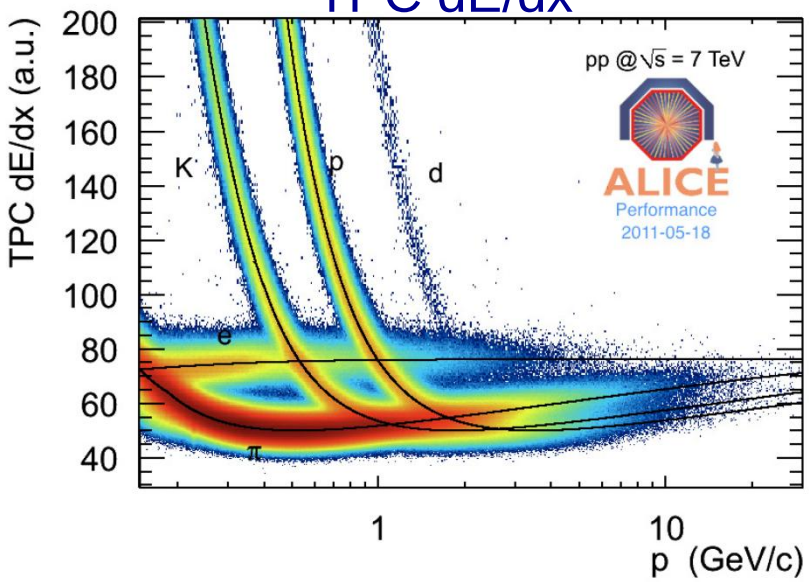
PRL106 (2011) 032301



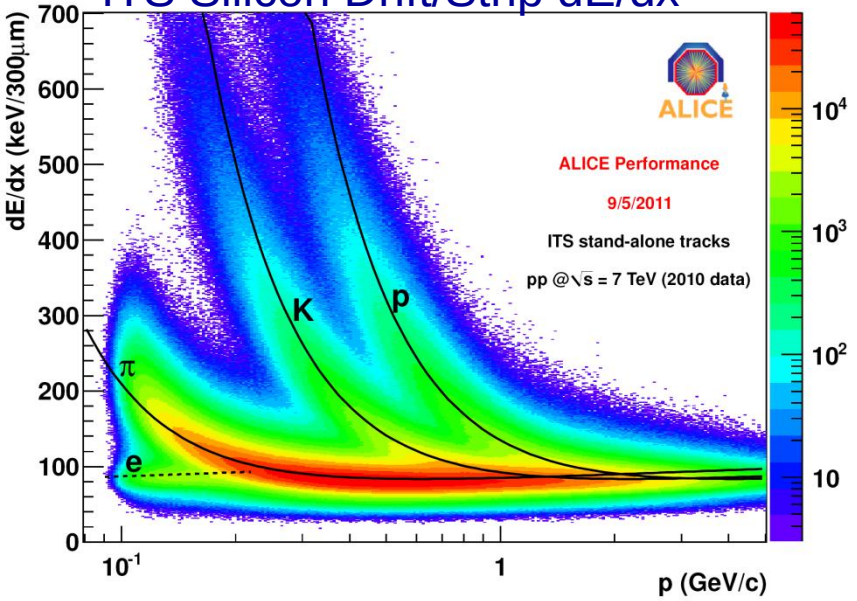
- Trigger
  - MB: Minimum bias trigger based on VZERO (scintillator array in forward and backward direction) and Silicon Pixel Detector
- Centrality selection in PbPb
  - Amplitudes in the VZERO scintillators
  - reproduced by Glauber model fit

Particle Identification performance: selected plots

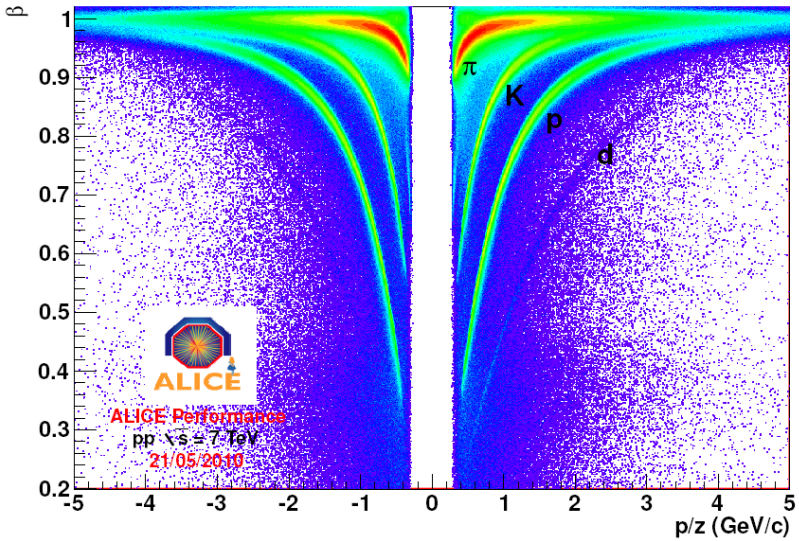
TPC dE/dx



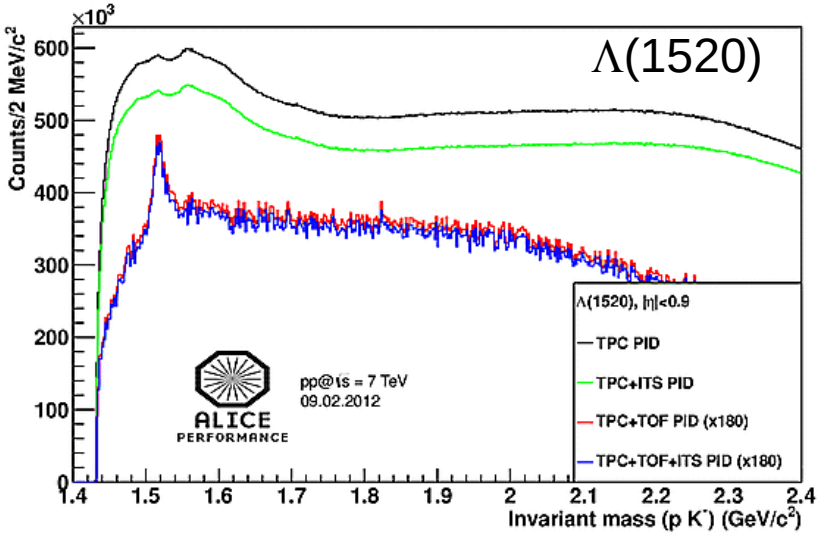
ITS Silicon Drift/Strip dE/dx



TOF

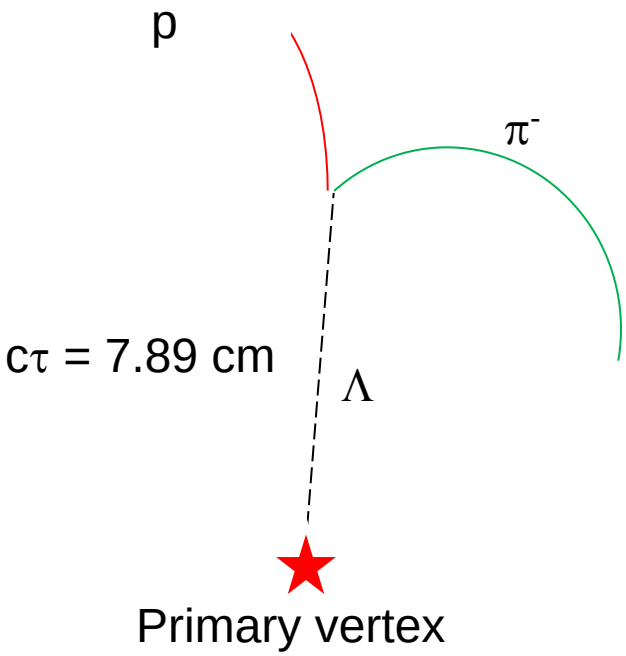


PID at work

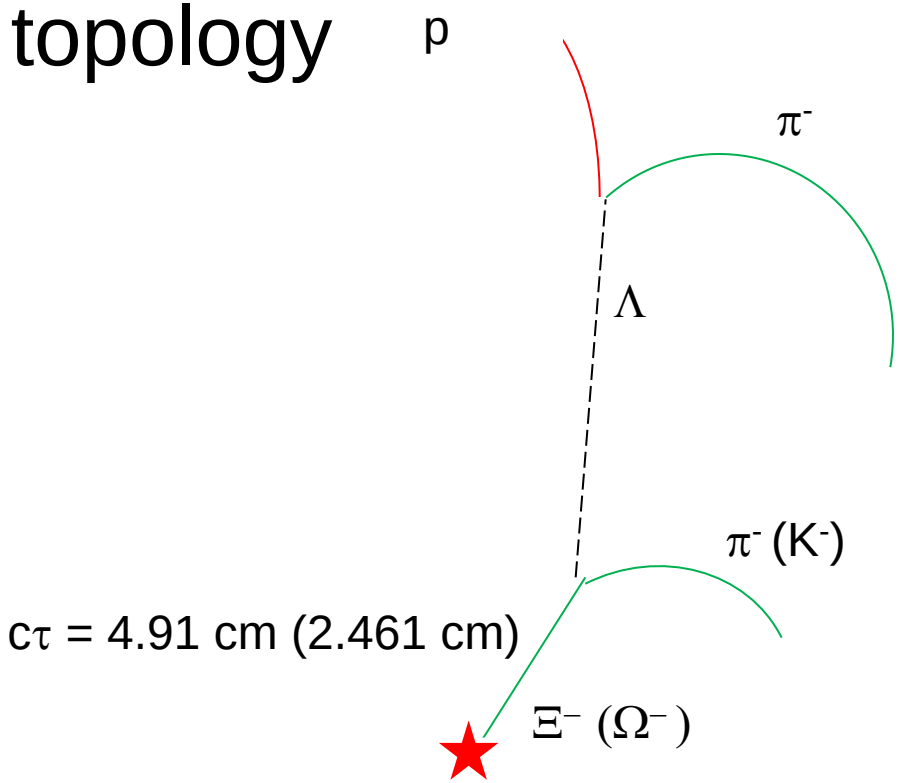


Hyperon production

- Detection via decay topology



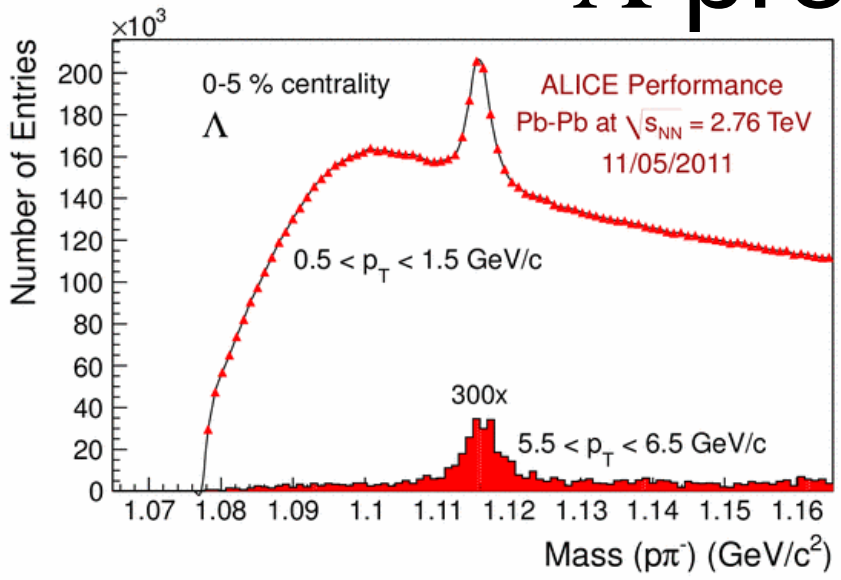
BR: (63.9 ± 0.5)% ($\Lambda \rightarrow p\pi^-$)
mass: (1115.683 ± 0.006) MeV/c^2

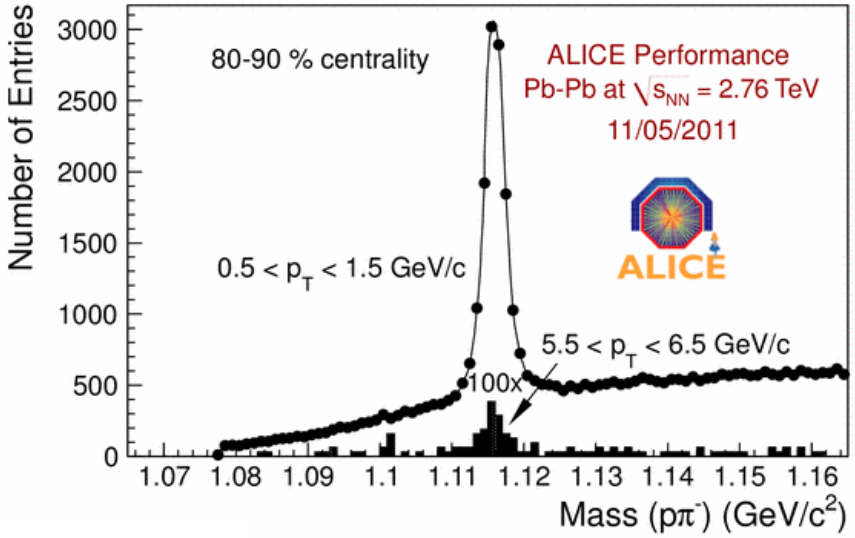


Ξ^-
BR: (99.887 ± 0.035)% ($\Xi^- \rightarrow \Lambda\pi^-$)
mass: (1321.71 ± 0.07) MeV/c^2

Ω^-
BR: (67.8 ± 0.7)% ($\Omega^- \rightarrow \Lambda K^-$)
mass: (1672.45 ± 0.29) MeV/c^2

Λ production

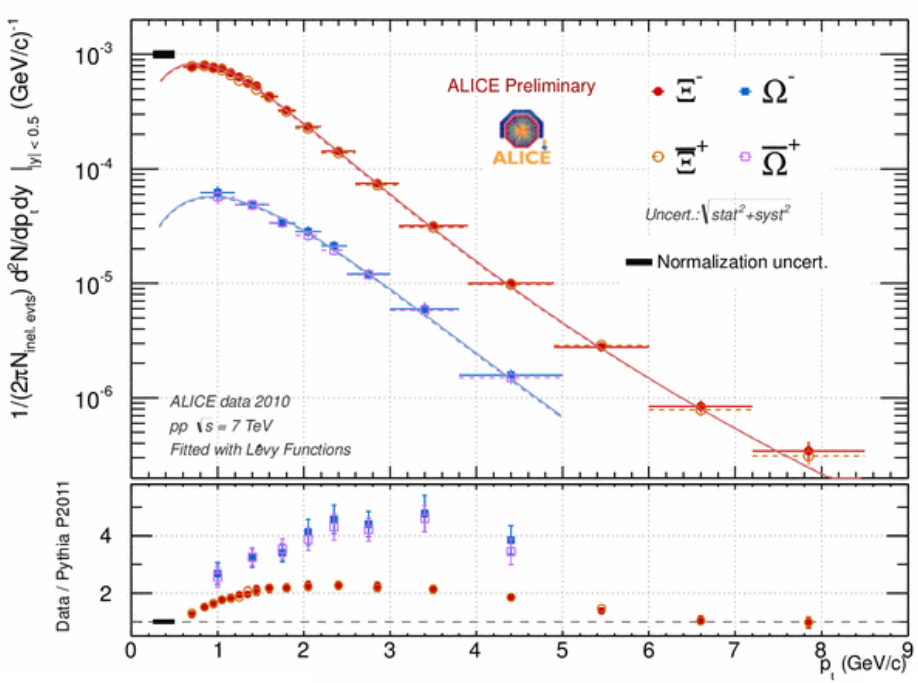


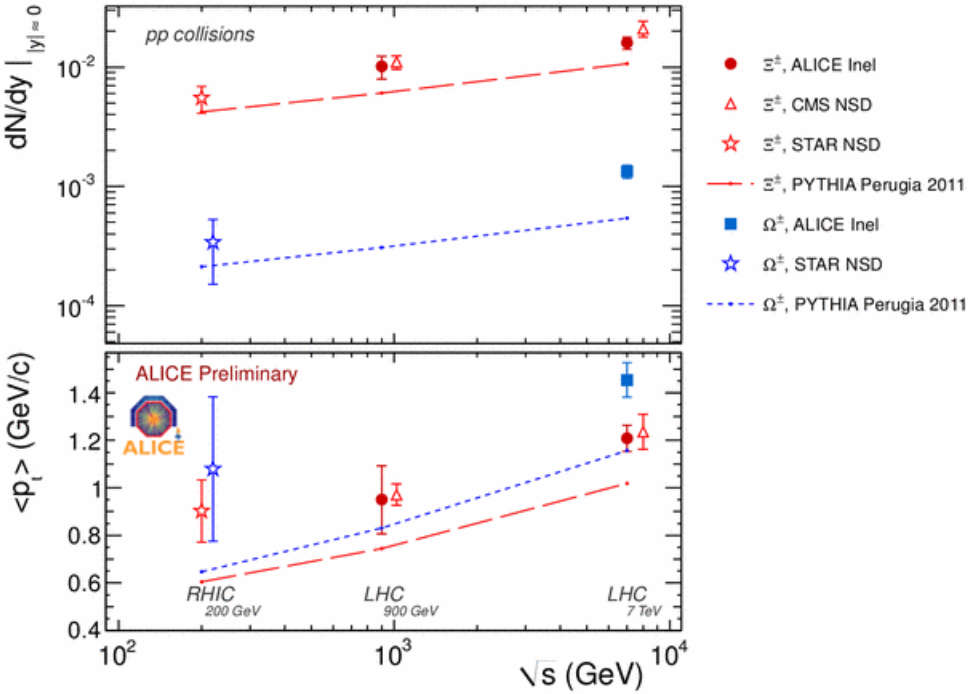


The decay topology allows the reconstruction of Λ over a large p_t range and in several centrality bins

→ R_{AA} and Λ/K^0_s ratio under intensive study

Multi-strange baryon production in pp@7 TeV

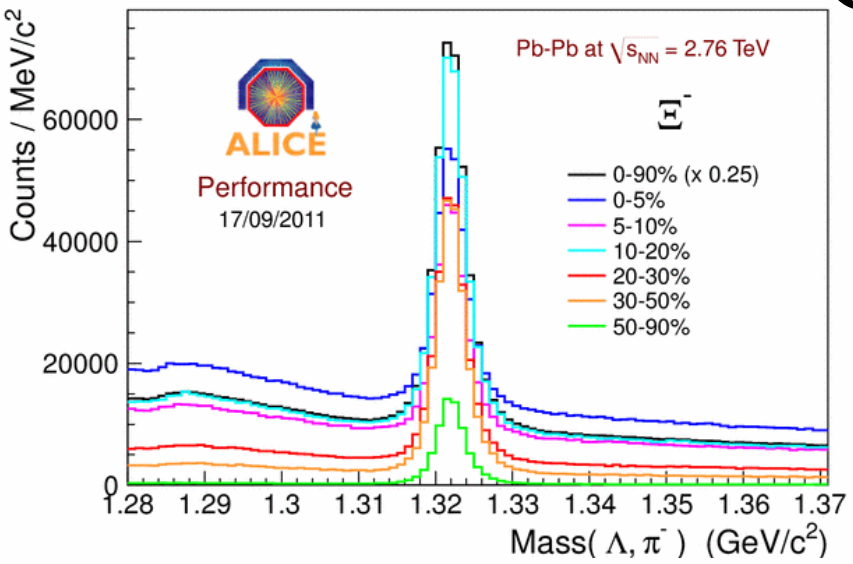


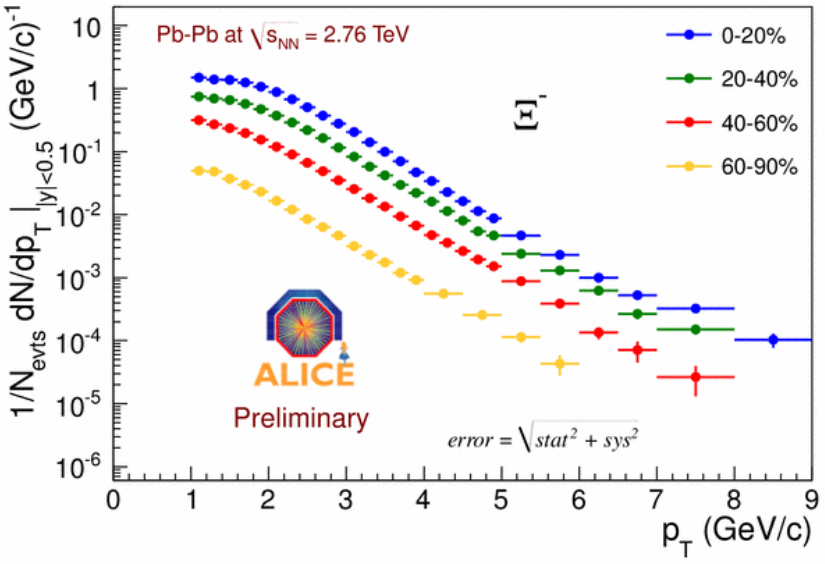


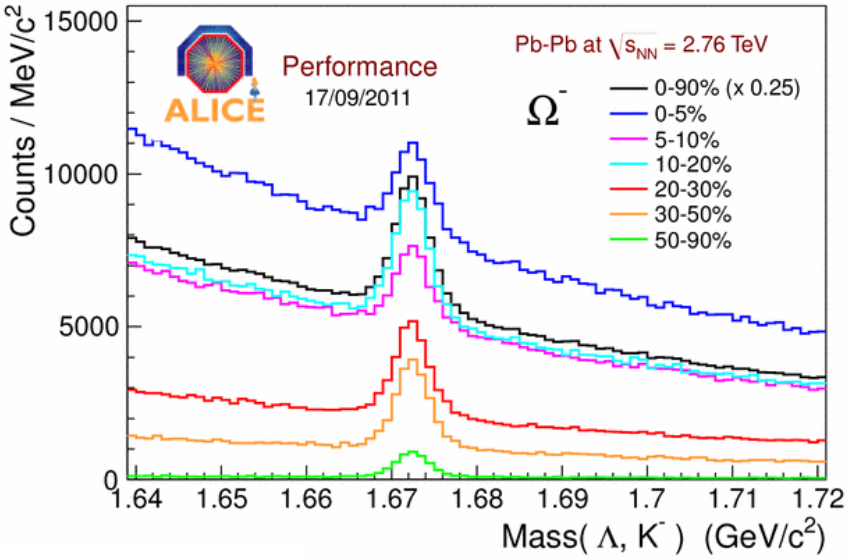
yield and $\langle p_T \rangle$ increase with energy

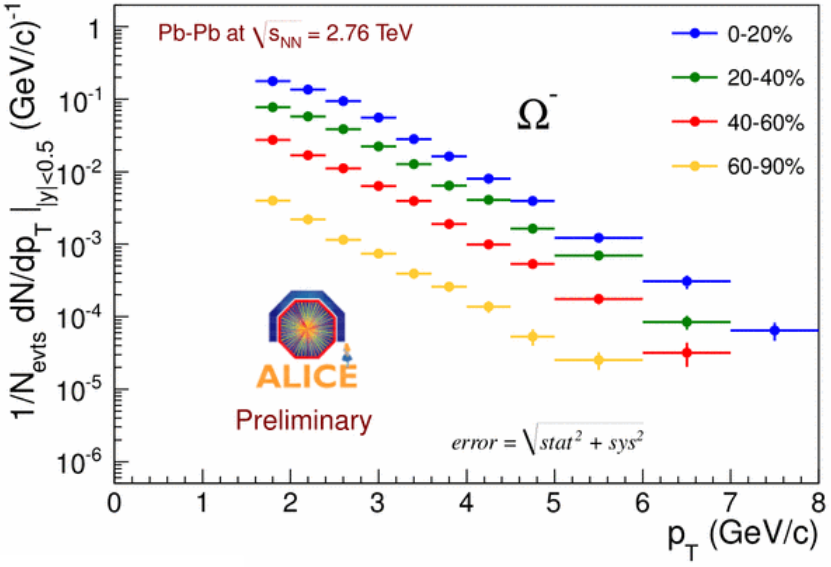
- ALICE and CMS agreement on Ξ
  - small difference due to different normalization choice (INEL vs. NSD)
- All PYTHIA tunes underestimate (multi-)strangeness production

Multi-strange baryon production in Pb-Pb@2.76 TeV

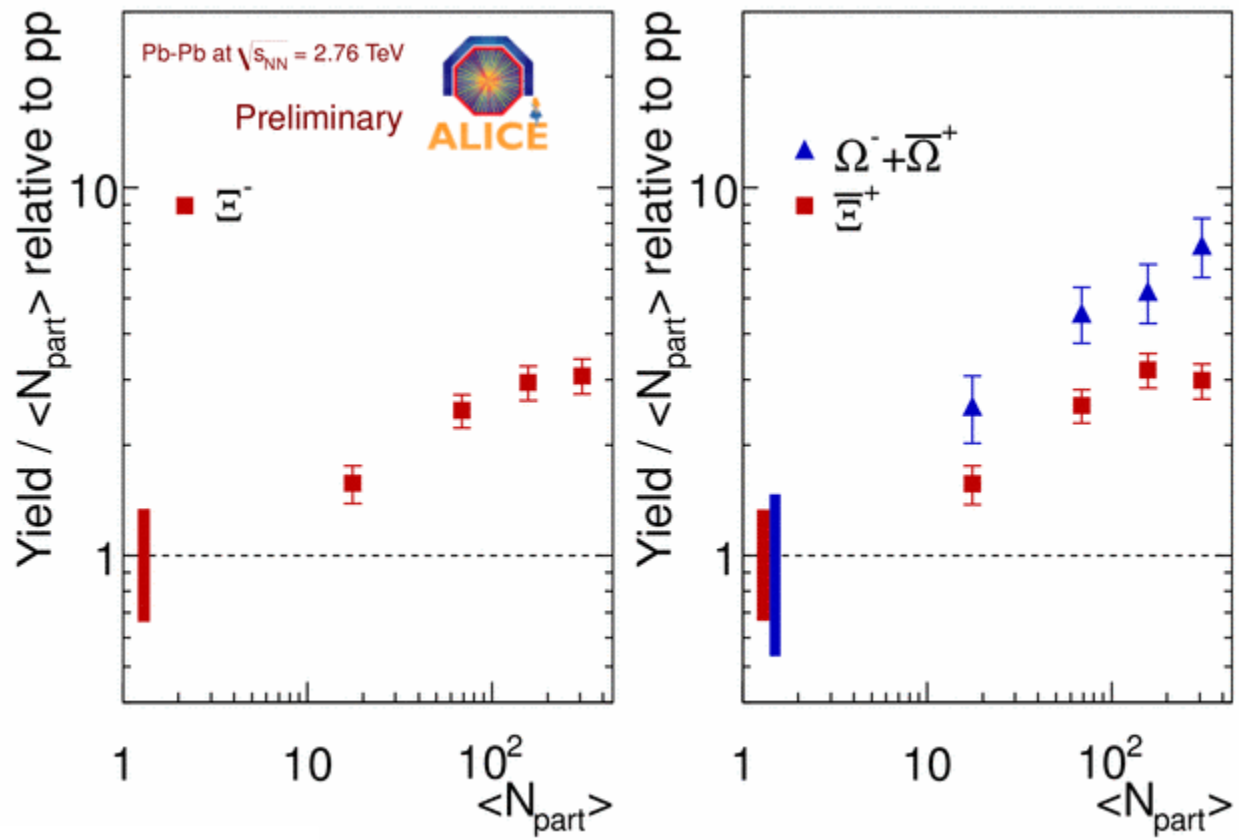






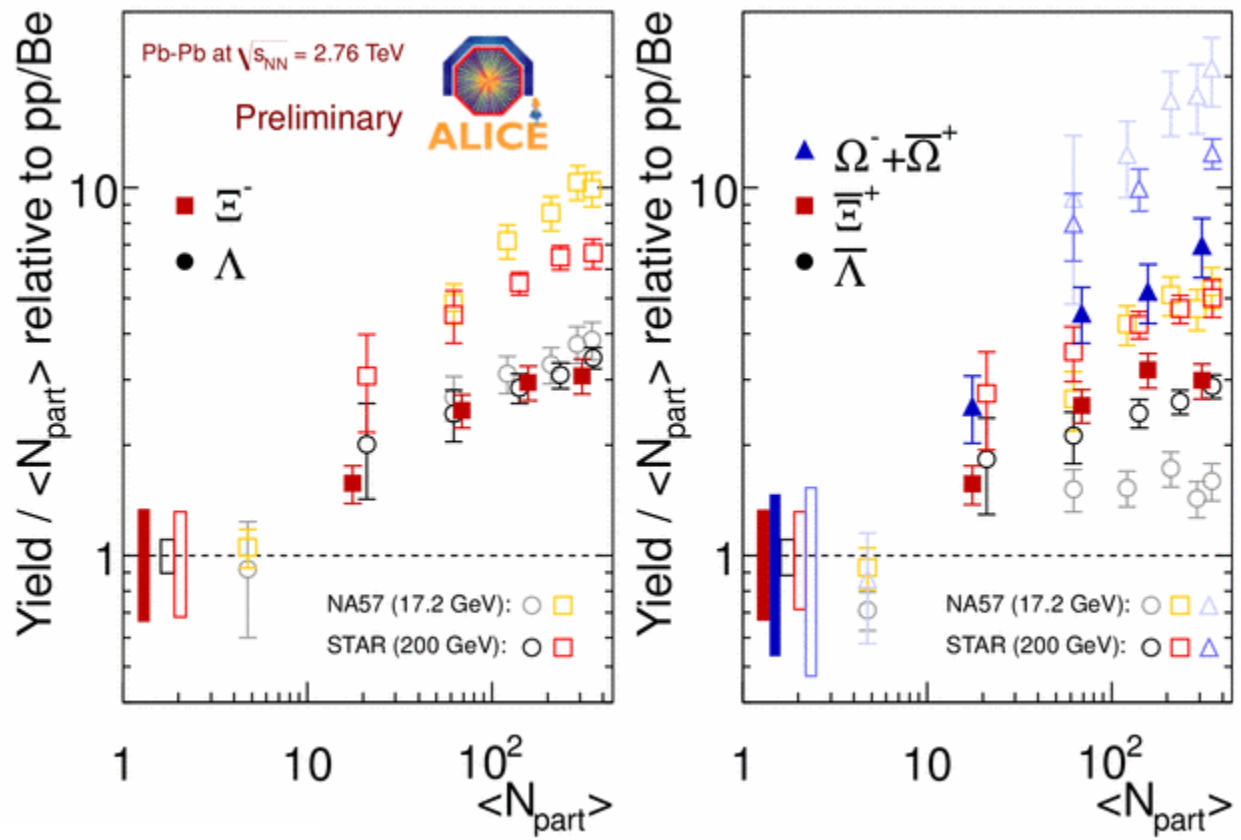


Multi-strange baryon production comparing Pb-Pb to pp



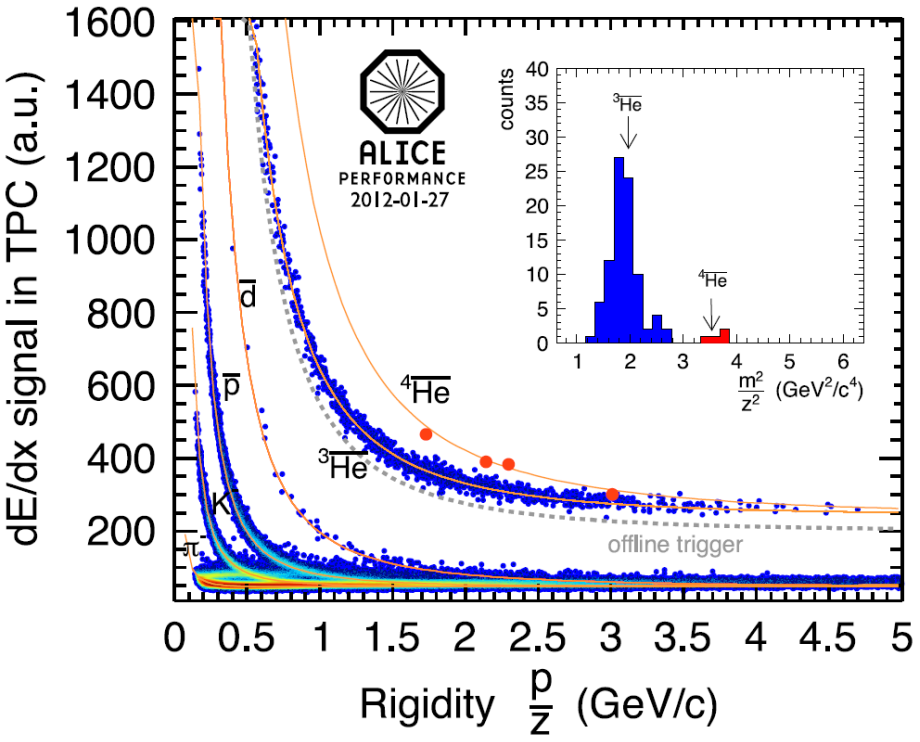
• Enhancements with respect to pp collisions confirm the hierarchy based on the strangeness content of the particle

Multi-strange baryon production comparing Pb-Pb to pp

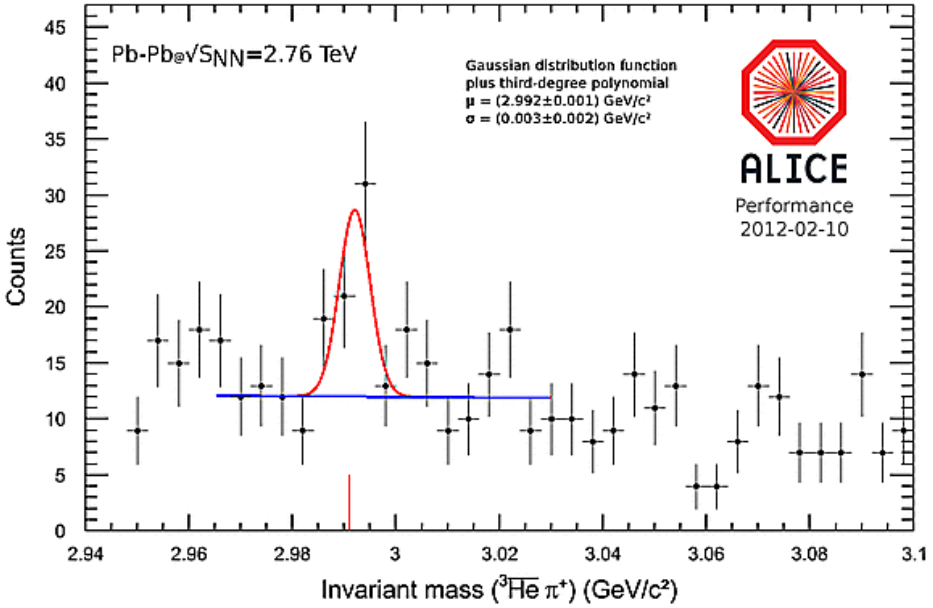


- Enhancements with respect to pp collisions confirm the hierarchy based on the strangeness content of the particle
- Comparison with lower energy data shows enhancement decreasing for increasing energy (same trend observed from SPS to RHIC)

Anti-Matter production



In the statistics from 2010 Pb-Pb we identified four anti-alphas



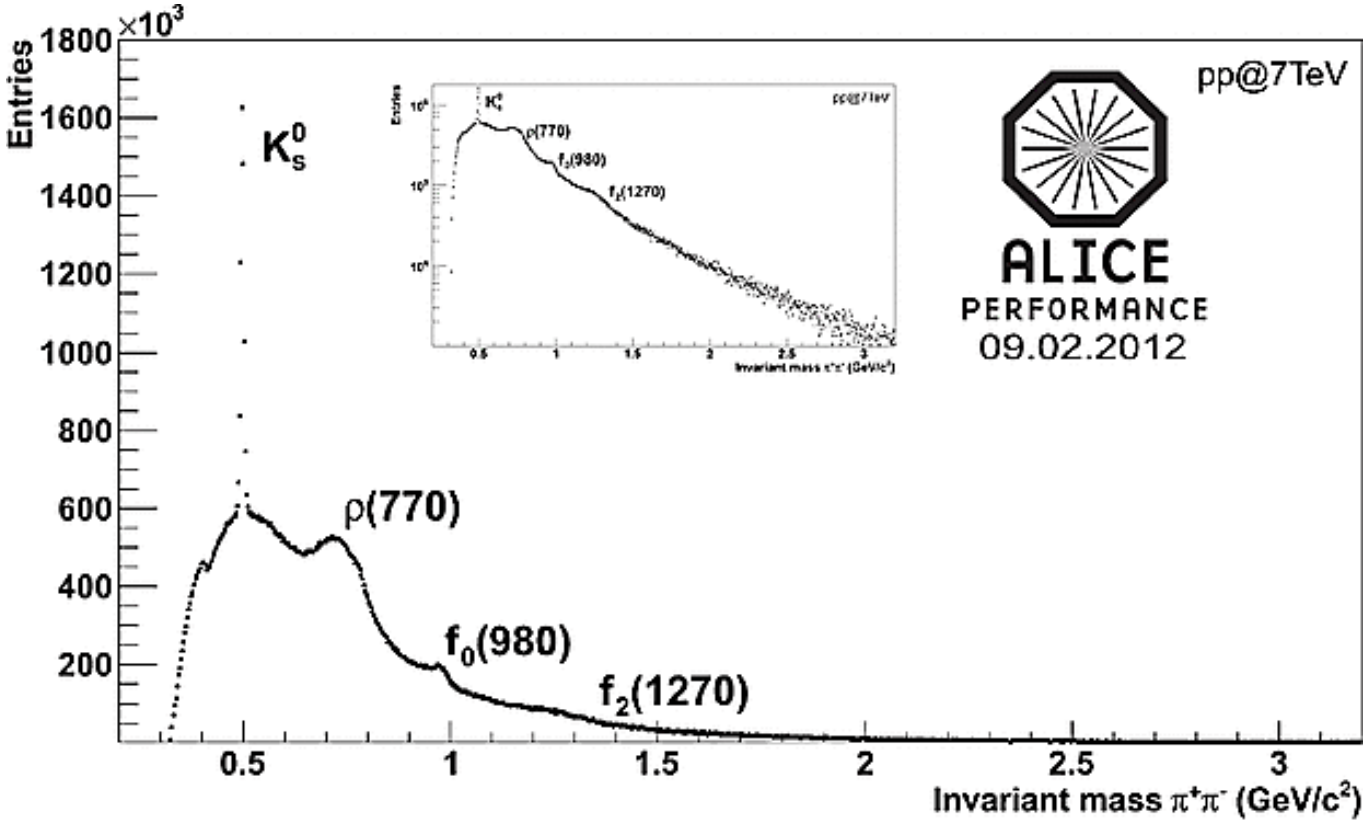
The anti-hypertriton was also detected using the 2010 Pb-Pb data

→ 2011 statistics will enhance the yields significantly

Both first observed by the STAR experiment

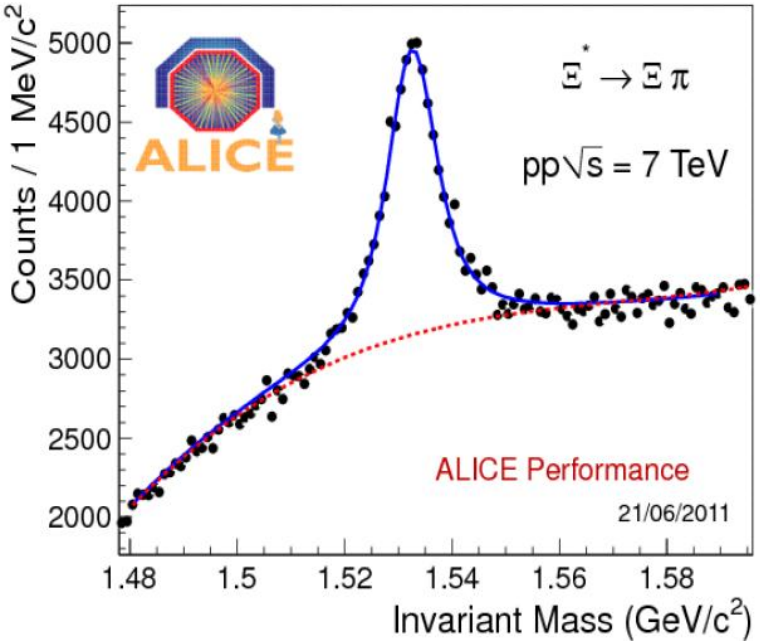
Science 328, 58 (2010) and Nature 473, 353 (2011)

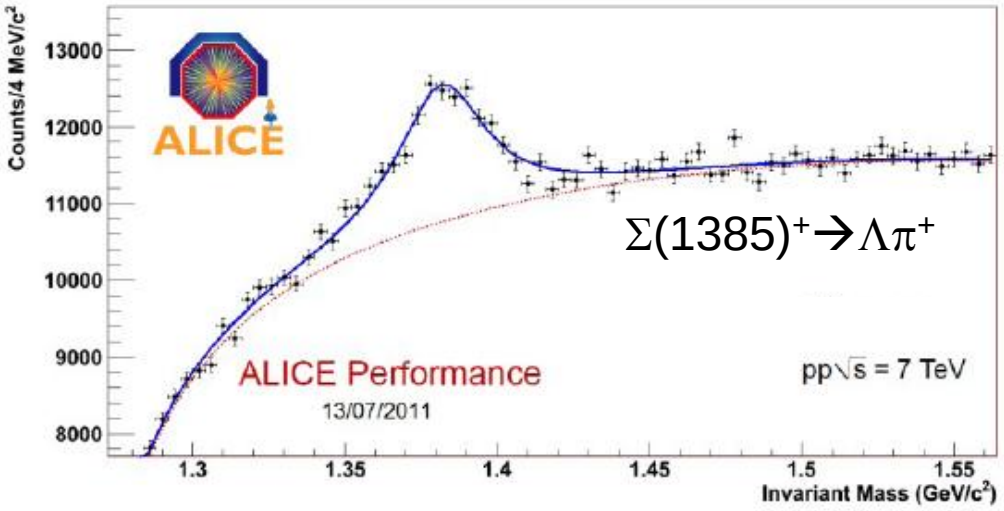
Resonances

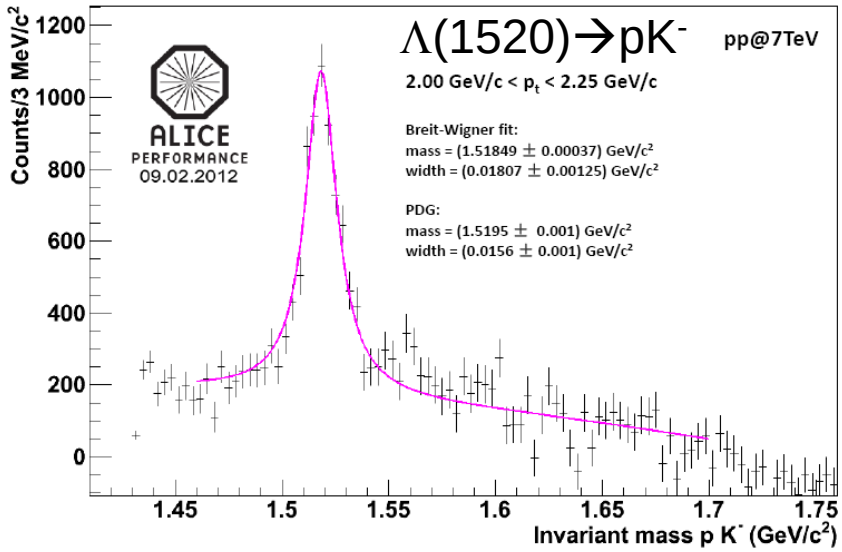


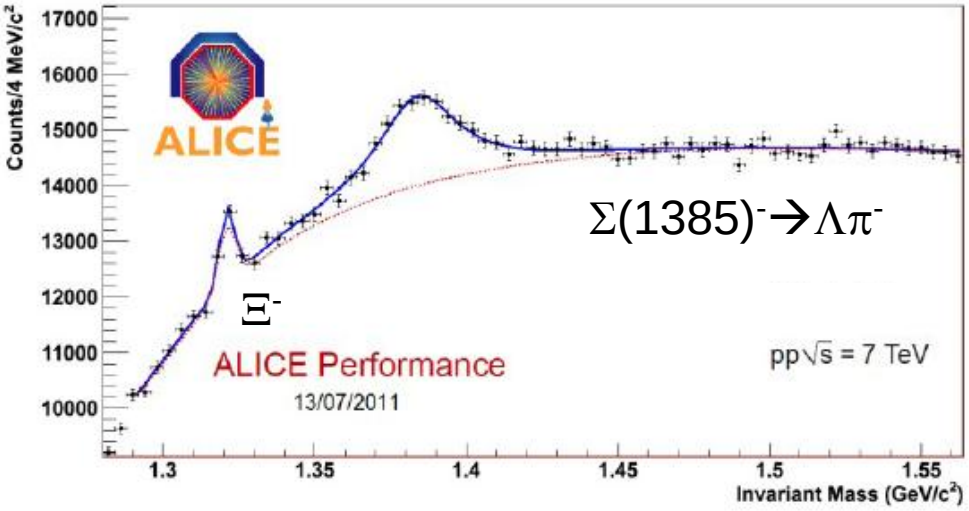
- ALICE is well suited to do a broad search thanks to excellent particle Identification
- Rich resonance program for pp and Pb-Pb on mesonic and baryonic resonances

Baryonic Resonances



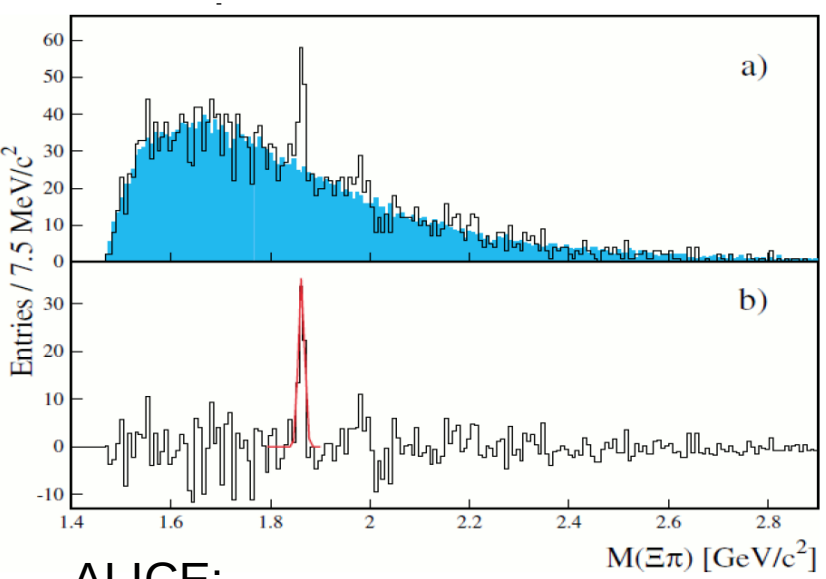




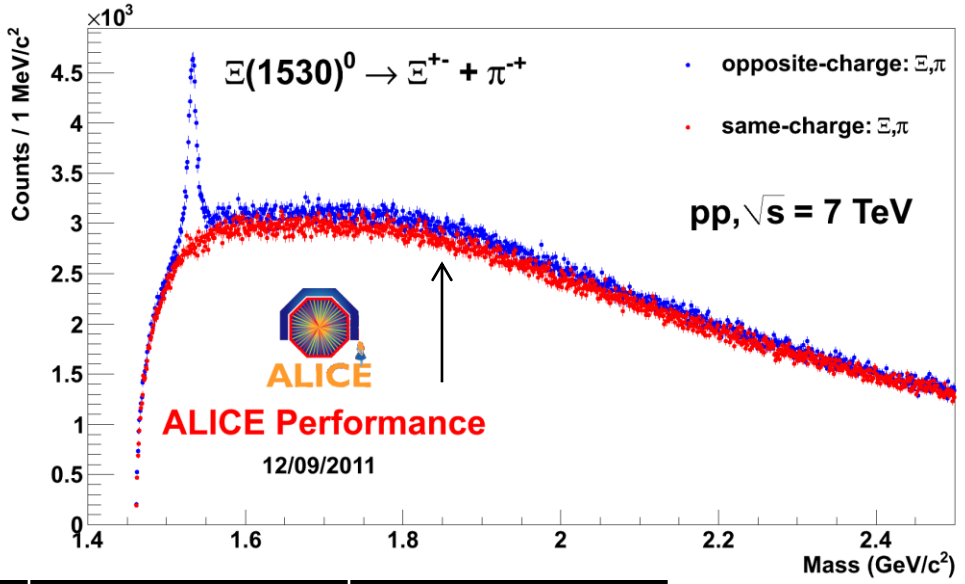


- p_t spectra are work in progress

Exotica



NA49:
Claimed "evidence" for the Ξ^{--} (dsdsū) pentaquark in pp 17.2 GeV **PRL 92 (2004) 042003**



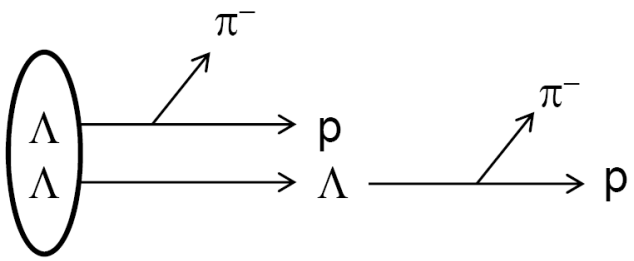
ALICE:
There is no indication for the (dsdsū) pentaquark in pp 7 TeV

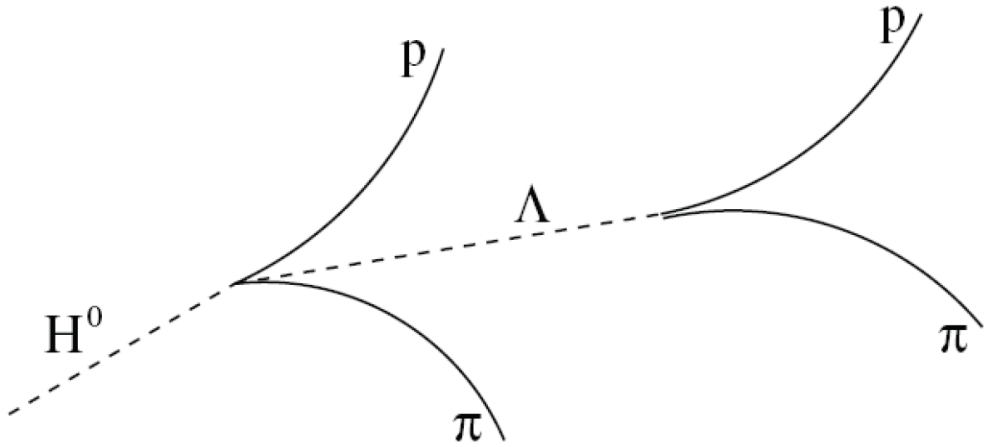
Experiment	Yield of $\Xi(1530)^0$	Yield of $\Xi(1860)^{--}$	Ratio of Yields
NA49	150	36	4.2
COMPASS	1700	< 79	>21.5
ALEPH	322	<24	>13.4
ALICE	26164	< 846	>31

H-Dibaryon

- Weakly bound: $H^0 \rightarrow \Lambda p \pi$

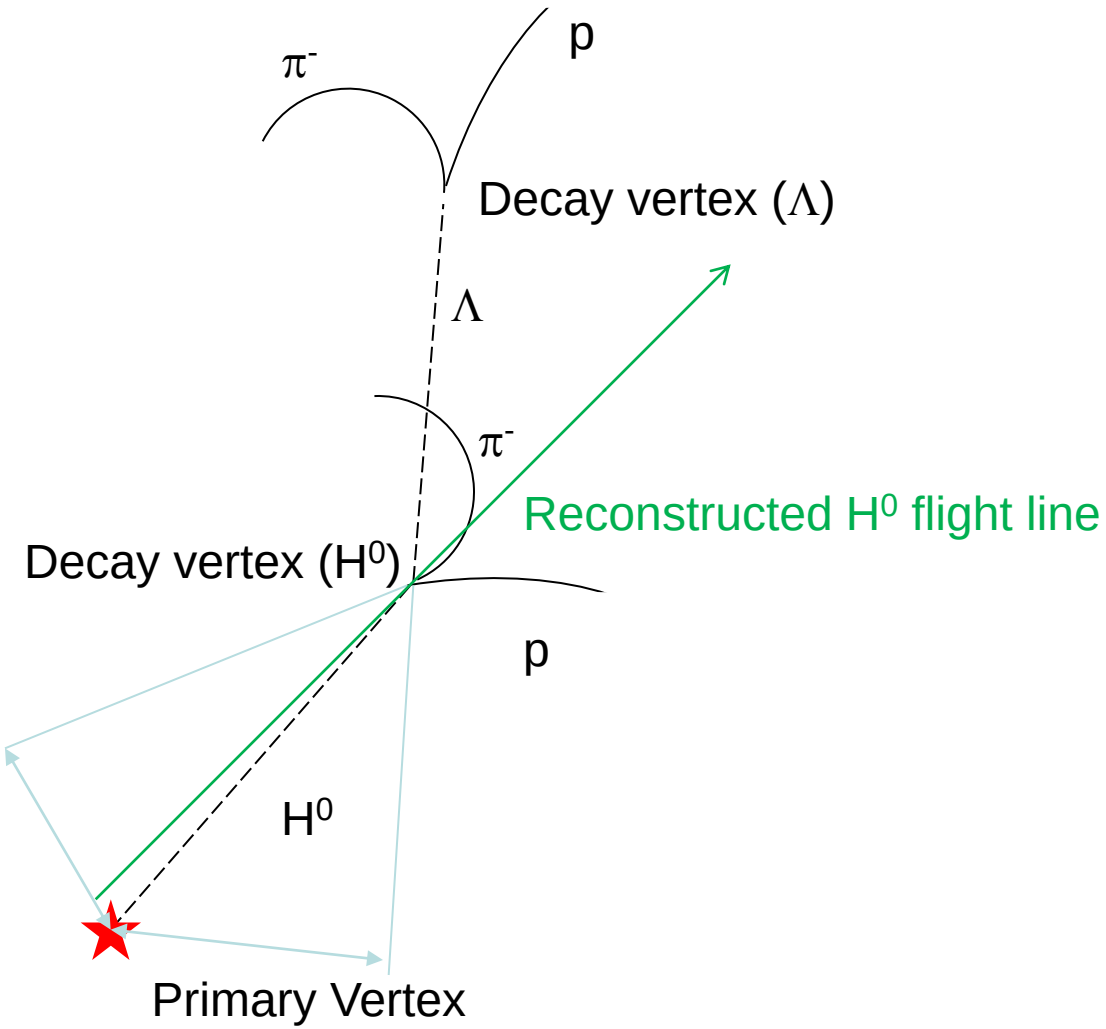
$m_H{}^0 \approx 2.21\ GeV/c^2$





- Or resonant state which could decay via $H^0 \rightarrow \Lambda\Lambda$ or $H^0 \rightarrow \Xi^- p$, if its mass is above $\Lambda\Lambda$ threshold

H-Dibaryon

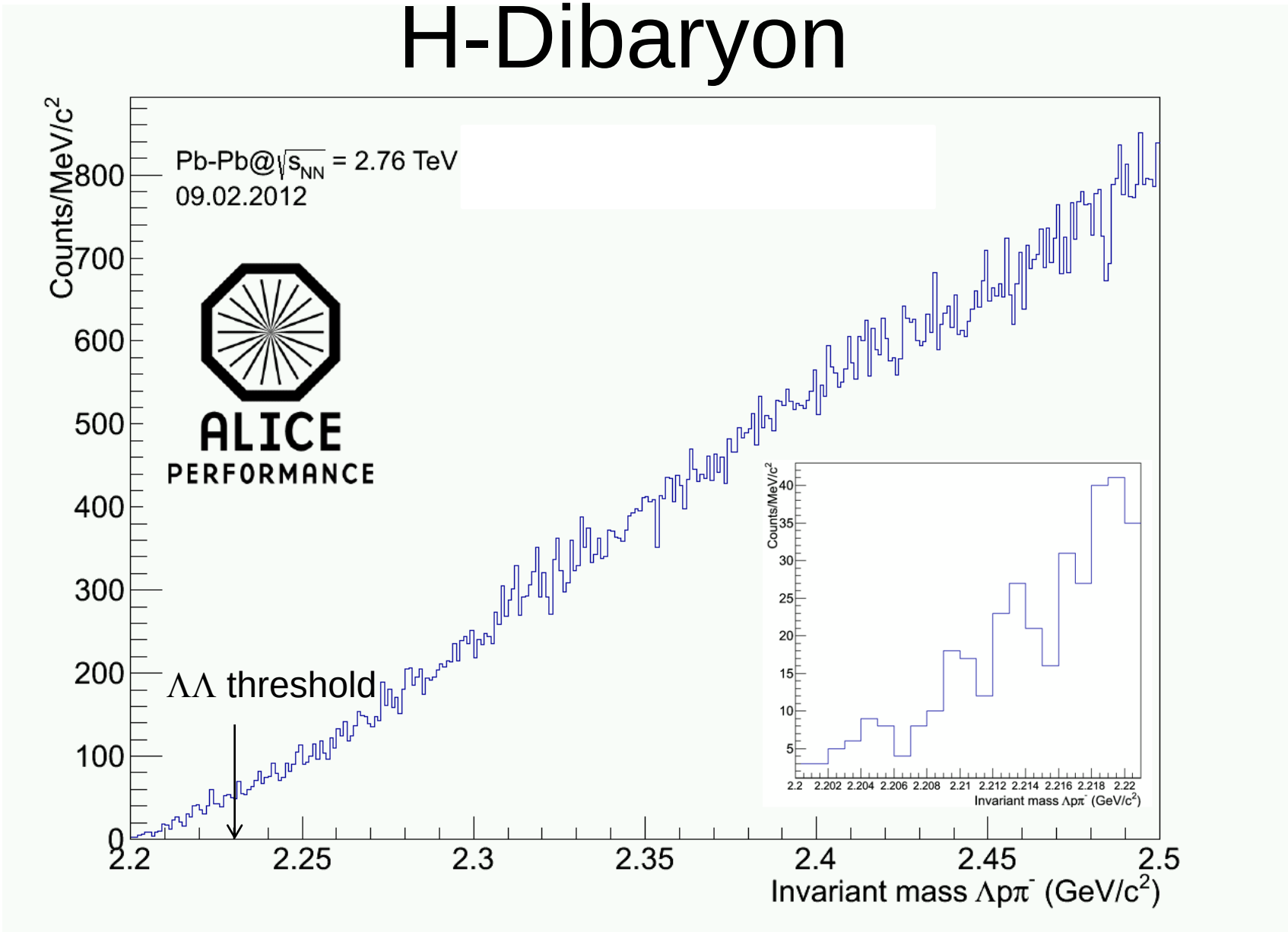


Cuts:
Track cuts:
- Reject Kink daughters
- TPC refit
- n_{cl}(TPC)>80
- χ^2(TPC) < 5
- -0.9 < η < 0.9

V0 cuts:
- dca V0 daughters < 1 cm
- dca positive V0 daughter-Vertex > 1 cm
- dca negative V0 daughter-Vertex > 1 cm

Kinematic cuts:
- dca positive H^0 daughter-Vertex > 1 cm
- dca negative H^0 daughter-Vertex > 1 cm
- Pointing angle of H^0 < 0.2

H-Dibaryon



Using the data from 2010, no signal is observed in $\Lambda p\pi/\Lambda\Lambda$

Summary

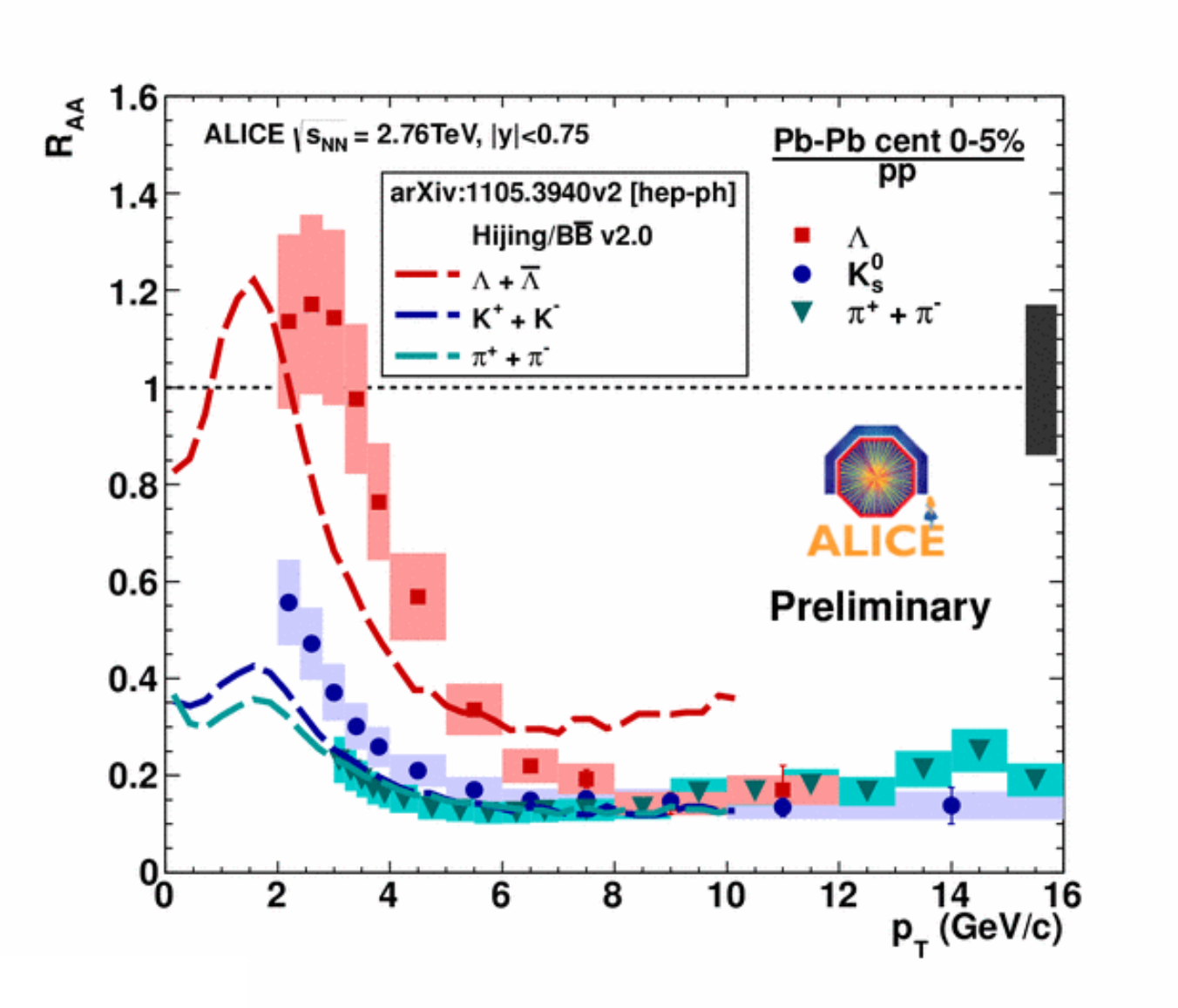
- ALICE setup and running conditions
- Hyperon production (Λ,Ξ,Ω)
- Resonances in pp
- Exotica ($\Xi^{--}\rightarrow\Xi^{-}\pi^{-}$, $H^{0}\rightarrow\Lambda p\pi^{-}$)

Not covered in this presentation but under study

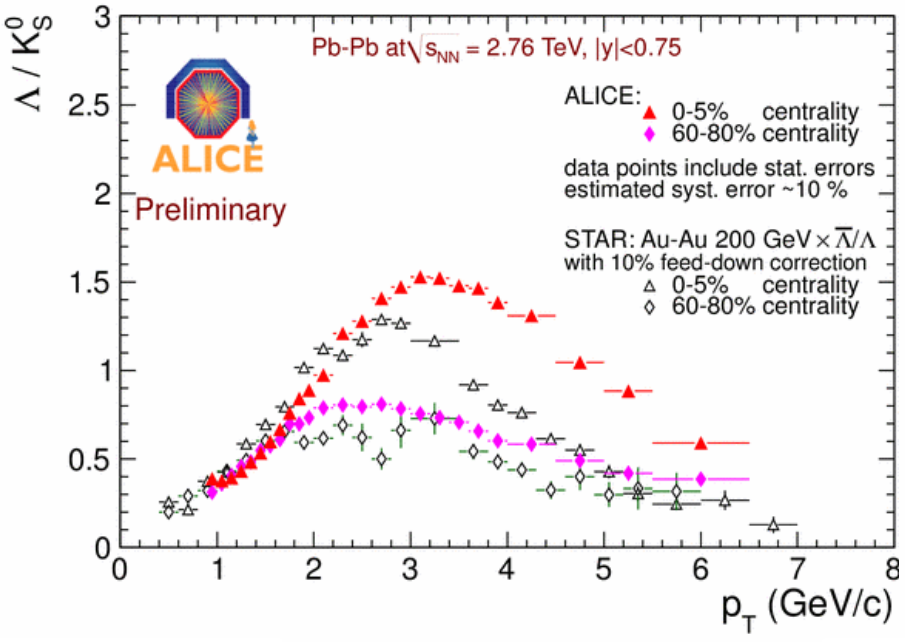
- Resonances in Pb-Pb and resonance-hadron correlations
- $H^{0}\rightarrow\Xi^{-}p$
- $\Lambda\Lambda$ correlations

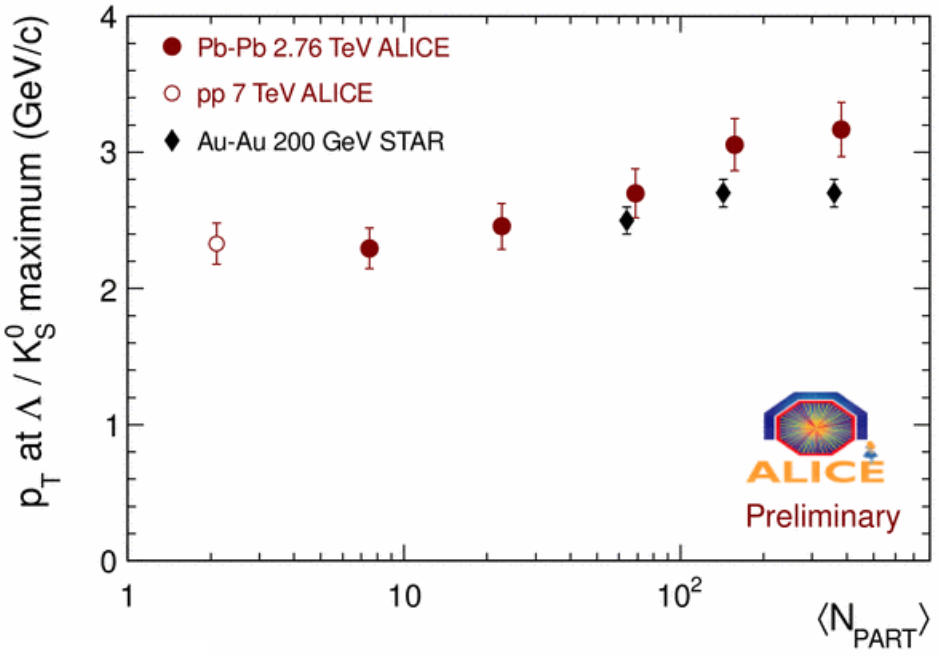
Backup

R_{AA}


ALICE $\sqrt{s_{NN}}$ = 2.76TeV, |y|<0.75
Pb-Pb cent 0-5%
pp
arXiv:1105.3940v2 [hep-ph]
Hijing/BB̄ v2.0
Λ + Λ̄
K⁺ + K⁻
π⁺ + π⁻
Λ
K⁰s
π⁺ + π⁻
ALICE
Preliminary
R_AA
p_T (GeV/c)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0
2
4
6
8
10
12
14
16

Λ/K^0_s


Pb-Pb at $\sqrt{s_{NN}}$ = 2.76 TeV, |y|<0.75
ALICE
Preliminary
ALICE:
0-5% centrality
60-80% centrality
data points include stat. errors
estimated syst. error ~10 %
STAR: Au-Au 200 GeV × $\overline{\Lambda}/\Lambda$
with 10% feed-down correction
0-5% centrality
60-80% centrality
Λ / K^0_S
p_T (GeV/c)


Pb-Pb 2.76 TeV ALICE
pp 7 TeV ALICE
Au-Au 200 GeV STAR
ALICE
Preliminary
p_T at Λ / K^0_S maximum (GeV/c)
$\langle N_{PART} \rangle$

Λ(1520)

Λ(1520)

quark content: uds

mass: (1519.5 ± 1.0) MeV/c^2

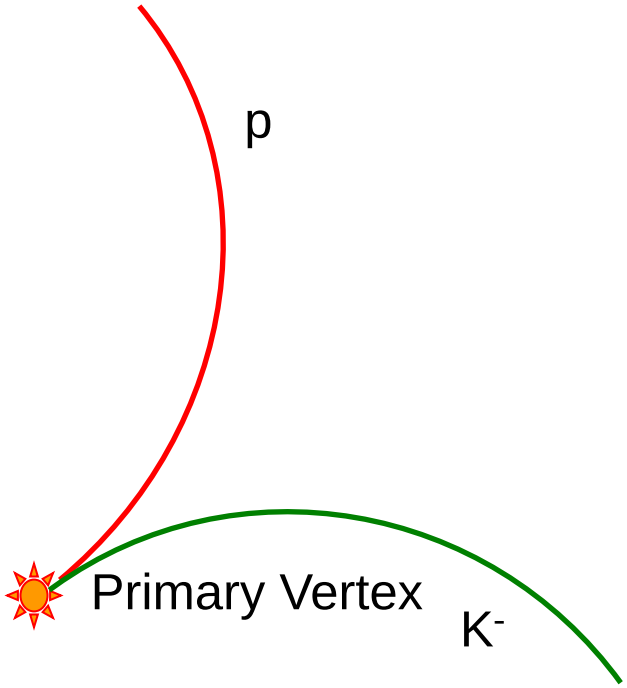
width: (15.6 ± 1.0) MeV/c^2

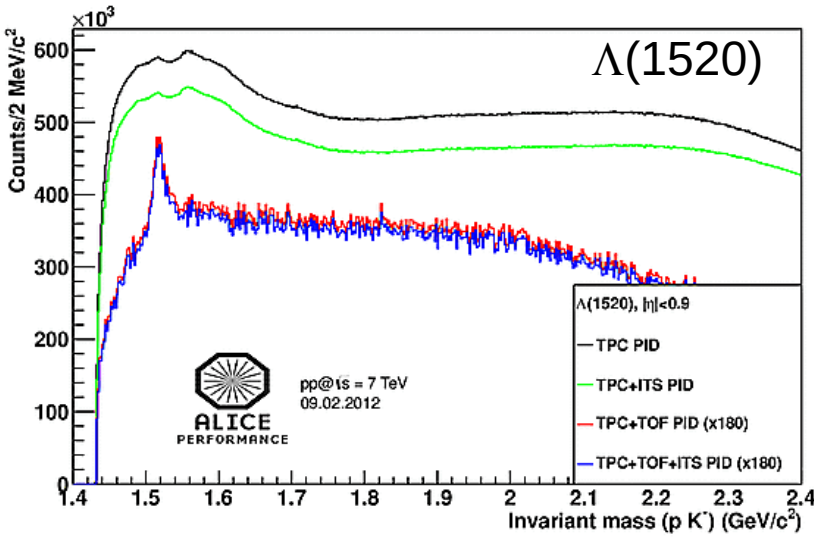
→ τ ~ 12.6 fm/c

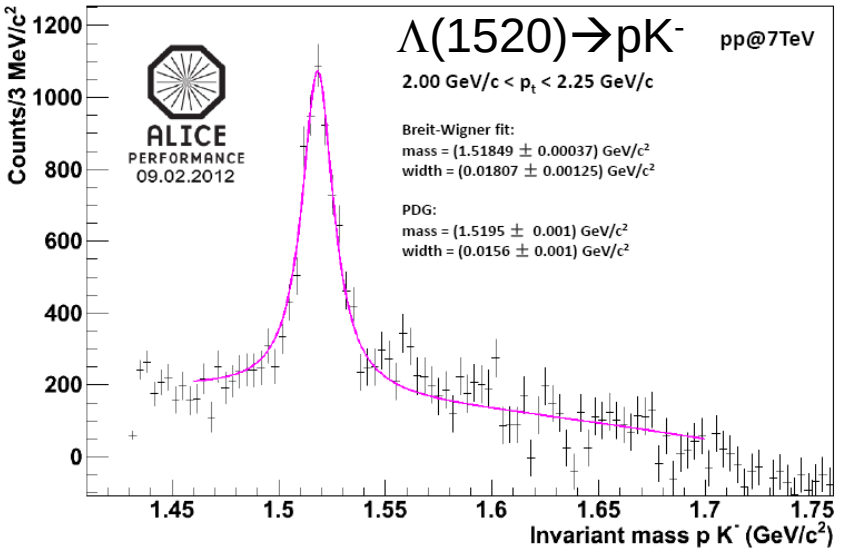
Channel:

$N\bar{K}$ (45.0 ± 1.0)%

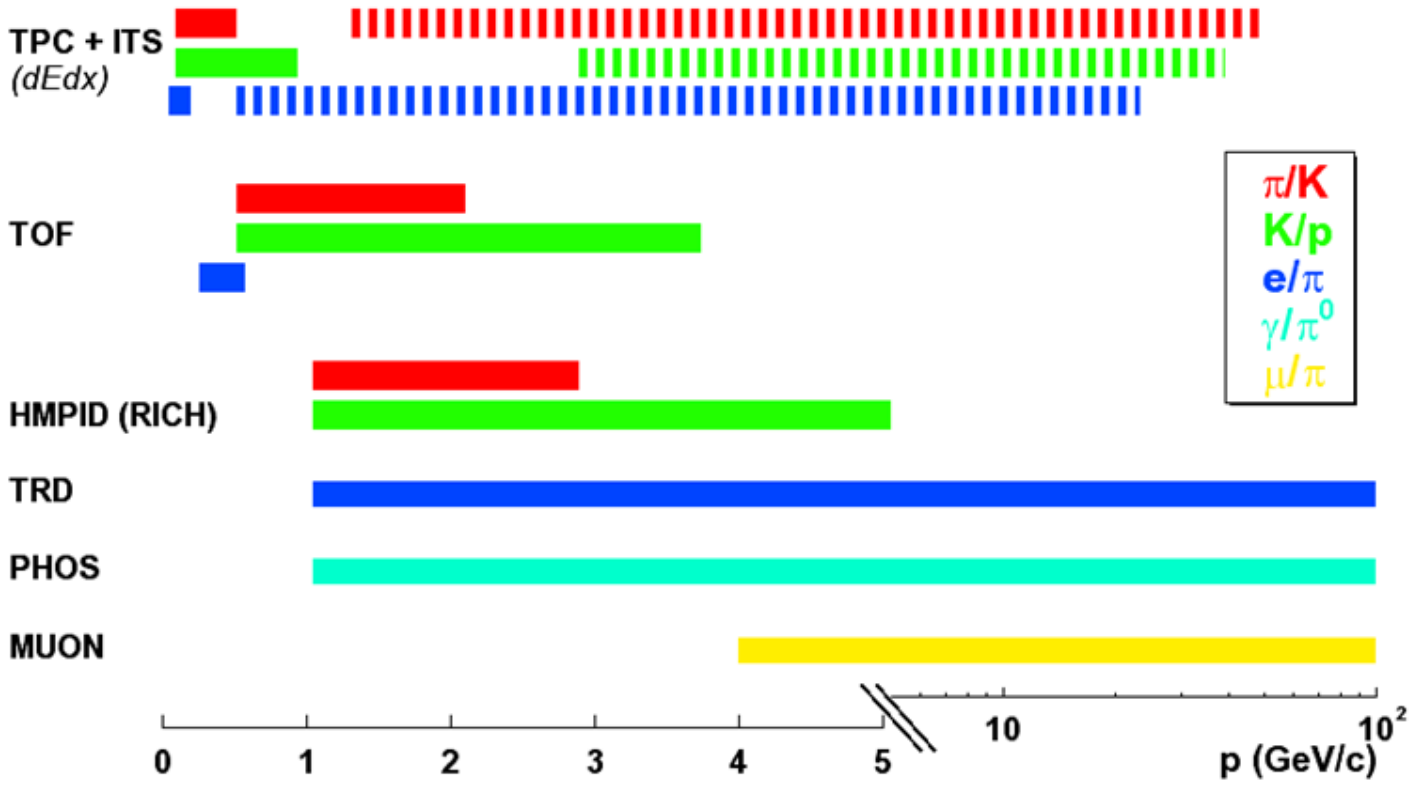
→pK^- (22.5 ± 0.5)%







Particle Identification in ALICE



- ‘stable’ hadrons (π, K, p): 100 MeV/c < p < 5 GeV/c
  - dE/dx in silicon (ITS) and gas (TPC) + time-of-flight (TOF) + Cherenkov (RICH)
- decay topologies (K^0, K^+/K^-, Λ, $\Xi^-/\bar{\Xi}^+$, $\Omega^-/\bar{\Omega}^+$)
- leptons (e,μ), photons, π^0
  - electrons TRD: p > 1 GeV/c, muons: p > 5 GeV/c, π^0 in PHOS: 1 < p < 80 GeV/c

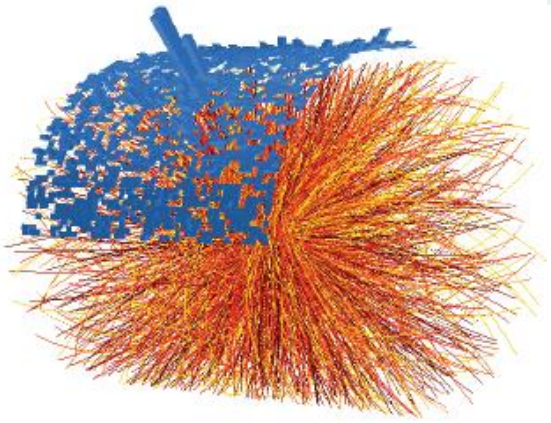
Running 2011

Pb-Pb events taken

Trigger	Events
Minimum Bias	8.8 M
Central	29.9 M
SemiCentral	35 M
EMCAL Jet	10.8 M
EMCAL Gamma	7.9 M
Barrel Ultra-Peripheral	7.9 M
PHOS	948 k
Single Muon (low pt)	6.9 M
Single Muon (high pt)	22.9 M
Muon Ultra-Peripheral	3.4 M
Di-Muons	21.6 M

pp events taken

Trigger	Events
Minimum Bias (SPD or V0)	609 M
Minimum Bias (Both V0s)	177 M
EMCAL	114 M
PHOS	7.3 M
Central Barrel Diffractive	3.5 M
Single Muon (low pt)	35.5 M
Single Muon (high pt)	59 M
Muon Ultra-Peripheral	1.2 M
Di-Muons	18.9 M



Triggers → Enhance statistics x20

High-Level-Trigger → Data compression