Particle identification at the LHC with the ALICE experiment

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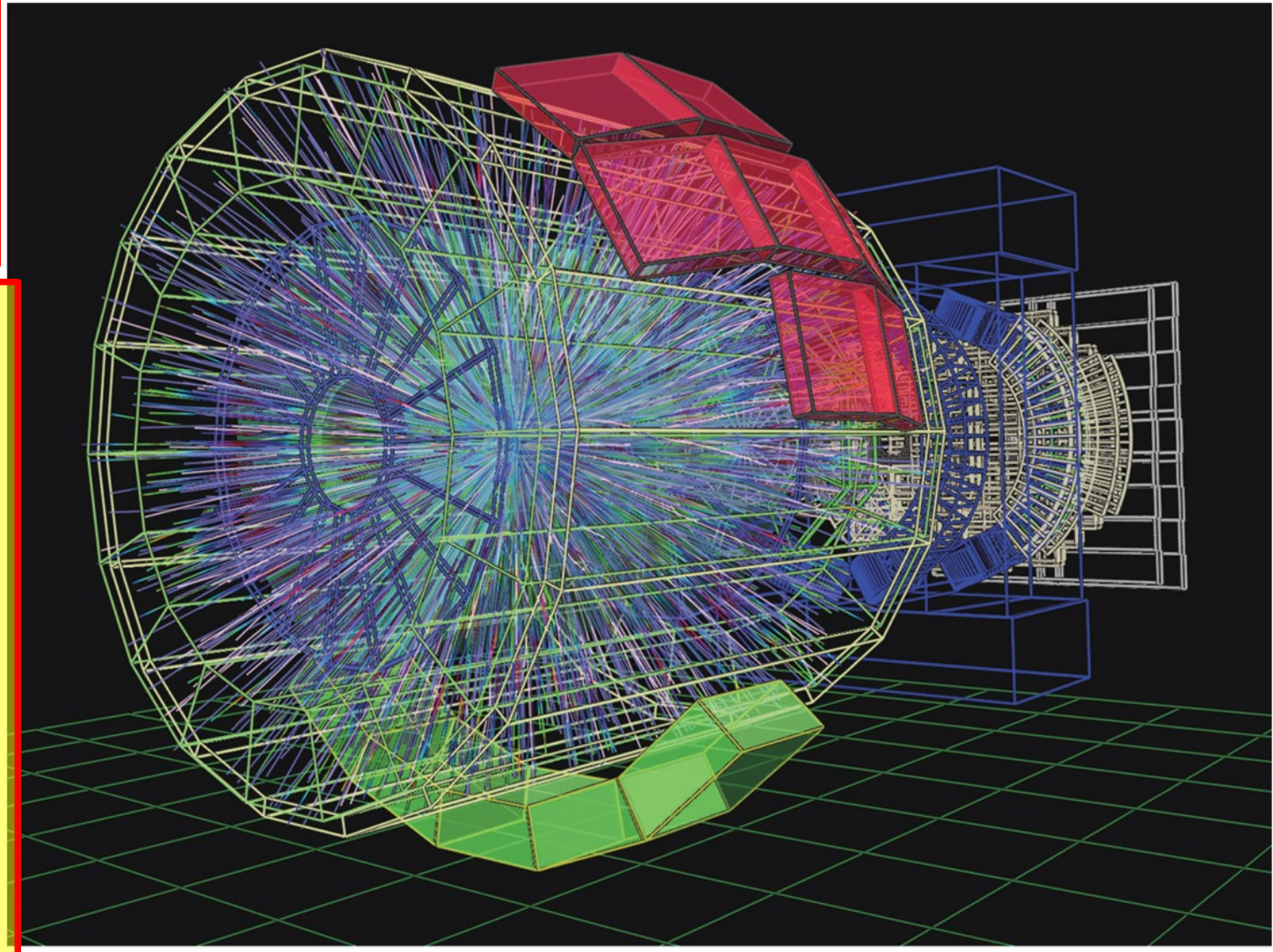
The ALICE experiment at LHC

designed to cope with very high charged-particle multiplicity
$dN_{ch}/d\eta \leq 8000$

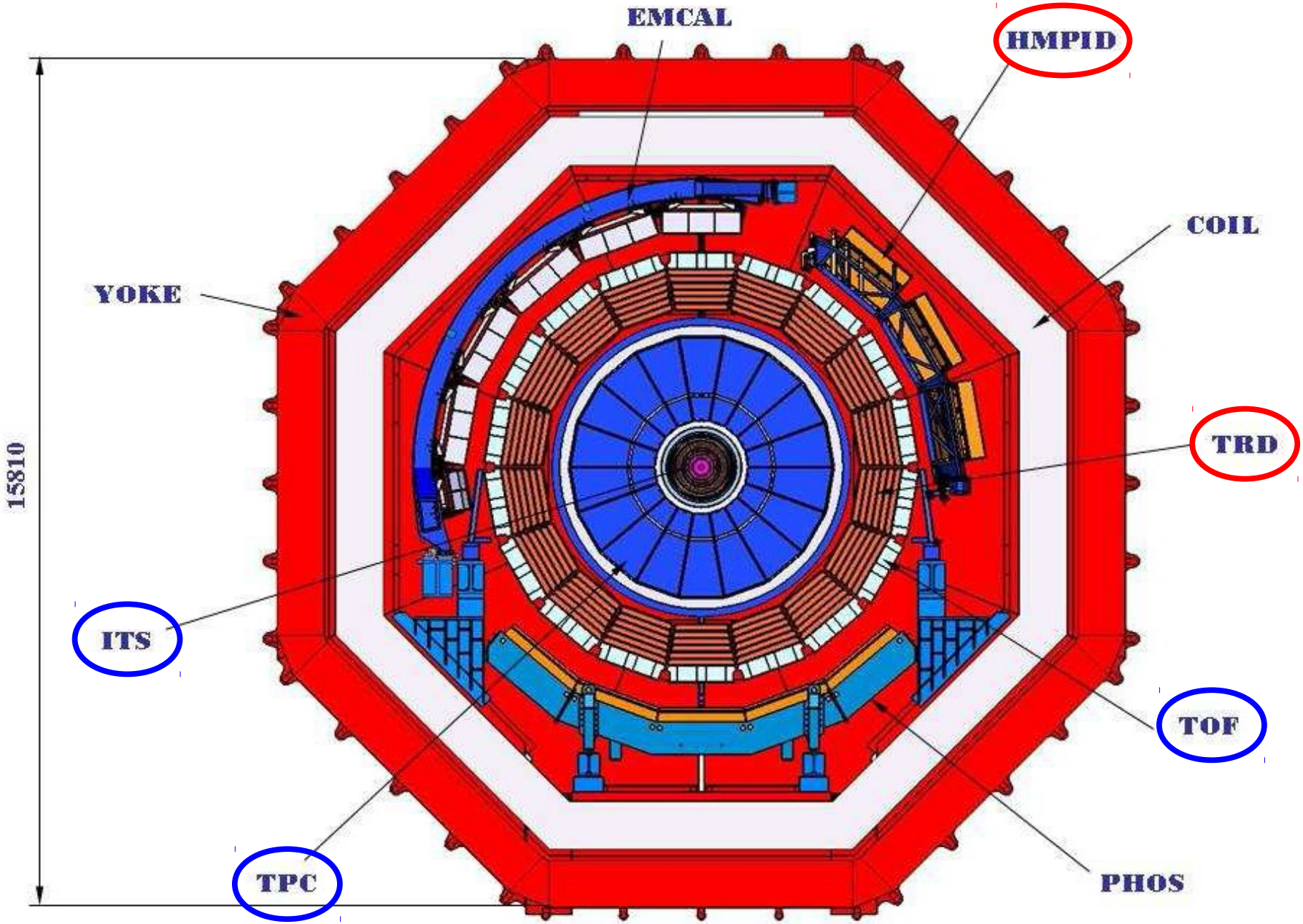
3D tracking with many points

moderate B = 0.5 T
thin materials
for low-p_T particles

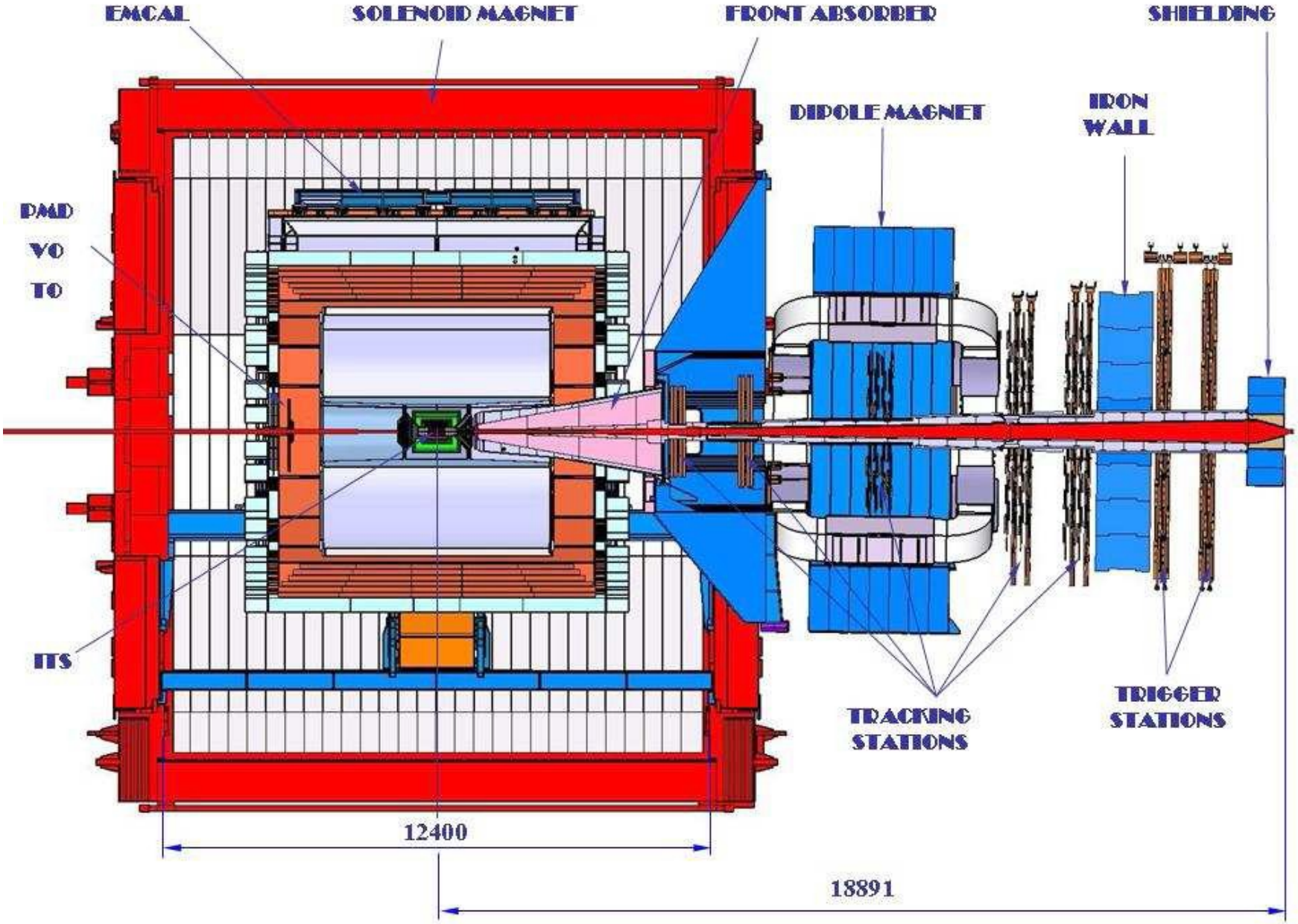
uses all known PID techniques
dE/dx, TOF, transition radiation, Cherenkov radiation, calorimetry, muon filters, topological decay



The ALICE detector: central barrel



The ALICE detector: forward systems

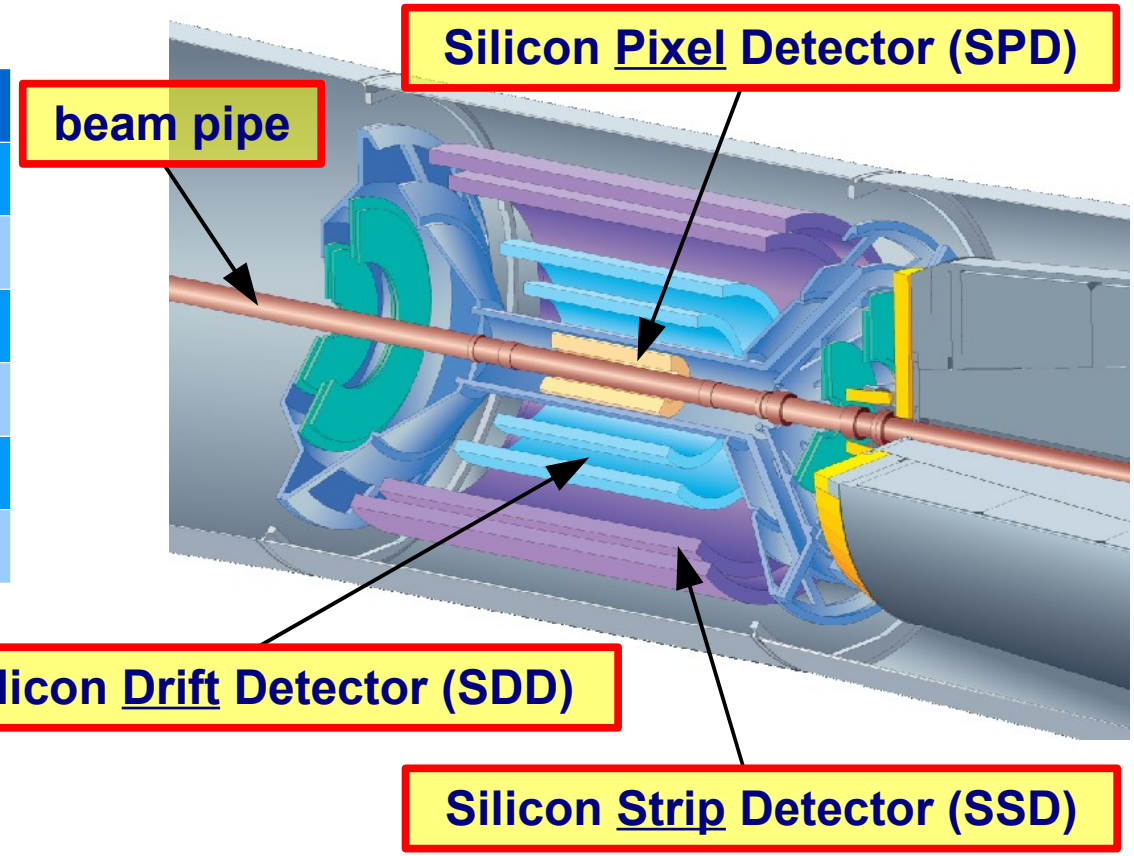


Inner Tracking System (ITS)

6 layers of silicon detectors

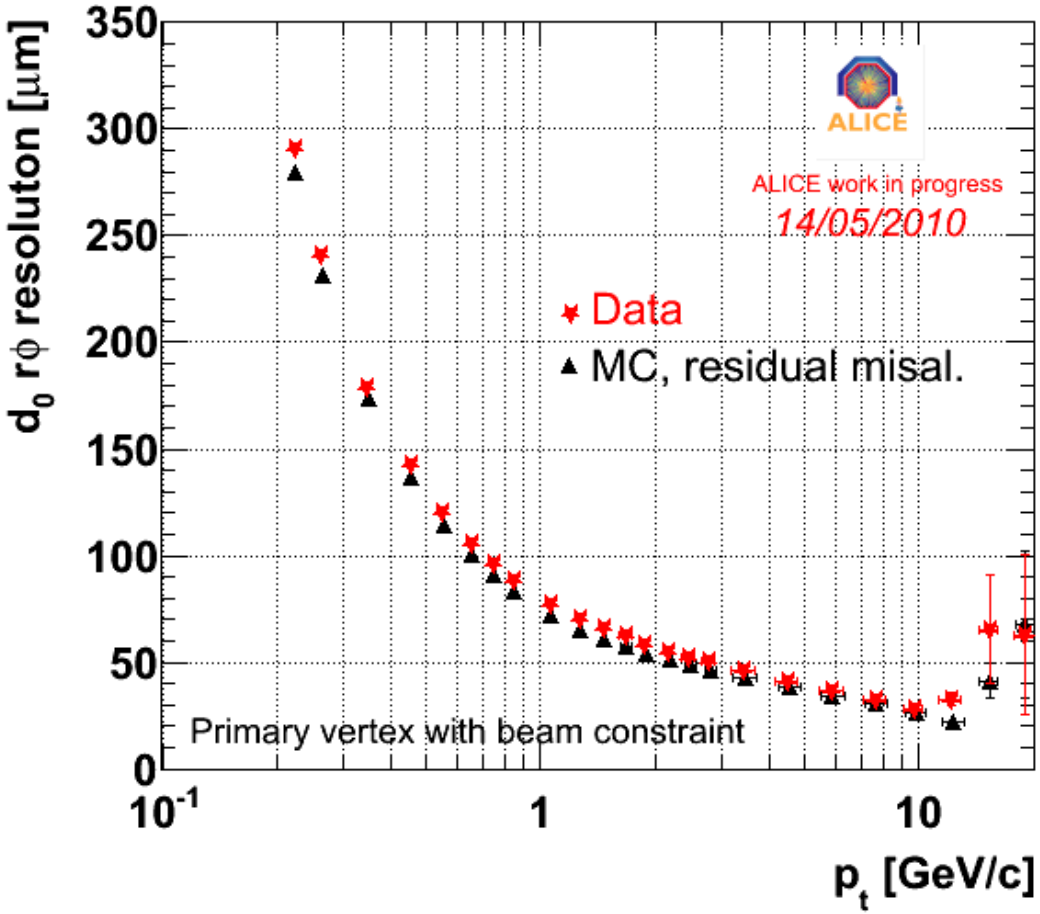
layer	detector	radius (cm)	length (cm)
1	SPD	3.9	28.2
2	SPD	7.6	28.2
3	SDD*	15.0	44.4
4	SDD*	23.9	59.4
5	SSD*	38.0	86.2
6	SSD*	43.0	97.8

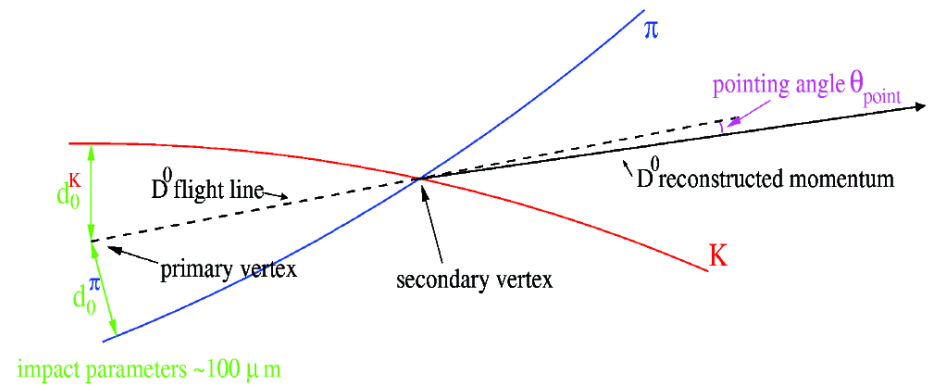
* with analog readout for *dE/dx* measurement



primary vertex reconstruction
secondary vertex reconstruction (hyperons and HF mesons)
reconstruction of low-p_T particles (not reaching TPC)
identification of low-p_T particles (SDD, SSD)
improve momentum resolution of high-p_T particles

ITS impact parameter resolution

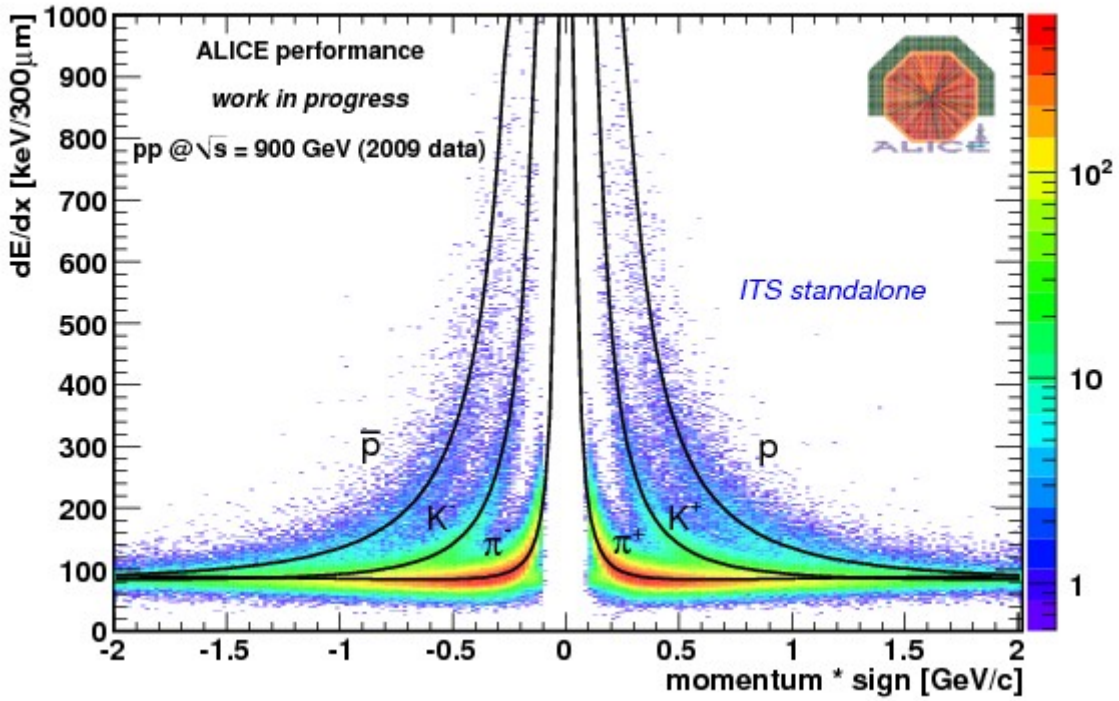




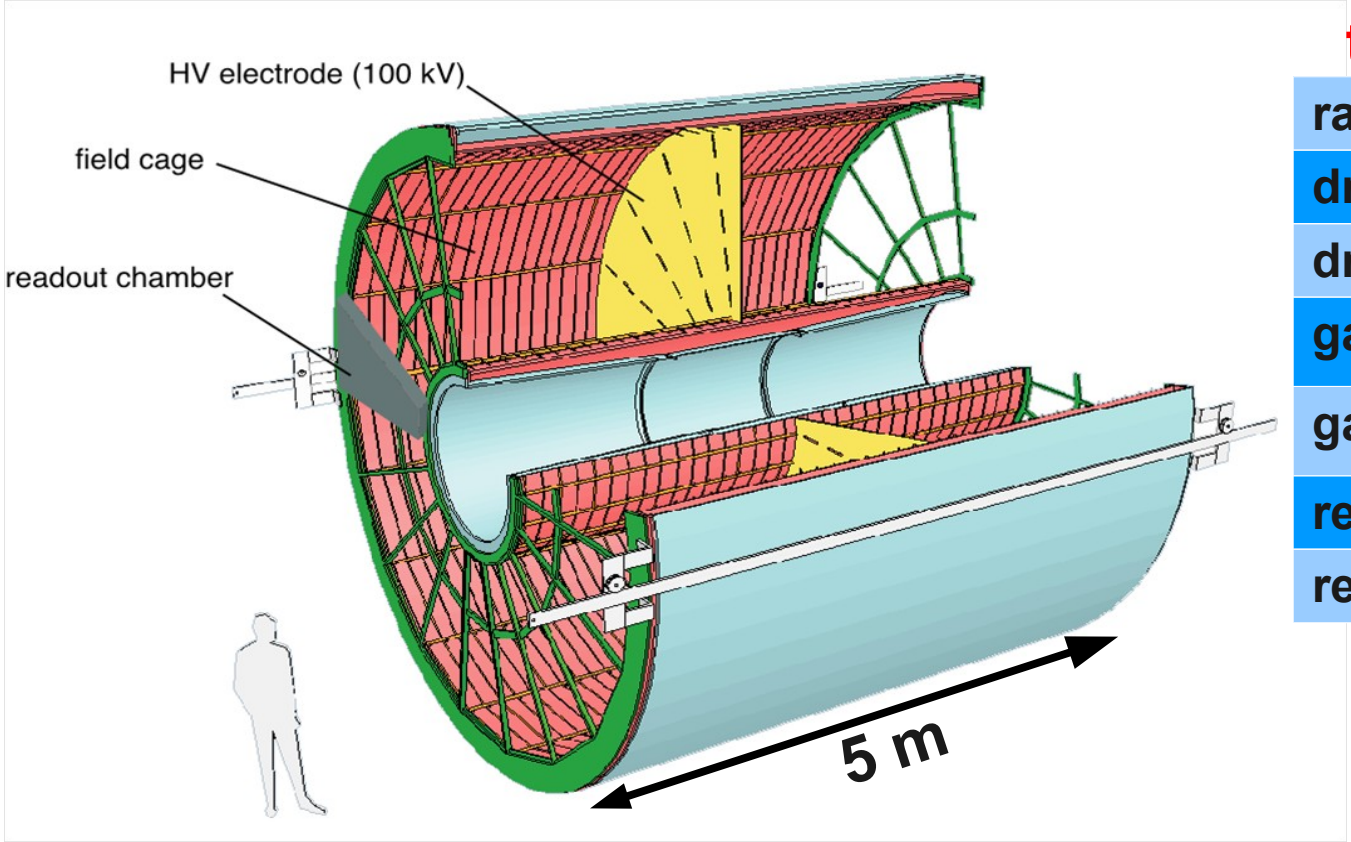
impact parameter resolution close to target value

ITS particle-identification

SDD and SSD have analog readout for PID at low momentum via specific energy loss measurement with up to 4 *dE/dx* samplings per track



Time-Projection Chamber (TPC)



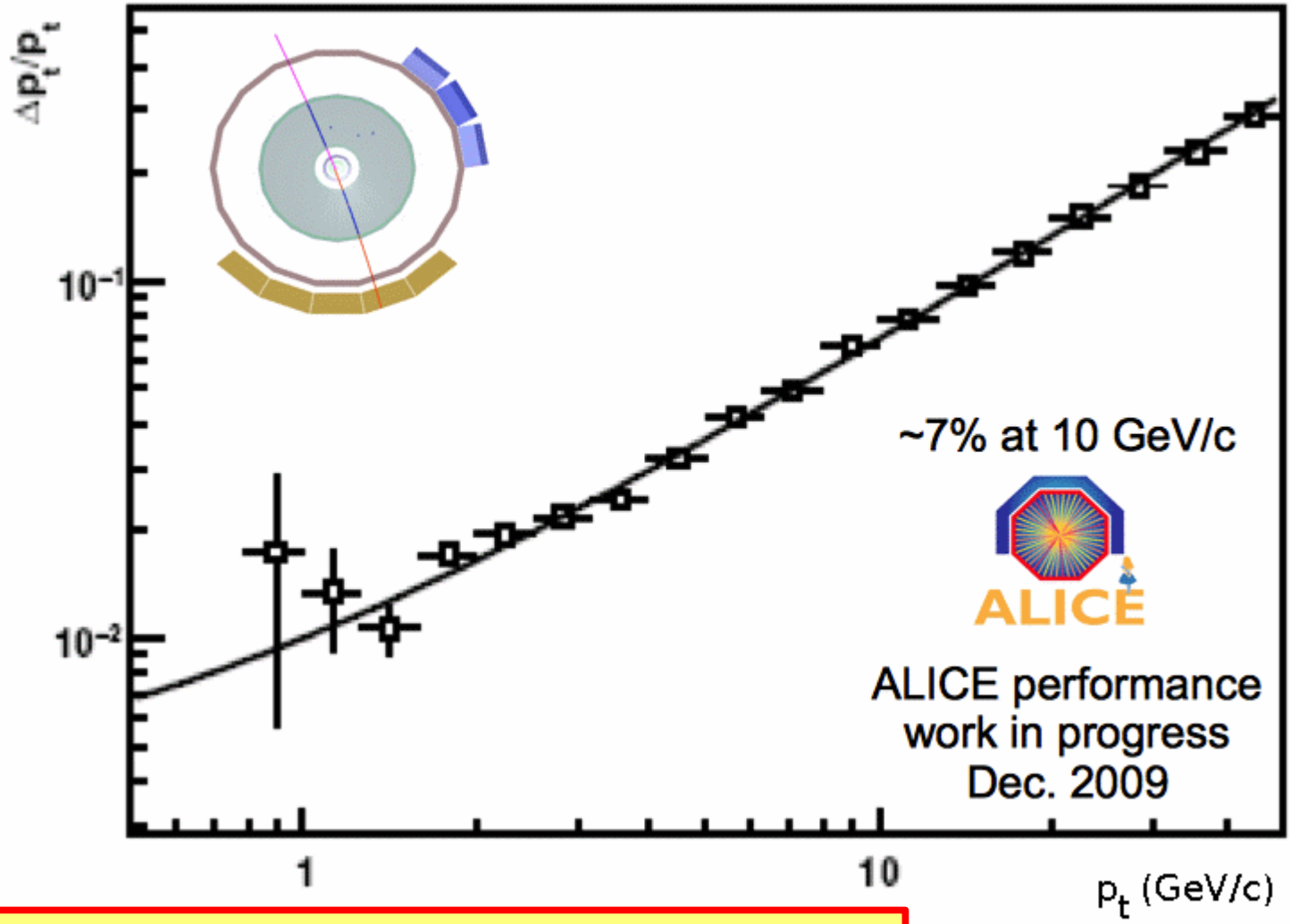
the largest TPC ever built

radius	845 – 2466 mm
drift length	2 x 2500 mm
drift time	92 µs
gas mixture	Ne-CO_2-N_2
gas volume	90 m_3
readout detector	MWPC
readout pads	557568

track reconstruction and momentum measurement
particle-identification via specific energy loss *dE/dx*
kink-decay topology reconstruction
data-taking up to 1 kHz in *pp*

TPC momentum resolution

calibration and performance measurements with cosmic rays matching sub-tracks from upper and lower half



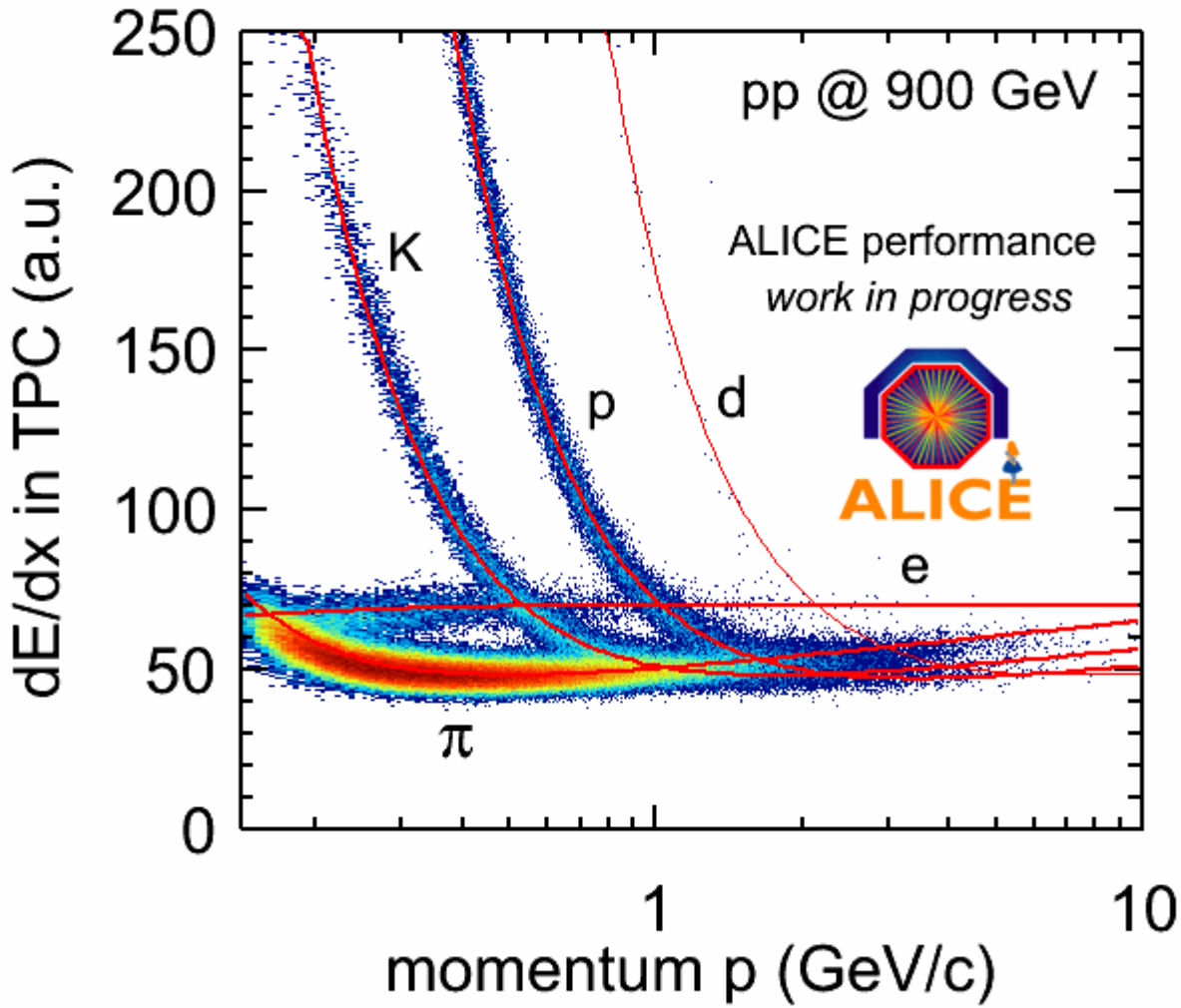
momentum resolution close to design value

TPC particle-identification

particle energy loss (actually energy deposit) sampled on each pad row

precise PID with TPC requires equalization of the gain of all the channels

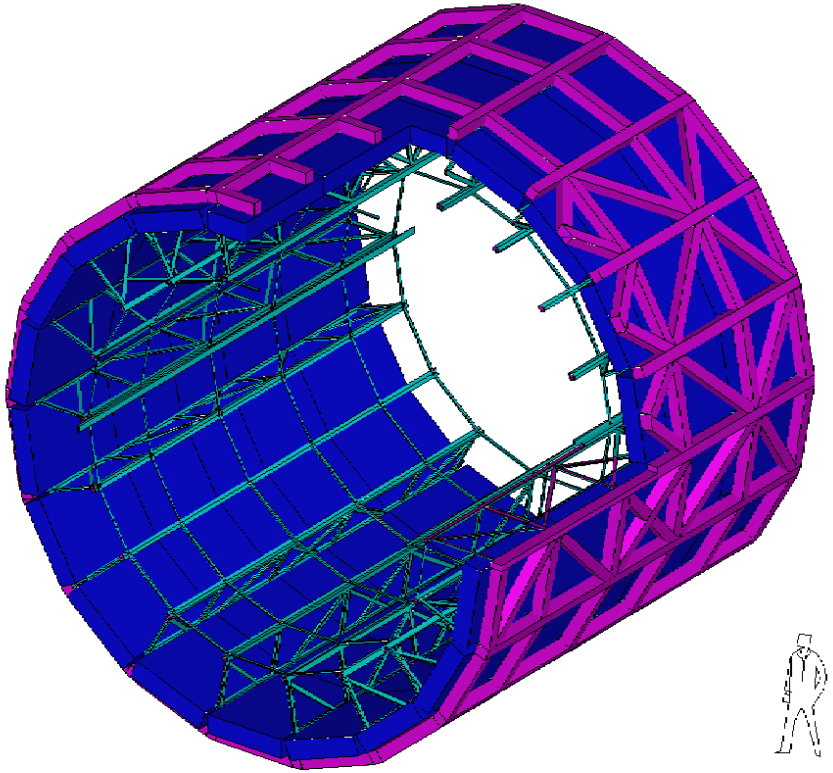
PID response from ALEPH parametrization of the Bethe-Bloch formula fitted to the data



Time-Of-Flight detector (TOF)

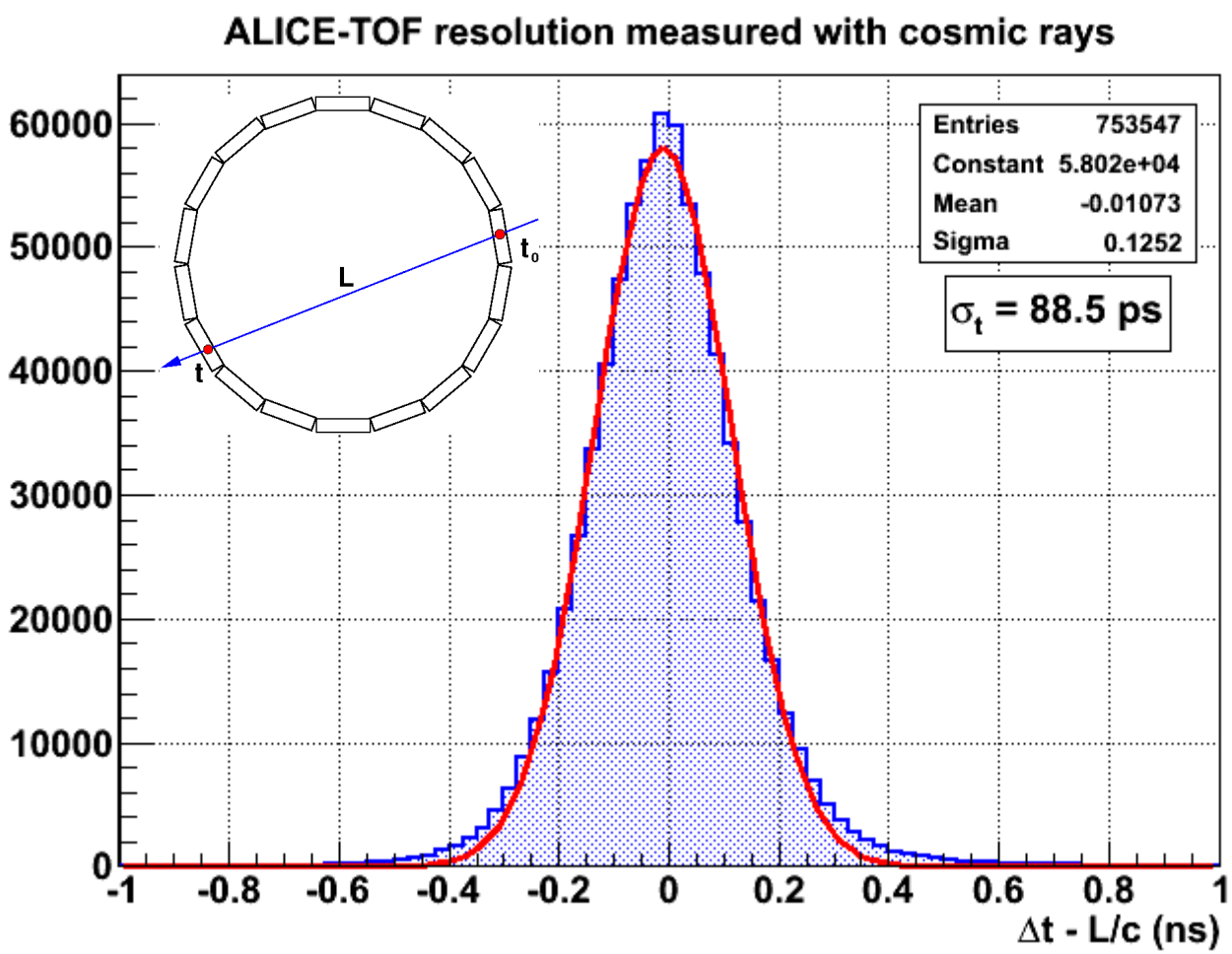
a large Multigap-RPC array

radius	~370 cm
polar acceptance	$\|\eta\| < 0.9$
azimuthal acceptance	full
coverage area	~140 m^2
detecting element	double-stack MRPC
MRPC efficiency	> 99 % (test beam)
MRPC time resolution	< 50 ps (test beam)
readout segmentation	2.5 x 3.5 cm^2
readout channels	157248



identification of charged hadrons at intermediate momenta
design time-of-flight resolution σ_{TOF} = 80 ps
π/K separation up to p = 2.5 GeV/c
K/p separation up to p = 4.0 GeV/c

TOF detector resolution



measured with cosmic-ray tracks hitting twice the TOF detector (B=0)

$\Delta t = t - t_0$

$t_{exp} = L/c$

measured resolution

σ = 125.2 ps

from two independent time measurements

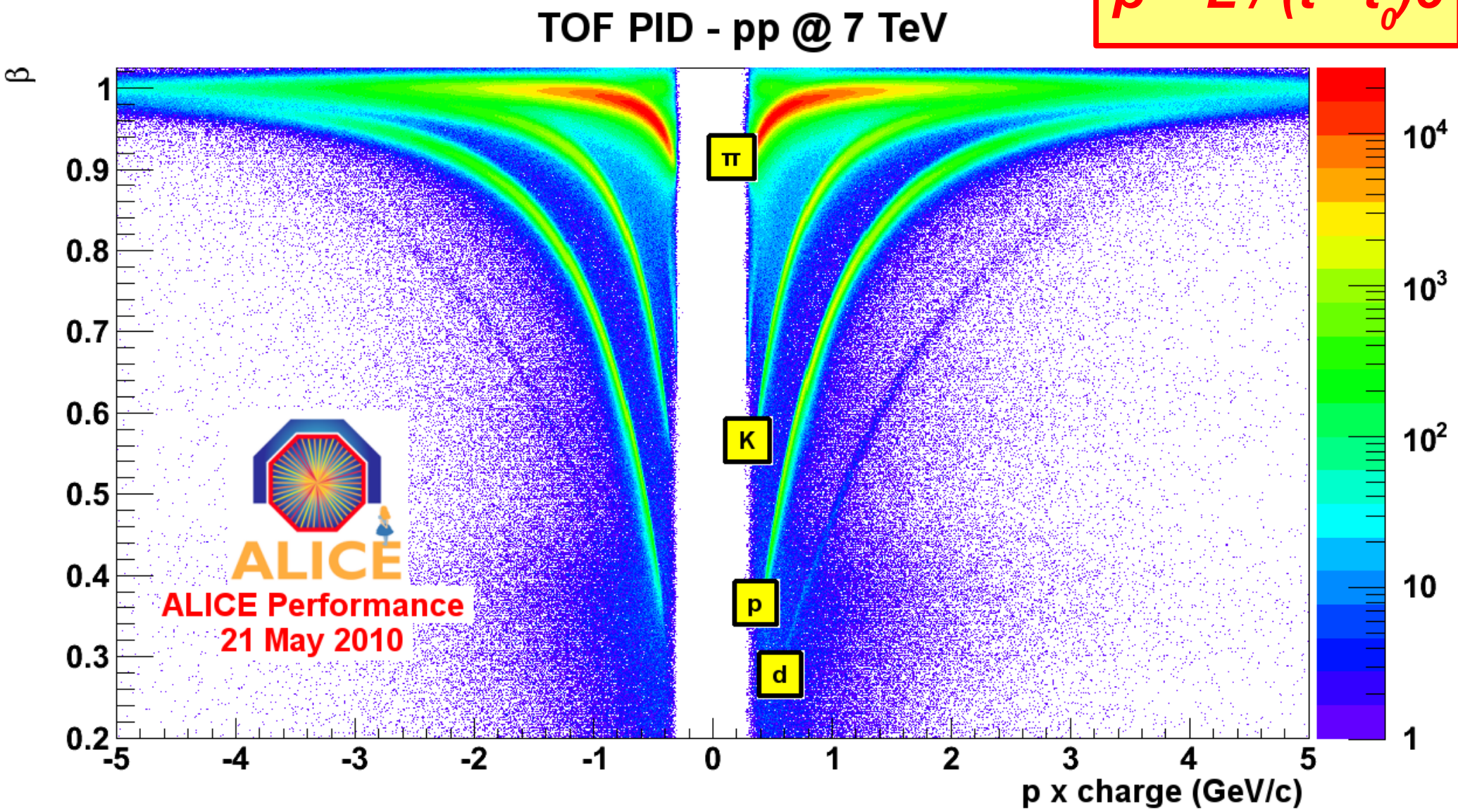
$\sigma_t = \sigma / 2$ = 88.5 ps

time resolution close to design value

further improvementes in progress following optimal detector calibration with high statistics

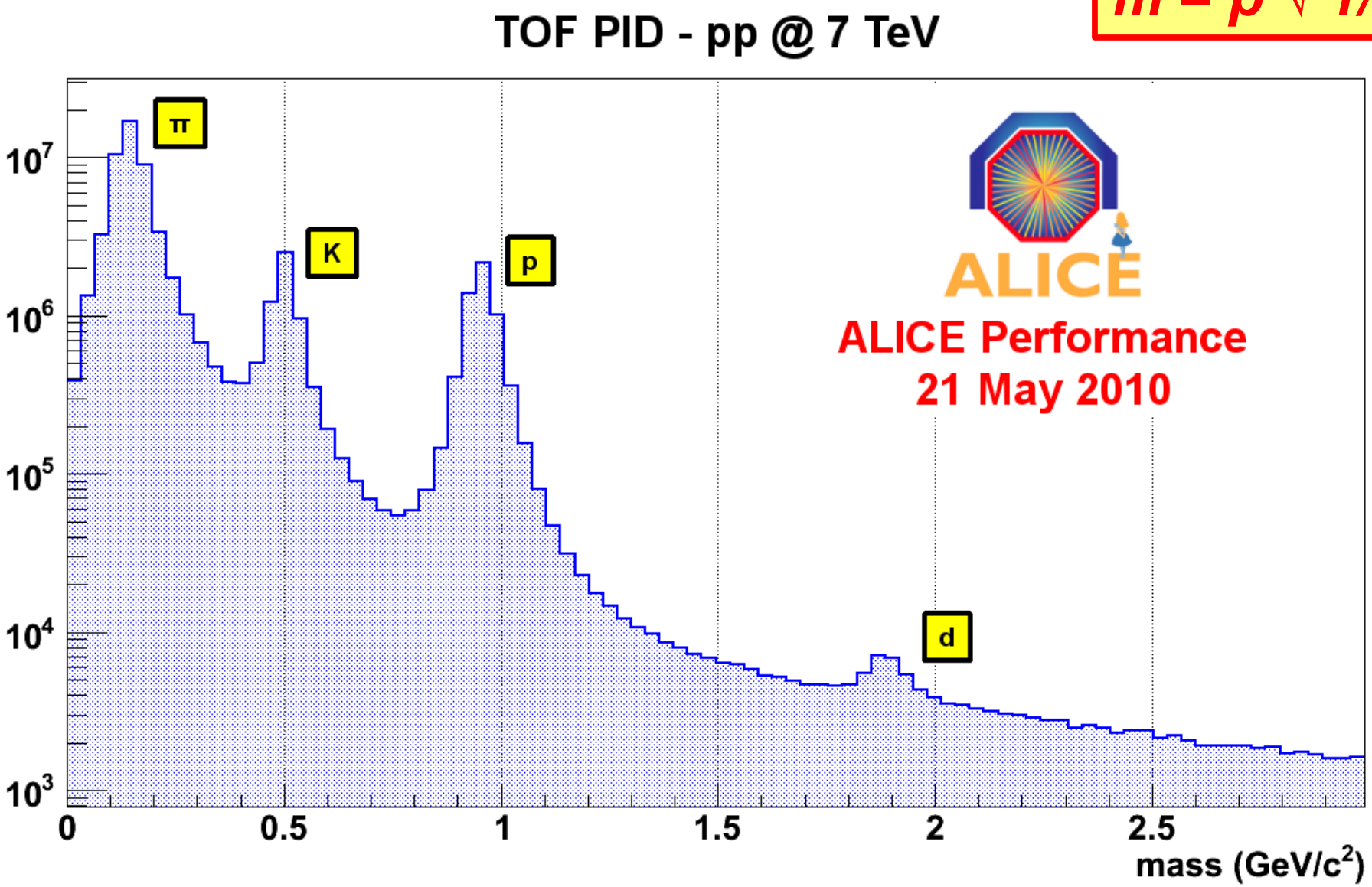
TOF particle-identification

$\beta = L / (t - t_0)c$

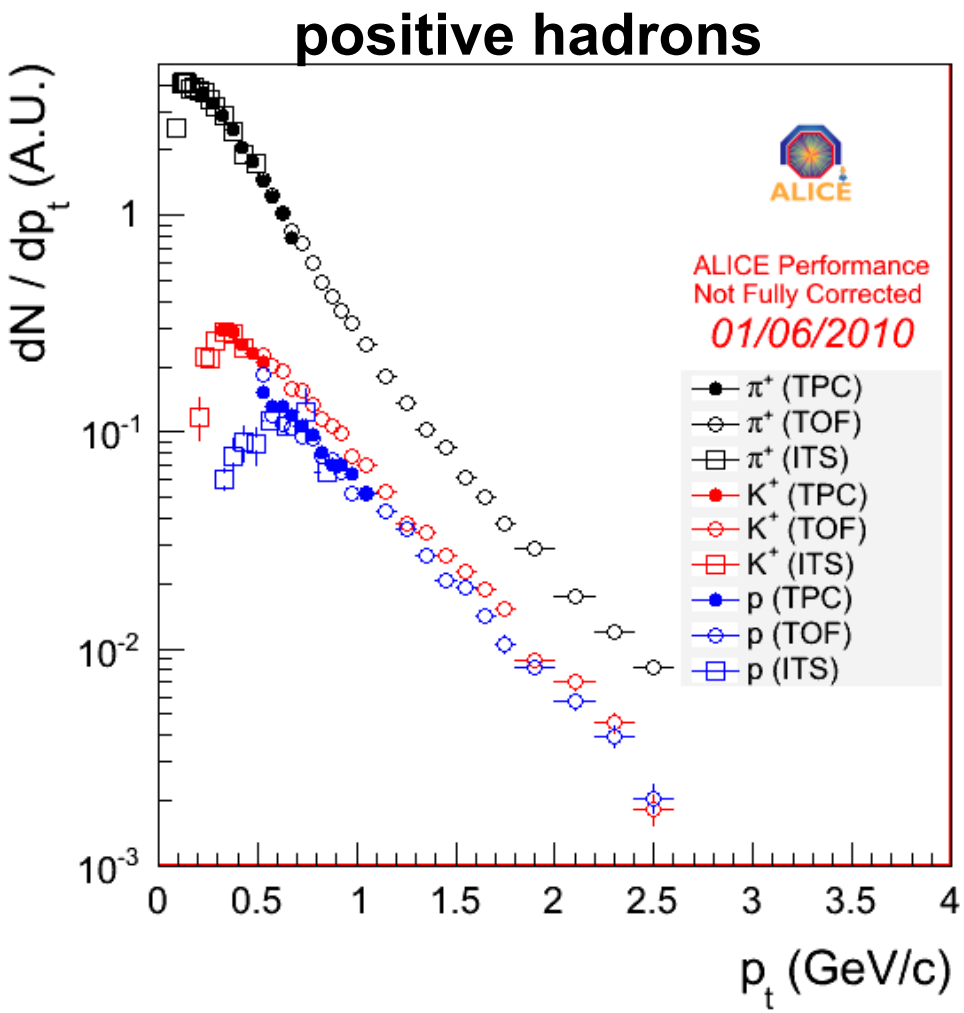


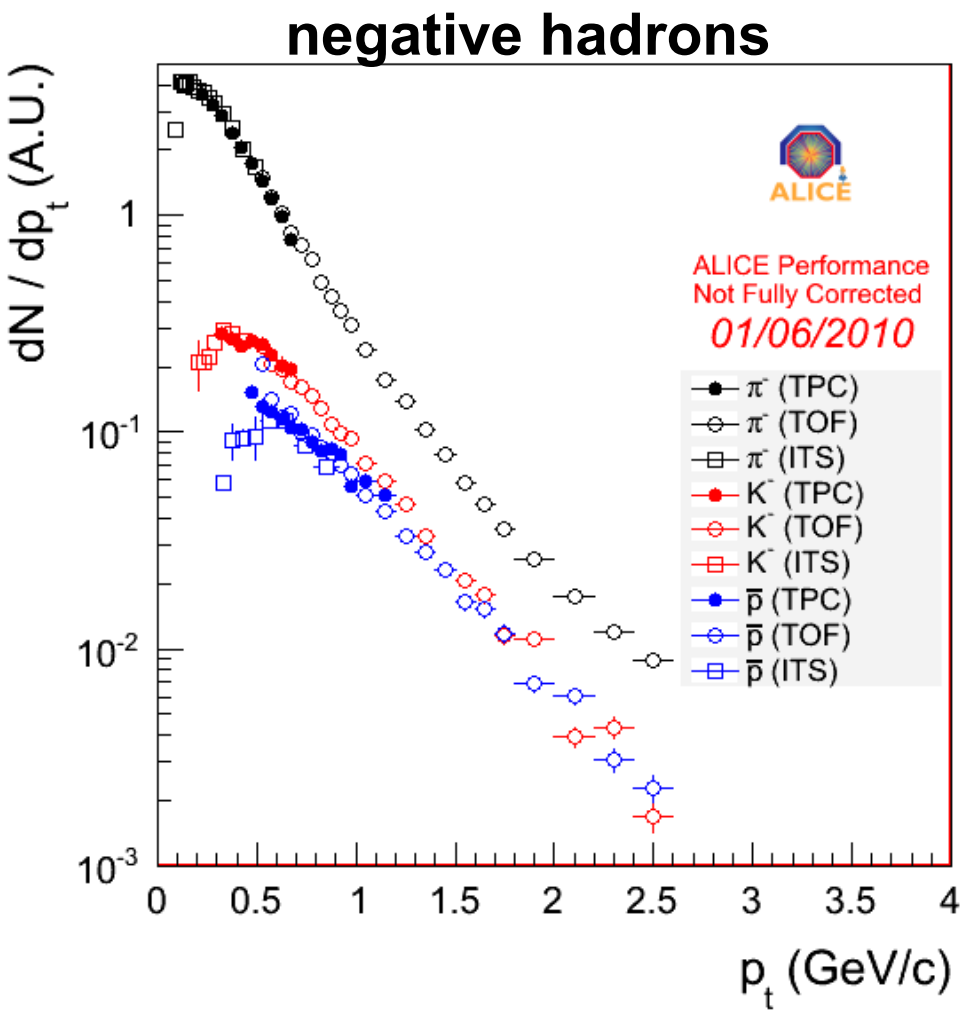
TOF particle-identification

$$m = p\sqrt{1/\beta^2 - 1}$$



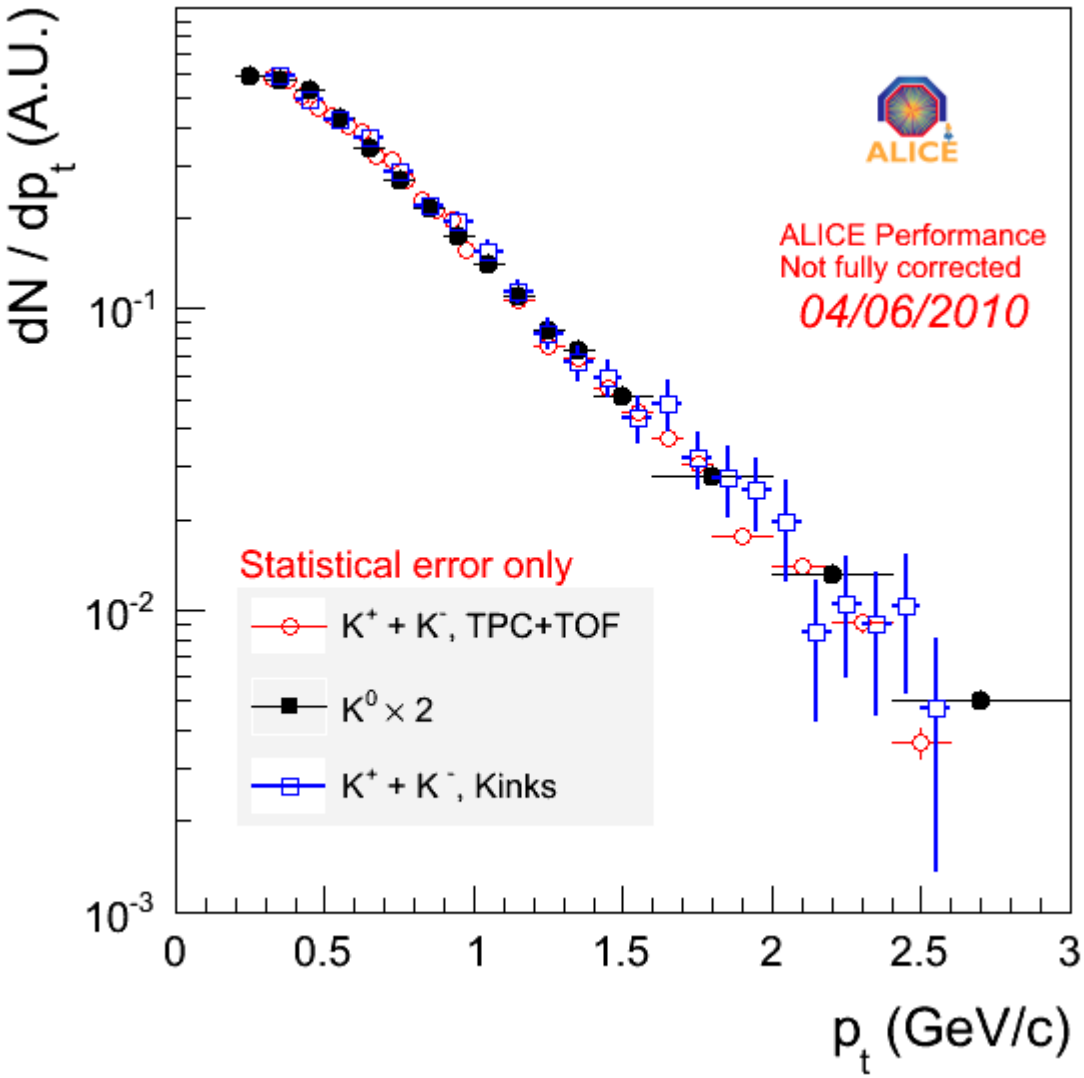
π/K/p spectra @ 900 GeV





analysis is in progress (spectra not fully corrected yet)
good agreement between the 3 detectors (ITS, TPC, TOF)

Internal consistency with kaons



three independent ways to measure kaon spectra

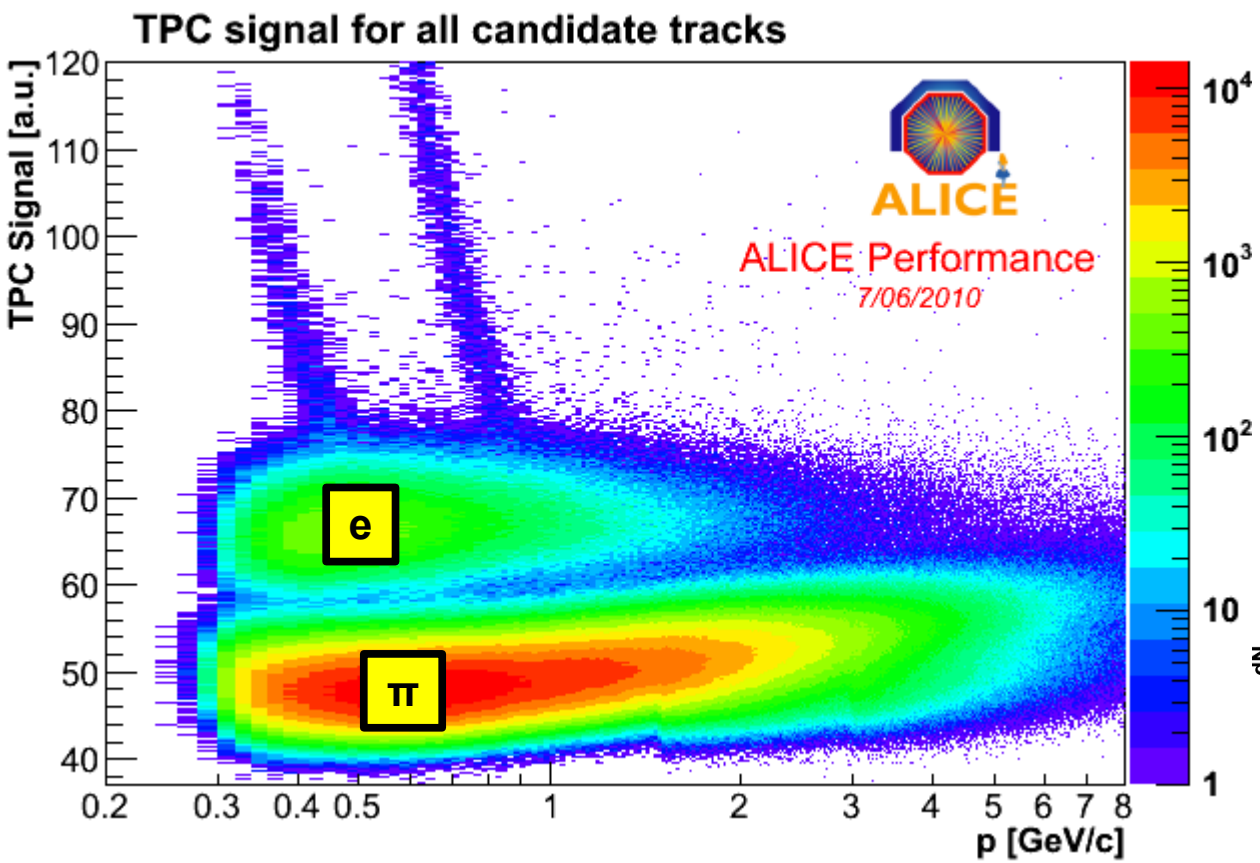
$K^{\pm}$
particle identification (TOF+TPC)
$K^0_S \rightarrow \pi^+\pi^-$
decay vertex reconstruction
$K^{\pm} \rightarrow \mu^{\pm}\nu$
kink decay reconstruction

which yield consistent results on kaon production

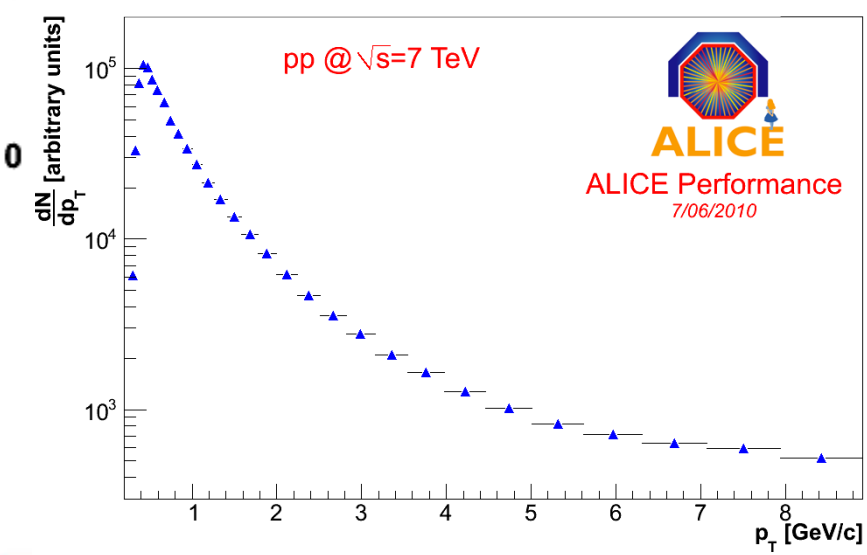
detector calibration and understanding is OK

Electron identification

electron-ID in the central barrel ($|\eta| < 0.9$) performed using TPC *dE/dx* for *e/π* separation and TOF information for *K* and *p* rejection



single-electron inclusive spectrum (uncorrected)



TRD and EMCAL will join soon

π^0 via conversion electrons

double conversions

$$\pi^0 \rightarrow \gamma\,\gamma \rightarrow e^+\,e^-\,e^+\,e^-$$

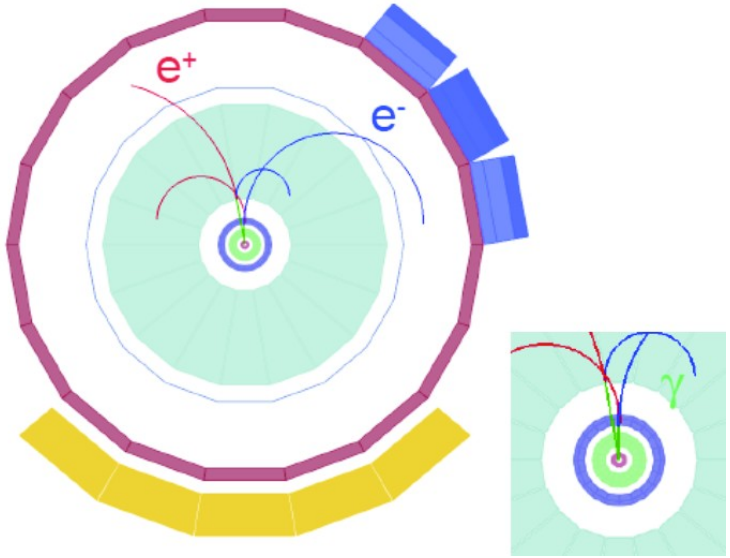
$$\eta \rightarrow \gamma\,\gamma \rightarrow e^+\,e^-\,e^+\,e^-$$

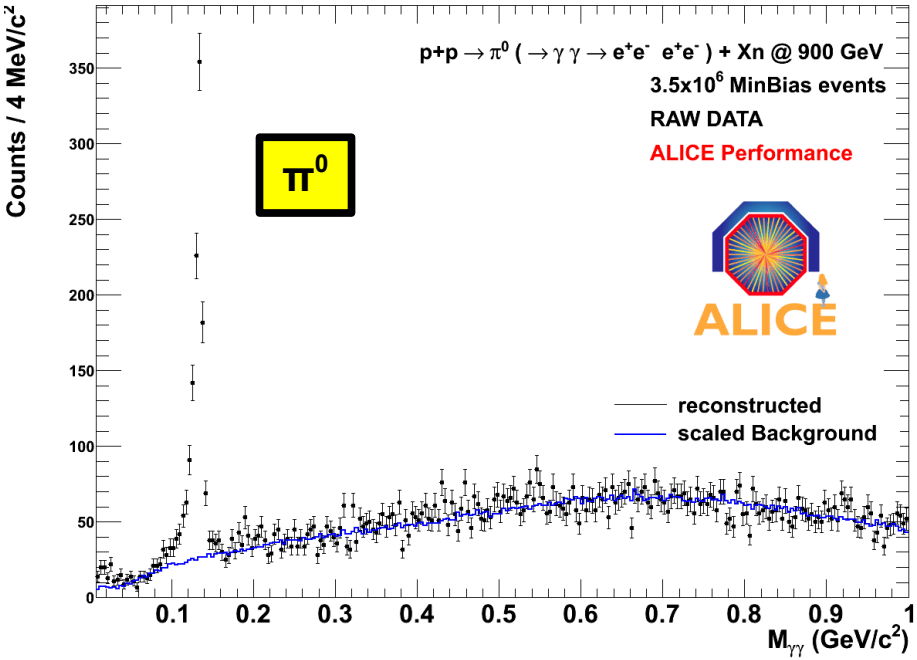
conversion reconstruction done in ITS+TPC

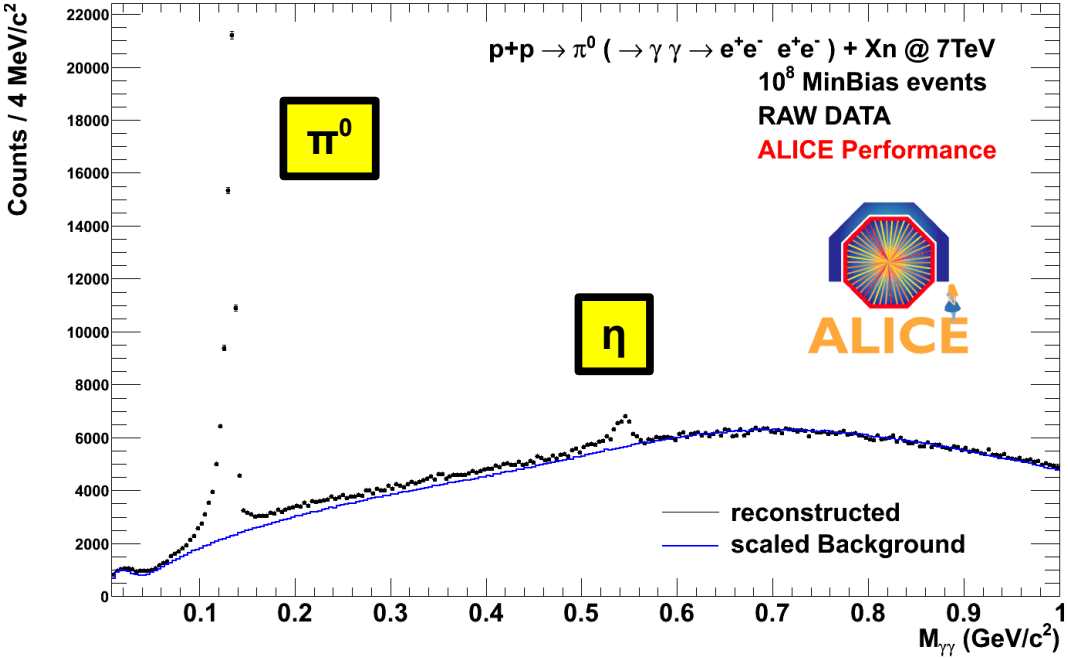
also important for material budget scan

electron-ID in TPC

TRD will join soon

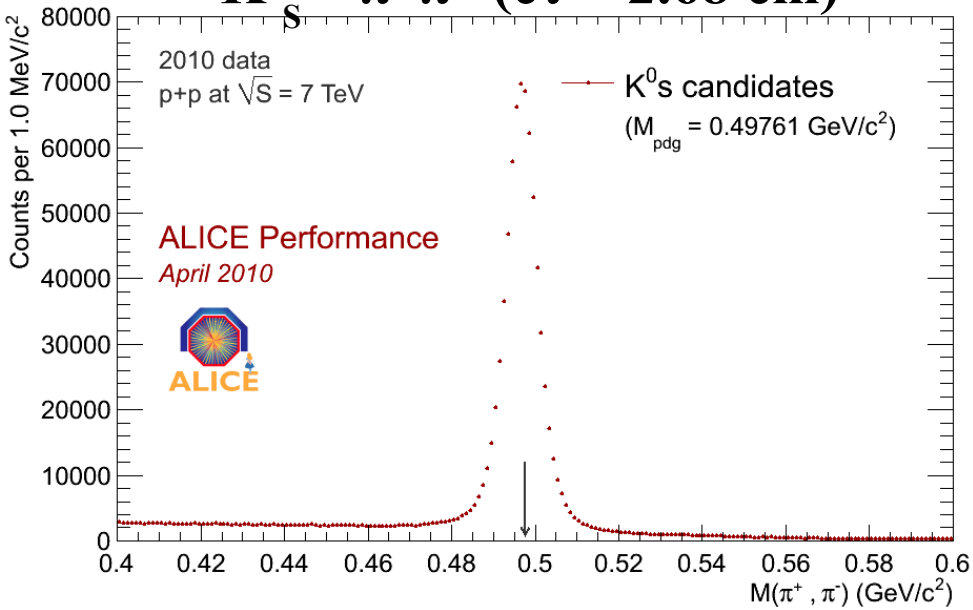




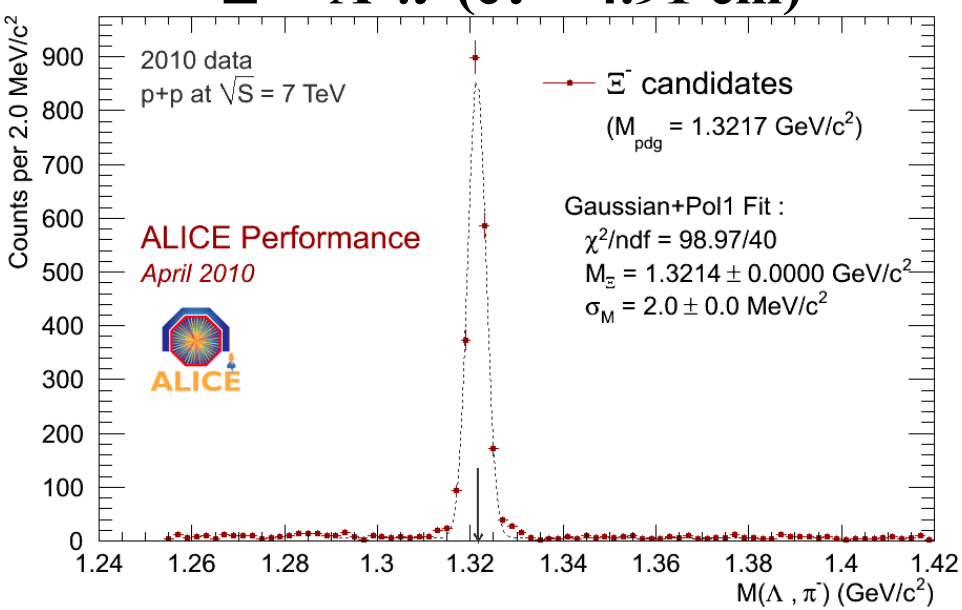


Strangeness via topological decay

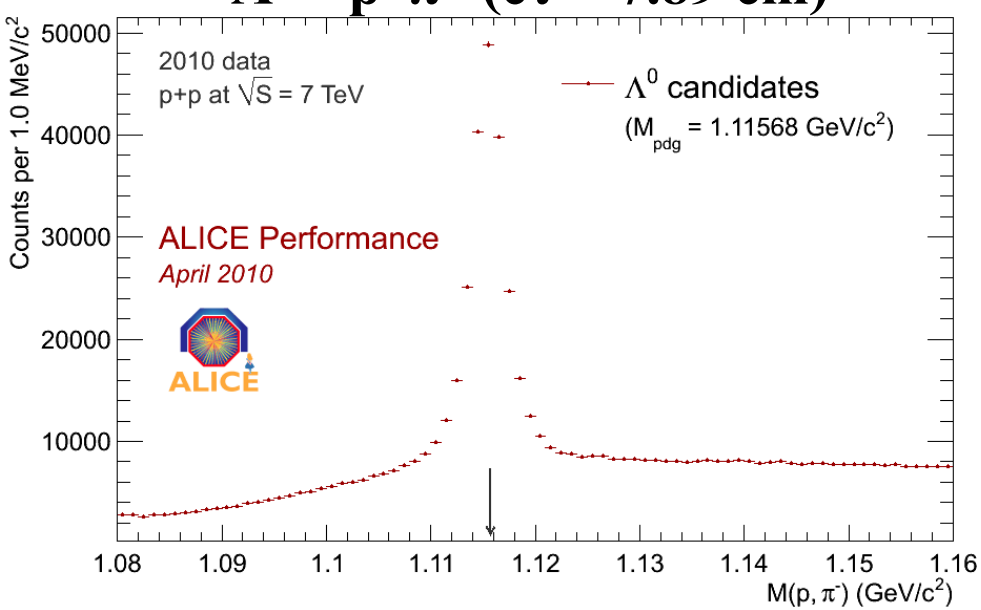
$K^0_S \rightarrow \pi^+ \pi^-$ ($c\tau$ = 2.68 cm)



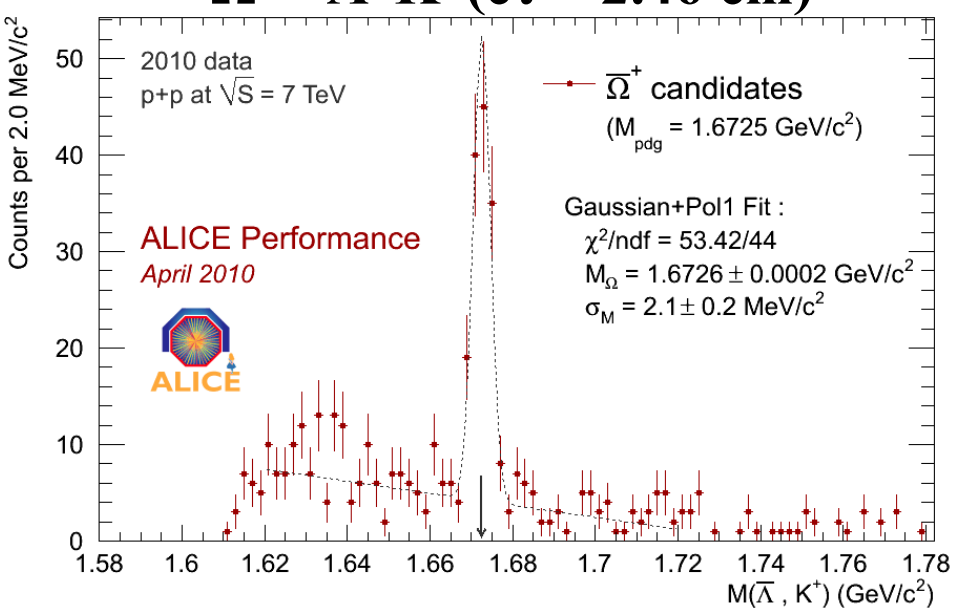
$\Xi^- \rightarrow \Lambda^0 \pi^-$ ($c\tau$ = 4.91 cm)



$\Lambda^0 \rightarrow p^+ \pi^-$ ($c\tau$ = 7.89 cm)

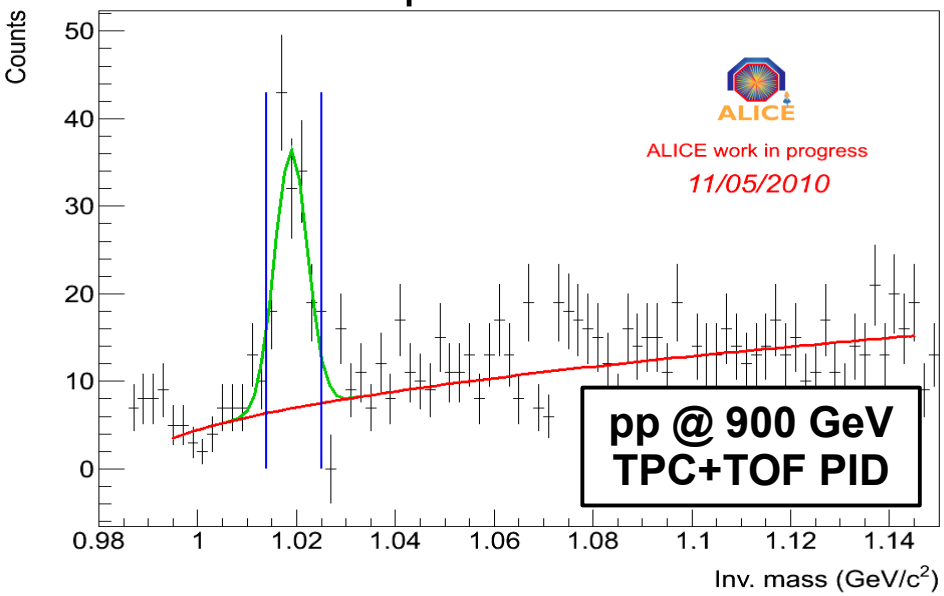


$\Omega^- \rightarrow \Lambda^0 K^-$ ($c\tau$ = 2.46 cm)

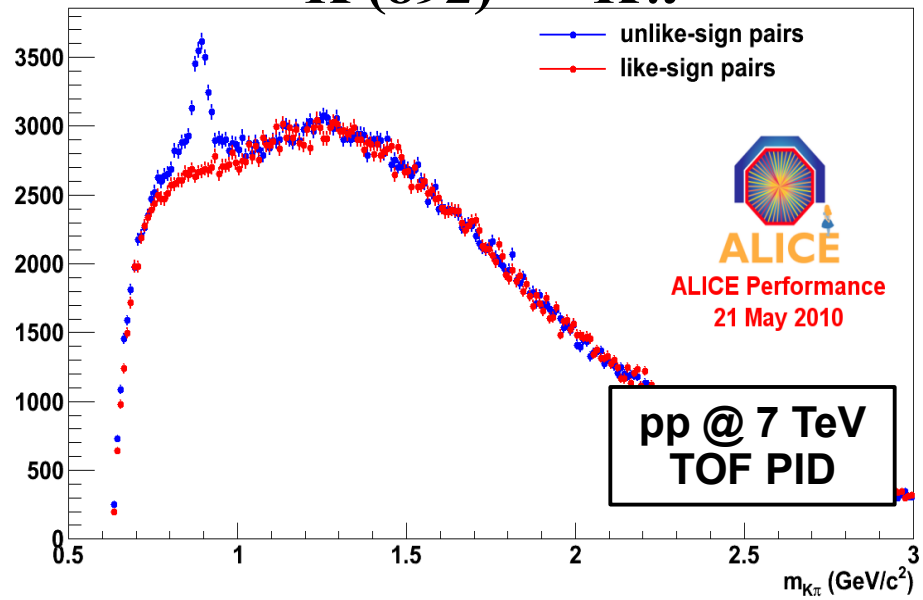


ϕ- and K*-meson reconstruction

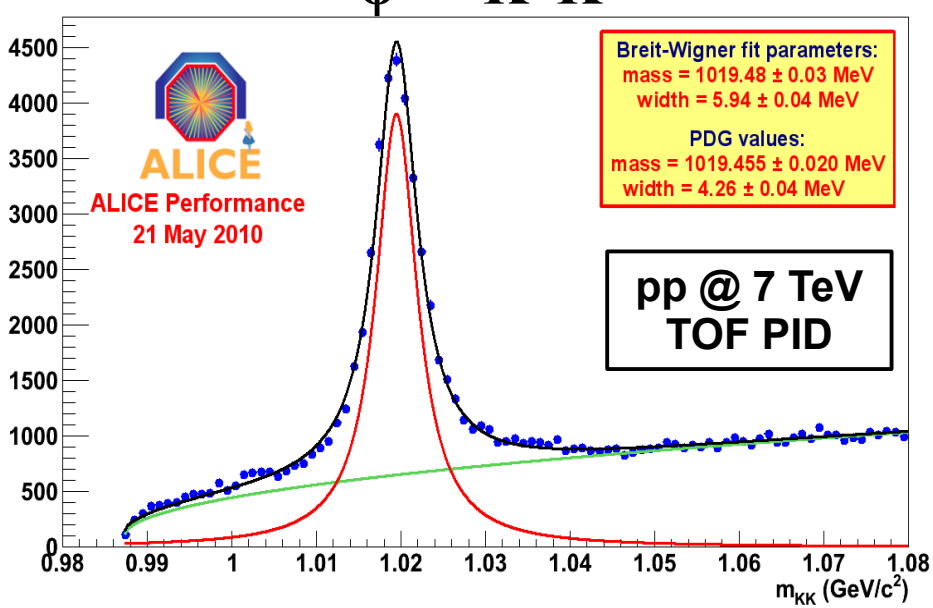
$\varphi \rightarrow K^+ K^-$



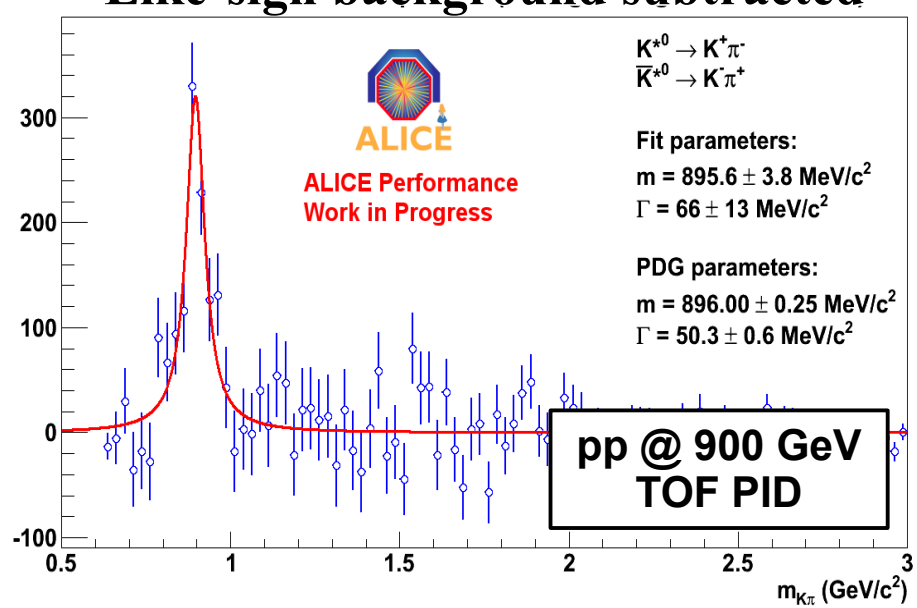
$K^*(892)^0 \rightarrow K\pi$



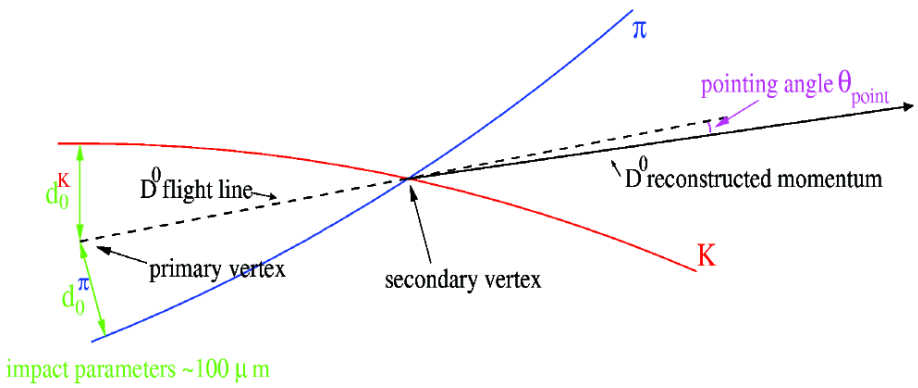
$\varphi \rightarrow K^+ K^-$



Like-sign background subtracted



Charm: D-meson reconstruction



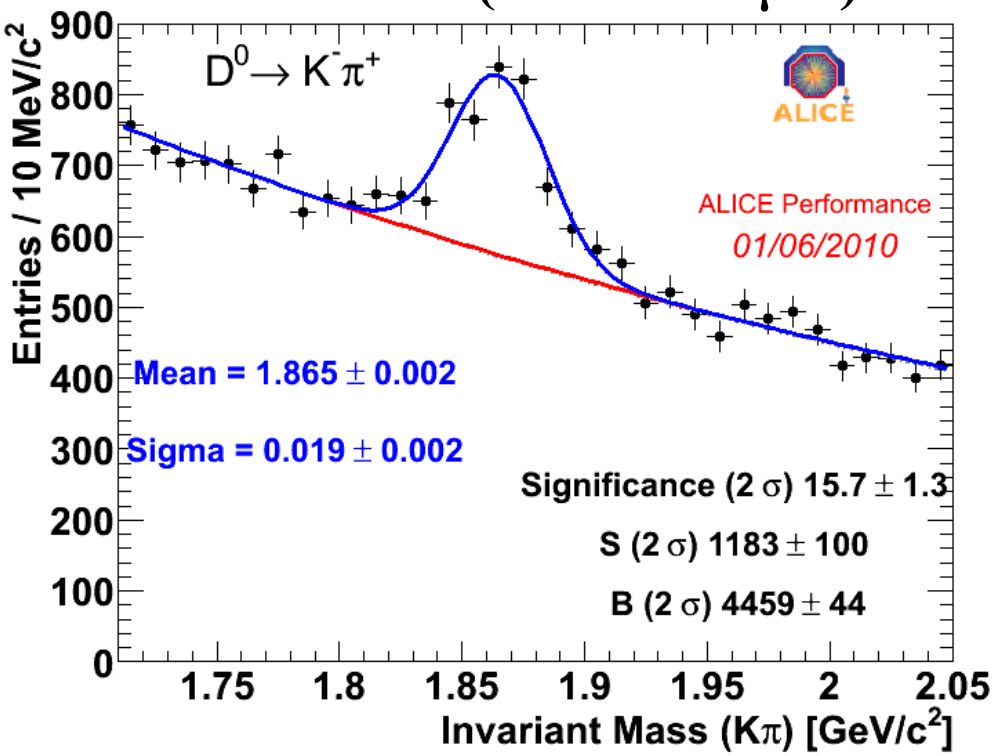
displaced-vertex topology

D momentum pointing to primary vertex

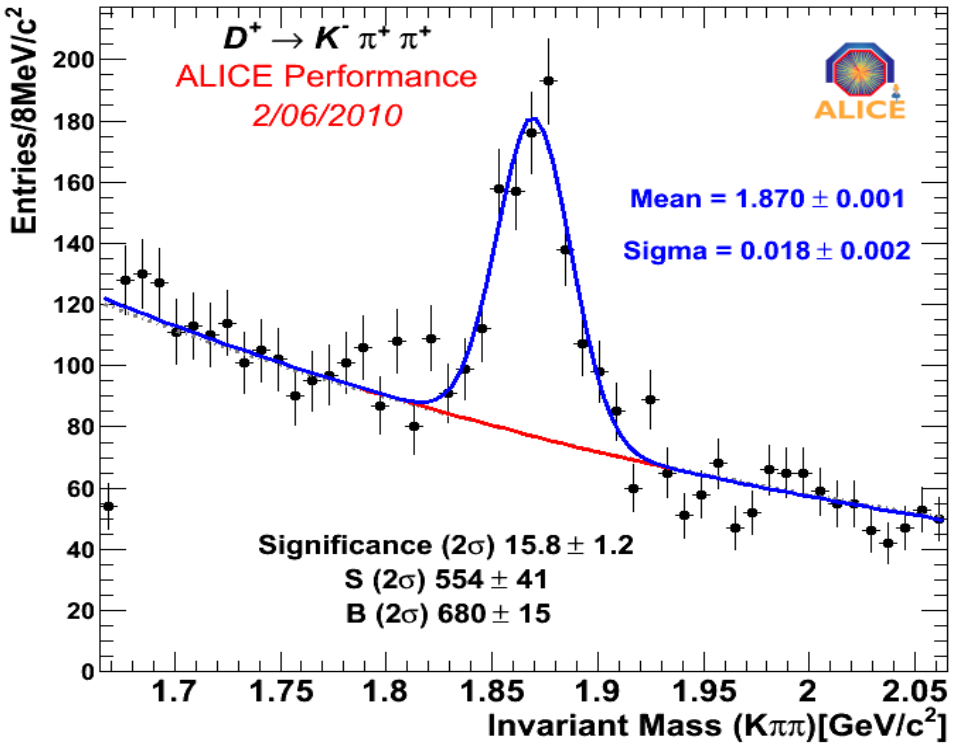
large impact parameter of daughters

PID in TPC+TOF helps bkg rejection

$D^0 \rightarrow K^- \pi^+ (c\tau = 122.9\ \mu m)$



$D^+ \rightarrow K^- \pi^+ \pi^+ (c\tau = 311.8\ \mu m)$

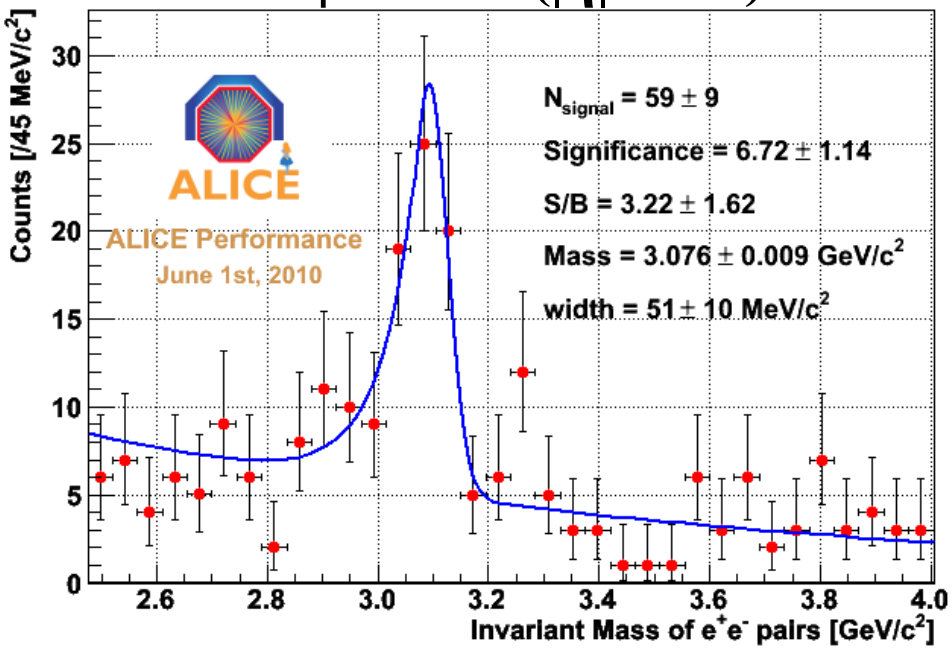


J/ψ reconstruction

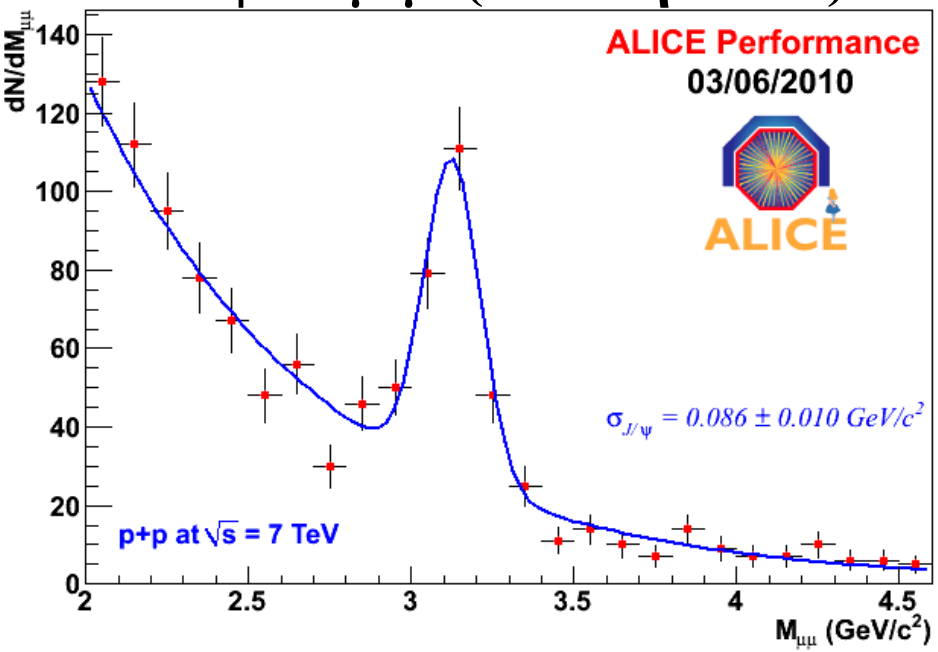
TPC electron-ID in the central barrel
$|\eta| < 0.9$
110 Mevents (pp @ TeV)

muon-track reconstruction in the forward muon spectrumeter
$-4.0 < \eta < -2.5$
31 Mevents (pp @ 7 TeV)

$J/\psi \rightarrow e^- e^+ (|\eta| < 0.9)$



$J/\psi \rightarrow \mu^- \mu^+ (-4.0 < \eta < -2.5)$



TDR EMCAL calibration ongoing

Conclusions

The ALICE experiment is well equipped for particle-identification in a wide momentum range and allows to carry out several studies based on identifed particles.

The performance of tracking, vertex reconstruction and particle-identification is already close to the design value. Ready for Heavy-Ion collisions (November 2010).

Internal consistency checks measuring the same quantity (i.e. kaon production) with independent methods signal the good status of calibration and detector understanding

First publications based on PID:
anti-proton/proton ratio → accepted for publication (PRL)
identifed hadron spectra → almost ready for publication

Several studies based on identified particles are in progess for more physics results to come.