The ALICE Inner Tracking System: performance with proton and lead beams

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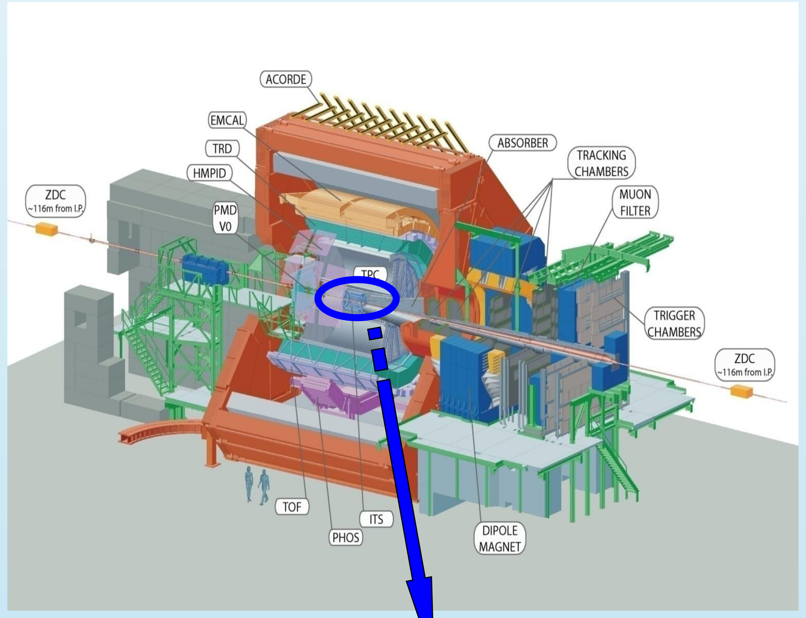
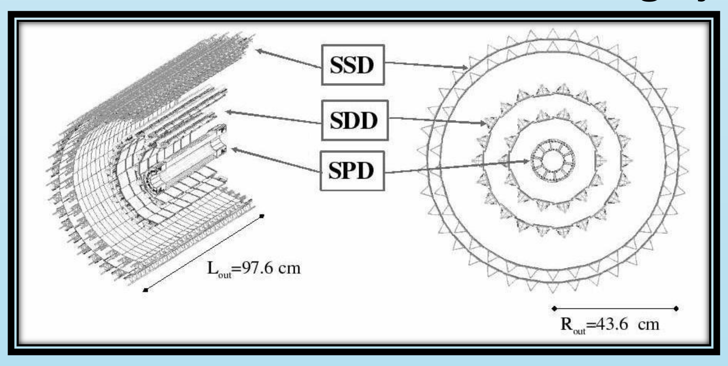
on behalf of the ALICE Inner Tracking System Collaboration

A Large Ion Collider Experiment



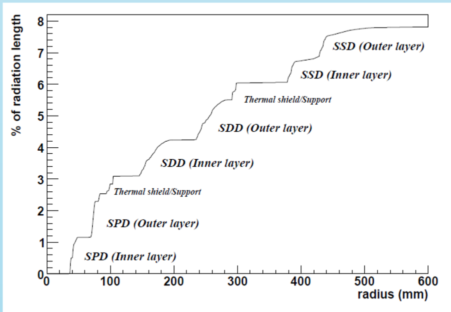
The ALICE[1] detector consists of a central barrel part, which measures hadrons, electrons, and photons, and a forward muon spectrometer. The central part is embedded in the large L3 solenoidal magnet (max field 0.5T). The Inner Tracking system (ITS) in conjunction with the Time-Projection Chamber (TPC) provide track finding, charged particle momentum measurement, particle identification and vertex determination in the pseudo-rapidity region $|\eta|<0.9$.

Inner Tracking System



6 cylindrical layers of silicon detectors:

- 2 Pixel (SPD), 2 Drift (SDD) and 2 Double-sided μ–Strip (SSD) layers
- few % of occupancy at midrapidity
- lowest material budget among the LHC experiments.

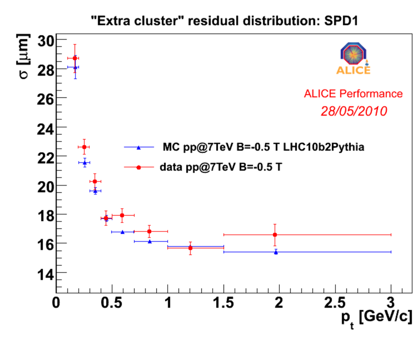


- Localize the primary vertex with a resolution better than 100 μm
- Reconstruct the secondary vertices from the decays of hyperons and D and B mesons
- Stand-alone capability as a low-p_t particle spectrometer below 200 MeV/c.
- Analogue readout for SDD and SSD: used for particle identification via dE/dx measurement in the non-relativistic Bethe-Bloch ($1/\beta^2$) region
- Contribution to the ALICE first level trigger (SPD only)

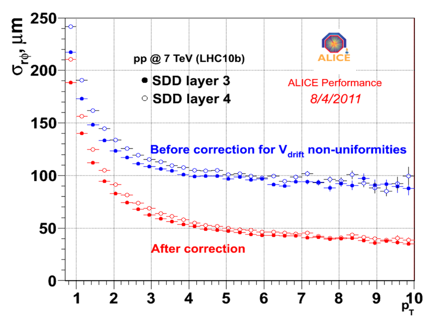
Layer	Technology	Radius (cm)	±z (cm)	Spatial resolution (mm)	
				rϕ	z
1	SPD	3.9	14.1	12	100
2	SPD	7.6	14.1	12	100
3	SDD	15.0	22.2	35	25
4	SDD	23.9	29.7	35	25
5	SSD	38.0	43.1	20	830
6	SSD	43.6	48.9	20	830

Alignment

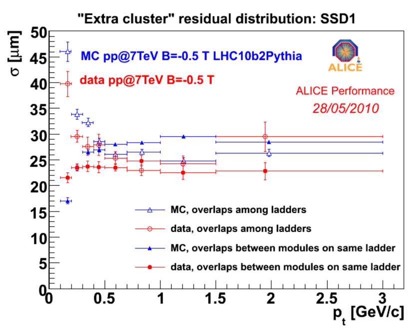
The achieved aligment is well in agreement with the ideal alignment from the Monte Carlo studies.



σ of residuals in the overlap regions of the SPD inner layer, in data (after alignment) and MC. The rise at low p_t is due to multiple scattering.



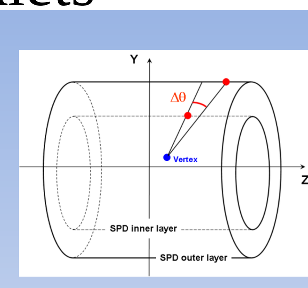
σ from Gaussian fit of the track–to-point distance distribution in rϕ plane.

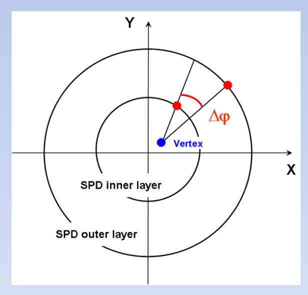


σ of residuals in the overlap regions of the SSD inner layer. The behavior at low pt for modules on the same ladder is due to the better accuracy of two-strip clusters (inclined tracks).

SPD tracklets

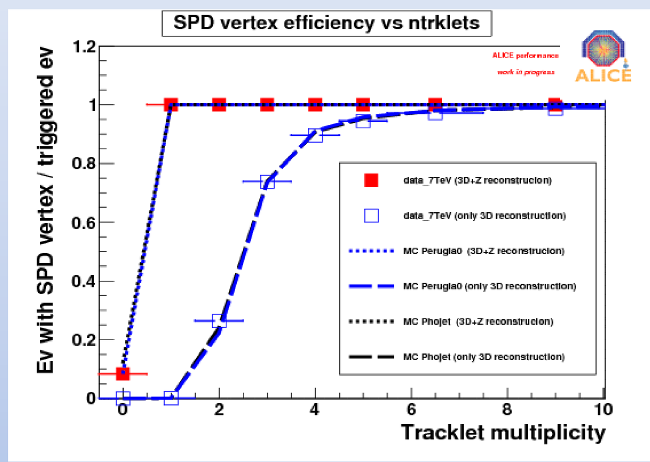
- A tracklet is a pair of clusters (inner/outer layer) aligned with the primary vertex within fiducial windows in θ and ϕ
- Tracklet definition cuts are optimized in p-p and Pb-Pb with respect to efficiency and background contamination
  - Efficiency: ≈99% in p-p and 80%-90% in Pb-Pb central to peripheral, respectively
  - Background: few % in p-p and 1%-14% in Pb-Pb peripheral to central, respectively.



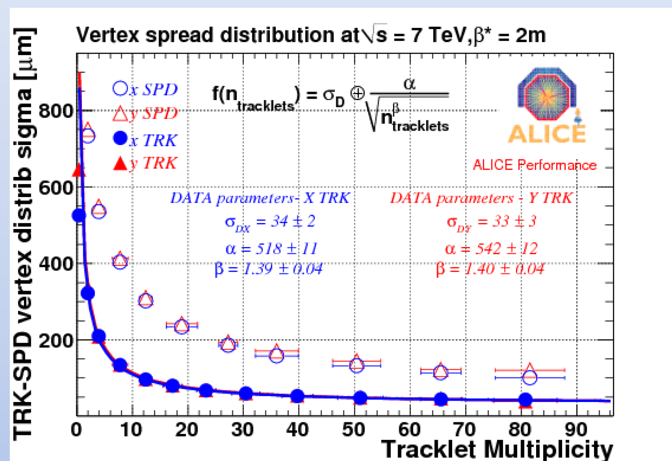


SPD tracklet distribution allows the measurement of charged dN/dη both in p-p and Pb-Pb collisions [2][3].

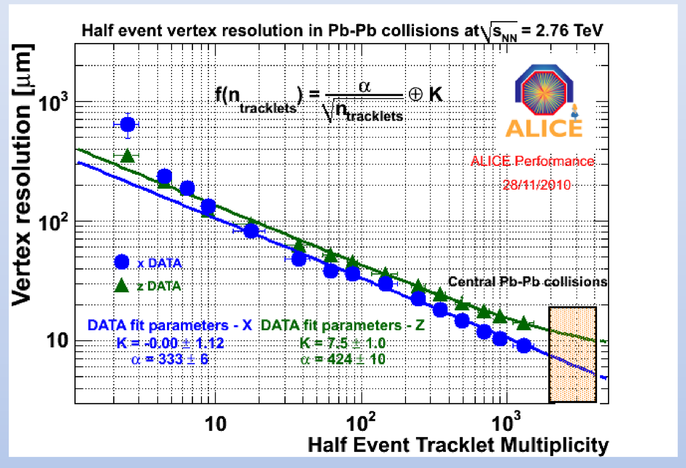
Vertexing Capability



Primary vertex efficiency with SPD tracklets: as a function of the multiplicity for data and Monte Carlo in p-p at $\sqrt{s}$= 7 TeV.

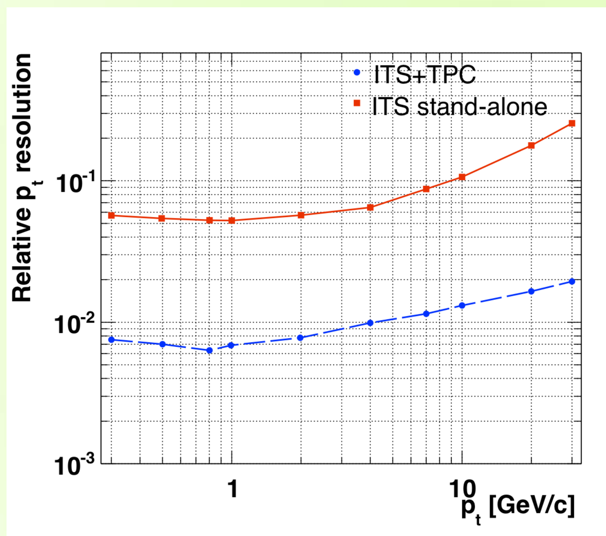


Primary vertex reconstructed with tracks and with SPD tracklets only in 7 TeV p-p data. The asymptotic limit of the vertices reconstructed with tracks (filled markers) estimates the size of the luminous region.



Primary vertex reconstructed with tracks in Pb-Pb data at 2.76 TeV per nucleon pair. The track sample is randomly divided into two. The primary vertex is reconstructed for each sub-samples. The residual distribution of the 2 vertices is fitted with a Gaussian and σ/√2 is taken as the vertex resolution. The resolution is extrapolated for most central (5%) Pb-Pb collisions.

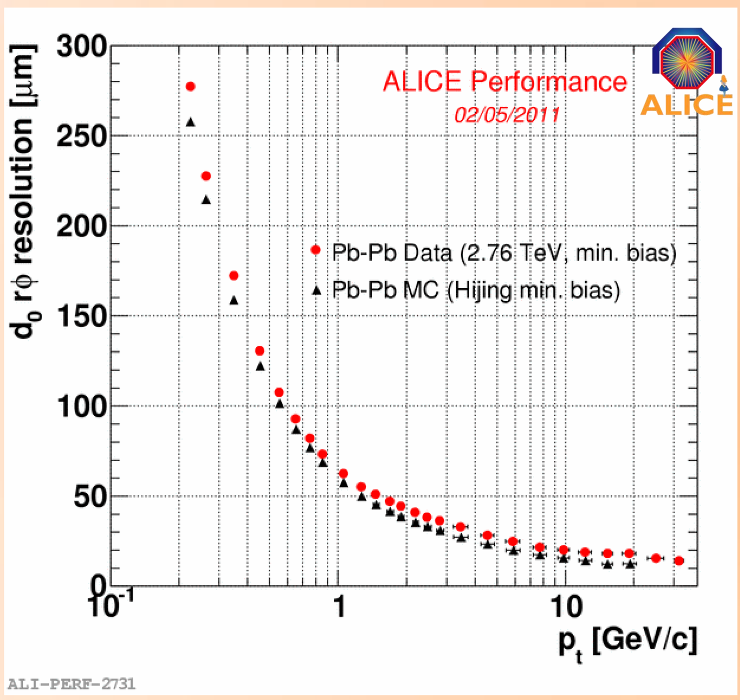
ITS Momentum Resolution



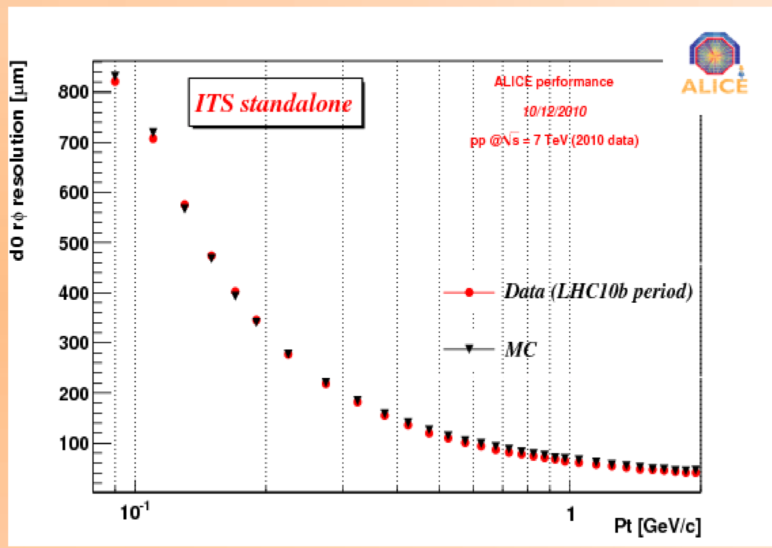
Comparison of the p_t resolution for the standard ITS + TPC tracking and for the ITS standalone tracking as a function of p_t [4]. The momentum resolution of the ITS standalone allows efficient tracking of very low momentum particles. It depends on the length of the lever-arm and the number of points per track.

Transverse Impact Parameter

The transverse impact parameter resolution (d_0 rϕ) is the convolution of the track-position and vertex resolutions in rϕ plane.
The impact parameter resolution is the σ of the Gaussian fit of the track Distance of Closest Approach distribution.



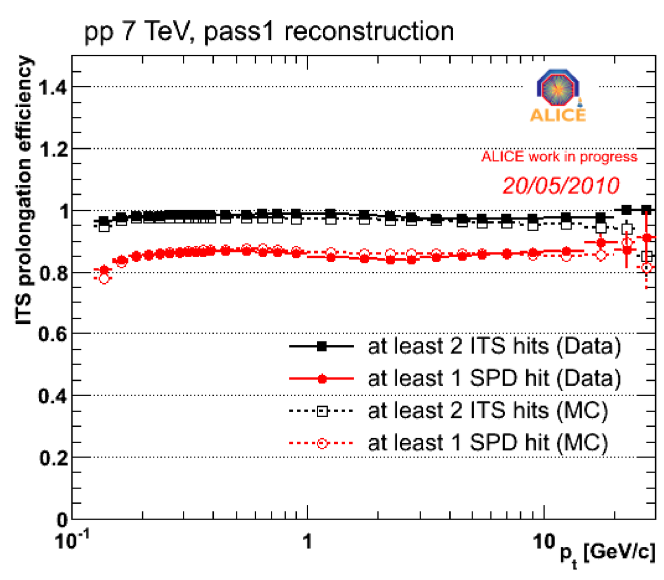
Transverse impact parameter resolution as a function of p_t for tracks reconstructed in minimum bias Pb-Pb collisions at 2.76 TeV.



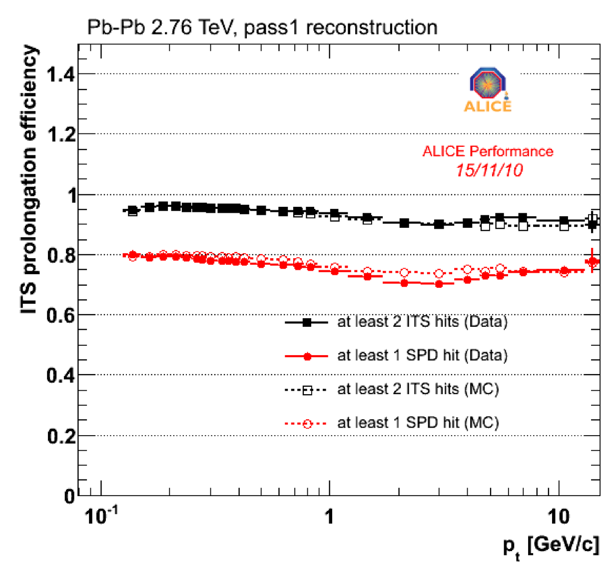
Transverse impact parameter resolution as a function of p_t for tracks reconstructed by the ITS standalone in p-p collisions at 7 TeV. ITS Standalone allows tracking for very low momentum particles.

ITS tracking efficiency

ITS standalone tracking is robust and higly efficient when matching with tracks prolonged from the TPC



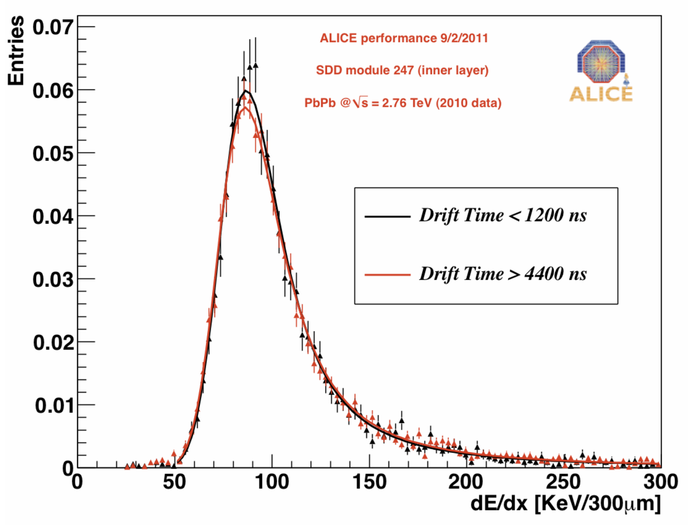
Efficiency of the track prolongation from the TPC to the ITS for p-p data at 7 TeV.



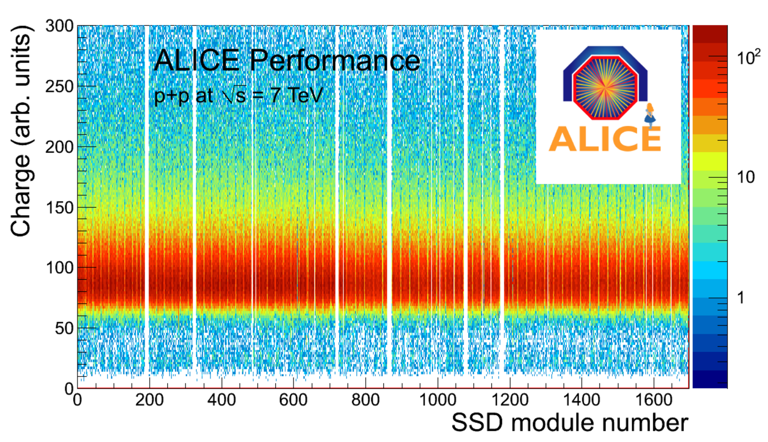
Efficiency of the track prolongation from the TPC to the ITS for Pb-Pb data at 2.76 TeV.

dE/dx

SDD and SSD analogue readout has a dynamic range large enough to provide the dE/dx measurement of low momentum high ionizing particles. This feature provides the ITS with a standalone capability for particle identification at very low-p_t.



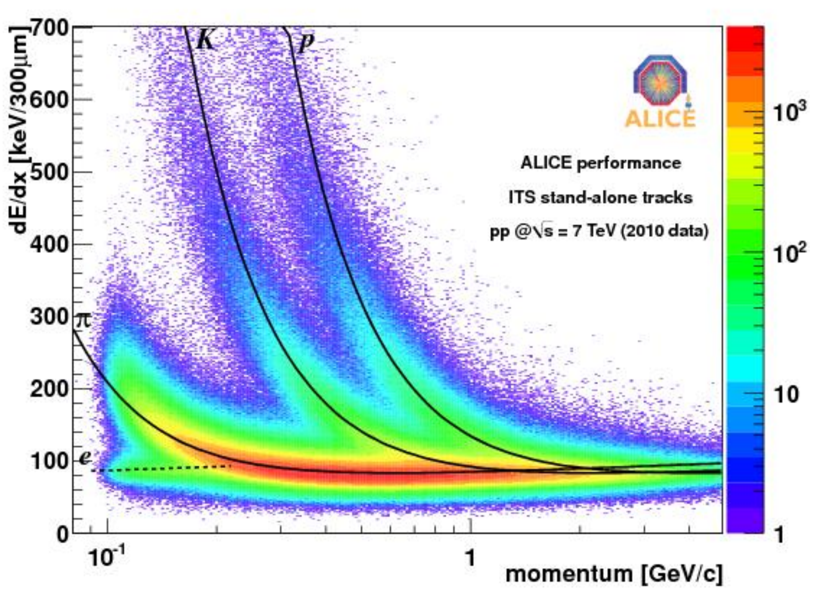
dE/dx distribution for 1 typical SDD module in 2 different drift time intervals during Pb-Pb 2010 run. The dE/dx is in keV/300 μm after applying all the needed calibrations and corrections. Fits with a convolution of a Landau and a Gaussian function are also shown. This plot demonstrates the effectiveness of the correction applied to account for the drift time dependence of the raw ADC counts per cluster.



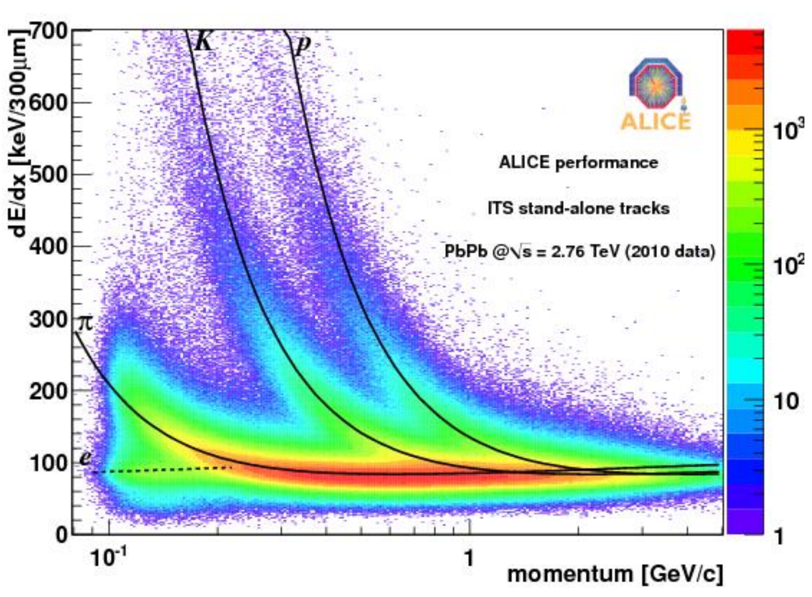
dE/dx distribution for all the 1698 SSD modules in pp collisions at 7 TeV. Each bin is a Landau-Gaussian convolution distribution. This plot shows the uniformity and stablility of the charge collection among all the modules.

Particle identification

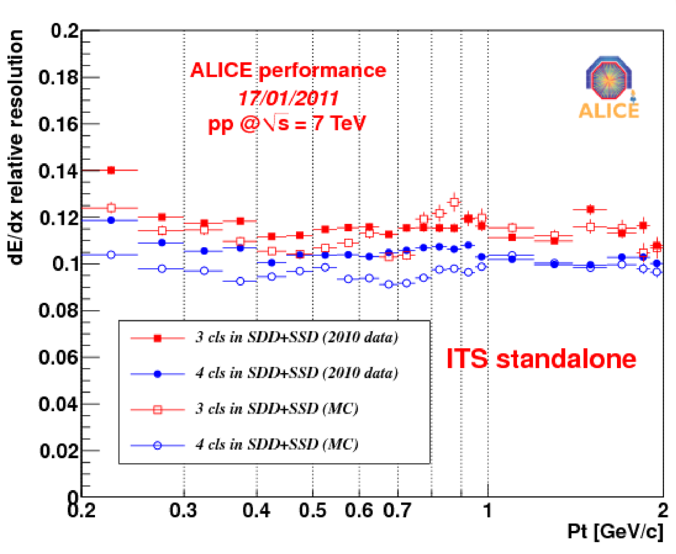
The estimated overall resolution of the ITS dE/dx measurement is about 11%, which allows a good π/K separation up to 450 MeV/c and a p/K separation up to about 1 GeV/c.



dE/dx of charged particles vs momentum measured by the ITS standalone in p-p collisions at 7 TeV. The solid lines are a parametrization[5] of the detector response based on the Bethe-Bloch formula.



dE/dx of charged particles vs momentum measured by the ITS standalone in Pb-Pb collisions at 2.76 TeV. The solid lines are a parametrization[5] of the detector response based on the Bethe-Bloch formula.



dE/dx resolution for charged particles vs momentum measured by the ITS standalone, in p-p collisions at 7 TeV.

[1] ALICE collaboration, "ALICE Technical Paper I", JINST 3 S08002, June 2008

[2] K. Aamodt *et al.*, The ALICE Collaboration, "Charged-particle multiplicity measurement in proton-proton collisions at √s = 7 TeV with ALICE at LHC", Eur. Phys. J C68 (2010) 345-354

[3] K. Aamodt *et al.*, The ALICE Collaboration, "Charged-particle multiplicity density at mid-rapidity in central Pb-Pb collisions at sqrt(sNN) = 2.76 TeV", Phys.Rev.Lett.105:252301,2010

[4] ALICE Internal Note, " Performance of the ITS stand-alone tracker in pp collisions", ALICE-INT 2009-046

[5] PHOBOS collaboration, Back, B. B. et al., Phys. Rev. C 75, (2007) 024910

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