The Silicon Drift Detector of ALICE

1) Quick introduction of ALICE and its Internal Tracking System
2) Principle of a Silicon Drift Detector (SDD)
3) Main systematic effects
4) Spatial resolution

G. Batigne – IFAE, Catania, March 30th 2005

ALICE : Study of Quark Gluon Plasma

- Ultra-Relativistic Ion Collisions :

  Study of nuclear matter at high energy density

  Study of the state equation of the nuclear matter

  Especially the Quark Gluon Plasma (QGP)

    Restauration of the chiral symmetry

    Deconfinement

- ALICE (A Large Ion Collider Experiment) :

  Collisions Pb-Pb à 5,5 TeV/A $\rightarrow$ New range in energy

  High Multiplicity $(dN_{ch}/d\eta)_{max}$ ~ 8000 particles (estimation with security factor)

  $\Rightarrow$ Excellent Tracking system

- Tracking system :

  Time Projection Chamber (TPC)

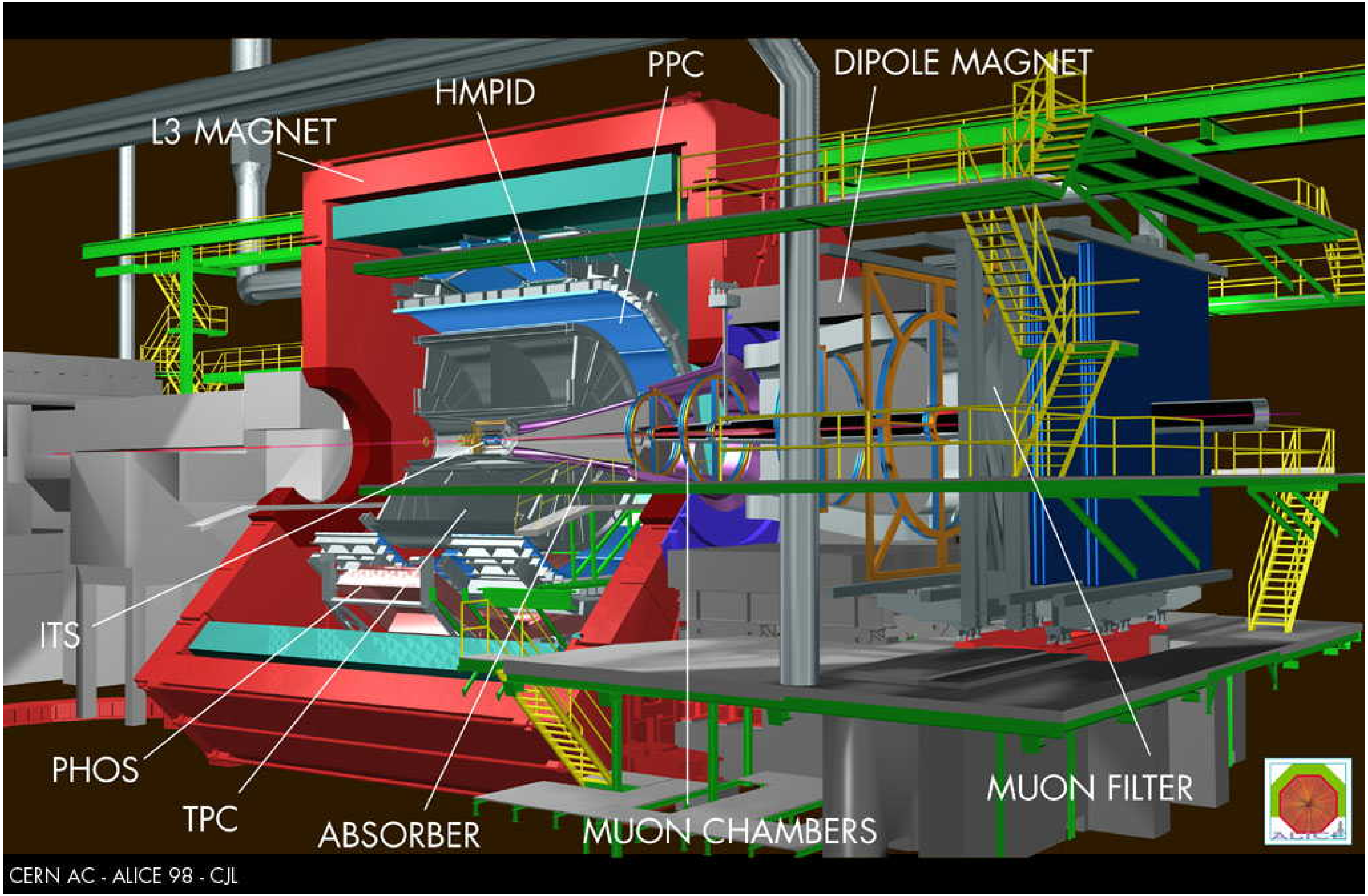
  Internal Tracking System (ITS) :

    position of primary vertices (100 μm)

    position of secondary vertices (hyperons, D, B)

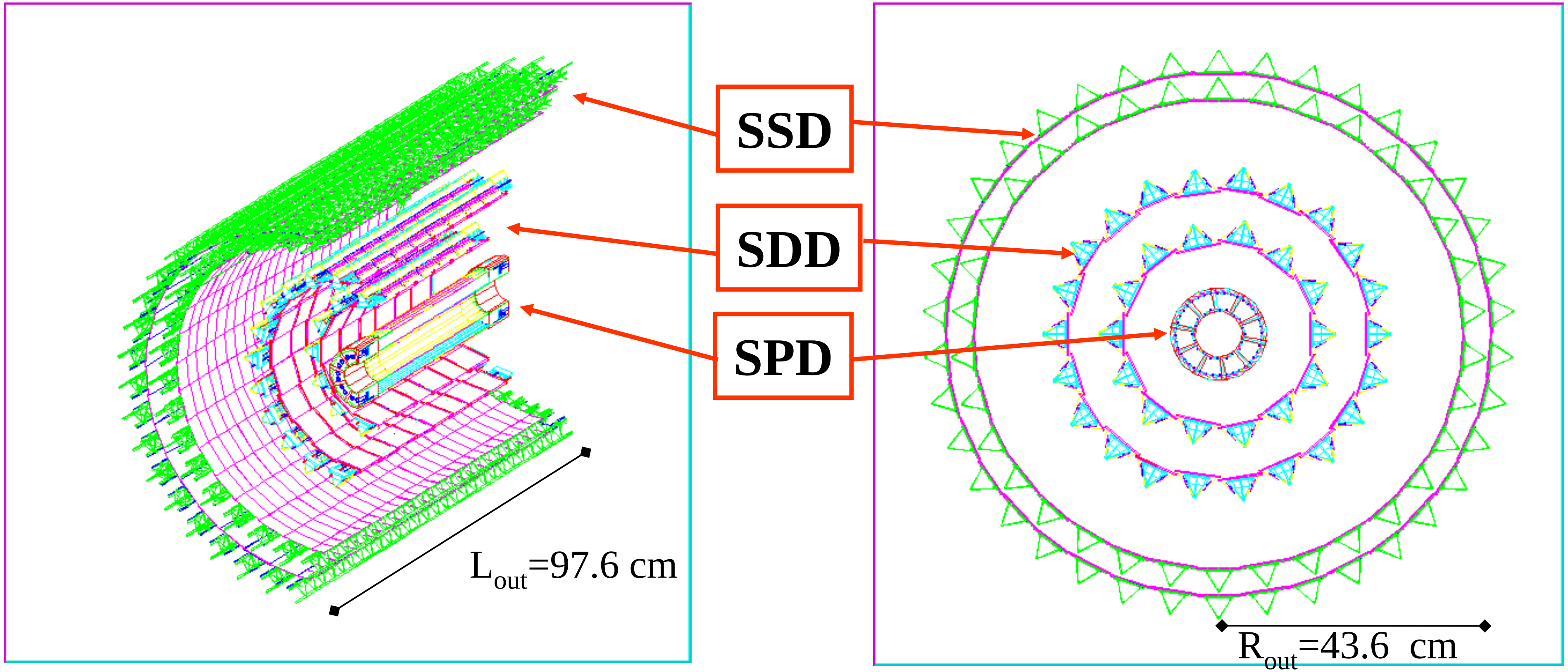
    identification and tracking of low momentum particles

    (p_T < 100 MeV/c)



PPC
DIPOLE MAGNET
HMPID
L3 MAGNET
ITS
PHOS
TPC
ABSORBER
MUON CHAMBERS
MUON FILTER
CERN AC - ALICE 98 - CJL

Internal Tracking System (ITS)

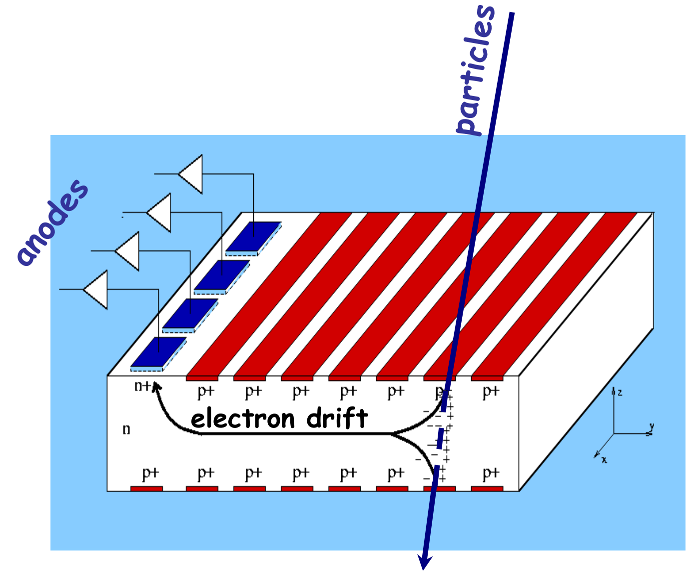


SPD (Silicon Pixel Detector) : excellent granularity

SDD (Silicon Drift Detector) : good granularity and measurement of dE/dx

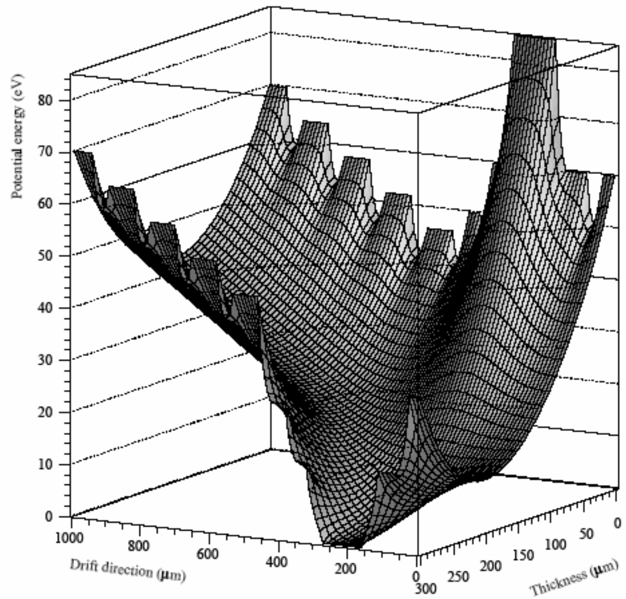
SSD (Silicon Strip Detector) : stereo-pairs of strips and measurement of dE/dx

Silicon Drift Detector : Principle



Cathods on both side of the wafer :

- Depletion of the Silicon
- HV decreases toward the anods
  - → Drift field
  - (Toboggan effect)
- Last cathods below anods :
  - kick-up voltage



Position reconstruction :

- Centroid calculation
- Position X : anods
- Position Y : drift time (calibration of V_{drift})
- dE/dx : Integral of the signal

Silicon Drift Detector of ALICE

Geometry :

7.5cm (anods) x 7.0cm (drift) x 300µm (thickness)

Two active areas in order to limit the drift path

256 anods with a pitch of 294µm

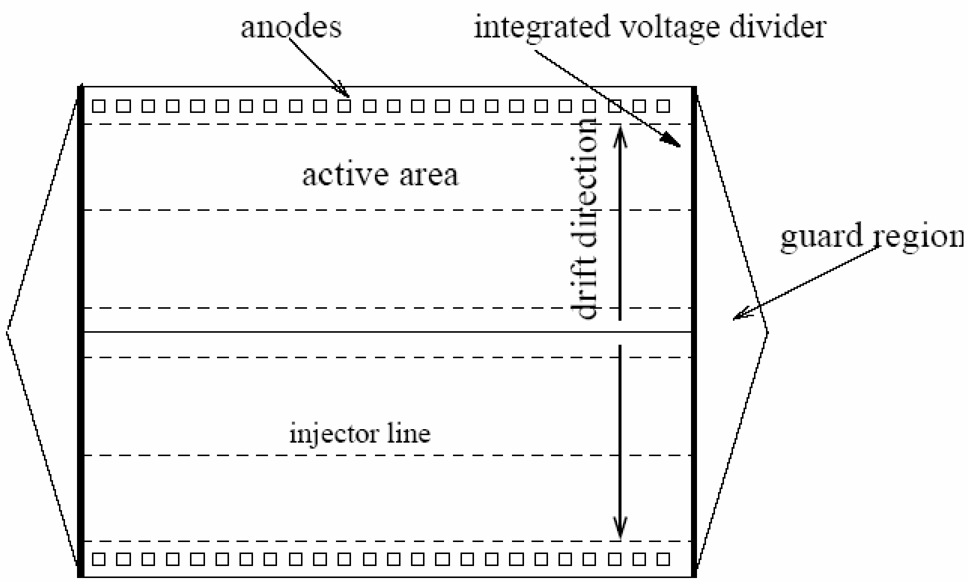
292 cathods with a pitch of 120µm

Integrated voltage divider

Required Performances :

Resolution in both direction ~ 35µm

Two tracks resolution ~ 600µm



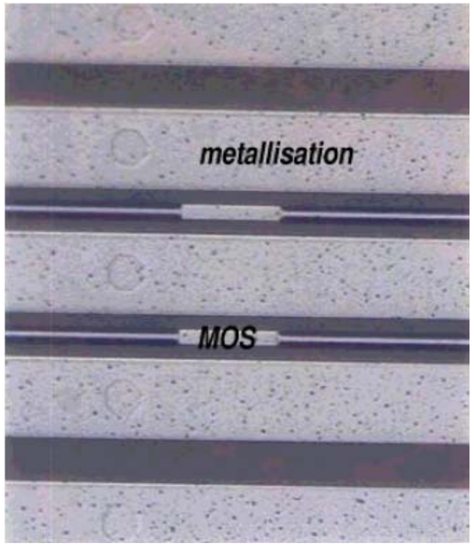
Drift Velocity Calibration

Mobility of electron : μ_e ~ 8 μm/ns

But $V_{drift} = f(HV, T) \propto T^{-2.4}$

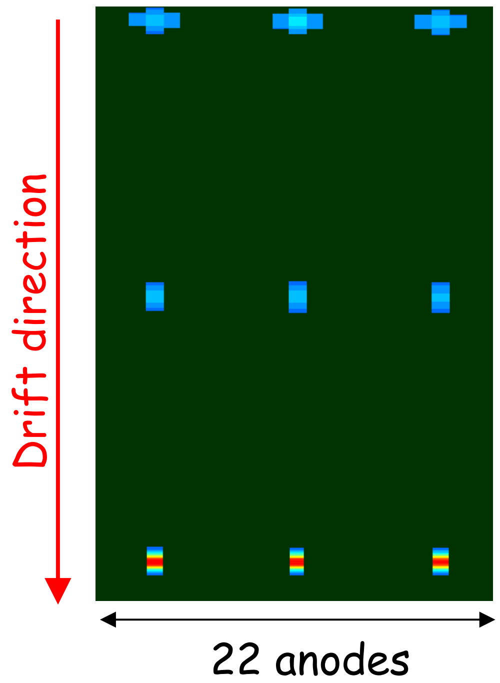
During the experiment, T must be stable within 0.1 K

⇒ Cooling system based on water flowing in tubes along the support
Calibration by using electron injectors (MOS) located at precise locations

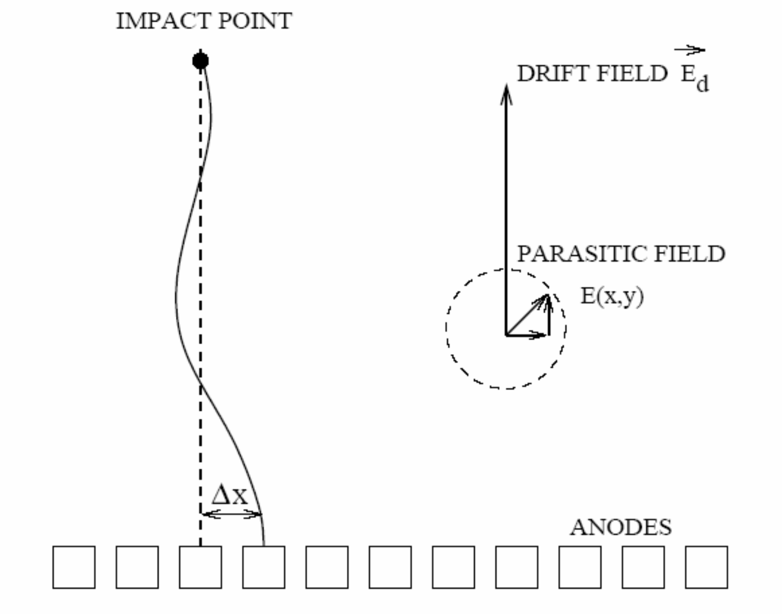


In SDD, there is 3 lines of 33 injectors
1 close to the anods
1 in the middle
1 at the far side

The drift time allows to deduce the velocity of electrons and therefore to make the conversion
$T_{drift} \rightarrow$ Position

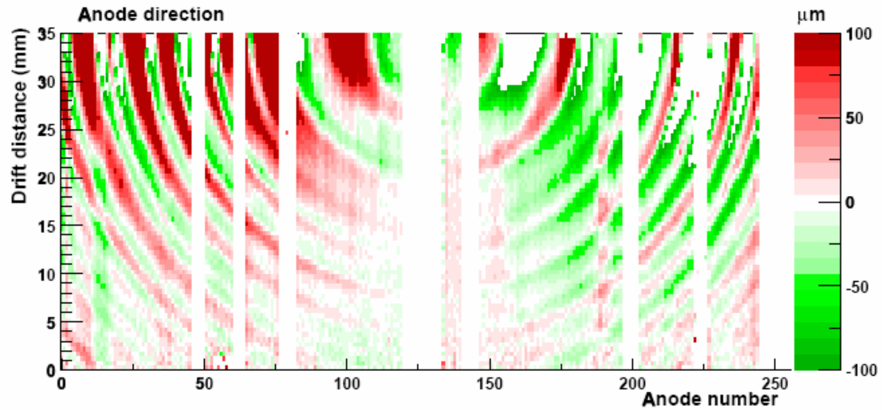


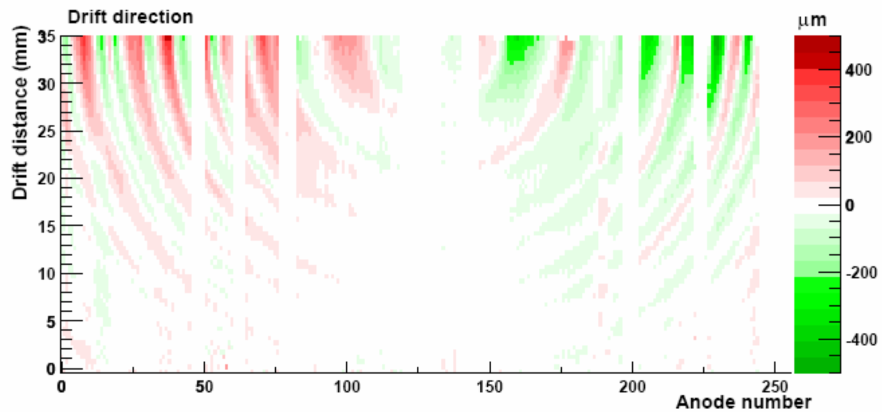
Deviations in Position



Defects in the doping induce Parasitic field (up to ~ 15%)

⇒ Error on the true position





Deviations :

$Pos_{meas} - Pos_{real} \rightarrow \pm 500\ \mu m$ (drift direction)

Systematic effect

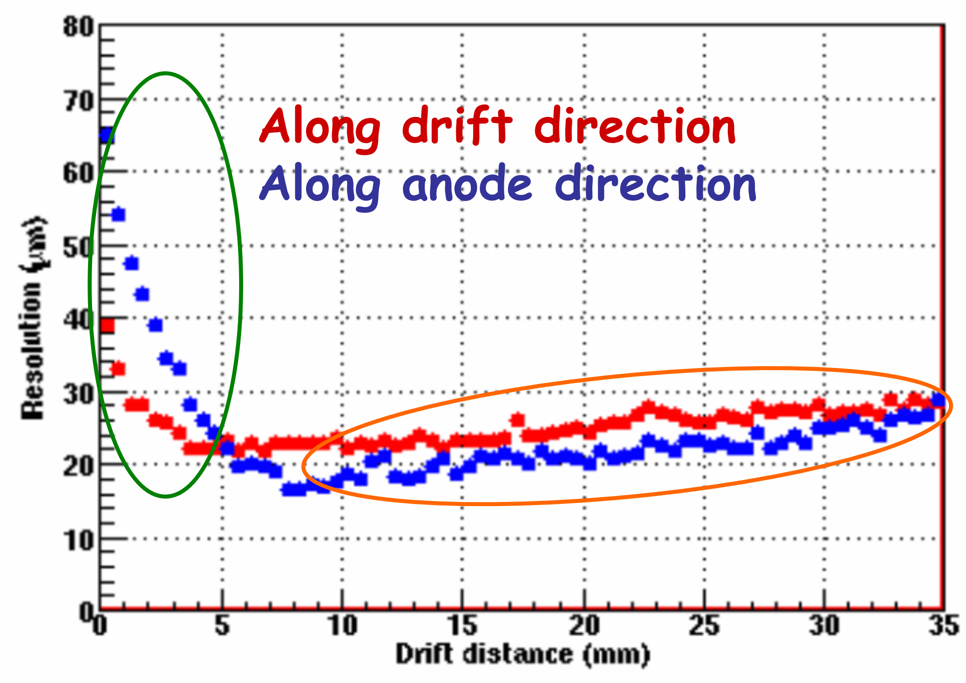
Measured with a laser in order to « map » each detector

SDD Position Resolution

Electron cloud has a 2D gaussian shape

Competition between two effects :

- Position along anodes : centroid on 1-2 bins close to the anodes
- Diffusion : the cloud is spreading in both directions with drift time
  ⇒ amplitude decreases so that ratio Signal/Noise increases



Resolution of about 35μm is achieved

Conclusion

Silicon Drift Detector :

☺ Low noise

☹ Sensitivity to temperature variation (μ_e)

☺ but under control : cooling and injectors

☹ Parasitic field → deviations in measured position

☺ Measurement of these deviations → Correction

+ Other effects (dark current, …)

SDD in ALICE :

Compromise between a good granularity (150x300 μm^2)
and energy loss measurement

Chosen also because the surface is greater than Pixel detector and it costs less

Meet the specifications : resolution of 35 μm
two tracks separation : 600 μm