A novel two-dimensional microstrip sensor for charge division readout

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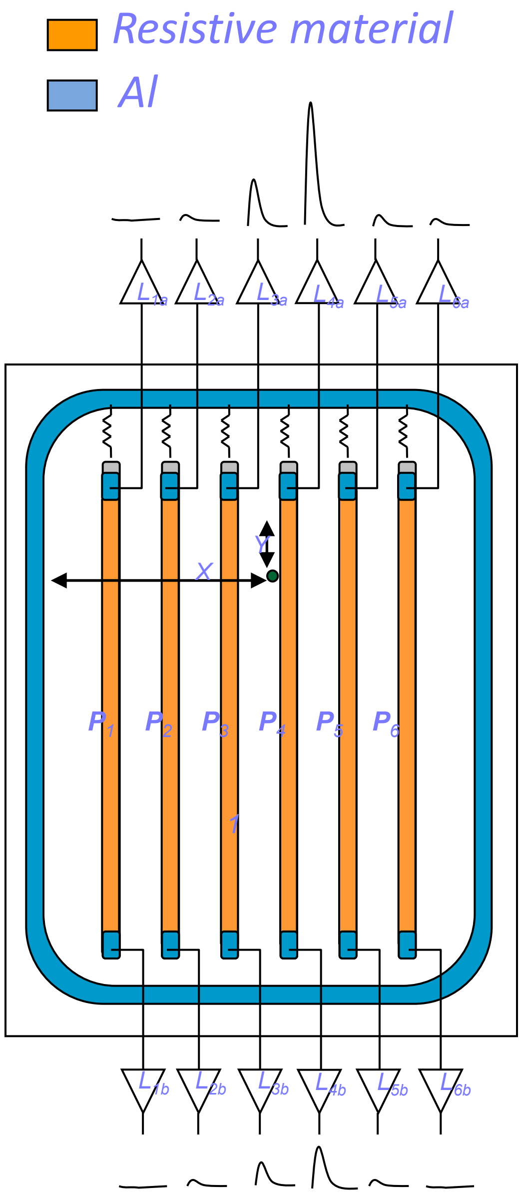
_Outline

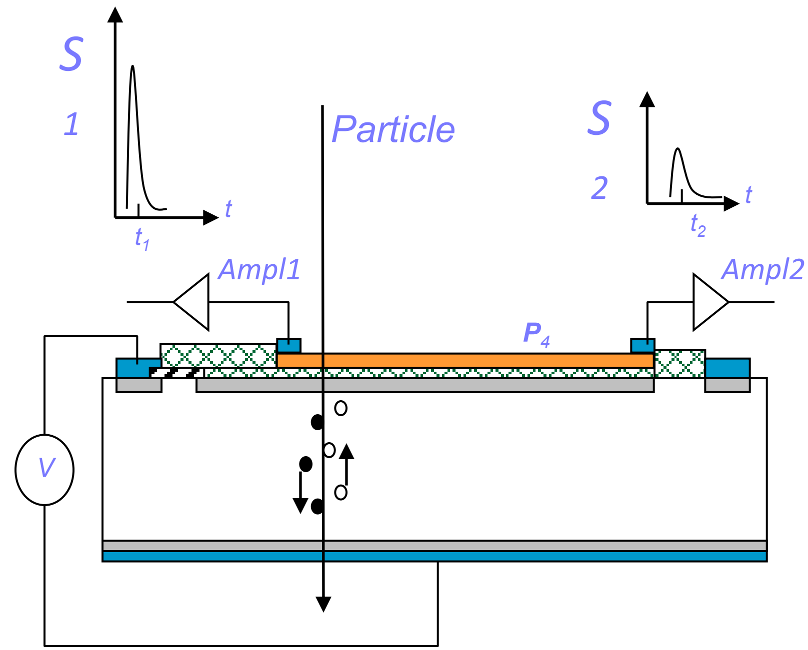
- Sensor's working principle.
- Prototype manufacturing.
- Electrical characteristics.
- Laser and radioactive source characterization.
- Test beam @ SPS.
- Conclusions and outlook.

_Charge division concept



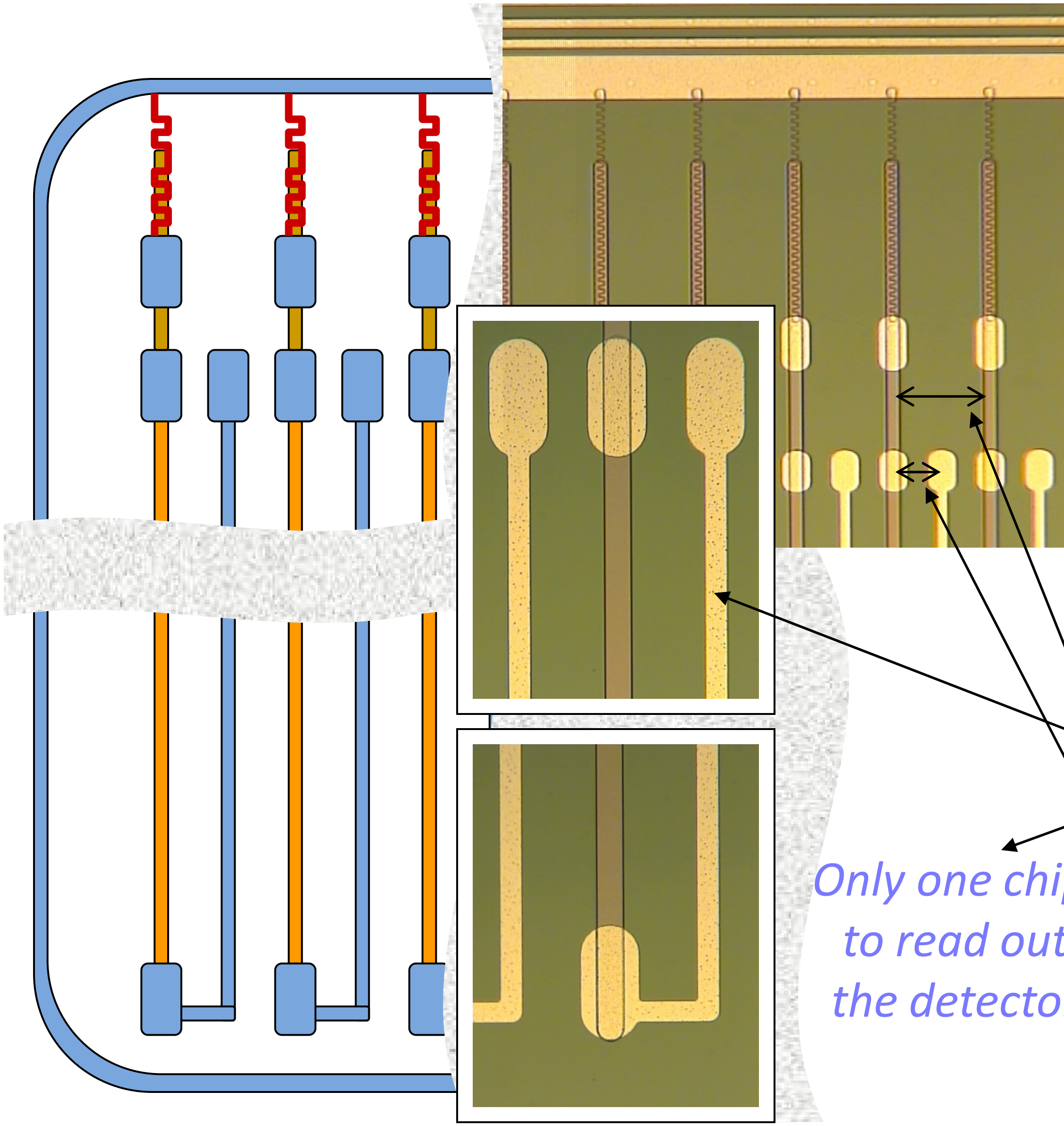
- Charge division used in wire chambers to determine the coordinate along the sensing wire.
- Same concept with conventional microstrips with slightly resistive electrodes

$S_1=f(y)$
$S_2=f(L-y)$



_Concept Demonstrator: P-Si sensor

Designed and produced at IMB-CNM.



standard technology of silicon microstrip detectors. P-on-n, 300 μm thick detectors.

Resistive material = highly doped polysilicon.

strip length= 14 mm.

Two different prototypes with different strip widths:

20 μm and 40 μm.

metal guides to drive the contact pads at the same edge of the detector.

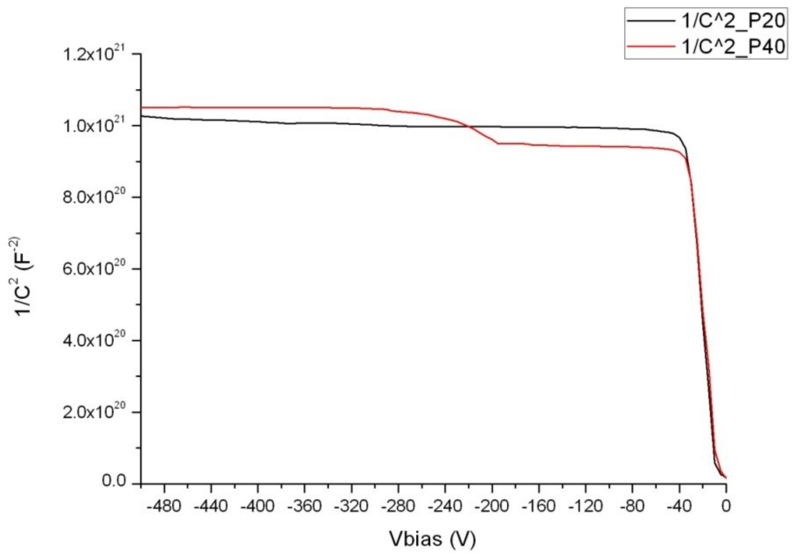
implant pitch= 160 μm

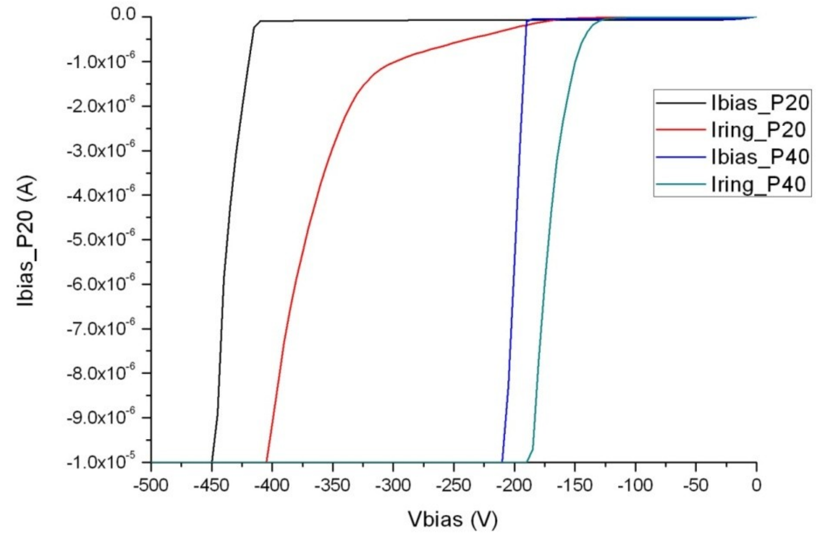
read out pitch= 80 μm

Multiple guard rings.

Only one chip to read out the detector

_Electrical Characterization

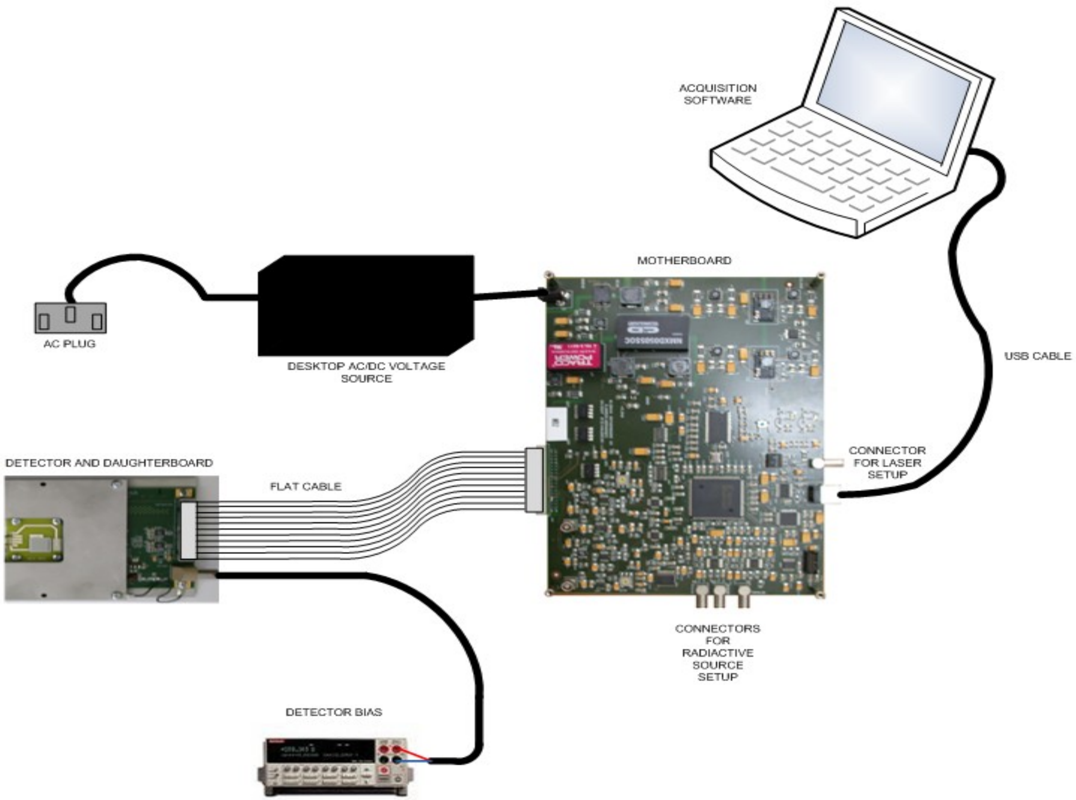


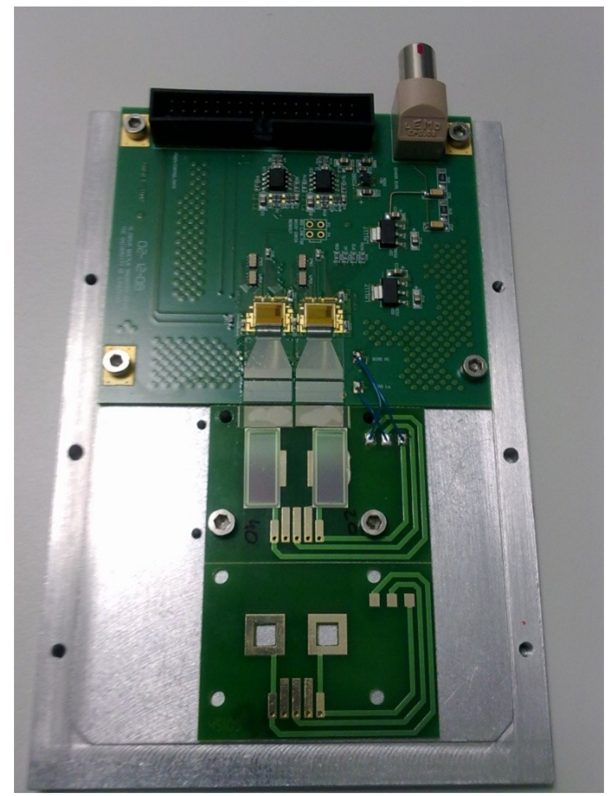


Strip Width	V_{depl}	V_{bd}	R_{bias}	R_{int}	C_{int}	C_{coupl}	$R_{electrode}$/ □	$R_{electrode}$/µm
20µm	40 V	> 400 V	1,31 MΩ	> GΩ	1,32 pF	248 pF	400 Ω/□	20 Ω/µm
40µm	40 V	> 200V	1,37 MΩ	> GΩ	1, 60 pF	487 pF	400 Ω/□	10 Ω/µm

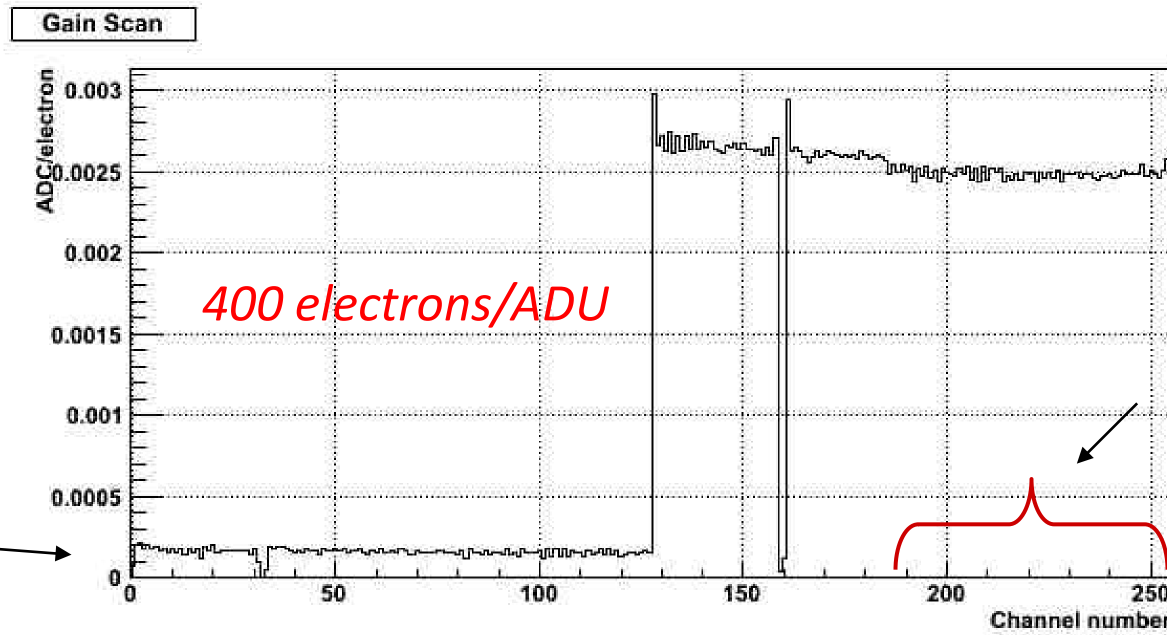
_Readout Electronics

ALIBAVA SYSTEM – Sensors P20 & P40 bonded at IFIC

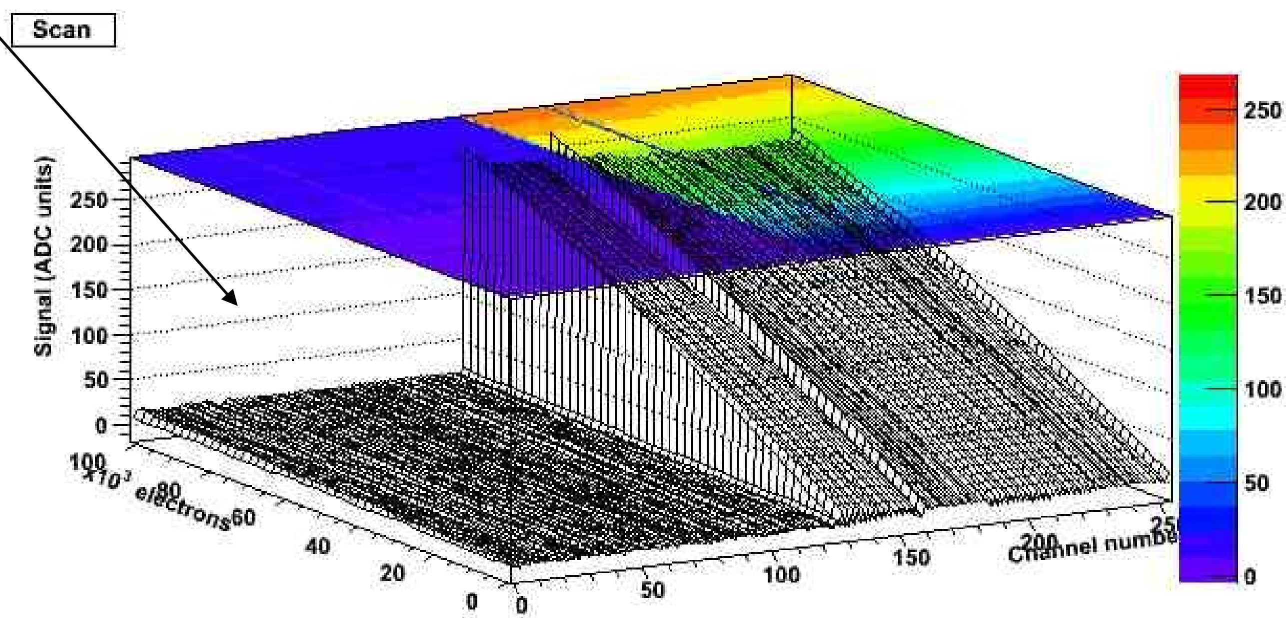




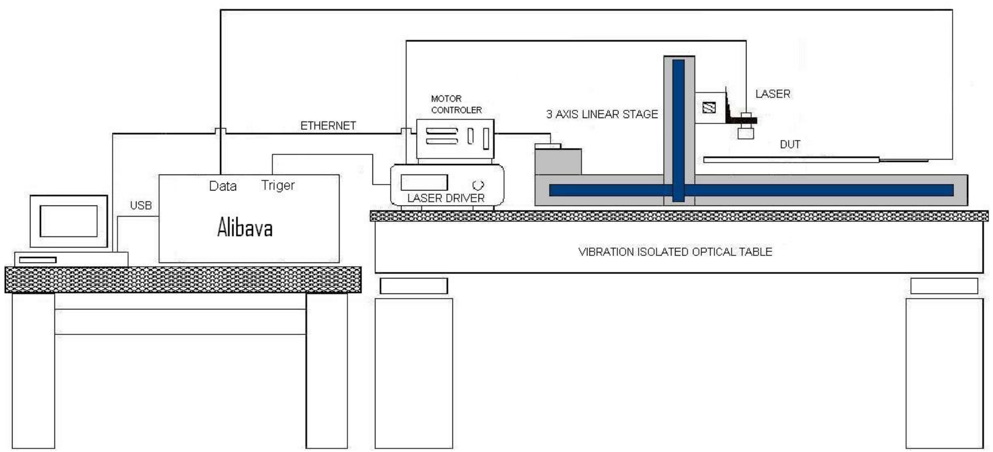
FE chip calibration

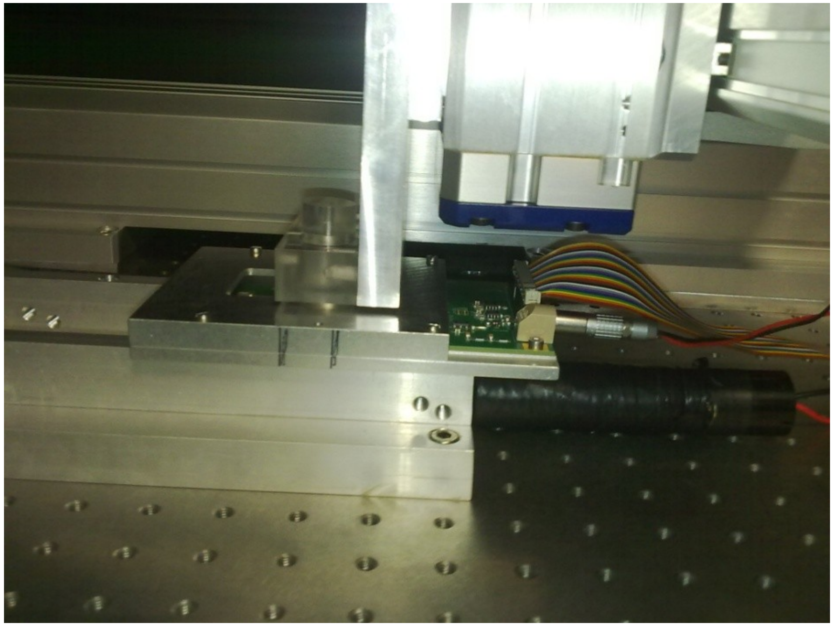


Chip 1 did not perform calibration



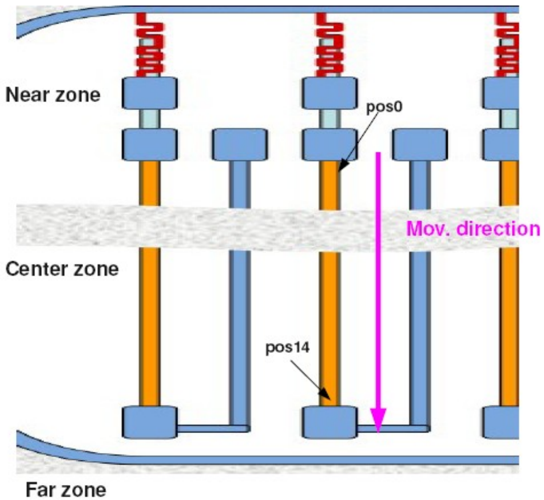
Laser characterization: test stand

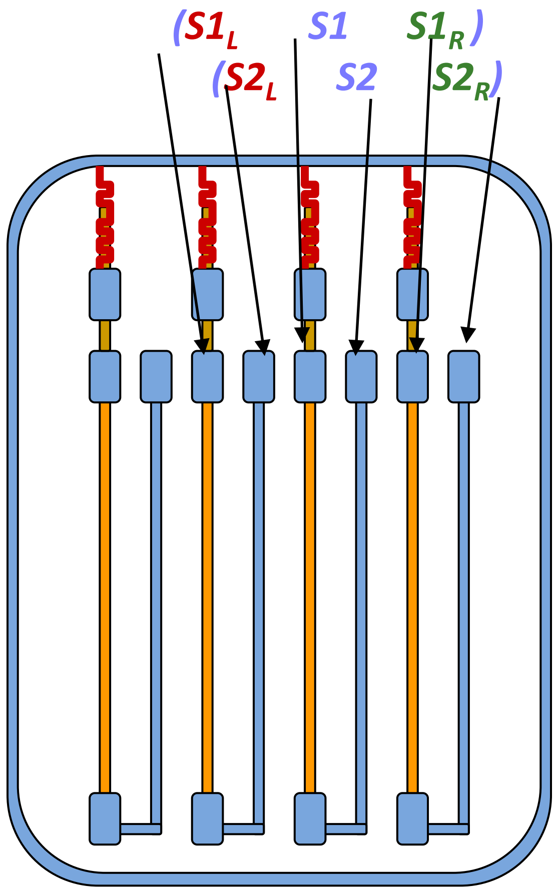




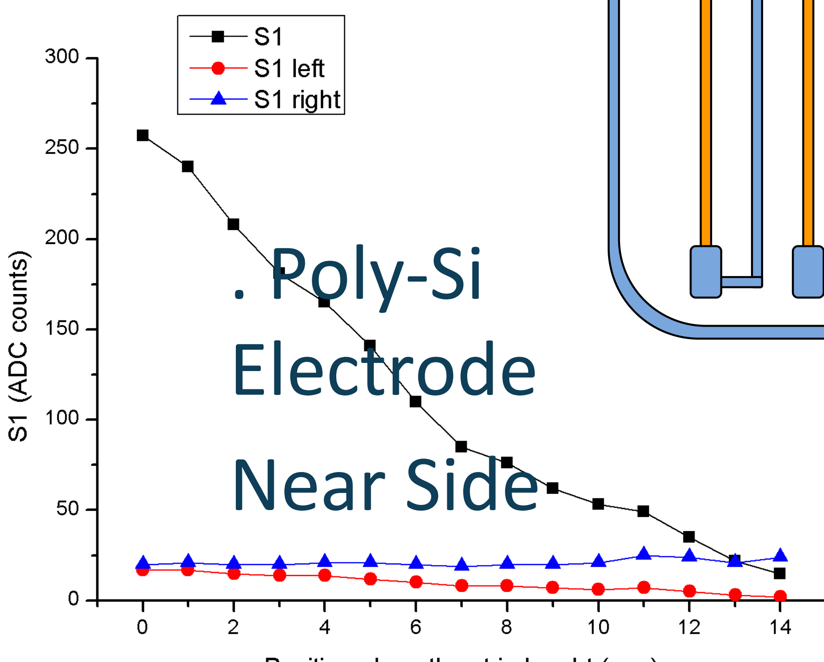
– Laser head on 3D platform (~ 5 um accuracy):
  - Gaussian profile with microspot width $2\sigma < 10$um
  - Wavelength 1080 nm
  - Pulse duration < 1ns
  - Pulse energy ~ 10% gaussian fluctuation.

Laser Longitudinal scan



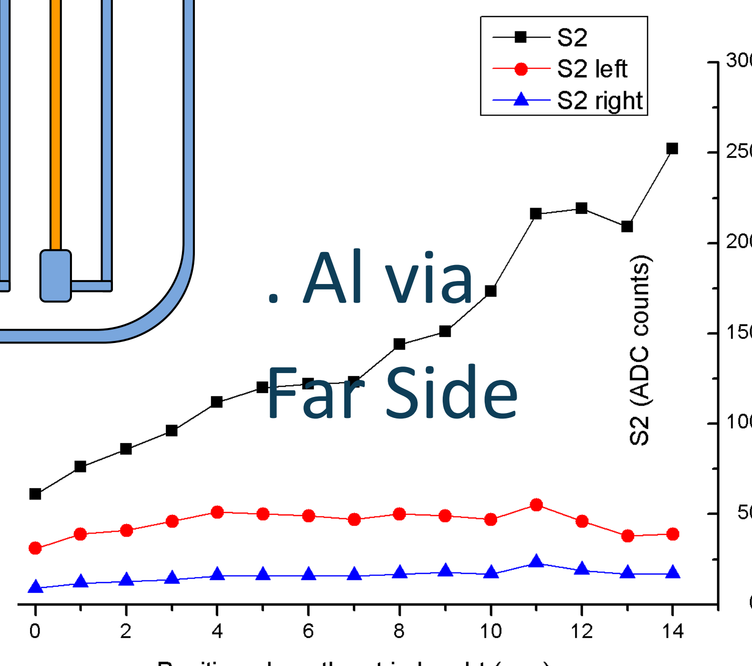


. Laser scanned along the polysilicon electrode



. Poly-Si Electrode

Near Side



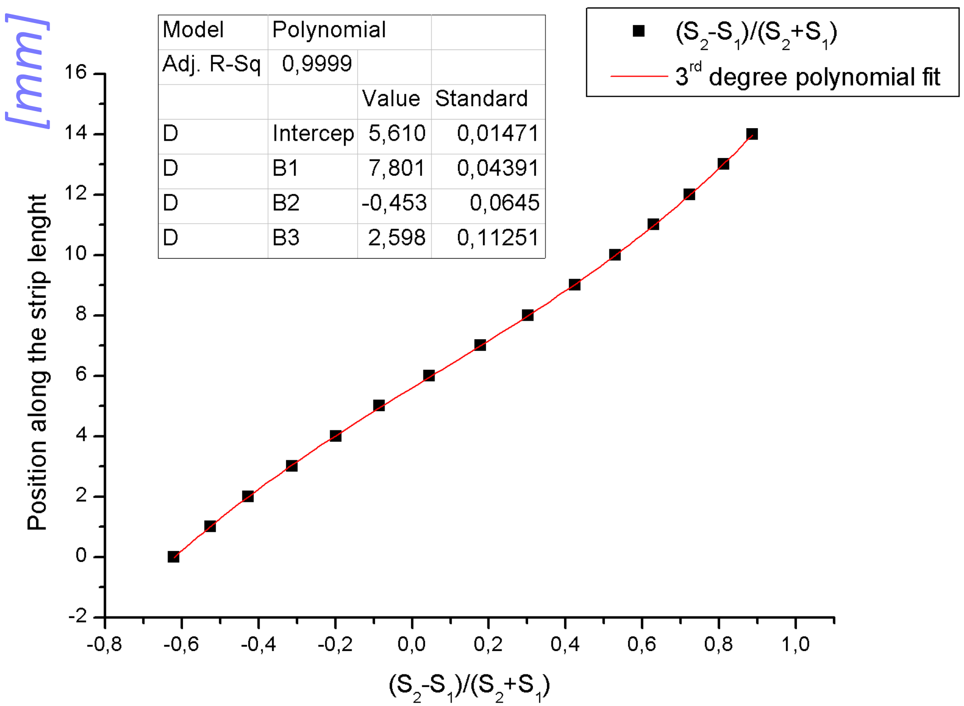
. Al via

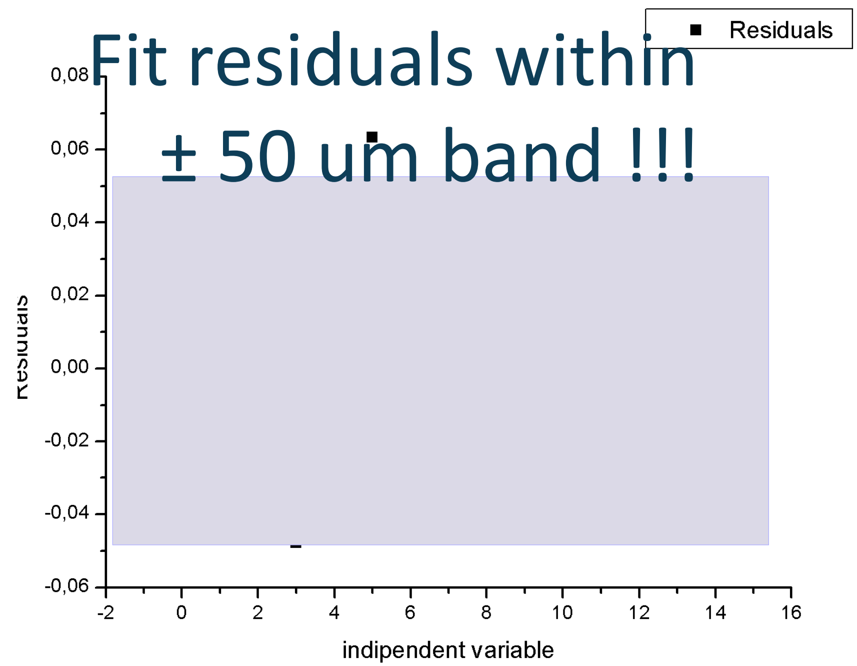
Far Side

Longitudinal coordinate from Q_{div}

– Naïve computation of position along the strip:

$$y = \frac{Q_{far} - Q_{near}}{Q_{far} + Q_{near}}$$





Fit residuals within ± 50 um band !!!

Longitudinal coordinate: Simulation vs. measurement

Spice simulation using electrical parameters

five strips (R_{str}, C_{cou}, R_{met}).

interstrip circuital elements (C_{int}, R_{int}, C_{m}, C_{p}).

bulk representation (R_{sub}, C_{sub}).

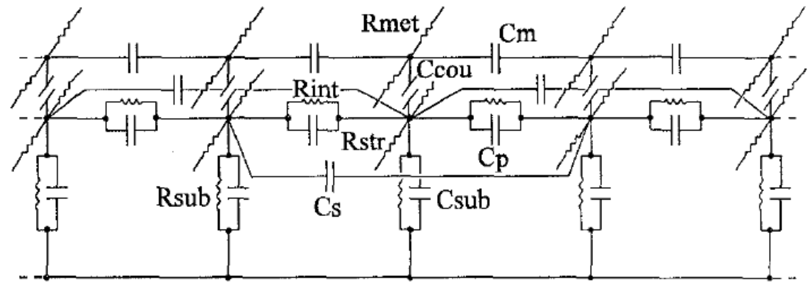
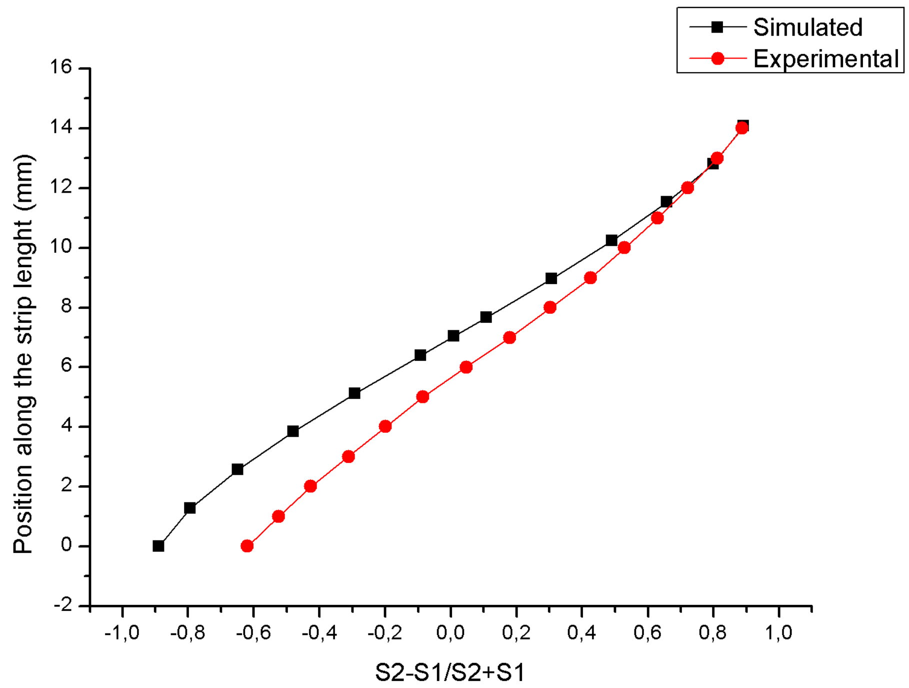


Fig.1 SPICE equivalent model of the microstrip detector.

– Overall shape reproduced.

– Bias introduced by direct coupling of the pulse to the Al via.



SNR determination

- Laser characterization demonstrated the soundness of the charge division method for strip sensors.
- Increased level of noise but not much (900 ENC)
- In the real world:

  What signal/noise ratio we should expect for a MIP particle ?

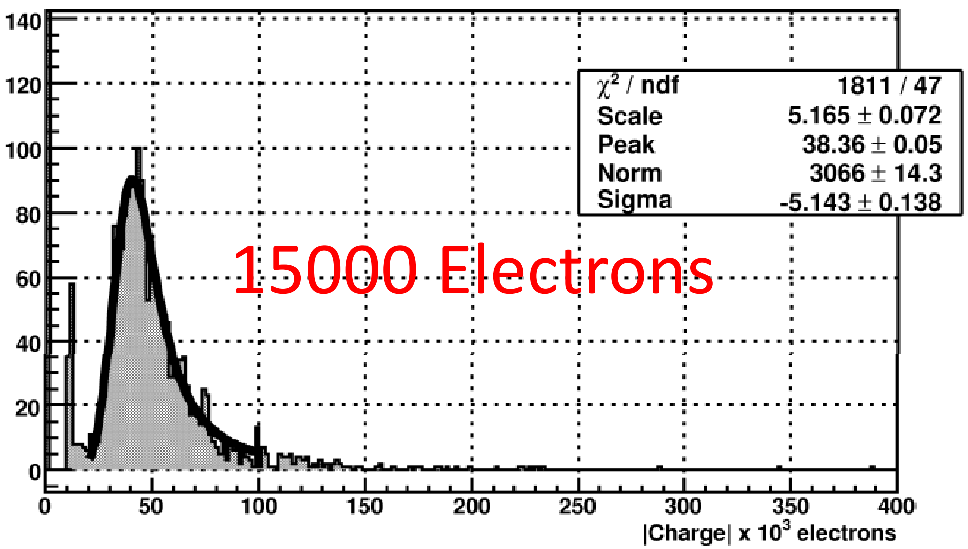
↓

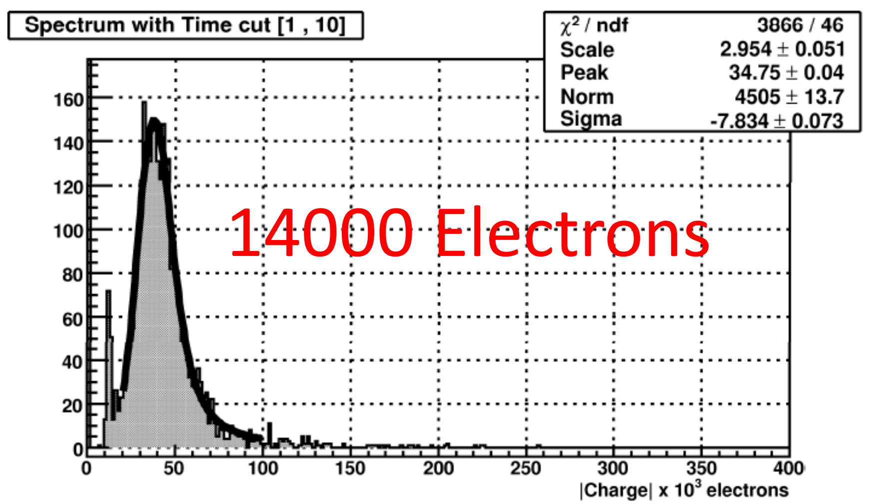
Sr90 beta source

120 GeV Pion test beam at SPS.

Sr90 Beta source

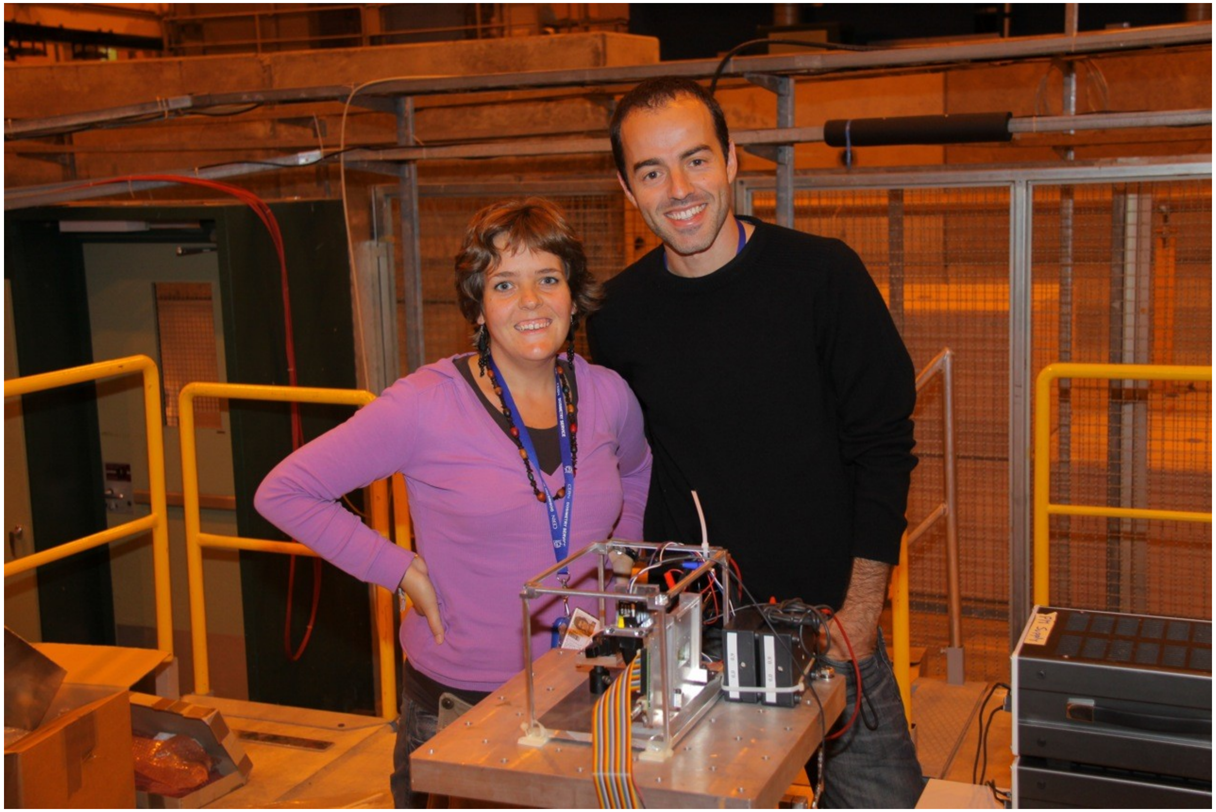
- Collimated (1mm) β-source, at the strip center
- Signal / Noise ~ 15



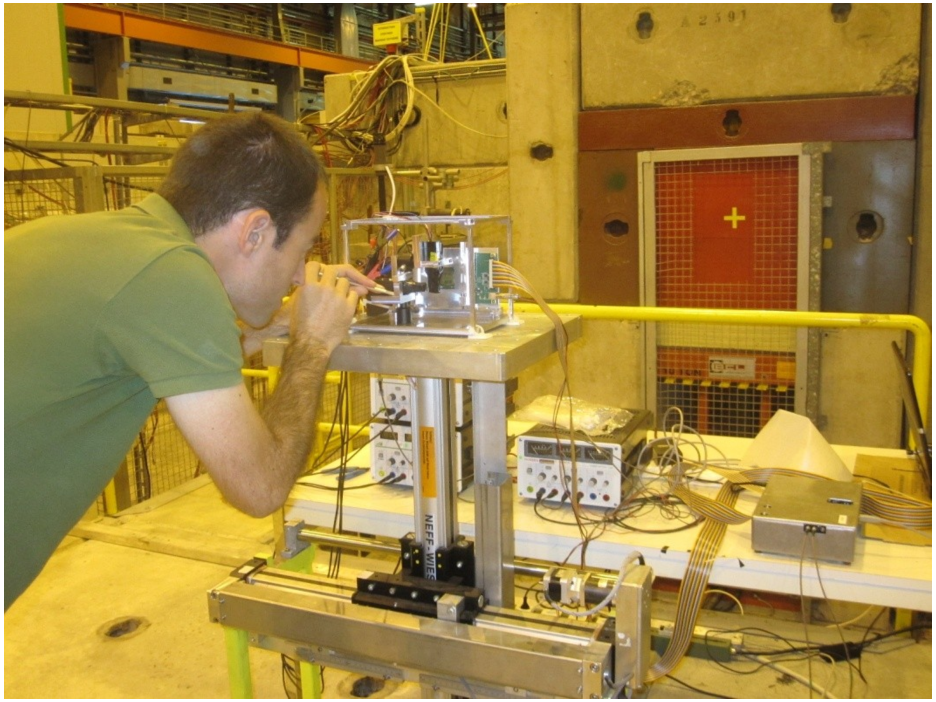


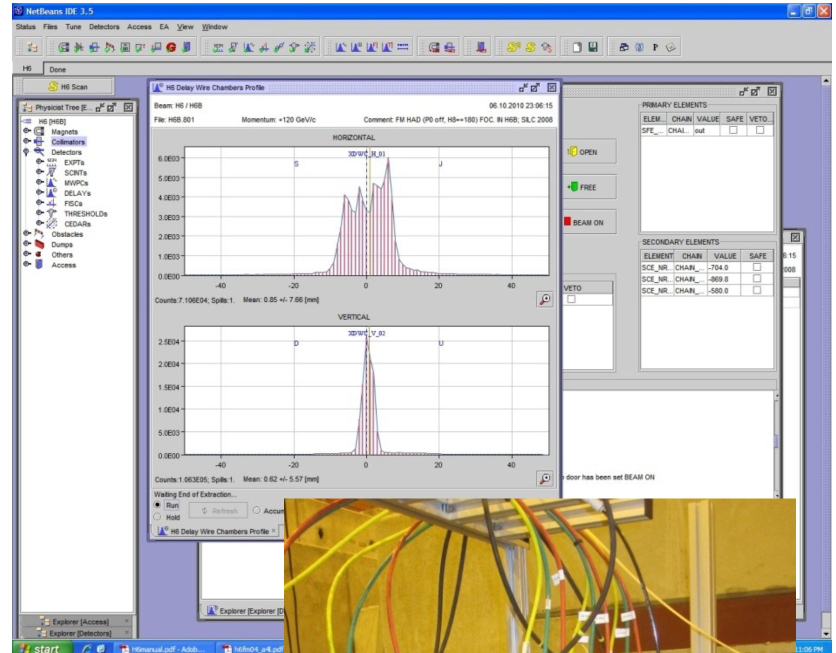
Test Beam @ SPS

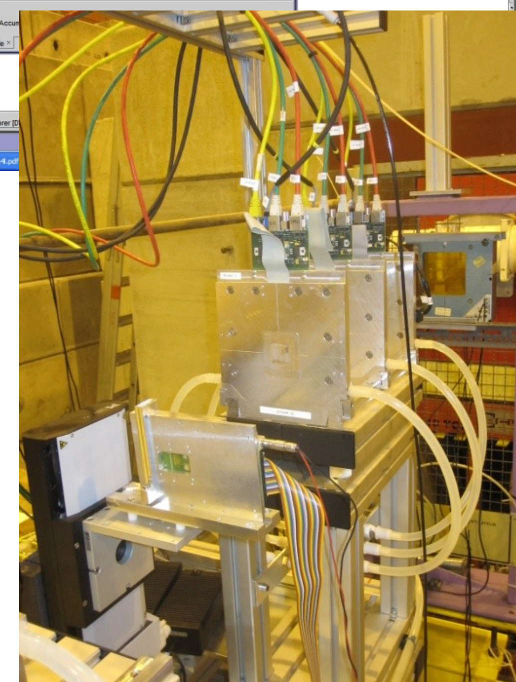
- During the first week of October testing at SPS pion beam in parasitic mode:
  - Standalone Testing (ALIBAVA daq) around 800Kevt.
  - Inside the EUDET mimosa telescope (APV25 daq)



Test Beam @ SPS (2)





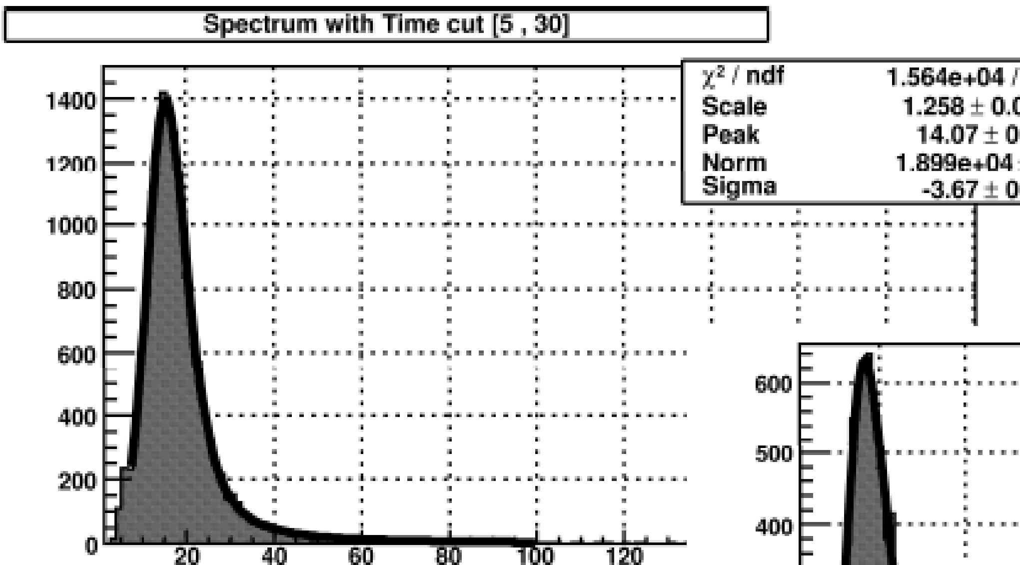


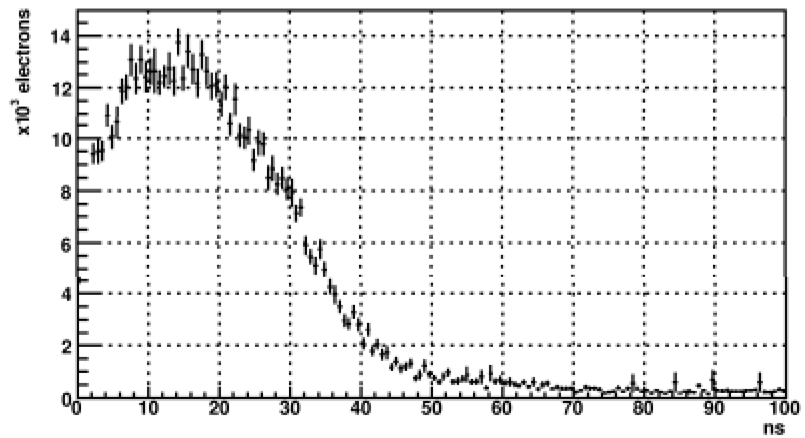
- SPS beam very stigmatic along the longitudinal (strip) direction.
- Last run with ALIBAVA as DUT inside EUDET telescope (BUT TLU too long trigger delay)

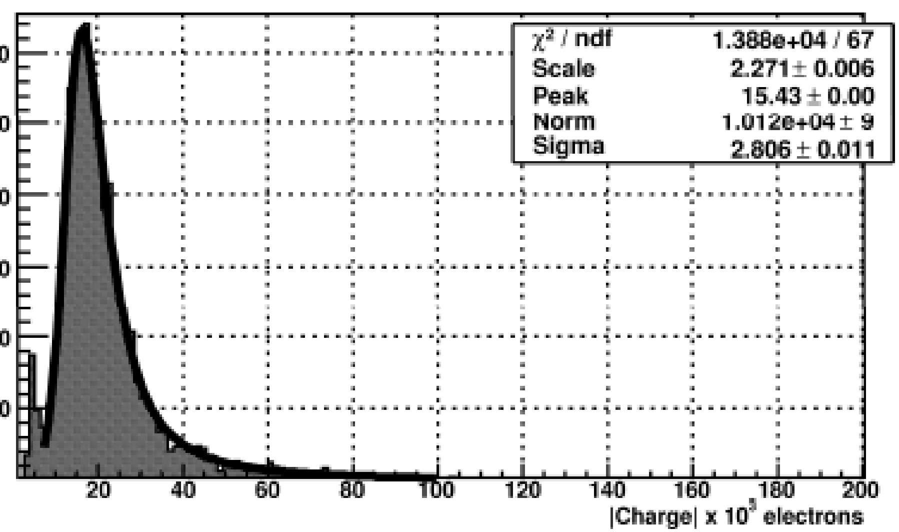
Test Beam @ SPS (3)

Signal Spectrum

& pulse shapes





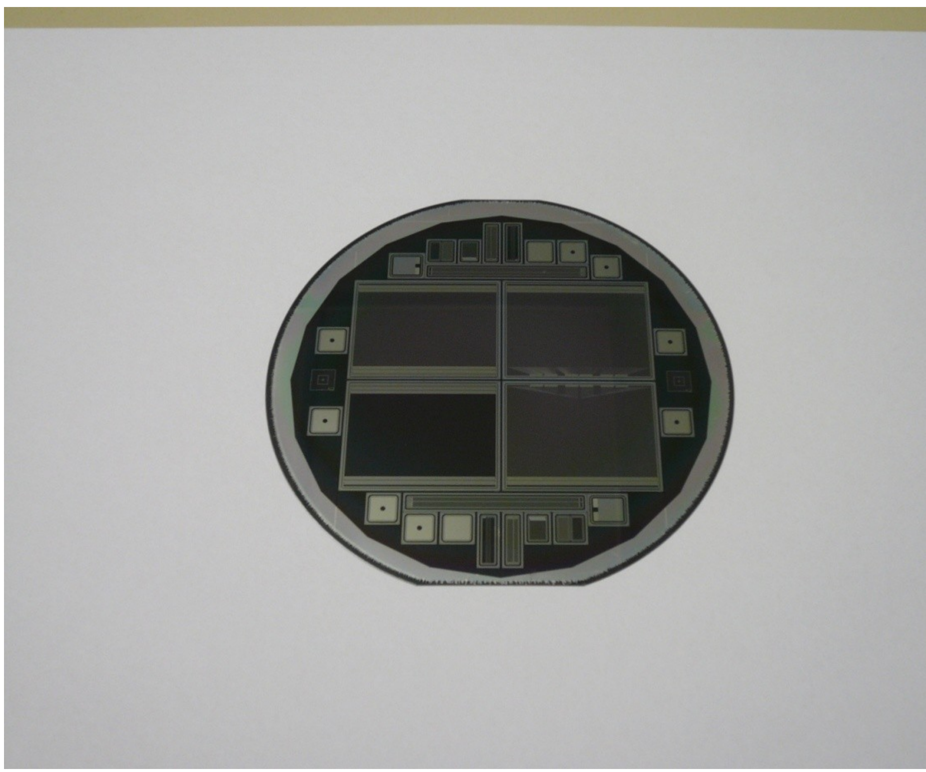


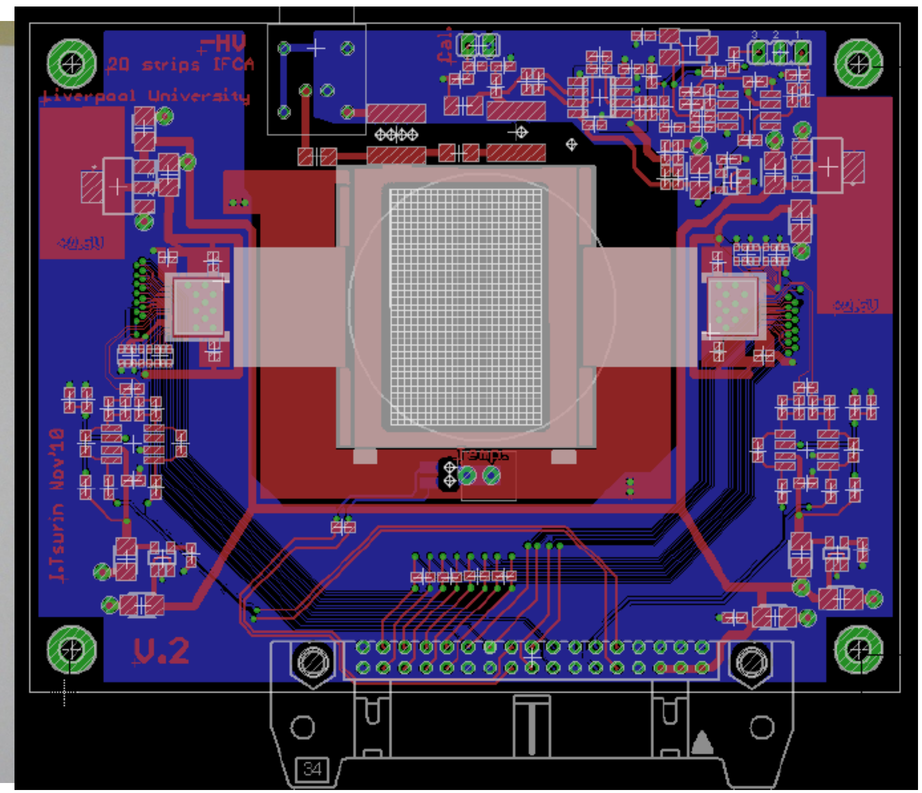
Short term plans

- Almost all the data to be analyzed from the test beam: ALIBAVA & AVP25 (Including EUDET telescope tracking).
- New 2D strip sensor of larger dimensions (~3 cm) already produced at CNM.
- Designed with contacts at both strip ends to be read out by two independent FE chips.

A longer desmostrator

– Each wafer: one reference sensor, poly sensor and two DML integrated PA sensors
– Reduced polysilicon resistivity (366 and 84 Ohm/□)
– Modified ALIBAVA daughter board to boh side read out





Conclusions

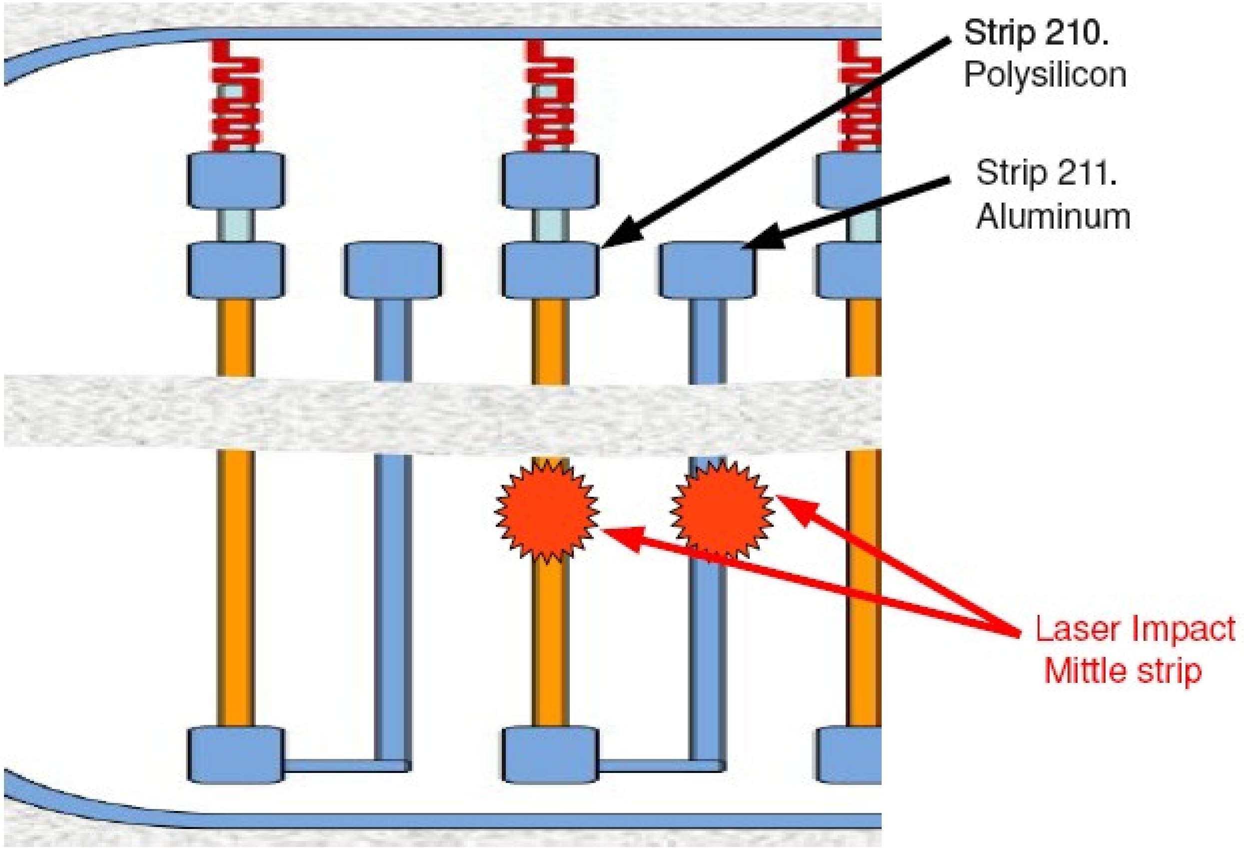
- We have demonstrated the feasibility of the charge division method in microstrip sensors to determine the coordinate along the strip.
- Resolution in the determination of the strip coordinate about few tens of micron.
- We have used the standard (cheap) technology to produce this genuine 2D single sided strip detector.
- Possible application targets:
  - Future detector outer trackers (trigger capable modules)
  - Ion tracking systems.
  - Neutron imaging (+ conversion element).
  - Space applications.
- New few cm long demonstrator under preparation

THANK YOU

BACK-UP

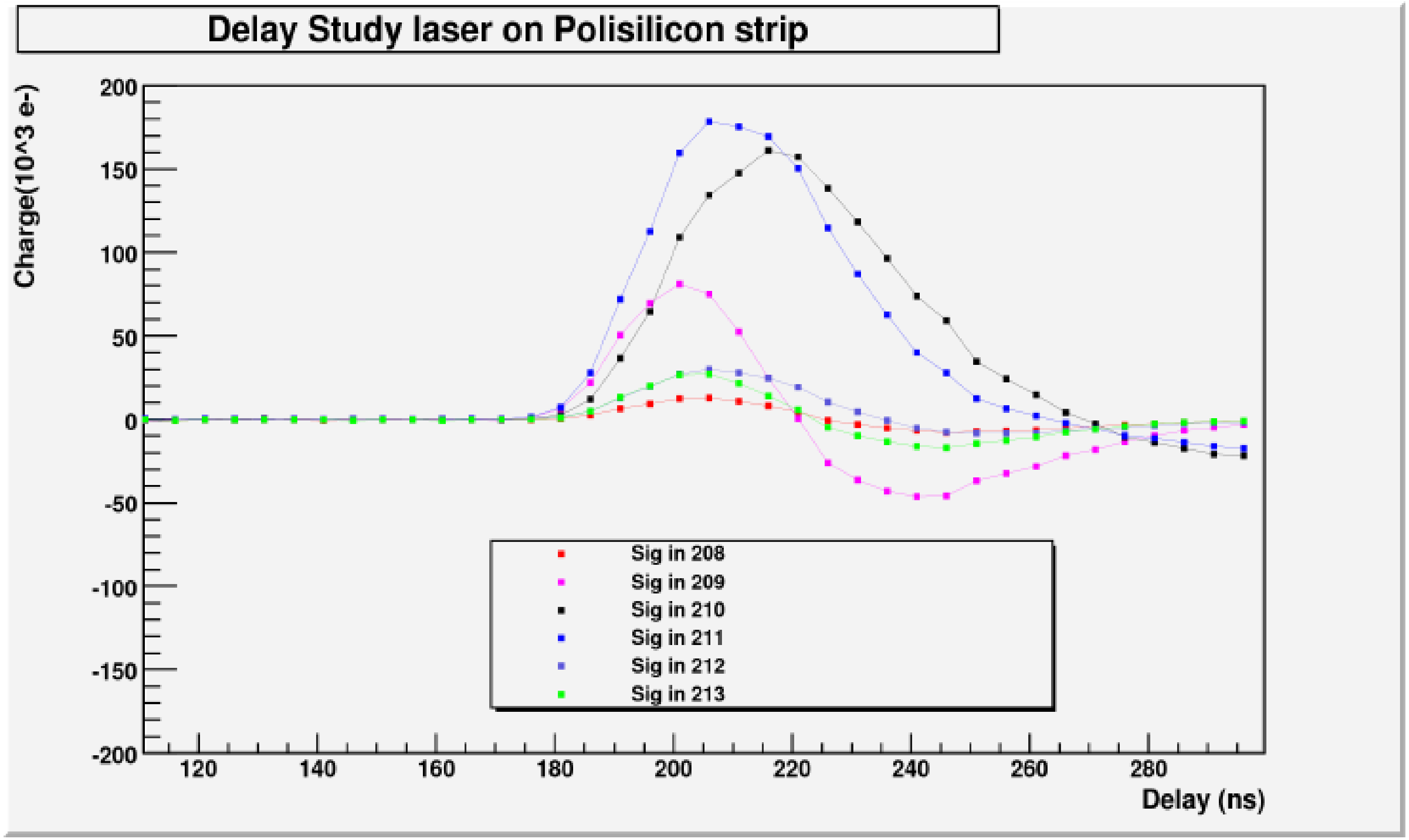
Signal directly induced in the metal via from sensor far side (1)

Impact points. Strip Center

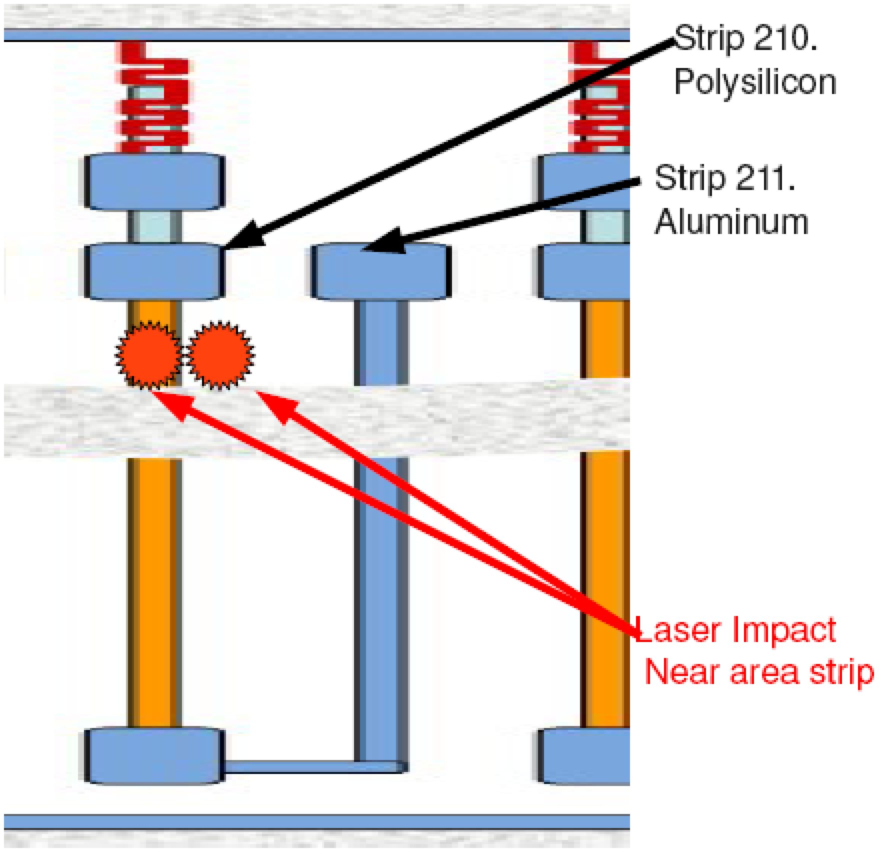


Signal directly induced in the metal via from sensor far side (2)

Polysilicon strip



Signal directly induced in the metal via from sensor far side (3)



Signal directly induced in the metal via from sensor far side (4)

Polysilicon strip. Near Area