New semiconductor 2D position-sensitive detector

Technology and Instrumentation in Particle Physics 2011

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Outline:

Recalling the charge division principle

Description "proof of concept" prototypes

Laser and ^{90}Sr source characterization

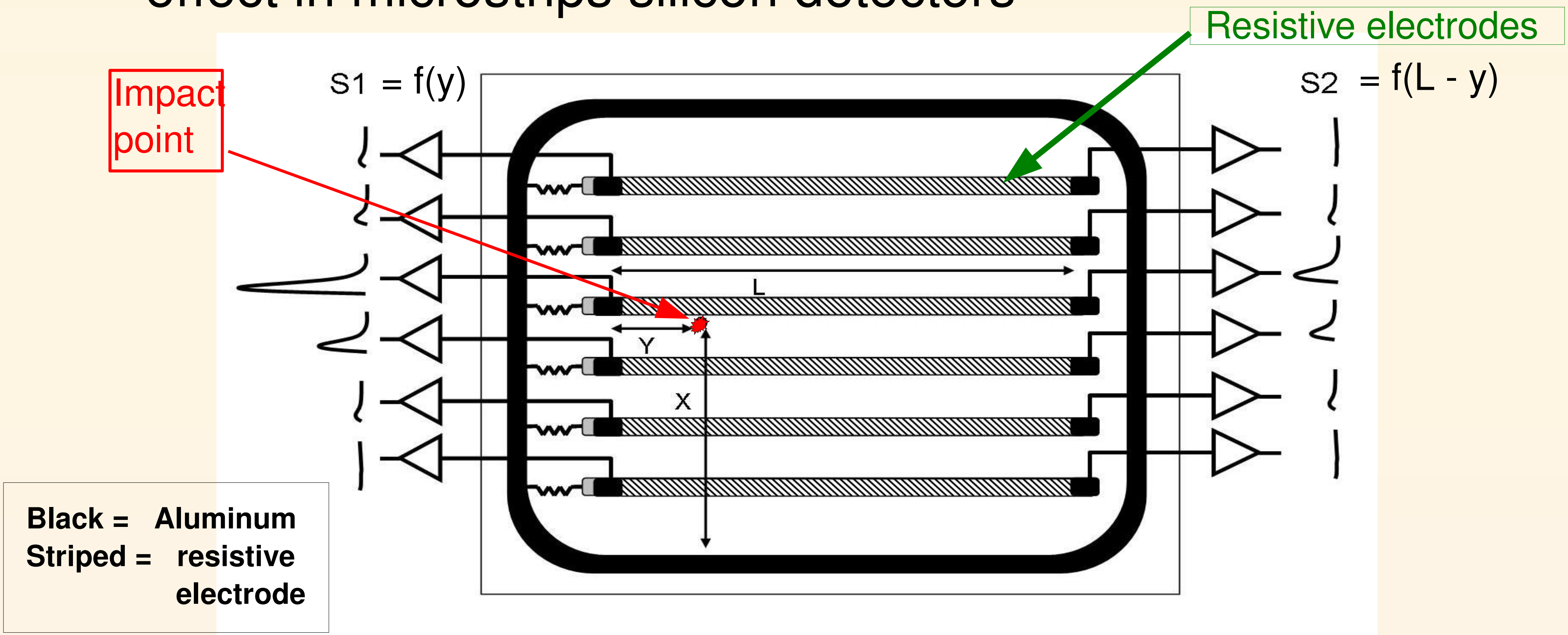
Results from test beam @ SPS (CERN)

Few words about second Prototype

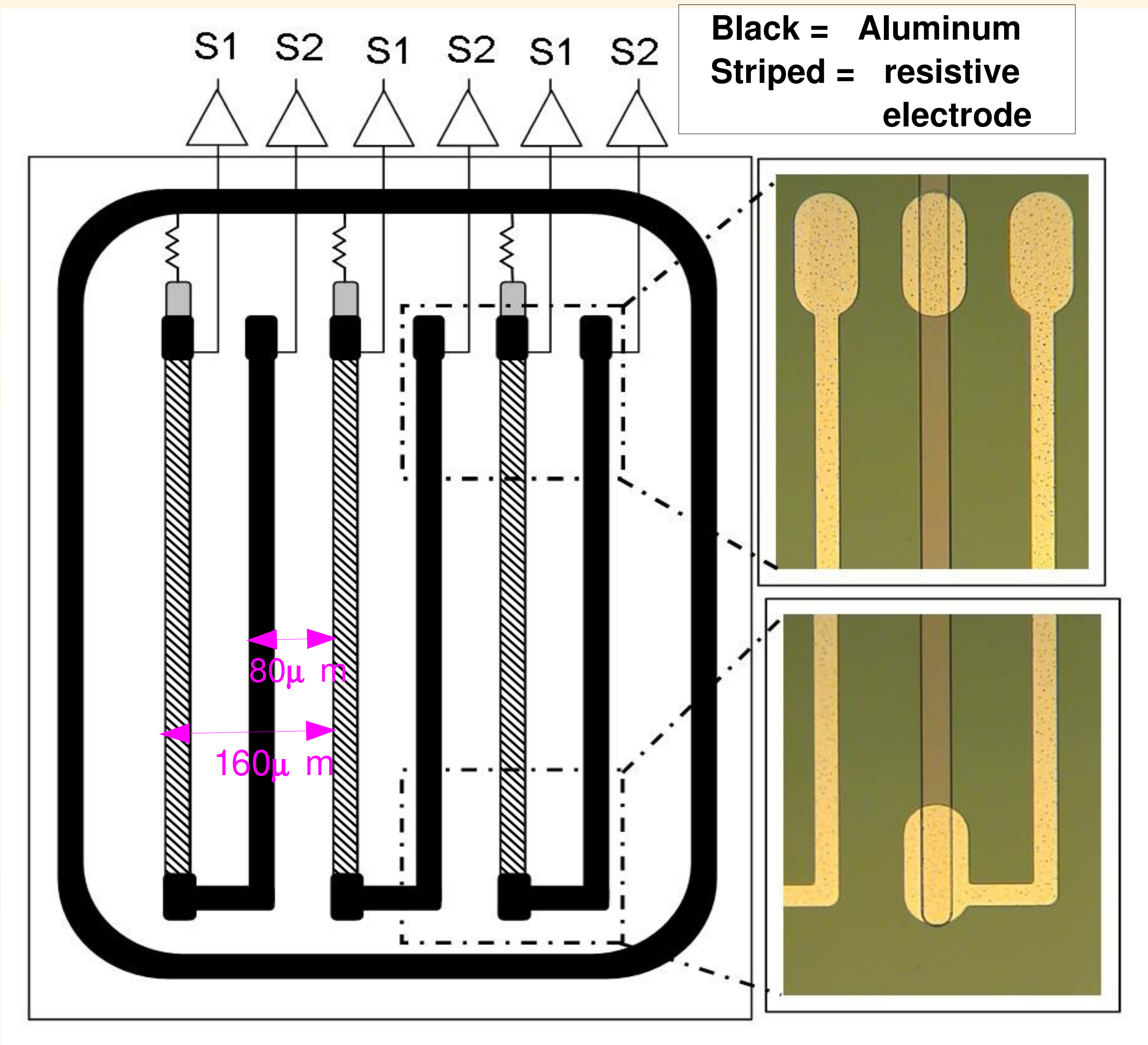
Next steps & Conclusions

Charge division principle

- Charge division in wire chambers is used to determine the coordinate along the sensing wire
- Electrodes with slightly resistive material produce same effect in microstrips silicon detectors



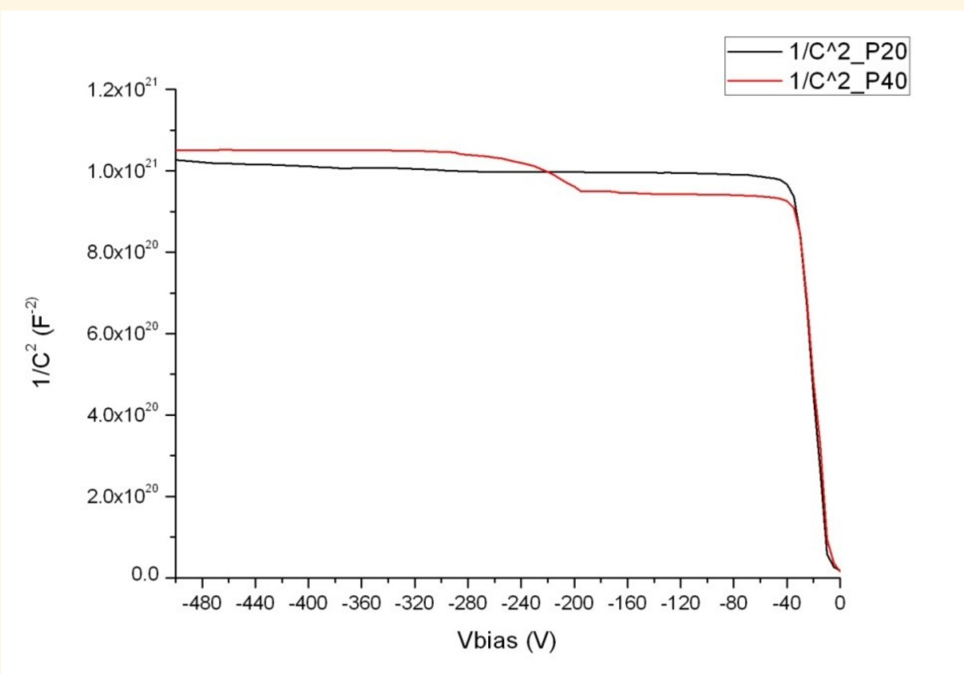
First prototype and main characteristics

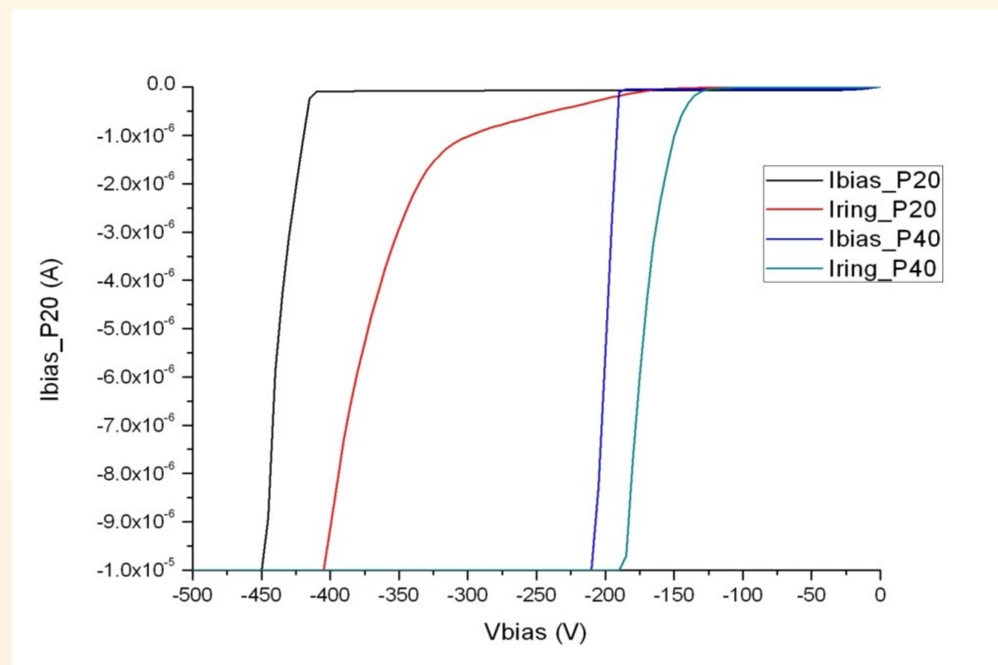


* The **first prototypes** of the new sensors have been designed and produced at the **IMB-CNM** facilities
* Standard planar **technology** p-on-n, 300 μ m thick
* Highly doped **polysilicon** as resistive electrode
* Strip length = 14 mm
* 68 strips/detector
* 2 prototypes with different strip widths: (20,40) μm
* Aluminum via to drive the contact pads at the same edge of the detector. **Only 1 chip to readout 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



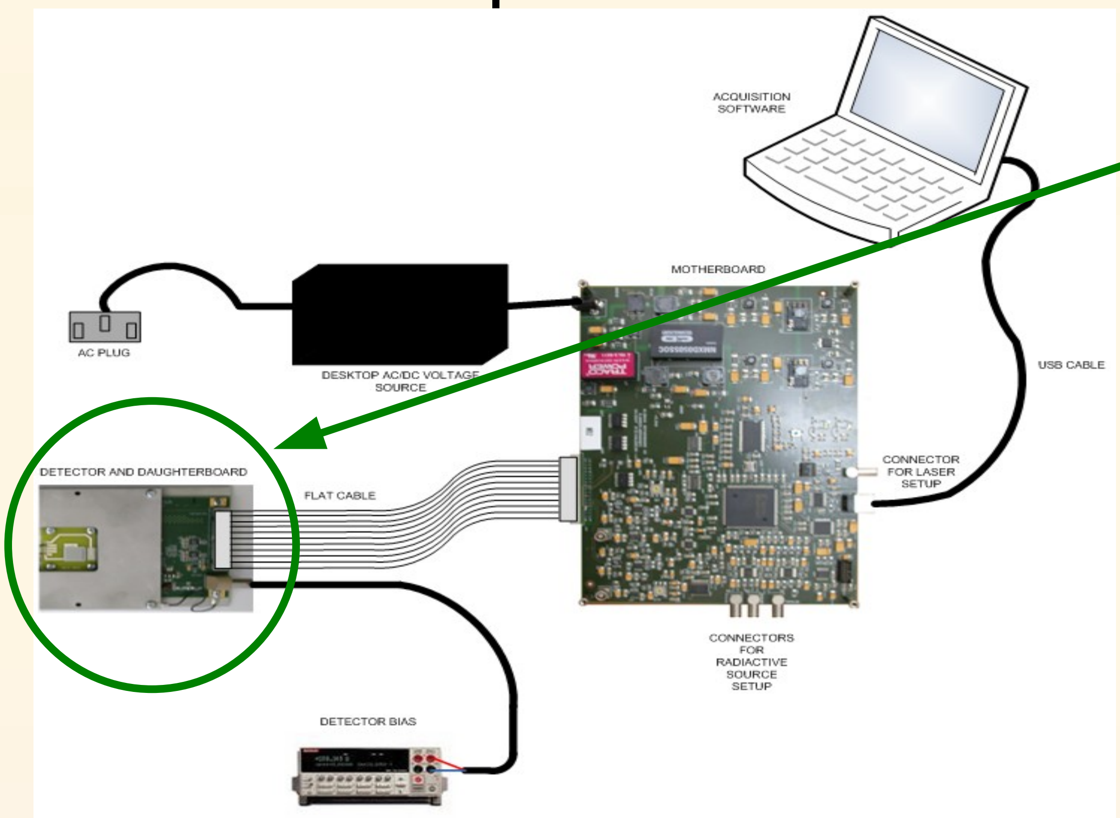


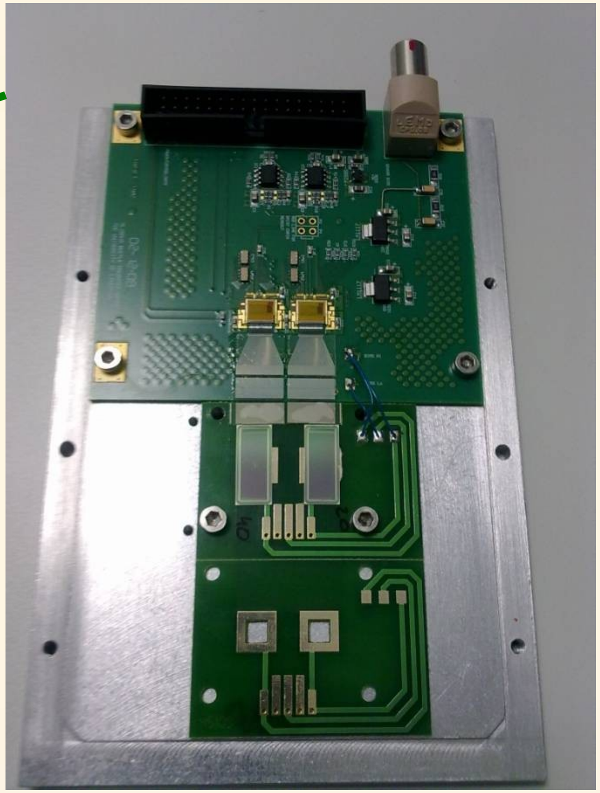
Readout electronic: ALIBAVA

Portable system

Beetle chip

Daughter board & detectors



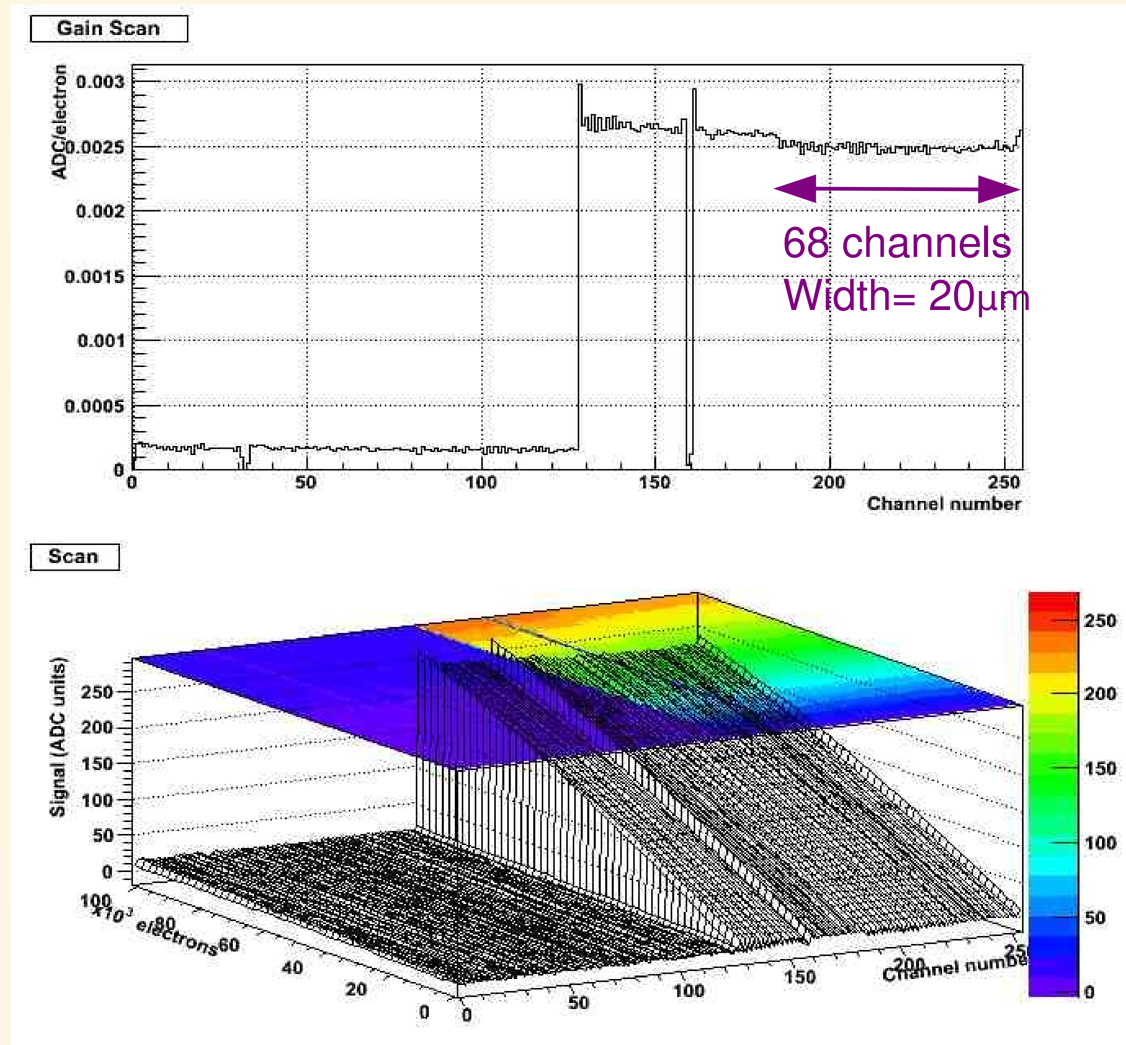


Chips calibration

* *Chip1* Did not perform the calibration

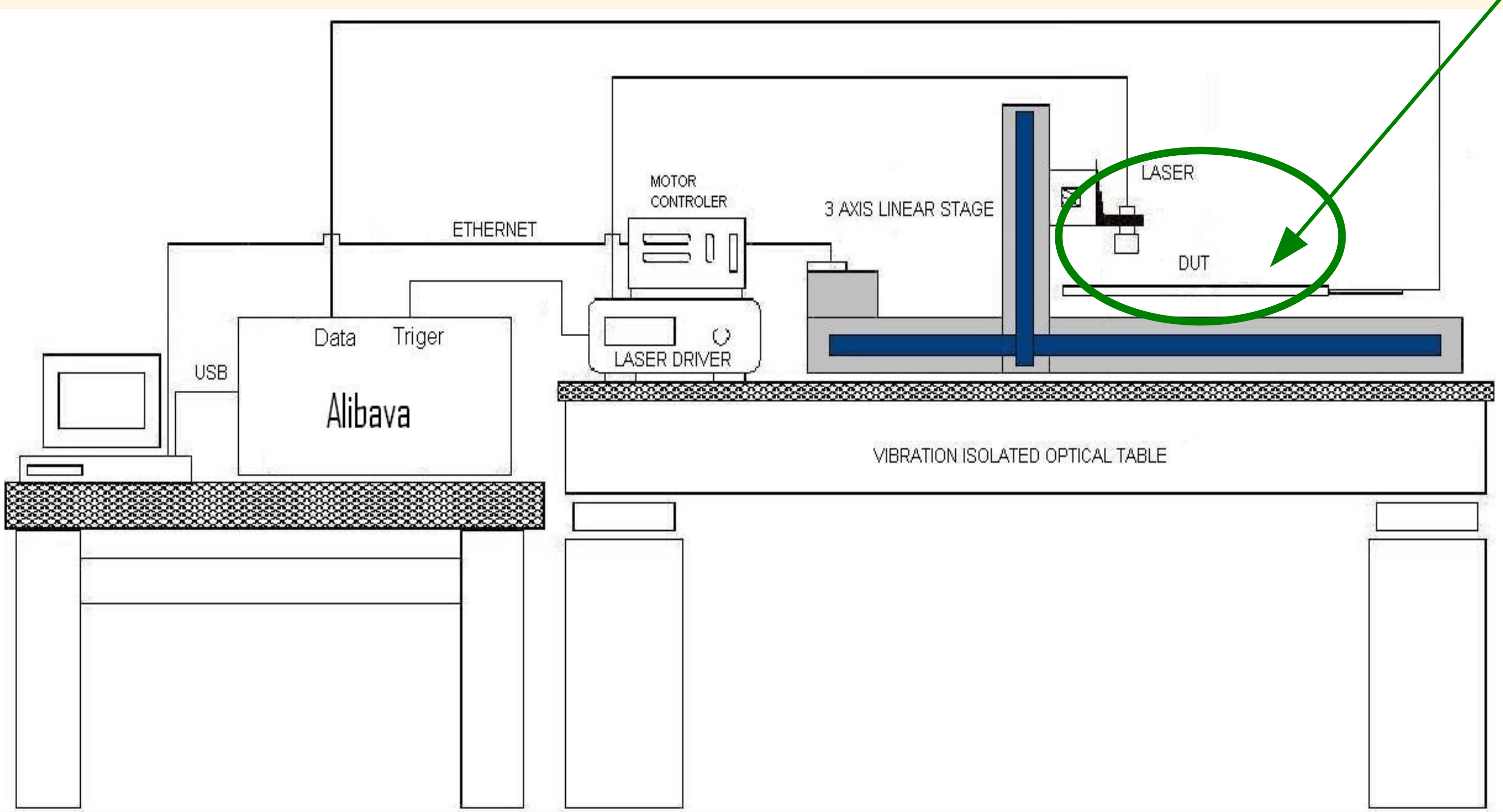
* No data for detector with a width of 40µm

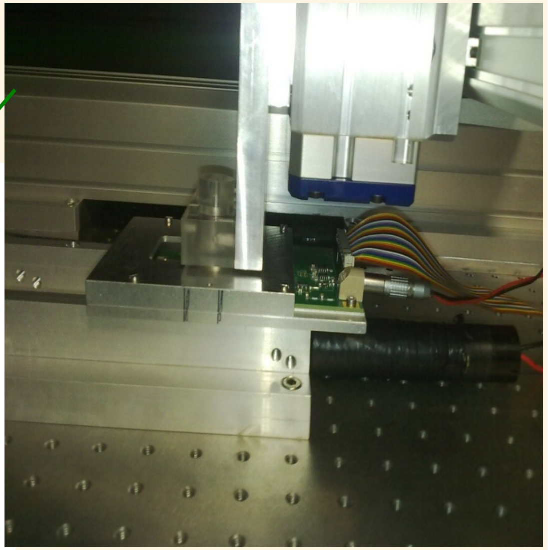
* Linearity on the response



Laser characterization.
Test stand

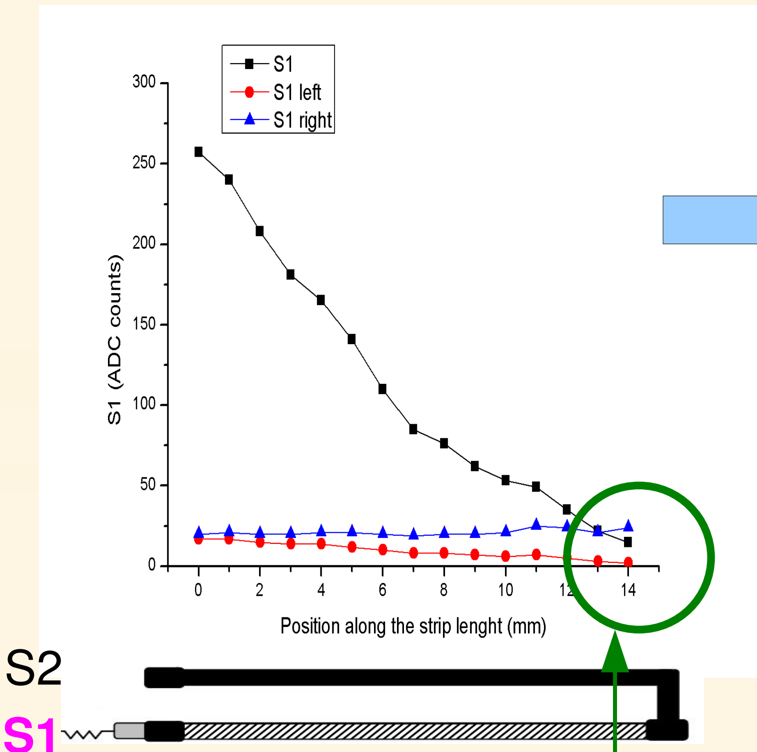
* 3D stage platform. ~ 5μm accuracy
* λ = 1080 nm
* Gaussian profile. Microspot width $2\sigma < 10$ μm
* Pulse duration <1ns
* Pulse energy ~ 10% gaussian fluctuation

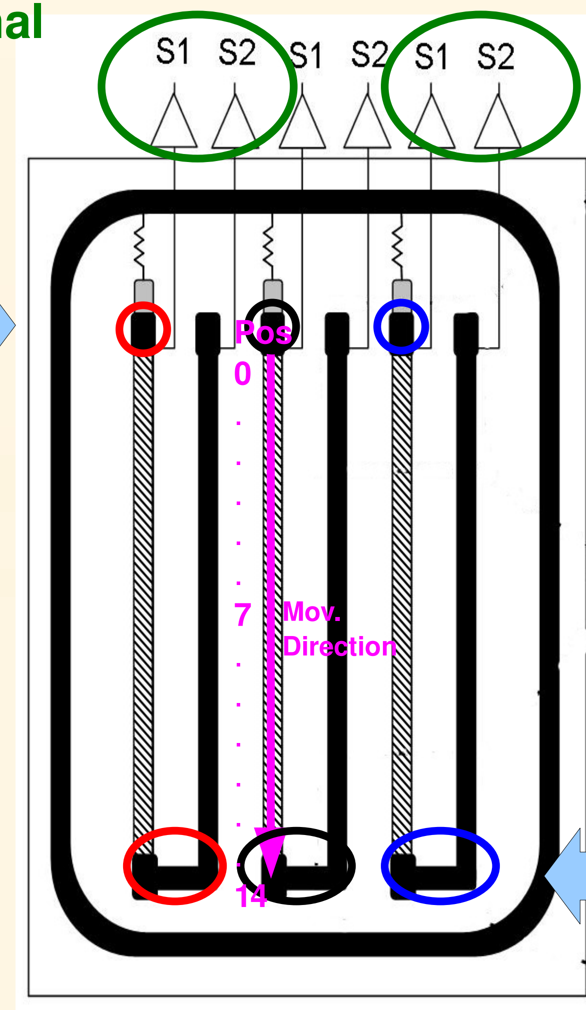




Laser longitudinal scan

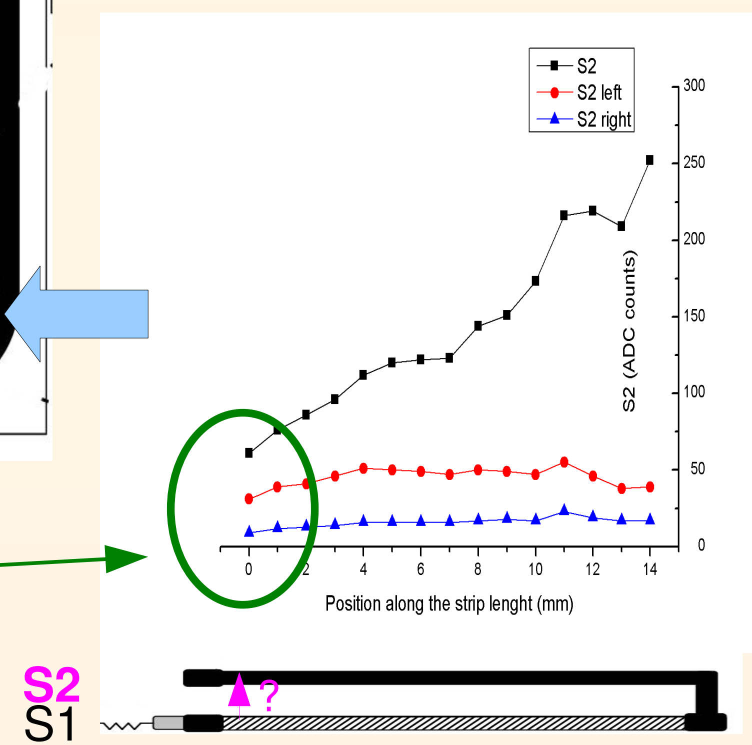
Left signal **Right signal**





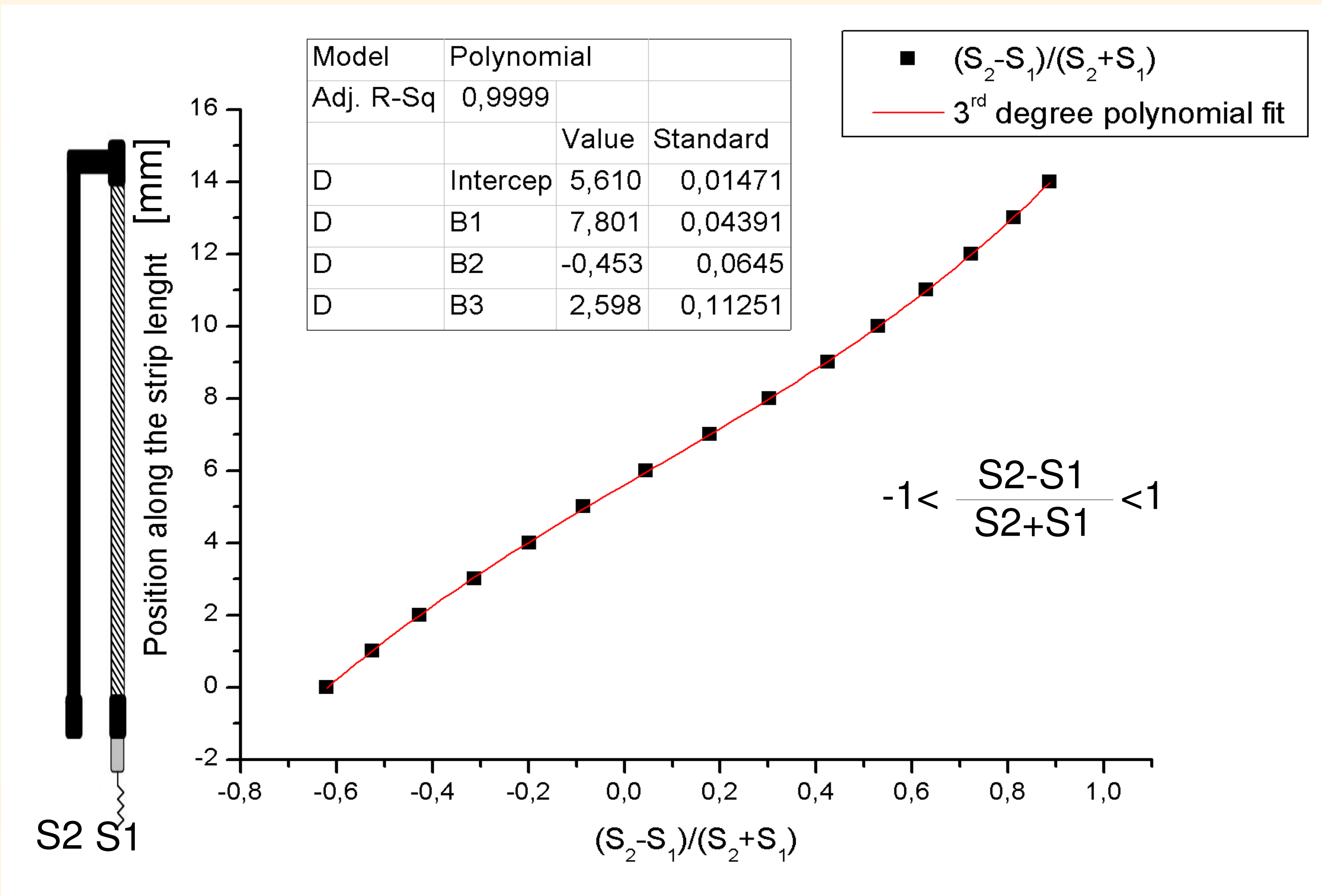
Are not perfectly antisymmetric!

Coupling effect?



At position 0: S2≠0

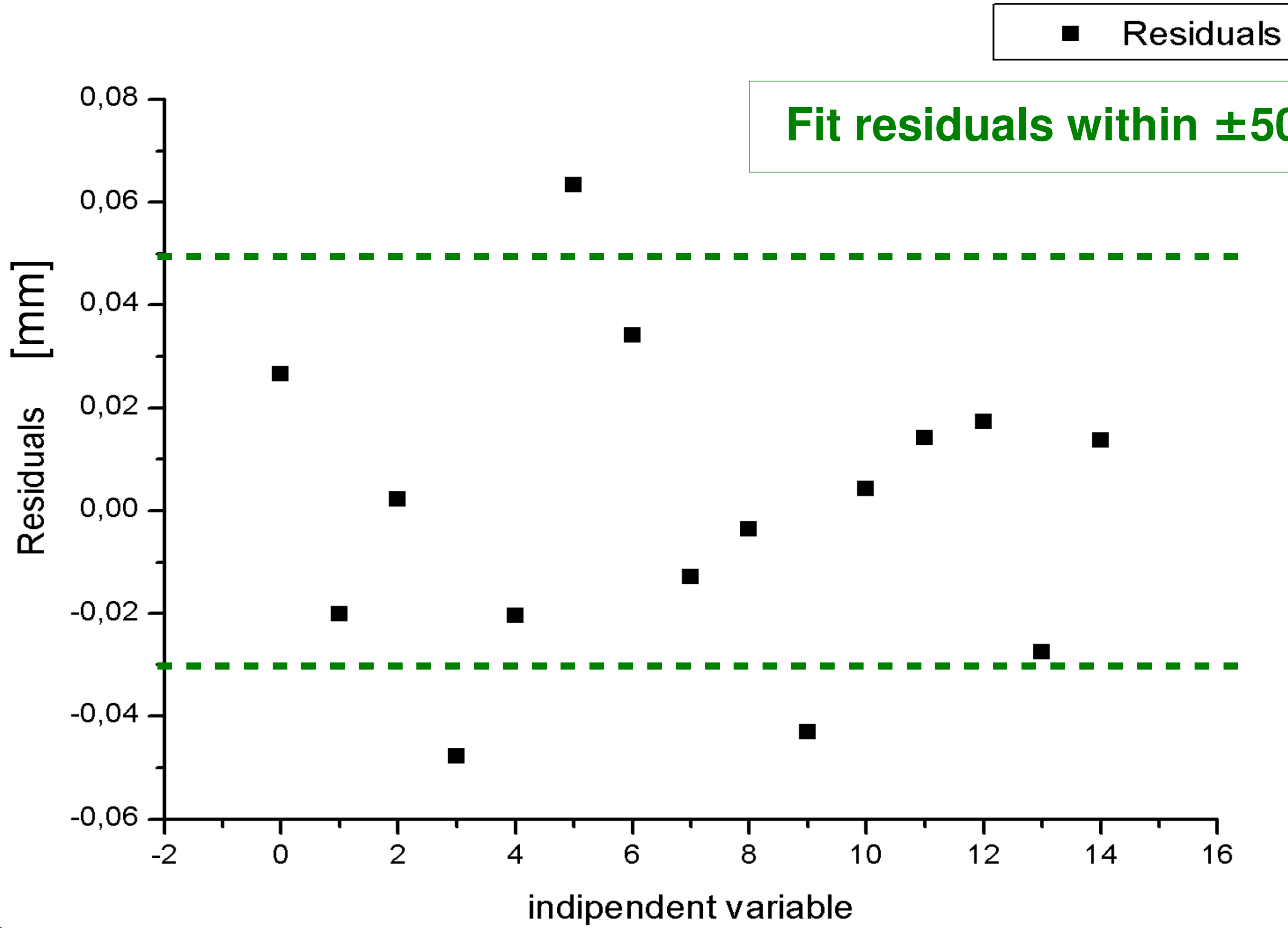
Charge division. experimental results



Model	Polynomial		
Adj. R-Sq	0,9999		
		Value	Standard
D	Intercep	5,610	0,01471
D	B1	7,801	0,04391
D	B2	-0,453	0,0645
D	B3	2,598	0,11251

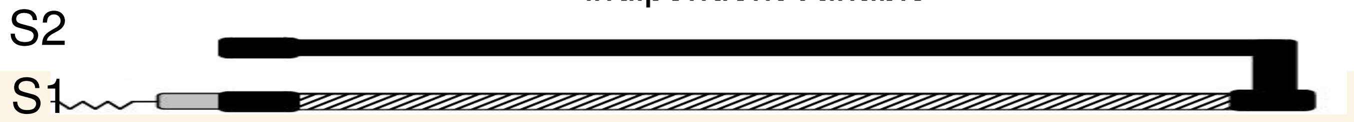
$$-1 < \frac{S2-S1}{S2+S1} < 1$$

Charge division. experimental results



Fit residuals within ±50 μ m band

With this detector, the coordinate along the strip can be determined in a range of 100 μ m

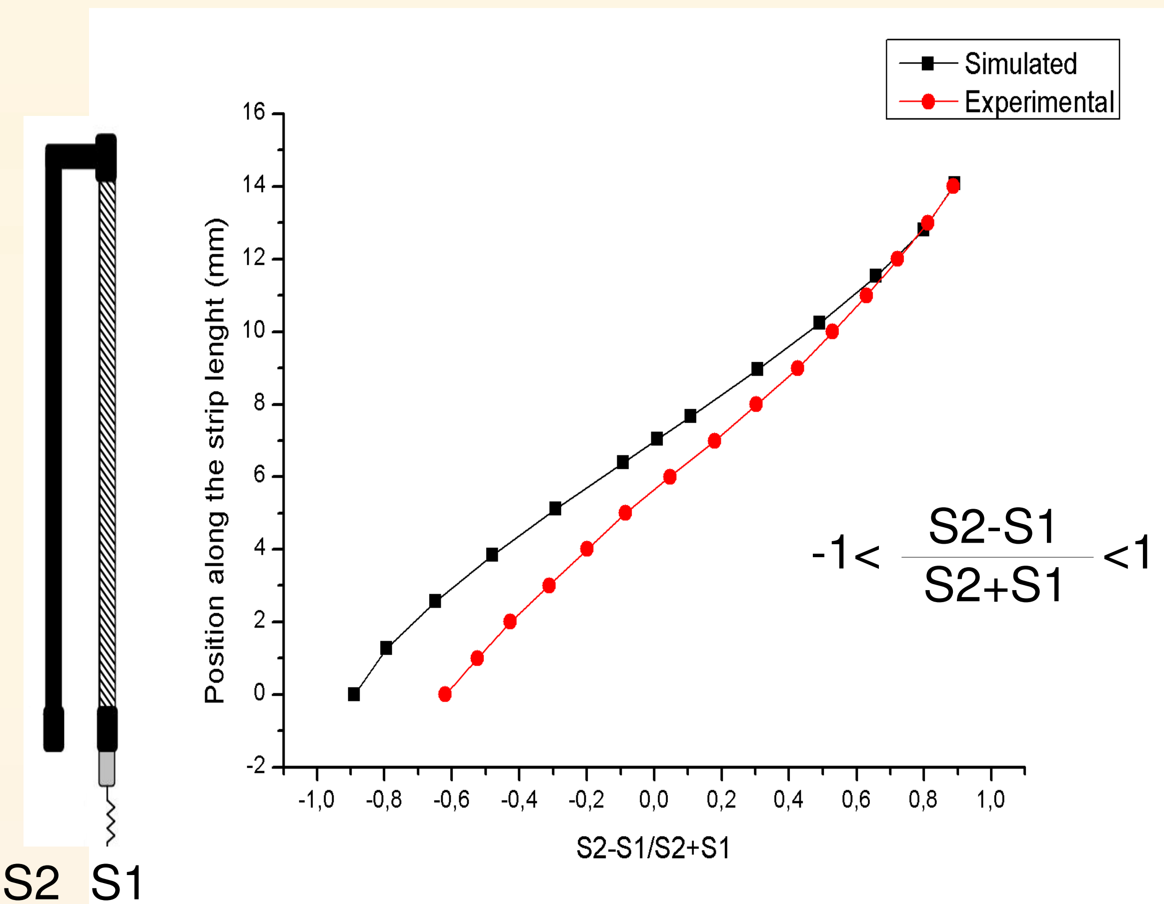


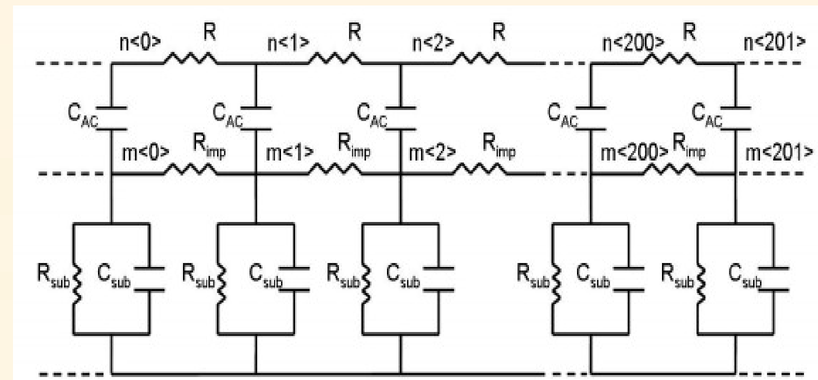
Simulation & data comparison

* <u>Circuital model:</u> *(N, Bachetta et al., IEEE, Vol 47, NO 4, August 1995)*

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})

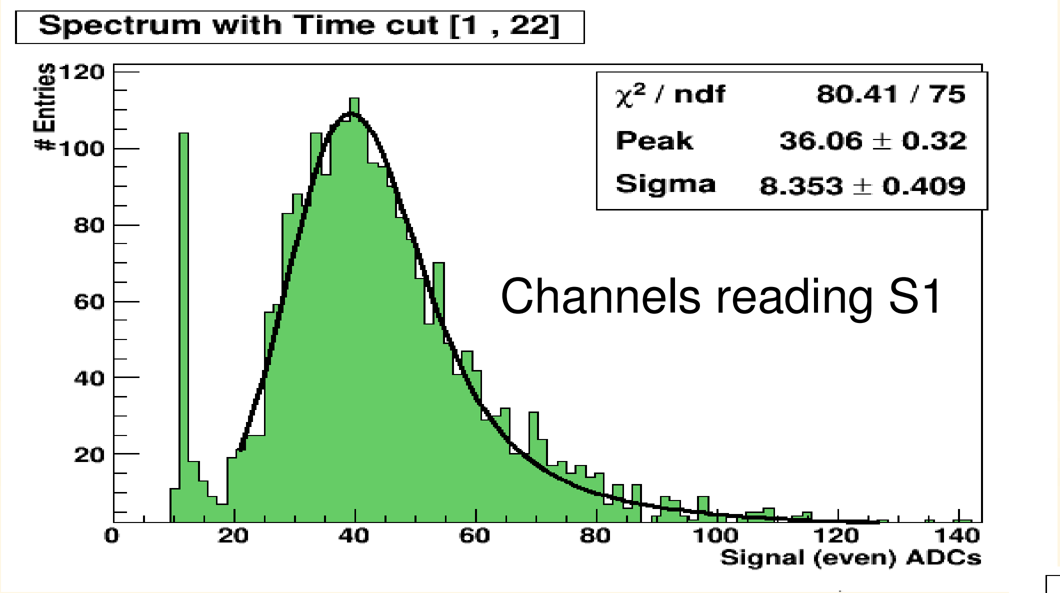


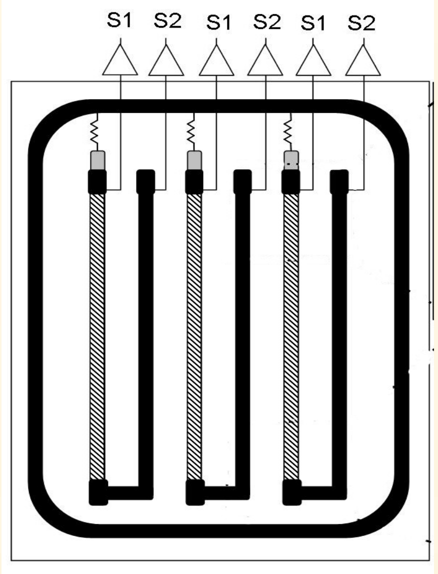


* Overall shape reproduced

* Signal excess in S2, caused for coupling between resistive electrode and metal wire

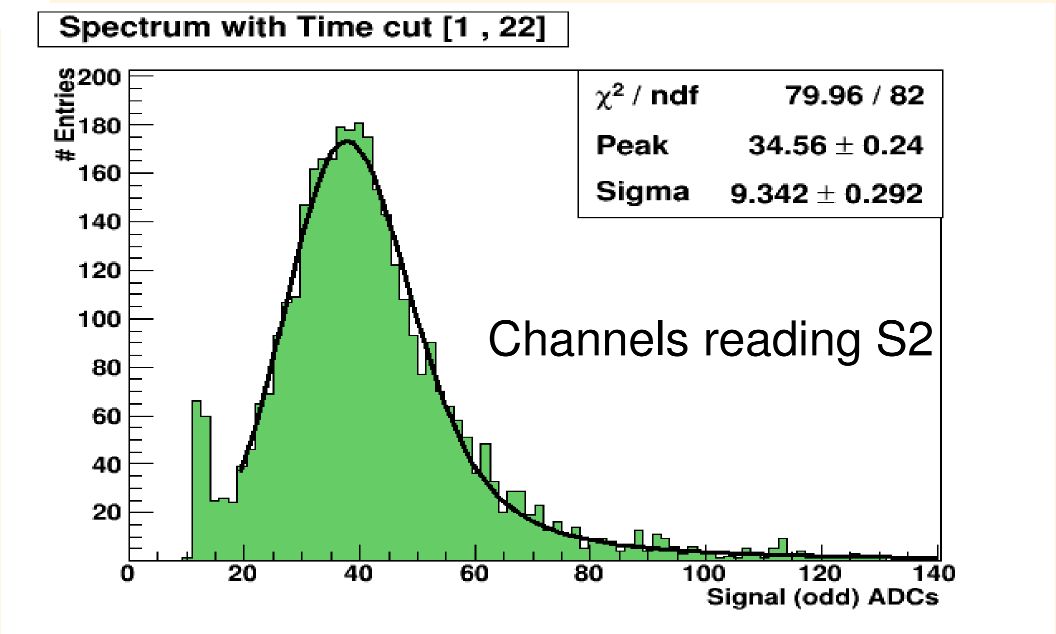
Radio source characterization.





Averaged noise Chip 2 = 2.18 ADCs

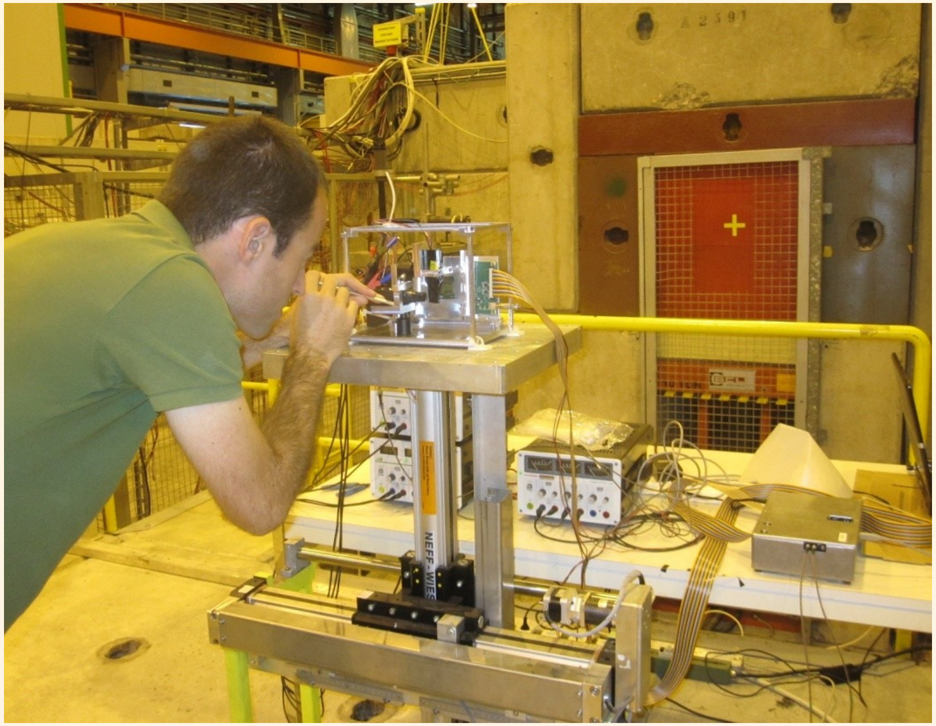
SNR ~ 15

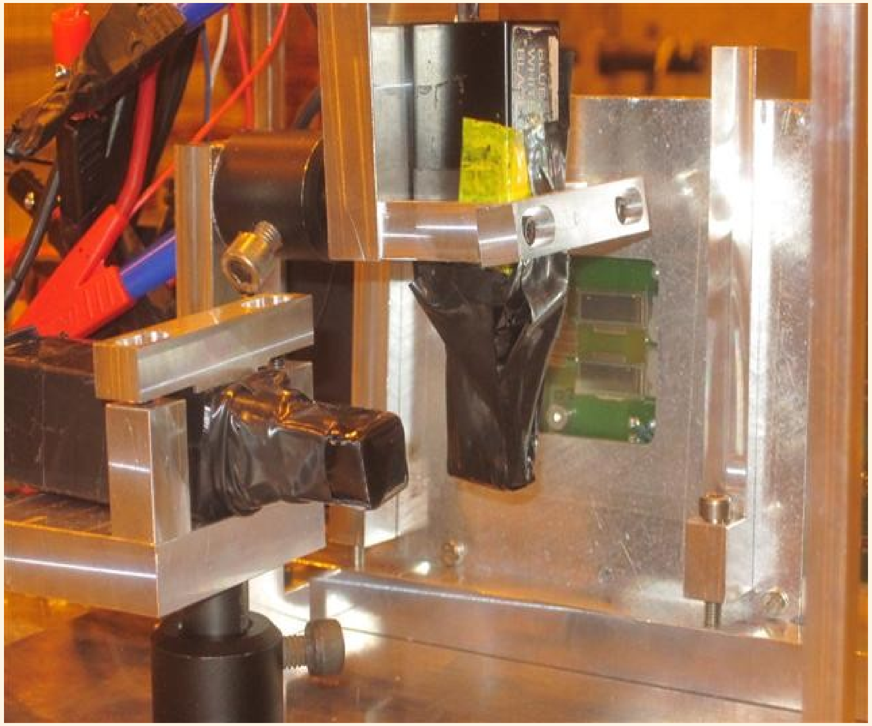


Test beam @ SPS

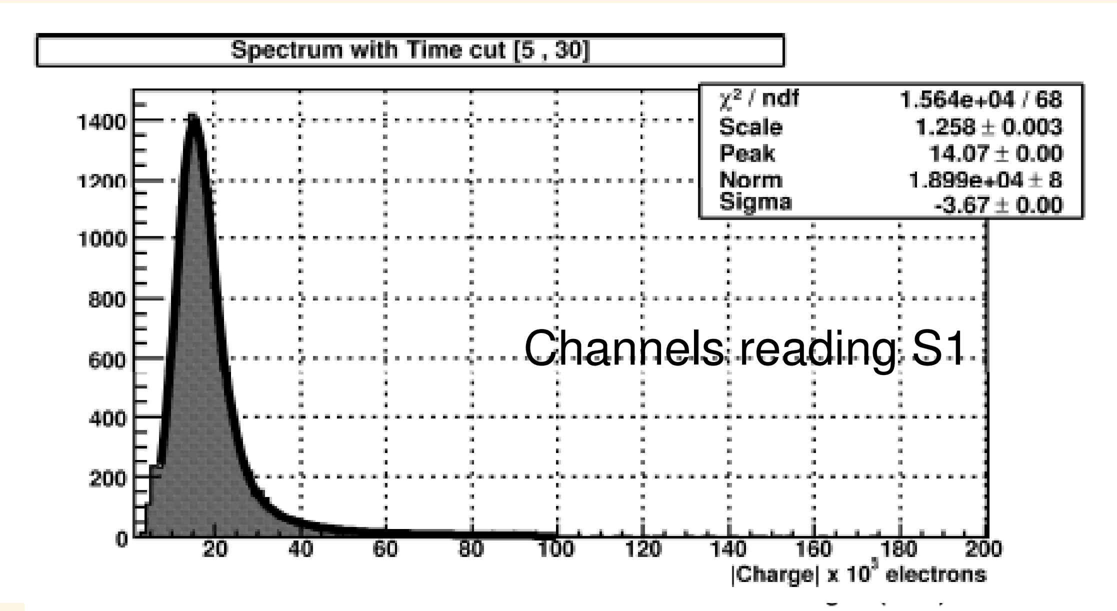
During the first week of October testing at SPS pion (120GeV) beam in parasitic mode

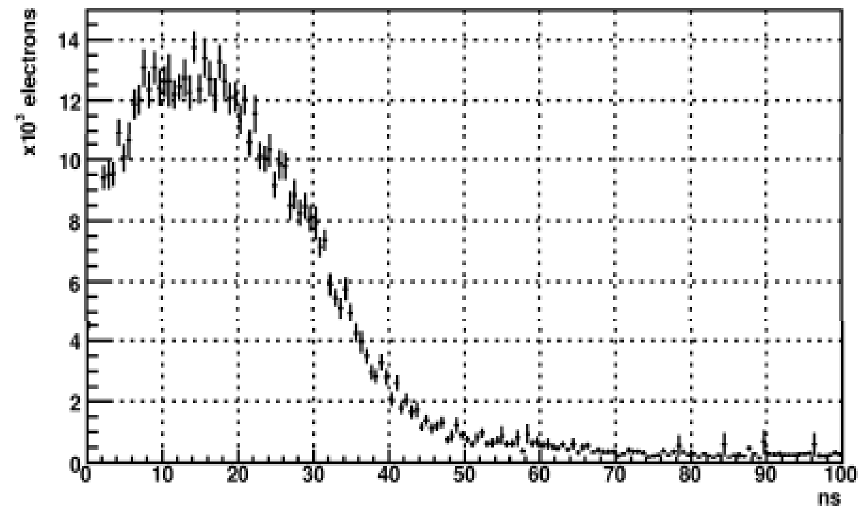
Alibava DAQ (LHCb beetle chip)





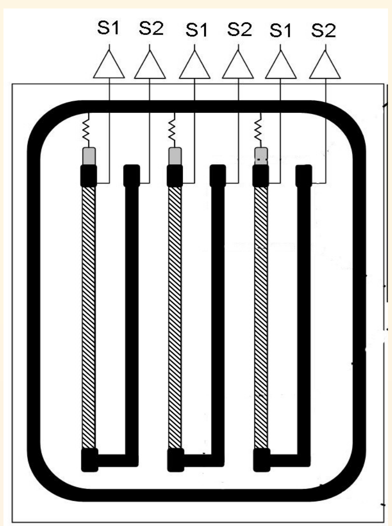
Test beam data

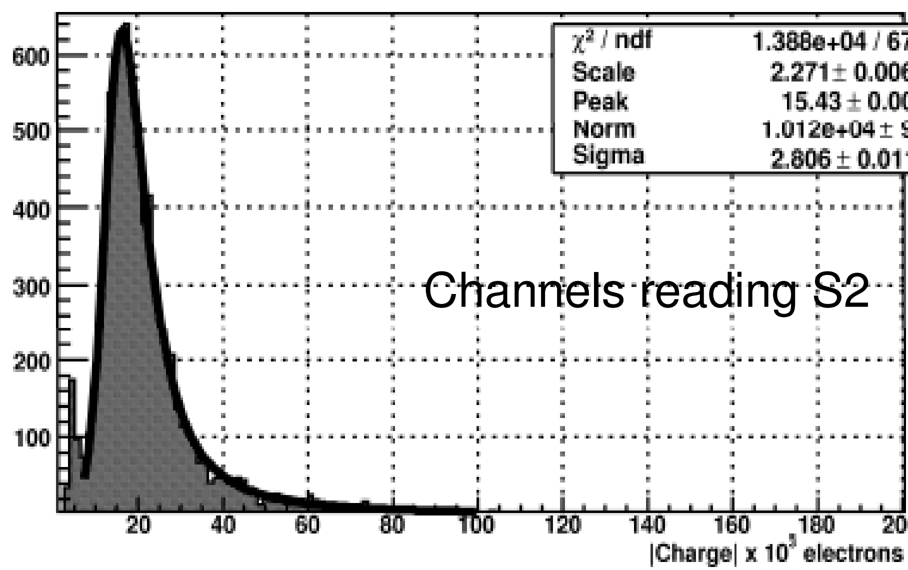




Noise:
Chip 2 = 900 ENC

SNR ~ 15





Test beam @ SPS

Inside EUDET mimosa telescope

* APV25 DAQ system

* T. Bergauer et al.

HEPHY institute (Vienna)

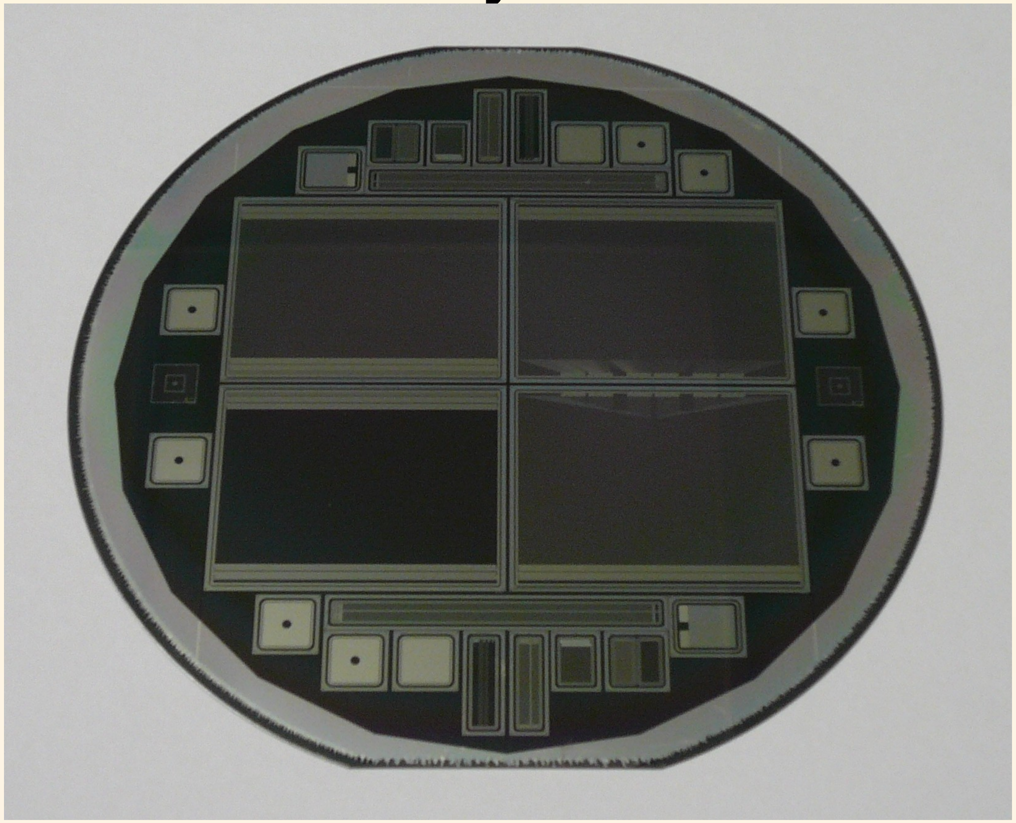
HEPHY Institut für Hochenergiephysik

*Analyzing data with telescope tracker

Second prototype

* New 2D strip sensor of large area produced at CNM (3 cm strip length). 6 Wafers.

* Electrically characterized



*Different electrical test structures

*Standard strip detector

*2 fanout integrated sensors

Second prototype &
Some electrical Characteristics

* No - Aluminum via. Contacts at both strip ends to be read out by two independent FE chips

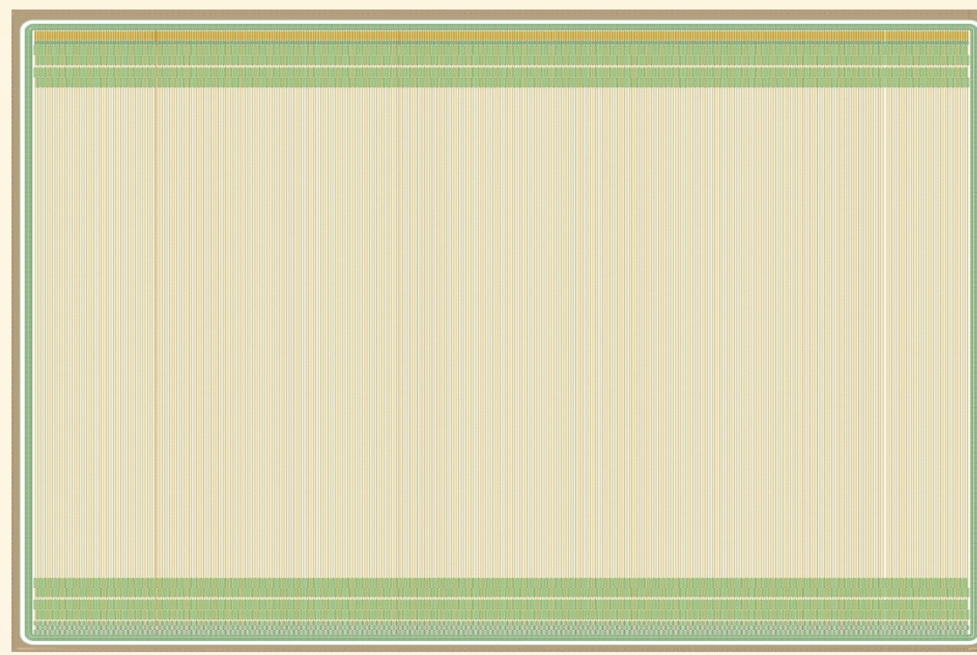
* New Sensor board produced at CNM adapted to ALIBAVA

Vfd ~ 40 V

Cint ~ 0.4 pF

Rint > GΩ

Rbias =2.5 MΩ

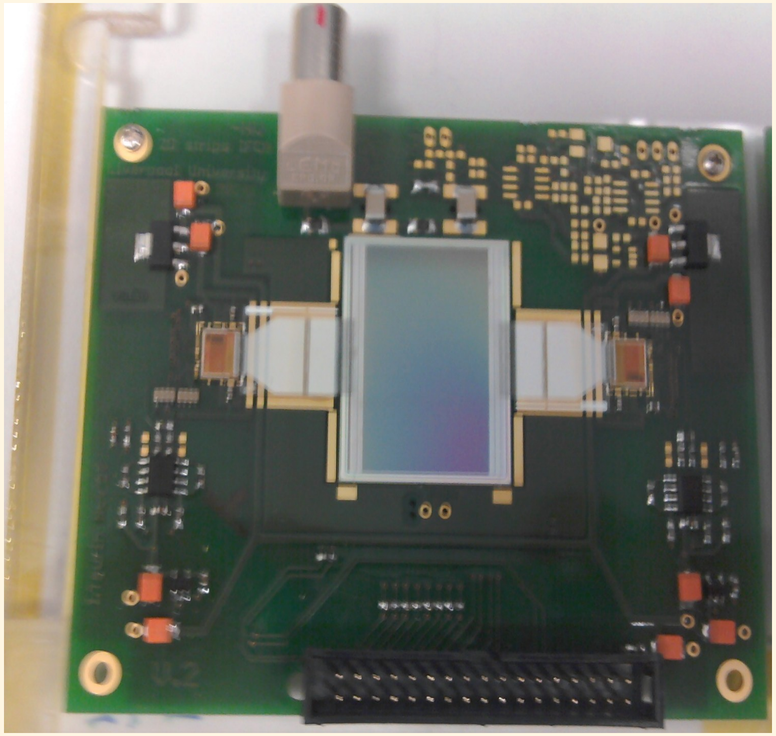


2 wafers $R_{electr.} = 90\ \Omega/sqr$

4 wafers $R_{electr.} = 380\ \Omega/sqr$

Short term plans

* 2 New prototypes already bonded. 128 channels each



Bonding done at:
UNIVERSITY of LIVERPOOL

UNIVERSITY OF LIVERPOOL

* Preparing setup to be tested with laser and radioactive source
* Next test beam at SPS on August 2011

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 much better that 100 um

* 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)

Ions tracking systems.

Neutron imaging (+ conversion element).

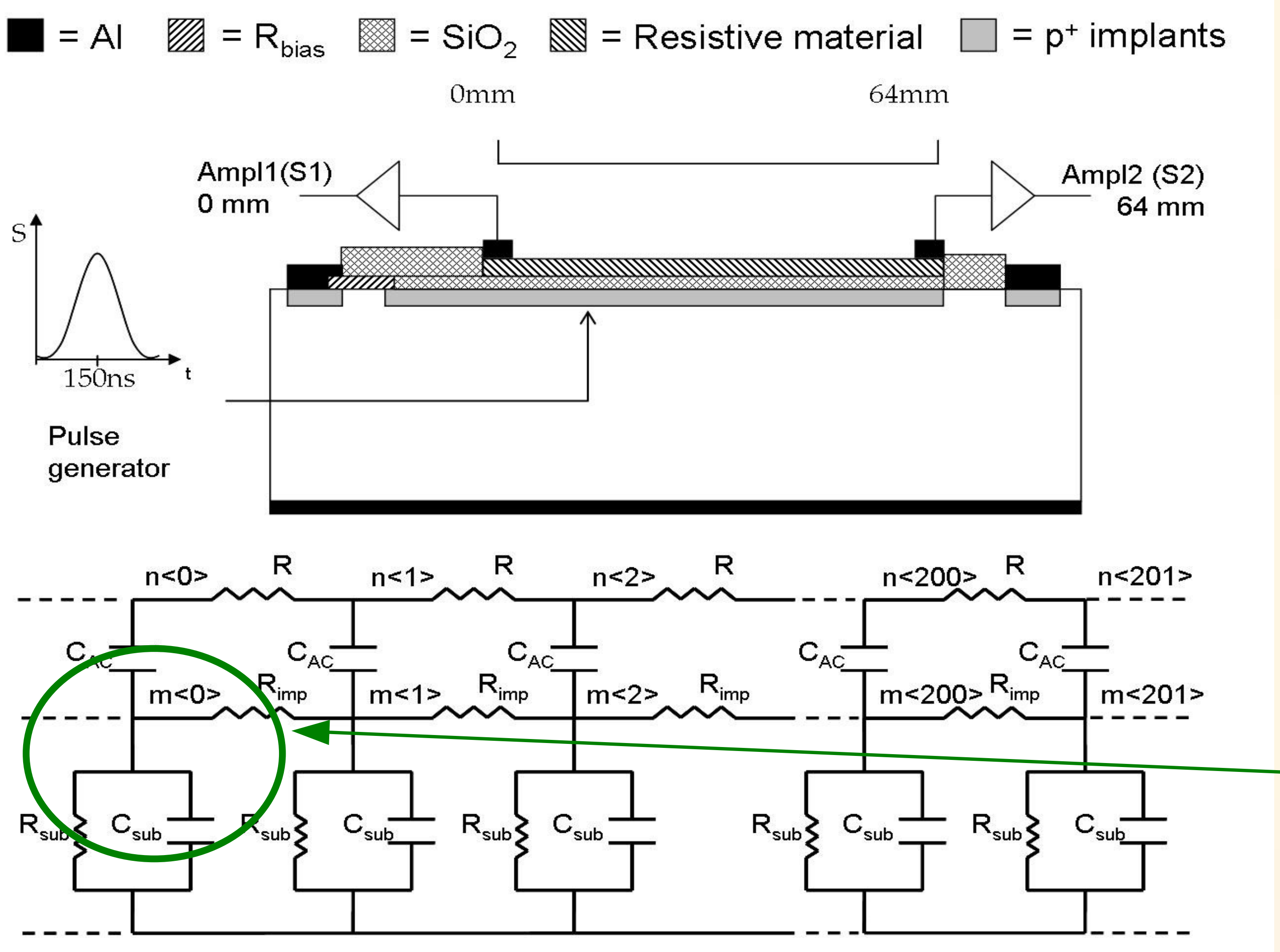
Space applications.

THANKS FOR YOUR ATTENTION!

BACKUP

SPICE model

D. Bassignana (CNM-Barcelona)



Circuital model:

(N, Bachetta et al., IEEE, Vol 47, NO 4, August 1995)

n= node number

m= pulse impact

R= electrode resistance

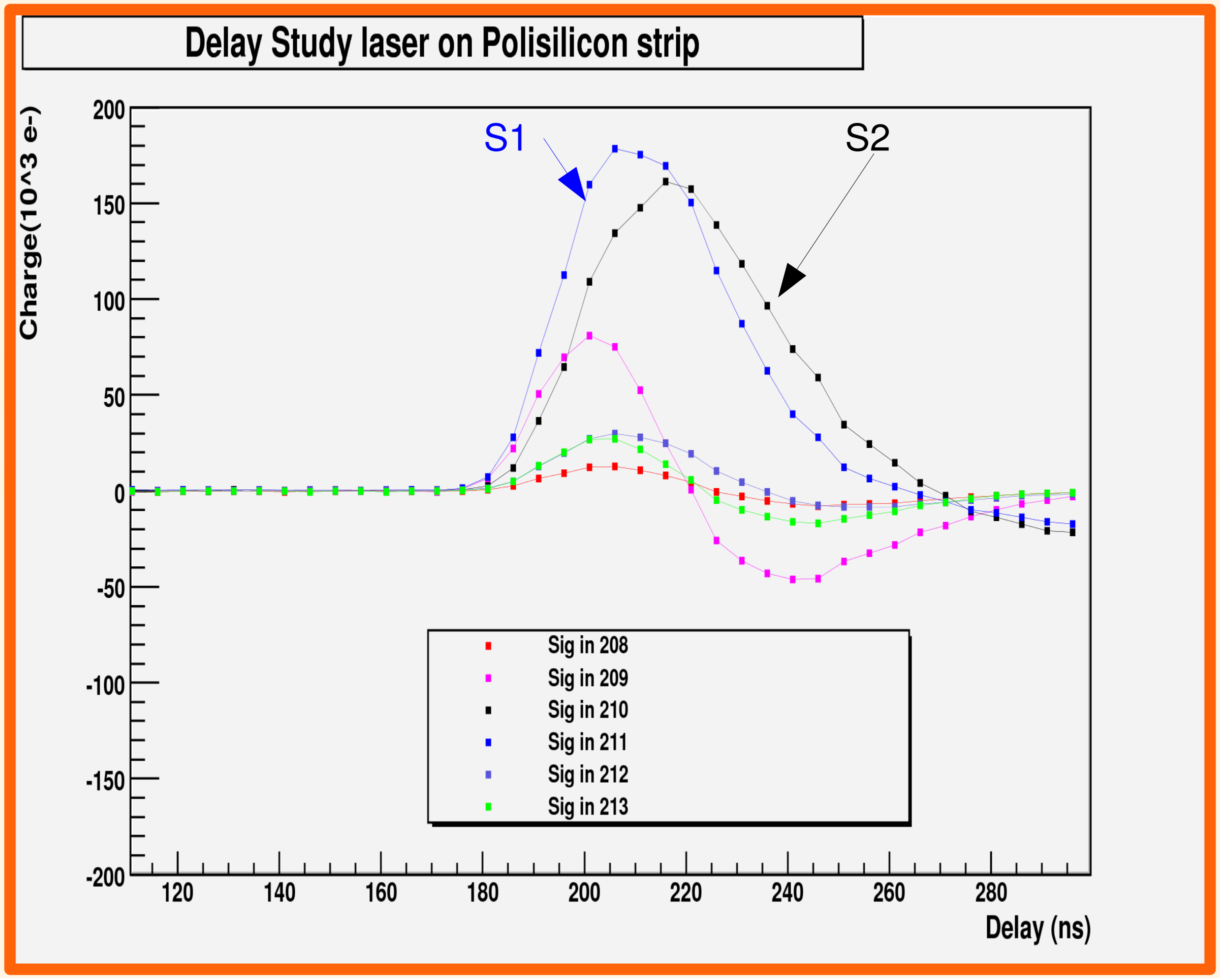
Rimp= implant resistance

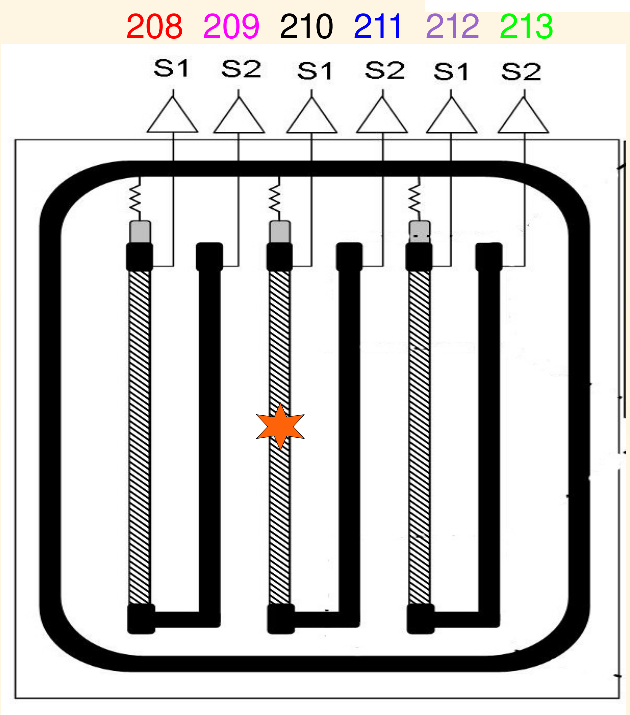
Rsub= substrate resistance

Csub= substrate resistance

Unit Cell, a chain of them represents a strip

Laser delay studies





Transversal scan