WP9.4 micro-strip advanced ideas

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Outline

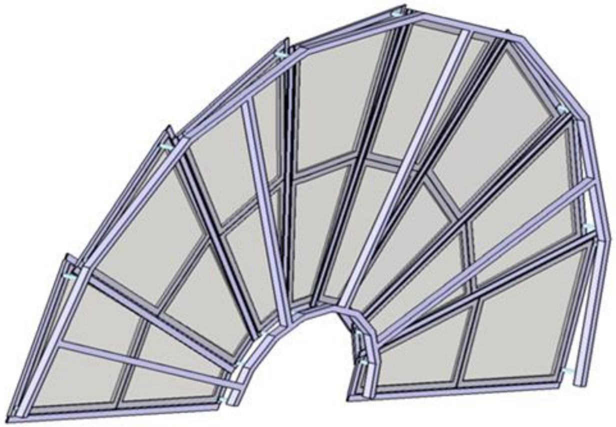
- Intro to the “advanced” strip studies.
- **Mechanics:** Self-monitoring CFRP structures.
- **Sensors:** 2D PSD strip sensors.
- **FE electronics:** long-shaping time ASIC

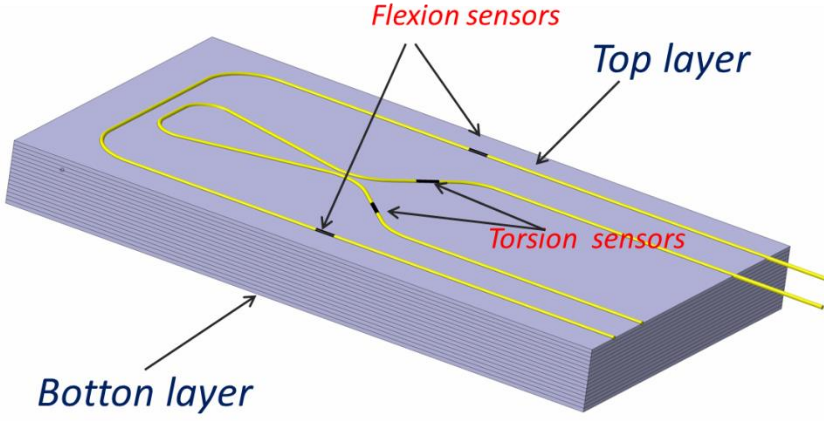
Introduction & Motivation

- Generic RD studies towards a ultralight strip tracking but aiming to fit the requirements for a Linear Collider Tracker
- Not aimed to for a deliverable.
- Covering several aspects: sensors, mechanics, FE ASIC, powering.

Mechanics

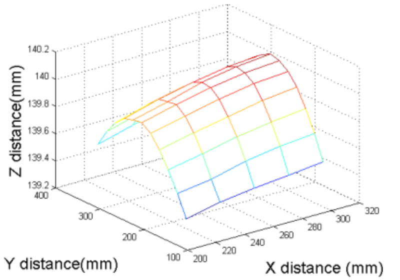
- The aim is to manufacture the ILD forward tracker support petals with integrated FOS
- Synergy with WP9.3 deliverable
- Intermediate step: shape measurement of CFRP plate with FOS embedded



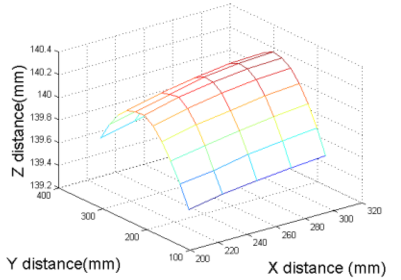


Mechanics(2)

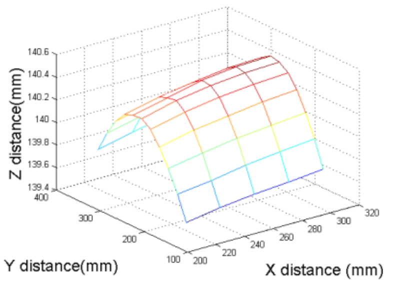
CMM measurements of flexion calibration z =0.8 mm

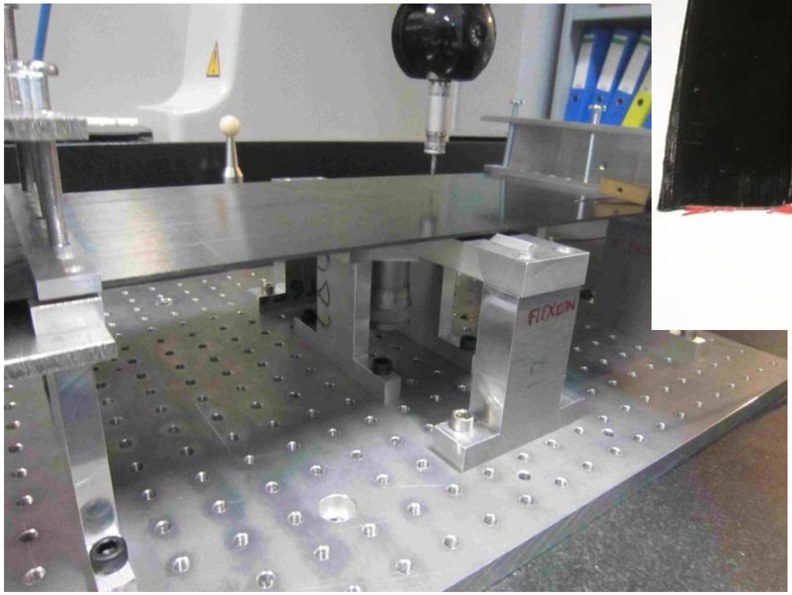


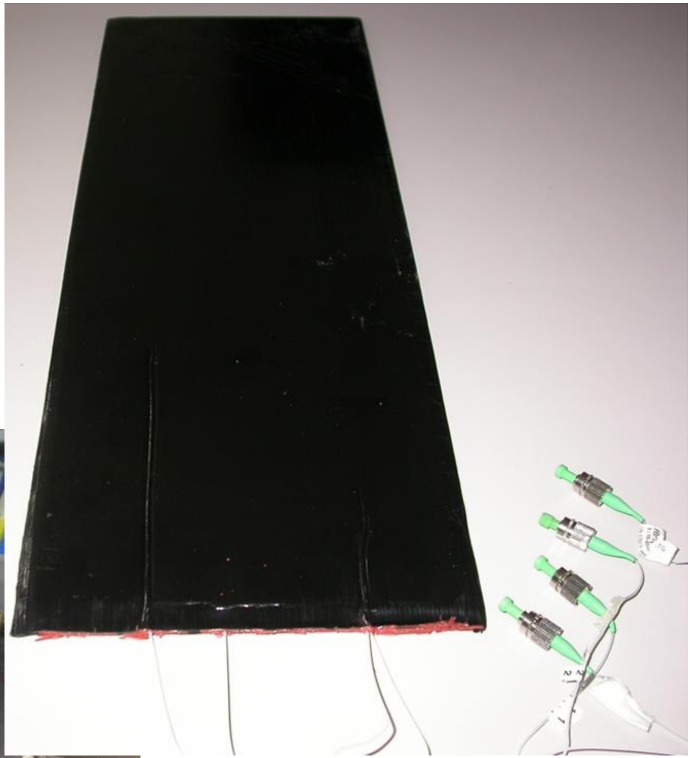
CMM measurements of flexion calibration z =1 mm



CMM measurements of flexion calibration z =1.2 mm

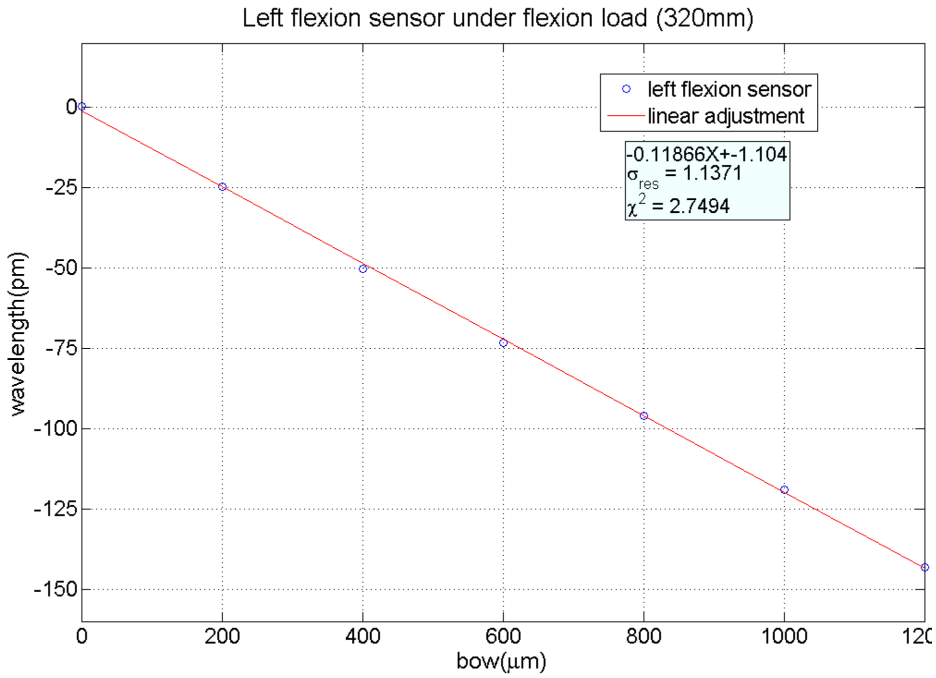


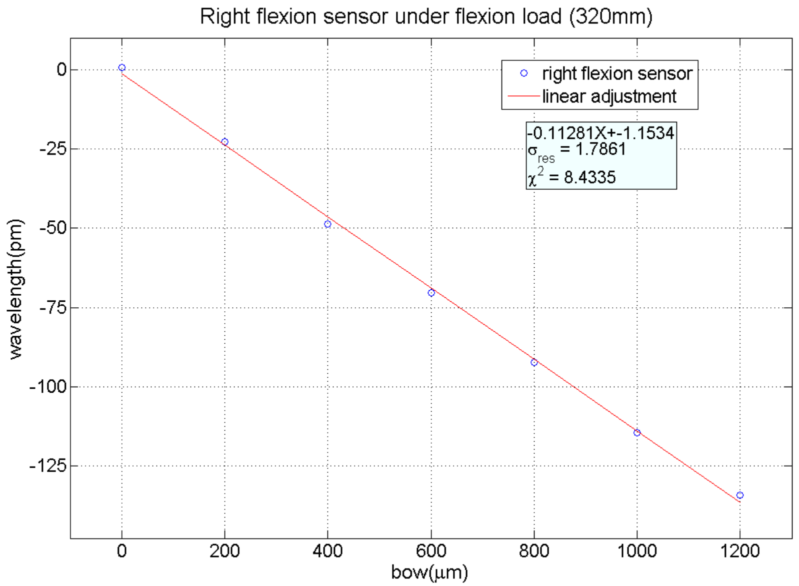




Mechannics(4)

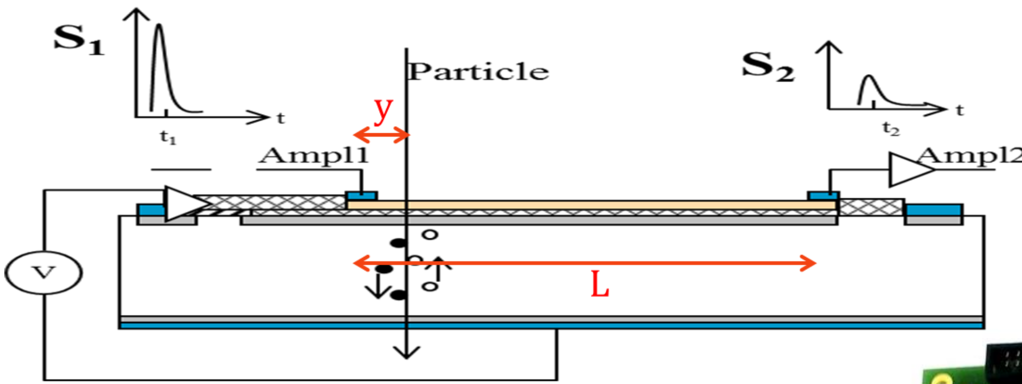
- Determining plate bow with resolution ~ 10um



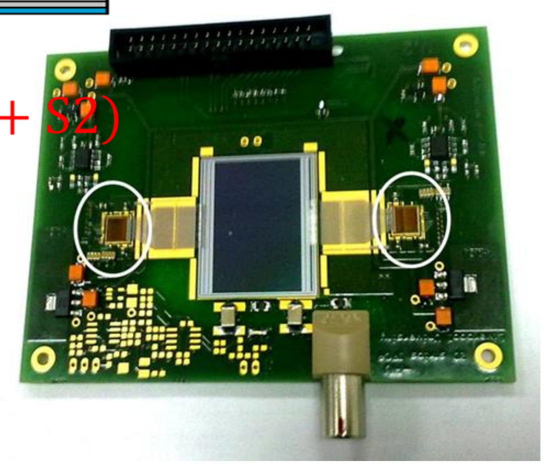


Charge Division in u-strip sensors

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



$$\text{Fractional Position} \equiv y/L = S2/(S1+S2)$$

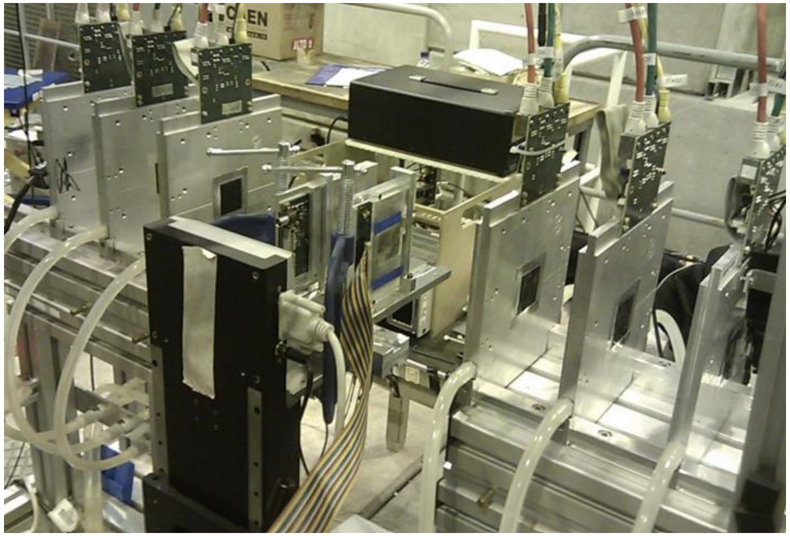


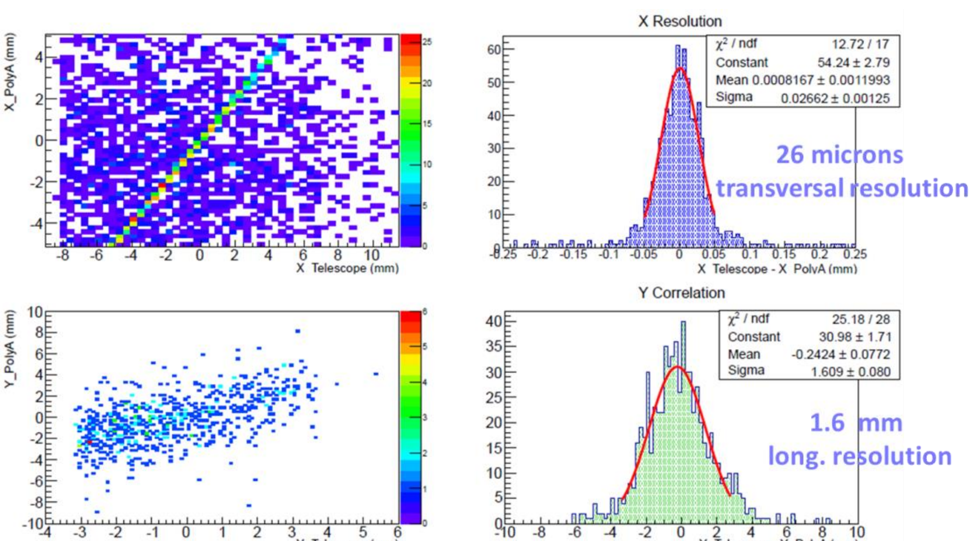
Strip:
- length =20 mm
- width =20 um

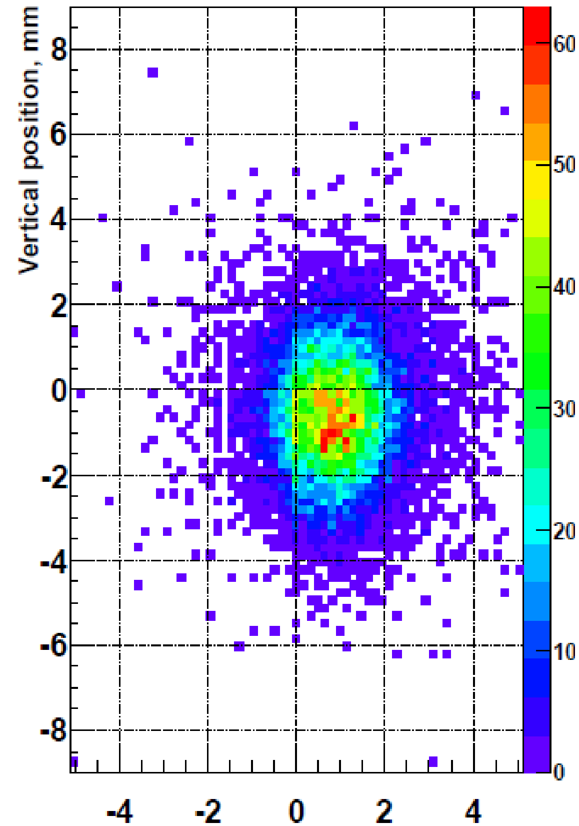
Pitches:
- Implant=80 um
- readout= 80 um

Electrode:
- R/um = 2.8 Ohms/um
- R/um = 12.2 Ohms/um

Charge Division in u-strip sensors



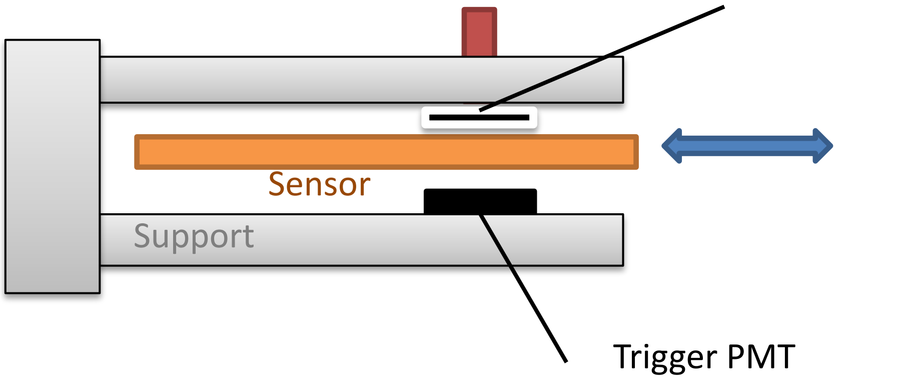


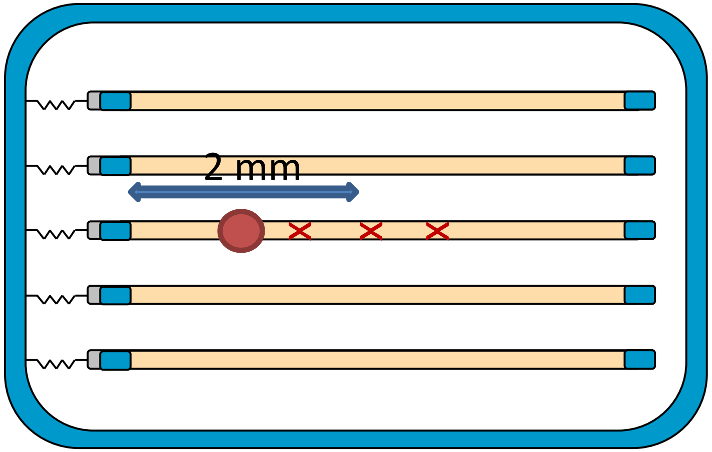


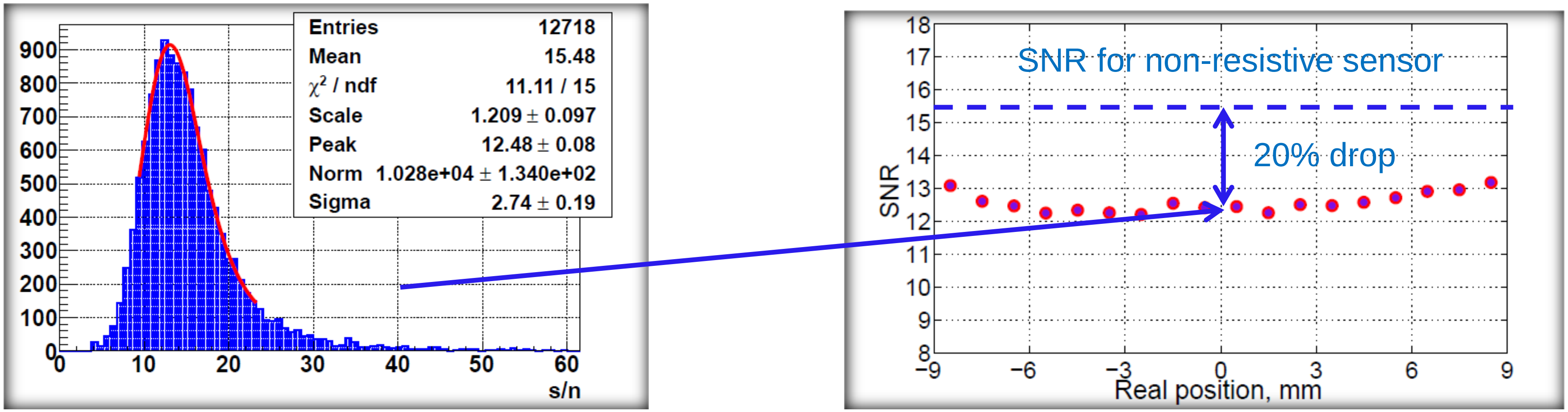
- Test beam at CERN SPS Pion Beam, Nov 2012
- First successful integration and synchronization with AIDA MIMOSA pixel telescope

Radioactive Source: SNR estimation

Defined as $SNR \equiv (S1 + S2)/\sqrt{\sigma 1 + \sigma 2}$ (drives the spatial resolution)



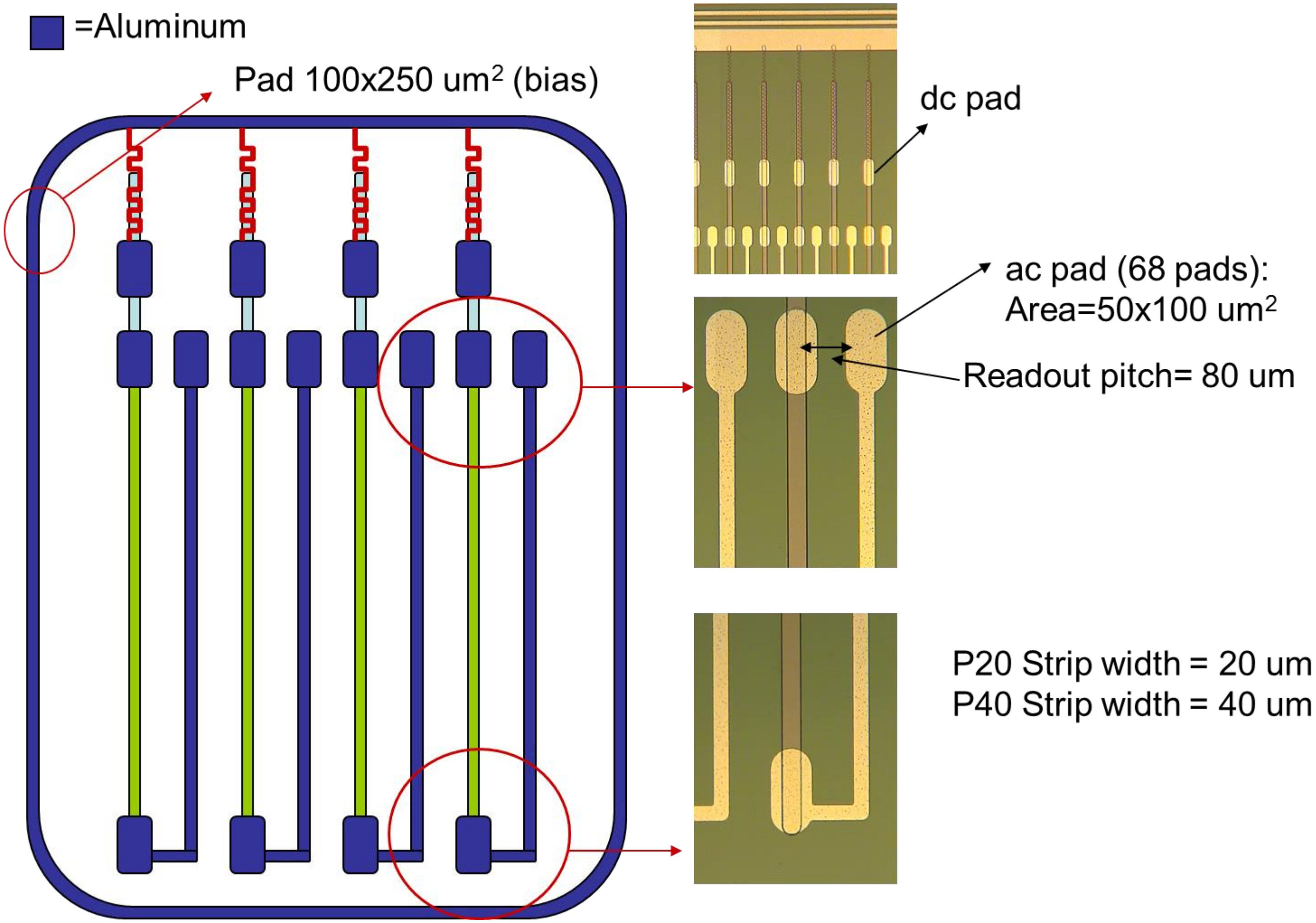




Resistive strips: Current Challenges

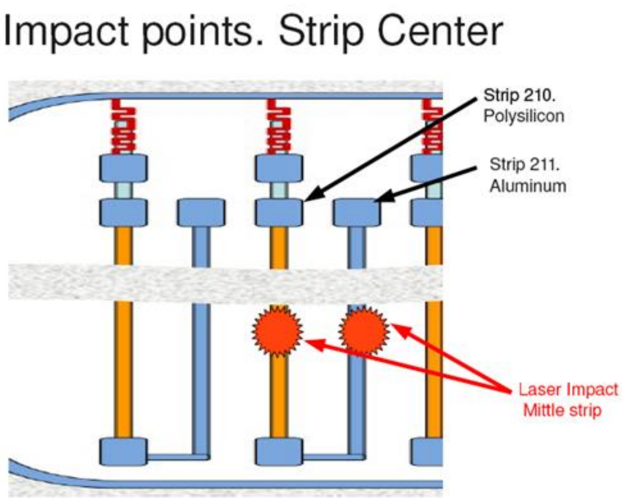
- The charge-division concept on microstrips has been confirmed experimentally, two limitations:
  – Both ends readout difficult to integrate in long ladder (need to combine the information from both ends)
  – Signal attenuation due to the strip resistance (current prototypes 20% signal loss for 2cm length sensor).
- Proposed solutions:
  – **Integrated signal lines** in the sensor to route the signals to the same end.
  – **Reduce the strip resistivity** (limited by the amp. charge resolution) and/or **integrate charge amplification mechanism** in the sensor.

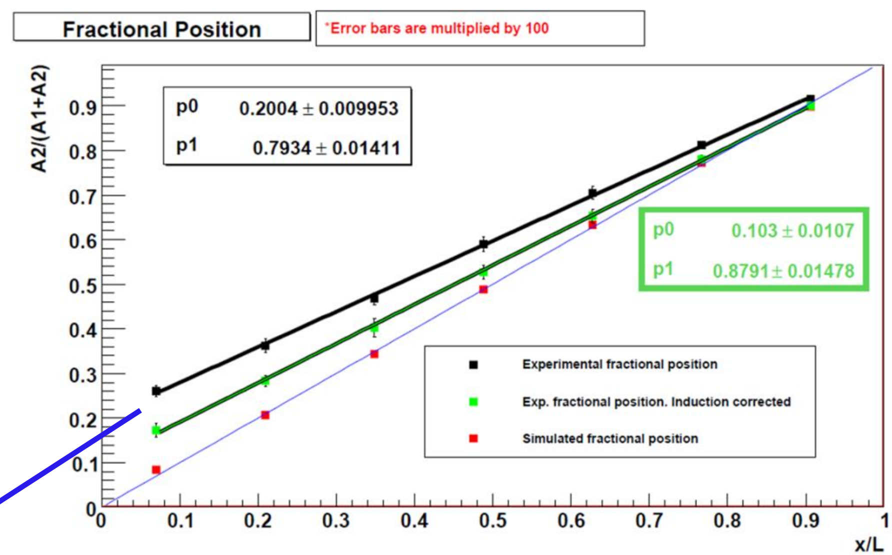
Resistive strips with integrated signal routing



Resistive strips with integrated signal routing(2)

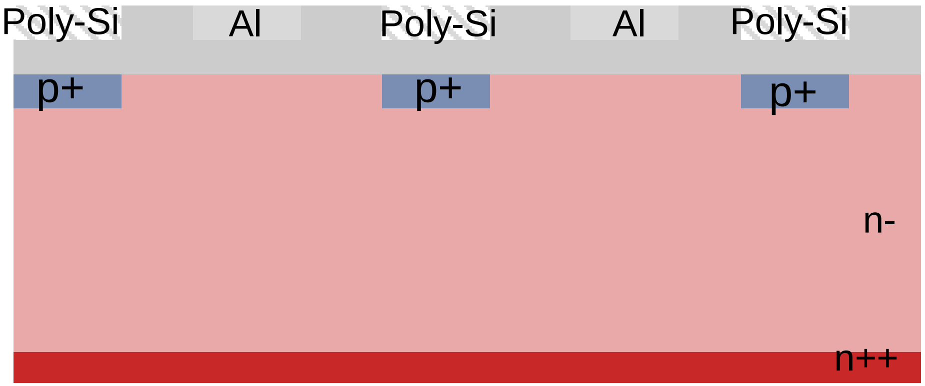
- Induced signal on metallic vias superposed to “direct signal” propagated through polysilicon electrode.

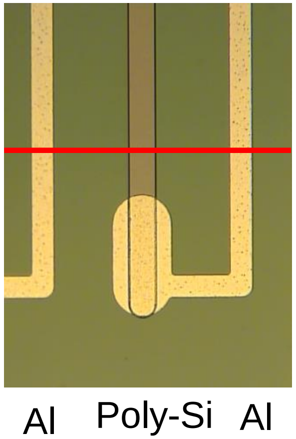




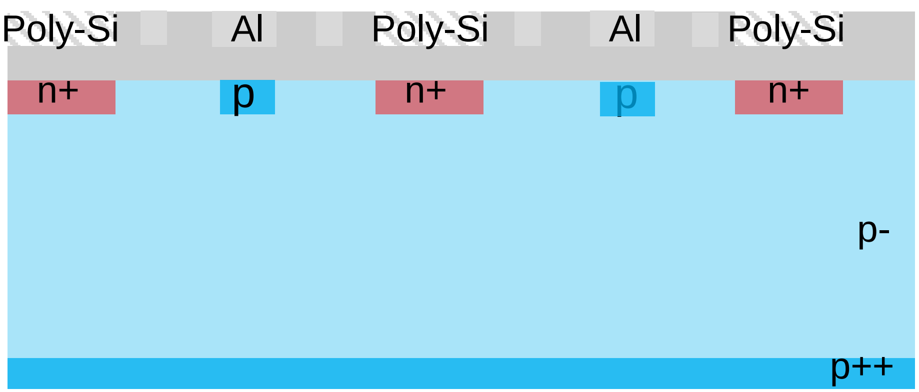
Measured Fractional position shows a clear bias

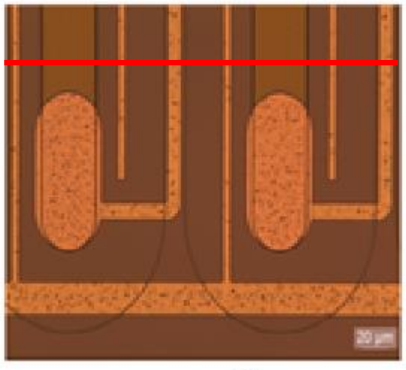
Isolation structures for cross-talk suppression





OLD DESIGN



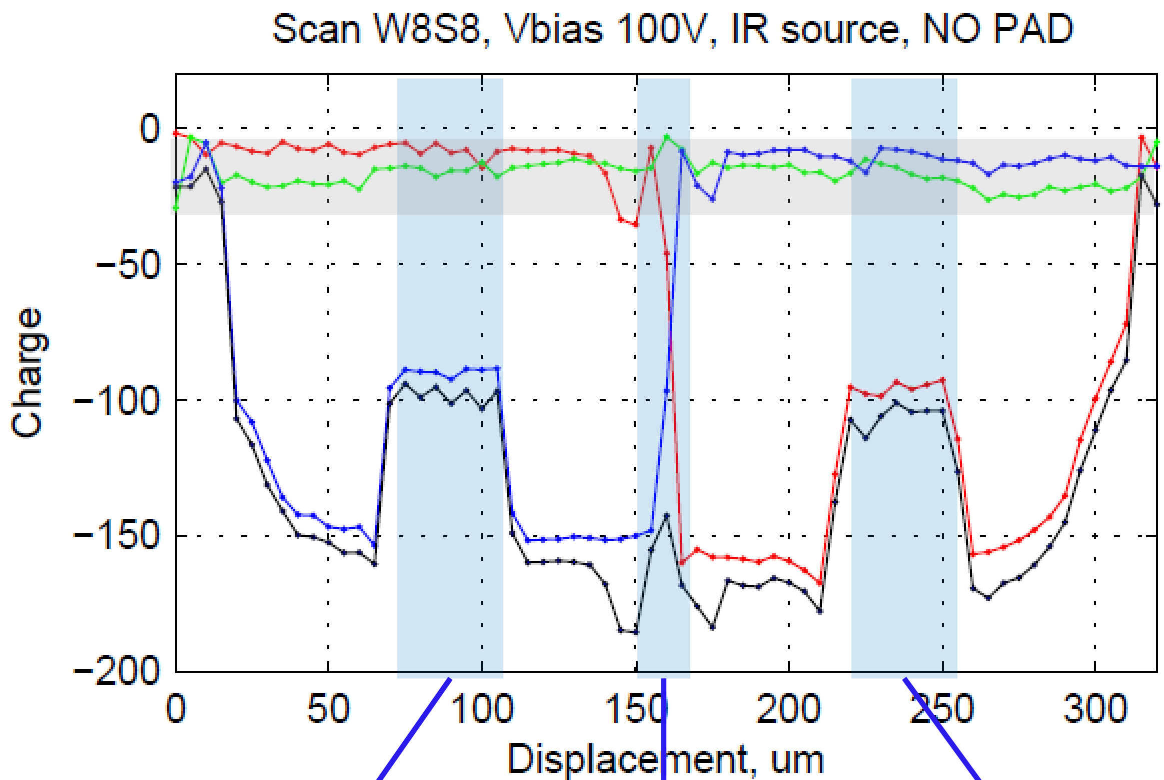


NEW DESIGN Common P-stop and field plates

Spin-off of FOSTER sensors proposed by KIT at CMS

Isolation structures for cross-talk suppression

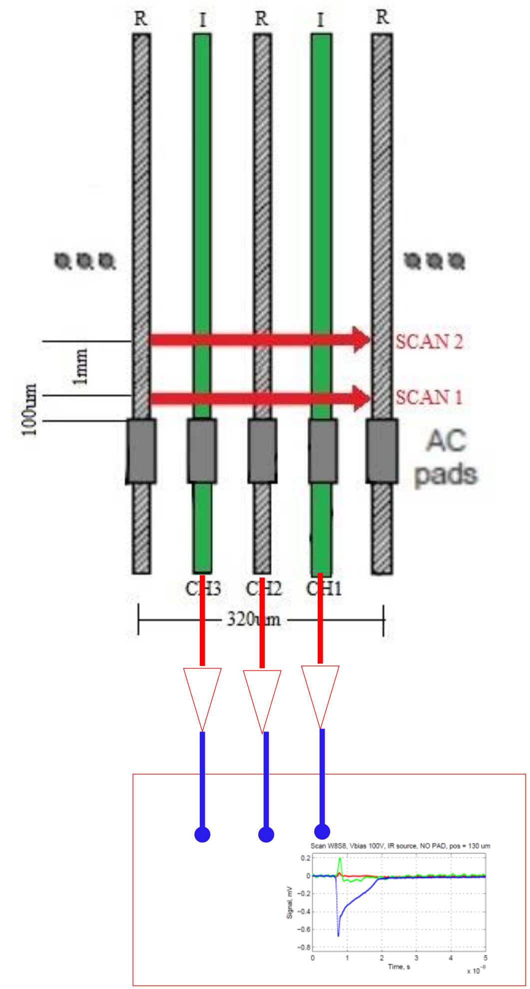
Flat charge pedestal for Al routing track, suppressed by calibration



Poly-Si Strip

Aluminum Strip

Poly-Si Strip

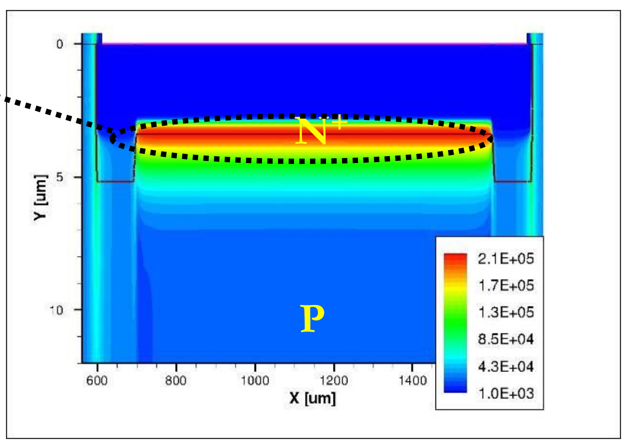


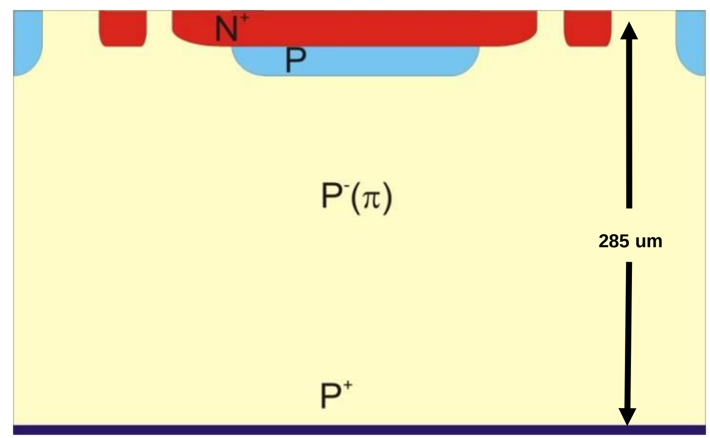
Increasing the signal: LGAD

Implanting an n++/p+/p- junction along the centre of the electrodes. Under reverse bias conditions, a high electric field region is created at this localised region, which can lead to a multiplication mechanism (impact Ionization).

Advantages = Thinning while keeping same S/N as standard detectors.

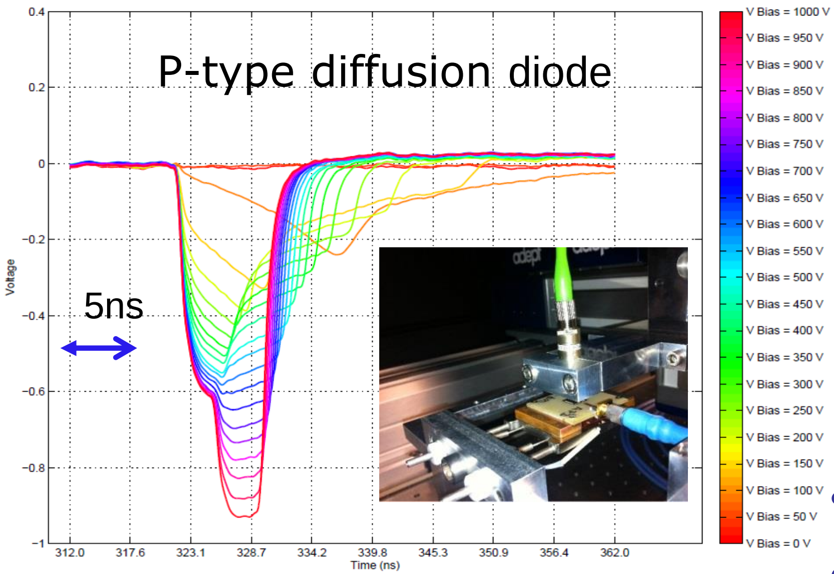
High Electric Field region leading to multiplication

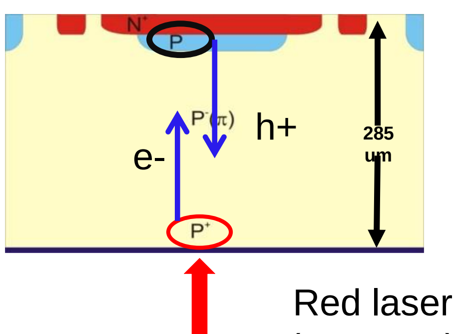




P. Fernandez et al, "Simulation of new p-type strip detectors with trench to enhance the charge multiplication effect in the n-type electrodes" , Nuclear InstrumentsandMethodsinPhysicsResearchA658(2011) 98–102.

LGAD: Red laser TCT characterization

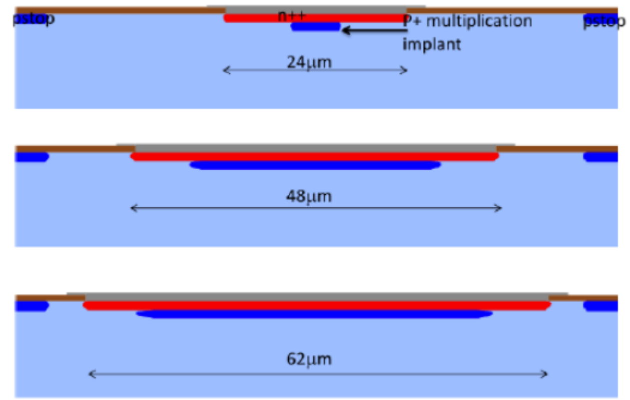




Red laser (1060 nm)

TCT Back-side injection

Different strips layout w/ 80 μm pitch:

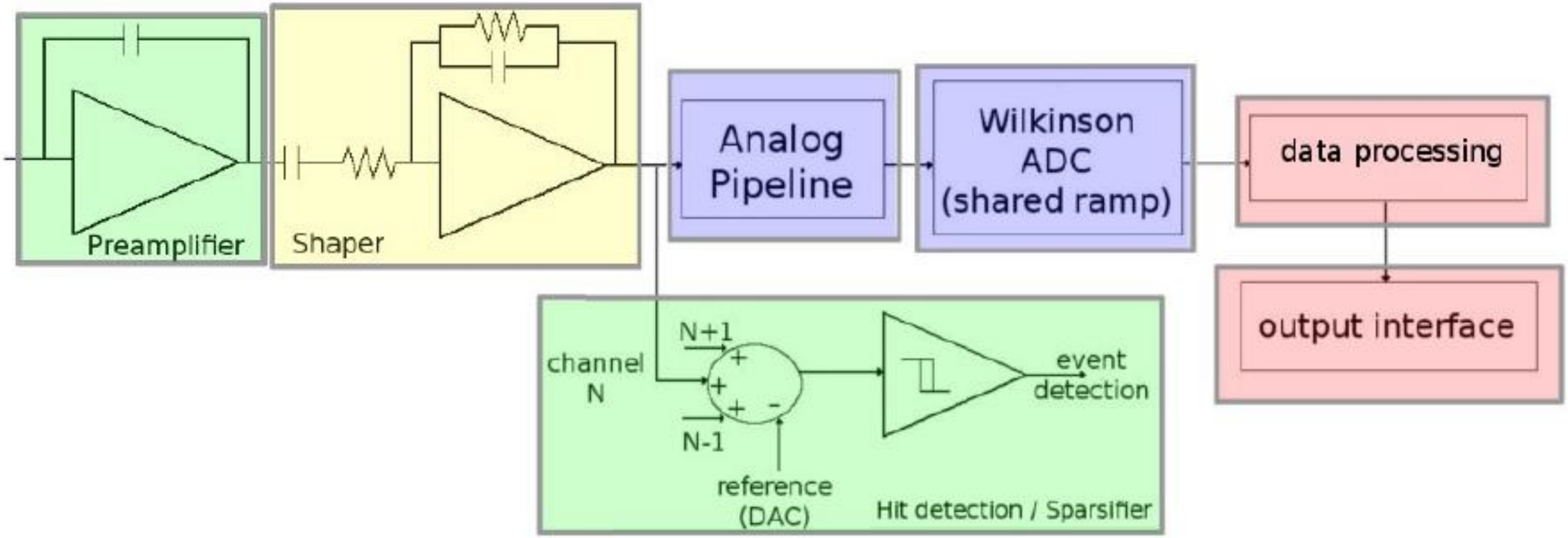


Marta Baselga 23rd RD50 workshop

- Excellent results for LGAD diodes
- First strip LGAD prototypes do not show signal amplification.
- New run in progress and new concept to implement: p-on-p sensor (holes readout with electron amplification in a non-structured anode (pad-like) to ensure uniform amplification

Microstrips RO ASIC

- Aiming to the design of a long shaping time FE electronics for microstrips (low power consumption)



Designed at schematic level
Layout of some individual modules

Noise comparison of different frontends

Frontend	A (e-)	B(e-/pF)	Shaping time
This design (*)	377	5,2	2µs
APV25	246	36	50 ns
MX6	340	20	
VA1	200	8	1µs
Beetle	303	33,6	25 ns
KPix	300	35	

Consumption, area estimation

Block / Part	Power consumption	Area estimation (*) 20µm x 2.5mm
Preamplifier	370µW	20µm x 400µm (16%)
Shaper Amp.	120µW	20µm x 200µm (8%)
Sparsifier	70µW	20µm x 125µm (5%)
Comparator	30µW	
ADC	100µW (estimated)	N/A

(*): Resistors not included.
(**): Power switching not considered

Summary

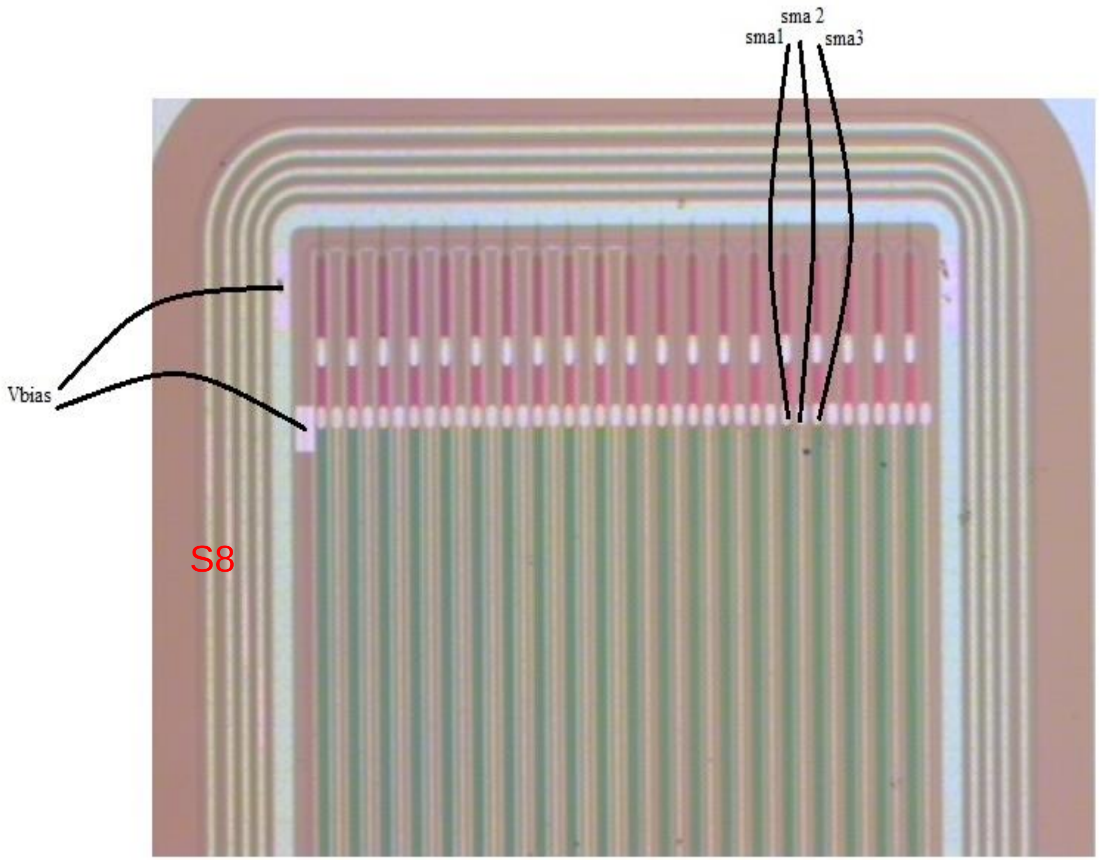
- In parallel with the baseline deliverable additional RTD and networking activity on advanced topics.
- Highlights: New detector concepts, self-monitoring and R/O ASIC.
- Future: AIDA was instrumental in achieving important development milestones but still a few years of work ahead (looking for AIDA-2020)

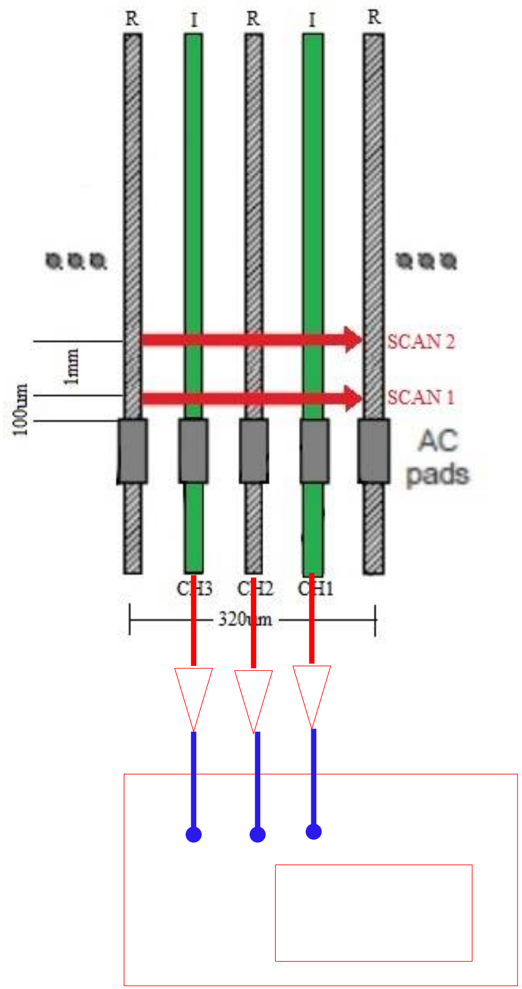
Backup

- THANK YOU FOR YOUR ATTENTION

Crosstalk suppression (common stop)

- Time Resolved Readout IR-laser induced (e-TCT like measurement)





No grid Al. Implant – Al routing – Implant

Crosstalk Suppression: Current pulses

Infrared pico second laser

(fast, 1GHz readout channel)