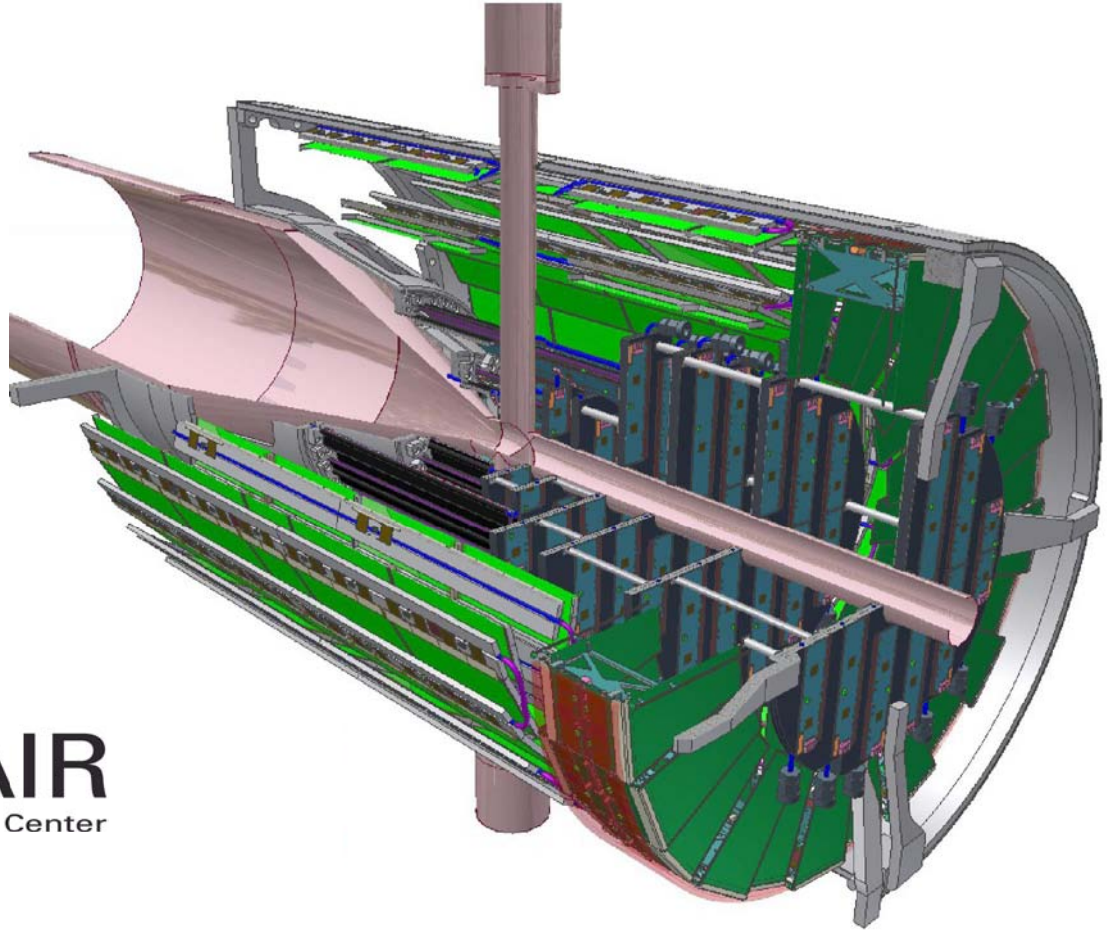
The PANDA MVD

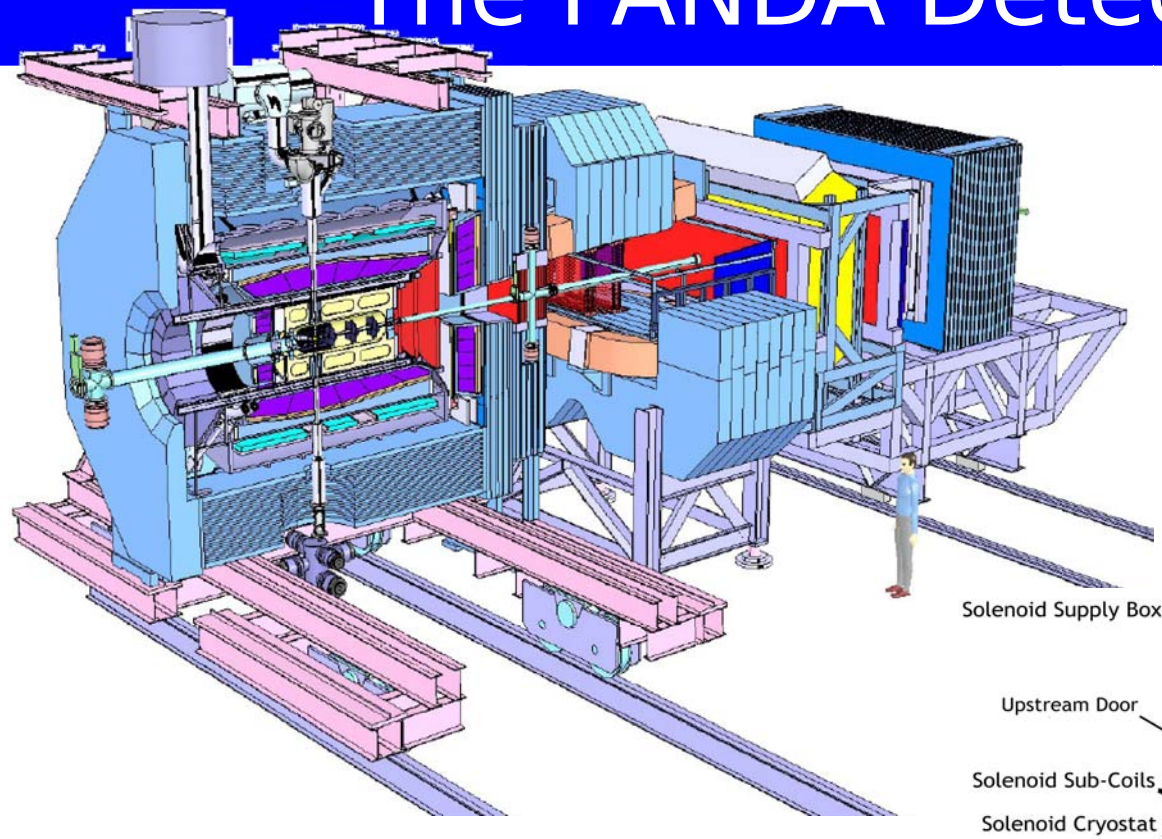


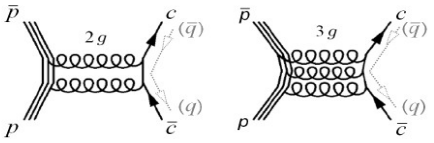
Hans-Georg Zaunick
II. Physikalisches Institut, JLU Gießen

II. Physikalisches Institut

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

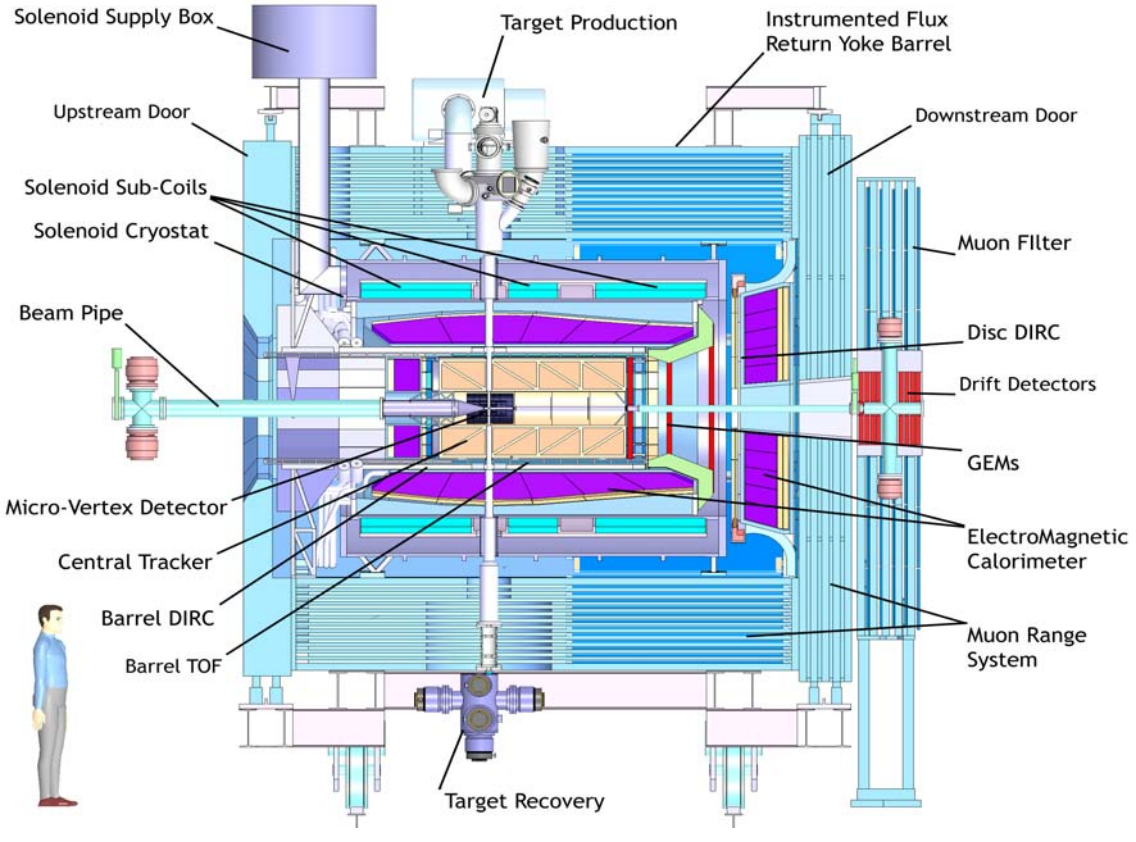
The PANDA Detector @ FAIR





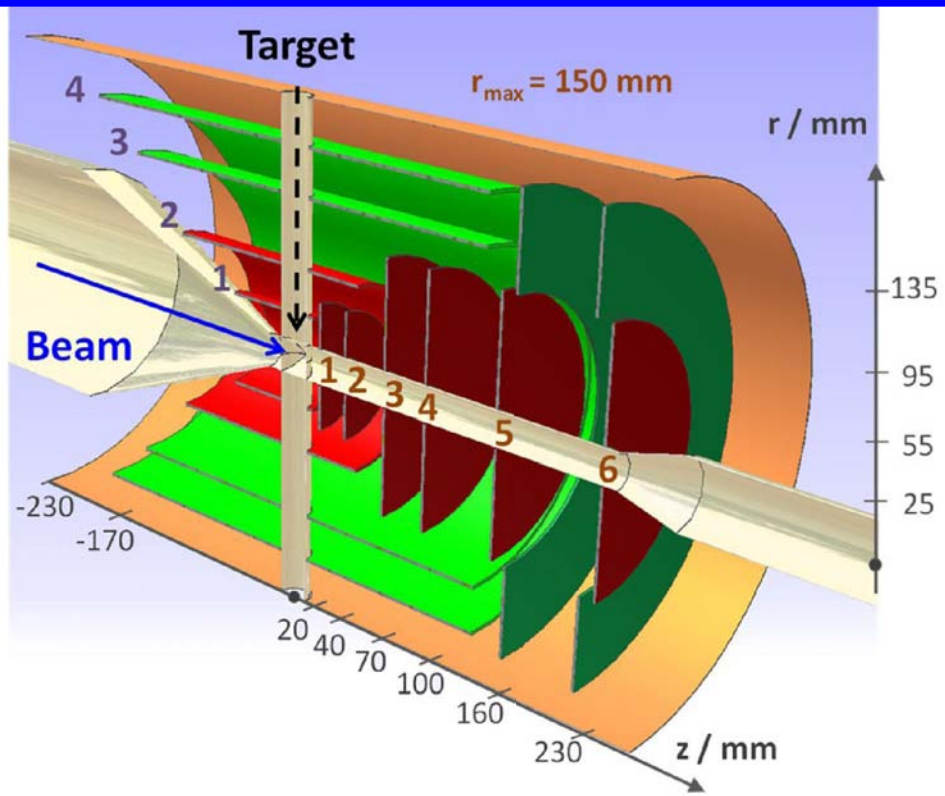
- Very broad physics program:
  - Hadron spectroscopy
  - In-medium effects
  - Hypernuclear physics

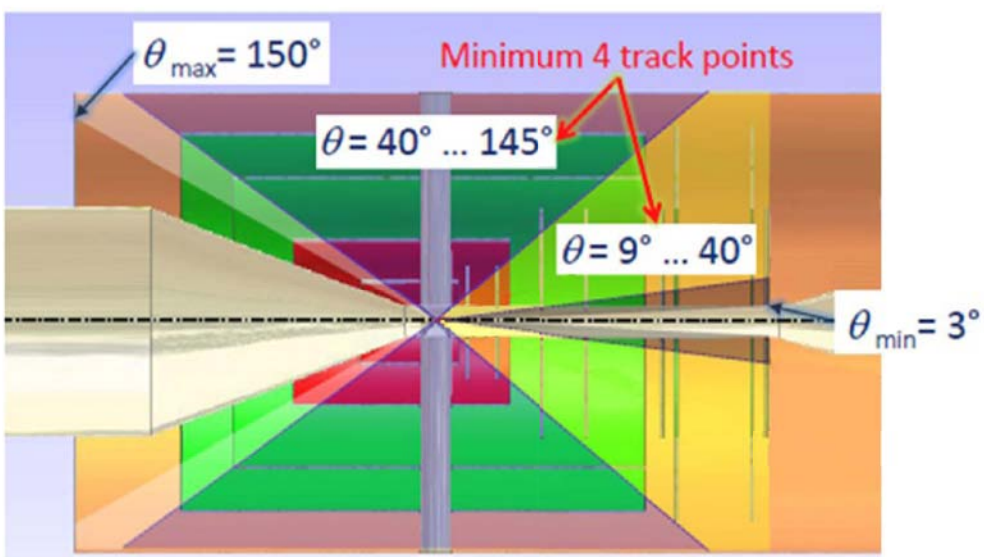
  → Focus on charmed hadrons



- 4pi acceptance
- High spatial and momentum resolution
- No hardware trigger

The Micro-Vertex Detector



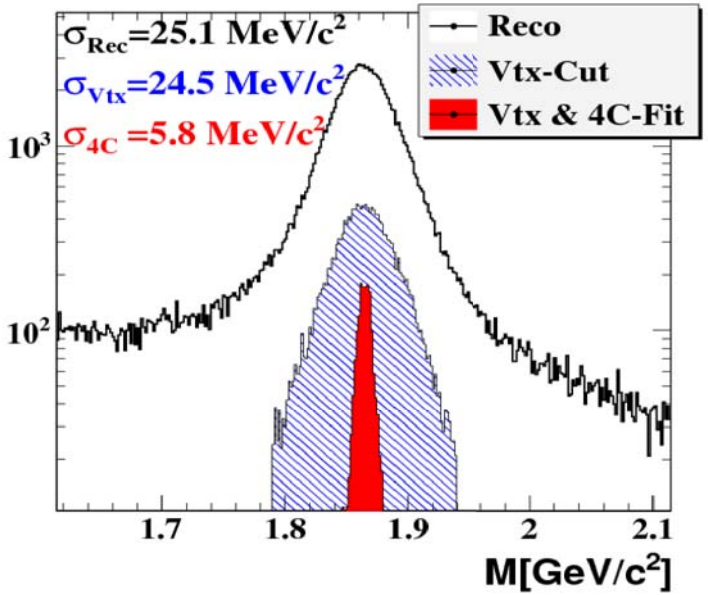


- 2 barrel pixel layers
- 4 pixel disks
- 2 barrel strip layers
- 2 mixed disks
- 2 optional forward wheels (@40 & 60 cm)

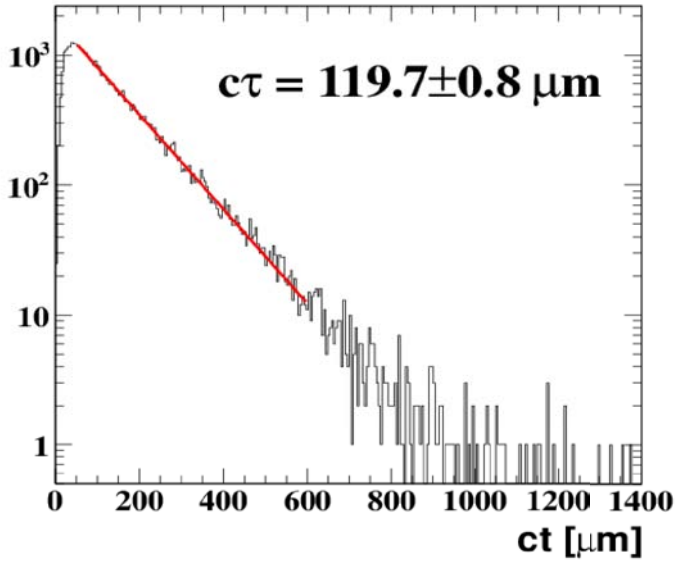
Benchmark Channels

open charm: e.g. $\bar{p}p \rightarrow D^+D^- \rightarrow K^-\pi^+\pi^+K^+\pi^-\pi^-$

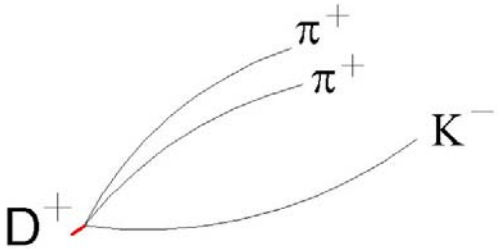
PANDARoot Simulations with detailed detector descriptions



Reco D^{+-} mass

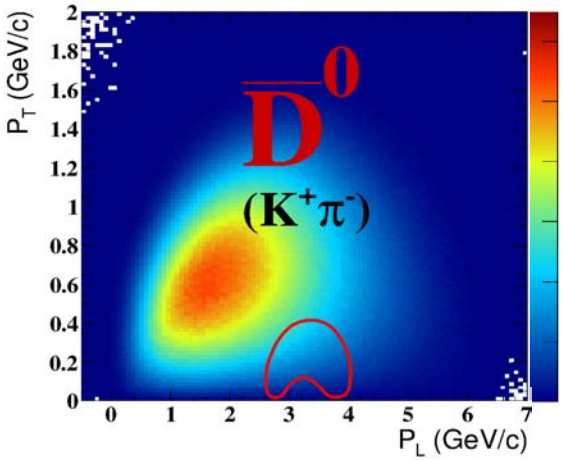


Reco D^{+-} decay length

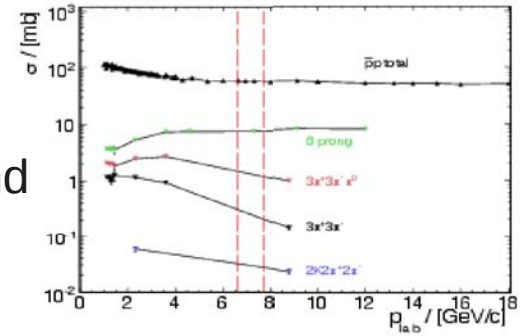


Benchmark Channels

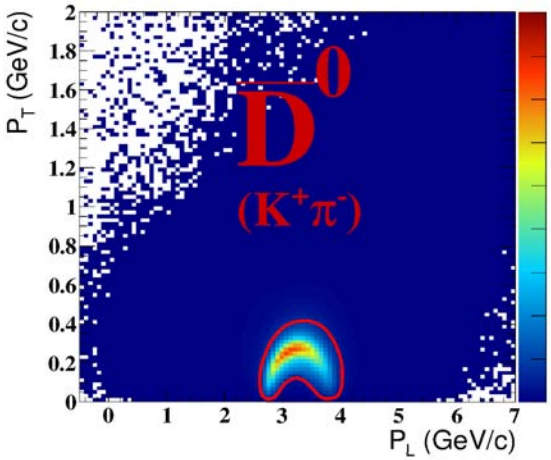
open charm: e.g. $\bar{p}p \rightarrow D^0\bar{D}^0 \rightarrow K_S\pi^+\pi^-K^+\pi^-$



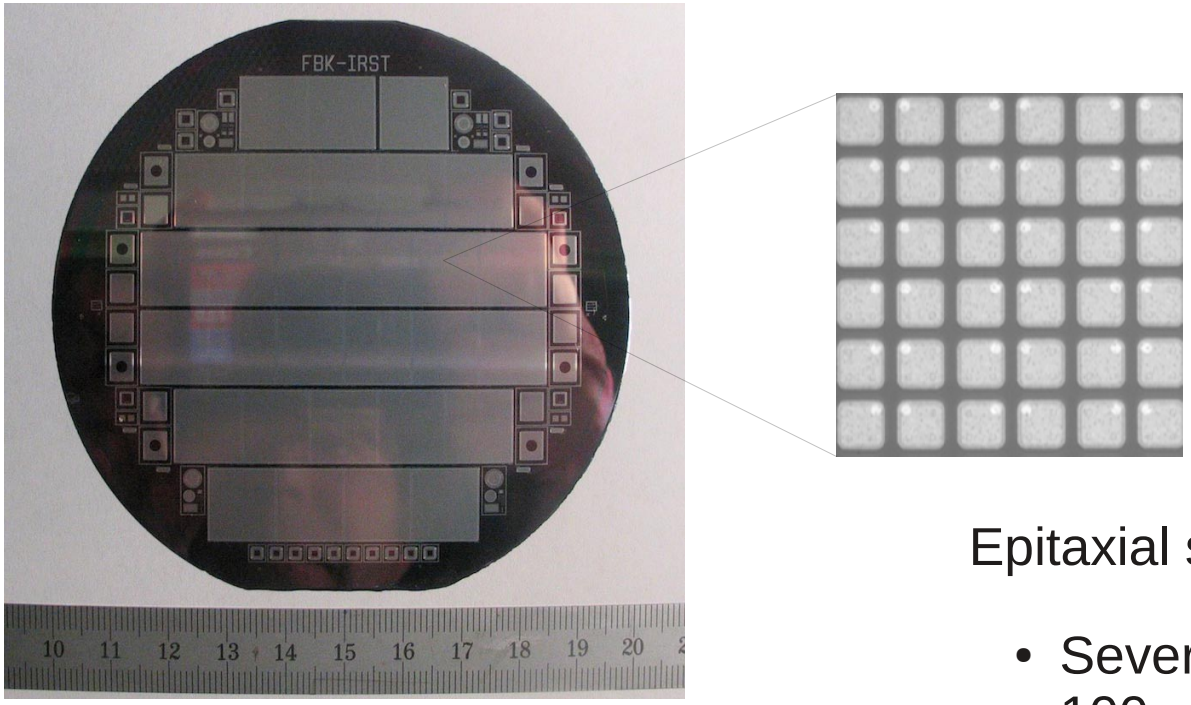
uncorrelated background



Signal events



Pixel Subdetector - Sensors



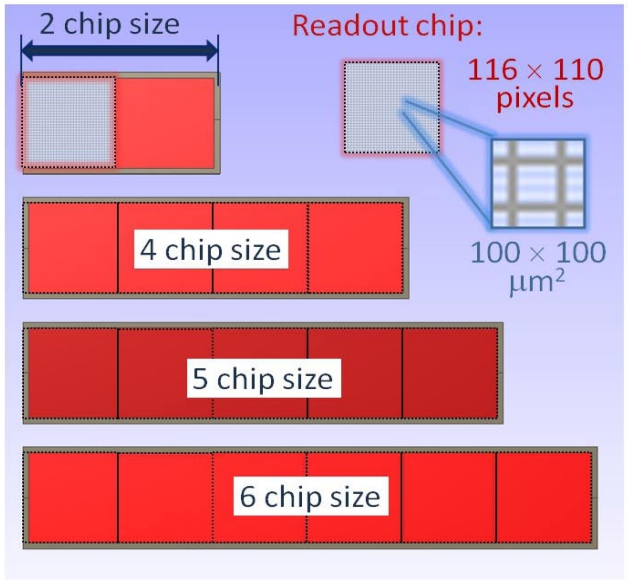
INFN Torino

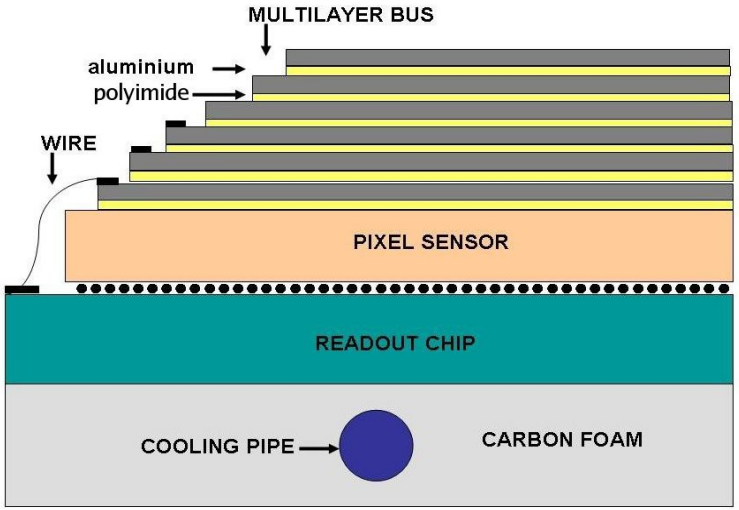
Epitaxial silicon pixel sensors

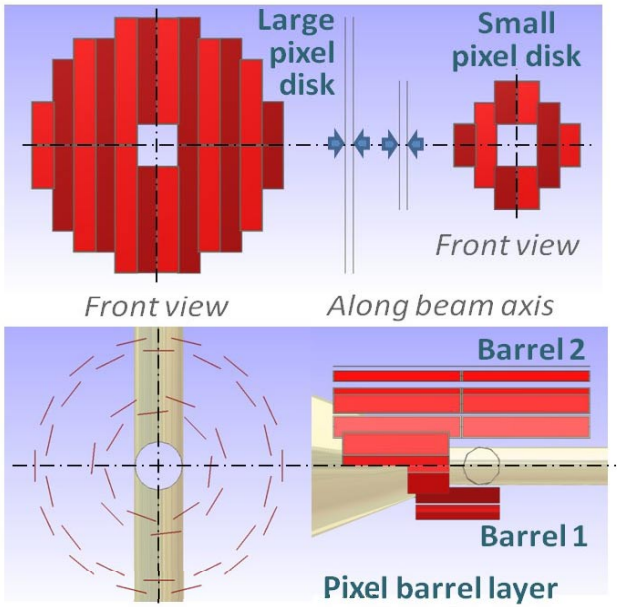
- Several thicknesses evaluated, 100 µm chosen for PANDA
- 100 x 100 µm² pixel array
- Full qualification of prototypes done
- Full size PANDA geometry

NIMA 594 (2008) p.29

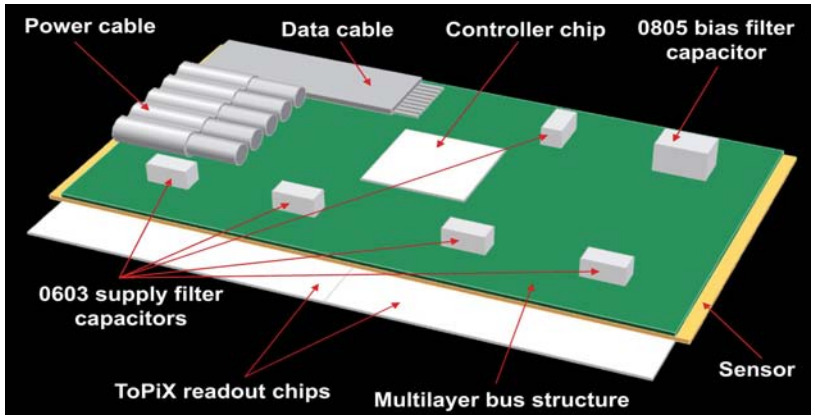
Pixel Subdetector - Modules





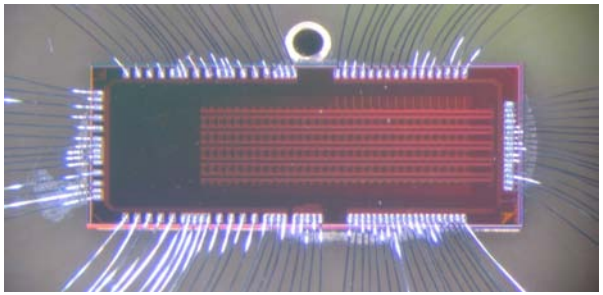


INFN Torino

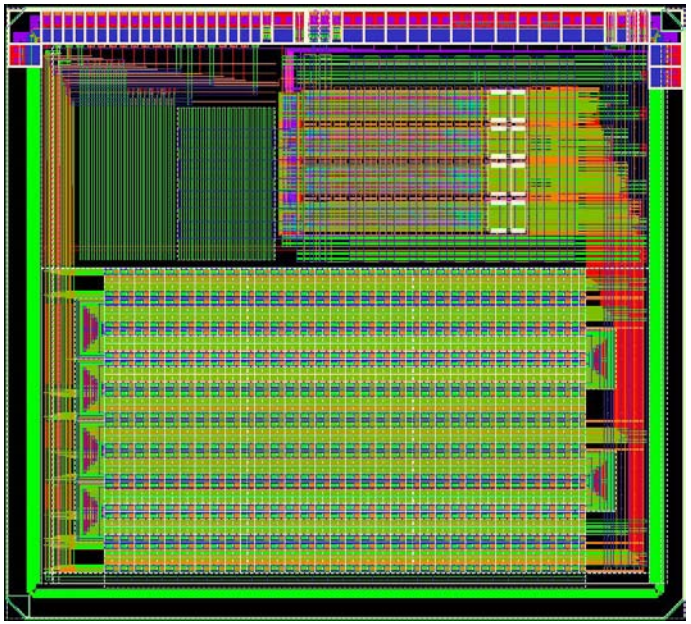


Pixel Subdetector - Front-end

INFN Torino



ToPix v2

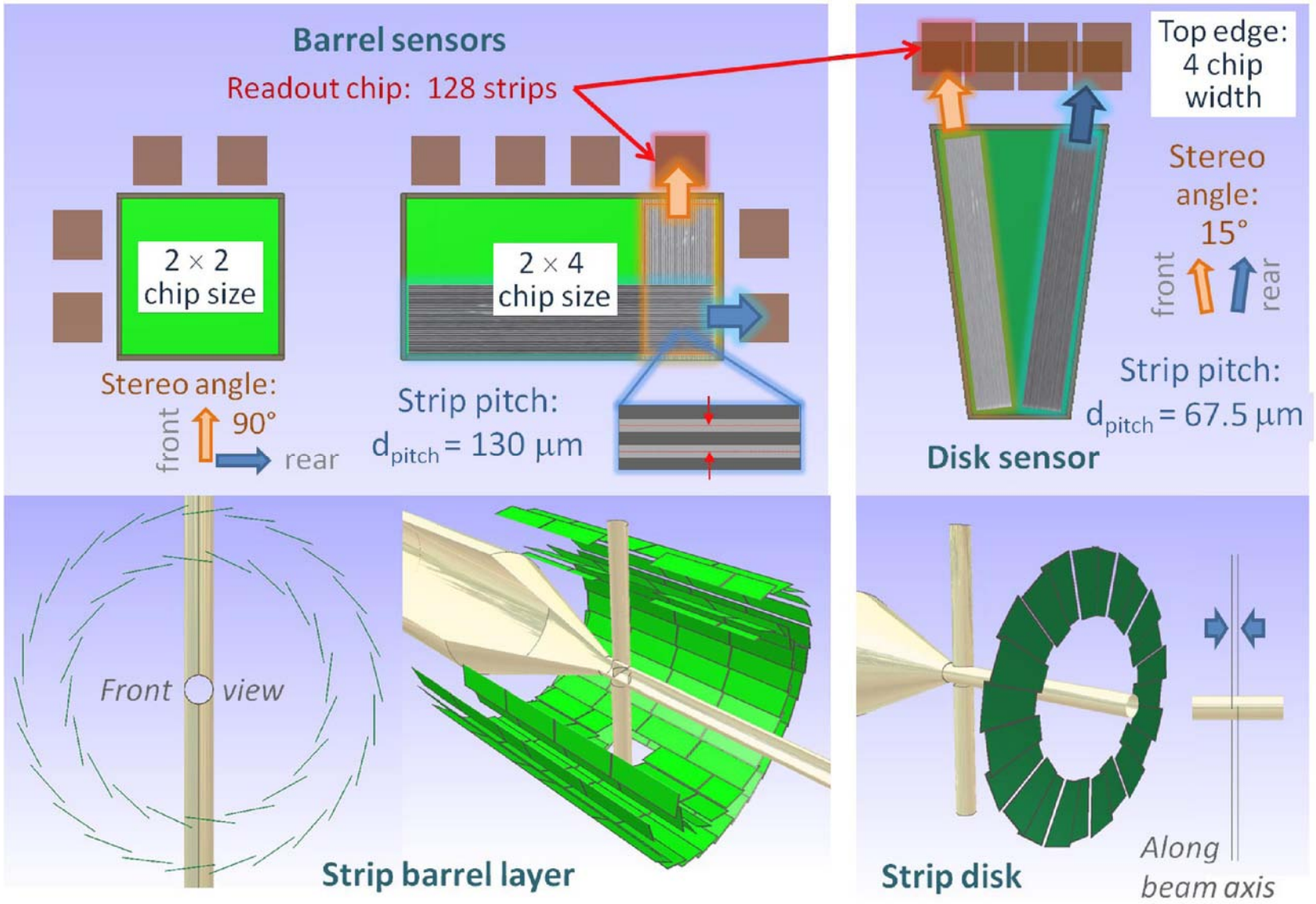


ToPix v3

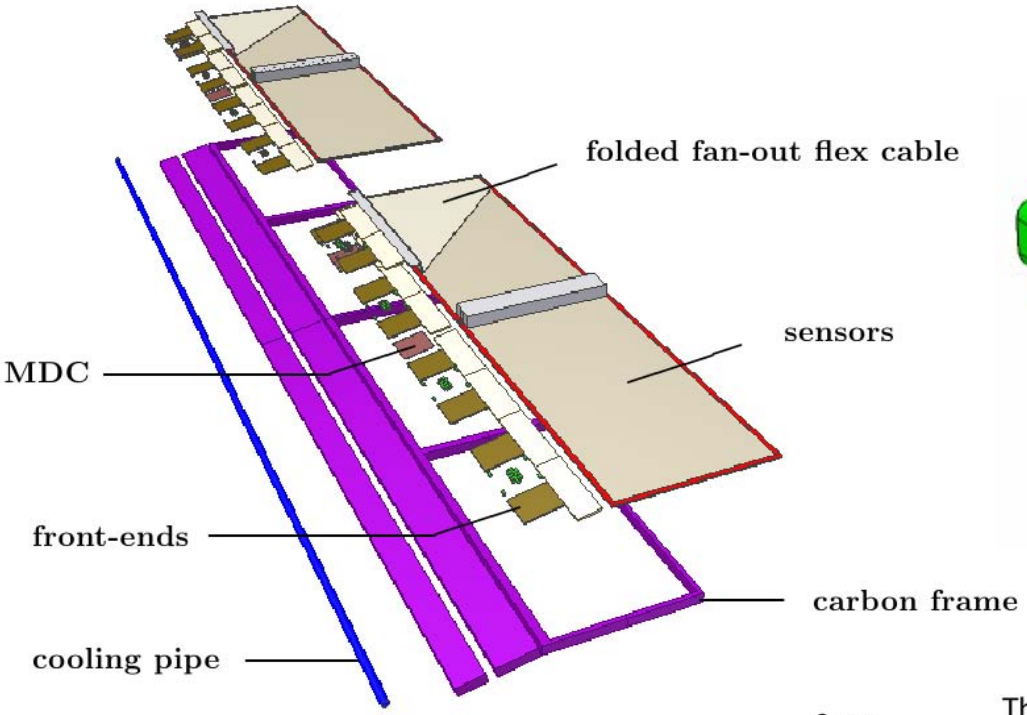
- Torino Pixel Readout Chip, current version V3
- 2 x 128 + 2 x 32 double columns
- size 4 x 4.5 mm²
- Complete pixel cells with full column architechture, end-of-column logic and buffers
- Fully tested in lab and beam setups
- Next prototype ToPix v4 submitted, lab tests pending

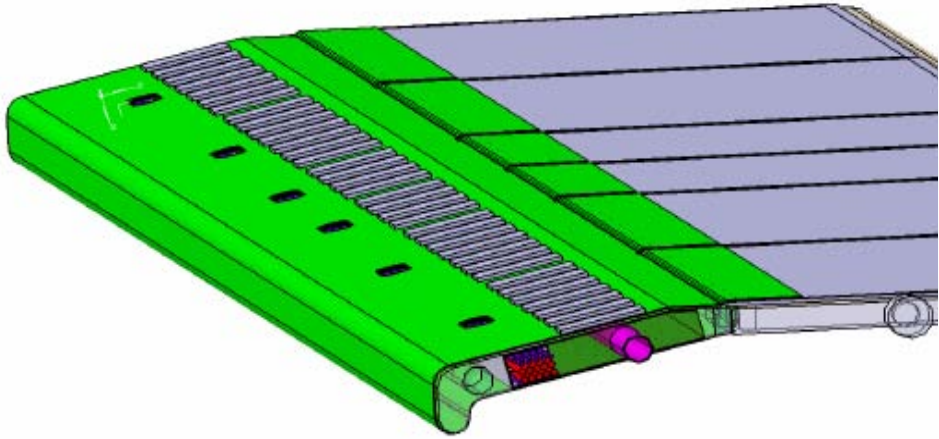
NIMA 596 (2008) p.96

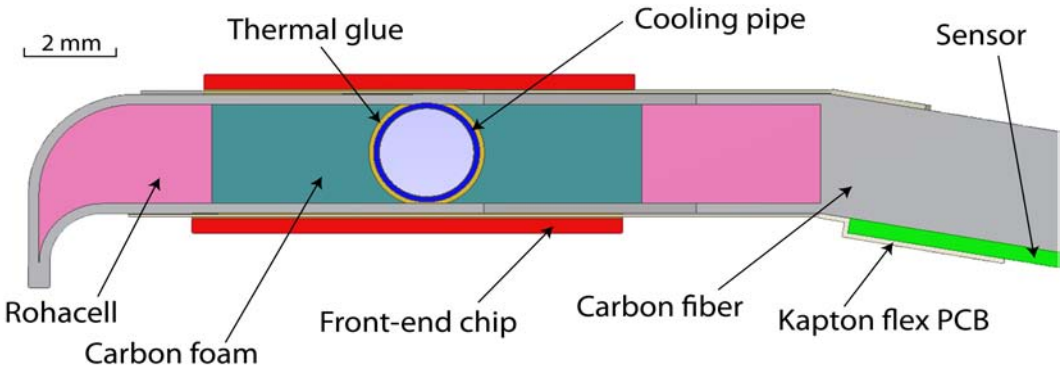
Strip Subdetector - Setup



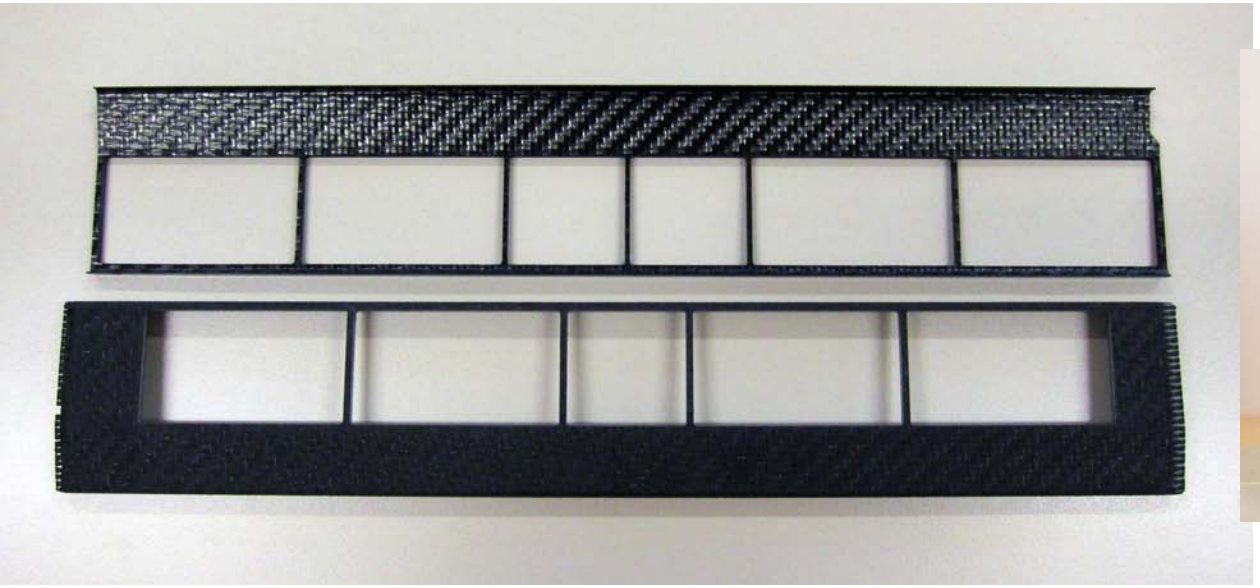
Strip Subdetector – Barrel Stave

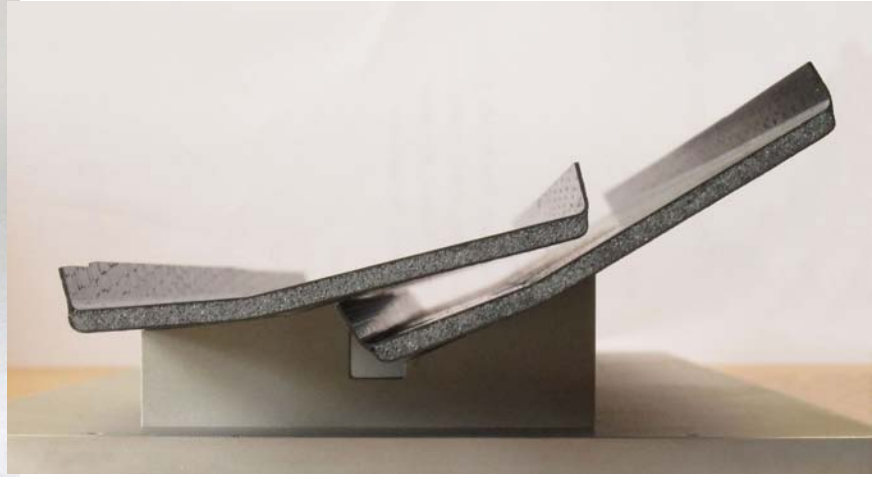






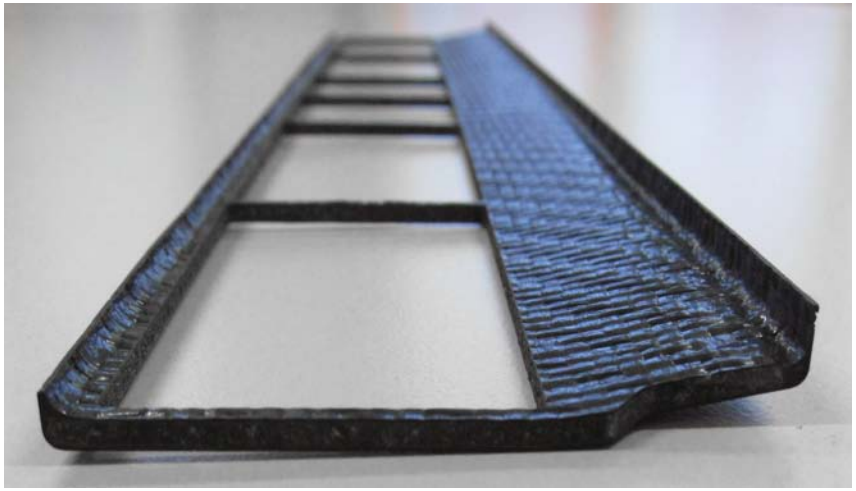
Stave prototypes





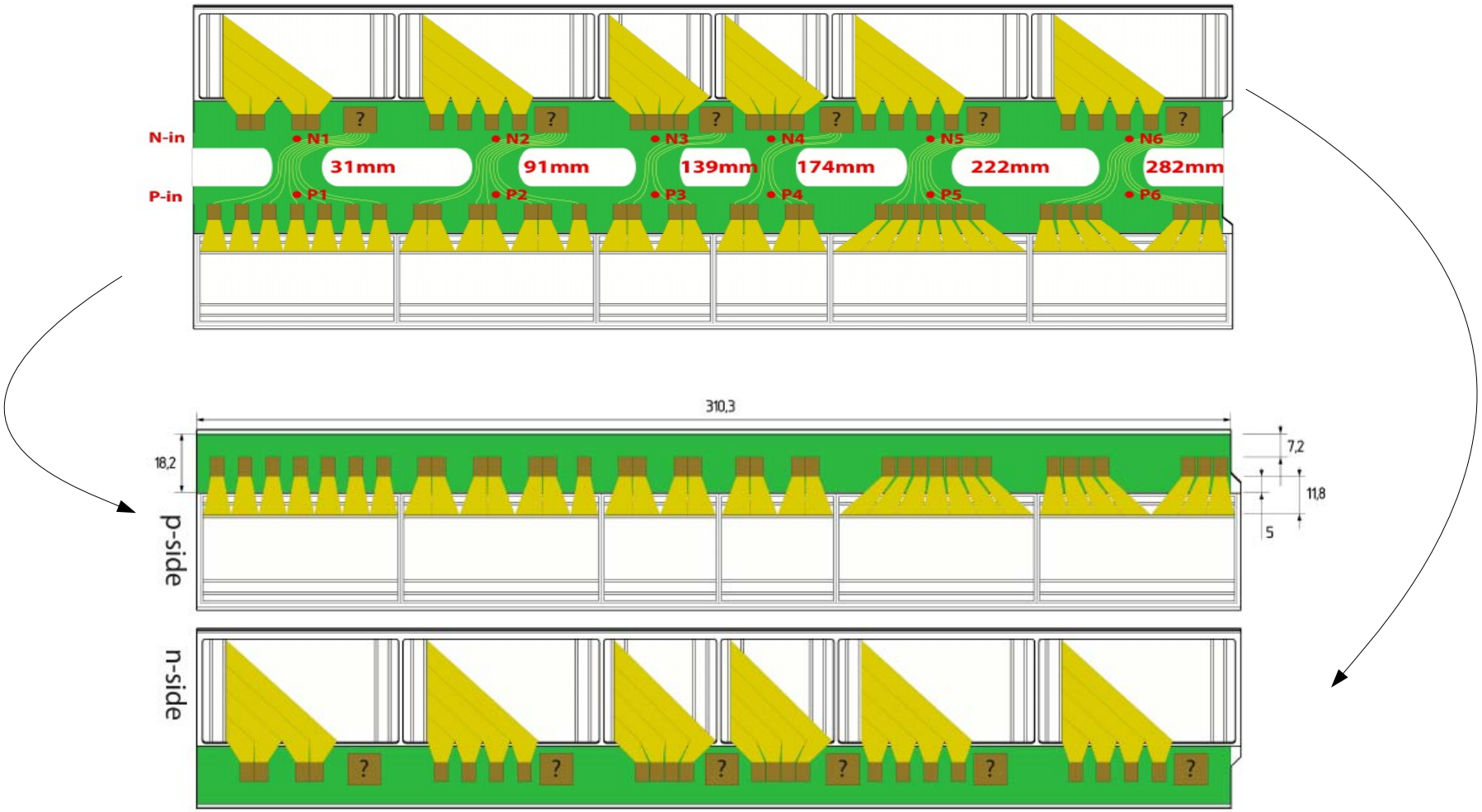
ZEA Jülich

- Ultralight carbon foam moulded in carbon fiber form sheet reinforcements
- Integrated cooling pipe in more recent prototypes



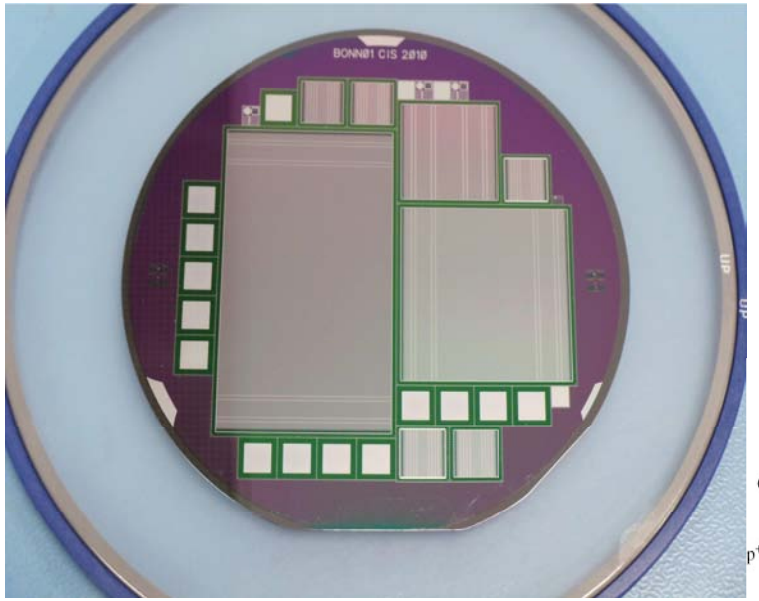
Stave prototypes

Folding of PCB around stave to connect n-side and p-side r/o



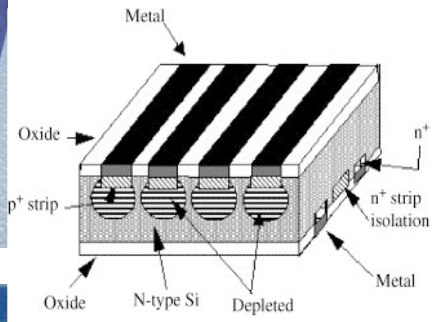
Sensors

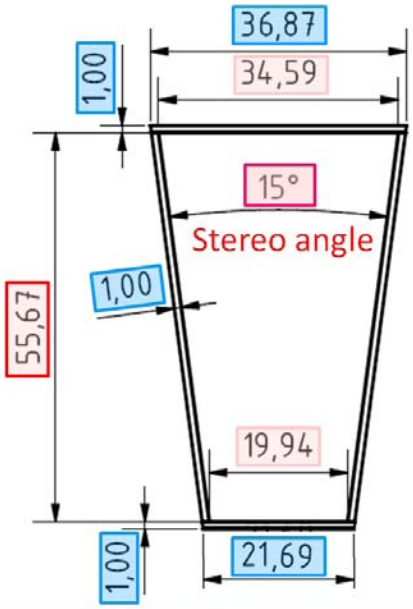
1st prototyping run (CiS Erfurt) 2010
2nd prototyping run (CiS Erfurt) 2013



Silicon Strip Sensor Prototypes

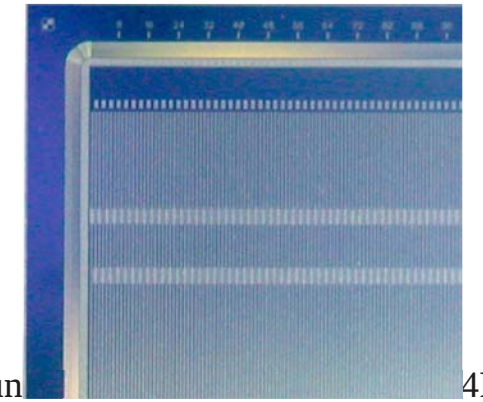
- Full size PANDA geometry
- 285 µm thickness
- Strip pitches of 65 and 50 µm (barrel sensors)
- 67.5 µm pitch for trapezoidal fw sensors
- Punch-through biased and poly-Si biased





IKP Jülich

JLU Gießen



Strip pitch: 67.5 µm
No. of channels: 512 (both sides)

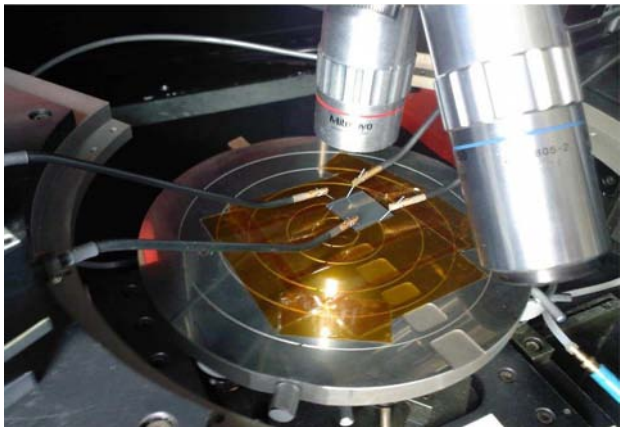
Sensor Probing and Prototype Assembly

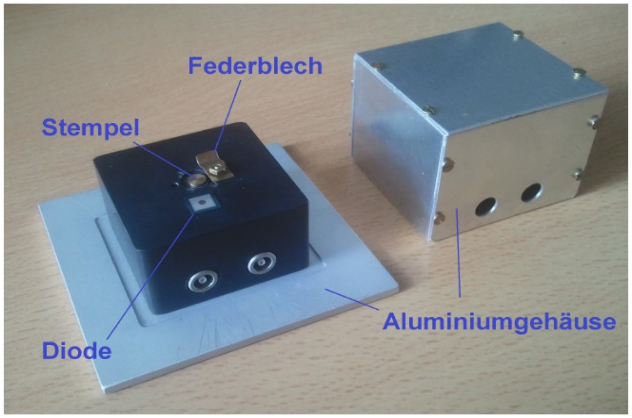
Sensors

Many sensor characterization capabilities available

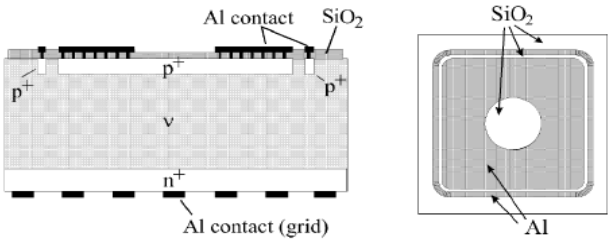
“Probecard”: fixed sensor assembly with all strips bonded to common lines (top and bottom)

Probe Station



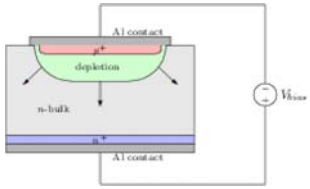


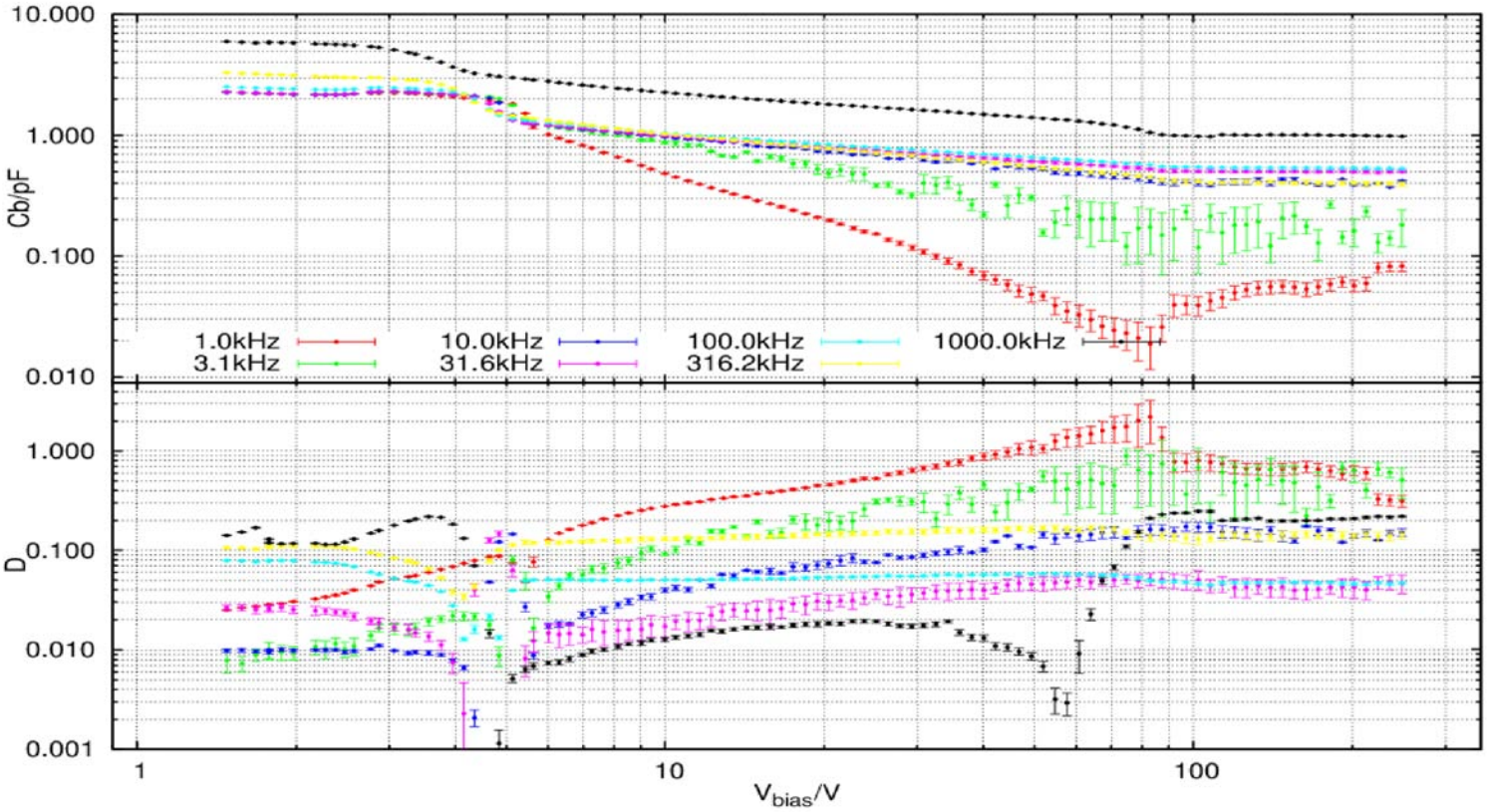
Wafer diode test fixture



Sensors

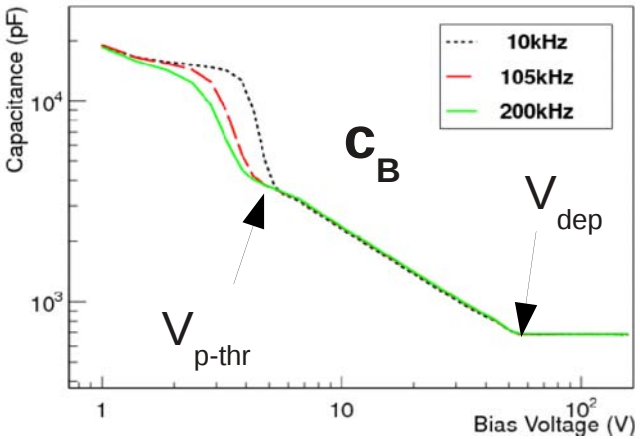
- All relevant parameters have to be monitored for QA
→ full sensor characterization required
- Analysis of irradiated sensors (p/n-irradiation)



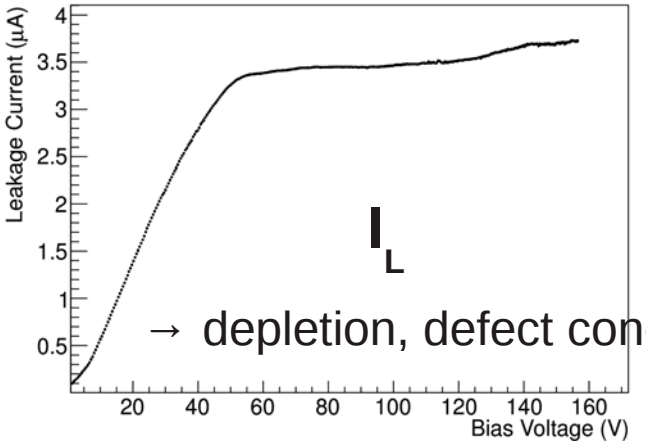


Sensors

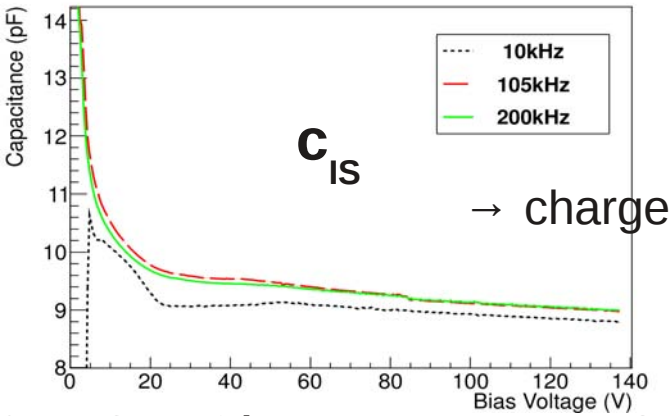
- All relevant parameters have to be monitored for QA
  → full sensor characterization required
- Analysis of irradiated sensors (p/n-irradiation)



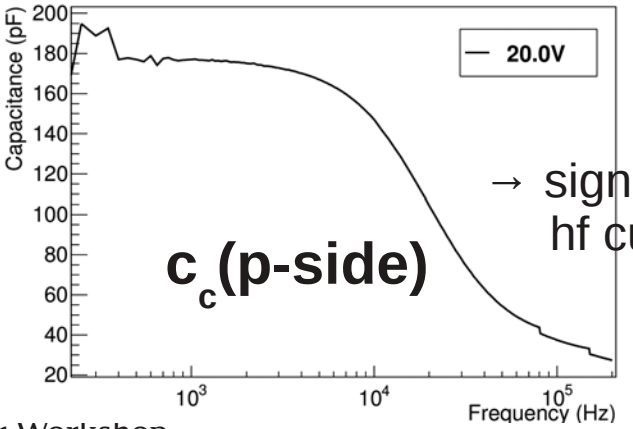
→ depletion, doping concentration



→ depletion, defect concentration

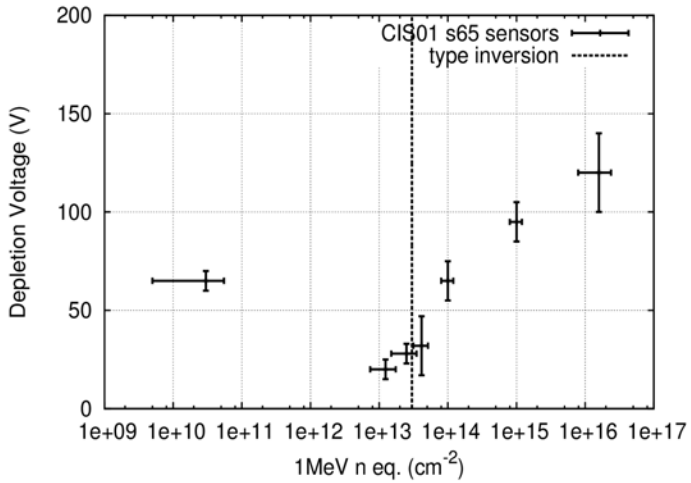


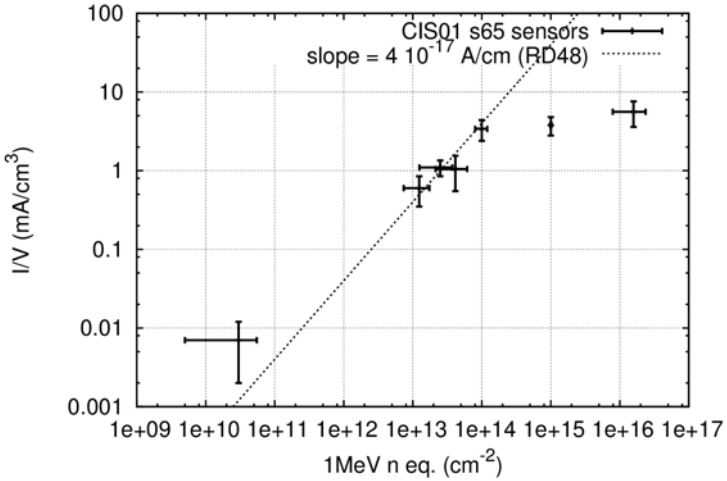
→ charge sharing



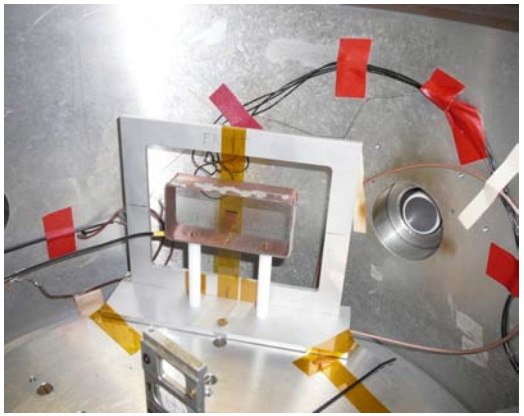
→ signal coupling, hf cutoff

Sensors

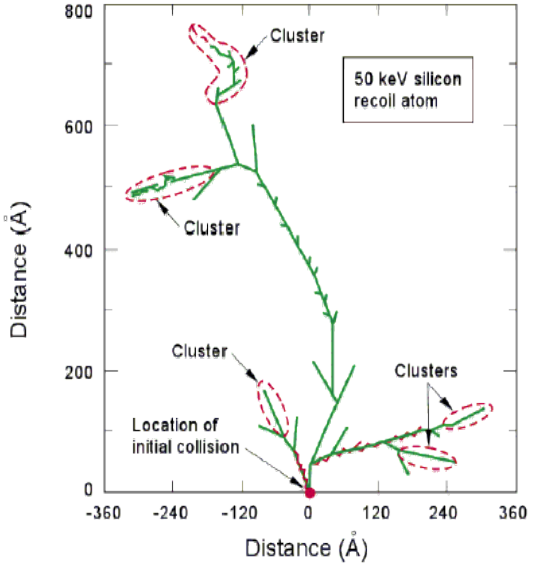




Irradiation with 14MeV Protons (Cyclotron Bonn)



Typical profile of hadronic lattice damage



Flex PCBs

Laser microvias diam. 50 µm

Varnish 15 µm

Cu 12 µm

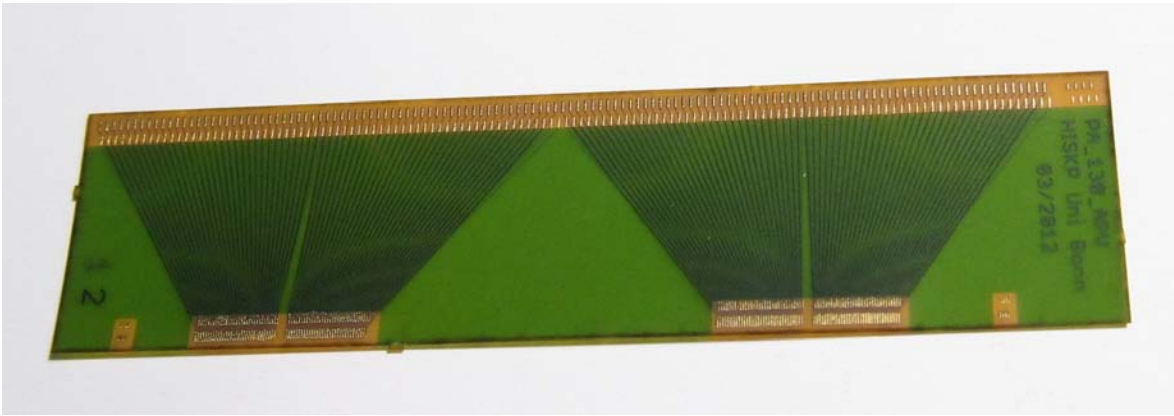
Kapton 25 µm

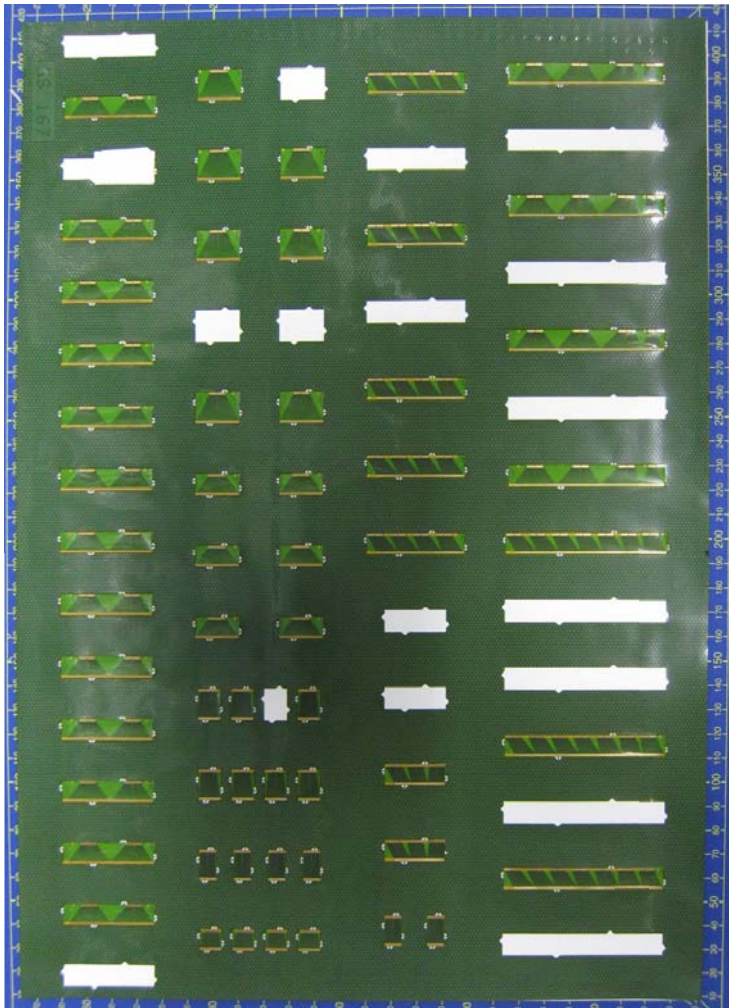
Cu 12 µm

duPont Pyralux Cu-Kapton-Cu laminate 49 µm

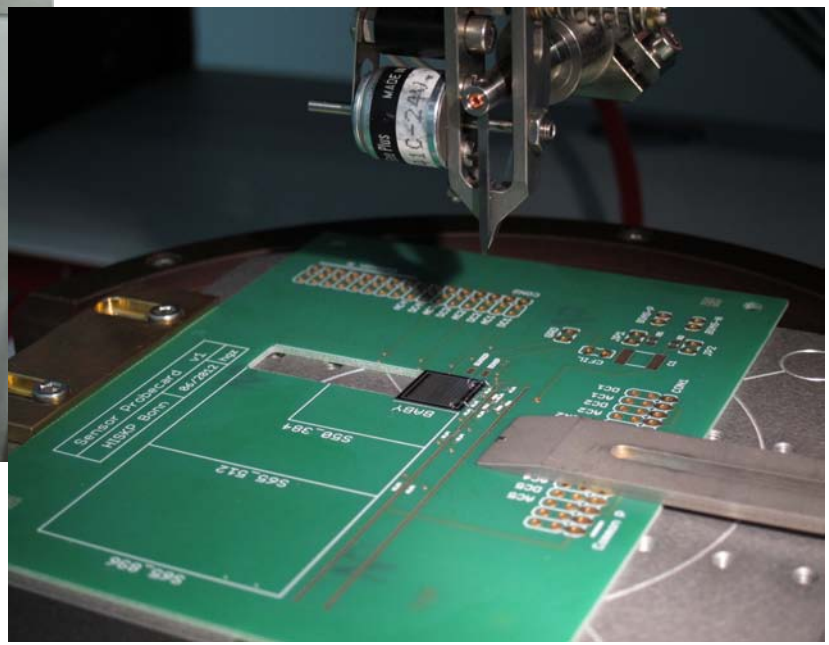
Ver. 1: varnish 15 µm

Ver. 2: Kapton coverlay 25 µm

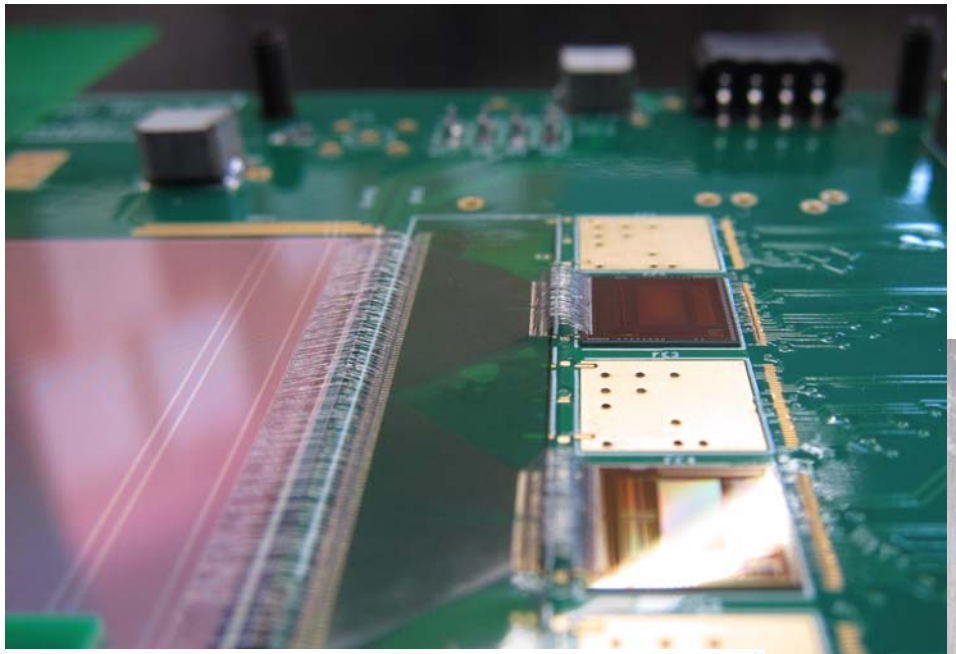




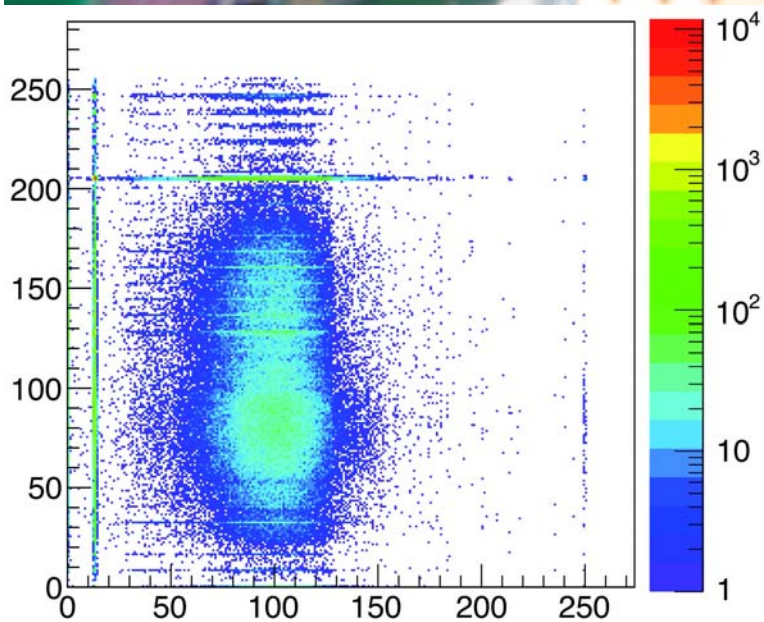
Assembly of Prototype Sensors

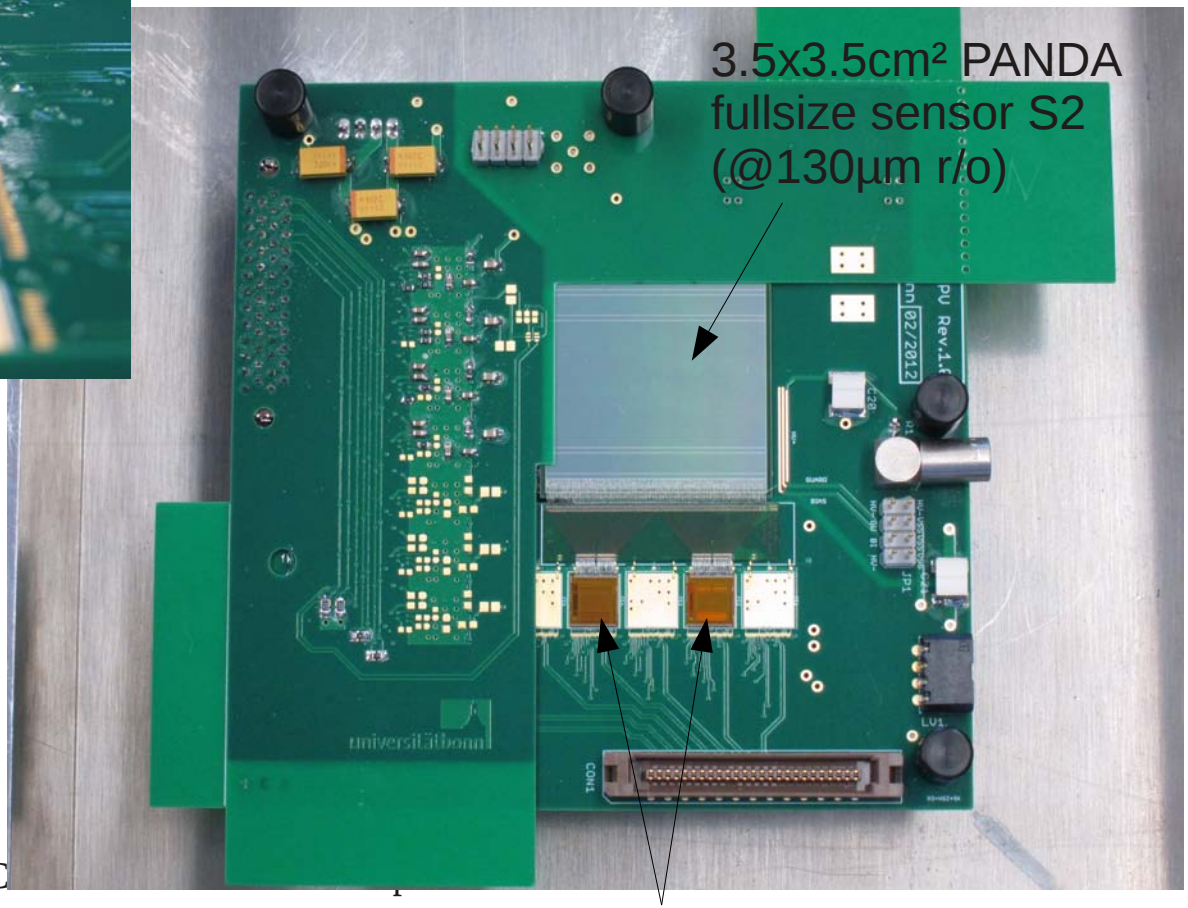


Prototypes



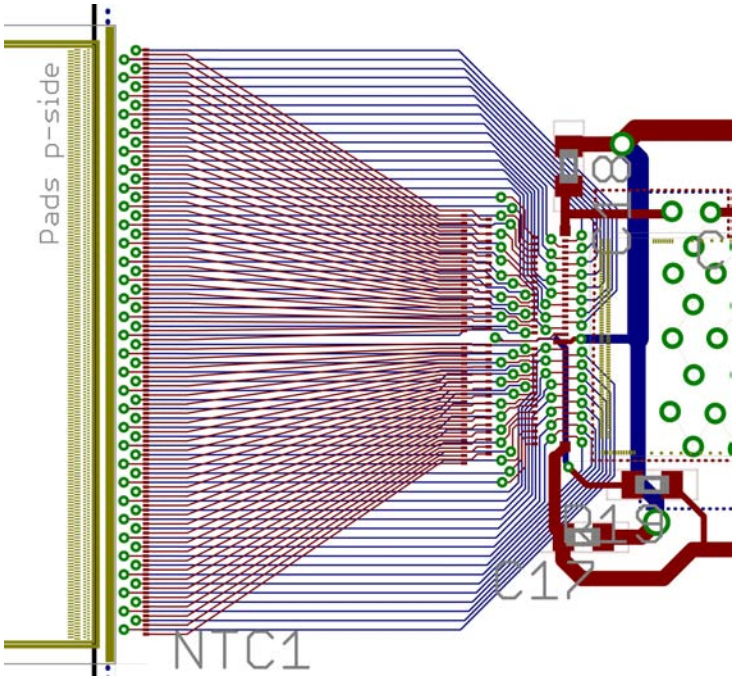
Flex-PA and squared sensor assembled on a test board and successfully tested at SPS, CERN (September 2012)

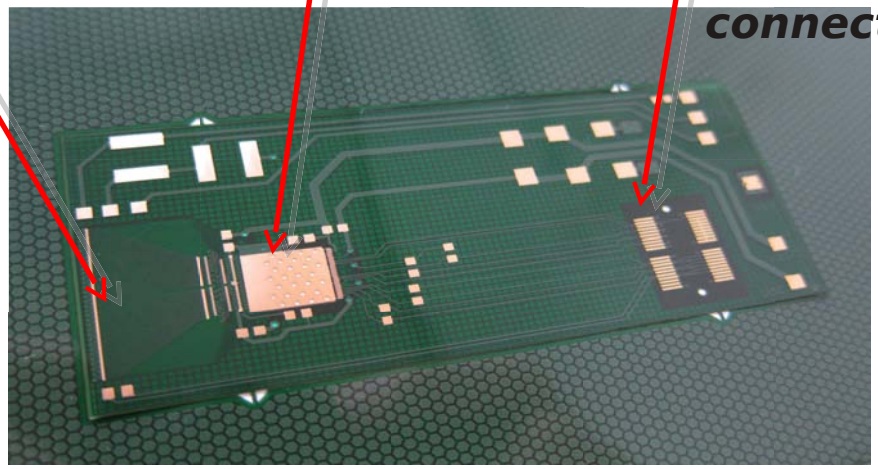




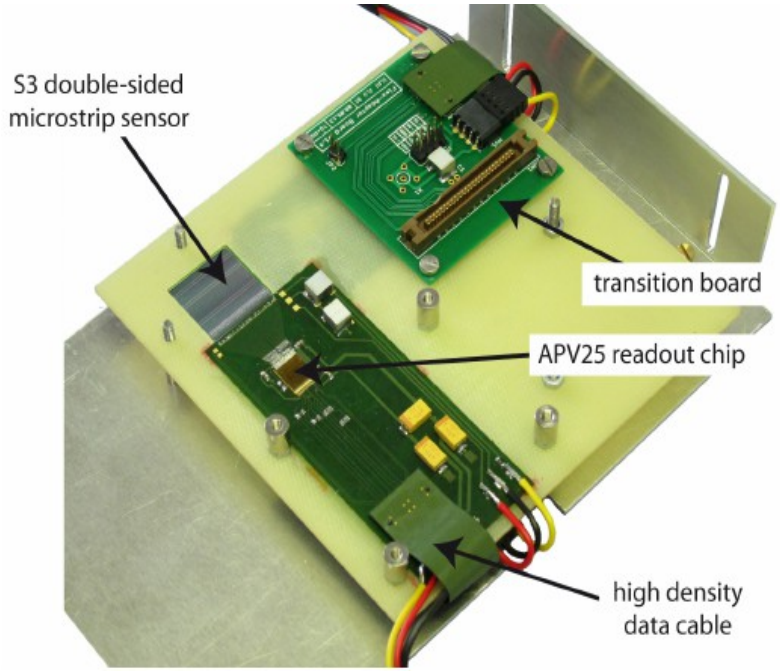
Prototypes

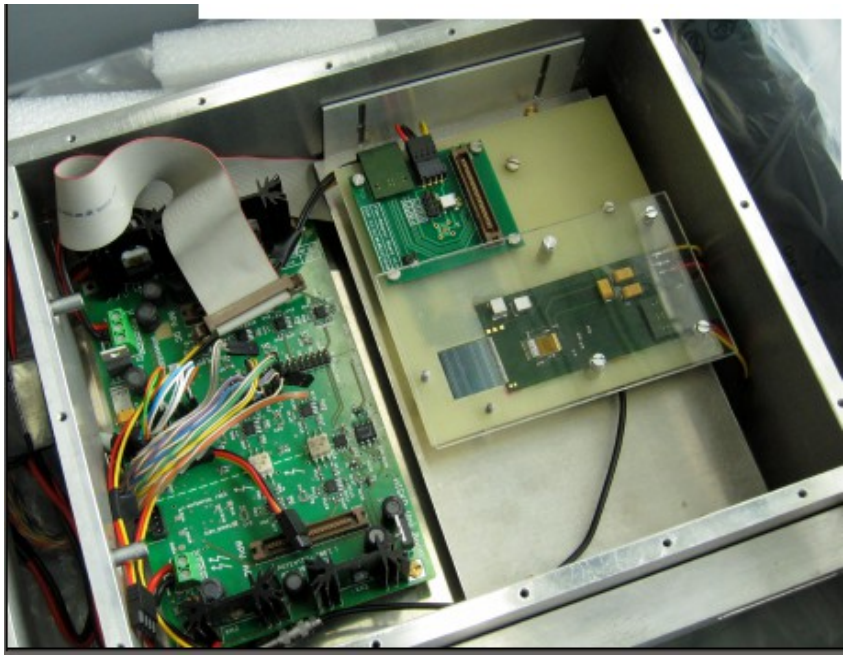

Laser microvias
diam. 200-650 µm
Varnish 15 µm
Cu 12 µm
Kapton 50 µm
Cu 12 µm
Thinflex A-2003AD
Cu-Kapton-Cu
laminate 74 µm
Varnish 15 µm


Pads p-side
NTC1

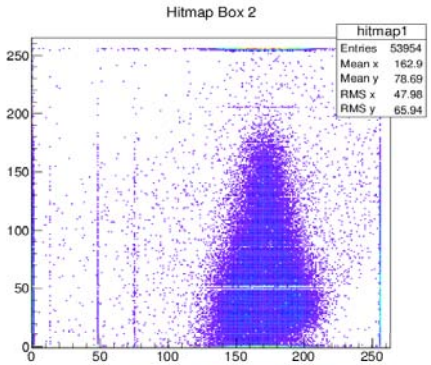

Bonding pads
for the sensor
Pad for 1 APV
readout chip
High density
data
connector

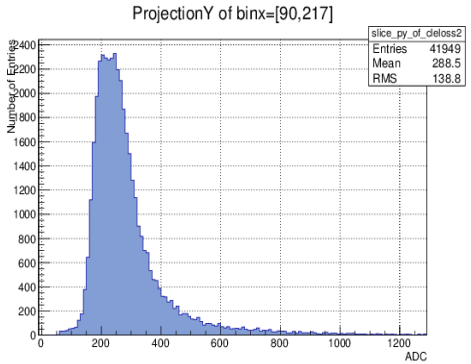
Prototypes

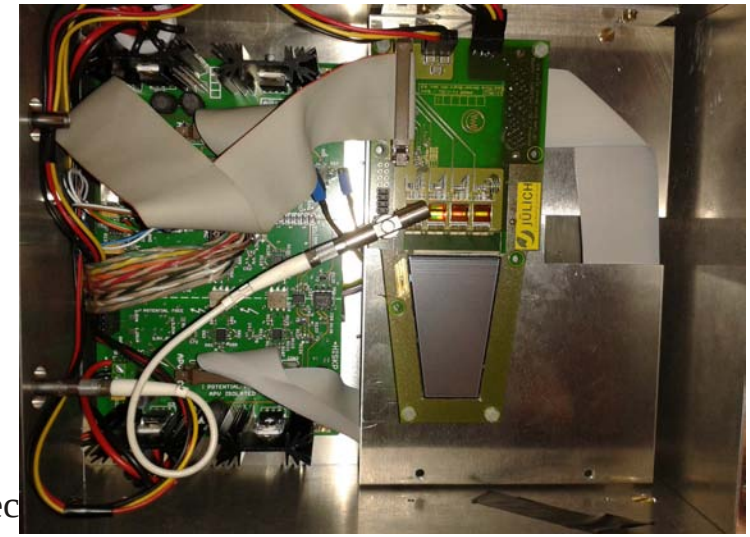




Very successfully tested in testbeams @ COSY





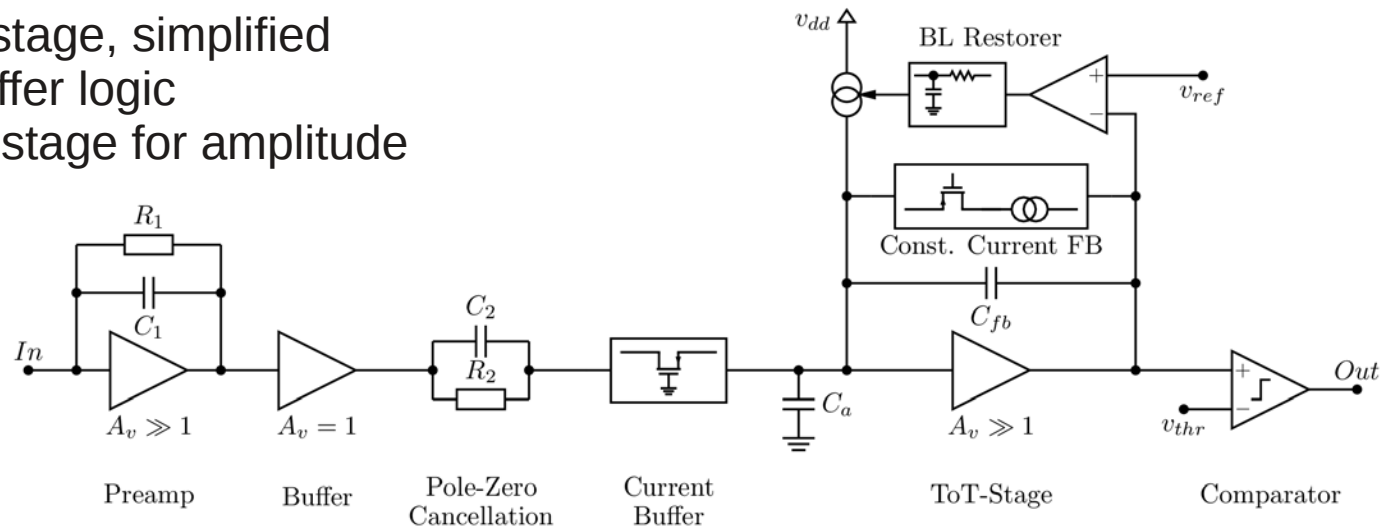


Prototypes

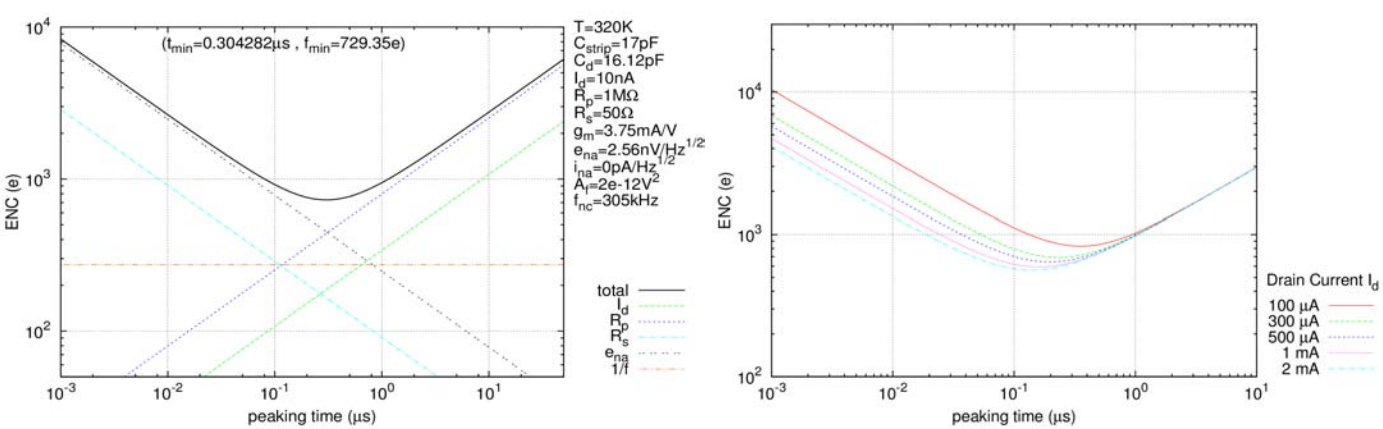
Strip Frontend

- design of new selftriggered FE based on ToPIX pixel FE and TOFPET ASIC started in 2013
- modified analog stage, simplified single column buffer logic
- ToT+HiRes TDC stage for amplitude measurement

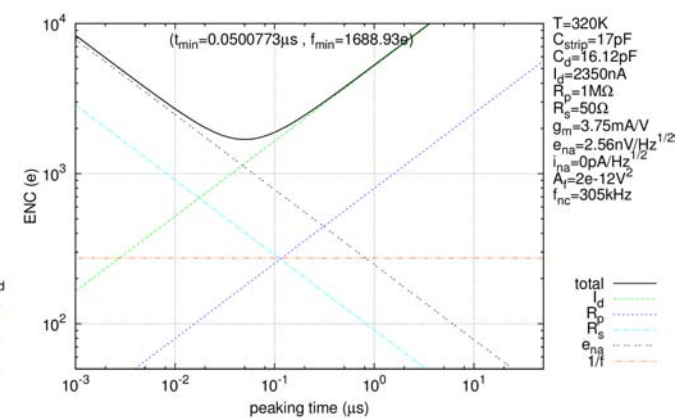
INFN Torino, JLU Giessen, IKP Jülich



Preamp. Noise:

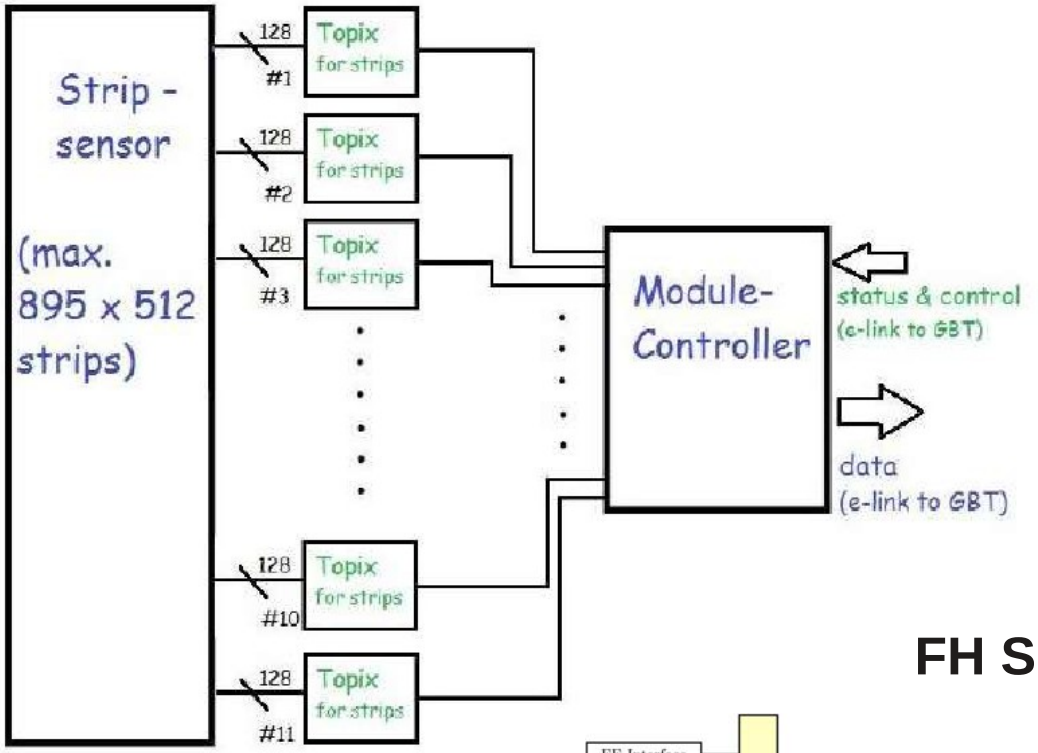


unirradiated



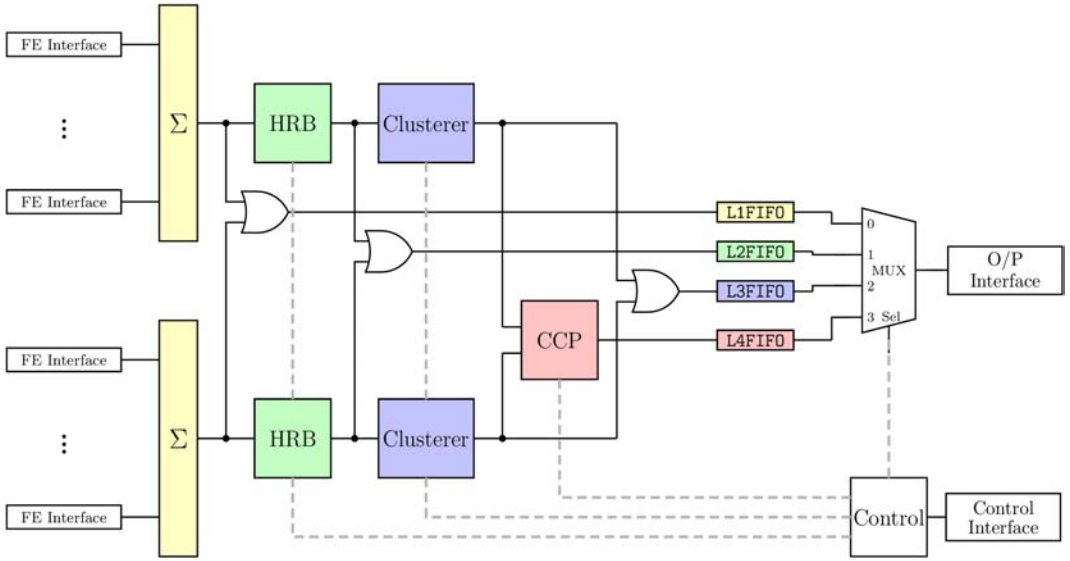
5e13 n. eq.

Module Data Concentrator



- On-module ASIC
- Multiplexes all FEs of one sensor
- Feature extraction: cluster finding, cluster correlation
- Manages slow-control + calibration of all attached Fes
- Fast GBT e-link for data out + config in

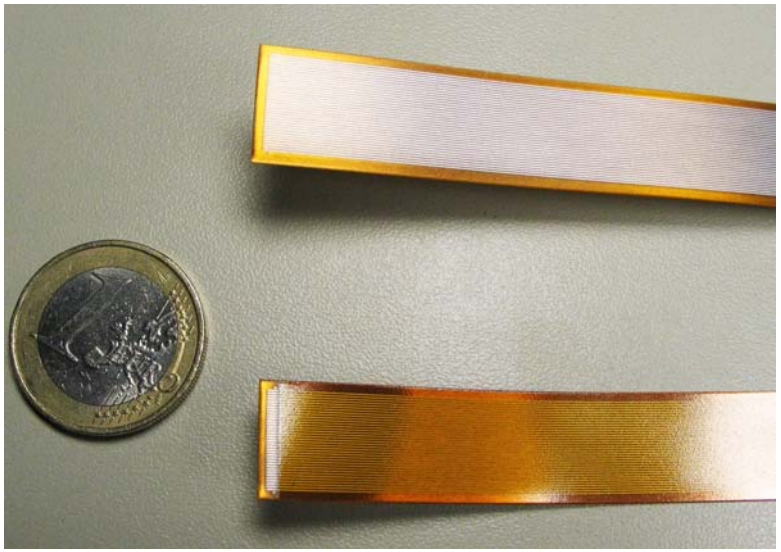
FH Südwestfalen Iserlohn



Infrastructure - Readout

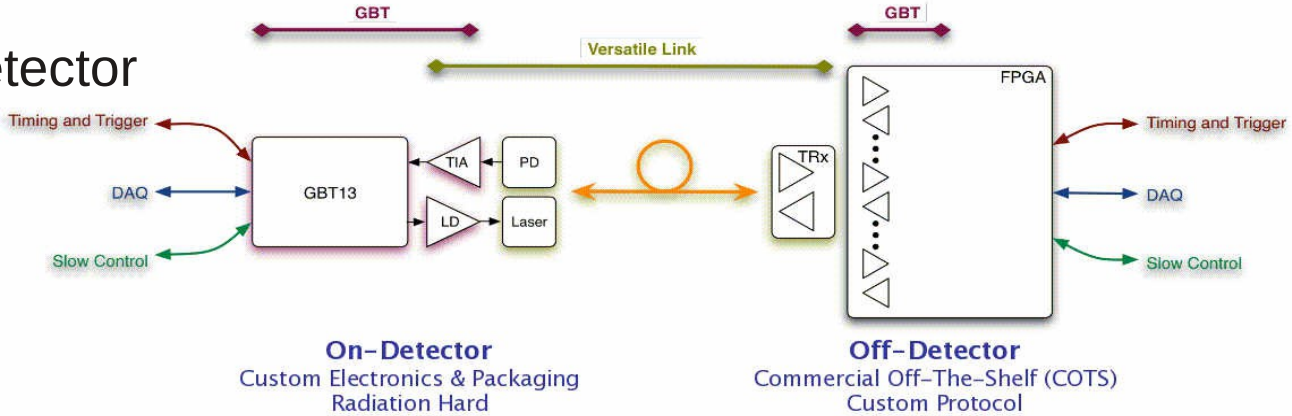
Thin Al-cables

- Thin kapton carrier
- Aluminum strips, 18 diff. pairs
- For data transmission out of the MVD
- Connect FEs/MDC to GBT receiver
- 320 Mbit/s serial links



GBT Project

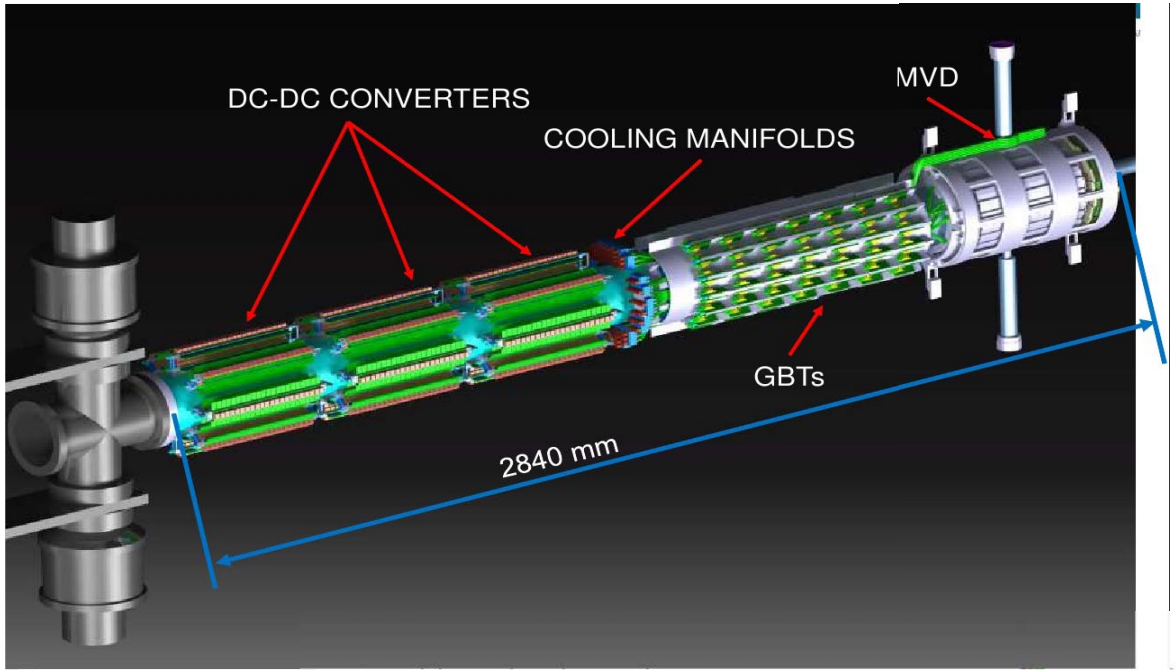
- E-link interface to on-detector node
- Optical link to the off-detector side

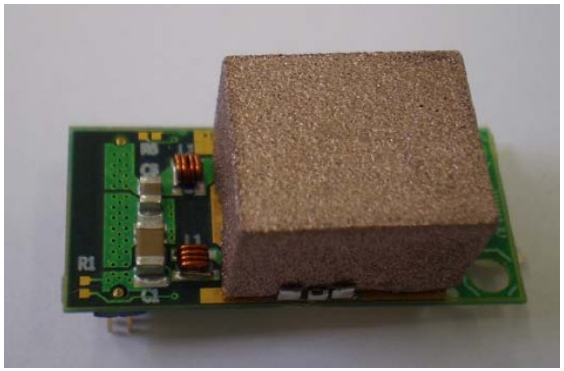


Infrastructure - Powering

DC-DC powering concept

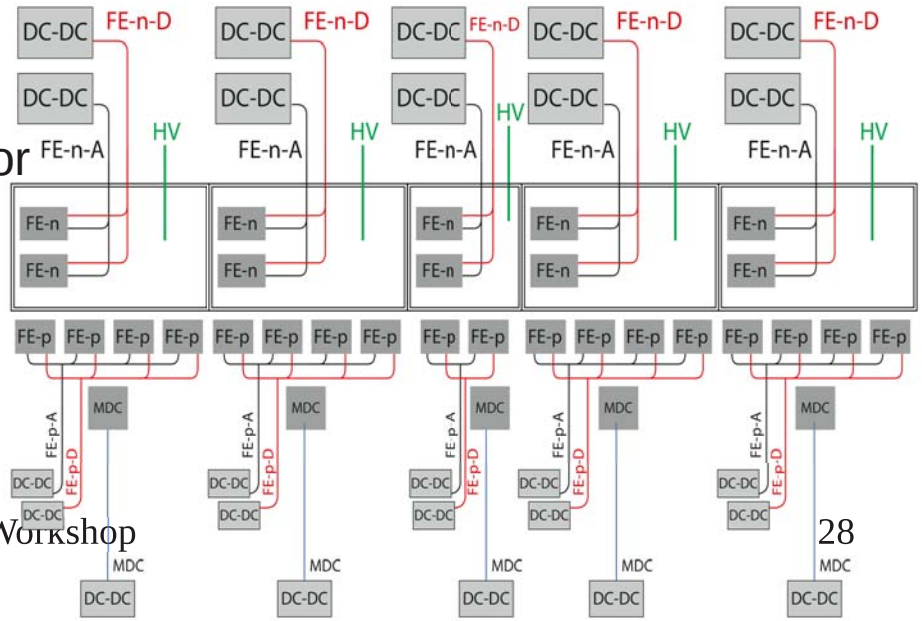
- Air-coil converters operate inside strong magnetic fields
- >80% efficiency
- Converter developed at CERN for LHC upgrade





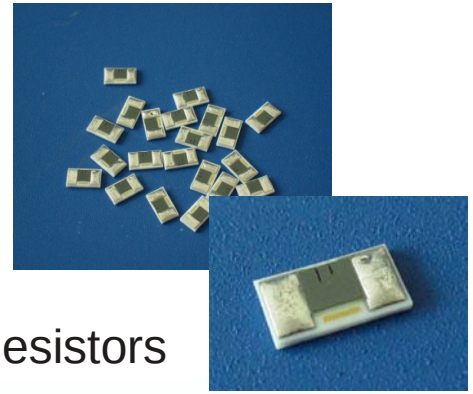
AMIS5MP DC/DC converter

Strip subdetector powering

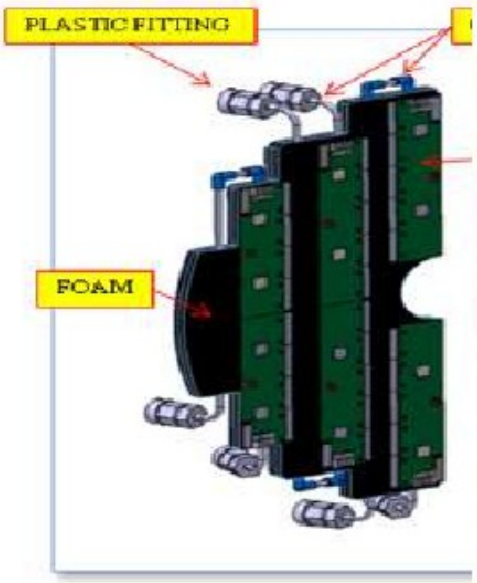


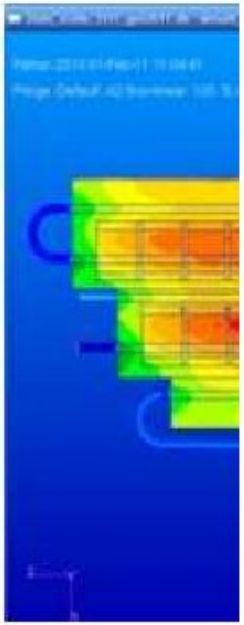
Infrastructure - Cooling

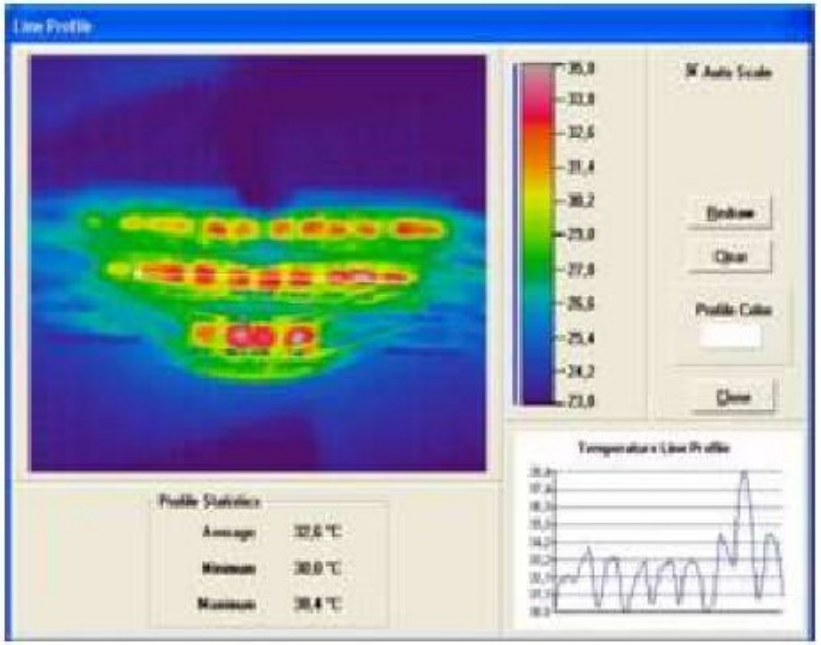
- Water cooling system in depression mode
- Operating at room temperature
- Carbon foam embedded in staves: high thermal conductivity
- Dummy staves w/ thermal loads built up and scrutinized



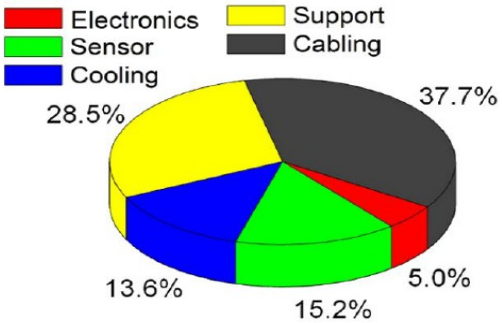
Customized Thermal Test Resistors







Numbers



- Number of sensors: 176 (pixel) 296 (strip)
- Number of FEs: 810 (pixel) 3112 (strip)
- Number of channels: 10.3 M (pixel) 200k (strip)
- Number of DC-DC: ~800(pixel) 1480 (strip)
- Active area (m²): 0.106 (pixel) 0.494 (strip)
- Cables off MVD: 1584 (disks) 3592 (barrels) 614 (GBT) 5790 (total)
- Cable cross section: 21835 mm² (total)
- Power dissipation: ca. 2 kW (pixel) 800 W (strips) (~.5kW in wires)