PROGRESS OF DOUBLE-SIDED PIXELATED LAYERS FROM THE PLUME COLLABORATION

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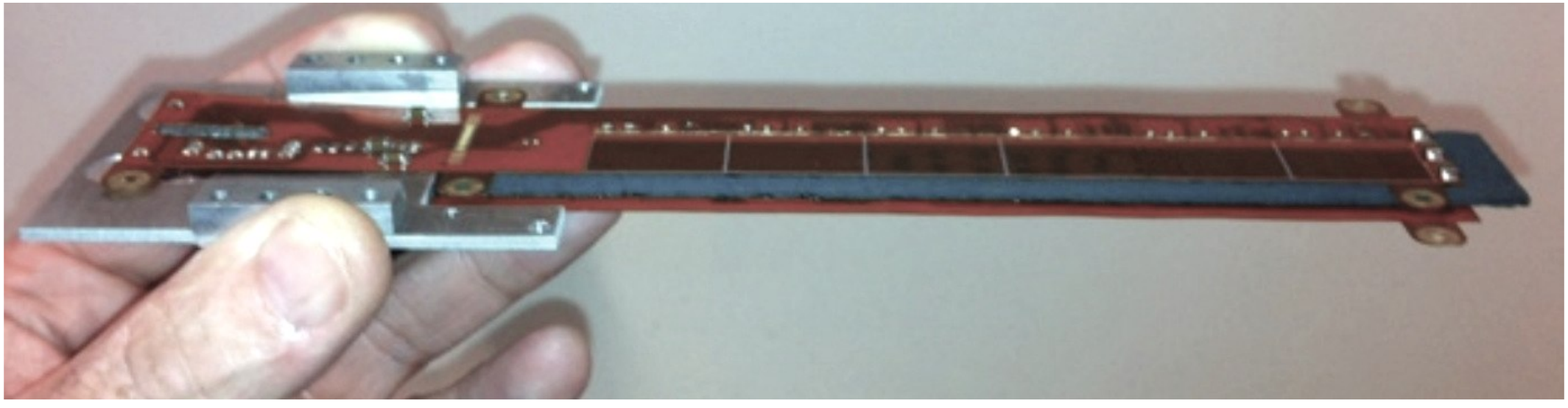
Introduction



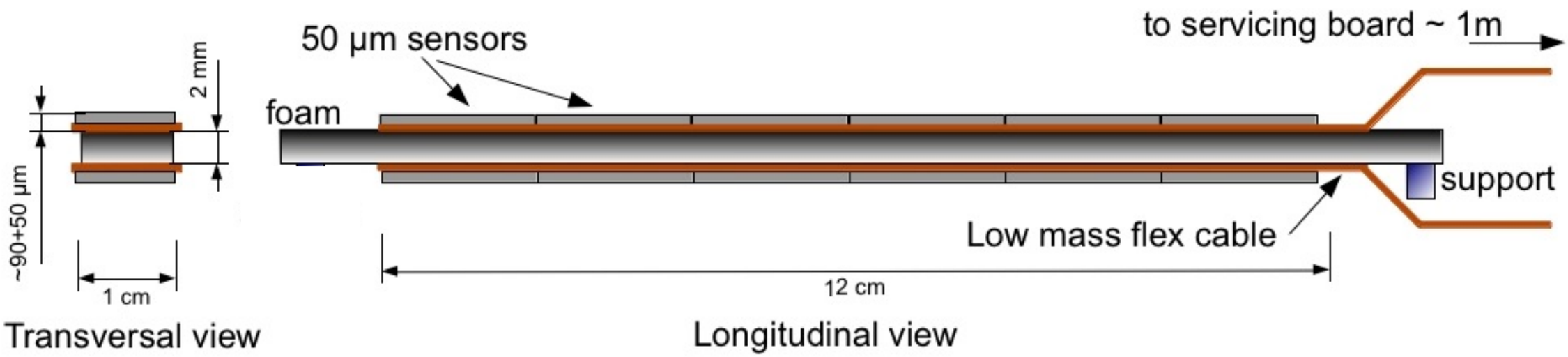
- ILC vertex detector requirements:
  - 3 μm spatial resolution
  - 0.15% X_0 or less material per active layer
  - 0.3% X_0 for double-sided ladders
- Plume collaboration:
  - Demonstrate functional ladders
  - Double-sided CMOS

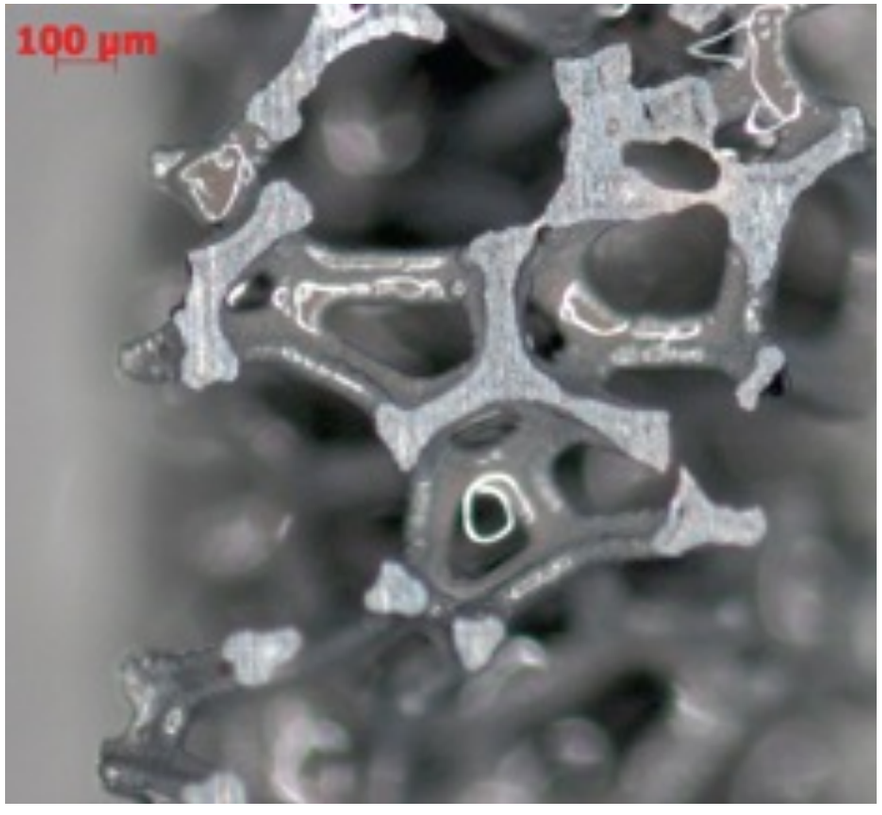
Collaboration

Pixel **L**adder using **U**ltra-low **M**aterial **E**mbedding

- Bristol
  - *Mechanical design, assembly and metrology*
- DESY
  - *FEA, thermomechanical modelling, power pulsing*
- IPHC
  - *Flex circuits, DAQ, infrastructure, test beam analysis*
- *Oxford no longer participate*
- Synergy with CBM (Frankfurt), STAR (LBL), ALICE

Ladder Design

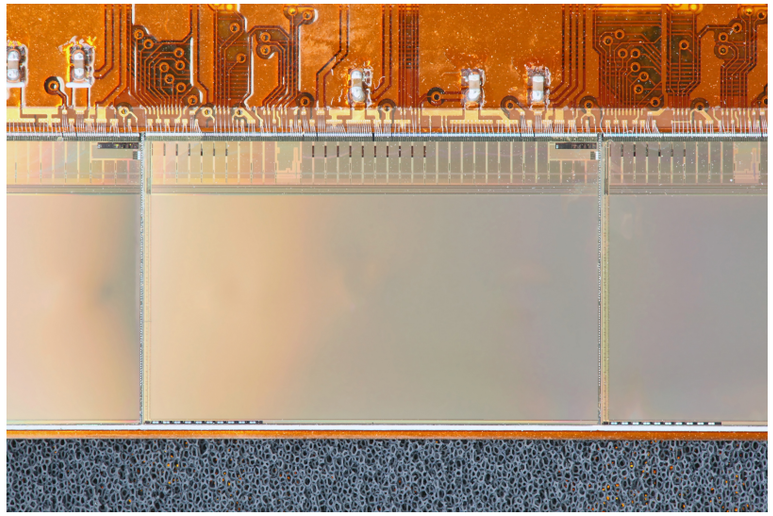




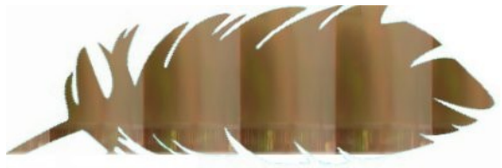
- 12 cm active length
- Mimosa 26
  - Thinned to 50 μm
- Kapton flex circuits, 2 metal layers
  - Passive components
- Silicon carbide foam core

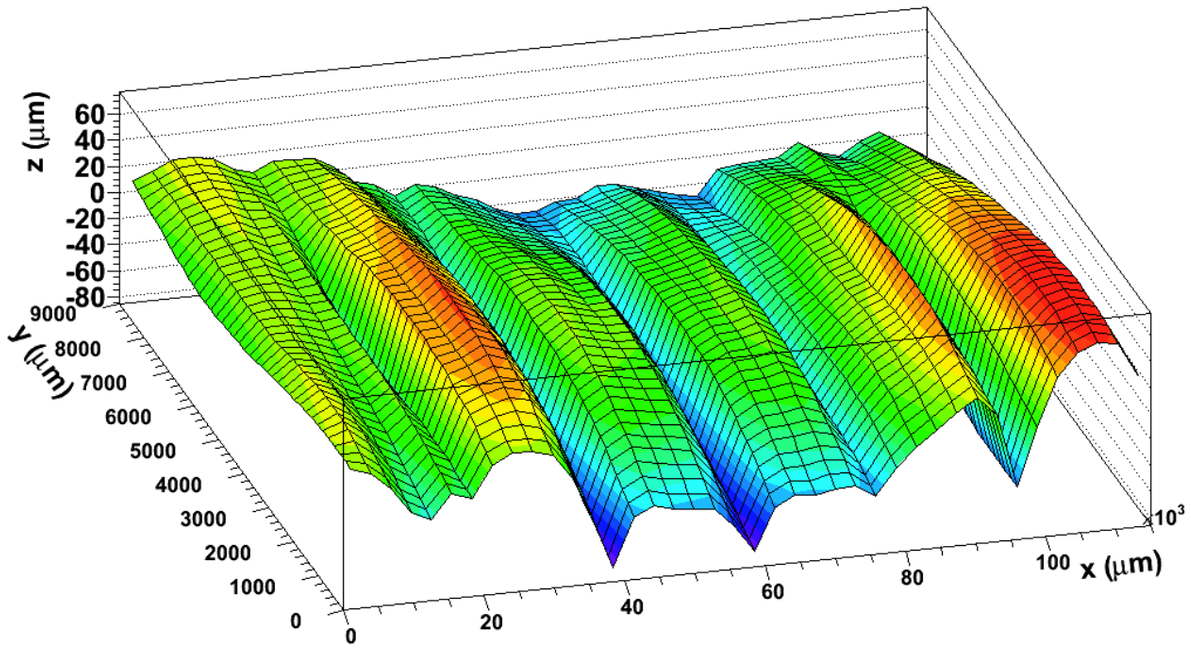
Past and Present

- Version 0 built and tested in beam in 2009
  - *Proof of principle*
- Version 1 2010-11
  - 5 "modules", 2 full electrical ladders
  - 6 sensors on each module
  - 24.5mm wide flex circuits, 20 μm copper
  - 8% foam
  - 0.6% X_0

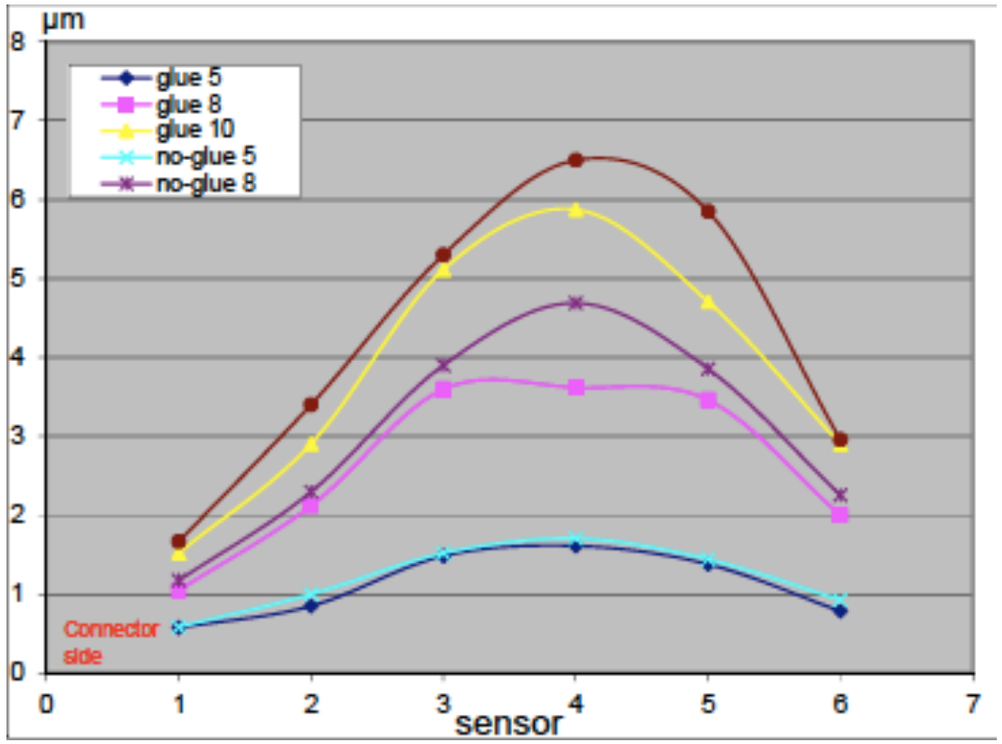


Metrology

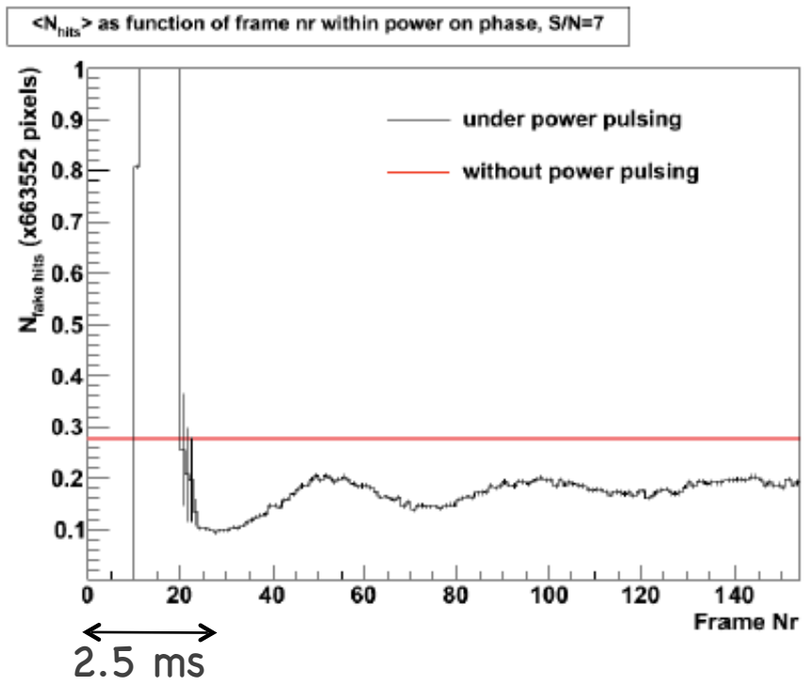


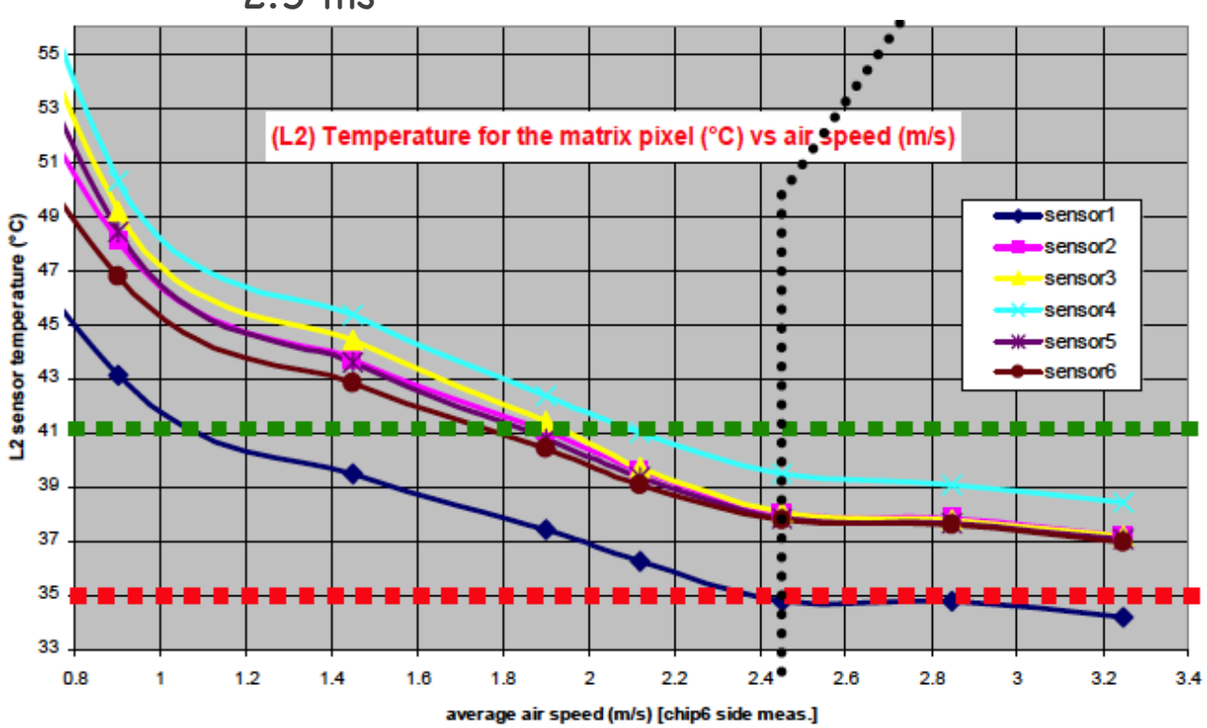


- Flatness ~100 μm
- Vibration analysis
- Measured with airflow ~ 3 m/s
- Observed 230-280 Hz
- Good agreement with FEA



Cooling/Pulsing

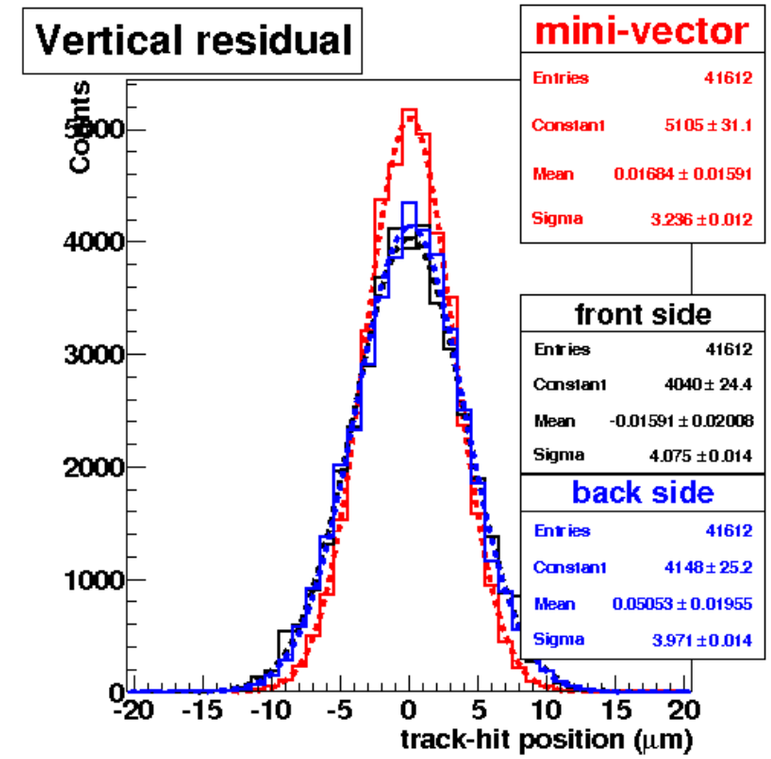


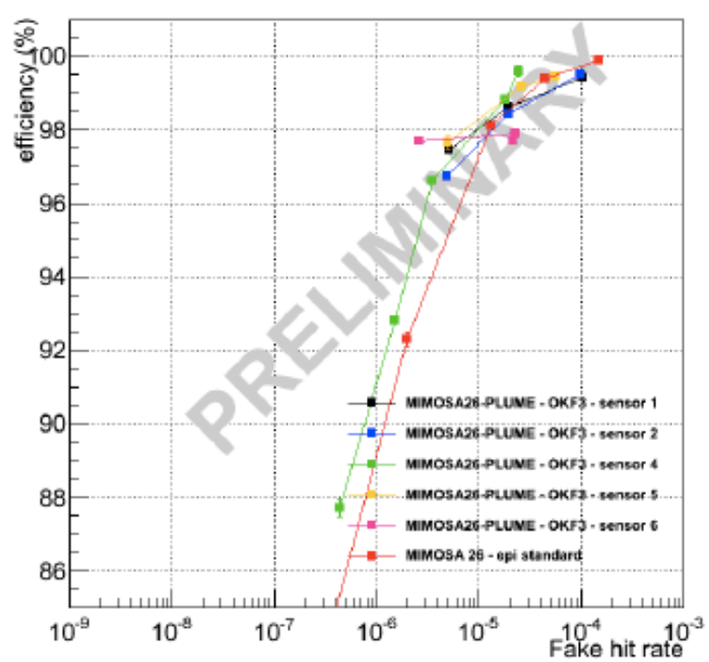


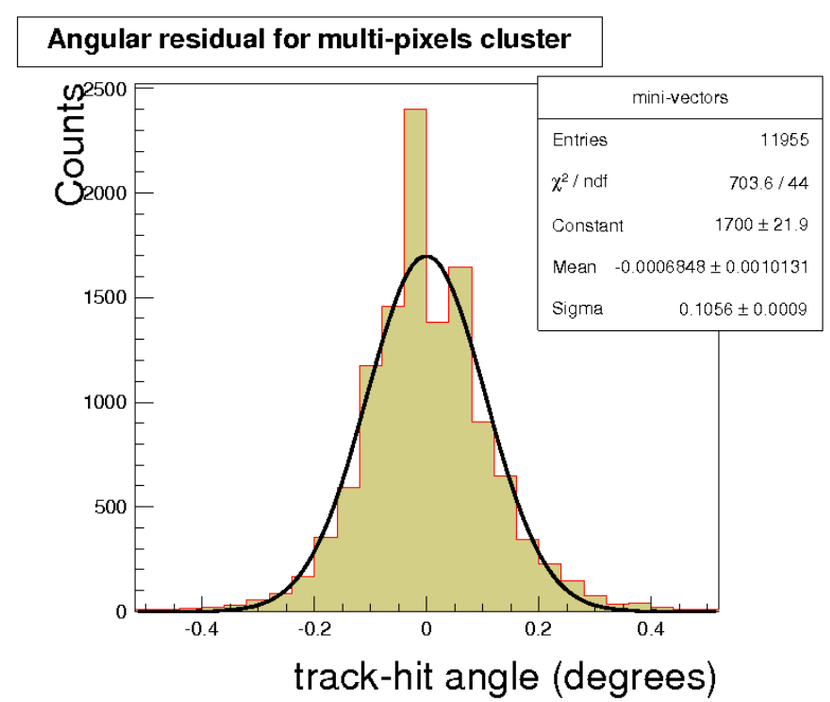
- Power Pulsing:
  - Not in Mimosa 26 spec
  - Pulsing entire circuit
  - Stable in ~2.5 ms
- Cooling:
  - Operating range 35-40°C
  - ~3m/s airflow sufficient

Test Beam

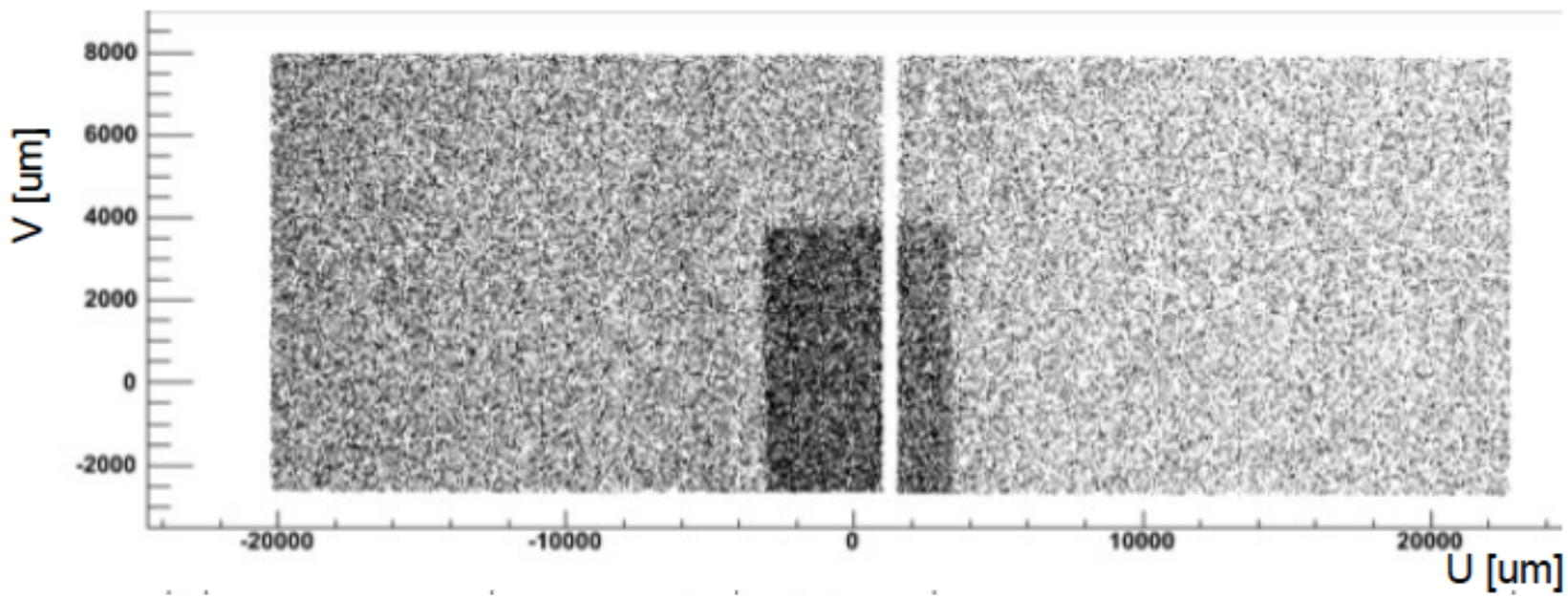
- CERN SPS in November 2011
  - 120 GeV pions
- Measured efficiency
- Position resolution ~ 3 μm
- Angular resolution 0.05-0.2°
- *Depends on incident angle, cluster size*

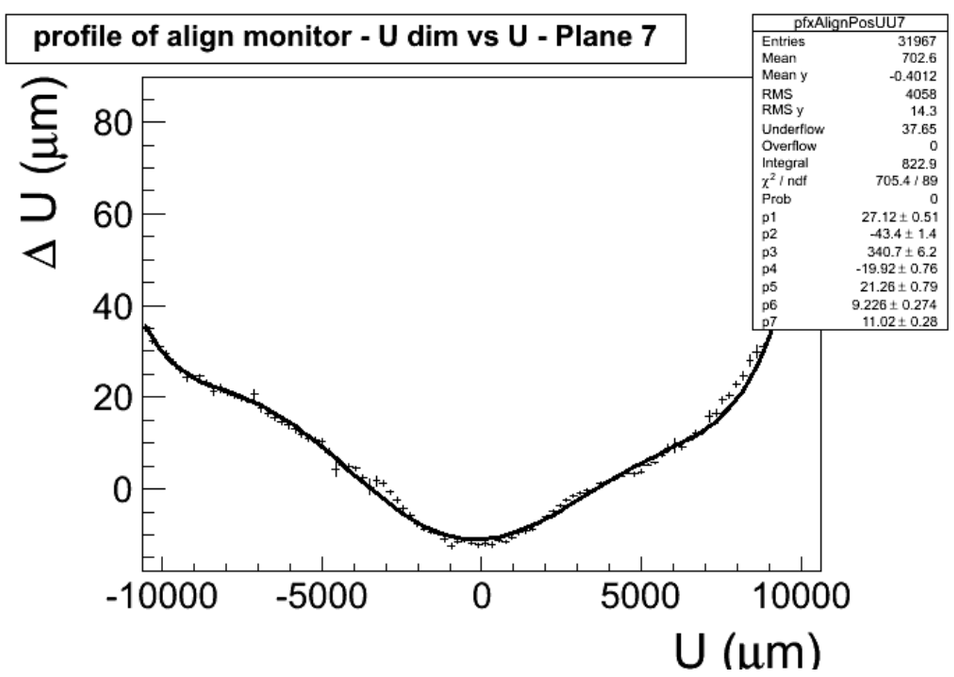






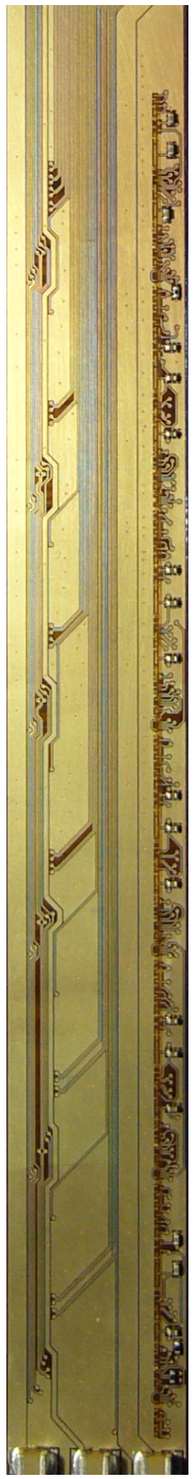
Beam Metrology





- Map active area
- Measure flatness of sensor
  - Compatible with metrology

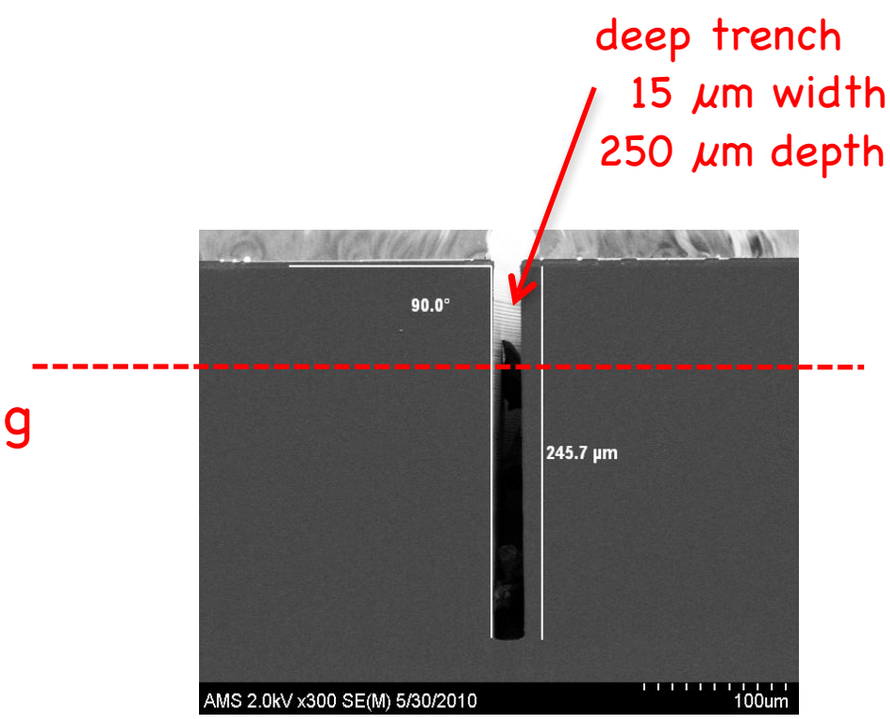
v2 Ladders



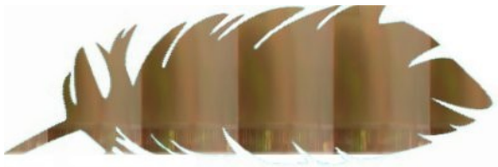
- New flex circuit design
  - Minimal width
  - Mirrored layout
  - 10 μm aluminium layers
- 4% foam core
- 0.35% X_0
- 3 modules produced so far
  - Test beam in 2015
  - Lorentz force measurements planned

To the Future

- Various options for improvement:
  - Optimised layout
  - Reduce dead area
  - Stitched sensors
  - Novel materials
  - New interconnects
  - …
- New sensors (*see Mark W's talk on Tuesday*)
- Realistic ladder and system design/integration



Conclusions

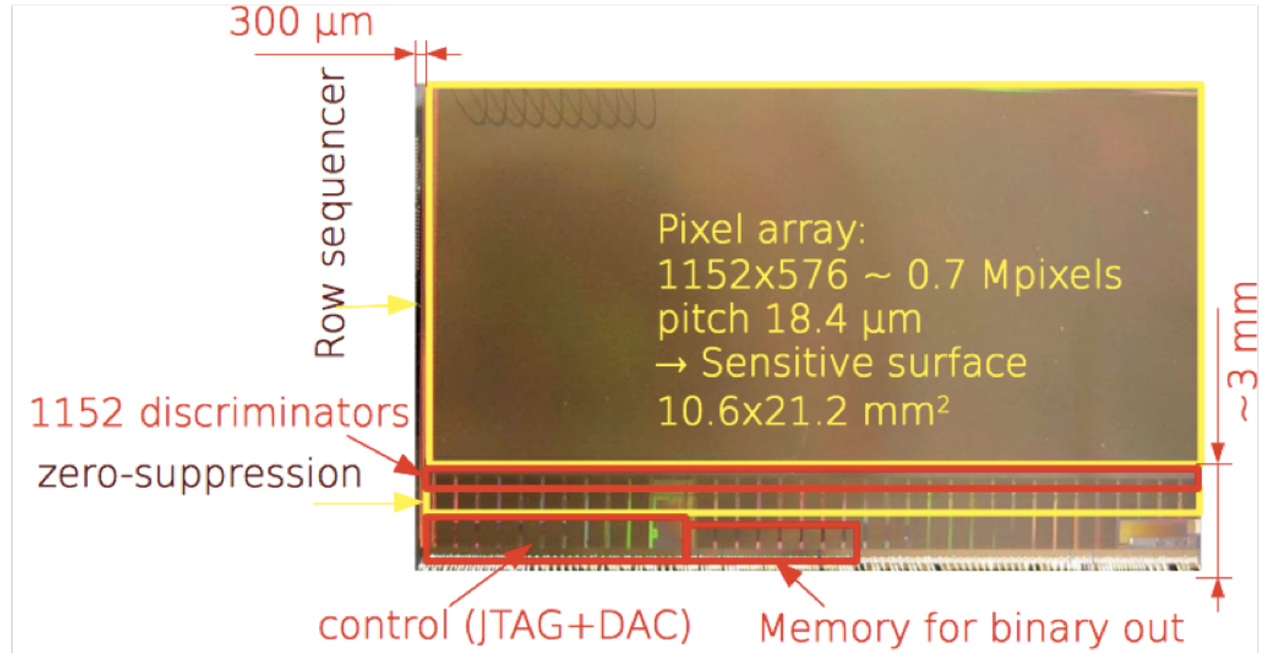


- Double sided CMOS ladders with 0.6% X_0 tested in beam
  - Perform as hoped
- Ladders with 0.35% X_0 currently being made
  - Beam tests in 2015
- Clear paths to further improvements
- Moving towards realistic ILC vertex detector

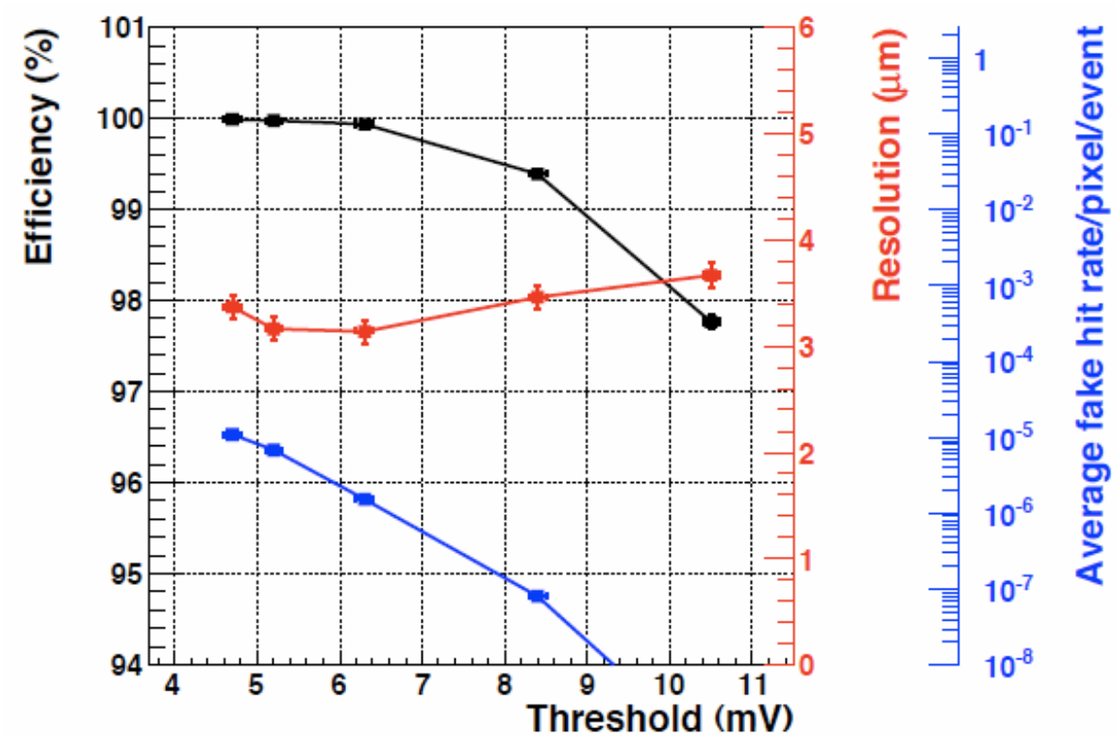
BACKUP

MIMOSA-26

- **Fabrication and specification**
  - Technology 0.35 μm AMS OPTO-process
  - Fabricated in 2009 and 2010
  - Sensitive layer: 14 μm thick,
    resisitivity > 400 Ω.cm
  - Thinned to 50 μm
  - Operating temperature ~30°C



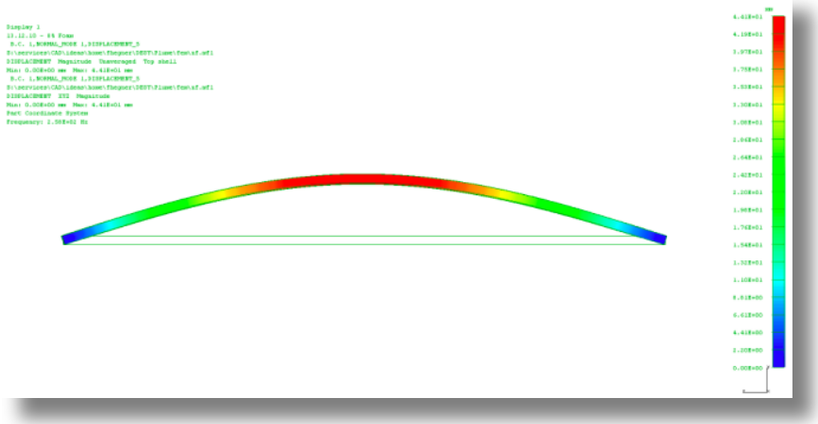
- **Performances**
  - Rolling-shutter steering
    Readout-time = integration time = 112 μs
  - Binary output
  - Spatial resolution ≃ 3μm
  - Hit rate sustainable > 10^6 $cm^{-2}.s^{-1}$
  - Radiation tolerance validation
    - Ionizing dose: 300 kRad
    - Non-ionizing fluence: 10^{13} n_{eq}/cm^2

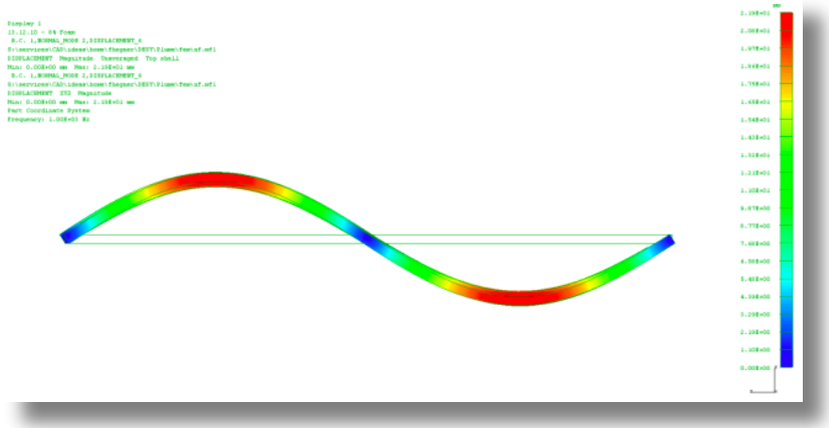


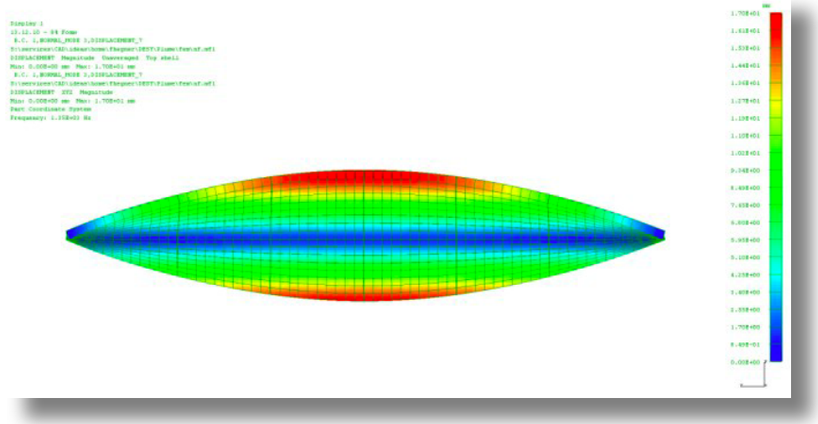
PLUME FE-simulations

ANSYS model, DESY

Ladder supported at both ends



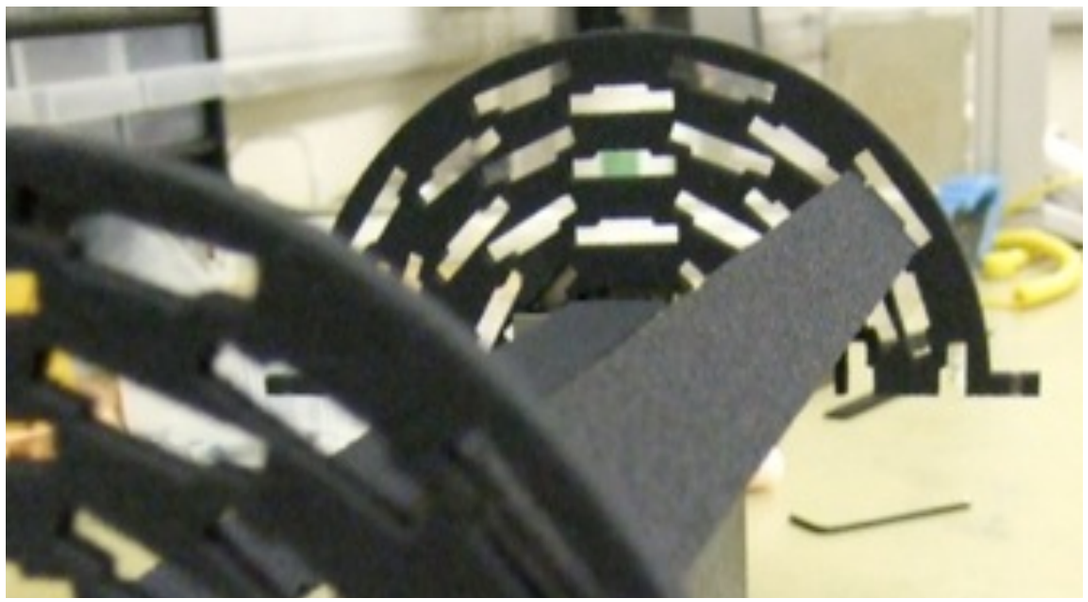




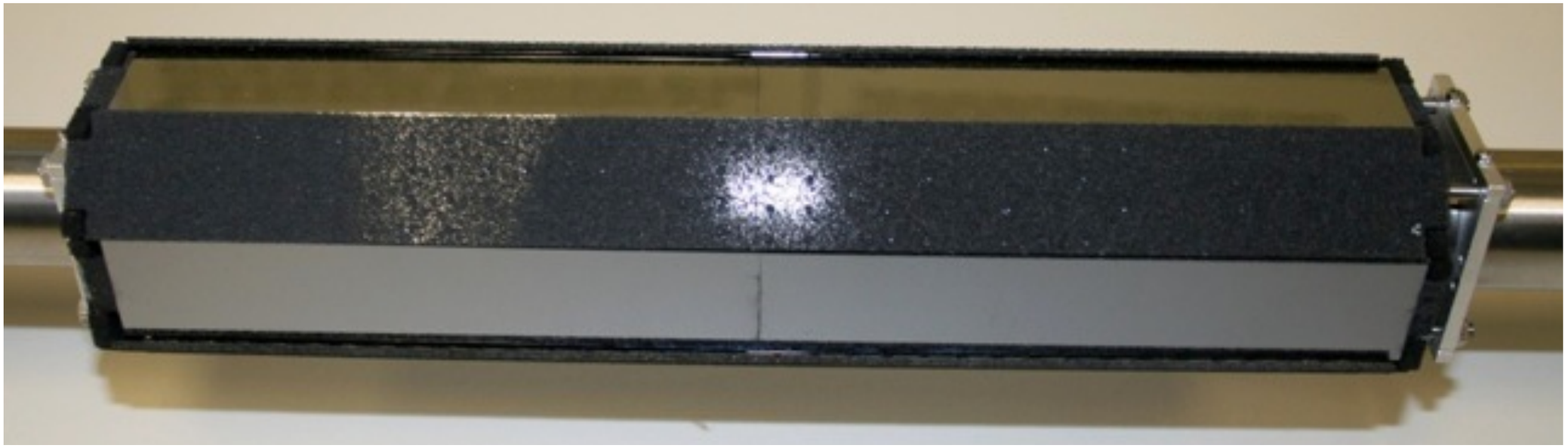
2C - Mode		SiC foam 8% in Hz	SiC foam 4% in Hz	RVC in Hz
One sensor/ Two sensors/ Three sensors	1	255	265	235
	2	990	981	453
	3	1281	1117	674

→ importance of sandwich effect for stiffness

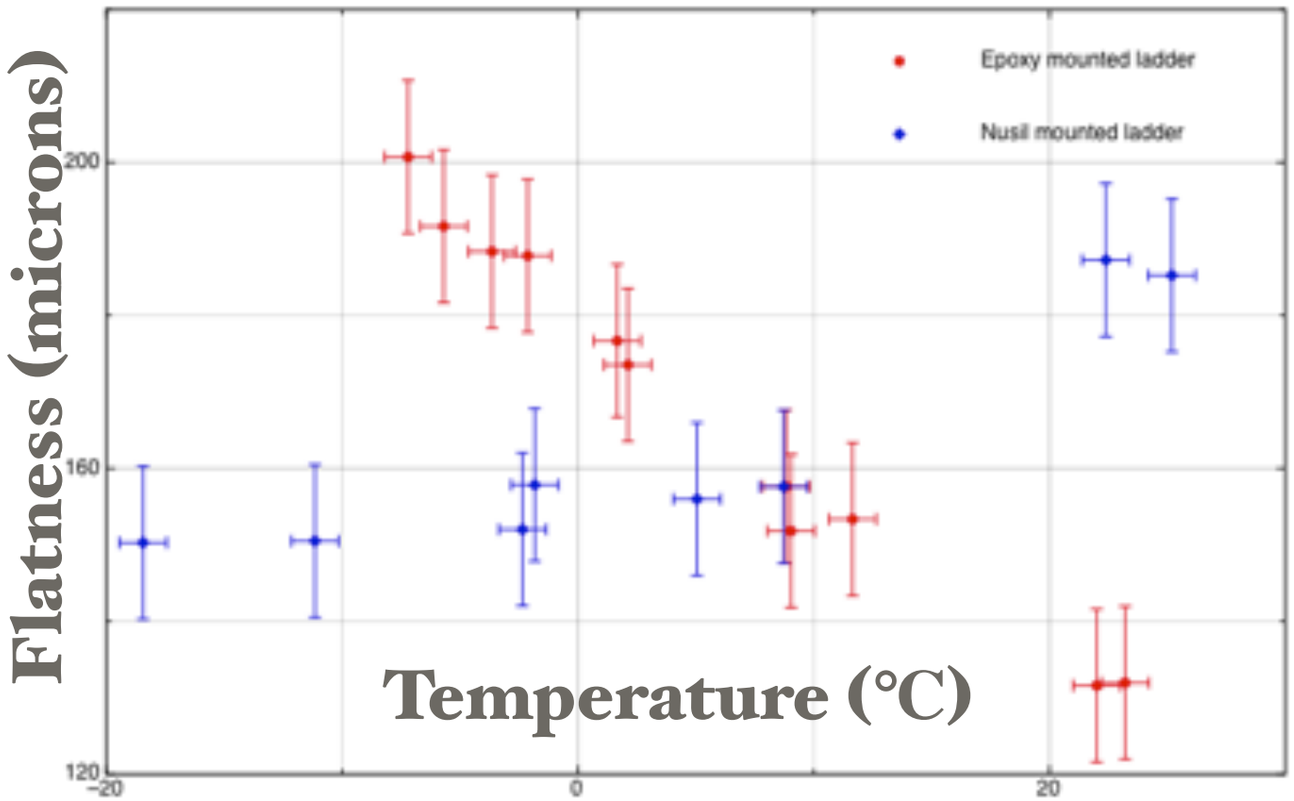
Prototype VXD



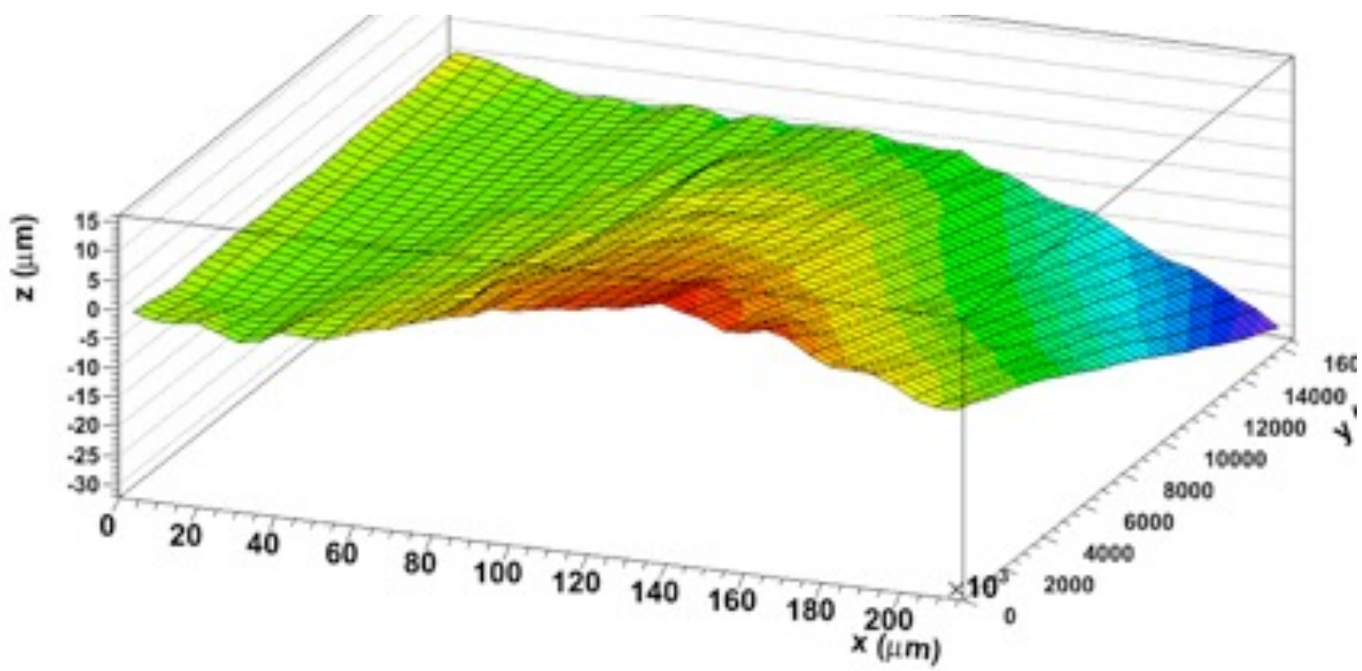
- Demonstrate all-SiC ILD VXD
- Layer 2: 3cm long, 2.5 cm radius
- Developed processing techniques



Thermal



- Installed ladder surveyed and cooled
  - Range of 40°C
  - Good flatness
  - Deviation small



Materials

* Highest specific stiffness