Development of carbon fiber staves for the strip part of the PANDA Micro Vertex Detector

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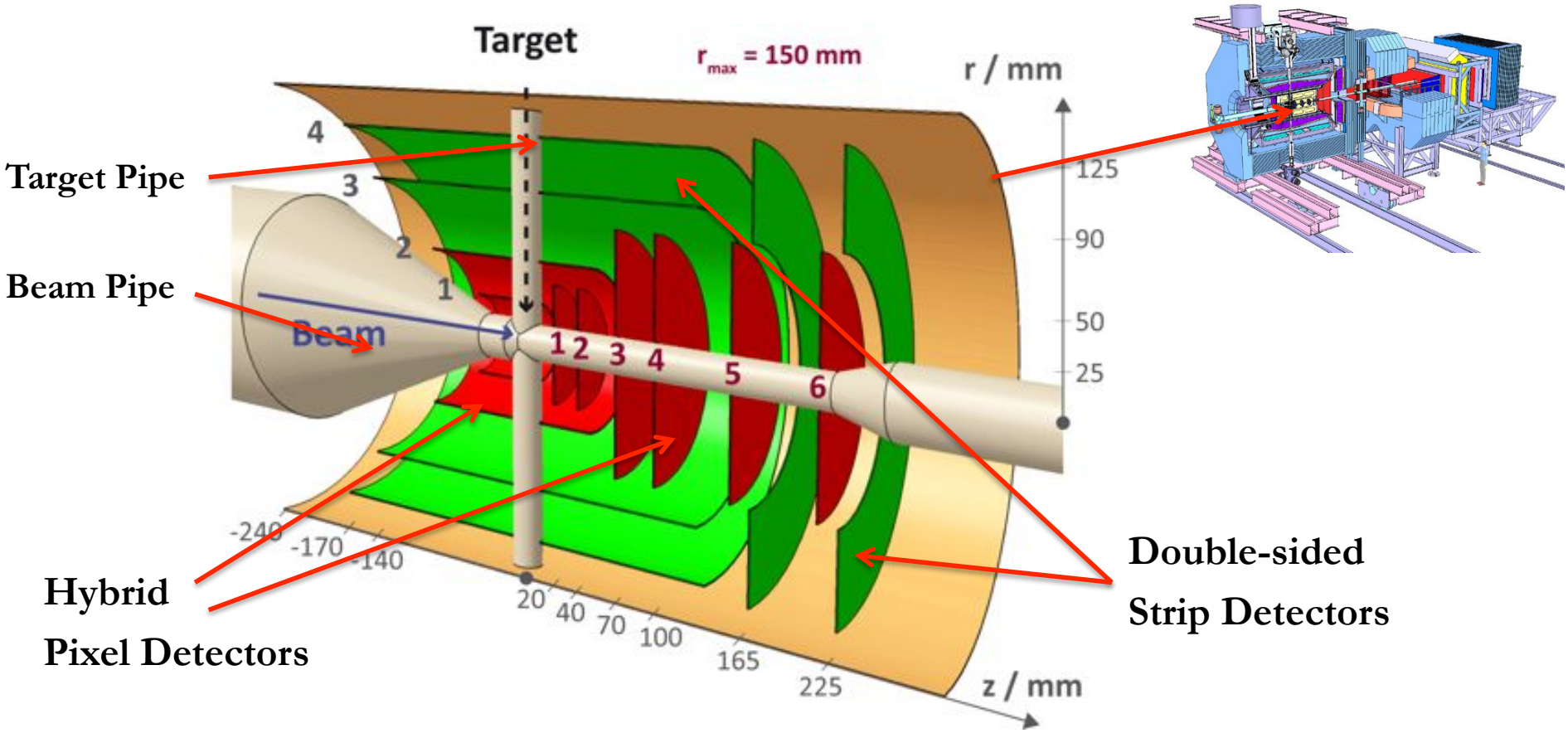
The Micro Vertex Detector

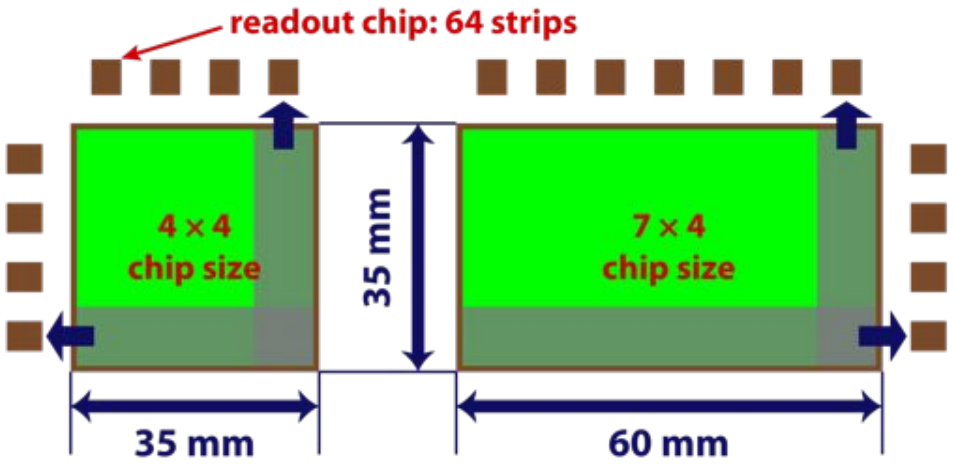
- Vertex reconstruction with high spatial (<100 μm) and time (<6 ns) resolution
- High rate capability ($2 \cdot 10^7$ pbar-p ann./s) and triggerless readout
- Low material budget (<10% radiation length overall) and high radiation tolerance

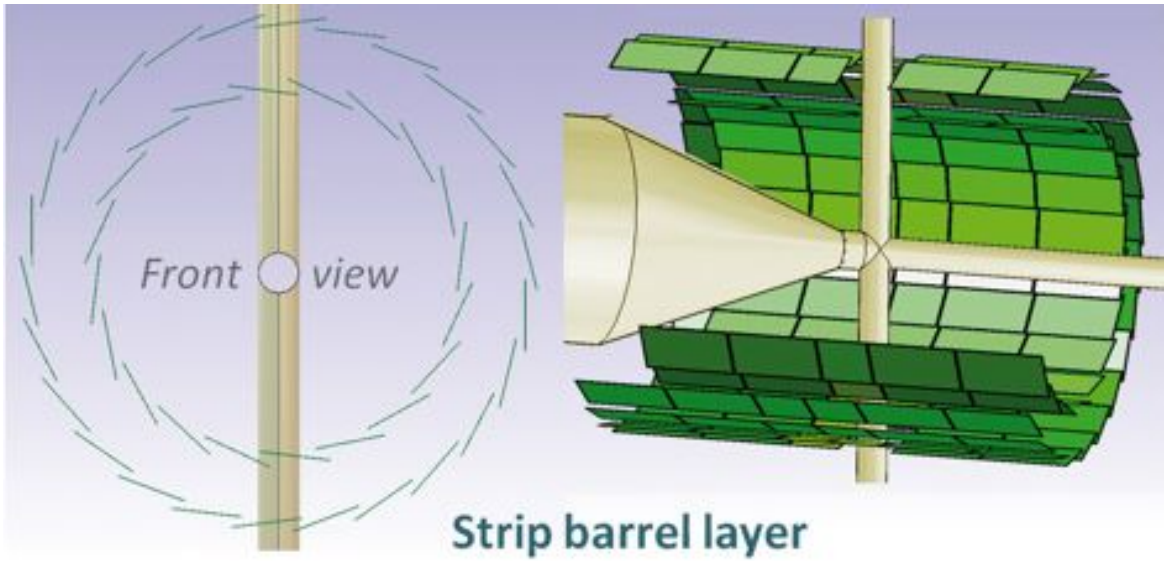


See also S. Esch, HK2.1

Strip Barrels – Design Concept

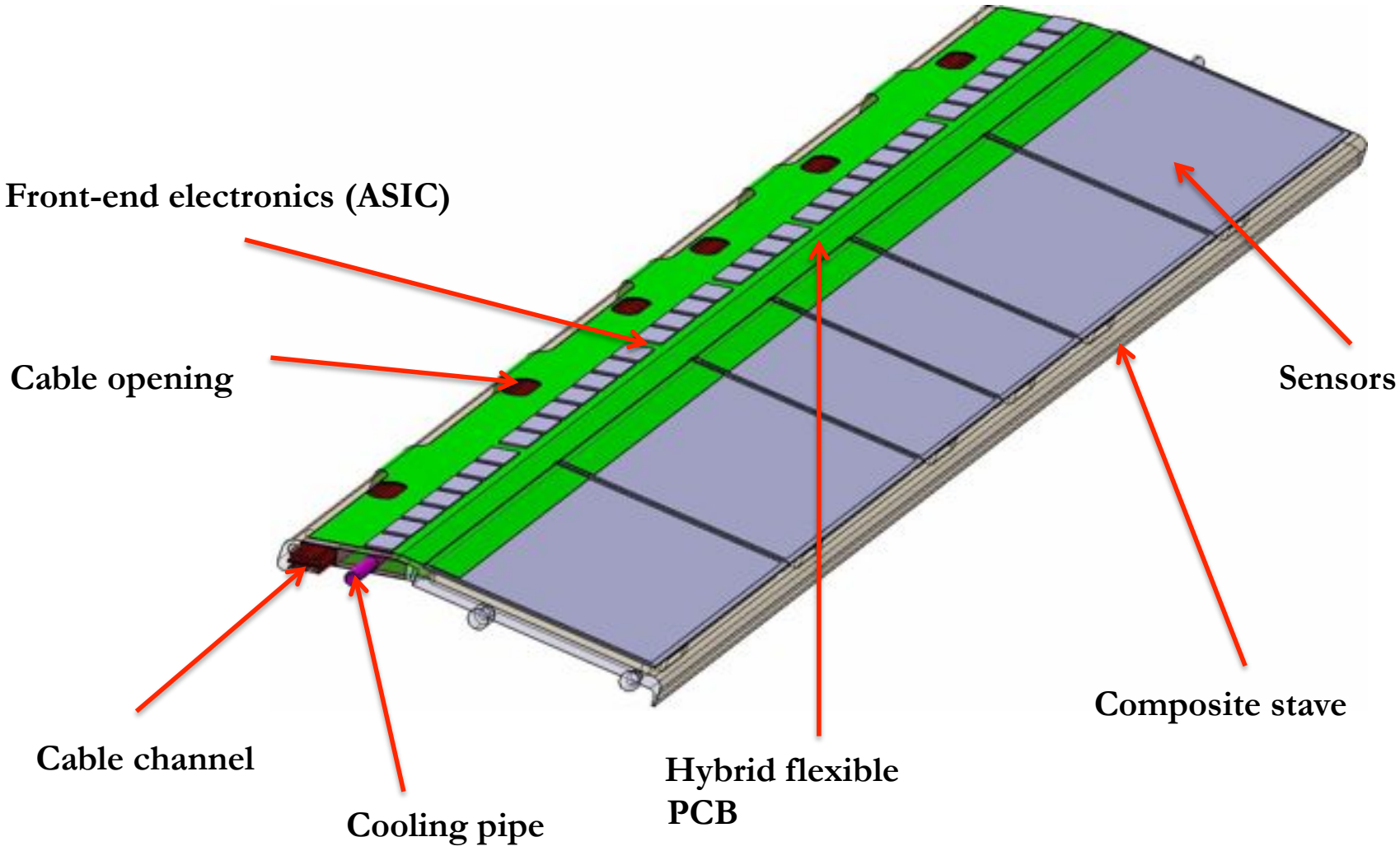
- Rectangular (512 × 896 channels) and squared (512 × 512 channels) sensors
- Stereo angle: 90°, strip pitch 65 μm
- Readout every second strip
- Two barrels at r = 92 and 125 mm
- 4 – 6 sensors on each of the 46 staves (248 sensors in total)





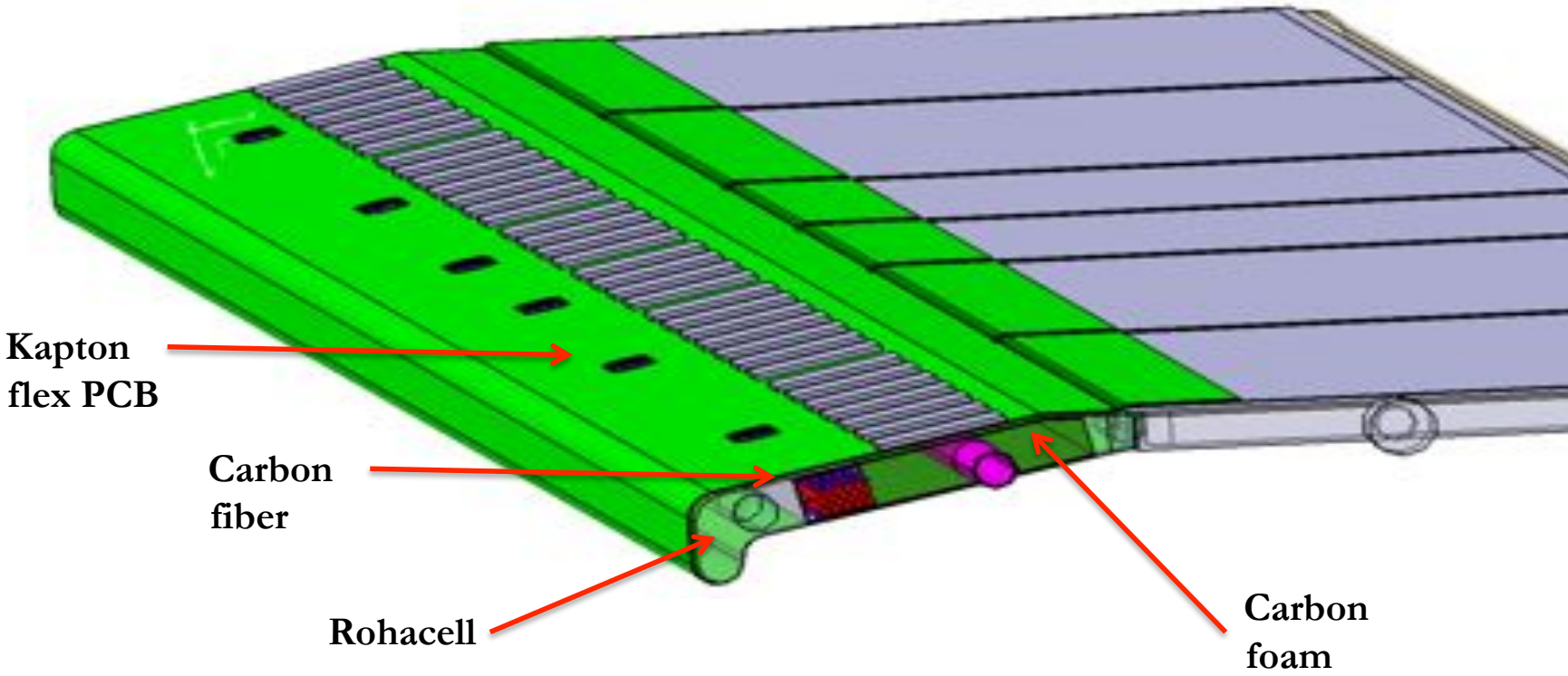
- Coverage: 0.422 m^2 (162k channels)
- ~2500 readout chips
- ~700 W power consumption
- Barrel 3: 20 staves 28 cm long
- Barrel 4: 26 staves 31 cm long

Strip Module – Stave Design

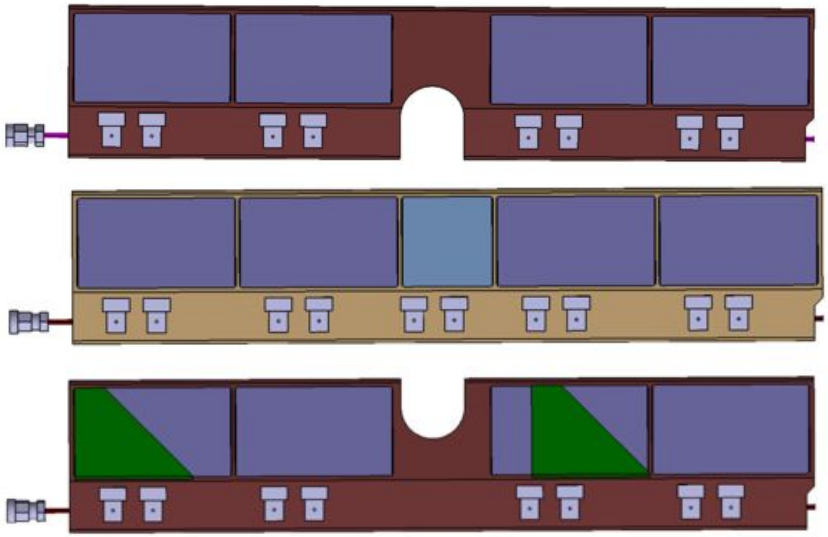


Strip Module – Stave Design

- Sandwich structure of CFRP (200 µm pre-preg 90°/0°) and foam (2 mm Rohacell)
- Embedded cooling pipe in nickel-cobalt alloy (2 mm diameter, 80 µm wall thickness)
- Carbon foam (POCO Foam or HTC) in the area around the cooling pipe
- Cable channel embedded in the stave



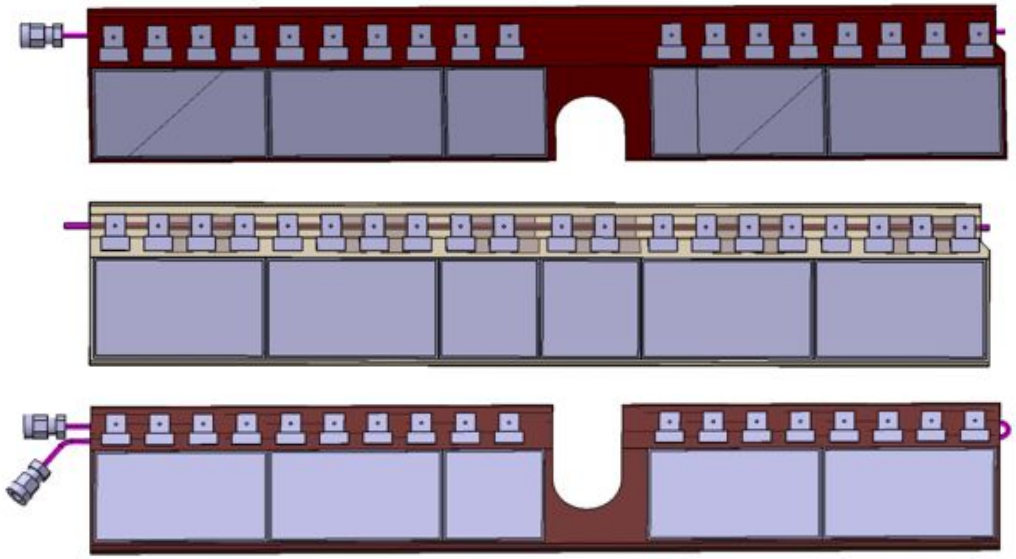
Strip Barrels



Barrel 3, top (2x)

Barrel 3, standard (16x)

Barrel 3, bottom (2x)



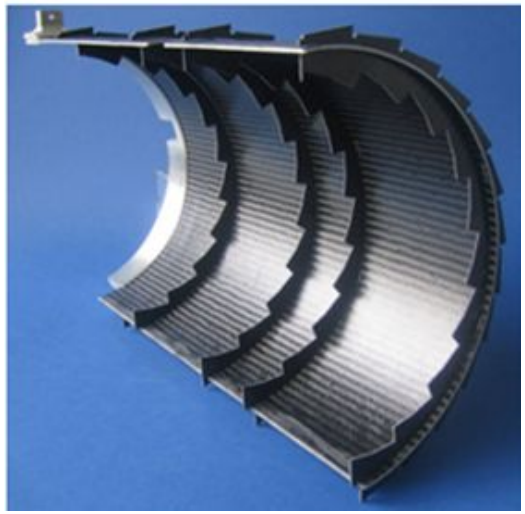
Barrel 4, top (2x)

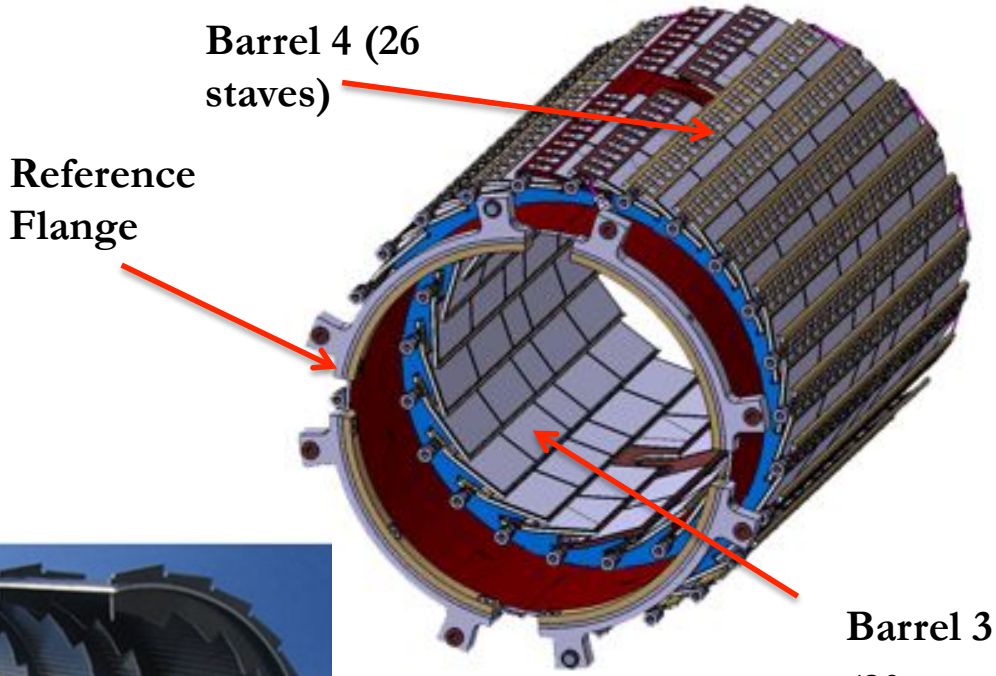
Barrel 4, standard (22x)

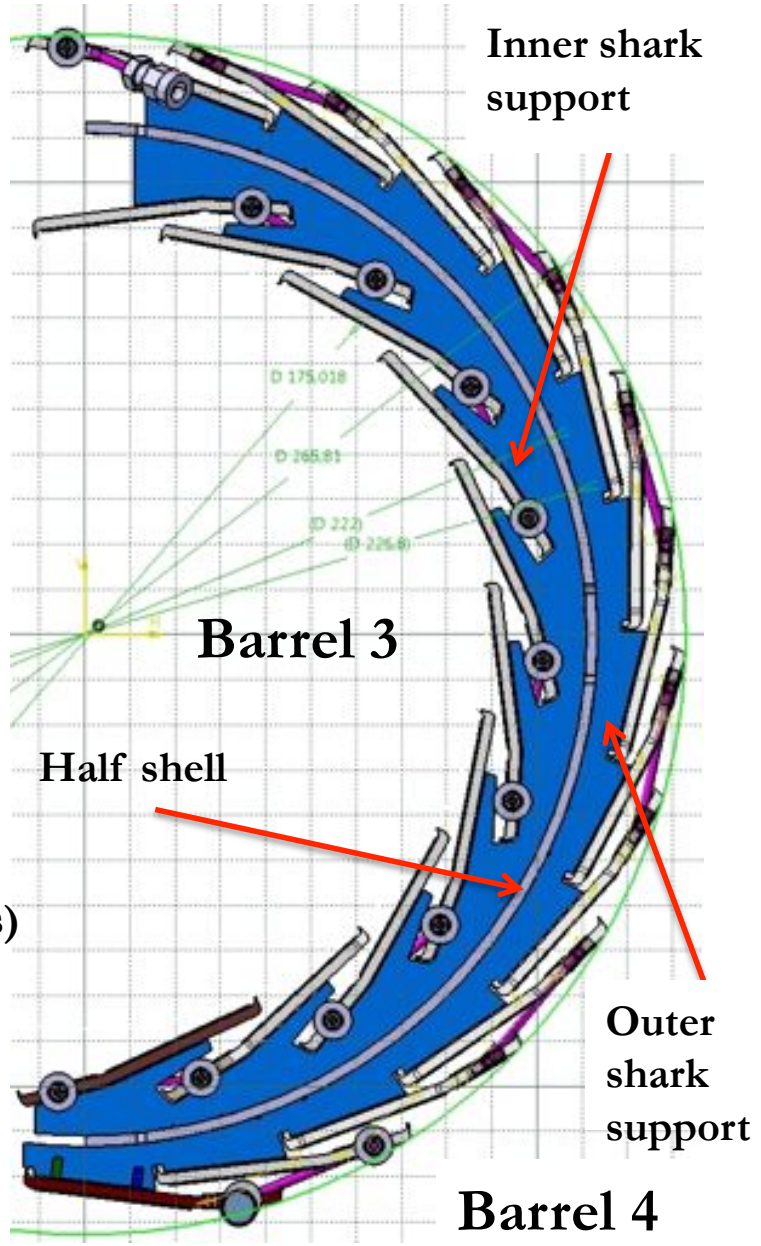
Barrel 4, bottom (2x)

Strip Barrel Support

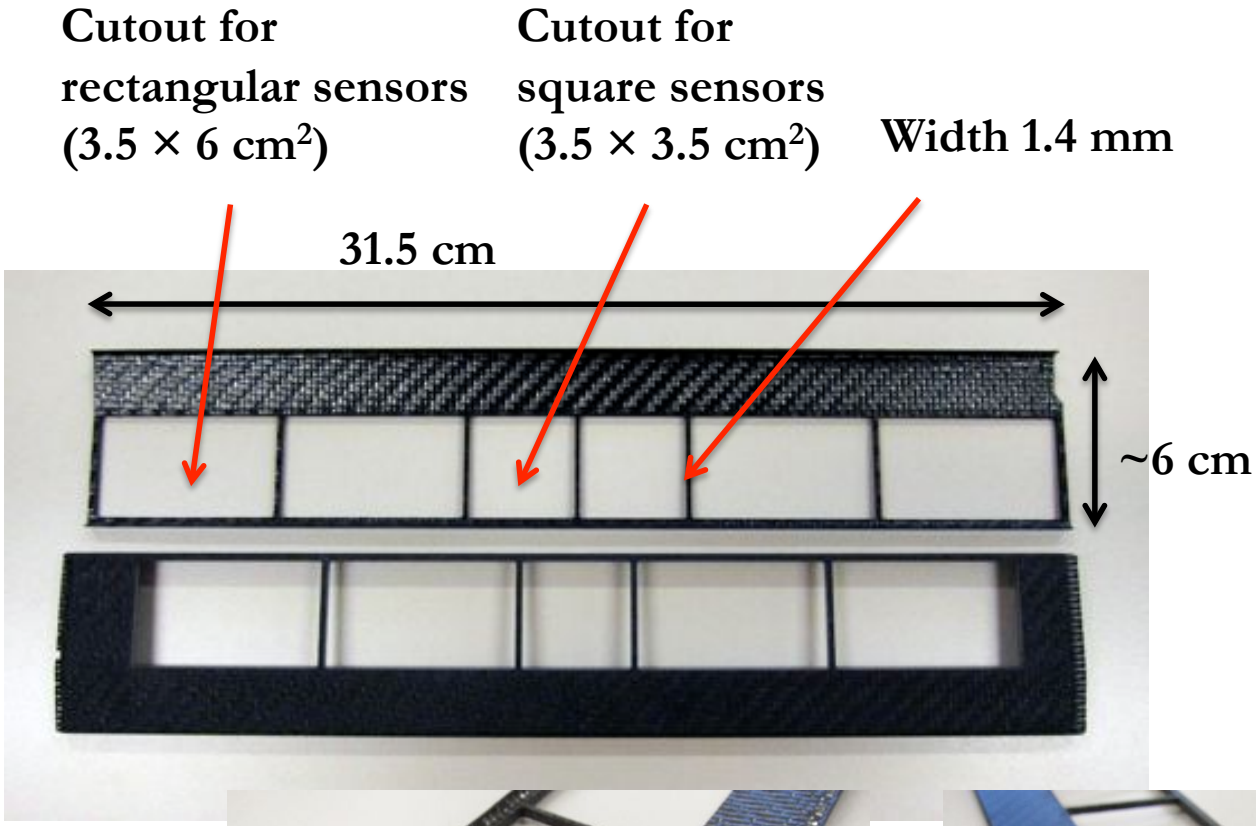
- CFRP cylindrical half shells
- Two shark supports per barrel

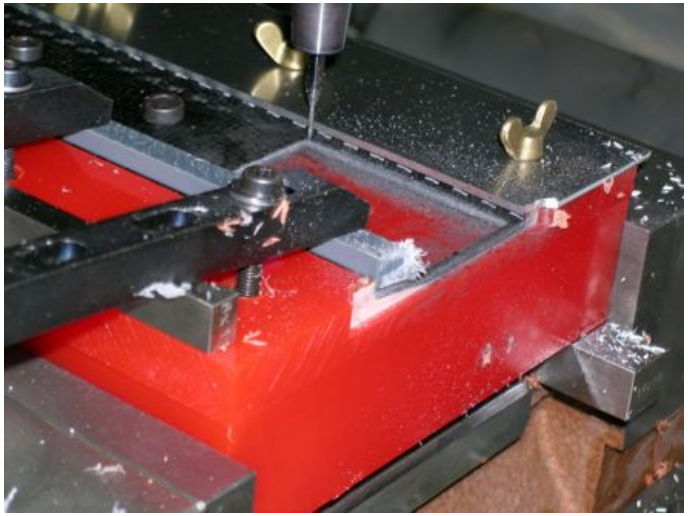




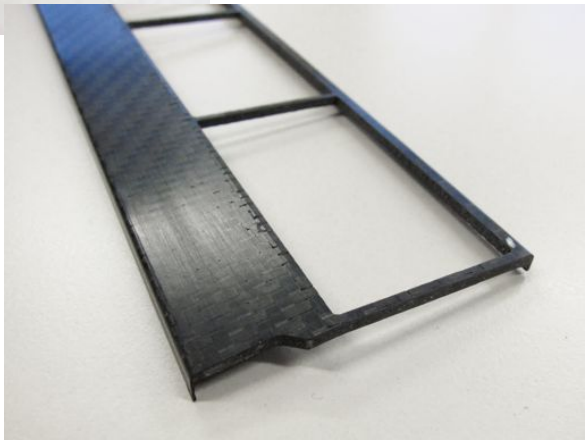


Strip Stave Prototypes





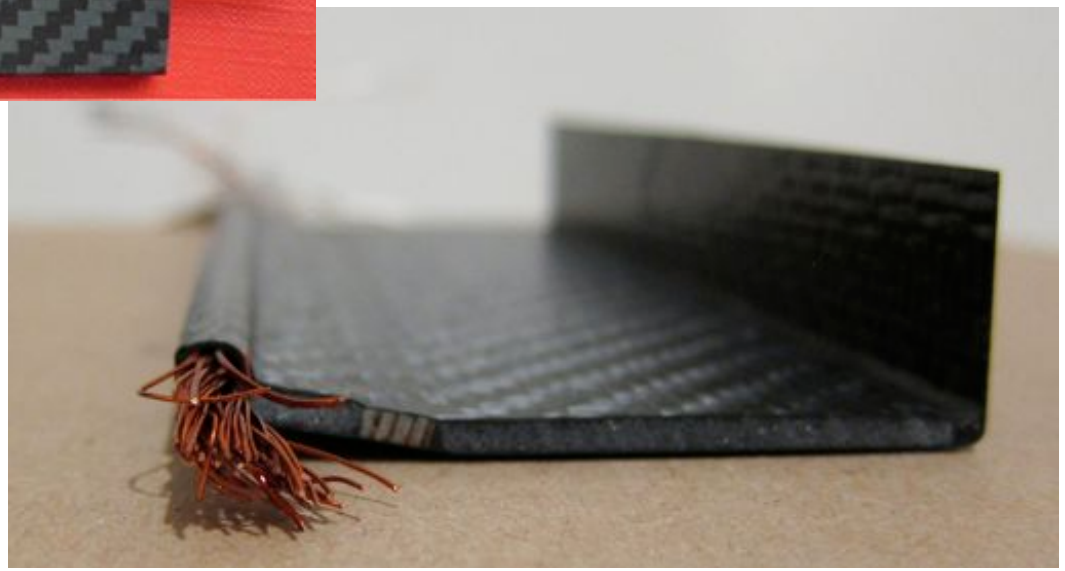
Milling of the stave cutouts



Strip Stave Prototypes

Cooling pipe embedded in the carbon foam

Reduced size stave with carbon foam and pipe

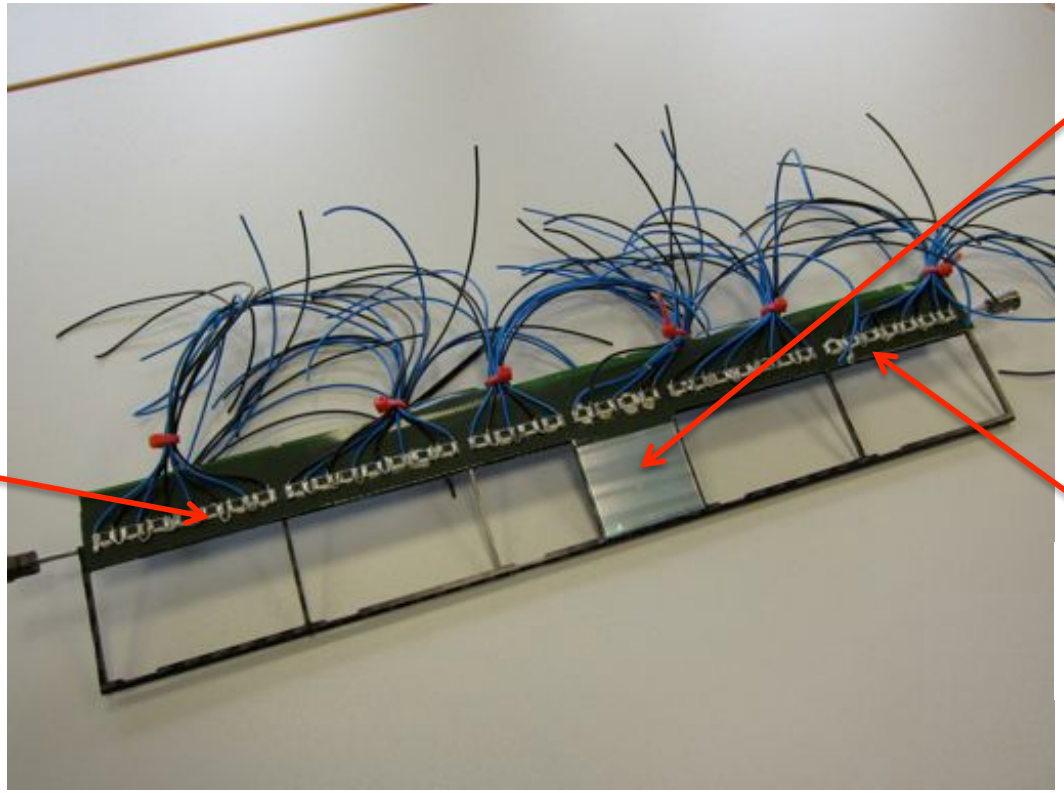


Reduced size stave with cable channel hosting 60 enameled copper wires with diameter between 0.15 and 0.55 mm

Strip Stave Prototypes – Cooling tests

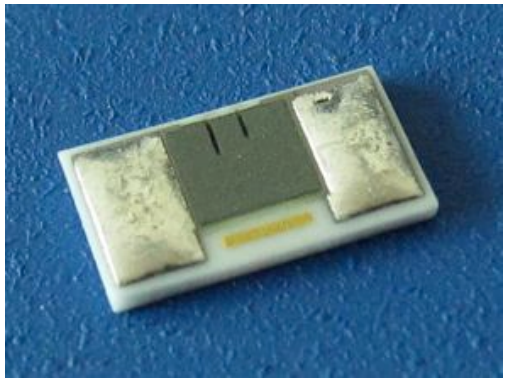
Dummy-chip resistors:

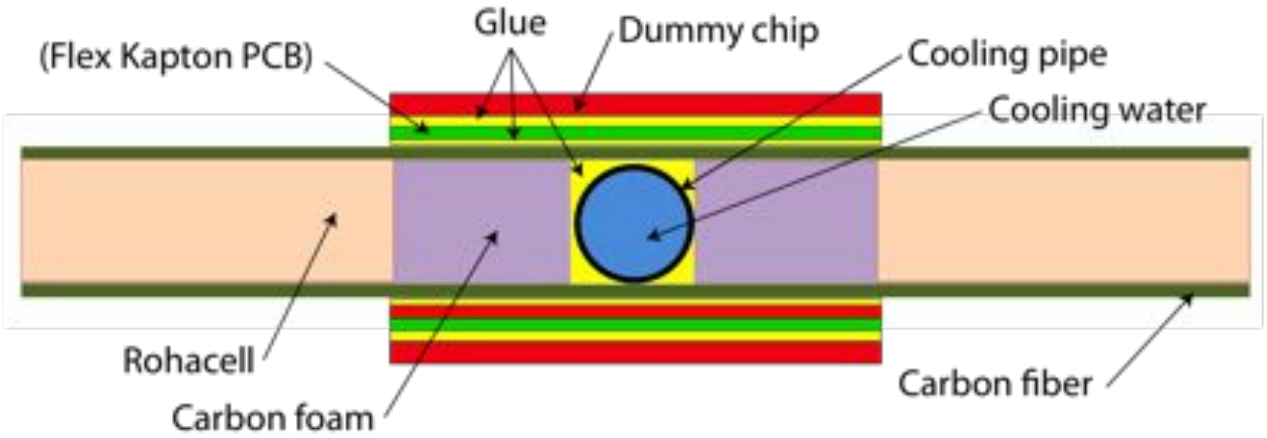
- Area 7.15 × 4 mm^2
- Active area 3 × 3 mm^2
- Nominal power 256 mW (max. 600 mW)
- High power density: 2.8 W/cm^2



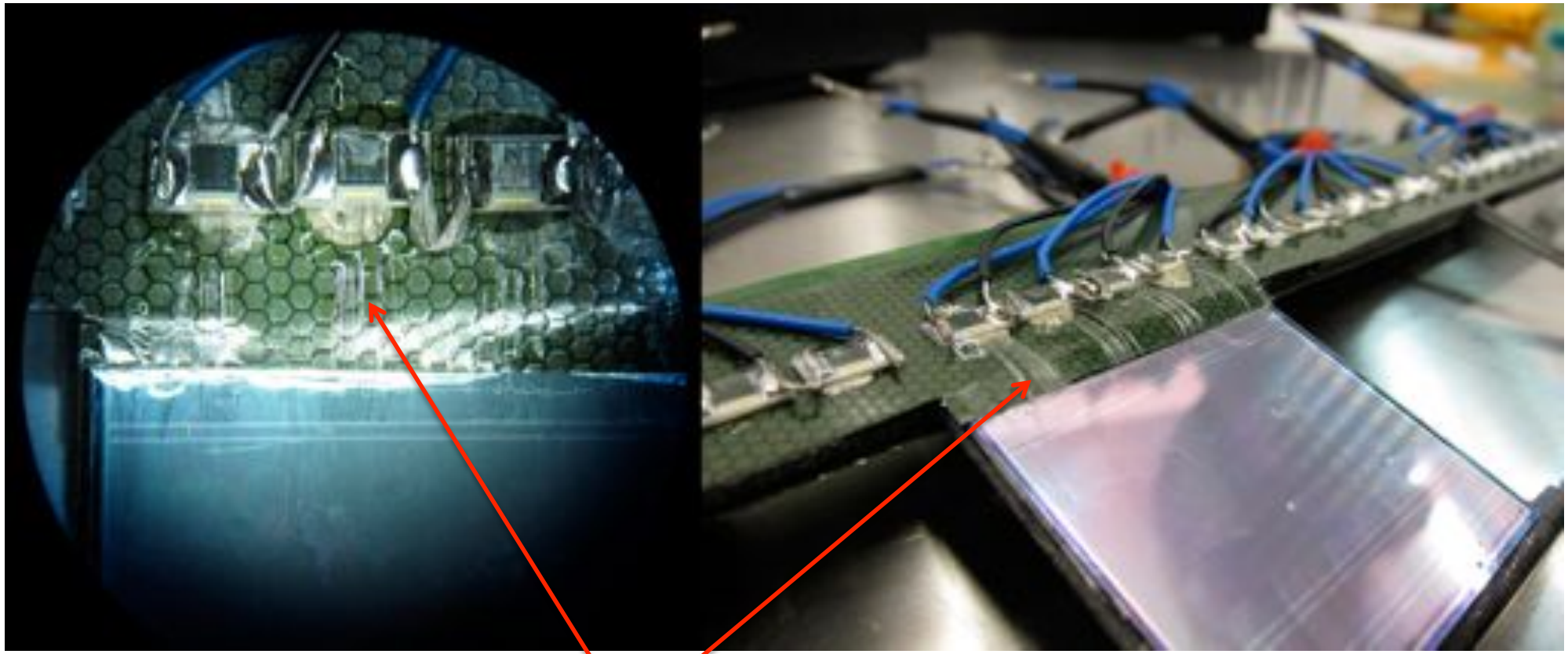
Square PANDA sensor

Flex PCB (Kapton-copper)



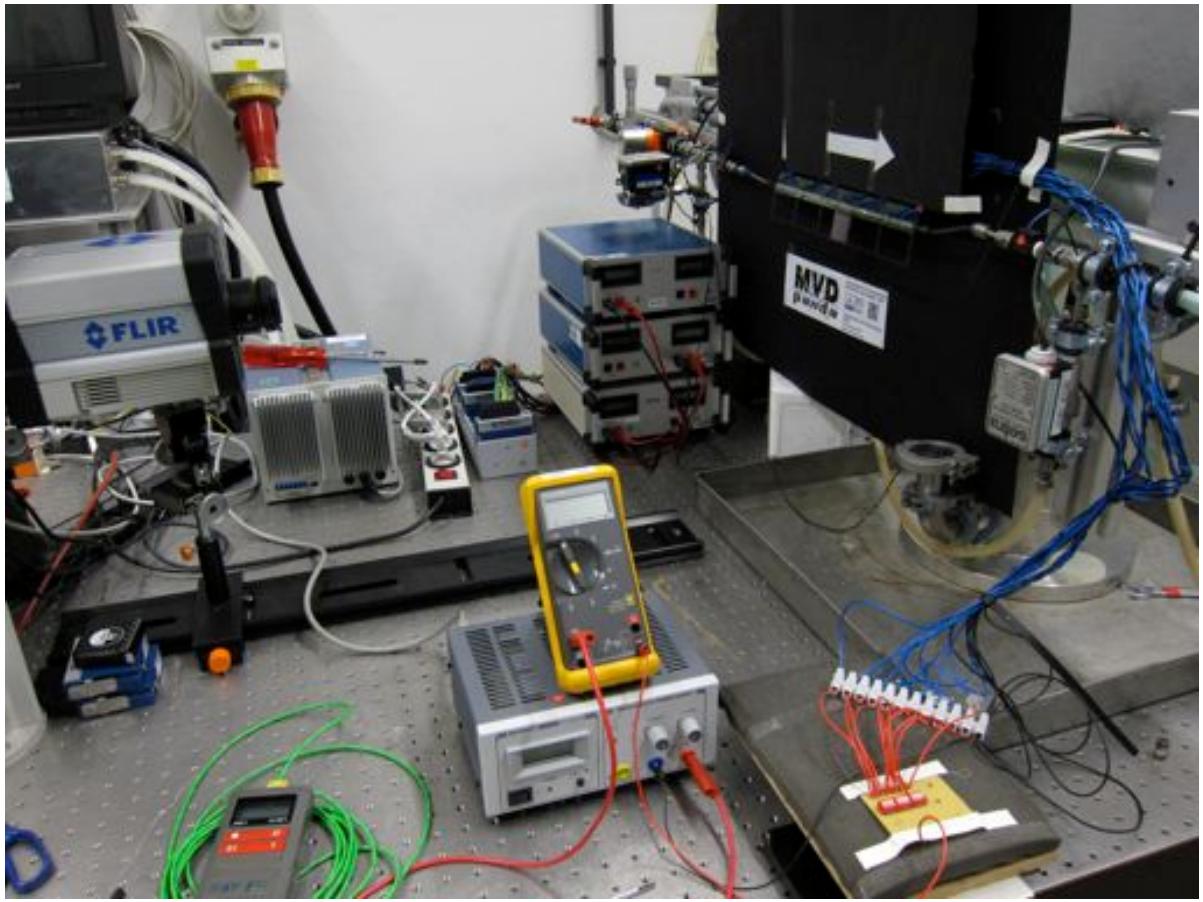


Strip Stave Prototypes – Cooling tests



Wire bonding between resistors and sensor

Strip Stave Prototypes – Cooling tests



FLIR SC6000

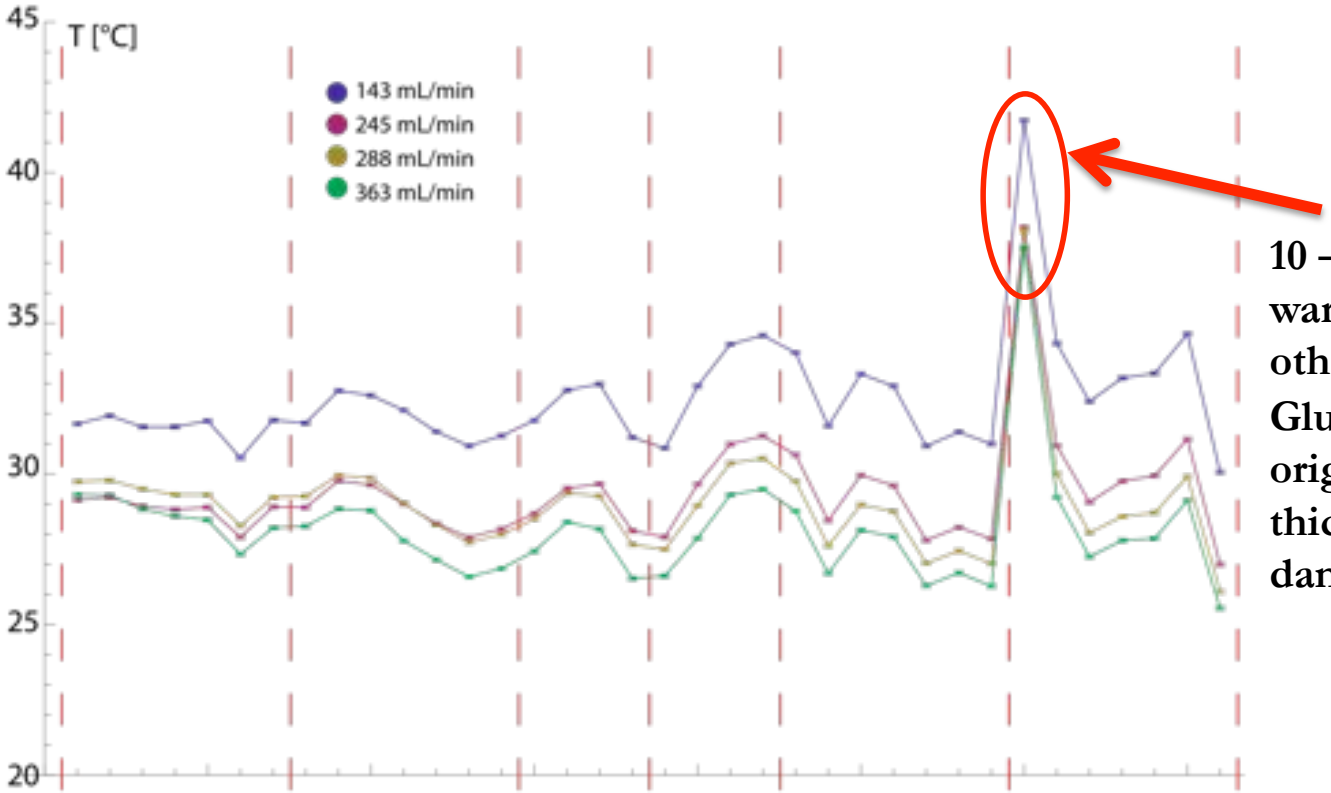
- Spectral range 8 – 9.2 μm
- Resolution 640 × 512 pixel
- Frame rate 1 – 125 Hz

Available Measurements:

- Inlet and outlet water temperature
- Closed, underpressure water cooling circuit
- Water temperature control
- Volume flow
- Pressure

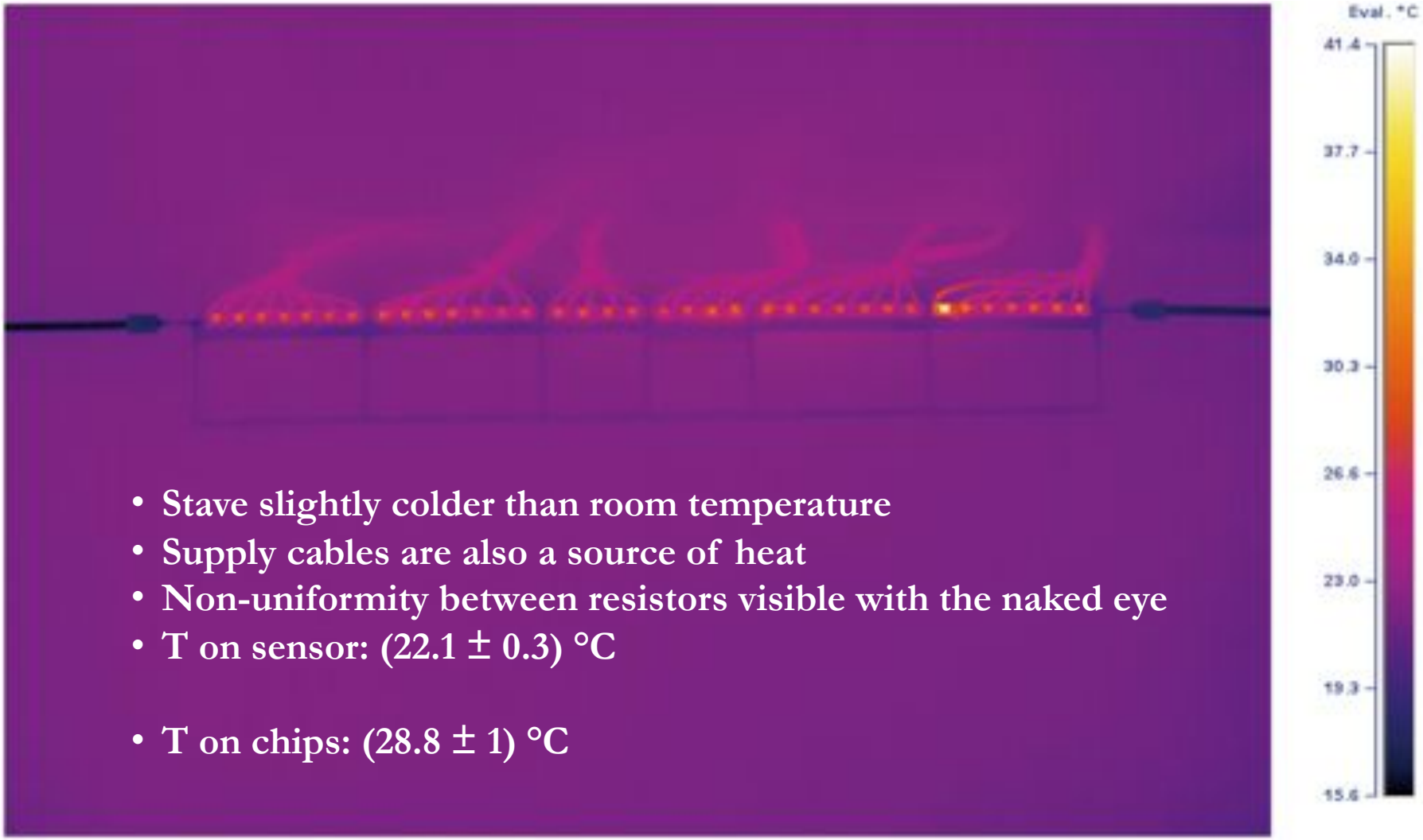
Strip Stave Prototypes – Cooling tests

Temperature profile with heating at nominal power (16.9 W); cooling water @ 18°C, different fluxes. Room temperature ~20 °C



10 – 15 °C warmer than other resistors: Glue layer originally too thick, then damaged

Strip Stave Prototypes – Cooling tests

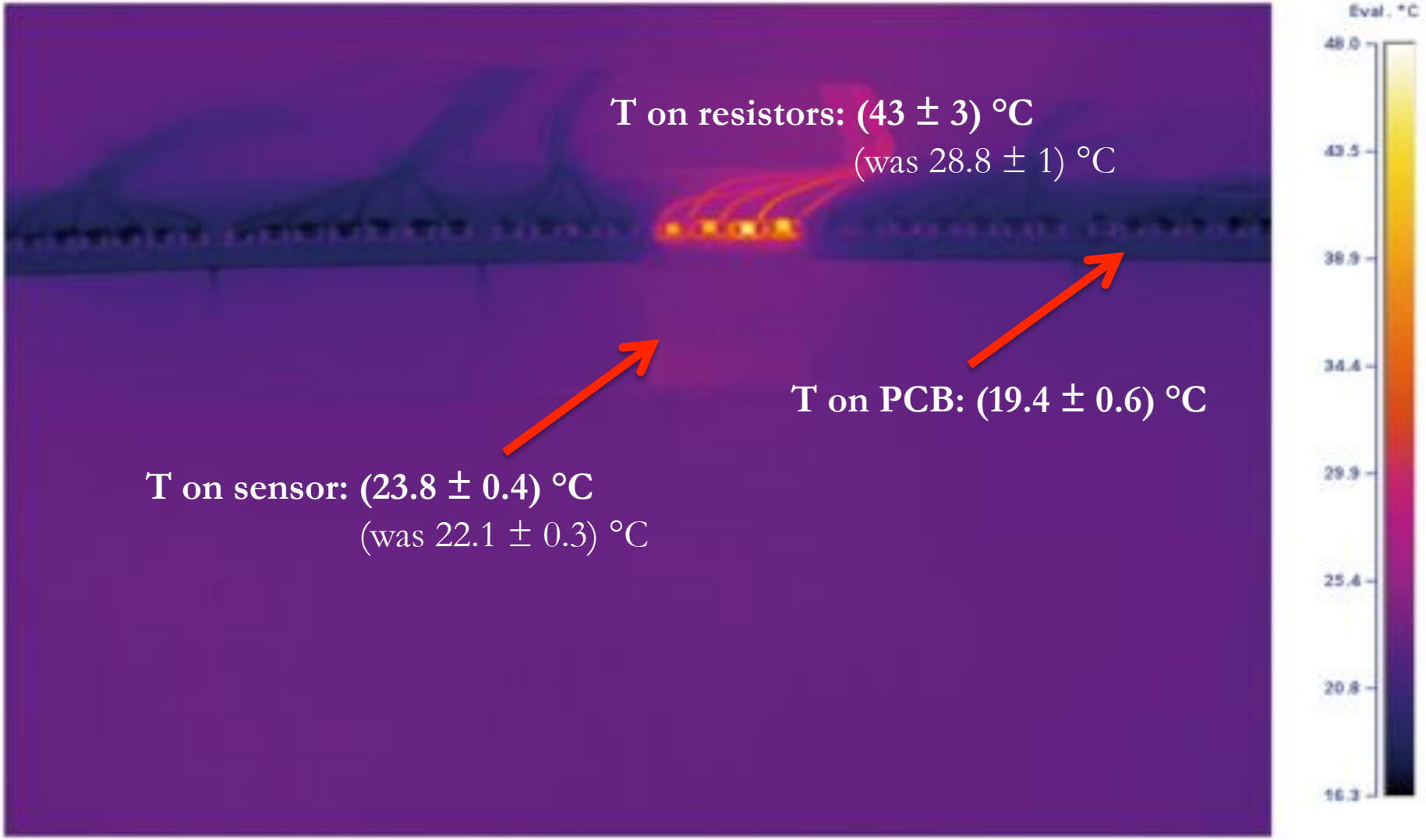


- Stave slightly colder than room temperature
- Supply cables are also a source of heat
- Non-uniformity between resistors visible with the naked eye
- T on sensor: (22.1 ± 0.3) °C

- T on chips: (28.8 ± 1) °C

Strip Stave Prototypes – Cooling tests

Additional test with double power (512 mW per chip), only on 9 resistors around the sensor

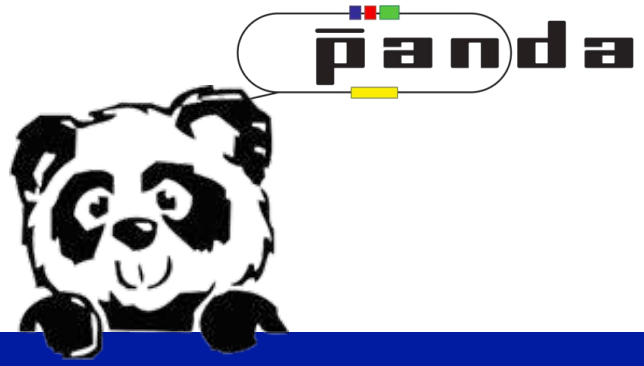


Summary & Outlook

- **The mechanical design of the PANDA MVD strip barrel is finalized; some small optimizations in the components are still required.**

- **The prototyping and validation of the components is ongoing: first successful tests of the stave cooling system in March 2015.**

- **Some future steps:**
  - new, more complete cooling tests taking into account environment temperature;
  - development of a mounting and alignment procedure (and relative tools) for the barrel staves.



Thank you for your attention!

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für Bildung
und Forschung

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MVD panda

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