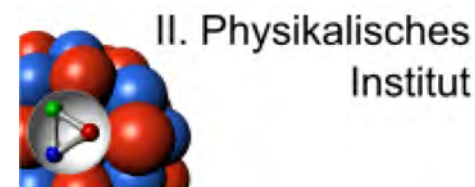# Integration of the strip detector
of the PANDA Micro Vertex Detector

Tommaso Quagli, Kai-Thomas Brinkmann

II. Physikalisches Institut, JLU Gießen

International Conference on
Science and Technology for
FAIR in Europe 2014, Worms
October 15th, 2014

JUSTUS-LIEBIG-
UNIVERSITÄT
GIESSEN

II. Physikalisches
Institut

The PANDA Experiment

- Fixed target experiment at FAIR, Darmstadt
- Antiproton beam with p = 1.5 − 15 GeV/c and hydrogen or nuclear target
- Maximum luminosity $2 \cdot 10^{32}$ cm^{-2} s^{-1}; interaction rate $2 \cdot 10^{7}$ s^{-1}
- Continuous, triggerless readout
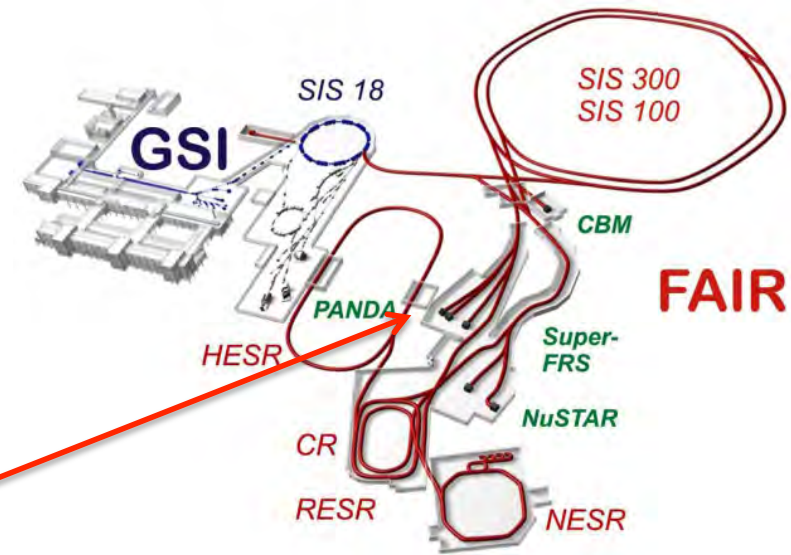
**Target Spectrometer**

Forward Spectrometer
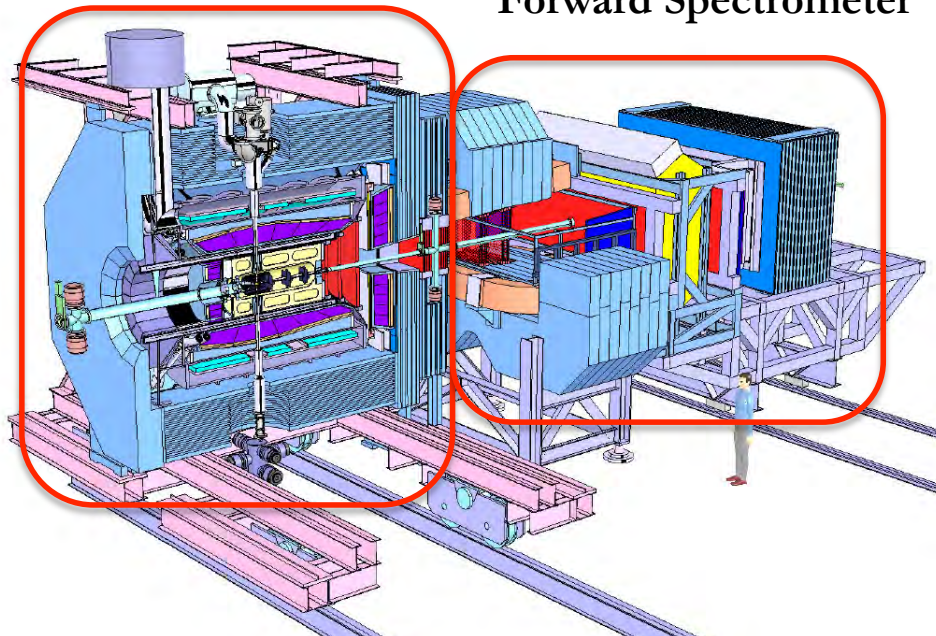
Physics program:

- High precision charmonium spectroscopy
- Search for hybrids and glueballs
- Study of exotic states (X, Y, Z)
- Nucleon structure
- Hyper-nuclear physics

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
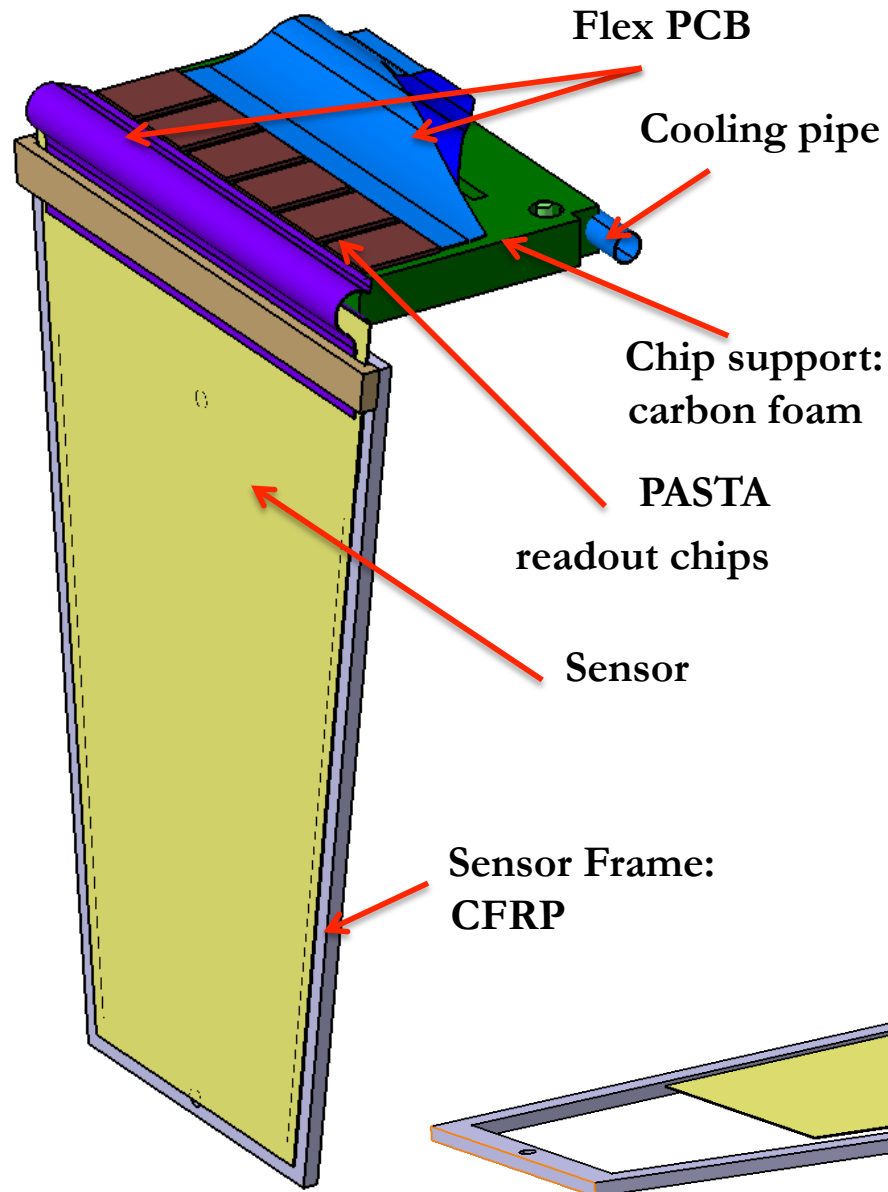- Hybrid pixels and double-sided silicon strip detectors
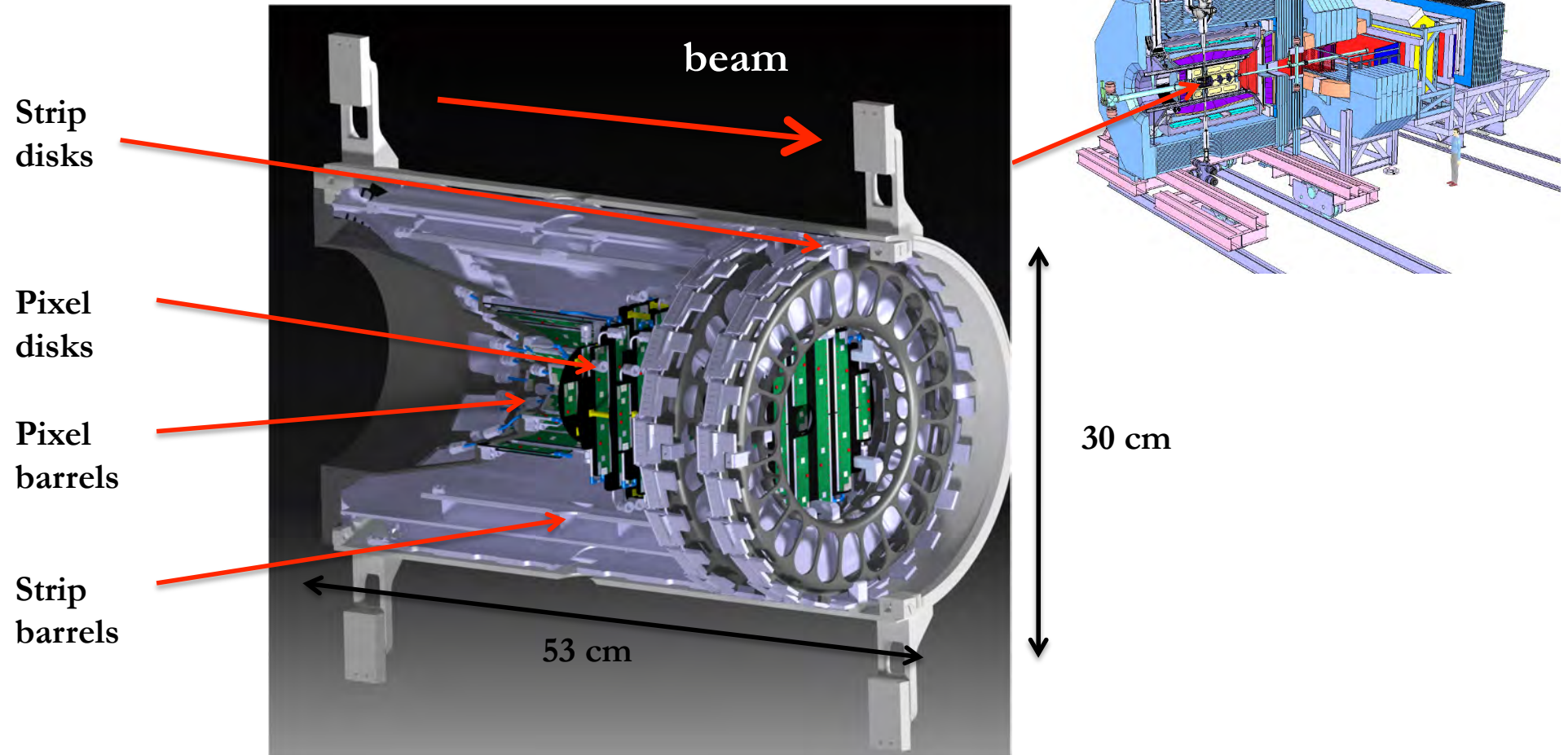
Strip Disks – Design Concept

- Trapezoidal sensors, 285 μm thick

- Stereo angle: 15°

- Strip pitch: 45 μm; readout every second channel

- 768 strips per side

- 2 disks at z = 172 and 232 mm, 24 sensors per disk
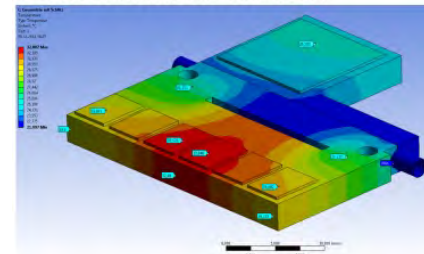
- Adjacent sensors overlap to avoid dead zones

37 mm

readout chip: 64 strips

6 × 6 chip size

57 mm

22 mm

Strip disk

Along beam axis
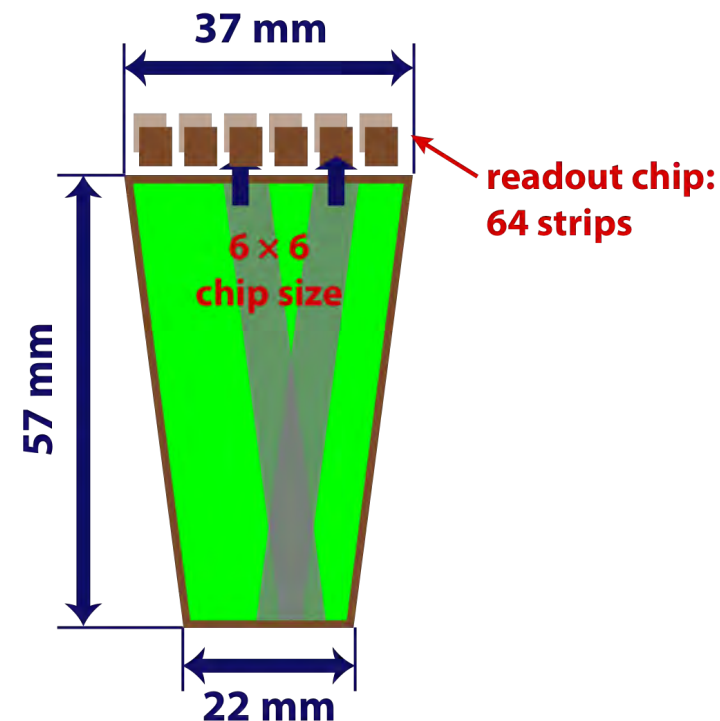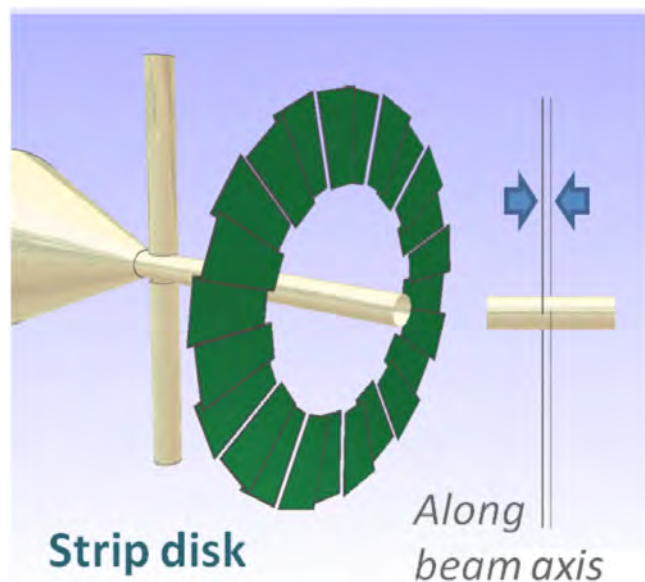
- Coverage: 0.07 m^2 (12% of the full MVD)

- 37k channels

- 288 readout chips

Strip Disks – Module Design

Flex PCB

Cooling pipe

Chip support:
carbon foam

PASTA
readout chips

Sensor

Sensor Frame:
CFRP
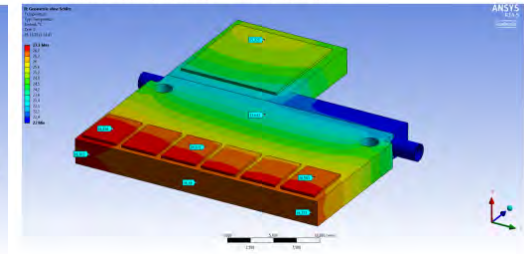
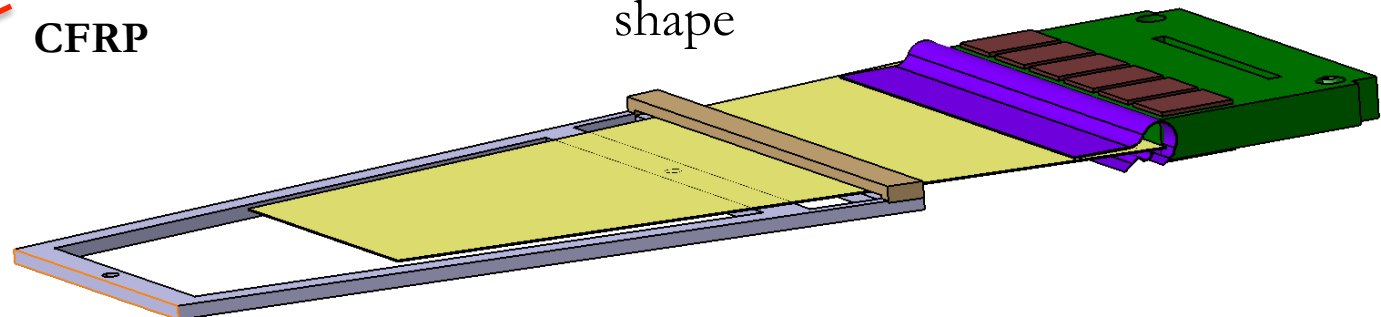2. Berechnung ohne Konvektion – mit Kabelschlitz:

3. Berechnung ohne Konvektion – ohne Kabelschlitz:
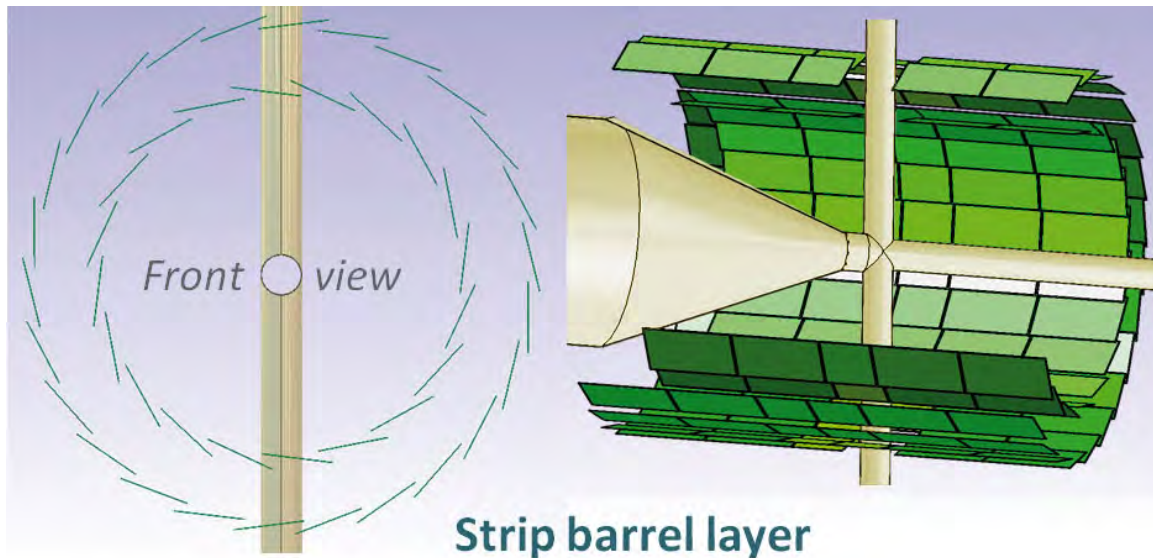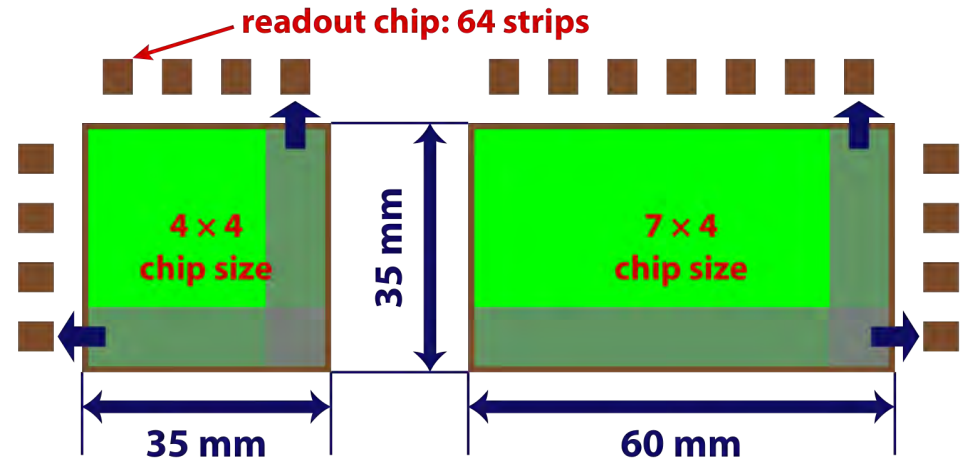
Cooling performance studied with FEM analysis.

Complex procedure for assembly:

- Wire bonding is performed on both sides, while module is kept flat
- The frame is slid on the sensor
- The module is bent in the final shape
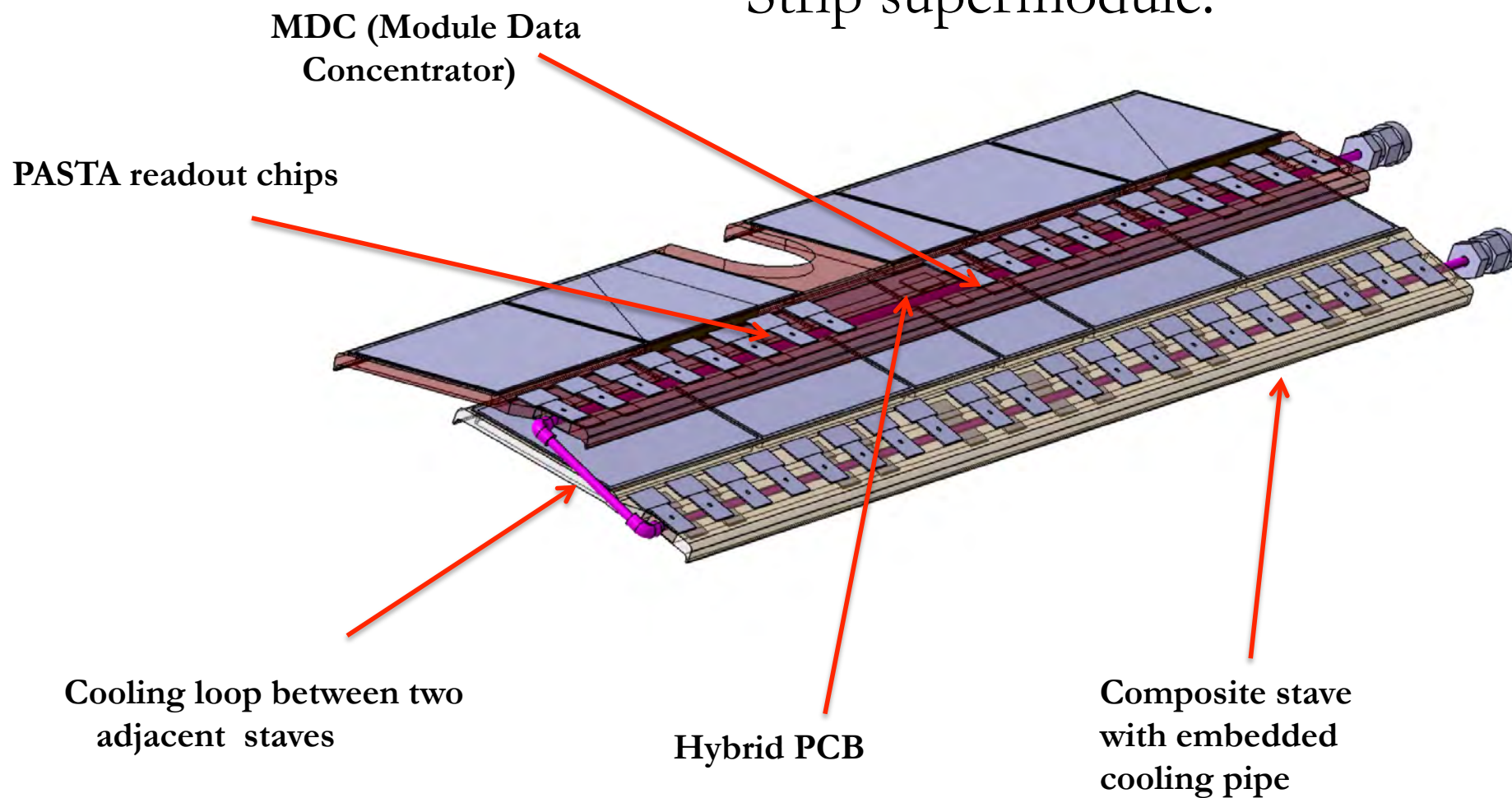
Strip Disks – Module Design

MDC support (carbon foam)

Cooling pipe (one quarter)

MDC (Module Data Concentrator)

- The 6 modules on a quarter are glued to the support and to the cooling pipe
- The MDC support is added
- Wire bonding is performed on the 6 MDCs

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)

readout chip: 64 strips

4 × 4 chip size

7 × 4 chip size

35 mm

35 mm

60 mm

Front view

Strip barrel layer

- Coverage: 0.422 m² (70% of the full MVD)

- 162k channels

- ~2500 readout chips

- ~700 W power consumption

- Barrel 3: 20 staves 28 cm long

- Barrel 4: 26 staves 31 cm long

Strip supermodule:

MDC (Module Data Concentrator)

PASTA readout chips

Cooling loop between two adjacent staves

Hybrid PCB

Composite stave with embedded cooling pipe

Strip Module – Stave Design II

- Sandwich structure of carbon fiber (200 µm) and foam (2 mm)
- Up to 18 W dissipated on one stave → active water cooling
- Embedded cooling pipe in nickel-cobalt alloy (2 mm diameter, 80 µm wall thickness)
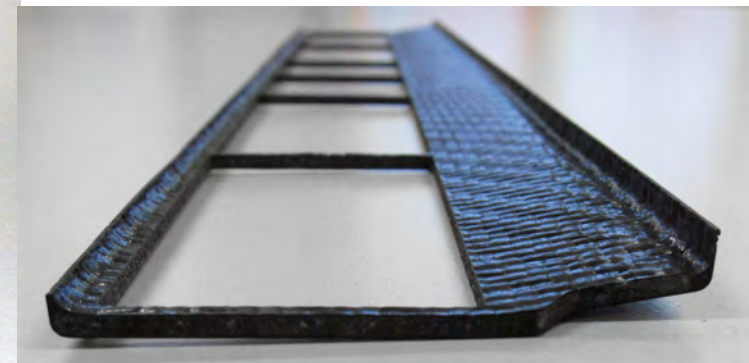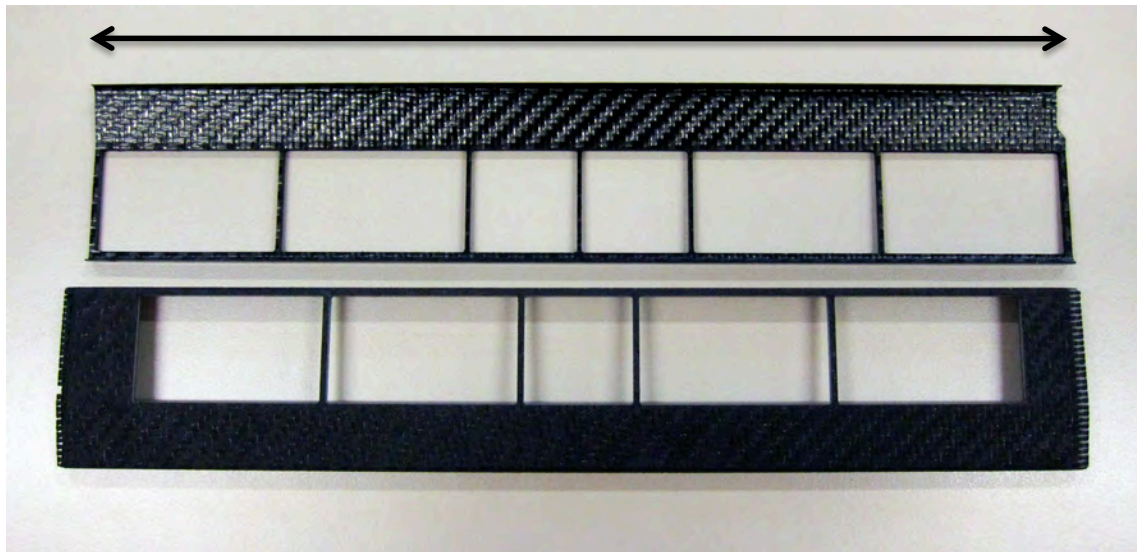- Carbon foam (POCO HTC) in the area around the cooling pipe
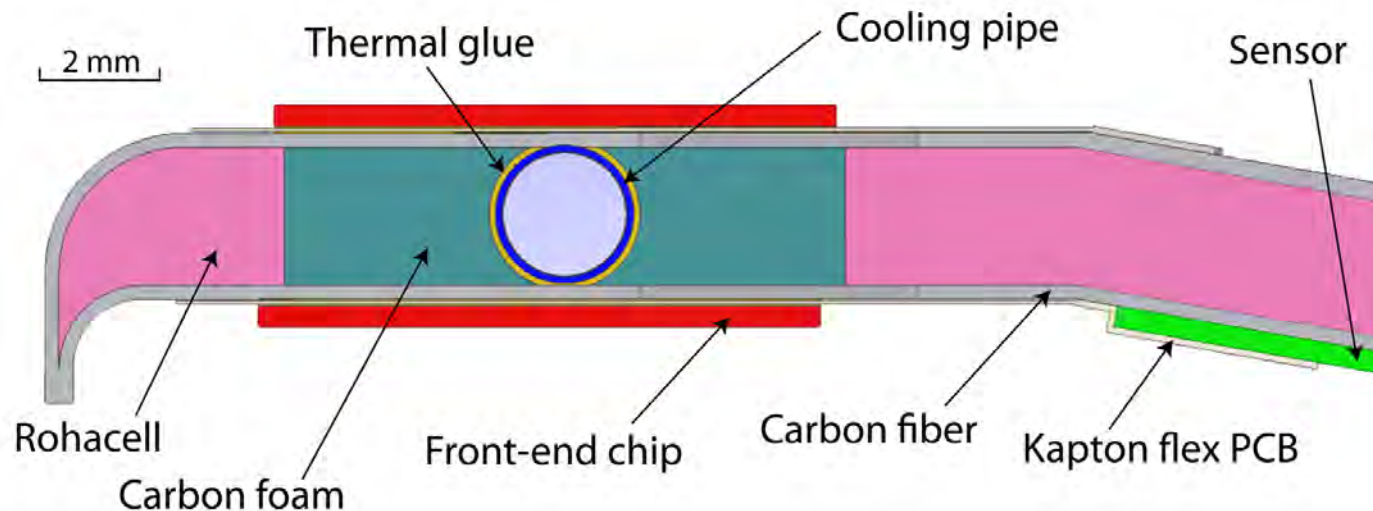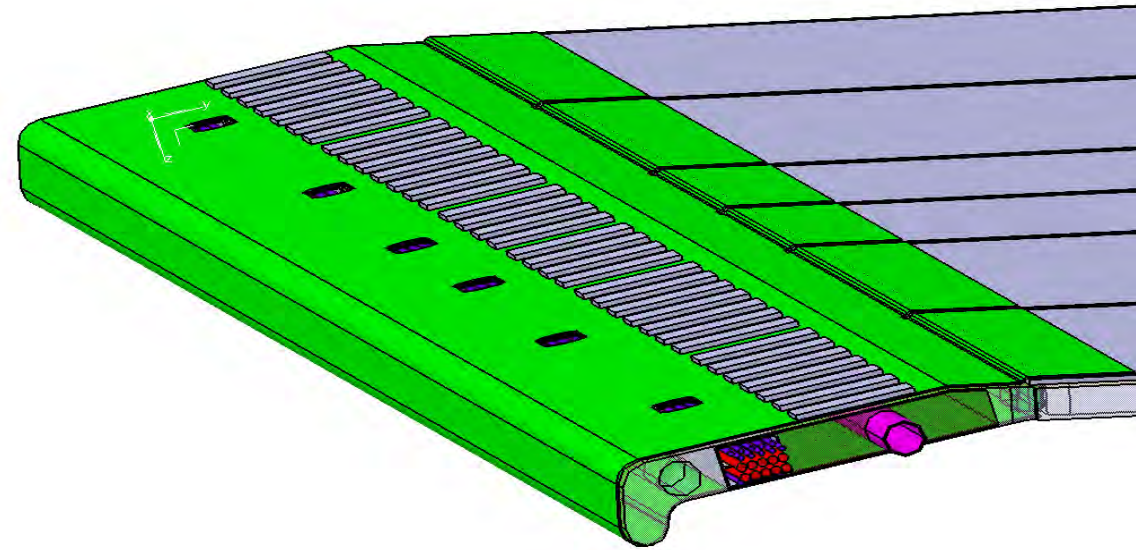
Strip Module – Stave Prototypes I

- Design in collaboration with ZEA-1, Jülich

- Large cutouts for the sensors

- Special design for top/bottom staves around the target pipe

- 6 different designs in total
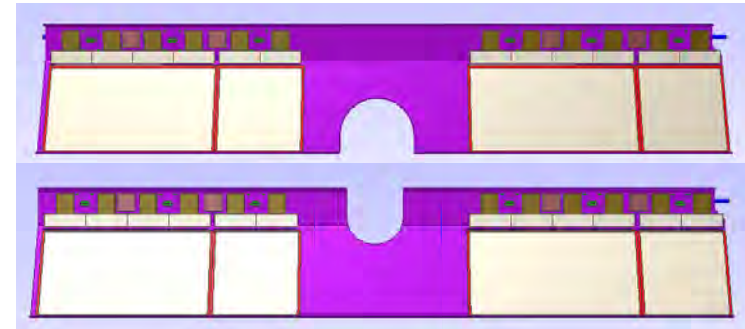
31.3 cm

~6 cm

- Thermal tests to validate the cooling system are ongoing
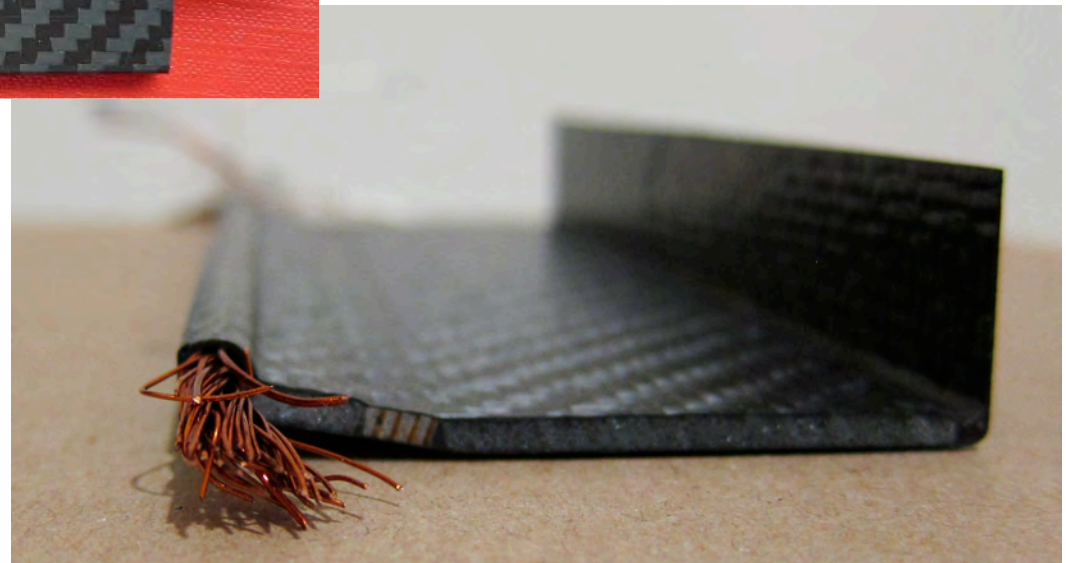
Strip Module – Stave Prototypes II

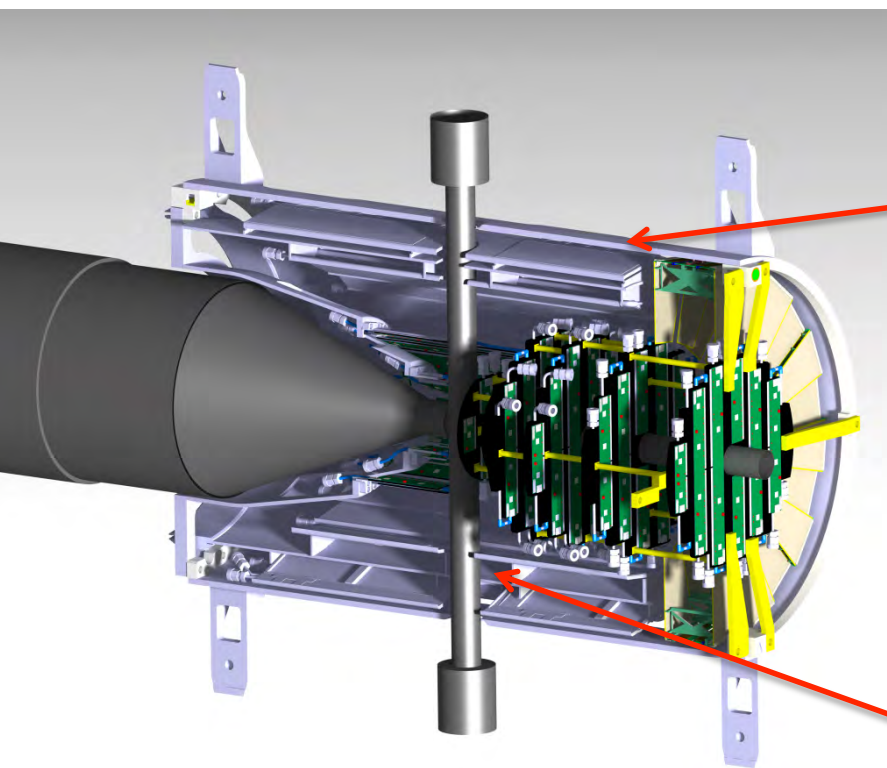Cooling pipe embedded in the carbon foam

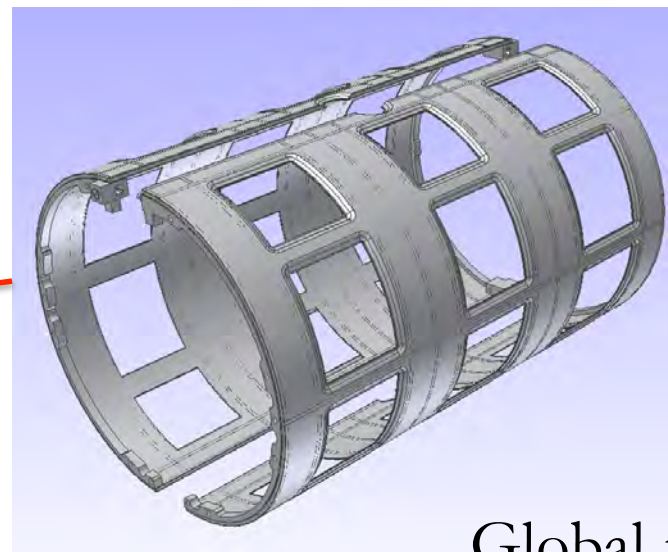

Reduced size stave with carbon foam and pipe

Reduced size stave with cable channel hosting 60 enameled copper wires with diameter between 0.15 and 0.55 mm
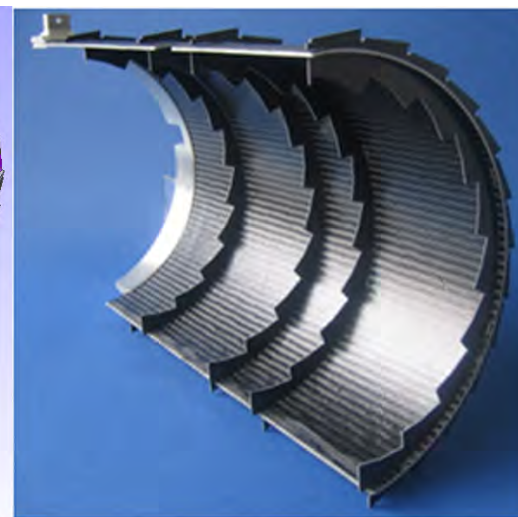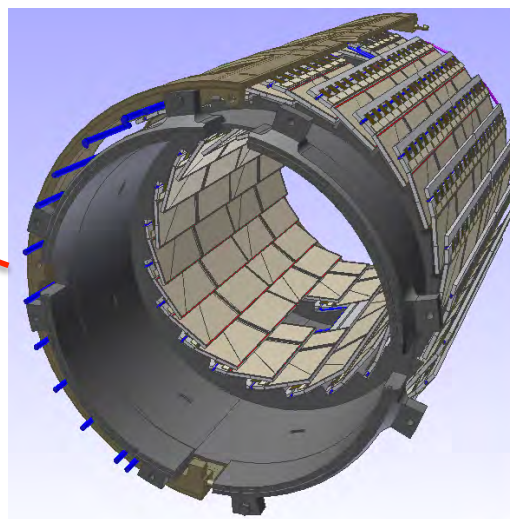
Strip Barrels – Mechanical Integration

Global frame

Complete half-detector
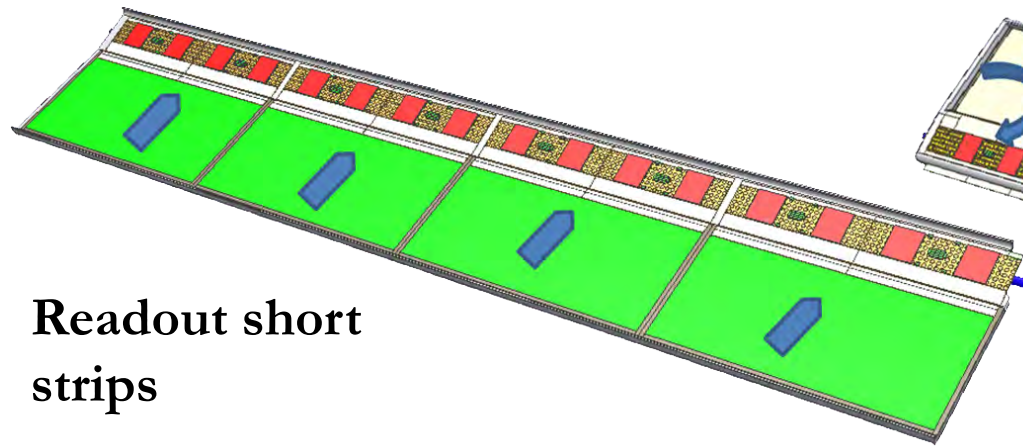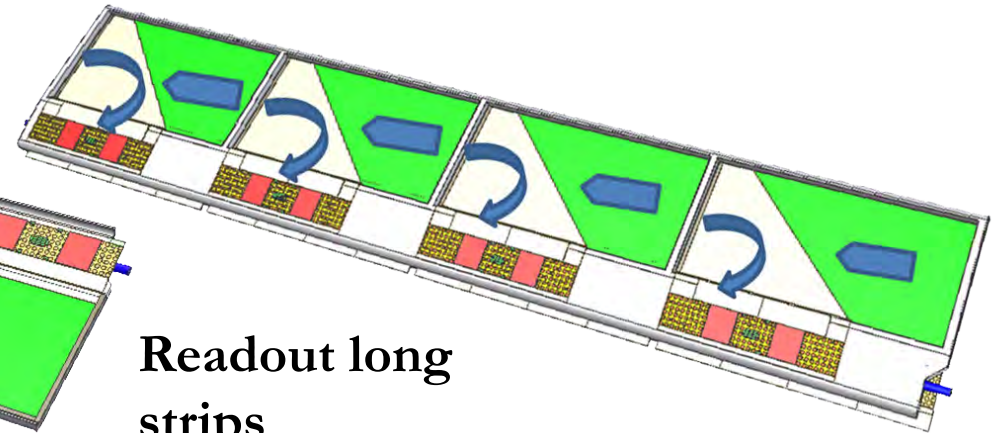
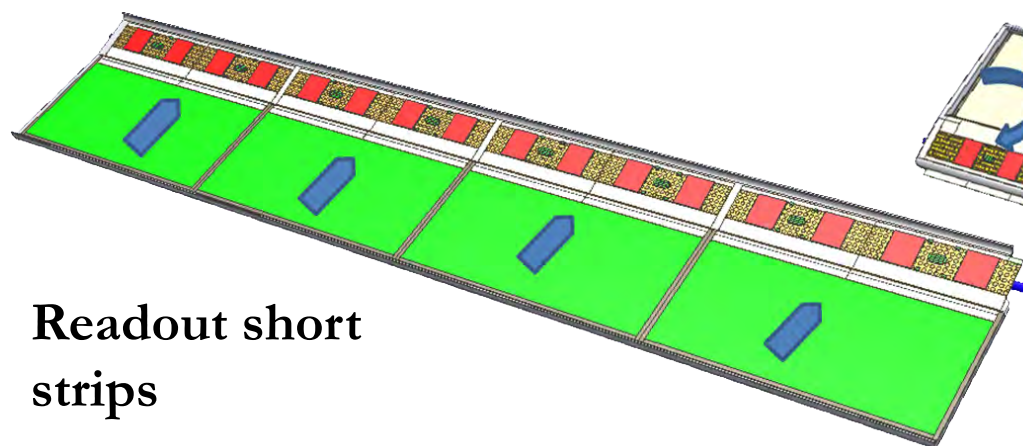Strip barrels support

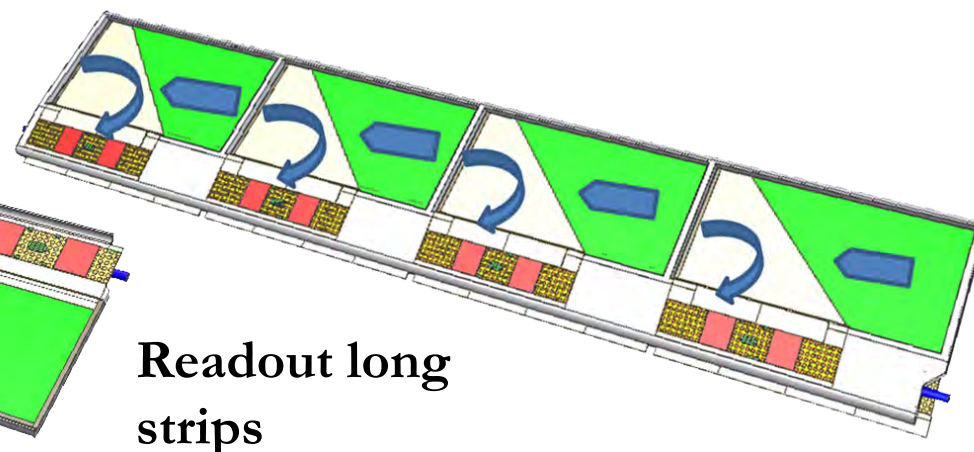# Strip Module – Hybrid Bus I

Readout short strips

Readout long strips
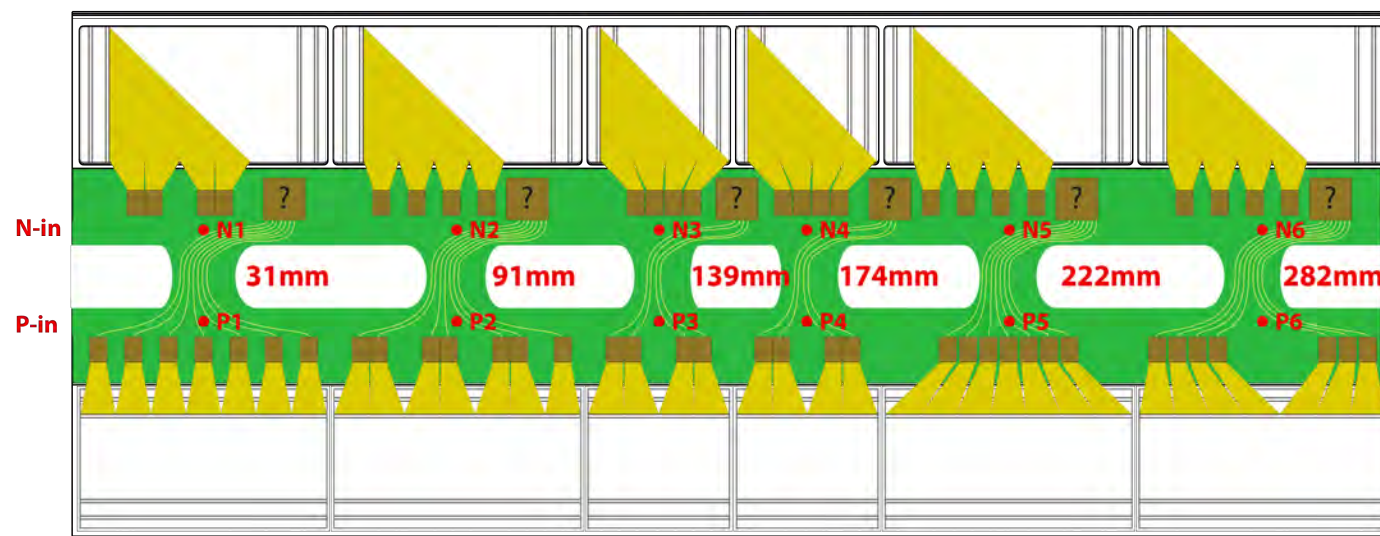
Strip Module – Hybrid Bus I

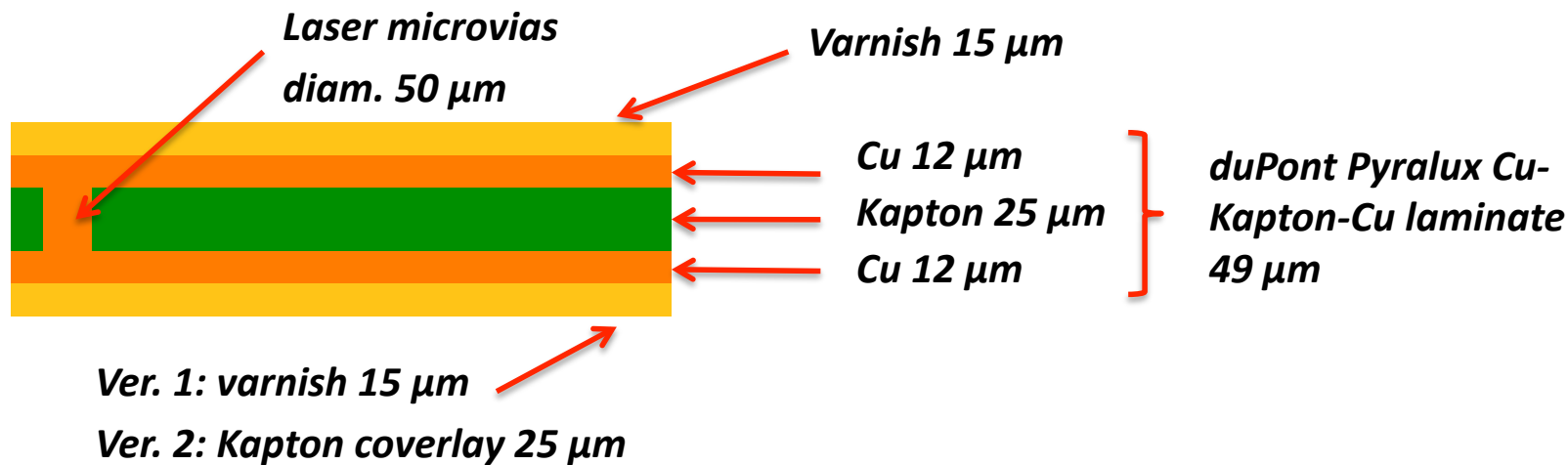**Readout short strips**

Readout long strips

- Connects the sensor and the front-end chips, adapting the pitch
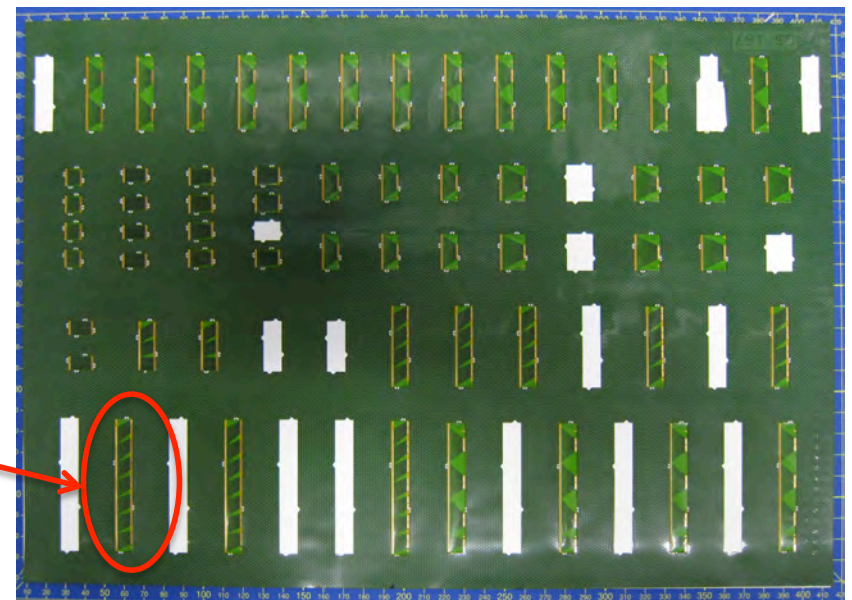- Distributes I/O signals and power to the chips

Proposal for the full hybrid layout

N-in

N1   N2   N3   N4   N5   N6

31mm   91mm   139mm   174mm   222mm   282mm

P-in

P1   P2   P3   P4   P5   P6

Strip Module – Hybrid Bus II

- First prototypes with flexible technology: flex pitch-adapters

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

Flex pitch-adapter prototype

- Reduced-scale prototype with APV25 readout chip produced

Laser microvias
diam. 200-650 μm

Cu 12 μm
Kapton 50 μm
Cu 12 μm

Thinflex A-2003AD
Cu-Kapton-Cu
laminate 74 μm

Varnish 15 μm

Pitch
adapter

Pad for 1 APV
readout chip

Bonding pads
for the sensor

Sensor biasing
connectors

APV power supply
connectors

S3 double-sided
microstrip sensor

transition board

APV25 readout chip

high density
data cable
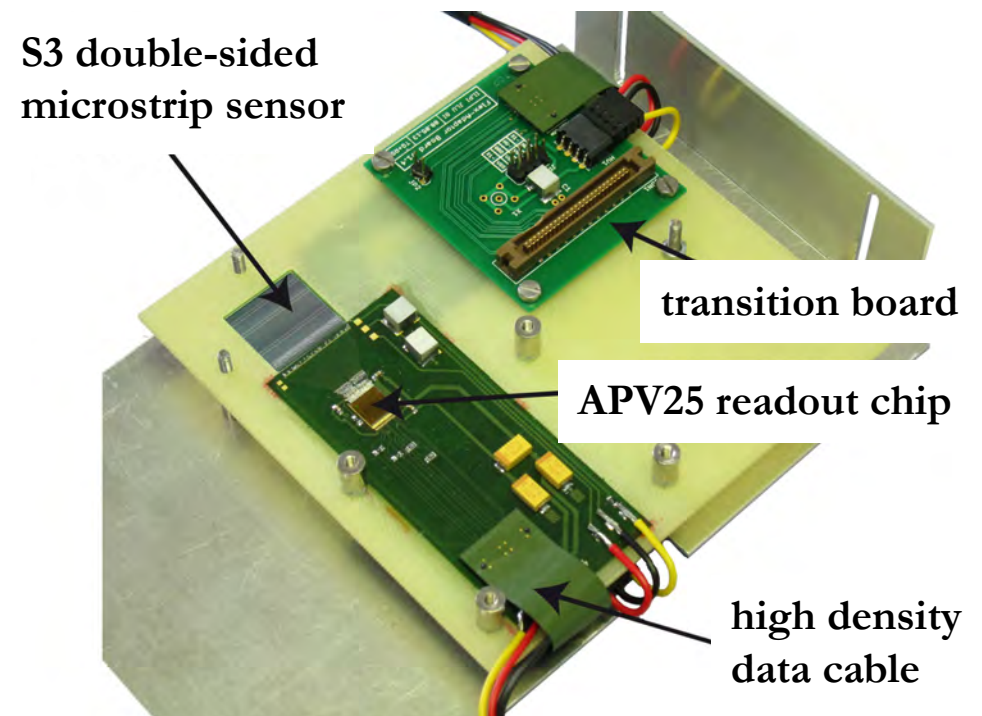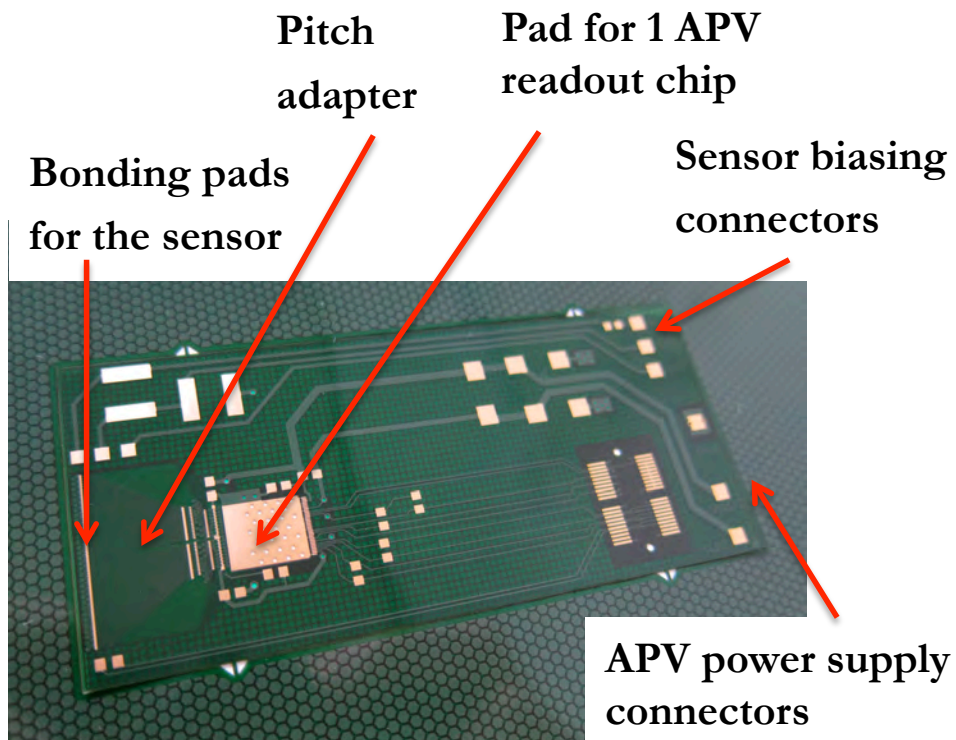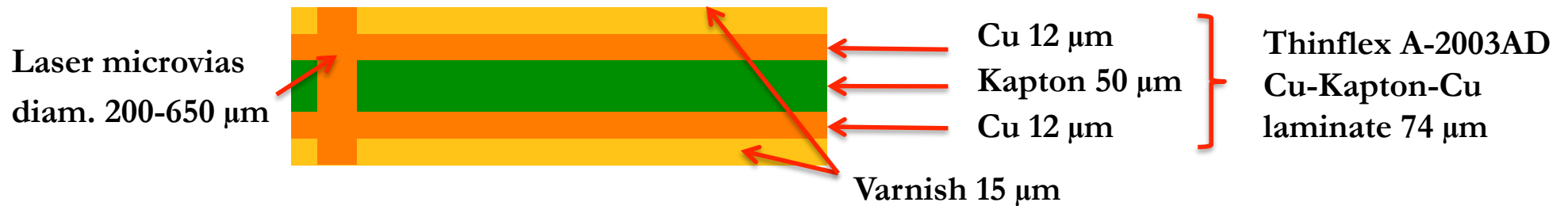
Summary & Outlook

- **The general design of the PANDA MVD is finalized.**

- **Development and validation of components is ongoing:**
  - Carbon fiber stave prototypes under study;
  - Flex pitch adapters and small-scale PCB produced and tested successfully.

- **Next steps:**
  - Design and test of a full-scale hybrid;
  - Validation of the stave cooling system;
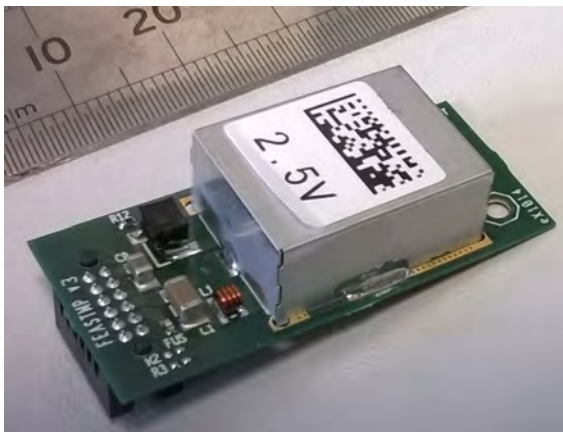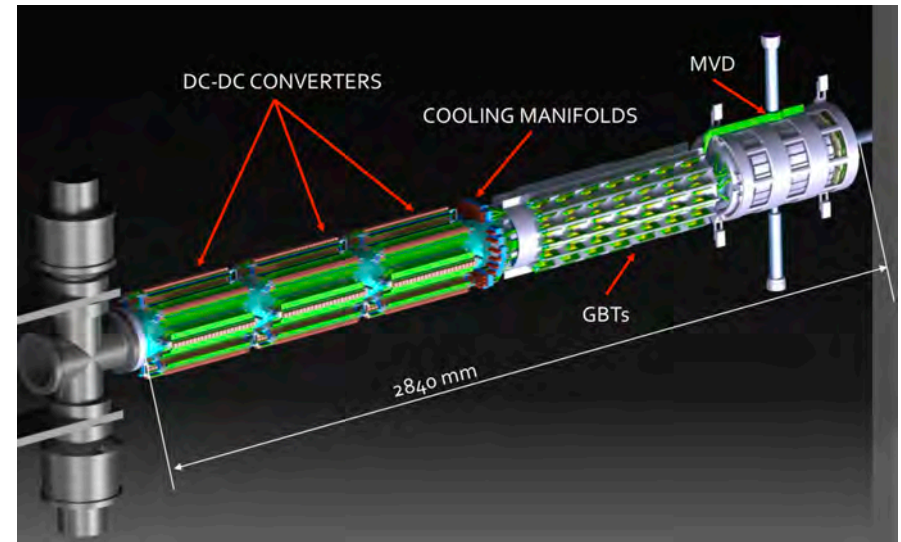 - Study of the assembly procedures and tools.
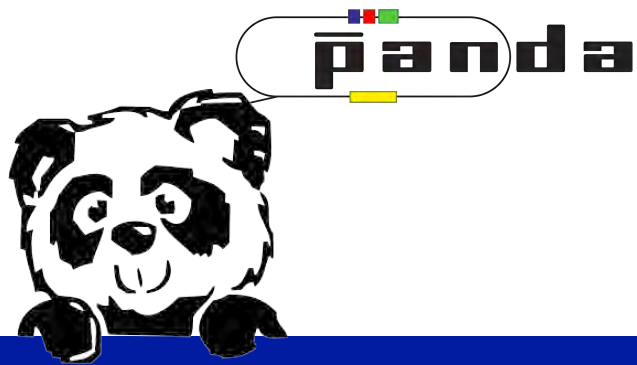
Thank you for your attention!
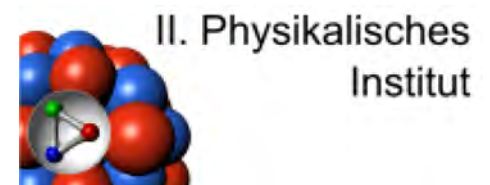
Strip Barrels – Powering

- DC-DC powering operating in B=2T

- 4 power domains per sensor

- up to 50 power supply cables per strip barrel stave (up to 4 m long)

- ~1200 converters for barrels + disks (+600 for pixel detector)

- MVD services routing is a crucial issue

Stave A

FEASTMP converter (CERN development)