Materials for HEP Detectors

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09/03/2016

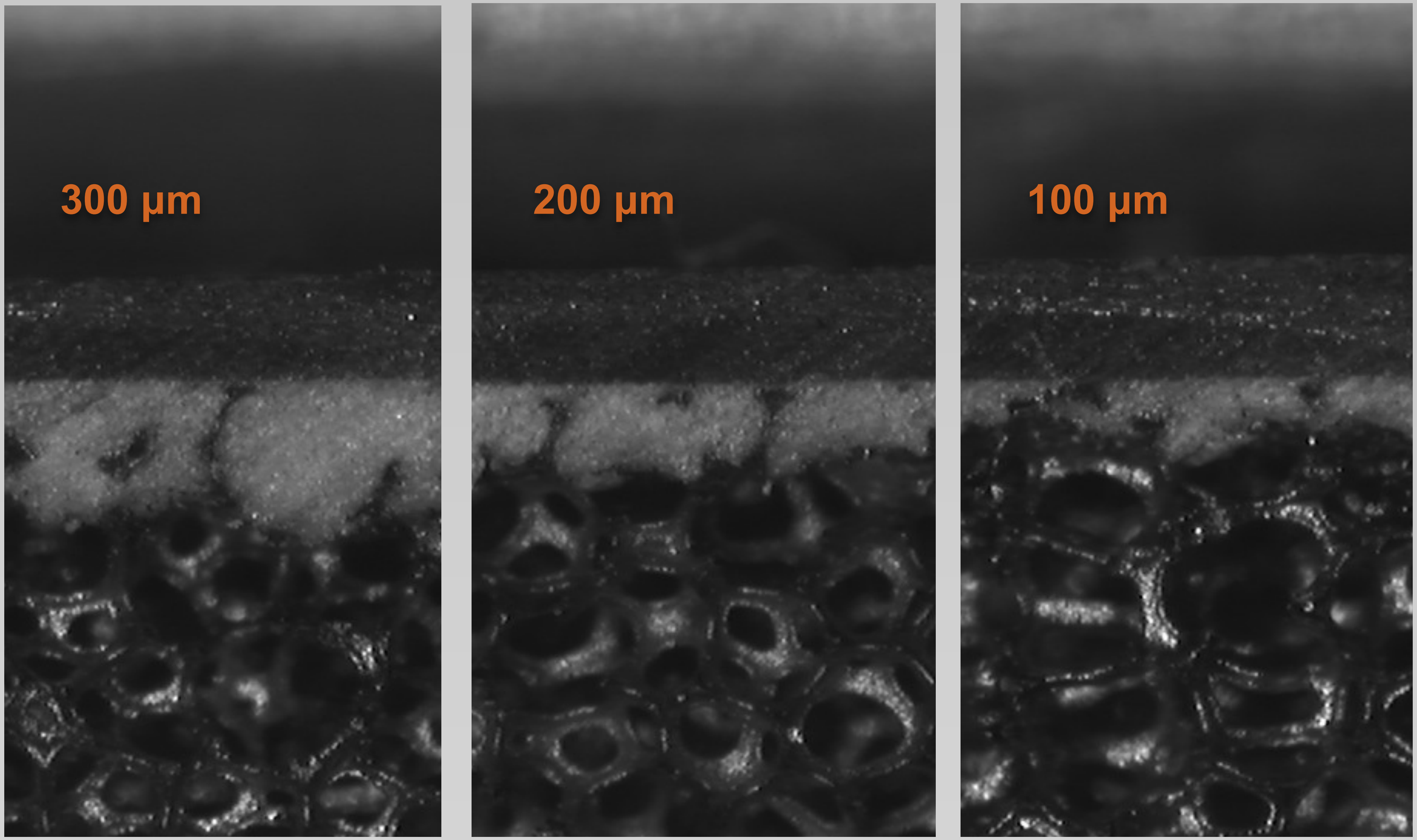
DESY

JÜLICH
FORSCHUNGSZENTRUM

CVD Carbon Foam

CMS

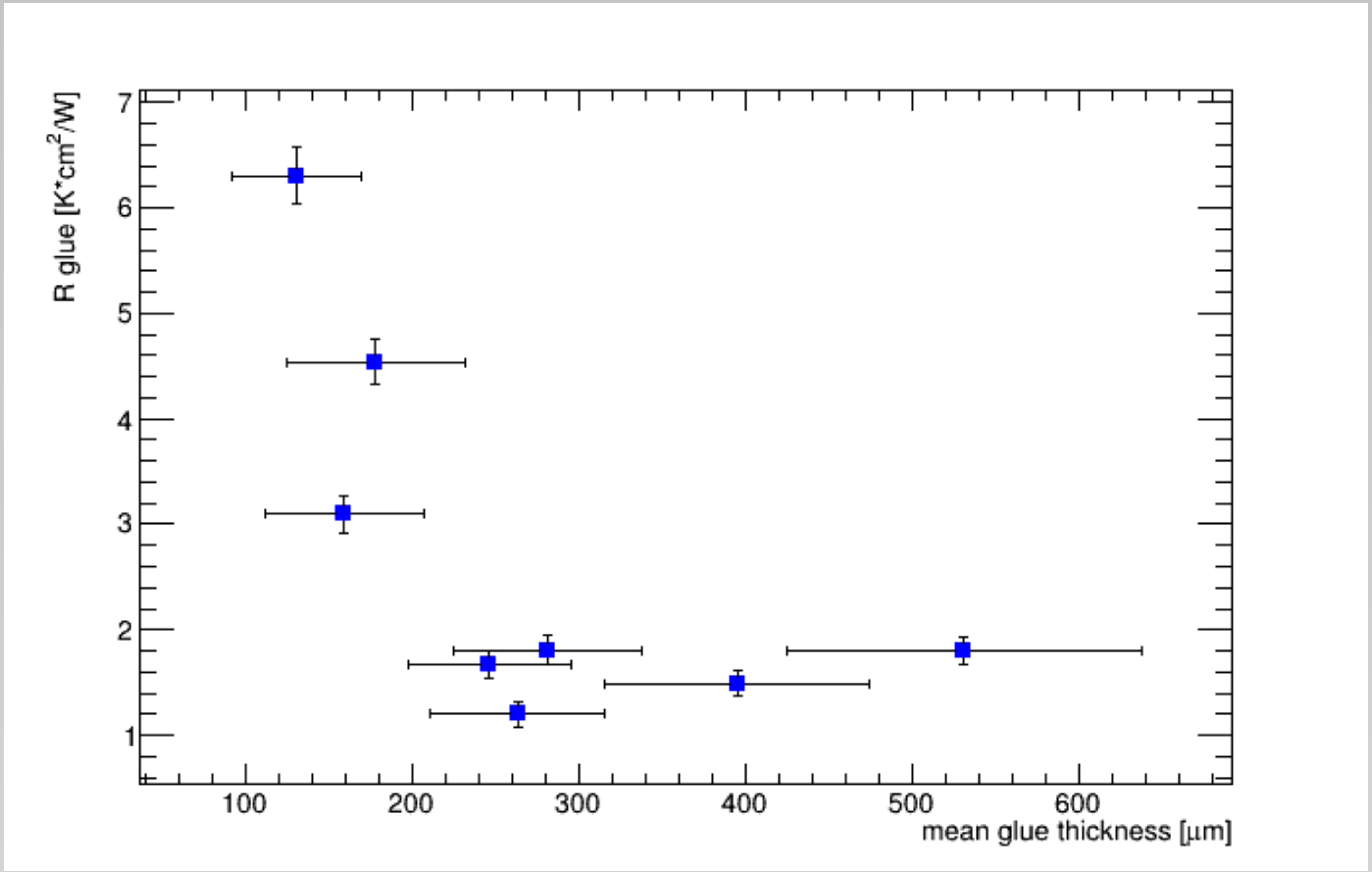
- high thermal conductivity at low density
  - thermal conductivity: 10 W/m/K - 75 W/m/K
  - density: 0.09 g/cm^3 - 0.35 g/cm^3
- thermal impedance of contact between foam and pipe / CFRP / … depends in amount of glue
  - glue is mostly pushed into the foam and increases contact area
  - not enough glue: large thermal impedance
  - too much glue: excess mass



CVD Carbon Foam - Measurements

CMS

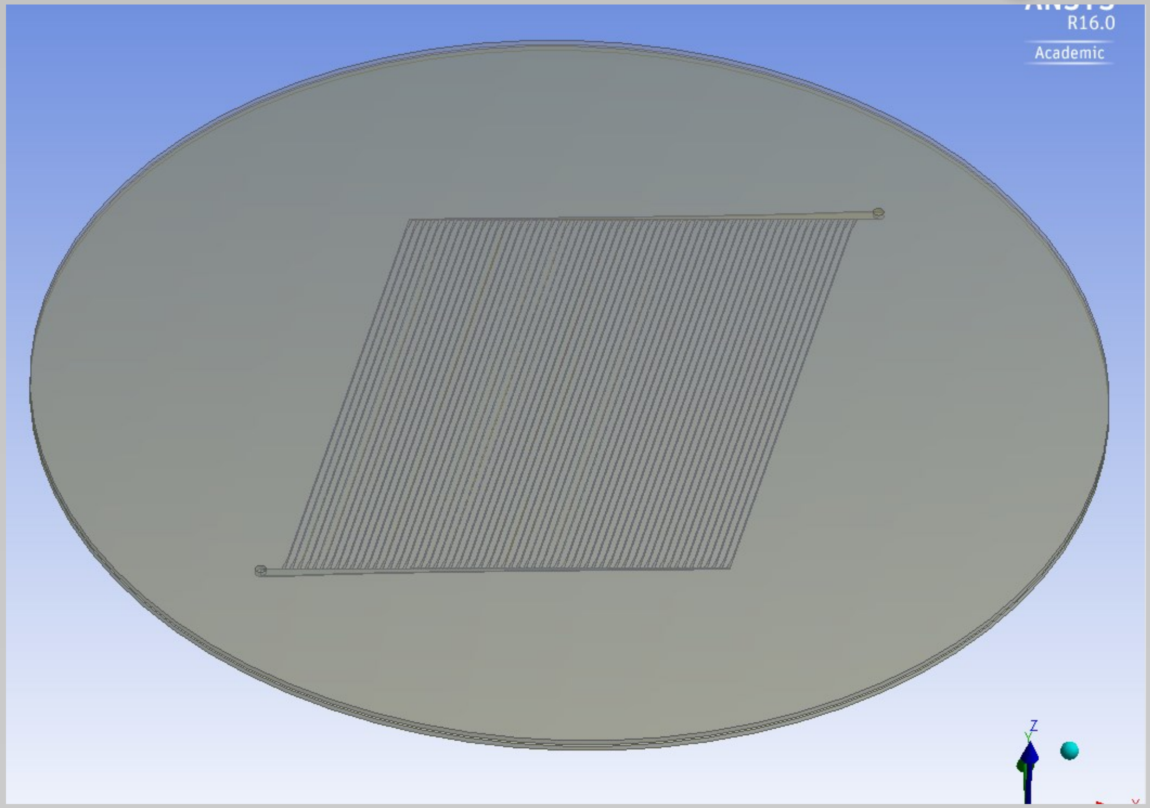
- thermal impedance as a function of glue thickness was investigated
  - thermal impedance reaches a minimum at about a glue thickness of 250 µm

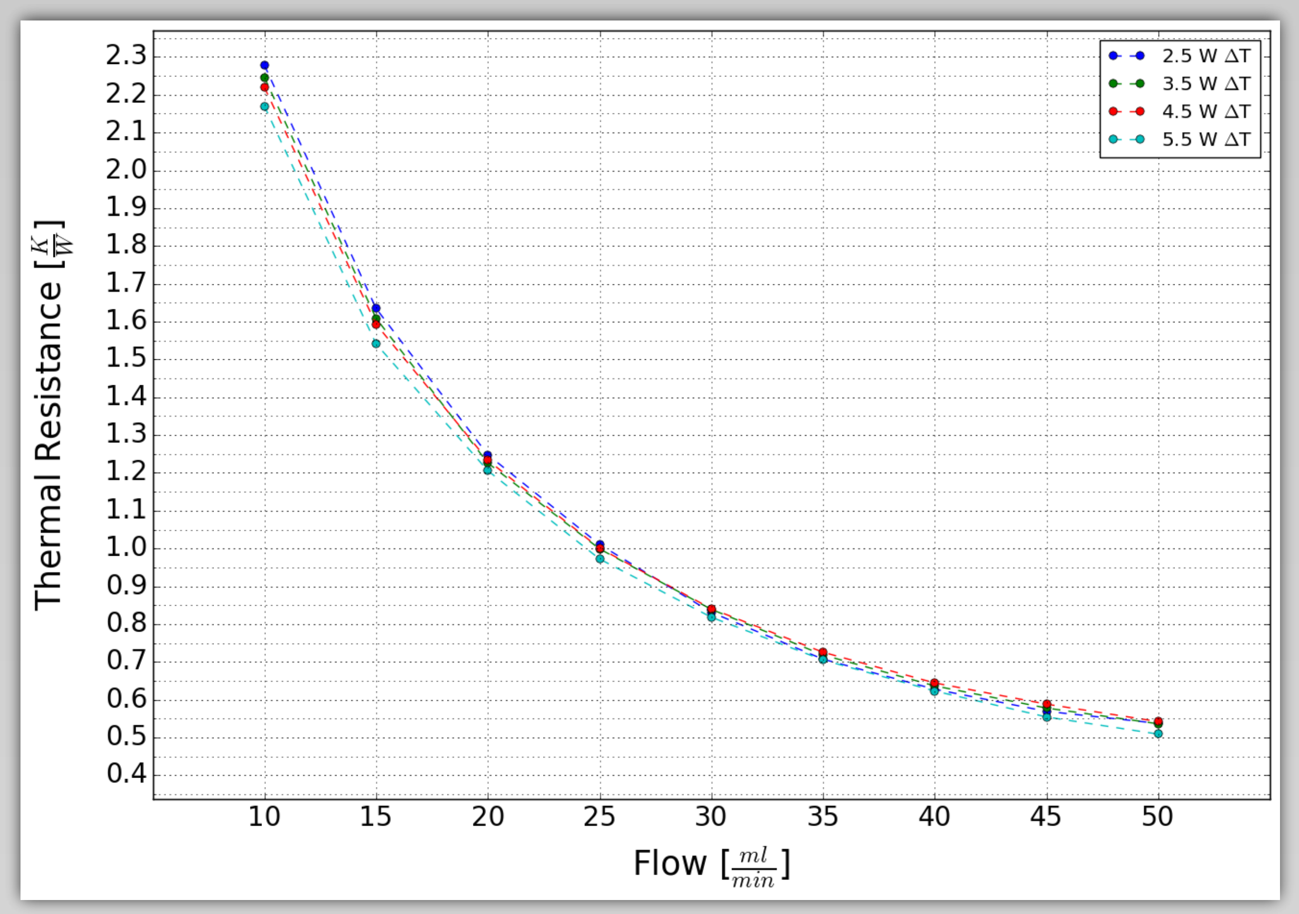


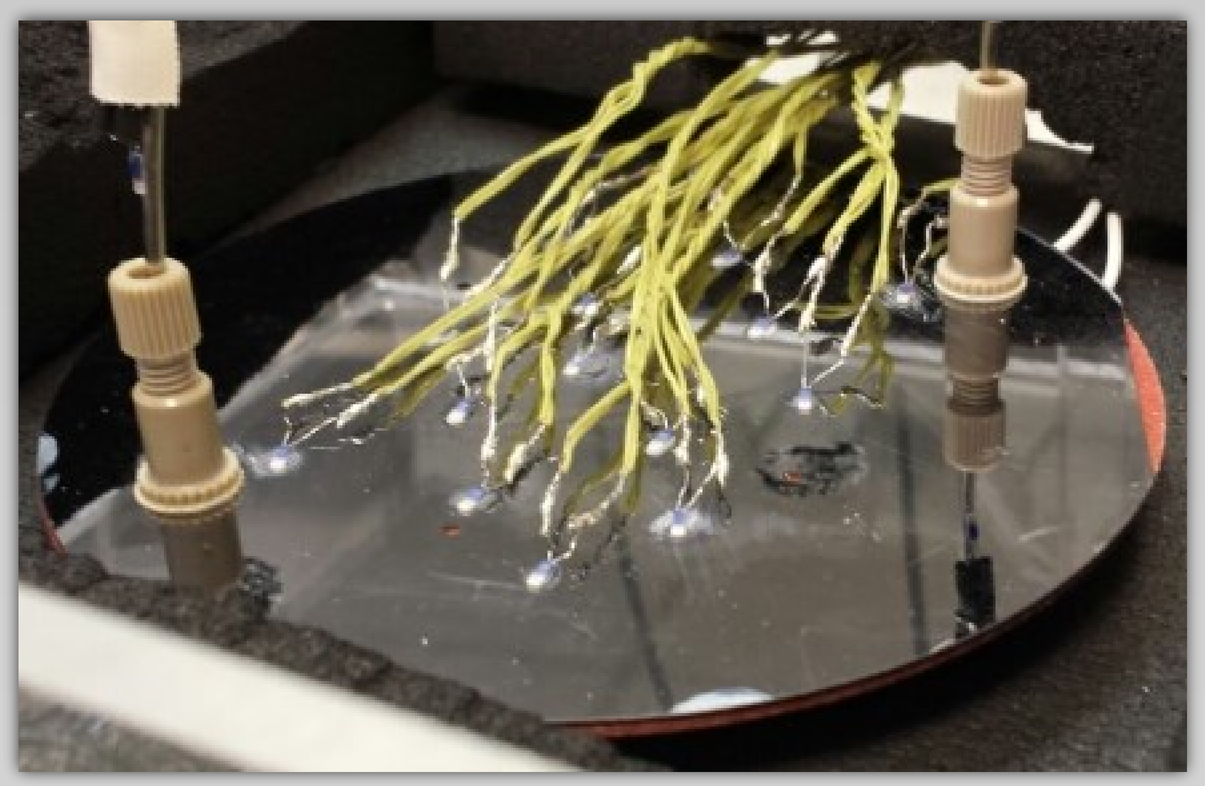
Microchannel Cooling

ATLAS

- microchannels etched into 4” silicon wafer of 500 μm thickness
- sixty 100 μm x 100 μm channels connected via manifolds
    - 675 μm pitch
- integrated into setup containing flow, pressure and temperature sensors
- wafer equipped with 4” heater
- temperature sensors on the surface and at the inlet and outlet

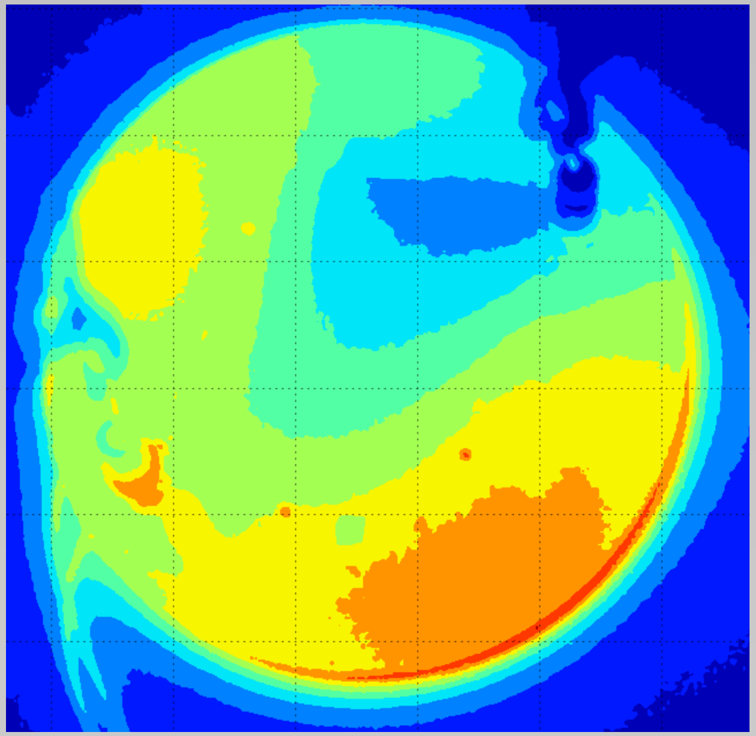


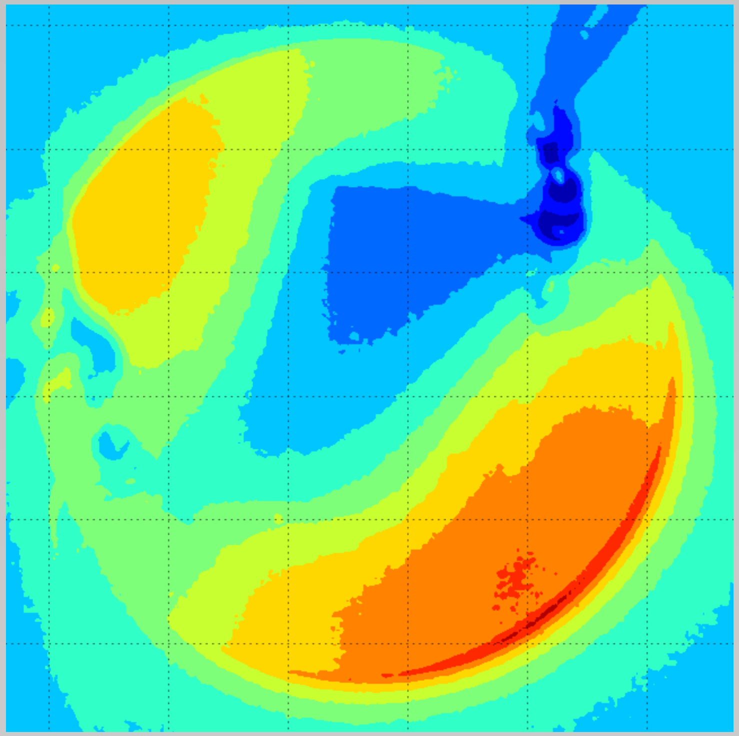


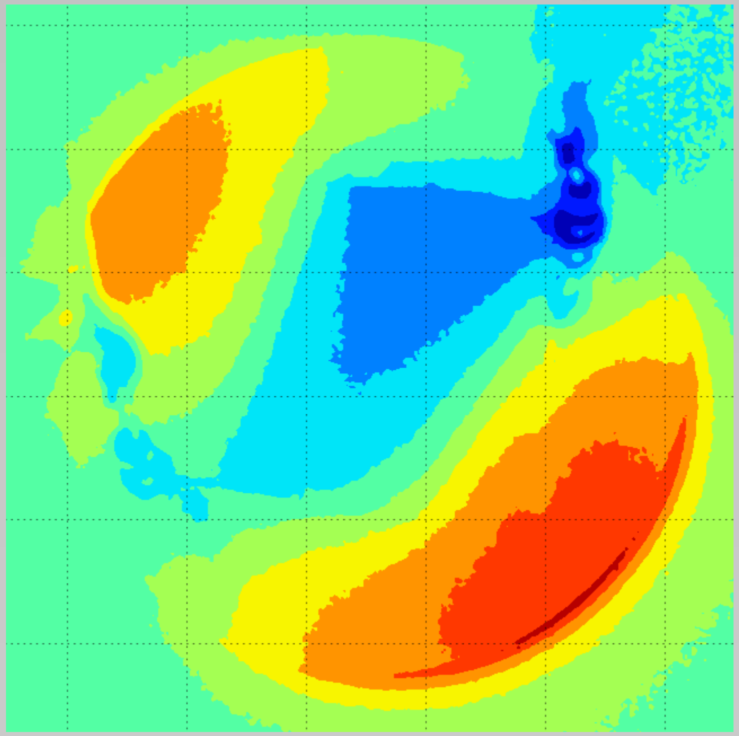


Microchannel Cooling

IR Camera

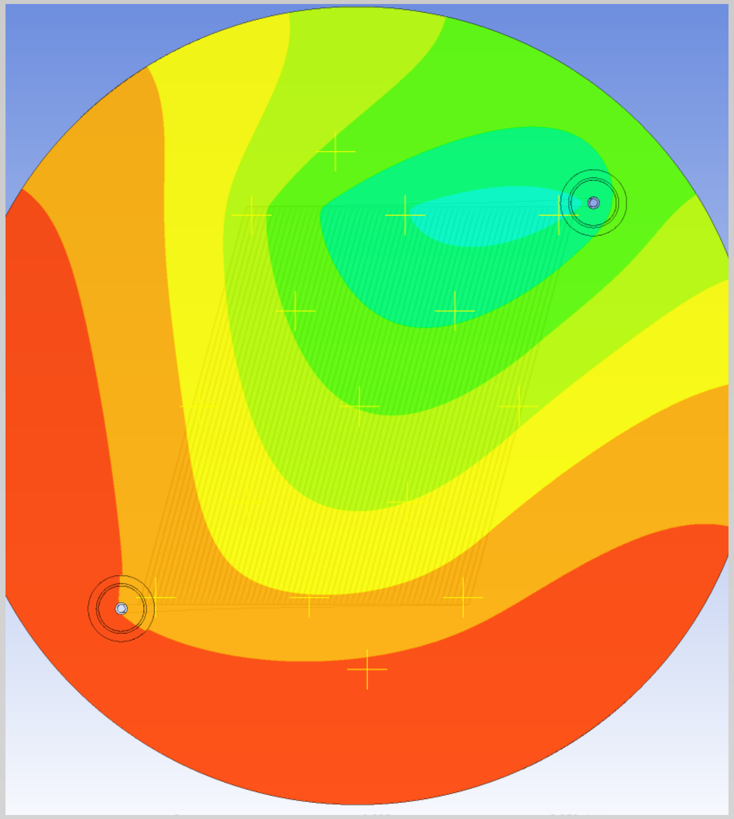


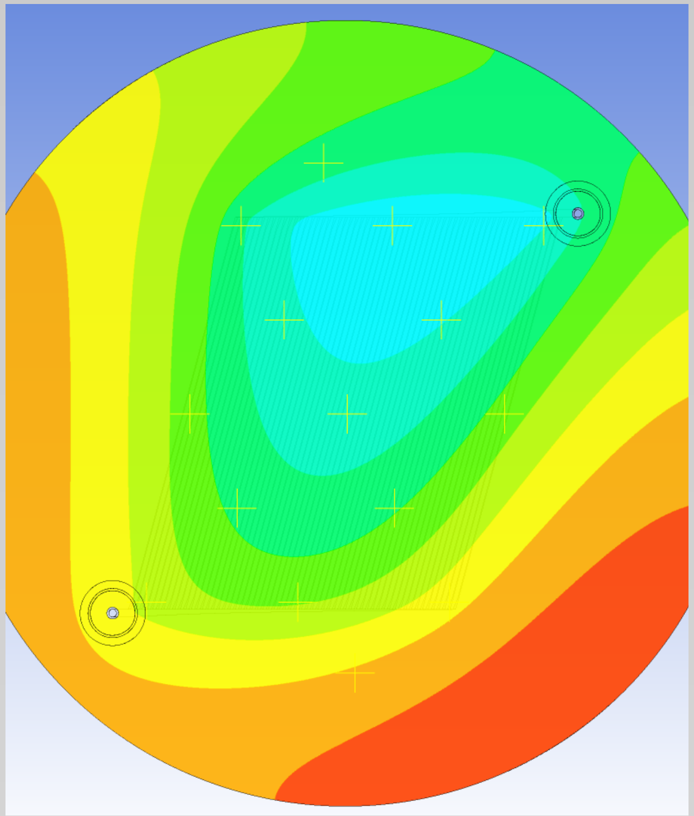


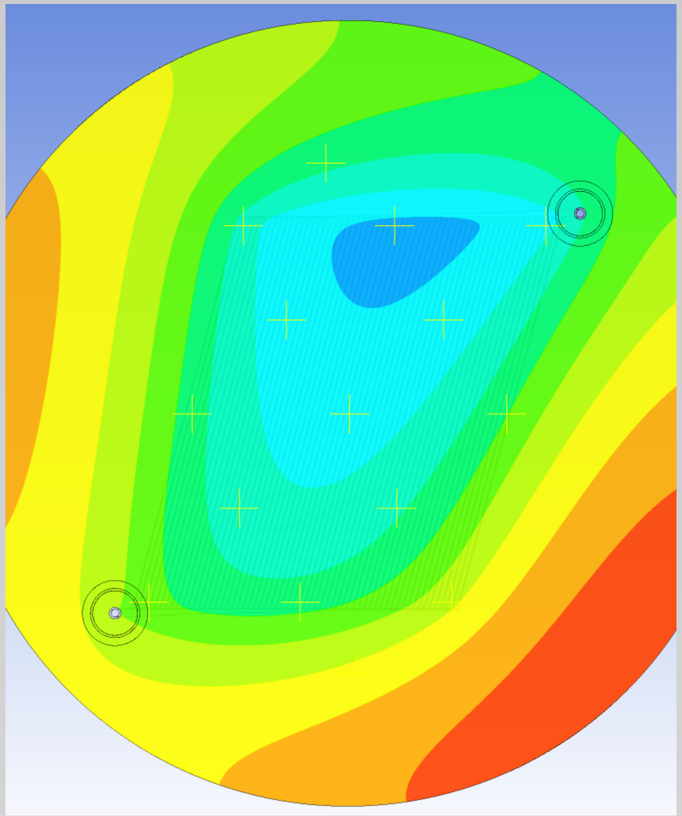


10 ml/min | **30 ml/min** | **50 ml/min**

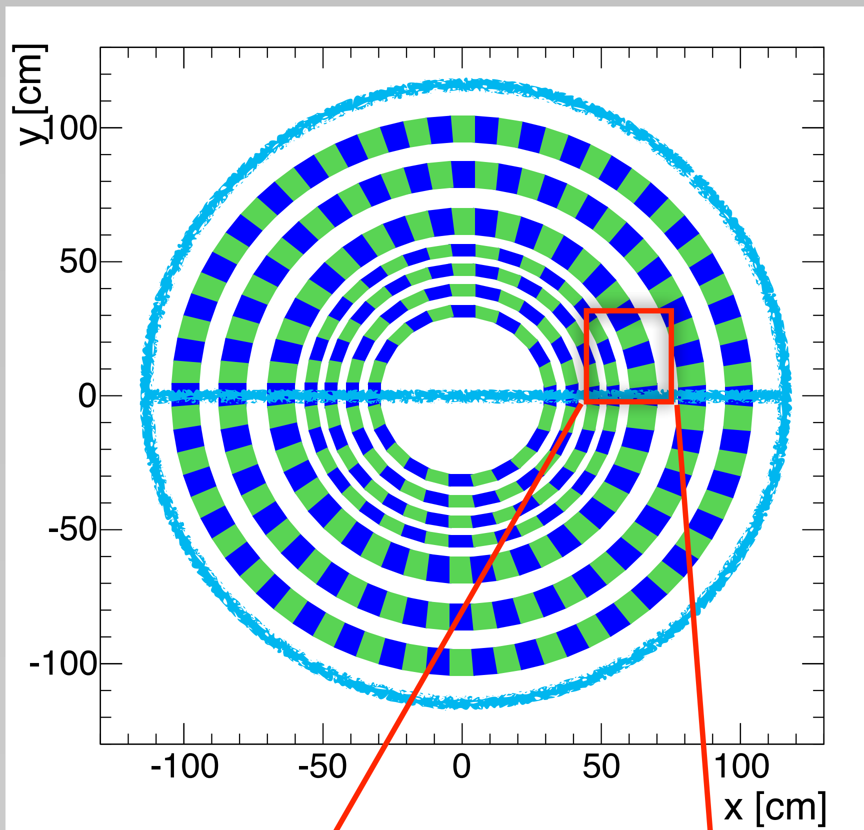
Simulation

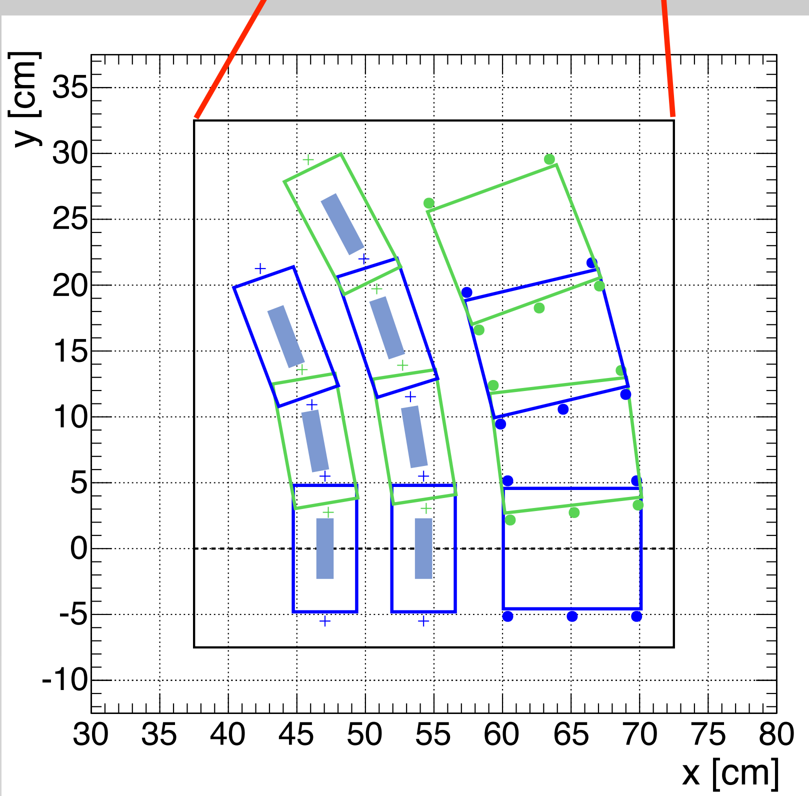




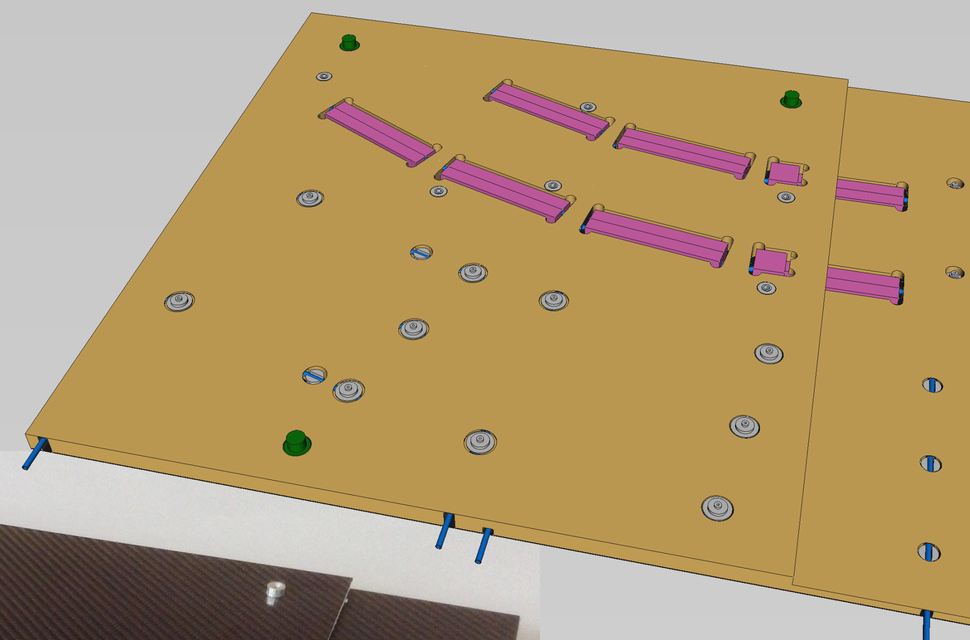


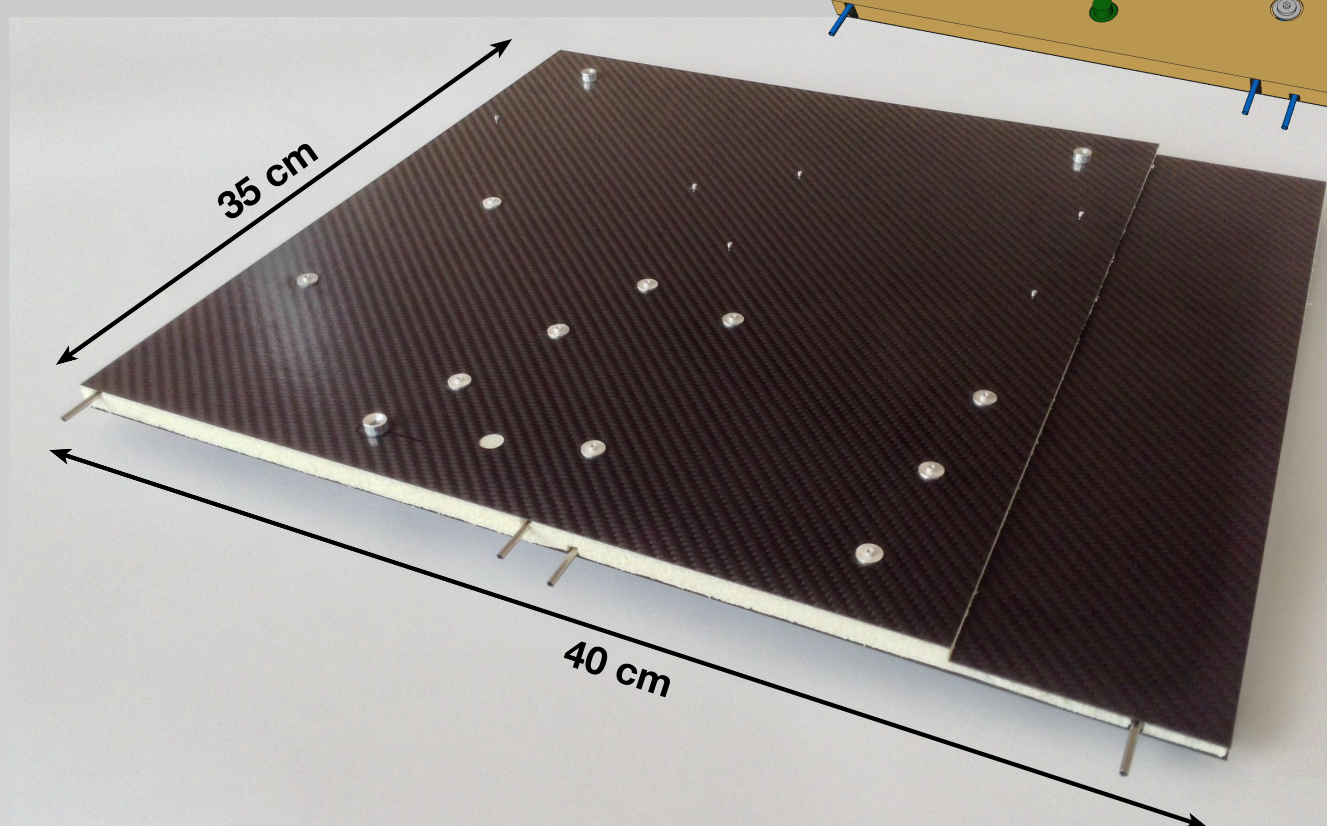
CMS TEDD Prototype





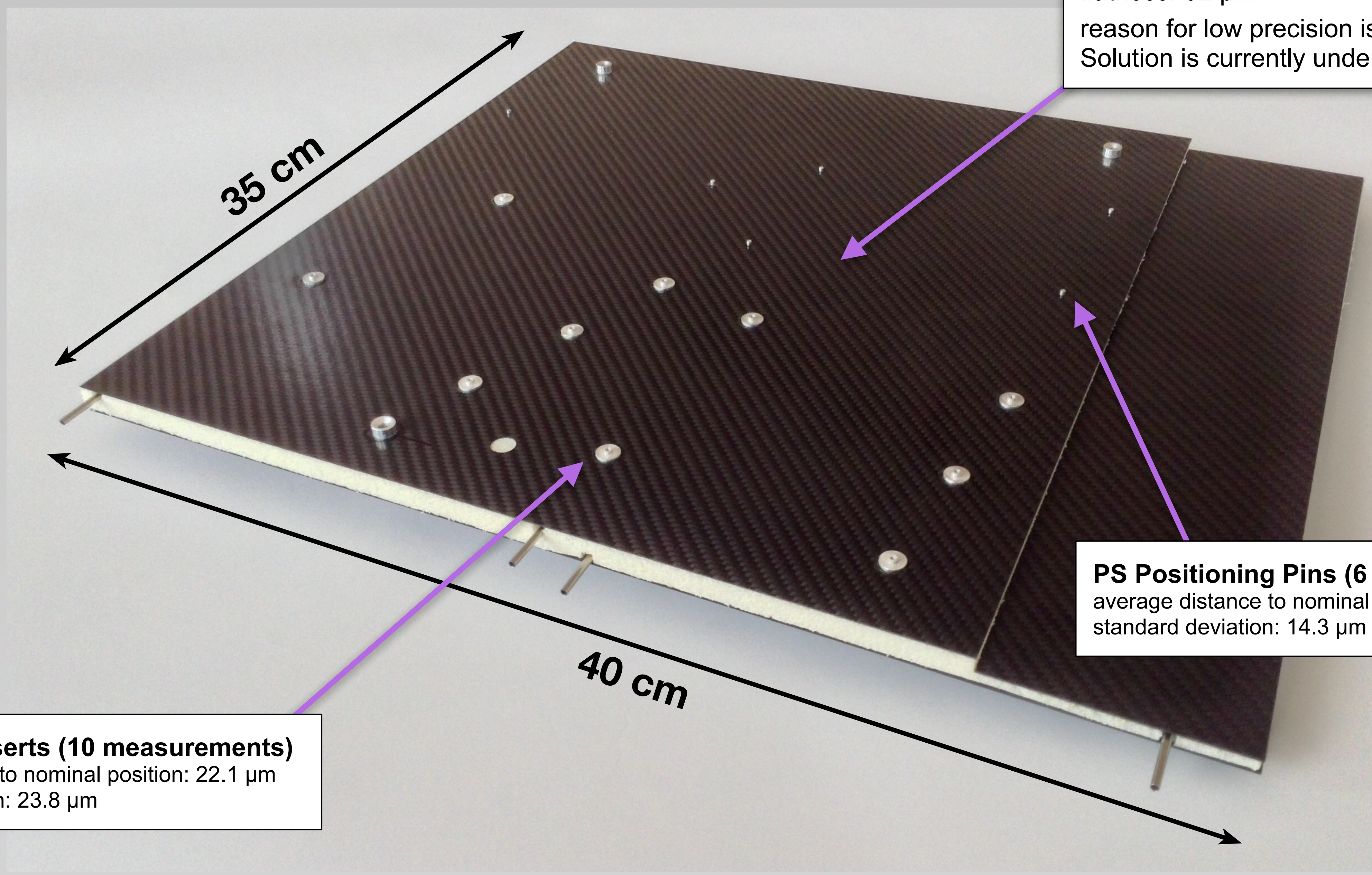
- modules are either mounted on dedicated cooling and positioning insert (2S module) or directly glued to support structure (PS module)
- CO_2 cooling pipes routed in two tiers inside end cap support structure





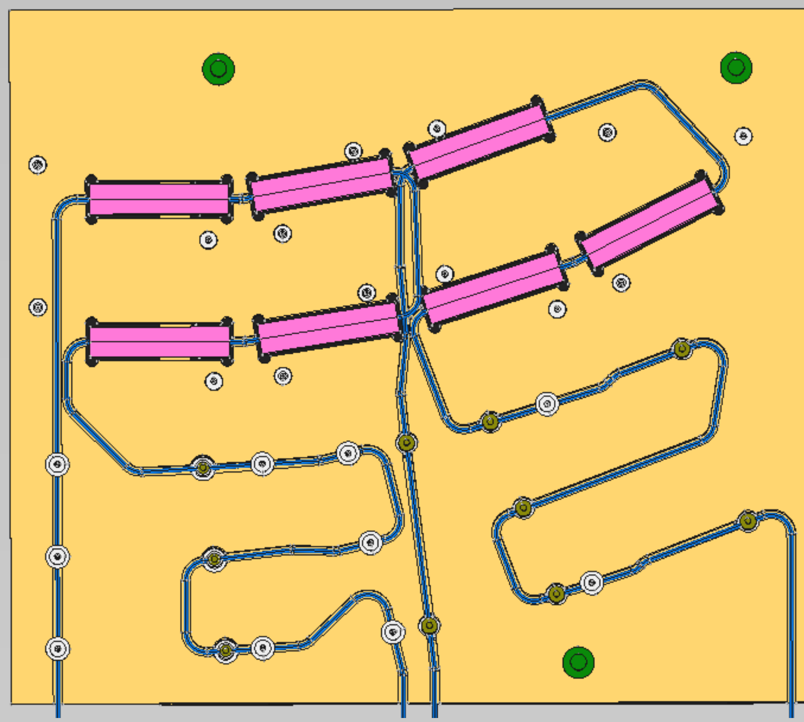
CMS TEDD Prototype

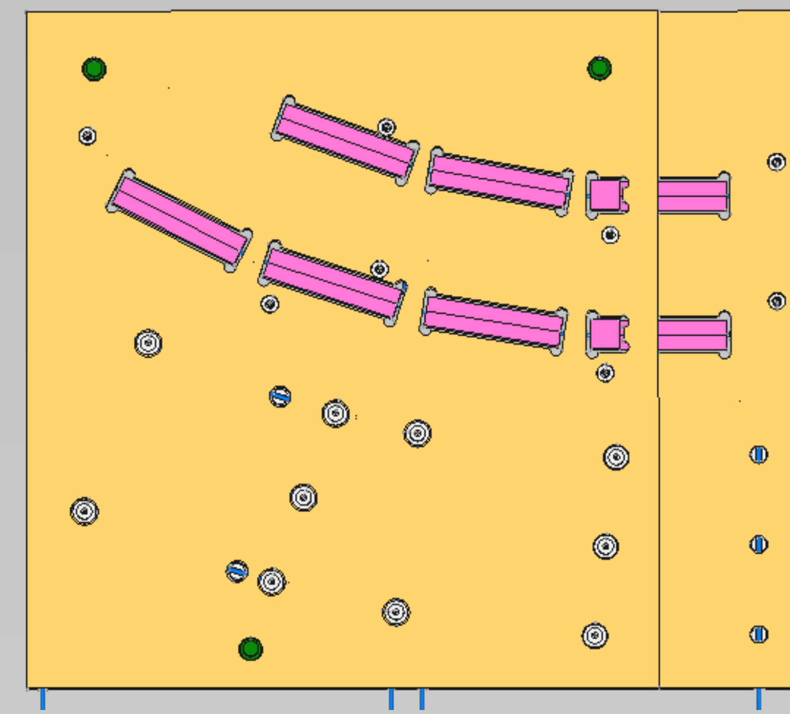
- assembly precision is within specifications
- some drawbacks in the assembly procedure and tooling were discovered
  - will be solved for the second prototype

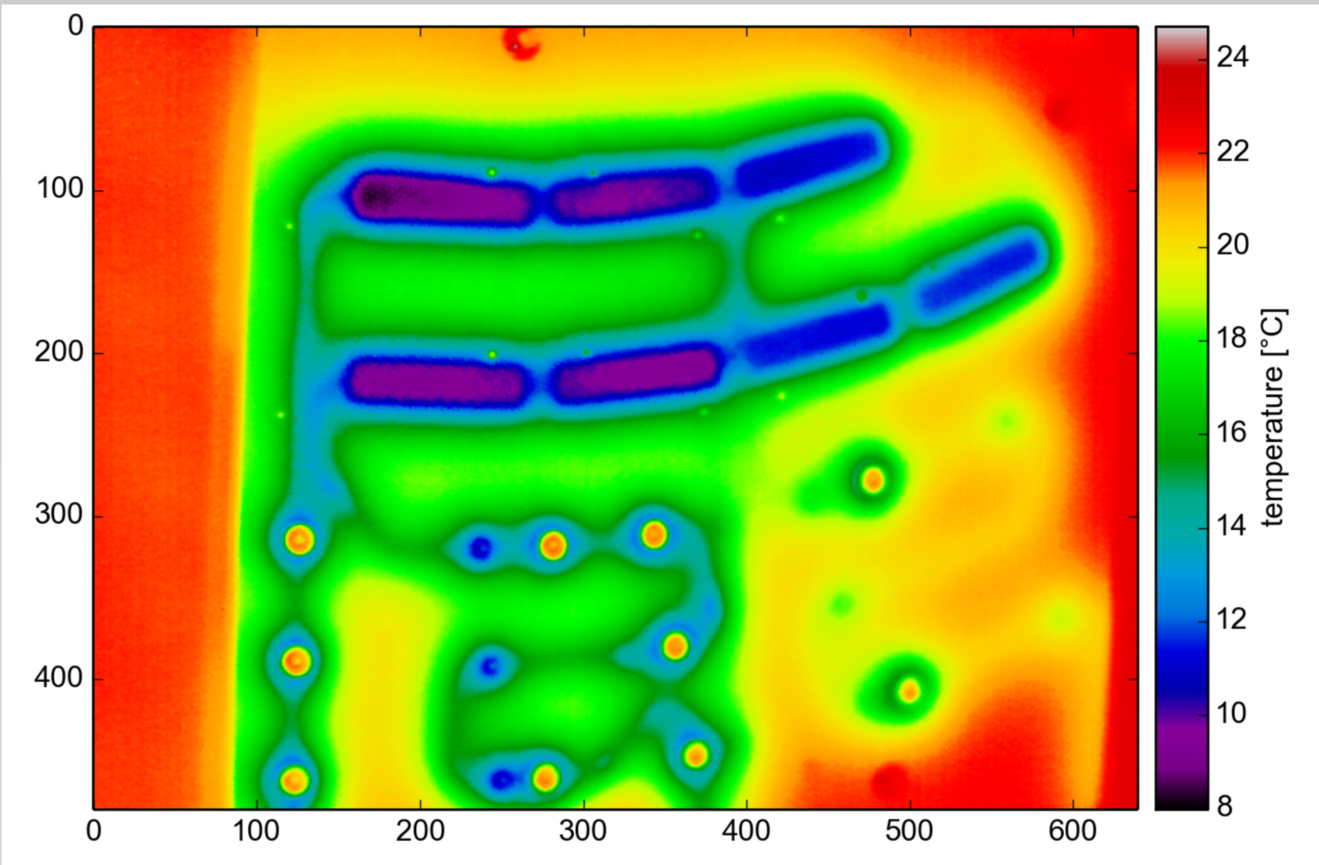


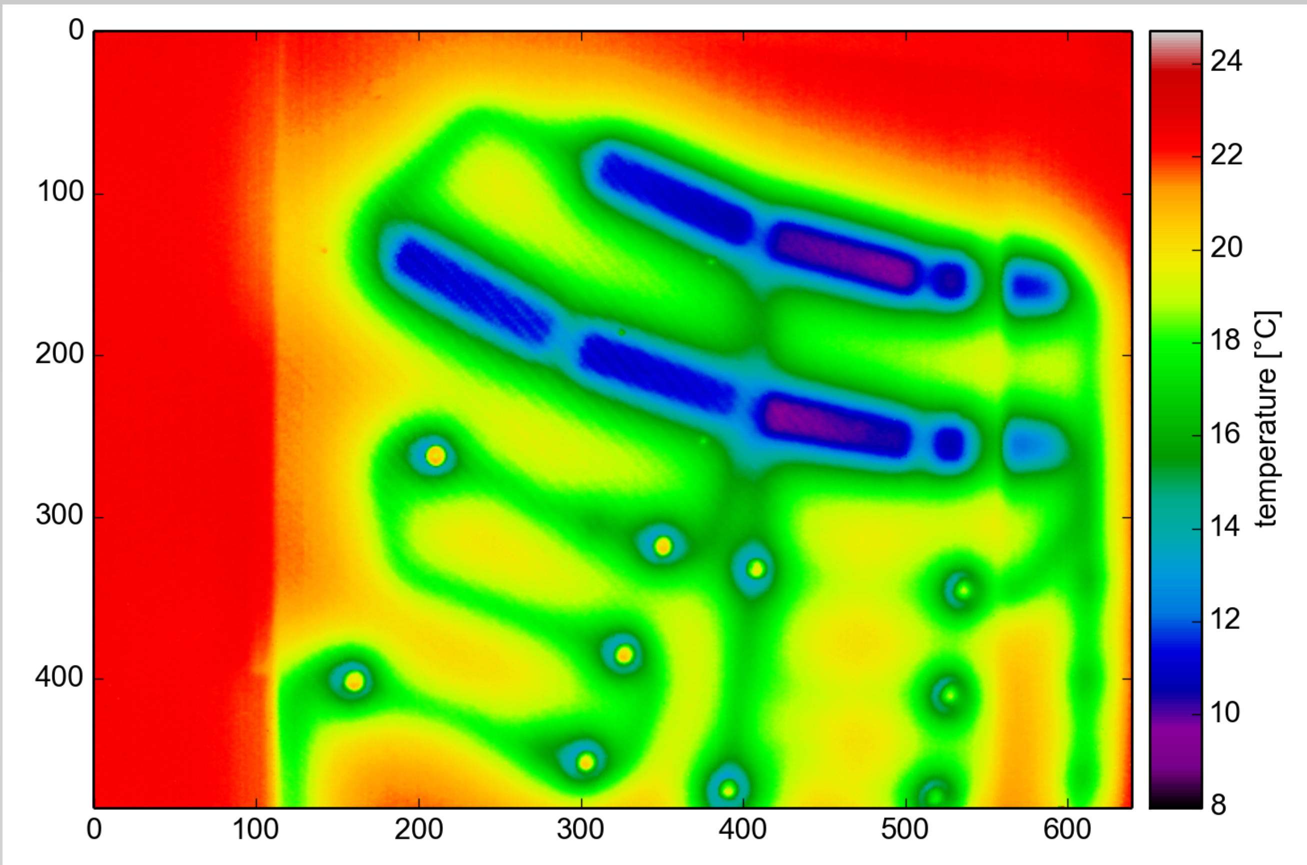
- second prototype will also include recent changes to the official design

CMS TEDD Prototype





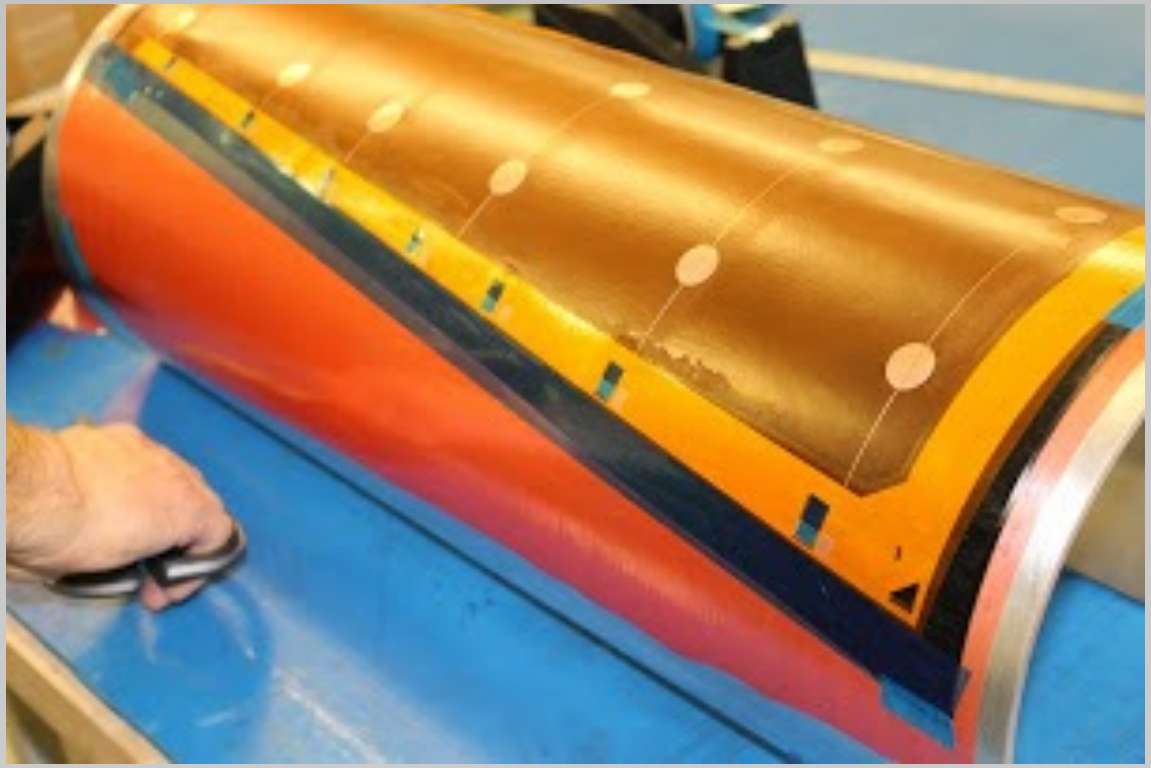


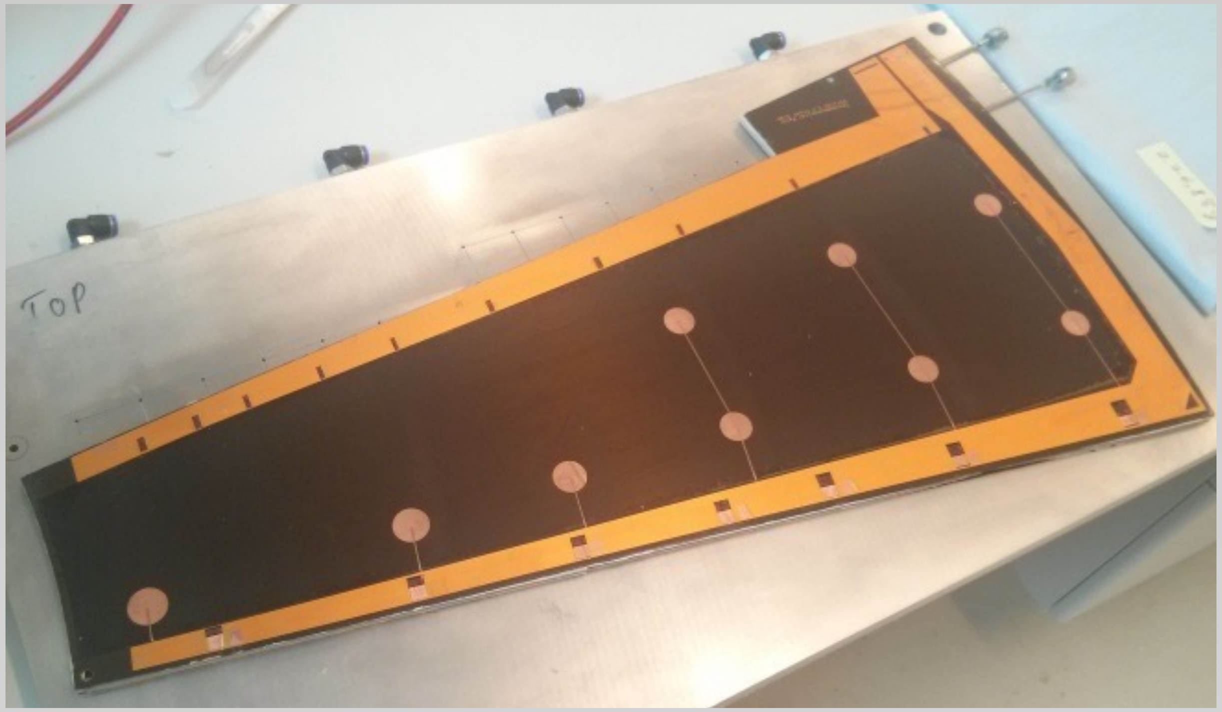


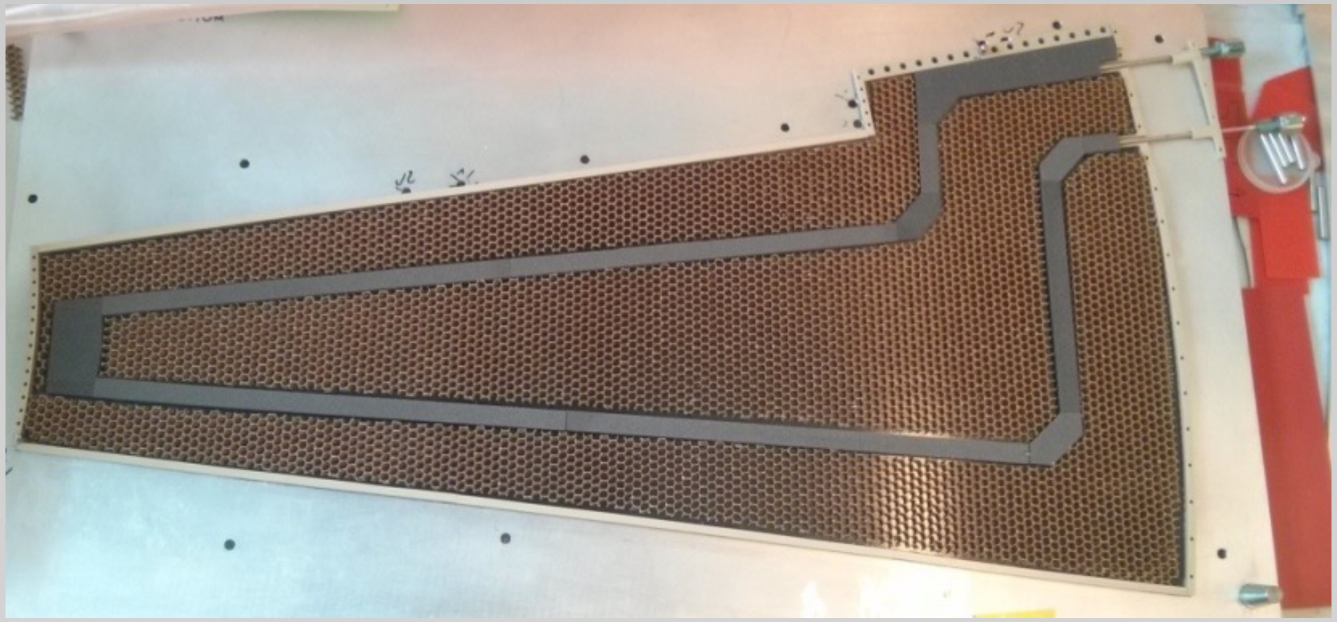
ATLAS End Cap Petals

ATLAS

- Stiff, light-weight composite carbon fibre-based structures to host the silicon microstrip modules, directly glued on core surface
- Integrated cooling pipes in the internal structure surrounded by high thermally conductive foam
- Multi-layered Kapton-Cu tape with power rails and differential data lines co-cured together with carbon fibre skins



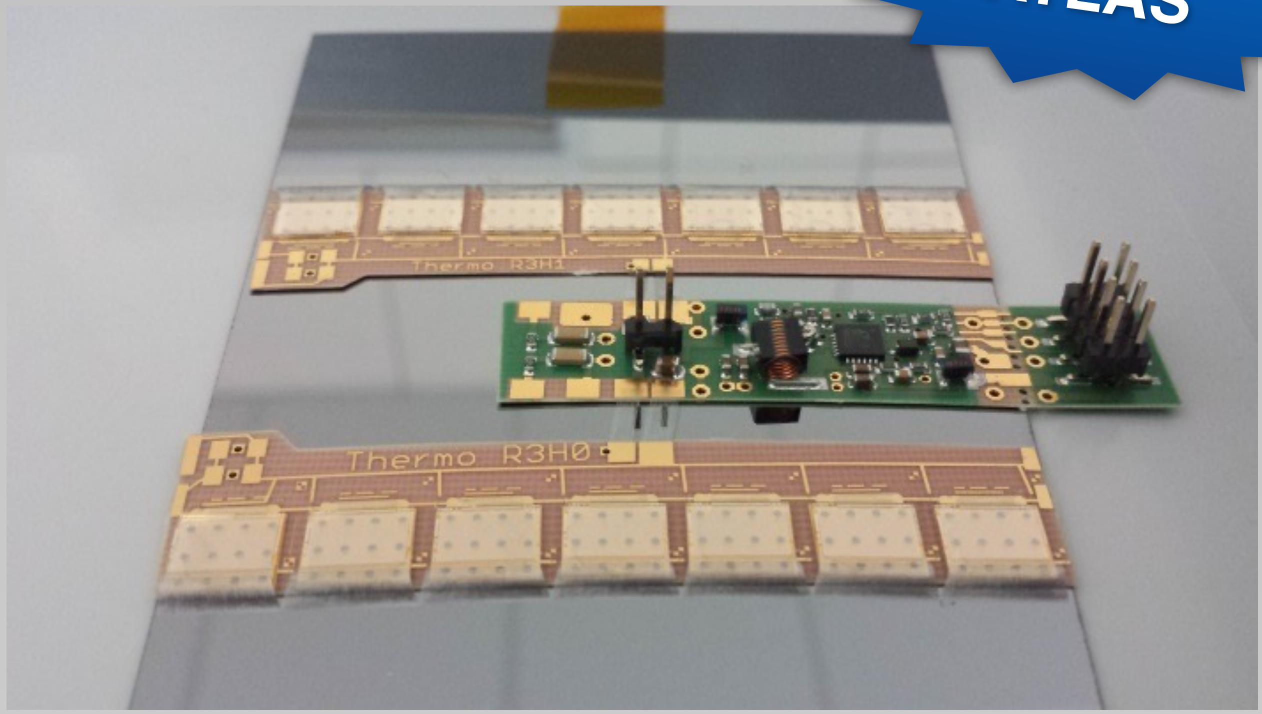


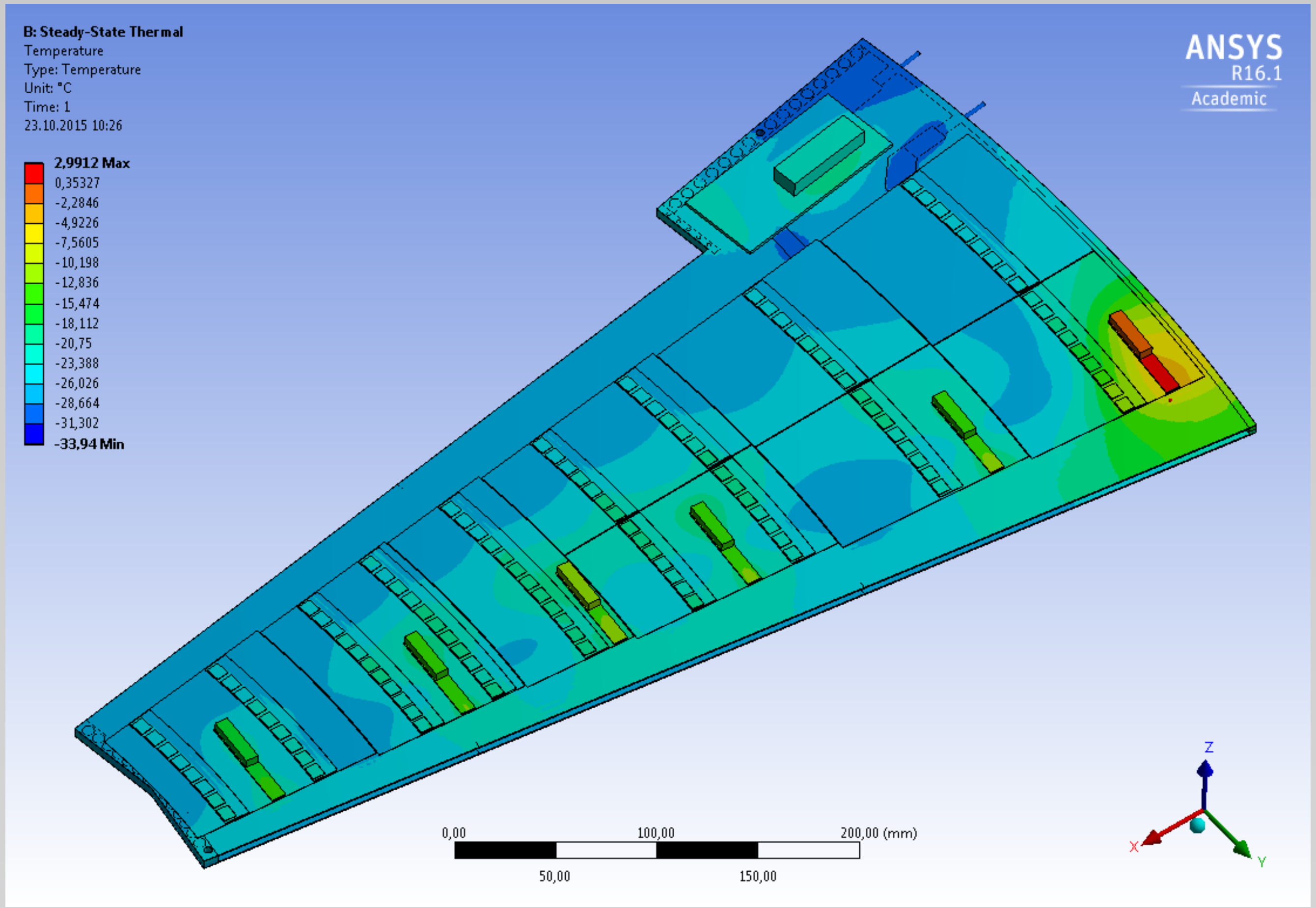


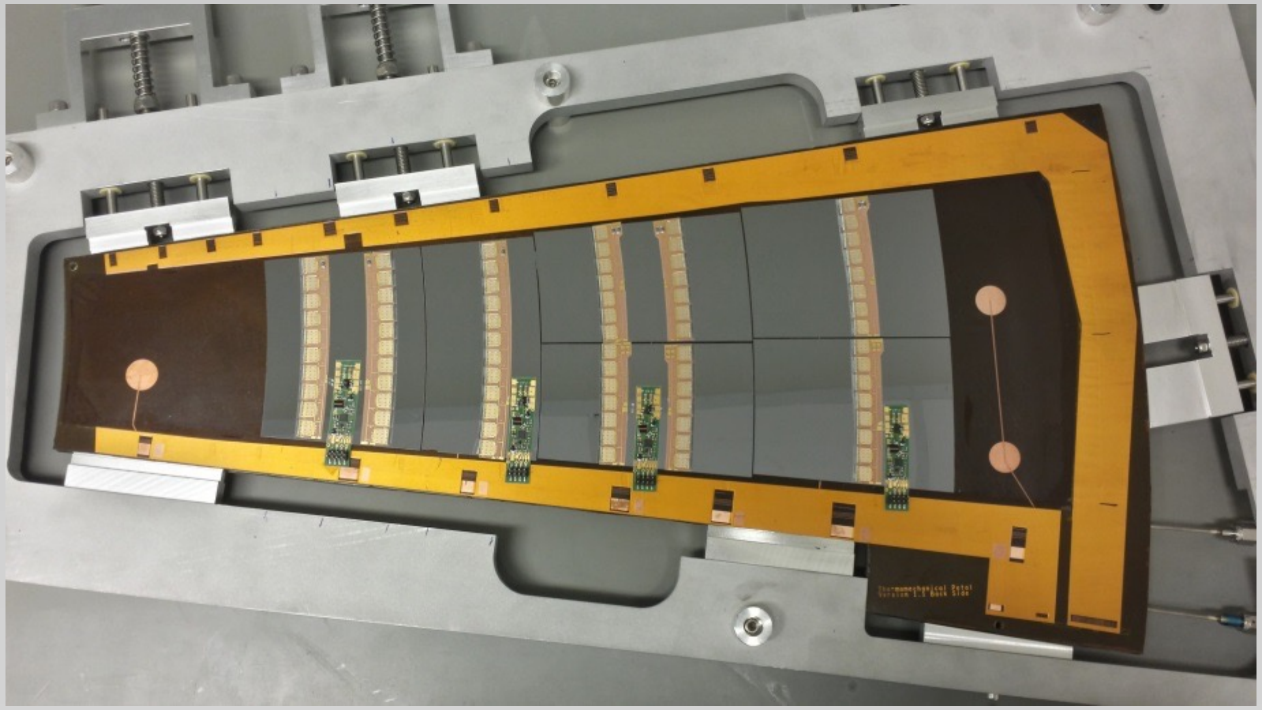
ATLAS End Cap Thermo-Mechanical Petal

ATLAS

- real petal core structure
- dummy silicon wavers with the real geometry
- FR4 hybrids and glass heaters to simulate front-end power
- real power boards, based on commercial DC-DC converters on a custom board
  - very first approximation to custom DC-DC converters
- module-on-core mounting tools currently in development



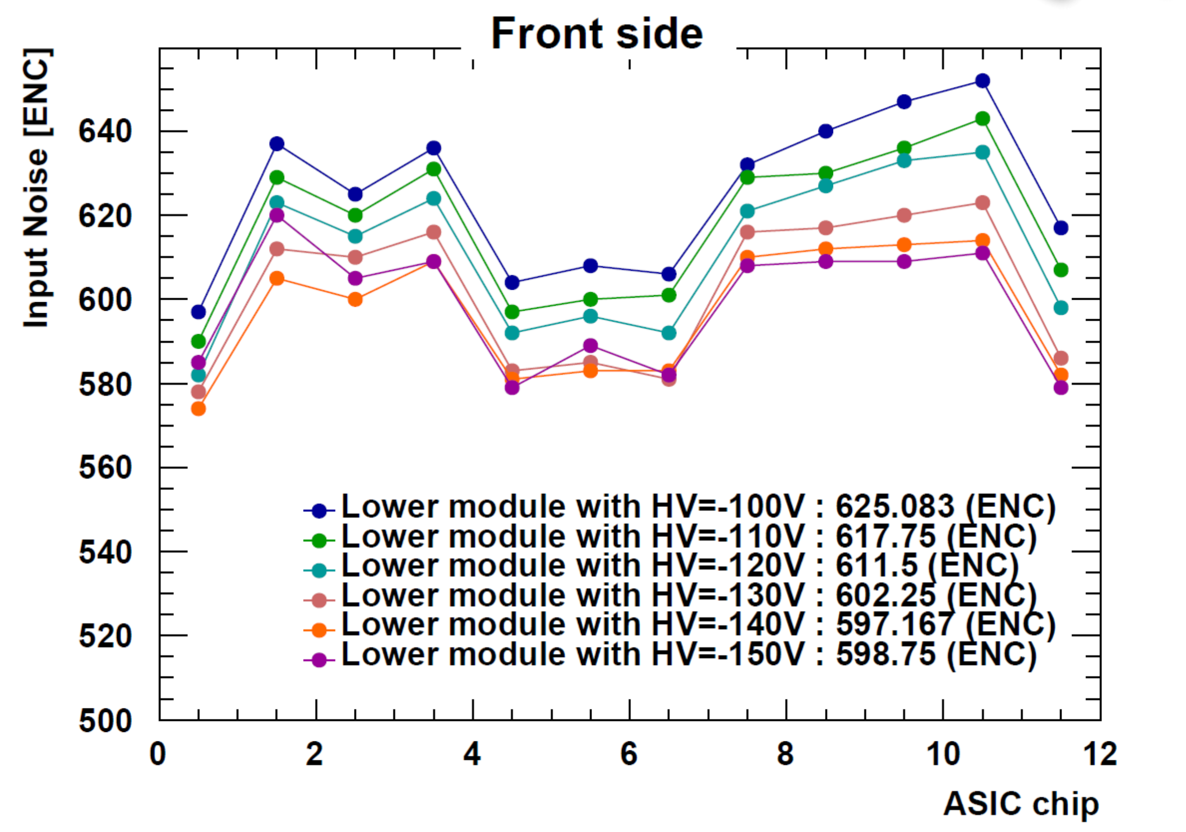


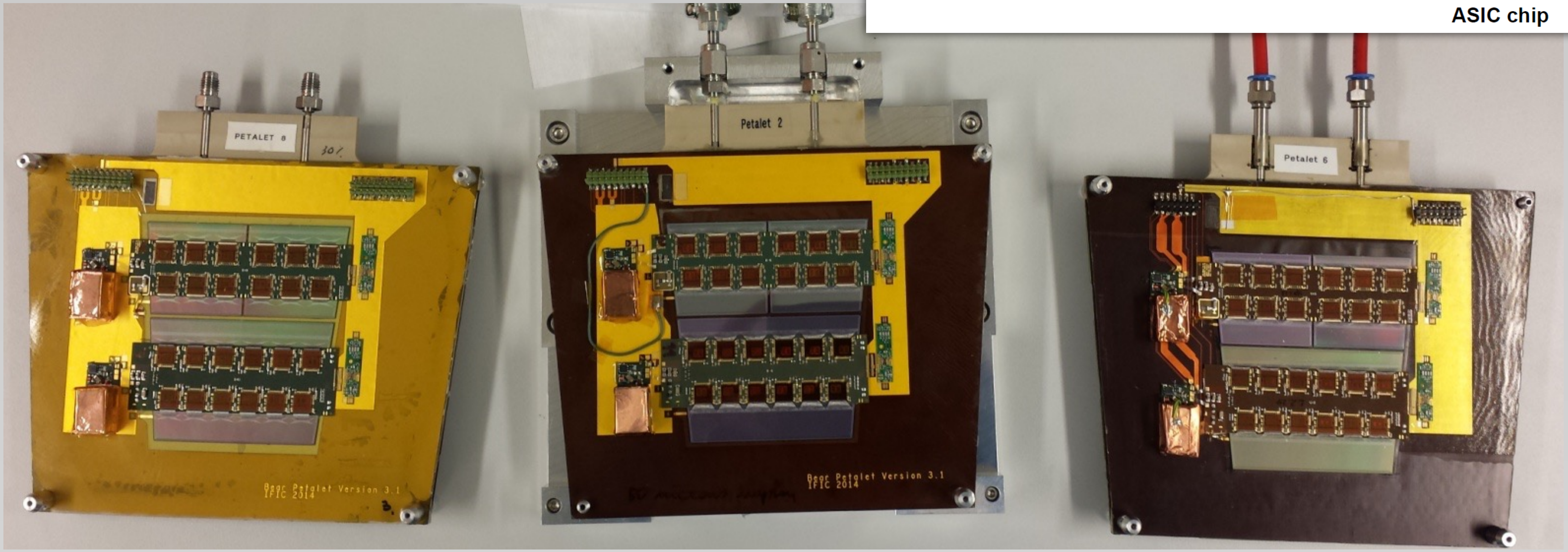


ATLAS Petalet

ATLAS

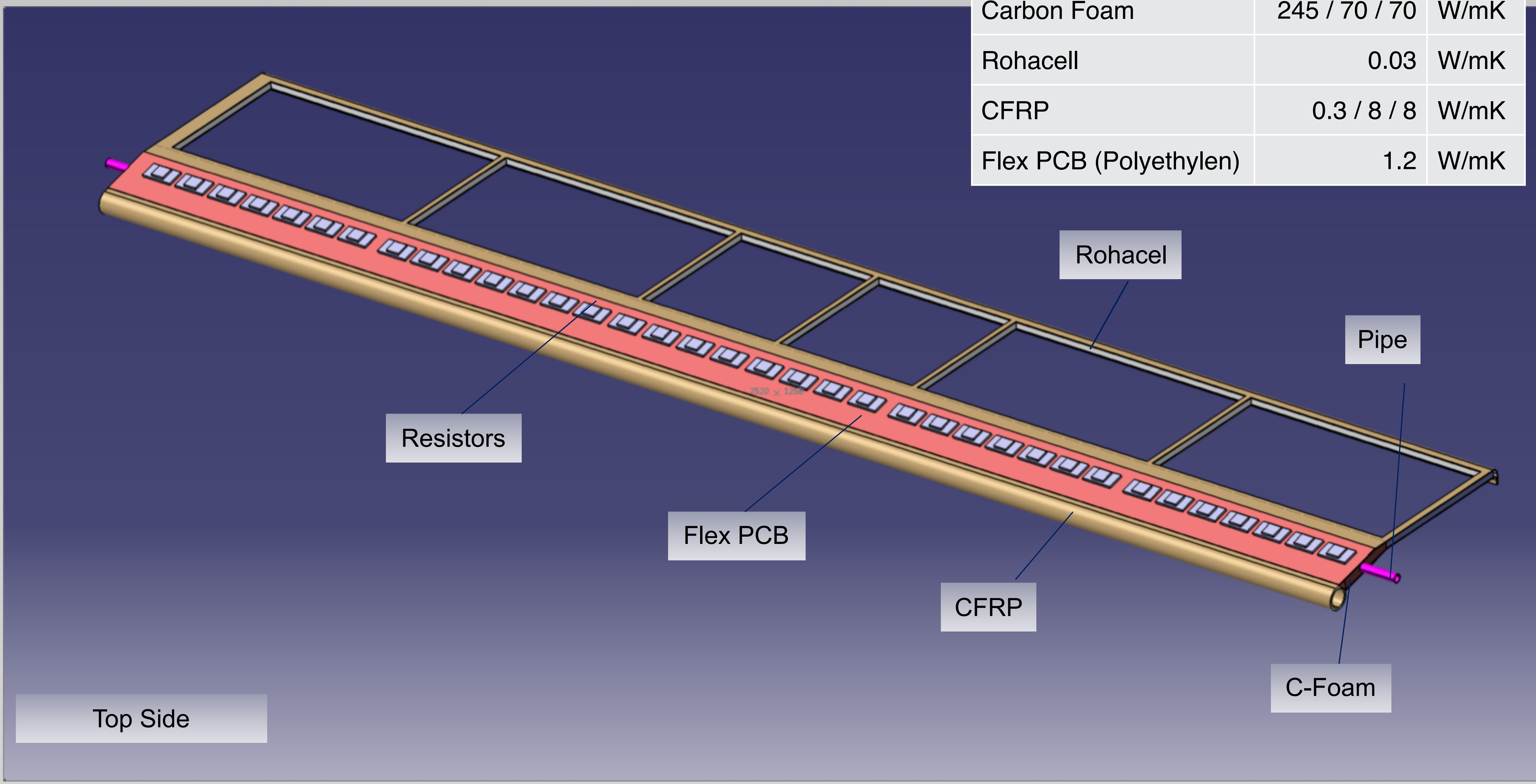
- Petalet program was meant to build smaller, electrically functional versions of petals to validate numerous aspects of the petal design
- one double-sided and two single-sided petalets were built and thoroughly tested at DESY





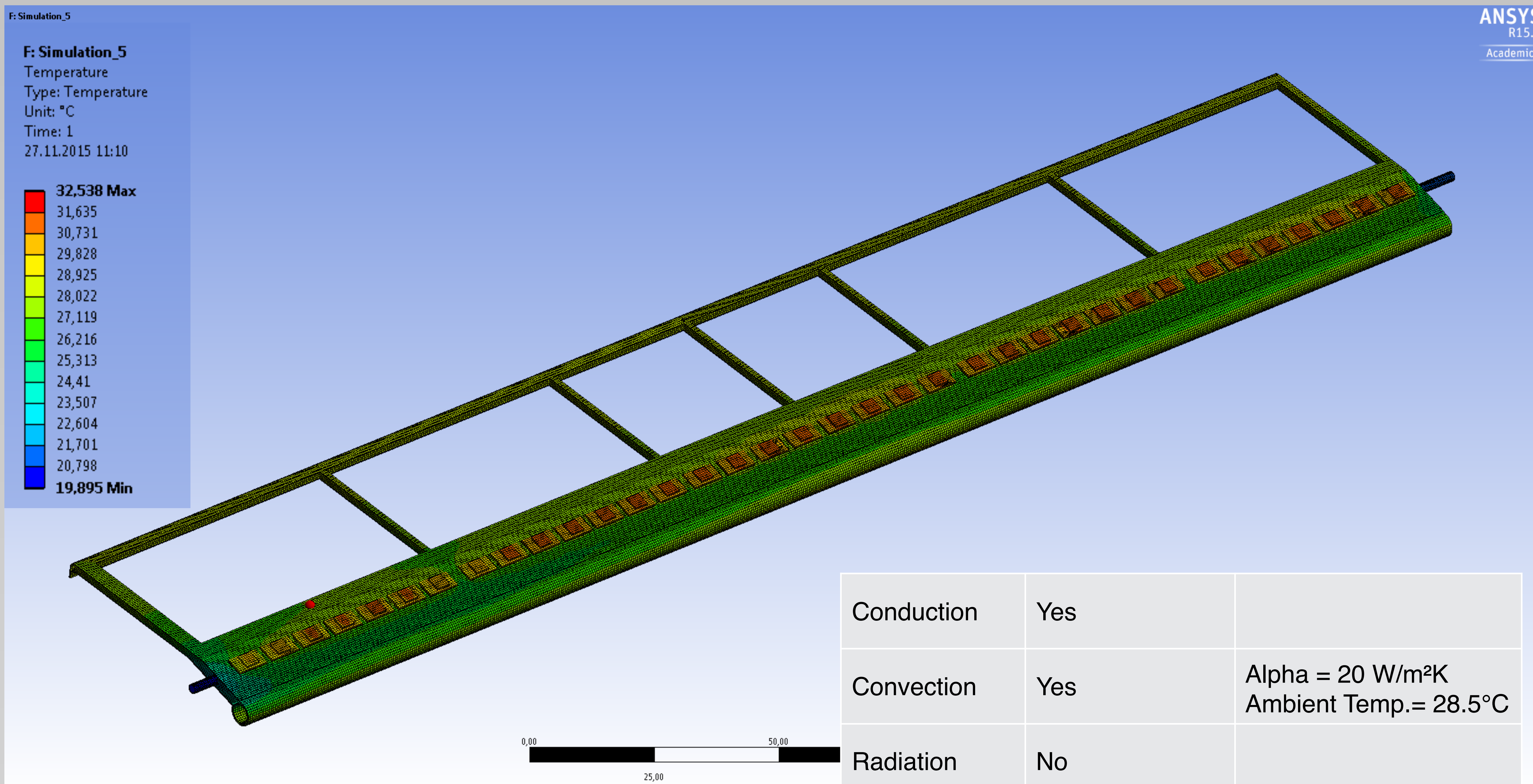
PANDA MVD Prototype Stave

Stainless Steel	13.8	W/mK
Ceramic	60.5	W/mK
Carbon Foam	245 / 70 / 70	W/mK
Rohacell	0.03	W/mK
CFRP	0.3 / 8 / 8	W/mK
Flex PCB (Polyethylen)	1.2	W/mK



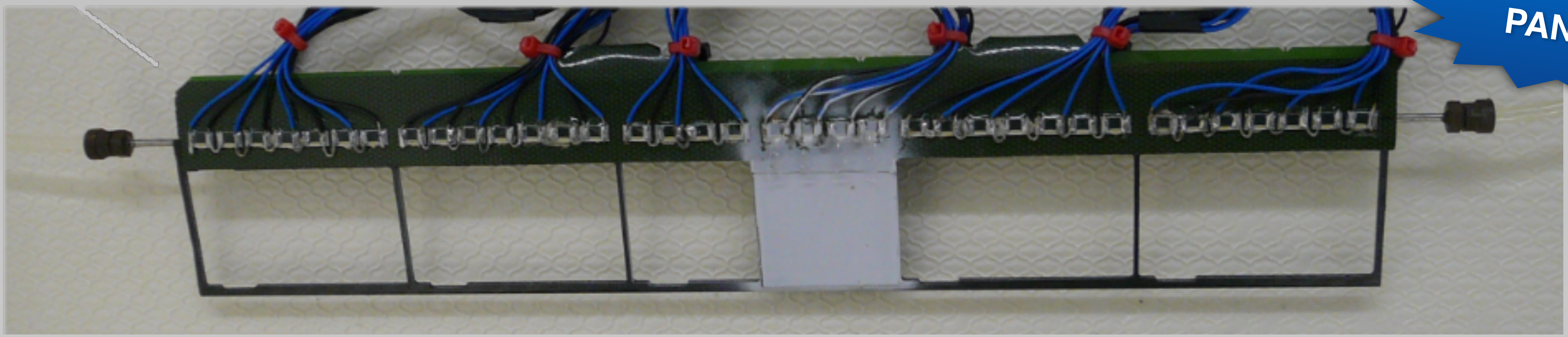
PANDA MVD Prototype Stave FEA

PANDA

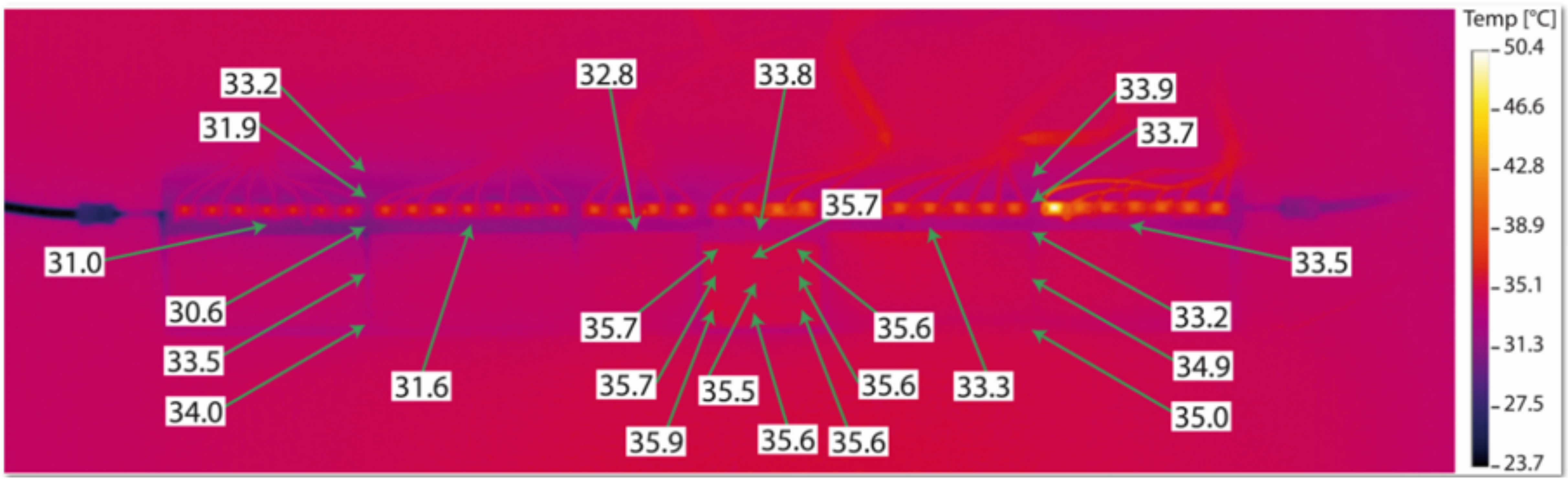


Conduction	Yes	
Convection	Yes	Alpha = 20 W/m²K Ambient Temp.= 28.5°C
Radiation	No	
Contact	Glue / Layer Th.	0.3 / 1 W/mK 100 µm

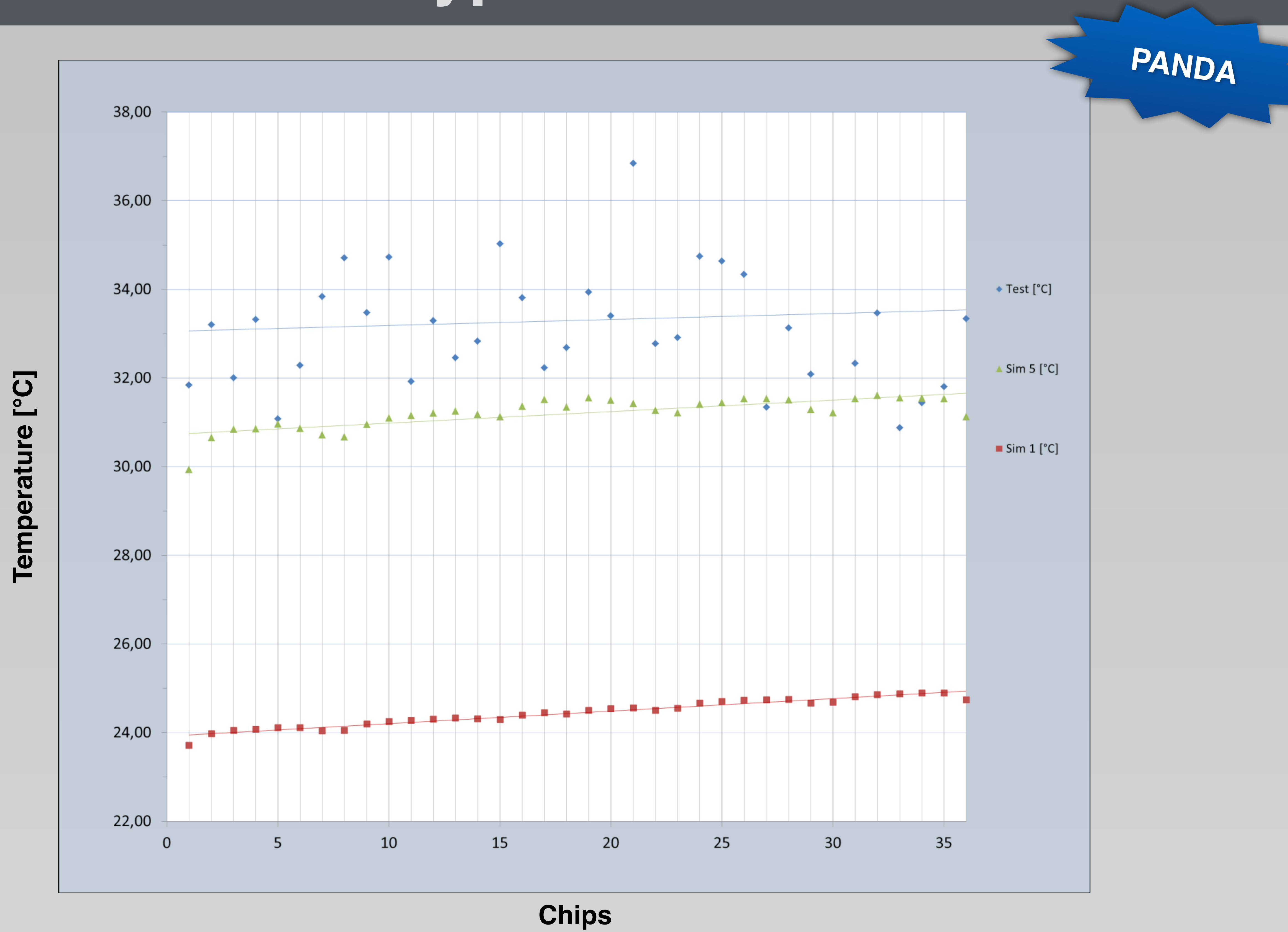
PANDA MVD Prototype Stave Measurements



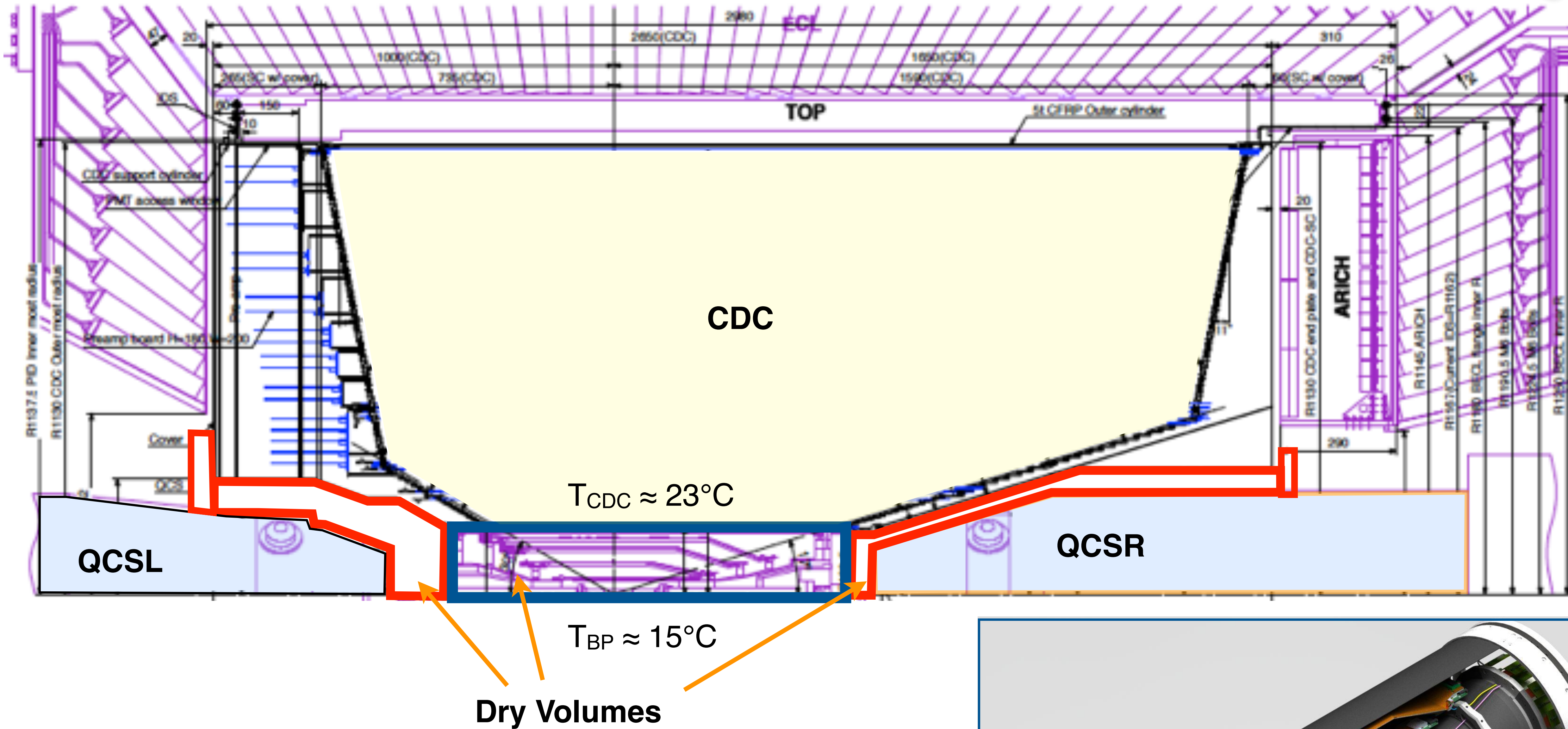
Experimental validation of simulation data



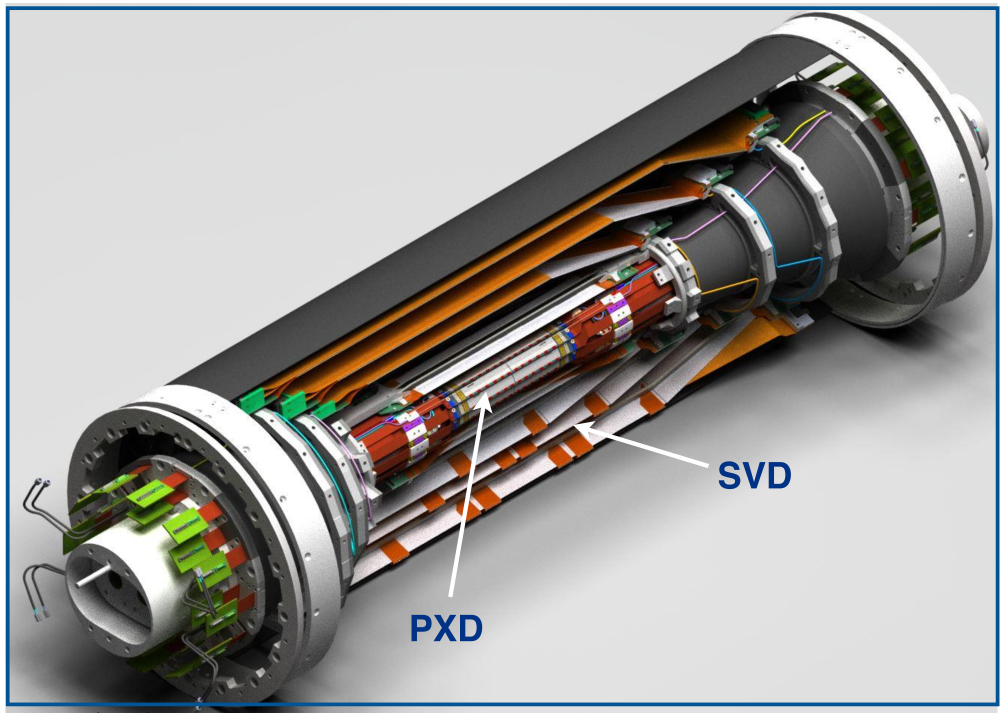
PANDA MVD Prototype Stave Measurements



Belle II VXD Cooling Environment



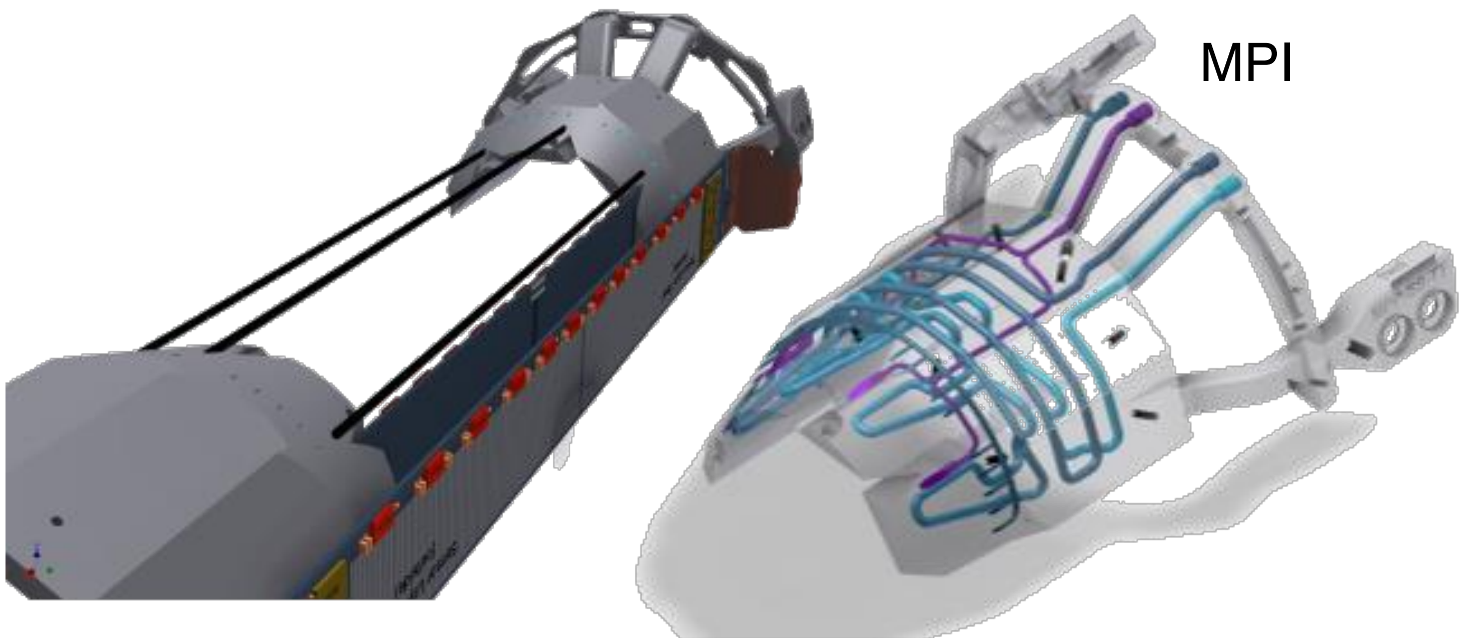
- goal of VXD thermal mock-up at DESY:
  verify and optimize overall cooling concept



Heterogeneous VXD Cooling System

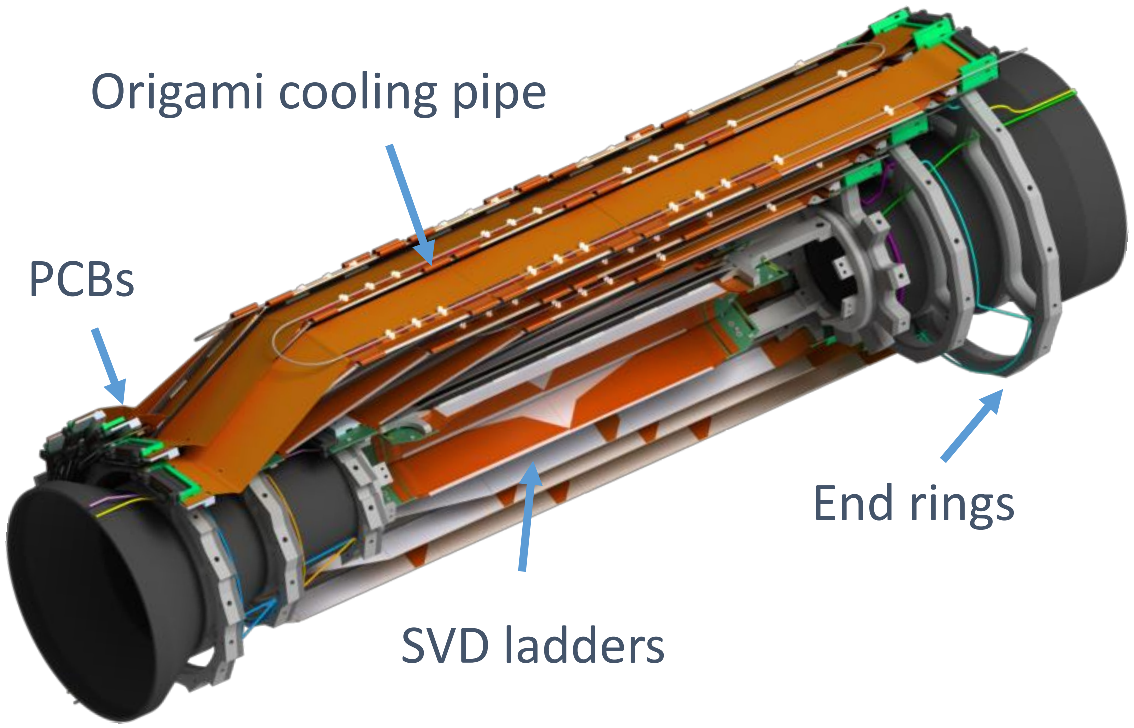
BELLE II

Cooling of the PXD



Support and Cooling Block (SCB) manufactured using 3D printing technology with integrated CO_2 and N_2 channels

Cooling of the SVD

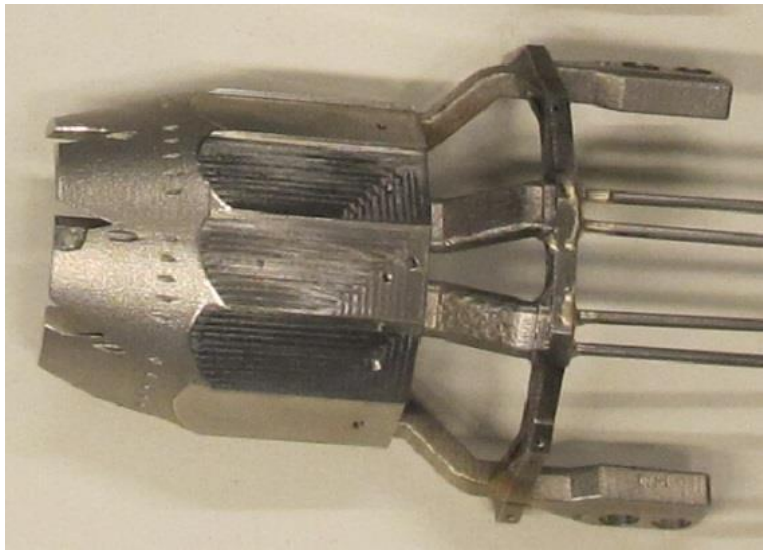


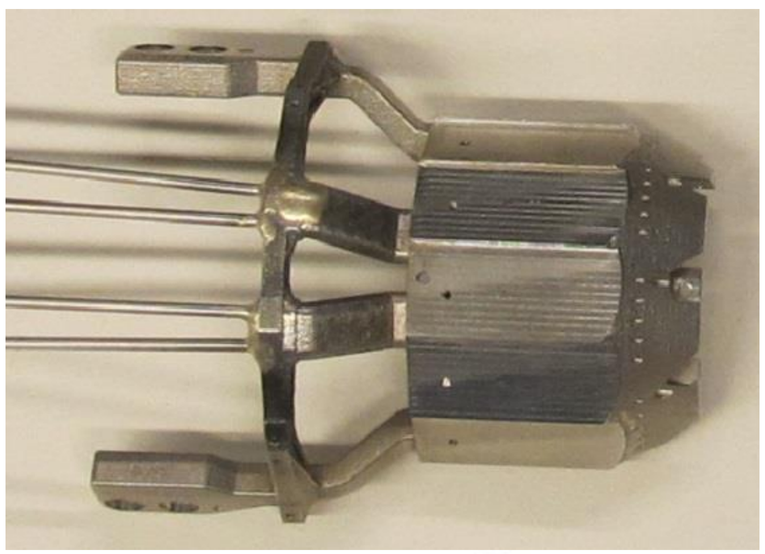
Requirements

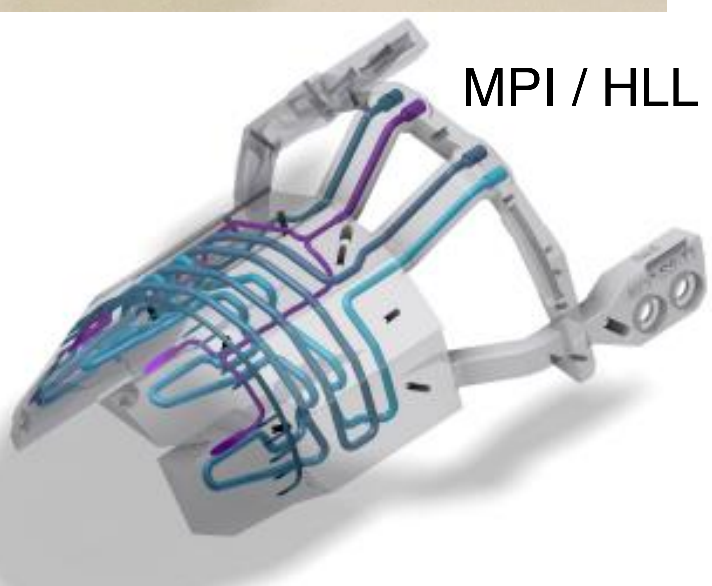
- ❑ PXD: Sensor < 25°C to minimize shot noise due to leakage current; ASICs < 50°C to avoid risk of electro-migration;
- ❑ SVD: APV25 readout chips surface@~0°C for SNR improvement;
- ❑ Power consumption: PXD 360W; SVD 700W, required cooling capacity of 2-3kW.

Assembly of PXD Thermal Mock-up

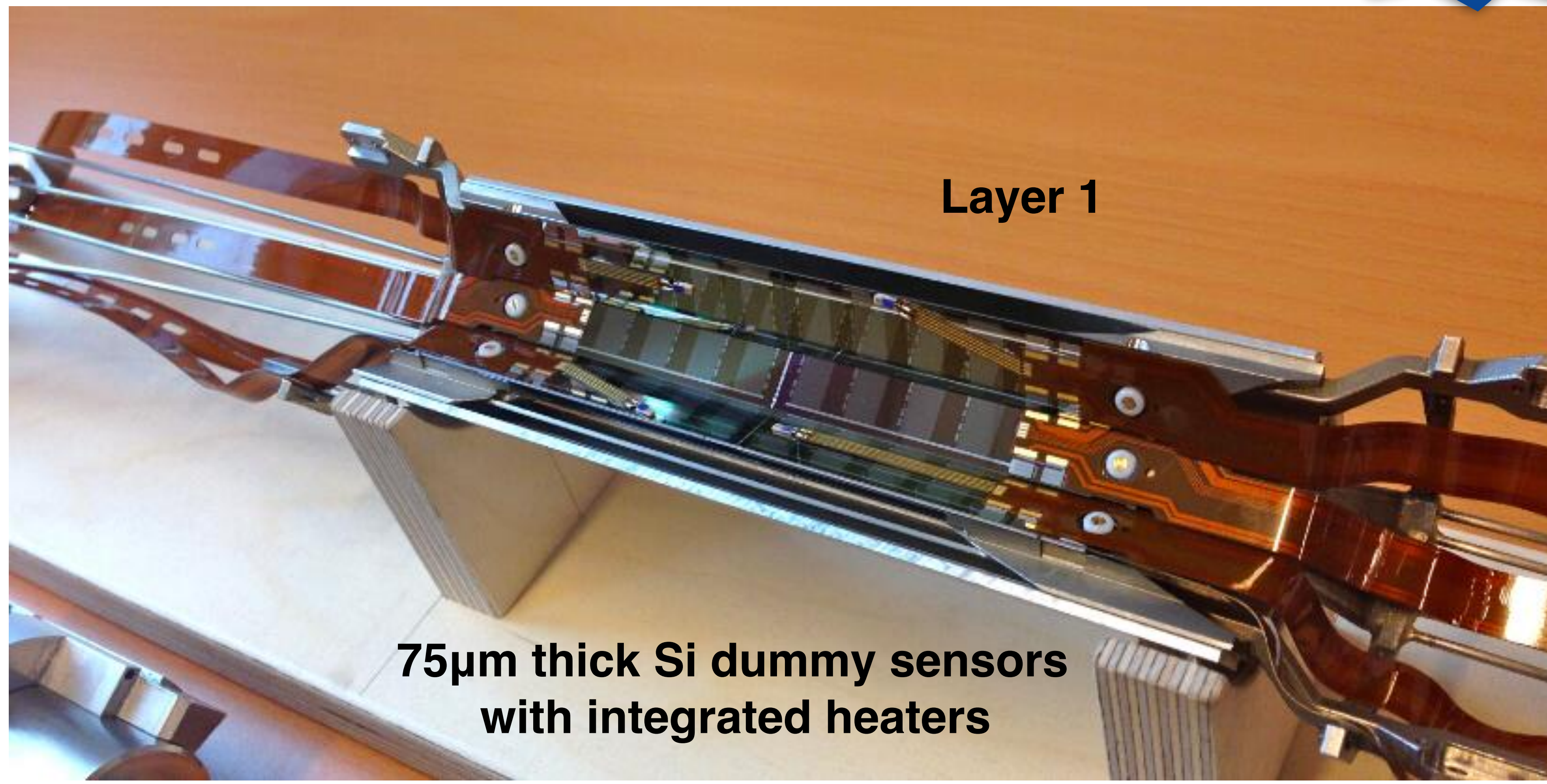
BELLE II

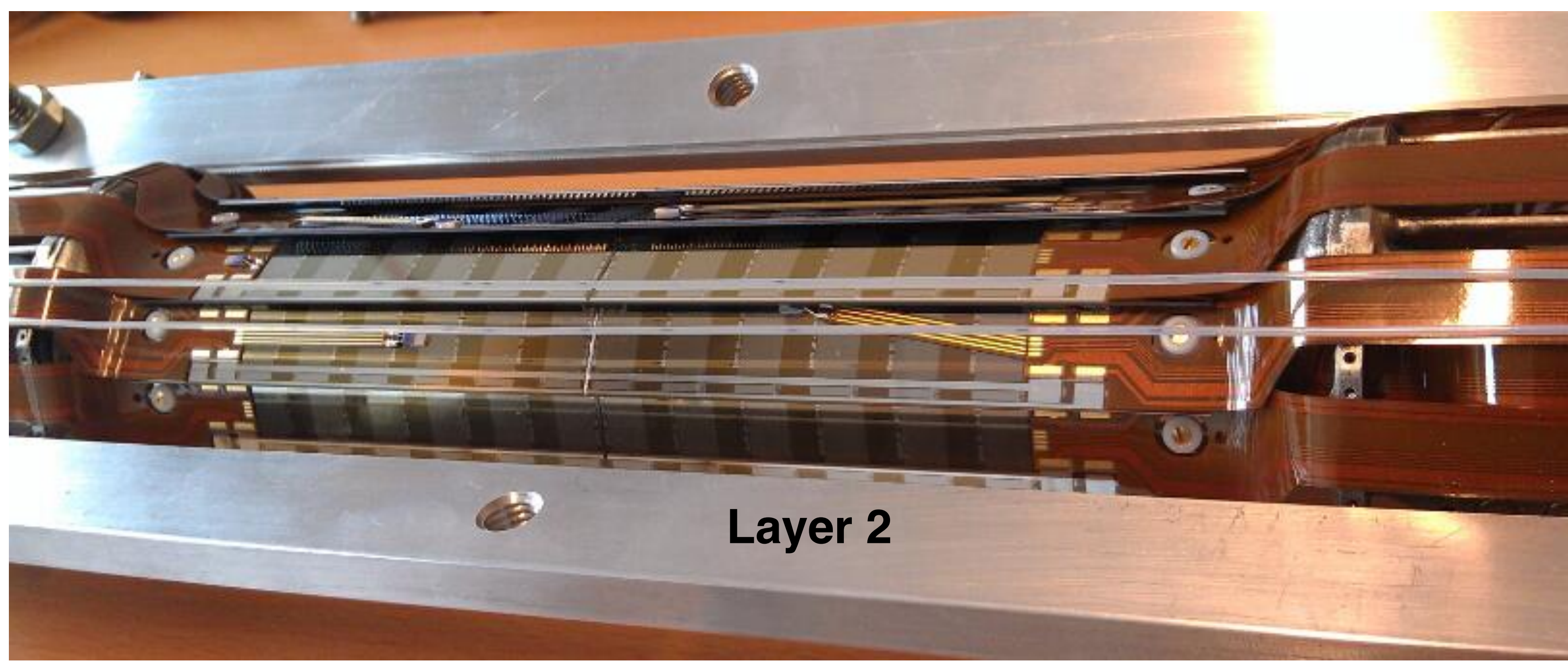






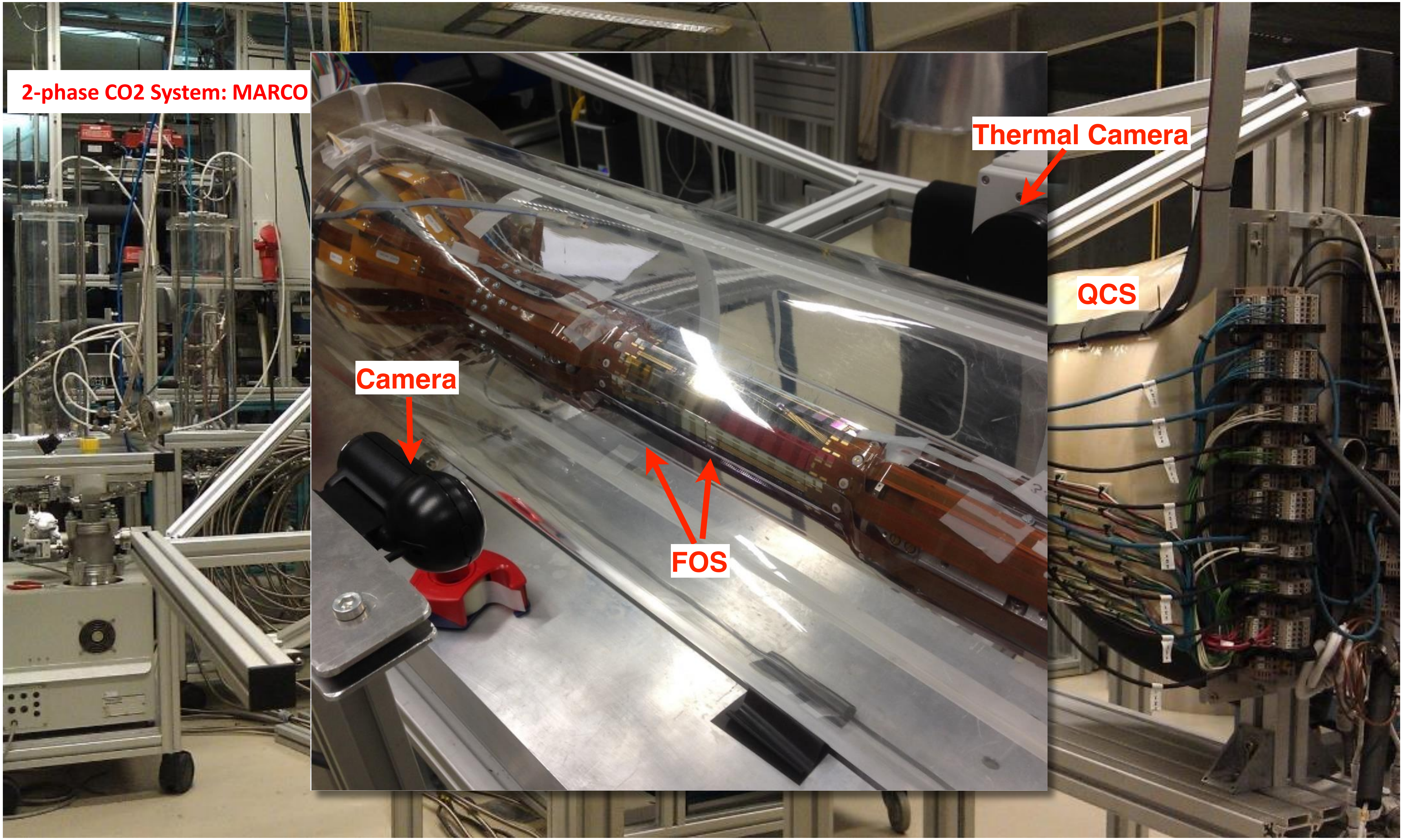
MPI / HLL





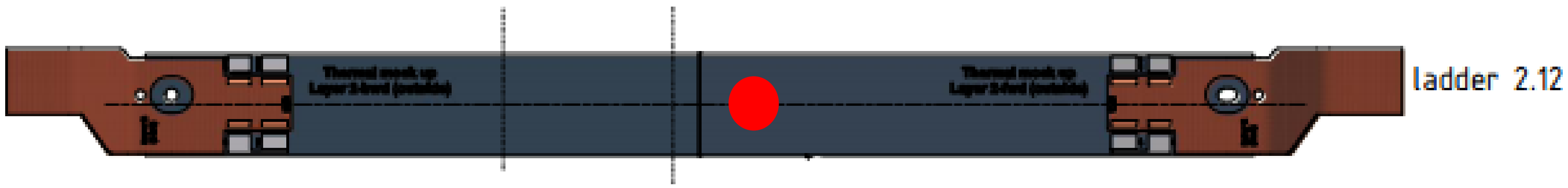
Status of Thermal Mock-up

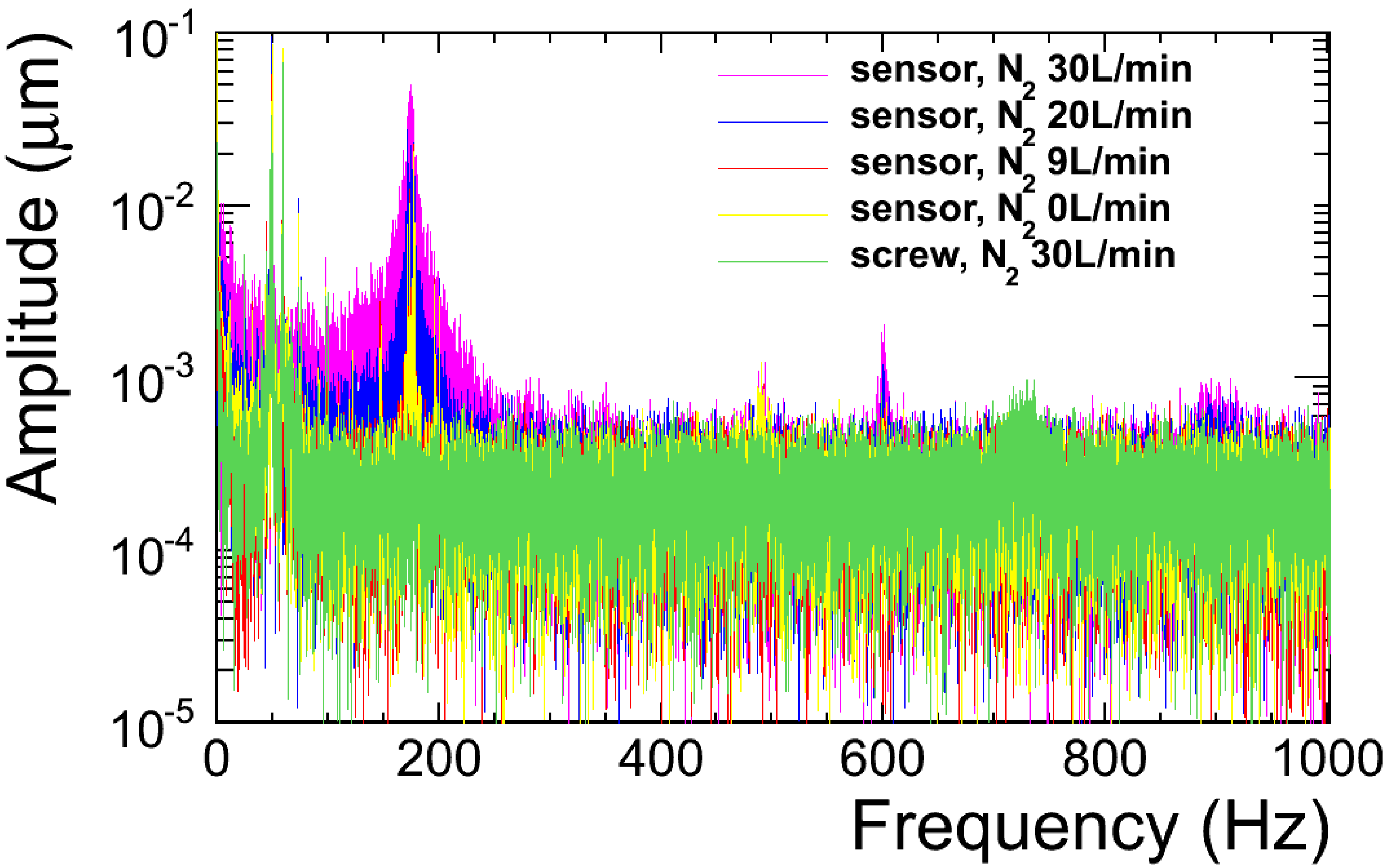
BELLE II



PXD Vibration Studies

Using non-contact
capacitive (sensitivity of 0.05um, band width of 5kHz)
laser (sensitivity of 0.02um, band width of < 50kHz)
displacement sensors.





- Measure amplitude and frequency spectrum vs N_2 flow
  - frequency peak at 175 Hz
  - amplitude < 0.04 μm at a flow rate of 20-30 L/min
- Not a concern for PXD operation

Forum on Tracking Detector Mechanics 2016

A meeting to discuss issues of engineering and integration for present and future tracking systems

- 23 - 25 May 2016
- University of Bonn
- http://indico.cern.ch/event/469996
- Abstract submission deadline: **11 March 2016**

- Topics
  - Detector cooling
  - Deflection, stability and precision of the structures
  - Thermal expansion differences inside the detector
  - Mass and therefore radiation length of mechanics, cables and pipes
  - Humidity control
  - Structural issues concerning humidity or outgassing
  - Choices of construction materials
  - Alignment systems, requirements and "weak modes" of the system
  - Pipe materials, pipe connection techniques and fittings
  - Shock and vibration issues
  - Effects on mechanics during fast discharge of magnet coils
  - Tracker to beam-pipe interfaces
  - Radiation and mechanics: impacts on design, materials and access constraints
  - Maintenance scenarios and the required special tooling
  - FEA and its comparison to real objects