# Material Tests at DESY

## Setups and Measurements


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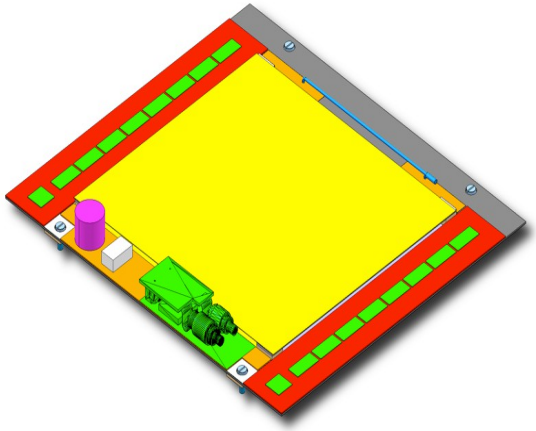
HELMHOLTZ
ASSOCIATION

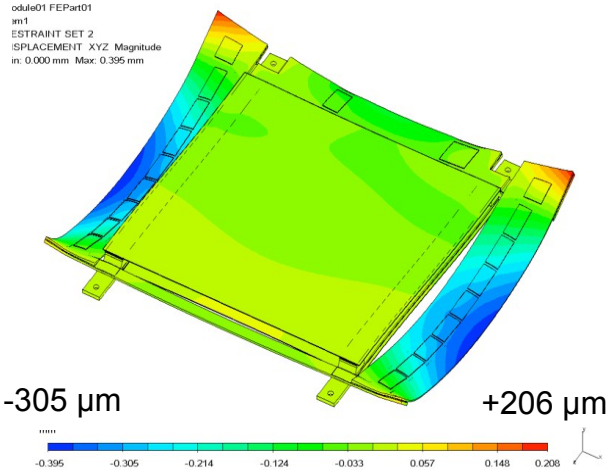
DESY

# Introduction

- Deformation due to thermal stress is an issue for detector modules
  - Modules made of multi layer sandwiches of material
  - Different coefficient of thermal expansion (CTE)
  - Operated at -20 °C
  - Mechanical stress on sensors reduces life time
  - Problematic for wire bonds, bump bonds, …
- Deformation is also an issue for larger structures, petals and staves for example

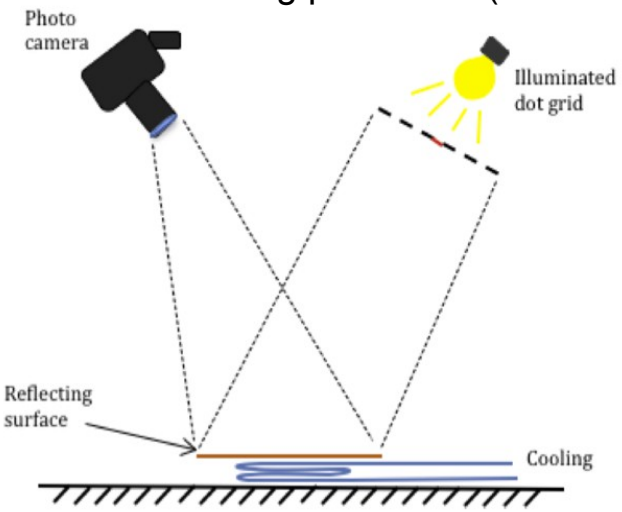


- Several setups being built and calibrated at DESY
  - Optical Deformation Measurement Setup (ODM)
  - Thermal Measurement setup
  - Climate Chamber for extreme thermal tests



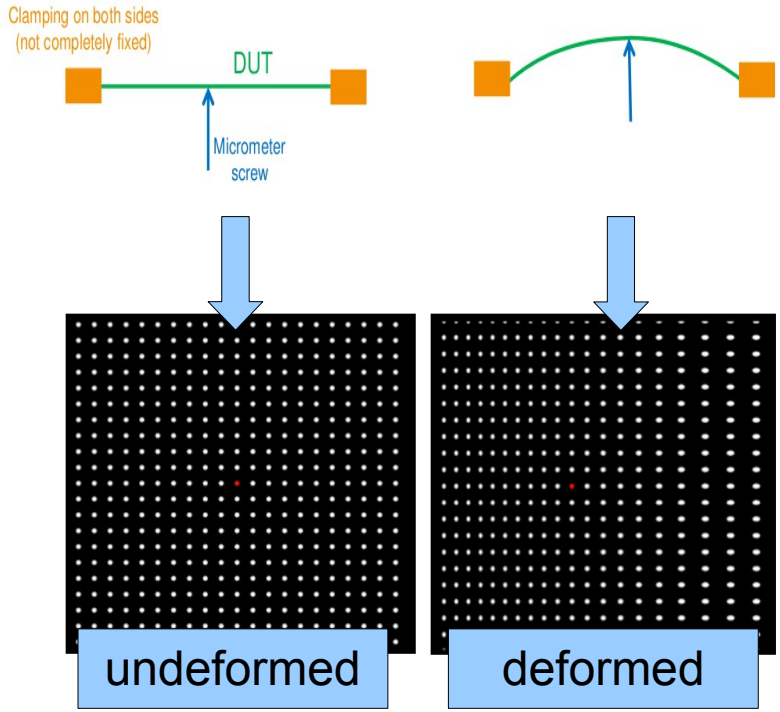
# Optical Deformation Measurement (ODM) - setup

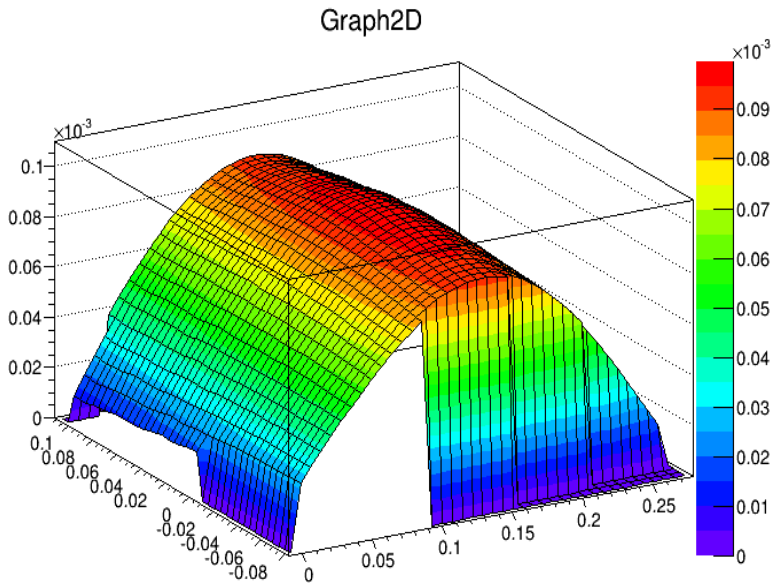
- ODM setup is used to measure the deformation occurring on Device Under Test (DUT) due to different thermal conditions
  (this type of setups was initially proposed by MPI Munich, also built and used at RWTH Aachen)
- Requirements:
  - Continuous and well Reflective DUT surface
    (the treatment of rough surfaces need to be understood in order to measure them)
  - Light source directed onto the DUT
    (5 LED-panels with dotted grid)
  - Camera (Canon EOS 550 DSLR)
    directed to DUT capturing the reflected light dots
  - Cooling procedure (is in commissioning phase)




# ODM - Calibration

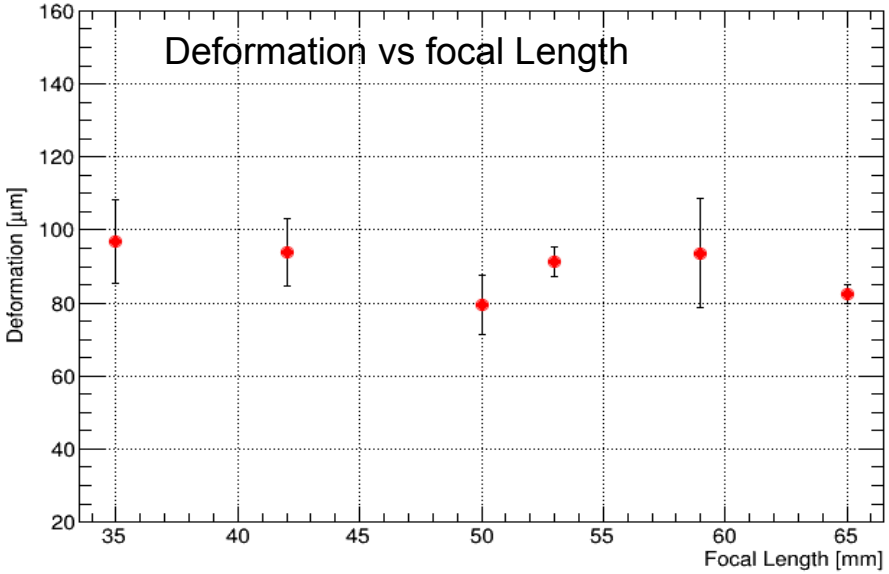
- For calibration, very well reflecting metallic plate is used
  - Deformation is applied by micrometer screw
  - Deformation is reconstructed from two images
    - Reference image
    - Deformed image
  - 10um precision is the goal (almost there)
  - Setup is available to external users

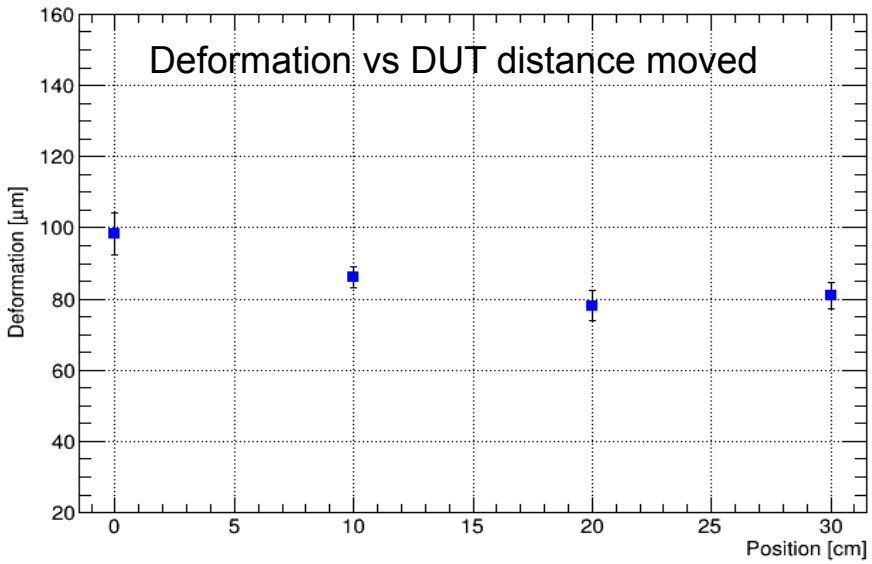


# ODM - Calibration

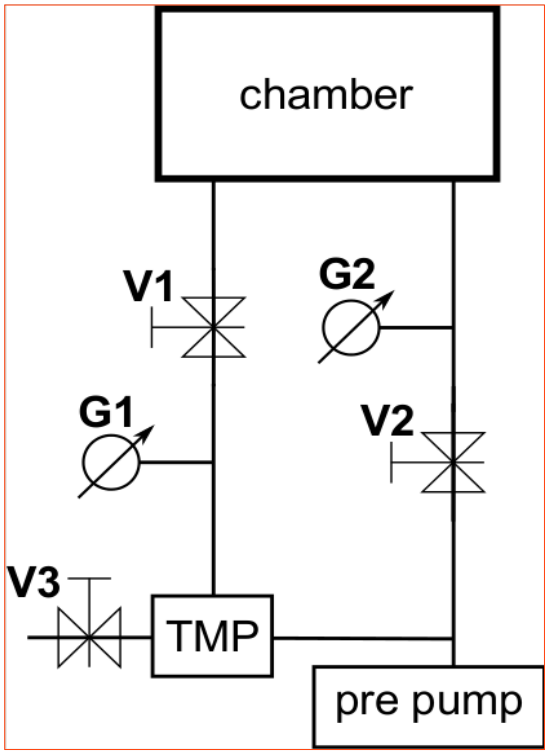
- In the future large DUTs (e.g. ATLAS petals, CMS end cap structures, ...) would be put under test in the ODM
- Calibration using the plate was done with
  - Various focal lengths
  - Different plate position
- Variation less than 20 um interval, and still much space for improvement



# Thermal conductivity tests - setup

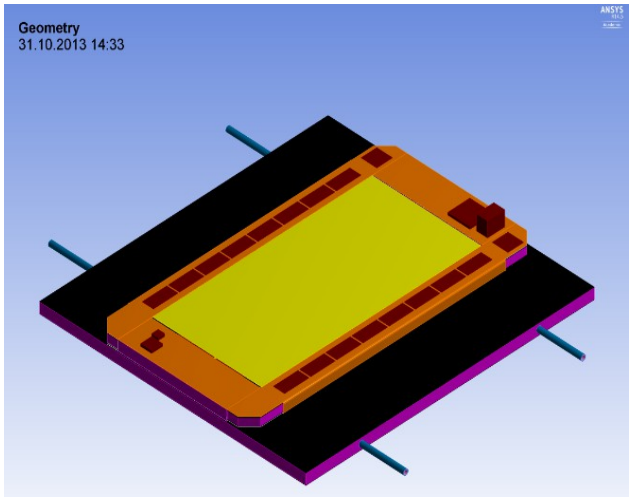
- Thermal conductivity tests in vacuum chamber
  - Chamber with cooled testing table
  - Chiller for cooling
  - Mechanical pump + turbo molecular pump (~ 10e-5 mbar)
  - 10 pt100 temperature sensors with four-wire read out mode
  - Test samples designed according to desired measurement (mostly by mechanics workshop at DESY)

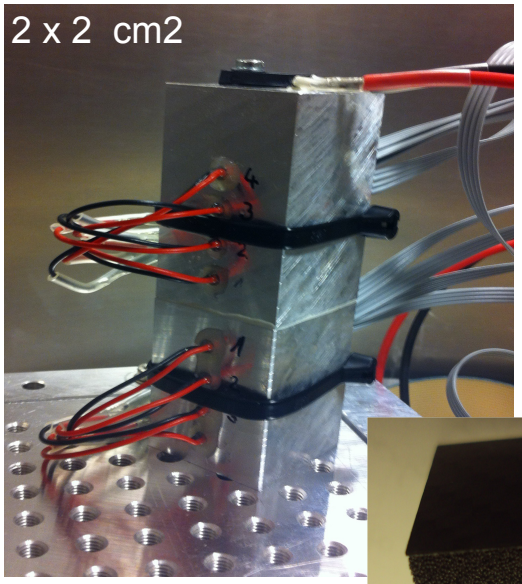


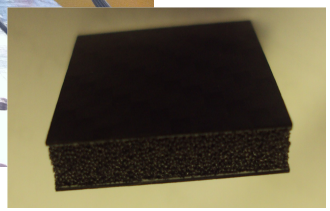

- Since detector modules will be operated at -20 °C this setup can be used for example to:
  - optimize the thermal contact between the cooling pipes and the module support needed
  - optimize the thermal interface for low thermal impedance and low mass at the same time

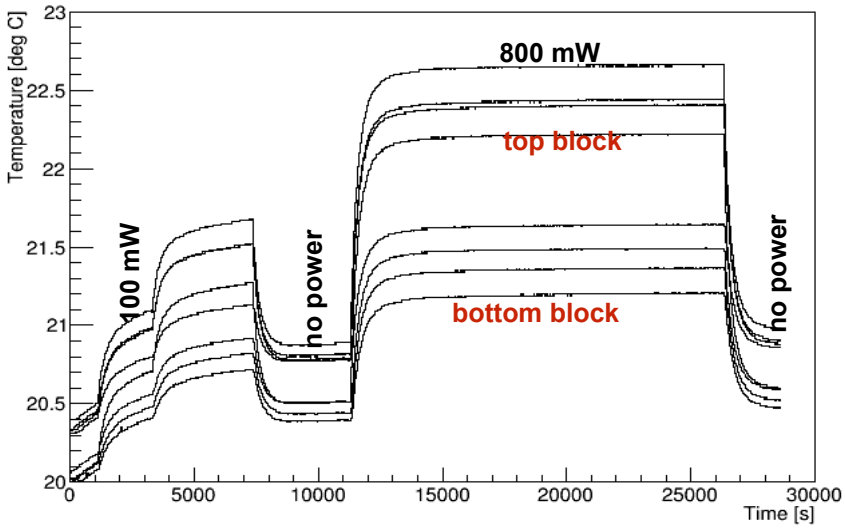
# Thermal conductivity tests setup - measurements

- Thermal interface tests
  - in the CMS PS module, cooling pipes will be embedded in C-Foam core with CFRP facings
  - Samples with 300um thick CFRP glued to C-Foam
  - placed between two Aluminum blocks with four pt100 sensors in each block at equal spacing within block
  - Heat generated using thermal resistor on top block
  - Extrapolate the temperature of the interface





# Thermal conductivity tests setup - measurements

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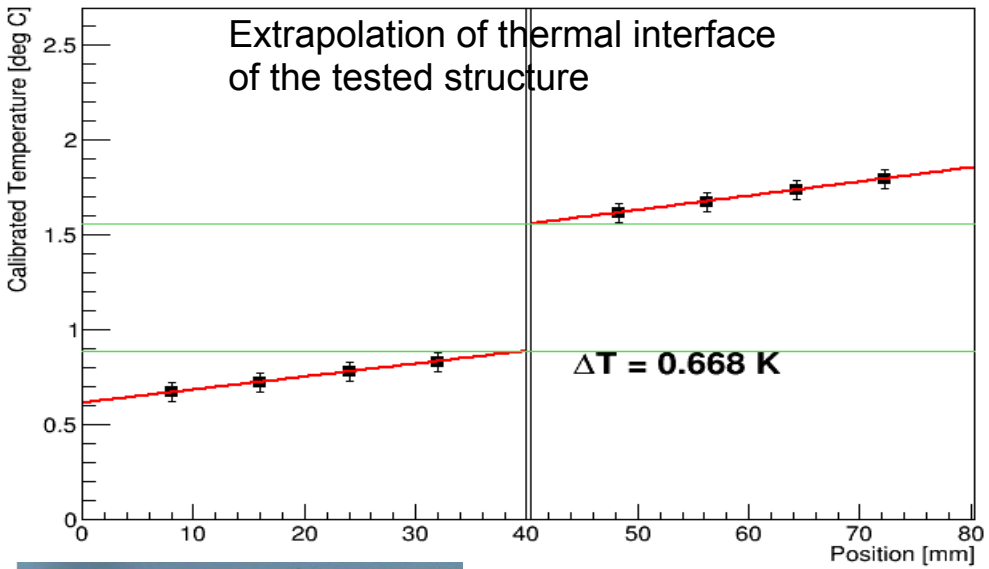
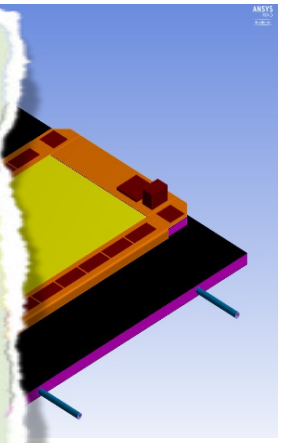
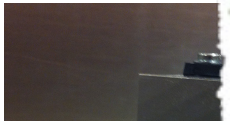
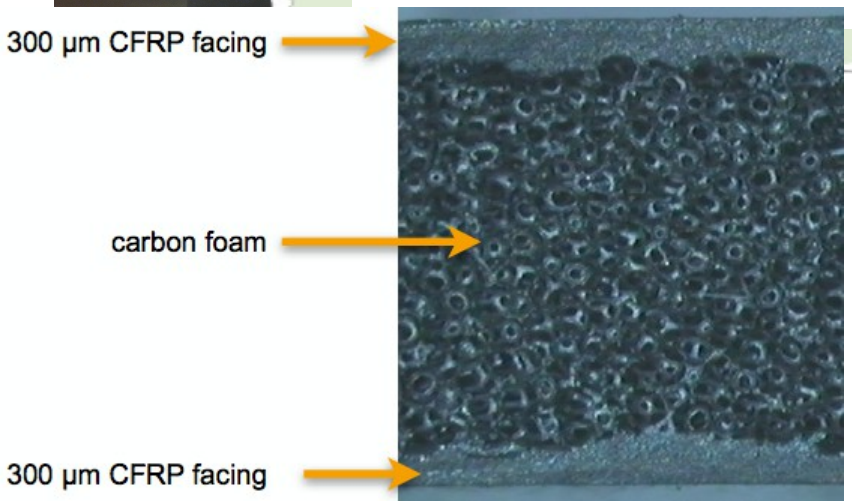
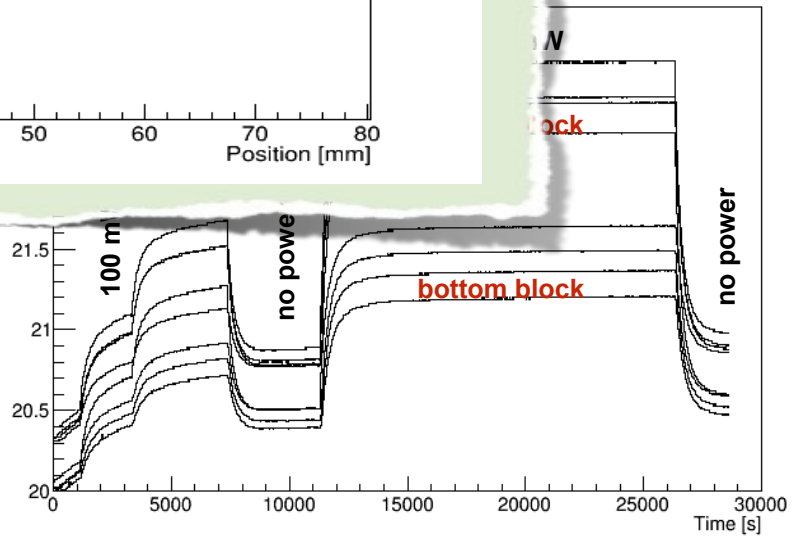


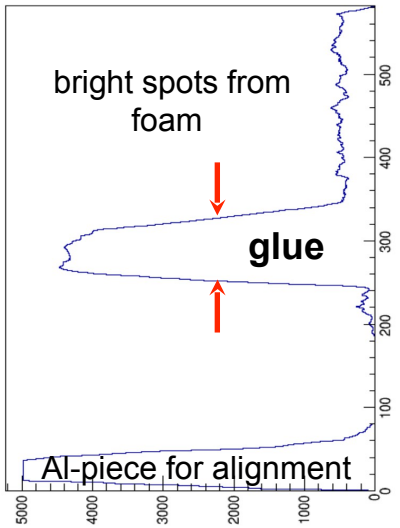


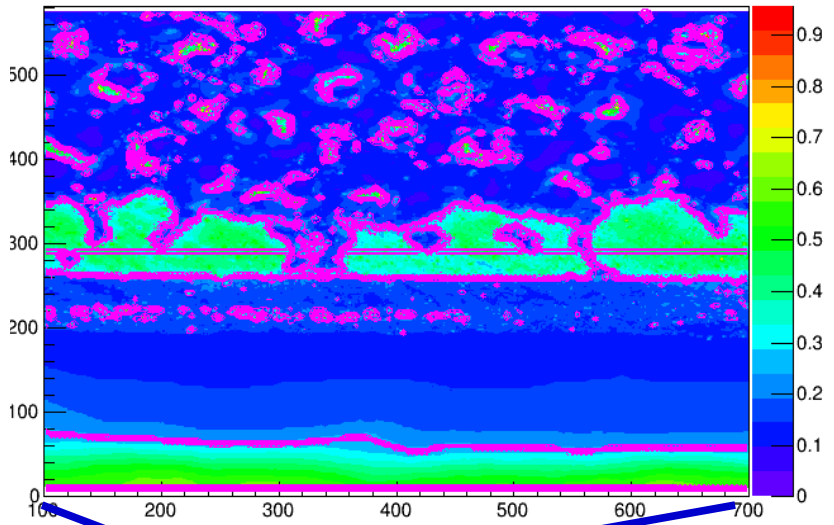


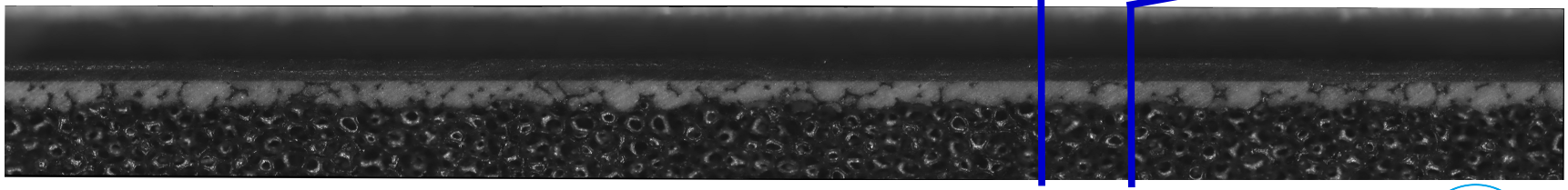



# Glue tests

- In order to measure the thickness of glue applied
  - Alignment
  - scan along the X-Axis in steps of 2 mm and take photo at each step (microscope)
  - Photos stitching using *OpenCV* stitching algorithm
- Used glue, Hysol with boron nitride powder
- convert RGB value of each pixel into a brightness
- produce a ROOT 2D histogram, project and get thickness



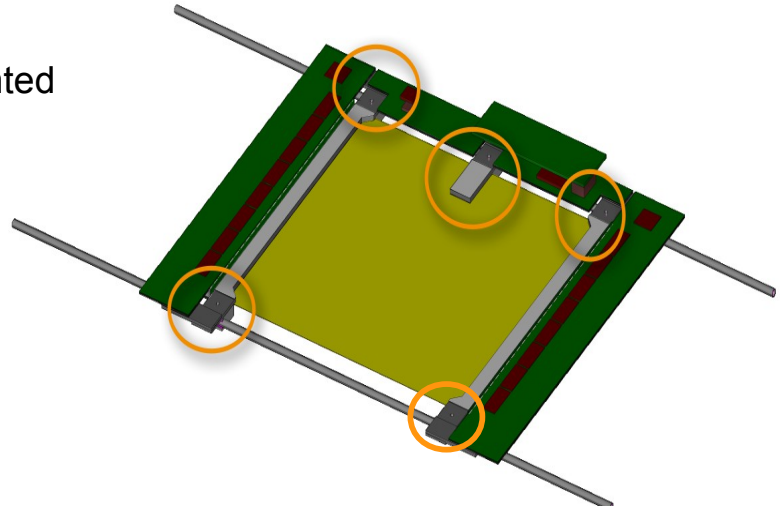



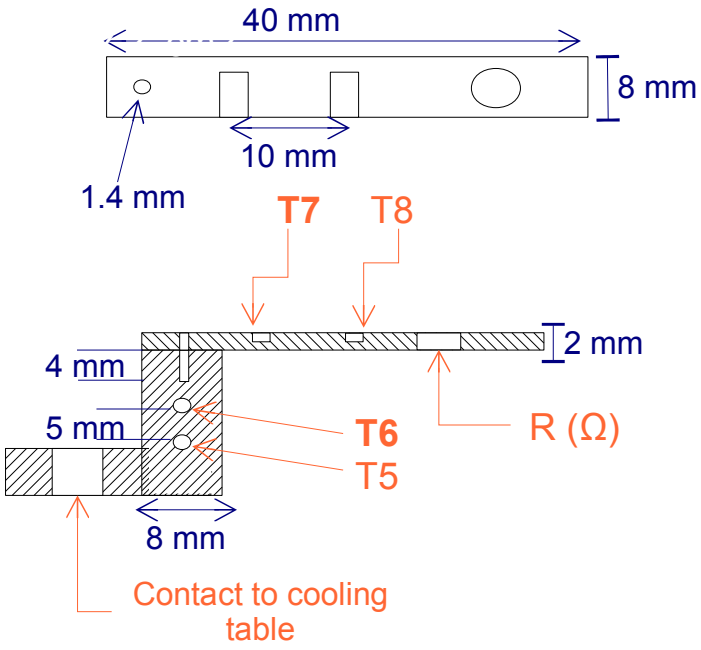



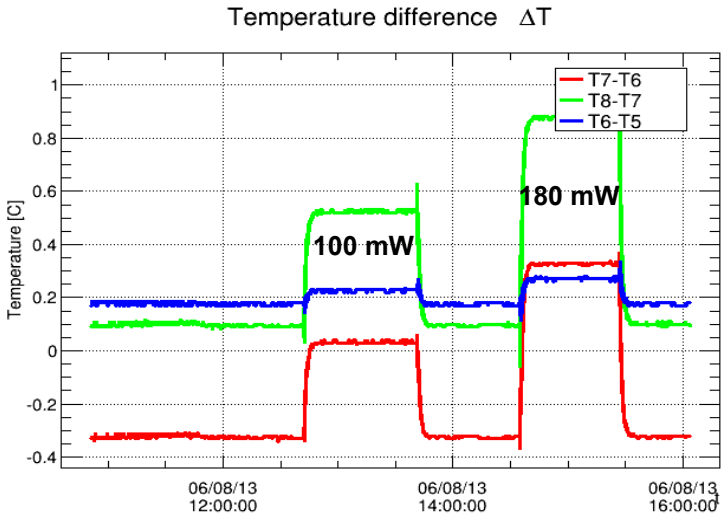
# Thermal conductivity tests setup - measurements

## > Cooling contacts

- e.g. CMS 2S module has 5 cooling points mounted to blocks on cooling pipes by M1.4 screws
- Sample was made with same dimensions for testing temperature vs torque
- Two samples, one with actual screw connection and one one-piece sample
- fixed on test table (constant cooling by chiller)
- Screw mounted using torque screw driver





# Thermal conductivity tests setup - measurements

- Cooling contacts
  - e.g. CMS 2S module has 5 cooling points mounted to
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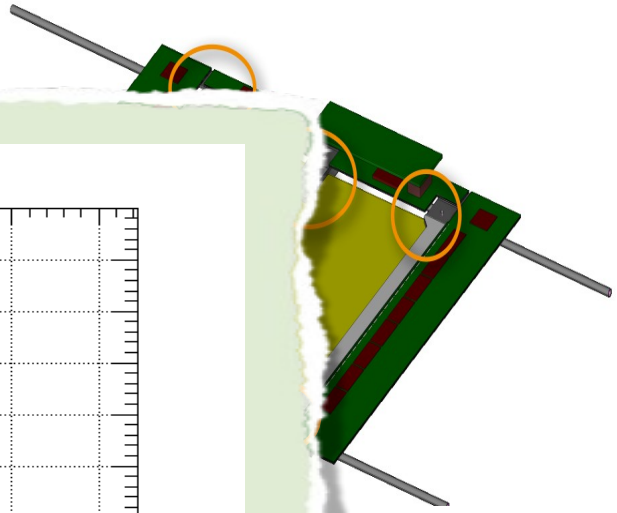
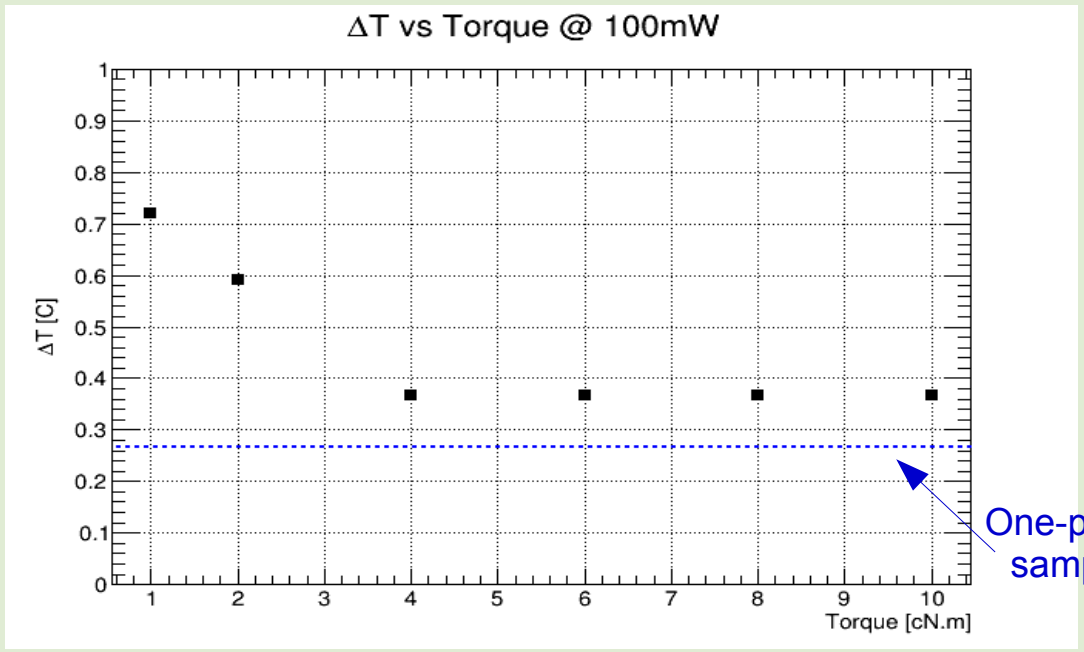
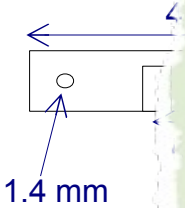
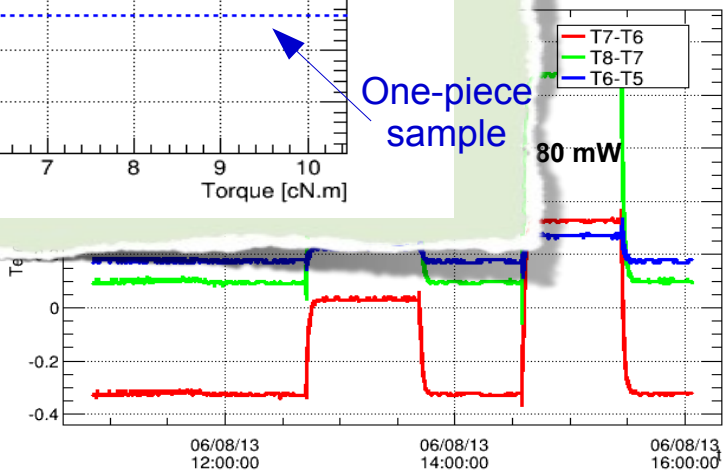
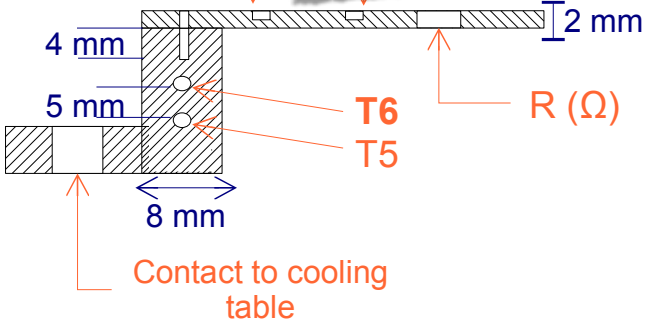




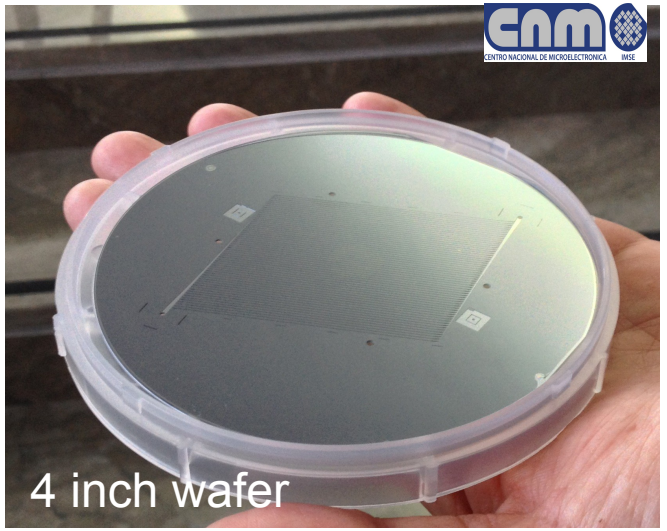



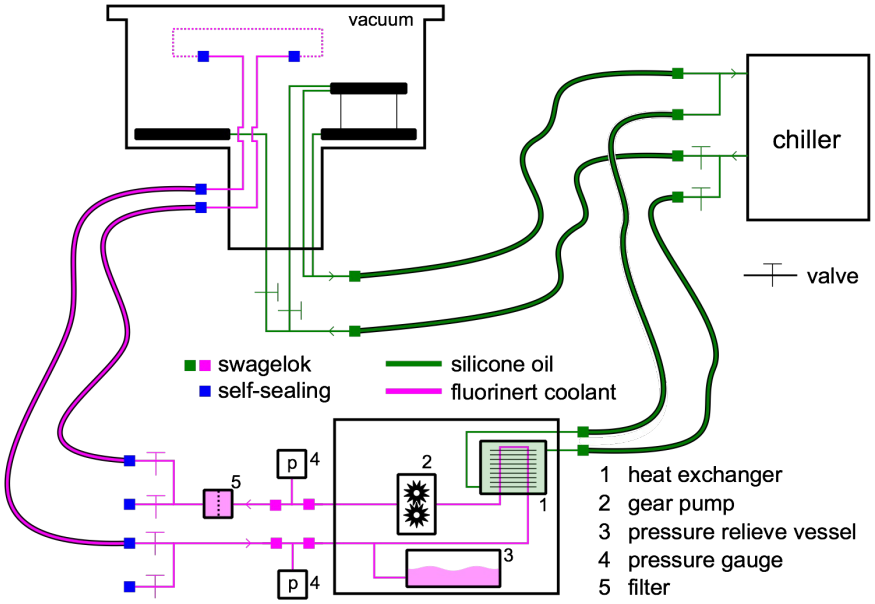



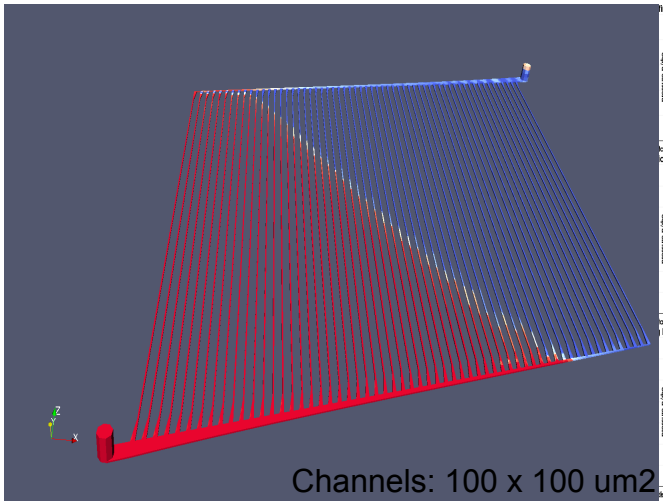



# MicroChannel Cooling - setup

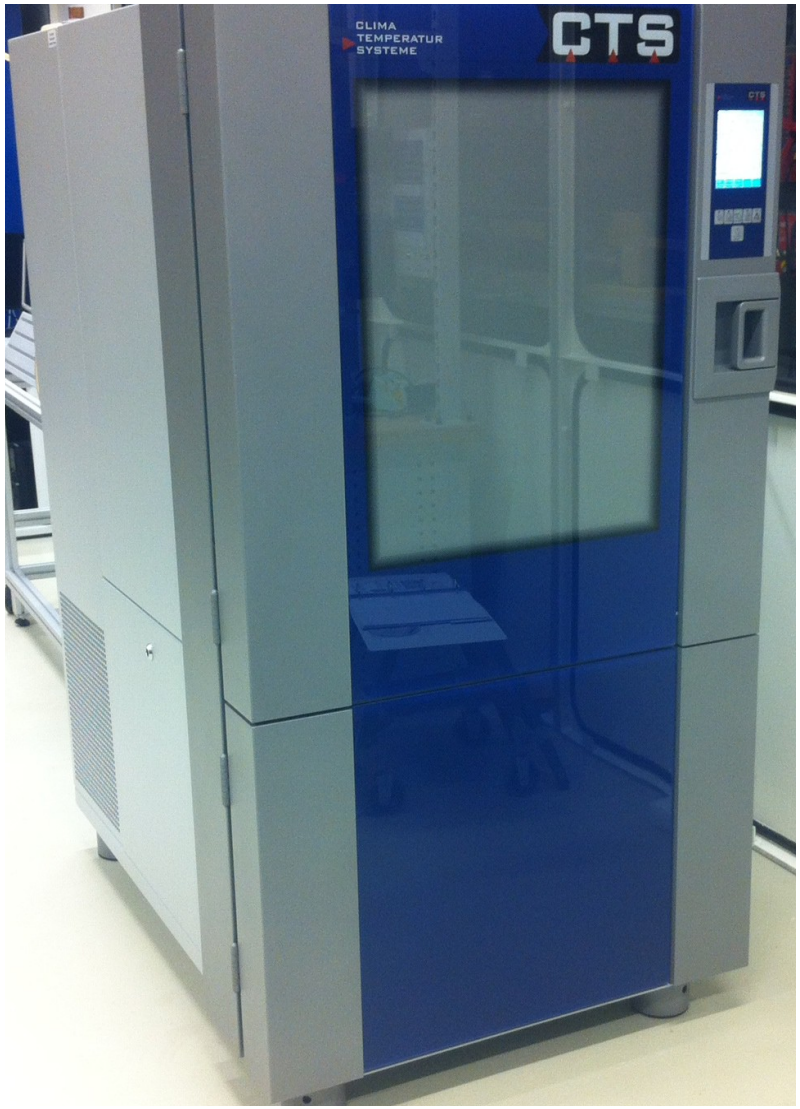
- To be tested: MicroChannels in 4 inch wafers, 350um thick by CNM Barcelona
- Two coolant circuits
  - one with silicon oil cooled by the chiller
  - one for the fluorinert coolant cooled in the heat exchanger
- Pump for pressure up to 70 bar
- Filter to avoid blockades in the micro-channels
- Status: start tests in next weeks



# Climate Chamber




- Studying detector modules under extreme thermal conditions
- longevity studies. e.g. of C-foam glue samples and ATLAS petals...

- Climate chamber CTS T-40/200
  - lowest temperature: -40 °C
  - volume: 200 l
  - 750 mm x 650 mm x 400 mm
- digital valve to flush with gas
  - controlled via front panel
- about 6 kW power
- refrigerator cooled by water

- device controller will be extended by a Pt100 input that can be used by the temperature regulation
- device is ready to be used
- need to install Nitrogen supply lines (next week)

# Summary and Outlook

- summary
  - thermal measurement setup is ready to be used
  - ODM needs a little more work both from hardware side (cooling) and software (extra calibration coefficient for large surfaces)
  - surface treatment needs to be understood.
  - climate chamber is almost ready to be used.
- outlook
  - measurement of thermal impedance of CFRP to C-foam interface will be finished.
  - thermal interface of module to cooling block will be continued.
  - mechanical connection will be optimized based on results.
  - pixel phase 1 bump bond samples will be tested in climate chamber
  - thermal measurement setup and climate chamber will be used to investigate various phase change glues needed for the PS module