Status and plans for module test facilities at DESY Hamburg

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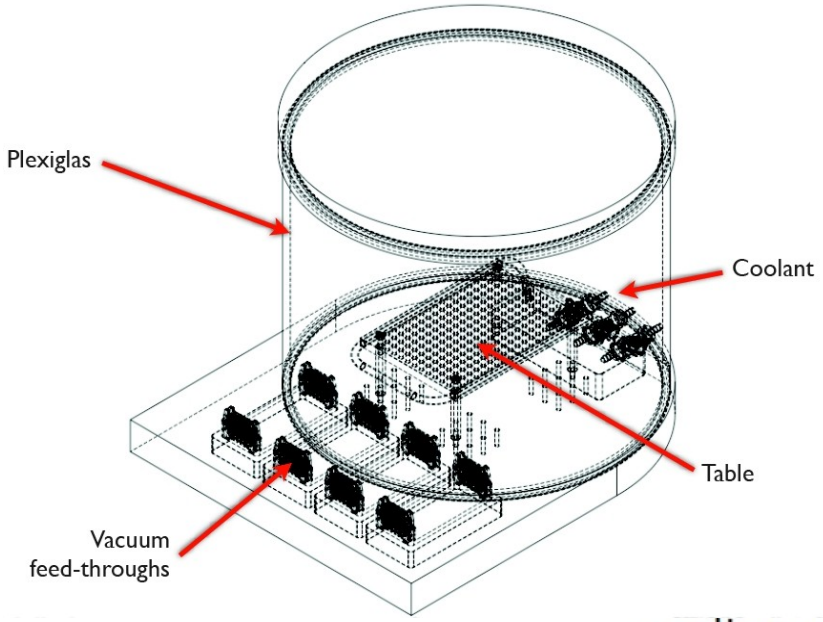
Outline

Strip module design development
→ combine FE simulations & lab measurements at an early stage

- Test setup for cooling efficiency of test structures & prototypes
  - purpose, construction & capabilites
  - commisioning & first measurements
  - mid-term plans

- Future enhancement for optical deformation measurements
  - module deformations due to thermal stress
  - principle of optical deformation measurements
  - current status

Cooling efficiency measurements

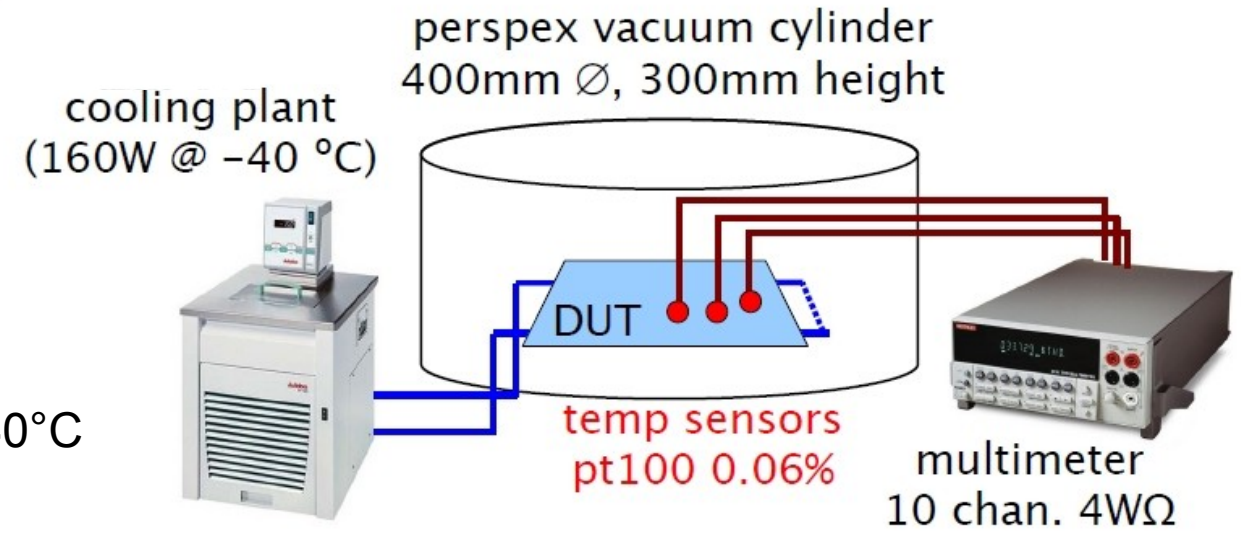


Design goals:

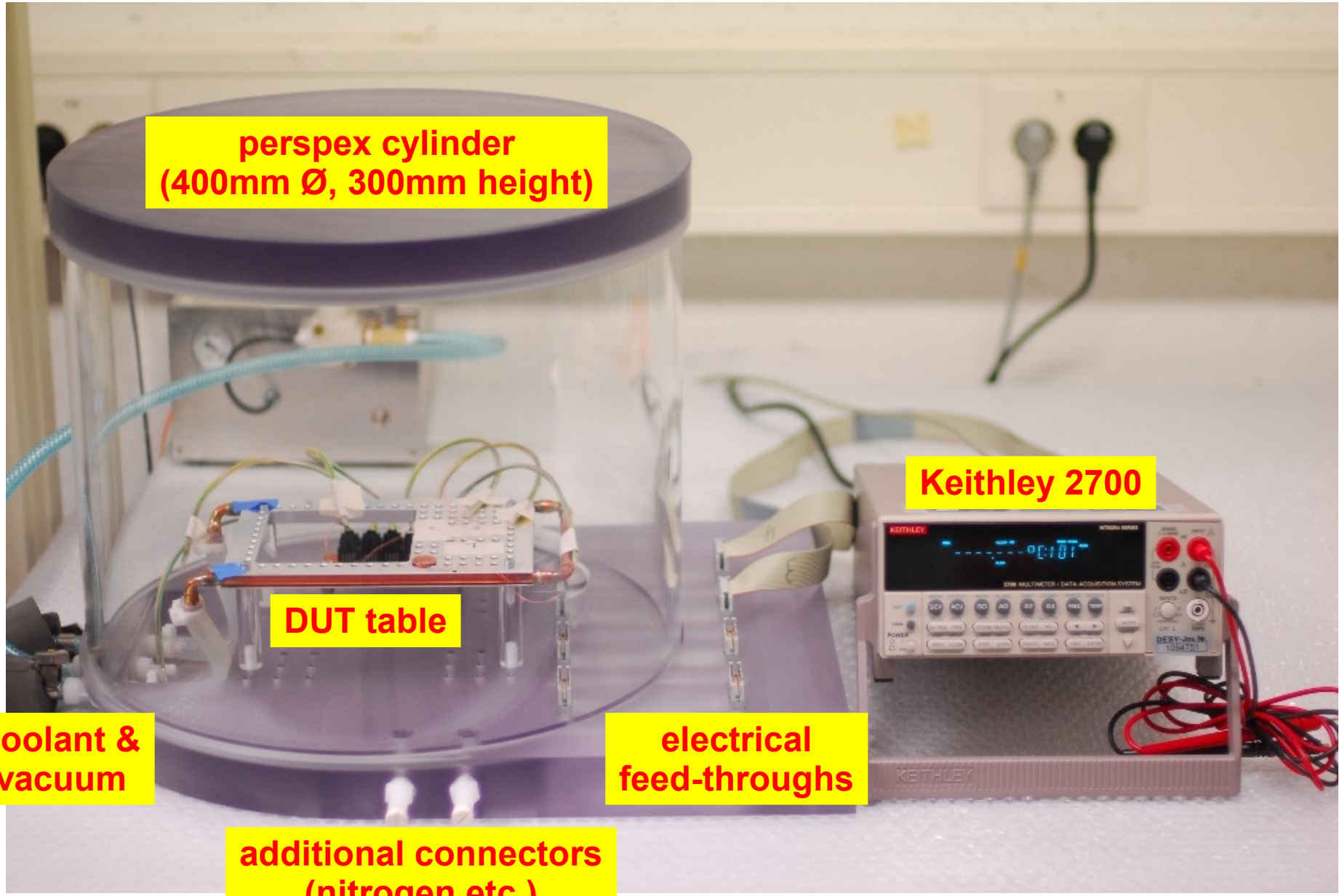
- measure cooling efficiency of test structures and module prototypes
- possibility of vacuum evacuation to determine influence of convection
- High precision temperature measurements

Cooling:

- conventional chiller (Julabo FP50-MC)
- 160W cooling power @ -40°C
- 0.45 bar+
- Coolant: silicon oil



Cooling efficiency setup



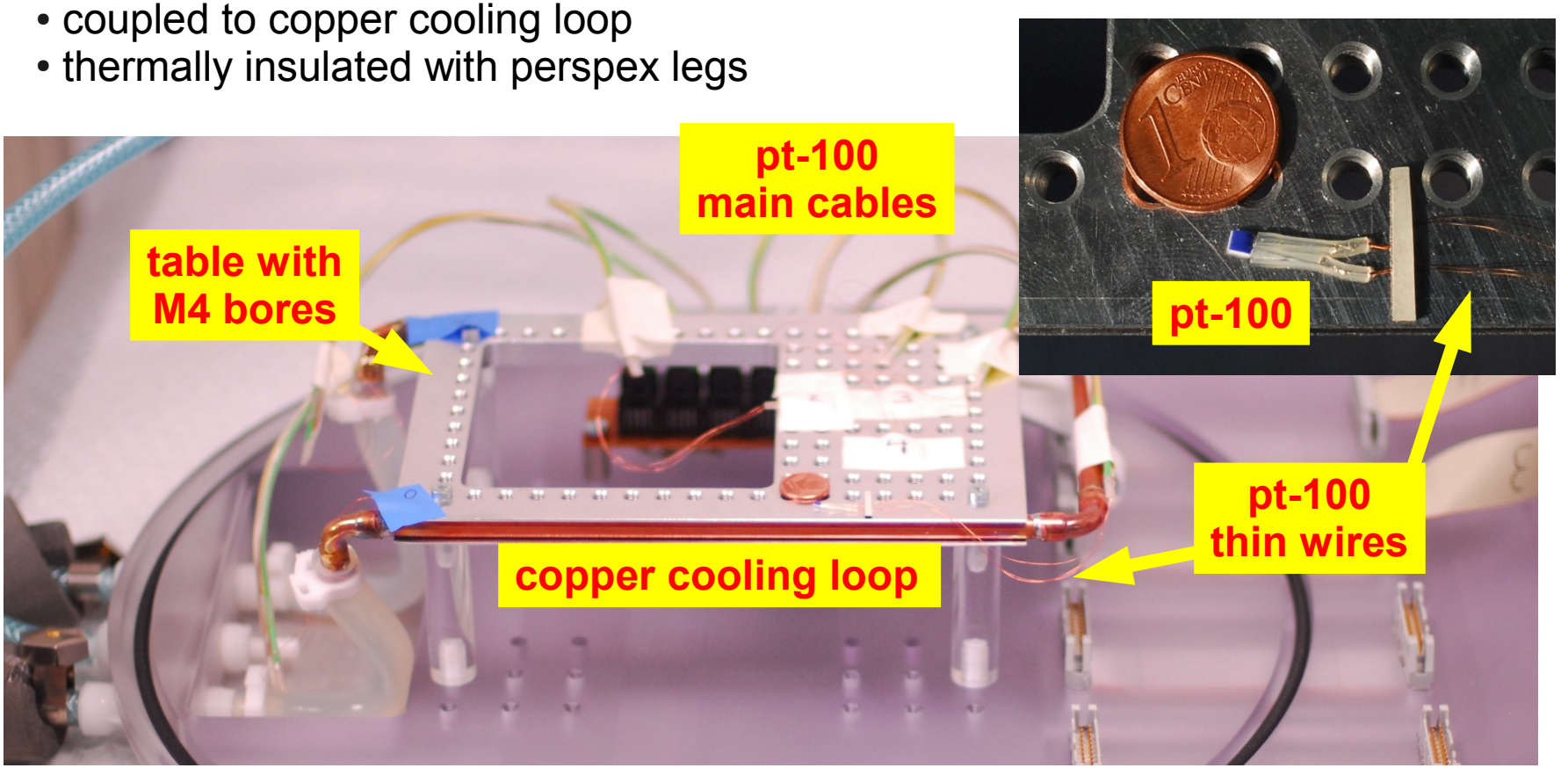
DUT table

10 channels for temperature measurements

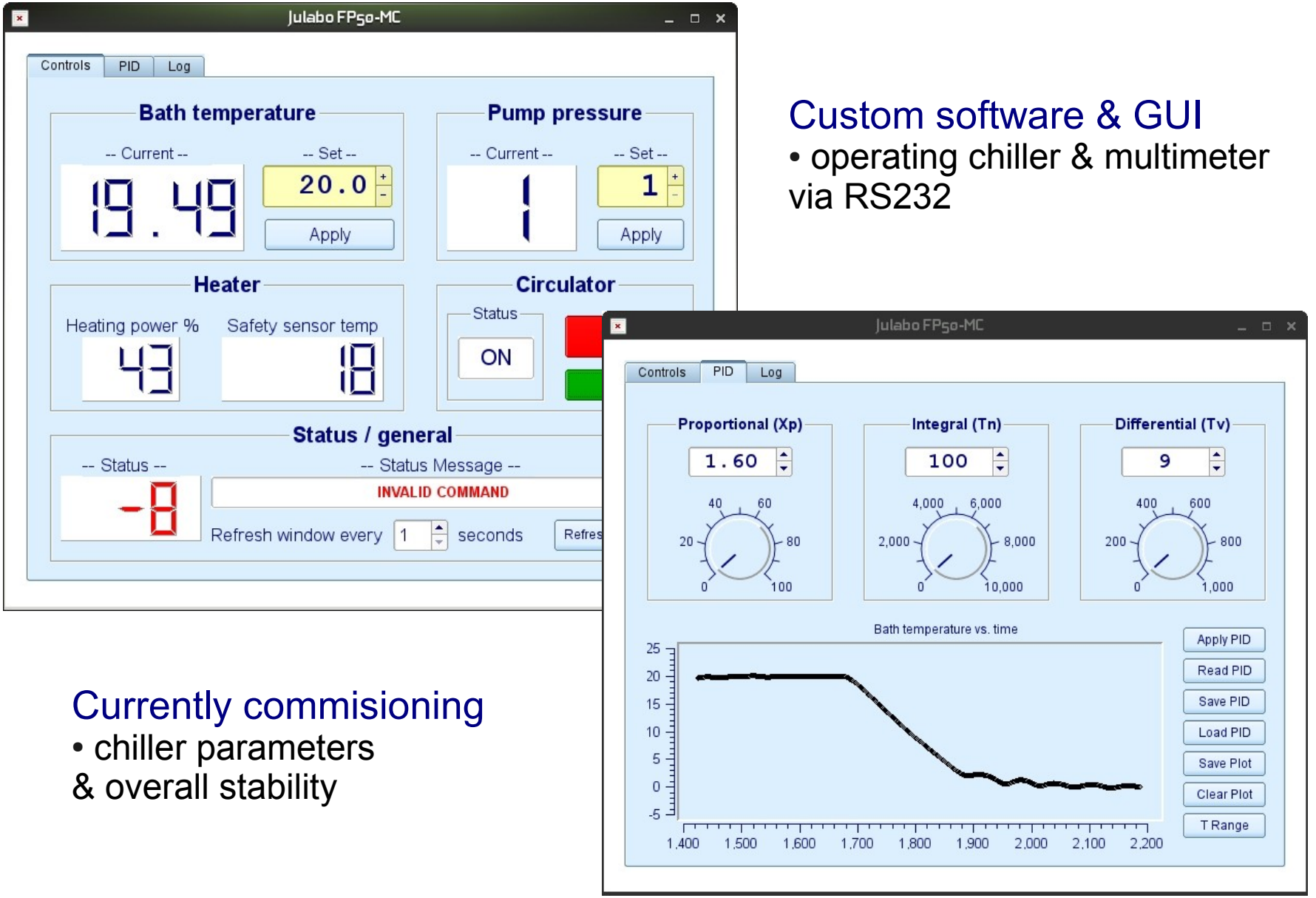
- pt-100 class A (0.06 % @ 0°C), 4WΩ readout by Keithley 2700+7700
- connected with 0.1mm copper wire (12cm) for minimizing heat input

Steel DUT table with M4 bores

- for flexible mounting
- coupled to copper cooling loop
- thermally insulated with perspex legs



Cooling efficiency setup - software



Custom software & GUI

- operating chiller & multimeter via RS232

Currently commisioning

- chiller parameters & overall stability

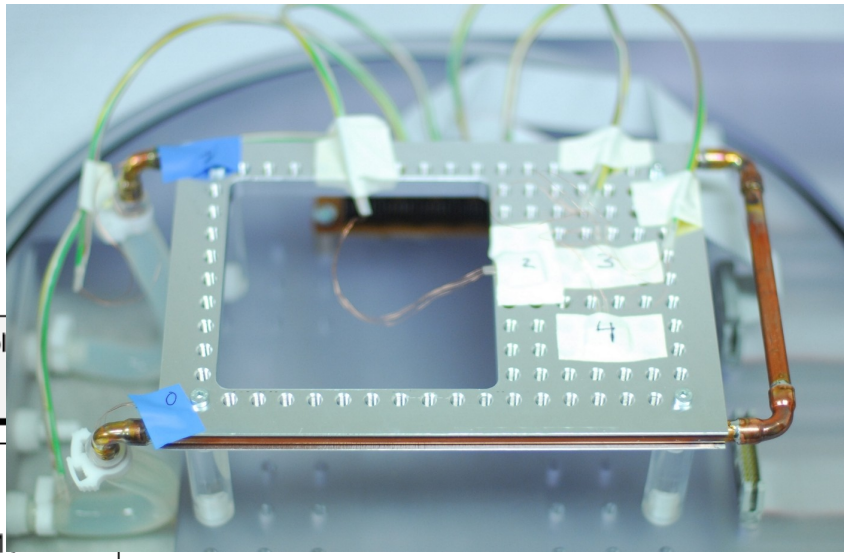
Next steps: commissioning

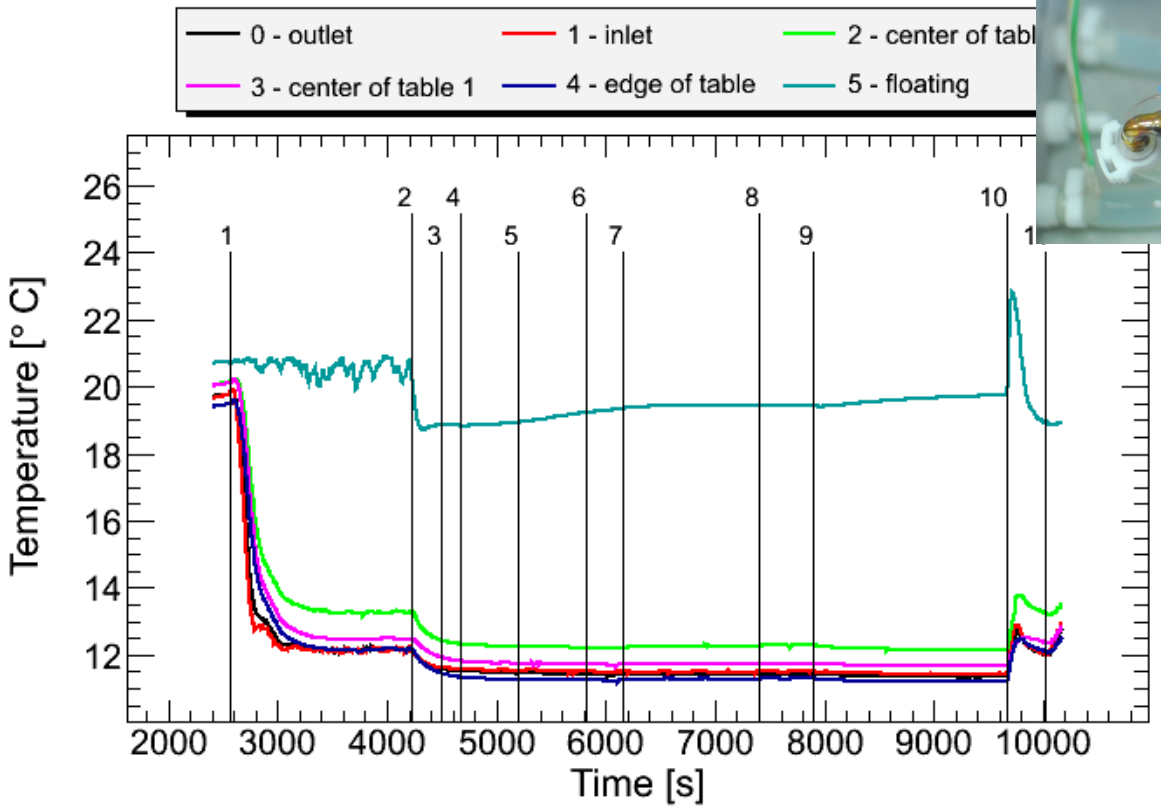
Understanding temperature readings & time constants -

- intercalibration of sensors
- temperature map of DUT table

Gain experience in handling -

- attaching pt-100 sensors
- using heat sink compounds & foils
- mounting devices & test structures



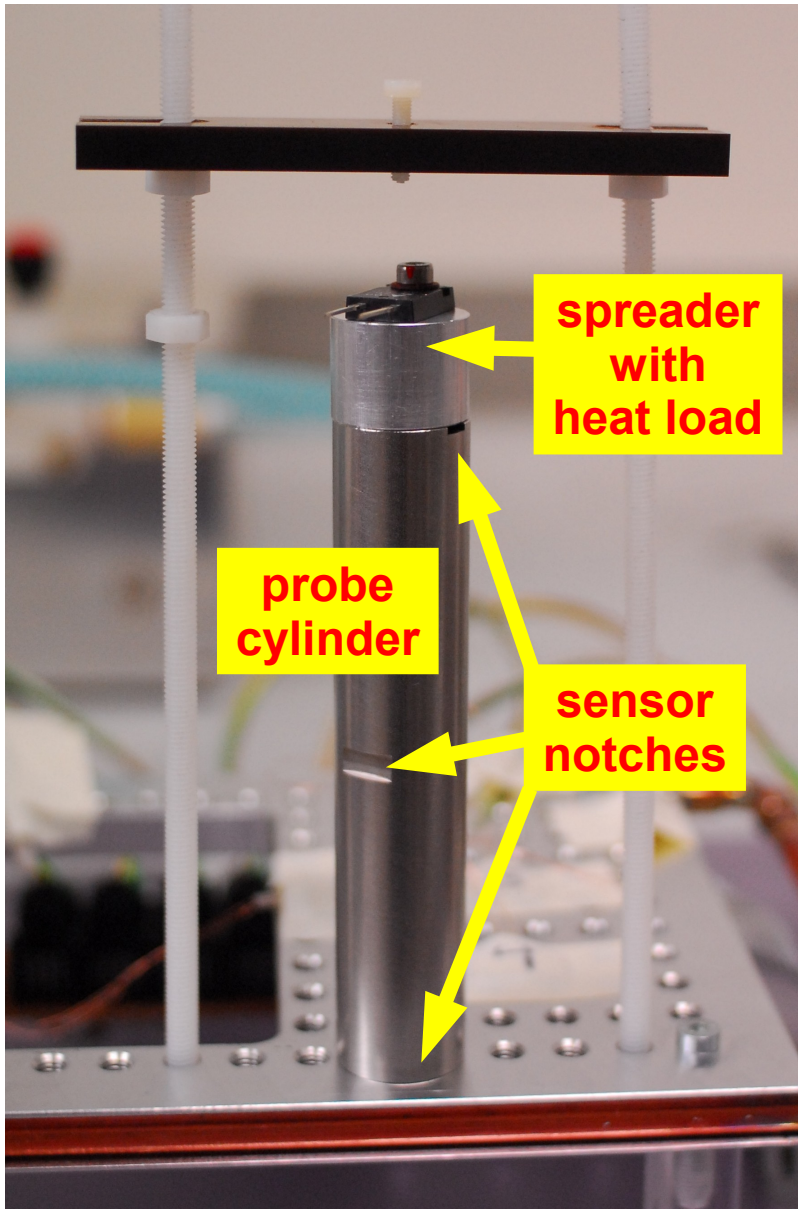


Operate heat loads -

- thin plane resistors
- heat load foils

All 10 sensors
are operational
(showing 1-6 only)

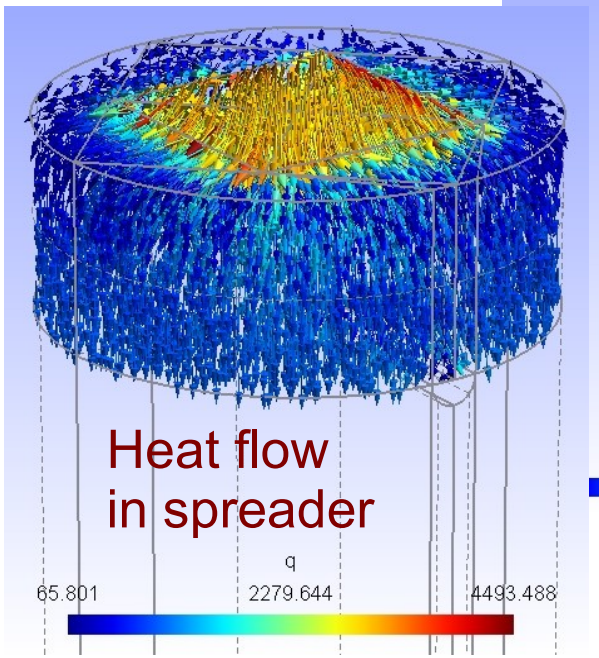
Measuring thermal conductivity

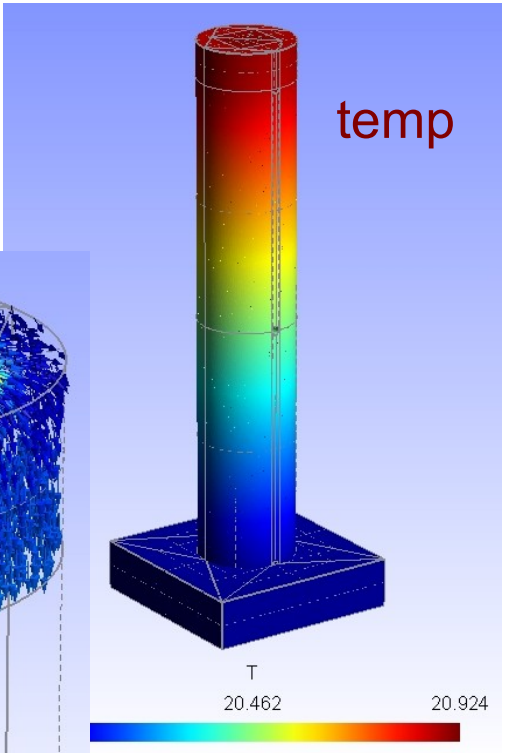


Measuring thermal conductivity of various material probes -

- "exercise" for gaining experience with the setup

Cylindrical probes with10 Ω load on aluminum heat spreader



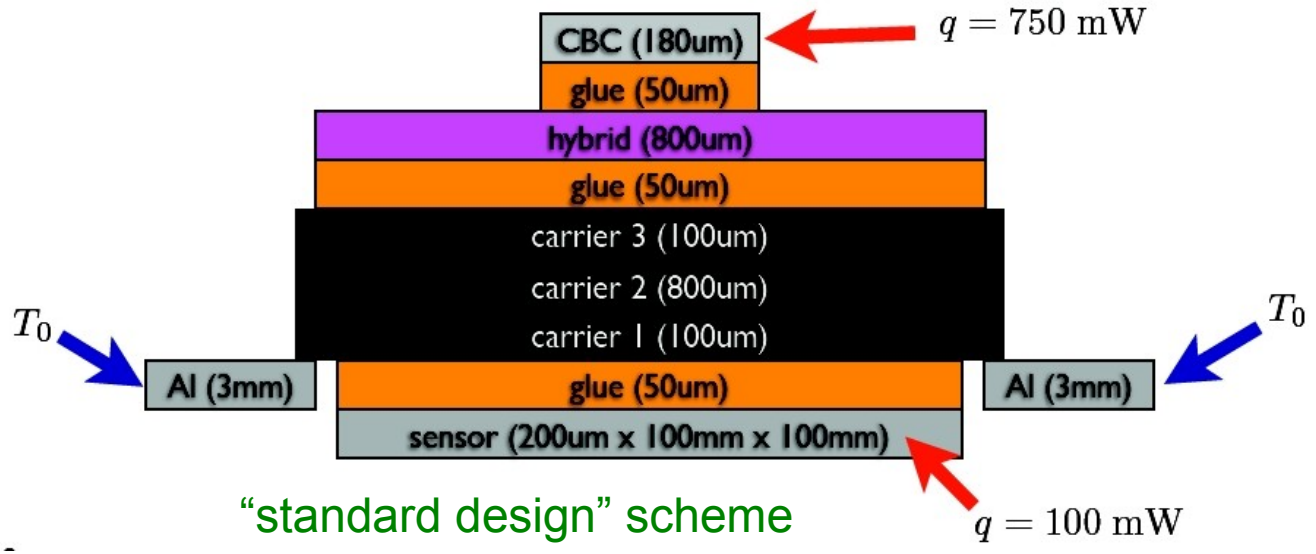


FE simulation

Cooling efficiency – mid term plans

First target is studying material junctions & gluings -

- weak point of FE calculations
- gluings currently modeled with constant 50 µm and 1.5 W/m/K
- thermal conductivity naturally expected to strongly vary



"standard design" scheme

Next goals -

- start investigating composites of Si, CFK, kapton (+Al spreaders)
- get hands on TGP & similar materials
- finally heading towards full dummy prototypes
- all in conjunction with FE simulations

Module deformations under thermal stress

Thermal properties of materials used in current TEC modules

material	thermal conductivity	expansion coefficient
silicon	$84\ W/mK$	$\sim 4.7\ ppm/K$
Al_2O_3	$25\ W/mK$	$\sim 6.5\ ppm/K$
FE779	$65\ W/mK$	$\sim 7.4\ ppm/K$
carbon fibre	$300\ W/mK$	$\sim 0.5\ ppm/K$

- Modules will be composites of different materials -

Deformations due to thermal stress -

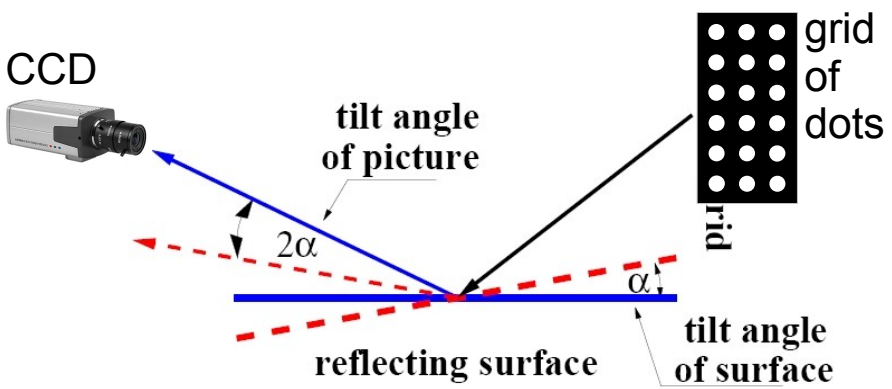
- modules assembled at room temperature, but operated at (below) -25ºC
- different expansion coefficients will lead to module deformations
- expect temperature cycles (due to Tk shutdown / maintenance)

Some possible problems with deformations -

- failure of gluings after few temperature cycles
  (degrades heat transfer to cooling system / may lead to destruction)
- micro-cracks in silicon (increased noise & leakage current)
- degradation of coordinate measurements (“misalignment”)

Minimizing thermal stress deformations has been an important issue during the design of the current Tk modules

Deformation test setup



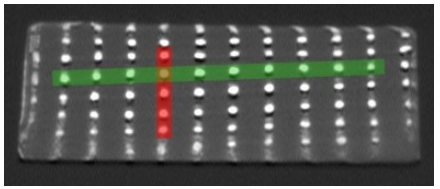
(by S. König)

Working principle:

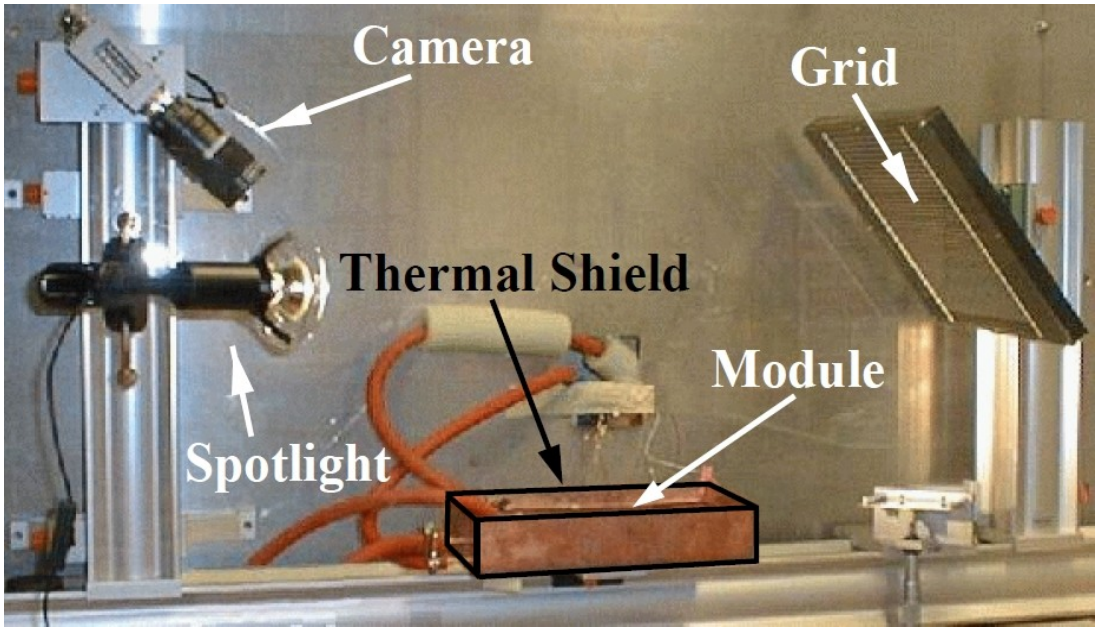
- A grid of dots is reflected by the surface
- Reflected dots observed by CCD
- change in slope of surface element results in movement of reflected dots on CCD

→ full 3D surface reconstruction @ **10 µm**
(relative to a reference state, e.g. 20ºC)

- Originally implemented by H.G. Moser et al., MPI Munich
- Used for TEC / TIB module optimization at Aachen 1B (S. König / J.O.)


Deformation studies:
kapton hybrids on FE779
(2003)

Deformation measurement setup at Aachen 1B

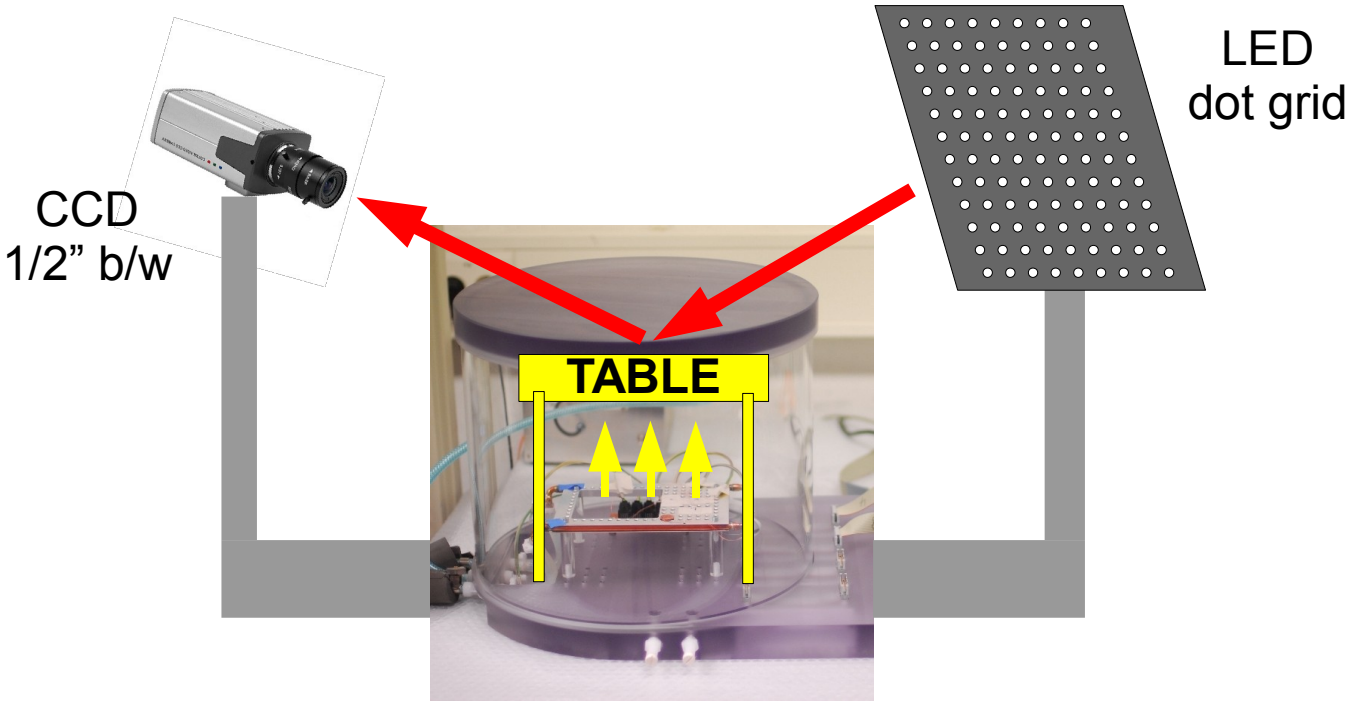


developed by S. König (now PSI)

Deformation test setup - hardware

Extension of existing setup:

- 1/2” b/w CCD + lens
- brightness adjustable LED dot grid (→ optimum contrast)
- robust modular mounting frame



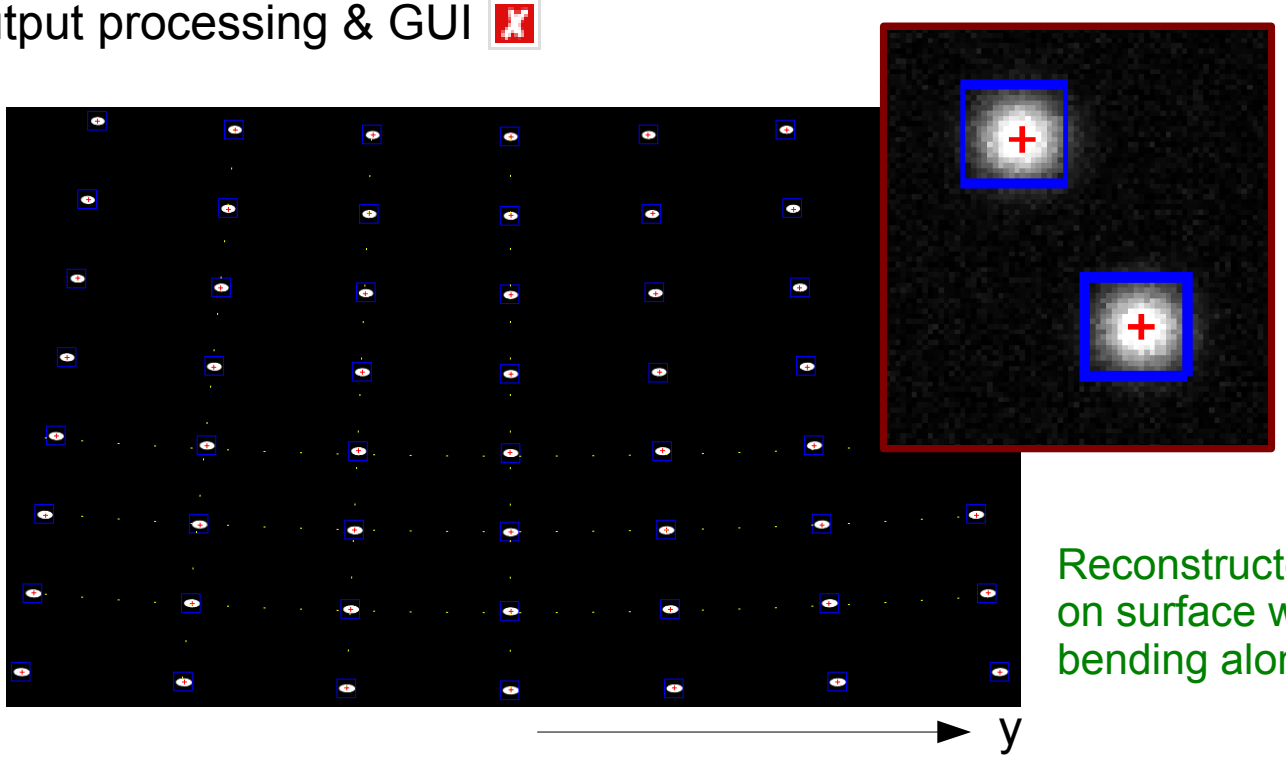
Deformation test setup - preparations

Currently preparing the software using simulated images:

- Reflecting surface simulated by raytracer program (POVRay)
- results will be used to determine optimal hardware layout
- required hardware: 1/2” b/w CCD + lens, optical led grid, frame & mounting (enhancement of existing cooling setup)

Required software developments:

- image processing / reconstruction of dot positions ✓
- spline fitting / surface reco (in progress)
- output processing & GUI ✗



Reconstructed dot positions, simulated with blurring & CCD noise

Reconstructed dot positions on surface with +2mm bending along y

Conclusions

Strip module test facilities @ DESY Hamburg

Setup for cooling efficiency measurements nearly completed -

- hardware & software in place, **now commisioning**
- next steps: measuring test structures
  – **improve modeling of joints & gluings**
  in combination with FE simulations (expected ~ mid 2010)

Setup for deformation measurements being developed -

- optical measurements of surface deformations **with 10 µm precision**
- currently **developing basic software** & algorithms using simulations
- starting on hardware design within 1-2 months
- expect to be **operational by end of this year**