

Mechanical testing of the IFMIF HFTM-DC prototype during operation in the HELOKA-LP helium loop

Author: Georg Schlindwein

The High Flux Test Module - Double Compartment (HFTM DC)

- Prototype design is derived from the IFMIF HFTM-V with a reduced number of compartments from 8 to 2
- Construction at 1:1 scale
→ cooling flow conditions identical to the original IFMIF-HFTM
- Compartment A loaded with 3 full operational rigs (design point temperature 350 °C), compartment B with rig mock-ups

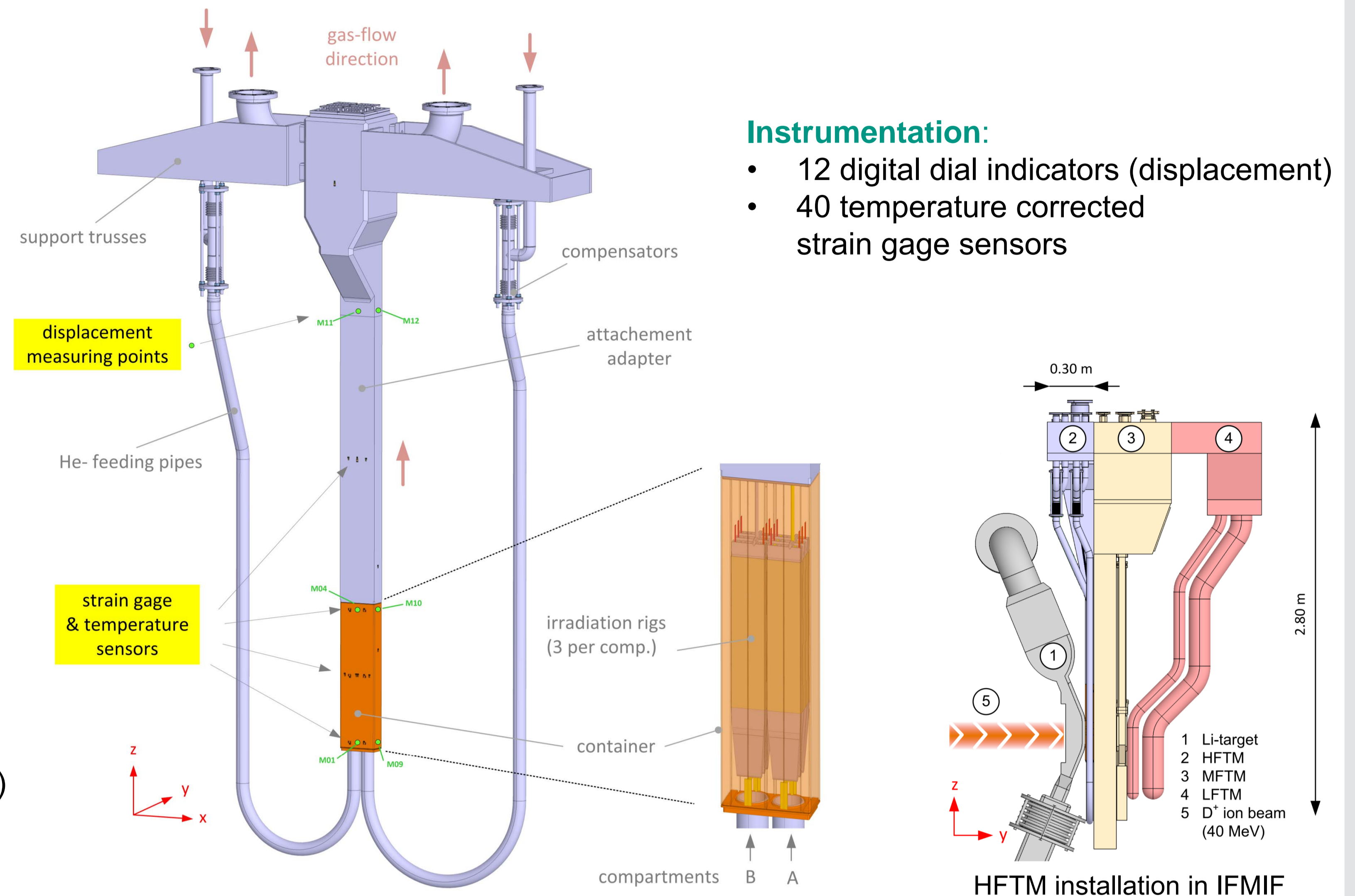
Background:

The IFMIF-HFTM (International Fusion Irradiation Facility) is a dedicated device to irradiate material specimens with neutrons having an energy spectrum peak near 14 MeV → Design database for DEMO

Key features:

- Low pressure (0.3 MPa a.) helium gas cooled pressure vessel
- Low neutron attenuation in beam direction by a thin-walled container design
- Effective utilisation of the limited high flux region (500 cm³ @ ≥ 20 dpa/fpy¹) by the use of mini cooling channels

¹ 1 displacements per atom per full power year



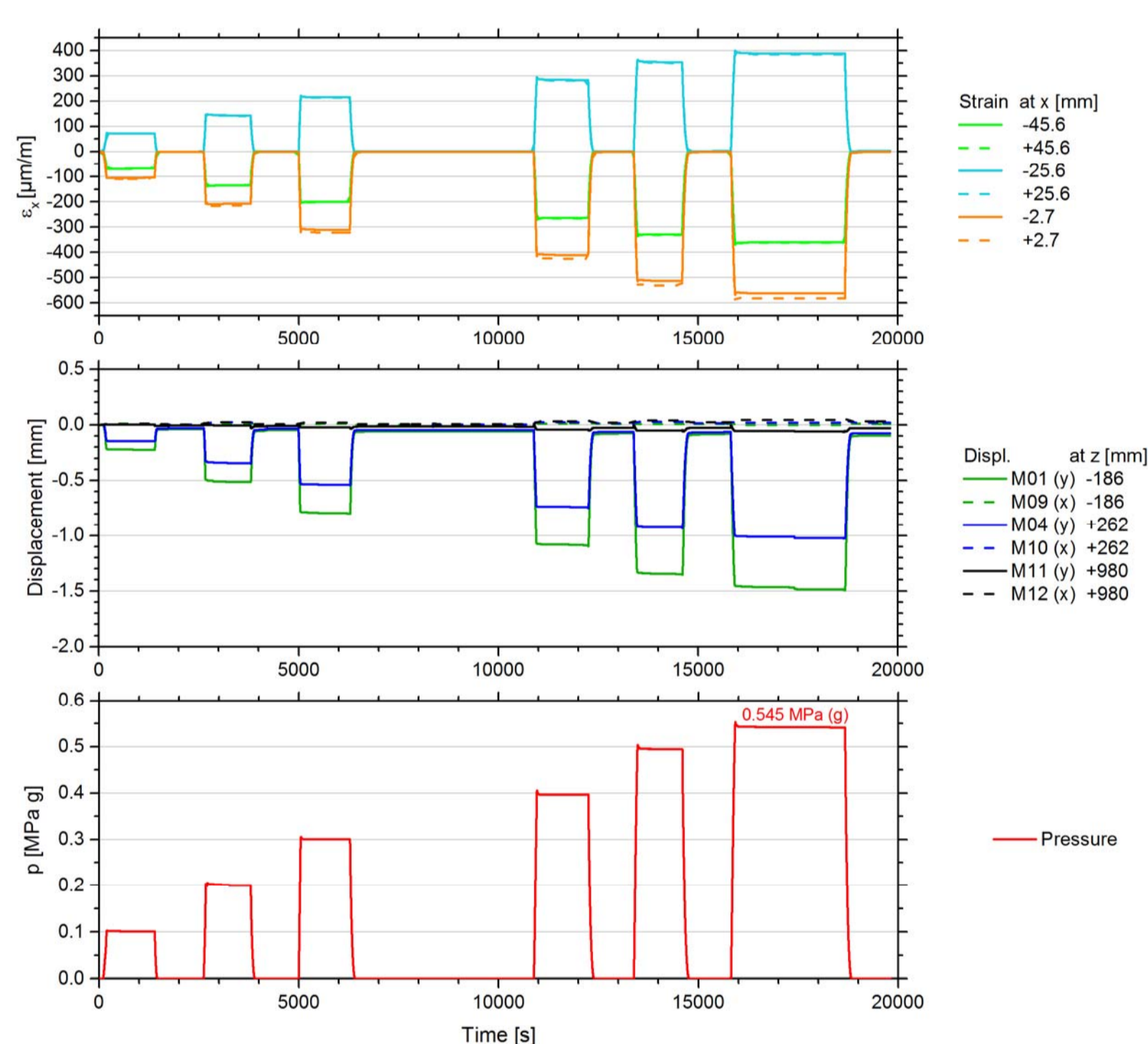
Instrumentation:

- 12 digital dial indicators (displacement)
- 40 temperature corrected strain gage sensors

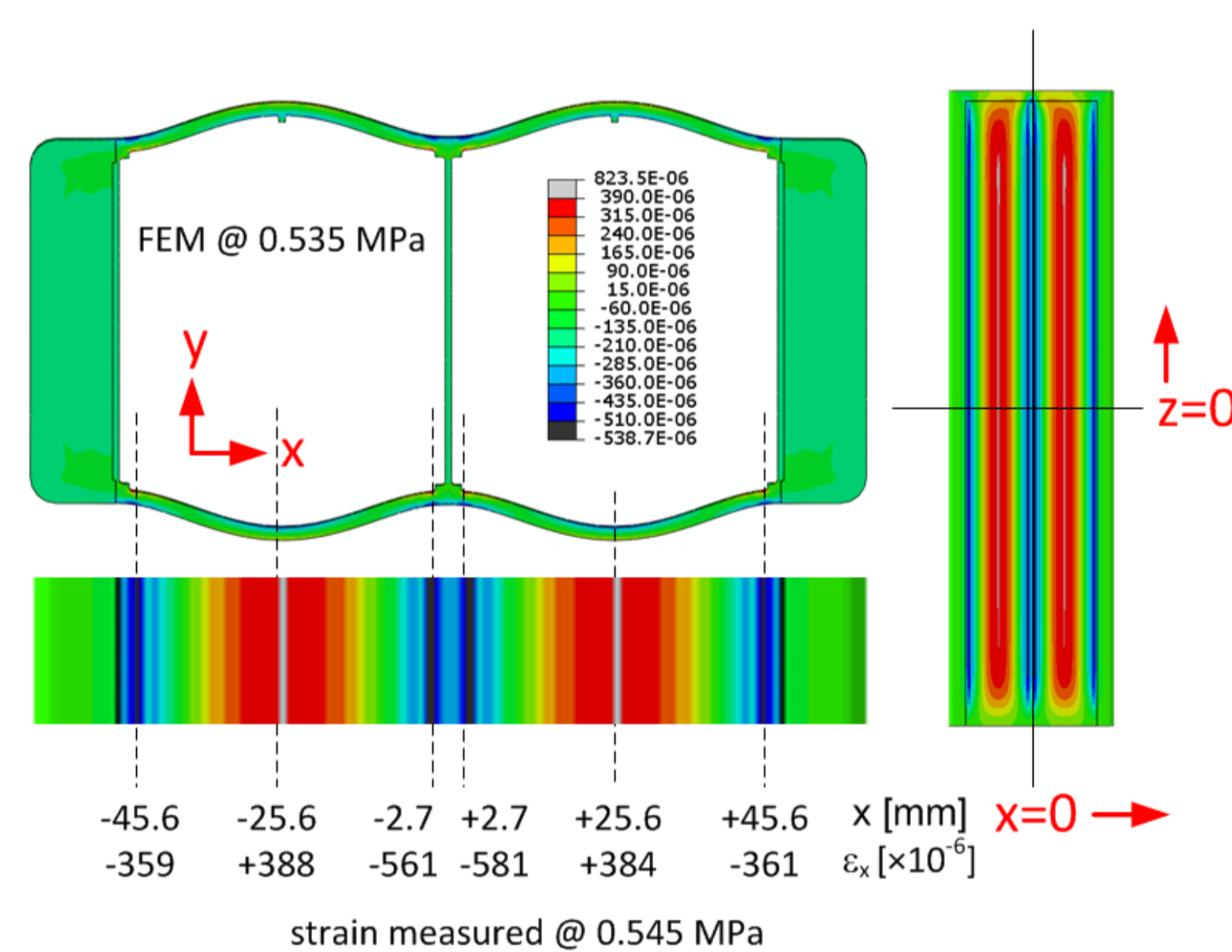
Static pressure test

Proof of safety at room temperature and a test pressure of 0.545 MPa (g)
Nominal operation pressure: 0.3 MPa (abs.)

Experimental results



FEM simulation

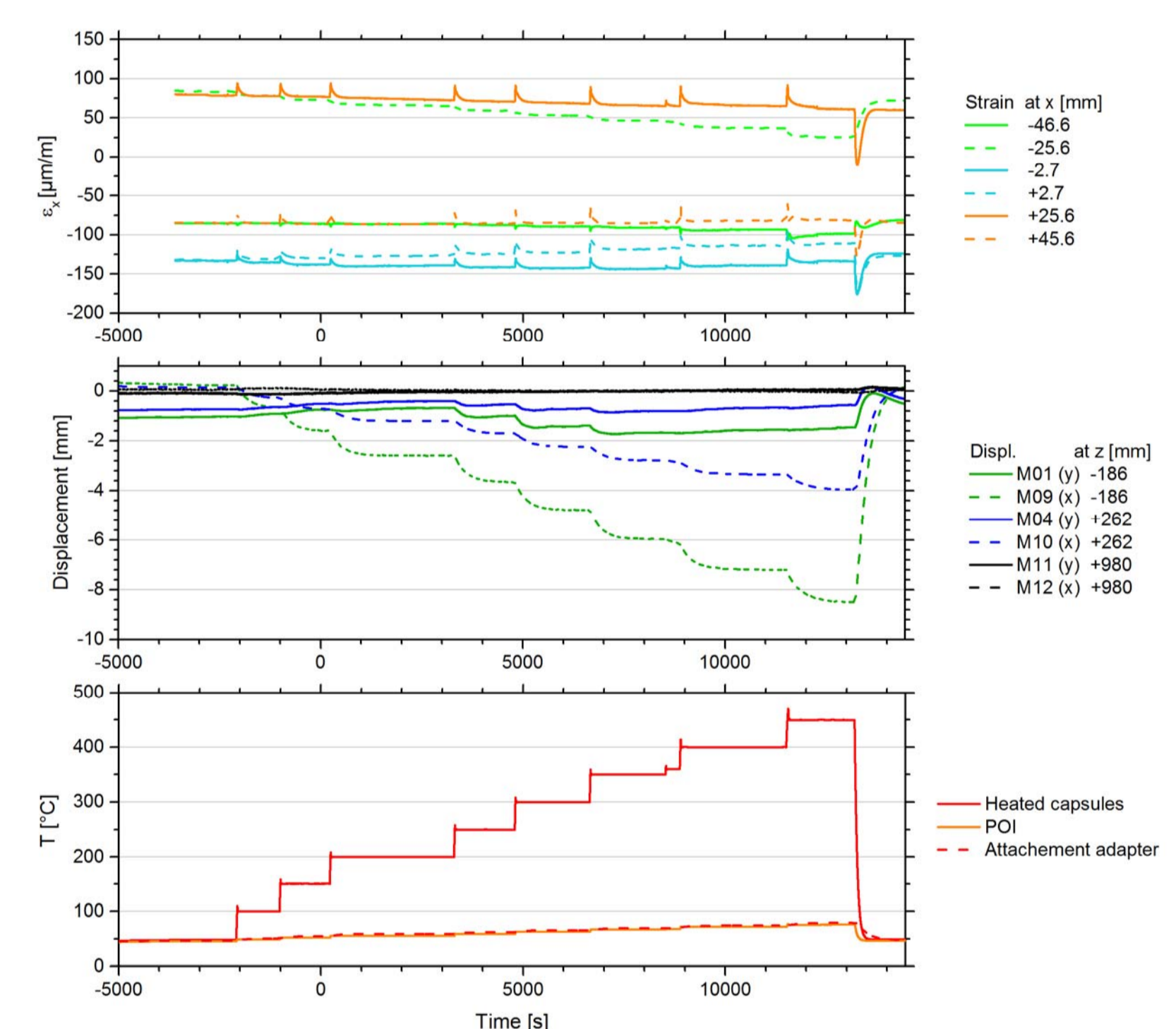


- Symmetry of the strain field ε_x at container centre-line (z=0) in x-direction
- 1.5 mm displacement of container towards y-direction (towards IFMIF target) due to asymmetry in module design, no displacement in lateral x-direction
- Pressure proportionality of measured strains and deflections
- Strain measurements consistent to FEM simulation studies
- Magnitude of (-)600 μm/m at 0.545 MPa (g) corresponding to 120 MPa local stress
- Detected leakage rate approx. 20 Pa·L · s⁻¹
- No significant residuals of strain and displacement after pressure relief
→ No indication for a plastic deformation or damage

Safety of the HFTM-DC prototype successfully confirmed ✓

Thermal test SCN TH-006

Demonstration of the maximum possible capsule pre-heating temperature



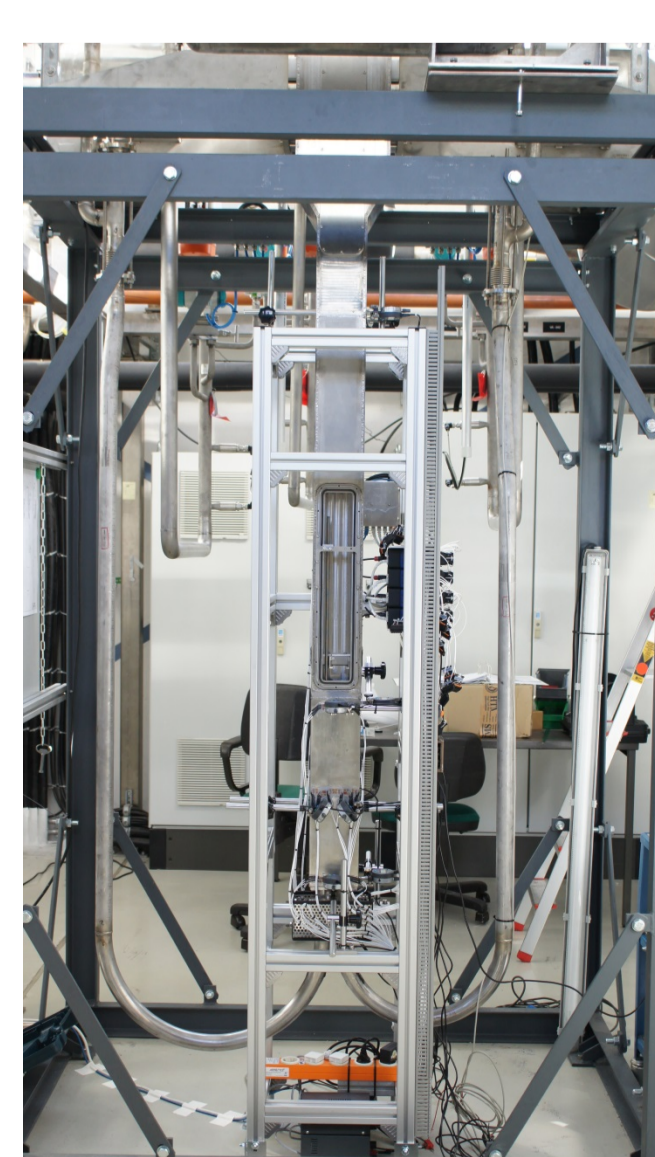
Test conditions:

- He mass-flow 14.6 g/s (Comp. A), 18.0 g/s (Comp. B)
- 50 °C compartment inlet bulk gas temperature
- 0.24 MPa (abs.) compartment inlet pressure

Experimental Results:

- Maximum container surface temperature 80.9 °C
- Large deflection (8.5 mm) of container in x-direction due to asymmetrical heating
- Maximum strain at fast temperature transient: (-)175 μm/m
- After capsule heater shut-down values for strain and displacement return to their initial, pre-heating state

- 1. Reproduction of IFMIF relevant cooling flow conditions
- 2. Possibility to operate capsule 100 K above design point (350 °C)
- 3. No indications for an excessive deformation of rigs or container



✉ georg.schlindwein@kit.edu
☎ +49 721 / 608-23974

29TH SYMPOSIUM
ON FUSION TECHNOLOGY



SEPTEMBER 5-9, 2016
PRAGUE, CZECH REPUBLIC

