Karlsruhe Institute of Technology

Cryogenic Material Tests Karlsruhe
CryoMaK – an overview

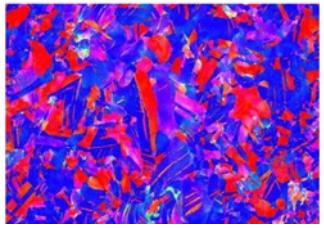
Dr. Klaus-Peter Weiss

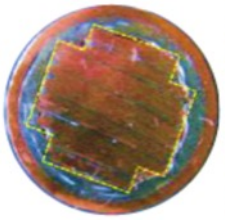
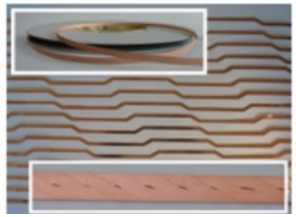
INSTITUTE FOR TECHNICAL PHYSICS

Institute for Technical Physics

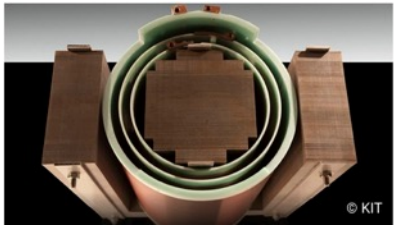
Research Topic

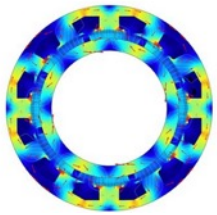
- Superconducting and Cryo-Materials
  Prof. Dr. B. Holzapfel



- Superconducting Power Engineering Applications
  Prof. Dr. Ing. M. Noe






- Superconducting Magnet Technology
  Prof. Dr. T. Arndt

- Fusion Fuel Cycle Technologies
  Dr. C. Day

Cryogenic material laboratory within ITEP

- Characterize materials at operational temperatures → 400 K – 4.2 K

- Advantage of combination of test methods in one laboratory with expertise of about 30 years

Cryogenic Materialtests Karlsruhe

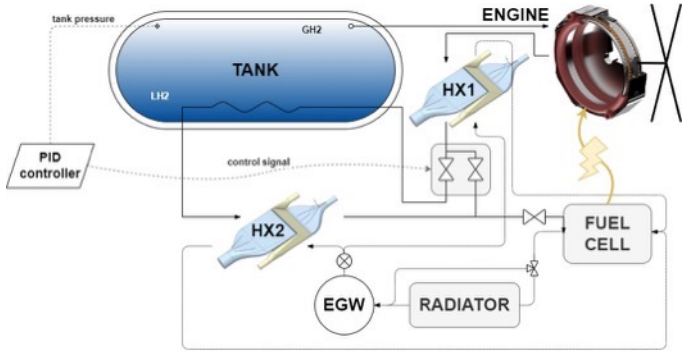
CryoMaK

Cryogenic material laboratory within ITEP

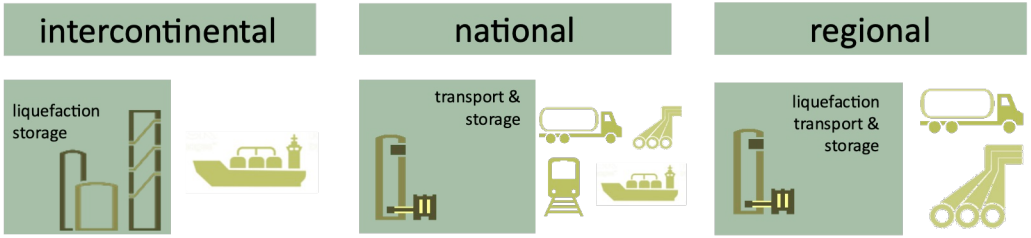
Major projects 2023

Material characterization and development (thermo-physical/mechanical):

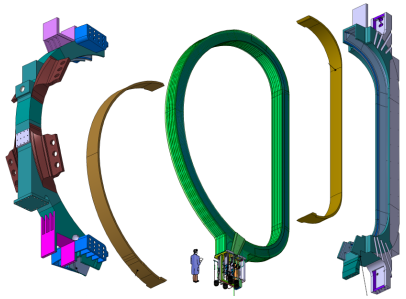
- ***AdHyBau***
  Development of a cryo-H2 electrical propulsion system using advanced / hybrid manufactured materials



- ***ApplHy!***
  Setup of a Cryo-Hydrogen facility (applications, materials)



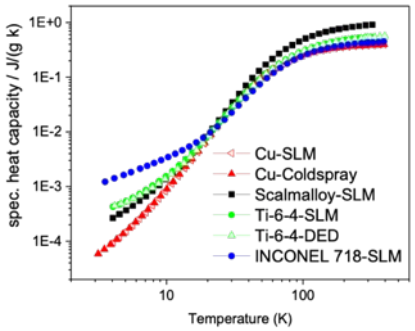
- ***Magnet Technology***
  Structural and functional material for fusion magnets
  High strength materials (EUROfusion and Fusion startups)

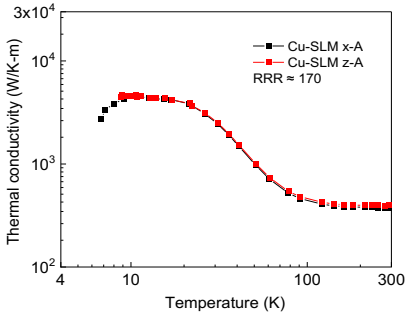


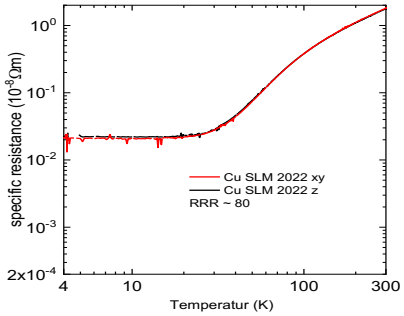
- ***Standardization IEC/ISO***

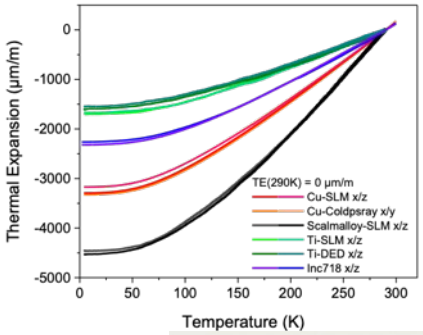
Testfacility CryoMaK – Physical Properties

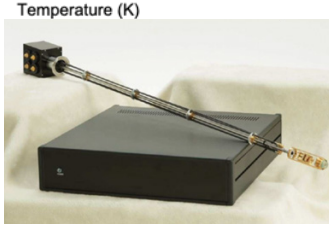
Physical Property Measurement System (9T and 14T, 1.9K - 400K)
Heat capacity, thermal conductivity, electrical conductivity, dilatometer











elastic constants Q4/2023

Testfacility CryoMaK

- Mechanical investigation (4.2K – 400K)

ATLAS axial ± 650 kN
„Full-Size" components

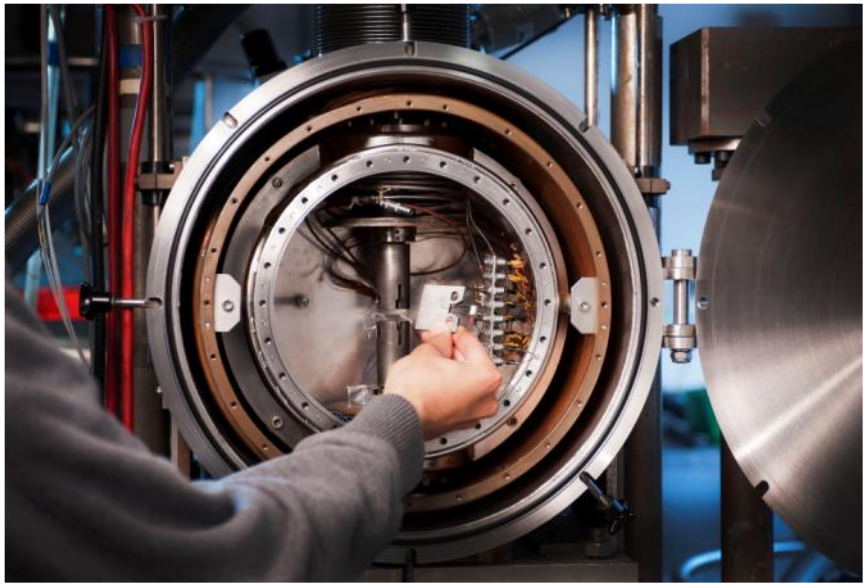
PHOENIX
axial ±100 kN

Testfacility CryoMaK

- Mechanical investigation (4.2K -300K)

TORSION axial ± 100 kN
torsion ± 1000 Nm

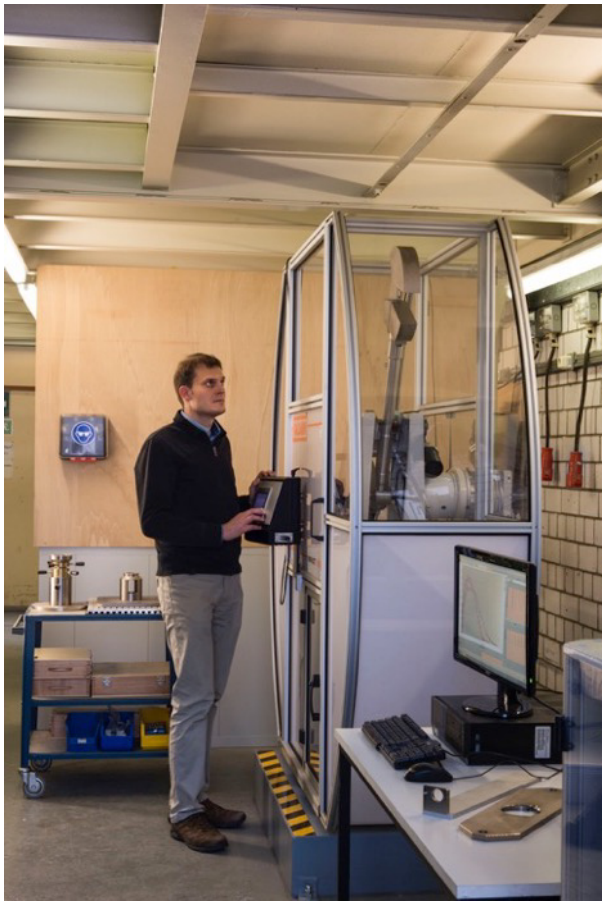
MTS25 & 50
axial ± 25 kN und ± 50 kN



Testfacility CryoMaK

- Impact test (77K/RT)

Charpy 450J



Drop weight tower

Testfacility CryoMaK

Poisson-ratio assembly

High-precision Extensometer

10-fold specimen rig

high-sensitive load cell

ASTM D3039/D3039M

- **Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials**

- Specimen size according to standard
- Specimen shown equipped with several clip-on-extensometer

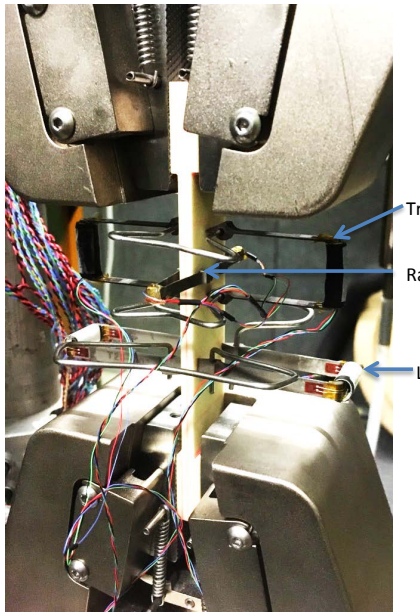


Figure 16 Test configuration for Poisson determination from transversal tensile specimen at 4K.

ASTM D3410/D3410M & Compression/Shear

- **Standard Test Method for Compressive Properties of Polymer Matrix Composite Materials with Unsupported Gage Section by Shear Loading**

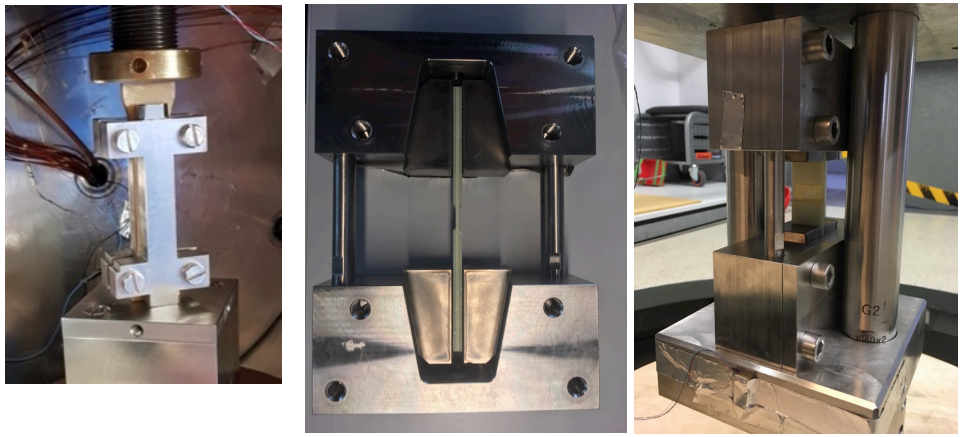


Figure 14 Compression test according to ASTM D3410M.

- **Compression/Shear Loading by Tilted Test Rig**

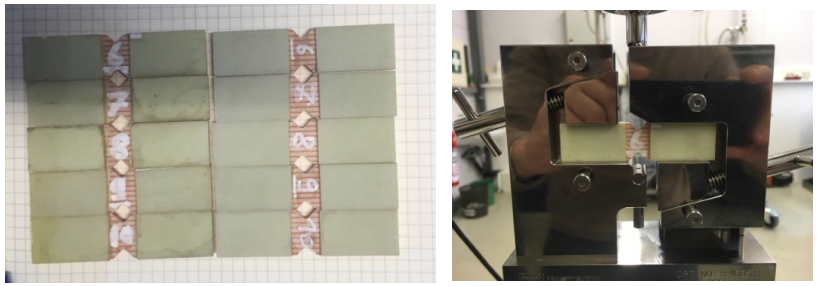


Figure 19 V-notch shear test samples before test on the left, on the right side the test rig equipped with sample

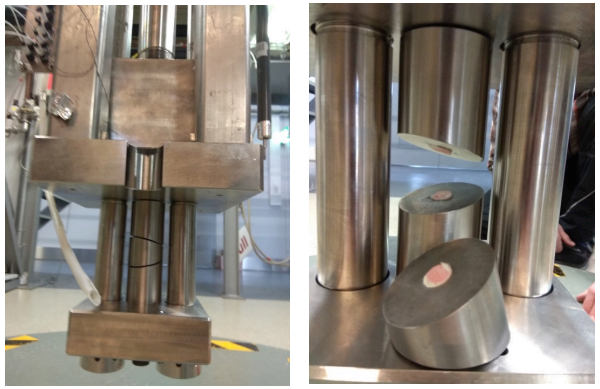


Figure 2 Compression-shear tilted test arrangement for RT and 4K test

Further test methods / adhesives ...

- **Double Lap Shear ASTM D3528**

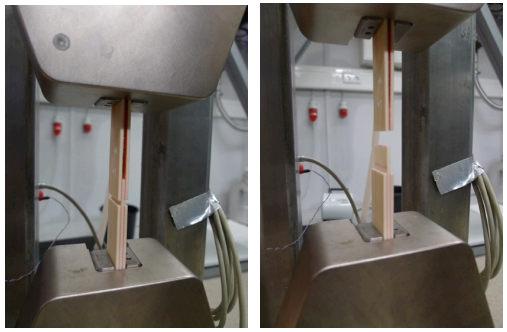


Figure 10 Example of double-lap-shear sample before (left) and after (right) test at 4K.

- **Fracture Mode II ASTM D7905/D7905M**

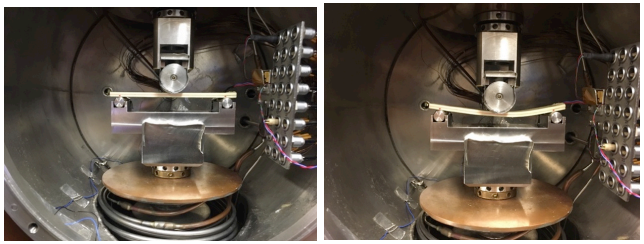


Figure 7 Mode II sample before loading (left) and at full deflection tested at room temperature.

- **Fracture Mode I ASTM D5528**

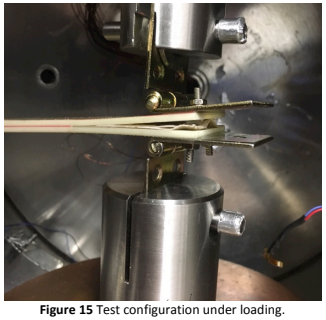


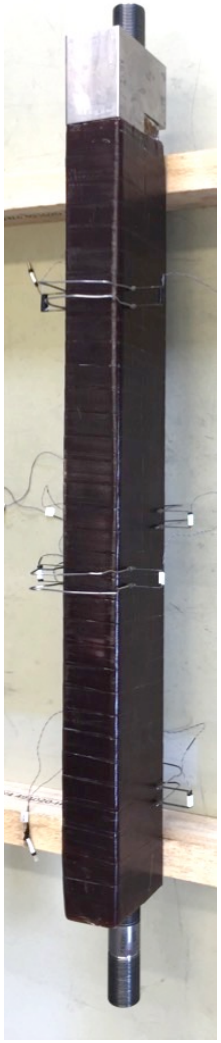
Figure 15 Test configuration under loading.

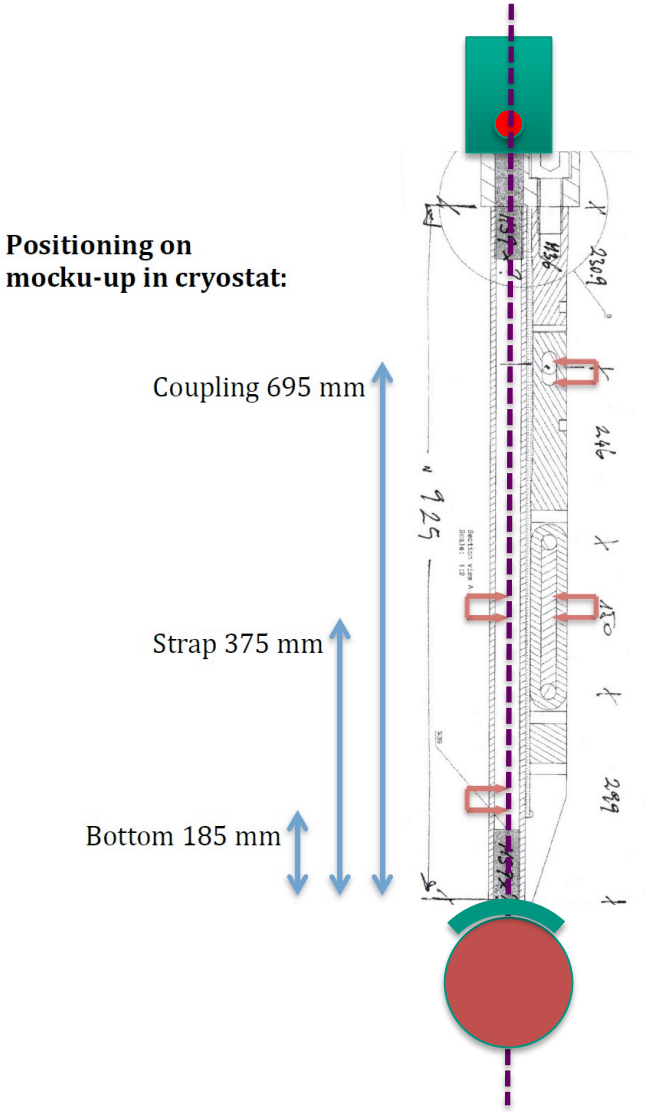
D2344/D2344M Short-Beam Strength
D2094 Specimens for Adhesion Tests
...

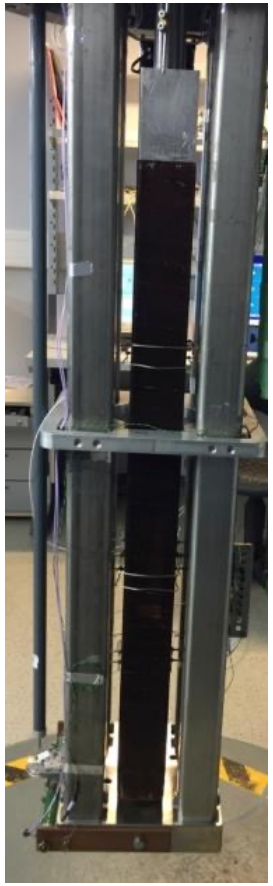
Testfacility CryoMaK – ATLAS

Example full size:
ITER
PF coil tail
strain-cycling
4.2K or 77K

PF Winding Pack
Mockup



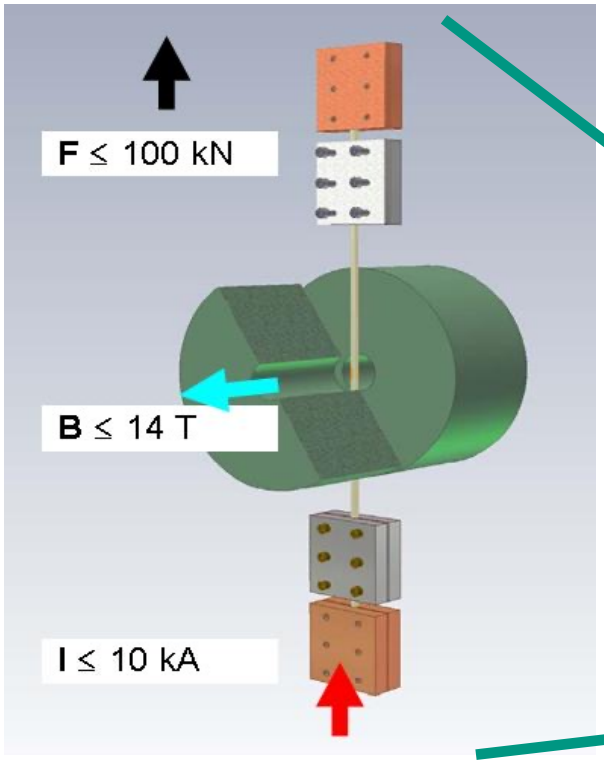


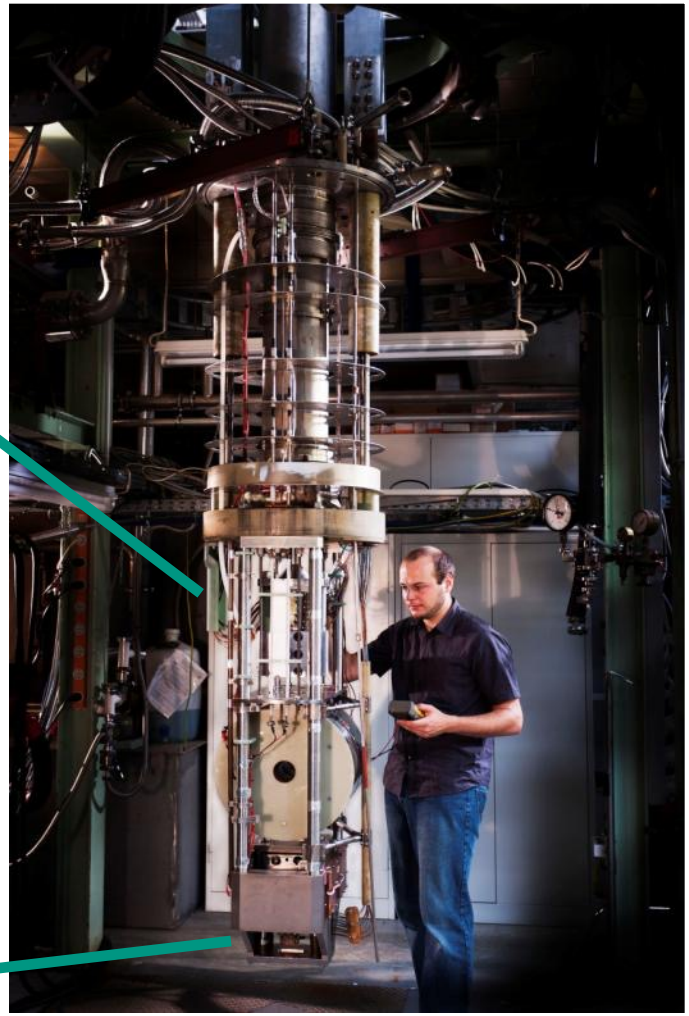


Testfacility CryoMaK – FBI facility

- Electro-Mechanical investigations of superonductors in magnetic field

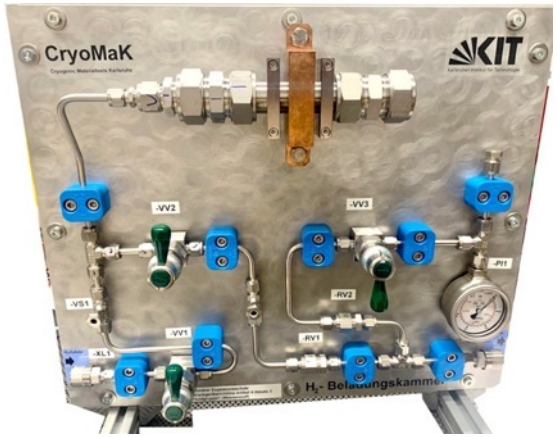
FBI
4.2 K to 77 K





Testfacility CryoMaK

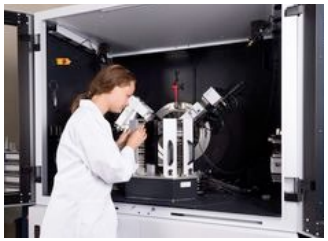
- Bruker Spectrometer Chemical composition of metals
- ONH-Analysis
- H2-preloading
  (200bar, 77K-300K)
- Optical assessment
- Vickers Hardnesstest



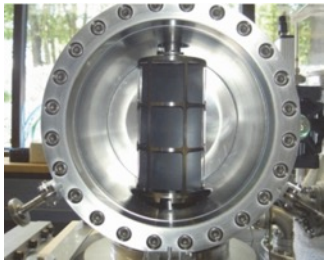
Further Characterization at ITEP

- SEM - Leo1530 (Zeiss) with EDX-System Noran SystemSix (Thermo Scientific) and EBSD-System Nordlys II (Oxford Instruments)

- XRD- D8-Discover(Bruker)



- High Voltage Lab for small specimen up to components at RT or cryogenic temperatures



- Outgassing rate measurements of stainless steel and polymer

Thank you for listening!

Dr. Klaus-Peter Weiss
klaus.weiss@kit.edu

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