MNL MARIA Neutron Laboratory, current state, nearest actions and development plans

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NARODOWE CENTRUM BADAŃ JĄDROWYCH ŚWIERK

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Outline:

- MARIA Reactor
- Experimental hall
- MNL MARIA NEUTRON LABORATORY
- Instruments
- Preparations for the creation of the MNL laboratory
- Materials Research in NCBJ

National Centre for Nuclear Research (NCBJ)

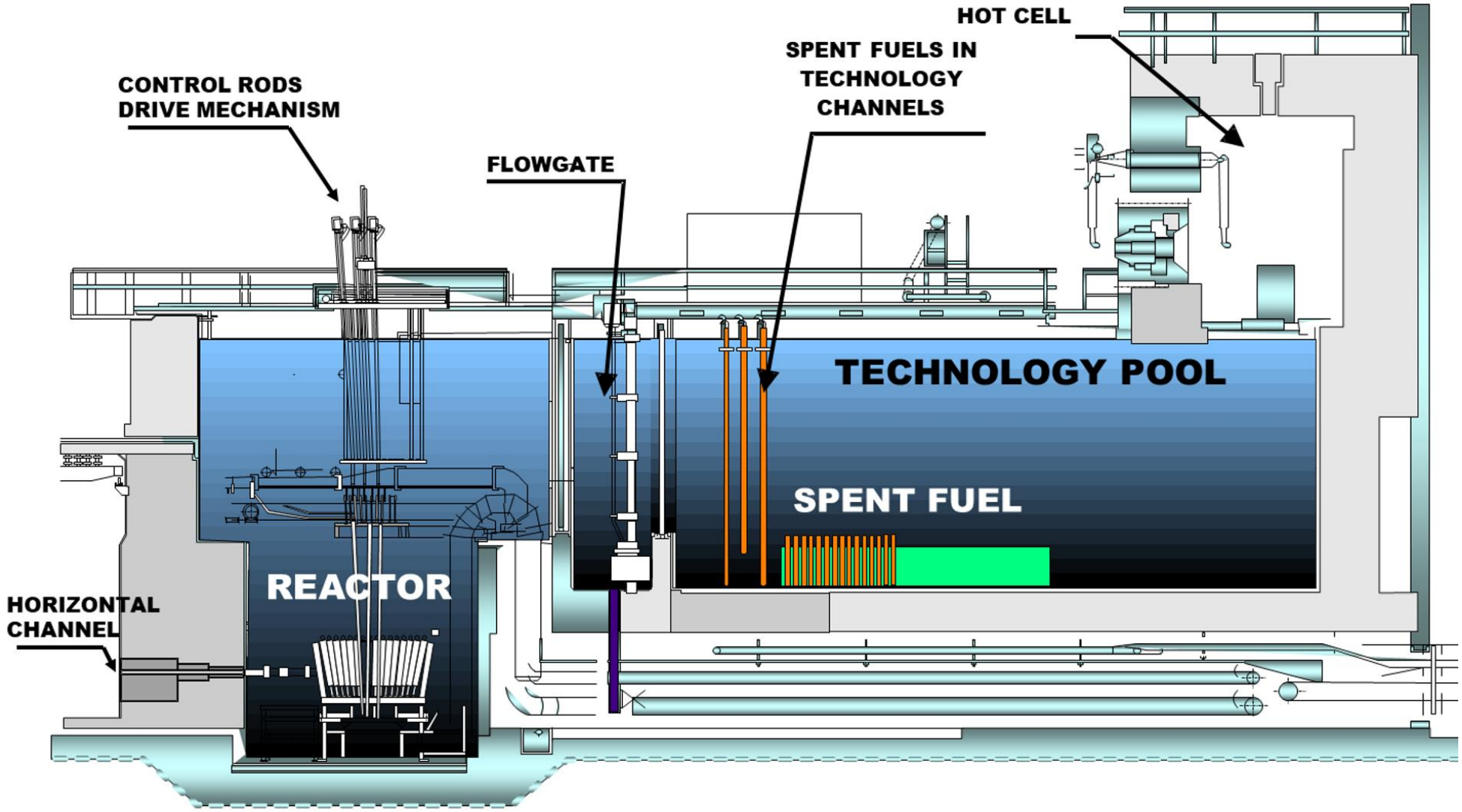
MARIA Reactor

Reactor type	pool-type reactor with pressurized fuel channels
Start operation	1974
Thermal power	Max. 30 MW,
Nominal power	19-26 MW
Fuel	MC-5 19,7 % 485 g U-235 U_3Si_2 MR-6 19,75 % 485 g U-235 UO_2-Al
Thermal neutron flux	$2{,}5 \times 10^{14}$ n/cm^2·s
Fast neutron flux	2×10^{14} n/cm^2·s
Moderator	H_2O; beryllium
Reflector	graphite

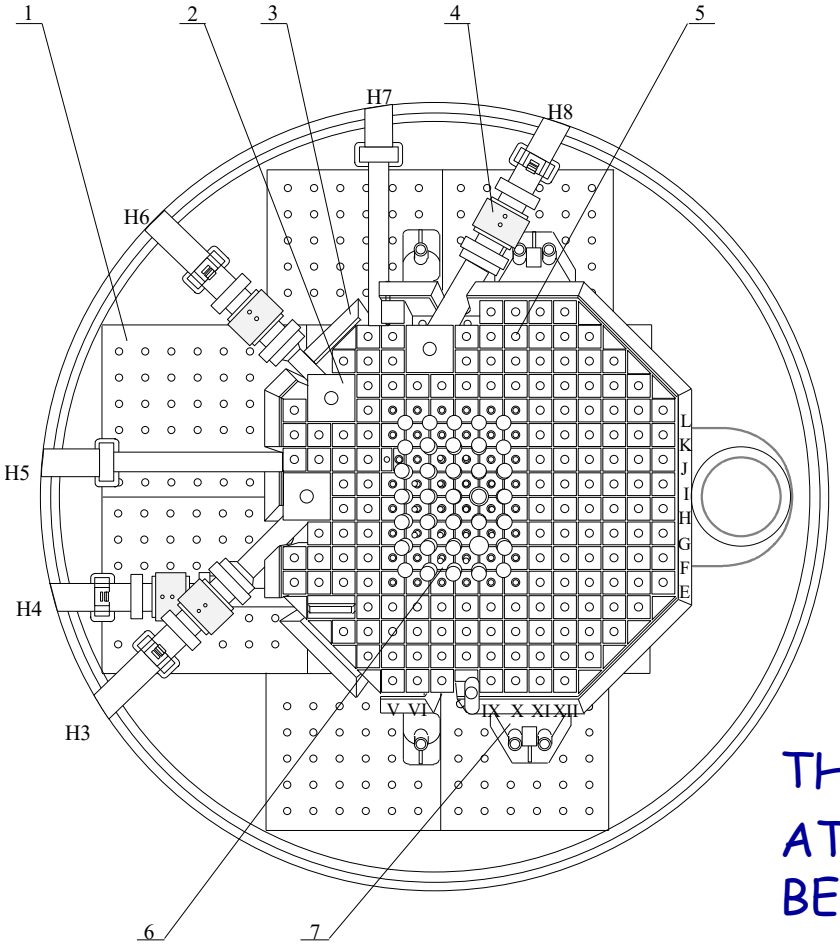
Current main reactor applications:

- production of radioisotopes,
- testing of fuel and structural materials for nuclear power engineering,
- neutron transmutation doping of silicon,
- neutron modification of materials
- research in neutron and condensed matter physics
- neutron radiography,
- neutron activation analysis,
- neutron beams in medicine
- training in the field of reactor physics & technology.

MARIA Reactor

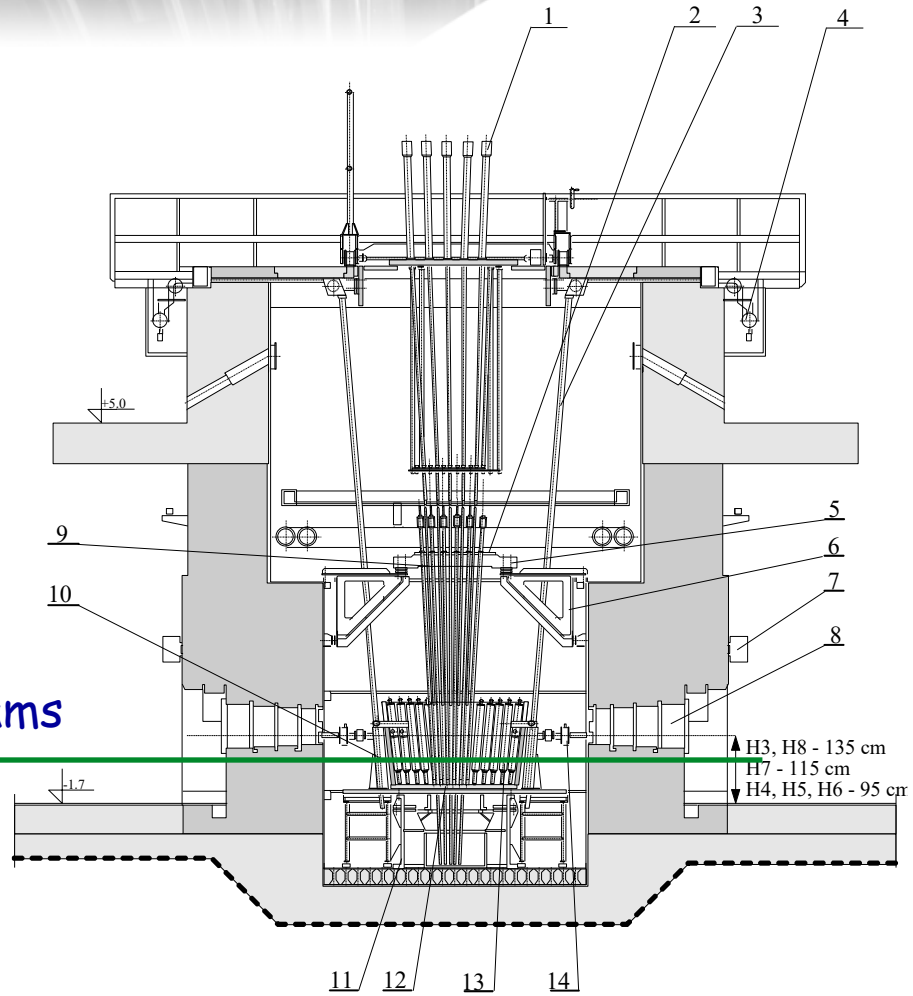


NRR MARIA cross-section



1. core and reflector support plate
2. multiple graphite block
3. reflector support structure
4. beam tube compensator joint
5. graphite reflector block
6. beryllium block
7. ionization chambers shield

Horizontal neutron beams



1. control rod drive mechanism
2. mounting plate
3. ionization chamber channel
4. ionization chamber drive mechanism
5. fuel and loop channels support plate
6. plate support console
7. horizontal beam tube shutter drive mechanism
8. beam tube shutter
9. fuel channel
10. ionization chambers shield
11. core and support structure
12. core and reflector support plate
13. reflector blocks
14. beam tube compensator joint

THERMAL NEUTRONS FLUX AT HORIZONTAL NEUTRON BEAMS OUTLETS

$4 \times 10^{9}\ cm^{-2}\ s^{-1}$

NARODOWE CENTRUM BADAŃ JĄDROWYCH ŚWIERK

Since 2021 the experimental hall @ MARIA NRR has been refurbished for five HZB thermal neutron instruments

MARIA NEUTRON LABORATORY MNL

Open access on the application competition

HZB MACHINES

E2 - Flat Cone Diffractometer,

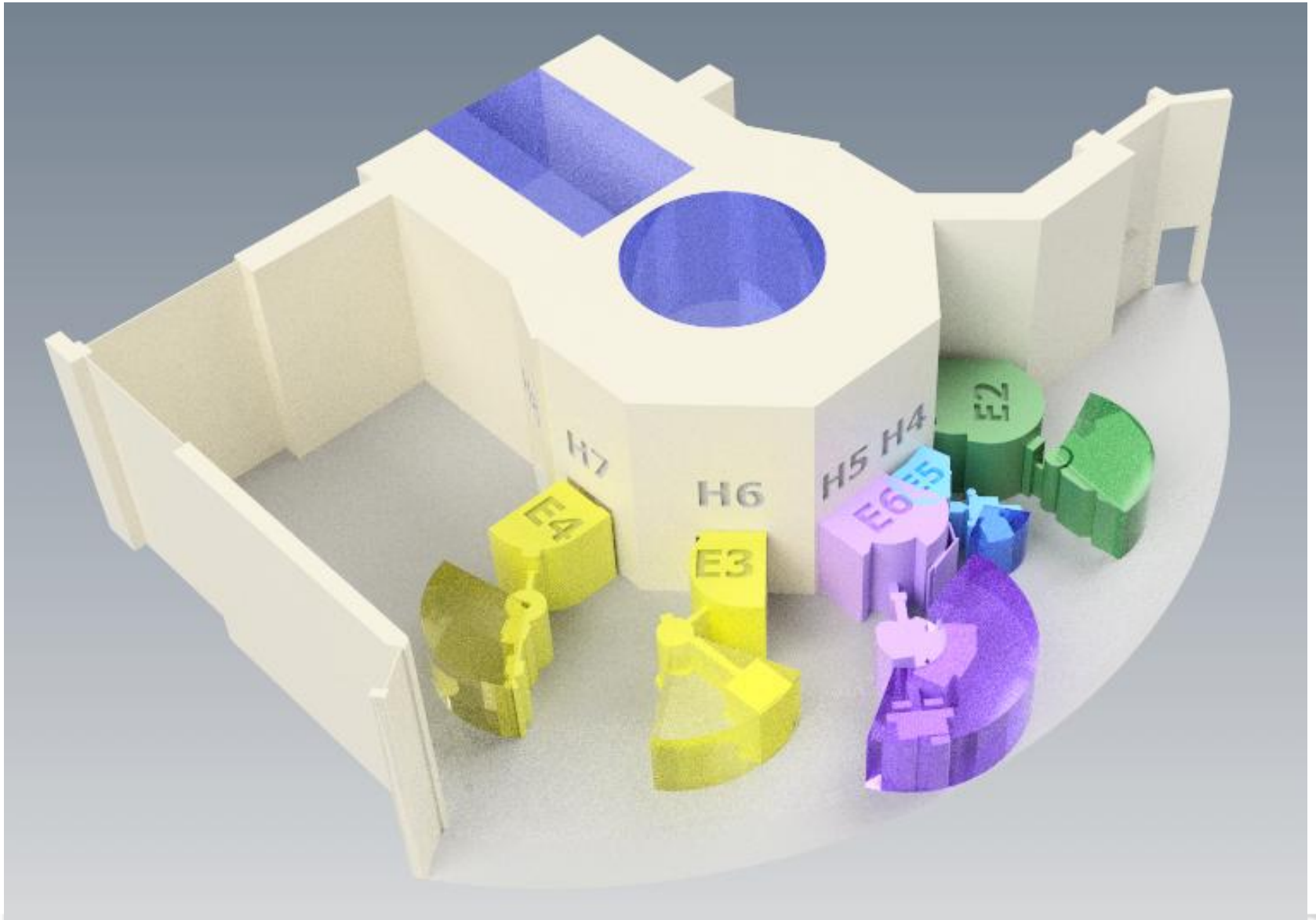
E3 – Residual Stress Analysis Diffractometer,

E4 – Two-Axis Diffractometer,

E5 - Four-Circle Diffractometer,

E6 – Focusing Diffractometer.

PLANNED ARRANGEMENT @ THE MARIA EXPERIMENTAL HALL



All diffractometers are equipped with 2-dimensional position sensitive He^3 neutron detectors and focusing monochromators

E2. Flat cone diffractometer
Monochromator, Cu (220), λ=0.91 Å Ge (311), λ=1.21 Å, PG (002), λ=2.41 Å; 4 x 2D PSD 30 x 30 cm

E3. Diffractometer for Microstructure and Residual Stress Analysis
Monochromator Si (400), Double focusing, λ = 1.48Å; 2D PSD 30 x 30 cm

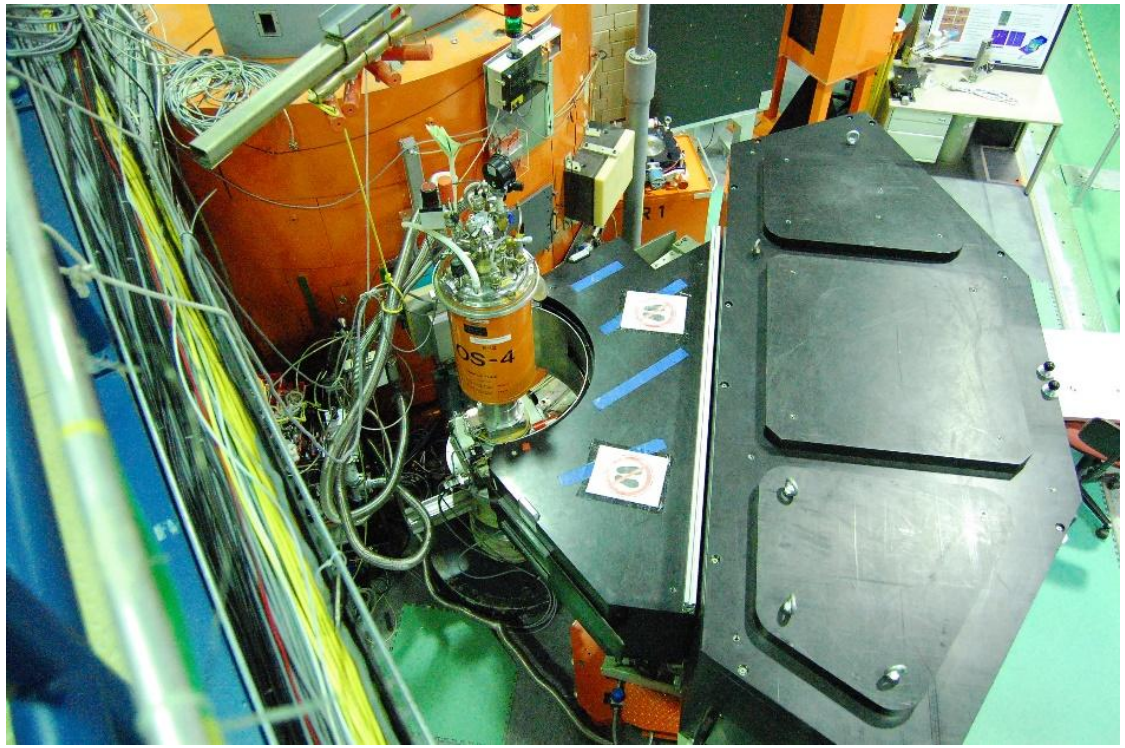
E4. Two-Axis Diffractometer.
Monochromator PG (002): λ = 2.4Å or Ge (113): λ= 1.2Å; 2D PSD 20 x 20 cm

E5. Four-Circle Diffractometer.
Monochromator Cu(220); λ = 0.9Å or PG(002), λ=2.4Å, PSD 9 x 9 cm

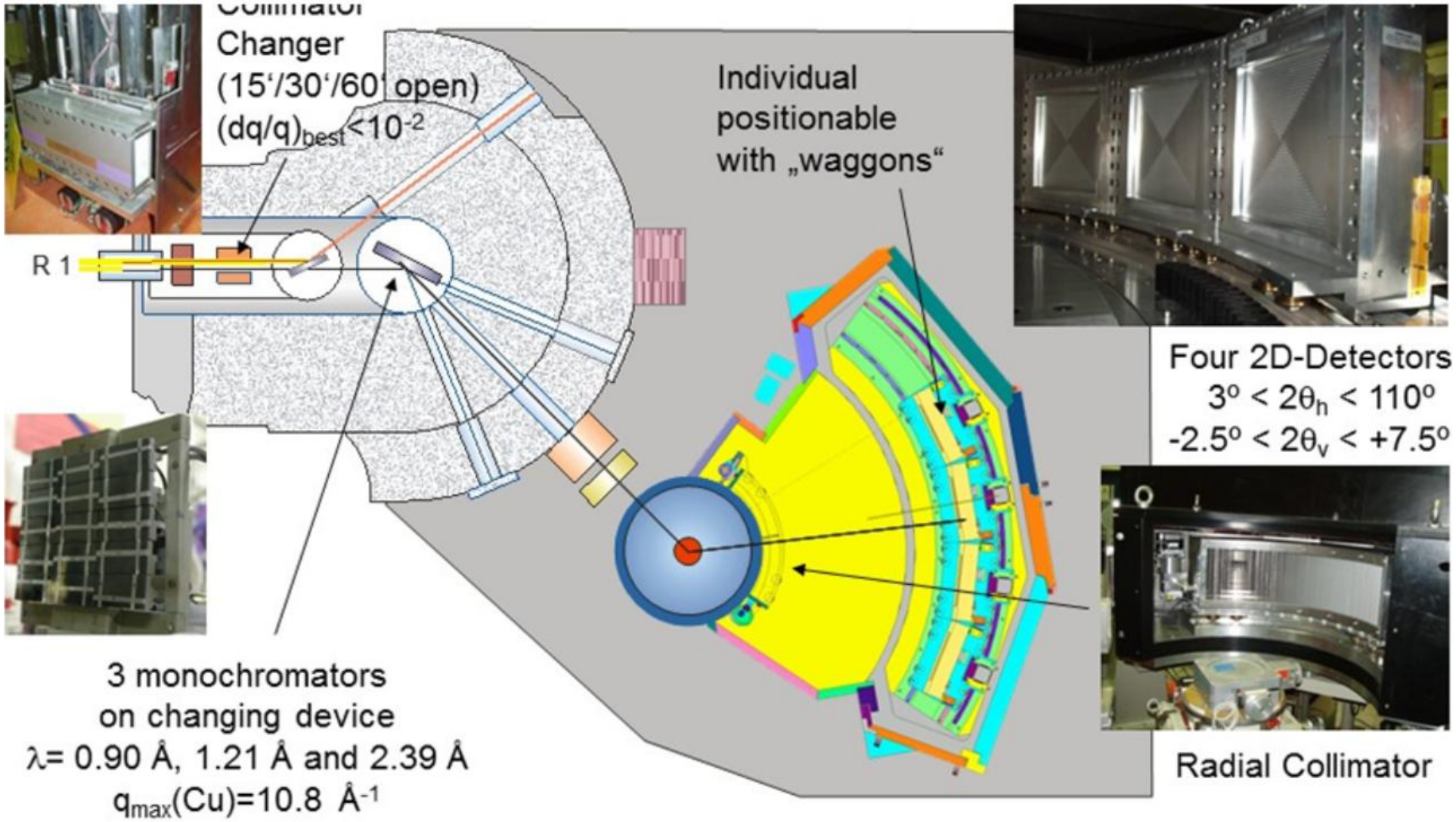
E6. Focusing Diffractometer.
Monochromator PG (002) λ = 2.4Å double focusing, two 2D PSD each 30 x 30 cm

E2 diffractometer
Possiblity of tilting the detector from the horizontal scattering plane

- *A 3-dimensional part of the reciprocal space can be scanned in less than five steps by combining the “off-plane Bragg-scattering” and the flat-cone layer concept while tilting axis of the detector bank.*
- *Parasitic scattering from cryostat or furnace walls is reduced by an oscillating „radial“ collimator.*

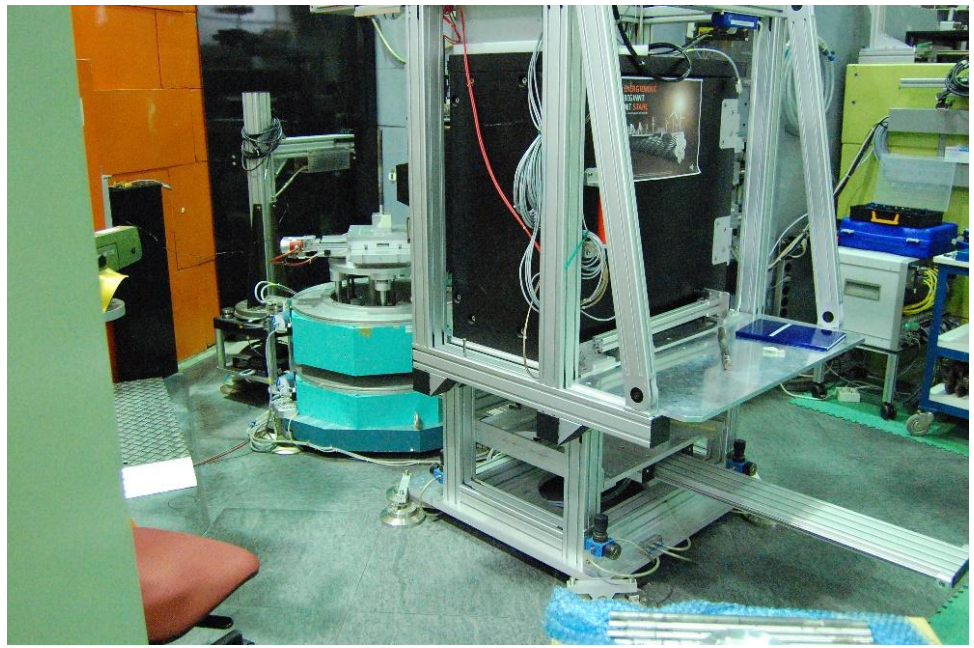


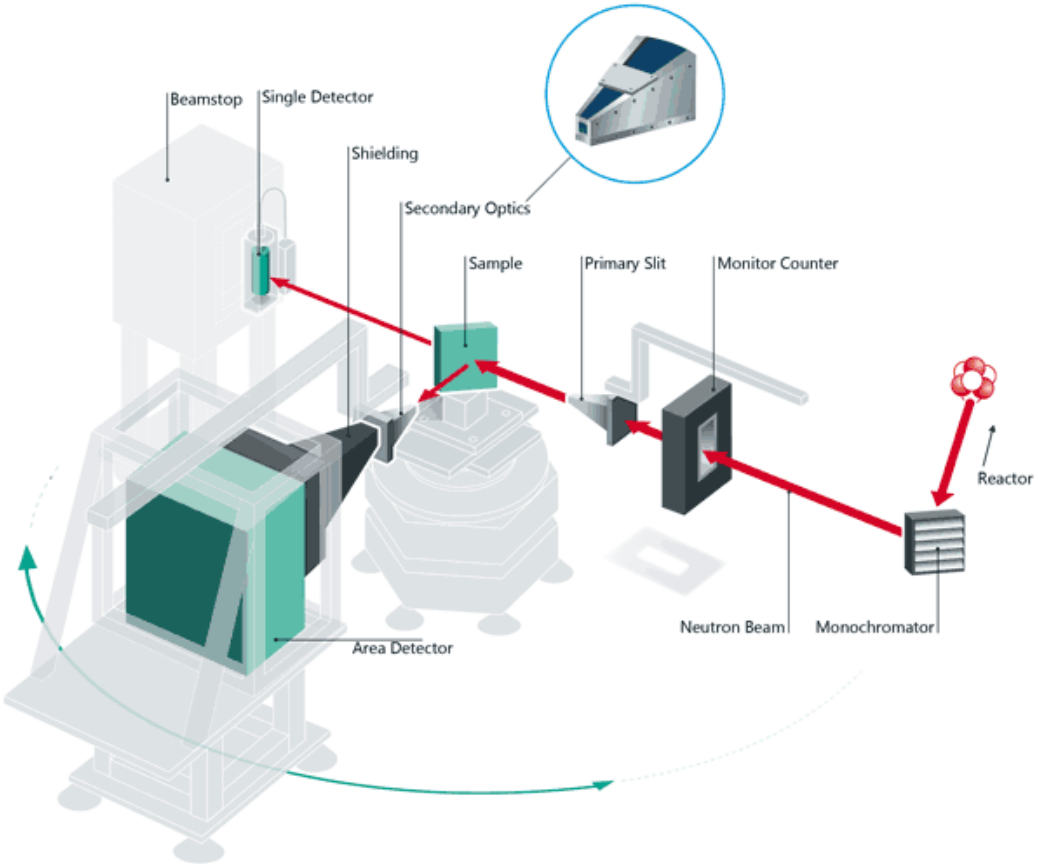
E2 diffractometer



E3 diffractometer for internal stress studies in macroscopic elements

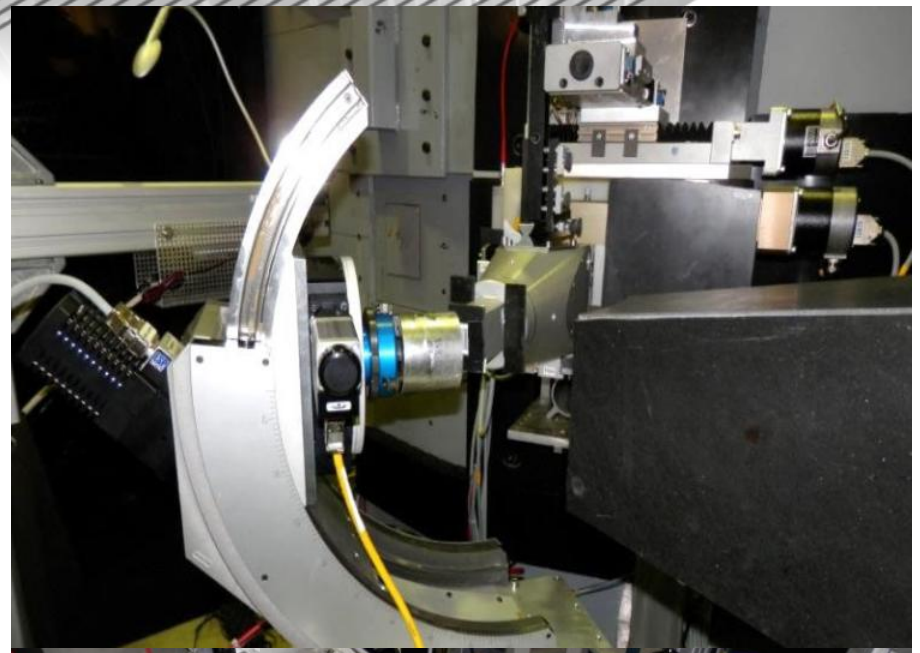
- *The diffractometer is designed for strain and stress analysis for simple geometric samples as well as for industrial applications and heavy components of arbitrary shape.*
- *The diffractometer itself consists of two big omega circles (Ω and 2Θ) with a diameter of 800 mm and upon a translation table (xyz-direction) for sample positioning in vertical and horizontal direction.*

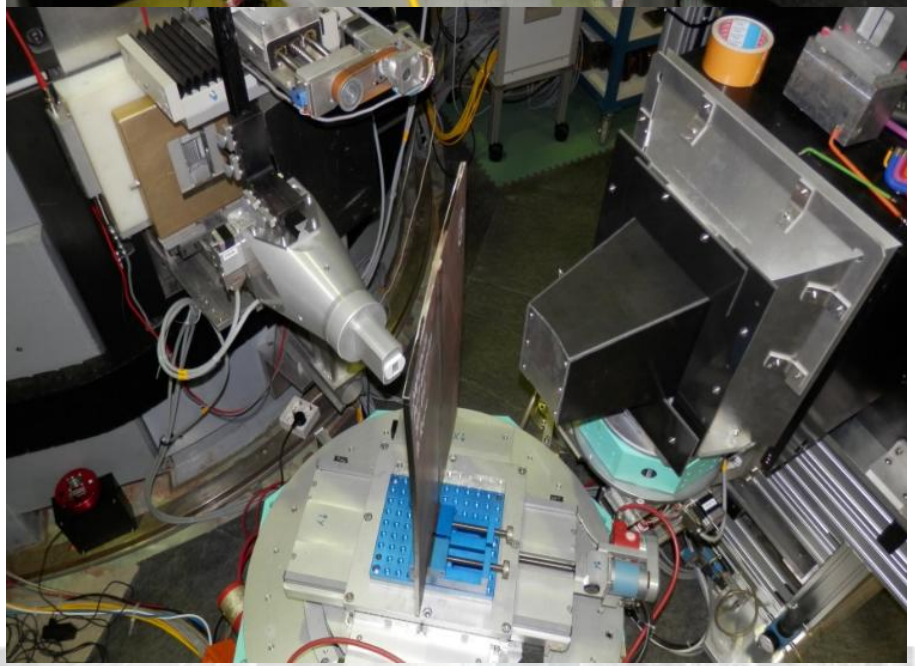




DOI: 10.17815/jlsrf-2-126

E3 diffractometer





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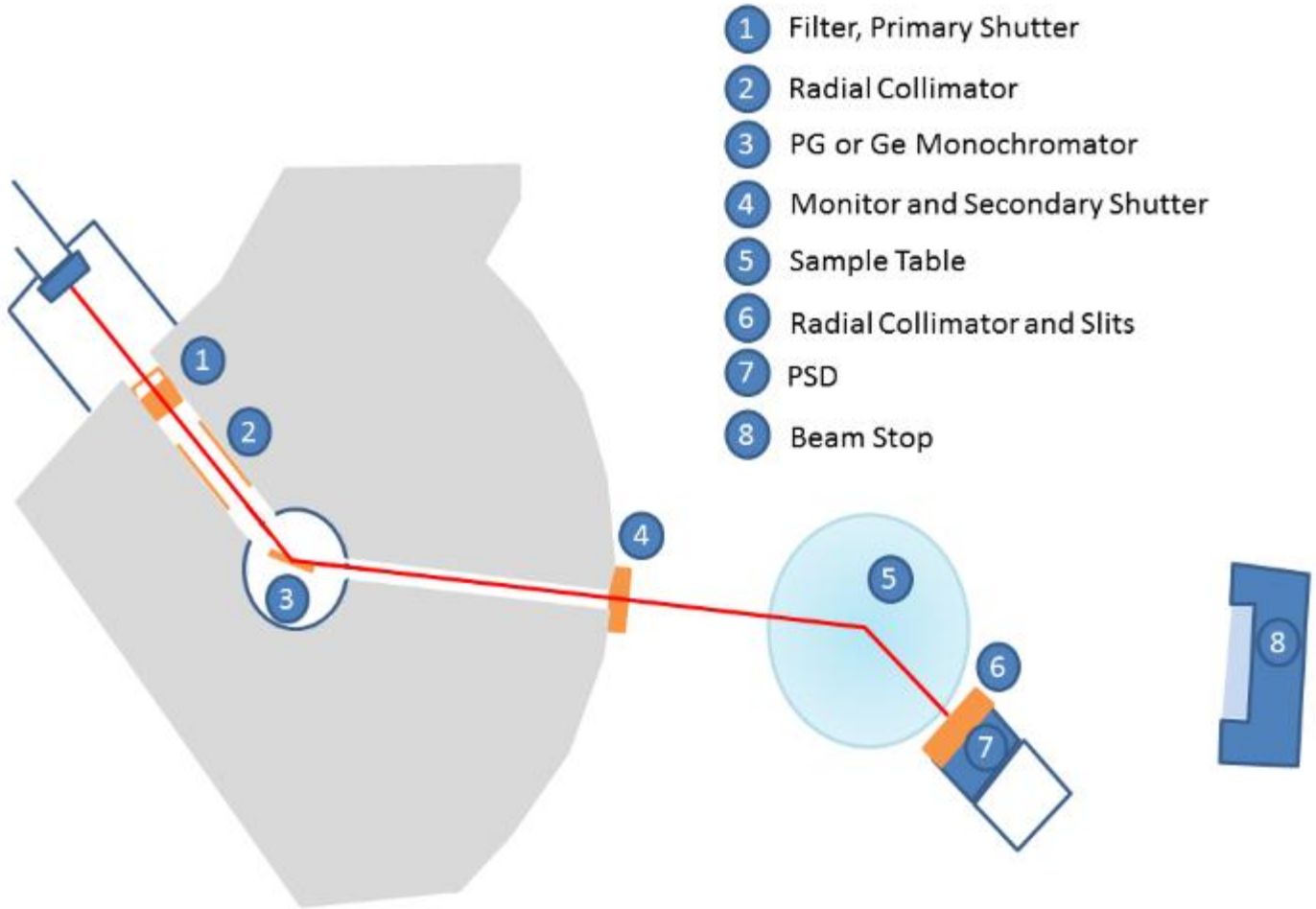
E4 diffractometer

The instrument is primarily suited for magnetic structure determination under various conditions, which includes:

- magnetic fields,
- low temperatures,
- pressures.

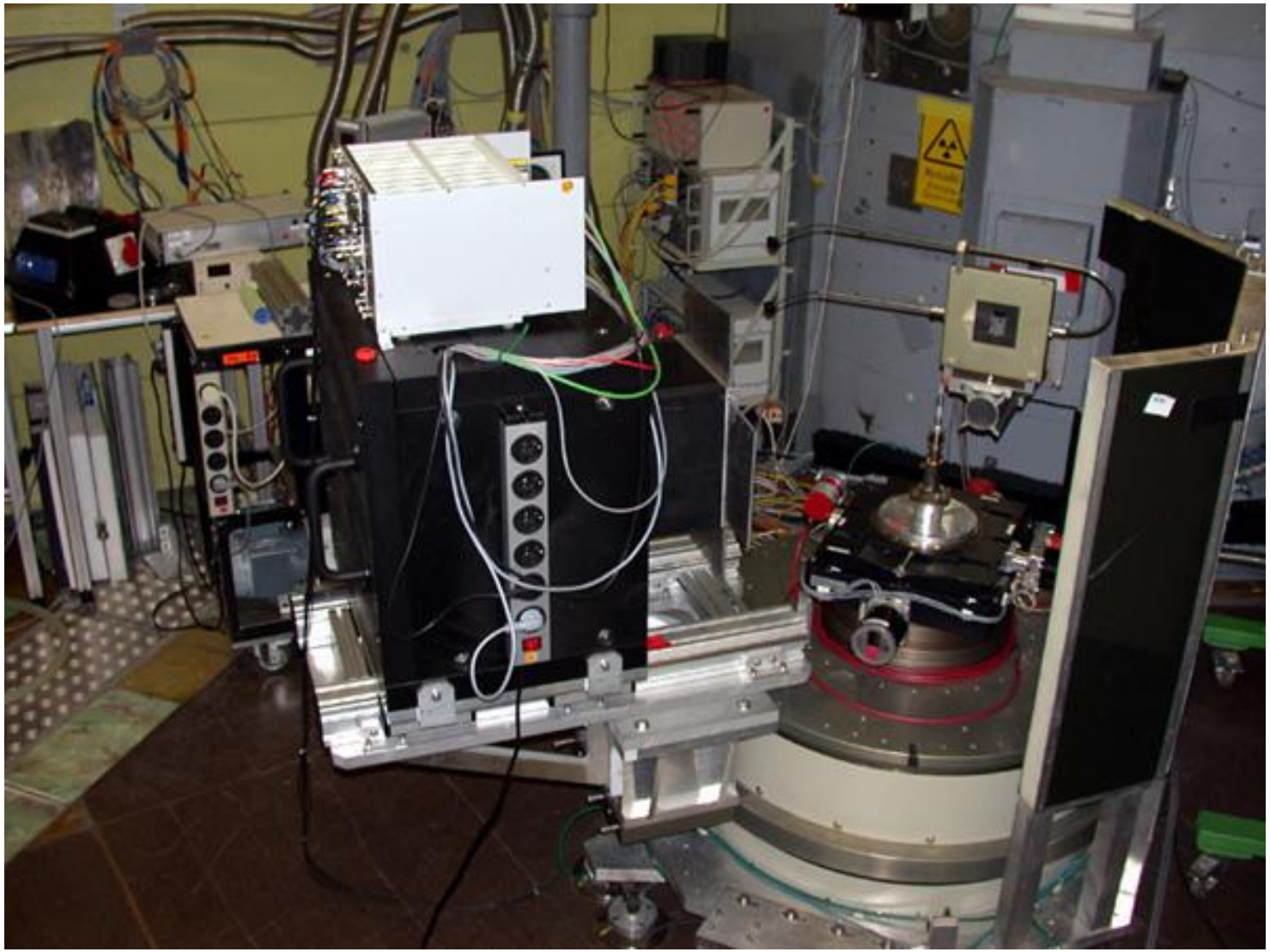
The most common application is to reveal spatial arrangement ordered spin structures.



E4 diffractometer

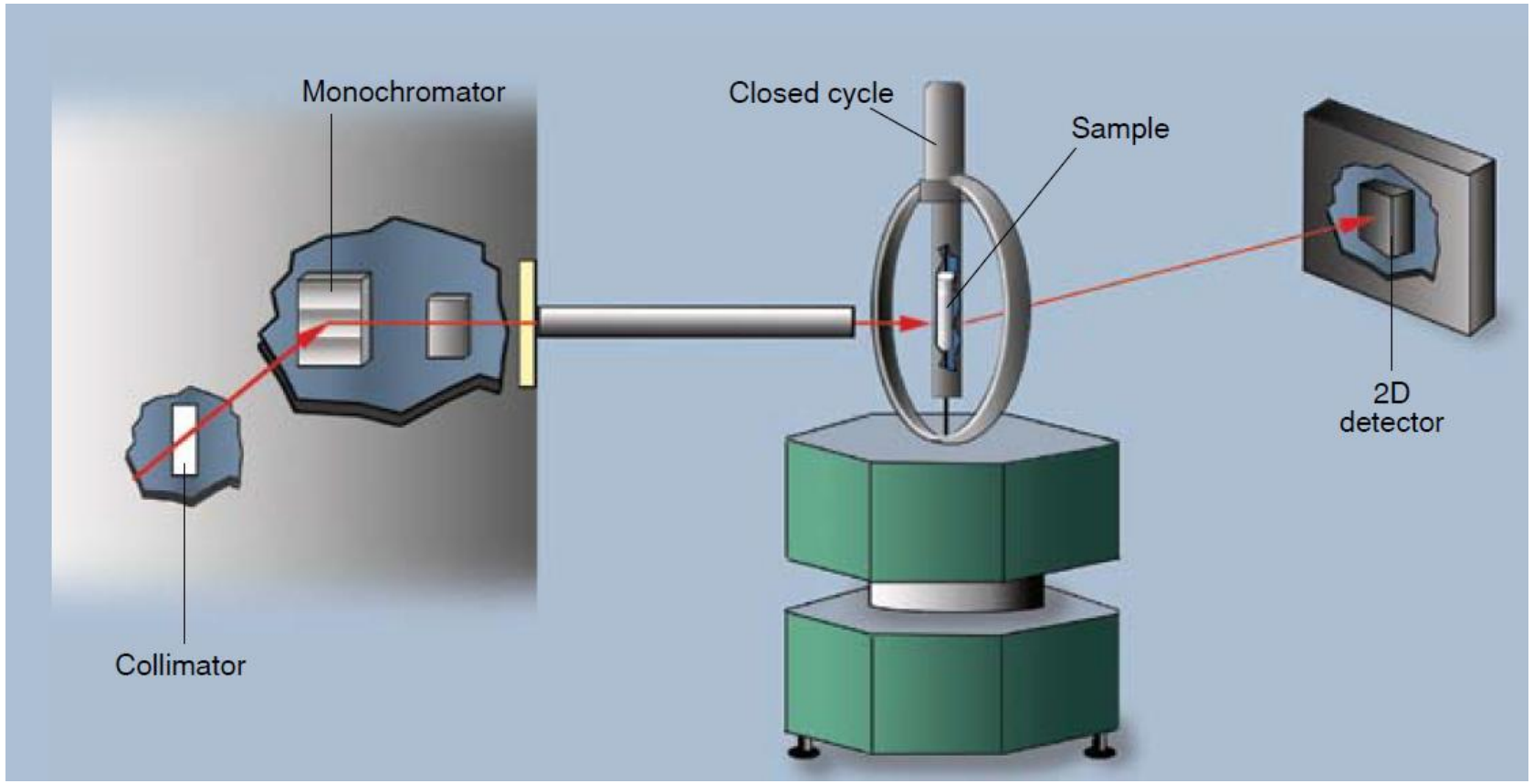
Applications:

- Magnetic structure determination
- Study of magnetic and structural phase transitions
- Determination of magnetic phase diagrams
- Study of critical points as a function of magnetic field and temperature
- Measurement of correlation functions above the ordering temperature



E5 diffractometer

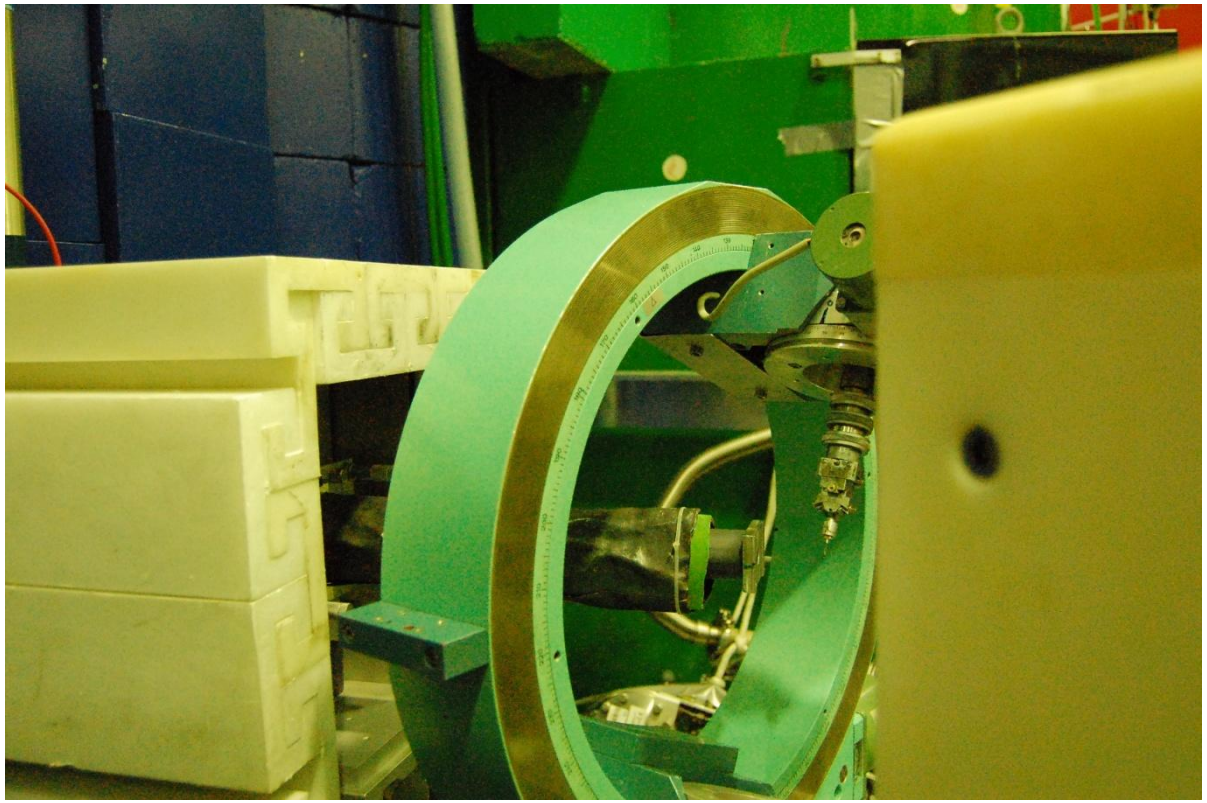
- E5 is a conventional four-circle diffractometer.
- The instrument is equipped with a two-dimensional position sensitive 3He-detector.
- The monochromator take-off angle is fixed at 42°.
- The instrument setup is ideal for the determination of crystal and magnetic structures.

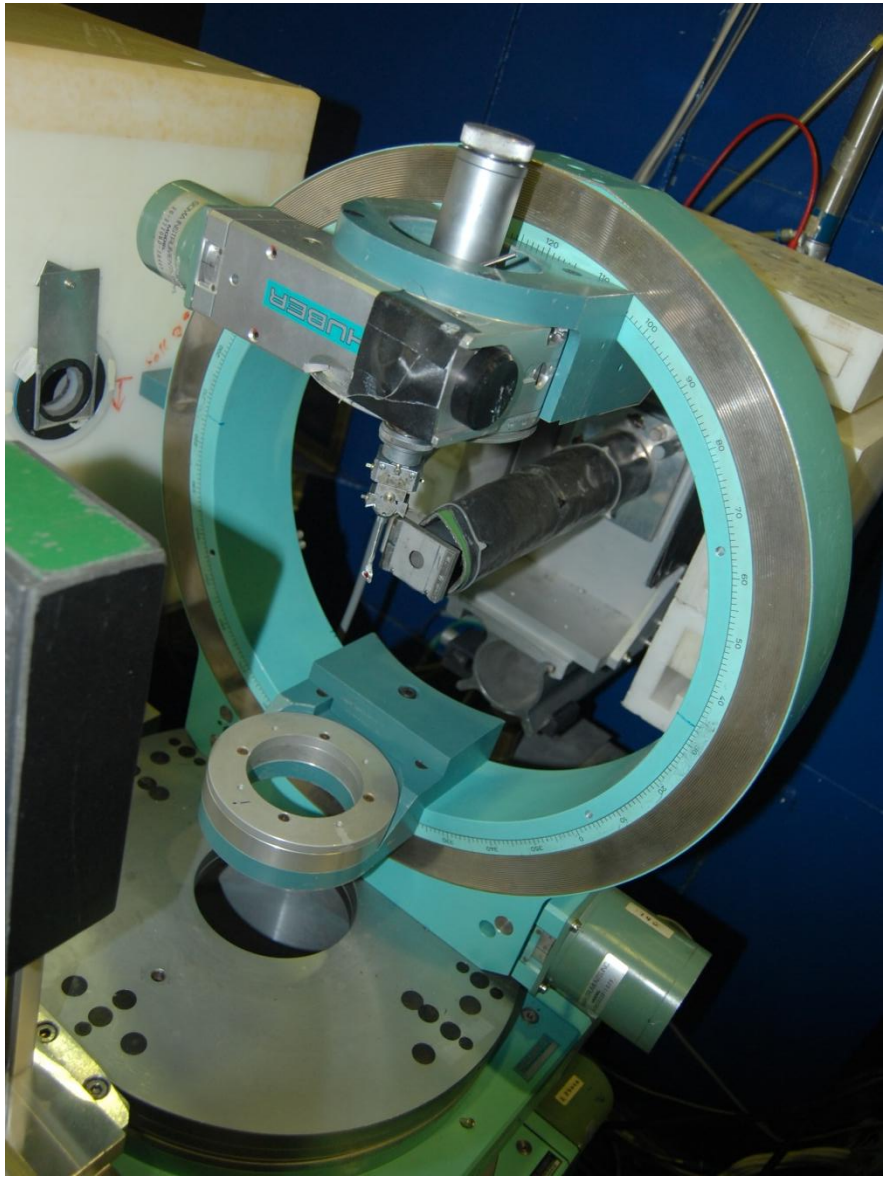


E5 diffractometer

Applications

- investigation of crystal structures of molecular, ionic or intermetallic systems
- determination of positional and thermal parameters of light atoms (H, D or Li)
- complex magnetic structures (especially to deduce weak magnetic components)
- structural and magnetic phase transitions (interplay between structural changes and physical properties)



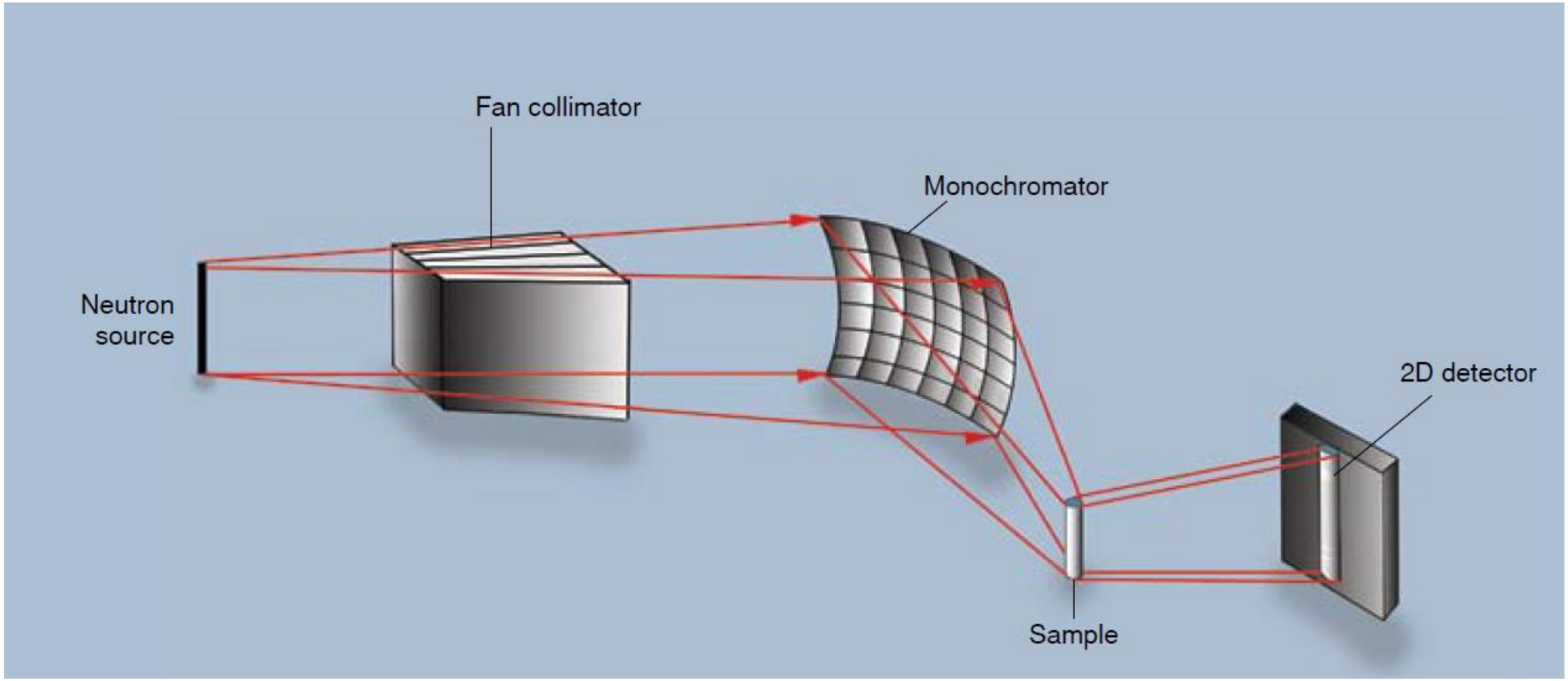


E6 uses a horizontally and vertically bent monochromator and an in-pile fan collimator.

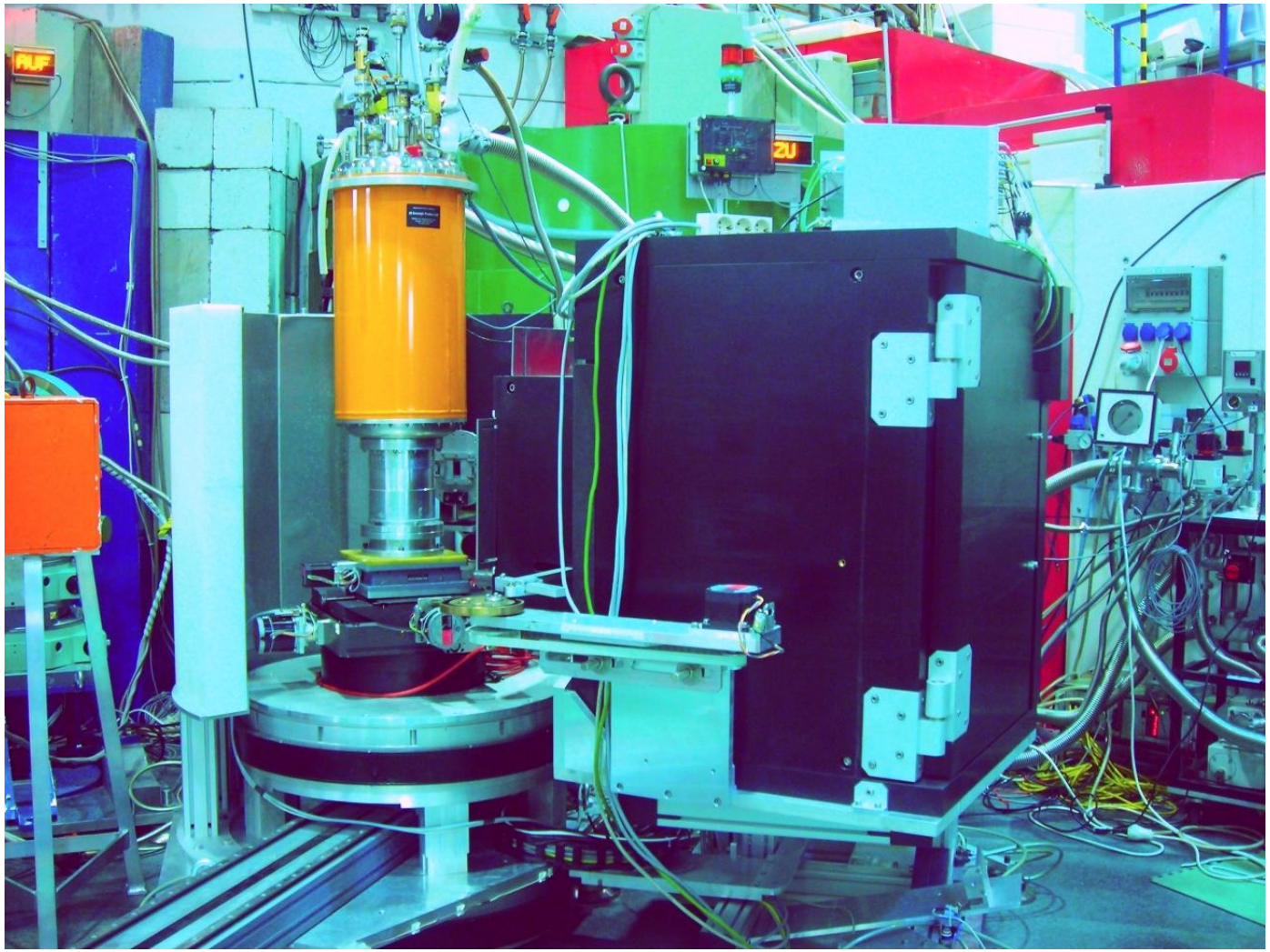
The fan collimator imitates a vertical slit with adjustable distance to the monochromator.

This diffraction geometry achieves a focusing in reciprocal space.

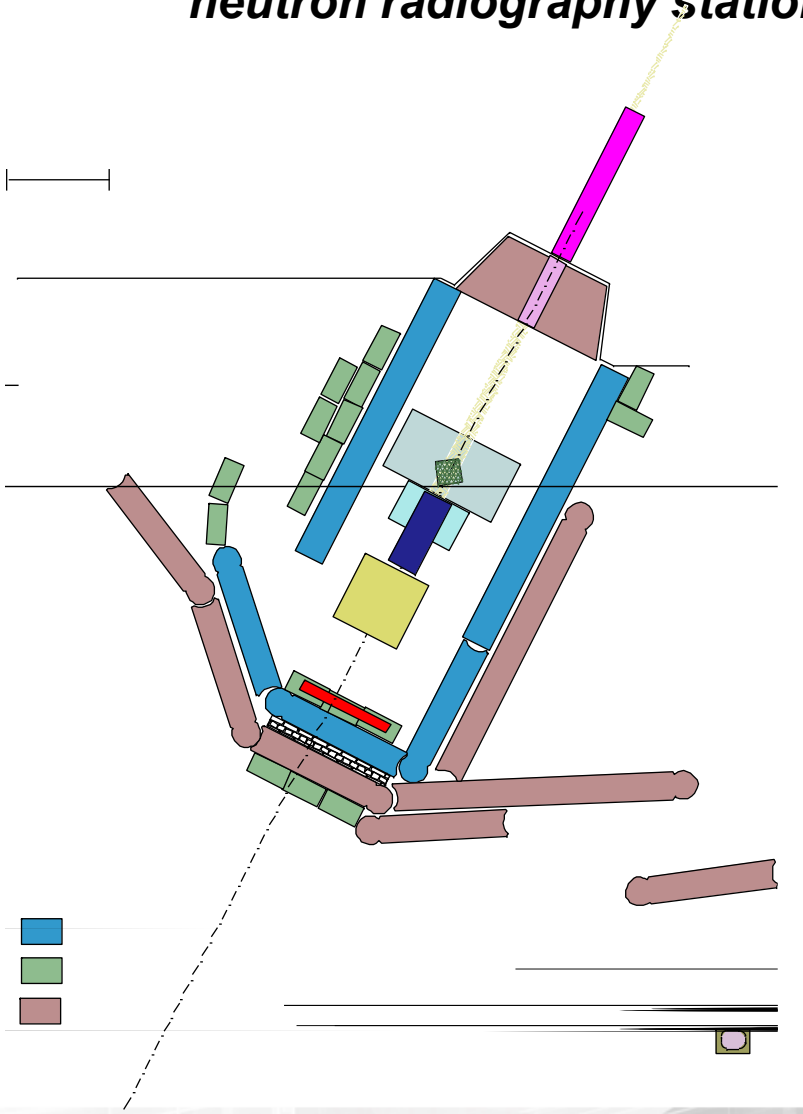
At medium resolution, the neutron flux is increased by a factor of two compared with diffractometers that use standard Soller collimators.



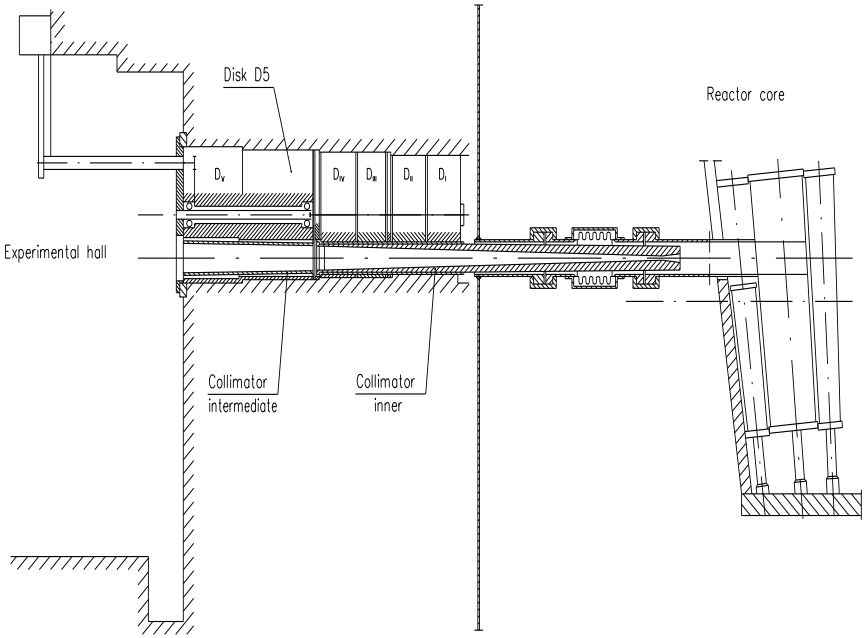
E6 diffractometer



H8
neutron radiography station

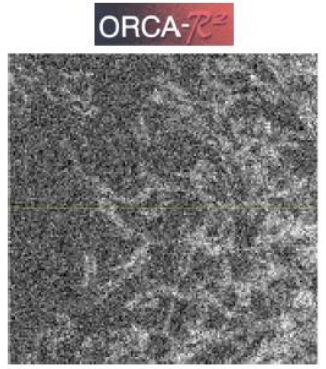


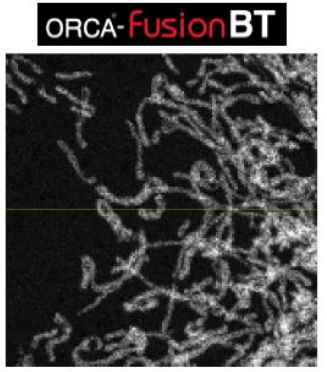
Collimators



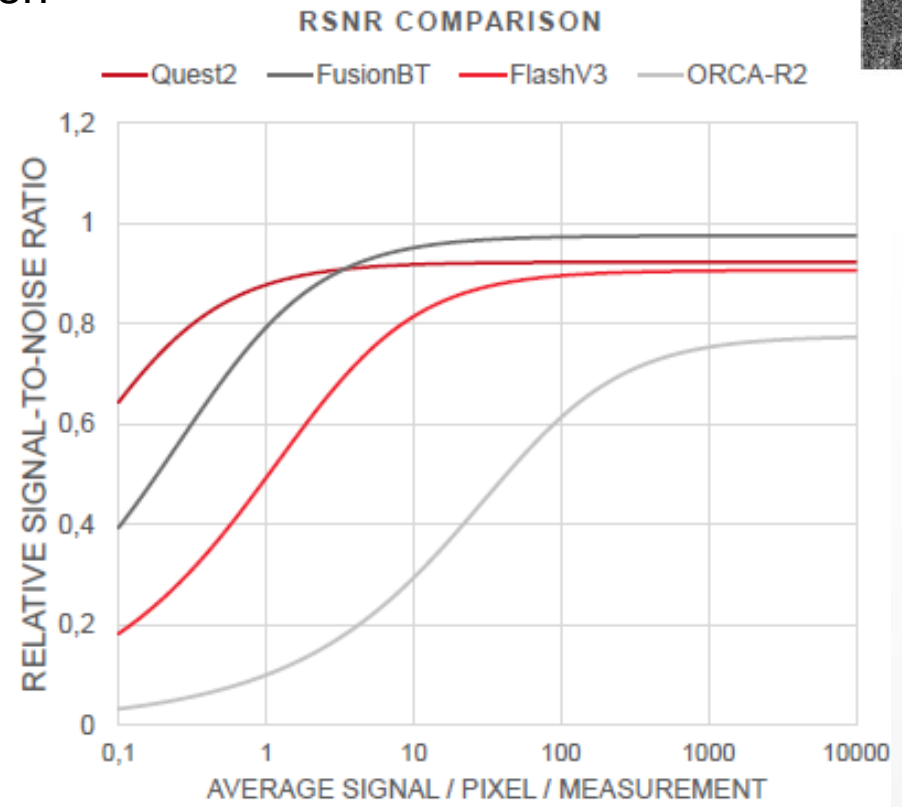
Neutron radiography station upgrade -

- Camera CMOS Hamamatsu ORCA Fusion BT
- PC Dell Precision 5860 Inter Xeon W3
- Motorized rotary stage Standa 8MR190 with a resolution better than 15’’
- Precision mirror and luminescent screen





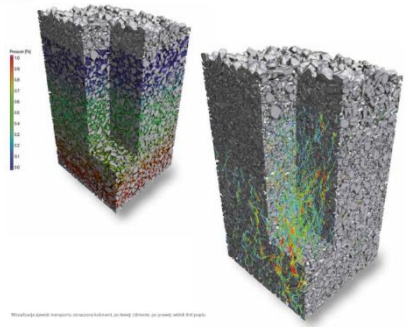
Feature	ORCA-R2	ORCA-Fusion BT
Sensor type	Interline CCD	Back-illuminated sCMOS
Sensor size	10,9 mm diagonal	**22 mm diagonal**
Pixel size	6.45 µm	6.5 µm
Resolution	1344 × 1024	**2304 × 2304**
Peak QE	~60%	**95%**
Read noise	~6–8 e^-	**0.7 e^- (UQ mode)**
Dark current	**0.0005 e/px/s**	1 e/px/s
Max frame rate	~16 fps (full frame, no binning)	**89 fps full frame**

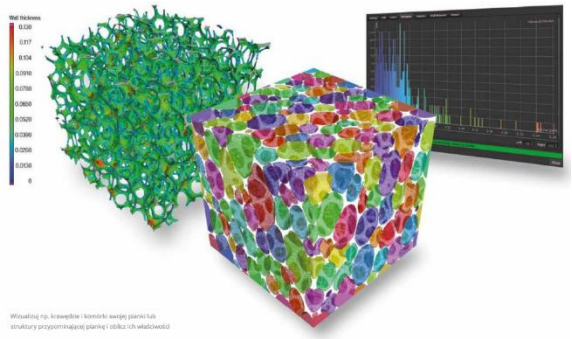


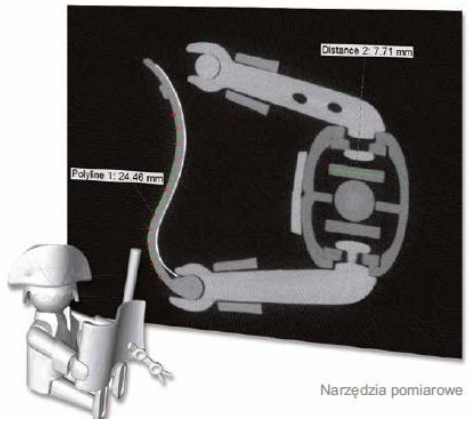
https://www.hamamatsu.com/

Neutron radiography station upgrade - 3D analysis and visualisation

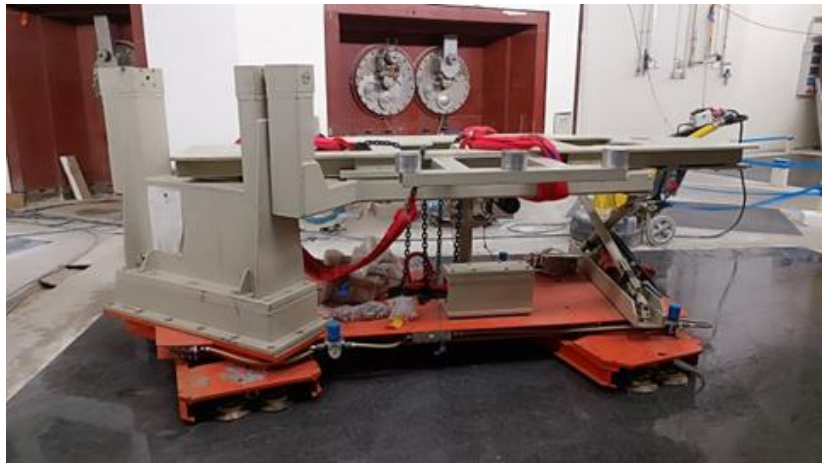
Module / Feature	VGSTUDIO	VGSTUDIO MAX
CT volume visualization (rendering, slicing, ROI)	✔	✔
Basic measurements (distances, angles, profiles)	✔	✔
Wall Thickness Analysis (basic)	✔	✔
Porosity / Inclusion Analysis (basic)	✔	✔
Coordinate system alignment	✔	✔
Basic reporting	✔	✔
Nominal/Actual Comparison	✘	✔
Coordinate Measurement (3D metrology, GD&T)	✘	✔
Defect Analysis (advanced porosity/inclusion analysis)	✘	✔
Material Analysis – Fiber Composite	✘	✔
Material Analysis – Foam Structure	✘	✔
Structural Mechanics Simulation (FEA-based)	✘	✔
Automated inspection (macros, scripting)	✘	✔
VGinLINE compatibility (production automation)	✘	✔
Advanced reporting (templates, automation)	✘	✔
Batch processing	✘	✔
Multi-material segmentation	✘	✔
Tool Correction / Manufacturing Geometry Correction	✘	✔
Additive Manufacturing Analysis	✘	✔
Advanced visualization (e.g., Volume Rendering Pro)	✘	✔







https://volumegraphics.hexagon.com/



Pressurized air, He recovery, cooling water, N_2 and He installations

- **Equipment orders**

- **Dyfraktometers**

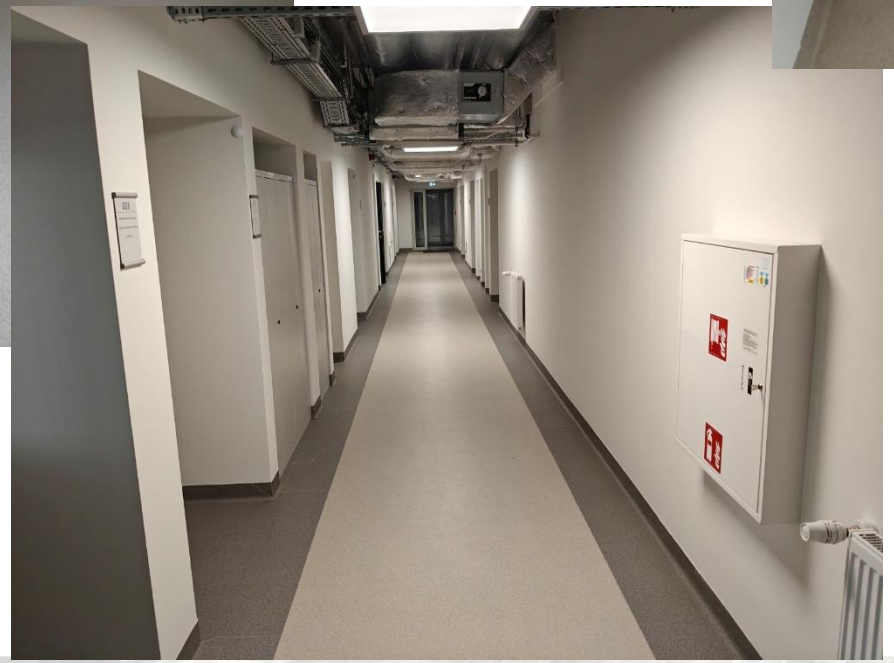
• New dancing floor - Sintered Stones

- *Chemical resistance*
- *Good Durability*
- *Resistance to high and low temperatures*
- *Resistant to water*
- *Resistant to scratches*

- **New shieldings**

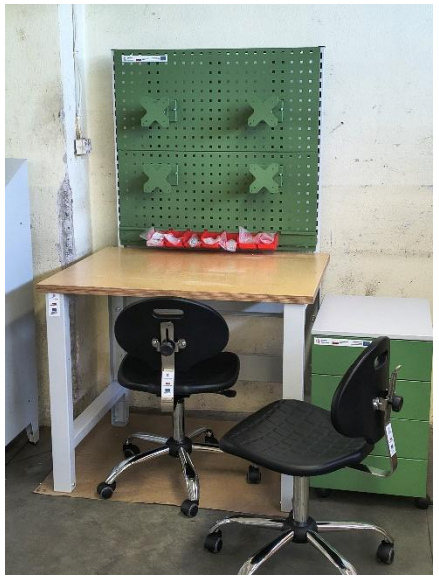
• New recovery and liquefaction helium station

- **Modernized rooms**



• New furniture











National Recovery and Resilience Plan (KPO): MNL Maria Neutron Laboratory

Eligible expenses: *25 124 047,06 PLN*
Funding: *19 830 000,00 PLN*

- *Helium recovery and liquefaction station*
- *Liquid helium and nitrogen dewars*
- *Adaptation of shields*
- *CEPH based reliability cluster for storing measurement data*
- *Control and for processing results computers, industrial computer for detectors*
- *Software*
- *Modernization of the radiography station*
- *Radiation protection equipment*
- *Modernization of rooms for MNL in the LBM building*

KRAJOWY PLAN ODBUDOWY

Rzeczpospolita Polska

Sfinansowane przez Unię Europejską NextGenerationEU

Materials Research in NCBJ: main objectives

- ***Develop high-quality scientific research while maintaining the ability to act as an expert for government institutions***
  - *Scientific publications, research grants, international collaborations, doctorates, habilitations **BUT** also maintaining accreditations, certificates, equipment and competences necessary for technical expertise*

- ***Position as an attractive partner in broad cooperation rather than a "lone wolf" competitor***
  - *Specialization in areas where our partners have limited competences (in-situ analyses at high temperatures, ion-neutron comparison), flexibility in work planning, effectiveness in acquiring new projects*

- ***Obtaining a stable position as an expert organization in the Polish Nuclear Power Plant Program***
  - *Ability to test materials for nuclear applications, including test samples from reactor, qualification of structural materials and components,*

- ***Close collaboration with Polish industry***
  - *Supporting the industry in performing the necessary material tests (e.g. material composition, material strength, fracture toughness, thermal properties, non-destructive tests, sample miniaturization, weld joint strength in accordance with ASME NQA 1, CEN 64 workshop etc.),*

The Materials Research Laboratory / NOMATEN CoE capabilities:

- *14 Hot Cells for structural materials*
- *NDT testing of materials and welded joints with accredited procedures*
- *Macro- and microstructure characterization and metallographic analyses with LM, SEM and TEM techniques*
- *X-ray diffraction phase analysis*
- *Mechanical testing of materials with accredited procedures*
- *Nanohardness testing*
- *Thermal properties testing*
- *Chemical composition and elemental analysis*
- *Synthesis of PVD layers and coatings*
- *Analysis of thin layers and coatings with Raman spectroscopy*
- *Surface modification of materials with Ion implantation techniques*
- *Engineering consulting in the field of Materials Science, Surface Engineering, Corrosion Science, Heat Treatment Technologies of metals and alloys….*

Nuclear and Conventional Power Industry

Tooling Industry

Aerospace Industry

Automotive Industry

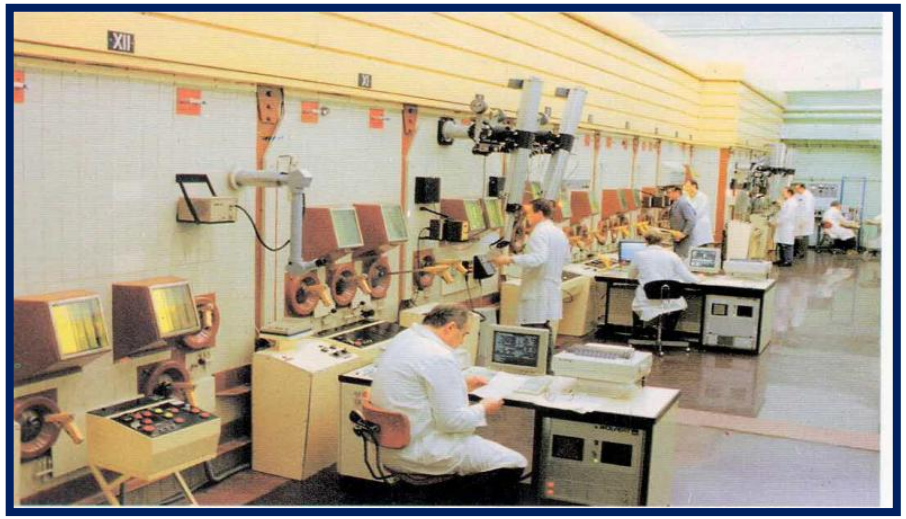
Biomaterials and Implantology

Oil and Gas Industry

NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

NOMATEN
Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

Materials Research Laboratory
Hot Cells



Ability to test the radioactive samples coming from nuclear reactors:

- Transfer of the samples from reactors to hot cells
- Cutting, polishing etc
- Analysis of mechanical properties

NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

NOMATEN
Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

Materials Research Laboratory
Non Destructive Testing – NDT Services

Non-Destructive Testing NDT Division – Research Infrastructure

The non-destructive testing division carries out tests with using following methods:

- Visual test method (VT)
- Penetration testing method (PT)
- Magnetic particle method (MT)
- Ultrasonic method (UT)
- Eddy current method (ET)
- Magnetic permeability testing

NDT Testing Research Infrastructu

UT Defectoscope Olympus OMNISCAN MX2

ET Defectoscope Olympus NORTEC 600D

Foerster MAGNETOSCOP 1.069

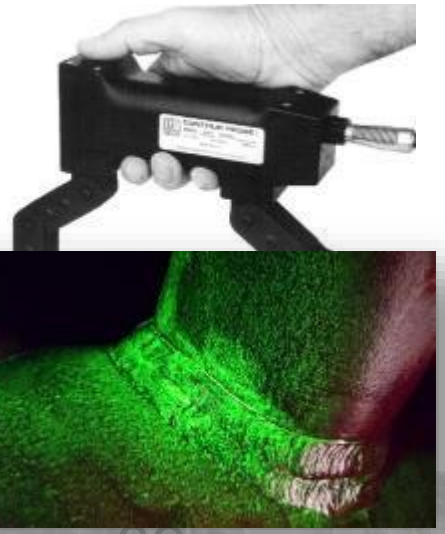
Accredited NDT Testing
Polish Centre for Accreditation
Accreditation number AB 025

AB 025

Financed by
PROJECT HTGR

VT Flexible Videoendoscope
Mentor Visual iQ - Waygate Technologies

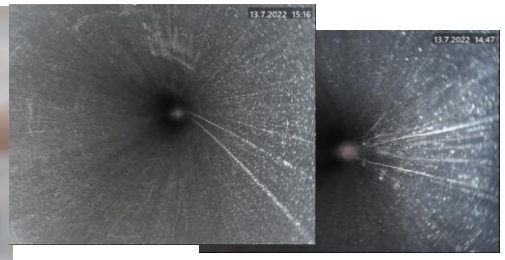
Penetrant method

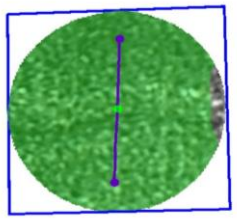


Magnetic particle method

Non-Destructive Testing NDT Division – NDT Expertise works and testing

AISI 316L seamless pipes NDT testing for ITER Blanket System components (First wall panels cooling system) – commissioned by ITER's supplier BIMO TECH





Accredited NDT tests realized according to:

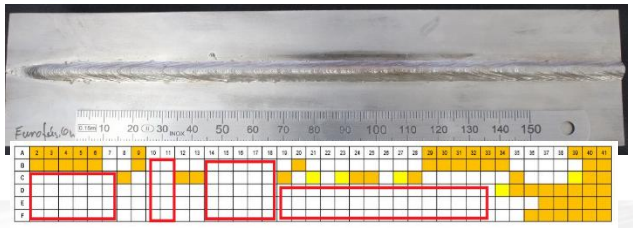
X2CrNiMo17-12-2, (AISI 316L) First Wall Panels for ITER Blanket System Specification

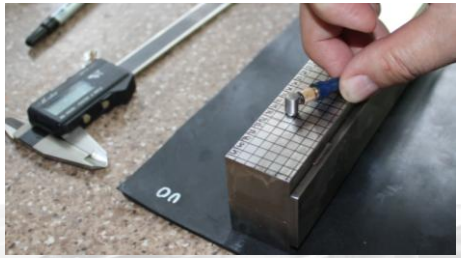
***Visual Testing VT** – visual inspection outer / inner surface*
***Ultrasound thickness test UTT** – wall tchickness*
***Direct meaurements** – pipes dimensions*

Magnetic Permeability Test according to IEC 60404-15 and ASTM A342M

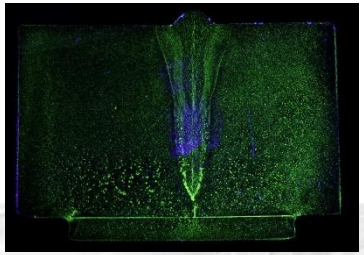
Cold drawing effects depth measurements Analysed by VT Flexible Videoendoscope

EUROFER 97 after Electron Beam Welding NDT testing in cooperation with Karlsruher Institut für Technologie





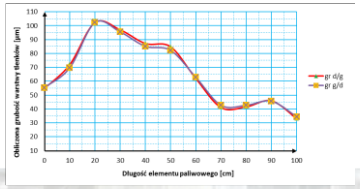
Ultrasound testing UT



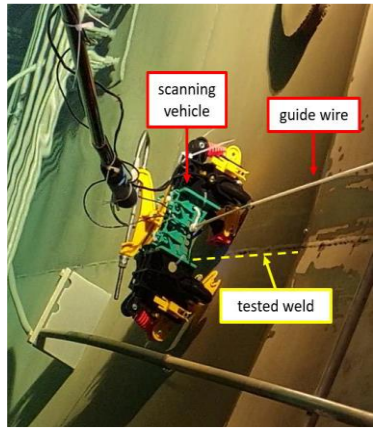
Magnetic particle inspection MT

MARIA Reactor NDT Inspections

Welded joints on secondary circuit piping with UT, VT, MT



Thickness evaluation of Al_2O_3 layer of the fuel element shells, Eddy Current Testing



VT, UT reactor pool weld joints inspection

MARIA reactor weld joints UT scanning vehicle designed by Reactor and MRL engineers

NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

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Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

Materials Research Laboratory
Mechanical Testing Services

Mechanical Testing Division – Research Infrastructure

Accredited Mechanical Testing
Polish Centre for Accreditation
Accreditation number AB 025

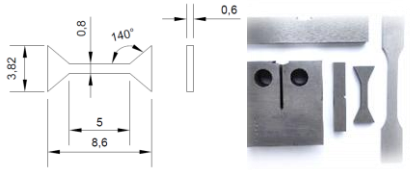
AB 025

Materials hardness testing at micro- / nanoscale

Semi-automatic Zwick/Roell DuraVision G5 hardness tester

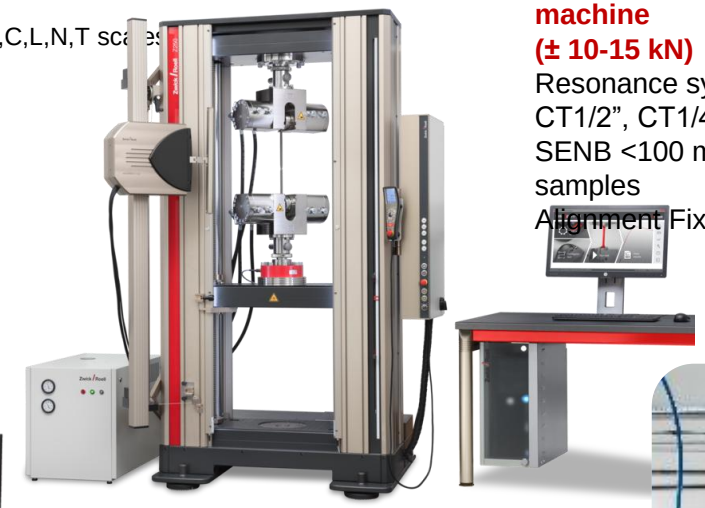
- Low-load hardness testing
- Load range 0.3-250 kg
- Brinell HB according to ISO 6506 (ASTM E10 2.5/5 mm ball
- Vickers HV according to ISO 6507 (ASTM E-92)
- Rockwell HR.. according to ISO 6508 (ASTM E-18)
  - A,B,C,L,N,T sca

Miniaturized samples testing



Dynamic testing machine (± 10-15 kN)

Resonance system CT1/2", CT1/4" and SENB <100 mm samples
Alignment Fixture

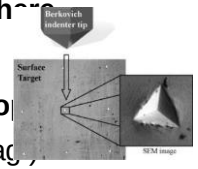


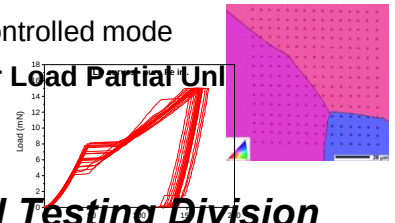
Static testing machine (20 kN)

Electromechanical
0.5 class starting from 20 N
Furnace up to 1000 °C
Non-contact extensometer
DIC software
Sub-sized tensile specimens
Alignment Fixture

Nanohardness tester NanoTest Vantage by Micro Materials Ltd., Wrexham UK

- **Berkovich, Vickers, Cube Corner and Conical** type indenters available for RT testing
- **HT measurements** with diamond (up to 450°C) and cBN (up to 750°C) indenter Measurements under **controlled argon atmosph**
- **Humidity cell**
- Coupled **Atomic Force Microsco**
- Optical microscope (up to 40x mag
- Convers range forces from 0.1 mN to 20 N
- Load or depth-controlled mode
- **Single forces or Load Partial Unl**





25J and 450J Pendulum Impact Testing Machines

Mechanical Testing Division realizes:

- ***Tensile testing***
- ***Compression testing***
- ***Fracture toughness testing K_{IC}, critical CTOD, J_{IC} (CT25, SENB)***
- ***Determination of the rate of fatigue crack growth da/dN***
- ***Small Punch Test (SPT)***

According to International Standards ISO, ASTM, BS…accredited tests !

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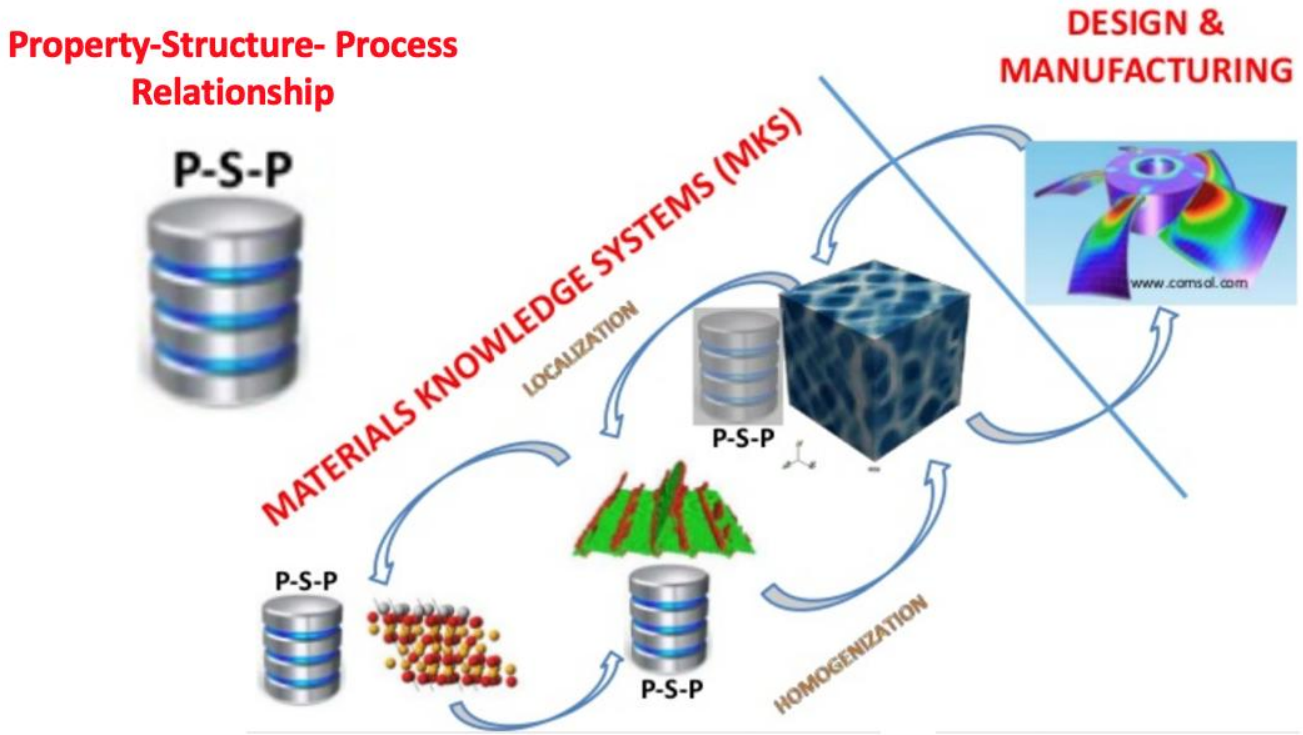
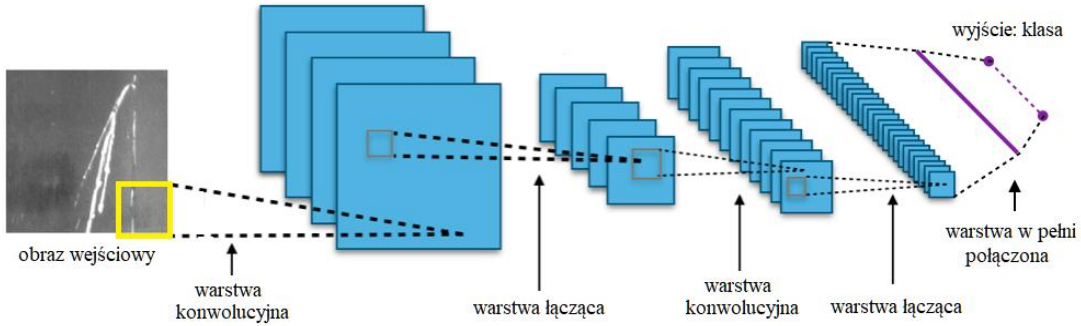
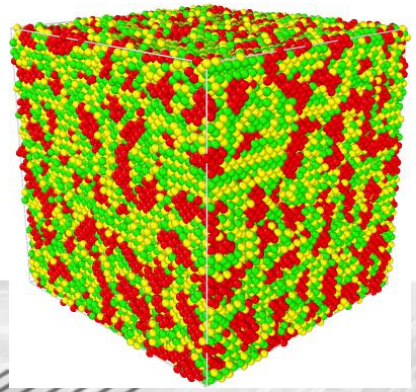
Materials Simulation Division

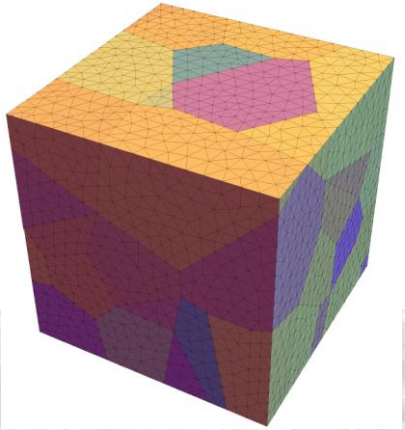
Simulations at NOMATEN CoE

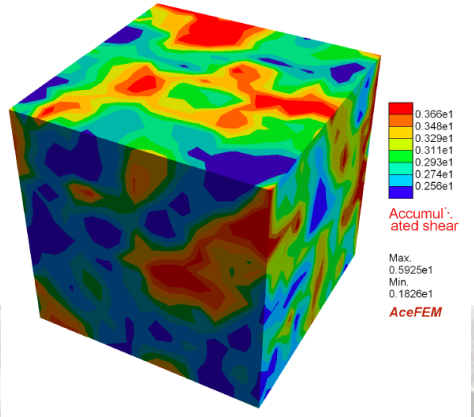
- **Multiscale simulations capabilities:** density functional theory, molecular dynamics, discrete dislocation dynamics, crystal plasticity and macroscopic plasticity,
- **Artificial intelligence at every level:** machine vision, natural language processing, optimization, machine learning interatomic potentials,











NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

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Materials Research Laboratory Structure Analysis and Corrosion

Structure and Corrosion Research Division – Research Infrastructure

Metallographic samples preparation and analysis

Metallographic sample prepartion section

- Cut-off machines (precision cutting)
- Manual or automatic grinder / polisher
- Manual or automatic, electrochemical (0-100V) and vibropolishing (60 - 120 Hz)
- Electrochemical polishing and etching (0-25V) / possibility of electrolytic polishing in cool temperature mode
- Hot Mounting Press

QATM Opal 410 press

QATM Saphir Vibro polisher

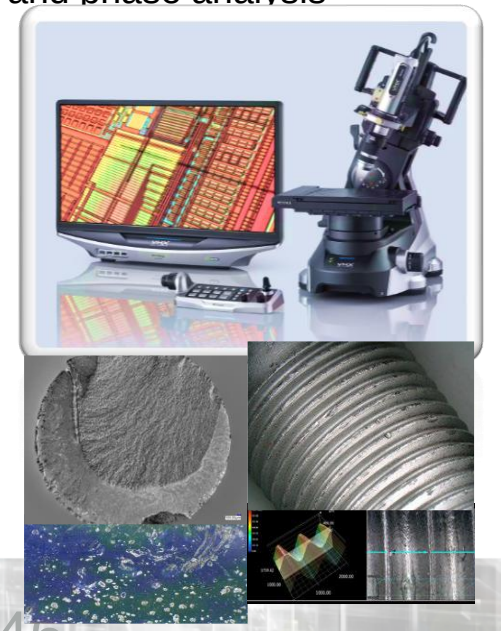
STRUERS – LectroPol electrochemical polishing / etching system

QATM Saphir 250 M2 automatic grinder / polisher

Microstructure characterization – Light Microscopy

- Leica DM IL Inverted Metallurgical Microscope
- Olympus BX53M Metallurgical Microscope
- Keyence VHX-7000 Optical Microscope
- ✓ Light microscopy contrast methods such as Brightfield BF, Darkfield DF, Polarized light POL, and Differential Interference Contrast DIC
- ✓ Olympus licensed software for determining average grain size according to international standards (i.a. ASTM E112, ISO 643) and phase analysis

Olympus BX53M Metallurgical Microscope



KEYENCE VHX-7000 Optical Microscope

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NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

Structure and Corrosion Research Division – Research Infrastructure

Samples preparation and microstructure analysis

SEM/TEM Laboratory financed b NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

SEM microscope Helios 5 UX DualBeam (Thermo Fisher Scientific)

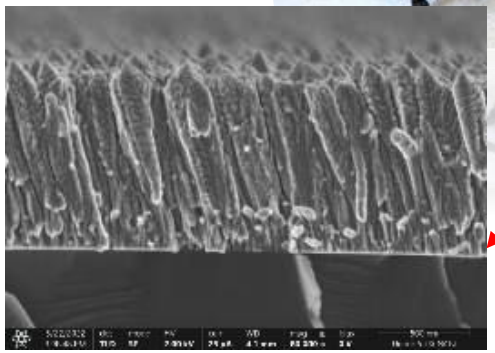
The Extreme High Resolution (XHR) Field Emission Scanning Electron Microscope (FE SEM) equipped with:

- ❑ FIB (Focused Ion Beam) technology
- ❑ EDS (Energy Dispersive X-ray Spectroscopy)
- ❑ EBSD (Electron Backscatter Diffraction)

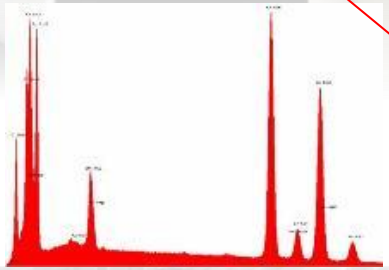
Ion Beam Precision Etching System

The PECS II and PIPS II (Gatan) is used to polish surfaces and remove without damage with two broad argon beams. This method is powerful for producing high-quality samples:

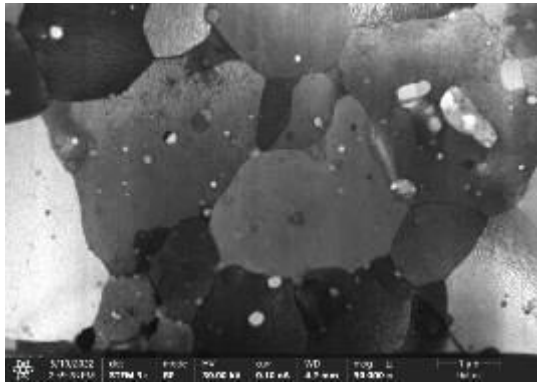
- ➢ for scanning electron microscope (SEM) observations
- ➢ for SEM imaging and EDS mapping
- ➢ for EBSD analysis,
- ➢ for STEM, TEM observation etc.



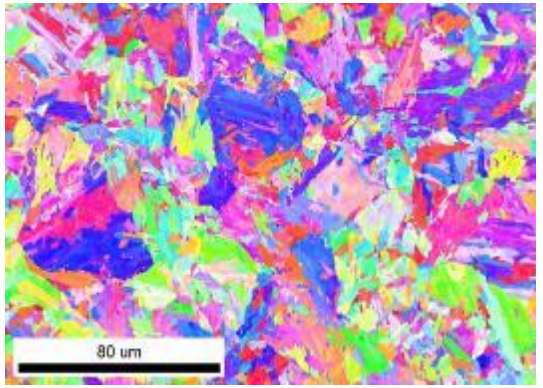
High resolution SEM imaging
Acceleration voltage: 350V – 30kV
Resolution: 0.6 nm (2 - 15kV), 0.7 nm (1 kV)
Detectors: ETD, TLD, ICD, MD, ICE



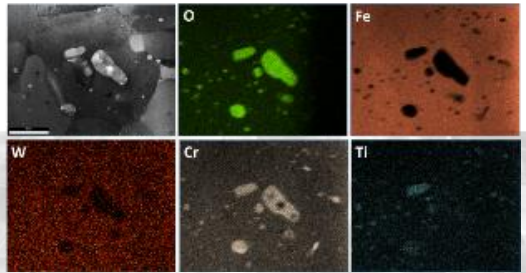
EDS Chemical composition analysis
Octane Elite Plus EDS System
SSD detector, area: 30mm2, resolution: 125eV, Si3N4



STEM imaging
Recractable STEM 3+ detector



Crystal orientation mapping
Hikari Super EBSD Camera, 1400 fps
Operation down to 100 pA/5kV



Structure and Corrosion Research Division – Research Infrastructure

Samples preparation and microstructure analysis

SEM/TEM Laboratory financed by

NOMATEN
Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

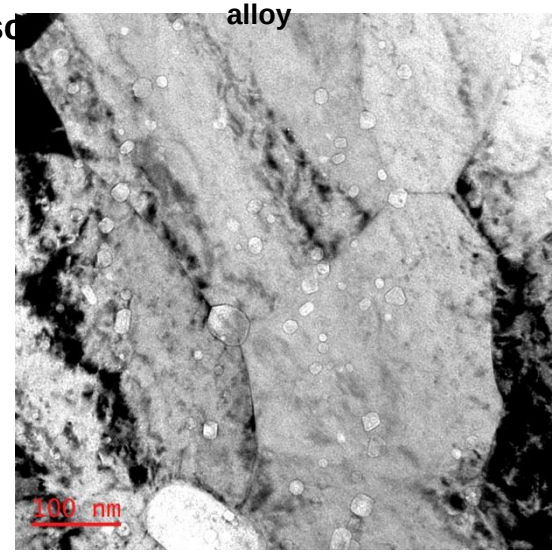
TEM Microscopy

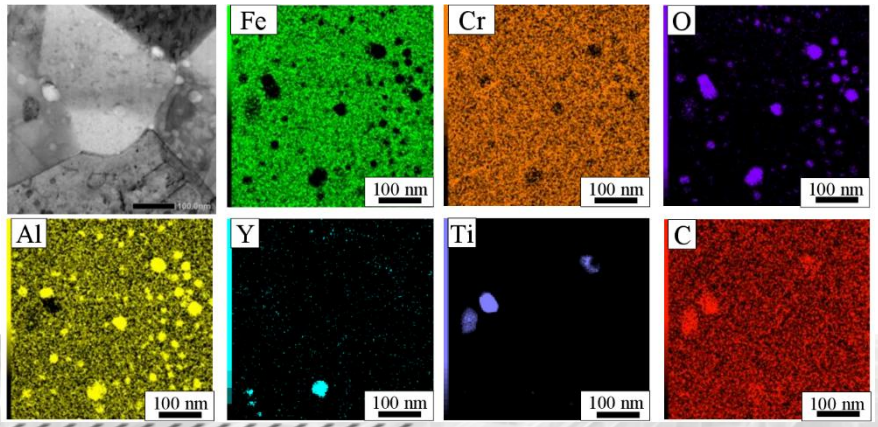
Transmission Electron Microscopy TEM – JOEL F200 Microsc

TEM with STEM, HAADF, EDS, BEI, BF and ABF detectors
Equipped with in-situ tensile and HT annealing up to 1000°C holders

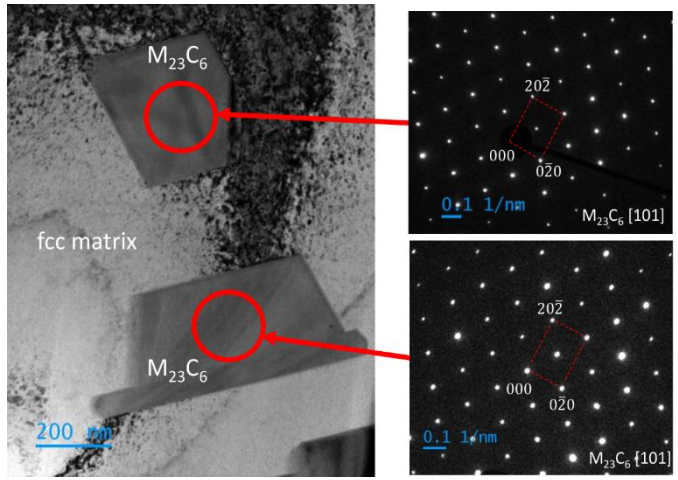
JEOL

STEM-EDS chemical composition analyses of nanometric precipitates in FeCrAl-Y2O3-Ti ODS alloy





SafeG Project
Inconel produced in collaboration with the University of Sheffield - Nuclear Advanced Manufacturing Research Centre)



TEM image and SAED patterns of M23C6 carbide in additively manufactured Inconel 617 alloy

48

NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK

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Materials Research Laboratory
Phase Analysis and Chemical Composition Research Services

Phase analysis Laboratory NOMATEN XRAYLAB – Research Infrastructure

X-ray diffraction phase analysis

X-Ray Laboratory financed by
NOMATEN
Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

Key X-ray research abilities:

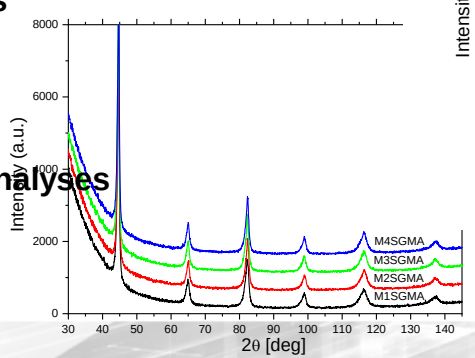
X-ray powder diffraction (XRPD)
- Identification of crystalline and amorphous phases and determination of specimen purity
- Quantitative analysis of both crystalline and amorphous phases in multi-phase mixtures
- Microstructure analysis (crystallite size, microstrain, disorder…)
- Bulk residual stress resulting from thermal treatment or machining in manufactured components
- Texture (preferred orientation) analysis
- Indexing, ab-initio crystal structure determination and crystal structure refinement

Analysis of amorphous, poorly crystalline, nano-crystalline or nano-structured materials
- Phase identification
- Structure determination and refinement
- Nano particle size and shape

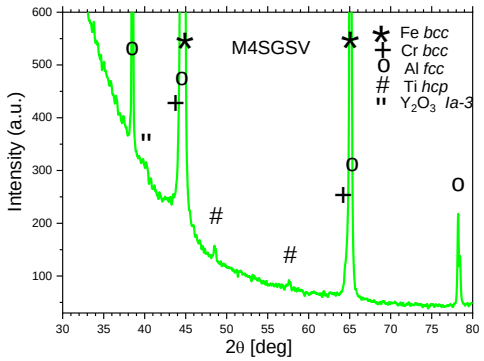
Thin Films and Coatings high quality analyses
- Grazing incidence diffraction
- X-Ray Reflectometry
- High resolution X-ray diffraction
- Reciprocal space mapping

D8 ADVANCE
- equipped with a sealed Cu X-Ray tube, TWIN-TWIN optics and LYNXEYE XE-T strip detector
- Cu radiation, $\lambda_{K\alpha1}$ = 1.540562 Å
- Energy Resolution < 380 eV at 8 keV
- B-B/GID geometries

High-temperature stage - Anton Paar HTK 1200 N
- temperature up to 1200°C
- operates Under Vacuum or Selected Gas Environment
- specimen Stage with Rotation (Rocking)



FeCrAl-ODS alloys powders analysis



Sample	Fe-rich solid solution (bcc)				Cr-rich solid solution (bcc)		
	Lattice constant [Å]	Crystallite Size [nm]	Strain parameter	Phase content	Lattice constant [Å]	Crystallite Size [nm]	Strain parameter
M1SGMA	2.868	28	0.0049	74	2.891	14	0.0057
M2SGMA	2.866	23	0.0048	87	2.889	11	0.0051
M3SGMA	2.869	23	0.0047	79	2.891	14	0.0053
M4SGMA	2.868	23	0.0047	87	2.891	14	0.0057

Structure and Corrosion Research Division – Research Infrastructure

Spectroscopic phase and chemical composition analysis

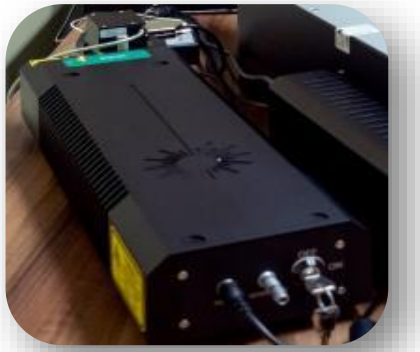
Raman Spectroscopy

Research Features

- Obtaining qualitative to semi-quantitative information on material phase composition (Raman imaging)
- Determination of stress distribution
- Examination of phase transition and corrosion of materials
- Observations of structural changes after ion implantation - defects type and amount determination

WITec focus innovations

Alpha 300R Raman Spectrometer



Ultra-high throughput spectrometer (UHTS), for high speed and high resolution Raman imaging.

High temperature stage (up to 1000 C)

Optical microscope: Zeiss Neofluar objectives magnification x10, x50, x100

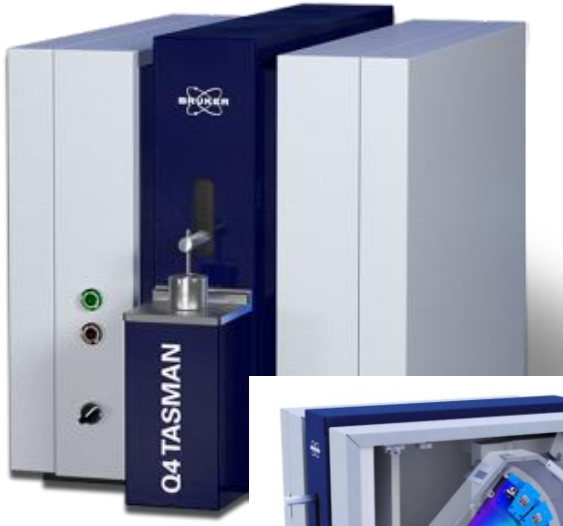
BRUKER

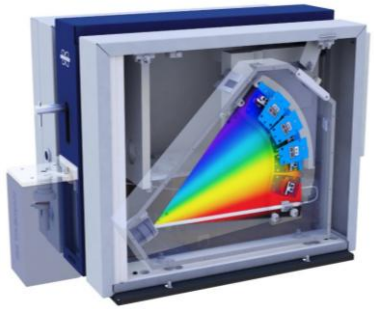
Q4 TASMAN Spark Optical Emission Spectroscopy OES

Series 2

Research features:

- Quantitative elemental analysis
- Improved precision and stability
- High accuracy and sensitivity levels, full capabilities including C, P, S, Sb, Te
- Digital Spark Source delivers improved analytical precision and shorter time-to-result.
- Dual optics concept with robust Paschen Runge mount, multi-chip systems with temperature stabilization





PCA Polskie Centrum Akredytacji BADANIA AB 025

ilac-MRA

Accreditation procedure in progress !!!

4 Analytical Bases Fe, Al, Ni and Ti alloys

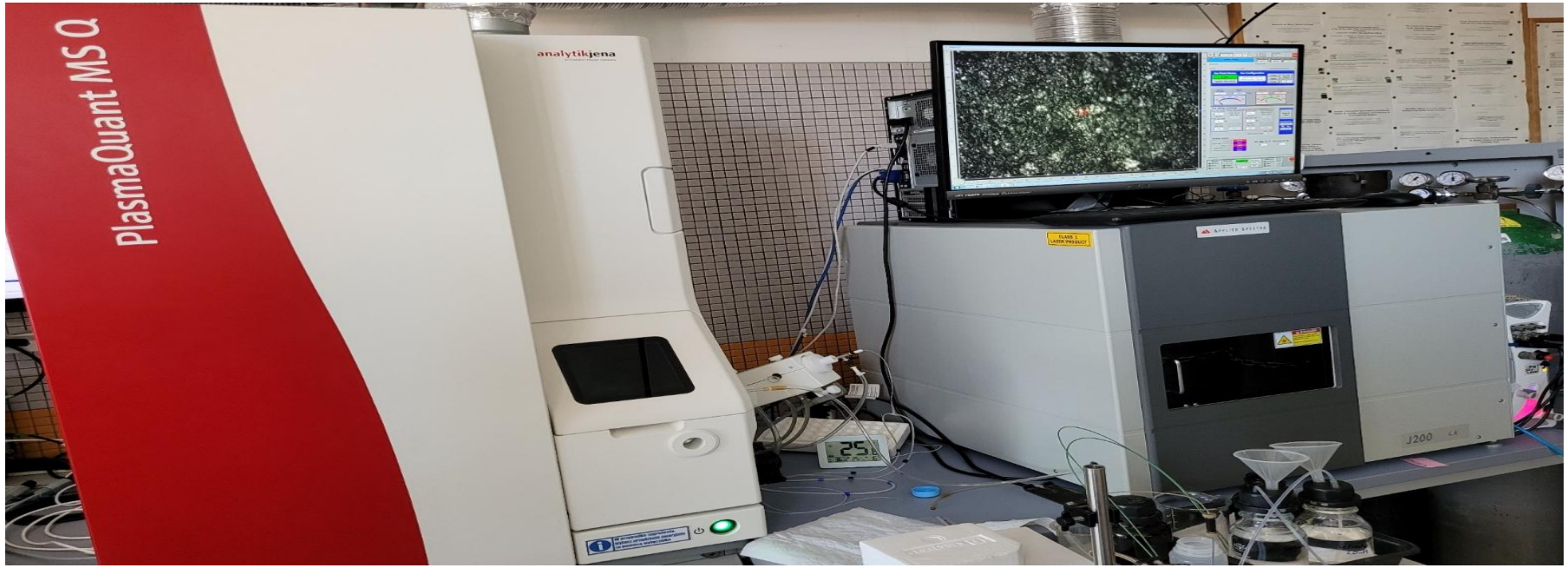
30 CRM materials with ISO 17034 Standard

Structure and Corrosion Research Division – Research Infrastructure

Spectroscopic phase and chemical composition analysis

ICP-MS integrated with Laser Ablation LA and LIBS spectrometer

Analytik Jena Plasma Quant MS Q **<> Applied Spectra J200 LA system with LIBS**



Financed by PROJECT HTGR

Chemical analysis at .ppm and .ppb level of high purity graphite in accordance with IAEA regulations

TOYO TANSO

Impurity Analysis Example

Unit: mass ppm

Element	Content: Ultra High Purity Graphite	Content: High Purity Graphite	Content: Regular Graphite	Measurement Method
Li	<0.001	<0.001	<0.03	ICP-MS
B	0.10	0.15	3	ICP-MS
Na	<0.002	<0.002	<0.5	ICP-MS
Mg	<0.001	0.004	0.2	ICP-MS
Al	<0.001	0.012	14	ICP-MS
Si	<0.1	<0.1	2	UV
K	<0.03	0.04	2	FL-AAS
Ca	<0.01	0.08	6	FL-AAS
Ti	<0.001	<0.001	33	ICP-MS

Element	Content: Ultra High Purity Graphite	Content: High Purity Graphite	Content: Regular Graphite	Measurement Method
V	<0.001	0.018	40	ICP-MS
Cr	<0.004	0.006	<0.3	ICP-MS
Mn	<0.001	<0.001	<0.2	ICP-MS
Fe	<0.02	0.06	26	ICP-MS
Co	<0.001	<0.001	<0.3	ICP-MS
Ni	<0.001	0.006	4	ICP-MS
Cu	<0.002	<0.002	<1	ICP-MS
Zn	<0.002	<0.002	<0.6	ICP-MS
Pb	<0.001	<0.001	<1	ICP-MS

Other research plans:

- solid samples inpurities analysis
- C,H,O,N detection in materials (LIBS)
- MARIA reactor water analysis

High temperature stage (up to 1000 C)

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NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

Materials Research Laboratory
Thermal Properties Analysis Services

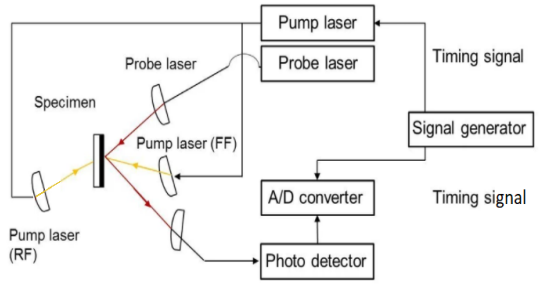
Thermal Properties Testing Laboratory – Research Infrastructure

Thermal Research Laboratory
Financed by Project HTGR
PROJECT HTGR

The Thermal Laboratory enables full characterization of the thermal properties of advanced materials

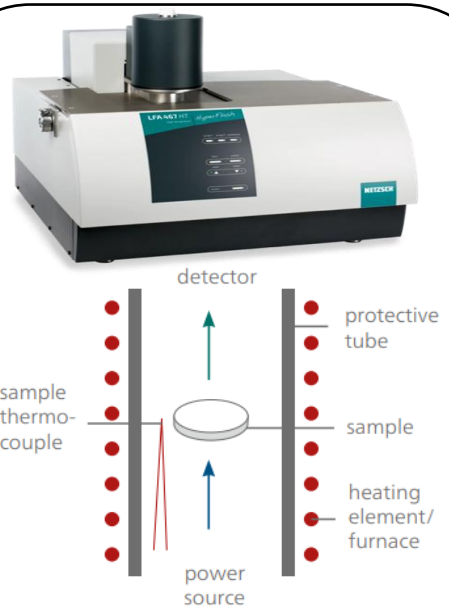
The laboratory equipment includes:

(I) high-temperature dilatometer
(II) device for measuring of thermal diffusivity of volumetric materials,
(III) device for measuring of thermal diffusivity of thin films,
(IV) a set for simultaneous thermal analysis
(V) a thermal mass spectrometer.



NanoTR enables measurements of thermal diffusivity of metallic, ceramic and composite layers in the range from 0.01 to 1000 mm^2/s with an accuracy of 5%.

High-temperature Dilatometer Netzsch DIL402
Operates in horizontal mode within the temperature range from RT to 1600°C.
The load on the sample is in the range from 50mN to 3N, with measurement of cylindrical samples and cuboidal samples with an accuracy of 1 nm and in the range of measuring 10 mm.



Netzsch LFA 467 *HT HyperFlash*® allows for measurement of **thermal diffusivity and thermal conductivity between RT and 1250°C with Xenon Flash**

Netzsch STA 449 F3 Jupiter®
STA instrument combines two measuring techniques: Thermogravimetry (TG) and Differential Scanning Calorimetry (DSC) for a single sample.
The device includes two high-temperature furnaces:

- High-temperature furnace enabling operation in a protective atmosphere (in the range of RT to 1600°C)
- High-temperature furnace enabling operation in a water vapour atmosphere (in the RT to 1250°C range, at a relative humidity in the range of 5-90%.).

Netzsch Mass Spectrometer QMS 403 Aëolos Quadro useful tool for obtaining the chemical and analytical information about the products causing the weight changes of the different materials during heat treatment.

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Nearest investments

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NOMATEN Centre of Excellence in Multifunctional Materials for Industrial and Medical Applications

- **Two autoclaves for SCC (PWR or BWR conditions),** ***plus one for small samples (already installed)***
- **FTIR** ***(already installed)***
- **HT tribotester, various geometries** ***(already installed)***
- **SEM/EDS/EBSD + tensometric stage up to 1000C** ***(already installed)***
- **Nanoindentation stage for SEM microscope**
- **3D printer**
- **Next setup for powder metallurgy** ***(mills, glove boxes, etc)***
- **Spark Plasma Sintering**

Thank you for your attention

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www.ncbj.gov.pl