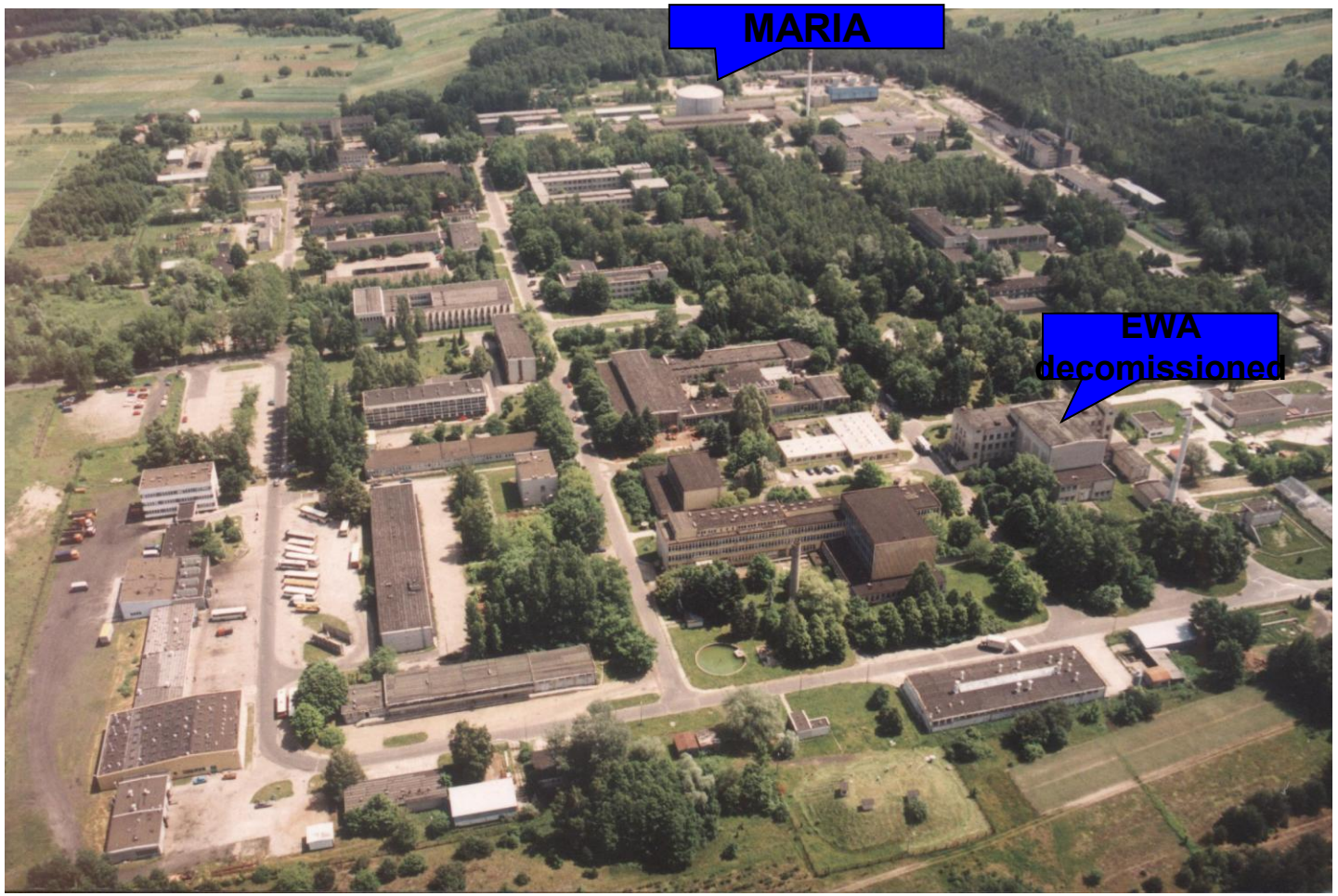
Possibilities and plans for materials research using neutron beams in the MARIA Reactor

NARODOWE CENTRUM BADAŃ JĄDROWYCH
ŚWIERK

Outline:

- *MARIA Reactor*
- *Experimental hall*
- *MARIA NEUTRON LABORATORY MNL*
- *Instruments*
- *Preparations for the creation of the MNL laboratory*

National Centre for Nuclear Research
Narodowe Centrum Badań Jądrowych (NCBJ)



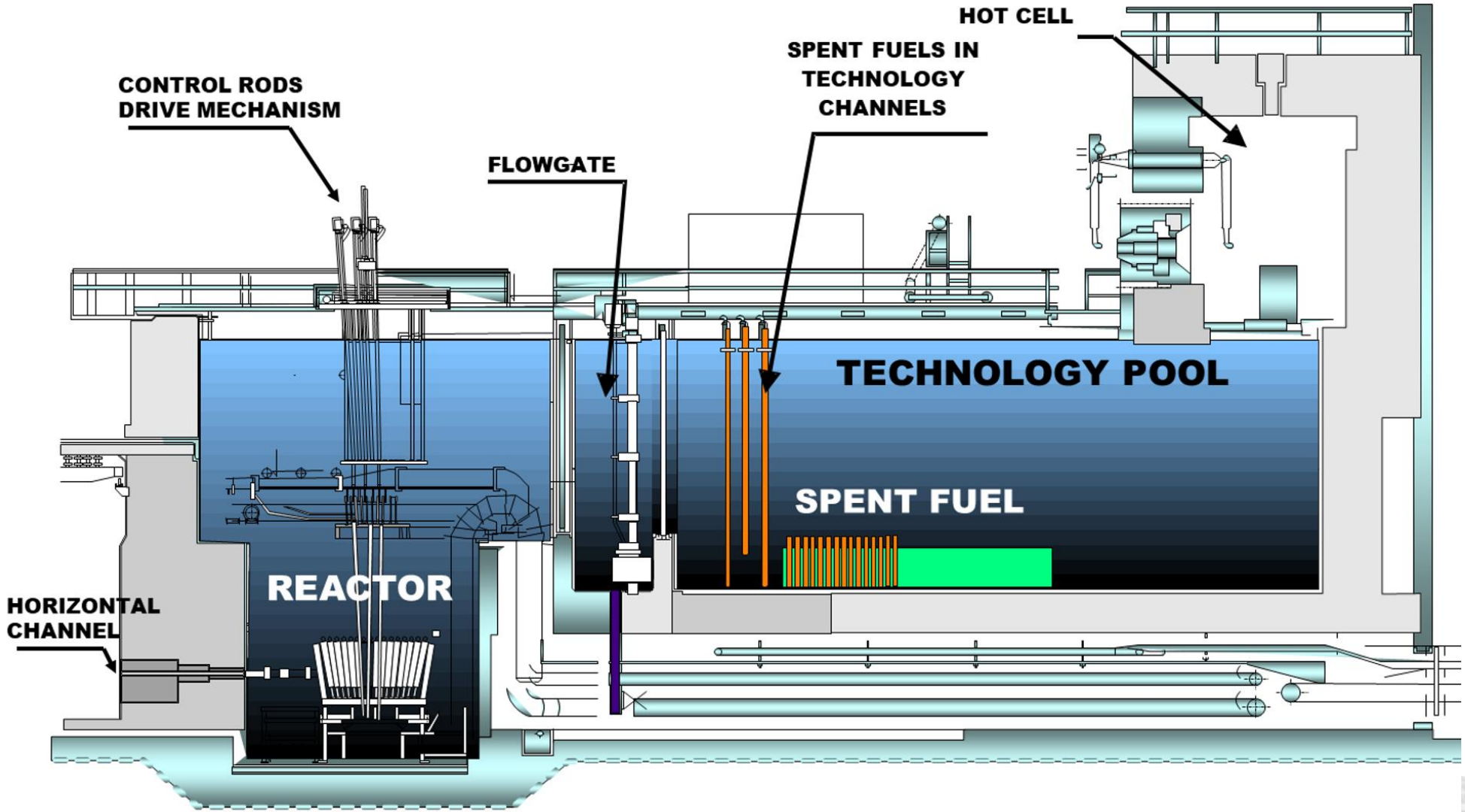
MARIA Reactor

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
Licence	2025, Relicensing to ….

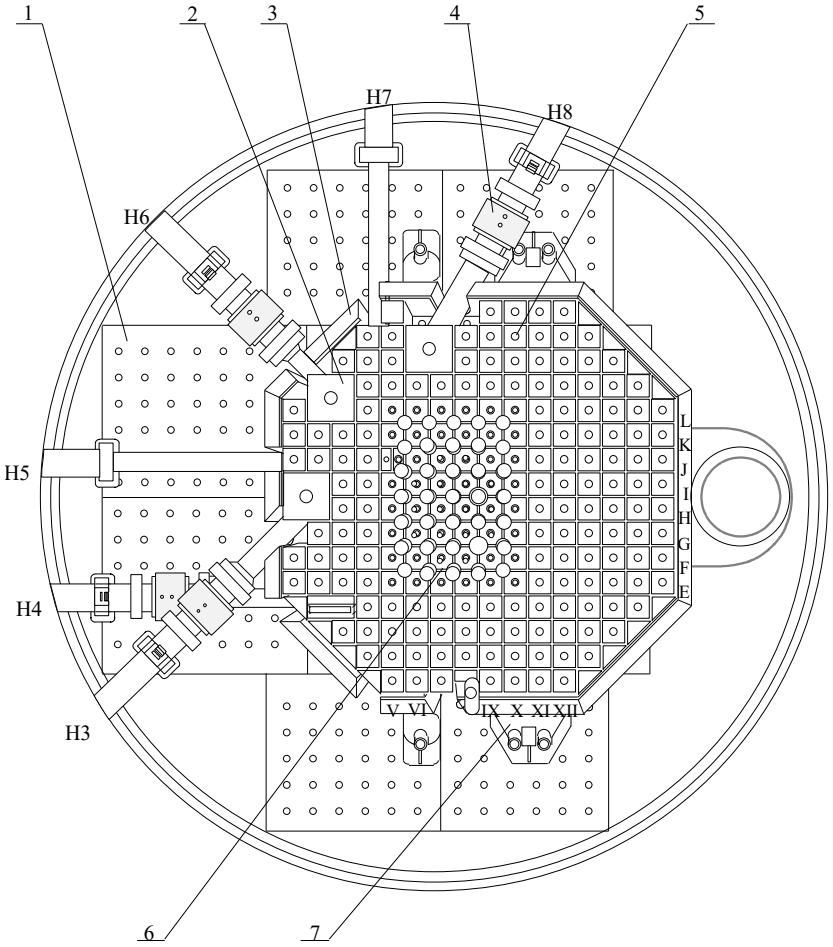
Current main reactor applications:

- *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.*

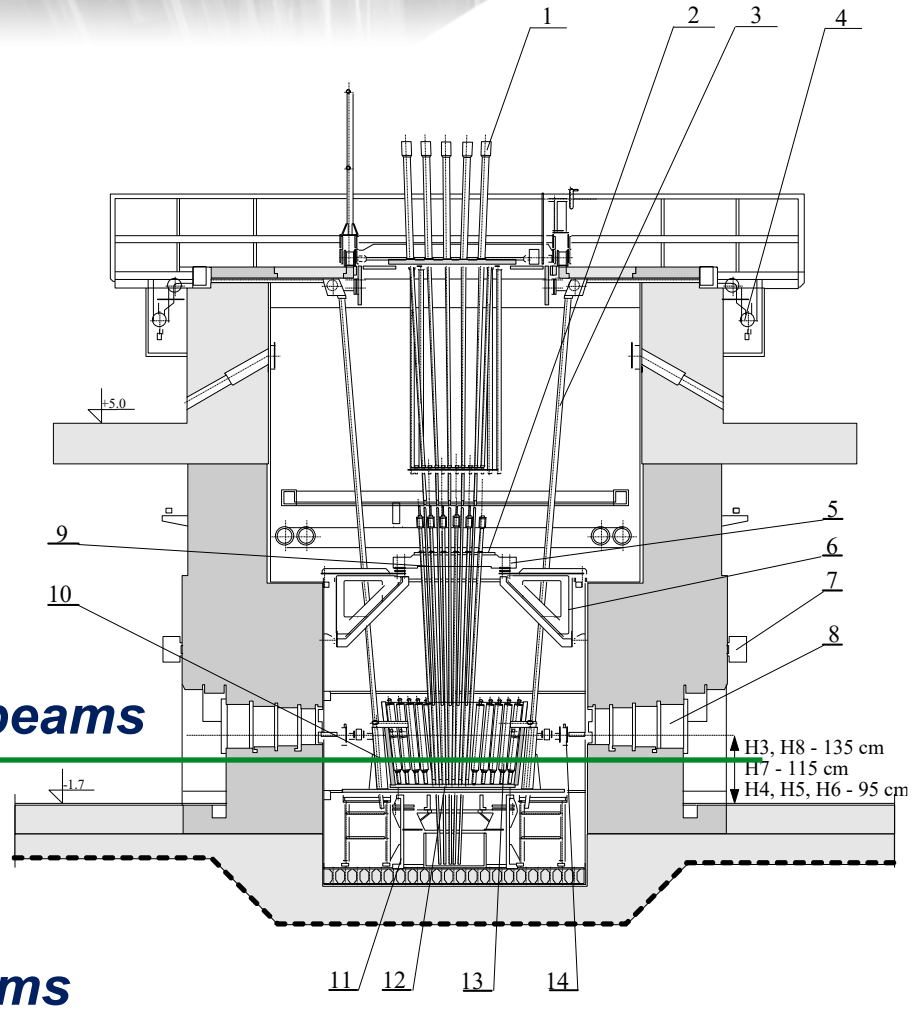
MARIA Reactor



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



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

Horizontal neutron beams

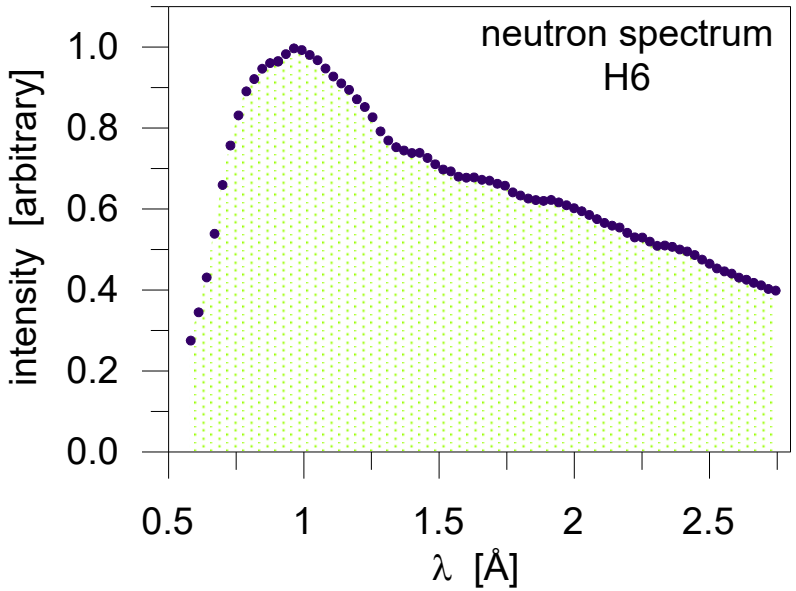
Thermal neutrons flux at horizontal neutron beams outlets

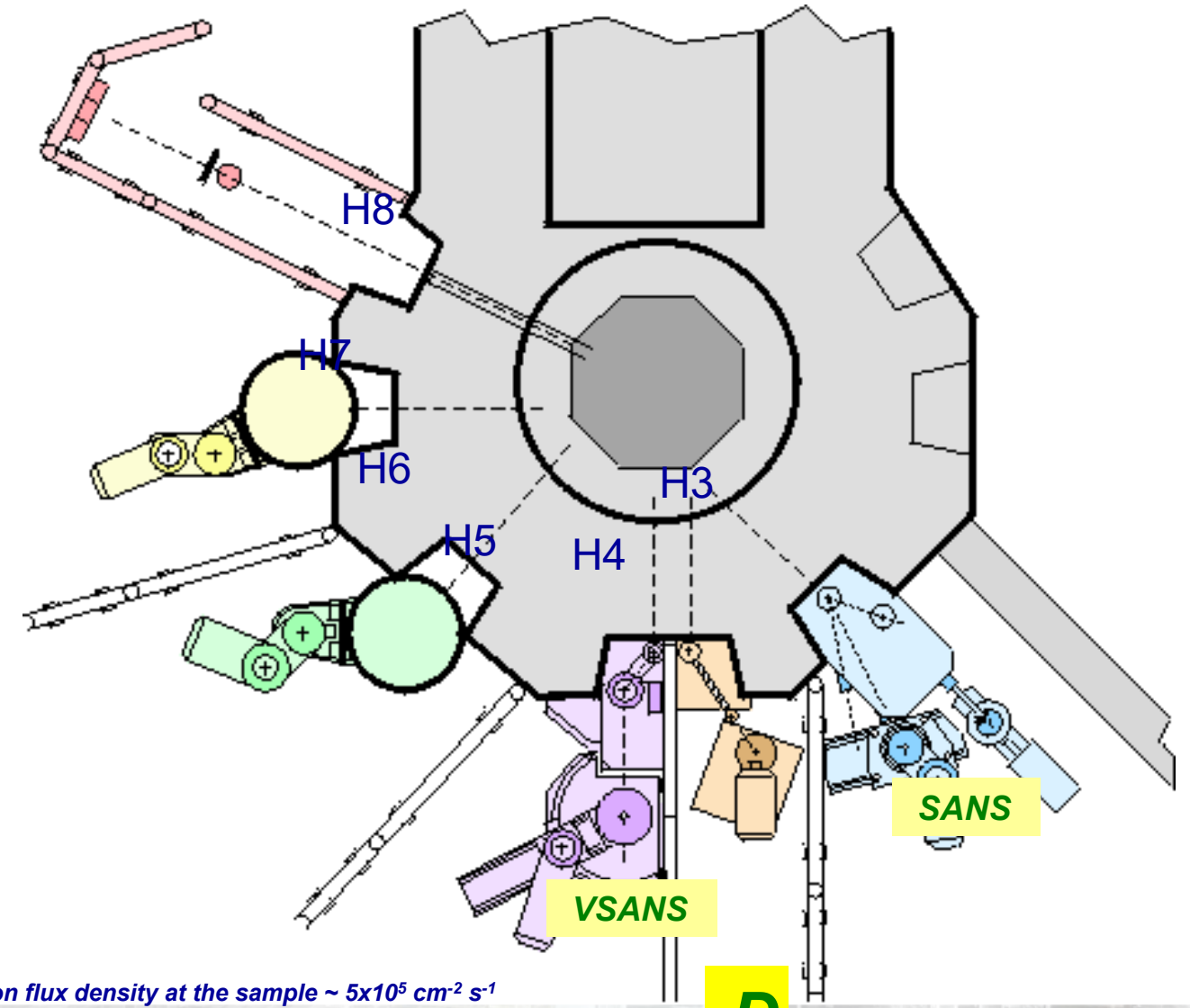
$$4 \times 10^{9}\ cm^{-2}\ s^{-1}$$

The experimental hall of neutron scattering laboratory before 2017 comprised 7 thermal neutron instruments:

- *2 neutron spectrometers*
- *2 neutron diffractometers*
- *2 small angle scattering (SANS) difractometers*
- *Neutron/gamma radiography – tomography facility*

EXPERIMENTAL HALL before 2017





neutron flux density at the sample ~ 5x10^5 cm^{-2} s^{-1}

EXPERIMENTAL HALL before 2017

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,

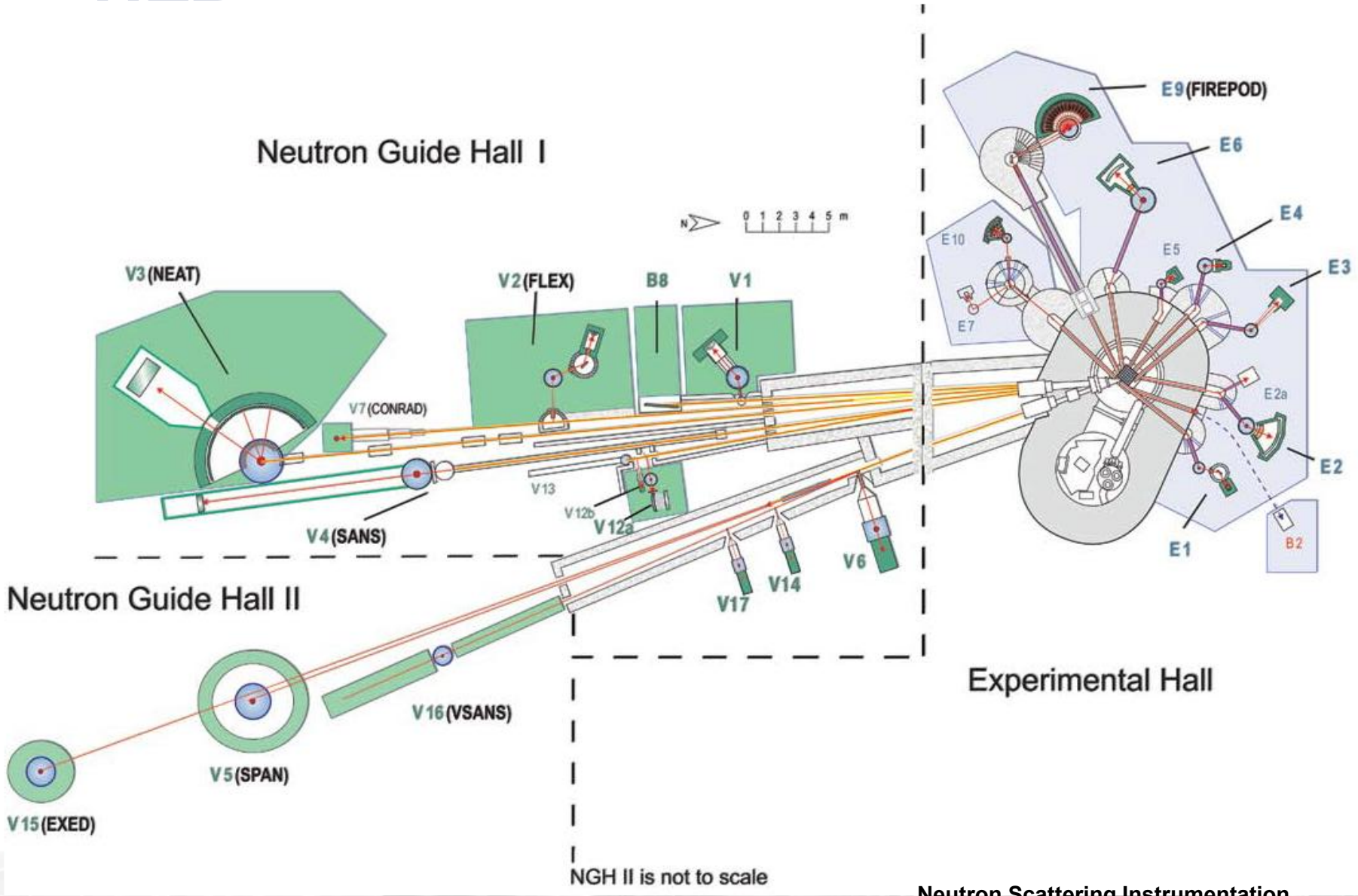
E3 – Residual Stress Analysis Diffractometer,

E4 – Two-Axis Diffractometer,

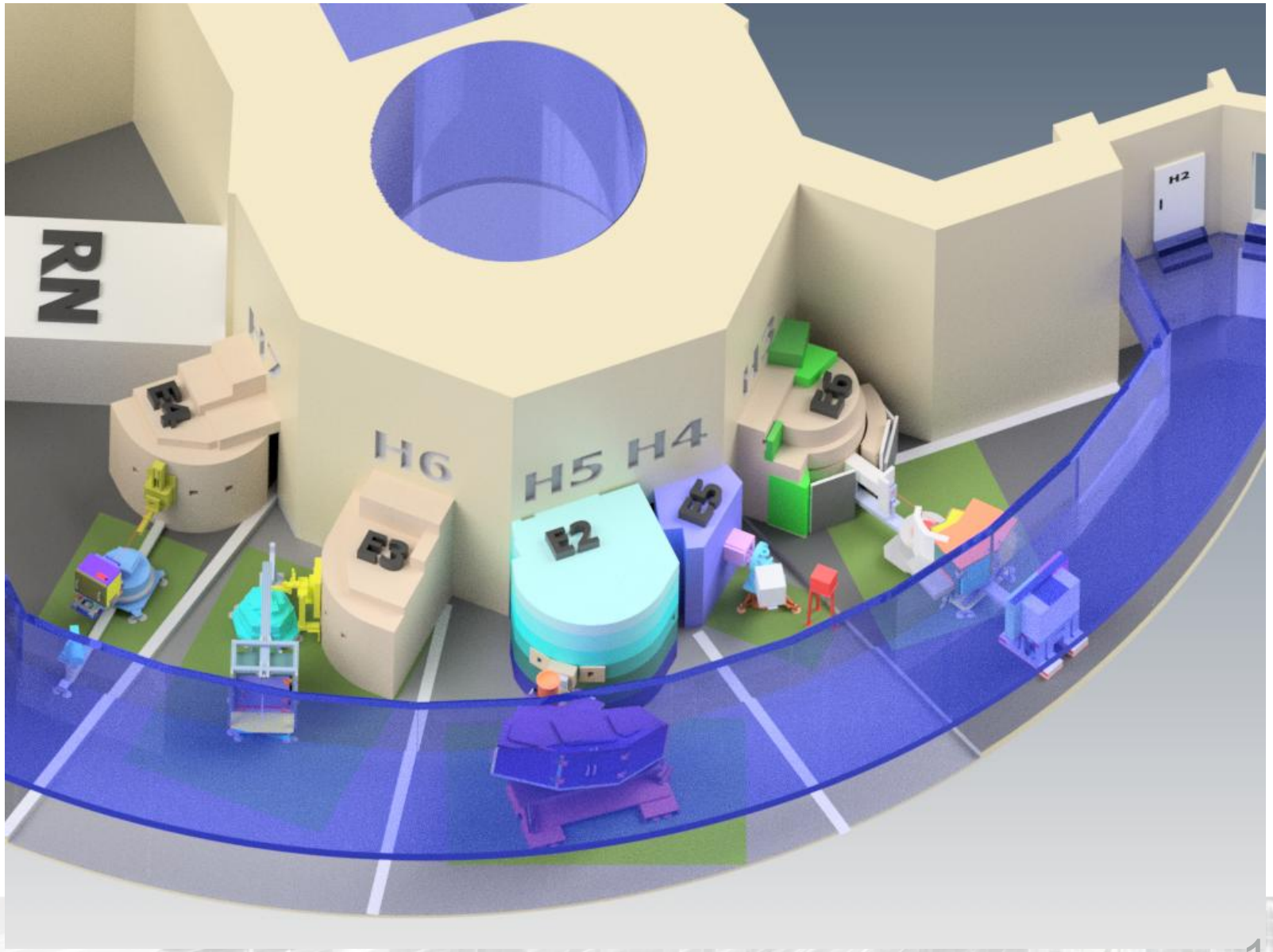
E5 - Four-Circle Diffractometer,

E6 – Focusing Diffractometer.

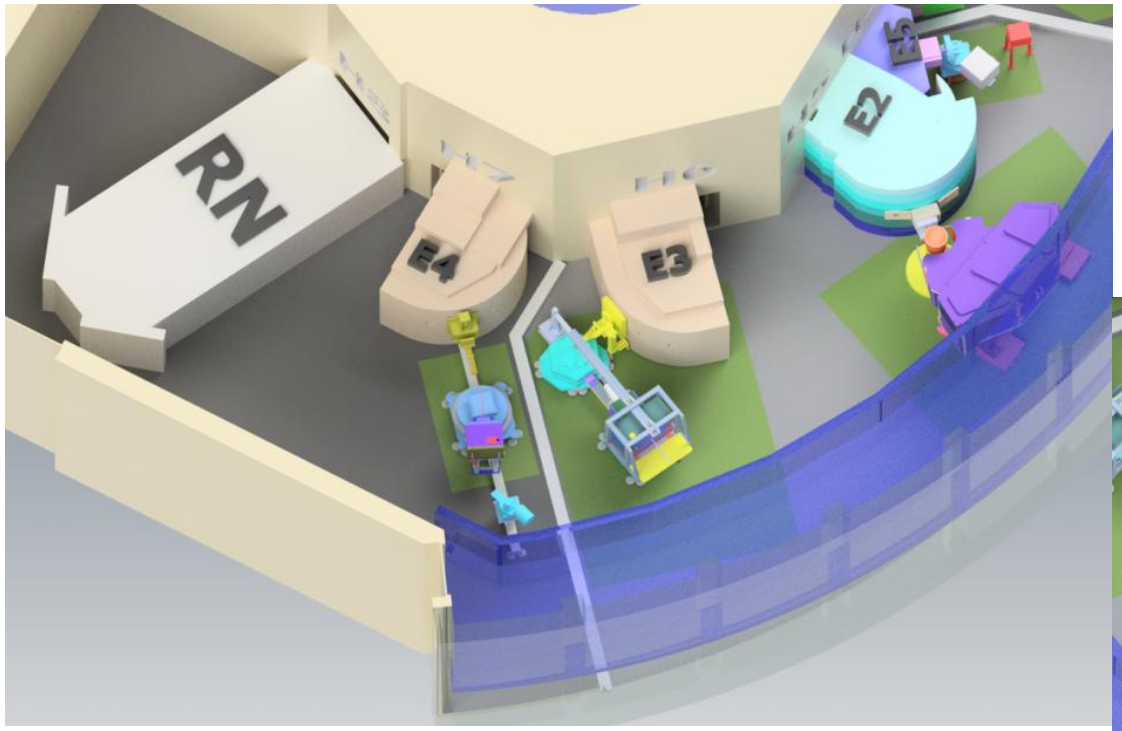
HZB

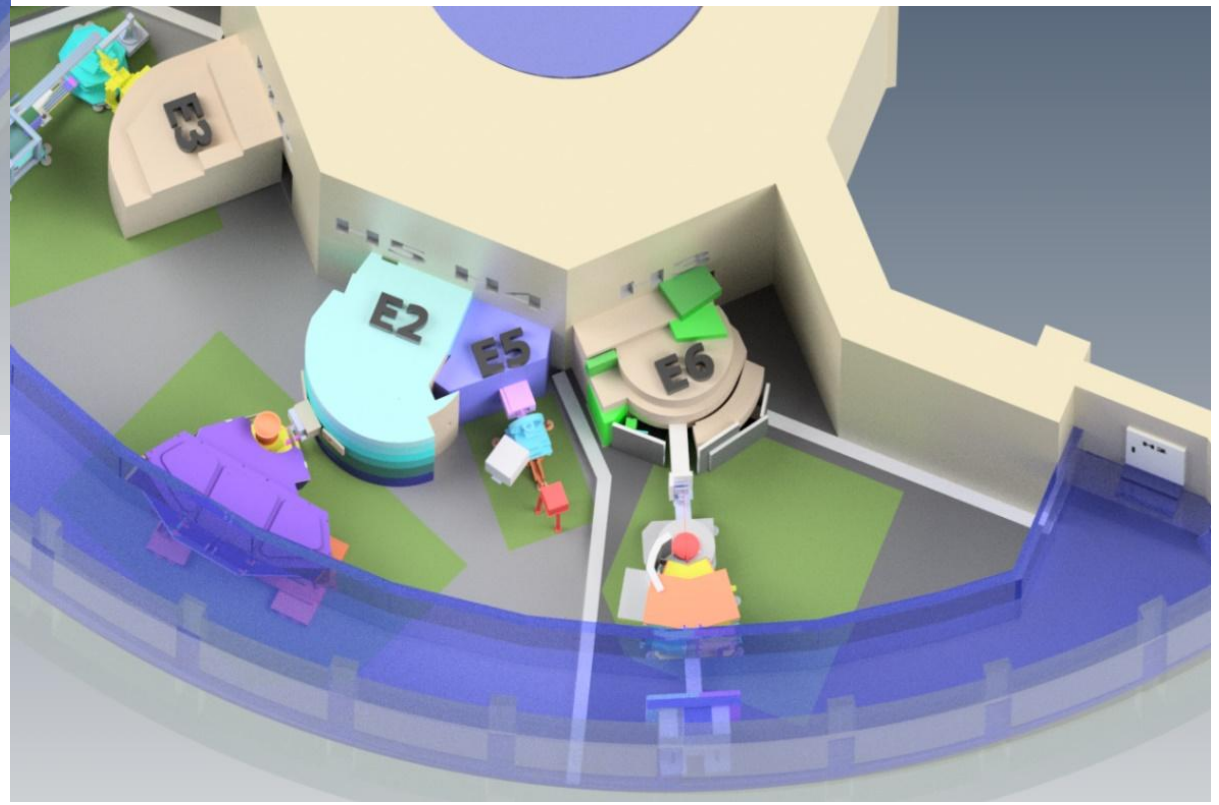

Neutron Guide Hall I
N
0 1 2 3 4 5 m
V3 (NEAT)
V2 (FLEX)
B8
V1
V7 (CONRAD)
V13
V12b
V12a
V4 (SANS)
V6
V17
V14
Neutron Guide Hall II
V16 (VSANS)
V5 (SPAN)
V15 (EXED)
E9 (FIREPOD)
E6
E4
E10
E5
E3
E7
E2a
E2
E1
B2
Experimental Hall
NGH II is not to scale

PLANNED ARRANGEMENT @ THE MARIA EXPERIMENTAL HALL



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

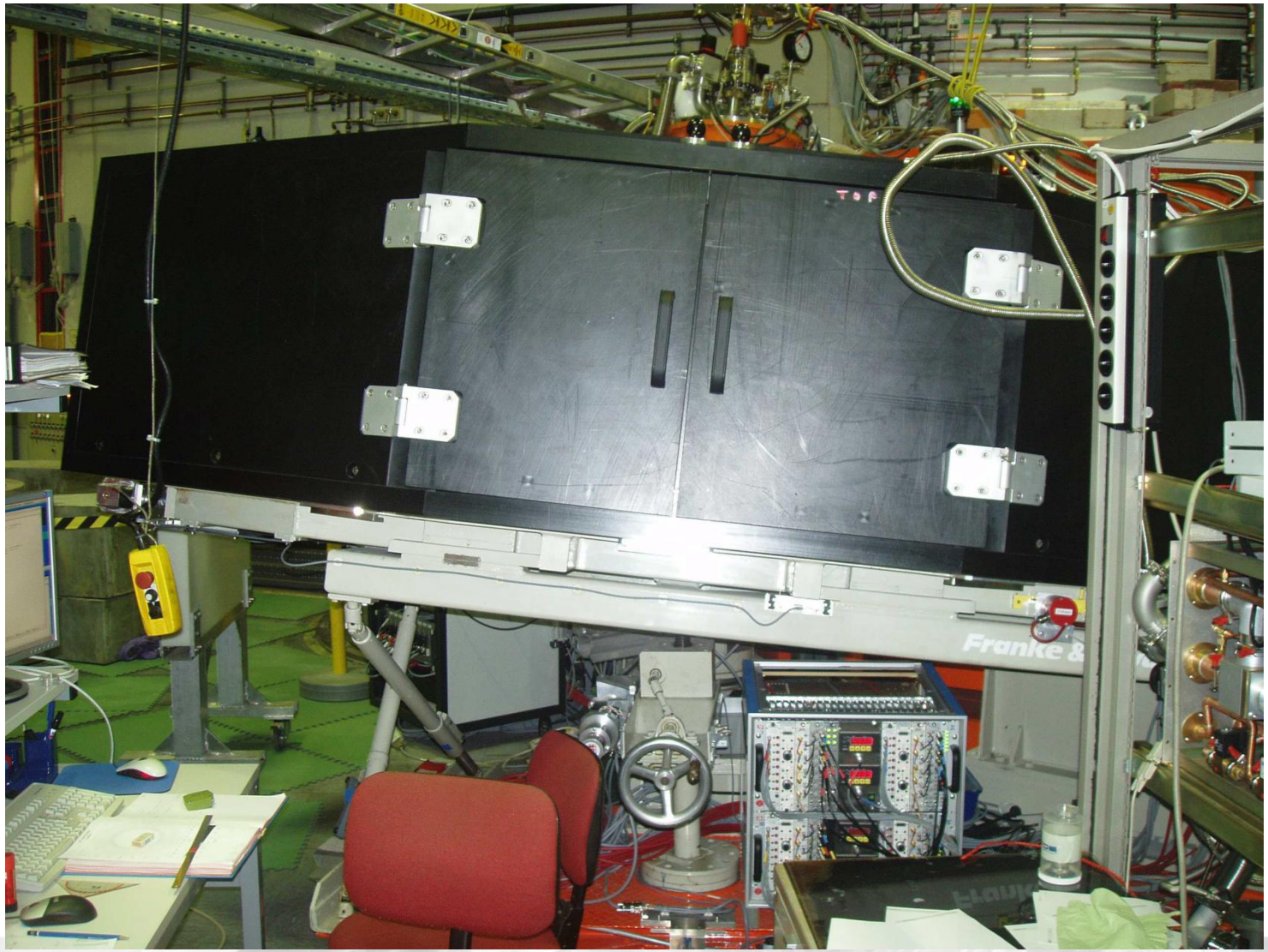
E3. Diffractometer for Microstructure and Residual Stress Analysis
Monochromator Si (400), Double focusing, λ = 1.48Å; 2D PSD 30 x 30 cm

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

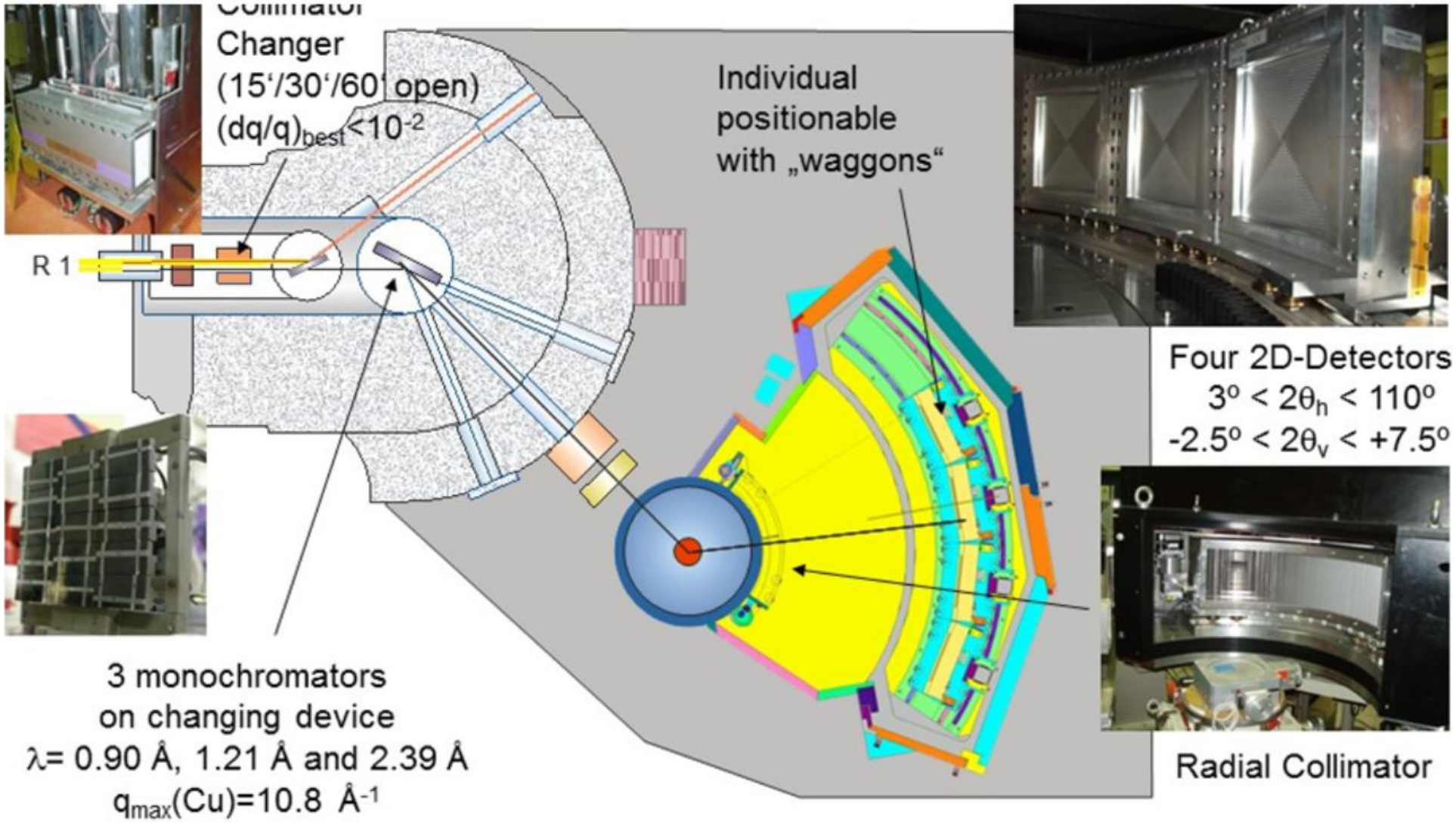
E6. Focusing Diffractometer.
Monochromator PG (002) λ = 2.4Å double focusing, two 2D PSD each 30 x 30 cm

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



https://www.helmholtz-berlin.de/pubbin/igama_output?modus=datei&did=628

E2 diffractometer



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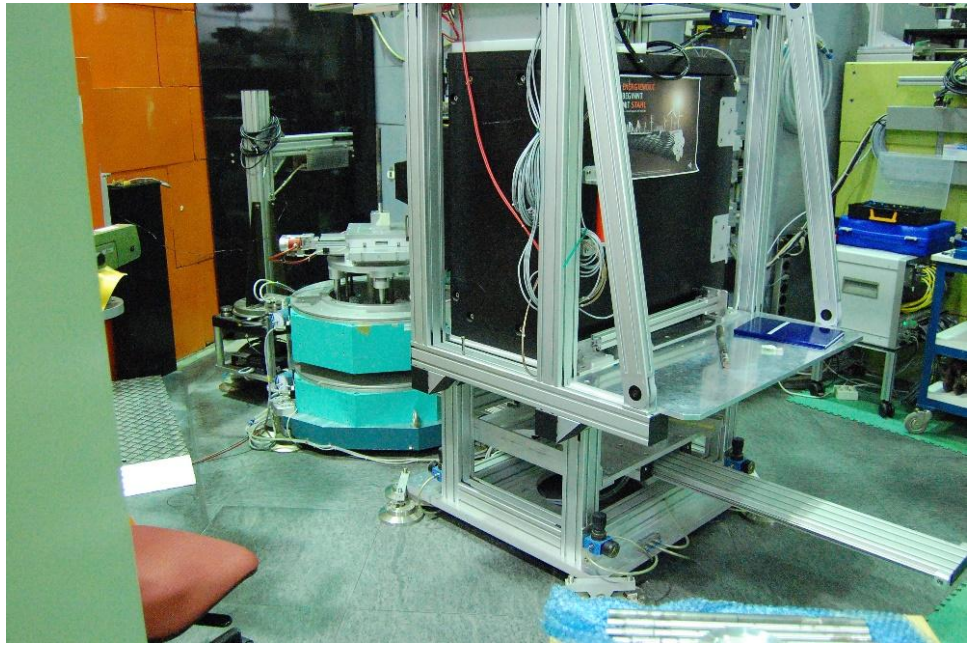
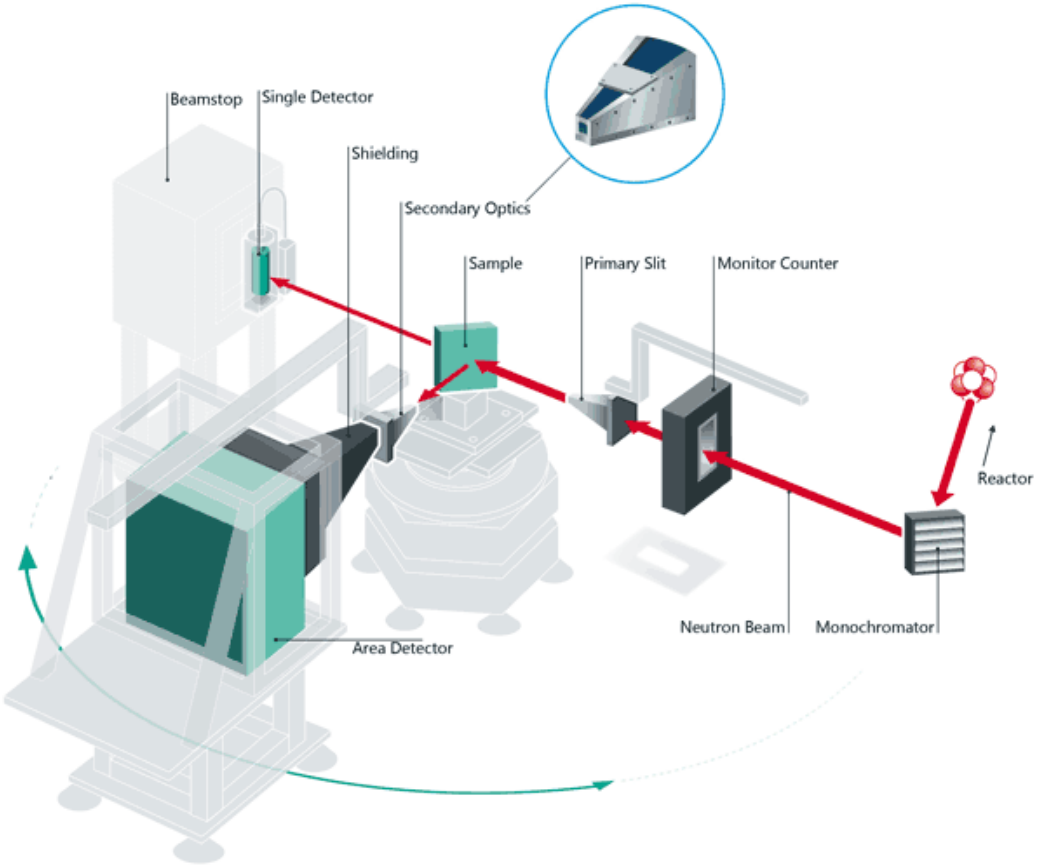
E3 diffractometer for internal stress studies in macroscopic elements





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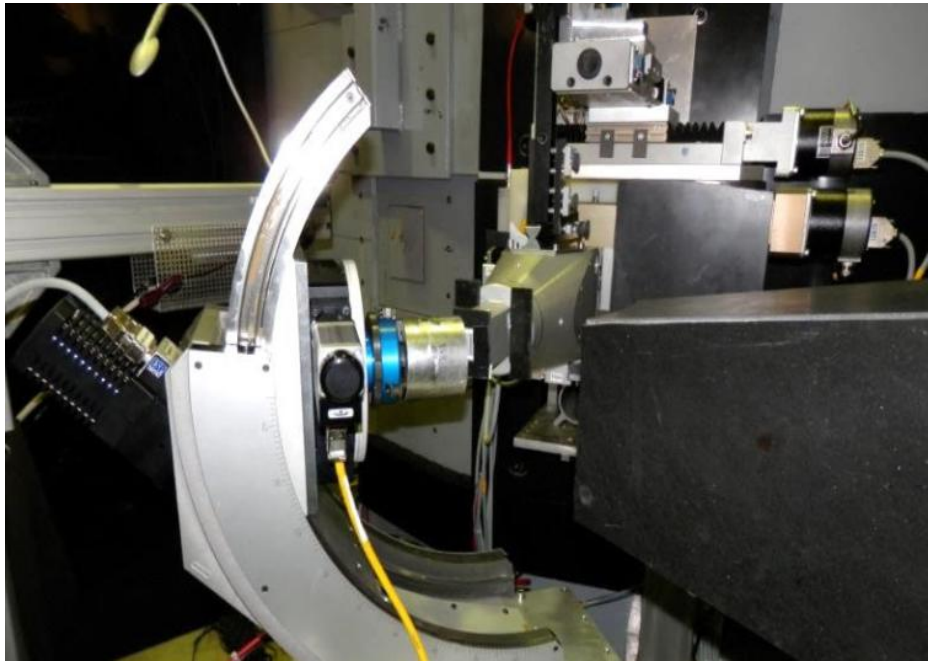
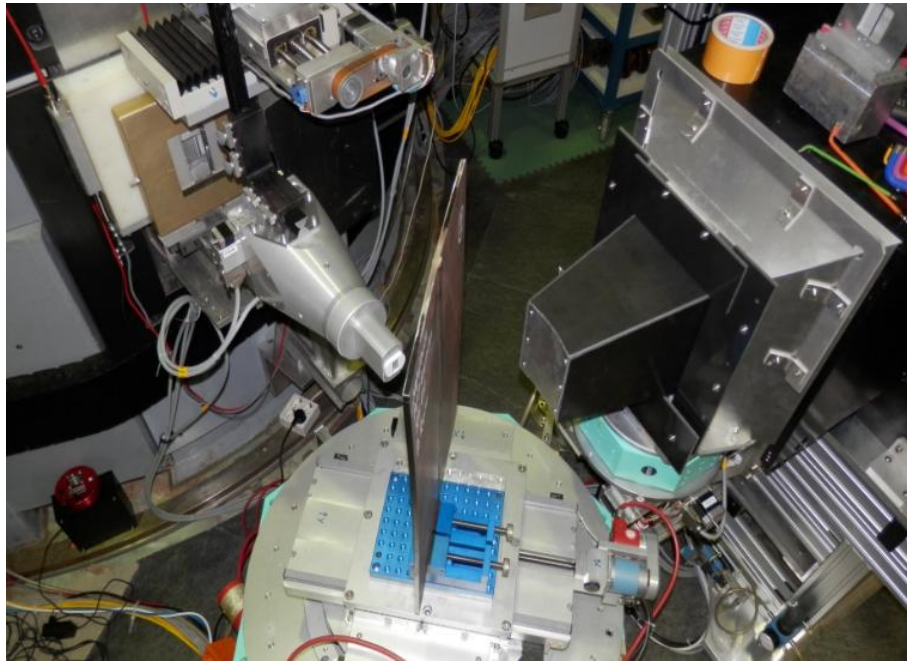
E3 diffractometer





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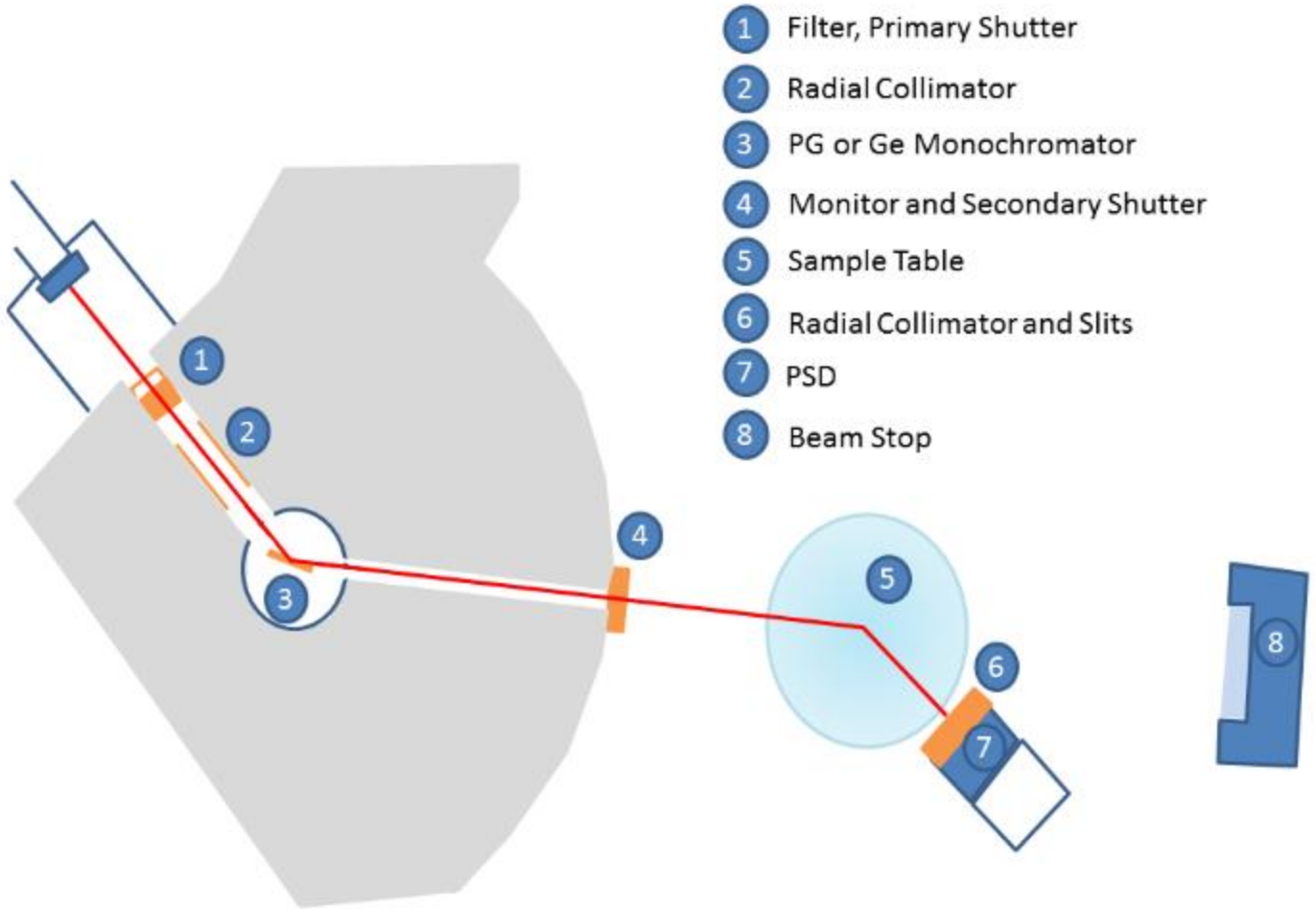
E4 diffractometer



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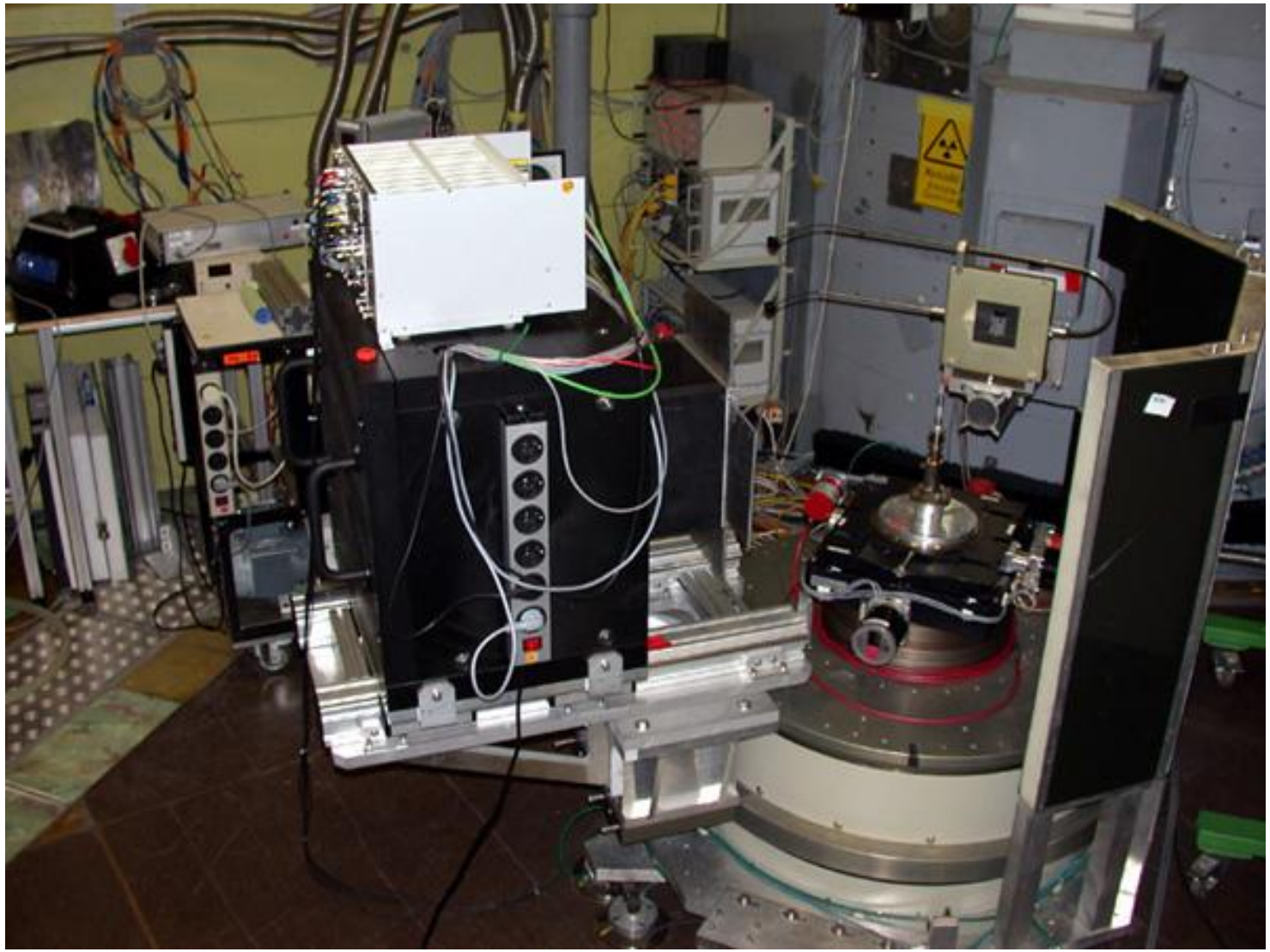
E4 diffractometer



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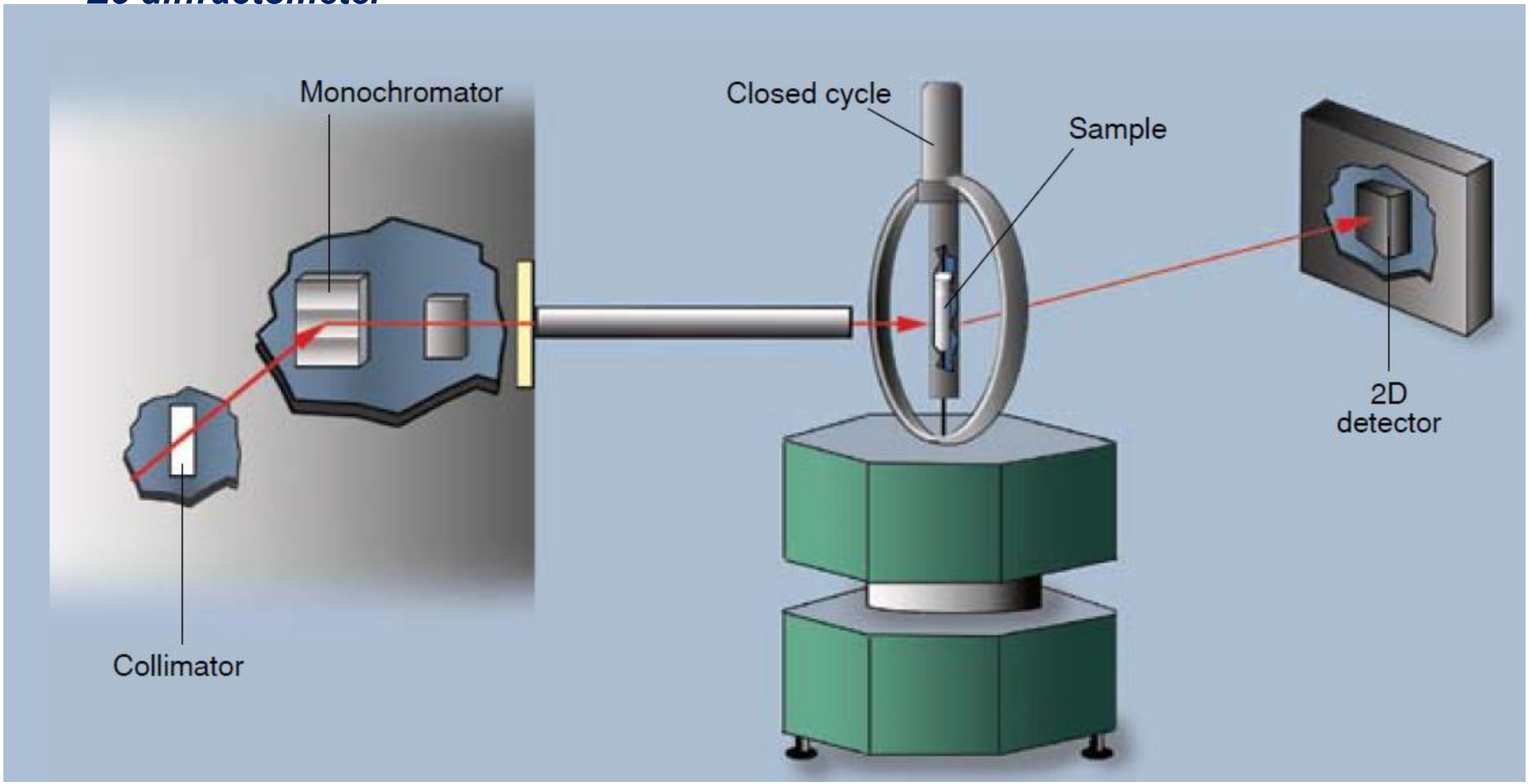
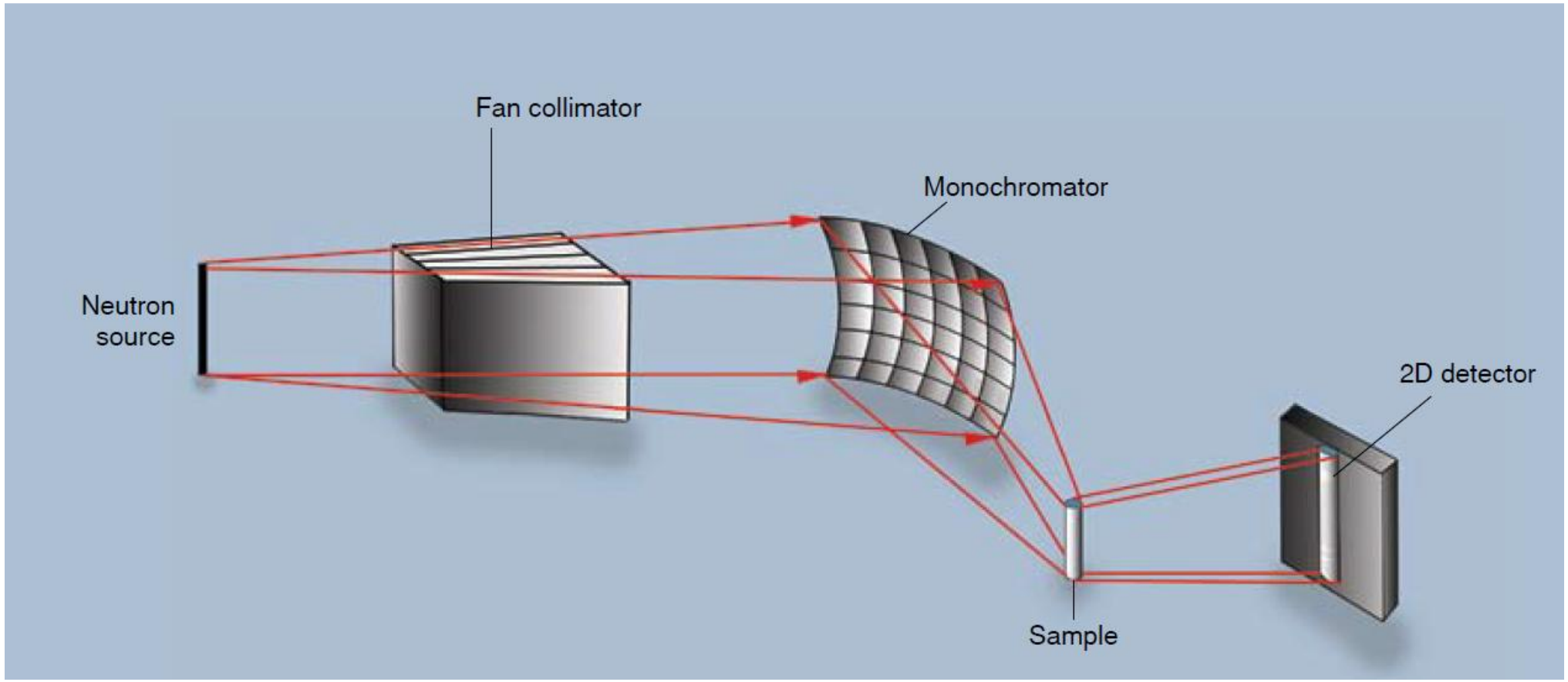
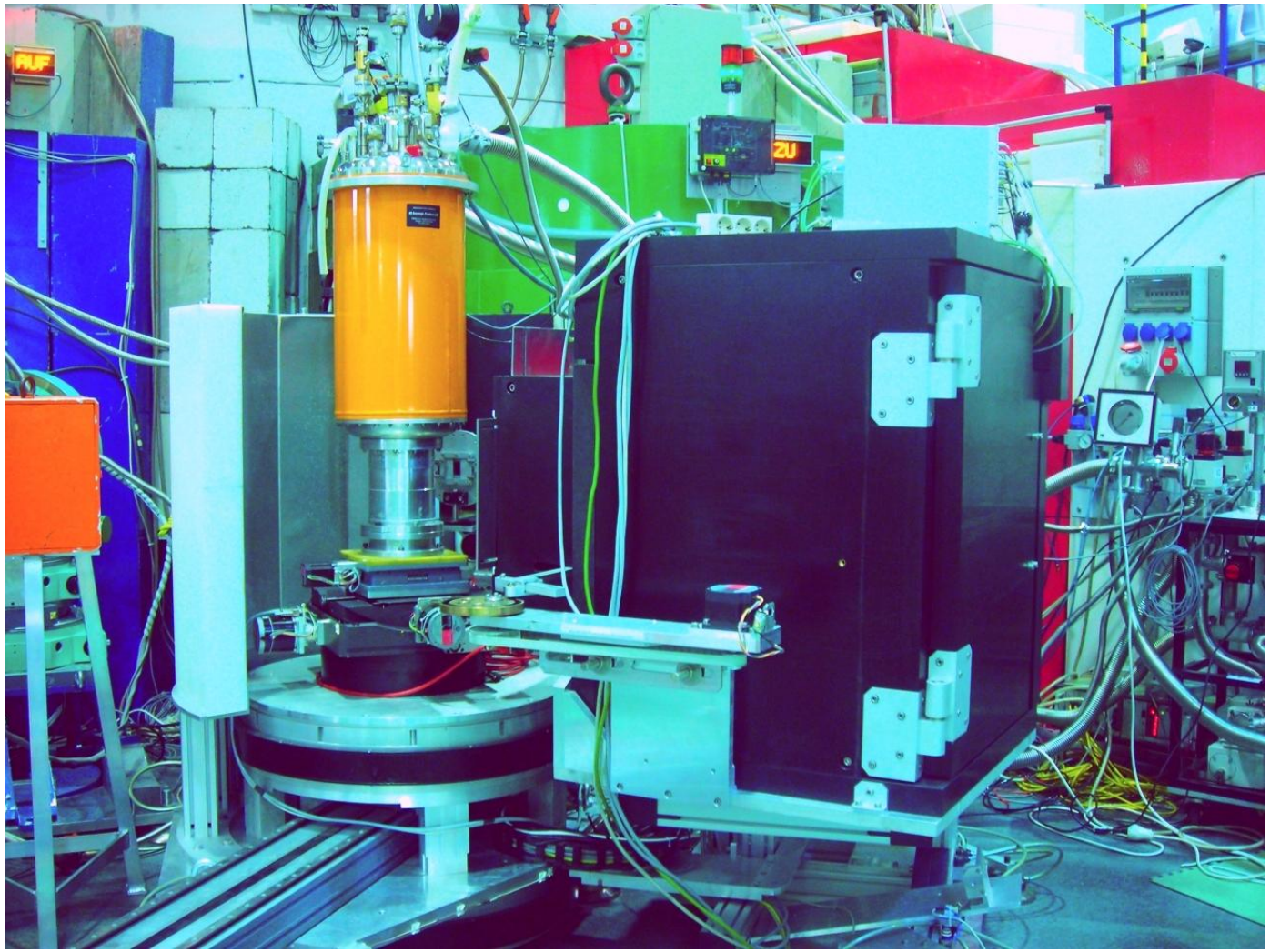
E5 diffractometer



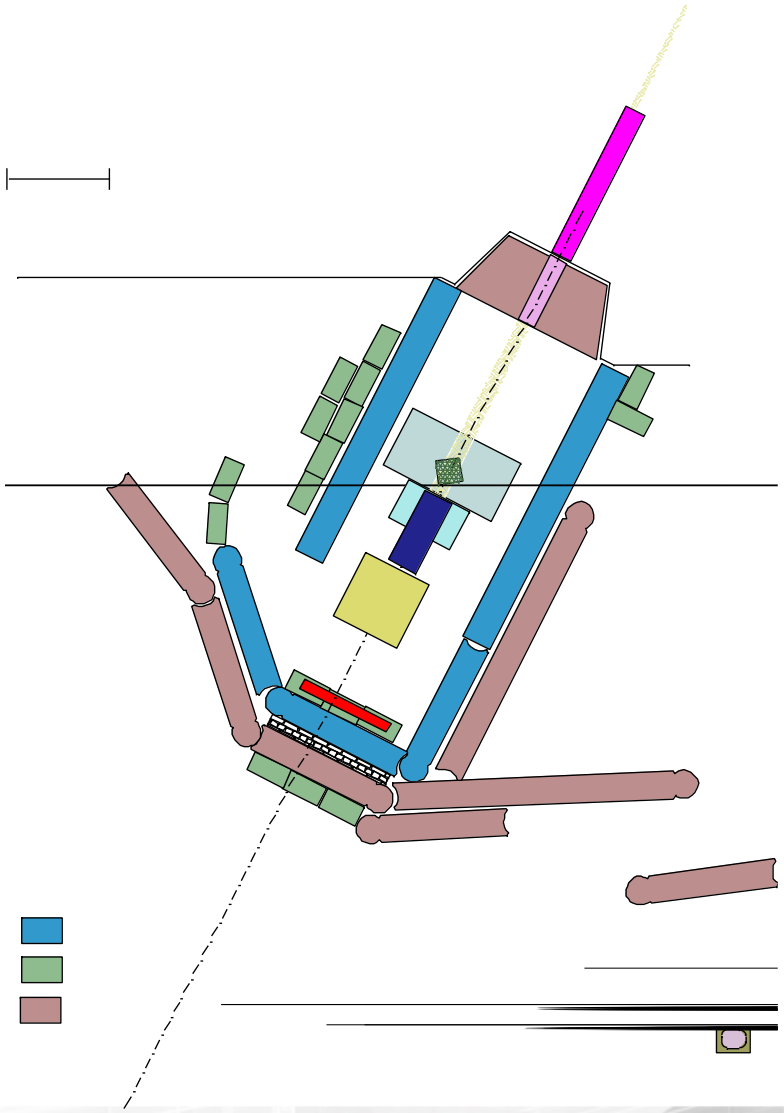
E6 diffractometer



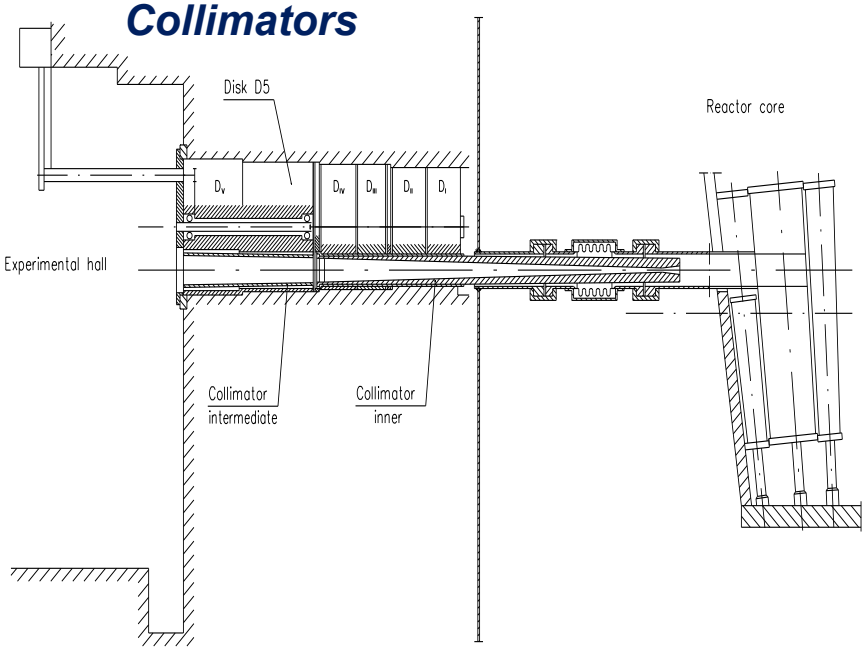
E6 diffractometer



H8 neutron radiography station



Collimators



Neutron Radiography facility main parameters

100 < L/D < 200

neutron flux density = 1.1 x 10^7 n cm^{-2} s^{-1} (at L/D = 150)

ILL 2.9 x 10^9 n cm^{-2} s^{-1} at L/D = 100

Converter screen size: 250 x 250 mm

Converters:

gamma : Gd2 O2 S: Tb

neutrons: ^{6}Li:ZnS:Cu, Al, Au (green light)

Camera: CCD ORCA-ER (Hammamatsu)

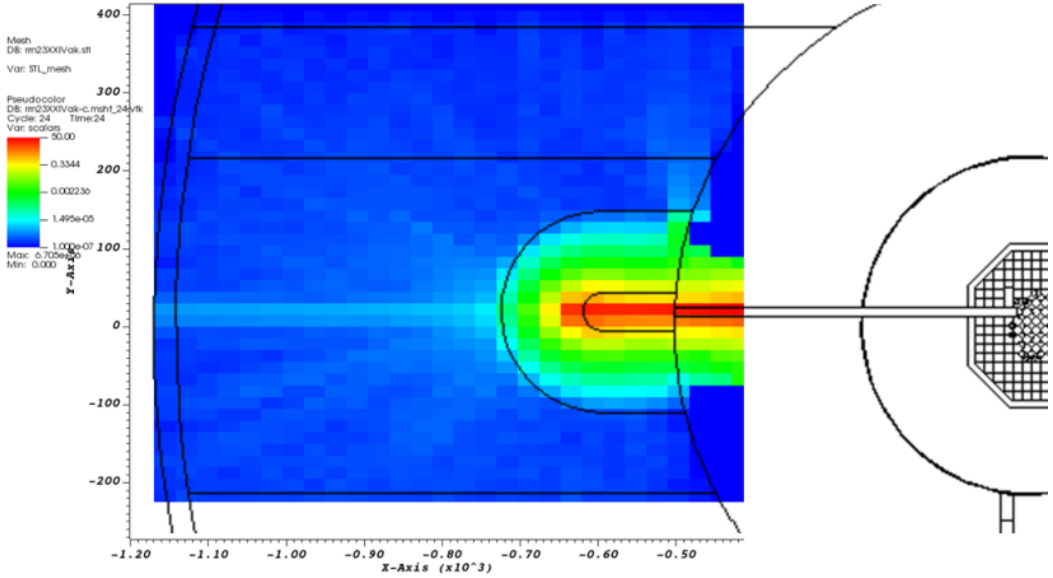
Linear resolution: 0.1 mm, time resolution: 1 s

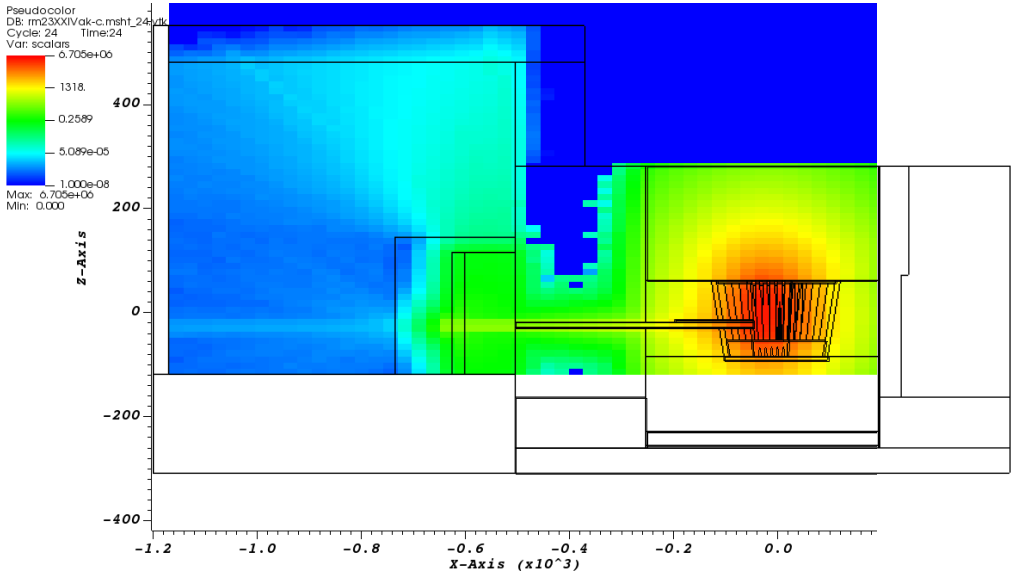
Objects: medium size technical devices

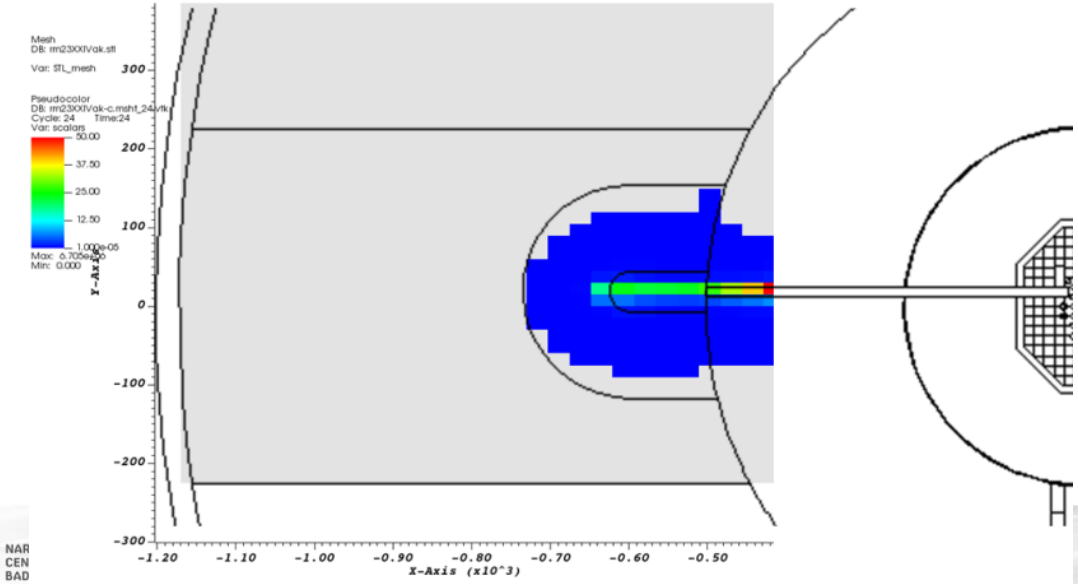
Processes: water migration in porous systems

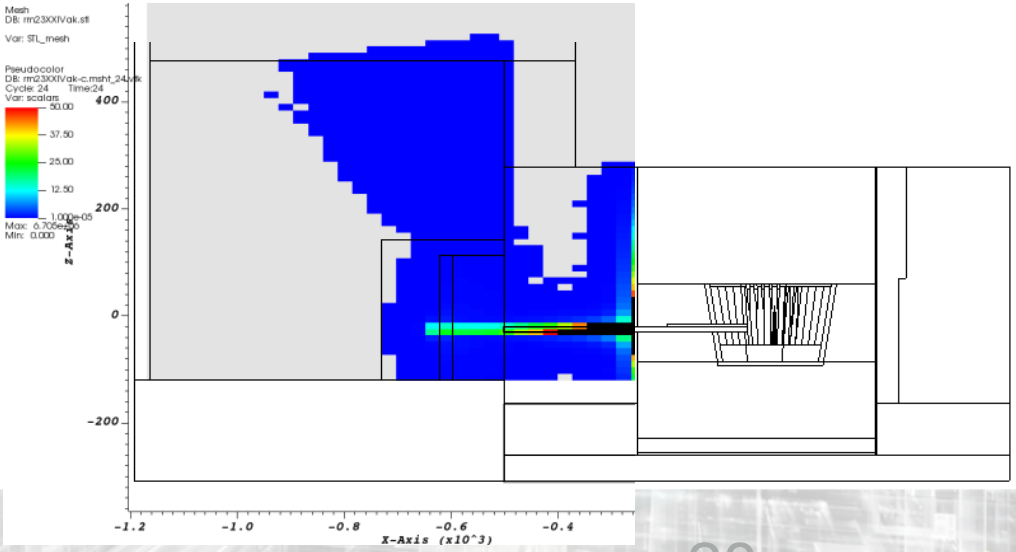
self-diffusion in water

Modeling of E2 shield from HZB

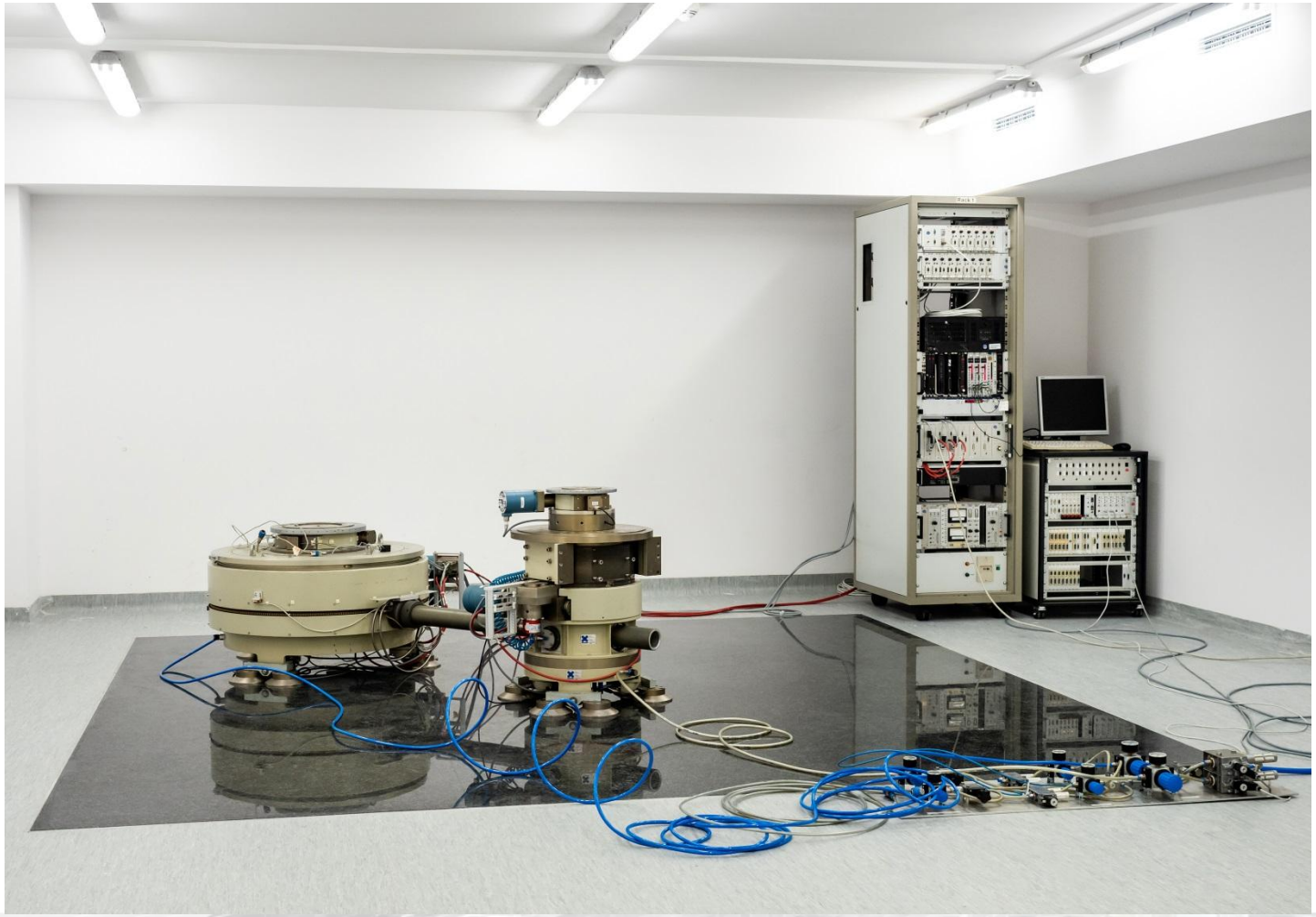




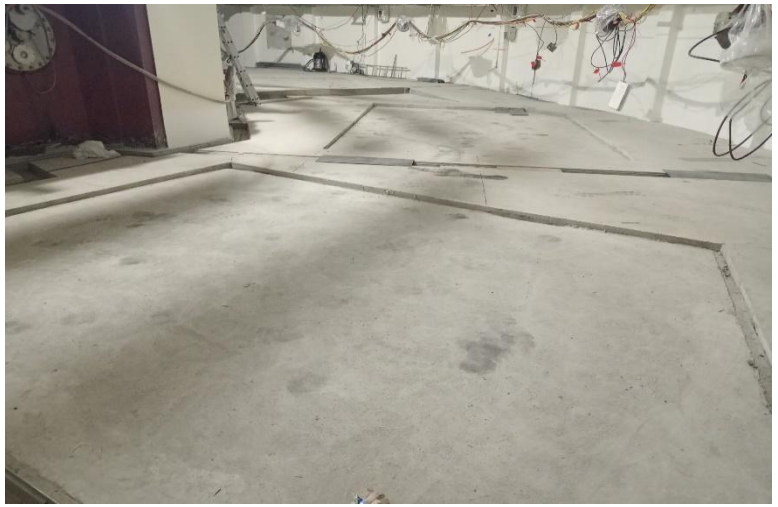




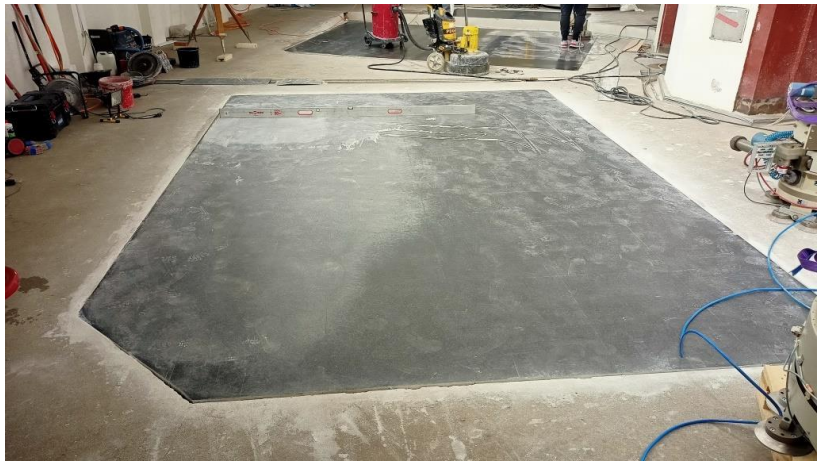
The main systems (sample and analyser tables, and control) of the E1 spectrometer deployed on the granite floor for training at NCBJ



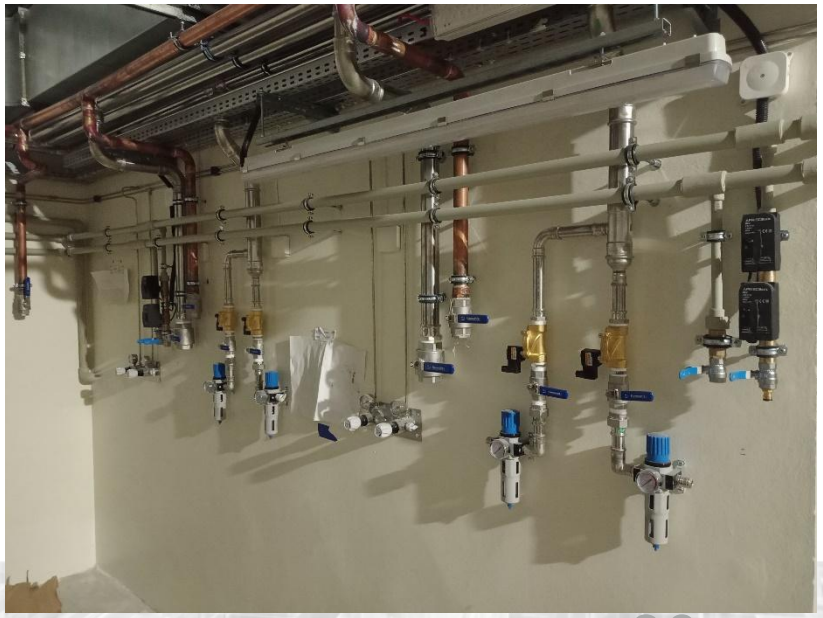
Concrete floor



Granite floor



Pressurized air, He recovery, cooling water, N2 and He installations



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***
- ***Computers***
- ***Software***
- ***Modernization of the radiography station***
- ***Modernization of rooms for MNL in the LBM building***

KRAJOWY PLAN ODBUDOWY

Rzeczpospolita Polska

Sfinansowane przez Unię Europejską NextGenerationEU

Thank you

NARODOWE CENTRUM BADAŃ JĄDROWYCH ŚWIERK

www.ncbj.gov.pl