Current status of the DN-6 diffractometer for the studies of materials at ultra-high pressures

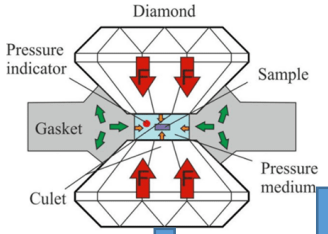
E.V. Lukin

Joint Institute for Nuclear Research

Frank Laboratory of Neutron Physics

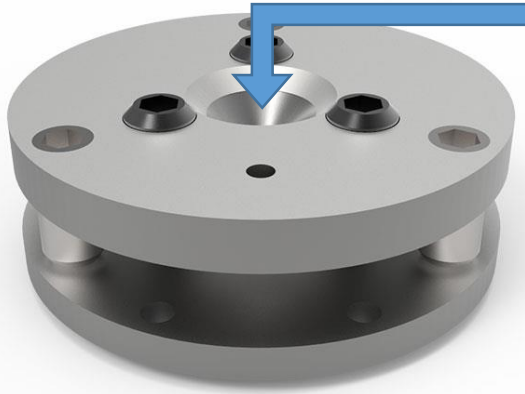
High-pressure technique on laboratory instruments.

X – ray diffractometer Xeuss 3.0, by Xenocs

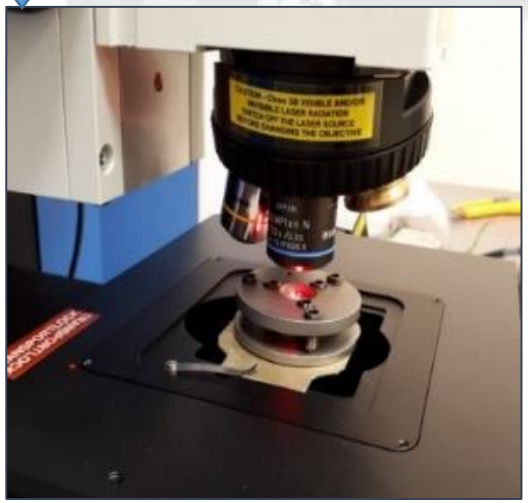


Raman spectrometer LabRam, by Horiba

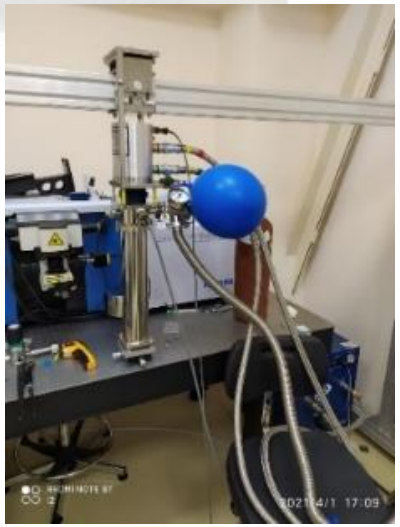
DAC in an X-ray beam.
pressure up to 100 Gpa.



Diamond anvil cell (DAC)



DAC under 633 nm laser light.
Pressure up to 100 GPa.

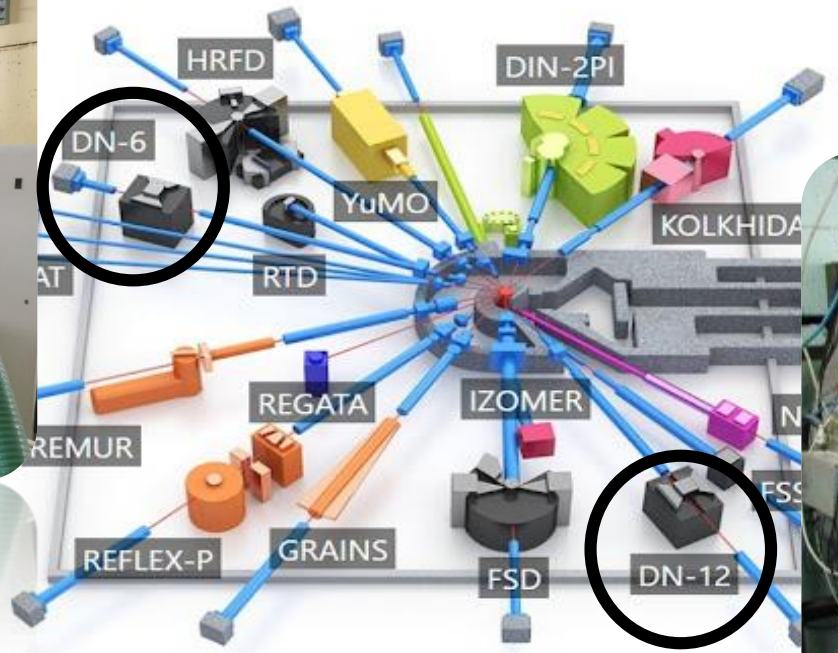


Low vibration CCR for Raman study of materials under pressure
Temperature down to 20K

High-pressure technique on laboratory instruments.

DN-6 diffractometer on 6 beamline

IBR-2



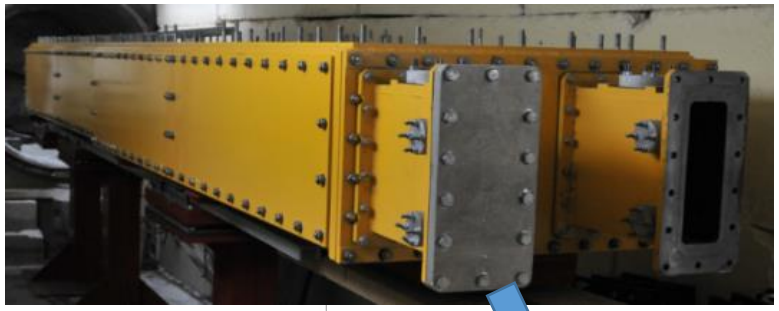
DN-12 diffractometer on 12 beamline correspondingly

DN-6 and DN-12 diffractometers. Main parameters.

Parameters	DN-6	DN-12
Neutron flux density at sample position	~3.5×10^7 n/cm^2/s	~1.5×10^6 n/cm^2/s
TOF distance:	30.5 m	26.0 m
Ranges:		
wavelengths		0.8 – 10 Å
scattering angles	45° – 90°	45° – 135°
d-spacing	0.5 – 11.2 Å	0.6 – 12 Å
Resolution Δd/d (d=2 Å)		
at 2ϑ=45°	~0.04 (McStas simulation)	0.030
at 2ϑ=90°	0.025	0.022
at 2ϑ=135°		0.012
Average sample volume	0.01 mm^3	1 mm^3
Temperature range	4-320K	10-320K
Pressure range	↑ 50 GPa with diamond anvils ↑ 12 GPa with sapphire anvils	↑8 GPa with sapphire anvils
Exposition time per pressure point	2-20 h	12-36 h

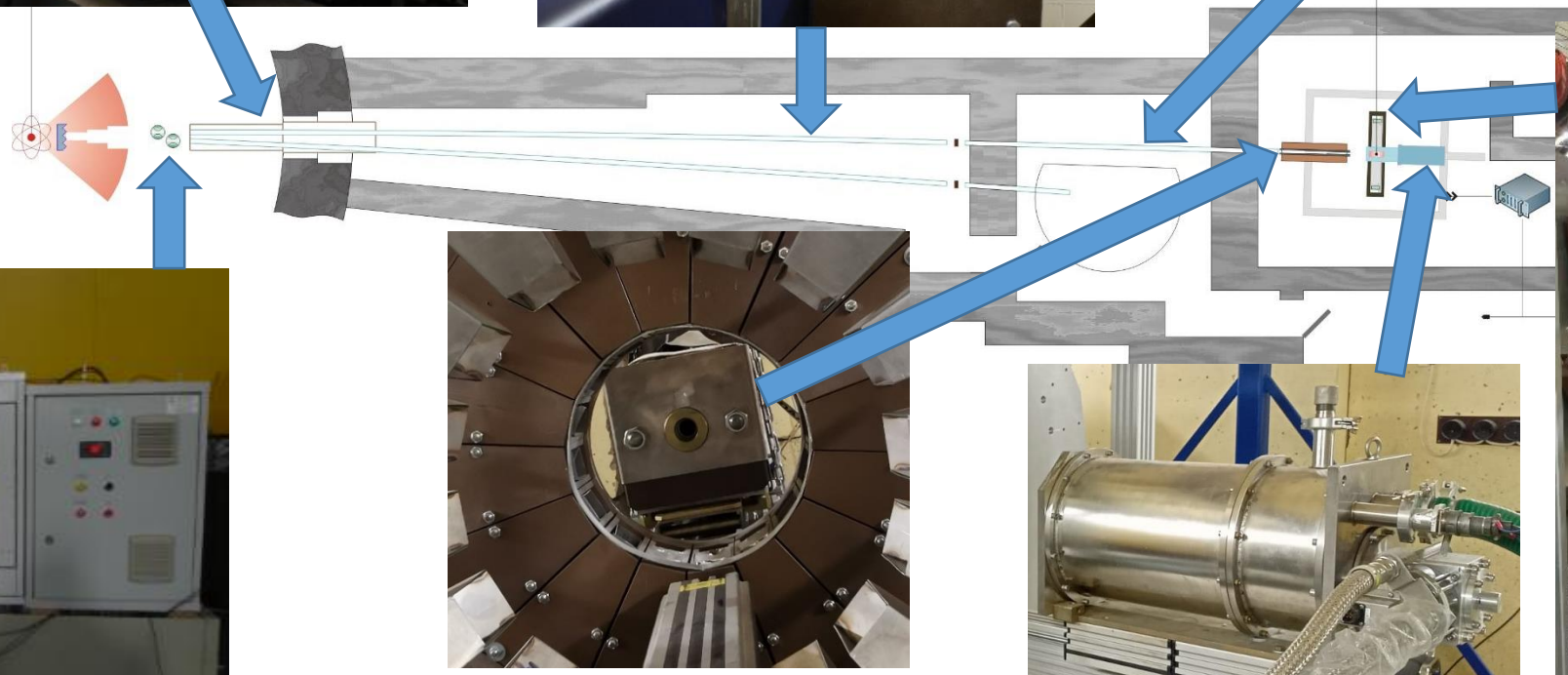
DN-6: general information

Neutron flux splitter



Curved part of neutron guide

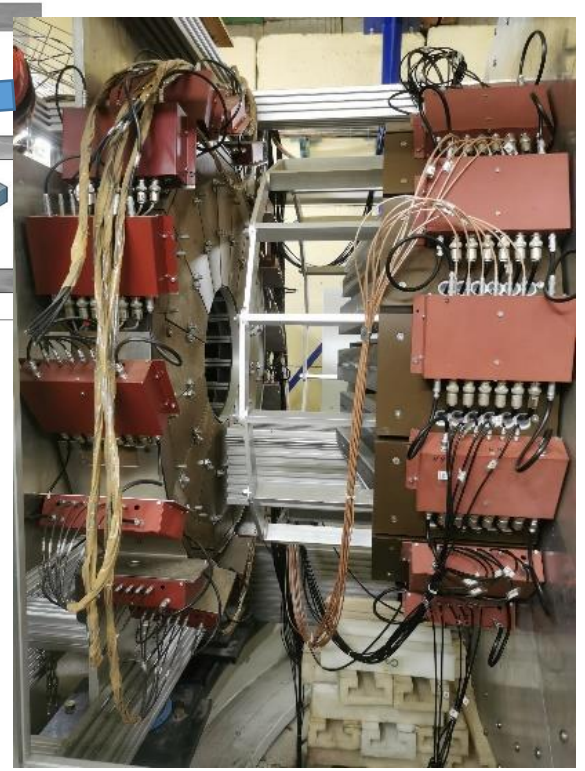
Focusing part of neutron guide



Background chopper

Collimator

Close circle refrigerator



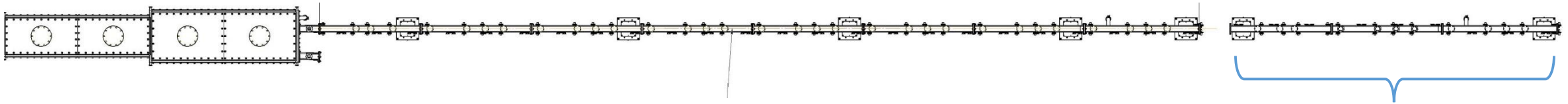
Detector system

DN-6: neutron guide/focusing part

splitter

curved neutron guide

focusing neutron guide



vertical parabolic tapered neutron guide

-Profile (hor./vert.): parallel/parabolic tapered (linar appr.)

-Entrance: 180.00 mm(h)x 15.00 mm(w)

-Exit: ~60 mm (h)x 15.00 mm(w)

Reflectivity:

-Top/bottom R_{ave}=92%

-Sides R_{total}~99,5%

First three units:

Coating: Ti/Ni

-Top/bottom m=3

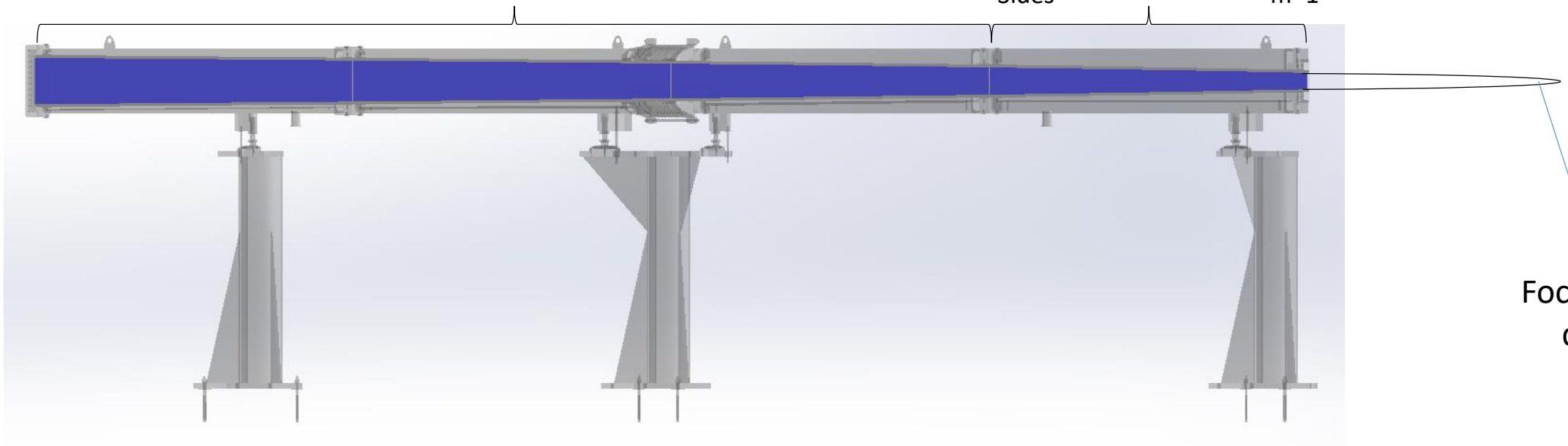
-Sides m=1

Last unit:

Coating: Ti/Ni

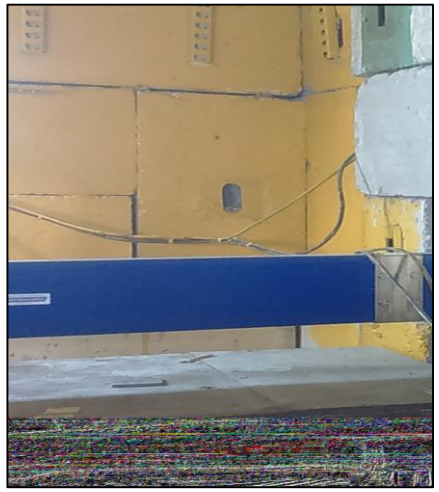
-Top/bottom m=5

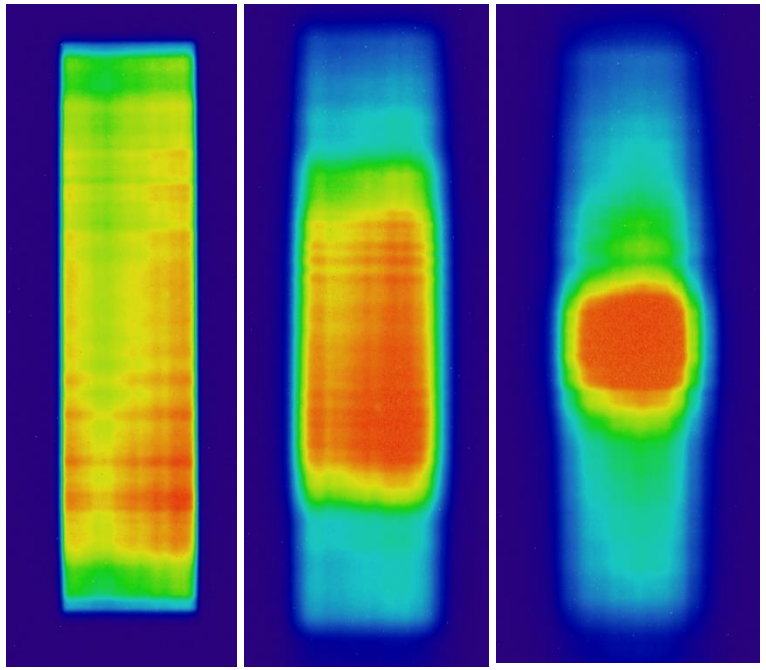
-Sides m=1

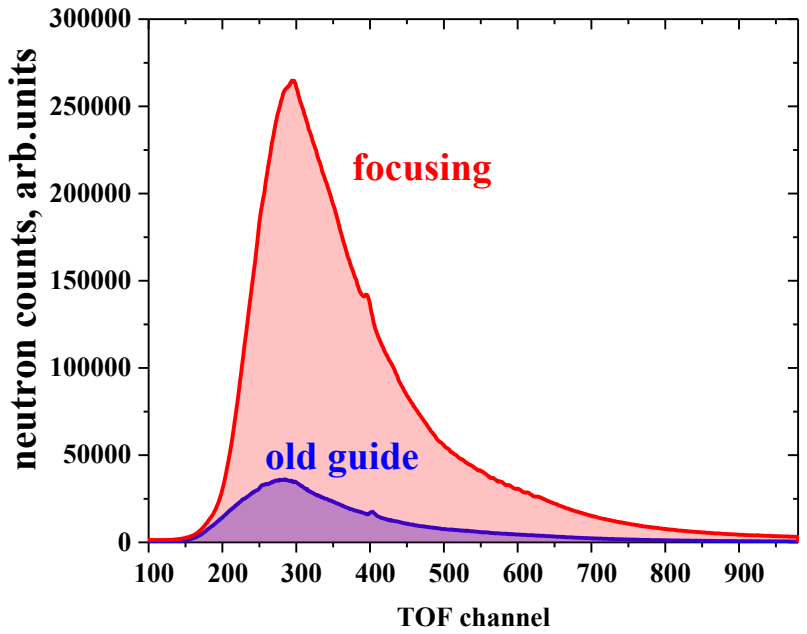


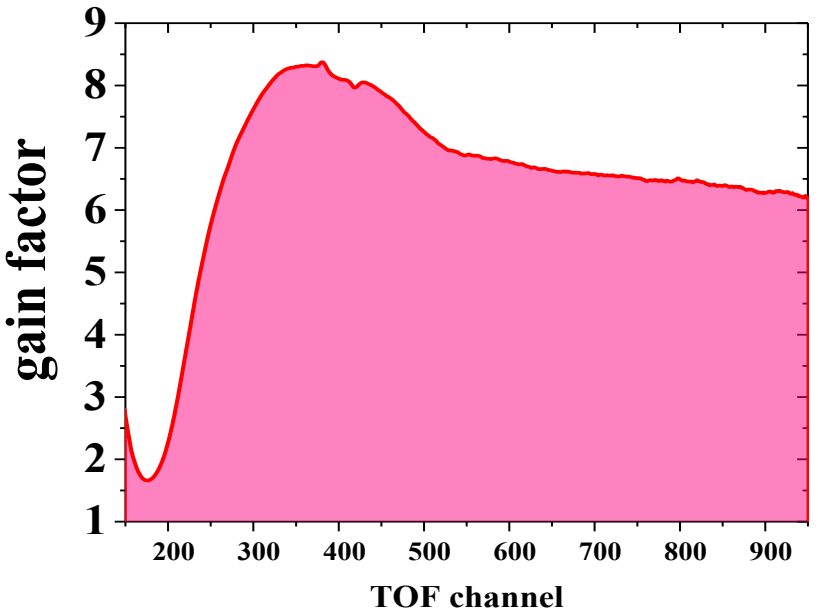
Focus at 87 cm downstream

DN-6: neutron guide/focusing part



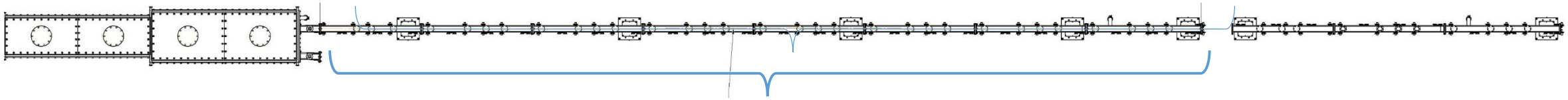






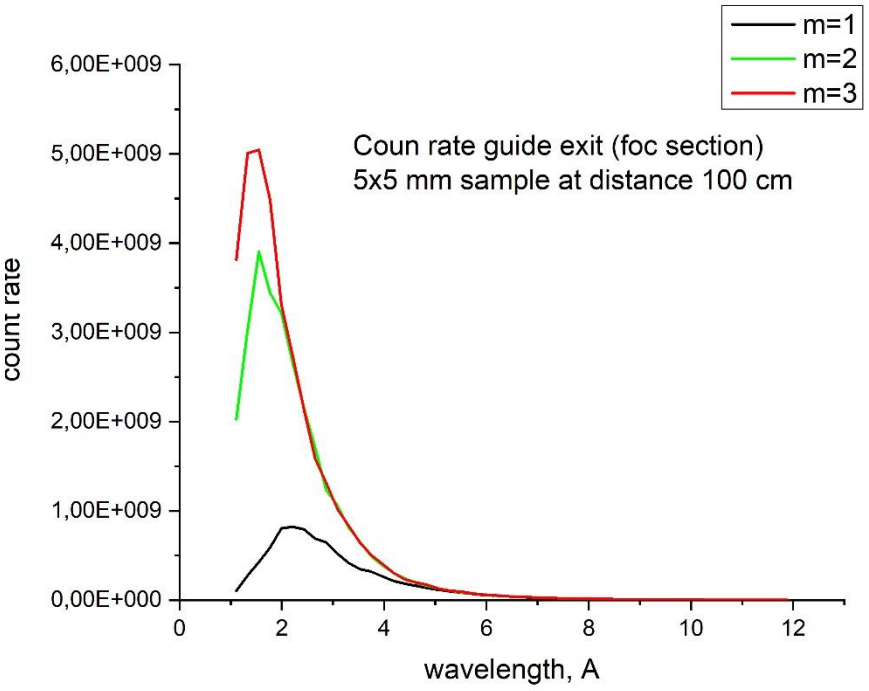
DN-6: neutron guide/curved part/design

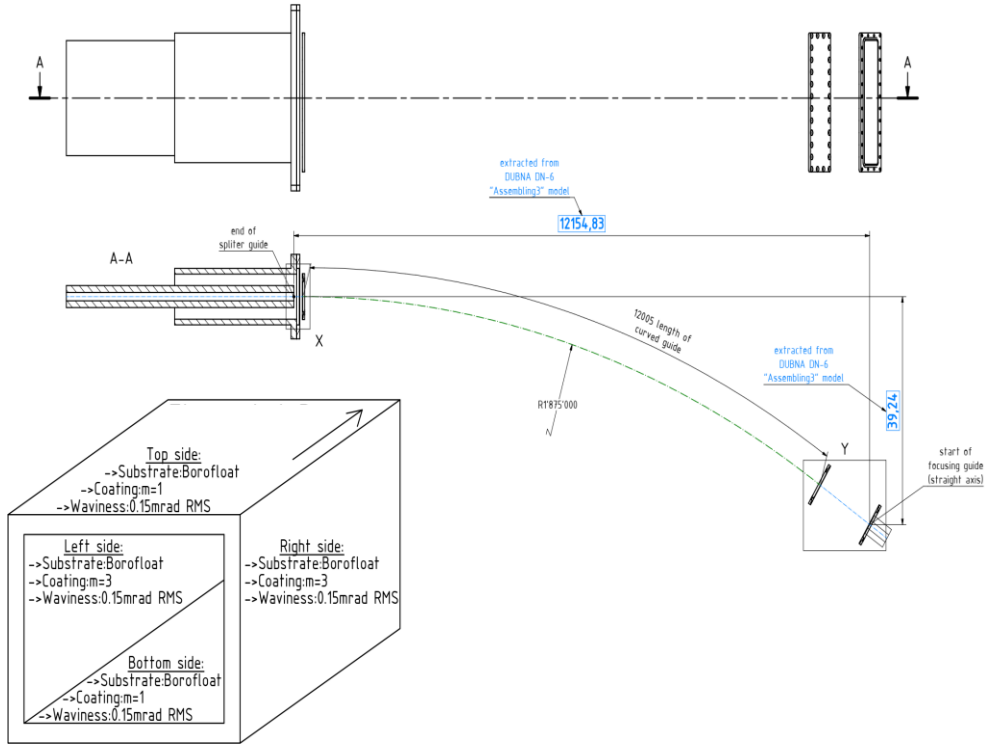
splitter | curved neutron guide | focusing neutron guide

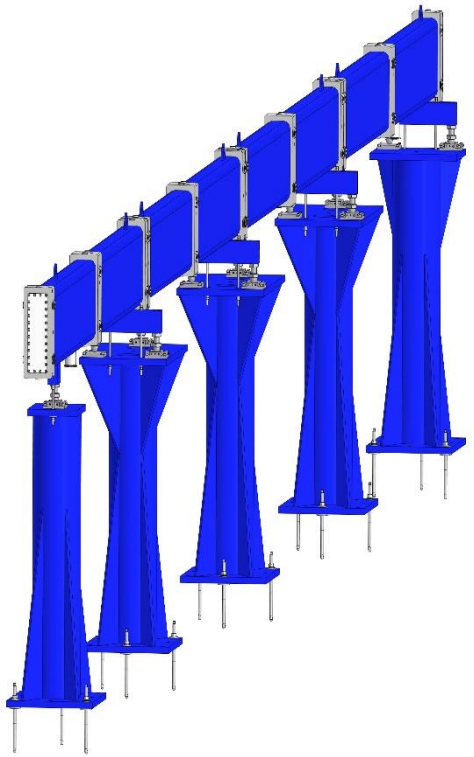


Replacement part – curved neutron guide based on natural Ni coating mirrors (coating: m=1)

Calculations → Mechanical layout → Final model



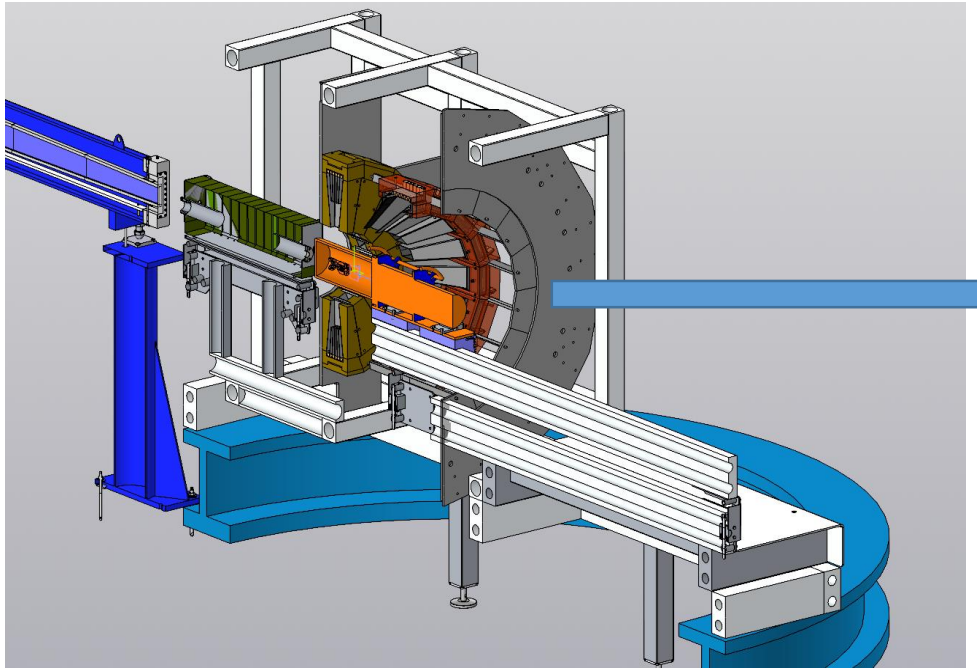


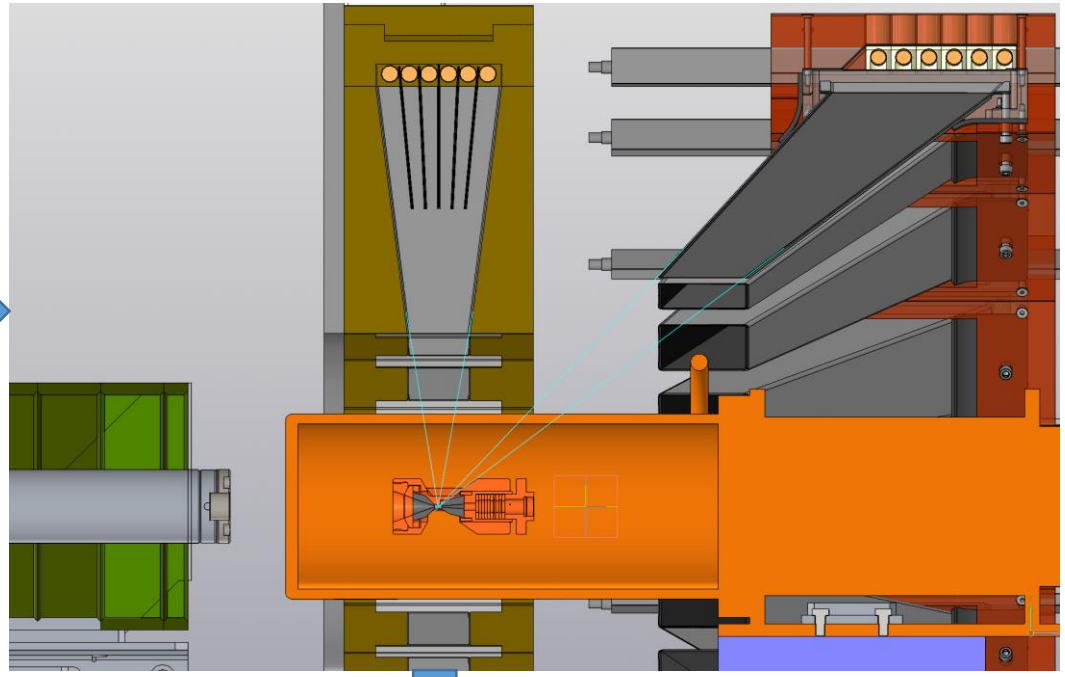


DN-6: neutron guide/curved part/install

Engineers from Swiss Neutronics

DN-6: detector system/90 degrees detector ring





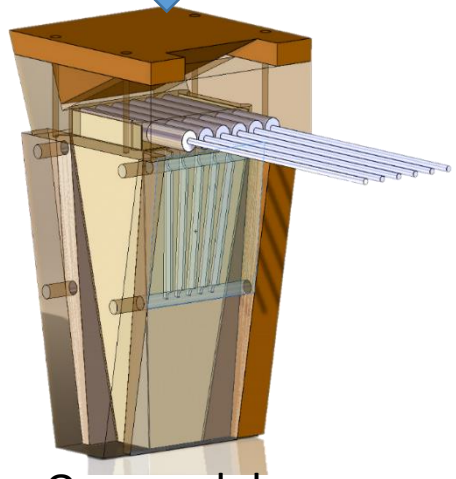
96 independent neutron counters group in

16 independent modules **within**

6 counters in each module

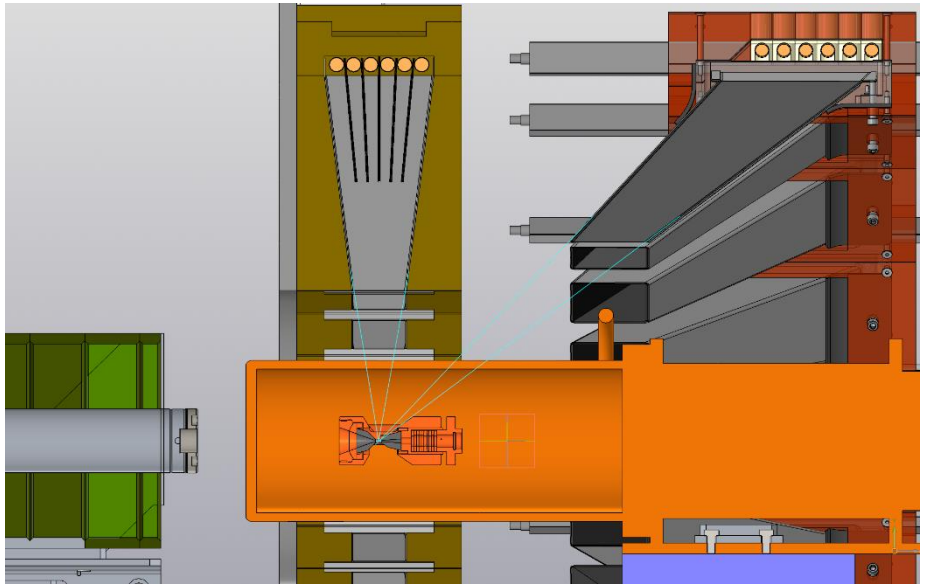
87-93 2θ deg. covering

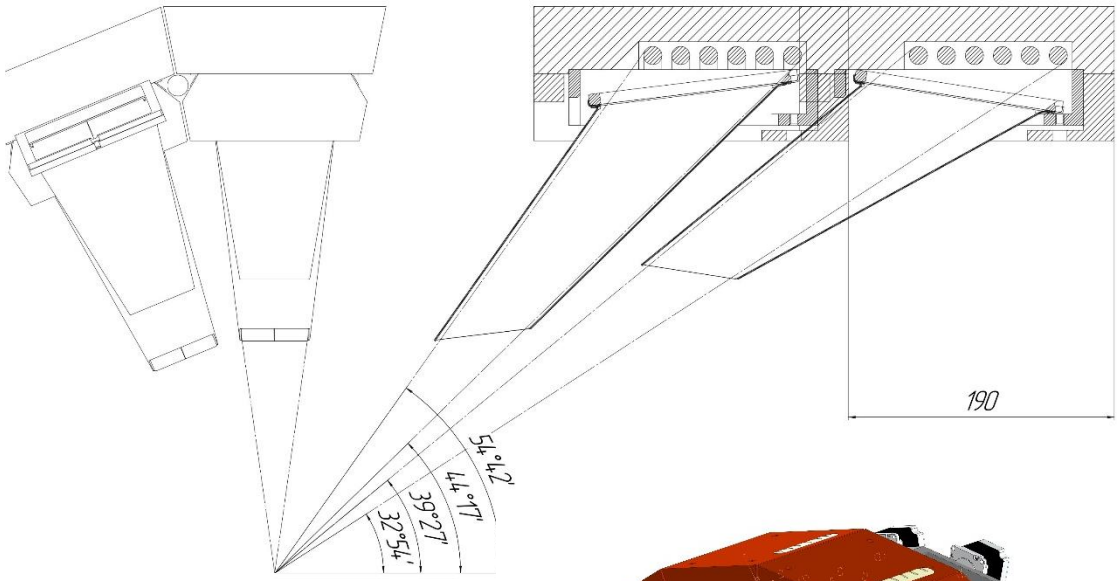
He filled neutron counter (8 bar)

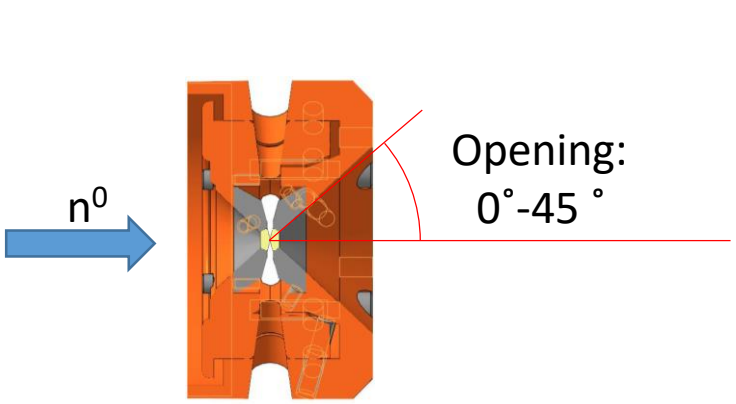


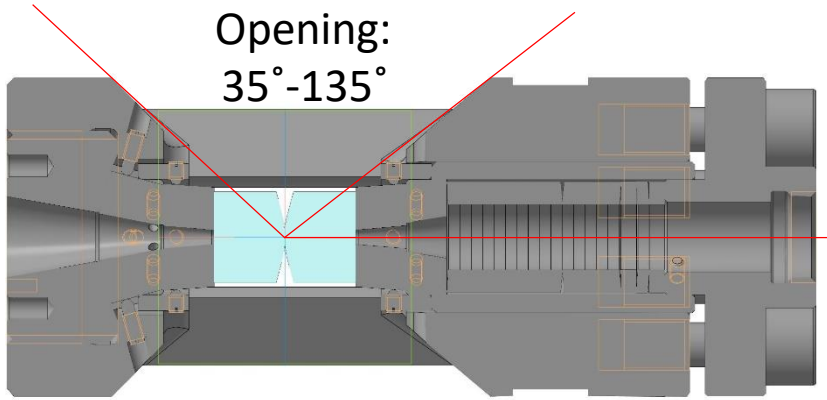
One module

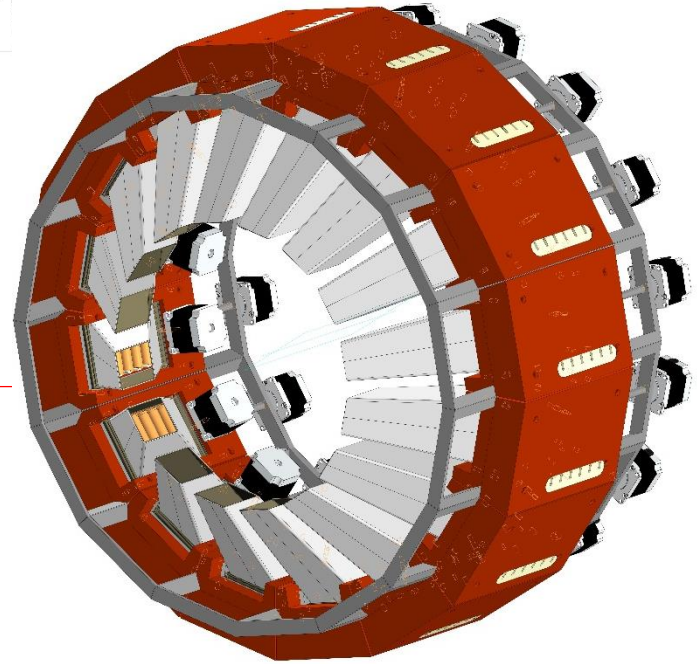
DN-6: detector system/45 degrees detector ring/design



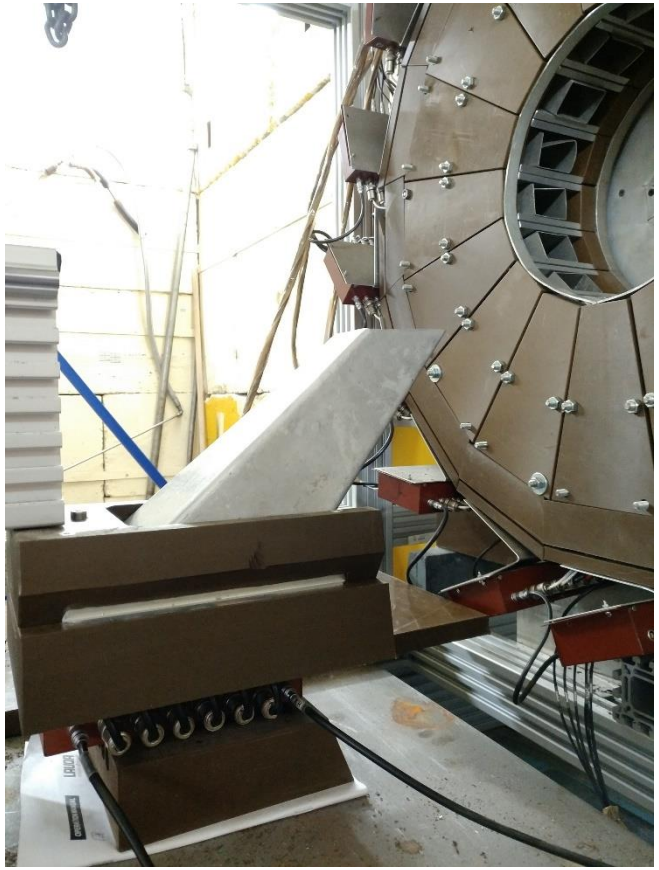




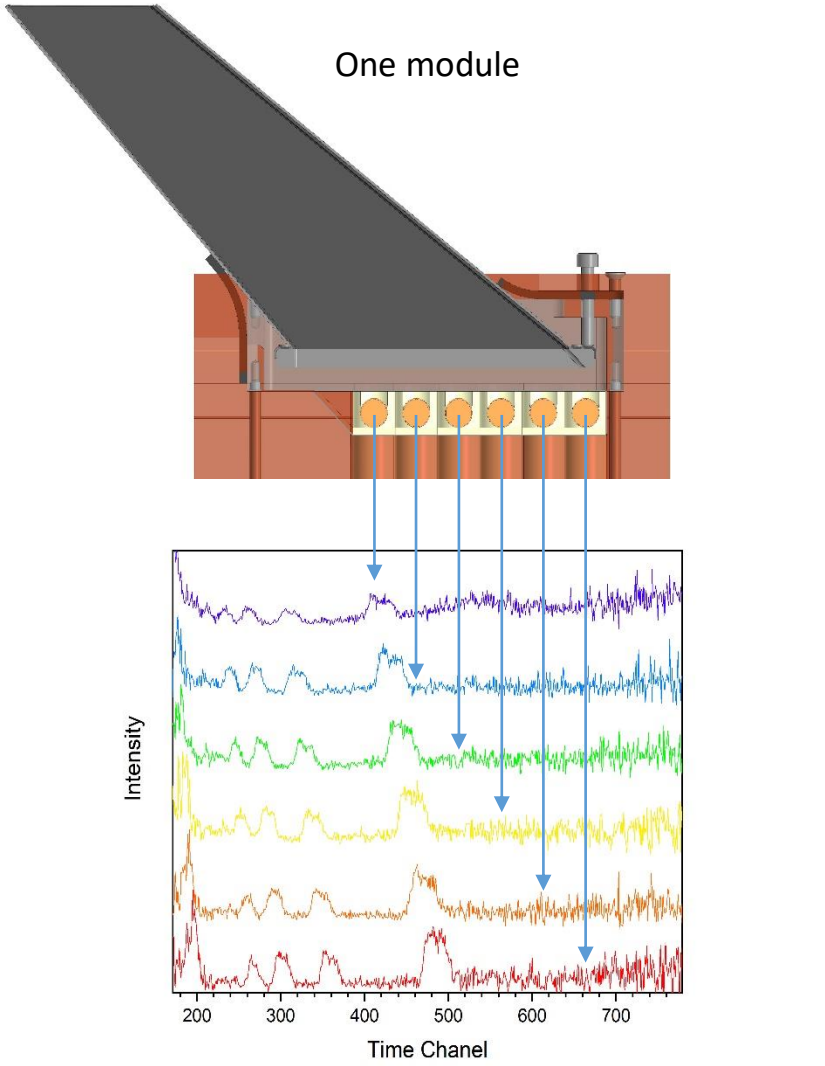




DN-6: detector system/45 degrees detector ring/test



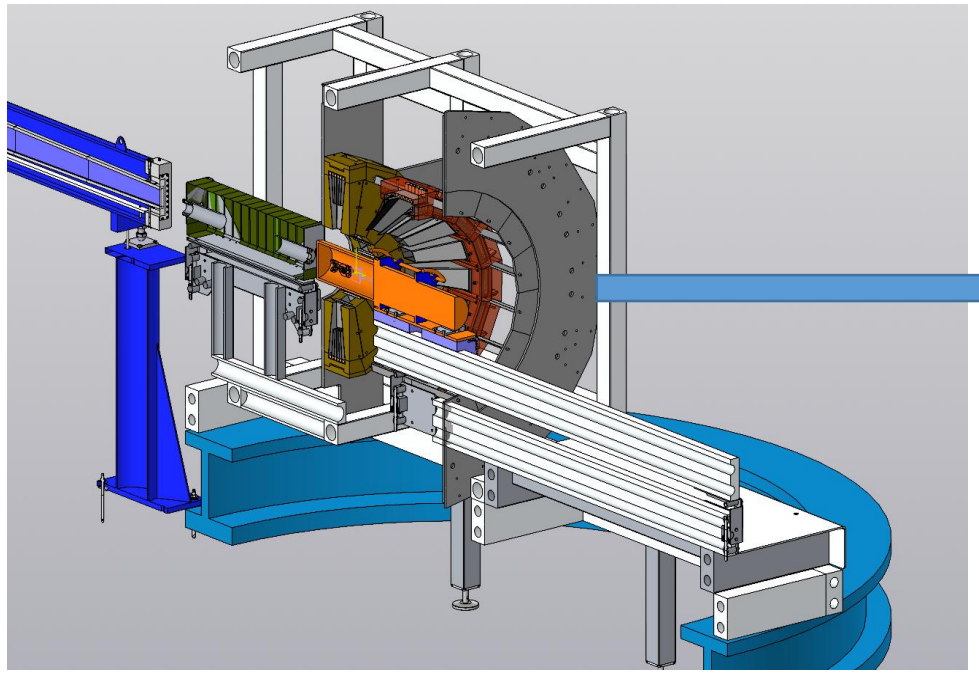
Test experiment setup



Neutron diffraction patterns of 1mm^3 La(^{11}B)$_6$ for 2θ region 40-48.

d_{hkl} range	Up to 12Å
Solid angle	Up to 0,63 sr
2θ angle range	32°-54°

DN-6: detector system/45 degrees detector ring/install



45 deg detector ring

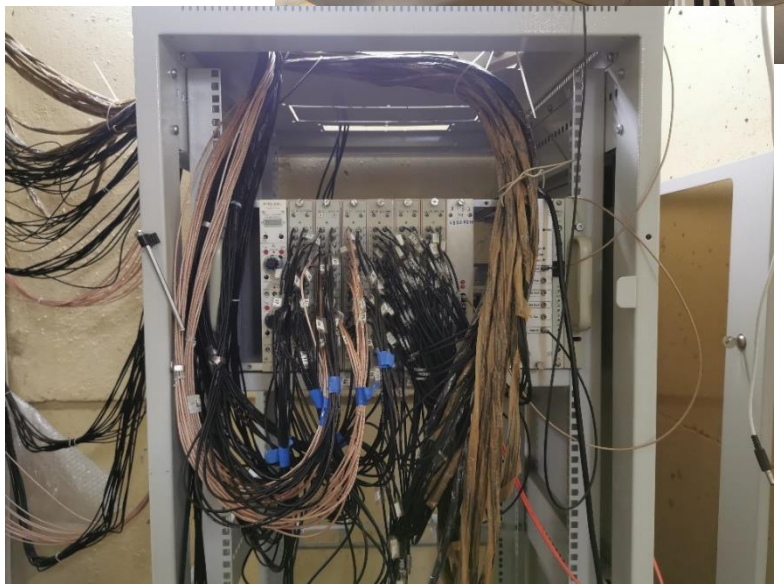
80 independent neutron counters group in

15 independent modules **within**

6 counters in each module

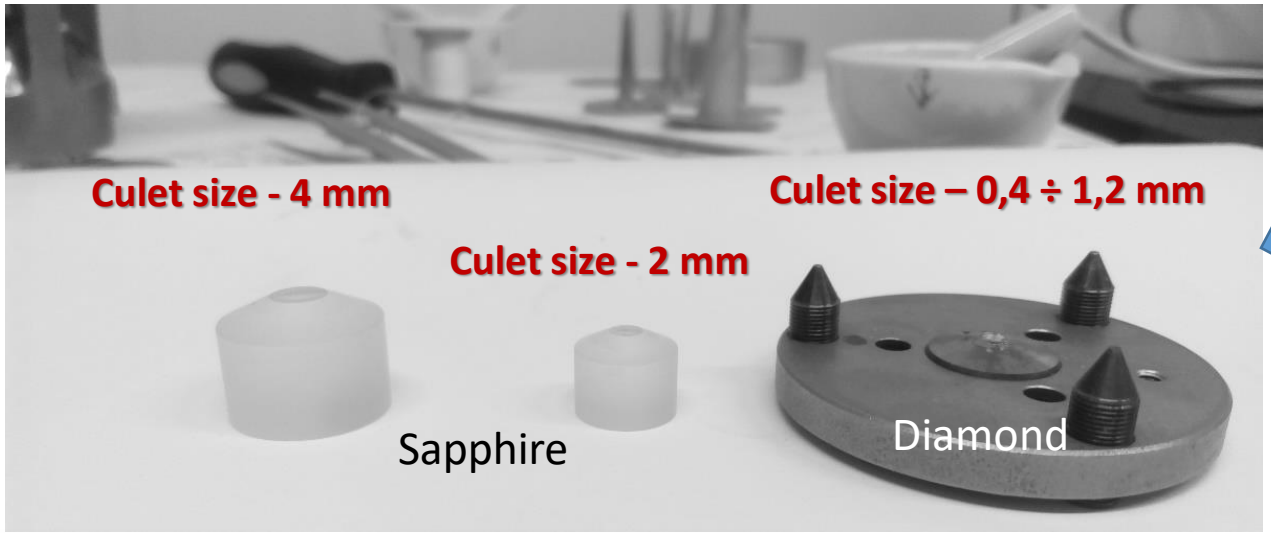
32-54 2θ deg. covering

He filled neutron counter (8 bar)



detector ring control unit

DN-6: high-pressure techniques.



Types of anvils used in high pressure experiments

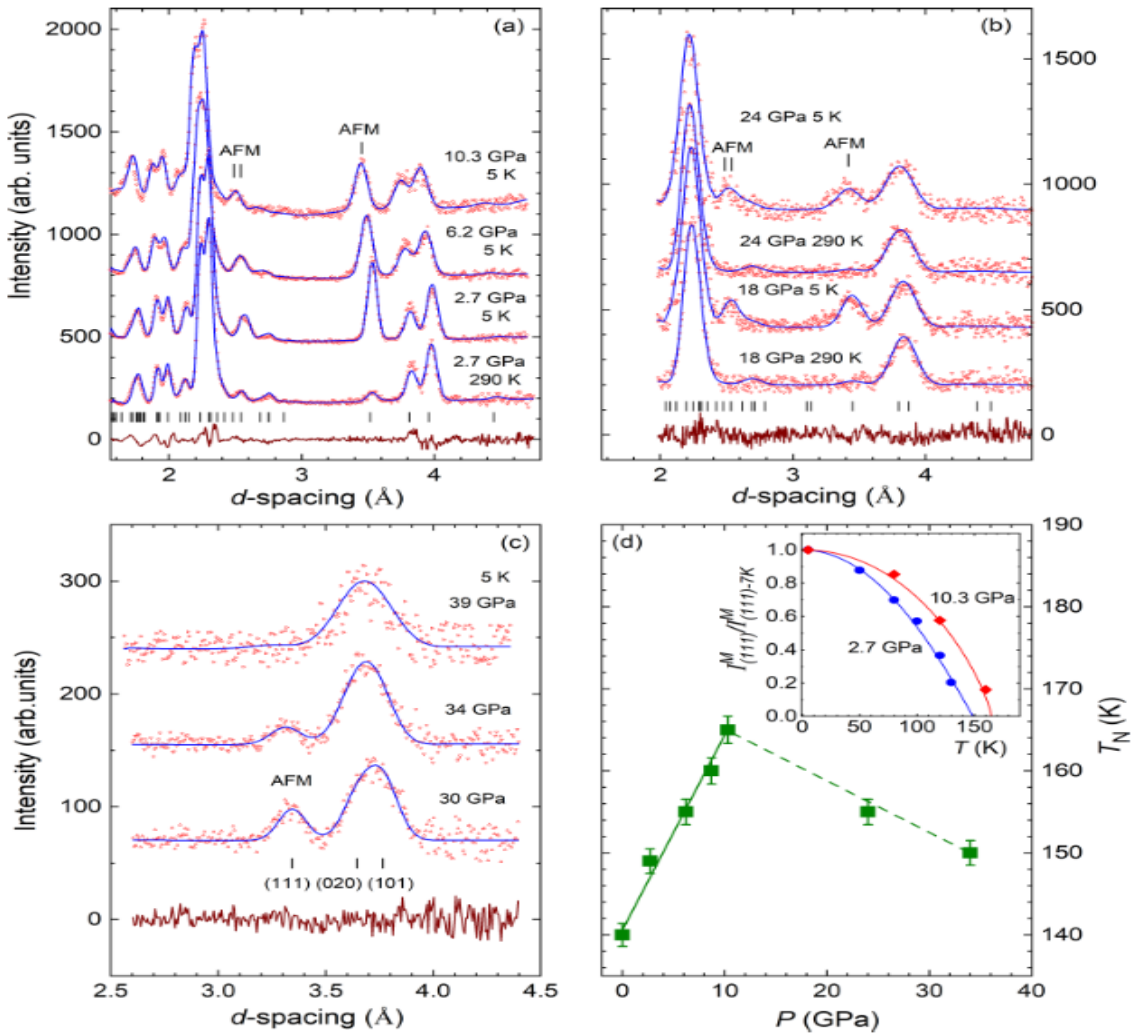
Types of cells used in high pressure experiments

Sapphire anvils cells

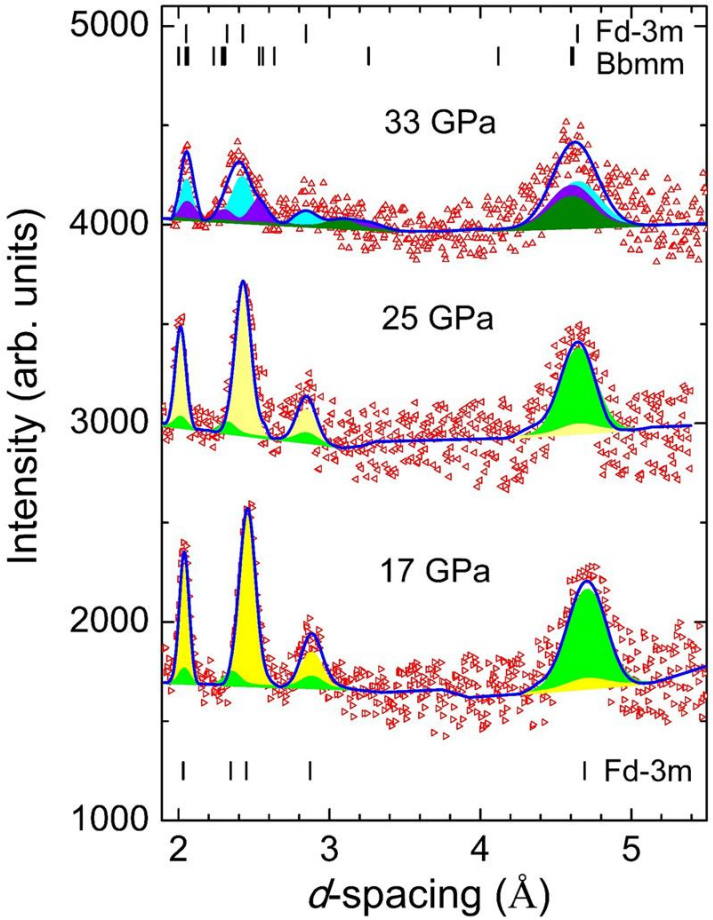
Diamond anvils cells (DAC)

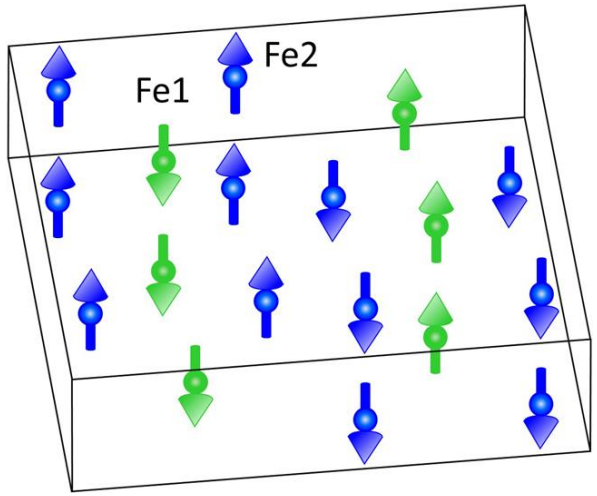
Böhler Almax Plate DAC

DN-6: some scientific results.



*D. P. Kozlenko, E. V. Lukin, S. E. Kichanov, Z. Jirák, N. O. Golosova, and B. N. Savenko "High-pressure evolution of the magnetic order in $LaMnO_3$", Phys. Rev. B **107**, 144426 (2024)*

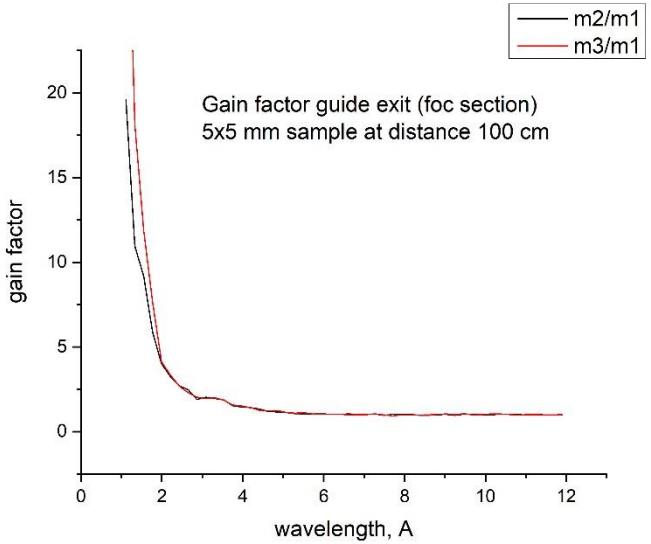




*Kozlenko, D.P., Dubrovinsky, L.S., Kichanov, S.E. et al. Magnetic and electronic properties of magnetite across the high pressure anomaly. Sci Rep **9**, 4464 (2019).*

Conclusions.

- The work on modernization the curved part of the neutron guide was carried out. Replacing mirrors from m=1 coating to mirrors with m=3 coating will, according to calculations, lead to a significant increase in the flux of neutrons with wavelengths up to 4 angstroms.



- A new detector ring for small scattering angles was developed and manufactured. This element will not only increase the solid angle of the detector system, but will also make it possible to expand the range of interesting interplanar spacing to 12 angstroms.

I express my deep gratitude to:

Denis Kozlenko
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Thank you for attention