International Seminar on Interaction of Neutrons with Nuclei

INSTALLATION OF NEW WIDE-APERTURE SCINTILLATION DETECTORS ASTRA-M AND BSD ON THE IBR-2M FOURIER-DIFFRACTOMETERS: FIRST RESULTS

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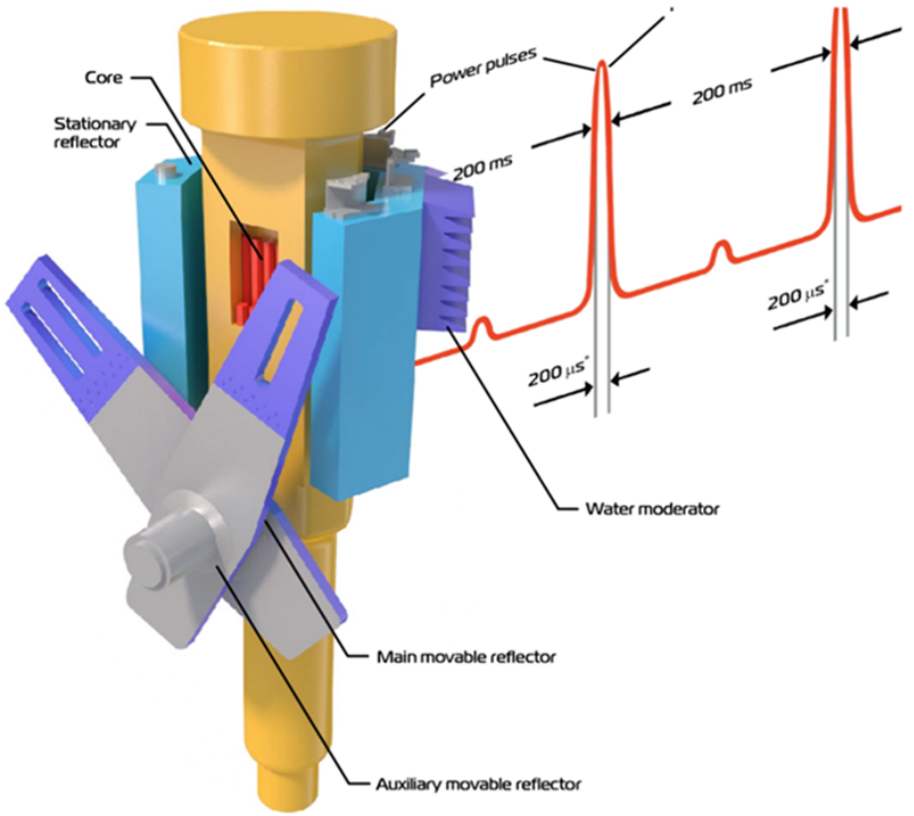
Dongguan, 26-30/05/2025

IBR-2 reactor FLNP (JINR)

Technical parameters of the IBR-2 reactor after modernization

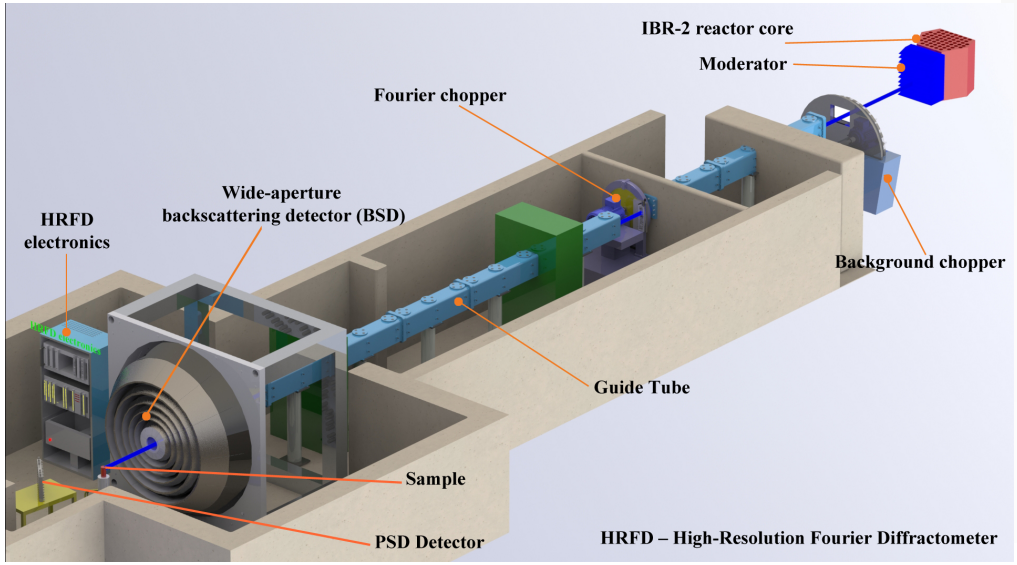
Average power	2 MW
Burst power	1850 MW
Fuel	PuO_2
Number of fuel assembles	69
Maximum burnup	9%
Pulse repetition rate	5, 10 Hz
Pulse half-width:	
fast neutrons	240 μs
thermal neutrons	340 μs
Background	7.5 %
Thermal neutron flux density (from the surface of the moderator):	
time average	~10^{13} n/cm^2/s
burst maximum	~10^{16} n/cm^2/s



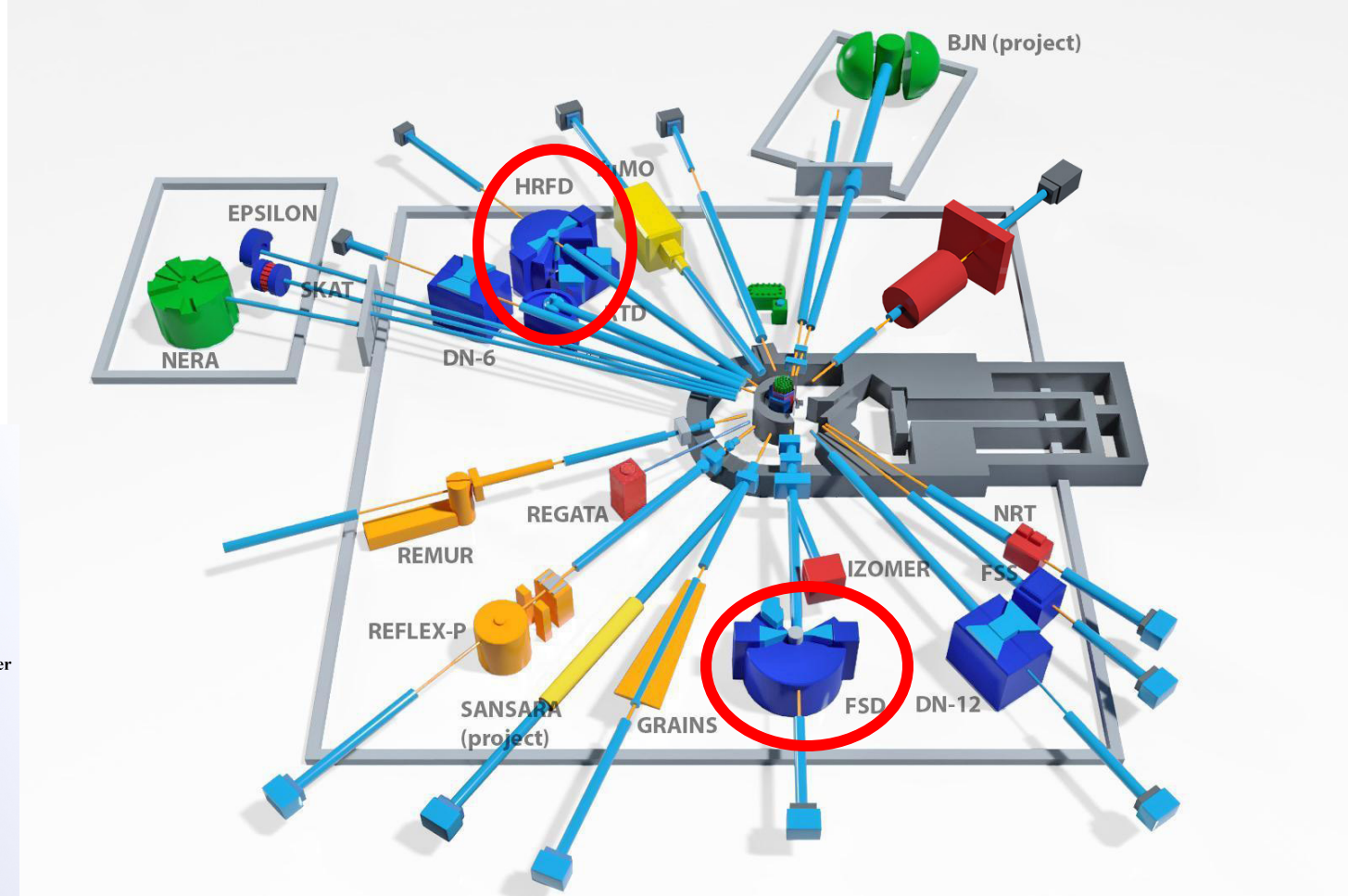
IBR-2 reactor https://flnp.jinr.int/

IBR-2 scientific facilities

18 research facilities:
- 14 - condensed matter physics
- 2 - nuclear physics
- 1 - radiation materials science
- 1 - neutron activation analysis.



Main view of HRFD
https://flnp.jinr.int



scientific facilities of the IBR-2 reactor
https://flnp.jinr.int

Geometric focusing technique

Bragg-Wolf equation

$$2d\sin(\theta/2) = n\lambda$$

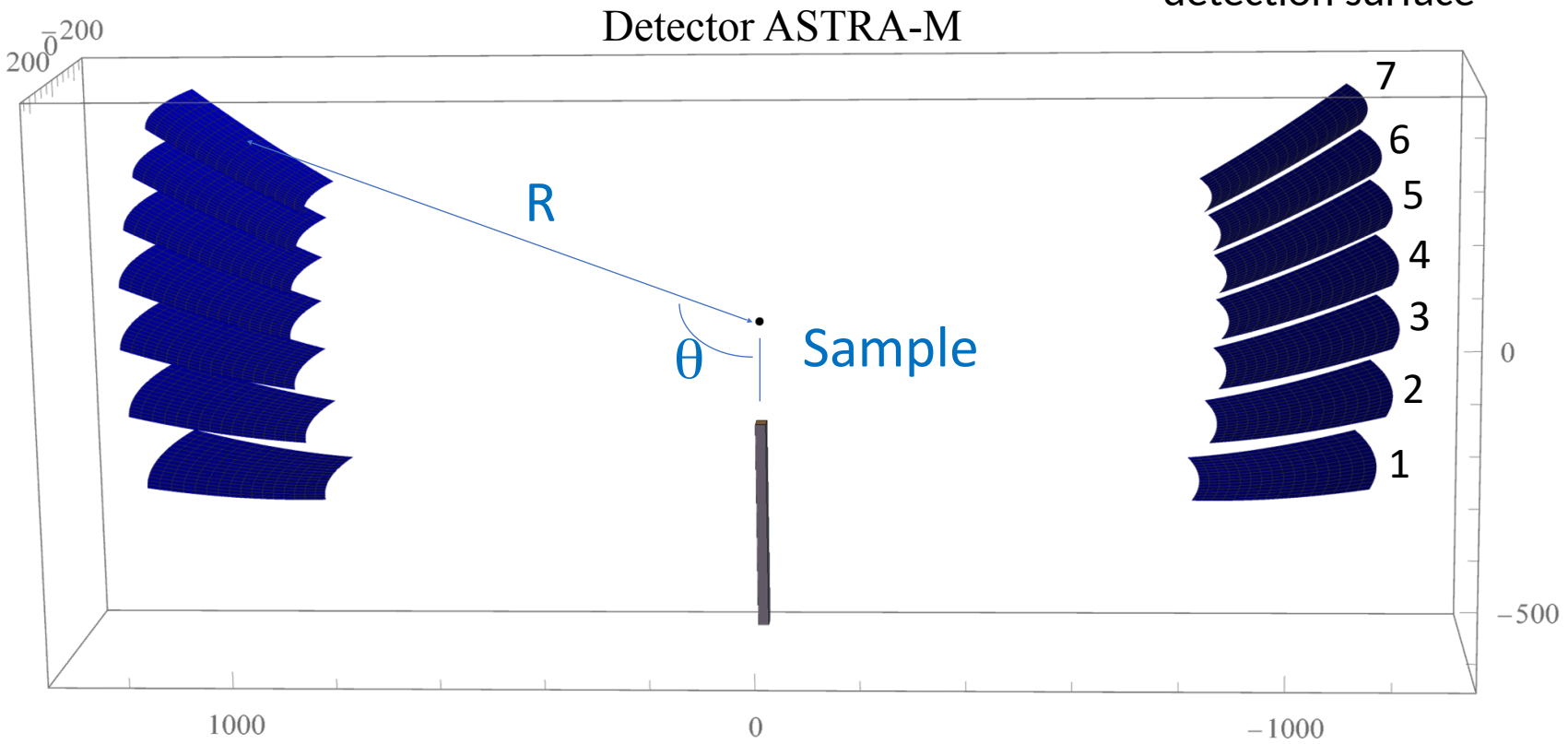
Focusing curve

$$R(\theta) = \frac{A_0}{\sin(\theta/2)} - L_0$$

L_0 – distance from Fourier chopper to sample;

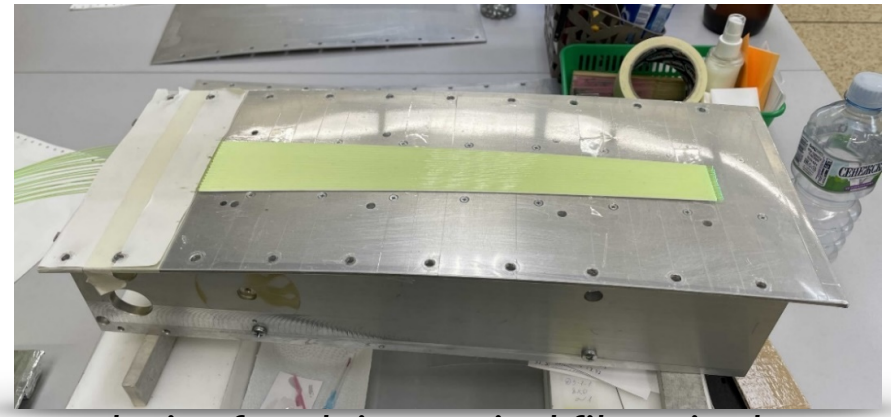
A_0 – parameter that specifies the position of the detector;

R – distance from sample to detection surface

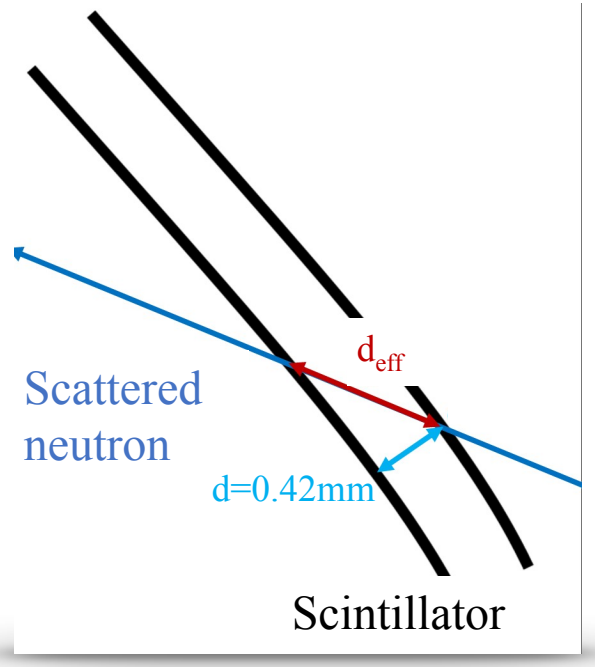


Scintillation screen ^{6}LiF/ZnS(Ag), 0.42 мм

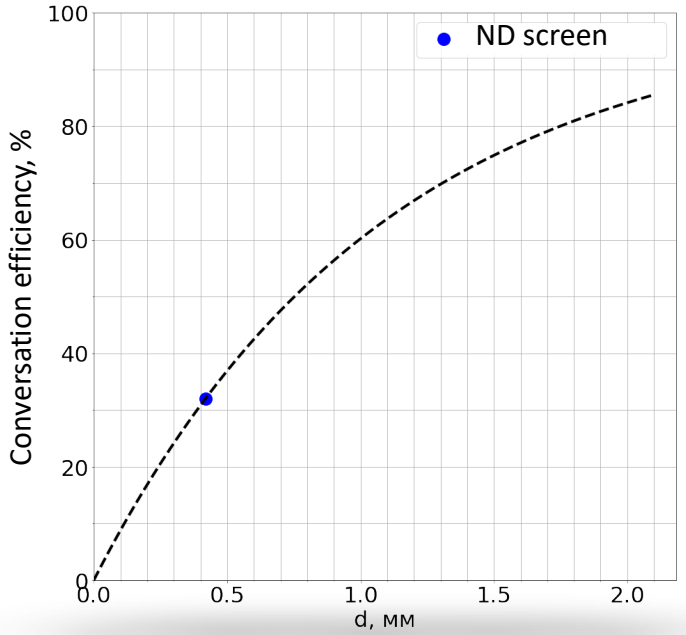
Screen Type	ND
Formulation	*6 LiF ZnS:Ag*
Phosphor Type	*Particulate blend*
Emission color	*Blue*
Peak Emission	*450nm*
Decay to 10%	*80μs*
Afterglow	*Low level*
X-ray Absorption	*Very low*
UV Absorption	*Broad band*



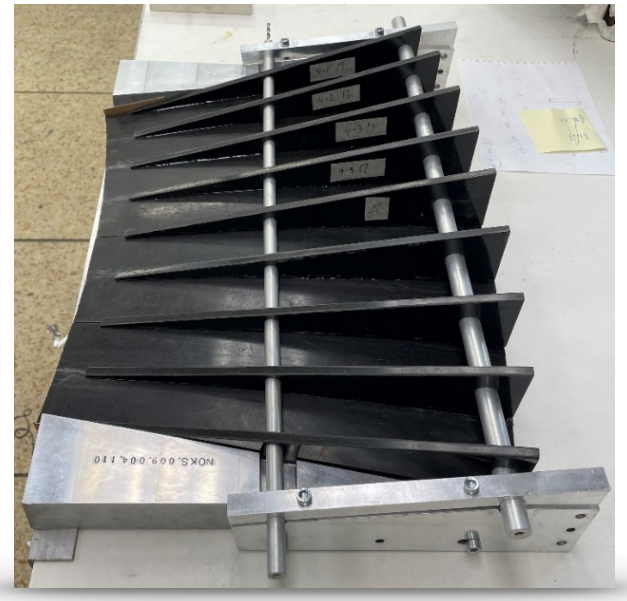
A device for gluing optical fibers in the required bend of the scintillator



Increased conversion efficiency due to screen placement at an angle to scattered neutrons

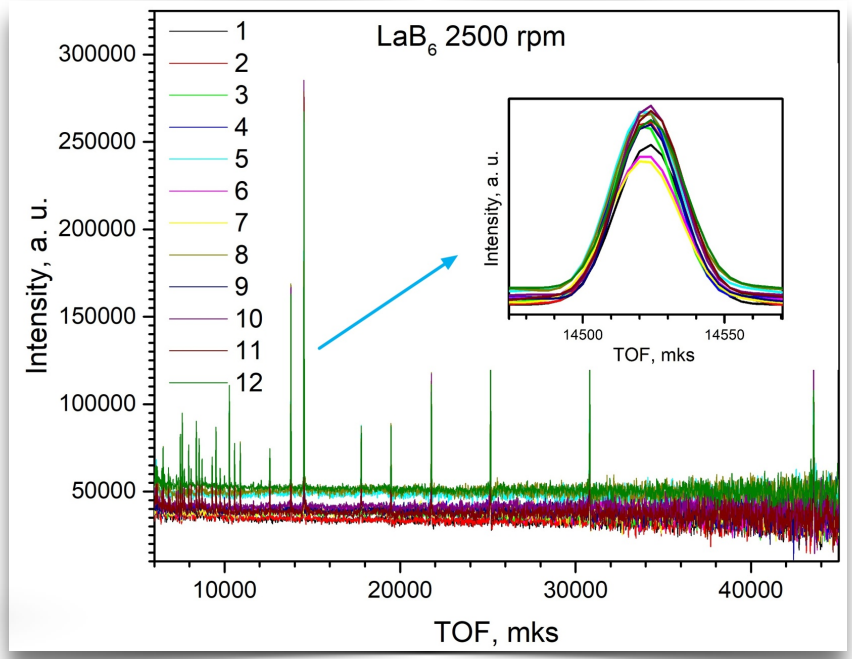


Positioning & Focusing accuracy exceeds 0.1%



A device for giving the detector body precise geometry, made on a CNC machine

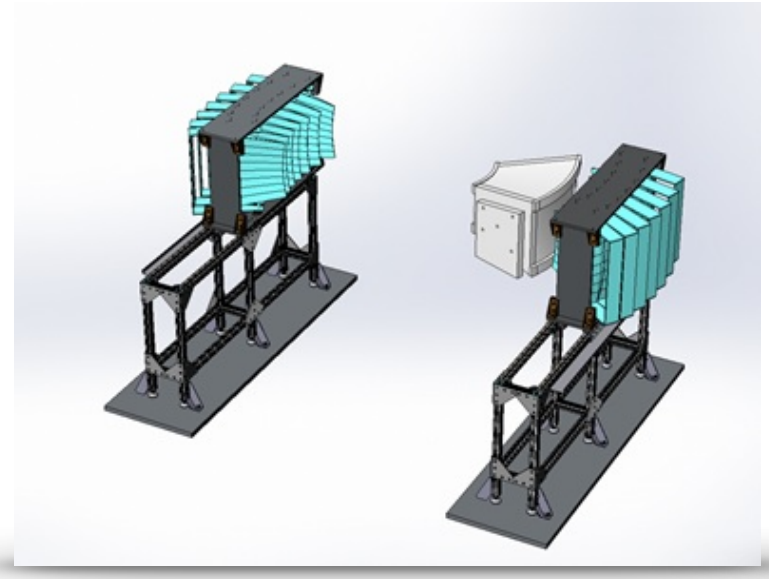
Wide-aperture backscattering detector body



ToF spectrum from 12 counters, LaB_6 sample

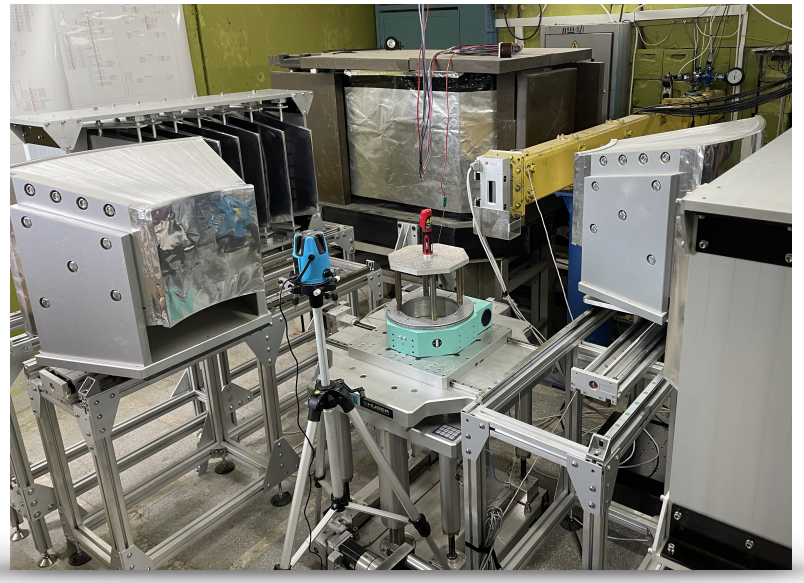
Detector ASTRA-M

- Covers scattering angles: $\theta=\pm90\pm20°,\varphi\in[-12°;12°]$ (Ω = 0.55 sr);
- Combined focusing method (14 detecting elements);
- High efficiency of thermal neutron conversion *(72%)*;
- 14 recording channels; signal processing using 1 MPD-240 module



Detector design

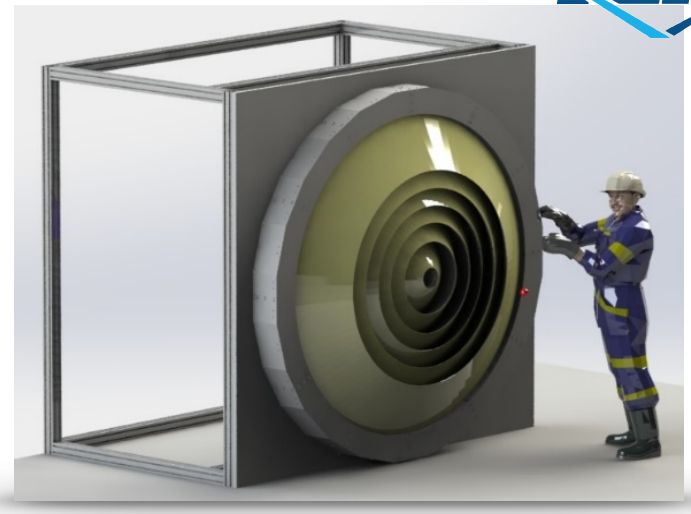
Detecting element



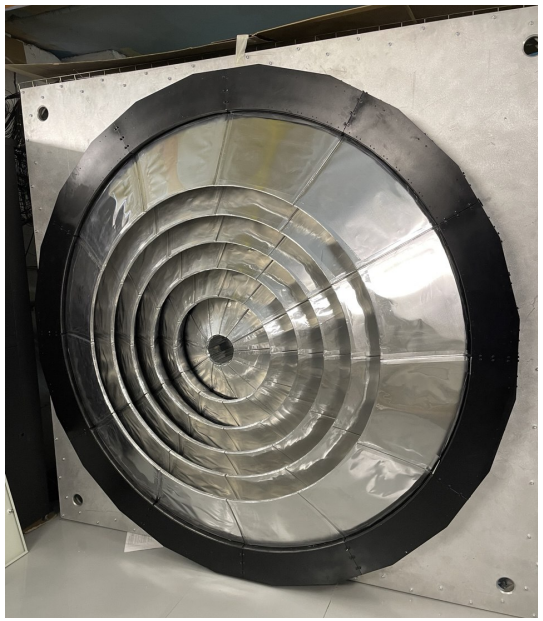
Detector mounted on Fourier-stress diffractometer FSD

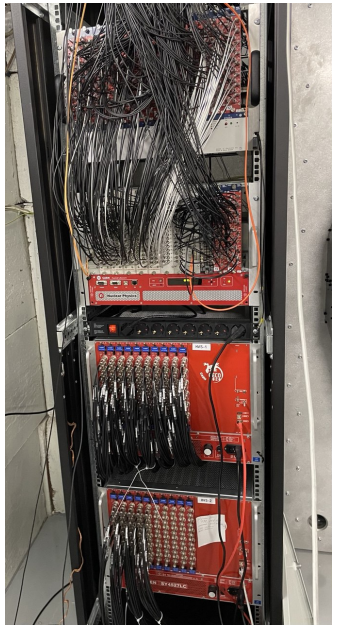
Wide-aperture backscattering detector

- Covers scattering angles $\theta = (133 - 175)°$ *($\Omega = 2$ sr)*;
- Combined focusing method (6 rings divided into 12 sectors);
- 2 scintillator layers, average conversion efficiency 85%;
- 108 detector elements (216 registration channels)
- Signal processing using 8 MPD-32 modules



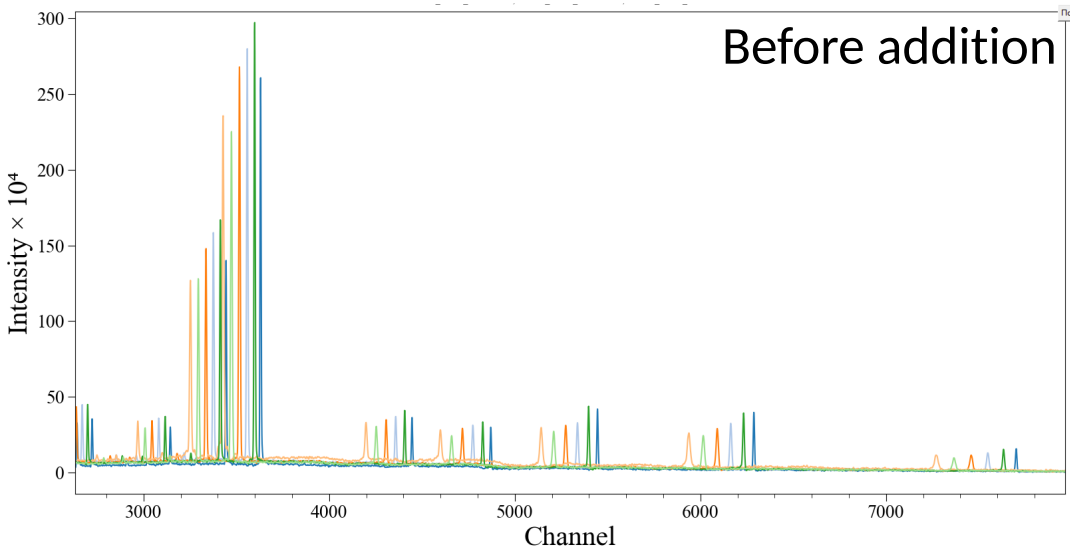
Detector design



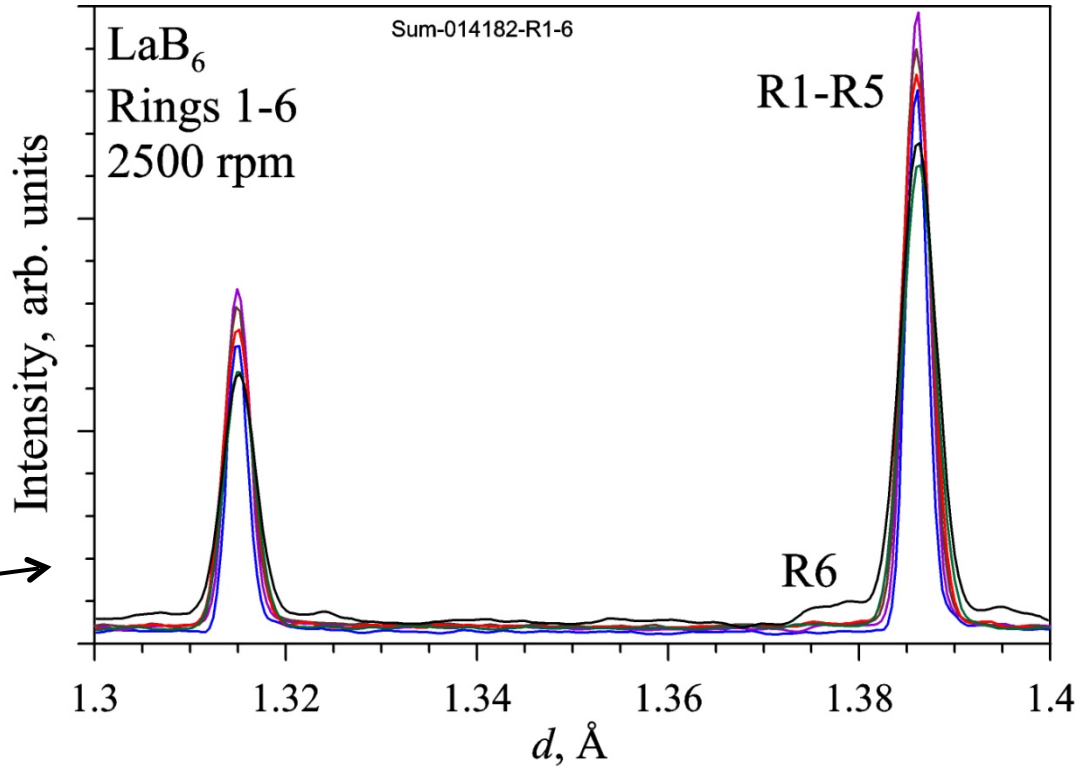


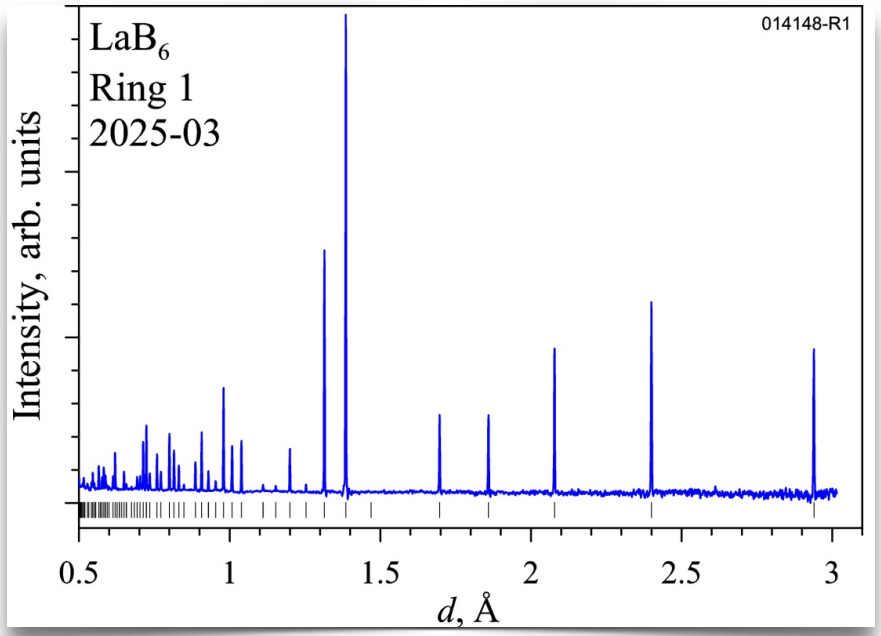
appearance of the detector and its components, September 2024

LaB_6 Spectra from 6 rings BSD

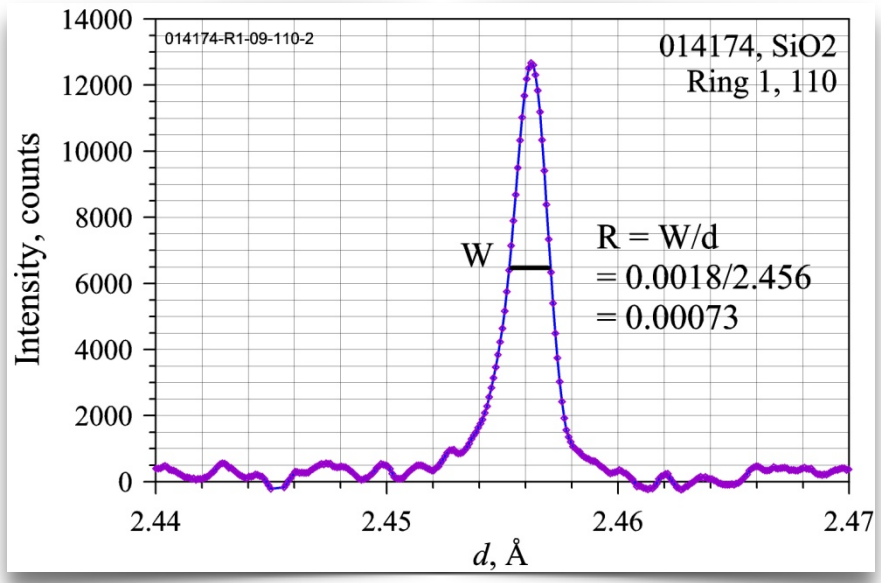


Peak profiles

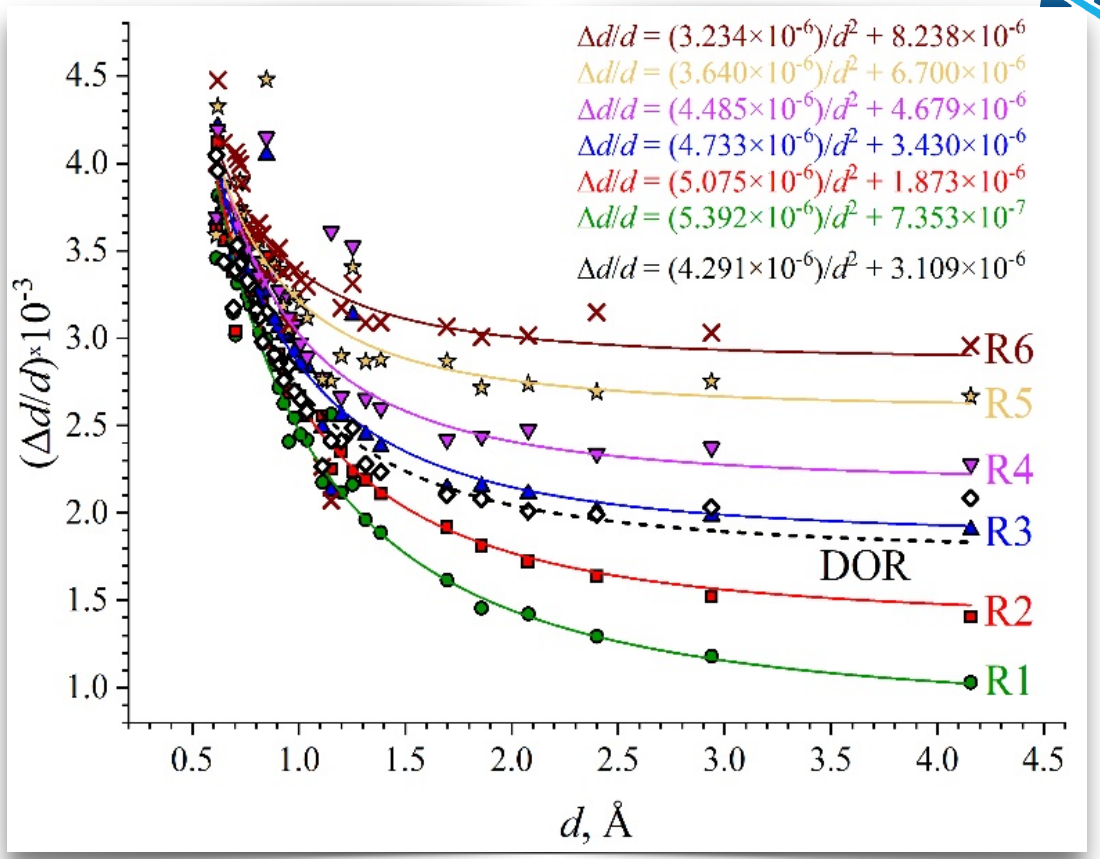




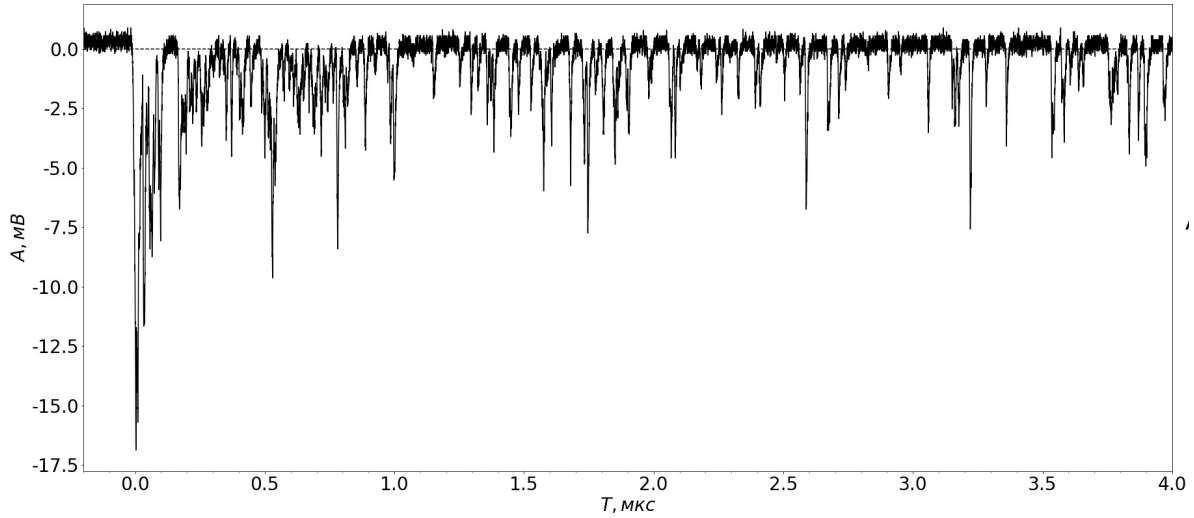
LaB_6 High-resolution spectrum (Ring 1)



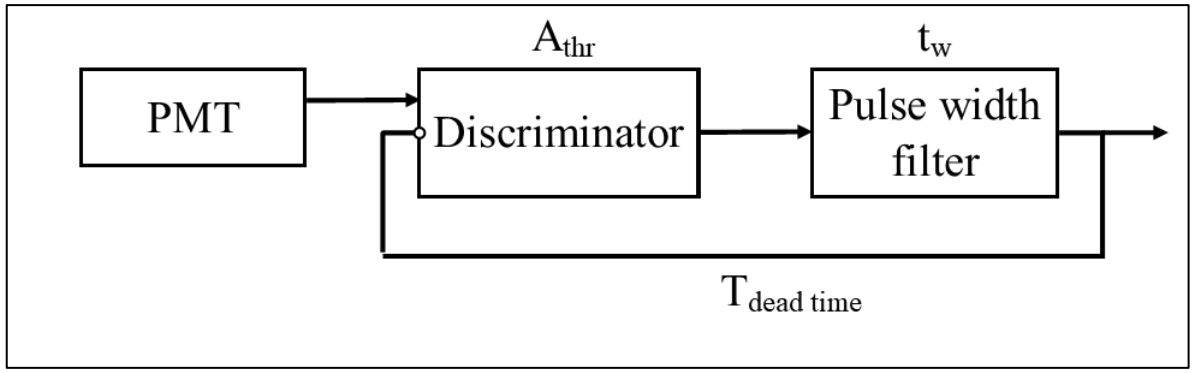
Single-crystal SiO_2 peak profile



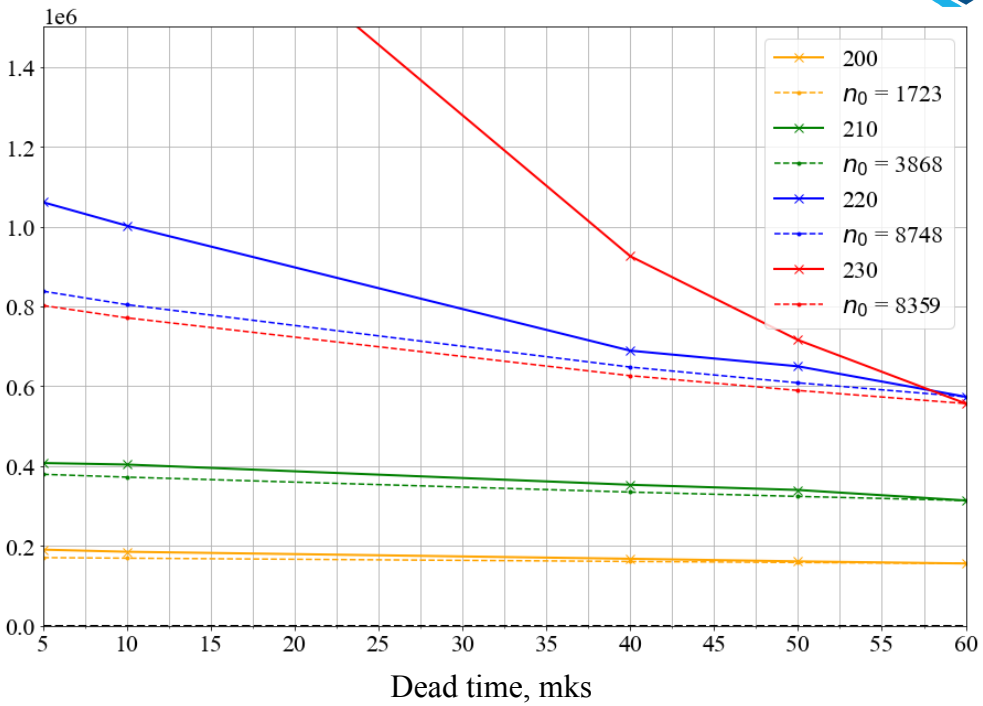
Resolution of the BSD rings and the previous detector



Neutron signal

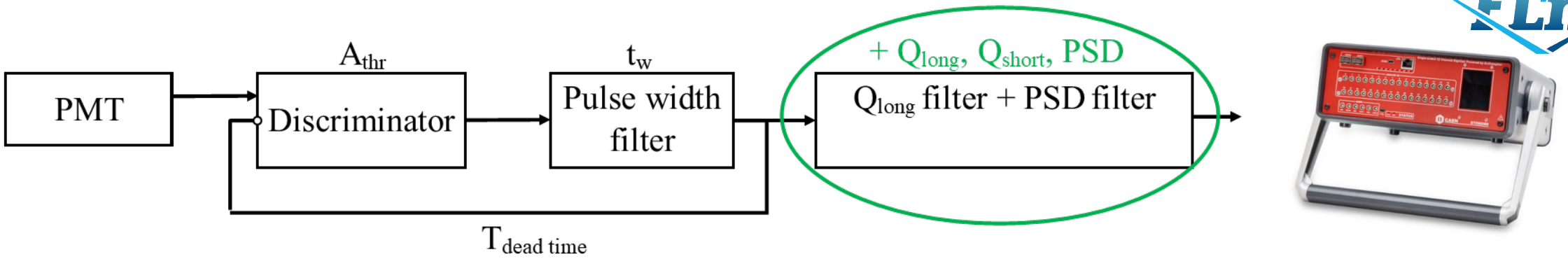


Neutron discrimination method (MPD-240)

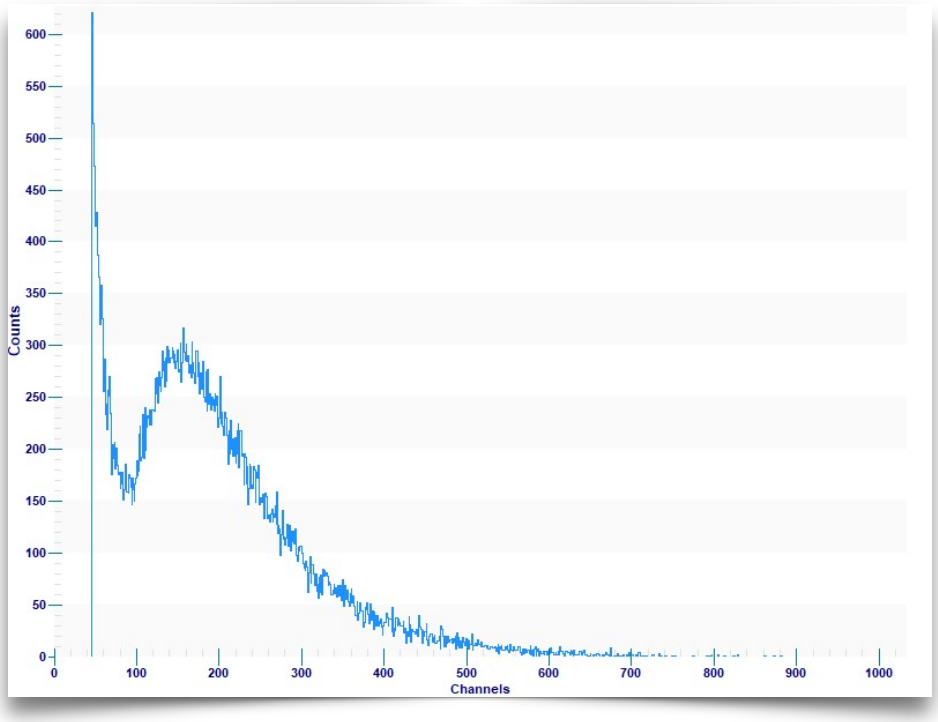


Neutron count rate with different Discriminator thresholds and dead time

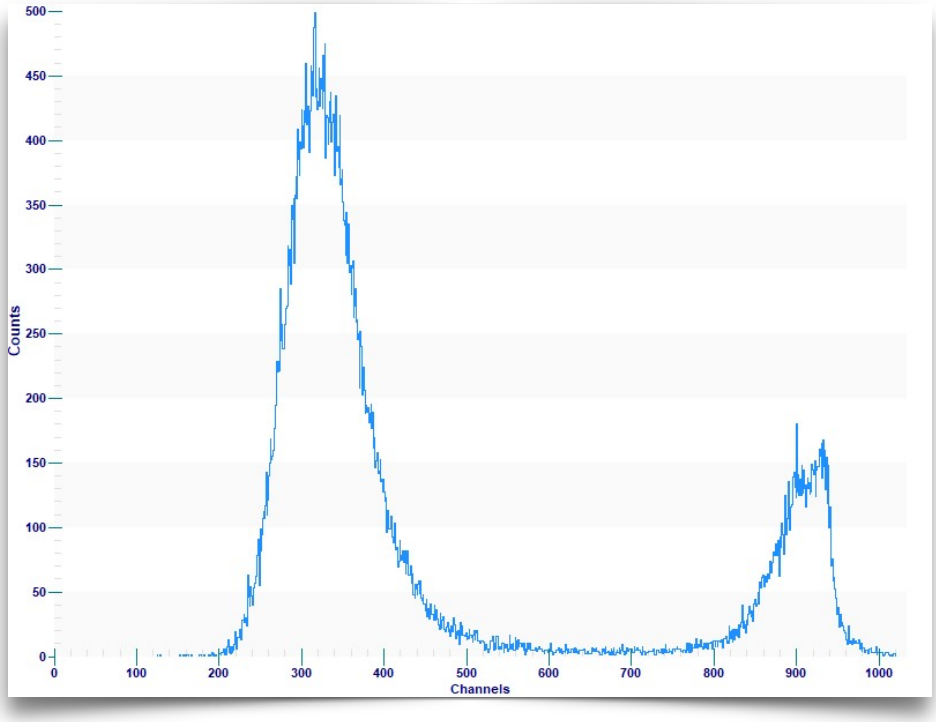
MPD-240 module



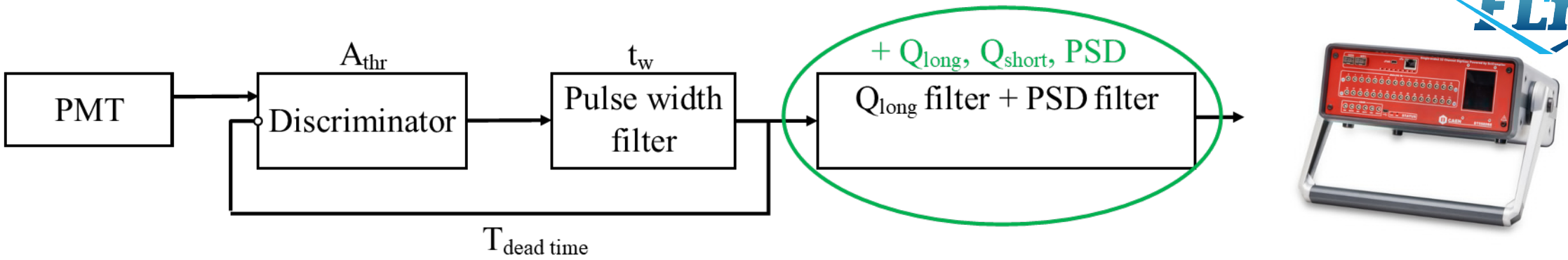
Neutron discrimination method (Caen digitiser)



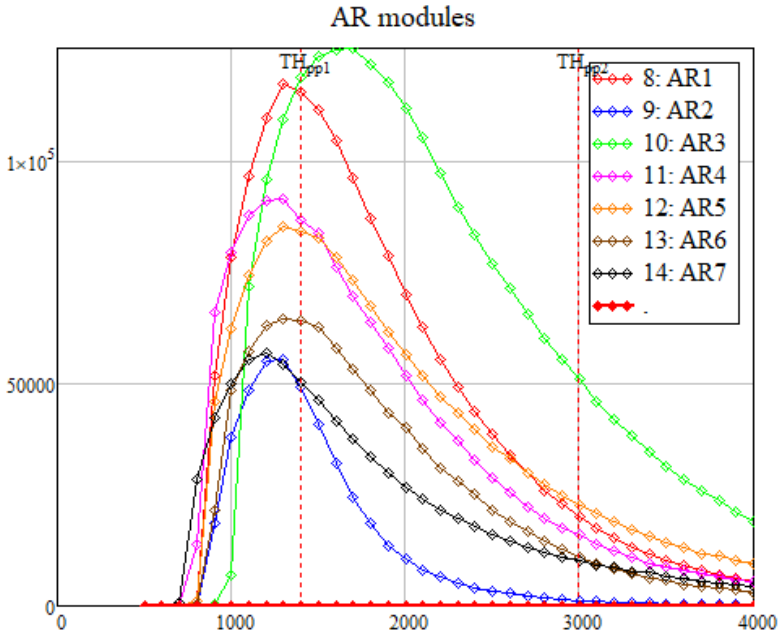
Q_{long} filter



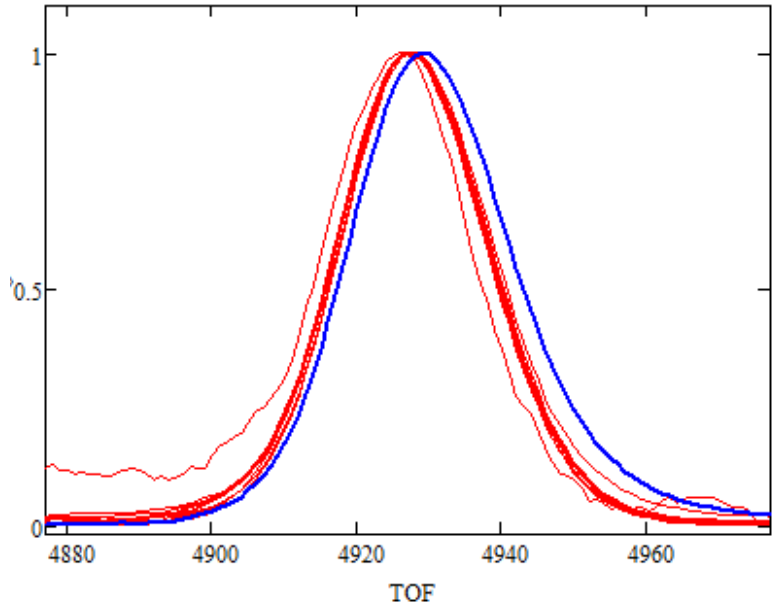
PSD filter



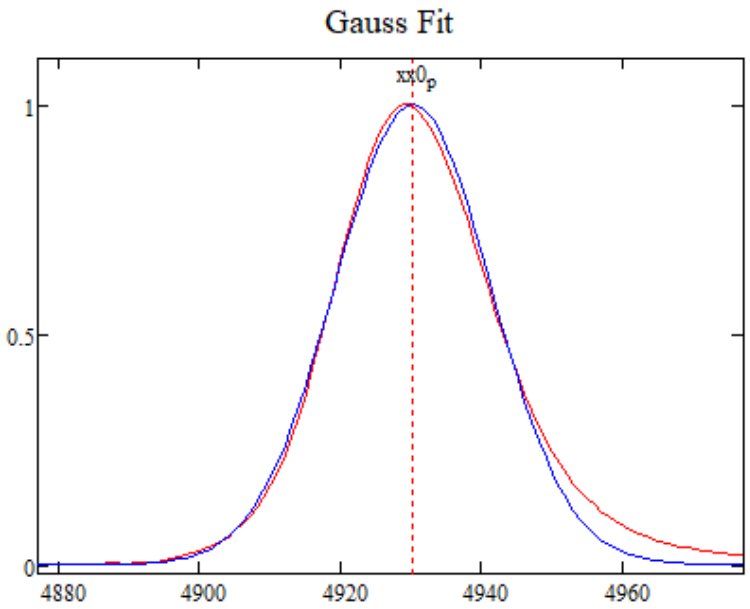
Neutron discrimination method (Caen digitiser)



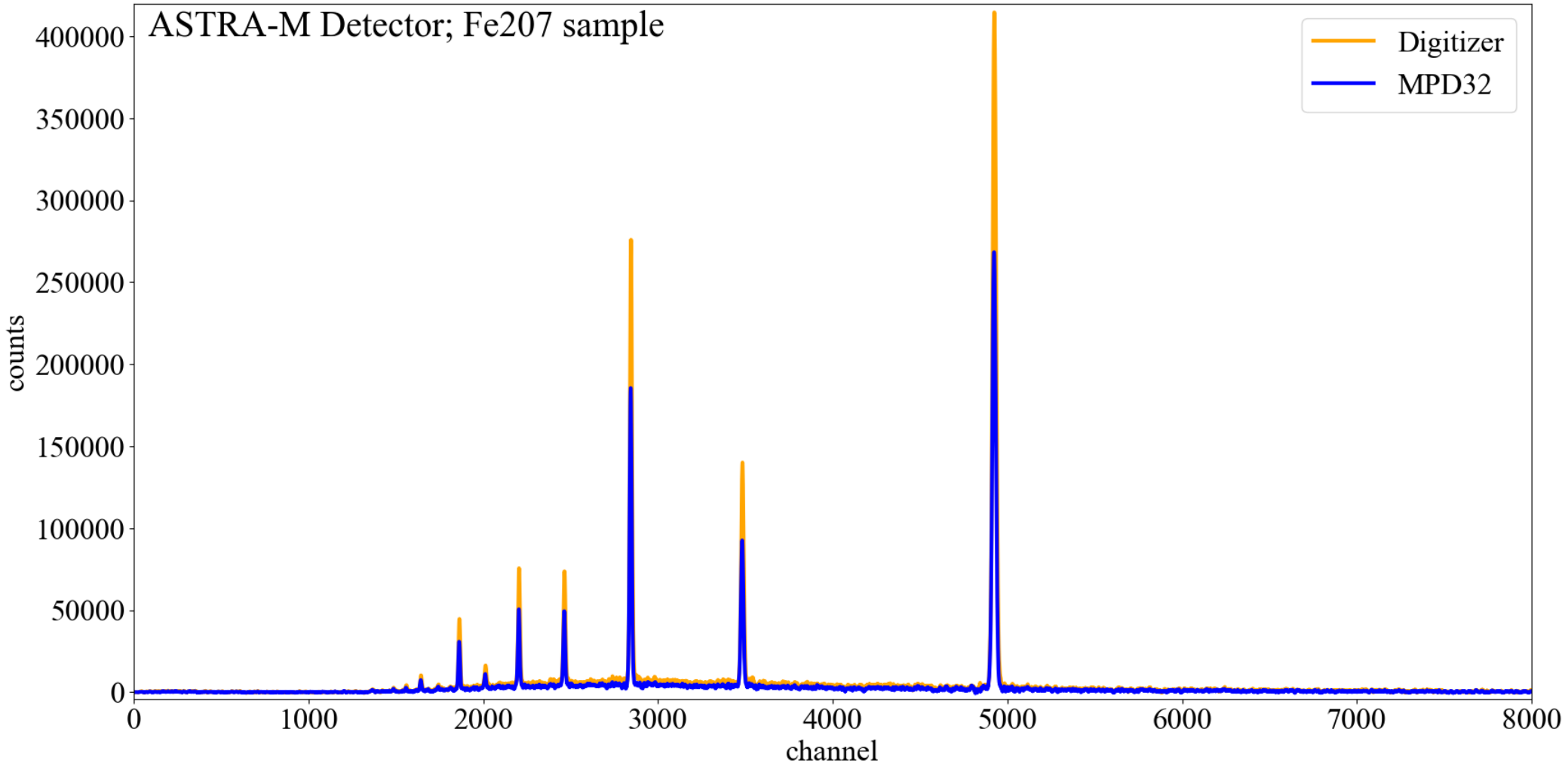
Dependence of high resolution peak amplitude from discriminator threshold value for ASTRA-M counters



High resolution peak shape for different discrimination parameters

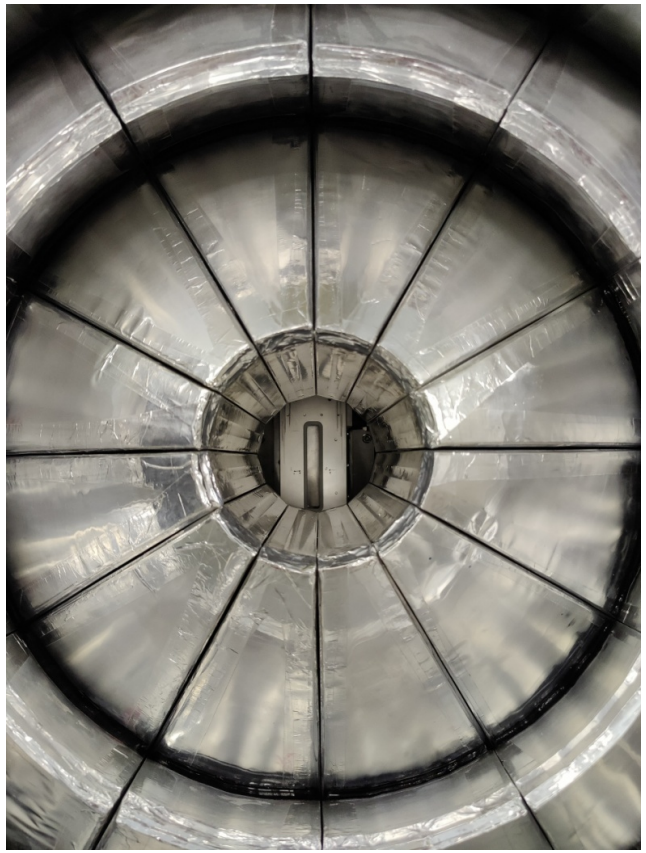


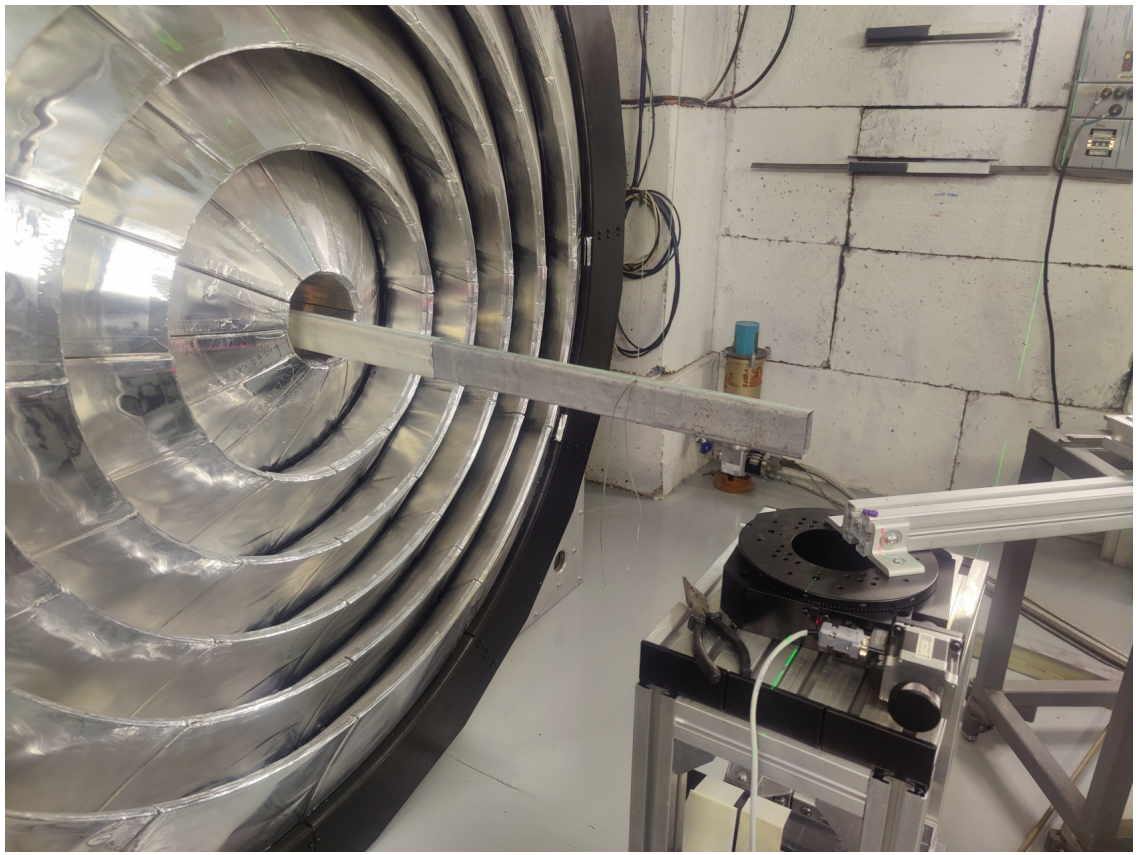
High-resolution peak fit with Gauge function

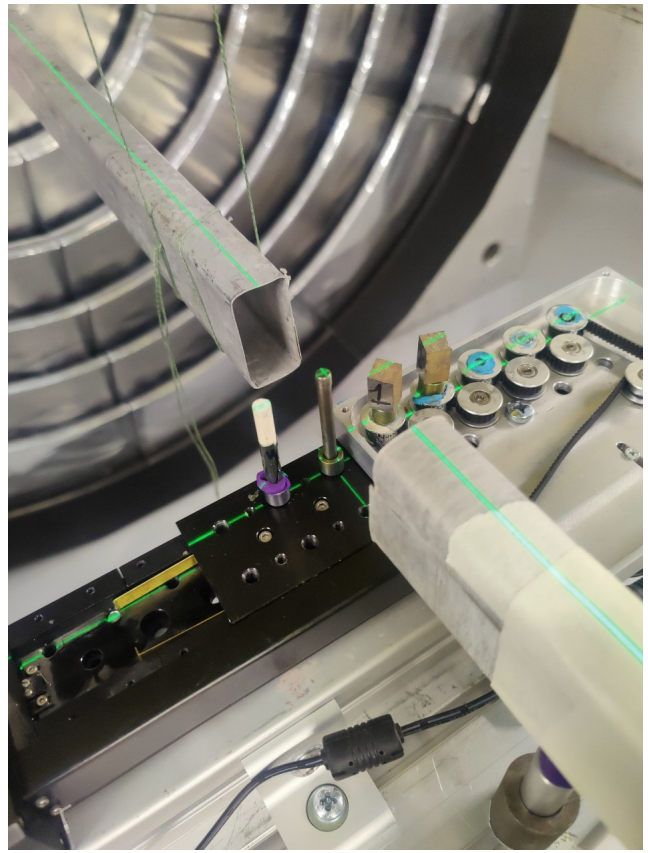


Comparison of 2 discrimination methods

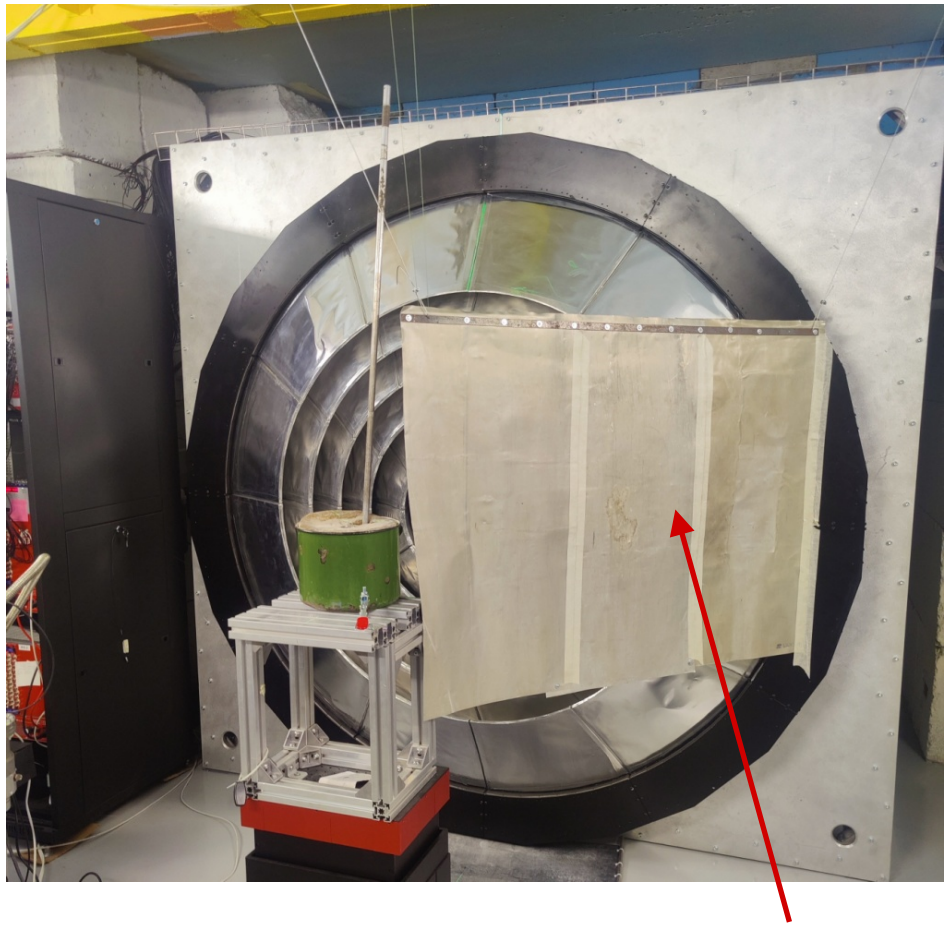
Cadmium masks for background neutrons reduction

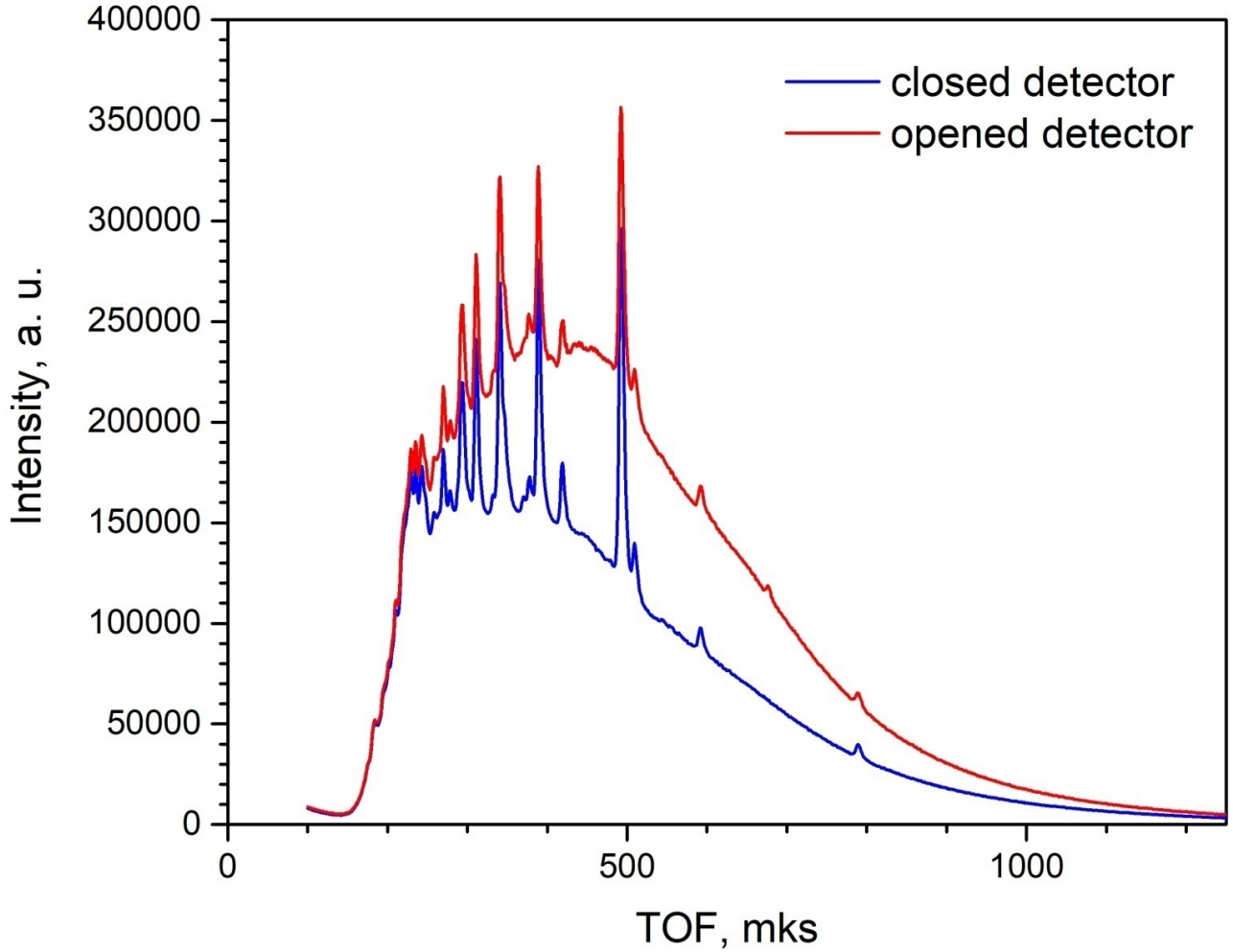




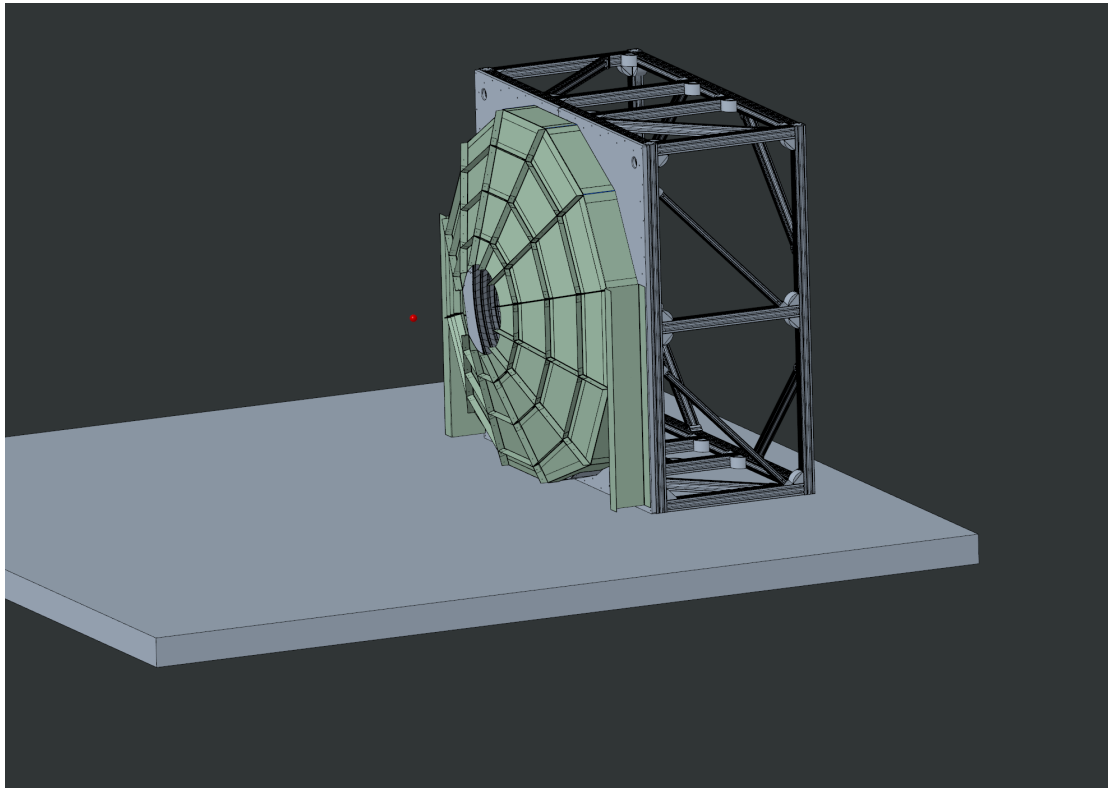


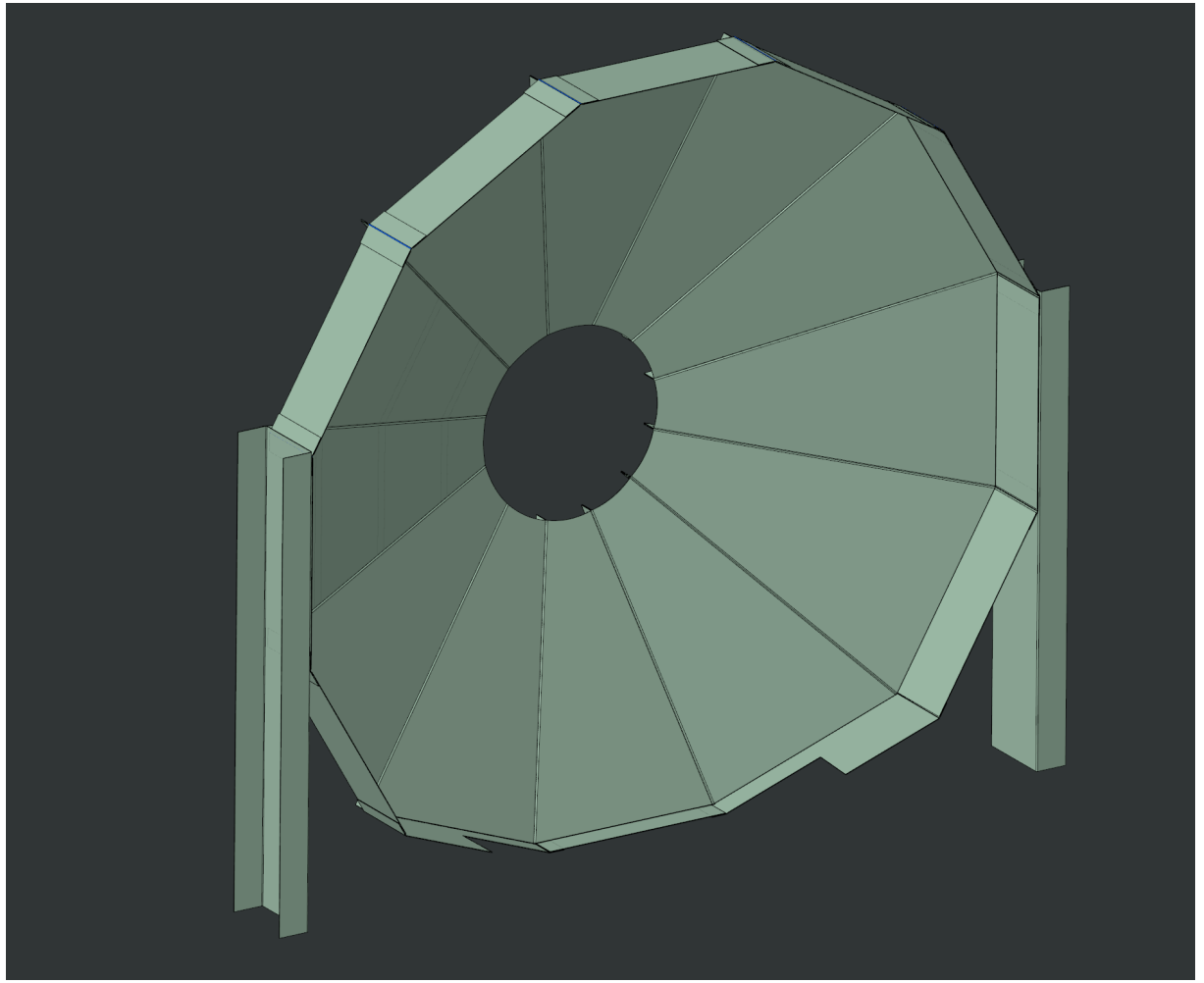
Outer ring background problem

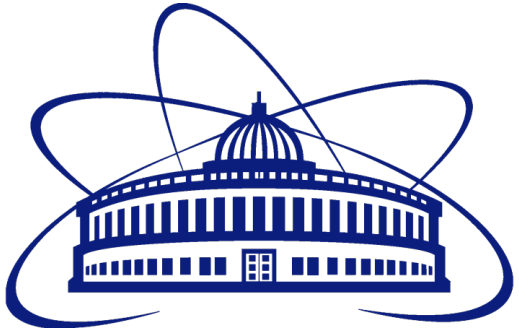




Collimator for the 6-th ring







Thanks for your attention!

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