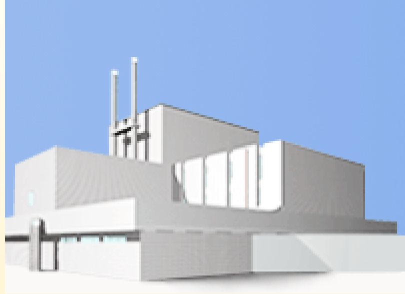
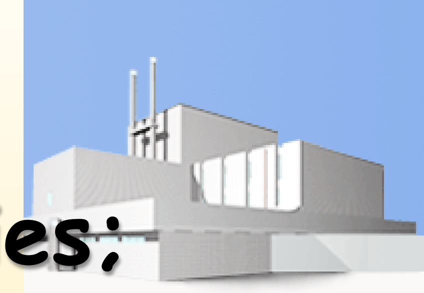


JOINT INSTITUTE FOR NUCLEAR RESEARCH

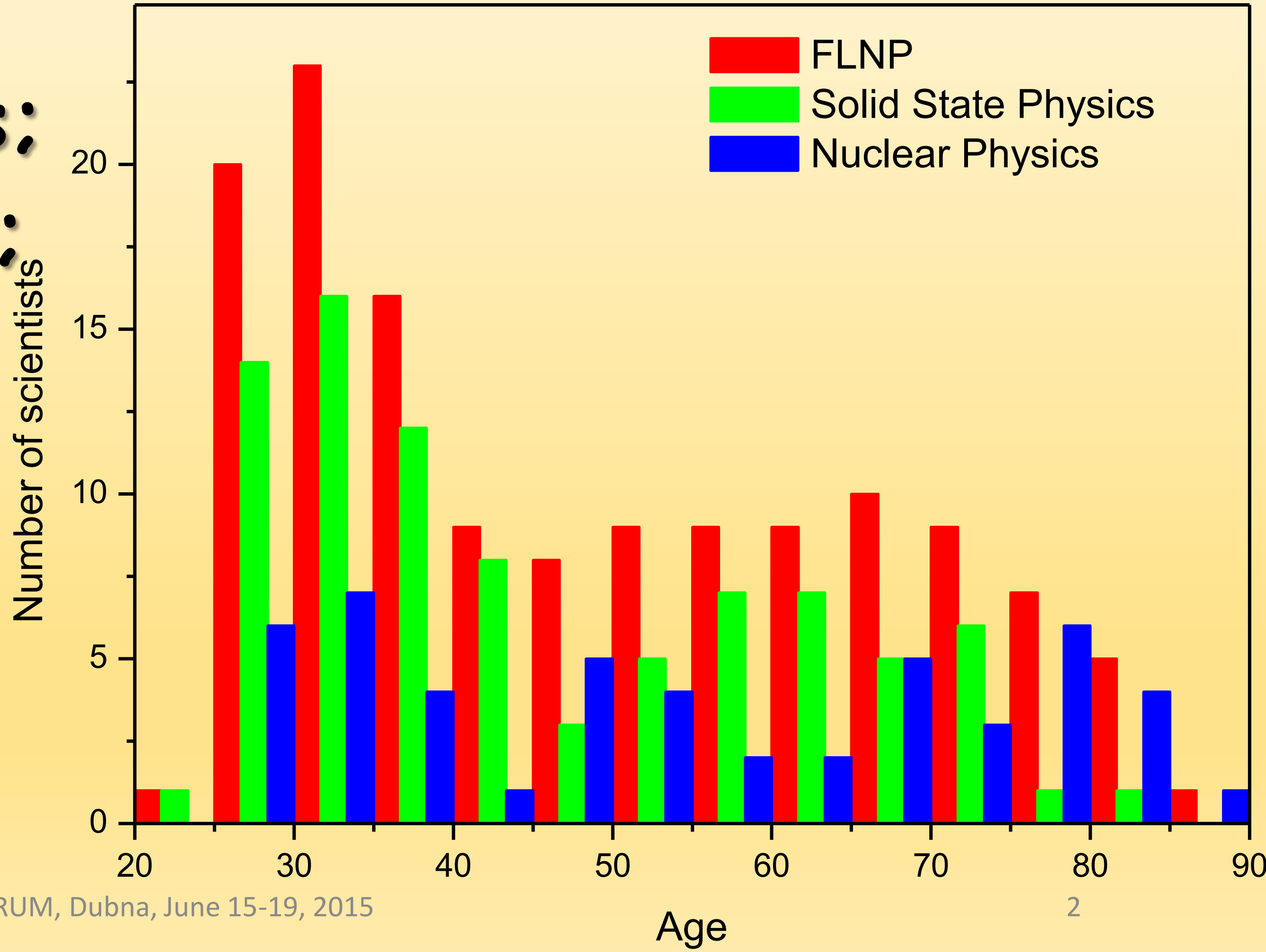
Research Directions in the Frank Laboratory of Neutron Physics

V.Shvetsov

FLNP some numbers



- 457 staff members, 72 from member countries;
  - 150 scientists;
  - 140 engineers
- Average age – 48 years;
- 18 M$ - annual budget;



flnp.jinr.ru/25/

Foto.Mail.Ru Go.Mail.Ru Mail.Ru Video.Mail.Ru @MAIL.RU: поч...

Frank Laboratory of Neutron Physics

About Laboratory | Events | Internal Structure | IBR-2 Pulsed Reactor | IREN Facility | Issues Archives | Annual Reports | Local Network Info

- About Laboratory
- Scientific Directions
- Prizes »
- Discoveries
- History »
- Education »
- For IBR-2 Users
- Contacts

Найти

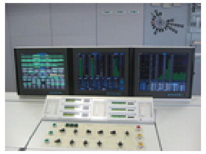
About Laboratory

News

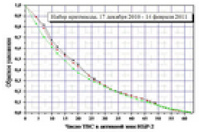
17/09/2012
We are pleased to announce that the call for proposals for experiments at the IBR-2 spectrometers for the first half of 2013 is now open. Applications for beam time can be submitted at ibr-2.jinr.ru *(please note that our site address has changed)*. The deadline for submission is November 1, 2012. More>>

27/04/2012
The JINR obtained the Rostekhnadzor (Federal Service for Ecological, Technological and Nuclear Supervision) license to operate the IBR-2 research nuclear facility at 2 MW. According to the Work schedule of the IBR-2 facility in 2012 six cycles of physical experiments on the extracted neutron beams will be carried out. The seven spectrometers (YuMO, HRFD, REMUR, REFLEX, FSD, DN-12, DIN-2PI) placed in service in 2011 will be in operation during the first reactor cycle, from May 21 to June 1. The NAA REGATA instrument has also been prepared to operation.

17/10/2011
The IBR-2 reactor achieved the rated power of 2MW on October 12, 2011 at 14.34. The program of power start-up has been completed and the reactor operates at 2MW for test physical experiments at extracted neutron beams.



14/07/2011
Results of physical start-up of pulsed reactor IBR-2M.
Report of chief engineer of FLNP A.V.Vinogradov at the PAC Meeting on Condensed Matter 27-28.06.11



20/02/2011
Modernization of IBR-2 has been completed! Physical start-up of the reactor is in progress.
On 04.02.2011 at 12.35 reactor IBR-2M reached subcritical conditions for delayed neutrons with accelerating period of about 300 s and power of 10 W. More>>

Web-site for proposal submission for IBR-2
ibr-2.jinr.ru

Current power of the IBR-2 reactor and state of the shutters

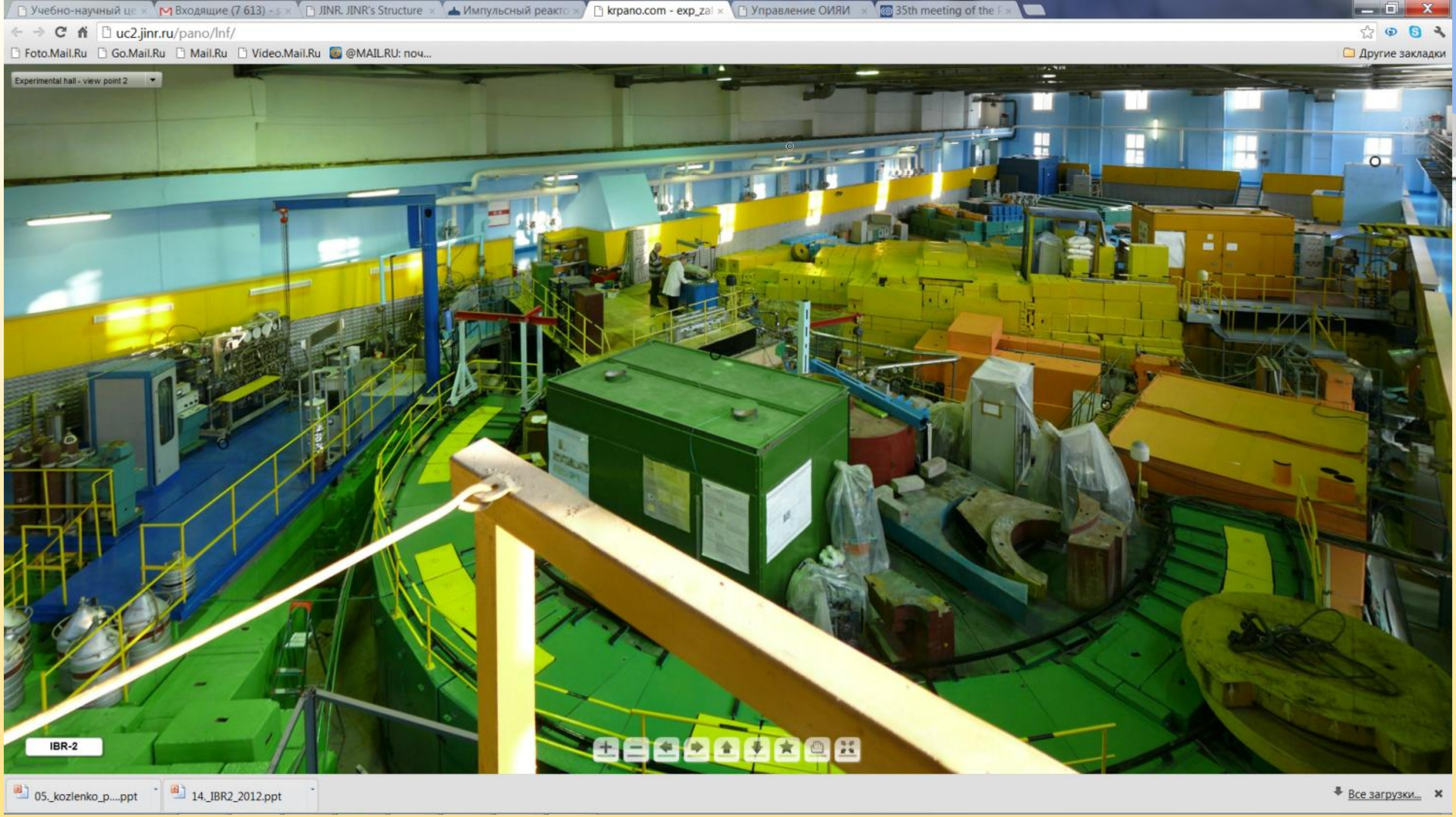
Work schedule of the IBR-2 reactor in 2012

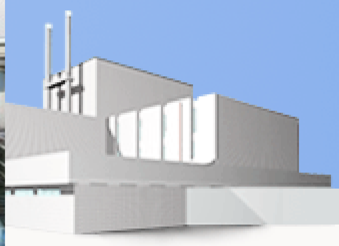
STC:

Seminars:

Conferences:

Booklet FLNP





Virtual excursion to IBR-2M spectrometers

http://uc2.jinr.ru/pano/lnf/

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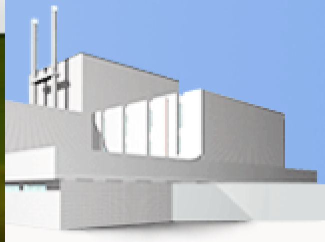
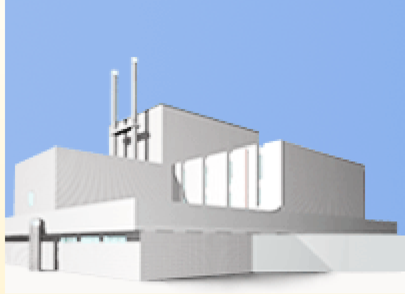


Virtual excursion to IREN facility

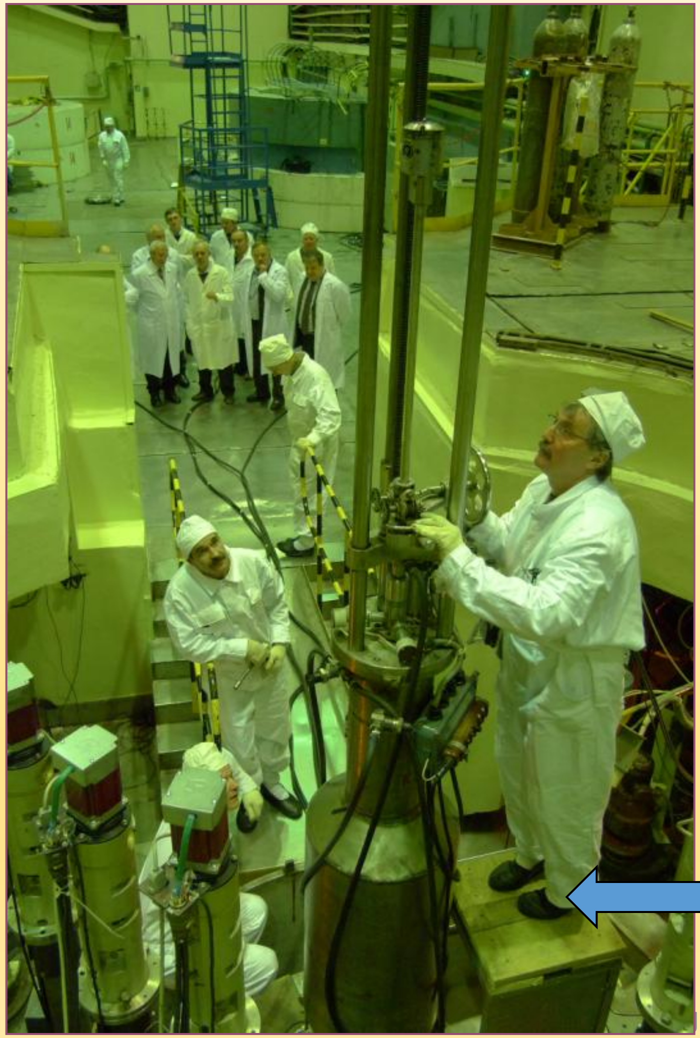
http://uc2.jinr.ru/pano/iren/

FLNP research directions



- Two scientific directions:
  - –Neutron nuclear physics;
  - –Condensed matter physics;
- Methodic;
- Basic facilities:
  - –IBR-2M;
  - –IREN;

IBR-2M

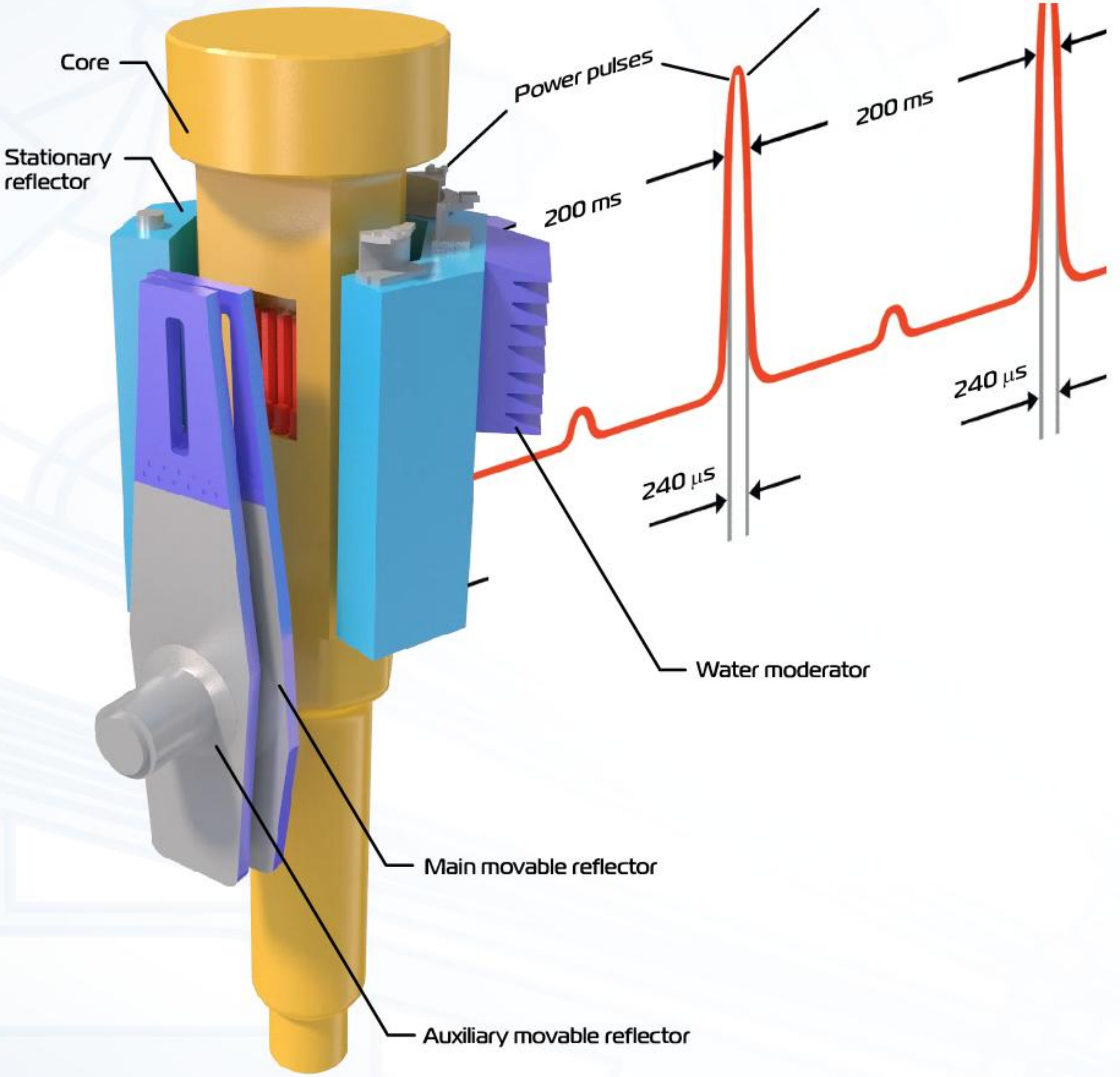


JINR Directorate members at the reactor hall

Loading of first fuel assembly into the active zone

First power stage was started on July 5 2011

Parameters of IBR-2M

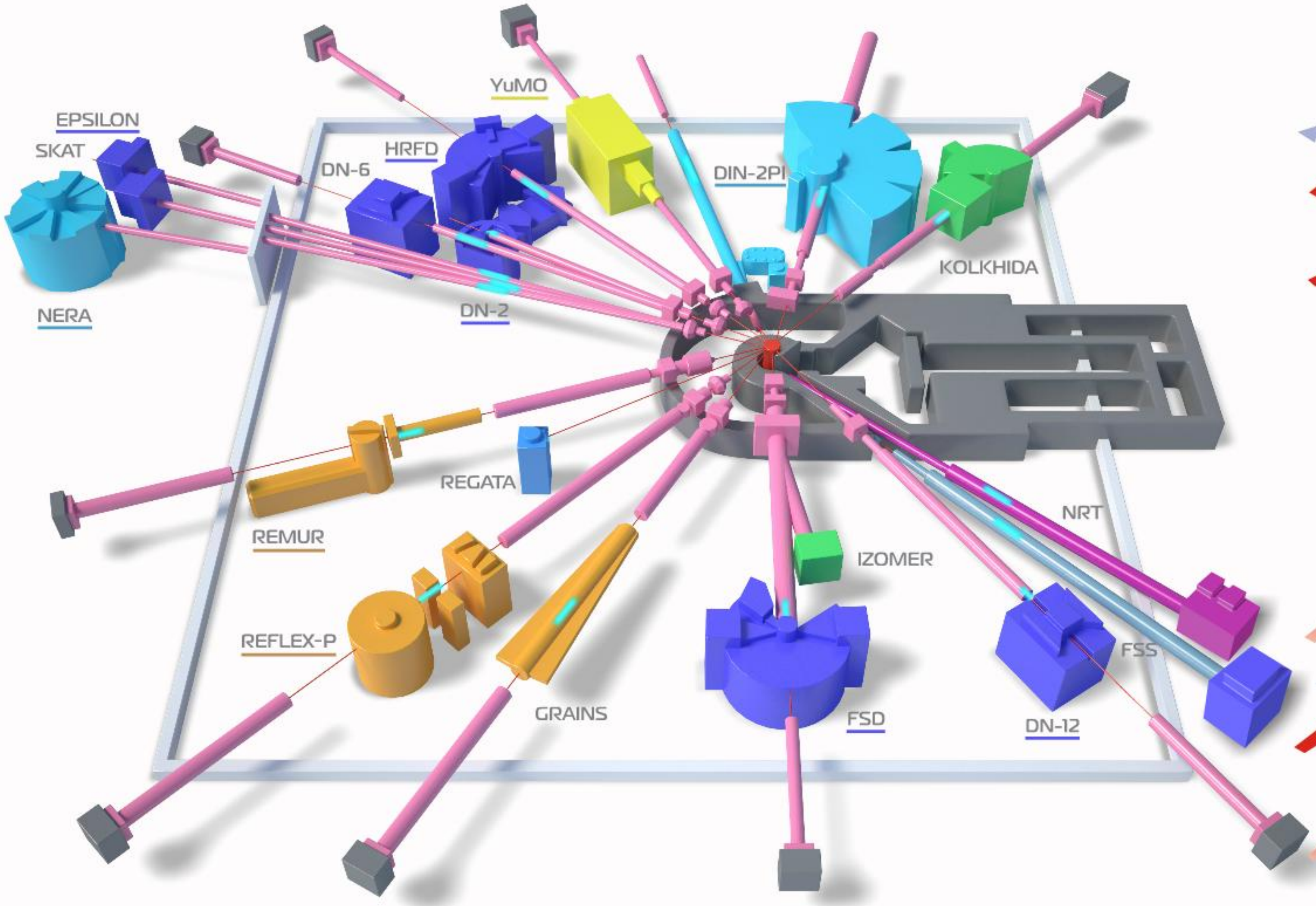


Average power, MW	2
Burst power, MW	1850
Fuel	PuO_2
Number of fuel assemblies	69
Maximum burnup, %	9
Pulse repetition rate, Hz	5; 10
Pulse half-width, µs: fast neutrons thermal neutrons	 240 320
Rotation rate, rev/min: main reflector auxiliary reflector	 600 300
MMR and AMR material	nickel + steel
MR service life, hours	55000
Background, %	7.5
Thermal neutron flux density from the surface of the moderator*: - time average - burst maximum	 $\sim10^{13}$ n/cm^2·s $\sim10^{16}$ n/cm^2·s

* More precise data on the thermal neutron flux density after the modernization will be available when the reactor operates at full power.

Experimental facilities

MAIN MENU



Diffraction
DN-2, DN-12, DN-6, FSD, FSS, HRFD, SKAT, EPSILON

Small-angle scattering
YuMO

Reflectometry
GRAINS, REFLEX-P, REMUR

Inelastic scattering
DIN-2PI, NERA

Nuclear Physics
ISOMER, KOLHIDA

Neutron Activation Analysis
REGATA

Neutron imaging
NRT

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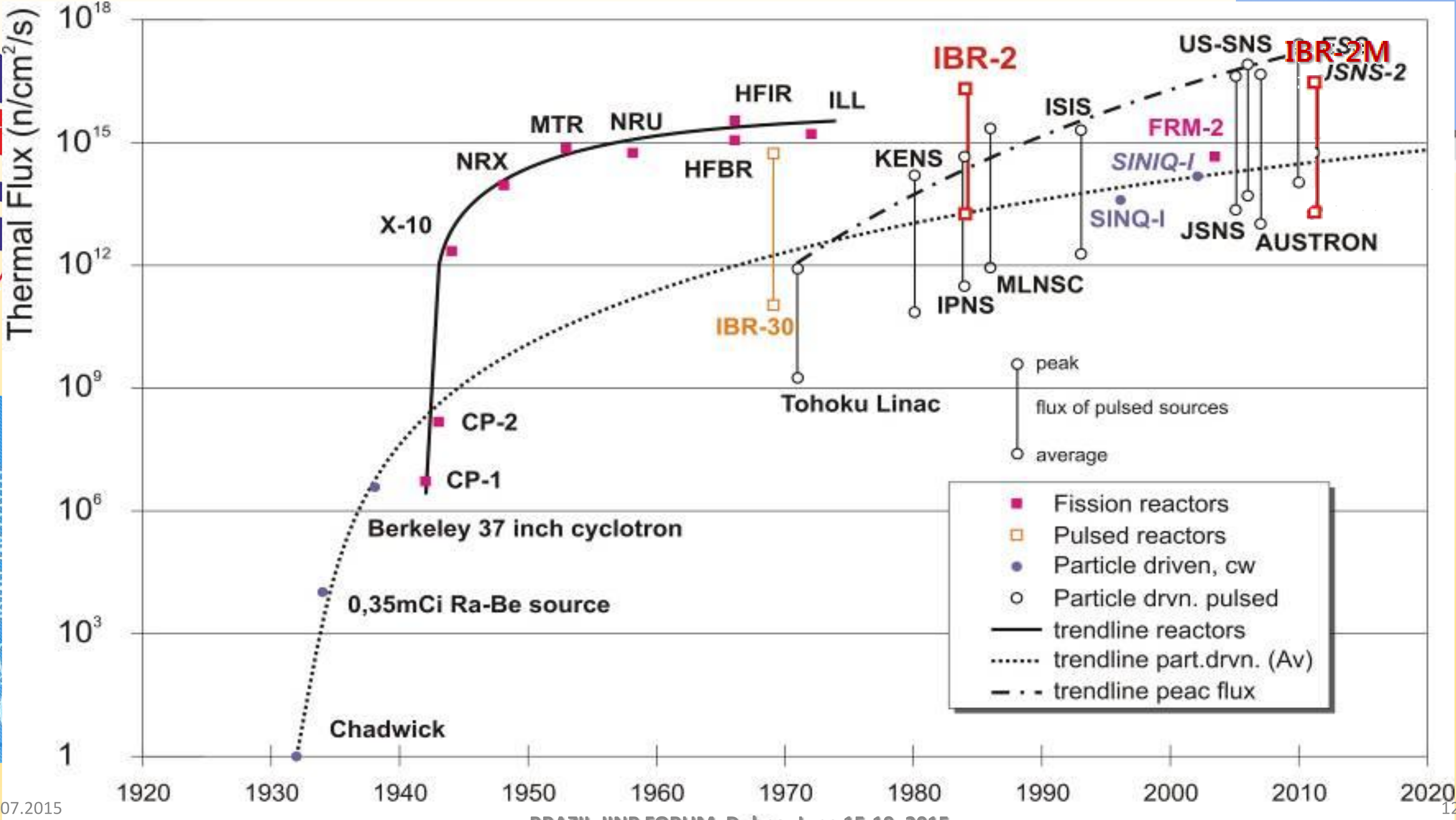
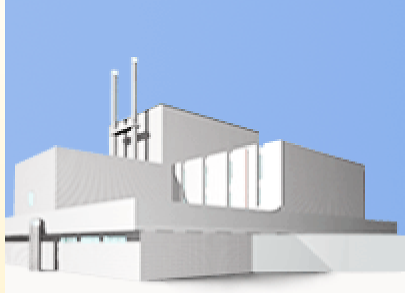
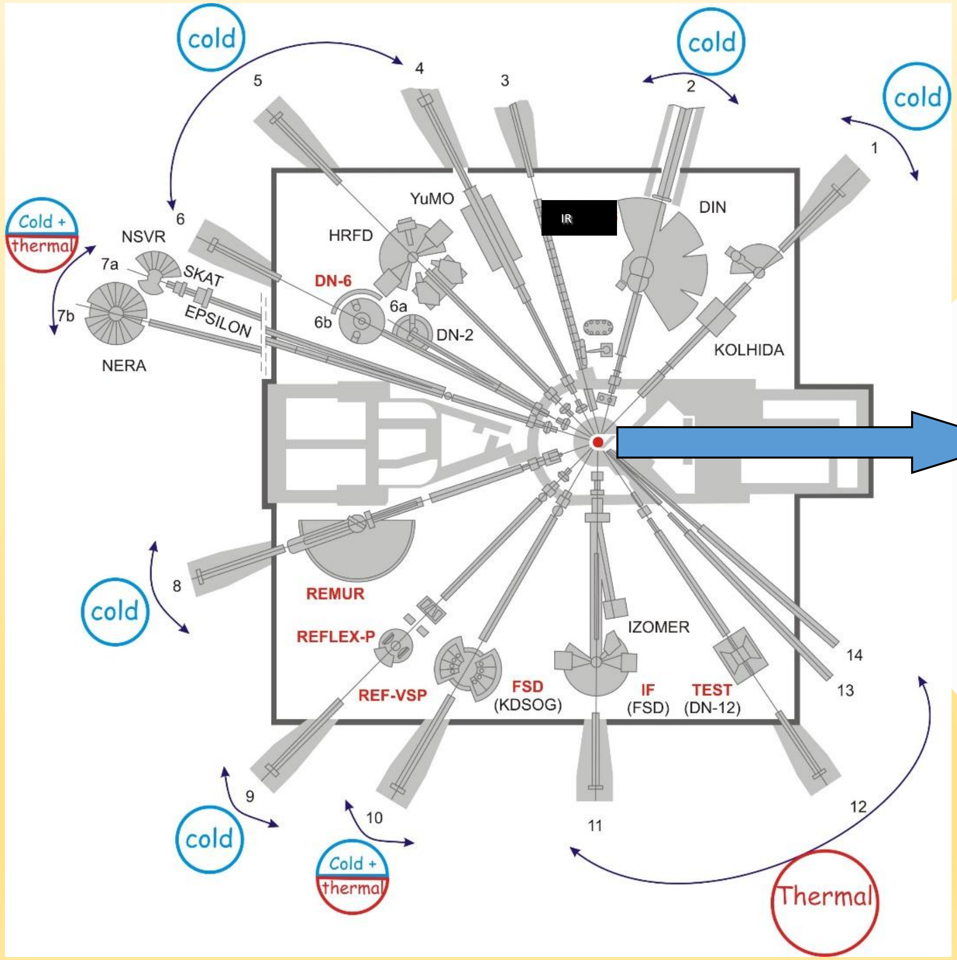
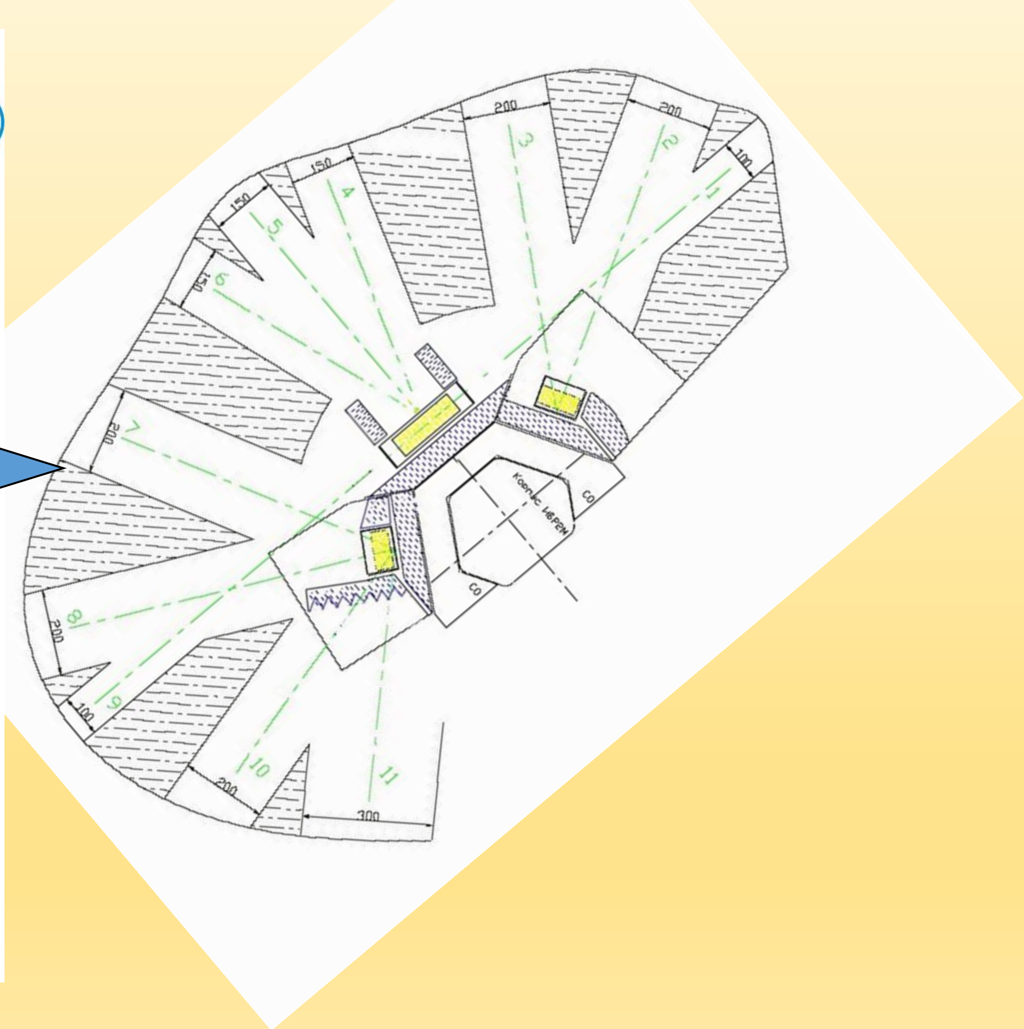

Thermal Flux (n/cm²/s)
10^18
10^15
10^12
10^9
10^6
10^3
1
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Year
Chadwick
0,35mCi Ra-Be source
Berkeley 37 inch cyclotron
CP-1
CP-2
X-10
NRX
MTR
NRU
HFIR
HFBR
ILL
IBR-30
Tohoku Linac
KENS
IBR-2
IPNS
MLNSC
ISIS
SINQ-I
SINQ-I
FRM-2
JSNS
AUSTRON
US-SNS
IBR-2M
JSNS-2
peak
flux of pulsed sources
average
Fission reactors
Pulsed reactors
Particle driven, cw
Particle drvn. pulsed
trendline reactors
trendline part.drvn. (Av)
trendline peac flux

Complex of moderators of the IBR-2 reactor

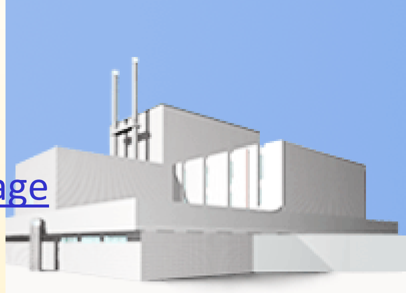


The neutron moderators with cold part slow down neutrons on 9 orders of magnitude. (from the energy of MeV (reactor core) down to meV (moderator surface))





Complex of moderators of the IBR-2M reactor

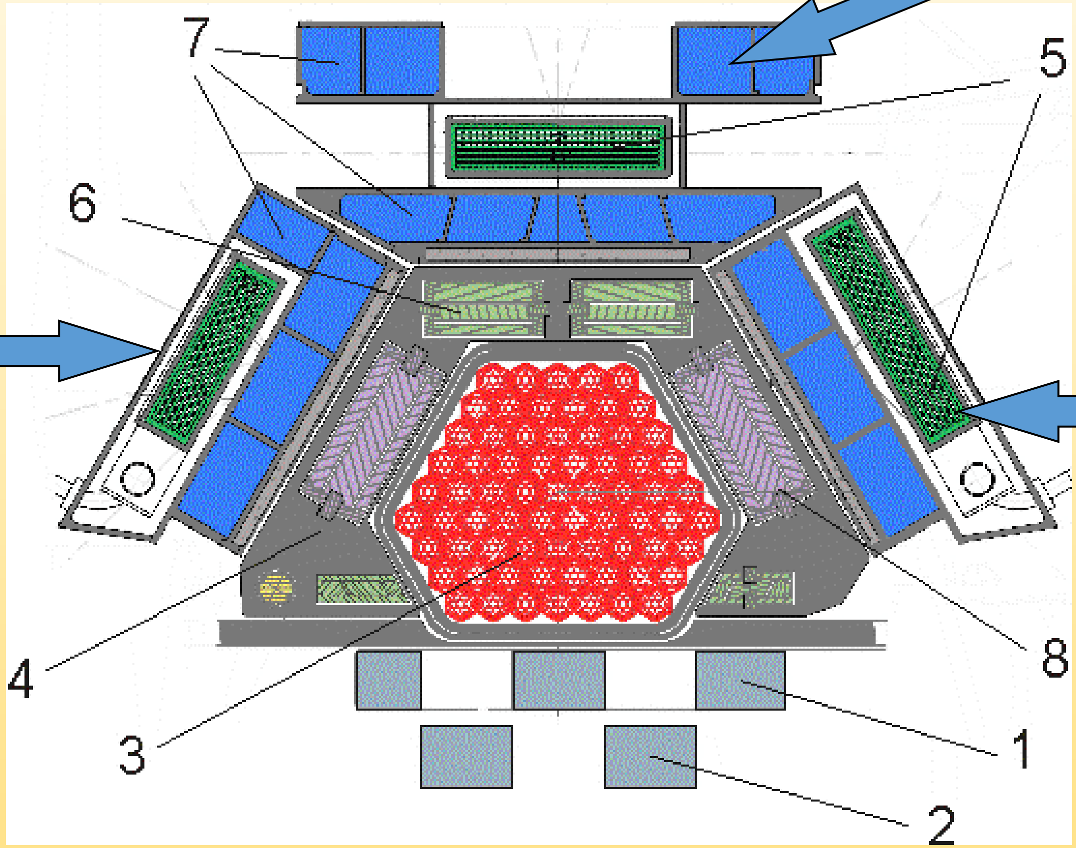


The second stage

Moderator for beams #1,4-6, 9

The first stage

Moderator for beams #7,8,10,11



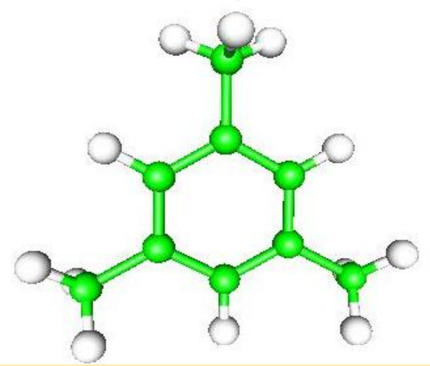
The third stage

_Moderator for beams #2, 3

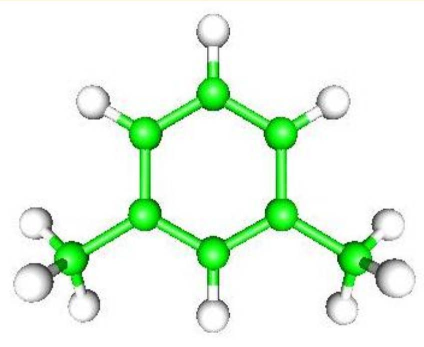
1. Main moveable reflector,
2. Auxillary moveable reflector,
3. Fuel assembly,
4. Stationary reflector,
5. Cold moderators,
6. Emergency system,
7. Water moderators,
8. Control rods;

Solid mesitylene as a material for cold moderators

mesitylene



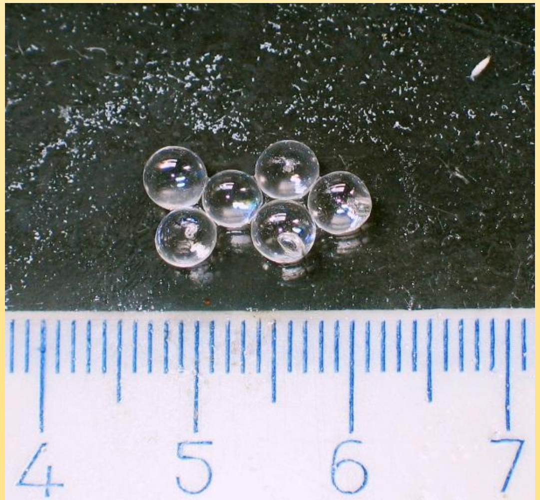
m-xylene



T_m = 227 K

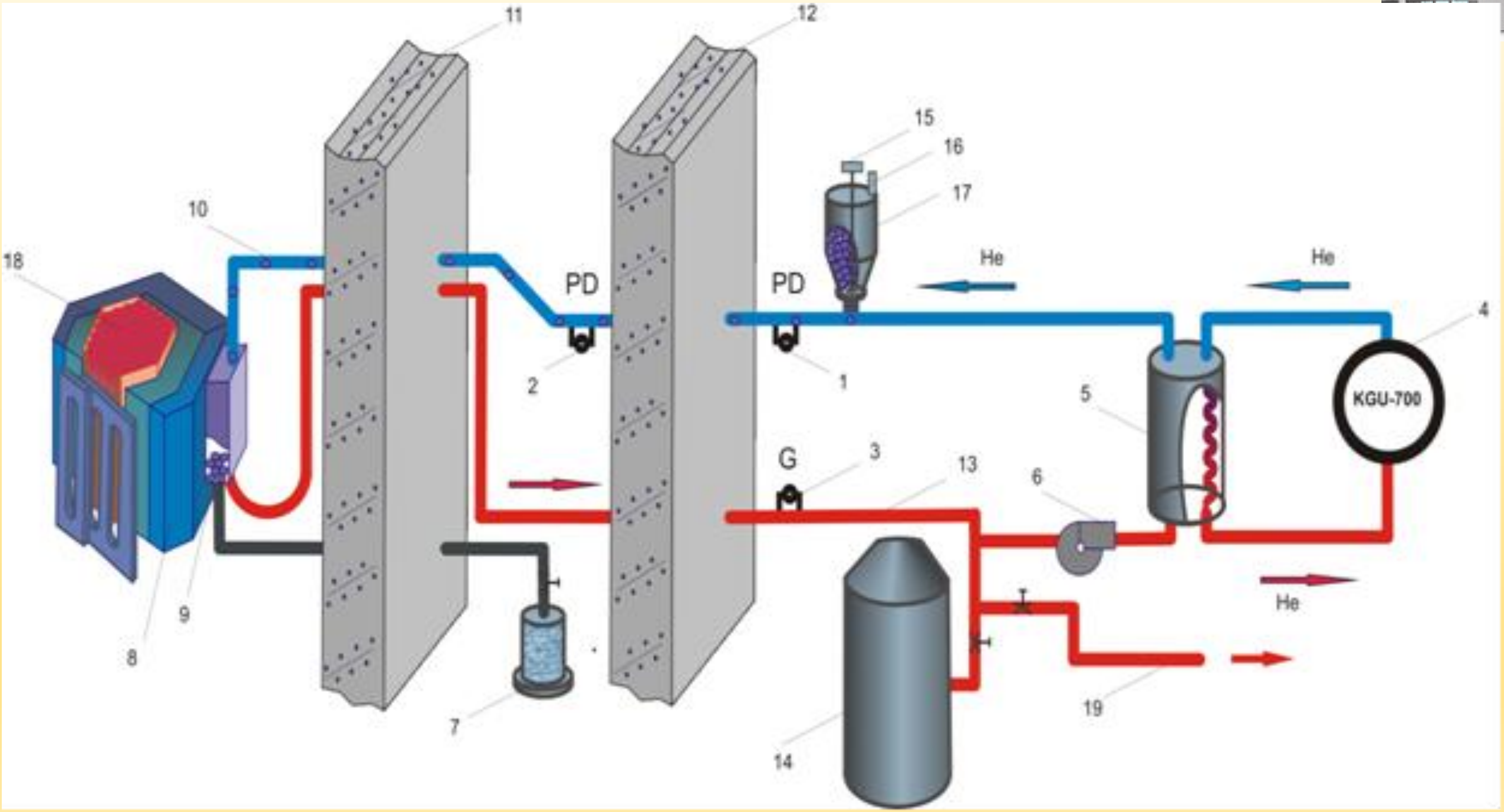
T_m = 225 K

Mixture with m-xylene or pseudocumene is of glassy structure, and has good neutron thermalization property.

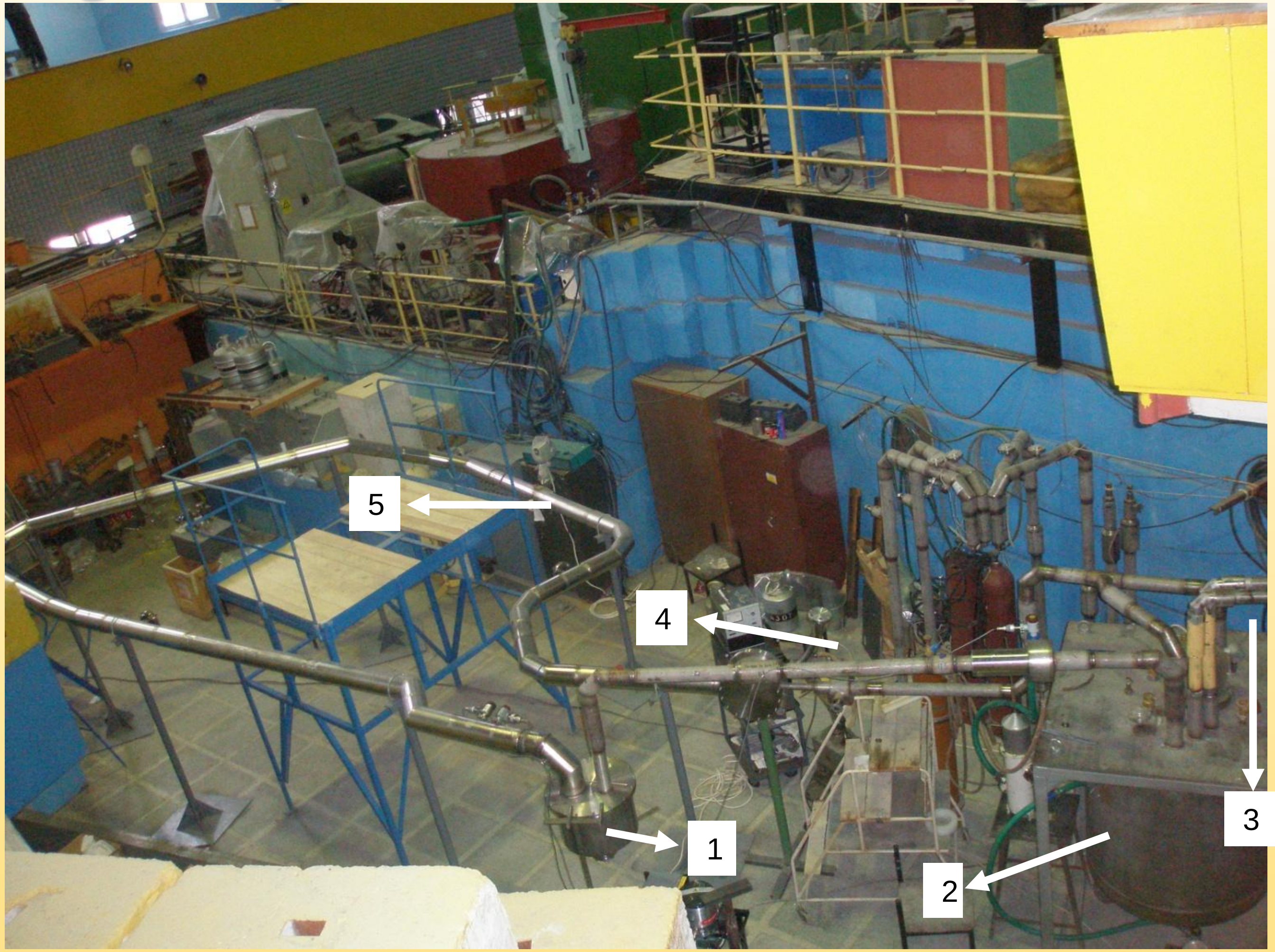


Solid balls of the frozen mixture of mesitylene and m-xylene

Principal scheme of the IBR-2 moderator system

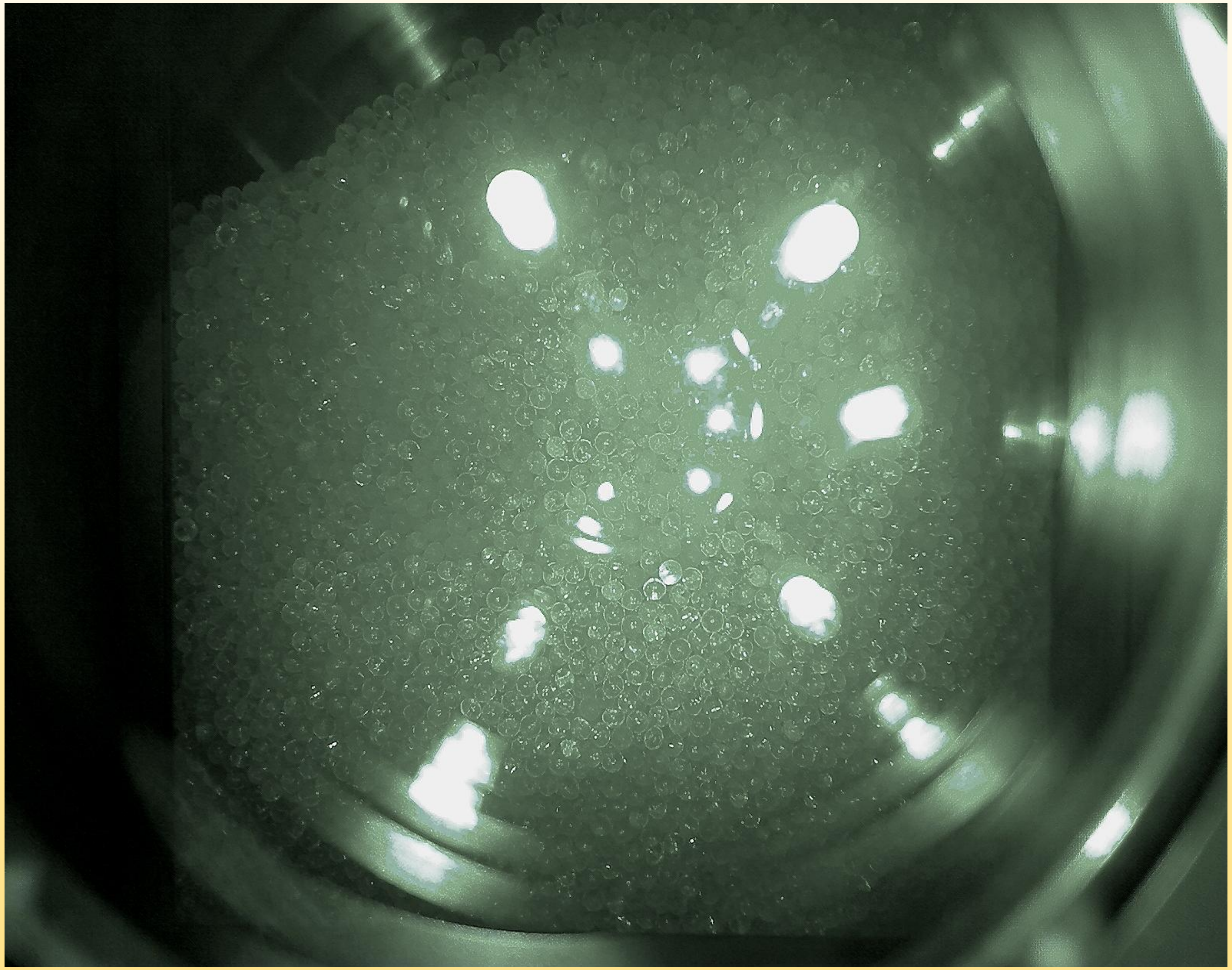


The full scaled model of the conveying path and technological system of the IBR-2 cryogenic moderator



1 – chamber-imitator of cryogenic moderator, 2 –thermal exchanger with helium blower, 3 - cryogenic pipelines from\to refrigerator, 4 – charging device, 5 – transport cryogenic pipeline

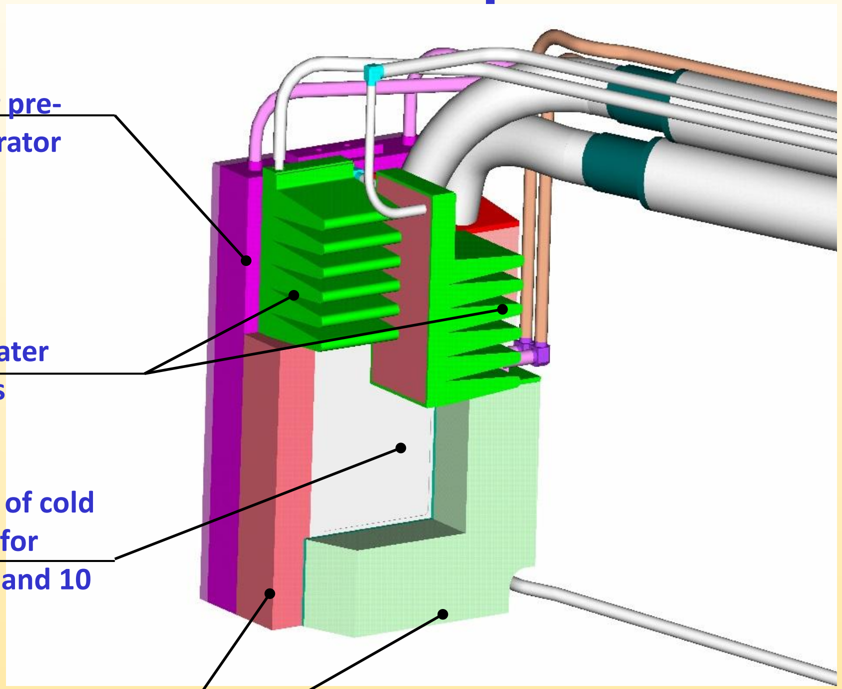
View through windows into the chamber



Completely loaded chamber (18 cm x 18 cm x 4 cm) by beads. Temperature inside is ~50K

(1 l of volume of cryogenic moderator is ~ 24 000 of beads, d=3.8 mm)

Bi-spectral moderator for beams 7,8,10,11

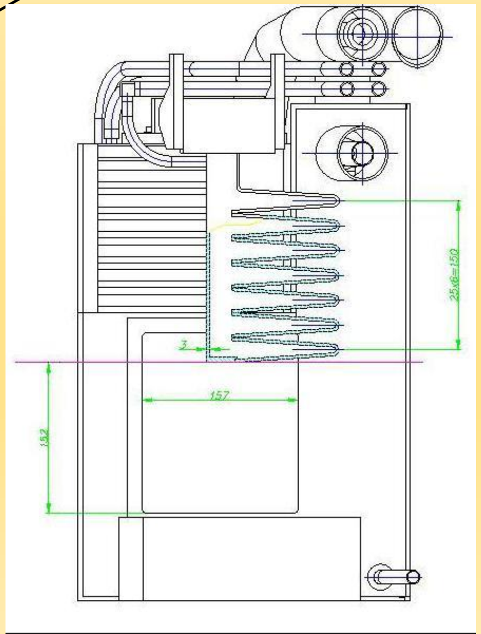


Water pre-moderator

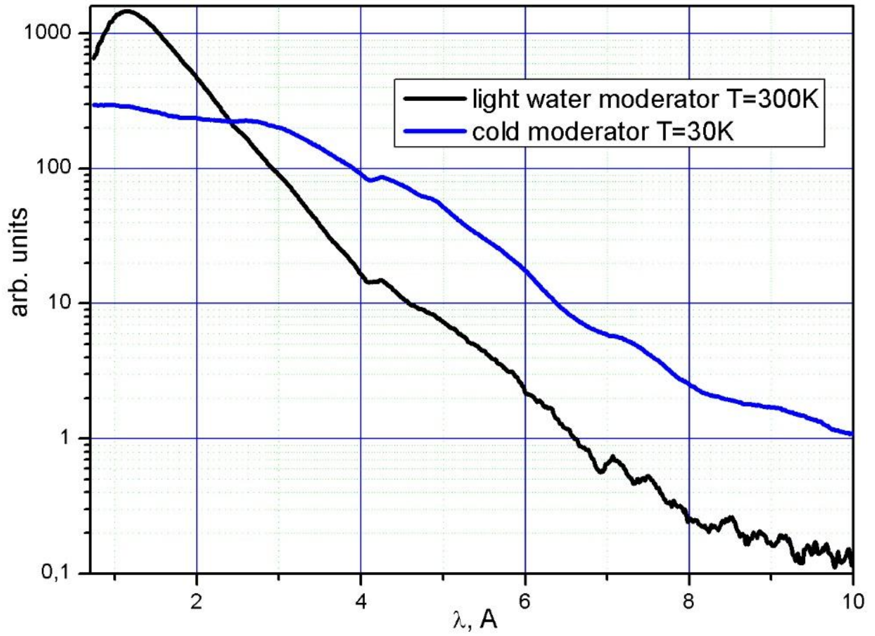
Grooved water moderators

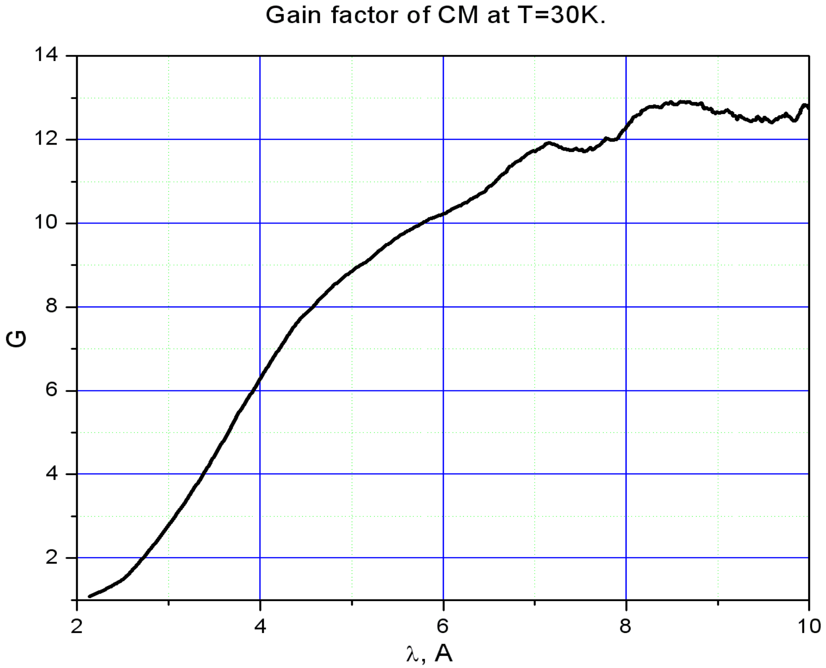
Membrane of cold moderator for beams 7, 8 and 10

Flat water moderator

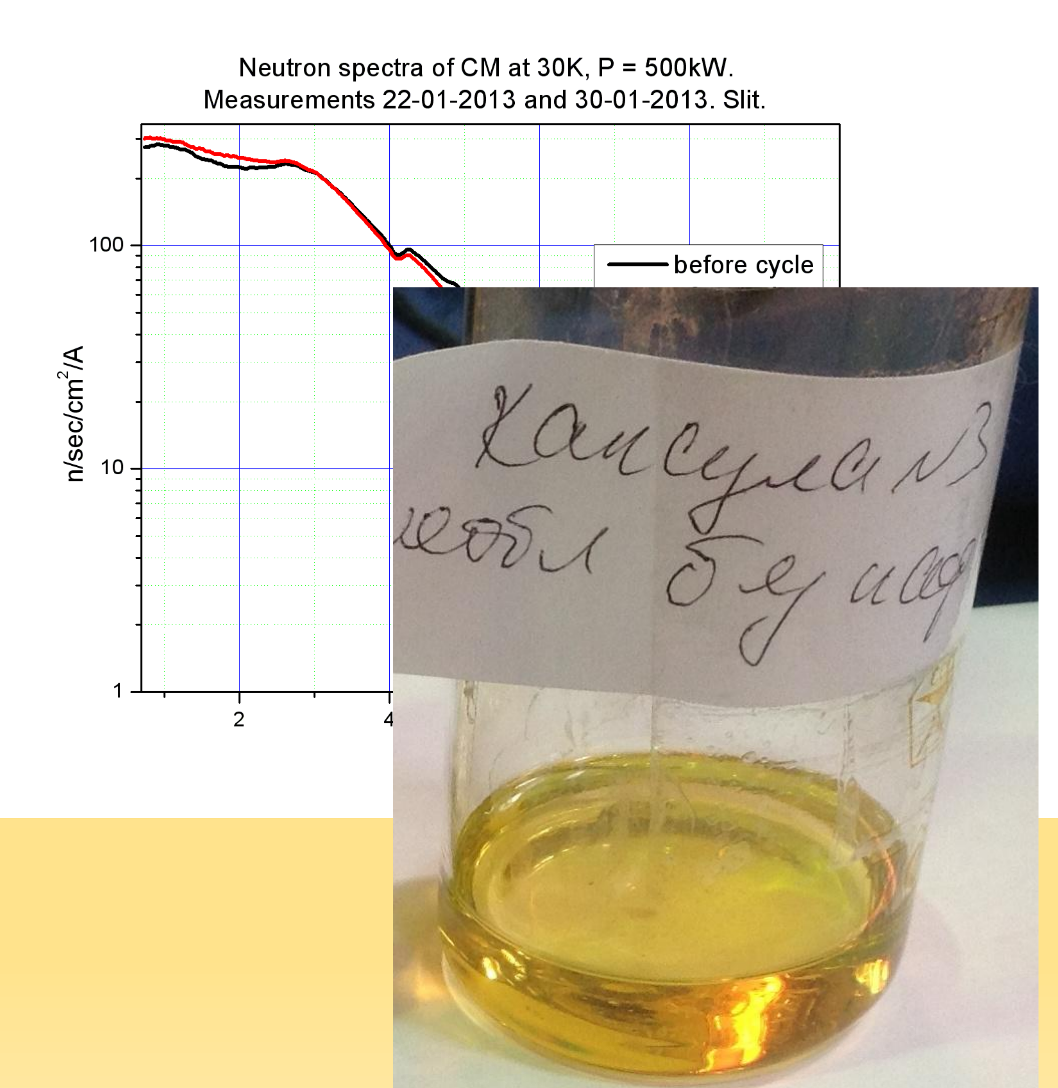


Bi-spectral moderator for beams 7,8,10,11

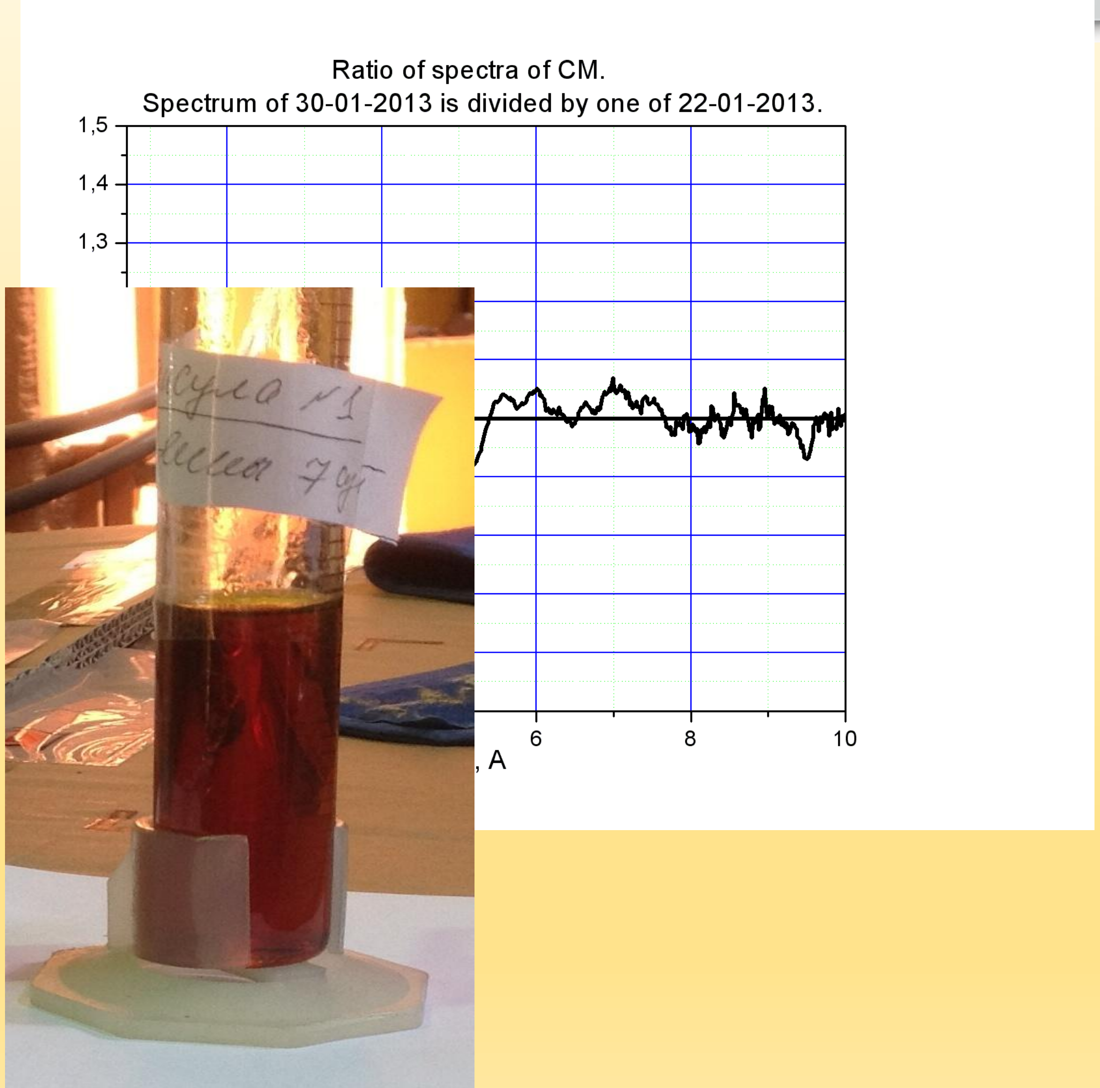




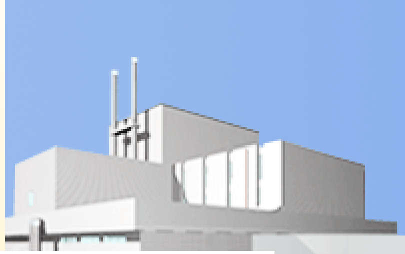
Measurements of spectra change after 7 days of irradiation

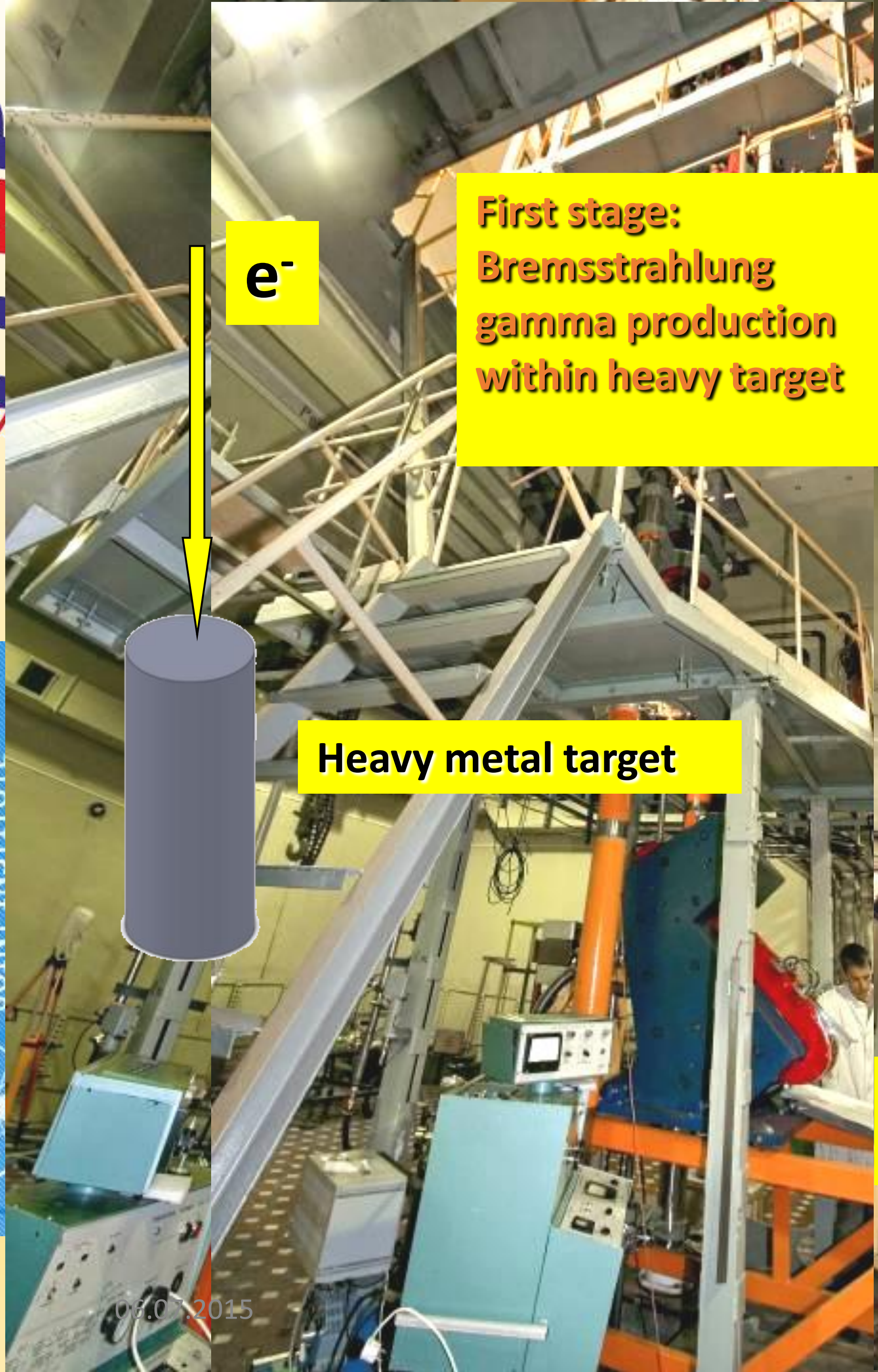


3 days of irradiation



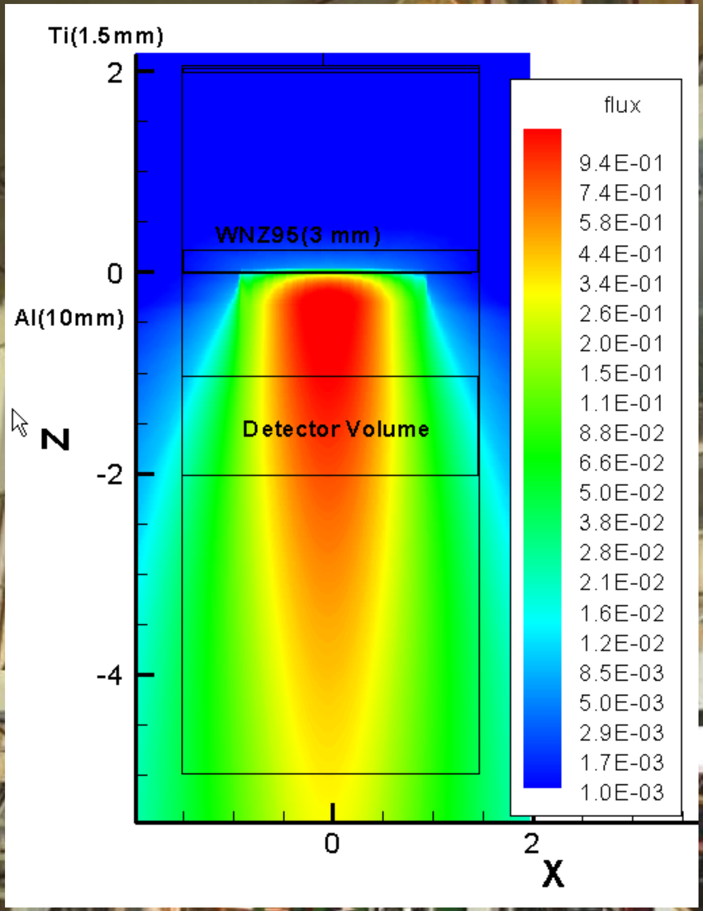
7 days of irradiation



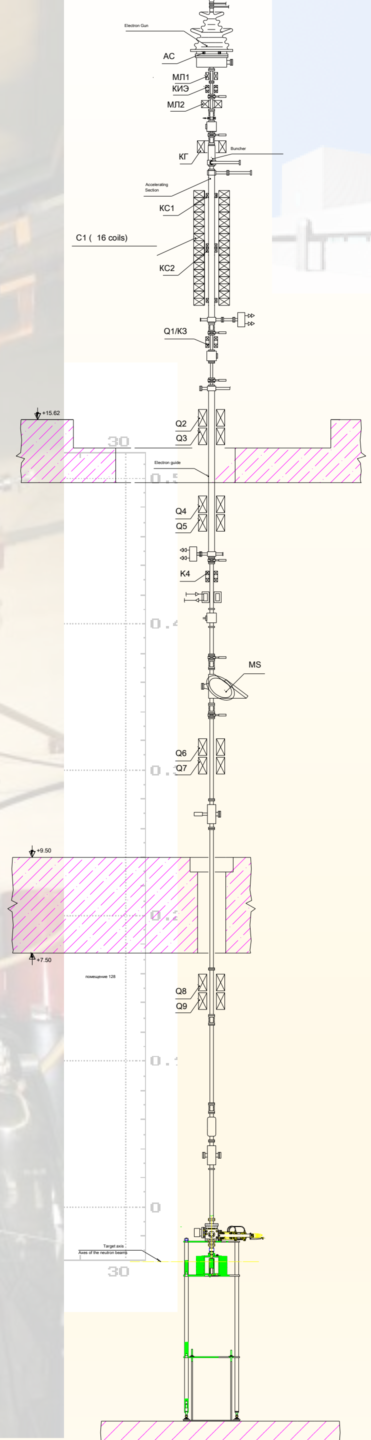


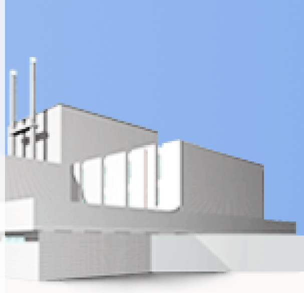
First stage:
Bremsstrahlung gamma production within heavy target

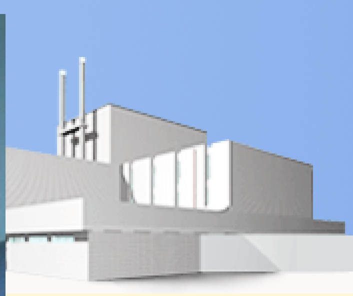
Heavy metal target



Gamma quanta distribution in case of 3 mm W converter

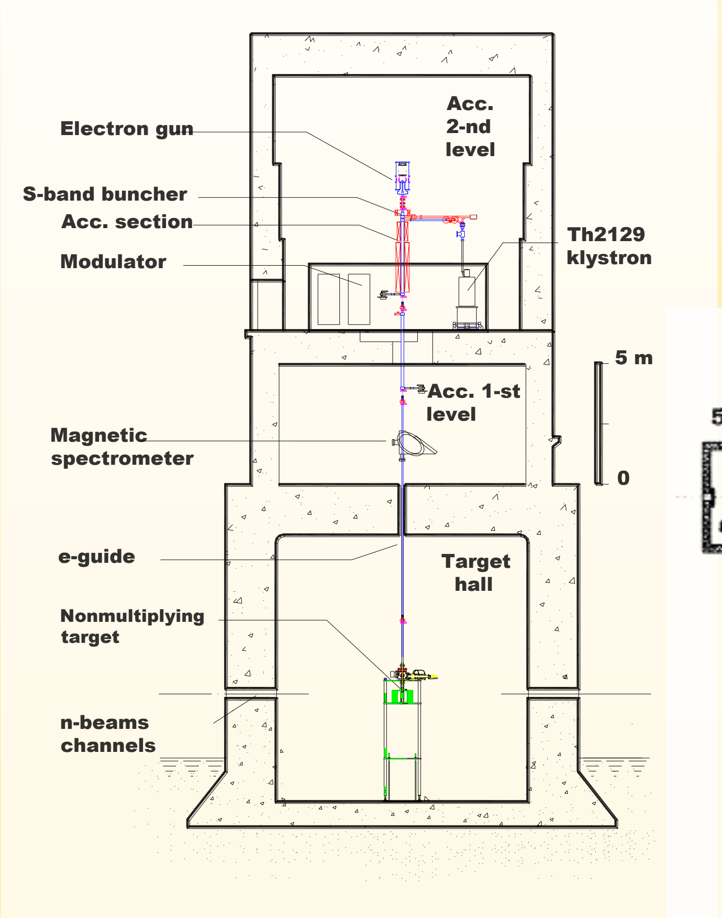


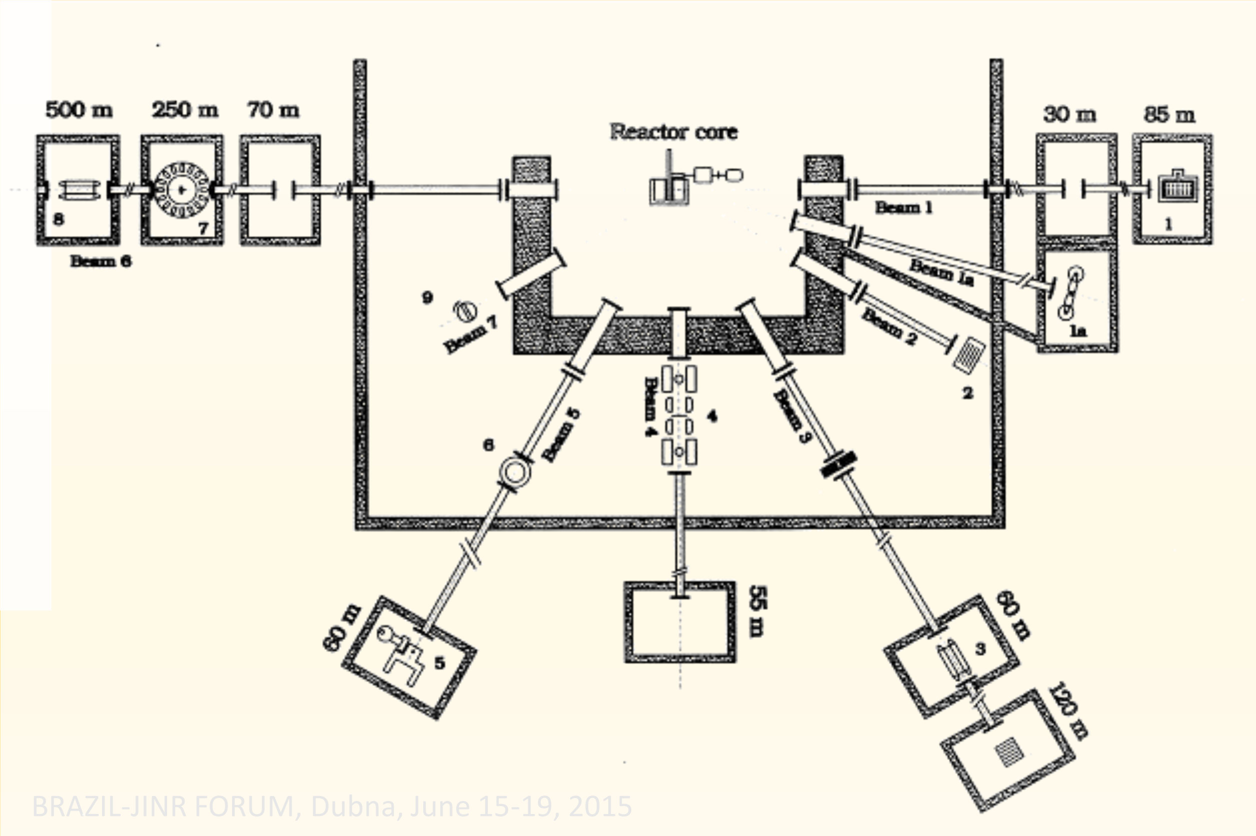


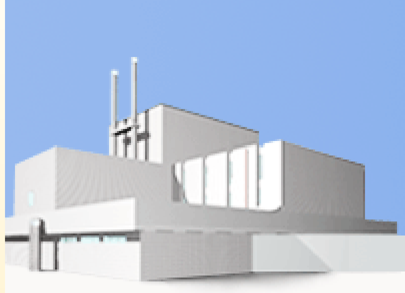


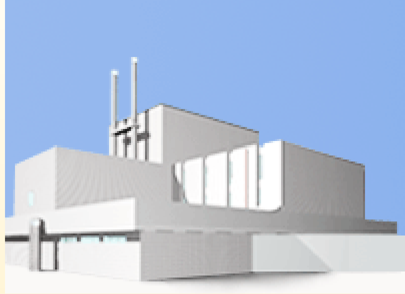
Январь 2009 года, фото Ю.А.Туманова

IREN facility

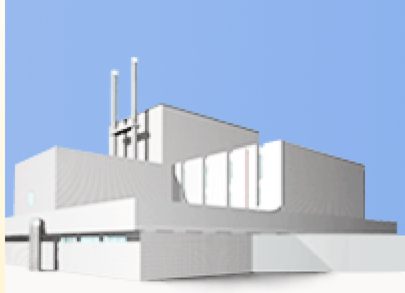




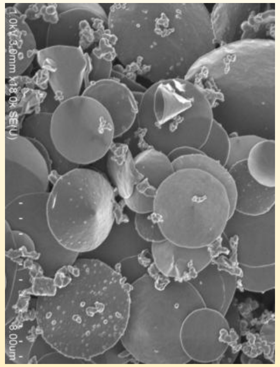




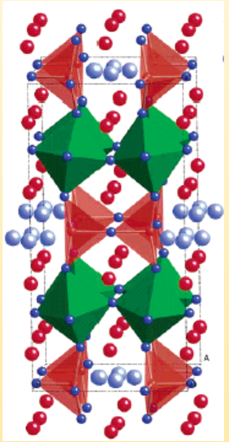
Neutron Scattering



The priority directions of fundamental research :

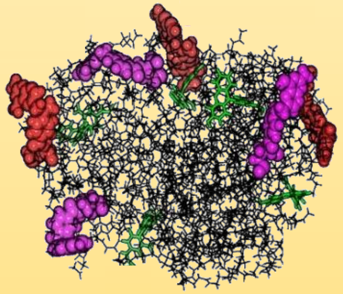


- Nanoscale physics

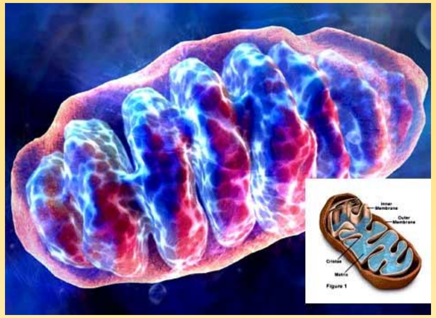


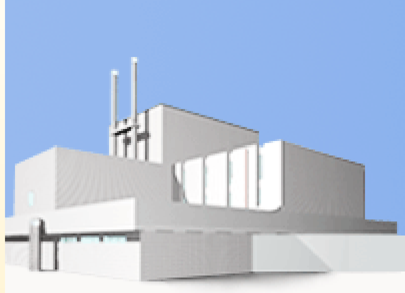
- Physics and Chemistry of Functional Materials

- Physics and Chemistry of
  Complex Liquids and Polymers



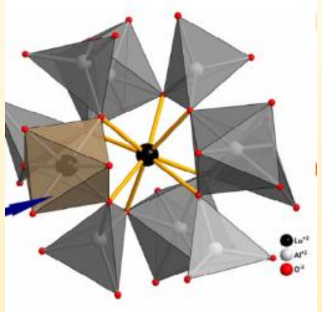
- Physics of Soft Condensed Matter



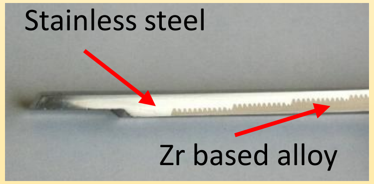


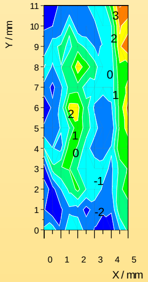
The priority directions of applied research:

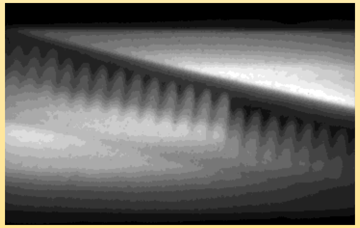
- Structural characterization of functional materials used in different (nano)technologies



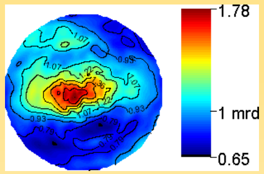
- Non-destructive control of residual stresses and internal organization of bulk materials and products

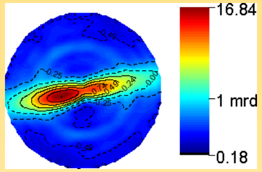






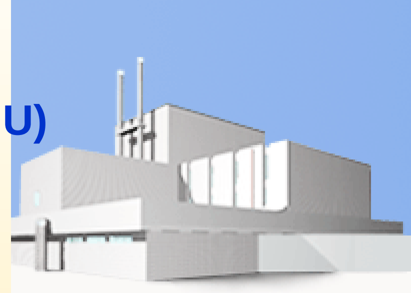
- Texture analysis of geomaterials and constructional materials



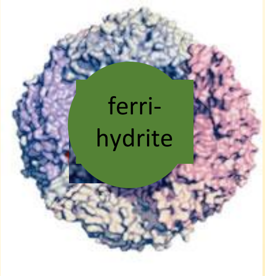


Interactions of nanoparticles with bio-macromolecules

(FLNP JINR - IEP SAS –HZG - KNU)

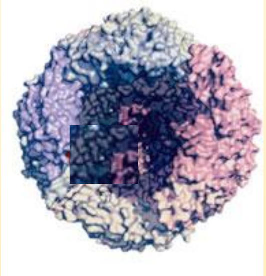


Magnetoferritin

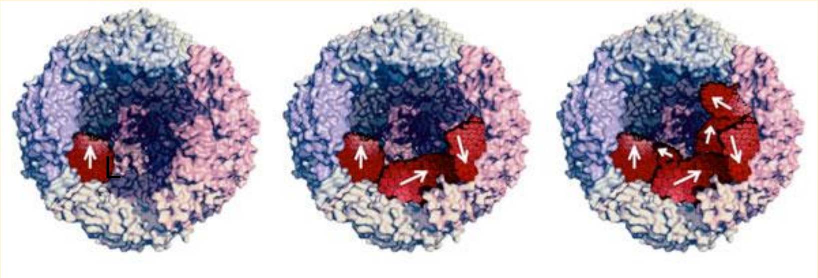


apoferritin

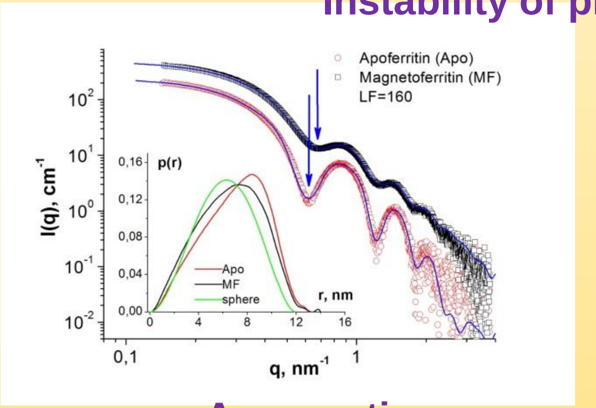
$\varnothing_{out}$ 12 nm
$\varnothing_{in}$ 8 nm

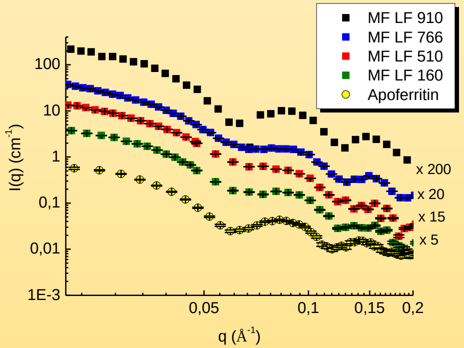


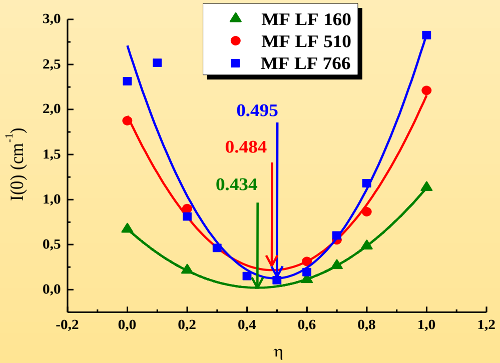
Loading factor (LF)



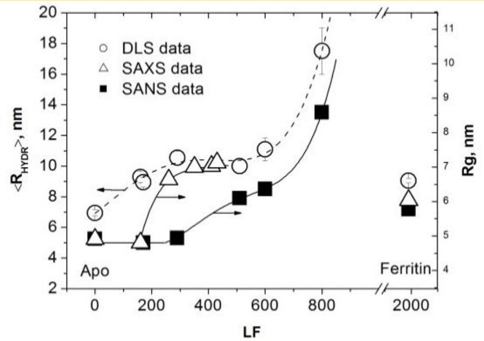
Instability of protein shell



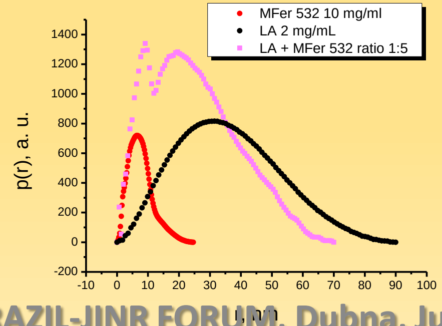




Aggregation



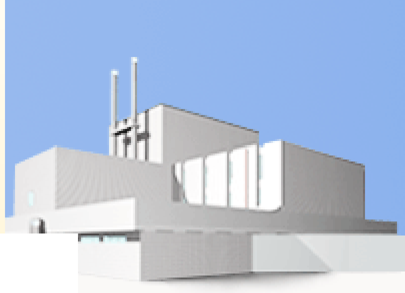
Destroy of amyloids

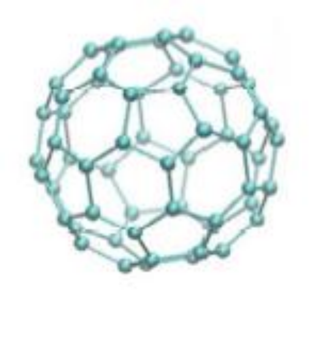


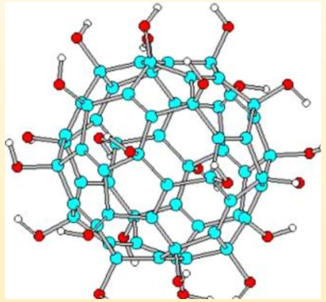
L.Melníková, V.I.Petrenko, M.V.Avdeev, et al, ***Colloids and Surfaces B*** (2014) in press.
P.Kopcansky, K.Siposova, L.Melnikova, et al. ***JMMM*** (2014) in press.
L.Melnikova, V.I.Petrenko, M.V.Avdeev, et al. ***JMMM*** (2014) in press.

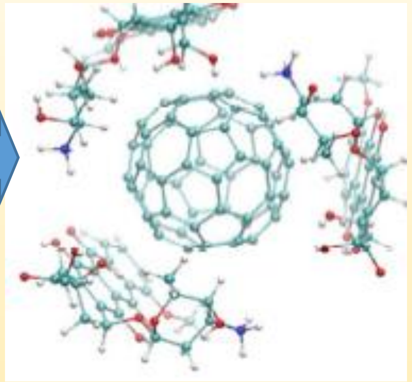
Structural organization of bioactive fullerene derivatives

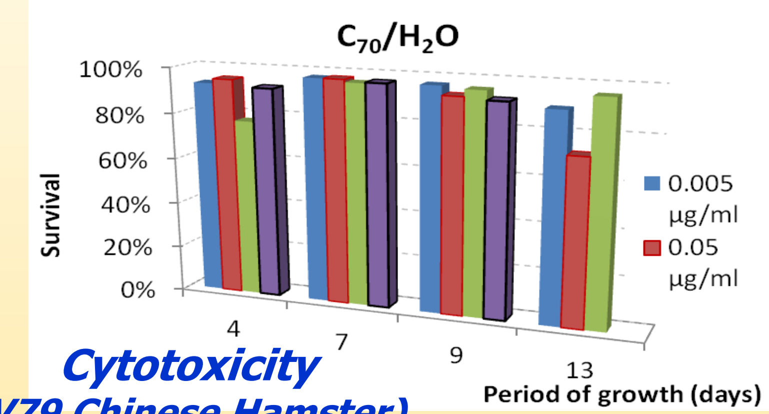
(FLNP JINR – KNU – MSU)





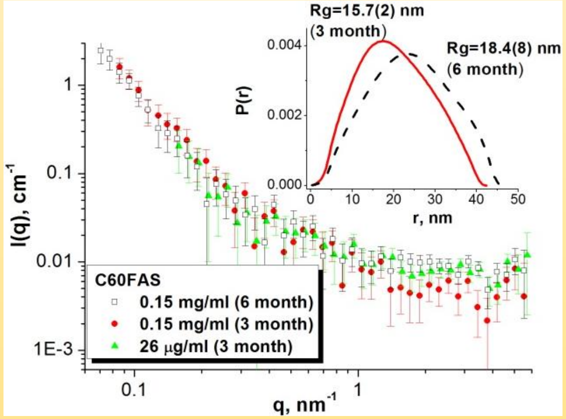




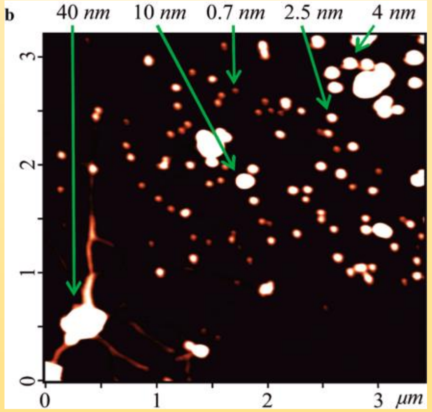


Cytotoxicity

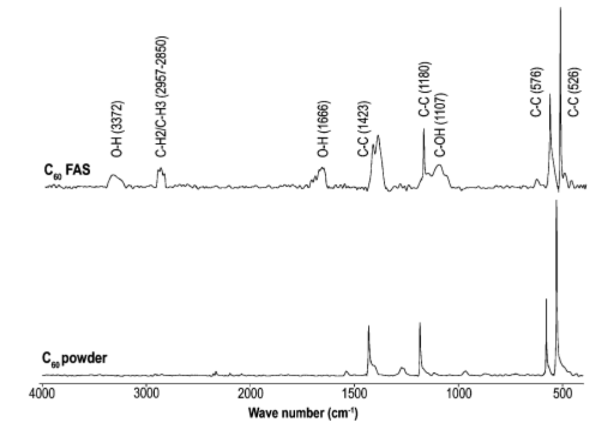
(V79 Chinese Hamster)



SANS



AFM

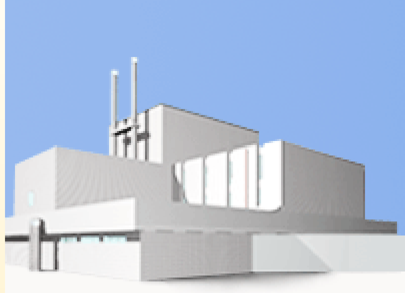


FTIR

Yu.I.Prylutskyy, V.I.Petrenko, O.I.Ivankov, O.A.Kyzyma, L.A.Bulavin, O.O.Litsis, M.P.Evstigneev, V.V.Cherepanov, A.G.Naumovets, U.Ritter. ***Langmuir*** 30 (2014) 3967–3970.

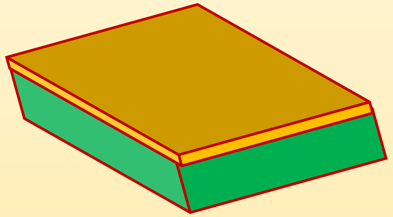
Kyzyma O.A., Tomchuk A.A., Bulavin L.A., Petrenko V.I., Almasy L., Korobov M.V., Volkov D.S., Koshlan` I.V., Koshlan` N.A., Blaha P., Avdeev M.V., Aksenov V.L. ***J. Surface Invest.*** (2014) in press.

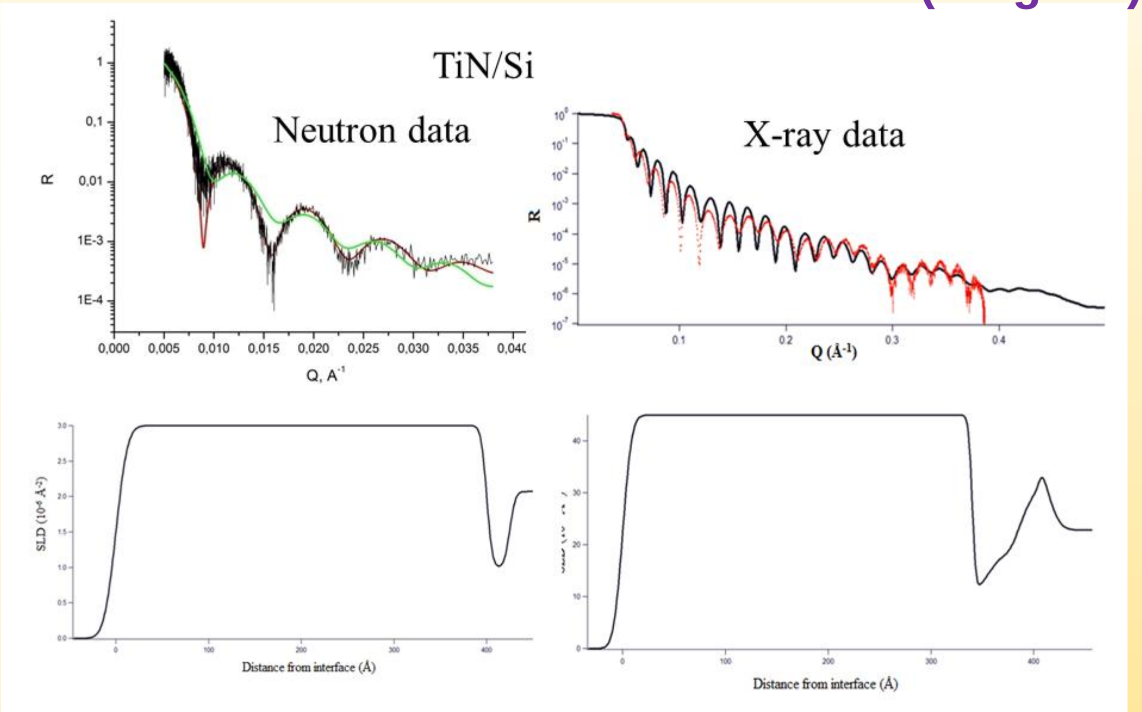
Structural study of TiN hardening coatings



JINR – IE BAS (Bulgaria)

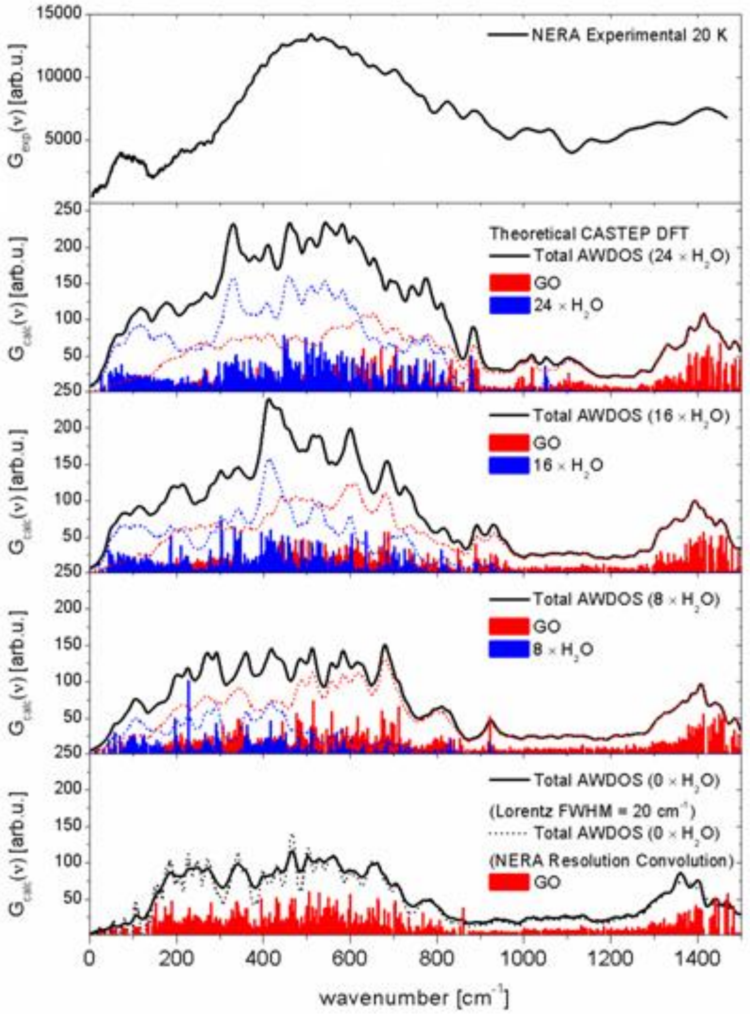
TiN/Si nanostructure

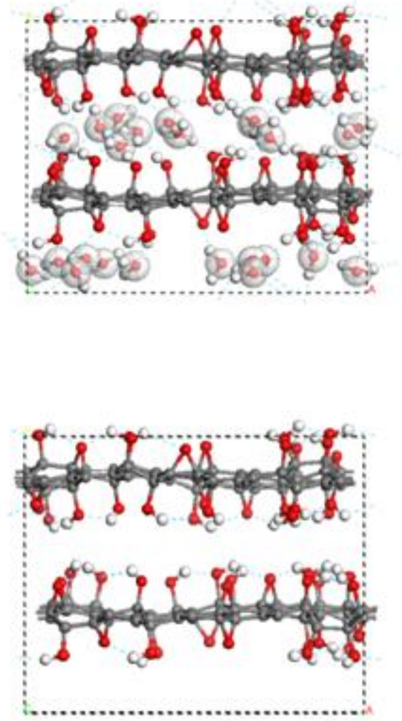




Reflection coefficients obtained by neutron and X-ray reflectometry and the scattering length density profile obtained from the experimental data for the TiN(36nm)/Si system.

Vibrational dynamics of water withheld in graphene oxide

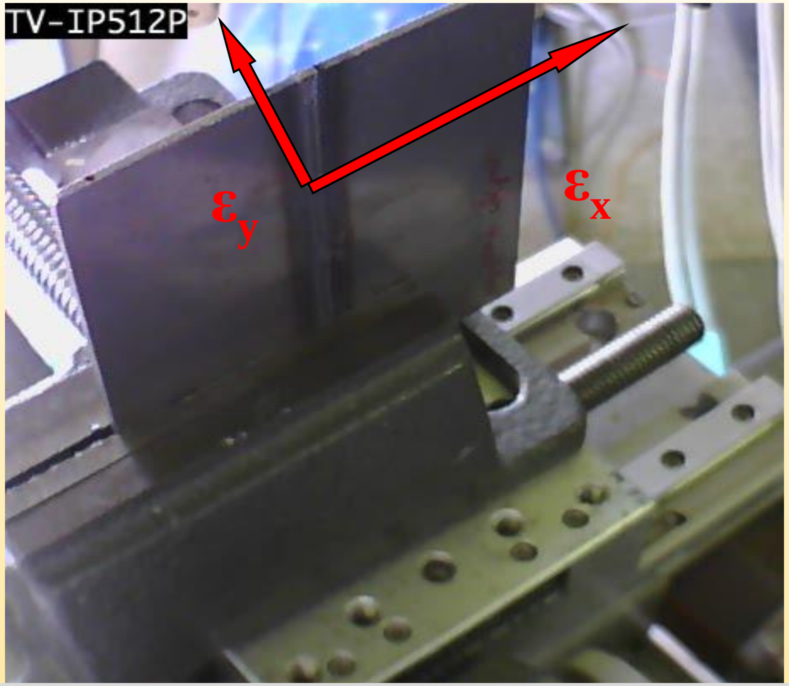




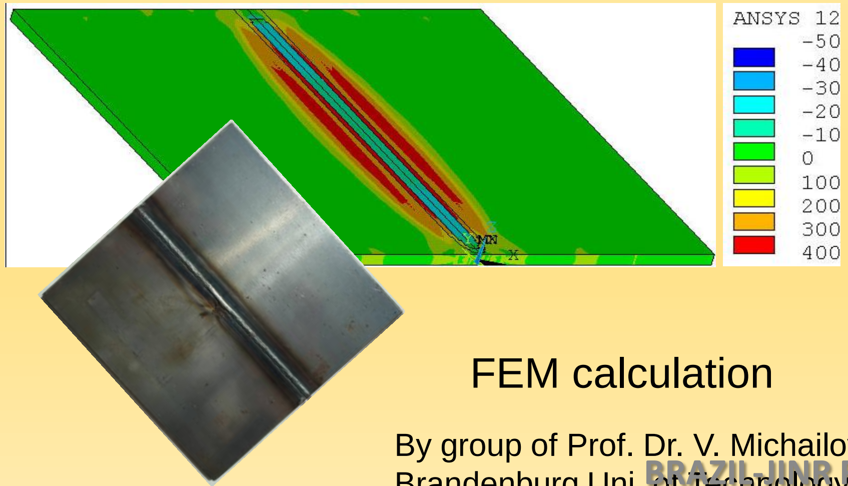
Experimental INS spectra and calculated amplitude weighted vibrational density of states (AWDOS) of graphene oxide obtained by DFT calculations taking into account interlayer water molecules.

Drużbicki K., Natkaniec I., Chemical Physics Letters (2014).

A study of residual stresses in welds obtained by different beam welding methods

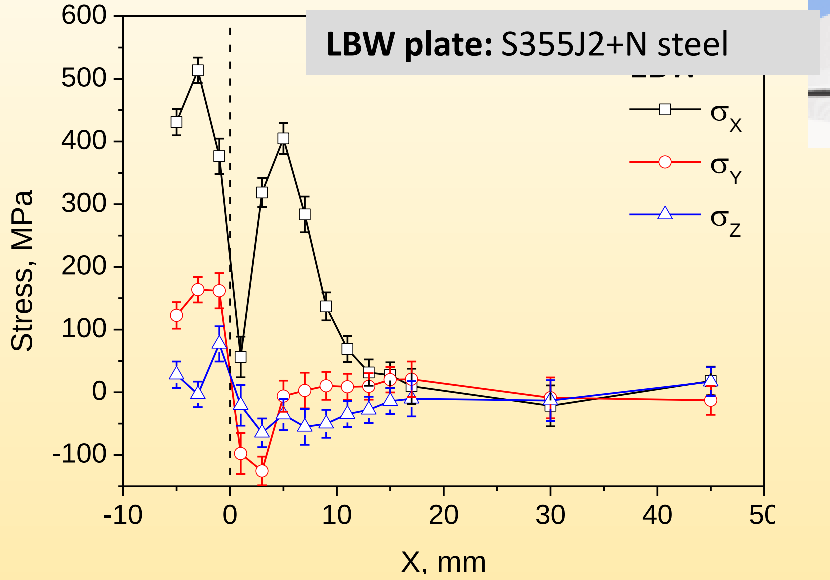


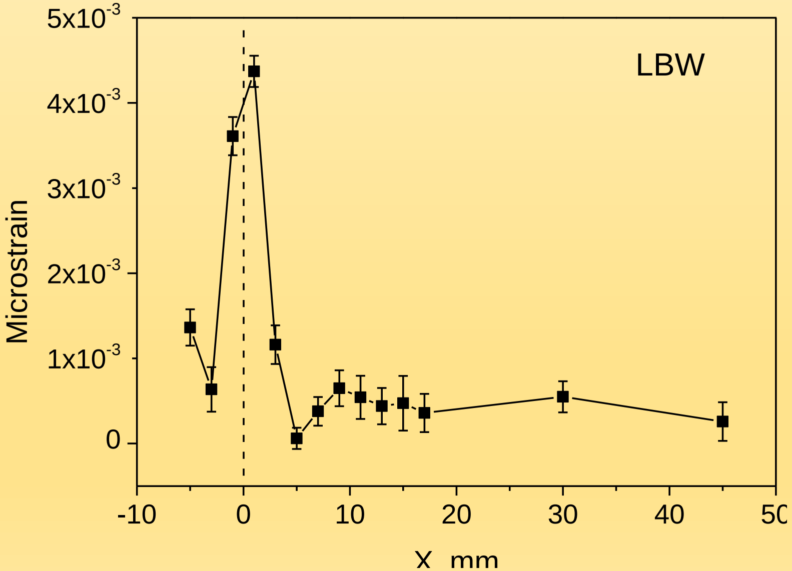
The layout of experiment for residual stress study in steel plate with LBW



FEM calculation

By group of Prof. Dr. V. Michailov ,
Brandenburg Uni. of Technology

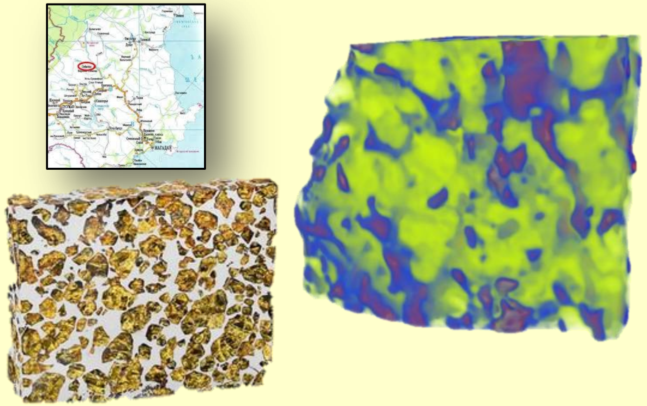




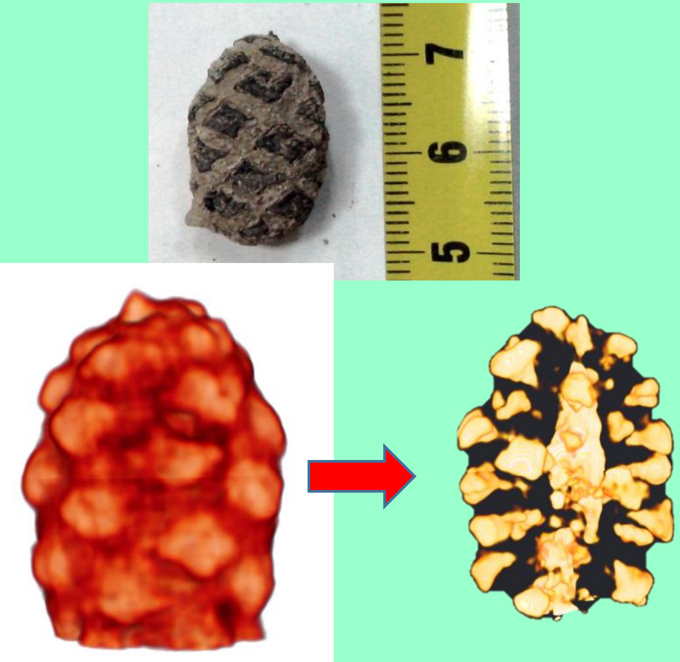
Residual stress (top) and microstrain (bottom) in steel plate with laser beam welding

Development of neutron tomography technique at neutron imaging instrument

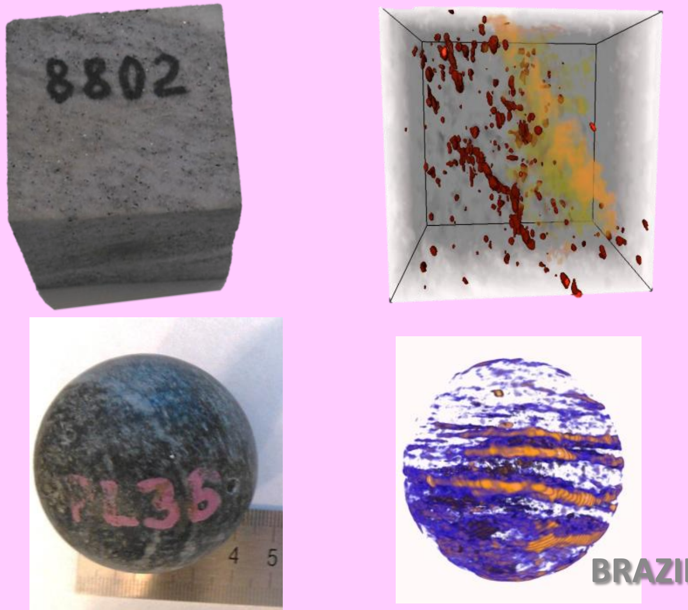
Sample and detector position



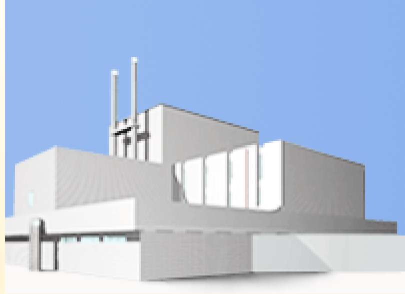
3D reconstruction of Fe-Ni alloy distribution in Seimchan meteorite



3D reconstruction of internal structure of Protosequoia cone (cretaceous period) from Paleontological Institute RAS

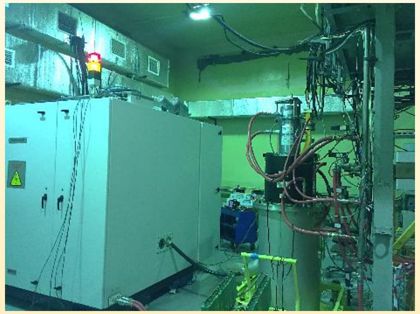


3D reconstruction of internal structure of the biotite gneiss sample from Kola Superdeep Borehole, depth 8802 m and its surface analogue

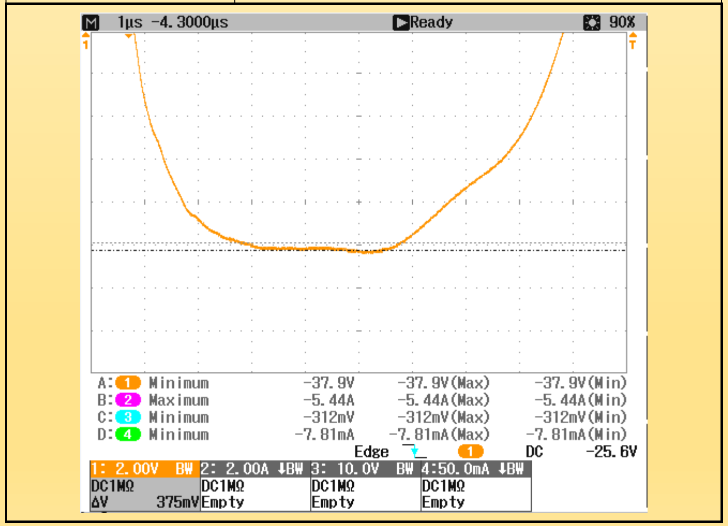


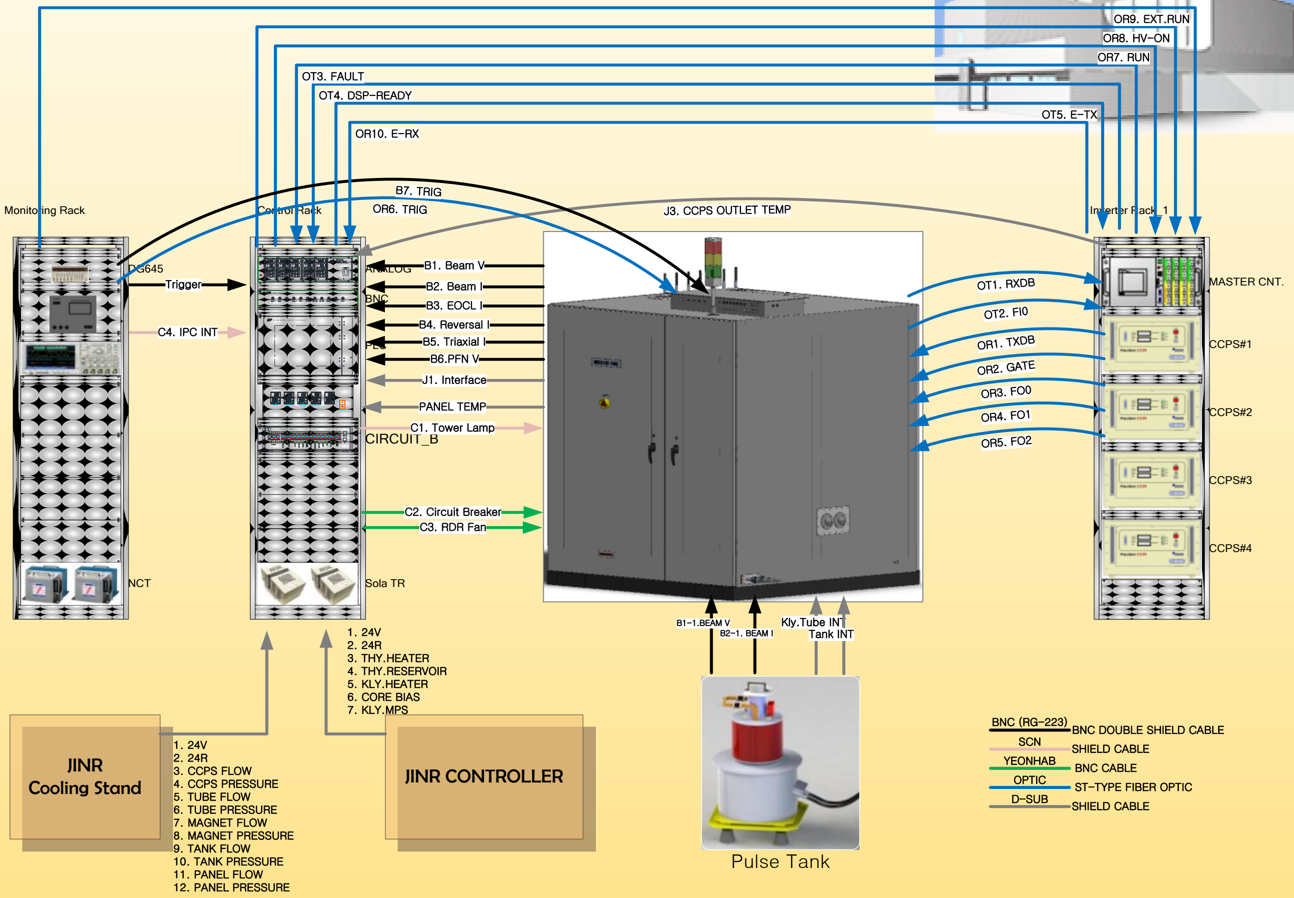
Neutron nuclear physics

Development of the IREN facility

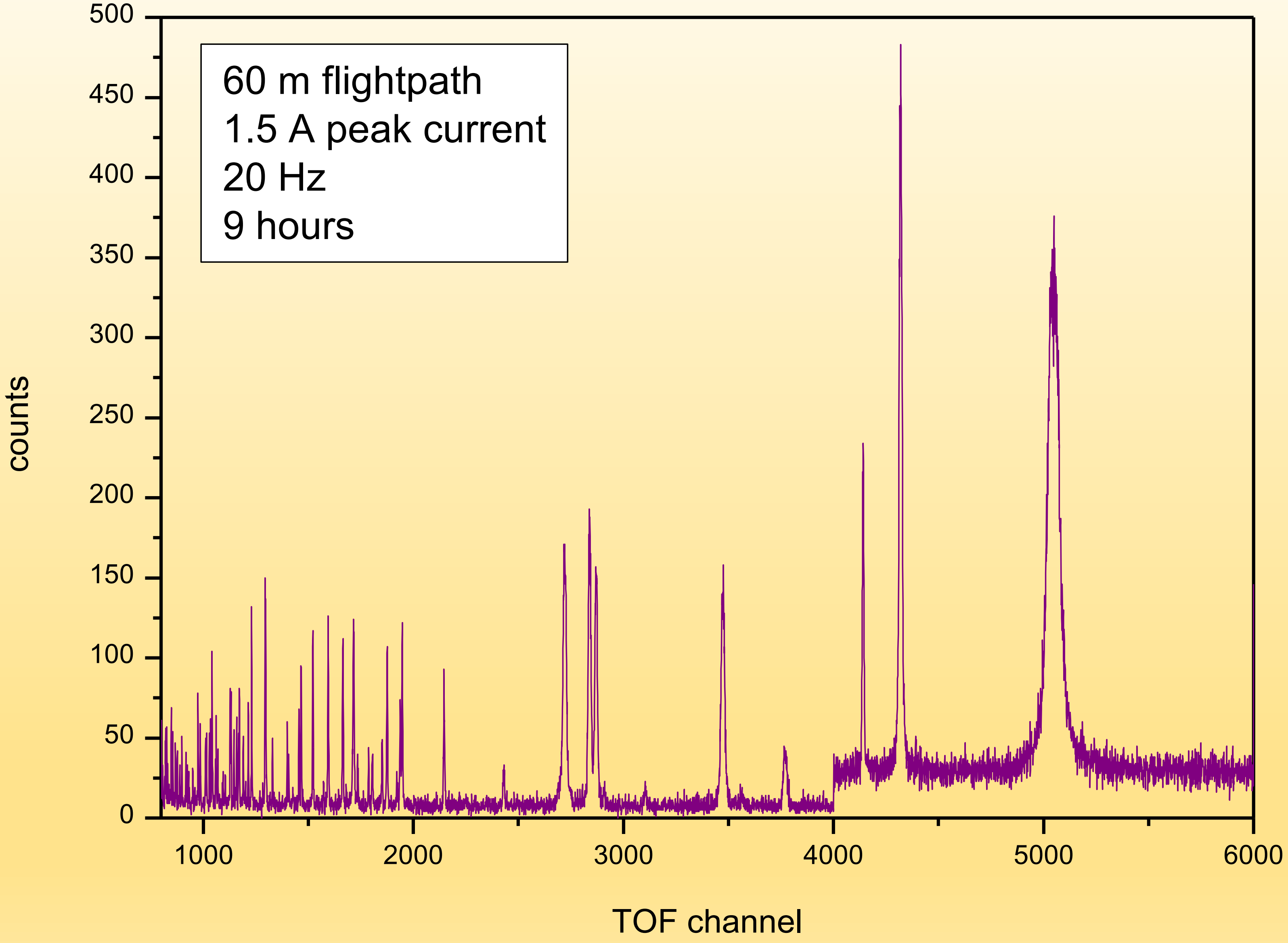


Test	Status
Beam V Flatness	<1%
Beam V Flat-top	2.8us

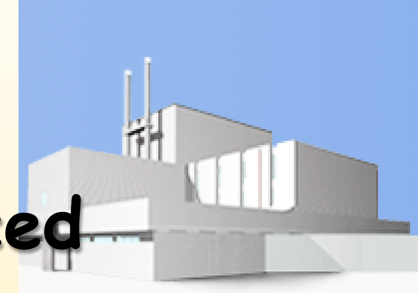




New klystron modulators assembling and testing April 14 – May 8 2015


60 m flightpath
1.5 A peak current
20 Hz
9 hours
counts
TOF channel
0
50
100
150
200
250
300
350
400
450
500
1000
2000
3000
4000
5000
6000

Fundamental symmetries in neutron induced reactions



- Measurements of the P-odd asymmetry in neutron induced reactions at light nuclei;

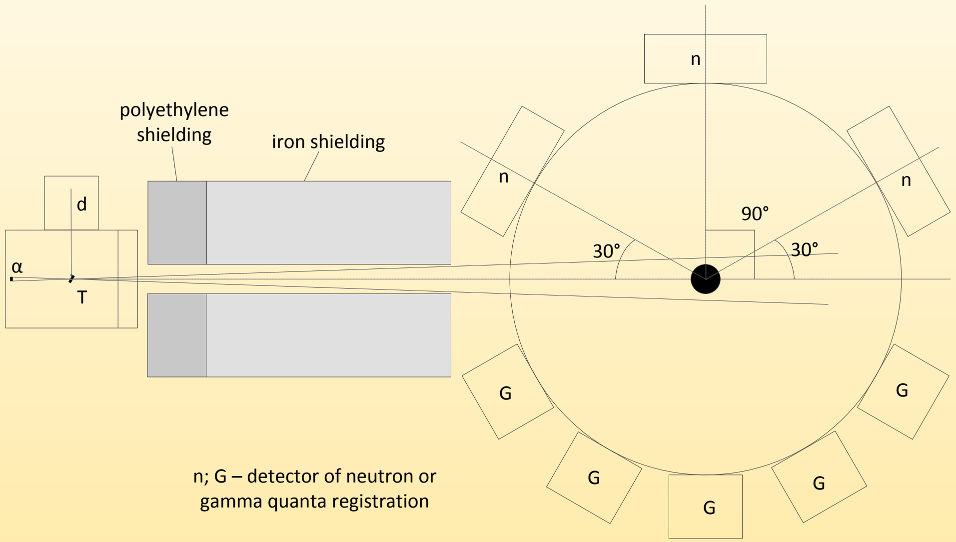
$$^{6}\text{Li}(n,\alpha)\,^{3}\text{H}, \quad A_t = -(8.8 \pm 2.1)\cdot 10^{-8}$$

$$^{10}\text{B}(n,\alpha_1)\,^{7}\text{Li}^* \rightarrow {}^{7}\text{Li} + \gamma, \quad A_\gamma = (0.7 \pm 2.3)\cdot 10^{-8}$$

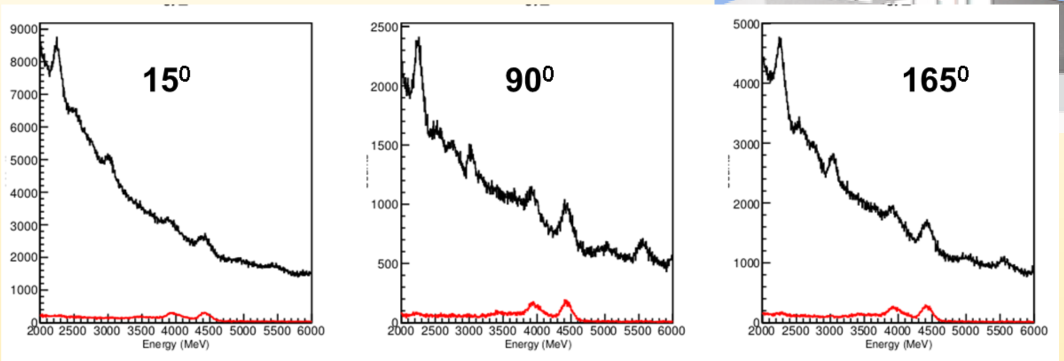
- Investigations of the T-odd effects in neutron induced fission: TRI and ROT effects studies;

$$W(\Omega) \sim 1 + \alpha_{PNC}(\sigma_n \cdot P_{f'}) + \alpha_{PC} \cdot \sigma_n \cdot [P_f \times P_n] + D_{TRI} \cdot \sigma_n \cdot [P_f \times P_\alpha] + D_{ROT} \cdot \sigma_n \cdot [P_f \times P_\alpha] \cdot (P_f \cdot P_\alpha)$$

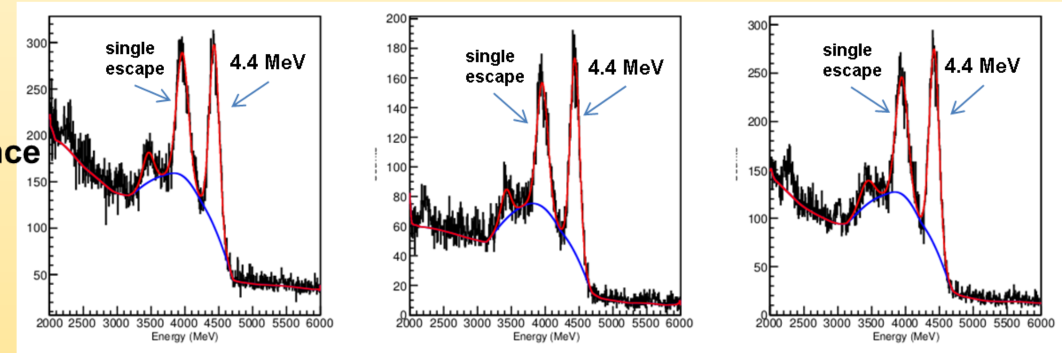
Experiments with tagged neutrons

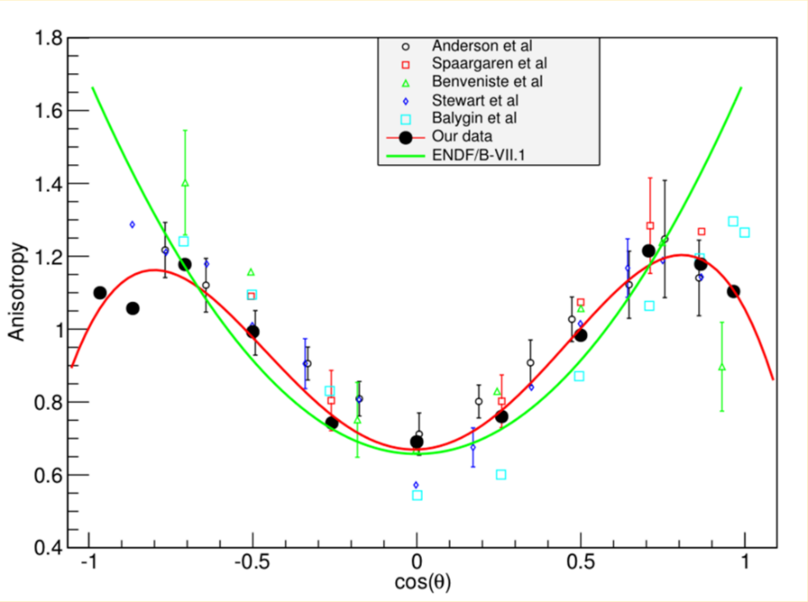


All events



α-γ coincidence





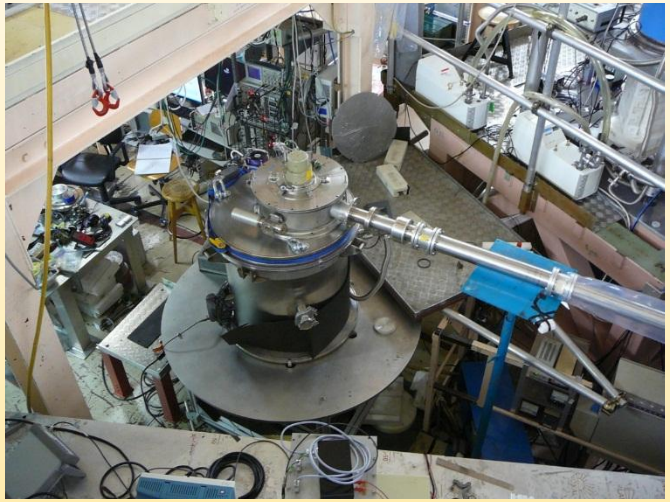
$$w \sim 1 + a \cdot \cos^2\theta - b \cdot \cos^4\theta$$

a=1.58±0.04

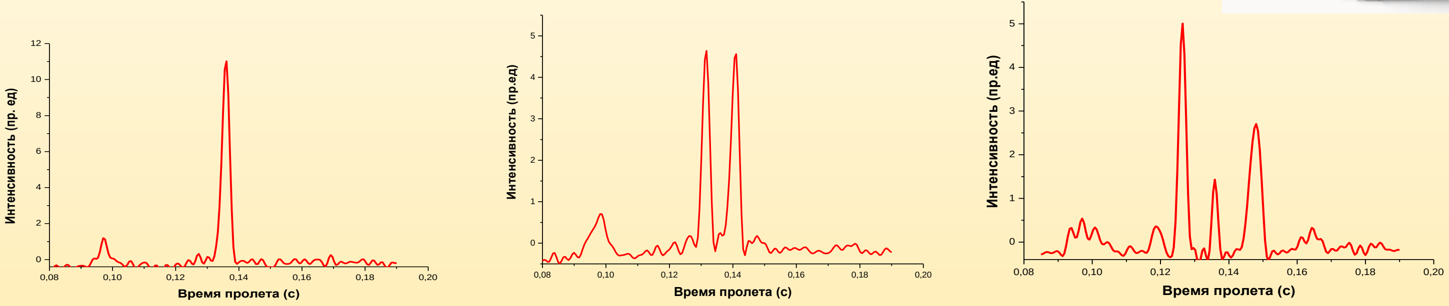
b=1.22 ±0.05

TANGRA Collaboration

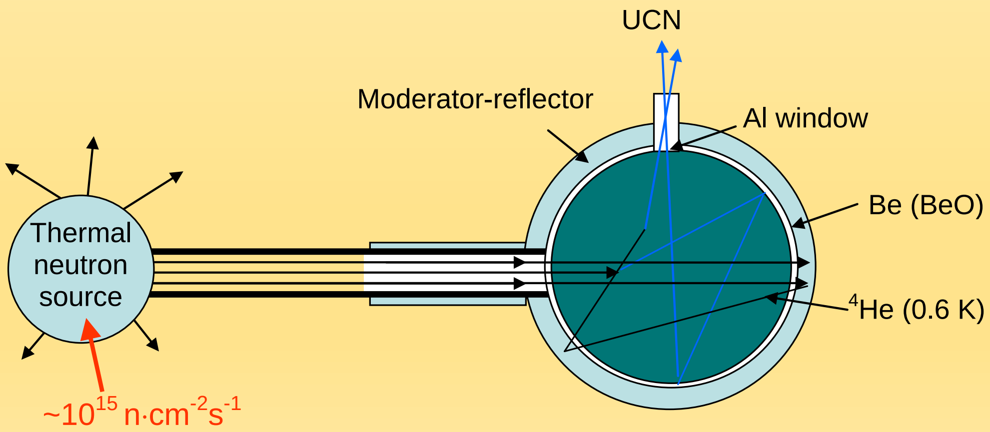
UCN physics



Nonstationary quantum effects in neutron optics

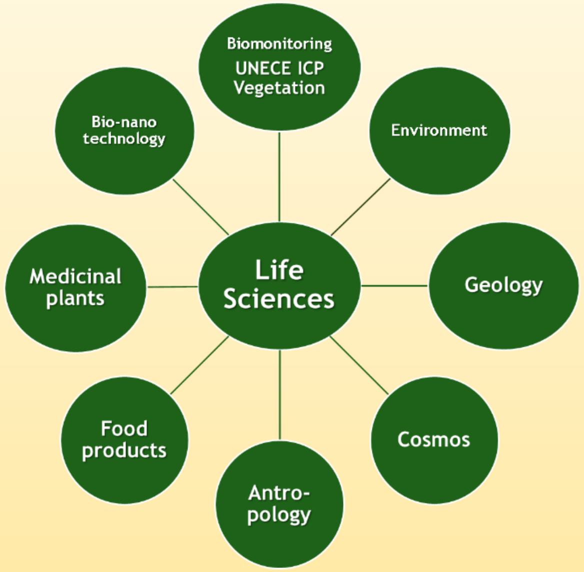


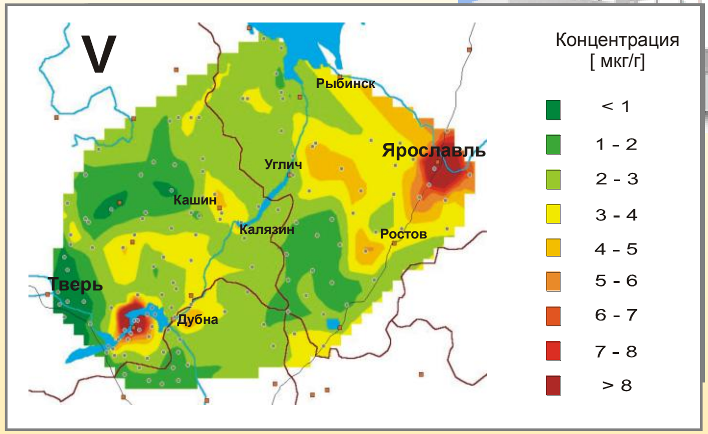
UCN spectra at diffraction on stationary diffraction grating and rotating at 1500 and 2400 rpm (left-right)



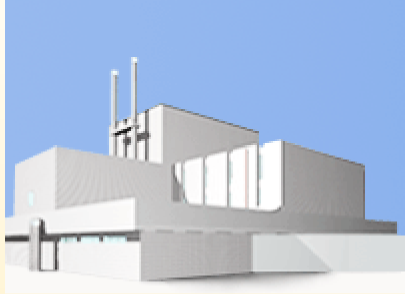
Proposal of the new type UCN sourve

Applied research: NAA and detectors for space crafts



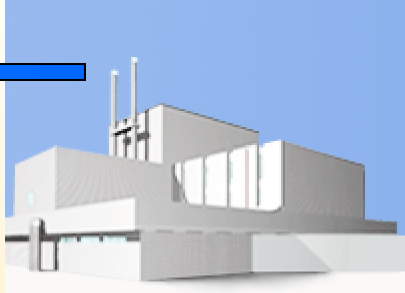


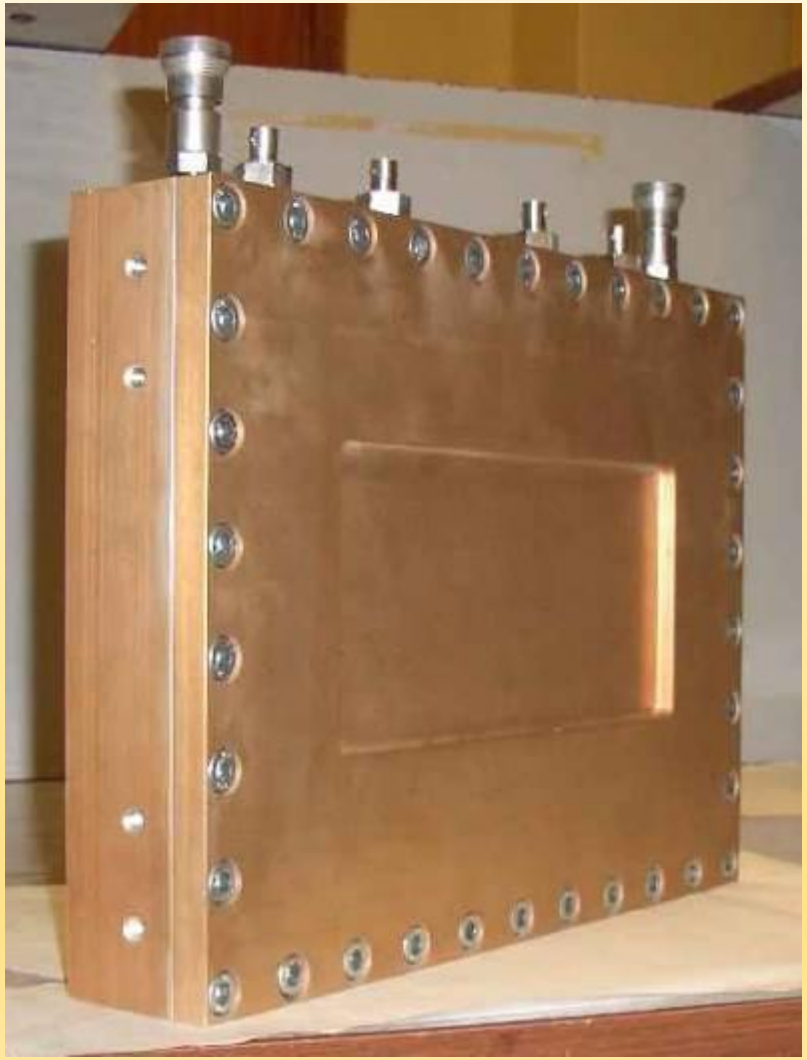
Methodical research



- Neutron spectrometers;
- Detectors;
- Sample environment;
- Hardware & software;
- Cryogenics;
- Network and computing;

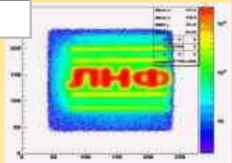
1D PSD 200x80 mm^2



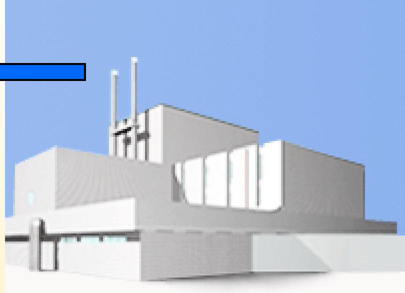


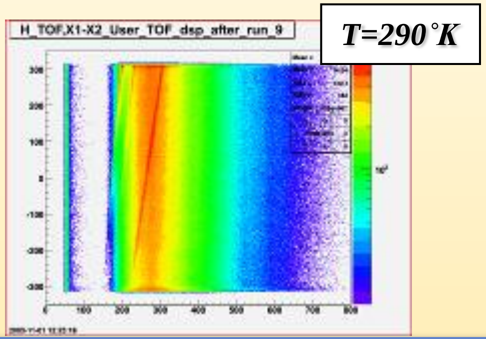
Multi-purpose instrument for neutron scattering measurements

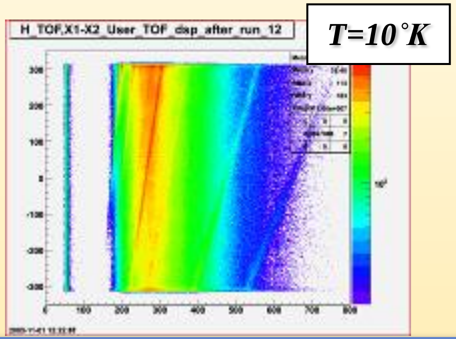
Parameter	Value
Sensitive area	200 x 80 mm^2
Position resolution (FWHM)	$\Delta x \approx 1{,}8$ mm
Sensitivity for thermal neutrons	60%
Range of neutron wavelength	0.4 Å – 12 Å
Channel nonlinearity	>5%
Count rate	1 – 100 kHz
Readout	Delay lines



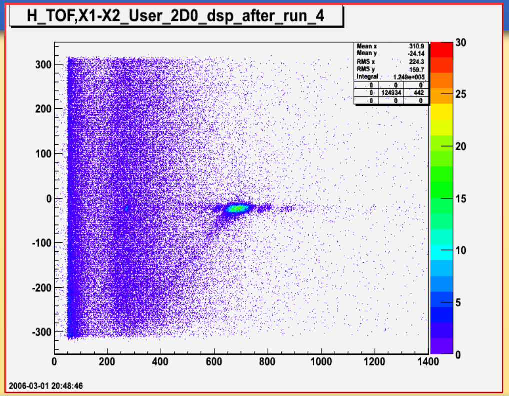
IBR-2 measurements





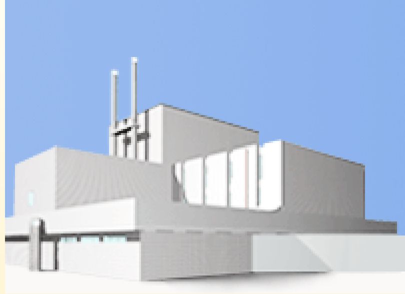


Diffraction spectra of the $(La_{0.1}Pr_{0.9})_{0.7}Ca_{0.3}Mn_{0.3}$ sample, measured at the channel №5. At low temperatures it separated at FM-metallic and AFM-CO-insulating mesoscopic phases.

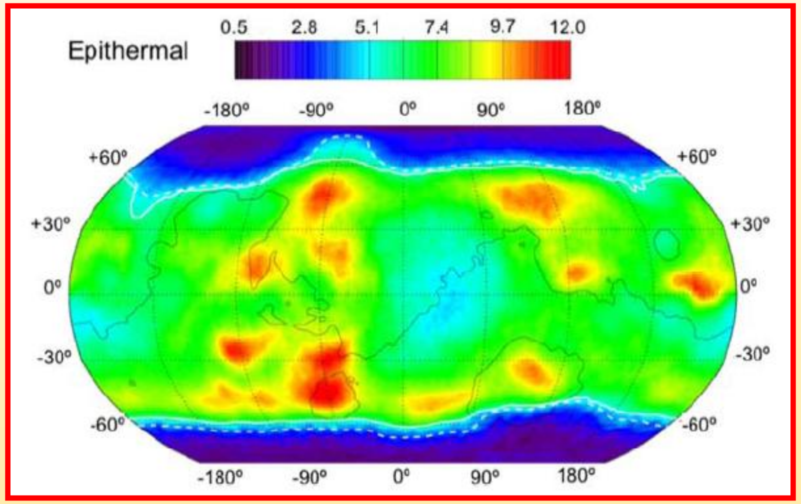


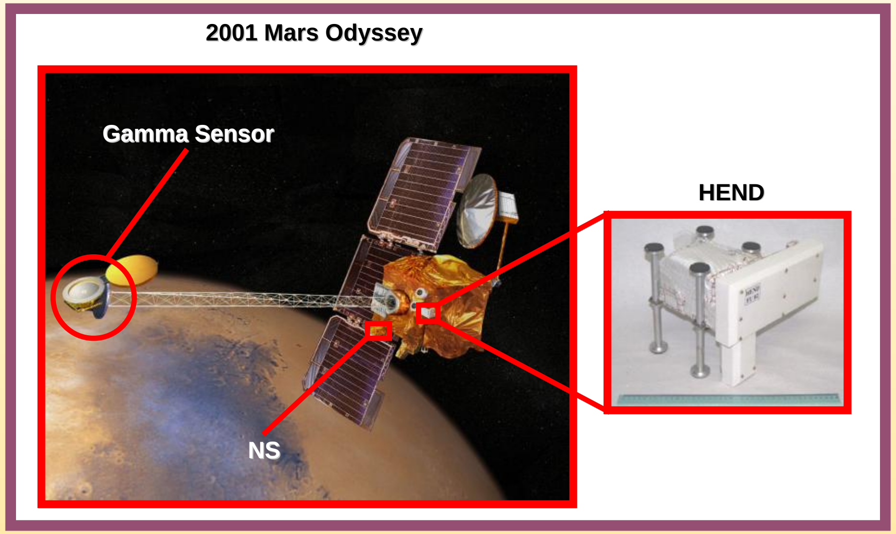
Spectrum of the MgO/(4.7nm)Fe/(4.7nm)V]10/[(1ML)Fe/(1ML)V]17/(36.5nm)V/(2nm)Pd multilaye r sample measured at the refletometer REFLEX (channel №9)

Neutron detectors at space

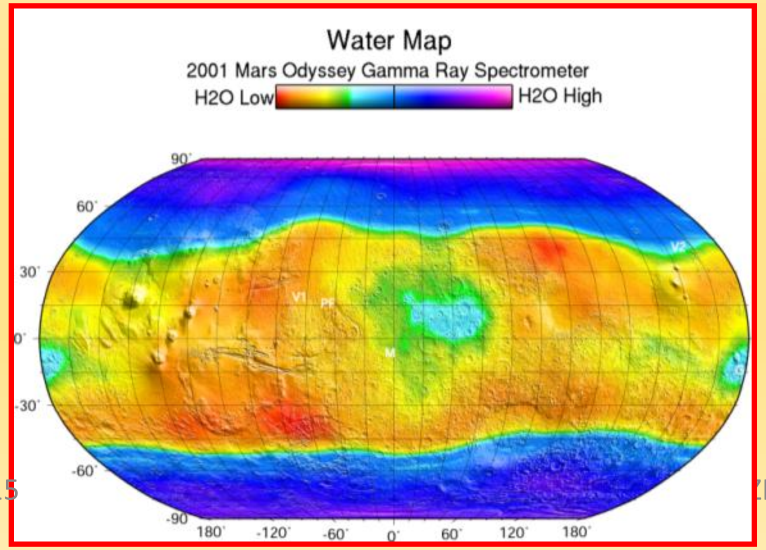


Neutron Spectrometer (NS)

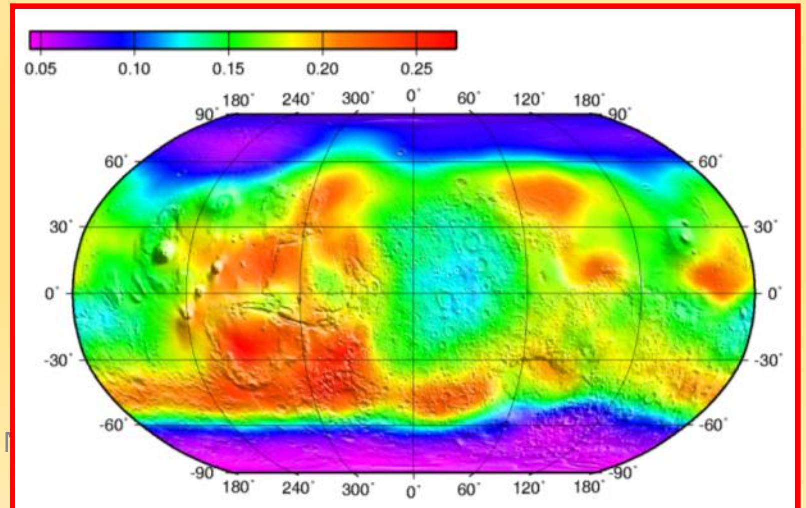




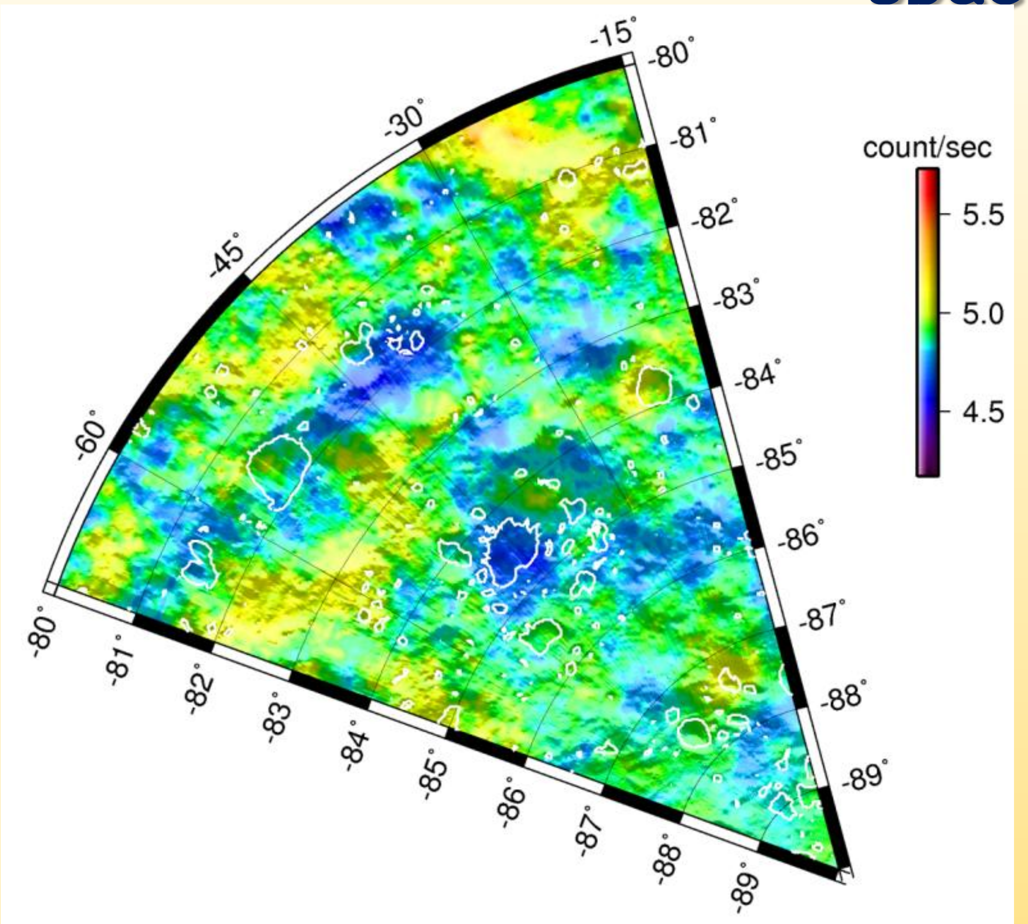
Gamma Spectrometer



HEND

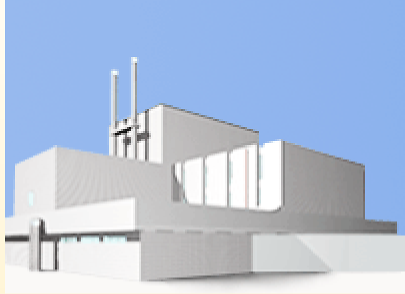


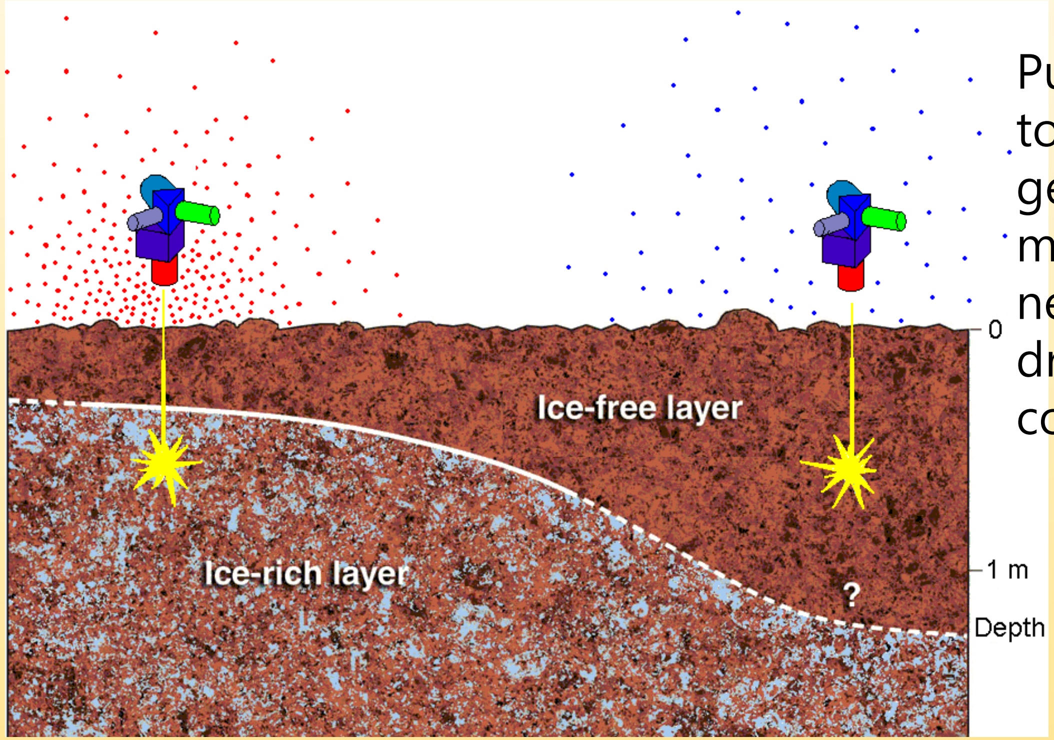
Neutron detectors at space



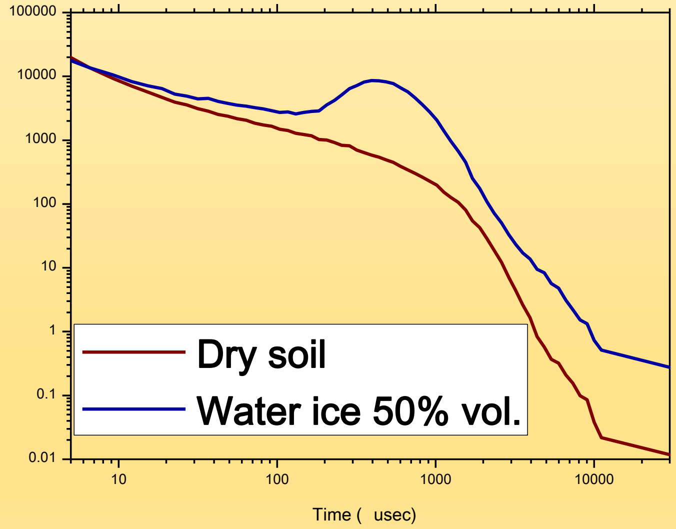
The first neutron mapping data from LEND

Dynamic Albedo of Neutrons (DAN) Russian detector onboard of the Curiosity Rover

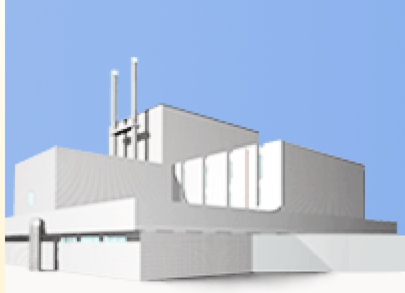




Pulsed neutron Logging: idea belongs to G.N.Flerov. Fast neutrons from generator penetrates into the soil and moderated. Time profile of the slow neutron counter located above the soil drastically depends on the hydrogen content in the soil.

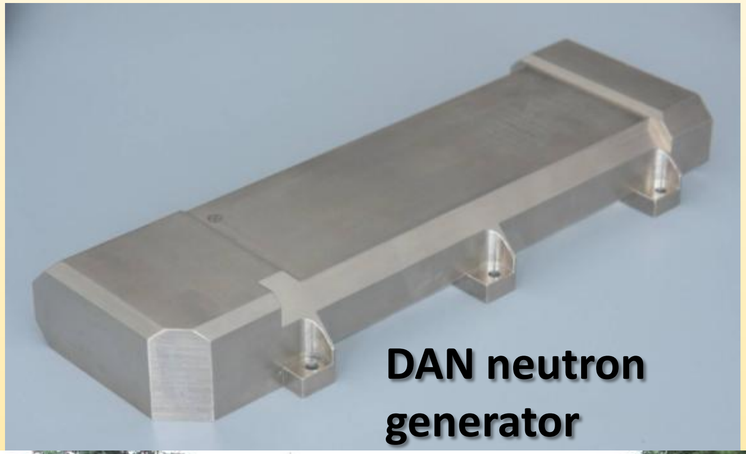


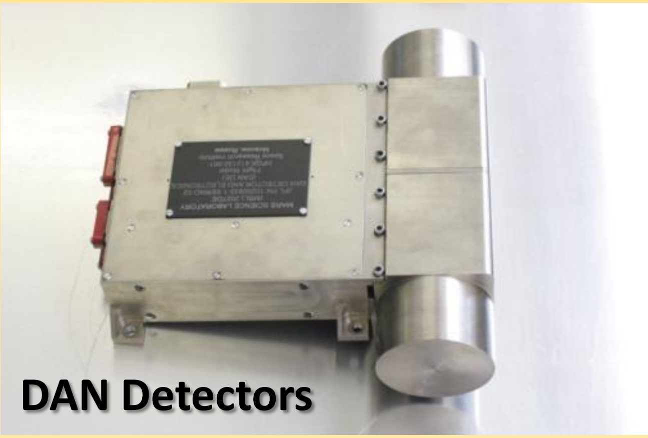
FLNP and LRB of JINR are collaborating with Russian Space Research Institute since 1997. DAN device was proposed in 2003 as one of the scientific instruments onboard of the Mars Science Laboratory and in the beginning of 2004 after non-advocating review was accepted by NASA.



Dynamic Albedo of Neutrons (DAN) Russian detector onboard of the Curiosity Rover

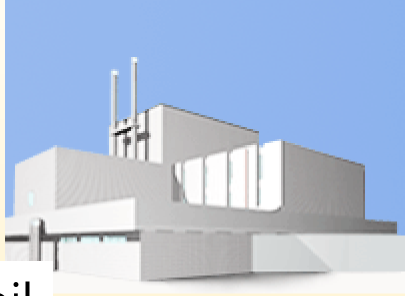
http://mars.jpl.nasa.gov/msl/

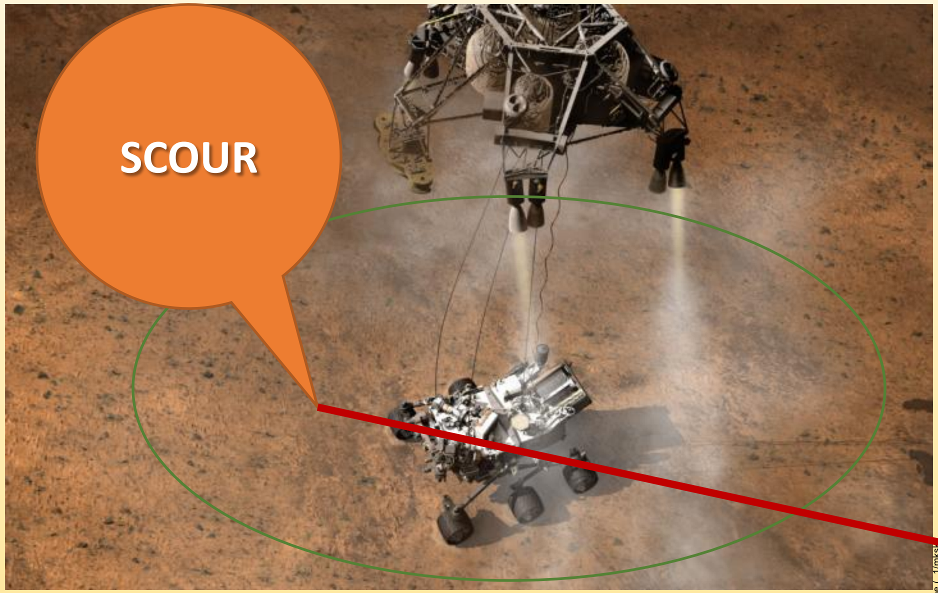

DAN neutron generator


DAN Detectors

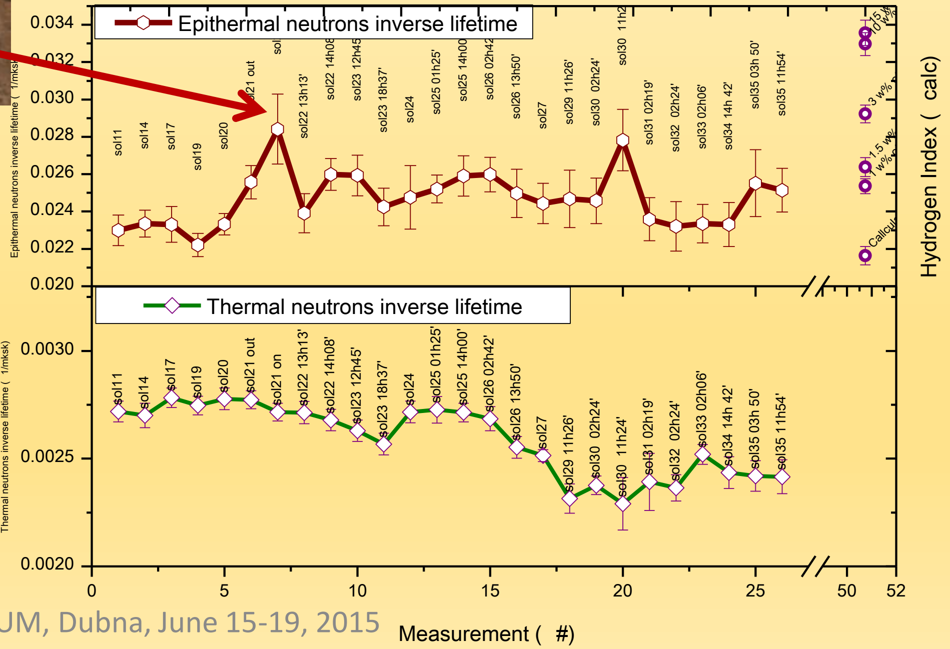
DAN Calibration Tests at JINR

Dynamic Albedo of Neutrons (DAN) Russian detector onboard of the Curiosity Rover: first data



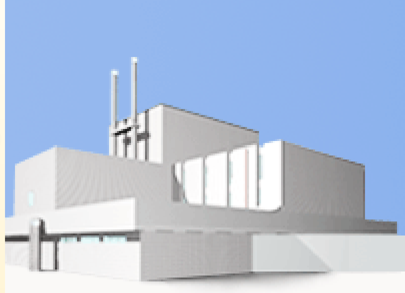


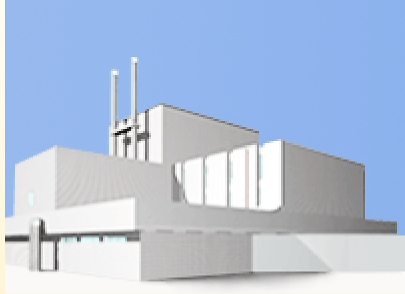
During Curiosity landing top layer of soil was blown aside and some kind of scour appears (few centimeters depth). During sol21 Curiosity moved over the scour and DAN registered slight difference in thermal neutrons fluxes above the scour and out of it



Epithermal and thermal neutron detectors die-away inverse times during first month of Curiosity operation

Test site for planetary soils modeling





Thank you for your attention and welcome to FLNP JINR

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