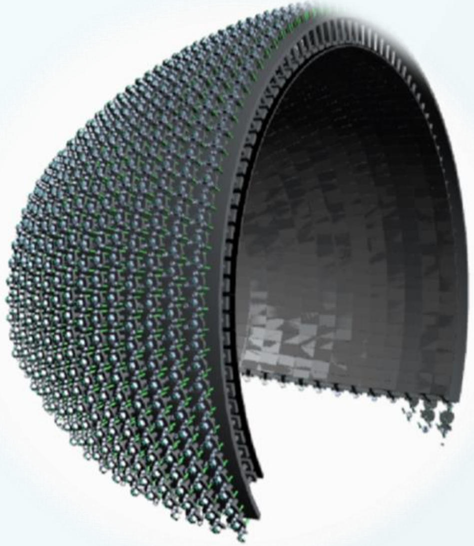
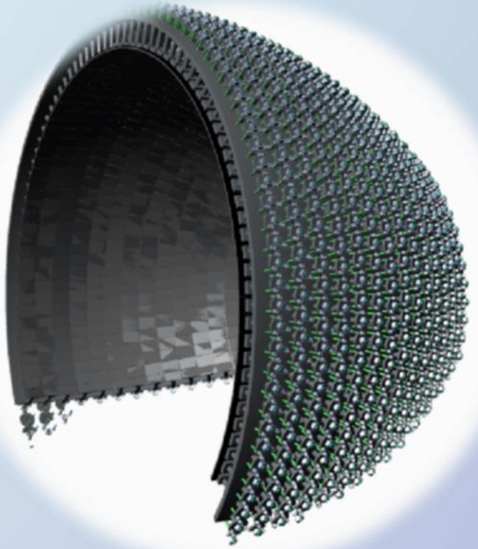
INS @ FLNP JINR



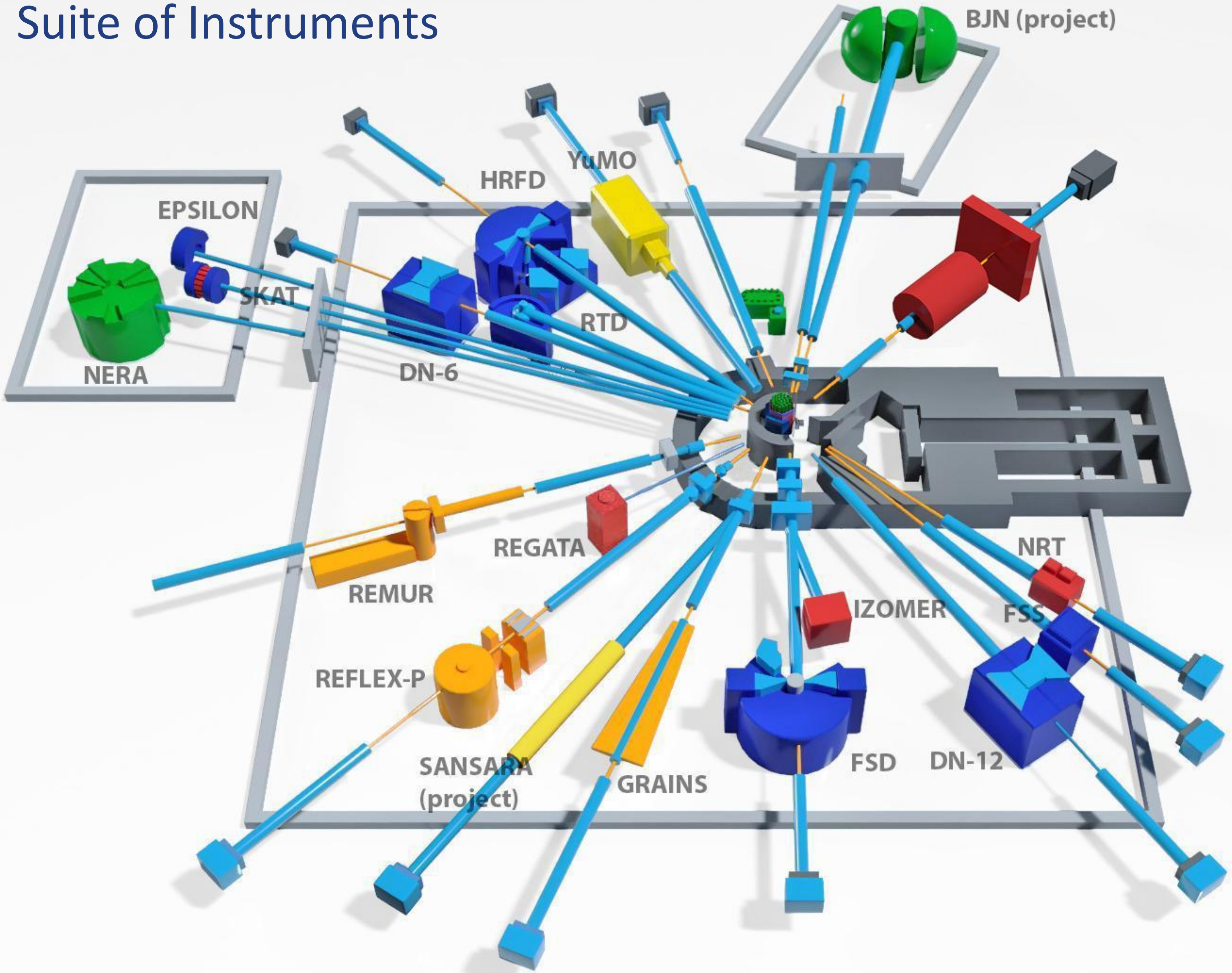
Dorota Chudoba

Frank Laboratory of Neutron Physics
International Intergovernmental Organization
Joint Institute for Nuclear Research
Dubna



FLNP JINR – CSNS IHEP, 13-15.05.2024

Suite of Instruments



FLNP User Program

Nanosystems and Soft Matter (YuMO, GRAINS, REFLEX, REMUR, SANSARA-project)

Atomic and Magnetic Structure (RTD, DN-6, DN-12, SKAT, EPSILON, FSD, HRFD)

Lattice and Molecular Dynamics (NERA, BJN-project)

Neutron Activation Analysis (REGATA)

What can we do with INS?

Magnetic dynamics of systems with strong electronic correlations

High-temperature superconductors / Quantum magnets, multi-ferroics / Compounds with Non Fermi liquid (NFL) behavior / Systems near the quantum critical point / Mixed valence, Kondo effect, heavy fermions

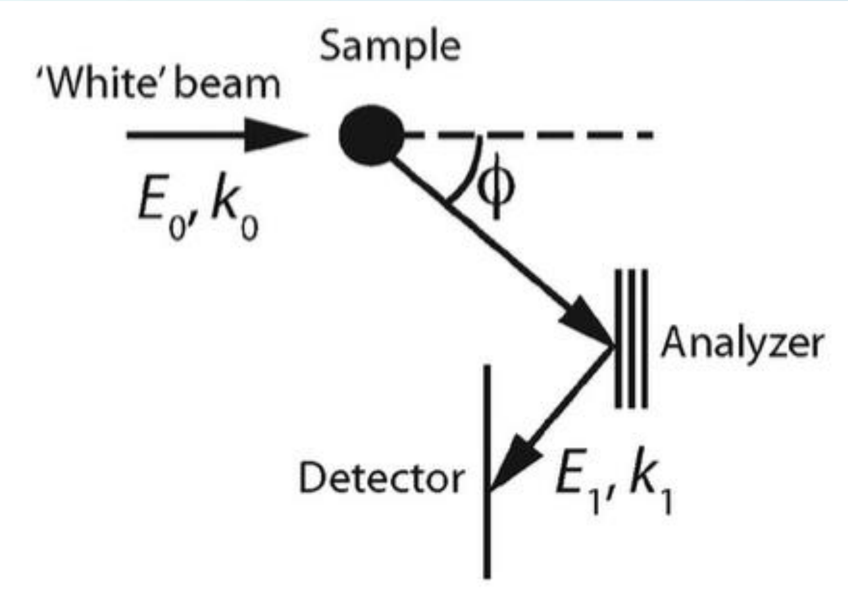
Phonons, Molecular dynamics

Dynamics of molecular systems such as metal-organic frameworks, molecular crystals, medicines- biologically active substances, metal-organic frameworks, crystalline oxide materials.

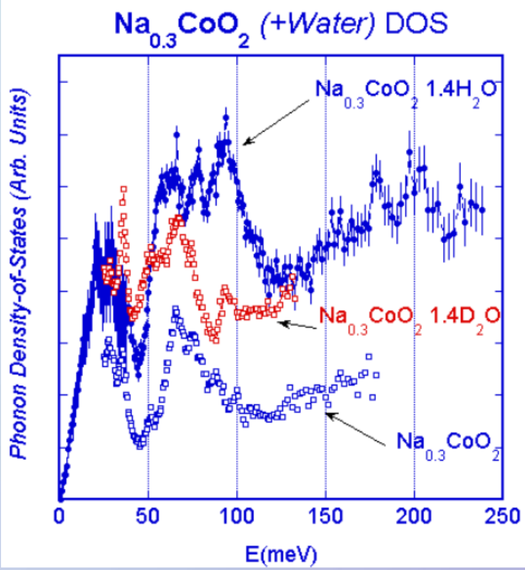
Unlike optical methods such as FTIR or Raman,
INS has no selection rules based on molecular symmetry,
meaning all overtones are observable.

The **Time-of-flight (TOF)** technique is a general method for determining the kinetic energy of a traveling neutron, by measuring the time it takes him to fly between two fixed points whose distance is known.

Indirect (inverted) geometry spectrometers:
in which the sample is illuminated by a white incident beam, the incident energy is determined at the sample position by the measurement of the time-of-flight, and the final energy is measured by a single crystal.



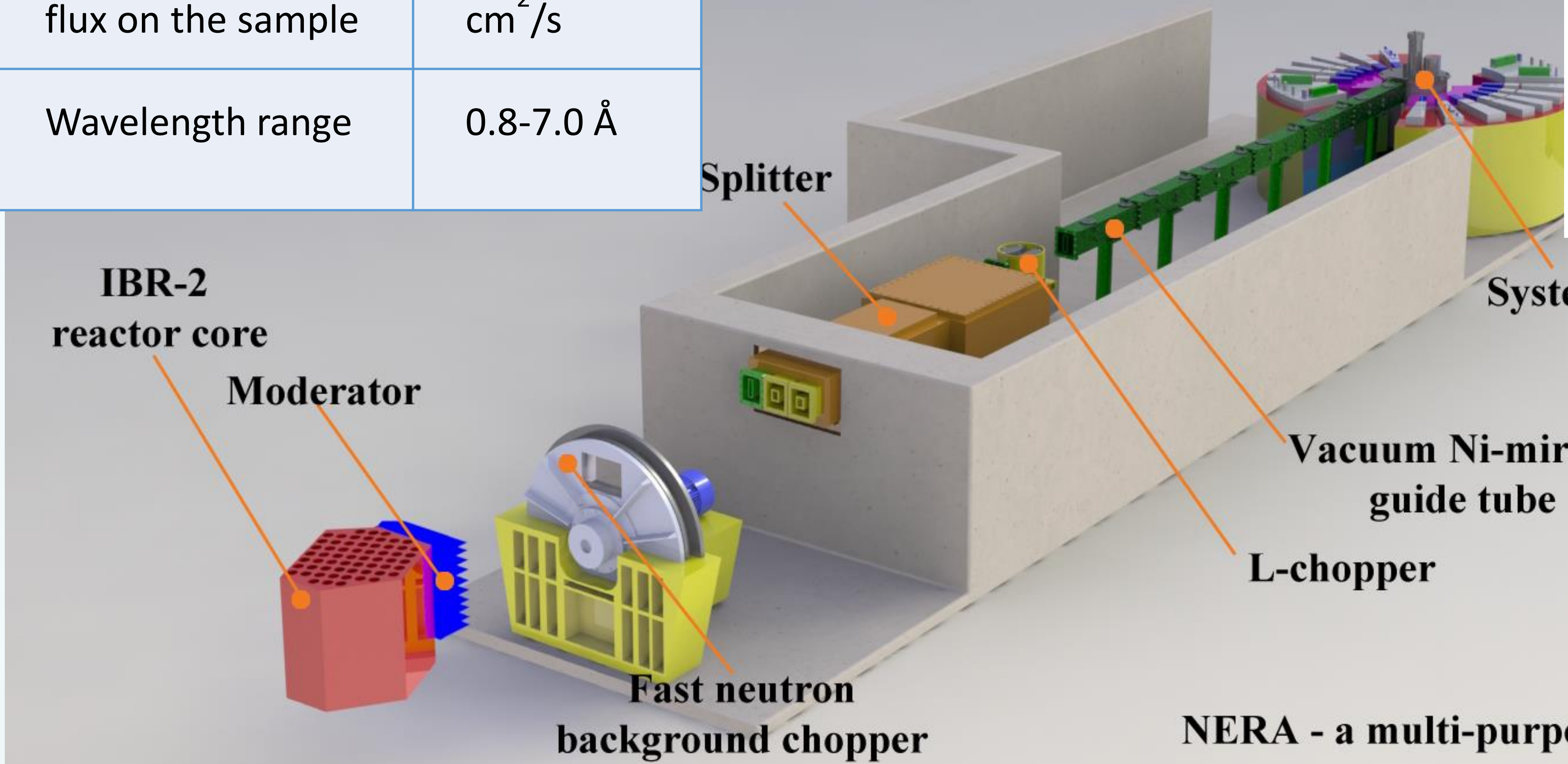
$$g(\omega) = \sum_{n,k} \delta(\omega - \omega_n(k))$$

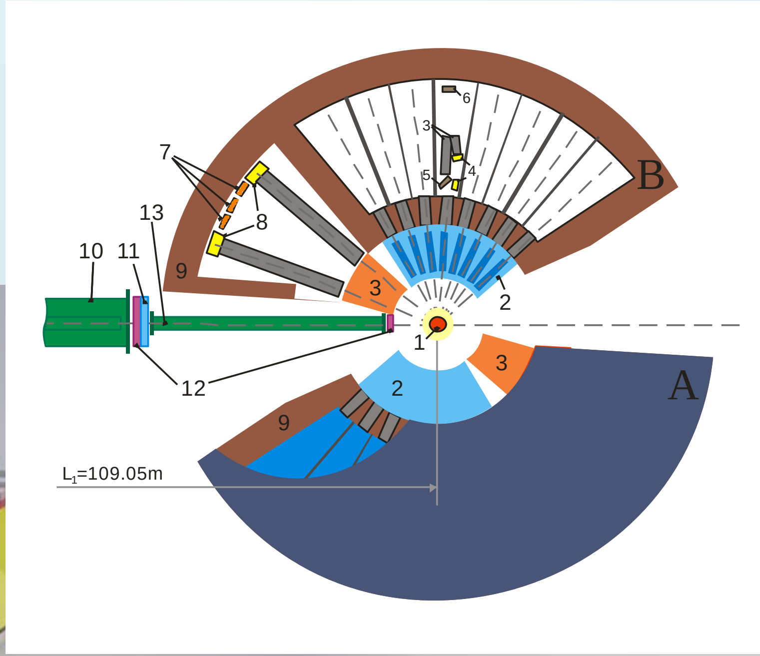


NERA - inverted (indirect) TOF geometry spectrometer:

the excitation energy scanned by E_i with a fixed E_f using filter technique

Thermal neutron flux on the sample	4.6×10^{6} n/cm^{2}/s
Wavelength range	0.8-7.0 Å

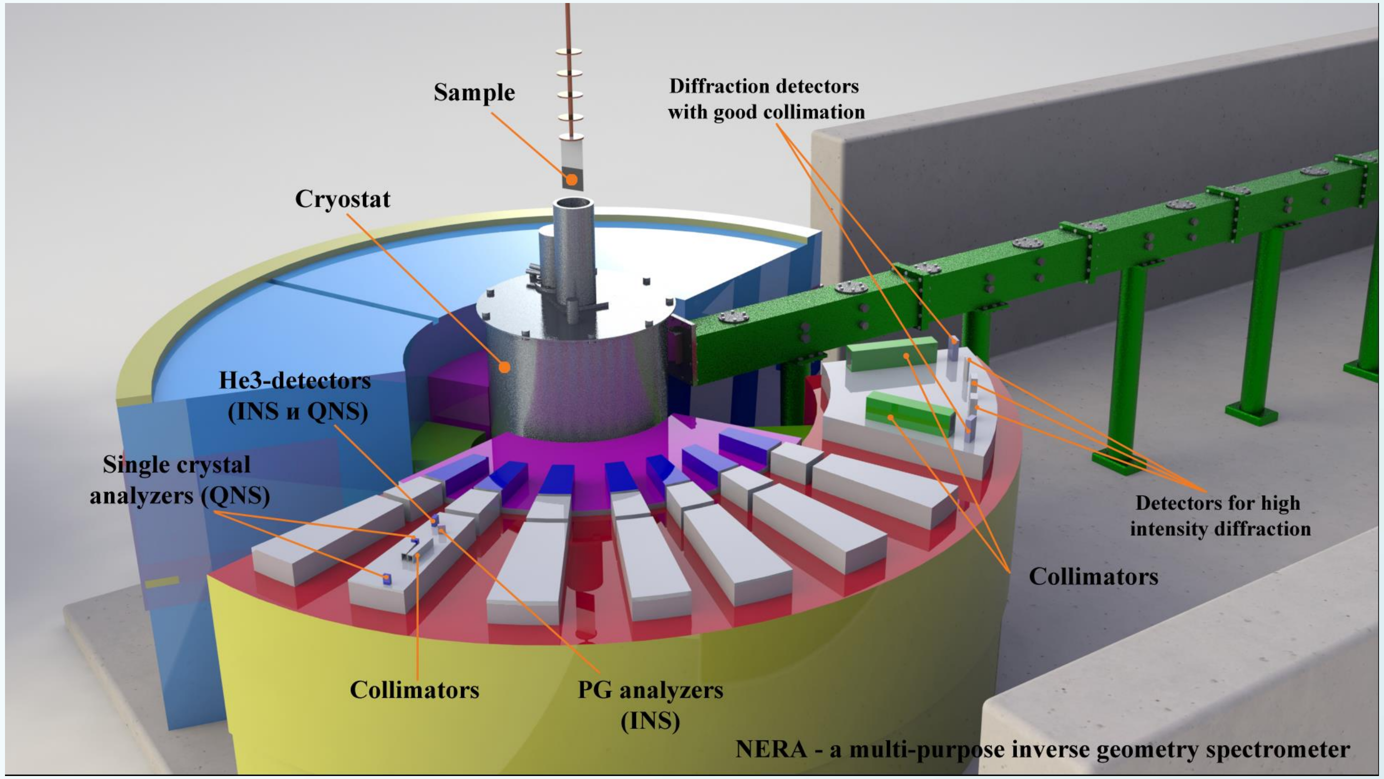


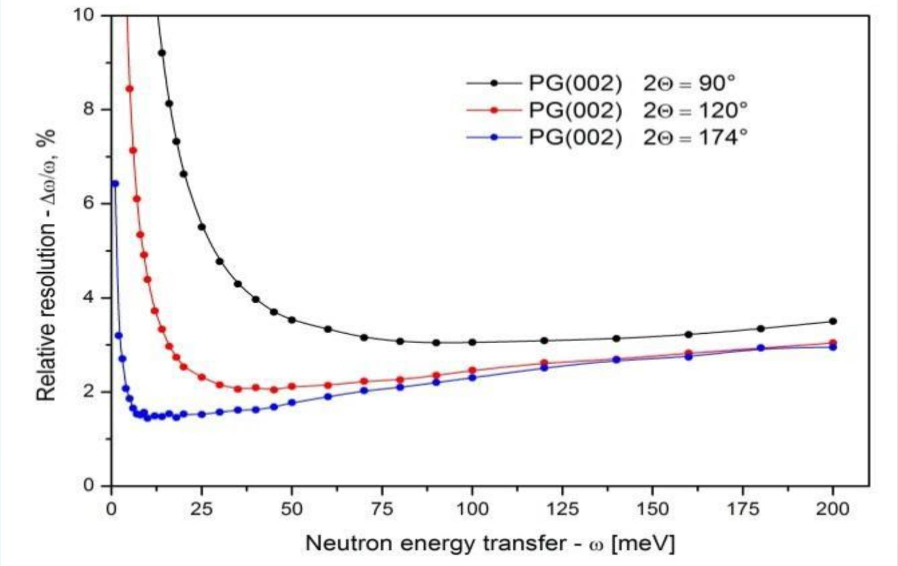


+ 25m parabolic vertically tapered supermirror guide

NERA - a multi-purpose inverse geometry spectrometer

INS TOF @ FLNP - NERA





- **low luminosity → large samples or long counting time**
- limited energy transfer range
- solid angle **0.2 sr**

INS TOF @ FLNP – NERA-->BJN

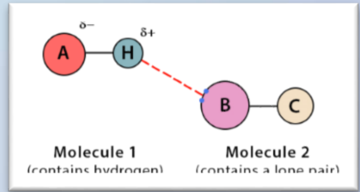
	NERA
pros	- quite wide energy transfer range - reasonable energy resolution - simultaneous ND and INS measurements
cons	- low luminosity and therefore need for large samples or long counting time

until 2022

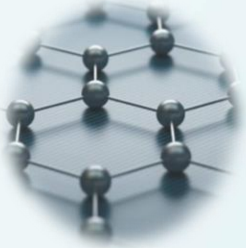
User Program:
slightly oversubscribed
Users from:
PL, RU, RO, DE, BU, RS

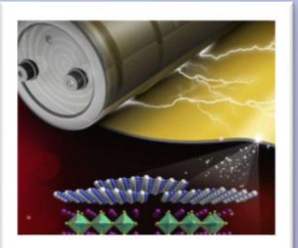
Scientific motivation

- **Hydrogen bonds in molecular matter (vibrational analysis)**



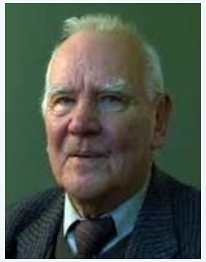
- **Dynamics studies of pharmaceutics (in bulk (native) state and as "micronized" or amorphized powders)**
- **Dynamics studies of liquid crystals**
- **Materials for energy storage, e.g. plasticizer-SPE systems for Li batteries**
- **Studies of soft matter**
- **Nanocomposite materials**



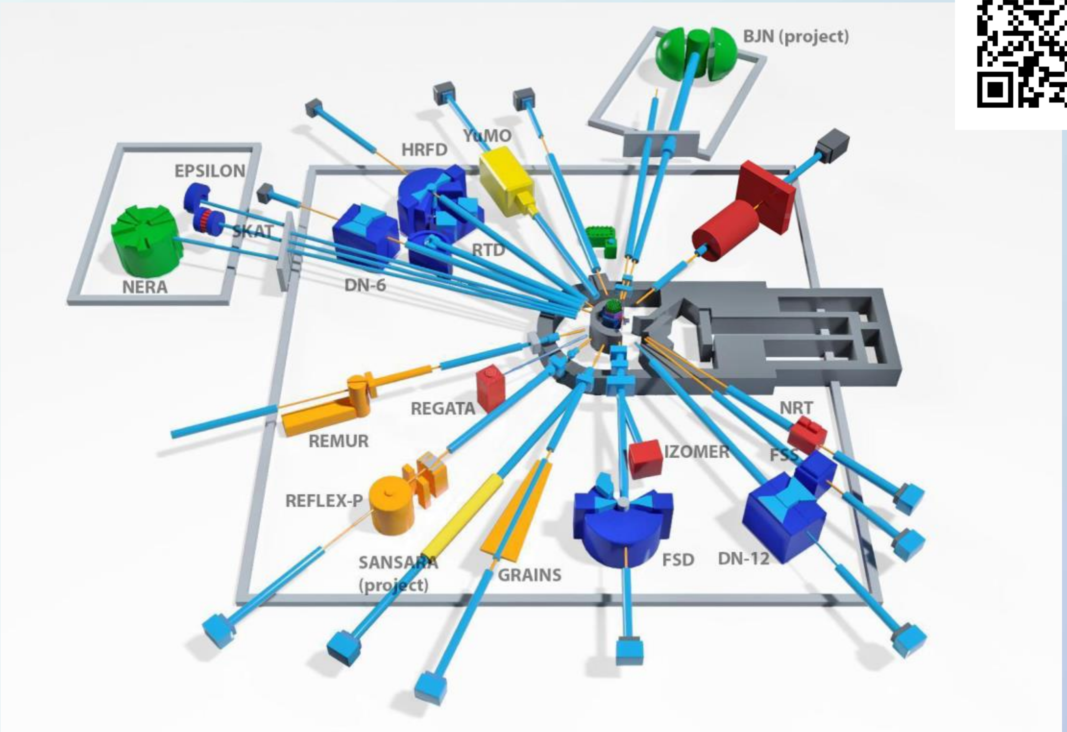


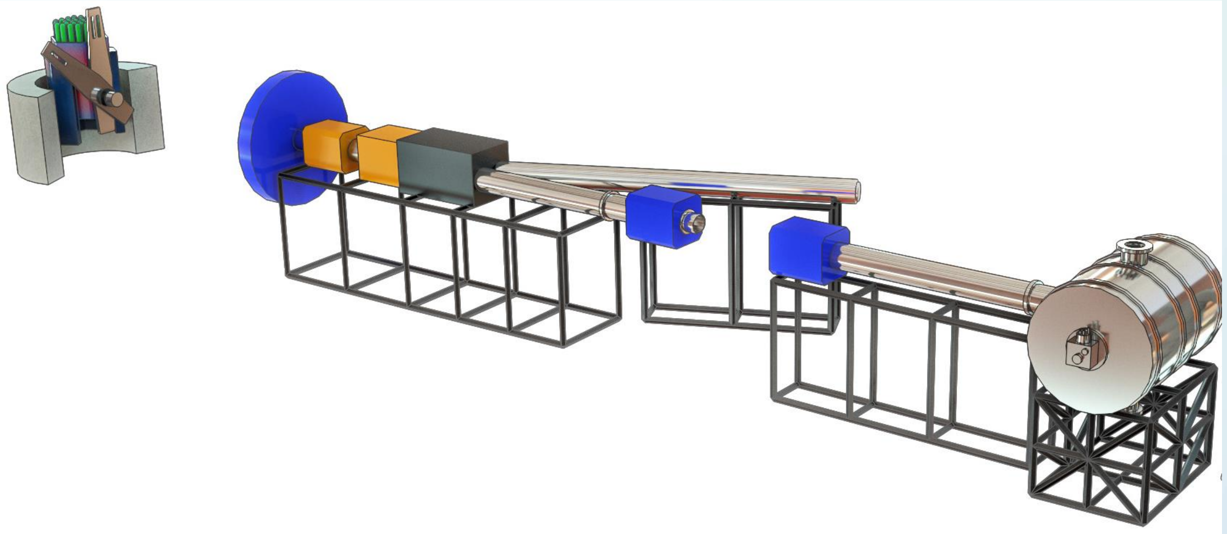
New inelastic neutron scattering spectrometer in inverse geometry

***BJN* (*B*ajorek-*J*anik-*N*atkaniec)**



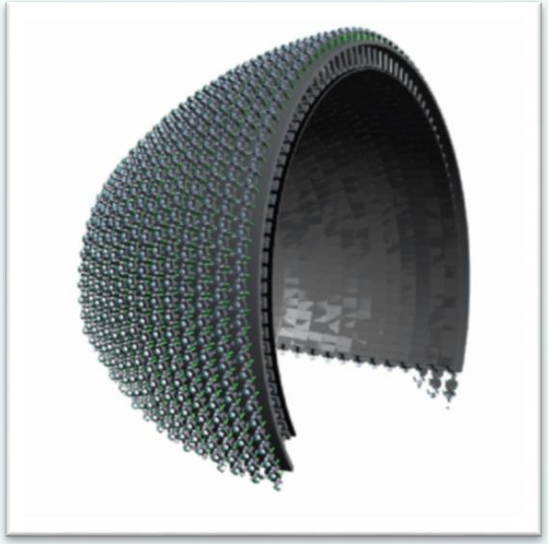
OPENNING of the PROJECT: January 2021

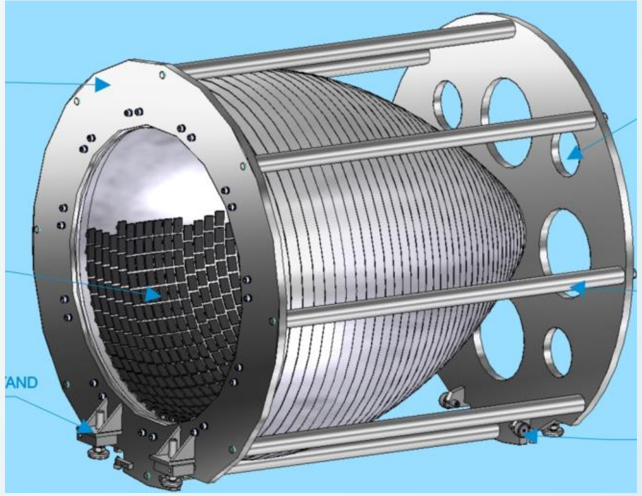


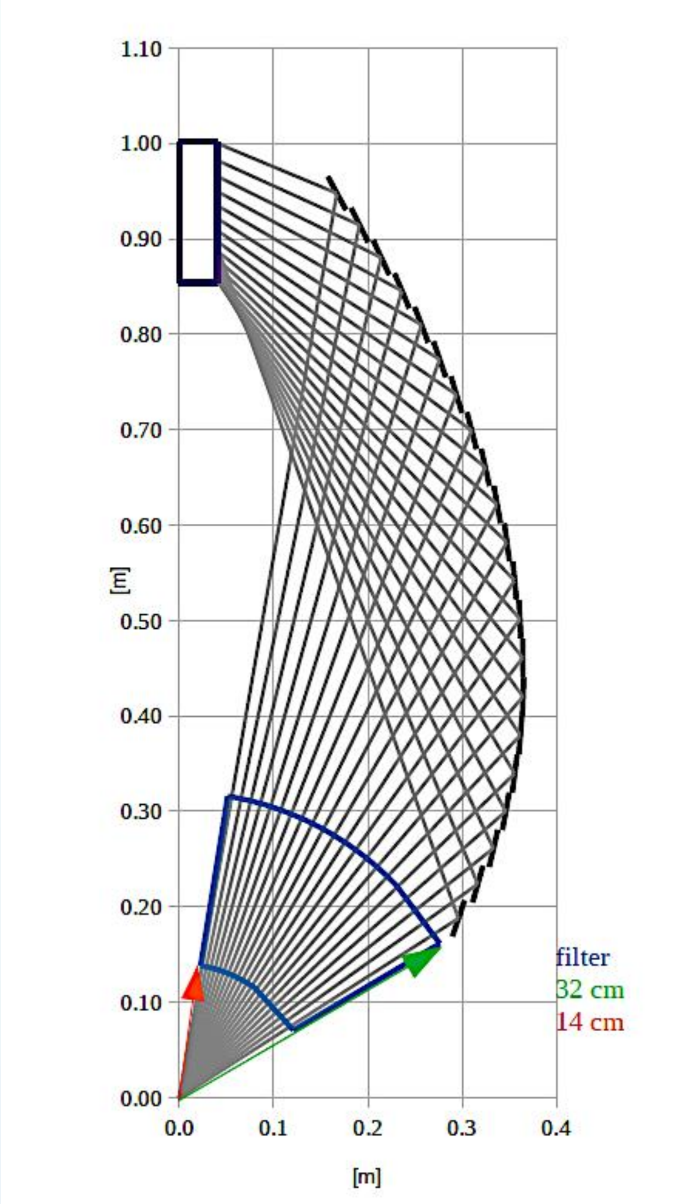


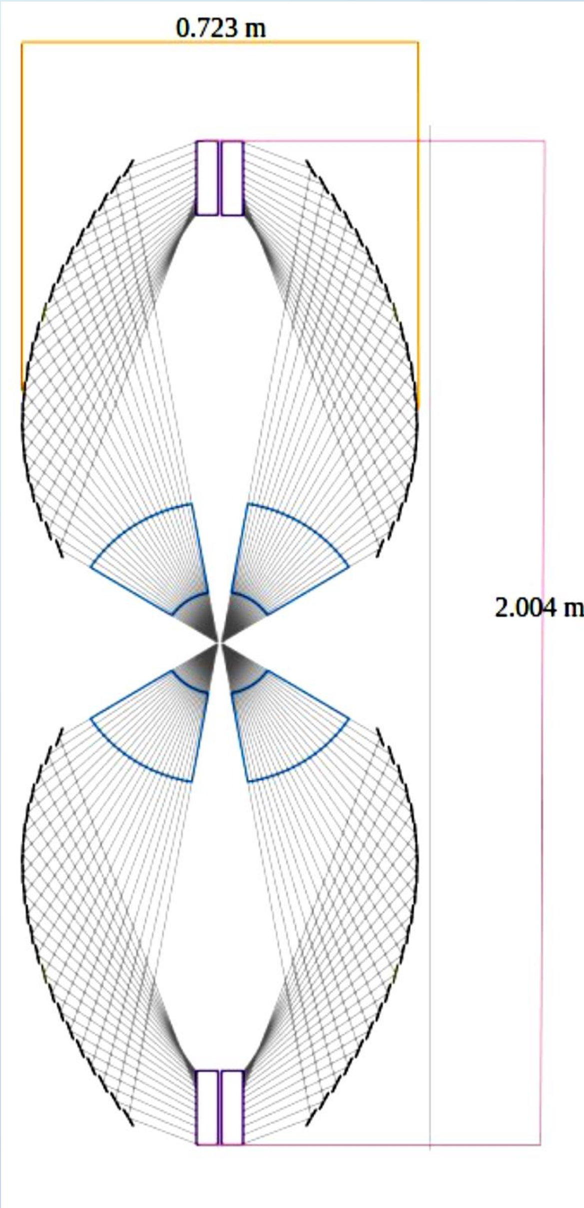
Based on the available space and needed time resolution and energy range the distance between the source and the sample of new spectrometer was chosen equal **105 m.**

The main concept for the secondary spectrometer is to place a set of **HOPG** (higly oriented pyrolytic graphite) analyser plates resembling together **a bell shape**, on both sides of sample.

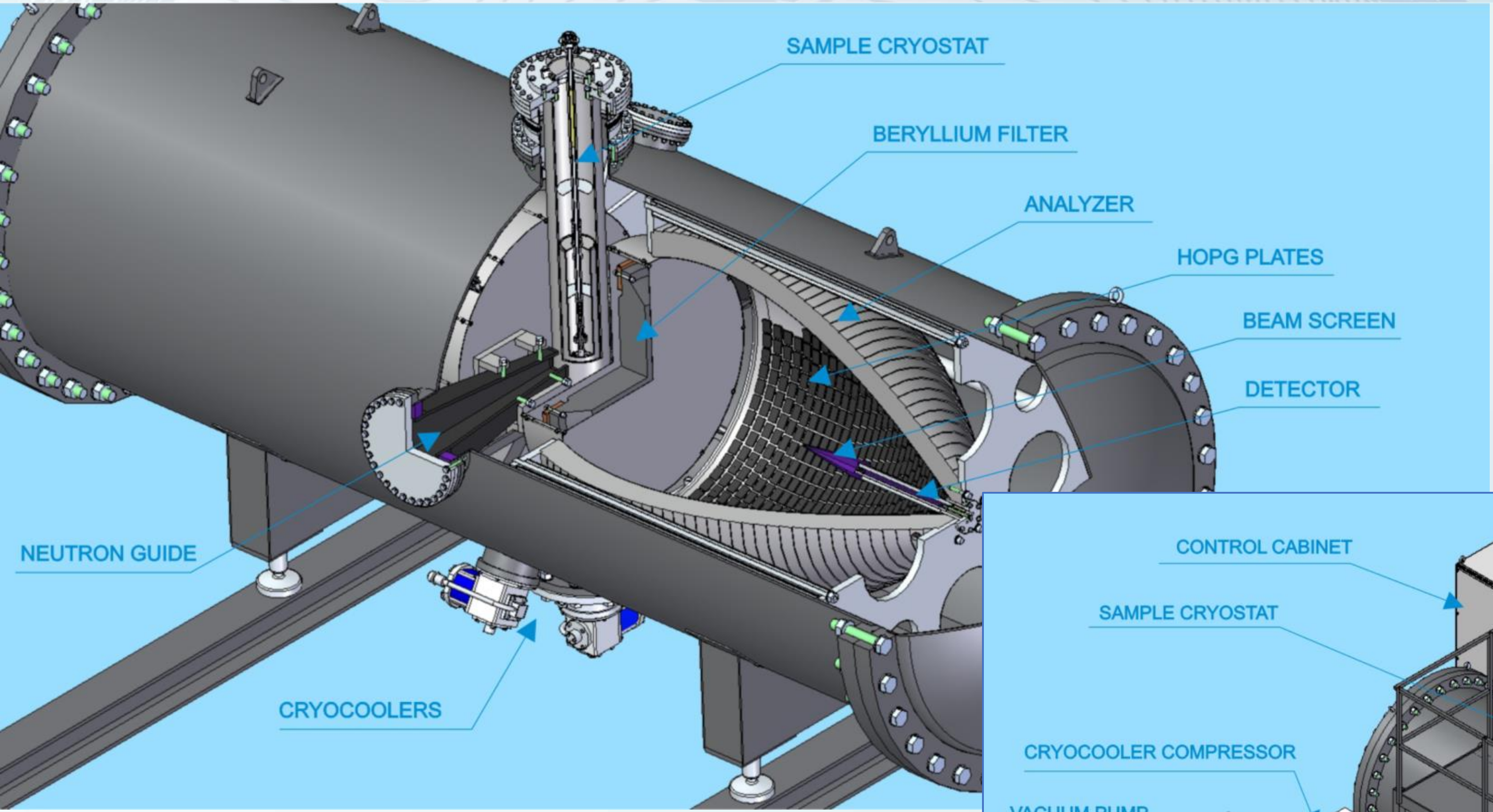


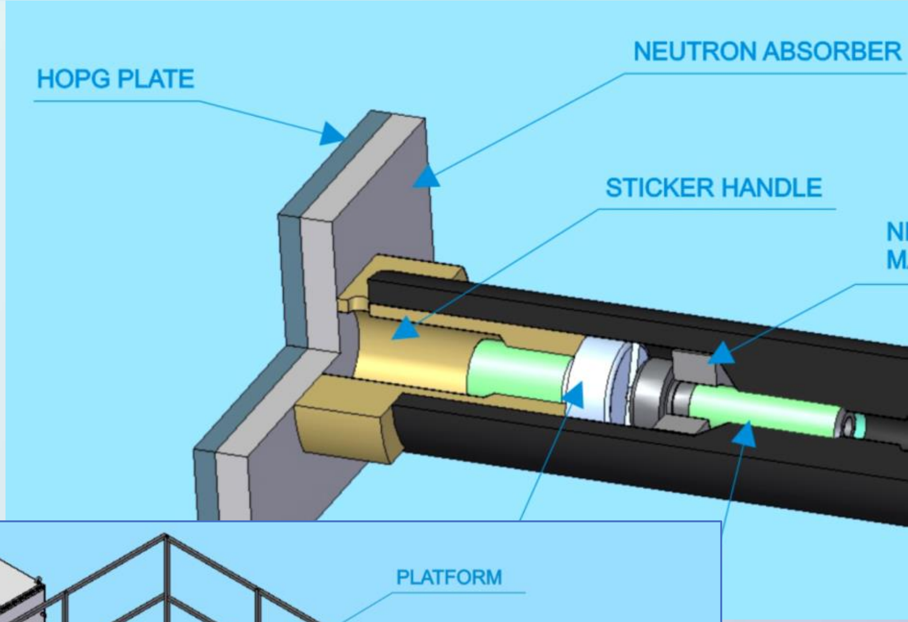


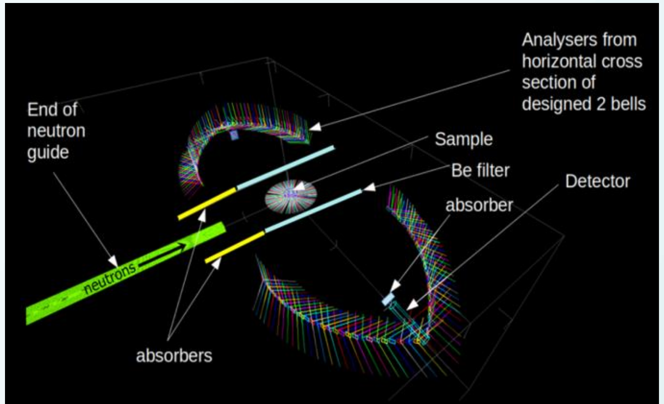


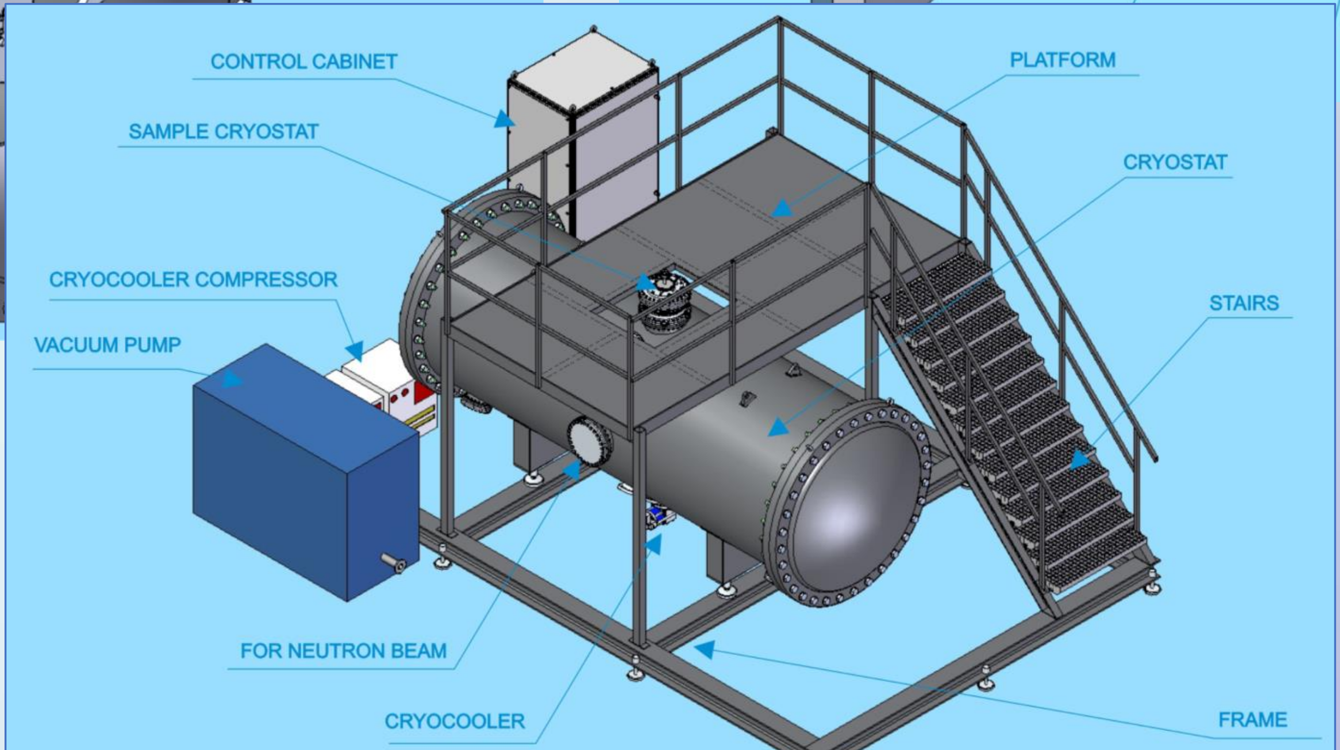


INS TOF @ FLNP – BJN



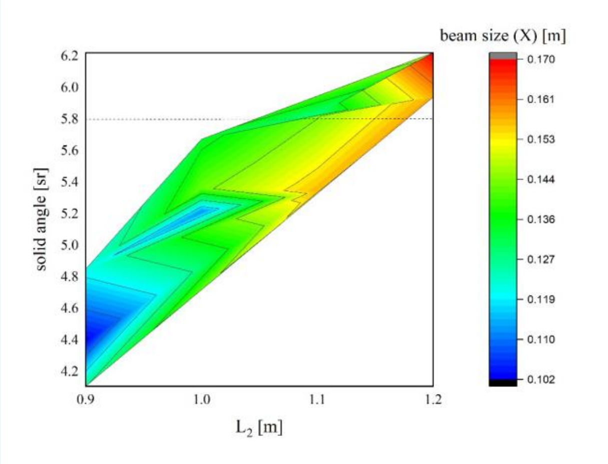


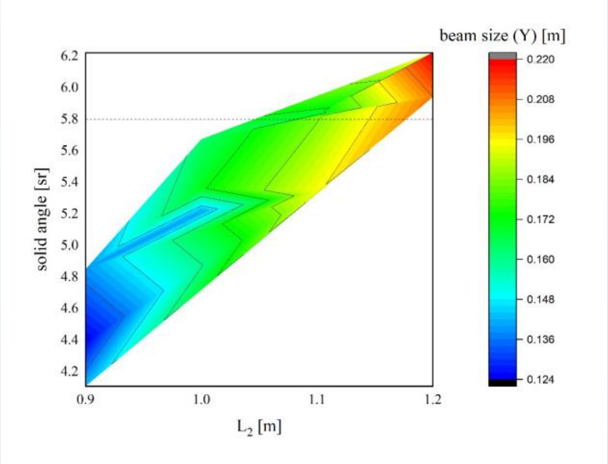




SIMULATIONS (McStass):

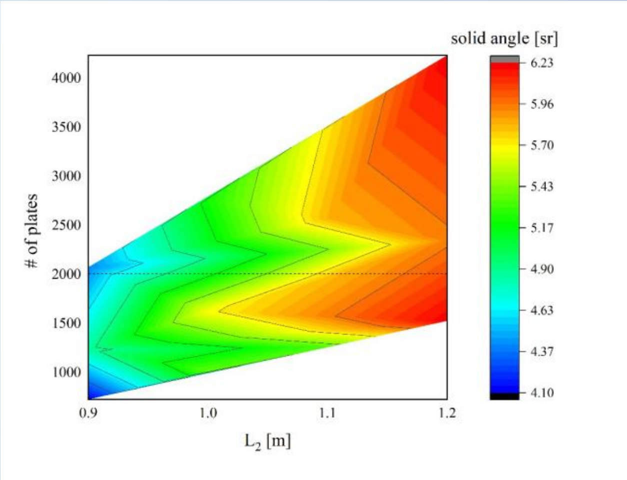
Size of the neutron beam at the detector position in depence with various neutron path lengths within the secondary spectrometer, each corresponding to a specific solid angle.





The dotted line - minimum accepted value of the solid angle.

The number of analyzer plates required to cover the inner surface of the secondary spectrometer construction varies with different values of L2, corresponding to specific solid angles.

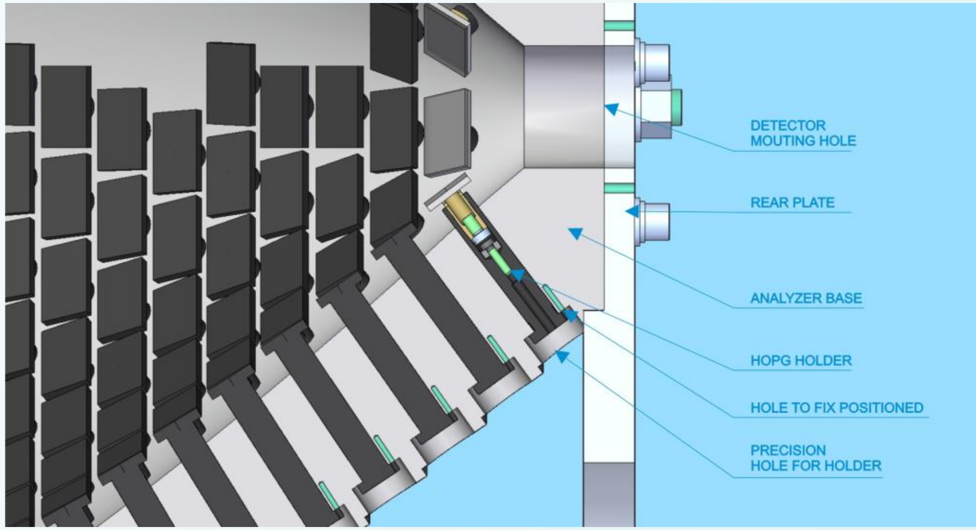


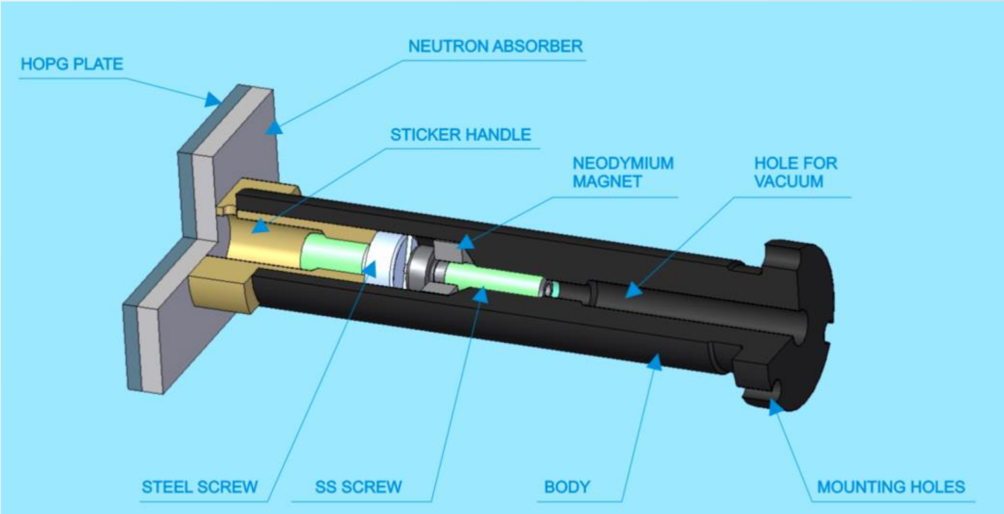
The maximum acceptable **number of plates – 2000 ps.**

Path length between sample and detector was fixed to **1.1 m.**

boron carbide & HOPG crystal system

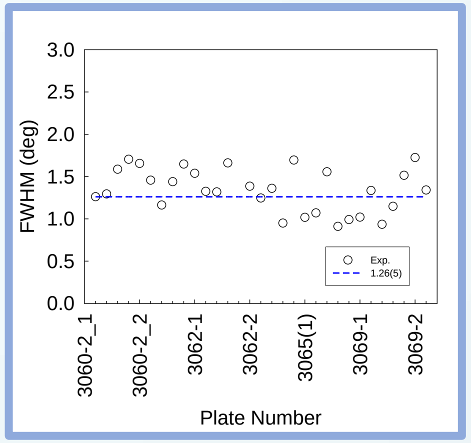
4cm x4cm x 1962



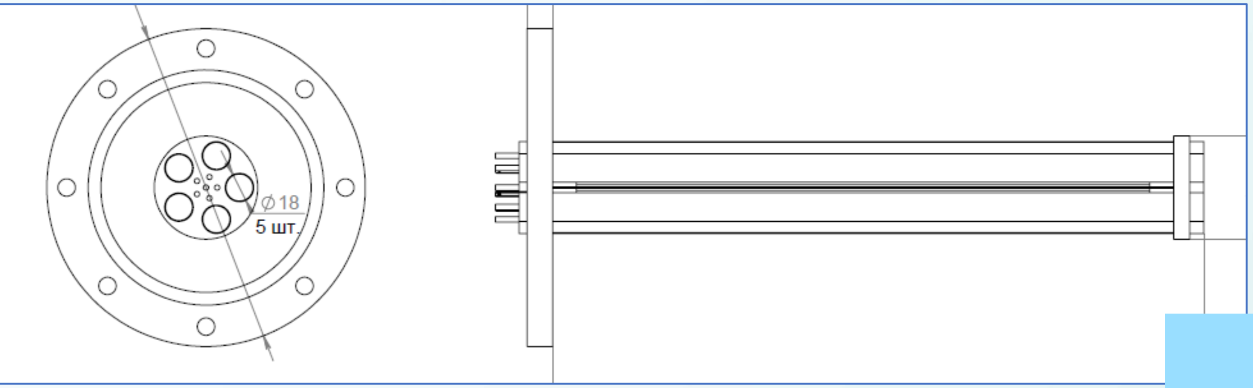


HOPG

B4C



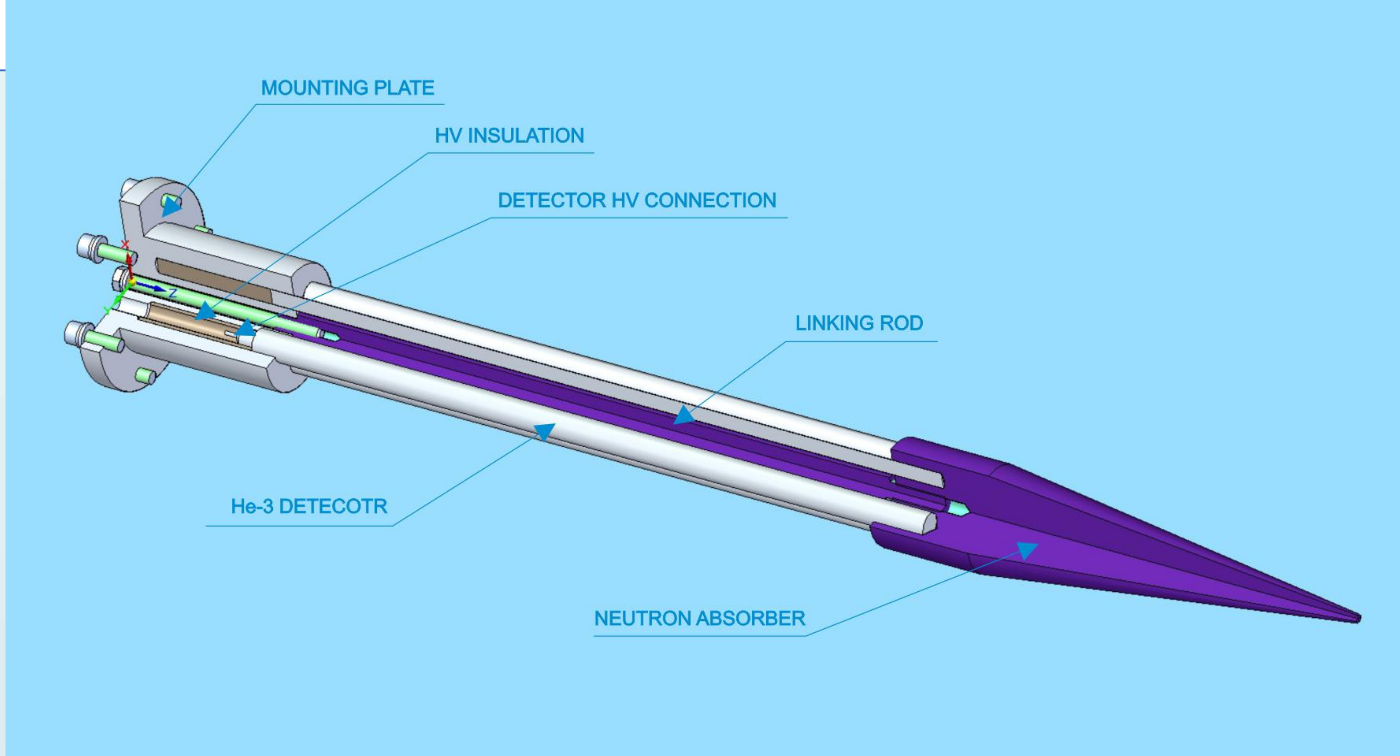
detector mounting systems

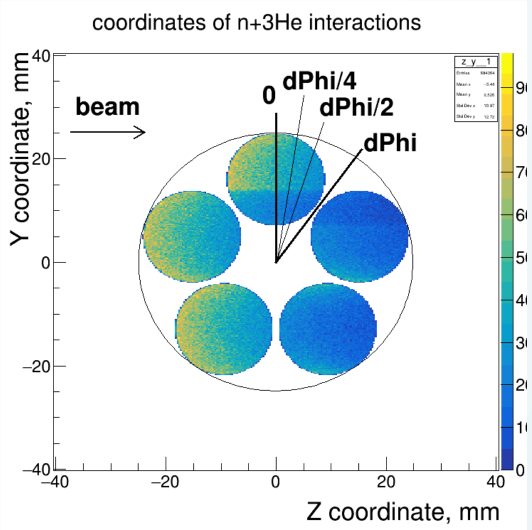


5 tubes of He^3 detectors for one bell

The counter wall thickness is 0.2 mm

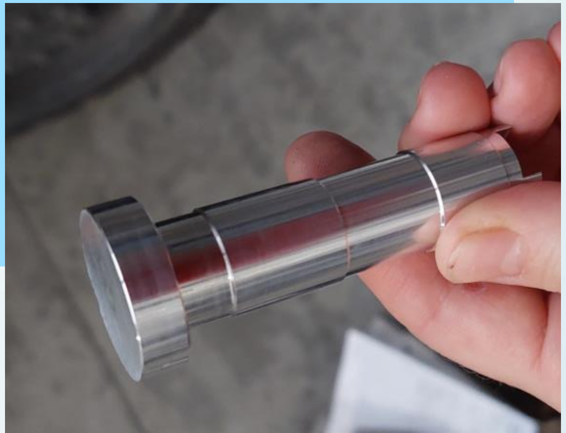
^{3}He pressure is 8 atm.



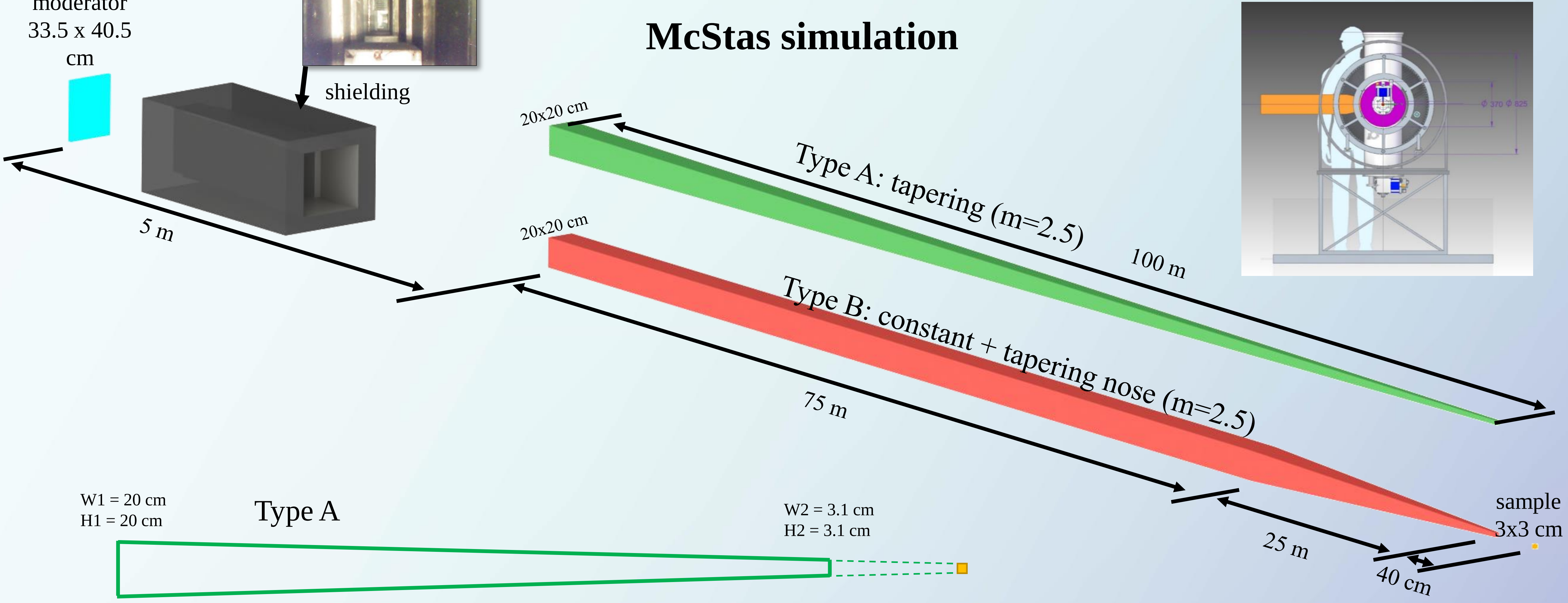


Assembly of cylindrical counters d≈18 mm (analogue of SNM-18).

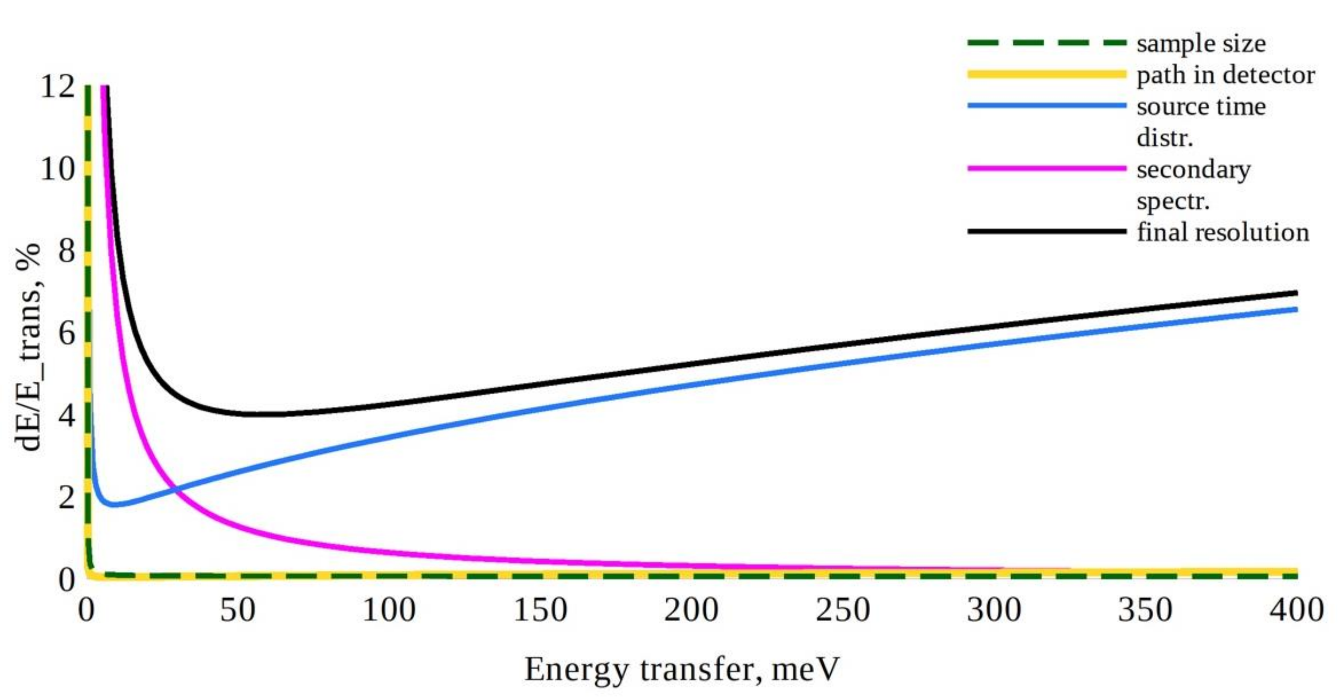
INS TOF @ FLNP – BJN



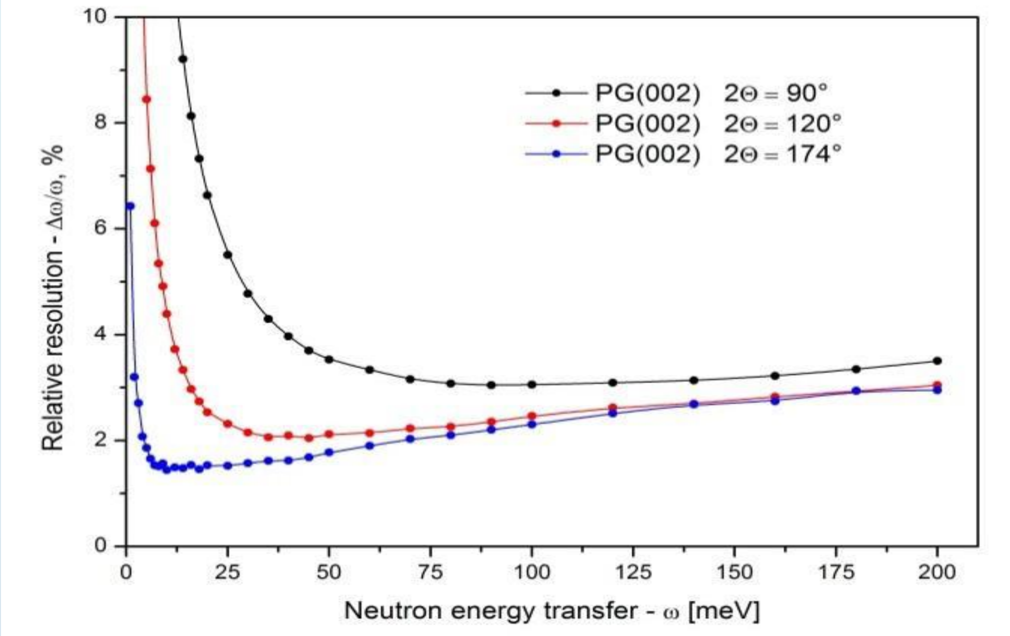
McStas simulation



Contributions to the final **resolution** of the BJN spectrometer



Resolution of the NERA spectrometer



INS TOF @ FLNP –NERA & BJN

	NERA	**BJN**	
Analyzer area	15x3X25 **1 125 cm^2**	4x4x1962 **31 392 cm^2**	**28 times** greater analyzer area
Energy transfer	**Below 160 meV**	**Up to 300 meV**	
Ratio input/output to neutronguides	$16x5cm^2/5x5cm^2$ **3.2**	$20x20cm^2$ / $3x3cm^2$ **44.44**	**a gain in flux density** (without taking into account the higher quality of the neutronguide) 44.44/3.2 = **14**
Solid angle	~ 0.2 sr	~ 5.64 sr	Solid angle gain **28**
Ratio of luminosity of new spectrometer and NERA			28x14 = **392** times higher i.e. **measurements** of a sample with the mass of **10-20 mg will be possible**.

- **Molecular dynamics of hydrogen-containing compounds, including pharmacological substances.**
- **Atomic dynamics and structure of condensed matter, in particular, the investigation of substances with phase polymorphism;**
- **Investigation of the magnetic and atomic dynamics of highly correlated systems.**
- …

Visit our User club: https://ibr-2.jinr.ru
Choose NERA ☺

Acknowledgments

A. BELUSHKIN
E. GOREMYCHKIN

M. KLEPACKA

A. CHURAKOV
V. SADILOV
A. CHERNIKOV
V. BODNARCHUK
D. KOZLENKO

A. KRUGLOV

W. KOZŁOWSKI
Ł. TOMKÓW
K. MALINOWSKI
I. DUBOWIK

P. KONIK

A. PETROVA
Y. KIRIENKO

A.IVANOV

J.KULDA

E. JUSZYŃSKA-GAŁĄZKA
W. ZAJĄC

Thank you for your attention!