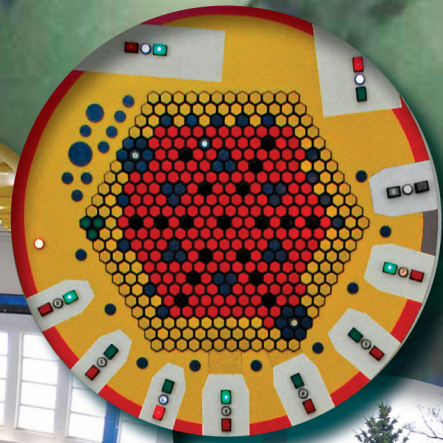


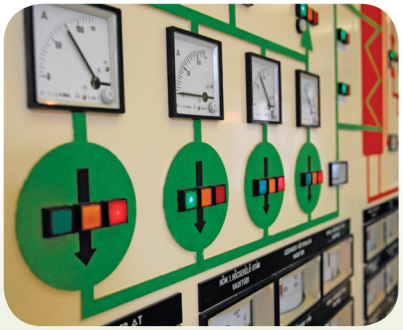
www.bnc.hu

BUDAPEST NEUTRON CENTRE

...for research, science and innovation in the heart of Europe!

BRR

The Budapest Research Reactor (BRR) is a water cooled and moderated type reactor. It went critical in 1959. After a full-scale reconstruction and upgrade which was finished in 1992, the reactor operates at 10 MW. In 2001 a cold-neutron source was installed and neutron guides were built. The 10 MW power corresponds to a



- Thermal flux of the core: 2.5×10^{14} n/cm^{2}s and
- Fast neutron flux: 1×10^{14} n/cm^{2}s in the core.

The reactor has eight radial and two tangential beam ports and nearly all of them are constantly in use. Altogether thirteen instruments serve everyday user needs in the reactor hall and in Guide Halls No. 1 and 2. At present two additional instruments are under installation.

During 2012 a core conversion program has been completed, the high enriched (36%) fuel was replaced with low (20%) enrichment fuel.

The BRR has been utilized as a neutron source for research and various industrial and medical applications. Irradiations are performed in vertical channels whereas physical experiments are carried out at the horizontal neutron beam ports.

BRR operates around 2800 hours per year until 2023.

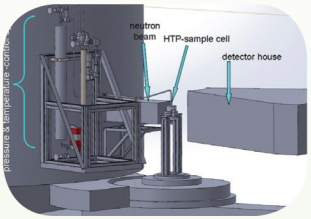
BNC

The scientific utilization of the research reactor is coordinated and managed by the Budapest Neutron Centre, which is a consortium founded by academic institutions in 1993. BNC is now a consortium of two research centres of the Hungarian Academy of Sciences – the Centre for Energy Research (MTA EK) and the Wigner Research Centre for Physics (MTA Wigner FK). BNC is legally represented by the Centre for Energy Research.

Under the guidance of the BNC, the thirteen facilities opened a possibility for BRR to be a regional centre. BNC participates in several EU supported programmes, such as NMI3 (Integrated Infrastructure Initiative for Neutron Scattering and Muon Spectroscopy), IPERION CH (Cultural heritage science), C-ERIC (Central European Research Infrastructure Consortium, SINE2020 (Science and Innovation with Neutrons in Europe in 2020) and CHANDA (Solving Challenges in Nuclear Data). In the frame of these programmes European scientists can get access to the BRR experimental facilities.

SOME DETAILS OF BNC'S FLAGSHIP INSTRUMENTS

PSD – Neutron diffractometer



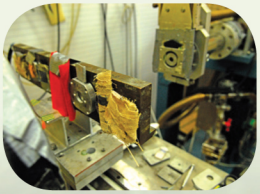
The instrument (a two-axis diffractometer equipped with a linear position sensitive detector system) is installed on a tangential thermal channel in the reactor hall with a neutron flux of 10^6 cm^{-2}s^{-1} at the sample position. The detector assembly on the diffractometer arm spans a scattering angle range of 25° at a given detector position. The entire diffractogram can be measured in five steps. The neutron diffractometer is most suitable for atomic structure investigations of amorphous materials, liquids and crystalline materials where the resolution requirements are moderate.

Under installation a new High Pressure and Temperature Cell (HTP-CELL) for in-situ measurements, to solve structure by direct method, in real time – in two mode:

TiZr cell: T_{max}: 450°C; p_{max}: 300 bar | (Ti 52.5% – Zr 47.5%, null matrix alloy) and | Sapphire cell: T_{max}: 950°C; p_{max}: 300 bar

SANS – Small Angle Neutron Scattering Diffractometer

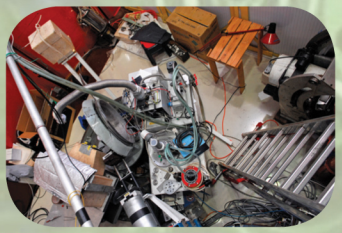
The SANS instrument of BNC, the "Yellow Submarine" covers a Q-range from 0.003 to 0.5 Å^{-1} probing structural length scales from 5 Å to 1400 Å. The instrument is installed on a curved supermirror neutron guide with a cross section of 4x4 cm^2. It has a wide range of applications from studies of defects and precipitates in materials, surfactant and colloid solutions, magnetic correlations, alloy segregation, polymers, proteins, biological membranes and even of ferromagnetic correlations in magnetic nanosystems.



In most of the experiments an automatic sample changer with 6 positions is used. It can be thermostated from an external bath between –10 and 100°C. A 11 position sample changer can be used for ambient temperature experiments. Liquid nitrogen cryostat, or closed cycle refrigerator can be used (from 10K-300K). Electromagnets can also be mounted on the sample table (field 1.4T in the gap 25mm).

MTEST – M(aterial)TEST neutron diffractometer

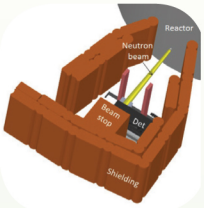
The M(aterial)TEST neutron diffractometer was originally designed for studying internal stresses in alloys. Recently has been upgraded by a position sensitive detector and by a monochromator changer; this way, a more efficient use of the available beamtime, with various sample environments, can be achieved. The instrument allows for performing total (Bragg and diffuse) scattering measurements on powder, liquid and amorphous materials. The four-circle goniometer maintains also the chance for texture measurements.

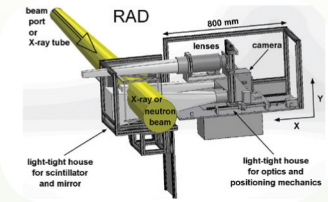


The diffractometer is installed on the 6th axial thermal channel of the reactor. The maximum flux can be obtained at a wavelength of 0.144 nm. A sapphire single crystal is used, deep inside the beam shutter, to filter out epithermal neutrons. The neutron flux at the sample table is $2*10^6$neutron/(cm^{2*}sec) at a wavelength of 0.133 nm.

RAD and NORMA - Imaging with neutrons and X-rays

THERMAL-NEUTRON AND X-RAY IMAGING (RAD)

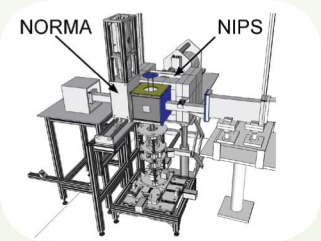




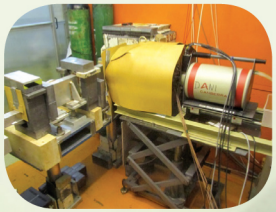
Neutron radiography detects the neutron transmission to obtain information about the structure and/or inner processes of a given object. The **RAD facility** with a pin-hole-type collimator is installed on a thermal radial channel in the reactor hall, with a thermal neutron flux: 3.38×10^{7} cm^{-2}s^{-1}. It gives a possibility to study objects needing a large field of view (up to 20 cm) and massive sample manipulator performing even two-modality (neutron and X-ray radiography and tomography) or real-time imaging. The spatial resolution is 100-500 μm and the exposure times are in the range of seconds.

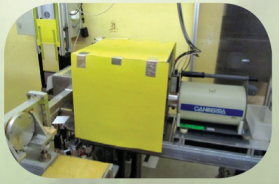
COLD-NEUTRON IMAGING (NORMA)

The Neutron Optics and Radiography for Material Analysis (NORMA) facility has been designed to make cold-neutron radiography and tomography of small objects (up to 4 cm), with or without position-sensitive elemental analysis by PGAI at NIPS. The spatial resolution of the imaging is 100-500 μm, with exposure times of 1-2 seconds. The acquisition time of a spectrum for elemental mapping is in the range of hours, giving a spatial resolution of about 3-5 mm.



PGAA, NIPS and NAA - Element analysis with neutrons





PGAA-NIPS

There are two facilities at the end of neutron guide No 1. for prompt-gamma activation analysis, i.e. non-destructive element analysis based on radiative neutron capture. The supermirror-guided neutron-beam is shaped into two sub-beams by suitable collimators to serve the two facilities with thermal-equivalent neutron fluxes of 7.5×10^{7} cm^{-2} s^{-1} and 2.3×10^{7} cm^{-2}s^{-1}, respectively. Beam sizes from 40×40 down to 5 mm^{2} are available. The photons are detected with Compton-suppressed HPGe detectors. Signals are processed with analog signal processing chains, or with fast digital acquisition modules.

The Prompt-gamma activation analysis (PGAA) and the Neutron-induced prompt gamma-ray spectroscopy (NIPS) facilities were designed for a variety of experiments involving nuclear-reaction induced prompt and delayed gamma radiations, e.g. routine element analysis, gamma-gamma-coincidences, large-sample PGAA, Prompt-Gamma Activation Imaging (PGAI). With PGAA, all chemical elements can be observed, with detection limits between 0.1 and 1000 ppm. Measurements on enriched isotopes can be performed for nuclear physics purposes. At the NIPS station, position-sensitive and radiography-driven PGAI can also be carried out.

NAA

For trace element analysis, an instrumental neutron activation analysis (NAA) laboratory is operational, forming an ideal combination with PGAA.

Guidance for proposals at Budapest Neutron Centre

The Budapest Neutron Centre offers its instruments to the national and international scientific user community through a peer-reviewed proposal system.
Beam time applications are welcome in the following fields of research:

- ✓ Structural analysis
- ✓ Inelastic neutron scattering
- ✓ Powder diffraction
- ✓ High resolution powder diffraction
- ✓ Small angle neutron scattering
- ✓ Neutron activation analysis
- ✓ Prompt-gamma activation analysis
- ✓ Neutron reflectometry with polarization option
- ✓ Neutron and X-Ray imaging

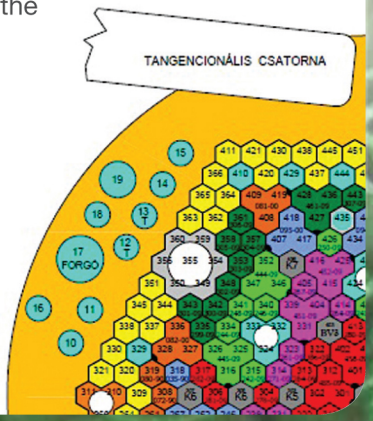
Before submitting a proposal for a specific instrument, please contact the appropriate instrument scientist to make sure your proposed experiment is feasible at that instrument. Information about the instruments offered in each call (2x) available on the website.
All proposals are evaluated by the international User Selection Panel (USP), assessing the feasibility, safety and the potential for high-impact science.

DEADLINES FOR PROPOSALS:

For September-January reactor cycles: 1 April, for February-June reactor cycles: 1 October.
To apply for beam time, please use the on-line proposal form or use the template available for download at **www.bnc.hu**. This is mandatory format, as it contains all information need to efficiently process your proposal.
Available instruments for general users

ATHOS: Triple-axis spectrometer on a cold neutron guide
BIO: Irradiation port for biological samples
PSD: Powder diffractometer with position sensitive detector
MTEST: Material test diffractometer with a four-circle cradle
TOF: Time-of-flight diffractometer
SANS: Small angle neutron scattering with xy-detection
NIPS: Neutron-induced prompt gamma spectrometer
PGAA: Prompt-gamma activation analysis
PREF: Polarised beam neutron reflectometer, mirror tester
GINA: Neutron reflectometer with polarization option
RAD: Thermal-neutron and X-ray imaging
NAA: Neutron activation analysis
NORMA: Imaging with cold neutrons

Still in installation phase at the time of printing:
FSANS: Focusing SANS instrument
IBMS: In-beam Mössbauer Spectometer



Contact us and submit your proposal!
For more information go to **www.bnc.hu** or contact the User Office **useroffice@bnc.hu**

CENTRAL EUROPEAN TRAINING SCHOOL ON NEUTRON SCATTERING (CETS) IN MAY, BUDAPEST

The school is the continuation of a very successful CETS school series of the last two decades. It gives insight into neutron research methods and applications for about 30 students and young scientists to study the structure, composition and dynamics of condensed matter. Theoretical training and practical work together with a poster section gives good opportunity for the participants to connect their own research with neutrons.

BNC USER MEETING IN NOVEMBER, BUDAPEST

The aim of this meeting is to bring together present and potential users to discuss recent scientific results utilizing BRR's neutrons. This meeting will emphasizes current and emerging research trends will influence the development of new neutron facilities. The UM is an unique event in every year where the users can meet the BNC staffs, can present the highlights of their results and learn about the new services and tools within the neutron centre.