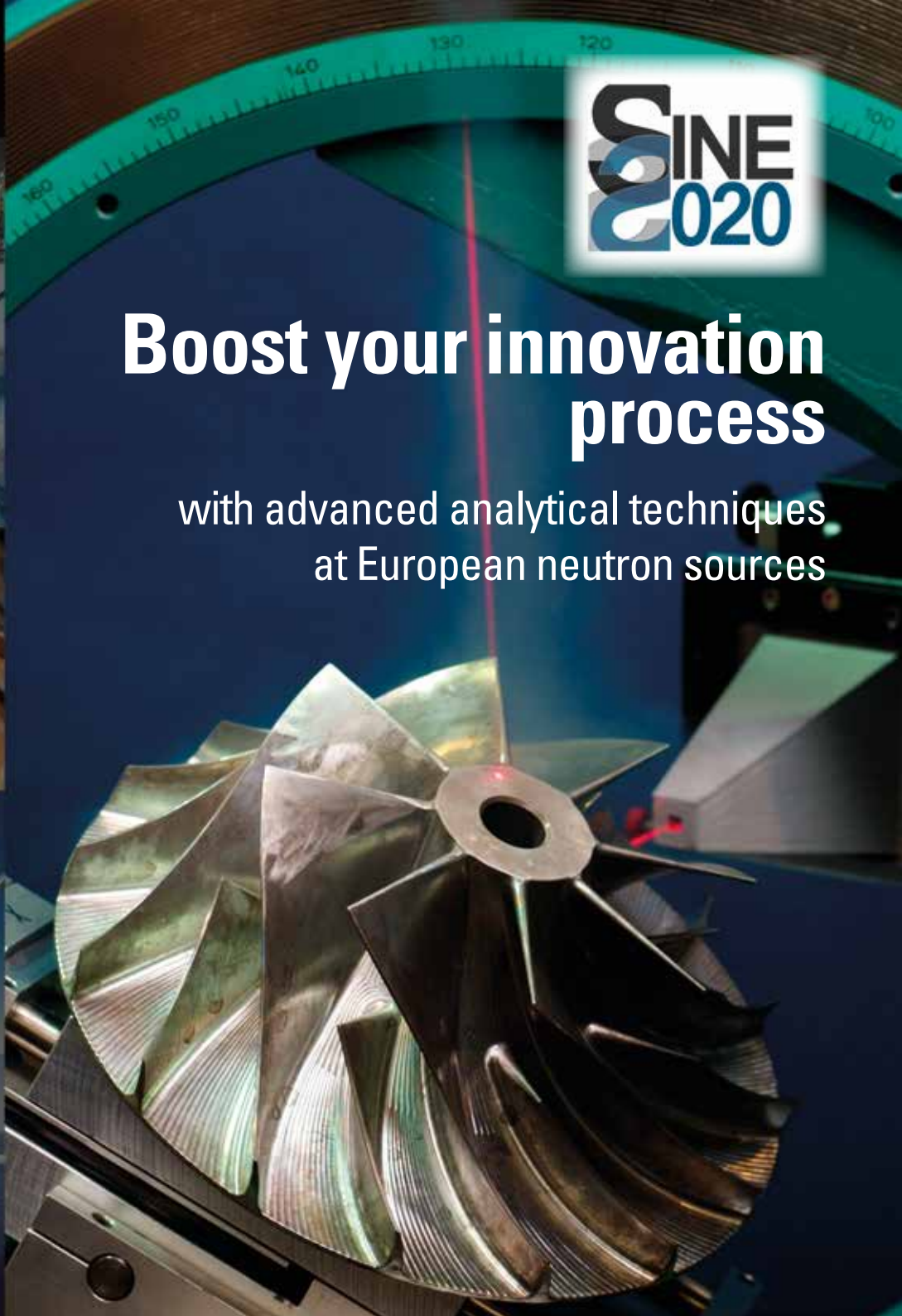




**SINE**  
**2020**

# Boost your innovation process

with advanced analytical techniques  
at European neutron sources

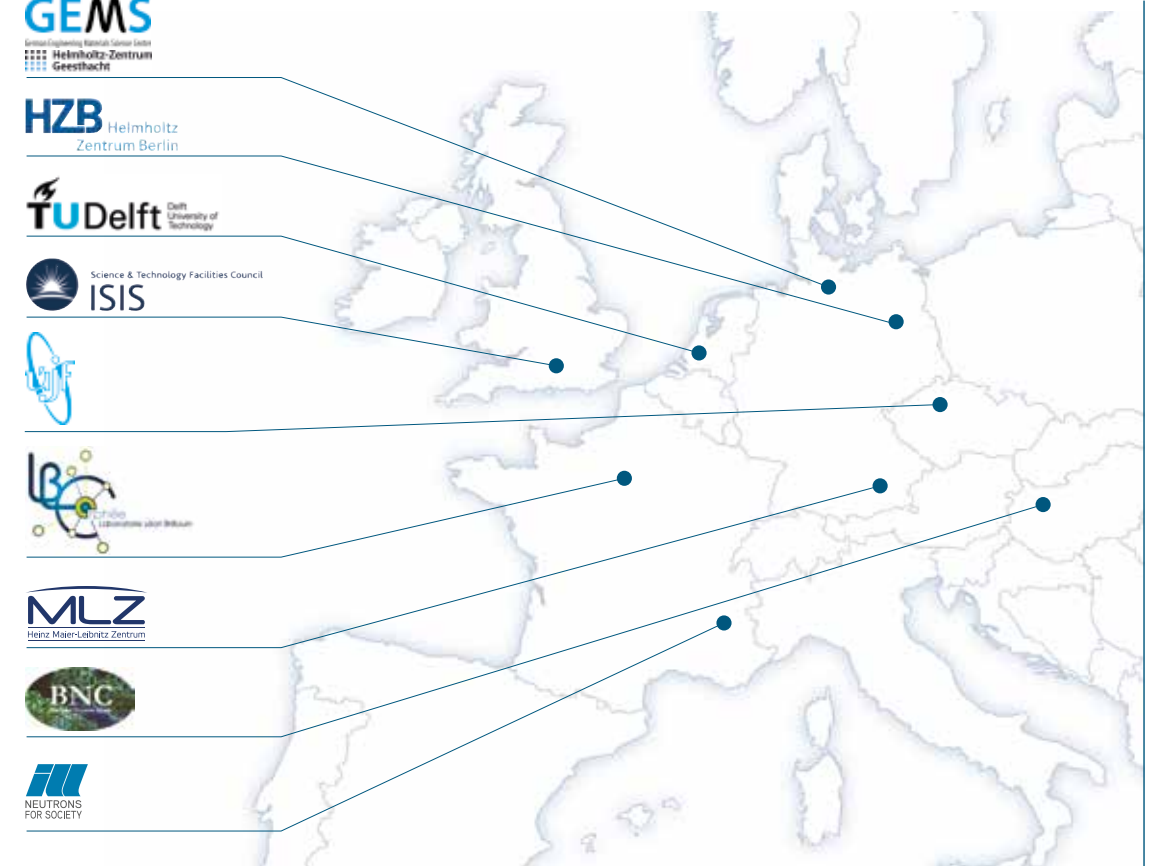


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**PARTNERS FROM:**  
Czech Republic,  
France,  
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**Mark Johnson**  
*Science Director, ILL*

The neutron was discovered in 1932 by James Chadwick. The use of neutrons to probe and understand matter and test scientific theory was developed through the second half of the 20<sup>th</sup> century, and neutrons have become a unique, major analytical tool in the scientist's toolbox. Neutrons underpin spectacular advances in materials that are at the heart of new technologies and, more generally, allow scientists to tackle the full range of societal challenges.

A major challenge for neutrons is that neutron beams are only available in central research facilities. Europe has the most powerful research reactor in the world at the Institut Laue-Langevin (Grenoble, France), and, at ISIS (Oxford, UK), the pioneer of neutron spallation sources. A new generation of spallation sources is now emerging, particularly in Europe with ESS (Lund, Sweden) – currently one of the largest European infrastructure projects. Large national facilities in France (LLB), Germany (FRM II and HZB) and Switzerland (PSI) and smaller facilities in the Netherlands (Delft), the Czech Republic (Prague) and Hungary (Budapest) complete the ecosystem of closely collaborating sources that sustains the vibrant, European neutron scattering community of almost 10000 users.

Compared to lab-based techniques, education and training in universities and industry in neutron-based research is much more limited. To meet this challenge, a high level of integration between facilities and the user community has been achieved through European-funded projects, culminating most recently in the 7<sup>th</sup> Framework Programme with the Neutron and Muon Infrastructure Integrating Initiatives - NMI3\*. These projects combine networking, joint research activities and trans-national access to national sources. In particular, NMI3-II explored existing and potential interaction between industry and neutron sources.

**SINE2020\*** is a 12 M€ infrastructure development project in the Horizon2020 Framework Programme which started in October 2015. It builds on inter-facility cooperation and some of the key components of NMI3\* projects, to prepare the European community for first neutrons at ESS in 2020 - a major goal of **SINE2020**. Data management is a clear focus of **SINE2020** since it underpins all scientific output. **Industry**, in particular, requires the quickest, most efficient production of scientific data and results - enhancing industry use of facilities is the second major goal of **SINE2020**.

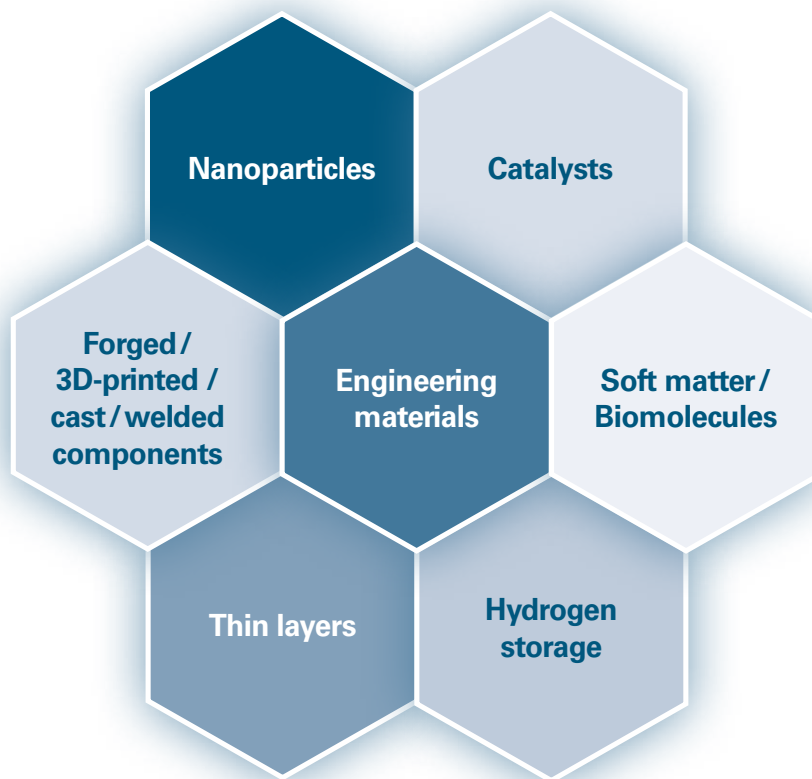
This goal will be addressed by the activities of the 1.7 M€ "Industry Consultancy" work package presented in the following pages.

\*See <http://sine2020.eu> and <http://nmi3.eu>

# Neutron techniques have already proved their worth for Industry

Neutron techniques have already proved their worth for Industry in the following areas:

- **Engineering materials:** bulk construction materials, magnetic materials, industrial metallurgy, glasses, etc.
- **Chemical engineering:** soft functional materials such as surfactants, polymers, foams, fibres.
- **Environment and energy:** hydrogen storage, fuel cells, CO2 sequestration, lithium batteries, biomass processing.
- **Microelectronics:** from ingots and wafers to on-board devices, nanomaterials, quantum computing and advanced data storage.
- **Life sciences,** with many examples in biotechnology and the agri-food industry.



*Have you ever needed to measure residual stress non-destructively, in the bulk of an engineering-size component?*

*Neutrons can easily penetrate several centimetres of metal.*





# Free test measurements and feasibility studies

**SINE2020's** Industry Consultancy programme demonstrates the potential of neutron technology to companies not yet familiar with neutron analytical techniques. As part of its drive to encourage industrial users to exploit the unique properties of neutron beams for R&D, **SINE2020** can arrange for test measurements and feasibility studies to be performed free of charge for European companies.

**SINE2020** takes a resolutely problem-oriented approach. An evaluation panel is appointed to assess the capacity of neutrons to address the case in point, identify the technique and facility most suited to the industrial user's requirements, and confirm feasibility. The service provided includes the design and planning of the experiment to be performed through to the measurement and data analysis phases.

No detailed knowledge of neutron techniques is required and a comprehensive report will be provided on the results.

## Proposal process



If you are interested, feel free to submit a short application to SINE2020 via the project website. Your application will be reviewed by a panel of scientists, often appointed as industry liaison officers, from the partner facilities.



***You want to know what's going on inside your fuel cell or hydrogen storage material?***

*Neutrons are perfect for locating hydrogen and water, even on devices in operation.*

## Scope of the service:

- **Test measurement:** Experimental measurement using well-established methods (e.g. powder diffraction, tomography) on a limited number of samples. The aim of the measurement is simply to demonstrate that variations between samples can be observed by the chosen technique.
- **Feasibility study:** Development or adaptation of an existing method to guarantee output for specific types of sample. The study should, above all, clarify feasibility on one sample. A few other samples may be included to demonstrate the capacity to observe differences between them.
- **Data analysis:** Provision of a final report on the experiment by the local experts, including clear and intelligible results.

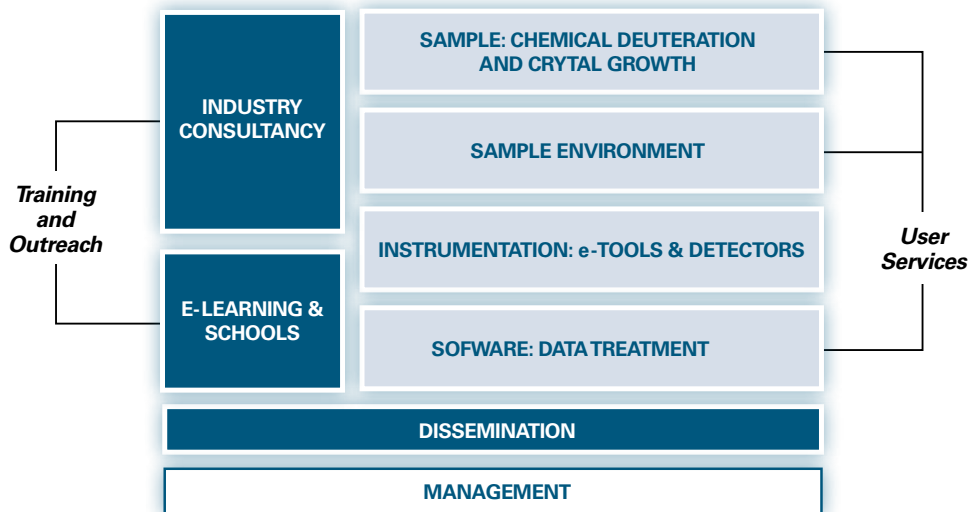


## SINE2020 - The project

New and improved services will be developed in SINE2020, by the large-scale facilities and partners, in an approach that includes outreach, samples, instrumentation and software.

- **Industry Consultancy:** This activity will strengthen links and relations between the facilities and the members of industry using them.
- **Training:** The e-learning platform E-Neutrons.org will be extended to provide students and scientists around the globe with a free tool to learn about neutron scattering. A selection of general introductory schools as well as more specialized courses will be financed each year.
- **User Services:** Improvements to the user services covering sample preparation (with a focus on chemical deuteration, crystal growth), sample environment and data treatment, based on standardization across facilities.
- **R&D Technology:** Cutting-edge instrumentation and detectors are pillars supporting the world-class science that users can perform at neutron centers.

## Organisation of the SINE2020 project



**Are you interested in the self-assembly of polymers into nano- or microscopic structures?**

*Small-angle neutron scattering can help determine the shape and size of particles in the nano and micrometer range.*

## SINE2020 - Industry Consultancy

The SINE2020 Industry Consultancy initiative is working to provide you with:

- **Information and Outreach:** ensuring that Industry remains fully informed of the latest neutron characterisation techniques via a European-scale information network.
- **Education and Training:** providing industrial researchers with sophisticated skills in the application of neutron-based techniques.
- **Access:** structured direct access to Europe's foremost neutron centres, through payment-free test measurements and feasibility studies; this includes technical support at the data-processing stage and tailoring the business model for continued future use (access, IP, regional legislation).



***Need to know more about the chemical processes in your catalyst or active substance?***

*Inelastic neutron scattering can determine the molecular structure within opaque, non-crystalline materials.*

***Are you investigating thin-layered systems?***

*Characterize your layers in the nanometer range with neutron reflectometry.*



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# The Facilities



## The Institut Laue-Langevin (ILL)

In Grenoble is an international research centre at the leading edge of neutron science and technology. The Institute operates the most intense reactor source in the world, supplying neutrons to a suite of 40 high-performance instruments which are constantly upgraded. Over 800 experiments are conducted annually in a variety of fields including condensed matter physics, nuclear physics, chemistry, biology, and materials science. ILL has a role to play in supporting industrial R&D in its quest for technological development. ILL's instruments are optimised to analyse your materials and samples in real time and in real conditions (temperature, pressure, stress, ageing, etc.). ILL is funded and managed by France, Germany and the United Kingdom, in partnership with 10 other European countries.

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## The Helmholtz-Zentrum Geesthacht (HZG)

Is specialised in coastal and materials research. The HZG's main materials research areas are advanced engineering materials, materials research with neutrons and synchrotron radiation, active biomaterials and regenerative medicine. The German Engineering Materials Science Center (GEMS) is its central user platform. As part of the Institute of Materials Research, HZG provides unique infrastructure worldwide for complementary research with photons and neutrons. GEMS runs instruments dedicated to materials science at the synchrotron DESY in Hamburg and at the FRM II neutron source in Garching near Munich.

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**How about pin-pointing the tiniest impurities in a silicon wafer material?**

*Neutron activation analysis provides non-destructive trace element analysis.*



## Delft University of Technology (TUD)

Hosts a 2 MW research reactor (Hoger Onderwijs Reactor), producing neutrons and positrons. It is one of the world's thirteen IAEA Collaborating Centres. The reactor is used for training and materials research in health and energy by the Radiation Science and Technology department (RST) and the Reactor Institute Delft (RID). Embedded in an academic environment, this centre plays an active role in knowledge dissemination, within the University by organizing the Master's course on Nuclear Science and Technology, and within the Netherlands by holding regular series of lectures. It contributes at international level to the organization of schools and conferences.

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### The Nuclear Physics Institute (NPI)

Is a member of the Academy of Sciences of the Czech Republic (ASCR), the leading public, non-university, fundamental research institution in the Czech Republic. NPI performs scientific research in nuclear physics, both theoretical and experimental, and in related fields such as solid state physics and trace elements detection. The beams of thermal neutrons produced by the LVR-15 nuclear reactor of NPI's neighbouring Nuclear Research Institute are also employed for materials research using neutron diffraction, for experiments in nuclear physics and for neutron activation analysis.



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### The UK Science and Technology Facilities Council (STFC)

Is the UK funding agency responsible for all large research infrastructures, both national facilities and subscriptions to international facilities. STFC operates the neutron and muon source ISIS at the Rutherford Appleton Laboratory, the only such source in Europe. ISIS provides neutron and muon beams for studies in a very diverse range of science areas ranging from clean energy and the environment, pharmaceuticals and health care, through to nanotechnology and materials engineering, catalysis and polymers, and on to fundamental studies of materials. It has dedicated programmes for industrial access, and is leading technological and computational developments for neutron scattering in many areas.



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### The Heinz Maier-Leibnitz Zentrum (MLZ)

Located in Garching, near Munich, Germany is a leading centre for cutting-edge research with neutrons and positrons. The MLZ is funded by the Bavarian State Ministry of Education, Science and the Arts, the German Federal Ministry of Education and Research and the partners of the cooperation (TUM, FZ-Jülich, HZG). Typical industrial applications comprise strain and stress determination in engineering materials or phase identification and composition of materials by neutron diffraction, radiography/tomography of objects (neutron imaging), identification and amount of many elements simultaneously even of very low concentration (prompt gamma and neutron activation analysis), irradiation of electronic devices (fast neutrons) and silicon doping (irradiation facility). In particular non-destructive in-situ and in-operando studies for example in batteries, high-temperature loaded materials or hydrogen storage materials or fuel cells benefit from using neutrons and are therefore in the focus of MLZ.



**Wondering what's going on inside that battery?**

*Neutron imaging and diffraction will give you the answers, in situ and in operando.*

# The Facilities



## The LLB (Laboratoire Léon Brillouin)

Is a major research infrastructure devoted to the study of condensed matter by thermal neutron scattering. It is part of the Fundamental Research Direction (DRF) of the French Alternative Energies and Atomic Energy Commission (CEA). The neutron beams at LLB are produced by the Orphée reactor, a recent (1980) medium-flux reactor, equipped with 19 instruments. Orphée operates around 120 days/year, and about 1/3 of the beam time is allocated to international teams, mainly European. LLB promotes research by industrial partners through various types of contracts (provision of beam time or expertise, or collaborative research). LLB-Orphée is located on the CEA site at Saclay and is a member of the new Paris-Saclay University which brings together all research institutions, engineering schools and universities in the area. Each year around 100 students come in the LLB to participate in schools or training sessions organised with French and foreign universities. The LLB is a joint research unit of the CEA and Centre National de la Recherche Scientifique (CNRS).

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## The Helmholtz Zentrum Berlin für Materialien und Energie GmbH (HZB)

Operates two of Berlin's largest research centres: the BERII neutron source and the BESSYII synchrotron. HZB is member of the German Helmholtz Association of national research institutes. The strategic emphasis of HZB is on materials and energy research, aiming at a better understanding and control of the function of matter and materials. HZB operates a successful international user program at both facilities, with more than 2000 visiting researchers each year. HZB has expertise in world-leading sample environment for complex experiments under extreme conditions, e.g. highest magnetic fields, lowest temperatures and high pressures. HZB is also open for applied research with industry, particularly in the field of solar energy research and x-ray optics.

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## The Budapest Neutron Centre (BNC)

BNC was formed in 1993 as a consortium of neutron-based laboratories of academic institutes to co-ordinate open access research activities at the Budapest Research Reactor (BRR). Today the Budapest Neutron Centre is an association of the Centre for Energy Research (CER) and the Wigner Research Centre for Physics (Wigner CRP) of the Hungarian Academy of Sciences. BNC offers open access to 15 neutron experimental stations for 150 days per year and runs a yearly neutron training school. The main role of the Budapest Neutron Centre is to operate the neutron research infrastructure and to provide services for the international user community through an international user programme. An important mission of BNC is also to provide opportunities for industrial users - pilot experiments and measurements, for example, are conducted for potential new applications, ensuring competitive results for companies' R&D.

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**You're interested in examining the assembly of ceramic and metallic parts, or visualising a fluid within a metallic part?**

*Neutron imaging is the method you need.*



***Do you need to observe  
your sample under a load  
at high temperatures?***

*Neutron centres can  
provide sophisticated  
sample environment  
facilities.*



# Contact

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[www.sine2020.eu/industry](http://www.sine2020.eu/industry)  
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