A successful European collaboration for science

The contribution of the Neutron and Muon consortium to science 2012-2016

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This brochure is interactive. Please click on the links skip provided to know more.

(Video-) Editorial

Mark Johnson, coordinator of NMI3-II, tells us how NMI3 contributes to advancing science. In the following video he gives an overview of all the project's activities and stresses how each of them is relevant to the European scientific community.

Click to watch the video.

NMI3 in a Nutshell

NMI3: The Integrated Infrastructure Initiative for Neutron Scattering and Muon Spectroscopy

- 18 partners from 12 countries
- Four years of NMI3-II: 2012 – 2016
- Total budget: EUR 15,9 million (EU contribution: EUR 13,3 million)

NMI3-II supported achievements on three fronts:

Transnational Access Programme

- 2300 experiments, representing a total of 5000 days, were eligible for funding.
- Financially supported 40 % of transnational access of European scientists.

Joint Research Activities

- Collaborative development of new techniques, instruments, and methods to improve. the service at neutron and muon centres for visiting scientists.

Networking and dissemination

- Education: 15 supported schools, e-learning platform now available at e-neutrons.org
- Dissemination: nmi3.eu training (to read training schools), e-newsletter, Neutronsources.org, Muonsources.org, external websites reaching over 3000 visitors each month
- Integrated User Access: harmonized access via common procedures among facilities
- Data Analysis standards for neutron experiments

Fostering innovation in Europe:

- Events to improve interaction and collaboration between research facilities and industry

This project has received funding from the European Union's 7th Framework Programme for research, technological development and demonstration under the NMI3-II Grant number 283883.

A project to respond to Europe's Scientific Challenges

1. **Advanced solutions to the challenges that confront our technology-based society**
From energy and environment to health, progress and breakthroughs are crucially dependent on advanced knowledge of material properties down to the atomic scale. Neutron scattering and muon spectroscopy offer unique analytical tools for material investigation.

2. **Facilitating integration of Europe's large research infrastructures for efficient use of resources**
Research infrastructures providing neutrons and muons are used by academia, industry, museums, and others. NMI3 aimed at pan-European integration between facilities in different countries and their users coming from different backgrounds. This effort rendered public investment more effi cient by harmonizing and reinforcing the services provided, and thus maintaining Europe's leading position.

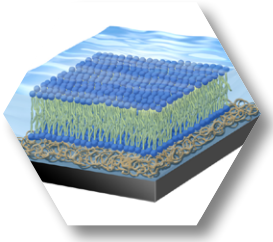
3. **Increased capacity and mobility for European users**
Transnational, free access to research facilities was offered to scientists to conduct experiments. This fostered mobility and improved scientific knowledge. Networking activities aimed at harmonizing procedures across Europe, setting standards and disseminating knowledge.

4. **Developing the European scientific community**
The large number of over 6000* neutron and muon users in Europe reflects the trend towards multidisciplinary research as there is an increasing number of scientists from other fields of research using the techniques. Particular attention was thus given to train early career researchers via funded schools and through the set-up of the new e-learning platform: e-neutrons. Users must be trained to exploit the future European Spallation Source (ESS) efficiently from day one.

5. **Better instrumentation, equipment and methods to increase scientific capability**
Joint Research Activities fostered synergies for innovative instrumentation development that fed directly into more efficient provision of services to the users. Particular focus was put into preparing for the highly-intense beams of the future ESS.

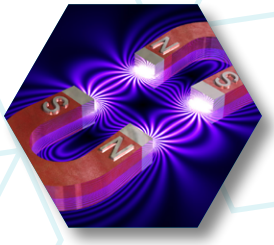
*http://www.esfri.eu/esfri-news/european-landscape-research-infrastructures-neutron-scattering-facilities-europe-present

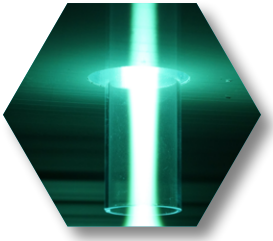
Impact of NMI3 Activities



The Tools for Soft & Bio Materials JRA developed new model membranes, which are much simpler than biological membranes, making it **easier to investigate life's processes;** soft-material-specific sample environments that can withstand dynamic external stimuli, allowing the **study of new processes**; and **in-situ devices**. Scientists can now analyse materials at higher humidity, temperature, electric field, and pressure, addressing grand challenges in energy, environment, and health.

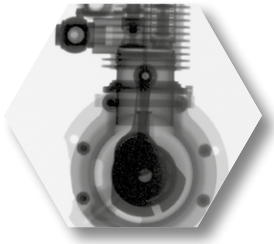
The Advanced Methods & Techniques JRA investigated new instrument designs and sample environments to exploit the very high intensity neutron beams at the future source ESS. The JRA provided the conditions to **analyse very small samples** in more **extreme environments**, and polarise all neutrons in a beam, which can be used e.g. to investigate magnetic materials.

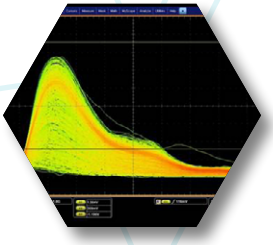




For many years neutron scattering facilities have depended on helium-3 for many of their detectors. The current penury in supply of ^{3}He requires new technologies for cost effective, large area detectors. To tackle this problem, the Detectors JRA worked on two promising alternatives: scintillation detectors using ^{6}Li, and gas detectors using ^{10}B. These advances underpin new science.

Neutron Imaging looks inside objects without damage. This JRA developed innovative methods to probe structures in bulk materials (e.g. a car engine). It is now possible to conduct experiments with **better contrast** and **higher definition**, and reconstruct **3D configurations** of large arrays of nanostructures. This technique is used by experts from museums, materials science, and industry.

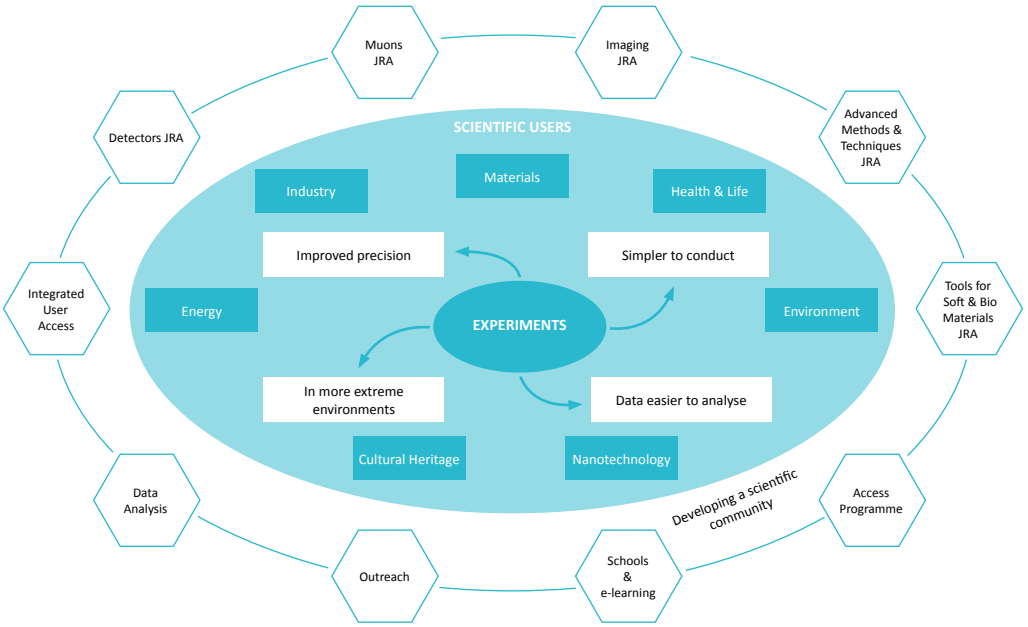




The Muon JRA developed new algorithms, together with a link between analysis and simulation codes, which provided the user with **improving data analysis for the user.** Concept studies were performed for future muon sources centred on **improved targets, advanced micro-beams and high intensity sources.**´

The Integrated User Access and Data Analysis Standards activities each proposed a set of recommendations for a shared online European neutron infrastructure. The aim is that the proposal submission and the analysis of data can be done similarly across facilities.

The impact of NMI3-II

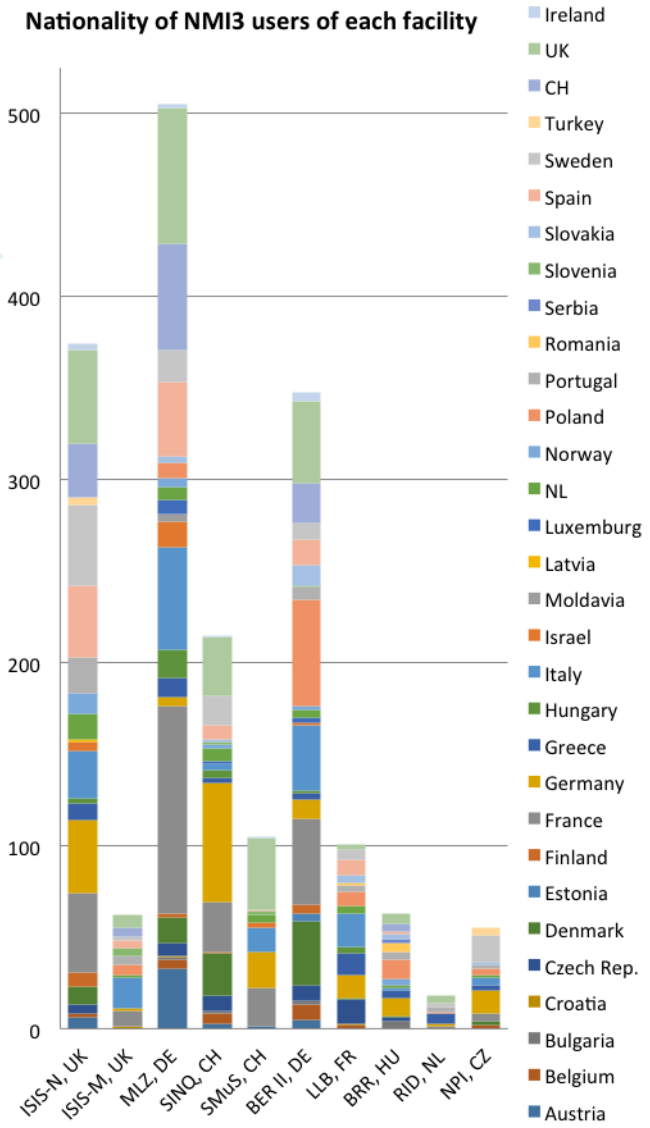


The access programme: facilitating mobility of european scientists

Neutron and muon facilities **provided beamtime** to scientists from foreign, European countries who required access to to use neutron scattering or muon spectroscopy. Thanks to the NMI3 project funds, facilities could offer **open access to the scientific community**. Proposals selected on scientific excellence were awarded additional funds to support **travel and subsistence** for the scientists.

10 facilities for research

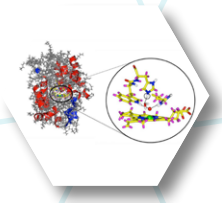
Europe's scientists benefited from ten member facilities providing access to their instruments and beamlines. **Nearly half of the users of each facility came from other EU countries.** The graph (see on the right) shows the countries of origin of scientists using each facility, demonstrating the importance and impact of EU funding. NMI3 helped attract new scientists to the technique, with up to **40% of scientists using neutrons for the first time.** Many of these users were early career researchers, **23% being under 30**.



Click the headlines to know more.
Other scientific highlights can be found here.

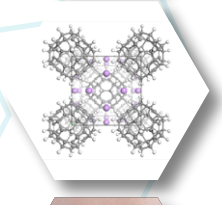
Supporting all fields of science

Nearly **2000 scientists** have received NMI3 support to use over **5000 beam days** at the facilities. This generated **over 210 publications** (and counting) in peer-reviewed journals. Results shed light across the fields of **chemistry, engineering, life, materials, ICT, earth & environment, humanities, energy, and physics**. The examples below illustrate the range of applications of the techniques (e.g. to investigate enzymes, hydrogen storage, tooth fillings, plants, and statuettes), as well as the necessary researchers' mobility.



How does an enzyme detoxify the cells of living beings?

Scientists used neutrons to shed light on the reduction of use proper formula H_2O_2 to water by CcP (an enzyme thought to detoxify living beings cells), concluding that the process, which is the focus of a long-standing and highly contentious question, needs to be reassessed.



Muons help understand the mechanism behind hydrogen storage

Contrarily to what was previously thought, hydrogenation could be more effective at low temperatures.

Will we have stronger, enduring teeth? New material for tooth fillings investigated

Scientists used neutrons and X-rays to better understand the structure and hydration process of glass ionomer cements. This material is a promising alternative for dental fillings.

SANS: a unique technique to look inside plants' leaves

Small-angle neutron scattering enabled researchers to look inside intact leaves to learn how their structure and functions change when submitted to environmental changes.

Egyptian statuettes of Osiris: production unveiled by neutrons and lasers

A group of scientists from Italy, Germany and the United Kingdom applied an innovative approach to study Egyptian copper alloy figurines.

Supporting all steps from call for proposals to publication

Call for Proposals

Calls for proposals launched by facilities were widely disseminated by NMI3, so that potential users could easily find all the necessary **information in one place**.

Proposal Submission

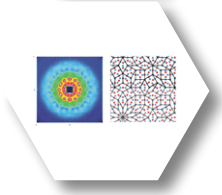
The **Integrated User Access** activity proposed a single entry point for proposals, so that scientists encounter the same proposal environment when submitting to any of the facilities in Europe.

Training and education

Early career researchers who attend one of the 15 funded schools or use the **e-learning** platform e-neutrons.org go to the facilities better prepared and therefore conduct experiments more efficiently.

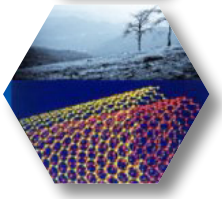
Experiment

Travel and subsistence expenses were covered for EU scientists who went to research facilities for experiments. Experiments at **higher pressure, temperature,** with **smaller samples in extreme environments**, offering **better visualisation**, and closer to **physiological conditions**, were made possible thanks to our JRAs.



Data Analysis

Experiments produce large amounts of data and facilities have provided bespoke software for data treatment. **Standards for data analysis** were developed to make it easier for scientists to analyse data across European facilities.



Publication

Experiments resulted in a large number of publications in prominent journals, which **inform a variety of fields** such as medicine, agriculture, energy, arts, transport, information technology, environment, and industry.

IMPRINT

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Useful links

Neutronsources.org and Muonsources.org are initiatives of neutron and muon facilities from around the world. The aim is to provide information and news on research using neutron and muon beams.

SINE2020.eu, world-class Science and Innovation with Neutrons in Europe in 2020, is a consortium of 18 partner institutions from 12 countries. It is funded by the European Union under the H2020 programme.

YouTube – Students who attended funded schools tell us what they liked the most in our School Videos. In our JRA Series videos scientists explain their work within their NMI3 JRA. And more!

www.nmi3.eu

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