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The Second Target Station Project at the UK’s ISIS neutron source moved a major step closer to completion in summer 2008 when the first neutrons were created in the ISIS Second Target Station.

After five years of planning and construction, the first neutrons were detected by the Inter instrument at 1308 BST on 3 August 2008. The first neutrons met all of the technical performance predictions and marked a significant milestone in the life of the ISIS and the start of a new era in neutron scattering at ISIS.

A second milestone was achieved at ISIS on 18 September 2008 when both neutron targets were operated at full power for the first time.

More recently, in December 2008, a further three instruments were brought online: the polarised neutron reflectometers Polref and Offspec, and Nimrod, a diffraction instrument optimised for the study of liquids and disordered materials. All of the instruments are reporting that the new neutron source has a very high brightness, as anticipated from technical calculations.

Neutrons are produced at ISIS when bunches of protons travelling at 84% of the speed of light are transferred from the circular ISIS synchrotron accelerator and fired into a tungsten targets inside each of two target station. This creates billions of neutrons per second that can be used for experiments.

Running the two targets together is achieved by sending four proton bunches to target station one followed by one bunch to target station 2 and then repeating the pattern. Since September, 10 Hz beam has been routinely delivered to the second target station whilst at the same time delivering 40 Hz beam to target station one.
ISIS is Europe’s only source of pulsed neutron beams and has some 30 neutron instruments that cater for a range of experiments from condensed-matter physics to biomedicine. Operated by the Science and Technology Facilities Council at the Rutherford Appleton Laboratory in Oxfordshire, it is already a world leading centre for research in the physical and life sciences. Over 9000 papers have been published in the last 20 years based on work carried at the facility. Since the first target station opened in 1984, ISIS has exceeded all expectations and the neutron source has become a vital part of many research projects. ISIS has answered questions about fundamental magnetism at the atomic level through to everyday problems like the most economic way to make fabric softener.

Neutrons are now a vital analysis technique for research on subjects as varied as clean energy and the environment, pharmaceuticals and health care, through to nanotechnology, materials engineering and IT.

The second target station at ISIS will allow scientists to study new systems ranging from polymers and materials that sequester carbon dioxide, to soft matter and biomaterials. Building on the success and expertise developed at ISIS over the past 25 years, it will enable fundamental research that will shape major technological advances of the future.

“Throughout the 90s, it became apparent that there was some science that we just couldn’t do with target station 1,” says Andrew Taylor, ISIS Director. “The message we were getting from the community was that they wanted to study bigger molecules, over longer timescales.

“They wanted to look at polymers, surfactants, aggregates. The applications from scientists wanting to study soft matter and biomaterials were becoming more ambitious. These things have got structures bigger than a few angstroms. Bigger molecules need neutrons which are matched to their structure - longer wavelength neutrons. The new target station supplies these and its high flux allows greater control of intensity, wider bandwidth and quicker experiments.”
This is tremendous news for the science community, both in the UK and much further afield. The ISIS Second Target Station will open research into new types of materials that has not been previously possible at ISIS, and we look forward to a world of new science flowing from the new instrument suite.

Andrew Harrison
UK Director, Institut Laue Langevin, Grenoble, France

ISIS is the world’s leading spallation neutron facility and has performed world class outstanding science. Adding the second target station is the next great step for ISIS to enhance the ability and extend the reputation of neutron sciences world wide. Together with the great scientific environment at ISIS, the skilful design and the mature know-how in neutron technology applied on the second target station will open up unexplored areas for pulsed cold neutron experiments. ISIS can stay as the world-leader even as more powerful spallation neutron sources, such as J-PARC and the US Spallation Neutron Source come online.

Masatoshi Arai
Neutron Science Section Leader of the J-PARC accelerator project, Japan

This is a remarkable achievement by the ISIS team and adds an exciting new dimension to the capabilities of the European neutron scattering toolkit.

Ian Anderson
Associate Director, Neutron Sciences at Oak Ridge National Laboratory, USA

Science at the ISIS Second Target Station

The ISIS second target station will provide a high flux of long-wavelength neutrons allowing users to study larger molecular structures and perform experiments faster. Seven new instruments are initially available opening up new possibilities in the areas of advanced materials, soft matter and bio-science.

ADVANCED MATERIALS
More new materials have been synthesised in the past twenty years than ever before, and neutrons will continue to be an extremely effective way of studying them. When it comes to studying magnetic properties of materials, neutrons often provide the only viable option. Instruments at the ISIS second target station will allow researchers to gain fundamental knowledge about these interactions at the nanoscale. At the same time it will unearth new applications such as magnetic recording devices in the rapidly expanding area of spintronics, where the magnetism of electrons is manipulated in addition to the charge.

SOFT MATTER
Research interests are increasingly motivated by the commercial significance of products that are complex mixtures of components. Many industrial processes involve the flow and processing of soft matter and an understanding of how these substances behave under various conditions. The new instrument suite is going to be extremely useful in probing polymers, surfactants, and colloids. It will enable study of a wide variety of systems, including the behaviour of biosurfactants, the interfaces between thin polymer films in organic LED screens, and the way drug molecules interact with membranes in the body.

BIOSCIENCE
Biological and life sciences are an extremely vibrant area of scientific activity. Dynamic areas of research, including drug creation and delivery, metabolic pathways, processing effects, pesticide activity, artificial bio-synthetic materials and virus interactions, are all closely linked to an understanding of the structures of membranes, membrane-protein interactions, the structure of macromolecular complexes and bio-compatibility. Neutron scattering can give either low-resolution information about large features such as lipids surrounding a macromolecule. It can also provide high-resolution information about water solvent structure, hydrogen binding and precise active site geometry. We are expecting more and more biologists to begin using ISIS and the new instruments at the second target station.
**First Neutrons on the Inter instrument**

**Sunday 3 August 2008 13:15**

*First neutrons down the Inter beamline! Congratulations ISIS!*

Inter was the first instrument to receive neutrons at the second target station. Inter is a high-resolution, high-flux reflectometer designed by ISIS scientist John Webster to study chemical interfaces by bouncing neutrons off them.

The first data from the instrument was the monitor spectrum showing the distribution of neutron intensity varying with wavelength. Intensities agreed with calculations and the distribution is consistent with the temperature of the solid methane in the moderator. Further data measured from a calibration sample of a 1216 Å Ni/C film on glass, demonstrates the huge bandwidth of the new instrument. The interference fringe pattern can be measured in one instrument setting over a Q-range from 0.2 Å down to well below 0.02 Å, at least double the range that can be measured using the Surf reflectometer at target station one.

Inter will study a wide variety of systems, including the behaviour of biosurfactants, the interfaces between layers of thin polymer films used in organic LED screens, and the way drug molecules interact with membranes in the body.

A great advantage of neutrons over other techniques, such as x-rays, is that they are scattered by atomic nuclei. This means that they can distinguish between isotopes of atoms in a sample, for example, between hydrogen and deuterium. By altering the deuterium content, different components of a complex mixture can be highlighted to see how much of each there is at a particular time. The improved signal-to-noise ratio of the new Inter instrument means more complex mixtures can be studied, with smaller components labelled.

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**Reaction**

“**This is an incredible technical achievement and demonstrates how everyone can pull together and enable STFC to deliver massive science projects that underpin the long-term future of science and innovation in the UK. I’m very proud of every single person who has played a part in getting the ISIS Second Target Station project through to this very important milestone.**

*Peter Warry*

Chairman, UK Science and Technology Facilities Council

“**I wish to congratulate to all my friends at the ISIS Second Target Station Project for this great achievement, which besides expressing the capabilities of British scientific and technological communities, is also a matter of pride for all of us believing in the unique contributions that neutron techniques are able to make towards a better quality of life.**

*Rolando Granada*

Centro Atomico Bariloche, Argentina
Instruments at the ISIS Second Target Station

The ISIS Second Target Station represents a major step forward in the UK’s material science capabilities. It will enable the study of a wider range of systems and welcome scientists who have never used neutrons before. There are seven new instruments in the first phase, with funds already allocated for a further five. The full complement of 18 instruments at the second target station is expected by 2016.

**PHASE 1 INSTRUMENTS**

**REFLECTOMETERS**
Neutron reflectometry is a powerful technique for studying surfaces and interfaces between solids, liquids and gasses. Three state-of-the-art reflectometers have been constructed.

**INTER** builds upon the success of the world-leading Surf instrument at ISIS and will provide a unique facility for the study of air/liquid, liquid/liquid, air/solid and liquid/solid interfaces.

**OFFSPEC** will characterise the increasingly important area of in-plane interface structure using the spin-echo resolved grazing incidence scattering technique.

**POLREF** is a polarised neutron reflectometer designed for the study of the magnetic ordering in and between the layers and surfaces of thin film materials. Three-directional polarisation control will allow unique information to be obtained on the size and direction of the magnetism as a function of depth in multi-layer structures.

**SMALL-ANGLE SCATTERING**
Small angle neutron scattering, SANS, is a powerful technique for determining structural dimensions in the nanometre to micrometre range.

**SANS2D** represents a new concept in small angle scattering, using multiple position sensitive detectors to give unsurpassed simultaneous data collection across a wide range of length scales. It will be well-placed to exploit the trend towards studying non-equilibrium and multi-component chemical systems.

**INTERMEDIATE RANGE ORDER**
Changes in local molecular environment to affect the phase and function of materials is essential in many current and emerging fields of technology.

**NIMROD** is a total scattering instrument that will offer greater insight into the subtle balance between short, medium and long-range interactions found in many materials.

**HIGH-RESOLUTION MAGNETIC DIFFRACTION**
The ability to produce diffraction patterns at nearly constant resolution over a wide range of lattice spacings is one of the distinct features of time-of-flight sources such as ISIS.

**WISH** is a long-wavelength instrument optimised for studying magnetism at an atomic level. Designed for powder diffraction at long d-spacing in magnetic and large unit-cell systems, it will specialise in such topics as magnetic clusters, extreme conditions of magnetic field and pressure, and new designer magnetic systems tailored for specific applications.

**HIGH-RESOLUTION SPECTROSCOPY**
The study of atomic motion in matter with inelastic neutron scattering provides one of the most exacting tests to understand the microscopic origin of material properties.

**LET** will introduce unique flexibility to low-energy spectroscopy, with the ability to make quasi-elastic and inelastic measurements over a wide dynamic range.

**PHASE 2 INSTRUMENTS**
£46 million has been earmarked for instrument development at ISIS through to 2016. The UK government (Department of Universities, Innovation and Skills) has announced that £25 million has been earmarked for investment in instrument development at ISIS through the Large Facilities Capital Fund. This investment will cover the period 2012-2016 and is in addition to the £21 million already earmarked for Target Station 2 Phase
2 for the period 2009-2013. The sustained investment programme will allow ISIS to keep its instrument suite at the forefront for the next decade, enabling cutting edge research by its many hundreds of UK and international users. The Target Station 2 Phase 2 instrument design and construction will start in 2009. There are currently 5 instruments proposed.

CHIPIR will specialise in producing high energy neutron beams up to 800 MeV and matching the atmospheric neutron spectrum for testing of microchip components.

ZOOM is a second small angle scattering instrument to complement Sans2d with high intensity and reaching smaller Q than Sans2d by using a neutron lens.

LARMOR aims to make use of a number of recently developed techniques based on the application and extension of the neutron spin-echo concept to provide a multi-purpose instrument for small-angle scattering, diffraction and spectroscopy. LMX ideally suited to ISIS TS2, and will play a crucial role at the forefront of modern molecule-based materials and molecular biology. The design includes a long incident beam path and novel neutron optics, to deliver a high flux of cold neutrons and to resolve low d-spacing Bragg reflections.

IMAT is a beamline for neutron imaging, materials science, engineering and archaeology. The energy-resolved imaging mode will be unique and will introduce new techniques unavailable elsewhere.

**Inside the target, moderator and reflector assembly**

The ISIS Second Target Station is a low-power, low-repetition-rate neutron source optimised to maximise the production of long wavelength neutrons. One of the most important factors in the target station design is the geometric coupling between the target and the moderators. With the majority of neutrons travelling straight from the target to the moderators, the angle covered by the moderators has been maximised, whilst keeping the distance each neutron travels through the target to a minimum to reduce absorption.

The low power of the target (48 kW) enables the use of solid methane as a moderator material, and this choice dominates much of the target design, principally in minimising power deposition into the solid methane to prevent damage. This is the first time that cold solid methane moderators have been operated with such a high beam power anywhere in the world.

The target is a 6.6 cm diameter rod of tungsten, clad in tantalum to prevent corrosion, cooled from its surface with deuterated water (D2O) and surrounded by a D2O cooled beryllium reflector. Water pre-moderator layers between the target and moderator need to reduce damage to the solid methane.

The new target station produces neutrons with two pulse shapes: a relaxed pulse (300 µs) is generated by a coupled moderator; a pulse from a de-coupled moderator, with little or no tail, and a width comparable to those of the existing ISIS methane and hydrogen moderators (30–50 µs).

The coupled moderator is a composite hydrogen/solid-methane system without a decoupler or poisoning layer. It generates an intense, long-wavelength flux with broad pulse shapes from two distinct faces. The flux per accelerator pulse for the coupled moderator is more than 10 times that of the existing decoupled hydrogen moderator at long wavelengths.

A solid-methane face with a deep, narrow groove giving high brightness and a cold spectrum has been designed for small angle scattering and reflectometer instruments that view only a small area of the moderator surface. A flat hydrogen face has a slightly warmer spectrum and a much larger flux integrated over the whole face.

The decoupled solid-methane moderator gives a similar flux to the existing ISIS water or liquid-methane moderators, but with a much colder spectrum.
The light of SPARX FEL

L. Palumbo
Università di Roma La Sapienza and INFN, Roma

INTRODUCTION

Free Electron Lasers (FELs) are sources of coherent electromagnetic radiation having similar optical properties as conventional gas or solid-state lasers. The relevant difference is the lasing medium being, for FELs, an electron beam which moves freely through a magnetic structure, the undulator which causes transverse electron oscillations (Fig. 1). While traveling in the undulator, the coupling of electron transverse velocity with an electromagnetic radiation field results in energy transfer. This causes micro-bunching of the electron beam in dependence of the radiation wavelength and leads to coherent emission. In Linac based FELs, the micro-bunching instability can be created in a single pass through sufficiently long undulators, where an exponentially growing power radiation is produced. This spontaneous amplifying mechanism is called Self Amplified Spontaneous Emission (SASE) which ensures only the transverse coherence radiation, the longitudinal distribution showing large numbers of spikes generated by the noise in the electron bunch density. “Seeding” the electron beam with an external radiation source allows to drive the instability and to control the longitudinal radiation properties.

The generated output radiation is extremely interesting in terms of brilliance, coherence, pulse duration and intensity, these unique features offer new opportunities in many fields of research: material science, chemistry, biology, medical science, industrial applications.
The SPARX (Sorgente Pulsata Autoamplificata di Radiazione X) FEL project is aiming at the realization of a coherent light source covering the range of wavelengths ($\lambda$) from 0.6 to 40 nm at fundamental harmonic of the coherent emitted radiation and will reach the Angstrom-region using the third and fifth harmonics where high power is still produced. The SPARX source covers a radiation spectrum complementary to those of other existing or in construction facilities, such as FLASH ($\lambda$>6 nm), FERMI (10$<\lambda<$100 nm), X-FEL (0.1$<\lambda<$1.6 nm), LCLS (0.15$<\lambda<$1.5 nm), SCSS ($\lambda$>0.1 nm), and will produce, with special magnets, radiation up to the THz region. These ranges showing some convenient overlap, have the advantage of providing sufficient access to users, expected to be proposing experiments in many fields of disciplines, and ensuring at the same time a beneficial level of competitiveness. Furthermore, the available site for the construction of SPARX does not limit the expansibility of the facility for future upgrades up to the Angstrom-region in the first harmonic.

It is worth reminding that the SPARX initiative follows the path of a long tradition in the development of Synchrotron Light sources and FELs concentrated in the Frascati area since the late ’50s. Here, pioneer researchers constructed the first Italian synchrotron, and the first-in-the-world colliding electron-positron storage ring “ADA”, where radiation-beam phenomena, up to then unknown, were discovered and interpreted by Bruno Touschek and his team. Eventually, dedicated Synchrotron radiation beam-lines were built, in collaboration with CNR, on the storage ring ADONE where two generations of Italian synchrotron radiation scientists were trained and had the opportunity to develop world wide recognized cutting-edge experiments. More recently, a high level of expertise has been reached by ENEA and INFN on FEL science and technology.

THE EVOLUTION OF THE SPARX PROJECT
The SPARX project was planned as an evolutionary research infrastructure exploiting the large site available at the Tor Vergata University campus, an area about 1.5 km long. The machine and the related infrastructures have been designed by a project team in the framework of a collaboration among the major national research institutes, CNR, ENEA, INFN, the University of Rome “Tor Vergata”, in strong partnership with many Italian and foreign universities well recognized for their expertise on FELs and their scientific applications. The project is now entering a new R&D phase, recently funded by MIUR, which will allow a further step toward the realization of this light source in
Rome. The overall project, funded by MIUR and Regione Lazio and UE, has already seen relevant steps of development:

1. The construction of the Test Facility (SPARC), dedicated to a robust R&D program on ultra-brilliant electron beam Linacs, and on FEL physics (Fig. 2). It was approved and funded in 2003 by the Italian Ministry of Research in the framework of the national strategic research program (FISR), and got additional support by the EUROFEL Projet within the 6th Framework Programme of UE. The test facility is now completed, hosting a 150 MeV electron beam Linac which feeds a 12 meters long undulator. The Linac has been commissioned and the tests of most critical FEL components have been successfully completed, including High-Order Harmonic Generation (HHG), based on the interaction between the laser beam and a gas target, used for the seeding experiment. During the last commissioning days the spontaneous emission from the undulators has been observed. In the coming weeks and months an exciting R&D program is expected to be performed in order to generate the classical SASE radiation, and make the test of innovative radiation generation schemes based on the “seeding process” and High Gain Harmonic Generation (HGHG) which can extend the operating wavelength of SPARX-FEL down to sub nanometer wavelength. In a near future SPARC will be available to the user community, for testing diagnostics, detectors and techniques dedicated to FEL based experiments.

2. The preparatory phase of the SPARX facility (Fig. 3), which is in an advanced state of progress with the completion of the Technical Design Report (TDR), the preparation of the updated Scientific Case and the starting of the Consortium “LUCE”, being constituted by CNR, ENEA, INFN and the University of Rome “Tor Vergata”, which will take care of the construction and the operation of the source.

The next step will be to implement the objectives foreseen by the agreement (“Accordo quadro”) signed between the MIUR, Regione Lazio and the Consortium “LUCE” partners. The agreement includes the construction of the civil infrastructures funded by Regione Lazio, expected to be initiated within 2009, when the digging of the first part of the tunnel should take place. The agreement also includes the design and construction of the machine which will be based on the existing equipment (SPARC linac and undulators). The project foresees an energy upgrade of the Linac up to 1.5 GeV in a first phase, and 2.64 GeV in a second phase, able to
feed three undulators providing coherent radiation from 0.6 nm to 40 nm, with a significant range of tunability.

SCIENCE AND TECHNOLOGY WITH SPARX-FEL
Many advanced scientific and technological opportunities can be opened by the SPARX-FEL source based on:

• Time-resolved X-ray techniques, based on both scattering and spectroscopy, which allow accessing time resolution ranges from pico-seconds to femto-seconds thanks to the pulsed structure of the beam. In particular:
  - Femtophysics (physical transformations observed on the femtosecond time scale), for instance for direct tests of quantum mechanics, to study the dynamics of single and collective motions, phase transitions, spontaneous and induced atomic rearrangements, relaxation of systems prepared in states far from the thermodynamic equilibrium etc.
  - Femtochemistry (chemical reactions on the femtosecond time scale), such as bond breakage and recovery of atoms in molecules and solids in activated complexes, selection of particular reaction channels among those permitted, evolution of photoexcited systems etc.
• Coherent X-ray imaging, thanks to the spatial coherence typical of the laser emission. In particular:
  - Coherent X-ray diffraction that, for instance, enables imaging non-periodic objects on nanoscale, such as single proteins, thus overcoming the limitations imposed by the optical elements aberrations.
  - X-ray holography, i.e. the reconstruction of the coherent scattering pattern by interference of the scattered beam with a reference beam to study, for instance, the structure of simple crystals.

• Photon hungry measurements, which require extremely high photon fluxes. As examples, the following cases can be mentioned:

Figure 4. SPARX Experimental hall.
- **Diffraction from poor scatterers**, such as systems at very low electron densities, i.e. low numerical density and/or formed by light elements (which tend to scatter inelastically), as in the case of biological systems containing much hydrogen.
- **Diffraction from dilute solutions**, in which the main contribution comes from the solvent and the solute signal is a slight perturbation (thus requiring a high statistics to be detected).
  - Spectromicroscopy, which allows analyzing chemical elements that have energy levels in the X-ray range, this with more than spatial resolution of 100 nm and spectral resolution of 0.1 eV.
  - Structural studies of biological systems, allowing crystallographic studies on biological macromolecules.

**MACHINE DESCRIPTION AND PARAMETER LIST**

SPARX-FEL facility will host two beamlines for each undulator source in order to maximize the users’ accessibility (Fig. 4). The beamlines, optimized for high photon energy resolution and for short-pulse handling, have been designed for the following energy ranges:

1. **VUV-EUV beamline**: 40 - 124 eV (10 - 30.5 nm)
2. **EUV - Soft X-ray beamline**: 88.5 - 1240 eV (1 - 14 nm)
3. **Soft-X-ray beamline**: 1.28 keV - 2 keV (0.6 - 1.2 nm)

The photon beamlines are driven by the SPARX accelerator, which is meant to be realized in two phases with two different electron beam energies: one up to 1.5 GeV and the other up to 2.4 GeV. In order to reach SASE saturation in undulators of reasonable length, a peak current $I_{pk}=1\div2.5$ kA is needed for lower and higher energies respectively. The required final beam energy spread is 0.1% in each case and the machine is designed to operate at a repetition rate of 100 Hz. The main parameter list are reported in Tables I and II.

<table>
<thead>
<tr>
<th>Energy</th>
<th>(GeV)</th>
<th>$E$</th>
<th>1÷1.5</th>
<th>2.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak current</td>
<td>(kA)</td>
<td>$I_{pk}$</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>Normalized transverse emittance slice</td>
<td>(µm)</td>
<td>$\varepsilon_n$</td>
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<td>1</td>
</tr>
<tr>
<td>Correlated energy spread</td>
<td>(%)</td>
<td>$\sigma_{\delta}$</td>
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<td>0.1</td>
</tr>
<tr>
<td>Radiation wavelength</td>
<td>(nm)</td>
<td>$\lambda$</td>
<td>40÷3</td>
<td>3÷0.6</td>
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</table>

**Table 1.** Electron beam parameter list.
CONCLUSIONS
SPARX FEL project is now ready to see the green light and prepare the activities necessary to construction of a powerful Free Electron Laser source in Rome, which will offer unique opportunities to a wide multidisciplinary user community. The FEL will provide a large radiation spectrum from THz to Soft X-rays (1 KeV), and has been conceived as an evolutionary source which can undergo further developments toward the Angstrom region. A wide community of machine physicists and engineers are designing the machine, while a large community of potential users are investigating the feasibility of advanced experiments exploiting the unique features of the source.

ACKNOWLEDGEMENTS
The author is reporting here a brief summary of the SPARX TDR, designed by the SPARX project team, gathering about hundred collaborators from many Italian and international scientific institutions.

Table 2. Radiation parameters of the FEL sources.

<table>
<thead>
<tr>
<th></th>
<th>Units</th>
<th>U1</th>
<th>U2</th>
<th>U2</th>
<th>U3</th>
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<tr>
<td>Electron beam energy</td>
<td>GeV</td>
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<td>0.96-1.5</td>
<td>1.9-2.4</td>
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<td>Wavelength</td>
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<td>15–4</td>
<td>4-1.2</td>
<td>1.2-0.6</td>
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<td>Photon Energy</td>
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<td>80-300</td>
<td>300-1000</td>
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<td>Peak power</td>
<td>GW</td>
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<td>–150</td>
<td>–130</td>
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<td>Photon beam divergence (FWHM)</td>
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<td>%</td>
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<td>0.2-0.1</td>
<td>0.15-0.1</td>
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</tr>
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<td>Pulse duration (FWHM)</td>
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<td>30-250</td>
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<td>Repetition rate</td>
<td>Hz</td>
<td>100-50</td>
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<tr>
<td>Number of photons per pulse</td>
<td>#</td>
<td>1.0*10¹⁴</td>
<td>1.5-8.5*10¹³</td>
<td>5*10¹²</td>
<td>0.5-1.5*10¹²</td>
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<td>Peak brilliance*</td>
<td></td>
<td>≈10¹⁸</td>
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<tr>
<td>Average brilliance*</td>
<td></td>
<td>≈10¹⁰</td>
<td></td>
<td>≈10¹⁹</td>
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</tbody>
</table>

* standard units: Number of photons (sec·mrad²·mm²·0.1 % BW). Mean values have been considered for the different cases.
INTRODUCTION

Neutron tomography is a rapid developing technique in the field of nondestructive material investigations [1]. Nowadays, a number of experimental stations are already operational, aiming to take advantage of neutron imaging techniques [2, 3] while other are envisaged [4] and should become available in the next future. The greatest part of these experimental installations is built at reactor based neutron sources where high fluxes are available; indeed a high neutron flux is essential to achieve good quality images in a short enough time.

Today, pulsed neutron (spallation) sources, such as the ISIS facility at the Rutherford Appleton Laboratory (UK), offer a neutron flux that can be usefully employed for neutron imaging and some preliminary neutron radiographic experiments have been previously performed [5]. The pulsed nature of the neutron beam flux at accelerator based sources allows obtaining energy selective images of the investigated samples in a conceptually simple way. In fact, using time of flight (TOF) techniques, i.e. selecting appropriate time windows for the image acquisition, it is possible to select narrow energy ranges of the detected neutrons. In such a way, tuning the energy of the probe near the Bragg edges characteristic of the different materials, it is possible to enhance the image contrast for the various substances present in the sample. As a result, materials that are indistinguishable under “white beam” illumination because of almost equal absorption coefficients can be easily discriminated [6].

INES [7, 8] is the CNR experimental station at ISIS that, since 2005, has been used to produce a large amount of neutron diffraction results, texture analysis of materials, as well as a number of detector and neutron instrumentation tests. One of the main investigation fields in which the INES station has been employed is archaeometry, where neutron diffraction technique allows the examination of mineral and metal phase contents, crystal structures, grain orientations, micro-phases and micro and macro strains; in addition, texture analysis provides clues to the deformation history of the materials and hence to the peculiar working processes adopted [9]. Since many archaeological samples contain interesting details that are hidden in the inner bulk of the investigated objects (and often the object itself is hidden into different enclosures), the availability of techniques that are able to detect and spatially localize such items is extremely important. Of course, given the nature of archaeological objects, those techniques that can perform this task in a non-invasive and non-destructive way are the preferred. Among these techniques, neutron tomography has the further advantage of being able to easily penetrate materials that are opaque at other investigating methods such as x-rays. For these reasons having the possibility of obtaining 3 dimensional maps of unknown, and often delicate or unique samples, could be of paramount importance.
Recently, the INES station has been used to develop a portable imaging system to be used for beam monitoring and sample alignment on different instruments [10]. For this test, we had chosen a very basic configuration suitable for the intended aim of the apparatus. The obtained results, however, were encouraging and have suggested to slightly modify the setup in order to allow obtaining neutron tomography of small samples, thus widening the features that INES users may benefit in their experimental proposals.

In the following, we will report some preliminary results on the first exploitation of neutron tomography at a pulsed neutron source.

**EXPERIMENTAL SETUP**

The neutron tomography camera is mounted on an extension of the INES sample container tank. The neutron flight path length, with the presently employed sample position, is $L=23.84$ m. Due to the beam collimation, the size $D$ of the beam source (water moderator), as seen by the sample, is about 8.5 cm. This gives a value for the $L/D$ ratio, which measures the accessible image definition, of about 280. The beam dimension at the sample position is about 4.4×4.4 cm$^2$. A schematic view of the setup is shown in Fig. 1.

![Figure 1. The neutron tomography chamber at INES.](image-url)
The incoming neutron flux, entering from the left, is attenuated by the sample that is placed on a platform. Such a platform can rotate around a vertical axis by means of a stepper motor that is remotely controlled by a personal computer equipped with a homemade controller and a National Instrument USB-6211 interface. The beam transmitted through the sample hits a scintillator screen, made of ZnS:6LiF on an Aluminium substrate, which emits visible light centered at a wavelength $\lambda \approx 520 \text{ nm}$. The scintillator is placed at a mean distance $d$ of 100 mm from the rotation axis and is tilted of an angle $\theta = 45^\circ$. From the values of $L/D$ ratio at the sample position and the average distance from the sample to the scintillator screen, we estimated an average spatial resolution $u_g$ of about 340 $\mu\text{m}$ [11]. Since the distance between the sample and scintillator is not constant, the spatial resolution is better at the bottom than at the top of the image ($0.261\text{mm} < u_g < 0.421\text{mm}$).

A commercial black and white CCD camera (The Imaging Source model DMK 21BF04) equipped with a commercial objective (Computar M0814-MP $f=8\text{mm}$, $F1.4$) is used to gather the light coming from the scintillator. The camera is equipped with a digital trigger input that is used to start the image acquisition, and is controlled by a personal computer (PC) fitted with an IEEE1394 interface that allows a bidirectional communication between the PC and the camera. The CCD camera has a resolution of $640 \times 480$ pixels, with a 10bit ADC whose most significant 8bits are sent as an output; it operates at room temperature and it does not use, at present, an image intensifier. It can be programmed for exposure times ranging from 100 $\mu\text{sec}$ to 30 sec. The frame readout frequency can be varied from 3.75 Hz to 60 Hz and the camera gain ranges from 0dB to 36dB. The CCD sensor is a Sony ICX098BL with a pixel size of 5.6x5.6 $\mu\text{m}^2$. To protect the sensor from $\gamma$-rays and fast neutrons we have interposed a lead-glass window in front of the objective and wrapped the camera with a neutron absorbing boron plastic. Notwithstanding these cautions, we observed that a few white spots have developed onto the CCD sensor after some time. The stepper motor which rotates the platform can be operated at 1.8$^\circ$/step in full step mode or at 0.9$^\circ$/step in half step mode; this gives a total of 100 or 200 steps for 180$^\circ$ respectively.

Before each measurement, we always recorded the dark image (to subtract the background noise) and the image of the unobstructed beam (to normalize for

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**Figure 2.** Beam cross-section.
**Figure 3.** Neutron radiography of the vacuum tube.
**Figure 4.** 3D reconstruction of the vacuum tube inner part.
In fact, the beam intensity is not uniform along its cross-section as shown in Fig. 2. For each sample, 100 or 200 images were taken at different incident angles between the sample and the beam. The exposure time was varied together with the camera gain in order to optimize the image quality (low gain) versus the total acquisition time. Exposure times of 22 s and 120 s were used for the samples shown in this work. Since the camera has a maximum exposure time of 30 s, external accumulations were performed when needed. Each image was corrected for the beam intensity fluctuations by selecting an area free from sample and normalizing its intensity over the entire image set. Each time, the dark contribution was subtracted and the resulting images were normalized to the open beam picture. Finally a 3x3 median filter was applied to take into account some hot or dead pixels in the CCD sensor.

Since the rotation axis of the object does not coincide exactly with the optical axis of the camera, a procedure to correctly estimate both the position and the inclination of such axis was applied at the images taken at 0° and 180°. A Filtered Backprojection algorithm with a Shepp Logan Filter [12] was applied to the obtained images in order to reconstruct the tomography slices of the investigated objects.

RESULTS AND DISCUSSION
The first investigated object was a vacuum tube. In this case, the exposure time was set to 120 s for each image and 200 images were acquired on a total rotation angle of 180°. One of the neutron radiography is shown in Fig. 3 and a 3D reconstruction of the inner part of the vacuum tube is shown in Fig. 4. Even though the present radiographic image is not surprising, due to the transparent nature of the glass bulb, we should consider that a similar quality image could be obtained, even with a metal enclosure, and we were quite satisfied with the result.

Figure 5. The “black box” is composed by 2 plastic spheres that are wrapped by a Cu-Ni wire and inserted into a brass inner cylinder. This in turn, is wrapped by a copper wire and inserted in a steel cylinder. The resulting package is closed into an air-tight aluminium container, sealed with steel screws.
For a second test, we decided to use a totally different and more complex object. To this aim, we used an on-purpose built “black box” composed by various metallic and plastic elements. Its assembly is shown in Fig. 5 and one of the neutron radiographies is reported in Fig. 6, as an example. The exposure time for each image of this sample was 22 s and the camera gain was set to the maximum available (36dB). As it can be seen from the figure, the noise level observed in the image is satisfactorily low, in spite of the large gain. From the three sections (coronal, sagittal and axial) of the “black box” shown in Fig. 7 it is possible to tell apart almost all the components. Only the external can is nearly transparent, as it should be expected, because of the low absorption coefficient of the Aluminium container.

Modern 3-D visualization software, such as VGStudioMAX [13], can be employed to show the complex nature of the objects in a user-friendly way (see Fig. 8). Here again, notwithstanding the less than optimal quality of the radiographic images, the internal structure of the object is clearly visible.

**CONCLUSIONS AND PERSPECTIVES**

Neutron tomography can give important insight on the three dimensional structure of delicate objects such as the archaeological artifacts. Even with the basic setup, as the one we have realized at the INES station, it is possible to obtain important information about the unknown 3D structure of small objects. The use of better image detectors and the inherent possibility of taking advantage of the pulsed neutron beam time structure will allow, in the future, to extend such a technique towards phase resolved imaging.

**REFERENCES**

3. www.ultrasonic.de/article/wcndt00/papers/idn801/idn801.htm
The Elettra Full Energy Booster is in Operation

ABSTRACT
The new Elettra booster injector is in operation since March 3rd, 2008. Beside the 2.5 GeV booster synchrotron, the new full energy injector is made up by a 100 MeV linac pre-injector and by two beam transfer lines, one at low energy (100 MeV) and the other at high energy (2.5 GeV). This injection complex replaced the old 1.2 GeV linac injector. Elettra was shutdown for 5 months between October 2007 and February 2008 to allow the installation of the new 2.5 GeV transfer line connecting the Booster to the Storage Ring and to carry out the final part of the booster commissioning. The Booster Project started in March 2005 and lasted therefore exactly 3 years, as planned initially. The main project challenge was to replace the existing Linac injector with the new full energy Booster, located in a new building inside the Storage Ring main building, affecting as less as possible the users’ operation of the facility. This required careful planning of both installation and commissioning, foreseeing the consequences of possible delays and programming appropriate back-up plans. Strong overlap between hardware and beam commissioning phases was needed to mitigate the effect of unexpected issues.

INSTALLATION
The booster building and the technical services were completed in July 2007 (Fig. 1), with several months of delay on the foreseen schedule, for various reasons. In the shadow of the building delay there were delays of 3 to 5 months in the delivery of hardware components, like magnets, power converters, Linac sub-systems. Magnets, in same cases pre-assembled on their girder, and supports started to be available in April 2007. Thus, end of April 2007 co-occupancy of the building allowed to start installation of the accelerator components, starting from the Linac accelerating sections and going on with the booster dipoles and with the quadrupole girders. Three months later the

Figure 1. The booster building in July 2007
installation of the Linac, of the low energy transfer line, of the booster and of a first section of the high energy transfer line was complete. The west arc of the booster ring is shown in Fig. 2, at the end of the installation phase. July and August 2007 were then dedicated to hardware commissioning of the various sub-systems. The Linac RF conditioning started beginning of August and was completed after about one month. The overall performance of the majority of the new injector sub-systems was within specifications already at the end of the hardware commissioning phase, with the notable exception of the main booster power converters, which performance tuning has required a longer time to get within specification. This activity has overlapped with the commissioning phase and has continued during the 2008 operation period.

**COMMISSIONING**

Commissioning activities were focussed to get a working injector, in order to avoid delays that would compromise the timely restart of the facility for users. Beam commissioning was performed in three different phases. During the first phase, between September 7th and October 13th, 2007, the beam was first extracted from the gun, accelerated through the linac pre-injector to the nominal energy, 100 MeV, and then injected into the booster. First 100 turns in the booster were obtained on September 26th, while in the following days the beam could be ramped in energy up to 800 MeV and extracted from the booster. The maximum achievable energy was at that time limited by the booster main magnets power converters, not yet performing to specification. On December 11th the high energy transfer line installation was completed. At that time also the new injection septa magnets of Elettra, capable of operating up to 2.5 GeV, were installed. Meanwhile, also one of the limiting factors on the power converters, a distortion of the output current waveform at low currents, could be removed. Just prior to the Christmas shutdown, during the second
beam commissioning phase, the beam could then be extracted from the booster for the first time at 2.0 GeV, in single shot mode.

The Christmas shutdown allowed a further improvement in the performance of the power converters. During the third and final commissioning phase, booster operation at 2.0 GeV, 1 Hz repetition rate, could be established. On February 11th it was finally possible to inject for the first time into Elettra at full energy, i.e. 2.0 GeV. In order to quickly recover good vacuum conditions in the storage ring, after the new septum installation, the beam current intensity in the Storage Ring was kept as high as possible, by successfully testing the frequent injection mode, as shown in Fig. 3. During these tests the insertion devices were opened and the beamline shutters closed.

**OPERATIONS**

Users’ operation at 2.0 GeV started on March 3rd, 2008, with routine full energy refills on top of the stored current. On the 13th of April the beam was then injected in Elettra at 2.4 GeV, the other user operation energy. In May, single bunch operation of the injector was established for Storage Ring FEL users at 0.9 GeV.

In the timeframe between April and August 2008 injection for users has been performed at 0.9 GeV, due to a harmful fault on one of the cabinets of the bending magnets power converters, occurred on April 17th. The repair of this cabinet has been included in a general refurbishing program which is being carried out by the supplier of the converters to finally meet their original specified performance. After the intervention scheduled during the summer shutdown in August, booster operation at 2.0 GeV, 2.4 Hz, 2mA of extracted beam current has been established (Fig. 4) with good reliability and improving reproducibility. Injection rates of 1.5 mA/sec have then been achieved, with best injection efficiencies measured to be close to 100%.

**CONCLUSIONS**

The Booster inauguration ceremony was held on March 28th, 2008. The project was concluded on time and on budget. Key performance achievements are:

Users’ operation at 2.0 GeV established

Overall efficiency larger than 80%
MERLIN: a high count rate chopper spectrometer at ISIS

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ABSTRACT
MERLIN is a new high intensity, medium energy resolution spectrometer. As such, it complements the high-resolution MAPS spectrometer at ISIS. MERLIN has an m=3 supermirror guide to enhance flux as well as a massive $\pi$ steradians of detector solid angle with an angular range from -45 to +135 degrees in the horizontal plane and ±30 degrees in the vertical plane. The detectors are 3m long position sensitive detectors placed in the tank vacuum to eliminate gaps in the coverage, making it ideal for both single crystal and powder/liquid users. The guide extends the dynamic range of the instrument allowing the study of excitations from a few meV to hundreds of meV. The construction phase of MERLIN finished in February 2008, followed by a brief commissioning period for one cycle before starting a full user program in June 2008.

INTRODUCTION
MERLIN is a high count rate direct geometry spectrometer and was built to replace the aging 20-year-old HET spectrometer at ISIS which has just finished its last user cycle. HET was always conceived as a high energy inelastic neutron spectrometer that would concentrate on polycrystalline magnetic systems. However, the development of position sensitive detectors (PSDs) made it possible to study magnetism in crystalline systems, and the MAPS spectrometer was built to exploit this new technique. MAPS created a new paradigm in inelastic neutron scattering providing an ability to measure large volumes of reciprocal space in a single measurement; however because of flux limitations,
it is largely confined to measurements of low-dimensional magnetic systems. The development of high m-value supermirrors (SM) made it possible to conceive of an instrument that could deliver considerably more flux to the sample opening up the possibility of a machine that could map all the excitations in the whole Brillouin zone. Funding to build such a machine was secured in 2004 and the instrument now called MERLIN was completed early in 2008 (Fig. 1). MERLIN builds on the success of the PSDs on the MAPS spectrometer, but uses a much larger solid angle detector coverage. This large detector coverage has been achieved partly by bringing the detectors in to a relatively short sample to detector distance of 2.5m, making MERLIN a medium resolution spectrometer with typical energy resolutions of 3-5%. This was a deliberate policy; MERLIN was built to complement the high-resolution MAPS spectrometer which has a 6m sample to detector distance and typical resolutions of 1.5-4%. PSDs make the instrument very versatile, being equally able to study single crystal samples as well as powders, liquids and amorphous materials. Its high count rates open up many fields including detailed parametric studies as a function of pressure, temperature and composition; studies of complex multi-component materials; novel materials for which only small quantities are available; experiments on single crystals where the signals are weak or the crystals are small; complete four dimensional mapping of the Brillouin zone and experiments involving the use of complex sample environments. MERLIN is being built specifically with complex sample environments in mind. Features include a non-magnetic sample tank and piezo-electric beam defining jaws so that high-field magnets may be used. A wider sample flange allows the use of larger pieces of sample environment equipment.

**INSTRUMENT DESIGN**

The basic instrument layout can be seen in the engineering drawing with cutaways shown in Fig. 2. All of the direct geometry spectrometers at ISIS,
including MERLIN, have a moderator to sample distance of 11.8m, which is about as short as is possible within space constraints. In fact MERLIN is so large that it takes the space of two beam port positions (only acceptable because it occurred at the same time funding became available to build the second target station). MERLIN is currently the only chopper spectrometer at ISIS to employ a supermirror guide to boost the flux. The guide is all m=3 (critical reflection angle is 3 times natural Ni) and begins at 1.7m from the moderator face with an opening of 94x94mm, converging continuously to 50x50mm just before the sample.

Fig. 3 shows the measured flux gains of MERLIN compared to HET. The flux gains come from three components, the largest gains come from the supermirror guide, but some gains are from increasing the apertures so that the sample views the full moderator face. This gives the factor of two gain at higher energies where the guide is clearly doing nothing. The third factor in the flux gain is from the moderator. Unlike most instruments which share a moderator MERLIN views its own decoupled, ambient temperature water moderator with the poisoning chosen to be central to increase flux compared to an asymmetrically poisoned moderator used on HET and MAPS. The combined effect is to give flux gains of up to 20 times HET at an incident energy of 10 meV (Fig. 3). The simulations give slightly different expected gains to the measured. The slight differences probably come from the moderator component to the flux gains as it is very difficult to obtain accurate moderator calculations.

Of course these large flux gains are at the expense of a larger beam divergence that is dependent on the incident energy. At high energies the beam divergence has a FWHM of about 0.5°, which increases to a value of 2° at 10meV incident energy. The effect of this on the Q resolution of the instrument is presented in Fig. 4.

The high count rate on MERLIN was also achieved by using a massive position sensitive detector array covering a full π steradians of solid angle. A view of this large detector bank from the sample position can be seen in Fig. 5. For
comparison this is 8 times the solid angle of HET and 7 times that of MAPS. Position sensitive detectors now make it possible to measure in two spatial dimensions in addition to a function of time; this means that each measurement on MERLIN takes a large three dimensional cut out of the four dimensional $S(Q,\omega)$.

The detectors form a cylindrical array with an angular range of $-45^\circ$ to $+135^\circ$ degrees in the horizontal plane and $\pm 30^\circ$ degrees in the vertical plane. The detectors are 25mm wide and 3m long and the centre point of the detectors is 2.5m from the sample. To keep the detectors straight small aluminium straps are used at two points along the length (see Fig. 5.). Notice that there are no windows of any sort between the sample position and the detectors. This is to stop any secondary scattering taking place which could potentially cause ‘spurious’ inelastic events.

MERLIN was the first instrument to use such long detectors. It means that it does not suffer from the large gaps in angular coverage that occur when shorter tubes are used as is the case with MAPS. The gaps were further minimized on MERLIN by putting all the detectors within the tank vacuum.

To eliminate any secondary scatter of neutrons, all the spectrometers at ISIS use evacuated secondary flight paths. However, the usual practice before MERLIN was to place the detectors in air behind aluminium windows. Struts are needed to support these windows, which are under huge forces, creating further gaps in the detector coverage. Putting the detector electronics in the tank vacuum could have potentially caused problems, heat dissipation and potential high voltage breakdown at intermediate pressures. The solution we chose for MERLIN was to keep the electronics at the end of each tube in air with vacuum feed throughs from each tube. Groups of 32 tubes are attached to large doors which vacuum seal to the back of the tank. These doors can be removed if it is necessary to replace a faulty tube. There are nine doors on the tank with a two tube gap between each door. Vertical vanes are positioned in these gaps to stop any cross scatter within the tank, see Fig. 5. The whole tank is lined with neutron absorbing $\text{B}_4\text{C}$ panels. These panels use a special non-hydrogenous glue to reduce potential scattering and also to reduce vacuum pump down times. The MERLIN tank is approximately 30m$^3$ in size and despite all the $\text{B}_4\text{C}$ and vacuum seals a cryogenic vacuum of about $4 \times 10^{-6}$ mbar is obtained eliminating the need for thick tails on the cryostats. For example, the total aluminium thickness from the tail and 30 K shield on the MERLIN top loading CCR is less than 0.5mm.

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Figure 5. A ‘Flattened out’ view of the detectors from the sample position. The get lost pipe can be seen on door 3 and the thin aluminium supporting straps at 1/3 and 2/3 of the way along the 3m tubes. The vertical structures are absorbing vanes to stop cross scatter. A ‘standard’ man is shown for scale. The dotted yellow lines show the solid angle of the MAPS detectors for comparison.

Figure 6. Debye Scherrer rings on the MERLIN detector bank from a powder sample.
COMMISSIONING MERLIN

One of the biggest challenges of this project was obtaining a good neutron position resolution along the 3m detector tubes. The original specification was to obtain a position resolution better than 25mm, the width of a tube. To obtain this meant re-designing the standard detector electronics. Measurements on MERLIN show that the position resolution achieved is about 20mm at the centre of the tubes increasing slightly to 23mm at the ends, well within specification. Detector and electronic stability also looks good with no change in detector efficiency or position resolution observable over the 9 months period of running. Another important factor for spectrometers is to have low backgrounds. A lot of care was taken on MERLIN both in the design of the guides and the shielding to minimize neutron backgrounds and spurious reflections. Results on MERLIN show that the backgrounds are homogeneous across the detector banks (no hot spots) with backgrounds of approximately 28 neutrons/hour/meter of detector tube. This was expected and compares well with the other spectrometers at ISIS.

In practice each 3m tube is split into 256 detector elements or 'pixels' of approx. 11mm in size. This gives 69000 pixels for the whole detector array. Each pixel typically has 2500 time channels giving a total of 172 million bins. Obviously for powders these pixels are grouped into rings. The power of the pixilated detectors is shown in Fig. 6 where the elastic scattering from a powder sample onto the large detector array shows well defined Debye Scherrer rings. One of the first inelastic measurements made on MERLIN was on powder UPd₃. This was previously measured on HET, enabling us to make a direct comparison by running with the same incident energy and chopper speeds. The measurements were performed with an \( E_i = 25 \text{meV} \) and a strong crystal field excitation can be observed at 16 meV (Fig. 7). HET only has a low angle detector bank from 3 to 30°, MERLIN proved to have 30 times the count rate of HET in the same angular range; a factor of 10 from the flux on the sample and another factor of 3 from the increase in solid angle. In reality MERLIN is not limited to such a small angular range and the real gain in signal is much more.

![Figure 7. The inelastic scattering from UPd₃ on a) HET and b) MERLIN.](image)

![Figure 8. Phonon dispersion in calcite single crystal (\( E_i = 45 \text{meV}, \text{room temperature} \)). The plot shows the Bragg peaks at the elastic line, and cuts in the inelastic region evidence the dispersion curves covering multiple Brillouin zones in both the \( a^* \) and \( c^* \) directions.](image)
However, the resolution on MERLIN is approximately 10% worse than on HET partly due to the broader moderator pulse and the slight increase in opening time of the Fermi chopper because of the extra beam divergence. Table 1 shows a comparison of the spectrometers performance at ISIS.

One of the most exciting possibilities for MERLIN is its ability to map complete Brillouin zones. This technique uses a single crystal and combines a series of measurements at different angles or energies to create a complete four dimensional map of the Brillouin zone with the four dimensions, $Q_x$, $Q_y$, $Q_z$, and energy being independent of one another. It is then possible to extract 3D, 2D or 1D cuts from this data in any direction within the crystal in software. In a test measurement using a calcite crystal, one hundred and eighty 10 minutes long runs were made where the crystal was rotated by one degree between runs. The lack of symmetry in calcite means that a full 180 degrees are required, for systems with cubic symmetry this would be reduced to just over 90 degrees. All the runs are then combined in software to produce a large 40Gb file from which cuts can be made. Fig. 8 shows a sample of the data where one can clearly see the phonon branches. This experiment shows that it is possible to measure all the excitations (below the incident energy) in all symmetry directions in approximately two days. In fact the majority of the requested beam time on the instrument is for this new mapping technique.

<table>
<thead>
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<th>MERLIN</th>
<th>HET</th>
<th>MARI</th>
<th>MAPS</th>
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<td>53</td>
<td>24</td>
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**Table 1.** Shows a comparison of various spectrometers at ISIS. The intensity is at 50meV and for 3% energy resolution. The last row is just a figure of merit.

**SUMMARY**

MERLIN is performing as was predicted in all aspects of operation from flux to backgrounds and beam divergence. Although MERLIN has only been running for a short period of time it has already produced some excellent science and has its first papers published on Phys. Rev.¹,² and Nature.³ In the last proposal round it was over-subscribed by a factor of three which shows the demand for this type of spectrometer. In December a new wide angle 9 Tesla magnet arrives at ISIS which has been designed specifically for MERLIN with large openings to view the complete detector bank. The HET spectrometer provided the science community with 20 years of excellent science and we believe MERLIN is a fitting successor.

We would like to thank Keith McEwen and Duc Lee for allowing us to present their data in Fig. 7, Martin Dove and Elizabeth Cope for the data in Fig. 8.

**REFERENCES**

3. Unconventional superconductivity in Ba0.6K0.4Fe2As2 from inelastic neutron scattering, A.D. Christianson et al., Nature 456, 930-932 (2008).
Oak Ridge Neutron Scattering Capabilities continue to expand

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The High Flux Isotope Reactor had six and one-half reactor cycles for users during the year ending September 2008. HFIR had 258 unique users: whether a user comes once or three times, they are counted once. Over 3500 hours of neutron production were delivered to users on seven instruments. During 2009, two additional instruments will become available to users, the Four-Circle Diffractometer and Neutron Powder Diffractometer, and a new wet-chemistry lab will become available. In addition to neutron scattering, HFIR also supported materials irradiation, commercial and medical isotope production, and neutron activation analysis.

The HFIR SANS instruments (General Purpose SANS and Bio-SANS) had the first publication of a peer-reviewed article resulting from research at those instruments. The article by Roger Pynn and his experimental team from Indiana University, Oak Ridge and Los Alamos National Laboratories appeared in Journal of Applied Crystallography, October 2008 [volume 41, issue 5, page 897]. The SANS data from ORNL provided critical corroboration of the correlations seen in a test of the spin echo angle measurement technique. The SANS data is included in the paper. The data in the paper represents the superior low-Q range from the General Purpose SANS obtained in a single instrument setting. The Spallation Neutron Source provided more than 2700 hours of neutron scattering for users during the year ending September 2008. In its first full year of operation, SNS had 165 unique users: whether a user comes once or three times, they are counted once. By the end of the year, four instruments were part of the user program. In 2009, users will visit five additional SNS instruments: Spallation Neutrons and Pressure (SNAP) Diffractometer, Cold Neutron Chopper Spectrometer (CNCS), Extended Q-Range SANS, Powder Diffractometer (POWGEN3), and Fine-Resolution Fermi Chopper Spectrometer (SEQUOIA).

The Fine Resolution Fermi Chopper Spectrometer (SEQUOIA, SNS BL 17) opened its shutter on October 7, 2008. SEQUOIA will provide unprecedented, high-resolution neutron scattering studies of the dynamics of atoms and molecules in materials. Researchers in the condensed matter and materials sciences will experience exceptional ability to analyze and understand the dynamics behind high-temperature superconductors, quantum and molecular magnetism and ferroelectric, piezoelectric and thermoelectric materials. The Fundamental Neutron Physics Beam Line (SNS, BL 13) opened its shutter to receive neutrons and its construction was completed in September 2008. This instrument will address the details of the internal structure of the neutron as well as the way in which the free neutron decays. Such experiments have important implications for fundamental questions in particle physics and cosmology. The first peer-reviewed article resulting from research utilizing the Wide Angular-Range Chopper Spectrometer (ARCS, SNS BL-18) appeared in Physical Review Letters, October 8, 2008 [volume 101, issue 15, article

ORNL’s Doug Abernathy describes operation of the ARCS instrument at SNS. (credit: ORNL)
157003]. Led by Andrew Christianson of ORNL, the experimental team used ARCS to probe iron-arsenic compounds. Construction has begun on the Joint Institute for Neutron Sciences (JINS) building adjacent to the SNS Central Laboratory and Office building. It is scheduled for completion early in 2010. Funded by the State of Tennessee, JINS will house University of Tennessee researchers, SNS scientists, and other ORNL researchers, but a significant portion of the space will be devoted to temporary visitors and facility users.

Preparations for the International Conference on Neutron Scattering continue. The Program Committee has been established with Paul Butler, NIST, as chair, and Meigan Aronson, Brookhaven and SUNY-Stony Brook, and Lee Robertson, ORNL, as co-chairs.

Additional information is available on this event, to be held in Knoxville, Tennessee, on May 3-7, 2009. Go to the web site http://neutrons.ornl.gov/conf/icns2009/index.shtml for additional information.

The book Neutron Applications in Earth, Energy and Environmental Sciences has been published by Springer. Edited by Liyuan Liang (ORNL), Romano Rinaldi (University of Perugia) and Helmut Schober (Institut Laue-Langevin), this is a comprehensive overview of the wide ranging applications of neutron scattering techniques to explain the fundamental materials properties at the nano-, micro- and meso-scale, which underpin research in these fields. More details about the book are available at www.springer.com/978-0-387-09415-1.

Mission Need Statement
approved for Second SNS Target Station

A Statement of Mission Need has been approved for the SNS Second Target Station by Raymond Orbach, Under Secretary for Science of the U.S. Department of Energy. This is the first step in the approval process for funding a facility that will double the science of the Spallation Neutron Source. By focusing on and optimizing for the production of cold neutrons, this new facility will provide much higher cold-neutron intensities than heretofore available on any pulsed neutron source.

The second target station at SNS will address three major themes appearing throughout discussions in forefront scientific areas that will rely on neutron studies. The first is the desire to extend current capabilities to be able to answer more difficult questions. These may involve extending measurements to higher resolution performing the measurements in the presence of a more difficult sample environment and concomitant restrictions to smaller samples, or measurements made to higher precision to look for subtle intensity variations or line shape effects. The second is the desire to extend most types of measurements to parametric studies exploring ranges of compositions, external fields such as temperature or pressure, or time scales, as in kinetic studies. The third is the general tendency toward the study of systems exhibiting greater complexity, such as the complex chemical systems that occurs in many soft matter studies, aspects of macromolecular functionality important in biology that may be explored using neutron scattering, or the multi-component systems important to the geophysical properties and functions relevant to earth sciences.

A. Ekkebus

Neutron/X-ray School attendees smile between lectures and experiments in Oak Ridge (credit: C. Boles, ORNL).
ACCESS under NMI3

Enabling optimum science to be performed under optimum conditions

Neutron and muon facilities are large scientific infrastructures. It is thus not surprising that they are geographically rather thinly spread. In addition, their distribution is not very homogeneous for various historical and science political reasons. With a continuously diversifying science landscape the optimum use of neutron sources cannot be assured locally but relies more than ever on efficient access mechanisms for a broad user community. From an encompassing performance point of view the most interesting scientific subjects have to be investigated with the most appropriate experimental probes under the best experimental conditions. Enabling this merger of best science and best infrastructure is particularly important for Europe, where many science political decisions are still taken on a national level. To preserve Europe’s pre-eminent position in neutron scattering it is more than legitimate to ask for mechanisms that give any scientist from any member state a fair chance of obtaining beam time on the facility best suited for his or her research on the sole basis of scientific excellence. In the case of the Institut Laue-Langevin this has been achieved via direct scientific membership of meanwhile 14 European countries. Through this route more than 90% of the neutron scattering community in Europe now has access to this European flagship facility. It is unrealistic to think that similar mechanisms could be set in place for the national sources. The cost in contractual and administrative burden is prohibitive.

Being a genuinely European task access to national sources asks for a European solution. The European Commission has recognized this fact and provided funding for trans-European access to national neutron and muon facilities via the Neutron and Muon Integrated Infrastructure Initiative NMI3 in Framework Programme 6. All major neutron and muon providers in Europe where integrated into the NMI3 network. From 2004 to 2008 more than 900 experiments have been conducted by 1800 users from 26 countries (European Union as well as associated countries; see Fig. 1). More than half of the users visited the respective facility for the first time, more than half of the users came from countries without a national source, and more than half of the users were of age under 40. These numbers clearly demonstrate the success of NMI3 ACCESS in developing and structuring the user community in the European Research Area.

The final verdict on the success of the programme is not statistics but science. ACCESS has given rise to a large number of outstanding results published in high-impact journals. In the present article we would like to showcase a few scientific investigations. It is our intention to convince the reader both about the quality and breadth (see Fig. 2) of the research carried out in the frameworks of ACCESS. The topics span the full range from fundamental questions of solid-state physics, via nano- and life-sciences to cultural heritage. The choice of examples naturally has to be arbitrary with such a huge amount of experiential work. It does in no way imply a rating of the science performed under NMI3 ACCESS.
Given the undeniable success of NMI3 ACCESS it may come as a surprise that its future is currently sincerely put into question. Due to cuts in the funding of NMI3 under FP7 a satisfactory ACCESS programme is currently only guaranteed for the years 2009 and 2010. We can only hope that in the context of a second European call for proposals in 2010 the situation will be reversed. The user community and the neutron and muon providers are willing to go further in their effort towards European integration by coming up with innovative solutions. However, as outlined above the orchestration of such an effort is a genuinely European task. To be efficient it relies on the support of the European Commission. It has to take into account both the aspirations of the user community and the legitimate interests of the national facilities. We as a community should do everything in our power to preserve and further develop this outstanding tool of scientific collaboration. This will require imagination in preparing the next European call for proposals as well as lobbying on the political front to make this call happen.

The NMI3 project has been supported by the European Commission under the 6th Framework Programme through the Key Action: Strengthening the European Research Area, Research Infrastructures. Contract n°: RII3-CT-2003-505925

The draft agreement has been signed for the 7th Framework Programme and the project is expected to start in February 2009.

Figure 2.
Use of ACCESS by the European Neutron and Muon Community broken down by nationality.
Shown is the number of unique ACCESS users normalised to the population.
The nationality is the site of the user’s affiliation.
The distribution is rather smooth.
Countries with no national facilities have a proportionally high share. This shows that NMI3 fulfils its role of bringing the wider European science community to the facilities.
Muons reveal a cascade of bulk magnetic phase transitions in Na$_x$CoO$_2$

P. Mendels, D. Bono, J. Bobroff,
N. Blanchard, H. Alloul, I. Mukhamedshin and F. Bert
Université Paris-Sud

G. Collin and D. Colson, CEA Saclay

A. Amato, Paul Scherrer Institut

A. Hillier, ISIS

Beyond their long-known ionic mobility which opened the route to applications for batteries, cobaltates are layered compounds which are receiving considerable attention. Whereas the Li-compound is famous for battery cells, the discoveries of both high thermoelectric power in metallic Na$_{0.7}$CoO$_2$ and superconductivity, maybe unconventional, in the hydrated Na$_{0.35}$CoO$_2$ compound, are at the heart of much intriguing physics in the Na compounds. A very rich phase diagram seems to involve many and possibly competing parameters such as doping, charge order, magnetism, frustration, strong electronic correlations. The physics relates to most topical problems in the field of correlated systems. We used µSR as a primary to reveal the magnetic phases of these Na$_x$CoO$_2$ compounds at low T. We have found that when the compounds display strong correlations, a magnetic order commensurate with the network is observed. Mutiple phases, all different, were clearly distinguished for $x \geq 0.75$. The $x = 0.5$ compound has the simplest Na ordering but displays a series of intriguing commensurate magnetic transitions unambiguously revealed by our work. This underlines that charge order is not the only parameter at work in these systems.

Figure 3. The frequencies at the muon sites reveal a cascade of magnetic transitions at 85, 48 and possibly 29 K. Inset: structure of lamellar cobaltates.

REFERENCES


New Phases of Ice

Despite its simple molecular structure, the water molecule exhibits considerable structural versatility and complexity in its condensed forms in which the H$_2$O molecules form extended hydrogen bonded networks. In fact, the water/ice system is the system frequently used in basic studies of both polymorphism of crystalline structures and polymorphism of non-crystalline ones. The existence and state of water or ice in the solar system is currently of great interest in international space research, and many space missions are concerned with finding and characterising ice or water in the solar system – for example in the permafrost soils on Mars, the existence of a possible sub-surface ocean on Jupiter’s moon Europa, and the cyrovolcanoes on the icy moons of Saturn.
We have recently synthesised a comb-type anionic copolymer, by grafting neutral poly (N,N-dimethylacrylamide) (PDMAM) chains onto an anionic poly(sodium acrylate-co-sodium 2-acrylamido-2-methylpropane sulphonate) backbone (P(NaA-co-NaAMPSA)), and studied the formation of soluble complexes with the protein bovine serum albumin (BSA), at pH lower than 4.9, i.e. the pI of BSA, where the protein molecules are positively charged. The complexation of BSA with two such anionic graft copolymers containing 75 and 87.5 wt.% of PDMAM, shortly designated as G75 and G87.5 correspondingly, at pH = 3.0, was investigated by small-angle neutron scattering (SANS), carried out at the Laboratoire Léon Brillouin (Saclay, France), in conjunction with dynamic light scattering (DLS) measurements.

REFERENCES

Small Angle Neutron Scattering for the Characterization of the Soluble Nanoparticles formed through Coulombic Interaction of Bovine Serum Albumin with Anionic Graft Copolymers at Low pH

We have recently synthesised a comb-type anionic copolymer, by grafting neutral poly (N,N-dimethylacrylamide) (PDMAM) chains onto an anionic poly(sodium acrylate-co-sodium 2-acrylamido-2-methylpropane sulphonate) backbone (P(NaA-co-NaAMPSA)), and studied the formation of soluble complexes with the protein bovine serum albumin (BSA), at pH lower than 4.9, i.e. the pI of BSA, where the protein molecules are positively charged. The complexation of BSA with two such anionic graft copolymers containing 75 and 87.5 wt.% of PDMAM, shortly designated as G75 and G87.5 correspondingly, at pH = 3.0, was investigated by small-angle neutron scattering (SANS), carried out at the Laboratoire Léon Brillouin (Saclay, France), in conjunction with dynamic light scattering (DLS) measurements.

REFERENCES
Liquid crystalline nanostructures, comprising bicontinuous cubic, sponge or inverted hexagonal lipid phases, as well as their nanoparticulate forms, are attractive systems for nanoencapsulation, protection and sustained release of peptides and protein drugs.

The lyotropic mesophases formed upon hydration of nonionic polar lipids, such as monoolein (MO), display enhanced encapsulation capacity resulting from the higher internal bilayer surface of the three-dimensional lipid architecture as compared to bilayer organizations in liposomes.

The structural evolution of a diamond-type bicontinuous lipid cubic phase of MO upon application of thermal and chemical (hydration agent) stimuli was investigated by means of small-angle neutron scattering (SANS). Two-dimensional SANS images were recorded upon heating and cooling scans. At low and ambient temperatures, and at low concentration of the hydration agent (n-octyl-beta-D-glucopyranoside surfactant, OG), the MO cubic phase swells from a DNormal to a DLarge cubic structure. The diameter of the aqueous nanochannels of the cubic structure increases twice (Left-side figure).

The neutron scattering intensity of the mixtures of BSA with G75 and G87.5 in solution in D_{2}O, was considerably increased, at low values of the wave vector q, in comparison with the scattering of the two pure components. This increase indicates the formation of hydrophobic complexes between the positively charged BSA molecules and the anionic backbone of the two graft copolymers. The low-q scattering, which is sensitive to the dimensions of individual, non-interacting and dense objects, has been exploited to determine the mass and radii of the complexes of BSA with G75 and G87.5. These radii, equal to 27 and 17 nm, respectively, can be compared to the hydrodynamic radii of 83 and 65 nm obtained by DLS. As the latter technique characterizes the hydrodynamic size, this discrepancy reveals a core-shell structure, with a dense complex core as observed by SANS, and a looser shell governing hydrodynamics, as it is depicted in Fig. 1. The BSA-anionic polymer complexes are thus stabilized in water by the neutral hydrophilic PDMAM side chains.

REFERENCES

"Characterization of the Soluble Nanoparticles Formed through Coulombic Interaction of Bovine Serum Albumin with Anionic Graft Copolymers at Low pH" Biomacromolecules 2007, 8, 1195-1199.
squeezing out the OG from the higher-curvature regions of the lipid bilayer, suggest a possible mechanism for the established transformations. The obtained results put forward a structure-based concept for release of encapsulated guest molecules from stimuli-responsive cubosomic nanocarriers. This study contributes to the development of controlled drug delivery systems, biosensors, and nanostructured fluid biomaterials.

REFERENCES

Bronze Age Manufacturing Techniques

Non-destructive characterisation of archaeological bronze finds from “Terramare” dwellings in Northern Italy, was carried out by ToF neutron scattering at the spallation neutron source ISIS of the Rutherford Appleton Laboratory, UK. The work provided information on the ancient metal technology during the Bronze Age in that region. Pieces pertaining to three different classes of materials as to use and manufacture, dating from the Middle to Late Bronze Age, were investigated on the ROTAX and GEM beam lines. Different workmanships were involved in the production of such diverse pieces hence providing evidence for manufacturing signatures. Data collected provided stable refinements of the phase fractions and lattice parameters by the Rietveld method allowing for the determination of Sn contents from the unit cell expansion due to the incorporation of Sn into the Cu-type α-phase. The objects exhibit a range of Sn contents from 1.6 to 14.3 wt% showing different degrees of alloy homogeneity. The higher Sn weight fractions are associated with the presence of two bronze phases (α and the eutectoid δ), interestingly coexisting with some pure unalloyed Cu. The identification of oxidation and alteration products such as cuprite and nantokite was crucial for conservation issues.

REFERENCES
The 9th edition of the School of Neutron Scattering “F. P. Ricci”, was held in S. Margherita di Pula (CA - IT) from September 22nd to October 3rd. This year, the school has been focused on the application of neutrons to structural determination in soft matter, in a wide range of correlation distances. Near and intermediate range order, along with wetting processes, have been considered and the students have been exposed to both theory and data handling sessions on SANS, neutron diffraction, and neutron reflectometry.

Teachers and students have represented a wide sample of European countries ranging from Spain to Hungary and from Scotland to Sicily. Among the teachers, we are pleased to mention and acknowledge, in particular, Bob Thomas, who has delivered in S. Margherita his last tutorial before retirement. His experience and enthusiasm, for science and teaching, have been an enjoyable lesson delivered to all of us.

The students have appreciated the general lectures and, in particular, the exercises and data handling sessions that were held during the second week. It was a pleasant surprise to discover with what care and competence they prepared and delivered their final reports.

It is worthwhile mentioning that our originally planned series of scientific talks, on subjects of interest in the recent literature that were scheduled at the beginning of section in the morning and after lunch with the undisclosed aim of bringing back the students to work, were hardly necessary. We are happy to admit that sometimes we had to change the schedule, because we felt unfair to
take their attention off while they were at work before us, and so busy with their data handling session. Lecture notes and other information on the school, along with a series of pictures, are available at the school website: http://webusers.fis.uniroma3.it/sns_fpr/.

The school would not have been complete without paying visit to Sardegna Ricerche, a research center established in S. Margherita di Pula in 1985, by the regional government of Sardinia. Students have spent an afternoon there and met staff scientists involved in research programs on renewable energy, biophysics, and new communication technologies.

The main topic of the school was the liquid state. As a matter of fact, liquids were everywhere, not only in our minds: the sea in front of our conference room, the mirto, in our glasses at the “baretto” after dinner, and unfortunately also some rain, almost every day over our packed lunch, no to mention the flooding of the conference room, which however was not able to interrupt the lectures that were held in the hall of Hotel Flamingo, under the curious sight of the other guests. As directors, we can only apologize for the inconvenience and stress, stating, if needed at all, that weather is usually much better in Sardinia.

Finally we acknowledge the financial support of: Association School of Neutron Scattering F.P. Ricci, Consiglio Nazionale delle Ricerche, Università degli Studi di Milano Bicocca, Università degli Studi di Palermo, Università degli Studi di Roma Tor Vergata, Università degli Studi Roma Tre and Department of Physics E. Amaldi, Sardegna Ricerche, ISIS Pulsed Neutron Source (UK) and ILL Reactor (F).
Call for Proposal [Deadlines for proposal submission]

Neutron Sources
http://pathfinder.neutron-eu.net/idb/access

1st March and 1st September 2009   **BENSC**
www.hmi.de/bensc/user-info/call-bensc_en.html

17th July 2009   **FRM II**
https://user.frm2.tum.de/

At anytime during 2009   **GeNF - Geesthacht Neutron Facility**
www.gkss.de/index_e.js.html

5th March 2009   **ILL**
www.ill.eu/users/experimental-programme/

16th April and 16th October 2009 **ISIS**
www.isis.rl.ac.uk/applying/

6th April and 14th September 2009 **JCNS FZ-Jülich**
www.jcns.info/jcns_proposals/

1st April and 1st October 2009   **LLB - Laboratoire Léon Brillouin**
http://pathfinder.neutron-eu.net/idb/access

15th May and 15th September 2009 **NPL - Neutron Physics Laboratory**
http://pathfinder.neutron-eu.net/idb/access

Synchrotron Radiation Sources
www.lightsources.org/cms/?pid=1000336#byfacility

30th June, 2009   **ANKA - Institute for Synchrotron Radiation**
http://ankaweb.fzk.de/user_information/beamtime.php?id=7

6th March and 10th July, 2009 **APS - Advanced Photon Source**
www.aps.anl.gov/Users/Calendars/GUP_Calendar.htm

1st March and 1st July, 2009   **AS - Australian Synchrotron**
Proposals are evaluated twice a year

- **BSRF - Beijing Synchrotron radiation Facility**
  - [www.ihep.ac.cn/bsrf/english/userinfo/beamtime.htm](http://www.ihep.ac.cn/bsrf/english/userinfo/beamtime.htm)
- **CFN - Center for Functional Nanomaterials**
- **CHESS - Cornell High Energy Synchrotron Source**
  - [www.chess.cornell.edu/proposals/index.htm](http://www.chess.cornell.edu/proposals/index.htm)
- **DIAMOND - Diamond Light Source**
  - [www.diamond.ac.uk/ForUsers/Welcome](http://www.diamond.ac.uk/ForUsers/Welcome)
- **ELETTRA**
  - [https://vuo.elettra.trieste.it/pls/vuo/guest.startup](http://https://vuo.elettra.trieste.it/pls/vuo/guest.startup)
- **FELIX - Free Electron Laser for Infrared experiments**
  - [www.rijnh.nl/research/guthz/felix_felice/](http://www.rijnh.nl/research/guthz/felix_felice/)
- **FOUNDRY - The Molecular Foundry**
- **HASYLAB - Hamburger Synchrotronstrahlungslabor at DESY**
  - [http://hasylab.desy.de/user_info/write_a_proposal/2_deadlines/index_eng.html](http://http://hasylab.desy.de/user_info/write_a_proposal/2_deadlines/index_eng.html)
- **NSLS - National Synchrotron Light Source**
- **NSRRC - National Synchrotron radiation Research Center**
  - [www.nsrrc.org.tw/](http://www.nsrrc.org.tw/)
- **SLS - Swiss Light Source**
- **SRC - Synchrotron Radiation Center**
  - [www.lightsources.org/cms/?pid=1000336](http://www.lightsources.org/cms/?pid=1000336)
- **SSRL - Stanford Synchrotron Radiation Laboratory**
  - [www-ssrl.slac.stanford.edu/users/user_admin/deadlines.html](http://www-ssrl.slac.stanford.edu/users/user_admin/deadlines.html)

**Proposals Schedule**

- **31st January, 31st May and 30th September, 2009**
- **30th April and 30th October 2009**
- **1st March, 1st April and 1st October, 2009**
- **28th February and 31st August, 2009**
- **1st June and 1st December, 2009**
- **11th February, 2009**
- **1st March and 1st September, 2009**
- **31st January, 31st May and 30th September, 2009**
- **30th January, 31st May and 30th September, 2009**
- **15th February, 15th March, 15th June, 15th September and 15th October, 2009**
- **1st February and 1st August, 2009**
- **1st April, 1st May, 1st July, 1st November and 1st December, 2009**
### Calendar

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<tr>
<th>Date</th>
<th>Location</th>
<th>Event</th>
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<tr>
<td>February 1-7, 2009</td>
<td>Cancun (Mexico)</td>
<td><strong>ICQNM 2009 - The Third Int. Conf. on Quantum, Nano and Micro Technol.</strong></td>
<td><a href="http://www.iaria.org/conferences2009/ICQNM09.html">www.iaria.org/conferences2009/ICQNM09.html</a></td>
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<td>February 1-6, 2009</td>
<td>Cancun (Mexico)</td>
<td><strong>ICDS 2009 - The Third International Conference on Digital Society</strong></td>
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<td>February 2-5, 2009</td>
<td>Grenoble (France)</td>
<td><strong>ESRF Users' Meeting 2009</strong></td>
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<td>February 10-13, 2009</td>
<td>Villigen (Switzerland)</td>
<td><strong>QENS 2009 9th Int. Conf. on Quasielastic Neutron Scattering</strong></td>
<td>Paul Scherrer Institut – <a href="http://qens2009.web.psi.ch/">http://qens2009.web.psi.ch/</a></td>
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<td>February 12-16, 2009</td>
<td>Chicago, IL (USA)</td>
<td><strong>2009 AAAS Annual Meeting</strong></td>
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<td>February 15-19, 2009</td>
<td>San Francisco (USA)</td>
<td><strong>TMS Symposium on Emerging Applications of Neutron Scattering in Materials Science and Engineering</strong></td>
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<td>February 25-27, 2009</td>
<td>Berlin (Germany)</td>
<td><strong>Workshop: Neutrons and X-rays meet biology</strong></td>
<td>Helmholtz Zentrum – <a href="http://www.helmholtz-berlin.de/events/biology/">www.helmholtz-berlin.de/events/biology/</a></td>
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<td>March 1 – April 4, 2009</td>
<td>Grenoble (France)</td>
<td><strong>Hercules 2009</strong></td>
<td><a href="http://hercules.grenoble.cnrs.fr/accueil.php?lang=en">http://hercules.grenoble.cnrs.fr/accueil.php?lang=en</a></td>
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<td>March 16-20, 2009</td>
<td>Pittsburgh, PA (USA)</td>
<td><strong>2009 American Physical Society Meeting</strong></td>
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<td>March 22-26, 2009</td>
<td>Salt Lake City, UT (USA)</td>
<td><strong>237th ACS National Meeting &amp; Exposition</strong></td>
<td><a href="http://portal.acs.org/portal/acs/corg/content/?_nfpb=true&amp;_pageLabel=PP">http://portal.acs.org/portal/acs/corg/content/?_nfpb=true&amp;_pageLabel=PP</a> _TRANSITIONMAIN&amp;node_id=2040&amp;use_sec=false&amp;sec_url_var=region1</td>
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<td>March 26 – April 3, 2009</td>
<td>Berlin (Germany)</td>
<td><strong>30th Berlin School on Neutron Scattering</strong></td>
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<tr>
<td>March 30-31, 2009</td>
<td>Villigen (Switzerland)</td>
<td><strong>NMI3 - FP7 General Meeting 2009</strong></td>
<td>Paul Scherrer Institut – <a href="http://neutron.neutron-eu.net/n_nmi3fp7/meetings">http://neutron.neutron-eu.net/n_nmi3fp7/meetings</a></td>
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April 13-17, 2009  San Francisco, CA (USA)
2009 MRS Spring Meeting
www.mrs.org/s_mrs/sec.asp?CID=10891&DID=201200

May 3-7, 2009  Knoxville, Tennessee (USA)
International Conference on Neutron Scattering
Knoxville Convention Center
www.mrs.org/s_mrs/sec.asp?CID=16316&DID=215968&SID=1

May 4-6, 2009  Argonne, IL (USA)

May 4-8, 2009  Vienna (Austria)
Int. Topical Meeting on Nuclear Research Appl. & Utilization of Accelerators
www-pub.iaea.org/MTCD/Meetings/Announcements.asp?ConfID=173

May 11-18, 2009  Giens peninsula
Contribution of Symmetries in Condensed Matter
www.ill.eu/news-events/workshops-events/ecotheorie-des-groupes/

May 11-15, 2009  Delft (Netherlands)
Neutron probing for compositional and structural characterisation of materials and biological samples
http://cdsagenda5.ictp.trieste.it/full_display.php?ida=a08219

May 13-16, 2009  Saint-Paul-lez-Durance (France)
4th International Workshop on Fission and Fission Product Spectroscopy
Chateau de Cadarache – www.fission2009.com/

June 24-25, 2009  Kuala Lumpur, Malaysia
Int. Conf. on Neutron and X-Rays Scattering 2009 (ICNX 2009)

June 25-28, 2009  Saskatoon (Canada)
Delta Bessborough Hotel – www.harmst.ca/

July 25-30, 2009  Toronto, Ontario (Canada)
ACA2009 - 2009 Annual Meeting of the American Crystallographic Ass.
Toronto Sheraton City Centre Hotel – www.cins.ca/aca2009/

July 26-31, 2009  Camerino (Italy)
XAFS 14 - 14th Int. Conf. on X-Ray Absorption Fine Structure
“Benedetto XII” Hall – www.xafs14.it/

July 27-30, 2009  Berlin (Germany)
Energy materials research using neutron and synchrotron radiation
http://physicsworld.com/cws/event/13658

July 26-31, 2009  Karlsruhe (Germany)
18th Int. Conf. on Magnetism ICM 2009
www.icm2009.de/
**Facilities**

**Neutron Scattering**

WWW SERVERS IN THE WORLD
http://idb.neutron-eu.net/facilities.php

**BNC - Budapest Research reactor**
Budapest Research Centre, Hungary
Type: Swimming pool reactor, 10MW
Email: tozser@sunserv.kfki.hu
http://www.bnc.hu/

**BENS - Berlin Neutron Scattering Center**
Hahn-Meitner-Institut
Glienicker Strasse 100, D-14109 Berlin, Germany
Phone: +49/30/8062-2778
Fax: +49/30/8062-2523
Email: bensc@hmi.de
http://www.hmi.de/bensc/

**FLNP - Frank Laboratory of Neutron Physics**
Gpulsed reactor, mean 2 MW, pulse 1500 MW
Joint Institute for Nuclear Research, Dubna, Russia
Email: post@jinr.ru
http://www.jinr.ru/

**FRG-1**
Type: Swimming Pool Cold Neutron Source.
Flux: 8.7 x 10^13 n/cm²/s
Address for application forms and info: Reinhard Kampmann, Institute for Materials Science, Div. Wfn-Neutronscttering, GKSS Research Centre, 21502 Geesthacht, Germany
Phone: +49 (0) 4152 87 1316/2503
Fax: +49 (0) 4152 87 1338
Email: reinhard.kampmann@gkss.de
http://www.gkss.de/central_departments/genf/index.html.de

**FRM II**
Technische Universität München
Type: Compact 20 MW reactor.
Flux: 8 x 10^14 n/cm²/s
Address for information: Prof. Winfried Petry,
FRM-II Lichtenbergstrasse 1 - 85747 Garching
Phone: 089 289 14701
Fax: 089 289 14666
Email: wpetry@frm2.tum.de

**HFIR**
ORNL, Oak Ridge, USA
Phone: (865)574-5231
Fax: (865)576-7747
Email: ns_user@ornl.gov
http://neutrons.ornl.gov

**HIFAR**
ANSTO, Australia
New Illawarra Road, Lucas Heights NSW, Australia
Phone: 61 2 9717 3111
Email: enquiries@ansto.gov.au
http://www.ansto.gov.au

**ILL Grenoble (F)**
Type: 58MW High Flux Reactor.
Flux: 1.5 x 10^15 n/cm²/s
Scientific Coordinator: Dr. G. Cicognani, ILL, BP 156, 38042 Grenoble Cedex 9, France
Phone: +33 4 7620 7179
Fax: +33 4 76483906
Email: cico@ill.fr and sco@ill.fr
http://www.ill.eu

**IPNS - Intense Pulsed Neutron at Argonne**
Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439-4814, USA
Phone: 630/252-7820
Fax: 630/252-7722
for proposal submission by e-mail send to cpeters@anl.gov or mail/fax to IPNS Scientific Secretary, Building 360
http://www.pns.anl.gov/

**ISIS Didcot**
Type: Pulsed Spallation Source.
Flux: 2.5 x 10^16 n fast/s
Address for application forms: ISIS Users Liaison Office, Building R3, Rutherford Appleton Laboratory, Chilton, Didcot, Oxon OX11 0QX, UK
Phone: +44 (0) 1235 445592
Fax: +44 (0) 1235 445103
Email:uls@isis.rl.ac.uk
http://www.isis.rl.ac.uk

**JRR-3M**
Tokai-mura, Naka-gun, Ibaraki-ken 319-11, Japan
Jun-ichi Suzuki, JAERI - Japan Atomic Energy Research Institute
Yuji Ito (ISSP, Univ. of Tokyo)
Fax: +81 292 82 5922
Telex: JAERI24596
Email: www-admin@www.jaea.go.jp
http://idb.neutron-eu.net/facilities.php
JEEP-II Reactor
Type: D2O moderated 3.5% enriched UO2 fuel.
Flux: 2 x 10^13 n/cm²/s
Address for application forms: K.H. Bendiksen, Managing Director
Institutt for Energetikk, Box 40, 2007 Kjeller, Norway
Phone: +47 63 806000, 806275
Fax: +47 63 816356
Email: kjell.bendiksen@ife.no

KENS
Institute of Materials Structure Science
High Energy Accelerator research Organisation
1-1 Oho, Tsukuba-shi, Ibaraki-ken, 305-0801, JAPAN
Email: kens-pac@nml.kek.jp
http://neutron-www.kek.jp/index_e.html

KUR - Kyoto University Research Reactor Institute
Kumatori-cho Sennan-gun, Osaka 590-0494, Japan
Phone: +81-72-451-2300
Fax: +81-72-451-2600
http://www.ri.kyoto-u.ac.jp/en/

LANSCE
Los Alamos Neutron Science Center
TA-53, Building 1, MS H831, Los Alamos National Lab, Los Alamos, USA
Phone: +1 505-665-8122
Email: tichavez@lanl.gov
http://www.lansce.lanl.gov/

LLB Orphée Saclay (F)
Type: Reactor. Flux: 3.0 x 10^14 n/cm²/s
Laboratoire Léon Brillouin (CEA-CNRS)
Email: experience@llb.cea.fr
http://www-llb.cea.fr

NFL - Studsvick Neutron Research Laboratory
Uppsala University - Studsvik Nuclear AB, Stockholm, Sweden
Type: swimming pool type reactor, 50 MW, with additional reactor 1 MW
http://ridb.neutron-eu.net/facilities.php

NCNR - NIST Center for Neutron Research
National Institute of Standards and Technology
100 Bureau Drive, Stop 6100, Gaithersburg, MD 20899-6100, USA
Robert Dimeo, Deputy Director
Phone: (301) 975-6210
Fax: (301) 869-4770
Email: robert.dimeo@nist.gov
http://www.ncnr.nist.gov

NPL - NRI
Type: 10 MW research reactor.
Address for information: Zdenek Kriz, Scientific Secretary
Nuclear Research Institute Rez plc, 250 68 Rez - Czech Republic
Phone: +420 2 20941177 / 66173428
Fax: +420 2 20941155
Email: krz@ujv.cz and brv@nri.cz
http://neutron.ujf.cas.cz/

NRU - Chalk River Laboratories
The peak thermal flux 3x10^14 cm⁻² sec⁻¹
Neutron Program for Materials Research
National Research Council Canada
Building 459, Station 18, Chalk River Laboratories, Chalk River
Ontario - Canada K0J 1J0
Phone: 1 - (888) 243-2634 (toll free)
Phone: 1 - (613) 584-8811 ext. 3973
Fax: 1- (613) 584-4040
http://neutron.nrc-cnrc.gc.ca/home_e.html

RID - Reactor Institute Delft (NL)
Type: 2MW light water swimming pool.
Flux: 1.5 x 10^13 n/cm²/s
Address for application forms:
Dr. M. Blaauw, Head of Facilities and Services Dept.
Reactor Institute Delft, Faculty of Applied Sciences
Delft University of Technology, Mekelweg 15
2629 JB Delft, The Netherlands
Phone: +31-15-2783528
Fax: +31-15-2788303
Email: m.blaauw@tudelft.nl
http://www.rid.tudelft.nl/live/pagina.jsp?id=b15d7df9-7928-441e-b45d-6ecce78d6b0e&lang=en

SINQ Villigen (CH)
Type: Steady spallation source
Flux: 2.0 x 10^14 n/cm²/s
Contact address: PSI-Paul Scherrer Institut
User Office, CH-5232 Villigen PSI, Switzerland
Phone: +41 56 310 4666
Fax: +41 56 310 3294
Email: sinq@psi.ch
http://sinq.web.psi.ch

SNS - Spallation Neutron Source
ORNL, Oak Ridge, USA
Address for information: Allen E. Ekkebus
Spallation Neutron Source, Oak Ridge National Laboratory
One Bethel Valley Road, Bldg 8600, P.O. Box 2008, MS 6460
Oak Ridge, TN 37831-6460
Phone: (865) 241-5644
Fax: (865) 241-5177
Email: ekkebusae@ornl.gov
http://neutrons.ornl.gov
Facilities

Synchrotron Radiation Sources
WWW SERVERS IN THE WORLD
www.lightsources.org/cms/?pid=1000098

ALBA - Synchrotron Light Facility
CELLS – ALBA, Edifici Ciències. C-3 central. Campus UAB
Campus Universitari de Bellaterra. Universitat Autònoma de Barcelona
08193 Bellaterra, Barcelona - Spain
Phone: +34 93 592 43 00
Fax: +34 93 592 43 01
http://www.cells.es/

ALS - Advanced Light Source
Berkeley Lab, 1 Cyclotron Rd, MS6R2100, Berkeley, CA 94720
Phone: +1 510.486.7745
Fax: +1 510.486.4773
Email: alsuser@lbl.gov
http://www-als.lbl.gov/als/

ANKA
Forschungszentrum Karlsruhe Institut für Synchrotronstrahlung
Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany
Phone: +49 (0)7247 / 82-6071
Fax: +49-(0)7247 / 82-6172
Email: info@fzk.de
http://ankaweb.fzk.de/

APS - Advanced Photon Source
Argonne Nat. Lab. 9700 S. Cass Avenue, Argonne, IL 60439, USA
Phone: (630) 252-2000
Fax: +1 708 252 3222
Email: fenner@aps.anl.gov
http://www.aps.anl.gov/

AS - Australian Synchrotron
Level 17, 80 Collins St, Melbourne VIC 3000, Australia
Phone: +61 3 9655 3315
Fax: +61 3 9655 8666
Email: contact.us@synchrotron.vic.gov.au

BESSY - Berliner Elektronenspeicherring
Gesellschaft für Synchrotronstrahlung
BESSY GmbH, Albert-Einstein-Str.15, 12489 Berlin, Germany
Phone: +49 (0)30 6392-2999
Fax: +49 (0)30 6392-2990
Email: info@bessy.de
http://www.bessy.de/

BSRF - Beijing Synchrotron Radiation Facility
BEPC National Laboratory, Institute of High Energy Physics, Chinese Academy of Sciences
P.O.Box 918, Beijing 100039, P. R. China
Phone: +86-10-68235125
Fax: +86-10-68222013
Email: houbz@mail.ihep.ac.cn

CAMD - Center Advanced Microstructures & Devices
CAMD/LSU 6980 Jefferson Hwy, Baton Rouge, LA 70806, USA
Phone: +1 (225) 578-8887
Fax: +1 (225) 578-6954
Email: leeann@lsu.edu
http://www.camd.lsu.edu/

CANDLE - Center for the Advancement of Natural Discoveries using Light Emission
Acharyan 31, 375040, Yerevan, Armenia
Phone/Fax: +374-1-629806
Email: baghiryanzasls.candle.am
http://www.candle.am/index.html

CESLAB - Central European Synchrotron Laboratory
Coordinated by The Academy of Sciences of the Czech Republic
Assoc. Prof. RNDr. Stanislav Kozubek, DrSc.
Director of the Institute of Biophysics AS CR, v.v.i
Kralovopolska 135, 612 65 Brno, Czech Republic
Phone: +420-541517500
Email: kozubek@ibp.cz
http://www.synchrotron.cz/synchrotron/Central_European_Synchrotron_Laboratory_EN.html

CFN - Center for Functional Nanomaterials
User Administration Office
Brookhaven National Laboratory, P.O. Box 5000, Bldg. 555
Upton, NY 11973-5000, USA
Phone: +1 (631) 344-6266
Fax: +1 (631) 344-3093
Email: cfnuser@bnl.gov
http://www.bnl.gov/cfn/

CHESS - Cornell High Energy Synchrotron Source
Cornell High Energy Synchrotron Source
200L Wilson Lab, Rt. 366 & Pine Tree Road, Ithaca, NY 14853, USA
Phone: +1 (607) 255-7163 / +1 (607) 255-9001
http://www.chess.cornell.edu/

CLIO - Centre Laser Infrarouge d’Orsay
CLIO/LCP
Bat. 201 - P2, Campus Universitaire
91405 ORSAY Cedex, France
http://clio.lcp.u-psud.fr/clio_eng/clio_eng.htm
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**CLS - Canadian Light Source**  
Canadian Light Source Inc., University of Saskatchewan  
101 Perimeter Road Saskatoon, SK., Canada. S7N 0X4  
**Phone:** (306) 657-3500  
**Fax:** (306) 657-3535  
**Email:** clsuo@lightsource.ca  
**http:** //www.lightsource.ca/  

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**CNM - Center for Nanoscale Materials**  
Argonne National Laboratory, 9700 S. Cass Avenue. Bldg. 440  
Argonne, IL 60439, USA  
**Phone:** (630) 252-2000  
**http:** //nano.anl.gov/facilities/index.html  

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**CTST - UCSB Center for Terahertz Science and Technology**  
University of California, Santa Barbara (UCSB), USA  
**http:** //sbfel3.ucsb.edu/  

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**DAFNE Light**  
INFN-LNF  
Via Enrico Fermi, 40, I-00044 Frascati (Rome), Italy  
**Fax:** +39 6 94032597  
**http:** //www.lnf.infn.it/esperimenti/sr_dafne_light/  

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**DELSY - Dubna Electron SYnchrotron**  
JINR Joliot-Curie 6, 141980 Dubna, Moscow Region, Russia  
**Email:** post@jinr.ru  
**http:** //www.jinr.ru/delsy/  

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**DELTA - Dortmund Electron Test Accelerator**  
FELICITA I (FEL)  
Institut für Beschleunigerphysik und Synchrotronstrahlung, Universität Dortmund  
Maria-Goeppert-Mayer-Str. 2, 44221 Dortmund, Germany  
**Fax:** +49-(0)-231-755-5383  
**http:** //www.delta.uni-dortmund.de/index.php?id=2&L=1  

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**DFELL - Duke Free Electron Laser Laboratory**  
Duke Free Electron Laser Laboratory  
PO Box 90319, Duke University Durham, North Carolina 27708-0319, USA  
**Phone:** 1 (919) 660-2666  
**Fax:** +1 (919) 660-2671  
**Email:** beamtime@fel.duke.edu  
**http:** //www.fel.duke.edu/  

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**Diamond Light Source**  
Diamond Light Source Ltd  
Diamond House, Chilton, Didcot, OXON, OX11 0DE, UK  
**Phone:** +44 (0)1235 778000  
**Fax:** +44 (0)1235 778499  
**Email:** useroffice@diamond.ac.uk  
**http:** //www.diamond.ac.uk/default.htm  

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**ELETTRA - Synchrotron Light Laboratory**  
Sincrotrone Trieste S.C.p.A  
S.S. 14 - Km 163,5 in AREA Science Park, 34012 Basovizza, Trieste, Italy  
**Phone:** +39 40 37581  
**Fax:** +39 (040) 938-0902  
**http:** //www.elettra.trieste.it/  

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**ELSA - Electron Stretcher Accelerator**  
Physikalisches Institut der Universität Bonn  
Beschleunigeranlage ELSA, Nußallee 12, D-53115 Bonn, Germany  
**Phone:** +49-228-735926  
**Fax:** +49-228-733620  
**Email:** roy@physik.uni-bonn.de  
**http:** //www.elsa.physik.uni-bonn.de/elsa-facility_en.html  

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**ESRF - European Synchrotron Radiation Lab.**  
6 Rue Jules Horowitz, BP 220, 38043 Grenoble Cedex 9, France  
**Phone:** +33 (0)4 7688 2000  
**Fax:** +33 (0)4 7688 2020  
**Email:** useroff@esrf.fr  
**http:** //www.esrf.eu/  

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**FELBE - Free-Electron Lasers at the ELBE radiation source at the FZR/Dresden**  
Bautzner Landstrasse 128, 01328 Dresden, Germany  
**http:** //www.fzd.de/db/Cms?pNid=471  

---

**FELIX - Free Electron Laser for Infrared eXperiments**  
FOM Institute for Plasma Physics ’Rijnhuizen’  
Edisonbaan, 14, 3439 MN Nieuwegein, The Netherlands  
**Phone:** +31-30-6096999  
**Fax:** +31-30-6031204  
**Email:** B.Redlich@rijnh.nl  
**http:** //www.rijnh.nl/felix/  

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**FOUNDATION - The Molecular Foundry**  
1 Cyclotron Road  
Berkeley, CA 94720, USA  
**http:** //foundry.lbl.gov/index.html  

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**HASYLAB - Hamburger Synchrotronstrahlungslabor**  
DESY - HASYLAB  
Notkestrasse 85, 22607 Hamburg, Germany  
**Phone:** +49 40 / 8998-2304  
**Fax:** +49 40 / 8998-2020  
**Email:** HASYLAB@DESY.de  
**http:** //hasylab.desy.de/  

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**HSFC - Hiroshima Synchrotron Radiation Center**  
HiSOR  
Hiroshima University  
2-313 Kagamiyama, Higashi-Hiroshima, 739-8526, Japan  
**Phone:** +81 82 424 6293  
**Fax:** +81 82 424 6294  
**http:** //www.hsrc.hiroshima-u.ac.jp/english/index-e.htm

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iFEL
Institute of Free Electron Laser, Graduate School of Engineering, Osaka University
2-9-5 Tsuda-Yamate, Hirakata, Osaka 573-0128, Japan
Phone: +81-(0)72-897-6410
http://www.fel.eng.osaka-u.ac.jp/english/index_e.html

INDUS -1 / INDUS -2
Centre for Advanced Technology Department of Atomic Energy Government of India, P.O. CAT Indore, M.P - 452 013, India
Phone: +91-731-248-8003
Fax: 91-731-248-8000
Email: rvn@cat.ernet.in
http://www.cat.ernet.in/technology/accel/indus/index.html
http://www.cat.ernet.in/technology/accel/atdhome.html

IR FEL Research Center - FEL-SUT
IR FEL Research Center, Research Institutes for Science and Technology The Tokyo University of Science
Yamazaki 2641, Noda, Chiba 278-8510, Japan
Phone: +81 4-7121-4290
Fax: +81 4-7121-4298
Email: felsut@rs.noda.sut.ac.jp
http://www.rs.noda.sut.ac.jp/~felsut/english/index.htm

ISA Institute for Storage Ring Facilities - ASTRID-1
ISA, University of Aarhus, Ny Munkegade, bygn. 520, DK-8000 Aarhus C, Denmark
Phone: +45 8942 3778
Fax: +45 8612 0740
Email: fyssp@phys.au.dk
http://www.isa.au.dk/

ISI-800
Institute of Metal Physics
National Academy of Sciences of Ukraine
Phone: +(380) 44 424-1005
Fax: +(380) 44 424-2561
Email: metall@imp.kiev.ua

Jlab - Jefferson Lab FEL
12000 Jefferson Avenue, Newport News, Virginia 23606 USA
Phone: (757) 269-7767
http://www.jlab.org/FEL

Kharkov Institute of Physics and Technology - Pulse stretcher/Synchrotron Radiation
National Science Center, KIPT, 1
Akademicheskaya St., Kharkov, 61108, Ukraine
http://www.kipt.kharkov.ua/indexe.html

KSR - Nuclear Science Research Facility - Accelerator Laboratory
Gokasho, Uji, Kyoto 611
Fax: +81-774-38-3289
http://wwwal.kuicr.kyoto-u.ac.jp/www/index-e.htmlx

KSRS - Kurchatov Synchrotron Radiation Source
Siberia-1 / Siberia-2
Kurchatov Institute 1
Kurchatov Sq., Moscow 123182, Russia
http://www.kiaeu.ru/

LCLS - Linac Coherent Light Source
Stanford Linear Accelerator Center (SLAC)
2575 Sand Hill Road, Menlo Park, CA 94025, USA
Phone: +1 (650) 926-3191
Fax: +1 (650) 926-3600
Email: knotts@ssrl.slac.stanford.edu
http://www-ssrl.slac.stanford.edu/lcls/

LNLS - Laboratorio Nacional de Luz Sincrotron
Caixa Postal 6192, CEP 13084-971, Campinas, SP, Brazil
Phone: +55 (0) 19 3512-1010
Fax: +55 (0)19 3512-1004
Email: sau@lnls.br
http://www.lnls.br/lnls/cgi/cgilua.exe/sys/start.htm?UserActiveTemplate=lnls%5F2007%5Fenglish&tpl=home

MAX-Lab
Box 118, University of Lund, S-22100 Lund, Sweden
Phone: +46-222 9872
Fax: +46-222 4710
http://www.maxlab.lu.se/

Medical Synchrotron Radiation Facility
National Institute of Radiological Sciences (NIRS)
4-9-1, Anagawa, Inage-ku, Chiba-shi, 263-8555, Japan
Phone: +81-(0)43-251-2111
http://www.nirs.go.jp/ENGi/index.html

MLS - Metrology Light Source
Physikalisch-Technische Bundesanstalt
Willy-Wien-Laboratorium Magnusstraße 9, 12489 Berlin, Germany
Phone: +49 30 3481 7312
Fax: +49 30 3481 7550
Email: Gerhard.Ulm@ptb.de
http://www.ptb.de/MLS/

NSLS - National Synchrotron Light Source
NSLS User Administration Office
Brookhaven National Laboratory, P.O. Box 5000, Bldg. 725B, Upton, NY 11973-5000, USA
Phone: +1 (631) 344-7976
Fax: +1 (631) 344-7206
Email: nslsuser@bnl.gov
http://www.nsls.bnl.gov/

NSRL - National Synchrotron Radiation Laboratory
University od Sciente and Technology China (USTC)
Hefei, Anhui 230029, PR China
Phone: +86-551-3601989
Fax: +86-551-5140178
Email: zdh@ustc.edu.cn
http://www.nsrl.ustc.edu.cn/en/
NSRRC - National Synchrotron Radiation Research Center
National Synchrotron Radiation Research Center
101 Hsin-Ann Road, Hsinchu Science Park, Hsinchu 30076, Taiwan, R.O.C.
Phone: +886-3-578-0281
Fax: +886-3-578-9816
Email: user@nsrrc.org.tw
http://www.nsrrc.org.tw/

NSSR - Nagoya University Small Synchrotron Radiation Facility
Nagoya University
4-9-1, Anagawa, Inage-ku, Chiba-shi, 263-8555, Japan
Phone: +81-(0)-43-251-2111
http://www.nagoya-u.ac.jp/en/

PAL - Pohang Accelerator Laboratory
San-31 Hyoja-dong Pohang Kyungbuk 790-784, Korea
http://pal.postech.ac.kr/eng/index.html

PF - Photon Factory
KEK 1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan
Phone: +81 (0)-29-879-6009
Fax: +81 (0)-29-864-4402
Email: users.office2@post.kek.jp
http://pfwww.kek.jp/

PSLS - Polish Synchrotron Light Source
Centrum Promieniowani Synchrontronowego Sp. z o.o.
ul. Remonta 4, PL - 30-059 Kraków
Phone: +48 (12) 663 58 20
Email: mail@synchrotron.pl
http://www.if.uj.edu.pl/Synchro/

Ritsumeikan University SR Center
Ritsumeikan University (Rits) SR Center
Biwako-Kusatsu Campus, Noji Higashi 1-chome, 1-1 Kusatsu,
525-8577 Shiga-ken, Japan
Phone: +81 (0)-77 561-2806
Fax: +81 (0)-77 561-2859
Email: d11-www-adm@se.ritsumei.ac.jp
http://www.ritsumei.ac.jp/se/re/SLLS/newpage13.htm

SAGA-LS - Saga Light Source
Kyushu Synchrotron Light Research Center
8-7 Yayoigaoka, Tosu, Saga 841-0005, Japan
Phone: +81-942-83-5017
Fax: +81-942-83-5196
http://www.saga-ls.jp/?page=173

SESAME Synchrotron-light for Experimental Science and Applications in the Middle East
E-mail: hhelal@mail.eun.eg

SLS - Swiss Light Source
Paul Scherrer Institut reception building, PSI West,
CH-5232, Villigen PSI, Switzerland
Phone: +41 56 310 4666
Fax: +41 56 310 3294
Email: slsuo@psi.ch
http://sls.web.psi.ch/view.php/about/index.html

SOLEIL
Synchrotron SOLEIL
L’Orme des Merisiers
Saint-Aubin - BP 48 91192 Gif-sur-Yvette Cedex, France
Phone: +33 1 6935 9652
Fax: +33 1 6935 9456
Email: frederique.fraissard@synchrotron-soleil.fr
http://www.synchrotron-soleil.fr/portal/page/portal/Accueil

SPL - Siam Photon Laboratory
The Siam Photon Laboratory of the National Synchrotron Research Center
111 University Avenue, Muang District, Nakhon Ratchasima 30000,
Thailand
Postal Address: PO. BOX 93, Nakhon Ratchasima 30000, Thailand
Phone: +66-44-21-7040
Fax: +66-44-21-7047, +66-44-21-7040 ext 211
http://www.slr.or.th/new_eng/

SPring-8
Japan Synchrotron Radiation Research Institute (JASRI)
Kouto, Sayo-cho, Sayo-gun, Hyogo 679-5198, Japan
Phone: +81-(0)-791 58-0961 - fax: +81-(0)-791 58-0965
Email: sp8jasri@spring8.or.jp
http://www.spring8.or.jp/en/

SRC - Synchrotron Radiation Center
Synchrotron Radiation Center
3731 Schneider Dr., Stoughton, WI 53589-3097, USA
Phone: +1 (608) 877-2000
Fax: +1 (608) 877-2001
http://www.src.wisc.edu/

SSLS - Singapore Synchrotron Light Source - Helios II
National University of Singapore (NUS)
Singapore Synchrotron Light Source, National University of Singapore
5 Research Link, Singapore 117603, Singapore
Phone: (65) 6874-6568
Fax: (65) 6773-6734
http://ssls.nus.edu.sg/index.html

SSRC - Siberian Synchrotron Research Centre VEPP3/VEPP4
Lavrentyev av. 11, Budker INP, Novosibirsk 630090, Russia
Phone: +7(3832)39-44-98
Fax: +7(3832)34-21-63
Email: G.N.Kulipanov@inp.nsk.su
http://ssrc.inp.nsk.su/english/load.pl?right=general.html
SSRF - Shanghai Synchrotron Radiation Facility
http://ssrf.sinap.ac.cn/english/

SSRL - Stanford Synchrotron Radiation Laboratory
Stanford Linear Accelerator Center
2575 Sand Hill Road, Menlo Park, CA 94025, USA
Phone: +1 650-926-3191
Fax: +1 650-926-3600
Email: knotts@ssrl.slac.stanford.edu
http://www-ssrl.slac.stanford.edu/users/user_admin/ura_staff_new.html

SuperSOR - SuperSOR Synchrotron Radiation Facility
Synchrotron Radiation Laboratory
Institute for Solid State Physics, The University of Tokyo
5-1-5 Kashiwa-no-ha, Kashiwa, Chiba 277-8581, Japan
Phone: +81 (0471) 36-3405
Fax: +81(0471) 34-6041
Email: kakizaki@issp.u-tokyo.ac.jp
http://www.issp.u-tokyo.ac.jp/labs/sor/project/MENU.html

SURF - Synchrotron Ultraviolet Radiation Facility
NIST, 100 Bureau Drive, Stop 3460, Gaithersburg,
MD 20899-3460, USA
Phone: +1 (301) 975-4200

TNK - F.V. Lukin Institute
State Research Center of Russian Federation
103460, Moscow, Zelenograd
Phone: +7(095) 531-1306 / +7(095) 531-1603
Fax: +7(095) 531-4656
Email: admin@niifp.ru
http://www.niifp.ru/index_e.html

TSRF - Tohoku Synchrotron Radiation Facility
Laboratory of Nuclear Sciente
Tohoku University
Phone: +81 (022)-743-3400
Fax: +81 (022)-743-3401
Email: koho@LNS.tohoku.ac.jp
http://www.lns.tohoku.ac.jp/index.php

UVSOR - Ultraviolet Synchrotron Orbital Radiation Facility
UVSOR Facility, Institute for Molecular Sciente, Myodaiji,
Okazaki 444-8585, Japan
http://www.uvsor.ims.ac.jp/defaultE.html

VU FEL - W.M. Keck Vanderbilt Free-electron Laser Center
410 24th Avenue, Nashville, TN 37212, Box 1816, Stn B,
Nashville, TN 37235, USA
http://www.vanderbilt.edu/fel/

INFORMATION
on Conference Announcements and Advertising
for Europe and US, rates and inserts can be found at:
www.cnr.it/neutronielucedisincrotrone

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