FRM II
Forschungs-Neutronenquelle
Heinz Maier-Leibnitz

JCNS
Jülich Centre for Neutron Science

HZB Helmholtz
Zentrum Berlin

Helmholtz-Zentrum
Geesthacht
Zentrum für Material- und Küstenforschung

ToFToF:
Extended number of detectors

FRM II news

6

Contents

Instrumentation

Science & Projects

Events

Inside

Outside

User Office

Don‘t forget to submit your proposal!
Next deadline: November 4th, 2011

FRM II
Forschungs-Neutronenquelle
Heinz Maier-Leibnitz

JCNS Jülich Centre for Neutron Science

user.frm2.tum.de

fzj.frm2.tum.de

FRM II
Forschungs-Neutronenquelle
Heinz Maier-Leibnitz

JCNS Jülich Centre for Neutron Science

HZB Helmholtz Zentrum Berlin

Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung

TUM

Dear users of the FRM II,

it is a special and unique feature of the instrumentation of the FRM II that the suite of instruments for neutron science and technology was planned, developed and realized by a large number of groups from various universities and research centres in Germany. Almost all prominent groups active in this research area contributed with their large spectrum of experience to the conceptual design of the different instruments. In this way know how from national and international neutron sources was integrated. Besides of the major institutions like the Technische Universität München (TUM) and the Helmholtz Centres at Jülich, Geesthacht and Berlin also the Max-Planck-Gesellschaft (MPI for Solid State Research and MPI for Metals Research) and Universities from Aachen, Augsburg, Clausthal, Darmstadt, Dresden, Göttingen, Köln and München (UniBw and LMU) were involved. The first 14 neutron beam instruments started their commissioning and became soon operational with the beginning of the routine operation of FRM II in 2005. After the shut down of the Jülich research reactor FRJ-2 in 2006, the Jülich Centre for Neutron Science (JCNS) was founded and seven additional instruments were installed at the FRM II. Also the HZB and the GKSS, especially after the shut down of the FRG-1 reactor in 2010, have increased their engagement at the FRM II. Actually altogether 27 instruments and are available now. The planning and realization of the instruments was coordinated by a board of specialists, the so-called "Instrumentierungsausschuss", who gave their advice to the "Strategierat" and the directors of the FRM II.

Even now, after the periods of construction and commissioning are finished, scientists from the various groups operate and constantly upgrade the instruments to assure that the FRM II is one of the world's leading facilities in neutron science and technology. The current long maintenance break of the FRM II is also used for reconstruction of instruments and to modify or exchange components of the neutron beam optics. Moreover, these scientists are the local contacts for the users. They give support and instructions to help them to obtain highest quality experimental results.

Gernot Heger

Gernot Heger has chaired the Instrumentation advisory board from 1996 to 2001 and the steering committee (Strategierat) from 2001 to 2011.

SANS-1

The new magenta coloured colossus for small-angle scattering

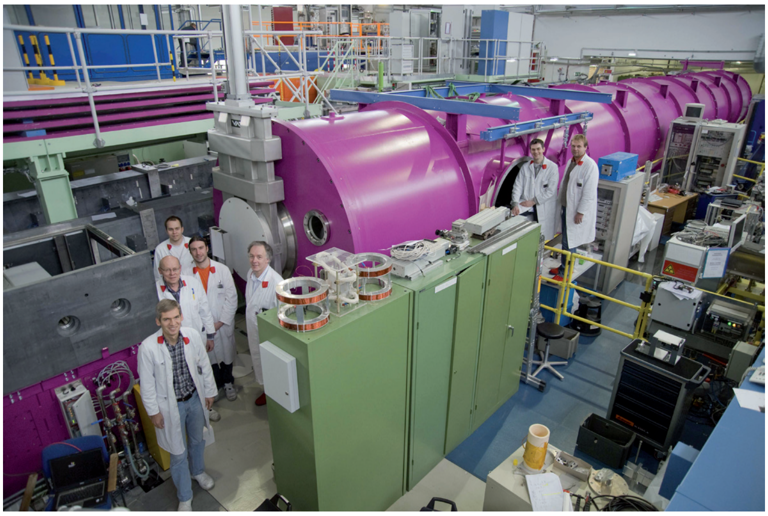


Fig. 1: The detector vessel and the end of the collimation part of SANS-1.

The new small-angle neutron scattering instrument SANS-1 (fig. 1) is a joint project of the Technische Universität München (TUM) and the Helmholtz-Zentrum Geesthacht (HZG).
The instrument is dedicated to cover a wide range of applications in the field of small-angle neutron scattering including chemical aggregation, defects in materials, surfactants, colloids, ferromagnetic correlations in magnetism, alloy segregation, polymers, proteins, biological membranes, viruses, ribosome and macromolecules.
Sample can be an aqueous solution, a solid, a powder, or a crystal.

Fig. 2: The selector tower for flexible wavelength resolution and the possibility to provide a white beam for time of flight mode.

To ensure the instrument as state of the art many calculations and variations of instrument parameters were performed by Monte Carlo simulations in advance. Especially the various neutron optic options were treated with great care. Using the software package MCSTAS the whole instrument was simulated from the source up to the detector. As one of the results a vertical S-shaped guide section was included to dump fast neutrons still inside the tunnel of the FRM II. This provides an ideal shielding and reduces the background at the sample position due to the fact that neutrons below 3 Å will be cut off. In comparison to a single-curved neutron guide a S-shaped neutron guide allocates a more homogenous intensity distribution on the detector.
The installation of the selector tower with three eligible positions for the two selectors (high resolution 6% or standard resolution 10–25% with high intensity) and for a neutron guide is completed (fig. 2). The high intensity selector and the neutron guide are implemented for the first step while the high resolution selector is in maintenance and will be integrated later. The collimation system hosts four different tracks: a laser adjustment apparatus, background apertures, collimation apertures, and neutron guides (fig. 3). Each track is subdivided in 13 sections which can be moved separately lateral to the neutron beam direction. It allows to combine the optical components in various options for the demanded application.
The laser system is used for controlling all movements of optical components in the neutron beam inside the vacuum chamber (the accuracy is better than 0.01 mm). If one optical component is not perfect aligned in the neutron beam direction a PSD detector mounted on each of the 13 sections shows the misalignment for correction. The second use of the system is to support the sample alignment by positioning the laser in the neutron beam position.
Two V-shaped polarizers of the type Fe/Si supermirrors (m = 2.5) coated on both sides of silicon

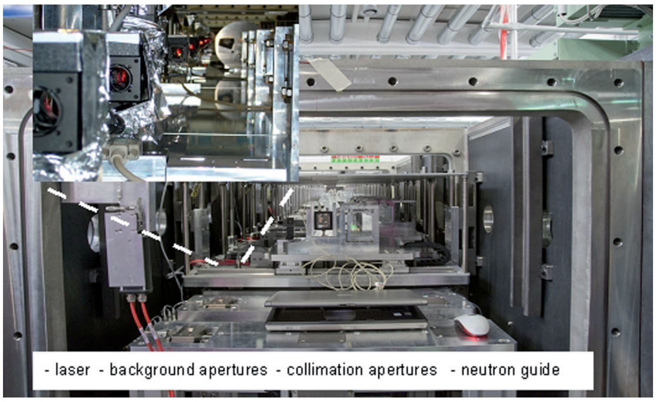


Fig. 3: A glance in the inner part of the collimation system with the four tracks marked in the photo.

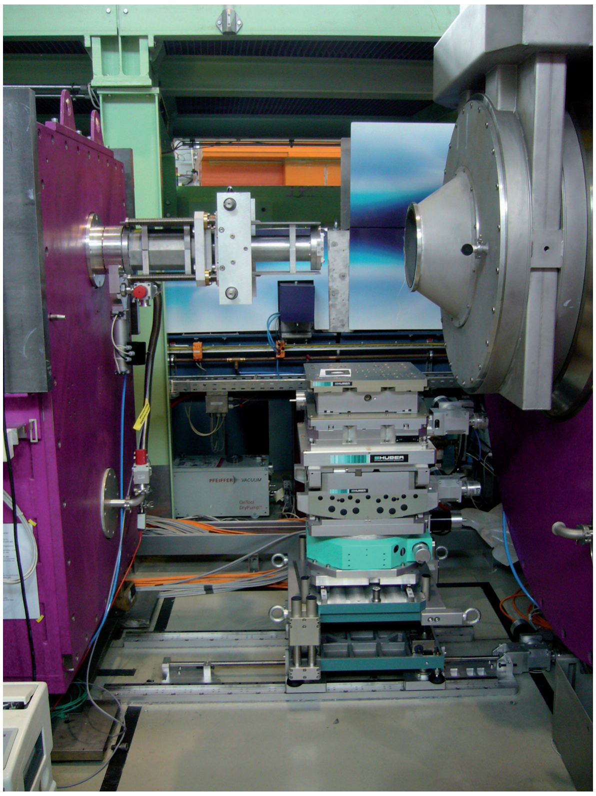


Fig. 4: The tower of sample environment for various set-ups

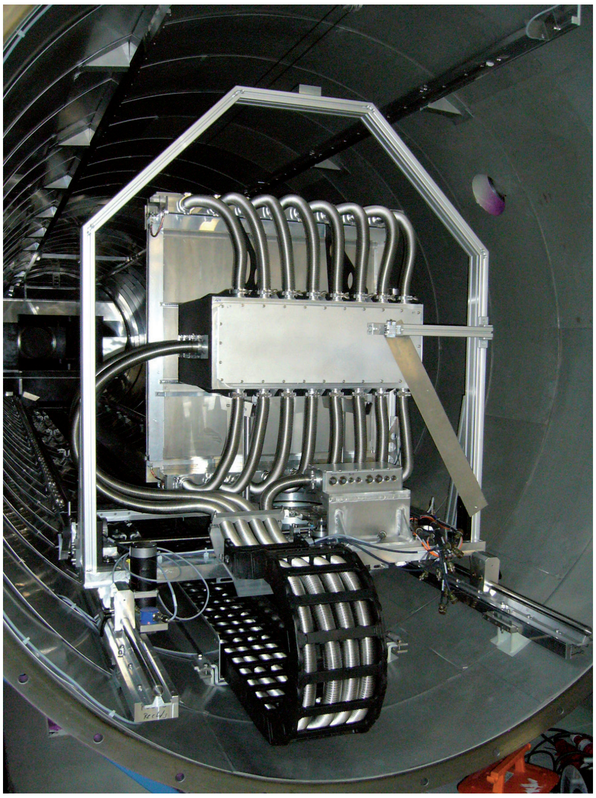


Fig. 5: The large area detector (backside) with electronic device in the detector vessel.

wafers, a spin flipper and the guide field with permanent magnets for polarized neutrons are installed to equip the instrument for magnetic small-angle neutron scattering measurements.

For the set up of the sample environment at first the focus is on the field of materials science. Therefore a flexible sample tower was constructed which is equipped with x,y and z-movements together with two cradles and two rotation tables for omega and phi movement (fig. 4). As a first sample holder, a sample exchanger for 22 positions is provided to measure fluid samples (in Helma cuvettes) or solid samples.

It is foreseen to start with general apparatuses as high temperature furnace, cryostat and heated sample holder as the first provided sample environments. Together with user groups we will upgrade step by step the scope of equipment for the parameters as temperature, magnetic field, pressure, time resolved and kinetic measurements. In addition a tensile test machine will be allocated.

In spring 2012, a horizontal 5 Tesla magnet is available to expand the possibilities for magnetic research projects. A vertical 7.5 Tesla magnet has been recently tested at the SANS-1 sample tower and is ready to use. The first detector composed of 128 position sensitive detectors (area of 1 m x 1 m) is mounted and calibrated in the detector vessel. External tests of the position sensitivity of the single tubes and the electronic device were performed successfully and yield a position resolution of 8 x 8 mm^2 for the large area detector (fig. 5). Due to the fact that the large area detector can perform a lateral movement of 0.5 m a second detector with higher resolution 3 x 3 mm^2 will be integrated later with the second necessary detector wagon. This allows us to cover a larger Q-range for a fixed detector position and to measure smaller Q-values.

First tests with the neutron beam up to the sample position ask for an improvement of the shielding before operation. This work is in progress to be able to thread the beam up to the detector. Meanwhile the shielding around the sample position is constructed and will be mounted soon. The first friendly users are expected to be served from the SANS-1 team (fig. 6) in the end of the year. In future, further components as lenses, ToF mode with choppers, polarization analysis or MIEZE technique etc. are foreseen after the instrument is running smoothly in operation.

Ralph Gilles, FRM II

Fig 6: The SANS-1 team (left to right: André Heinemann, Ralph Gilles, Svato Semeckey and Tobias Heller).

TOFTOF

Extended number of detectors

Dr. Giovanna Simeoni in the treasury room – view of the flight chamber from the sample position: 1006 ^{3}He detectors, aligned tangentially to the intersection lines between the Debye-Sherrer cones and the surface of a sphere (4 m radius) centered with the sample.

TOFTOF is a direct geometry multi-disc chopper time-of-flight spectrometer for cold neutrons installed at the FRM II, suitable for both inelastic and quasi-elastic neutron scattering. It represents a quite versatile instrument, known for its excellent signal-to-background ratio as well as high energy resolution and high neutron flux (also at short wavelengths, down to 1.4 Å). It allows the investigation of a great variety of scientific topics, ranging from the dynamics of disordered systems (liquids, glasses, colloids, proteins and biological samples) to the properties of new hydrogen storage materials and low-energy magnetic excitations in multiferroics or molecular magnets.

During the last long shut-down of the neutron source the instrument experienced an overall technical maintenance and a considerable upgrade of both the primary and the secondary spectrometer.

The upgrade of the primary spectrometer started already two years ago with the installation of completely new electronics for the magnetic bearings of the chopper discs (maximal rotational speed increased up to 22000 rpm). The work is now concluded with the installation of a new dedicated monitoring system.

On the secondary spectrometer the detector capacity of the flight-chamber has been increased from 605 to 1006 detectors. The detectors are squeezed ^{3}He counting tubes with an active area of about 3 x 40 cm^2, and a mean thickness of about 14.5 mm. In comparison with standard 6 bar detectors, these gas tubes are filled with a mixture of 97% ^{3}He and 3% CF_4 at a total pressure of 10 bar, thus achieving a gain in detector efficiency of more than 20% for neutrons with wavelengths below 3 Å.

Thanks to the almost doubled number of detectors, the active area has been enhanced from 7.26 m^2 up to 12 m^2, thus covering a solid angle of 0.75 sr (around 6% of the total scattering angle). The higher neutron luminosity and statistics are expected to significantly reduce the acquisition time (40% shorter) as well as the statistical error, and to allow the investigation of weaker signals.

In order to further improve the signal-to-noise ratio, a completely new electrical grounding concept for the whole flight-chamber has been developed, thus minimizing the electronic noise. Furthermore, the shielding of the electronic cables has been optimized, reducing the electromagnetic interaction with external factors (e. g. the crane).

The instrumental upgrade has been carried out bearing in mind both a quantitative improvement of “traditional TOFTOF” and a qualitative enlargement of its scientific fields of interest.

Among them, particular attention has been dedicated to magnetism as well as measurements under extreme conditions (high pressure and temperature).

The higher luminosity of the detector bank, together with the high detector efficiency at short wavelength, the high neutron flux in the first thermal region (< 3 Å) and the corresponding high energy resolution, are making way for a more intensive investigation of novel (exotic) magnetic effects.

As next step, a focusing neutron guide is ready to be installed.

It has been recently realized and is expected to be able to shrink the cross section of the beam over a surface of a few squared millimeters, with an intensity gain up to a factor 3. This is aimed at satisfying the crescent demand of studying quite small samples (limited availability or extreme environmental conditions). The prototype is going to be tested (and eventually optimized) during the next reactor cycle.

TOFTOF is looking forward to welcoming the neutrons!

Giovanna Simeoni, FRM II

KWS-2

Optimization and upgrade

Fig. 1: The double-disc chopper installed in front of the collimation system; the chopper housing, the chopper shielding and the collimation housing with the pneumatic cylinder of the 20th NG segment are visible.

In the middle of 2010 the JCNS small-angle neutron diffractometer KWS-2 for high intensity studies of biological and soft-matter systems entered a phase of conceptual changes and major upgrades aiming for the improvement of its manoeuverability and increase of its performance.

A new collimation system was designed and built to fulfill the stability, safety and manoeuverability conditions required by the routine use of large beam-sizes (the fast detection electronic commissioned in 2009 accepts high counting rates, up to 0.6 MHz). The new concept is based on movable neutron guides in and out of the beam and apertures installed in a fixed position always in beam.

A new concept of variable-opening apertures has also been designed and constructed: the new slits are more compact than those used between September 2007 and May 2010 and present additional elements that increase their performance (transducers, special driving systems, large $^{10}B_4C$ masks, special positioning and alignment systems).

The double-discs chopper from Central Department for Technology (ZAT) of Forschungszentrum Jülich GmbH, planned for the time-of-flight wavelength analysis was built in front of the collimation housing (fig. 1) and commissioned in September 2010. The two phase-shifted rotating discs (20 ÷ 200 Hz) are made of Al alloy and coated with ^{10}B. Each disc has two diametrically opposite windows (90° sectors). The width of the effective window for neutrons can be thus varied by defining angular off-sets between the two discs. The MgF_2 aspherical neutron lenses that are planned for the high resolution mode (exploration of low Q domains up to 10^{-4} Å) and the high intensity mode (gain in intensity by increasing the sample area while holding the resolution) have been installed in a special chamber (by ZAT, Forschungszentrum Jülich GmbH) at the end of the collimation housing, in front of the sample area (fig. 2). The 26 lenses will be divided in several groups that are optimized for different neutron wavelengths between 4.5 Å and 19 Å. In order to increase their transparency and thereby to obtain an additional gain in intensity the lenses are used at low temperature.

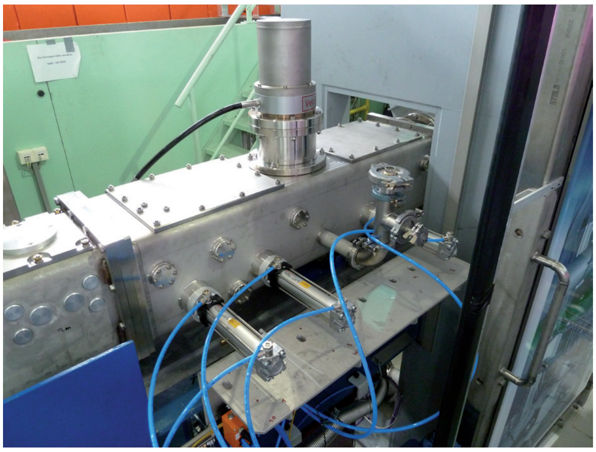


Fig. 2: The neutron lenses chamber; the cooling system and the pneumatic cylinders moving the three packages of MgF_2 lenses in and out of the beam are visible.

The optimization of the cooling system enables to reach 77 K, a temperature for which a gain factor of 2 in intensity in comparison to room temperature is expected when using 26 lenses and full lens area. The design of the system enabling the manipulation and control of the high-resolution position sensitive detector planned to be used together with the lenses and chopper for the high resolution mode is finished and entered the production phase. The system will be installed and commissioned in the summer of 2011.

With all these innovations allowing for the increase of the manoeuverability and performance and with the upgrades of the control and data-acquisition software, KWS-2 will be again operational in complete multi-functional configuration (standard pinhole, high-resolution and high-intensity modes) in the middle of 2011.

Aurel Radulescu, JCNS

NECTAR

Radiography and tomography with fission neutrons

Fig. 1: Measuring room of NECTAR with a wooden sample on the turntable.

The radiography and tomography facility NECTAR is the only facility worldwide that is using fission neutrons for the non-destructive investigation of dense and/ or large sized objects. Located at the beam tube SR10 of the FRM II it is sharing the neutron beam time with the MedAPP facility mainly used for medical applications and irradiation tests.

Since 2004 a large number of different samples were investigated at NECTAR. At the beginning the main focus of the investigations was on the utilization of the unique feature of fission neutrons being sensitive to hydrogen containing materials like oil, water etc. while being more or less transparent for dense materials like iron, lead etc. Therefore objects like motors, gear boxes, iron or lead containers etc. were the preferred types of samples answering questions on the distribution of oil, water or plastics within these objects.

During these investigations it also became obvious that radiography and tomography of large sized wooden objects might become one highly interesting domain of NECTAR. In the following logs, girders, plywood etc. were investigated. Actually the largest thickness that could be radiographed showing the positions of knots and annual rings in a wooden girder was nearly 50 cm. Especially for this object a partial angle tomography applied. Occasionally also art-historical objects like sculptures, bronzes, an antique handgun etc. as well as objects from archeological museums or excavations (e.g. a presumably Etruscan statue) were investigated. Often these investigations at NECTAR are the only possibility to get information on its authenticity non-destructively.

Since 2008 feasibility studies on imaging of dynamic processes within sealed objects took place as this is of vital interest in many fields of application like life sciences, medical applications, mechanical engineering etc. In all these processes some physical properties are changing with time. The time scales may range from quasi static processes up to nearly infinitively fast processes. As one of the main limitations for these investigations was the low time resolution of the available detection system, the studies were limited to periodic or slowly varying processes. As an example fig. 3 shows the results of water uptake in a trunk at different times.

Based on the results of the investigations of the

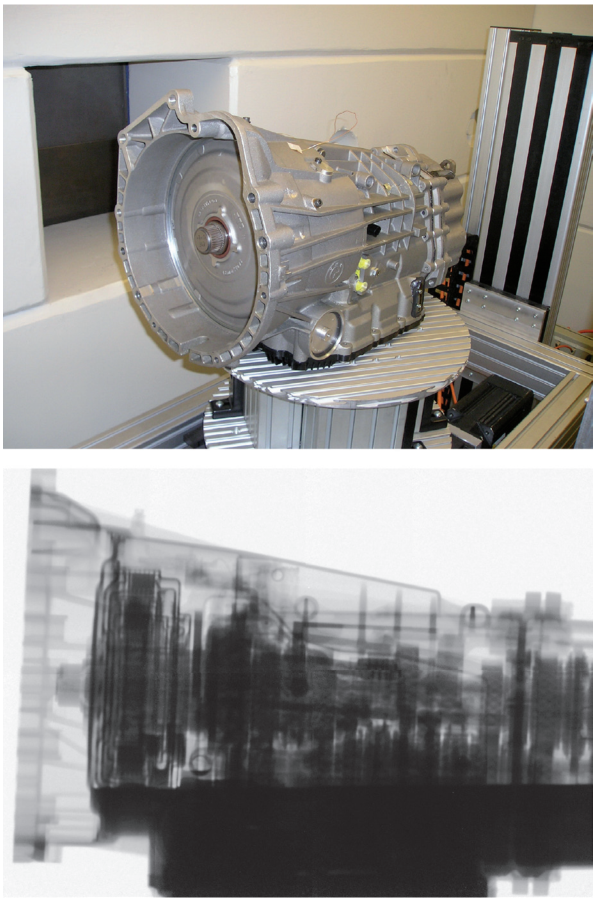


Fig. 2: Photo (top) and radiography (bottom) of a car's gear box.

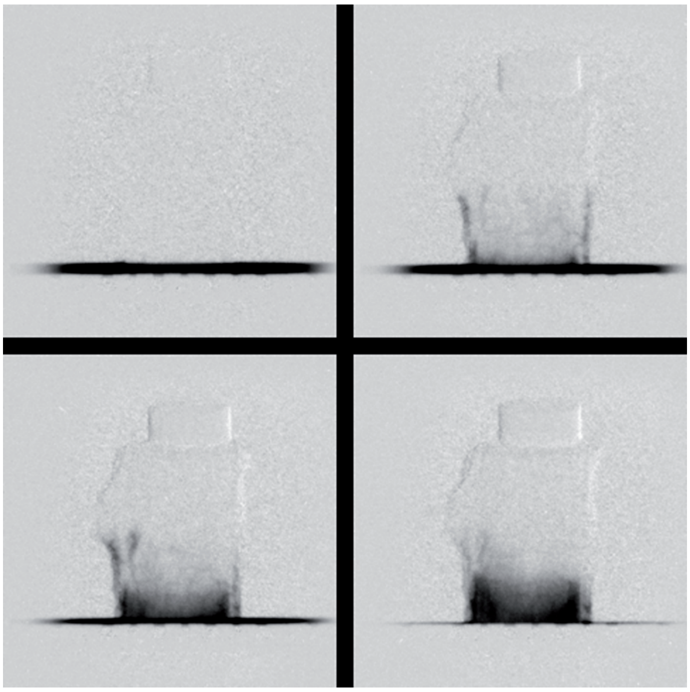


Fig. 3: Results of dynamic radiography of water uptake in a trunk. The images are difference images, i.e. an original image before water uptake is subtracted from each radiography thus only the distribution of water remains visible. Upper left: Begin of experiment; the water is homogeneously distributed on the bottom of a bowl. Others: increasing water content with time.

past years a revision of the NECTAR facility had taken place during the scheduled shutdown of the FRM II in winter 2010/ 2011. By optimization of the beam dump measurements without collimator will become possible, increasing the neutron flux at the sample position by a factor of about 150, but on the deterioration of the inherent spatial resolution to about 1.7 mm. This will enable exposure times of down to 3 ms still giving sufficient image information. As these times cannot be resolved with the actual CCD camera an optional new detection system is under construction using a CCD with integration times of less than 1 ms and no read out delay due to on-board memory.
To give more flexibility to the users on sample handling, on setting up special experimental equipment and to extended the possibilities for the variation of the sample and detector positions, the auxiliary devices like detector table, positioning unit for the sample manipulator, electrical connectors etc. are completely redesigned, too.
With these optimizations which base to the greatest possible extent on suggestions and requests of users the NECTAR facility will be ready for some additional successful state-of-the-art years of operation.
A summary of the facility's main parameters facility will be given in T. Bücherl et al., “NECTAR—A fission neutron radiography and tomography facility”, Nucl. Instrum. Meth A, in press.

Thomas Bücherl, TUM

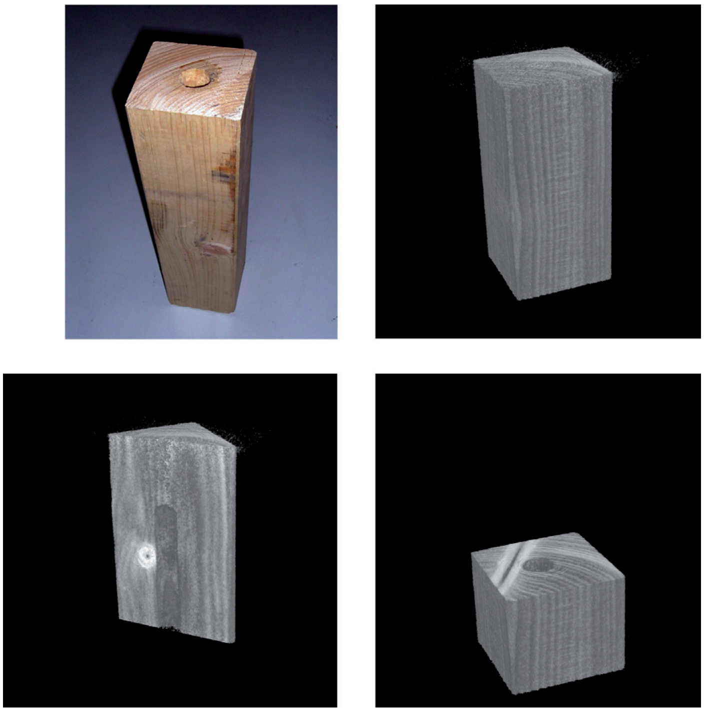


Fig. 4: Photo (top left) and different sections of a 3D-tomography of a wooden trunk with knobs, an inner drilling and annual rings.

The electric dipole moment of the neutron

Particle physics experiments with slow neutrons are somewhat exotic applications at a research reactor. Within a priority programme of the DFG, several particle physics experiments are currently being set up at the FRM II to probe the neutron's fundamental properties and interactions. One prominent experiment is the search for a static distribution of charge within the neutron, the neutron's electric dipole moment (EDM). An EDM of a quantum system with spin would violate one of the basic symmetries in the Universe: the invariance of the laws of physics against time reversal. Based on rather solid foundations, our Universe seems to obey the combined symmetries of C (the exchange of matter and antimatter), P (point-like mirror reflection) and T (time reversal). Although it is reasonable to assume that in the Big Bang an equal amount of matter and antimatter was produced, at some point an excess of matter on the level of 1000.000.000 : 1000.000.001 must have occurred to explain the observed amount of matter in the universe. Currently known particle physics fails to explain this fact by eight orders of magnitude. Electric dipole moments of fundamental atomic systems, e.g. of protons or neutrons, are very promising candidates to find new manifestations of symmetry breaking required to solve this problem, and are therefore powerful probes of physics beyond the Standard Model.

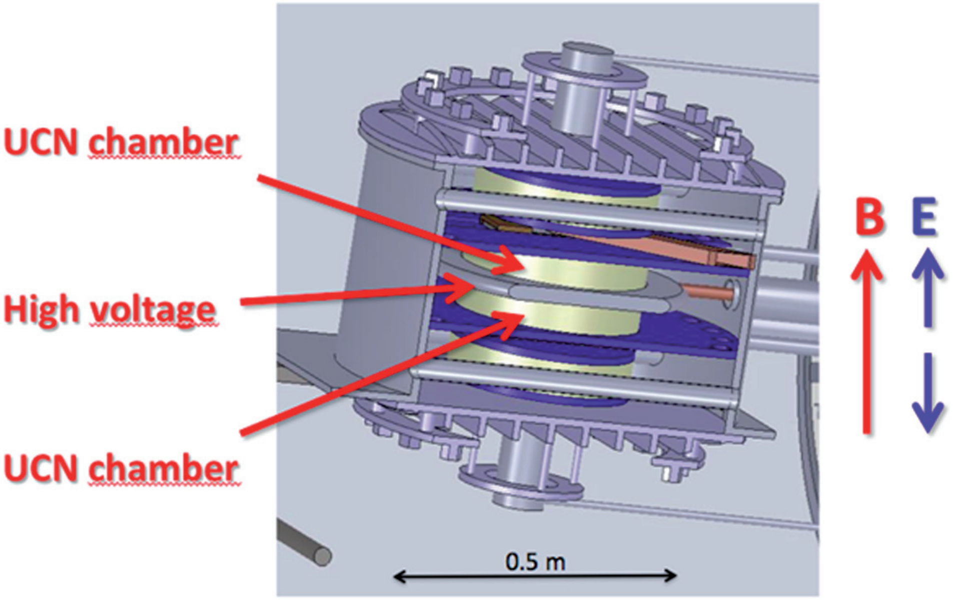


Fig. 1: Conceptual layout of the new EDM measurement. Two UCN storage chambers in a strong magnetic field are used for the EDM measurement, surrounded by different magnetometers.

New theories that could potentially explain this problem (e.g. Supersymmetry) are being tested at LHC at CERN, with energies in the TeV (Tera-Electronvolt) regime. These theories also require EDMs of a magnitude that would be ‚just around the corner’ and should thus be observable with our new generation EDM experiment. EDM experiments are extremely accurate measurements with a sensitivity to the separation of two unit charges of 10^{-26} cm. Any further improvement comes with exponentially increasing effort, and this is what is being done for the new generation approach at the FRM II.

Almost all EDM measurements are based on Ramsey's method of separated oscillatory fields, where the spins of trapped ultra-cold neutrons precess in a homogeneous and stable magnetic field for several hundreds of seconds. In addition, an electric field is applied parallel or antiparallel to the magnetic field. Any dependence of the precession frequency on the electric field would be a sign of an EDM. UCN are chosen as, due to their unique properties (nano-eV energies, wavelengths > 50 nm), it is possible to trap them in bottles for several minutes. The conceptual layout of a new measurement is shown in fig. 1. Basic ingredients to improve the precision are: (1) more neutrons, (2) a double chamber layout to measure with E and B fields parallel and antiparallel simultaneously, and (3) better magnetic field stability and uniformity compared to previous approaches.

One of the main improvements to achieve the statistical sensitivity in the new experiment is to increase the density of ultra-cold neutrons (UCN) in the experiment from a few per cm^3 to > 1000 per cm^3 using the new source of UCN and high-transmission replica UCN guides that are currently being built by the physics department E18 at the Technische Universität München (TUM). The systematic sensitivity must be increased by a similar factor, which is mainly achieved by preparing a magnetically highly stabilized and controlled environment.

The new UCN physics laboratory at the FRM II will provide unique conditions for such a measurement. As shown in fig. 2, UCN coming from SR6

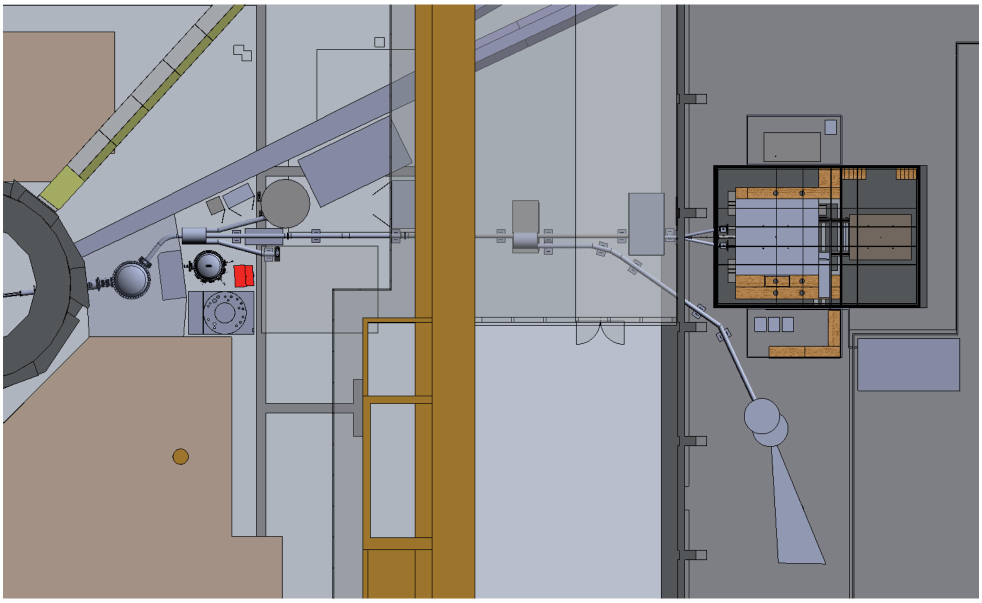


Fig. 2: Schematic layout of the new UCN physics laboratory at the FRM II. The UCN beam line starts in SR6, guides UCN from the source to experiments in the experimental hall, through the intermediate structure and finally in to the neutron guide hall east. (Other experiments and installations are not shown here.)

are guided to experiments placed in the experimental hall (PENELOPE – an improved measurement of the life-time of the neutron and QBOUNCE – a variety of quantum physics experiments with UCN) and into the neutron guide hall east (EDM and beam tailoring positions). In the intermediate structure the UCN beam passes a solenoid magnet with spin flipper, so that perfectly polarized (100.0000%) UCN are available for experiments in the neutron guide hall east with the additional possibility to modify the average energy of the UCN spectrum. The EDM experiment is then placed in a magnetically controlled environment. An artist's view of the installation is shown in fig. 3. Magnetically and vibrationally decoupled from the surrounding building structures and placed inside a non-magnetic concrete pit, an elaborate sequence of measures to control the magnetic fields will be put in place: the outermost layer is a set of 24 large magnetic-field-compensation coils with 180 Fluxgate sensors used to actively compensate and stabilize the magnetic environment in a volume of 9 x 6 x 6 m around the actual experiment. Inside this installation, a vibration- and temperature-controlled passive magnetic shield consisting of six nested layers of Mu-metal is placed to reduce disturbances from outside at frequencies down to the milli-Hz level by a factor of > 100.000. Finally, inside the shield a magnetic field with few micro-Tesla is generated by an optimized coil arrangement and stable current sources, which provide homogeneity of $< 3{\cdot}10^{-4}$ and fluctuations < 100 fT/ 100 s. Such a highly homogeneous magnetic field is required to suppress systematic effects, in particular so-called geometric phases of the neutron spin moving in gradients and electric fields. In addition to generating such a field, a major effort of the local groups involved in the setup (Universe-Cluster and physics department E18) is the accurate measurement of magnetic fields with LTc SQUIDs, atomic magnetometers (polarized 199-Hg vapor) and spin-polarized noble gases. Such techniques have been developed locally within the xenon EDM experiment, located at the neutron guide hall east in 2009 and 2010, to understand ambient magnetic fields.

The experiment receives substantial support from the DFG to realize the large-scale magnetically shielded environment in sequential steps, which are currently being realized. A tender call for the passive Mu-metal shield could be successfully finalized in spring 2011 and main components are now in production. Installation of the coil cage components is scheduled for the end of 2011 and the passive Mu-metal shield will be delivered and installed in January 2012. This will be followed by a 1-year commissioning phase inside the coil cage, itself dust protected during the ongoing construction work.

Peter Fierlinger, TUM

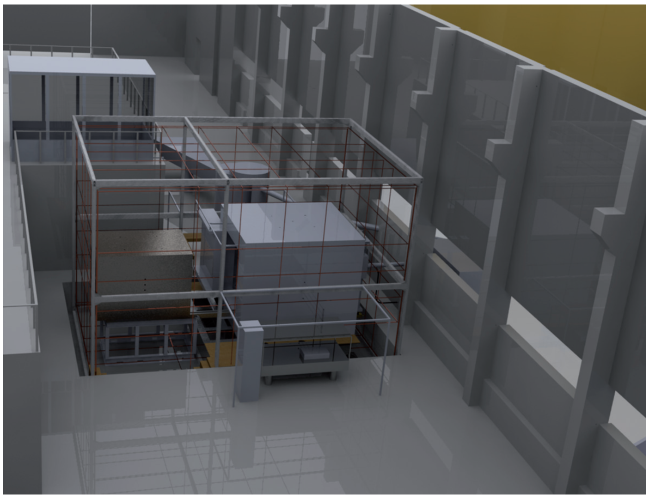


Fig. 3: Artist's view of the EDM installation in the neutron guide hall east. The experiment itself is placed inside a magnetically shielded room (grey box with sliding door). The inner magnetic field is mounted on rails and can slide into the shielded room. A 3D arrangement of field coils surrounds the assembly.

Long maintenance break: Men at work

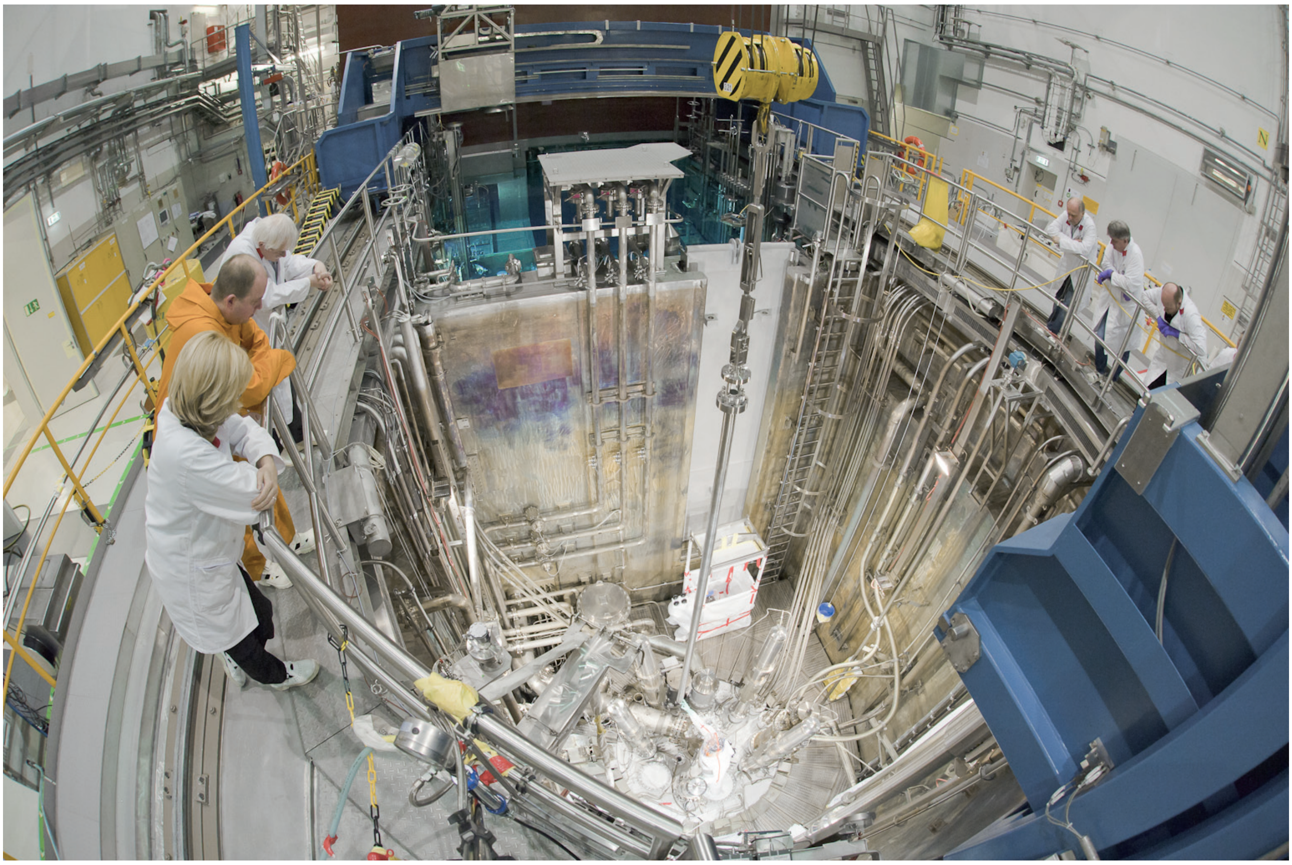


Fig. 1: View into the reactor pool, while the thimble is inserted supervised by the authority and quality management of the FRM II .

Since the beginning of its operation, the FRM II has undergone its first long maintenance break. Several works have been successfully completed, as the construction and insertion of a new thimble for the production of molybdenum-99, the exchange of the beam tube for the positron source NEPOMUC and the exchange of several neutron guides. Many instruments have used the maintenance break for a major upgrade (see TOFTOF, cf p. 6) or have been completely reconstructed as the tomography station ANTARES. The new instrument POLI has prepared its own beam port to the hot neutron source. Furthermore, neutron guides have been exchanged.

Since the beginning of February, the new thimble for the production of molybdenum-99 has been integrated into the moderator tank of the FRM II. The thimble is part of the facility producing the isotope molybdenum-99, the mother isotope of the medically most important radioisotope technetium-99m (see FRM II News No. 5). The thimble is a tube consisting of the long living zircalloy-4, measures 9 cm in diameter and 5 m in length. Starting in 2014, the tube will provide room for the parallel irradiation of 15 so-called targets, which contain the raw material uranium-235. The new thimble was thoroughly specified, tested several times and finally approved for the usage in the neutron source after its successful qualification. Before the irradiation facility will be operated, it still has to be accredited by the authorities. Furthermore, additional works have to be performed. For example, the detailed construction and production of the insert, which contains the irradiation targets, and the strengthening of the FRM II freight elevator to transport the massive shielding containers for the targets.

ANTARES goes green: The radiography and tomography facility was completely dismantled and moved from beam tube 4b to 4a to make room for a neutron guide towards the new neutron guide hall east. The team of Burkhard Schillinger took advantage of this situation and planned more room for experiments, while reducing the volume of the shielding with a new patented mixture. The new shielding of ANTARES consists of steel casings, containing a boron mixture, iron powder and paraffin oil. The shielding material saves about 20% of volume and reduces the weight compared to the former concrete shielding, while providing the same shielding effect. The material is also recyclable: Due to its consistency resembling wet sand, it can be extracted from the casings after eventual dismantling and filled into new shielding

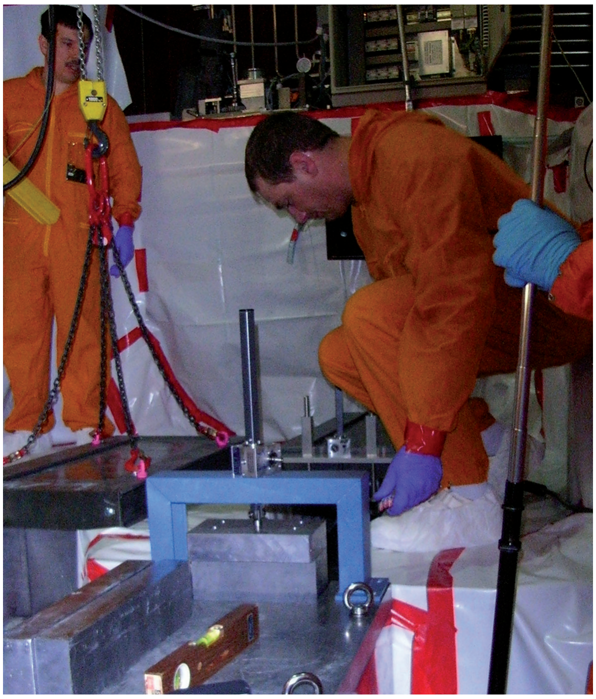


Fig. 2: Works at the beam tube pointing at the hot source to feed the new instrument POLI@HEiDi with hot neutrons.

elements of arbitrary geometry.

Furthermore, the beam tube number 11 of the positron source NEPOMUC has been exchanged. The change was necessary as the cadmium in the beam tube was depleted. In the new beam tube, isotope clean cadmium is used, which has a longer life time. In order to change the beam tube, its inner parts had to be removed and the moderator tank of the FRM II had to be dried. Using a special changing device with an adjusted shielding, the 3 m long beam tube was pulled. As a next step, the FRM II staff successfully mounted the three new nested tubes of the positron source. The intensity of the positron source at the FRM II will remain the highest worldwide even after having changed the beam tube. The brilliance of the positron beam has even been raised with the new tube, says instrument scientist, Christoph Hugenschmidt. The cadmium in the beam tube will suffice for experiments using positrons for the next 25 years.

A new instrument will soon use hot neutrons. The beam port of the hot source has been modified in order to supply the new polarized hot neutron diffractometer POLI independently from HEiDi. During the long maintenance break a plug in the hitherto unused port A of beam tube 9 was removed, the collimators of the HEiDi diffractometer replaced in a separate channel and beam shutter reprogrammed to allow the operation of two instruments at the hot source. The neutron channel for POLI has been opened. The replacement work at the open beam tube took only a few days in March 2011, while preparation and exercising had started in fall 2010. Due to the better beam adjustment, new collimator configuration and better monochromator shielding the performance of the existing diffractometer HEiDi will increase after the reassembling. Both HEiDi and POLI@HEiDi are going to be available soon, after some recalibration, for the user operation.

Fig. 3: Michael Schulz (l.) and a contractor working at the temporary hot cell in the experimental hall to dismantle parts of the beam tube SR11.

The neutron optics group exchanged boron float glass based guide elements of the neutron guides NL 1,3,5 and 6. These elements situated in the neutron guide tunnel after the main six fold shutter of beam tube SR1 showed premature radiation caused aging. The new guide elements now are built from sodium float glass, alike the elements closer to the source. At the same time vacuum tubes made of stainless steel were replaced by aluminum tubes to avoid high radiation levels in the tunnel due to activation of the steel.

Vladimir Hutanu, RWTH Aachen; Burkhard Schillinger, Peter Link, Andrea Voit, FRM II

Fig. 4: Members of the neutron optics group aligning a new guide element in the neutron guide tunnel.

DNS

A versatile diffuse scattering spectrometer with polarization analysis

Neutrons interact not only with a nucleus and nuclear spins, but also with the magnetic field produced by the unpaired spins of an atom. Thus one challenge in a neutron scattering experiment is to disentangle different contributions from various scattering processes. An unambiguous separation of nuclear coherent, nuclear spin-incoherent and magnetic scattering simultaneously over a wide dynamic range can be achieved at DNS, a cold neutron diffuse scattering spectrometer with polarization analysis at the neutron guide NL6a, FRM II (see fig. 1). Since early 2008, DNS has been in successful user operation on the studies of magnetism and strongly correlated electrons, soft condensed matters and emergent functional materials via intense polarized neutrons.

Fig. 1: Current look of DNS at FRM II .

DNS offers a number of unique features such as wide-angle polarization analysis, a large position-sensitive detector array, and a high frequency double disc chopper system. With its compact design and the powerful double-focusing PG(002) monochromator, DNS is optimized as a high intensity instrument with medium resolution. The usage of only a small amount of the almost neutron transparent materials for the double-focusing mechanical support structure allows the use of the transmitted beam without significant losses at the downstream backscattering instrument SPHERES. The monochromatic neutron beams with the wavelength ranging from 2.4 to 6 Å are available at DNS. Newly constructed polarizers and polarization analyzers, both using m = 3 Schärpf bender-type focusing supermirrors, perform very well. A polarized neutron flux as high as 5 x 10^6 n/(s·cm^2) has been achieved at 4.74 Å. The polarization rate of the incident neutron beams is nearly 96%. The wide-angle polarization analysis in the horizontal scattering plane is achieved via using 24 units of polarization analyzers simultaneously (see fig. 2). The neutron spins are manipulated using a Mezei-type π-flipper, followed by a set of orthogonal XYZ-coils situated around the sample position for providing guide fields.

The successful operation with high polarized neutron flux in the diffraction mode and the subsequent production of the sound scientific results has placed DNS as one of the leading instruments with polarized neutrons. However, the full potential of DNS can only be realized after the completion of the second phase of the DNS project: installation of a new position sensitive detector bank and a new high-performance double disc chopper system. The installation of 128 position-sensitive ^{3}He tubes of 1 m height and half inch diameter at DNS has just been completed, and the commissioning is expected soon. This will increase the covered solid angle up to 1.9 sr (see fig. 3). The time-of-flight option at DNS will be achieved with a double disc chopper system running up to 300 Hz for better resolution and repetition rates up to 900 Hz. The setup with two phase controlled choppers would allow to eliminate high-order (e.g. λ/2) background. Once these new features are fully implemented, DNS is expected to be a powerful medium-resolution time-of-flight spectrometer ideal for the studies of spin dynamics in frustrated spin systems and strongly correlated electrons.

In addition to high intensity, the unique strength

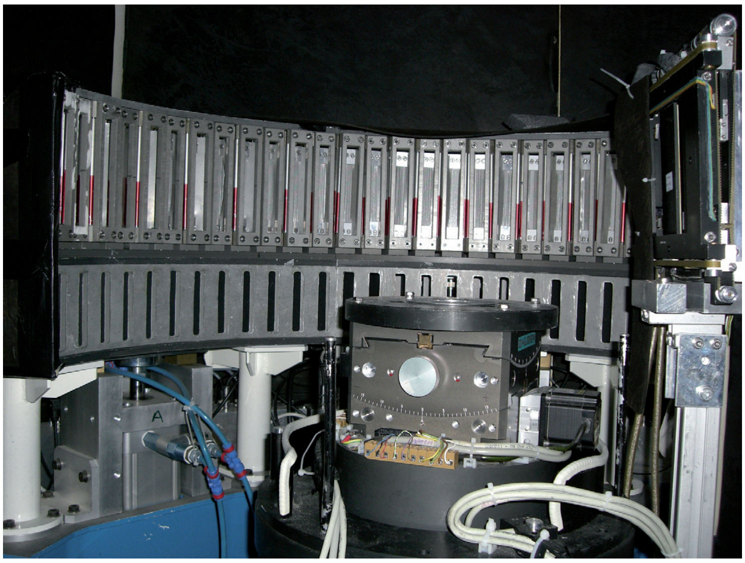


Fig. 2: Wide-angle polarization analyzers (24 units of m=3 supermirror benders).

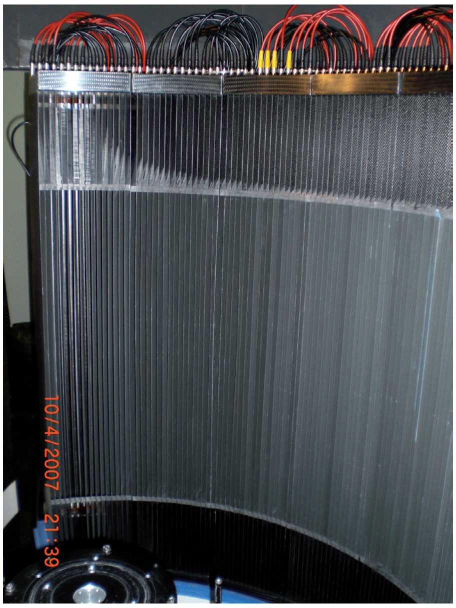


Fig. 3: New position-sensitive detector banks at DNS with 128 ^{3}He-tubes of 1m height and 0.5 inch diameter housed in a black radial collimation frame.

of DNS lies on its extreme versatility. DNS can be operated in a number of modes for a wide range of samples. There are three polarization analysis (PA) modes at DNS: uniaxial-PA for separation of coherent and spin-incoherent scattering in non-magnetic samples; longitudinal-PA for separation of magnetic scattering in paramagnetic and anti-ferromagnetic samples; vector-PA for the determination of complex magnetic structures. All three PA setups can be operated either in a diffraction mode or in a time-of-flight measurement. With its unique combination of single-crystal time-of-flight spectroscopy and polarization analysis, DNS is also complementary to many modern polarized cold neutron triple-axis spectrometers.

With the increased flux and efficiency at FRM II, DNS has become ideal for the studies of complex magnetic correlations, such as in highly frustrated magnets and strongly correlated electrons, as well of the structures of soft condensed matter systems, such as the nanoscale confined polymers and proteins, via polarization analysis. The exploration of unusual magnetic properties can also be efficiently undertaken on single-crystal samples by reciprocal space mapping. Fig. 4 shows an example of the measured magnetic diffuse scattering patterns in the hexagonal plane of a highly frustrated kagome spin system, due to in-plane spin-components as determined by spin-flip scattering of the initial P_z polarization. In addition to the separation of magnetic cross section from nuclear and spin-incoherent ones, polarization analysis can also be used to explore possible anisotropy of spin correlations in complex materials. It has also been well demonstrated that polarized powder diffraction carried out at DNS is complementary to standard neutron powder diffraction and may be extremely useful for magnetic structure refinements, particularly in case of small magnetic moments by improving the signal to background ratio. Fig. 5 shows the magnetic and nuclear scattering of the iron-based superconductor Sr_2CrO_3FeAs measured at DNS via polarization analysis and the corresponding Rietveld refinements.

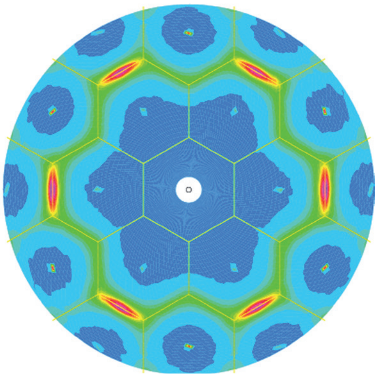


Fig. 4: Magnetic diffuse scattering in the hexagonal plane of a highly frustrated kagome spin system due to in-plane spin-components as determined by spin-flip scattering of the initial Pz polarization (taken from W. Schweika, unpublished).

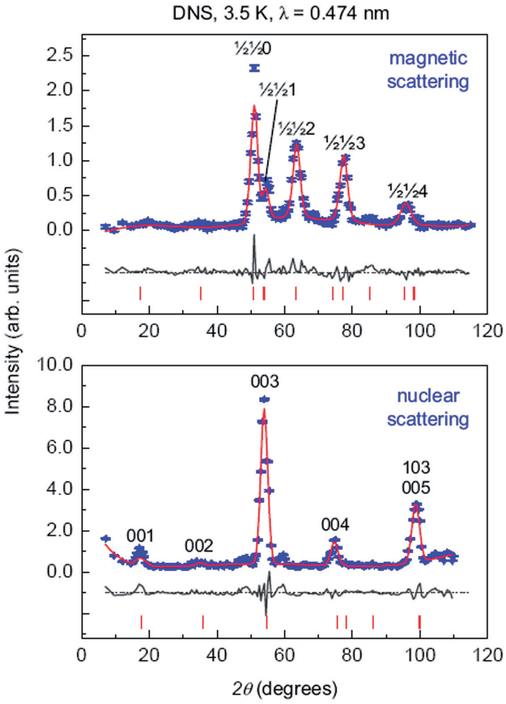


Fig. 5: Magnetic and nuclear scattering of iron-based superconductor Sr_2CrO_3FeAs (blue) at 3.5 K as measured at DNS via polarization analysis and the Rietveld refinements (red) (taken from M. Tegel et al., EPL 89, 37006 (2010)).

DNS also represents a powerful instrument for the soft condensed matter community for the separation of nuclear coherent scattering from often dominating spin incoherent scattering background. The main scientific applications at DNS can be summarized as the follows:

- Application of polarization analysis: uniaxial-, longitudinal-, and vector-PA
- Magnetic, lattice and polaronic correlations: geometrically frustrated magnets, strongly correlated electrons, emergent materials
- Single-crystal and powder time-of-flight spectroscopy: spin-waves and magnetic fluctuations
- Soft condensed matters: separation of coherent scattering from hydrogenous materials, polymer, liquids, and glasses.

Yixi Su, JCNS

Heinz Maier-Leibnitz’ 100th birthday

Garching, March 28th

DFG President Matthias Kleiner, Minister Wolfgang Heubisch, President of the TUM Wolfgang A. Herrmann and Scientific Director of the FRM II Winfried Petry (f.l.) at the colloquium.

Heinz Maier-Leibnitz would have turned 100 years on March 28th, 2011. To celebrate his birthday, the two scientific institutes of the Technische Universität München (TUM) bearing the name of Maier-Leibnitz, the neutron source Heinz Maier-Leibnitz and the accelerator Maier-Leibnitz, had invited to a colloquium.

Heinz Maier-Leibnitz is known as the father of the so called Atomic Egg in Garching, the first research reactor in Germany, and the physics department of the Technische Universität München. The professor at the TUM also greatly contributed to the construction of the neutron source Institut Laue-Langevin in Grenoble and became its first director from 1967 to 1972. At the end of his scientific career, Heinz Maier-Leibnitz was the president of the German Research Foundation DFG. A research prize for young scientists is named after Maier-Leibnitz. He died in the year 2000.

About 350 participants listened to the talks.

At the colloquium for his 100th birthday, speakers from all parts of his scientific and political career were invited. Winfried Petry and Stephan Paul welcomed the 350 guests. The Bavarian Minister for Science, Wolfgang Heubisch, started with an opening speech praising the far-reaching scientific excellence of Maier-Leibnitz’ actions. Speaking as a successor of Maier-Leibnitz the actual President of the German Research Foundation, Matthias Kleiner, remembered the scientific managing of the great physicist and gave an insight in the nowadays funding of science. The scientific work of Maier-Leibnitz was acknowledged by the President of the TUM Wolfgang A. Herrmann. A personal view to the researcher and tutor of his Diploma thesis, gave Paul Kienle in his review. After a lunch break, Colin Carlile, Director of the European Spallation Source in Sweden gave an outline of future neutron science. Stephan Paul of the TUM excellence cluster “Universe” explained afterwards, how the neutron can be used to explain the origin of the universe. And finally, the Heinz Maier-Leibnitz’ prize laureate 2010, Ansgar Reiners, talked about the freedom of research, which led him to interesting results in astronomic spectroscopy.

The talks of Matthias Kleiner, Paul Kienle and Ansgar Reiners (in German) can be downloaded: **www.frm2.tum.de/en/aktuelles/events/100-geburtstag-maier-leibnitz/index.html**

Andrea Voit, FRM II

NREX mini workshop

Garching, January 10th-11th

The Max-Planck-Society funded the construction of two instruments at the FRM II, the spectrometer TRISP (department Keimer, MPI for Solid State Research) and the reflectometer NREX (department Dosch, MPI for Metals Reseach). Recently, Helmut Dosch was appointed to become director of the DESY synchrotron facility and left the MPI. Thus it was a natural choice to combine the two instruments in a single group.

As the MPI funding period ended in 2010, researchers from different MPI's with interest in neutron reflectometry met at the FRM II in Garching on January 10th-11th, 2011 to work out a plan for the future scientific profile of NREX. This plan served both as a basis for a meanwhile accepted proposal to the MPI to extend the funding and for a currently running upgrade program.

Three main topics for the future use of NREX were defined:

- polarized reflectometry with a dynamic range $>10^7$ for the investigation of superconducting and ferromagnetic heterostructures.
- Non-polarized reflectrometry on organic systems. The possibility to use X-ray reflectometry to monitor the systems during the neutron experiments is attractive, as most organic systems tend to show fast aging processes. In addition, neutron vs. X-ray contrast variation provides additional information about the samples.
- The implementation of spin-echo techniques promises important new applications, such as the measurement of the specular reflectivity from wavy surfaces.

Many interesting systems are wavy and not perfectly flat and thus are not accessible by conventional neutron or X-ray reflectometry. Spin-echo for the first time will allow to reconstruct the specular reflectivity and the chemical depth profile of those wavy samples.

MPI FKF-Team

Tutorial at DPG Meeting

Dresden, March 13th

Within the DPG Spring Meeting, it became a tradition to organize tutorials to give insight into special fields and methods of the organizing divisions. For the 2011 meeting, Christine Papadakis was asked to organize a tutorial about neutron scattering methods for chemical and polymer physics. Three speakers were asked to outline a neutron scattering method within a 45 minute talk. The talks were held on Sunday afternoon, before the welcome-party. Surprisingly, the 90-seat lecture room was too small to house all, mainly young people.

Most resonance was given to the first speaker, Stephan Förster of Universität Bayreuth. He clearly explained the application of small angle scattering on the relation between polymer architecture and self-assembly. Several examples as well as practical hints for the application of beamtime at neutron facilities were generally acclaimed by the listeners.

Principles and applications of neutron reflectometry and grazing incidence small angle neutron scattering were presented by Roland Steitz, Helmholtz-Zentrum Berlin für Materialien und Energie (HZB). A detailed illustration of the basics was helpful to understand the shown results e.g. on polymer films at solid-gas interfaces or on the immobilisation of a protein at solid-liquid interfaces. The practicability of neutron scattering which does not damage the organic samples but does give much information with elementary experiments was convincingly shown.

The last talk by Astrid Schneidewind (HZB-TU Dresden-FRM II), gave an introduction on spectroscopic measurements with neutrons. Three-axis spectroscopy and the main time-of-flight techniques were compared and their complementary use was demonstrated on examples.

Finally, the auditorium was struggled by the ambitious talks but the surprisingly big resonance demonstrated the high interest on neutron scattering methods. We gratefully thank Christine Papadakis to take the initiative for this tutorial.

Astrid Schneidewind, HZB-TU Dresden-FRM II

It is all about dynamics

Colloquium in honour of Winfried Petry's 60th birthday

The FRM II and the chair E13 of the physics department at the Technische Universität München celebrated Winfried Petry's 60th birthday on June 16th in a colloquium.

Welcoming words were spoken by the director of the Bavarian ministry for research, Adalbert Weiß, in the name of Minister Wolfgang Heubisch. He praised Petry's ability, to explain neutron science to ordinary persons. The president of the Technische Universität München, Wolfgang A. Herrmann, honoured Petry as a science communicator. And the dean of the physics department Martin Stutzmann highlighted the "dynamics" of Winfried Petry, both in his research and every day life.

The invited talks also dealt with dynamics in Winfried Petry's research, for example the at the liquid-glass transition and the soft matter dynamics. They were given by Winfried Petry's Ph.D supervisor Gero Vogl (Universität Wien), his colleague Richard Wagner (Institut Laue-Langevin Grenoble) and his former Ph.D. student Andreas Meyer (Deutsches Zentrum für Luft- und Raumfahrt). The latter praised Winfried Petry's enthusiasm for research, which inspired numerous younger scientists. Furthermore he surprised the honoured by offering him the participation in a parabolic flight.

The FRM II and the chair E13 staff presented their boss with a mosaic of pictures and a weekend at a winery.

Peter Müller-Buschbaum of E13 had organized a special issue of the *Journal of Physics - Condensed Matter* (vol. 23, No. 25, **http://iopscience.iop.org/0953-8984/23/25**). After the talks, the 320 guests were invited to a buffet.

Andrea Voit, FRM II

Internal science meeting

Burg Rothenfels, June 6th-9th

From June 6th-9th, 2011, the 5th internal biennial science meeting of the FRM II took place at the Burg Rothenfels am Main. 65 participants mainly from the FRM II, JCNS, the Helmholtz centre Geesthacht and the institutes E13 and E21 of the Physics Department of the Technische Universität München, enjoyed the inspiring scenery of the medieval castle above the picturesque Main valley. This exceptional surrounding, the beautiful "Burgkeller" of the castle and the excursion to the city of Wertheim with a very nice boat trip on the river Main enabled extensive scientific discussions.

More than 20 talks were given during the three days, and nearly 30 posters presented. They showed the very broad range of science performed on-site at the FRM II, ranging from magnetism over soft matter to nuclear and fundamental physics. They demonstrated the very rich field for the use of the neutrons as probes from large scales structures to microscopic properties.

In the evening talk Konrad Kleinknecht gave an interesting insight into Germany's energy supply situation, a hot topic in the actual public discussion. According to the participants, this workshop helped to gain an overview of the science performed at the FRM II and to improve the exchange of discussions across the different disciplines.

Robert Georgii, FRM II

NMI3: new funding, new project

NMI3 is a European initiative that has been integrating neutron and muon facilities since 2000, starting with the Neutron Round Table under the European Union 5th Framework Programme (FP5). Since its inception, NMI3 has funded transnational access to all major European neutron and muon facilities. Through its networking activities, it has contributed to the training of new generations of users, and via workshops and foresight studies, it has helped to pave the future of neutron and muon research.

In 2009, NMI3 had to undergo some changes due to limited resources attributed by the first FP7 call, which led to a project that will run until January 2013. The access programme had to be reduced considerably in scope, and it was decided that the funds would be used over a period of two years only. All networking and collaboration projects (Joint Research Activities or JRAs) were downsized.

Fortunately for neutron and muon scientists, the EU opened a second call within FP7, and a new NMI3 proposal was accepted. The new project intends to restore NMI3 activities to their original level; there will, nevertheless, be some changes.

In the next project, which will run from February 2012 to 2016, NMI3 will continue its efforts to foster and stimulate knowledge creation, innovation and the advancement of neutron and muon science. To this end, it is essential that European researchers have access to the facilities that are best adapted to their research. Integration and harmonisation of access procedures will be key issues for the next four years. NMI3 will comprise 18 partner organisations, including nine facilities in twelve countries.


The NMI3 management team: Miriam Förster, Helmut Schober (ILL) and Juliette Savin (FRM II).

NMI3 will continue to foster JRAs focusing on areas of strategic importance, with a large potential for innovation and synergy. In the next project, such collaborations between researchers from different institutions across Europe will work on developing advanced methods and techniques for new instrumental set-ups, structural and magnetic imaging at the micro and nano-scale, advanced neutron tools for soft and biomaterials, detectors and muons.

Ensuring the training of new users has always been one of NMI3's main aims and it will continue to be. However, the process of funding education has changed. Fourteen European neutron and muon schools expressed their interest during the proposal phase and have been directly integrated in the project. A close link will be established to the future e-learning pages of the NMI3 website.

To coincide with the new project, the NMI3 website (**www.nmi3.eu**) will undergo a complete revamping. With improved navigation and clearer pages, the new website will offer the NMI3 community and the general public relevant and up-to-date information about neutron and muon research in Europe.

Juliette Savin, NMI3

Time-resolved SANS

Kinetics with millisecond time resolution at KWS-1 and KWS-2

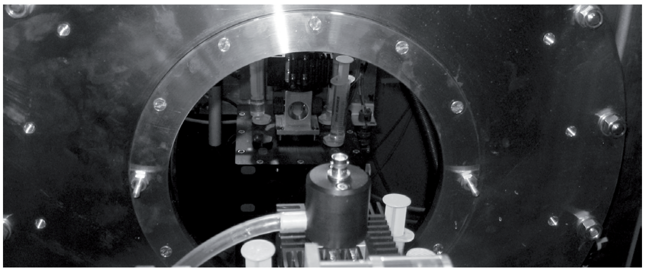


Fig. 1: Stopped-flow device SFM-300 from BioLogic™ installed at the KWS-1 sample position in front of the detector entrance window.

After a crucial update of the detector electronics at the two small-angle neutron-scattering (SANS) instruments KWS-1 and KWS-2 in 2009, we could deal with counting rates up to 0.5 MHz and keep up to 1024 frames in the detector memory without time loss associated with external signal triggers. By this update three options could be released here, namely time-resolved SANS (TR-SANS) with millisecond time resolution, time-of-flight SANS mode (TOF-SANS), and time-resolved stroboscopic small-angle neutron-scattering techniques (TISANE). In frame of this report we will present examples using only the first option.

In the standard mode, issues like: uncertainty in the starting time, manual synchronization between the investigated process and the detector electronics, time-consuming transferring of the detector image from the detector electronic after each step do not allow to follow kinetics with step better than, at best, a few seconds. On the other side, the best possible time resolution by the new TR-SANS mode is a few milliseconds for the shortest sample-to-detector distance (1 m) and nearly 50 ms for the longest one (20 m). This time resolution is limited by the overlap between neutrons belonging to different pulses or time-frames due to the inherent wavelength spread of the incoming beam. Another limitation is the scattering signal. For example, in case of a maximal possible count rate at the detector of 0.5 MHz with 1 ms frame duration, the integral intensity of the whole detector would only be 500 counts. Therefore the statistics per time step in case of SANS with the millisecond time resolution is poor by default. In order to get reasonable statistics one should repeat the kinetic run many times.

The first tests of the real time mode in the millisecond regime were done by implementing a BioLogic™ stopped flow apparatus (fig. 1). This apparatus is designed to mix 2-3 components and transport the obtained mixture to the SANS cell with dead time better than 50 ms. The sample volume for a single shot is nearly 1 mL. Single filling of syringes allows to repeat the "reaction" up to 20 times (2 x 10 mL). A nice example showing TR-SANS results with 50 ms time step is shown in fig. 2.

Now both SANS instruments KWS-1 and -2 operated by JCNS are ready for millisecond real time experiments with different types of the external triggering of the kinetics process. If you have a sample, where the kinetic process could be started by mixing different liquids, e.g. inducing pH, salt, etc. jumps; (or by changing of magnetic, electric, light, temperature, pressure etc. field) and observe the response in the 10^{-3}...10^{5} seconds time window, you are welcome for the submission of proposals and instrument developing cooperation.

Vitaly Pipich, JCNS

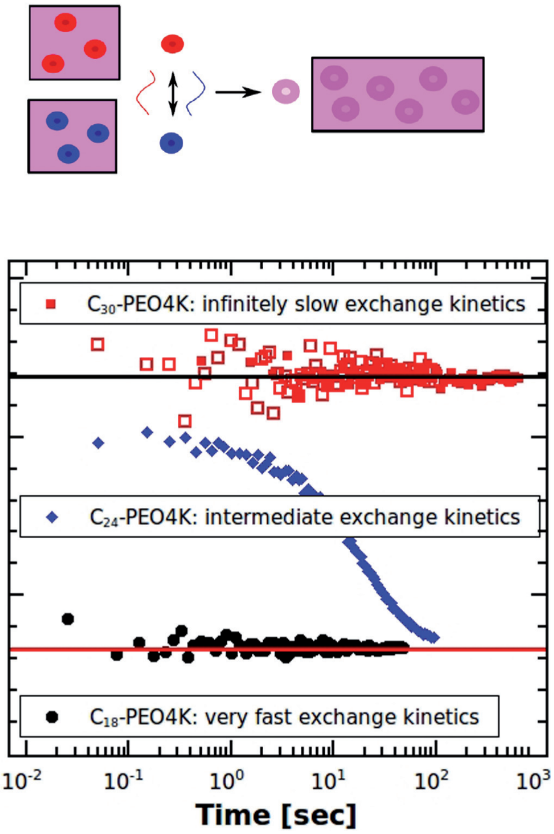
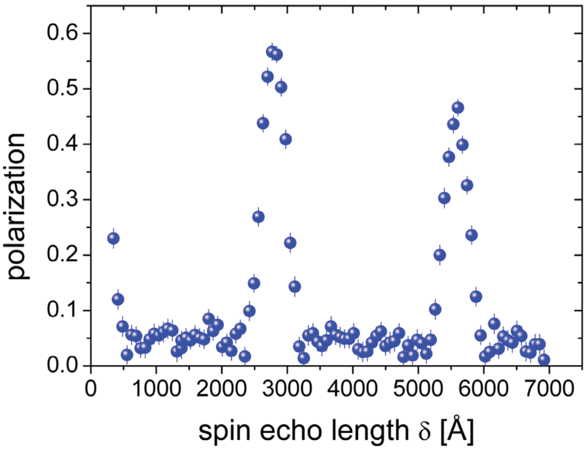


Fig. 2: (above) Principle of equilibrium exchange kinetics experiment: by stopped flow apparatus two identical solutions with of n-alkoxide-PEO [Cn-PEO4K, C_n == $C_n(H/D)_{2n+1}O$] polymer micelles of opposite scattering length density with respect to the H_2O/D_2O selective solvent mixture are rapidly mixed. After full exchange the average scattering length density of solvent and micelles equals and the average contrast becomes zero. The count rates of polymer micelles with three different lengths of the hydropobic core block and similar PEO-corona block lengths as a function of time after mixing are shown below. Micelles with a long n-alkoxide core block (C_{30}-PEO4K; red box: open 50 ms, filled 1000 ms step) do not show exchange kinetics over almost five orders in time; micelles with short core block (C_{18}-PEO4K, black circle) are already in equilibrium after 30 ms, faster as the dead-time of the stopped-flow instrument; exchange kinetics of micelles with an intermediate core block (C_{24}-PEO4K, blue rhombus) could be investigated by SANS. [Proposal 4747: T. Zinn, L. Willner, V. Pipich, R. Lund, D. Richter].

TRISP and NREX joined by spin echo

The construction of the spin echo spectrometer TRISP and the reflectometer NREX was funded by the Max-Planck-Society with the aim to make these instruments available for Max-Planck-Institutes interested in materials research with neutrons at the FRM II. These are in particular the MPI for Metals Research (MF), the MPI for Solid State Research (FKF), the MPI for Polymer Research, the MPI of Colloids and Interfaces, the MPI for Chemical Physics of Solids and the MPI for Plasma Physics. TRISP was constructed by the MPI-FKF, NREX by the MPI-MF. As the former head of the NREX group, Helmut Dosch, left the MPI, NREX was transferred to the FKF group in beginning of 2011. The MPG awarded additional three years of funding for NREX. After that period, the supporting MPI's will operate NREX from their institute budgets. A nearly completed upgrade program aims to make NREX competitive among the best current reflectometers.



Result of a spin-echo GISANS experiment. The sample was a optical grating with 3600 lines/ mm. The spin-echo raw data in the plot show the Fourier-transform of the sample surface with a peak at the line spacing of 2800 Ångstrom.

Although at the first glance TRISP and NREX have little in common, one of the main links between them will be the spin-echo technique. Spin-echo in combination with triple-axis spectrometry at TRISP is now well established for the measurement of the lifetimes of phonons and magnons. In addition Larmor diffraction offers unique resolution among other diffraction techniques especially for thermal expansion measurements at low and high temperatures and under pressure, where conventional techniques like dilatometry or strain gauges tend to fail.

NREX on the other hand will be mainly operated as a conventional reflectometer, either with polarized neutrons or non-polarized in combination with a X-ray reflectometer mounted on the sample table orthogonal to the neutron beam. The latter will allow for in-situ sample characterization and neutron/ X-ray contrast variation experiments. The main feature of NREX is a large dynamic range (> 10^7) for small sample sizes in the order of 1 cm^2. This is achieved by increasing the primary flux with a specially designed monochromator with variable bandwidth, by using focusing elements and by reducing the background. The spin-echo setup is currently in the design phase.

It was early pointed out by Pynn that spin-echo allows to decouple the momentum resolution from intensity in small angle scattering (SESANS) and reflectometry. It is (in principle) possible to measure the specular reflectivity with an uncollimated and thus very intense neutron beam with very high resolution. This is analogous to conventional spin-echo, where the Larmor precession of neutron spins in uniform magnetic fields is used to decouple the energy resolution from the intensity. During the last years, there was some effort to implement spin echo on reflectometers, where the main goal was to resolve off-specular small angle scattering bearing information of lateral structures of thin films (GISANS, grazing incidence small angle scattering). The first spin-echo GISANS experiment was conducted nearly one decade ago (see fig.) at V2 at the HZB, the prototype of the TRISP spectrometer. The main building block of such a spin-echo reflectometer are uniform field regions with inclined field boundaries, either generated by radio frequency spin flippers or by triangular shaped DC coils. The special challenge for reflectometry is that these coils should not generate small angle scattering, which is harmless in the case of a triple-axis spectrometer, but which will obscure small signals in reflectometry, where large dynamic ranges are required.

At NREX, besides spin-echo GISANS we will investigate a new application based on a proposal by Pynn. He suggested to use spin-echo to reconstruct the specular reflectivity from wavy sample surfaces. Usually neutron and X-ray reflectometry only works for perfectly flat samples. Many interesting thin film samples like biological membranes or thin functional polymer films, such as those used for next generation solar cells, could for the first time become accessible to neutron reflectometry.

We thank János Major, Adrian Rühm and Jörgen Franke for many years of hard work at NREX.

MPI FKF-Team

Crystallography with neutrons

The RWTH Aachen University at the FRM II

The Institute of Crystallography at RWTH Aachen University, headed by Gernot Heger for more than 15 years until his retirement in 2009, has quite significantly contributed to neutron research. Over the years, the group operated single crystal neutron diffractometers at Saclay, Jülich and now at Garching. The incentive was always to provide state of the art, optimum performance single crystal diffractometry to the user community and at the same time take best advantage of these capabilities for the groups' own research. In 2009 Georg Roth took over the responsibility and continues the commitment of the institute to neutron crystallography.

Currently, the group operates HEiDi, the single crystal 4-circle diffractometer at the hot source of the FRM II that was built and is still run by Martin Meven as the responsible instrument scientist. HEiDi takes advantage of the high flux at small wavelengths available from the hot source of the FRM II and has proven to be particularly successful in applications where such small wavelengths are beneficial. An example is the collection of single crystal neutron diffraction data from crystals such as $GdMnO_3$ or $DyMnO_3$ which are usually considered as “no-goes”, due to their huge absorption coefficients. Choosing a wavelength as low as 0.55 Å, where HEiDi still delivers an appreciable flux, results in a substantial reduction of the absorption cross section allowing one to obtain good diffraction data from such crystals without having to turn to isotope enriched rare earths.

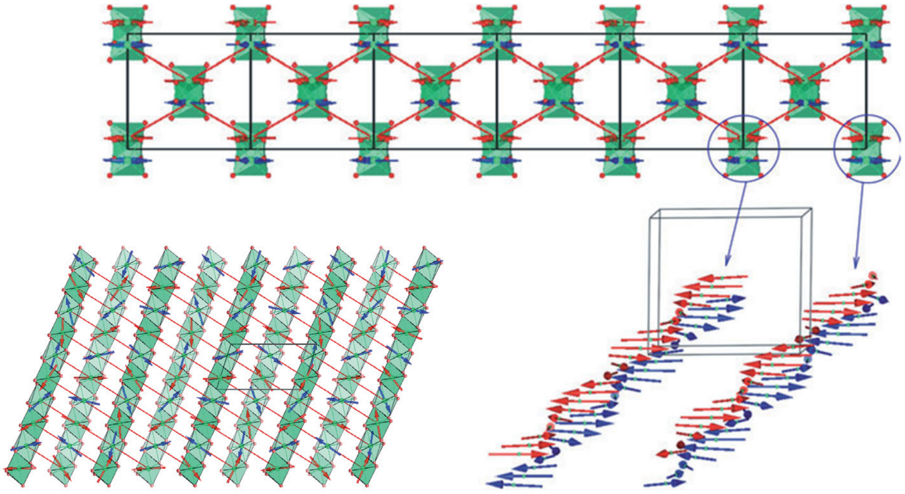


Fig. 1: Crystal and magnetic structure of $NaFeGe_2O_6$ along a* (left), c* (top) and schematic drawing of the spin structure in the a-b-plane, Redhammer et al. 2010.

Another good reason for choosing small wavelengths is the collection of diffraction data to high Q-values in order to obtain very accurate atomic coordinates and displacement parameters for purposes like a subsequent combined X-ray (synchrotron) and neutron electron density study. A recent example from our own research is the Ph.D. thesis of Andrew Sazonov (2009) on structure and magnetism of Cobalt-Olivine Co_2SiO_4.

An example for the application of HEiDi to the study of complex magnetic structures with unpolarized neutrons stems from the long standing collaboration with Günther Redhammer from University of Salzburg: $NaFeGe_2O_6$ is a pyroxene closely related to the multiferroic compound $NaFeSi_2O_6$ and was shown by powder- and single crystal neutron diffraction to exhibit a very complex double-cycloidal antiferromagnetic structure (fig. 1).

This example is also prototypical for one branch of research our group in Aachen is currently pursuing. That is the investigation of structure and magnetism of electronical/ magnetical low dimensional transition metal oxide crystals with unconventional ground states, e.g. spin-chains, spin-ladders, magnetic layer structures, multiferroics etc.

Another long term research activity focuses on studying hydrogen bonded crystals, taking advantage of the large cross sections of H/D for thermal neutrons. Examples are KDP-type ferroelectrics and superprotonic conductors. A recent example from the Ph.D. thesis of Yoo Jung Sohn (2011) is the proton conductivity and orientational disorder in the high temperature phase of $(NH_4)_3H(SO_4)_2$ (fig. 2).

The Fourier map shows clearly the disorder of the oxygen atom O1 that is part of the SO_4-groups with three split positions and at least two split positions for the proton H1. This leads to a highly disordered, 2D- O1-H1-O1 hydrogen-bond network that is assumed to be responsible for the pronounced 2-dimensional superprotonic conductivity.

Since 2004, our group - with Vladimir Hutanu as the person in charge and funded by the federal government (BMBF) - has developed POLI as a complement to HEiDi for polarized neutron measurements with spherical neutron polarimetry (SNP) using the third generation polarimeter Cryopad (ILL). At the moment, POLI shares primary beam optics with HEiDi.

Among the many potential uses of POLI are the accurate determination of complex magnetic structures (non-collinear, incommensurate, helicoidal) using SNP, the detailed study of magnetic domains by 3D-depolarization analysis, and ex-

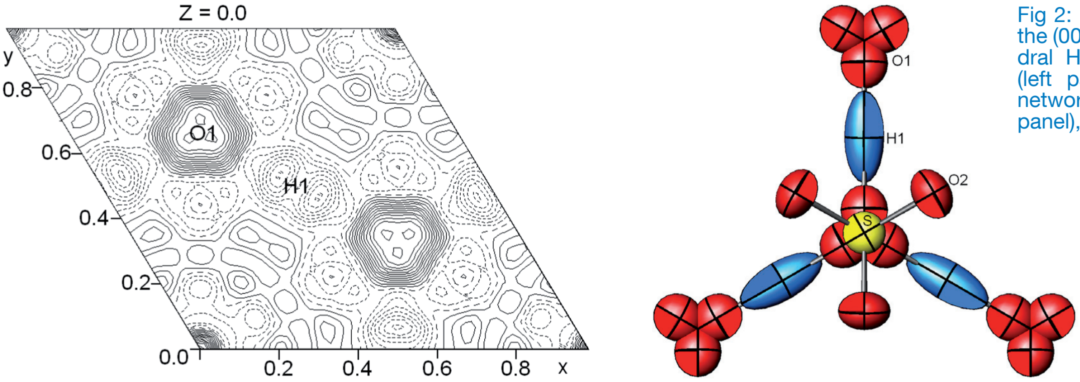


Fig 2: Difference-Fourier map of the (001) plane of the rhombohedral HT-Phase of $(NH_4)_3H(SO_4)_2$ (left panel), 2D-hydrogen-bond network in the (001) plane (right panel), Sohn et al. 2011.

perimental determination of spacially resolved magnetization densities and transferred magnetic moments on nominally non-magnetic anions using polarized neutron diffraction (PND). The latter is particularly important in order to understand the ground states of magnetic systems close to frustration.

POLI@HEiDi has become operative in 2010 and is also available for external users. First SNP experiments on POLI@HEiDi performed in 2010 have led to the discovery of a new incommensurate magnetic phase in the antiferromagnetic superconductor $HoNi_2B_2C$. Another experiment demonstrated the possibility of the precise measurement of the distribution ratio of antiferromagnetic domains in the magnetoelectric (multiferroic) material Cr_2O_3. New experiments on 3D depolarization analysis for the determination of the magnetic domain size in $CePd_{1-x}Rh_x$, formation and redistribution of magnetoelectric domains under applied electric field in multiferroics ($TbMnO_3$, $DyMnO_3$) and refinement of the chiral magnetic structures (MnSi) as well as incommensurate magnetic structures e.g. $NaFeGe_2O_6$ (see above) are planned for the near future.

In the current BMBF-funding period (2010-2013), POLI is being developed into a stand-alone diffractometer for measurements with polarized neutrons. For that purpose the previously plugged beam channel SR9a was opened and the biological shielding and primary beam optics are reconstructed (fig. 4).

Fig.3: Part of the “crew” of HEiDi and POLI (back, from left to right: Martin Meven, Florian Gärtner, Vladimir Hutanu, Georg Roth, front: Eddy Lelièvre-Berna, ILL) during the first test measurements with Cryopad.

After completion of the project, POLI will be available as a dedicated instrument for single crystal measurements with polarized neutrons and polarization analysis. This will hopefully also relieve some of the strain on HEiDi, which was heavily overbooked during the past years.

Other activities of the group include the implementation of a transmission polarizer for the cold triple axis spectrometer IN12 at ILL Grenoble, in close cooperation with JCNS (Jülich Centre for Neutron Science, Thomas Brückel). We cooperate with the group of Götz Eckold (Göttingen) who is running the triple-axis spectrometer PUMA (FRM II) that is being extended towards polarization analysis using the polarized ^{3}He technique. Another important cooperation between RWTH, TUM and HZB is aimed at sharing specific sample environments like zero-field polarimeters and magnets in order to implement PND at POLI in Garching and SNP in Berlin.

Fig. 4: Construction work at the HEiDi site during the reactor shutdown in March 2011.

As a consequence of the re-organization of the FRM II funding in 2010, HEiDi is going to be turned from a Technische Universitat München/FRM II instrument to a JCNS instrument. It will be operated jointly by JCNS and the Institute of Crystallography at RWTH Aachen University. We are looking forward to continuing the very fruitful collaboration with both JCNS and FRM II.

Georg Roth, RWTH Aachen

Neutron scattering at TU Dresden

At the Technische Universität Dresden, there is a long successful tradition to use scattering techniques for physics and materials science. X-ray scattering methods were used and developed both for fundamental research and applied science. Since 1995, when Michael Loewenhaupt accepted the professorship "Experimentalphysik", neutron scattering came from a niche to one of the important experimental methods in Dresden physics, not only at the university but also for the collaborating institutes like IFW, MPI-CPfS and MPI-PKS. Therefore, neutron experiments played a prominent role among other projects within the Sonderforschungsbereich 463 "Structure, magnetism and transport in rare-earth transition-metal compounds" (from 1995 till end of 2008).

Magnetism of rare earth intermetallics is the main topic of the research. Neutron scattering as the appropriate method is used to study magnetic structures, spin wave dispersion and crystal-electric field (CEF) excitations. One focus was set on the $R\mathrm{Cu}_2$ (R = rare earths) compounds which exhibit a large variety of interesting phenomena: CeCu_2 is a magnetically ordering Kondo lattice, TbCu_2 and DyCu_2 show similar phase diagrams with roughly similar antiferromagnetic magnetic structures, PrCu_2 undergoes a Jahn-Teller transition. The sequence of magnetic phase transitions with temperature and magnetic field in NdCu_2 challenged development of cryogenics as well as of scattering techniques. Most of the compounds order with antiferromagnetic spin arrangements below the ordering temperature, and several additional 1st and 2nd order phase transitions occur under change of temperature and external magnetic field. These complex magnetic phase diagrams are the result of the interplay of crystal electric field – introducing a strong anisotropy on each R-atom in the lattice – and the magnetic exchange coupling which is of RKKY-type.

Fig. 1: Michael Loewenhaupt.

Within these studies, interest focused onto magneto-elastic phenomena like the so-called "ISING-axis conversion" accompanied by giant magnetostriction effects (GMS). Excepting LaCu_2 which crystallizes in a hexagonal lattice, the compounds of the $R\mathrm{Cu}_2$ series order in the orthorhombic Imma space group. However, the crystallographic structure is in the vicinity of hexagonal symmetry, reflected by the c/a lattice parameter ratios (i.e. 1.696 for TbCu_2 is near to the hexagonal value of 1.732). Applying an external magnetic field within the pseudo-hexagonal ac-plane, due to the strong magneto-elastic coupling the overall symmetry changes from orthorhombic to hexagonal by splitting into orthorhombic variants with a quasi-hexagonal arrangement (see fig. 2). The related macroscopic observation is a change in lattice parameters up to 4% (DyCu_2) called GMS. To interpret these characteristics also within theoretical models, knowledge of the strength and directions of the exchange coupling would be help-

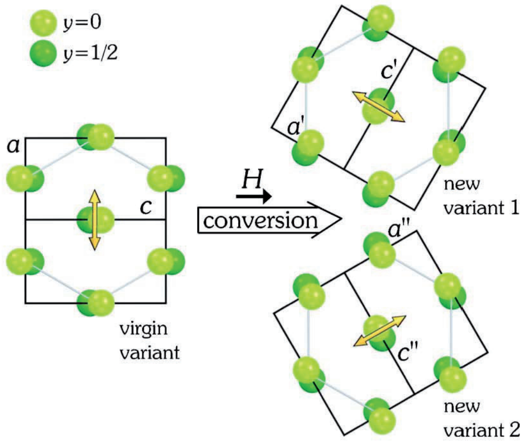


Fig. 2a: The rare earth atomic positions before (left) and after (right) the conversion with the magnetic field perpendicular to the easy axis [$\angle(H,a) = 90°$]. Effectively the unit cell is rotated. The virgin TV gets entirely depopulated. Two new twin variants arise. Only the rare earth ions are shown. The double arrows symbolize the easy axis. The hexagon shows the idealized austenite state.

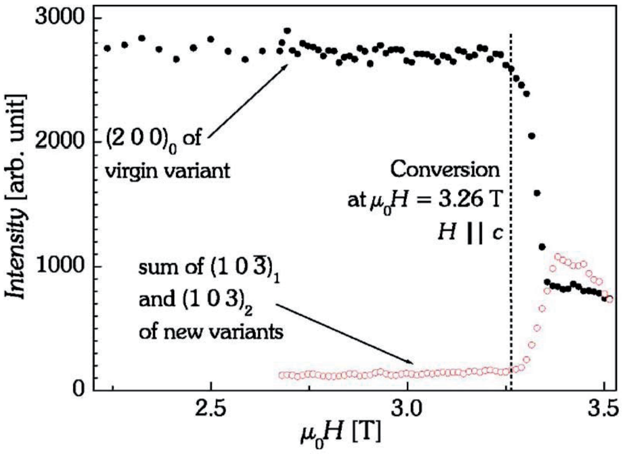


Fig. 2b: Field dependent intensities of the $(2\ 0\ 0)_0$ reflection full spheres and of the emerging $(1\ 0\ \bar{3})_1$ and $(1\ 0\ 3)_2$ reflections (empty spheres). Intensities were integrated within the two-theta regions with a fixed sample rotation at T = 29 K. Since the reflections are only 0.4° apart in two-theta the integration regions of both curves overlap slightly. The background has not been subtracted.

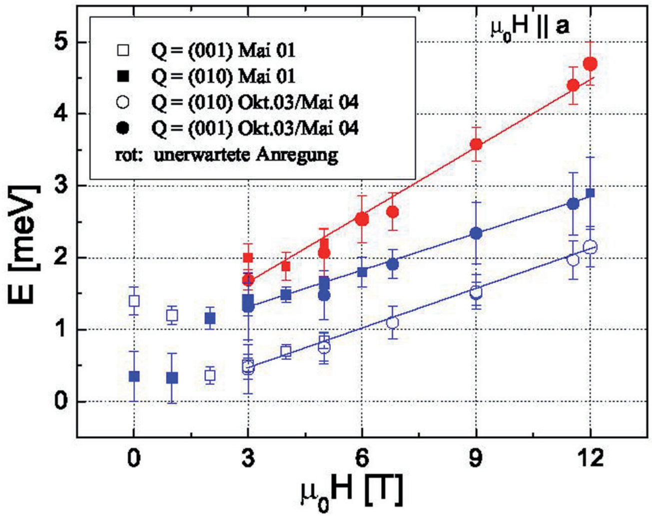


Fig. 3: Field dependence of the magnetic excitations in $CeCu_2$ at the X-points (001) and (010). Below 3 T, only the expected magnon modes are observed (blue). Above 3 T, a new excitation occurs with a slope doubled in comparison to the lower-lying modes.

ful. Therefore, spin wave dispersion was measured dependent on temperature and magnetic field. In addition to the expected behaviour, a spin-wave softening was observed in $NdCu_2$ depending on the field direction as well as the occurrence of a new dispersionless spin-wave mode in high magnetic fields in $CeCu_2$ (see fig. 3).

The fascinating interplay of magnetism and crystallographic structures is intensively studied in another series of rare-earth compounds: R_2PdSi_3. Again, complex magnetic phase diagrams are observed, here together with spin glass-like behaviour measured in the magnetic susceptibility and low-dimensional effects. By use of neutron diffraction, the complicated magnetic structures were determined and systematized in a generic phase diagram. The macroscopically observed spin glass-like behaviour could be identified as a consequence of a competition of nearly degenerate magnetic structures. Initialised by the analysis of the symmetry of the CEF excitations measured without and with applied magnetic field, the crystallographic structure was reviewed and finally corrected: In addition to the main hexagonal *P6/mmm* symmetry the stacking of Pd-Si planes with determined site distribution creates a superstructure. This leads not only to nuclear satellite reflections but also to two different environments of the magnetic atoms and, therefore, to a splitting of the CEF levels (see fig. 4).

Further topics of interest were the unusual magnetic behaviour of intermetallic Gd compounds, the interplay of magnetism and superconductivity in RNi_2B_2C compounds and the coupling between rare earth ions and iron in hard magnetic materials like NdFeB.

In 1998 the development of the TU Dresden cold three-axis spectrometer for the location at FRM II was started. Operating since 2005, PANDA is one of the world-leading cold TAS instruments.

Astrid Schneidewind, HZB-TU Dresden-FRM II

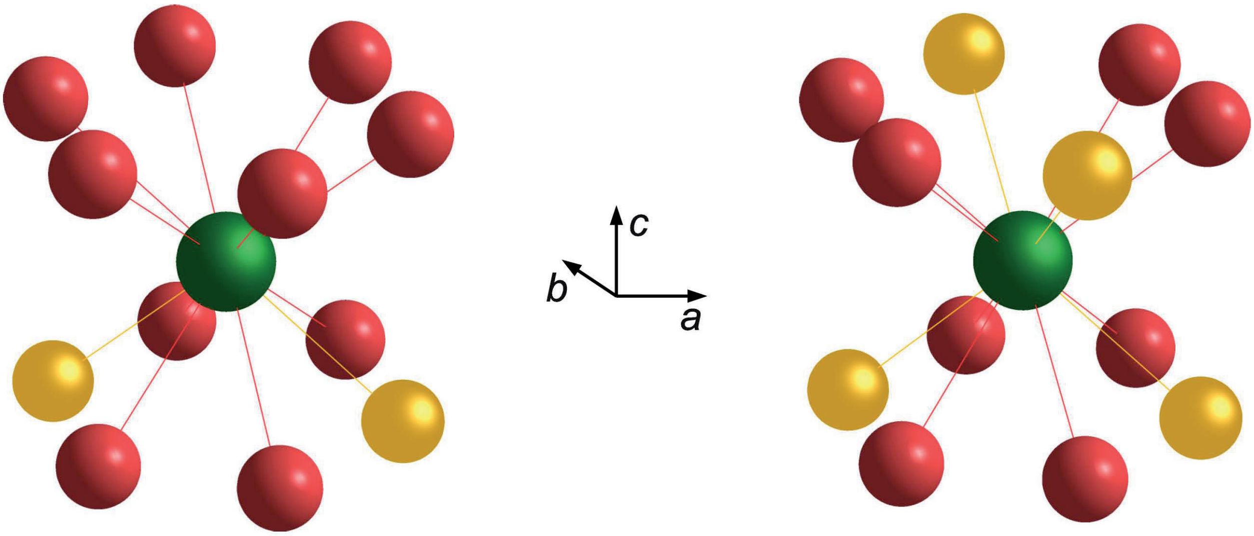


Fig. 4: Sketch of the local environment for two different rare-earth sites: For R (3) type (left) there are no nearest neighbouring Pd atoms while for R (4) type (right) there are four nearest neighbouring Pd atoms, two above and two underneath. The superstructure lowers the local hexagonal symmetry of the rare earth ion to a two-fold symmetry. The different local symmetry of the two sites is reflected in two CEF transitions observed in inelastic neutron scattering experiments.

Neutrons for FEMaS

FEMaS - **F**usion **E**nergy **Ma**terials **S**cience – is an EU-FP7-project among 27 European universities and research centres, which is coordinated by the materials research division of the Institut für Plasmaphysik (IPP) in Garching. The objective of this programme is to “form a strong European network involving institutions and large-scale facilities to strengthen the application of advanced materials characterization methods as an essential ingredient for the successful development of fusion reactor materials in Europe”, as stated in the Grand Agreement for the FEMaS - coordinated action (**www.femas-ca.eu**).

The Forschungs-Neutronenquelle Heinz Maier-Leibnitz (FRM II), located next to IPP Garching, is scientifically best suited to contribute the power of neutron-based methods to the study of material problems occurring in FEMaS.

One focus of FEMaS are plasma facing materials and coatings (“first wall”), which have to withstand enormous temperatures (more than 1000°C), heat fluxes (about 10 MW/m²) and irradiation doses up to tens of dpa (displacements per atom).

Three FRM II instruments turned out to be most powerful in the nearly three years course of the current FEMaS-project:

ANTARES

(**A**dvanced **N**eutron **T**omography **A**nd **R**adiography **E**xperimental **S**ystem)

ANTARES, the neutron imaging facility of FRM II, run by Burkhard Schillinger as responsible instrument scientist, uses different transmissions of neutrons through matter due to their element-specific absorption-coefficients and thus allows for a computed 3d reconstruction of the structure transmitted.

In fig. 1 a plasma facing test-component of the current Wendelstein 7-X experiment at IPP Greifswald is shown as reconstructed neutron tomography image. The carbon fibre composite (CFC) material (upper part) is impregnated with highly absorbing gadolinium as contrast agent (yellow), whereas the copper plate (bottom, blue) is seen as a massive structure, which serves as watercooled heat sink. A close bonding between the CFC and the cooling structure is necessary to avoid overheating of this thermally highly loaded component. Some microfissure at the interface CFC/ copper is clearly recognized, possibly causing a reduced heat transfer. Contrary to X-rays, which cannot penetrate the copper plate, the CFC/ copper interface could be made visible here by neutron computed tomography. Up to now, such failures were nearly undetectable by conventional metallographic methods.

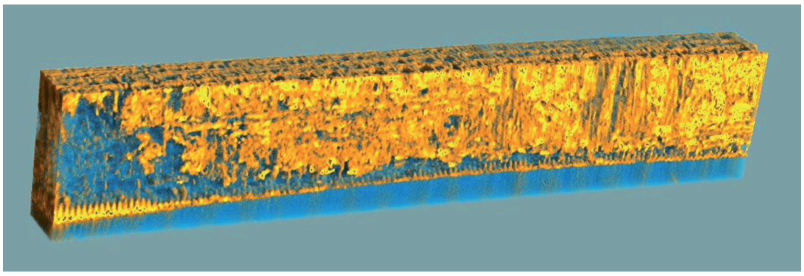


Fig. 1: Neutron tomographic image of a "Wendelstein 7-X" carbon fibre composite structure. The sample was loaded with 5000 heat pulses (10 MW/m² for 10 s per pulse). The delamination zone (ca. 8.5 cm long), between CFC and the copper structure (blue, bottom) is clearly detected (yellow, filled with contrast agent).

NEPOMUC

Neutron induced **Po**sitron source **Mu**ni**c**h

The FRM II is not only a high flux neutron source, but also a strong positron source (9 · 10⁸ e⁺/s) with the instrument NEPOMUC designed for the study of irradiation induced defects in metals such as first wall materials in FEMaS applications.

In collaboration with research groups at IPP Garching and Universität der Bundeswehr München, open volume defects of tungsten before and after loading with deuterium were examined by the instrument scientist Christoph Hugenschmidt.

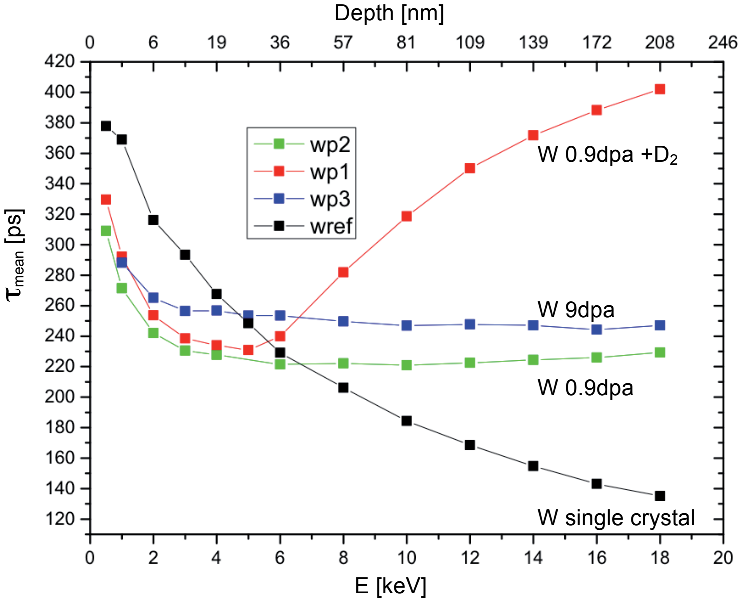


Fig. 2: Depth-dependent lifetime of positrons in tungsten (W) irradiated with two different doses of W-ions (W single crystal for comparison).

For this purpose, annealed tungsten samples (2740 K) were irradiated with W ions with different doses of 0.9 dpa and 9 dpa. In addition, one of the samples was subsequently exposed to deuterium at 350 K. Fig. 2 shows the measured mean positron

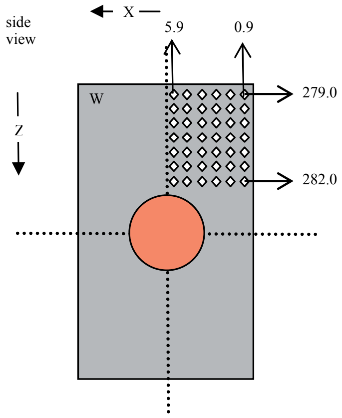


Fig. 3a: Schematic drawing of the side view for the measurement of the tangential strain depicting the line scans at different positions (indicated by the dots) in X and Z direction.

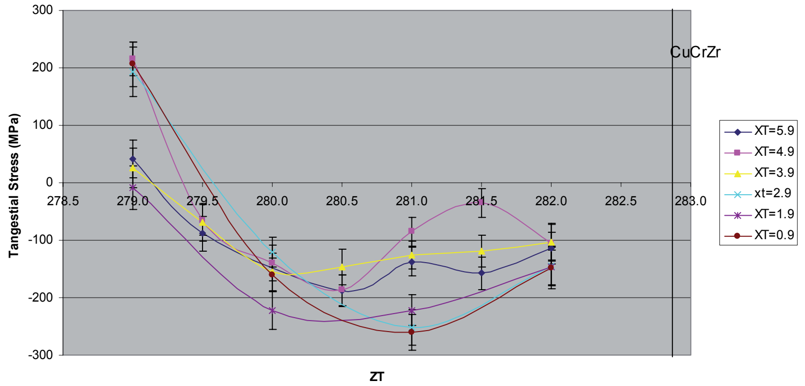


Fig. 3b: Experimental tangential stress as function of Z position for various X positions (collaboration with Demokritos, Athens, Greece).

lifetime as a function of depth. All irradiated samples show a clearly increased positron lifetime in the bulk (> 200 nm) due to the creation of open volume defects. The even higher mean positron lifetime in the D_2-exposed sample is attributed to the fact that single vacancies are occupied by deuterium, leading to a higher trapping of positrons in larger vacancy clusters. The detailed analysis and the comparison with theoretical calculations suggest that about 20% of the positrons annihilate in vacancy clusters with a size of 12-15 missing atoms. After D_2 exposure this number is increased to 65% of positrons trapped in vacancy clusters before annihilation.

STRESS-SPEC

Neutron Bragg diffraction provides an elegant destruction-free method to determine internal 3d stress-states even deep in the bulk of materials. STRESS-SPEC, maintained by the instrument scientist Michael Hofmann, uses the shift of Bragg peaks from a stress-loaded material to calculate the stress-components in a small gauge-volume (about 1 mm³) via the theory of elasticity.

Fig. 3a shows the experimental mapping of one quadrant of a CuCrZr tube acting as heat sink, brazed to a tungsten tile – the plasma facing component. Stresses induced through the brazing process may cause a damage of the weld. The measurement of the tangential stresses (fig. 3b) clearly shows that they change from compressive (negative values) near the interface to zero or tensile at the tungsten surface.

Such an experimental verification of the induced stresses at brazed interfaces is of vital interest for optimising the tungsten tile as a plasma facing component in fusion energy applications.

These examples - and more results – have recently been presented at the "1st International Conference on Fusion Energy Materials Science" (at Rosenheim/Germany on May 9th–13th, 2011, fig. 4), where about 300 participants from 27 countries met, forming a network of material scientists and large scale facilities with FRM II as provider of unique neutron-based methods for today's and future FEMaS-applications.

Christoph Morkel, TUM

Fig. 4: 1st FEMaS-conference in Rosenheim/ Germany, organized by IPP Garching, the coordinator of FEMaS-CA.

Larmor diffraction of quantum phase transitions

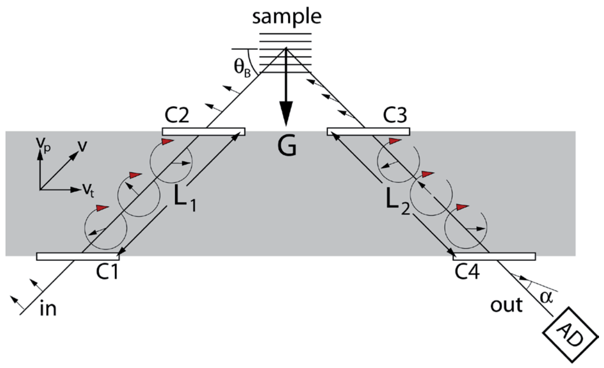


Fig. 1: Schematic of Larmor diffraction; C1 through C4 are radio frequency spin flipper coils, G is the reciprocal lattice vector; Θ_B is the Bragg angle; AD is the polarization analyzer and detector.

Motivation

Quantum phase transitions (QPT) are phase transitions driven by quantum fluctuations. In recent years QPTs have attracted great scientific interest as the origin of novel ordered states. Quantum critical points (QCPs) are defined as zero-temperature second-order phase transitions that are tuned by nonthermal control parameters such as hydrostatic pressure or magnetic field. For the unambiguous identification of novel phases measurements of a physical property are required, that is conjugate to the control parameter. For instance, for the appearance of a new state as a function of temperature, one considers the temperature dependence of the conjugate variable, the entropy S, and measures the specific heat $C_p = T(\partial S/\partial T)|_p$. In particular for the appearance of a new state as a function of pressure at zero temperature, the relevant conjugate variable is the unit cell volume or, equivalently, the lattice constants.

Neutron Larmor diffraction (LD, developed by Keller and Rekveldt) is a novel technique capable of offering major advances in studies of QPTs for three reasons. First, LD allows measurements of lattice constants with an unprecedented precision of 10^{-6} even under extreme conditions. Second, LD allows in-situ measurements of the primary order parameter, e.g. the sublattice magnetization in antiferromagnets, under the same conditions than measurements of the lattice constants. Third, LD allows measurements of the distribution of lattice constant across the entire sample volume. The experiments described in the following were carried out at the thermal triple-axis spectrometer TRISP.

Operating principle of Larmor diffraction

The operating principle of LD is illustrated in fig.1, where the sample is illuminated by a polarized neutron beam (arrows indicate the polarization). The radio frequency spin flipper coils, denoted as C1 through C4, continuously change the polarization direction of the beam as a function of time. Coils C1 and C3 are set up such that they generate a time dependence of the polarization as if the polarization would precess in the scattering plane at twice the radio frequency Ω of the coils. Coils C2 and C4 are then tuned to terminate this time dependence of the polarization; at any given location in the gray shaded regime the beam polarization hence appears to precess even though there is no applied magnetic field. Coils C1 through C4 are aligned parallel to the lattice planes, because this way changes of the lattice parameter sensitively affect the total time of travel t_{tot} along $L = L_1+L_2$ (t_{tot} is purely determined by the velocity component v_p of the neutrons parallel to G). The total phase of precession Φ along L_1 plus L_2 depends linearly on the lattice constant a: $\Phi = 4\omega Lma/h$ (m is the mass of the neutron). Changes of a affect hence the angle α and thus the intensity recorded by the polarization analyzer and detector AD.

NFL phase in MnSi without quantum criticality

In contrast to low-dimensional systems a breakdown of Fermi liquid theory for three-dimensional metals is expected only at QCPs. An exception is the transition metal compound MnSi, which is probably the best candidate with a genuine non-Fermi liquid (NFL) metallic state in a pure three-dimensional metal that is not sensitive to fine-tuning of the underlying interactions (see fig. 2a). We have settled the question of whether the NFL resistivity in MnSi is driven by a QCP or is the characteristic of a novel metallic state far from any instability by Larmor diffraction in a study of the lattice con-

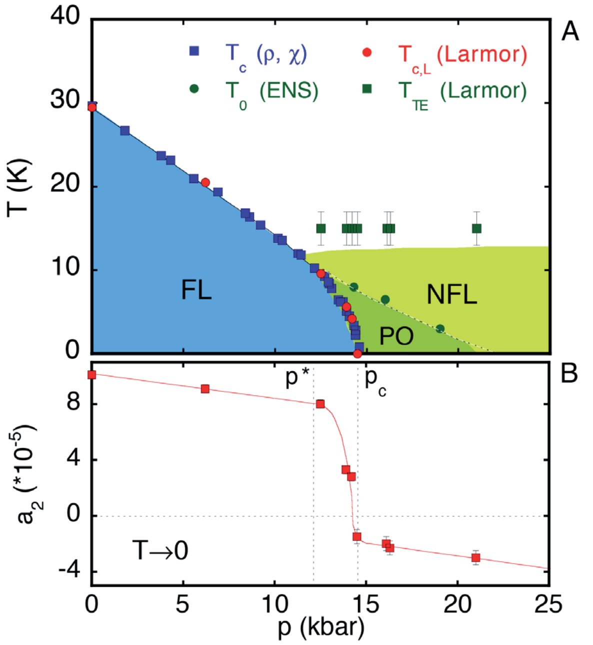


Fig. 2: (A) Temperature versus pressure phase diagram of MnSi. (B) Extrapolated zero temperature magnetic contribution to the lattice constant determined in LD as a function of pressure.

stant of MnSi under pressures up to 21 kbar and temperatures down to 0.5 K.

At ambient pressure the lattice constant of MnSi decreases quadratically with temperature down to T_c. Below T_c a large spontaneous lattice expansion is observed. The extrapolated zero-temperature magnetic contribution to the lattice constant is shown in fig. 2b. With increasing pressure the onset of this spontaneous lattice expansion tracks the pressure dependence of T_c as determined from the resistivity and susceptibility. When T_c is suppressed below about 15 K the lattice constant above T_c displays not only the quadratic temperature dependence. Below $T_{TE} \approx 15$ K an additional gradual volume contraction emerges. With respect to the quadratic temperature dependence, the lattice constant hence changes sign from an expansion to a contraction at T_{TE}; the thermal expansion changes sign from negative to positive. Such a change of sign is also expected at a QCP. However, for a QCP it occurs at $T = 0$ and not at a finite temperature as observed here. Our data in turn establish that the transition at p_c is first order.

Furthermore, in the range $p^* < p < p_c$ the extrapolated spontaneous lattice expansion decreases and vanishes at p_c, consistent with a decreasing volume fraction of helical order inferred from μ-SR. This suggests a phase separation of the magnetic properties into a volume fraction with helical order and a corresponding volume fraction with the high pressure state.

Finally, at the onset temperature T_0 of the partial order the lattice constant is featureless. In contrast, if the partial order on local length scales was akin to the helical order observed at ambient pressure, we would expect a strong signature. Taken together this clearly suggests that the NFL resistivity in MnSi under pressure is not related to quantum criticality and most likely the signature of a novel metallic state.

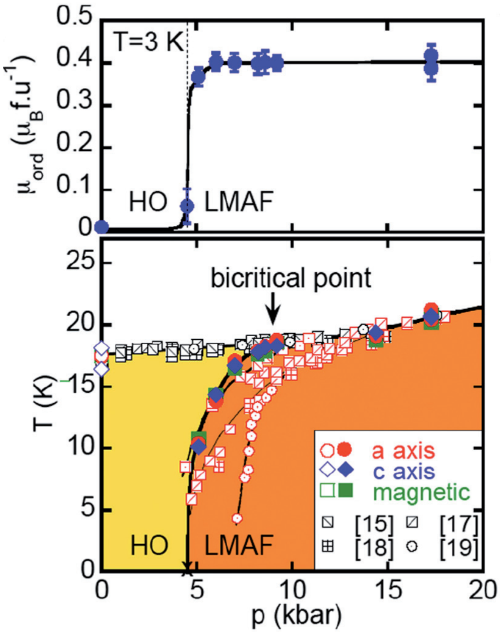


Fig. 3: (top) Pressure dependence of the low-temperature magnetic moment m_s. (bottom) Phase diagram of URu_2Si_2 based on Larmor diffraction and conventional magnetic diffraction data. The onset of LMAF and HO in our data is marked by full and empty symbols, respectively (x marks a transition near base temperature). For better comparison data of T_N and T_0 from the literature are shown, where symbols with bright contours refer to T_N and symbols with dark contours to T_0.

Parasitic nature of SMAF in URu_2Si_2

For over 20 years one of the most prominent unexplained properties of f-electron materials has been a phase transition in URu_2Si_2 at $T_0 \approx 17.5$ K into a state known as “hidden order” (HO). The discovery of the HO was soon followed by the observation of a small antiferromagnetic moment (SMAF), $m_s \approx 0.01\text{-}0.04\ \mu_B$ per U atom then believed to be an intrinsic property of the HO. The discovery of large-moment antiferromagnetism (LMAF) of $m_s \approx 0.4\ \mu_B$ per U atom under pressure consequently prompted intense theoretical efforts to connect the LMAF with the SMAF and the HO. In particular, models have been proposed that are based on competing order parameters of the same symmetry and hence linearly coupled in a Landau theory; such models assume that the SMAF is intrinsic to the HO. This is contrasted by proposals for the HO parameter such as incommensurate orbital currents, multipolar order, or helicity order, where HO and LMAF break different symmetries.

We have used Larmor diffraction for simultaneous microscopic measurements of the lattice constants, the distribution of the lattice constants, and the antiferromagnetic moment of URu_2Si_2 as a function of temperature for pressures up to 18 kbar (see fig. 3). Our data of the distribution of lattices constants $f(\Delta\eta/\eta)$ establishes quantitatively that the SMAF must be purely parasitic. In addition, we find a rather abrupt transition from HO to LMAF which extends from $T = 0$ up to a bicritical point. Our study demonstrates that the transition from HO to LMAF is intrinsically first order; i.e., the HO and LMAF must have different symmetry.

Ongoing and future challenges

As an important line of experimental work we are currently pursuing the interplay of magnetism and superconductivity in selected f-electron compounds. For instance, in the non-centrosymmetric heavy-fermion superconductor $CePt_3Si$ our measurements explain the observation of an increase of the superconducting transition temperature with decreasing sample quality in terms of an effective negative pressure near a quantum phase transition. We have even been able to show, that Larmor diffraction may be used in certain strongly ferromagnetic materials such as the superconducting ferromagnet UGe_2. With further improvements in resolution, expected for the future, there will be an even wider range of scientific problems involving extreme sample conditions, that may be resolved with Larmor diffraction.

Christian Pfleiderer, TUM

Newly arrived

NMI3

Juliette Savin

Phone:
+49.(0)89.289.14615
Email:
juliette.savin@frm2.tum.de

I am Information Manager for NMI3, the European Integrated Infastructure Initiative for Neutron Scattering and Muon Spectroscopy.
Before that, I organized science events for the University of Rio de Janeiro, in Brazil.
I studied biology, but as a science communicator, I have worked with researchers from many different areas, such as biomedicine, paleontology, photovoltaic systems… and now neutron and muon science!

JCNS

Rainer Bruchhaus

Phone:
+49.(0)89.289.10745
Email:
r.bruchhaus@fz-juelich.de

I am the new JCNS manager and also engaged in the JCNS user office.
Before I was senior scientist at the Peter-Grünberg-Institut (PGI-7) in Jülich and worked on resistive switching in transition metal oxides, concepts and technologies of emerging non-volatile memory technologies.
My scientific interests are nano thin film deposition and patterning technologies, resistive switching in oxides and higher chalcogenides, underlying mechanisms.

NREX

Yury Khaydukov

Phone:
+49.(0)89.289.14769
Email:
yury.khaydukov@frm2.tum.de

I am a responsible for the reflectometer NREX.
I finished my PHD in JINR (Dubna, Russia) on studying of magnetic and superconducting layered structures by PNR.
I am very interested in two-dimensional stronlgy correlated electron systems like magnetic and/or superconducting thin films, heterostructures, surface and interface effects in them. Further development of the method of polarized neutron reflectometry.

TOFTOF

Wiebke Lohstroh

Phone:
+49.(0)89.289.14735
Email:
wiebke.lohstroh@frm2.tum.de

I am instrument scientist at ToFToF.
Before, I was at the Karlsruhe Institute of Technology (KIT) working on materials for hydrogen storage. During my preceding PostDoc stays at Amsterdam and Oxford I was working on thin films for smart window applications.
My special scientific interests are materials for energy storage (hydrogen storage and batteries).

Newly arrived

PGAA

Zsolt Revay

Phone:
+49.(0)89.289.12694
Email:
zsolt.revay@frm2.tum.de

What are you doing at the FRM II ?
I am an instrument responsible at PGAA (together with Petra Kudejova, who is part time back). I have been invited here by the owners of this facility for a sabbatical year. My task is to improve the facility: redesign the shielding, install new detectors and make it suitable for the measurement a large variety of sample from ordinary ones (like minerals) to special materials, which can only be measured here, in the highest-flux PGAA facility of the world.

What have you done before?
I was working at the other cold-neutron-beam PGAA facility of Europe, at the Budapest Neutron Center as a deputy department head. I have been invited to several research reactors of the world to design new, or improve existing PGAA facilities from Argentina through United States to Beijing.

What are your special scientific interests?
My special interest is the improvement of nuclear data and methodological developments. The Garching facility will provide unique opportunities to measure the spectroscopic data of low-cross-section nuclides, some of which have never been determined. Accurate nuclear data are essential for nuclear calculations and modeling. I am also interested in developing new nuclear analytical methods, and I hope I can try some of my ideas at the new facility: measurement of nuclides emitting charged particles and scanning neutron microscopy.

New entrance hall inaugurated

The reconstruction of the entrance building at the neutron source is finished. Now, scientists and visitors can enter the FRM II via a lucid and friendly entrance hall.
The neutron source officially opened the new entrance building in May at a reception for the FRM II staff and the companies, which were involved in the several months of construction works. The Scientific Director of the FRM II, Prof. Dr. Winfried Petry, thanked the project team at the neutron source as well as the companies for their excellent work. He also thanked the staff of the FRM II and other institutes as well as the security staff for their patience with restricted access due to the construction.

The new entrance hall links the old gatehouse and the seminary room at the entrance of the FRM II. The new building provides enough space for the increasing number of scientists and visitors, who want to enter the neutron source. The former reception desk had become cramped with more than three persons. The construction costs were financed thanks to the new cooperation of the Technische Universität München and the three Helmholtz Centres Jülich, Geesthacht and Berlin.

Andrea Voit, FRM II

Safety features of the FRM II

Designed to withstand floods, earthquakes and crashing planes

Fig. 1: Anton Kastenmüller, Technical Director of the FRM II, explaining the Fukushima accident to staff of the Technische Universität München. The lecture hall was filled with 700 people.

The earth quake, tsunami and subsequent accident at the Fukushima I reactors in Japan have again raised questions about the safety of nuclear facilities. The FRM II has faced a massive public interest, organized and participated at several talks and panel discussions for a total of ca. 4000 listeners. The Technical Director of the neutron source, Anton Kastenmüller explained in his presentations (see fig. 1) the causes and consequences of the Fukushima accident and why such a scenario would not happen at the FRM II.

The pure facts show the huge difference between a nuclear power plant and the research facility FRM II : Whereas a reactor at the Fukushima plant produces between ca. 1500 (Unit 1) and 3000 MW (Unit 6) thermal power, the FRM II only produces 20 MW. The low power is linked to a decreased temperature of 51°C and non-pressurised water within the reactor of the FRM II, compared to ca. 250°C and pressure at 70 bar in a boiling water reactor. The single fuel element of the research neutron source is embedded within a reactor pool containing 700 m^3 of water. In case of a breakdown of all cooling systems, this water volume would still suffice to remove the residual heat of the fuel element and only heat up to 80°C.

Three subsequent cooling circuits guarantee the safe dissipation of the 20 MW. While passing the fuel element, the temperature of the cooling water only increases from 36 to a maximum of about 51°C. Neither steam nor high pressures are produced.

Redundant safety installations (i.e. multiple, independently constructed units) are a key feature of the safety concept at the FRM II. The central control rod inside the fuel element, for example, is used to regulate and shut down the reactor. Additionally, a redundant set of five shut-down rods is available. Each of these systems is constructed such that the reactor can be shut down in a fast and durable manner, completely independently.

The 1.8 metre thick outer concrete wall of the reactor building protects the reactor against all impacts from outside. It has been designed to resist the crash of a fast military jet (ca. 2500 km/h for the type “Phantom”) as well as the crash of a passenger aircraft. This has been approved by independent experts. Furthermore, the building can withstand earthquakes up to 5.8 on the Richter scale, which is beyond the strength of possible earthquakes in the region, or a high floodwater from the nearby river Isar with a height, that might occur once every 10,000 years.

Like other high-performance neutron sources around the world, the FRM II uses highly enriched uranium in its fuel element. This leads to a high neutron flux producing a minimal amount of radioactive waste.

Andrea Voit, FRM II

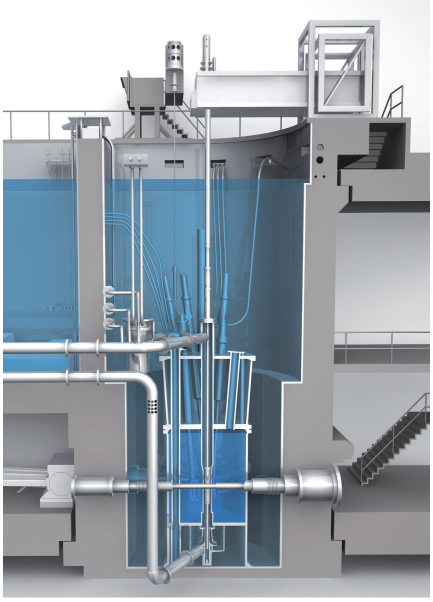


Fig. 2: Cross-section of the reactor pool of the FRM II showing the moderator tank and the fuel element on the bottom (dark blue) and the reactor pool with control rods and irradiation facilities at the top (light blue).

Merging forces

SPONSORED BY THE
Federal Ministry
of Education
and Research

Bayerisches Staatsministerium für
Wissenschaft, Forschung und Kunst

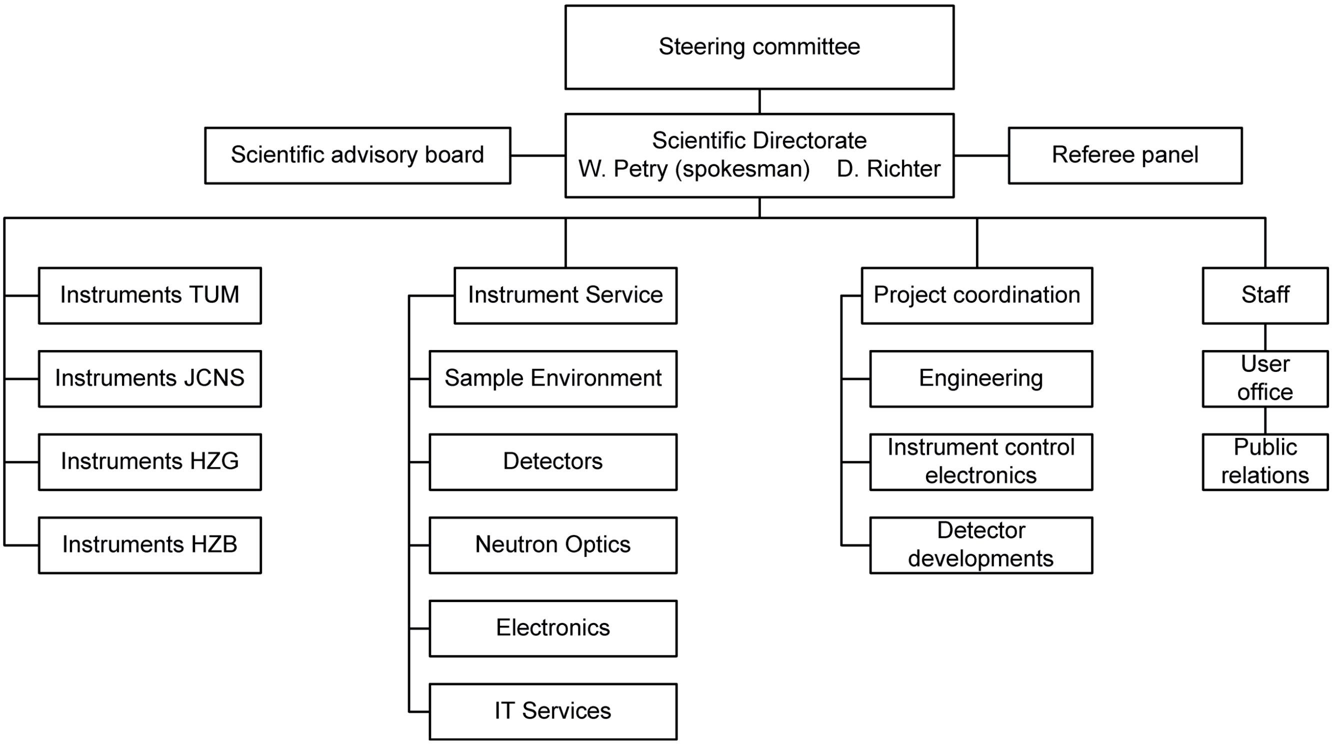
Right from the beginning, the FRM II has been organized as a user facility for German users with an open access for European and international scientists. In 1998 a call for tender for the first instruments brought together expert knowledge from universities, Max-Planck institutes and groups from Helmholtz Centres to build up a well balanced suite of world class beam hole instruments.

Supported by the local service groups for neutron optics, sample environment, detector and electronics as well as software and IT services, the operation of the instruments is ensured by groups of scientists originating from the different participating organizations. Whereas the funding of the reactor operation is ensured by the Bavarian Ministry of Science, Research and the Art, the scientific exploitation is jointly funded by the Bavarian and Federal Governments through the TUM and the Helmholtz Centers. In addition substantial contributions were provided by German universities and the Max-Planck society.

With the signature of the Collaboration Agreement on December 18th, 2010 – as reported in our last newsletter - this common effort has obtained the necessary financial support and organisational structure. Three Helmholtz institutions lead by the Forschungszentrum Jülich and the TUM now share the scientific exploitation of FRM II. The common funding of the BMBF and the Bavarian Ministry has led to a new scientific directorate. Two directors represent the consortium of the Helmholtz Centers in Jülich, Geesthacht and Berlin (Prof. Richter) and the TUM (Prof. Petry), respectively.

This new structure will promote the symbiotic efforts of university groups, neutron centers and Max-Planck institutes. The established mixture of 2/3 external user operation and 1/3 in house research of the available beam time guaranties an optimum of service for our users and a continuous development of the instruments to maintain a top position for neutron research in Garching.

Winfried Petry *Dieter Richter*



New organisational structure of the scientific usage at the FRM II.

Komitee
Forschung mit
Neutronen

Dear reader,

for German neutron users, the current period of time is somewhat boring since both national sources, the FRM II in Garching as well as the BER-II in Berlin, are not in operation. At both sites, important upgrades of instruments or neutron guides are currently underway and the restart is expected only in August. Hence, most of the German neutron activities are currently concentrated at the high-flux reactor of the ILL in Grenoble that started again in April after the long winter shut-down. We are confident that the normal situation with the reliable supply of neutrons all places will be recovered in the second half of this year.

Even if several neutron experiments had to be postponed, there are a lot of activities of neutron scientists especially in promoting the project of the European Spallation Source ESS. Funded by the BMBF a design update project was launched in which the German neutron centres in Jülich (FZJ), Berlin (HZB), Geesthacht (HZG) and Garching (TUM) explore optimised designs of the spallation target, of instruments and critical components. Moreover, the whole community is invited to contribute to the discussion of challenging scientific topics that can be studied using the ESS. The exchange of even unconventional ideas is needed to define the requirements that efficient instruments have to meet in order to make scientific visions come true. To start this process, the neutron centres, the ESS management and the KFN have jointly organised a workshop entitled “Science Vision for the European Spallation Source” that will take place at October 10th-12th in Bad Reichenhall. I would like to encourage all of you to attend this meeting. Please, raise your voice when possible new aspects of neutron applications are discussed that may have a great impact on the development of new instruments optimised for exciting future applications. Germany has one of the most lively and active neutron communities worldwide. Therefore, its members should also contribute significantly to the concept and design of the ESS and its instrumentation.

The next German Neutron Scattering Conference will take place in fall 2012 near Jülich. Placed between the ECNS in Prague 2011 and the ICNS 2013 in Edinburgh, this national meeting will be a good opportunity to present first results of the design update project for the ESS.

Finally, some words concerning the Komitee Forschung mit Neutronen (KFN) itself, as the representation of the German neutron users: The period of the 8th KFN expires in fall and the following committee was elected in June and will continue to formulate and support the needs of our fascinating scientific field. I am strongly convinced that it is the fruitful cooperation between neutron centres, universities and Max-Planck-institutes that strengthens the German position in neutron science. This is documented in the new strategy paper published by the KFN in July 2011. If you are interested to receive a copy, please contact our webmaster under **kfnadmin@physik.uni-kiel.de**

Since we are always interested to keep our user database up to date: may I ask you to check your registration in the KFN user data base?
https://sni-portal.uni-kiel.de/kfn/user.php
This will help us to distribute information about the KFN-activities and related topics among our neutron community.

Götz Eckold
Chairman of the 8th Komitee Forschung mit Neutronen (KFN)
(**geckold@gwdg.de**)

Experiments starting in August

Due to the long maintenance break (lasting since October 2010) the User Office has not seen any users for nearly ten months!

Though many planned milestones could successfully be reached during the break, some incidents were responsible for the repeated postponements of the reactor start.

Major issues close to the reactor were the replacement of the positron source including the beam tube SR11 and the exchange of a thimble in the reactor vessel for future radio-isotope production, i.e. the new 99-Mo facility. On this occasion we have modified the inserts of SR4 to open a cold neutron beam for particle physics (new MEPHISTO in the guide hall east) and rebuild completely the imaging instrument ANTARES. The shutdown enabled further work on the instruments like opening a second channel of hot neutrons for POLI@HEiDi at SR9 or upgrading TOFTOF from 600 to 1000 detectors.

During the inspection of the heavy water circuit, corrosion on a bearing of a security cap has been discovered. The repair of this problem hindered us so far to restart the reactor in time. We will lose 1,5 cycles this year due to this problem. We therefore decided to shift all experiments of our external users to the beginning of August in order to have a reliable schedule. As a second consequence we will shift the deadline of the next proposal round to November 4th, 2011. There will be no proposal round in January 2012. The new deadlines for 2012 will be published as soon as possible.

We are looking forward to welcoming neutrons and users in August!

Jürgen Neuhaus, FRM II

No neutrons but many proposals!

Proposal round 13 (FRM II) and 9 (JCNS)

Despite the lack of neutrons many proposals were submitted for the FRM II's 13th and the JCNS' 9th round. A total of 285 asked for beam time at the 24 instruments located at the FRM II.

Many of our users asked questions about the reviewing process - that is why we use the opportunity to give you an insight.

After the deadline is reached, the first overlook is made by the instrument scientists. Each of them reads the proposals submitted for his instrument carefully and decides if the proposed experiment is technically feasible at the instrument and with the available sample environment. Ideally the proposer contacted the instrument scientist in advance.

All information about the technical feasiblity is very valuable for the referees who have to suggest the distribution of the beam time to the FRM II directorate. The review panel consists of independent international scientists who are asked to assess submitted proposals touching their area of research. For a three years period they review the proposals twice a year basing the decision only on the scientific merit of the proposed experiments.

This time, the review panel of the FRM II is divided into six subcommittees, dealing with magnetism and phonons, structure research, soft matter and bio physics, applied science I and II (positrons, nuclear and particle physics; texture and stress measurements, radiography) and finally magnetism and thin films.

The subcommittee magnetism and thin films is a new one. Due to the high amount of proposals in the field of magnetism, the already existing subcommittee has to be discharged and so a new group of referees was established.

The JCNS established two subcommittees: One for magnetism and one for soft matter.

For the most part, the review process is an online process. Within a special account at the digital User Office system, each referee has access to the proposals of his subcommittee as well as to submitted reports describing prior experiments carried out in connection with the new proposal. The system enables the referees to store comments and votes. All this is done in advance to the review held at Garching about 6 to 8 weeks after the deadline of the proposal round.

Organized by the User Office all referees meet and discuss the proposals within their subcommittee. Each subcommitttee is accompanied by a secretary, a scientist of the FRM II. She or he documents the discussion and the decisions taken. It is an intense and very busy day for every participant!

Ina Lommatzsch, FRM II

Dear users of FRM II and JCNS,

you are invited to apply for beam time at the German neutron source Heinz Maier-Leibnitz (FRM II).

Deadline for proposals: November 4th, 2011

Just **register** at the digital user office. With your personal account you can access the proposal and reporting system. Have a look at

www.frm2.tum.de/en/user-office

for additional information and guidance to perform experiments at the FRM II.

Please note: The beam time on the instruments of the JCNS facility hosted at the FRM II neutron source in Garching are distributed through the JCNS proposal system.
Proposals have to be submitted via the web portals within your personal account

- for FRM II instruments: **user.frm2.tum.de**
- for JCNS instruments: **fzj.frm2.tum.de**

They are **reviewed** twice a year. The next **review** will take place on December 15th-16th, 2011. Results of the review panel meeting will be online about two weeks later.

The FRM II is a partner in the EU supported network of European neutron facilities (**NMI3** in FP7). Researchers working in EU Member States or Associated States other than Germany can **apply for travel and subsistence reimbursement**.
Please find all details at

- for FRM II instruments: **www.frm2.tum.de/en/user-office/nmi-3/index.html**
- for JCNS instruments: **www.jcns.info/NMI3/**

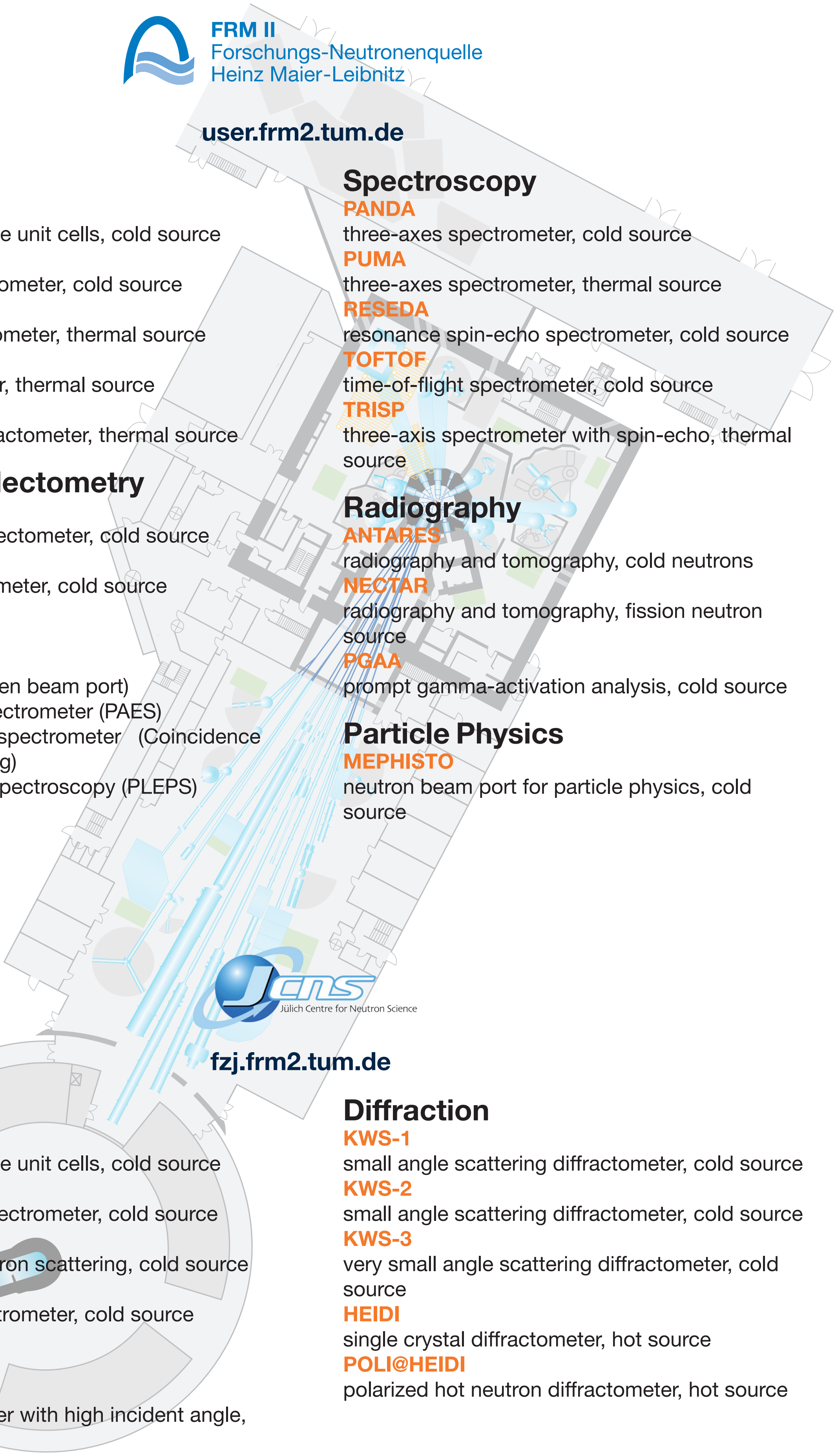
To ensure the feasibility of the proposed experiment please contact the instrument scientist in advance.

Furthermore you can apply for CRG beam time at JCNS instruments at ILL and SNS for German users. For more information abot this please refer to

www.jcns.info/jcns_proposals

In addition to beam tube experiments irradiation facilities are available for neutron activation analysis, isotope production and silicon doping.

Call for proposals: Next deadline November 4th, 2011



FRM II
Forschungs-Neutronenquelle
Heinz Maier-Leibnitz

user.frm2.tum.de

Diffraction

BIODIFF
diffractometer for large unit cells, cold source
MIRA
multi purpose diffractometer, cold source
RESI
single crystal diffractometer, thermal source
SPODI
powder diffractometer, thermal source
STRESS-SPEC
material-science diffractometer, thermal source

SANS and Reflectometry

NREX
polarized neutron reflectometer, cold source
REFSANS
time-of-flight reflectometer, cold source

Positrons

NEPOMUC

- positron beam (open beam port)
- positron auger spectrometer (PAES)
- positron defect spectrometer (Coincidence doppler broadening)
- positron life time spectroscopy (PLEPS)

Spectroscopy

PANDA
three-axes spectrometer, cold source
PUMA
three-axes spectrometer, thermal source
RESEDA
resonance spin-echo spectrometer, cold source
TOFTOF
time-of-flight spectrometer, cold source
TRISP
three-axis spectrometer with spin-echo, thermal source

Radiography

ANTARES
radiography and tomography, cold neutrons
NECTAR
radiography and tomography, fission neutron source
PGAA
prompt gamma-activation analysis, cold source

Particle Physics

MEPHISTO
neutron beam port for particle physics, cold source

Jülich Centre for Neutron Science

fzj.frm2.tum.de

Spectroscopy

BIODIFF
diffractometer for large unit cells, cold source
J-NSE
neutron spin-echo spectrometer, cold source
DNS
polarized diffuse neutron scattering, cold source
SPHERES
back-scattering spectrometer, cold source

Reflectometry

MARIA
magnetic reflectometer with high incident angle, cold source

Diffraction

KWS-1
small angle scattering diffractometer, cold source
KWS-2
small angle scattering diffractometer, cold source
KWS-3
very small angle scattering diffractometer, cold source
HEIDI
single crystal diffractometer, hot source
POLI@HEIDI
polarized hot neutron diffractometer, hot source

Upcoming

July 17-22, 2011
5th European Conference on Neutron Scattering
(Prague, Czech Republic)
www.ecns2011.org

September 5-16, 2011
15th JCNS Laboratory Course - Neutron Scattering
(Jülich/ Garching, Germany)
www.jcns.info/wns_lab_now/

September 7-9. 2011
MECA SENS VI: 6th International Conference on Mechanical Stress Evaluation by Neutrons and Synchrotron Radiation
(Hamburg, Germany)
www.mecasens2011.de/

September 12- 16, 2011
Summer School on “Application of Neutrons and Synchrotron Radiation in Engineering Materials Science”
(Lauenburg near Hamburg, Germany)
www.hzg.de/mw/summerschool/

October 4-7, 2011
JCNS Workshop 2011: Trends and Perspectives in Neutron Instrumentation: From Continuous to Spallation Sources
(Tutzing, Germany)
www.jcns.info/Workshop_2011//

October 10-12, 2011
ESS Workshop: Science Vision for the European Spallation Source
(Bad Reichenhall)
www.fz-juelich.de/SharedDocs/Termine/JCNS/EN/ESS-Workshop2011.html

October 15, 2011
Open Day at the neutron source FRM II and the campus Garching
(Garching, Germany)
www.frm2.tum.de

Reactor Cycles 2011

26:	August 1st - September 29th
27:	October 19th - December 16th

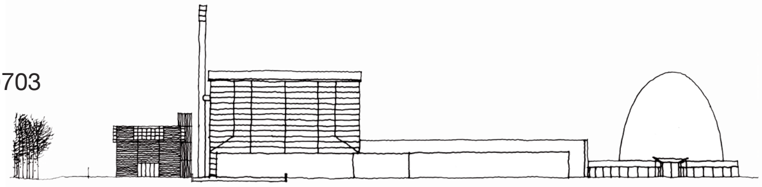
IMPRINT

Editors
Rainer Bruchhaus
Peter Link
Ina Lommatzsch
Jürgen Neuhaus
Andrea Voit

Picture Credits
Uli Benz (TUM): 16 both; Henrich Frielinghaus (JCNS): page 39; Andreas Heddergott (TUM): 4 top, 5 bottom right; Christine Papadakis (TUM): 17 right; Wenzel Schürmann (TUM): title image, page 3 top, 6, 8 top, 12, 13 top, 14 top, 18 both top, 31 both bottom, 32 top.

If not indicated: By editors, authors and/ or TUM.

Contact
Technische Universität München
Forschungs-Neutronenquelle Heinz Maier-Leibnitz (FRM II)
User Office
Lichtenbergstraße 1
D-85747 Garching
Phone: +49.(0)89.289.10794 / 10703
Fax: +49.(0)89.289.10799
e-mail: userinfo@frm2.tum.de
www.frm2.tum.de



From dusk till dawn...

news 6 (2011)

SPONSORED BY THE

Federal Ministry
of Education
and Research

funded by

Bayerisches Staatsministerium für
Wissenschaft, Forschung und Kunst