The combustion chamber of an Ariane launch vehicle is being investigated with neutrons at the Hahn-Meitner-Instiut (Residual stress analysis)

# User Service



Photo: Bernhard Schurian

# BENSC Operation

Director: Prof. Ferenc Mezei

It is the mission of the Hahn-Meitner-Institut as a research center of the Helmholtz Association *to operate large-scale facilities for providing best state-of-the-art research opportunities for the national and international user community*. The Berlin Neutron Scattering Center (BENSC) was established at the HMI to accomplish this task for the neutron research community and more recently also for users of synchrotron radiation with a particular focus on promoting the complementary use of both probes: neutrons and photons.

BENSC is characterised by two important strengths: extreme sample environment providing the world's highest magnetic fields and lowest temperatures in neutron scattering and development of new instrumentation concepts and techniques both for continuous and pulsed neutron sources. As a result, experimental capabilities at several BENSC instruments are unique or competitive with the best at high-flux sources. Other BENSC instruments provide solid performance for a nearly complete spectrum of neutron scattering studies, for purposes of both high quality research and education of students and new neutron users. Between 3 and 7 diploma as well as between 12 and 16 PhD theses are based on experiments performed at BENSC each year. Once a year, a tutorial is held for students from European countries allowing hands-on experiments at various BENSC instruments. The user programme has been highly rated and is strongly supported by the EU since 1993.

## Profile of BENSC

BENSC is characterized by an extraordinarily wide ranging instrumentation, which is remarkable for a medium flux neutron facility. With the exception of a backscattering machine, a complete spectrum of instrument types allows experiments to be performed in practically all areas of neutron science, from basic to applied research. Several advanced BENSC instruments provide neutron intensities and resolutions competitive with the best available worldwide. Most instruments have the option of using polarized neutrons. Examples for especially advanced and partly unique instruments are

- the polarized neutron option SANSPOL
- the multidetector option of the time-of-flight spectrometer NEAT
- the wide-angle spin-echo spectrometer SPAN with a time-of-flight option
- the flat-cone diffractometer

and in particular the sample environment.

BENSC has a long-standing, world-wide recognised tradition in developing and providing sample environment for extreme conditions. Experiments can be performed over a large range of temperatures and magnetic fields. Two cryomagnets designed by Oxford Instruments in cooperation with HMI scientists allow users to routinely carry out neutron scattering experiments at fields up to 15 T in combination with temperatures down to 30 mK. For temperatures down to 1.5 K, the magnetic field can be increased up to 17.5 T, the highest static magnetic field world-wide available for neutron scattering experiments. BENSC strives for further pushing the present field limit towards significantly higher values in cooperation with the National High-Field Laboratory of the USA in Tallahassee. A design study for a new magnet has been undertaken aiming at a field of 25 T with the option of a further upgrade to 35 T.

The BENSC neutron scattering instruments are described in detail on the BENSC webpage: http://www.hmi.de/bensc/instrumentation/instrumentation_en.html.
A new colour-printed instrument brochure replacing the present brochure (HMI-B 577) published in March 2001 will be available on request end of 2006. A detailed technical handbook on the BENSC sample environment is also available on the web: http://www.hmi.de/bensc/sample-env/index_en.html

## The New Neutron Guide Hall II

Completing the instrumentation in the new Neutron Guide Hall II is presently the most important upgrade project of BENSC. The construction of the building itself was finished end of 2004. Beginning of 2005, the multi-spectral beam extraction system replacing the old neutron guide 4 had been installed and reactor operation could start again. Further during the year 2005, the first part of the guide system for the new hall was mounted and connected to the extraction system. This novel extraction system feeds cold as well as thermal neutrons into the guide for the new time-of-flight diffractometer EXED. Two other guides serve for the new high resolution SANS-instrument (VSANS) which is presently constructed and for the spin-echo instrument SPAN which was shifted from the old neutron guide hall to the new one. The *Extreme Environment Diffractometer* EXED was especially designed for investigations using the planned 25 T magnet (later upgraded to 35 T) which shall ensure the leading position of BENSC in neutron scattering experiments at high magnetic fields.

## BENSC User Policy

BENSC is open to the national and international scientific community. About 70% of the beam time is available to external users, 30% to in-house researchers. A minor part of the beam time for external users (up to 20% of the total beam time of an instrument) can be given to long term collaborating groups from German universities and other research institutions, the rest (at least 50% of the total beam time) is given to short term projects via a peer-review selection process. The long term collaborations serve mainly two purposes: they (i) allow university groups a reliable planning of thesis works and (ii) enlarge the pool of scientific expertise available at BENSC. Proprietary research by commercial companies is also possible at request, mainly at special instruments, but will be charged.

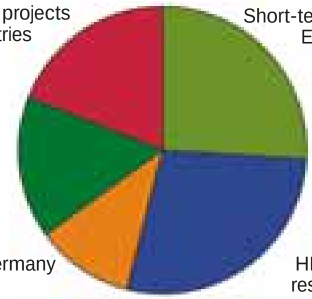



Fig. 1: Distribution of BENSC instrument time in 2005

## BENSC User Service

BENSC provides extensive logistic, technical and scientific support for all external users at the scheduled instruments. Beam time allocation and assistance in all logistic matters are organised by the BENSC user office.

## Beam time allocation

The beam time allocation is based on a proposal system with two proposal rounds per year. Proposals for short-term projects submitted by external users are peer-reviewed by an international Scientific Selection Panel, which is meeting and discussing the proposals at the HMI. Following the decisions of the Scientific Panel, proposers of accepted short-term projects are invited to perform the proposed experiment at BENSC. In general, all rejections are accompanied by comments with the objective to help for a potential resubmission or give further suggestions, e.g. references of better suited instruments at other sources.

## Logistic support

BENSC is prepared to assist external users with travel and subsistence expenses, whereby users from German Universities get preferential treatment. Users from EU member states and associated states are eligible for grants provided by the European Commission for access to BENSC. EU users can get full travel refund for up to two participants per experiment. The BENSC guest office is assisting the users in all these logistic matters including housing. BENSC runs a 30 bedroom hostel on site.

## Technical and scientific support

All external users carrying out experimental work at BENSC have HMI instrument scientists as local contacts who assist in preparing and performing the experiments thus ensuring the efficient use of the beam time. In addition, a pool of BENSC technicians is available for technical assistance during the preparation and running of the experiments. For experiments under extreme sample environment conditions special staff is taking care of the sample environment such as the high-field cryomagnets.

## BENSC User Statistics 2005

For 2005, more than 160 short-term projects of external users have been accepted by the Scientific Selection Panel (see Table 1) with over 1060 days of beam time allocated. Although three normally scheduled instruments of the neutron guide hall were still out of operation due to the ongoing upgrade project Neutron Guide Hall II, the figures are almost identical to those of 2003, the last "normal" year with a complete instrument suite and full reactor operation.

| Countries of origin | accepted projects | allocated days |
|---|---|---|
| Germany | 54 | 282 |
| EU + Associated | 81 | 454,5 |
| Russian Federation | 7 | 191 |
| Australia, Indonesia, India, Japan, Republic of Korea, Mongolia, USA, South Africa | 20 | 141 |
| Sum: | 162 | 1068,5 |

Table 1: Allocation of BENSC beam time for short term projects in 2005

## BENSC user service at BESSY

To promote the complementary use of neutrons and synchrotron radiation, the HMI has initiated an upgrade project for the synchrotron source BESSY including the development and installation of two new insertion devices: the undulator UE46 providing soft X-rays with worldwide highest brightness and flux density and the 7T wiggler 7T-MPW shifting the photon energies to the hard X-ray regime. HMI-BENSC has built and operates 3 beamlines with four instruments S1–S4 at these devices and a further instrument, the X-ray tomography station S5, at a non-HMI beamline. Access to these instruments is organised via the BESSY proposal system,
http://www.bessy.de/boat/www/
while the user service is performed by HMI-BENSC personnel.

The instrument S1 at the undulator beamline has been in routine user operation since 2003. In 2005, a second experimental station was commissioned in addition to the spectroscopy chamber: a reflectometer with a magnet providing a field of 7T at the sample position (see p. 29). This high-field reflectometer opens up exciting new possibilities, in particular for investigating thin magnetic films and nanostructures.

Two beamlines are installed at the 7T wiggler: a monochromatic beamline providing photons with energies between 4 keV and 40 keV for the instruments S2 and S3 and a white beamline providing photons of energies up to 150 keV for the materials science instrument S4. The instrument S2 is specialised on resonant magnetic scattering and high resolution diffractometry, the instrument S3 on anomalous small-angle scattering (ASAXS) and grazing incidence scattering (GISAXS) (see p. 28). S2 and S3 are operated alternatively at the monochromatic beamline. The instrument S4 at the white beamline is dedicated to materials science and engineering investigations, in particular to stress analysis using energy dispersive methods. All three wiggler instruments have been commissioned in 2005. S2 and S3 are in full user operation since April 2005, S4 since beginning of 2006. The X-ray tomography instrument S5 operated by HMI-BENSC at the 7T wavelength-shifter beamline of the Bundesanstalt für Materialprüfung (BAMline) at BESSY is in full user operation since 2004.

A detailed description of these five instruments is given in the new instrument brochure of BENSC which will be available end of 2006 and on the BENSC web pages.

| | Main instrument characteristics | External groups | External beamtime | Inhouse groups | Inhouse beamtime |
|---|---|---|---|---|---|
| S1 at UE46 | Spectroscopy/ reflectometry | 16 | 24 weeks | 6 | 14 weeks |
| S2 at 7T-MPW | Res. magn. scatt./ high-resol. diffract. | 5 | 7 weeks | 3 | 11 weeks |
| S3 at 7T-MPW | ASAXS/GISAXS (commissioning) | – | – | 1 | 4 weeks |
| S4 at 7T-MPW | Materials Science stress analysis | 6 | 10 weeks | 5 | 6 weeks |
| S5 at BAMline | Tomography | 20 | 24 days | 5 | 6 days |

Table 2: Short user statistics for HMI-BENSC instruments at BESSY in 2005

### Support for European Access to BENSC from the European Commission

Right from the beginning of the BENSC user programme in 1993, the access of European research groups to BENSC was generously supported by the European Commission under framework programmes FP3, FP4, FP5 and FP6 of the European Commission – with funds for the BENSC access programme increasing from contract to contract.

The successful European Access programme to BENSC is presently continued under the 6th EU Framework Programme (FP6), however, with a slightly modified contractual situation: BENSC is now a partner in the Integrated Infrastructure Initiative for Neutron Scattering and Muon Spectroscopy (NMI3). NMI3 brings together 23 partners from 14 countries, including 11 research infrastructures, together with other interested organisations. The most important branch of NMI3 includes 12 different Access Activities offering European users approximately 5000 beam days of access to 150 instruments at different facilities with support for travel and subsistence. Under NMI3, BENSC will provide a minimum access of 1040 instrument days, distributed over four years.

In 2005, the second year under NMI3, over 60 projects of European user groups have been completed. BENSC delivered 360 instrument days. A total of 119 users from 56 groups from 16 countries were involved. Since the start of NMI3, BENSC has thus provided already more than 800 days for the European user community.

### BENSC User Meeting 2005

The BENSC User Meeting held in September 2005 attracted more than 100 participants. One half of them came from national and foreign research institutions. 15 invited talks and 46 posters gave ample opportunity for lively discussions and scientific exchange on the latest results from experiments performed at BENSC.

### Scientific Results of Experiments performed at BENSC

Each short-term project carried out at BENSC must be followed by an *Experimental Report* within due time (not more than half a year delay). These are short descriptions of the experiments performed and the data obtained. It is clear that the results given in the reports can often only be preliminary. The reports are collected and published annually as *BENSC Experimental Reports*. They are distributed to all users of BENSC and give a complete overview on the scientific activities at BENSC. Starting with the year 2000 the *BENSC Experimental Reports* are also available on the BENSC web pages (http://www.hmi.de/bensc/user-info/reports.htm). Most important for the reputation of BENSC, however, are the regular publications of its users, a remarkably high fraction of them being published in high ranking journals.

Three examples of highlight results from external user groups are included in the Scientific Highlights Section of this Report.

# NAA Laboratory and Irradiation Service at BER II

D. Alber, G. Bukalis, B. Stanik, A. Zimmer
HMI, SF6

The laboratory for neutron activation analysis (NAAL) at HMI's research reactor BER II provides irradiation services for universities, scientific institutions and industry. Typical fields of applications are:

- Trace elements analysis by means of neutron activation analysis (NAA) for example in biology, medicine, geology and archeology. Certification of reference materials.
- Irradiation experiments, such as isotope production for medical applications, sources for Mößbauer spectroscopy and production of tracers for scientific and industrial applications.

The operation and further development of the irradiation devices at BER II and of the NAA measuring systems are a central task of the department SF6.

Fig. 1: Granules of pure Silicon enclosed in ampoules made of highly pure silica

### Irradiation devices

Three irradiation devices are available for different applications.

DBVK: irradiation device in the reactor core
DBVR: rotatable irradiation device in the Beryllium reflector of the reactor core
TBR: dry irradiation device outside the Beryllium reflector

DBVK and DBVR are used for long term irradiation experiments. Up to nine aluminum containers can be irradiated simultaneously. Short time irradiation experiments are carried out by means of TBR. A fast rabbit system (SRT) is closed for the time being.

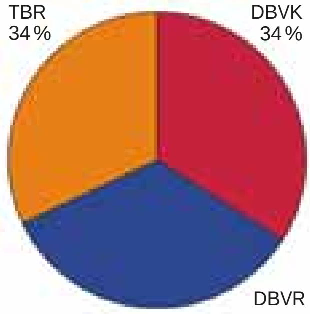
| Device | $\Phi_{thermal}$ [1/cm²s] | $\Phi_{fast}$ [1/cm²s] | Container |
|---|---|---|---|
| DBVK | $1{,}5\times10^{+14}$ | $4{,}3\times10^{+13}$ | 6 |
| DBVR | $7{,}5\times10^{+12}$ | $1{,}9\times10^{+10}$ | 9 |
| TBR | $3{,}4\times10^{+12}$ | $2{,}2\times10^{+10}$ | 1 |

### Irradiation Experiments 2005

Since June 2004, irradiation of destructible material, particularly biological material in the DBVK has been possible. Consequently, the contribution of this device rose from 9 % in 2003 to about 35 % in 2004 and 2005.

A total of about 3700 samples were irradiated in 2003. Two thirds of the 333 irradiation experiments were performed with the DBVK or DBVR. With these devices it is possible to irradiate up to 24 samples simultaneously in one aluminum container. About 48 % of the irradiation experiments and the analysis of samples were done for external users.

Utilization of the different Irradiation devices



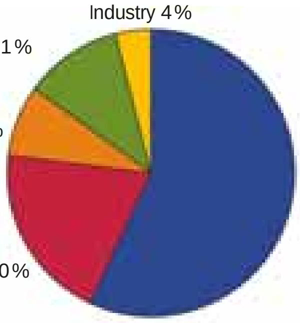

### Internal users

Most of the internal users are from the Dept. SF6, but irradiation and analyses were also performed for users from other departments (SF2, SF4, SE5, reactor department).

### External users

Irradiation experiments and NAA were performed for users from German universities (Berlin, Gießen, Mainz, Heidelberg, Leipzig, Munich, Kiel, Nuremberg) and from research institutes such as the Federal Institute for Materials Research and Testing BAM (Berlin), the Leibniz Institute for Zoo and Wildlife Research IZW (Berlin), the National Research Center for Environment and Health GSF (Neuherberg), DESY (Hamburg) and the Dresden branch of the Fraunhofer Institute for non-destructive testing.

Origin of Samples irradiated in 2005



# ISL Operations and Developments

Scientists: H. Homeyer, A. Denker, W. Pelzer, C. Rethfeldt, J. Röhrich
Operators:J. Bundesmann, R. Grünke, G. Heidenreich, H. Lucht, E. Seidel, H. Stapel

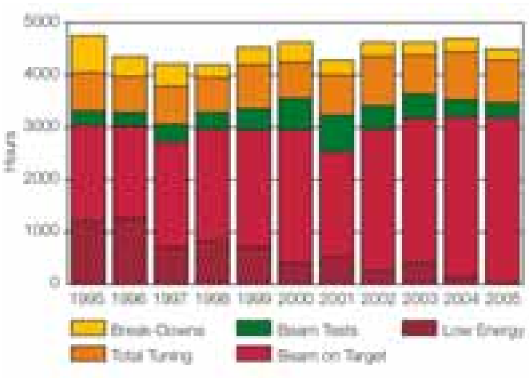



Fig. 1: ISL Operations since 1995: ISL's operation has been very stable over the past ten years. In 2005, the same beam time on target as 2004 could be produced with lower total scheduled operation time.

The Ion-Beam Laboratory ISL offers ion-beams from various accelerators and accelerator combinations with energies ranging from some tens of eV to several hundred MeV dedicated to the application of ion-beam techniques. Internal and outside users study the basics of the interaction of ions with solids. They modify and analyse materials with ion beams and they perform radiotherapy of eye tumours with fast protons in a joint venture with university clinics. Users have at their disposal 15 different irradiation areas equipped with specific instrumentation.

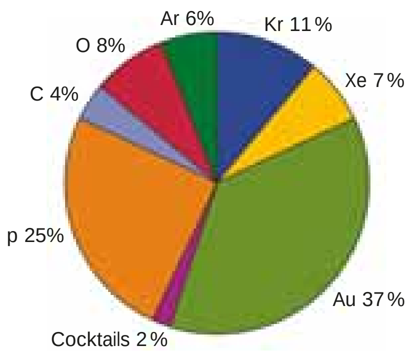



Fig. 2: Ions produced at ISL in 2005: Au-beams with a share of 37 % are the most frequently used beams at ISL. Main applications are ion beam analysis (ERDA) and ion beam induced materials modifications.

ISL operations went smoothly in 2005 (see Fig. 1) except for one major breakdown. Over a shutdown weekend, a water leak arose at the RF-coupling loop of the RFQ leading to a complete flooding of the injector. It took some days for a complete repair, cleaning and drying.

Within the scheduled operation time of 4500 hours, 3200 hours of beam time on target were produced. The loss of scheduled beam time due to break-downs was again lower than 5 %. The high reliability of 95 % is essential for a successful user programme, in particular for the therapy of ocular melanomas with high energy protons. As in the years before, Au-ions and protons were again the most attractive beams used in 2005. Au-beams are used as projectiles for materials analyses and ion beam induced materials modifications. Apart from therapy, there is a large demand for high energy proton beams, either for high-energy PIXE, radiation hardness testing or device testing for a large proton therapy machine.

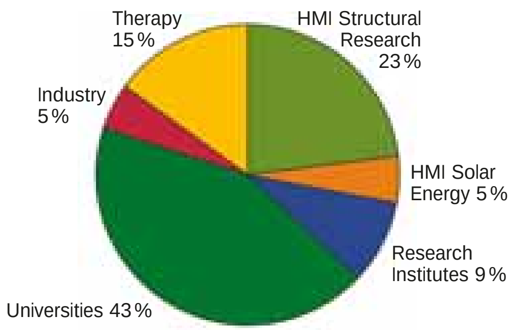



Fig. 3: Home institution of ISL-users: HMI-activities (SF4 and solar energy) use less than 30 % of the beam time. University based researchers are still the largest subgroup at ISL.

In total, 39 different projects (49 in 2004) involving more than 100 scientists received beam time in 2005. In total, more than 80 projects were active at ISL. More than 40 % of the users came from universities, their main topic of research being materials modifications. Research groups of the HMI use less than 30 % of the beam time. This reflects ISL's importance as an outside user facility (see Figs. 3 and 5)

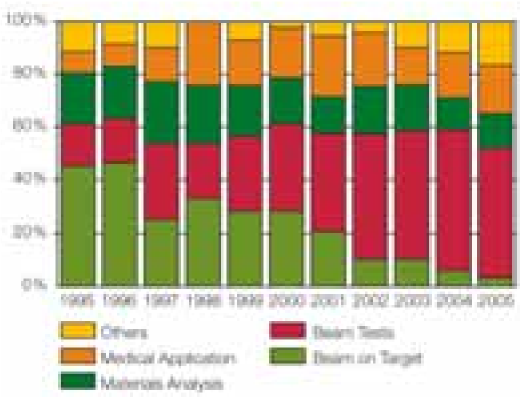



Fig. 4: Use of ISL ion beams: Materials modifications have become the largest part of research and development at ISL. The corresponding user groups come essentially from universities documenting ISL's importance for the FSI (*Forschung mit nuklearen Sonden und Ionenstrahlen* – Research with nuclear probes and ion beams.) community.

Materials analyses with an average of 15 % of the beam time have been performed exclusively with fast ions. The ERDA method uses the heaviest ions to determine the stoichiometry of thin layers for the solar cells development programme of the HMI. High-energy PIXE utilizes fast protons preferentially for the analysis of objets d'art or archaeological samples. Eye tumour therapy was performed at 10 therapy blocks (5 days/block) for more than 140 patients. The total medical share of 15 % includes beam time for research work. It turns out that, since 2002, the relative share of beam time for the different ion beam applications at ISL is relatively stable (see Fig. 4). The rise of "others" reflects guest activities in nuclear physics with the excellent ISL beams and the Q3D magnetic spectrometer. As shown in Fig. 5, the amount of beam time used by external users varies slightly around 70 %.

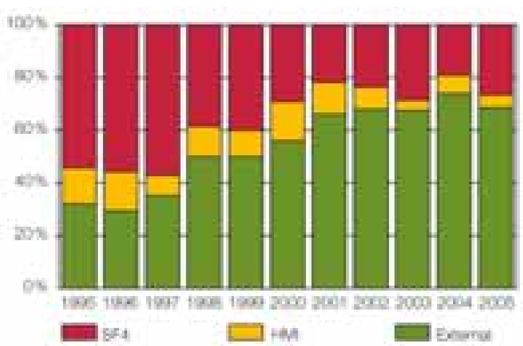



Fig. 5: User Facility ISL: development into a user facility. External users including proton therapy used 75 % of the beam-time in 2004.

Most of the development was dedicated to keeping the reliability of the facility in general. These activities included the replacement of CAMAC power supplies for the control system, power supplies for some quadrupole and dipole magnets and ion getter pumps. The upgrade of the control system was continued. Both ion sources are now being VISTA controlled.

The most important innovation was the end of the commissioning phase of the new ion source platform. The new platform has been in full operation since the beginning of 2006. Tuning new beams has become easier since the next beam can be started while the previous experiment is still running.

Fig. 6: New ion source platform: A rather unconventional layout of the new platform was necessary to fit it into the existing building

For the final 12 months of ISL's operations users applied for 368 shifts in addition to 96 shifts left over from the last meeting. At its last annual meeting before the shut-down of ISL by the end of 2006, the programme advisory committee carefully checked 48 proposals. On the basis of the proposals' scientific merit, their status and obligations 44 proposals, 20 new ones and 24 addenda to running experiments were accepted, partially with severe reductions of the applied beam-time.