HMI's new Neutron Guide Hall II. Currently, two new neutron scattering instrument are being built up in this hall

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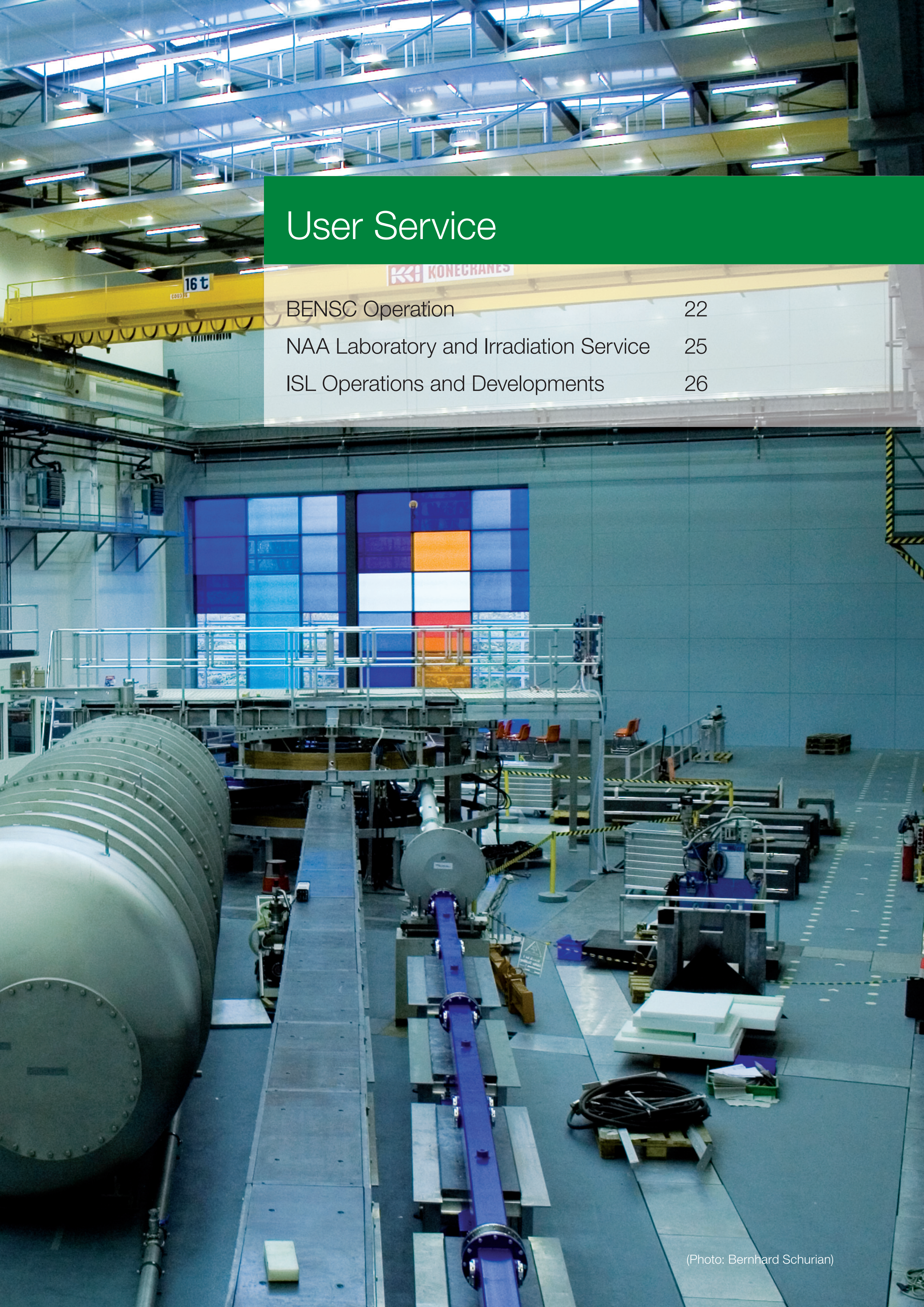

(Photo: Bernhard Schurian)

BENSC Operation

Director: Ferenc Mezei

It is the mission of the Hahn-Meitner-Institut as a research centre 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. The BENSC user programme has always been highly rated and is strongly supported by the EU since 1993.

BENSC Instrumentation

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. At present, 14 instruments are offered to users on a regular basis. These are five thermal diffractometers (E2 – flat-cone, E3 – residual stress, E4 – single crystal, E6 – single crystal and powder, E9 – powder), one cold diffractometer (V1), a thermal three-axes spectrometer (E1), a cold three-axes spectrometer (V2 – FLEX), a time-of-flight spectrometer (V3 – NEAT), a small-angle scattering instrument (V4), a spin-echo spectrometer (V5 – SPAN), a reflectometer (V6), a tomography station (V7 – CONRAD) and a USANS/tomography instrument (V12). Two more user instruments are presently being installed in the new Neutron Guide Hall II – the extreme environment diffractometer EXED and the high-resolution small-angle diffractometer VSANS. The next commissioning of these two novel instruments is forseen for end of 2007 / beginning of 2008.

BENSC User Programme

BENSC operates a comprehensive user programme at these 14 instruments. About 70% of the beam time at each instrument is offered 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 allocated to short-term projects. The long-term collaborations serve mainly two purposes: (i) they allow university groups a reliable planning of thesis works and (ii) they enlarge the pool of scientific expertise available at BENSC. Scientifically extremely fruitful collaborations of this kind exist with the universities of Tübingen, Darmstadt, Kassel, Berlin, with the Max-Planck institutes at Golm (Potsdam) and at Stuttgart and with the reactor centre of Gatchina (St. Petersburg, Russia).

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 at the HMI to discuss and evaluate the proposals. Following the decisions of the Scientific Panel, proposers of accepted short-term projects are invited to perform the proposed experiment at BENSC free of charge. Proprietary research by commercial companies is also possible at request, mainly at special instruments, but this will be charged.

BENSC provides extensive technical and scientific support for all external users at the scheduled instruments. The instrument scientists assist in preparing and performing the experiments and in the data evaluation process. Advanced sample environment such as high-field cryomagnets or high-temperature furnaces is operated by experts from the sample environment group. BENSC also provides extensive logistic support. It runs a 30 bedroom hostel on site and assists external users by contributing to 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. EU users can get full travel refund for up to two participants per experiment.

User statistics for 2006
In 2006, 254 short-term proposals were submitted to BENSC, 160 have been accepted by the Scientific Selection Panel of BENSC. Out of these, 155 were executed in 2006 by 299 visitors (233 individual researchers) using 1059 out of 2574 instrument days. In addition, 11 long-term projects and 81 internal projects were performed. The distribution of the different kinds of projects over the totally available beam time of 2574 instrument days is displayed in Fig. 1.

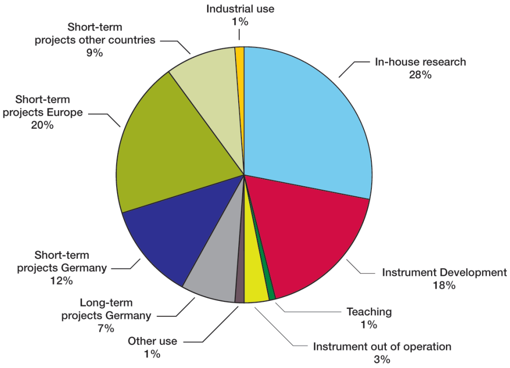

Fig. 1: The share of beam-time for the different kinds of projects in 2006. The percentage figures relate to the totally available beam time of 2574 effective instrument days.

Research fields covered external projects
Fig. 2 displays the research fields covered by the external projects (including long-term projects) in 2006. The figure demonstrates the particular attractiveness of BENSC for researchers working in the field of magnetism. This is certainly due to the special sample environment BENSC offers to its users: highest magnetic fields in combination with lowest temperatures, unmatched world-wide. Throughout all the last years the beam-time share of

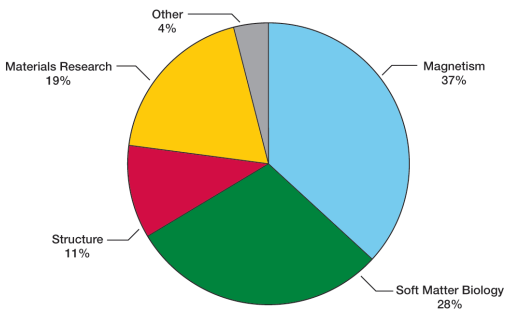

Fig.2: The research fields covered by external projects (including long-term projects) performed at BENSC in 2006.

magnetism projects was around 40%. With regard to 2006 one has to keep in mind that the statistics is slightly biased, because two instruments, which traditionally have a high proportion of magnetism projects, were only part-time operational in 2006. This underlines that magnetism is the most important field for the external BENSC users. It is, however, also interesting to see that Soft Matter & Biology is continuously increasing, from 24% in 2002 to 29% in 2006. This can be traced back to the fact that four instruments in the old neutron guide hall, the membrane diffractometer V1, the time-of-flight spectrometer V3 (NEAT), the small-angle scattering machine V4 and the reflectometer V6, have succeeded in attracting a growing user community from this very dynamically developing field.

	Projects	Visitors
Germany	43	93
Europe	83	153
Russia	8	12
Others*	21	41
Sum	155	299

*Australia, India, Japan, Mongolia, Ukraine, U.S.A

Table 1: Short term projects performed at BENSC in 2006 listed according to the origin of the proposer groups.

Table 1 shows the origin of the groups performing the short-term projects with respect to the institution the main proposer is affiliated to. In contrast to individual researchers the number of visitors is based on multiple counting of the same person if present at more than one experiment per year (corresponds to number of visits). Table 1 clearly demonstrates that BENSC has established itself as a truly international, world-wide recognised centre for neutron science. This is due to the unique opportunities offered by the neutron instrumentation and sample environments of BENSC, but also to the particular service provided at the instruments. Even scientists from overseas countries with own strong neutron sources such as the USA and Japan come to BENSC to perform experiments. It is especially the high field sample environment, which attracts these users. Many of their experiments resulted in publications in high-ranked journals. A large part of the European users could be supported by the NMI3 access programme to large-scale facilities of the European Commission under contract number RII3-CT-2003-505925 which is gratefully acknowledged by BENSC. From 2004 to 2006, 365 individual users performing 228 projects benefited from this European programme.

Output of BENSC – publication record

Each short-term project carried out at BENSC must be followed by an Experimental Report within due time. The call goes out at the end of the year. For continued projects, the report on the predecessor project is prerequisite for the allocation of further beam time. The contributions to the Experimental Report 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).

BENSC's share in the production of neutron scattering results published in recognised quality journals is outstanding compared to its size and neutron source power. A scientific focus of BENSC user publications in highly ranked journals is the field of magnetism. This particular strength of BENSC also becomes apparent at national and international conferences, where BENSC contributions to the field of magnetism often play a dominant role. At the European Conference on Neutron Scattering 2003 in Montpellier the BENSC share in the field of magnetism was more than 20%, at the last national conference, the SNI 2006 in Hamburg which was a joint meeting of users of synchrotron, neutron and ion beam radiation, the BENSC share in the field of magnetism was 30%.
Two examples of highlight results from external user groups are included in the Scientific Highlights Section of this Report.

Contribution of BENSC for educating young scientists

A minimum of 4 diploma theses and 23 PhD theses were based on experiments performed at the neutron facilities of BENSC in the years 2005 and 2006 (the true figures are higher, since not all achievements of diploma and PhD theses are communicated to BENSC). Once a year, a neutron tutorial is held with lectures and practical exercises, allowing students and postdocs from all over Europe hands-on training at the neutron scattering instruments of BENSC.

Additional services of BENSC

BENSC has built up additional laboratory services for its users which are becoming increasingly important. The laboratory for soft-matter and biological samples is frequented by more than 30% of all users of the instruments in the neutron guide hall for preparing their samples and making additional measurements. More recently, a laboratory for physical properties measurements (LaMMB, Laboratory for Magnetic Measurements at BENSC) with a state-of-the-art PPMS system and highly-specialised instrumentation for specific heat measurements has been opened for users. A throughput of 59 samples from 13 internal and 6 external users in 2006 demonstrates the attractiveness of this additional BENSC service. Presently, these services are expanded by installing a state-of-the-art laboratory system for adsorption measurements allowing users to perform additional experiments in parallel to investigations by e.g. neutron small-angle scattering.

Fig. 3: Tutorial on neutron scattering in 2006

Fig. 4: Laboratory for Magnetic Measurements at BENSC – LaMMB

Neutrons and photons from BENSC

In particular to promote the complementary use of neutrons and synchrotron radiation, BENSC is engaged at the Berlin Synchrotron Radiation Source BESSY with three beamlines in the framework of a CRG programme: at the undulator UE46 it operates a world-leading soft x-ray beamline with two end stations, a spectroscopy chamber and a high magnetic field reflectometer. At the 7T Wiggler, BENSC operates two beamlines, one specialised on residual stress measurements and one with two experimental options: (i) a resonant magnetic scattering instrument and (ii) an instrument for anomalous small-angle and grazing incidence scattering. An x-ray tomography instrument installed at a non-HMI beamline allows investigations complementary to the neutron tomography station of BENSC. User access to these BENSC operated facilities at BESSY is organised via the BESSY proposal system.

NAA-Laboratory and Irradiation Service

D. Alber, G. Bukalis, H. Kizilkay, B. Stanik (SF6)

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

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

- Trace element 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.

Irradiation devices

Three irradiation devices are available for different applications.

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

Device	$\Phi_{thermal}$ [1/cm^{2}s]	Φ_{fast} [1/cm^{2}s]	Container
DBVK	1,5E+14	4,3E+13	6
DBVR	7,5E+12	1,9E+10	9
TBR	3,4E+12	2,2E+10	1

Table 1: Fast and thermal neutron flux at different irradiation positions

DBVK and DBVR are used for long term irradiation experiments. Up to 9 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.

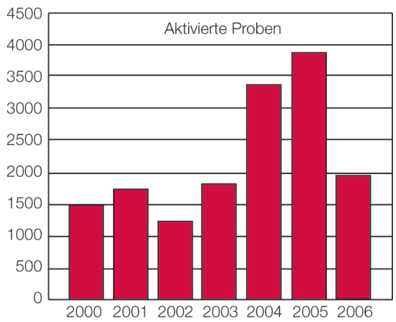

Fig. 2: Statistics of irradiated samples.

Irradiation Experiments 2006

A total of about 1900 samples were irradiated in 2006. Most of the 221 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.

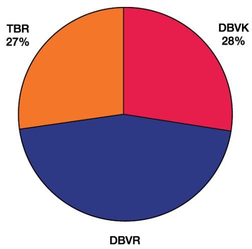

Fig. 3: Utilization of the different Irradiation devices.

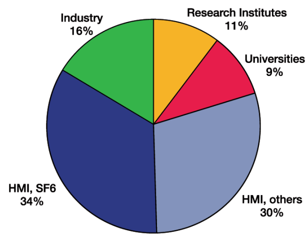

Fig. 4: Origin of Samples irradiated in 2006

About 48% of the irradiation experiments and the analysis of samples were done for external 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 the German universities (Berlin, Mainz, Münster, Leipzig, Nuremberg) and from research institutes like BAM (Berlin), GSF (Neuherberg), and Fraunhofer Institute (Dresden).

ISL Operations and Developments

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

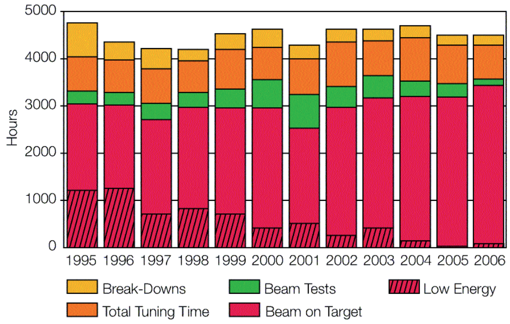

Fig. 1: ISL operations since 1995: it is very stable over the past ten years. In 2006, the maximum beam time on target ever produced was achieved, although the scheduled beam time was less than in previous years.

Following the decision of the board of directors, 2006 was the last year of operation at HMI's ion beam laboratory ISL. In spite of that, ISL operations went extremely well in 2006 (see Fig. 1). This was due to the efforts of the accelerator crew and the result of improvements concerning the reliability.

ISL offered 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 external users studied the basics of the interaction of ions with solids. They modified and analysed materials with ion beams and they performed radiotherapy of eye tumours with fast protons in a joint venture with university clinics. Users had at their disposal 15 different irradiation areas equipped with specific instrumentation.

The second ion source for the RFQ, installed in 2005, allowed shorter tuning times, as one source could already be started whilst the other one still delivered beam to the target. Within the scheduled operation time of 4400 hours, nearly 3500 hours of beam time on target were produced. The loss of scheduled beam time due to break-downs reached an all-time low of 4%. The high reliability of 96% was essential for a successful user program, in particular for the therapy of ocular melanomas with high energy protons. Like in last year, Au-ions and protons were the most attractive beams in 2006. Au-beams were used as projectiles for ma-

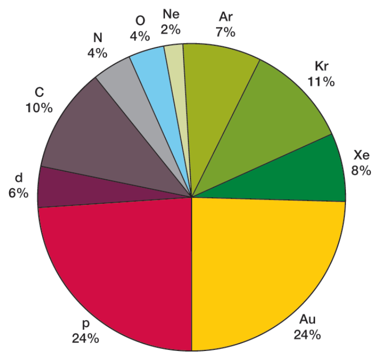

Fig. 2: Ions produced at ISL in 2006: Au-beams with a share of 37% are the most frequently used beams. Main applications are ion-beam analysis (ERDA) and ion-beam induced materials modifications.

terials analyses and ion-beam induced materials modifications. Apart from therapy, there was a large demand for high energy proton beams, either for high-energy PIXE, radiation hardness testing or device testing for hadron therapy machines.

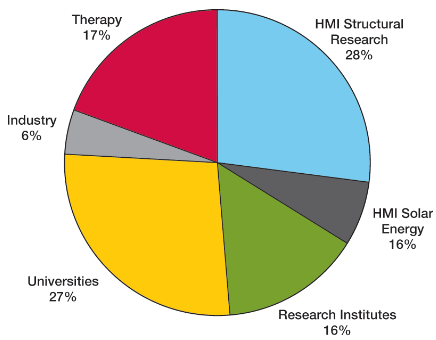

Fig. 3: Home institutions of ISL-users: HMI-activities (SF4 and solar energy) use about one third of the beam time. University based researchers used nearly one third of the beam time.

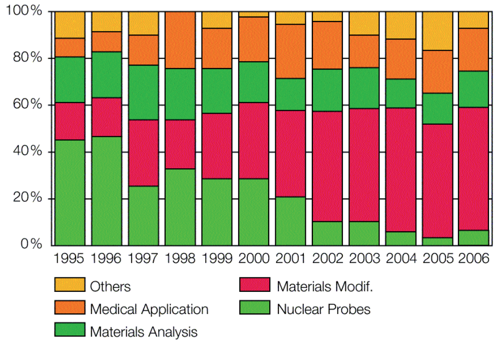

Fig. 4: Use of ISL ion beams: Materials modifications became the largest part of research and development at ISL. Most of the corresponding user groups came essentially from universities documenting ISL's importance for the FSI (*Forschung mit nuklearen Sonden und Ionenstrahlen*) community.

In total, 37 different projects involving more than 100 scientists received beam time in 2006. About 30% of the users came from universities, their main topic of research being materials modifications. Research groups of the HMI use one third of the beam time.

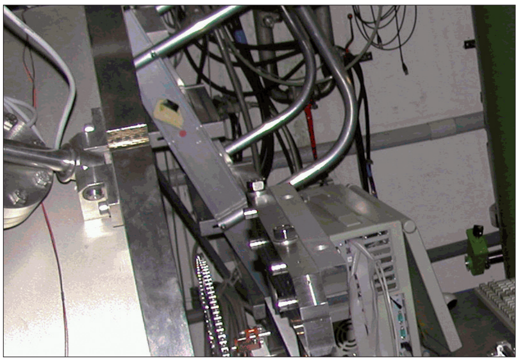

Fig. 5: Boards for satellite on-orbit servicing during the installation in the BIBER chamber. On these boards, radiation hardness tests were performed using a 5.6 MeV/u cocktail beam of Xe, Kr, Ar, and O ions.

It turned out that, since 2002, the relative share of beam time for the different ion-beam applications at ISL has been relatively stable (see fig. 4). Materials analyses with an average of 15% of the beam time were performed exclusively with fast ions. The ERDA method used the heaviest ions to determine, among others, the stoichiometry of thin layers for HMI's solar cells development programme. High-energy PIXE utilized fast protons preferentially for the analysis of objects d'art or archaeological samples. In addition, radiation hardness tests were performed using protons as well as heavy ion cocktails (see fig. 5). Eye tumour therapy was performed at 10 therapy blocks (5 days/block) for more than 150 patients. The total medical share of 15% includes beam time for the Helmholtz health programme Precision Proton Therapy. Since the start in 1998, a total of more than 800 patients have been treated at ISL.
The quota of "others" reflects guest activities in nuclear physics with high-energy heavy ion beams and the Q3D magnetic spectrometer. As shown in fig. 6, the amount of beam time used by external users varies slightly around 70%.
Most of the efforts undertaken in 2006 were dedicated to keep the reliability of the facility in general and to deliver as much beam as possible in order to allow our users to finish their experiments.

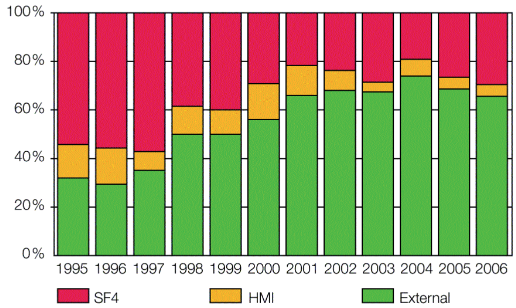

Fig. 6: User Facility ISL: Development into a user facility. External users including proton therapy had a stable share of about 70% in the past years.

In December 2006, a „final colloquium", reviewing the impact of ISL on accelerator technology, the role of ion beams as shaping tools for the nano world, their analytical power for understanding and preserving our cultural heritage, and their use in tumour therapy, once again demonstrated the broadness and the success of the ISL activities.

Thus, a very fruitful phase of research using fast ions comes to an end. We thank our users for exciting experiments and the ISL accelerator crew for their endeavours.