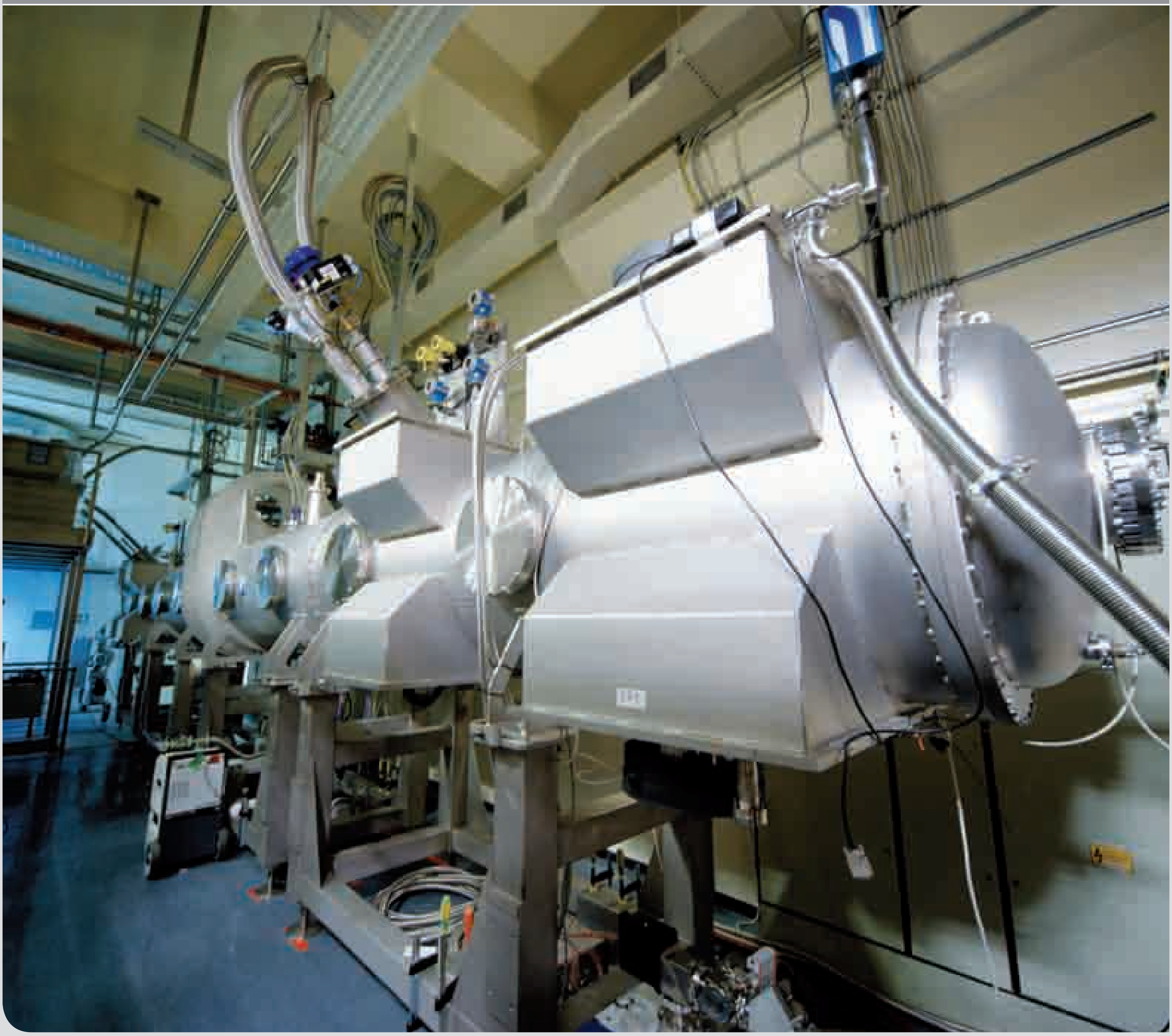
Karlsruher Institut für Technologie

ITEP – Institute for Technical Physics

Progress in Research and Development
2010 Annual Report

INSTITUTE FOR TECHNICAL PHYSICS



KIT – University of the State of Baden-Wuerttemberg and
National Laboratory of the Helmholtz Association

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Imprint

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Preface

The Institute for Technical Physics (ITEP) is a national and international center of excellence for fusion, superconductivity and cryotechnologies. Its main activities are in these fields:

- Technology for fusion magnets.
- Tritium process technology.
- Vacuum technology.
- Cyotechnology.
- Development of superconducting materials and applications of superconductivity in power technology.
- Superconducting high-field magnets.

ITEP's work is part of the "Fusion," "Efficient Energy Conversion and Use (REUN)," and "Astroparticle Physics" long-term programs of the Karlsruhe Institute of Technology (KIT) and the Helmholtz Association of German Research Centers.

The complex and, in most cases, multi-disciplinary activities of ITEP are carried out by means of unique large experimental facilities, laboratories, and the technical infrastructure to match. Here are some examples: The Karlsruhe Tritium Laboratory (TLK) is the world's only laboratory for civil uses equipped with a closed tritium loop. The Karlsruhe Toroidal Coil Test Facility (TOSKA) is used to test large magnets for fusion, and to develop components for future fusion power plants. The test facility for the ITER model pump (TIMO) serves for the development of cryovacuum pumps. A high-field magnet laboratory is available to develop superconducting high-field magnets, a cryogenic high-voltage laboratory is employed for studies of the high-voltage strength of cryogenic insulating materials. ITEP researchers study the electrical and mechanical properties of materials at extremely low temperatures in cryogenic materials laboratories.

2010 was characterized not only by scientific results but also by some special challenges and events which will be described briefly below:

In the **Fusion Magnets** area, ITEP reached an important milestone in the development of current leads with high-temperature superconductors (HTS) for the Wendelstein 7-X fusion project. The two prototype current leads were successfully tested at up to 20,000 A; they meet all requirements. In a parallel effort, the first series-produced current leads were manufactured, and a facility was built to test them. The cryogenic materials laboratory built a new torsion unit which allows tensile forces of up to 160,000 Newton and moments of up to 1000 Newton meters to be applied at the same time.

The **Karlsruhe Tritium Laboratory (TLK)** will contribute the work packages for water detritiation and cryogenic isotope separation within the ITER international fusion experiment (www.iter.org). In 2010, the contract was signed for a water detritiation concept; at the same time, the development of new membrane techniques for recovering minute amounts of tritium in large helium throughputs was started. The instrumentation and control systems for the tritium infrastructure systems in TLK were installed at the same time. The first two systems have been commissioned successfully at only minimal outage periods.

The **Vacuum Technology** area of ITEP is responsible, within ITER, for the design, preparation, and testing of the cryovacuum pumps. In 2010, the focus was on completing the build-to-print design of the prototype of the ITER torus cryopump and on other experimental activities associated with design validation. Conversion of the TIMO plant for testing this vacuum pump was almost completed. In addition, there was the further extension of an experimental database for vacuum flows in the entire range of the Knudsen number, plus modeling and simulation of vacuum flows.

In the area of **Development of Superconducting Materials,** the development of economically viable low-loss conductor concepts with high-current capability is a core issue. In 2010, a group of Helmholtz university junior scientists began to investigate AC losses in high-temperature superconductors under the leadership of Dr. Francesco Grilli. Some first findings confirm that filamented Roebel conductors are able to reduce losses. Moreover, the scientists continued the development of multi-conductor concepts with magnesium diboride superconductors. As regards **applications of superconductivity in power technology,** a new EU project was started in 2010 for the development of a medium-voltage current limiter (www.eccoflow.org). In addition, a current-limiting transformer demonstrator was built and tested successfully.

The **High-field Laboratory** of ITEP has test facilities ranging up to 20 T (25 T under construction), which are unique and were used very successfully in the development of high-field NMR systems for nearly 25 years based on know-how of the staff. In 2010, ITEP agreed with an industrial partner of many years on the joint development of high-field NMR systems with high-temperature superconductors. International record current densities at 20 T were achieved in an HTS conductor specimen.

The **Cryotechnology** area, among other things, develops and expands the extensive, complex cryosystems for the Karlsruhe Tritium Neutrino Experiment, KATRIN, and the fusion experiments, such as TOSKA or TIMO. In addition, this area ensures safe and reliable operation of the cryofacilities and the supply to KIT of liquid he-

Topping-out ceremony at the building replacing our office building No. 410.

lium and liquid nitrogen. In 2010, the scientists completed important instrumentation and control systems for the cryotechnology side of experiments, among them the KATRIN demonstrator and the DPS2-F magnet section, which they commissioned. Moreover, they perform ongoing work to improve thermal insulation and for the development of sensors at low temperatures.

In the **Karlsruhe Tritium Neutrino Experiment, KATRIN** (www-ik.fzk.de/tritium/), ITEP has been responsible, since the onset of the project, for building and operating the tritium loops, building and operating the cryosupply system, and for making available the superconducting magnets. In 2010, delivery and construction of the so-called WGTS demonstrator for verifying beamline cooling constituted a major project milestone. Moreover, the laser Raman technique developed at TLK for precise measurement of the isotopic composition of gaseous tritium was used for the first time on circulating tritium gas, and its detection limit was greatly improved.

As far as **personnel changes** are concerned, the number of staff members undergoing training, such as students of the "Duale Hochschule," diploma and doctoral students and trainees, fortunately continued to increase in 2010. We mourn the death of our highly esteemed staff member for many years, Gerhard Hellriegel. He was the group leader responsible for measurement and control at the Karlsruhe Tritium Laboratory.

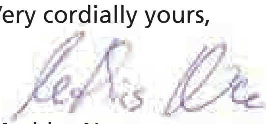
In the field of **Teaching,** the lectures presented or supported by ITEP staff were expanded further. The scope now comprises more than ten lectures, most of them in the areas of superconductivity, fusion, and cryotechnology. Numerous national and international seminars, summer schools, and workshops organized by ITEP supplement the lecture program.

In December 2010, the topping-out ceremony was celebrated at the building replacing our **office building,** building No. 410. I am most grateful to everybody involved. My special thanks go to our Vice President, Dr. Peter Fritz, the Behnisch architectural office, the participating internal and external staff members, and the construction companies.

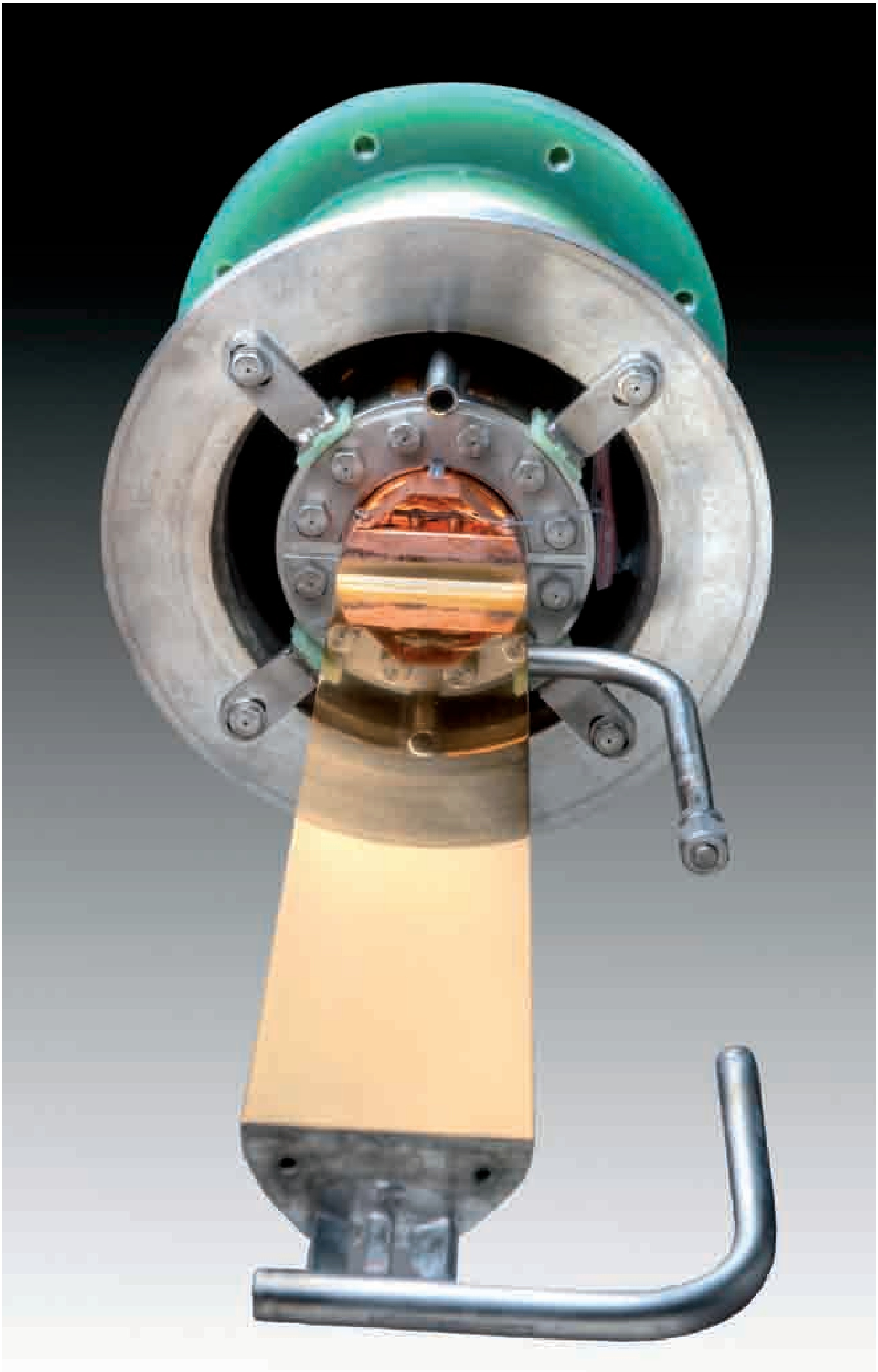
In 2010, staff members of ITEP won some special **distinctions and appointments.** At the ASC conference, Dr. Francesco Grilli was awarded the prestigious Van Duzer Prize for the best publication in the "IEEE Transactions of Applied Superconductivity." Dr. Sonja Schlachter was appointed member of the Executive Board of the renowned journal, "Superconductor Science and Technology," Dr.Steffen Grohmann was appointed member of the Cryophysics, Cryo-engineering Committee of the International Institute of Refrigeration.

My special vote of thanks goes to all partners of ITEP from universities, research institutions, and industry for the trustful as well as fruitful and successful cooperation in 2010.

Very cordially yours,



Mathias Noe



Cold contact (4,5k) of the 18200 Ampere HTS current lead

Results from the Research Areas

Fusion Magnets

Head: Dr. Walter Fietz

In the Fusion Magnets area, ITEP works for the national W7-X project and the international JT-60SA and ITER projects. Moreover, preparations are being made for the magnet system of the future DEMO demonstration reactor.

Development and Construction of Current Leads for W7-X and JT-60SA

Work for Wendelstein 7-X

ITEP is responsible for developing, building, and testing sixteen current leads for the Wendelstein 7-X plasma experiment (W7-X). W7-X is being built at Greifswald by the Max-Planck Institute for Plasma Physics (IPP) for commissioning in 2014. The current leads, two prototype and fourteen series current leads, must be installed overhead. Therefore, they are equipped with high-temperature superconductors (HTS), which also considerably reduces the necessary cryopower. The current leads are designed for a maximum current of 18.2 kA.

In 2009, ITEP had largely completed manufacturing the two prototype current leads. In 2010, these plus a superconducting short connection circuit supplied by IPP were combined in a test unit and connected to TOSKA in a test cryostat. The detailed test was run successfully in summer 2010; subsequently, the fourteen series-manufactured current leads were released for production.

In the meantime, series production has started at KIT. It is to be continued in 2011, and the first completion tests of series current lead pairs are to be carried out.

Work for JT-60SA

Germany declared its willingness in 2007 to take on part of the work package promised by the EU to Japan to build the JT-60SA satellite tokamak. Also in this project, ITEP is responsible for building the current leads. In 2009, the basic data were negotiated with the EU and Japan. The contract was signed in early 2010.

The rough design was elaborated in 2009; in 2010, the design was refined further. At the present time, connecting areas in JT-60SA are determined together with the European Fusion for Energy Agency (F4E) and Japan.

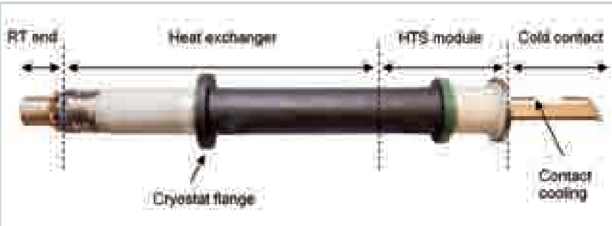


Fig. 1: Prototype current supply lead after assembly.

The design is based on the results of a prototype test. For this purpose, ITEP used the test unit built for the W7-X prototype test; the test was run under conditions related to JT-60SA, i.e. in the pulsed mode. The design is to be completed and finalized in 2011; purchasing the materials and components is to begin afterwards.

CuLTKa Current Lead Test Facility, and Preparation of TOSKA for the Test of the W7-X Prototype Power Supply Leads

A total of 16 current leads for W7-X and 26 current leads for JT-60SA must be tested.

For this purpose, a new test facility, **Cu**rrent **L**ead **T**est Facility **Ka**rlsruhe (CuLTKa), is being erected and integrated into the existing cryo-infrastructure of ITEP. CuLTKa has been designed so that both overhead operation of the current leads for W7-X and normal operation of the current leads for JT-60SA are possible.

In order to conclude as soon as possible the test of the W7-X prototype current leads, ITEP ran this test in TOSKA in 2010. The serial tests will be performed in TOSKA also up to completion of CuLTKa. The CuLTKa facility will be specially designed for these tests. Compared with TOSKA, it allows a much higher test frequency to be achieved, which is necessary if all current leads for W7-X and JT-60SA are to be completed in time. Construction of the series current leads for W7-X and the corresponding acceptance tests are to be completed by the end of 2012. Subsequently, the 26 current leads for JT-60SA are to be built. They are to be tested in CuLTKa by the end of 2015.

Fig. 2: Test cryostat for the test of the W7-X prototype power supply leads in TOSKA.

Studies of Transient High Voltages in ITER Coils

The electric voltage loads acting within the ITER PF3 coil and the ITER PF6 coil were calculated for quick discharge, rated operation, and for two fault cases with one fault to earth. Even at the voltages applied to the coil connections, levels were found to be up to 23% above the maximum levels so far indicated by the ITER Organization (IO). For the voltages at the winding insulation, levels were computed which are more than one order of magnitude higher than those so far shown in IO publications for this type of insulation.

The widely differing findings about the maximum voltage load acting on the winding insulation can be explained by the fact that the IO assumes a linear voltage distribution within the coil. No reason is given for that assumption. Scientists of ITEP have demonstrated, on the basis of different models, that fast excitations, for instance a fault to earth, cause highly non-linear voltage distributions within the two coils under study.

Tests of Cryogenic Materials and Mechanical Tests of Superconducting Cables

Work for ITER

ITEP began tests of steel jacket materials to qualify the material and the manufacturing process for the different types of cables used for TF, CS, and PF coils. Drastic differences were found in the mechanical properties, especially in ductility. One measure of this can be defined by the maximum strain achieved. For a Japanese TF reference material, which had been compacted and annealed, values above 30% were found, while a European specimen in the same state showed strain values of less than 15%. SEM images of the fracture surfaces were made for more detailed studies of this effect. The micrographs show very pronounced so-called dimple patterns in the Japanese ductile specimen, and an extremely grainy surface of the European specimen. The grain boundaries obviously constitute the weak spots.

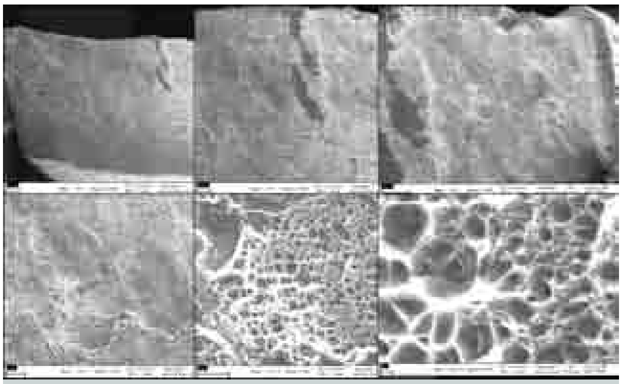


Fig. 3: SEM images of the Japanese reference specimen with a marked ductile dimple pattern.

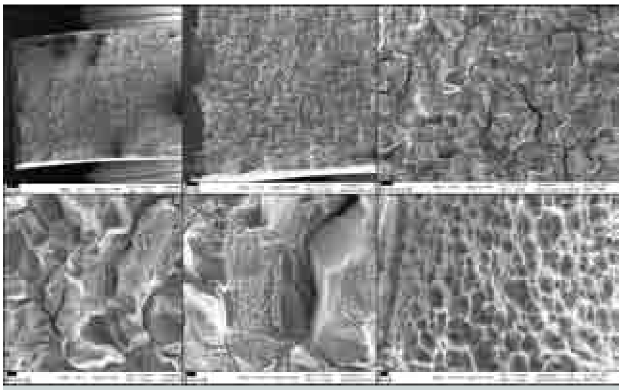


Fig. 4: SEM images of the European specimen with weak spots along the grain boundaries.

Other work served for mechanical qualification of the process of manufacturing the radial plates. Two methods are relevant: Manufacture by forging has the advantage of large elements being made at low cost. A drawback are the residual stresses which need to be balanced out when making the grooves for the TF cable.

An alternative would be production by hot isostatic pressing (HIP). This would avoid residual stresses. However, compared to forging, HIP has the disadvantage of the products being smaller and the manufacturing process being more expensive.

ITEP conducted tensile tests and fracture toughness tests of materials manufactured by both processes. It was seen that the forged material, as far as fraction toughness is concerned, is far above the required levels. On the other hand, the specimens for the HIP process are just at, or slightly above, the limit of 180 MPam$^{0.5}$. This is due to the extremely fine-grained structure of the material manufactured in this way, which favors crack initiation.

In testing prototypes of electric high voltage separators for tubing of the superconducting magnets, not only electrical tests and He-pressure tests are to be carried out, but also mechanical loads are to be applied in tension, compression, bending, and torsion. For this purpose, ITEP commissioned a torsional test facility with a maximum tensile force of 160 kN and a moment of 1000 Nm. Some first tests conducted at room temperature were successful. At the present time, ITEP performs final calibrations of the sensors.

Moreover, preparations were made for two contracts in the field of tests of cryogenic materials. Thus, the CryoMaK Laboratory applied for an ITER service contract for three years and for an F4E contract for four years. This will involve numerous mechanical tests of small specimens up to large components.

Electromechanical Examinations in Magnetic Field – FBI

Within the framework of a doctoral thesis, mechanical properties of Roebel conductors will be modeled and studied experimentally. Loads in an axial direction, bending and torsion play key roles. Initially, the influence of geometry was considered so as to minimize excessive voltages under mechanical loads. In the light of these findings, optimized Roebel conductors will be assembled for use in high-current Rutherford cables.

Preparatory Work for the Magnet System of the Future DEMO Demonstration Reactor

Studies and analyses of HTS materials currently available clearly show that second-generation HTS (Re-Ba-Cu-O tape conductors) can be used in future fusion reactors to operate magnet coils at comparatively high tempera-

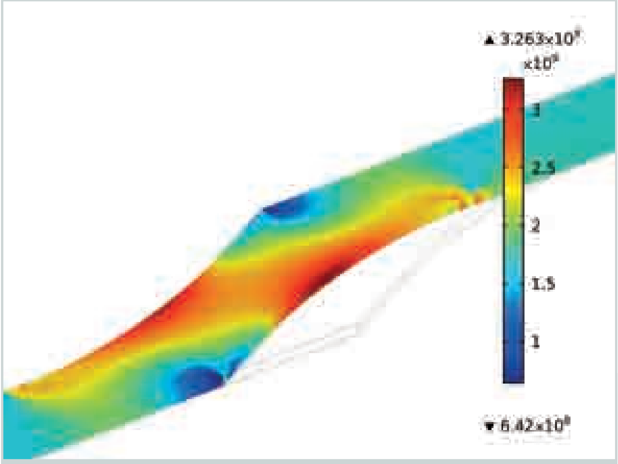


Fig. 5: FEM computation of the stress distribution in a Roebel tape under axial loading.

tures of 65 K. This opens up the opportunity to design a simpler cooling concept, which would save cryopower and thus achieve a simpler and more efficient fusion reactor. Work at ITEP on the development of HTS cables for fusion magnets of the next generation was concentrated in 2010 mainly on two topics: reducing the AC losses of single tapes by laser structuring, and development of a cable concept for HTS conductors for currents >10 kA in fields >10 T and at temperatures >50 K. Details of these activities are described in the section dealing with the development of superconductor material and applications in power technology.

Highlight 1
Test of the HTS Prototype Current Leads for Wendelstein 7-X

ITEP built two prototype current leads, combined them with a superconducting connecting into a Paschen-resistant arrangement, and installed them in a test cryostat. The test cryostat was attached to the vacuum vessel of the TOSKA facility and connected with the cryosystem, the data processing and control system, and the high-current facility. After cooling of the test assembly in early June 2010, a four-week test of the current leads was begun under a variety of steady-state and transient conditions. The focus was on loss measurements without and with current operations, current tests up to 20 kA, ramp tests, long-time tests at 18.2 kA, tests of temperature margins and losses of coolant.

As tests have shown, both current leads correspond to the expected data in all parameters: Heat losses at the 4.5 k level amount to (2.1 ± 1) W; the helium mass flow at an operating current of 18.2 kA is 1.38 g/s. The temperature margin is more than 26 K, which ensures sufficient margin for later operation in Wendelstein 7-X. In case of a loss of coolant at 18.2 kA operating current, it takes around 18 minutes for quench to occur in the HTS part of the current leads.

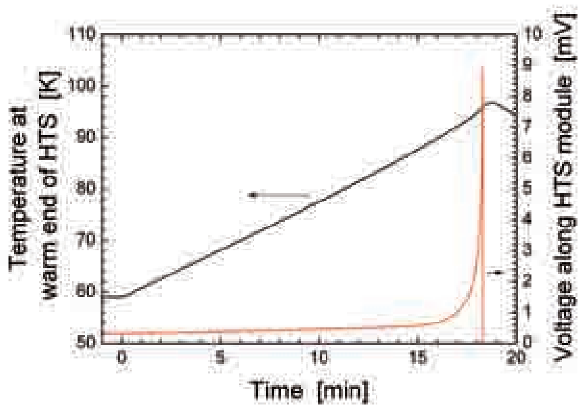


Fig. 7: Temperature and voltage during simulation of a loss of coolant.

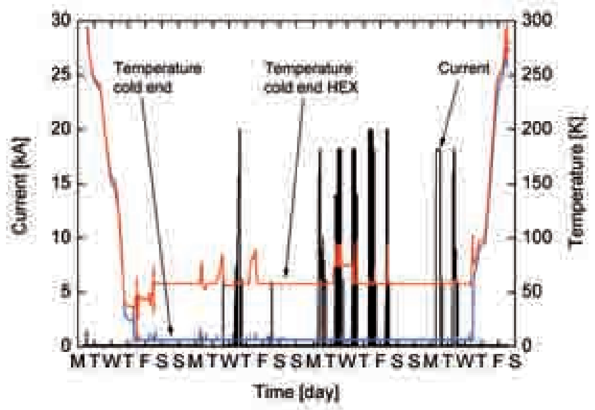


Fig. 6: Time curve of the prototype test from cooling to experimental operation to heating.

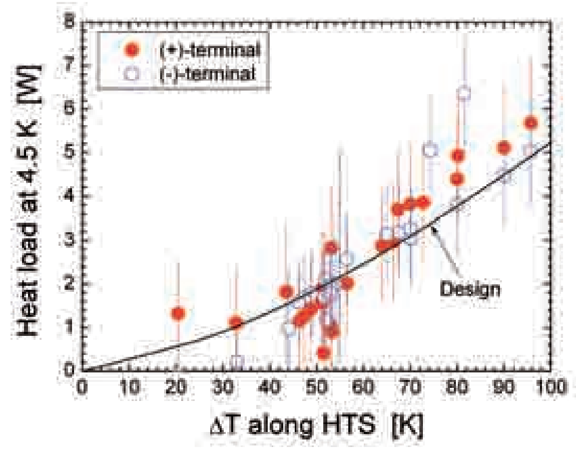


Fig. 8: Thermal load at the 4.5 K level as a function of the temperature gradient across the HTS module.

Highlight 2
ITER Service Contract: "Provision of Conductor Jacket Mechanical Testing Reference Laboratory"

The CryoMaK Laboratory has been appointed reference laboratory by the ITER Organization for running the required mechanical tests of cryogenic materials for qualification and quality assurance (ITER Service Contract IO/10/4300000292). For 2010/2011, a budget of EUR 180,000 and, optionally, for 2012/2013 an amount of EUR 120,000 have been earmarked. The subject of studies is mainly the cable jacket material of the toroidal, poloidal, and central field coils. Tensile tests and fatigue tests as well as fracture mechanics tests are to be carried out. Some first tests were already under way.

Fig. 9: Fracture surface of 4 mm dia. of a fatigue specimen made of PF jacket material after some 25,000 cycles at a loading amplitude of 100 MPa to 1100 MPa at 4.2 K.

In order to qualify the prototypes of HT separators for the ITER experimental fusion reactor, tests of structural integrity (He-tightness, electric insulation) are required. To simulate conditions in operation, additional loading tests are planned, inter alia mechanical torsion tests in the CryoMaK Laboratory. In these tests, the components are to be exposed repeatedly to a torque of up to 100 Nm. For this purpose, a cryogenic test facility for mechanical axial and torsional loading was commissioned. The maximum tensile force is 160 kN, the maximum torque is 1000 Nm. For this purpose a new oil compressor (approx. 43 l/min) for the hydraulic system was installed.

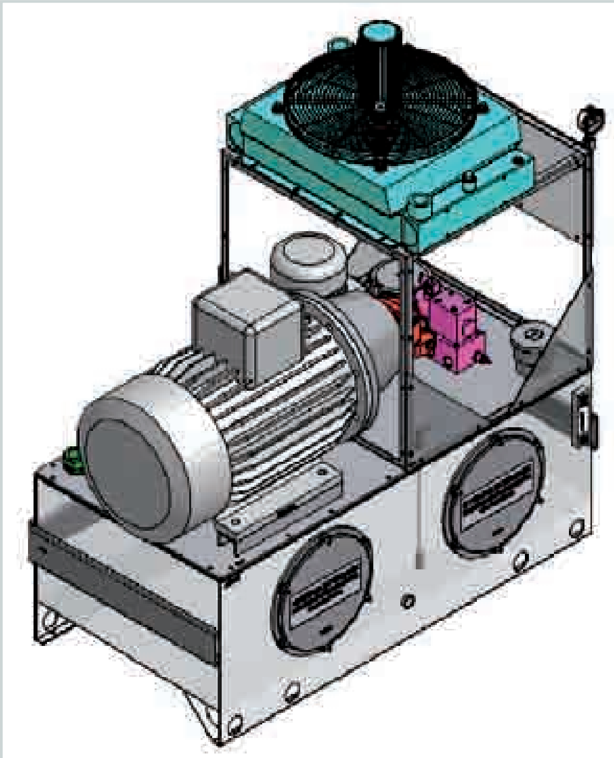


Fig. 10: Commissioning the cryogenic test facility for mechanical axial and torsional loading.

HOMER II – Superconducting High Field Magnet facility with magnet flange and triple insert coil.

Results from the Research Areas

Superconducting High-field Magnets

Head: Dr. Theo Schneider

The High Field Magnet Laboratory

Feed back from visitors, as well as the reaction from partners in international projects, shows that the high field laboratory with its experimental facilities JUMBO, HOMER I and HOMER II possesses a unique character. In 2010 the scientists at the ITEP used the ability to provide high resolution E(I) measurements with extremely high transport current of up to 2000 A in magnetic fields up to 20 T in a bath temperature of 1.8 K to demonstrate, amongst other things, the recent enormous growth in potential of the high temperature super conductor YBCO.

Expansion of the Homer II Facility

The construction of high field insert coils to be operated in a background field of up to 20 T requires detailed knowledge of the physical behaviour of the super conductor in question, especially under electro-mechanical stress. These characteristics are determined by the scientists from the super conducting high field magnet group by means of special test objects (triple coil assemblies) that are mounted on a separate magnet flange equipped with a quadruple current feed and installed in the free bore of the experimental facility. To achieve this, the super conductor is wound on to three coil bodies with increasing diameters nested inside each other. The E(I) measurements are then carried out, for example, in the HOMER I facility in a background field of up to 15 T at temperatures of between 4.2 K and 1.8 K under simulated Lorentz forces. The results thus obtained are then incorporated in the design and construction of the high-field facilities HOMER I and HOMER II and the NMR spectrometer magnets developed in cooperation with our industrial partner Bruker BioSpin GmbH.

An expansion of HOMER II to accommodate fields of 24 and 25 T required the construction of a new magnet flange with a triple coil assembly. In 2010 the super conducting high field magnet group completed the magnet flange and test objects. Figure 1 shows the complex structure of the magnet flange and the photograph opposite shows the complete flange ready for insertion into the HOMER II facility.

This arrangement now enables the determination of the E(I; B, T, F_L) characteristic curves under a simulated Lorentz force, $F_L = r \cdot B \cdot I_{mag}$, under realistic conditions, i.e. a background magnetic field of 20 T in a helium bath of 1.8 K with a maximum diameter of 180 mm with a transport current of up to 2000 A.

The researchers in 2010 also upgraded the quench detection system of the HOMER II facility as far as possible. Quench detectors are installed in general for the secure and stable operation of the superconducting magnet systems. In the HOMER II facility this constitutes an essential component. However such highly complex quench detectors are not commercially available and therefore our own design was necessary from the beginning. In the high field laboratory, this included the fundamental design of the circuit and circuit board, the selection and procurement of the components, mounting and complete assembly. Figure 2 shows the finished mounted circuit boards and the complete quench detector.

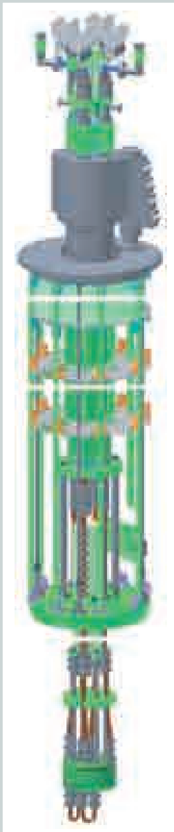


Fig. 1: Technical drawing of the magnet flange with triple insert coil.

Modernisation of the Facilities in the HFL

The JUMBO facility constantly changes between one of two operating coil configurations. After routine renovation of the facility, the 15 T configuration unexpectedly quenched. A subsequent inspection of the current feed showed that the superconducting bus between the main coils and the Nb_3Sn insert coil needed renewing due to wear and tear after many years of operation (magnetic field and temperature cycles). As a modernisation measure, the scientists integrated a comprehensive PC-monitor of the bus cables and magnet coils according to the example of HOMER I.

Service and modernisation of the HOMER I facility in 2010 included the entry and outlet valves, as well as the

Fig. 2a:

Fig. 2b: Quench detector from HOMER II.

by-pass valve. For this, pneumatic valve positioners were built into the controls of the entry and by-pass valves to enable more accurate adjustment and to minimise loss of air pressure. The outlet valve was equipped with a continuous position indicator. The new components were integrated into the process control system and operated successfully. The hot summer and many parallel experiments in the experimental halls of the ITEP highlighted a big problem; that of the power supply spontaneously shutting down due to hot cooling water. In order to protect the superconducting magnet system from such an undesired shut down and possible damage, temperature sensors and pressure transducers were implemented in the water cooling system. Assembly and connection of the measurement positions on a new AS-I cable, SPS integration and visualisation with WinCC were completed. A further 19" plug-in module with PID-regulator was installed in the HOMER I measurement cabin and monitored by the SPS in order to stabilise the bath temperature during experiments.

Superconductor Characterisation

The composite superconductors tested in the experimental facilities of the High Field Laboratory in 2010 ranged from extremely thin NbTi/Nb_3Sn superconductors for the undulator projects in EuCARD and ANKA to the high field, high current $(NbX)_3Sn$ conductor of the NMR magnet technology project and many different YBCO high temperature superconductors from international manufacturers. Many new test objects for JUMBO and HOMER I (see figure 3) were constructed in the workshop for determining the E(I) curves of the YBCO coated conductors. In doing so, optimised terminals for current feed and new winding geometries were completed.

In June the measurement of an YBCO coated conductor in cooperation with the firm Bruker HTS GmbH passed the deciding test. In the HOMER I facility a record value critical current of 1975 A at 4.2 K with a field of 18 T parallel to the band surface was measured. Further measurements at a reduced temperature of 1.8 K showed I_c values of approximately 2000 A in an applied magnetic field of 20 T.

In addition to experimental characterisation, the team was occupied with the theoretical description and analysis of the E(I) curves.

KATRIN

A focal point of research at KIT is the large international experiment KATRIN (Karlsruhe Tritium Neutrino Experiment) which aims to determine a model-independent measurement of the neutrino mass with a sensitivity of 200 meV/c^2. The layout of this experiment is divided into

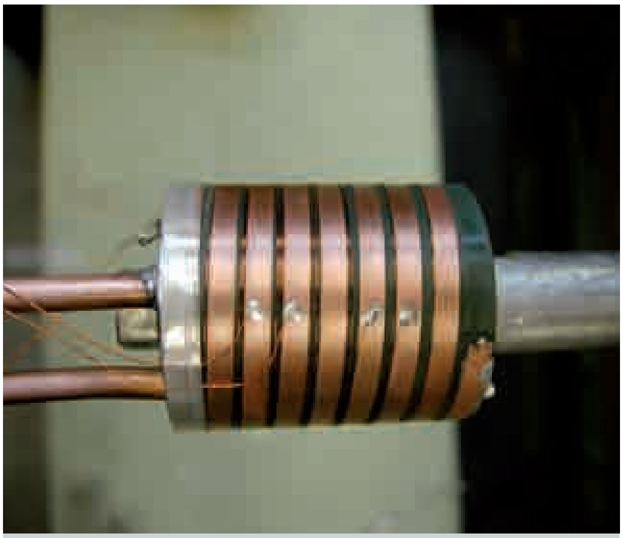


Fig. 3: Test object with YBCO winding.

the source and transport system, consisting of the tritium source WGTS and the tritium pump segment with DPS2-F and CPS, as well as the detection system with two electrostatic spectrometers and the semiconductor detector for electron analysis. Within the framework of the project, the ITEP leads in tritium process techniques, cryotechnics and magnet technology. For both the WGTS and the DPS2-F and CPS, superconducting magnets are implemented as waveguides that produce a magnetic field of between 3.6 T and approximately 5.6 T along the beam axis.

Whilst the components DPS2-F installed at KIT have been in the test phase since 2009, difficulties occurred during the industrial design of the WGTS during assembly and test of the altogether seven superconducting solenoids. This lead to an intensive discussion about magnet design, protection concept and quench safety. Central to this discussion were the diodes used in the protection concept. These were subjected to intensive more precise tests in the high field laboratory. Figure 4 shows the conceptual design for diode measurements in the JUMBO experimental facility. The time dependant measurements under a temperature variation of 4.2 K to 0° C and operating current of up to 350 A showed the partial destruction of the diode. These results prompted new calculations and simulations by the industrial partners involved.

Further intensive discussions were held about the protection concept, the results of the persistent mode measurements of the individual magnets and the general operation of the superconducting magnets of the KATRIN experiment. Conclusions are expected in 2011.

EuCARD

An essential goal of the EU-Project EuCARD is the development of superconducting dipole magnets of the 20 T class and their necessity, amongst other things, for a medium- to long-term planned upgrade of the LHC. The dipole design consists of an external coil with a free bore of 100 mm made of $(NbX)_3Sn$ that delivers a field of 14 T and an insert magnet wound from high temperature superconductor (HTS) that should deliver a field of 6 T. The researchers are currently examining the suitability of the commercially available HTS Bi-2212 and YBCO coated conductor. To this end, a pancake-wound existing YBCO coil from the French project partners CNRS was assembled and the first tests carried out in 2010. Further analysis of the HTS solenoids will be carried out by the ITEP in 2011 in the HOMER I experimental facility.

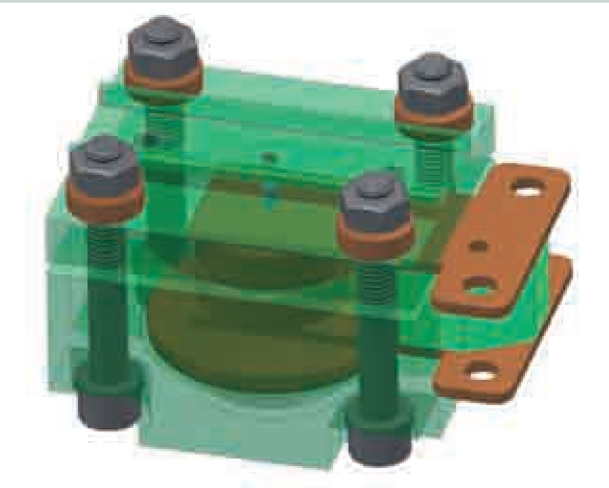


Fig. 4: Diode housing for U(I) measurement.

Another goal of the EuCARD project is the development and construction of superconducting undulators. For this the so-called Restacked Rod Process (RRP) high current Nb_3Sn conductor from Oxford Instruments should be used. However, for the relevant applied field range of 3 to 5 T, the typically above 10 T operated superconductor offers no data for the critical current density and n-value. Therefore the ITEP analysed the physical characteristics of several test windings of the conductor in the JUMBO experimental facility. The experiments showed that not only I_c and n-value but also the Lorentz force stress on the merely 0.5 mm thick conductor affect its performance.

NMR Magnet Technology

In intensive, long standing collaboration with the company Bruker BioSpin GmbH, the ITEP developed innovative superconducting high field magnets for the high resolution NMR spectroscopy of the partner and supported them in the world wide market introduction and quality assurance. For more than ten years research scientists have been testing commercial technical superconductors developed specifically for the NMR magnet technology project and qualifying them by high resolution E(I) measurements in the JUMBO and HOMER I facilities. The superconductors under examination varied according to their manufacturing process, material composition, dimensions and physical characteristics and therefore required a multitude of experimental set-ups. As well as superconductor characterisation superconducting joints between conductors connecting these were characterised and their resistivity was optimised. Experiments and results are industrial secrets and therefore remain confidential.

1200 MHz NMR-Project

An ambitious new NMR project aims to develop a NMR-compatible HTS insert coil in the construction of an NMR spectrometer with a proton resonance frequency of approximately 1200 MHz. Success in achieving such an insert coil is based on the comprehensive characterisation and qualification of the commercially available HTS coated conductor at helium temperatures and background fields of up to 20 T. In the first project phase the scientists of the ITEP are therefore analysing the fundamental physical properties of selected YBCO coated conductors at down to 1.8 K and 20 T in the JUMBO and HOMER I facilities.

Highlight in 2010: Continuation of 25 years of collaboration between the Karlsruhe Institute of Technology (KIT) and Bruker BioSpin GmbH.

Chronology

1985: Start of the cooperation between (former) Karlsruhe Nuclear Research Centre and Bruker Analytische Messtechnik GmbH to develop superconducting high field magnets for High resolution NMR and NMR-tomography.
1991: Commissioning of the world's first 750 MHz NMR prototype magnet at the former Karlsruhe Research Centre.
1995: Commissioning of the world's first 800 MHz NMR prototype spectrometer in Frankfurt.
1996: Extended contract for the development of a 900 MHz magnet system.
2001: Cooperation contract for the appraisal of a 1000 MHz NMR spectrometer.
2009: Installation of the world's first 1000 MHz NMR spectrometer in classical technology at Bruker.
2010: Agreement on the development of a NMR-compatible HTS insert coil.

In 2010 the KIT and the Karlsruhe-based company Bruker BioSpin GmbH looked back over 25 successful and creative years of collaboration in the development of superconducting magnet systems for high resolution NMR spectrometry. (See figure 5). The innovative fundamental magnet techniques developed at the ITEP (primarily in the areas of the composite superconductor and construction of superconducting coils, but also in cryostatic technology) with continuous development and quality assurance, led to high quality products that helped Bruker BioSpin become a world market leader.

This successful collaboration in NMR technology was officially carried forward by means of a ratified contract in October 2010. The aim of the new project, with a lifetime of 5 years, is to develop a NMR-compatible insert coil wound from a high temperature superconductor. With this insert coil a high resolution NMR spectrometer with a proton resonance frequency of 1200 MHz should be realised with a corresponding central magnetic field of 28.2 T.

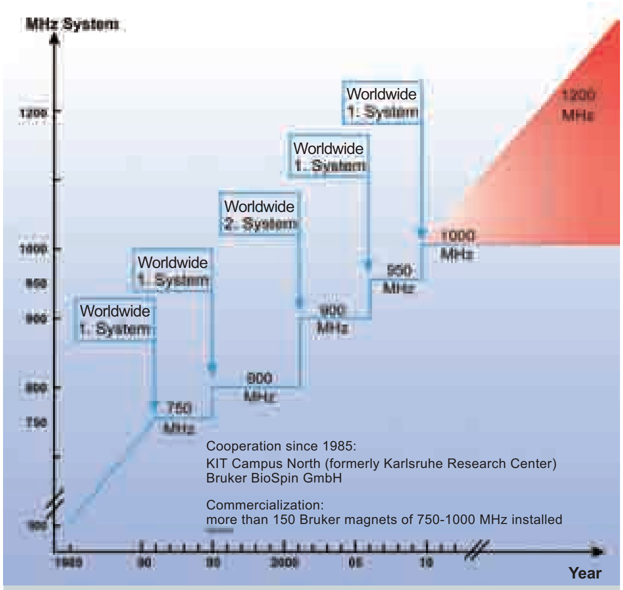
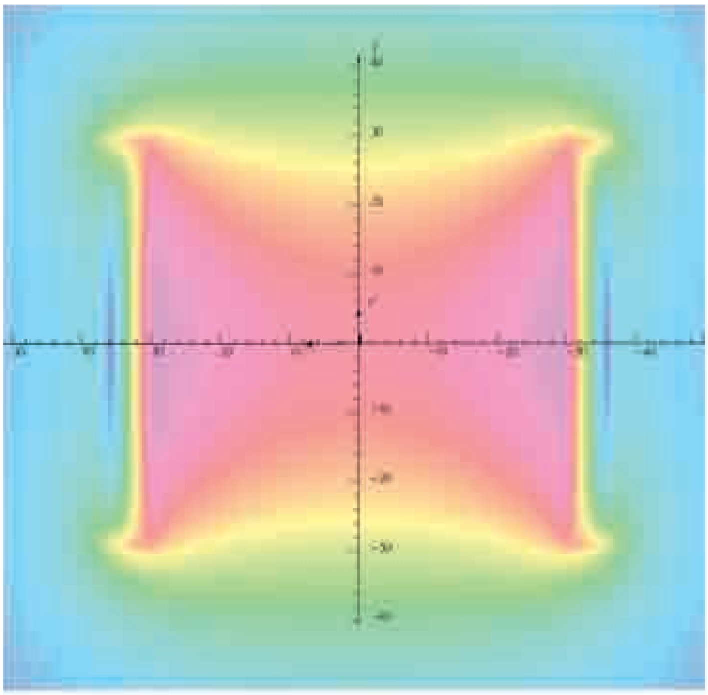


Fig. 5: Chronological development of the superconducting magnet systems for high resolution NMR spectroscopy for frequencies from 750 MHz.

Whilst the construction of NMR magnet systems up to 1000 MHz used exclusively the well-researched, commercially available, low temperature superconductors NbTi and $(NbX)_3Sn$, a magnet system with a central field greater than 25 T requires that modern high temperature superconductors must be used for the innermost high field coil. The HTS available for consideration are first generation Bi2223-HTS from the Japanese firm Sumitomo and the favoured second generationYBCO based coated conductors. Potential conductor manufacturers are American Superconductors (AMSC), SuperPower Inc. and Bruker HTS GmbH and also possibly Japanese and Korean companies.

Fig. 6: Contract signing ceremony on 21 October 2010. Seated from left to right: Dr. G. Roth (Bruker BioSpin), Dr. B. Gewiese (Bruker BioSpin), Dr. A. Kurz (KIT-Board), Dr. P. Fritz (KIT-Board). Standing from left to right: Prof. Dr. P. Komarek (ITEP), Dr. Th. Schneider (ITEP), Prof. Dr.-Ing. M. Noe (Institute head, ITEP), Ms. K. Sauer-Roesner (KIT legal department), Prof. Dr. A. Kasten (Bruker BioSpin).



Field computation for an MgB_2-coil (top left), coil production (top right), and annealed coils prior to sealing with wax (bottom).

Results from the Research Areas

Superconducting Materials and Applications in Power Technology

Head: Dr. Wilfried Goldacker

Work in 2010 of the Superconducting Materials and Applications in Power Technology group was focused on the development of concepts for low-AC-loss conductors and cables for applications in power technology as well as fusion magnets of the next generation. Another focus was on the production of low-ohmic contacts between high-temperature superconducting (HTS) strip conductors of the second generation within the "Highway" project of the German Federal Ministry of Economics (BMWi). Within a project of the European Aeronautic Defense and Space Company (EADS) funded by ESA, the European Space Agency, on the subject of "Hydrodynamic Shielding," the group manufactured MgB_2 and coated-conductor coils for vibration tests in which the mechanical loads during a rocket launch were simulated. In the area of power technology applications, the scientists designed, developed, and tested modules for superconducting fault current limiters within the ECCO-FLOW (EU) and ENSYSTROB (Federal Ministry of Economics) projects.

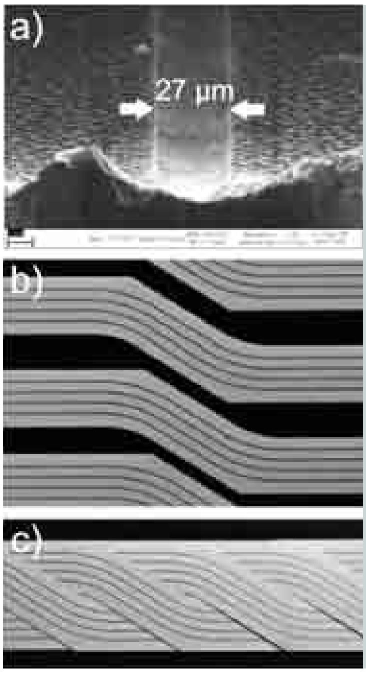


Fig.1: SEM-image of a slit 27 micrometers wide made by a picosecond laser in the superconducting layer of a REBCO strip conductor (a); slitted Roebel strands (b), and Roebel cable with slitted strands (c).

Superconducting Materials

Concepts of low-AC loss REBCO-strip conductors and cables

Work on low-AC-loss HTS strip conductors of the second generation (REBCO-RE-Ba-Cu-O; RE – rare earth element) was concentrated on concepts to reduce losses by structuring individual strips, on the development of low-AC-loss Roebel cables, and the development of concepts of high-current cables for fusion magnets with current carrying capacities >10 kA in magnetic fields >10 T and at temperatures >50 K. The Roebel cable geometry allows loss reduction by transposition of the individual strips of a cable and, thus, also of the current path. Further loss reduction can be achieved by modifying the individual strips making up the cable, for instance by

1. reduction of hysteresis losses by reducing the width of the meandering single strips;
2. reduction of the width of the current path by filamenting, or
3. reduction of the aspect ratio (width/thickness) of the cable by stranding stacks of strips instead of single strips.

Work in 2010 was focused on the second possibility, i.e., filamenting single strips.

Filamenting was achieved by parallel slitting of the superconducting layer in the direction of the strip by means of a picosecond laser (see Fig.1). The slitting process proved to be reproducible and reliable. No significant deterioration of the current carrying capacity due to slitting was found. Effective reduction of losses by filamenting was observed both in slitted single strands and in a Roebel cable with slitted strands.

The use of HTS magnets in fusion reactors of the next generation, i.e. in DEMO and the following reactors, promises a major increase in reactor efficiency and a reduction in complexity as a result of avoiding a thermal shield. The extremely tough requirements, such as current carrying capacities >10 kA in magnetic fields >10 T at temperatures >50 K, combined with high demands on mechanical stability and low AC losses, necessitate completely new conductor concepts for REBCO strip conductors of the second generation. Simply scaling up the Roebel technology is not sufficient to meet requirements of a fusion conductor. A novel concept is the use of Roebel cables as strands for a larger Rutherford cable (Fig.2). Transposition of the punched strips in the Roeble cable, and transposition of the Roebel cable proper, effectively contribute to a reduction of AC losses in the Rutherford cable. The Superconducting Materials and Applications in Power Technology group presented the idea of the Rutherford cable with Roebel strands (CCRC-Coated Conductor Rutherford Cable) in ITEP and began building a short demonstrator cable (Fig.3).

In the preparatory phase, the researchers performed numerous measurements on short REBCO-CC specimens in order to determine the dependence of current carrying capability on the field and the angle. In addition, they designed a special piece of equipment which allows the mechanical influence to be simulated when the Roebel strands cross between the top and the bottom sides of the Rutherford cable.

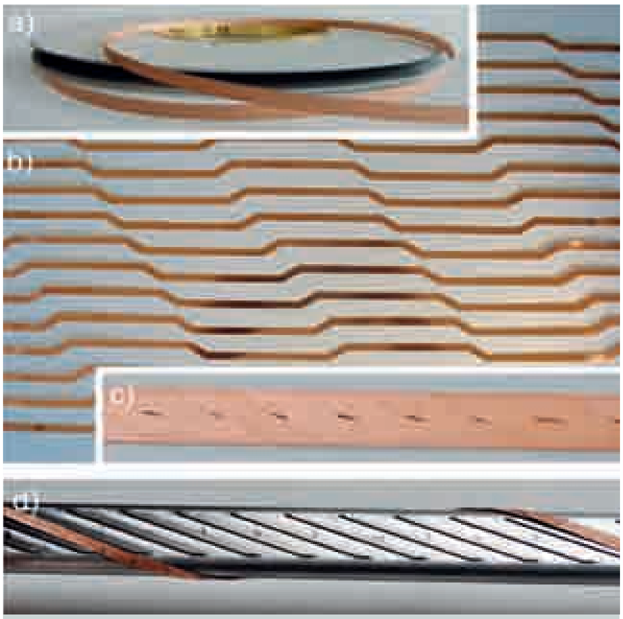


Fig.2: Commercial REBCO-CC strip (a), punched strips (b), Roebel cable (c), Rutherford cable mold with a Roebel strand (d).

Fig.3: CAD design of the CCRC demonstrator cable.

The results of measurements of single strips show that there is only a slight influence on the current carrying capacity of the strip at a mold thickness of ten millimeters. The maximum degradation of the strip was only about four percent up to winding angles (the angles between the Roebel strand and the mold axis on the top and bottom sides, respectively, of the mold) of 90 degrees. In 2011, the group will equip the CCRC-demonstrator cable fully with ten Roebel cables which, in turn, will be made up of ten individual strips, and will also study current distribution in the cable and the influence of eigenfield effects.

Concepts of Low-AC-loss MgB_2 Cables

During a stay as guest scientists within the NESPA EU project, low-AC-loss cables were made from commercial MgB_2 wires of the Hyper Tech Research Company. The 0.83 millimeter diameter of the wires supplied in the unreacted condition was reduced to 0.57 millimeters by wire drawing. Then the wires where stranded by means of a cable machine developed in 2009, and then reacted. It was seen that the current carrying capacity of a cable made up of six MgB_2 wires corresponded to the sum total of the current carrying capacities of six single unstranded MgB_2 wires. So, no degradation was found (see Fig. 4). For 2011, measurements of AC losses of the MgB_2 cables are planned.

Lamination of Superconducting YBCO Strips

To produce conductors for AC applications, researchers are developing structured YBCO strip conductors. They designed a laser structuring process for structuring the strips. ITEP ordered one laser structuring facility. Delivery was earmarked for mid-March 2011.

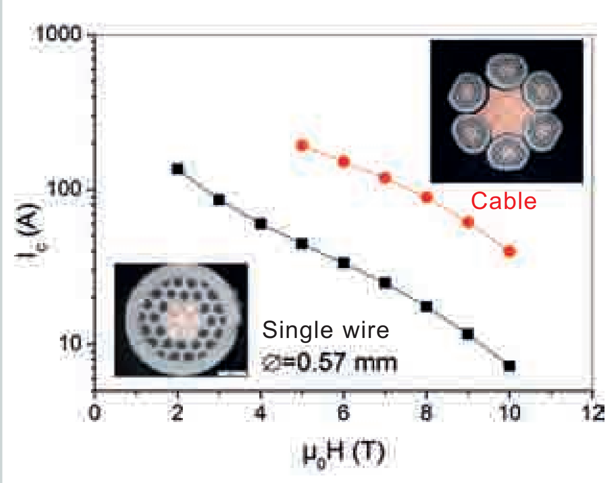


Fig.4: Comparison of the current carrying capacities of a single MgB_2 wire and a cable made up of six single wires.

The scientists concentrated their work on laminating YBCO strip conductors. Ag diffusion and terminal contacts as well as YBCO/YBCO joints were examined. They characterized these specimens under the scanning electron microscope and by means of E-I measurements. Figure 5 shows the example of characterization by E-I measurements.

Laboratory for AC Losses

In 2010, ITEP equipped the unit for measuring magnetization losses with a new instrument interface, rewriting the measurement program in a modern Labview environment. The upgraded system was used to determine the magnetization losses of REBCO strips and Roebel cables. In addition, the scientists began building a new

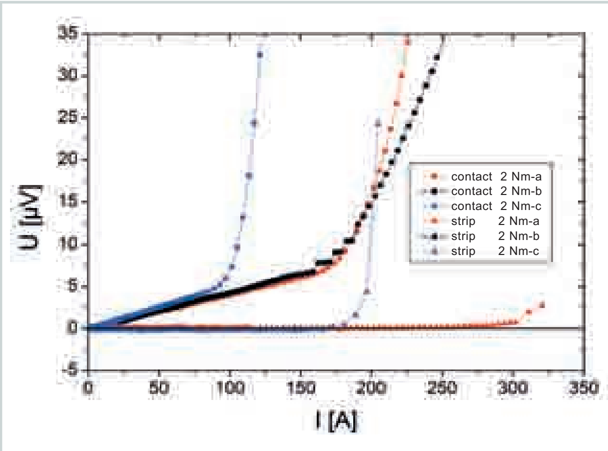


Fig.5: Three Ag diffusion contacts bolted with 2 Nm.

system for determining transport current losses. A transformer allows losses to be measured for current amplitudes above 1 kA (Fig. 6).

Numerical Modeling

The researchers expanded the methods of numerical modeling in various directions:

1. Detailed comparisons of three different models for simulating superconducting magnet heterostructures.
2. Development of a new model for evaluating eigenfield effects and current distributions within Roebel cables.

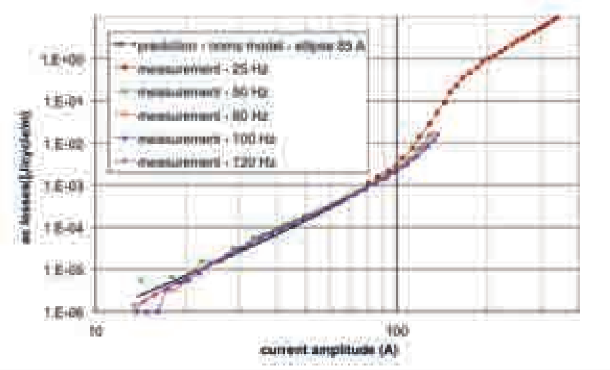


Fig.6: Transport current losses of a BSCCO strip.

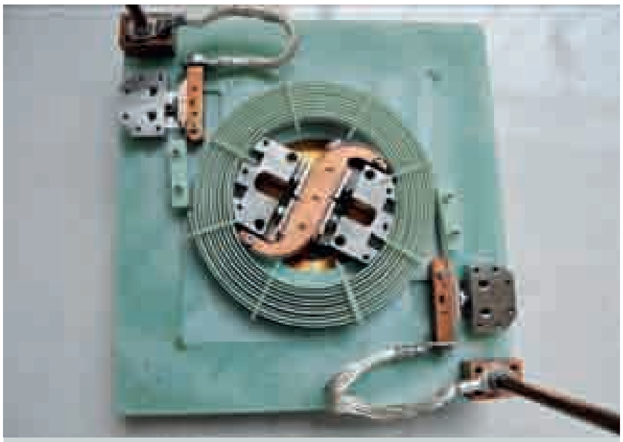


Fig.7: Test component of an HTS current limiter made of a coated conductor.

3. Development of a new technology for deriving analytical terms for AC losses in simple geometries.
4. Optimization of an existing 2-D finite-element model for calculating AC losses in the light of practical applications (Roebel cable, current limiter).

Electrical Applications

Within the ENSYSTROB project sponsored by the German Federal Ministry of Economics (FKZ 03KP102B), the scientists developed and tested the prototype and a component module of a superconducting current limiter made of bifilar wound HTS strip conductors. Figure 7 shows the test component of the current limiter which was used to verify functioning of the design.

To achieve a compact design, the researchers used the technology of bifilar pancake winding with conductor pairs in a back-to-face arrangement. The strip lengths of 2.3 meters roughly corresponded to half the length of the planned real component. The low-ohmic contacts were made by pressing the strips with an indium foil (R_{cont} <0,5 µohm). The helical insulation bars were made out of fiber-reinforced polymer, the twin strips were inserted into the spaces in between. Successful high-voltage tests with 10 kV in air at room temperature indicate safe behavior up the application temperature of liquid nitrogen. Figure 8 shows the measurement of a short circuit resulting in an overload current in this component. The limitation of the overload current is clearly visible in the time curve shown.

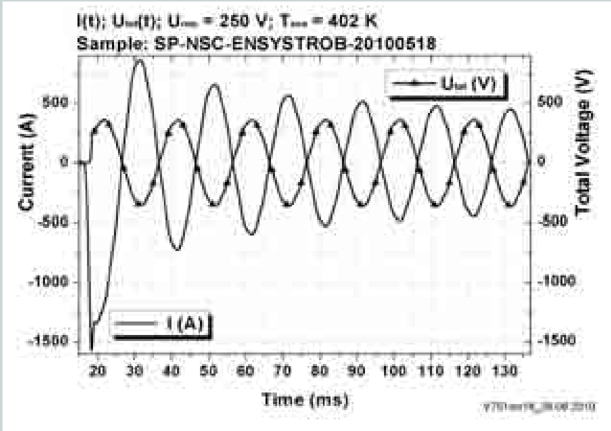


Fig.8: Short-circuit test of a current limiter model component.

In the application laboratory, a new switching system for coupling to the 12/20 kV grid and a new single-phase short-circuit-current transformer with a continuous rating of 1,2 MVA were installed in 2010 (see Fig. 9). The transformer has eight separate windings (125 V, 1200 A continuous load) which can be connected in series or parallel, for instance, to test superconducting cables or current limiters.

Fig.9: New single-phase 1.2-MVA continuous-load short-circuit current test facility of ITEP.

The test facility with two synchronized thyristor switches allows programming of the load or short-circuit profiles with two separate resistor networks. In addition to the usual measurements of short-circuit currents it allows the "recovery under load," "recovery time to load after short circuit," and "short circuit after load/overload" variants to be programmed. The test specimens can be tested with the two-stage overload profiles to model startup currents.

Highlight
Superconductor Coils for Space Applications – Successful Shaker Test of the MgB_2 Coil

Within a project funded by ESA on "Flight Experiment Concepts for Electrodynamic Thermal Shields," the scientists manufactured various magnet coils out of MgB_2 wires and REBCO coated-conductor strips. The MgB_2 wires used for the coils were either made at ITEP or supplied by a commercial source (Hyper Tech Research). For the coated-conductor coils, HTS strip conductors of the second generation (REBCO) made by Superpower were used. While the coil was built up, the scientists conducted measurements of the current carrying capacity in a magnetic field (dependence on field and angle) and mechanical studies of single conductors.

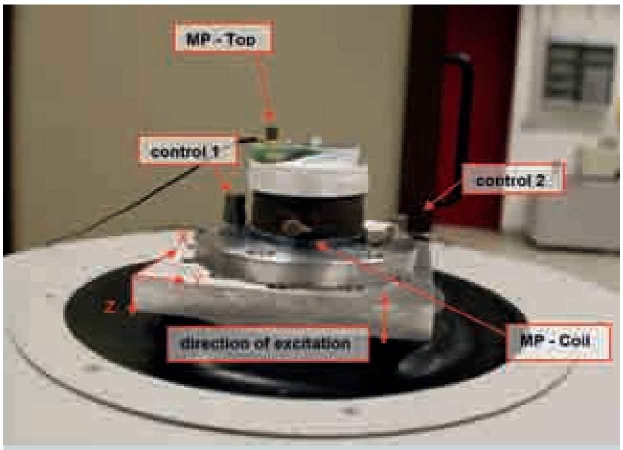


Fig. 10: MgB_2 coil mounted on a shaker for excitation in the axial direction (z-direction).

Figure 11 shows the current carrying capacities of a short MgB_2 specimen made at KIT and a wind-and-react coil made of this wire as a function of the maximum total field along the conductor. The current carrying capacities of the coil were measured in background fields of 2, 3, and 4 T, the whole field is calculated as the sum total of the background field and the maximum coil-generated field at the winding. The loading line shows

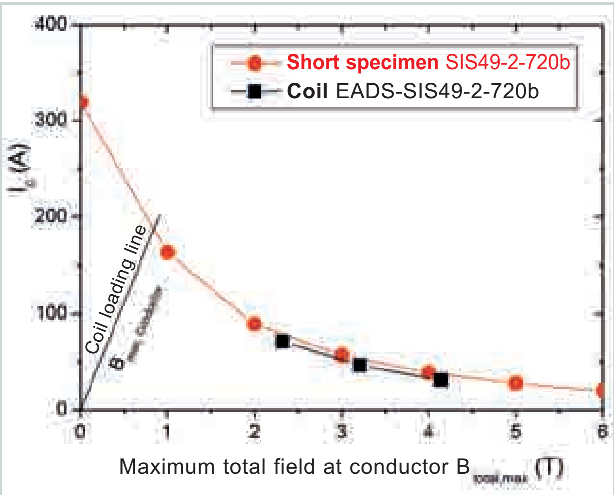


Fig. 11: Current carrying capacities of a short MgB_2 specimen produced at KIT, and a coil produced from this wire, as a function of the maximum total field along the conductor. The loading line shows the connection between the coil current and the maximum field in the coil without a background field.

the connection between the coil current and the maximum field in the coil without a background field. The current carrying capacity of the MgB_2 coil was found to be almost identical to the current carrying capacity of the short specimen; no degradation of the wire was seen.

After the ITEP experiments, the scientists sent the coil to DLR Berlin, which conducted a shaker test (Fig. 10). The test was carried out with sinusoidal excitation and a random vibration spectrum covering both a "Qualification Acceptance Vibration Test" (QAVT) as per ESA Recommendation, and the spectrum of the envisaged carrier rocket. Despite the high mechanical load during the shaker test, no changes were observed in the coil tested. Also the E(I) measurements determining current carrying capacity, which were conducted subsequent to the test at ITEP in fields of 2 and 4 T, showed no change over the measurements prior to the shaker test. For 2011, additional shaker tests are planned for coils produced with REBCO strip conductors.

Figure 12 shows a split-coil magnet made out of twice three double-pancake coils. The double-pancake coils were wound with commercial REBCO coated conductor made by SuperPower, the individual layers were insulated from each other by Kapton® film. The double-pancake coils were connected electrically by brazing with copper sheet. The aggregate resistance of all contact joints is approx. 17 µohm at 77 K. For mechanical stabilization of the windings the split-coil magnet was sealed with beeswax. Subsequently, the current carrying capacity of the magnet at 77 K was measured in the eigenfield (Fig. 13). The critical current, I_c, was 20,6 A (E-criterion: 1 µV/cm measured across the entire coil).

Field calculations with OPERA-3D, and field- and angle-dependent I_c measurements of short specimens, showed that the current carrying capacity in the magnet is determined mainly by field components positioned on the conductor surface diagonally (45 and 135 degrees, respectively) and normally (90 degrees). The maximum diagonal field component occurs at the outer ends of the coils, producing a local drop of the critical current to approx. 19.1 A (estimated on the basis of field calculations and measurements of short specimens). Only at

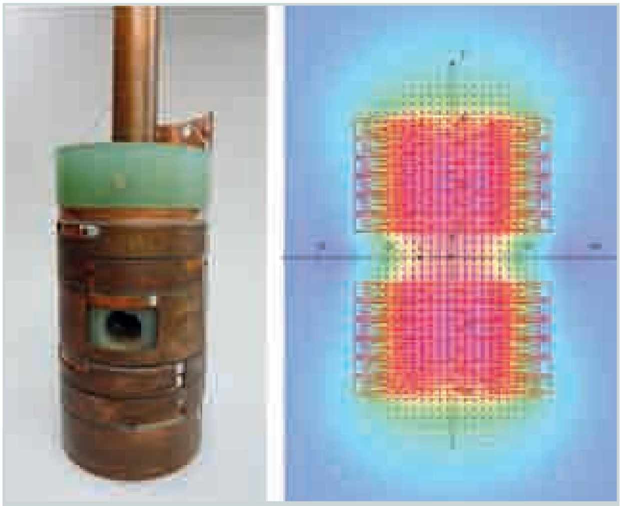


Fig. 12: Coated-conductor split-coil magnet consisting of twice three double pancakes (left), and field distribution computed with OPERA-3D (right).

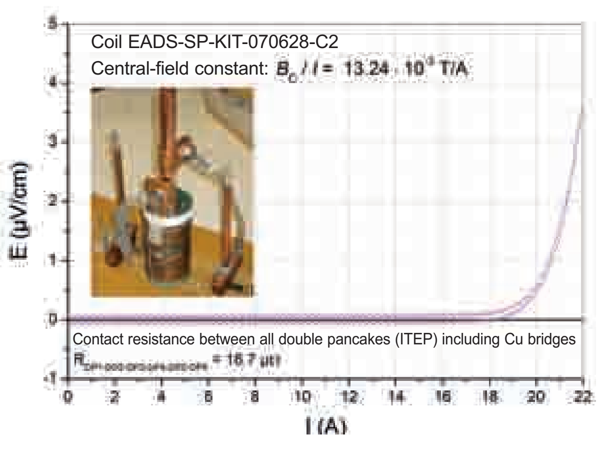
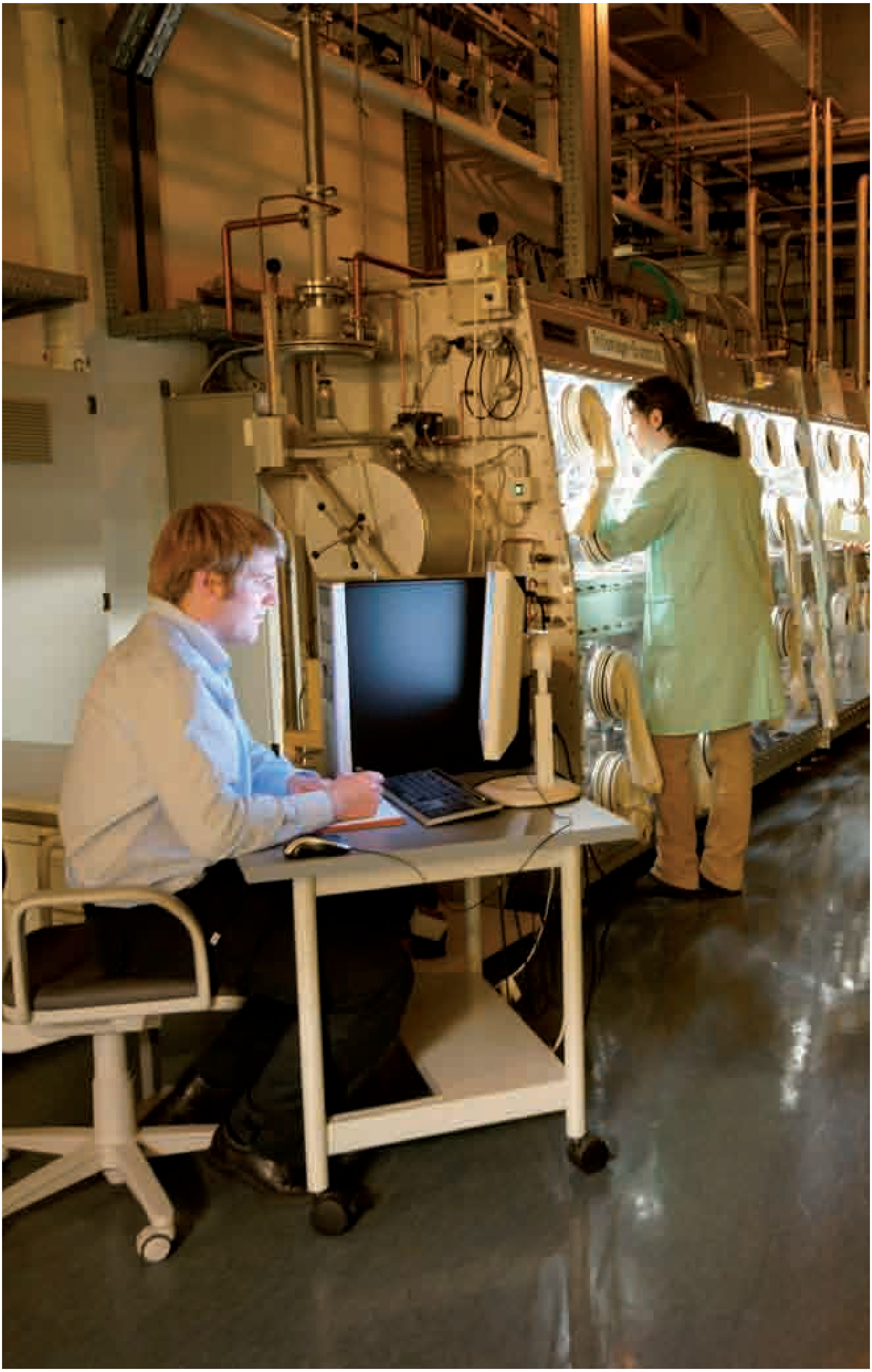


Fig.13: Determining the critical current of a REBCO-CC split-coil magnet.

currents of approx. 22.7 A and 23.9 A, respectively, the vertical and the parallel field components, respectively, locally limit the current carrying capacity of the coil. The calculated coil constant, B/I = 13.24 x 10^{-3} T/A, can be used to calculate the field generated in the center of the coil at I_c=20.6 A and T=77 K: $B_{Z,77\,K}$ = 273 mT. At lower temperatures, the current carrying capacity and the field compatibility of the superconductor rise markedly. Estimates indicated that a field strength far above 3 T could be achieved in this coil at a temperature of 4.2 K. For 2011, shaker tests of a REBCO coil are planned to demonstrate the feasibility of this material for use in space.



Junior Staff at TLK – a step into the future

Results from the Research Areas

Tritium Laboratory Karlsruhe (TLK)

Head: Dr. Beate Bornschein

The Tritium Laboratory Karlsruhe is a semi-technical scale experimental facility unique in Europe and America with a permit to handle 40 g (1,5*10^{16} Bq) of tritium, 100 kg of depleted uranium, as well as rubidium and krypton as test emitters for calibration. An experimental area in excess of 1000 m^2 holds more than ten glove box systems with an aggregate volume of approx. 125 m^3 as enclosures for the experimental equipment carrying tritium. The purpose of TLK when it was founded, and the most extensive research item to this day, has been the development of technologies for the fuel cycle of fusion reactors. A second main area of activity is the construction of key systems for the Karlsruhe Tritium Neutrino Experiment (KATRIN) measuring the rest mass of the electron neutrino. Accordingly, work is supported in equal proportions within the “Fusion” and “Astro” programs.

In the past two years, TLK has attracted an increasing number of students and graduate students by commissioning interesting research projects (see Table). Young scientists are very important for the future of TLK, and so the Laboratory is highly interested in offering them excellent, balanced training which, in addition to the technical and scientific aspects, also includes the soft skills now in demand everywhere.

	2007	2008	2009	2010
Diploma/Master	1	2	7	9
Ph. D.	3	3	4	7

Fig. 1: Work at TLK completed and going on.

The following sections will contain brief descriptions of the activities and results in the areas of operation and infrastructure of TLK, and research and development for fusion. A separate chapter is devoted to the KATRIN area.

TLK Operation and Infrastructure

In 2010, the conventional infrastructure as well as the tritium infrastructure of the Tritium Laboratory were fully available to research projects within the Fusion and Astro programs. The tritium store supplied in particular the CAPER experimental facility, which serves both operational purposes, such as the detritiation of exhaust gases (see Fig. 2), research and development purposes, and the LOOPINO experiment (see chapter on KATRIN) with pure tritium. The CAPER facility in addition produced special tritium gas blends for other experiments, which it enabled in this way. The regulatory conditions imposed in the new operating permit were met throughout. The supervisory visits by the regulatory authority did not give rise to any criticism. There were no notifiable events.

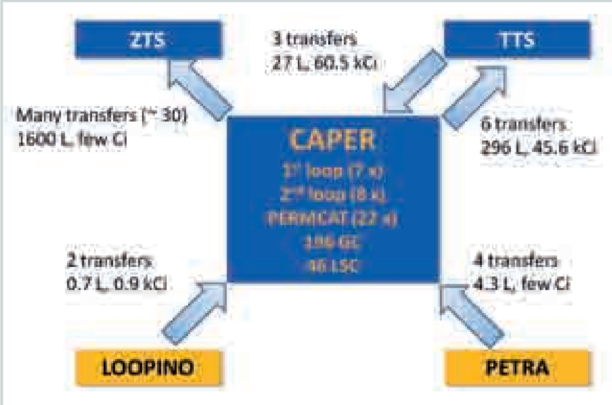


Fig. 2: Survey of tritium transfers of the CAPER plant. Waste gases came from LOOPINO and PETRA.

Intensified training of young scientists increased the number of persons working at TLK to more than 50, which necessitated an expansion of office space. As this was impossible to achieve in Building 451, the necessary working rooms were installed in a new container complex (Fig. 3).

Work in instrumentation and control focused on the first stage of replacement of the TLK process I&C system. As the old Teleperm-M system is no longer maintained by the supplier, and as no replacement components are available, exchange was indispensable. After nearly two years of planning and conceptual design work, the switch between the first two automation systems was achieved shortly before the end of 2010 (see also Highlight 2010).

Fig. 3: New additional office building for TLK.

R&D for ITER

Current work on the tritium loop of ITER is concentrated on the European contribution, "Water Detritiation and Isotope Separation (WDS-ISS)." For this purpose TLK, within the framework of the Fusion program, studies processes of water detritiation and hydrogen isotope separation by means of the TRENTA facility. These activities serve to generate important data for the WDS and ISS ITER systems and, in this way, contribute decisively to the ITER design.

Like the future ITER system, the TRENTA facility at TLK is made up of two subsystems, WDS and ISS. WDS uses the familiar Combined Electrolysis Catalytic Exchange (CECE) process for recovering tritium from tritiated water. The two main systems of the CECE process are two electrolysis units with a total capacity of 2 m³/h of hydrogen gas and an 8 m long Liquid Phase Catalytic Exchange (LPCE) column. Hydrogen isotope separation is achieved by cryogenic distillation at temperatures of -253°C and -247°C. This makes use of the fact that the different species (H_2, HD, D_2, HT, DT, T_2) have different boiling temperatures.

As far as licensing ITER is concerned, the focus is on the tritium inventory in the isotope facility. This inventory depends on the type and quantity of the packing material to be used in the distillation column. The most important activity in 2010 was the continuation of tests of various packaging materials, in particular the so-called CY packing, which is a fabric packing and, according to the first preliminary experiments, has promising properties. As a task for the European Fusion for Energy Agency (F4E), TLK performed several measurement campaigns of one week duration each, testing the different packings with different H-D mixtures in the cryocolumn. At the same time, it slightly modified the design of the column. According to some first results of evaluations, the hydrogen inventory established in the cryocolumn in normal operation generally is slightly higher than expected in all packings tested. As far as the requirements for ITER ISS are concerned, the findings altogether were promising. At present, TLK is discussing with F4E and ITER to what extent another series of tests should be repeated with an ITER-like column of the same diameter.

While conducting the measurement campaigns with the cryocolumn, TLK advanced work on the process technical combination of WDS and ISS into the TRENTA 4 facility (see Fig. 4). Activities were focused on electric work for the local control system of the technical plant, final modification of the heat exchangers in the cyrocolumn, and adaptation of the cryofacility to the expanded mode of operation. Another important activity was the construction of a second accessible hood as an enclosure of the storage tanks for tritiated hydrogen and tritiated water.

A European-wide consortium, in which TLK personnel are responsible for project management, created the first process flow diagrams and design studies for the ITER storage tanks for trititated water as part of the future ITER WDS. They were accepted by F4E and ITER. In the same context, a HAZOP study, i.e. a safety analysis, was completed successfully, thus paving the way for further design activities.

Fig. 4: View of the TRENTA facility: In the front left, the opened cryocolumn can be seen. The black column on the right hand side of the picture is part of WDS. The blue unit in the background is the Linde cryofacility for ISS.

In addition to carrying out design work, TLK produced simulation software of its own for the processes running in WDS and ISS, thus creating the possibility to test directly the consequences of various design proposals for ITER. The simulation software had first been compared successfully with the experimental data of the TRENTA experiments.

The TRENTA facility allows TLK in the future to feed the tritium recovered from WDS directly to the cryocolumn (ISS) and, in this way, test the combined system, which will be used also for future fusion reactors, like ITER, for tritium recovery. At the same time, the TRENTA facility, as part of TLK tritium infrastructure, is going to process tritiated waste water of TLK and, in this way, complete the closed tritium cycle of TLK.

Analytical Work at TLK

Managing qualitative and quantitative analyses of the six hydrogen isotopologues, H_2, HD, D_2, HT, DT, and T_2, as well as other tritiated compounds (such as HTO) constitutes a major precondition for handling tritium, imposing strict requirements on experimentalists and their equipment. Because of the great importance to TLK of analytical work, the research and development activities are coordinated comprehensively across programs and groups. In 2010, work concentrated on these areas:

- Laser Raman spectroscopy of tritiated hydrogen isotopologues. For the first time, TLK conducted measurements of nearly pure tritium for more than two weeks (gas pressure roughly 200 mbar).
- Development of a new process for precise determination of volumes.

Alongside pure research and development activities, TLK optimized calorimeters, ionization chambers, and gas chromatographs as well as existing calibration processes. The instruments referred to above are used regularly, constituting the backbone of analytical work at TLK.

Blanket and Tritium Technologies

Within the Fusion program, and with a view to the future DEMO demonstration fusion reactor, tritium recovery from the breeding blanket constitutes a major technical challenge. To accumulate practical experience, various concepts are to be tested in a first step in the ITER experimental fusion reactor under construction (see Fig. 6).

In the past two years, TLK has contributed greatly to a thorough process review of the systems involved. The focus was on the question of how to simplify the process so as to make it more reliable and robust. The system newly proposed and accepted contains a getter bed and an adsorption column in the extraction system, followed by a palladium membrane reactor (permcat) for extracting tritium from the blanket in a molecular and oxidized form. As these technologies were developed at TLK, TLK is also going to participate closely in future research and development activities.

Compared to ITER, technical requirements of the outer tritium loop of DEMO are much stricter (roughly by a factor of 1000 in the fluxes). Therefore, it is impossible to simply scale up the technical processes. Instead, new processes must be designed. Preference is given to continuous processes so as to minimize the tritium inventory in the systems involved, and avoid pronounced temperature fluctuations due to cooling or heating.

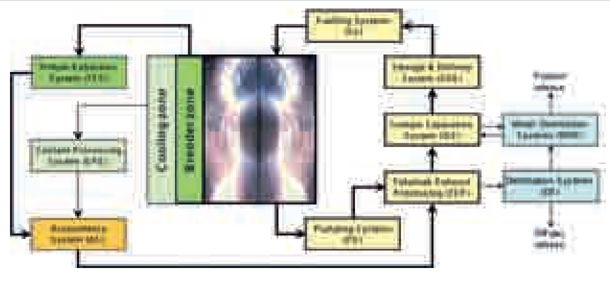


Fig. 6: Flowsheet of the inner (right) and outer (left) tritium loops of a fusion reactor. The inner tritium loop is responsible for pumping off the contaminated tritium/deuterium fuel, its cleaning, and refeeding the correctly set fuel mix. In the external tritium loop, the tritium produced by a nuclear reaction of the fusion neutrons with lithium in the blanket is swept out of that blanket by means of a purge gas (helium), extracted by it in the downstream tritium extraction system and, after balancing, made available to the internal fuel loop.

The continuous concept proposed by TLK requires a permcat to recover tritium from water and a selective permeator as a preliminary stage in order to separate, as far as possible, the helium from the blanket purge gas. In this connection, TLK intensified its cooperation with the KIT Institute for Thermal Process Technology (TVT) last year. Both a Ph. D. thesis and a master's thesis have been started. This cooperation serves to demonstrate that a multi-stage permeation process based on novel zeolite membranes is feasible. For this purpose, TLK built an experimental unit in 2010 for testing prototype membranes and commissioned it. The experiments are to be continued next year in order to accumulate sufficient data for the design of the extraction system for DEMO.

One of the first safety studies for ITER emphasizes the need to install an additional system able to detritiate highly radioactive water (up to HTO, 1.4 MCi/kg). Under a service contract with ITER, TLK took part in a study comparing the different processes. At the same time, the experimental CAPER facility was expanded in an effort to check one of the concepts (water detritiation by means of permcat) with tritiated water (up to HTO) experimentally under realistic conditions.

Another main area of work at the laboratory was the continued refurbishment of the oldest TLK glove box, the so-called PETRA box. This is new territory to TLK. In order to obtain an overview, TLK first mapped the surface contamination within the box (see Fig. 5). The purpose of the exercise is to remove the internals of the box as far as possible by late 2011.

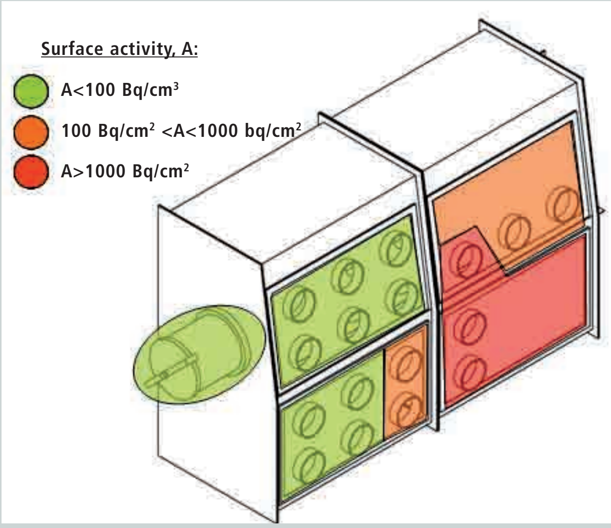


Fig. 5: Map of surface contamination of the inside of the PETRA glove box in TLK.

Highlight in 2010: Replacement of the Process I&C System

The TLK Measurement and Automation Technology group (MAT) has successfully completed its planning for replacement of the six Teleperm-AS488 automation systems and the associated Simatic S5 cabinets for binary signal processing by Simatic PCS7-AS417 for automation of the tritium infrastructure trade at TLK in 2009. Now these plans were to be put into effect in 2010.

Fig. 7: Cabinets for Teleperm-AS488 and Simatic-S5.

Quite generally, the specialists of the MAT group were to assume responsibility for all software work and for project coordination, while hardware activities, such as the construction of switching cabinets and the wiring, were to be sourced out to an external partner. In this way, it was possible, on the one hand, to minimize the expense in terms of time and money and, on the other hand, pay tribute to the highly specialized configuration in the Tritium Laboratory. The MAT group has extensive as well as detailed knowledge and skills in measurement and automation technology accumulated and expanded as a result of intense education and in-career training.

Work in 2010 began in Phase I with replacement of the AS3 (tritium transfer systems) and AS4 (tritium store) automation systems. This had been agreed upon in time and technically with the Siemens company. Siemens, as the system vendor, was responsible for delivering, assembling and wiring all hardware required. Specialists of TLK at the same time independently conducted all programming and project design work off line. At the same time, using specialized systems, they submitted the new software to thorough functioning tests. For this purpose, they used the SimbaPro subassemblies of Siemens to simulate all process signals (input/output periphery). For flexible control of the subassemblies, special programs were developed with Labview of National Instruments.

The software work was estimated to take roughly two person-years, its execution being closely related in time with progress in hardware activities. The year before, Siemens together with the MAT Group had examined the feasibility of tool-based automatic migration. The feasibility study showed that migration of that type, within the given constraints of time and costs, would not achieve the desired success. The reasons are the many specialized functional modules and automatic process control systems that cannot be changed automatically. In the early 1990s, when Siemens built up the automation technology for the Tritium Laboratory, merely developing these special modules and process control systems and their implementation for controlling the six automation systems took approximately eight ppy.

Fig. 8: The automation room of TLK with the old automation cabinets.

The decision to perform all software activities in-house saved TLK expenses of approx. EUR 200,000 in 2010, which would have had to be spent on an external contract. In addition, no time had to be spent on harmonizing and defining software technology with an external contractor. The basis for automation and visualization was the PCS7 modular library developed at TLK and used and tested earlier in the automation of KATRIN subsystems. It was expanded and adapted specifically to this project.

Laboratory operation, especially operation of the automation systems to be replaced and the associated auto-

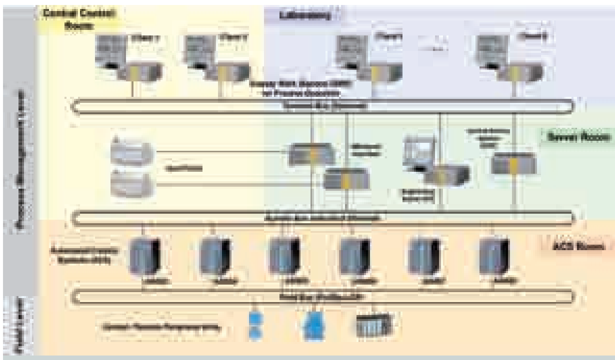


Fig. 9: Schematic diagram of the I&C components of the process I&C system in the Tritium Laboratory with six automation systems, six programmable control systems and automation cabinets, one network cabinet for the plant bus and the terminal bus with the appropriate optical fibers, two redundant OS servers, one central data archive server, eight service stations, one engineering station, and more than 200 I/O peripheral subassemblies and 4.2 km (2.1 t) of 32-wire jumper cable with connectors.

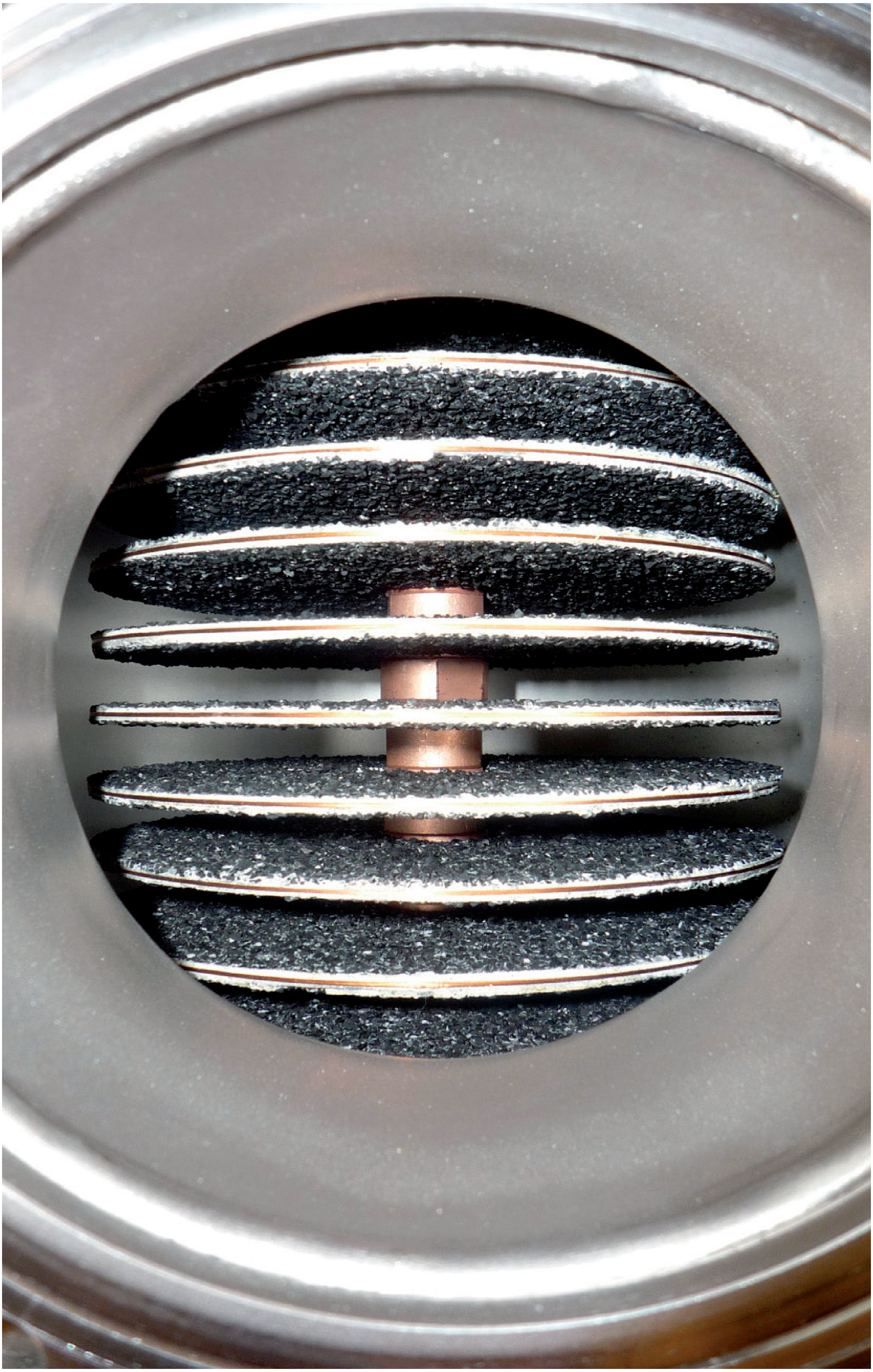
mated trades carrying tritium, was not affected, let alone restricted, at any point in time during the entire course of programming and installation work. One special challenge was posed by the parallel operation of new systems and old systems not yet replaced. For this purpose, a gateway was used which must exchange comprehensive data between the heterogeneous systems.

In mid-November 2010, the two old systems were cut off and replaced by the new ones. There was no need for complete recommissioning because accompanying tests during the development phase had been successful, Siemens had verified the hardware side of the wiring, and the existing terminal blocks together with the field wiring had been preserved completely. In this way, the new systems took over the duties of the old ones after an outage of only two days of the systems concerned. Operation continued to run smoothly into the new year.

In 2011, the new systems must be set up at their target positions and, at the same time, the old systems must be removed. Next year, within the framework of phase II, the next two automation systems will be replaced. In the third phase, which will be completed only by the end of 2012, the remaining two automation systems will be replaced.

The costs of delivery, assembly, and wiring by Siemens of all necessary components, in all three project phases, amount to a total of approx. EUR 600,000. The amount saved by TLK producing the software is on the same order of magnitude.

Fig. 10: New Simatic PCS7-AS417 control unit with analog and digital I/O peripheral subassemblies.



Prototype cryosorption pump for SIS100/FAIR

Results from the Research Areas

Vacuum Technology

Head: Dr. Christian Day

The activities in 2010 of the Vacuum Technology research area were characterized clearly by the work for ITER under contracts with the European Fusion for Energy (F4E) Agency. Above all, researchers continued to work on the detailed designs of the prototype torus cryopump (PPC) and the cryopump for neutral particle injection (NBI). Moreover, they conducted further experiments to back the design of specific components. In addition, they prepared the cryopump test facility, TIMO-2, for the planned tests of the PPC.

Also, some first considerations were given to the vacuum systems of a commercial fusion power plant beyond ITER. This topic will be pursued by a working group specifically set up at EFDA, the European Fusion Development Agreement.

In a second main field of activities, the Vacuum Technology area in 2010 continued to advance the development and validation of software tools describing the vacuum flow in all three regimes: molecular, transition, continuum. For the first time, in-house codes were implemented in a supercomputer, which greatly reduced computation time. As a special highlight, a cryopump was modeled completely in quantitative terms.

In 2010, the Vacuum Technology area has achieved clear progress. Its commitment to two European training networks makes the leading role of ITP in vacuum technology even more visible.

The Prototype Torus Cryopump

In the development program of the ITER torus cryopump system, a prototype cryopump is to be built and tested thoroughly in the TIMO-2 facility at ITEP. The prototype is to be built in such a way that it can be used later as a replacement cryopump in ITER. As a consequence, all regulations and design criteria for nuclear components must be met. In particular, the design process must be documented in a detailed catalog of accompanying calculations: strength calculations; thermo-mechanical and hydraulic calculations; seismic events, etc. The Vacuum Technology area processed this catalog almost completely in 2010. Figure 1 shows the present state of development of the pump. The picture shows the main assemblies: the inlet valve, the thermal shields (green), and the cryopanels (light blue).

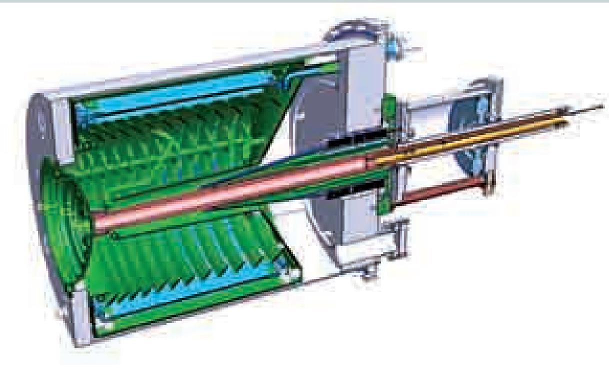


Fig. 1: 3D CAD-model of the prototype torus cryopump.

The pump has a cylindrical shape, is 2054 mm long and has a diameter of 1776 mm. The thermal shield system is cooled by cold helium at 80 K; the cryopanel system coated with activated carbon is cooled in operation to 4.5 K by means of supercritical helium. The cryopanel system constitutes a pumping surface of more than 11 m², which allows pumping speeds of the order of 75 m³/s to be achieved.

The torus cryopump contains an integral inlet valve for control of the incoming gas flow from the plasma chamber, and for closing under regeneration conditions. A static metal ring is used to seal the valve at the pump body. The behavior of that seal in this unusual dynamic application, however, was not known in advance. To back the design, the scientists therefore set up a test facility in which they studied quantitatively the dependence of the resultant leak rate on the closing force (see Fig. 2).

With regard to the ITER pump they then decided to size the inlet valve (Fig. 3) for a force of 125 kN by means of a pneumatic driving cylinder (500 mm diameter, 7 bar pressure differential).

The upgrade measures of the TIMO-2 test facility have meanwhile been completed. Now the two newly defined additional ITER modes of operation can be run in

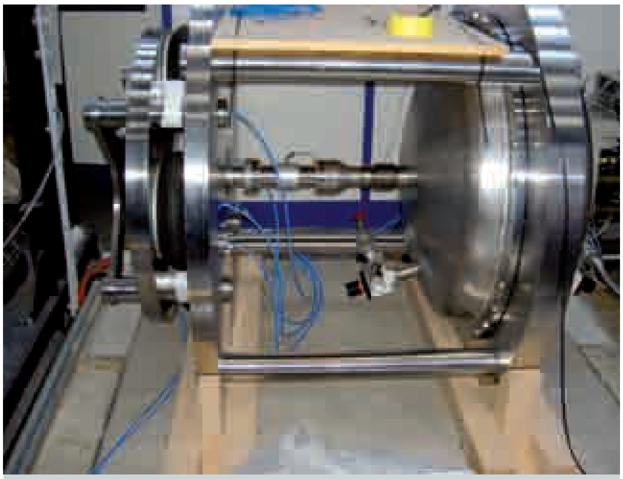


Fig. 2: Facility for testing static metal seals.

TIMO-2 with the PPC installed. This is, first, supply at 4.3 K instead of 4.5 K. At ITEP, this is simply achieved by pumping the liquid helium bath in the control cryostat of the test facility to a lower pressure. In addition, sup-

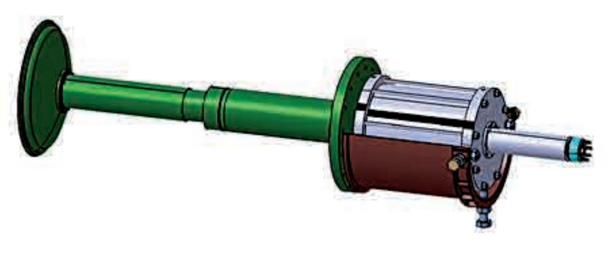


Fig. 3: Pump inlet valve drive.

ply at 100 K is achieved. This increase over the standard temperature level of 80 K results from the findings in earlier experiments and allows a nearly 100% release of hydrogen in standard regeneration of the cryopump. In TIMO-2, helium gas at 100 K is produced by heat exchange with liquid nitrogen which, at that temperature, is under a boiling pressure of approx. 8 bar. Figure 4 shows the new 100 K facility.

ITER NBI Cryopumps

The Vacuum Technology research area of ITEP is also responsible for the development and design of the ITER NBI cryopumps. Like the torus pumps, also the NBI cryopumps are to be subjected to a full-scale test. These cryopumps, of which there will be eight in ITER, are characterized by their enormous size; each of them is up

Fig. 4. The new 100 K facility for TIMO-2 ready for the PPC tests.

to 8 m long and up to 2.5 m high. They are complex components which, in addition, will be exposed to very different temperatures in different parts – between 4 K and 470 K. As a consequence, a lot of effort was invested into supporting mechanical FEM studies. At a size like this, thermal expansion or shrinkage effects will quickly add up to a few centimeters. Normally, metal bellows are used to accommodate the mechanical stresses arising; however, this should be avoided in ITER as much as possible, as the service life of the bellows is limited. Figure 5 shows a typical calculation of a thermal shield. Instead of bellows, flexible pipe bends are used.

Another critical point in running these huge pumping systems is the optimum cryosupply, in particular at an

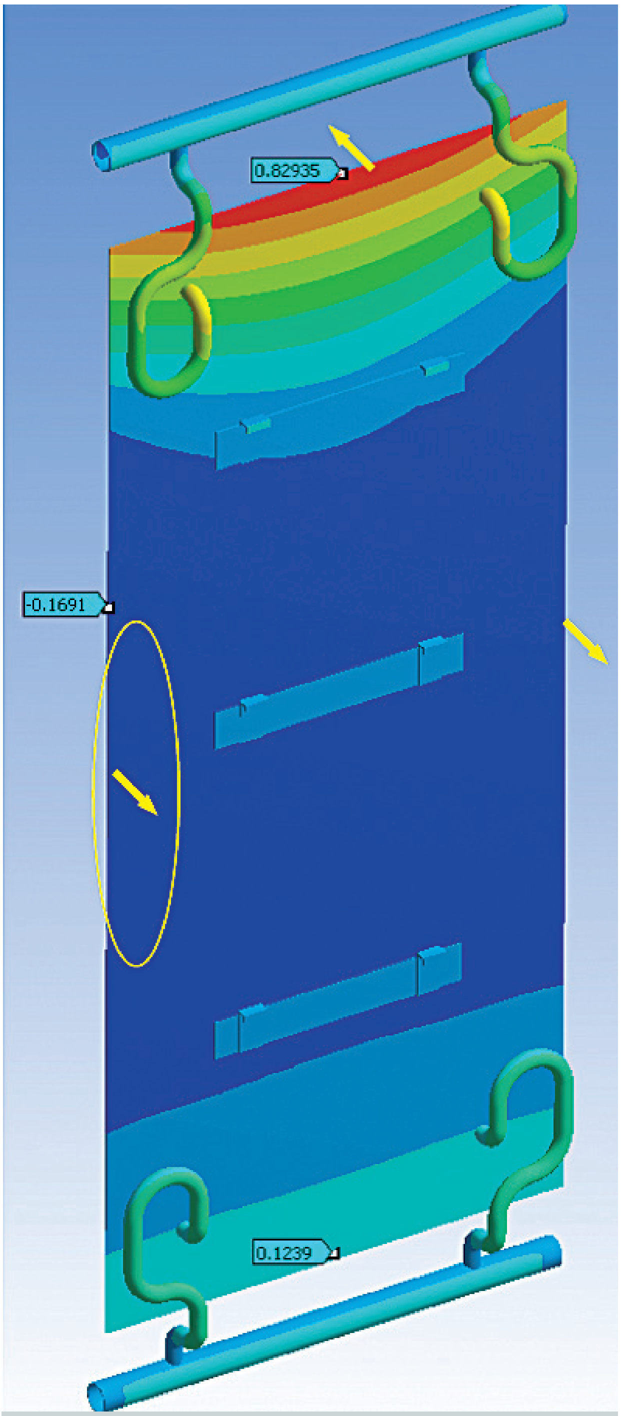


Fig.5: Computing the bending, in mm, forward (negative) and backward (positive) of a thermal shield during cooling from 300 K to 80 K.

acceptably low pressure loss and, at the same time, uniform distribution into the parallel cooling loops. As a consequence of the use of so-called hydroformed components it is not possible, however, to predict the pressure loss reliably. For this reason, the scientists in 2010 concentrated on measurements of hydroformed components. They used the results to develop a complete thermal hydraulic model of the cryopump. In doing so, they took care to ensure that, despite the high mass flows of cryogenic helium, only minimal pressure losses occur.

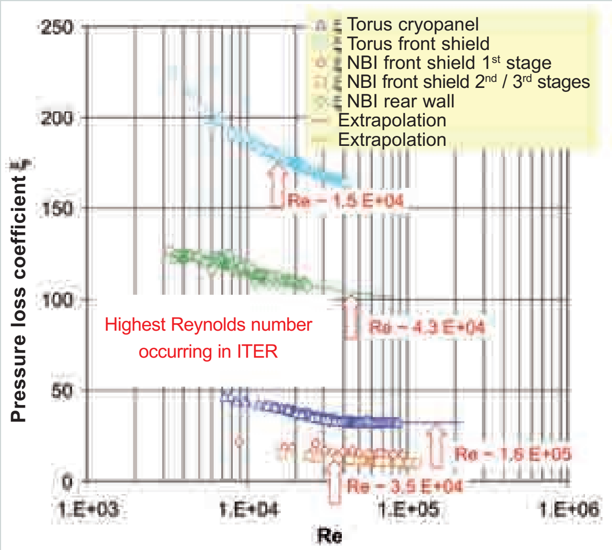


Fig. 6: Pressure loss coefficients, ξ as a function of the Reynolds number for various hydroformed components.

Modeling Vacuum Flows

In modeling vacuum flows, the research area in 2010 achieved remarkable results. The TRANSFLOW test facility was in operation nearly throughout the entire year. Various short flow channels were measured. There is no fully developed flow mode in short channels; consequently, the approaches of simplified kinetic flow theory no longer apply. The scientists therefore developed a 2D Monte Carlo code based on the DSMC approach, which also takes into account intermolecular interactions.

To achieve good convergence, the numerical grid must be optimized. For this reason, the code is individually matched to each geometry. Calculations were carried out for all channels examined experimentally: for the short cylindrical pipe of various lengths; for a pipe with a step in diameter; and for the geometry of two parallel plates.

Comparisons of measurements of pipes with different surfaces but otherwise identical dimensions allowed the coefficient of accommodation to be extracted which describes the momentum accomodation coefficient of particles with the surface.

Its manifold experimental activities involving the TRANSFLOW facility, and the theoretical code developments in the same group, constitute a clear USP of the Vacuum Technology area. The experiments feed in a steadily growing pool of data for validating new computer codes. On this basis, plans for 2011 envisage the development of a new computation tool for continuous further refinement of the underlying correlations, and to allow always the most recent data to be used.

Highlight in 2010: Simulation of a Cryopump in the Transition Regime

For more than two decades, the Vacuum Technology area of ITEP has been active in cryopump development, thus acquiring a worldwide leading position. In that period of time, the scientists accumulated comprehensive experience in the design and behavior of cryopumps.

The high pumping speed cryopumps can show usually is employed to generate low ultimate pressures in a vacuum system. In fusion, however, it is mainly about pumping the highest gas flows possible, and do so at a moderate vacuum. In this application, the cryopump is operated in the so-called transition mode, i.e., the pressure inside the high-vacuum pump is so high that particles collide not only with the wall but also with each other.

Describing this mode of flow is particularly complicated and sophisticated. Design on the basis of computation so far has simply been unfeasible. For this reason, cryopumps designed for those applications mostly were developed on the basis of past experience. For this purpose, so-called Monte Carlo calculations were carried out, where necessary, for the free molecular flow regime, geometries being simplified and intermolecular collisions neglected, and the findings subsequently were extrapolated to the conditions of transition flow. In that approach, the scientists of ITEP were able to exploit an excellently documented database from the TIMO experiments, which ensured that extrapolations worked reliably.

Encouraged by the most satisfactory progress in code development, the Vacuum Technology area in 2010 tried to simulate a cryopump in the transition mode, namely the ITER model pump whose pumping characteristics were well known from the experiments of the past few years (see Fig. 7).

The idea was to combine two complementary Monte Carlo calculations in such a way that their strengths would be used and their weaknesses would not upset.

The first step was a classical test particle Monte Carlo (TPMC) simulation. However, the ProVac3D in-house code was used, which has the advantage over other codes of being able to describe also structures of complex geometry. Thanks to the underlying concept, this code can also handle non-isothermal systems – which is another requirement for simulating well a cryopump with surfaces at 4 K, 80 K, and room temperature. The model pump is made up of complex cryogenic parts – cryopanels, thermal shields –, but otherwise has a simple cylindrical geometry. The new approach made use of the fact that all areas around the cryogenic components, because of the low temperatures, have low densities. Thus, the basic assumptions of TPMC are met very well. Finally, all cryogenic areas (see Fig. 8) were described by a pumping equivalent volume. This equivalent volume was then taken to the next simulation stage (Fig. 9).

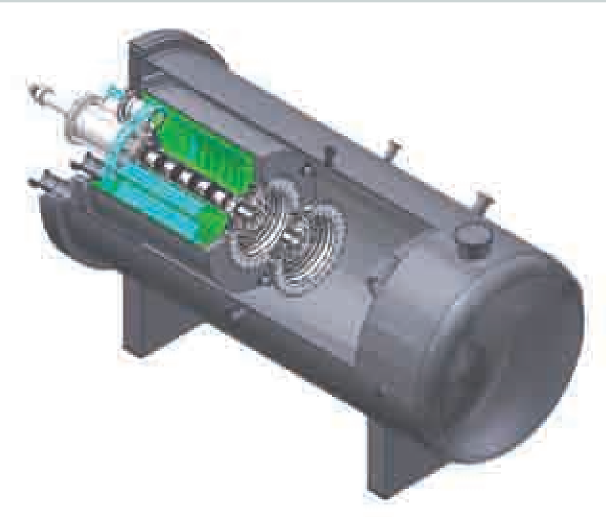


Fig. 7: Model pump installed in TIMO.

For this purpose, the scientists developed a code based on the DSMC method (Direct Simulation Monte Carlo). This procedure is most demanding both mathematically and in terms of computational efforts, but furnishes an exact description of the mode of flow, within the assumptions made, when intermolecular interactions are taken into account correctly. The major drawback of the approach – only relatively simple geometries can be described if computation time is to remain within acceptable bounds – did not matter because of the previous trick with the equivalent volume.

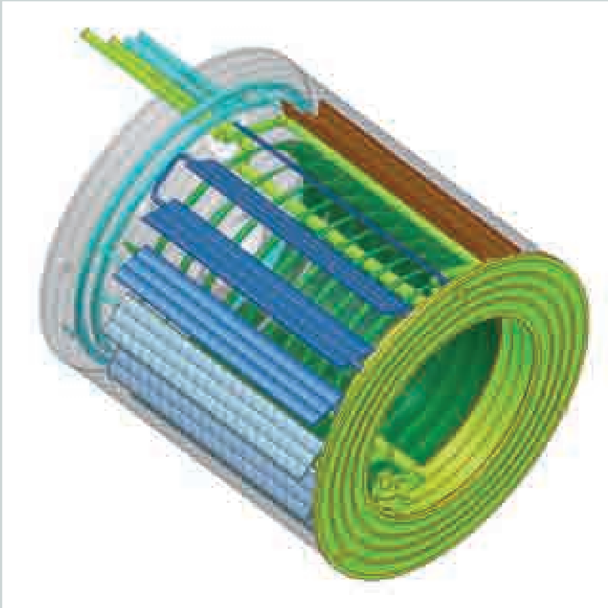


Fig. 8: The cryogenic parts of the pump are replaced by an equivalent volume (cylindrical shell).

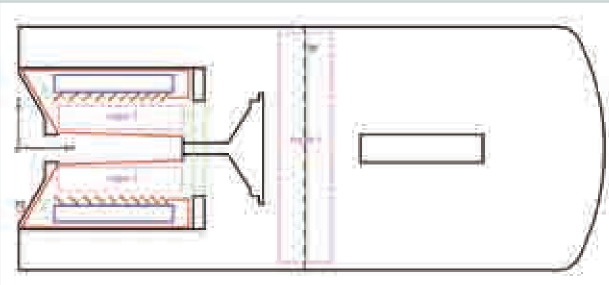


Fig. 9: Simplified 2D model of the TIMO design.

The results were absolutely convincing. Figure 10 is a comparison of the calculated and the measured pumping speeds for various valve positions and types of gas at a gas flow kept constant.

As the functionality of the approach was validated sufficiently well by the good agreement of simulation and experiment, the scientists used it also when computing other quantities. In doing so, they made use of another advantage of the DSMC method: The DSMC solution fulfills the Boltzmann equation, i.e., all macroscopic quantities, such as velocities, pressure, density, temperature, and energy input, can be computed on the basis of the simulation. This is shown, for example, in Fig. 11 for the Mach number. It is obvious that large valve openings induce supersonic velocities at the injection tube, i.e. far upstream of the pump, and that small valve openings, in addition, give rise to supersonic velocities at the valve head which reduce pumping speed overproportionally. This explains the drastic decrease of pumping speed at small valve openings as shown in Fig. 10.

This work is probably the first time a component as complex as a cryopump was simulated over the entire flow range. This convincing result constitutes another important building block in the expert knowledge of the Vacuum Technology research area.

The scientists are further developing this successful approach. It is to be used to control the cryopumps in ITER

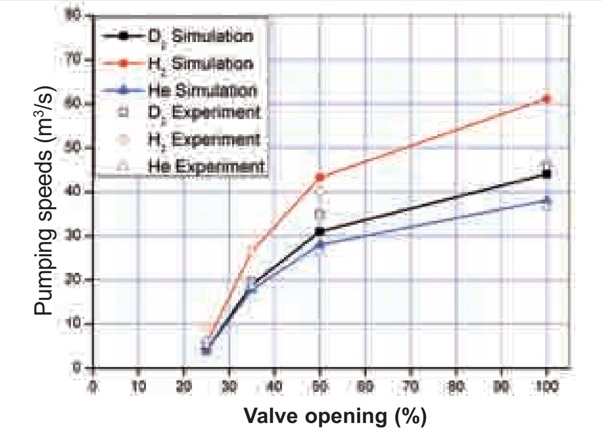


Fig. 10: Simulation results compared with TIMO measurements.

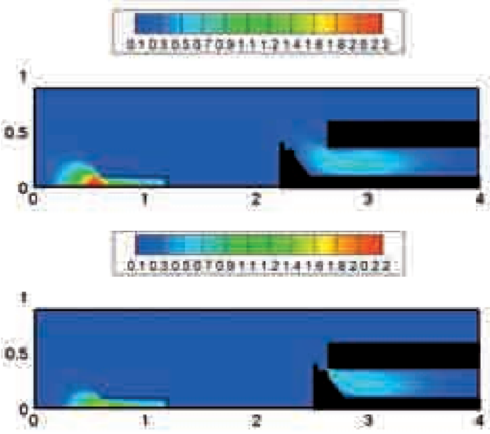


Fig. 11: Representation of the Mach number contours for helium and two valve positions (100 % open and 25% open).

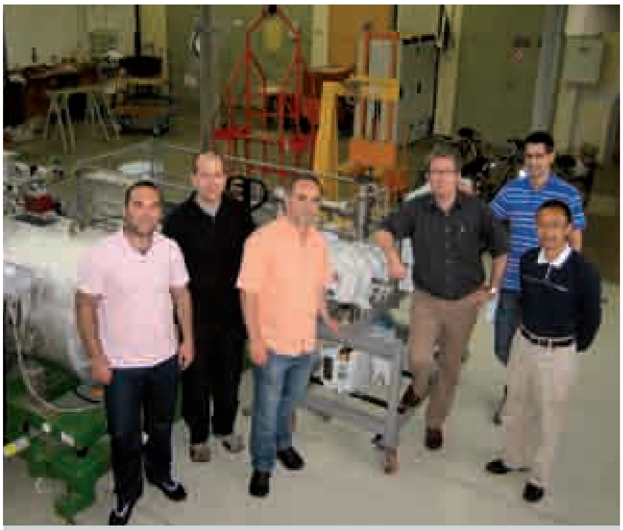


Fig. 12: The "Vacuum Flow Group" in front of the TRANSFLOW experimental facility.

operation. For this purpose, it could be made accessible to the ITER operators by means of a graphic user interface. Moreover, the approach in principle lends itself to simulations of areas of high neutral gas density by thermal gradients, which will become particularly important, for instance, in the design of new divertor concepts for DEMO (Super-X).

The Flow Group (Fig. 12) will organize a workshop in 2011 with leading international scientists in the field.

Compressor station of he 2 kW-He-refrigerator

Results from the Research Areas

Cryogenics

Head: Dr. Holger Neumann

Cryogenics for Fusion

Cryotechnology work within the Fusion program in 2010 concentrated on completing and testing the prototype power supply leads for W7X and on building up the Current Lead Test facility Karlsruhe (CuLTKa) power supply lead test rig.

Preparation and Test of the W7X Prototype Power Supply Leads

Planning and design work for the test cryostat in 2009 was followed in 2010 by construction of the test cryostat and its connection to TOSKA. In this effort, the scientists at the same time adapted the piping and sensor installations of TOSKA and examined them in a successful cold test. Moreover, they built a transfer line connecting the test cryostat to the B300 main cryostat of TOSKA. The test cryostat and the thermal shield (see Fig. 1) were successfully tested for leaks, evacuated, and purged repeatedly.

In the next step, scientists installed the prototype power supply leads and the short-circuit bar and applied the Paschen-resistant insulation. Initially, this did not pass the Paschen test; however, the defect was ultimately found and repaired. The prototype test of the power supply lead was conducted successfully without any incident. The computed temperatures, incident heat levels and required mass flows were in agreement with the measured data.

In this way, it has become possible for the first time in the world to build and test successfully a superconducting power supply lead in which the cold end is at the top and the hot end at the bottom.

Fig. 1: Test cryostat with cryoshield.

Fig. 2: Installation and connection to B300.

Fig. 3: Test cryostat with prototype power supply lead in the test phase.

CuLTKa – Current Lead Test facility Karlsruhe

For CuLTKa, the department of cryogenics first erected a stage into which the individual cryostats can be fitted. It set up a measurement both for these purposes and also completed the infrastructure systems for electricity, air conditioning, etc.

The specification for the control box with the associated transfer line sections and the lN2 system was largely completed in 2010. As a consequence, the tendering documents will be sent out to industry in the spring of 2011. The production drawings for the first valve box and the second test cryostat were completed, most of the materials and components as well were ordered and also delivered in 2010 so that manufacturing and assembly could be started.

Cryogenics for REUN

Within the "Efficient Energy Conversion and Use (REUN)" program, the department of cryogenics of ITEP installed an additional control valve in the THISTA thermal insulation rig in order to keep constant the pressure in the cryogenic reservoir. This allows measurements to be performed at a higher level of stability and accuracy independent of any fluctuations in ambient pressure.

In order to study the degrading influence of tees when using superinsulation, several measurements were performed on a cylinder with transverse struts (see Fig. 4) within the framework of a diploma thesis; the cylinder had been insulated with superinsulation in various ways. The surface of the cylinder with transverse struts is identical to that of a smooth cylinder examined before.

The findings obtained from this body, which cannot be developed, clearly show that the quality of the insulation is degraded considerably because of numerous junctions. Therefore, alternatives in the form of bulk materials should be considered for complex geometries.

Fig. 4: Insulated vessel with tees.

There are plans to modernize the calibration laboratory for temperature sensors in order to have it accredited. For this purpose, the department of cryogenics contacted the Physikalisch-Technische Bundesanstalt (PTB) and sent it a RhFe sensor for calibration which acts as a standard sensor in the calibration cryostat. For modernization, the Area revised a piping and instrumentation (R&I) flowsheet of the calibration cryostat and selected new equipment for improved measurement and process technology. For process technology, a list of specifications to be met has already been compiled.

As some first failures had already been encountered in the previous expansion stage, scientists in 2010 adopted several measures to ensure ongoing calibration operation. Thus, they replaced the heating strip for helium heating by a water pool with a removable pipe system. Also the vacuum pump rig was replaced; meanwhile, a turbo molecular pump with a roughing pump is being used. A slide valve is used to protect the pump rig. To ensure high suction capacity of the pump, the pump was installed in an aluminium section close to the calibration cryostat.

In the field of sensor development, the scientists developed an FBG mass flow sensor in which a movable wall element uses the wall shear stress of the flow to strain an optical fiber with an FBG sensor. This sensor has a number of advantages:

- It is independent of any magnetic field.
- There are no flow losses, as there are no additional internals that could affect the flow.
- Only the prototype sensor needs to be calibrated; all identical sensors can use this calibration.

To calibrate a sensor of this type, a cryogenic flow section was designed (see Fig. 5). It is to be built with THISTA in 2011 to make use of these facilities, such as the water pool heater and, above all, the laminar flow elements for mass flow measurement.

Moreover, the department of cryogenics developed an FBG displacement meter for a variety of length measurements with an accuracy of 20 pm/µm (see Fig. 6). Some first studies have shown its suitability for cryogenic temperatures. Other studies will follow in 2011, most of them being devoted to the respective materials and compounds.

Together with the High-field Magnet area of ITEP, the Cryotechnology area fitted FBG sensors to a test coil (NbTi). In this way, the mechanical stresses produced during ramping and quenching were determined. This first experiment may therefore pave the way for further measurements and a future measurement system.

Cryo-infrastructure

Work on cryo-infrastructure included extensive maintenance and repair, expansion and adaptation as well as operation of existing, and planning, building, and commissioning of new, cryogenic experimental facilities for research purposes.

At the time of writing, the 300 W (1.8K) He cryogenic facility had been in operation for 943 hours. Of that

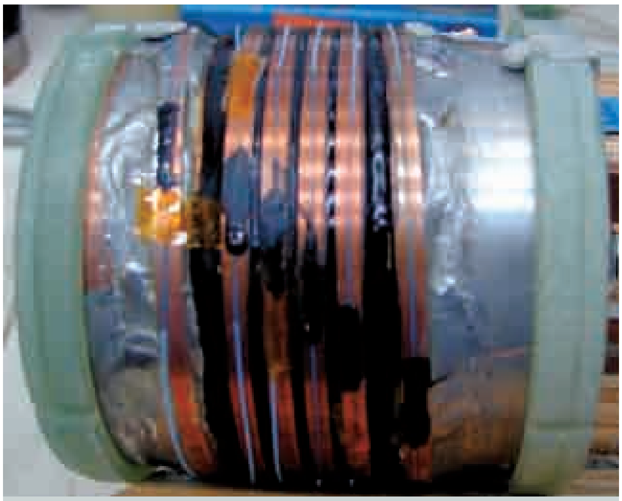


Fig. 5: NbTi test coil with FBG sensors.

Fig. 6: LN_2 filling station.

time, 155 hours were spent on liquefaction, 52 hours on purging as well as cooling and heating the facility, which leaves 736 hours of cryogeneration for experiments in the High-field Magnet area. The 2 kW (4.5K) He cryogenic facility had been in operation for approx. 2120 hours. Of that time, 396 hours were for liquefaction, 239 hours for purging and cooling and heating the facility. In this way, 1496 hours were devoted to cryoproduction for experiments in the Fusion area. On the whole, the facilities liquefied some 123,363 liters of helium, with 76,933 liters for experiments in ITEP, and 46,430 liters for other institutes.

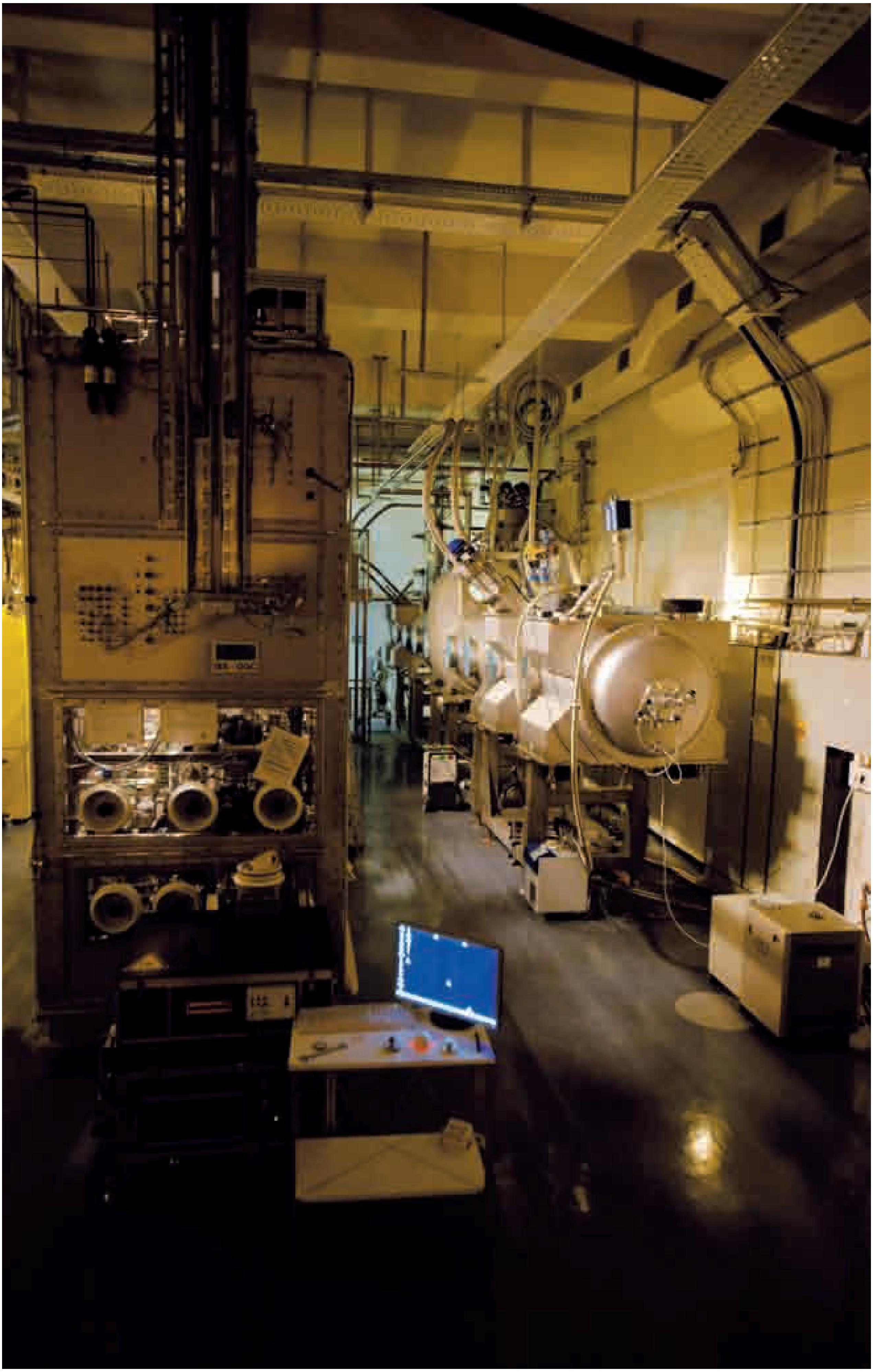
A major improvement was introduced by the installation of an automated LN_2 filling station (see Fig. 8). It is cleared for use by scanning of a bar code on cards distributed only to authroized persons. In this way, any use by non-expert personnel is avoided, and safety is increased. Moreover, the quantity filled is weighed and can be charged to other institutes.

Another improvement was achieved by replacing the oil diffusion pumps by turbo molecular pumps for the insulating vacua at the cold box and the valve box of the 2 kW He cryogenic facility (see Fig. 7). In earlier prolonged operation there were backflows of oil into the vacuum chamber, which polluted the superinsulation and diminished its quality. The new turbo molecular pumps avoid this type of contamination and improve the vacuum.

The three V20, V29 and V40 compressors of the recuperation plant were subjected to a revision after 2000 hours of operation. Besides standard filter replacement, also the suction and pressure valves were inspected. Other major activities performed in the 2 kW plant were the replacement of temperature sensors, repair of a valve, and replacement of a heat exchanger for recooling.

To adapt the cryo-infrastructure to new experiments, the pressure measurement transducer cabinets were designed, built, and leak tested for CuLTKa. For KATRIN, the scientists extended the PCS7 system with respect to the supply of lN_2. For this purpose, they also translated the R&I flowsheet into WinCC, programmed the control modules and implemented them into the I&C system. The lN_2 supply system was commissioned successfully.

Fig. 7: Turbo molecular pumps with a control system.



Silence in the Lab: on the right the demonstrator, on the left the clovebox with the LARA Set-up

Results from the Research Areas

KATRIN, Karlsruhe Tritium Neutrino Experiment

Head: Dr. Beate Bornschein

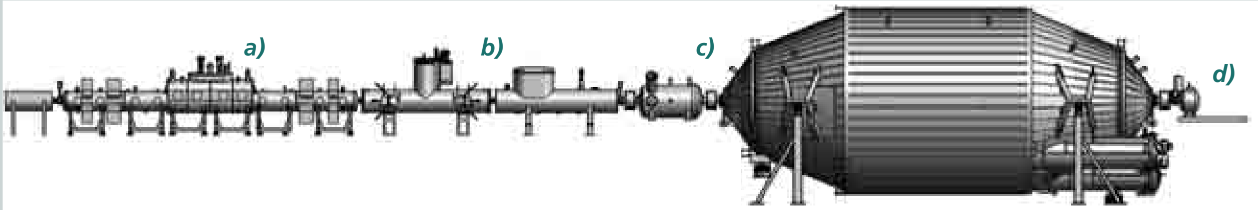


Fig. 1: Schematic diagram showing the KATRIN international large experiment. The electrons produced in β-decays in a high-intensity windowless molecular tritium source (WGTS, a) are passed through a tritium pumping section with the active and passive elements of DPS2-F and CPS (b) to a system (c) consisting of two electrostatic spectrometers (roughing and main spectrometers). The analyzed electrons are detected in a solid-state detector (d).

KATRIN, the Karlsruhe Tritium Neutrino Experiment, is to be used for model-independent measurement of the neutrino mass with a sensitivity of 200 meV/c^2. The reason for building KATRIN is evident from the key role of neutrinos in astroparticle physics: On the one hand, neutrinos with a mass play a specific role as hot dark matter in the evolution of large structures in the universe. On the other hand, neutrino mass has a key function in the unsolved problem of the origins of mass.

The experimental principle of KATRIN is based on precise measurement of the spectrum of electrons from the ß-decay of molecular tritium close to the kinematic end point of 18.6 keV. For this purpose, electrons from a windowless high-intensity source of tritium gas are run adiabatically through strong magnetic fields of superconducting magnets through the 70 m long experimental facility. A system of two electrostatic retardation spectrometers allows the electron energies to be determined at a resolution of 0.93 eV (Fig. 1).

A worldwide collaborative venture of more than 150 scientists, engineers, and technicians under the leadership of KIT is currently in the process of building up this key experiment in astroparticle physics at and in the Karlsruhe Tritium Laboratory (TLK). The first data are expected to come forth in 2012. The design, construction, and successful execution of the KATRIN experiment impose very strict requirements in terms of process technology, especially tritium process technology, ultrahigh vacuum and cryotechnologies, and high-voltage stabilization technology. Additional requirements are a functioning project management in order to harmonize the allocation of resources (financial and manpower) with the objectives of KATRIN in terms of time and content.

Fig. 2: WGTS magnet cryostat. The 16 m long cryostat is of an extremely complex technical structure and must meet strict technical requirements. The system has 12 cryogenic loops; six different fluids (He, Ne, N_2, Ar, T_2, and Kr) are used.

Within the framework of the KATRIN experiment, ITEP as the leader is responsible for tritium process technology and for magnet and cryotechnologies. More than 95% of ITEP's scope of work in the KATRIN project lies in the so-called source and transport system shown as a block diagram in Fig. 3, which is being built up completely within TLK because of the need to handle tritium.

The main component is a 16 m long superconducting magnet system called WGTS (see Fig. 2), which contains the source of tritium gas in its cold beam tube at 30K. In addition, the so-called calibration and monitoring system (CMS-R) is situated in the rear part and, the transport system in the front part of the beam axis (in the direction of the spectrometer). The transport system has the function of conducting the tritium decay electrons into the spectrometer and, at the same time, reducing by pumps the tritium gas flow into the spectrometer system by more than 12 orders of magnitude. This is done, on the one hand, by means of the differential pumping section (DPS2-F) and, on the other hand – as the last stage –, a cryopump section (CPS) operated at 3.5 to 4 K. Also shown in Fig. 4 are the tritium loops (inner loop, outer loop) ensuring controlled tritium gas feeding and keeping tritium purity at levels above 95%. Si-

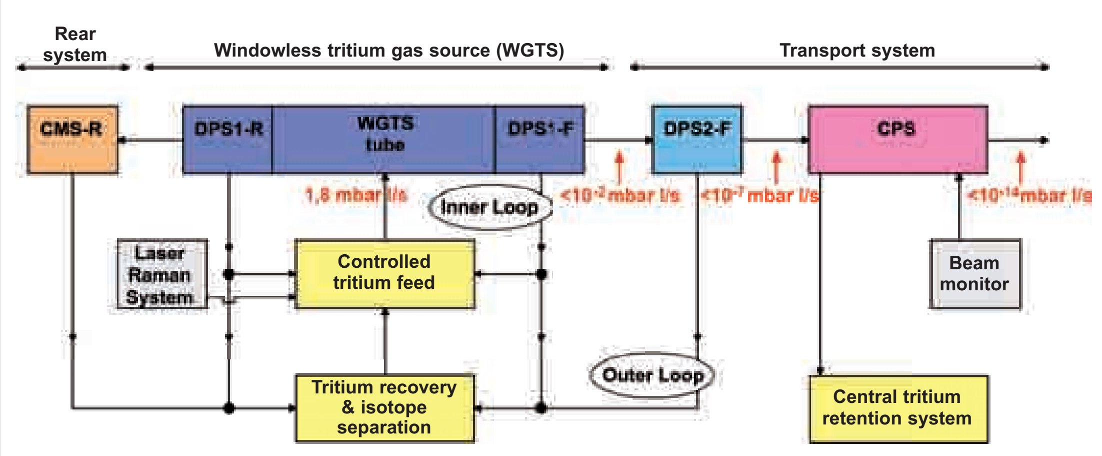


Fig. 3: Block diagram of the KATRIN tritium source and its interfaces with the infrastructure of TLK.

multaneous feeding and removal of the tritium gas by pumps finally produces a steady-state gas column density in the beam tube of WGTS (= tritium source).

Both DPS2-F and CPS are superconducting magnet systems 7 and 9 m long respectively. Like WGTS, they are, or were, manufactured by external companies, with ITEP supervising fabrication. The status of these activities will be outlined below.

WGTS and Demonstrator

WGTS is currently being built by RI, while the magnets are being made by BASC, both activities on behalf of VARIAN. VARIAN acquired the original contract when taking over the ACCEL company and then commissioned the RI and BASC companies, parts of former ACCEL, to do the construction work.

Technical supervision of the design and manufacturing phases with the industrial partners implies great expense on the part of ITEP: On the one hand, the WGTS design is very complex, and cooling requirements are extremely high (30 K stabilized to 0.1 %). On the other hand, WGTS later will have a tritium throughput of 1.5 x 10^{16} Bq per day (40 g) and, as a system carrying tritium, will have to meet high quality standards. Because of the extremely sophisticated cooling concept for the source tube, a preliminary version of WGTS was built first, a so-called demonstrator, which does not yet contain the magnets and the central helium tank. At the same time, the seven superconducting magnet modules, the helium tank, and other subassemblies are manufactured which are part of the differential pumping section of WGTS.

While technical difficulties with the magnet modules were encountered by the manufacturer, which delayed the project and required an even greater commitment of the ITEP magnet specialists, the demonstrator project ran satisfactorily. The demonstrator was delivered in April 2010 (see Fig. 4) and erected in the space in TLK provided for the test. In the following months, the machine was connected to the refrigerator and prepared for commissioning with respect to MSR and automation. Shortly before Christmas 2010, the demonstrator then was cooled to 30 K for the first time. This achieved an important milestone in the KATRIN project. The actual stability tests are envisaged for 2011.

DPS2-F

After many months of assembly work, DPS2-F delivered by ASG, Genova, was cooled down and tested for the first time in September 2010 within the acceptance tests (see Highlight). This constituted another important milestone of KATRIN.

Fig. 4: Delivery of the demonstrator and installation in TLK on April 8, 2010.

CPS

CPS is being built by ASG, Genova. Fabrication is accompanied by an inter-institute project team representing KATRIN. In 2010, the focus of quality assurance work was on checking the preliminary inspection documents and the inspections in Italy, which involve checks of welds and leak tests, among other things. At the same time, the cryospecialists of ITEP finished calibration work of the sensors (such as 16 RhFe sensors) of CPS, which they sent to Genova for installation on time.

Manufacturing of CPS in Genova mostly proceeded according to schedule. The seven magnet modules passed the cold tests. Both liquid-helium containers (1100 and 1300 liters) and the thermal shield were completed and also passed the QA tests (see also Fig. 5). A delay was suffered only in the production of the beam tube elements because of an unexpected shortening of some elements after brazing work performed to attach the heat conductors. ASG has been requested to find a solution of this problem. Delivery of CPS is now scheduled for the late autumn of 2011.

Cryofacility & Cryotransfer Line

Work in 2010 was focused on commissioning DPS2-F (see Highlight) and the demonstrator (see above). Cooling down these very complex systems in an almost par-

Fig. 5: Thermal shield of CPS. In the middle of the system, which is more than 7 m long, the high tower can be seen which later will accommodate the large lHe tank.

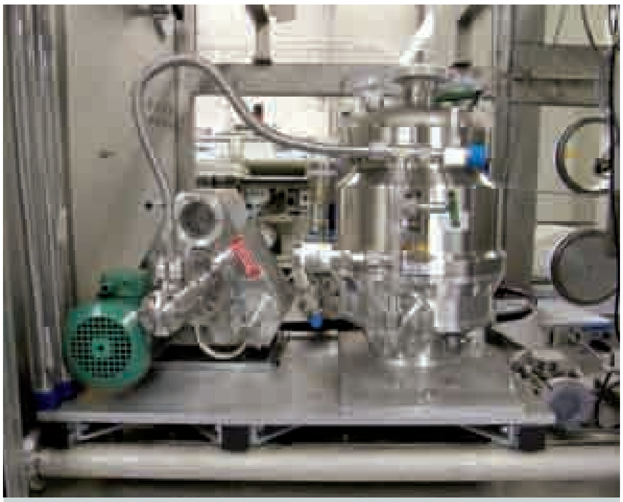


Fig. 6: TRITOP experiment under construction. The two pumps involved can be seen; on the left, Normetex ("triangle"), on the right, the MAG2800 turbopump.

allel effort necessitated precise planning and preparation of the work by the cryogroup of ITEP, and was handled very successfully. Another major activity in 2010 was planning, tendering, and supervising fabrication of the third part of the cryotranfer line and the third valve box required for cryogenic connection of CPS.

Tritium Loops

The tritium loops of KATRIN are being developed and built in TLK (mostly in the framework of diploma and doctoral theses). In 2010, hardware activities were concentrated on construction of the two important tritium test experiments, TRITOP and TRIREX, in which special components will be examined under tritium conditions for their usefulness for KATRIN. Figure 6 shows the main components of the TRITOP (Tritium Test of Pump) experiment in which a MAG2800 turbopump with magnetic bearings will be exposed to the same tritium gas flow for one year as, later on, the eight turbo molecular pumps at the first pump chambers of WGTS.

TRIREX (Tritium Rear System Experiment) is used to study the possibility of determining the tritium concentration in WGTS by means of the bremsstrahlung generated by the decay electrons in the rear wall of WGTS. Both experiments are to be commissioned in early 2011.

The focus in physics research was on Laser Raman Spectroscopy (LARA) of the hydrogen isotopologues H_2, HD, D_2, HT, DT, and T_2. Above all, long-time measurements of nearly pure tritium gas (up to 97%) were conducted in the new small test loop, LOOPINO. This loop was built and commissioned at TLK in 2009 in order to allow tritiated gas mixes to be circulated under the same conditions as those later found in KATRIN. In a measurement phase of three weeks, in which a total of approx. 770 g of tritium gas was passed through the equipment, it was demonstrated that gas composition changes with time and, in addition to the hydrogen isotopologues, methane is produced (see Fig. 7). Both effects can be explained by hydrogen isotope exchange reactions and gas – wall interactions – one stainless steel wall has a coating of carbon – and can be seen also in KATRIN. These facts are to be studied further in 2011; moreover, the influence of a tritium atmosphere on the laser windows used in LARA is to be examined in more detail.

Acknowledgement

ITEP scientists addressed activities for KATRIN in an interdisciplinary fashion and conducted them successfully. Besides TLK, naturally the Cryo-engineering area assumed a major share of the duties. All areas benefitted of a close and fruitful cooperation with students, technicians, engineers, and scientists of ITEP, the Institute of Nuclear Physics (IK), the Institute of Experimental Nuclear Physics (IEKP), the Central Shop (TID-F), and the KIT Project Management group (PMQ). Thanks are due to all of them.

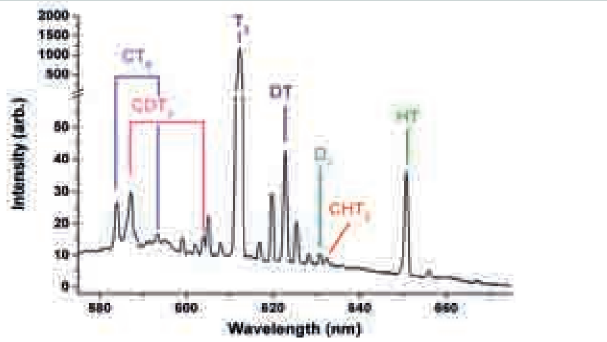


Fig. 7: LARA spectrum recorded in the Loopino test loop with a tritium gas mix of extremely high purity (approx. 97 %), which was left in the loop for 21 days. The methane species (CT_4, etc.) generated can be seen clearly.

Highlight in 2010: First Commissioning of DPS2-F

After the delivery of DPS2-F for KATRIN in 2009, the pumping section was prepared for acceptance tests almost throughout the entire year of 2010. The necessary activities included these, among others:

- Assembly of auxiliary scaffolds and cable ducts.
- Assembly of all cryogenic connecting lines.
- Assembly and cabling of all MSR cabinets and all sensors (see Fig. 9).
- Installation of the connections for cooling water and compressed air.
- Installation of the vacuum pump system for the beam tube (see Fig. 10).
- Installation of a small control room in Building 457 for control of DPS2-F on the spot (see Fig. 8).
- Adaptation of the software for automation, and balancing with the automation systems of the cryotransfer line and the refrigerator.

Some technical problems as well had to be solved, such as a leak in a beam tube flange. After the necessary leak tests had been completed positively, DPS2-F was ready for the first cooling test in September 2010.

First Cooling of DPS2-F

For cooling, the cryogenic system of DPS2-F is flooded with a blend of helium gas of approx. 5 K and helium gas of approx 300 K. The blend is set so that the gas initially is at room temperature and gradually becomes colder. As DPS2-F has a mass of several tons, and the generation of mechanical stresses must be minimized, its cooling proceeds extremely slowly; it was completed only after some 20 days (see Fig. 11). In this first cooling process, the team identified some potential technical improvements which are going to simplify future temperature control.

After operating temperature had been reached, the first magnet operation tests were conducted. The current flowing through the magnets was raised step by step, and the stable response of the system was waited for. After a current of slightly more than 190 A had been reached, there was a quench of one of the magnet modules. Quench means that part of the superconducting coil returns to normal conductivity, and subsequent

Fig. 8: Combined operation of the refrigerator, cryotransfer line with the valve box, and DPS2-F requires a maximum of concentration and experience.

Fig. 9: View of DPS after assembly of all connecting lines (such as those leading to the cryotransfer line).

heating transfers the entire magnet into the state of normal conductivity and makes it lose its magnetic field. The energy stored in the magnet is converted into heat in this process, which causes abrupt evaporation of the liquid-helium inventory.

As that event was repeated in the next few days, the scientists responsible decided to run further commissioning tests with a magnet current of 185 A (instead of the specified 200 A), which corresponds to a magnetic field of approx. 5.2 T. Despite this measure, there was one other quench, this time caused by a technical problem which was recognized and remedied. The representatives of the ASG company were on the spot at that time, and all decisions were agreed with them.

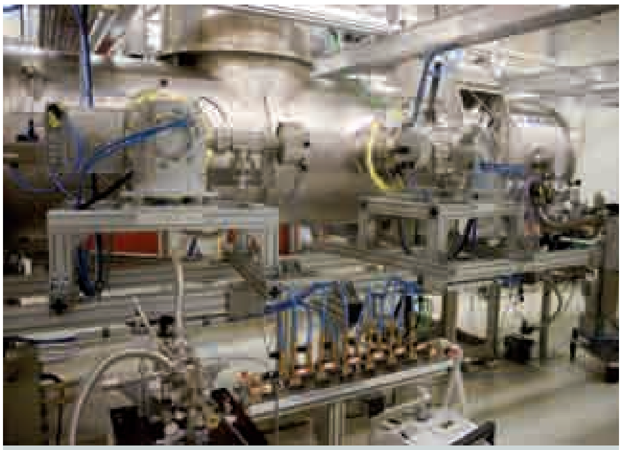


Fig. 10: View of pumping chambers No. 2 and 3 and the attached valves and turbo molecular pumps of the MAG2800 type.

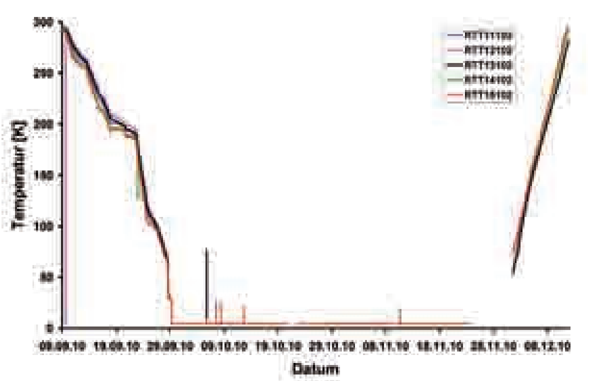


Fig. 11: Temperature curve of the five magnet modules of DPS during the first commissioning phase. The five peaks in October and November are the temperature increases caused by magnet quenches and a fast discharge of the field via the safety diodes, respectively.

Measuring Magnetic-field Stability

KATRIN imposes the following requirement on stability of the magnetic field of DPS2-F: The decline of the field over a period of 60 days (corresponding to one measurement period) is to be less than 0.01 %. Converted into a time constant for an exponential decline, this must be in excess of 5.2 x 10^{10} s.

The stability of the magnetic field was measured at a magnet current of 185 A by means of an NMR probe from METROLAB, which had been installed in the middle of the fifth magnet module. Its temperature was stabilized to 36°C in order to prevent air from condensing on the probe. The decay of the magnetic field over time (Fig. 12) proceeded like this: Over the first three days after switching to the persistent mode, i.e. autonomous operation of the magnets without current in the current

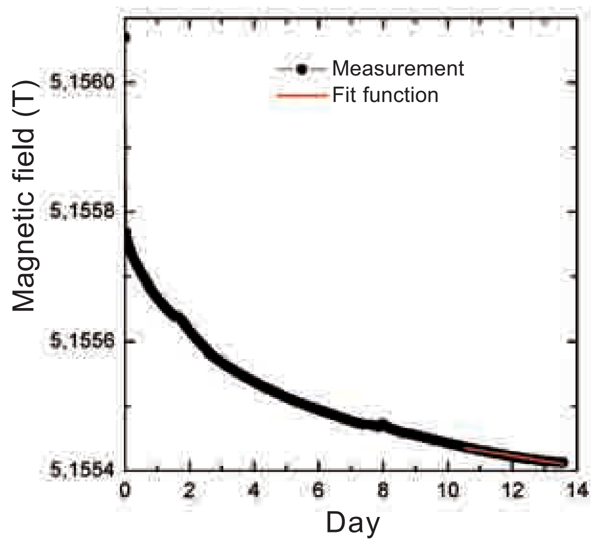


Fig. 12: Measurement of magnetic field stability in module 5 in the period between October 26 and November 29, 2010. The red line is explained in the text.

leads, the decay of the field is much steeper than in the following days because the currents in the individual filaments of the multi-filament superconductor are redistributed. For this reason, the entire process cannot be described in one single field decay period. When the exponential function superimposed on the measurements of the previous days, a field decay time of 5.55 x 10^{10} s results (see red line in Fig. 12). This is very close to the required value and, consequently, is a good result.

As the field decay time becomes increasingly shorter with time, KATRIN later on merely will have to wait for a few days after turning into the persistent mode in order to reach the area of decay times required.

Teaching and Education

Lectures, Seminars, Workshops, Summer Schools

Lectures

KIT – Fakultät Elektrotechnik und Informationstechnik
WS 09/10-10/11 – Supraleitende Systeme für Ingenieure (Noe, Neumann, Siegel)
SS 10 – Supraleitertechnologie (Noe, Schlachter, Weiss)
SS 10 – Seminar Projektmanagement für Ingenieure (Noe, Day, Grohmann)

KIT – Fakultät für Chemieingenieurwesen und Verfahrenstechnik
WS 09/10-10/11 – Vakuumtechnik I (Day)
WS 10/11-10/11 – Kryotechnik (Neumann)

KIT – Fakultät Maschinenbau
WS 09/10-10/11 – Fusionstechnologie I* (Fietz, Weiss)
SS 10 – Fusionstechnologie II* (Bornschein, Day)

Leibniz Universität Hannover – Fakultät Elektrotechnik und Informationstechnik
SS 10 – Neue Komponenten der elektrischen Energieversorgung* (Noe)

Dresden International University – Masterstudiengang Wasserstofftechnologie
SS 10 – Kernfusion (Bornschein)

Fachhochschule Karlsruhe – Masterstudiengang Maschinenbau und Mechatronik
WS10/11 – Wärmeübertragung (Grohmann)

Duale Hochschule BW – Fachbereich Maschinenbau
WS 09/10-10/11 – Konstruktionslehre I (Bauer)
SS 10 – Arbeitssicherheit und Umweltschutz (Bauer)
WS 09/10-10/11 – Thermodynamik I für Maschinenbauer (Neumann)
SS 10 – Technische Thermodynamik II für Maschinenbauer (Neumann)

Seminars/Summer Schools

1st ITEP Young Scientists Seminar
18.–21. Januar 2010, Schruns, Österreich

VDI-Seminar Kryotechnik
23.–25. Februar 2010, Karlsruhe

2. Tagung Zukunft und Innovation der Energietechnik mit Hochtemperatur-Supraleitern
16.–17. März 2010, Bonn

3. Karlsruhe-Dresden Doktorandenseminar zur Supraleitung
9.–11. Juni 2010, Bad Liebenzell

4th ESAS Summer School on Materials and Applications on Superconductivity
12.–16. Juli 2010, Karlsruhe

CIGRE Workshop on Status of High-Temperature Superconducting Power System Applications
25. August 2010, Paris, Frankreich

4th International Summer School on Fusion Technologies
6.–17. September 2010, Karlsruhe

Haus der Technik, Seminar Kryostatbau
8.–10. September 2010, Karlsruhe

VDI Seminar Cryogenics
15.–17. September 2010, Karlsruhe

* with participation of ITEP

Teaching and Education

Diploma Theses, Bachelor, Master Theses, Term Papers, Technician Papers, Doctoral Theses

Diploma/Bachelor/Master Theses Supervised in 2010 (*completed)

Thomas Voigt*
Rückkühlverhalten von Supraleitern in Fehlerstrombegrenzern

Rolf Schön*
Untersuchung eines BIXS-Detektors zur Messung der Tritiumkonzentration in Wasser

Florian Priester*
Systematische Untersuchungen zum Stabilitätsverhalten des KATRIN Tritiumloops

Sebastian Fischer*
Untersuchungen der Laserstabilität im KATRIN Raman-Aufbau und erste Depolarisationsmessungen mit Tritium am TLK

Frank Wandschneider*
Messungen der thermischen Isolationsqualität von Superisolation (Vakuum-Vielschichtisolation) zwischen Raumtemperatur (» 300 K) und LN2-Temperatur (» 77 K)

Oliver Näckel*
Supraleitendemagnetische Energiespeicher zum Ausgleich fluhtuierender regenerativer Energieerzeugung

Thomas Giegerich*
Theoretical and experimental investigation of rarefied gas flows under vacuum through various duct geometries

Patrick Lenz*
Genauigkeitsanalyse für ein kalorimetrisches Messprinzip zur Messung der thermischen Isolationsqualität im Tieftemperaturbereich

Stefan Welte*
Erstellen eines Designvorschlages für eine Experimentieranlage zur Detritiierung von hochtritiiertem Wasser mittels eines membranreaktors

Christian Pulch*
Umfassende Betriebskostenschätzung und -planung für das Projekt KATRIN

Katrin Lehmann (STOPA Anlagenbau GmbH u. Co KG)*
Konstruktion einer Hubwelle für ein Regalbediengerät und Definition der Konstruktionsprinzipien

Marius Beisel (BLANCO GmbH + Co KG)*
Rüstanalyse und –Optimierung im Bereich KSA Element

Philipp Herwig
Aufbau des endgültigen Laser Raman Systems für KATRIN

Marco Röllig
Rear Wall tritiumexperiment

Tobias Bode
Untersuchungen zum thermischen Verhalten der Tritiumquelle im KATRIN-Experiment

Kerstin Schönung
Test von Anti-Reflexionsbeschichtungen unter Tritiumatmosphäre für KATRIN

Jicheng Li
Investigation of FBG based displacement sensors for low temperature applications

Teresa Parracho
Helium and Hydrogen Permeation Experiments with MFI Zeolite Membranes for Tritium Processes

Timo Fabian Henninger
Konstruktion der letzten beiden Elektrodenmodule für das KATRIN Experiment

Technician Papers Supervised in 2010 (*completed)

Sebastian Stämmler (TVT Campus Süd)*
Membranverfahren zur Abtrennung von Wasserstoff und Wasserdampf

Severin Strauß*
Untersuchung der Machbarkeit von supraleitenden Windkraftgeneratoren

Christian Pulch*
Internes Benchmarking in einem wissenschaftlichen Institut

Roland Richter
Erstellung eines Programms zur Auslegung und Validierung von Vakuumsystemen beliebiger Komplexität auf Server – Client Basis

Stanislav Plohotski
Materialcharakterisierung für den Kryostatbau

Maurizio Festa
Experimentelle Untersuchung der thermischen Isolationsqualität von Microsphere-Hohlglaskugeln und Perlit an einem Körper mit nicht abwickelbarer Oberfläche

Exchange Program of DH Students with Industrial Partner, Babcock Noell (Ramona Kuhn, Kerstin Brohl and Clemens Frenzel)

Duale Hochschule Baden-Württemberg 2010 (*completed)

Christian Pulch*
Wirtschaftsingenieurwesen – DH-Karlsruhe

Kerstin Brohl
Wirtschaftsingenieurwesen – DH-Karlsruhe

Clemens Frenzel
Wirtschaftsingenieurwesen – DH-Karlsruhe

Isabelle Ehleben
Maschinenbau – DH-Karlsruhe

Marcus Oberle
Maschinenbau – DH-Mannheim

Pit-André Singer
Elektrotechnik – DH-Karlsruhe

Beate Frank
Mechatronik – DH-Karlsruhe

Michael Schmidt
Maschinenbau – DH-Mannheim

Nadja Kästle
Wirtschaftsingenieurwesen – DH-Karlsruhe

Steffen Mundt
Wirtschaftsingenieurwesen – DH-Karlsruhe

Sascha Singer
Elektrotechnik – DH-Karlsruhe

Nando Gramlich
Maschinenbau – DH-Mannheim

Manuel Mungenast
Elektrotechnik – DH-Karlsruhe

2010 Doctoral Theses (*completed)

Robert Michling*
Performances Assessment of Water Detritiation Process

Michael Sturm*
Aufbau und Test des Inner Tritium Loop von KATRIN

Alexander Winkler*
Transient electrical behaviour of ITER PF coils

André Berger
Entwicklung supraleitender strombegrenzender Transformatoren

Olaf Mäder
Gleichstrom-Höchststromübertragungsleitungen mit Hochtemperatur-Supraleitern

Stanimira Terzieva
Preparation and investigation of Roebel-Cables from Coated Conductors

Christian Barth
Mechanisch stabilisierte Hochtemperatur-Supraleiter-Kabel

Magnus Schlösser
High-precision Laser Spectroscopy on Hydrogen Isotopologues

Florian Priester
Optimierung der KATRIN Tritium-Loops

Philipp Krüger
AC Loss characterization of HTS devices for power applications

Enrico Rizzo
Thermal-fluid dynamic and electrical optimization of high temperature superconductor current leads for fusion magnet systems

Martin Babutzka
Entwicklung, Aufbau und Integration des Calibration und Monitoring Systems (CMS) am KATRIN-Experiment

Sebastian Fischer
Laser Raman Spectroscopy For The KATRIN Experiment

Zoltan Köllö
Further Development of Tritium analytic devices

Oliver Näckel
Untersuchung strombegrenzender Spuhlen

Thomas Giegerich
Entwicklung eines Vakuumpumpkonzepts für zukünftige Fusionsreaktoren

Olga Borisevich
Simulation and experimental study of a multi-stage permeation process for tritium recovery in breeder blanket

Guest Researcher

Prof. Felix Sharipov
01.08.2009–31.07.2010; University Curitiba/Brasilien

Anna Kario
25.01.2010–05.02.2010; IFW Dresden/Deutschland

Prof. Srinivasan Kasthuriregan
19.07.2010–23.07.2010; CCT, Bangalore/Indien

Tomás Holúbek
05.07.2010–30.07.2010 und 23.08.2010–30.09.2010
Ansaldo Superconduttori SpA Genua/Italien

Misdanitis Serafeim
02.08.2010–31.08.2010 und 07.11.2010–07.12.2010
University of Thessaly Volos/Griechenland

Michal Vojenciak
01.05.2010–14.11.2010; IEE Bratislava/Slowakei

Ahmed Alshahrie
16.02.–19.02.2010; Universität Swansea/Großbritannien

Prof. Dr. Helmut Telle
08.03.–11.03.2010 und 04.10.–08.10.2010
Universität Swansea/Großbritannien

Timothy James
16.02.–19.02.2010; Universität Swansea/Großbritannien

George Ana
13.09.–05.11.2010; National Institute of R & D for Cryogenic and Isotopic Technologies – Valcea/Rumänien

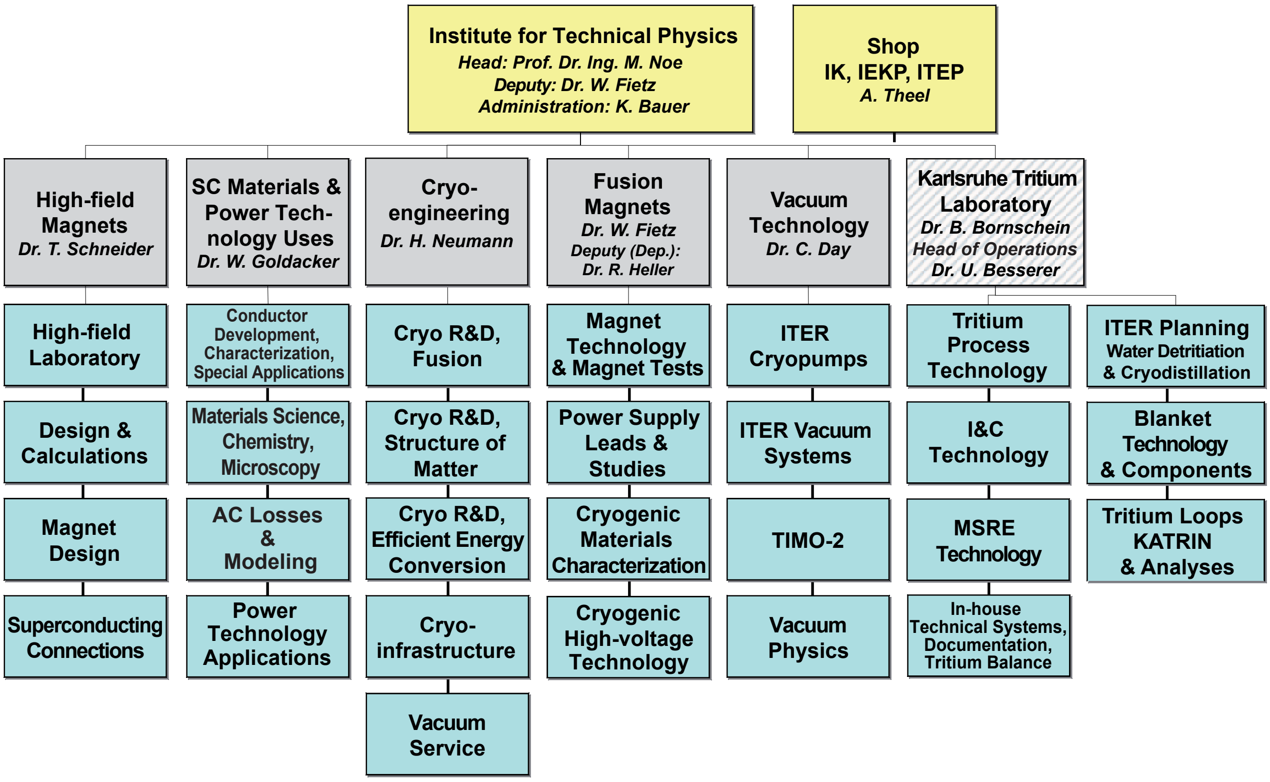
Teaching and Education

2010 ITEP Colloquies

2.3.2010	LHD, heliotron reactor design incl. HTS related work Dr. Nagato YANAGI, NIFS, Japan; Fusionsmagn.
13.4.2010	Magnetfelder und Helium machen die Lunge sichtbar Dr. S. Karpuk, Uni Mainz; HFL
20.4.2010	Ziele und Umfang der WGTS Demonstrator Tests Dr. S. Grohmann; Kryo
27.4.2010	Kryopumpsektion für das KATRIN Experiment – Projektstatus Dr. Woosik Gil; Supra
3.5.2010	Characterization of the resistivity of commercially available HTS materials over their entire J-B-T domain using ultra-fast regulated current pulses Frédéric Sirois Ecole Polytechnique de Montréal, Canada; Supra
4.5.2010	Präsentation U-Web 2000 H.-M. Briese; Verw
8.6.2010	Messungen der thermischen Isolationsqualität von Superisolation (Vakuum-Vielschichtisolation) zwischen Raumtemperatur und LN_2-Temperatur Wandschneider (Diplomarbeit); Kryo
15.6.2010	Rarefied Gas Dynamics and its application to vacuum technology Prof. Felix Sharipov; Vakuum
26.6.2010	R&D „Activities of HTS technologies at KERI“ Sang-Soo Oh, KERI, Korea; Supra
29.7.2010	Glimpses of R&D activities at Centre for Cryogenic Technology, IISc S. Kasthurirengan, Indian, Institute of Science, Bagalore; KRYO
10.8.2010	Vorstellung der einzelnen Projekte der Auslandssemester der DH-Studenten K. Brohl, C. Frenzel, C. Pulch; Verw
12.8.2010	Exploring the vortex dynamics with time-resolved magneto-optical imaging Andrea Lucarelli, ETH Zürich; SUPRA
21.9.2010	Supraleitender magnetischer Energiespeicher zum Ausgleich erneuerbarer fluktuierender Energieerzeugung Oliver Näckel (Diplomarbeit); SUPRA
21.10.2010	Transientes Verhalten der ITER Poloidalfeldspulen A. Winkler; Fusion
26.10.2010	Theoretical and experimental investigation of rarefied gas flows under vacuum through various duct geometries Th. Giegerich; Vakuum
16.11.2010	Ergebnisse des Prototyptests der W7-X HTS Stromzuführungen Dr. R. Heller; Fusion
23.11.2010	Regelungen für Arbeitsmedizinische Vorsorgeuntersuchungen Dr. med. Volker List; MED
30.11.2010	Gas flow computations and measurements under low, medium and high vacuum conditions S. Misdanitis; Vakuum
7.12.2010	REM – ein Schlüsselinstrument in der Materialforschung Dr. A. Jung; SUPRA
14.12.2010	SCC-Dienste und E-Mail im KIT A. Helget; S C C

Figures and Data

ITEP Chart of Organization (September 22, 2010)



Personnel Status (November 19, 2010)

Total	**184**	**In 2010**	
University graduates	55	Trainees	12
Engineers and technicians	60	Guests	10
Others	28	Student assistants	19
Pre-doctoral students (of these, 1 not funded by ITEP)	17		
Diploma students	11		
DH students	13		

Figures and Data

Personnel Changes in 2010

Leaving (Excluding Trainees, Guests, and Student Assistants)

Max Beckenbach

Alexander Ehrlich

Dr. Frank Eichelhardt

Kirsten Günther

Gerhard Hellriegel (verstorben)

Maximilian Kienzler

Dr. Gunther Kotzyba

Thomas Möhring

Christian Pulch

Dr. Michael Schwarz

Ralf Zweig

Rolf Schön

Dr. Ana Parracho

Newly Recruited (Excluding Trainees, Guests, and Student Assistants)

Martin Babutzka

Dr. Nadezda Bagrets

Dr. Nicolas Bekris (zurück aus Delegation)

Tobias Bode

Olga Borisevich

Dr. Sandra Drotziger

Simeon Eckerle

Sebastian Fischer

Thomas Giegerich

Frank Gröner

Philipp Herwig

Sebastian Heuser

Zoltan Köllö

Philipp Krüger

Benedikt Kuffner

Jicheng Li

Manuel Mungenast

Oliver Näckel

Santiago Ochoa Guamán

Teresa Parracho

Stanislav Plohotski

Enrico Rizzo

Astrid Rimikis (zurück aus Beurlaubung)

Marco Röllig

Uwe Saller

Alessia Santucci

Kerstin Schönung

Severin Strauß

Michael Sturm

Dr. Michal Vojenciak

Ralf Zweig

Dr. Ana Parracho

Figures and Data

Membership in Relevant Technical and Scientific Organizations

Beate Bornschein
- Seit Oktober 2010 Mitglied im „International Steering Committee" der „International conference on Tritium Science and Technology
- Mitglied im „Executive Committee of IEA Nuclear Technology for Fusion Reactors" (IEA ist die International Energy Agency)
- Network Co-ordinator for EU network trainee programmes 'FUEL CYCLE' and 'TRI-TOFFY'

Ion Cristescu
- Project Leader of the Consortium for the European Contributions to the ITER Tritim Plant Systems

Christian Day
- Mitglied des Vorstandsrates der Dt. Vakuumgesellschaft (DVG)
- Stellv. Vorsitzender des Fachverbandes Vakuumphysik und -technik der Dt. Physikalischen Gesellschaft (DPG)
- Geladener Experte für Vakuumtechnik, Innovationsdialog der Bundeskanzlerin mit Wirtschaft und Wissenschaft
- Associated Expert of the Indian Vacuum Society (IVS)
- Chartered Engineer of American Vacuum Society (AVS)
- Chairman of the Coordinating Committee on Fuelling & Pumping, EFDA (CCFP)
- Deputy Leader of the Topical Group Heating & Current Drive, EFDA (TG)
- Co-ordinator des VACU-TEC Goal oriented Training Programme, EFDA (GOT)
- International Symposium of Fusion Nuclear Technology, Mitglied im International Programme Committee (ISFNT).
- Mitglied im Verein Dt. Ingenieure (VDI)

Wilfried Goldacker
- Member Board of Directors International Cryogenics Material Conf. (ICMC)
- Executive Board Member IOP-SUST
- Program Board Member ICSM-Conf. Antalya, Turkey
- Chair of ICEC-ICMC-Wroclaw for ICMC
- European Chair of ICC3 (Int. Ceramic Conf.) Osaka
- DKE Deutsche Kommission Elektrotechnik Informationstechnik im DIN und VDE Referat K 184 „Supraleiter"

Steffen Grohmann
- International Institute of Refrigeration (IIF/IIR), Commission A1: Cryophysics, Cryoengineering
- Verein zur Förderung der Luft- und Kältetechnik e.V. (Träger des ILK Dresden)
- KATRIN Executive Committee
- KATRIN Publications Committee

Reinhard Heller
- Applied Superconductivity Conference, Member of International Program Committee
- Applied Superconductivity Conference, elected Board member Large Scale
- Computation of Thermo-Hydraulic Transients in Superconductors (CHATS-AS), Board member
- DKE/DIN K 184 – Supraleiter
- International Electrotechnical Commission (IEC TC90) – Superconductivity – Member WG 12 – „Superconducting Power Devices-General Requirements for Characteristic Tests of Current Leads designed for Powering Superconducting Devices"

Mathias Noe
- International Council of Large Electric Systems (CIGRE) Secretary of working group D.1.38 „Emerging Test Techniques Common to High Temperature Superconducting (HTS) Power Applications"
- International Council of Large Electric Systems (CIGRE) Member of working group D.3.23 „Application and feasibility of fault current limiters in power systems"
- International Energy Agency, Implementing Agreement for a co-operative programme for assessing the impacts of high-temperature superconductivity on the electric power sector, German representative
- The European Society for Applied Superconductivity, Board member
- Fusion for Energy (F4E) – Member of Technical Advisory Panel
- International Conference on Magnet Technology, Member of International Organizing and Scientific Program Committee
- Applied Superconductivity Conference, Member of International Program Committee
- European Conference on Applied Superconductivity, Member of International Program Committee
- Industrieverband Supraleitung, Gastmitglied
- Helmholtz Programm Rationelle Energieumwandlung und -nutzung, Topicsprecher Supraleitung
- Mitglied im Verwaltungsrat der Heinrich-Hertz-Gesellschaft
- KIT Zentrum Energie, Mitglied im Lenkungsausschuss und Ko-Sprecher Energiespeicherung und -verteilung
- Mitglied der Bewertungsgruppe des Wissenschaftsrates zum Rating der Fakultäten für Elektrotechnik und Informationstechnik

Sonja Schlachter
- Executive Board Member IOP-SUST

Klaus-Peter Weiss
- DKE Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE Referat K 184 „Supraleiter"
  Stellvertretender Obmann
- IEC International Electrotechnical Commission/Technical Comittee 90 „Superconductivity" Mitglied

Publications

"Nuclear Fusion" Program (*Cited in ISI)

* Aiello, A.; Bühler, L.; Ciampichetti, A.; Demange, D.; Dörr, L.; Freibergs, J.F. ; Ghidersa, B.; Ilic, M.; Laffont, G.; Messemer, G.; Platnieks, I.; Rampal, G.
Mockup testing facilities and qualification strategy for EU ITER TBMs.
Fusion Engineering and Design, 85(2010) S.2012–2021
DOI:10.1016/j.fusengdes. 2010.07.007

Alecu, C.G.; Köllö, Z.; Kloppe, B.; Bornschein, B.; Besserer, U.; Wendel, J.
Reachable accuracy and precision for tritium measurements by calorimetry at TLK.
9th Internat.Conf.on Tritium Science and Technology (TRITIUM 2010), Nara, J, October 24–29, 2010

* Antipenkov, A.; Day, Chr.; Amoskov, V.; Belov, A.; Belyakov, V.; Gapionok, E.; Kukhtin, V.; Lamzin, E.; Shatil, D.; Sytchevsky, S.
Numerical simulations of electro-magnetic transients in ITER cryopumps with the use of TYPHOON code.
Bulletin of the Peoples' Friendship University of Russia, Series Mathematics, Information Sciences, Physics, 2(2010) Nr.3, S.81–86

Antipenkov, A.; Bersier, J.L.; Boussier, B.; Day, Chr.; Dremel, M.; Hauer, V.; Meitner, S.; Pearce, R.; Worth, L.
Overview of the tritium handling within the ITER vaccum pumping system.
9th Internat.Conf.on Tritium Science and Technology (TRITIUM 2010), Nara, J, October 24–29, 2010

Barth, C.; Weiss, K.P.
Influence of shear strain on current carrying capabilities of HTSC tapes.
3rd Dresden-Karlsruhe Seminar on Materials and Applications of Applied Superconductivity, Bad Liebenzell, June 9–10, 2010

Borgognoni, F.; Demange, D.; Welte, S.; Tosti, S.
Processing test of an upgraded mechanical design for PERMCAT reactor.
9th Internat.Conf.on Tritium Science and Technology (TRITIUM 2010), Nara, J, October 24–29, 2010

Bornschein, B.
Between fusion and cosmology – the future of the Tritium Laboratory Karlsruhe.
9th Internat.Conf.on Tritium Science and Technology (TRITIUM 2010), Nara, J, October 24–29, 2010

Boussier, B.; Pearce, R.; Mayaux, Chr.; Evrard, B.; Journeaux, J.Y.; Day, Chr.; Marechal, J.L.
ITER vacuum control system. Current status overview and technical challenges.
18th Internat.Vacuum Congress (IVC-18), Internat.Conf. on Nanoscience and Technology (ICN+T 2010), 14th Internat.Conf.on Surfaces Science (ICSS-14), Vacuum and Surface Sciences Conf.of Asia and Australia (VASSCAA-5), Beijing, China, August 23–27, 2010

Ciampichetti, A.; Aiello, A.; Nitti, S.; Ricapito, I.; Liger, K.; Demange, D.; Moreno, C.
Design of coolant purification system for the European test blanket modules.
26th Symp.on Fusion Technology (SOFT 2010), Porto, P, September 27 – October 1, 2010

Ciampichetti, A.; Aiello, A.; Nitti, S.; Ricapito, I.; Liger, K.; Demange, D.; Moreno, C.
Design of tritium extraction system for the European HCPB test blanket module.
9th Internat.Symp.on Fusion Nuclear Technology (ISFNT-9), Dalian, China, October 11–16, 2009

Ciampichetti, A.; Aiello, A.; Coccoluto, G.; Ricapito, I.; Liger, K.; Demange, D.; Sedano, L.
The coolant purification system of the European test blanket modules: preliminary design.
9th Internat.Symp.on Fusion Nuclear Technology (ISFNT-9), Dalian, China, October 11–16, 2009

Day, C.; Cristescu, I.; Pegourie, B.; Weyssow, B.
Considerations towards the fuel cycle of a steady-state DT fusion device.
23rd IAEA Fusion Energy Conference, Daejeon, Korea, October 11–16, 2010

Day, C.
Contributions of rarefied gas dynamics to state-of-the-art vacuum science and technology. (eingeladen)
27th Internat.Symp.on Rarefied Gas Dynamics (RGD 2010), Pacific Grove, Calif., July 10–15, 2010

Day, C.
Kryovakuumtechnik und Kryopumpen.
VDI-Wissensforum Kryotechnik, Karlsruhe, 23.–25.Febraur 2010

Day, Ch.; Hauer, V.
Measurement of the conductance in the Knudsen flow regime.
5th Symp.on Vacuum Based Science and Technology, Kaiserlautern, September 28–30, 2010

Day, Chr.
Cryogenics vacuum technology and cryopumps.
VDI Wissensforum Cryogenics, Karlsruhe,
September 15–17, 2010

Day, Chr.; Haas, H.; Hanke, St.; Hauer, V.; Luo, X.; Scannapiego, M.; Simon, R.; Strobel, H.; Fellin, F.; Lässer, R.; Papastergiou, St.; Dremel, M.; Mayaux, Chr.; Pearce, R.
Design progress for the ITER torus and neutral beam cryopumps.
26th Symp.on Fusion Technology (SOFT 2010), Porto, P, September 27–October 1, 2010

Day, Chr.; Hauer, V.; Luo, X.; Sharipov, F.; Varoutis, S.; Valougeorgis, D.
Recent developments in vacuum flow modelling. (eingeladen)
18th Internat.Vacuum Congress (IVC-18), Internat.Conf. on Nanoscience and Technology (ICN+T 2010),
14th Internat.Conf.on Surfaces Science (ICSS-14),
Vacuum and Surface Sciences Conf.of Asia and Australia (VASSCAA-5), Beijing, China, August 23–27, 2010

Day, Chr.; Haas, H.; Hanke, St.; Hauer, V.; Luo, X.; Varoutis, St.
Vacuum engineering of customized cryosorption pumps.
11th European Vacuum Conf.(EVC-11),
8th Iberian Vacuum Meeting (IVM-8),
6th European Topical Conf.on Hard Coatings Salamanca, E, September 20–24, 2010

Demange, D.; Le, T.L.; Simon, K.H.; Wagner, R.; Welte, S.
CAPER modifications and first experimental results on highly tritiated water processing with PERMCAT at the Tritium Laboratory Karlsruhe.
9th Internat.Conf.on Tritium Science and Technology (TRITIUM 2010), Nara, J, October 24–29, 2010

* Demange, D.; Glugla, M.; Günther, K.; Le, T.L.; Simon, K.H.; Wagner, R.; Welte, S.
Counter-current isotope swamping in a membrane reactor: the PERMCAT process and its applications in fusion technology.
9th Internat.Conf.on Catalysis in Membrane Reactors, Lyon, F, June 28–July 2, 2009

Demange, D.; Glugla, M.; Günther, K.; Le, T.L.; Simon, K.H.; Wagner, R.; Welte, S.
Counter-current isotope swamping in a membrane reactor: the PERMCAT process and its applications in fusion technology.
Catalysis Today, 156(2010) S.140–145
DOI:10.1016/j.cattod.2010.02.033

Demange, D.; Stämmler, S.; Kind, M.
Membranes and catalytic membrane reactors in breeder blanket for improved tritium management and facilitated accountancy.
26th Symp.on Fusion Technology (SOFT 2010), Porto, P, September 27–October 1, 2010

Dremel, M.; Pearce, R.; Mayaux, C.; Hemsworth, R.; Hanke, S.
ITER neutral beam cryopumps design requirements for the integration.
26th Symp.on Fusion Technology (SOFT 2010), Porto, P, September 27–October 1, 2010

Fietz, W.H.; Heller, R.; Schlachter, S.I.; Goldacker, W.
Application of high temperature superconductors for Fusion.
26th Symp.on Fusion Technology (SOFT 2010), Porto, P, September 27–October 1, 2010

Fietz, W.H.; Fink, S.; Heiduk, M.; Heller, R.; Lange, C.; Lietzow, R.; Möhring, T.; Rohr, P.; Süßer, M.; Rummel, T.
Test arrangement for the W7-X HTS-current lead prototype testing.
Applied Superconductivity Conf., Washington, D.C., August 1–6, 2010

Ghirelli, N.; Demange, D.; Gastaldi, O.
Calculations of tritium mass transfer in HCPB TBM concept and impact on systems for DEMO scale up.
9th Internat.Conf.on Tritium Science and Technology (TRITIUM 2010), Nara, J, October 24–29, 2010

Haas, H.; Day, Chr.
TIMO-2. A versatile cryogenic test bed with supercritical helium supply.
23rd Internat.Cryogenic Engineering Conf.(ICEC 23) and Internat.Cryogenic Materials Conf.(ICMC 2010), Wroclaw, PL, July 19–23, 2010

Heller, R.; Fietz, W.H.; Kienzler, A.; Lietzow, R.
High temperature superconductor current leads for fusion.
26th Symp.on Fusion Technology (SOFT 2010), Porto, P, September 27–October 1, 2010

* Heller, R.; Class, A.; Batta, A.; Lietzow, R.; Neumann, H.; Tischmacher, M.
Modeling of the fin type heat exchanger for the HTS current leads of W7-X and JT60-SA.
Cryogenics, 50(2010) S.222-30
DOI:10.1016/j.cryogenics.2009.08.006

Heller, R.; Fietz, W.H.; Fink, S.; Heiduk, M.; Kienzler, A.; Lange, C.; Lietzow, R.; Rohr, P.; Möhring, T.; Rummel, T.; Mönnich, T.; Buscher, K.P.
Test results of the high temperature superconductor prototype current leads for Wendelstein 7-X.
Applied Superconductivity Conf., Washington, D.C., August 1–6, 2010

Lässer, R.; Papastergiou, S.; Piazza, G.; Day, Chr.; Haas, H.; Hanke, S.; Hauer, V.; Poncet, J.M.; Cirstescu, I.; Michling, R.; Glugla, M.; Pearce, R.; Antipenkov, A.; Dremel, M.; Mayaux, Ch.; Babineau, D.; Kazachenko, O.; Perevenzentsev, A.
Management and status of the European in-kind system of the INTER fuel cycle.
9th Internat.Conf.on Tritium Science and Technology (TRITIUM 2010), Nara, J, October 24–29, 2010

Liger, K.; Ciampichetti, A.; Demange, D.
HCLL and HCPB coolant purification system: preliminary measurement and instrumentation plan.
9th Internat.Conf.on Tritium Science and Technology (TRITIUM 2010), Nara, J, October 24–29, 2010

* Luo, X.; Day, C.
A 3D Monte Carlo vacuum modeling of the neutral beam injection system of ITER.
Fusion Engineering and Design, 85(2010) S.1446–50
DOI:10.1016/j.fusengdes.2010.04.002

Luo, X.; Day, Chr.
Investigation of a new Monte Carlo method for transitional gas flow.
27th Internat.Symp.on Rarefied Gas Dynamics (RGD 2010), Pacific Grove, Calif., July 10–15, 2010

Luo, X.; Haas, H.; Hauer, V.; Sharipov, F.; Day, Chr.
Systematic vacuum study of the ITER model cryopump by test particle Monte Carlo simulation.
18th Internat.Vacuum Congress (IVC-18), Internat.Conf. on Nanoscience and Technology (ICN+T 2010),
14th Internat.Conf.on Surfaces Science (ICSS-14),
Vacuum and Surface Sciences Conf.of Asia and Australia (VASSCAA-5), Beijing, China, August 23-27, 2010

Maruyama, S.; Yang, Y.; Pitts, R.A.; Sugihara, M.; Putvinski, S.; Li, B.; Li, W.; Baylor, L.R.; Meitner, S.J.; Day, C.; LaBombard, B.; Reinke, M.
ITER fuelling system design and challenges.
23rd IAEA Fusion Energy Conference, Daejeon, Korea, October 11–16, 2010

Masiello, A.; Milnes, J.; Waldon, C.; Alonso, J.; Minea, T.; Boilson, D.; Hemsworth, R.; Franzen, P.; Heinemann, B.; Day, C.; Hanke, St.; Bigi, M.; Chitarin, G.; Luchetta, A.; Marcuzzi, D.; Pomaro, N.; Pasqualotto, R.; Serianni, G.; Sonato, P.; Toigo, V.; Zaccaria, P.
The European contribution to the developments of the ITER NB injector.
26th Symp.on Fusion Technology (SOFT 2010), Porto, P, September 27–October 1, 2010

Misdanitis, S.; Pantazis, S.; Lihnaropoulos, J.; Valourgeorgis, D.; Varoutis, S.; Hauer, V.; Day, Chr.
Experimental and numerical investigation of vacuum gas flows in fusion vacuum systems.
9th School and Workshop on Fusion Physics and Technology, Volos, GR, April 19–23, 2010

Munakata, K.; Demange, D.
Development of numerical simulation code of membrane reactor for detritiation.
26th Symp.on Fusion Technology (SOFT 2010), Porto, P, September 27–October 1, 2010

Pantazis, S.; Varoutis, S.; Day, C.; Valougeorgis, D.
Gas-surface scattering effect on vacuum gas flows through rectangular channels.
11th European Vacuum Conf.(EVC-11),
8th Iberian Vacuum Meeting (IVM-8),
6th European Topical Conf.on Hard Coatings Salamanca, E, September 20–24, 2010

Papastergiou, S.; Lässer, R.; Piazza, G.; Day, Chr.; Haas, H.; Hanke, S.; Hauer, V.; Poncet, J.M.; Pearce, R.; Antipenkov, A.; Dremel, M.; Mayaux, Ch.
The European supplied components of the ITER vacuum pumping systems.
9th Internat.Conf.on Tritium Science and Technology (TRITIUM 2010), Nara, J, October 24–29, 2010

Parracho, A.I.R.T.; Brennan, P.D.; Demange, D.; Knipe, S.
Characterisation and optimisation of small Sieve beds in adsorption/desorption process of tritiated water.
9th Internat.Conf.on Tritium Science and Technology (TRITIUM 2010), Nara, J, October 24–29, 2010

Pearce, R.J.H.; Antipenkov, A.; Bersier, J.L.; Boussier, B.; Bryan, S.; Dremel, M.; Hughes, S.; Kersevan, R.; Mayaux, C.; Worth, L.; Wykes, M.; Baylor, L.; Gardner, W.; Meitner, S.; Rasmussen, D.; Laesser, R.; Piazza, G.; Papastergiou, S.; Day, C.; Haas, H.; Hanke, S.; Hauer, V.; Poncet, J.M.
The realisation of the ITER vacuum systems.
18th Internat.Vacuum Congress (IVC-18), Internat.Conf. on Nanoscience and Technology (ICN+T 2010),
14th Internat.Conf.on Surfaces Science (ICSS-14),
Vacuum and Surface Sciences Conf.of Asia and Australia (VASSCAA-5), Beijing, China, August 23–27, 2010

Rizzo, E.; Heller, R.; Savoldi Richard, L.; Zanino, R.
Heat exchanger CFD analysis for the W7-X high temperature superconductor current lead prototype.
26th Symp.on Fusion Technology (SOFT 2010), Porto, P, September 27–October 1, 2010

* Savoldi Richard, L.; Class, A.; Fietz, W.H.; Heller, R.; Rizzo, E.; Zanino, R.
CtFD analysis of HTS current lead fin-type heat exchanger for fusion applications.
IEEE Transactions on Applied Superconductivity, 20(2010) S.1733-1736
DOI:10.1109/TASC.2010.2041546

Scannapiego, M.; Poncet, J.M.; Day, C.; Hanke, S.; Hauer, V.; Papastergiou, S.; Dremel, M.; Mayaux, C.
Thermohydraulic investigation on the operation of the ITER torus and neutral beam cryopumps.
26th Symp.on Fusion Technology (SOFT 2010), Porto, P, September 27–October 1, 2010

Schlachter, S.I.
Energie der Zukunft – Fusion 2050.
Tag der offenen Tür, KIT, Karlsruhe, 25. September 2010

Schlachter, S.I.; Fietz, W.H.; Goldacker, W.; Grilli, F.; Heller, R.; Kudymow, A.
High-current HTS cables for fusion magnets.
26th Symp.on Fusion Technology (SOFT 2010), Porto, P, September 27–October 1, 2010

Schlachter, S.I.
High temperature superconductivity.
Karlsruhe Internat.School on Fusion Technology, Karlsruhe, September 6–17, 2010

Schön, R.
Untersuchung eines BIXS-Detektors zur Messung der Tritiumkonzentration in Wasser.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 18.1 Abstract

Schwarz, M.; Schacherer, C.; Ehrlich, A.; Weiss, K.P.
Thermal conducitivity of High Temperature Superconductor coated conductors.
Balachandran, U. [Hrsg.]
Advances in Cryogenic Engineering : Transactions of the Internat.Cryogenic Materials Conf., Tucson, Ariz., June 28–July 2, 2009
Melville, N.Y.: AIP, 2010 S.388–93 incl.CD-ROM
(AIP Conference Proceedings; 1219)
(Advances in Cryogenic Engineering; 56)
ISBN 978-0-7354-0761-9

* Sharipov, F.; Graur, I.; Day, Chr.
Leak rate of water into vacuum through microtubes.
Journal of Vacuum Science and Technology A, 28(2010) S.443–48
DOI:10.1116/1.3372839

Sharipov, F.; Graur, I.; Day, Chr.
Modelling of water leak rates through crevices.
26th Symp.on Fusion Technology (SOFT 2010), Porto, P, September 27–October 1, 2010

Sharipov, F.; Varoutis, S.; Day, Chr.; Luo, X.; Haas, H.
Numerical modeling of the ITER model cryopump.
18th Internat.Vacuum Congress (IVC-18), Internat.Conf. on Nanoscience and Technology (ICN+T 2010), 14th Internat.Conf.on Surfaces Science (ICSS-14), Vacuum and Surface Sciences Conf.of Asia and Australia (VASSCAA-5), Beijing, China, August 23–27, 2010

* Sharipov, F.
Numerical simulation of turbomolecular pump over a wide range of gas rarefaction.
Journal of Vacuum Science and Technology A, 28(2010) S.1312–1315
DOI:10.1116/1.3484139

Sonato, P.; Bonicelli, T.; Chakraborty, A.K.; Hemsworth, R.; Watanabe, K.; Day, C.; Franzen, P.; Waldon, C.
The ITER neutron beam facility in Padua – Italy: a joint international effort for the development of the ITER heating neutral beam injector prototype.
23rd IAEA Fusion Energy Conference, Daejeon, Korea, October 11–16, 2010

Stämmler, S.; Demange, D.; Kind, M.
Potential use of zeolite membranes for separation and recovery of tritium produced in the breeder blanket of fusion machines.
5th Internat.Zeolite Membrane Meeting, Loutraki, GR, May 23–26, 2010

Varoutis, S.; Misdanitis, S.; Pantazis, S.; Hauer, V.; Giegerich, T.; Day, C.; Valougeorgis, D.
Experimental and numerical investigation of vacuum gas flows in fusion vacuum systems.
26th Symp.on Fusion Technology (SOFT 2010), Porto, P, September 27–October 1, 2010

Varoutis, S.; Pantazis, S.; Giegerich, T.; Day, C.; Valougeorgis, D.
Experimental and numerical investigation of vacuum gas flows through tubes with sudden expansion of contraction.
11th European Vacuum Conf.(EVC-11), 8th Iberian Vacuum Meeting (IVM-8), 6th European Topical Conf. on Hard Coatings Salamanca, E, September 20–24, 2010

Varoutis, S.; Hauer, V.; Day, Chr.; Pantazis, S.; Valougeorgis, D.
Experimental and numerical investigation in flow configutations related to the vacuum systems of fusion reactors.
Fusion Engineering and Design, 85(2010) S.1798–1802
DOI:10.1016/j.fusengdes.2010.05.041

Varoutis, S.; Sharipov, F.
Rarefied gas flow through channels of finite length due to arbitrary pressure ratio.
27th Internat.Symp.on Rarefied Gas Dynamics (RGD 2010), Pacific Grove, Calif., July 10–15, 2010

Wagner, R.; Besserer, U.; Demange, D.; Dittrich, H.; Le, T.L.; Simon, K.H.; Guenther, K.
Improvement and characterization of small cross-piece tritium ionization chambers at the Tritium Laboratory Karlsruhe.
9th Internat.Conf.on Tritium Science and Technology (TRITIUM 2010), Nara, J, October 24–29, 2010

Weiss, K.P.
Cryogenic material test Karlsruhe – CryoMaK at the Karlsruhe Institute of Technology.
E.S.E. – Efficiency, Speed, Environment, (2010) Nr.16, S.36–39

Weiss, K.P.; Goldacker, W.; Nannini, M.
Finite element analysis of torsion experiments on HTSC tapes.
Applied Superconductivity Conf., Washington, D.C., August 1–6, 2010

Weiss, K.P.; Ehrlich, A.; della Corte, A.; Vostner, A.
Tensile test results on compacted and annealed 316LN material.
Balachandran, U. [Hrsg.]
Advances in Cryogenic Engineering: Transactions of the Internat.Cryogenic Materials Conf., Tucson, Ariz., June 28–July 2, 2009
Melville, N.Y. : AIP, 2010 S.3-8
incl.CD-ROM
(AIP Conference Proceedings ; 1219)
(Advances in Cryogenic Engineering ; 56)
ISBN 978-0-7354-0761-9

Winkler, A.; Fietz, W.H.; Fink, S.; Noe, M.
Calculation of transient voltages of ITER poloidal field coils.
21st Internat.Conf.on Magnet Technology (MT-21), Hefei, China, October 18–23, 2009

* Winkler, A.; Fietz, W.H.; Fink, S.; Noe, M.
Calculation of transient voltages of ITER poloidal field coils.
IEEE Transactions on Applied Superconductivity, 20(2010) S.419–422
DOI:10.1109/TASC.2010.2041913

Winkler, A.
Transient behaviour of ITER PF coils.
3rd Dresden-Karlsruhe Seminar on Materials and Applications of Applied Superconductivity,
Bad Liebenzell, June 9–10, 2010

Publications

"Efficient Energy Conversion" Program (*Cited in ISI)

Berger, A.; Cherevatskiy, S.; Noe, M.; Leibfried, T.
Comparison of the efficiency of superconducting and conventional transformers.
Journal of Physics: Conference Series, 234(2010) S.032004/1-8
DOI:10.1088/1742-6596/234/3/032004

Berger, A.
Development of superconducting, current limiting transformers.
3rd Dresden-Karlsruhe Seminar on Materials and Applications of Applied Superconductivity, Bad Liebenzell, June 9–10, 2010

Berger, A.; Noe, M.; Goldacker, W.; Kudymow, A.
Recovery characteristic of coated conductors for superconducting fault current limiters.
Applied Superconductivity Conf., Washington, D.C., August 1–6, 2010

Berger, A.; Noe, M.; Goldacker, W.; Kudymow, A.
Test results of 60 kVA current limiting transformer with full recovery under load.
Applied Superconductivity Conf., Washington, D.C., August 1–6, 2010

Gehring, R.; Sander, M.
Anlage zur supraleitenden magnetischen Energiespeicherung, elektrolytischen Wasserzerlegung und wassersynthetisierenden Stromerzeugung.
DE-OS 10 2007 042 711 (2009.03.12)
DE-PS 10 2007 042 711 (2010.07.07)

Goldacker, W.; Schlachter, S.I.; Weiss, K.; Barth, C.
Bending of HTS conductors and cables. (eingeladen)
VAMAS-TWA 16 Mini Workshop on Evaluation Technologies for Superconducting Wires,
Tsukuba, J, November 1–2, 2010

Goldacker, W.; Schlachter, S.I.
Cables fro HTS coated conductors for high DC and AC transport currents. (eingeladen)
3rd Internat.Congress on Ceramics (ICC3), Osaka, J, November 14–18, 2010

Goldacker, W.; Terziewa, S.; Kudymow, A.; Schlachter, S.I.
Current transfer and redistribution i CC-ROEBEL cables.
23rd Internat.Cryogenic Engineering Conf.(ICEC 23) and Internat.Cryogenic Materials Conf.(ICMC 2010),
Wroclaw, PL, July 19–23, 2010

Goldacker, W.; Schlachter, S.
Development of MgB_2 conductors.
Japanese-EU Workshop 'Superconductivity',
Washington, D.C., August 1, 2010
Goldacker, W.; Terziewa, S.; Kudymow, A.; Nast, R.;

Grilli, F.; Drechsler, A.; Schlachter, S.
High current low AC loss HTS-ROEBEL-cables for energy devices. (eingeladen)
12th Internat.Conf.on Modern Materials and Technologies (CIMTEC 2010),
Montecatini Terme, I, June 6–18, 2010

Goldacker, W.; Schlachter, S.I.; Grilli, F.
High transport current 2G HTS cables with low ACS losses. (eingeladen)
Materials Science and Technology Conf.and Exhibition (MS&T 2010), Houston, Tex., October 17–21, 2010

Goldacker, W.
Hochtemperatur-Supraleiter.
Supraleitung: Grundlagen, Materialien und Eigenschaften, Leitertechnologie und Anwendungsbeispiele,
Seminar, Karlsruhe, 23.–24.September 2010

Goldacker, W.
Properties of high temperature superconductors for application.
Spring School and Educational Courses (SSEC 2010),
Antalya, TR, April 20–25. 2010

Goldacker, W.
Properties of REBCO coated conductor.
Spring School and Educational Courses (SSEC 2010),
Antalya, TR, April 20–25. 2010

Goldacker, W.; Terzieva, S.; Grilli, F.; Vojenciak, M.;
Kling, A.; Kudymow, A.; Schlachter, S.I.
Properties of Roebel bars from coated conductors. (eingeladen)
23rd Internat.Symp.on Superconductivity (ISS 2010),
Tsukuba, J, November 1–3, 2010

Goldacker, W.
Properties of ROEBEL cables from coated conductors. (eingeladen)
Internat.Conf.on Superconductivity and Magnetism (ICSM 2010), Antalya, TR, April 25–30, 2010

Goldacker, W.; Stanimira, S.; Grilli, F.; Vojenciak, M.;
Kling, A.; Kudymow, A.; Nast, R.; Schlachter, S.I.
Roebel bars from coated conductors.
Internat.Workshop on Coated Conductors for Applications (CCA 2010), Fukuoka, J,
October 28–30, 2010

* Grilli, F.; Sirois, F.; Brault, S.; Brambilla, R.; Martini, L.; Nguyen, D.N.; Goldacker, W.
Edge and top/bottom losses in non-inductive coated conductor coils with small separation between tapes.
Superconductor Science and Technology, 23(2010) S.034017/1-7
DOI:10.1088/0953-2048/23/3/034017

Grilli, F.; Sirois, F.; Brault, S.; Brambilla, R.; Martini, L.; Nguyen, D.N.; Goldacker, W.
Edge and top/bottom losses in non-inductive coated conductor coils with small separation between tapes.
9th European Conf.on Applied Superconductivity (EUCAS'09), Dresden, September 13–17, 2009

Grilli, F.
H-formulation with edge elements for finite-element modeling of HTS tapes and devices.
1st Internat.Workshop on Numerical Modelling of HTS, Lausanne, CH, May 5–7, 2010

Grilli, F.
Numerical modeling of AC losses in fault current limiters.
12th Internat.Conf.on Modern Materials and Technologies (CIMTEC 2010), Montecatini Terme, I, June 6–18, 2010

Grilli, F.; Sirois, F.; Brambilla, R.
Numerical modeling of thin superconducting tapes.
COMSOL Conf.2010, Paris, F, November 17–19, 2010

Grilli, F.; Pardo, E.; Vojenciak, M.; Terzieva, S.
Simulation of ac loss in Roebel coated conductor cables.
Internat.Workshop on Coated Conductors for Applications (CCA2009), Barcelona, E,
November 22–24, 2009

* Hornung, F.; Rimikis, A.; Schneider, Th.
Current sharing and critical current distribution in Be-2223 tapes.
IEEE Transactions on Applied Superconductivity, 20(2010) S.1589–1592
DOI:10.1109/TASC.2010.2040722

* Jung, A.; Schlachter, S.I.; Runtsch, B.; Ringsdorf, B.; Fillinger, H.; Orschulko, H.; Drechsler, A.; Goldacker, W.
Influence of Ni and Cu contamination on the superconducting properties of MgB_2 filaments.
Superconductor Science and Technology, 23(2010) S.095006/1-6
DOI:10.1088/0953-2048/23/9/095006

Kario, A.; Nast, R.; Häßler, W.; Rodig, C.; Schubert, M.; Ringsdorf, B.; Schlachter, S.; Goldacker, W.; Herrmann, M.; Holzapfel, B.; Schultz, L.
Chemical stability of ex situ MgB_2 powder in tube conductors.
Applied Superconductivity Conf., Washington, D.C., August 1–6, 2010

* Kario, A.; Morawski, A.; Häßler, W.; Nenkov, K.; Schubert, M.; Herrmann, M.; Ringsdorf, B.; Schlachter, S.I.; Goldacker, W.; Holzapfel, B.; Schultz, L.
Ex situ MgB_2 barrier behavior of monofilament in situ MgB_2 wires with Glidcop sheath material.
Superconductor Science and Technology, 23(2010) S.115007/1-9
DOI:10.1088/0953-2048/23/11/115007

* Kario, A.; Häßler, W.; Herrmann, M.; Rodig, C.; Scheiter, J.; Holzapfel, B.; Schulz, L.; Schlachter, S.; Ringsdorf, B.; Goldacker, W.; Morawski, A.
Properties of MgB_2 tapes prepared by using MA in -ex situ powder.
IEEE Transactions on Applied Superconductivity, 20(2010) S.15-1523
DOI:10.1109/TASC.2009.2039777

Krüger, P.; Grilli, F.; Farinon, S.
Compliance of numerical formulations for describing superconductor/ferromagnet heterostructures.
23rd Internat.Symp.on Superconductivity (ISS 2010), Tsukuba, J, November 1–3, 2010

Krüger, P.; Grilli, F.; Farinon, S.
Compliance of numerical formulations for describing superconductor/ferromagnet heterostructures.
COMSOL Conf.2010, Paris, F, November 17–19, 2010

Kudymow, A.; Elschner, S.; Fink, S.; Goldacker, W.; Grilli, F.; Schacherer, C.; Noe, M.; Hobl, A.; Bock, J.
ENSYSTROB – resistive fault current limiter based on coated conductors for medium voltage applications.
Applied Superconductivity Conf., Washington, D.C., August 1–6, 2010

Kudymow, A.; Elschner, S.; Maeder, O.; Goldacker, W.
Optimisation of 2G YBCO wires for resistive fault current limiter.
Applied Superconductivity Conf., Washington, D.C., August 1–6, 2010

Leys, P.
Superconducting high field magnets.
VDI Wissensforum Cryogenics, Karlsruhe, September 15-17, 2010

Mäder, O.; Noe, M.; Kudymow, A.; Goldacker, W.
Investigation of the stability of coated conductor.
Applied Superconductivity Conf., Washington, D.C., August 1–6, 2010

Mäder, O.
Simulation models for stability of coated conductors.
3rd Dresden-Karlsruhe Seminar on Materials and Applications of Applied
Superconductivity, Bad Liebenzell, June 9–10, 2010

Mentink, M.G.T.; Anders, A.; Dhalle, M.M.J.; Dietderich, D.R.; Godeke, A.; Goldacker, W.; Hellman, F.; ten Kate, H.H.J.; Slack, J.L.; Sumption, M.D.; Susner, M.
Bulk and thin film model samples for the analysis of the strain sensitivity of niobium-tin.
Applied Superconductivity Conf., Washington, D.C., August 1–6, 2010

Meyer, J.; Langebach, R.; Süßer, M.
Numerische Thermalanalyse einer externen Temperaturmesseinrichtung für kryogen durchströmte Rohrleitungen.
DKV-Tagung, Magdeburg, 17.–19.November 2010

Mrozik, C.; Karpuk, S.; Heil, W.; Otten, E.; Schneider, T.; Beckenbach, M.; Kläser, M.; Hiebel, S.
Homogenisierung des magnetischen Führungsfeldes für die Polarisation von 3He in einer kompakten Anlage.
Frühjahrstagung DPG, Fachverband Atomphysik, Hannover, 8.–12.März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) A 2.8 Abstract

* Müller, R.; Süßer, M.
Comparison of cryogenic temperature sensor installation inside or outside the piping.
Weisend, J.G. [Hrsg.]
Advances in Cryogenic Engineering: Transactions of the Internat.Cryogenic Engineering Conf., Tucson, Ariz., June 28 – July 2, 2009
Melville, N.Y.: AIP, 2010 S.1641-46
(AIP Conference Proceedings; 1218)
(Advances in Cryogenic Engineering; 55B)
ISBN 978-0-7354-0761-9

Nast, R.
BSCCO materials.
ESAS Internat.Summer School on Materials and Applications of Superconductivity, Karlsruhe, July 12–16, 2010

* Nast, R.; Ringsdorf, B.; Runtsch, B.; Weiss, K.P.; Goldacker, W.
The influence of the maximum heat treatment temperature on the performance of thin reinforced multifilament Bi-2212 wires for cables.
Journal of Physics: Conference Series, 234(2010) S.022026/1-7
DOI:10.1088/1742-6596/234/2/022026

Neumann, H.
Cryogenics
Fusion Summer School, Karlsruhe 14.09.2010

Neumann, H.
Experimental investigation of thermal insulation arrangements within a flexible cryostat for HTS power cables.
23rd Internat.Cryogenic Engineering Conf.(ICEC 23) and Internat.Cryogenic Materials Conf.(ICMC 2010), Wroclaw, PL, July 19–23, 2010

Neumann, H.
Heat transfer in cryogenics. Cooling techniques.
VDI Wissensforum Cryogenics, Karlsruhe, September 15-17, 2010

Neumann, H.
Kühltechniken.
VDI-Wissensforum Kryotechnik, Karlsruhe, 23.–25. Februar 2010

Neumann, H.
Thermodynamische Grundlagen.
Vortr.: Haus der Technik, Essen, 8. September 2010

Neumann, H.
Thermal insulation.
VDI Wissensforum Cryogenics, Karlsruhe, September 15-17, 2010

* Neumann, H.
Thermal performance of different glass microspheres in comparison to perlite between 77 and 300 K.
Weisend, J.G. [Hrsg.]
Advances in Cryogenic Engineering: Transactions of the Internat.Cryogenic
Engineering Conf., Tucson, Ariz., June 28–July 2, 2009
Melville, N.Y. : AIP, 2010 S.747-54
(AIP Conference Proceedings ; 1218)
(Advances in Cryogenic Engineering ; 55A)
ISBN 978-0-7354-0761-9

Neumann, H.
Thermische Isolation.
VDI-Wissensforum Kryotechnik, Karlsruhe, 23.–25. Februar 2010

Neumann, H.
Vakuum- und Sicherheitstechnik.
Vortr.: Haus der Technik, Essen, 10. September 2010

* Nguyen, D.N.; Ashworth, S.P.; Willis, J.O.; Sirois, F.; Grilli, F.
A new finite-element method simulation model for computing AC loss in roll assisted biaxially textured substrate YBCO tapes.
Superconductor Science and Technology, 23(2010) S.025001/1-5
DOI:10.1088/0953-2048/23/2/025001

Noe, M.
Fault current limiters.
Superconductivity in Energy Technology Applications 2010, Tampere, SF, November 4–5, 2010

Noe, M.
Fault current limiters – materials, applications and prospects. (eingeladen)
12th Internat.Conf.on Modern Materials and Technologies (CIMTEC 2010), Montecatini Terme, I, June 6–18, 2010

Noe, M.
Hochtemperatur-supraleitende Materialien auf dem Weg in die Anwendung.
Vortr.: AWT-VDI Arbeitskreis Werkstofftechnik Bremen 2009/2010, Institut für Werkstofftechnik, Bremen, 24. März 2010

Noe, M.; Marzahn, E.
Hochtemperatur-Supraleiter, Kabel und Strombegrenzer.
75. Kabelseminar, Hannover, 23.–24. Februar 2010

Noe, M.
Neue Konzepte für eine effiziente Energieversorgung.
ZIEHL II: Zukunft und Innovation in der Energietechnik mit Hochtemperatur-Supraleitern, Bonn, 16.–17. März 2010

Noe, M.
Superconductivity for power applications is getting more and more attractive.
Applied Superconductivity Conf., Washington, D.C., August 1–6, 2010

Prikhna, T.A.; Gawalek, W.; Sacchuk, Ya.M.; Eisterer, M.; Goldacker, W.; Weber, H.; Sokolovsky, V.; Tkach, V.N.; Danilenko, N.I.; Habisreuther, T.; Wendt, M.; Dellith, J.; Meerovich, V.; Dub, S.; Moshchil, V.; Sergienko, N.; Fesenko, I.; Litzkendorf, D.; Schmidt, Ch.; Tompsic, M.; Karau, F.; Nagorny, P.; Sverdun, V.
High-pressure synthesized MgB_2-based materials with high critical current density and upper critical field.
23rd Internat.Cryogenic Engineering Conf.(ICEC 23) and Internat.Cryogenic Materials Conf.(ICMC 2010), Wroclaw, PL, July 19–23, 2010

* Rajinikumar, R.
Fiber Bragg grating sensors for localized strain measurements at low temperature and in high magnetic field.
Weisend, J.G. [Hrsg.]
Advances in Cryogenic Engineering : Transactions of the Internat.Cryogenic Engineering Conf., Tucson, Ariz., June 28–July 2, 2009
Melville, N.Y.: AIP, 2010 S.1197-1204
(AIP Conference Proceedings; 1218)
(Advances in Cryogenic Engineering; 55B)
ISBN 978-0-7354-0761-9

* Rajinikumar, R.; Narayankhedkar, K.G.; Süßer, M.; Krieg, G.; Atrey, M.D.
Temperature measurement using Fiber Bragg grating sensors for superconductor magnets.
Proc.of the 22nd Nat.Symp.on Cryogenics (NSC-22), Bangalore, IND, December 6–8, 2008
Indian Journal of Crygenics, 34(2009) Nr.1–4, S.441–17

Sander, M.; Gehring, R.; Noe, M.
A novel energy storage concept based on hydrogen and superconductors.
Applied Superconductivity Conf., Washington, D.C., August 1–6, 2010

Sander, M.
LIQHYSMES – a novel energy storage concept based on hydrogen and superconductors.
Workshop on Industrial Applications of Superconductivity, Sestri Levante, I, October 4–5, 2010

Schacherer, C.; Schwarz, M.
Mit einer Kühlschicht versehener hochtemperatur-supraleitender Bandleiterverbund.
DE-OS 10 2007 061 891 (2009.07.02)
WO-OS 2009/080156 (2009.07.02)
EP-OS 2 223 355 (2010.09.01)

* Schlachter, S.I.; Braun, U.; Drechsler, A.; Goldacker, W.; Holubek, T.; Kling, A.; Schmidt, C.
Cabling of thin MgB_2 strands for high-current conductors with reduced AC losses.
Balachandran, U. [Hrsg.]
Advances in Cryogenic Engineering : Transactions of the Internat.Cryogenic Materials Conf., Tucson, Ariz., June 28 – July 2, 2009
Melville, N.Y.: AIP, 2010 S.302-09
incl.CD-ROM
(AIP Conference Proceedings; 1219)
(Advances in Cryogenic Engineering; 56)
ISBN 978-0-7354-0761-9

Schlachter, S.I.; Goldacker, W.; Grilli, F.; Heller, R.; Kudymow, A.
Coated conductor Rutherford cables (CCRC) for high-current applications: concept and properties.
Applied Superconductivity Conf., Washington, D.C., August 1–6, 2010

Schlachter, S.I.; Drechsler, A.; Ringsdorf, B.; Goldacker, W.; Grilli, F.; Heller, R.; Kudymow, A.; Terzieva, S.
HTS cables for high-current applications. (eingeladen)
Internat.Conf.on Superconductivity and Magnetism (ICSM 2010), Antalya, TR, April 25–30, 2010

Schlachter, S.I.; Goldacker, W.; Heller, R.; Grilli, F.; Terzieva, S.; Kudymow, A.
HTS Roebel- und Rutherford-Kabel für Hochstrom-anwendungen.
HTS Roebel and Rutherford cables for high-current applications. (eingeladen)
IOP Superconductivity Group Seminar 'Development and Applications of HTS Conductors', London, GB, January 15, 2010
5. Braunschweiger Supraleiter-Seminar, Braunschweig, 23.–24. Juni 2010

Schlachter, S.I.
MgB_2 material.
ESAS Internat.Summer School on Materials and Applications of Superconductivity, Karlsruhe, July 12–16, 2010

Schlachter, S.I.
Vision 2050: Energie der Zukunft – Fusion 2050.
Hannover-Messe Industrie, Hannover, 19.–23. April 2010

* Schneider, Th.; Beckenbach, M.; Ernst, R.; Hornung, F.; Kläser, M.; Lahn, H.; Leys, P.; Ruf, C.; Neumann, H.; Stamm, M.
Superconducting high field magnet engineering at KIT.
IEEE Transactions on Applied Superconductivity, 20(2010) S.624-627
DOI:10.1109/TASC.2010.2041914

Steurer, M.; Marchionini, B.; Darman, F.; Lambert, F.; Noe, M.
Towards a guide for testing emerging fault current limiters.
CIGRE Session 2010, Paris, F, August 22–27, 2010

Süßer, M.
Diskussion der Druckabsicherung von Kryostaten mit supraleitenden Magneten.
DKV-Tagung, Magdeburg, 17.–19. November 2010

Süßer, M.
Druckabsicherung von LHe-Druckbehältern ein-schließlich der Sicherheitseinrichtungen gegen Druck-überschreitung.
Sitzung des Normenausschusses NA 016-00-07 AA, Karlsruhe, 21. September 2010

Süßer, M.
Kryogene Mess-, Regel- und Sicherheitstechnik.
Seminar Kryostatbau, Karlsruhe, 8.–9. September 2010

Süßer, M.
Kryogene Mess- und Regeltechnik.
VDI-Wissensforum Kryotechnik, Karlsruhe,
23.–25. Febraur 2010

Süßer, M.
Low temperature measurement and control technique.
VDI Wissensforum Cryogenics, Karlsruhe,
September 15–17, 2010

Süßer, M.
Messen von kleinen Durchflüssen.
VDI Wissensforum 'Durchfluss- und Mengenmessung in Rohrleitungen', Stuttgart, 6.–8. Oktober 2010

Süßer, M.
Messverfahren für Kleinstdurchflüsse.
VDI-Seminar 'Durchfluss- und Mengenmessung in Rohrleitungen', Düsseldorf, 3.–5. März 2010

Terzieva, S.; Nast, R.; Goldacker, W.; Grilli, F.; Kudymow, A.; Vojenciak, M.
Effect of striated strands in 2G ROEBEL cable.
Applied Superconductivity Conf., Washington, D.C.,
August 1–6, 2010

Terzieva, S.; Vojenciak, M.; Pardo, E.; Grilli, F.; Drechsler, A.; Kling, A.; Kudymov, A.; Gömöry, F.; Goldacker, W.
Transport and magnetization ac losses of ROEBEL assembled coated conductor cables: measurements and calculations.
Superconductor Science and Technology, 23(2010)
S.014023/1-8
DOI:10.1088/0953-2048/23/1/014023

Publications

"Astroparticle Physics" Program (*Cited in ISI)

Bauer, S.; Beck, M.; Prall, M.; Rosendahl, S.; Thümmler, T.; Weinheimer, C.; KATRIN Collaboration
Hochspannungsversorgung der Drahtelektrode im Hauptspektrometer des KATRIN-Experiments.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 36.64

Beck, M.; KATRIN Collaboration
Status des KATRIN Experimentes zur Bestimmung der Masse des Elektronenneutrinos.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 28.1

Benning, S.; Hannen, V.; Hillen, B.; Ortjohann, H.W.; Prall, M.; Weinheimer, C.; Zacher, M.; KATRIN Collaboration
Production and installation of the wire electrode for the KATRIN-experiment.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 28.8

Bornschein, L.; Fränkle, F.; Glück, F.; Hugenberg, K.; Mertens, S.; Weinheimer, C.; Zacher, M.; KATRIN Collaboration
Simulation und Vermeidung von Penningfallen an den Spektrometern des KATRIN-Experiments.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 36.59

De Boer, W.; Hoffmann, K.H.; Sabellek, A.; Schmanau, M.; Schneider, M.; Zhukov, V.; Schneider, T.
Lorentz shift measurements in heavily irradiated silicon detectors in high magnetic fields.
9th Internat.Conf.on Large Scale Applications and Radiation Hardness of Semiconductor Detectors (RD09), Firenze, I, September 30 – October 2, 2009
POS, Proceedings of Science PoS(RD09) 022

Fischer, S.; Sturm, M.; Schlösser, M.; Bornschein, B.; Drexlin, G.; Priester, F.; Lewis, R.J.; Telle, H.H.
Monitoring of tritium purity during long-term ciculation in the KATRIN test experiment LOOPINO using laser Raman spectroscopy.
9th Internat.Conf.on Tritium Science and Technology (TRITIUM 2010), Nara, J, October 24–29, 2010

Fischer, S.; KATRIN Collaboration
Systematische Untersuchungen zur Laser-Raman-Spektroskopie von Tritium für das KATRIN-Experiment.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 28.3

Fischer, S.; Sturm, M.; Schlösser, M.; Lewis, R.J.; Bornschein, B.; Drexlin, G.; Telle, H.H.
Tritium accountancy with laser Raman spectroscopy for KATRIN.
30th Internat.Symp.on Physics in Collision (PIC 2010), Karlsruhe, September 1–4, 2010

Fränkle, F.; KATRIN Collaboration
Untersuchung der Untergrundeigenschaften des KATRIN Vorspektrometers.
Frühjahrstagung DPG, Fachverband Teilchenphysik, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) T 109.4

Gehring, P.; Jüngst, K.P.; Kuperman, G.; Noe, M.
Stromversorgung und Verfahren für eine gepulst betriebene induktive Last.
DE-PS 10 2008 053 679 (2010.01.28)
WO-OS 2010/049023 (2010.05.06)

* Gil, W.; Bonn, J.; Bornschein, B.; Gehring, R.; Kazachenko, O.; Kleinfeller, J.; Putselyk, S.; KATRIN Collaboration
The cryogenic pumping section of the KATRIN experiment.
IEEE Transactions on Applied Superconductivity, 20(2010) S.316–319
DOI:10.1109/TASC.2009.2038581

Görhardt, S.; KATRIN Collaboration
Status der Testmessungen am KATRIN Vorspektrometer.
Frühjahrstagung DPG, Fachverband Teilchenphysik, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) T 109.2

Goullon, J.; KATRIN Collaboration
Hochspannungsüberwachung bei KATRIN mit nuklearen Standards.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 69.3

Grohmann, S.; KATRIN Collaboration
Entwicklung und Optimierung einer UV-Laser-gestützten Elektronenkanone für KATRIN.
Frühjahrstagung DPG, Fachverband Teilchenphysik, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) T 69.9

* Grohmann, S.; Gil, W.; Neumann, H.; Weiss, C.
Commissioning of the cryogenic transfer line for the KATRIN experiment.
Weisend, J.G. [Hrsg.]
Advances in Cryogenic Engineering : Transactions of the Internat.Cryogenic Engineering Conf., Tucson, Ariz., June 28–July 2, 2009
Melville, N.Y. : AIP, 2010 S.1095–1102
(AIP Conference Proceedings ; 1218)
(Advances in Cryogenic Engineering ; 55B)
ISBN 978-0-7354-0761-9

Grohmann, S.; Schön, H.; Süßer, M.
Erprobung des Strahlrohrkühlsystems für den Quellmagnetkryostaten in KATRIN.
DKV-Tagung, Magdeburg, 17.–19. November 2010

Hannen, V.; Kranz, C.; Sejersen Riis, A.; Weinheimer, C.; KATRIN Collaboration
Deconvolution method for determination of the KATRIN energy loss function.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 36.32

Hannen, V.; Kopmann, A.; Vöcking, S.; Weinheimer, C.; KATRIN Collaboration
Intelligentes web-basiertes Datenmanagement für das KATRIN-Experiment.
Frühjahrstagung DPG, Fachverband Teilchenphysik, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) T 71.7

Hein, H.; Bauer, S.; Beck, M.; Bonn, J.; Hannen, V.; Hugenberg, K.; Ortjohann, H.W.; Rosendahl, S.; Streubel, S.; Valerius, K.; Weinheimer, C.; Zboril, M.; KATRIN Collaboration
Winkelselektive Photo-Elektronen Kalibrationsquelle für KATRIN.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 69.5

Hergenhan, J.; KATRIN Collaboration
Sensornetz zur Überwachung des Magnetfeldes am KATRIN Hauptspektrometer.
Frühjahrstagung DPG, Fachverband Teilchenphysik, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) T 69.8

Hötzel, M.; KATRIN Collaboration
Modellierung der Tritiumquelle von KATRIN.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 28.4

Kernert, N.; KATRIN-Collaboration
Experimental setup and measurements of the rotor temperature of turbo-molecular pumps in magnetic fields.
18th Internat.Vacuum Congress (IVC-18), Internat.Conf. on Nanoscience and Technology (ICN+T 2010), 14th Internat.Conf.on Surfaces Science (ICSS-14), Vacuum and Surface Sciences Conf.of Asia and Australia (VASSCAA-5), Beijing, China, August 23–27, 2010

Leiber, B.; KATRIN Collaboration
Nicht-axialsymmetrische Feldberechnungen und Teilchenbahnverfolgung im KATRIN Experiment.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 28.7

Prall, M.; Bornschein, L.; Fraenkle, F.; Goerhardt, S.; Weinheimer, C.; KATRIN Collaboration
Untersuchung der Transmissionseigenschaften des KATRIN-Vorspektrometers.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 69.7

Priester, F.; KATRIN Collaboration
Inbetriebnahme der Tritiumkreisläufe von KATRIN.
Frühjahrstagung DPG, Fachverband Teilchenphysik, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) T 110.8

Reich, J.; KATRIN Collaboration
Inbetriebnahme des Luftspulensystems am KATRIN Hauptspektrometer.
Frühjahrstagung DPG, Fachverband Teilchenphysik, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) T 108.10

Renschler, P.; KATRIN Collaboration
Simulationen der Detektorantwort von Siliziumdetektoren auf niederenergetische b-Strahlung.
Frühjahrstagung DPG, Fachverband Teilchenphysik, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) T 68.1

Schäfer, T.; Weinheimer, C.; Beck, M.; Ortjohann, H.W.; Wegmann, A.; KATRIN Collaboration
Eine kondensierte Krypton-Kalibrationsquelle für das KATRIN-Experiment.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 36.77

Schlösser, M.; Fischer, S.; Sturm, M.; Bornschein, B.; Lewis, R.J.; Telle, H.H.
Laser Raman measurements on tritium mixtures and implications for the design of systems for tritium accountancy of process control applications.
9th Internat.Conf.on Tritium Science and Technology (TRITIUM 2010), Nara, J, October 24–29, 2010

Schlösser, M.; Sturm, M.; Fischer, S.; Bornschein, B.; Lewis, R.; Telle, H.
Online Laser-Raman-Spektroskopie an Tritium für KATRIN.
Frühjahrstagung DPG, Fachverband Quantenoptik und Photonen, Hannover, 8.–12. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) Q 54.6

Schmitt, U.; Babutzka, M.; KATRIN Collaboration
Entwicklung eines Präzisions-Intensitätsmonitors für einen keV-Elektronenstrahl.
Frühjahrstagung DPG, Fachverband Teilchenphysik, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) T 67.4

Schwarz, J.; Katrin Collaboration
Messungen der elektro-optischen Eigenschaften der differentiellen Pumpstrecke von KATRIN.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 28.6

Steidl, M.; Maurel, D.; KATRIN Collaboration
Beta induced X-ray spectroscopy for a precise measurement of the column density of a gaseous tritium source.
Frühjahrstagung DPG, Fachverband Teilchenphysik, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) T 67.5

* Sturm, M.; Schlösser, M.; Lewis, R.J.; Bornschein, B.; Drexlin, G.; Telle, H.H.
Monitoring of all hydrogen isotopologues at tritium laboratory Karlsruhe using Raman spectroscopy.
Laser Physics, 20(2010) S.493-507
DOI:10.1134/S1054660X10030163

Süßer, M.
Conditioning of 27 W rhodium-iron ceramic sensors for extremely difficult application.
23rd Internat.Cryogenic Engineering Conf.(ICEC 23) and Internat.Cryogenic Materials Conf.(ICMC 2010), Wroclaw, PL, July 19–23, 2010

Süßer, M.; Mao, H.; Schlachter, S.
Magnetic behaviour of rhodium-iron cryogenic sensor and high field correction.
23rd Internat.Cryogenic Engineering Conf.(ICEC 23) and Internat.Cryogenic Materials Conf.(ICMC 2010), Wroclaw, PL, July 19–23, 2010

Thümmler, T.; KATRIN Collaboration
Status und Testmessungen des Karlsruher Tritium Neutrino Experiments KATRIN.
Frühjahrstagung DPG, Fachverband Teilchenphysik, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) T 109.1

Titov, N.; KATRIN Collaboration
Plasma effects and ion transport in the KATRIN windowless gaseous tritium source.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 36.31

Wandkowsky, N.; KATRIN Collaboration
Systematische Effekte bei den Tritiummessungen mit KATRIN.
Frühjahrstagung DPG, Fachverband Teilchenphysik, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) T 110.9

Wegmann, A.; Beck, M.; Ostrick, B.; Schäfer, T.; Ortjohann, H.W.; Weinheimer, C.; KATRIN Collaboration
Ellipsometrie für die CKrS des KATRIN-Experiments.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 36.56

Windberger, A.; KATRIN Collaboration
Das elektrostatische Dipolsystem zur Ionenunterdrückung im Transportsystem des KATRIN-Experiments.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 69.4

Zacher, M.; Vöcking, S.; Weinheimer, C.; Dropmann, M.; KATRIN Collaboration
Electromagnetic design of the pump port region of the KATRIN main spectrometer.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 36.83

Zboril, M.; Beck, M.; Bonn, J.; Dragoun, O.; Kaspar, J.; Kovalik, A.; Ostrick, B.; Otten, E.W.; Schlösser, K.; Spalek, A.; Thümmler, T.; Venos, D.; Weinheimer, C.; KATRIN Collaboration
Electron 83Rb/83mKr source for the energy scale monitoring in the KATRIN experiment.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 28.5

Zepter, S.; KATRIN Collaboration
Systematische Magnetfeldvermessung der differentiellen Pumpstrecke und des Luftspulensystems von KATRIN.
Frühjahrstagung DPG, Fachverband Physik der Hadronen und Kerne, Bonn, 15.–19. März 2010
Verhandlungen der Deutschen Physikalischen Gesellschaft, R.6, B.45(2010) HK 36.30

Publications

Invited Papers

Beate Bornschein

- David Demange, E. Fanghänel, B. Kloppe, T.L. Le, F. Scheel, K. H. Simon, R. Wagner, S. Welte. CAPER MODIFICATIONS AND FIRST EXPERIMENTAL RESULTS ON HIGHLY TRITIATED WATER PROCESSING WITH PERMCAT AT THE TRITIUM LABORATORY KARLSRUHE. 9th ICTST (TRITIUM), Nara, Japan, October 2010.
- Fischer, Sebastian. „Monitoring of tritium purity during long-term circulation in the KATRIN test experiment LOOPINO using laser raman spectroscopy". 9th ICTST (TRITIUM), Nara, Japan, October 2010

Christian Day

- Chr. Day, „Contributions of Rarefied Gas Dynamics to state-of-the-art vacuum science and technology", Int. Symp. On Rarefied Gas Dynamics, Pacific Grove, CA, USA, Juli 2010.
- Chr. Day, Th. Giegerich, V. Hauer, X. Luo, F. Sharipov, St. Varoutis, D. Valougeorgis, „Recent developments in vacuum flow modelling", Int. Vacuum Congress, Beijing, China, August 2010.
- Chr. Day, H. Haas, St. Hanke, V. Hauer, St. Varoutis, „Vacuum engineering of customized cryosorption pumps", European Vacuum Congress, Salamanca, Spain, Sept. 2010.

Wilfried Goldacker

- W. Goldacker, „HTS Hochstromleiter für Wechselstrombetrieb", ZIEHL „Zukunft und Innovation in der Energietechnik mit HTSL" , Bonn 16.–17.03.2010
- W. Goldacker, "High performance MgB_2 wires for application in energy, lH2 and space technology". Japanese-EU Workshop „Superconductivity" 1st. Aug. 2010, Washington USA
- W. Goldacker, S. Terzieva, R. Nast, S.I. Schlachter, A. Drechsler, F. Grilli, A. Kudymow, „Properties of ROEBEL cables from coated conductors" ICSM Conference, 26th.–30th. April 2010, Antalya Turkey
- W. Goldacker, S.Terzieva, A. Kudymow, S.I. Schlachter, „Current transfer and redistribution in CC-Roebel cables", CIMTEC 14th.–18th. June 2010, Montecatini, Italy
- W. Goldacker, S.I. Schlachter, F. Grilli, „ High transport current 2G HTS cables with low AC losses" MS&T Conference, 18th.–22nd.Oct, 2010, Houston, USA
- W. Goldacker, S. Stanimira, F. Grilli, M. Vojenciak, A. Kling, A. Kudymow, R. Nast, S.I. Schlachter, „Roebel bars from Coated Conductors", CCA2010, 27th.–30th. Oct. 2010, Fukuoka, Japan
- W. Goldacker, S. Stanimira, F. Grilli, M. Vojenciak, A. Kling, A. Kudymow, S.I. Schlachter, R. Nast, „Properties of Roebel bars from Coated Conductors", ISS Conference, 2nd.–6th.Nov. 2010, Tsukuba, Japan
- W. Goldacker, S.I. Schlachter, K. Weiss, Ch. Barth, „Bending of HTS conductors and cables", VAMAS-TWA16 Mini Workshop on Evaluation Technologies for Superconducting Wires, 1st–2nd Nov. 2010 NIMS-Tsukuba, Japan
- W. Goldacker and S.I. Schlachter, „Cables From HTS Coated Conductors For High DC And AC Transport Currents", ICC3-Conference, 15th.–18th. Nov.2010, Osaka, Japan.

Francesco Grilli

- F. Grilli. „Numerical Modeling of AC Losses in Fault Current Limiters". CIMTEC 2010 – 5th Forum on New Materials, Montecatini Terme, Italy, 13–18 June, 2010.

Mathias Noe

- M. Noe „Simulation and modelling" Eccoflow Kick-off Meeting, 8.–9. Februar 2010
- M. Noe, E. Marzahn „Hochtemperatur-Supraleiter Kabel und Strombegrenzer" 75. Kabelseminar, 23.–24. Februar 2010, Leibniz Universität Hannover
- M. Noe „Neue Konzepte für eine effiziente Energieversorgung" Workshop Zukunft und Innovation der Energietechnik mit Hochtemperatur-Supraleitern, 16.–17. März 2010, Wasserwerk Bonn
- M. Noe „Hochtemperatur-supraleitende Materialien auf dem Weg in die Anwendung" AWT–VDI–Arbeitskreis Werkstofftechnik, 24. März 2010, Bremen
- M. Noe „Fault Current Limiters – Materials, Applications and Prospects" 5th Forum on New Materials, 13.–18. Juni, Montecatini Terme, Italien
- M. Noe „Superconductivity for Power Applications is getting more and more attractive" Plenarvortrag Applied Superconductivity Conference, 1.–6. August 2010, Washington, USA
- M. Noe „High Temperature Superconducting Rotating Machines" CIGRE Workshop on Status of High-Temperature Superconducting (HTS) Power System Applications, 25. August 2010, Paris
- M. Noe „Superconducting fault current limiters in smart grid applications" CIGRE Workshop on Status of High-Temperature Superconducting (HTS) Power System Applications, 25. August 2010, Paris
- M. Noe „Fault Current Limiters" Superconductivity in Energy Technology Applications 2010, 4.– 5. November 2010, Tampere, Finnland

Sonja Schlachter

- S. I. Schlachter, W. Goldacker, R. Heller, F. Grilli, S. Terzieva, A. Kudymow. "HTS Roebel and Rutherford Cables for High-Current Applications". IOP Superconductivity Group Seminar: Development and Applications of HTS Conductors, 15. Januar, 2010, London

- S.I. Schlachter, A. Drechsler, B. Ringsdorf, W. Goldacker, F. Grilli, R. Heller, A. Kudymow, S. Terzieva, „HTS Cables for High-Current Applications“. International Conference on Superconductivity and Magnetism (ICSM 2010), 25.–30. April 2010, Antalya
- S. I. Schlachter, W. Goldacker, F. Grilli, R. Heller, A. Kudymow, R. Nast, S. Terzieva. „HTS Roebel and Rutherford Cables for High-Current Applications”, 5. Braunschweiger Supraleiterseminar, 23. und 24. Juni 2010, Braunschweig

Stanimira Terzieva

- S. Terzieva, R. Nast, W. Goldacker, F. Grilli, A. Kudymow, M. Vojenciak, Jan Souc. „Effect of striated strands in 2G ROEBEL Cables“. Applied Superconductivity Conference (ASC 2010), 2.–6. August 2010, Washington, USA

Publications

Patents Held

* New patent applications in 2010
** Patents granted for Germany in 2010

Strombegrenzer mit elektrischen Ventilen zum Begrenzen des Kurzschlussstromes in einem elektrischen Leistungsstromkreises
Jüngst, Klaus-Peter; Kuperman, Grigory
CA 2,365,228
CH 1149452
DE 1149452
FR 1149452
GB 1149452
US 6654222

Verfahren zur Steuerung der Netzgeräte zum Laden der Energiespeicher eines Leistungsmodulators und Leistungsmodulator zur Durchführung des Verfahrens
Jüngst, Klaus-Peter; Kuperman, Grigory
DE 10036519
EP 01116149.4-1233

Einrichtung zur Rekondensation von tiefsiedenden Gasen mit einem Kryogenerator des aus einem Flüssiggas-Behälter verdampfenden Gases
Hofmann, Albert
CN 2815086
DE 10137552
US 699818

Flacher, aus elektrisch leitenden Strängen zusammengesetzter verlustarmer elektrischer Leiter
Klimenko, Evgueni
EP 03001748.7-2208

Zusätzliche Einrichtung in einem Strombegrenzer zur Strombegrenzung im Fehlerfall
Jüngst, Klaus-Peter; Kuperman, Grigory; Noe, Mathias
CA PCT/EP2005/010850
CN 200580041670.7
DE 102004058633
EP 05791533.2-1231
S 7327542

Planar-helischer Undulator
Beckenbach, Max; Eisele, Matthias; Kläser, Marion; Leys, Pauline; Lott, Bernd; Schneider, Theo
DE 102006056052
EP 07846613.3-1226
JP 2009538613
US 12/516,508

Kryostat mit einem Magnetspulensystem, das eine LTS- und eine gekapselte HTS-Sektion umfasst
Kläser, Marion
DE 102006012508
EP 07723071.2-1231
US 12/225,192

Kryostat mit einem Magnetspulensystem, das eine unterkühlte LTS- und eine in einem separaten Heliumtank angeordnete HTS-Sektion umfasst
Schneider, Theo
DE 102006012511
EP 07723070.4-2208
US 12/225,188

Anlage zur supraleitenden magnetischen Energiespeicherung, elektrolytischen Wasserzerlegung und wassersynthetisierenden Strombegrenzer
Gehring, Rainer; Sander, Michael
DE 102007042711

Mit einer Kühlschicht versehener hochtemperatursupraleitender Bandleiterverbund
Schacherer, Christian; Schwarz, Michael
US 12/809,133

Stromversorgung und Verfahren für eine gepulst betriebene induktive Last
Gehring, Rainer; Jüngst, Klaus-Peter; Kuperman, Grigory; Noe, Mathias
DE 102008053679 **
EP PCT/EP2009/005909

Verfahren zur Herstellung einer Verbindungsstruktur zwischen zwei Supraleitern und Struktur zur Verbindung zweier Supraleiter
Drechsler, Antje; Goldacker, Wilfried; Oomen, Marijn; Rabbers, Jakob Johan; Schlachter, Sonja
DE 102009043580.8-34

Vorrichtung zur Strombegrenzung mit einer veränderbaren Spulenimpedanz
Noe, Mathias; Schacherer, Christian
DE 102010007087.4-34 *
WO PCT/EP2010/007837 *

Massenstromsensor und Verfahren zur Bestimmung des Massenstroms in einem Rohr
Neumann, Holger; Ramalingam, Rajini K; Süßer, Manfred
DE 102010012924.0-52 *

Verfahren zur Herstellung einer supraleitenden Verbindung von Nb3SN und NbTi-Leitern und supraleitende Verbindung
Hehn, Werner; Schneider, Theo; Turowski, Peter

CH	459156.
ES	459156
FR	459156
GB	459156
NL	459156
SE	459156
DE	459156

NMR-Magnetsystem mit supraleitender Spule in einem unterkühlten Heliumbad auf Atmosphärendruck
Graf, Franz; Lehmann, Wolfgang; Müller, Wolfgang; Roth, Gerhard; Turowski, Peter

US	522800

Elektrischer Leiter mit supraleitenden Kernen und Verfahren zur Herstellung eines solchen Leiters
Flükiger, René; Goldacker, Wilfried

DE	CH736/95-3

Kapazitiver Spannungsteiler zur Messung von Hochspannungsimpulsen mit Millisekunden-Impulsdauer
Jüngst, Klaus-Peter; Kuperman, Grigory; Salbert, Heinrich

CH	1097385
DK	1097385
FR	1097385
GB	1097385
JP	3589984
US	6456094
DE	1097385

Schutzsystem in einem Leistungsmodulator zum Schutze der Last
Jüngst, Klaus-Peter; Kuperman, Grigory

CH	1131874
DK	1131874
FR	1131874
GB	1131874
NL	1131874
SE	1131874
US	665518
DE	1131874

Kapazitiver Spannungsteiler zur Messung von Hochspannungsimpulsen mit Millisekunden-Impulsdauer
Jüngst, Klaus-Peter; Kuperman, Grigory; Salbert, Heinrich

DE	19923211

Axialer, kryotechnisch geeigneter Potentialtrenner
Fink, Stefan; Friesinger, Günter

DE	1196711

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