SEVENTH FRAMEWORK PROGRAMME

EuroMagNET II

A coordinated approach to access, experimental development and scientific exploitation of all European large infrastructures for high magnetic fields.

PROJECT FINAL REPORT
2009-2013

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Website: http://www.euromagnet2.eu

cnrs

Radboud University Nijmegen

HZDR

UNIVERSITÄT LEIPZIG

1918
TALLINNA TEHNIKAÜLIKOOL
TALLINN UNIVERSITY OF TECHNOLOGY

LNCMI

HFML
Science in High Magnetic Fields

HLD.
HELMHOLTZ
ZENTRUM DRESDEN
ROSSENDORF

UNIVERSITY OF
OXFORD

מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE

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Birth of EuroMagNET II: From FP6 to FP7

Research infrastructures are part of the EC's current priorities in structuring the European research area. Among these, the importance of high magnetic field facilities has been recognized, as witnessed by the continued EC funding of many high magnetic field projects.

Under FP6, three different projects have been accepted. The Grenoble High Magnetic Field Laboratory (GHMFL) is currently running a TNA program (until 31/12/2007), whereas the TNA of the High Field Magnet Laboratory (HFML Nijmegen, the Netherlands), the Hochfeld Labor Dresden (HLD Dresden, Germany) and the Laboratoire National des Champs Magnétiques Pulsés (LNCMP Toulouse, France) was being coordinated by the I3 EuroMagnet (until 31/12/2008). The European pulsed high magnetic field laboratories were executing a Design Study for the next generation pulsed field user facilities (until 31/3/2009). All these programs were running very satisfactorily and contributed to the excellence of Europe's high magnetic field research.

For FP7, the principal actors of Europe's high magnetic field research, the LNCMI (Laboratoire National des Champs Magnétiques Intenses, ex-LNCMP & ex-GHMFL), the HFML, and the HLD have proposed to unite all their transnational access, together with joint research activities and networking activities into one I3, called 'EuroMagNET II'. This I3 was considered as a very important step towards full collaboration between Europe's high field facilities, and as a necessary intermediate step towards the creation of a multi-site European Magnetic Field Laboratory (EMFL).

Project reference :	FP7 - 228043
Type of funding scheme:	Combination of Collaborative Project and Coordination and Support Action for Integrating Activities
Workprogramme topic:	INFRA-2008-1.1.1: Bottom-up approach: Integrating Activities in all scientific and technological fields.
Duration:	48 months
Start Date:	1st January 2009
End Date:	31 December 2013
Number of participants:	7 participants / 6 countries
EU Funding:	7,5 million euros

LIST OF PARTICIPANTS

Participant n°1 / Coordinator / Centre National de la Recherche Scientifique (CNRS)
Laboratoire National des Champs Magnétiques Intenses at Grenoble (LNCMI-G)
Laboratoire National des Champs Magnétiques Intenses at Toulouse (LNCMI-T)

Participant n°2 / Radboud University Nijmegen (RU)
High Magnetic Field Laboratory (RU-HFML)
Solid state NMR laboratory (RU-NMR)

Participant n°3 / Helmholtz-Zentrum Dresden-Rossendorf (HZDR)
Dresden High Magnetic Field Laboratory (Hochfeld-Magnetlabor Dresden, HLD)

Participant n°4 / University of Leipzig (ULEI)

Participant n°5 / University of Oxford, Department of Physics (UOX-DK)

Participant n°6 / Tallinn University of Technology (TUT)

Participant n°7 / Weizmann Institute of Science (WI)

EuroMagNET II STRUCTURE

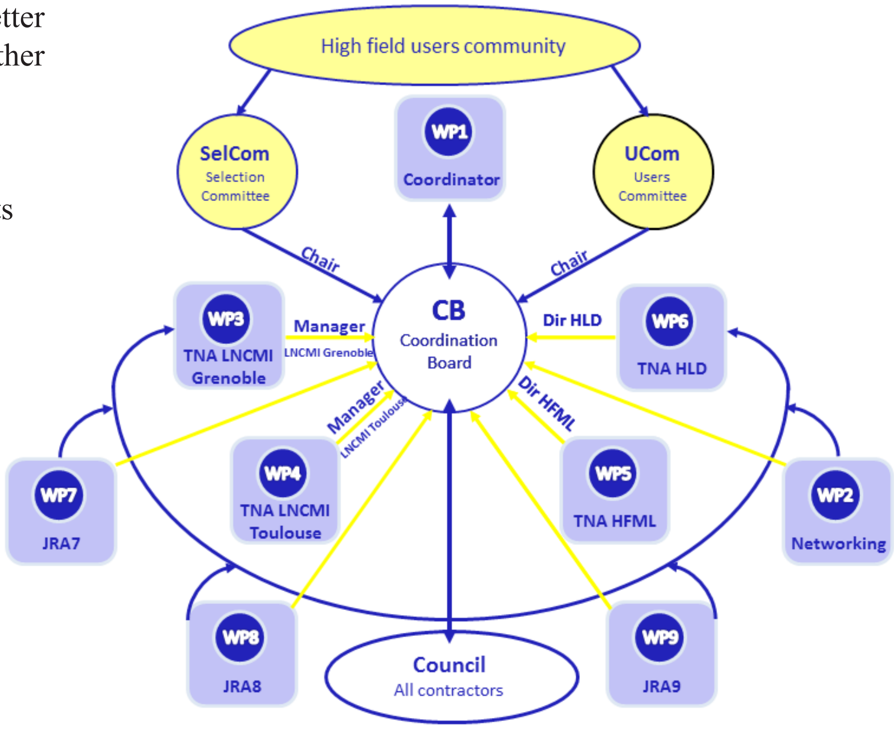
The consortium management structure has been established to ensure efficient and effective management of all the operational, technical and financial aspects of the EuroMagNET II I3, the communication between the consortium and the EC services, the communication with the scientific community and the general public and the dissemination of scientific and technical results.
The Consortium Management, the Networking Activities, the Transnational Acces and the Joint Research Activities are organised into work packages (WP).

- WP1 Management

- WP2 Networking Activity (NA)
  Objective: to structure and expand the high field user community by stimulating the exchange of information between high field user groups, the high field facilities and other potentially interested scientific communities. This is implemented by thematic networks, training and secondments.

- WP3-6 Trans National Activity (TNA)
  Objective: to stimulate and to coordinate the transnational access to all European large infrastructures for high magnetic fields in order to optimally use the capacity and optimally satisfy the users' needs
  - WP3 TNA LNCMI-G Static magnetic fields
  - WP4 TNA LNCMI-T Pulsed magnetic fields
  - WP5 TNA RU-HFML Static magnetic fields
  - WP6 TNA HZDR-HLD Pulsed magnetic fields

- WP7-9 Joint Research Activity (JRA)
  Objective: to improve the performance of existing magnets and instrumentation, and to develop new magnet types and new instrumental techniques to better serve the existing users and to further attract new users
  - WP7 High Field User Magnet Technology and Operation
  - WP8 Nano object measurements and local spectroscopy
  - WP9 Enhanced Sensitivity and Single Scan NMR (ES3-NMR)



EuromagNET2: A coordinated approach to access, experimental development and scientific exploitation of all European large infrastructures for high magnetic fields

A magnetic field is a very powerful thermodynamic parameter to influence the state of any material system. Consequently magnetic fields serve as an experimental tool in very diverse research areas like condensed matter physics, molecular physics, chemistry and, with increasing importance, in biology. The versatility and the universality of magnetic fields as a research tool lies in their coupling to the charge and the spin of the particles that constitute the matter that surrounds us. Many magnetic field based research techniques are standard and can be done with conventional commercially available magnets and associated equipment (MRI-scanners, NMR and ESR spectrometers, conventional superconducting magnets, etc.). On the other hand there are many cases where very high magnetic fields, only available in a few specialized facilities, are essential and where the prospect of new discoveries is often the greatest. This scientific motivation has always formed a strong drive to develop techniques and installations to generate the highest possible magnetic fields and to perform experiments with them. In recent surveys, both by the European Science Foundation (ESF, «The Scientific Case for a European Laboratory for 100T Science», 1998) and by the USA National Research Council («Opportunities in High Magnetic Field Sciences», COHMAG 2005), a compelling case has been made for high magnetic fields as a research tool for a wide variety of research topics and strong recommendations were made to stimulate high magnetic field infrastructures. In this spirit, the EuroMagNET2 IA was created to improve the performance and utility of the European high field facilities and to better serve the European high field user community.

The main objectives and the main results of the EuroMagNET II integrating activity are:

(1) to stimulate and to coordinate the transnational access to all European large infrastructures for high magnetic fields in order to optimally use the capacity and optimally satisfy the users' needs. A common access request procedure and a common selection committee have been created to guarantee this. During this IA, eleven calls for magnet time proposals have been issued and 86% more access has been provided to the European users than foreseen by the EC contract.

(2) to structure and to expand the high field user community by stimulating the exchange of information between high field user groups, the high field facilities and other potentially interested scientific communities. This has been implemented through the organisation of three thematic workshops and three summer schools, the organisation of five user meetings, the attribution of secondment funding, and the publication of a quarterly magazine on new developments at the EuroMagNET2 facilities, that is freely distributed among all potential European high magnetic field users.

(3) to develop new and advanced experimental possibilities as well as improved magnet performance at the EuroMagNET2 infrastructures by joint research activities involving facilities and user groups. These activities will improve the quality of existing instrumentation and will create unique instrumental possibilities, to better serve the existing users and to further attract new users.

Three joint research activities (JRA) are implemented:

- High Field User Magnet Technology and Operation

The central tools of all high field science are the magnets and their power supplies. The focus of this JRA is to jointly enhance the performance, reliability, and ergonomics of the technical installations in the European high field facilities for the benefit of the user community. Important improvements in field noise and drift have been obtained, a detailed study of the heat exchange in DC magnets has been performed and sSeveral special purpose magnets have been designed, built and tested, like radial access pulsed magnets for use in Xray, neutron and laser scattering experiments, and improved homogeneity magnets for pulsed field NMR.

- Nano object measurements and local spectroscopy

An important trend in modern science is the investigation of smaller and smaller structures with properties determined by a nano-sized group of atoms or molecules. Examples are semiconductor quantum dots, organic nanostructures and carbon-based systems like nanotubes and graphene. To unravel their electrical, optical and magnetic properties it is crucial to measure the response of individual nanostructures. The objective of this JRA is to develop new experimental techniques, adapted to the very heavy spatial and temporal constraints of high field magnets, to determine the properties of individual nanostructures and to perform local spectroscopy. During this JRA, setups to perform transport measurements on single nano-objects in pulsed magnetic fields, and single nano-object luminescence and Kerr imaging in DC fields were built and tested and made available for use by external users.

- Enhanced Sensitivity and Single Scan NMR (ES3-NMR)

The aim of this JRA is to jointly develop the necessary instrumentation for cost-efficient NMR experiments in ultra-high magnetic fields and to make it available to the high field user community. The focus of this JRA is the enhancement of the NMR sensitivity, to compensate for the high cost of resistive DC magnetic fields and the limited duty cycles of pulsed magnetic fields. During this JRA, setups for doing single-scan free induction decay experiments in pulsed magnetic fields have been completed and used for experiments on a realistic sample, a cuprate high Tc superconductor. Several methods to improve NMR sensitivity and throughput, like cryogenic low noise preamplifiers, dynamic nuclear polarization and μMAS have been realized.the first pulsed field experiment on a realistic sample, a cuprate high Tc superconductor, was successfully performed.

http://www.euromagnet2.eu

EuroMagNEWS
N°14 / April - June 2012

cnrs@William.Knafo

3rd EuroMagNET Summer School - Science in High Magnetic Fields
September 30 - October 07, 2012 - Rügen - Germany

Cover of
EuroMagNEWS#14

3rd EuroMagNET Summer School

Science in High Magnetic Fields

September 30 - October 07, 2012 - Rügen - Germany

High Magnetic Fields are an indispensable tool to access the fundamental properties of matter.
In the 20th century they enabled significant scientific breakthroughs witnessed by several Nobel prizes, and, undoubtedly, high magnetic fields will continue to play a decisive role in shaping the European research landscape in the future.

Within Europe, high field research is bundled in the EuroMagNET II programme, a coordinated approach to access, experimental development and scientific exploitation of all European large infrastructures for high magnetic fields.

The 3rd EuroMagNET Summer School follows the tradition established by the 1st EuroMagNET Summer School 2007 in Corsica and the 2nd Summer School 2010 in Ameland.
It will be held from 30 September - 7 October 2012 on the North German island Rügen (http://www.ruegen.de/).

http://www.hzdr.de/summerschool

The school is dedicated to recent advances in Science in High Magnetic Fields. Outstanding scientists will give tutorial lectures on different areas such as semiconductor physics, low-dimensional materials and nano-scaled objects, strongly correlated electron systems, magnetism, superconductivity, molecular systems, high-magnetic-field technology and new high-field experimental techniques.

Participants will be selected among young scientist based on their motivation, curriculum vitae and abstract submission. They will have the possibility to present their own work as an oral contribution or a poster. EuroMagNET II will provide substantial financial support for travel and subsistence.

Important dates:
October 2011: 1st announcement and web-page open (via http://www.euromagnet2.eu/)
February 2012: 2nd announcement with list of subjects and invited speakers
15 July 2012: Application and abstract submission deadline
31 July 2012: Notification of acceptance
30 Sept. - 7 Oct. 2012 3rd EuroMagNET Summer School

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Announcement of the
third Summer School

NETWORKING ACTIVITY (WP2)

WP Coordinator: Jochen Wosnitza, HLD, Dresden, Germany

The main objectives of the Networking activities of EuroMagNET II are to stimulate the exchange of knowledge, information and techniques among the community of researchers using high magnetic fields to make it more coherent and internationally competitive.
3 tasks have been implemented: training activities, thematic networks and secondments.

Training activities

Summer Schools

Following a tradition established during the EuroMagNET I programme by a Summer School held in 2007 in Cargèse, Corsica, 2 other EuroMagNET Summer Schools have been organised under the FP7 Program.

- Summer School n°2 on the Dutch island of Ameland from September 5 to 11, 2010.
- Summer School n°3 at Juliusruh on the German island Rügen from September 30 to October 7, 2012.

Each time, more 80 young researchers from 15 different countries have registered to this event.

Prizes

During the International Conference "Research in High Magnetic Fields", which was held in Dresden in July 2009 and which was organized by FZD-HLD, Dr. Cyril Proust has been awarded the EuroMagNET prize for outstanding research performed by use of high magnetic fields.

The prize 2010 was awarded to Dr. Jos Giesbers by the chairman of the EuroMagNET prize committee, Prof. Jochen Wosnitza, director of the Dresden High Magnetic Field Laboratory, during the 2nd EuroMagNET summer school. The award includes a prize money of 2,000 €, a EuroMagNET trophy, and a certificate.

Amalia Coldea from the University of Oxford won the EuroMagNET price 2011.
During the 3rd EuroMagNET Summer School in 2012, Benno Meier was awarded the EuroMagNET price 2012 for his work on pulsed field NMR.

Thematic Networks

A first workshop of the thematic network "Molecular Materials in High Magnetic Fields" took place at October 29, 2009 at the auditorium of the Radboud University Nijmegen, the Netherlands. The workshop was appended to the 3rd International Conference on Magneto Science (Magneto Science 2009) to benefit from the presence of the large Asian (Japanese and Chinese) science community actively engaged in this field of research.
http://www.hfml.ru.nl/magnetoscience2009

A second thematic network meeting has been organized as an extension of the topical course on science with Free Electron Lasers and other THz sources at high magnetic fields. On 15 June 2010, a workshop on the thematic network 'Harmonisation of experimental conditions' has been carried out.
http://www.euromagnet2.eu/spip.php?rubrique72

On September 13-14, 2010 a third thematic network workshop in the frame of “Molecular Materials in High Magnetic Fields” took place at the LNCMI, Toulouse. The title was “Quantum Chemistry in Strong Magnetic Fields”. The goal was to bring together experts in the production of strong magnetic fields, experimentalists in magneto-optics, and quantum chemists to present and discuss the perspectives of the field in view of tighter collaborations between all these different actors.
http://www.euromagnet2.eu/spip.php?rubrique71

A forth thematic network workshop was held during the 22nd Magnet Technology Conference (http://www.mt22.org/) in Marseille, France, from 11 to 16 September 2011. Leading scientists working on ultra-strong conductors and reinforcement materials for superconducting, resistive or pulsed magnets came together in a satellite meeting on 14 September. The aim of this 1st International Meeting on “Materials for high-field magnets” was to put the efforts in developing stronger materials for high magnetic field magnets on an international level.
http://www.euromagnet2.eu/spip.php?rubrique80

The fifth Thematic Network Workshop was held in Les Houches, France from 21 May to 25 Mai 2012 on the topic High field physics of strongly correlated electron system.
http://scef2012.grenoble.cnrs.fr

STRONGLY CORRELATED
ELECTRON SYSTEMS
IN HIGH MAGNETIC FIELDS

SCEF 2012

May 21st → 25th 2012

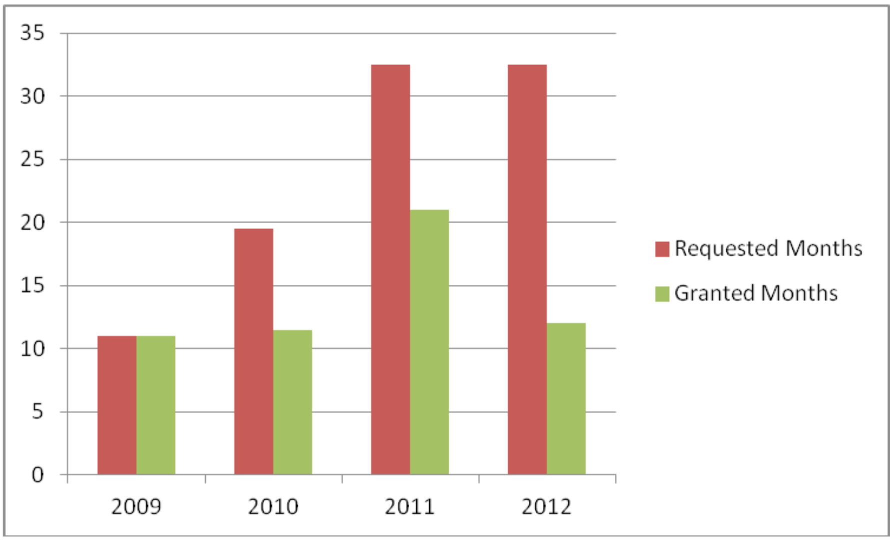
Les Houches (France)

http://scef2012.grenoble.cnrs.fr

2 Topical courses were also organised during EuroMagNET II :
the first one in Dresden from 14 to 16 June 2010 (***http://www.fzd.de/THz2010***) and the second one in Grenoble from 17 to 19 October 2012 (***http://www.esrf.eu/events/conferences/synemag-2012***).

Secondments

As part of the Networking Activities in WP2 an exchange program was established that permitted short, mid and long-term secondments of researchers between institutions, for typically a few weeks up to a few months. This stimulated early-stage as well as experienced researchers to work on all aspects of magnetic-field related topics, such as the preparation of sophisticated experimental setups, the design, development and testing of special high field equipment, the discussion of experimental results as well as writing high-field related publications. The program was very successful. Within four years, a total of 58 applications asking for 95.5 months of exchange time was received. Due to this large request the program was heavily overbooked and only the best projects were granted. After finishing the secondments the scientist had to submit a short report. Besides the development of new experimental high-field techniques, fruitful collaborations and a number of publications resulted from the visits.



TRANS NATIONAL ACTIVITIES (WP3-6)

WP Coordinators: Geert Rikken, LNCMI, Toulouse & Grenoble, France
Jan Kees Maan, HFML, Nijmegen, the Netherlands
Jochen Wosnitza, HLD, Dresden, Germany

In the context of the EuroMagNET II project, the four facilities

- LNCMI - Grenoble - France: Static magnetic fields to 35 T
- HFML - Nijmegen - the Netherlands: Static magnetic fields to 33 T
- HLD - Dresden - Germany: Pulsed magnetic fields to 80 T
- LNCMI - Toulouse - France: Pulsed magnetic fields of long duration to over 80 T and short duration to over 150 T.

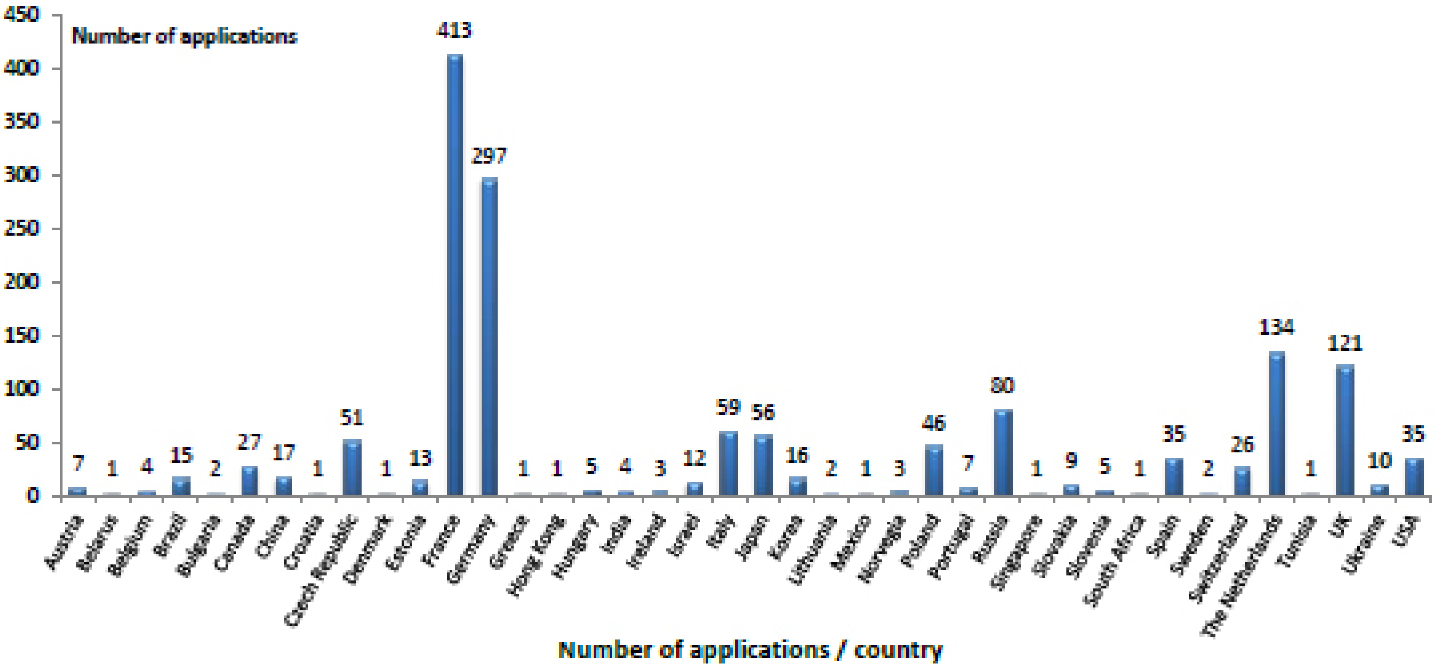
operated a joint TNA program, which gave full access to their installations and all accompanying scientific infrastructure to qualified external users, together with the necessary support from their scientific and technical staff, at no additional cost to these users.

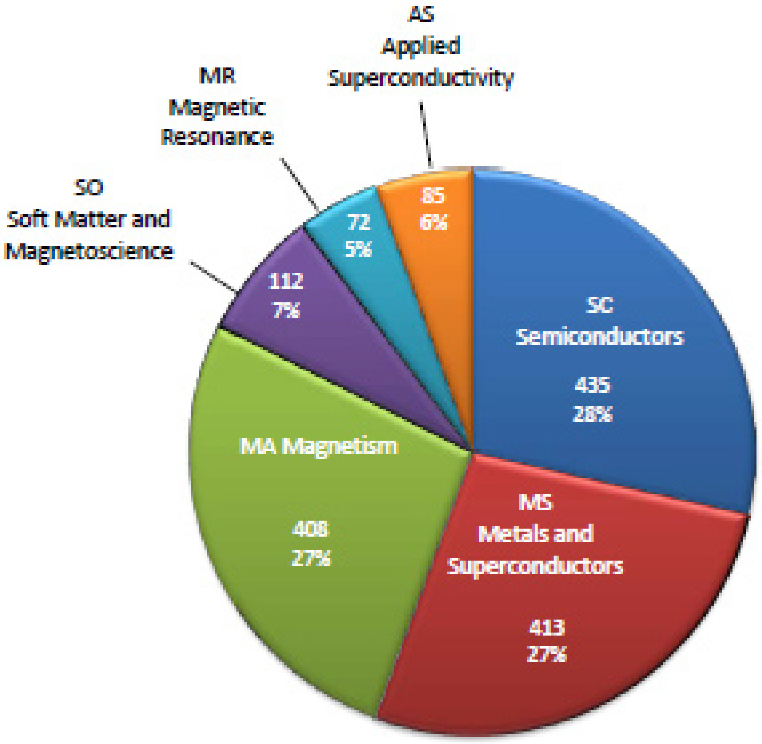
Eleven calls for proposals have been launched during 2009-2013 inviting proposals for research requiring access to one of the large installations for high magnetic fields collaborating within EuroMagNET II.

- Call#0 / 165 applications from 24 different countries
  Evaluation by selection committee on December 2008
- Call#1 / 133 applications from 20 different countries
  Evaluation by selection committee on June 12th, 2009
- Call#2 / 158 applications from 21 different countries
  Evaluation by selection committee on December 15th, 2009
- Call#3 / 113 applications from 21 different countries
  Evaluation by selection committee on June 16th, 2010 (face-to-face meeting, Dresden, Germany)
- Call#4 / 120 applications from 19 different countries
  Evaluation by selection committee on December 2010 (phone)
- Call#5 / 130 applications from 20 different countries
  Evaluation by selection committee on June 24th, 2011 (face-to-face meeting, Toulouse, France)
- Call#6 / 128 applications from 20 different countries
  Evaluation by selection committee on December 2011 (phone)
- Call#7 / 147 applications from 21 different countries
  Evaluation by selection committee on June 15th, 2012 (face-to-face meeting, Grenoble, France)
- Call#8 / 146 applications from 21 different countries
  Evaluation by selection committee on December 2012 (e-mail)
- Call#9 / 118 applications from 18 different countries
  Evaluation by selection committee on on June 14th, 2013 (face-to-face meeting, Nijmegen, Netherlands)
- Call#10 / 167 applications from 20 different countries
  Evaluation by selection committee on December 2013 (e-mail)

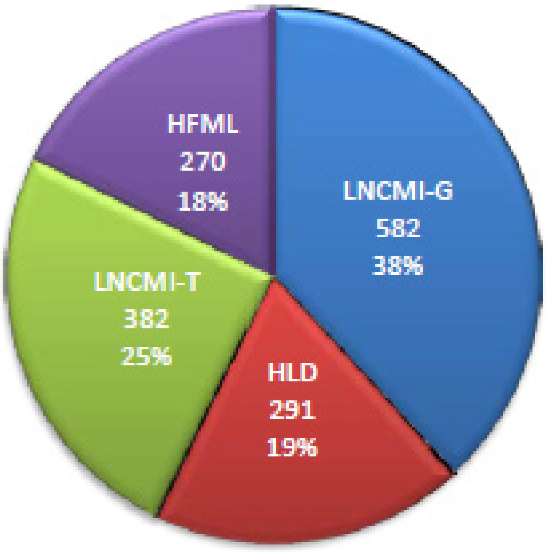
Facilities	Number of access Planned for 2009 - 2012	Number of access Planned for 2009 - 2013	*Total access delivered for 2009 - 2013*	TNA EuroMagNET Access delivered for 2009 - 2013	TNA EuroMagNET Access EC Requested for 2009 - 2013
LNCMI - T	1 600 shots	1 700	*9 323*	2 234 *(+31%)*	1 870
LNCMI - G	2 400 hours	2 600	*14 651*	4 755 *(+83%)*	2 860
HFML	1 200 hours	1 300	*7 173,17*	3 344,5 (+157%)	1 430
HLD	750 shots	800	*3 217*	1 589 *(+99%)*	800

EuroMagNET II has received 1 525 applications from 40 different countries.





Distribution of applications
by scientific domain



Distribution of applications
by facility

JRA7 High Field User Magnet Technology and Operation (WP7)

WP Coordinator: Walter Joss, LNCMI, Grenoble, France

Objective

The current impact of magnetic fields on science is mainly due to the wide availability of high magnetic fields and the accompanying scientific instrumentation to a large scientific community, by means of access to several large research infrastructures in Europe, the USA and Japan. High field magnet development and operation requires sophisticated knowledge in materials science, mechanical and electrical engineering as well as in advanced modeling and simulation. In Europe, the different high field facilities have historically operated in an independent manner, which limits their effectiveness in magnet development. The Joint Research Activity "High Field User Magnet Technology and Operation" (JRA7) of the EuroMagNET2 Integrating Activity aims to improve significantly the collective performance, reliability, versatility, and user friendliness of the magnets at the four high field infrastructures of the EuroMagNET network. Collaborative approaches have been realized wherever possible. The improved usefulness translates into improved field intensity and quality and special purpose user magnets. The achievements of this work package will benefit the general user community of the EuroMagNET facilities, and also more concretely the activities of JRA9 "ES3-NMR" and JRA8 "Nano-object measurements" described below.

Main achievements for 2009-2013

The activities of JRA7 are structured into different tasks, each with its own deliverables, and their main achievements are outlines below:

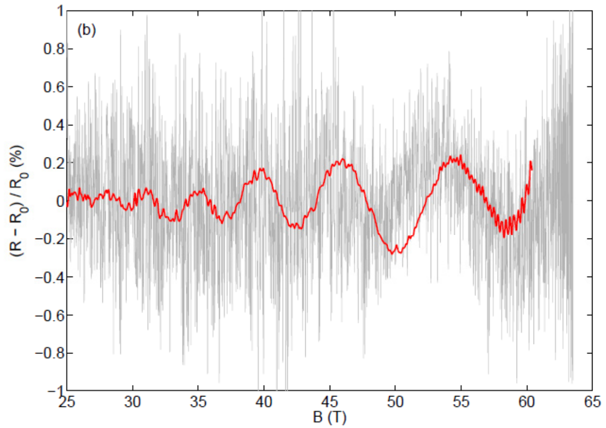
Task 1: Inventory & benchmarking of magnet technology at the infrastructures

A common database for the EuroMagNET II network has been created to share materials and structural data relevant for magnet design, for technical information exchange and knowledge dissemination between all EuroMagNET II partners. It has led to exchange, synergy effects and design improvements both for DC and pulsed magnets. Focused characterization efforts have been made to complete the database where information was scarce, like on new insulating materials for pulsed magnets and on heat transfer for water cooling of DC magnets. For this latter aspect, a dedicated hydraulic test loop was constructed, that allows to measure heat transfer coefficients of structures, surface treatments etc

General view of the hydraulic test loop

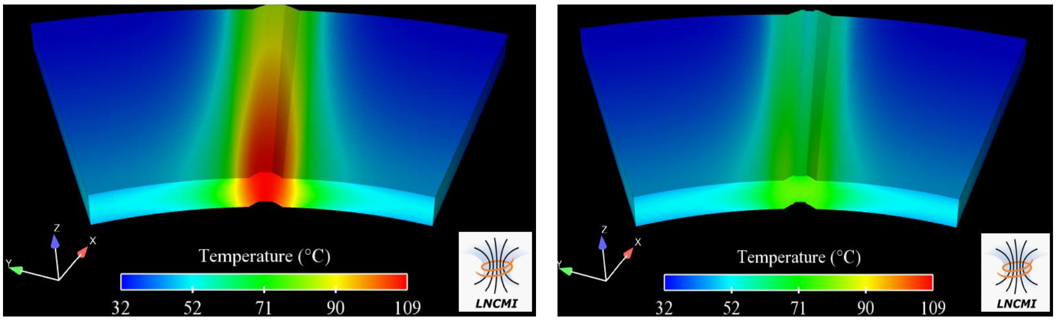
Task 2: Improved user magnet performance

The main characteristic of a high field magnet are its field strength, bore diameter, and for pulsed magnets, the pulse duration. However many other factors determine the ergonomics and utility of high field magnets, like noise, stability, lifetime, cooling and duty cycle for pulsed magnets. Within this task, large efforts have been made to improve all these seemingly secondary aspects, often with quite good results as shown below for noise reduction on a HLD pulsed field coil.



Noise reduction in pulsed magnets ;
a typical magneto transport measurement before (gray) and after (red) implementing different mechanical and electrical noise reduction strategies.

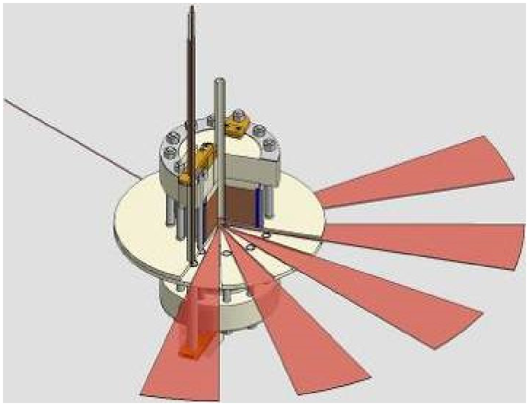
Other significant improvements obtained are the cooling rate of pulsed magnets through axial channels, the radial cooling of the LNCMI polyhelix magnets through micro-channels and the noise and drift of the LNCMI DC power supply. All these improvements increase the strength, quality or quantity of magnetic fields offered to the EuroMagNET users.



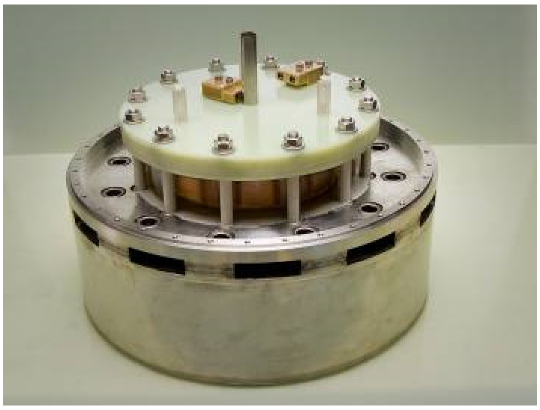
3D modelization of the effect of the addition of a microchannel on the temperature of a radially cooled helix.
Left (actual configuration), right with the additional microchannel. A reduction of the maximum temperature by 25 C was calculated, and confirmed by experiment.

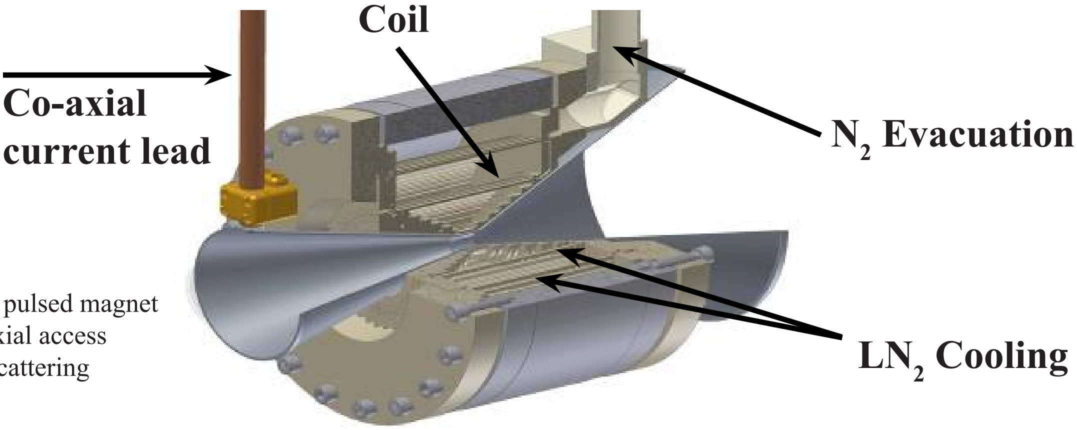
Task 3: Special purpose magnets

Standard high field magnets are solenoids, with a limited high firld region in their center, and with only access to this region along the magnetic firld direction. However, there are plenty of experiments that require an access perpendicular to the magnetic field, a large access angle, an extended magnetic field region, parallel or perpendicular to the field, or very good homogeneity in a certain volume. Examples are several optical techniques, neutron scattering, NMR etc. In order to open high magnetic field experiments to such techniques, this task has designed and constructed several special purpose magnets. In particular radial access, conical access, very long pulse and high homogeneity pulsed magnets were constructed and put into use in the user program. A 12 MW radial access DC magnet was designed and costed, but for lack of funding, could not be constructed yet.



Full angle radial access 30 T pulsed magnet.
Left: schematic view.
Right: Magnet with top half of the cryostat removed.





Rapid cooling 40 T pulsed magnet
with conical axial access
for neutron scattering

JRA8 Nano object measurements and local spectroscopy (WP8)

WP Coordinator: Peter Christianen, RU, Nijmegen, The Netherlands

Objective

An important trend in modern science is the investigation of smaller and smaller structures with properties determined by a nano-sized group of atoms or molecules. Examples are semiconductor quantum dots, organic nanostructures and carbon-based systems like nanotubes and graphene. To unravel their electrical, optical and magnetic properties it is crucial to measure the response of individual nanostructures. In ensemble measurements only the average value of an observable parameter is detected, and limited information is obtained about the contribution of individual objects to the overall process. For instance, temporal information about dynamical processes might get lost by ensemble averaging, as well as spectroscopic information when the averaging occurs over objects that are not precisely identical.
Stimulated by the increasing demand from the high field user community to extend local probe and single-object measurements up to the highest magnetic fields, this JRA aimed to develop a complementary set of advanced experimental (both electrical and optical) techniques in pulsed and continuous magnetic fields to benefit from the powerful combination of nanoscience and high fields.
At high fields the magnetic length (4 nm at 40 T) becomes comparable to typical dimensions of nano-objects, leading for instance to significant changes in their energy spectrum, allowing advanced magneto-spectroscopy experiments.

Main achievements for 2009-2013

Task 8.1 Electrical transport on individual nano-objects in pulsed fields

Several low-temperature experimental set-ups have been developed to measure transport properties of individual nano-objects in the pulsed field magnets of LNCMI-Toulouse (Figure 1) and HLD-Dresden (Figure 2). For this type of experiments electronic filters and shielding protect the nano-devices against the aggressive electrostatic environment due to the capacitors bank. The equipment is available for users and has been used to investigate several types of individual nanostructures. The right panel of figure 1 shows the resistance of chemically derived graphene nanoribbons (GNRs). The application of a perpendicular high magnetic field induces a marked enhancement of the conductance, irrespective of the applied gate voltage and in large contrast to the magnetofingerprints of graphene flakes. Landauer-Büttiker conductance simulations convincingly support the scenario of an entangled interplay between the magnetic bands formation and a disorder-induced interband scattering suppression.

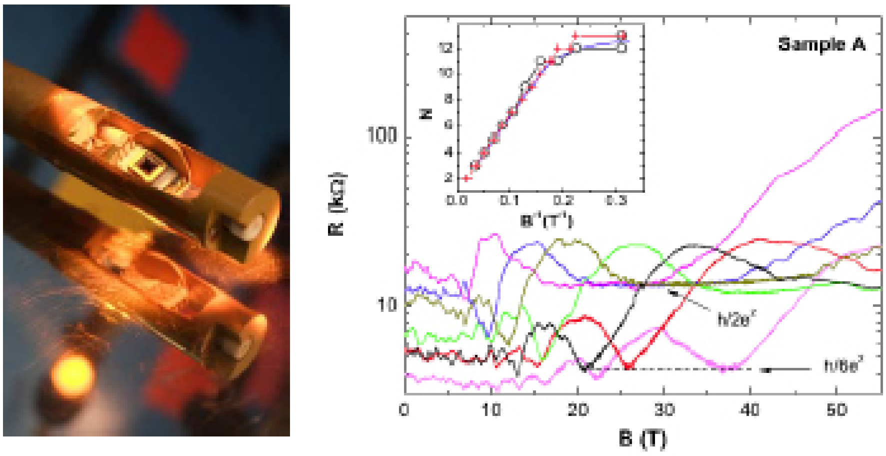
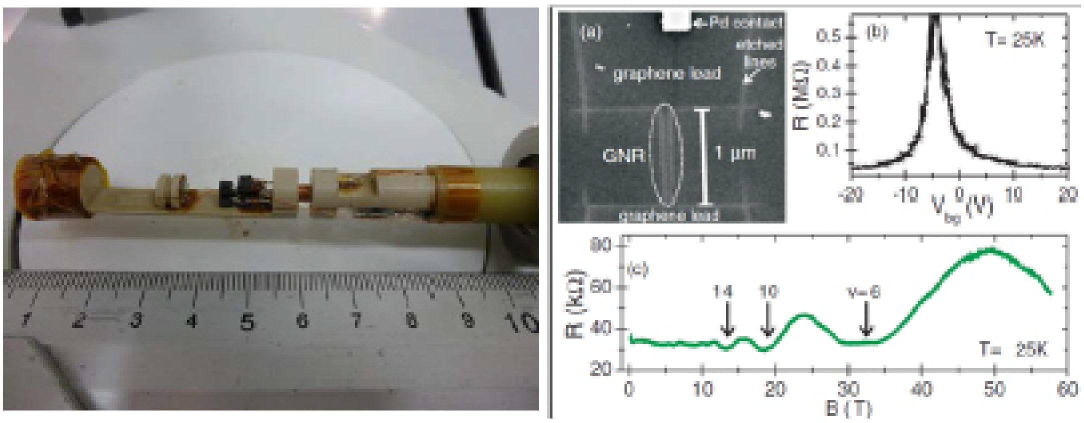


Figure 1: Left panel: rotating sample holder for single nano-object transport measurements in pulsed magnetic field at the LNCMI-Toulouse. Right panel: magnetoresistance of a 100 nm thick graphene nanoribbon for several bias voltages in pulsed magnetic fields (Ribeiro et al. Phys. Rev. Lett. 107, 086601 (2011).

The right panel of figure 2 shows magnetotransport of GNRs in fields up to 60 Tesla. At high carrier densities Shubnikov-de-Haas oscillations and the quantum Hall effect were observed, while at low densities the oscillations disappear and an initially negative magnetoresistance becomes strongly positive at high magnetic fields. The strong resistance increase at very high fields and low-carrier densities is tentatively ascribed to a field-induced insulating state in the bulk graphene leads.



- *Figure 2: Left panel: the lower part of the insert for single nano-object transport measurements in pulsed magnetic field at the HLD-Dresden. Right panel: (a) Scanning electron microscope image of a typical graphene nanoribbon (GNR) sample. The length of the GNRs is 1 µm, the width is 70 nm. (b) Two-terminal resistance as a function of gate voltage at zero magnetic field. (c) Magnetoresistance trace at showing profound quantum Hall features (S. Minke et al. Phys. Rev B 85, 195432 (2012)).*

Task 8.2 Single-object photoconductivity in DC and pulsed fields

Several low-temperature experimental set-ups have been developed to measure photoconductivity of individual nano-objects in both pulsed field (LNCMI - Toulouse) and DC magnets (LNCMI – Grenoble) (Figure 3). The equipment is available for users and has been used to investigate several types of individual nanostructures.

Figure 3: Left panel: Lower part of the insert for photoconductivity experiments in pulsed field magnets at the LNCMI – Toulouse. Right panel: Lower part of the insert for photoconductivity experiments in DC field magnets at the LNCMI – Grenoble.

Task 8.3 Time-resolved Photon-Correlation spectroscopy in DC fields

Inserts for single object spectroscopy and photon correlation methods have been fabricated (Figure 4) and successfully applied to a broad range of nanoscale objects: photoluminescence on single semiconductor quantum dots/rings and individual carbon nanotubes, as well as micro-magneto-Raman scattering on graphene. An example of a typical result is shown in the right panel of figure 4, which illustrates the magnetic field evolution of the photoluminescence spectra from a single CdTe quantum dot with a single Mn2+ ion.
Photon correlations experiments on semiconductor quantum dots have been applied to study charge fluctuation effects. These investigation emphasize the importance of the actual semiconductor environment for the optical properties of quantum dots and, in consequence, for their applications in optoelectronics. The insert is available for the user programme.

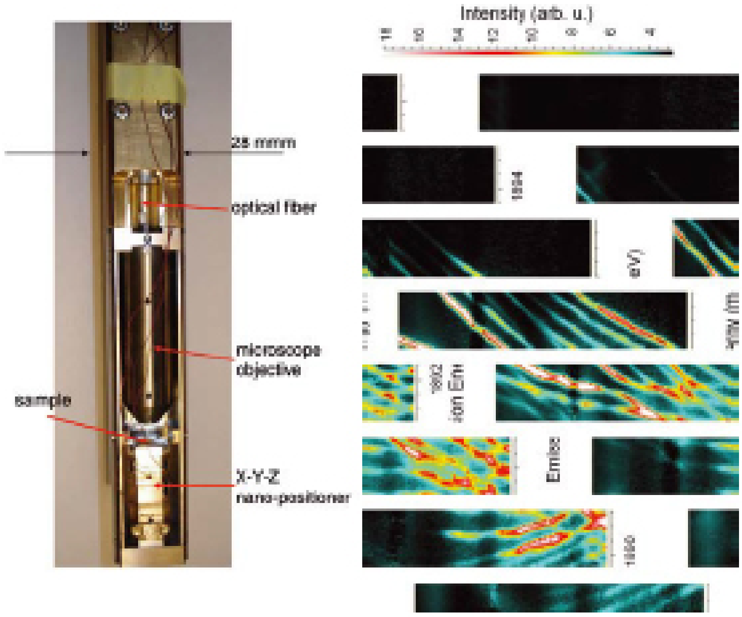
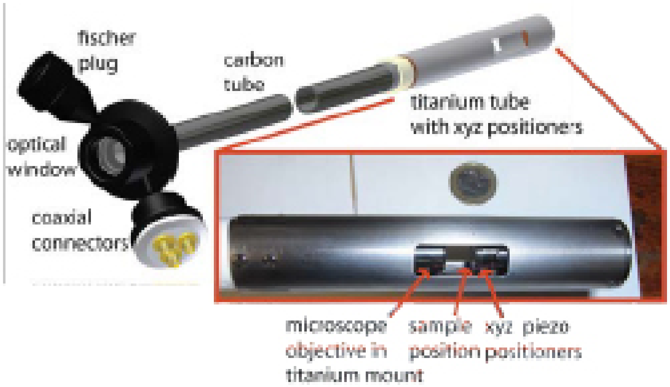


Figure 4: Left panel: the lower part of the insert for single nano-object photoluminescence experiments at LNCMI – Grenoble. Right panel: color-scale plot of the photoluminescence intensity of a single Mn-doped quantum dot as a function of emission energy and magnetic field. The observed emission lines can be assigned to bright (X) and dark (DX) exciton transitions. (M. Goryca et al., Phys. Rev. B 82 165323 (2010)).

Task 8.4 Photoluminescence and Magneto-Optical-Kerr-Effect imaging in DC fields

A probe for photoluminescence and magneto-optical Kerr-effect imaging has been developed at HFML – Nijmegen using a design that is complementary to the LNCMI – Grenoble set-up (Task 8.3).

The insert fits in the 50 mm bore, 31 T Florida-Bitter magnet of HFML and consists only of titanium and carbon materials to improve the positional stability up to the highest fields. It is equipped with xyz piezo positioners with read-out of their position using encoders. Because of the lens-design it is possible to independently control the excitation and detection light, which allows for detecting photoluminescence emission as a function of the position relative to the laser excitation spot (imaging). Alternatively, the emission of individual nano-objects can be measured. A typical result is shown in Figure 5, which displays the PL emission of an individual Ga(AsN) quantum dot in magnetic fields up to 30 T.



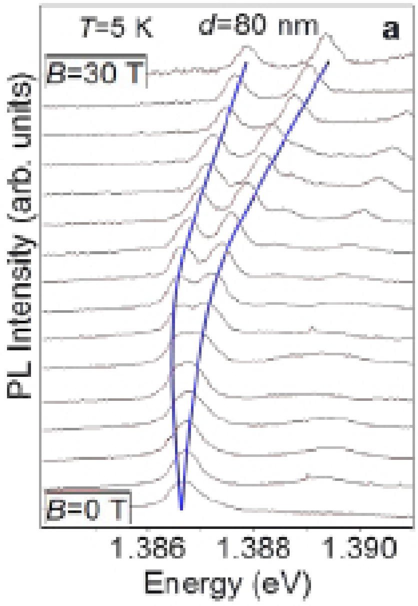


Figure 5: Top panel:overview of the HFML - Nijmegen photoluminescence imaging insert. Right panel: Magneto-photoluminescence of site-controlled Ga(AsN) quantum dots that are fabricated by a novel nanofabrication method based on nitrogen passivation by hydrogen in GaAsN (R. Trotta et al., Adv. Mat. 23, 2706 (2011).

The insert is available for users and has been used for experiments on a broad range of different nano-objects: monodomains of self-assembled colloidal quantum rod arrays, single semiconductor quantum dots, wires and rings. Figure 6 shows the magneto-photoluminescence spectrum of a single GaAs wire spectra, measured both at the LNCMI – Grenoble and HFML Nijmegen facilities. A problem with the production of these nanowires is that the material can crystallize in different crystal structures much easier than bulk material, resulting in non-homogeneous structures with poor optical properties. These results now showed GaAs nanowires of excellent quality, which even approaches the quality of the best bulk material, which is promising for the application of such nanowires in small electronic devices.

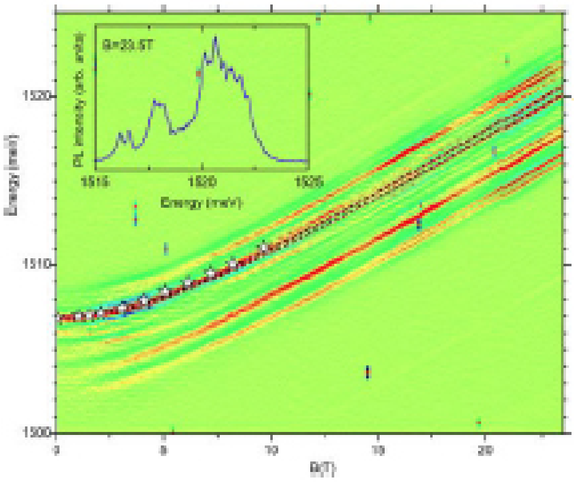


Figure 6: False color plot of the differential micro-photoluminescence spectra of a GaAs nanowire, showing the evolution of the emission as a function of magnetic field applied perpendicular to the wire axis. Inset represents a photoluminescence spectrum at 23.5 T (P. Plochocka et al. Nano Lett. 13, 2442 (2013)).

JRA9 Enhanced Sensitivity and Single Scan NMR (ES3-NMR) (WP9)

WP Coordinator: A. Kentgens, RU, Nijmegen, The Netherlands

Main achievements for 2009-2013

The largest research field using superconducting high field magnets is arguably the NMR community, both for spectroscopy and for medical (MRI) applications. Originally developed as a curiosity in physics, it matured into an indispensable tool in materials science, structural chemistry and biology and in routine chemical analysis for many fields in industry and medical diagnostics. The NMR field continues to push for higher and higher magnetic fields, mostly to increase the information content of 2D correlation spectroscopy in large (bio) molecules. Higher field provide an intrinsic higher sensitivity and resolution. The NMR industry (Bruker, Agilent, JEOL and others) provides commercial instruments at fields up to 24 T (1 GHz proton frequency), while novel spectrometers are expected to become available in the next two years for fields up to 28 T, using inner coils made of high Tc superconductors. Exploration of NMR opportunities at even higher field necessary requires the use of resistive or hybrid magnet technology, as is presently available in several high magnetic field user-facilities around the world. Both Japan and the US embarked on ambitious programs to capitalize on these opportunities. The present JRA was started with the motivation to improve accessibility of the European facilities for NMR research and to develop new instrumentation to open exploratory new research fields. The main arguments why NMR at magnetic fields above 20-30 Tesla would be attractive, can be summarized by the following points.

- In many correlated electron systems, the magnetic field itself induced structural or quantum phase transitions. NMR can be a unique tool to study local interactions and symmetries for various nuclei in the system.
- The majority of the periodic system comprises of nuclei with a spin larger than S=1/2. These so-called quadrupolar nuclei have additional interactions, most notably to the electric field gradients in the lattice that leads to additional information content. Technically, the experiment becomes more challenging because the spectral width (typically 10's of Hz in a liquid state experiment) can increase to span many MHz. The sensitivity for these (mostly low γ) nuclei is very low and experiments require excessive amounts of measurement time. At higher magnetic fields, the quadrupolar spectral width reduces and with the improved Boltzmann polarization factors one can reduce the measurement time, opening new fields of materials science.
- Even in the case where the quadrupolar coupling is weak, it is often difficult to distinguish different sites in the lattice because of overlapping signals. This can be resolved by more advanced (multi-quantum) correlation NMR at the expense of a substantially longer measurement time. 1D NMR at fields above 30 T could resolve the spectrum in a direct way.
- The NMR chemical shift range for protons is rather limited. For this reason most structural biology experiments are targeting 13C nuclei, which provide a better spectral resolution but at the expense of a lower sensitivity. At very high magnetic fields, the Zeeman splitting becomes larger than the other spin-spin interactions and it is possible to obtain proper resolutions in the proton spectrum. Combined with the mature toolbox in multi-dimensional NMR this can provide a unique tool to unravel structural and dynamical interactions in complicated biomolecules.
- In materials science, NMR is mostly used for analysis of powder samples. Applications to functional devices, such as thin film layered structures or small single crystals is generally not possible. With novel techniques that improve sensitivity at high magnetic fields it is hoped that NMR can become effective for functional devices under realistic working conditions.

With these arguments in mind, the European partners decided to embark on an ambitious research and development program to extend the frontiers for high magnetic field NMR at the large scale facilities in Grenoble, Nijmegen, Toulouse and Dresden. From the outset it was clear that the challenges are formidable and the specifications of the resistive or pulsed field magnets are at least a factor 1000 away from the desired stability and homogeneity to compete with routine superconducting NMR instrumentation. Also, the effective measurement time at the resistive magnets is far from the standard 24/7 operation in modern NMR spectrometers. For this reason, the emphasis was partly placed on improving NMR detection sensitivity including options to transfer the much larger electron spin polarization to the nuclear spin system. For the pulsed field facilities, the challenges are even more ambitious as the weak NMR signal must be captured ‘on the fly’ in a very fast changing field.

Unfortunately, the funding of the project did not allow to proceed with sufficient manpower and essentially without investment funds to implement the rather expensive tools that are needed. The EU budget for high field NMR, as represented by this JRA, is estimated to be at least an order of magnitude below for example the US efforts. In the last five years worldwide investments for new NMR instrumentation can be estimated at above 5 Billion Euro (excluding MRI and excluding manpower and infrastructure at the research institutes). The present JRA thus represents only a small (0.01 %) ripple in the total NMR effort. To a large extend, the present JRA must be considered mainly as an exploration of the possibilities for future realization. Nevertheless, the present consortium is proud to present the results. It is safe to claim that Dresden and Toulouse are leading in the development of pulsed field NMR. Also in the field of NMR investigations of quantum phase transitions in correlated electron systems Grenoble is ahead of our international competitors. Nijmegen has shown that high resolution solid state NMR in resistive magnets is feasible, including 2D options, down to about 0.2 ppm and with potential for improvement. Novel technologies developed in the various labs have shown that improved sensitivity allows the measurement of functional materials even at the level of the most challenging quadrupolar systems. Note that many of the development are also valuable for the next generation high Tc magnets that will most probably be actively driven and will have less than optimal homogeneity with possible field drift/fluctuations.

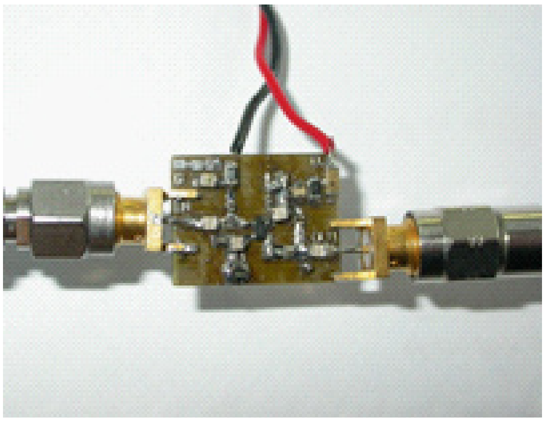
To capitalize on these efforts it is necessary to make the next step, in terms of additional investments and the implementation of new dedicated NMR research groups at the various facilities. In particular it would be beneficial to implement a dedicated hybrid magnet for prolonged NMR experiments at one of the European sites. In this report we will reproduce the original tasks as specified at the outset of the project (in italics) and give a short summary of the main results that were achieved. For more details we refer to the interim reports and to the specific deliverable and milestone items.

Task 1 Cryogenic probe heads for pulsed field solid state NMR

The aim is to develop cryogenic probe heads, containing very low noise preamplifiers in order to have the best possible signal-to-noise ratio in a single free induction decay. These probe heads should be operating at discrete frequencies between 200 MHz and 1 GHz and be able to function inside pulsed magnetic fields up to 60 T and at temperatures between 1.2 and 77 K. The main issues are the development of robust and compact cryogenic low noise amplifiers, their compatibility with very strong and pulsed magnetic fields, and their protection against RF overload without degrading their noise performance.

Based on previous tests and hands-on knowledge transferred from the Leipzig partner, we have designed and constructed a cryogenic probehead operating around 250 MHz, with the preamplifier still at room temperature. We have successfully observed single shot free induction decay, but several modifications will be necessary to improve the mechanical stability and the RF performance.

In the meantime a dedicated RF electronics laboratory has been created, equipped with a fast oscilloscope, spectrum analyzer and network analyzer, in order to develop and characterise low noise RF preamplifiers. A temporary RF engineer has been hired to perform these tasks.

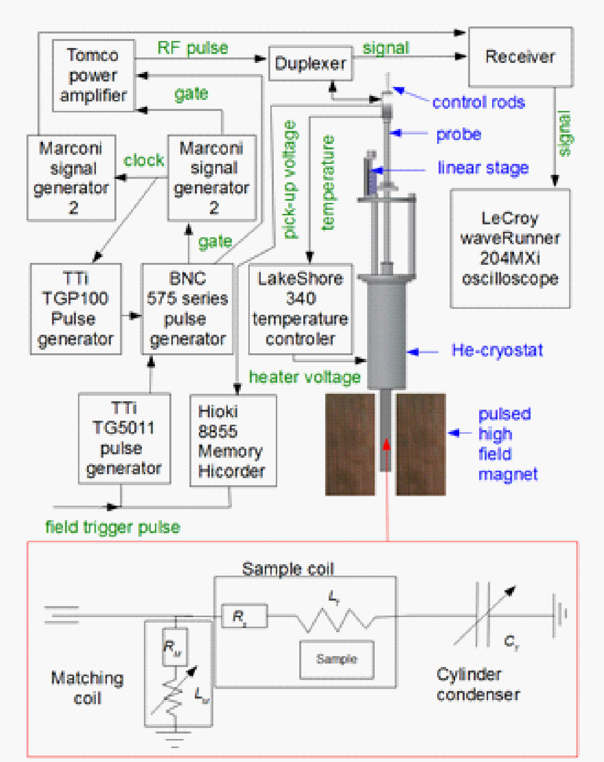

Cryogenic LNA

A literature study of available cryogenic low noise amplifiers has been completed, and based on literature designs, the first compact one-stage cryogenic LNA has been constructed and tested, with quite promising behaviour (NF = 0,5 dB at 77 K, measured at the LAAS, a micro-electronics laboratory in Toulouse) . Other LNA's are under construction and will be characterised with the new in-house equipment.

Task 2 Design and optimization of pulsed NMR magnet setup

In this task we develop NMR spectrometers that can efficiently operate in pulsed magnetic fields. Pulsed field magnets are characterised by a rather poor spatial homogeneity, the absence of a temporally constant field, and very low repetition rates. The main issues are the optimisation of the magnet design, accurate synchronization with the magnetic field pulse, and reproducibility of the field pulses.

The University of Leipzig (ULEI) and the Forschungszentrum Dresden-Rossendorf (FZD) have set up a new 2.7 GHz NMR Spectrometer. This equipment was installed at the Dresden High Magnetic Field Laboratory (HLD) at FZD. We will add another radio frequency (RF) signal analysator to the console in order to be able to perform double resonance experiments. During this project, a spectrometer and a probehead for nuclear magnetic resonance (NMR) measurements was set up at the LNCMI and is now available for measurements. We developed the necessary adjustments to the method to cope with the inherent time-dependence of a pulsed magnetic field. We showed that signal-averaging can be performed even in a pulsed magnetic field [1] as well as the feasibility of advanced NMR experiments. Here, we were able to measure the longitudinal relaxation time T1 and shifts of in between two different compounds in a single measurement (publication in preparation). Further investigations are ongoing.

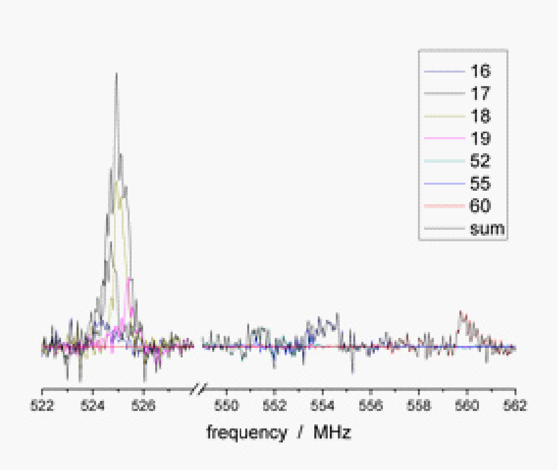


Schematic of the pulsed field NMR spectrometer at Toulouse

Task 3 NMR experiments in pulsed magnetic fields

The aim is to perform pilot solid state NMR experiments in pulsed magnetic fields up to 60 T with the NMR spectrometer and cryogenic probe heads described above.

The spectrometer operates satisfactorily and with it we have performed successfully 1H, 27Al, ^{63}Cu, ^{65}Cu and ^{93}Nb-NMR experiments, using frequencies up to 600 MHz and pulsed magnetic fields up to 50 T. As ultimate test of the spectrometer performance, we have performed a pulsed field NMR experiment on a single crystal of $YBa_2Cu_3O_{6.51}$. Sample size was 2.5x1.5x0.3 mm^3 in a rectangular RF coil wound from silver wire with outer dimensions 3x2x0.5 mm^3. We were able to identify the $_{63}$Cu centre line and the satellites associated with specific copper atom positions in the crystal. In addition we observed the $_{65}$Cu central line. The result is shown in the figure. This successful 'proof-of-concept'-experiment on YBaCuO shows that NMR in pulsed high-field magnets is now approaching a degree of maturity, sufficient for actual scientific applications. Basically, the signal-to-noise ratio needs to be further improved and a better field reference is needed, allowing averaging over several field pulses. These issues will be dealt with by improving the shielding of the spectrometer (since the noise level is currently limited by external perturbations – not by thermal noise) and adding a substance with a known NMR line position to the sample. Tests show that an improvement of the SNR by at least a factor of 3 is still possible.



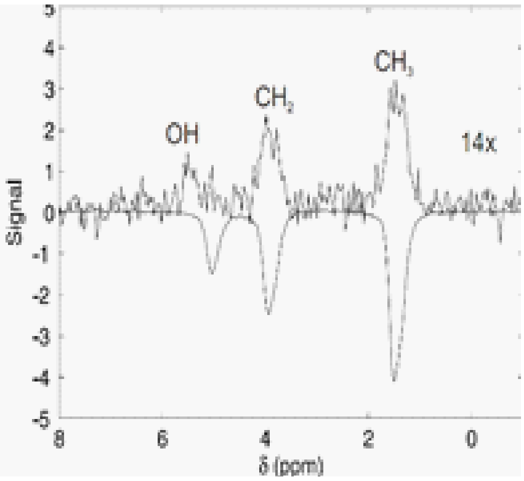
Series of deconvoluted MR spin echo-spectra of a single crystal of $YBa_2Cu_3O_{6.51}$ measured during a single magnetic field pulse with maximum at (46.8±0.5) T.

Task 4 Sensitivity optimized NMR instrumentation for DC fields

In this task we intend to provide tailored options for sensitivity optimized general purpose NMR up to the highest available DC fields of currently 35 T and to place them at the disposal of the user groups of the high field facilities. Its implementation will make these laboratories more attractive for a wider research community, in particular for chemists and material scientists. In addition, these developments will also lead to a more cost effective use of the high field facilities.

Task 5 Dynamic Nuclear Polarization (DNP) at high magnetic fields

The aim of this task is to improve NMR measurements by increasing the nuclear spin polarization beyond the thermal Boltzmann level. This may help to reduce measurement time and improve the cost-effectiveness of high field NMR. In Dynamic Nuclear Polarization one attempts to transfer the much bigger electronic spin polarization to the nuclei. In the solid state this requires low temperature Magic Angle Spinning under high B1 microwave excitation. In addition, we will explore the limits for Overhauser Dynamic Nuclear Polarization in solution. In theory one predicts that the efficiency of the Overhauser coupling decreases at higher frequency. We will test various strategies to improve high frequency DNP, either based on improvement of the electron-nuclear contact or by reduction of the relaxation losses. The basic technical objective for efficient DNP is the construction of a highly efficient resonator structure that allows simultaneous EPR and NMR.



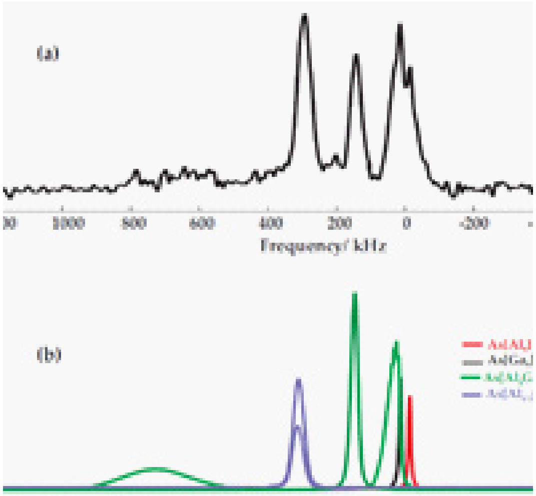
Liquid state Overhauser DNP on ethanol.

Liquid state Overhauser DNP of water molecules is possible with a maximum enhancement of -165 at a field of 3.4 T. The NMR SNR at this polarization level equals that of a similar experiment at a high magnetic field of about 60 T. Modelling the dynamics with in situ experimental verification provides a quantitative prediction of the field dependent DNP efficiency. It is predicted that for supercritical solvents such as CO_2 at pressures above 200 Bar, the Overhauser effect remains sizable for fields up to 15 T. A microfluidic NMR probe coupled to a supercritical chromatography instrument is developed and is now operational. The present setup (without DNP) allows single scan NMR spectroscopy of small molecules with an SNR~1 for 0.1 nano-mole of protons or about 2 nano-mole ^{13}C spins in the sample, with uncompromised resolution (~1Hz at 14 T). A new method is introduced to combine solid state DNP with liquid state NMR detection. For this purpose a low temperature microwave cavity is combined with fast capillary sample shuttling and controlled melting at a time scale of about 300 ms or less. With this setup, a DNP enhancement is demonstrated of about 50-100 above the equilibrium Boltzmann polarization for protons. Both methods (supercritical Overhauser and rapid melt solid DNP) could in principle be used in the context of high field resistive magnets. For example in the case of a wide bore hybrid magnet, the DNP could be done at the low field of the superconductor magnet (8-12 T), followed by a ramp to full field. The only requirement is that the sweep time is less than the nuclear relaxation time. This is possible for some 13C nuclei in the liquid state and probably for most proton and 13C nuclei in the low temperature solid phase if the temperature is close to the liquid helium range. The previously presented methods using a special Ferroshim and a dedicated high bandwidth NMR frequency lock demonstrate the capability to perform high resolution 1D and 2D NMR experiments. At the HFML such experiments combined with DNP could for example be possible if the superconductor of the 30 T hybrid becomes operational.

Task 6 Single scan multidimensional NMR

One of the most important aspects of NMR spectroscopy is the ability to study local interactions, dynamics and order/disorder at an atomic scale, even when there is no long range ordered crystallographic structure. This is usually done in a 2D or 3D experiment where a relevant parameter is systematically varied. The downside of multi-dimensional NMR is that it requires long measurement sequences. In fully automated superconducting spectrometers this is not a problem, but in resistive magnets this becomes critical in terms of energy and financial costs. If a single scan FID contains sufficient information, it is possible to perform a 2D NMR experiment in a single scan by multiplexing the experiment over different sections of the sample. The methodology for single scan 2D NMR, as developed at the Weizmann institute is at a mature state. The goal is to explore options for the transfer of this methodology to high field magnet facilities.

In anticipation of the adaptation of the 30T hybrid for prolonged NMR measurements we decided to concentrate the work in this task on the development of efficient NMR detection schemes for ultra wideline quadrupolar systems. A CP pulse sequence is developed with an excitation bandwidth that is up to ten times greater than that available from a conventional spin-locked CP pulse sequence. The pulse sequence, broadband adiabatic inversion CP (BRAIN-CP), makes use of the broad, uniformly large frequency profiles of chirped inversion pulses, to provide these same characteristics to the polarization transfer process. In addition, we have successfully utilized a new sensitivity enhancement scheme, viz., Side Band Selective Double Frequency Sweep (ssDFS) to enhance the NMR central transition, CT, of half-integer spin quadrupolar nuclei in solid-state NMR experiments. In this scheme, the population of the nuclear spin states associated with the satellite transitions, STs are manipulated in such a way that the population difference between the central mI = 1/2 and mI = -1/2 energy states is increased resulting in sensitivity enhancement of the CT. At ultra high magnetic field, the quadrupolar spectral width will decrease not only on a relative (ppm) but also on an absolute (kHz) scale and a combination of high B1 microcoils with BRAIN-CP excitation could provide an effective method to tackle even the most challenging wide line quadrupolar systems. For the analysis of thin film crystalline samples we have developed a new probe based on a stripline concept that allows crystal rotation. This was used to probe for example light induced photochromic transitions in yttrium hydrides doped with oxygen. Also, the detailed local order could be probed in functional thin film AlGaAs solar cells. At higher magnetic fields and in combination with cryogenic sample tempertures, this method could open a new field of materials research.



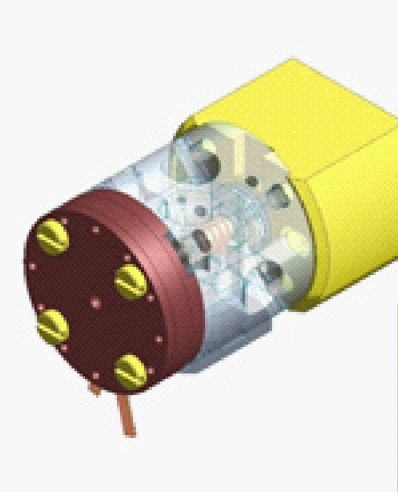
Experimental 75As static NMR spectrum of a crystalline thin film AlGaAs solar cell measured at a field of 20T.

Task 7 Low temperature µMAS, DNP and high magnetic fields

The aim of this task is to develop and test a suitable probe setup for DNP at high magnetic fields. In a combined MAS-micro-MAS probe we try to combine an improved cooling efficiency with options for single mode high frequency microwave excitation. Further miniaturization of the main rotor and stator of a MAS setup allows much faster spinning speeds and potentially lower temperatures. This can be a relevant addition to the high field instrumentation with or without DNP options.

The micro-MAS concept as developed at the IMM combines a very sensitive detection (about 10 times more sensitive than commercially available MAS probes) with an ultra-wide excitation bandwidth. Sustained high power proton decoupling allows record high T2 times in the solid state and could be used for future high resolution solid state NMR at the highest field. The small size of the coil facilitates the scaling to very high frequencies and at the same time, the limited sample size could allow high resolution MAS-NMR even in the presence of static field gradients in non-ideal shimmed magnets. Also, the piggy-back assembly of the micro-rotor allows a direct cooling of the small sample without the complication of local heating in the turbine/bearing sections of the MAS. Finally, the small dimensions of the micro-MAS in principle allow the incorporation of a micro resonator with free access for microwave DNP excitation. At present we are anticipating the delivery of a 395 GHz gyrotron to start DNP-MAS experiments at our 600 MHz spectrometer site. A micro_MAS probe is now operational for the 20 T NMR magnet. As funds are lacking for a dedicated DNP excitation source we decided to omit the low temperature options and microwave waveguide for the moment. In the future these options will be reconsidered.

Low temperature DNP MAS probe with THz excitation waveguide. The probe is designed to spin at 20 kHz down to a temperature of 30 K.



Task 8 Coordination, reporting and dissemination

Internet provides the main contact platform for the collaboration. Direct contact and exchange of information was organized at various high field user meetings and at specialized NMR conferences. A general mid-term meeting for all participants in this JRA is organized as a satellite for the EUROMAR/ISMAR NMR conference in Florence (3-10 July, 2010). Dissemination of the results is stimulated at various meetings and conferences. Preliminary results are shown in user meetings and the EuroMagNET newsletter.

A second high field NMR user discussion meeting was organized as a satellite conference for the EUROMAR meeting in Crete (2013). Sensitivity enhanced methodology for high magnetic fields was discussed in detail at dedicated workshops in Rehovot (2013) and Tallahassee (2013). The progress in DNP applications was discussed at various DNP workshops and conferences in Nottingham (2009), Frankfurt (2011), Leiden (2010) and Kopenhagen (2013). A summerschool for PhD students was organized in Leiden (2012).

AFTER EuroMagNET II .... EMFL...

EuroMagNETII finishes by the end of 2013 and for the moment, there will be no EU support for user access to high magnetic fields. Whether there will be a new EU call for transnational access in the Horizon 2020 program and whether a EuroMagNET-like proposal would be eligible remains to be seen.

The four facilities (Dresden, Grenoble, Nijmegen and Toulouse) will nevertheless continue to provide access to external users. However the costs will have to be entirely covered by national funding, and access therefore will become restricted. That will mean that less proposals may be executed and that perhaps we will not be able to reimburse travel and subsistence for guest researchers.

The four facilities will continue to work towards a stronger synergie of their activities through the creation of a European Magnetic Field Laboratory (EMFL), an ESFRI Roadmap project. A FP7 project has been granted to define the structure of the future EMFL. It will be a single entity consisting of the high magnetic field facilities in France (LNCMI-CNRS), Germany (HLD-HZDR) and the Netherlands (HFML-RU/FOM) in order to guarantee continuity and at the same time it will ensure that the advantages of a common entity (visibility of high field research in Europe, balance US supremacy, shared expertise, networking and coordinated user access) materialize. The EMFL structure should make the participation of other countries in the operation of the facilities possible in order to guarantee access for all European researchers.

The EMFL project is governed by a board consisting of Jan Kees Maan (HMFL), Geert Rikken (LNCMI) and Jochen Wosnitza (HLD). It has been decided to create a foundation with CNRS, HZDR and RU/FOM as participants and governed by the same board. Through this foundation most activities of EuroMagNET, like networking and coordinated user access, will be continued. Since a foundation is a legal entity, it can associate other partners and receive financial contributions to run the EMFL. This decision implies that the EMFL Preparatory Phase Project (P3) will soon transform into the embryonic EMFL.

EMFL Mission

EMFL develops and operates world class high magnetic field facilities, to use them for excellent research by in-house and external users.

EMFL
European Magnetic Field Laboratory

We believe that in this way the achievements of EuroMagNET, except the support for user access, can be preserved without EU funding. At the same time adhesion of other partners is made possible. As a consequence the proposal selection procedure will be continued as an EMFL activity and the EuroMagNET II selection committee will become an EMFL selection committee. The EMFL board will also continue the coordination between the four facilities, organise network activities (user meetings, workshops and the school) and represent the EMFL externally. A logo representing the EMFL and the production of leaflets and brochures testify to the external world its existence.
We appeal to our user community to support us through this transformation phase, and we hope to continue to host your experiments in high magnetic fields.

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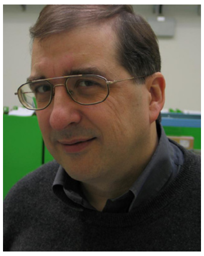

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