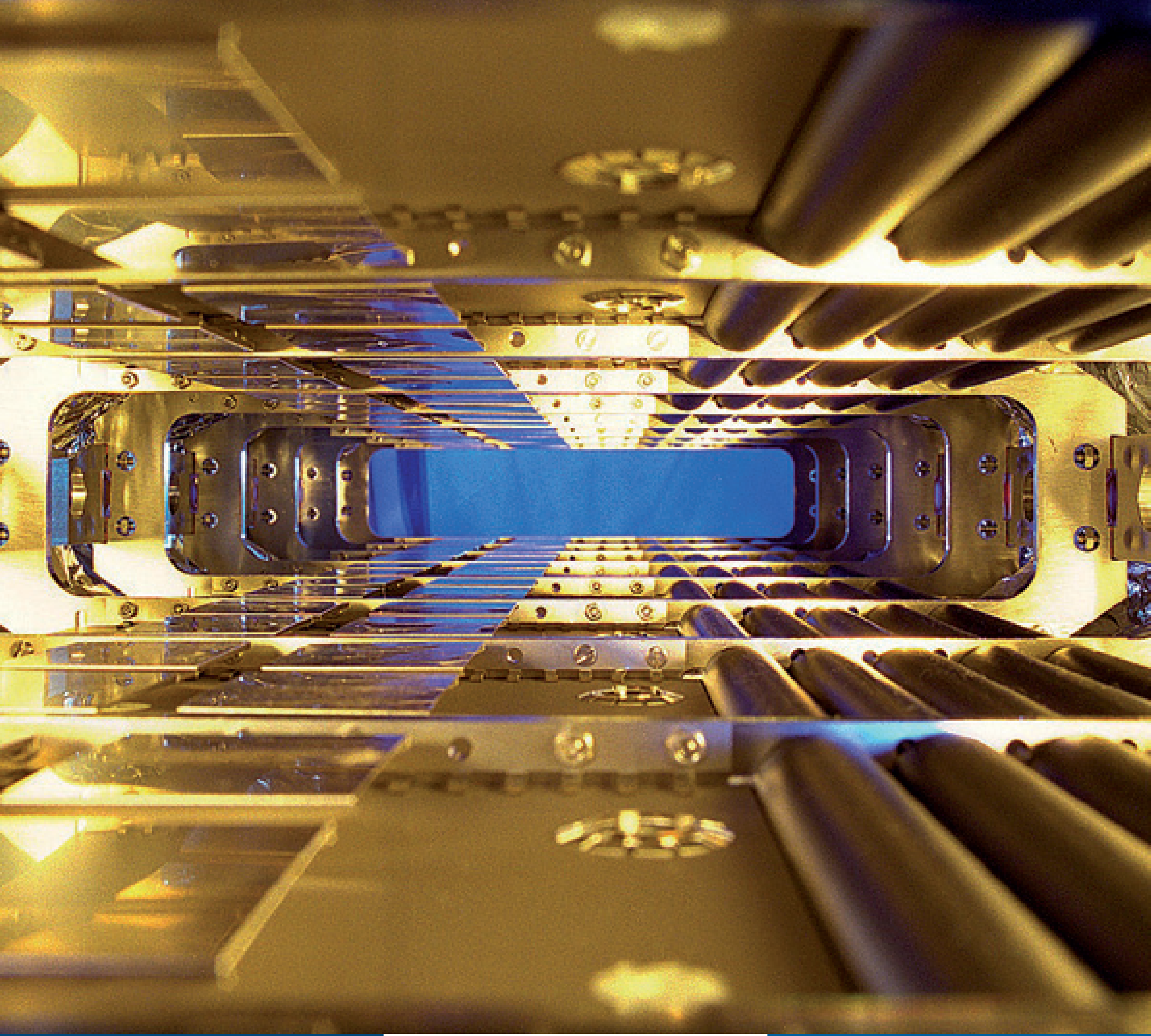


HELMHOLTZ-ROADMAP FOR RESEARCH INFRASTRUCTURES

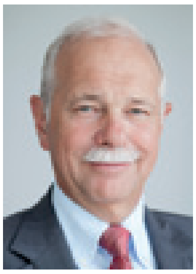
HELMHOLTZ
ASSOCIATION

CONTENTS

As of 2011

HELMHOLTZ-ROADMAP FOR RESEARCH INFRASTRUCTURES

INTRODUCTION



Research in sophisticated scientific topics frequently requires large-scale and complex scientific infrastructures. At the Helmholtz Association, the existing scientific infrastructures, financed primarily by federal funding, provide outstanding research conditions and thus ensure that the association maintains its capacity to work at the highest standards. With the help of such infrastructures, new research fields can be developed and crucial scientific advances can be made. Research infrastructures pave the way for significant advances by facilitating not only deeper insights into nature, but also the concrete development of useful materials, effective diagnostic and treatment methods and new technologies.

The Helmholtz Association is the only research organisation in Germany whose mission is to set up, operate and further develop such research infrastructures. Its facilities are made available to teams from universities and non-university research institutes both within Germany and abroad, and they thus constitute a focal point of major international collaborations and networks. They contribute significantly to Germany's appeal as a location for research and technological development.

Furthermore, the set up and further development of research infrastructures offers young scientists the opportunity to obtain optimal, comprehensive training – not only through groundbreaking research, but also through collaborations with international partners, challenging managerial tasks and close contact with high-tech companies that frequently develop new technological solutions in collaboration with scientists. In economic terms, research infra- structures are an important source of added value. Suppliers profit from the high standards to which research facilities are subjec since they are compelled to improve the quality of their own products and services over the long term. In this way, research facilities with large-scale equipment can help to shape entire regions and increase their innovative capacity.

Setting up research infrastructure requires strategic planning. In this regard, the "roadmap process" at the Helmholtz Association must be linked to the other processes already in place. In the portfolio and foresight process, for example, the individual research fields are devoted to the optimisation of their scientific programmes for the next ten to twenty years. Ideally, demand for new research infrastructure will be defined in these discussions. Conversely, decisions regarding the construction of new research infrastructure will have a profound influence on the research portfolio. Furthermore, the research strategy pursued by the Helmholtz Association will be subject to review every five years and will be evaluated by a team of international experts. Research infrastructures are part of this strategy and must be included in the evaluation.

Within the context of these processes, we will work with all participants on an ongoing basis to lay the groundwork for decisions about future research infrastructures and to define the course for future research at the Helmholtz Association. This publication presents the initial results.

Prof. Dr. Jürgen Mlynek
President of the Helmholtz Association

THE ROADMAP PROCESS IN THE HELMHOLTZ ASSOCIATION

This roadmap presents a list that has been coordinated within the Helmholtz Association of those research infrastructures which will be strategically relevant for the Helmholtz Association, or in the individual research fields, for implementation of the scientific portfolio. These projects are regarded as being desirable and necessary in the six research fields of the Association from a scientific point of view and in consideration of scientific policies. The roadmap of the Helmholtz Association is based on role models such as the ESFRI [European Strategy Forum on Research Infrastructures] roadmap. The list that has been coordinated in the individual research fields with the prioritised research infrastructures over the next ten years, from a current point of view, is supplemented by an overview of the planned building period and estimated investment costs, as well as a brief profile for each research infrastructure.

The list of Helmholtz projects is supplemented with a list of those ESFRI projects, in the preparation and implementation of which, the Helmholtz Centres are now already significantly involved. The Helmholtz Roadmap serves as a basis:

- for discussing the strategic planning with the sponsors. It therefore forms a cornerstone for binding planning within the BMBF [Federal Ministry of Education and Research] processes, e.g. for preparation of a national roadmap.
- for consultations on the strategies for financings, setup and operation of the research infrastructures using already-formulated evaluation criteria and processes (i.e. using precise timescales and budgets, summary cost estimates, setting priorities, including the planning for closures/switch-offs and [new] structuring of the management for these infrastructures),
- for independent assessment of the research infrastructures by the Science Council, if applicable,
- for concrete consultation with the user community,
- and not least, for the ongoing discussion within the Helmholtz Association itself, for regular revision and updating of the Association's research portfolio, as well as the infrastructure planning.

In order to prepare such a roadmap, a Helmholtz steering group was formed under the auspices of the President, whose members are comprised of the scientific executive board/management levels of all centres of the Association. On the basis of these preliminary activities in the research fields and in consultation with them, this steering group has formulated the criteria and additional guidelines for preparing the Helmholtz Roadmap for research infrastructures. It has managed the process for creating the existing roadmap and formulated specifications for further updating.

The roadmap process to be established within the Association must be intertwined with the existing processes, in terms of timing and content:

1. with the portfolio process: Each research field has started a discussion about the relevant research portfolio, followed by a foresight process, in order to deal continuously with the further development of the scientific programmes for the next 10-20 years. The demand for new research infrastructures ideally arises from the results of these portfolio discussions/foresight discussions. Conversely, decisions regarding the realisation of new research infrastructures will have a significant influence on the research portfolio.

2. with the investment process > €15 million: Investments in research infrastructures represent strategic course-setting for the Association and are intended to be discussed and decided at the Association level, within the context of a transparent and quality-assuring process. For this process, the criteria have been revised and bindingly recorded within the Helmholtz Association, on the basis of which, the discussion takes place and the decisions are ultimately made about future strategic investments. The Helmholtz budget for strategic investments is initially also determined by the available financial corridor.

3. with the programme evaluations as part of the foresight process within the Helmholtz Association: The research strategy of the Helmholtz Association is scrutinised every five years and is evaluated by international teams of experts. The infrastructures form part of this strategy and must be included in the planning of the programmes and their assessment in a suitable manner.

4. with the "dialogue platform": Within the context of the dialogue platforms at the Association level and at the research field level, a strategic discussion forum is established with the sponsors in order to further intensify the interlinking of the research programmes of the Helmholtz Association funded with institutional funds with the project funding by the federal government. In doing so, the long-term planning for the construction, operation and financing of large-scale, and increasingly also international research infrastructures, will gain considerable significance.

OVERVIEW OF RESEARCH INFRASTRUCTURES

	Research infrastructure	approximate costs / Helmholtz's share in million €	expected operating costs p.a. / Helmholtz's share in million €	Time period for construction and operation of the research infrastructure	Centres involved	Research infrastructure categories	Site	on other roadmaps	Planned financing
Energy	**Karlsruhe Laboratory for Nuclear Material Characterisation and Radionuclide Speciation (KARAS)**	45/45	2/2	Construction: 2012–2016; Operation: 20 years	KIT	FP	single-site		H
	Helmholtz Energy Materials Characterization Platform (HEMCP)	40	n.a.	Construction: 2013–2016; Operation: 20 years	FZJ (poss. DESY, DLR, HZB, HZDR*, KIT)	FP	multi-site	poss. contribution to EERA	H
	Energy Lab – energy-efficient process chains	38/38	2/2	Construction: 2012–2015; Term of use: 15-25 years	KIT	FP	multi-site		H
	Geothermal Laboratory in a Mine (GeoLaB)	28/28	3/3	Construction: 2012-2015; Operation: min. 2015–2020	KIT	FP	single-site		H+n
	HElmholtz Liquid Metal MAterial and Technology Laboratory (HELiMA)	22/22	1.5	Construction: 2012-2015; Operation: 2015–2035	KIT	FP	multi-site		H
Earth and Environment	**Global Earth Monitoring- and Validation System (GEMiS)**	405	7	Construction: 2013–2020; Operation: from 2015 (15 years)	AWI, FZJ, GFZ, HMGU, HZG, KIT, UFZ	NW	multi-site	ESFRI, through EPOS	H+n
	ATMO-SAT	80/30	2/2	Construction: 2015–2020; Term of use: approx. 5 years	FZJ, KIT	KG	multi-site		H+n
	Ice Laboratory - Igloo	45	1	Construction: 2015–2017; Use: > 25 years	AWI	FP	single-site		H+n+i
	Frontiers in Arctic marine Monitoring / FRAM - Observatory	25	2.3	Construction: 2013-2016; Operation: > 20 years	AWI	FP	single-site		H
	REEPON – A Large Scale Reef and Pond Facility for Ecological Climate Research in Shallow Coastal Seas	23.3/23.3	0.7	Construction : 2013-2015; Operation: 2015–2035	AWI	FP	multi-site		H
	National Cloud Research Centre AiDA – Grande	21/21	1/1	Construction: 2014-2016; Use: 2016–2030	KIT	FP	multi-site		H+n
	ACROSS – Advanced Remote Sensing – Ground Truth Demo and Test Facilities	18	1,5	Construction: 2013-2016; Operation: 2015-2020	AWI, FZJ, GFZ, HMGU, HZG, KIT, UFZ	NW	multi-site		H
Health	**Centre for integrated Diabetes Research (CiDR)**	48/48	7/7	Construction: 2013–2015; Operation: 35 years	HMGU	FP	single-site		H
	HZI Centre for Substance Research and Functional Genome Research	35/35	9.2/9.2	Construction: 2013–2015; Operation: 35 years	HZI	FP	single-site		H+n
	F&E Centre for Imaging, Radio-Oncology and Preventative Oncology	34/34	24/24	Construction: 2012–2015; Operation: 35 years	DKFZ	FP	single-site		H
	Institute for Cardiovascular Research (Cardio Berlin)	33/33	1.7	Construction: 2014-2017; Operation: 35 years	MDC	NW	multi-site		H
	Bavarian NMR Centre at the HMGU (BNMRZ)	25/25	0.5/0.5	Constuction: 2013-2014; Operation: > 30 years	HMGU	FP	single-site	Roadmap structural biology	H
	Expansion of the MR-PET imaging centre	25/25	4.2	Construction: 2014-2017; Operation: 15 years	MDC	FP	single-site		H

* updated information from 2012

Abbreviations

AWI – Alfred Wegener Institute for Polar and Marine Research
DESY – Deutsches Elektronen-Synchrotron DESY
DKFZ – German Cancer Research Centre
DLR – German Aerospace Center
DZNE – German Centre for Neurodegenerative Diseases (DZNE)
FZJ – Forschungszentrum Jülich
GSI – GSI Helmholtz Centre for Heavy Ion Research
HZB – Helmholtz-Zentrum Berlin für Materialien und Energie
HZDR – Helmholtz-Zentrum Dresden-Rossendorf
HZI – Helmholtz Centre for Infection Research
UFZ – Helmholtz Centre for Environmental Research – UFZ
HZG – Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research
HMGU – Helmholtz Centre Munich – German Research Centre for Health and Environment
GFZ – Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences
KIT – Karlsruhe Institute of Technology
MDC – Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch
IPP – Max Planck Institute for Plasma Physics

Categories for research infrastructure (see column 6):

KG – Classic large-scale infrastructure (accelerator, detector, telescope, research facility, research ship, etc.)
NW – Network (interlinked research infrastructure, e.g. TERENO)
FP – Research platform (equipment pool with a specific purpose, e.g. nanocentres)
WR – Knowledge resources (data archives, collections, e.g. biorepository)
RE – Computer, supercomputer

Planned financing (see column 9):

H – Helmholtz Association internally
H+n – Helmholtz Association with national involvement
H+i – Helmholtz Association with international involvement
exH – Financing outside of the Helmholtz Association

	Research infrastructure	approximate costs / Helmholtz's share in million €	expected operating costs p.a. / Helmholtz's share in million €	Time period for construction and operation of the research infrastructure	Centres involved	Research infrastructure categories	Site	on other roadmaps	Planned financing
Aeronautics, Space and Transport	**Tandem-L**	257 (NASA share >450)	8 (NASA share: 12)	Construction: 2013-2019; Operation from 2020	AWI, DLR, FZJ, GFZ, HMGU, HZG, KIT, UFZ	NW	multi-site		H+n+i
	Research Multiple Unit Next Generation Train (NGT FT)	30	<1	Acquisition period: approx. 1.5 years; Operation: 15 years	DLR	KG	single-site		H+n
	iSTAR – Inflight Systems & Technology Airborne Research	27.6	1.5	Construction (device installation and tests): 2012–2016; Operation: 30 years	DLR	KG	multi-site		H
	Research Vehicle Next Generation Car (NGC)	20	<1	Construction: 4 years; Operation: 10 years	DLR	KG	single-site		H+n
	C-Cube - Concurrent Certification Centre	16	4.0	Construction: 2012-2014; Operation 1st phase: 5 years	DLR	KG	multi-site		H+n
Key Technologies	**Exascale Computer (ExaCom)**	150	6/6	Contin. expansion from 2016, 3-5 years	FZJ	RE	single-site		exH
	Centre for Integrative Biology	45	2.2/1.8	Construction: 2014–2016; Term of use not limited	KIT	FP	single-site		H
	Helmholtz Data Centre (HDC)	39	1.5/1.5	Contin. expansion 2012–2016; Operation until 2020	FZJ, KIT	RE	single-site		H
	Centre for Structural Biology FZJ / KIT	39	1/1	Construction: 2013-2016; Use: 2014–2029	FZJ, KIT	FP	multi-site	Roadmap structural biology	H
	Helmholtz Nanoelectronic Facility II	33		Construction: 2013-2015; Operation: 25 years	FZJ	FP	single-site		H
	Innovation Platform for Loadbearing & Multifunctional Matter Systems	25		Construction: 2012-2015; Operation: 2016–2025	HZG	FP	single-site		H
Structure of Matter	**European XFEL Phase II**	550	100 (for entire XFEL)	Construction: from 2020–2023; Operation earliest from 2023	DESY, HZB, HZG	KG	single-site		H+n+i
	FAIR Modules 4-6	500	80 (for entire FAIR)	Construction: 2019-2022; Operation: from 2020 (> 15 years)	FZJ, GSI, HZDR	KG	single-site		H+n+i
	AugerNext	110/16.2	5	Construction: 2016-2019; Operation: 10 years 2018-2028	KIT	KG	single-site	ASPERA roadmap	H+i
	Upgrade PETRA III and FLASH	84	5	Construction: 2018-2019; Operation: 2019–2040	DESY	KG	single-site		H
	Expansion of the Ångström Source Karlsruhe (ANKA)	50	5/5	Construction: 2015-2020; Operation: 20 years	KIT	KG	single-site		H
	EDM@COSY	50	5/5	Construction: 2016-2018; Operation: 2019–2029	FZJ	KG	single-site		n
	Detector Laboratory and LHC Upgrades	45		Construction : 2013-2019; Operation: 10-20 years	DESY, poss. GSI	FP	single-site		H
	ARD Test Facility	40	3	Setup and further development: 2015-2019; Operation from 2016	DESY, FZJ, GSI, HZB, HZDR, KIT	FP	single-site		H
	Helmholtz-Beamline at European XFEL	40	2	Construction: 2015-2018; Operation: 2018–2035	DESY, HZDR	KG	single-site		H
	Helmholtz-Beamline with High-Power Lasers at FAIR	40	2	Construction: 2018-2020; Operation: 20 years	GSI, HZDR	KG	single-site		H
	CW Linac	29.5	1,5	Construction: 2014-2016/17; Operation from 2016/17 for more than 15/20 years	GSI	KG	single-site		H

INVOLVEMENT BY THE HELMHOLTZ CENTRES IN ESFRI PROJECTS

The ESFRI is the “European Strategy Forum on Research Infrastructures", which was initiated by the Council of the European Union in 2004. It provides the delegates of the various European ministries with a forum for exchanging information about the national planning beyond the setup of research infrastructures for planned projects, which will take on a European dimension on the basis of their size.
As stated in the preliminary remarks, the Helmholtz Association is the only research organisation in Germany with the explicit mandate to build, operate and further develop large-scale research infrastructures anchored in its mission. It is therefore self-evident for the centres of the Helmholtz Association to be involved in the process for structuring the ESFRI roadmap, as well as in the Europe-wide activities for its implementation. In these activities, the Federal Ministry of Education and Research, which represents the German position in the ESFRI process and currently holds the presidency, is a reliable and supporting partner for the centres.

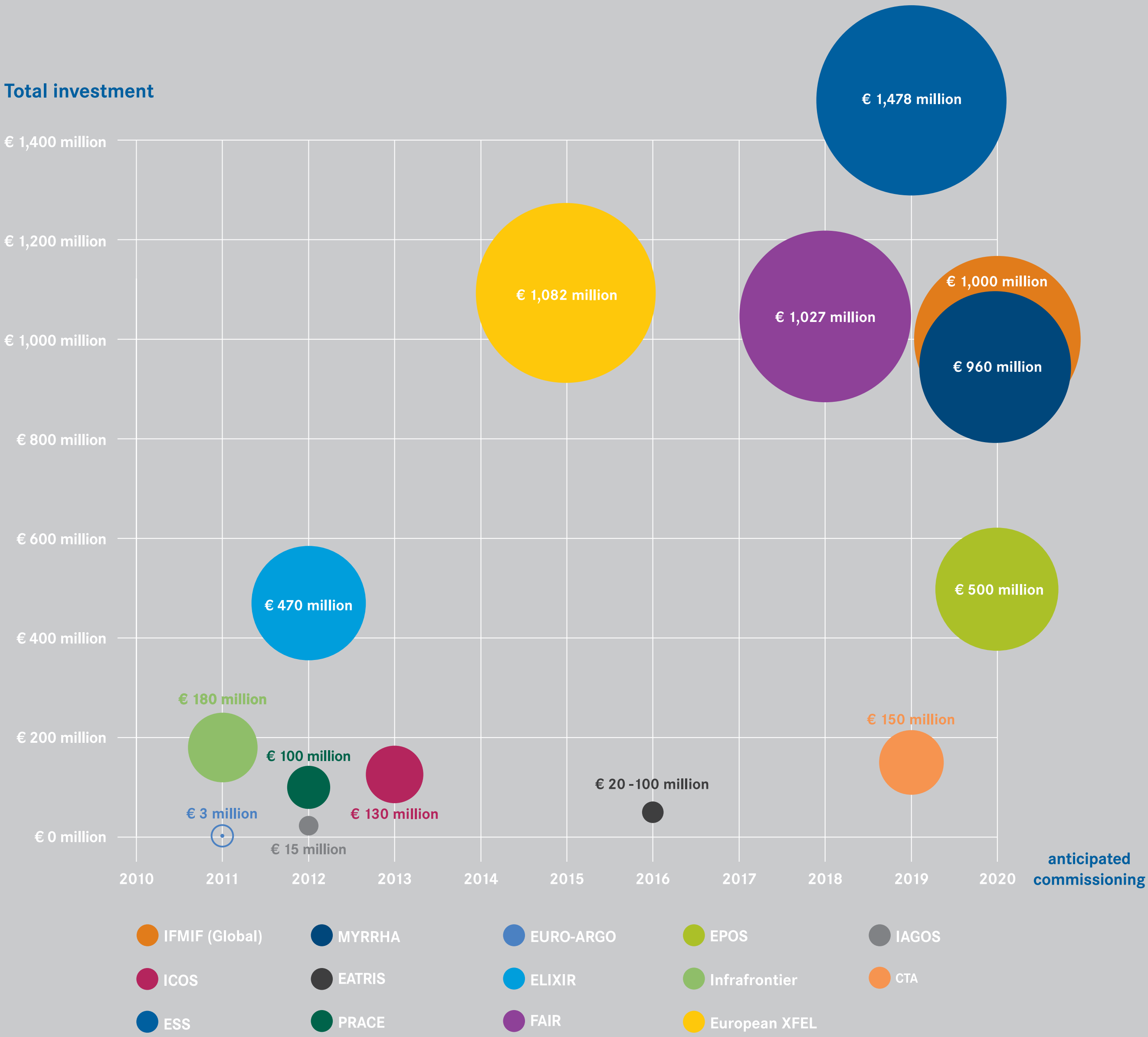
In a total of seven projects on the ESFRI list, centres of the Helmholtz Association currently have a coordinating role.* They are involved significantly or with minor activities in another 32 projects. Within the context of the existing Helmholtz Roadmap, selected ESFRI projects are listed. They went through the same selection process in the Association's research fields as the other prioritised projects. This means that the ESFRI projects listed here represent those projects, which are classified by the research fields as having a priority in the coming years, from the point of view of the Helmholtz Association. They are projects with high relevance for the research topics in the Helmholtz Association, as well as with significant involvement of the Helmholtz centres. The criteria for acceptance to the list below are shown in the guidelines. Extra profiles are not added to the projects listed here; reference is made to the presentation and explanations in the current ESFRI Report (as of 2010):
http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfr

Research infrastructure Short form	Research infrastructure	Construction costs (planning as per ESFRI roadmap in million €)	expected operating costs p.a. in million €	expected commissioning	planned involvement by Helmholtz centres	Research infra-structure categories	Site
IFMIF (GLOBAL)	**International Fusion Materials Irradiation Facility**	1000	150	2020	**KIT**	KG	single-site
MYRRHA	**Multipurpose hYbrid Research Reactor for High-technology Applications**	960	46,4	2020	FZJ, GSI, HZDR, KIT	KG	single-site
EURO-ARGO	**Ocean observing buoy system**	Preparatory costs: 3	8,4	2011	AWI	FP	multi-site
EPOS	**Infrastructure for the study of tectonics and Earth surface dynamics**	500	80	2020	GFZ	FP	multi-site
IAGOS	**Climate change observation from commercial aircraft**	15	5-10	2012	DLR, **FZJ**, HZG, KIT	FP	multi-site
ICOS	**Integrated carbon observation system**	130	36	2013	AWI, FZJ, UFZ	FP	multi-site
EATRIS	**European advanced translational research infrastructure in medicine**	20-100	3-8	2016	DKFZ, GS Berlin, **HZI**	NW	multi-site
ELIXIR	**Upgrade of the European Life-science infrastructure for biological information**	470	100	2012	DKFZ, GS Berlin, HMGU	FP	multi-site
Infrafrontier	**European infrastructure for phenotyping and archiving of model mammalian genomes**	180	80	2011	GS Berlin, **HMGU**, HZI	FP	multi-site
CTA	**Cherenkov Telescope Array for Gammaray astronomy**	150	10	2019	DESY	KG	multi-site
ESS	**European Spallation Source for neutron spectroscopy**	1478	110	2019-2020	FZJ, HZG, HZB, HZDR, DESY, KIT	KG	single-site

ESFRI projects in the implementation phase

Research infrastructure Short form	Research infrastructure	Construction costs (planning as per ESFRI roadmap in million €)	expected operating costs p.a. in million €	expected commissioning	planned involvement by Helmholtz centres	Research infra-structure categories	Site
PRACE	**Partnership for Advanced Computing in Europe**	100 over the next 5 years	100 over the next 5 years	2012	**FZJ**	RE	multi-site
FAIR	**Facility for Antiproton and Ion Research**	1027 (2005)	118 (2005)	2018	FZJ, **GSI**, HZDR	KG	single-site
European XFEL	**Hard X-Ray Free Electron Laser**	1082 (incl. commissioning)	77	2015	**DESY**, HZB, HZG	KG	single-site

** The centres highlighted in the table hold a coordinating role within the ESFRI project.*



The diagram shows the anticipated amount of total investment and the anticipated commissioning for research infrastructure.

ENERGY

The research field

The sustainable, secure and affordable provision of energy is one of the global tasks of our time. The Energy research field in the Helmholtz Association fulfils this task and develops technological solutions and innovative concepts for tomorrow and the day after tomorrow. For this, all relevant systemic aspects are taken into consideration, including the dialogue with society.

Global objectives and future research emphases:

The Energy research field of the Helmholtz Association supports the strategy of the federal government in their efforts to transform the energy system in order to supply the population and economy with secure, environmentally friendly and low-cost energy, while simultaneously reducing greenhouse gas emissions. For implementation of this strategy, in addition to renewable energies and efficiency technologies, energy storage technologies, grid aspects and interaction of all energy technologies will play a key role in the next energy research programme. Furthermore, research for safe handling of radioactive waste remains indispensable. Research on nuclear fusion keeps the option open for profiting from this energy source in the more distant future. These aspects are addressed by the Energy research field of the Helmholtz Association, while setting its own priorities, for example, with research on thin-layer photovoltaics, concentrating solar energy, utilisation of biomass and geothermal power, as well as further development of storage systems, which is advanced in association with partners. In doing so, the energy research is supplemented with socioeconomic research.

Integration of the planned research infrastructures into the objectives and prospects of the research field and into the existing infrastructural landscape:

In a process that is coordinated between all participating centres and linked closely with the thematic orientation of the research activities, investment projects are planned and applied for with regard to setting up or expanding the research infrastructures (e.g. large-scale investments). This orientation of the planned large-scale investments on the basis of the research programme is a key management instrument and unique feature for the research activities of the Helmholtz Association. Two strategic expansion investments have already been assessed positively for the Energy research field: (**“EnergyLab – Energy-Efficient Process Chains“** and **"HELiMA - HElmholtz Liquid Metal MAterial and Technology Laboratory”**). Three additional investment projects (**“HEMCP – Helmholtz Energy Materials Characterization Platform”**, **“GEOLAB – Geothermal Laboratory in a Mine”**, **“KARAS – Karlsruhe Laboratory for Nuclear Material Characterisation and Radionuclide Specification”**) are on the list of the projects prioritised by the Energy research field, for the roadmap of the research infrastructures.

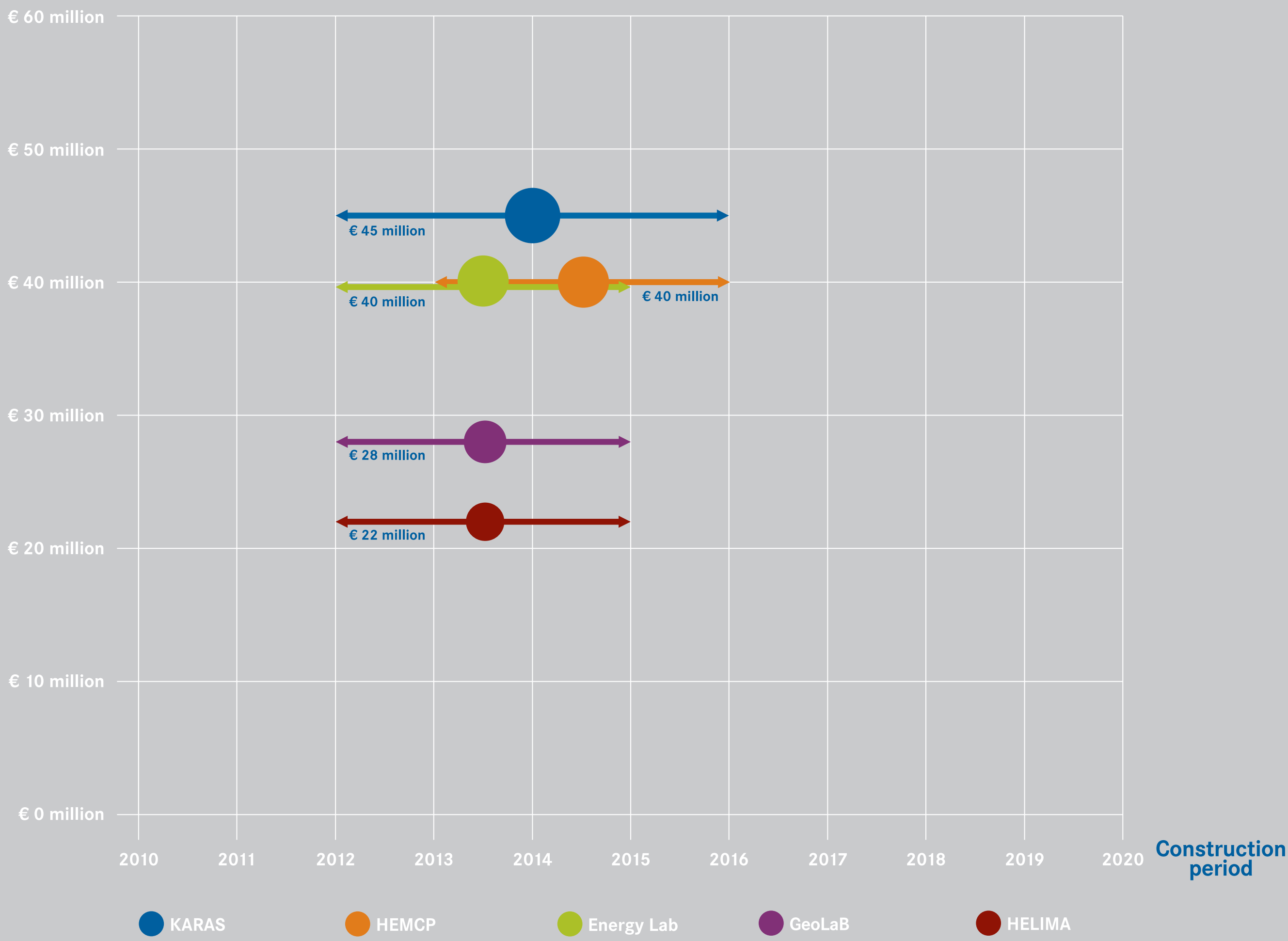
Further strategic approach:

The Energy research field emphatically supports the strategy of the federal government with regard to the transformation of the energy system in Germany. The research infrastructures of the Helmholtz centres make an important contribution to the successful transformation to a sustainable energy system. Major potential for the future lies in the realisation of synergy effects in the research infrastructures of the Energy research field. Through efficient, internal coordination processes, it is ensured that the research infrastructures of the Helmholtz centres ideally complement one another. This way, large-scale research equipment can be used jointly in a more efficient manner. Beyond the coordination between the Helmholtz centres, collaboration with international partners is becoming increasingly important. The aim of the research field is to set up and expand complementary research infrastructures within a short period of time, within and outside of the EU. This aim is reflected in our activities related to the Strategic Energy Technology (SET) plan of the European Commission and in the European Energy Research Alliance (EERA). The training of excellent young scientists is an equally important objective of the research field. Intensive collaboration with universities enables the use of research infrastructures in the Helmholtz centres in teaching – for example, within the context of university degree programmes, which offers unique opportunities for the promotion of young scientists.

Centres involved in the Energy research field:

- German Aerospace Center
- Forschungszentrum Jülich
- Helmholtz Centre Berlin for Matter and Energy
- Helmholtz-Zentrum Dresden-Rossendorf
- Helmholtz Centre for Environmental Research – UFZ
- Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences
- Karlsruhe Institute of Technology
- Max Planck Institute for Plasma Physics

Research field Energy



The diagram shows the anticipated amount of total investment and the construction period planned for the research infrastructure. The size of the circles corresponds to the anticipated Helmholtz share of total investment.

KARLSRUHE LABORATORY FOR NUCLEAR MATERIAL CHARACTERIZATION AND RADIONUCLIDE SPECIATION (KARAS)

Brief description

Fewer and fewer research laboratories in Germany have the capacity to handle radioactive substances. However, fundamental social precautionary research is urgently necessary for the disposal of radioactive waste, which is generated by the use of nuclear energy. Within the Energy research field, a competence centre is intended to be established at the KIT, in which the chemical behaviour of radionuclides is intended to be researched in different systems, in close collaboration with other Helmholtz centres. The prime objective of this research platform is to provide an experimental and analytical research infrastructure for scientists from Germany and abroad to characterise radioactive substances and radiated materials. The research topics will focus on the safe interim and final storage of highly radioactive waste, the development of alternative disposal techniques and radiation protection.

Scientific background

Using a unique combination of the latest analytical spectroscopic/microscopic (incl. synchrotron-based x-ray spectroscopy, laser spectroscopy) and theoretical methods, the chemical behaviour of relevant radionuclides is intended to be clarified at a molecular level. This shall facilitate scientifically well-founded replies to unanswered questions regarding nuclear disposal and radiation protection. All activities take place in close cooperation with other Helmholtz centres (Forschungszentrum Jülich, HZDR, HMGU) and universities. The fundamental scientific approach of KARAS has received an excellent assessment from international experts.

Prospective benefits

Through the synergy of experimental infrastructure, of theoretical and technical expertise, KARAS offers a unique scientific platform in Germany with international significance. On the basis of the currently-existing global networking of the INE, KARAS will be integrated into the international research landscape. KARAS will take on a prominent position in teaching and training, thereby contributing to ensuring scientific expertise over the long term. For the general public, the safety of nuclear disposal and protection from radiation is a very important topic, which is debated quite controversially in some cases. KARAS will make an objective contribution to the debate and provide significant research input.

Facts and figures

Timetable:
- Construction: 2012–2016
- Operation: 20 years

Estimated costs:
- Preparation/planning costs: approx. € 2 million
- Building and investment measures: approx. € 43 million
- Operating costs: approx. € 2 million p.a.
- Reinstatement costs: not yet specifiable

International dimension:

INE is now already integrated into European networks as a user laboratory. KARAS will therefore be fully integrated into the international research landscape and be open to nationall and international users. Already-existing cooperations with, for example, IAEA, CEA, ANDRA, PSI, NAGRA, SKB, JAEA, KAERI, etc. shall be further expanded using this platform.

Role of the centre/centres:

KIT will actively take on the role of the architect for KARAS for a research network on nuclear– waste disposal in the Helmholtz Association, thereby integrating the other Helmholtz centres, which can provide contributions to the topic (Forschungszentrum Jülich, HZDR, HMGU).

Additional information:

KIT will further expand its position as a scientific flagship in the field of safety research forr nuclear disposal. KIT and the Helmholtz Association will profit from this.

www.ine.kit.edu/english/

HELMHOLTZ ENERGY MATERIALS CHARACTERIZATION PLATFORM (HEMCP)

Brief description

HEMCP represents an infrastructure platform for the development of new materials for energy technology. These are an essential requirement for innovations regarding future energy supply and transformation of the energy system. The focus of HEMCP is on researching functional materials and on materials for extreme loads. For this purpose, the existing equipment in the centres will be strategically combined and supplemented in a targeted manner. An orientation of the research activities along methodological competencies leads to added value across the programmes and research fields. The range of investigation methods and know-how created in HEMCP, complementing each other in an ideal manner, make it possible to develop innovative materials for the various energy technologies in a more targeted and accelerated manner.

Scientific background

HEMCP focuses on the topic of material characterisation in order to answer questions regarding the "structural characterisation of functional materials", for example, using synchrotron radiation, and positron and ion beam methods - including in situ analysis - and also the "characterisation of materials for extreme loads in energy technology", for example, high-temperature materials or materials under extreme thermomechanical loads. The combination of existing methods with planned additions, as well as the selected fields of application, makes it possible to address the current essential and fundamental issues of material development for use in various energy technologies.

Prospective benefits

The platform concept creates a network of expertise that is unique in Europe in the field of characterisation methods for materials research. Beyond the acquisition of scientific knowledge, research is linked directly to application development in the relevant industry. The selected approach therefore strengthens the innovation potential in the field of energy technologies right at the beginning of the value-added chain: for the materials. Important, overarching questions and problems regarding sustainable energy supply–are dealt with, from nanomaterials for photovoltaics to innovative battery materials. HEMCP therefore ideally fulfils the Helmholtz mission of developing solutions for socially relevant tasks of tomorrow.

Facts and figures

Timetable:
- Construction: 2013–2016
- Operation: 20 years (for the entire platform)

Estimated costs:
- Investment volume: approx. € 40 million

International dimension:
In its final form, HEMCP will represent a top-class international platform and a contact point for basic research in the field of energy materials.

Role of the centre/centres:
The centres involved will contribute their characterisation methods. Collaboration relating to the various energy technology applications will also be established across the centres.
Forschungszentrum Jülich (Coordinator); DLR; HZB; HZDR; KIT

ENERGY LAB – ENERGY-EFFICIENT PROCESS CHAINS

Brief description

Future safe and sustainable energy supplies are a function of further development and use of renewable energy resources, increasingly more economical use of conventional sources of primary energy, and efficient conversion of primary energy resources into secondary energy resources, such as fuels, electricity and heat, and their use. The share of fluctuating energy resources, such as the sun and wind, and energetically less efficient fuels will increase significantly.

The necessary process chains in energy conversion, improvement and storage and in energy management need to be optimised significantly and integrated into new concepts. This makes a holistic assessment under technical, ecological, economic, and socio-economic aspects indispensable.

The “Energy Lab” large-scale investment by KIT together with the Helmholtz partners, DLR and the Forschungszentrum Jülich, constitutes a research infrastructure unique in the world and not available so far, allowing the multitude of these process chains to be integrated in one location and in a comprehensive modular concept, their highly dynamic interactions to be studied, and a unique energy laboratory to be established as an object of research.

Scientific background

The backbone of the Energy Lab is the bioliq® process chain, which will be developed into a unique complex of facilities by 2012 in which second-generation BTL (biomass-to-liquid) fuels will be produced from biomass.

The process chains of the Energy Lab can be classified as follows:

- Process chain 1: Biomass-based IGCC (Integrated Gasification Combined Cycle) power plant
- Process chain 2: Hydrogen production and storage
- Process chain 3: Management of fluctuating energy systems
- Process chain 4: Carbon-based chemical stores

The Energy Lab is made up of 20 modules either built from scratch or prepared for incorporation into in the Energy Lab, respectively.

Prospective benefits

The Energy Lab allows scientific and industrial partners in research, both in Germany and abroad, as well as other Helmholtz Centres to be included. An open user platform is being established in order to secure long-term operation of the Energy Lab and enhance its attractiveness.

Facts and figures

Timetable

- Construction: 2012–2015
- Operation: unlimited

Estimated costs:

- Preparation / planning costs: approx. € 1 million
- Construction costs: approx. € 39 million*
- Operating costs: € 2 million p.a. on top of activities in the EE and REUN programmes
- Demolition costs: not specified

International dimension:

The Energy Lab is a research infrastructure unit within a specific harmonised format of cooperation in the Helmholtz programme research ambit, in research and development projects among partners of the Helmholtz Association and with external partners. Its function will be that of a user lab of international significance. The scientific and technical work planned for the Energy Lab will be integrated into European research networks, such as KIT-coordinated KIC InnoEnergy, the “Bio-Energy” Network of Excellence, and EERA initiatives.

Role of the centre/centres:

The Energy Lab enables the KIT to provide the foundations of an energy supply system sustainable in the future. In this effort, the KIT is supported by major contributions from the DLR and Forschungszentrum Jülich partners. Numerous Helmholtz partners have already declared their interest in the R&D activities to start with operation of the Energy Lab.

Additional information:

www.bioliq.de
www.energie.kit.edu
www.kit.edu/forschen/1295.php

* Updated figures from 2012

GEOTHERMAL LABORATORY IN A MINE (GEOLAB)

Brief description

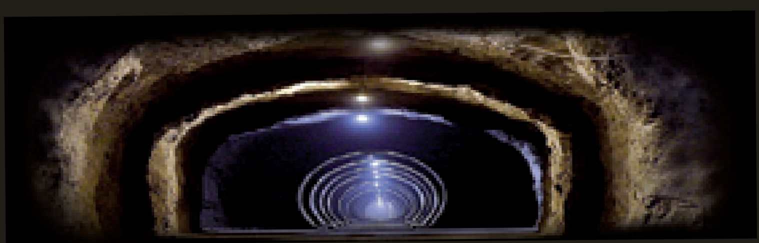
Successful implementation of geothermal energy will be improved through controlled, key experiments and development of highly efficient geotechnologies. For this, an internationally unique infrastructure shall be developed through the GeoLaB project, which maps the geothermal process chain – from exploration to reservoir creation. The first investment focus is construction and instrumentation of a mine as an underground research laboratory. Crystalline rock, at depths of more than three kilometres, is regarded as the most important geothermal resource in southern Germany. Being accessible in the mountains of the Black Forest., these rocks shall be experimentally investigated. As the only geothermal research facility in a mine anywhere in the world, this project will attract international cooperation and has high innovative potential for advancing the use of deep Variscian rocks for energy production. The results will also be applicable to related geotechnologies using fractured rock (e.g. future reservoir condition in hydrocarbon industry). As a second investment focus in the future, an EGS project ("CREGS") shall be created with electricity production, mapping the geothermal process chain up to power plant construction.

Scientific background

Geothermal research depends strongly on logging- and test-data from greater depths. The intended GeoLaB underground laboratory allows implementation and control of measurements in a 1:1 scale, particularly for reservoir generation. In realistic experiments, microinvasive exploration, stimulation and monitoring technologies can be developed. The focus is on

- Increasing the efficiency of the sub-surface, e.g. through stimulation processes and geotechnical experiments on fracturing behaviour,
- Reduction of environmental influences (e.g. induced seismicity) and a comprehensive understanding of the process of reservoir creation,
- Validation and optimisation of exploration techniques such as surface geophysics.

In the GeoLaB, a comprehensive investigation of massive fluid flow a fractured reservoir can be executed for the first time in one location. By linking different technical disciplines within the Helmholtz Association institutions, the prerequisites for top-class research can be provided in the field of geoscience.



Prospective benefits

Geothermal energy is one of the few renewable energy sources with a base load capacity and enormous potential that is attended by comparably minor environmental impact. In spite of its increasing importance (perspective: five percent share of the national electricity mix), geothermal energy can only be used at selected sites at present. The obstacles lie mainly in the lack of efficiency of energy production from hot, crystalline rock. The research cooperation targeted here is intended to lead to sustainable improvement of reservoir technologies aimed at enhancing large blocks of hot rock. The techniques can then be scaled up to routinely enable the development of 10 MW power projects in this non-volcanic geologic domain. The KIT is suitable for such a successful implementation of this project, due to the ideal underground conditions and the up-and-coming geothermal industry in the surrounding area. The findings shall be integrated and implemented in a teaching and training program at the KIT. Close strategic integration of other Helmholtz centres as well as national / international academic institutions is planned.

Facts and figures

Timetable:

- Construction: 2012–2015
- Operation: 2015–2020 (minimum)

Estimated costs:

- Preparation/planning costs: € 1.5 million
- Construction costs: € 26.5 million
- Operating costs: € 3 million
- Reinstatement costs: € 1 million

International dimension:

In the major industrialised nations, vast areas exist with similar geological conditions to those around Karlsruhe. EGS use in crystalline is now also already planned or implemented in France, Switzerland and the USA. An excellent scientific exchange of information already exists in this field. Through the GeoLaB's research infrastructure, the necessary platform shall be created to also conduct relevant experiments with international project sponsors.

Role of the centre/centres:

The GeoLaB is organisationally managed by the KIT, with the scientific management being subject to an Executive Board that is strongly supported by the KIT.

Experts from leading foreign institutions shall also be represented in the Executive Board. With the focus on crystalline rock, a structure shall be created at the KIT that is complementary to the hydrothermal projects of the GFZ. Within the KIT, numerous synergies shall be created through this research activity (e.g. with the Schiltach Geophysics-Geodetic Community Observatory).

Additional information:

Plans have been made to carry out the project in three stages. Initially, the general feasibility shall be examined. For this, the location selection, an improved cost estimate and the necessary mining planning and approval process shall be clarified.

In a second stage, expansion of the mine and setup of experimental equipment are envisaged. In the third stage, the experimental platform shall be used for large-scale experiments.

HELMHOLTZ LIQUID METAL MATERIALS AND TECHNOLOGY LABORATORY (HELIMA)

Brief description

The Helmholtz Association and the KIT are among the world leaders in liquid metal research. HELIMA is a strategic expansion of the strong scientific foundation with the aim of establishing an internationally-orientated liquid metal research platform. At the same time, a novel innovation centre shall be created with HELIMA for the use of liquid metal technology in sustainable energy supply, industrial process technology and secure and sustainable reduction of long-lasting radioactive waste. Through specialised user labs, HELIMA opens up access to the Helmholtz liquid metal expertise for users from science and industry in a yet unprecedented manner, thereby creating innovative added value.

Scientific background

The HELIMA scientific programme encompasses all key questions relating to the use of liquid metals – from investigation of corrosion behaviour of structural materials in liquid metals, to development of cleaning technologies, right up to investigations of the systemic interaction between the components in liquid metal systems. A key goal of all of these activities is the formulation of physical models and their implementation in simulation programmes, in order to guarantee a transfer to all technologically relevant applications. The basis for this scientific programme is formed by the many years of developed expertise in the KALLA Liquid Metal Laboratory in Karlsruhe, in the KASOLA Sodium Laboratory in Karlsruhe, in the MEKKA Magnetohydrodynamics Laboratory and other laboratories situated at the KIT as well as the long lasting research and experience with industrial liquid metal application in the Helmholtz-Zentrum Dresden-Rossendorf (HZDR).

Prospective benefits

Helmholtz liquid metal research, for example, in the field of transmutation and neutron sources, is positively received by the general public, as a result of its contribution to solving key social questions. The HELIMA "Applied Industrial Technology Laboratory" and "Advanced Liquid Metal Simulation Laboratory" user laboratories will also generate professional training and advanced training services, facilitate liquid metal pilot tests for science and industry thereby creating a unique, innovative environment for completely new applications, e.g. in the fields of industrial process technology and concentrating solar power high-temperature heat transfer.

Facts and figures

Timetable:

- Construction: 2012–2015
- Operation: 2015–2035

Estimated costs:

- Preparation/planning costs: € 1 million
- Construction costs: € 21 million
- Operating costs: € 1.5 million p.a.
- Reinstatement costs: not yet specifiable, however, no specific disposal requirements

International dimension:

HELIMA will take on an architectural role in liquid metal systems in international, large-scale projects, in the physical basic research and energy research: International Fusion Material Irradiation Facility IFMIF, Test Facility for the Transmutation of long lived radioactive waste MYRRHA, European Spallation Source ESS etc.

Role of the centre/centres:

At the KIT, the user laboratories and additional large-scale testing facilities will be domiciled as the core of HELIMA. The collaboration between the liquid metal laboratories of the KIT and the Helmholtz-Zentrum Dresden-Rossendorf (HZDR), the French CEA, additional international partners and industrial companies shall be established through scientific exchanges, contracts, organisational and personnel links and will be strengthened further through HELIMA. HELIMA therefore represents the entire range of the Helmholtz liquid metal expertise.

Additional information:

www.tvt.uni-karlsruhe.de/336.php

EARTH AND ENVIRONMENT

The research field

The global challenge for Earth and Environment research is to provide the necessary basic and applied knowledge for securing sustainable and long-term foundations for human life. This includes the development of strategies for handling terrestrial resources, natural phenomena and hazards and the evaluation of human impact on natural systems.

Global objectives and future research emphases:

Future emphases of research lie in expansion and networking of long-term monitoring systems, improvement of forecasts and their transfer to society. The REKLIM Helmholtz Climate Initiative combines the expertise of eight Helmholtz centres in order to improve regional and global climate models. In the “Water Science Alliance”, Helmholtz experts investigate the influence of global change on water resources in close collaboration with universities and other partners. For the transfer of the results to society, a central structure shall be established, which combines existing knowledge in the research field and builds on already-existing and tested concepts (e.g. CEDIM, CSC). Integration of the IFM-GEOMAR into the Helmholtz Association, which is envisaged for 2012, will make it possible for the research field to expand its range in the area of marine sciences. Collaboration with other research fields, particularly Energy, Health and Aeronautics, Space and Transport, will lead to integration of collected knowledge within the context of Earth and Environment in these research areas and, in addition to the continuation of important key topics (e.g. sustainable bioeconomy, Earth Observing System), will also allow new technical enhancements (e.g. georesources/geoenergy, environmental health, space weather, terrestrial magnetic field).

Integration of the planned research infrastructures into the objectives and prospects of the research field and into the existing infrastructural landscape:

Planning within the context of the Helmholtz Roadmap will concentrate on the topic of “Earth Monitoring”. A global Earth monitoring and validation system (**GEMIS**) will be discussed, through which the basis for effective early warning systems and prevention measures is intended to be created in sensitive regions. In order to prepare for this, suitable methods and technologies shall be developed with **ACROSS**, in order to establish the link between the observatories operated on a local scale (e.g. TERENO, ICOS, Fluxnet, etc.) and the scenarios required on a global scale. Through this, the Helmholtz Association can achieve a leading international role. The **FRAM** observatory, which is intended to combine the multidisciplinary measurement data of existing marine measurement systems (HAUSGARTEN deep-sea observatory, HAFOS, Kongsfjord ecological long-term station), will make a substantial contribution to the improvement of global models. FRAM is involved in national and international Earth monitoring networks, which exist/are in preparation (ESFRI projects EMSO, SIOS and ICOS, Arctic-ROOS, COSMOS, EuroSites, iAOOS, LTER, NOON, SAON, GEOSS). The planned **ATMO-SAT** satellite mission shall use three-dimensional measurement of atmospheric temperatures and selected trace gases to contribute to recording the natural variability of regional climate and weather and significantly improve its forecasting ability. The scientific use of the data by international institutions shall be coordinated by the Helmholtz centres. With the **REEPON** and **AIDA-Grande** research infrastructures, experiments shall be carried out for comprehension of ecological processes in shallow coastal seas, i.e. the effect of aerosols on cloud development. Both platforms envisage utilisation by international institutions. The **Ice Laboratory Igloo** is a research platform for the storage, preparation and analysis of ice cores, which will also be made available to international users.

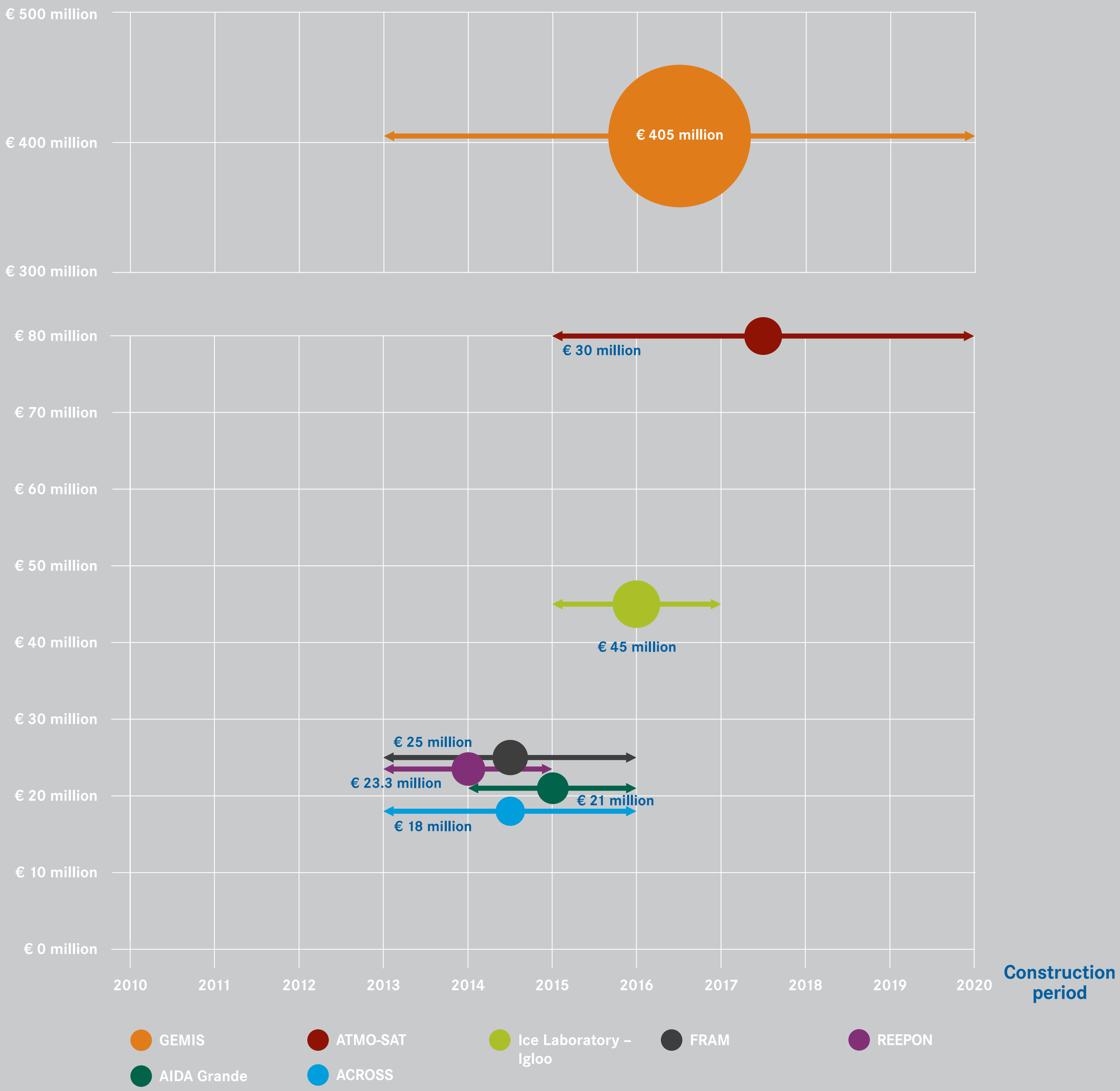
Further strategic approach:

In order to effectively deal with the aforementioned challenges, the research field will also effectively bundle capacities of the involved centres into integrated and integrating topics of a common research portfolio in the future. This process creates new coalitions and facilitates the expansion of technological competences of Earth monitoring and knowledge systems, as well as integrated model approaches.

Centres involved in the Earth and Environment research field:

- Alfred Wegener Institute for Polar and Marine Research
- Forschungszentrum Jülich
- Helmholtz Centre for Environmental Research – UFZ
- Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research
- Helmholtz Centre Munich – German Research Centre for Health and Environment
- Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences
- Karlsruhe Institute of Technology

Research field Earth and Environment



The diagram shows the anticipated amount of total investment and the planned construction period for the research infrastructure. The size of the circles corresponds to the anticipated Helmholtz share of total investment (except for GEMIS).

GLOBAL EARTH MONITORING- AND VALIDATION SYSTEM (GEMIS)

Brief description

The Global Earth Monitoring and Validation System (GEMIS) is intended to provide spatial high-resolution measurement series of critical parameters and properties over long time intervals for an improved process understanding in the Earth system, improved models and more reliable forecasts. The focus is on recording natural hazards and observing global change. GEMIS forms the basis for effective early warning systems and preventative measures for sensitive and vulnerable regions. The important features of this are homogeneous data series with consistent quality in order to minimise input uncertainties in models and scenarios. The Earth monitoring system shall comprise various components:

- land-based, permanent multi-parameter observatories (MPIO) coupled with temporary sensor arrays and focussed, high-resolution experiments,
- system of mini satellites for global data entry in real time,
- centre for operating of the infrastructure and for capacity development.

Scientific background

The MPIOs serve the purpose of precise monitoring of diverse abiotic (physical and chemical) and biological variables, flows and parameters under defined conditions in key regions for natural hazards and global change and are linked with the headquarters through efficient communication systems. The MPIOs shall also provide the urgently required ground segment for Earth monitoring satellites resulting in better calibration and absolute measurements and the downloading of satellite data for the relevant region. The supplemental focussed experiments provide the necessary local spatial resolution for key questions (e.g. earthquake zones or volcanos).

Prospective benefits

Due to the rising vulnerability of human society to natural hazards and the growing need by decision-makers for well-founded, scientifically-based forecasts and scenarios for the future development of human living space, the necessity of providing scientific monitoring data and the prevention and early warning of natural hazards and the consequences of global change are becoming increasingly important. In particular, the development of real-time management processes is based on the ability to monitor the terrestrial systems in virtually "real time". Furthermore, the capacity development in the partner countries will play an important role, coupled with options for training young scientists at the participating Helmholtz centres.

Facts and figures

Timetable:

- Construction: 2013–2020
- Operation: 2015–2030. An overlapping of the building and operating phase is envisaged, as work will already be taken up with the first completed observatory.

Estimated costs:

- Preparation/planning costs: € 5 million
- Construction costs: € 400 million
- Operating costs: € 7 million p.a.
- Reinstatement costs: not envisaged, MPIOs are envisaged as permanent institutions for later acquisition by partner countries/organisations

International dimension:

Multi-parameter observatories are very attractive for the respective host countries, as well as for the globally linked geo-community. A well-equipped global, basic network is globally neither planned nor envisaged, but represents a previously non-existent, important component for an international and global monitoring system. With this, the Helmholtz Association would have a unique selling point.

Role of the centre/centres:

The centres of the Earth and Environment research field have many years of scientific and technological experience in monitoring the Earth system. The strategy and architecture of the envisaged infrastructure is based on the results of the discussion in a Helmholtz "Observatories" working group.

ATMO-SAT

Brief description

The ATMO-SAT satellite mission shall provide unique information about the impact of the natural (e.g. sun-induced) variability on the regional climate and weather. The significantly improved understanding of the underlying processes shall lead to considerable improvements in regional climate forecasts and seasonal weather forecasts. The scientific targets require the monitoring of three-dimensional distributions of atmospheric temperatures and selected trace gases with a previously unachieved spatial resolution. For this, the method developed in the suggesting centres will be used for limb imaging of the atmosphere, on a satellite basis.

Scientific background

Numerous indications exist that the upper atmosphere has a crucial influence on our regional climate weather (IPCC 2007). This occurs through vertical couplings (e.g. wave dynamics, radiation and transport of chemical species, which, inter alia, affect the average distribution of ground pressure (e.g. NAO, ENSO). In contrast, the underlying mechanisms are still essentially not understood and represent a main source of uncertainty in terms of regional climate and weather forecasts. The role of the natural (e.g. sun-induced) variability is also unclear in comparison to anthropological effects. ATMO-SAT will supply innovative data, which is essential for the quantitative understanding of the underlying processes.

Prospective benefits

Global change is jeopardising the foundations for human life and the development opportunities of future generations. ATMO-SAT will make an important contribution to quantitative forecasting of regional climate and weather changes, one of the greatest social challenges of the 21st century. These contributions are urgently required for major international initiatives in this field (e.g. IPCC, WRCP, WMO...), On a national level, the Helmholtz Climate Initiative, Regional Climate Changes (REKLIM), of the Earth and Environment research field, plays an important role. ATMO-SAT is also of high scientific interest for the new national initiative, "The Role of the Middle Atmosphere for Climate" (ROMIC), in which numerous leading institutes of the MPG, Helmholtz Association, Leibniz Association and universities are involved. An economically relevant field of application for ATMO-SAT is the medium-term weather forecast.

Facts and figures

Timetable:

- Construction: 2015–2020
- Operation: approx. 5 years

Estimated costs:

- Preparation/planning costs: "Atmosphere and Climate" programme
- Construction costs: € 30 million for scientific instrument, € 50 million for mission (platform, rocket, ground segment)
- Operating costs: majority contained in costs for the ground segment; 2 x € 1 million p.a. for scientific ground segment (Forschungszentrum Jülich and KIT)
- Reinstatement costs: not applicable

International dimension:

The scientific use of data by numerous international (approx. 50) institutions from Europe, the USA, Canada, Japan, Korea, etc., as well as applications in the field of numerical weather forecasting (e.g. ECMWF) shall be coordinated by the recommending centres.

Role of the centre/centres:

The recommending centres have an architectural role with the specification of the instrument with regard to investigation of scientific questions. Their expertise covers all aspects of data evaluation up to scientific exploitation (and dissemination).

Additional information:

www.imk-asf.kit.edu
www.klima-umwelt.kit.edu/index.php www.fz-juelich.de/iek/iek-7

FRONTIERS IN ARCTIC MARINE MONITORING (FRAM)

Brief description

The rapid decline in Arctic sea ice will have far-reaching consequences for the Arctic Ocean and the entire Earth system. It is a key task of polar and marine sciences to monitor the changing Arctic system. The planned FRAM integrated marine observation system will be installed in Fram Strait, the key region for exchange between the North Atlantic and Arctic Ocean. It will combine existing observatories of the AWI into a multidisciplinary Earth-monitoring system, including the HAUSGARTEN deep-sea observatory, the HAFOS oceanographic array and the Kongsfjord long-term ecological station. Furthermore, FRAM provides new, innovative sensor modules and interfaces, which facilitate the study of complex interactions between physical, chemical, biological and geological components of the Arctic Ocean.

Scientific background

Climate change in the Arctic has caused a rapid warming of the ocean and a large reduction of sea ice. FRAM contributes to improved monitoring of seasonal, inter-annual and long-term environmental changes in this climate-sensitive region – from the coast and ocean surface, to the deep sea. Monitoring of local variations will be linked with information about the global climate system. Long-term data series over several decades with sufficient spatial coverage and data quality are a requirement for understanding the consequences of climate change for the Atlantic-Arctic region.

Prospective benefits

By combining multidisciplinary, high-resolution data in space and time, FRAM makes a substantial contribution to improving remote sensing data, ecosystem models and climate models and their predictability. It provides an attractive platform for national and international research cooperations, e.g. networking with planned observation components for monitoring gas hydrate and slope stability, as well as mobile observation systems in the ice edge zone. Another prospect is the linking of FRAM to the planned German-Norwegian undersea cable network off the coast of Spitsbergen for real-time data recording and interactive access to relevant data for Earth system monitoring.

Facts and figures

Timetable:

- Construction: 2013–2016
- Operation: > 20 years

Estimated costs:

- Preparation/planning costs: € 5 million
- Construction costs: € 20 million for instrumentation
- Operating costs: € 2.3 million p.a.
- Dismantling costs: not yet specifiable

International dimension:

FRAM is involved in current and future national and international Earth monitoring networks (ESFRI projects EMSO, SIOS and ICOS, Arctic-ROOS, COSMOS, EuroSites, iAOOS, LTER, NOON, SAON, GEOSS). European partners are, inter alia, Norway, France, England and Poland.

Role of the centre/centres:

As a leading polar research institute, AWI coordinates the FRAM observation network and provides the modular observation components, as well as the databases, according to GEOSS standards.

Additional information:

www.awi.de/de/forschung/tiefsee/
www.damocles-eu.org
www.emso-eu.org
www.sios-svalbard.org/
www.icos-infrastructure.eu
www.havobservatorium.no/
www.ioc-goos.org
www.arcticobserving.org

ICE LABORATORY – IGLOO

Brief description

The Ice Laboratory – Igloo in Bremerhaven is a unique research platform in the European and international research landscape for storage, preparation and analysis of ice cores. The shape of an igloo results from the shell-shaped arrangement around a newly introduced -60° C storage area for long-term storing of particularly sensitive samples in the centre. The additional rings form a -30°C storage area, as well as the processing line for non-destructive analyses and preparation at -20° C. Both outer rings house cold laboratories, each with an adjacent warm laboratory. This revolutionary laboratory concept meets the requirements for a deep-freeze environment for the ice samples right next to heated rooms for cold-sensitive analysis technology. In this manner, ice cores can be effectively processed with an ensured quality standard.

Scientific background

Polar ice cores provide the only available archive for past atmospheric conditions. Worldwide, the IPICS consortium has compiled the questions to be addressed by the ice cores in the next decades. In addition to determining global (last 2,000 years) and polar (last 40,000 years) distribution patterns of the atmospheric status parameters, reconstruction of the last warm period more than 130,000 years ago in Greenland and the longest continuous time span with a different forcing mode for the climate over more than 1.2 million years in the Antarctic are flagship projects.

Prospective benefits

Any reliable database for political decision-makers, such as the status report of the IPCC is centrally founded, inter alia, on ice core analyses. This pertains to recent changes in snow accumulation for sea level change forecasts, as well as to recording of natural climate change over long time periods. The Ice Laboratory – Igloo provides an infrastructure for effective preparation and standard analyses of a sufficient number of shallower and deeper cores to a wide community of users. New users (nations) without their own infrastructure can also study ice cores.

Facts and figures

Timetable:

- Construction: 2015–2017
- Operation: more than 25 years

Estimated costs:

- Preparation/planning costs: approx. € 5 million
- Construction costs: approx. € 40 million
- Operating costs: approx. € 1 million
- Reinstatement costs: not yet specifiable

International dimension:

The Ice Laboratory – Igloo strengthens the Bremerhaven facility which is already used by many international users. The integration of European partners in the supervision of analyses creates a concentration of competence.

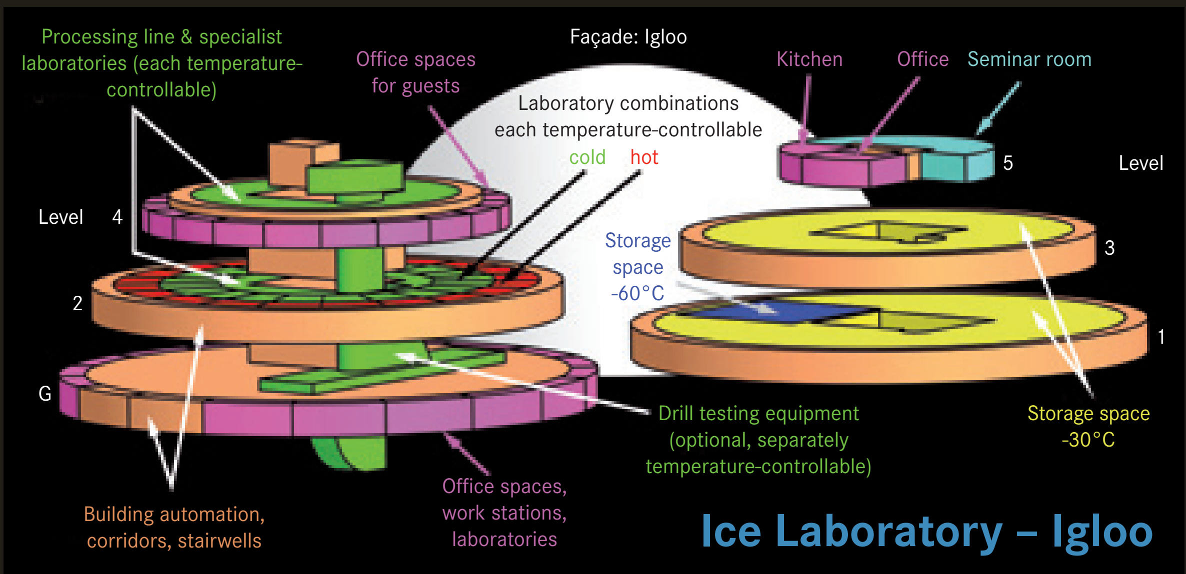
Role of the centre/centres:

The AWI is the architect for structuring the laboratory space and the structure of the analyses with the best-qualified European partners. It is also a contractor for the operation, which is intended to be partially financed by EU funds.

Additional information:

European Partnerships in Ice Core Sciences (EuroPICS):
www.esf.org/research-areas/polar-sciences/europics.html

International Partnerships in Ice Core Sciences (IPICS):
www.pages-igbp.org/ipics/



REEPON – A LARGE SCALE REEF AND POND FACILITY FOR ECOLOGICAL CLIMATE RESEARCH IN SHALLOW COASTAL SEAS

Brief description

As a research platform, REEPON is unique in its focus on ponds and reefs for the experimental study of ecological processes in coastal and shelf seas. REEPON provides, for the first time, an intermediate scale research environment to address current and relevant rapid coastal ecosystem changes. Moreover, REEPON utilises and combines existing information, e.g. from COSYNA, EU Water Framework Directives, research expeditions and laboratory studies. REEPON will provide authorities and modellers with indispensable ecosystem data and management advice. REEPON will also stimulate the European research cooperation and promote new technologies (e.g. underwater systems, sensors), which in turn will create economic synergies.

Scientific background

Current research into the mechanisms and consequences of climate-driven changes in coastal and shelf seas are based on time-limited studies on research ships, as well as small-scale laboratory studies. Conclusions gained from these methods can be difficult due to the extreme variability of coastal systems in terms of space and time; fundamental principles are hardly recognised. Only sufficiently large and controllable research facilities, such as REEPON, provide the necessary and reality-based experiments. REEPON combines small-scale laboratory studies with large-scale research (ships & monitoring). Interests in marine technology, monitoring and modelling are linked and create new research synergies.

Prospective benefits

20 percent of the protein requirement for approximately three billion people is covered by marine organisms from coastal seas. The importance of these waters as a resource (food, transport, river runoff and habitat) is indisputable. The understanding of these complex ecosystems is however disproportionately low, and existing coastal research infrastructure is comparably "modest" and insufficient. REEPON as a new infrastructure will provide ecosystem data and advice (e.g. regarding the disappearance of commercial fish, consequences of warming seas) at relevant scales to authorities and decision-makers. New technologies in REEPON (e.g. sensors, underwater systems) also underpin new economic and international scientific collaborations.

Facts and figures

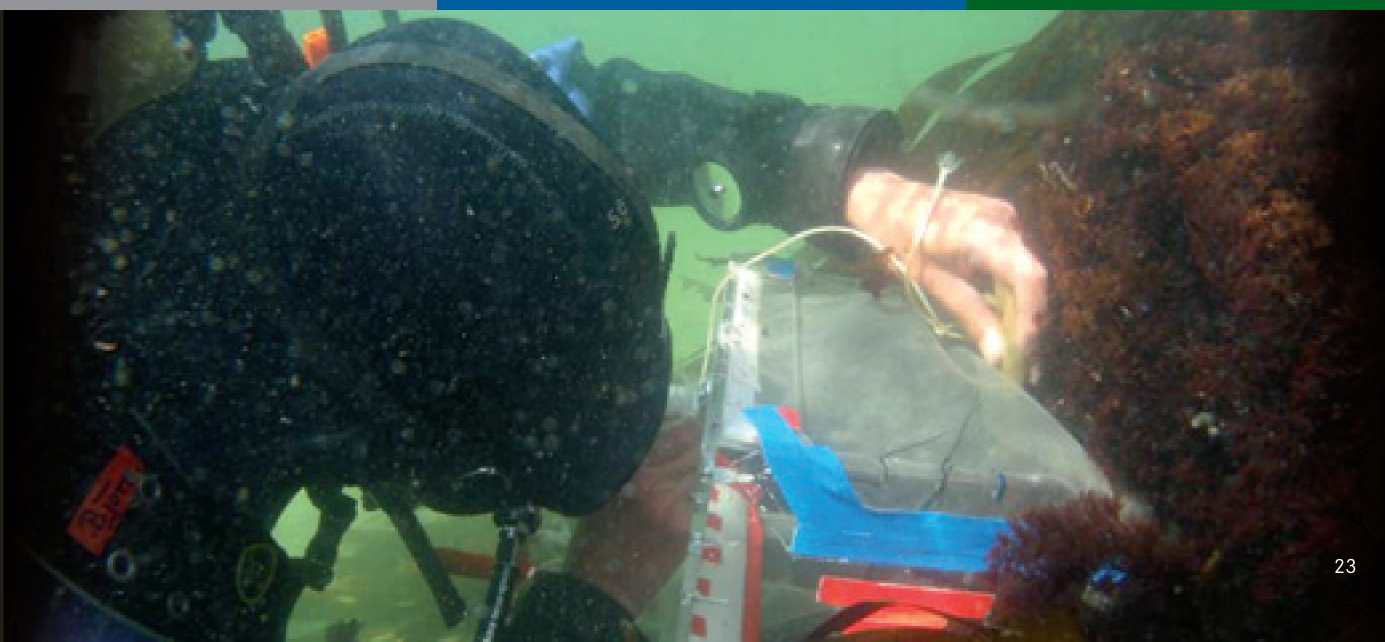
Timetable:
- Construction: 2013–2015
- Operation: 2015–2035

Estimated costs:
- Preparation/planning costs: € 800,000
- Construction costs: 2x 11,250,000 (Sylt & Helgoland) – € 22.5 million
- Operating costs: 2x 350,000 (Sylt & Helgoland) – € 700,000
- Dismantling costs: unknown

International dimension:
REEPON would be a showpiece project for Germany and Europe. No similar infrastructures worldwide to date. International use is provided through the existing research & guest infrastructure of the coastal part of the AWI (28,000 guests/year) and collaboration with the other facilities (HZG, BSH, WAS, MPI, Kiel, Bremen and Oldenburg universities, etc.) and authorities.

Role of the centre/centres:
REEPON is a coastal research project of the AWI. The major interdisciplinarity of the centre, the operation with international data centres (PANGAEA and HELGOLAND ROADS) and links Arctic coasts support the concept. Close links to COSYNA (HZG) and GEOMAR will support REEPON.

Additional information:
www.awi.de/de/forschung/fachbereiche/biowissenschaften/oekologie_der_schelfmeere/long_term_studies/reepon/
www.cosyna.de/
www.radiobremen.de/wissen/dossiers/klima/themen/wissenawilaborhelgoland102.html
www.awi.de/en/news/press_releases/detail/item/new_underwater_experimental_field_off_coast_of_helgoland/



NATIONAL CLOUD RESEARCH CENTRE AIDA-GRANDE

Brief description

AIDA (Aerosol Interaction and Dynamics in the Atmosphere)-Grande is a national research platform for studying human influence on clouds and thus on climate and precipitation. It comprises a cloud laboratory at the KIT, in which realistic clouds can be artificially created and studied, as well as two research stations with a linking research cable car at the summit of the Zugspitze, which permits observation within real clouds, which is resolved in terms of space and time. As a platform, AIDA-GRANDE will provide German and international climate and cloud research with new and unique possibilities for understanding the human influence on clouds.

Scientific background

The human population is modifying clouds, and subsequently the climate and precipitation as well, through the emission of aerosols and their precursor gases. This has an impact on the degree of cloud coverage and the lifetime of clouds and thus on the precipitation and the spatiotemporal distribution of fresh water resources. The formation of cloud ice is the most important step in cloud development and formation of precipitation. It is significantly determined by ice nuclei, which represents a disappearing, small subquantity of the atmospheric aerosol particles. To this day it is not understood which aerosol particles promote the formation of cloud ice under which conditions. AIDA-GRANDE will enable quantification and evaluation of the overall influence of aerosols on clouds and climate, for the first time, in coordinated laboratory and field measurements. For this purpose, state-of-the-art optical, mass spectrometric and imaging processes will be used, in order to better understand details of aerosol-cloud interactions from the micro scale to the macro scale.

Prospective benefits

In a changing world, the quantity and distribution of fresh water is one of the most important geopolitical constraints. More so than the rise in temperature, it determines the social effects of anthropological climate change. In contrast to the rise in temperature, the change in precipitation will be highly variable, in terms of region and timing, and will depend on numerous constraints. Particularly, the influence of aerosol distribution on precipitation processes and the repercussions from climate change on aerosol sources represent one of the most important unknown factors. Through a combination of laboratory and field measurements with numerical model studies, the research platform is intended to assist AIDA-Grande in significantly reducing the prevailing uncertainties.

Facts and figures

Timetable:

- Construction: 2014–2016
- Operation: 2016–2030

Estimated costs:

- Preparation/planning costs: € 1 million
- Construction costs: € 20 million
- Operating costs: € 1 million p.a.
- Reinstatement costs: not applicable

International dimension:

As with its precursor AIDIA facility, large, international measurement campaigns will take place on AIDA Grande. For this, cloud researchers from Germany, Europe and the world will come to Karlsruhe and Garmisch. Particularly close relationships exist nationally to the Max Planck Society, as well as internationally to the Clermont-Ferrand, Manchester and Leeds universities, as well as the US National Center For Atmospheric Research (NCAR).

Additional information:

www.imk-aaf.kit.edu/73.php

ACROSS – ADVANCED REMOTE SENSING – VALIDATION AND TEST FACILITIES

Brief description

The large-scale investment, "Advanced Remote Sensing – Validation and Test Facilities (ACROSS)" targets the development of suitable methods and technologies for validating complex satellite data (ground-truth) concerning issues of global Earth monitoring. Based on the currently available multi-parameter modelling systems in the environmental sciences and geosciences, possible future scenarios can be forecasted. Hence, the question arises how the complex models can be reliably parameterised on a regional and global scale. ACROSS is intended to represent the link between the process observatories operated on a local scale (e.g. TERENO, ICOS, Fluxnet, etc.) and the scenarios required on a global scale. The possible field of application encompasses virtually all topics of the Earth and Environment field of research.

Scientific background

On the basis of concrete demonstration projects from various fields of application, (e.g. Polar region/Arctic, Europe, particularly Southern Europe, Northern Africa, Middle East and Central Asia), methods and technologies are to be developed for ground-truth validation of complex satellite signals. For this purpose, various combinations of satellite signals are to be validated through ground measurements in existing, appropriately equipped observatory regions (e.g. TERENO). The environmental sciences and geosciences have numerous detailed process and parameter measurement methods at their disposal. However, success has thus far only been achieved for a few parameters relating to the transition from ground-based measurement methods to a clear, quantitative context with satellite-based measurement methods. The latter, however, is absolutely necessary for large-scale regionalisation.

Prospective benefits

The Helmholtz Association holds a very comprehensive arsenal of observatories, measurement networks and mobile measurement platforms which serve the purpose of Earth monitoring. The monitoring systems, which have been set up with major investment funds and which have partly been in operation for many years, offer unique possibilities for process and parameter studies to be conducted on various environmental and geoscience questions. However, national or even global questions can only be dealt with if sufficiently reliable data records can be obtained without the world-wide replication of these complex monitoring systems. Over the past 10 to15 years, significant advances have been made, particularly with regard to satellite-based monitoring technology. Now, there exists the opportunity to operate even complex national/global modelling systems (e.g. applications concerning the quantification of carbon and water balances – from local to global scale, biomass production, the quantification of GHG emission, changes in sea level in the coastal area, air quality, etc.). With the ACROSS initiative the Helmholtz Association is offered the opportunity to develop a leading role in the model-based evaluation of national and global scenarios in addition to the important role it already has assumed as the operator of the monitoring networks.

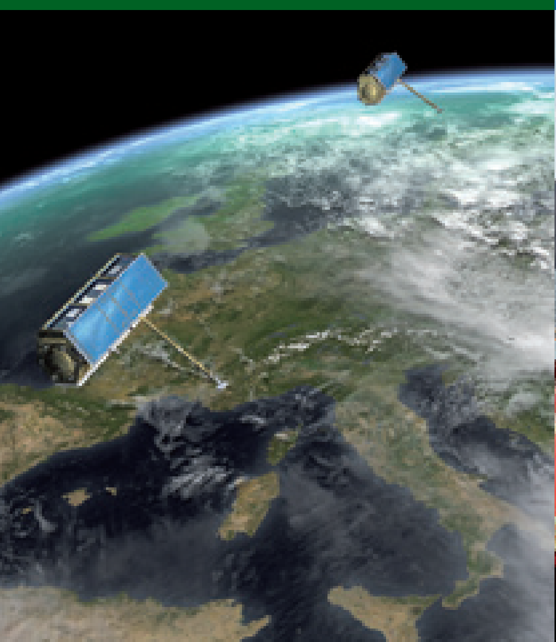
Facts and figures

Timetable:
- Construction: 2013–2016
- Operation: 2015–2020

Estimated costs:
- Preparation/planning costs: € 0.5 million
- Construction costs: € 18 million
- Operating costs: € 1.5 million
- Reinstatement costs: none

International dimension:
The complex interpretation of satellite data and the link with observatory data is one of the greatest global challenges of modern environmental sciences and geosciences. Similar to the TERENO observatories, the Helmholtz Association can take on a globally leading position in this regard.

Role of the centre/centres:
The centres of the Earth and Environment research field have many years of scientific and technological experience in monitoring the Earth system. The strategy of the ACROSS initiative was developed by the Management Board of the Research division.



HEALTH

The research field

Our society is characterised by demographic and socioeconomic changes. The subsequent and increased occurrence of widespread diseases such as cancer, cardiovascular diseases, metabolic disorders, lung diseases, infections and disorders of the nervous system, are confronting medical science and the economy with increasing challenges. In collaboration with partners from university medical centres, universities and industry, the Helmholtz centres for the Health Research field are pursuing the study of complex and frequently chronic widespread diseases, whereby the efficient and effective translation of findings from basic research into clinical application is of particular importance.

Global objectives and future research focus:

A primary long-term objective of Helmholtz health research is the improvement of medical care and quality of life into old-age, with consideration for the health-economic factors. The future research programmes of the Health division (cancer research, cardiovascular diseases and metabolic disorders, infection research, disorders of the nervous system, as well as the interplay of health and environment) will jointly develop new approaches for prevention, early identification and diagnostics, as well as treatments for widespread diseases and tailor these to the requirements of the individual patients in suitable models. This requires the identification of the molecular causes and origination mechanisms of the widespread diseases through first-rate basic biomedical research. Systems biology analyses and modelling of disease processes contribute to better understanding of complex relationships concerning the origin of a disease. Through development of innovative intervention processes in fields such as immunotherapy, novel drugs or radio-oncology, findings from research can be transferred into clinical application.

Integration of the planned research infrastructures into the objectives and prospects of the research field and into the existing infrastructural landscape:

The **Centre for Integrated Diabetes Research (CIDR, at the HMGU)**, as a national and international focal point for interdisciplinary diabetes research, will make an important contribution to improved networking with the partners from science, hospitals and industry in the “Health and Environment” programme, together with the German Centre for Diabetes Research (DZD).

The **R&D Centre for Imaging, Radio-Oncology and Preventative Oncology (at the DKFZ)** will combine state-of-the-art development laboratories for medical imaging and radio-oncology, as well as patient areas, under one roof. The research at the DKFZ as well as the translation into clinical application is significantly supported in close collaboration with local and national partners from university medical centres in the National Centre for Tumor Diseases (NCT) and in the German Consortium for Translational Oncology.

As part of the German Centre for Cardiovascular Research, the new **“Cardio Berlin” (at the MDC)** institute will create fundamental requirements for the implementation of the “Cardiovascular and Metabolic Disorders” programme and by bringing together all activities significantly accelerate translational research at the Berlin location.

Structural biology is a comprehensive activity which extends across the research fields of Health, Key Technologies and Structure of Matter. It is essential for basic biomedical research, as well as for the structure-based development of drugs. The **Bavarian NMR Centre** will provide important infrastructures for researching novel drugs in the portfolio topic of the same name.

The **MR-PET Imaging Centre at the MDC** will form an important infrastructure for the “Cardiovascular and Metabolic Disorders” and “Nervous System Disorders" programmes, particularly for research projects on early identification, i.e. non-invasive imaging.

The **HZI Drug Research and Functional Genomics Centre** will primarily be integrated into the “Infection Research” programme and the “Drug Research” portfolio topic, and offers a platform for interdisciplinary cooperation on a national and international level.

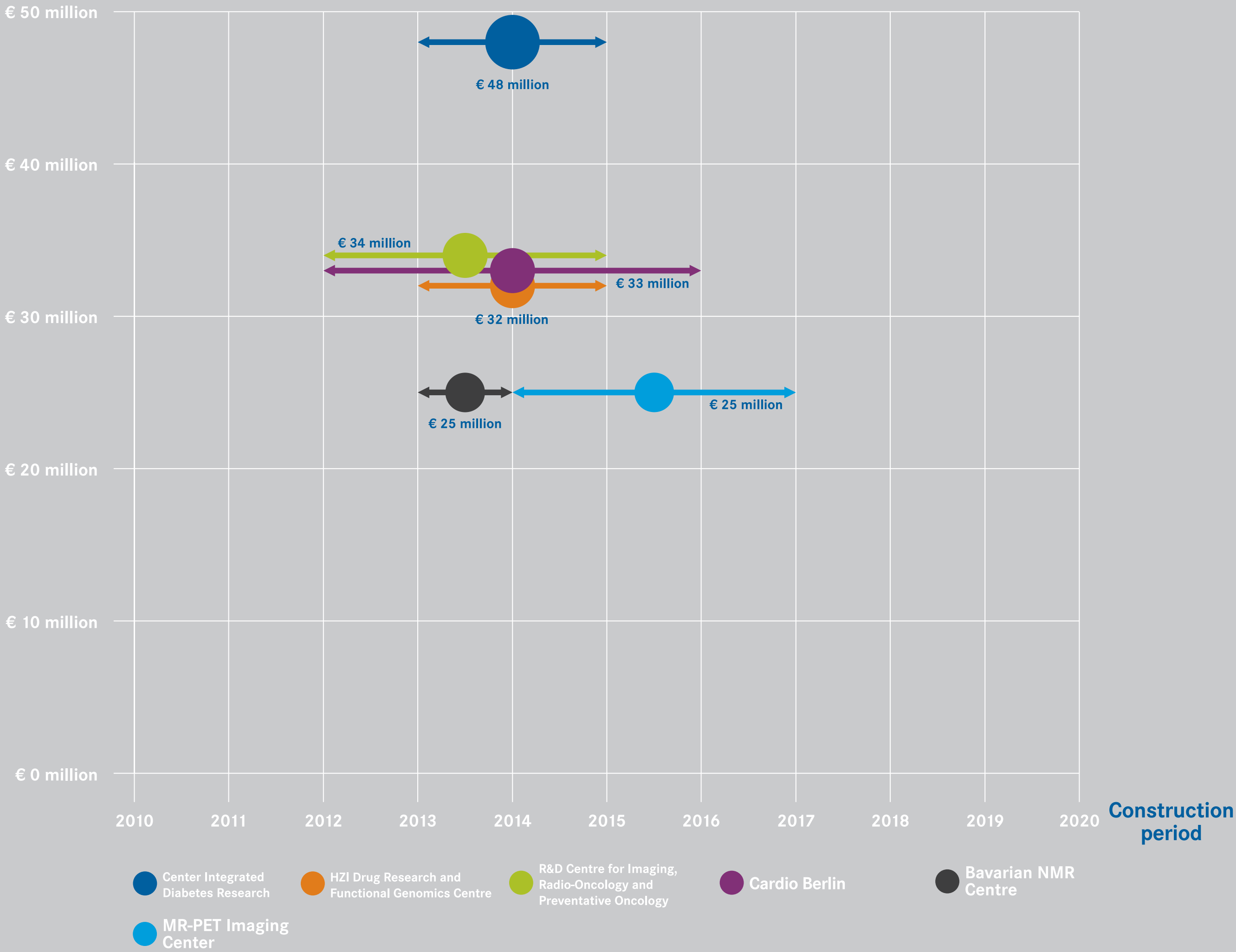
Further strategic approach:

For realisation of the roadmap projects, the research field follows a closely coordinated approach in order to achieve the greatest possible synergies. In consultation with partners from university medical centres and industry, joint targets will be defined, priorities set and strategies developed for implementation of the targets.

Centres involved in the Health research field:

- German Cancer Research Centre
- German Centre for Neurodegenerative Diseases (DZNE)
- Forschungszentrum Jülich
- GSI Helmholtz Centre for Heavy Ion Research
- Helmholtz-Zentrum Dresden-Rossendorf
- Helmholtz Centre for Infection Research
- Helmholtz Centre for Environmental Research - UFZ
- Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research
- Helmholtz Zentrum München – German Research Center for Environmental Health
- Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch

Research field Health



The diagram shows the anticipated amount of total investment and the planned construction period for the research infrastructure. The size of the circles corresponds to the anticipated Helmholtz share of the total investment.

CENTER FOR INTEGRATED DIABETES RESEARCH

Health

Brief description

In 2008, the Federal Ministry of Education and Research announced the establishment of a National Diabetes Centre at the Helmholtz Zentrum München. As a result of this, the "German Centre for Diabetes Research" was founded with partners in 2009. Within the context of this national function, the Helmholtz Zentrum München is intensively expanding its focus on diabetes. In order to accommodate the new diabetes activities according to an international standard and to combine them for optimum interaction, a new, state-of-the-art diabetes research building needs to be realised on the campus of the Helmholtz Zentrum München. The Centre for Integrated Diabetes Research (CIDR) is a scientific research infrastructure which offers a paradigm change in diabetes research. This is based on an integrated and interdisciplinary research approach, knowledge transfer and added value.

Scientific background

In order to combat the widespread disease of diabetes, new, individualised preventative and treatment approaches need to be developed. This requires an integrated research approach that would promote collaboration between basic researchers and clinicians using state-of-the-art biomedical technologies and systems biology. The Helmholtz Zentrum München is intensifying its diabetes activities by establishing new institutes, junior research groups and clinical cooperation groups in collaboration with university partners and clinical partners. This will create an internationally visible focus on diabetes with a translational orientation.

Prospective benefits

The CIDR will strengthen national diabetes research and promote new partnerships with industry. In the facility concept, flexibly-usable guest laboratories are envisaged, so that the CIDR can be used for joint projects with national and international partners from science, clinics and industry. By combining all of the scientific disciplines in diabetes research, synergies will be created which contribute to provision of innovative solutions for treatment of the epidemic-like, rising number of diabetes patients.

Facts and figures

Timetable:

- Planning: 2012
- Construction: 2013–2015
- Operation: 35 years

Estimated costs:

- Planning costs: € 5.35 million
- Construction costs: € 32.5 million
- Basic equipment: € 10.15 million
- Operating costs: € 7 million p.a.

International dimension:

Through the CIDR, an internationally visible focus will be created on diabetes, which will have a high attraction for highly-qualified international professionals. Numerous cooperations and participations already exist in international consortia (e.g. NIH, IMI, DIAGRAM).

Role of the centre/centres:

As a partner of the German Centre for Diabetes Research, the Helmholtz Zentrum München has a national function, which it fulfils with the expansion and intensification of its diabetes research.

Additional information:

The concept for the CIDR has been described as excellent, unique and distinguished in Europe by international experts. A resilient feasibility study already exists.

HZI DRUG RESEARCH AND FUNCTIONAL GENOMICS CENTRE

Health

Brief description

Das HZI Drug Research and Functional Genomics Centre – DRFG represents a unique infrastructure, which will accommodate research activities for the study and characterisation of infection processes, as well as for the discovery and further development of natural substances as key structures for new anti-infective drugs. The DRFG is designed as a research platform that is based on two connected building modules and will be located in a central position on the campus of the Helmholtz Centre for Infection Research (HZI). The combination of research activities and the concentration of top-level technologies within the DRFG will serve as a basis for interdisciplinary collaborations, which are required for efficient identification and further development of drug candidates for translation into the clinical pipeline.

Scientific background

New and re-emerging infectious diseases, as well as increasing resistances to antibiotics pose a serious threat to society. The development of urgently needed, new anti-infective drugs is currently being insufficiently pursued by industry. Research conducted at the HZI with foci on host-pathogen interactions, microbial natural products, drug research, and translation provides all the requirements for tackling this important task. One key instrument in modern drug research is functional genomics, where large quantities of data are analysed from deep-sequencing and proteome studies and placed in a functional context. At the HZI, functional genomics approaches are developed and applied to understand infection processes at the molecular level and to discover new targets for anti-infective drugs. Within the DRFG, these activities are to be further expanded and combined with the HZI's long-standing expertise in natural product and drug research, as well as its unique bio-resource bank, which will facilitate the investigation and identification of new anti-infective drugs at a previously unachieved level.

Prospective benefits

Through research at the DRFG, the development of new approaches and strategies for combatting infectious diseases will be efficiently promoted. Within the context of numerous national and international collaborations of the HZI and its future function in the German Centre for Infection Research, the DRFG will play a key role for many partners from science and industry. The synergies of research cooperation in the new centre will result in considerable acceleration of the transfer of findings from basic research to application.

Facts and figures

Timetable:

- Construction: 2013–2015
- Operation: 2015–2050

Estimated costs:

- Construction costs: € 32 million*

International dimension:

The HZI is closely cooperating with many regional, national and international partners, so that numerous institutions will profit from the DRFG. This unique infrastructure will be a key contribution to the creation of further valuable collaborations.

Role of the centre:

The HZI shall take on planning, construction, development and operation of the DRFG.

Additional information:

www.helmholtz-hzi.de/en

* Updated figures from 2012

R&D CENTRE FOR IMAGING, RADIOONCOLOGY AND PREVENTIVE ONCOLOGY

Health

Brief description

The DKFZ is planning to build and operate a research and development centre for imaging, radiooncology and preventive oncology, which fulfils the technical and regulatory requirements in order to carry out radio-oncology research at the highest international level. A key aspect of this is the integration of innovative technologies for imaging and radio-oncology under one roof. The laboratory and equipment infrastructure, as well as the necessary patient areas, will be housed in a new building. This creates optimum conditions for the development and testing of new types of equipment and processes and offers a basis for the implementation of innovative screening and preventative studies.

Scientific background

Major advances in cancer research have led to new treatment approaches, which significantly improve the patients' survival. However, one of the key problems for oncology continues to be the initial diagnosis, which is too late in most cases involving this disease. Individual risk identification, early recognition and prevention therefore pose a major challenge to cancer research and cancer medicine. By combining modern approaches of laboratory diagnostics with innovative imaging processes, innovative new prospects are also opened up for preventative oncology. This is intended to be linked with imaging and radio-oncology in the planned centre.

Prospective benefits

In this centre, the DKFZ will map the entire added-value chain, from radiological research and development to implementation on the patient, all under one roof. Partners from the DKFZ and from the university medical centre are closely involved in the planning. The centre will be open to national partners from university medical centres and industry as a research infrastructure.

Facts and figures

Timetable:

- Construction: 2012–2015
- Operation: approx. 35 years

Estimated costs:

- Construction costs: € 34 million

International dimension:

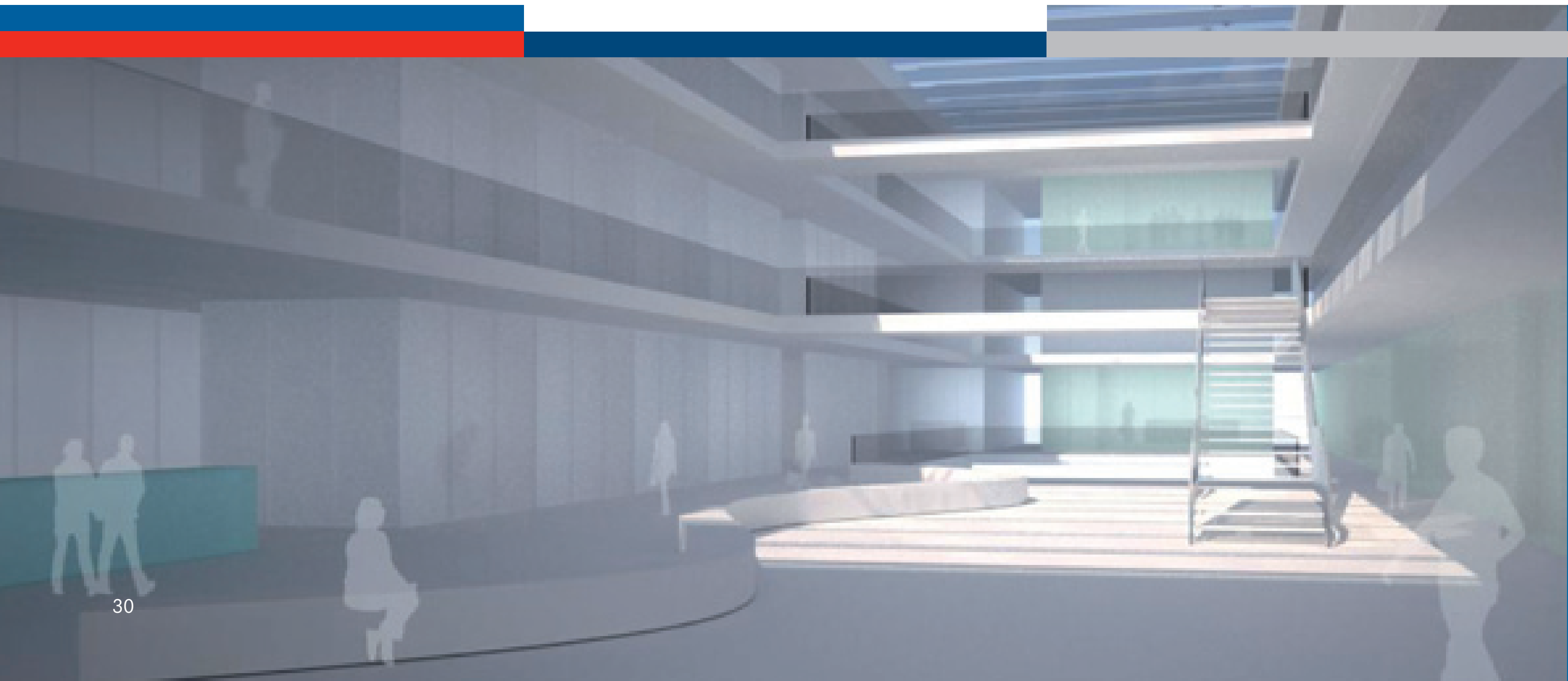
In the fields of imaging and radio-oncology, the DKFZ is one of the leading centres in the world. The research infrastructure planned here is unique internationally; only a few facilities pursue comparable goals (e.g. MGH, Boston or Oncoray, Dresden).

Role of the centre/centres:

The DKFZ will take on the architectural role in planning this research infrastructure.

Additional information:

www.dkfz.de/en



INSTITUTE FOR CARDIOVASCULAR RESEARCH (CARDIO BERLIN)

Health

Brief description

The MDC, together with the Charité and the German Heart Institute Berlin (DHZB), forms the Berlin location in the German Centre for Cardiovascular Research (DZHK). Associated partners in Berlin are the German Institute of Human Nutrition, Potsdam, and the Robert Koch Institute, Berlin. In this context, a new research institute (Cardio Berlin) is to be founded, which combines research activities in the field of cardiovascular and metabolism research in Berlin. Cardio Berlin will concentrate on investigating new, possible approaches to the future prevention of all stages of advancing cardiovascular diseases in order to delay or prevent cardiovascular end points such as myocardial infarction or strokes.

Scientific background

Cardiovascular diseases are the most frequent cause of death in Germany, other western industrialised nations, and worldwide. The founding of the DZHK aims to alleviate this situation. The DZHK will primarily deal with frequent cardiovascular diseases, including relevant risk factors for the cardiovascular system (such as metabolic disorders) and develop new concepts for their prevention and treatment. A key concern of Cardio Berlin, as part of the DZHK, is to significantly accelerate the transfer of research results to clinical applications.

Prospective benefits

In the new Cardio Berlin institute, Berlin activities in cardiovascular and metabolism research are to be accommodated and combined. Experimental approaches will be closely interlinked with clinical research. In order to guarantee optimum collaboration, a new, state-of-the-art research building will be built on the campus. The departments covering the overlapping functions of the DZHK such as an information centre, an IT platform and a coordination office for clinical studies will also be accommodated here.

Facts and figures

Timetable:

- Construction: 2014–2017
- Operation: approx. 35 years

Estimated costs:

- Preparation/planning costs: € 5 million (total ancillary costs)
- Construction costs: € 28 million
- Operating costs: € 1.7 (not including scientific research groups)
- Reinstatement costs: This involves a research building for which no specific reinstatement costs are necessary.

International dimension:

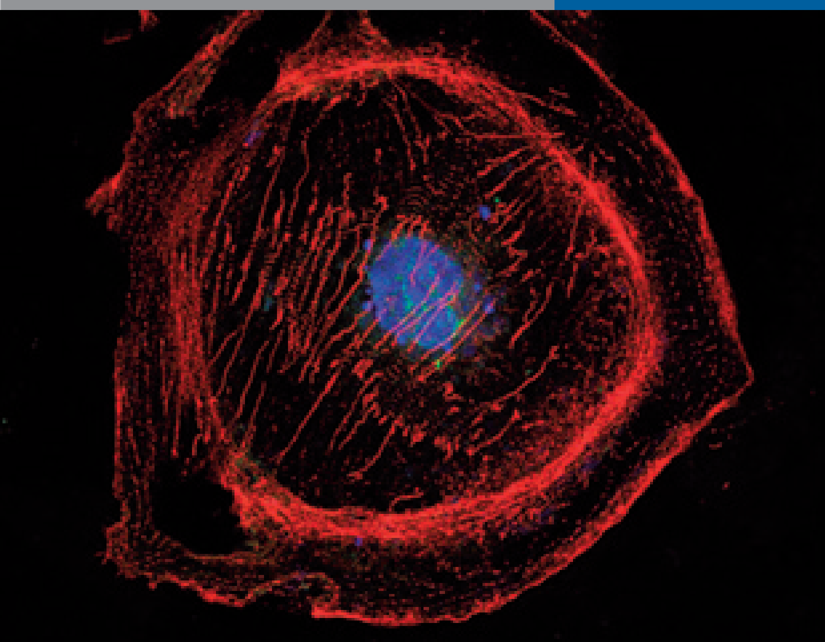
The founding of the DZHK is a significant contribution to combatting these widespread diseases. German cardiovascular research will be even more competitive and visible by international comparison.

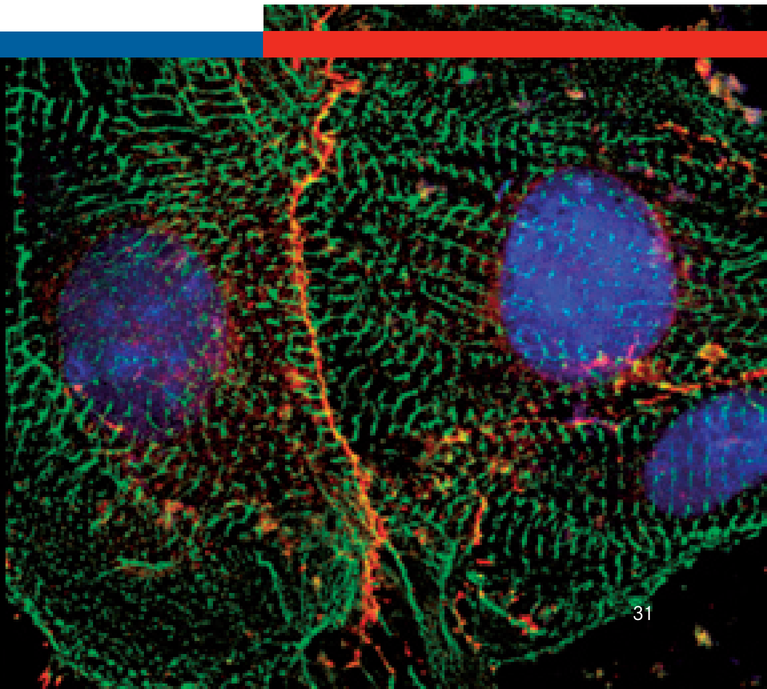
Role of the centre/centres:

The DZHK will make a considerable contribution to permanently combining scientific expertise across the boundaries of different research institutions. The MDC has taken on a national function as a partner in the DZHK.

Additional information:

In recent months, an international board of experts has evaluated the overall scientific concept of the selected partner locations. The experts have recommended starting with the setup of the DZHK. The concept for the DZHK documents the high potential for joint research activities in this strategically important field.





BAVARIAN NMR CENTRE AT THE HMGU (BNMRZ)

Health

Brief description

Together with the Technische Universität München, the Helmholtz Zentrum München hosts one of the leading NMR centres in Germany with the Bavarian NMR Centre (BNMRZ). It has internationally recognised expertise in all fields of NMR spectroscopy. In order to make advances in magnetic field strength and technology development available for biomedical research and secure international competitiveness, the BNMRZ needs to be expanded. For this, acquisition of a 1.2 GHz NMR spectrometer, an 850 MHz DNP solid-state NMR spectrometer and the construction of a building are necessary. The BNMRZ represents a research platform that is an important partner in the Roadmap "Structural Biology in the Helmholtz Association".

Scientific background

Nuclear magnetic resonance (NMR) spectroscopy plays an essential role in basic biomedical research for structural clarification of biological macromolecules, as well as in structure-based drug development. Current technical innovations in high-intensity NMR magnets promise a quantum leap regarding sensitivity and resolution for solution and solid-state NMR spectroscopy. This enables analysis of multi-protein complexes which were previously difficult to access, thereby facilitating new approaches for molecular understanding of pathological mechanisms to combat chronic diseases and promote the development of optimised drugs for health research and the pharmaceutical industry.

Prospective benefits

The BNMRZ is an internationally recognised research infrastructure that is jointly operated by the Helmholtz Zentrum München and Technische Universität München. This is used by both universities and non-university partners, regionally and nationally. Expansion of the NMR centre will ensure that its research in structural biology for understanding biological and disease mechanisms and the translation in structure-based drug discovery will remain internationally competitive at the highest level for the benefit of biomedicine.

Facts and figures

Timetable:

- Planning: 2012
- Construction: 2013–2014
- Operation: > 30 years

Estimated costs:

- Equipment costs: € 15.5 million for 1.2 GHz NMR spectrometer; € 6 million for 850 MHz DNP solid-state NMR spectrometer
- Planning costs: € 0.5 million
- Construction costs: € 3 million
- Operating costs: € 500,000 p.a.

International dimension:

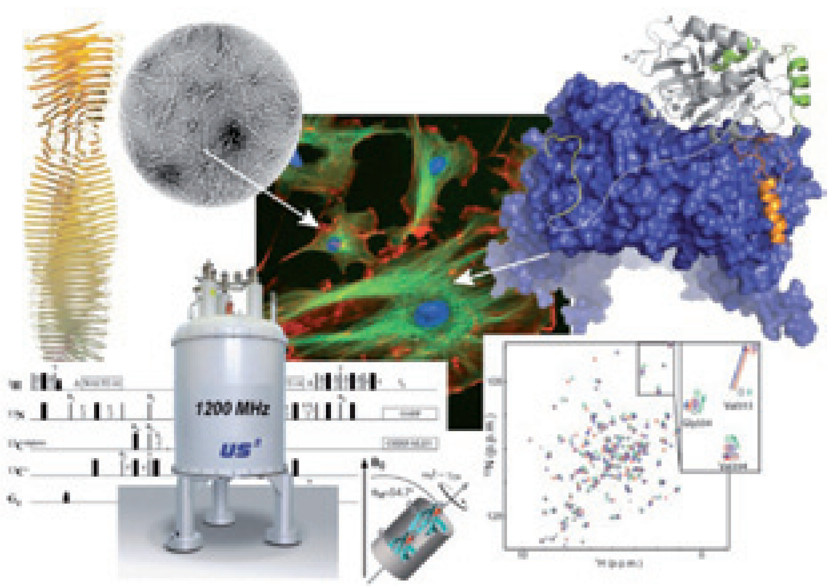
The expansion of the research infrastructure will consolidate the national and international top position of the BNMRZ and thus, the Helmholtz structural biology. The researchers are involved in numerous international cooperations and joint projects, e.g. Harvard / MIT, Boston; Pasteur, Paris; ISB/ILL Grenoble; NIM3; Bio-DNP.

Role of the centre/centres:

Together with the Helmholtz NMR locations at the Jülich Research Centre and at the KIT, the NMR Centre of the Helmholtz Centre Munich forms the decentralised Helmholtz-High Intensity-NMR Centre (HEHNZ) of the Helmholtz Association.

Additional information:

See roadmap, "Structural Biology in the Helmholtz Association", regarding the analysis and further development of the Helmholtz structural biology and the concept paper, "Status and Perspectives of Structural Biology in the Helmholtz Association"; (www.helmholtz-muenchen.de/STB/roadmap and www.helmholtz-muenchen.de/STB/Perspektiven)
Homepage of the Bavarian NMR Centre: *www.bnmrz.org*.



MR-PET IMAGING CENTRE

Brief description

After the successful commissioning of the ultra-high-field magnetic resonance (MR) facility at the MDC by the partners of the Berlin Imaging Consortium (MDC, Charité, Leibniz Institute for Molecular Medicine and the Physikalisch-Technische Bundesanstalt), in collaboration with the equipment manufacturers, Siemens AG and Bruker Biospin, it will be necessary to add positron emission tomography (PET) in the mid-term. The development of the MR-PET process is to take place as a close collaboration between the MDC and Charité and will be open to all disease areas that are worked on at the Charité. Bayer Health Care intends to build a large cyclotron in Berlin for the development of innovative PET substances. The MR-PET centre is an important addition for activities in the national cohorts, in the DZHK, and for drug validations in pre-clinical tests.

Scientific background

Linking biologically relevant molecules with positron-emitting radionuclides allows them to be detected in vivo with high sensitivity. The basic disadvantages of the PET – poor spatial resolution with limited anatomical information with most tracer substances – can be compensated for by combining MRT with higher field strengths. Particularly for pathologies with an immuno-infectious or degenerative character (cardiomyopathy, multiple sclerosis, morbus Alzheimer, morbus Parkinson), which often start years prior to clinical manifestations, an early diagnosis and better understanding of pathological mechanisms will influence the management of treatment.

Prospective benefits

The imaging centre will accommodate the functional space for interdisciplinary and cooperative development laboratories, equipment infrastructure and test subject/patient units, while taking radiation protection factors specifically into consideration during construction. Using heart-MRT-based diagnostics combined with PET should result in a metabolic understanding of cardiovascular diseases. Clinically relevant MR-PET research fields will concentrate on myocardial infiltration and cardiac remodelling, accompanied by developments in the fields of PET tracers and MR technology.

Facts and figures

Timetable:

- Building: 2014–2017
- Operation: Equipment approx. 15 years, building approx. 30 years

Estimated costs:

- Preparation/planning costs: € 4 million (total ancillary costs)
- Construction costs: € 21 million
- Operating costs: € 4.2 million (not including scientific research groups)
- Reinstatement costs: not yet specifiable

International dimension:

The ultra-high-field MR centre of the MDC is a world leader in methodological developments and applications for MR tomography of the heart. The expansion as an MR-PET centre will contribute to both the maintenance and expansion of this ranking.

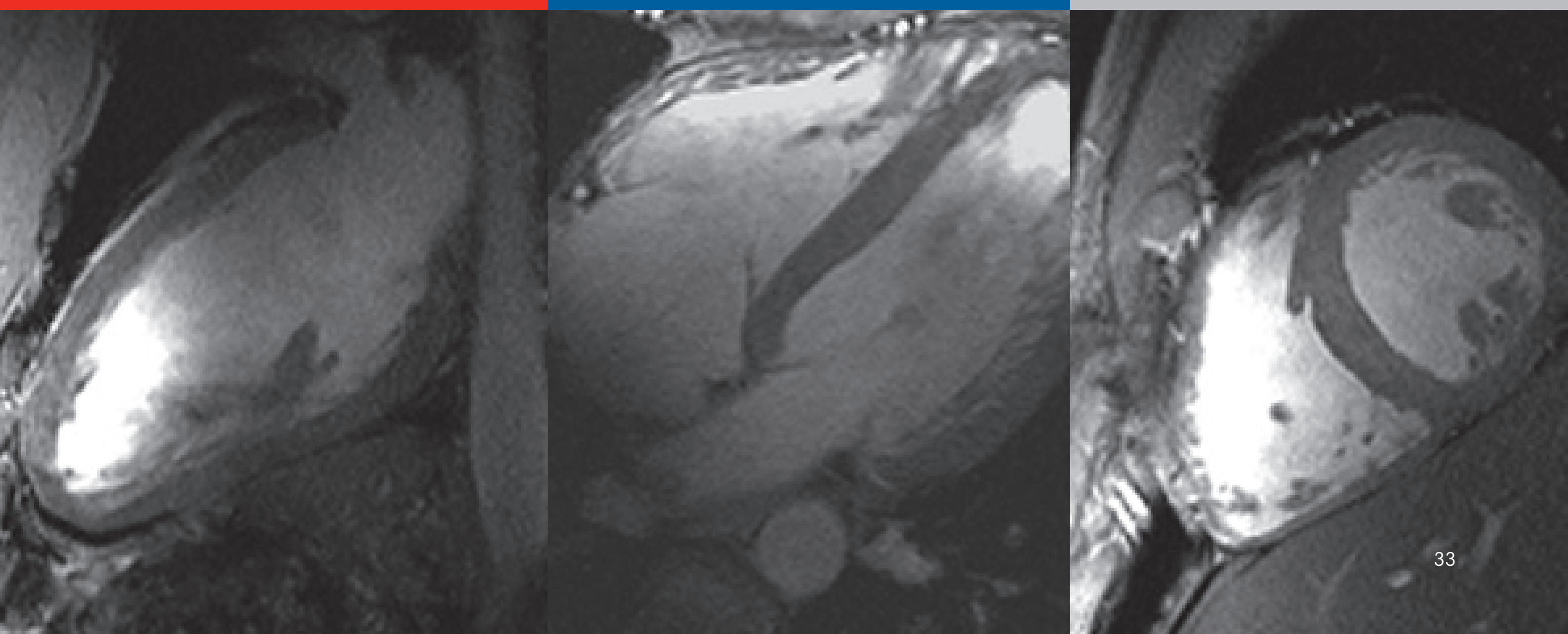
Role of the centre/centres:

Partners in the German Centre for Cardiovascular Research will profit from the expertise and newly developed methods and applications from the MDC in non-invasive imaging.

Additional information:

European Journal of Nuclear Medicine and Molecular Imaging (2011) 38 (1): 138-152

www.mdc-berlin.de/en/research/research_teams/experimental_ultrahigh_field_mr/index.html



AERONAUTICS, SPACE AND TRANSPORT

Aeronatics, Space and Transport

The research field

In the research field Aeronautics, Space and Transport, contributions are developed to overcome the major social challenges. The activities extend from fundamental research to applied research. With this bridging function, the interaction between invention and innovation is used in order to provide effective concepts and technological system solutions for global challenges and to strengthen and make visible Germany's role as a major site for research and innovation.

Global objectives and future research emphases:

Mobility, information, communication, resource management, environment and security are crucial factors to which inventions and innovations contribute. The activities are integrated into the national and European research agendas, e.g. ACARE beyond vision 2020, the ESA programme and the EU White Paper Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system.

Leadership and initiator roles on the national, European and international level are assumed through bridge building from fundamental research to innovative applications, the transferral of knowledge and research results to industry and politics, and the operation of research facilities. Participation in structuring boards and platforms at the European level in particular enables the exertion of influence, on scientists' behalf, concerning the structuring and implementing of the upcoming EU Research Framework Programme. Furthermore, national and European funding programmes must become even better interlinked. Networking and cooperation with universities, scientific organisations, specialist research facilities of the BMWi and the BMVBS as well as industrial research facilities are being expanded.

Integration of the planned research infrastructures into the objectives and prospects of the research field and into the existing infrastructural landscape:

The planned research infrastructures are closely linked with the current and future research focuses, as well as with the national and international strategies and roadmaps. The **iSTAR** test vehicle serves the purpose of testing new aeronautics technologies and validating new flight guidance and flight control systems in direct flight operation. In addition to classic flight tests, the flight behaviour of newly designed, virtual/generic aircraft is intended to be reproduced.

The **TanDEM-L** satellite mission will facilitate a new level of quality and resolution in the global monitoring of dynamic processes on the Earth's surface. On the basis of its innovative mapping technologies and enormous intake capacity, it will supply urgently required information for solving current and pressing scientific questions from the fields of biospheres, geospheres, cryospheres and hydrospheres.

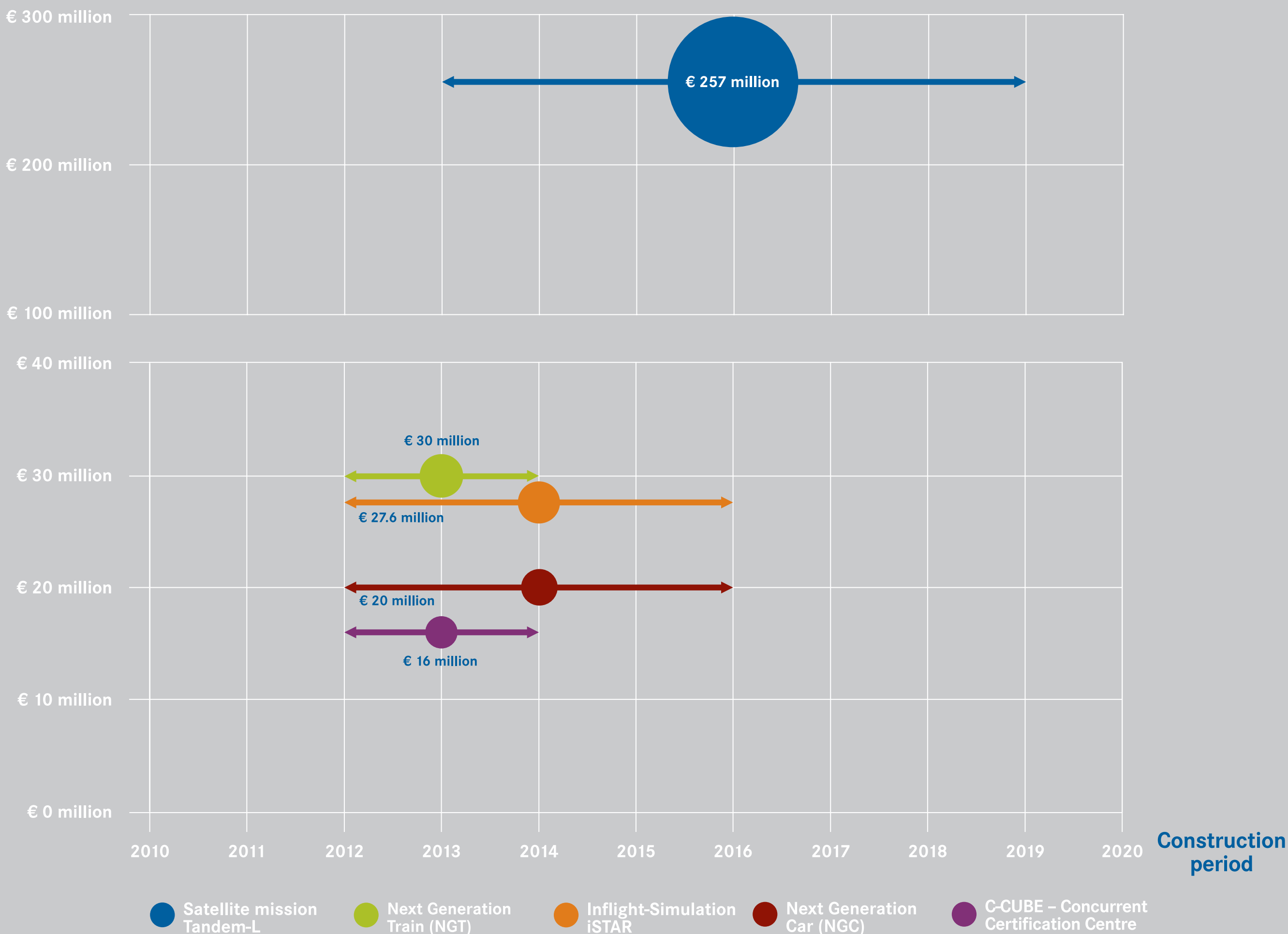
With the **Next Generation Train** and **Next Generation Car**, the methods, processes and technologies for the next generation of trains/road vehicles are intended to be researched not only in simulation and laboratories, but also under realistic conditions, and their functional viability proven independently from manufacturers and free from operational limitations. **C-CUBE** serves as an excellent basis for the development of new numerical tools and the targeted development of process technologies, materials and modes of construction. Throughout the development process of design – process technology – component, specific data are structurally configured and filed in a database.

Further strategic approach:

For these various proposals and in addition to the possible realisation of its own contribution through federal ministries, the DLR negotiates with various national and international partners.

The centre involved in the Aeronautics, Space and Transport Centre is the German Aerospace Center.

Research field Aeronautics, Space and Transport



The diagram shows the anticipated amount of total investment and the planned construction period for the research infrastructure. The size of the circles corresponds to the anticipated Helmholtz share of the total investment (except for Tandem-L).

TANDEM-L

Aeronatics, Space and Transport

Brief description

Tandem-L is a proposal for a highly innovative satellite mission for the global observation of dynamic processes on the Earth's surface with hitherto unknown quality and resolution. Thanks to the novel imaging techniques and the vast recording capacity, Tandem-L will provide urgently needed information for solving pressing scientific questions in the areas of the biosphere, geosphere, cryosphere, and hydrosphere. Tandem-L will be implemented in close cooperation between 8 Helmholtz centres involved in the research fields Aeronautics, Space and Transport as well as Earth and Environment. Through joint use of relevant expertise at the Helmholtz centres involved, a globally unique radar observatory will be created that sets a historical milestone in Earth-system research, with its highly aggregated data products, and makes a crucial contribution to a better understanding of the Earth system and its dynamics.

Scientific background

Tandem-L will make a significant contribution to climate, environment and Earth-system research. Examples of this are global measurements of forest biomass for a better understanding of the carbon cycle, systematic monitoring of Earth deformation with millimetre accuracy for earthquake research and risk analysis, quantification of glacier movements and melting processes in the Polar regions for a better understanding of climate change and its effects, as well as the fine-scale measurement of variations in ground moisture near the surface, for a detailed analysis of the water cycle. Furthermore, Tandem-L, through its high level of innovation, will sustainably consolidate Germany's international leading-role in radar remote sensing.

Prospective benefits

Tandem-L will unlock the door for obtaining a new view of the Earth-system and its dynamics. The innovative Tandem-L data products will not only advance analysis, modelling and understanding of the diverse processes in the different Earth spheres, but also show their relationships in synergy. In times of intensive scientific and public debates about the extent and effects of climate changes, Tandem-L will provide important, currently missing information for improved scientific forecasting and related socio-political recommendations.

Facts and figures

Timetable:

- Construction: 2013–2019
- Operation: from 2020

Estimated costs:

- Preparation/planning costs: € 1-2 million
- Construction costs: € 257 million (2013 to 2018)
- Operating costs: € 8 million p.a. (from 2019)
- Reinstatement costs: -

International dimension:

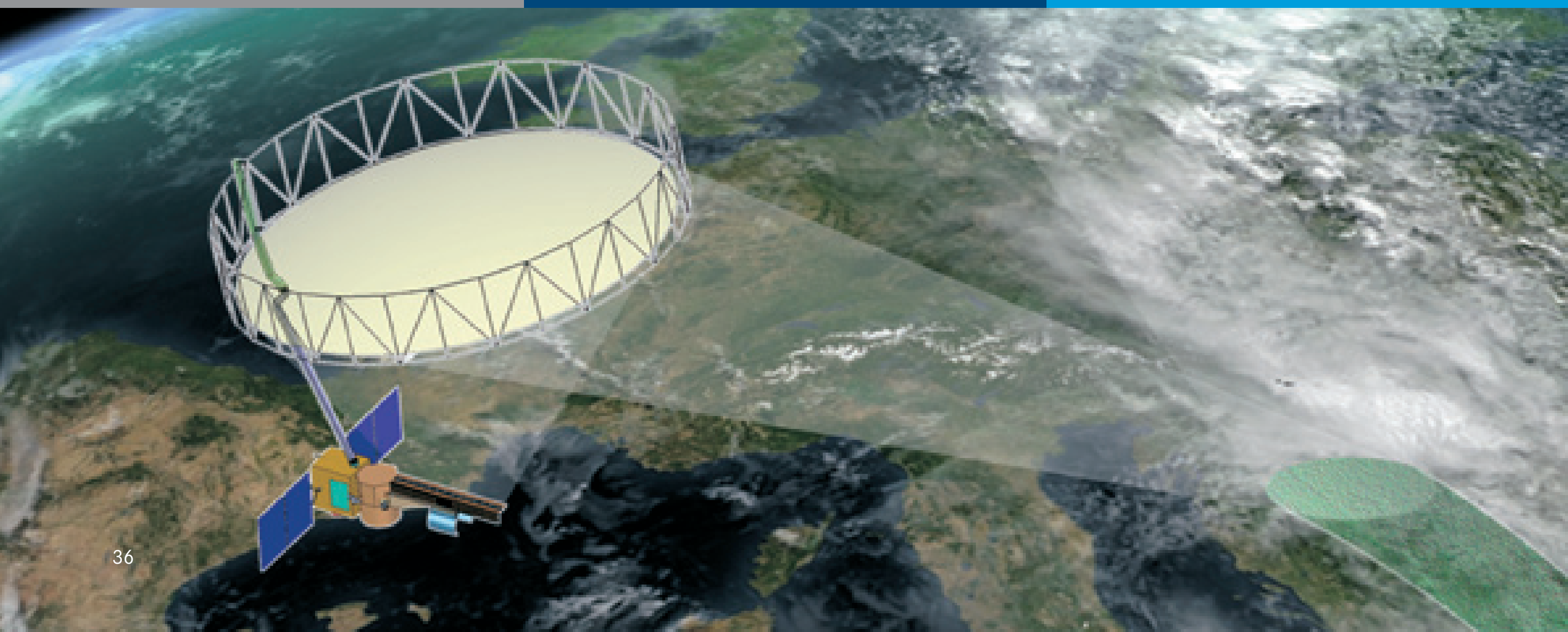
It is planned to realise the Tandem-L mission in cooperation with NASA/JPL. This enables the cost-efficient implementation of a globally unique remote exploration system for monitoring the Earth and its environment.

Role of the centre/centres:

Tandem-L is a highly interdisciplinary project with participation of 8 Helmholtz centres. Data evaluation, modelling and application occurs in the Helmholtz centres AWI, DLR, Forschungszentrum Jülich, GFZ, HMGU, HZG, KIT, UFZ, while DLR is responsible for implementation and operation.

Additional information:

A detailed project proposal has been prepared for Tandem-L and can be requested by e-mail. A Tandem-L brochure is available at the following website: *www.dlr.de/HR/en*.



NEXT GENERATION MULTIPLE-UNIT RESEARCH TRAIN (NGT FT)

Brief description

In the Next Generation Train (NGT) and Next Generation Railway System (NGRS) projects, the DLR is processing all system-technology issues regarding a rail vehicle and its integration into the railway network.

With the NGT FT, methods, processes and technologies for the next generation of trains are intended to be researched not only in simulation and laboratories, but under realistic conditions and their functional viability proven, independently from manufacturers and free from operational limitations.

In essence, the NGT FT is a commercially available (diesel) electric multiple-unit train with individual carriages in a differential construction. Both middle coaches will be refitted and used as testing area for experiments. Another middle coach is envisaged for further interventions in the car body structure.

Scientific background

In the context of the NGT and NGRS projects, we are addressing the challenges of future rail transport worldwide with a special focus on Europe and Germany. With our innovative solutions, we are becoming significantly involved in its design.

Our research systematically encompasses the product development process, from demand and customer requirements, to operational and technical solutions, which are characterised in components and assemblies, right up to the production processes.

Although we have some unique testing facilities such as railway-specific wind tunnels, simulators, laboratories and the RailDriVE© bi-directional vehicle, only the NGT FT will allow the necessary in-situ verification.

Prospective benefits

The NGT FT facilitates translation of our railway-specific research from the laboratory scale into practical demonstration of outstanding results. With this, a further step is achieved in the direction of realisable innovations.

Their early integration into product development is ensured by our collaboration with the rail vehicle manufacturers. In this way, Germany's position as the global technology market leader and largest production location for rail technology is not only maintained, but also expanded.

The NGT FT can be made available through cooperations to other Helmholtz centres, universities, and SME.

Facts and figures

Timetable:

- Purchase: Release + 6 months tender + 12 months delivery
- Operation: Delivery + 15 years

Estimated costs:

- Preparation/planning costs: € 5 million
- Purchase/refitting costs: € 25 million
- Operating costs: < € 1 million p.a.
- Disposal: included in purchase price

International dimension:

As far as we are aware, there is no multiple-unit train operated by another research centre in the world, with which tests are conducted on a manufacturer-independent or operator-independent basis.

Role of the centre/centres:

The DLR operates the NGT FT. The manufacturer or a customer of the base multiple-unit train carries out the maintenance. The maintenance company provides support with refitting for research activities and applies for the necessary approval on behalf of the DLR.

Additional information:

DLR Next Generation Train

www.dlr.de/dlr/desktopdefault.aspx/tabid-10467/740_read-916/

RTR Special "Next Generation Train", DVV Media 2011

ISTAR – INFLIGHT SYSTEMS & TECHNOLOGY AIRBORNE RESEARCH

Brief description

The ATTAS (Advanced Technologies Testing Aircraft System) used by DLR serves as a test vehicle to investigate new aviation technologies and, particularly, for the validation of new guidance and flight control systems in an operational environment. This test bed has been in service for 25 years and has now reached the end of its operating life. The aim is to establish, with iSTAR, a new, preferably low-cost, research platform based on a small to mid-size business jet as a successor for ATTAS. To enable in-flight simulation, the new test vehicle will be equipped with additional control surfaces, as well as a new, digital flight control and experimental system over a period of approx. five years. Furthermore, the new aircraft shall also facilitate research in the classical fields of aerodynamics, aeroelasticity, structures, propulsion and flight guidance right from the start.

Scientific background

In its final development stage, the new test vehicle will be able to emulate configurations ranging from newly designed, virtual aircraft to UAVs (unmanned aerial vehicles). Atmospheric and other disturbances can be reproduced, e.g. vortex encounter or damage and degradation of aircraft systems. The in-flight evaluation of new technologies (for example for load- or flow-control) and components such as adaptive high-lift systems is conducted under realistic operational conditions. The data and findings gained in these flight tests enable a more effective optimisation of the investigated flight concept/system.

Prospective benefits

There is a high level of demand, within DLR as well as from the German key aeronautics industry, for a new, versatile, multi-purpose test vehicle. In addition to state of the art flight test capabilities, the ATTAS successor, iSTAR, is also required to establish and expand the architectural role of DLR, particularly in the field of aircraft subsystems. In addition to important scientific benefits, this is also of considerable significance for the German share of work within new aircraft programmes.

Furthermore, the potential fields of research as described above could also be implemented in new flight safety and security concepts.

Facts and figures

Timetable:

- Assembly: 2012–2016 (mainly installation and testing of flight control and experimental systems in the acquired test vehicles)

Estimated costs:

- Preparation/planning costs: € 1.5 million
- Construction costs: € 15 million
- Operating costs: € 1.5 million p.a.
- Reinstatement costs: no estimate possible yet
- Acquisition costs: € 20 million

International dimension:

The new test vehicles will be used by DLR institutes, by national and European research facilities and aircraft manufacturers and equipment suppliers. It is ideally suited for applications in national and European research programmes, for example in collaboration with universities.

Role of the centre/centres:

The DLR flight-experiments facility is the leader in acquisition, refitting, operation and maintenance of the new test vehicle. Refitting, e.g. for inflight simulation, with new control surfaces, flight systems and new components if necessary, shall be specified by the relevant DLR institutes.

Additional information:

Current press releases by the DLR regarding the use of the ATTAS:
http://www.dlr.de/desktopdefault.aspx/tabid-10/60_read-29753/
http://www.dlr.de/rm/desktopdefault.aspx/tabid-3836/8930_read-16194/
http://www.dlr.de/fb/desktopdefault.aspx/tabid-3670/5739_read-8547/

RESEARCH VEHICLE NEXT GENERATION CAR (NGC)

Brief description

Sustainable and affordable mobility with a high level of both safety and comfort for the consumer, as well as the illustration of concrete solutions for consumption- and emission-reduction for the vehicle industry are important motivating factors behind vehicle research at the DLR.

Solutions are indeed being currently formulated worldwide for sub-problems, however these are not yet convincing with regard to optimisation of the overall vehicle concept. This particularly applies to electric vehicles, which require integral and interdisciplinary approaches.

With the NGC, the methods, processes and technologies developed in our projects are intended to be combined and validated for far-reaching generations of road vehicles on a non-proprietary basis, not only in simulation and laboratories, but also under reality-based conditions. For this, the NGC shall be set up as a rolling test vehicle.

Scientific background

We approach the goal of future alternative vehicles in our projects from an overall system's perspective: vehicle concepts, structures, materials, power trains, energy supply and management, driving dynamics, comfort, communication, with all their reciprocal effects, are good examples thereof.

In addition to this, there is the interaction with the transport and energy infrastructure. An appropriate system architecture ensures that the intricacy and complexity of the system, as well as its scalability and flexibility, are manageable.

The NCG facilitates the necessary in-situ verification and ideally integrates itself into the existing network in the DLR of, in some cases, unique laboratories and test facilities, as well as research platforms and research vehicles.

Prospective benefits

The NGC facilitates the transfer of our vehicle-specific research from the laboratory scale into the practical demonstration of outstanding results. With this, a further step is achieved in the direction of realisable innovations. Their early integration into product development is ensured by our collaboration with the vehicle manufacturers.

The NGC can be made available to other Helmholtz centres and universities, as well as SME, through collaborations.

Facts and figures

Timetable:

- Construction: Release + 4 years
- Operation: Completion + 10 years

Estimated costs:

- Preparation/planning costs: € 1.5 million
- Construction costs: € 18.5 million
- Operating costs: < € 1 million p.a.
- Disposal: included in building costs

International dimension:

Due to its independence from manufacturers, the NGC promises high attractiveness, not only for research, but also for suppliers and SME. The major potential of the NGC also supports the binding of excellent researchers and engineers with the Helmholtz Association.

Role of the centre/centres:

The DLR will develop, erect and operate the NGC. If required, roadworthiness approval can also be prepared by the DLR.

Additional information:

DLR Terrestrial Vehicles
www.dlr.de/dlr/desktopdefault.aspx/tabid-10106/194_read-28/
Infrastructures in the Helmholtz Transport Programme
www.dlr.de/desktopdefault.aspx/tabid-5157/8700_read-15474/
Spant-Space-Frame
www.dlr.de/desktopdefault.aspx/tabid-618/1034_read-19864/
Application Platform Intelligent Mobility
www.dlr.de/fs/desktopdefault.aspx/tabid-6422/10597_read-23684/

C-CUBE – CONCURRENT CERTIFICATION CENTER

Brief description

C-CUBE is a closed engineering system, which consequently feeds back results from component tests and data from manufacturing processes into an integrated numerical simulation, data fusion and database tool including probabilistic effects along the whole engineering chain. C-CUBE consists of the three levels CUBE Test House, CUBE Design & Manufacture and CUBE Simulation. The key data are fused according to algorithms to be developed, in order to determine relevant critical data for process technology and make these interpretable along the three levels. C-CUBE allows the experimental verification of numerical tools on a full-scale component up to dimensions of 6x3 metres. The closed concept uniquely permits the reverse optimisation of the structure and the relevant process parameters including probabilistic effects as the scattering of processing parameters and material quality. **Consequently, C-CUBE** serves primarily as a platform for virtual certification and furthermore as a unique, excellent base for the development of numerical tools, processing technologies and design principles.

Scientific background

With C-CUBE, a platform will be created for the development and verification of tools for virtual certification of aerospace components. It forms an excellent basis for the development of new structural technologies. With the system, the DLR will be able to certify, evaluate and prepare risk profiles for process technologies and structures, with the integration of probability effects using numerical methods. Furthermore, through the IT structure and the consistent recording and synthesis of all relevant process data, reverse optimisation of a component is possible along all process channels.

Prospective benefits

C-CUBE will make a major contribution to the reduction of development costs and the evaluation of efficiency and robustness of aerospace components, which can later be used in other sectors. An interface is realisable with the existing CASE multidisciplinary competence centre for numerical flight physics simulation. In Germany and Europe, no system is known of to date that corresponds to the described concept for the CUBE. In terms of testing technology, the related industry is more broadly positioned. In contrary C-CUBE allows simulation, testing and verification of numerical tools along the entire process chain, including component manufacturing and the implementation of a virtual certification tool.

Facts and figures

Timetable:

- Cooperation: 2012–2014
- Operation: 2014–2019 (only 1st phase)

Estimated costs:

- Preparation/planning costs: € 1 million
- Operating costs: € 4 million p.a.
- Reinstatement costs: no estimate possible yet
- Construction costs: € 15 million (for infrastructure, hardware and software, as well as their first-time commissioning)

International dimension:

With C-CUBE a unique platform is being created in Europe that can be used by both internal and external partners from research and industry. A C-CUBE campus model is currently being formulated.

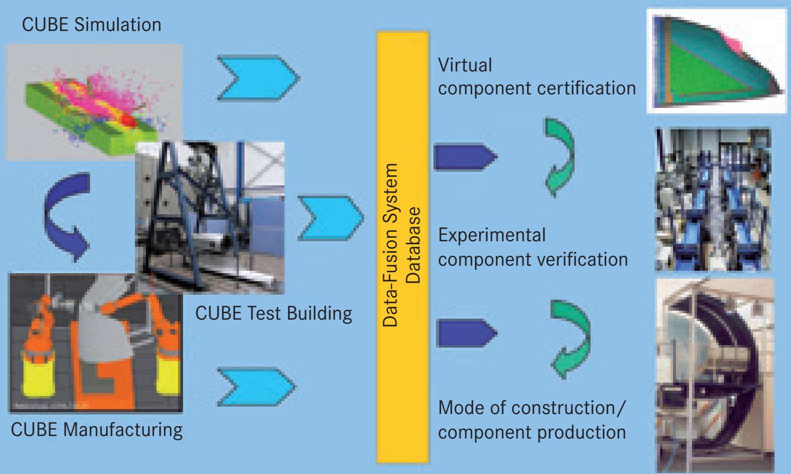
Role of the centre/centres:

In the DLR, the Institute for Building and Construction Research will assume responsibility for the setup and marketing of C-CUBE.

Additional information:

C-CUBE can best be compared with the already-existing CASE competence centre in the DLR (*www.dlr.de/as/desktopdefault.aspx/tabid-4083/6455_read-9239/*) for which an interface is planned.

C-CUBE Concurrent Certification Centre



KEY TECHNOLOGIES

The research field

In the research field of Key Technologies, scientists of the Helmholtz Association predominantly work on generic technologies for securing the future viability of our society and economy. New methods are conceived in order to formulate sustainable solutions for the major challenges of global and future-proof development. The activities of Key Technologies, inter alia, provide excellent contributions to the federal government's High-Tech Strategy 2020. The efficiency of this research field, for the whole spectrum from application-orientated fundamental research to the application itself, results from comprehensive programmes and an outstanding, large-scale-research-specific infrastructure.

Global objectives and future research emphases:

New research emphases evolve from the dynamic on-going development of the programmes, dialogue with the worlds of science, society and business, as well as interaction with other research fields. Important future elements for on-going development of the research field and its orientation comprise:

- The length scales from the atomic world to the macro world;
- Material sciences and nano-sciences, information and communication technologies, and life sciences;
- Research on electronic and photonic basic components of future technologies for supercomputers and data transfer;
- Simulation, data management and data analyses in the exascale range;
- Technology & simulation in medicine;
- Research on material sciences, chemical and physical processes in the atomic and nano range, with implementation of the findings in sustainable mobility, energy supply and medical treatments;
- Sustainable bioeconomy;
- Technology assessment and innovation.

The research field will make significant contributions to these topics and, as indicated, assume leadership and initiator roles on the national and international level. It acts as a bridge with the transferral of fundamental research to innovative applications, as well as knowledge and research findings into industry and politics.

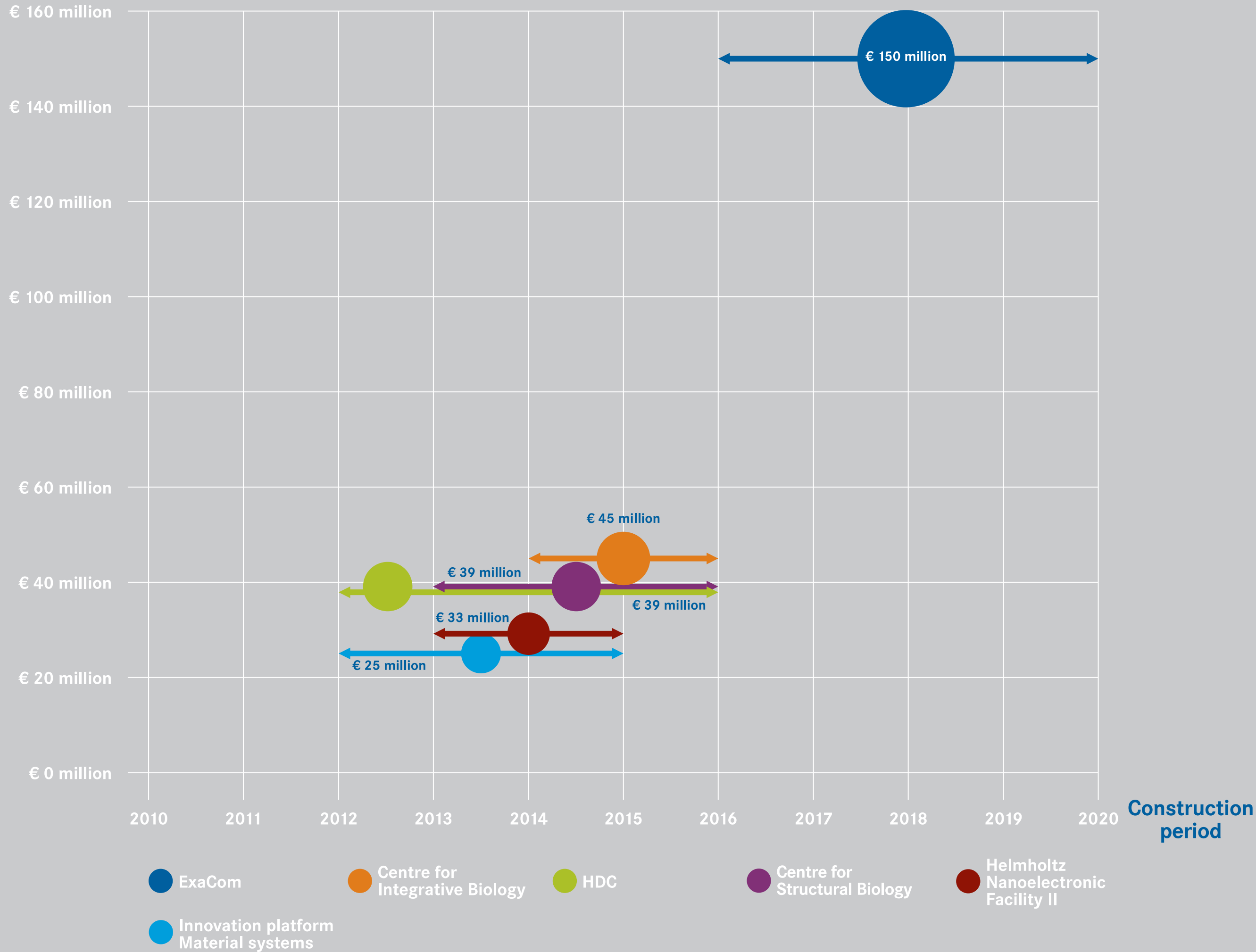
Integration of the planned research infrastructures into the objectives and prospects of the research field and into the existing infrastructural landscape:

Technology platforms, including supercomputers and data centres, represent the characteristics of research infrastructures for the research field Key Technologies. The platforms are often operated in association with selected external partners. The planned research infrastructures are closely linked to the research focuses of the research field, as well as to the national and international strategies and roadmaps.
The research activities within the context of the “Supercomputing” programme, in conjunction with the new activities in the portfolio process on the topic of “Large Scale Data Management and Analysis” require a combined computer and storage infrastructure, which is to be realised in the Roadmap by the **“Exascale Computer"** and the **"Helmholtz Data Centre"**. These infrastructures offer several possibilities: They are able to realise complex scientific simulations such as the creation of an organ model of the human brain and simultaneously process, store and analyse large quantities of data, which occur with image recording and processing in microscopy, for example. In addition, simulation laboratories and data lifecycle laboratories associated with both of these infrastructures are established, which enable optimum support of the user community.
New, energy-efficient high-performance computer architectures require fundamental, new approaches in nanoelectronics. The planned user centre of the **“Helmholtz Nanoelectronic Facility”** is intended to support the scientist and thus represents an important step for the success of the research activities with the emphasis on green microchips and computing.
User facilities at the interface between biology, physics, chemistry, engineering sciences and IT, such as the planned **“Centre for Integrative Biology (CIntBio)”** and the **“Centre for Structural Biology”**, make it possible to implement findings from molecular and cellular life mechanisms in new processes, technologies and materials. An emphasis of this is on NMR spectroscopy.
A central challenge for the research field Key Technologies is the exploration of new materials, which are used in lightweight construction in transport and energy technology, in chemical process technology, in future hydrogen and medical technology, among others. For innovative leaps in material development, the fundamental relationships between manufacturing processes, the resulting microstructures and the achievable macroscopic characteristics must be qualitatively and quantitatively recordable. In-situ studies of materials within the context of the **"innovation platform for load-bearing and multifunctional material systems"** research infrastructure, inter alia, with globally unique in-situ process environments in the laboratory area and on the new synchrotron and neutron radiation sources, will play a key role in this.

Further strategic approach:

The development of Key Technologies in the international top field will take on a crucial role for the technical, economic, market-determining innovations. Therefore, the timely investment in large-scale, strategic expansion measures in a competitive context of key technologies is essential. The planned, strategic, large-scale research infrastructures of the research field are secured by longstanding acquisition of expertise and close cooperation with universities and businesses on the basis of smaller expansion investments. The large-scale research infrastructures form a cornerstone of the research activities of the Helmholtz centres in the third programme period and through joint research projects with external partners. They will develop a far-reaching innovative effect beyond the Helmholtz Association.

Research field Key Technologies



The diagram shows the anticipated amount of total investment and the planned construction period for the research infrastructure. The size of the circles corresponds to the anticipated Helmholtz share of total investment (except for ExaCom).

Centres involved in the Key Technologies research field:

- Forschungszentrum Jülich
- Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research
- Karlsruhe Institute of Technology

EXASCALE COMPUTER (ExaCom)

Brief description

Through the expansion of its HPC infrastructure, the Forschungszentrum Jülich has made important contributions to the development of supercomputer technology and, through coordination of the European HPC infrastructure project, PRACE, has reached the top position among supercomputer centres in Europe.
In cooperation with manufacturers, the design and construction of energy-efficient, new, high-performance computer architectures will be strengthened and the use of future supercomputers prepared with prototypes. The aim of the Forschungszentrum Jülich is the setup and operation of an exascale computer, in order to provide its users with the most efficient instrument for gaining scientific knowledge and maintaining international competitiveness. In particular, the exascale computer is to become the central large-scale device of the planned Jülich Human Brain Facility.

Scientific background

Supercomputers have developed into a key technology of the 21st century. With simulations on supercomputers, findings are gained beyond the realms of theory and experimentation. The computing time requirements of leading scientific communities, documented in various scientific cases, are rising rapidly and will reach the exascale range before the year 2020. In order to maintain scientific competitiveness and assume a leading role in the science discipline, it is essential to make the best possible supercomputer resources available to the science groups and support them with the development of new processes.

Prospective benefits

The HPC infrastructure that has been created so far in Jülich offers national and European scientists an outstanding simulation platform under the umbrella of the Helmholtz Association. The results achieved directly contribute to solving social issues with the highest relevance. An expansion of this infrastructure to the exascale level is crucial for science in the Helmholtz Association.

Facts and figures

Timetable:

- Construction: 2016–2020 (continuous expansion)
- Operation: 3 to 5 years after last expansion

Estimated costs:

- Preparation/planning costs: € 2 million
- Construction costs: € 150 million
- Operating costs: € 6 million p.a.
- Reinstatement costs: none

International dimension:

The exascale computer that is planned in Jülich will be the leadership system of the European Tier-0 centres and therefore offer researchers in the Helmholtz Association, in Germany and Europe a competitive advantage.

Role of the centre/centres:

The Forschungszentrum Jülich is the ideal location and architect of the infrastructure on the basis of its more than 25 years of experience and excellence in setting up and operating national and European supercomputers.

Additional information:

www.fz-juelich.de/ias/jsc/EN/
www.prace-ri.eu

CENTRE FOR INTEGRATIVE BIOLOGY

Brief description

The Centre for Integrative Biology (CIntBio) at KIT is planned as an innovative centre which combines transdisciplinary research, innovation and teaching. At the heart of this building will be closely interacting user facilities and technology platforms operating at the interface of biology, physics, chemistry, engineering sciences and IT. Embedding these user facilities in the transdisciplinary research and development environment of the BioInterfaces programme will ensure continuous adaptation of technology to the changing requirements of research. Furthermore, CIntBio will be open to industrial and international users and thereby ensure that research and technology development remain at the forefront, and that innovation results in marketable products. Another vital component of this centre will be teaching, which inevitably serves as a key tool for integrating the various disciplines.

Scientific background

The aim is to acquire and then exploit basic knowledge of living mechanisms at the molecular level to design new processes, technologies and materials. A detailed understanding of the interaction between cells and their environment (e.g. stem cell biology, bacterial biofilms) is a prerequisite for generating innovative technological solutions (functional biomaterials, cell-free synthesis reaction systems, etc.). This requires cross-disciplinary teamwork involving natural and engineering sciences, which is already taking place at KIT. However, only with CIntBio will it be possible to maintain and expand the international standing of these activities.
With a particular focus on stem cell biology and the development of new technologies for manipulating stem cells, this measure will not only fulfil the research policy requirements of the federal government, but will also meet the medical and social challenges that arise from an ageing population.

Prospective benefits

Research at the interface between biology and engineering sciences is recognised worldwide as a basis for innovative technologies with high added-value potential. This is indeed part of the research policy requirements of the federal government (Bioeconomy, Biotech 2020, HighTech Strategy). CIntBio will bundle local and regional competence (University of Heidelberg, KIT) into a centre of international, top-class research. Through industrial co-operations and its own technology- driven spin-offs, CIntBio will contribute to regional and national economic development. With its unique combination of technology platforms and research emphases, it will become a highly visible international user facility. Already, the current expertise on zebrafish research and automation of analytical processes at KIT is achieving international recognition at the highest level.

Facts and figures

Timetable:

- Construction: 2014–2016
- Operation: unlimited

Estimated costs:

- Preparation/planning costs: € 0.8 million
- Construction costs: € 44.2 million
- Operating costs: € 2.2 million p.a.
- Dismantling costs: not applicable

International dimension:

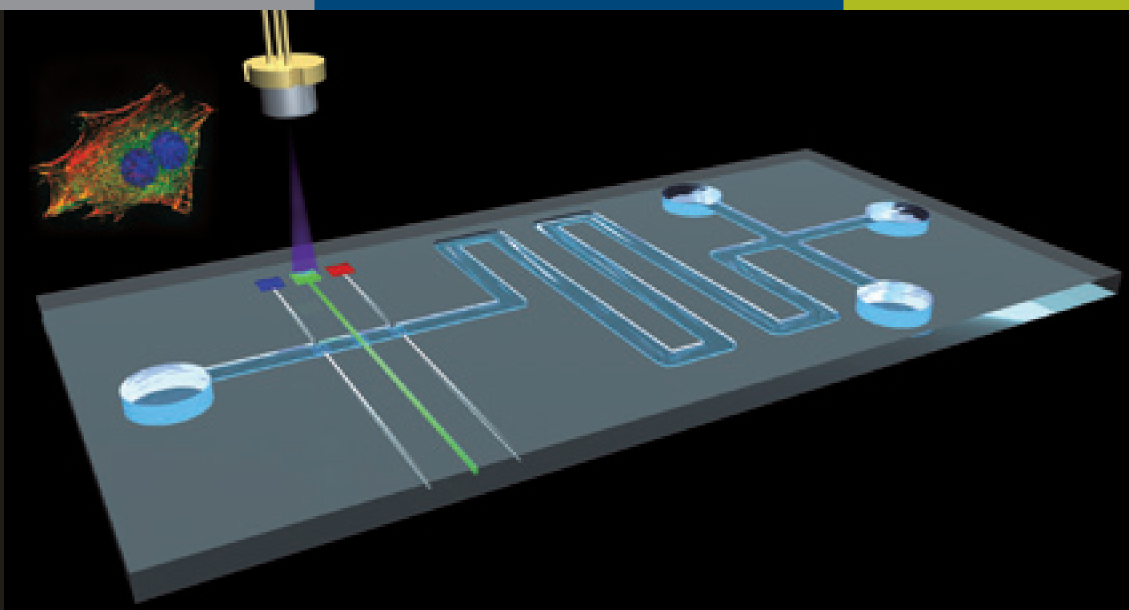
Worldwide, efforts are being undertaken to set up similar centres, however, in CIntBio, the specific combination of technological platforms and scientific expertise is unique.

Role of the centre/centres:

With CIntBio, KIT will expand its biotechnology and create a central research infrastructure in the Key Technologies research field of the Helmholtz Association.

Additional information:

BioInterfaces: *www.itg.kit.edu/26.php*



HELMHOLTZ DATA CENTER (HDC)

Brief description

A wide range of scientific fields requires more storage, management and handling of big data as well as analysis and semantic evaluation with efficient tools and systems of data-intensive computing. This requires a combined storage and processing infrastructure, which extends into the Exabyte range. The aim is to build and operate this infrastructure with the Helmholtz Data Centre on a national and international level and make them available to all sciences.

Scientific background

Until a few years ago big data was mainly generated through simulations on supercomputers. Currently and in the near future, much larger data quantities will be generated by complex experiments, observations and measurements in virtually all scientific disciplines. These data represents particularly valuable goods, as they can usually never be generated again. High-performance storage services, which, in addition to trustworthy storage and effective data management with fast access also provide appropriate possibilities for data analyses, are therefore essential for a basic infrastructure for science. KIT, as a central location, has acquired the relevant competence since many years through the setup and operation of GridKA and the LSDF and is therefore able to focus on data storage, data analysis and data-intensive computing, supplemented by appropriate user support. Forschungszentrum Jülich has comprehensive expertise in supercomputing, in the field of data management and use, and complements the competencies of the KIT in this area.

Prospective benefits

With the Helmholtz Data Centre, the entire data lifecycle will be covered: from the generation of raw data, to an initial anlaysis, to compression of the data near to the source, to initial interim storage for supplying the analysis systems, to linking of the analysis findings with the original data, to publication of the data for review by other scientists and, finally, to archiving.
For this process of gaining scientific knowledge – from raw data to scientific information, to general knowledge – in addition to infrastructure and research, relevant structures for supporting and accompanying scientific communities in optimising already existing or defining new data lifecycles must be established.

Facts and figures

Timetable:

- Construction: 2012–2016 (continuous expansion)
- Operation: until 2020

Estimated costs:

- Preparation/planning costs: none
- Construction costs: € 39 million
- Operating costs: € 1.5 million p.a.
- Reinstatement costs: none

International dimension:

On a national level, the HDC is the first data-focussed infrastructure that is open, in principal, to all sciences. At a European level, the setup of a distributed data infrastructure will begin.

Role of the centre/centres:

On the basis of its documented experience and excellence in the operation of large-scale data and processing infrastructures, KIT is the central location and architect of the infrastructure.
With its experience in supercomputers and HPC data management, Forschungszentrum Jülich contributes to the HDC.

Further information:

www.scc.kit.edu/
www.scc.kit.edu/forschung/lsdf.php www.gridka.de/
www.fz-juelich.de/ias/jsc/

CENTRE FOR STRUCTURAL BIOLOGY IN JÜLICH AND KARLSRUHE

Brief description

The research infrastructure Centre for Structural Biology is a research platform with large-scale research equipment for NMR spectroscopy at the locations of Forschungszentrum Jülich and KIT. In a closely linked research network the methodology of NMR spectroscopy is applied, jointly with OCD spectroscopy, X-ray crystallography and neutron scattering in the centres. For the growing research priority Structural Biology, an expansion of the NMR spectroscopy is planned in both centres. At the heart of the investment, are two NMR spectrometers ≥1 GHz, one 800 MHz widebore DNP-NMR spectrometer as well as a state-of-the art office and laboratory facility. Within the framework of the Raoadmap Structural Biology in the Helmholtz Association this scientific infrastructure is planned as part of the decentralised Helmholtz Höchstfeld NMR Zentrum (HEHNZ).

Scientific background

NMR spectroscopy is a key technology in biomedical research. It enables the determination of high-resolution 3D structures of proteins, as well as the investigation of the dynamics of these biomolecules and the characterisation of their interaction with ligands. Investment in the latest technological developments in NMR spectroscopy enables the investigation of the molecular bases of extremely complex biological systems. This opens up new pathways in health, material and environmental research, such as development of possible approaches for therapy of neurodegenerative disorders and AIDS, design of biofunctional interfaces and development of procedures and processes, which form the basis of a society that will be increasingly bio-based in the future – Bioeconomy.

Prospective benefits

The Centre for Structural Biology offers a unique research infrastructure in the field of high-field NMR spectroscopy. A 1 GHz NMR spectrometer and a 800 MHz widebore DNP NMR spectrometer are currently only available at one location worldwide. With this new infrastructure, pressing questions in the field of health, material and environmental research (such as drug design, diagnostics, biointerfaces and bioeconomy) can be advanced in the targeted manner.

Facts and figures

Timetable:
- Construction: 2013–2016
- Operation: 2014–2029

Estimated costs:
- Preparation/planning costs: € 1 million
- Building costs/costs for large-scale research equipment: € 11 million/€ 27 million
- Operating costs: € 1 million p.a.
- Reinstatement costs: none

International dimension:

The research infrastructure is available to national and international cooperation partners of Forschungszentrum Jülich and KIT, such as the Institute de Biologie Structurale of the CEA (Grenoble) or Harvard (Boston). The graduate training of Forschungszentrum Jülich and KIT will also profit highly from this new research platform.

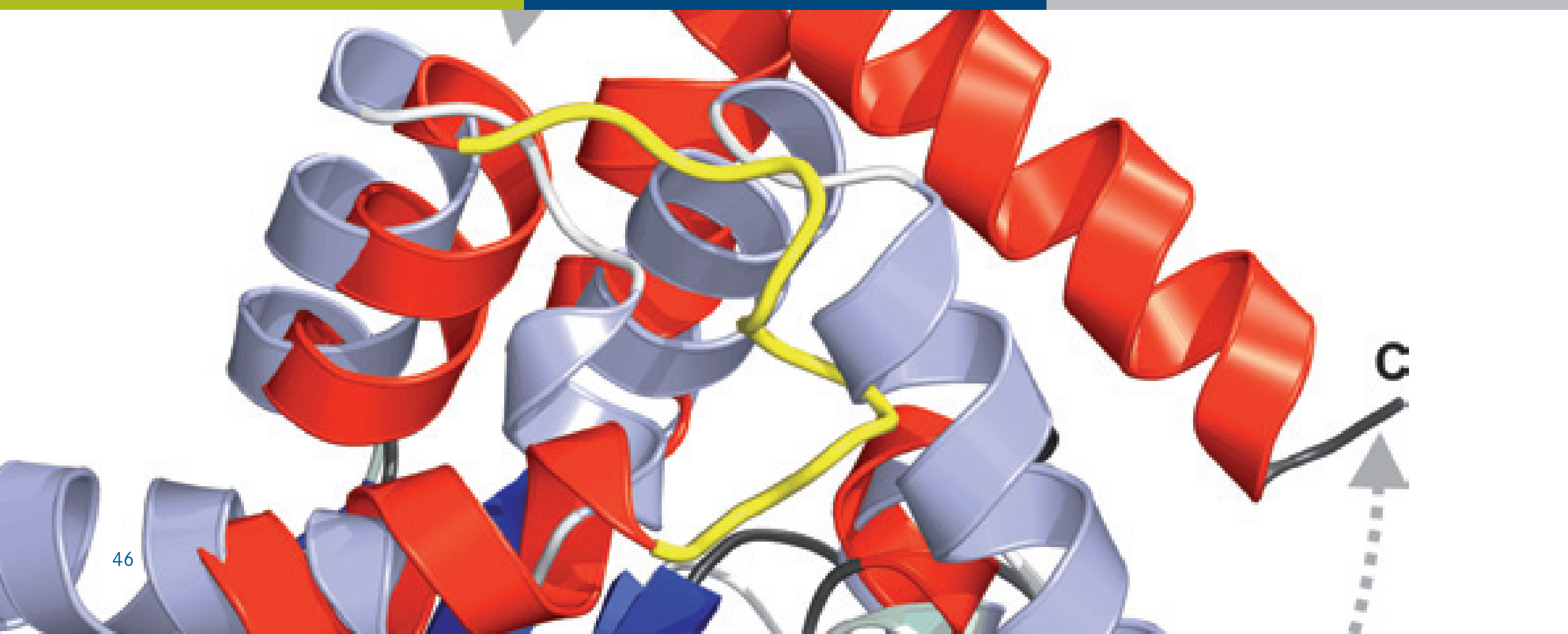
Role of the centre/centres:

Through realisation of the research infrastructure within the context of HEHNZ, Structural Biology in the Helmholtz Association will ensure that in Forschungszentrum Jülich and KIT, research projects in Structural Biology can be further performed at the highest international level.

Additional information:

Roadmap "Structural Biology in the Helmholtz Association" regarding the analysis and further development of the Helmholtz structural biology
www.fz-juelich.de/cae/servlet/contentblob/989868/publication-File/18517/roadmap.pdf
Concept paper "Status and Perspectives of Structural Biology in the Helmholtz Association"
www.fz-juelich.de/cae/servlet/content-blob/989856/publicationFile/18504/perspectives.pdf

Key Technologies



HELMHOLTZ NANOELECTRONIC FACILITY (HNF)

Brief description

The Helmholtz Nanoelectronic Facility (HNF) at the Forschungszentrum Jülich forms the central technological platform for nanoelectronics with an emphasis on “green microchips/computing” in the Helmholtz Association. It comprises a network of facilities, processes and systems for research, production and characterisation of nano and atomic structures for information technology with high strategic importance for the Key Technologies research field and JARA. The HNF facilitates broad access to these technologies for universities, research institutions, industry and the direct transfer of knowledge to society. With this user centre as a second expansion stage, the HNF is achieving full status as a centre of excellence for nanoelectronics in the Helmholtz Association.

Scientific background

A paradigm change is imminent in information technology, which is driven by the requirements for new functionalities and increasingly higher-performance and more energy-efficient components. Therefore, the future lies in cross-system and radical alternative approaches for information processing and data transport. The Research Centre will meet this challenge with the construction of a nanoelectronic platform for bio-inspired architectures, quantum information, non-volatile memory and CMOS switches at its physical limits.

Prospective benefits

Secure and environmentally-compatible use of energy represents one of the main challenges for modern society. Information technology must also face this challenge. The extreme hunger for energy of integrated circuits and applications is growing rapidly and currently lies at around ten percent of total electricity consumption for the Federal Republic of Germany, with a rising trend. The resource-conserving use of energy through increasing efficiency plays a key role in this, so that "green microchips" and "green computing" are the challenges for society that need to be solved.

Facts and figures

Timetable:

- Construction: 2013–2015
- Operation: 25 years

Estimated costs:

- Preparation/planning costs: € 3 million
- Construction costs: € 30 million
- Operating costs: not yet specifiable
- Reinstatement costs: not yet specifiable

International dimension:

Through the Peter Grünberg Institute, the HNF is represented in all relevant EU networks (e.g. SiNANO, ENIAC/AENEAS, MEDEA+) and has numerous industrial cooperations (e.g. HP, IBM, Sony, AMD, Leti).

Role of the centre/centres:

The HNF is an essential component for the Fundamentals of Future Information Technologies programme, the Key Technology field of the Forschungszentrum Jülich and for the Information field within JARA, as well as for the acquisition of additional cooperations from research and business.

Additional information:

The HNF is operated by the Peter Grünberg Institute and is one of the central infrastructures. The first expansion stage of the HNF, a clean-room facility, will be completed in 2012.

Further information:

www.fz-juelich.de, (Peter Grünberg Institute)

INNOVATION PLATFORM FOR LOAD-BEARING AND MULTIFUNCTIONAL MATERIAL SYSTEMS

Brief description

The challenge: The targeted model-based and simulation-based development and optimisation of material systems and their processing is regarded worldwide as a major challenge for material sciences and a key element in global competition. Currently, the fundamental relationships between production processes, the resulting microstructures and the achievable macroscopic characteristics can only be fractionally specified when making use, primarily, of empirical methods.

The breakthrough: Through the use of in-situ process testing environments in the laboratory sector that are unique worldwide, and the use of new high-performance large-scale devices for synchrotron and neutron radiation (PETRA III, XFEL, ESS, FRM II, etc.), rapidly occurring processes inside the materials will be qualitatively and quantitatively recordable.

The linking of findings from in-situ investigations with computer simulations at different length scales allows verification of material science models and, based on this, the targeted, model-based and simulation-based development of material systems.

Scientific background

The goals of the in-situ investigations of the research platform are, inter alia, the recording of fundamental morphological and kinetic processes in the load-bearing material systems with liquid-solid transfer (pouring and welding), as well as with plastic deformation (rolling, casting, extrusion, etc.), in order to derive considerably improved models for process optimisation.

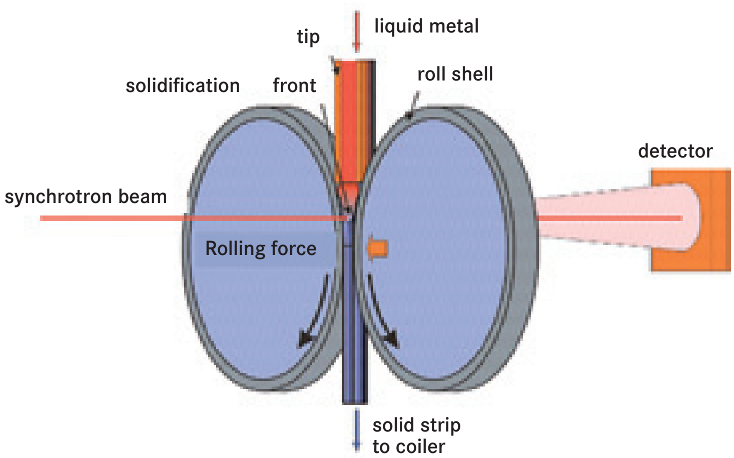
- the simultaneous recording of stress conditions and plasticity with deformation, damage, formation and extension of cracks,
- the analysis of biocompatibility and degradation properties of biomaterials under laboratory conditions at a mesoscopic and molecular level.

Prospective benefits

The research infrastructure makes concrete contributions to the socially relevant fields of application:

- **Lightweight construction and a mobile future, conservation of resources** for saving weight and increasing the safety of extremely lightweight structures under operating stress conditions,
- **Energy storage and implementation** with the aim of developing storage materials and tank systems for hydrogen technology, e.g. for storing renewably generated energy.
- **Alternative separation techniques** for energy-efficient and resource-conserving material separation with membrane technologies in the chemical industry and energy technology.
- Regenerative medicine for improving the transferability of test data to the living organism.

With these and further applications, the strategy of the planned research infrastructure supports the main topics of the "10-Point Programme for Material Sciences and Materials Engineering" of the Federal Ministry of Education and Research.



Facts and figures

Timetable:
- Construction: 2012–2015
- Operation: 2016–2025

Estimated costs:
- total € 25 million

Split not yet precisely specifiable.

International dimension:

The special feature of this approach lies in cross-research-field, sustainable use of the aforementioned, internationally-leading Helmholtz research infrastructure for the theoretical, scientific and application-orientated research from the atomic structure of technologically relevant materials to components and systems.

Role of the centre/centres:

With the establishment of this research platform, the HZG is linking internationally-leading large-scale equipment for research with photons and neutrons at various locations (PETRA III, XFEL, ESS, FRM II, etc.) with the bundled expertise of material sciences and materials engineering at the Geesthacht location in the aforementioned subject areas (Magnesium Innovation Centre/MagIC, Assessment, Computing and Engineering Platform and the planned Polymer Technology Centre).

Additional information:

www.hzg.de; gems.hzg.de (see particularly film: GEMS)
www.hzg.de/program/materials_systems/index.html.en

STRUCTURE OF MATTER

The research field

From the basic components of matter and fundamental forces, to complex materials and up to cosmological development of the universe, the research field studies matter in all its manifestations. Accordingly, the range of research activities extends from finding-orientated theoretical research to application- and technology-based projects.

Global objectives and future research emphases:

The strategic objectives of the Structure of Matter research field are based on the major questions and challenges in this sector. These include:

- elucidating the origin and development of matter in our universe,
- looking into the components of matter and their interactions,
- creating and characterising the diverse forms of cosmic matter in the laboratory,
- penetrating and controlling the function of matter at the level of atoms and electrons,
- controlling the evolution of complexity at the atomic level.

In order to answer these questions, the research field builds, operates and uses large-scale research infrastructure, such as world-wide unique accelerator and detector systems, high-performance laser systems, high-field magnet laboratories and state-of-the-art, high-performance computers for analysis and storage of huge data amounts. These research infrastructures are also available to external, national and international scientists for scientific-technical projects. In the future, the research programme is intended to develop an even stronger impact across disciplines and fields, to advance strategic cooperations with universities, to expand its international collaboration even further, to serve as an expert platform for national and international partners and to be open to industry.

Integration of the planned research infrastructures into the objectives and prospects of the research field and into the existing infrastructural landscape:

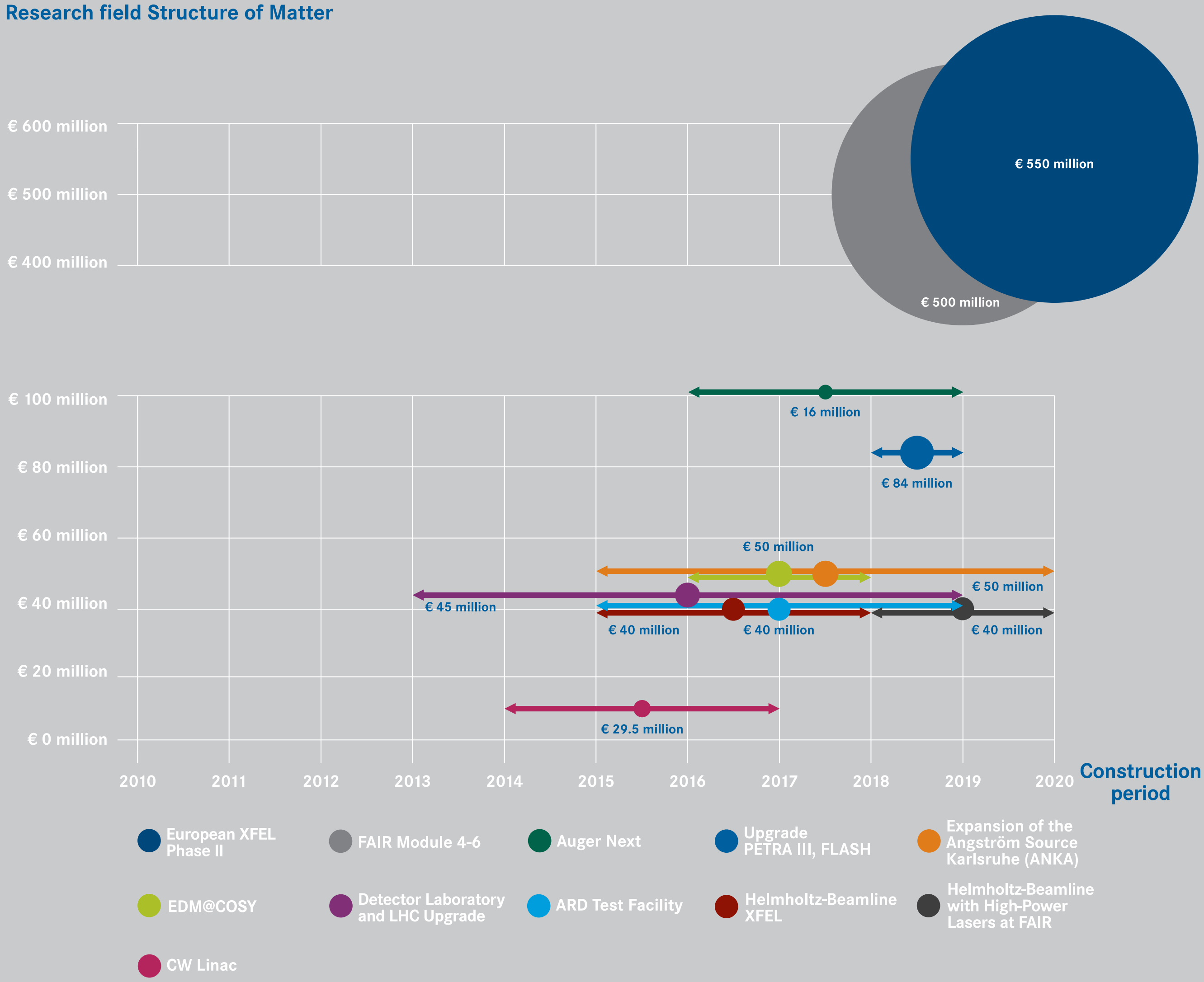
An important function of the research field is to anticipate the future requirements for large-scale research infrastructures together with the national and international scientific community and lead these to project readiness with applicable concept studies. Therefore, the research field makes a significant contribution to the future development of the research landscape in Germany and furthermore, to the structuring of the European Research Area.

The present roadmap contains the eleven new research infrastructures and upgrades of existing infrastructures, respectively recommended by the Structure of Matter research field: With the aim of better understanding the origin, the characteristics and the expansion of high-energy cosmic radiation, the former Pierre Auger Observatory shall be further developed into **AugerNext**. For further development of the CERN-LHC experiments, ATLAS and CMS, to search for the origin of particle masses and the matter-antimatter asymmetry, as well as the ALICE experiment for investigating the quark-“primal matter”, the **Detector Laboratory and Detector Upgrades** project has been recommended for realisation. The Helmholtz centres are involved in all three experiments in association with German universities. As a complementary method for investigating the origin of matter-antimatter asymmetry, the **EDM@COSY** project is intended to be carried out, which searches for particles with a constant electrical dipole moment (EDM). As an important addition to the research possibilities at the international FAIR project in Darmstadt, particularly in the emerging field of physics of dense plasmas and laser particle acceleration, the **Helmholtz-Beamline with High-Power Laser at FAIR** is intended to be realised. The expansion of the **FAIR** facility with the originally planned **Modules 4-6** also continues to be pursued by the Helmholtz centres in cooperation with FAIR GmbH and the international community of researchers. In addition to the existing UNILAC accelerator at the GSI, construction of a comparatively energy-saving and cost-saving **CW-Linac** is proposed, which will not only significantly improve the experimentation conditions for heavy element research, but also for other radiation experiments, e.g. in material research and radiobiology. In the Helmholtz Association, an excellent and complementary array – in terms of their methodological possibilities – of well-equipped synchrotron, neutron and ion-beam laboratories exist which facilitate state-of-the-art research on and for innovative materials. The **Upgrade PETRA III and FLASH** and **Expansion of the Angström Source Karlsruhe ANKA** promise dramatic improvements with the characterisation of matter and – based on this – with the development of new, functional materials and substances. As an important expansion to the research options at the XFEL European X-Ray Laser in Hamburg, the **Helmholtz Beamline at European XFEL** shall be realised, which opens up unique opportunities for studying matter with extremely high temperatures, densities and field strengths. The proposed **Phase II** of the **European XFEL** would double the available measuring time, so that approximately ten experiments can be conducted at the same time. In order to investigate and test innovative accelerator concepts for theoretical research and applications, the planned **ARD Test Facility** shall be realised as a distributed research infrastructure.

Further strategic approach:

Beyond the 10-year perspective of this roadmap, the Structure of Matter research field has identified a series of new future projects with high prospects. For example, it is being examined whether an upgrade to BESSY II is possible in relation to variable pulse lengths. This upgrade shall enable a better understanding of chemical and catalytic mechanisms and operating principles of materials. In addition to a next generation photon sources for the ultraviolet and soft x-ray beam range at the Helmholtz Centre Berlin, the participation in an International Linear Collider or the establishment of a Competence Centre for Materials and Life Sciences in Jülich is envisaged.

Research field Structure of Matter



The diagram shows the anticipated amount of total investment and the planned construction period for the research infrastructure. The size of the circle corresponds to the anticipated Helmholtz share of total investment (except with European XFEL Phase II and FAIR Modules 4-6).

Centres involved in the Structure of Matter research field:

- German Electron Synchrotron DESY
- Forschungszentrum Jülich
- GSI Helmholtz Centre for Heavy Ion Research
- Helmholtz Centre Berlin for Matter and Energy
- Helmholtz-Zentrum Dresden-Rossendorf
- Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research
- Karlsruhe Institute of Technology

EUROPEAN XFEL PHASE II

Brief description

Based on superconducting technology, up to 300,000 electron packages can be accelerated in the European XFEL linear accelerator, through which a larger number of FEL undulators can be supplied in parallel. In Phase II of the European XFEL, the available measurement period and the measurement options are intended to be expanded by a factor of two through the establishment of a second experimentation hall with 10 to 15 experiments and a further five FEL undulators. The upgrading of the accelerator to continuous operation with a uniform sequence of photon pulses would be associated with this. The development and testing of so-called superconductive CW high-frequency technology will be advanced at DESY within the context of the ARD accelerator research programme and shall initially be used at FLASH.

Scientific background

The pulsed version of the European XFEL linear accelerator already achieves a moderate photon intensity, which is around a factor of 100 above the conventional facilities, such as LCLS. Particularly the investigation of ultrafast dynamics with moderate excitation query experiments would profit significantly from this, if the high number of photon pulses were not only available over a short time period, but rather, evenly distributed in a continuous mode. The superconductive technology would thereby reach its ultimate potential, although such an upgrade must still be preceded by a series of development activities.

Prospective benefits

The European XFEL will supply unique photo parameters worldwide at x-ray laser proton beams. Due to the extremely short photon pulses, the investigation of the function and dynamics of matter will be possible on time scales into the fs range. These characteristics will make it possible, e.g. quasi 'to film' chemical reactions and their transition statuses on atomic length scales. With this knowledge, success will be achieved in controlling and optimising these reactions in order to e.g. optimise the generation and use of chemical energy. The coherency characteristics of FEL light will also make it possible to map non-crystalline matter into the atomic range. The superconductive technology of the European XFEL produces sufficient photon pulses in order to operate several laser undulators at the same time. The proposed Phase II of the European XFEL would double the available measuring time, so that approx. ten experiments can be conducted at the same time.

Facts and figures

Timetable:

- Construction: from 2020
- Operation: at the earliest from 2023

Estimated costs:

- Preparation/planning costs: see below
- Construction costs: € 550 million (incl. preparation/planning costs)
- Operating costs: € 100 million / p.a. (for the entire XFEL facility)
- Reinstatement costs: not yet specifiable

International dimension:

As a unique facility worldwide, after commissioning of phase 1 at the European XFEL, a strong rise in demand is expected from European users for beam time. In relation to this, the interest of international partners in upgrading the facility is expected to grow further.

Role of the centre/centres:

Phase II of the European XFEL will be coordinated and organised by DESY jointly with European XFEL GmbH.

Additional information:

www.desy.de/forschung/projekte/european_xfel/index_ger.html
www.xfel.eu/en/

FAIR MODULE 4-6

Brief description

In 2011, construction of the international “Facility for Antiproton and Ion Research” (FAIR) started. By 2016/17, modules 0 to 3 of a total of seven modules, forming the full FAIR Facility, are to be completed. Modules 0 to 3 make it possible to enter new scientific ground in all four research pillars of FAIR: in atomic, plasma and applied physics (APPA*), in the field of hot dense core matter (CBM*), in core structure and nuclear astrophysics (NUSTAR*) and in hadron physics with antiproton beams (PANDA*). In order to utilise the full discovery potential of FAIR, realisation of the next modules, 4 to 6, should be initiated by the end of this decade. As additional experimental facilities, module 4 includes the new NESR experiment storage ring, including a decelerator for experiments with highly charged ions and antiprotons at moderate and low energies; in addition to this, the low-energy experiment station for the investigation of exotic nuclei at rest, e.g. in traps. Through an additional ring – the RESR – module 5 improves research opportunities for PANDA and NUSTAR. With the high-energy synchrotron/stretcher ring SIS300, module 6 provides significantly increased opportunities for physics at CBM, as well as for physics at PANDA, through the addition of a high-energy electron cooler.

Scientific background

The international FAIR facility will open up world-wide unique research opportunities for a broad experiment programme, which ranges from the physics of hadrons and nuclei, to the fields of atomic physics, plasma physics, biophysics, materials research and geophysics. For these research fields, FAIR provides a system of accelerators and storage rings, with which stable and radioactive ions and antiprotons can be generated in a wide range of intensity and energy. After completion and commissioning of modules 0 to 3 in the next six years, modules 4 to 6 are intended to be realised from 2019 on, which will again crucially improve and expand the research opportunities for the APPA, CBM, NUSTAR and PANDA research programmes at FAIR.

Prospective benefits

The realisation of FAIR modules 4 to 6 opens up new/ significantly expanded opportunities for the 2500 - 3000 users of FAIR. This applies to all four research pillars at FAIR: APPA, CBM, NUSTAR and PANDA. Furthermore, the efficiency of the overall facility will be further increased, as with the additional large accelerator ring – the SIS300 – up to four experimental programmes can be run in parallel operation.

Facts and figures

Timetable:
- Construction: 2019–2022
- Operation: from 2020 (> 15 years)

Estimated costs:
- Preparation/planning costs: € 30 million
- Construction costs: € 400 million
- Operating costs: additionally approx. € 20 million p.a.
- Reinstatement costs: not yet specified

International dimension:

The realisation of FAIR modules 4 to 6 opens up new/ significantly expanded opportunities for the 2,500 - 3,000 users of FAIR. Furthermore, through the parallel operation of up to four experimental programmes, which will then become possible, the efficiency of the overall facility will be dramatically increased.

Role of the centre/centres:

Expansion of the FAIR modules is intended to be jointly carried out by GSI (leading institute) together with other Helmholtz centres, the Helmholtz institutes in Jena and Mainz, and with other national and international partners.

Additional information:

www.gsi.de

* APPA: **A**tomic, **P**lasma Physics and **A**pplications; CBM: **C**ompressed **B**aryonic **M**atter; NUSTAR: **Nu**clear **St**ructure, **A**strophysics and **R**eactions; PANDA: **P**roton-**A**ntiproton-**AN**nihilation at **DA**rmstadt

Structure of Matter

AUGER NEXT

Brief description

AugerNext is a next-generation observatory for the investigation of cosmic rays at highest energies. With an instrumented area of approx. 30,000 square kilometres, with optical telescopes for fluorescence light emission in the atmosphere and with innovative technologies (radio detection in various frequency ranges), a database will be created for the observation of the sky with cosmic particles, which exceeds the quality and quantity of what has been achieved so far (e.g. by the Pierre Auger Observatory in Argentina) by an order of magnitude and ideally covers the northern sky. The location will depend on the technologies available for the detector equipment and wireless data communication; a suitable range is between 30 and 45 degrees north.

Scientific background

Cosmic rays consist of nuclei, which impact on Earth with energies above 10 million TeV (in comparison: the LHC accelerates particles to 7 TeV). Such particles probably originate from sources outside our galaxy; they are very rare and require very large instrumented areas. The aims of the measurements are to determine the energies, arrival directions and types of particles with the largest possible statistics and to identify the cosmic sources. Sufficient measurement quality is important in order to study the particle interactions in the Earth's atmosphere at of centre-of-mass energies up to 400 TeV (LHC: up to 14 TeV).

Prospective benefits

AugerNext is the working title for a unique, international observatory for cosmic rays, which is based on the scientific results from the Pierre Auger Observatory (Mendoza/Argentina), the Telescope Array (USA/Utah) and other smaller projects. Interdisciplinary fundamental research and technology development will be combined into a very large research training platform with several hundred international PhD theses conducted over the duration of the project. The anticipated scientific insights cannot be achieved with any other method during the foreseeable future.

Facts and figures

Timetable:

- Construction: 2016–2019
- Operation: 2018–2028

Estimated costs (joint project; Helmholtz share approx. 15%):

- Preparation/planning costs: € 4 million
- Construction costs: € 110 million / € 16.2 million (planned Helmholtz share)
- Operating costs: € 5 million p.a.
- Reinstatement costs: not yet specifiable

International dimension:

A scientific collaboration among more than 15 countries will offer unique working opportunities to more than 400 direct users over more than 10 years. The cooperation is already partially established – e.g. within the Auger Observatory – and partially new; with important partners, such as Russia, Japan and China.

Role of the centre/centres:

The KIT Helmholtz centre will take on a leading architectural role; it has the scientific and technological competencies that are required to plan such a facility, to build large components, and operate it over more than a decade.

Additional information:

www.ikp.kit.edu/english/

UPGRADE PETRA III AND FLASH

Brief description
The aim of this measure is to expand the scientific technology potential of the existing PETRA III and FLASH accelerator facilities within the context of a coordinated upgrade programme. For this, two additional experimental halls in the west and northwest are intended to be built at the PETRA III synchrotron light source, following the successful model of the first expansion stage, each with up to 5 beamlines for experiments with high-energy synchrotron light. For FLASH, the free-electron laser facility which is directly adjacent to PETRA III, additional experimental options and expansion measures are also envisaged. This comprises an increase in the particle energy to 1.6 GeV, conversion of the linear accelerator to quasi-continuous operation, and installation of undulators with adjustable magnet separations. For this, the linear accelerator needs to be lengthened, a new injector installed, the high-frequency system replaced and the cryogenic supply needs to be expanded.

Scientific background
The use of synchrotron beams extends across material research, nano sciences, structural biology, solid-state physics and chemistry, etc. Most notably hard x-ray beams are gaining importance as non-destructive (non-invasive) probes for in-situ investigations under realistic conditions, for example, characterising buried boundary surfaces inside solid bodies, or examining chemical processes non-invasively within reaction vessels. In recent years, scientists have also learned to appreciate the advantages of this diagnostic tool from a series of new application fields, such as archaeometry, paleontology and environmental sciences. The light from FLASH, with pulse lengths in a range of several 10 fs, is also ideally suited to investigating the dynamics of matter on atomic timescales. For the investigation of biological samples or magnetic materials, higher photon energy is needed, which can be achieved with new undulator structures and particle energy of 1.6 GeV.

Prospective benefits
The planned expansion will round out the portfolio of available techniques in the field of hard synchrotron beams at DESY. Together with BESSY II (HZB), ANKA (KIT), and the German usage of the ESRF (Grenoble), as well as with the European XFEL, this expansion will ensure a first-class supply of light sources for German scientists in this field. The dynamics of matter on extremely short timescales and atomic dimensions is still a largely unresearched field. In addition to fundamental scientific questions regarding the understanding of such processes on extremely short timescales, the findings gained from this can contribute, for example, to understanding of chemical reactions or catalytic processes in order to influence and optimise these in a targeted manner.

Facts and figures

Timetable:
- Construction: 2018–2019
- Operation: 2019–2040

Estimated costs:
- Preparation/planning costs: € 4 million
- Construction costs: € 80 million
- Operating costs: € 5 million p.a. (incl. personnel, in addition to the current operating costs of PETRA III), with FLASH, apart from cryo plant, essentially as with the current operation
- Reinstatement costs: not yet specifiable (< € 1 million)

International dimension:
PETRA III and FLASH are unique research infrastructures worldwide, which are used nationally, as well as internationally.

Role of the centre/centres:
DESY will plan, build and operate this expansion of PETRA III and FLASH. As with the imminent expansion stage of PETRA III, it is anticipated that a series of national and international institutional partners will participate in the financing of this project.

Additional information: *hasylab.desy.de*

Structure of Matter

EXPANSION OF THE ÅNGSTRÖM SOURCE KARLSRUHE (ANKA)

Brief description

With the ANKA synchrotron radiation source, the KIT focuses its research emphasis on the intermediate-energy x-ray region, as well as on the field of THz/IR radiation. In order to optimally develop the performance parameters of the storage ring, particularly also in conjunction with superconducting insertion devices, and to create competitive operation conditions for the future, ANKA shall be upgraded with a full-energy injector comprised of a Linac and a 2.5 GeV booster synchrotron. At the low-energy end of the spectrum, the large-scale equipment landscape of the KIT will be supplemented with the TBONE (THz Beam Optics for New Experiments) facility. At the heart of this facility is a superconducting 100 MeV Linac, which will supply extremely short, broad-band, and highly brilliant pulses from the THz to the mid-IR range. With the TBONE User Facility, the KIT is pursuing the goal of operating the worldwide leading user facility in the THz/IR range.

Scientific background

Expanding ANKA with a full-energy injector and a top-up option is a necessary step to secure its future as a national/international light source. Through the upgrade, the beam availability will be significantly improved, both quantitatively and qualitatively. The TBONE facility additionally offers an integral THz/IR pulse output that is comparable to FELs; furthermore, it offers the bandwidth necessary for spectroscopy, exceeding those of storage rings by 2 orders of magnitude. The TBONE source will facilitate and promote new methods, particularly in linear and non-linear spectroscopy, near-field microscopy and methods for investigating ultrafast phenomena.

Prospective benefits

In its fully upgraded state, ANKA will make an essential contribution to the need for synchrotron radiation for internationally competitive research in the intermediate-energy x-ray range and in the field of THz/IR radiation. Furthermore, being embedded in the research infrastructure of the KIT, integrated access to state-of-the-art high-tech platforms is facilitated. With radiation from the THz to the mid-IR range, TBONE will be the only available strong source for this wide spectral range, which extends beyond the THz gap. This unique feature will significantly contribute to establishing ANKA as an international research platform.

Facts and figures

Timetable:

- Construction: 2015–2020
- Operation: 20 years

Estimated costs:

- Preparation/planning costs: € 5.5 million
- Construction costs: € 44.5 million
- Operating costs: € 5 million p.a.
- Reinstatement costs: not yet specifiable

International dimension:

The planned User Facility for Research with Synchrotron Radiation in the intermediate-energy x-ray range, as well as in the THz/IR range with a unique broadband THz/IR source, forms the core of an international combination of competences and infrastructures in this field. On this basis, the existing collaboration with PSI, HZB, TU Dresden and the HZDR will be strengthened and further expanded.

Role of the centre/centres:

The KIT will coordinate the construction and operation of the planned synchrotron radiation infrastructure to establish a worldwide-recognised cluster of excellence.

Additional information:

http://ankaweb.fzk.de/

EDM@COSY

Brief description

Using a dedicated precision storage ring to search for electric dipole moments (EDM) of charged particles (p, d, ^{3}He), the sensitivity compared to other approaches (e.g. neutron) can be improved by orders of magnitude, possible EDMs can be measured and their origin, i.e. the physics beyond the Standard Model, can be investigated. The method is based on the storage of a particle beam with the polarisation vector along the momentum direction ("frozen spin"); the signature for an EDM (an upper limit) lies in the (lack of) observation of a vertical polarisation build-up during the course of the storage time. This project requires construction of a conventional large-scale facility, for which COSY can be used as an injector. It is planned to realise the new ring within the existing building.

Scientific background

The search for a permanent EDM of particles (electron, neutron, proton, etc.) is of fundamental interest in physics, since EDMs violate both parity (P) and time reversal invariance (T) and therefore – through CPT – also CP. This violation is manifested in the matter-antimatter asymmetry in our universe, which the Standard Model of particle physics cannot explain at all, i.e. there must be additional sources for CP violation. Searching for these or finding them implies physics beyond the Standard Model and, ultimately, pursuing the question of the puzzle of our existence.

Prospective benefits

The EDM-search of charged particles in a storage ring is a must-do experiment; however, the technical challenges for the apparatus and the measurement technique are enormous. In addition to the fundamentally innovative precision storage ring (using a combination of high electrical and magnetic fields), inter alia, extremely precise and stable polarimeters and beam position monitors need to be developed. These will stimulate both accelerator and measurement technology. This precision measurement is complementary to high-energy experiments beyond the LHC.

Facts and figures

Timetable:

- Construction: 2016–2018
- Operation: 2019–2029

Estimated costs:

- Preparation/planning costs: € 1 million p.a.
- Construction costs: € 50 million
- Operating costs: € 5 million p.a.
- Reinstatement costs: not yet specifiable

International dimension:

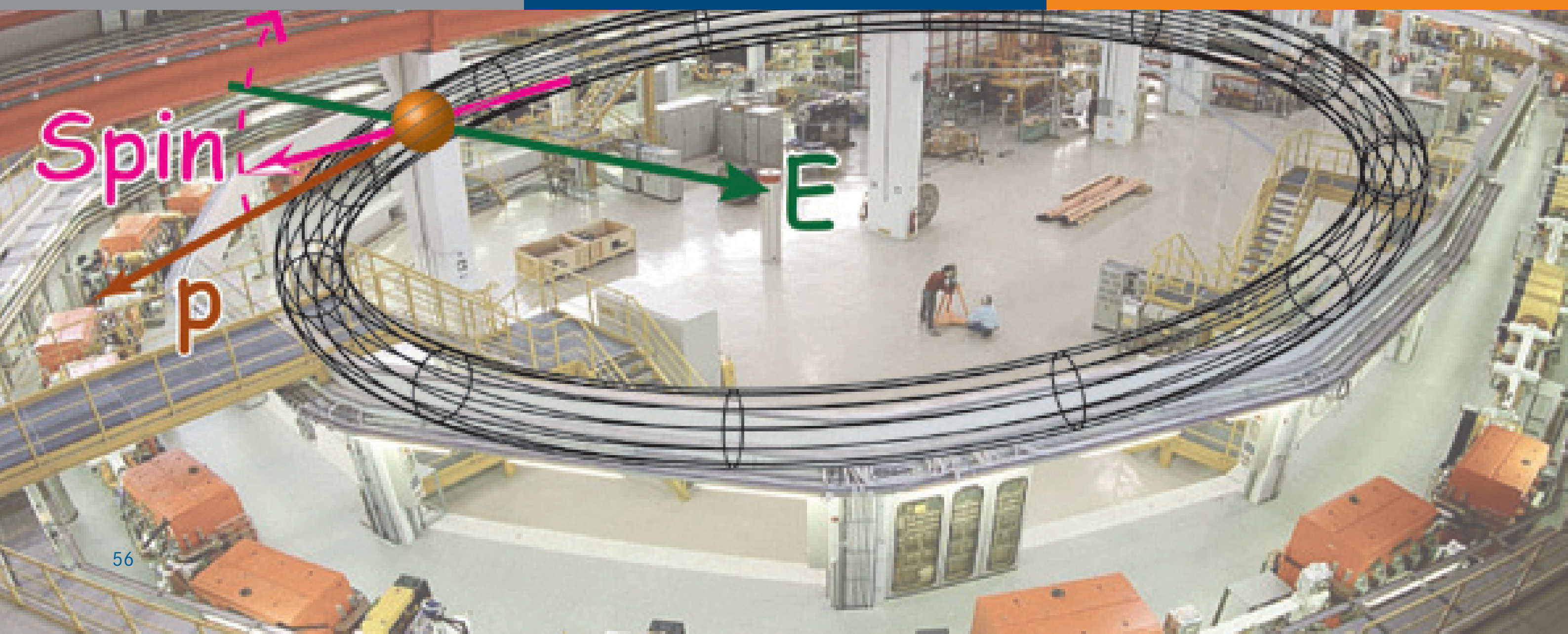
EDM storage is of international interest and is being advanced in global collaboration (Study Group FZJ – BNL (USA)). COSY is the ideal facility for all necessary preparatory studies.

Role of the centre/centres:

The Forschungszentrum Jülich is the exclusive applicant for the EDM@COSY research infrastructure. The location for the EDM ring will be the Forschungszentrum Jülich.

Additional information:

www2.fz-juelich.de/ikp/en/future_projects.shtml
www2.fz-juelich.de/ikp/de/future_projects.shtml



DETECTOR LABORATORY AND LHC UPGRADES

Brief description

The LHC is the most important international project in elementary particle physics, which was started very successfully with collision energy of 7 TeV in 2010 and from which, far-reaching, new findings are expected regarding the fundamental elements and forces in our universe. Furthermore, important contributions are to be made by DESY, in close collaboration with the participating German university groups, regarding the detector upgrades of the ATLAS and CMS experiments, which are necessary for the planned high-luminosity operation of the Large Hadron Collider LHC at CERN from around 2020. Analogous to this, GSI and the Forschungszentrum Jülich are intended to take on key contributions to upgrading the ALICE experiment. With this research infrastructure, Helmholtz centres will take on a coordinating role in Germany and a leading role internationally.

Scientific background

The Detector Laboratory and LHC Upgrade comprises the planning and construction of a laboratory building, including technical infrastructure at the DESY for the development and building of large-scale, high-precision detectors for future international experiments in particle physics. From around 2020, the collision rate (luminosity) is intended to increase by another factor of 5-10. For this, the replacement and improvement of many key detector components of the experiment are necessary. The LHC and the high-luminosity phase are projects with the highest priority in the European strategy for particle physics, which have been approved by the CERN Council and represent part of the ESFRI Roadmap.

Prospective benefits

The LHC is a global project in fundamental physics research, in which Germany participates with around 20 percent. More than 20 German universities, the Max Planck institutes and Helmholtz centres are participating in the experiments. With the research infrastructure proposed here, the prospects for Helmholtz and other German groups will be improved significantly through participation in the scientific results of the LHC through coordinated, joint projects. The Detector Laboratory will substantially increase the opportunities for German groups and of Helmholtz, of participating in major international projects relating to particle physics beyond the LHC, such as a future linear collider and other experiments. The Detector Laboratory fits seamlessly into the strategy of the Helmholtz Association playing a leading and internationally visible role in the field of innovative technologies. It offers the framework in which the expertise existing at Helmholtz in the field of detector development can be implemented in concrete projects. It therefore complements other initiatives at Helmholtz, such as the "Detector Technology Platform" portfolio topic.

Facts and figures

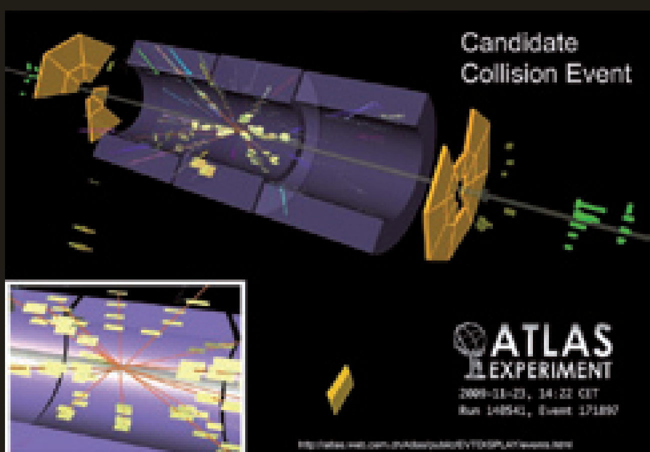
Timetable:
- Construction: Detector Laboratory 2013–2015, LCH Detector Upgrades 2015–2019
- Operation: Detector Laboratory from 2015 for > 20 years LHC Detectors; after upgrade from 2020 for ≥ 10 years

Estimated costs:
- Construction costs: Detector Laboratory incl. technical infrastructure: € 25 million
- ATLAS and CMS upgrade: € 20 million' ALICE upgrade not yet specified

International dimension:
The LHC experiments are major international collaborations, each with approx. 3000 scientists from more than 150 institutes, from 40 countries. In addition to CERN, all leading international centres of particle physics are represented. DESY will take on a leading role within the context of this research infrastructure in the upgrades of ATLAS, and CMS, GSI and Forschungszentrum Jülich will participate accordingly in ALICE.

Role of the centre/centres:
The proposed research infrastructure is intended to update the technical infrastructure, so that DESY will also play a leading international role in the future of elementary particle physics and can act as a German centre for particle physics. GSI and Forschungszentrum Jülich can expand their leading role with the FAIR detectors on heavy ion experiments with the highest energies at the LHC. Helmholtz centres will become architects of future particle physics projects through this research infrastructure.

Additional information: *www.desy.de/en*



ARD TEST FACILITY

Brief description

The aim of the ARD Test Facility is to further develop accelerator concepts with the highest gradients and investigate their potential in realistic fields of application, such as the generation of highest energies, compact beam sources or radiation medicine. The emphasis is placed on innovative plasma accelerators, which can be powered using intense laser pulses or relativistic particle pulses, depending on the application. Different particles, for instance electrons and ions, and constraints such as the average beam power of a facility, require different driver concepts, so that a division of the facility into two to three centres with various complementary and extendable driver technologies (DESY, HZDR, GSI) is advantageous.

Scientific background

Laser-powered plasma accelerators (LPWA) allow extreme high acceleration gradients, which have been demonstrated in experiments to exceed conventional technologies by three orders of magnitude. The challenge lies in improvement of the stability of the generated beams and in the development of complex systems, for example by cascading several stages, which allows to scale up the particle energy. Ion and electron accelerators require very different plasma characteristics and therefore, different driver characteristics, which require a distributed facility with different specialisations. Ultra-short particle bunches can be used both as drivers and as injectors, so that, as with diagnostics, large synergy effects can be realised for activities for the generation and diagnosis of such pulses.

Prospective benefits

Innovative concepts, which enable higher field gradients and therefore shorter accelerator structures than conventional systems, facilitate both the thrust into increasingly higher energy ranges, and the decentralised deployment of compact systems for either medical applications or as drivers for hard radiation sources. Initial experimental applications and approaches in the fields of radiation medicine, x-ray imaging (phase contrast imaging) and in the setup of a two-stage plasma accelerators are illustrative of these possibilities, which have only begun to be researched. This research infrastructure allows the continuing systematic pursuit of these application-based goals in the environment of established large-scale laboratory infrastructures.

Facts and figures

Timetable:

- Setup and further development: 2015–2019
- Operation: from 2015/16

Estimated costs:

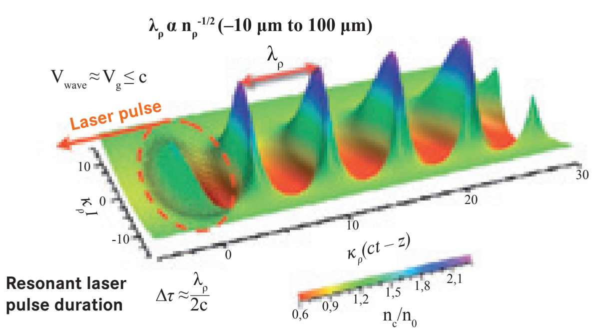
- Preparation/planning costs: within the context of the basic financing of the ARD programme
- Construction costs: € 40 million
- Operating costs: € 3 million p.a., currently to be financed within the context of the ARD
- Reinstatement costs: not yet specifiable

International dimension:

The research infrastructure will take on an internationally prominent position, as it will combine the latest technological concepts with previously unachieved quality, such as various ultra-short pulse lasers in the petawatt range, ion accelerators and GeV electron accelerators with an adapted fs pulse structure, in a jointly-coordinated structure, which can be used, in part, in a combined manner. Collaborations exist with international leading projects, such as BELLA and FACET (both USA). In Europe, linking points exist with the ELI and TIARA projects.

Role of the centre/centres:

The distributed facility will have a focus on particle-beam-powered plasma electron acceleration, which is based at the DESY (plasmaFLASH). This activity will be accompanied by laser plasma acceleration studies focussing on the PW and 100TW lasers that are in preparation at HZDR and DESY, including the cascading of LPWA levels. Systematic ion acceleration experiments will be conducted at the diode-laser-pumped PW laser of the HZDR and by studies with the Phelix high-energy system of the GSI.



HELMHOLTZ-BEAMLINE AT THE EUROPEAN XFEL

Brief description

The concept presented here for a Helmholtz-Beamline at the European XFEL is based on equipping an XFEL experimentation station combined with high-performance laser systems. It is planned to use a diode-laser-pumped short-pulse laser system in the petawatt (PW) output range, as well as a high-energy laser system, and high-field pulsed magnets. This experimentation station will therefore have a unique combination worldwide of ultra-intensive light pulses and high-brilliance x-ray pulses and will significantly expand the scientific field of application for the XFEL, as it will permit the study of matter under extreme laser-generated temperatures, densities, pressures and field strengths. Furthermore, laser-accelerated particle and radiation beams will provide new means for probing samples that have been radiated with the XFEL pulse. This research infrastructure builds optimally on the planned High-Energy-Density (HED) endstation of the baseline XFEL design, but could also be set up as an independent undulator line with additional, international participation.

Prospective benefits

Research on the new Helmholtz-Beamline at the XFEL will have a significant impact on investigations of ultra-fast and non-equilibrium processes in a broad range of systems under extreme conditions. These include, for example, studies of the fundamental QED vacuum in strong fields, the determination of the equation of state (EOS) of warm dense matter for geological and planetary research, the radiative, dynamic and magnetic properties of hot plasmas, of interest for stellar physics, supernovas and gamma ray bursts, and for fusion research; included also is research on ultra-fast processes in radiation-induced and particle-induced damage to materials, which is important for understanding and optimising ion-implantation in semi-conductors, or the question of material fatigue in reactors, or in spacecraft due to cosmic rays; as well as studies of excited-state chemistry for developing new means to reduce the risks of environmental contamination, and much more.

Scientific background

The study of matter at high-energy-density (HED), which is created and evaluated by extremely short and brilliant x-ray beams, is a supporting pillar of the scientific programme of the European XFEL, and will be significantly enriched by the Helmholtz-Beamline at the European XFEL. Samples will be driven by PW laser beams to much greater extremes of temperature, pressure, electric and magnetic field intensities, and particle and radiation fluxes, as well as being compressed to high density and pressure by kJ high-energy laser pulses. A particularly interesting perspective for exploring fundamentally new physics is offered by the direct determination of the polarisability of the QED vacuum in extremely strong electromagnetic fields. This requires measurements of the rotation of the polarisation direction of the XFEL x-ray pulse, because of the birefringence of the vacuum.

Facts and figures

Timetable:

- Construction: 2015–2018
- Operation: 2017–2035

Estimated costs:

- Construction costs: € 40 million Helmholtz Association (PW € 15 million, kJ € 5 million, target chamber € 5 million, detectors € 15 million).
- Operating costs: € 2 million* p.a.
- Reinstatement costs: not yet specified

International dimension:

As a unique facility worldwide, strong international participation is expected in the Helmholtz-Beamline at the XFEL from Europe (France: CEA / CNRS, UK: Oxford, Switzerland: PSI, as well as contributions from Russia, India and the USA: LANL, LLNL, SLAC). Additional international participation of € 23 million is being discussed for a dedicated undulator and x-ray beam tube (€ 13 million, undulator, € 5 million, x-ray beamline, € 5 million civil engineering).

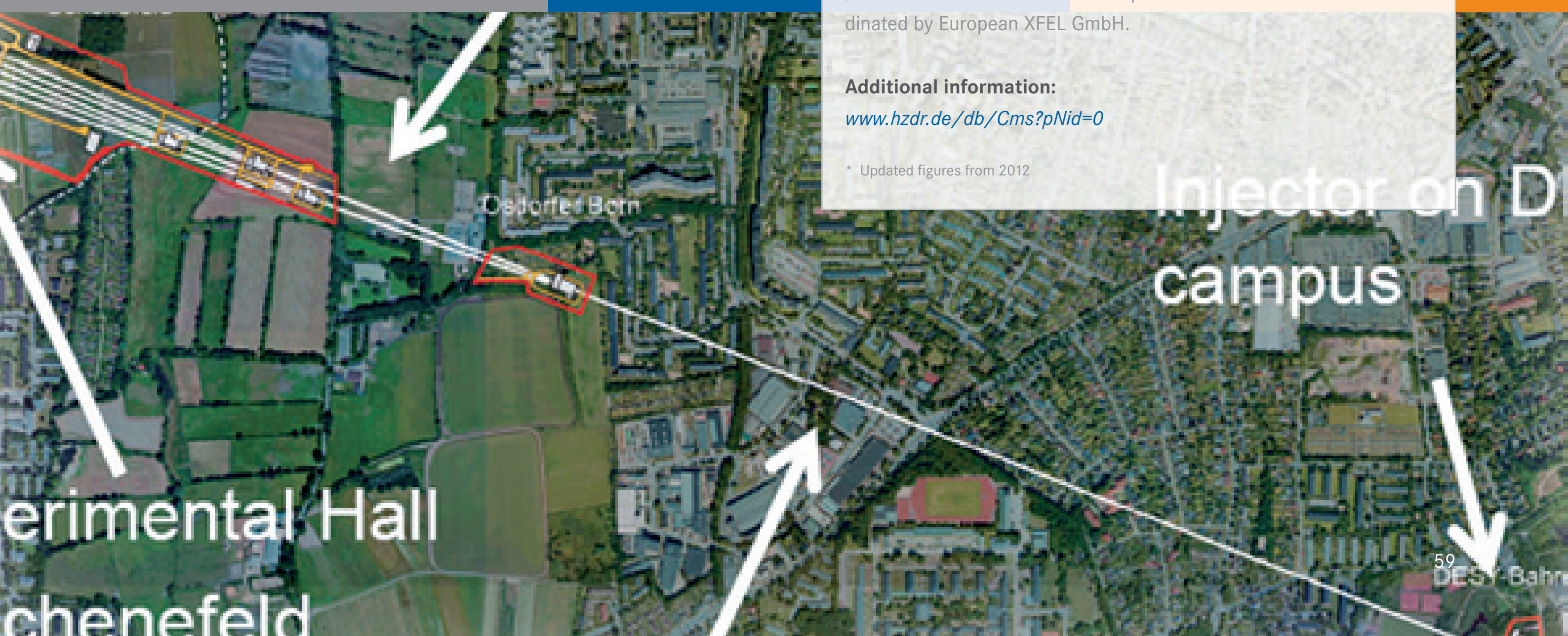
Role of the centre/centres:

The Helmholtz-Beamline at the European XFEL will be jointly developed by the HZDR (PW and kJ laser systems) and by DESY (chamber and detectors) in scientific collaboration with GSI, Helmholtz Institute Jena and IPP. The technical conception and construction will be coordinated by European XFEL GmbH.

Additional information:

www.hzdr.de/db/Cms?pNid=0

* Updated figures from 2012



HIGH-POWER LASER HELMHOLTZ-BEAMLINE AT FAIR

Brief description

With the Helmholtz-Beamline high-power laser at FAIR, a diverse experimentation facility shall be created, which is based on the diode-laser-pumped high-power short-pulse laser and a kilojoule high-energy laser, the pulses of which can be led to various stations of the FAIR accelerator complex. This provides a unique combination worldwide of high-energy heavy ion beams and high-power laser pulses, with the best-possible adapted pulse repetition rate, which will lead to a significant expansion of the experimental options at FAIR, particularly with the investigation of so-called "warm dense matter" (WDM), of laser ion acceleration and the physics of highly charged ions in strong electromagnetic fields, a focus of the APPA programme.

Scientific background

The high-intensity beams of high-energy and highly-charged heavy ions at FAIR open up the possibility for the preparation of large-volume samples of uniformly heated matter under extreme conditions and with unique characteristics, which cannot be realised with x-ray FELs or high-power-laser-driven implosions. This will enable the precise investigation of thermodynamic and transport characteristics of "warm dense matter", using laser-generated, intense particle and radiation sources. This addresses important questions in planetary physics and geophysics, laser plasma physics and fusion research. In addition, the interaction of PW laser pulses colliding with highly charged ions will enable the study of the physics of strong fields in new ways.

Prospective benefits

The Helmholtz-Beamline at FAIR will have a significant impact on the investigation of matter under extreme conditions (including "warm dense matter") and the physics of highly charged ions in strong external fields (including, multi-photon excitation and tunnel ionisation). With the availability of the highest available laser pulse repetition rates, the facility will permit the routine application of new analysis methods, which are currently being developed on the PHELIX system on a single-pulse basis. A wide base of users will profit from the facility at different experiment sites, whether it involves the single-pulse shot-on-demand or continuous 10 Hz operation of the PW laser.

Facts and figures

Timetable:

- Construction: 2018–2020
- Operation: 2020–2040

Estimated costs:

- Construction costs: € 40 million Helmholtz Association (PW € 17 million, kJ € 8 million, laser beam guide and diagnostics € 5 million, target chamber and detectors € 10 million).
- Operating costs: € 2 million p.a.
- Reinstatement costs: not yet specified

International dimension:

As a unique facility worldwide, this research infrastructure will attract strong international participation from Europe, Russia, Asia and the USA and promote new collaborations and experimental activities among the members of the existing HEDgeHOB/WDM and SPARC collaborations.

Role of the centre/centres:

The High-Power Laser Helmholtz-Beamline at FAIR will be developed in collaboration with HZDR (assuming central responsibility for the PW laser system) and GSI (atomic and plasma physics, kJ laser development). Important scientific and strategic collaborations exist with the Helmholtz Institute Jena, DESY and the Extreme Matter Institute EMMI within the context of the "Cosmic Matter in the Laboratory" Helmholtz Alliance.

CW LINAC

Brief description

With the aim of improving experimental conditions for heavy element research, the construction of a superconducting cw-Linac[1] is proposed, which will be set up in parallel with the UNILAC accelerator. The new heavy ion cw-linear accelerator (Linac) comprises nine superconducting, so-called crossbar H cavities and is operated at a rf-frequency of 216 MHz. The end energy of the heavy ion beam can be varied between 3.5 and 7.5 AMeV. Together with a superconducting 28 GHz-EZR ion source, which is presently under construction, the cw-Linac will allow an intensity increase of 1 to 2 orders of magnitude, with a significantly improved time structure for the heavy element experiments. Moreover, the operation of the new cw-Linac will be significantly more energy-saving and cost-saving than with the existing accelerator. As a further important aspect, the cw-Linac enables the complete decoupling of the UNILAC operation for low-energy experiments from the injection into the GSI/FAIR accelerator rings. This results in major advantages for the entire user programmes at GSI and later at FAIR.

Scientific background

The question regarding the stability limits of atomic nuclei – i.e. how large and heavy they can be, at a maximum – is not only of interest for nuclear physicists. It directly affects our notion of the structure of matter: how many chemical elements exist in the universe? Where and why were they created, etc.? With the discovery of six new elements, those with atomic numbers 107 to 112, and recently with verification of the elements 114 and 116, GSI and the Helmholtz Centre Mainz are taking on an international leading role in research efforts for sounding out the limits of the periodic system. In order to maintain this leading role in the future, an upgrade of the UNILAC accelerator is required, by means of the described project of a cw-Linac.

Prospective benefits

The cw-Linac promises significantly improved experimental conditions, not only for heavy element research, but also for irradiation experiments, e.g. in materials research and radiobiology. By decoupling the UNILAC operation for low-energy experiments from the injection into the GSI/FAIR accelerator rings, major added-value ensues for the efficiency of the international user programme at GSI/FAIR.

Facts and figures

Timetable[2]:

- Assembly: 2014–2017
- Operation: from 2018 (> 15-20 years)

Estimated costs:

- Preparation/planning costs: € 2 million
- Construction costs: € 27.5 million
- Operating costs: approx. € 1.5 million per year
- Reinstatement costs: not yet specified

International dimension:

The cw-Linac will facilitate to maintain and expand the international leading position of GSI and of the Helmholtz Institute Mainz in the field of heavy element research. Furthermore, the international users at GSI/FAIR will benefit from the decoupling of the UNILAC operation for low-energy and high-energy experiments.

Role of the centre/centres:

The project will be jointly conducted by GSI (leading institute) with the Helmholtz Institute Mainz and the Stern Gerlach Centre SGZ at the Goethe University Frankfurt. All partners have proven expertise in the construction of state-of-the-art (linear) accelerator structures.

Additional information:

www.gsi.de

1 cw Linac stands for continuous wave Linac. A cw Linac supplies a quasi-continuous ion beam, in contrast to a pulsed Linac.

2 Updated figures from 2012

PROCESS OF CREATING THE ROADMAP & OUTLOOK

PROCESS OF CREATING THE ROADMAP

The roadmap has been prepared in 4 steps:
1. Collecting data
2. Selecting criteria
3. Prioritising in the research fields using criteria and guidelines
4. Summarising and publication in a roadmap brochure

1. Collecting data
The process for preparation of the infrastructure roadmap was conceived within the Helmholtz Association as a bottom-up process. In terms of content and timing, it is interlaced with the portfolio process and the relevant discussions in each research field, and stands as a result of the same. For the research infrastructure, the question needed to be answered regarding which research infrastructures need to be newly built in the future, i.e. approximately in the next 10 - 15 years in the research field, in order to advance the planned research portfolio and conduct leading, excellent research in the international field. In doing so, it was also analysed in which internationally planned infrastructures a research field intends to participate in the future.

Result:
List of research infrastructures and their specification, sorted by research fields, specifying for example:
- Costs
- Time period for construction and operation
- Integration into the research infrastructure category (KG, NW, FP, WR, RE)[1]
- Occurrence on international roadmaps
- Estimation of the operating costs

2. Selecting criteria
As a necessary criterion, at the first meeting of the "Roadmap" steering group, the size of a research infrastructure was defined, since this is relevant for a Helmholtz Roadmap. With this, it was noted that on the one hand, the process for long-term strategic planning for the building of the research infrastructure in the Helmholtz Association was meaningfully interlaced with the process for strategic expansion processes > € 15 million and, on the other hand, the various orders of magnitude of the investments are complied with in the individual research fields. The € 15 million investment costs are applicable as a condition for inclusion in the roadmap.
In compliance with the process for prioritisation of the strategic expansion investments in the Helmholtz Association, a proposal was formulated by the steering committees for a list of criteria. The applicable criteria to be used across research fields for the roadmap have been summarised by the "Roadmap for Research Infrastructure" steering group and approved by the Meeting of the Member's Board, together with the criteria for the investment process. In addition to this, guidelines were formulated that regulate the concrete preparation of the roadmap lists for the individual research fields.

Result:
- Criteria list, on the basis of which it can be decided, which of the research infrastructures compiled under 1. will be included in the Helmholtz Roadmap
- Guidelines for the preparation of the Helmholtz Roadmap

3. Prioritisation in the research fields using the criteria
At the research field level, i.e. through intensive discussions conducted in several steps in the steering committees, the priority infrastructures were identified on the basis of the list of criteria and additional guidelines proposed during the Members' Board Meeting in January 2011. The research fields could decide internally whether they would like to call in external advisors, e.g. members of the Senate Committee or the Senate. With the identification of the research infrastructures envisaged for the roadmap, a comparison was created with already-existing roadmaps. There was initially no guideline for the length of the list in the individual fields; the length should result from the logical demand.

Result:
For each research field, a list of the research infrastructures to be built as a priority in the next 10 - 15 years.

4. Summarising and publication in a roadmap brochure
After the internal discussions in the research fields, the Roadmap steering group conducted a cross-field analysis, with the aim of compiling the planned infrastructures at a standardised presentation level in a roadmap. The presentation was to be based on the ESFRI list, i.e. the list itself was supplemented by a brief profile of the research infrastructure. The publication of the first Helmholtz Roadmap was taking place in 2011. It was discussed and approved by the Member's Board Meeting, Senate Commission and Helmholtz-Senate.

Updating of the roadmap
The first prepared roadmap – together with the research portfolio of the Association – will be revised and updated at regular intervals. Research infrastructures will be newly added or even removed. In doing so, steps 1.-4. will be carried out again, i.e. their results will be updated. Revision of the roadmap will be linked to the programme assessments in terms of timing, and will take place twice in five years: once in relation to the planning of the scientific programmes and strategies in the research fields for the evaluations within the context of the programme-based promotion, and once in the middle of the programme period.

1 KG: Classic large-scale device, NW: Network, FP: Research Platform, WR: Knowledge Resources, RE: Computer, supercomputer

Criteria for the selection of the research infrastructure projects

Analogous to the agreement of the Executive Board regarding the criteria for the selection of strategic expansion investments, as well as in correspondence with the discussion result of the first meeting of the Roadmap working group, the split into A and B criteria also applies to the roadmap criteria. A necessary condition for a research infrastructure remaining in the selection process is that the A criteria must be assessed with excellent/very good. Only then will further assessment of the measures take place on the basis of the B criteria. For user devices and networks/platforms, additional criteria are applied. The individual criteria are explained by the specified sub-points, which are listed in a neutral order.

As an assessment scale, the following 4 levels (also analogous to the investment process) have been defined:
- excellent
- very good
- good
- insufficient

In the Helmholtz Roadmap, research infrastructures are included from a size of € 15 million of investment costs.

A criteria

A1. Scientific quality of the question to be processed with the research infrastructure
The following should be addressed:
- the perspective and sustainable relevance of the research field upon which the research infrastructure will be implemented;
- the potential of the research infrastructure and the scientific concept, in order to realise first-class research;
- the expertise of the participants within the respective field of knowledge, which is relevant for building and operating the research infrastructure.

A2. Strategic importance of the research infrastructure for further development of the Helmholtz Association
The following criteria must be taken into consideration:
- National/international importance of the research infrastructure; unique selling point
- Strengthening the visibility of the Helmholtz Association
- Contribution to solving major social issues (also pure acquisition of knowledge)

B criteria

B1. Project maturity
The following points should be taken into consideration:
- Urgency of the implementation of the research infrastructure
- Degree of substantiation of the planning

B2. Consistency with the portfolio topics of the research fields
Here, it should be explained how the research infrastructure fits into the portfolio and the general strategy of a research area, i.e. how it fits into the strategy of the Helmholtz Association.

B3. Assessment of consequences
The following criteria must be taken into consideration:
- Regional and national economic factor
- Public acceptance
- Plans for reinstatement, and miscellaneous

B4. For user devices: Demand and use by third parties
It should be taken into consideration here whether a requirement exists for use and correspondingly, whether access to third parties is planned, as well as whether a consolidated concept exists for this.

B5. For networks or platforms: Added value from the formation of a network or platform
Here, it should be described whether the network/platform:
- provides added value and a functional context by combining equipment that is spatially distributed into one research infrastructure;
- includes the required minimum of synoptic stations/devices to fulfil the functions of the networked research infrastructure;
- is planned as one research infrastructure through joint coordination and management.

Guidelines for the preparation of the Helmholtz Roadmap

1. The approved criteria form the basis for the selection. The “scientific case”, the scientific quality and the strategic relevance of the project for the Helmholtz Association, as well as the research policy targets in the research fields are crucial.

2. Division of the roadmap into research fields, while limiting the number of research infrastructures per field (according to the specification made in the General Meeting): Maximum of 5 research infrastructure projects, for the Structure of Matter, max. 10 research infrastructure projects.

3. Division of the roadmap into time segments (presentation of the short-term, medium-term and long-term projects on a timeline):
   a. shorter-term projects (2011-2015). A decision will be made within the research fields regarding the relevance of those projects that are included on the list of strategic expansion investments, but have not yet been prioritised for financing, with regard to inclusion in the Helmholtz Roadmap.
   b. medium-term projects (2016-2020).
   c. long-term projects/visions (after 2021).

4. Projects for which a financing commitment (even partial) exists are no longer part of the roadmap. They are documented in a separate annex to the roadmap as additional information.

5. Important and relevant projects are included, regardless of their anticipated financing sources. The planned financing will be clearly shown and a distinction will be made between the following cases:
   a. complete Helmholtz financing planned.
   b. only proportional Helmholtz financing planned (i.e. Helmholtz + external partners, including international partners).
   c. Project will be financed outside of the Helmholtz budget (national or international financing).

6. The ESFRI projects with high relevance for the research topics in the Helmholtz Association and with considerable involvement by Helmholtz centres will be integrated into an additional list in the Helmholtz Roadmap. Criteria for inclusion in this list ("What is considerable?") are:
   a. A Helmholtz centre as the coordinating role in the project.
   b. A consortium of Helmholtz centres/several centres are involved (e.g. INSTRUCT, ESS, ...).
   c. Projects for which financial involvement has already been assured (even if the funds do not come from the Helmholtz budget: e.g. ESS).

OUTLOOK

By presenting this roadmap, a contribution is made to an in-depth dialogue with the board of funding bodies regarding the future research prospects of the Association and the necessary research infrastructure for their implementation. The building of the research infrastructures presented here will have the highest priority in the coming years, in consultation with the funding partners and possibly including other partners. At regular intervals and in close interaction with the other strategy building processes in the Helmholtz Association, the existing roadmap for research infrastructures will be revised. The next update will take place in connection with the programme evaluations in 2013-2014. Projects will be newly added, the time horizon enlarged, or projects that cannot be fully implemented, or not at all, will be removed from the list or modified.

It is already foreseeable that through the expansion of the research portfolio with new centres in the Association (Helmholtz-Zentrum Dresden-Rossendorf (HZDR) and GEOMAR), the demand for additional research infrastructures will also grow. Examples of this would be: replacement for the Poseidon research ship and expansion of the FRAM Observatory with a mobile ocean and deep-sea observatory near the Cape Verde Islands (tropical Atlantic) by GEOMAR. The HZDR is planning to augment the roadmap in coming years with a Helmholtz Facility for Solid State Science and Technology and a prototype for a diode-pumped petawatt laser for customised cancer treatment.

The Structure of Matter research field is, due to the nature of the topic, looking in its strategic planning at a time period that goes beyond the ten years presented in the existing roadmap. Additional projects have been identified which are regarded as necessary in order to implement the field's research results in the future. Examples worth mentioning are, for example, construction of a next generation photon source for the ultraviolet and soft x-ray beam range at the Helmholtz Centre Berlin, participation in an International Linear Collider, and the establishment of a Competence Centre for Materials and Life Sciences in Jülich.

An Internet platform for the planned research infrastructures in the Helmholtz Association will provide a current overview of the realisation status and further planning in the future.

Imprint

Publisher
Hermann von Helmholtz-Gemeinschaft
Deutscher Forschungszentren e.V.

Registered office of the Helmholtz Association
Ahrstraße 45, D-53175 Bonn
Telephone: +49(0) 228 30 818-0, Telefax: +49(0) 228 30 818-30
E-Mail: info@helmholtz.de, www.helmholtz.de

Communication and media
Berlin office
Anna-Louisa-Karsch-Straße 2, D-10178 Berlin
Telephone: +49(0) 30 206 329-57, Telefax: +49(0) 30 206 329-60

Responsible for content within the meaning of the Press Act
Thomas Gazlig
Editors
Dr. Angela Bittner, Dr. Ricarda Opitz, Kristine August

Picture credits:
Title: GSI/A. Zschau/Inside of the GSI linear accelerator – drift tubes;
P. 4: Helmholtz/D. Meckel; P. 12: FZJ; P. 13-16: KIT; P. 19: GFZ; P. 20: FZJ; P. 21/22: AWI;
P. 23: KIT; P. 24: AWI; P. 25: UFZ/UFZ/DLR-NASA; S. 28: HMGU/Study hammeskrause architekten;
P.29: HZI; P. 30: MDC/Chen Chen/AG Michael Gotthardt; P. 31: HMGU; P. 32: MDC; P. 33: HZI;
P. 36-40: DLR; P. 43: FZJ; P. 44/45: KIT; 46/47: FZJ; P. 48: HZI; P. 51: DESY; P. 52: GSI; P. 53: KIT;
P. 54: DESY; P. 55: KIT; P. 56-58: DESY; P. 59: GSI; P. 60: FZJ; P. 61: GSI

Design
unicom Werbeagentur GmbH, Berlin

Printer
mediabogen, Berlin

Print run
1,000 copies

As of: September 2011 (/February 2012)

MEMBERS OF THE HELMHOLTZ ASSOCIATION

Alfred Wegener Institute for Polar and Marine Research
Am Handelshafen 12, D-27570 Bremerhaven
Telephone: +49 (0) 471 48 31-0, Telefax: +49 (0) 471 48 31-1149
E-Mail: info@awi.de
www.awi.de/en

Deutsches Elektronen-Synchrotron DESY
Notkestraße 85, D-22607 Hamburg
Telephone: +49 (0) 40 89 98-0, Telefax: +49 (0) 40 89 98-3282
E-Mail: desyinfo@desy.de
www.desy.de/en

German Cancer Research Centre
Im Neuenheimer Feld 280, D-69120 Heidelberg
Telephone: +49 (0) 6221 42-0, Telefax: +49 (0) 6221 42-2995
E-Mail: presse@dkfz.de
www.dkfz.de/en

German Aerospace Center
Linder Höhe, D-51147 Cologne
Telephone: +49 (0) 2203 601-0, Telefax: +49 (0) 2203 67 310
E-Mail: kommunikation@dlr.de
www.dlr.de/en

German Center for Neurodegenerative Diseases
Ludwig-Erhard-Allee 2, D-53175 Bonn
Telephone: +49 (0) 228 43 302-0, Telefax: +49 (0) 228 43 302-279
E-Mail: information@dzne.de
www.dzne.de/en

Forschungszentrum Jülich
Wilhelm-Johnen-Straße, D-52428 Jülich
Telephone: +49 (0) 2461 61-0, Telefax: +49 (0) 2461 61-8100
E-Mail: info@fz-juelich.de
www.fz-juelich.de/portal/EN

GEOMAR | Helmholtz Centre for Ocean Research Kiel
Wischhofstr. 1-3, D-24148 Kiel
Telephone: +49 (0) 431 600-0, Telefax: +49 (0) 431 600-2805
E-Mail: info@geomar.de
www.geomar.de/en

GSI Helmholtz Centre for Heavy Ion Research
Planckstraße 1, D-64291 Darmstadt
Telephone: +49 (0) 6159 71-0, Telefax: +49 (0) 6159 71-2785
E-Mail: info@gsi.de
www.gsi.de/portrait/index_e.html

Helmholtz Centre for Infection Research
Inhoffenstraße 7, D-38124 Braunschweig
Telephone: +49 (0) 531 61 81-0, Telefax: +49 (0) 531 61 81-2655
E-Mail: kontakt@helmholtz-hzi.de
www.helmholtz-hzi.de/en

Helmholtz Centre for Environmental Research – UFZ
Permoserstraße 15, D-04318 Leipzig
Telephone: +49 (0) 341 235-0, Telefax: +49 (0) 341 235-1468
E-Mail: info@ufz.de
www.ufz.de/index.php?en=11382

Helmholtz-Zentrum Berlin für Materialien und Energie
Hahn-Meitner-Platz 1, D-14109 Berlin
Telephone: +49 (0) 30 80 62-0, Telefax: +49 (0) 30 80 62-42181
E-Mail: info@helmholtz-berlin.de
www.helmholtz-berlin.de/index_en.html

Helmholtz-Zentrum Dresden-Rossendorf (HZDR)
Bautzner Landstraße 400, D-01328 Dresden
Telephone: +49 (0) 351 260-0, Telefax: +49 (0) 351 269-0461
E-Mail: kontakt@hzdr.de
www.hzdr.de

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research
Max-Planck-Straße 1, D-21502 Geesthacht
Telephone: +49 (0) 4152 87-0, Telefax: +49 (0) 4152 87-1403
E-Mail: presse@hzg.de
www.hzg.de/index.html.en

Helmholtz Zentrum München –
German Research Center for Environmental Health
Ingolstädter Landstraße 1, D-85764 Neuherberg
Telephone: +49 (0) 89 31 87-0, Telefax: +49 (0) 89 31 87-3322
E-Mail: presse@helmholtz-muenchen.de
www.helmholtz-muenchen.de/en/start/index.html

Helmholtz Centre Potsdam
GFZ German Research Centre for Geosciences
Telegrafenberg, D-14473 Potsdam
Telephone: +49 (0) 331 288-0, Telefax: +49 (0) 331 288-1600
E-Mail: presse@gfz-potsdam.de
www.gfz-potsdam.de/portal/gfz/home

Karlsruhe Institute of Technology
Kaiserstraße 12, D-76131 Karlsruhe; Campus North
Hermann-von-Helmholtz-Platz 1
D-76344 Eggenstein-Leopoldshafen
Telephone: +49 (0) 721 608-0, Telefax: +49 (0) 721 608-44290
E-Mail: info@kit.edu
www.kit.edu/english

Max Delbrück Center for
Molecular Medicine (MDC) Berlin-Buch
Robert-Rössle-Straße 10, D-13125 Berlin-Buch
Telephone: +49 (0) 30 94 06-0, Telefax: +49 (0) 30 949-4161
E-Mail: presse@mdc-berlin.de
www.mdc-berlin.de/en

Max Planck Institute for Plasma Physics
(associate member)
Boltzmannstraße 2, D-85748 Garching
Telephone: +49 (0) 89 3299-01, Telefax: +49 (0) 89 32 99-2200
E-Mail: info@ipp.mpg.de
www.ipp.mpg.de/eng

www.helmholtz.de/roadmap_en