JÜLICH
FORSCHUNGSZENTRUM

Forschungszentrum JÜLICH
Excellent Science and Technology

10 Years of Georgian-German Science Bridge
07 July 2014

Sebastian M. Schmidt
Member of the Board of Directors

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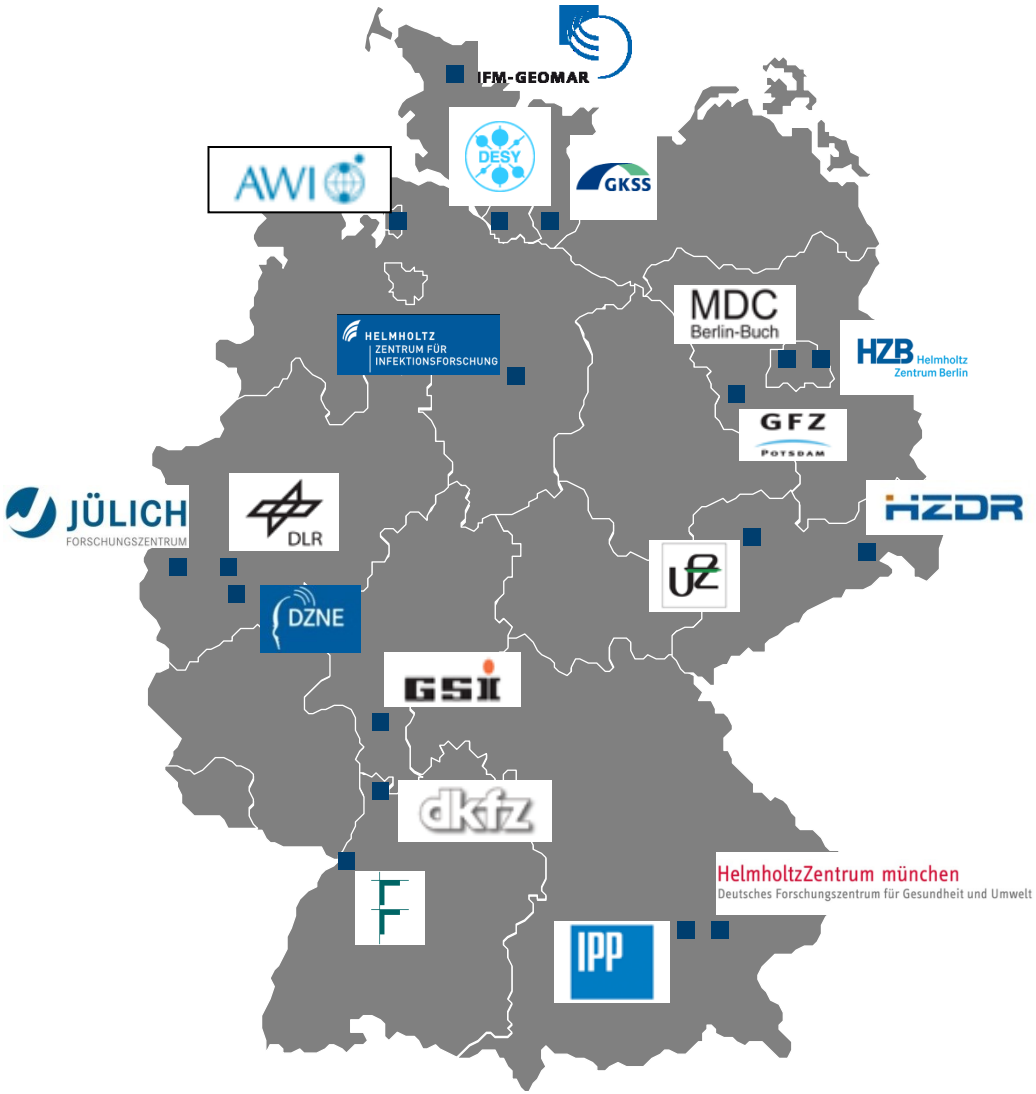
Forschungszentrum JÜLICH:
An Overview

JÜLICH – Member of the Helmholtz Association



Helmholtz at a glance:

18	Centres
35.600	Staff
12.300	Scientists
6.000	Doctoral students
7.400	Visiting scientists
3.3	Billion €

Science Campus JÜLICH

JÜLICH
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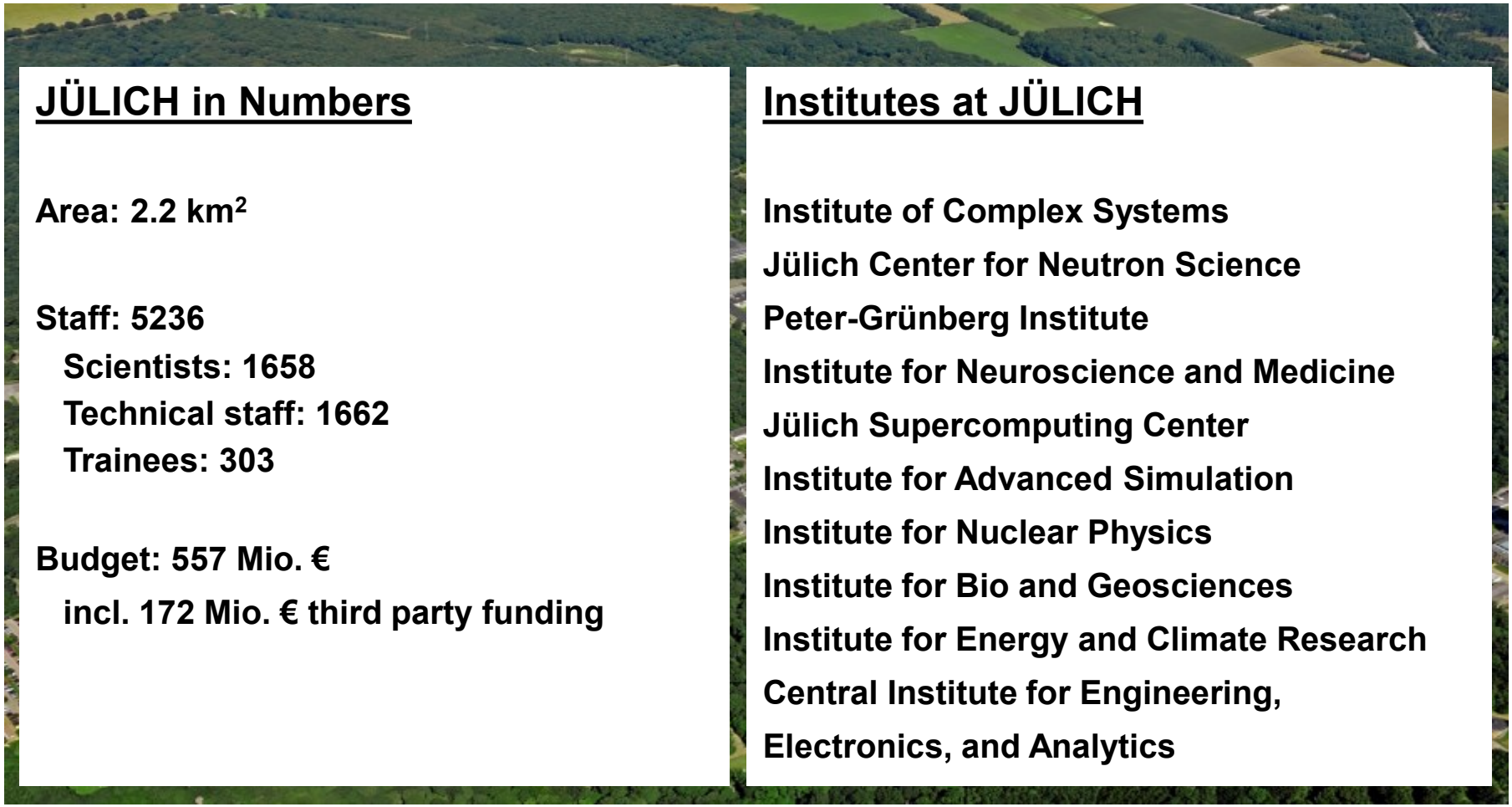


JÜLICH in Numbers

Area: 2.2 km²

Staff: 5236
- **Scientists: 1658**
- **Technical staff: 1662**
- **Trainees: 303**

Budget: 557 Mio. €
- **incl. 172 Mio. € third party funding**

Institutes at JÜLICH

Institute of Complex Systems
Jülich Center for Neutron Science
Peter-Grünberg Institute
Institute for Neuroscience and Medicine
Jülich Supercomputing Center
Institute for Advanced Simulation
Institute for Nuclear Physics
Institute for Bio and Geosciences
Institute for Energy and Climate Research
Central Institute for Engineering, Electronics, and Analytics

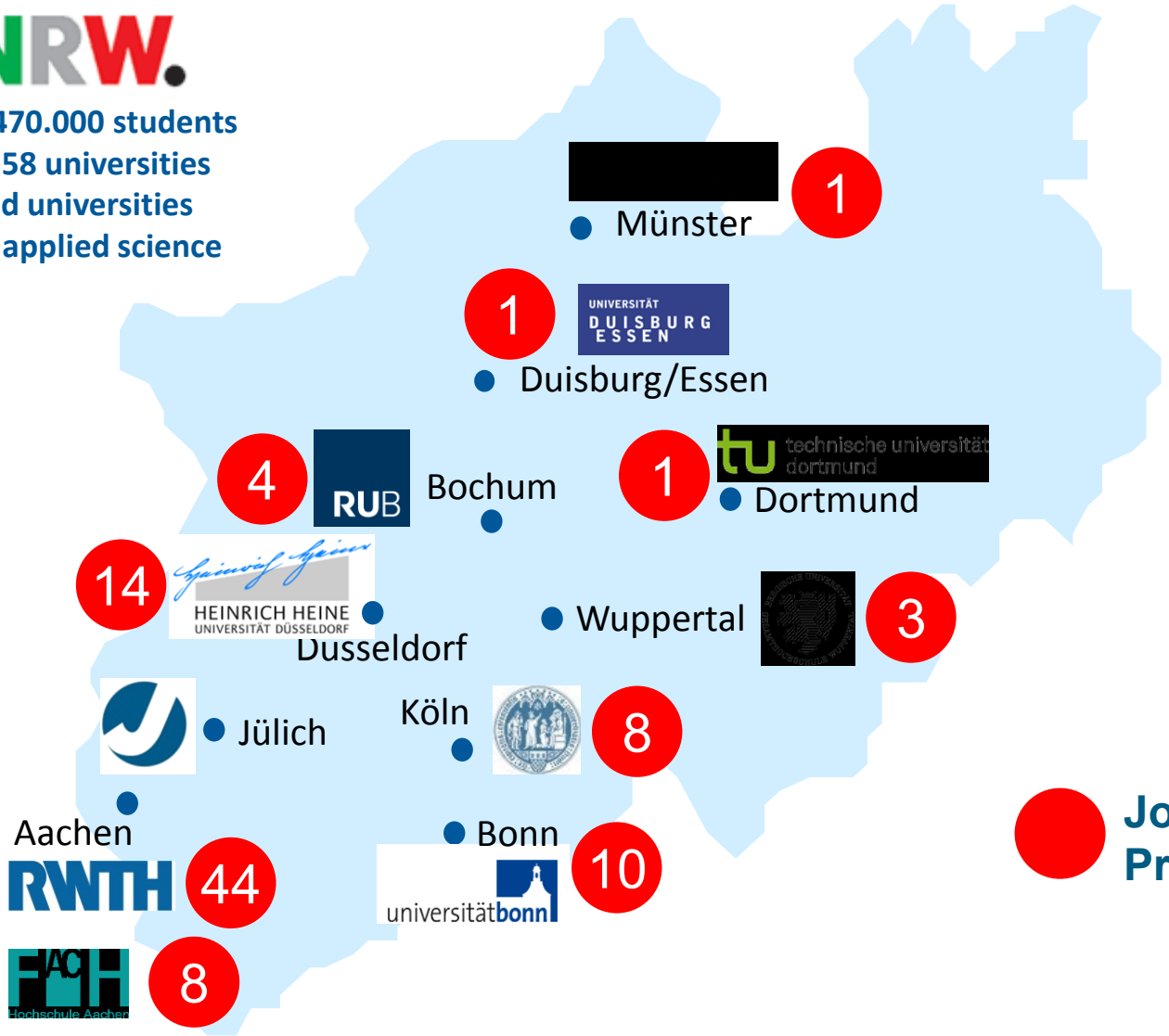
Research for generic key technologies of the next generation

The JÜLICH Model:
Strong Cooperation with Regional Universities

JÜLICH FORSCHUNGSZENTRUM

NRW.

> 470.000 students at 58 universities and universities of applied science



Joint Appointments of Professors by 2012

JÜLICH Aachen Research Alliance

JÜLICH FORSCHUNGSZENTRUM

JARA

RWTH AACHEN UNIVERSITY

Employees: 4000
Professors: 416
Annual Budget: 440 M €

Employees: 3800
Professors: 170
Annual budget: 350 M €

JÜLICH FORSCHUNGSZENTRUM

Employees: 5236
Professors: 93
Annual budget: 557 M €

From Invention to Innovation:

Creating value from science for society and industry

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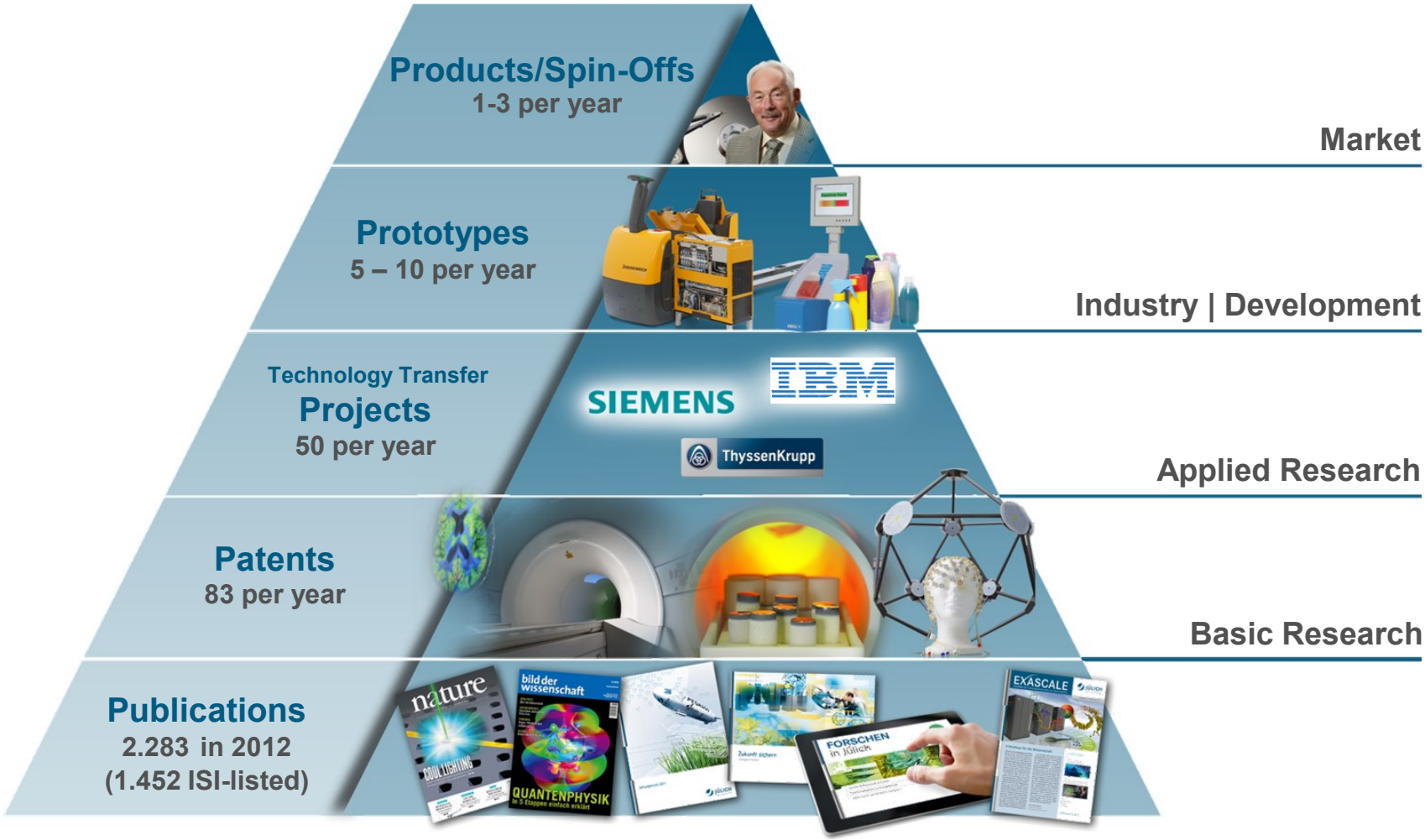

Selected International Collaborations

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EUROPEAN SPALLATION SOURCE

FAIR

Jülich Centre for Neutron

FRM II
Forschungs-Neutronenquelle
Heinz Maier-Leibnitz

NEUTRONS FOR SCIENCE

SNS
SPALLATION NEUTRON SOURCE

GCS
Gauss Centre for Supercomputing

lrz

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HLRS

Georgian-German Science Bridge

JÜLICH FORSCHUNGSZENTRUM

SRNSF PhD/Master Grants 2014:
Supporting outstanding students from Georgia

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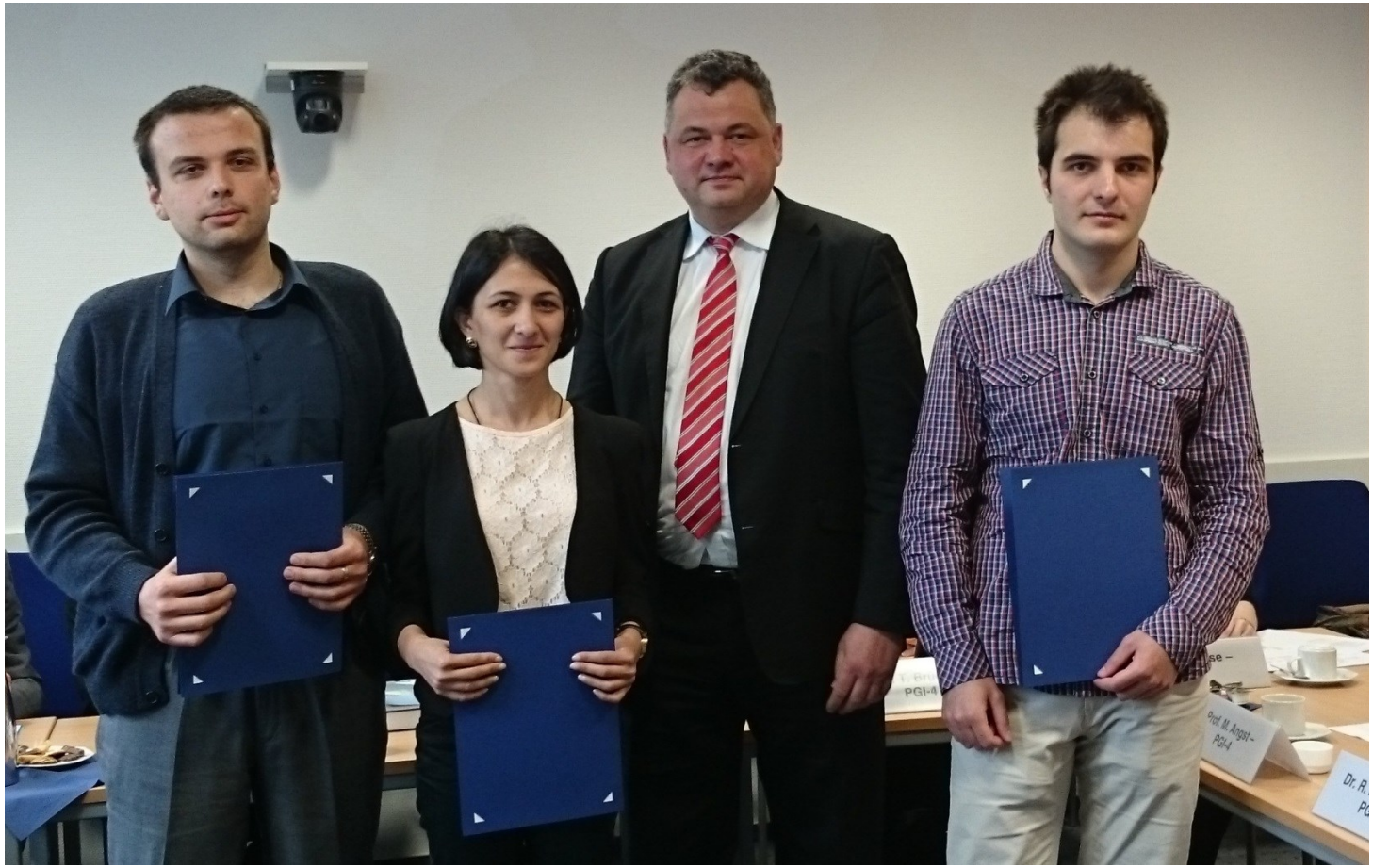

Mikheil Mebonia
PhD Student

Nino Kobalia
PhD Student

Giorgi Tukhashvili
M.Sc. Student

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Forschungszentrum JÜLICH:

Solving the Grand Challenges of Humanity

Grand Challenges adressed in JÜLICH

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1) Supercomputing and Simulation Science
2) Decoding the Human Brain
3) Nanoscience and Information Technology
4) Energy and Climate Research
5) The Structure of Matter

How will we live tomorrow?

Supercomputing and Simulation Science

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Information Technology:
A double-edged sword

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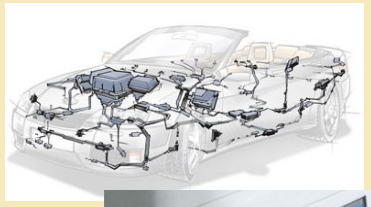
Energy saving by IT

Computer control & modeling
for energy-efficient processes

- **Production**

- **Power grids**

- **Cars**



- **House-hold appliances**

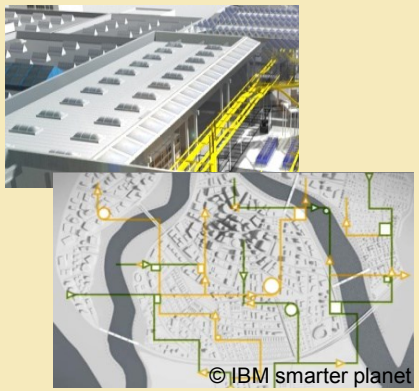
Information Technology:
A double-edged sword

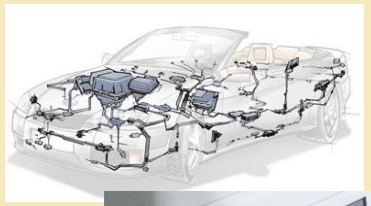
JÜLICH FORSCHUNGSZENTRUM

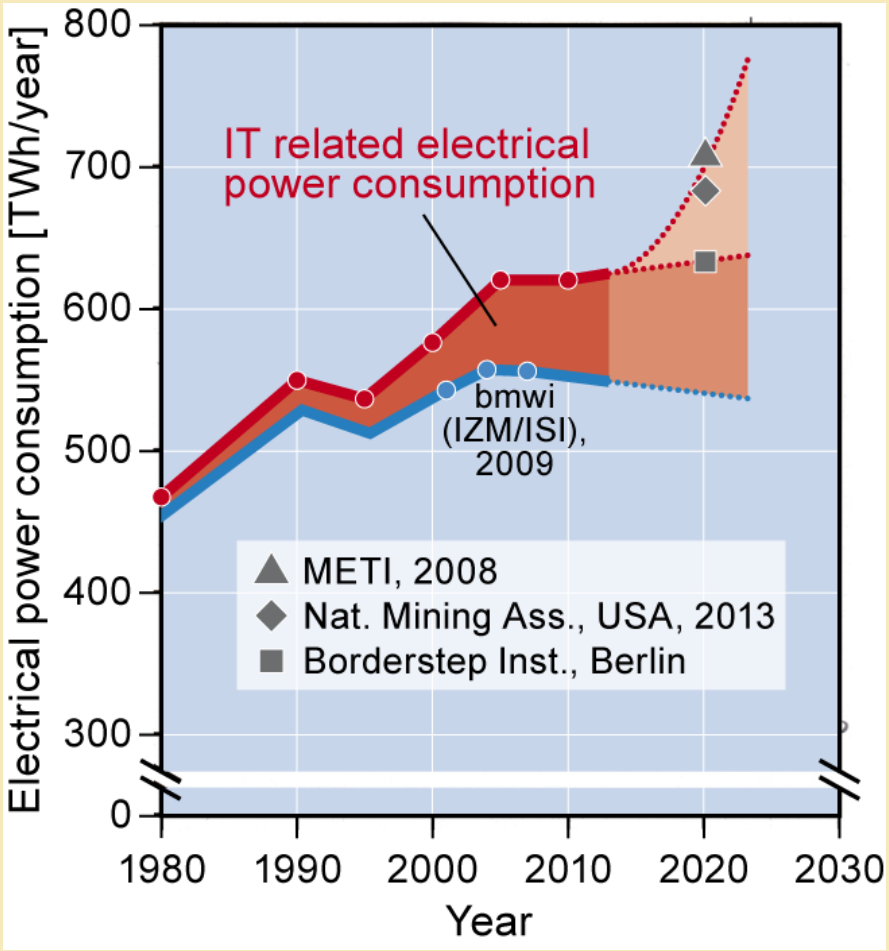
Energy saving by IT ⟷ Energy consumption by IT

Computer control & modeling
for energy-efficient processes

- **Production**
- **Power grids**
- **Cars**
- **House-hold appliances**







The Need for Green Computing

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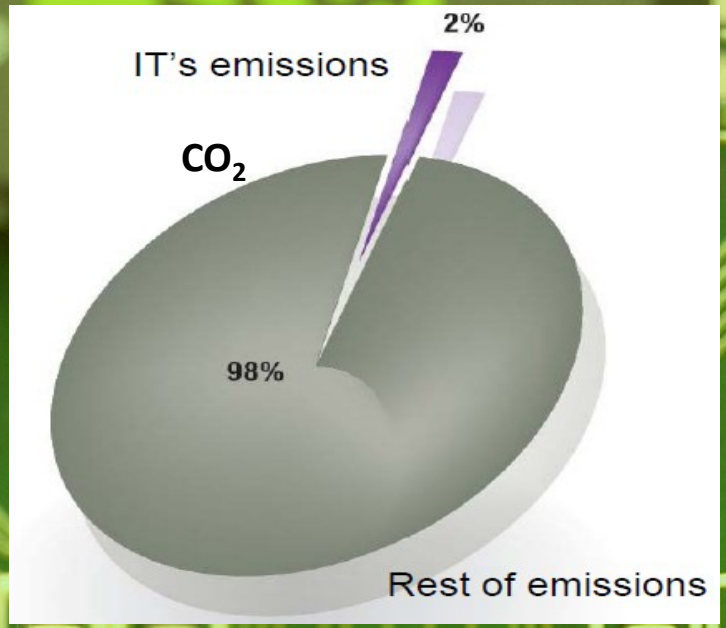
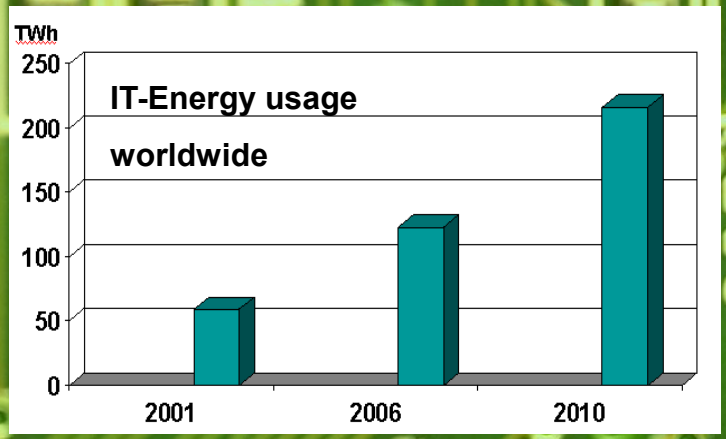




QPACE

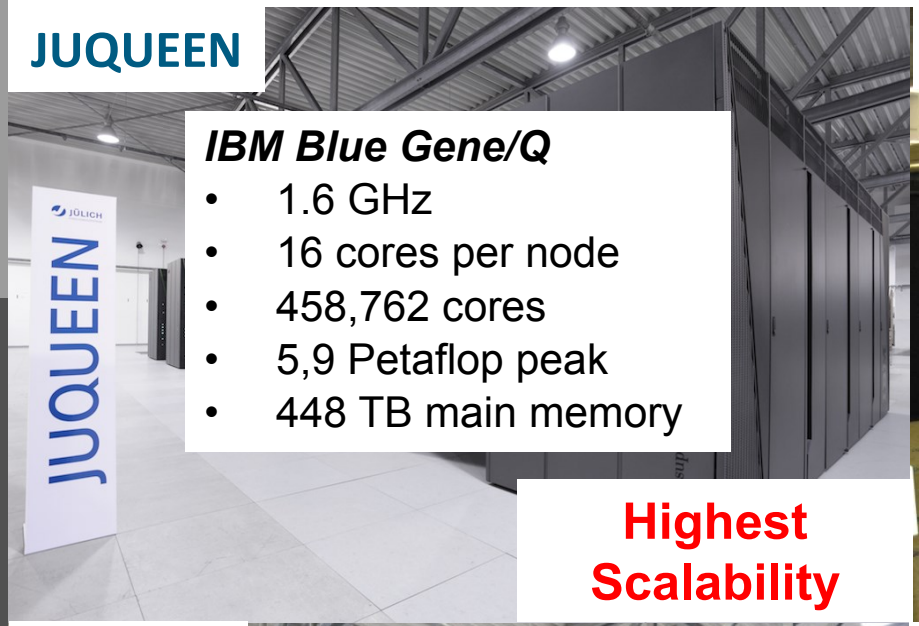
No. 1 in Green500 2009-2010

Supercomputing in JÜLICH:

Not only green, but also extremely fast and highly efficient!

JÜLICH FORSCHUNGSZENTRUM

JUQUEEN



IBM Blue Gene/Q

- 1.6 GHz
- 16 cores per node
- 458,762 cores
- 5,9 Petaflop peak
- 448 TB main memory

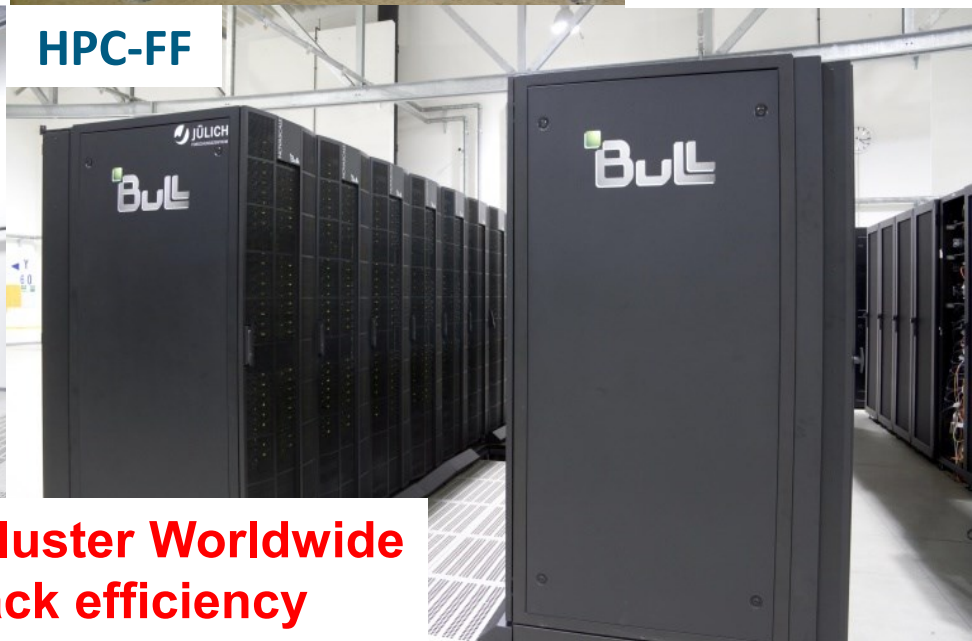
Highest Scalability

QPACE

Best Energy Efficiency

JUROPA

HPC-FF



Most Efficient Cluster Worldwide
91,5% Linpack efficiency

Simulation Labs and Infrastructure

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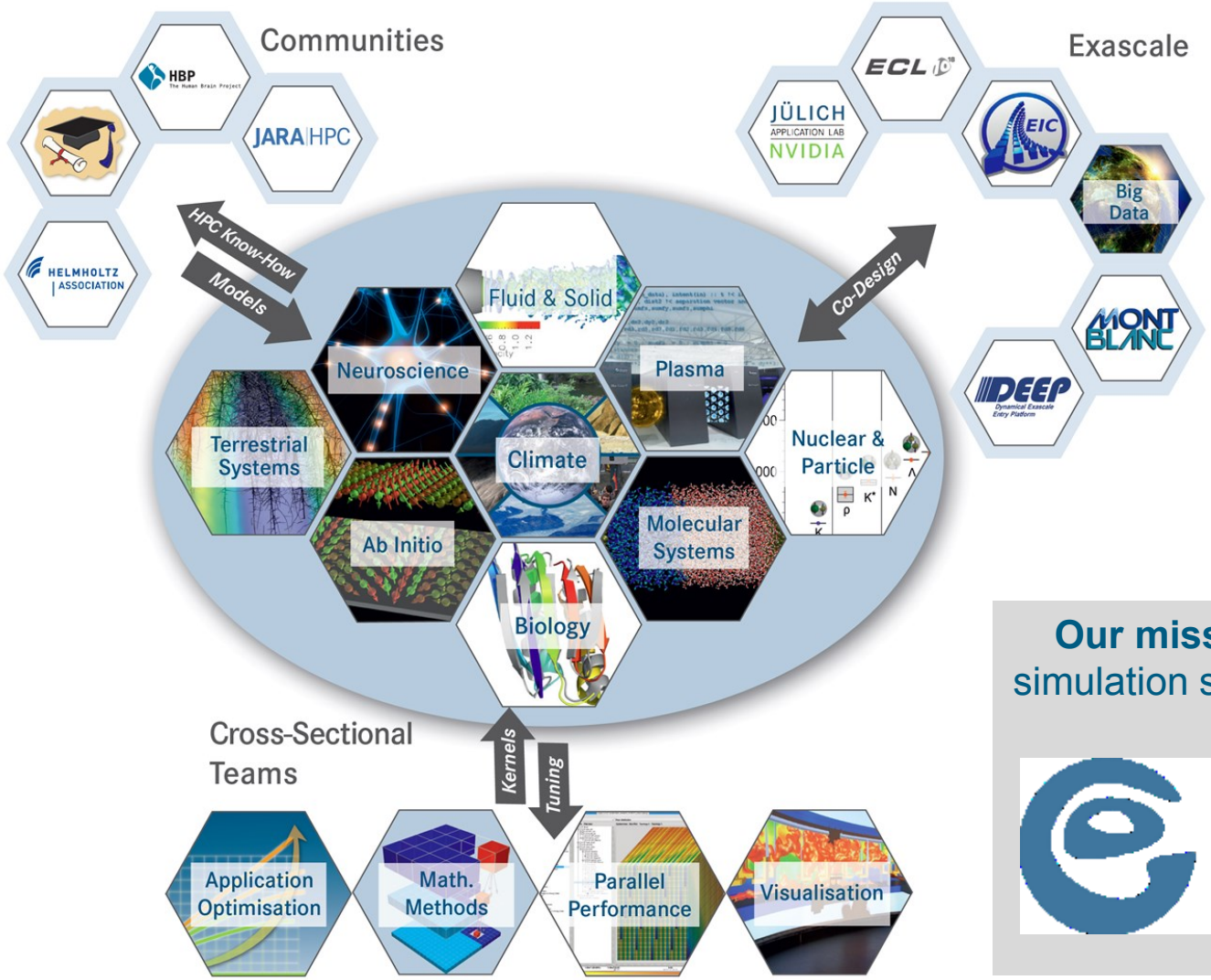

Our mission: Educating the simulation scientists of tomorrow!

German Research School for Simulation Sciences

The Next Generation of Simulation Scientists

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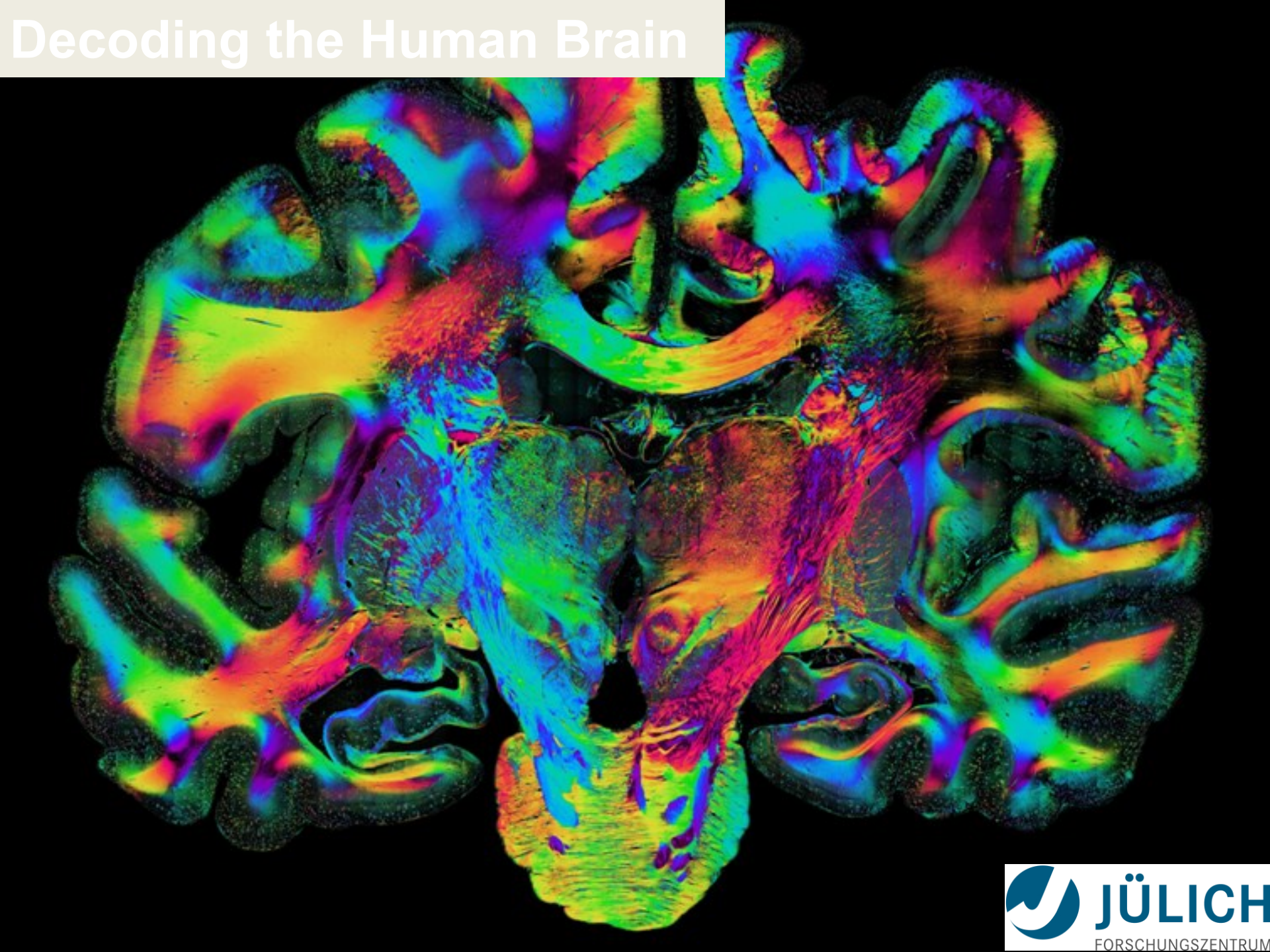
Extreme LAN Party

Decoding the Human Brain



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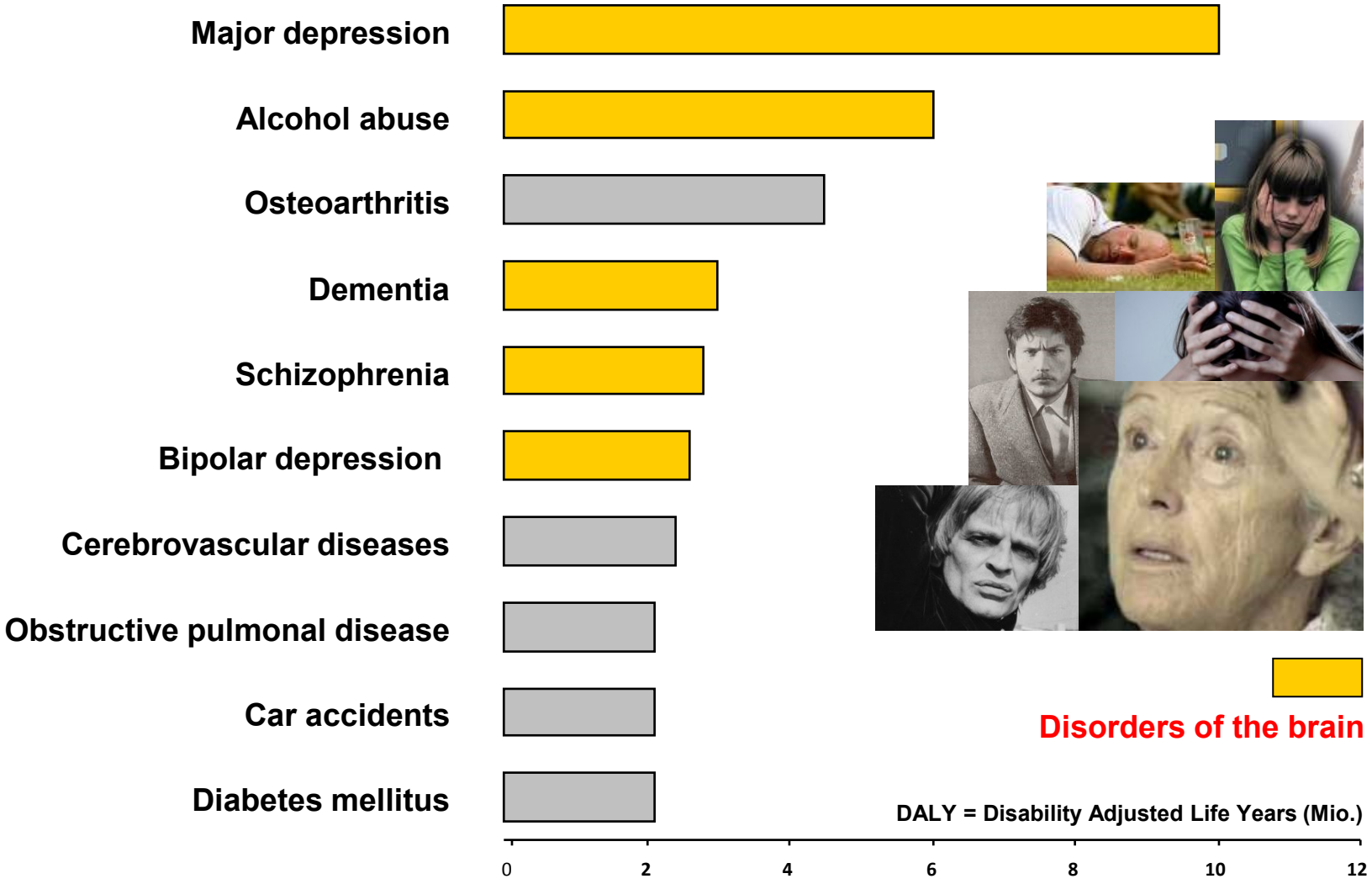
WHO: Burden of Disease in 2030



Multiscale Neuroimaging and Simulation

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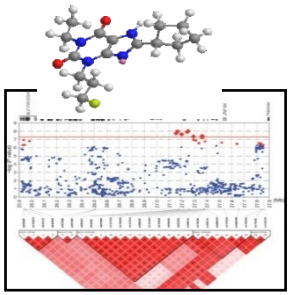
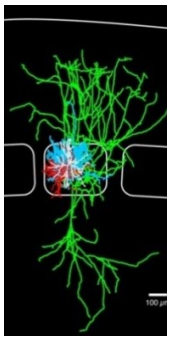
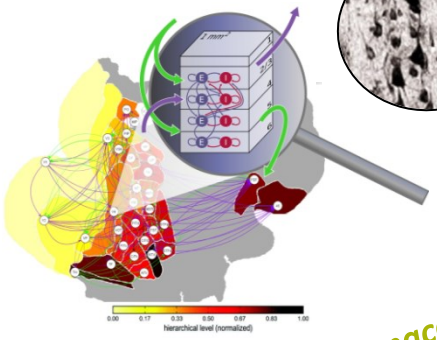
Molecules



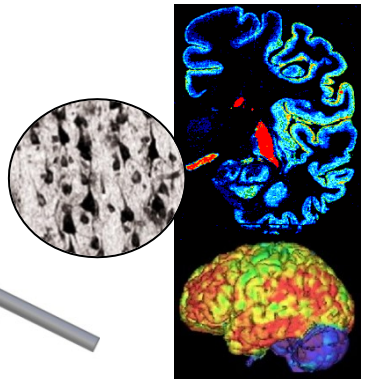
Cells



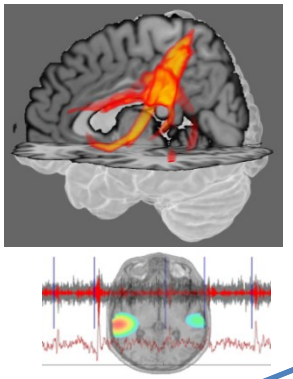
Small circuits



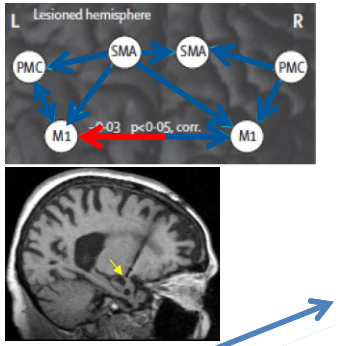
Local and global receptor distribution



Fiber tracts



Dynamic connectivity



Multiscale and multimodal in space and time

JuBrain: Digitalizing Neuroanatomy

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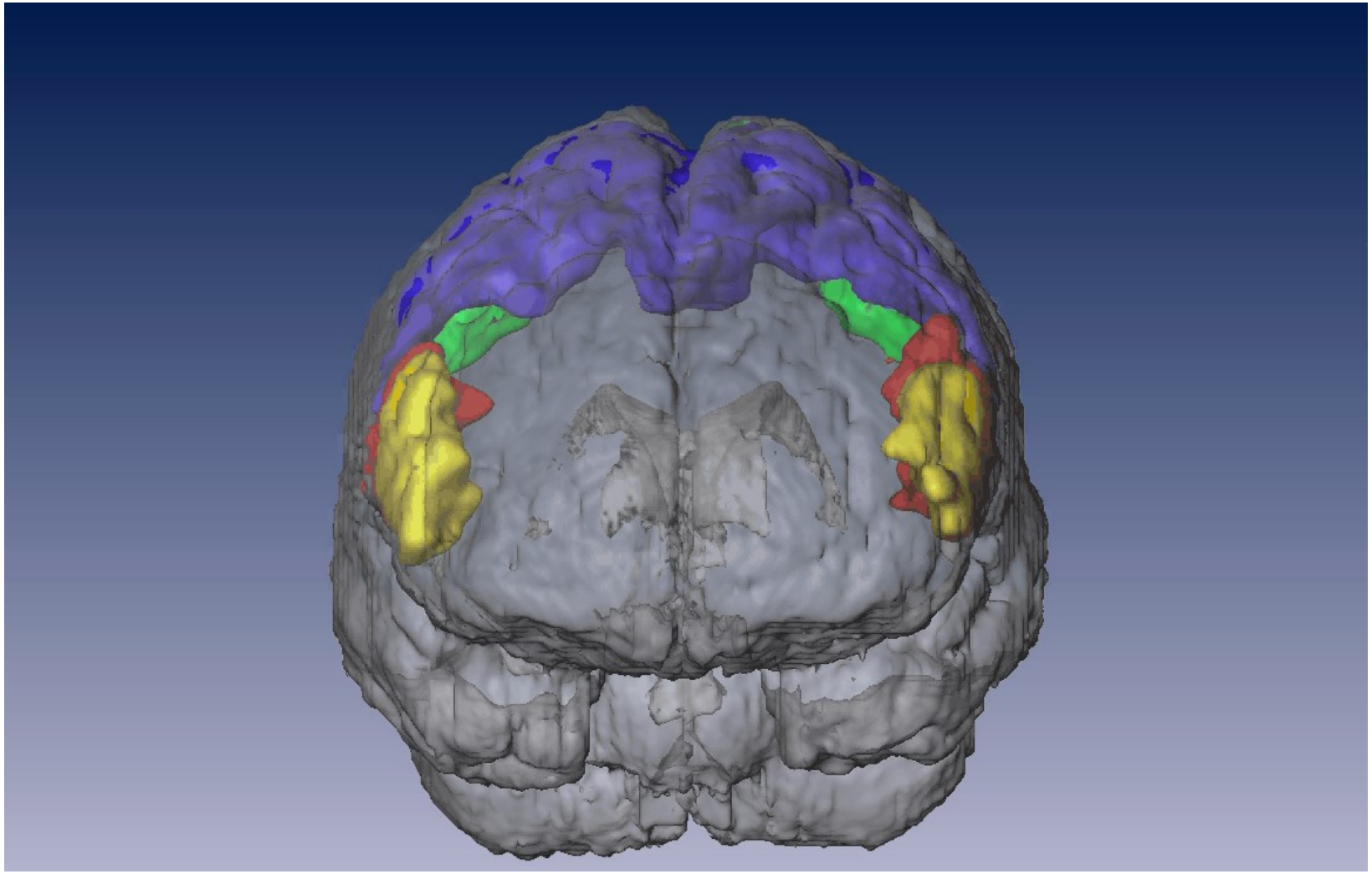

JuBrain: a 3-D model of the human brain which considers cortical architecture, connectivity, genetics and function → Freely available to the scientific community!

9.4 Tesla: High-Resolution MRI-PET Hybrid

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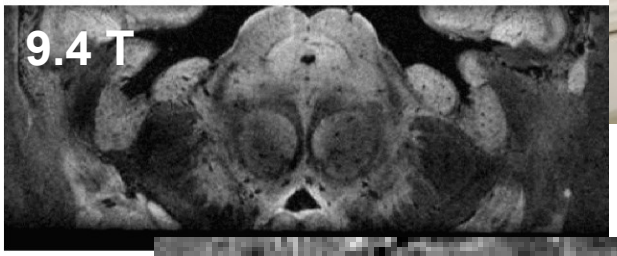
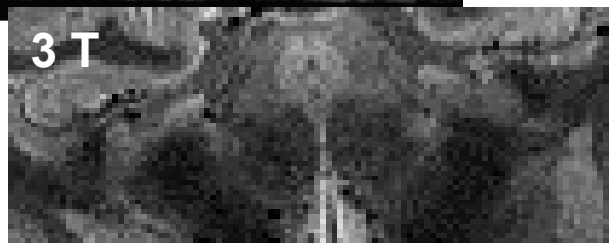
Weight: 57 T
870 Tonnes s

9.4 Tesla: 19
the geomagnetic

Prof. N. J. Shah
10 July 2014
Plenary session III





Routine Scanners:
1.5 T/64 MHz – 3.0 T/128 MHz

Research Scanners:
7.0 T/300 MHz – 9.4 T/400 MHz

PET: Positron Emission Tomography

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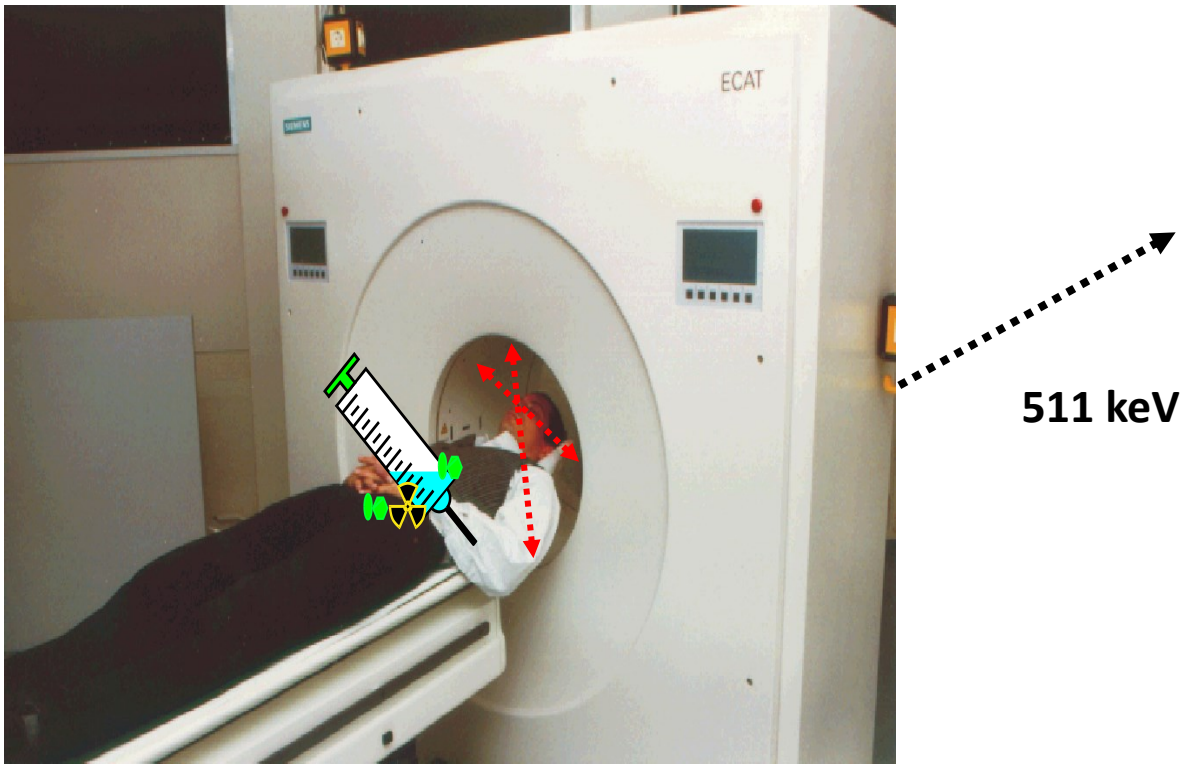
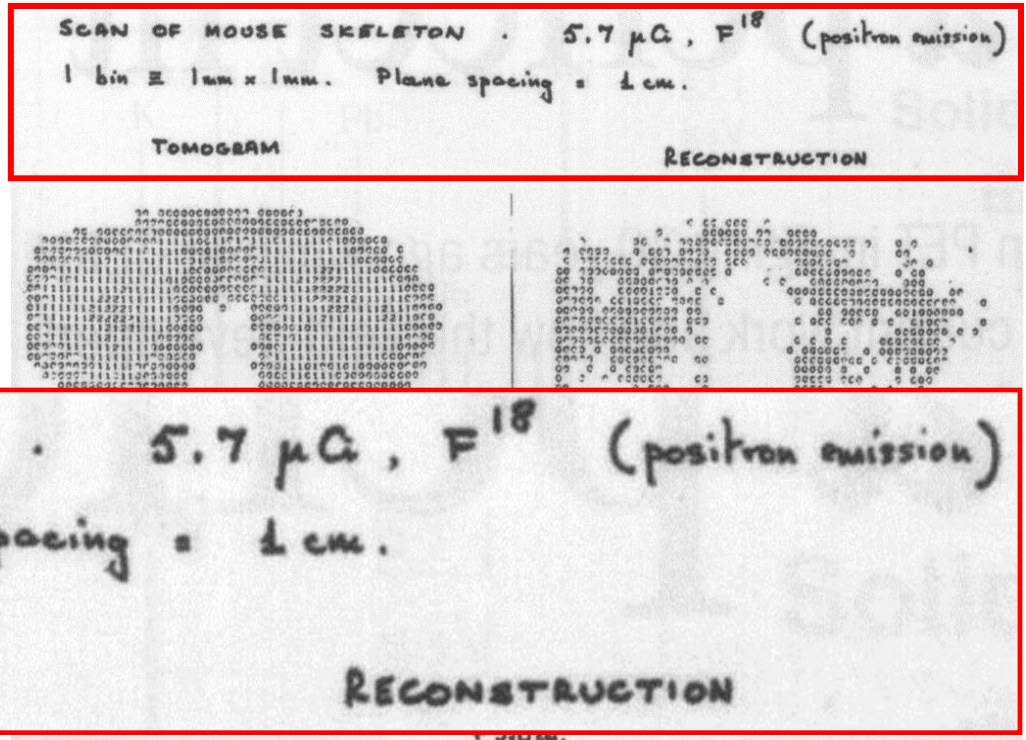
Principle of PET:

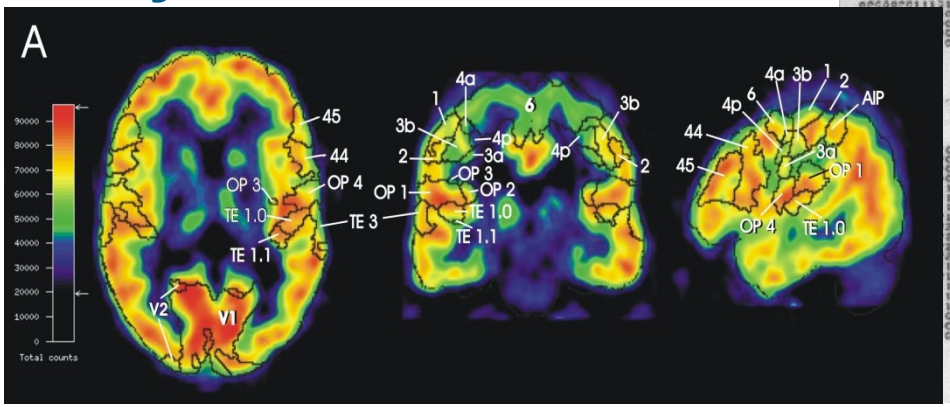
- Labeling of certain molecules with instabile radioactive isotopes
- Example: H_2O (Distribution in the body with the blood flow)
- Location can be determined by the direction of the decay beam



First PET (CERN, 1977)



Today



PET Center in Collaboration with HHU

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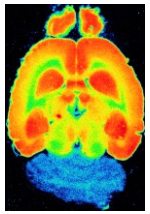
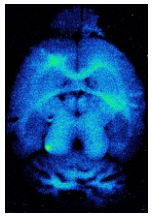
View from outside

Animal MRI-PET System





30 MeV Cyclotron

Brain Research and Supercomputing

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JUQUEEN: Scalable Petaflop System

IBM Blue Gene/Q

- 1.6 GHz
- 16 cores per node
- 458,762 cores
- 5,9 PFlop peak
- 448 TByte main memory

TODAY

Understand the human brain using **simulations** on the world's largest supercomputers.

TOMORROW

Learn from the human brain to build the **exascale** supercomputers of tomorrow.

Closing the Circle:
From basic research and technology to clinical translation

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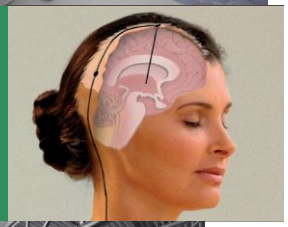
Clinic

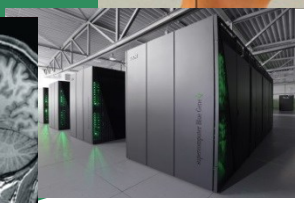
- Diagnosis
- Therapy

Technology

- Neuroimaging
- Neuromodulation (Therapy)
- High-performance computing and simulation
- Nuclear chemistry

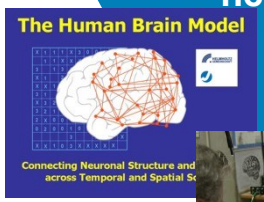


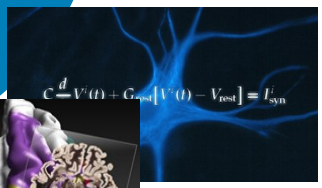
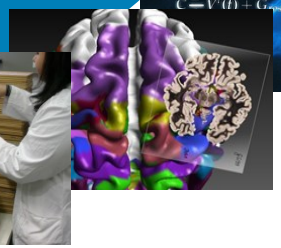




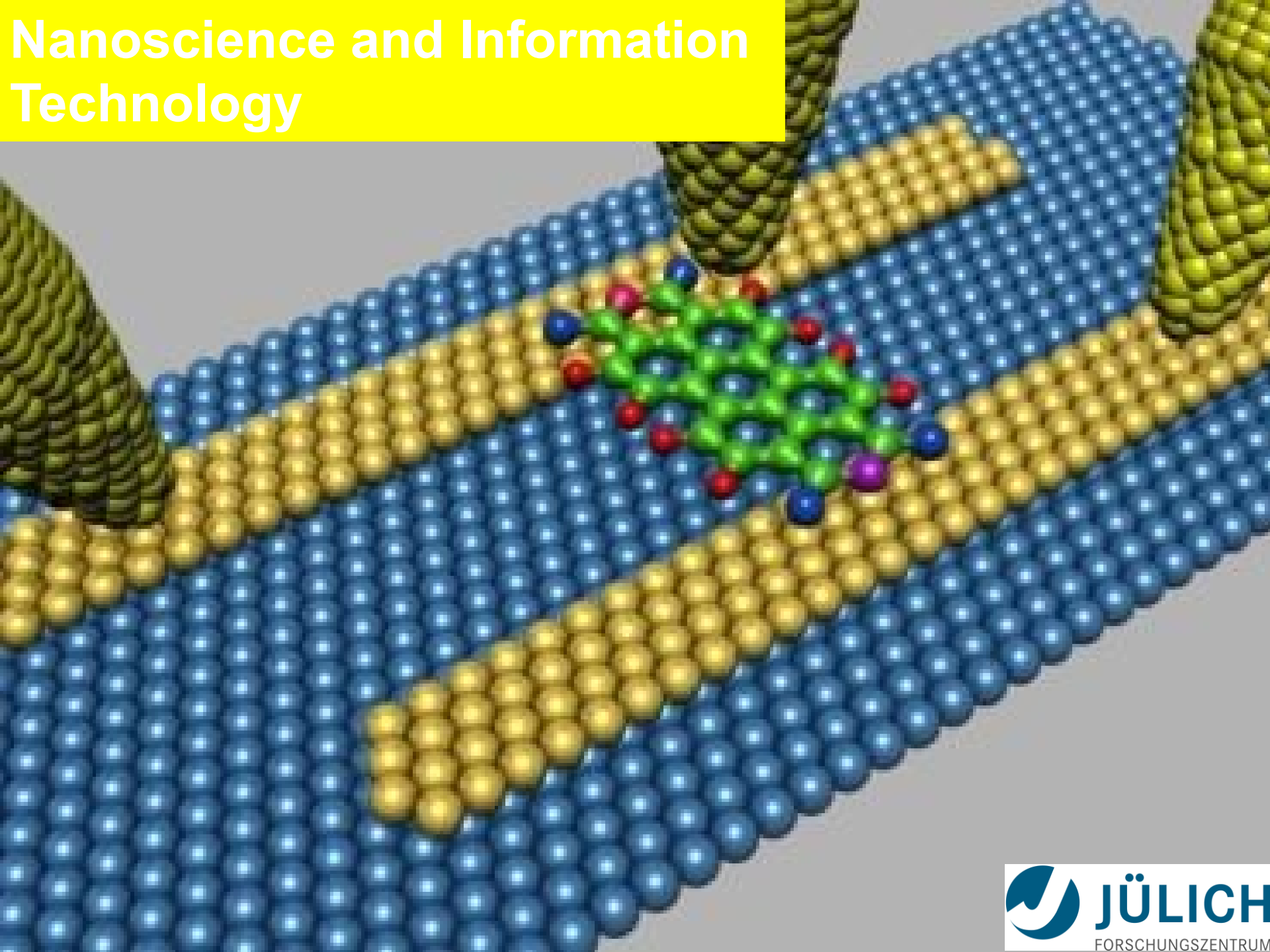
Basic research

- Brain structure
- Cognitive neuroscience
- Computational neuroscience
- Ethics



Nanoscience and Information Technology



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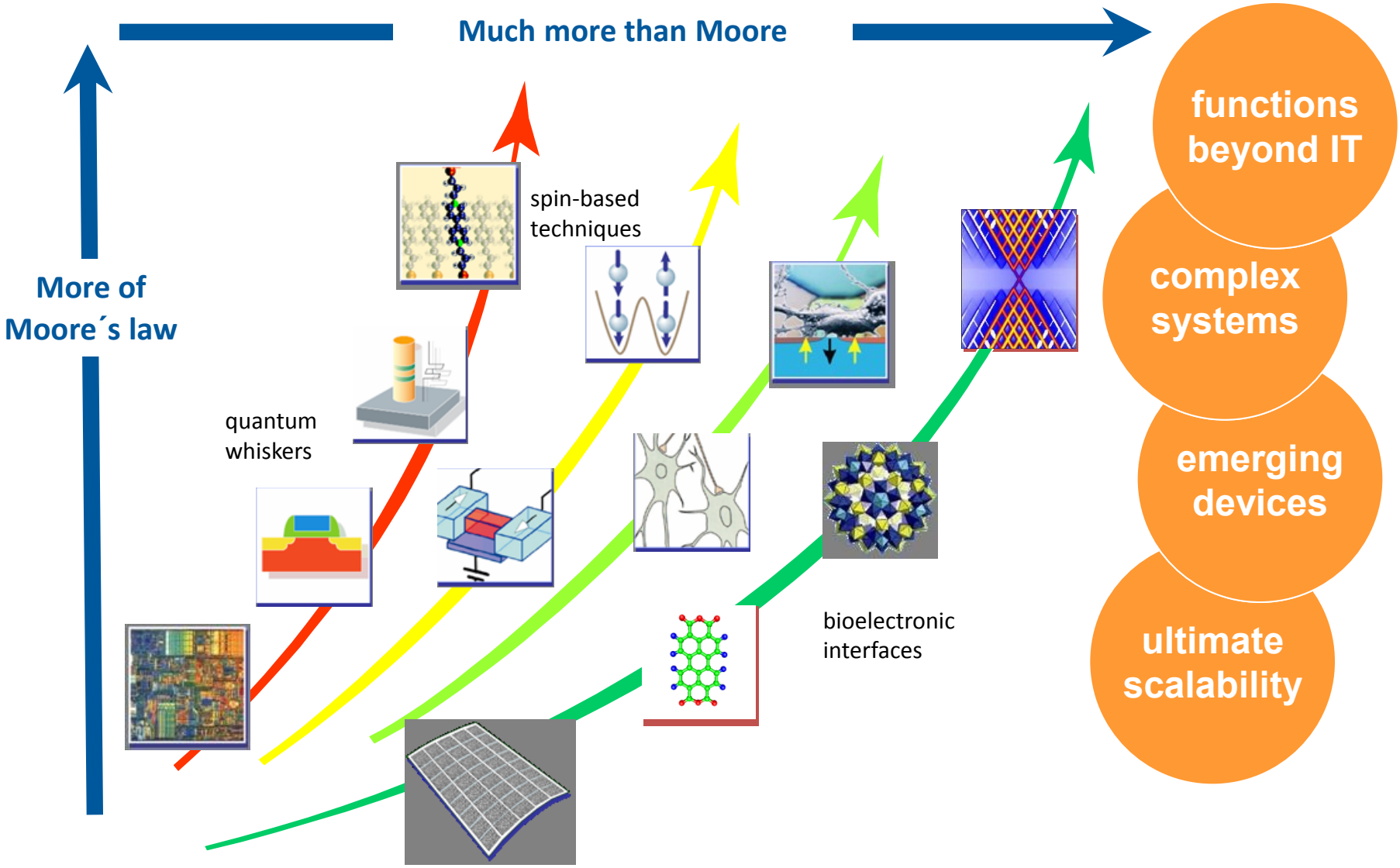
Bigger Computers, Smaller Structures:
Nanotechnology research in JÜLICH

JÜLICH FORSCHUNGSZENTRUM



From Electron Spins to Hard Drives

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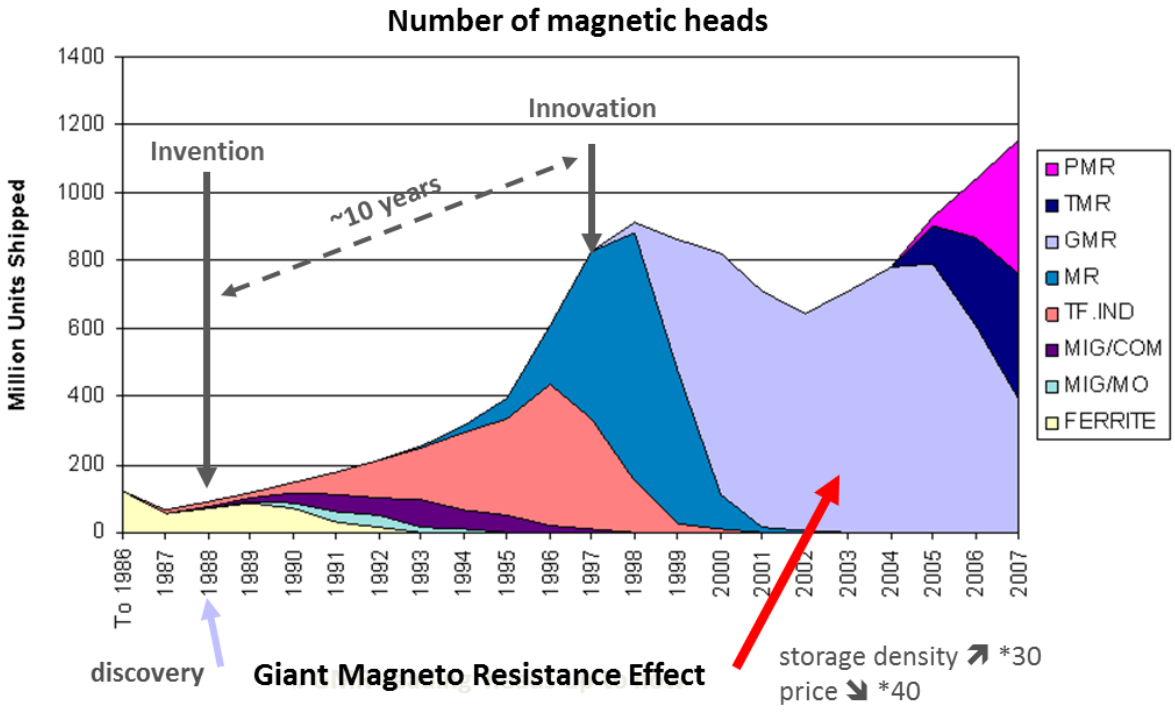
Prof. Peter Grünberg
Nobel Prize in Physics 2007

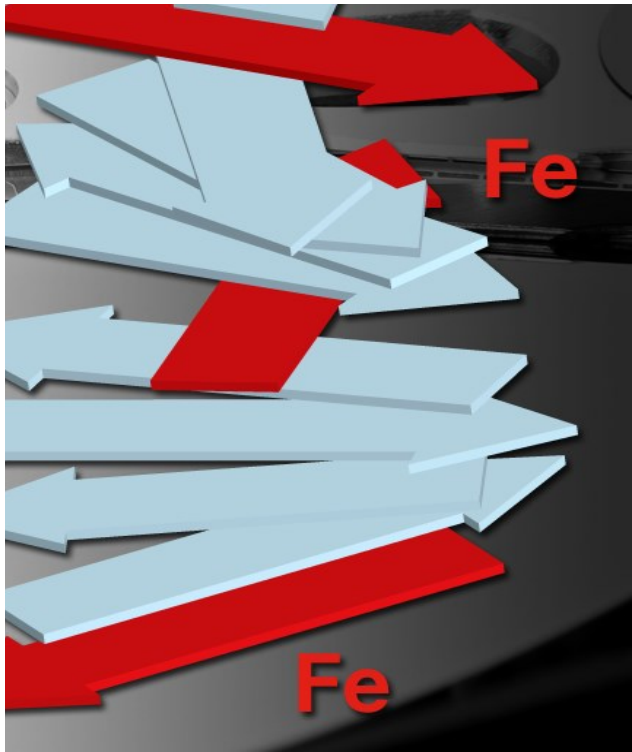
Example of how “disruptive science”…

…creates unexpected applications

…induces a billion-Euro-market

…initiates the new industrial key technology spintronics

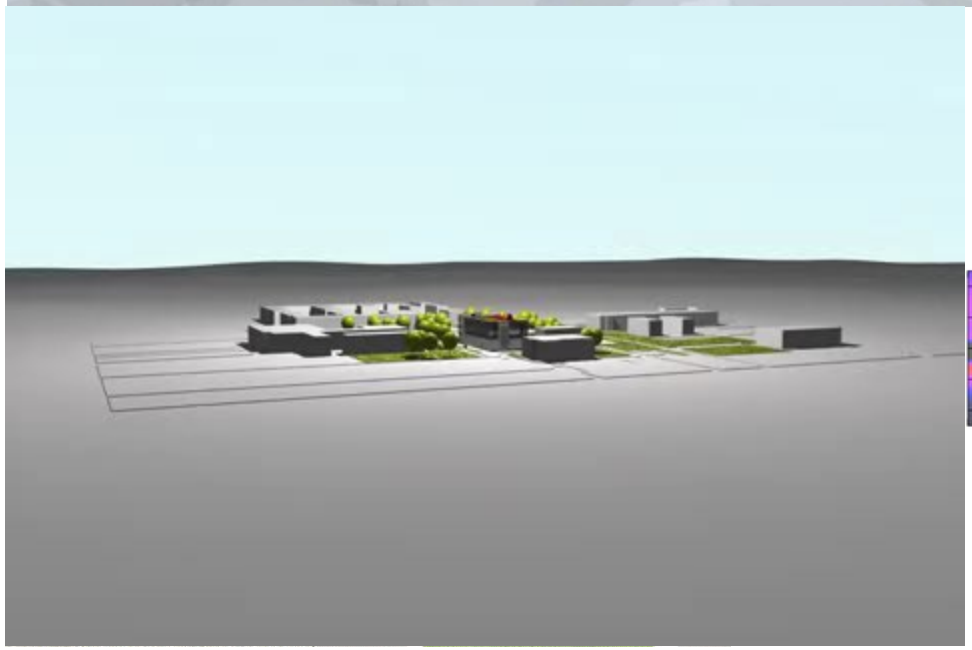


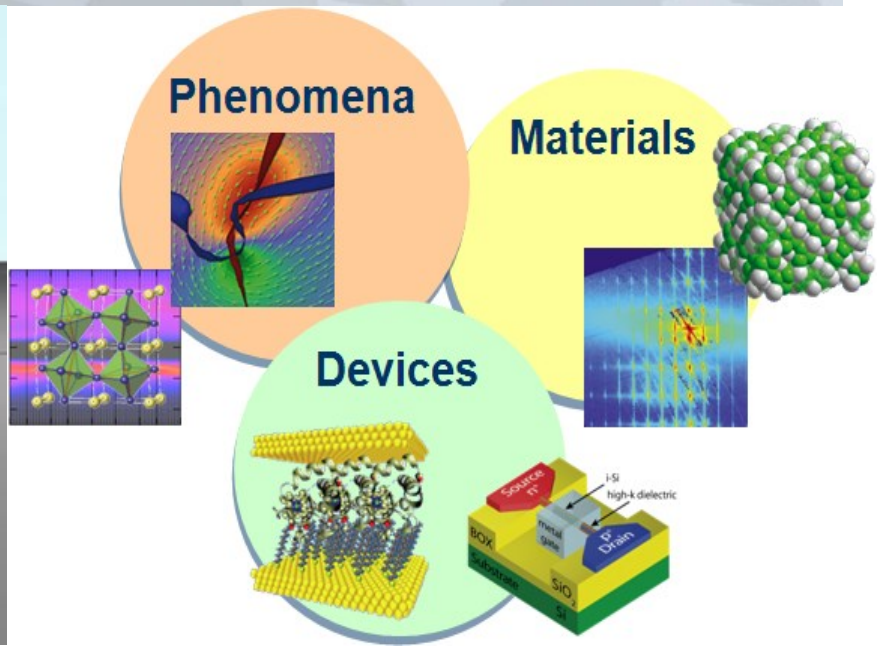


Helmholtz Nanoelectronics Facility (HNF)

JÜLICH FORSCHUNGSZENTRUM

- Central technology platform of the Helmholtz Association
- State-of-the-art clean-room centre
- Focus on „Green Microchips / Low Energy Devices“
- Development and characterization of materials, processes and structures in the nanometer range for the next generation of semiconductors in the chips of the future.
- User facility for industry and universities





Clean-room: 1000 m²

Novel Spin-based Multiferroics

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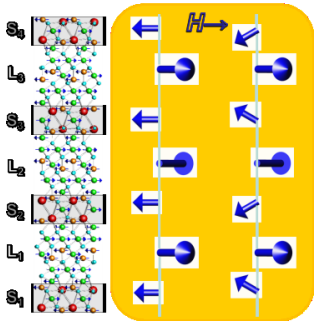
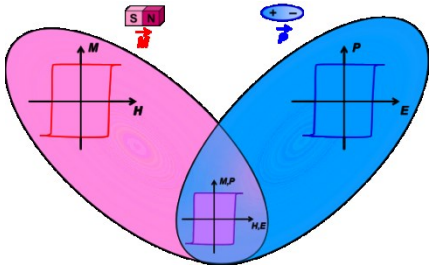
M. Sc. Giorgi Khazaradze,
PhD Student TSU & FZJ

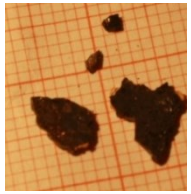
Example: large family of complex hexaferrites are amenable to spin-based multiferroicity at room temp.



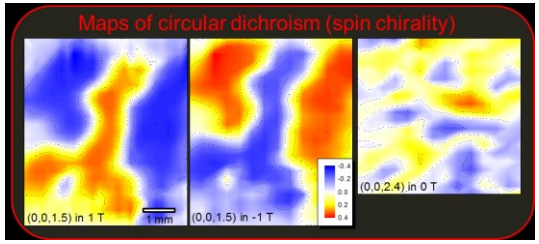
Multiferroics with strong magnetoelectric coupling: attractive for future IT applications



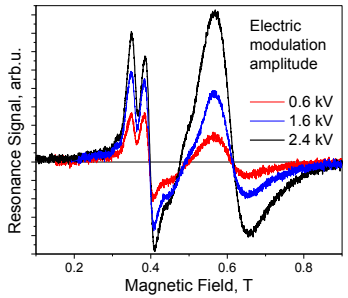
$Ba_{0.5}Sr_{1.5}Zn_2Fe_{12}O_{22}$



Crystal growth & magnetic/structural characterization



Characterization by advanced scattering methods

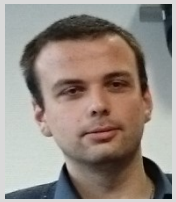


Characterization by EPR techniques, e.g. with electric-field modulation to „see“ directly the magnetoelectric coupling

Prof. M. Angst, FZJ & RWTH JARA Jülich Aachen Research Alliance

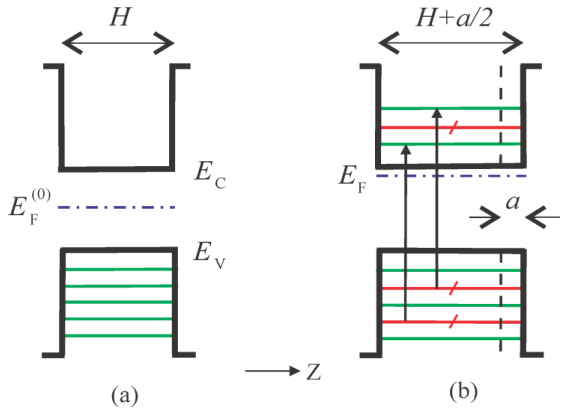
Prof. A. Shengelaya, TSU Ivane Javakhishvili Tbilisi State University

Thermoelectric Properties of Nanogratings



M. Sc. Mikheil Mebonia
PhD Student ISU & FZJ

Key idea: geometrically modulated density of electronic states (DOS)

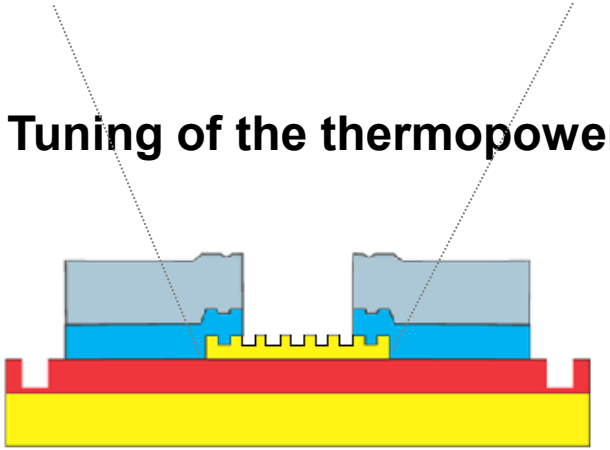


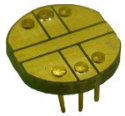
Nanoscale patterning that matches the electron De Broglie wavelength

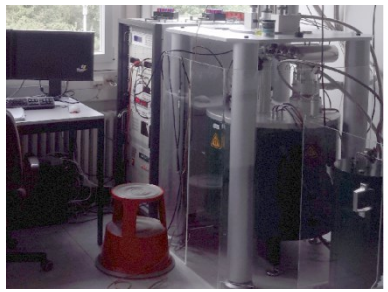
Prof. A. Tavkhelidze, ISU

Ilia State University

→ **Tuning of the thermopower, the derivative of the DOS at the Fermi level**







Fabrication with Extreme UV Lithography and in the future at the HNF

Structure and transport characterization: Scattering (JCNS, GALAXI) and cryomagnet

Prof. L. Jushkin, FZJ & RWTH

JARA Jülich Aachen Research Alliance

Prof. R. Hermann, FZJ

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Energy and Climate Research

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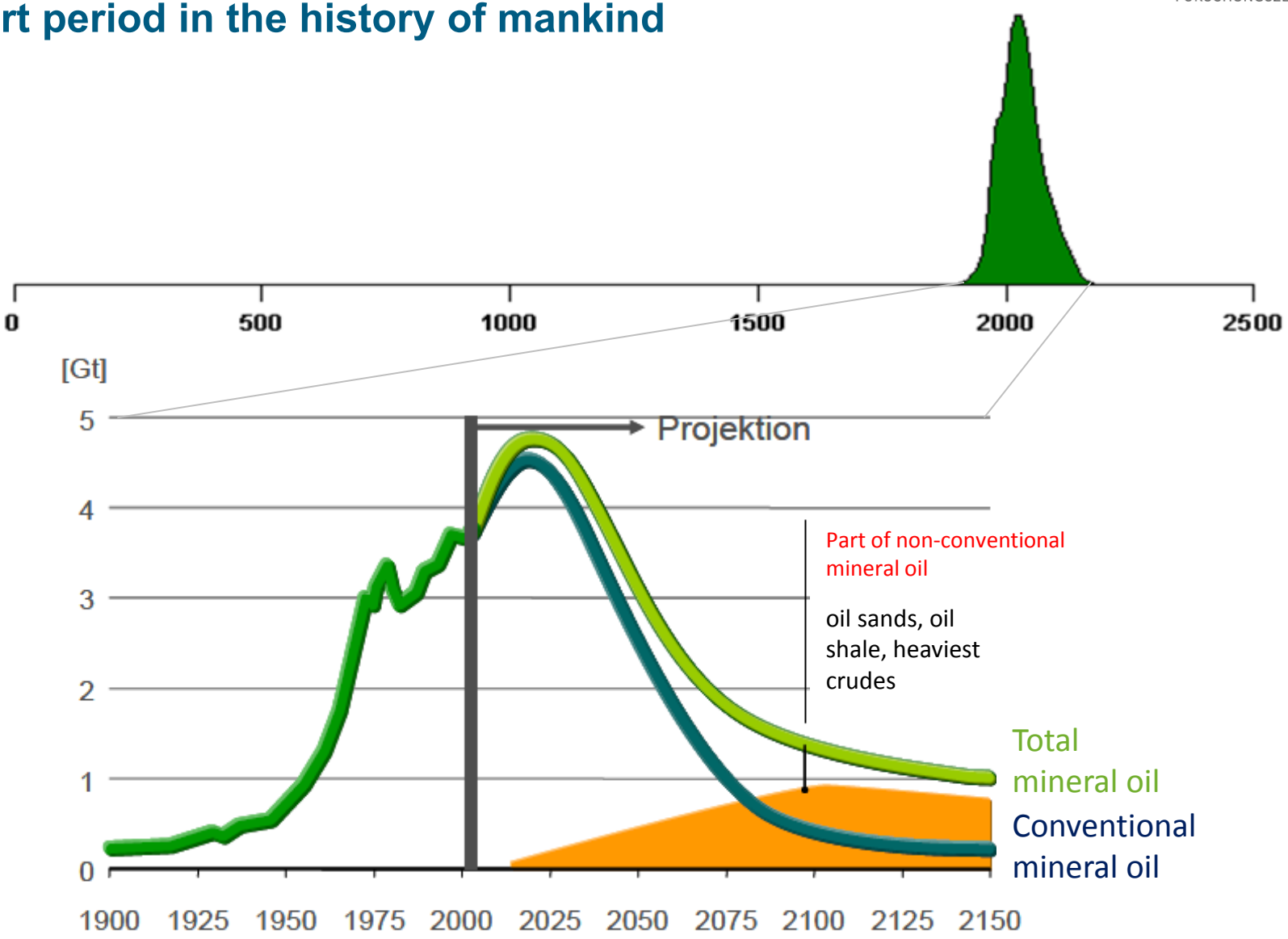
Fossile Energy

A short period in the history of mankind



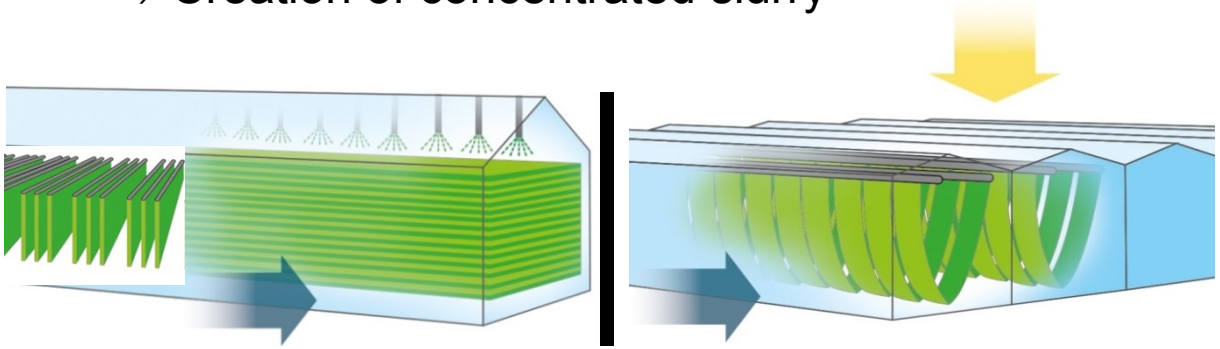
Per year we burn as much as oil as was developed in 5.3 Million years!

From Algae to Jet Fuel

JÜLICH FORSCHUNGSZENTRUM

Algae

- Cultivation of algae in different reactors
  ⇒ Creation of concentrated slurry



Oil

- Cell disruption and extraction with solvents at partner sites
  ⇒ Algae-oil „green crude“

Project coordination

- FZJ + 11 academic and industrial partners (Budget 7.4 M €)

Kerosene

- Hydration (saturation), decarboxylation at partner sites
  ⇒ Alkanes (kerosene & diesel)

Chemical Analysis of the Atmosphere

JÜLICH
FORSCHUNGSZENTRUM

Climate research

Using a variety of experimental, computational and theoretical approaches, we assess the influence of atmospheric changes on climate and the harvesting of renewable energies.

Chemistry-Climate Interactions
Methodological approach in JÜLICH

JÜLICH FORSCHUNGSZENTRUM

Open questions

Ozone production in the troposphere
Aerosol accumulation
Water vapor
…

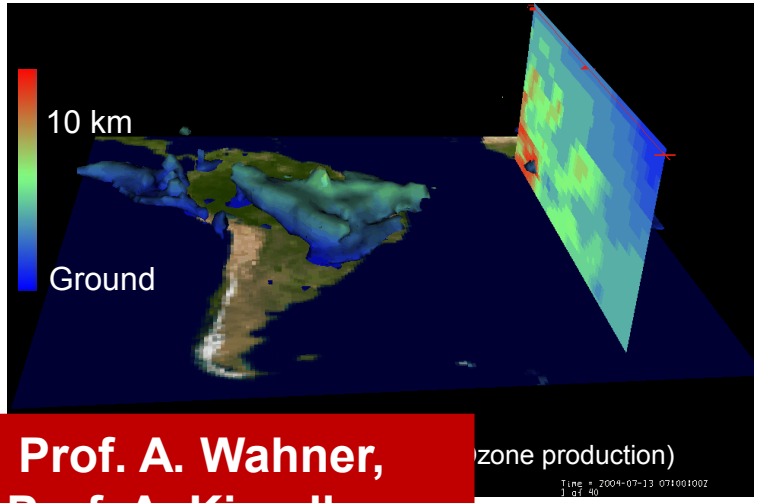
Monitoring and simulation

Measurements of flying platforms
Satellite monitoring
Atmosphere chamber
Modeling (HPC)

Process understanding

Parameterization of chemical, dynamic and micro-physical processes

Global and regional simulation and forecasting



GEM-AQ

Prof. A. Wahner, Prof. A. Kiendler-Scharr
08 July 2014
Plenary session II

Intergovernmental panel on climate change

WMO

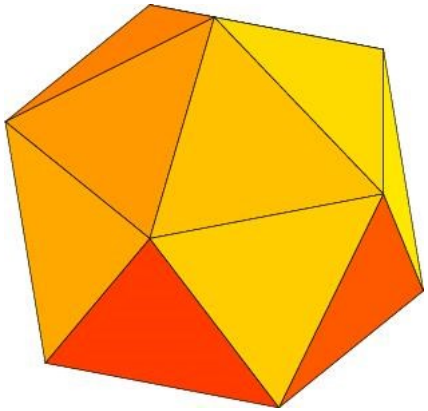
World Meteorological Organization

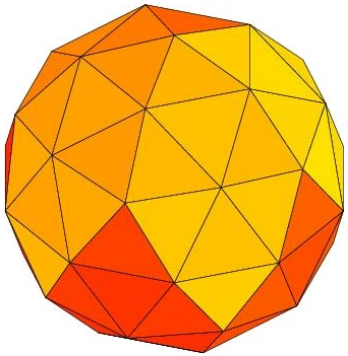
Improving the ICON Weather Model

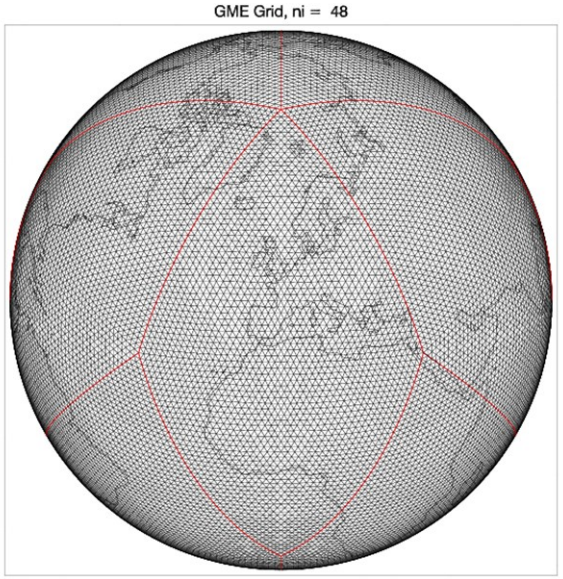
JÜLICH FORSCHUNGSZENTRUM

Bachelor projects:
Tako Janelidze (TSU)
Natalie Nebulishvili (TSU)

Project: Improving numerical advection and assimilation of trace gases on icosahedral grids







Tasks for ICON model with novel icosahedral grid:

1. Evaluate and improve numerical grid advection scheme (wind transport of trace gases)
2. Add adjoint for trace gas data assimilation

Prof. R. Botchorishvili, TSU

Ivane Javakhishvili Tbilisi State University

Prof. A. Wahner, FZJ
Dr. H. Elbern, FZJ

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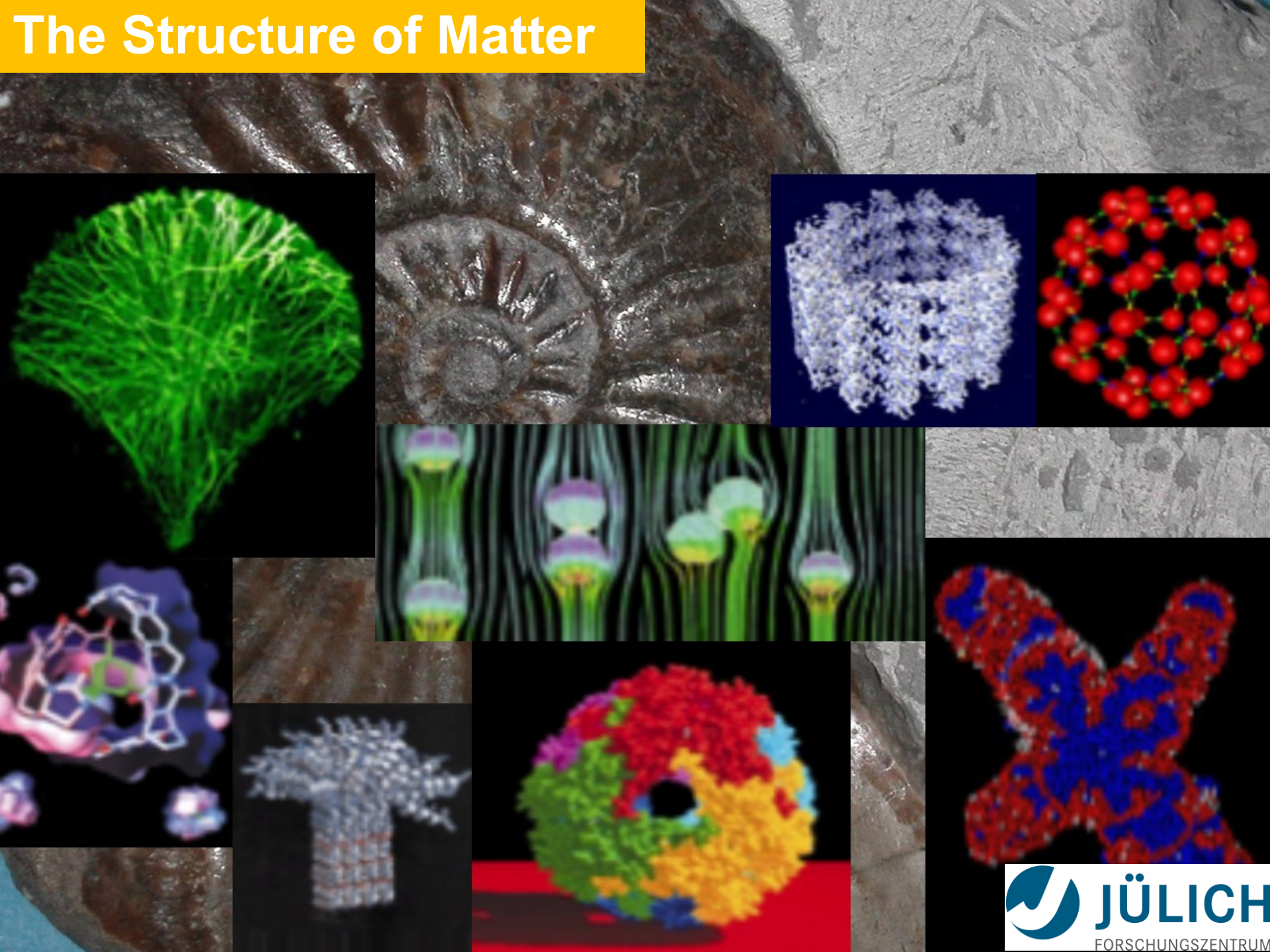
The Structure of Matter



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Generic Key Technologies

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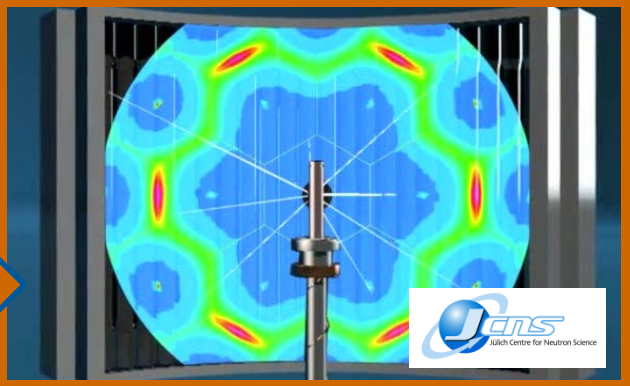
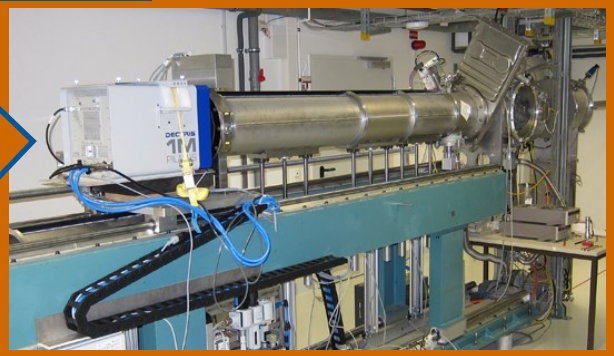
Protons



Neutrons

- Health
- Energy and Environment
- Information Technology
- Materials Science

Electrons



Photons

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Research with Protons:
Institute of Nuclear Physics

Cooler Synchrotron COSY

Hadron physics and technological development

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Characteristics of COSY:

- (Polarized) Proton-, Deuteron-beam with pulses < 3.7 GeV/c
- Phase space-cooling (Electron and Stochastic)
- Internal and external experiments

Past and Present

Georgian Students at the Institute for Nuclear Physics





Irakli Keshelashvili

2006 PhD (TSU)
PostDoc FZJ, Basel
2014 Staff IKP FZJ

David Chiladze

2009 PhD (TSU)
PostDoc FZJ
2014 FZJ, Industry

David Mchedlishvili

2013 PhD (TSU)
PostDoc FZJ
2014 PostDoc

Malkhaz Jabua

2011 Master (GTU)
PhD GTU/FZJ
2014 PhD Student

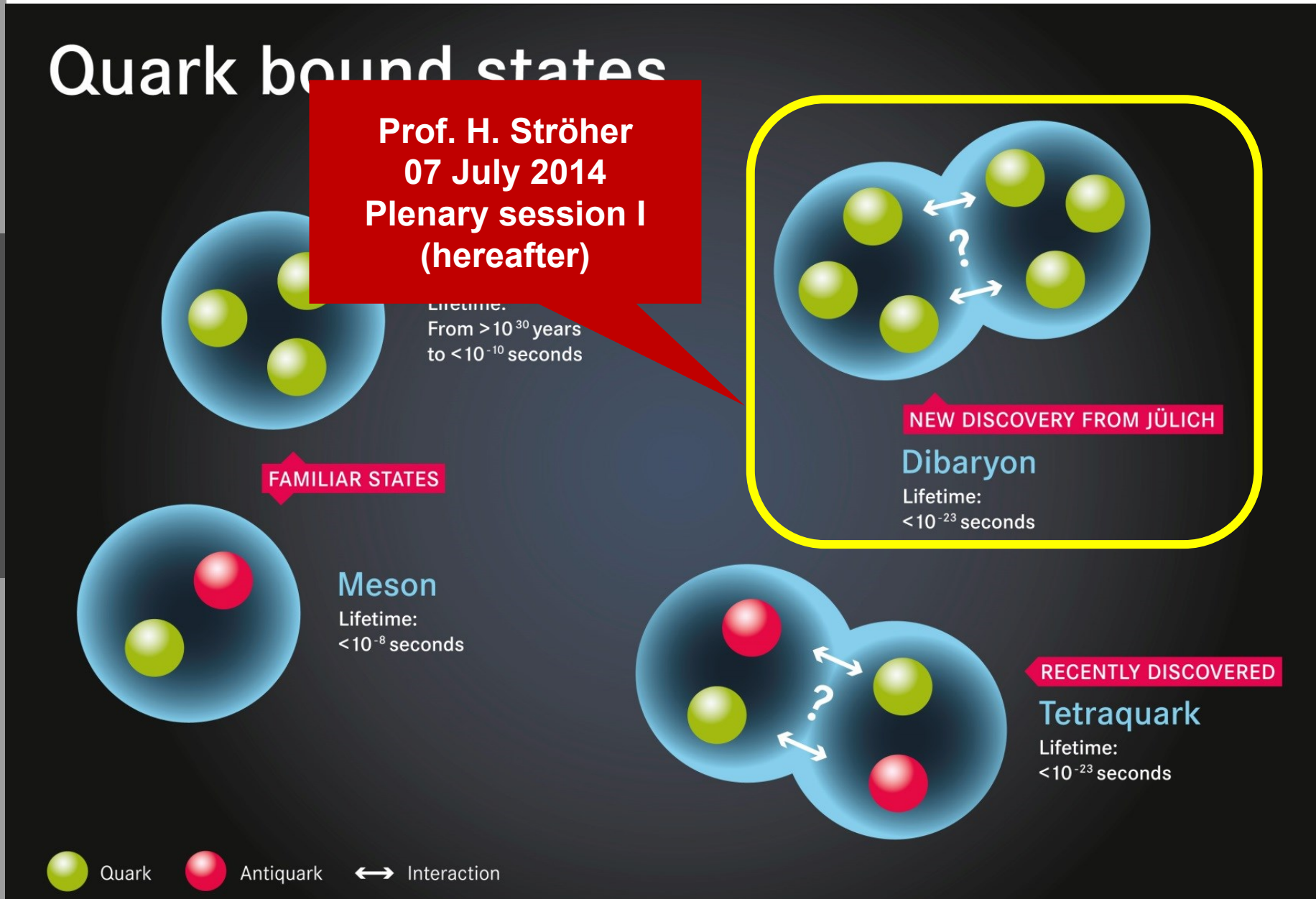
→ Poster

Zara Bagdasarian

2012 Master (TSU)
PhD TSU/FZJ
2014 PhD Student

→ Poster

Recent Discovery at COSY



Future Challenges for JÜLICH

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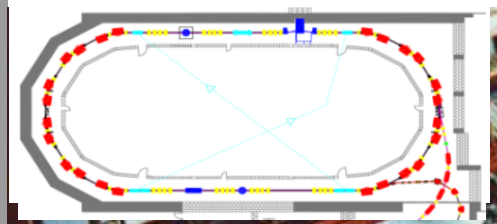
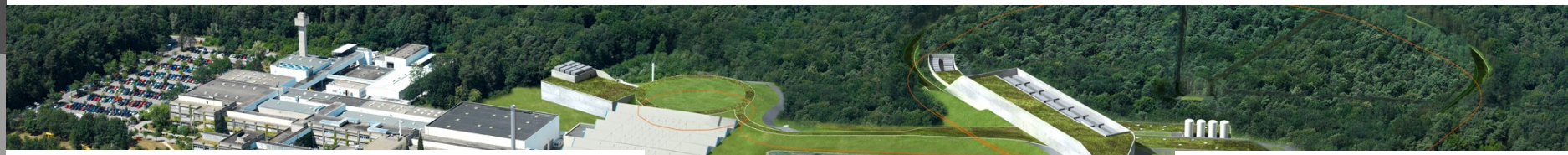
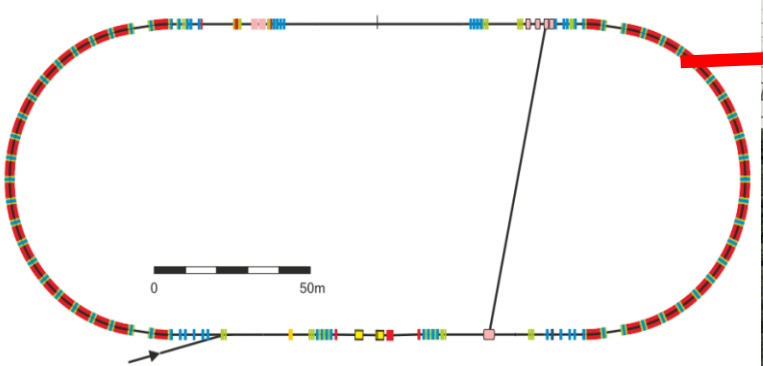
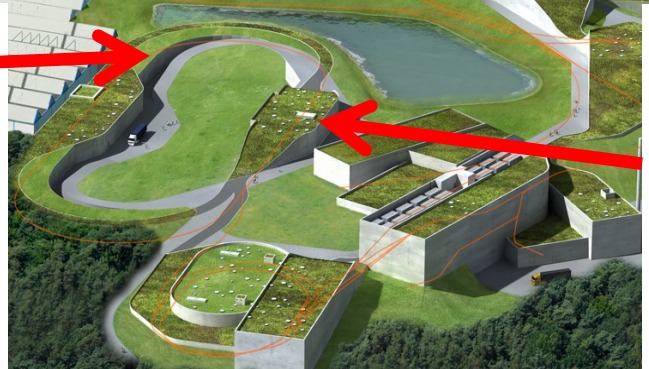
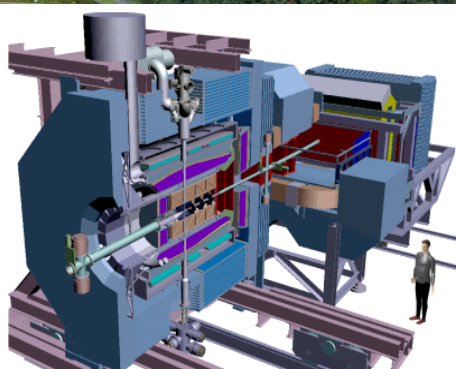


Transition from COSY@FZJ to HESR@FAIR









HESR vs. COSY

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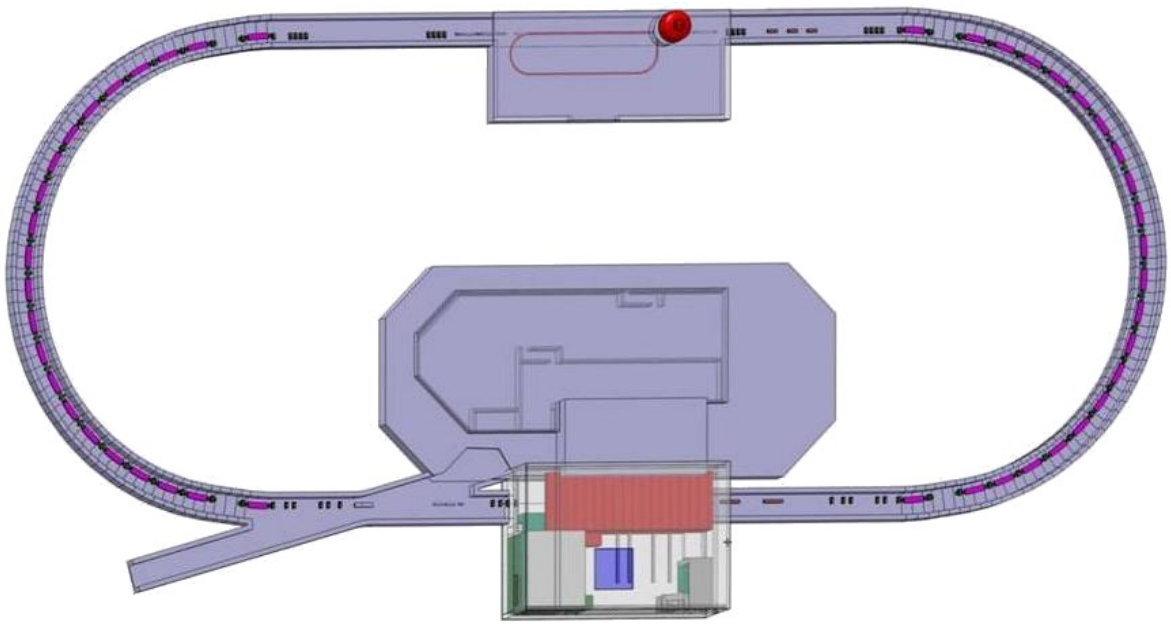
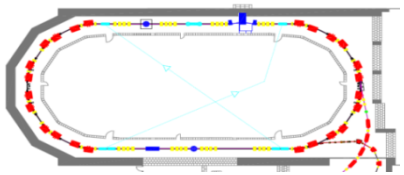


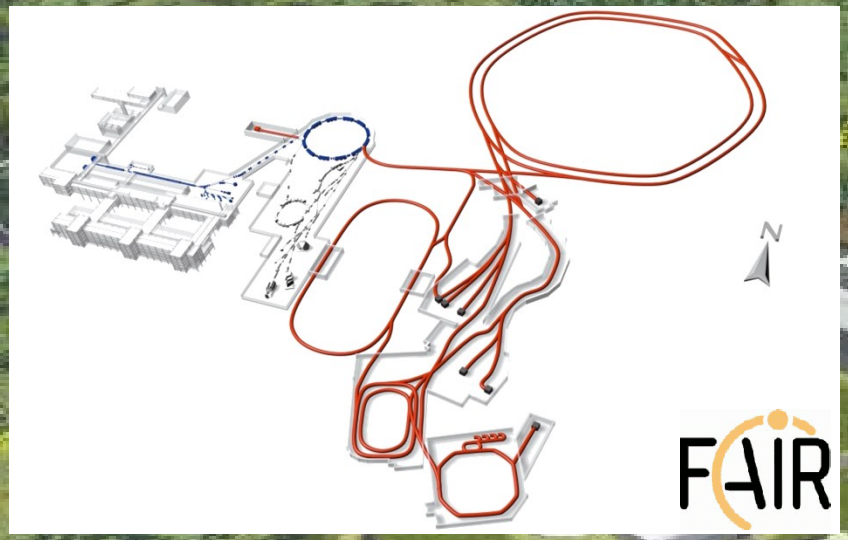
Technology development:
Dr. G. Natour
10 July 2014
Plenary session III



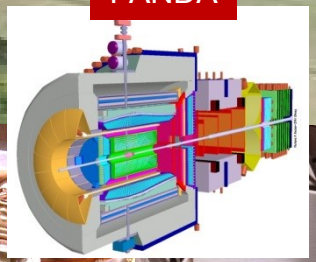
HESR		COSY
575 m	Circumference	184 m
1.5 – 15 GeV/c	Momentum	0.3 – 3.7 GeV/c
up to 9 GeV/c	Electron Cooling	up to 0.5 GeV/c
Full range	Stochastic Cooling	1.5 – 3.7 GeV/c

FAIR – An International Physics Facility

JÜLICH FORSCHUNGSZENTRUM

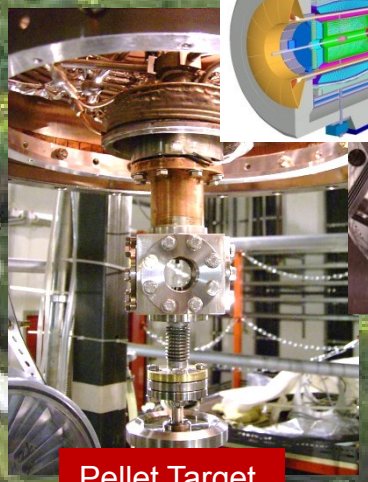


PANDA



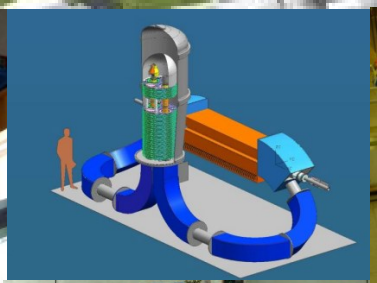
Straw Det. (TOF)

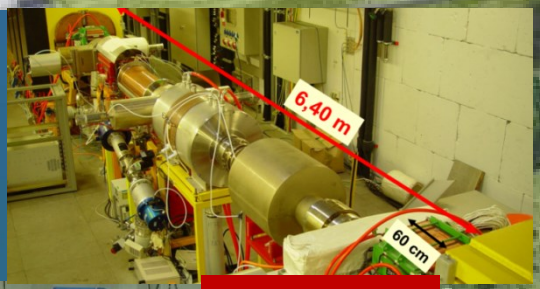
Cluster Jet Target (ANKE)



Pellet Target (Lab)

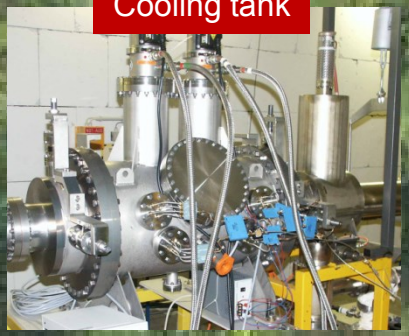
DETECTORS





Electron-Cooler (2 MV)

Stochastic Cooling tank



COOLING

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Research with Neutrons:
Jülich Center for Neutron Science

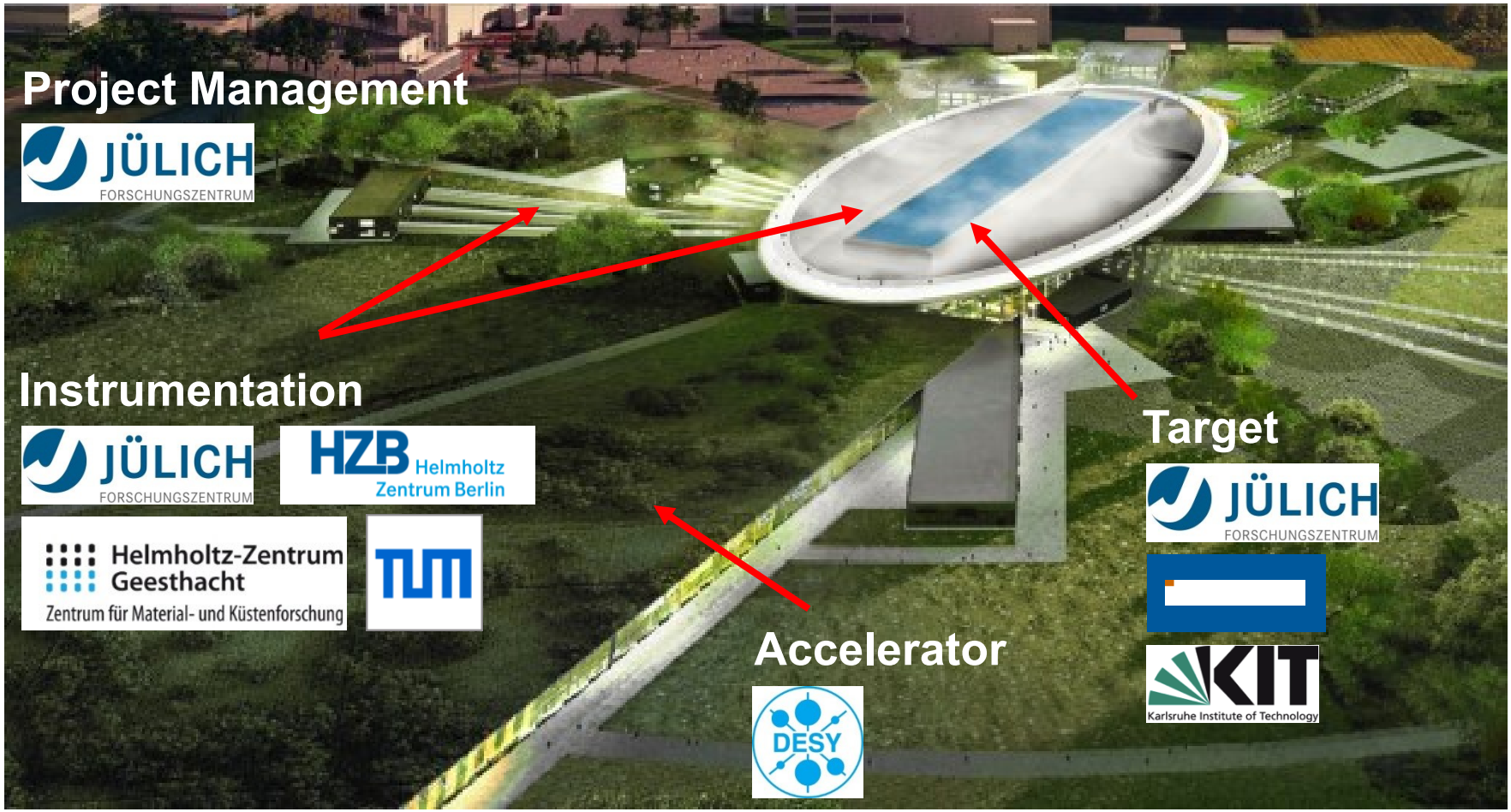
Jülich Center for Neutron Science (JCNS): Leadership in Neutron Science and Instrumentation

ESS

JCNS operates the best instruments at the best neutron sources of the world **FRM II**, **HFR@ILL**, **SNS** *and* ***ESS*** *from 2020!*

ESS Partners

German Design Update Project (2010-2014)



Germany contributes…

… to all major components of the ESS

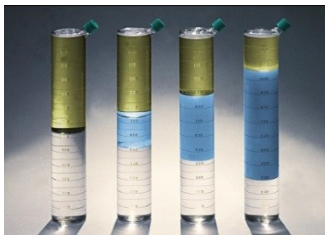
… 20.5M€ of 40 M€ in-kind to the pre-construction

From Neutrons to Cleaning Agents

JÜLICH FORSCHUNGSZENTRUM

CLOU®

Universal cleaning agent for retail



- Neutron scattering used to uncover the molecular structure of microemulsions
- JCNS scientists formulated a macromolecular surfactant which boosts the efficiency of cleaning agents
- Product CLOU: Bio-degradable, highly efficient, free of harmful ingredients, inexpensive
- Sold in supermarkets since 2012

Future@JÜLICH: Finding Tomorrow Today

JÜLICH
FORSCHUNGSZENTRUM