Mitglied der Helmholtz-Gemeinschaft

JÜLICH FORSCHUNGSZENTRUM

Technology for Excellent Science

ZEA- Central Institute of Engineering, Electronics and Analytics

5. Oktober 2015

Ghaleb Natour

JÜLICH
FORSCHUNGSZENTRUM

Structure Forschungszentrum Jülich

9 Instituts (>50 Sub-Instituts)

X

HOMEPAGE

- Portal
- Intranet

INSTITUTES

- Institute for Advanced Simulation (IAS)
- Institute of Bio- and Geosciences (IBG)
- Institute of Complex Systems (ICS)
- Institute of Energy and Climate Research (IEK)
- Institute of Neuroscience and Medicine
- Jülich Centre for Neutron Science (JCNS)
- Nuclear Physics Institute (IKP)
- Peter Grünberg Institute (PGI)
- Central Institute for Engineering, Electronics and Analytics (ZEA)

ADMINSTRATION

- Project Management Jülich (PTJ)
- Project Management Organization Energy, Technology, Sustainability (ETN)
- Technology Transfer

ZEA consists of three sub-institutes:
Engineering and Technology (ZEA-1)
Electronic Systems (ZEA-2)
Analytics (ZEA-3)

With ar. 250 experts

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Central Institute for Engineering, Electronics and Analytics (ZEA)

In cooperation with scientists from institutes at Forschungszentrum Jülich

develops technology:

- Devices/Instruments
- Processes
- Measuring and control equipment
- Detector systems
- Computer-assisted tools
- Imaging techniques

required for excellent science

that are not available on the market

Electronic Systems (ZEA-2)

develops complex system solutions in the fields of electronics and information technologies

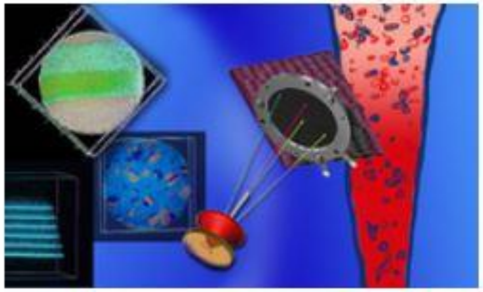
Leistungsangebot und Kompetenzen

Forschungs- und Entwicklungsbereiche

Ausbildung in versch. Berufen

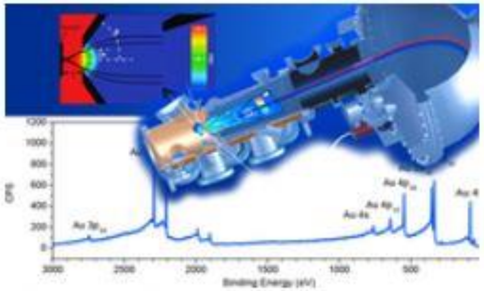
Analytics (ZEA-3)

works on solutions for complex analytical problems. Advises customers regarding all issues related to chemical analyses. ZEA-3 focuses on identifying and quantifying elements and molecules, and characterizing surfaces and layers.



3D-Atomprobe

particle size and distribution



Ambient Pressure XPS

Engineering and Technology (ZEA-1)

Mechanical Engineering, Control and Automation for Research on/with
Hadron, Neutrons, Photons,
Environment, Energy, Plants, Soil, Neuroscience

Time-of-Flight Chamber for Neutron Spectrometer TOPAS

- Initial Operation of 46 kg Fermi Chopper for BRISP Instrument at ILL
- "Gloria" Passes Acceleration Test in the Centrifuge
- Largest Magnetic Shield Room in the World Successfully Put into Operation
- GLORIA Instrument Holder Mounted to HALO Fuselage for the First Time
- "Vuvuzela" – radiometer for the measurement of moisture content in the ground.
- Measurement of Radicals in the Atmosphere with the HALO Research Aircraft

ZEA-1

- 160 employees (50 scientific, 80 technical-scientific)
- Since April 2013 as a whole institute ISO9001 certified

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Characteristics of R&D environment
Task

- Design, development and construction of Prototypes, demonstrators, measurement equipment innovative scientific instruments, processes, components

- Technology – feasibility studies

- Consulting

Characteristics of R&D environment deliverables

→ Large Setups and machines:
CT- scanner, production lines for innovative light sources UHP-, OLED-, accelerator components, neutron scattering experiments, innovative environment, soil and plant investigation instruments spectroscopy etc

→ Small tasks:
precise components and machined parts

→ Reports

Special aspects of R&D environment

- Not precisely specified requests, customers do not know the solution at an early stage
- Specification is frequently changed during the making of the prototype
- Changes require quick reaction no time for preparation training etc

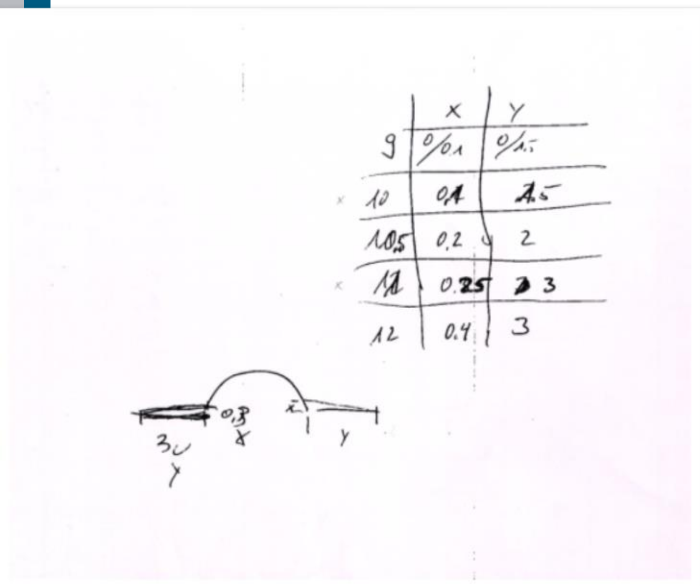
→ Fast and flexible, close interaction and communication with the customer is needed (customer orientation)

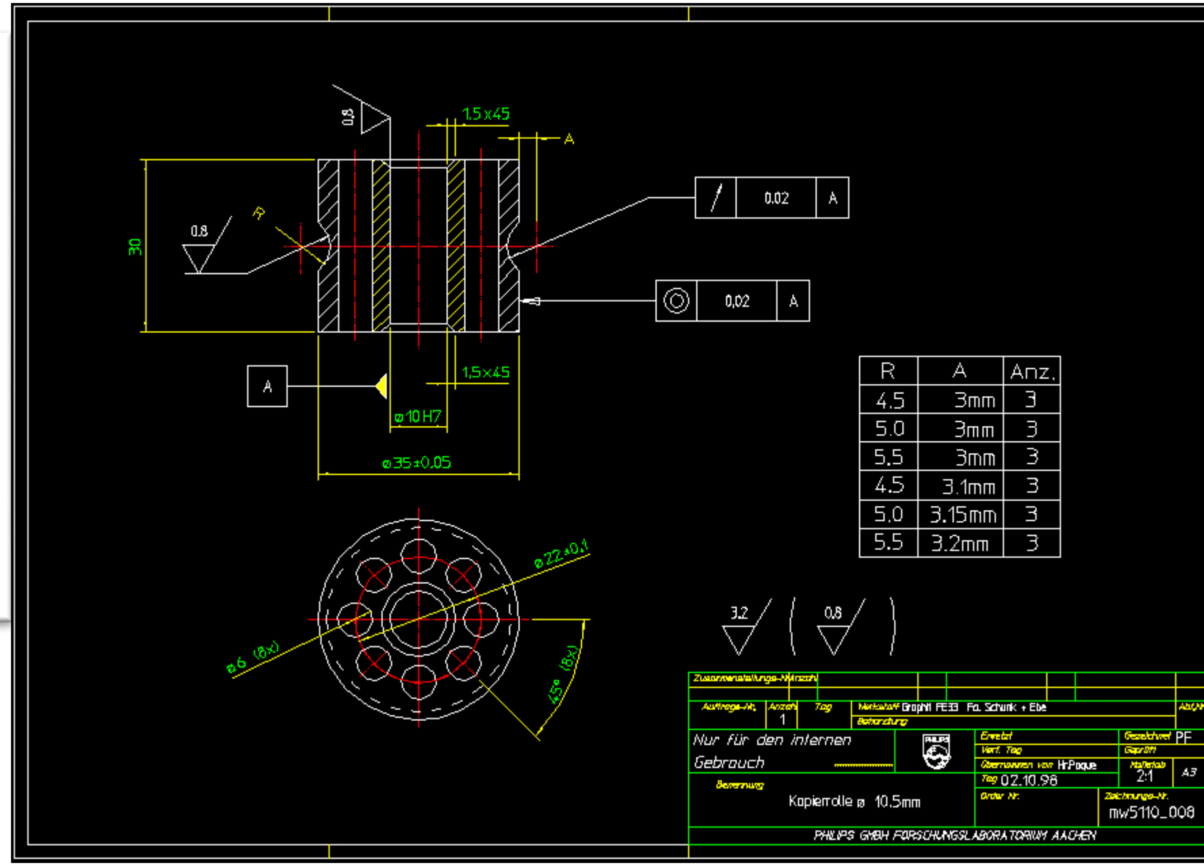
- Technology – Feasibility, the result is not known, no one did it before

→ Systematic approach learning from mistakes ,
good and comprehensive documentation needed

Example

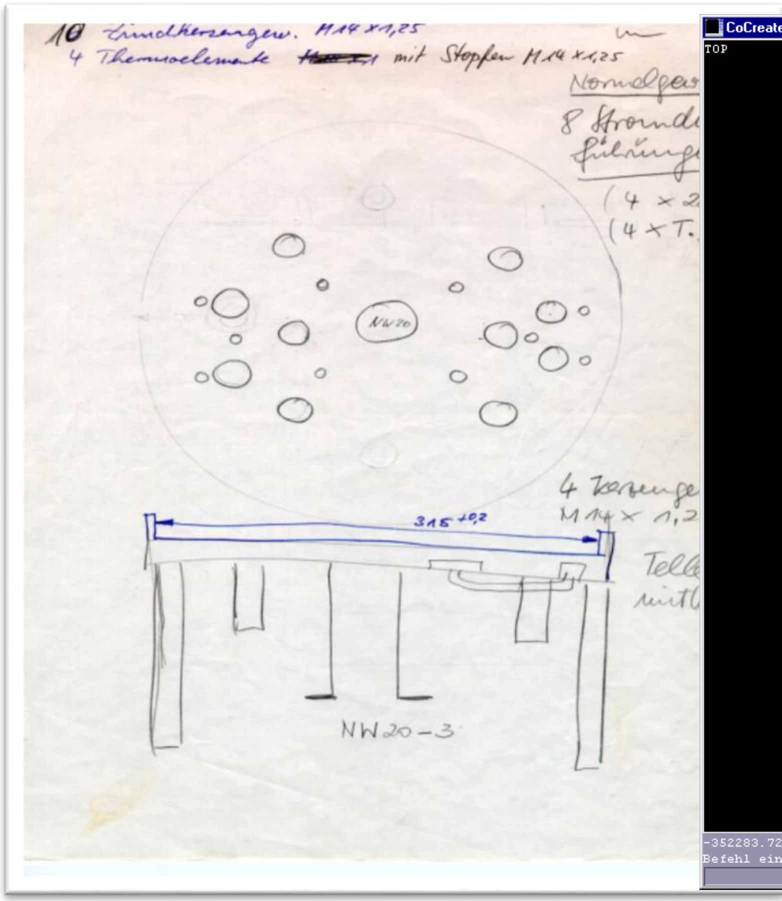
Translation of the abstract ideas of scientists into doable drawings

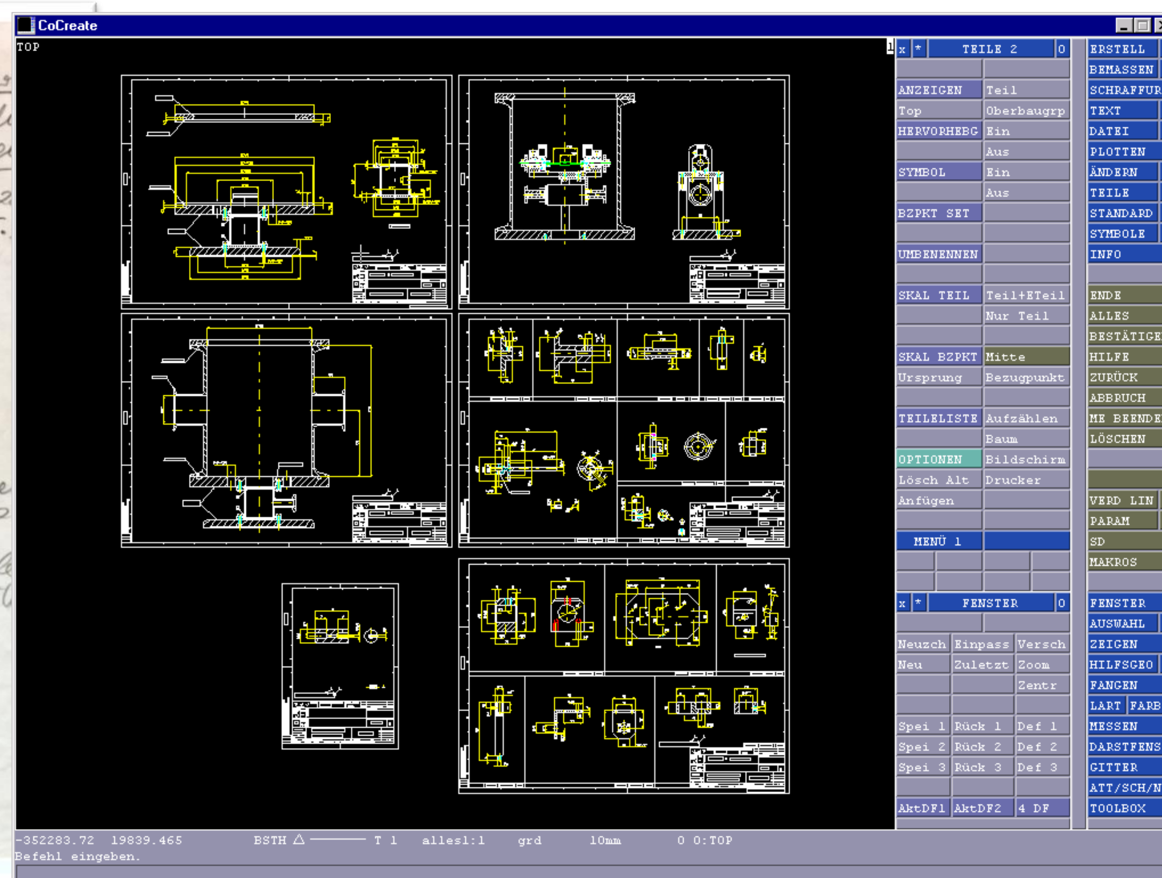


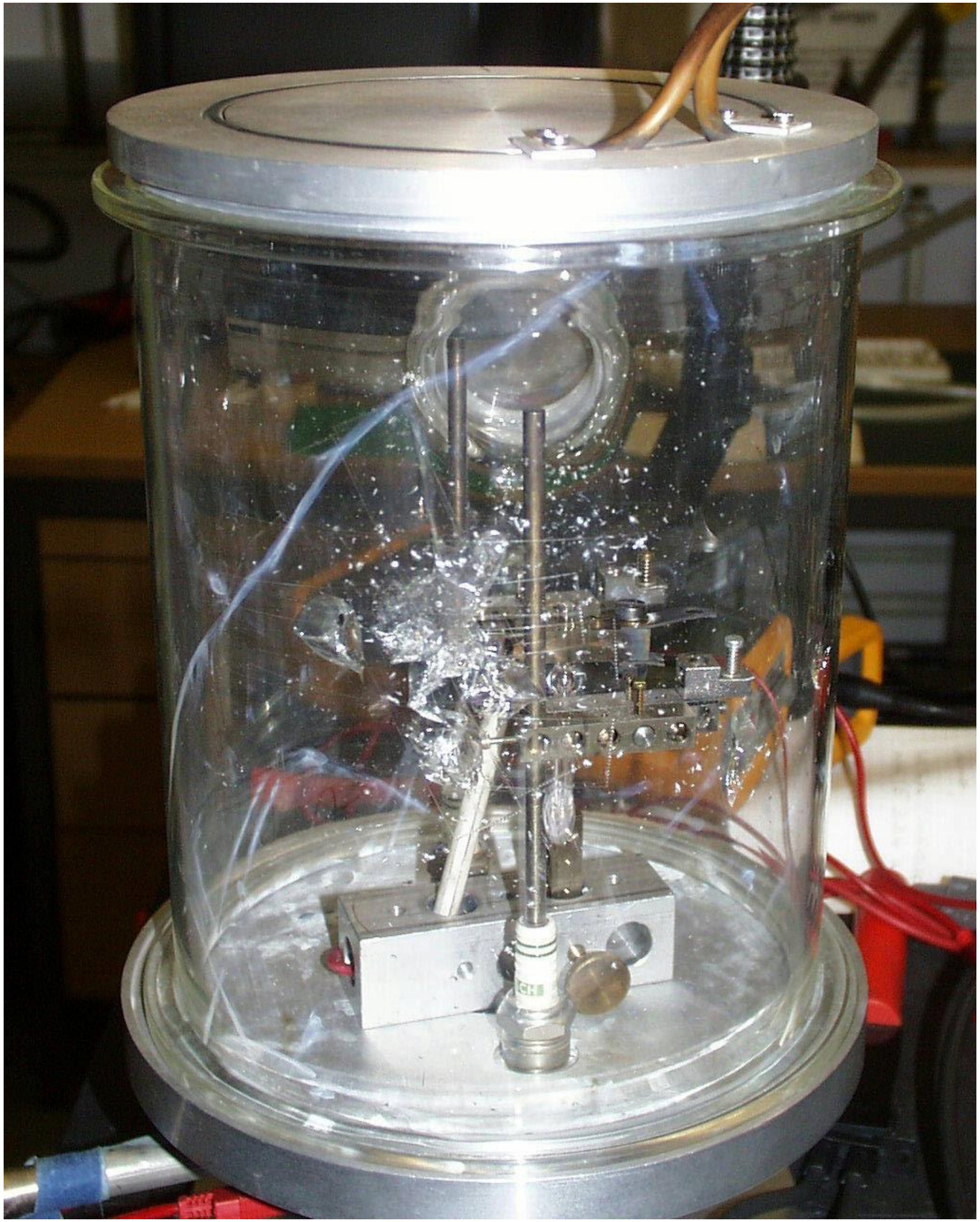


Example

Translation of the abstract ideas of scientists into doable drawings







Consequences for the way of working

- Customer focus is essential
  (nearby, way of thinking, put your self in his place and see it from his point of view

- Frequent contacts are necessary but this interrupt „flow of the work“
  Be prepared to this as a normal modus and not an exception

Right competence always on the right level normally very high
→ Permanent trainings to always be up-to-date
→ Being up-to-date concerning new technology developments
customers expect to be informed about news developments

Consequences for the way of working 2

- Customer relation management (measurement of customer satisfaction, feedback meetings) essential

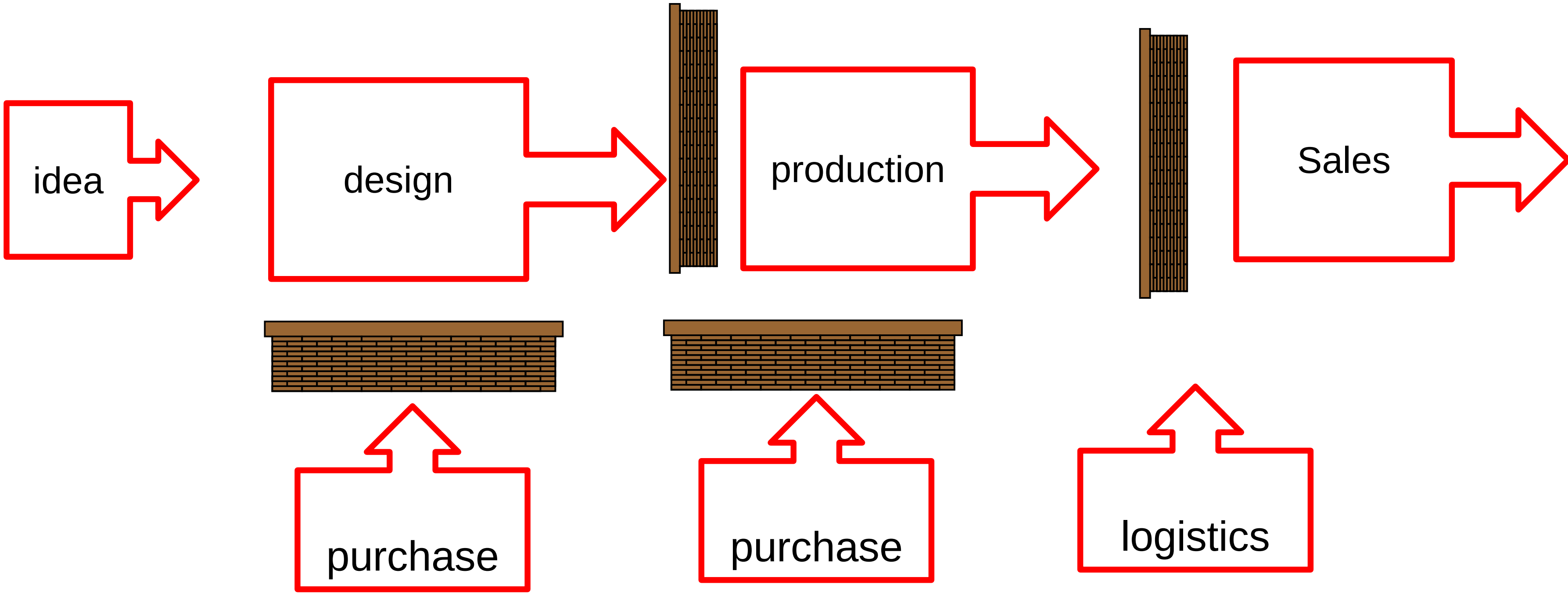
→ Based on the feedback improvement measures

Customers are innovative, engineering need to be prepared for always new ideas and requirements

Example 1: as design engineer at car manufacturer / supplier
→ Focus on e.g. design of car mirrors
Example 2: as design engineer in a hi-tech R&D environment
→ always new projects, possibility of reuse of expertise

Introduction
integrarted Product development

Classical (sequence) product development/production



Classical (sequence) product development/production

- product
- customer
- market
- competitors
- …

remain unchanged for a long time period
product specific processes are defined once and remain unchanged for many years

problematic

- different versions of the product
- complex technology
- international customers
- global markets
- always shorter development cycles
- the others are not sleeping

integrated product development

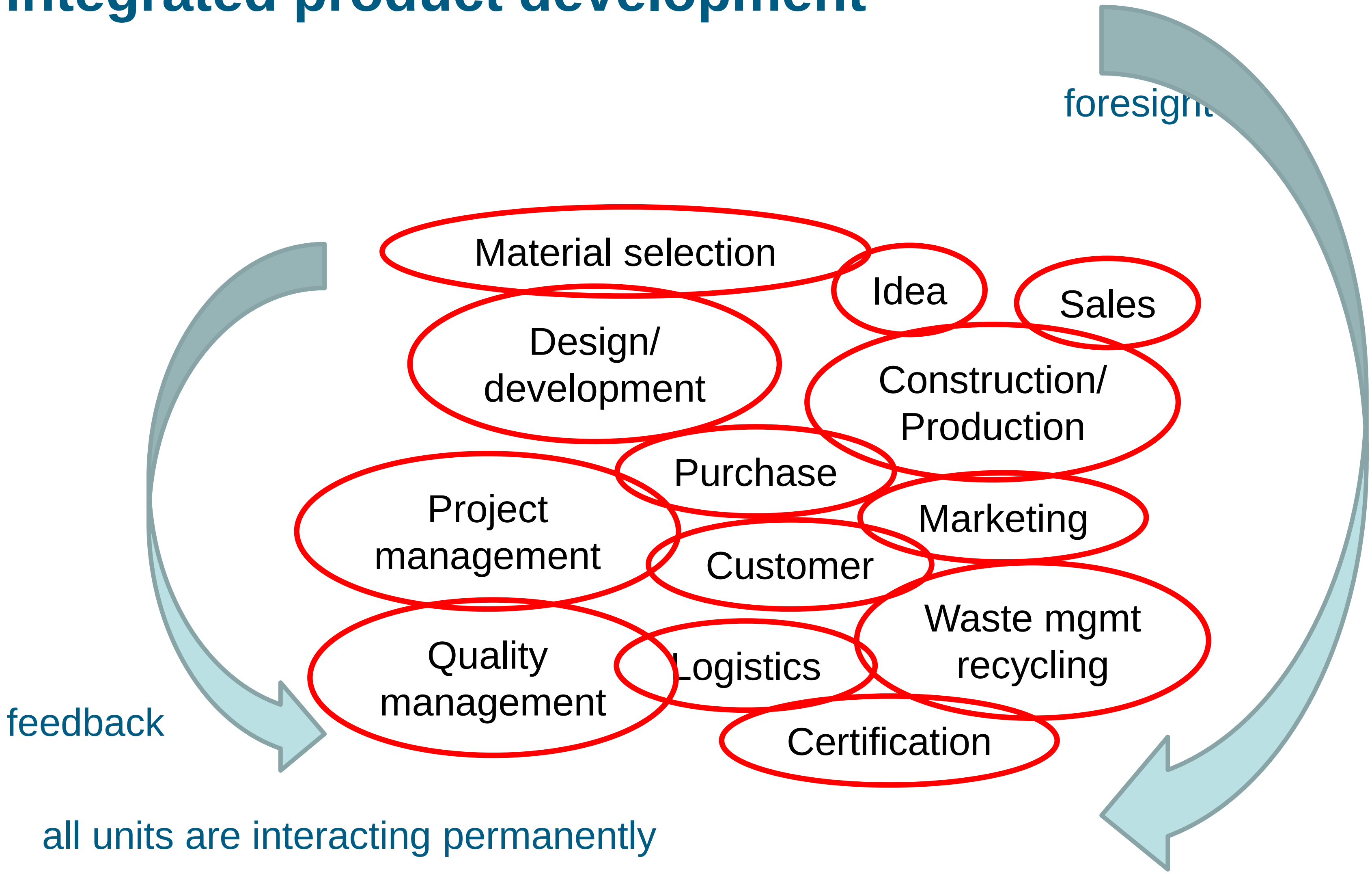
Design process
Production process
Purchase process Marketing process
Sales process
Logistics process

Are product specific processes

integrated product development:

In focus product and product specific processes
Organisation units and functions are cooperating closely
are synchronised and harmonised well integrated

integrated product development



all units are interacting permanently

Example: ZEA-1 competences

engineering und new technologies

- project management
- engineering design, numerical simulations and calculations (practical part)
- feasibility studies & experiments, physical measurements
- automation and control techniques
- joining technologies & materials research
- magnetic bearing and drive systems

manufacturing technologies & assembly

- welding technologies
- high precision machining and assembling, machine manufacturing
- rapid prototyping
- glass, plastics and ceramics machining
- surface treatment techniques

inspection and approval procedures, e.g.:

- certifications for pressure vessels and welding technologies
- CE certifications

The Benefit of Modern Simulation Tools

- identification of faulty designs and weak spots in the early development phase
- analysis of complex systems possible
- minimizing costly physical testing*
- results are available everywhere in the system
- fast and easy design optimization in terms of material stressing, weight, stiffness …
- assessment of lifetime

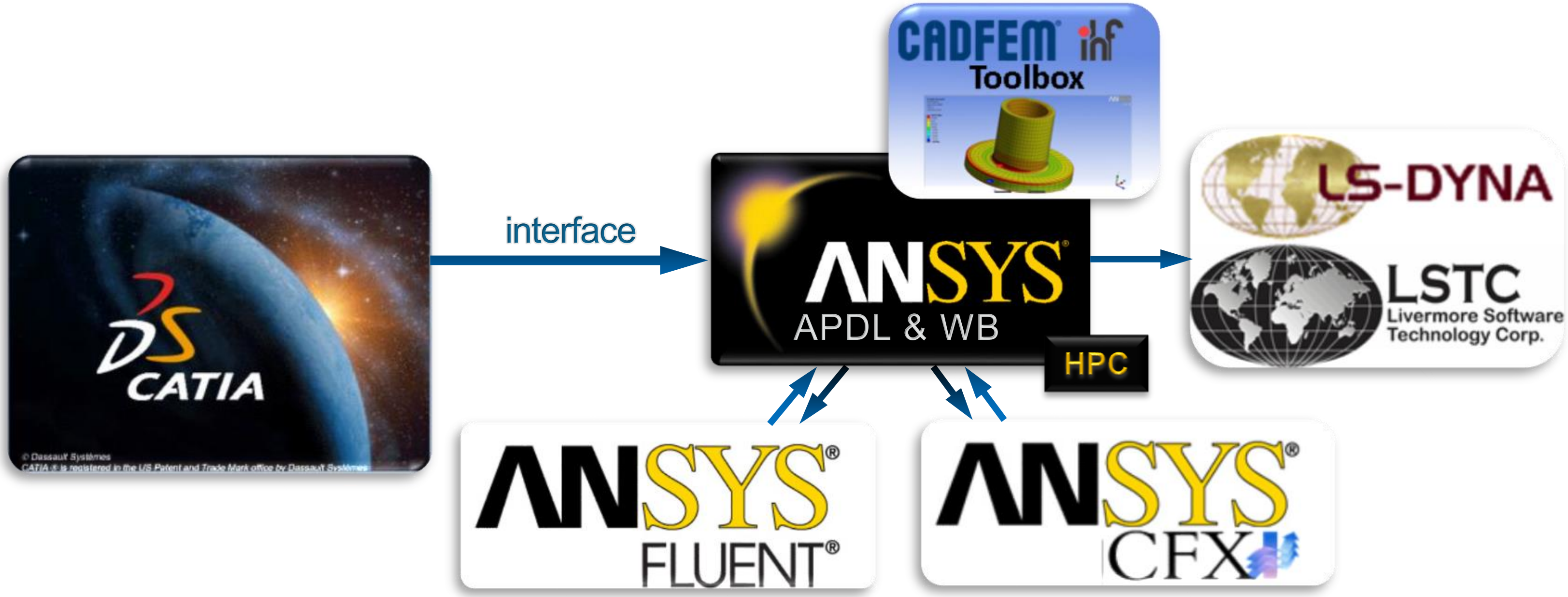
⇒

- enhanced product quality
- shortening of development phases
- reduction of development costs

*nevertheless, in most cases experiments are also indispensable in prototype development and only the combination of simulations and experiments will lead to optimal results

(Jörg Wolters)

Software (FEM / CFD / others)



Ampere / Magneto
INTEGRATED ENGINEERING SOFTWARE

Opera
Cobham

Rifest Plus
IMA DRESDEN

DIMy
DRUCKGERÄTE-DIMENSIONIERUNG

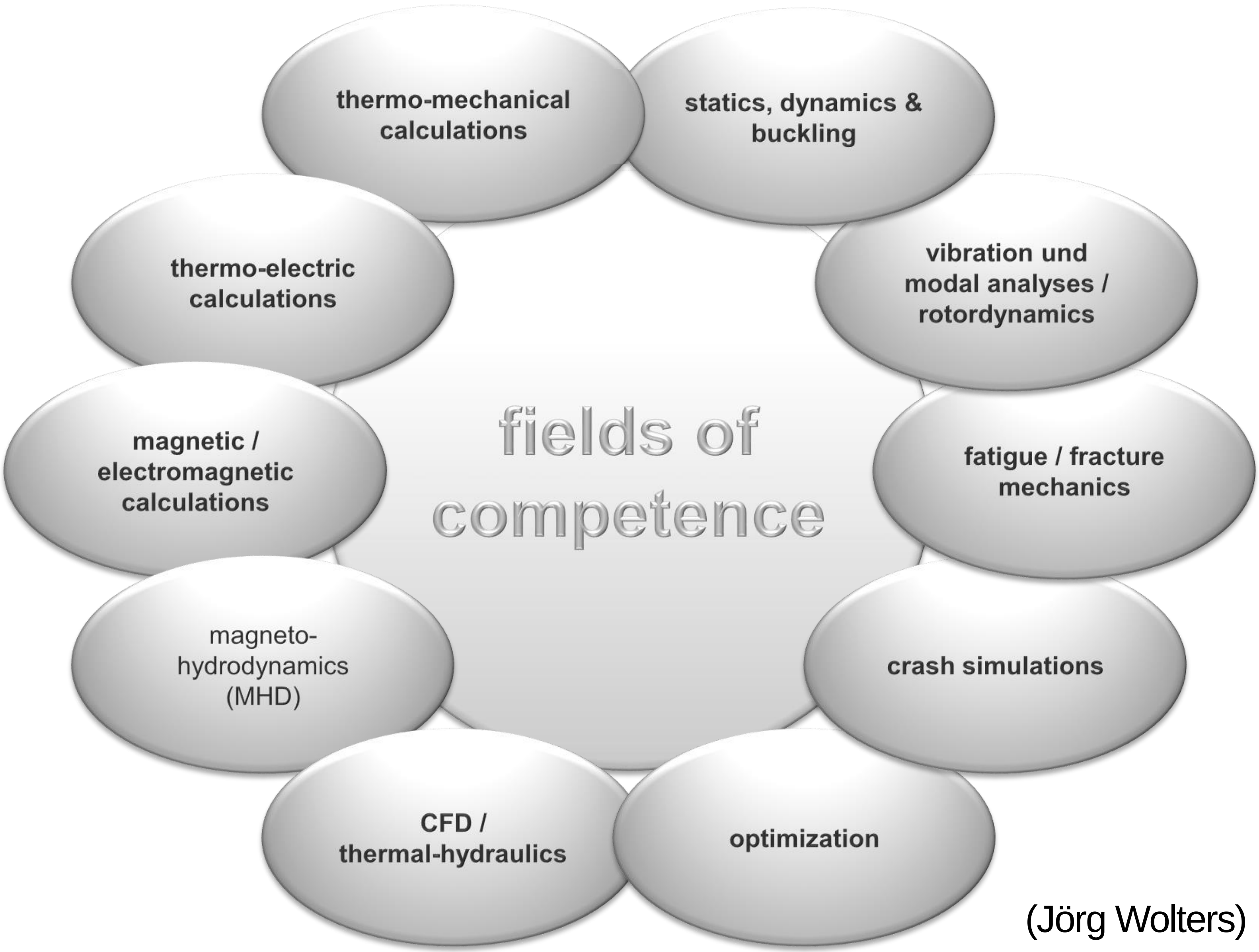
Maplesoft
command the brilliance

Microsoft Excel

Mathcad 15.0

(Jörg Wolters)

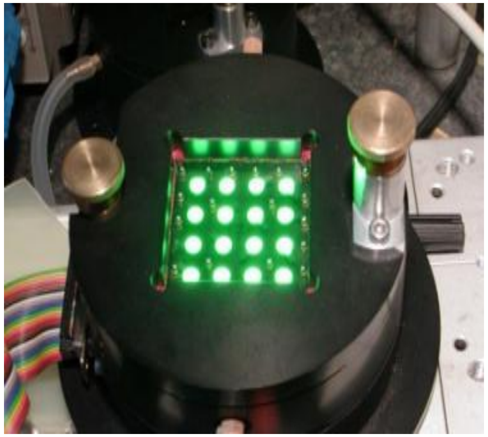
Fields of Competence



(Jörg Wolters)

Example production of OLED* for research

starting point:
Scientists use a commercial vacuum chamber
for evaporation of single substrates



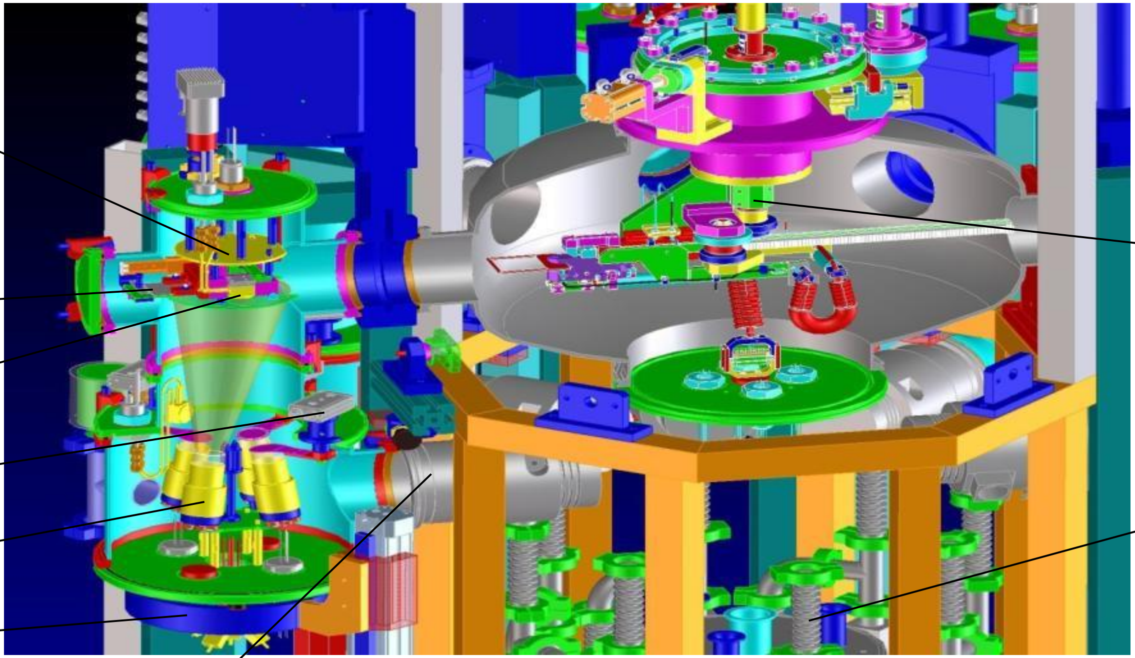
requirement:
user friendly, flexible and quick (U) HV- compatible with an accurate control

*Organic Light Emitting Diods

Example production of OLED for research

concept:

a modular system made of a central chamber with a manipulator and different chambers around it

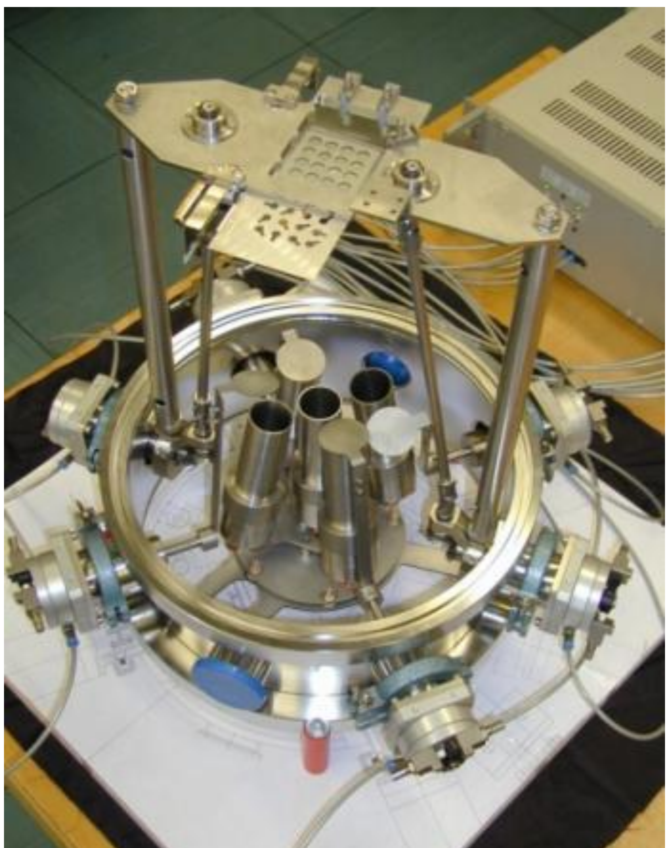


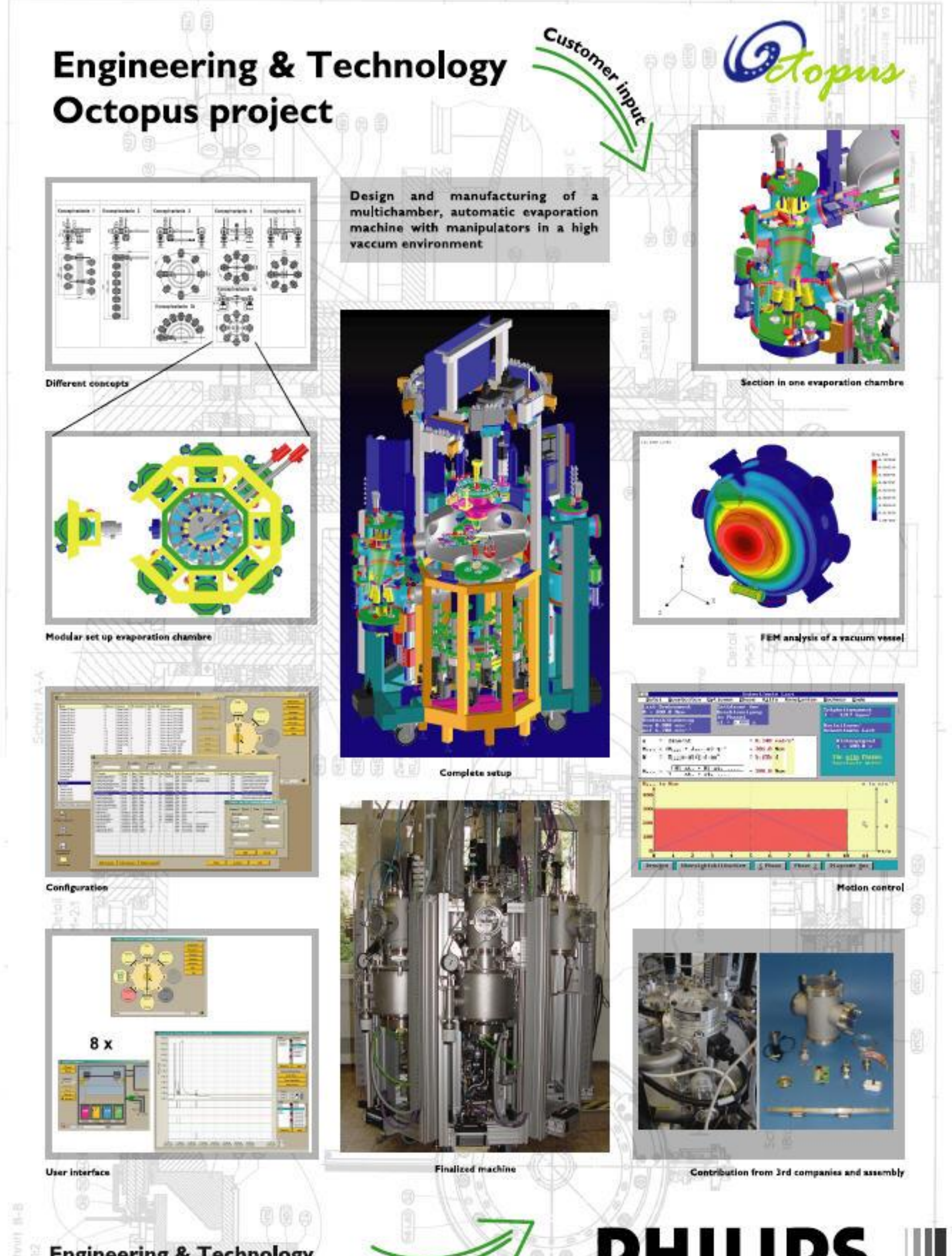
Gesamtanlage im Schnitt

→ motors, actuators, pumps, valves,
sensors (for layer thickness, pressure, temperature and position)

Example production of OLED for research

Challenges:
materials
accuracy
positioning
connections
control





Example production of OLED* for research

result:

- automatic
- very flexible
- UHV- compatible
- documentation and manual
- meeting customer specs
- In time and lower than budgeted

Projects Overview

Hadron Physics (IKP: Institute for Nuclear Physics) COSY, HESR, PAX

- Accelerator and accelerator components
- Detector systems for Proton – and Antiproton beams

Neutron Science (JCNS: Jülich Center for Neutron Science) FRMII, ESS

- Instruments for advanced Neutron sources
- Choppers for Neutron scattering (magnetic bearing)
- Design European Neutron Spallation Source ESS

Energy (IEK: Institutes for Energy and Climate Research) W7-X, ITER

- Instruments for Nuclear Fusions Research
- Projects for photovoltaic, full cells

Environment (IEK: Institutes for Energy and Climate Research) GLORIA, HALO, PEGASOS

- Setups for measurement of trace gases in the atmosphere

Bio-Geo Science (IBG: Institute for Bio- und Geo Science)

- Equipment for plant and soil investigations

Medicine (INM: Institutes for Neuroscience and Medicine)

- Work for MRT- und PET- set ups
- Equipment for production of radio nuclides

Neutron scattering –existing and planed JCNS outstations

The new Research Reactor FRM-II at Garching, Munich) , Germany

Neutron scattering instruments designed, developed and manufactured by the ZEA-1 for research at the FRM II

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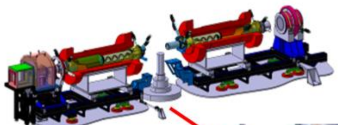
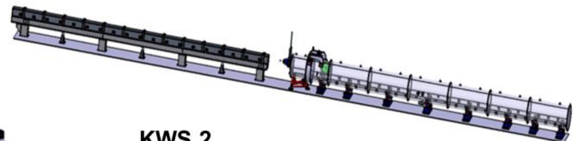
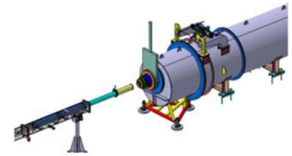


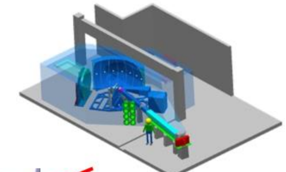
J-NSE
Instrument transferred from reactor Dido in Jülich and upgraded at FRMII



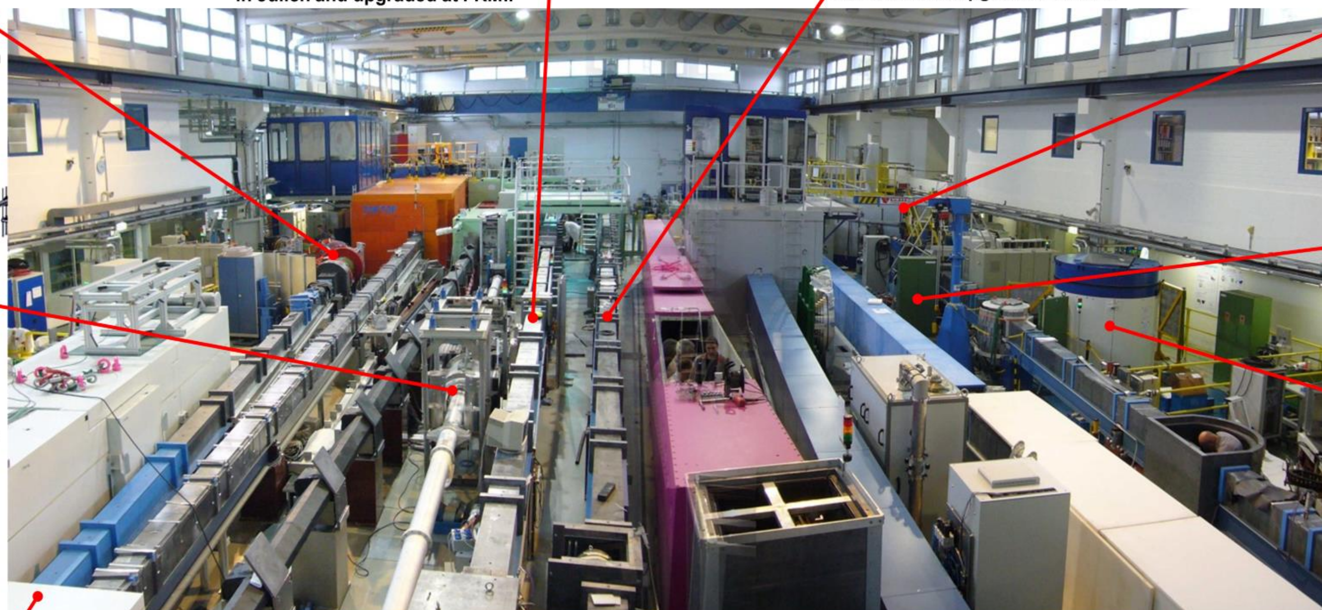
KWS 2
Instrument transferred from reactor Dido in Jülich and upgraded at FRMII

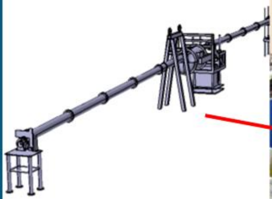


KWS 1
Instrument transferred from reactor Dido in Jülich and upgraded at FRMII

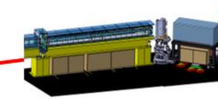


SPHERES

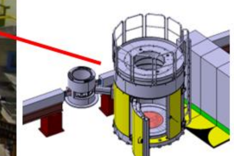




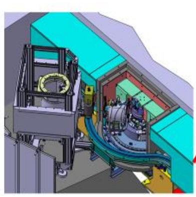
KWS 3
Instrument transferred from reactor Dido in Jülich and upgraded at FRMII



MARIA

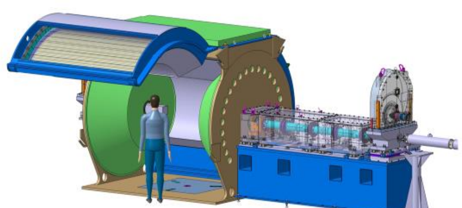


DNS
Instrument transferred from reactor Dido in Jülich and upgraded at FRMII

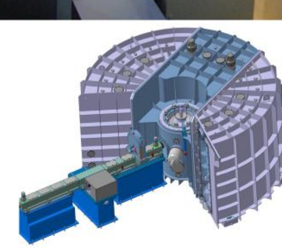


BIODIFF

In cooperation with
JCNS, ZEA-2, G-ELI
TUM, FRM II
RWTH-Aachen
Industry partners

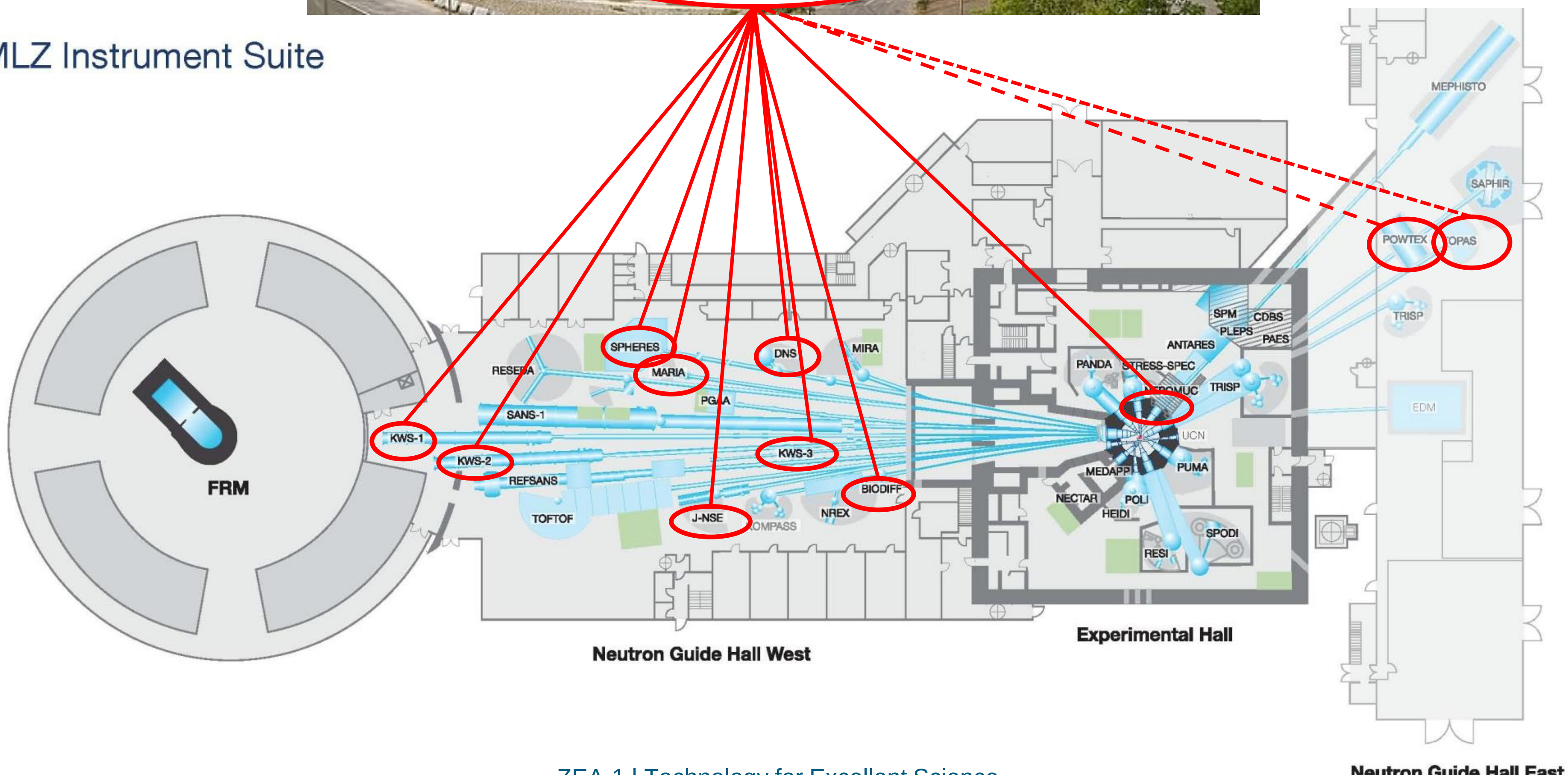


POWTEX
Neutron Guide Hall East
Spectrometer in development phase

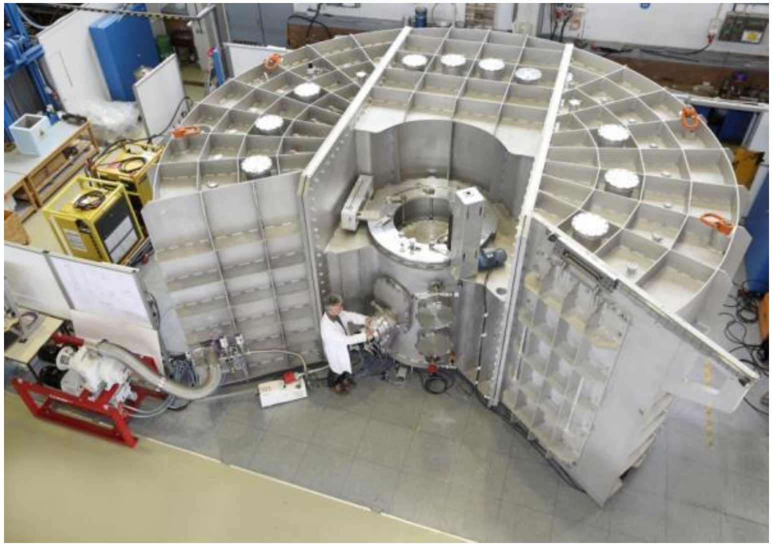


TOPAS
Neutron Guide Hall East
Spectrometer in assembly phase

MLZ Instrument Suite



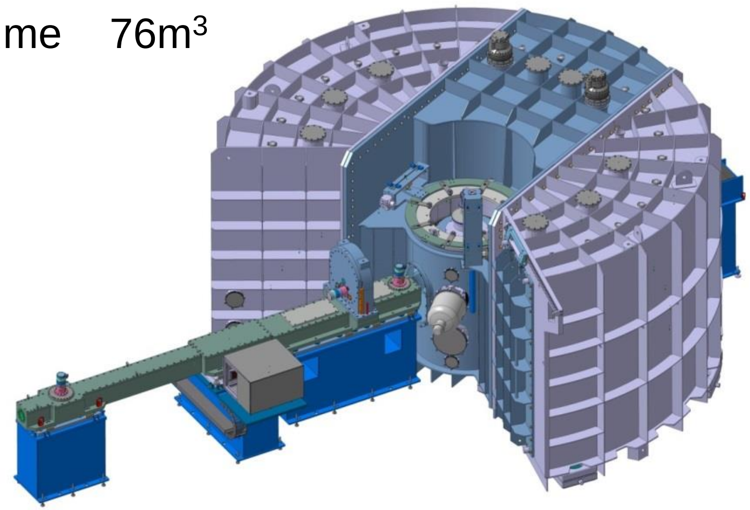
Time Of Flight Polarization Analysis Spectrometer



50 Tons of steal, 50m O-Ring,
3 km welding-seam

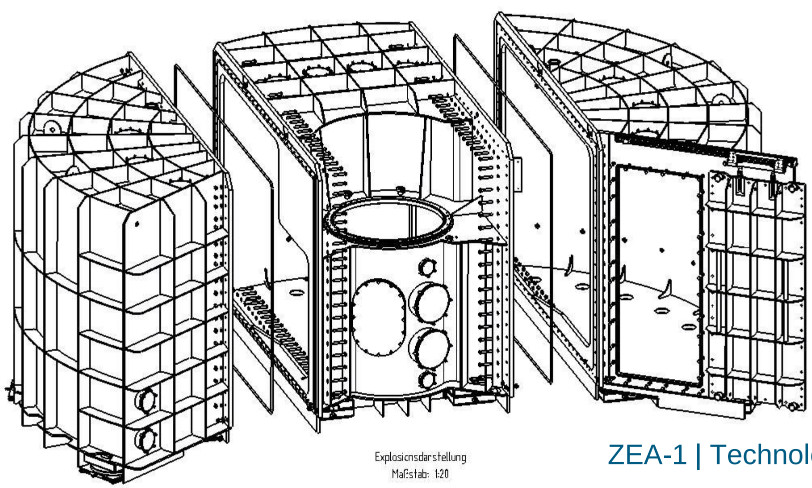
Ø 6,5m

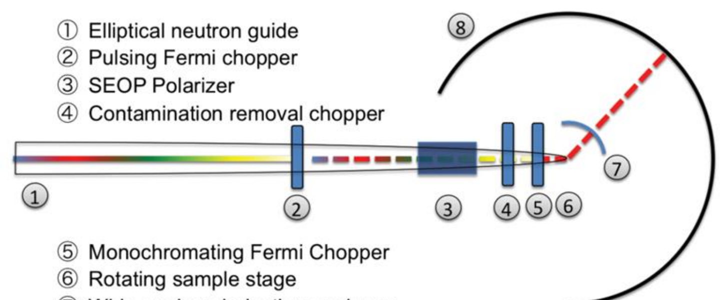
Volume 76m^3



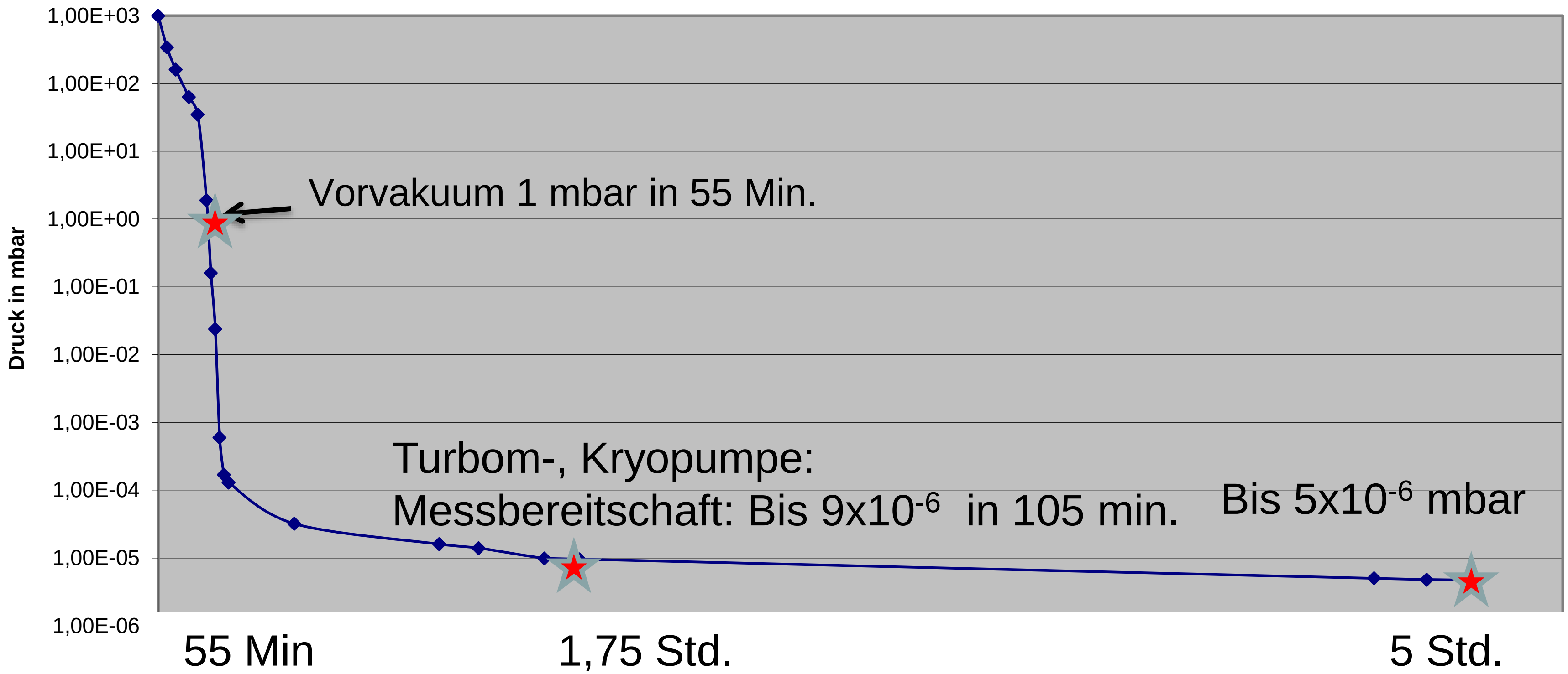
3,2m

Vacuum < 10^{-5} mbar





Evacuating TOPAS

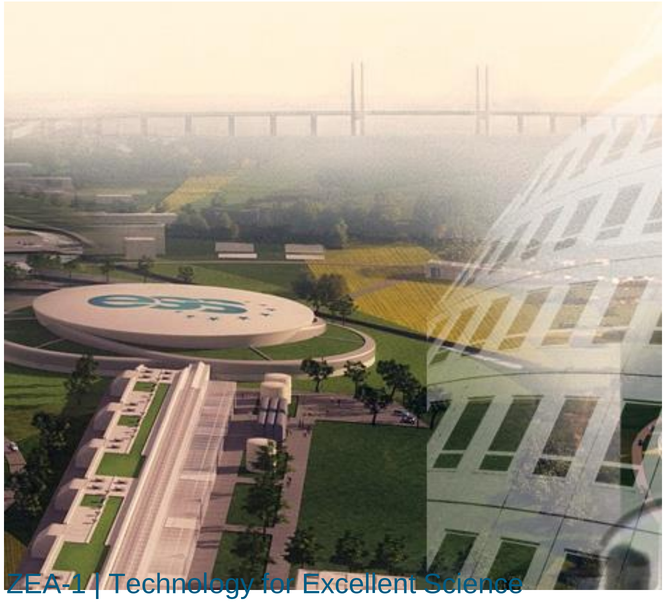


Neutron scattering –existing and planed JCNS outstations besides Munich

The first Megawatt Spallation source
SNS at Oak Ridge, USA

The High-Flux Reactor ILL at Grenoble, France

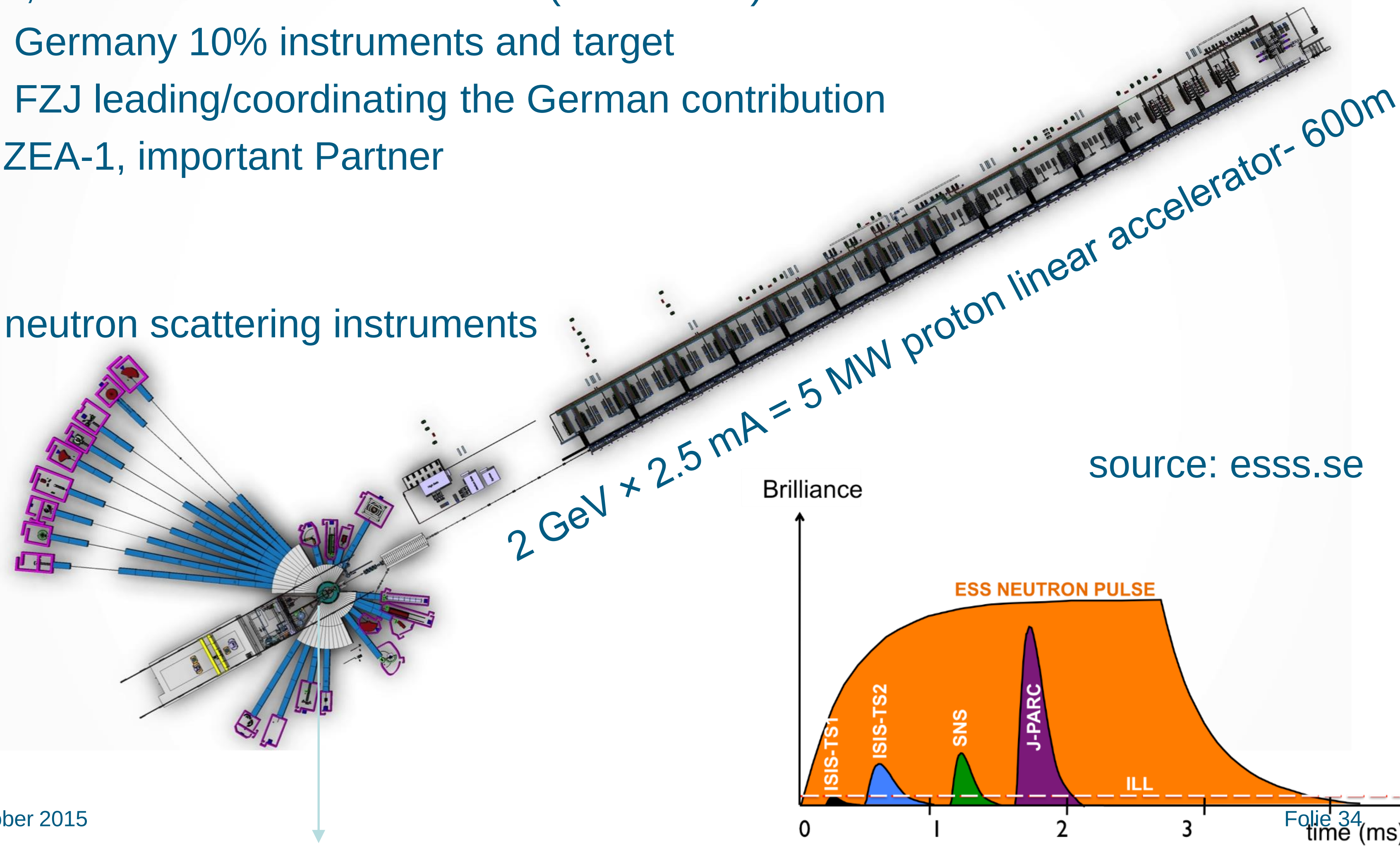
Being constructed European Spallation Source (ESS) in Lund, Sweden



European Spallation Source ESS Lund/Sweden

- 17 European partners
- 1,8 Billion € construction costs (2015-2020)
- Germany 10% instruments and target
- FZJ leading/coordinating the German contribution
- ZEA-1, important Partner

22 neutron scattering instruments

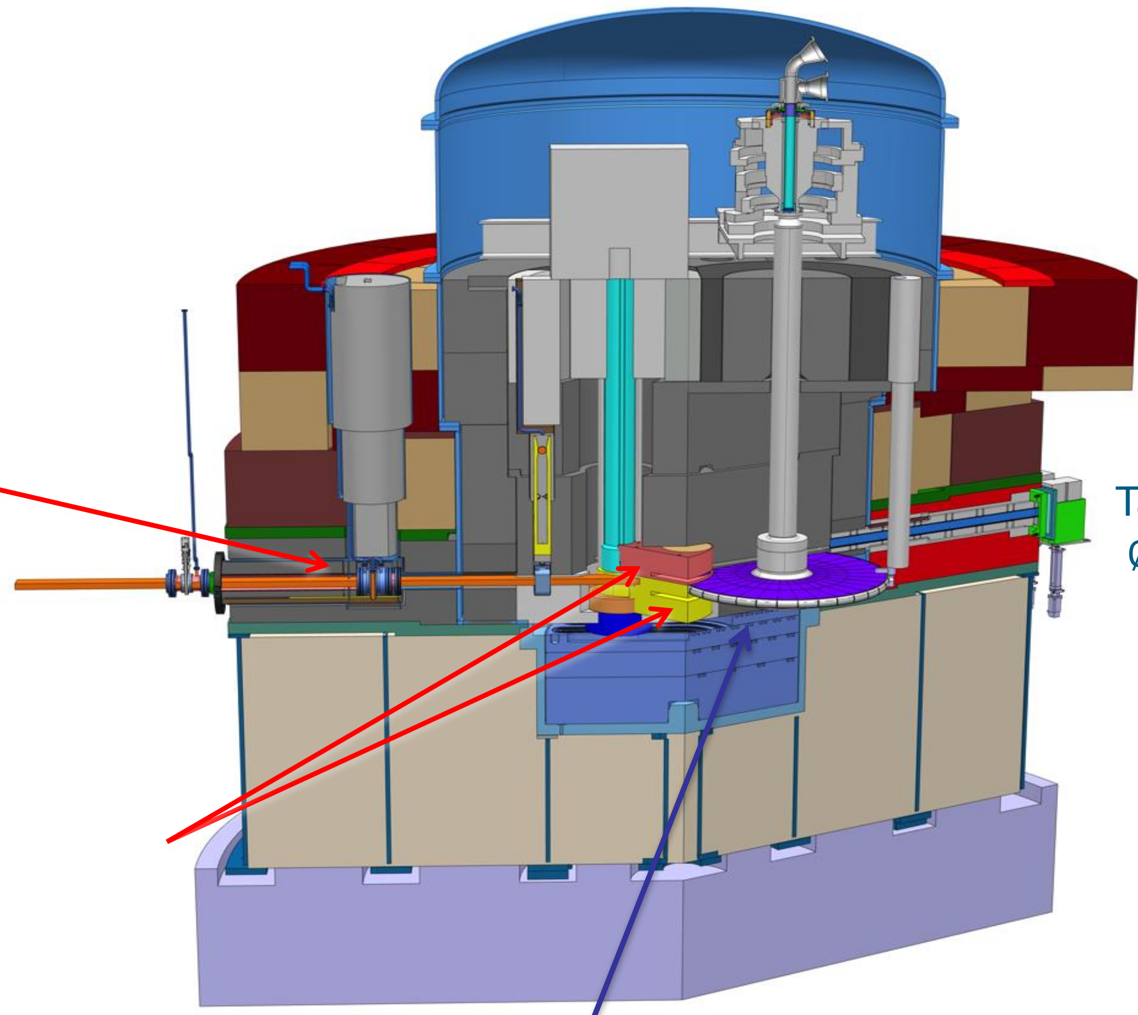


2 GeV × 2.5 mA = 5 MW proton linear accelerator- 600m

source: esss.se

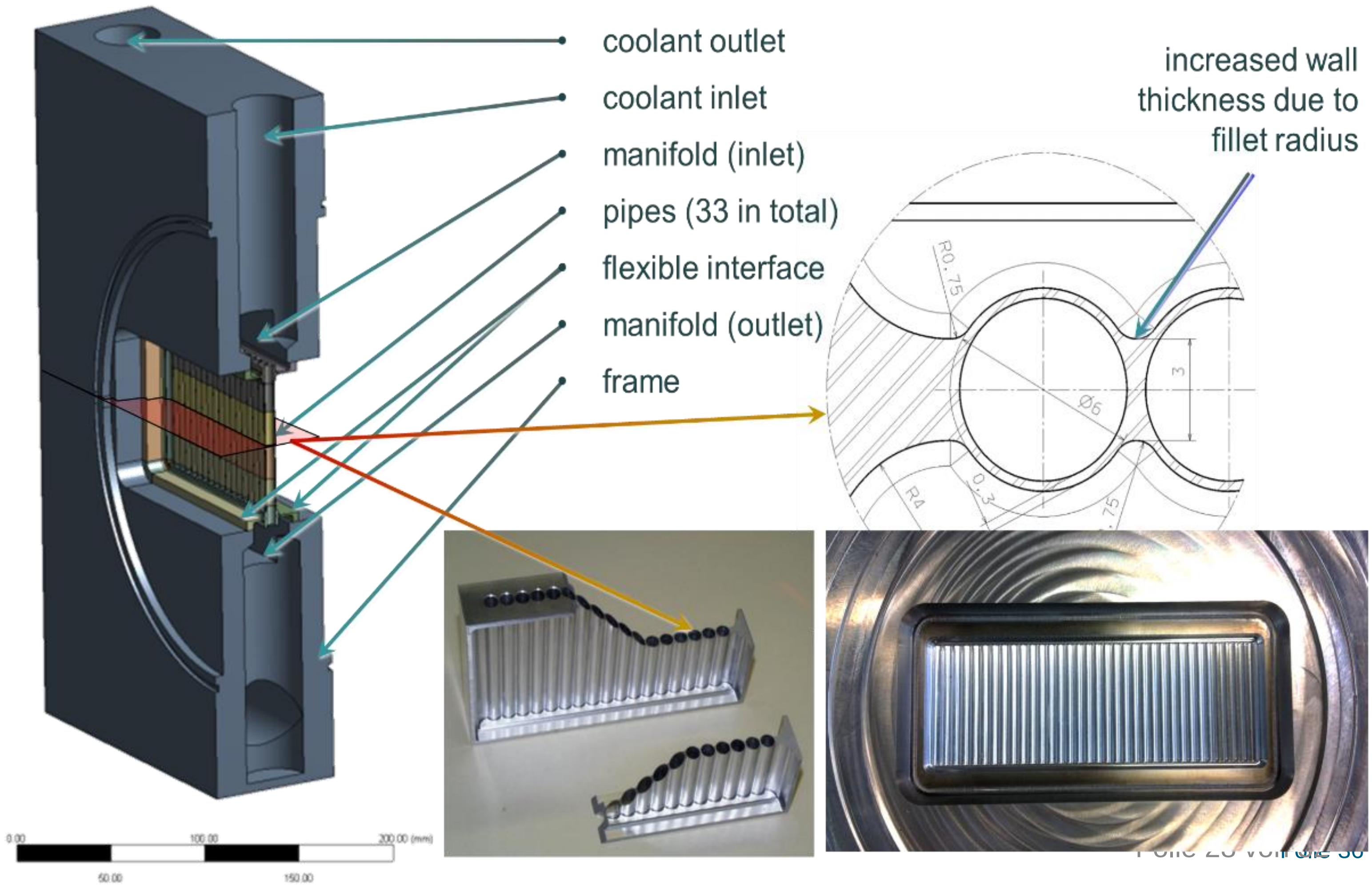
Design, construction and testing of ESS-Moderator

Iterative process: calculations, engineering plus input from physical requirements
→optimal size of „Hydrogen body“ maximal output of the right neutrons



ESS- Proton beam window

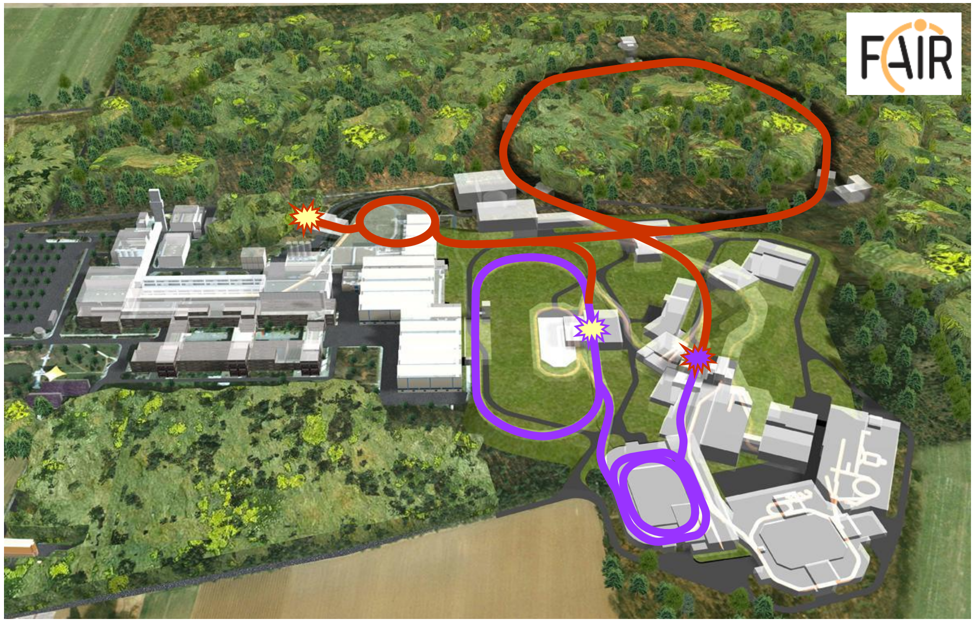
- Separation vacuum of proton accelerator and target area (3 bar He)
- Thermal load of 5MW power
- Internal cooling of 10 bar He
- → T_{max}100°C



Hadron physics - COSY

Cooler Synchrotron (COSY) in Jülich

Future accelerator facility at GSI
Facility for **A**ntiproton and **I**on **R**esearch
HESR: High Energy Storage Ring



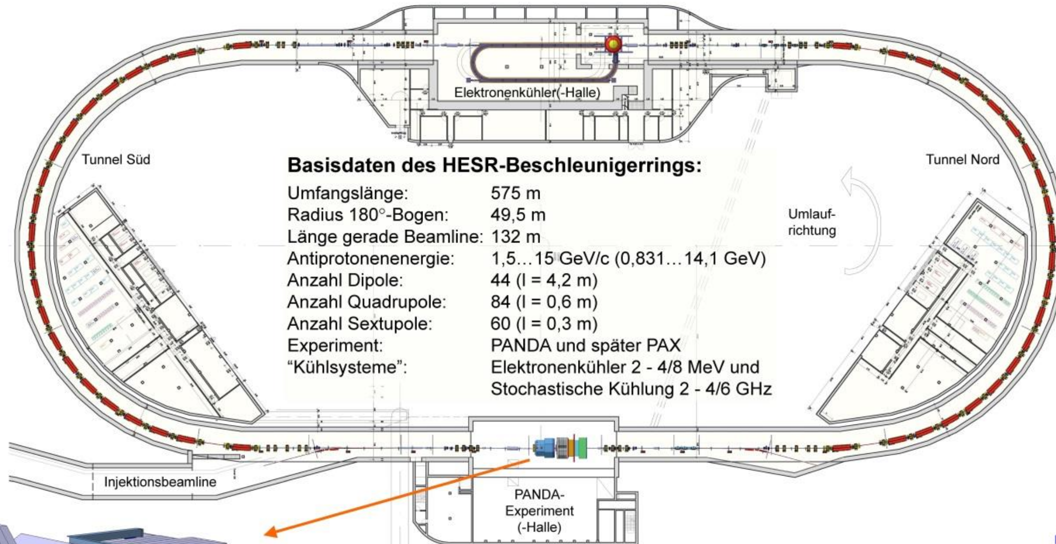
- Accelerator
- Vacuum systems
- Experiments and components
- Design of magnets
- PANDA experiment
- Data acquisition systems

HESR @ FAIR
Ein neuer Beschleuniger für Antiprotonen

Layout des HESR (High Energy Storage Ring) an FAIR (Facility for Antiproton and Ion Research)

Wissenschaftliche Zielsetzung

- „Mit dem HESR an FAIR steht uns bald das chirurgische Skalpell der Teilchenphysik zur Verfügung."
- Der HESR dient dem Verständnis der Hochenergiephysik von Antiprotonen, gebundenen Zuständen der hadronischen Materie und Quark-Gluon-Wechselwirkung.
- Ziel ist die Klärung grundlegender Fragen zur Entstehung und zum Aufbau der Materie durch Untersuchung der Wechselwirkung ihrer elementaren Bausteine, d.h. wie genau formt sich die Materie und welche Kräfte halten sie zusammen.
- Durchgeführt werden die Experimente mit polarisierten bzw. unpolarisierten Antiprotonen.



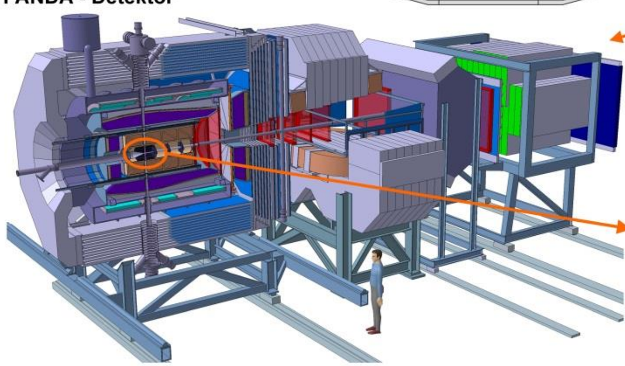
Basisdaten des HESR-Beschleunigerrings:

Umfangslänge:	575 m
Radius 180°-Bogen:	49,5 m
Länge gerade Beamline:	132 m
Antiprotonenenergie:	1,5…15 GeV/c (0,831…14,1 GeV)
Anzahl Dipole:	44 (l = 4,2 m)
Anzahl Quadrupole:	84 (l = 0,6 m)
Anzahl Sextupole:	60 (l = 0,3 m)
Experiment:	PANDA und später PAX
"Kühlsysteme":	Elektronenkühler 2 - 4/8 MeV und Stochastische Kühlung 2 - 4/6 GHz

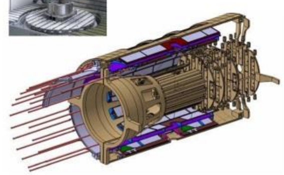
Anforderungen und Merkmale

- Das 575 m lange HESR-Synchrotron hat die Form einer "Rennbahn" mit normalleitenden Dipolmagneten einer Biegestärke von bis zu 50 Tm in den Bögen und zwei langen Geraden, in denen das interne Target mit dem hochauflösenden PANDA-Detektor und die Phasenraumkühlung installiert ist.
- Hohe Strahlenergie und -qualität und breites Energiespektrum.
- Ultrahochvakuum <10^{-10} mbar und ein späteres Upgrade auf ein XUHV von 10^{-12} mbar möglich.
- 236 Hauptmagnete, insgesamt 140 Pumpkreuze bestückt mit 560 Vakuumpumpen, 7 stochastische Kühltanks sowie 1 Elektronenkühler.
- Enge Zusammenarbeit mit Industrie und internationalen Partnern.

PANDA - Detektor

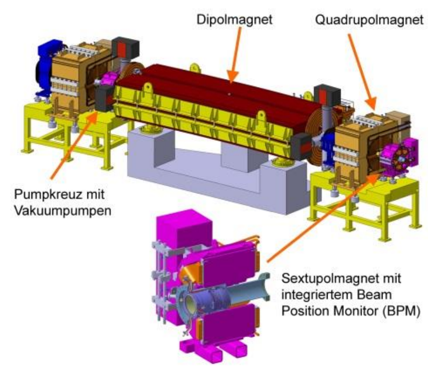


Bearbeitung der CFK-Trägerstruktur im ZEA-1

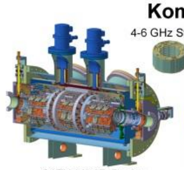


Micro Vertex Detector (MVD)
Ø 300 mm; L = 500 mm

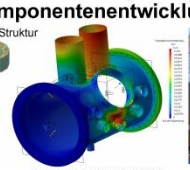
ZEA-1 Vakuumteststand mit HF Gitter im Pumpkreuz
(1:1 Originalaufbau einer Einheit von Mitte Dipol – Dipol)



Komponentenentwicklung im ZEA-1 und IKP für HESR am Beispiel: Stochastischer Kühltank



CATIA V5 3D-Design



FEM - Auslegung (ANSYS)

Reinraummontage Elektronik

Reinraummontage Vakuumtank

Vakuumtest und Kalttest bei 20K

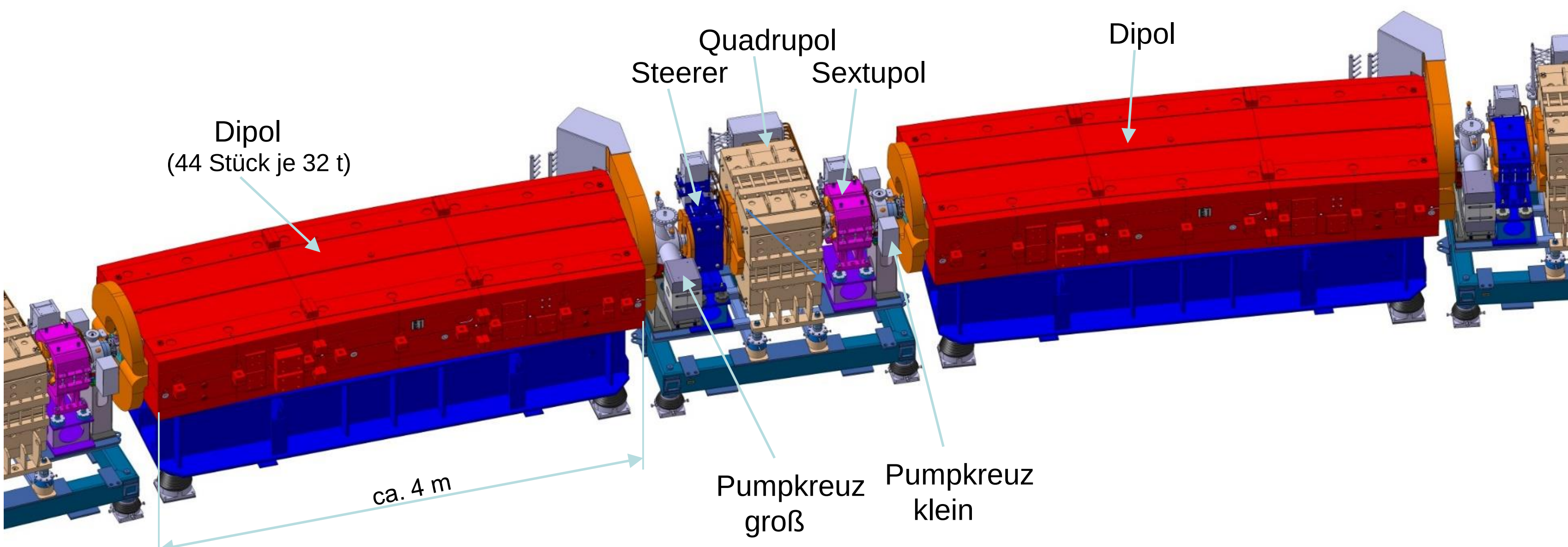
Einbau und Test an COSY (IKP)

In Zusammenarbeit mit:
IKP - Institut für Kernphysik

Zentralinstitut für Engineering, Elektronik und Analytik | ZEA

Engineering und Technologie | ZEA -1
Technologie für Spitzenforschung

Mitglied der Helmholtz-Gemeinschaft

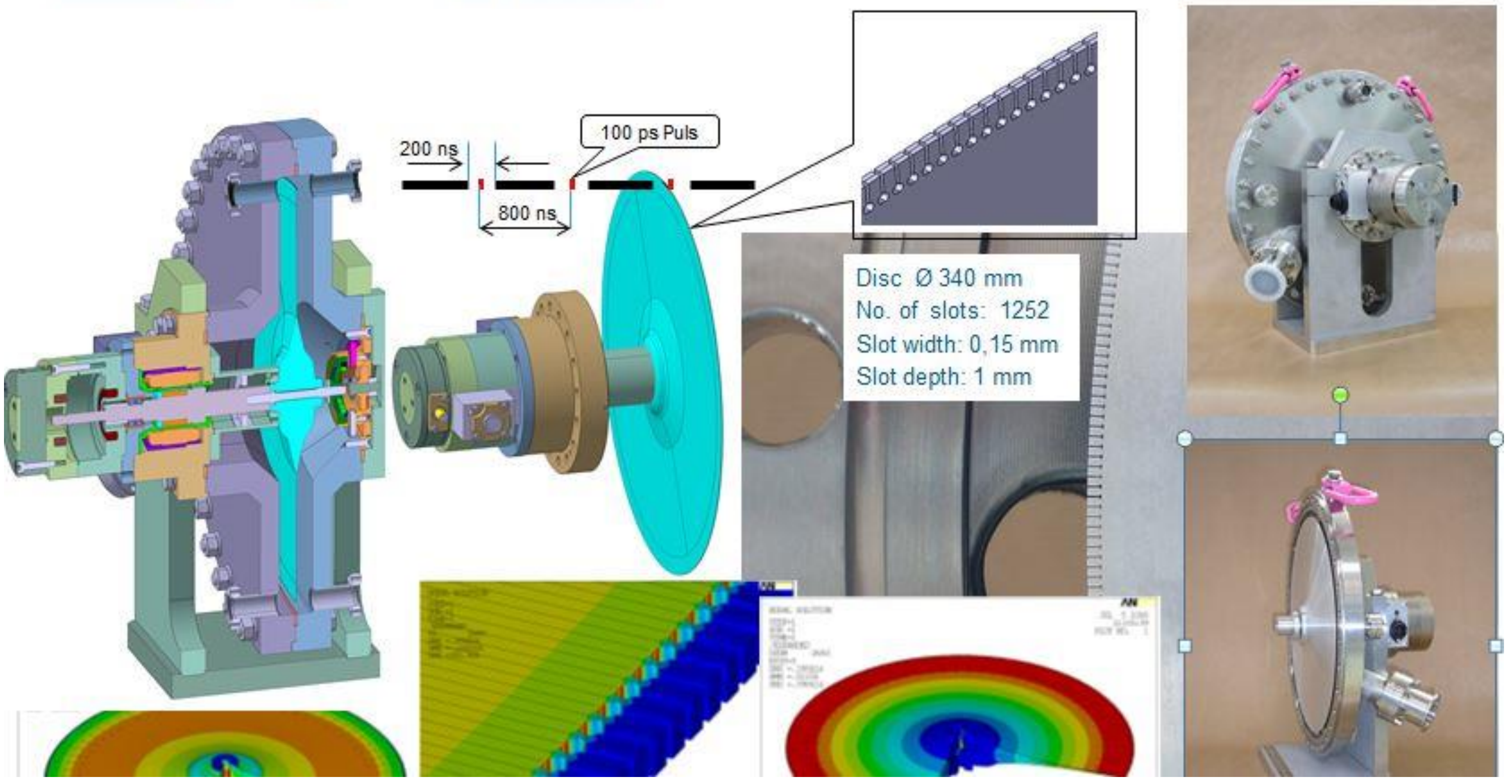

Quadrupol
Dipol
Steerer
Sextupol
Dipol
(44 Stück je 32 t)
ca. 4 m
Pumpkreuz
groß
Pumpkreuz
klein

Chopper Systems for Synchrotron and Neutron Experiments

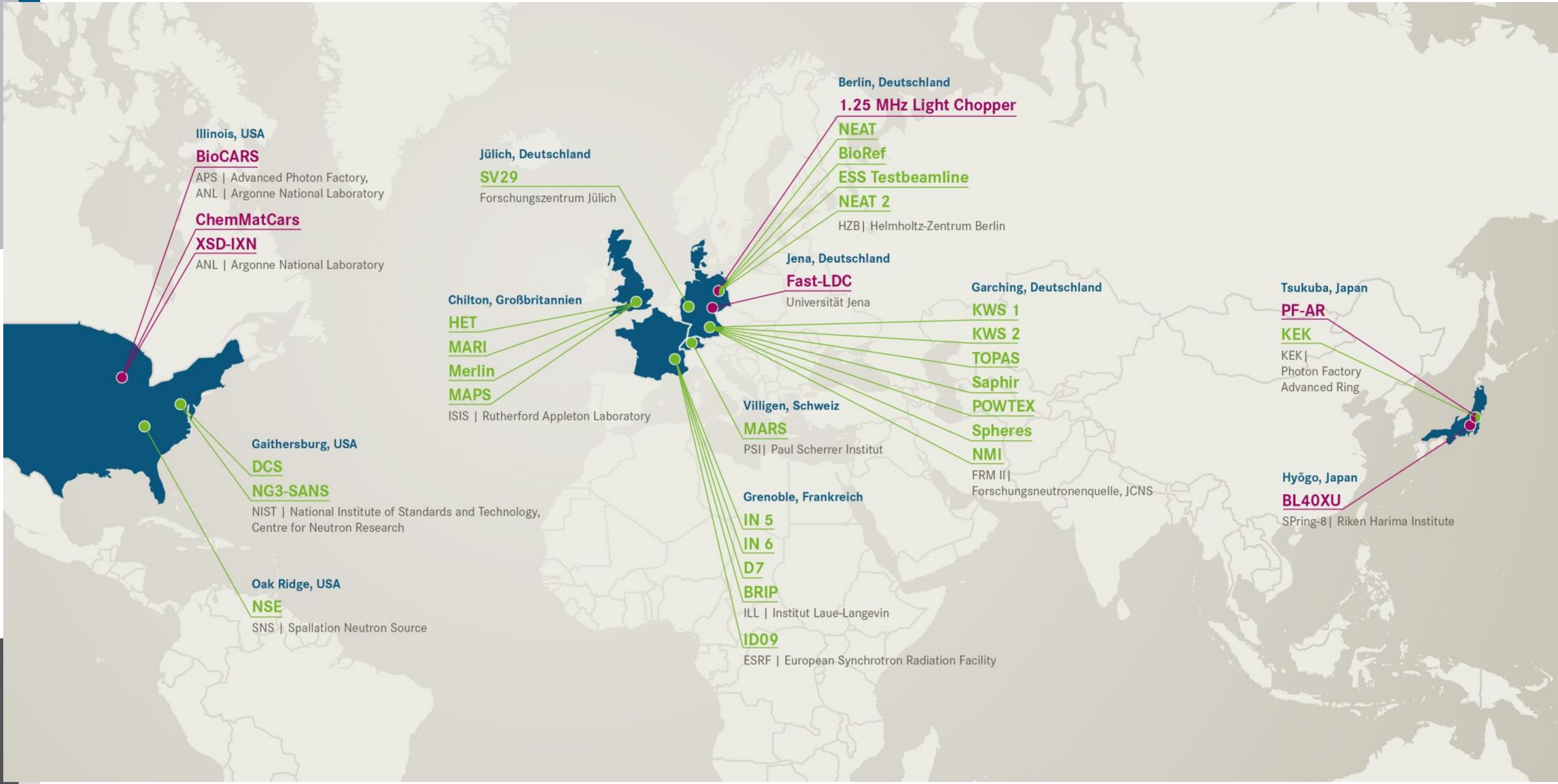
High precision machining and advanced control with magnetic bearing

1,25 MHz Light-Chopper for BESSY, Berlin

Extraction of 100 ps-Pulses with structured Al-Disc, 60.000 min-1



Chopper Systeme Made by ZEA-1- at Neutronen and Synchrotron Sources



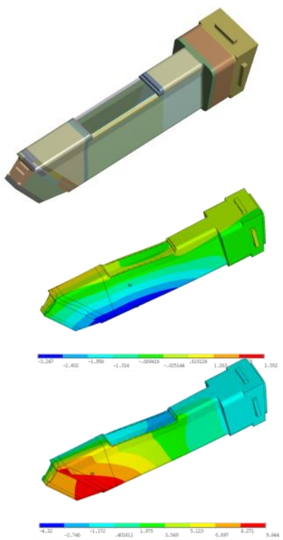
non contacting, wear-free, maintenance-free
from 3600 up to 60000 rpm
running since 1988, 1991, 2000, 2004, …

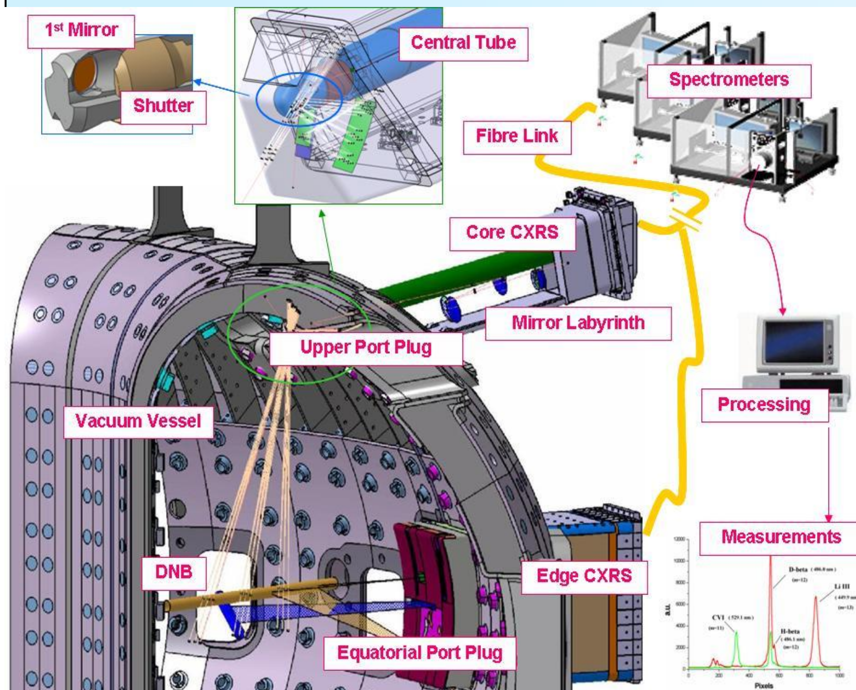
Contribution to ITER

ITER (Latin: *the way*) 7 Partners: European Union (incl. CH), Japan, Russia, China, S.Korea, India and USA- ITER should show the way to a usable, economical controlled fusion

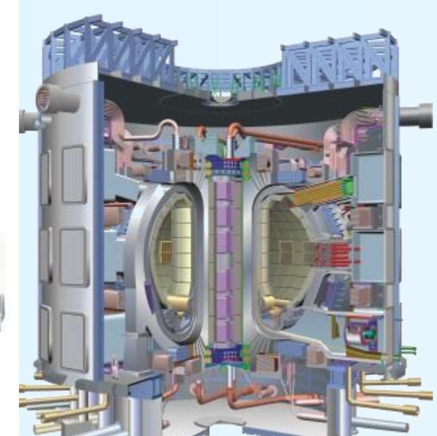
Ausschnitt aus ITER mit CXRS-Diagnostic

Mechanical design

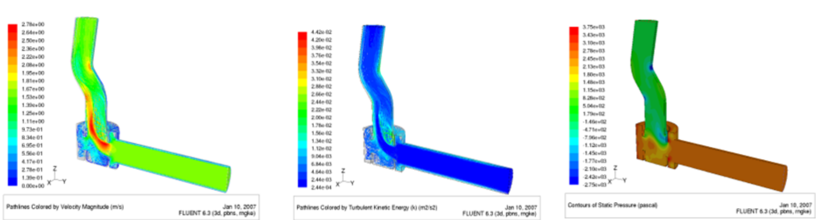




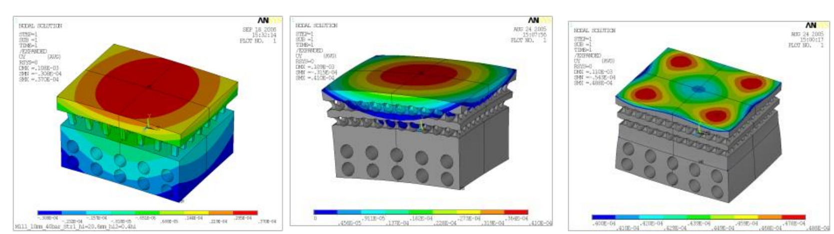
Cross section of ITER



Fluid dynamic calculation



Thermomechanical design



In cooperaton with IEK-4

Environment – Earth observation system

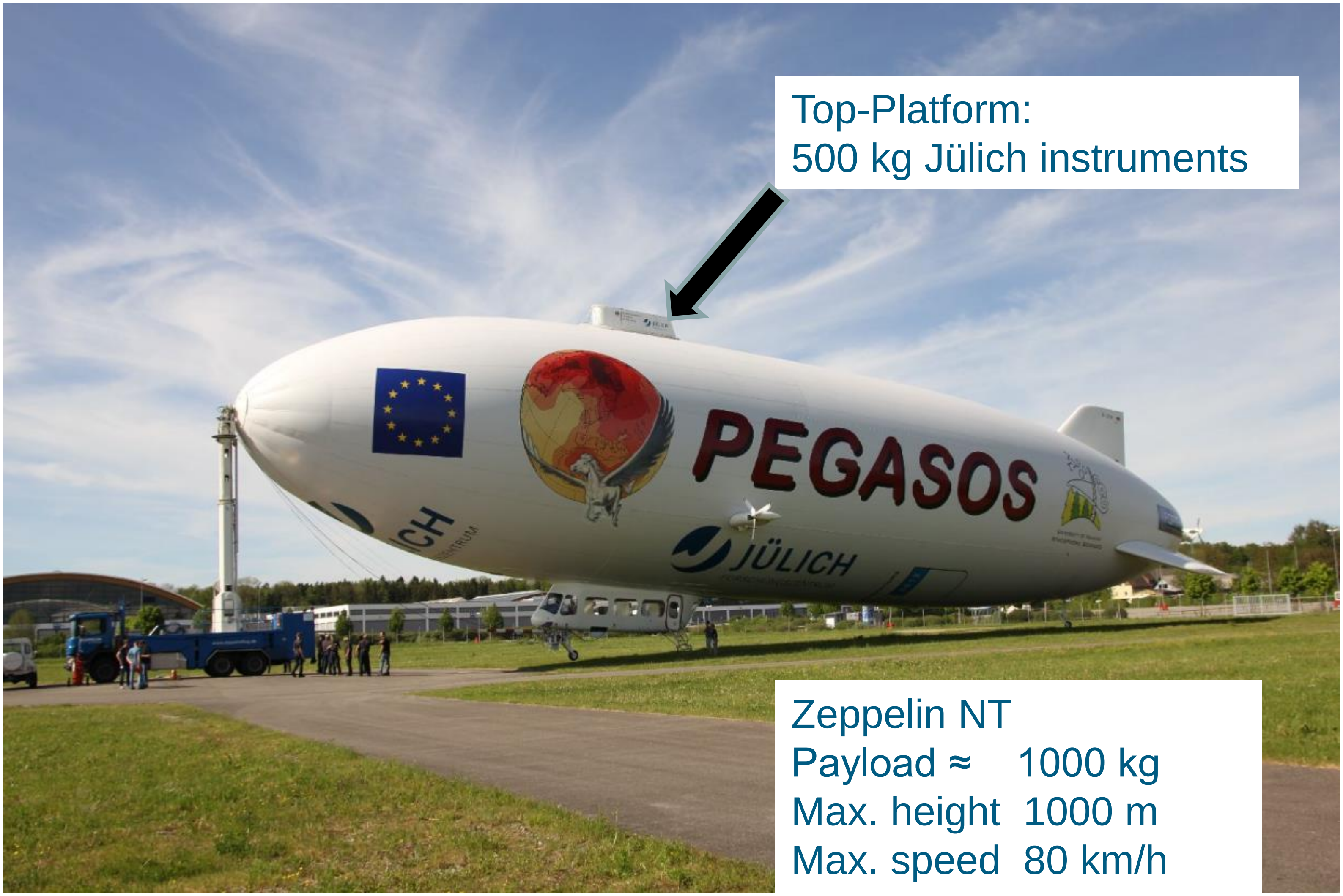
Weather Balloon: up to 35km

Satellite : LEO ~700km

Aircraft: HALO, up to 15km

Airship: Zeppelin
100m to 2km

Zeppelin NT carrier for atmospheric research



Top-Platform:
500 kg Jülich instruments

Zeppelin NT
Payload ≈ 1000 kg
Max. height 1000 m
Max. speed 80 km/h

Instruments developed in cooperation with IEK and external partners

in Top Platform:

different laser induced fluorescence spectrometers for reactivity measurement of water molecules

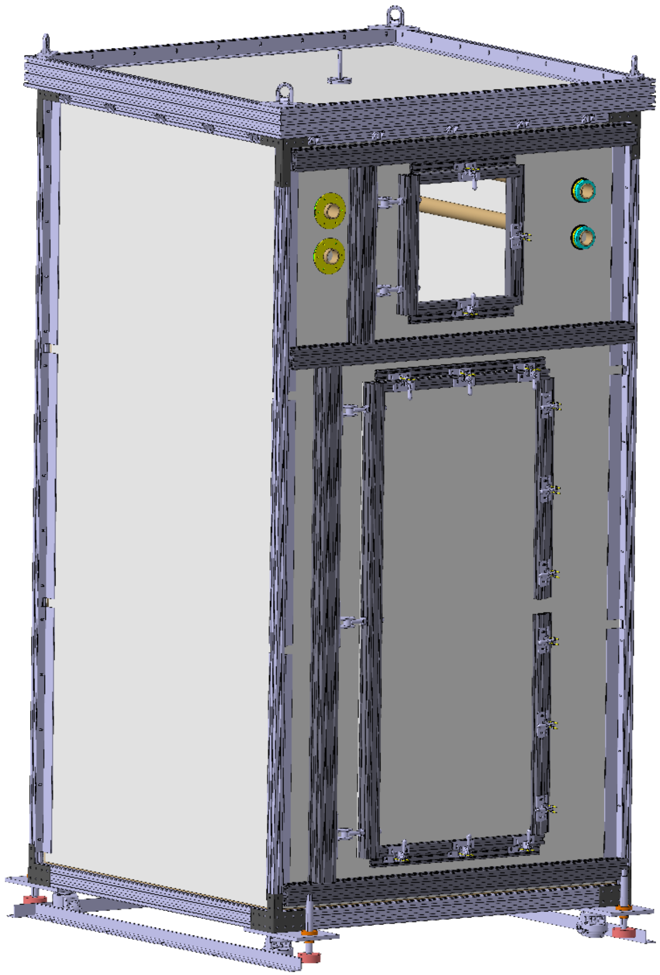
plant science

Aim

- Investigation of exchange of gases (CO2, Methane, NO, gaseous organic compounds)

concept

- Gas tight chambers incl. Control of
- Temperature: -5°C - 40° C
- Humidity : upto 80 %
- Light intensity: upto 2.000 µmol/(m²s)
- Addition of Ozone and CO2



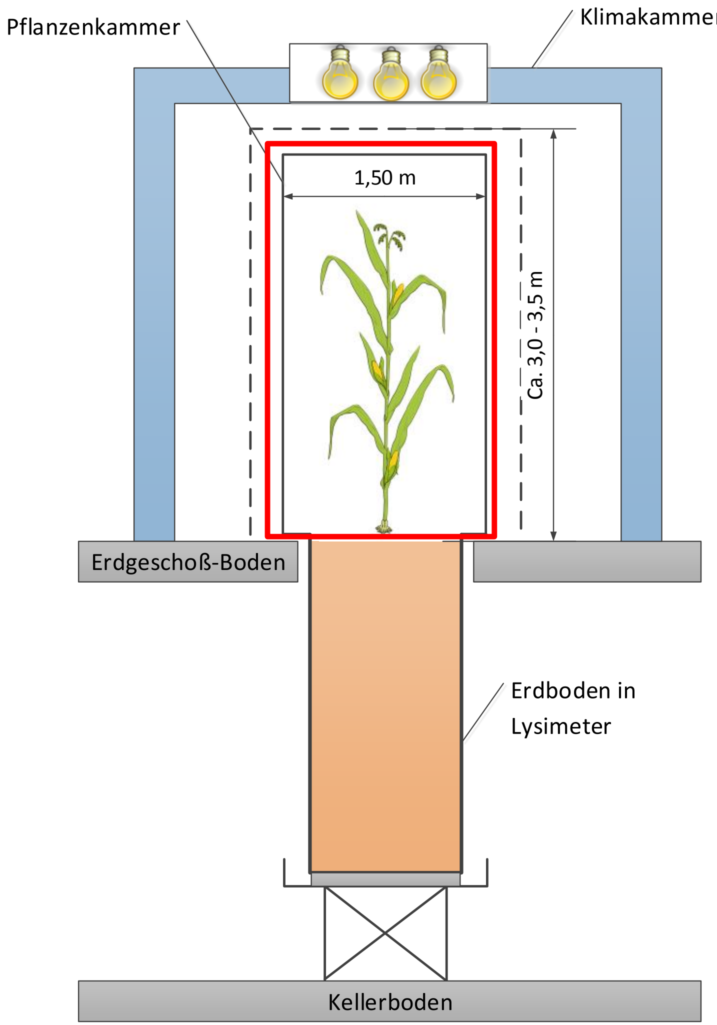
plant science

Challenges

- No external gases in the chamber
- No heat input from illumination

realisation

- Walls made of glass
- Mounting of glass from outside
- Additional internal chamber inside the main chamber
- Cooling of the walls of the main chamber from out side)
- Circulation fan made of glass or coated with silizium



brain functions

Aim

- Investigation of brain functions with combination of MRT und PET

concept

- Design and construction of a PET detector unit with higher resolution medical institut university and engineering institutes
- integration in 9,4T MRT

realizion

- Carrying structure
- Pipes for cooling medium and connections
- Encapsulation of energy supply parts
- Mounting of the detector crystals
- Adjusting of patient bed

Bildquelle: Inviscan

Test and measurement

3D precise measurement technologies

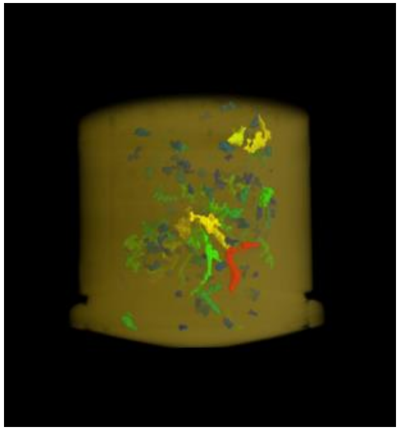
TOPAS: vacuum testing

(3D µfocus CT)

X-ray examination

stain ingress testing

CT investigation soil probe



3D µfocus CT

Micro and nano scale CT for diverse materials and applications

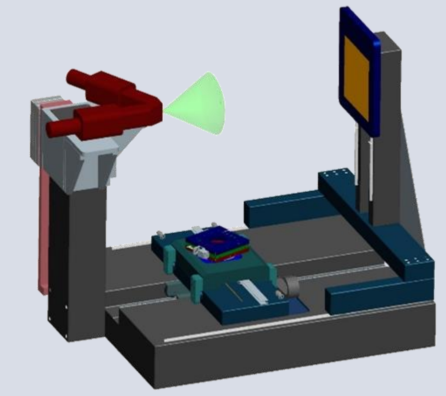
- “open” system for flexible use in a wide range of applications
- GPU based control and reconstruction system
- Optimized sequence control with online result check
- Modelling for optimized settings
- Fast final data reconstruction with high resolution
- Defect analysis by auto-segmentation

Technology „upgrade µCT"

Hardware

Gantry

	old: Sauerwein (1989)	new: Fraunhofer (2015)
motors control	analogue	**digital**
design	steel	**granite**
mounting	ball bearing	**air bearing**
accurecy	50 µm	**1 µm**



Detector

	old: Perkin Elmer XRD 1621 AN	new: Perkin Elmer XRD 1611 xP
size	400 x 400 mm²	400 x 400 mm²
no of pixel	2048^2	4096^2
distance of pixel	200 µm	100 µm

- Voxel =Volumen Bildpunkt (Volumen Pixel)

Pictures =pics =pix , pictures elements → Pixel (Bildpunkte)

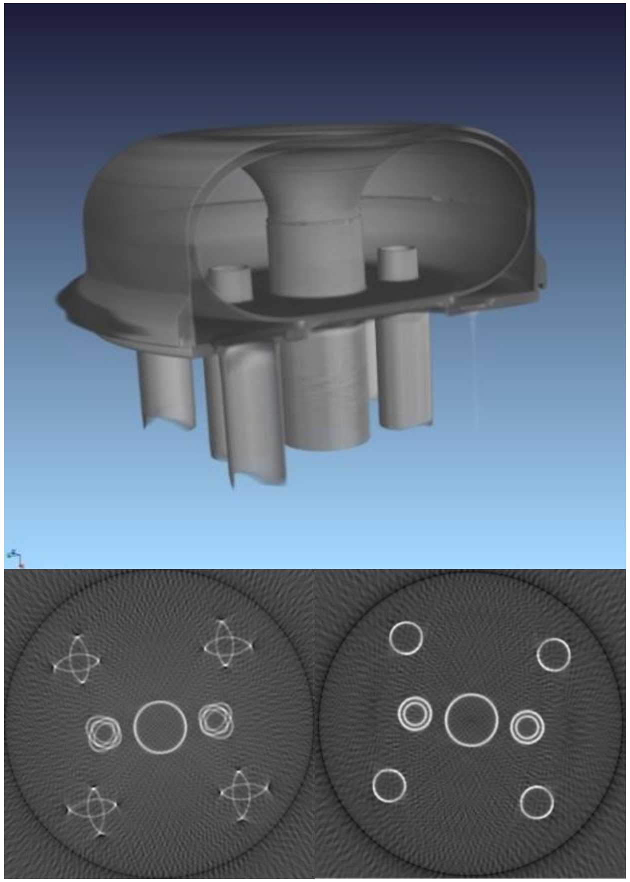
Technology „upgrade µCT“

Software

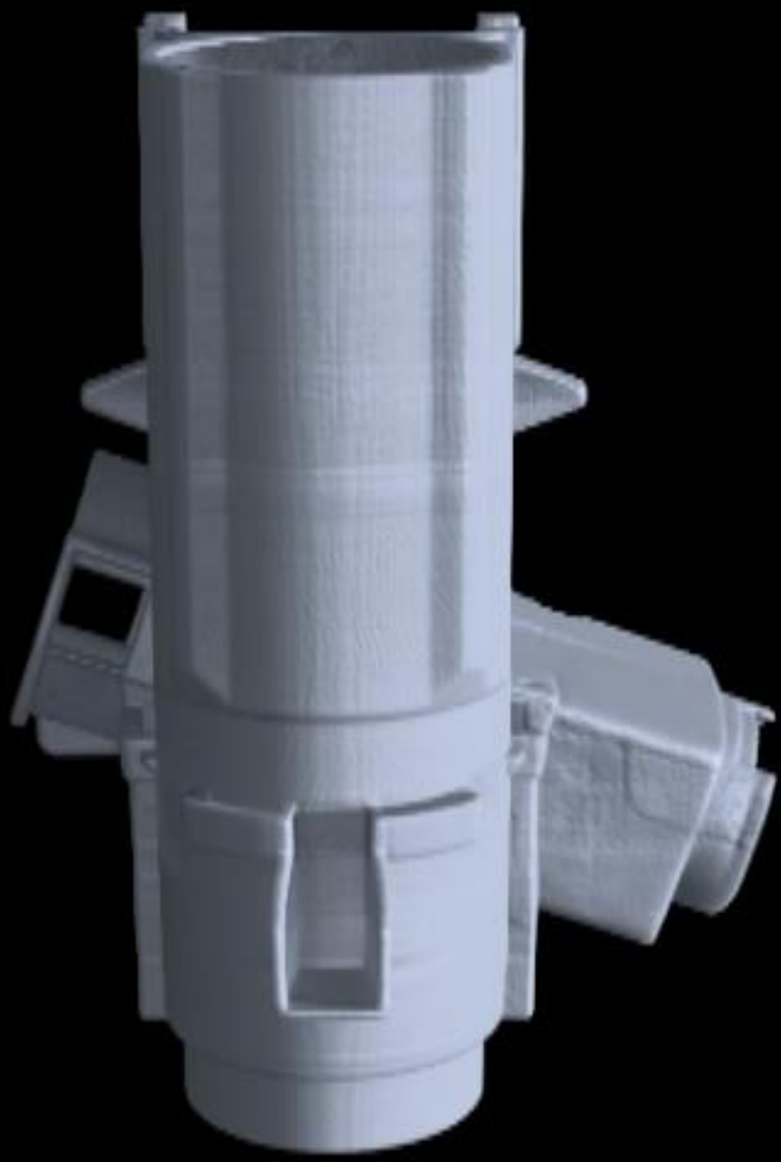
modification

- integration of different process in one application (analytic and iterative)
- quality improvement
- integration of new sensor
- change from CPU to GPU support
- higher throuhput
- Better extendable

	old:	new:
processor	CPU	GPU
analytical calculation	207 h	**12 min**
iterative calculation	5.000 h	**20 h**

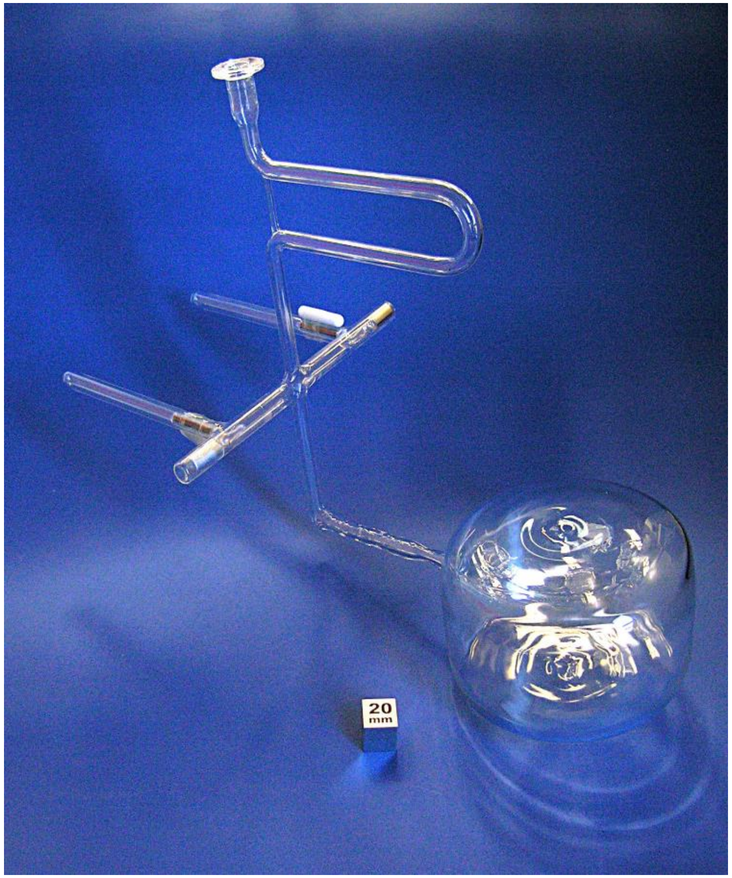


3D µfocus CT



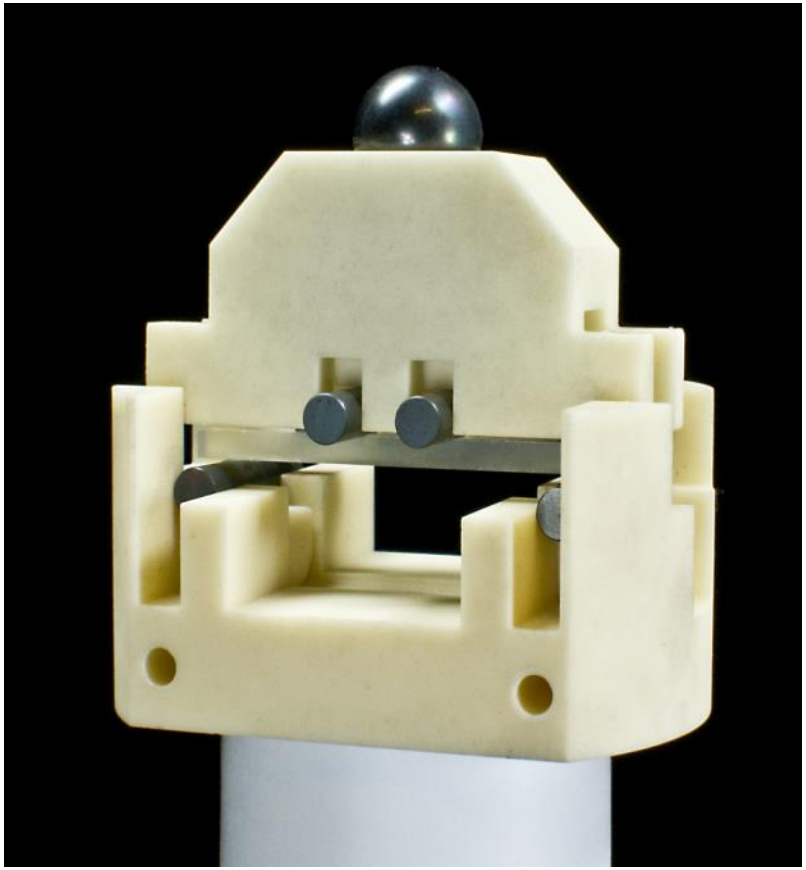
Glass machining/ blowing

Ceramics machining



He³ – Cells neutron polarisation

Special glass not containing Boron/pore free cell is world wide a unique device



Investigation of thermo-mechanical properties of ceramic materials in the range of 20-1500°C

Most abbriviations used in this lecture

ZEA: Zentralinstitut für Engineering, Elektronik und Analytik
TÜV: Technischer Überwachungsverein (technical certification)
ISO: International Organisation for Standardization
R&D: Research and Development
CT: Computed Tomography
UHP: Ultra High Pressure
OLED: Organic Light Emitting Diods
CE: Communautes Europeennes
FEM: Finite Element Methods
CFD: computational fluid dynamics
MHD: Magneto HydroDynamics
IKP: Institut für Kernphysik (nuclear physics)
COSY: Cooler Synchrotron
HESR: High Energy Storage Ring
PAX: Polarized Anti Proton eXperiment
JCNS: Jülich Center for Neutron Science
FRM: Forschungsreaktor München
ESS: European Spallation Source
IEK: Institute for Energy und Climate research
ITER: international thermonuclear experimental reactor (in France)
W7-X: Wendelstein 7 eXperiment- (experimental fusion reactor in Germany)
GLORIA: Gimballed limb observer for radiance imaging of the atmosphere
HALO: High Altitude and Long Range Research Aircraft
IBG: Institute for Bio- and Geo Sciences

MRT: Magnetic Resonance Tomography
PET: Positron Emission Tomography
KWS: Kleinwinkel Streuung
DNS: Diffuse scattering neutron time of flight spectrometer
MARIA: Magnetic reflectometer with high incident angle
TOPAS: Time-Of-Flight Spectrometer with Polarization Analysis
POWTEX: High-intensity time-of-flight diffractometer
J-NSE: Neutron Spin-Echo Spectrometer
BIODIFF: Diffractometer for large unit cells
TUM:Technische Universität München
G-ELI: Gebäude und Liegenschaftsmanagement
MLZ: Heinz Maier Leibnitz zentrum
GSI: Gesellschaft für Schwerionen Forschung
FAIR: Facility for Antiproton and Ion Research
PANDA: AntiProton ANnihilation in Darmstadt
BESSY: Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung m. b. H.
CPU: central processing unit.
GPU: graphics processing unit