ZEA-1 | TECHNOLOGY FOR EXCELLENT SCIENCE

OUR CONTRIBUTIONS TO THE GEORGIAN GERMAN SCIENCE BRIDGE

09.08.2023 DR. HARALD GLÜCKLER

OUTLINE

ZEA-1

- Facts, figures, research
- Core competences
- Example of or work

Tech_Lab as a future SMART | Lab within

- Motivation and objectives
- Mechanical engineering
- Next steps

ZEA-1 FACTS AND FIGURES

ZEA-1

9 PhDs, 5 Master- and
4 Bachelor students,
2 Trainees and 6 Colleagues
in Administration

Active in four HGF research fields:
Energy, Information, Matter, Earth and Environment

Within all research programmes, in every scientific priority of the FZJ

200 on-going FZJ-cooperation

30 on-going industrial cooperation

10 funded projects with external partners

Approx. 160 Employees

100 in the Department Engineering and New Technologies

50 in the Department Fabrication Techniques and Assembly

TÜVRheinland ZERTIFIZIERT

Management System
ISO 9001:2015

www.tuv.com
ID 9108620947

Prof. G. Natour
Director of ZEA-1
and
Professor at
RWTH Aachen University

OUR FIELDS OF RESEARCH

RESEARCH

PARTNERS IN RESEARCH

Cooperations

DLR

BAM
Bundesanstalt für Materialforschung und -prüfung

TÜVRheinland®
Genau. Richtig.

FAIR

EERA
European Energy Research Alliance

CERN

OAK RIDGE National Laboratory | 75 YEARS

iter
china eu india japan korea russia usa

PALAST
Promoting Science & Technology

DTU

ess EUROPEAN SPALLATION SOURCE

Palestinian-German ScienceBRIDGE
CONNECTING PEOPLE AND KNOWLEDGE

Federal Ministry of Education and Research

FCH
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

JCNS
Jülich Centre for Neutron Science

DESY

TECHNISCHE UNIVERSITÄT DRESDEN

JARA | Jülich Aachen Research Alliance

Georgian-German ScienceBRIDGE
CONNECTING PEOPLE AND KNOWLEDGE

ISF WELDING AND JOINING INSTITUTE | RWTH AACHEN UNIVERSITY

OVERVIEW

ZEA-1

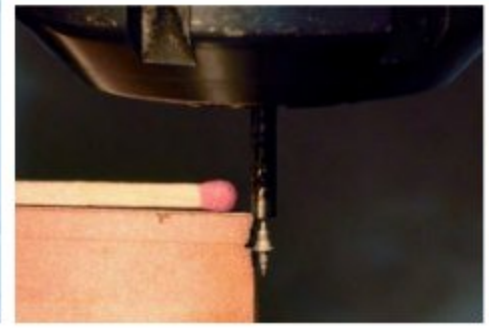
- Consultation
- Feasibility studies
- Concept and Design
- Modelling and Simulation
- Manufacturing
- Assembly
- Measurement and testing technologies
- Certification

FABRICATION TECHNIQUES & ASSEMBLY

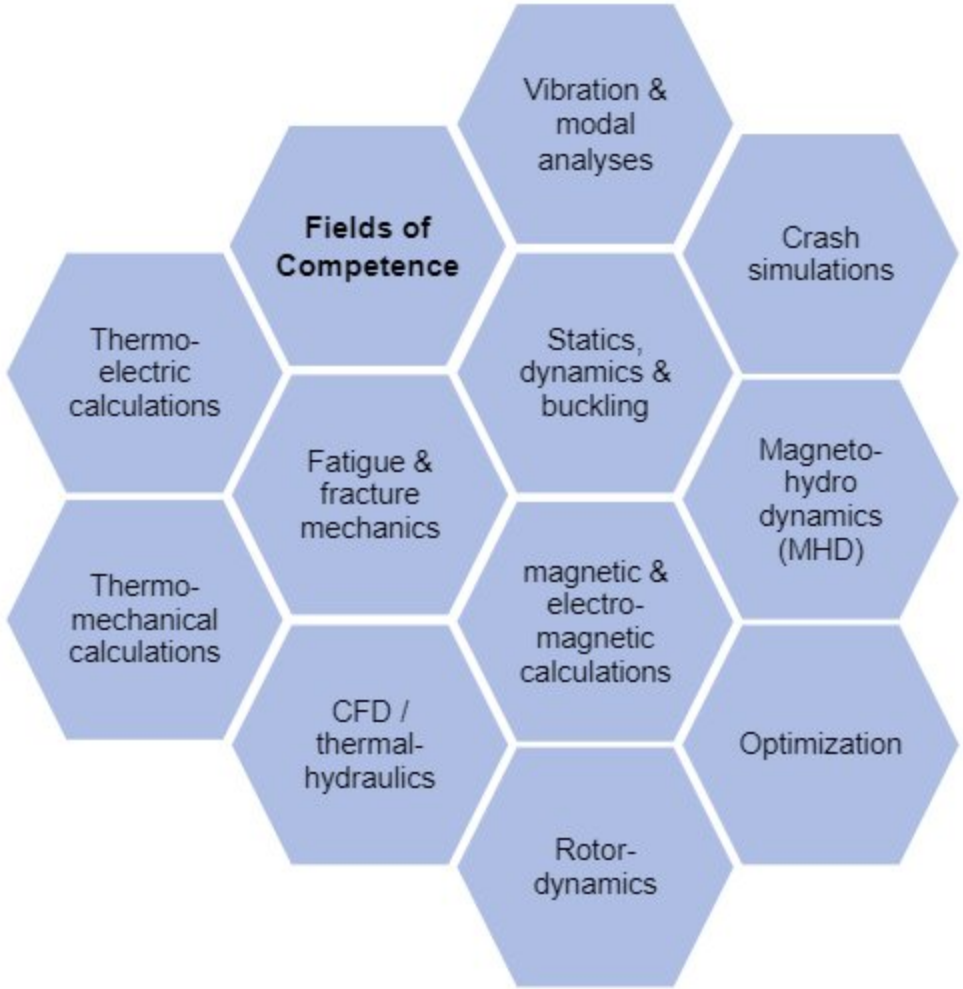
Core competence

- Manufacturing technologies & assembly
- High precision machining and assembling, machine manufacturing
- Glass, plastics and ceramics machining
- Welding technologies
- Surface treatment techniques
- Rapid prototyping

- (Micro-) Waterjet cutting
- Spark Erosion
- (Glass-) Reactors
- Ultrasonic - Milling
- Surface Treatment
- Assembly in Clean Room



MODELING & SIMULATION



Core competence

GPFS storage cluster

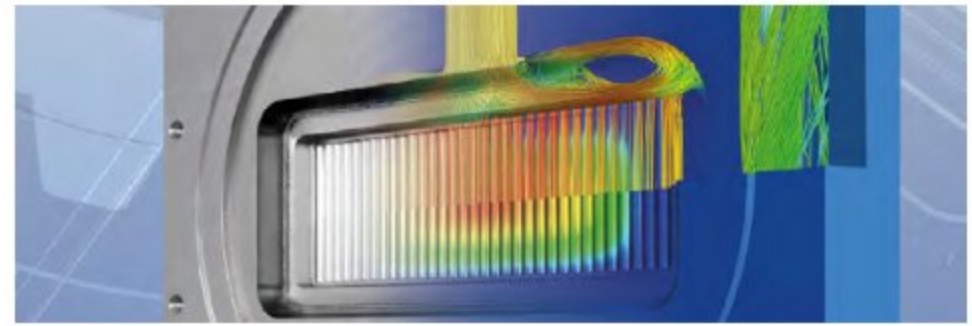
JuZEA-1@JSC

- 10 compute nodes (+ 3 nodes for login / service)
- 48 cores / node = 480 cores
- 100 Gbit/s InfiniBand network
- 4608 GB main memory

ZEA-1 Cluster

- 7 compute nodes
- 120 cores
- 10 Gbit/s Ethernet network
- 1920 GB main memory

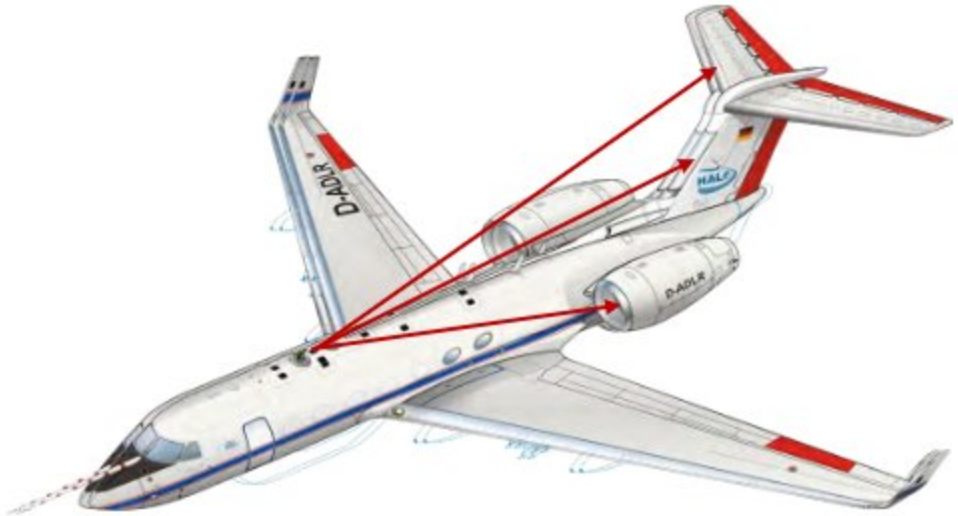
+2 ZEA-1file server



MODELING & SIMULATION: EXAMPLE

Inlet System on an Aeroplane for Atmospheric Research

Core competence

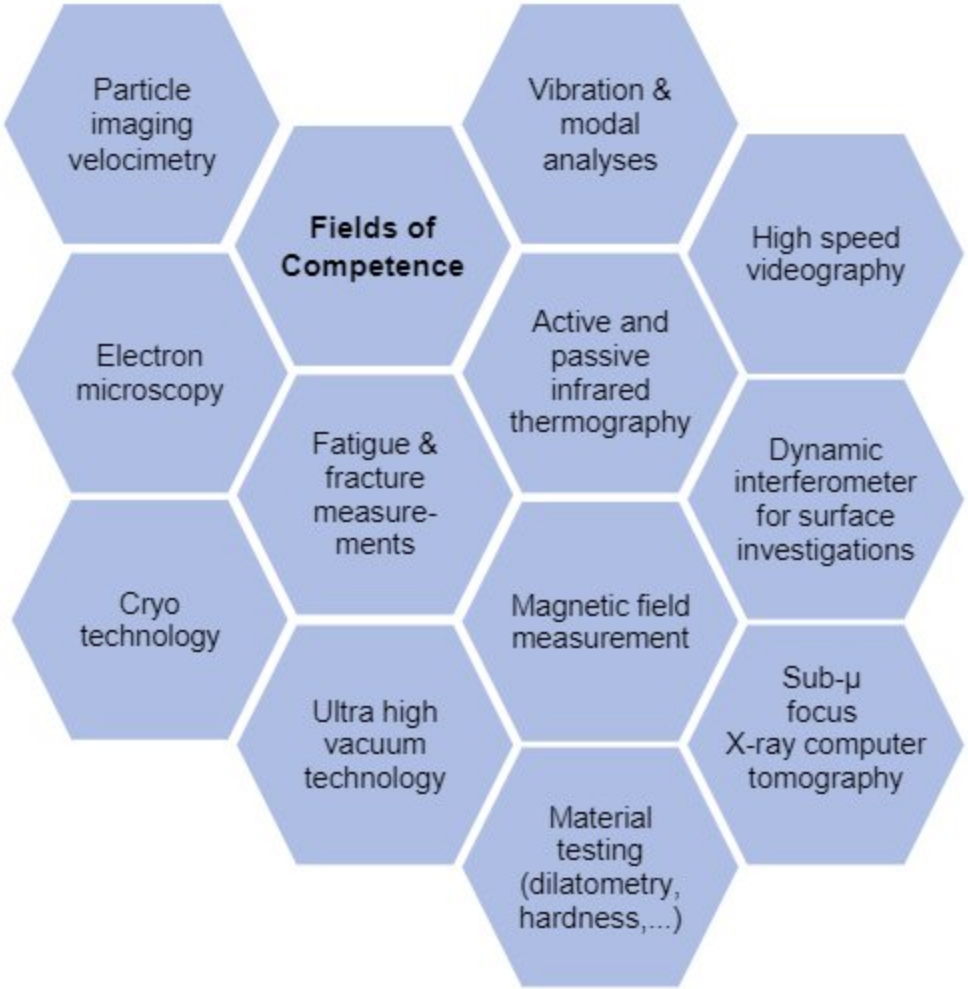


MODELING & SIMULATION: EXAMPLE

Inlet System on an Aeroplane for Atmospheric Research

Core competence

MODERN METROLOGICAL METHODS



Core competence

Dedicated Labs

- Sub µ-focus X-ray Computed Tomography lab
- Infrared thermography lab
- Temperature and humidity stabilized laboratories for interferometry, profilometry , dilatometry, electron microscopy
- Vibration damped laboratories for precision measurement at sub µm level (also T & H stab.)
- Cryo lab for liquid hydrogen
- Magnet lab
- ....

MODERN METROLOGICAL METHODS: EXAMPLE

Development of Neutron Moderators operated at 20 K

Core competence

Material:
Al 6061-T6 aluminum
Filler metal:
AlSi12

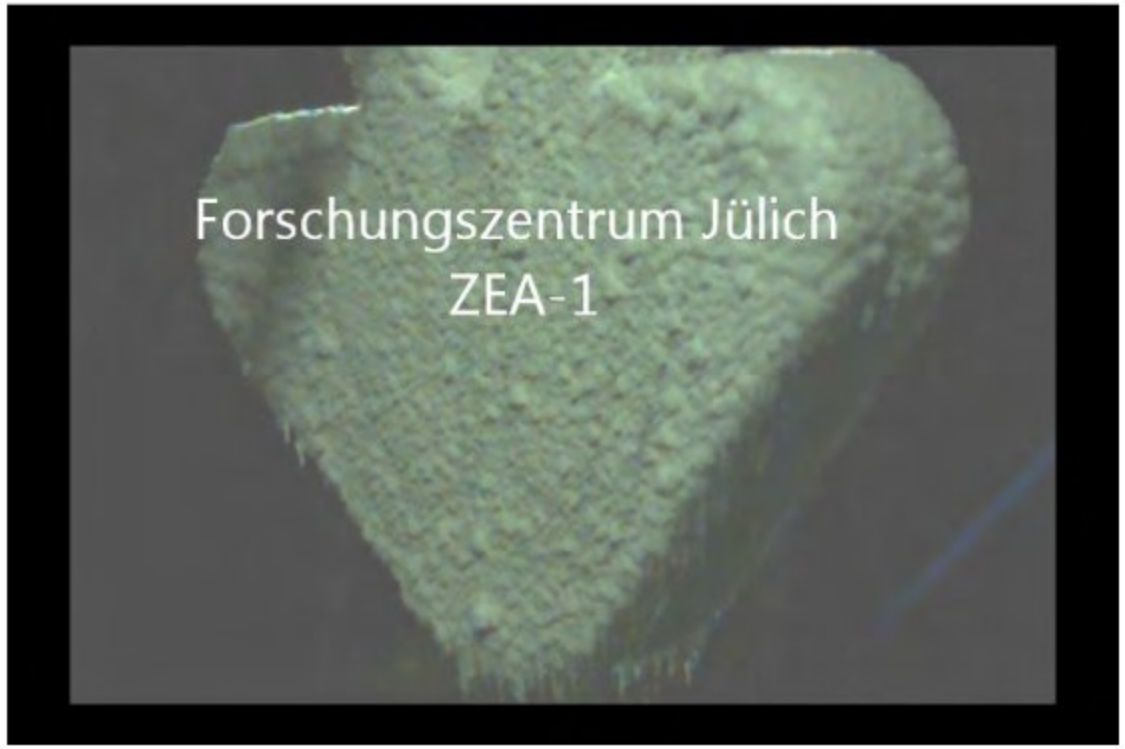
Wall thickness: 3.0 mm

Manufacturing methods
- high speed milling
- wire-cut EDM
- laser beam cutting
- electron beam welding

MODERN METROLOGICAL METHODS: EXAMPLE

Development of Neutron Moderators operated at 20 K

Core competence

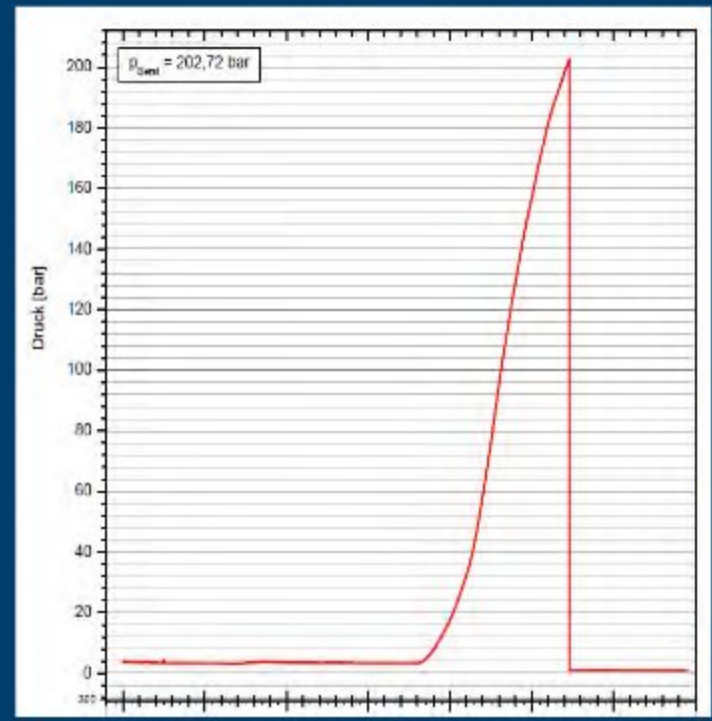


MODERN METROLOGICAL METHODS: EXAMPLE

Development of Neutron Moderators operated at 20 K

Core competence

- Test with liquid nitrogen at -196°C
- Consideration of material embrittlement due to low temperatures
- Questions about safe operation:
  - operation pressure 10 bar
  - design pressure 17 bar
  - at what pressure the vessel will burst?
- Burst at a pressure of more then 200 bar!

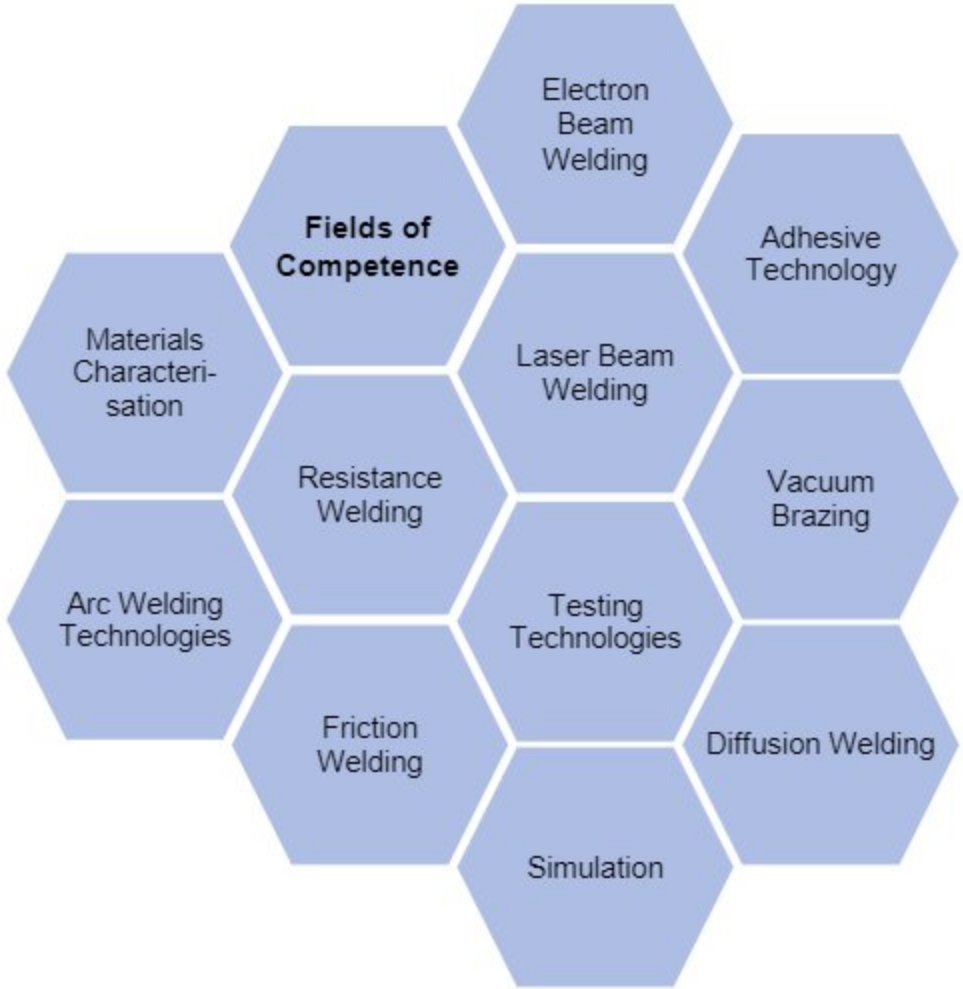


MODERN METROLOGICAL METHODS: EXAMPLE

Development of Neutron Moderators operated at 20 K

Core competence

JOINING TECHNOLOGIES



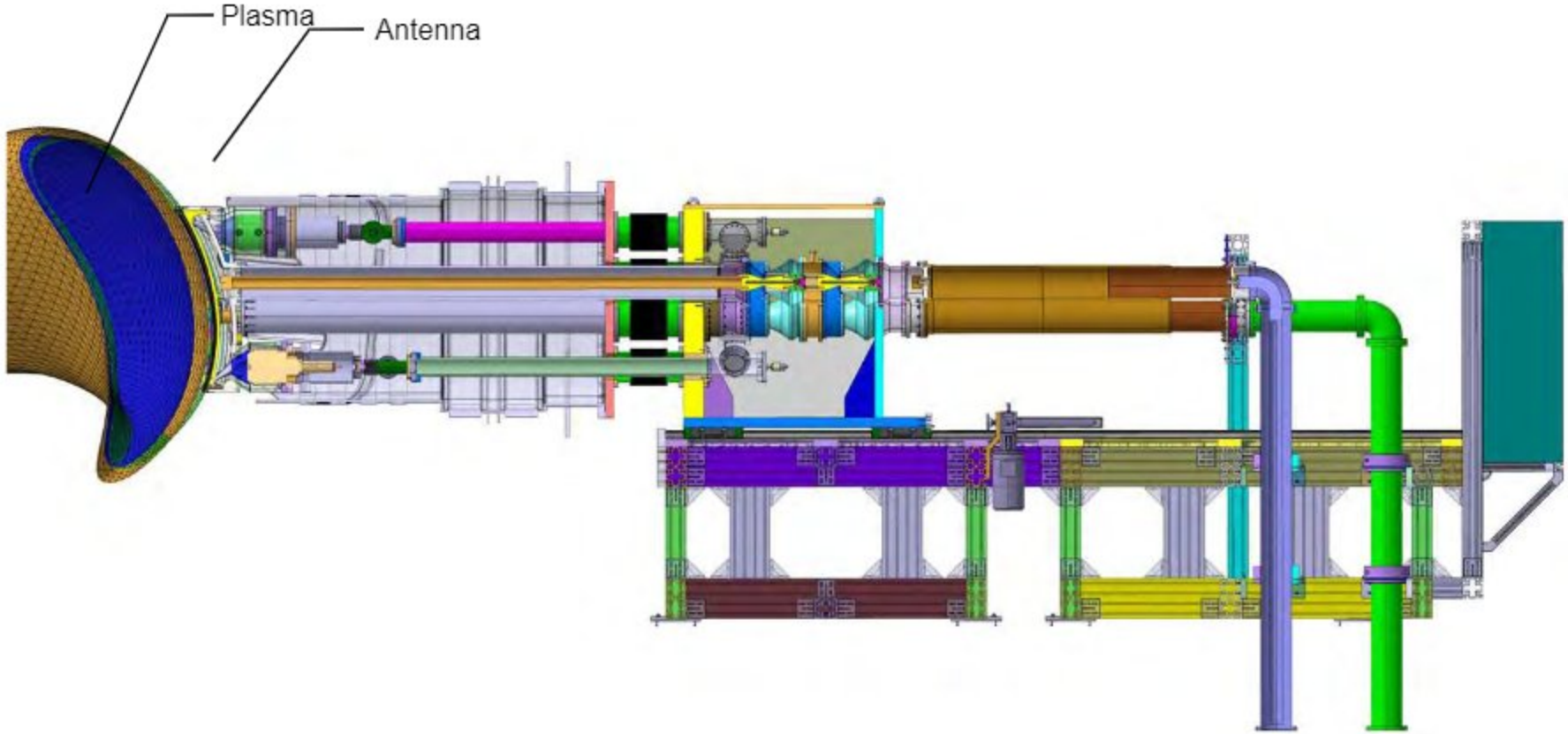
Core competence

- High Temperature Brazing Furnaces (up to 2000°C)
- Diffusion welding and Friction Welding system
- Various laser beam welding systems with different wavelengths
- Electron beam welding systems
- MIG, WIG, MAG, Orbitalwelding,…
- Virtual welding and welding simulation tools
- Collaboration with Welding and Joining Institute (ISF) of RWTH Aachen University

JOINING TECHNOLOGIES: EXAMPLE

Plasma Heater for Fusion Reactor W7X: ICRH Antenna

Core competence



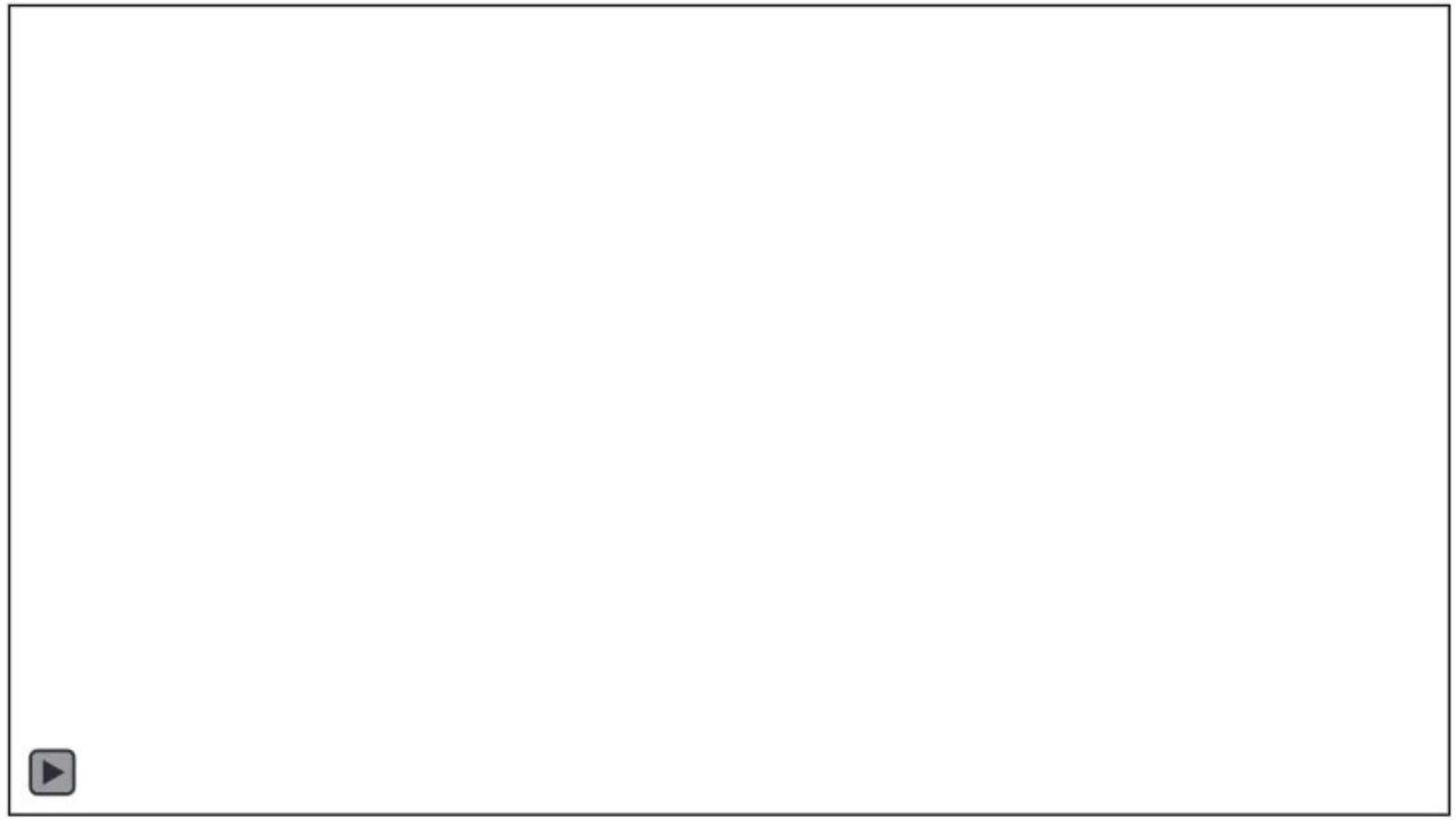
Total length: 10 m

JOINING TECHNOLOGIES: EXAMPLE

Plasma Heater for Fusion Reactor W7X: ICRH Antenna

Core competence

CAM Simulation



JOINING TECHNOLOGIES: EXAMPLE

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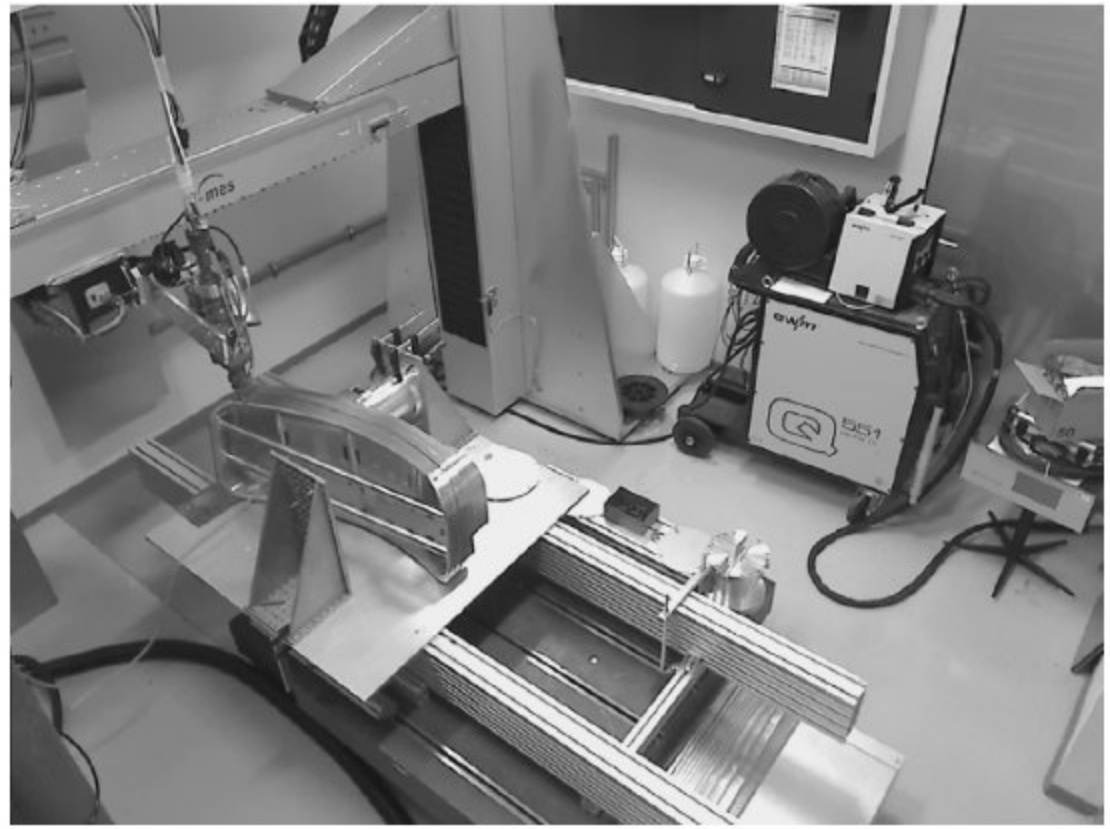


JOINING TECHNOLOGIES: EXAMPLE

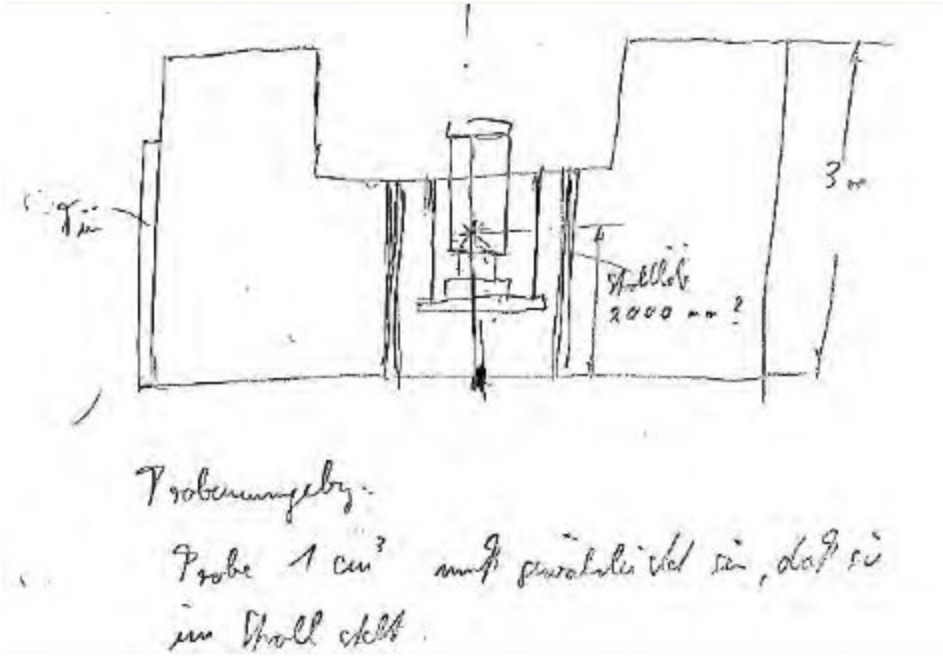
Plasma Heater for Fusion Reactor W7X: ICRH Antenna

Core competence

DAILY BUSINESS

Research with Neutrons

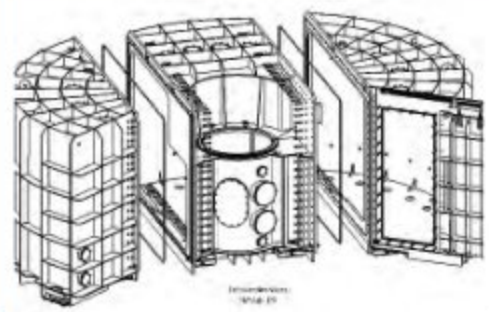
Scientists need something new and better…
Time of flight spectrometer with polarization analysis of scattered neutrons

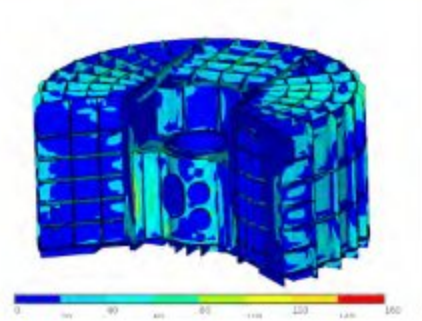


Holistic approach:

Design
Manufacturing
Calculations
Automation
Testing
Modification

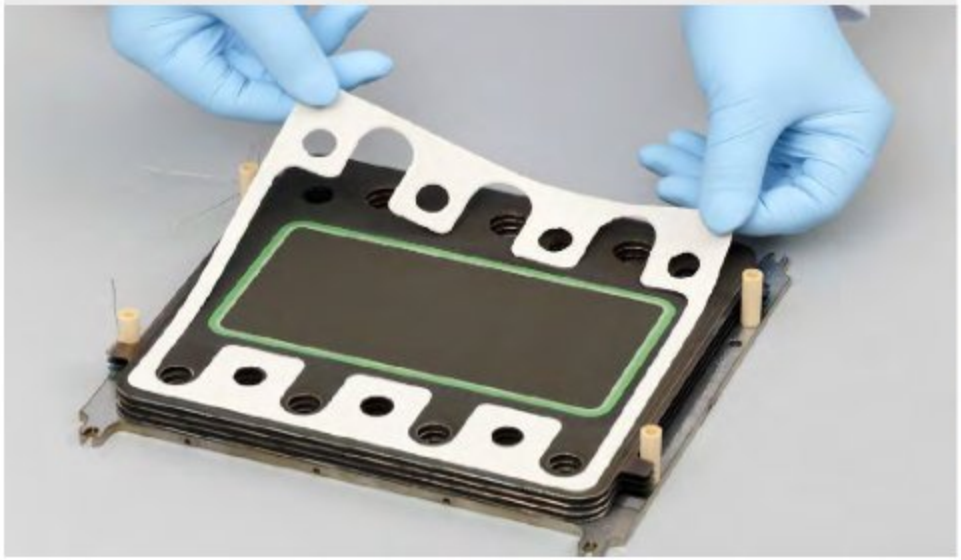
- 50 tons of steel
- 50 m O-ring sealing
- 3 km welding seam
- Max. tolerated deformation of 5 mm at 4 m length
- Ø 6,5 mm, volume 76 m^3, height 3.2 m
- vacuum < 10^{-5} mbar
- Time to achieve required vacuum < 2h



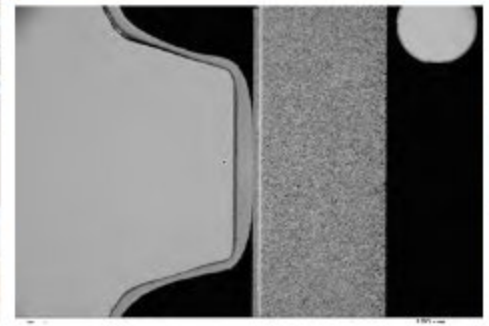


EXAMPLES OF ZEA-1 RESEARCH TO „ENERGY“

Energy research

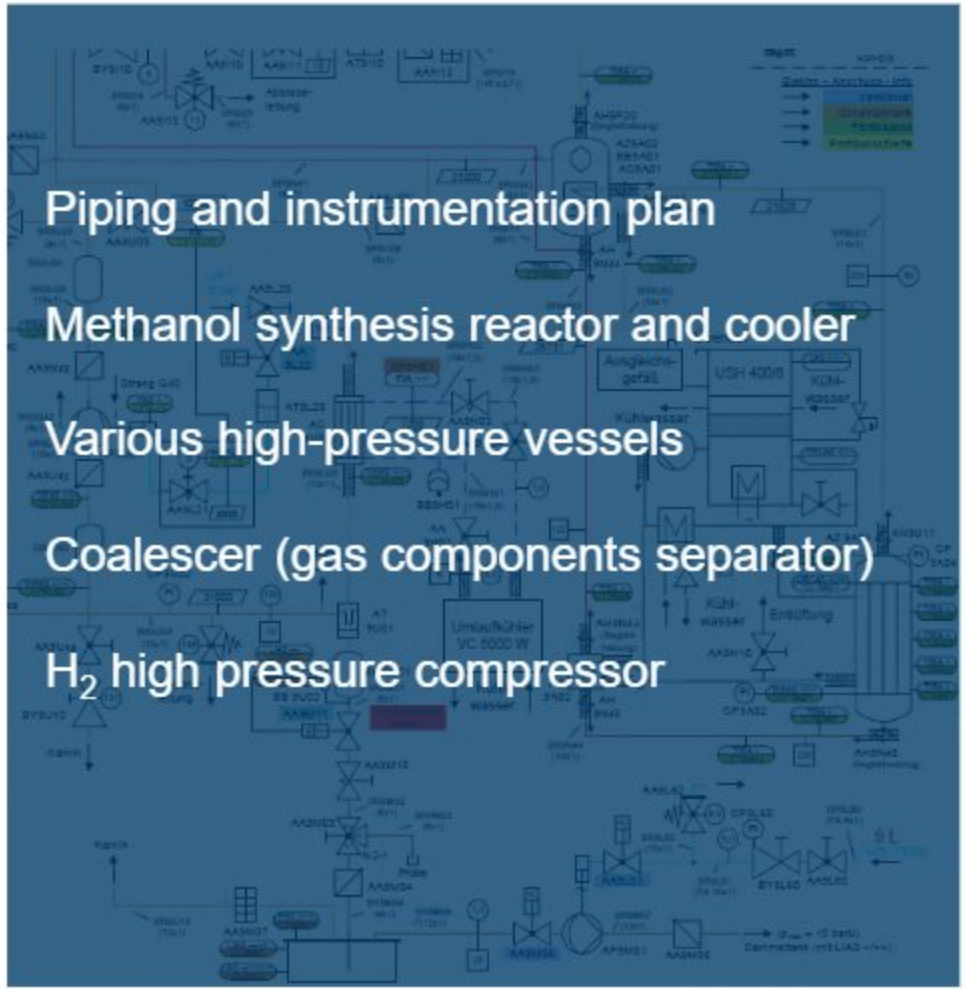


- **Photovoltaics**
- **Electrochemical energy storage**
- **Chemical technologies for integrated energy**
  - Electrochemistry for hydrogen
  - Renewable power based fuels & chemicals
  - Solar fuels
  - Fuel characterization
- **High temperature technologies**
- **Fusion research, plasma-wall interaction**
- **Nuclear waste management**
- **Energy system transformation**
- **Digitalization and system technologies**



METHANOL SYNTHESIS PLANT

Energy research



Piping and instrumentation plan

Methanol synthesis reactor and cooler

Various high-pressure vessels

Coalescer (gas components separator)

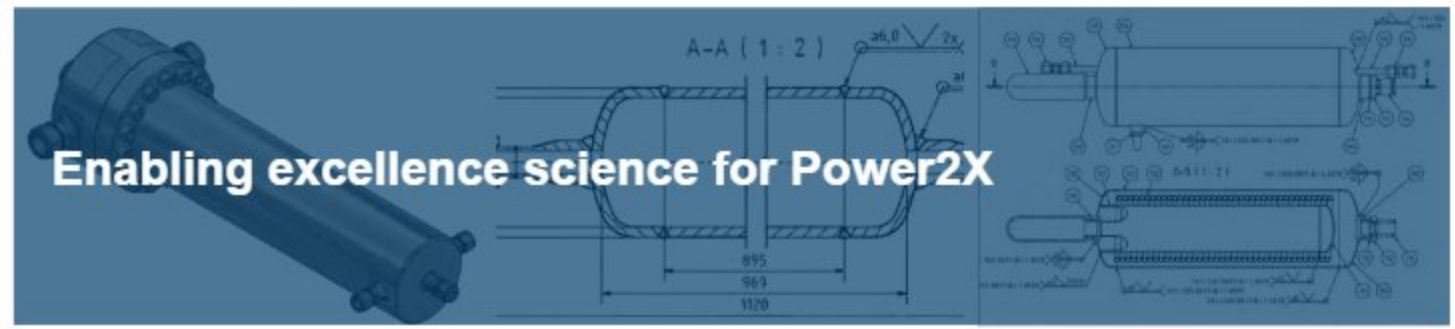
H_2 high pressure compressor

Challenging manufacturing

Integrating certification authorities

Considering all safety regulation

Design rules for CE-Certification



Enabling excellence science for Power2X

MULTIFUNCTIONAL REACTORS

Energy research

Various chemical reactors
for Power2X topic

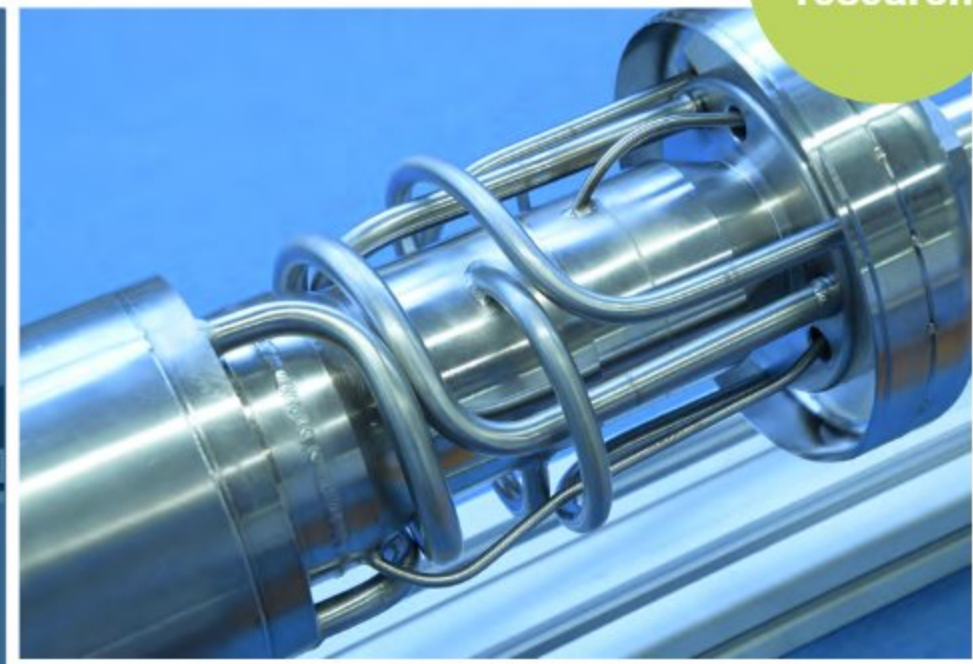
WGS (Water-Gas-Shift-Reactor),
CAB (Catalytic Burner),
ATR (Auto-Thermal-Reactor)

High temperature pressure vessels
(TÜV certification)

Especially:

Joining processes
by
welding / brazing

Demonstrator
assembly

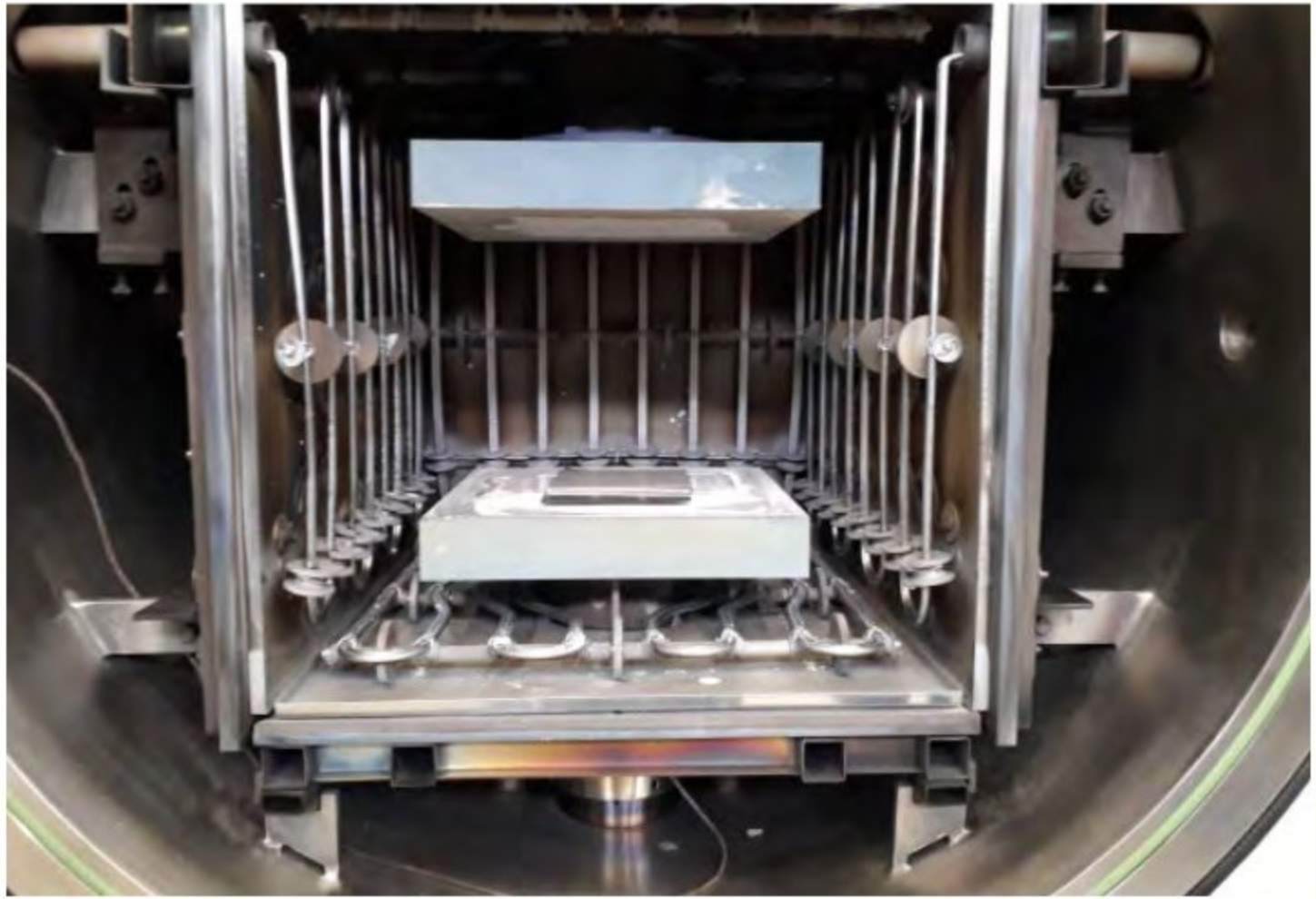


Minimized reactor weight
(wall thicknesses 0,2 mm)

Industrial manufacturing methods
for cost reduction

BIPOLAR PLATES FOR PEM ELECTROLYZERS

Energy research



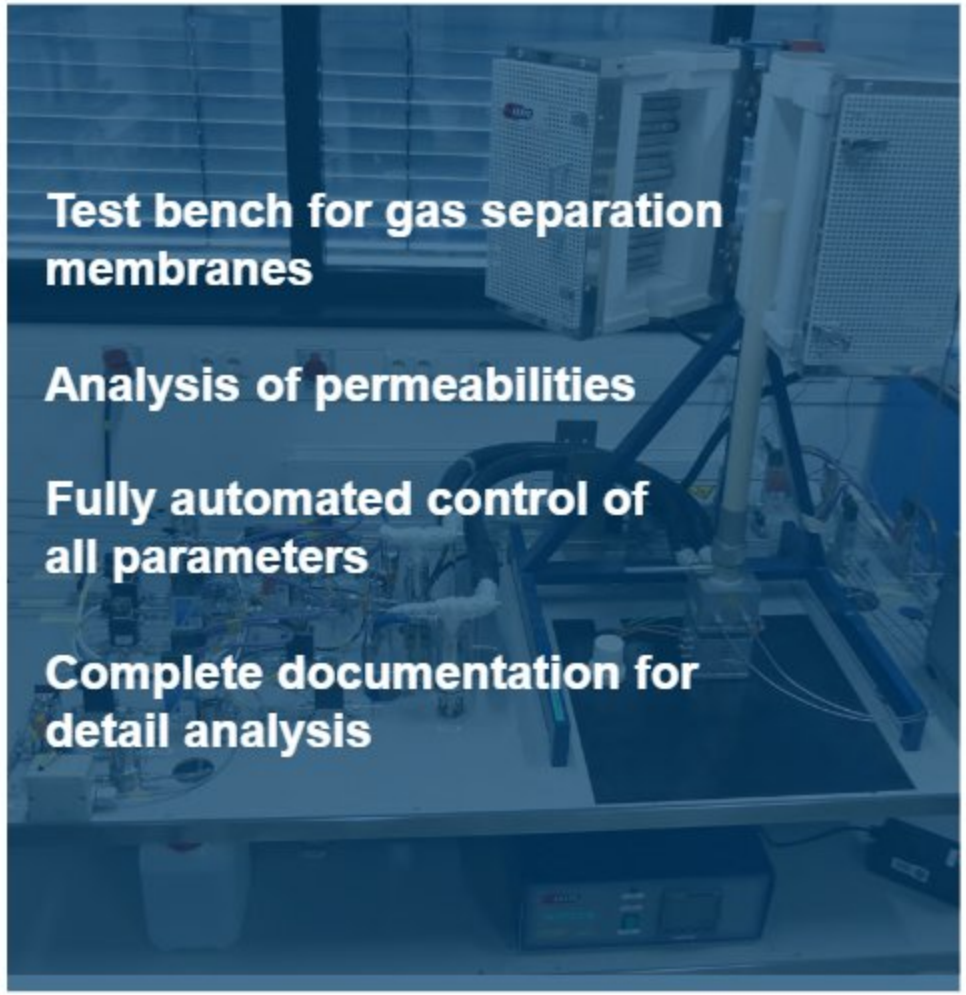
Manufacturing process for PEM Bipolar plates

- Ti-based bipolar plate using 1-piece approach
- Enables stack simplification by reducing number of components
- Minimizes cost of manufacturing

Special joining process using diffusion bonding

H2 PERMEABILITY TEST BENCH

Energy research



Test bench for gas separation membranes

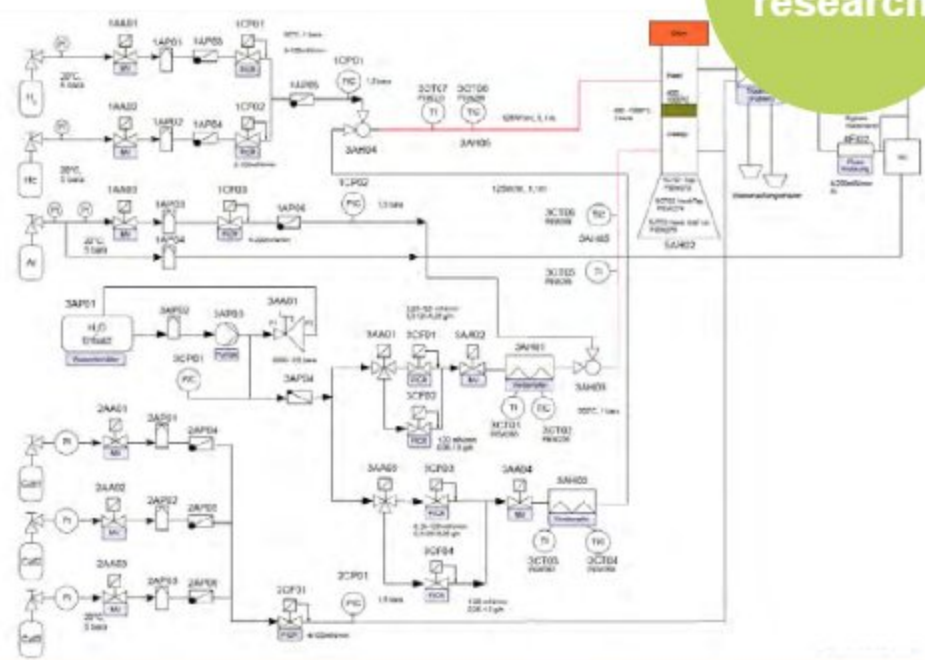
Analysis of permeabilities

Fully automated control of all parameters

Complete documentation for detail analysis

Holistic approach

Integration of all sensors and analysis equipment



CE Certification approach

LOGISTIC AND TRANSPORT OF HYDROGEN

Energy research

Cooperation started with new institute INW

Logistic and transport of Hydrogen

Chemical hydrogen storage:
Reversible hydrogenation/dehydrogenation of aromatic/alicyclic organic compounds (LOHC)

Project for turn-key test benches for LOHC catalysis materials screening

Project for new dehydrogenation reactor test bench

Up scaling of new technologies

Production of demonstrators

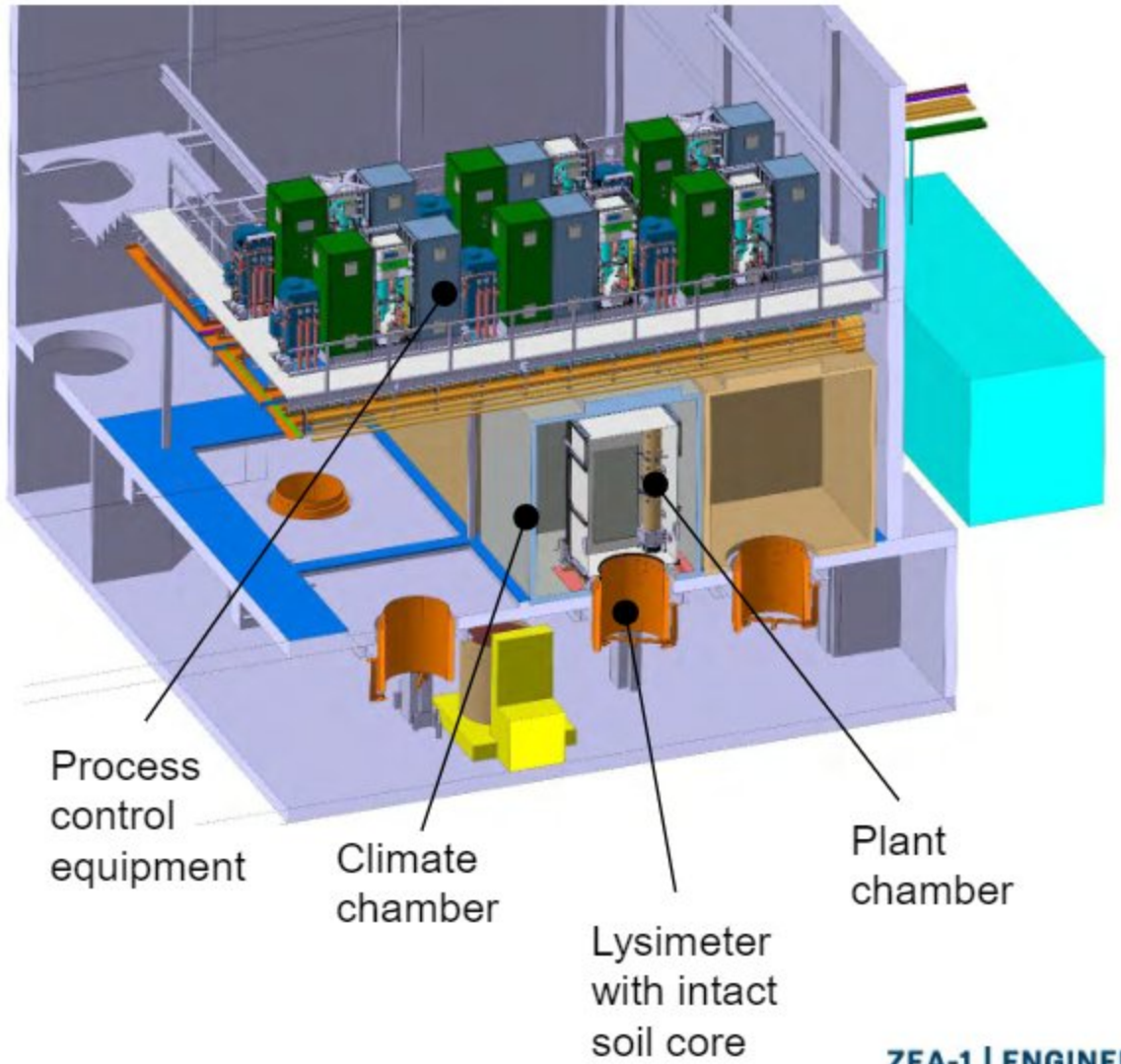
Integrative solutions (automation, data management, process solutions)

Novel reactor design development

Implementing all safety regulations

AGRASIM - AGRICULTURAL FOOD PRODUCTION SIMULATOR

Bio economy



Scientific goal

AGRASIM aims at the optimization of nutrient and water use efficiency of agricultural production systems based on detailed analysis and simulation of the key processes in the soil-plant-atmosphere system under present and future environmental conditions.

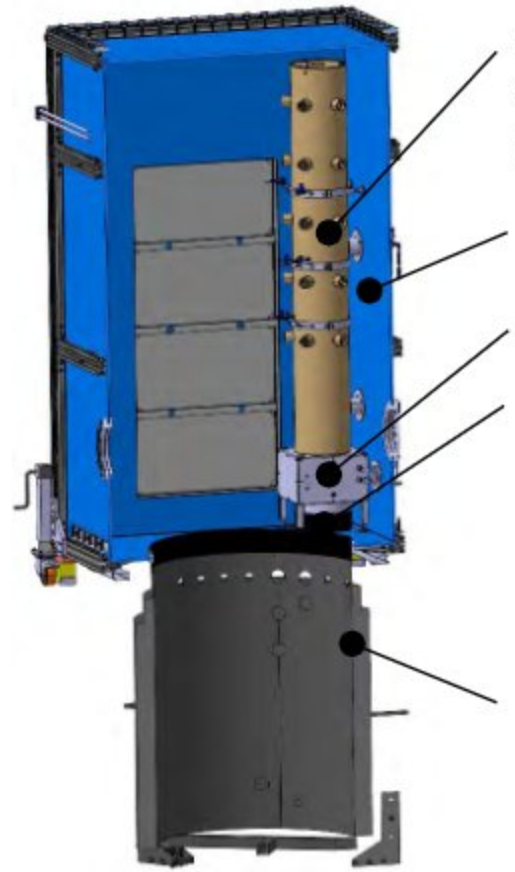
Solution and realization

- Concept development for the whole experiment
- Thermal design taking into account media flows and humidity
- Construction and mechanical design
- Selection and design of the process technology (valves, sensors, pumps, motors, etc.)
- Electrical planning
- Programming the software
- Manufacturing and assembling

AGRASIM – CONDITIONS AND CHALLENGES

Bio economy

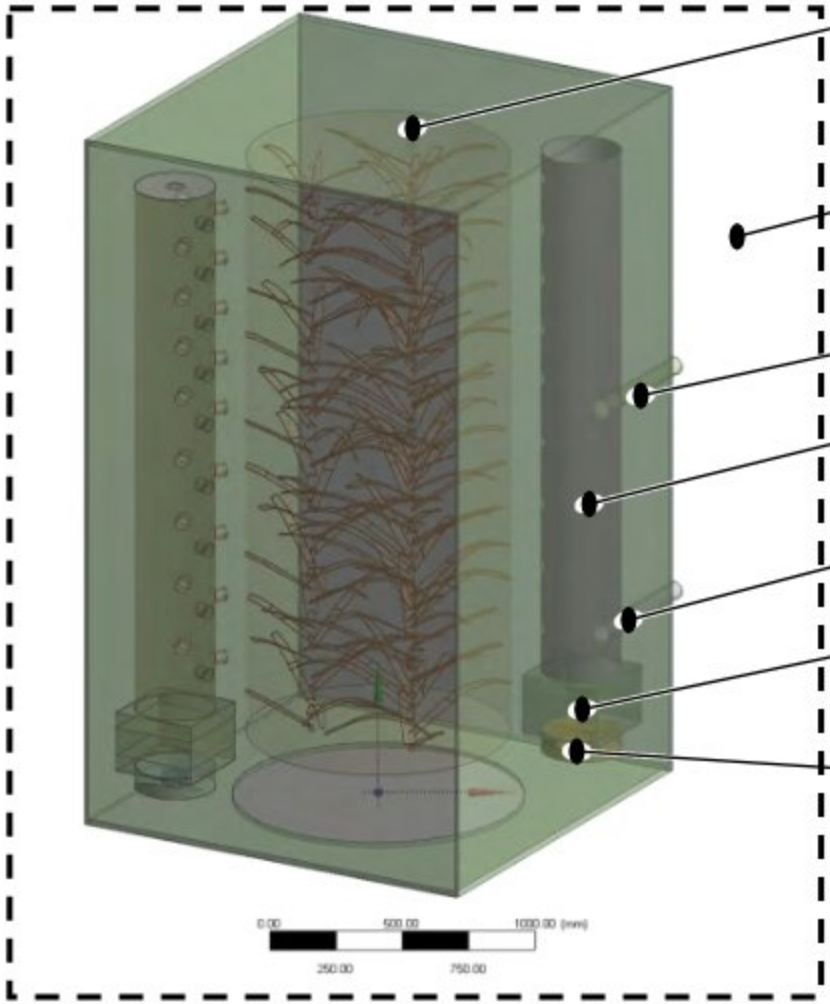
- Dimension: 1,6 x 1,6 x 2,7 m
- Heat input of 3 KW via the lighting
- Temperature in the plant chamber: -5…+40 °C
- Humidity: 10…80 % r. H.
- Condensation is not permitted (not even at high humidity)
- Variation of carbon dioxide, ozone and UV-light
- Homogeneous mixing of the atmosphere within the plant chamber



AGRASIM – SIMULATION MODEL

Bio economy

Heat input of 3 kW via plant lighting



Zone with plant for heat input and water vapor release

Consideration of the environmental conditions (climate chamber) and the heat transport via the outer walls of the plant chamber

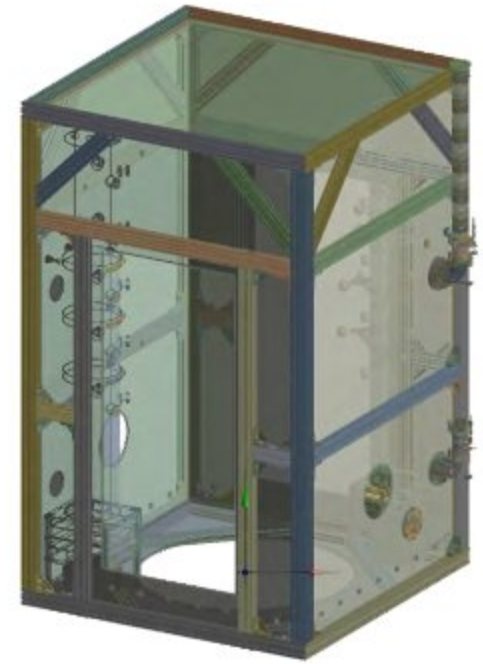
Exhaust air

Ventilation pipe (glass) with side socket

Supply air

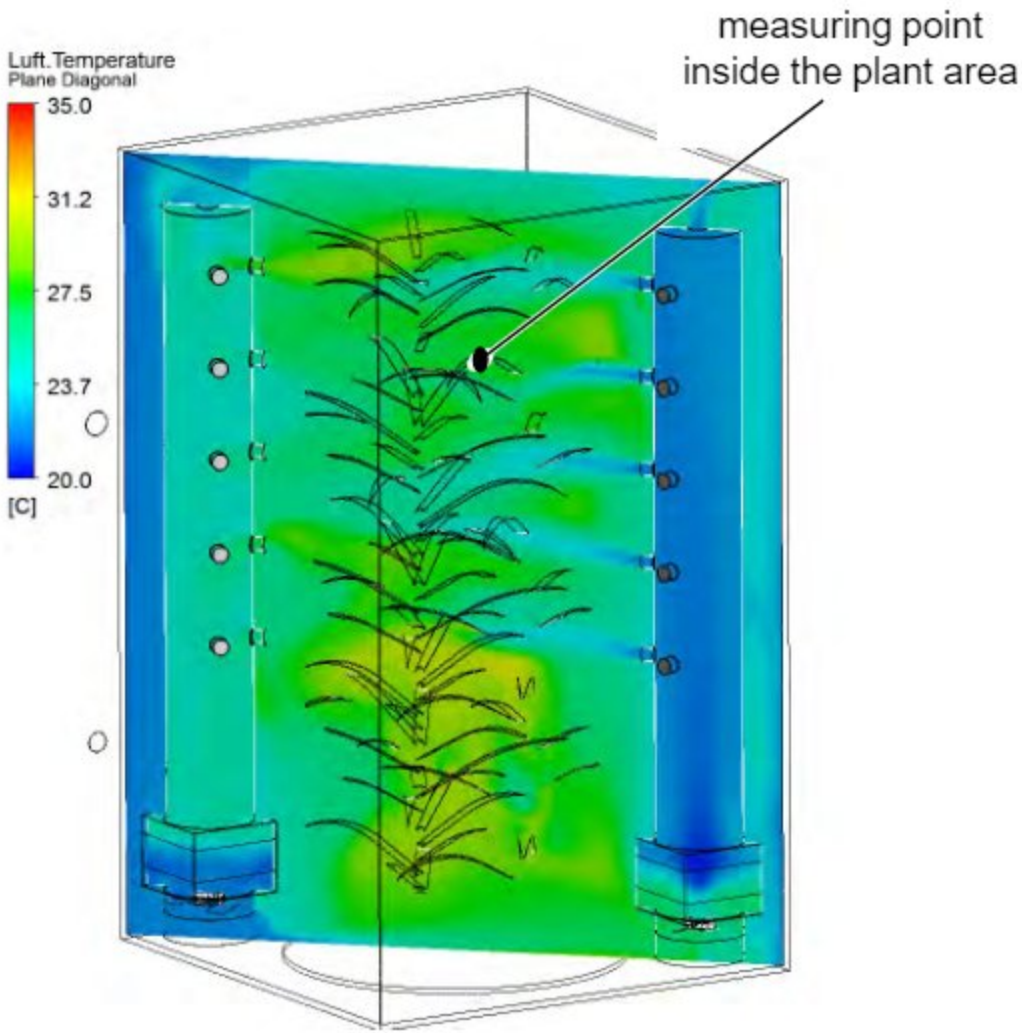
Heat exchanger

Fan with protective grating

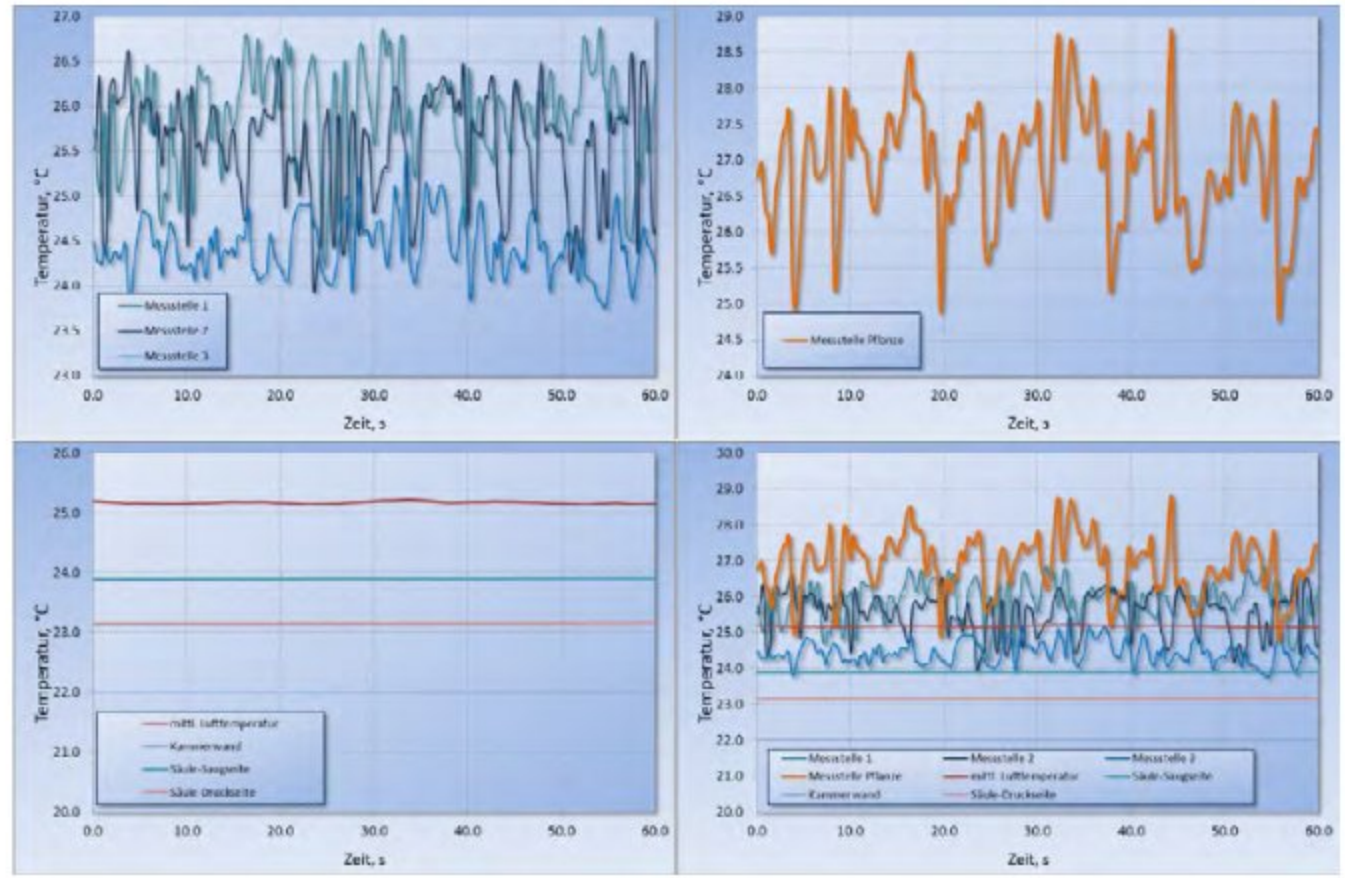


AGRASIM – THERMAL SIMULATION

Bio economy

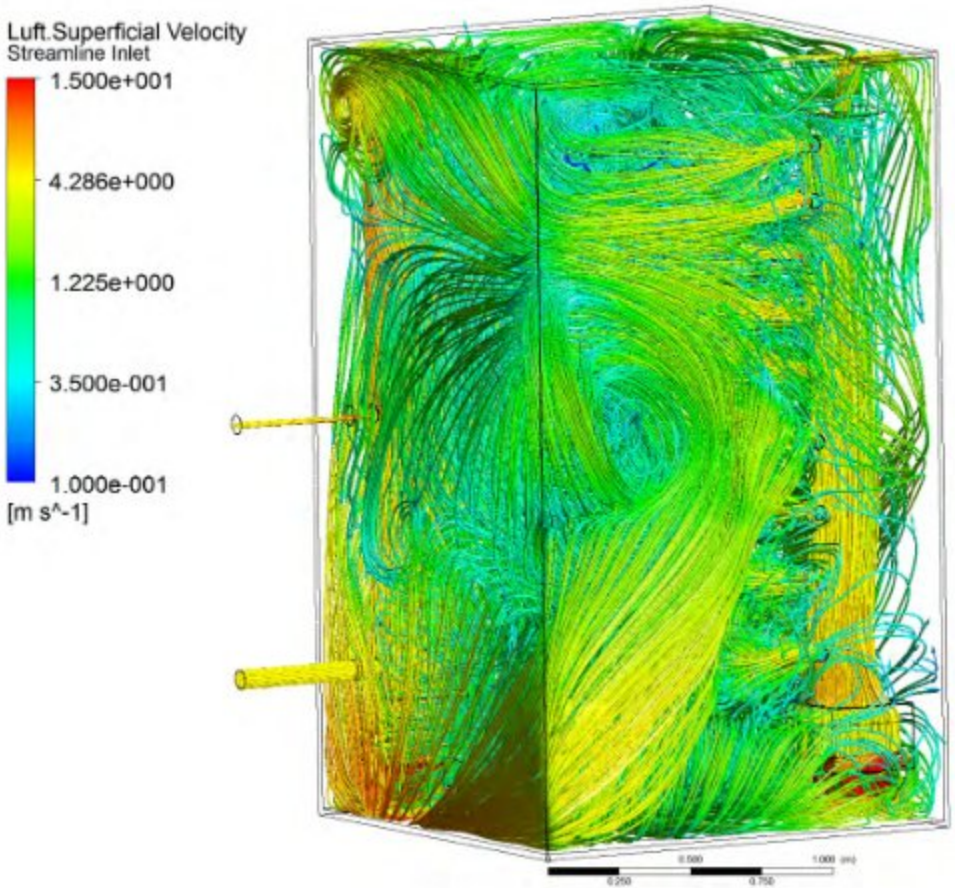


Fluctuations in temperature at selected locations

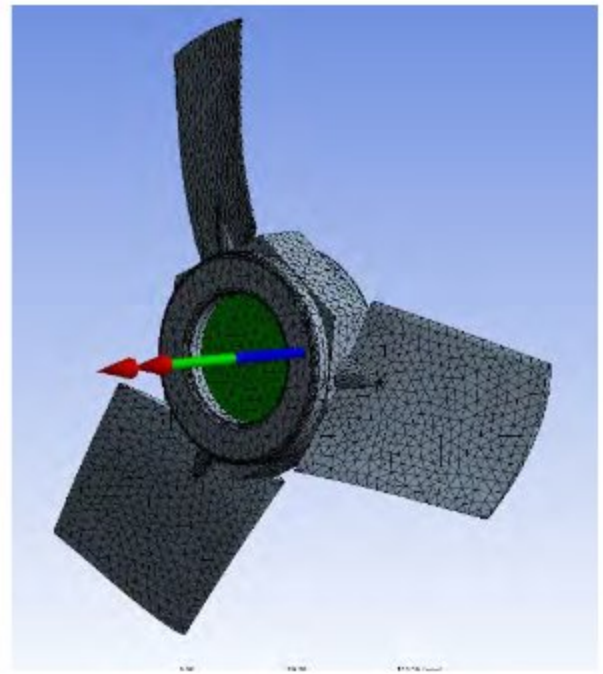


AGRASIM – ANALYSIS OF FLOW VELOCITIES

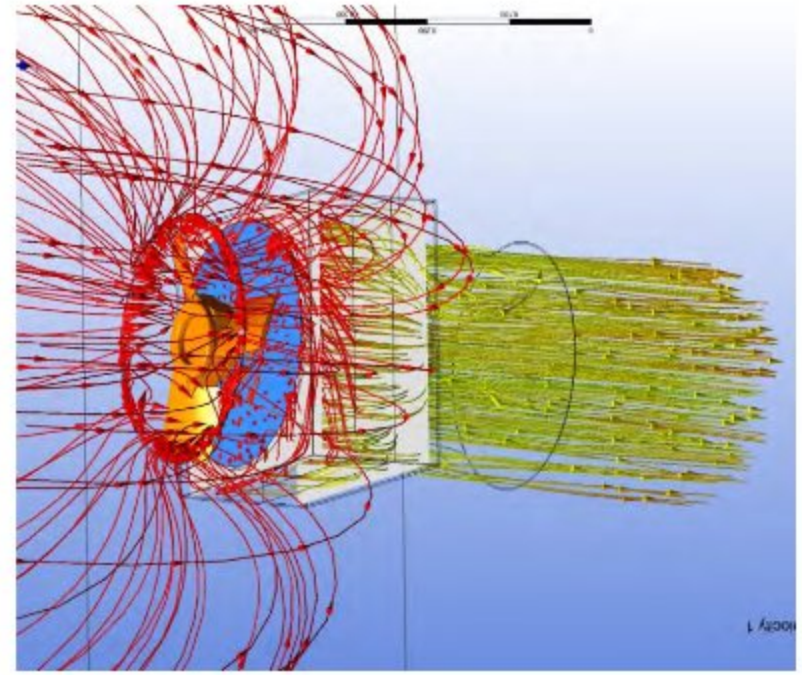
Plant chamber



Mesh
fan blade



Detail fan, heat exchanger
and cooling tower



AGRASIM

GGSB AND ZEA-1

Activities in the past

- 2012: first ZEA-1 scientists visit Georgia in 2012
- since 2013 participation at GGSG summer-schools in Jülich
- Summer 2018: first participation in the (AUG) student selection process
- Fall 2018: first student (Giorgi Gvasalia from AUG) invited for an internship at ZEA-1.
- Winter 2020: second student (David Togonidze from AUG) invited
- Spring 2020 – Spring 2022: COVID-19 shutdown, only virtual contacts
  thinking about a new SMART | Lab for T (mechanical engineering)
- Spring 2022: Aleksandre Kobeshavidze (from AUG) invited
- because of the Ukraine war many ZEA-1 activities were postponed

TECH_LAB IS AN INITIATIVE OF ZEA-1, AUG, TSU, GTU…

Motivation part 2 and Objectives

Knowledge Transfer in the Fields:

- Mechanical Engineering
- Modeling and Simulation
- Process Engineering
- Manufacturing Processes
- Modern Metrological and Testing Methods
- Materials Research

to **Strengthen** the **Skills** of Georgian students in these areas and

to **Train** capable **Young Scientists** and **Engineers**

TECH_LAB IS AN INITIATIVE OF ZEA-1, AUG, TSU, GTU,…

which students at which level should participate in the SMART Lab

Disciplines

- mechanical engineering
- process engineering
- applied physics

Academic level

- senior bachelor students
- master students

TECH_LAB AS AN INITIATIVE OF ZEA-1, AUG, TSU,GTU,…

Next steps

- Implementation of special lectures on numerical simulation and design calculations in engineering and on modern procedures and methods of non-destructive testing
- Establishing a computational cluster for engineering computation
- Help to build a laboratory for modern procedures and methods of non-destructive testing

TECH_LAB AS AN INITIATIVE OF ZEA-1, AUG, GTU,…

Next steps 2

- search for additional funding opportunities (DAAD, BMBF, Volkswagen Stiftung,…)
- Listen in the next days attentively to the students' presentations
- Start selection process and then start with the invitation formalities

Many thanks to my colleagues form ZEA-1

The organizers of GGSB for the invitation

Thank you very much for your attention!
Any questions?

TECH_LAB AS AN INITIATIVE OF ZEA-1, AUG, TSU,…

Cost estimation for the Start-Up of the lab

- Cost of computational cluster for engineering computation: 30.000 k€
- cost of software licenses (for educational purposes): will be covered by AUG, TSU?
- Cost of infrared thermography system: 40.000 €
- Travel expenses for Georgian and German scientists/engineers and Georgian students: 16.000 € p.a.

- Search for financial support
- Submission of applications to various official funding agencies (BMBF, DAAD, ...)