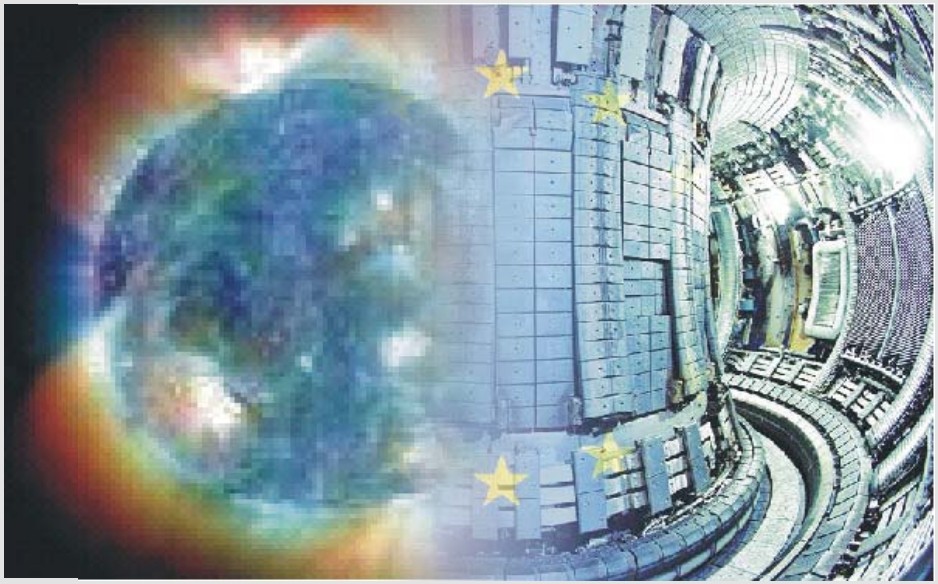
Karlsruhe Institute of Technology

Facility Review Meeting
May 27-28, 2008

Facilities' Perspectives
of the
Association Euratom-FZK

- Overview and Mission Orientation
- Important Facility Enhancements



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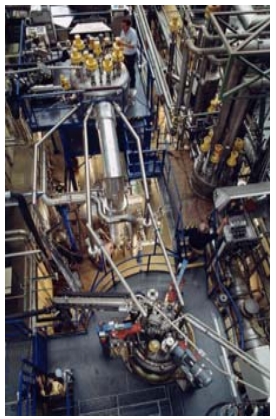
Part I – Overview and Mission Orientation

Mission Orientation of FZK Technology Facilities

- Mission 1: Burning Plasmas
- Mission 2: Reliable Tokamak Operation
- Mission 4: Long Pulse & Steady State
- Mission 7: DEMO Integrated Design (availability, efficiency)

Tritium Laboratory Karlsruhe (TLK)

- T supply
- T retention & concentration



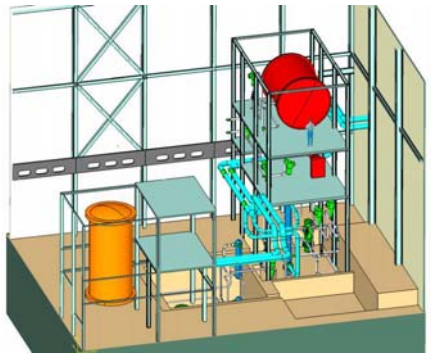
Cryo Pump Test Facility (TIMO-2)

- He removal by cryo- and/or mechanical pumping

Target: ITER Fuel Cycle; DEMO concept development & integrated design

Mission Orientation of FZK Technology Facilities

- Mission 3: First Wall Materials
- Mission 6: Materials & Components for Nuclear Operation
- Mission 7: DEMO Integrated Design (availability, efficiency)



Fusion Materials Laboratory (FML)

("Hot Cells" plus large capacity of non-nuclear materials testing (high temperature, long term)

Structural & functional (incl. First Wall) materials:

- ITER-TBM (breeder materials, neutron multipliers)
- DEMO (blanket & divertor structure, First Wall)

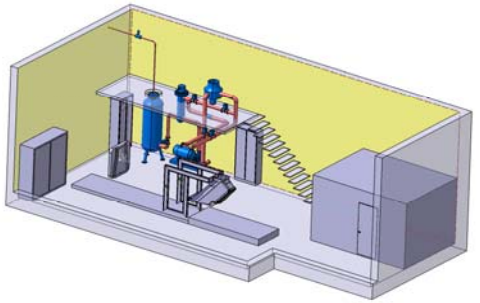
Helium Loop Karlsruhe (HELOKA)

- Testing of ITER in-vessel components (TBM, TDM)
- Development of advanced blanket, divertor and He cooling concepts for DEMO
- First Wall materials heat load testing

Target: Advanced materials / cooling concepts for efficient electricity production

Mission Orientation of FZK Technology Facilities

- Mission 1: Burning Plasmas
- Mission 2: Reliable Tokamak Operation
- Mission 4: Technology of Long Pulse & Steady State
- Mission 7: DEMO Integrated Design (availability, efficiency)



Gyrotron Test Facility

- Development & testing of high power / multi-frequency gyrotrons

ECRH Launcher Structural Test Facility

- Development & testing of microwave transmission and beam steering, port plug integration

Target: Plasma heating, current drive & plasma stabilization for ITER ECRH and DEMO concept development

Mission Orientation of FZK Technology Facilities

- Mission 2: Reliable Tokamak Operation
- Mission 7: DEMO Integrated Design (availability, efficiency)

Cryo- and Magnet Test Facility (TOSKA)

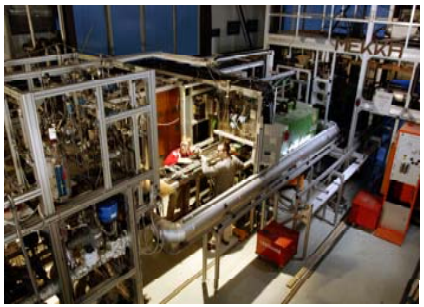
- Testing of magnets & current leads for W7-X and JT 60-SA
- Development of supercritical He pumping for ITER
- Development & optimization of conductors (conventional vs. HTS) for DEMO, model coil testing

Gas / Dust Explosion Facility (HYDEX)

- Determination of combustion / explosion behaviour of ITER relevant mixtures of gases and dusts
- Development of mitigation techniques

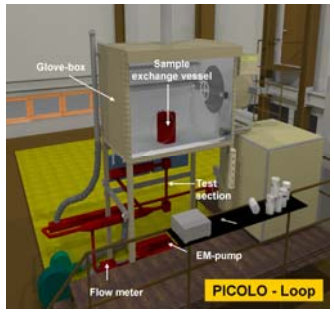
Mission Orientation of FZK Technology Facilities

- Mission 6: Materials & Components for Nuclear Operation
- Mission 7: DEMO Integrated Design (availability, efficiency)



Liquid Metal Magneto-hydro-dynamical Test Facility (MEKKA)

- Magneto-hydrodynamical investigations & design improvement



Liquid Metal Corrosion Test Facility (PICOLO)

- corrosion testing & optimization, development of T permeation barriers

Target: ITER TBM liquid breeding, DEMO dual coolant concept

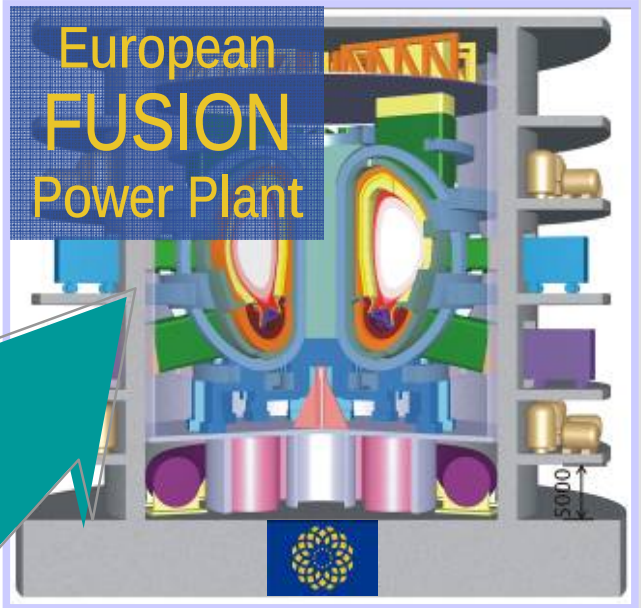
Part II – Important Facility Enhancements

Major Mission: # 6 - Key (In-Vessel) Components for Nuclear Operation;

Thermo-mechanical & gas-dynamical qualification of test blanket & divertor modules

2030ff

Further R&D, Optimization, Testing & Qualification for DEMO



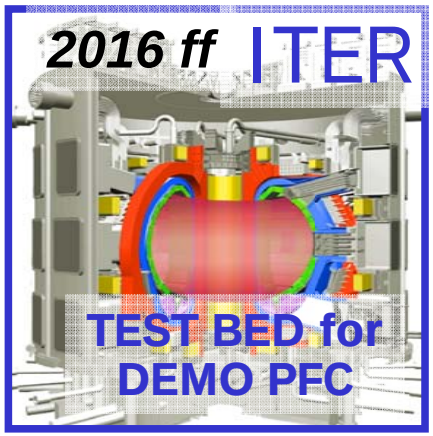
Prototype for ITER Helium Cooling Systems

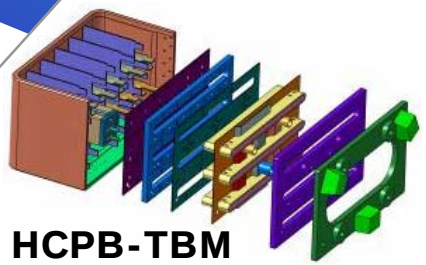
Complete TDM Test Loop available 2013 ff

TDM

TBM Test Loop available 2009 ff

TBM

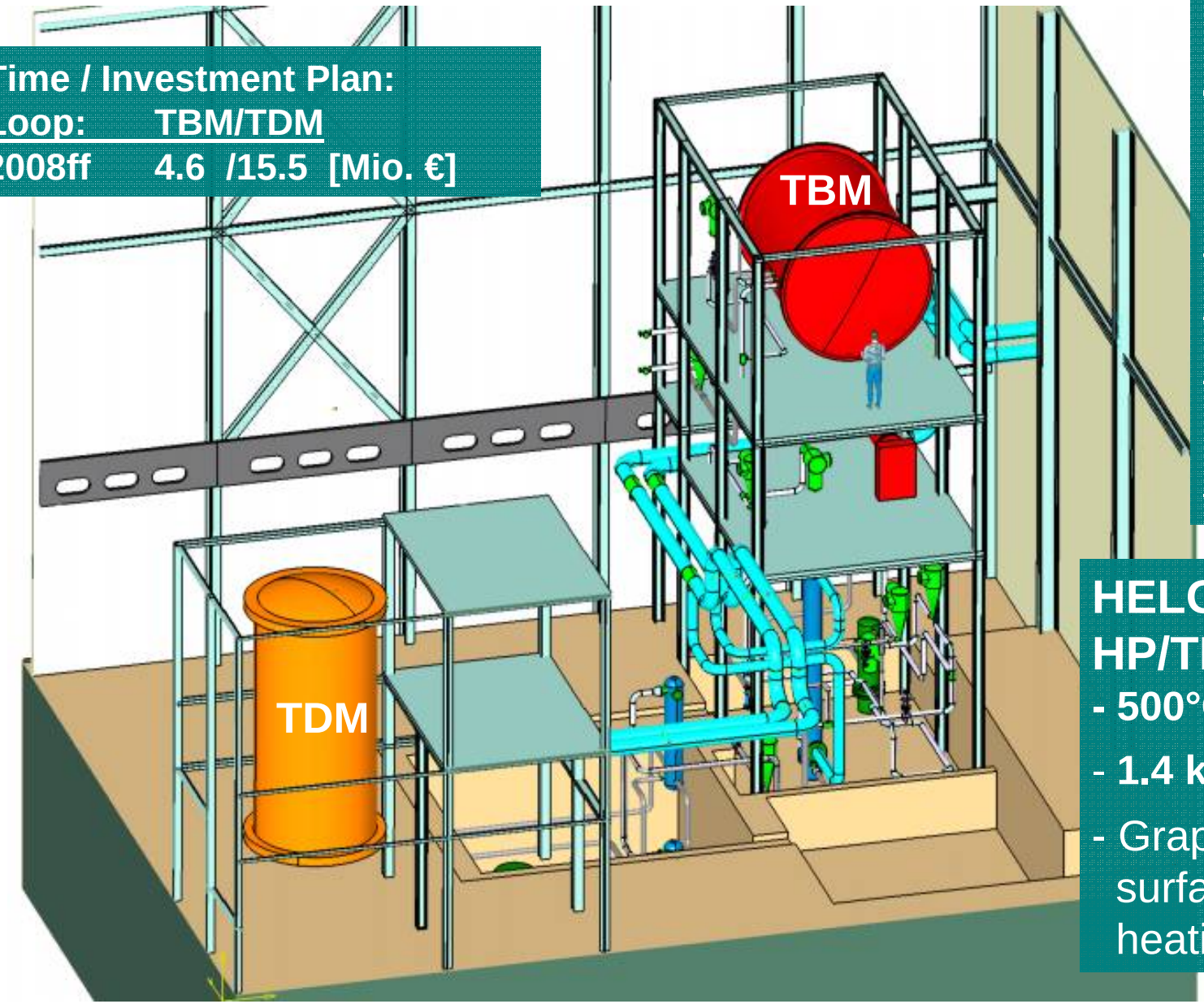




HCPB-TBM

Time / Investment Plan:

Loop:	TBM/TDM
2008ff	4.6 /15.5 [Mio. €]



HELOKA-HP

- Development of Helium Loop Technologies
- Qualification for ITER
- 80 bars (max 100 bars)
- Pulsed load operation ITER scenarios
- Long term operation

HELOKA-HP/TBM

- 500°C
- 1.4 kg/s
- Graphite rad. surface heating

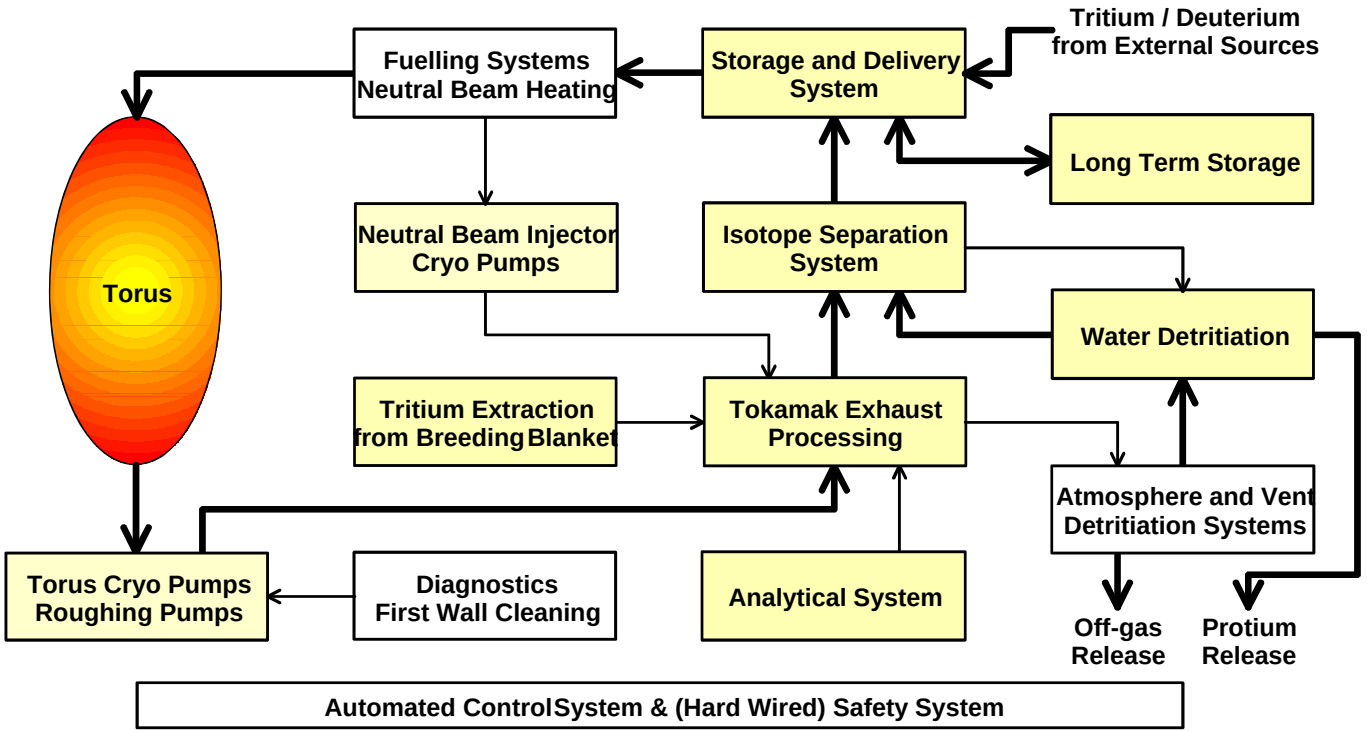
HELOKA-HP/TDM

- 700° - 750°C
- 3.9 kg/s
- Surface heat source

Tritium Laboratory Karlsruhe (TLK)

ITER (Missions 1, 2, 4):

- Leading role with regard to design and management of EU procurement package WDS-ISS
- Perform additional R&D as required
- R&D for processing of highly tritiated water



DEMO (Mission 7):

- Taking leadership for the design of the whole tritium fuel cycle of DEMO
- Upgrading TLK to house a He+T test facility to enable integrated tests for tritium extraction
- Assessment of DEMO requirements with regard to helium cooled breeder blankets to identify open items for further R&D on field of tritium extraction
- Design of DEMO fuel cycle, thereby optimization of processes and components
- Development of accountancy methods for wastes

TLK: Technical Capabilities

Unique semi-technical facility

- **Licence 40 g, actual on site 24 g**
  (1 g tritium = 10,000 Ci = 3.7 E+14 Bq)
- **10 glove box systems, 125 m^3**
- **More than 1400 m^2 total area**
- **Is operating a closed tritium cycle**
- **Tritium storage (10 metal getter beds)**
- **Plasma exhaust processing (CAPER, detritiation factor 10^6 in T-concentration)**
- **Isotope separation (enrichment up to >99% tritium purity)**

Extension in progress:

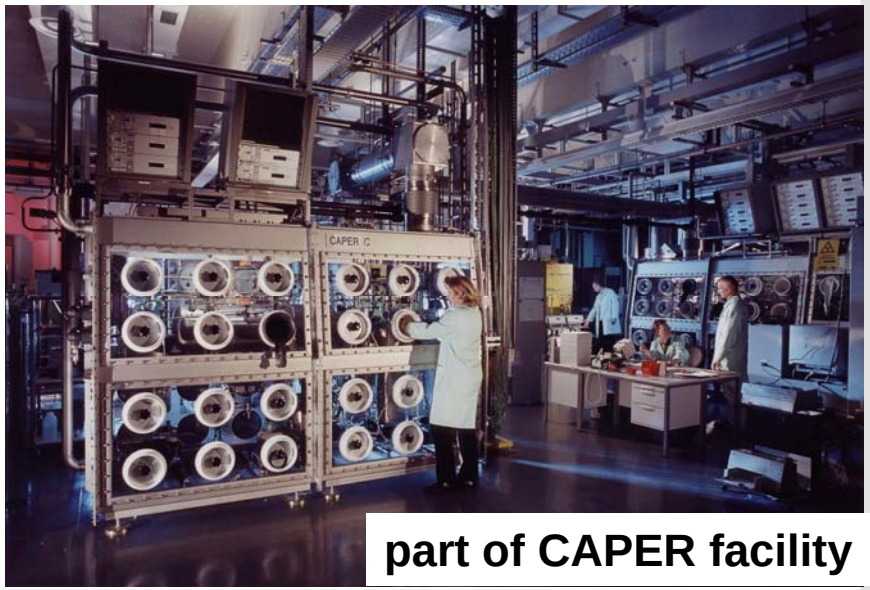
- **Water detritiation**
- **Cryogenic distillation**

Future extension:

He + T test facility for tritium extraction from large He flows (blankets)

~ 8 Mio €; 2015 – 2018 (building, He + T tubing & circulation, control & safety)

TLK building



part of CAPER facility

Gyrotron Test Facility

Development and testing of highly reliable continuous wave (CW) gyrotrons with high unit power and high efficiency as sources for the EC-waves:

- **Mission 1 (Burning Plasma, Burn Control by ECH),**
- **Mission 2 (Reliable Tokamak Operation, NTM stabilisation)**
- **Mission 4 (Technologies and Physics of Long Pulse & Steady State, ECH and ECCD)**
- **Mission 7 DEMO Integrated Design (availability, efficiency)**

Existing Test Facilities:

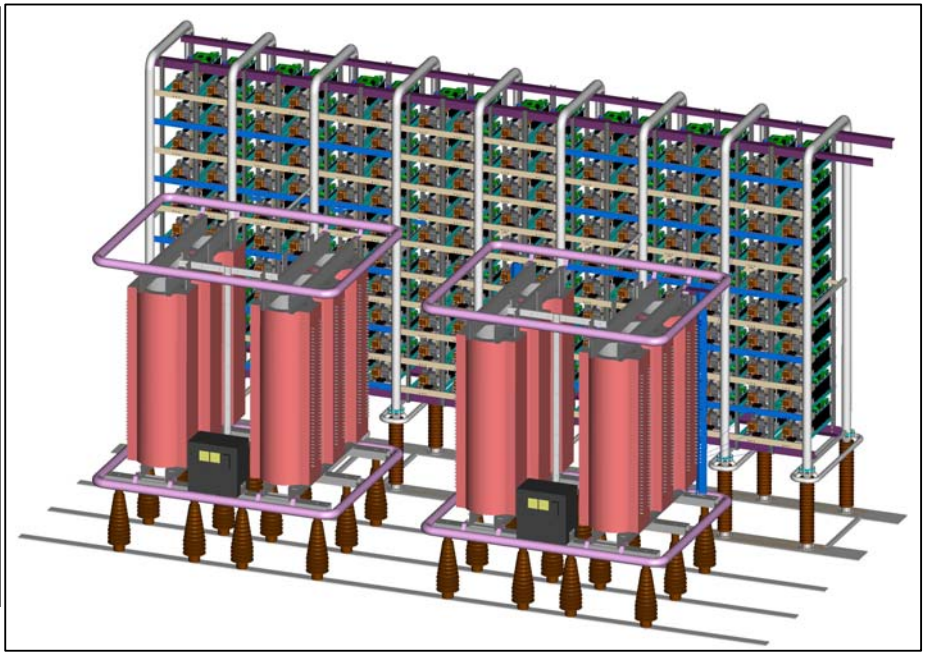
- **Testing of Gyrotrons up to up to 170 GHz and up to 500 kW CW (2 MW for 10 sec, 1 MW for 190 sec)**
- **All relevant power, frequency and mode purity diagnostic tools for high and low power available.**
- **Track record includes the development of the world´s first 1 MW CW 140 GHz gyrotron with high mode purity and 2.2 MW / 165 GHz Coaxial short-pulse (5 msec) Gyrotron.**
- **Development (unique in Europe) of computer codes for key gyrotron components (gun, cavity, quasi optical mode convertor, mirrors, window, collector etc.)**

1 MW 140 GHz CW Gyrotron at the FZK Test Facility

Gyrotron Test Facility

Planned Extensions

- **Future ECRH requirements: Higher unit power (> 1 MW), multi-frequency operation (reduction of costs and complexity; reliable operation – Missions 1& 2)**
- **Extension of FZK Gyrotron Test Facility to allow testing of DEMO relevant CW gyrotrons up to 4 MW (Mission 7); time frame: 2010 – 2012, cost: ~ 4.3 Mio € (biggest part: 10 MW CW power supply)**
- **Capacity for high power testing of larger ECH&CD components and systems**



Gyrotron Development

5 years perspective:	**Highly reliable CW 2 MW coaxial cavity gyrotron (Missions 1&2)**
	High efficiency 4 MW short pulse coax. cavity gyrotron (2 output beams)
	Multi frequency step tunable gyrotron for NTM stabilization (Mission 2)
10 years perspective:	**1 MW CW gyrotron for 200 GHz (more efficient ECCD for steady state tokamak operation (Mission 4)**
	High efficiency CW 4 MW gyrotron (Mission 7)
Longer term perspective:	**Continuation of 4 MW gyrotron development with frequency tunability option (Mission 7)**

ECRH Launcher Structural Test Facility

- **Primary goal:**
  - Experimental platform for ITER ECRH component development, assembly and validation

- **R&D missions:**
  - Structural components and remote handling/optical alignment for the ECRH are developed at the Launcher Structural Test facility
  - ECRH is indispensable for the stabilization of plasma instabilities (neoclassical tearing modes and sawtooth instability), i.e.:
    * Reliable Tokamak Operation (Mission 2)
    * Long Pulse Operation (Mission 4)

- **Further option for DEMO:**
  - Feasibility test platform for conceptual design, remote handling tools and procedures, i.e.
    * DEMO Integrated Design (Mission 7)

ECRH Launcher Structural Test Facility

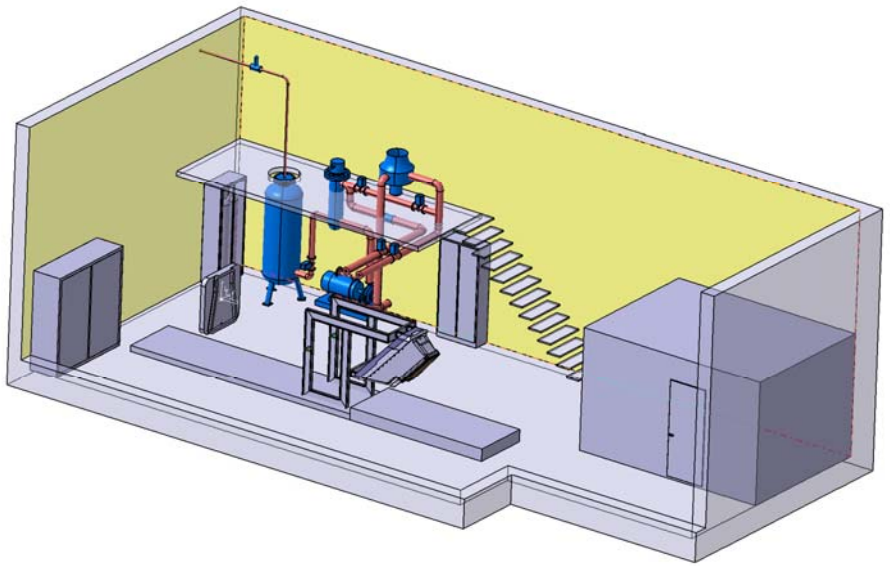
Capabilities and planned facility extension

First Stage completed (400k€):

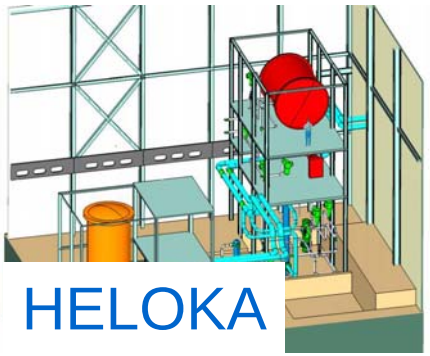
- Infrastructure for component testing and numerical simulation validation at relevant ITER operating conditions.
- Development platform for remote handling, especially for alignment of the optical system.

Second Stage planning (2 M€, 2008-2011):

- Infrastructure extension for complete Upper Launcher assembly.
- Acceptance test program towards component delivering suppliers.
- Acceptance test program of assembled Upper Launcher towards ITER.



Facilities' Spectrum of the Association Euratom-FZK



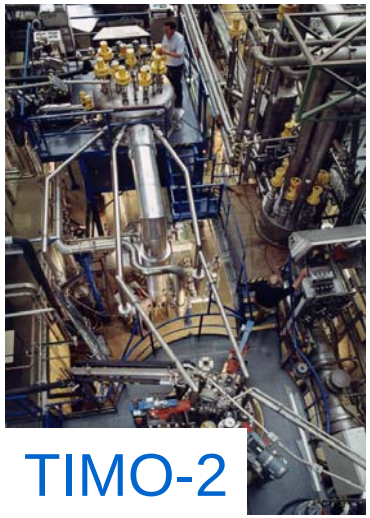
HELOKA

TOSKA

TLK

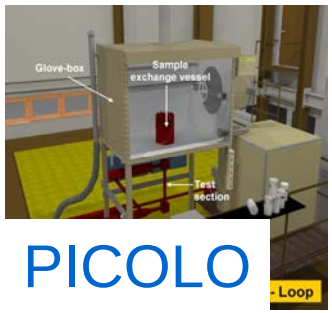
FML

MEKKA



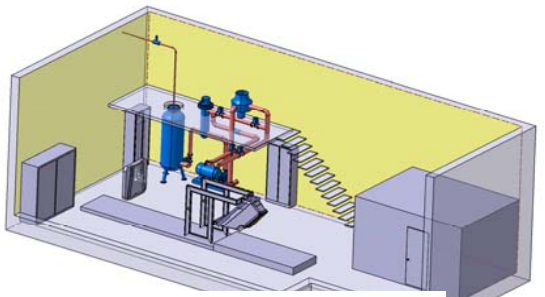
TIMO-2

HYDEX



PICOLO

Gyrotron Test Facility



ECRH Launcher Test Facility