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JÜLICH FORSCHUNGSZENTRUM

JULE-PSI project at Forschungszentrum Jülich for PMI studies in nuclear environment

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Specific issues of PMI research in linear plasma devices

General abilities of typical Linear Plasma Devices (LPDs)

- ♦ High particle fluence
- ♦ Well-controlled exposure conditions (i.e. sample temperature, plasma species, energy)

Research in LPDs is mainly aimed at effects distinctive for high fluence or specific exposure conditions, e.g.

- Fluence dependence of fuel retention
- High-Z material blistering
- W fuzz formation by He irradiation
- …

Unique features of particular LPDs and resulting scientific missions

(only existing experiments considered)

PISCES-B (UCSD, USA): capability of working with all ITER materials incl. beryllium

- Mixed-material R&D for ITER

NAGDIS-II (Nagoya U, Japan): high density plasma

- Detachment studies

TPE (INL, USA): tritium and moderate level of radioactivity

- Tritium permeation
- Performance of n-irradiated materials

DIONISOS (MIT, USA): in-situ surface analysis + target irradiation by MeV ions

- Dynamics of PMI processes
- Effects of target irradiation in plasma environment

Future Linear Plasma Devices

Recognizing and filling the scientific gaps in PMI towards ITER and DEMO

Scientific gap: too low plasma densities and fluxes

Solutions:

- **High B field for better confinement**
- **Novel plasma source**
- **Plasma heating**

Devices:

- ♦ **Magnum-PSI (FOM, Holland)**
- ♦ **Paloma (CIEMAT, Spain)**
- ♦ **PMTS (Oak Ridge NL, USA)**

Scientific gap: PMI of neutron damaged materials

Solutions:

- **Device in a glove box (moderate level of radioactivity)**
- **Device in a hot cell (high level of radioactivity)**

Devices:

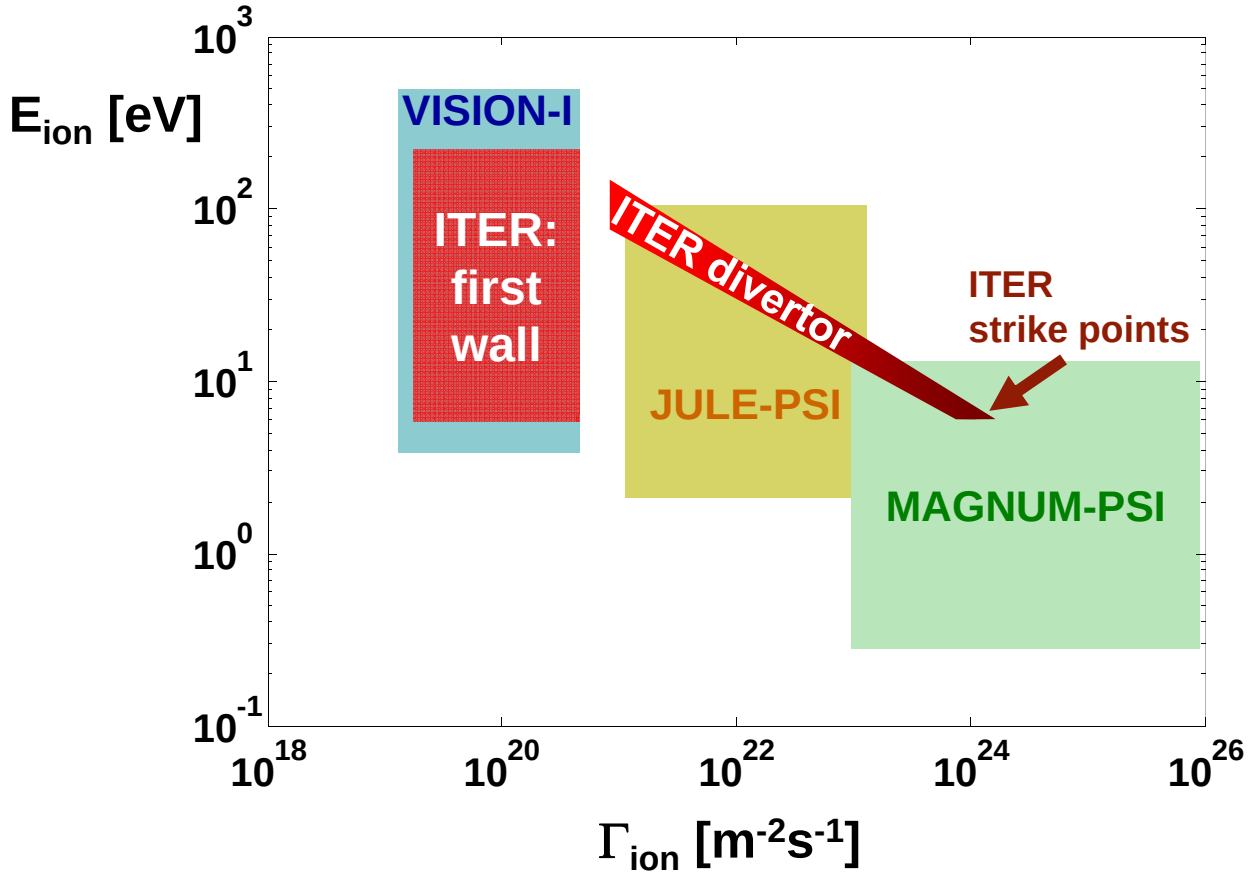
- ♦ **VISION I (SCK-CEN, Mol, Belgium)**
- ♦ **JULE-PSI (FZ Jülich, Germany)**

Plans for portfolio of complimentary LPDs in TEC

Trilateral Euregio Cluster (TEC):

- **FOM, Holland → Magnum-PSI**
- **ERM/ KMS with SCK-CEN, Belgium → VISION I**
- **FZJ, Germany → JULE-PSI**

Covering ITER operational space



Magnum-PSI: *True* divertor simulator

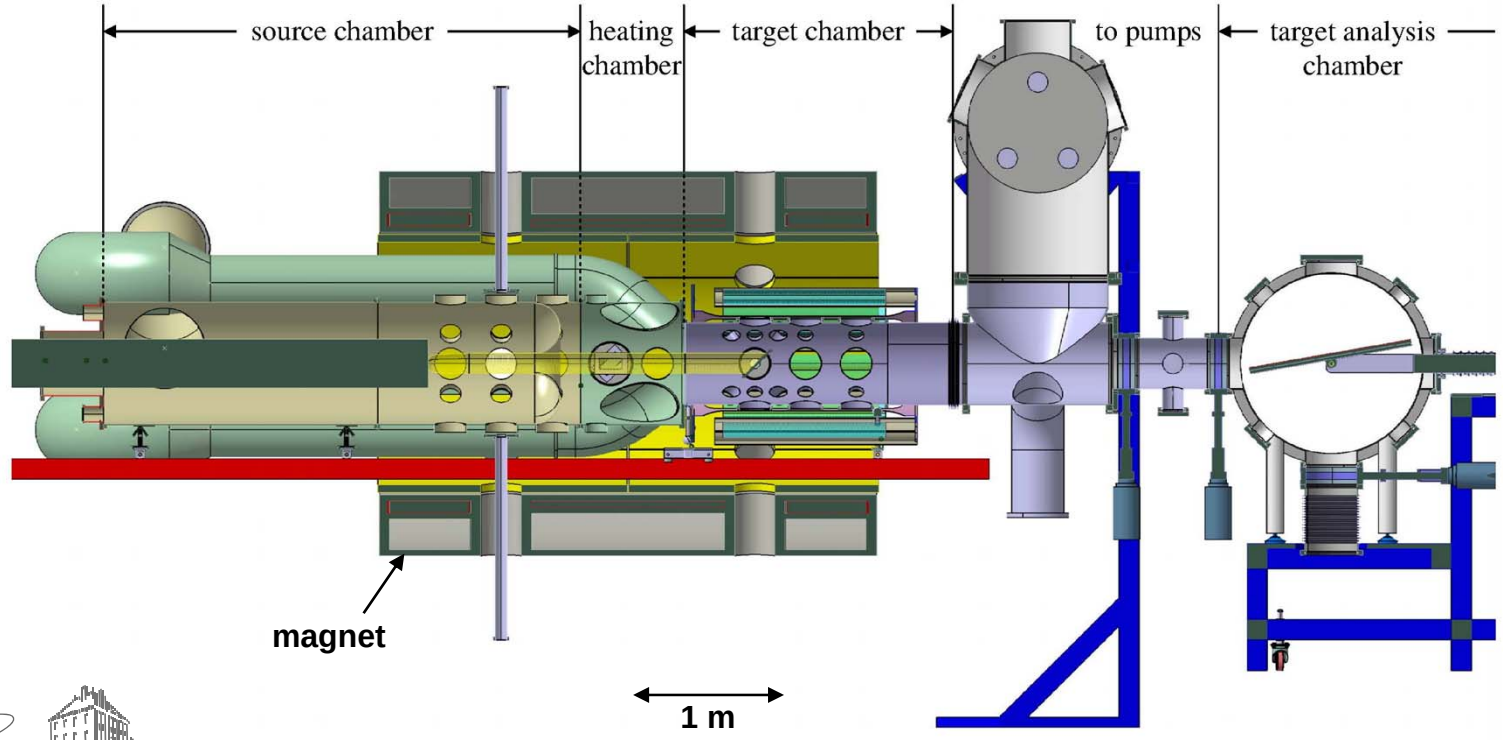
Design specifications

- 3 T steady-state, superconducting
- Plasma heating (Ohmic and helicon wave)
- ∅ 10 cm plasma column
- Inclined target

- Particle flux ~10^{24} H^+/m^2s
- Power fluxes ~10 MW/m^2
- El. density ~10^{20} m^{-3}
- El. temperature 1 – 5 eV

→ ***True*** **ITER divertor simulator**

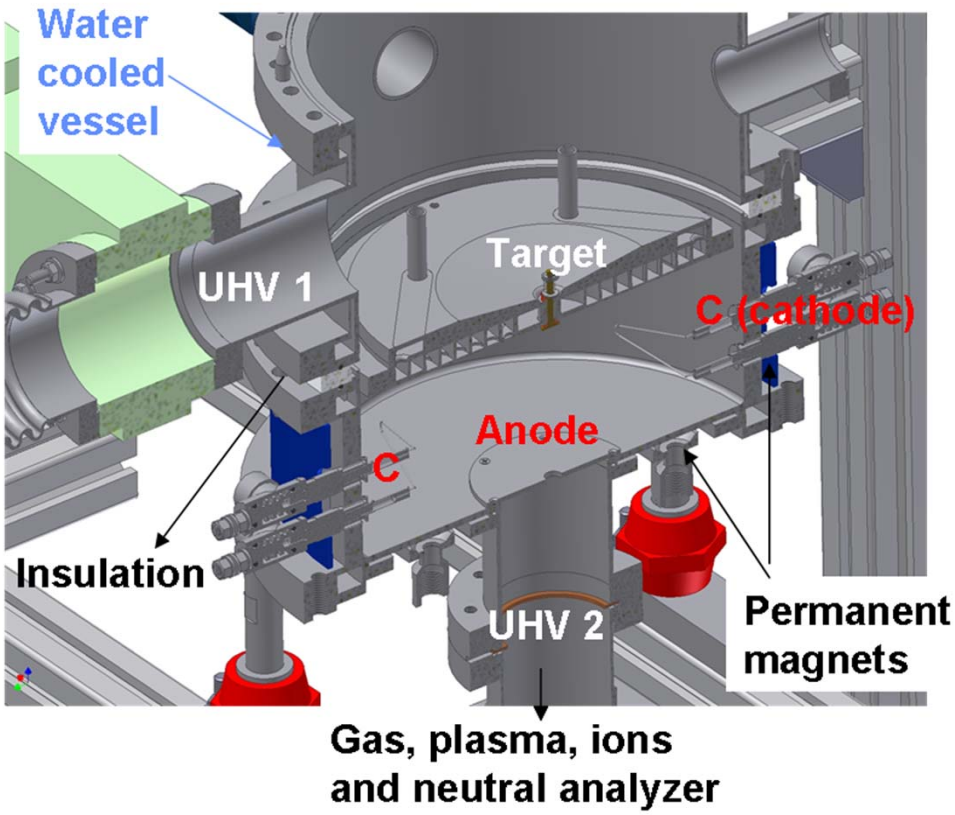
Schematic view



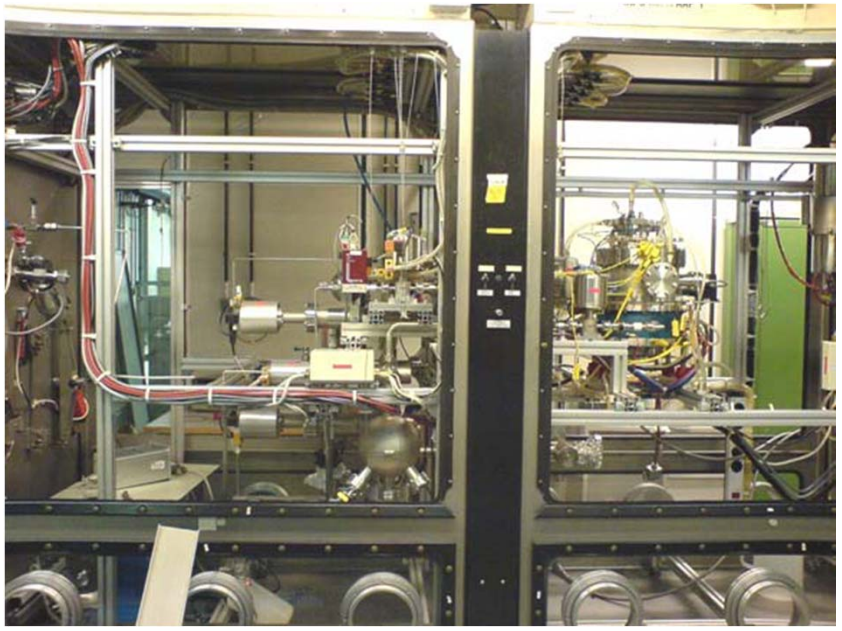
Delivery of SC magnets is scheduled for mid 2011

[J. Rapp et al., Fusion Eng. Des., in press, doi:10.1016/j.fusengdes.2010.04.009.]

Plasmatron VISION I: Versatile Instrument for the Study of Ion Interaction



Volume:	18 litres
Target diameter:	~ 24 cm
Ion energies:	20 - 500 eV
Magnetic field:	0.2T
Pulse duration:	steady state
Flux density target:	~ 10^{20}-10^{21} ions/m^2.s



Deuterium and Tritium plasma
Neutron Irradiated samples
Beryllium samples

[I. Uytdenhouwen, et al., AIP Conf. Proc. 996 (2008) 159]

JULE-PSI: Jülich Linear Experiment for PSI studies in a Hot Cell

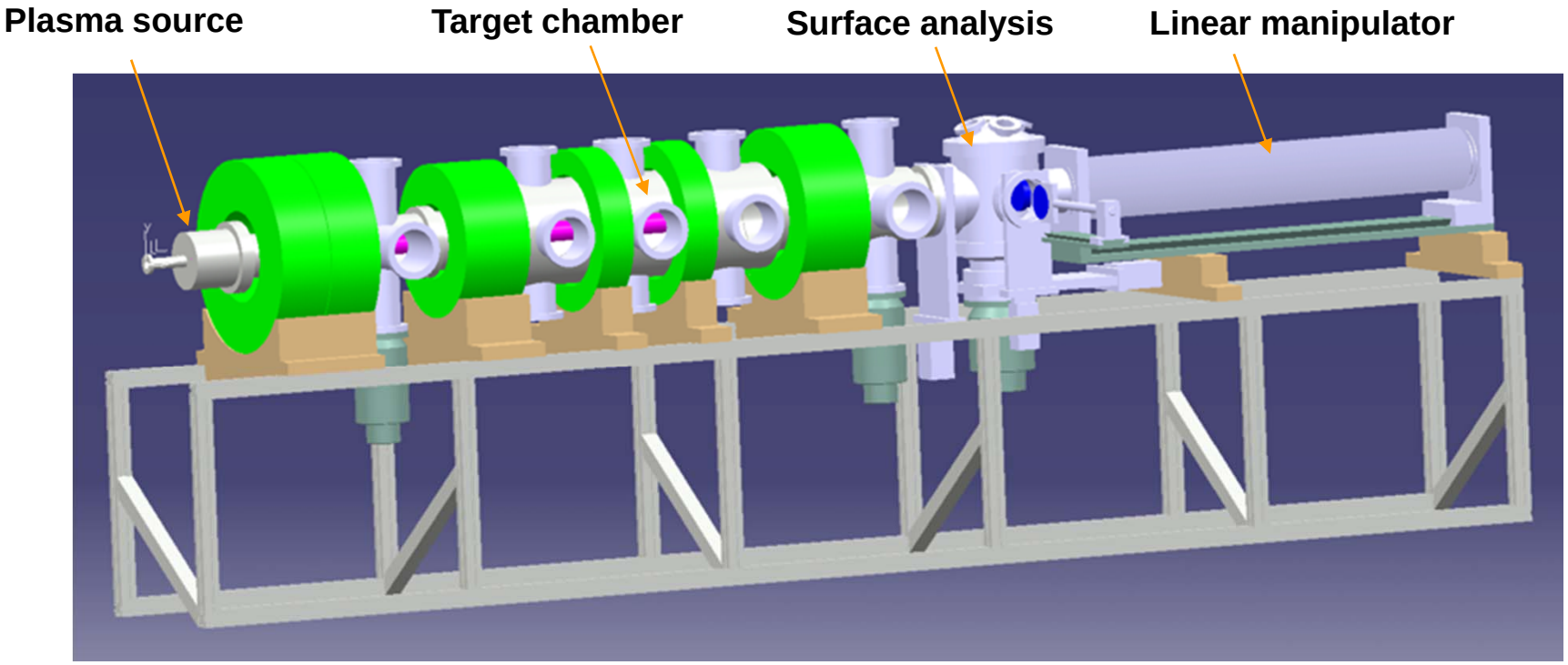
Based on PSI-2 / PISCES type device

Installation in a Hot Cell for handling of *radioactive* and *toxic* materials

PMI studies with

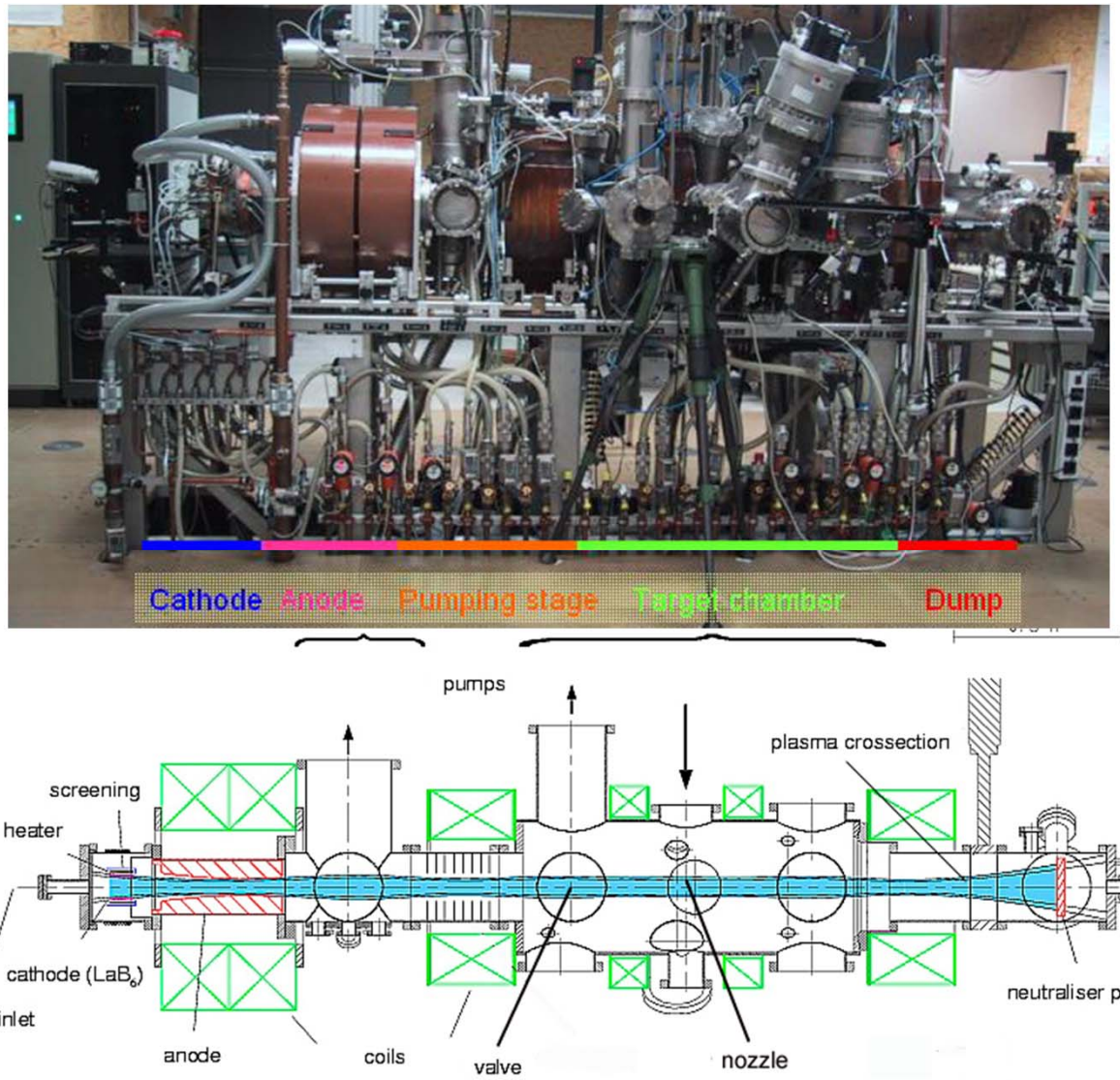
- **Neutron irradiated materials**
- **All wall materials incl. Beryllium**
- **Low quantities of Tritium**

Schematic view



PSI-2: pilot experiment of JULE-PSI

Formerly at IPP (Humboldt Univ), Berlin



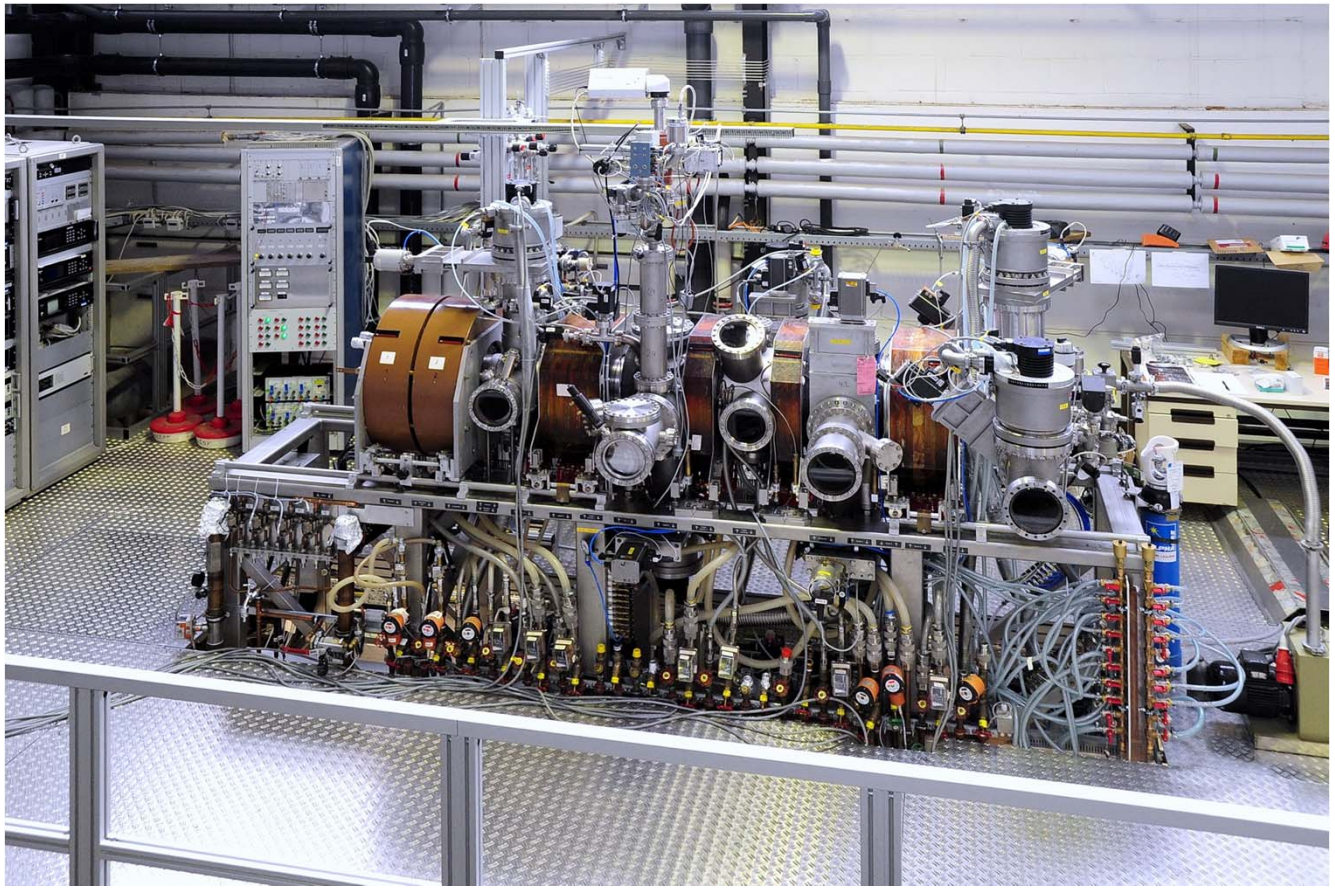
PSI-2: pilot experiment of JULE-PSI

Existing PSI-2 as forerunner experiment, not in hot cell

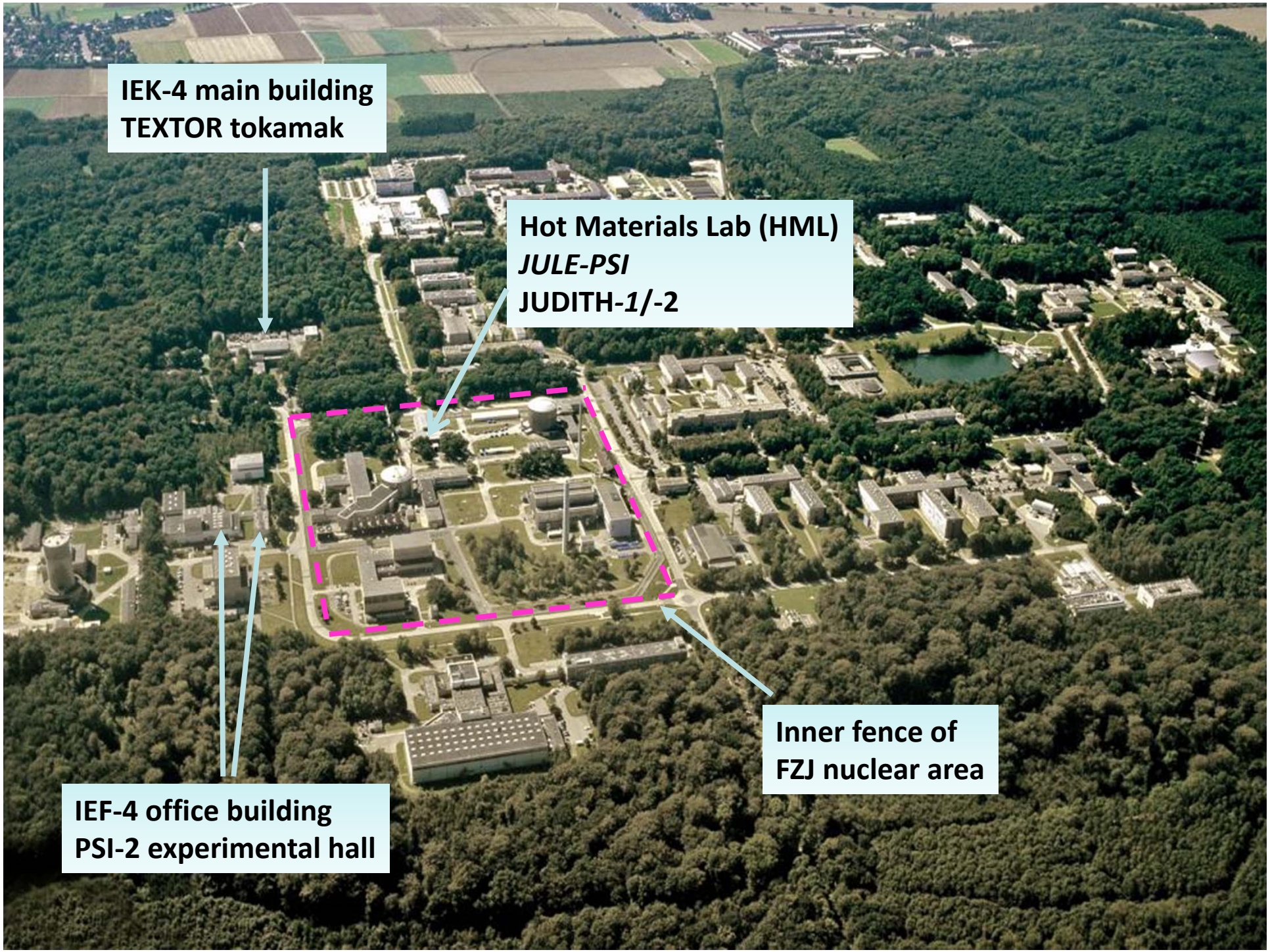
→ Transferred from IPP (Humboldt Univ), Berlin to FZJ in October 2009

→ First plasma scheduled for January 2011

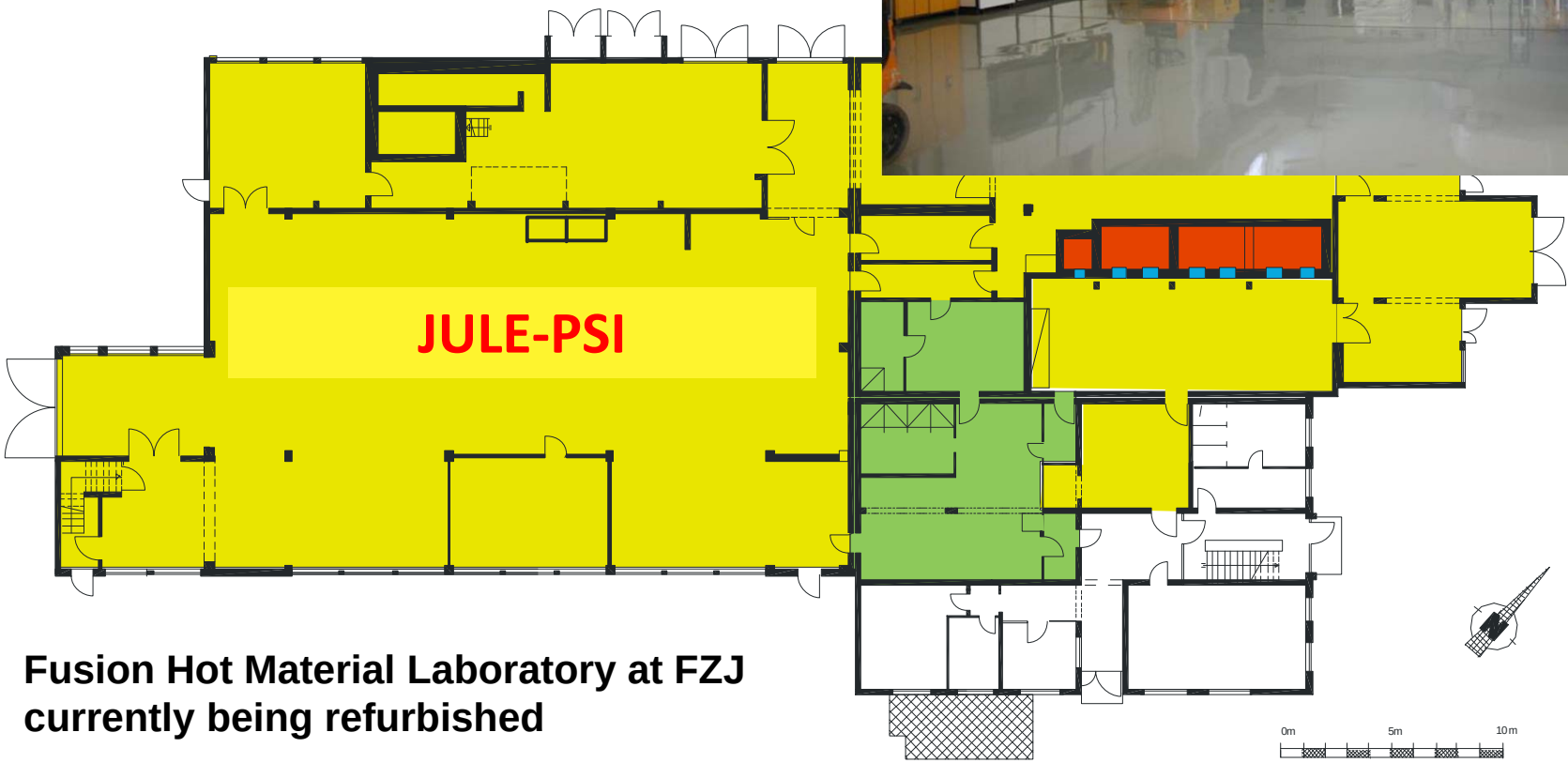
Installation in FZJ



All (diagnostic) components and solutions for JULE-PSI will be tested on PSI-2

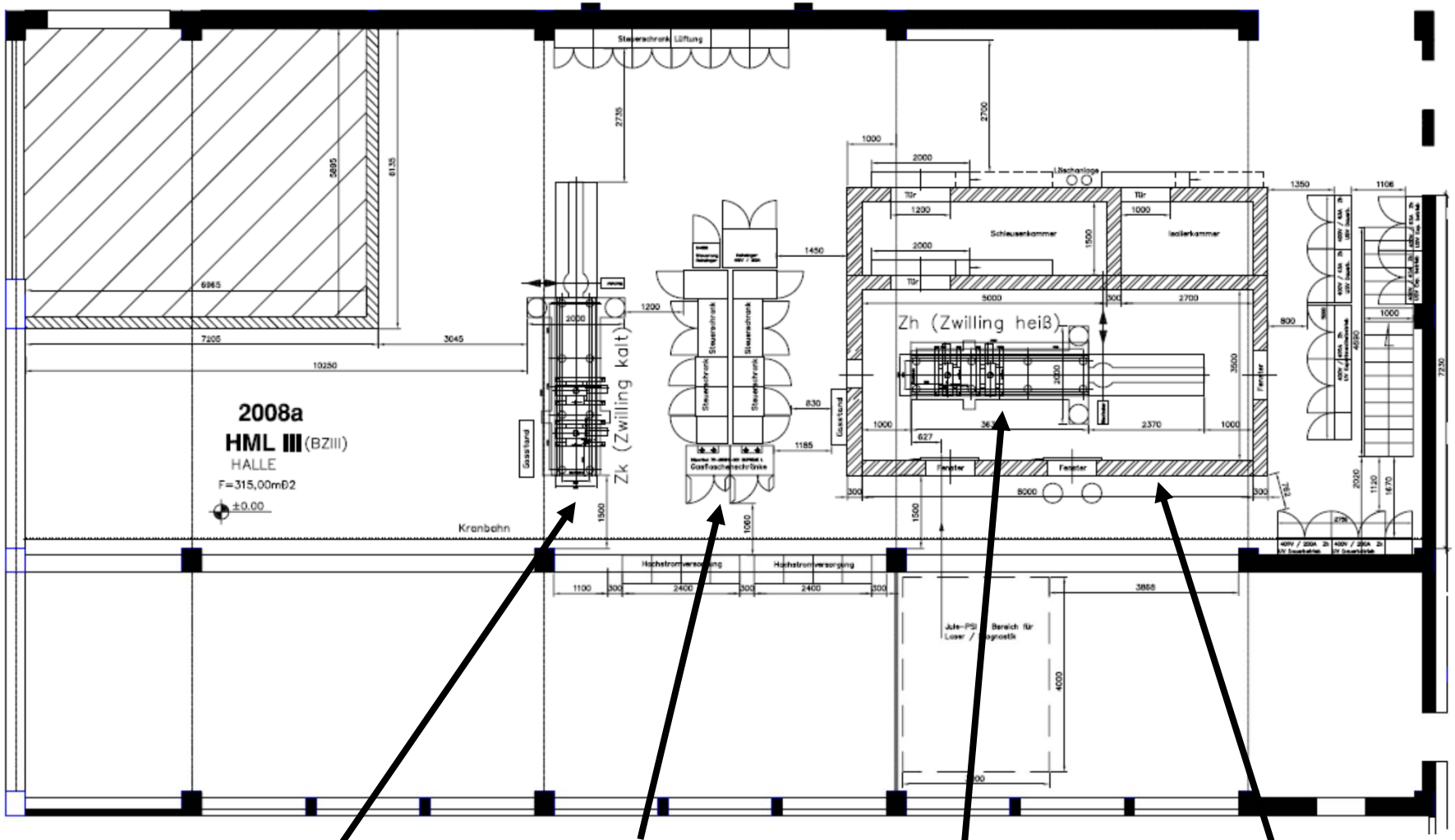

IEK-4 main building
TEXTOR tokamak
Hot Materials Lab (HML)
JULE-PSI
JUDITH-*1*/-2
Inner fence of
FZJ nuclear area
IEF-4 office building
PSI-2 experimental hall

Hot Materials Lab (HML) planning



Fusion Hot Material Laboratory at FZJ currently being refurbished

JULE-PSI Lab planning



Diagnostics concept for JULE-PSI

JULE-PSI will be in nuclear environment with limited access, and so the diagnostics

→ Reliability and easy maintenance are necessary

Plasma diagnostics (information on background plasma)

- **Optical spectroscopy**
- **Langmuir probe**

In-situ PMI diagnostics

- **Optical spectroscopy**
- **IR thermography**
- **Quartz microbalance (QMB)**

In-vacuo sample analysis

Target station: linear manipulator and surface analysis station with laser-aided analysis methods (LID, LIA, LIBS) → Talk by A. Huber

Ex-situ sample analysis

- **Thermal desorption spectrometry (TDS) – cold and hot**
- **Glow discharge spectroscopy – cold and hot**
- **SEM / EDX, metallography – cold and hot**
- **Ion beam analyses: NRA, RBS,.. – cold only**
- **SIMS, XPS,.. – cold only**

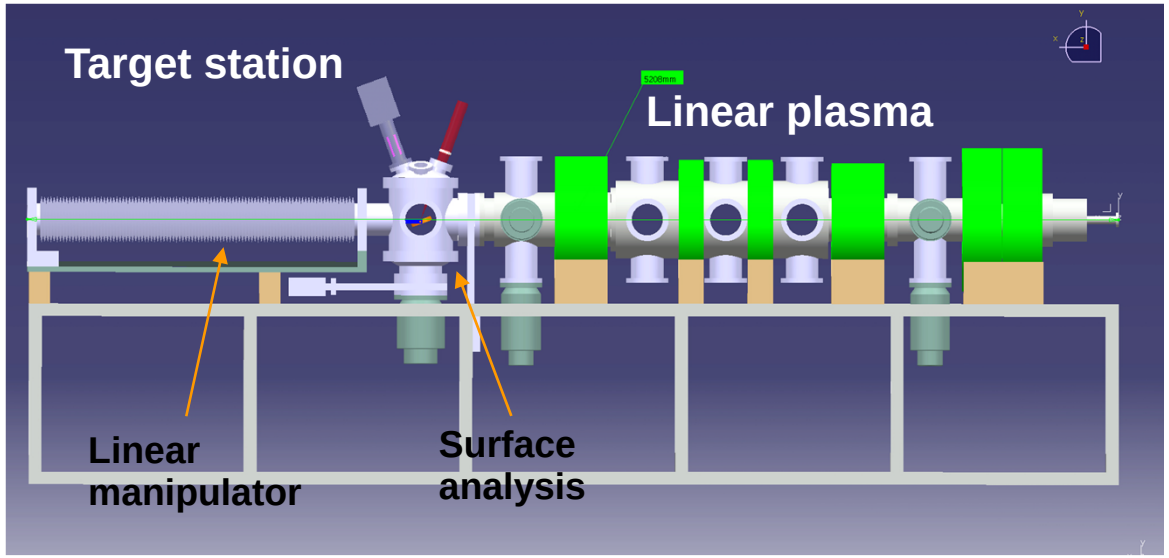
Target station of JULE-PSI

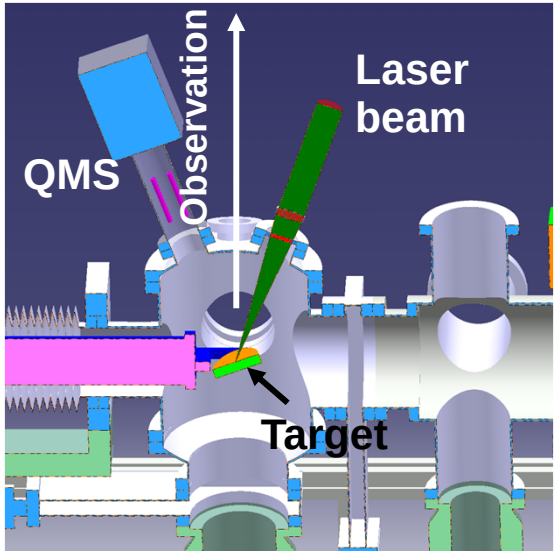
Based on design of target station for Magnum-PSI (by FZJ)

Equipped with laser-aided analysis techniques:

- **Laser Induced Desorption (LID)**
- **Laser Induced Ablation (LIA)**
- **Laser Induced Breakdown Spectroscopy (LIBS)**

Schematic view





JULE-PSI time schedule

2009	**Transfer of PSI-2 from Berlin to Jülich**
2010 - 2011	**Construction and upgrade of PSI-2 to pilot device (new target station, dedicated PWI diagnostics, optimization of source and vacuum chamber) – financial support FZJ funding**
2010 - 2011	**Upgrade of HML building for hot operation – financial support local state NRW**
2011	**Commissioning of existing hot cells** **Installation of surface analysis station for fuel retention in Be**
2011	**Start of detailed design for hot plasma device**
2012 - 2014	**Installation of supply systems and analytic labs , construction of JULE-PSI**
2015	**Commissioning of plasma device in hot cell**