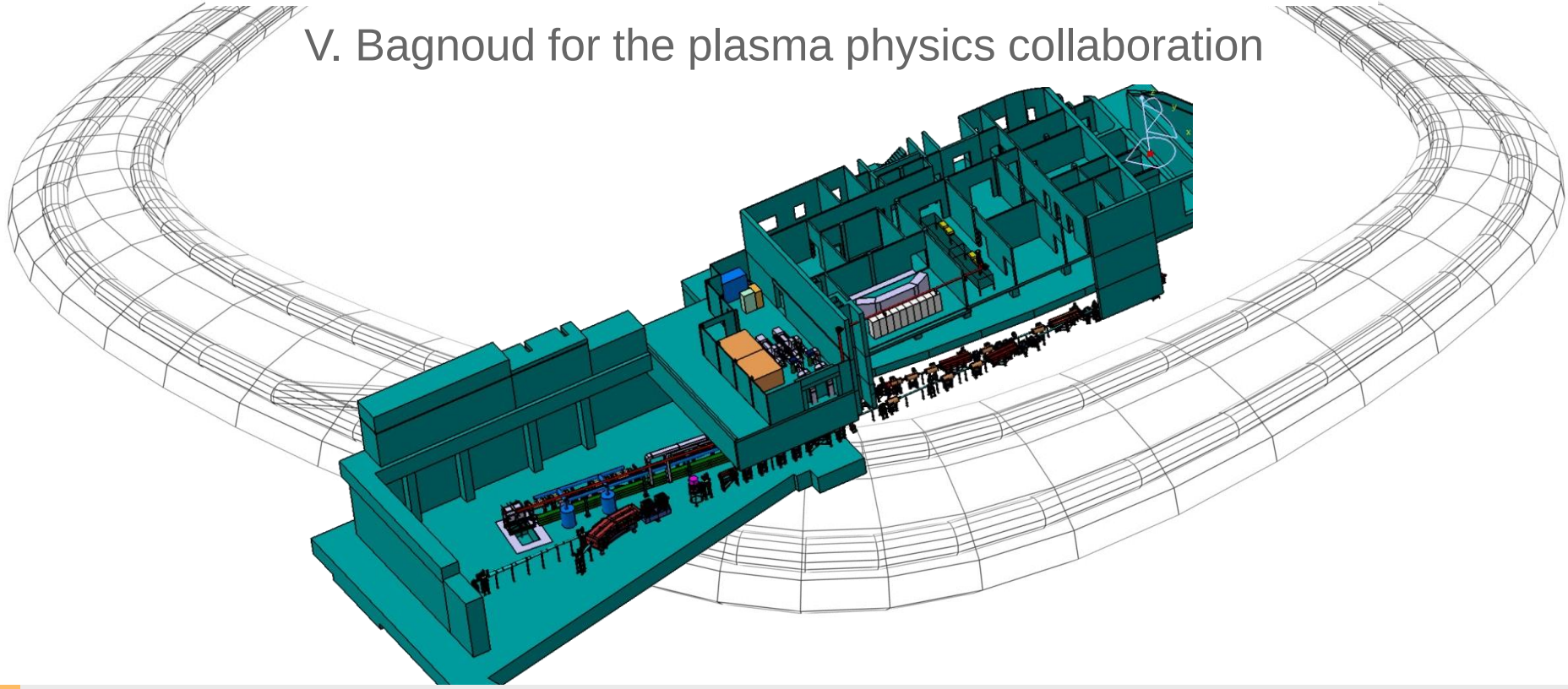
APPA Plamas: The plasma physics program at FAIR

V. Bagnoud for the plasma physics collaboration

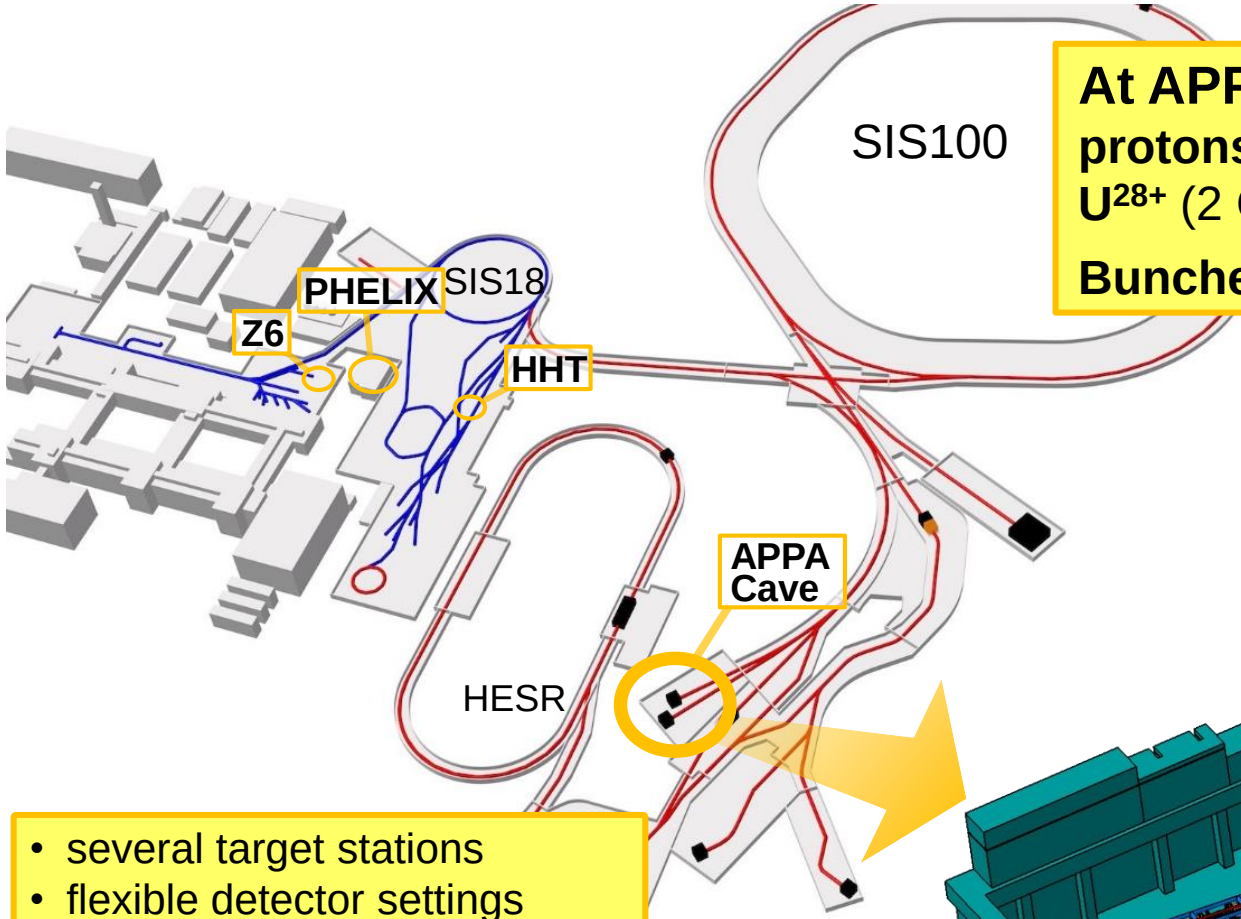


Summary

FAIR is a very attractive driver for plasma physics

- FAIR is pertinent to plasma physics with applications to some outstanding planetary science questions.
- Compared to other drivers, FAIR offers many unique advantages: quasi-equilibrium and mesoscopic scales.
- FAIR-generated plasma require powerful diagnostics.
  - pump-probe setups are standard in plasma physics
  - laser-generated sources of particles (ions, electrons) used to generate tertiary sources (neutrons, X-rays) offer the most promising solution for direct measurement of plasma parameters

Plasma physics infrastructure at GSI and FAIR

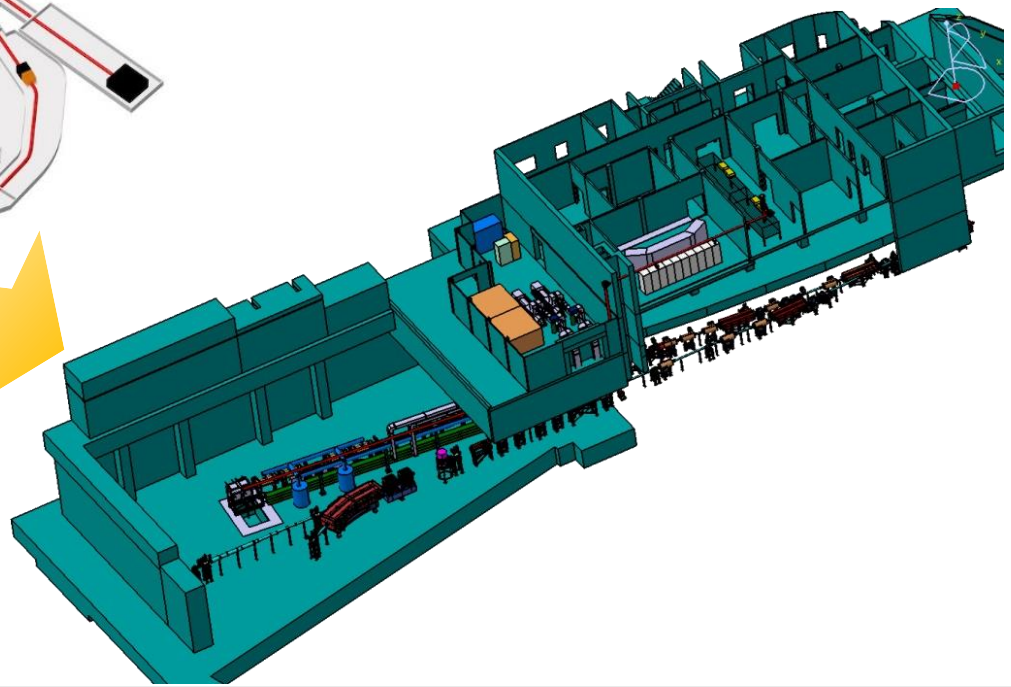


At APPA-cave:

protons (10 GeV): 2 x 10^{13} p/bunch

U^{28+} (2 GeV/u): 5 × 10^{11} ions/bunch

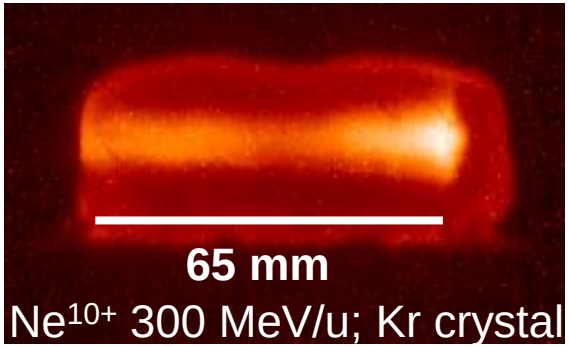
Bunched operation: ≈100ns



- several target stations
- flexible detector settings
- flexible beam shaping
- external drivers (HE-laser, pulsed power, gas gun, ...)

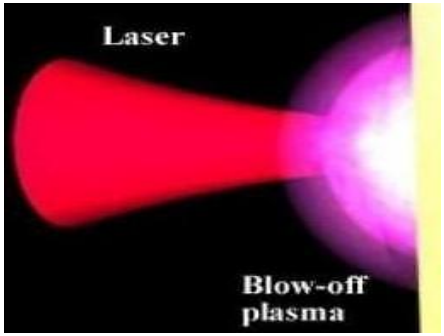
FAIR-generated plasmas are complementary to those obtained with other drivers

Intense, energetic beams of heavy ions (GSI & FAIR)



large sample volume (mm^3)
uniform physical conditions
any target material
long time scales (50 ns)

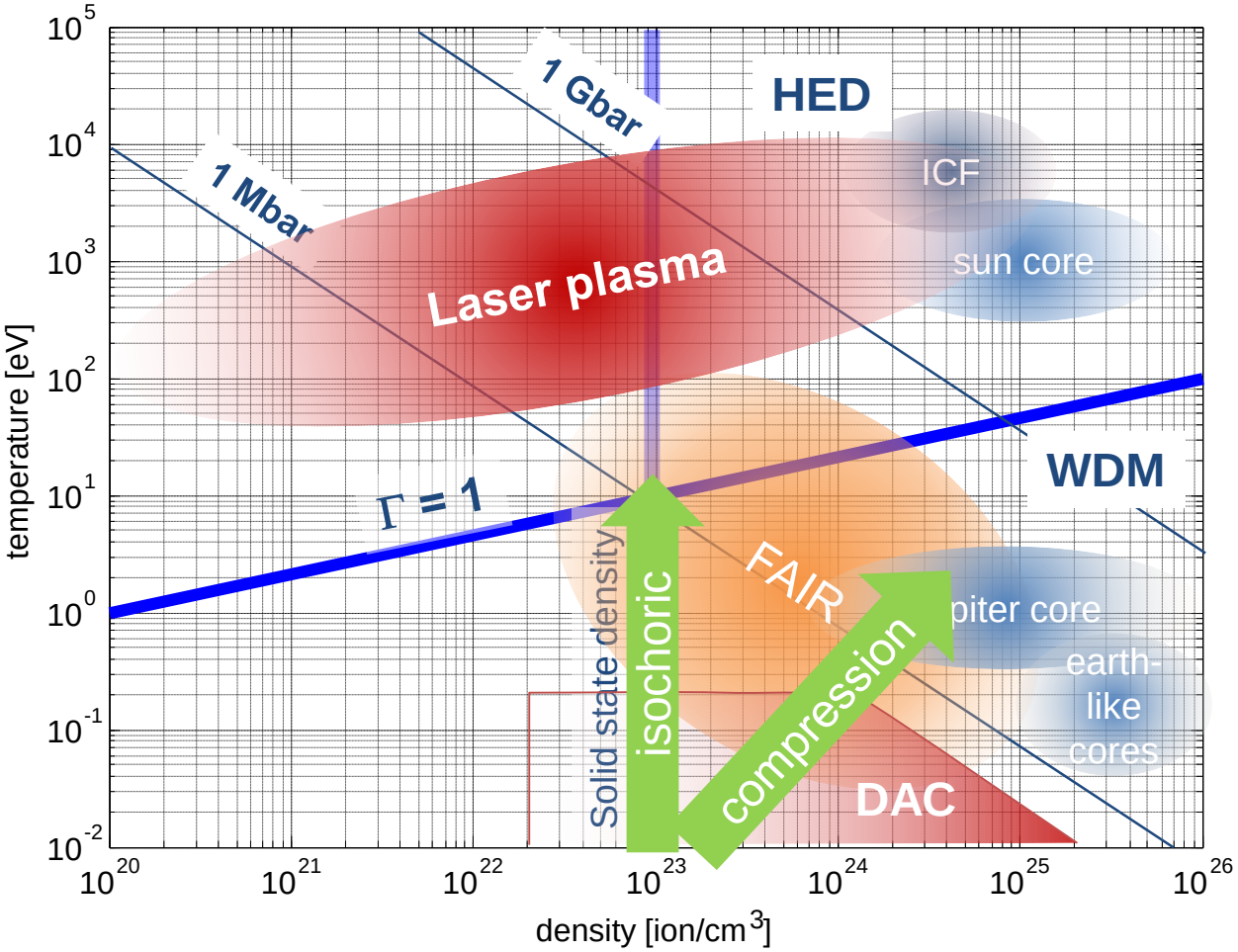
High-brilliance XUV photon sources (XFEL & DESY)



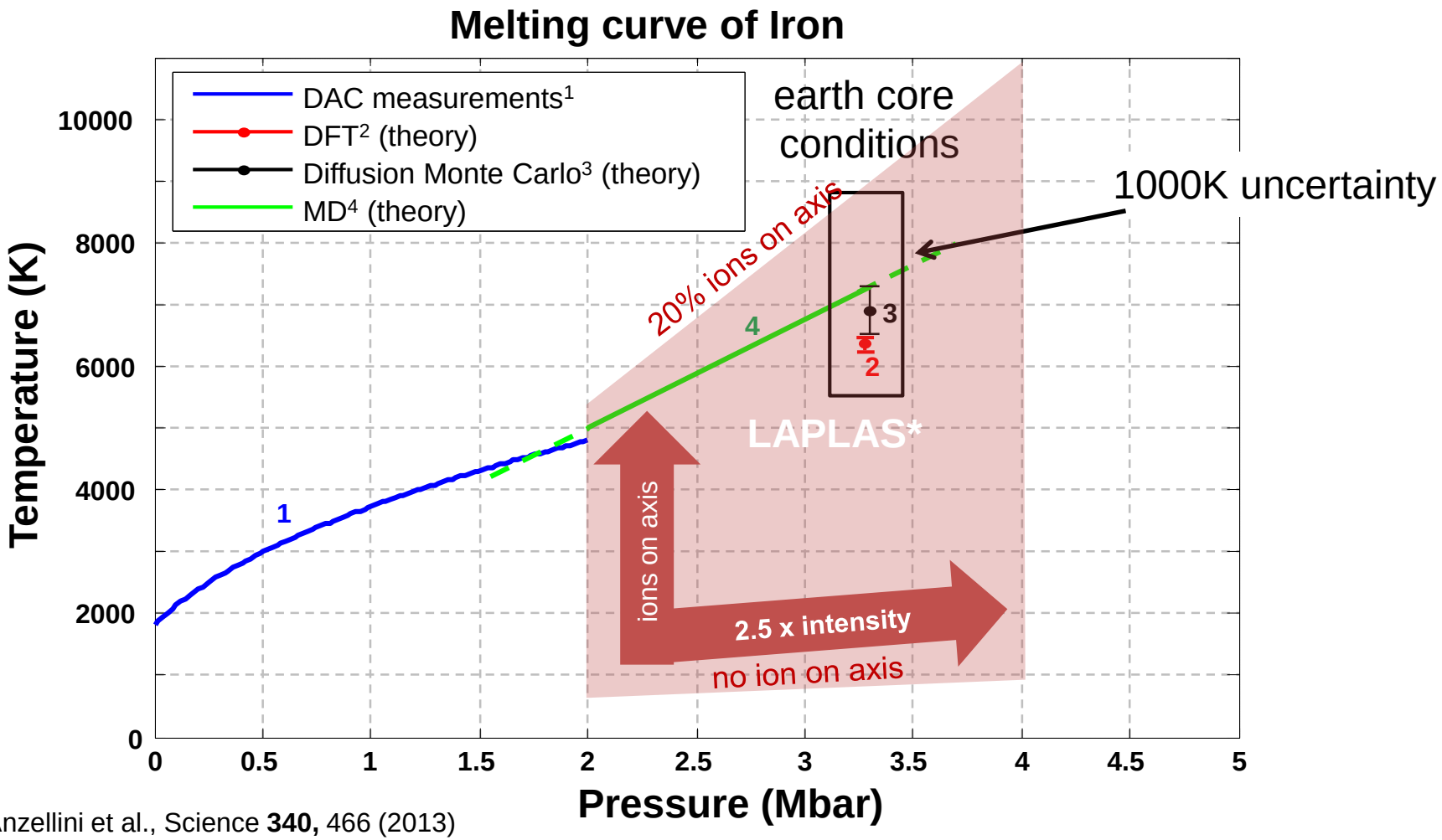
small sample volume (100 μm^3)
high gradients
low-Z target material
short time scales (100 fs)

- **Advantages of FAIR-generated plasma:**
  - **large samples**
  - **local thermodynamical equilibrium**
  - **uniform samples**

FAIR offers a unique alternative to other driver techniques



FAIR is ideal to study iron using the LAPLAS scheme

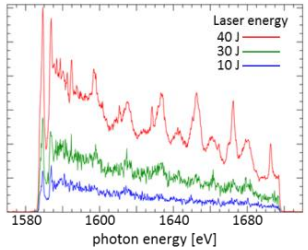


1. S. Anzellini et al., Science **340,** 466 (2013)
2. D. Alfè et al., Phys. Rev. B **79**, 060101 (2009)
3. E. Sola et al., Phys. Rev. Lett. **103** , 078501 (2009)
4. A. B. Belonoshko et al., Phys. Rev. Lett. **84**, 3638 (2000)

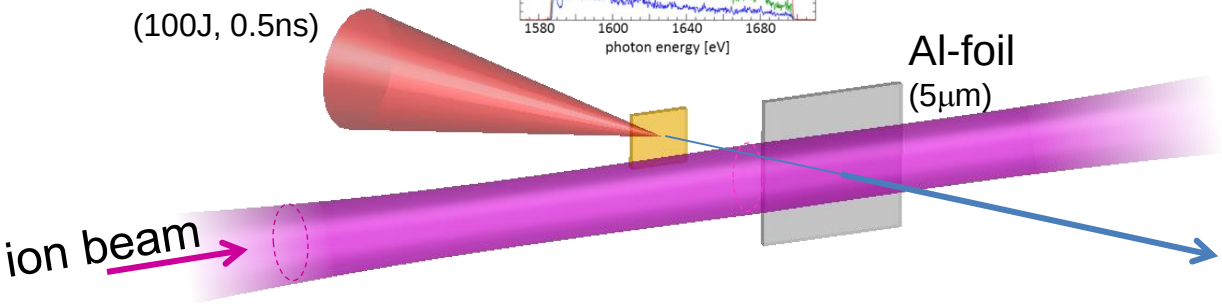
* calculations by N. Tahir (to be published)

Ionization potential depression will be studied at FAIR (already in phase 0)

- **Ionization Potential Depression (IPD) is an outstanding issue in plasma physics**
- **Recent experiments in dense plasmas shows significant discrepancies**
- **FEL- and Laser-produced plasmas: hot, highly non-equilibrium, inhomogeneous**

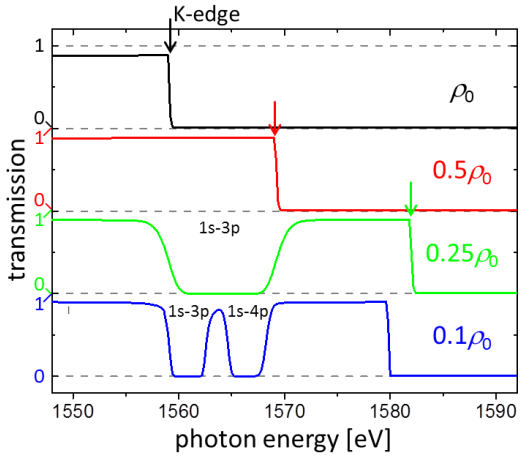


High-power laser drives x-ray source for probing



- Rapid heating by intense heavy-ion pulse
- Hydro-expansion to ρ =10%...50% ρ_0

Absorption spectra

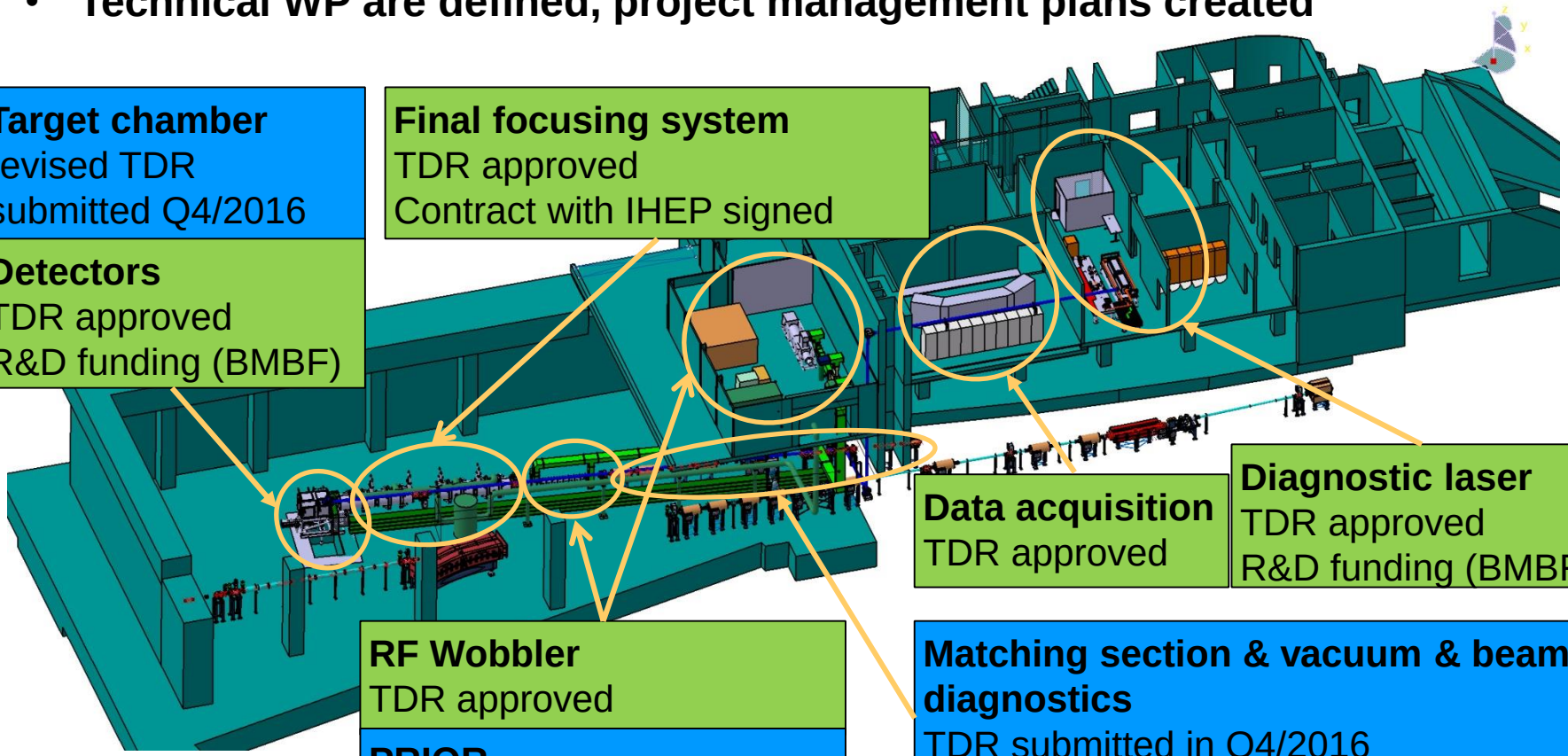


- K-edge shift
- M-shell rebinding

Experiment at FAIR will access transition from metal to dense atomic gas

Status of the plasma physics Beamline

- **Most TDRs are approved**
- **The last TDRs are being evaluated**
- **Technical WP are defined, project management plans created**



Target chamber
revised TDR
submitted Q4/2016

Final focusing system
TDR approved
Contract with IHEP signed

Detectors
TDR approved
R&D funding (BMBF)

Data acquisition
TDR approved

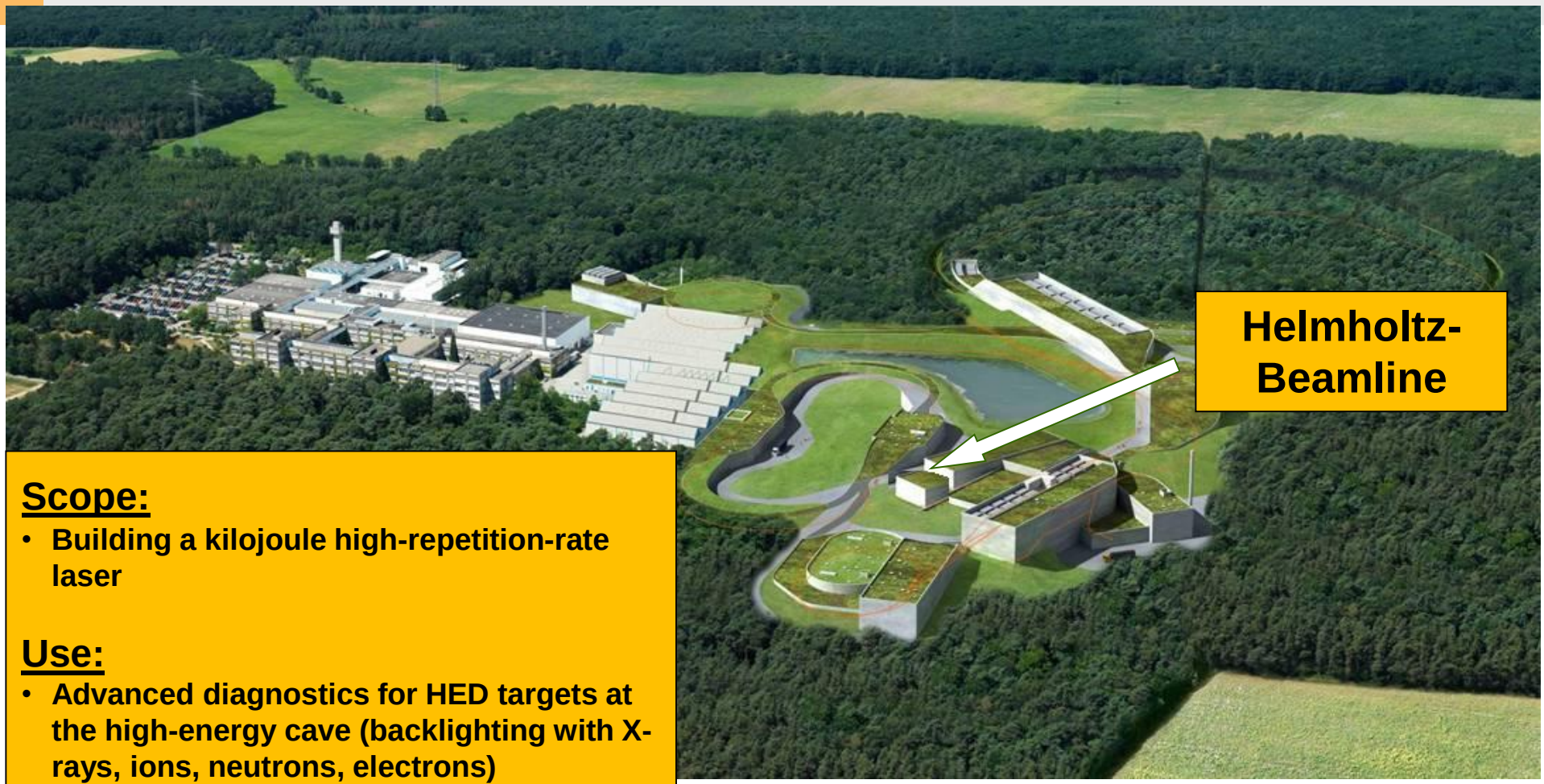
Diagnostic laser
TDR approved
R&D funding (BMBF)

RF Wobbler
TDR approved

PRIOR
TDR submitted in Q4/2016

Matching section & vacuum & beam diagnostics
TDR submitted in Q4/2016

The Helmholtz Beamline at FAIR



Scope:

- **Building a kilojoule high-repetition-rate laser**

Use:

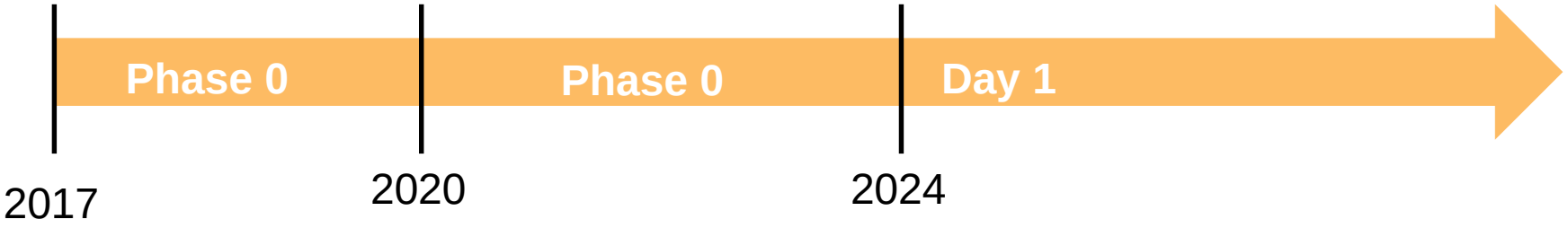
- **Advanced diagnostics for HED targets at the high-energy cave (backlighting with X-rays, ions, neutrons, electrons)**
- **Relativistic laser-ion interactions in the nearby HESR hall**

Time-line

- **PHELIX**
- **Laser-ions (Z6)**

- **PRIOR at HHT**
- **PHELIX @ HHT**

- **PRIOR in APPA cave**
- **HIHEX with 100 J Backlighter**



- **in the phase 0:**
  - **preparation experiments with PHELIX – 12 campaigns/years**
  - **PRIOR (from 2018)**
  - **R&D: Diagnostics/Laser**
- **in the starting phase (day 1)**
  - **PRIOR**
  - **HIHEX scheme**
  - **100 J laser**

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Thank You!