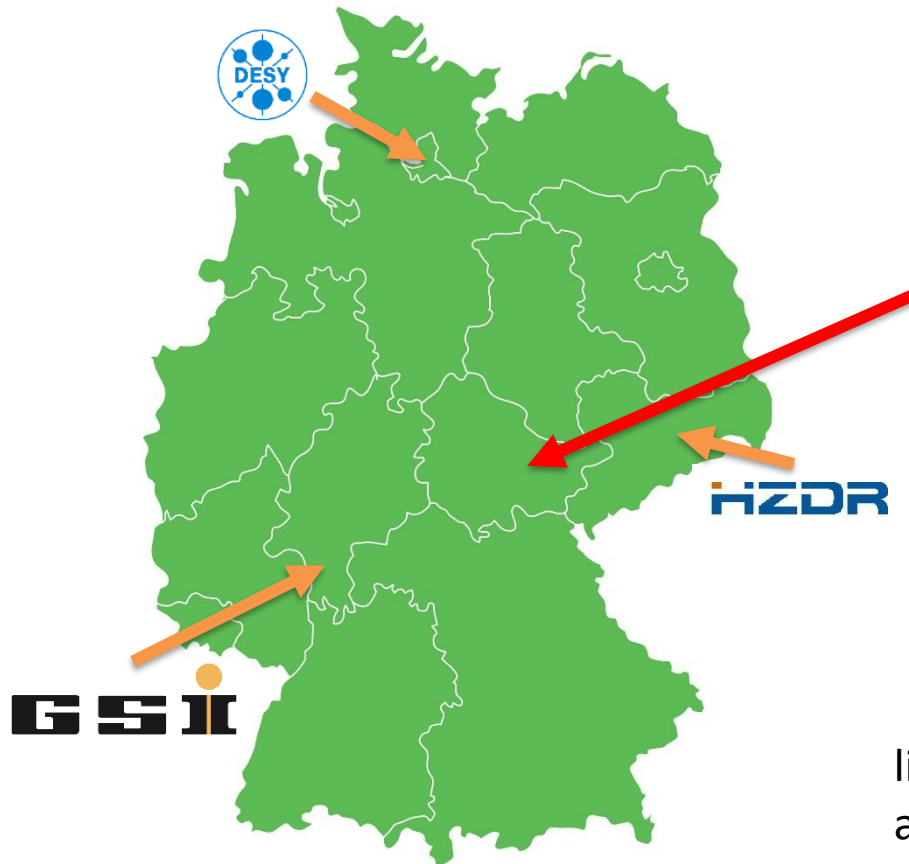


# A Control System for Helmholtz Institute Jena

Dominik Hollatz

37th Tango Community Meeting  
SKAO, Jodrell Bank, England  
06/27/2023

# Helmholtz Institute Jena



link between traditional accelerators (GSI)  
and laser driven particle accelerators (UNI Jena)

Close collaboration with



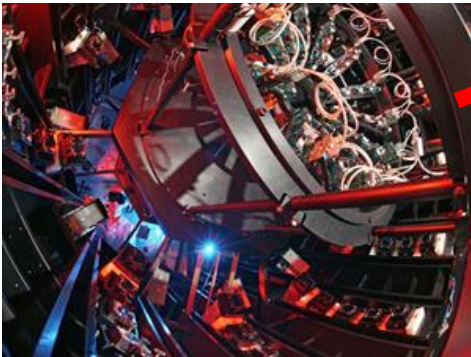
FRIEDRICH-SCHILLER-  
UNIVERSITÄT  
JENA

**HI JENA**  
Helmholtz Institute Jena

[www.hi-jena.de](http://www.hi-jena.de)

# High intensity lasers @ HI Jena & IOQ (2023)

## POLARIS



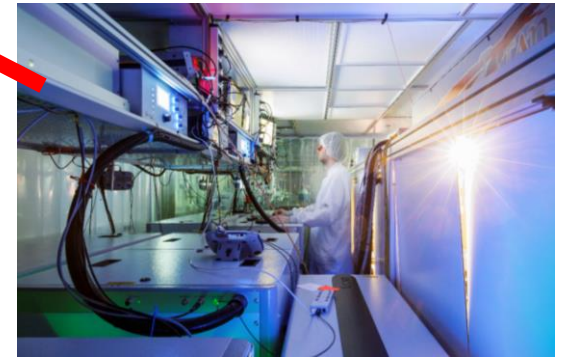
Wavelength: 1030 nm  
Energy on target: 16 J (54 J)  
Pulse duration: 100 fs  
Peak power: 160 TW  
Repetition rate: 1/50 Hz



located in the same building  
but operated completely  
independent

- individual staff
- 1 POLARIS Target Area
- 2 JETi200 Target Areas

## JETi200

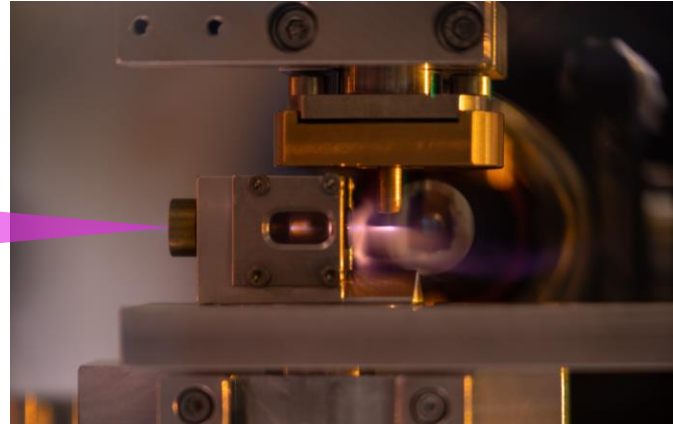


Wavelength: 800 nm  
Energy on target: 5 J  
Pulse duration: 17 fs  
Peak power: 300 TW  
Repetition rate: 5 Hz

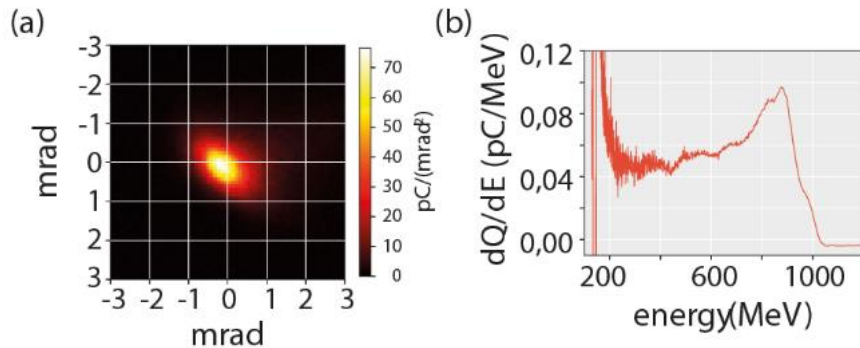
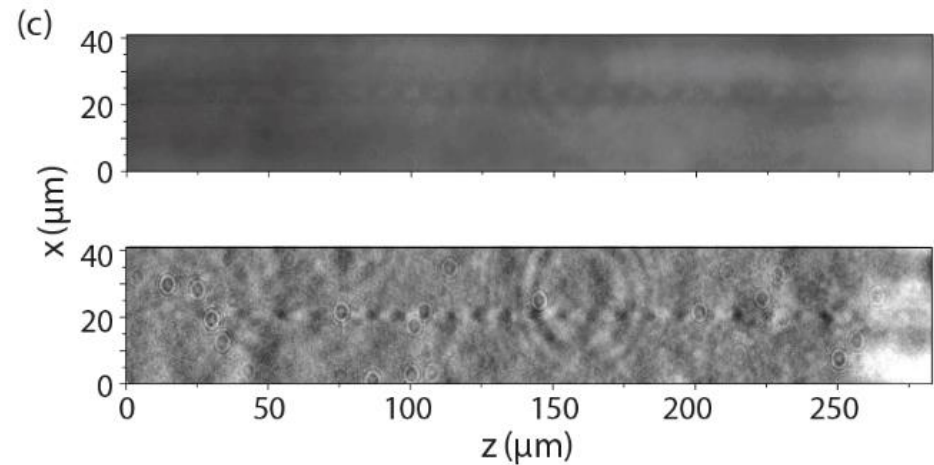


# Laser & Particle driven wakefield acceleration @JETi 200

## Electron acceleration



## Few-cycle microscopy with 5 fs NIR pulses

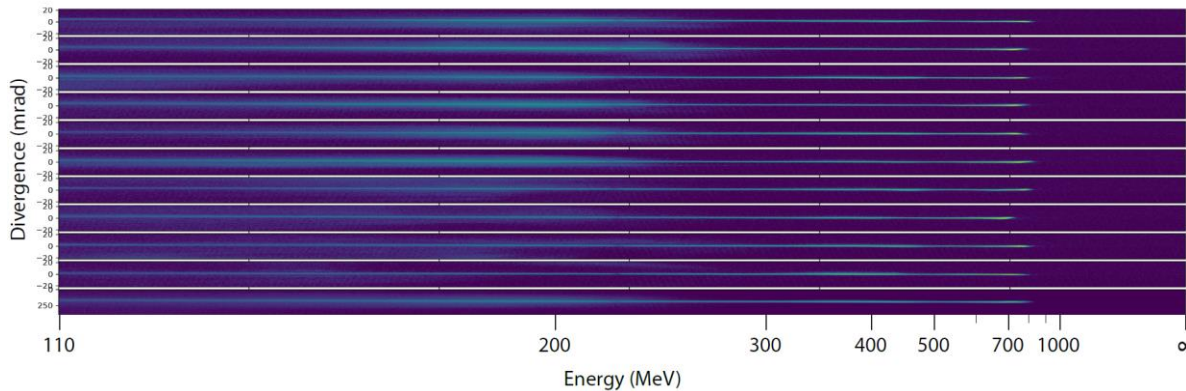


sub 1 mrad divergence & 70 pC charge  
in depicted energy range

**Evidence of electron driven plasma wave!  
Shadowgraphy & electron spectra**

# Electron acceleration to GeV level

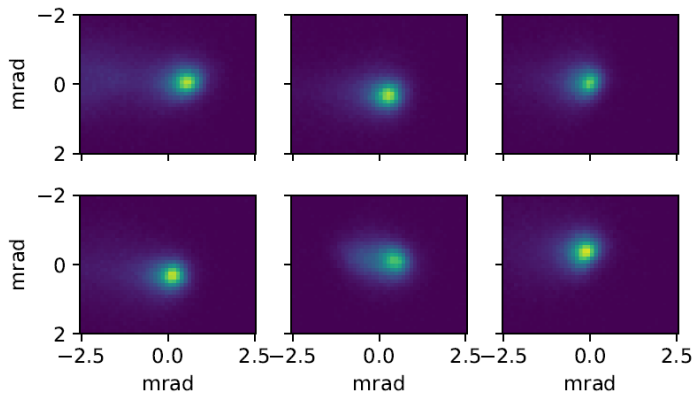
LWFA with ionization injection (95% He, 5% N<sub>2</sub>)



Optimization parameter for particle beams

- peak energy
- bandwidth
- charge
- pointing

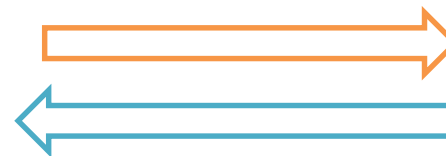
to get FEL quality.



- GeV beams with ultra low beam divergence  $< 0.5 \text{ mrad}^2$
- pointing fluctuations on same order as divergence
- new target design for bandwidth control

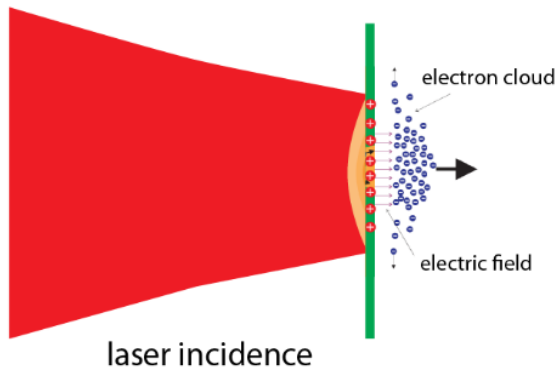


Online laser diagnostic & control



Experiment

# Ion acceleration @JETi200 with Nanofoils

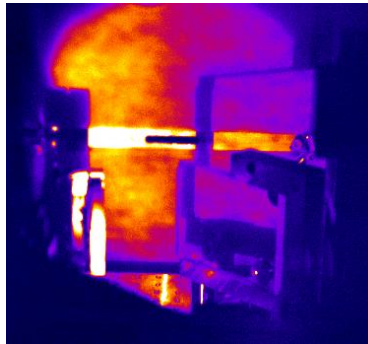


Peak intensity:  $2 \times 10^{21}$  W/cm<sup>2</sup>

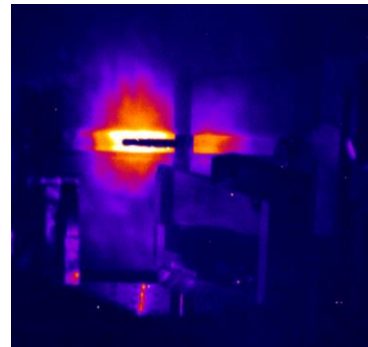
- circular polarization
- single plasma mirror
- variable pre-pulse

Target: 30 nm Formvar

Transmission screen



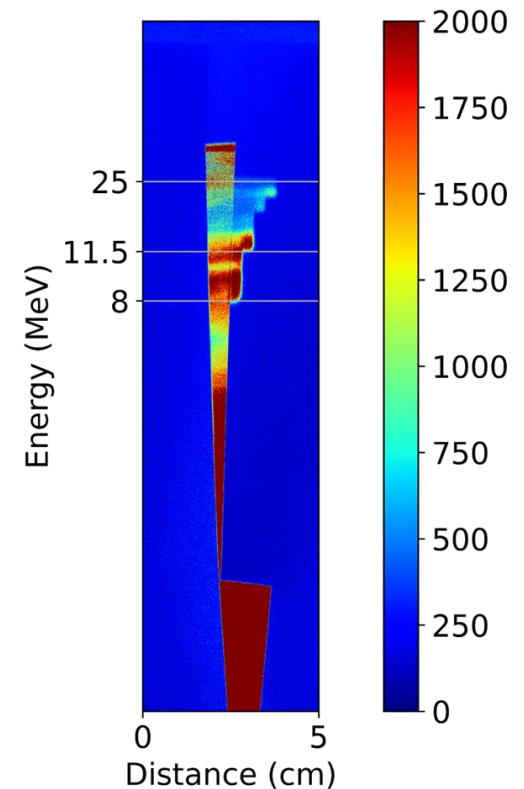
without target



with optimized pre-pulse

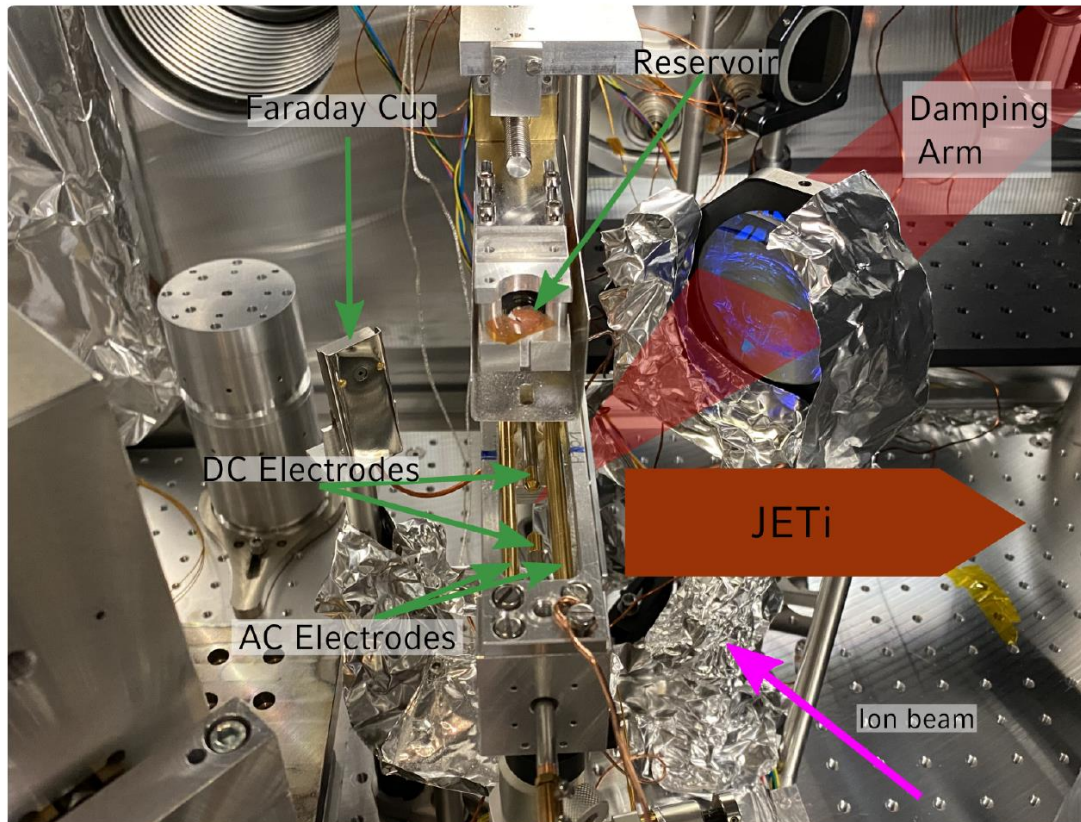
**Entering relativistic transparency regime**

Wide angle spectrometer

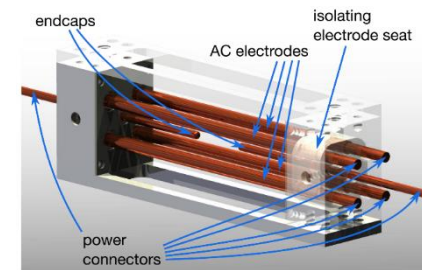


**Proton cut off energy: > 20 MeV  
with monoenergetic features**

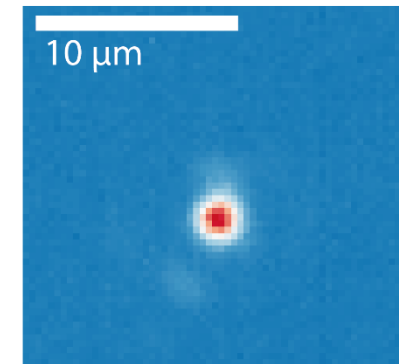
# Ion acceleration @JETi200 with true masslimited targets



Paul trap from Jörg Schreiber's group (LMU)



Paul trap



focal spot:  $d_{(FWHM)} = 2 \mu\text{m}$   
copper parabola

- First Tango Control System at Helmholtz-Institute Jena
- 5 Device Classes / 16 Devices (Motors, Cameras, logical DS / sequencer)
- shot preparation time reduction from 50 min to 5 min



# HI Jena extension





# HI Jena extension



**Ceremonial inauguration on 3<sup>rd</sup> of November 2022**

**HI JENA**  
Helmholtz Institute Jena

[www.hi-jena.de](http://www.hi-jena.de)

# HI Jena extension





# Target Area Fraunhofer -TAF (May 2023)



TAF experimental chamber by  
6 m x 2.5 m x 1 m



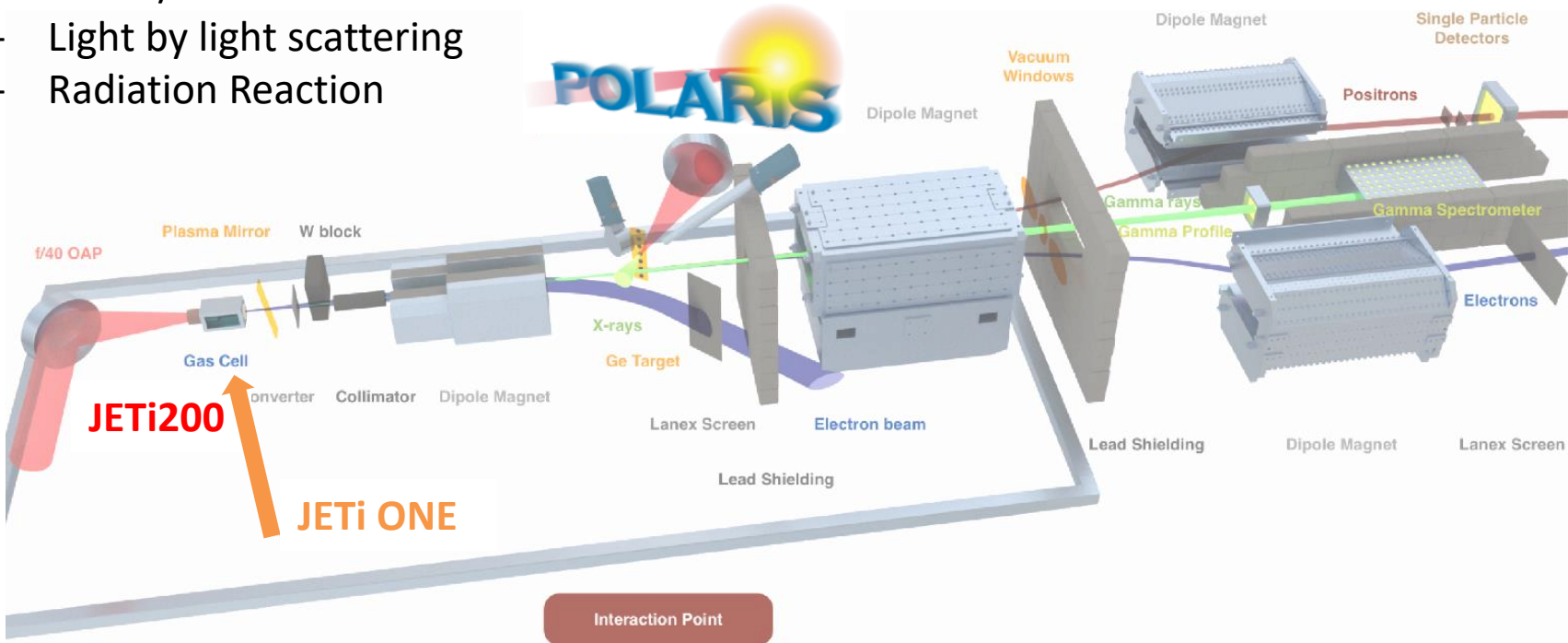
**HI JENA**  
Helmholtz Institute Jena

[www.hi-jena.de](http://www.hi-jena.de)



# Flag ship experiments at TAF / 2025 and beyond

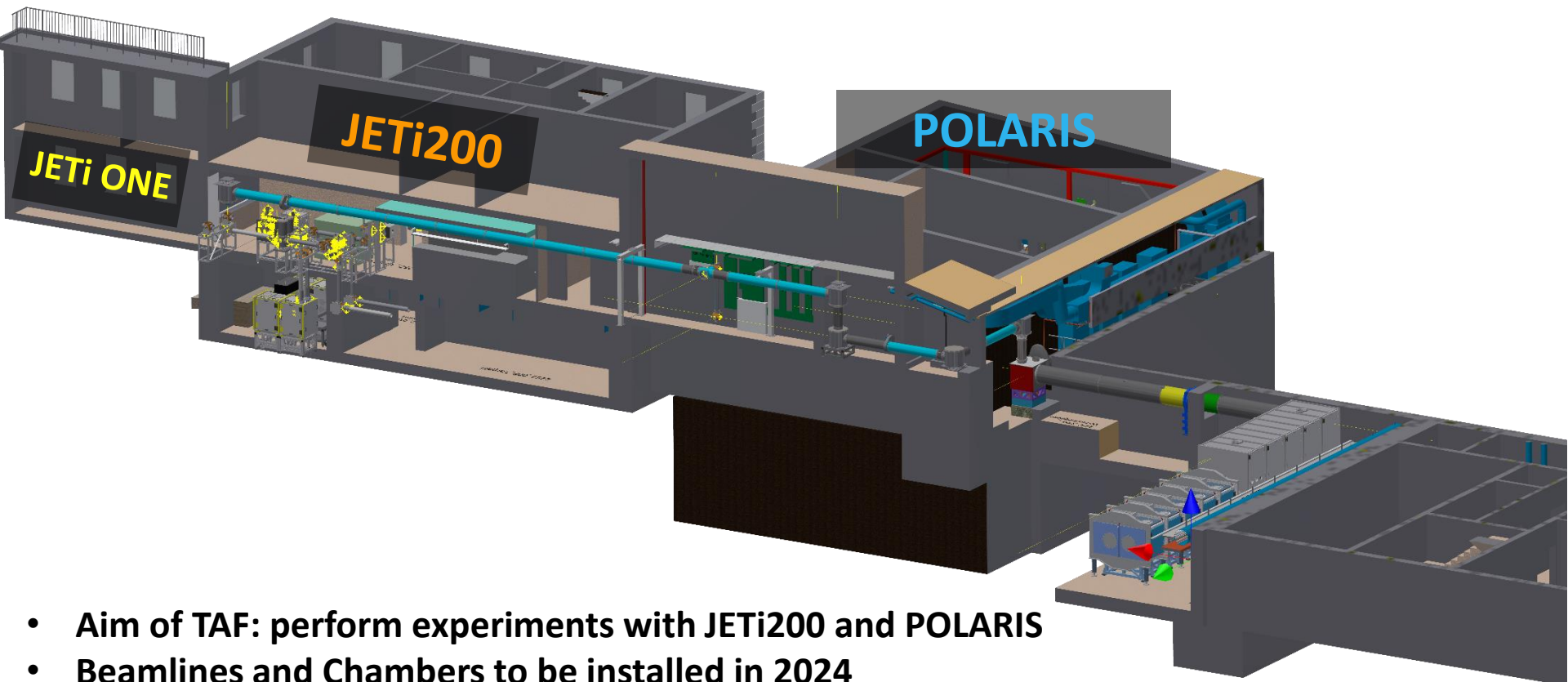
- Thomson scattering
- Linear/non-linear Breit-Wheeler experiments
- Light by light scattering
- Radiation Reaction



Few-cycle option for probing from 800 nm up to 7  $\mu\text{m}$  wavelength.

**Temporal ( $\sim 10$ s fs) and spatial overlap ( $< 3 \mu\text{rad}$ ) crucial.**

# Target Area Fraunhofer –TAF



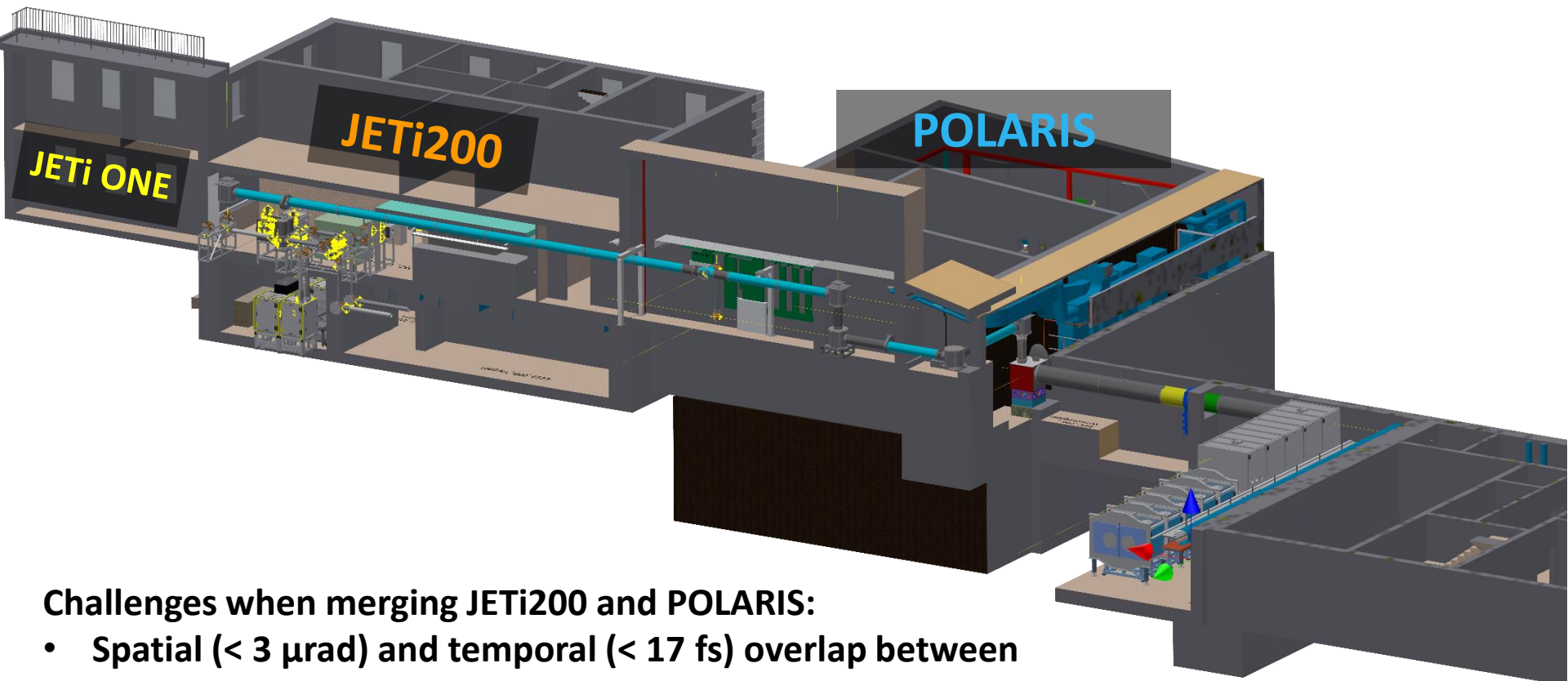
- Aim of TAF: perform experiments with JETi200 and POLARIS
- Beamlines and Chambers to be installed in 2024
- First experiments starting late 2025
- Upgrades on both lasers underway
  - JETi ONE, dedicated probe laser
  - new POLARIS compressor, 54J for 500TW

10 m

**HI JENA**  
Helmholtz Institute Jena

[www.hi-jena.de](http://www.hi-jena.de)

# Target Area Fraunhofer –TAF



## Challenges when merging JETi200 and POLARIS:

- Spatial ( $< 3 \mu\text{rad}$ ) and temporal ( $< 17 \text{ fs}$ ) overlap between POLARIS and JETi200 laser pulses needs to be ensured.
- New security and vacuum systems. Interface to current systems.
- Common data and metadata handling.
- Common laser and experiment control point.

10 m

**HI JENA**  
Helmholtz Institute Jena

[www.hi-jena.de](http://www.hi-jena.de)



# State of the art synchronisation < 20 fs (2025)



MASTER oscillator @ 1550 nm  
(lowest noise)

stabilized optical fiber links



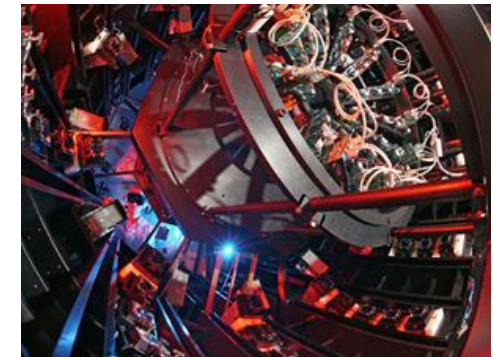
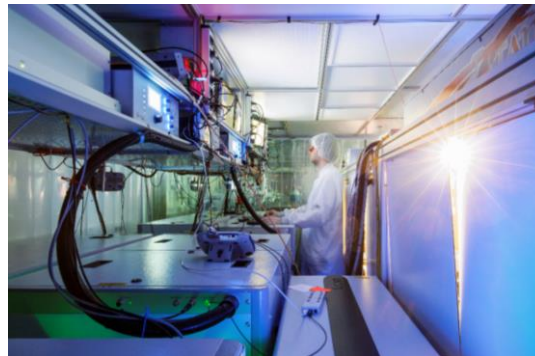
JETi ONE



JETi200



POLARIS



New 140 m<sup>2</sup> Target Area



HI JENA  
Helmholtz Institute Jena

[www.hi-jena.de](http://www.hi-jena.de)

# Supervision, control and data acquisition

## JETi200

- commercial product with own encapsulated control system (control command from Amplitude)
- scientists operate via remote desktop connection

## POLARIS

- built inhouse, custom and commercial hardware
- control with custom LabView solutions
- scientists operate via remote desktop connection

## Experiments

- 80% motors (inhouse controller) and cameras (Allied Vision, Basler) with custom LabView solutions
- inhouse analogue security and interlock systems
- vacuum control with Siemens SPS
- commercial software for gas systems (Bronkhorst)
- remote desktop from lab PC's to control room



FRIEDRICH-SCHILLER-  
UNIVERSITÄT  
JENA

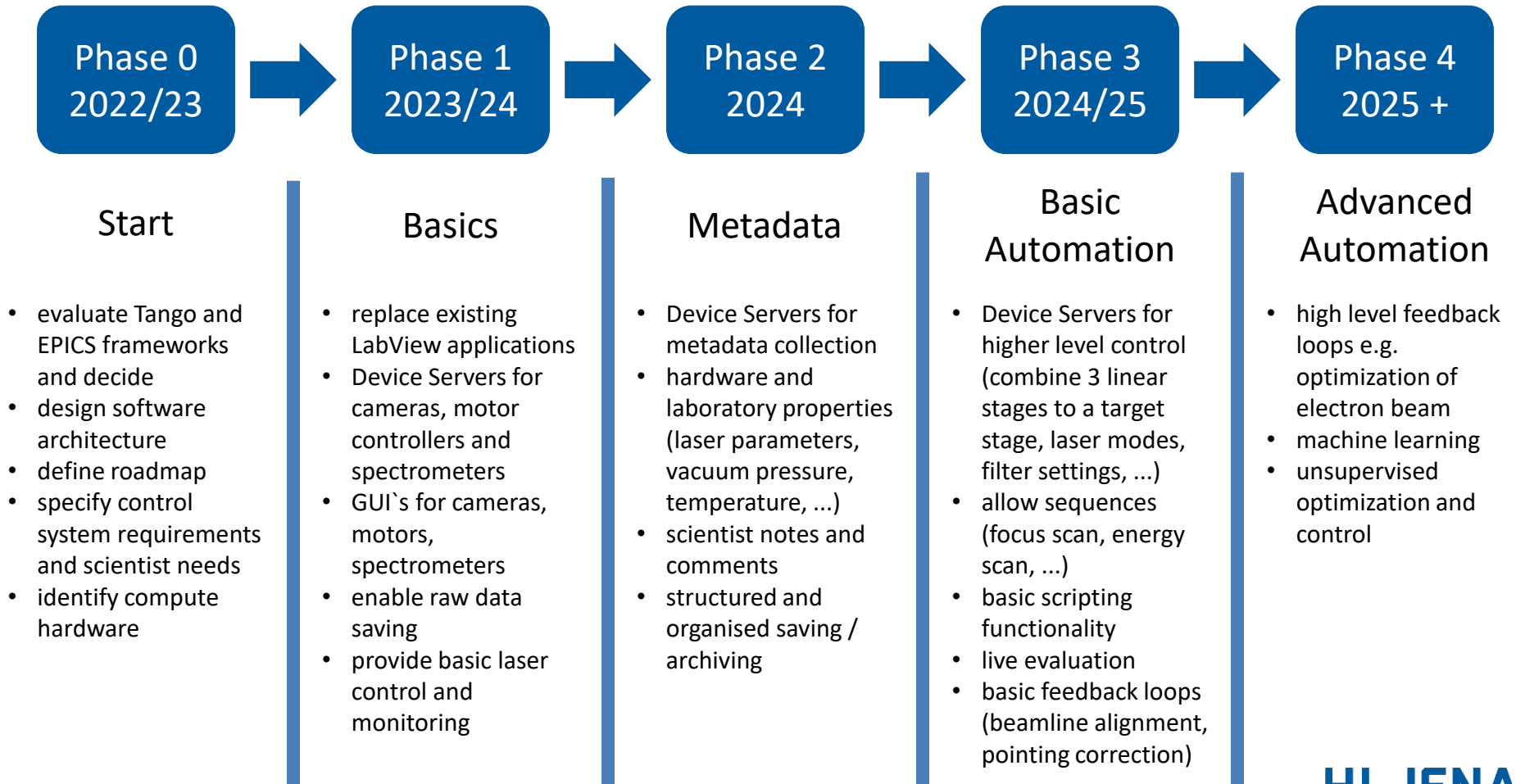


 Allied Vision

**HI JENA**  
Helmholtz Institute Jena

[www.hi-jena.de](http://www.hi-jena.de)

# Control system roadmap



**Thank you for your attention!**



**HI JENA**

Helmholtz Institute Jena

[www.hi-jena.de](http://www.hi-jena.de)