I-LUCE
INFN Laser indUCEd radiation production

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Created: February 2023
Last revision: December 2024

I-LUCE funds

Roma TV, LNF, Pisa CNR, LNS
15 M€

7.9 M€ WP3 High-Power lasers

Infrastruttura

Sistema laser e camere interazione

Electron acceleration

Advanced technologies for Human Centred Medicine

23 Istituti; Spoke 4: Caserta, Pavia, INFN

Electron acceleration for VHEE/ FLASH with laser-driven electron beams

1.3 M€, Accelerazione di elettroni e UHDR

0.8 M€, Accelerazione di protoni e ioni

BCT (**B**reast **C**ancer **T**herapy)

University of Catania, Cannizzaro Hospital, INFN-LNS
1.6 M€, Laser system upgrade for 70 MeV proton beams and diagnostics

I-LUCE current status

December 2024

December 2024

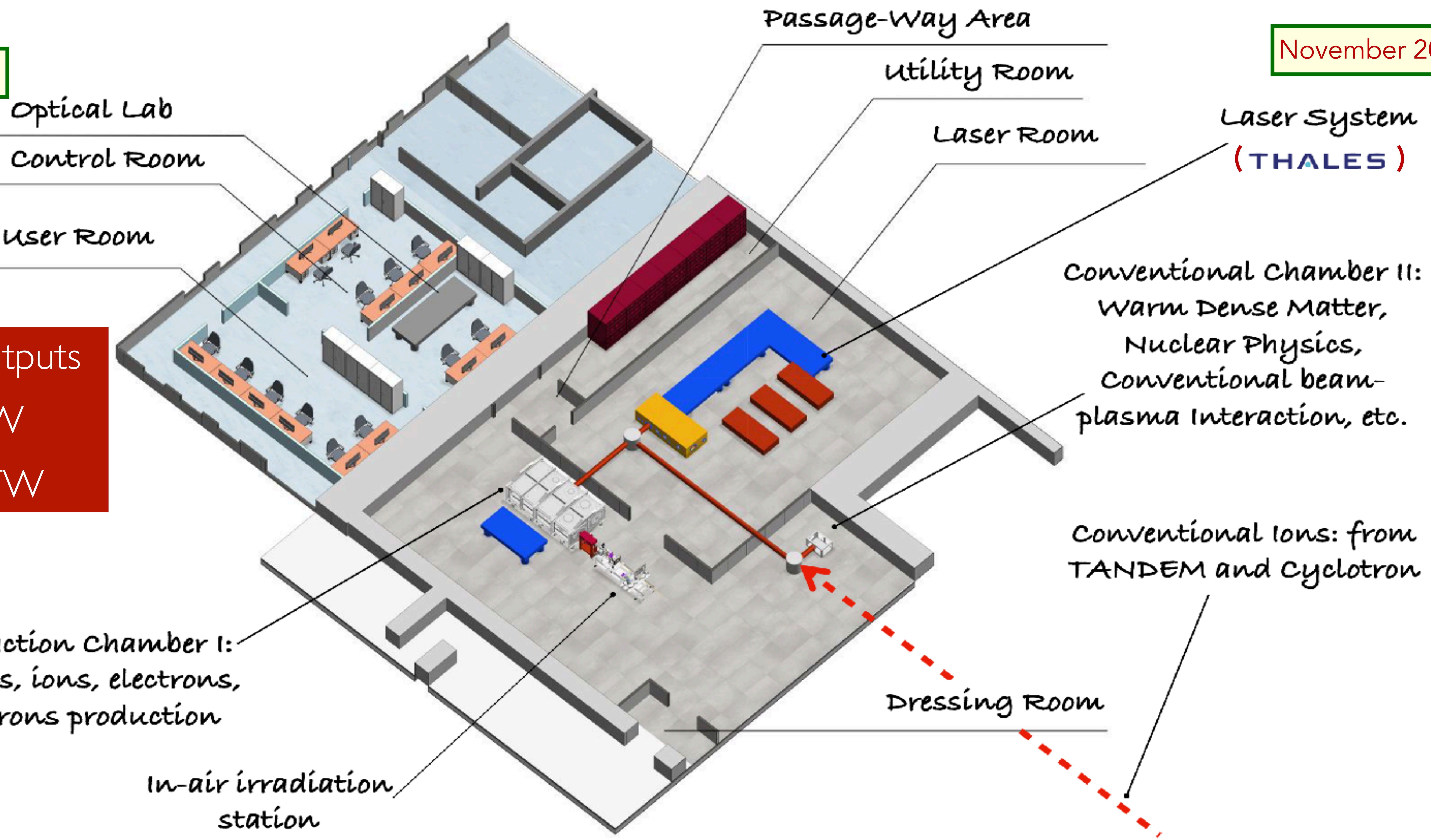
Two laser outputs

1J+/23fs/45TW

7J+/23fs/320TW

July 2026

November 2026



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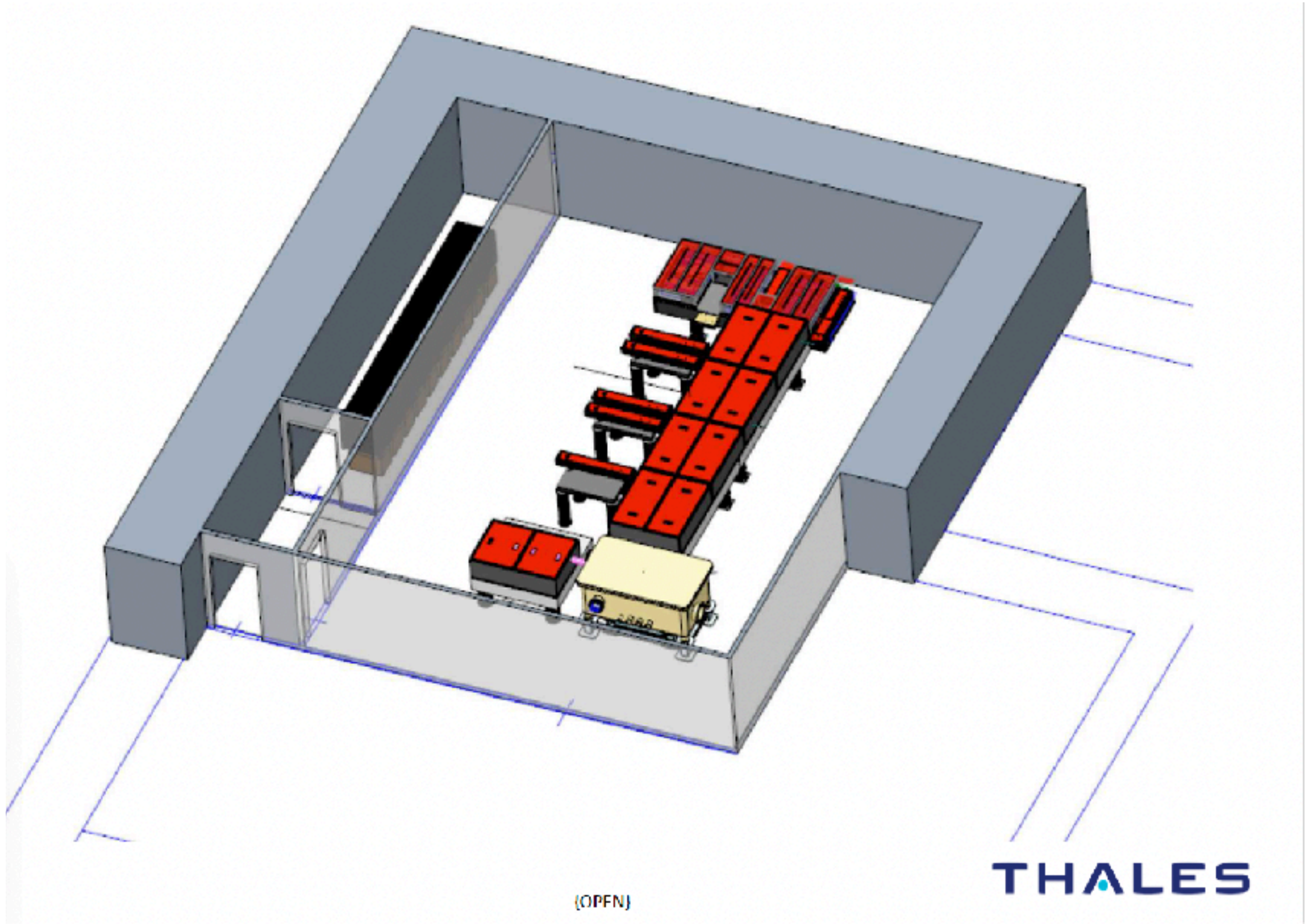
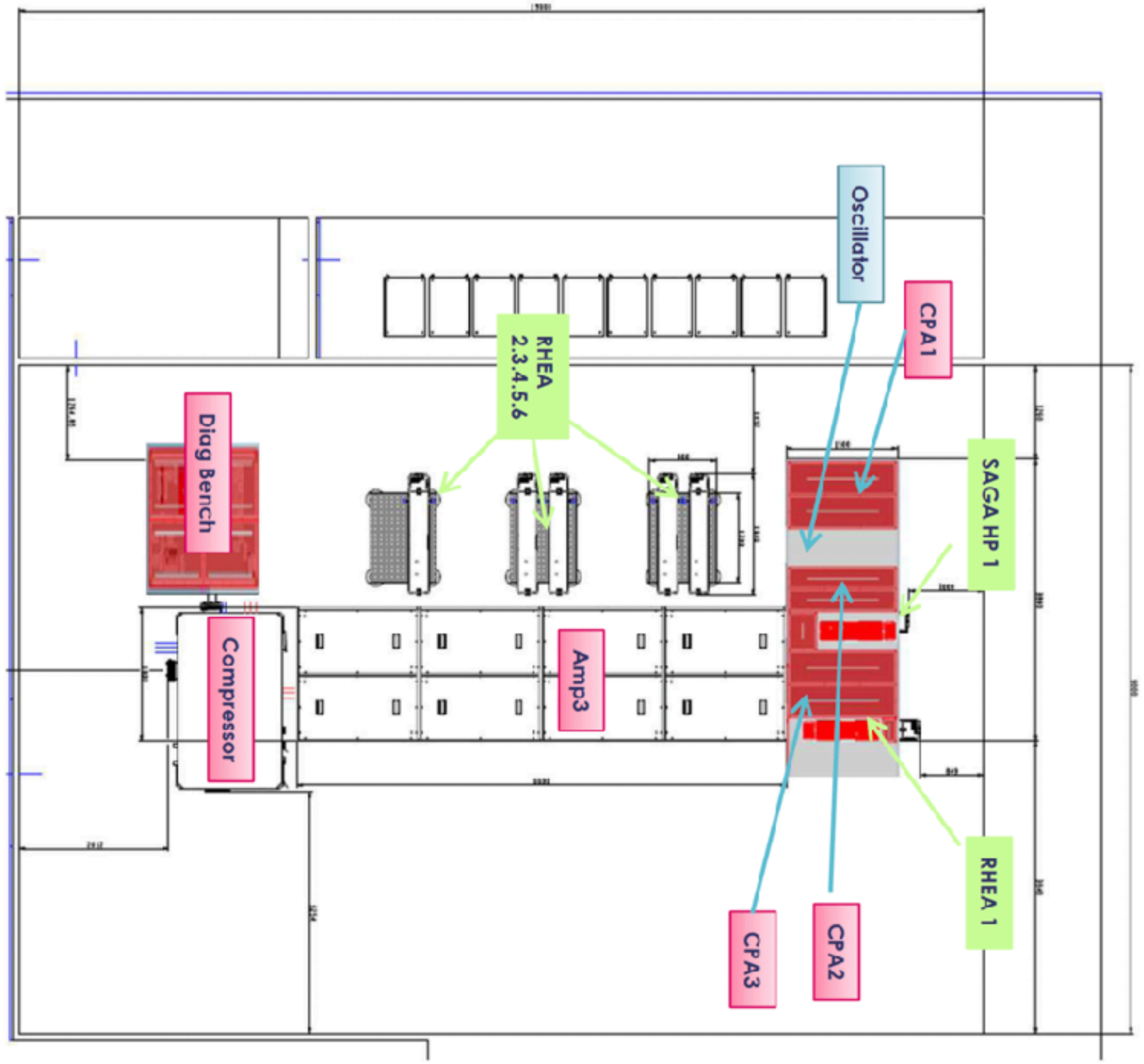
Critical Design Review is ongoing

On December 17th first presentation of the CDR

We gave the first feedback on 7th January 2025





Laser system and interaction characteristics

Laser Parameter	Low Power Mode	High Power Mode
Output Energy [J]	≥ 1.5	≥ 8
Pulse Duration [fs]	$\lesssim 23^{b}$	$\lesssim 23^{b}$
Peak Power [TW]	≥ 40	320^{a}
Repetition Rate [Hz]	≥ 10	≥ 2.5
Focusing Surface [μm^2]	36	36 or Better
Spectrum (FWHM) [nm]	≥ 40	≥ 40
Central Wavelength [nm]	800 ± 10	800 ± 10
Beam Profile	Super Gaussian Top Hat	Super Gaussian Top Hat
Strehl Ratio	>80% with Deformable Mirrors	>80% with Deformable Mirrors
Contrast Ratio @ ps	$< 1:\ 10^{8} - < 1:\ 10^{10}$	$< 1:\ 10^{8} - < 1:\ 10^{10}$
Energy Stability [% rms]	≤ 1.5	≤ 1.5
Maximum Intensity on Target [$\frac{W}{cm^2}$]	1×10^{20}	9×10^{20}

460 TW with BCT

First implementation phase

- **Two laser beamlines**: pulse duration < 23 fs
- **Low repetition rate high-power**: 1 Hz up to 350 TW
  - Power density at the target: > $1.25 10^{21}$ W/cm^2
  - I*λ2: > $8*10^{20}$ W · µm^2/cm^2
  - Proton beams: max energy 50 MeV;
  - Proton fluence: $5*10^{11}$ MeV^{-1} Sr^{-1}
  - Electron beams up to 4 GeV
  - X-Rays, neutrons
- **Higher repetition rate, lower power**: >10 Hz, > 50TW
  - Specific power at the target: > $2.9*10^{20}$ W/cm^2
  - I*λ2: > $1.33*10^{20}$ W · µm^2/cm^2
  - Proton beams: max energy 6 MeV;
  - Proton fluence: $5*10^{11}$ MeV^{-1} Sr^{-1}
  - Electron beams up to 500 MeV
  - X-Rays, neutrons

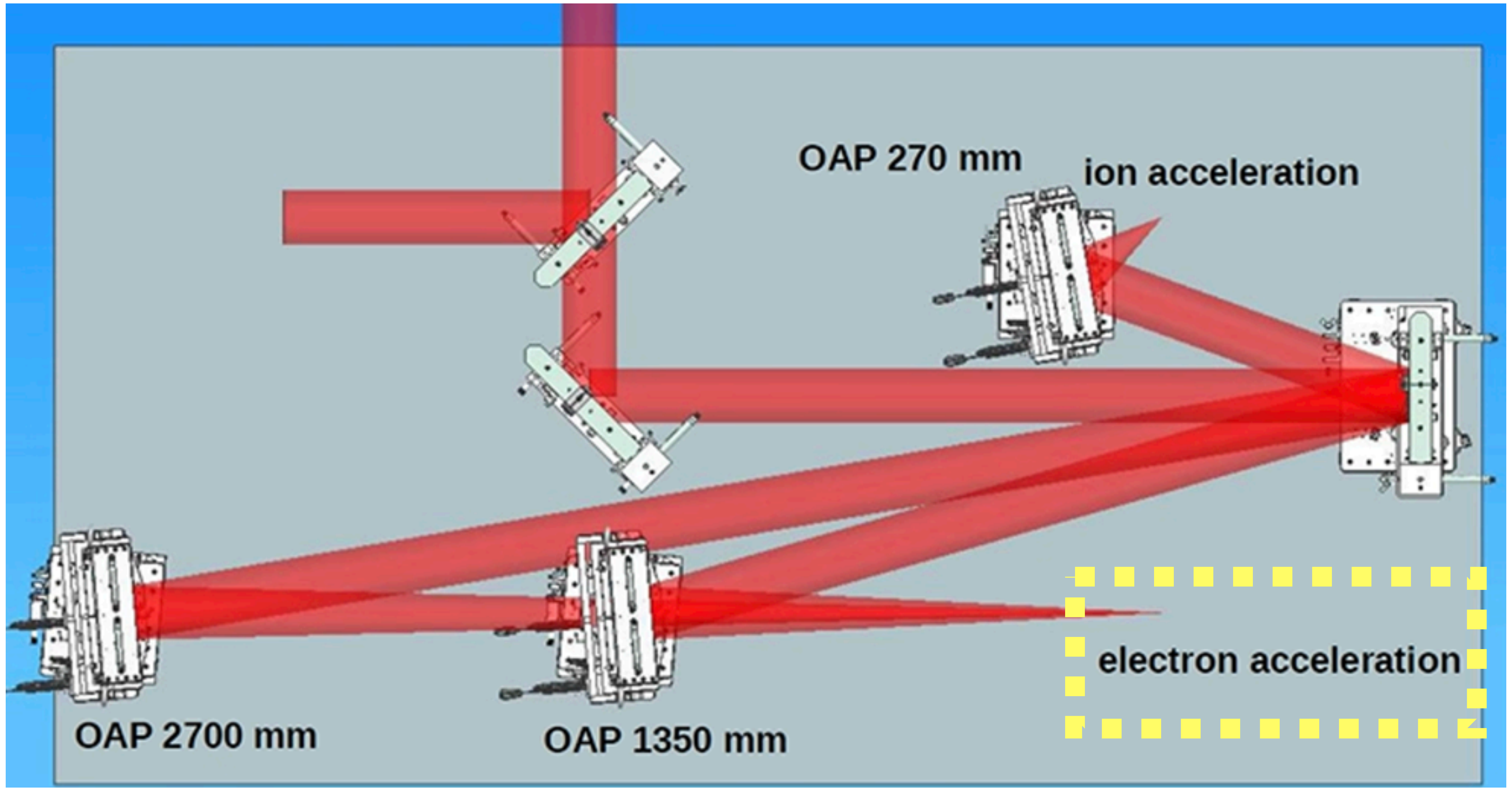
We are discussing the possibility to increase the duration of the laser pulse to the **ps level**

- Nuclear reactions in plasma
- Stopping power in plasma
- Nuclear decay
- Inertial fusion
- ……

Second phase

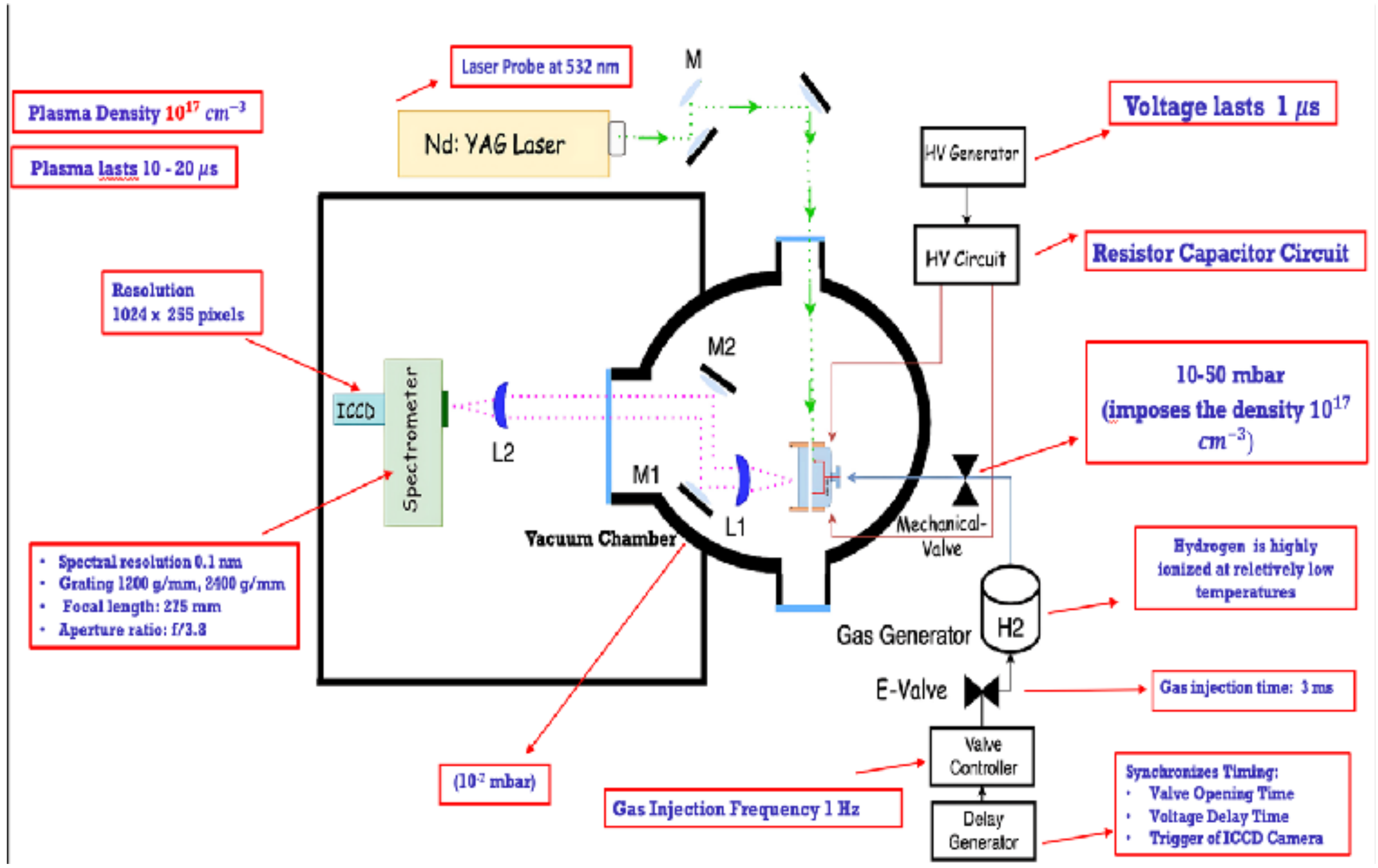
The laser system will be ready (oscillators, optics, compressor chamber, etc.) - BCT project

Plasma lab for electron acceleration (ANTHEM)

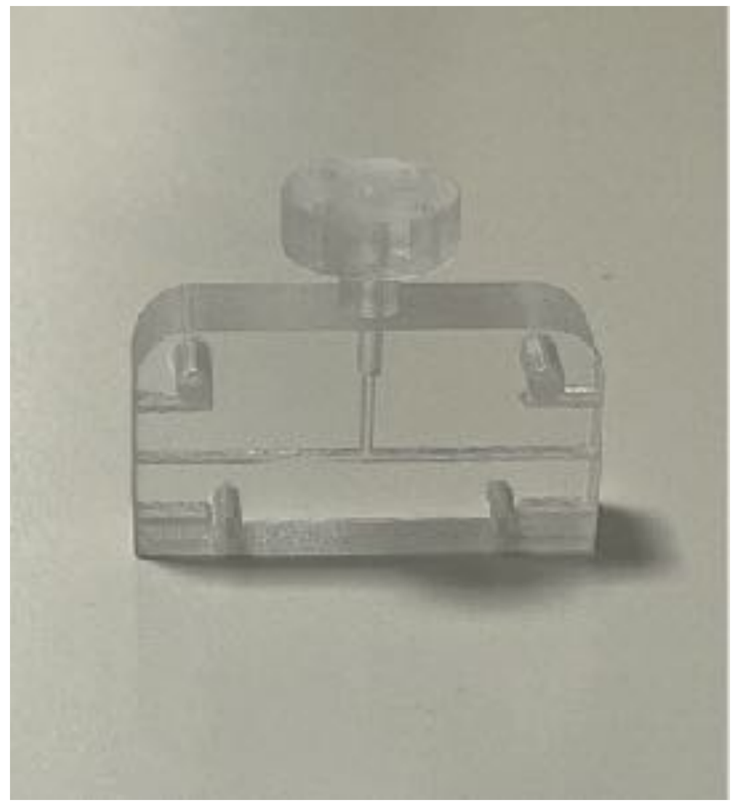


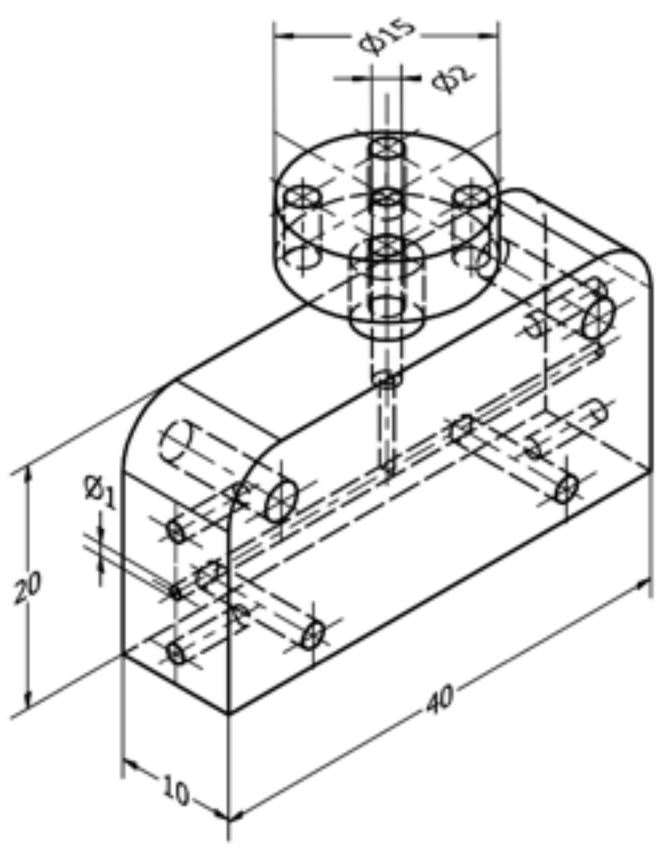
Supersonic gas-jet

Capillary discharge approach



3D Printed
VeroClear ($C_2O_2H_8$)
Plasma Discharge Capillary
(4 cm/long-1 mm/diameter)





S. Arjmand et al., JINST, 18, P08003 (2023)

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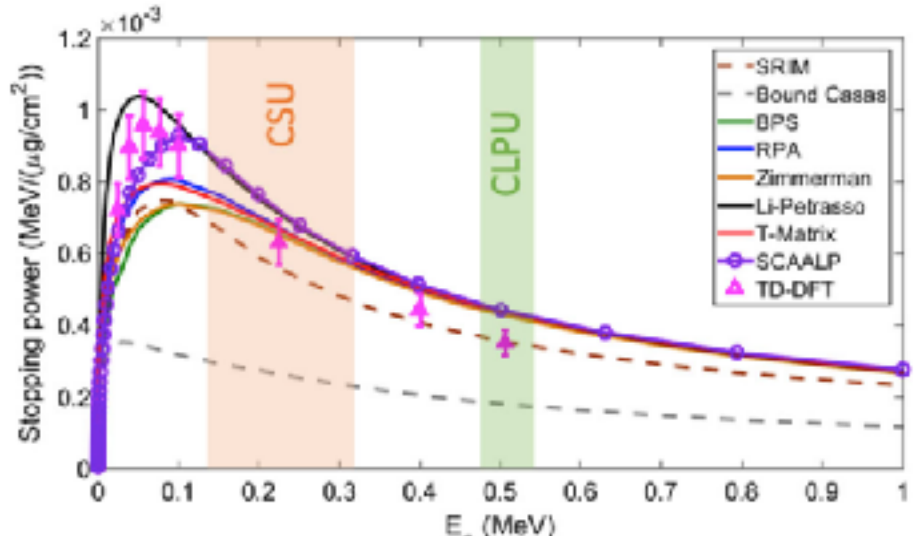
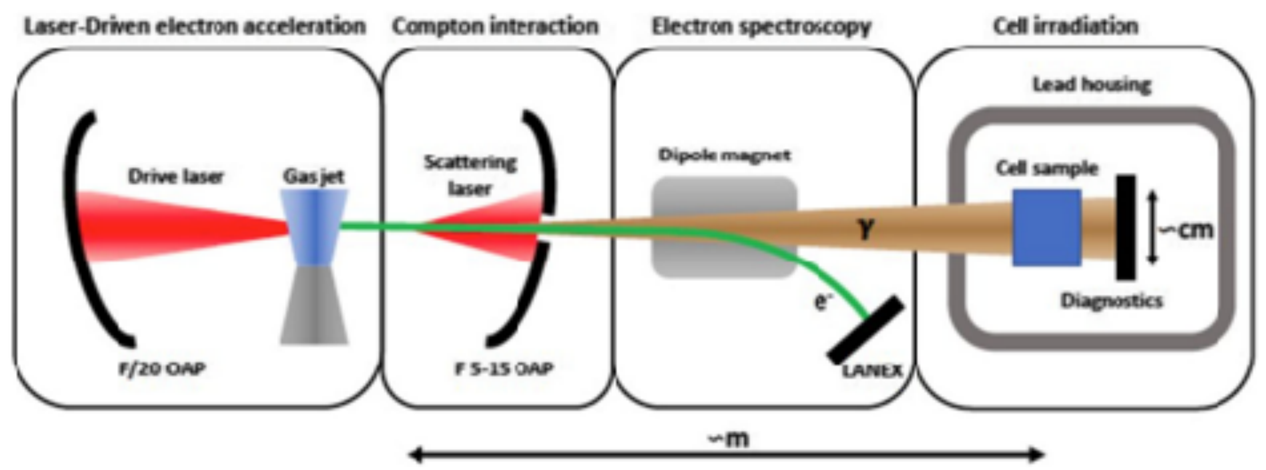
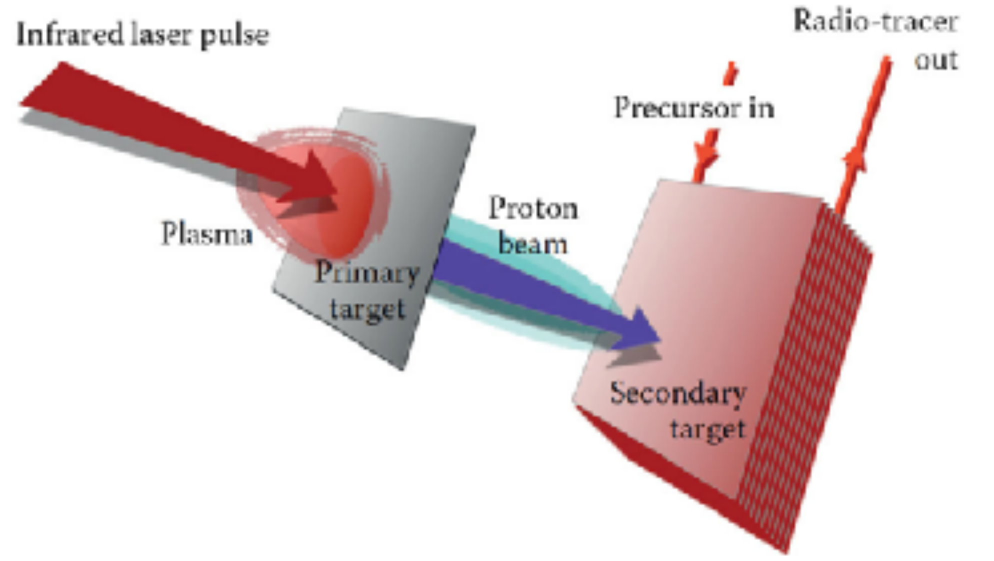
Physics cases



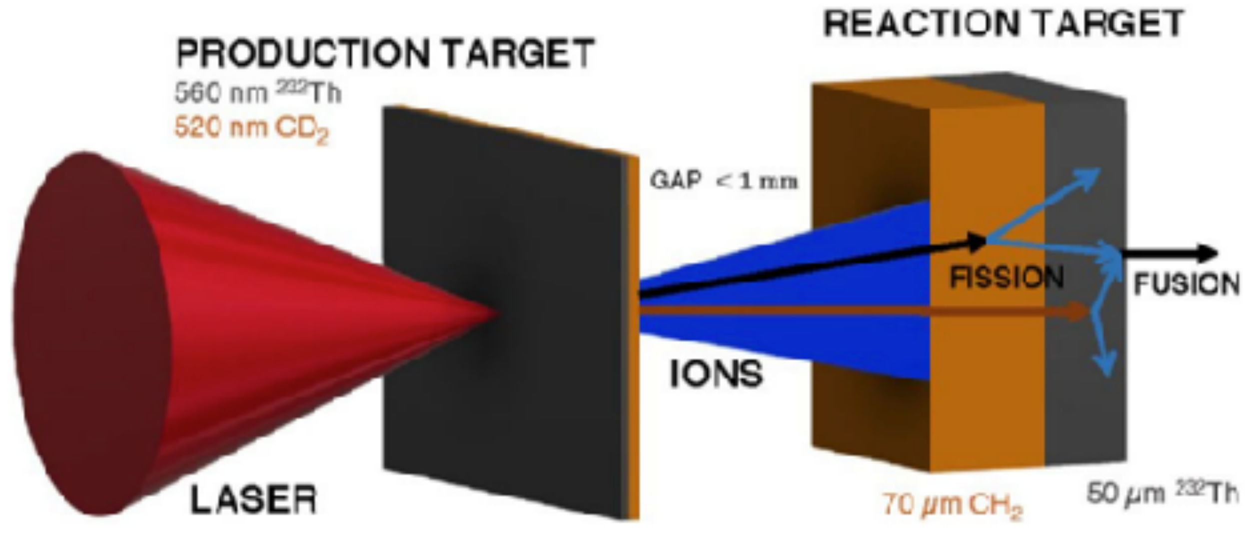
Stopping power in plasma



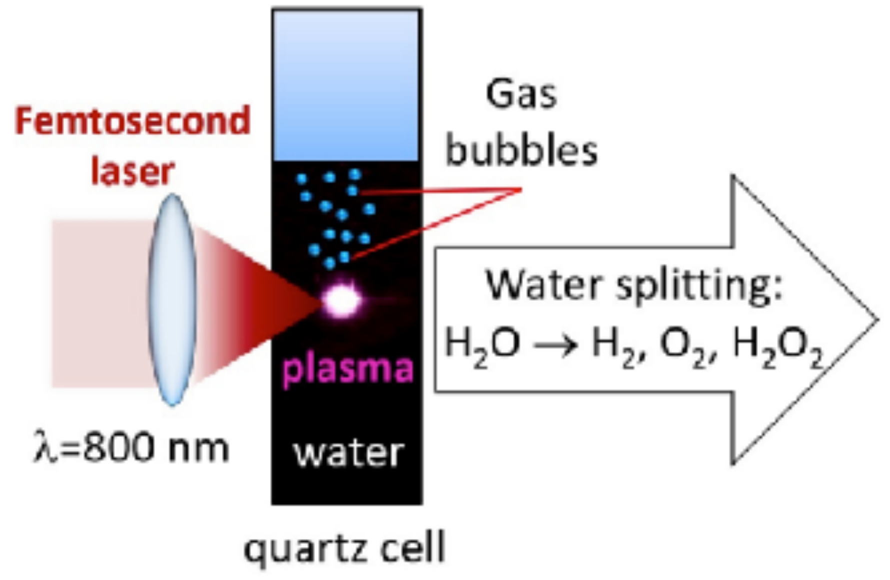
Positrons generation



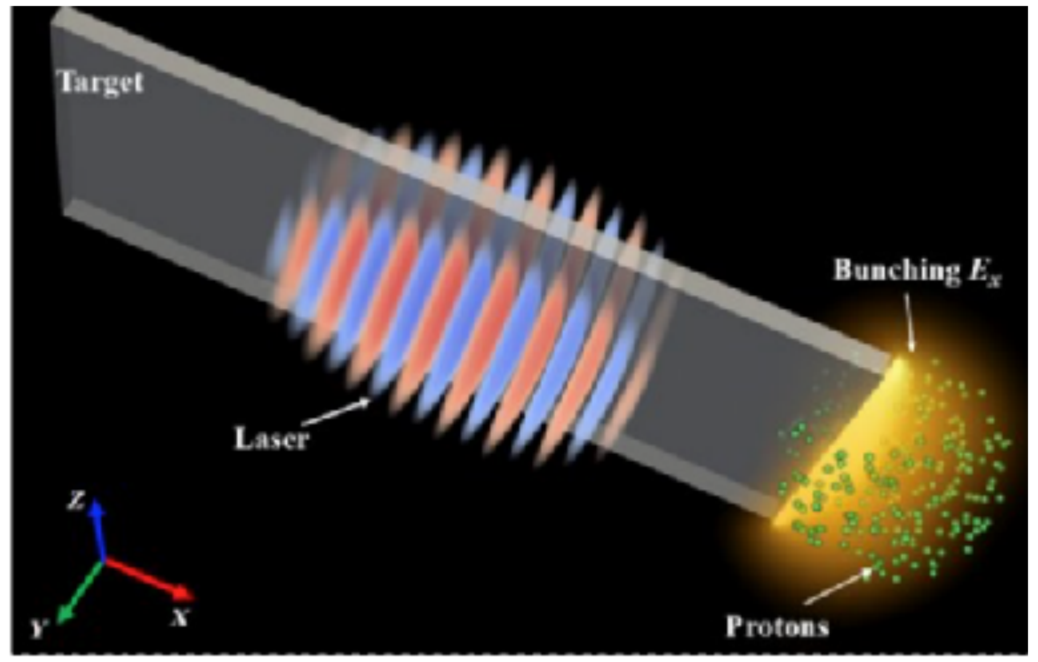
Radioisotopes



Nuclear reaction schemes



Hydrogen generation



Protons and electrons generation

Chapter 6.2 Laser applications


Eur. Phys. J. Plus (2023) 138:1038
THE EUROPEAN PHYSICAL JOURNAL PLUS
Regular Article

Nuclear physics midterm plan at LNS

C. Agodi, F. Cappuzzello, G. Cardella, G. A. P. Cirrone, E. De Filippo, A. Di Pietro, A. Gargano, …

C Agodi et al., Eur. Phys. J. Plus (2023) 138:1038