



I-LUCE

INFN Laser indUCEd radiation production

GAP Cirrone

Laboratori Nazionali del Sud - Istituto Nazionale di Fisica Nucleare

Created: February 2023

Last revision: December 2024

I-LUCE funds

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Roma TV, LNF, Pisa CNR, LNS
15 M€



7.9 M€ **WP3 High-Power lasers**

Infrastruttura

Sistema laser e camere interazione

Electron acceleration



0.8 M€, Accelerazione di protoni e ioni



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

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

Optical Lab

December 2024

Control Room

User Room

Passage-Way Area

Utility Room

Laser Room

November 2026

Laser System
(THALES)

Conventional Chamber II:
Warm Dense Matter,
Nuclear Physics,
Conventional beam-
plasma interaction, etc.

Two laser outputs
1J+/23fs/45TW
7J+/23fs/320TW

Conventional ions: from
TANDEM and Cyclotron

July 2026

Interaction Chamber I:
protons, ions, electrons,
neutrons production

In-air irradiation
station

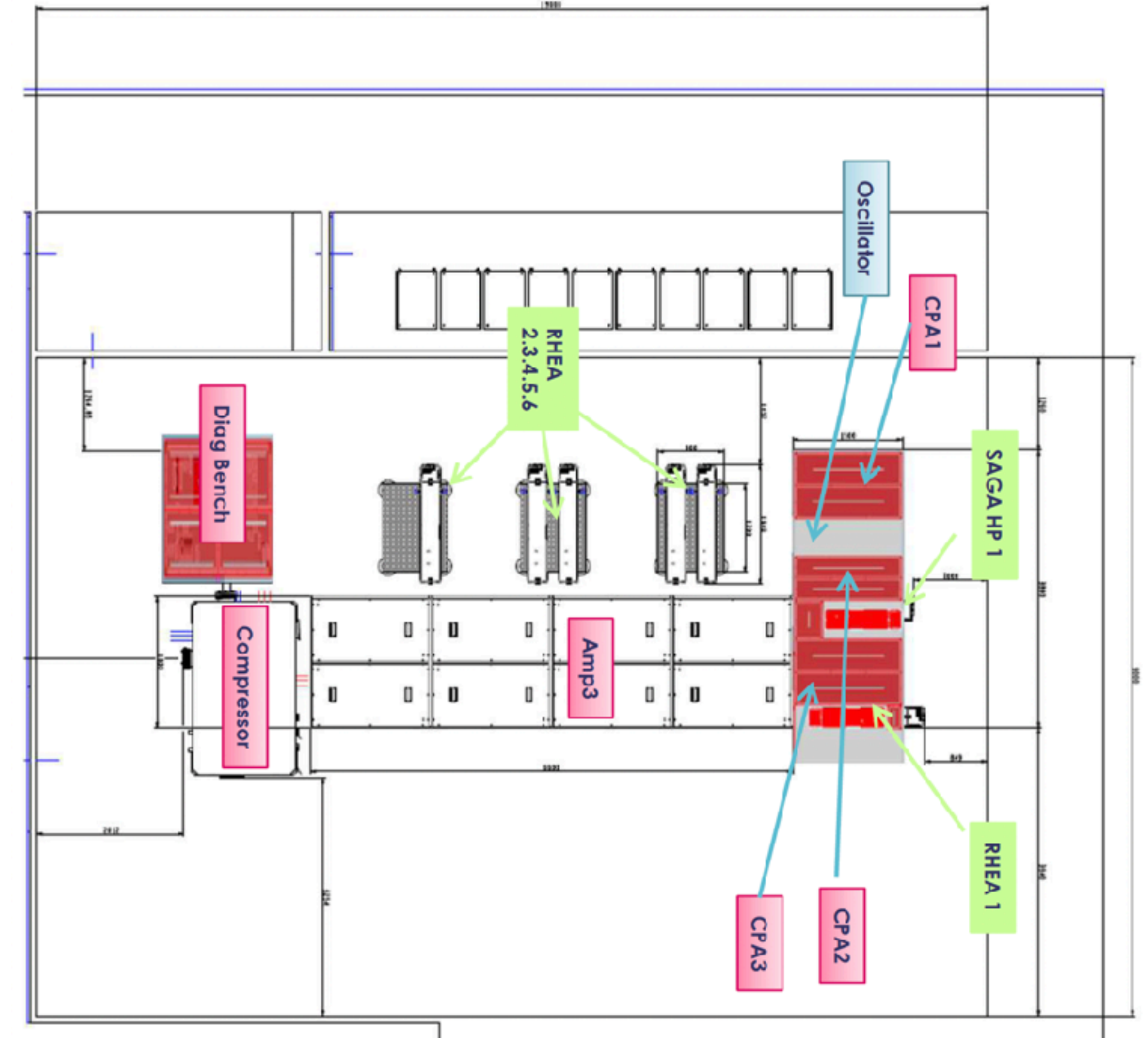
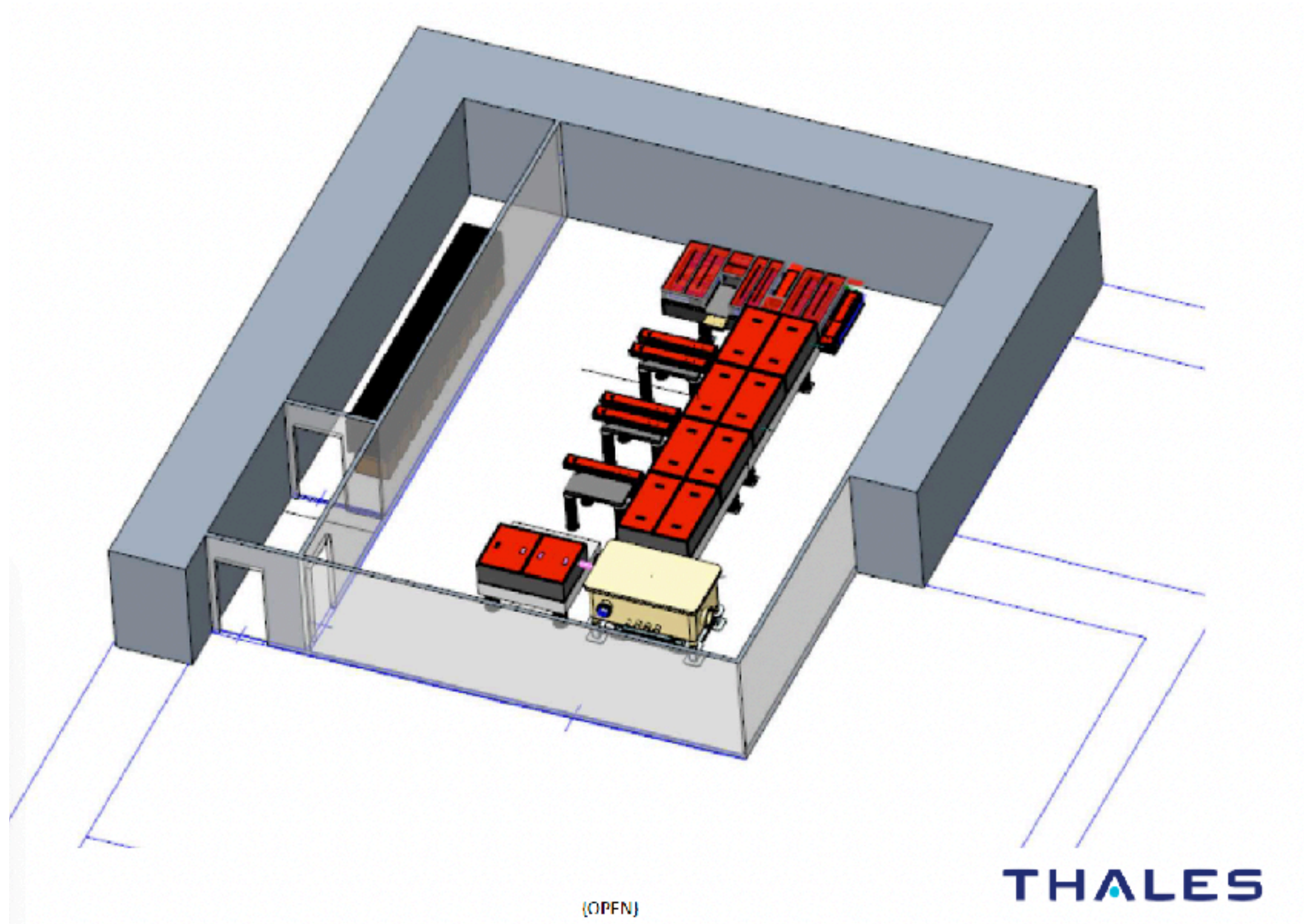
Dressing Room

Critical Design Review is ongoing

4

On December 17th first presentation of the CDR

We gave the first feedback on 7th January 2025



Laser system and interaction characteristics

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Laser Parameter	Low Power Mode	High Power Mode
Output Energy [J]	≥ 1.5	≥ 8
Pulse Duration [fs]	$\leq 23^b$	$\leq 23^b$
Peak Power [TW]	≥ 40	320^a 460 TW with BCT
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 [$\frac{\text{W}}{\text{cm}^2}$]	1×10^{20}	9×10^{20}

First implementation phase

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



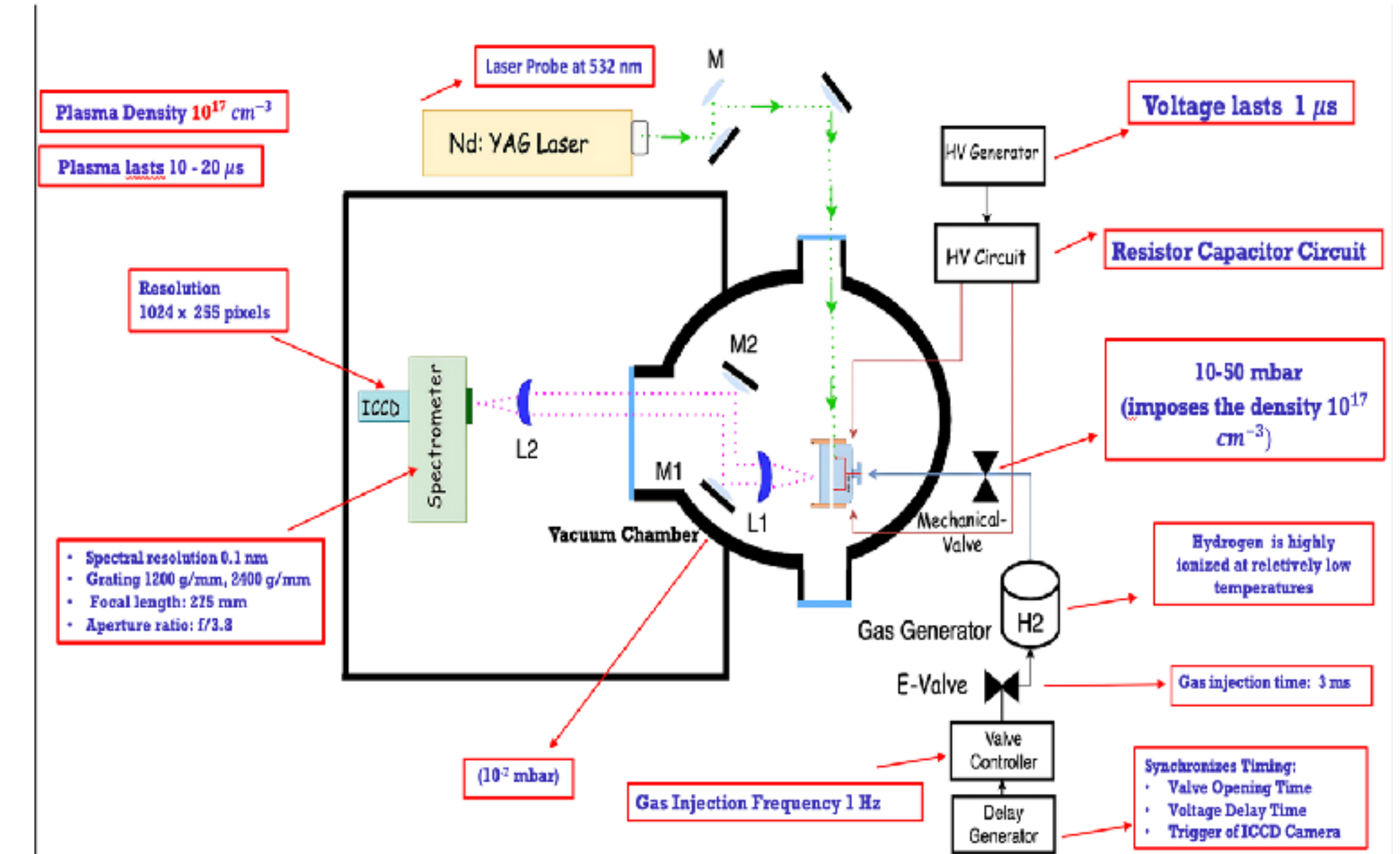
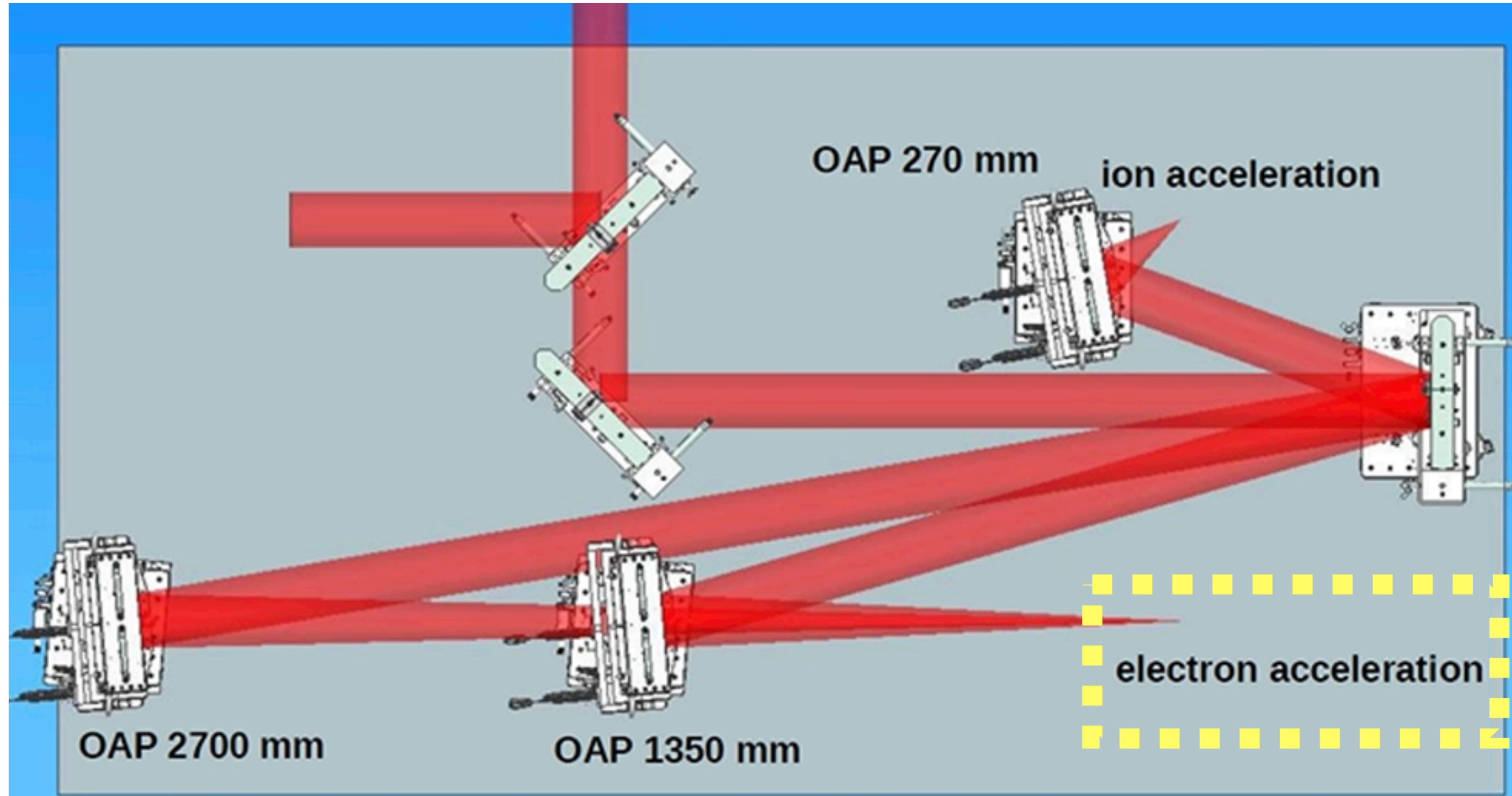
We are discussing the possibility to increase the duration of the laser pulse to the **ps level**

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

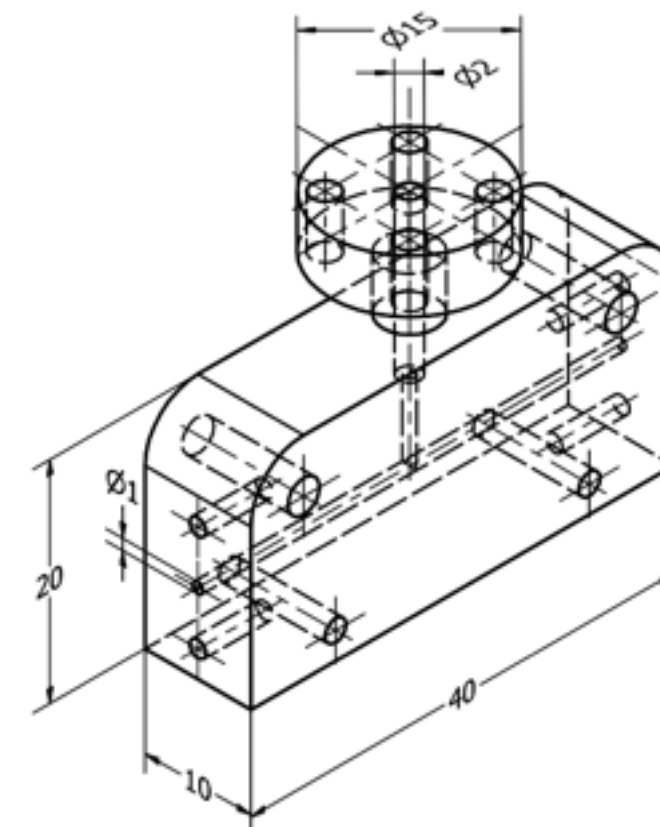
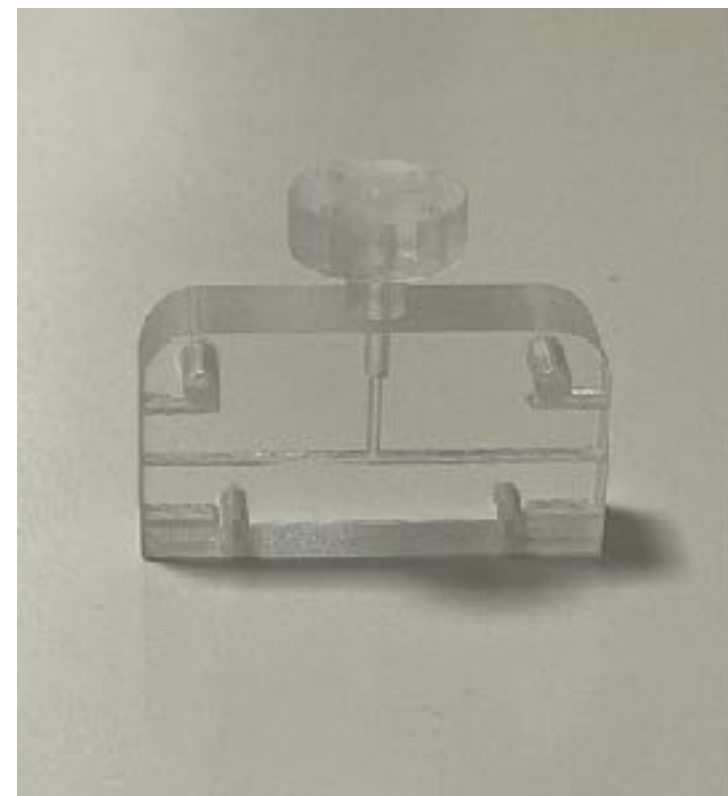
Second phase

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

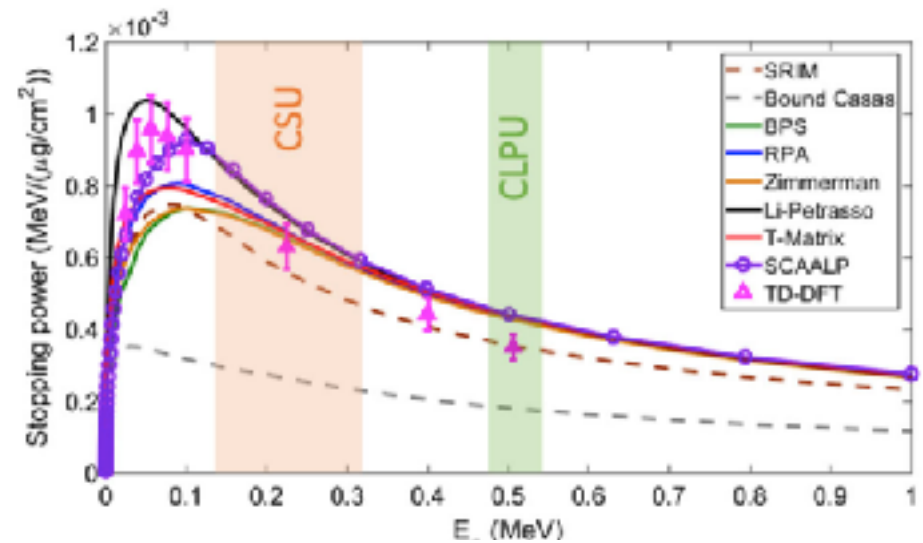
Supersonic gas-jet Capillary discharge approach



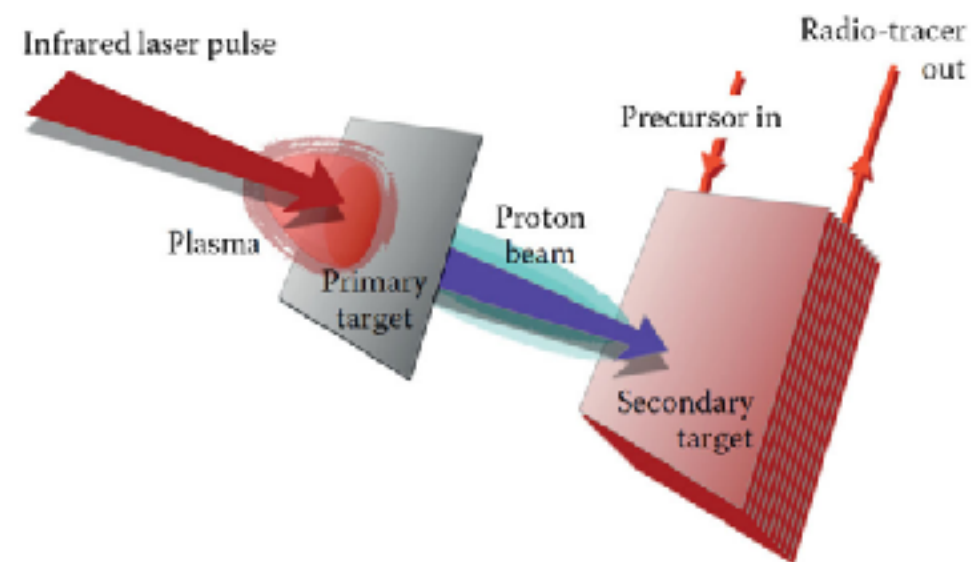
3D Printed
VeroClear ($\text{C}_2\text{O}_2\text{H}_8$)
Plasma Discharge Capillary
(4 cm/long-1 mm/diameter)



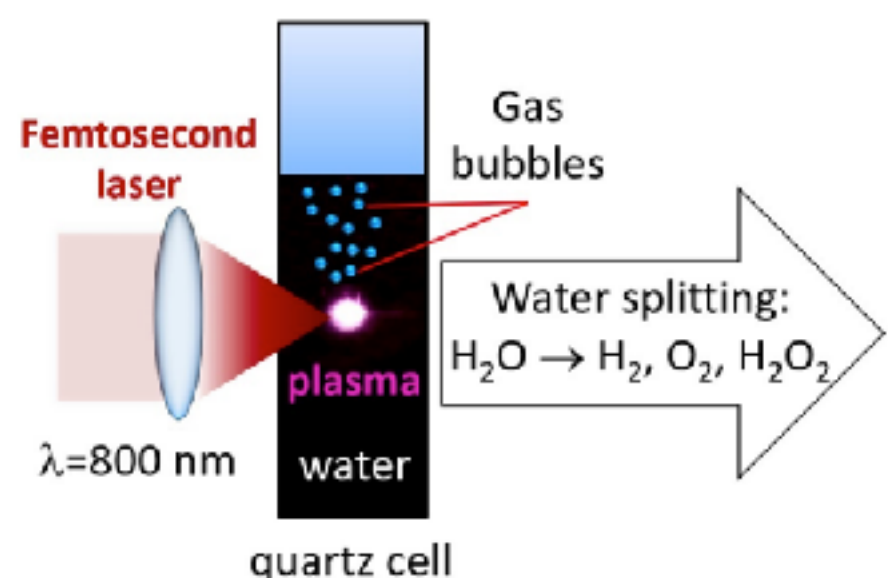
Physics cases



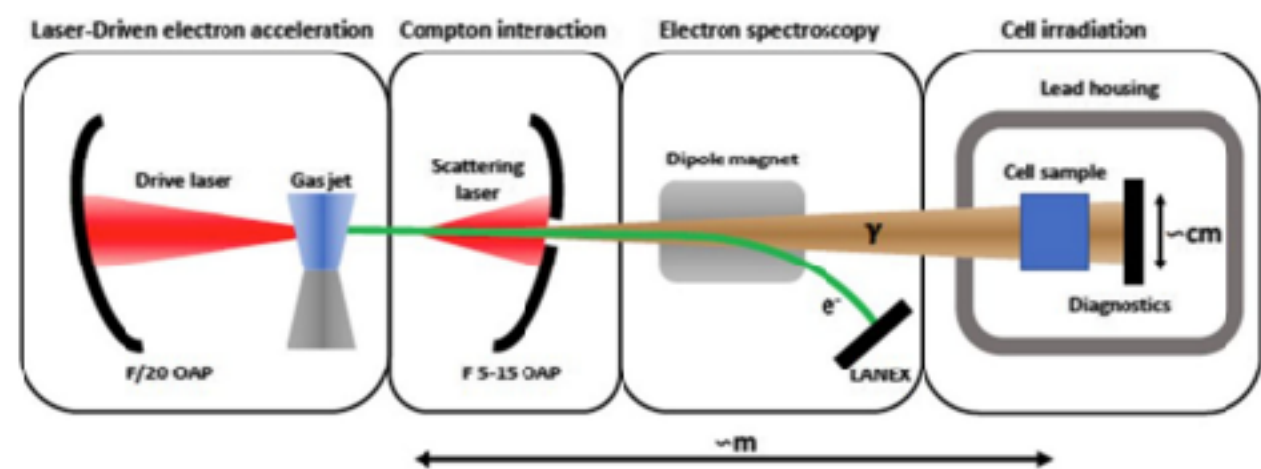
Stopping power in plasma



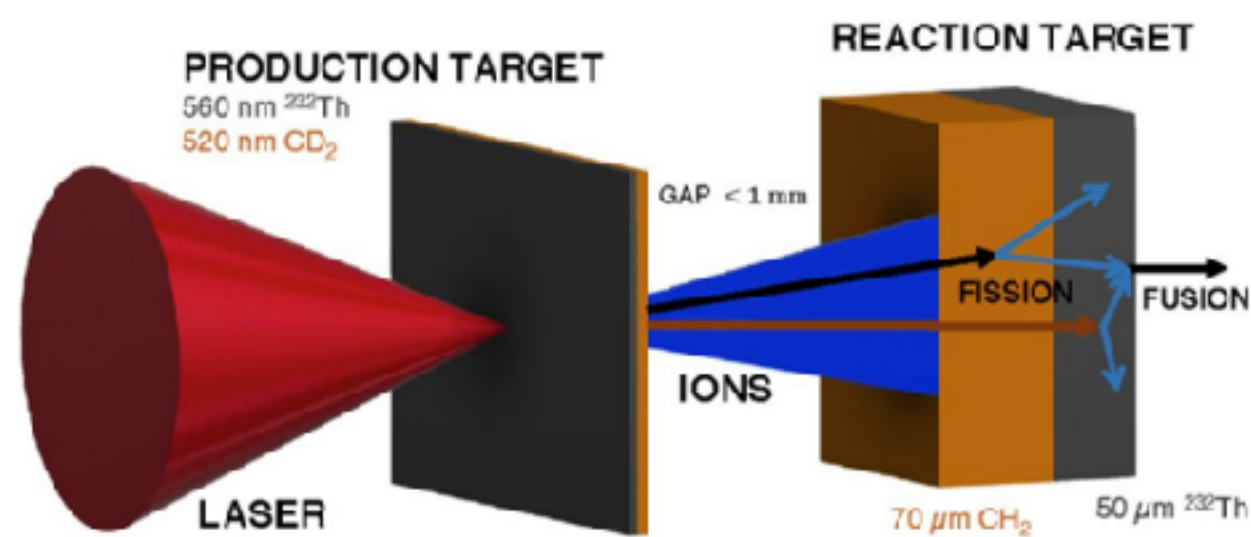
Radioisotopes



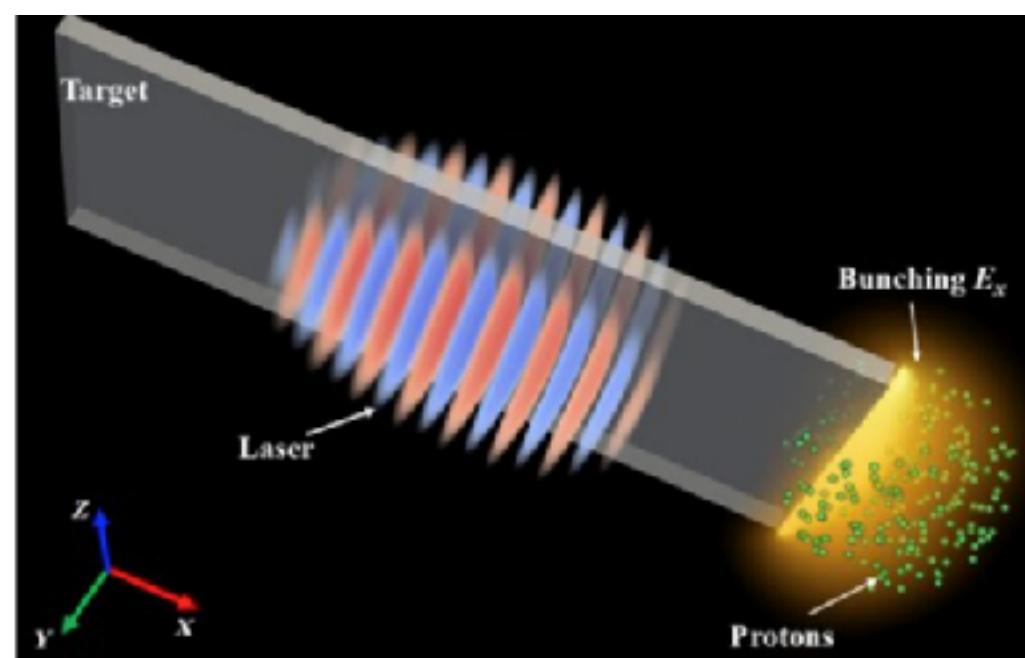
Hydrogen generation



Positrons generation



Nuclear reaction schemes



Protons and electrons generation

Chapter 6.2 Laser applications

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Regular Article

Nuclear physics midterm plan at LNS

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