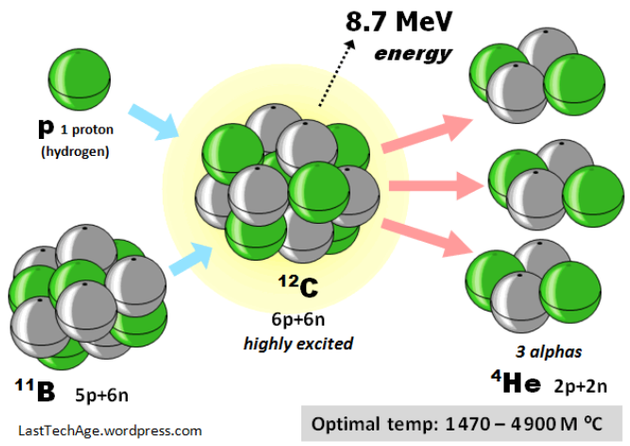
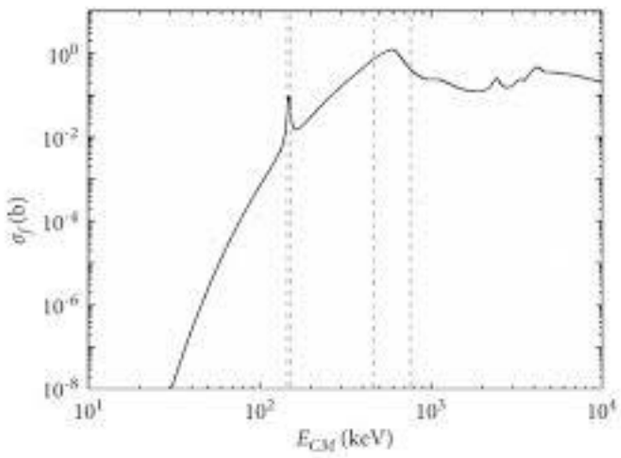
Istituto Nazionale di Fisica Nucleare

# FUSION

*FUsion Studies of prOton boron neutron-less reaction in laser-generated plasma*

*National: G A Pablo Cirrone (INFN-LNS) and Fabrizio Consoli (ENEA)*

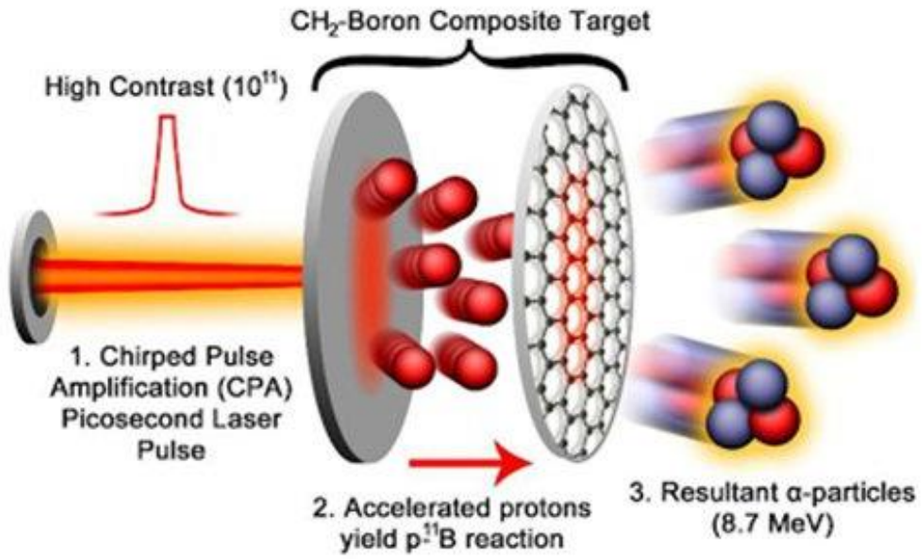

P(11B, a)2a

GAP Cirrone, PhD - pablo.cirrone@lns.infn.it

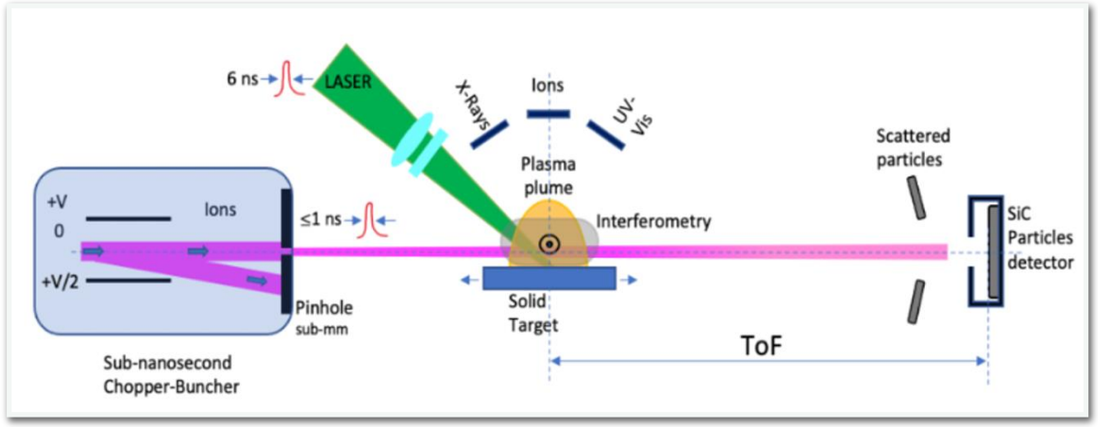
# Two working packages

Istituto Nazionale di Fisica Nucleare

**WP1**: study of the p(11B,a)2a reaction in a pitcher-catcher configuration




**WP2**: stopping power measurement of protons/helium beams in a borated plasma




Basic understanding of fusion mechanism in plasma

Realisation of new targets for the p11B reaction improvement

Development of new diagnostics

Maximisation of the alpha yields in plasma

Ion stopping power measurements in plasma and development of new computational approach

*GAP Cirrone, PhD - pablo.cirrone@lns.infn.it*

# WPs main activities



WP1

- Preparation and realisations of experiment in a KJ laser system

WP2

- Preparation of the set-up for the proton/helium stopping power evaluation in plasma

WP3

- Targets preparation for WP1 and WP2

WP4

- Diagnostic preparation for the WP1

# ATTIVITA’ 2024/2025

# Attività



## Targets:

foam targets (ENEA + FBK), ELI-Beamlines, UNICT, RAL

## Diagnostica:

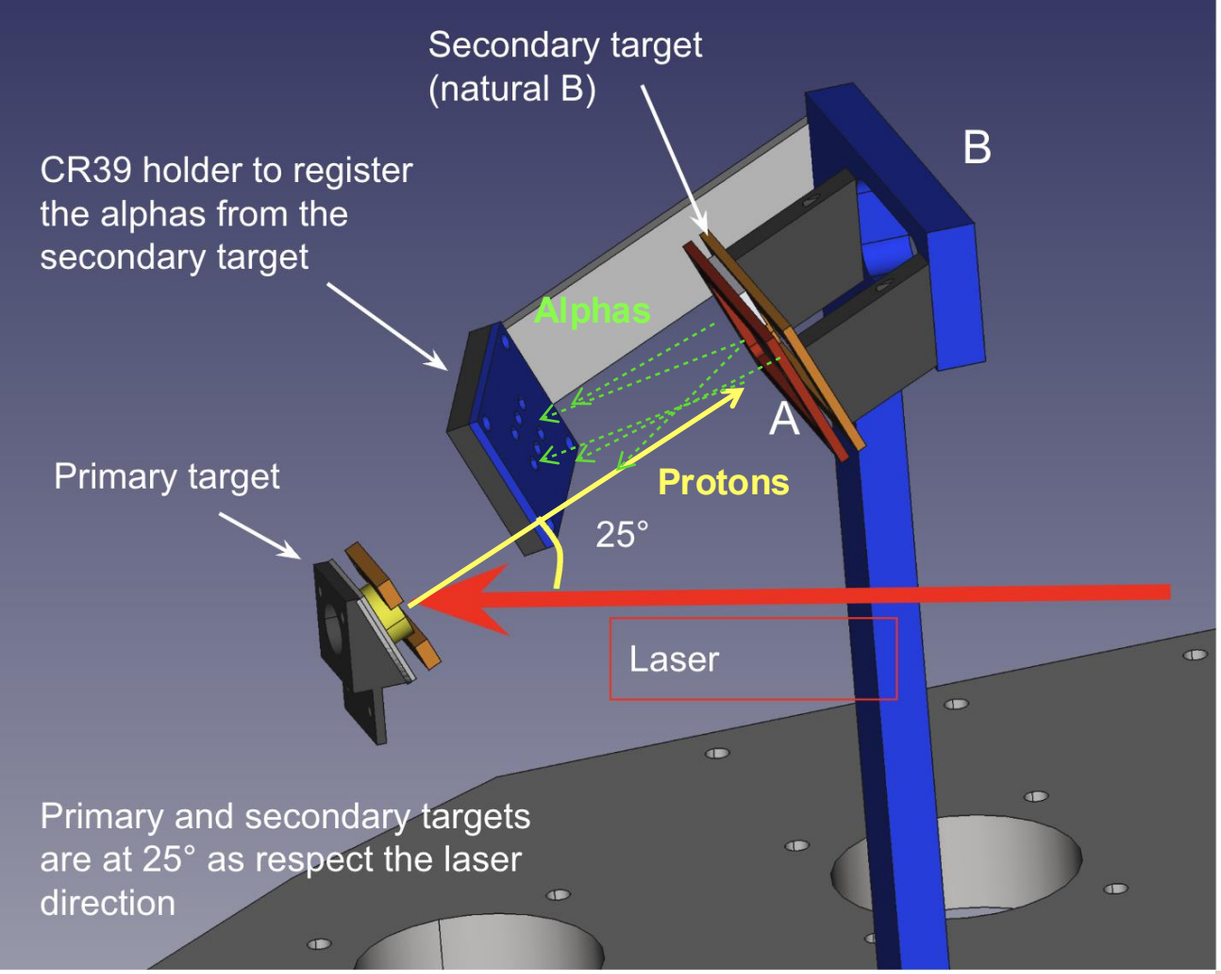
Thompson parabola (ENEA), CVD diamond matrix (UNI RM2), IC (LNS)

## Esperimenti

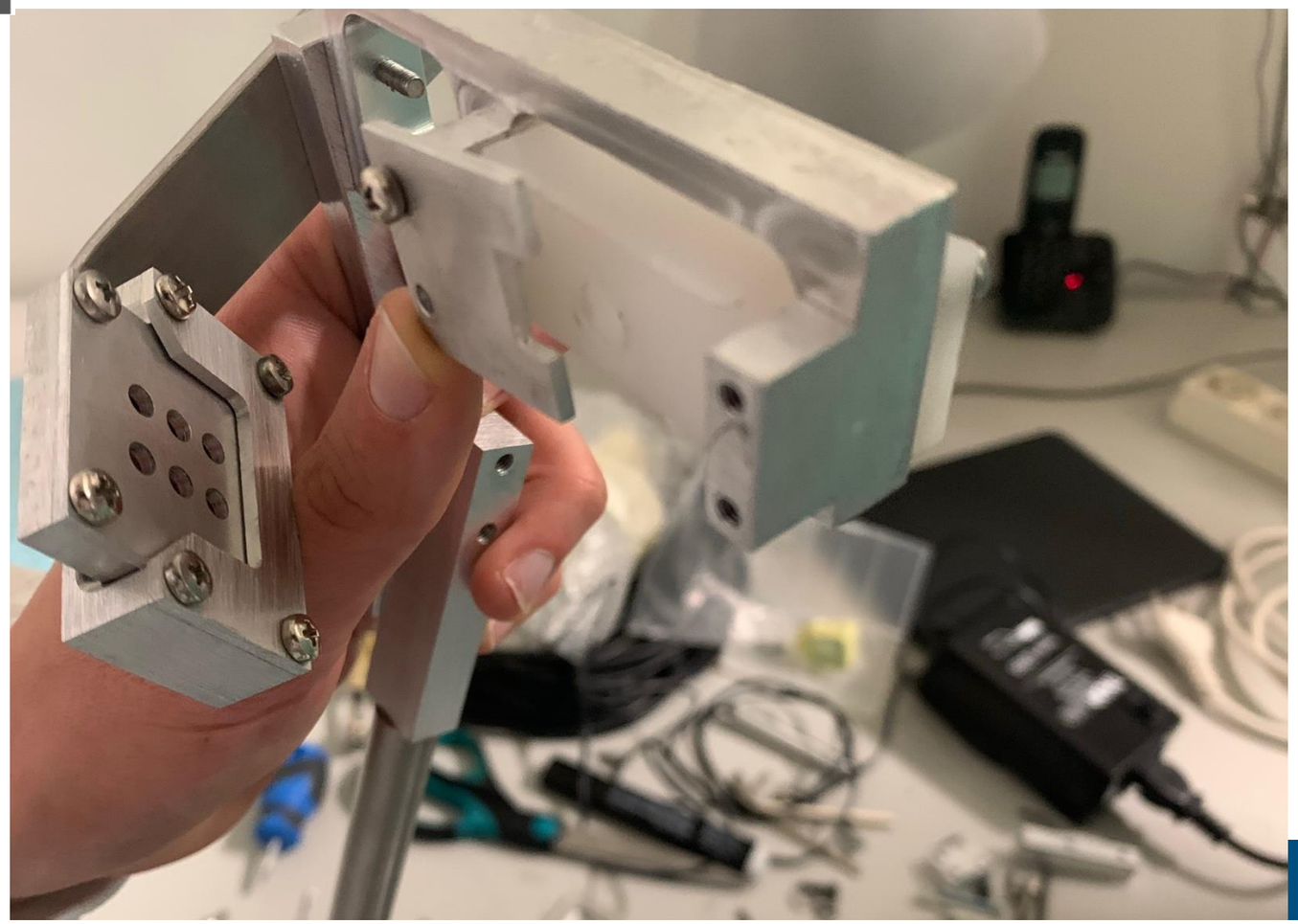
Proposto ed eseguito un lunghissimo turno sperimentale (6 settimane) presso il laboratorio PALS (CZ)

- record di energia dei protoni accelerati al PALS (6 MeV)
- prima misura di attivazione di 11B da protoni
- Analisi in corso

Quasi completato il set-up per la misura dello stopping power in plasma (WP2)







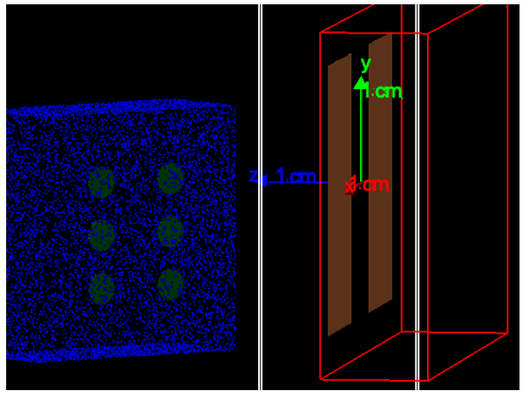
*GAP Cirrone, PhD - pablo.cirrone@lns.infn.it*

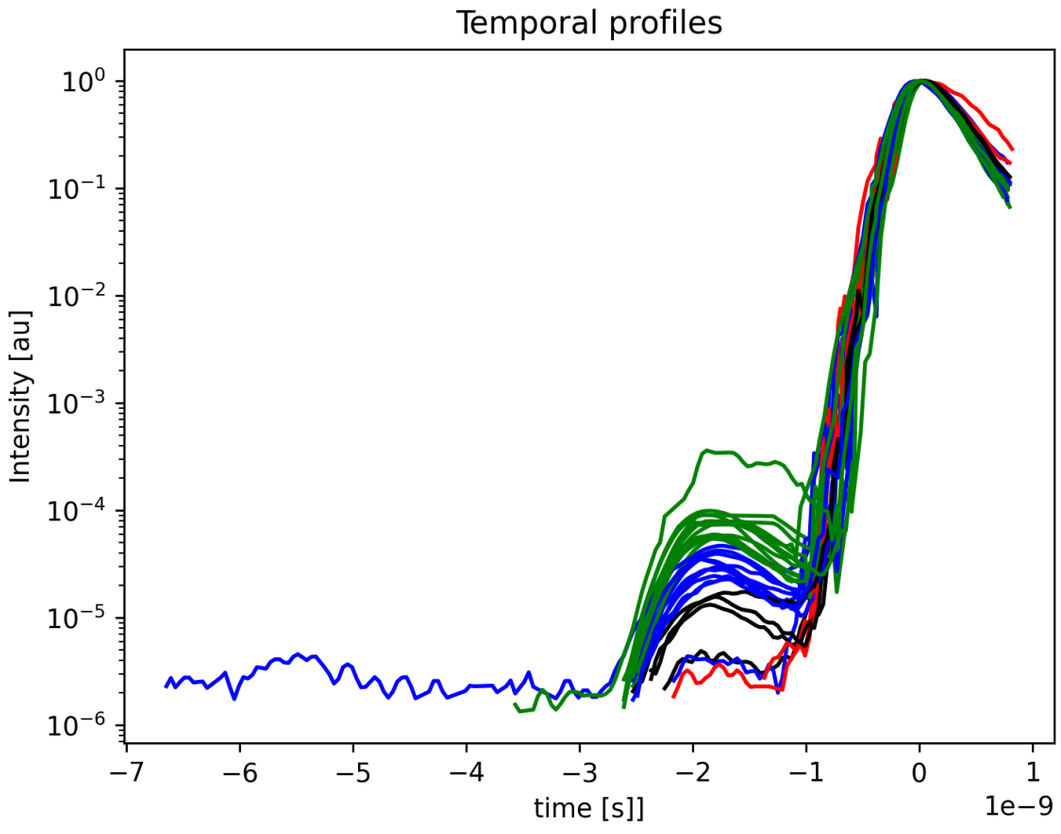
January 22 - March 1, 2024
PALS facility
Prague, CZ

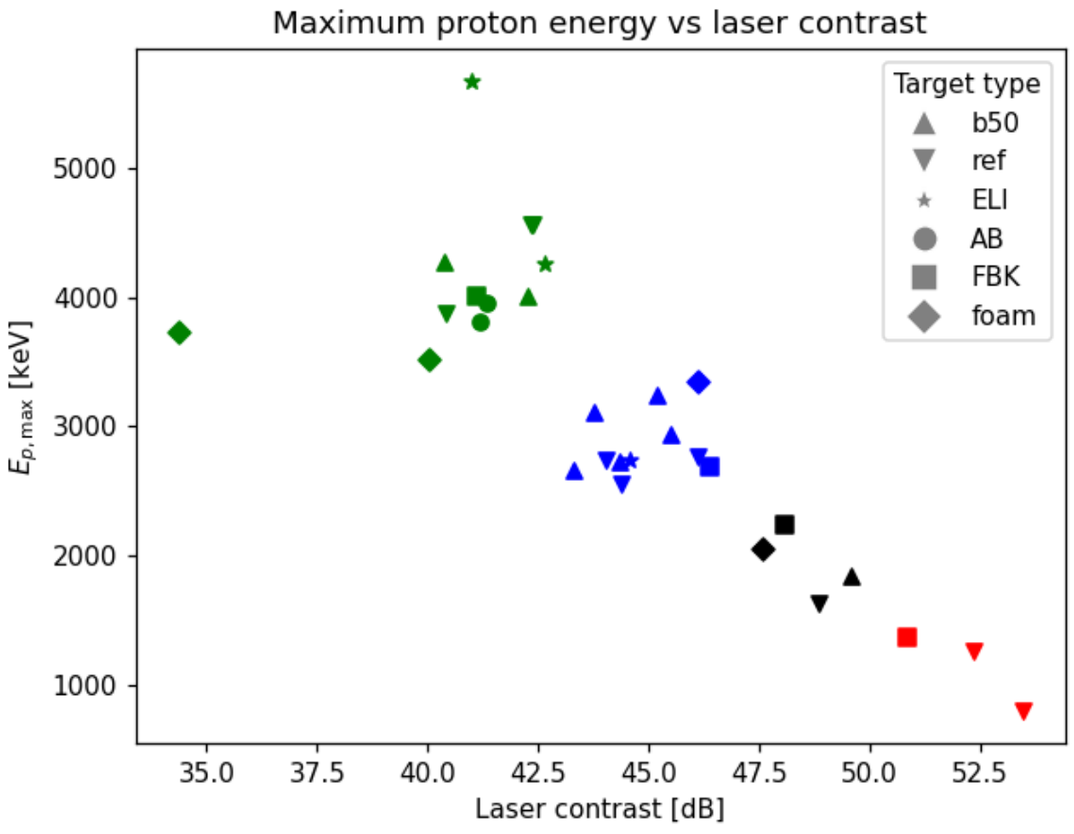
# Analysis is ongoing and publications already carried out

- Highest proton energy ever observed at PALS and proton fluxes able to activate the secondary B target p(10B,a)7Be
- Activation measure will give us the measure of the alpha produced in the catcher

Geant4 simulation of the proton-B interaction



# Analysis is ongoing and publications already carried out

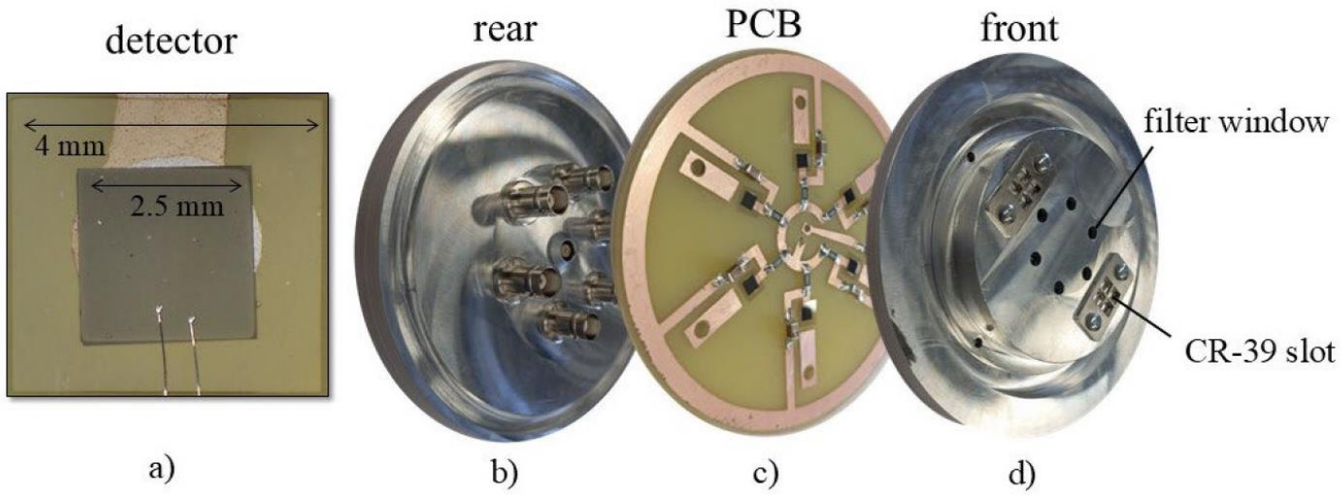



**Figure 1** a) Diamond detector soldered onto the PCB. b) Rear and d) front part of the aluminum housing. c) PCB hosting six diamond detectors.

**Submitted**

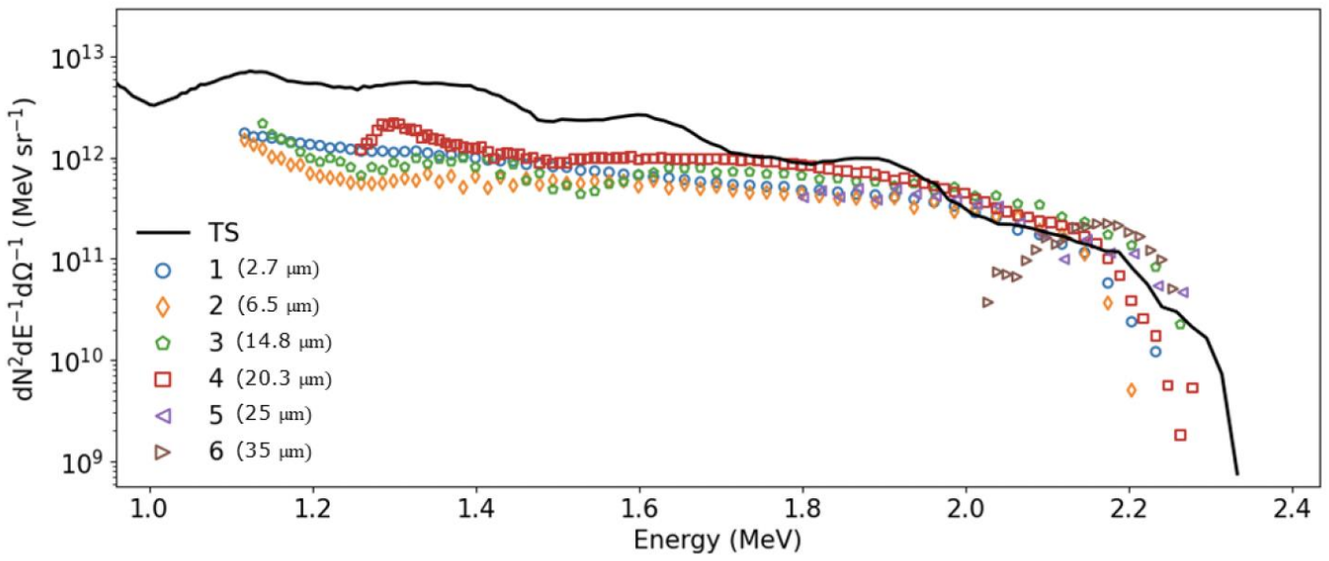
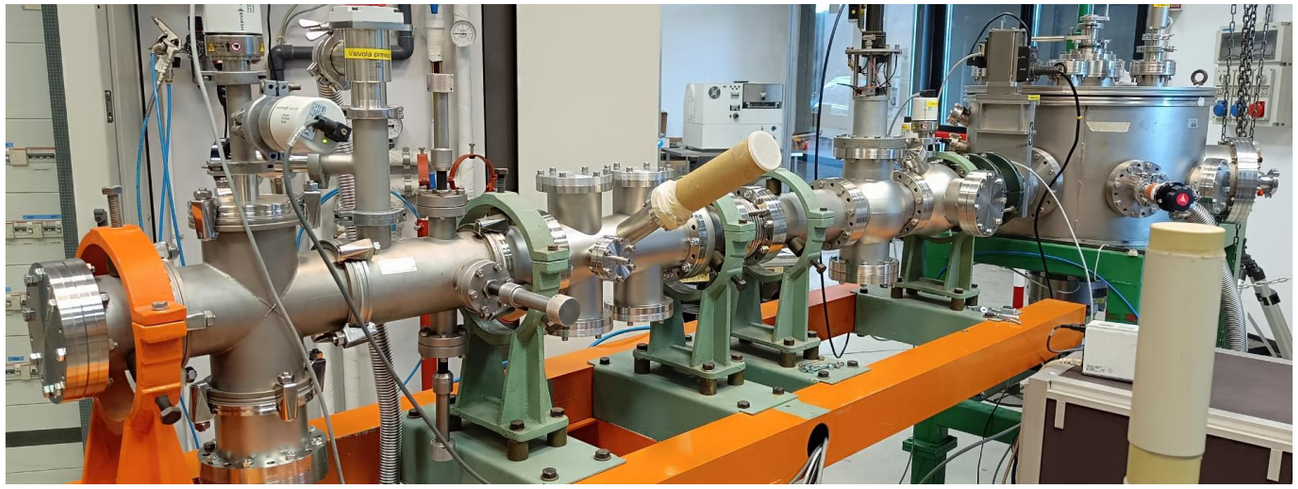
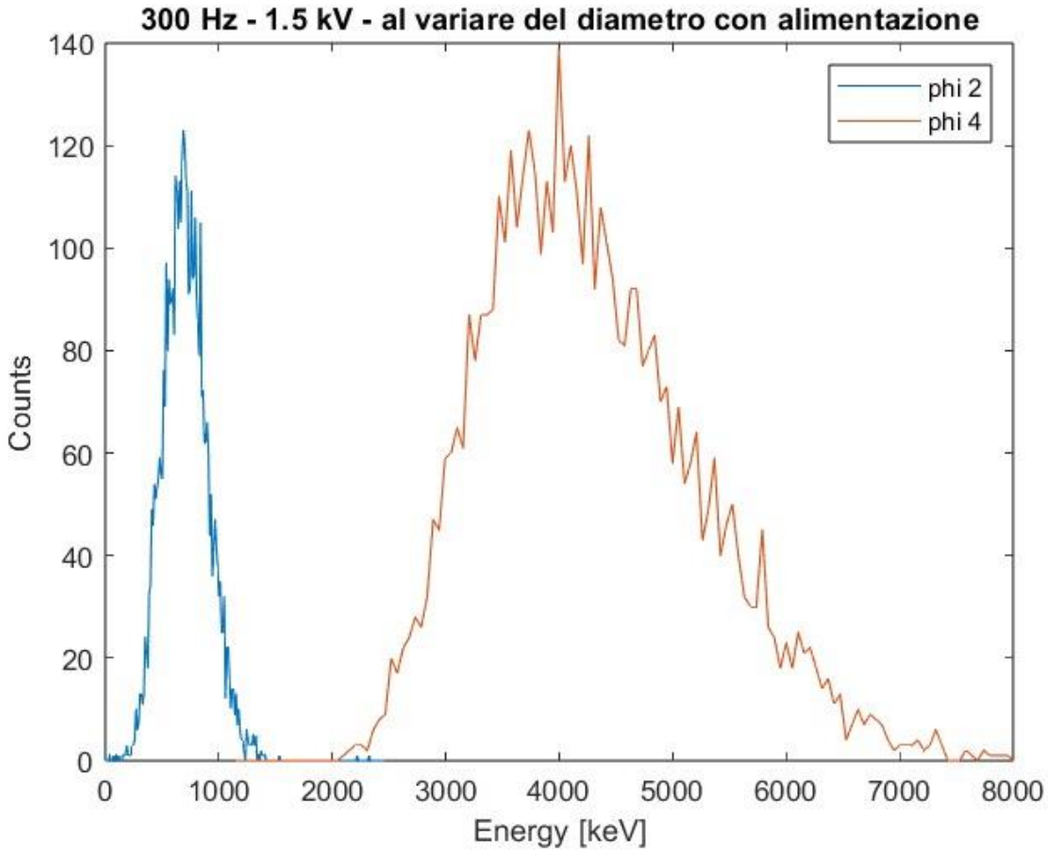



**Figure 9** Reconstructed protons spectra from MFDA (colored symbols) and TS (black line)

**Table 1** Max proton energy detected from MFDA, compared with TS. Number of protons per steradian comparison with TS taking into account of the energy interval integration for each MFDA unit, given by the different filter.

# WP 2






**Test del Chopper** presso il Singletron (DFA-UniCT) con Fascio di Protoni da 1MeV

**Spettro di energia** (raccolta tramite rivelatore SiC da 10 µm di spessore) durante ogni switch del chopper per due diverse aperture delle slitte

**Lug-Dic 2025:** test presso il Labec (Firenze) per ottimizzare i settaggi del chopper

**2026**: Istallazione dell'apparato sperimentale completo al Singletron di Catania (accoppiamento con il sistema di movimentazione, Fascio Laser e sistemi diagnostici) Prime miisurazioni di stopping power in plasma.

Pablo Cirrone, PhD - pablo.cirrone@lns.infn.it

# Next activities and notes

Istituto Nazionale di Fisica Nucleare

Experimental test just approved from November 24 to December 19th at the PALS facility (Prague, CZ)

New targets in preparation

Analysis and publications along 2025

WP2 tests in Catania

# Next activities and notes on one year extension

COST action PROBONO active until end of 2026

The COST action on Inertial Fusion we proposed (Pablo PI) was rejected but we will retry as HiPER+ consortium

We won three proposals to participate in experiments at ELI on the field of proton fusion for the 2026/2028 years

Call Reference: **CfP-FSD-AWP26-ENR-03**
Issued by: **EUROfusion / FSD department on 16/6/2025**

EUROfusion

**Call Details**

| | | | |
|---|---|---|---|
| Reference No. | CfP-FSD-AWP26-ENR-03 | PMU contact | Denis Kalupin |
| Due Date | 26/09/2025 | Department | Fusion Science Department |
| | | Status | Draft |

**Call for Enabling Research Proposals in the area of Inertial Fusion Energy (EnR-IFE) for the period of 2026-2027**

STMicroelectronics

HB11 ENERGY

2 PhD

# Richieste ed FTE 2026



| | |
|---|---|
| **Consumabili** | 2.0 (?) |
| **Impianti** | 0 |
| **Attrezzature** | 0 |
| **Altre spese** | 0 |
| **Missioni** | 2.0 |
| **Transport** | 0 |

| | |
|---|---|
| **Cirrone** | 10 |
| **Castro** | 0 |
| **Giardina** | 20 |
| **Giuffrida** | 50 |
| **Guarrera** | 50 |
| **Kurmanova** | 20 |
| **Lanzalone** | 10 |
| **Margarone** | 50 |
| **Fiori** | 100 |

# Papers/talks (partial)

- S. De Luca et al., Ions stopping power of p-11B reaction in laser-generated plasma , Workshop “On proton boron fusion”, Praga (Repubblica Ceca) 02-05 ottobre 2023.
- C. Altana et al., Stopping Power in plasma within the infn FUSION project, HPLA 2024, Catania (Italy) 11-12 January 2024.
- C. Altana et al. (Invited), Status and perspectives of nuclear reaches in plasma ,Twelfth International Conference of Radiation, Natural Sciences, Medicine, Engineering, Technology and Ecology, Herceg Novi (Montenegro) 17-21 June 2024.
- A. Trifirò et al., Ion Stopping Power studies in the energy domain of astrophysical nuclear reactions and nuclear fusion for energy production, 50th EPS Conference on Plasma Physics Salamanca (Spain) 8-12 July 2024.
- R. De Angelis et al., 50th EPS Conference on Plasma Physics Salamanca (Spain) 8-12 July 2024
- A. Trifirò et al., Measurement of ion stopping power in the framework of nuclear reactions in plasmas, International Conference Applied Nuclear Physics 2024, Thessaloniki (Greece) 23-27 September 2024.
- A Raso Multi Filter Diamond Array time-of-flight particle detector in laser-plasma experiments
- GAP Cirrone - Status and perspectives of the FUSION INFN project for the study and optimization of the 11B(p, α)2α nuclear fusion reaction for Inertial Confinement applications in press on Laser and Particle beams