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Diagnostics improvement in the ABC facility and preliminary tests on a laser-cluster experiment

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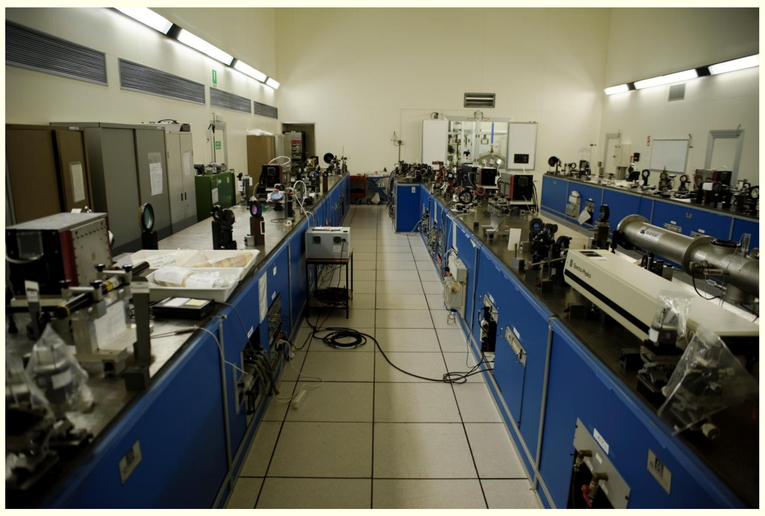
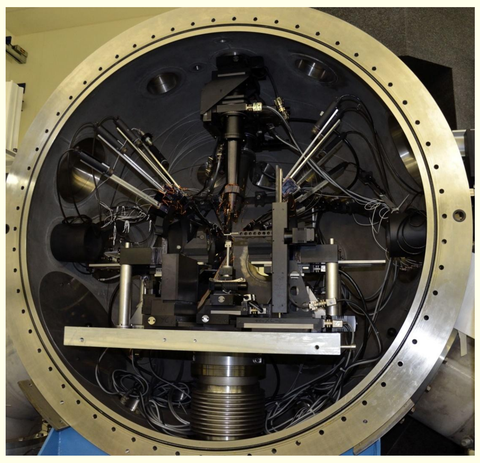
The research on Inertial Confinement Fusion (ICF) is mainly developed using high power laser facilities. In this context the diagnostics of particle flows is a delicate issue, due to the fast timescales and to the strong electromagnetic and radiative contributions. The discrimination of the different particles emitted by the plasma is therefore not trivial, and it requires the use of several diagnostic techniques. The ABC facility employs a two beams 100J/2ns Nd phosphate glass laser which can be focused up to about 10^{15} W/cm^2 on targets, from opposite sides, for investigation of high density plasmas. The experimental chamber is equipped with diagnostics for the measurement of the main plasma characteristics and for the evaluation of the target acceleration stability. In this contribution we describe the diagnostics improvement, which will provide a more detailed analysis of the particles and of the electromagnetic fields originating from the interaction of the laser with targets foreseen for future experiments. We also discuss the use of metal strips and diamond detectors to achieve a time resolved diagnostics of the particle flows.

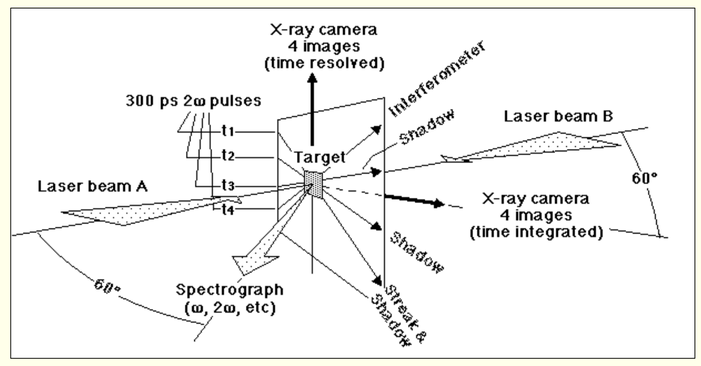
ABC facility





-Two-beam neodymium-phosphate glass laser, 2nd harmonic diagnostic beam, experimental vacuum chamber
-100 J/beam at the fundamental wavelength (1.054 μm)
- F/1 aspheric lenses - Possibility to focus up to 40 μm
- Beam smoothing by arrays of negative square lenses with random thickness
- FWHM pulse duration of ≈ 2 ns (tunable) with 2 ns pedestal (≈1% of total energy)
-2nd harmonic converters allow target irradiation also at λ= 0.527 μm

Diagnostics in the ABC facility



Time resolved optical diagnostics
- **Four light pulses at 2 ω and with a 300 ps FWHM are used for optical diagnostic**
  - Their delay can be easily tuned in order to choose the time interval for the target image
  - All of them can be equipped to perform a target shadowgraphy.
  - Time resolved target interferogram to estimate the plasma density and evolution
- **STREAK cameras:** Fast optical image of the target, with time resolution better than 2ps

Spectrometer: with ≈ 0.1 nm of optical resolution
Ion collectors: 10 Faraday cups, with variable voltage bias, at the same θ angle with respect to the target
X-rays diodes: 8 diodes, equipped with Ni filters of different thickness. To estimate electron plasma temperature
MCP: X-ray image of the target. 4 channels with different Be filters for estimation of plasma temperature
SLIX: Fast time scan MCP. Two different cameras. One with three and one with four strips. Target X-ray images at different times. 0.1-1.6 ns variable strip delay, 0.2-1.6 ns strip time gate, 100 μm spatial resolution

Diagnostic improvements

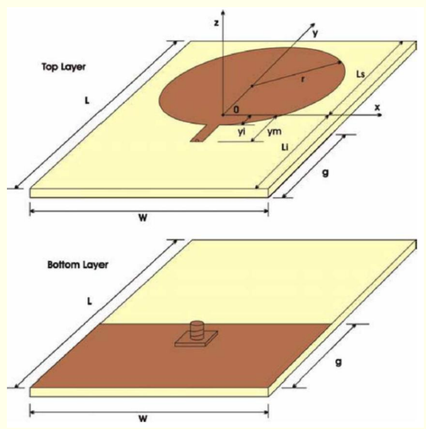
- **Improvement and updating of the previous diagnostics**
  - CCD cameras are substituting the Polaroid plates.
  - Survey visible spectrometer
- **Diagnostics for the analysis of particles produced by the laser-plasma interaction**
  - CR-39 plastic track detector ($C_{12}H_{18}O_7$ polimer)
  - Thomson Parabola
  - Metal strip with magnetic deflector
  - Diamond detector
- **Diagnostics for the analysis of the radiofrequency field produced because of the laser-plasma interaction**
  - Superwideband (SWB) microstrip antenna
  - Selective bandwidth antenna

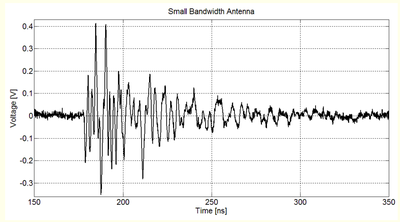
CR-39

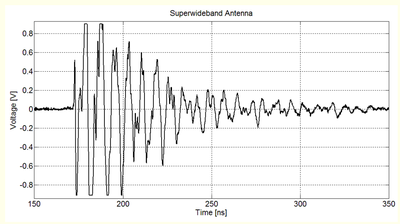
Appropriate mountings within the ABC experimental vacuum chamber have been prepared for good coverage of the solid angle of particle emission from the target, without blocking the other diagnostics

Radiofrequency field due to the laser-plasma interaction

Fast oscilloscopes are used to allow accurate Fourier transform of the detected signals

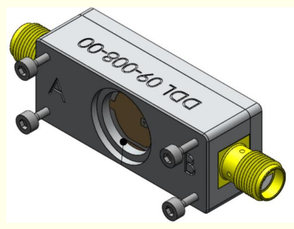


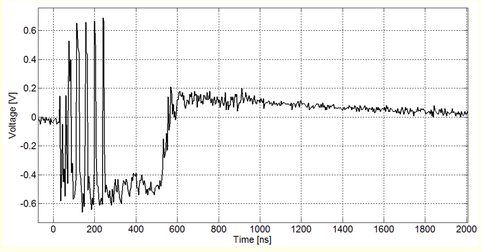




Diamond detector

High Purity Single Crystal Diamond:
BCMD-SCD464650D by Diam. Det. Ltd





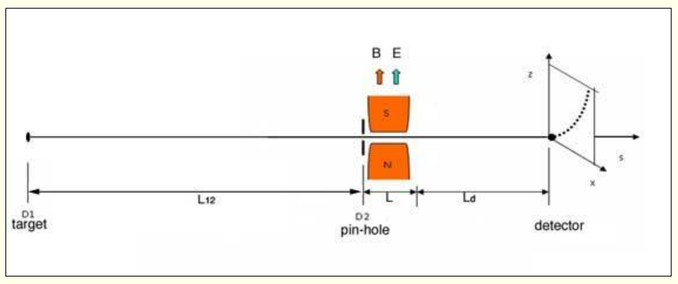
Thomson Parabolas

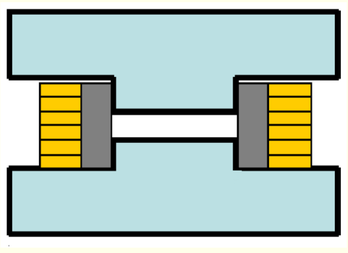
Detectors:
- CR39
- Image plate
- MCP - CCD

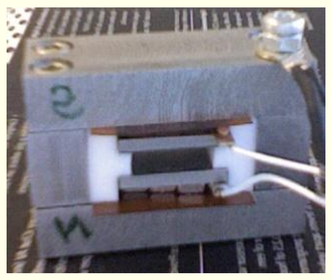
$$v_m = \frac{x_d}{z_d}\frac{E}{B}$$

$$\varepsilon_p / Z = \frac{1}{2 \cdot z_d} \cdot E \cdot L \cdot (\frac{L}{2} + L_d)$$

$$A/Z = \frac{1}{x_d \cdot v_p} \cdot \frac{e}{m_u} \cdot B \cdot L \cdot (\frac{L}{2} + L_d)$$

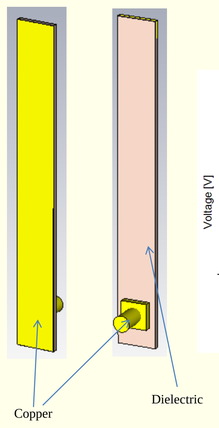


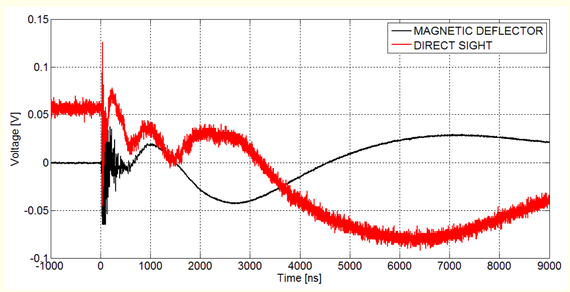




Metal Strips

- Coupled to a magnetic deflector
- Directly facing the target





$$f_{tot}(v) = \sum_{i=1}^{N} C_i \, f_i(v)$$

$$f_i(v) = \sqrt{\frac{2}{\pi}} \frac{v^2}{a_i^3} e^{-\frac{v^2}{2a_i^2}}$$

$$a_i = \sqrt{\frac{kT_i}{m_i}}$$