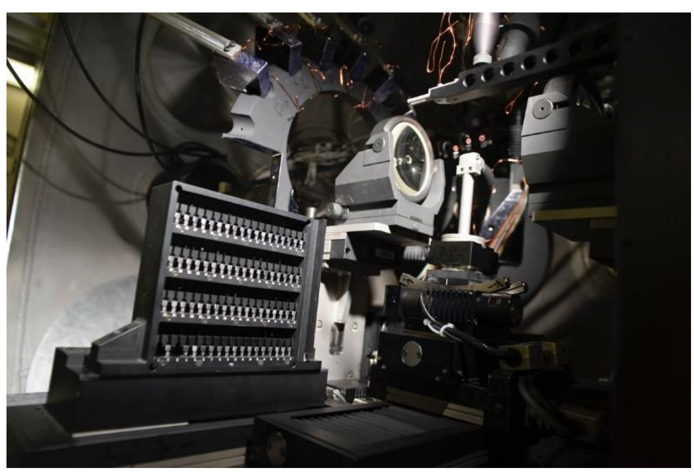
Ionizing and not-ionizing radiation for studies on materials and devices

Operated at ENEA-Centro Ricerche Frascati for inertial fusion research, ABC laser provides the most energetic laser pulse in Italy. It can deliver two infrared laser beams that, when interact with suitable targets generate intense ionizing and non-ionizing radiations. These can be used to study the response of specific materials and devices to pressures, electromagnetic and particle radiation stresses produced by the interaction, that become as a point-like compact intense radiation source, unavailable with other methods. The fields of application mainly regard nuclear fusion, particle acceleration, space applications, material science, radiation hardness of devices and materials, medical and biological studies.

Description of the technology

Laser-matter interaction can generate ionizing and non-ionizing radiation of various types even at high intensities. ABC is laser facility with the most energetic laser pulses in Italy and can deliver two counterpropagating beams of 100 J each in pulses of 3 ns, up to 1015 W/cm^2 of intensity on target. The laser beams are focused on a target placed at the center of the interaction chamber. A very large number of diagnostics is routinely used to monitor the evolution of the plasma created by the laser on the target. Accelerated particles, together with UV-X-rays and intense electromagnetic pulses in the microwave range, are generated during the interaction and accurately characterized for every shot. The behaviour of any material or device to ionizing and not-ionizing radiation produced by the interaction can be tested at the ABC facility, exploiting the precise knowledge of the source given by the wide set of diagnostic systems operating. By varying the laser energy and intensity on the target, the parameters of the accelerated particles or emitted electromagnetic radiation can be changed, according to the needs of the user. The exposed material or device can be examined after the experiment in order to determine the damage caused by the exposition to radiation.

The laser hall of the ABC laser facility.



Inside view of the experimental chamber of the ABC facility. In the picture: the target holder, the two focusing lenses and the repository for the targets, used for automatic target replacement.

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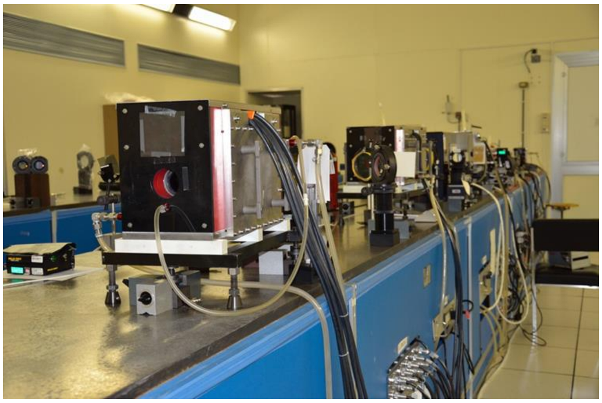
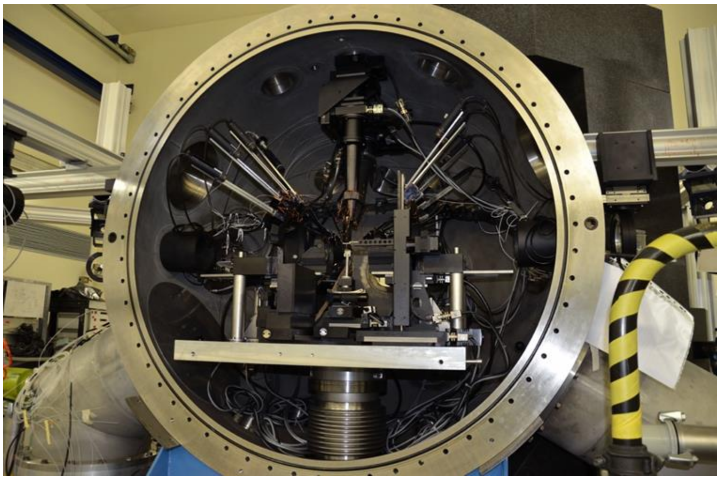
Description of the technology

The intense electromagnetic radiation in the radiofrequency-microwaves can be also used to test the resistance of electronic devices to harsh environments, heavily polluted by disturbances which could hinder their proper functioning or even irreparably damage them. Accurate characterization of the generated electromagnetic radiation is available through calibrated conductive and non-conductive probes for reliable testing. Among materials which can be subject to this specific short-time and intense radiation there are tissues and in general also living cells, for medical and biological studies. The ABC staff members are expert in the field of laser-matter interaction and specifically in the characterization of the plasma morphology and evolution along time, and of the wideband electromagnetic (radiofrequency, microwaves, UV, X, gammas) and particle (plasma, electrons, ions) radiation emitted because of it. Spectroscopy and imaging are among the main techniques used. All diagnostics are routinely used during each laser shot, with a dedicated acquisition software, for charged-particles detection, UV-X-ray and optical spectroscopy, plasma imaging and interferometry and calibrated conductive and non-conductive probes for the measurement of electromagnetic radiation. The staff can manage complex experimental setups to satisfy particular technical needs.



The custom-made amplifiers of the central beam line of the ABC facility. The initial laser beam is formed and amplified along this line, before being split and further amplified for two-beam operation.



The experimental chamber of the ABC facility with the lid open. Multiple diagnostics are mounted and functioning in every shot.

Patented technology: IT201900014385A1 - [WO2021024226]

EUROfusion
TECHNOLOGY TRANSFER PROGRAMME

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Innovation and advantages of the offer

The ABC laboratory offers a high-quality expertise in managing the high-power ABC laser and complex experimental requirements. It is an advanced platform to perform stress tests for materials and electronic devices exposed to plasma and radiation (ionizing and/or not-ionizing). This type of radiation sources is capable to provide a single intense burst of radiation, in short times that can be of the nanosecond order. This represents a unique test-bench for testing the working operations of devices and materials in very harsh environment and in conditions that cannot be reproduced by the several classical apparatuses commercially available.

Non-fusion Applications

The technology can be applied to perform stress tests on candidate materials and devices under the irradiation of ionizing and non-ionizing radiation, such as UV-X-rays, high-energy charged particles or high-intensity electromagnetic fields. The fields of application mainly regard nuclear fusion, particle acceleration, space applications, material science, radiation hardness of devices and materials, medical and biological studies. The technology is available for non-fusion application and demonstration. As an example, in the field of medical and biological studies, it can be used to make short-time resolved radiographies of living cells at very high resolution.

EUROfusion Heritage

The study and characterization of radiation (ionizing and not ionizing) caused by intense and energetic laser-matter interactions in the nanosecond regime typical of the ABC laser are one of the main topics of the Enabling Research Projects on the Inertial Confinement Fusion research of EUROfusion. One of the hot topics in this sense is the study of the transient electromagnetic pulses (EMPs) in the radiofrequency-microwave regime, included in several tasks of the funded ENR-IFE19.CCFE-01 (2018-2019): “Routes to High Gain for Inertial Fusion Energy”, and of the AWP15-ENR-IFE/CEA-02 “Towards Demonstration of Inertial Fusion for Energy” (2015-2018)

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