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First electrons from the new 220 TW Frascati Laser for Acceleration and Multidisciplinary Experiments (FLAME) at Frascati National Laboratories (LNF)

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ABSTRACT

A new era of laser based plasma accelerators is emerging following the commissioning of many high power laser facilities around the world. Extremely short (tens of fs) laser pulses with energy of multi-joules level are available at these newly built facilities. Here we describe the new 220 TW FLAME facility. In particular we discuss the laser system general layout, the main measurements on the laser pulse parameters, the underground target area. Finally we give an overview of the first results of the Self-Injection Test Experiment (SITE), obtained at a low laser energy. This initial low laser energy experimental campaign was necessary for the validation of the radio-protection shielding (Esposito, 2011 [1]) we discuss here. With respect to our preliminary configuration, with a pulse duration of 30 fs and a focusing optic of F/15, we discuss here the minimum laser energy requirements for electron acceleration and the forward transmitted optical radiation.

1. Introduction

The invention of Chirped Pulse Amplification (CPA) technique [2] has revolutionized the field of laser plasma interaction studies. This technique paved the path for the development of high power laser systems that can now be built on a small scale and hence led to an exponential growth in laser matter interaction studies. Laser-based particle accelerator [3,4], bright and ultrafast X/γ-ray sources [5] have reaching exciting results in the past few years. In particular new methods to control injection [6,7] and to produce ultrashort and collimated X/γ-ray beam [8,9] enhanced the interest in newly built laser facilities able to deliver from TeraWatt to PetaWatt laser pulses with relatively high repetition rate (10–1 Hz). Moreover the possibility to use in conjunction such laser systems with electron bunches from a LINACs is giving new thrust to Thomson scattering based X-ray sources [10].

The commissioning of the FLAME laser laboratory at *Laboratori Nazionali di Frascati—INFN* is aiming at this direction, providing facility which can deliver very intense and up to 220 TW laser pulses that can be used in conjunction with the SPARC LINAC. The FLAME laboratory is now fully assembled, the Clean Room hosting the Laser system (recently commissioned) with the control-command, the laser-beam transport line, the radio-protection shields and the Flame Target Area for laser gas-jet interactions. Actually a laser-plasma electron acceleration, the so-called Self Injection Test Experiment (SITE), is in progress to assess the overall performance of the facility and to deliver the first scientific results on laser-plasma acceleration. The first result using the minimum

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laser energy required for self-injection was used to obtain an initial dosimetry measurement for the validation of the radio-protection measures described elsewhere [1]. These preliminary data show that control of the main laser parameters at the target position has been achieved, including the off-axis parabola focusing, pulse duration and beam pointing. A general description of the FLAME facility will be given along with a summary of the first low energy results obtained in 2010.

2. The facility

A layout of the FLAME laboratory is shown in Fig. 1, in which three different zones can be identified: the first (white) is a free access zone that holds the Control Room, the second one (red) shows the Clean Room (or Laser Room) that contains the FLAME laser system. Finally the third zone (blue) is an underground bunker divided in two zones, one (right) for the laser pulse compression and diagnostic and another (left) hosting the target interaction chamber. The two areas are separated by a radio-protection wall labyrinth. A scheme of the laser-plasma accelerator with one photo of the internal view of the interaction chamber is also shown. After the compressor the beam can be sent alternatively in two different beam lines output: one is used to send the beam in the Flame Target Area and the other one to send the laser pulse in an adjacent bunker where the SPARC LINAC is placed. In this way it is possible to use the laser beam for all-optical setup (as for SITE) or for LASER-LINAC experiments.

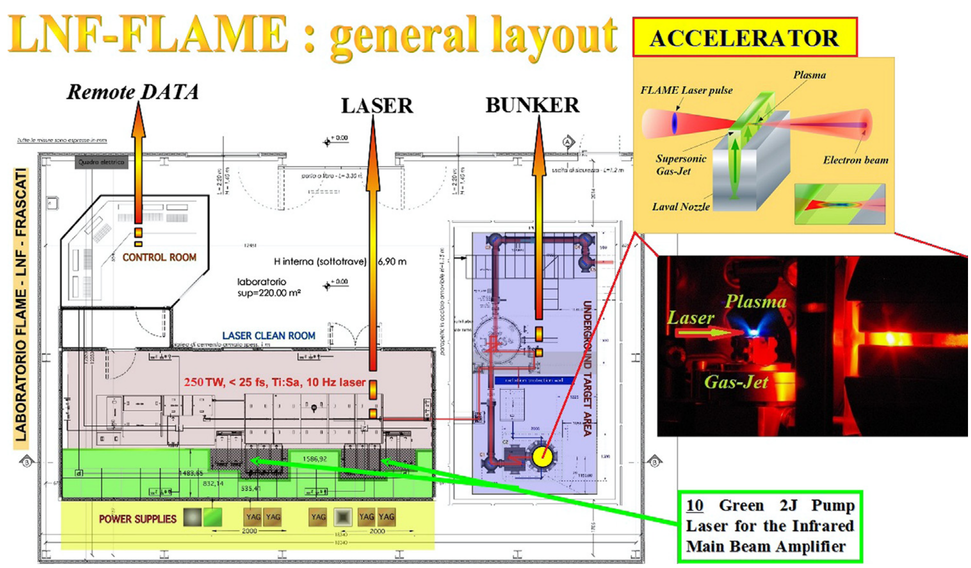

Fig. 1. Layout of the FLAME laboratory, three different zones are visible, the free access zone (white), the Clean Room containing the FLAME laser (red), the 6 m underground bunker (blue), and a scheme reproducing the laser-plasma accelerator with an internal view of the interaction chamber. (For interpretation of the references to color in this figure caption, the reader is referred to the web version of this article.)

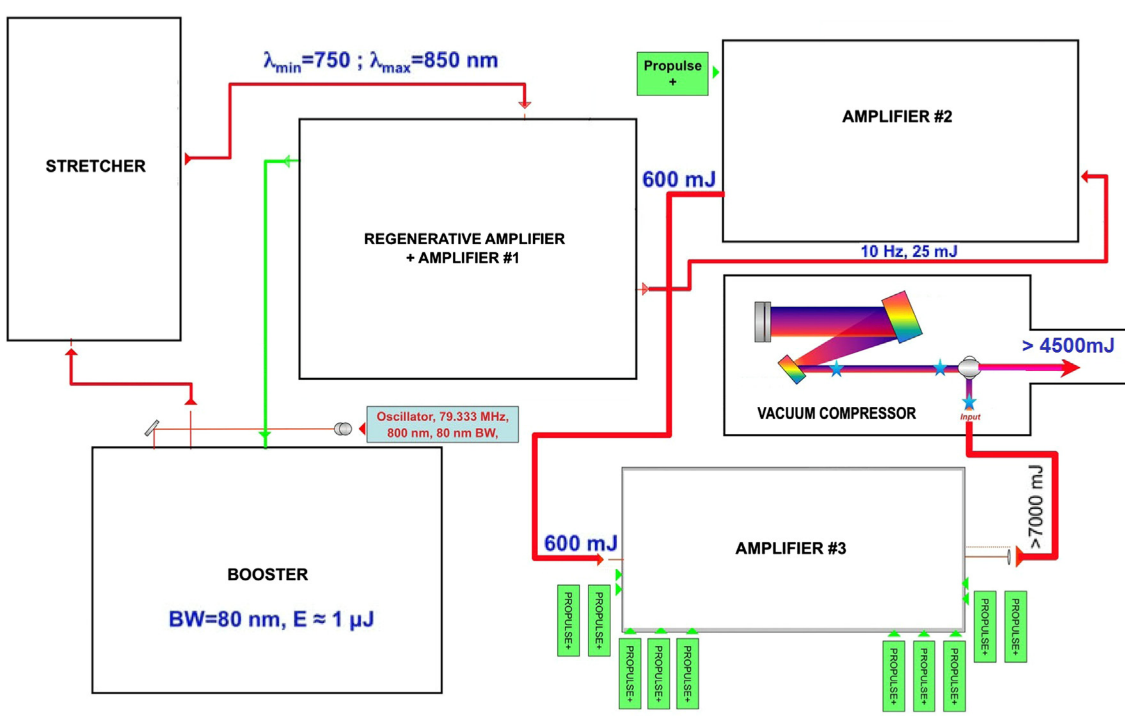

Fig. 2. Layout of the 220 TW FLAME laser system.