γ-RESIST

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1. Introduction

The aim of γ-resist is to realize a very compact high flux gamma ray source using a Compton scattering interaction. The novel approach in such experiment is to employ an all-optical setup. In fact, thanks to the latest techniques of electron beam generation/acceleration through laser-plasma excitation with high intensity lasers (10^{19} W/cm^2) [1], it is possible to get electron bunches on the order of tens-hundreds pC charge, with energies up to hundreds MeV in lengths of a few millimeters. Hence, the basic concept of such an arrangement is to split a high power laser, then to use one of the two replicas to drive the plasma interaction and produce the electrons, and the other one counter propagating would be scattered by the incoming electrons, thus being up shifted in frequency. A source like the one depicted has several advantages, compared to larger scale facilities, in terms of cost, compactness. A successful implementation of a scheme like that could be a considerable step ahead, respect to nowadays Bremsstrahlung based sources and comparable in performances just to very high cost, large scale facilities [2,3]. Furthermore, a laser-plasma based γ ray source has the unique feature of supplying very short photon beams (few fs in time), which could be employed in the next future whereas today interest is mainly focused in having a high average photon flux (rather than peak values).

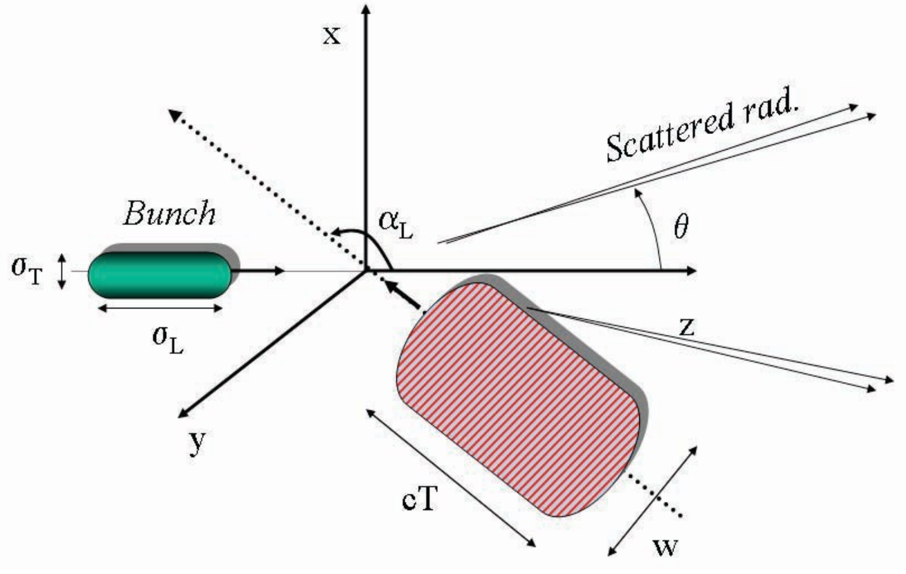

Figure 1 : Pictorial view of a Compton scattering of a laser beam by an electron bea

2. Features of the project and hosting structures

γ-resist, is a 3-years project, started in 2012, strongly based at LNF as the hosting laboratory, though several institutions are collaborating for the success of such a proposal.

Because of the increasing number of activities regarding plasma based acceleration techniques in the SPARCLAB framework at LNF, this shows to be an ideal environment for γ-resist. In particular, experience has been gained in the laser based generation/acceleration of e-beams [4], thanks to the high power laser FLAME (Frascati Laser for Multidisciplinary Experiments). This is a last generation Chirped Pulsed Amplification titanium-sapphire doped sapphire solid state laser, able to supply very short pulses (> 20 fs) with energies up to 5 J and repetition rate up to 10 Hz in the near infrared (800 nm central wavelength), for a maximum power of 250 TW. FLAME laboratory is placed right besides SPARC accelerator hall and it also features a small target area. Here it is possible to host the experiments which foresees the exclusive use of the laser, whereas transfer lines may alternatively deliver the laser pulse in the SPARC hall for the linac/laser based experiments.

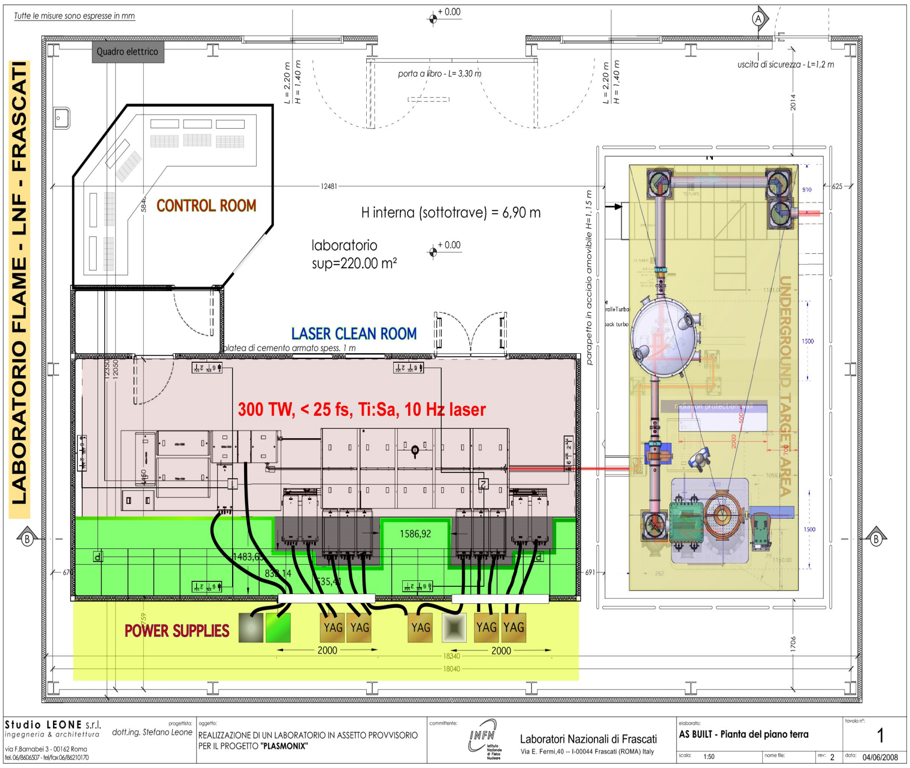

Figure 2 : Upper view of the FLAME laboratory with the target area on the right side

FLAME bunker is already hosting an interaction chamber used for laser plasma interaction whether on gas and on solid target, respectively for electron and for proton/ion generation. In particular, experience has been gained on the optimization of the interaction on gas target aimed to achieve stable, high quality electron beams. The target is given by a nozzle able to deliver a supersonic profile gas jet, whose densities are in the range of 10^{18}-10^{19} cm^{-3} electrons. Mainly nitrogen and helium have been used here so far. The scheme used to generate and accelerate electrons by just the laser in plasma is named self-injection, whereas for other schemes the two stages might be split and controlled by other parameters. γ-resist will use this same interaction chamber. Within the first steps, the aim would be to optimize the interaction in order to get maximum stability, high quality out of the electrons (low emittance and low energy spread), together with energy tunability. Then a quasi head-on interaction scheme would be taken in account in order to have the higher energy photons out of the scattering with the right synchronization and focal spot. Another important aspect is to study effects like radiation reaction, not directly observed, which should start playing a role, for example in the spectra of the emitted photon, and which computer codes are taking in account in order to model a real outcome of the all-optical Compton [5].

3. Achievements in 2012

The planning of the experiment foresees the completion of the project CDR (conceptual design report), which has been done. A real technical design report together with the first trials of a counterpropagating scheme in the interaction chamber, acquirement of detector for time/spectrally resolving the photon beam, simulations for the outcome of the interactions are foreseen for 2013.

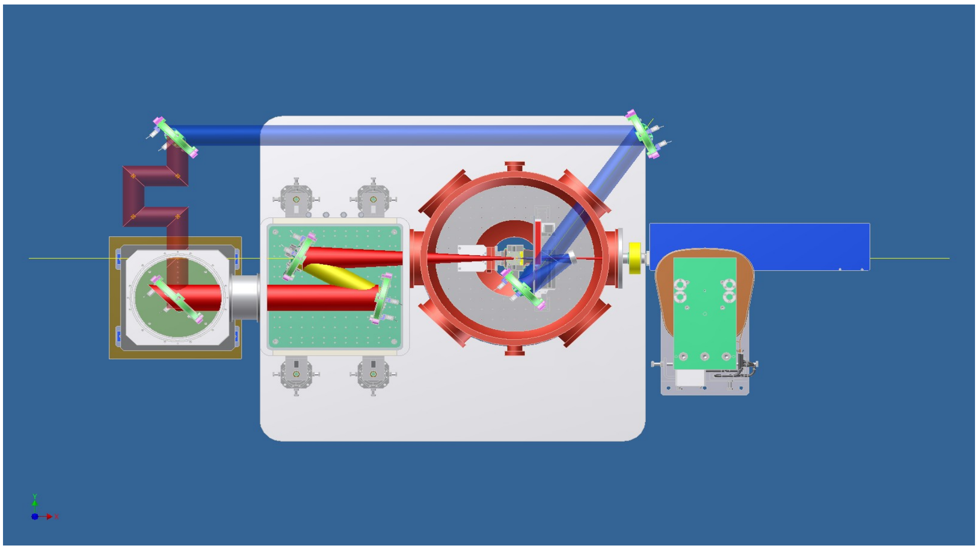

Figure 3 : Upper view of the experimental setup foreseen for the all-optical Compton scheme

References

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