Implementation and operational use of diagnostics to determine the useable energy in the center of the chamber on the LIL

O. Henry, C. Féral, D. Villate, E. Bar, V. Beau, P. Canal, L. Chauvel, T. Chies, V. Domin, P. Gendeau, H. Graillot, X. Julien, P. Le Gourrierec, O. Lobios, L. Patissou, D. Raffestin, P. Romary

CEA, Aquitaine Scientific and Technical Studies Center, F-33114 Le Barp, France

The LIL facility (Laser Integration Line) on the CESTA site in Aquitaine, France, is a prototype of the Megajoule Laser (MJL). Its challenge is to provide physicists with laser energy in the center of the chamber with the greatest possible precision. For that purpose, the LIL has developed and used a wide range of measurement resources.

When shoting on the target, only the incident energy on the chamber windows is sampled and measured using the Frequency Conversion Diagnostic (FCD) which consists of the Optic Sampling Module (OSM) and of the Conversion Diagnostic Module (CDM). The FCD is calibrated with the conversion standard sensors (CSS) at 2 kJ. The “f” fraction of the energy capable of penetrating into a target of a given diameter must then be evaluated.

An initial low flow calibration phase is performed at the start and the end of the experimental runs. This involves a mosaic of 4 calorimeters positioned behind a hole, 2 mm in diameter, in the center of the chamber (SYPEN-MC, SYstem for the analysis of the loss of ENergy in the chamber Nose by a Mosaic of Calorimeters).

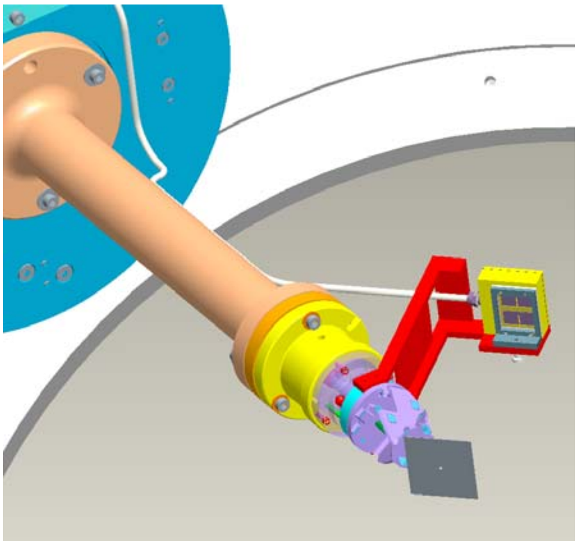

Figure n°1: View of the target-holder with positioning of the calorimeters and drilled target

In a shot, the purpose is to measure the energy running through a drilled target with a hole of a predefined diameter of 2 mm (figure n°1). By comparing that energy to the incident energy on the final optics, given by MP3ω, the loss of energy by transmission and by diffusion through the final optics can be deduced. The size of the target is 5 cm x 5 cm, with a 2 mm hole drilled in its center. The sufficient size of the target enables the elimination of such parasite diffusions as may reach the calorimeters. The flow resistance of the calorimeters enables the use of energies in the order of 0.5 to 1.5 J per beam. Those energies are too low to enable correct measurement on the MP3ω. To overcome that problem, absorbent glass panels in Paresol Bronze are added in front of the final optics and shots are performed with energies ranging from 200 J to 400 J per beam. The energy reaching the calorimeters is then in the order of 0.6 J to 1.2 J.

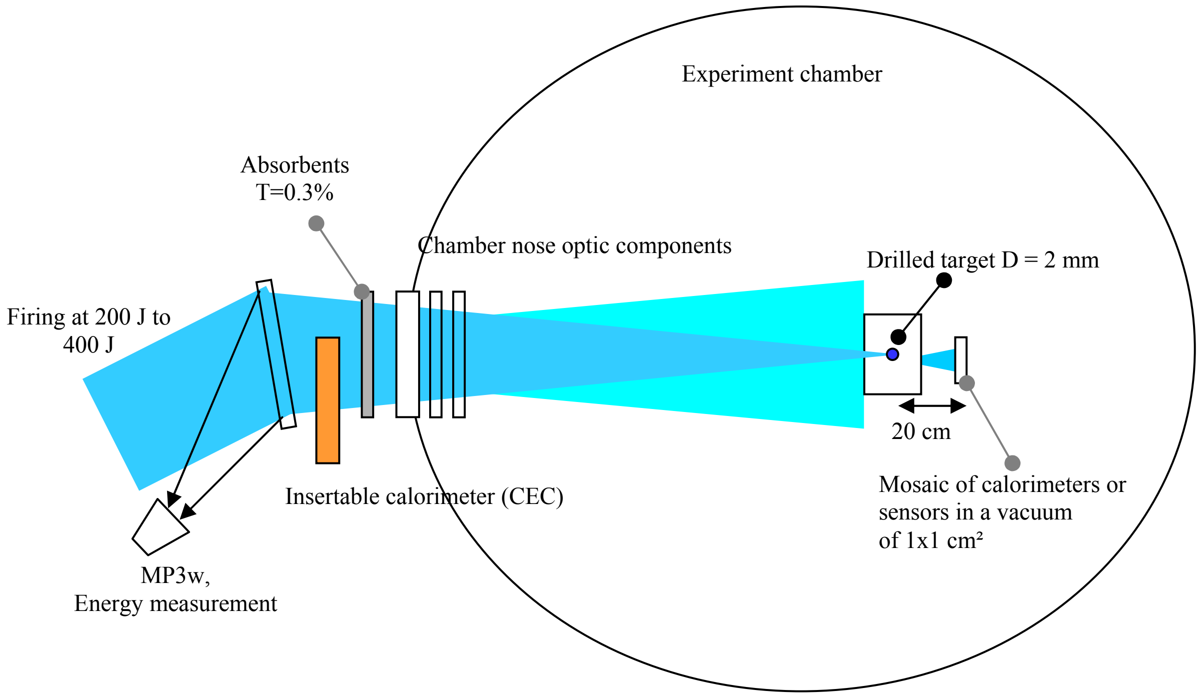

Figure n°2: diagram of the experiment chamber, measurement principle with 4 calorimeters

Measurement of the focal spot gives the spatial distribution of the energy in the center of the chamber and therefore the energy fraction contained in a circle of a given diameter. Combination of this measurement with the previous measurement enables evaluation of the fraction of the incident energy that can penetrate into a target with an entrance hole of a given diameter and establishes the link between the energy at the center of the chamber and the energy measured by the FCD.

A second phase consists of controlling any possible shift of this « f » fraction during an experimental run. A specific diagnostic has been developed for that purpose: the SYPEN-FS (SYstem for the analysis of the loss of ENergy in the chamber nose by a probe beam). This makes it possible to measure the evolution of the transmission of the final optics components (windows, debris shield) and to map the damage on those components. That data will also make it possible to assess by simulation the relative evolution of the spread of the energy in the focal spot.

The diagnostic does not require any shot on the laser line as it has its own UV light source for inspection of the chamber nose.

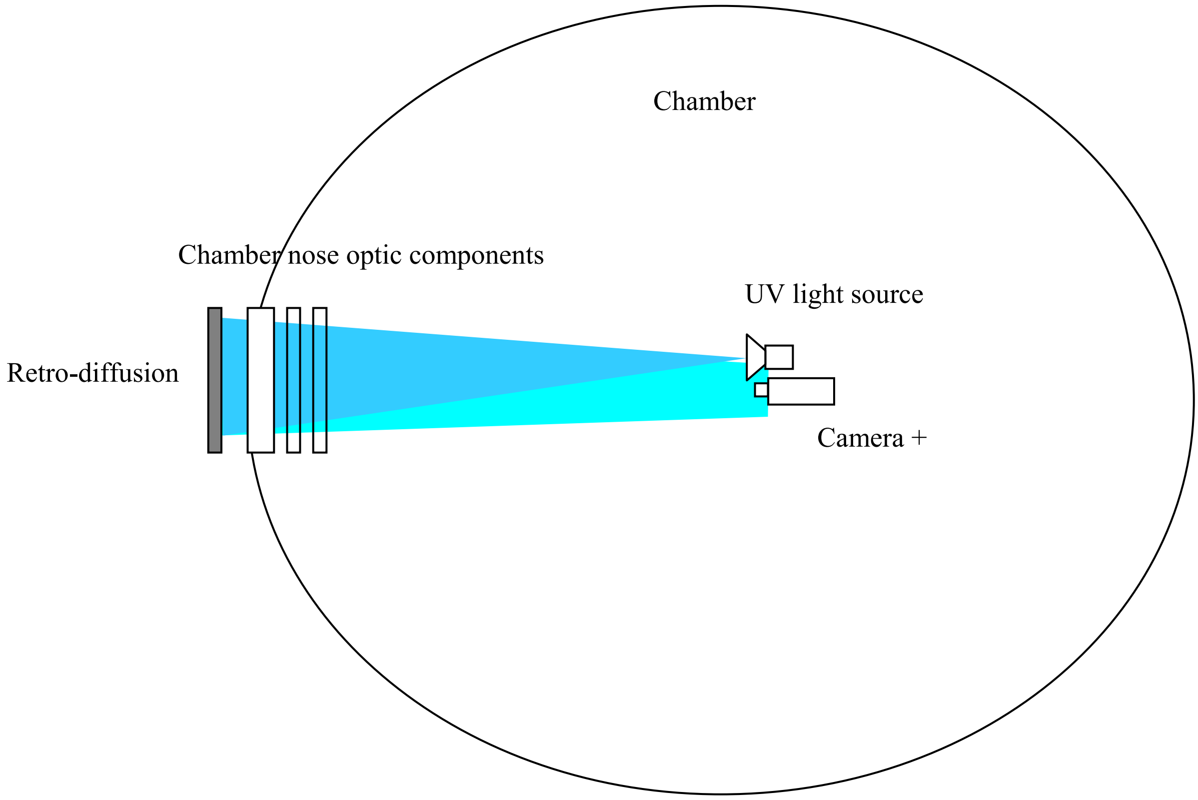

Figure n°3: diagram of the experiment chamber, measurement principle with the SYPEN-FS

The aim is to produce a system the performance levels of which are as follows:

- relative overall transmission measurement at 2% in relation to the new component
- evidencing of defects larger than 1 mm
- simplified exploitation
- no specific maintenance laboratory

The idea consists of injecting a LED-based low energy probe beam into the final optics. The beam runs through the final optics, is reflected on a retro-diffusion sheet positioned behind the chamber window and returns to the center of the chamber where it is analyzed (Figure N°

3). From this, the losses through the final optics can be deduced by comparing the incident beam with the return beam on the basis of a reference taken with new optics.

The sensor consists of a CCD enclosed in a tight-sealed chamber making it possible to maintain the camera at atmospheric pressure whereas the chamber is in a vacuum (figure N° 4). The doublet is surrounded by a ring of eight UV LEDs enabling sufficient lighting of the chamber nose with a 355 nm wavelength. This lighting makes it possible to improve the contrast of the images and to restrict the phenomena of speckles due to the diffuser. The resolution of the system makes it possible to display impacts or defects of less than 1 mm that will therefore be easy to distinguish from the real defects detected in the components.

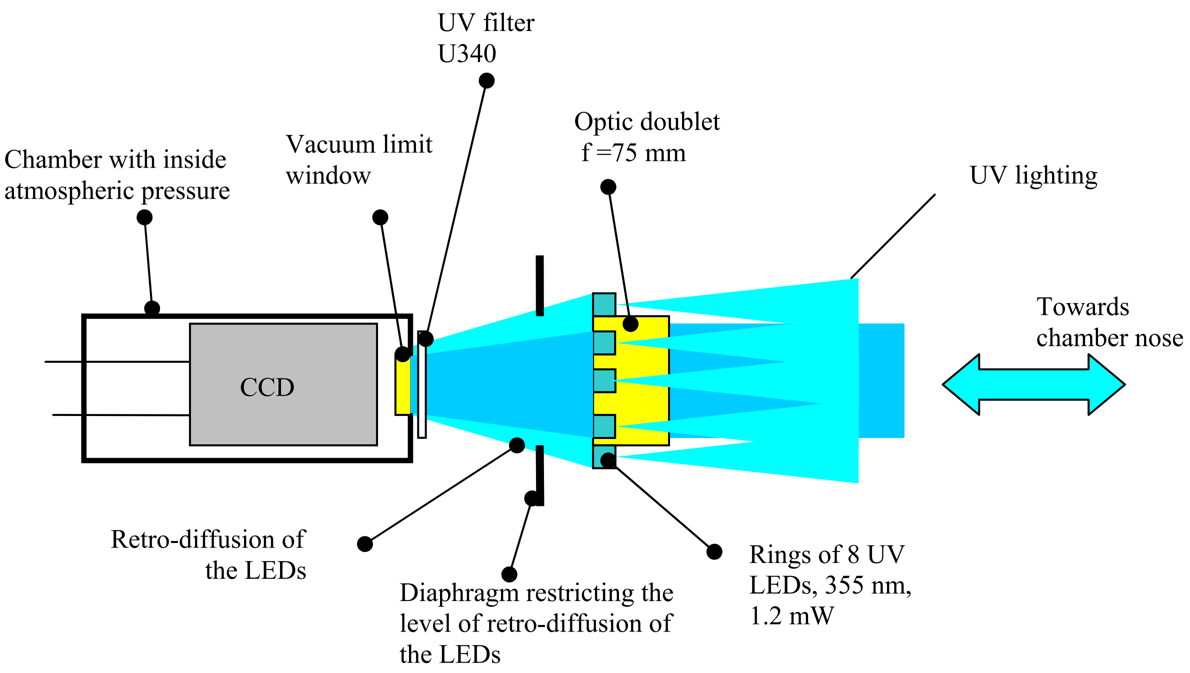

Figure n°4: detail of the sensor arranged in the chamber center

The system works by establishing the relative ratio between the light intensity sent to the chamber nose and the intensity returning from the nose. An incident reference is necessary made by using the retro-diffusion of the LEDS to the camera which will introduce a non nil background on the camera indicating the level of lighting of the LEDs. The reference is thus made simultaneously with the measurement of the chamber nose, making it possible to avoid variations in the sensitivity of the CCD.