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Commissioning of the HHG source at SPARC

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1. Introduction

The phase of installation of the required components for the seed source at SPARC has been successfully concluded. The last step consisted in the final assembly, alignment and test of the harmonic generation chamber with the laser system and the e-beam transfer line. The harmonic generation chamber was previously tested at CEA [1-2]. The femtosecond laser system (LUCA) of the Saclay Laser-matter Interaction Center (SLIC) was used as fundamental source for the tests. The main characteristics of this laser (2 TW, 20 Hz CPA Titanium:Sapphire System [3]) substantially outperform, in terms of energy per pulse and peak power, the one of the laser system which is available at SPARC. For this reason these preliminary tests were done downgrading the LUCA performances in order to determine the optimized geometry of the gas cell and the laser optical beamline in conditions similar to the one foreseen at SPARC. The chamber was then delivered to Frascati in the beginning of 2007 and the laser system for the seeding experiment has been completed in November of the same year. The latter step required the installation of a clean room to host the laser system and the realization of an optical beam line for transporting the light from the cathode drive laser to the amplifier. The laser system has been recently commissioned [4] and performances close to the specifications have been demonstrated. Now the laser has been employed in the commissioning of the harmonic generation source as it was foreseen in the seeding at SPARC experimental plan [5]. In this paper we provide a description of the harmonic generation chamber experimental layout, and we report on the measurement of harmonics generated in gas.

2. Layout of the harmonic generation source

The setup for the production of the harmonics in gas is composed by three chambers. The laser is focussed by a plano-convex lens (*f=2 m*) and delivered through an antireflecting coated 790 nm window in the first chamber where harmonic generation occurs. In this chamber a cell is filled by Argon gas and is illuminated by the laser source. The gas inlet valve is triggered at 10 Hz by the same low frequency trigger signal that enables the pockel cells extracting the pulse from the regenerative amplifier. A second chamber is used to increase the vacuum gradient between the first chamber and the SPARC transfer line. Then the third chamber, 1.5 meters downwards, is used to match the harmonic beam with a waist located in the middle of the first undulator for a correct overlap with the e-beam. The optical mode shaping is performed using two spherical mirrors reflecting nearly at normal incidence, both equipped with motorized mounts, and an additional translation stage under the second mirror, for the adaptation of the focusing point in the undulator. The distance between the gas jet and the middle of the first undulator is about 8 m. A view of the array of the three chambers is shown in Figure 1. A picture of the chambers in the SPARC HALL is shown in Figure 2.

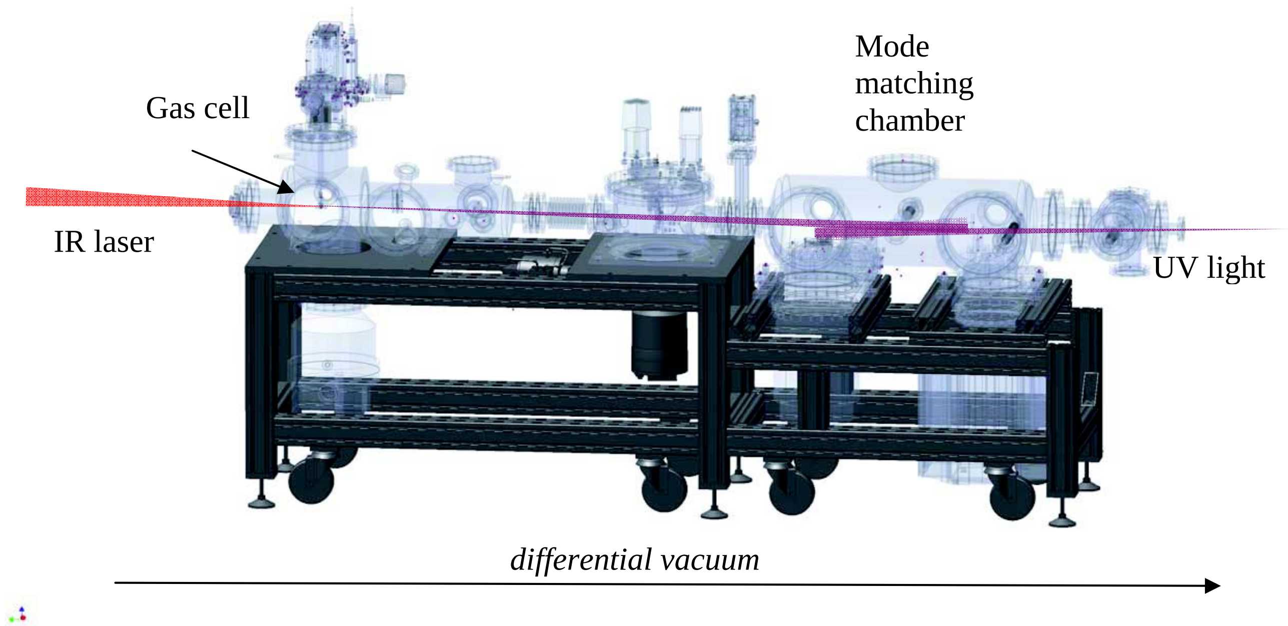

Fig. 1. *Layout of the harmonic generation chambers*

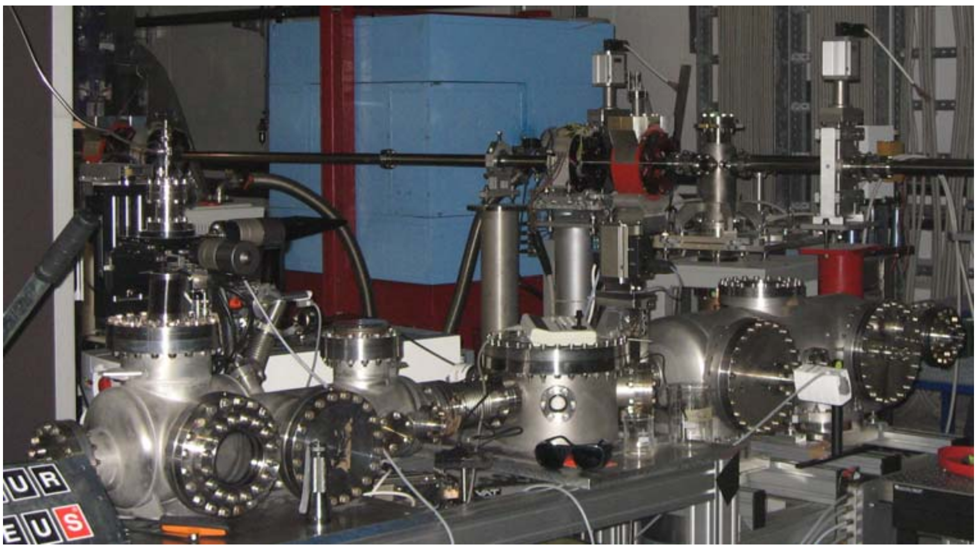

Fig. 2. *Harmonic generation chamber in the SPARC Hall*

3. Observation of harmonics

After optimization the laser was delivering 2.3 mJ per pulse after the compression stage. At the exit of the third chamber an optical table with the necessary diagnostics has been installed. An interferential filter centred at 266 nm is used to eliminate the infrared light. A focussing lens with focal length of 200 mm is used to set up an optimized detection position in the focus of the lens. Initially a yellow paper sheet has been positioned in the focal position in order to facilitate the eye detection of the third harmonic light. This set-up has been used in order to find the fine alignment which allowed the first observation of the harmonic light.

After the first observation an UV sensitive photodiode (DET710) has been mounted on the output optical table, at the focussing point of the UV lens. The photodiode has been used in the optimization of the signal by varying the position of the waist in the gas cell, the dispersion of the compressor after the regenerative amplifier, the pressure of the gas and the trigger delay between the laser and the aperture of the inlet valve.

In Fig. 3 the traces of two photodiodes are shown simultaneously. The upper trace is the infrared photodiode signal from the Ti:Sa laser detected before the harmonic generation chamber, the lower trace is the UV photodiode signal collected after the chamber. The lower signal could not be detected when the trigger enabling the gas inlet valve is inhibited.

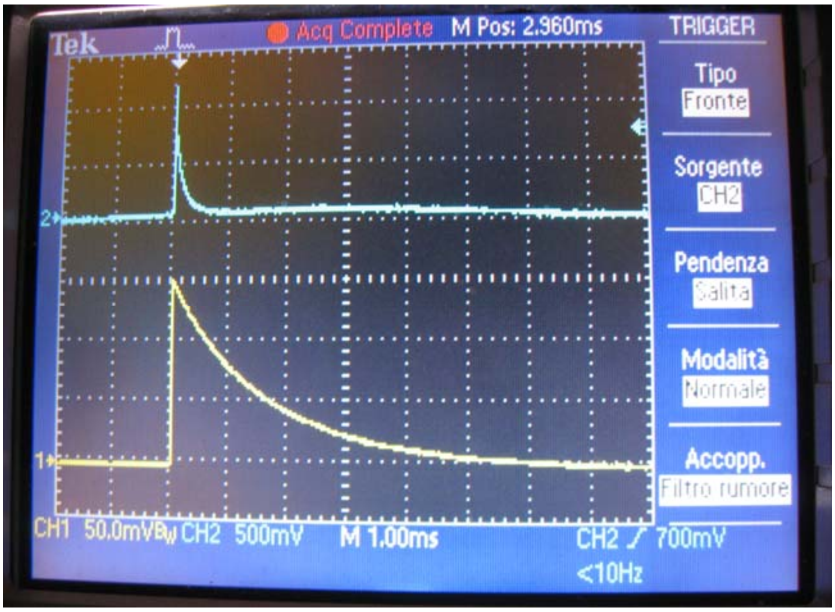

Fig. 3. *Photodiode signals in the infrared (cyan) and UV (yellow)*

A spectrometer with a resolution of 0.3nm has been installed on the output table, after the interferential filter and the focussing lens. The exposure time has been set to 200 ms in order to collect at least one harmonic pulse. The spectrometer output window is shown in Fig. 4.

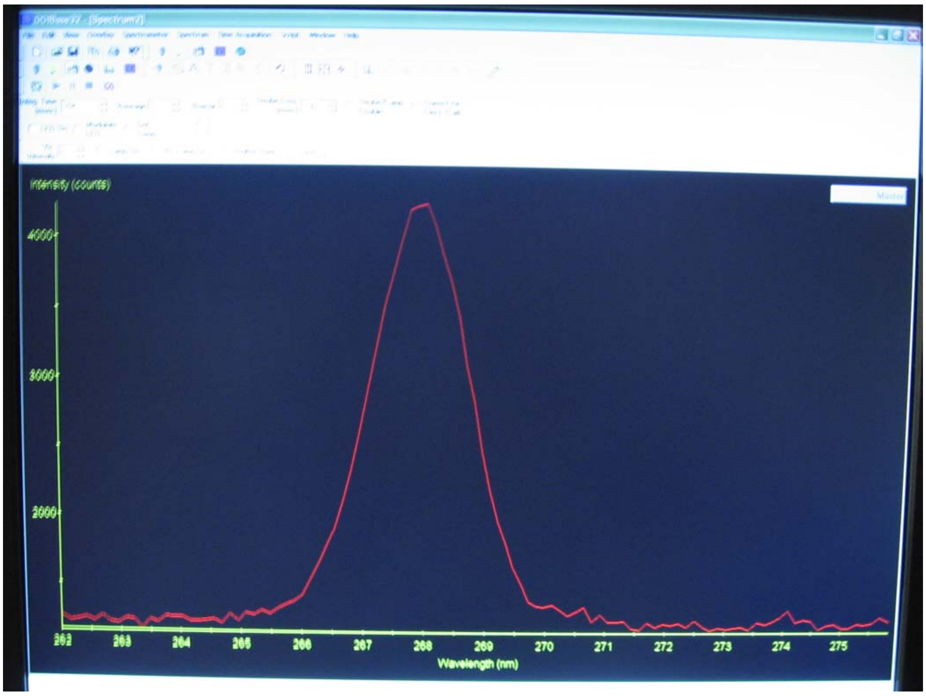

Fig. 4. *Spectrometer output window*

The observed spectrum corresponding to the third harmonic of the Ti:Sa laser is centred at 268 nm and the measured bandwidth is 1.8 nm-fwhm. A calibrated power meter (Molectron, Model 33-05, 3V/mJ) has been used instead of the photodiode to measure the energy of the third harmonic. The third harmonic intensity on the oscilloscope is 1.5±0.5 mV corresponding to an energy of 0.5±0.15µJ. No signal is observed without gas, for this reason we may neglect any contamination from the drive laser. Since the transmission of the interferential filter is around 20%, we assume an energy per pulse at the output of the gas jet of 2.5±0.8µJ. This value, assuming an energy per pulse of the drive laser of 2.2 mJ, corresponds to a conversion efficiency of about 10^{-3}.

The spatial profile of the radiation has been collected by projecting the beam on a reflecting screen. The image has been detected with an high sensitivity CCD camera (Canon IXUS 800 IS). The image is shown in Fig. 5.

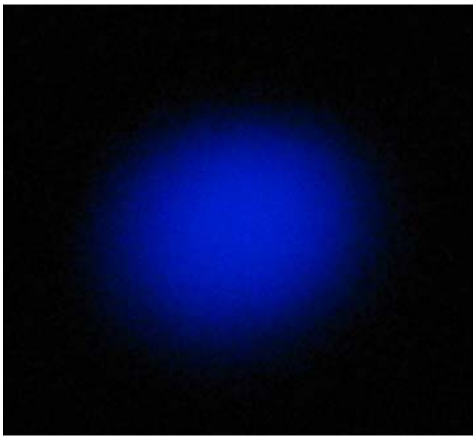

Fig. 5. *Spot of the UV radiation at the detection screen*

4. Conclusions

The third harmonics has been generated in a gas cell, with the 2.2 mJ IR laser. First optimisations have been performed in terms of gas pressure, IR spot size, interacting geometry and position of the focussing lens.

According to the first estimation (photodiode and power meter), the energy per pulse on the third harmonic is around 2.5 µJ. The spectral width is 1.8 nm (fwhm). The wave front could not be directly recorded with an UV sensitive camera but appeared quite homogeneous on the fluorescent screen.

5. Acknowledgments

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6. References

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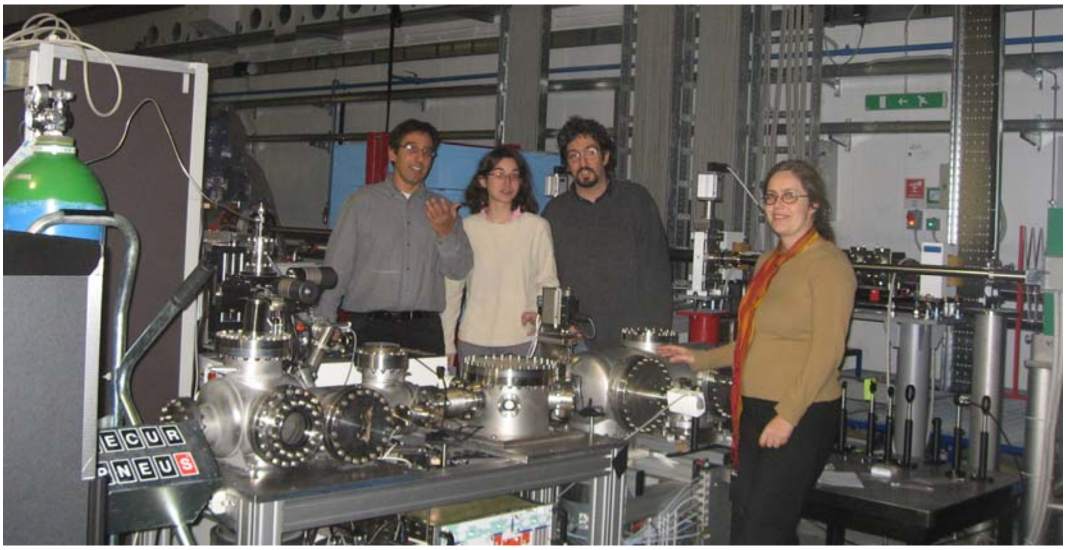

From left to right L. Giannessi, M. Labat, D. Garzella, M.E. Couprie