Laser-Plasma Coupling Study
In a Shock-Ignition Relevant Regime

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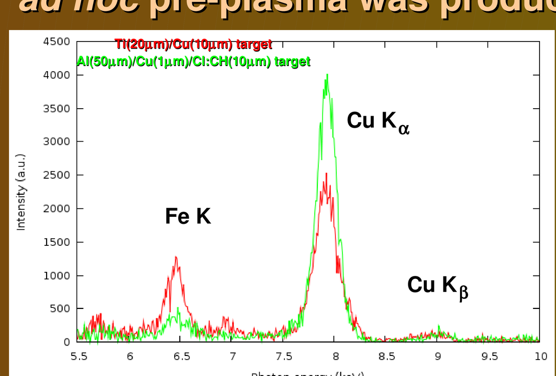
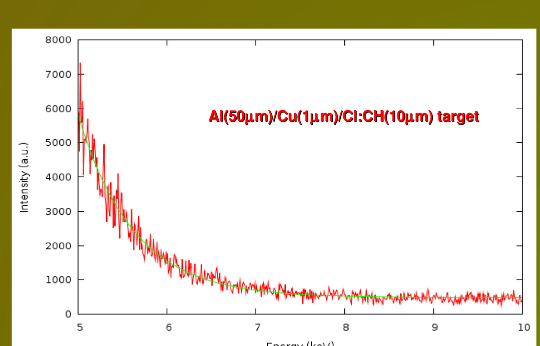
Abstract

HiPER related shock ignition relevant experiments have been performed very recently at Prague Asterix Laser System facility. In these experiments coupling between a 10^{16} W/cm² intensity pulse, with time duration of 300 ps, and a preformed plasma has been studied, in order to investigate phenomena such us shock wave production and propagation, parametric instabilities issues and fast electron yield in a shock-ignition-like scenario. Preliminary results from X-ray plasma emission and parametric instabilities backscattered light are shown in this poster . TheX-ray measurements have been performed by means of an innovative imaging technique with spectral resolution, the EEPHC diagnostic (L.A.Gizzi et al., PPCF 49, B221 (2007), L. Labate et al., Rev. Sci. Instrum. 78, 103506 (2007), L.Labate et al., LPB, 27, 643-649 (2009), T. Levato et al., NIMA 2010 doi:10.1016/j.nima.2010.02.082), developed by ILIL group. The backscattered radiation expected to arise from parametric instabilities, including Stimulated Brillouin Scattering, Stimulated Raman Scattering and Two Plasmon Decay, has been instead studied by means of optical imaging, calorimetry and spectroscopy. Preliminar analysis shows that less than 10% of the laser energy (at 438 nm, 250 J) is lost due to such instabilities scattering.

X-ray Spectra

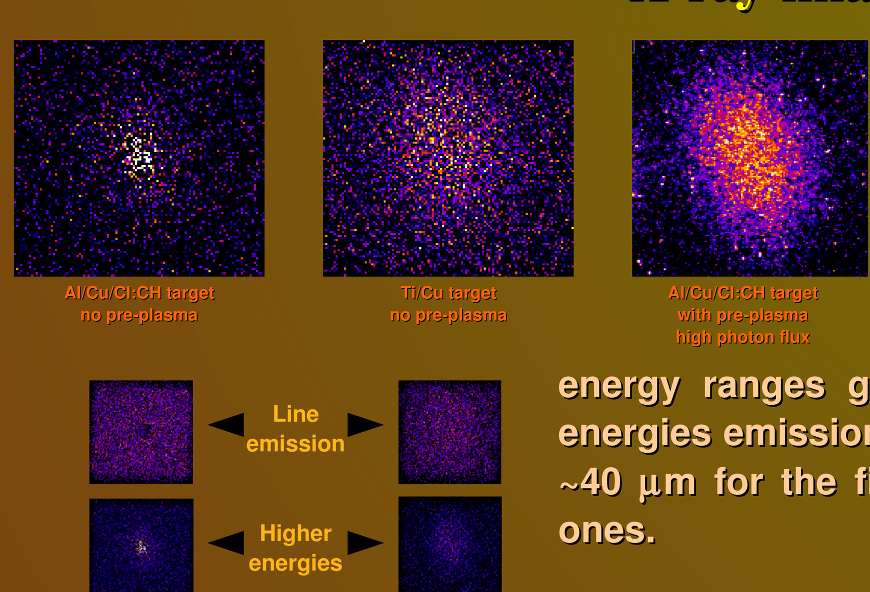
X-ray spectra acquired by the *EEPHC* diagnostic are shown, of a plasma produced by a main pulse focused at intensity of 4×10^{16} W/cm ² (left figure). In some shots an *ad hoc* pre-plasma was produced by a 80 J , 300 ps pulse (right). In the latter case bremsstrahlung emission is dominant, driven by electrons at an estimated temperature of 600 eV. In the left figure line emission in 5 – 10 keV range is instead clearly visible.





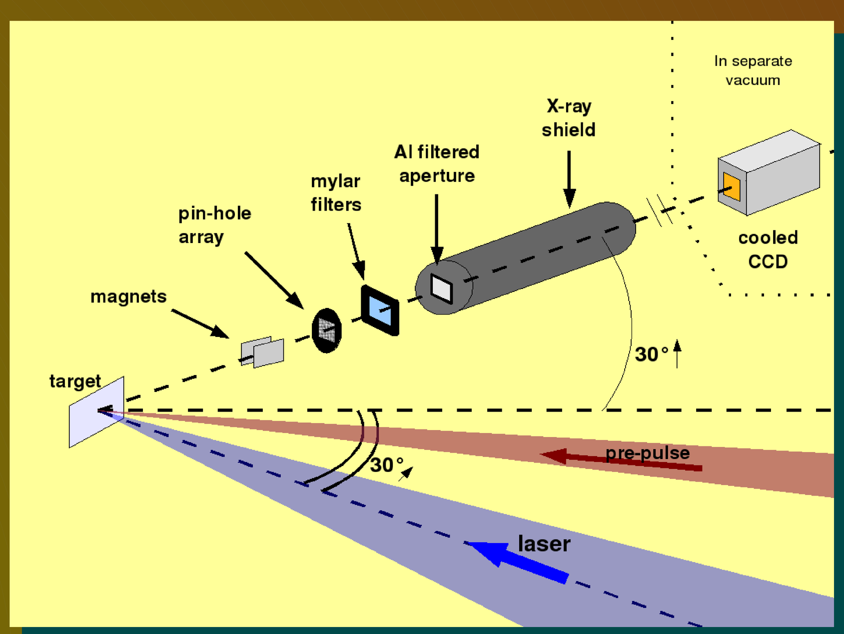
X-ray imaging

Image reconstruction of X-ray source is shown for different targets irradiation with the main laser pulse. The unique feature of *EEPHC* of imaging in different selected range of photon energies is also shown. The different kind of images arising from energy ranges give informations about selected photon energies emission zone. The size of emission region are of ~40 µm for the first image and of ~100 µm for the other ones.



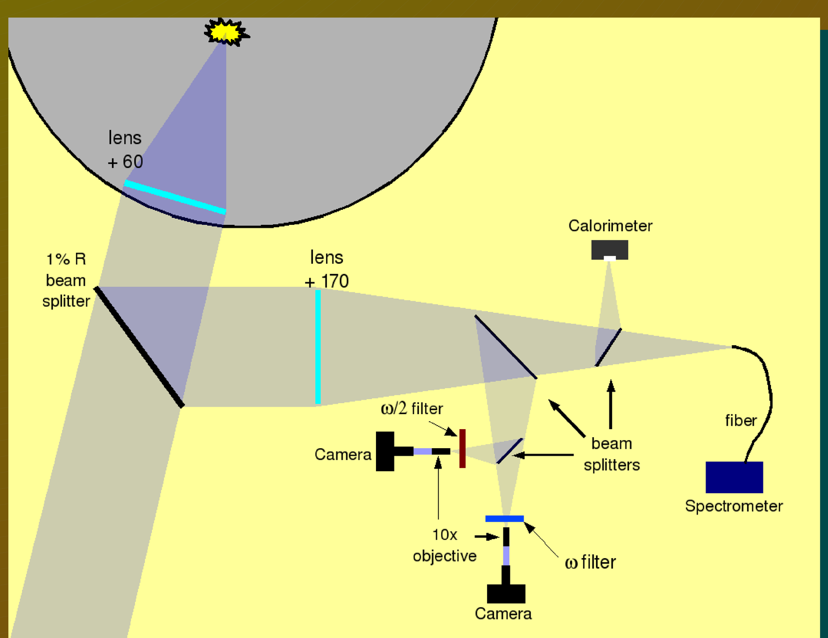
EEPHC Diagnostic Setup

In this experiment the *Energy Encoded Pin-hole Camera* diagnostic is set up to look at X-ray front emission of a ~1 keV temperature, mm scale plasma interacting with a 300 ps, 250 J pulse, in a shock-ignition-like scenario.



The diagnostic works in single-photon regime to be sensitive to the radiation spectrum, and allows reconstruction of X-ray source image by superimposition of many single photon images; these images are aquired in a sigle shot by means of an array of pin-holes each one making an image of the source onto a CCD detector. Up to 950 µm of mylar filters were used to reduce the photon flux to single photon regime, and a schielding tube of MgAlSi was set up in order to protect the detector from secondary X-ray noise and visible light. Also a pair of magnets were put in front of the pin-hole array to avoid electron escaping from plasma to emits by bremsstrahlung on the pin-hole array substrate.

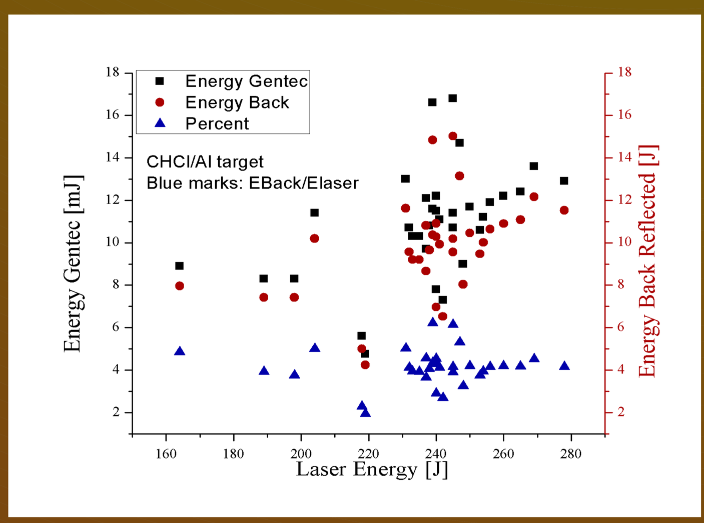
Backscattering Diagnostic Setup



Backscattered light expected to arise from parametric instabilities has been detected by means of spectroscopy, calorimetry and optical imaging. The scattered light is collected by the same lens used for focusing of the laser pulse to the target, and is then sent by a 1% transmission beam splitter to another lens which form an image of the interaction zone on the various diagnostics. The main contribution to backscattering is expected to arise from Stimulated Raman Scattering at wavelenght ≤ 2λ; significant contribution is expected to arise from Stimulated Brillouin Scattering too at the fundamental wavelength (438 nm).

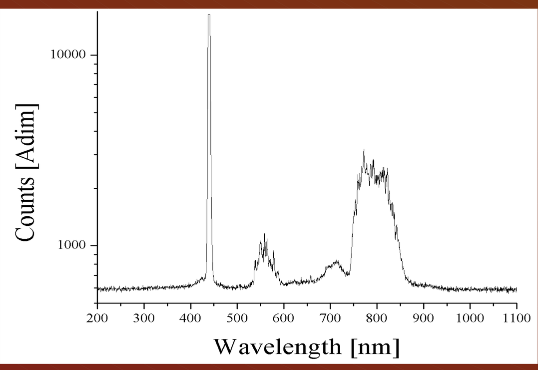
Backscattered energy measurments

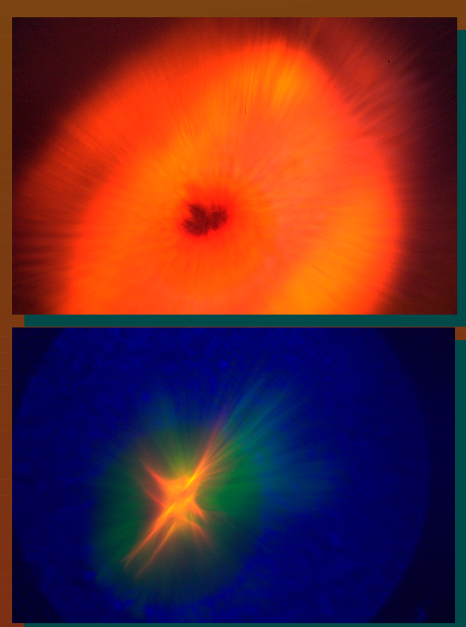
Calorimetry data allow to estimate the total energy loss due to backreflection of light from the plasma. The plot shows the energy measured by the calorimeter, the corresponding estimated backscattered energy (taking into account also the laser reflection by vacuum chamber window correction), and the percentage of backscattered energy as a function of laser energy. The preliminary data show that less than 10% of the pulse energy is backscattered due to parametric instabilities.



Backscattered light spectra and imaging

Peculiar spectrum observed during the experiment is plotted in the bottom figure. The peak corresponding to the fundamental wavelength is due both to SBS and laser light reflections, but strong broadband emission below 880 (ω/2) nm has always been observed corresponding to Raman signal. Interpretation of secondary peaks is not yet complete. The images on the right show the ω/2 and ω channel of optical imaging diagnostics. The emission below 800 nm is clearly visible in the ω/2 image and to a lesser extent in the ω image too (due to band selection filtering). The central holes visible for both the channels are maybe due to the laser intensity profile. Interpretation of results from imaging and spectroscopy is however a work in progress...





Conclusions

Experimental results of X-ray and optical emission measurements from a plasma in a shock-ignition-like scenario is presented. X-ray images with spectral resolution show a predominant emission of photons in the tens of keV energy range. Line emission has been obseved in that range too. Optical backscattering due to the growth of parametric instabilities has also been studied. Very preliminary results indicate that less than 10% of the laser energy is backscattered in our experimental conditions. Interpretation of optical imaging and spectroscopy data is an ongoing work.