Update on Fast Ignition Experiments at Nova Petawatt* IF

R.B. Stephens

General Atomics, P.O. Box 85608, San Diego, California 92186-5608

S.P. Hatchett, M.H. Key, J.A. Koch, R.W. Lee, A. McKinnon, D. Pennington, M. Tabak, and K. Yasuike

Lawrence Livermore National Laboratory, P.O. Box 808, Livermore, California 94550

R.R. Freeman and R. Snavely

UC Davis, Livermore, California

The PetaWatt laser (PW) in the Nova facility at LLNL was in operation for ~3 years, to May 1999. With its ability to deliver 500 J in 0.5 ps at 10^{19} W/cm^2 into a spot ~10 µs across, it was highly suitable for investigating the transport of an ignition pulse into and through a dense plasma. At the last IAEA Conference on Fusion Energy [1], we reported on initial results from the PW laser relevant to fast ignition and showed the potential of fast ignition to give a gain of 300x using the NIF laser as driver. We have since added substantially to our knowledge of the laser-plasma interactions. Two phenomena are especially interesting.

The generation of a collimated intense high energy proton beam from the rear surface of planar targets has opened up the novel possibility of using a laser generated ion beam for fast ignition. A last-minute addition to the previous IAEA presentation was observation of highly collimated energetic beams coming from the back of the target. At that time the beam was thought to be a beam of electrons generated by the laser-plasma interaction at the front of the foil. Subsequent experiments have shown it to consist of ~50 MeV protons. These proton beams are created when the laser-heated electrons expand out of the target foil and generate huge electric fields at sharply defined interface at the rear of the target [3].

The x-ray emissions from thin buried metal layers (Al, Au) have been used to examine the propagation of electron beams inside dense plasmas (CH foils), away from the disturbing influence of plasma surfaces; their spectra show the temperature and pinhole images show the distribution [2]. We find evidence of deep penetration of the electron beam. The foils heat to ~300 eV in a crescent or ring pattern, approximately constant in diameter (~70 µm) for depths up to ~100 µm into the film (Fig. 1). Perhaps the quasi-static magnetic field set up by the relativistic electrons is playing a role in this.

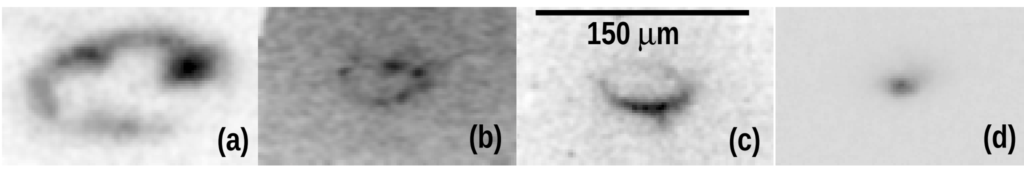

Fig. 1. X-ray pinhole images of thin diagnostic layers buried in CH targets. (a) is from an Al layer, buried 15 µs under the front surface and (b) from a Au layer at a depth of 50 µs. (c) is from a Au layer at a depth of 100 µs, viewed from the back of the foil. viewed from the front. (b) and (c) are from Au layers; In contrast, (d) shows the solid spot emitted by a solid Au film.

*Work was supported by the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48, with the additional corporate support of General Atomics.

Although dismantling of the PW has terminated that venue of research, parts from the Nova facility have been distributed to other labs to support their upgrade to petawatt capability. In the near future, our experimental FI effort will be based on developing collaborations with a number of these facilities. On that basis, we have proposed to the DOE a four year experimental program which will focus on the physics of energy transport into super-critical plasmas. We will consider both electron and ion transport, and will work closely with target designers to develop a realistic FI demonstration target.

[1] KEY, M.H., *et al.*, Proc. of the 17th IAEA Fusion Energy Conference, Yokohama, October, 1998, International Atomic Energy Agency, Vienna (to be published).

[2] KOCH, J., *et al.*, submitted to Phys Rev. E.

[3] LASINSKI, B.J., *et al.*, Phys. Plasmas **6**, 2041 (2000).