INERTIAL CONFINEMENT FUSION AND FAST IGNITOR STUDIES

O. WILLI, L. BARRINGER, A. BELL, M. BORGHESI, J. DAVIES, R. GAILLARD, A. IWASE, A. MACKINNON, G. MALKA, C. MEYER, S. NURUZZAMAN, R. TAYLOR, C. VICKERS
The Blackett Laboratory, Imperial College of Science,Technology and Medicine, London, SW7 2BZ, United Kingdom.
D. HOARTY
AWE Aldermaston, Reading, United Kingdom.
P. GOBBY, R. JOHNSON, R. G. WATT
Los Alamos National Laboratory, Los Alamos, USA.
N. BLANCHOT, B. CANAUD, H. CROSO, B. MEYER, J.L. MIQUEL, C. REVERDIN
Commissariat a l'Energie Atomique, Centre d'Etudes de Limeil-Valenton, France.
A. PUKHOV, J. MEYER-TER VEHN
Max-Planck-Institut für Quantenoptik, Garching, Germany.

ABSTRACT:

The paper discusses inertial confinement fusion research carried out at several different laser facilities including the VULCAN laser at the Rutherford Appleton Laboratory, the TRIDENT laser at the Los Alamos National Laboratory and the PHEBUS laser at Limeil. Low density foam targets were irradiated either with nanosecond laser or soft x-ray pulses. Laser imprinting was studied and in particular saturation of areal density perturbations induced by near-single mode laser imprinting has been observed. Several issues important for the foam buffered direct drive scheme were investigated. These studies included measurements of the absolute levels of Stimulated Brillouin and Raman Scattering observed from laser irradiated low density foam targets either bare or overcoated with a thin layer of gold.

A novel scheme is proposed to increase the pressure in indirectly driven targets. Low density foams that are mounted onto a foil target are heated with an intense pulse of soft x-ray radiation. If the foam is heated supersonically the pressure generated is not only the ablation pressure but the combined pressure due to ablation at the foam/foil interface and the heated foam material. The scheme was confirmed on planar targets. Brominated foil targets overcoated with a low density foam were irradiated by a soft x-ray pulse emitted from a hohlraum. The pressure was obtained by comparing the rear side trajectory of the driven target observed by soft x-ray radiography to one dimensional radiation hydrodynamic simulations. Further, measurements were carried out to observe the transition from super- to subsonic propagation of an ionisation front in low density chlorinated foam targets irradiated by an intense soft x-ray pulse both in open and confined geometry. The diagnostic for these measurements was K-shell point projection absorption spectroscopy.

In the fast ignitor area the channeling and guiding of picosecond laser pulses through underdense plasmas, preformed density channels and microtubes were investigated. It was observed that a large fraction of the incident laser energy can be propagated through preformed channels and microtubes. Magnetic fields in the megagauss range have been measured, with a polarimetric technique, during and after propagation of relativistically intense picosecond pulses on solid targets and preionised plasmas. Two types of toroidal fields, of opposite orientation, generated through different mechanisms, were detected. In addition, the production and propagation of an electron beam through solid glass targets irradiated at intensities above 10^{19} Wcm^{-2} was observed using optical probing techniques.

LASER BEAM IMPRINT SATURATION:

It is essential for laser fusion that a high degree of symmetry is maintained during the implosion phase. Asymmetries in the ablation pressure must be smaller than a few percent, otherwise an unacceptable level of instability growth occurs, reducing the fusion gain. Recent studies at Imperial College and elsewhere have demonstrated that the most sophisticated optical smoothing schemes available to date do not provide a sufficiently smooth laser beam to eradicate the initial imprinting of the laser drive on the cold target surface during the so called 'start-up' phase [1]. Once a plasma has been formed, thermal conduction from the absorption region to the solid target provides some smoothing of further absorbed irradiation, but the initially imprinted non-uniformities rapidly grow through the Rayleigh-Taylor instability and other hydrodynamic instabilities. The imprint problem imposes severe constraints on capsule design, forcing designers to operate on a less efficient, higher isentrope, in order to provide sufficient stabilisation of the instability growth such that the imprint seed can be tolerated, and does not grow sufficiently to buckle the capsule shell and render the implosion ineffective. It has been predicted computationally and analytically that imprinting may saturate and decay prior shock breakout[2]. Thus far, the saturation of areal density perturbation have not been reported experimentally since most experiments were performed with $d_{FOIL}/\lambda_{pert} < 1$ where d_{FOIL} and λ_{pert} are foil thickness and perturbation wavelength, whereas saturation is generally expected for $d_{FOIL}/\lambda_{pert} > 1$. It is difficult to study the latter condition experimentally for solid foil targets because of limitations associated with diagnostics such as spatial resolution and the high target opacity. Thus, an alternative experimental approach is presented, namely the study of the effect in low-density foams, which allow the use of high-resolution, high-sensitivity soft x-ray probing techniques [3].

The experiment was carried out at the Trident Laser Facility of the Los Alamos National Laboratory. Two beams of the Trident laser were used, providing laser pulses at a wavelength of 0.527μm. The pulse duration was 2.2ns full-width-at-half-maximum (FWHM) with ~ 150ps rise time and the beams were focused by f/6 optics to a focal spot of ~ 800μm (FWHM). A pair of transmission echelons were inserted in the drive beam line. The wavelength of the sinusoidal interference pattern produced was controlled by the relative angle of the pair. The beam profiles were recorded by an equivalent-plane-monitor (EPM).

The foam targets were manufactured from polystyrene with a pore size of 2-3 μm, a density of 200 mg/cc, and a length of 50 μm. Face-on radiographs of these targets were obtained by the soft x-ray imaging system at a probe photon energy of ~ 250 eV and 50x magnification. The mass modulations induced in the target by laser imprint generated optical depth modulations which were recorded by imaging a transmitted backlighter onto a gated microchannel plate framing camera at four different times with a temporal resolution of ~ 120 ps. The backlighter signal was provided by irradiating a gold foil by a second beam at an irradiance of ~ 2×10^{13} $\mathrm{Wcm^{-2}}$ for 2.2 ns. The Modulation Transfer Function (MTF) of the soft x-ray imaging system was measured. It was found that the MTF was ~ 0.4 at a wavelength of 5 μm. All observations were made during shock transit before acceleration could commence. Simulations of the experiments were performed with the two-dimensional (2D) Eulerian hydrodynamic code, POLLUX. Sinusoidal modulations were imposed on the laser drive with the modulation amplitude, perturbation wavelength and temporal beam profiles all taken from experimental measurements.

Optical depth modulations were calculated from the simulations. The RMS intensity modulation, $\Delta I/I$, was found to be 0.23 ± 0.03 perpendicular to the sinusoids. The optical depth modulation (ΔOD), was compared with the one predicted by the simulations. In Figure 1 the ΔOD from two different experiments (square and circles) and simulations (the dashed line) are compared. Two additional curves are obtained from simulations with the beam modulation amplitude $\Delta I/I = 0.17$ and 0.28 (the solid and dotted curves respectively). As can be seen in Figure 1, the optical depth modulations start to saturate at around 1250 ps, well before the shock breakout time of 1750 ps.

STIMULATED BRILLOUIN AND RAMAN BACKSCATTERING IN GOLD COATED FOAM TARGETS:

To overcome the imprint problem we have recently proposed novel plasma smoothing schemes including the Indirect Direct Drive (IDD) [4] and the Foam Buffered Direct Drive (FFD) [5] scheme. In the IDD scheme a soft x-ray pulse is incident on the target prior to the laser beam to generate a preformed plasma in which smoothing can take place. It is however difficult to control the plasma density scalelength and in addition a strong shock is launched by the the initial x-ray pulse. For these reasons the FDD scheme was proposed. It addresses the imprinting problem by utilising a thin overcoat of a high-Z material on a low density foam layer formed on the capsule's outer surface. The initial laser drive is converted to a brief soft x-ray flash, which supersonically preforms a plasma from the foam directly ahead of the advancing laser-driven shock front, providing rapid smoothing, and demonstrably suppressing the imprinting. Recent experimental observations [6] obtained on the VULCAN laser in Britain and the TRIDENT laser at Los Alamos with green irradiation, the PHEBUS laser at Limeil and the OMEGA laser at Rochester [7] with 3ω irradiation have shown a substantial reduction in the initial laser nonuniformity imprinting of directly irradiated targets when the foam buffer is used. It is however important that the absolute levels of SRS and SBS are low. Hence, experiments were carried out on the Trident laser facility to measure the SRS and SBS levels. Cylindrical bare or gold overcoated foam targets were irradiated with a flat topped, green, 1ns laser pulse. Spatial beam smoothing was used with a random phase plate resulting in a focal spot of about 120μm in diameter. Backscattered SBS and SRS light from the interaction region was collected and diagnosed using time resolved spectroscopy and calorimetry. The targets consisted of low density foams (30 or 50mg/cc) either bare or overcoated with 150Å of gold and plastic and gold planar foils. The irradiance on target was changed between 1 and 16×10^{14}Wcm^{-2} by varying the laser energy. In figure 2 the absolute SBS levels for several different target materials are plotted. It is observed that about 8% of the incident laser energy is backscattered at irradiances of 1×10^{15}Wcm^{-2}. Similar levels were observed for the solid plastic and the foam targets. The absolute levels of the backscattered SRS were in the 10^{-5} range with similar values for both the solid CH and foam interactions.

PRESSURE MEASUREMENTS ON TARGETS HEATED BY A SOFT X-RAY PULSE:

It is proposed that the pressure in indirectly driven targets can be enchanced by heating a low density foam supersonically that is mounted in front of the solid shell of the fusion capsule. The total pressure is then the material pressure of the foam and the ablation pressure generated at the foam/foil interface. Experiments were performed on the PHEBUS glass laser system at Limeil to investigate this novel scheme. Thin plastic foils (~15μm thick CHOBr) either bare or overcoated with a 50mg/cc polystyrene foam 50μm in length and 600μm in diameter were subjected to intense pulses of soft x-ray radiation generated by a single sided hohlraum that was heated with a PHEBUS third harmonic laser beam. The foam had a high degree of homogeneity with an average pore size diameter of approximately 2μm and was facing the hohlraum. Two different types of hohlraums were used namely 2.5mm in diameter, 3ns pulse, 2.6kJ resulting in a radiation temperature of about 80eV and 1.4mm in diameter, 3.5ns, 1.8kJ with a radiation temperature of 95eV. The target package was spaced 30μm from the surface of the hohlraum.

The foil/foam or bare foil targets were diagnosed perpendicularly to the soft x-ray source emitted from the hohlraum with a high magnification (50x) time-resolving soft x-ray imaging system using a spherical multilayered mirror (central wavelength ~50Å with a spectral bandwidth of ~5Å). The backlighter was produced by irradiating a lead doped glass target with one of the PHEBUS laser beams. The slit of the x-ray streak camera was oriented perpendicular to the target surface. The temporal resolution of the instrument was approximately 200ps while the spatial resolution was about 5μm. Simulations were performed with the one-dimensional hydrodynamic code, MEDUSA, coupled to an LTE radiation transport algorithm. The simulation results were compared with the experimental data by generating probe transmission contours from the predicted plasma density and temperature profiles for the rear side of the target. It was observed that for the foam/foil target the pressure was larger than for the bare case, i.e. the total pressure is the combined pressure due to ablation pressure at the interface and the material pressure of the heated foam. In figure 3 the pressures of the foam/foil and the foil shots are plotted. In addition, a pressure scaling is given as a function of radiation temperature. The data was obtained by irradiating thin plastic foils (25μm thick CHBr) by an intense pulse of soft x-ray radiation generated by the illumination of a thin gold converter foil between 0.9 and 1.1μm in thickness with one of the PHEBUS third harmonic laser beams with a pulse duration of 1.3ns (FWHM). Again the pressure was obtained from the simulations by comparing the rear side target trajectory to code predictions.

SUPERSONIC/ SUBSONIC IONISATION PROPAGATION:

For pressure enhancement the propagation of the ionisation wave through the foam has to be supersonic. Hence, an understanding of the transition from super- to subsonic propagation of an ionisation front is important. The transonic regime has been studied in x-ray irradiated low density foam targets using point projection absorption spectroscopy. The foams were doped with chlorine and irradiated with an intense pulse of soft x-ray radiation with a temperature up to 120 eV produced by laser heating a burnthrough converter foil. The cylindrical foam targets were radiographed side-on allowing the change in the chlorine ionisation and hence the front to be observed. From the absolute target transmission the density profile was obtained. Comparison of experimental absorption spectra with simulated ones allowed the temperature of the heated material to be inferred for the first time without reliance on detailed hydrodynamic simulations to interpret the data. The experimental observations were compared to radiation hydrodynamic simulations [8].

The experiments were carried out at the Rutherford Appleton Laboratory using the VULCAN laser system. The targets consisted of low density triacrylate foam with a density of 50mg/cc. The samples used were chemically doped with chlorine of 25% by weight. The foams were cylindrical and between 180 and 250µm in length with a diameter of 200µm and were irradiated with a soft x-ray pulse of either 1.0 or 1.5ns (FWHM) duration emitted from the rear of a laser-irradiated "burnthrough" converter foil. The laser energy was delivered into a 200µm focal spot on the burnthrough target through f/10 lenses by up to six separate beams arranged in the VULCAN cluster configuration. Laser irradiances of up to 10^{14}Wcm^{-2} were used. The soft x-ray flux and pulse shape emitted from the rear of the burnthrough foil was measured using an absolute calibrated time-resolving photodiode. Allowing for experimental uncertainties and spatial and angular variations in the emitted radiation, it is estimated that the peak soft x-ray flux at the surface of the foam was between $2\text{x}10^{12}$Wcm^{-2} and $8\text{x}10^{12}$Wcm^{-2}. The ionisation wave propagating through the foam was diagnosed with point projection K-shell absorption spectroscopy. The x-ray heated foam was probed side-on by a quasi-continuum, 90ps soft x-ray pulse provided from a bismuth coated gold backlighter pin irradiated with 0.53µm laser light. The data were recorded using a flat crystal spectrometer with a RbAP (2d=26.12Å), with a spectral resolution of 3eV, and Kodak Industrex C-type film.

Line scans of the absorption spectra were taken and were compared to a model of the population of chlorine charge state configurations which assumed local thermodynamic equilibrium (LTE). The material density was obtained from the measured continuum transmission and input to the model. Saha-Boltzmann statistics was used to calculate the relative populations in configurations of the chlorine charge states with a full K-shell, including all permutations of L shell electrons, satellites in M and N shells and detailed term structure. A detailed spectrum was then constructed, using transition energies and oscillator strengths from ab initio calculations of a multiconfiguration Dirac Fock code. The measured density was input to the atomic physics model and the temperature inferred by iterating the temperature in the model until the best match to the experimental absorption spectrum was obtained.

Simulations were performed using a 1D Lagrangian radiation-hydrodynamics code. The temporal behaviour and absolute levels of the x-ray drive were taken from the absolutely calibrated diode measurements, with the spectrum of the radiation assumed to be blackbody. For supersonic propagation the experimentally measured front position and the density were reproduced well by the simulation though the detail of the front temperature profile shows some differences. The subsonic temperature profile is reproduced well by the simulation but behind the heat front the temperature measured was slightly lower than that calculated. The density profile in particular the shock width and peak density ratio differ in experiment and simulation. The differences are due to 2D effects including a curvature of the shock front and radiation loss sidewards which the simulations do not include. The data at the boundary of the supersonic and subsonic regime show a density ratio of approximately two. The ionisation front is not preceded by the shock but both propagate together. In the subsonic case the front was preceded by a shock. In this case the shock has a density ratio of approximately three.

FAST IGNITOR STUDIES:

Experimental studies investigating the propagation of an intense laser pulse through preformed plasmas have been performed [9]. These experiments have great relevance for the fast ignitor concept. The pulse (1 ps in duration, 10 TW, λ=1.054 µm) was focused at an irradiance exceeding $5\text{x}10^{18}$ W/cm^2 onto a near critical, underdense plasma preformed by laser irradiation of a thin (0.1- 0.5 µm) plastic foil. The interaction in the investigated regime, i.e. significantly above the threshold for relativistic filamentation, appeared to be characterised by relativistic self-channeling of the pulse. The channeling was detected through spatially resolved second harmonic emission. A single emission filament (typically 5 µm in diameter and extending over several Rayleigh lengths) was observed, and interpreted as a signature of the spatial extent of the beam during the propagation. In addition, the transverse size of the channel appears to oscillate with a characteristic period of about 20 µm. These oscillations have also been observed in 3D PIC code simulations at the MPQ, Garching, for conditions used in the experiment. The code has also predicted the generation of large magnetic fields during the interaction, due to the current of relativistic electrons comoving with the laser pulse. These magnetic fields contribute to the confinement of the laser energy into the narrow channel.

The guiding of relativistically intense laser pulses in near critical preformed plasmas was studied at the P102 laser facility (Limeil). The plasma was produced by exploding a plastic foil with a long pulse (about 750 ps in duration) at moderate irradiance, typically $5x10^{13}$ W/cm^2. A channel producing infrared laser pulse with a duration in the range between 10 and 20ps was focussed into the preformed plasma at an irradiance of about $1x10^{17}$ W/cm^2. At the end of the pulse a green 300 fs laser beam was focussed into the channel at an irradiance of $1\text{-}4x10^{19}$ W/cm^2. It was observed that about 55 % of the incident energy was transmitted whereas only about 25% was measured when no channeling beam was used. The channel evolution was studied with optical probing.

An alternative approach to the plasma channel formation and guiding is the use of hollow capillary tubes. In this case the laser pulse is confined within the inner diameter of the guide and propagates through reflections off the inner walls of the tube. For high intensity pulses, an overdense plasma is created at the guide walls ahead of the main pulse, by the pulse's rising edge or by the prepulse. The beam is guided through reflections off the high density plasma. This approach, in principle also applicable to direct drive compression schemes, seems particularly promising for point ignition following indirect-drive compression of a pellet placed inside an hohlraum. In this case, in order to reach the compressed core, the igniting pulse can be guided inside a hollow capillary tube through the hohlraum wall and the gas fill. Efficient guiding of 1 ps infrared laser pulses with power exceeding 10 TW has been demonstrated through hollow capillary tubes with 40 and 100 μm internal diameters and lengths up to 10 mm, with transmittivity higher than 80% of the incident energy [10]. The beam is guided via multiple reflections off a plasma formed on the walls of the guide by the pulse's rising edge, as inferred from optical probe measurements.

The magnetic field induced by the relativistic electrons and the conventional thermal electric magnetic field have recently been observed in a preformed plasma using optical Faraday rotation [11]. The rotation angle inversion is clearly visible in a lineout from the experimental data. The value of the outer rotation (about 2°), suddenly decreases by almost 3° approaching the laser axis. The corresponding lineout for the product nB, extracted by Abel inversion. From the plot it is evident that the abrupt changes in the rotation angle observed in the data corresponds to an inversion of the magnetic field direction. A value for the outer magnetic field can be extracted from the corresponding rotation, dividing the product nB by the density n of the preformed plasma. This gives an amplitude of about 1 MG for the thermal electric field. The amplitude of the field inside the channel can be estimated as $B[MG]=(n_{in}/n_0)$ where n_{in} is the density inside the channel and n_0 is the background density of the preformed plasma. Values in the range 5-10 MG are obtained if one considers n_{in} to be of the order of $0.1\text{-}0.5\ n_0$. The interaction was studied, under conditions close to those of the reported experiment, using the 3D PIC code VLPL. A large toroidal magnetic field surrounding the laser axis is observed, in correspondence with a current of relativistic electrons travelling with the laser pulse. At a background density of $0.1\ n_c$, the magnetic field is predicted to be as large as 9 MG, peaking at a distance of 4-5 μm from the laser axis. In the predicted density profile, one observes that the beam has formed a hollow cylinder type of depression, with outgoing shocks and a density maximum on axis.

The channeling of a hot electron beam at densities close to solid is a fundamental requirement of the fast ignitor scheme, since an efficient coupling of the fast electron energy to the compressed fuel is essential. Experiments were carried out on glass targets that were irradiated with a high intensity 1ps laser pulse. The interaction in the glass was diagnosed with a picosecond green probing pulse perpendicular to the laser direction. A collimated ionised channel of a few hundred microns in length was clearly observed in the glass even when the glass was overcoated with 3μm of aluminium eliminating any laser light from reaching directly the glass. Simulations with a hybrid code in which the hot electrons are treated as particles and the background as a fluid with collision taken into account also show an electron beam collimated by the self-generated magnetic field. The magnitude of the self-generated magnetic field was a few megagauss. These simulations were carried out with a solid density plasma. Figure 4 shows (a) a schematic of the experiment, (b) experimental data and (c) a simulation. A clearly defined channel a few microns in diameter is seen in the experimental data. The simulations reproduced the experimental data well and a temperature above 1.4keV was observed in the centre of the channel with a current up to 20MA neutralised by the return current.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the staff of the Central Laser Facility for their assistance and technical support. In addition, we would like to thank the staff at the TRIDENT Laser Facility (Los Alamos) and PHEBUS Laser Facility (Limeil). This work was supported by EPSRC and some joint EPSRC/MoD grants.

REFERENCES

[1] TAYLOR, R., DAHLBURG, J., IWASE, A., FYFE, D.E., GARDNER J.H., WILLI, O., "Measurement and simulation of laser imprinting and consequent Rayleigh-Taylor growth", Phys. Rev. Lett. 76 (1996) 1643.
[2] TAYLOR, R., VELIKOVICH, A.L., DAHLBURG, J., GARDNER J.H., "Saturation of laser imprint on ablatively driven plastic targets", Phys. Rev. Lett. 79 (1997) 1861.
[3] IWASE, A., TAYLOR, R., NURUZZAMAN, S., WILLI, O., JOHNSON, R. P., GOBBY, P., WATT, R. G., "Observation of saturation of single mode laser imprinting in foam targets", submitted to Phys. Rev. Lett.
[4] DESSELBERGER, M., AFSHAR-RAD, T., KHATTAK, F., VIANA, S., WILLI, O., "Nonuniformity imprint on the ablation surface of laser irradiated targets", Phys. Rev. Lett. 68, (1992) 1539.
[5] DESSELBERGER, M., JONES, M., EDWARDS, J., DUNNE, M., WILLI, O., "Use of x-ray preheated foam layers to reduce laser structure imprint in direct-drive laser-fusion", Phys. Rev. Lett. 74 (1995) 2961.
[6] DUNNE, M., BORGHESI, M., IWASE, A., JONES, M., TAYLOR, R., WILLI, O., GIBSON, R., GOLDMAN, S. R., MACK, J., WATT, R.G., "Evaluation of a foam buffer target design for spatially uniform ablation of laser irradiated targets", Phys. Rev. Lett. 75 (1995) 3858.
[7] WATT, R.G., MASON, R.J, DUKE, J.R., ELLIOT, N.E., GOBBY, P.L., HOLLIS, R.V., KNOPP, R.A., WILSON, D.C., VERDON, C.P., BOEHLY, T.R., KNAUER, J.P., MEYERHOFER, D.D., SMALYUK, V.A., TOWN, R., IWASE, A., WILLI, O., "Laser imprint reduction using foam buffer buffer as a thermal smoothing layer at 351nm wavelength", Phys. Rev. Lett. 81 (1998).
[8] HOARTY, D., BARRINGER, L., VICKERS, C., WILLI, O., NAZAROV, W., "Observation of the transition from supersonic to subsonic propagation of ionization fronts", submitted to Phys. Rev. Lett.
[9] BORGHESI, M., MACKINNON, A.J., BARRINGER, L., GAILLARD, R., GIZZI, L., MEYER, C., WILLI, O., PUKHOV, A., MEYER-TER VEHN, J., "Experimental observation of relativistic self-channeling of an intense laser pulse in a preformed plasma", Phys. Rev. Lett. 78 (1997) 879.
[10] BORGHESI, M., MACKINNON, A.J., GAILLARD, R., WILLI, O., OFFENBERGER, A.A.,"Guiding of a 10 TW picosecond laser pulse through hollow capillary tubes", Phys. Rev. E. 57 (1998) 4859.
[11] BORGHESI, M., MACKINNON, A.J., GAILLARD, R., WILLI, O., PUKHOV, A., MEYER-TER VEHN, J., "Large quasi-static magnetic fields generated by a relativistic intense laser pulse in a preionised plasma", Phys. Rev. Lett. 80 (1998) 5137.

FIGURE CAPTIONS

Figure 1: Temporal evolution of the target areal density modulation, δm, in 200mg/cc polystyrene foam calculated from the POLLUX simulations for an intensity of $5\text{x}10^{12}$ Wcm^{-2} with $\Delta I/I = 0.23$. Two additional curves are shown that were obtained from simulations with the beam modulation amplitude $\Delta I/I = 0.17$ and 0.28. Saturation occurs with an amplitude of 0.57µm.g/cc after 1.45ns.

Figure 2: Absolute levels of Stimulated Brillouin Backscattering for different target materials (☐ 30mg/cc CH foam, ● 30mg/cc CH foam + 150Å of gold, ○ 50mg/cc CH foam, ■ gold target, x solid CH).

Figure 3: Pressure scaling versus radiation temperature for soft x-ray driven foils.

Figure 4: a) Schematic of experimental arrangement to study the propagation of an electron beam in a solid target. b) Shadowgraph showing a small collimated channel ionised by the hot electron beam. c) Simulation showing that the temperature is above 1keV in the centre of the channel.

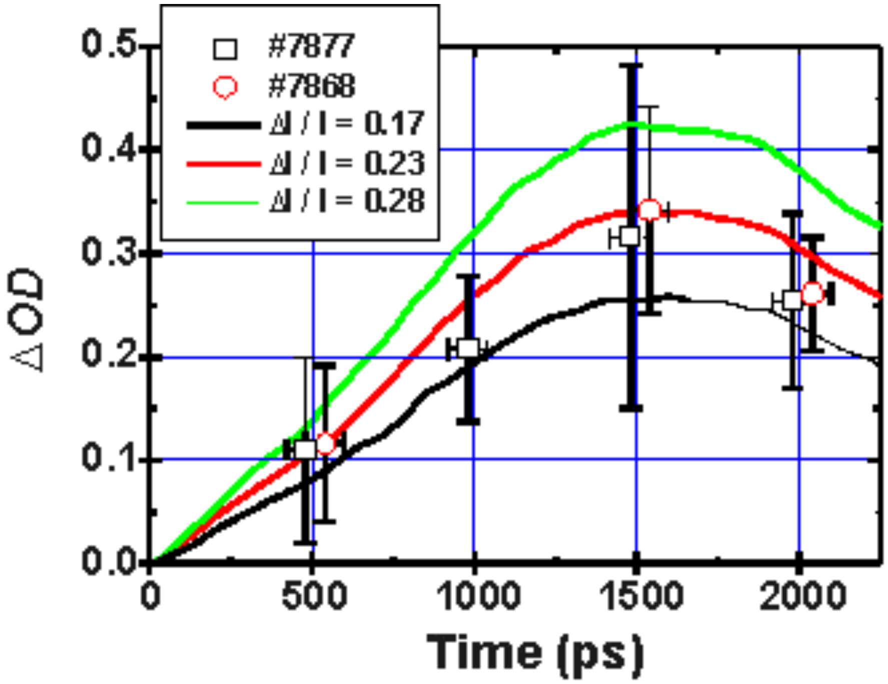

□ #7877
○ #7868
ΔI / I = 0.17
ΔI / I = 0.23
ΔI / I = 0.28
ΔOD
0.0
0.1
0.2
0.3
0.4
0.5
0
500
1000
1500
2000
Time (ps)

Fig.1

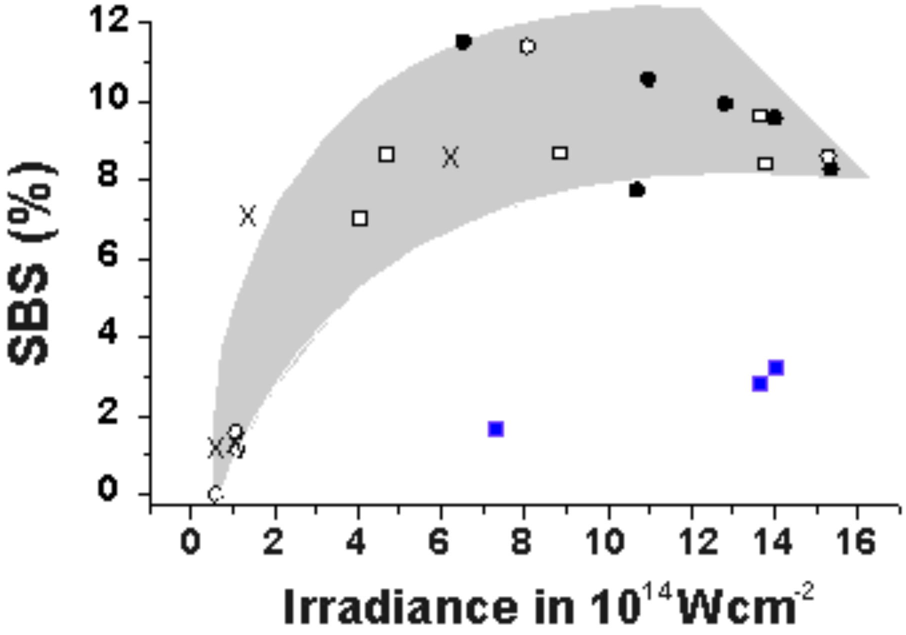
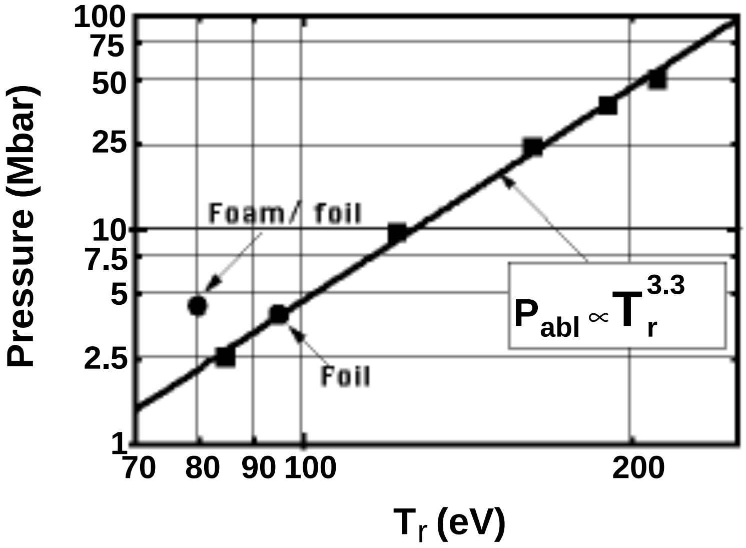
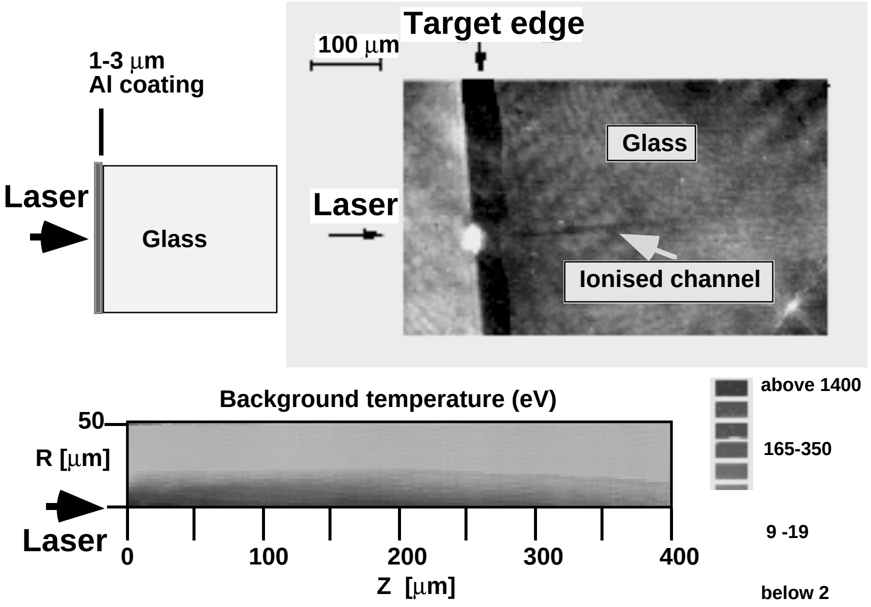

SBS (%)
0
2
4
6
8
10
12
0
2
4
6
8
10
12
14
16
Irradiance in 10^{14} Wcm^{-2}

Fig.2


100
75
50
25
10
7.5
5
2.5
1
Pressure (Mbar)
70
80
90
100
200
T_r (eV)
Foam/ foil
Foil
P_abl ∝ T_r^3.3


1-3 µm
Al coating
Laser
Glass
100 µm
Target edge
Laser
Glass
Ionised channel
Background temperature (eV)
50
R [µm]
Laser
0
100
200
300
400
Z [µm]
above 1400
165-350
9 -19
below 2