Measurements of Laser Generated X-ray Spectra from Irradiated Gold Foils

J.S. Davis[1], Y. Frank[2], E. Raicher[2], M. Fraenkel[2], P.A. Keiter[1], S.R. Klein[1], R.P. Drake[1], D.Shvarts[1]

[1]University of Michigan

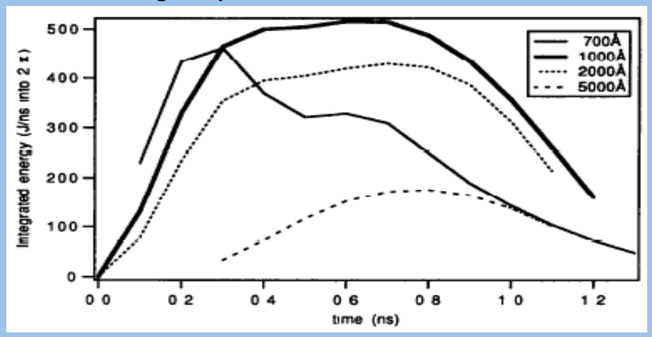
[2]Soreq Nuclear Research Center

Laser irradiated gold foils could be viable as a long duration (>1ns) x-ray source.

- High-energy laser facilities are useful for studying matter in the high-energy-density regime
- Lasers systems operate primarily between the IR and UV portions of the EM spectrum.
- For photoionization experiments these energies are too low and a long-pulse, soft x-ray source is needed.
- Hohlraums have a high x-ray conversion efficiency but produce plasmas that can affect the relevant physics. It is also more difficult to properly characterize their emission.
- Gold foils allow for more flexibility in experimental design and allow for targets to be built in house.
- Little work has been done characterizing long-pulse gold foil emission.

Previous studies of x-ray emission from laser irradiated foils have been limited to 1ns and below.

- When driving an x-ray source, plasma generated from laser ablation could affect the relevant physics. This can be mitigated by using the non-irradiated (rear) side of the foil as the source.
- Previous experiments using foils <0.5μm and pulse lengths of 1.0ns have shown that emission intensity decreases with foil thickness.
- Longer pulse-length x-ray sources require thicker targets in order to avoid burn-through.
- To understand how thicker foils and longer drive times affect emission we performed time resolved measurements of x-ray emission using 6ns pulses.



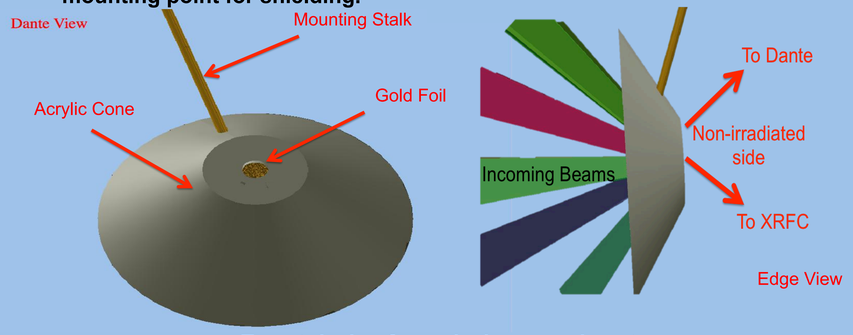
Previous work at the Nova Laser has studied the amount of energy emitted from gold foils of varying thicknesses as they were driven by a 1ns laser pulse.[1]

OMEGA experimental setup

- Using the Omega-60 laser system, 2kJ of energy was directed on target and time-resolved spectra were taken by the Dante spectrometer.
- Key Diagnostic: The Dante spectrometer is an x-ray photodiode array that allows for time resolved intensity measurements in up to 11 x-ray energy bands. The is bandwidth is set by using a specific combination of cathode materials, filters, and mirrors, so that each detector is only sensitive to x-rays within a certain energy range.

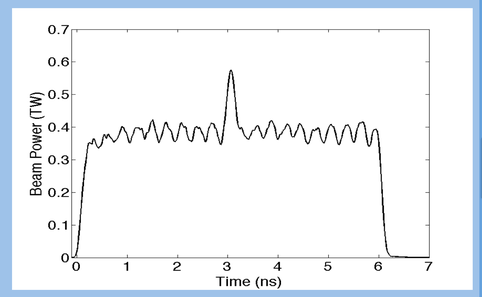
Experimental Details

- Pulse length: 6ns
- Number of Beams: 8
- Beam Intensity: 1e14 W/cm^2
- Gold Foil Thicknesses: 0.5, 0.75, 1.0, 1.5, 2.0μm
- Acrylic cones provide additional support to the foils, and act as a mounting point for shielding.

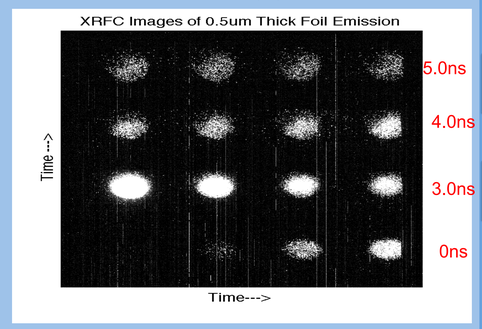


Target design for emission experiments

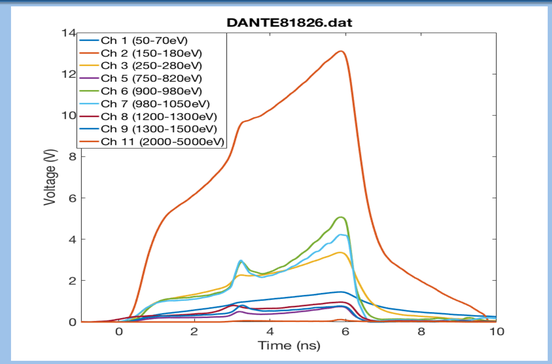
The 6ns laser pulse was generated by stitching together a pair of 3ns pulses. The spike in power at 3ns is the due to the overlap of the two pulses



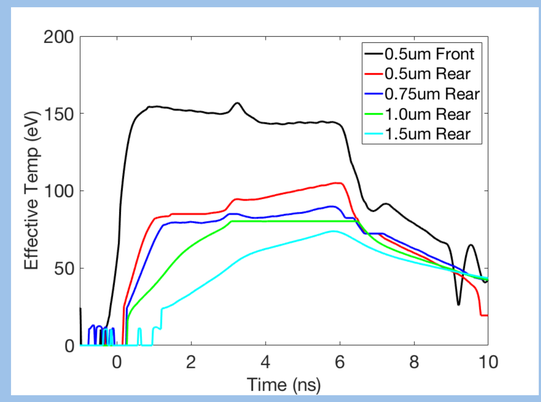
XRFC images of x-ray emission from the non-irradiated side a 0.5μm thick gold foil. Emission appears shortly after the beams fire and continue for the duration of the pulse. The bright spot at 3.0ns is from the temporary spike in laser power from two laser pulses overlapping



Experimental results show effective temperatures ranging from 50-100eV



- The Dante diagnostic outputs its results as a voltage signal. Processing the data converts the raw output signal of Dante into an effective radiative temperature.



- Temperature vs time plots for varying foil thicknesses. The 2μm foils had very week emission which prevented an effective temperature calculation from being made providing an upper limit for drive.

Conclusioms

- We have shown it is possible to produce a multi-ns soft x-ray source with an effective temperature of ~90eV using a laser heated gold foil.
- There is a significant decrease in effective temperaturte as foil thickenss increases with a 2μm foil being the upper limit for measureable emisssion

References

1. C.A. Back, L. DaSilva, H. Kornblum, D. Montgomery, B. Macgowan, G. Glendinning, J. Fenske, E. Hsieh, R.W.Lee . J Quant Spect. Rad Trans. **51**, 12 (1994)

Acknowledgements

This work is funded by the U.S. Department of Energy, through the NNSA-DS and SC-OFES Joint Program in High-Energy-Density Laboratory Plasmas, grant number DE-NA0001840, and the National Laser User Facility Program, grant number DE-NA0000850, and through the Laboratory for Laser Energetics, University of Rochester by the NNSA/OICF under Cooperative Agreement No. DE-FC52-08NA28302.