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

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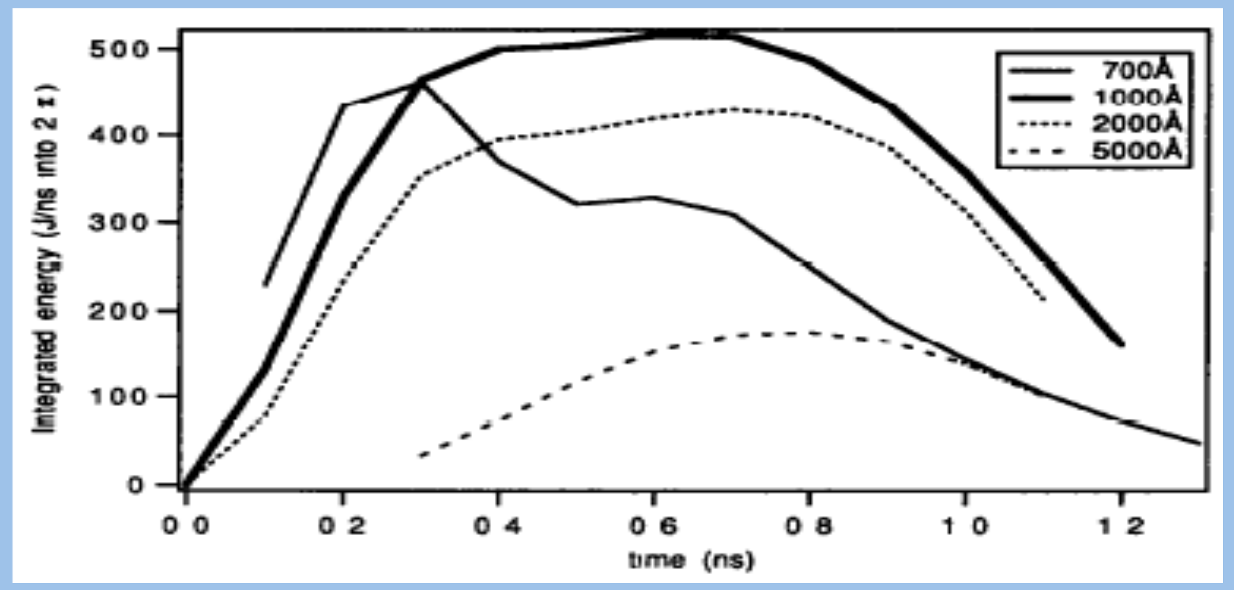
Laser irradiated gold foils could be viable as a long duration (>1ns) x-ray source.

- 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 are cheaper and allow for more flexibility in experimental design.
- 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 <0.5um 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.



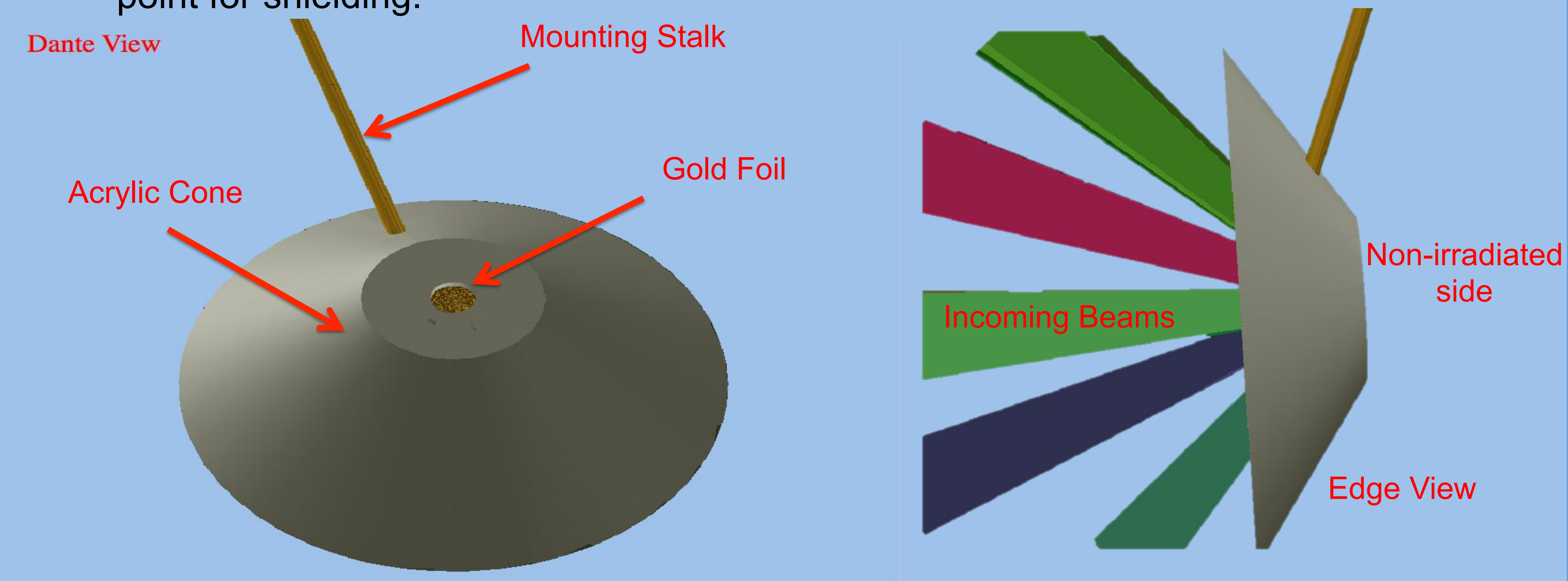
Previous work at the Nova Laser has studied the amount of energy emitted from gold foils of varying thicknesses as they were driven by a 1ns laser pulse.[1]

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.

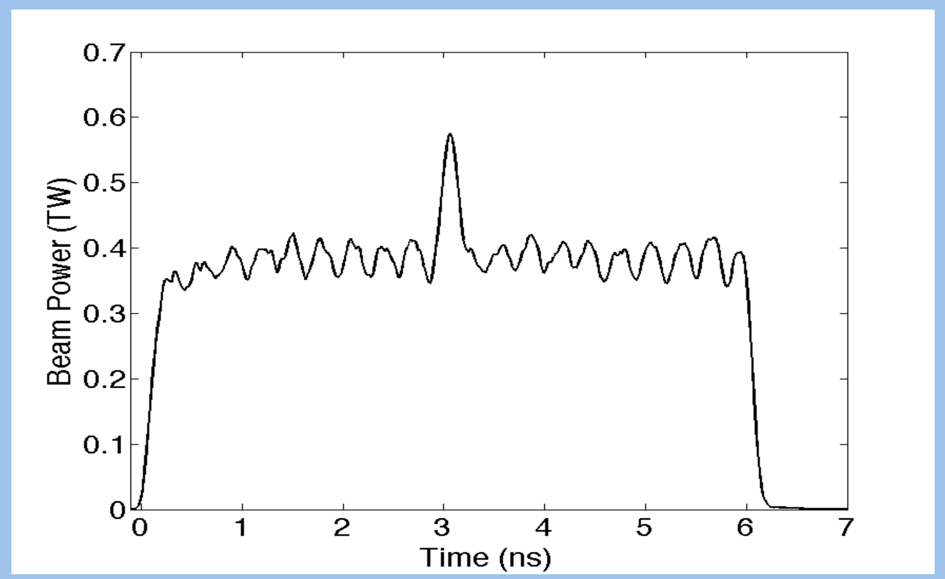
Experimental Details

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

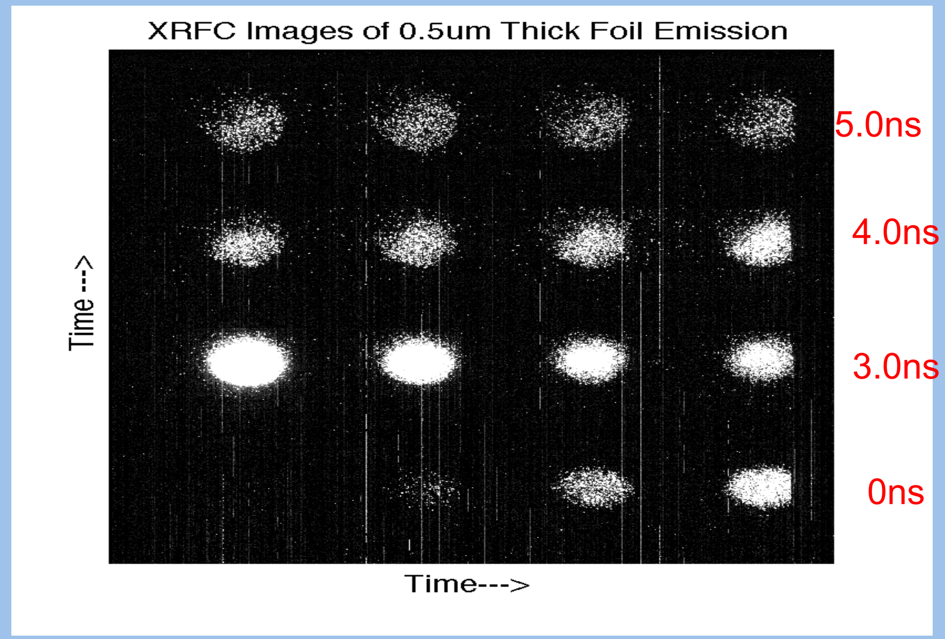


Target design for emission experiments

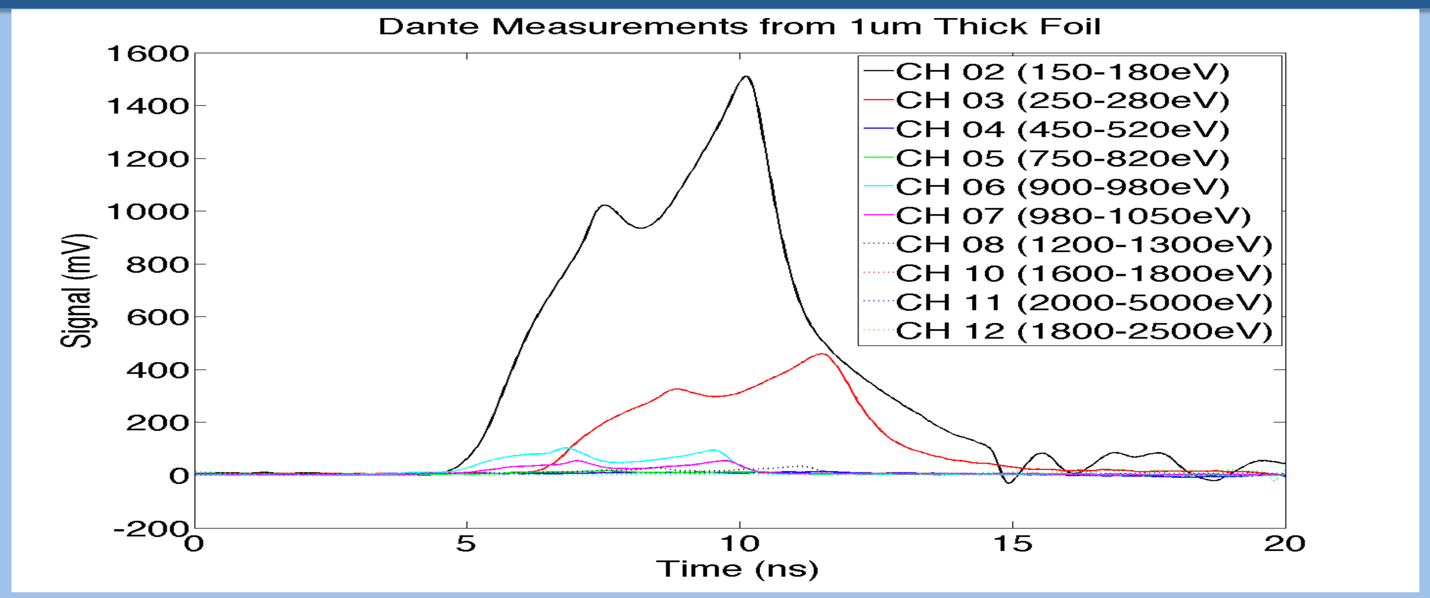
The 6ns laser pulse was generated by stitching together a pair of 3ns pulses. The spike in power at 3ns is the due to the overlap of the two pulses



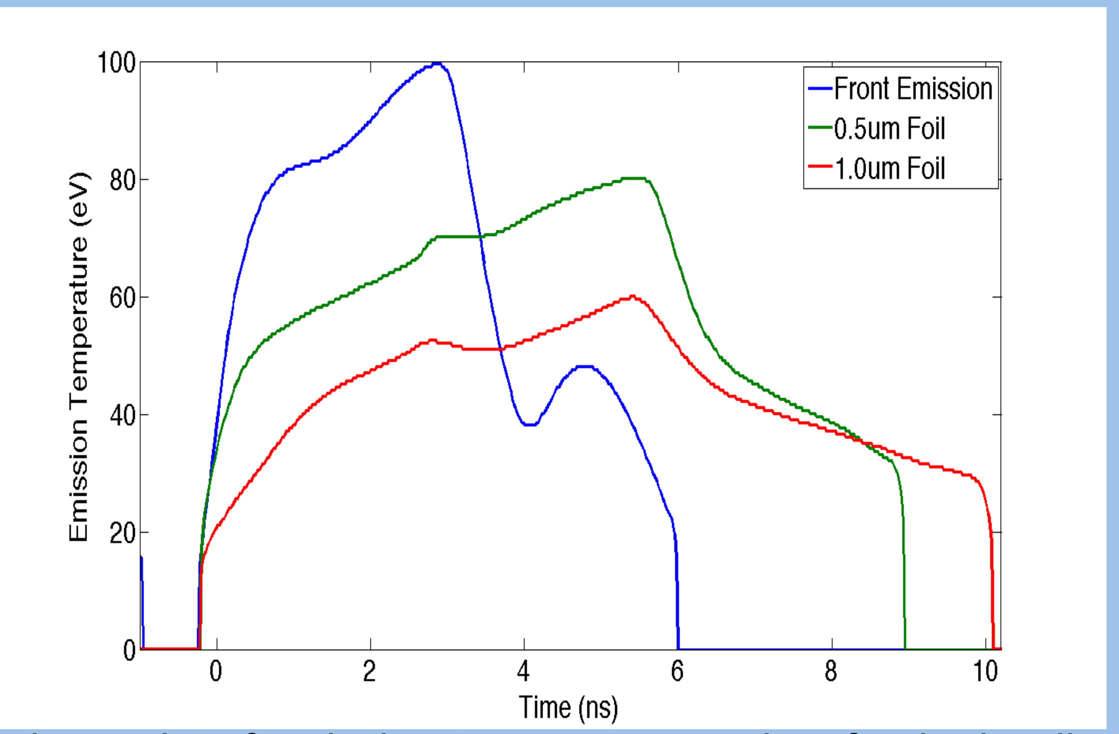
XRFC images of x-ray emission from the non-irradiated side a 0.5um thick gold foil. Emission appears shortly after the beams fire and continue for the duration of the pulse. The bright spot at 3.0ns is from the temporary spike in laser power from two laser pulses overlapping



Preliminary results found an inverse relationship between foil thickness and emission temperature.



- The Dante diagnostic outputs its results as a voltage signal. Processing is underway to convert the raw output signal of Dante into an emission temperature.



- Preliminary plot of emission temperature vs time for the irradiated side of 1.0μm thick gold foil (blue) with a 3ns pulse, the non-irradiated side of a 0.5um thick foil (green) driven by a 6ns pules ,and the non-irradiated side of 1.0μm thick (blue) foil driven by a 6ns pulse. This analysis could not be done with the 2.0μm foils as their signal was too low to distinguish from noise.

Future Directions

- Perform shots that have a greater variety of foil thickness to increase the number of data points in our burn-through and emission measurements
- Compare experimental results with different approaches to modeling gold foil heating and emission to attempt to create an analytical model for determining optimal foil thickness

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)

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