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

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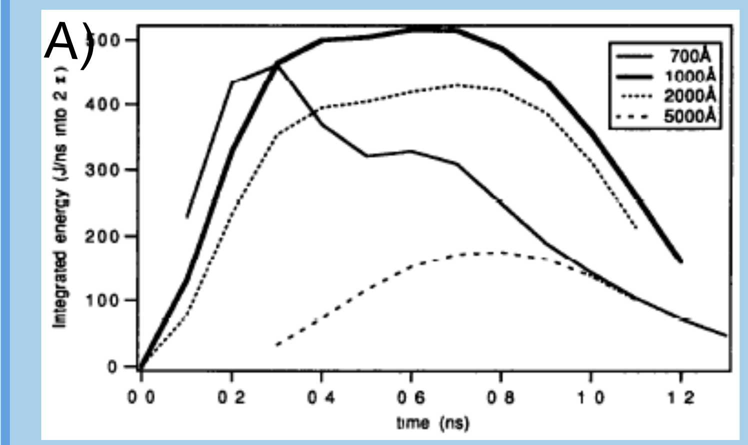
Use of gold foils as an x-ray source

Although there are numerous high-energy laser facilities that are invaluable for studying matter in the high energy density regime, they are limited in the fact that their lasers operate in wavelengths in the UV portion of the spectra. Some experiments require high photon energies for increased penetration depth into a plasma and thus an x-ray source would prove invaluable. If conversion efficiency was the only concern, a holharum would be the ideal choice for an x-ray source as its enclosed geometry traps much of the laser light allowing for greater conversion of the initial beam energy into x-rays. The drawback to holharums is that they are difficult to make in-house and complicate the analysis of the resulting spectra. However, gold foils of varying thickness are cheaper and allow for more flexibility in experimental design. Still, before using gold foils as a source, its important to understand how the x-ray emission from the foils varies with time and beam intensity.

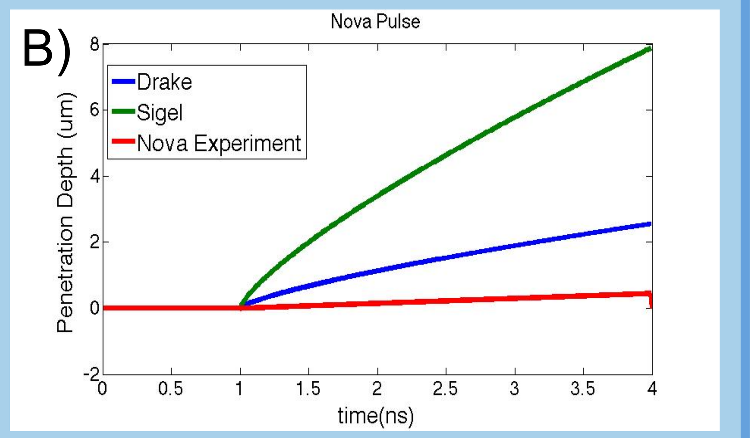
Design considerations

- To avoid having ablation plasma interfere with relevant physics it would best to use the non-irradiated (rear) side of the foil as the source, so calibrating rear emission is vital
- For longer pulse length x-ray sources a thicker target is needed to avoid burn through but the trade off is that thicker targets will attenuate early signals (Fig A).
- There are several different theoretical estimations for burn through time so experiments are useful in verification

A)



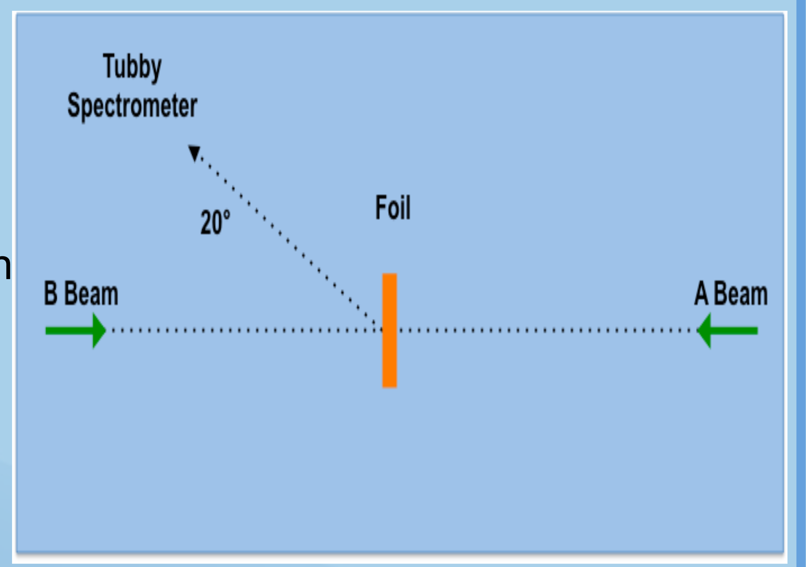
B)



A) Previous work at the Nova Laser has studied the amount of energy emitted from different thicknesses of gold foils[1]. B) Different theoretical approaches to calculating burn-through time vary widely in their predictions of the time to get emission from the rear end of the foil at an intensity of 1.05x10^{14} W/cm^2. [1,2,3]

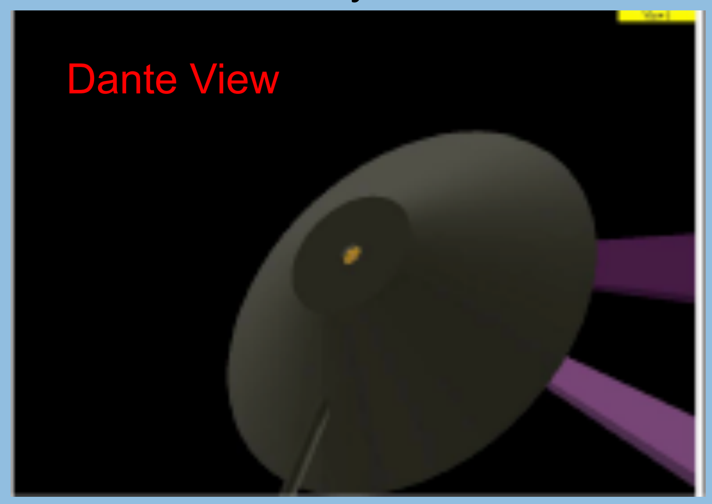
Trident experimental setup

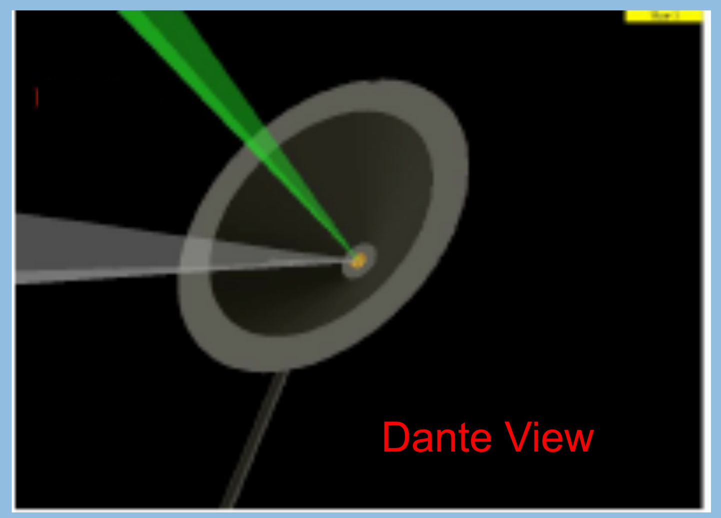
- We obtained spectra from the irradiated and non-irradiated sides of the gold foil using the alternating beams on the Trident laser system
- Key Diagnostic: Transmission grating spectrometer (Tubby) with wavelength resolution .0079nm/pixel
- Pulse length: 1-4ns
- Beam Intensity: 1e14 W/cm^2
- Gold Foil Thickness: 5um



OMEGA experimental setup

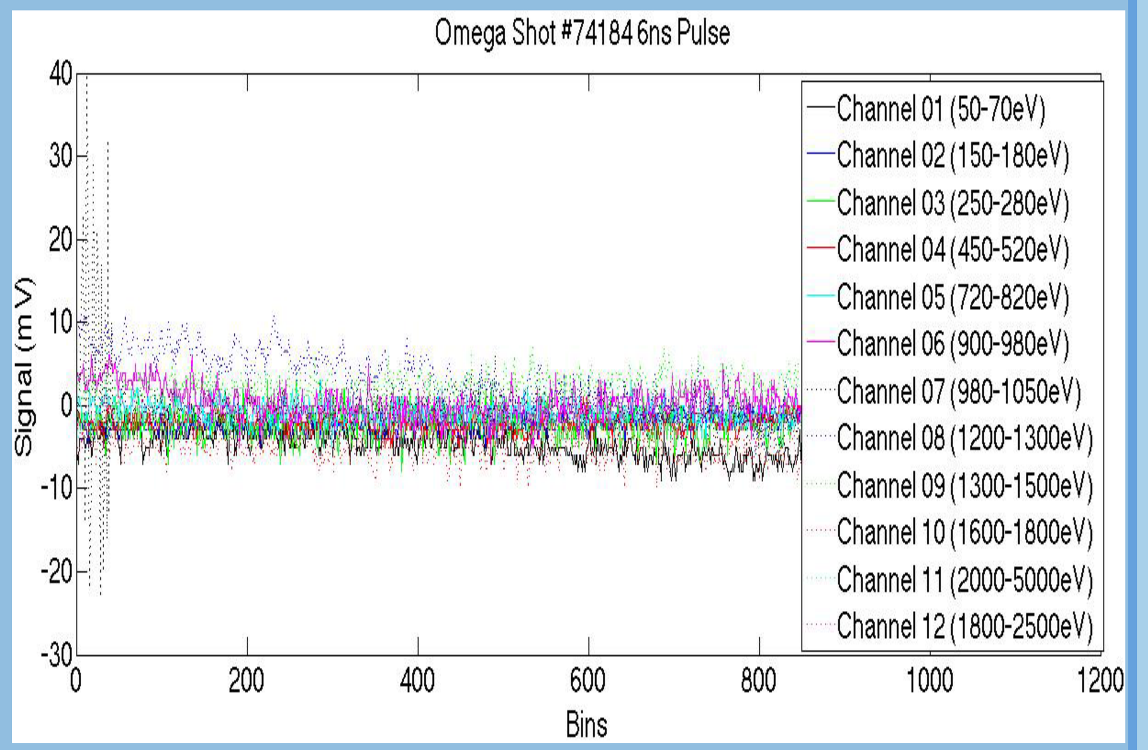
- Using the Omega-60 laser system, 1kJ of energy was placed on target and time resolved spectra was taken by the Dante spectrometer. High spectral resolution spectroscopy was unavailable on the day of the experiments
- Key Diagnostic: Dante time resolved spectrometer. Dante is a series of 12 photodiodes with each photodiode sensitive to a specific range of x-ray energies. The diodes convert the incoming photons into a voltage reading over time
- Pulse length: 2-6ns
- Beam Intensity: 1e14 W/cm^2





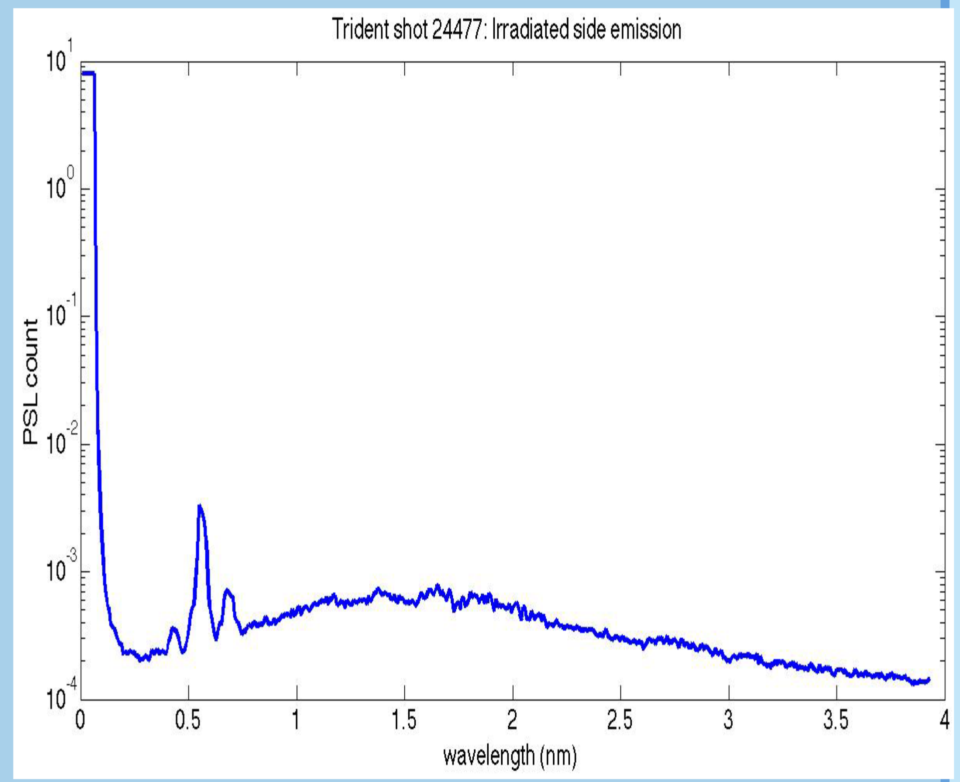
Measurements of the rear of the foil show no emission

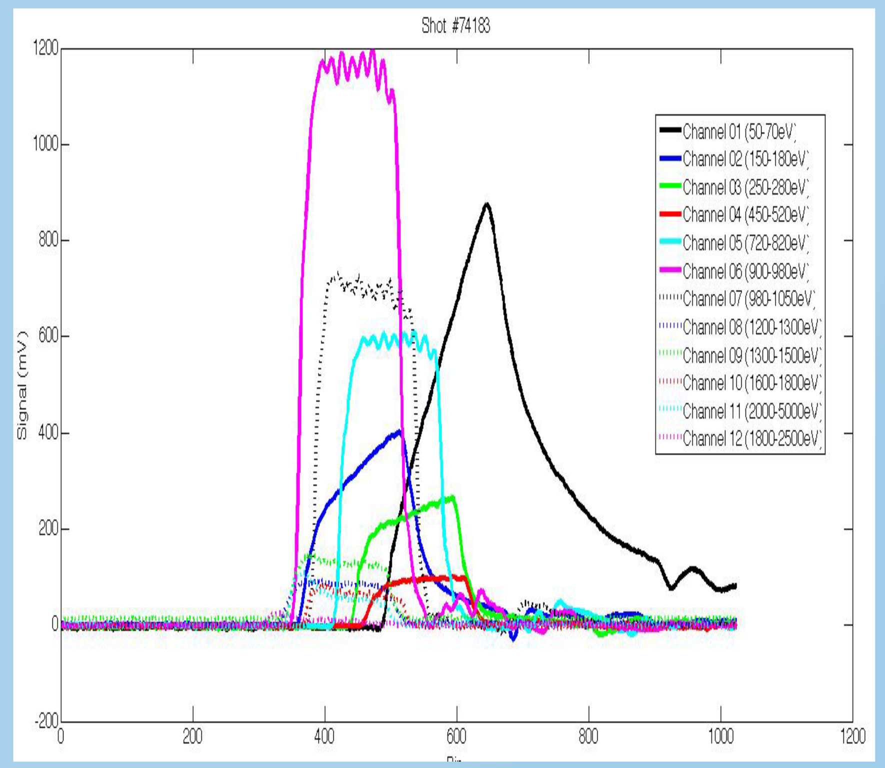
- The Dante Spectrometer at the Omega laser facility was unable to detect significant signal from the rear of the gold foil even with irradiances up to 1e14W/cm^2.
- Shots at Trident did detect a low amount of x-ray transmission through the gold foil but only at the central m=0 line limiting the characterization of emission
- Due to poor transmission at the intensities used, it can be determined that order to use the rear side of a gold foil as an x-ray source either a higher intensity or a thinner disk is needed



Spectra from irradiated side of the foil allows for plasma temperature to be determined

- The spectra from the TUBBY spectrometer allows for rough calculations of the plasma temperature of the foil by comparing the signal from the spectrometer with spectra generated from a radiative code like FLYCHK
- Once the Dante data is properly processed to convert its voltage signal to intensity and bins to time it will be possible to perform similar analysis but with time resolved data





References

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