The NIF Thomson Scattering Diagnostic

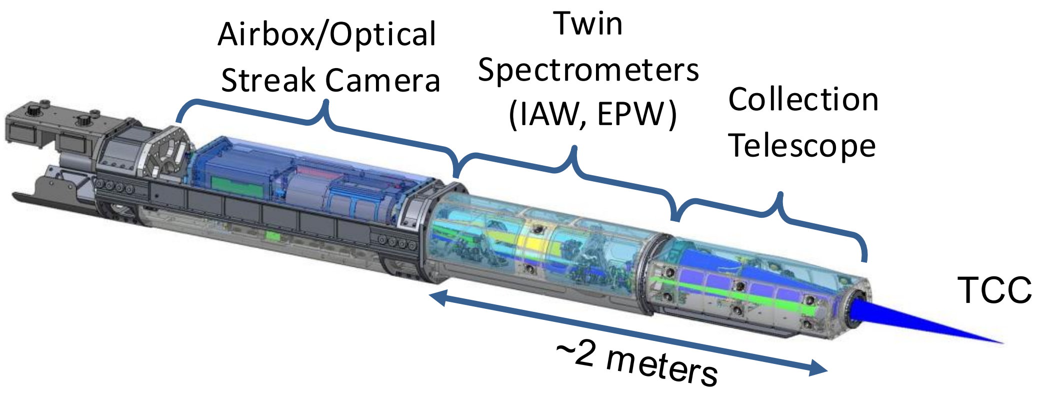
NIF User Group 12th Feb 2026

George Swadling

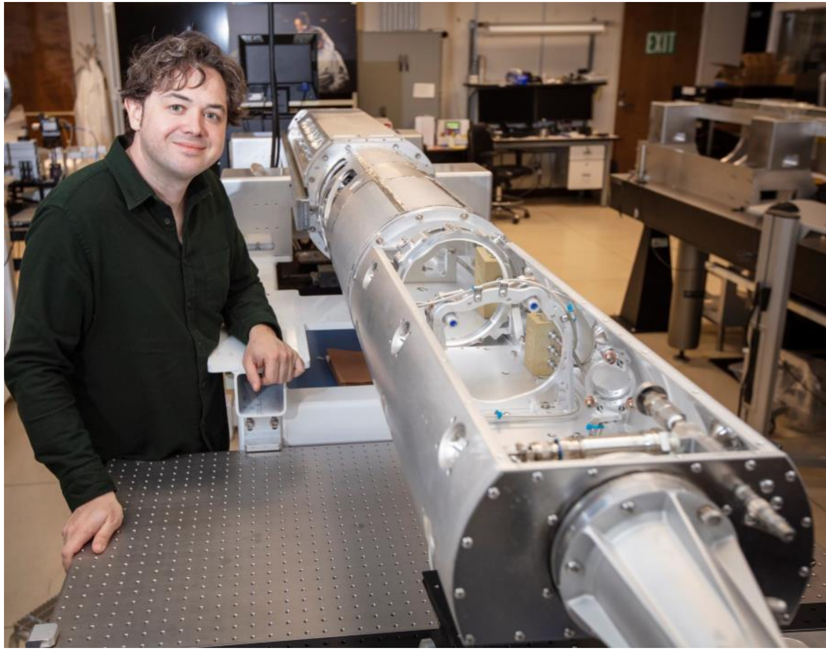
LLNL-PRES-2015534
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

Lawrence Livermore National Laboratory

The NIF Thomson Scattering diagnostic is a DIM-insertable optical spectrometer used to make measurements of Thomson scattered light from NIF experiments



The OTS diagnostic measures the spectrum of light scatted from dedicated probe beams to diagnose plasma conditions.

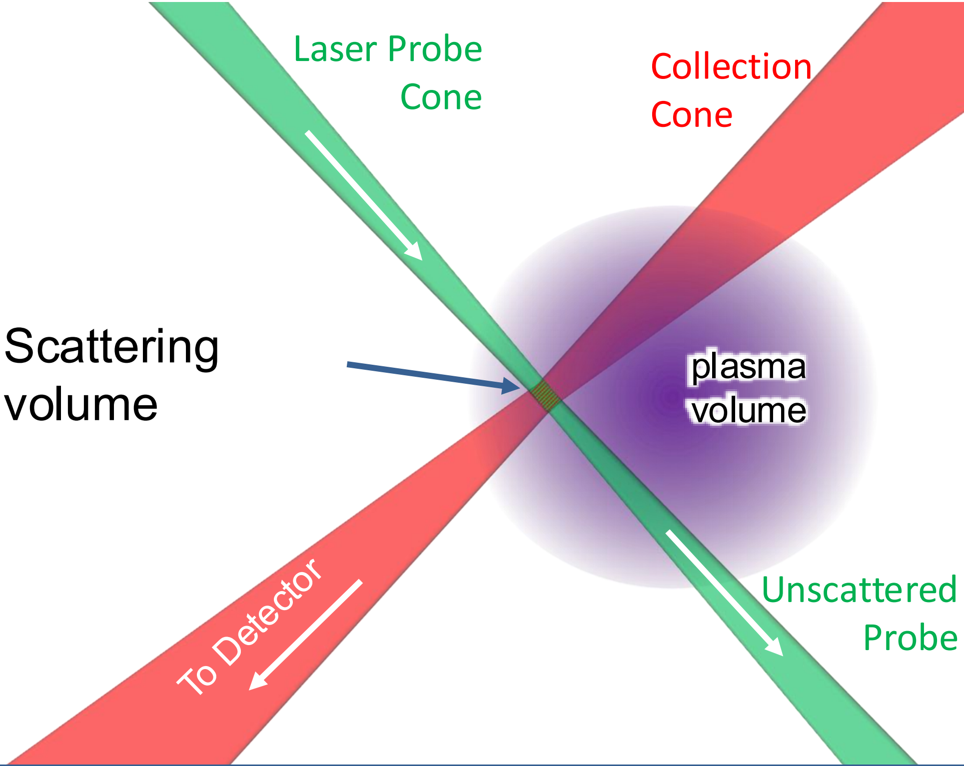


J. S. Ross - Rev. Sci. Instrum. 87, 11E510 (2016)
P. S. Datte - Rev. Sci. Instrum. 87, 11E549 (2016)

Fitting the spectrum of scattered light can allow us to infer measurements of the time-varying local plasma conditions, such as n_e, T_e, T_i, v_{flow}, $\bar{Z}$ etc.

The Thomson technique allows us to makes local measurements of under-dense plasmas parameters

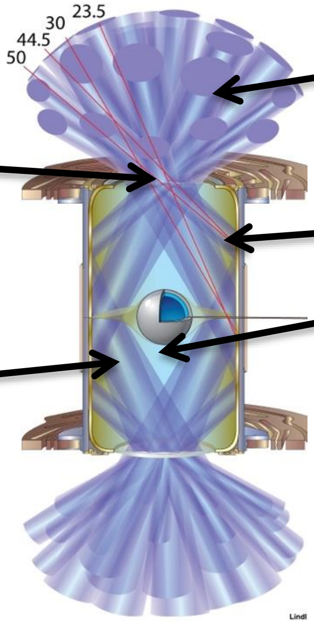
- Plasma parameters are often spatially variable
  - we want a local value
- TS signal is collected only from Scattering volume, defined by the overlap of:
  - probe beam
  - collection cone
- Typically ~10- 100µm scale size
  - Probe / collection alignment is a major diagnostic challenge



Thomson scattering allows us to make truly local measurements of plasma parameters

At the NIF, we plan to use Thomson scattering to better understand plasma conditions inside ICF hohlraums

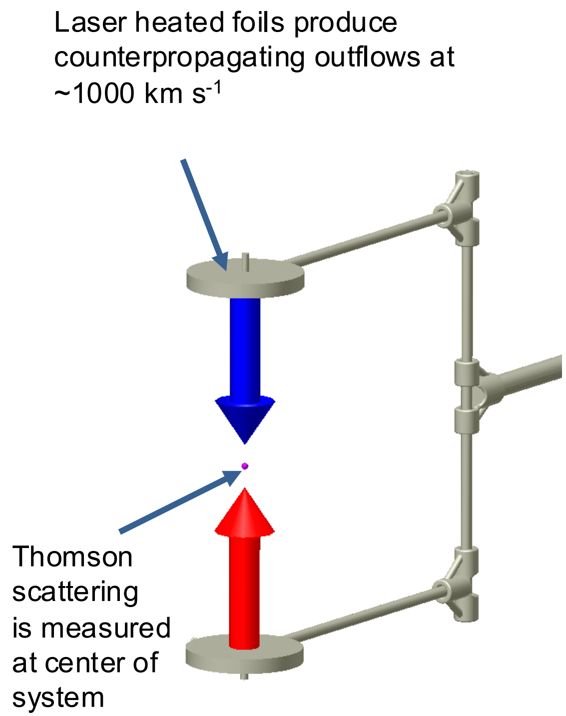
Measurement of Plasma parameters (T_e, n_e, v_{flow}) can inform understanding of:

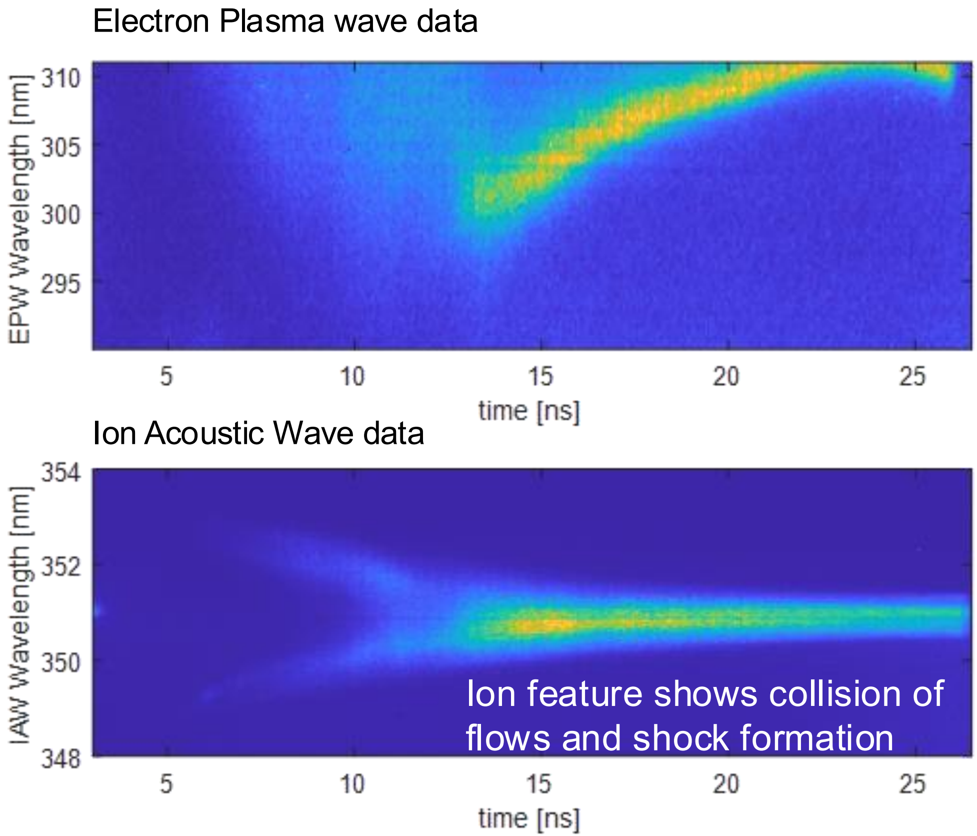


Additional physics: X-ray conversion, wall losses, wall-gas mix, hot-electron preheat, glint, re-amplification, transport…

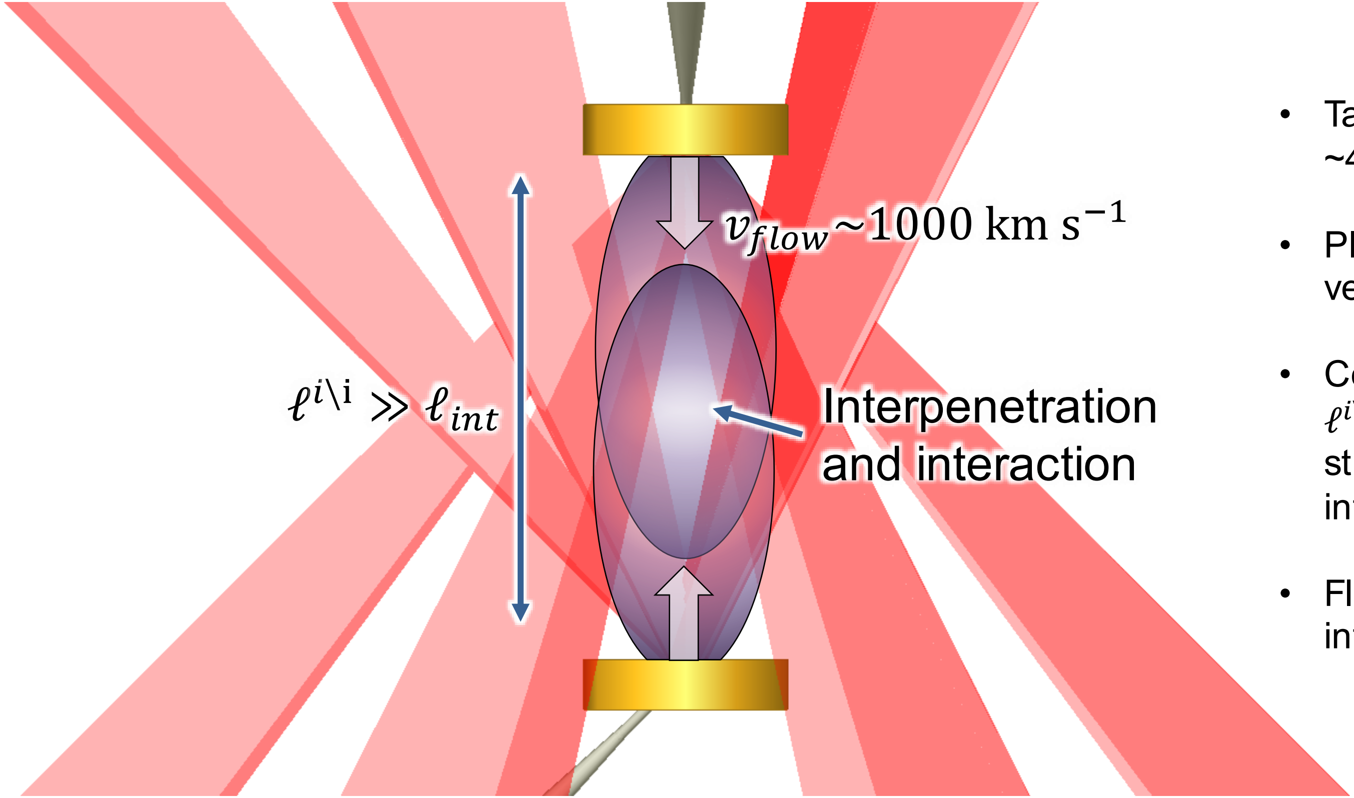
Thomson scattering has the potential to enhance our understanding of hohlraum plasma conditions and inform many of these issues

The NIF Thomson Scattering diagnostic has also been used to make a range of successful 3ω probe measurements of plasma dynamics in Discovery Science Experiments – e.g. Collisionless shock experiments



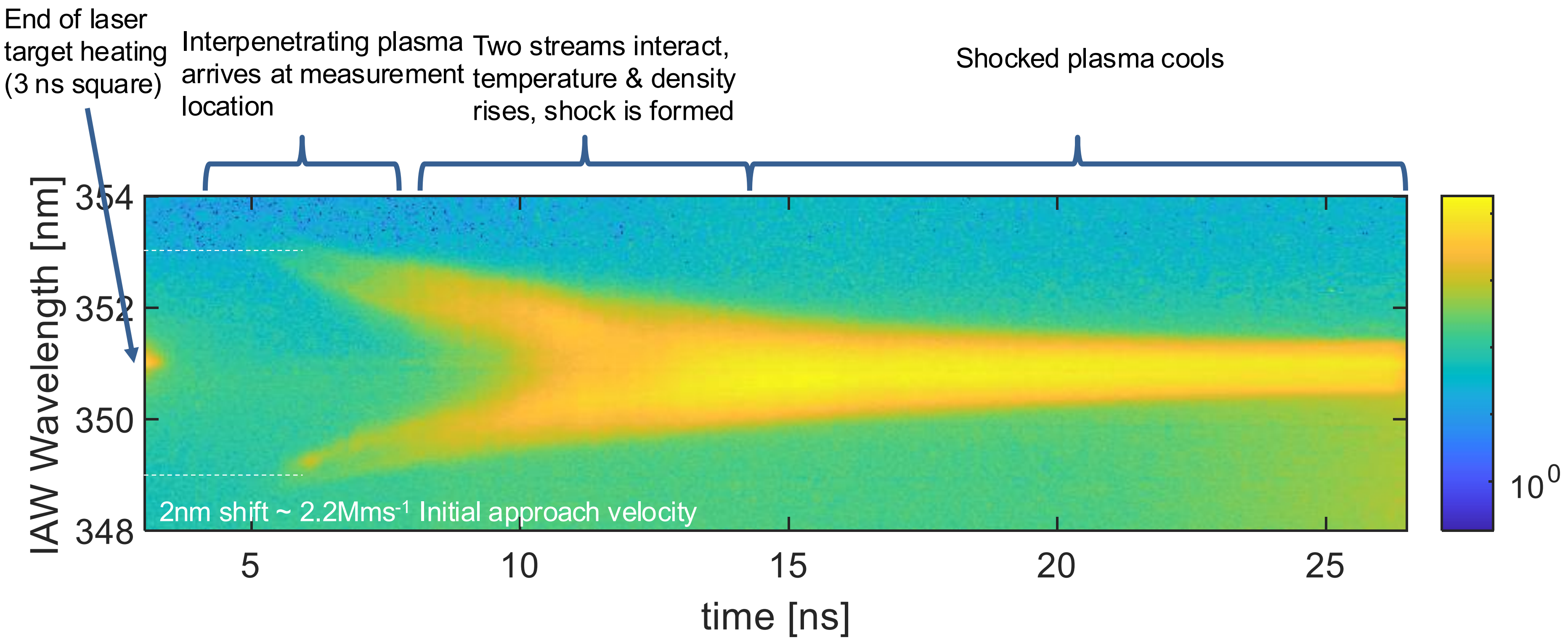


These discovery science experiments collide plumes of high velocity plasma generated from laser heated planar targets to study collisionless shocks and associated particle acceleration

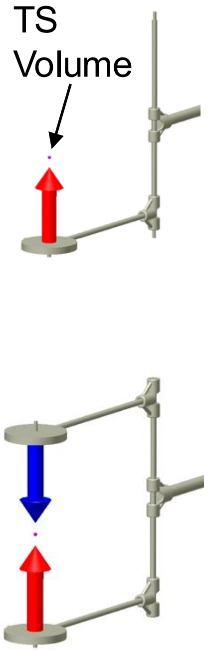


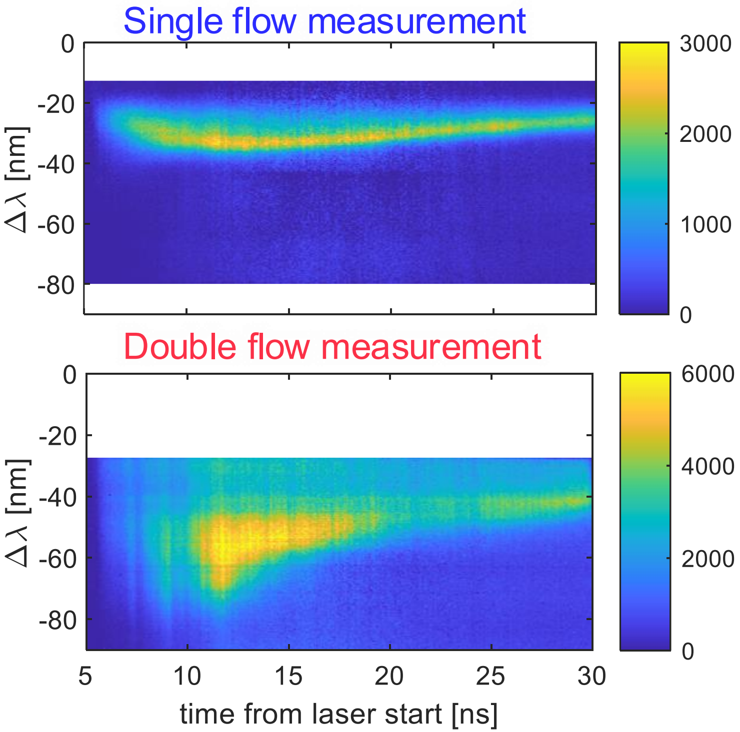
- Targets are laser heated (3ns, ~450kJ per target)
- Plasma expands forming high velocity flows
- Coulomb collision scale length $\ell^{i\backslash i}$ for ions in opposing streams is large compared to interaction scale length ℓ_{int}
- Flows interpenetrate and interact collisionlessly

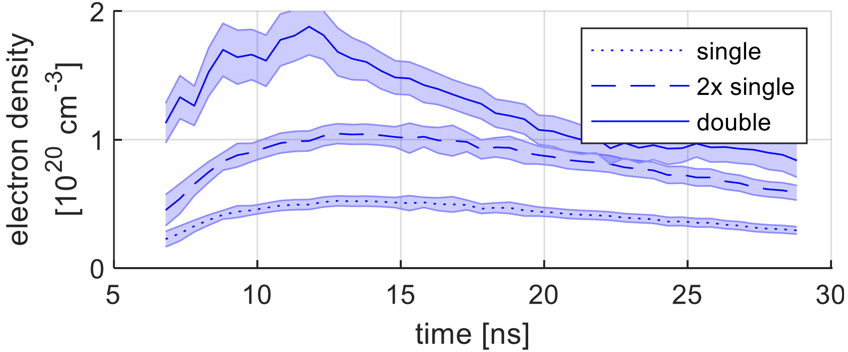
When shown on a log color scale the various phases of the experiment are evident in the ion feature (data from previous experiment)

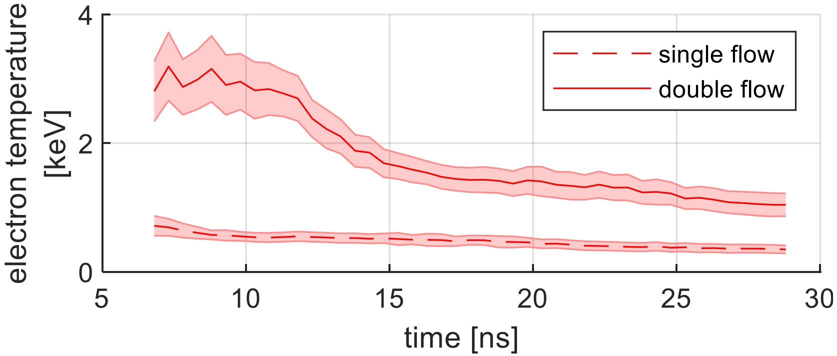


The TS data can be analyzed to extract measurements of the plasma parameters as they vary in time. In this example we see clear evidence for the formation of a collisionless shock





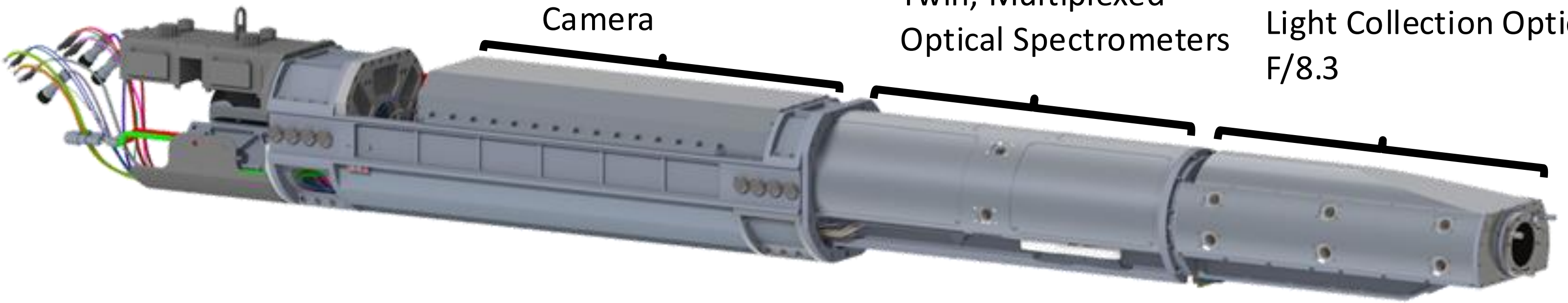




Factor of four density enhancement indicates that a shock has been formed

Fiuza, F., Swadling, G.F., Grassi, A. et al. Electron acceleration in laboratory-produced turbulent collisionless shocks. Nat. Phys. 16, 916–920 (2020).

The Optical Thomson Scattering Spectrometer DLP can be installed from 0-0, 90-78 & 90-351, providing flexibility in choice of scattering geometry for a wide range of experiments.



Specification	IAW	EPW
Measurement Bandwidth	4 nm	50 nm
Accessible Wavelength band	206 - 350 nm	150 - 370 nm
Approximate Spectrometer resolution	0.02 nm	0.5 nm
Approximate temporal resolution	200 ps	50 ps

Currently on 3ω probes are available.

We are developing a 4ω capability

Lawrence Livermore National Laboratory

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC