

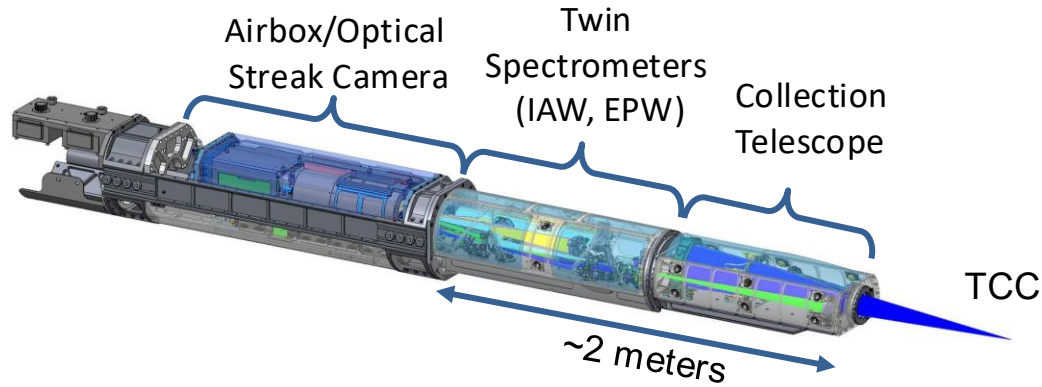
The NIF Thomson Scattering Diagnostic

NIF User Group 12th Feb 2026

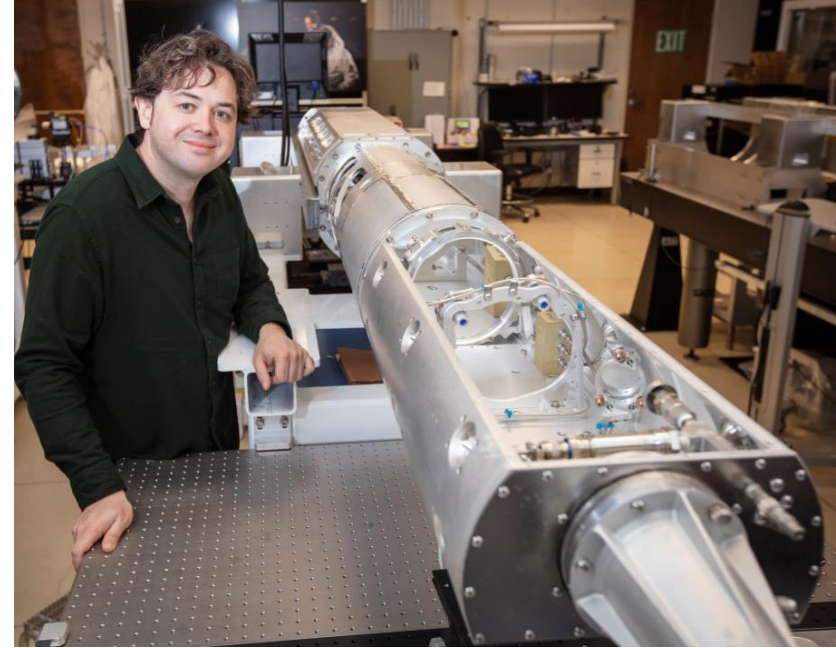
George Swadling



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 scattered from dedicated probe beams to diagnose plasma conditions.

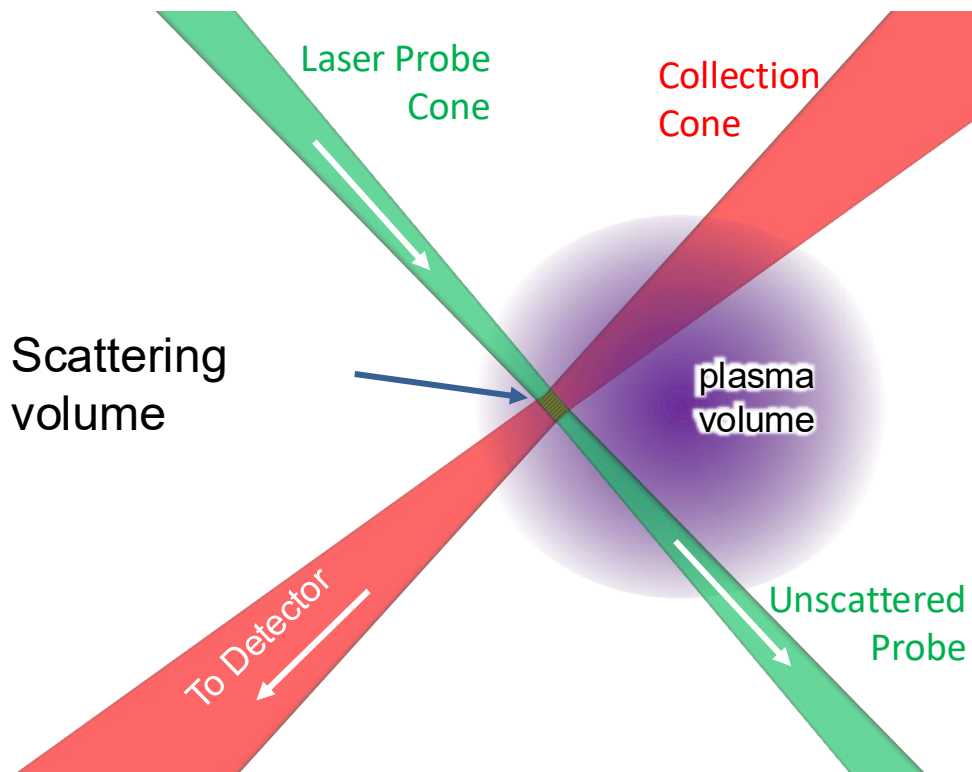


J. S. Ross - Rev. Sci. Instrum. 87, 11E510 (2016)
P. S. Datte - Rev. Sci. Instrum. 87, 11E549 (2016)

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 make local measurements of under-dense plasmas parameters

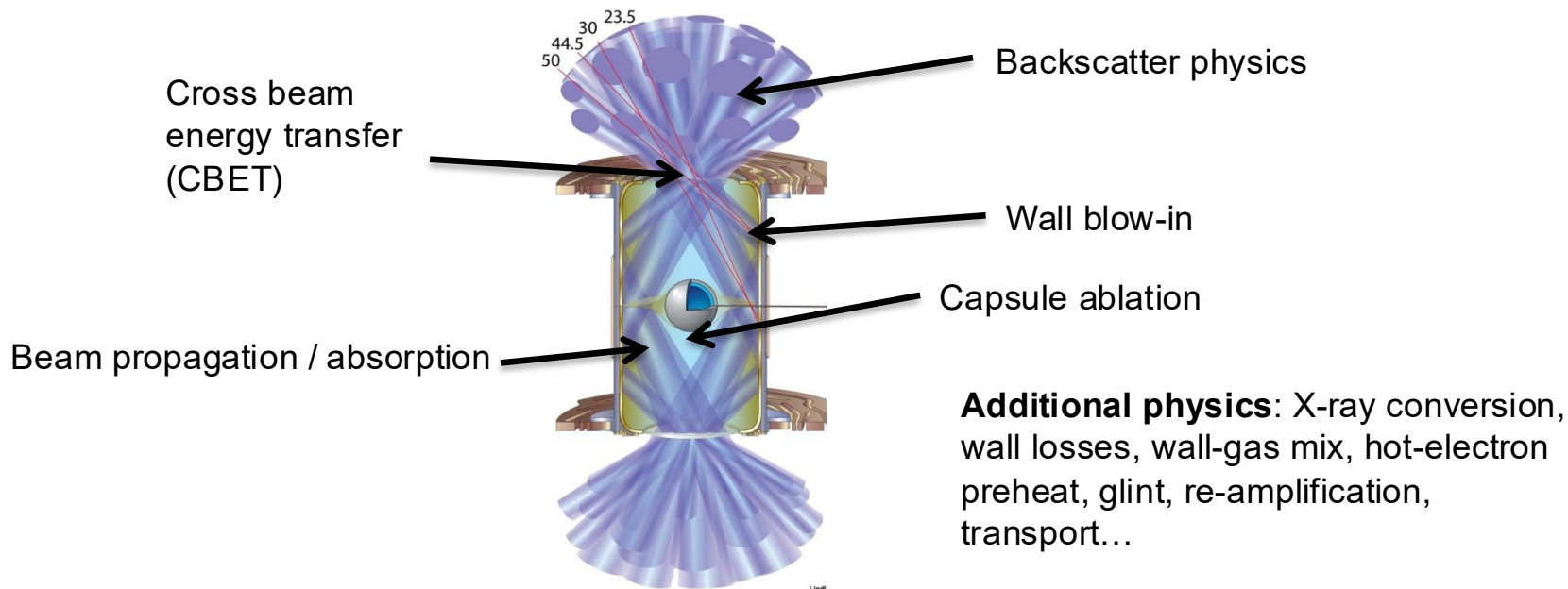
- Plasma parameters are often spatially variable
 - we want a local value
- TS signal is collected only from Scattering volume, defined by the overlap of:
 - probe beam
 - collection cone
- Typically $\sim 10\text{-}100\mu\text{m}$ scale size
 - Probe / collection alignment is a major diagnostic challenge



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

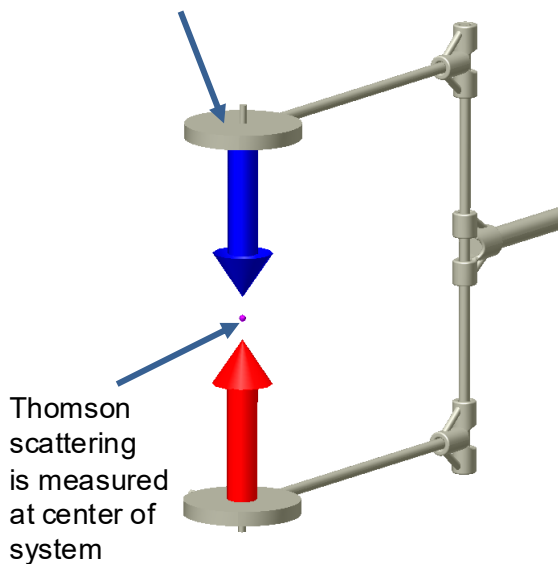
Measurement of Plasma parameters (T_e , n_e , v_{flow}) can inform understanding of:



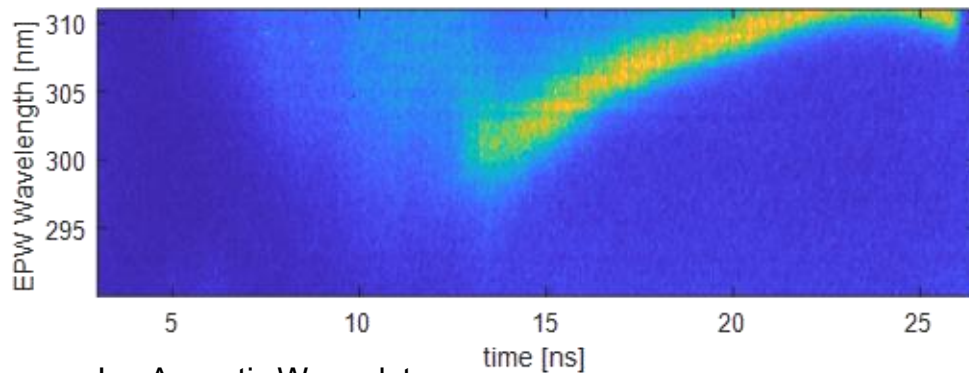
Thomson scattering has the potential to enhance our understanding of hohlraum plasma conditions and inform many of these issues

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

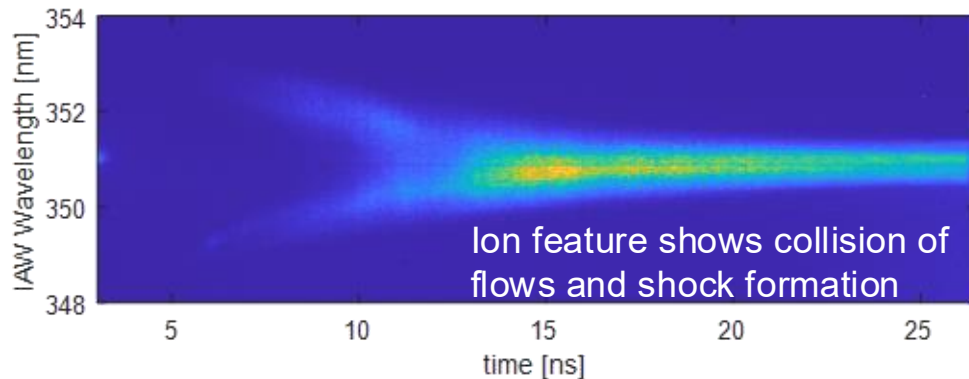
Laser heated foils produce counterpropagating outflows at $\sim 1000 \text{ km s}^{-1}$



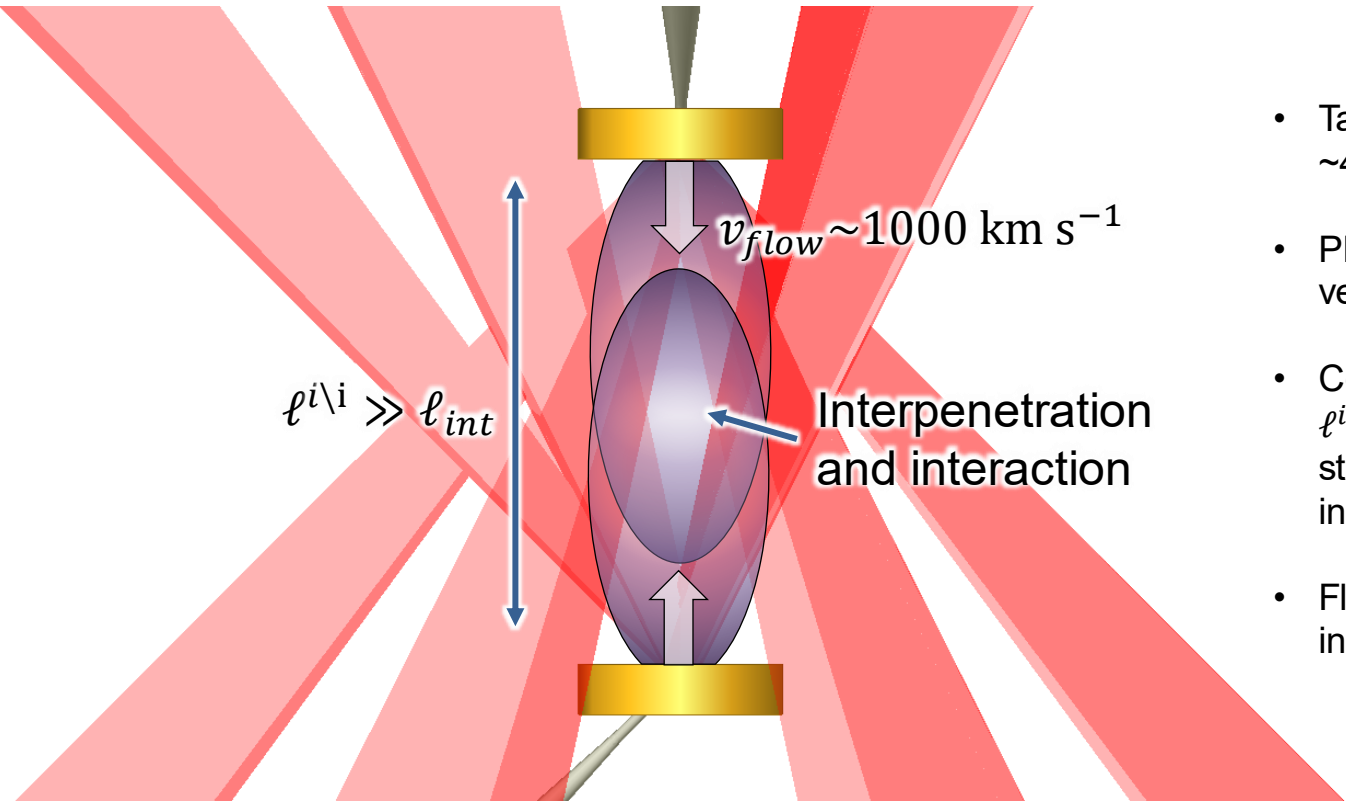
Electron Plasma wave data



Ion Acoustic Wave data



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 $\ell^i \lambda^i$ for ions in opposing streams is large compared to interaction scale length ℓ_{int}
- Flows interpenetrate and interact collisionlessly

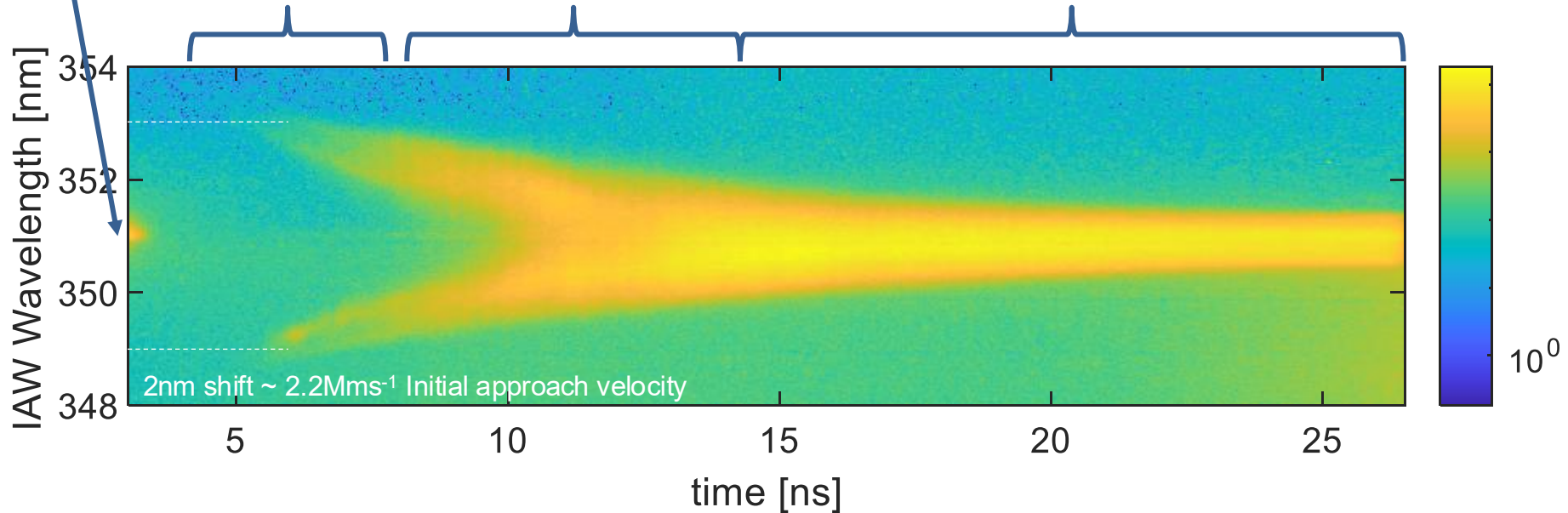
When shown on a log color scale the various phases of the experiment are evident in the ion feature (data from previous experiment)

End of laser target heating (3 ns square)

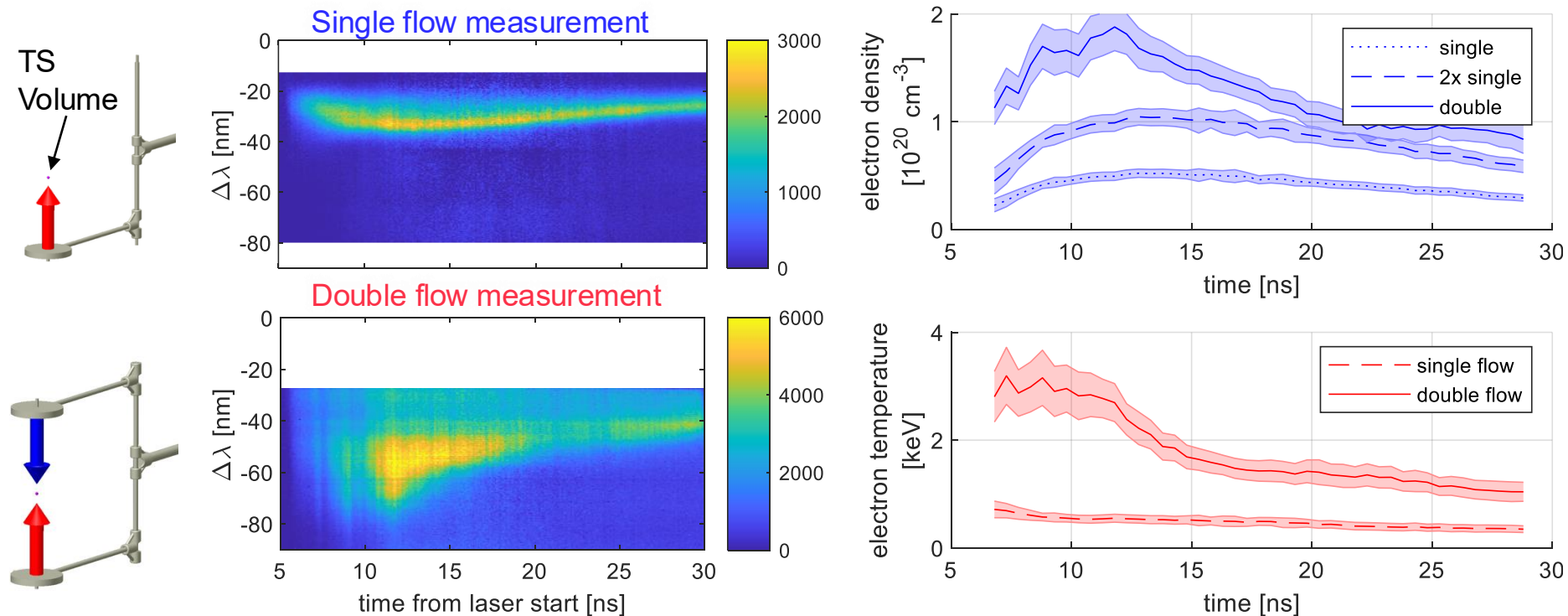
Interpenetrating plasma arrives at measurement location

Two streams interact, temperature & density rises, shock is formed

Shocked plasma cools

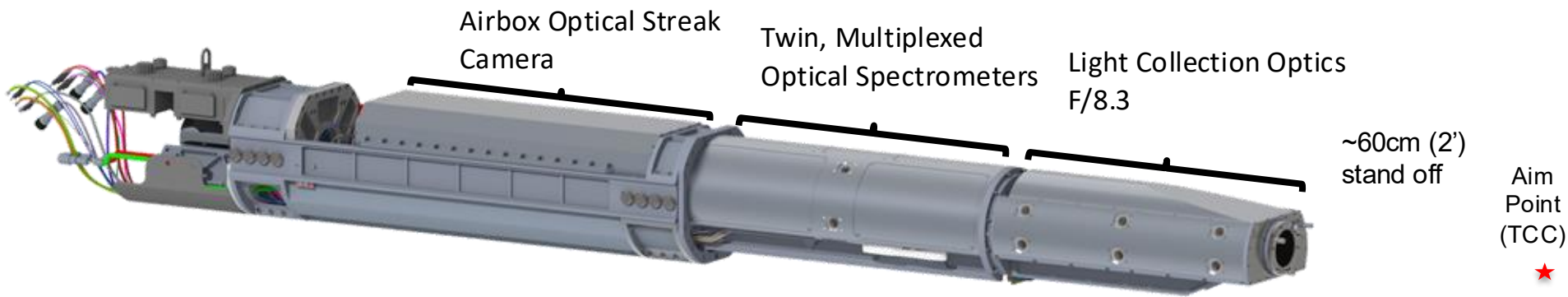


The TS data can be analyzed to extract measurements of the plasma parameters as they vary in time. In this example we see clear evidence for the formation of a collisionless shock



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

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 3w probes are available.

We are developing a 4w capability



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