Measurements of ion species separation using Thomson scattering

Presentation to
Kinetic Physics Workshop

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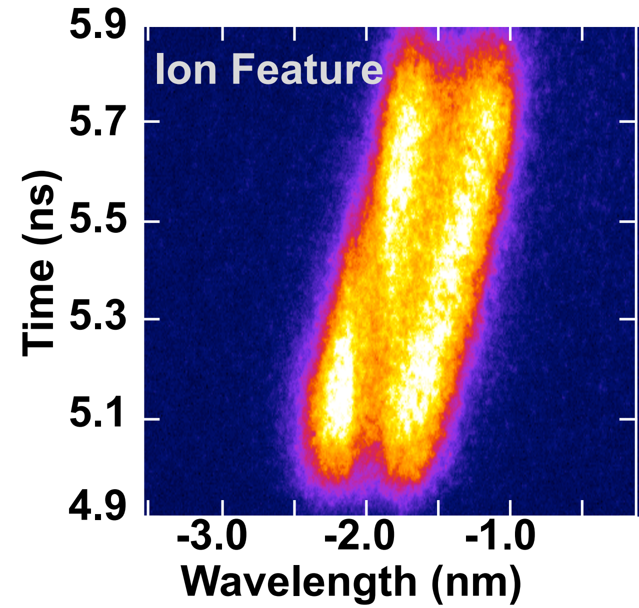
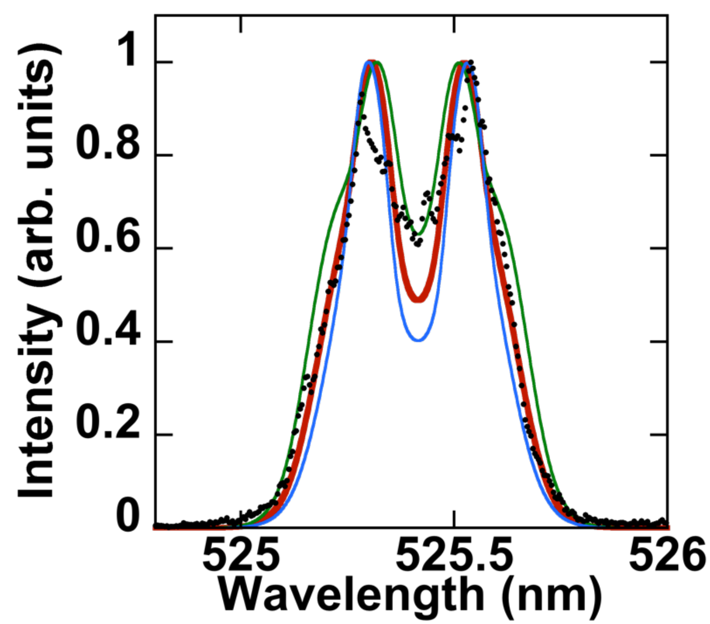
Summary

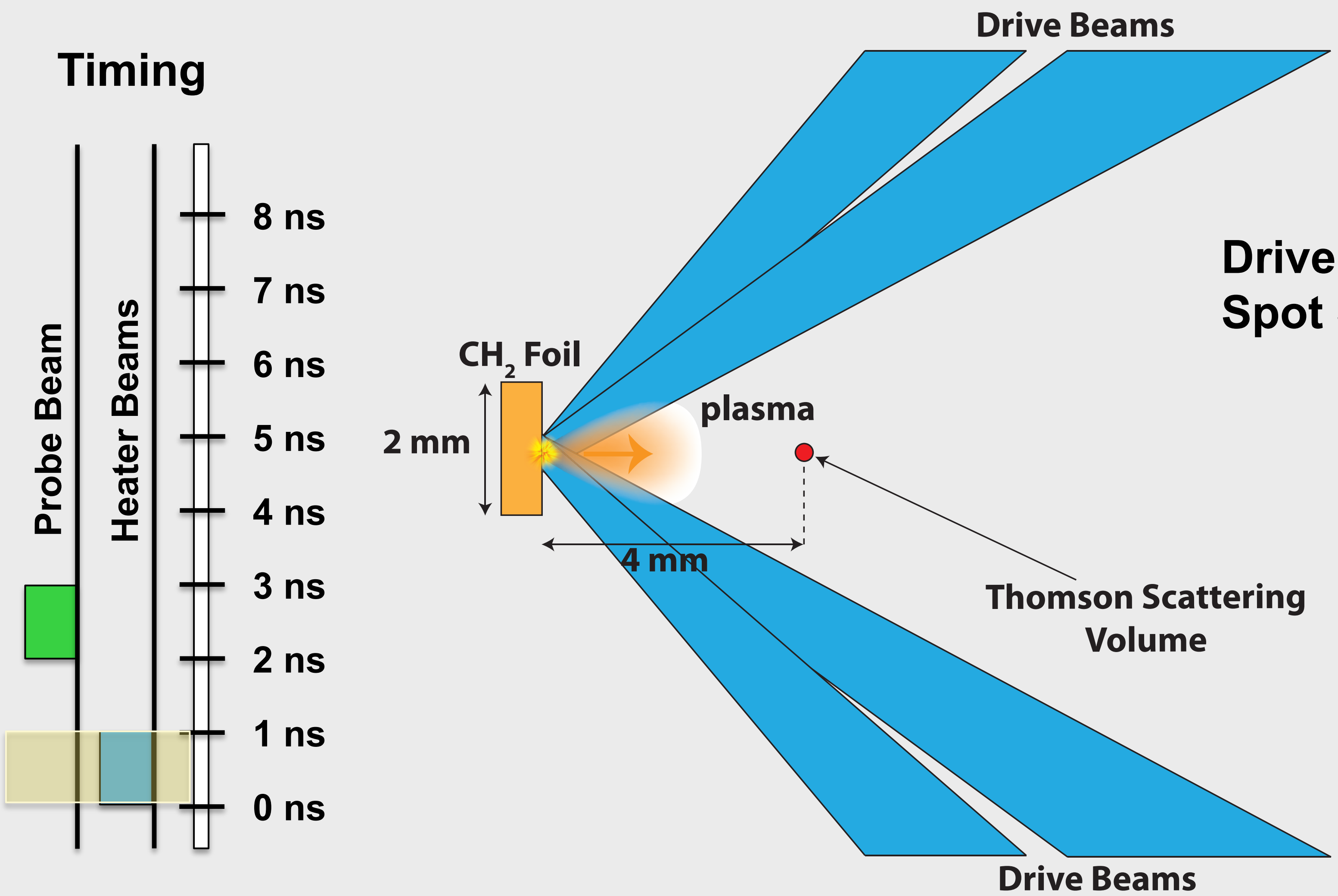
- Thomson scattering provides a local, time resolved measurement of plasma conditions (Te, Ne, flow)
- It can also be used to characterize ion species fractions for certain plasma regimes (small fraction of high-Z material in a low-Z plasma)
- The ion species fraction was measured for a CH laser ablated plasma
- The plasma is observed to be hydrogen rich at early times





We create a high velocity plasma flow by irradiating a CH_2 foil target with 10 beams from the Omega Laser

Heater beams are on for 1 ns and deliver 5 kJ to target



Drive Beams: 10
Spot Size: ~250 μm

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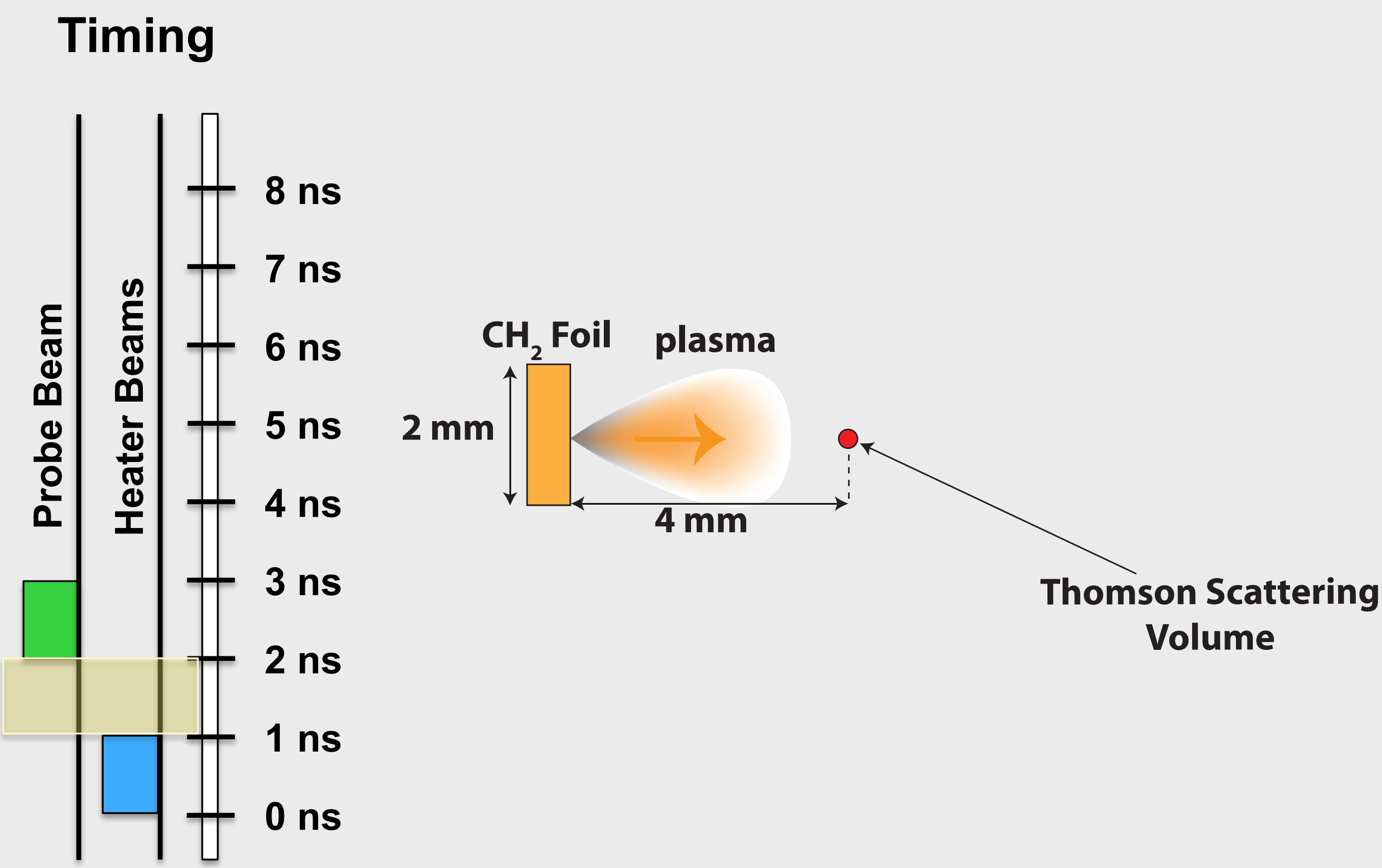
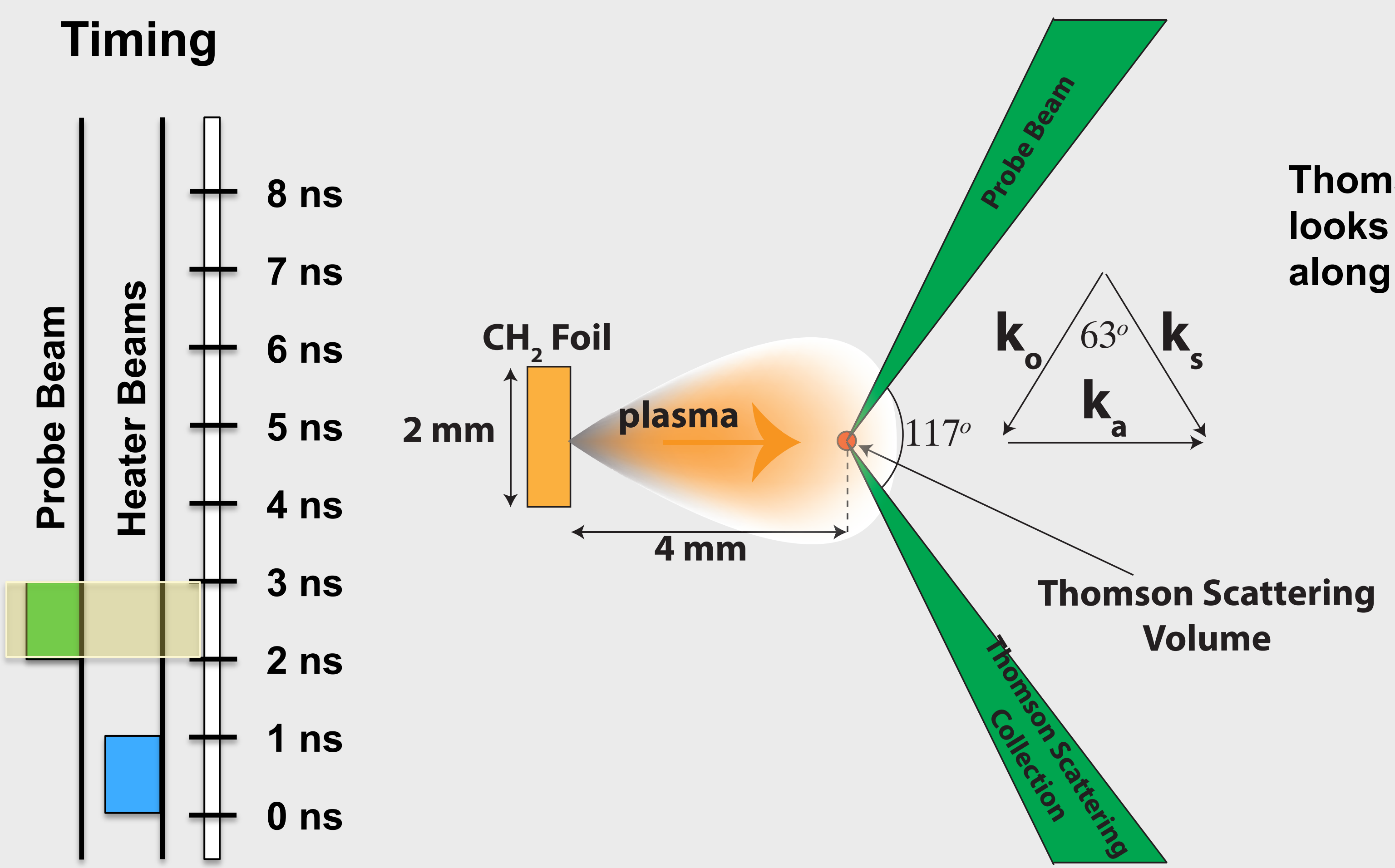
The plasma expands at high speed (> 10^7 cm/s)



We create a high velocity plasma flow by irradiating a CH_2 foil target with 10 beams from the Omega Laser

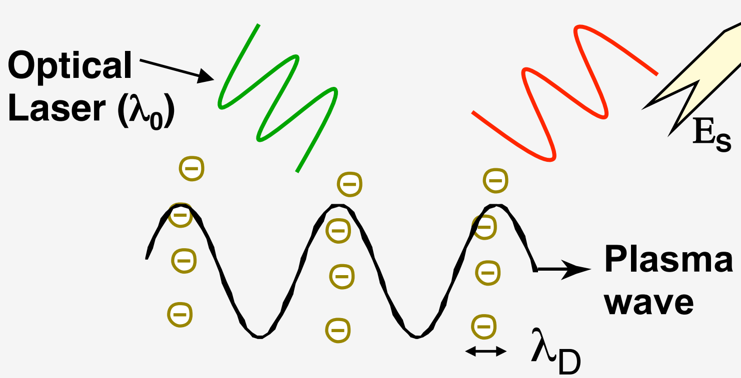
2ω Thomson Scattering data provides
n_e, T_e, T_i, v measurements



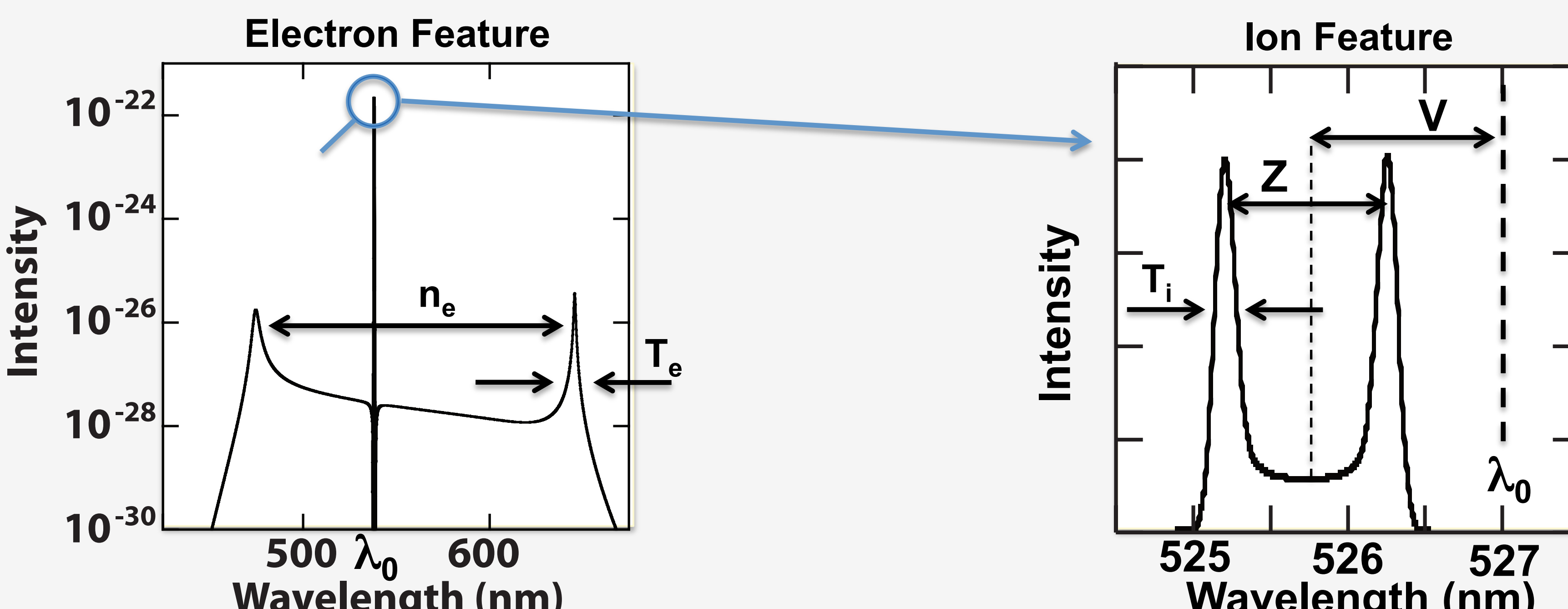
Thomson scattering looks at plasma waves along the k-vector (k_a)

Collective Thomson scattering from ion-acoustic and electron-plasma waves is used to measure the plasma conditions

Thomson scattering is the scattering of an electromagnetic wave by free electrons.

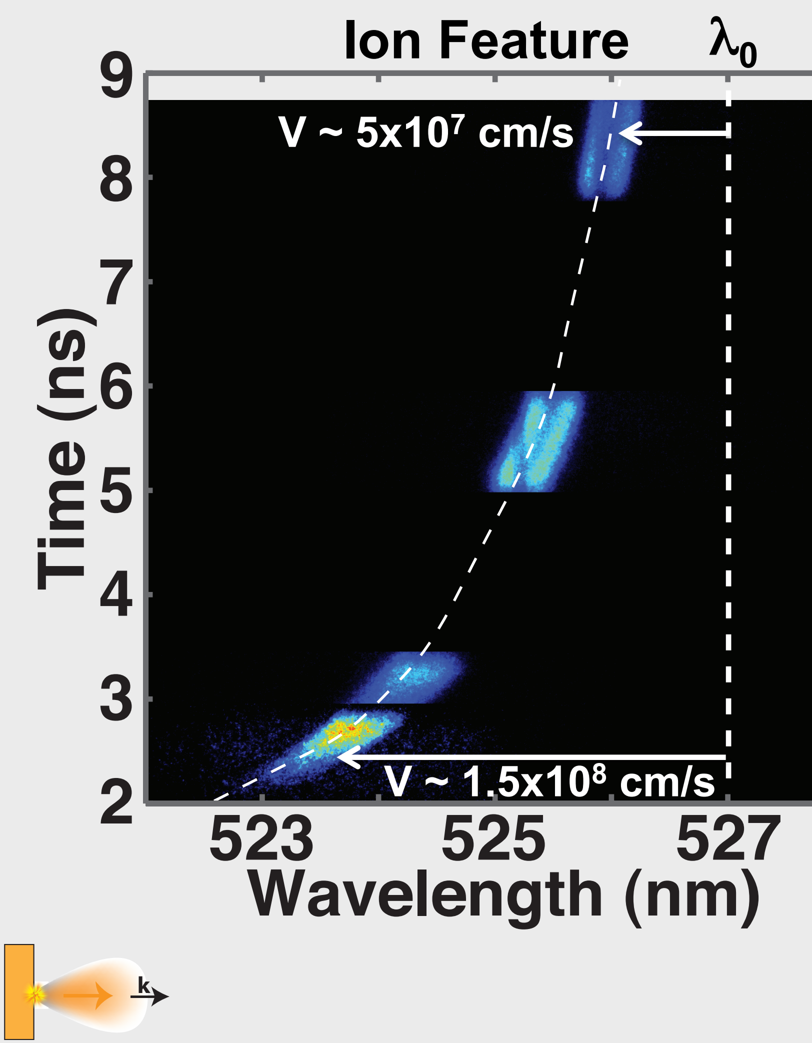


$$S(\mathrm{k},\omega) = \frac{2\pi}{k}\left|1 - \frac{\chi_e}{\varepsilon}\right|^2 f_e\left(\frac{\omega}{k}\right) + \frac{2\pi Z}{k}\left|\frac{\chi_e}{\varepsilon}\right|^2 f_i\left(\frac{\omega}{k}\right)$$

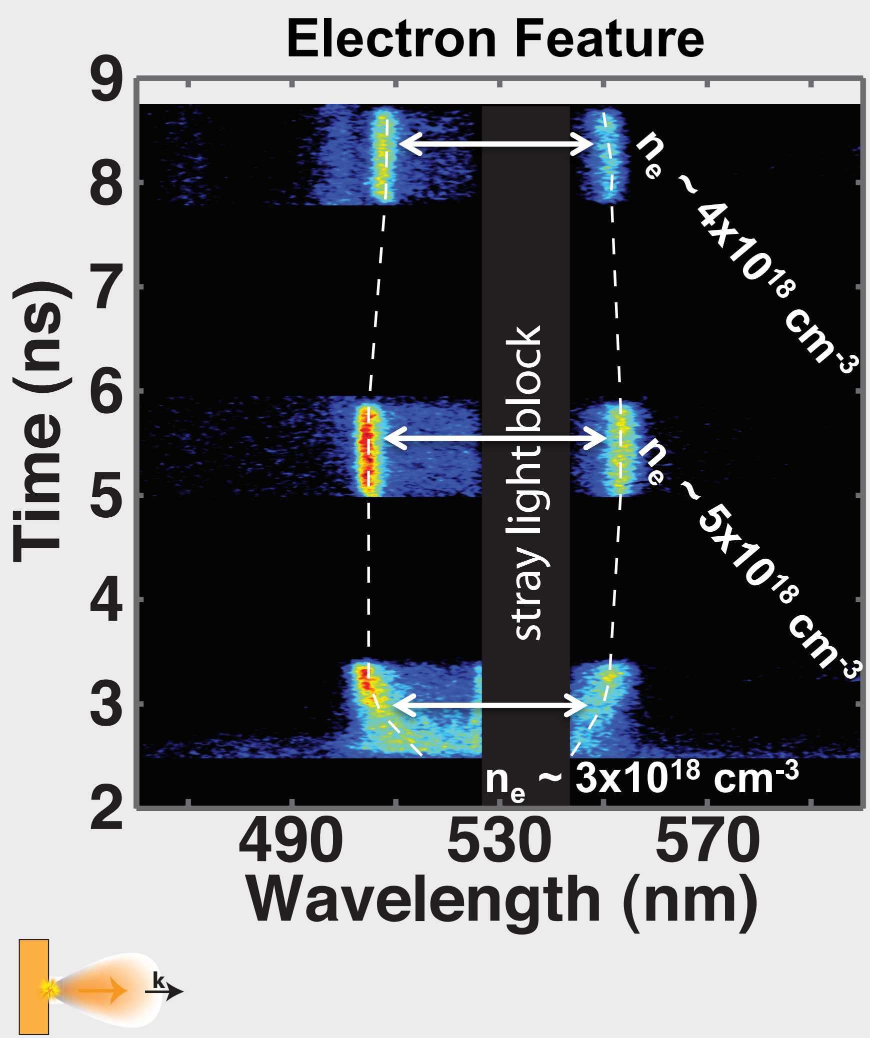


Single foil evolution is consistent with adiabatic expansion with velocities between 15 – 5 $\times 10^7$ cm/s and ne ~ 4×10^{18} cm^{-3}

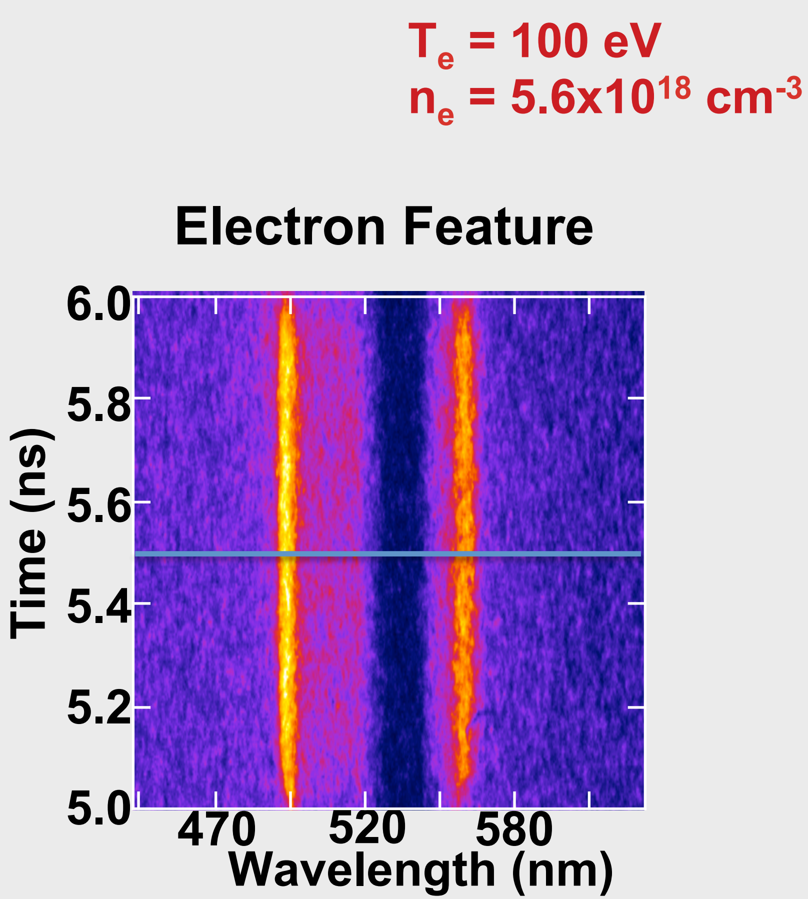
The wavelength shift from the incident wavelength (λ_0) is a measure of the flow velocity

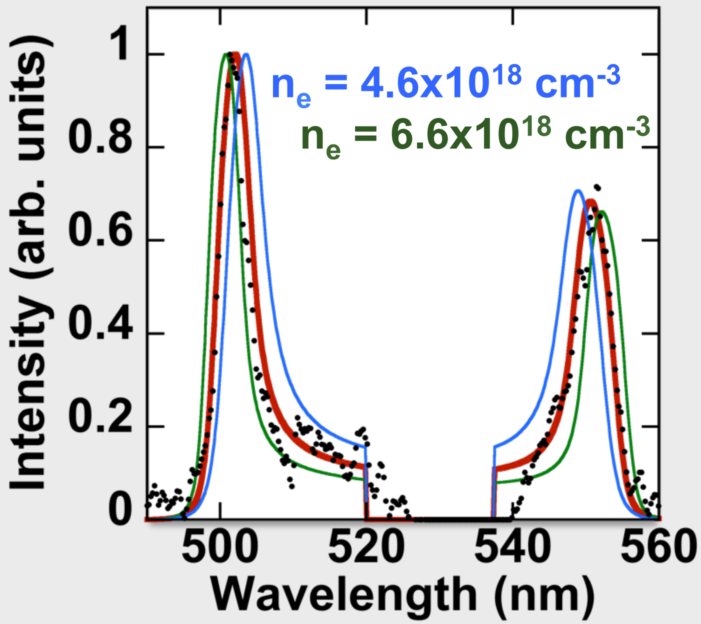


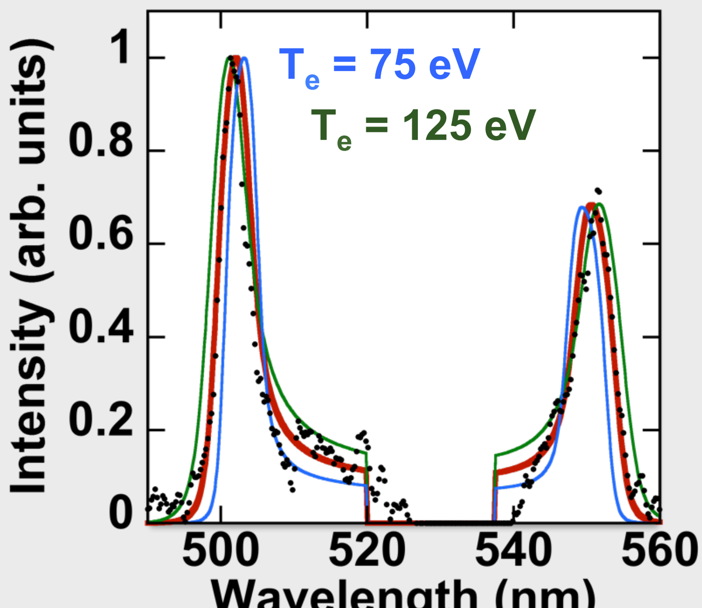
The wavelength shift between the peaks is a measure of the electron density



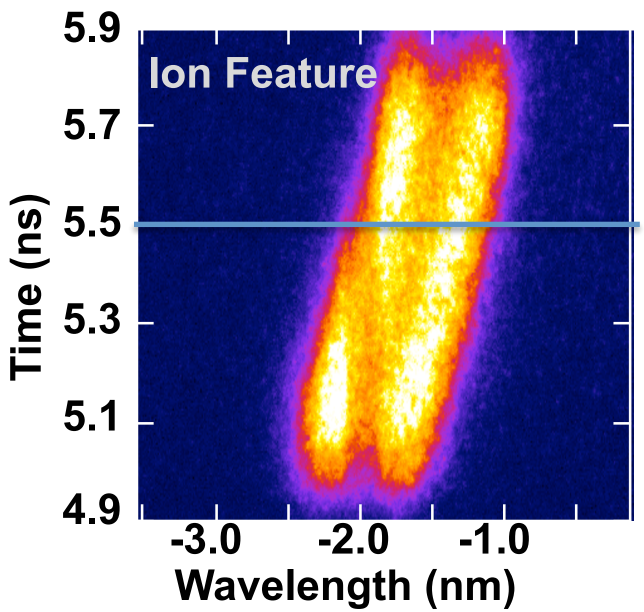
Scattering from the electron feature is used to measure the electron temperature and density

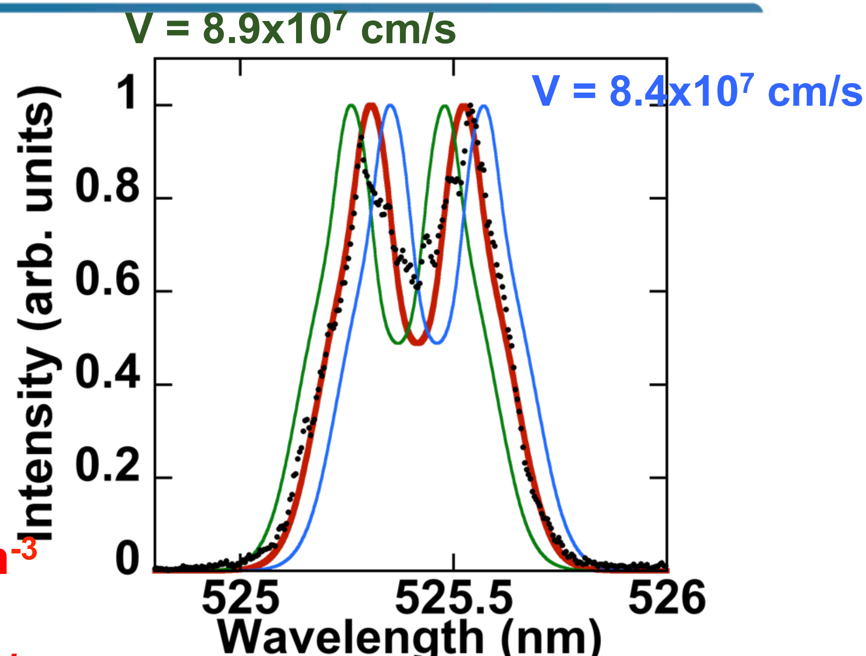




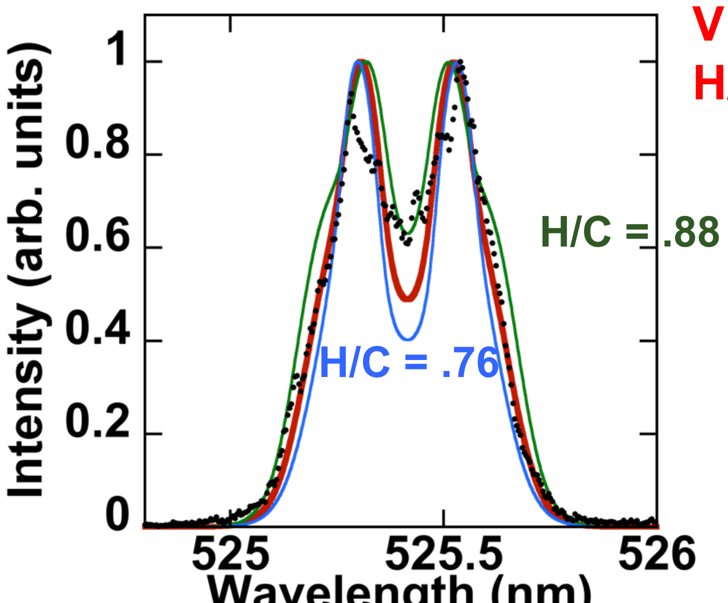


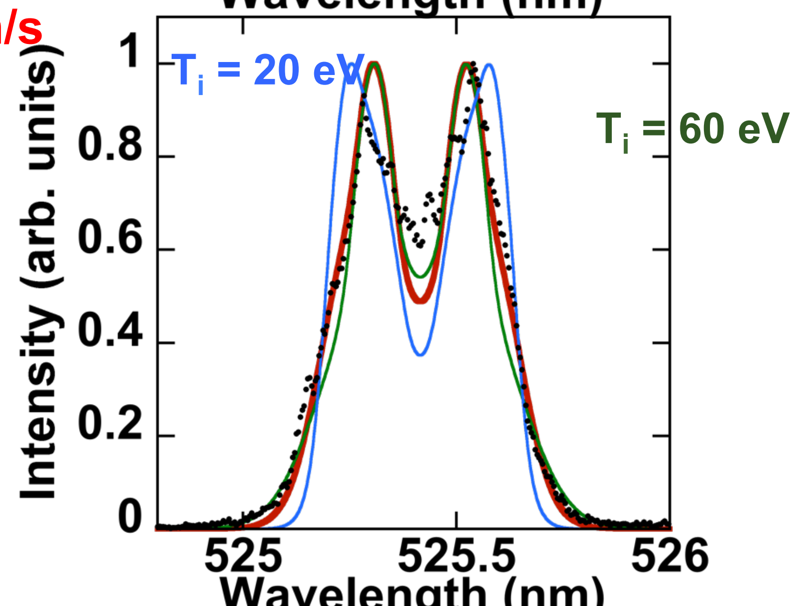
Scattering from the ion feature is used to measure the ion temperature, plasma flow velocity and species fraction





T_e = 100 eV
n_e = 5.6x10^{18} cm^{-3}
T_i = 40 eV
V = 8.65x10^7 cm/s
H/C = .82

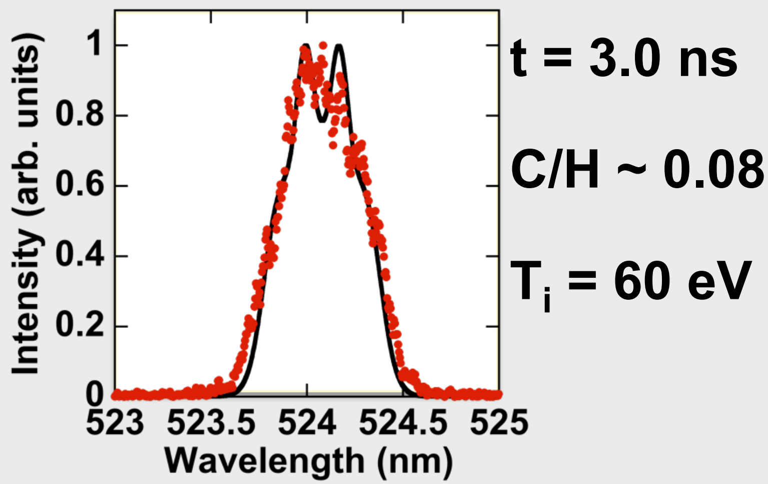


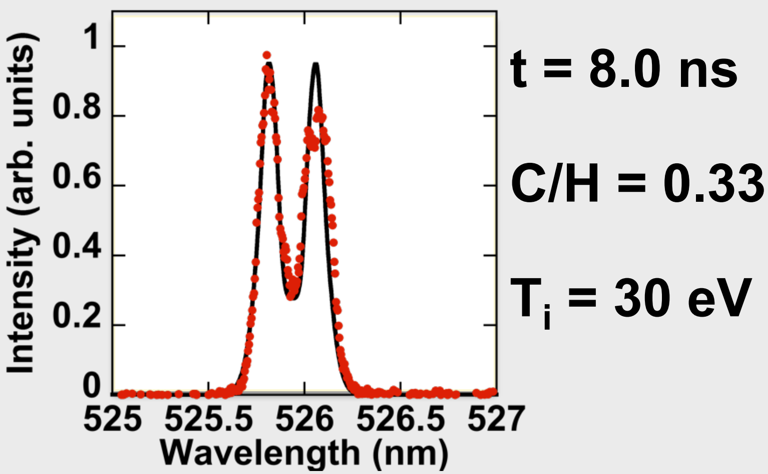


These measurements are only possible because n_e and T_e are constrained by the electron feature.

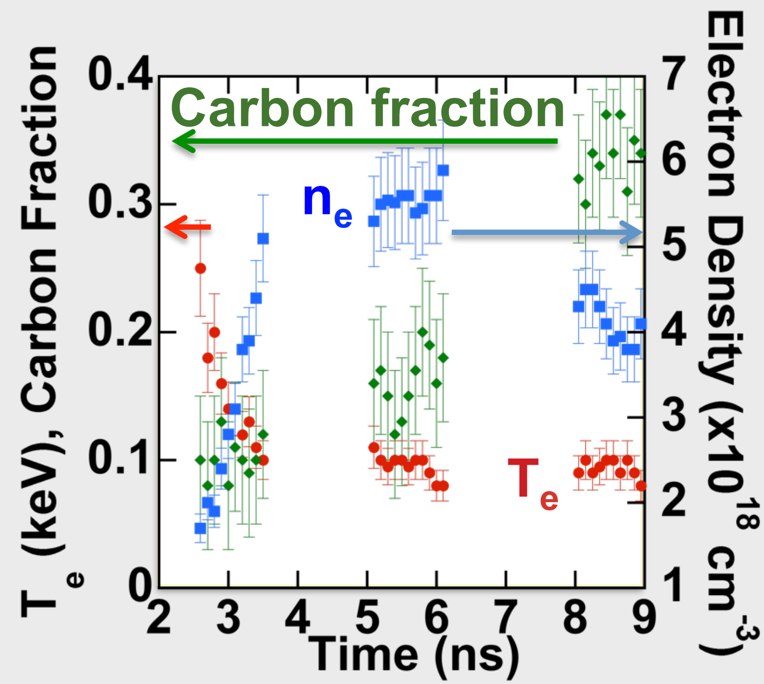
An increased Hydrogen percentage is measured in the Thomson scattering volume at early times

The ion feature can be used to measure the ion species fraction and ion temperature



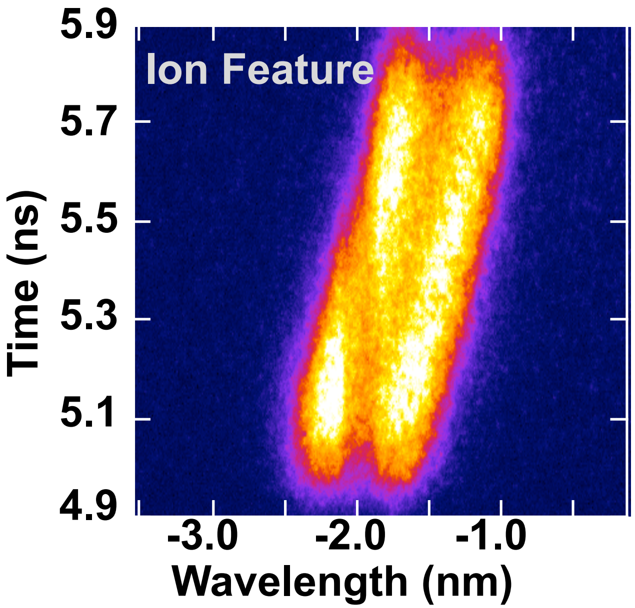


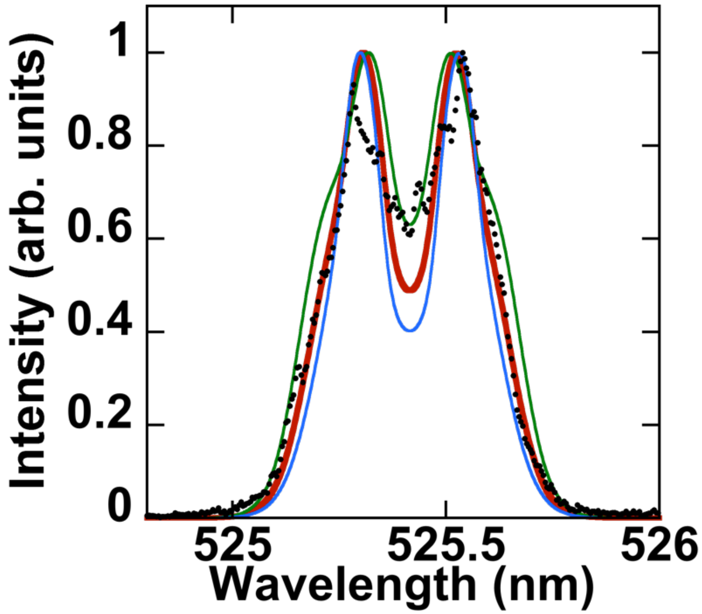
The electron temperature and density are measured using the electron feature



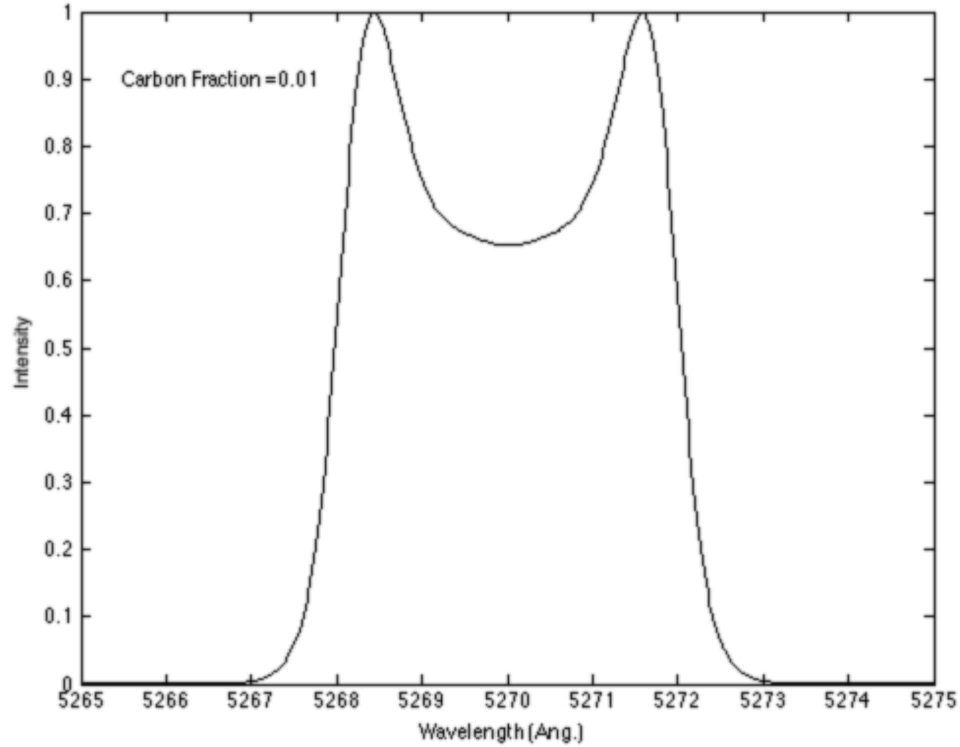
Summary and future work

- Thomson scattering provides a local, time resolved measurement of plasma conditions (Te, Ne, flow)
- It can also be used to characterize ion species fractions for certain plasma regimes (small fraction of high-Z material in a low-Z plasma)
- The ion species fraction was measured for a CH laser ablated plasma
- The plasma is observed to be hydrogen rich at early times
- This technique can also be used to characterize interpenetrating flows which will be discussed by S. Le Pape in the next talk






NIF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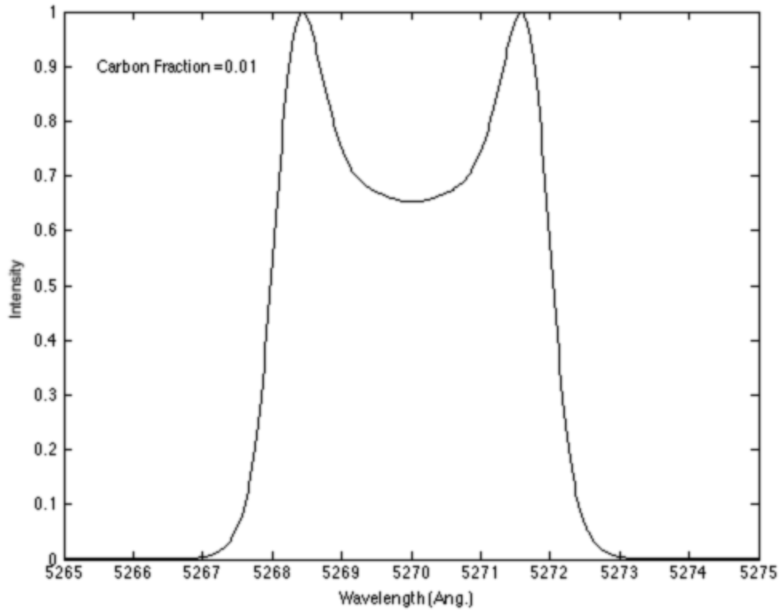
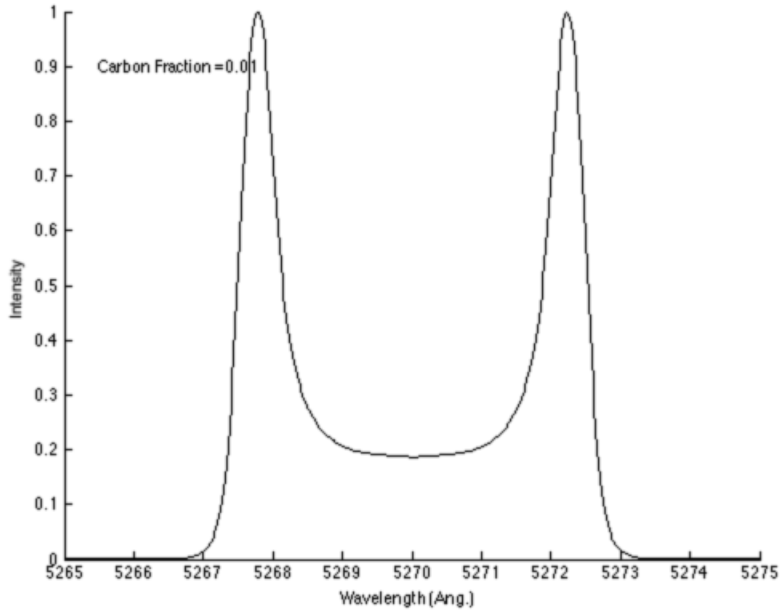
Intensity
Wavelength (Ang.)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
5265
5266
5267
5268
5269
5270
5271
5272
5273
5274
5275


Carbon Fraction = 0.01
Intensity
Wavelength (Ang.)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