



The Development of ChERS and Passive Spectroscopy in HSX



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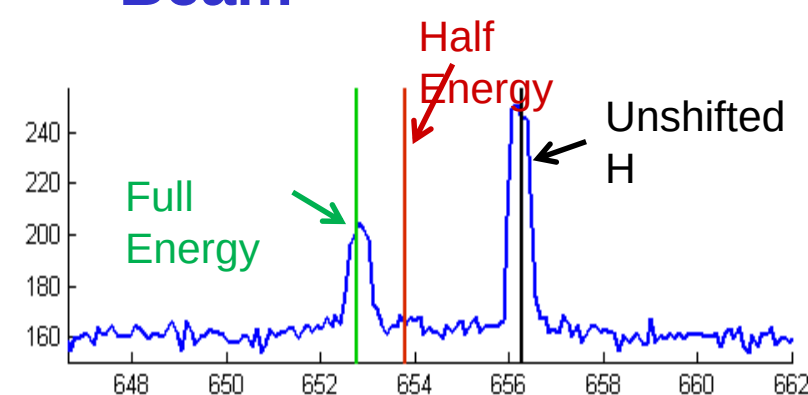
Overview

- Bullet_1:
 - Bullet_1.1
 - Bullet_1.2
 - Bullet_1.3
- Bullet_2:
 - Bullet_2.1
 - Bullet_2.2
- Bullet_3:
 - Bullet_3.1
 - Bullet_3.2

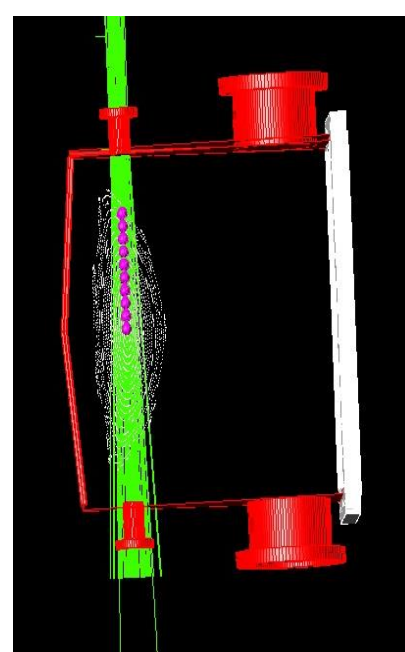
Neutral Beam

A Nominally 30keV 4 Amp 3ms Hydrogen Beam

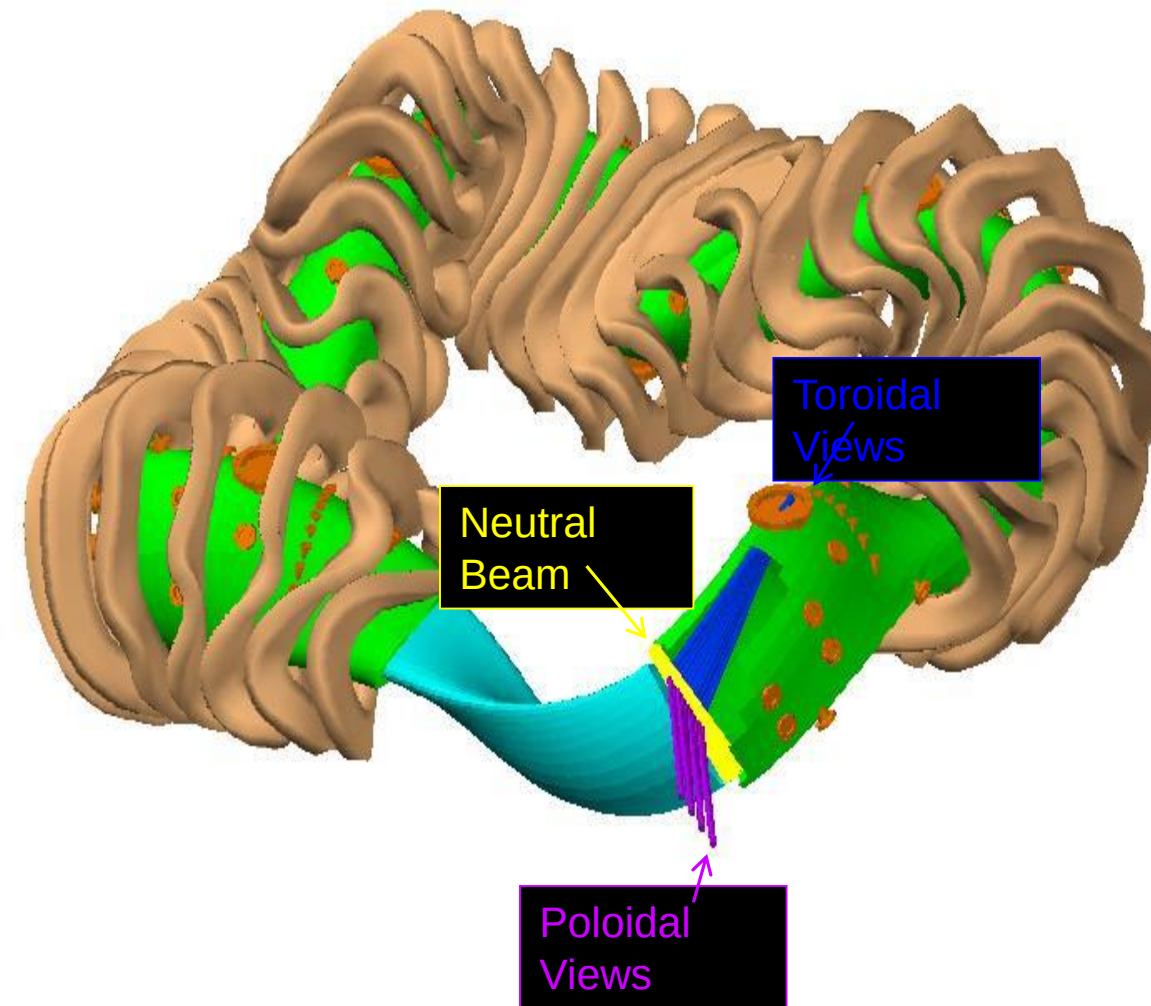
A spectrometer aimed at a 45° angle to the beam line has shown the beam to be primarily mono-energetic



Monte-Carlo simulations have been used to predict the beam distribution within the plasma



ChERS Viability



ChERS Optics

- 10 Toroidal Views and 12 Poloidal Views (10 of which intersect the beam at the same locations as the 10 toroidal views)
- Each View has a 2cm diameter
- 2 spectrometer/ccd systems are employed

Calculating Flow Velocity Vector and E_r

$$\text{Geometry Matrix } \tilde{A} \equiv \begin{bmatrix} \hat{r}_{\text{Poloidal View}} \\ \hat{r}_{\text{Toroidal View}} \\ \nabla \psi \end{bmatrix}$$

$$\text{Measured Assumed Values } \tilde{V}_{\text{Measured}} \equiv \begin{bmatrix} V_{\text{Measured Poloidal}} \\ V_{\text{Measured Toroidal}} \\ 0 \end{bmatrix}$$

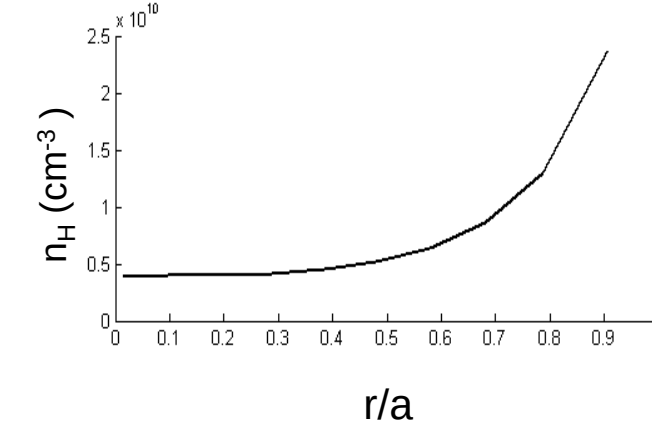
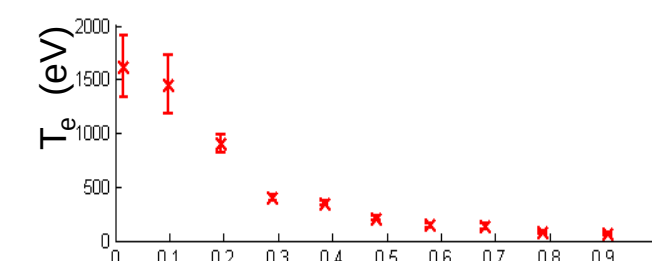
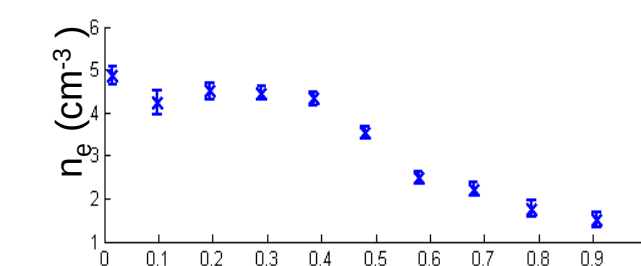
$$\text{Flow Velocity } \vec{U}_{\text{Impurity}} = \tilde{A}^{-1} \tilde{V}_{\text{Measured}}$$

Force Balance

$$E_r = \frac{1}{qn} \frac{\partial p}{\partial r} + (\vec{U}_{\text{Impurity}} \times \vec{B})_r$$

Equilibrium Impurity Ionization States

1 Tesla QHS 44kW ECH

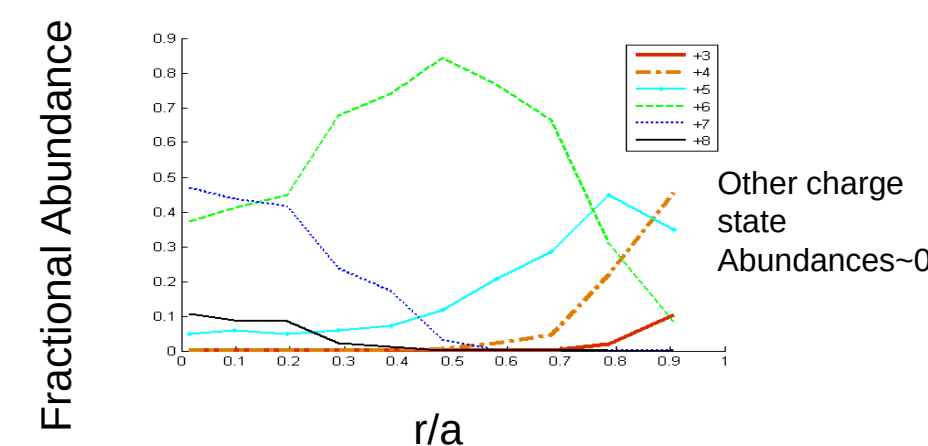


- N_e and T_e are measured using Thomson Scattering
- N_H is calculated using the DEGAS neutral gas modeling code and scaled to match H α detector measurements

$$\frac{d}{dt} N^{(z)} = N_e S_{CD}^{(z-1 \rightarrow z)} N^{(z-1)} - (N_e S_{CD}^{(z \rightarrow z+1)} + N_e \alpha_{CD}^{(z \rightarrow z-1)} + N_H C_{CD}^{(z \rightarrow z-1)}) N^{(z)} + N_e \alpha_{CD}^{(z+1 \rightarrow z)} N^{(z+1)} + N_H C_{CD}^{(z+1 \rightarrow z)} N^{(z+1)}$$

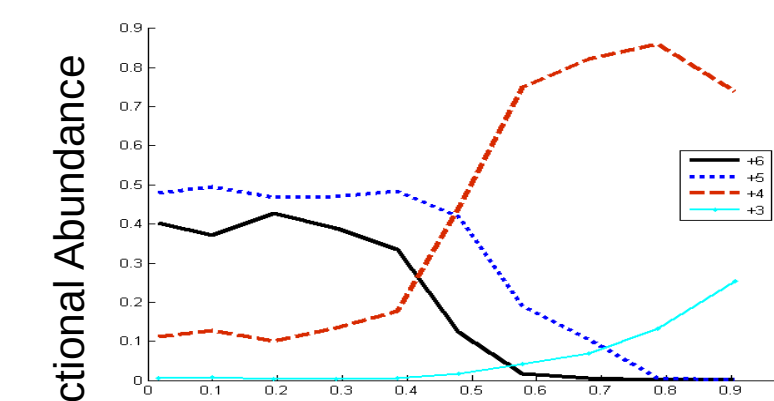
$$N_e \begin{bmatrix} -S_{CD}^{(0 \rightarrow 1)} & \alpha_{CD}^{(1 \rightarrow 0)} + (N_H / N_e) C_{CD}^{(1 \rightarrow 0)} & 0 & 0 \\ S_{CD}^{(0 \rightarrow 1)} & -(S_{CD}^{(1 \rightarrow 2)} + \alpha_{CD}^{(1 \rightarrow 0)} + (N_H / N_e) C_{CD}^{(1 \rightarrow 0)}) & \alpha_{CD}^{(1 \rightarrow 0)} & 0 \\ 0 & S_{CD}^{(1 \rightarrow 2)} & \cdot & \cdot \\ 0 & 0 & \cdot & \cdot \end{bmatrix} \begin{bmatrix} N^{(0)} \\ N^{(1)} \\ N^{(2)} \\ \cdot \end{bmatrix} = 0$$

Oxygen Charge States



A significant fraction of Oxygen which is not fully ionized is predicted throughout the plasma, facilitating the use of passive spectroscopy

Carbon Charge States



There should be a significant fraction of C+6 that can be used for ChERS in the core

Rate Coefficients

Using Charge Exchange with C+6 is preferable because spatial localization of the signal won't be masked by charge exchange with the neutral beam gas puff

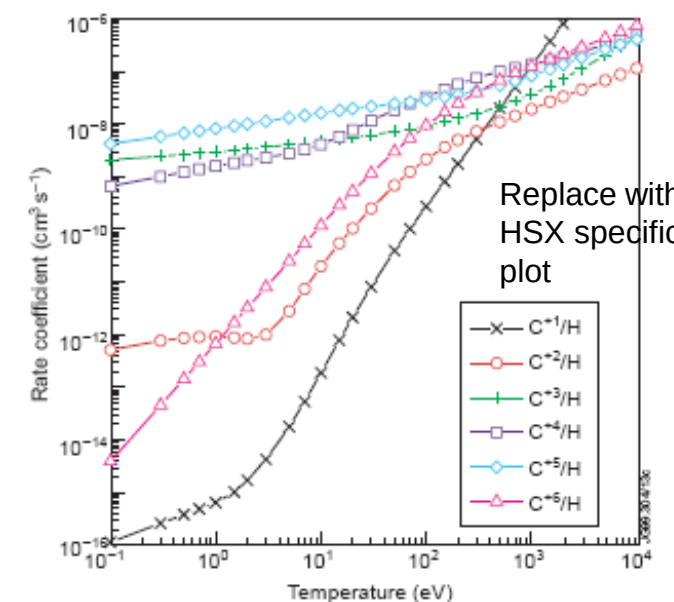


Figure 1. Total charge exchange rate coefficients for carbon ions. The donor isotope is deuterium and the calculation assumes double Maxwellian averages for equal donor and receiver temperatures $T_D = T_C$

Things To Add: Feedback Please!

- SCD, acd and CCD HSX specific plots to show what rates are important at which r/a?
- Time evolution of Charge state profiles to show steady state is reached on early in the shot?
- Plots of the background light seen near the ChERS line?
- Statements about background subtraction technique?

Future Work

- Align Beam, take data
- Inversion?
- Signal Prediction Comparison
- Use dispersion to more accurately predict ion abundances