Edge Impurity Ion Velocity and Temperature Measurements on NSTX

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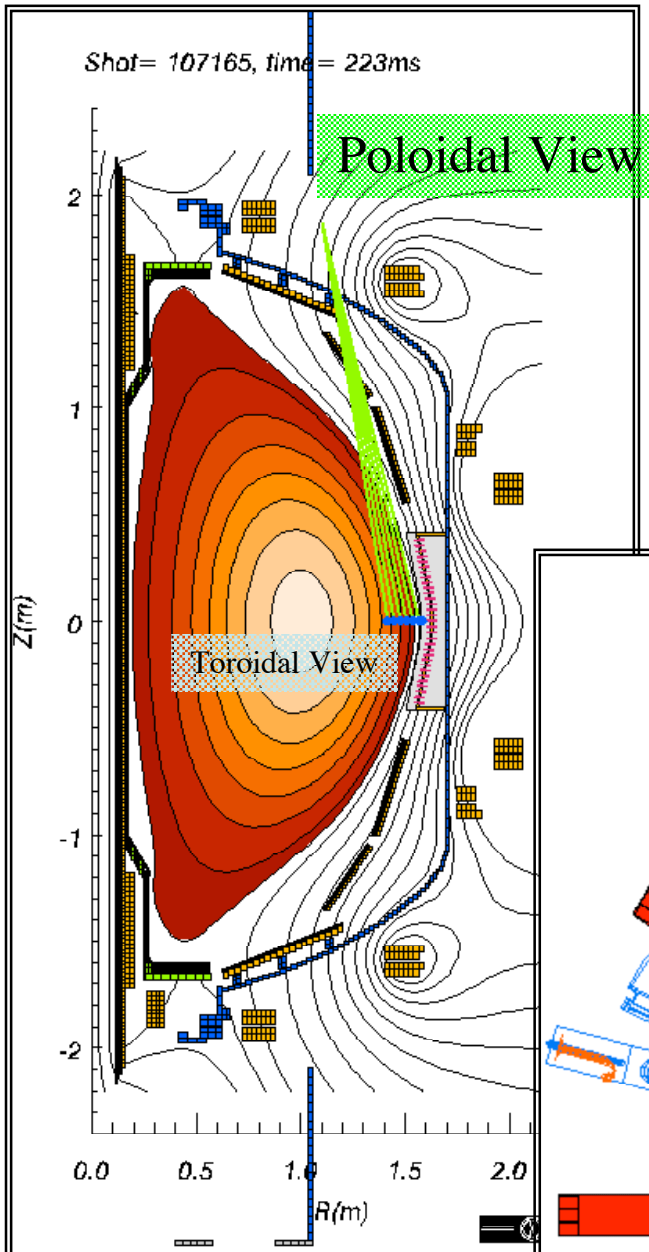
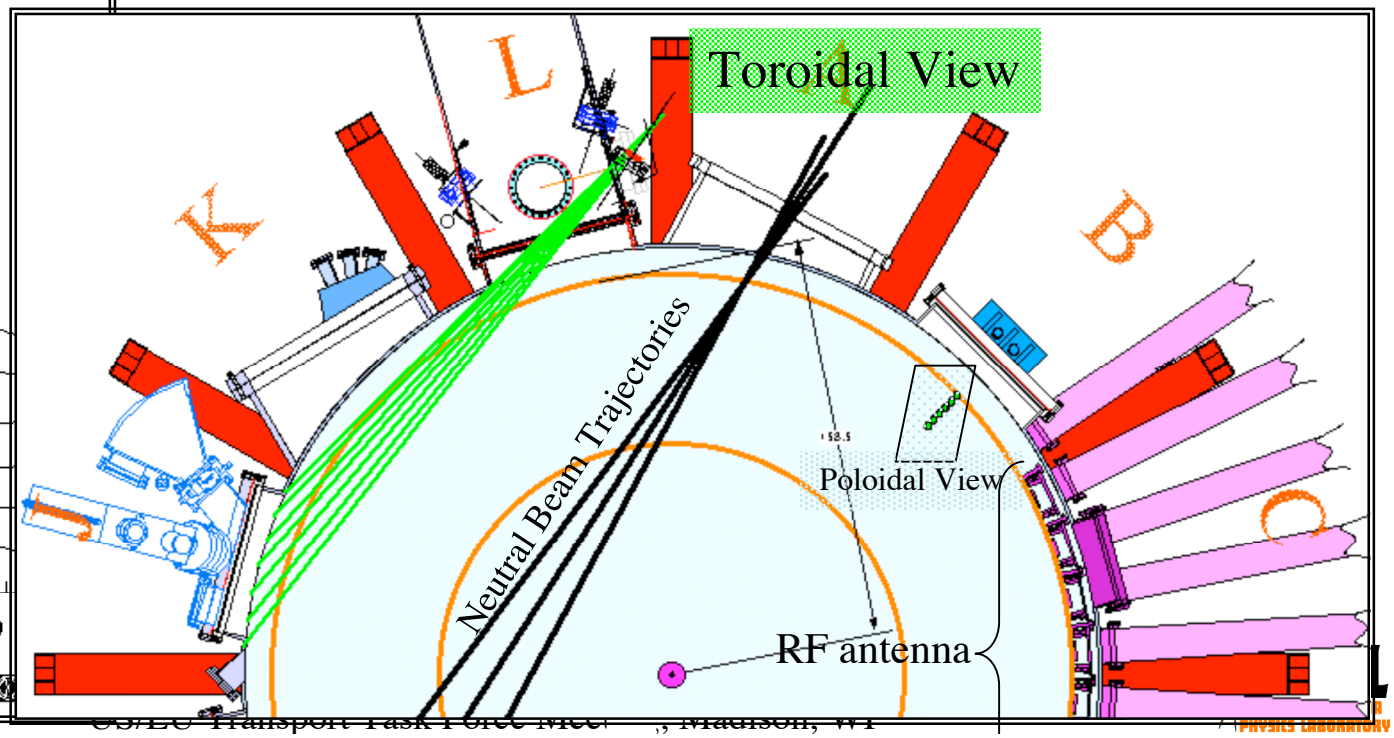
Summary

- Measurements from the new Edge Rotation Diagnostic
  - High SNR, but puzzling new data
  - Dynamics of C III, He II, and C IV
- NB heated plasmas
  - No large edge v or T_i changes as NB power increases
  - C III shell is inside the LCFS (EFIT)
  - Apparent minimum in T_i at LCFS, i.e. T_i increases in SOL
  - ELM-free H-mode corresponds with larger vxB
- RF heated plasmas
  - Puzzling changes in edge spectra with application of HHFW
  - Anisotropy in toroidal v. poloidal view may indicate anisotropy in parallel v. perp. distribution function
  - Non-Maxwellian distribution scales with sq.root P_{RF}
  - No RF direct ion heating method yet identified

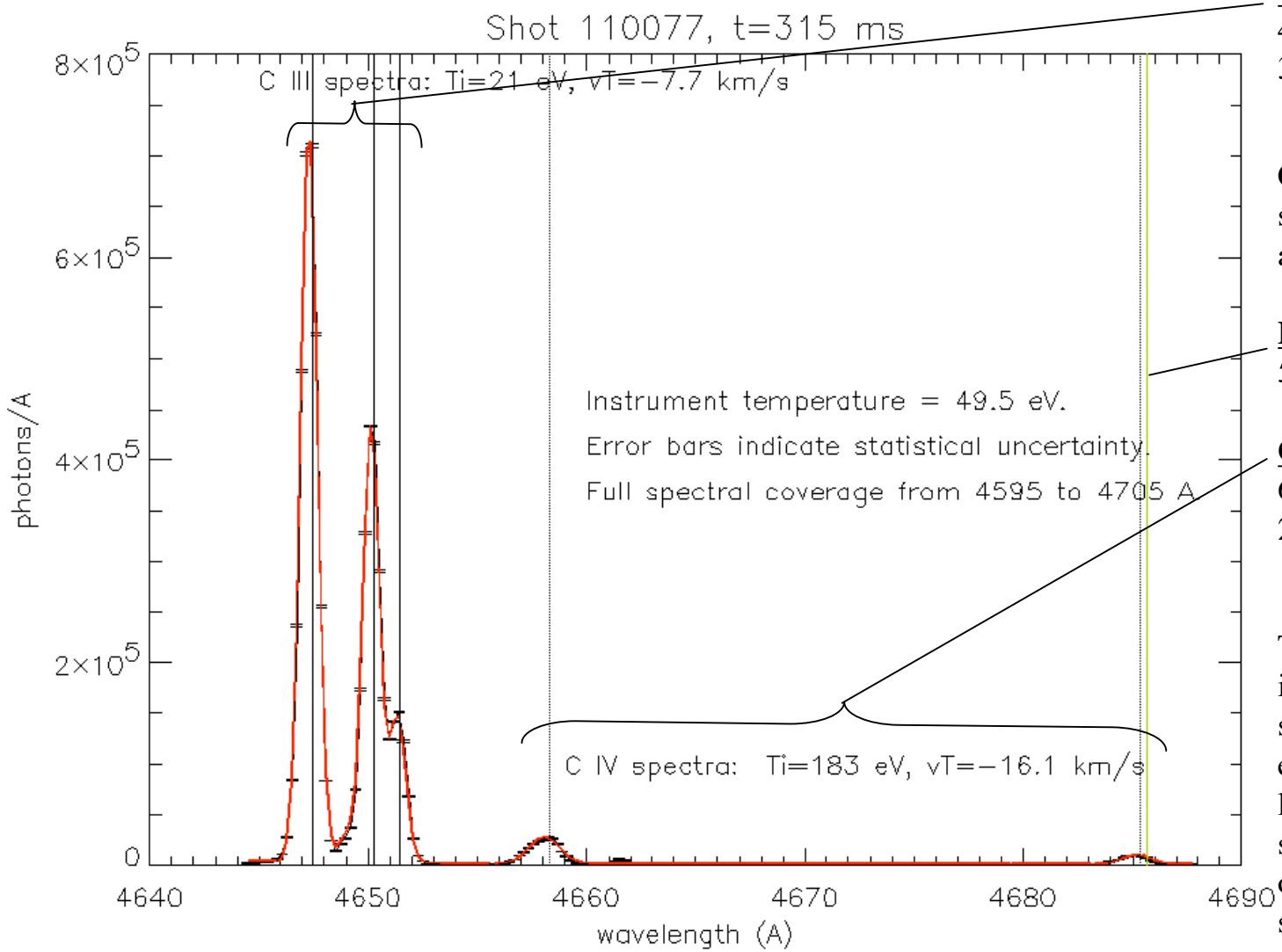
Overview of the Edge Rotation Diagnostic



- 10 ms time resolution
- 7 toroidal and 6 poloidal sightlines cover 140 to 155 cm at the outboard midplane.
- Sensitive to intrinsic emission light of C III, C IV, and He II.
- Measures velocity, temperature, and brightness of edge ions.
- Spectral resolution of 0.22 Å/pixel with 75 μm slits.



Impurity ion dynamics from C III, C IV, and He II are studied.



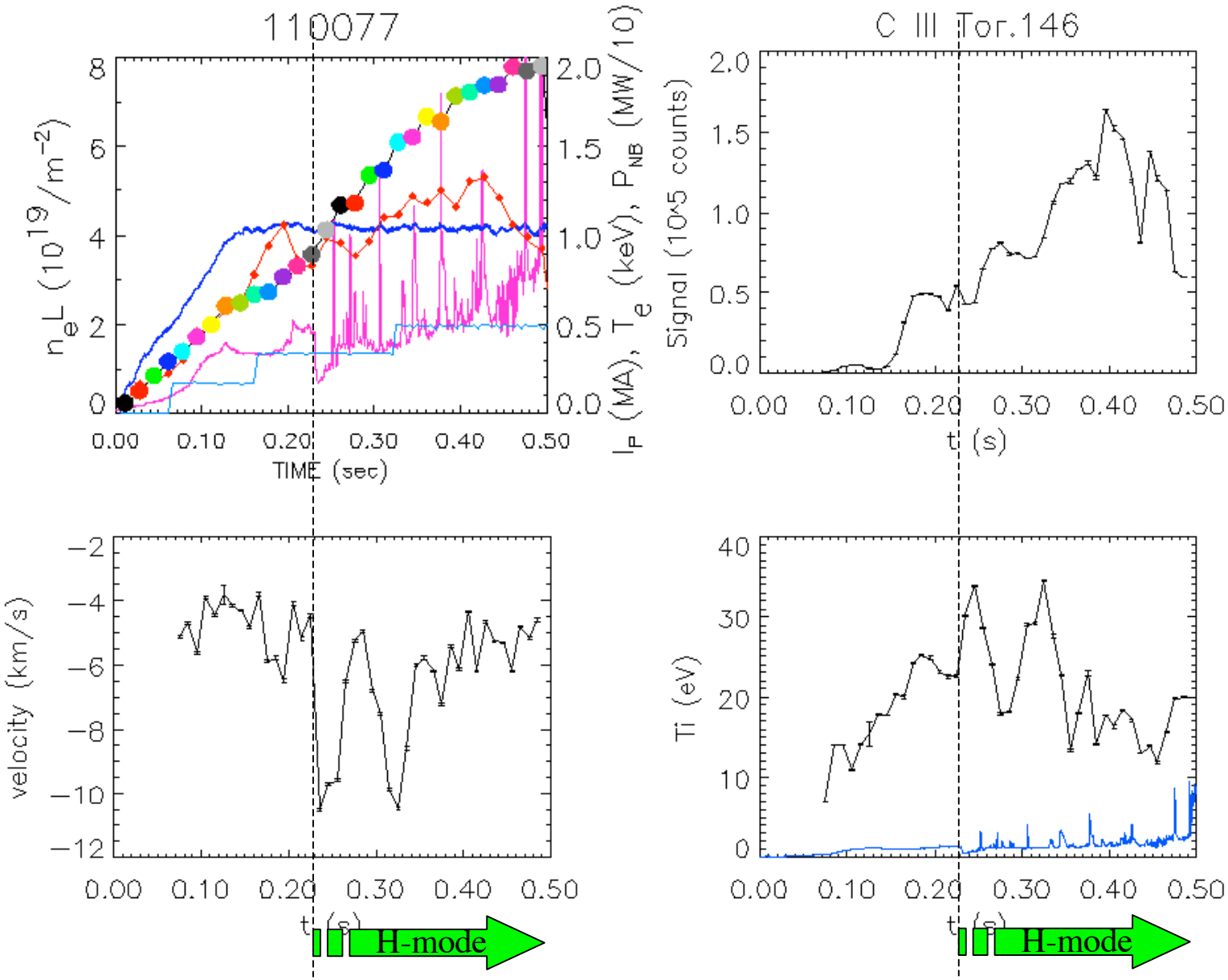
C III triplet
47.88 eV ionization
3S to 3P0 transition
relative amplitudes from theory
Can fit all 3 lines simultaneously to get very accurate v, T

He II
54.414 eV ionization

C IV doublet
64.489 eV ionization
2G to 2H0

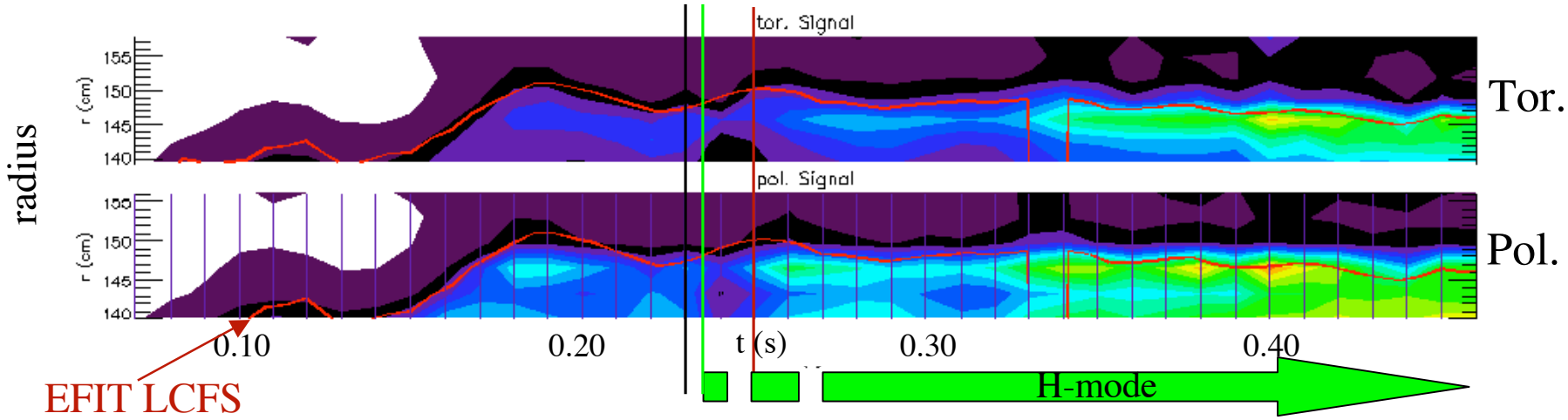
The ERD relies on the intersection of the sightline with the intrinsic emission shell for localization. But each sightline measures aspects of different emission shells, which peak at different radii.

C III dynamics are effected during ELM-free H-mode.



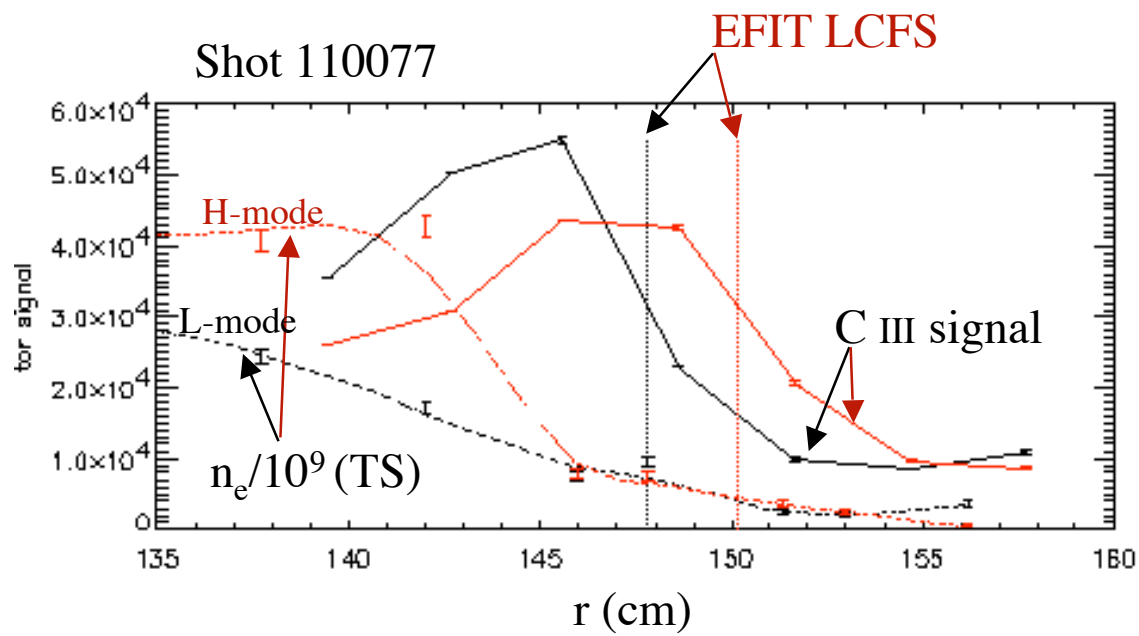
- No change in edge v, T with additional NB power
- Change in velocity during ELM-free H-mode periods
- Increase in T_i during ELM-free period

C III brightness is a good indicator of the plasma edge.

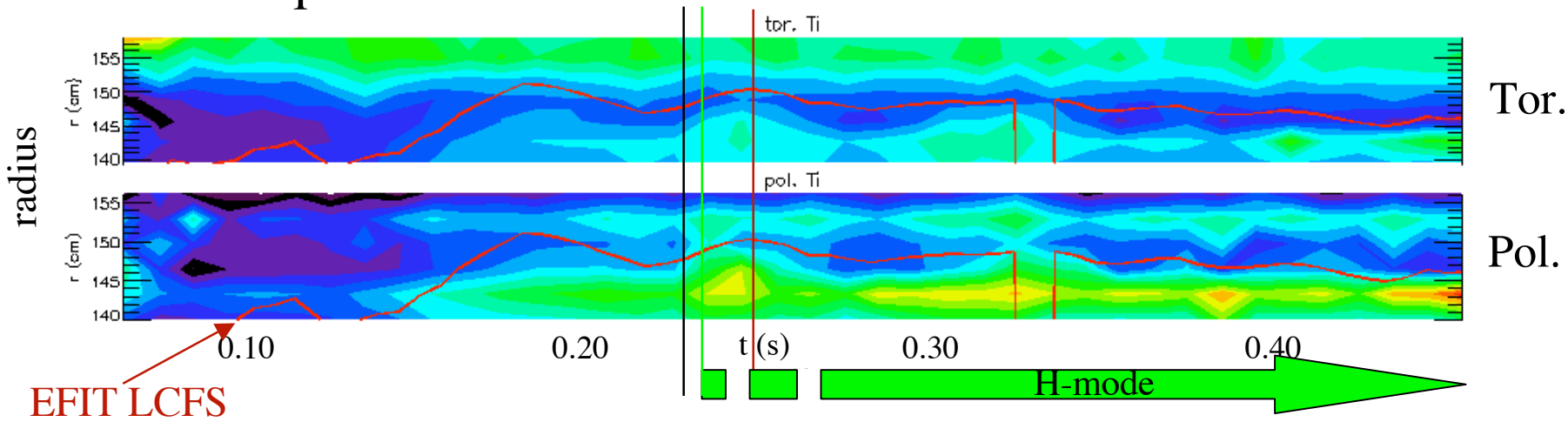


The C III shell from the ERD is consistent with EFIT reconstructions of LCFS.

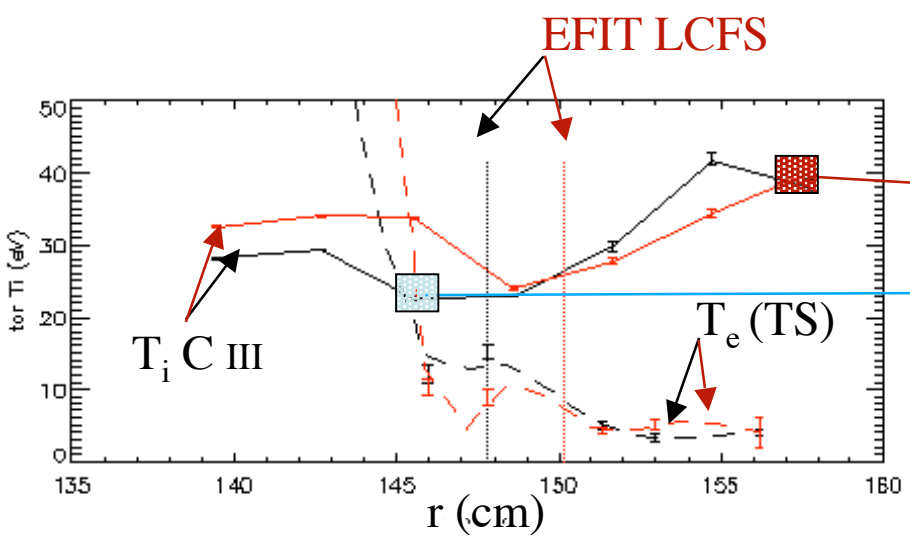
In H-mode, C III shifts outward, in agreement with steeper edge gradients.

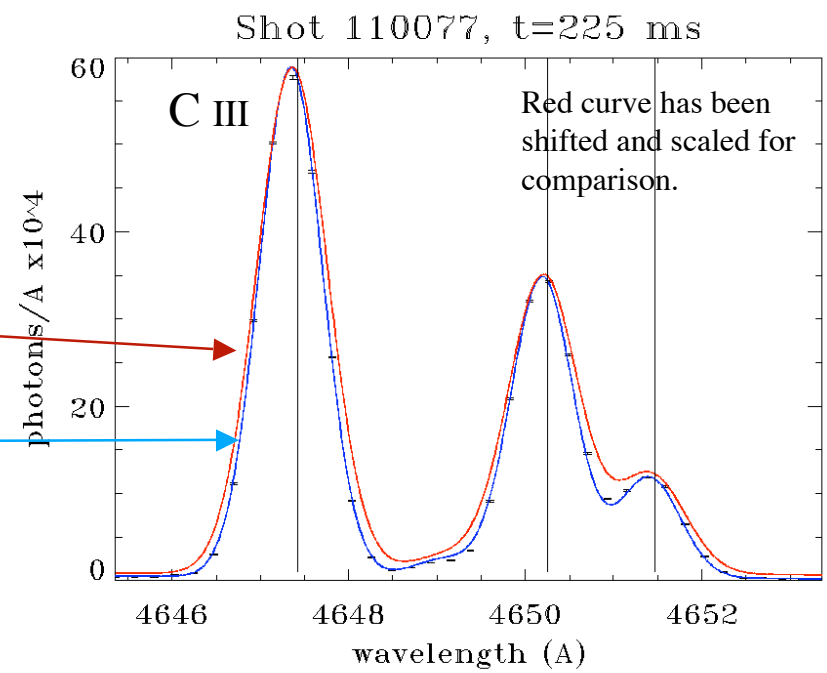


T_i minimum follows the LCFS.



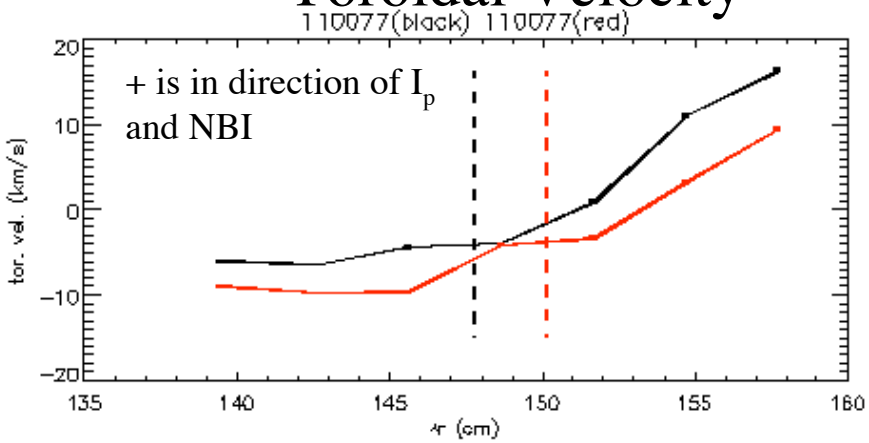
Impurity ions re-heat in the SOL, after the last closed flux surface.



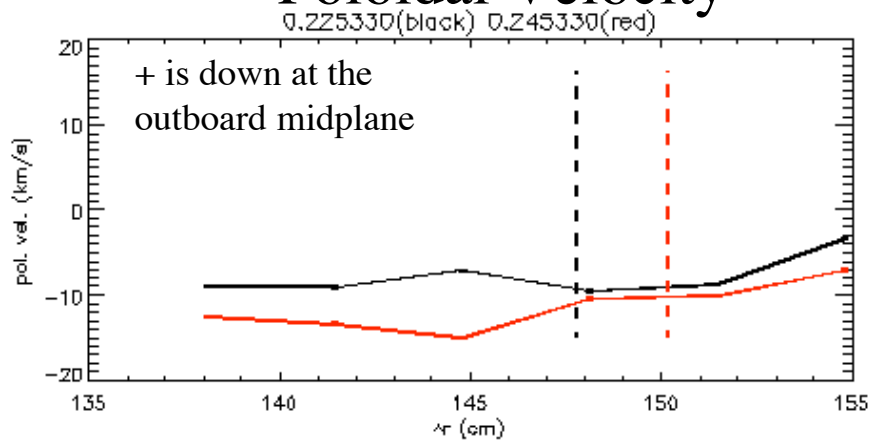


E_r deepens in the edge during ELM-free H-mode.

Toroidal Velocity



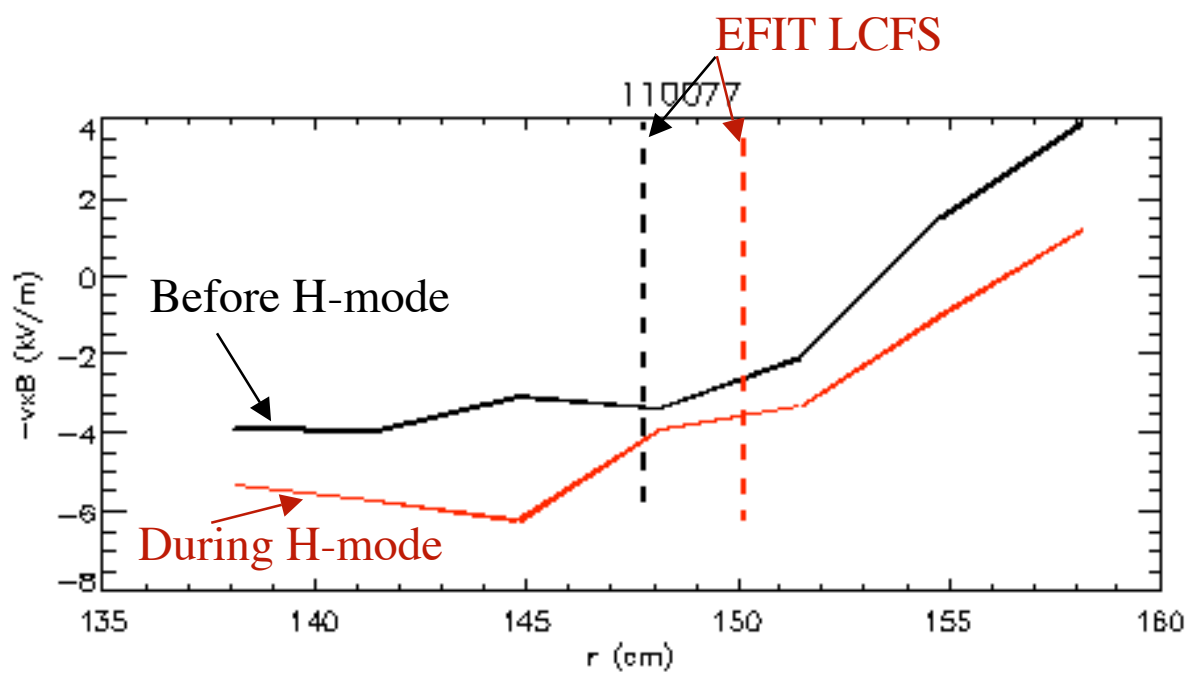
Poloidal Velocity



$E_r = -(v \times B)_r + \nabla p/eZn$

B from EFIT at midplane.

Estimates of $\nabla p/eZn$ for C III are on the order of 0.2 kV/m, though can be locally large.

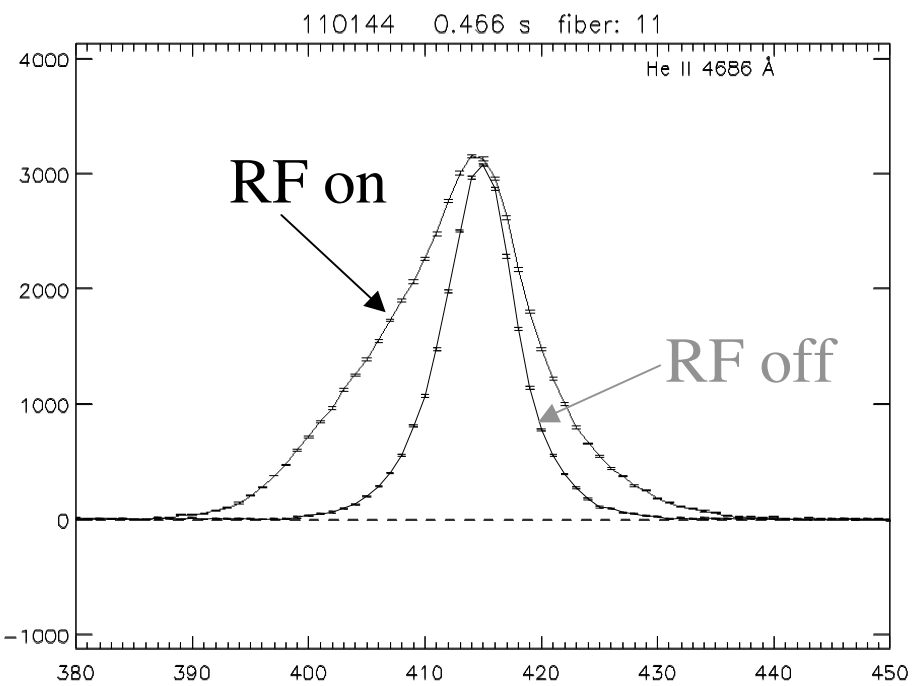


Anisotropic He II ion spectra during HHFW.

Two successive time frames clearly show the spectral consequences of 30 MHz HHFW heating (4.3 MW input) on the edge plasma.

This effect is apparent in edge C (impurity) ions and He (bulk) ions.

Poloidal, r_{tan}~146 cm



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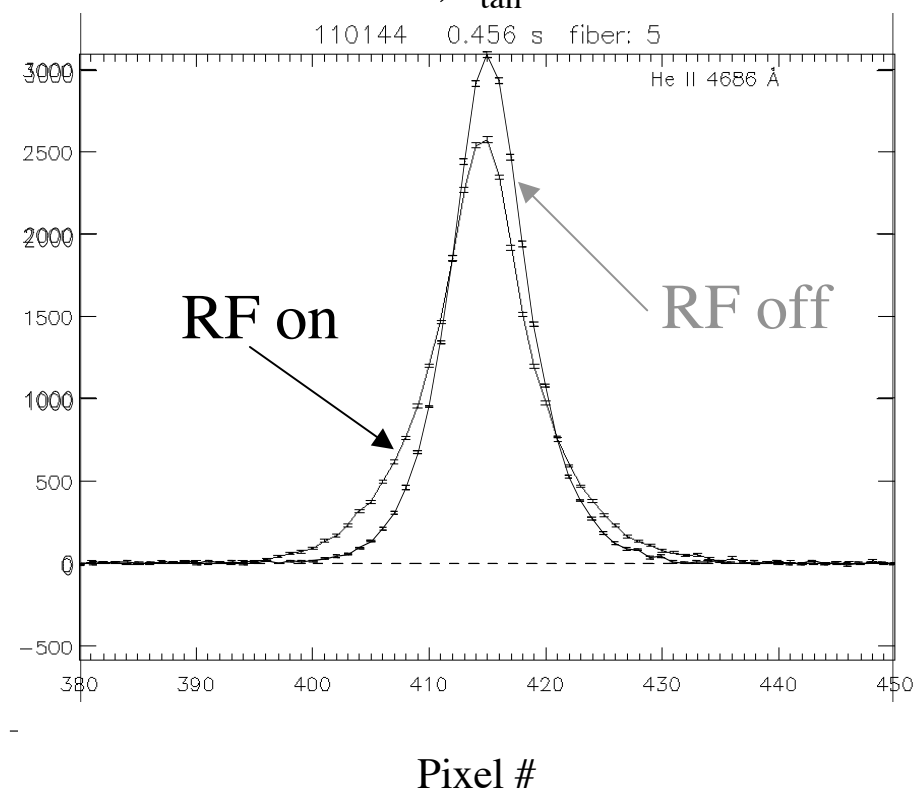
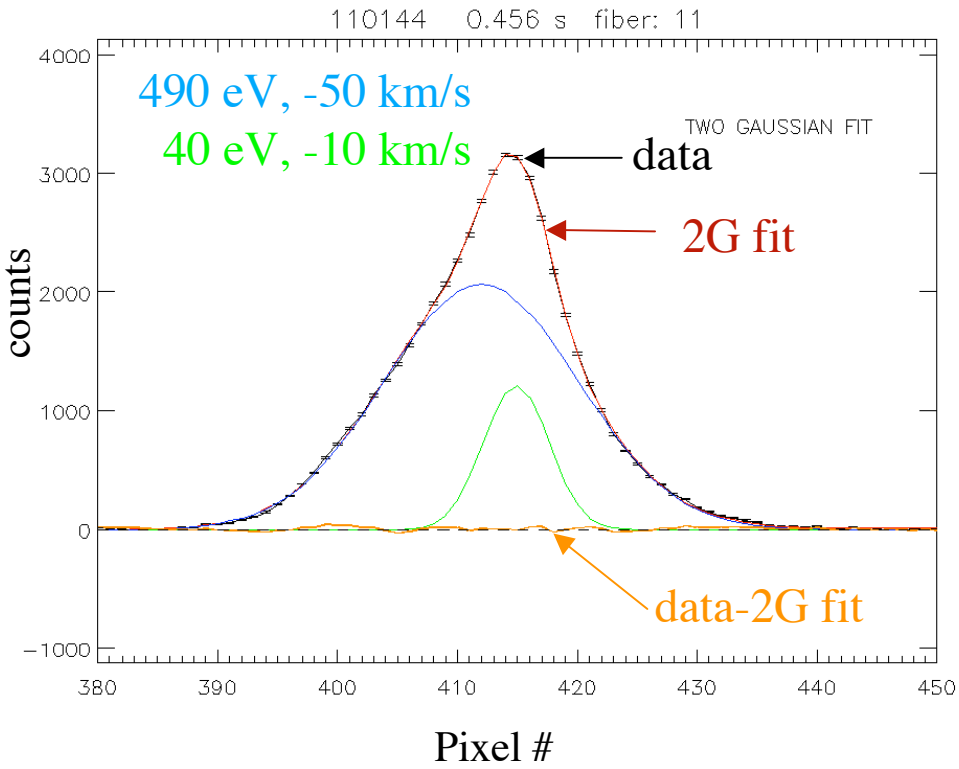


Two thermal populations of He II ions are present during RF.

Non-Maxellian distribution can be well represented by two Gaussians fit to the data.

Two populations is the current working assumption. Others?

Poloidal, r_{tan}~146 cm



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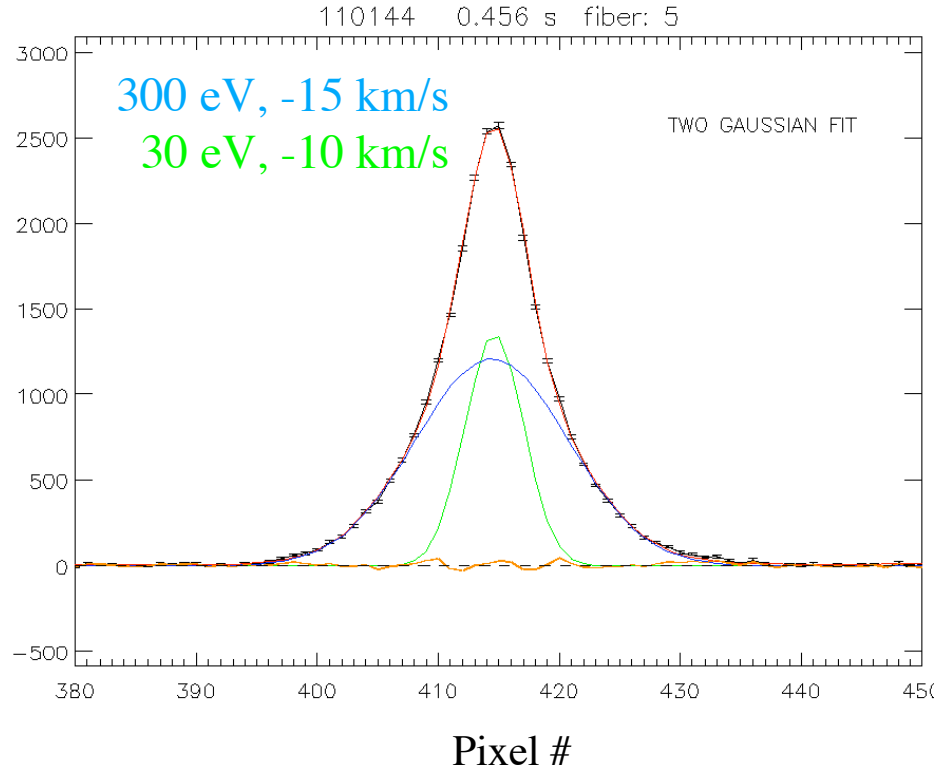
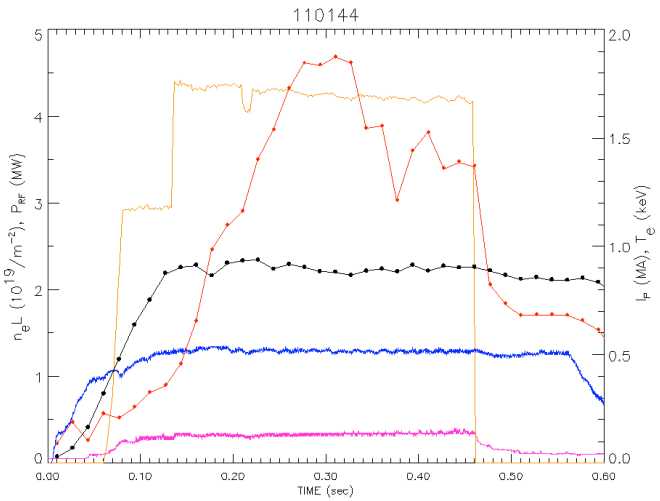
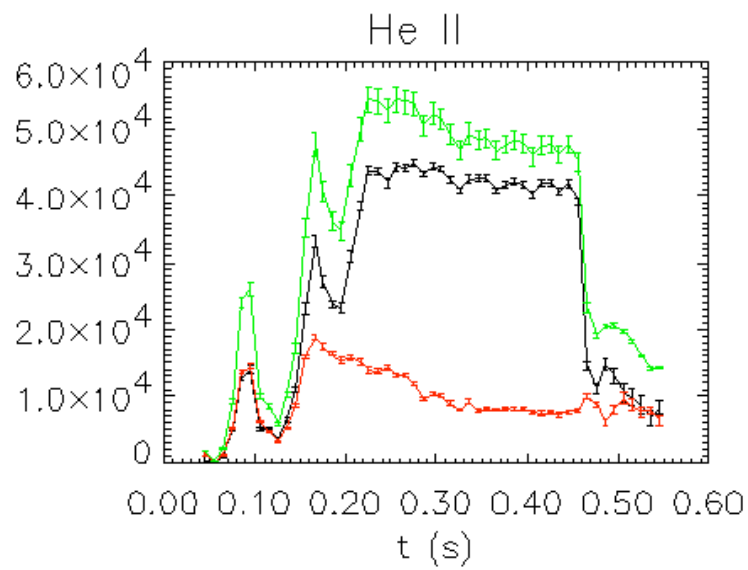


After equilibration, discharge very stable until RF termination.

r_{tan}~146 cm



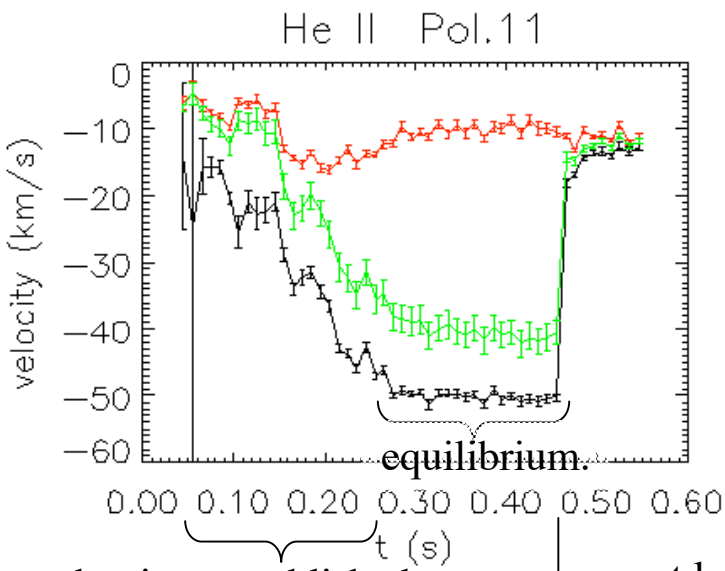


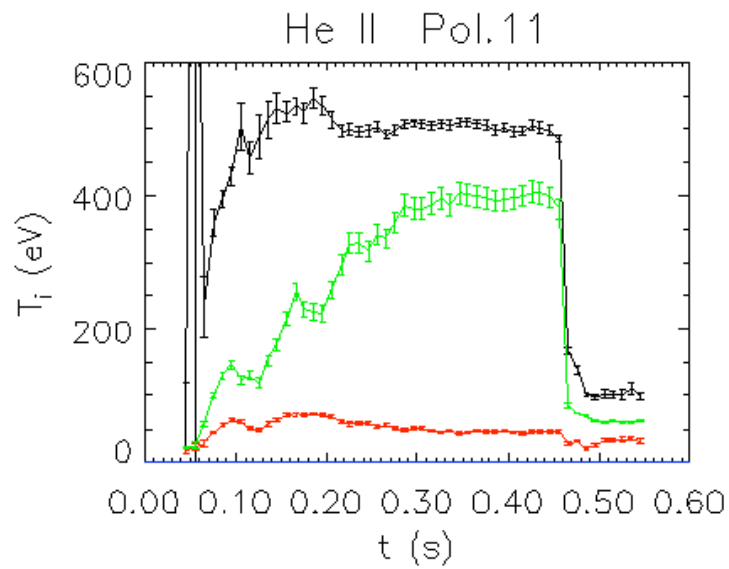
Key

1G fit

2G high

2G low



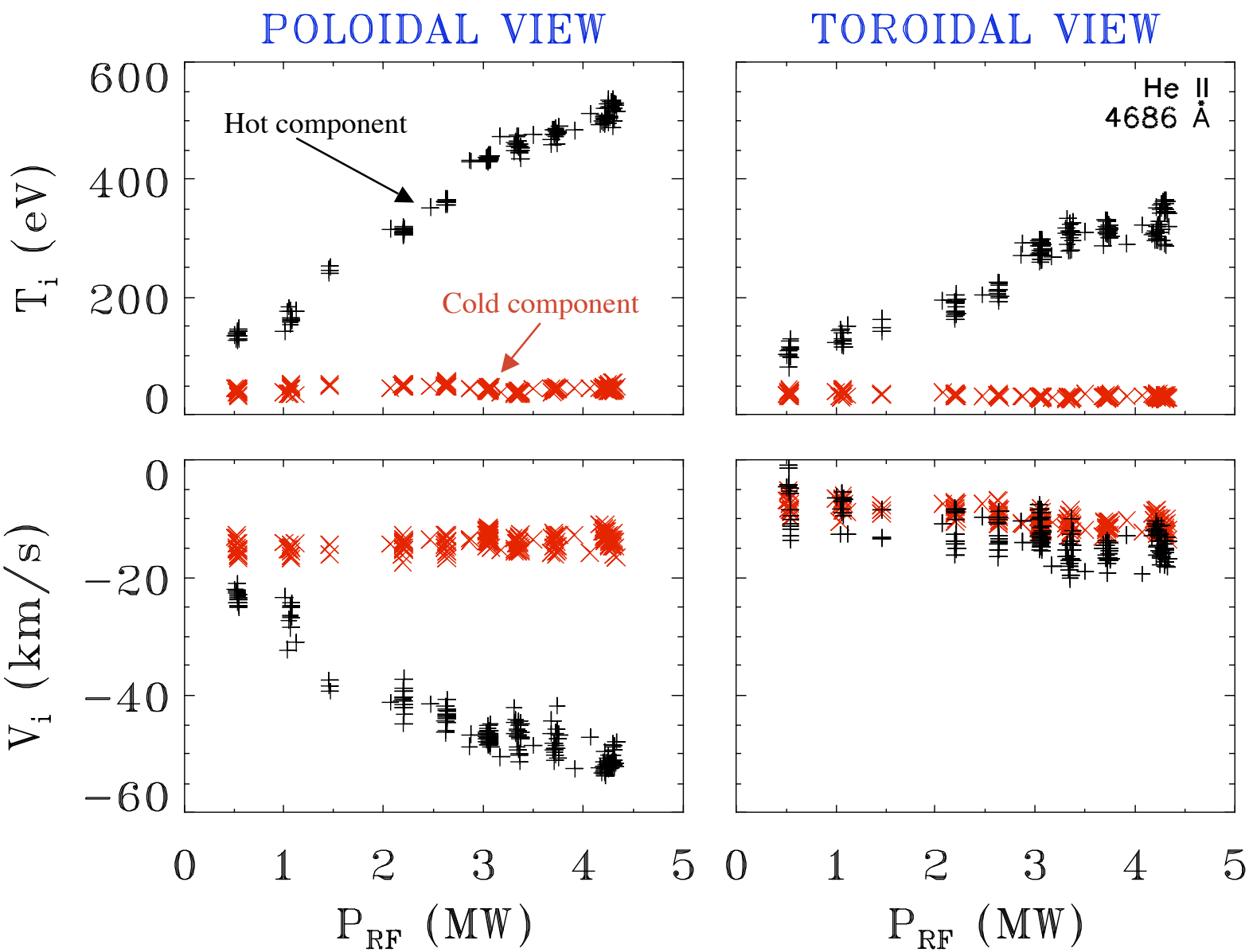


equilibrium.

hot ions established

prompt loss

"Hot" He II T_i and v increase with P_{RF}



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