# Edge Ion Heating in NSTX: Trash or Treasure?

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In 2003 and 2004 run campaigns, during the application of HHFW power, edge ions were observed to heat to high temperatures; 500 eV at 2 cm in from the LCFS.

Edge ion heating is observed whenever significant HHFW power is applied; for 3.5, 7, 14 $m^{-1}$ phasing, $D_2$ & He plasmas, in He II and C III edge ions.

IBW heating identified as a probable explanation for edge ion heating.
-parasitic to the launched HHFW

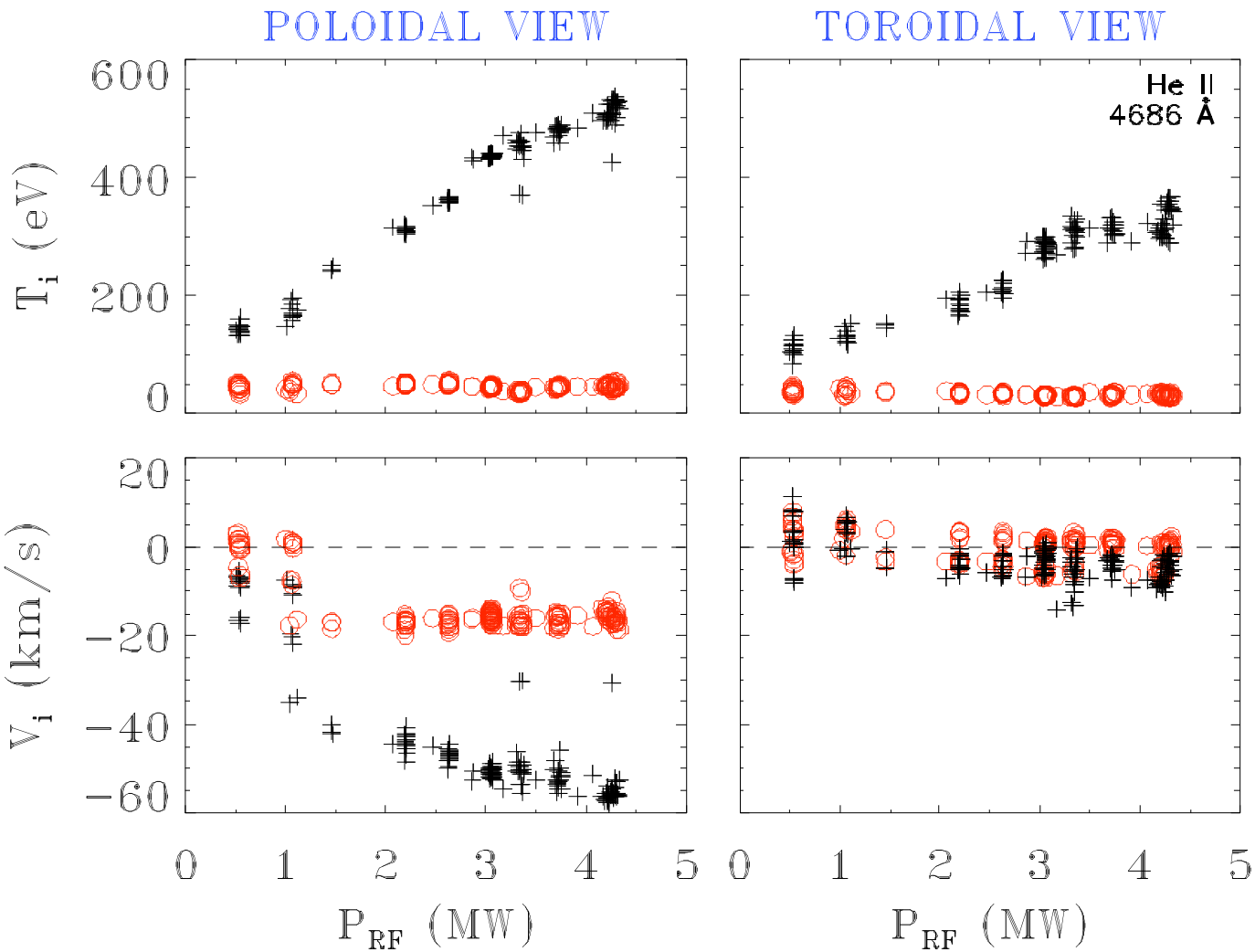
## What physics can we investigate with this edge $T_i >> T_e$?

# Introduction/Outline

- Edge $T_i$ and $v$ scale with applied RF power.
- IBW heating is plausible explanation.
  - Parasitic to launched HHFW (bad, since it reduces the amount of power available for core $e^-$ heating, CD)
- $T_i >> T_e$ in the edge (good, if it allows us to explore some physics)
- Discussion of physics issues to explore.

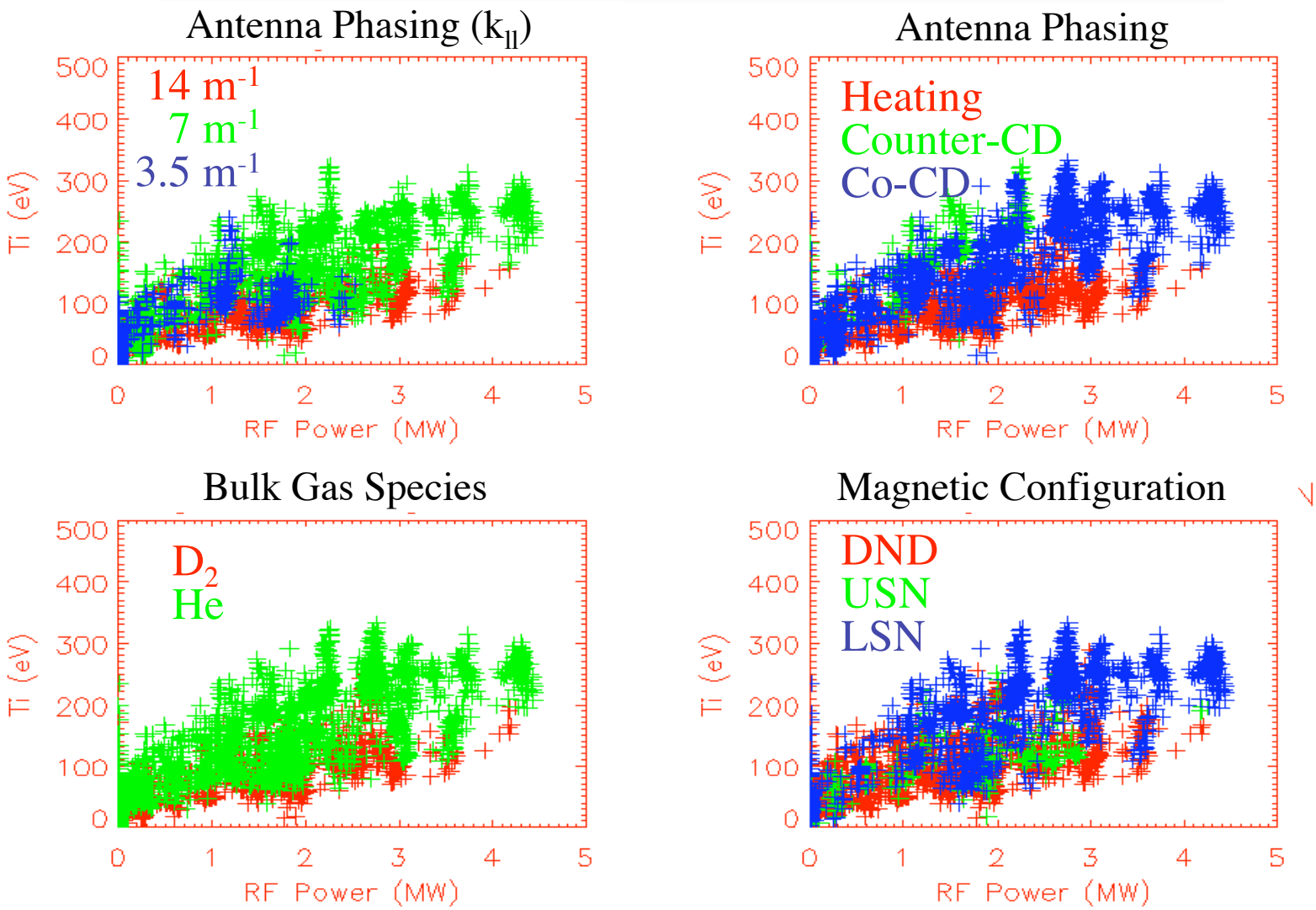
# More power leads to more heating.

From NSTX Shot 110133 to 110145 the applied RF power was increased.
Empirically, $T_i$ increases as $P_{RF}^{0.47}$.




Negative poloidal velocity is upwards on the outboard midplane.
Negative toroidal velocity is opposite to the direction of $I_p$.

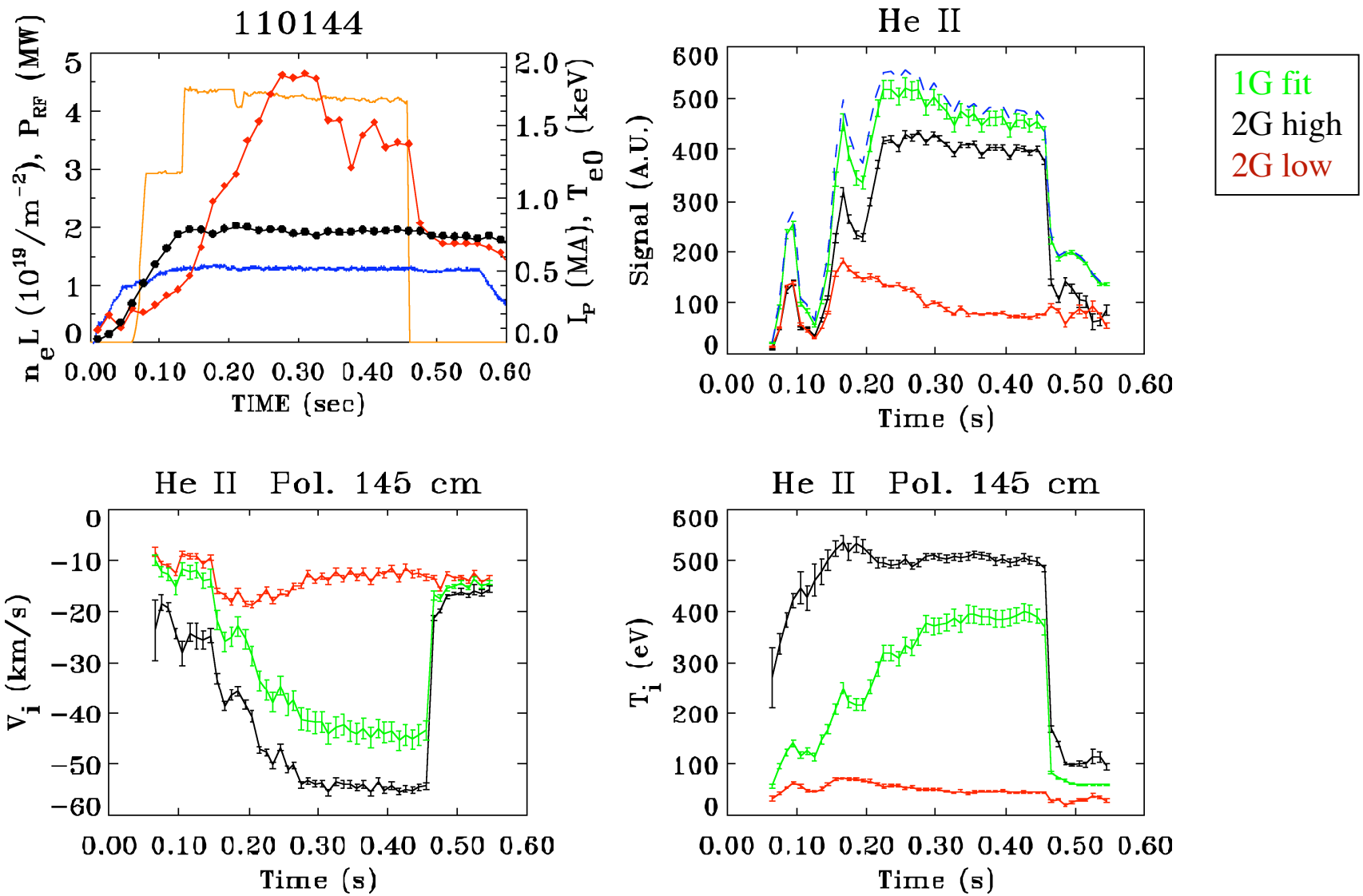
# Edge heating observed in many plasmas.




- 2004 run data spans a wide range of plasma conditions.

# Core e⁻ and edge ion heating is observed.

The launched HHFW is expected and observed to heat edge electrons, but hot edge ions are also observed.



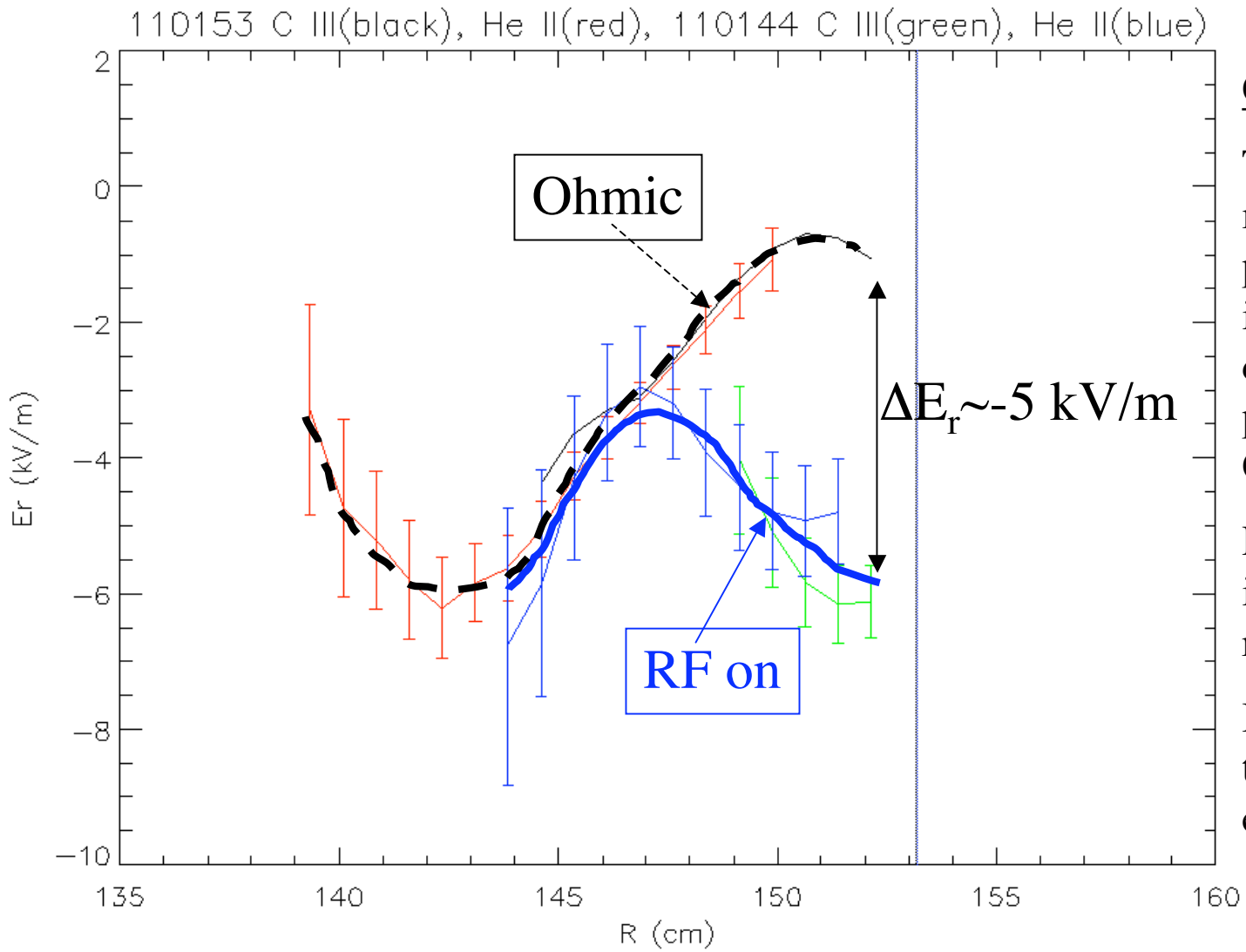
# Some issues . . .

- Don't really know how much power is going into edge ions (from IBW directly). Can assume no direct edge heating of electrons (TS data, modeling.)
- S. Diem calculations suggest ~ few 100's kW of power in collisional heating due to $T_i$-$T_e$ difference at edge.
- $P_{RF}$ could be used as "knob" to control the edge power balance in the electron channel.
- But $P_{RF}$ also affects core plasma (e.g. $T_{e0}$, MHD).
- Need to consider all the boundary sources and sinks, i.e. cylindrical nested shell model: SOL-edge-core.
- Do changes in edge electron transport ($X_e$) result in bulk plasma behavior changes (ETG driven MHD which reduces $T_{e0}$)?

# Summary

- Edge $T_i$ and $v$ increase with applied RF power.
- Edge ion heating diminishes the amount of power available to heat core electrons.
- Could hot edge ions be affecting (collisionally) edge electron transport?
- Is there other edge physics which can be explored with $P_{RF} \sim T_i/T_e$?

# $E_r$ from He II and C III (cold)




Ohmic v. RF heated

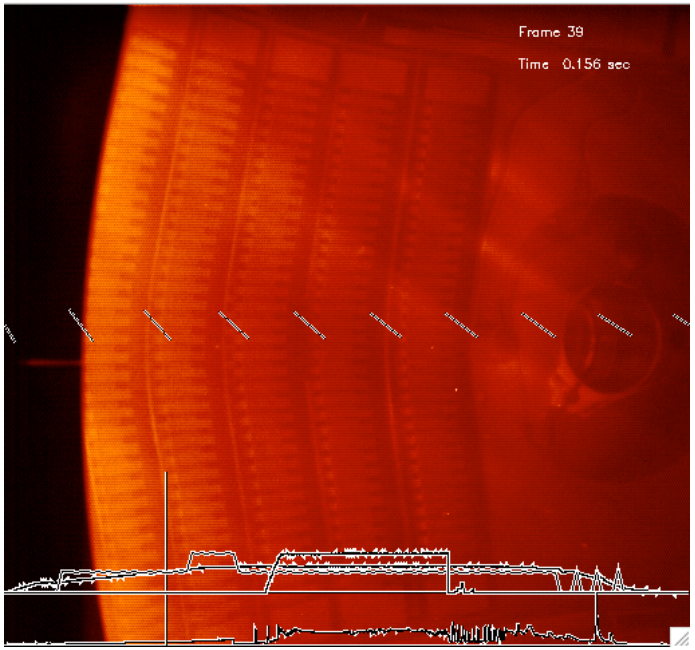
The $E_r$ at the edge most region of the plasma (R>146 cm) is more negative during RF heated plasmas than during Ohmic.

For R<146 cm the $E_r$ is similar (for the region measured)

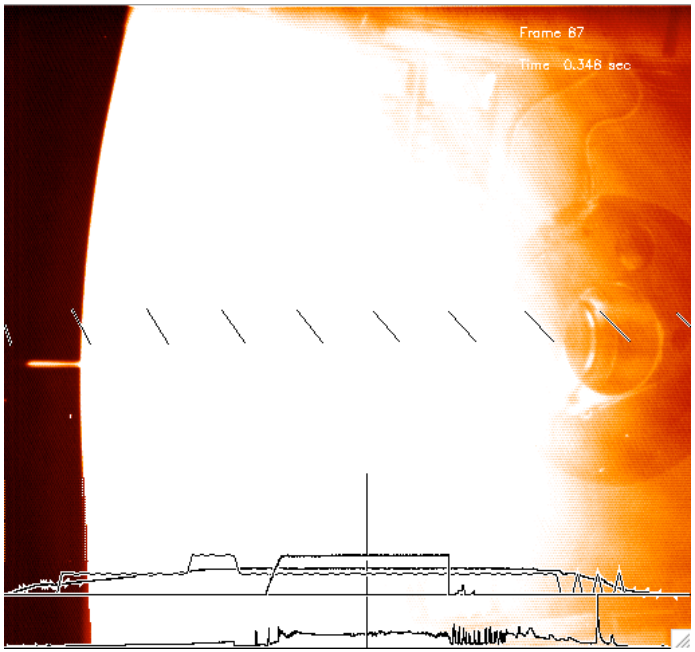
Implies that RF leads to ion loss at the edge of the plasma.

# Visible camera confirms antenna emission.

RF off



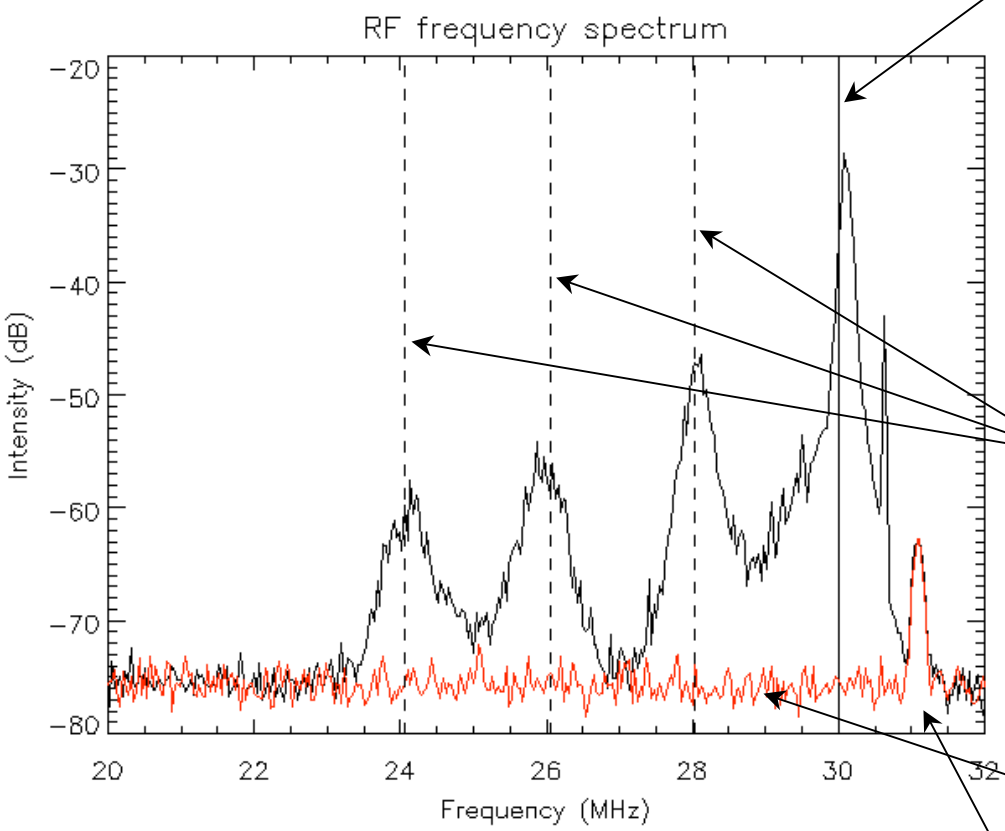

RF on




- Visible camera images show enhanced light emission near the RF antenna when power is applied.
- Diagnostic capability added for 2004 run campaign.

# IBW heating of edge ions plausible.

See following talk by S. Diem.




The 30 MHz launched HHFW is attenuated in this spectrum with a 40 dB notch filter.

A portion of the HHFW undergoes nonlinear parametric decay into a daughter IBW and an ICQM, which both damp in the outer 10 cm of plasma.

IBW's are observed as lower sidebands of the launched HHFW at the expected frequencies (dashed vertical lines) for the first 3 harmonics of the ion cyclotron quasi-mode.

An Ohmic shot (no RF) is shown (in red), indicating the noise-floor of the measurement.

Pick-up from a heterodyne network is present at 31 MHz in both spectra.