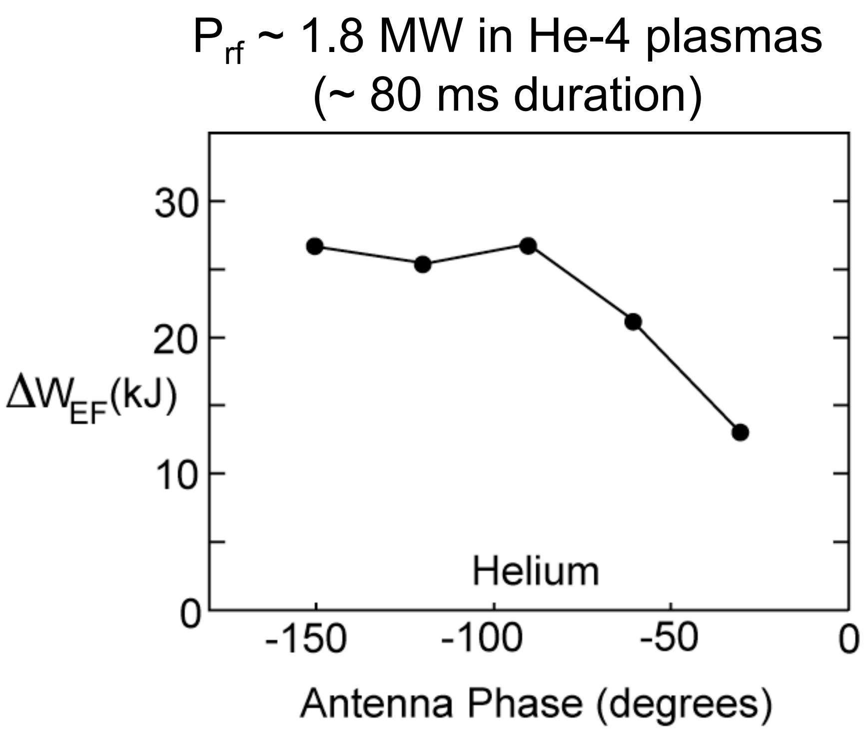
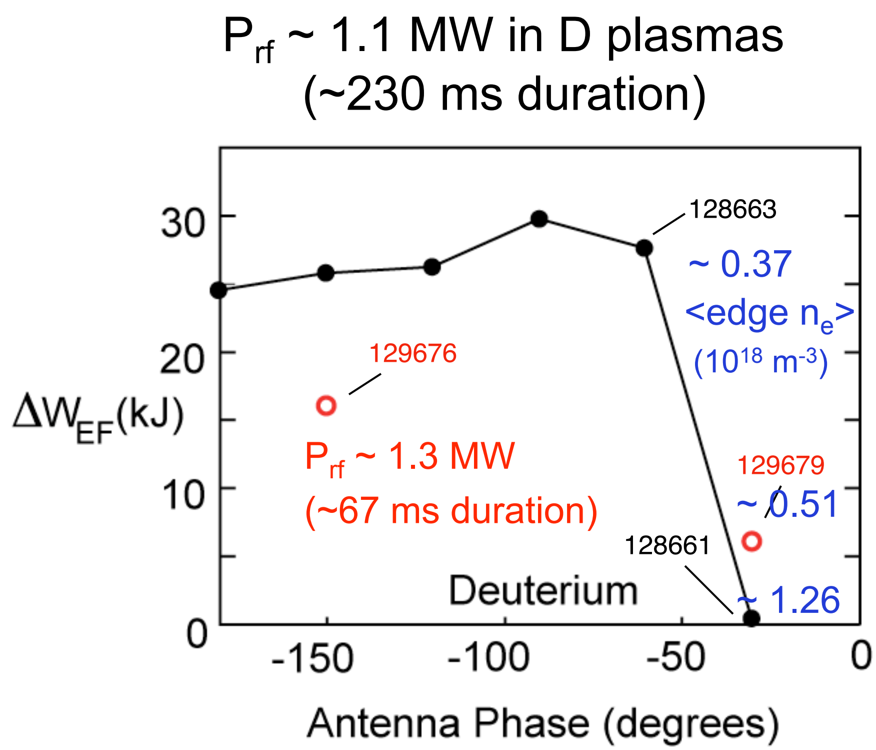
HHFW Edge Effects on NSTX

- Edge power loss has been found to be a function of edge density, antenna phase and magnetic field
  - loss enhancement consistent with onset density for perpendicular propagation being close to the antenna/wall
  - recent fast camera viewing of plasma indicates a major loss channel from region in front of antenna to outer divertor plate (non-axisymetric loss in SOL)
- Important to establish edge power loss properties/processes for L and H modes
  1. Visible and IR camera (and other diagnostics) studies of the divertor SOL region interaction/heating
     - Heating in divertor region and localization with possible erosion vs P_{RF} for range of selected conditions
     - Can heating/erosion be mitigated at highest powers for 150° and 90° antenna phases?
  2. Edge ion heating via PDI
     - Document carefully, especially in helium, to determine effect on E_r as deduced from rotation with HHFW, if possible
     - May be best to include this topic in the T&T study of intrinsic rotation

RF-induced increase in stored energy falls off at longer wavelength in Helium and Deuterium plasmas





- Fall off occurs when edge density exceeds onset density for perpendicular propagation of fast wave
- First measured increase in deuterium at -30° degrees (lithium injection)
- Very little heating at -30° in deuterium at elevated edge density

Edge loss mechanisms need to be identified experimentally and included in advanced RF codes

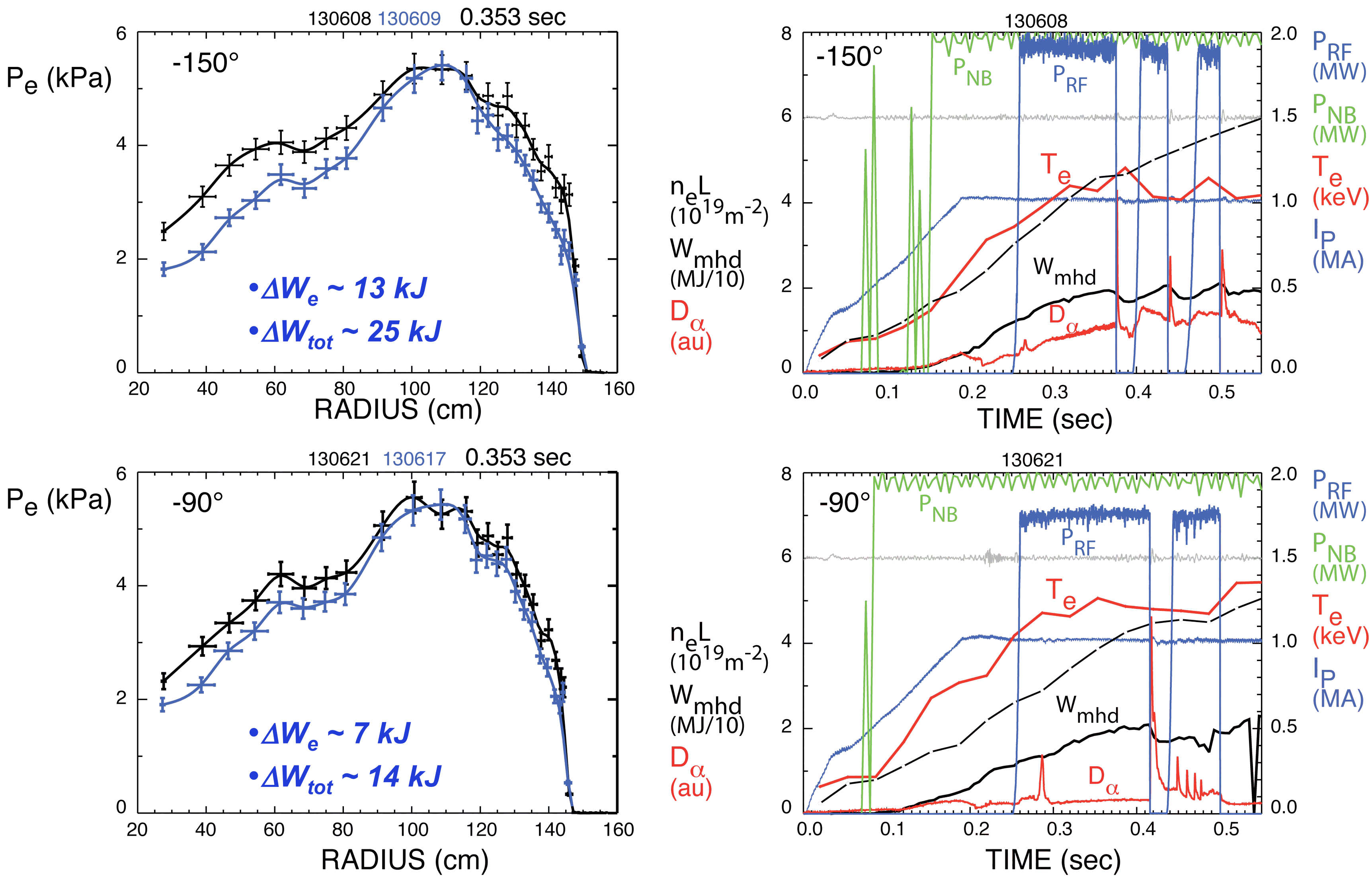
- Searching for edge RF power loss processes on NSTX:

- Fast wave losses for propagating and reactive fields
  - Associated sheath and collision effects
- PDI effects
- Non-toroidally symmetric, localized losses
- Etc.

- Diagnostic tools on NSTX include:

- edge reflectometer
- edge CHERS
- probes for PDI effects
- cameras for visible and IR light
- divertor diagnostics
- etc.

Heating H-mode plasmas at -150° and -90° antenna phases

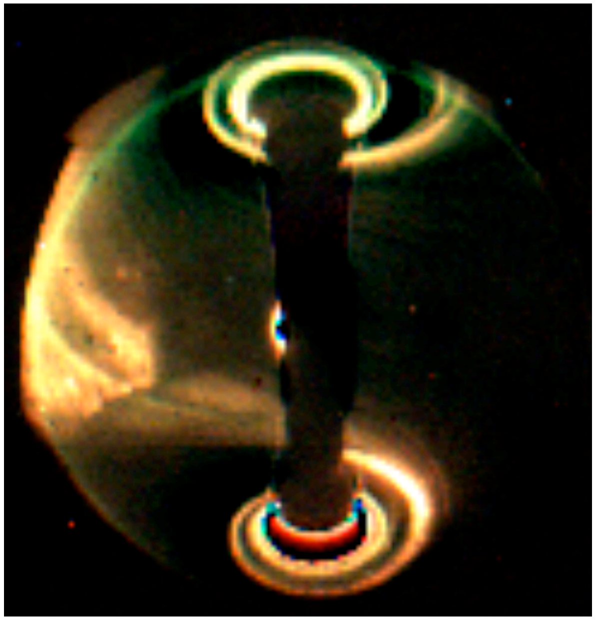


- $\tau_{\Delta Wtot}$ ~ 20 ms gives η_{eff} ~ 63%, 40% for -150°, -90° phasings
- P_{RF} losses coupled to edge are ~ 0.7MW, 1.1 MW for -150°, -90°

Strong interaction along field lines at lower phase/longer wavelength

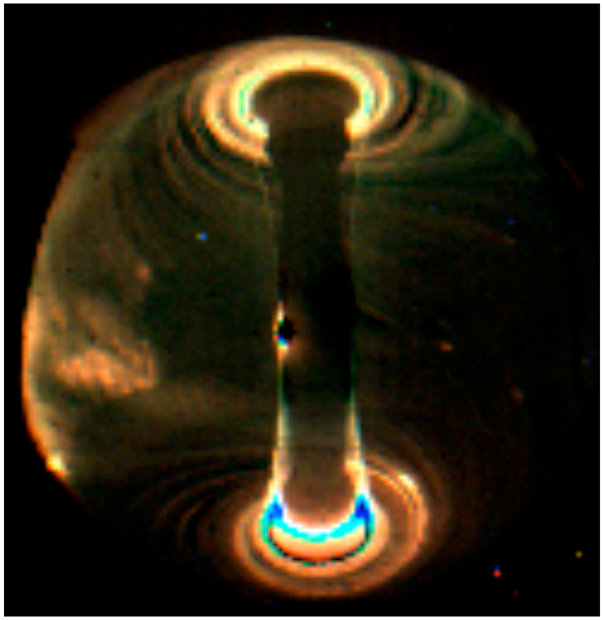
P_{RF} = 1.8 MW, P_{NB} = 2 MW, I_P = 1 MA, B_T = 5.5 kG

130621 -90°



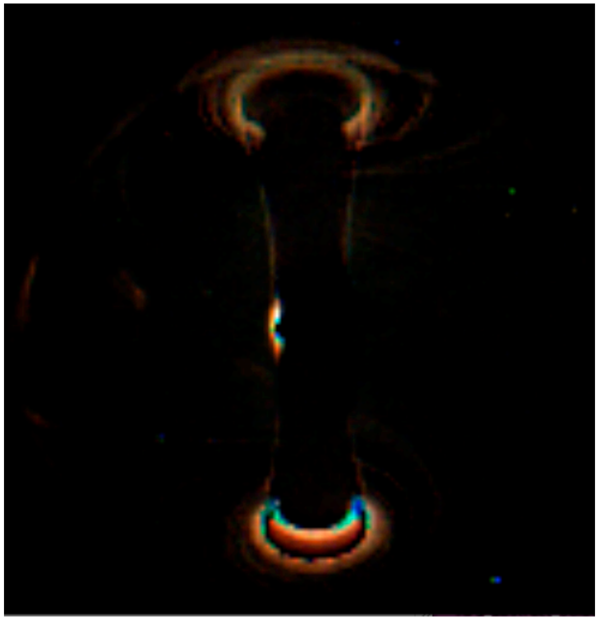
0.33512 sec (-.25012)

130608 -150°



0.33500 sec (-.25002)

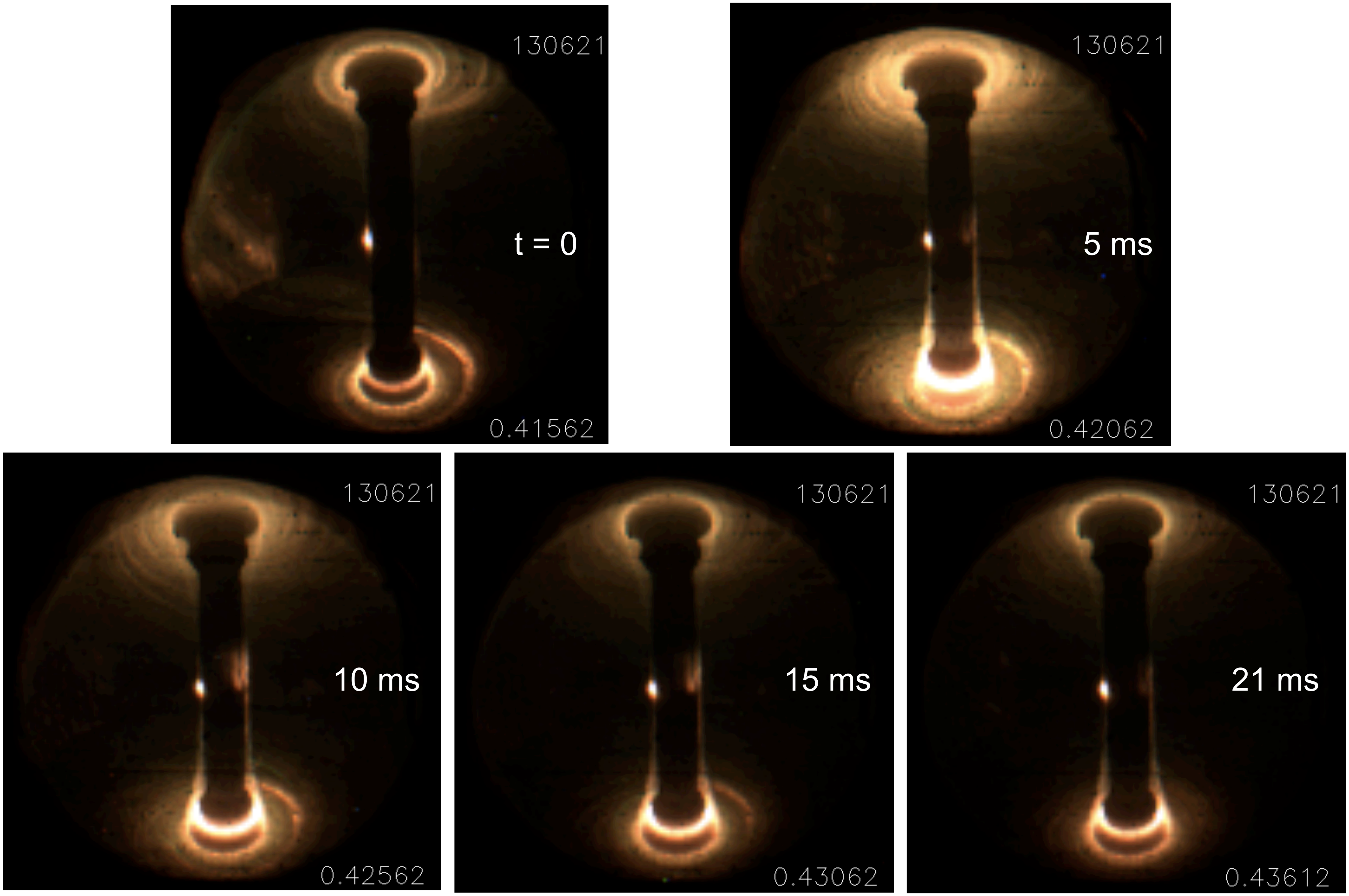
130609 No RF



0.34997 sec (-.24999)

- "Hot" region is much more pronounced at -90° than at -150°
  - Edge power loss is probably greater at -90°
  - Also, suggests fields move away from wall at -150° along with the onset density
- Time for "hot" spot to decay away is ~ 20 ms at -90° and ~ 8 ms at -150°

Hot region decay for Shot 130621 (without subtraction)

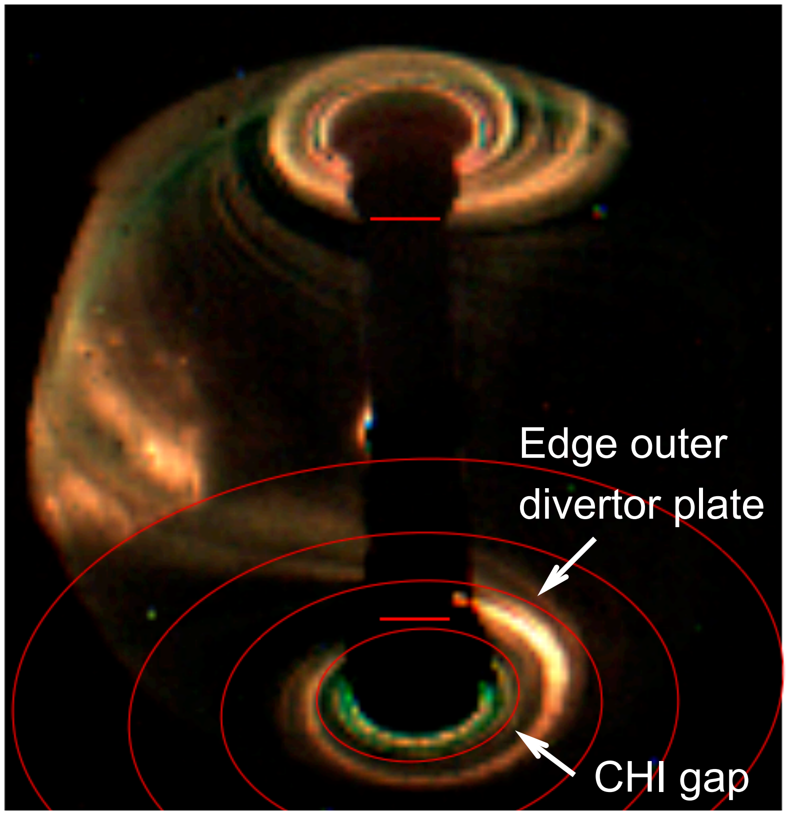


- Visible “hot” zone decays from view in ~ 20 ms

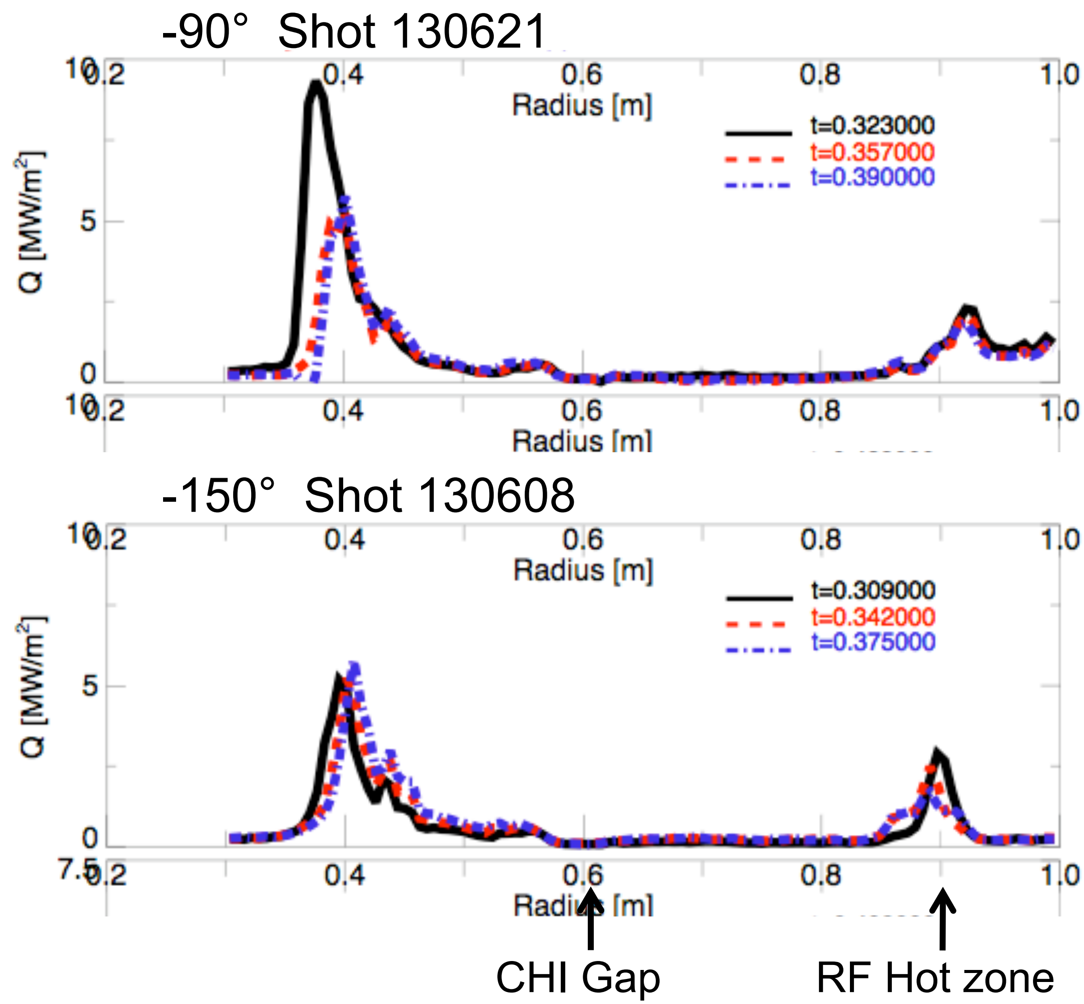
Infrared measurements show significant power deposition in the hot zones

Visible Camera with Subtraction

Shot 130621 (0.41562 s - 0.43762 s)



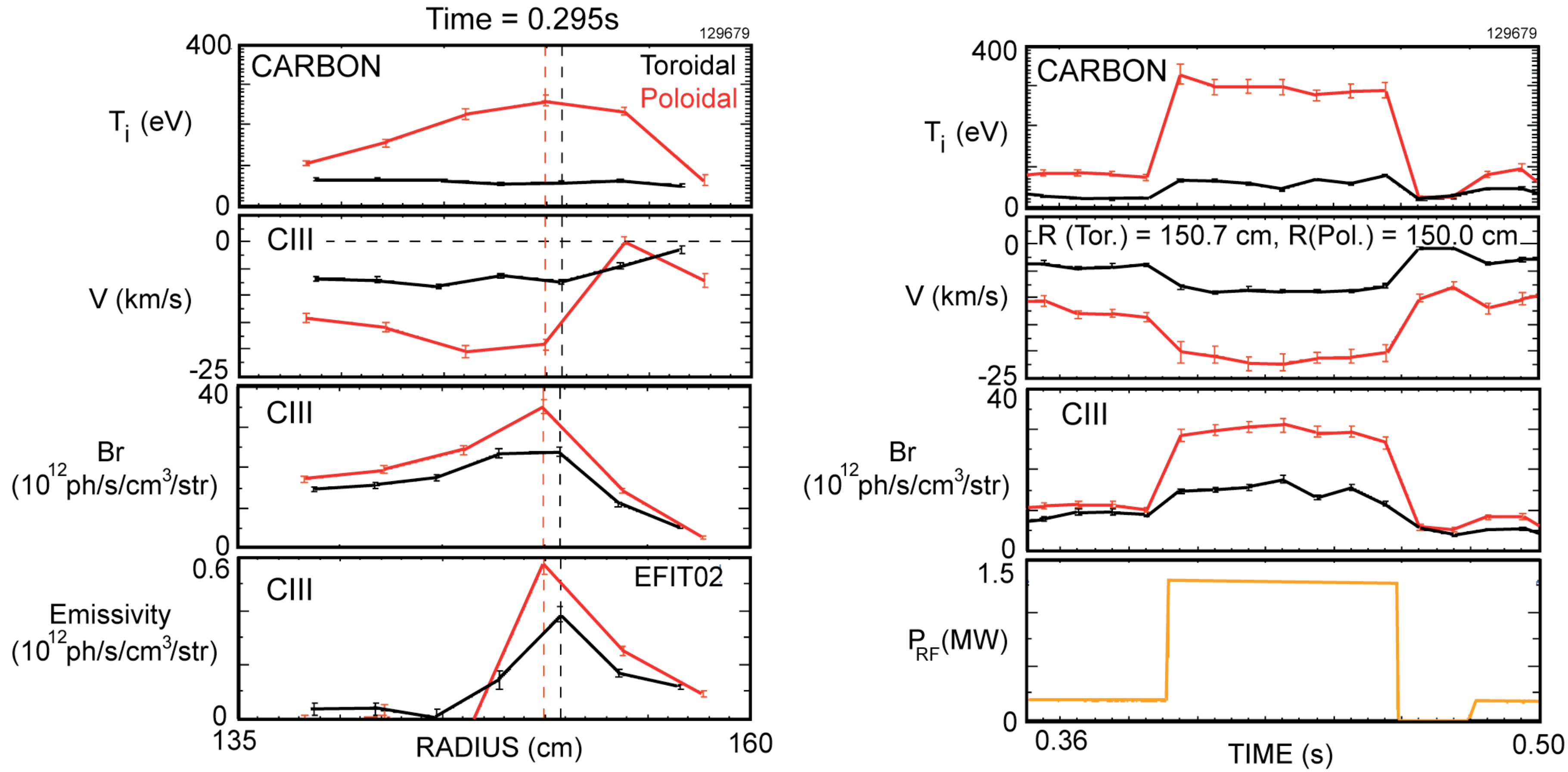
Infrared Measured Heat Flux



- IR results indicate several hundreds of kW deposited on outer divertor plate
- Deposition for -90° farther out along with onset density

Revisiting possible parametric decay effects in plasma edge

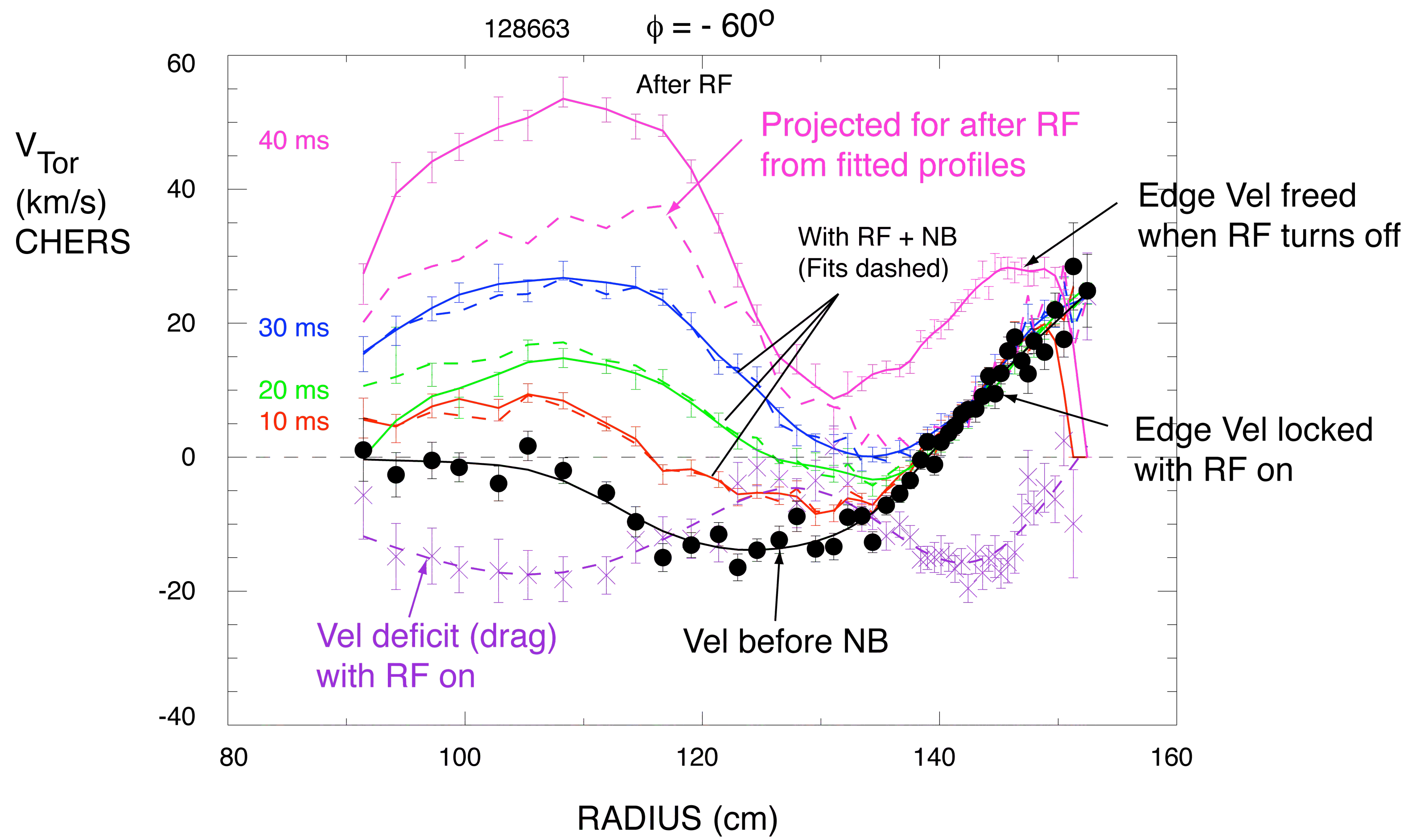
Poloidal heating in edge may eject energetic edge ions



- Edge ions are heated to hundreds of eV: CIII, CVI, LiII, and Helium
- Emission location for CIII and CVI is ~ 150 cm, just inside separatrix
- Edge ion heating may result in loss of energetic ions to SOL and the divertor

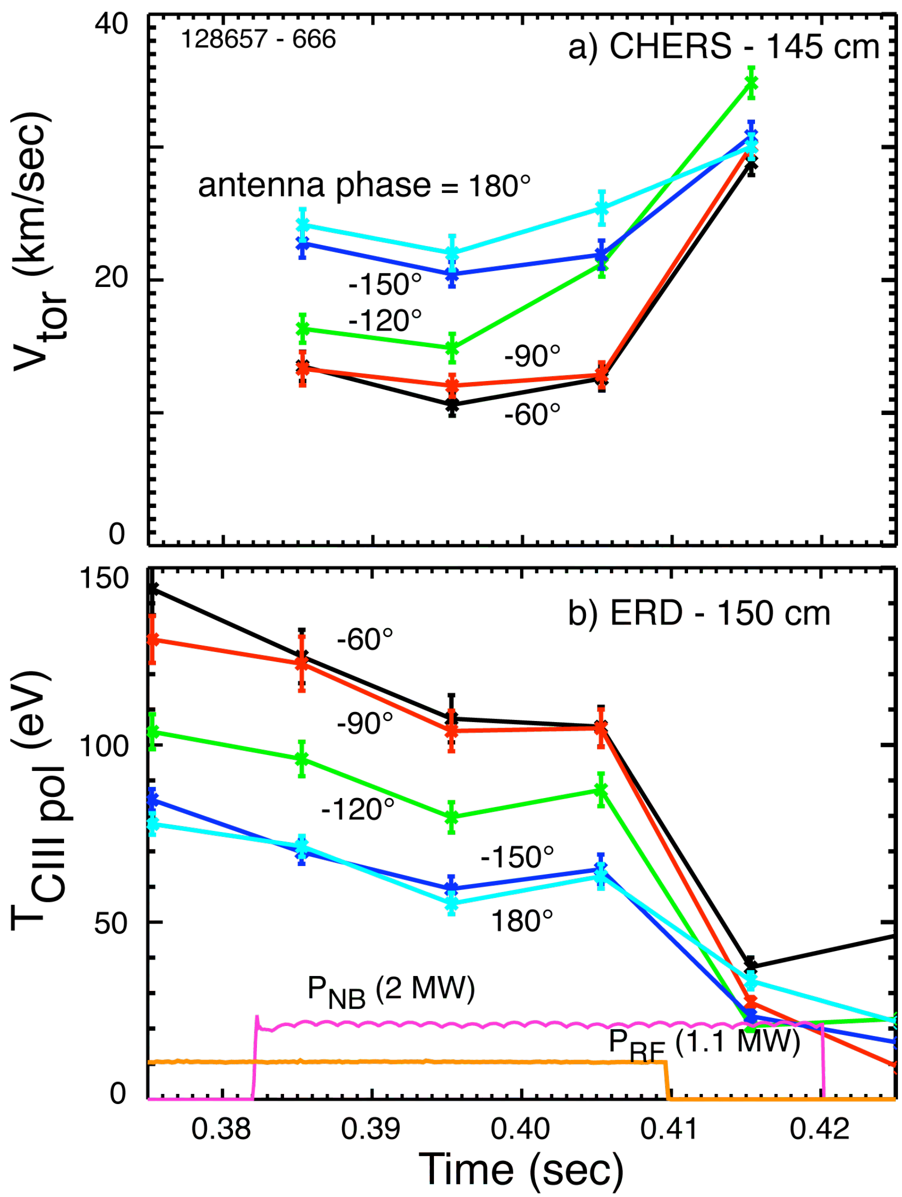
Edge toroidal velocity appears to be locked when the RF is on with the NB pulse

40 ms beam pulse – RF turned of at 30 ms during beam pulse



- The mechanism causing this effect is not understood but it may point to edge ion loss
- The RF apparently provides a drag on rotation inside the plasma as well

Edge toroidal velocity level decreases with phase as edge ion energy increases



- This correlation suggests ion loss is affecting rotation

Experimental Plan

Experimental Plan:

The experiments to be performed are:

1. Map out divertor hot spot properties vs power for L-Mode versus (follow-on of XP825):
    a. Antenna phase
    b. Edge density
    c. Outer gap
    d. Plasma current
    e. Toroidal field
2. Repeat for H-mode with close observation of ELM effects relative to the L-Mode case (follow on of XP835) – quiescent edge is preferable
3. Perform an up-down single null comparison to determine if heating is symmetric top-bottom and if the outer divertor plate heating can be shared top-bottom.
4. Perform comparisons for different magnetic field configurations if reversing fields is included in experimental program.

➢ Extensive lithium conditioning/injection is planned to help control the edge density.

Machine Time Required:

- 3 days

Experimental Plan (cont.)

Operational/Development:

- Considerable conditioning of the antenna will be required to provide high power to show heating of divertor plate.

Diagnostics:

- All the usual diagnostics plus those used to document the heating of the divertor regions.

Analysis:

- Heat deposition in the divertor regions needs to be documented and analyzed. RF code modeling of results is needed to understand flow of RF power in plasma edge.