Edge Effects for HHFW Heating and Initial Startup Results

Outline:

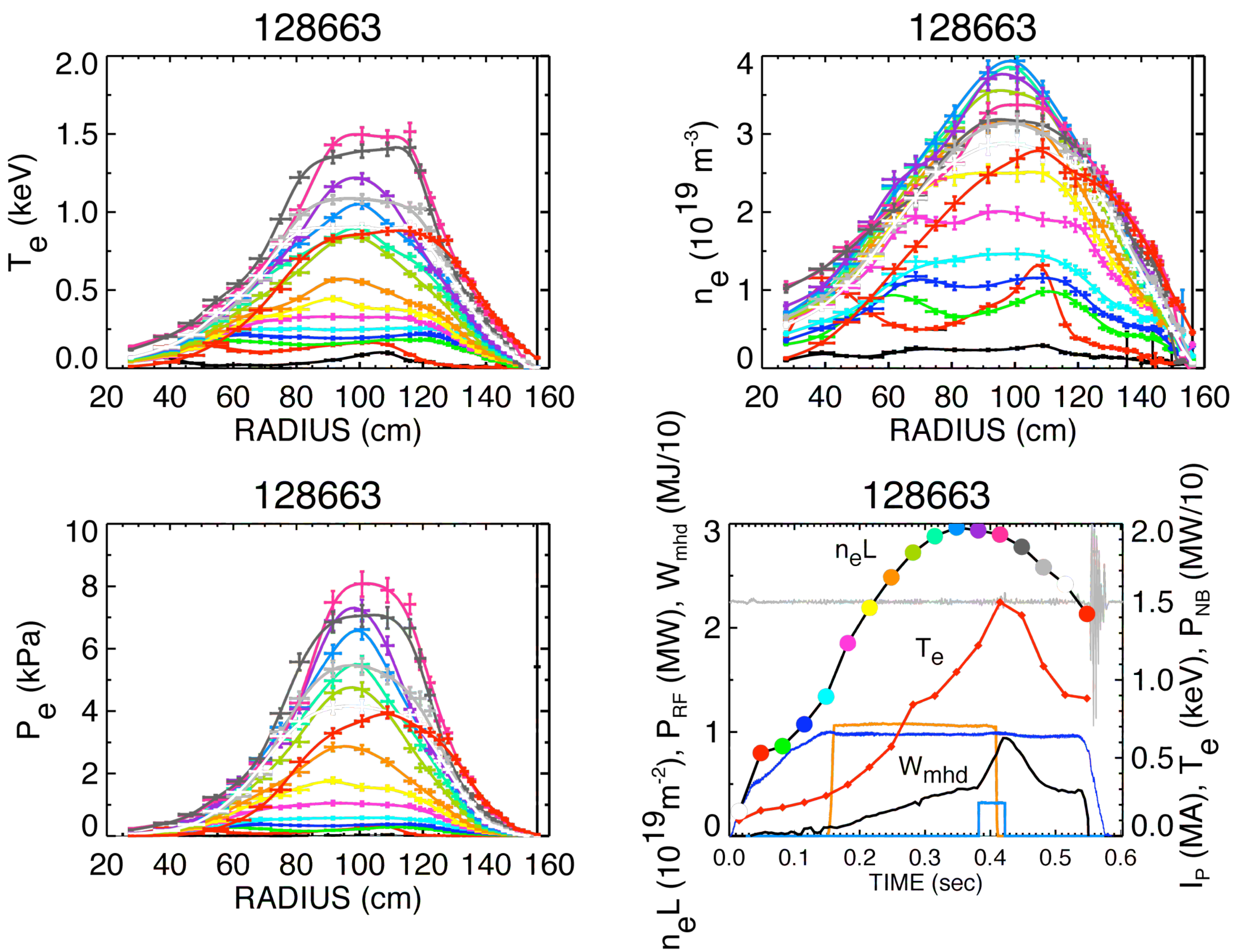
- Difficulty with heating at -30^{o} antenna phasing in deuterium even when heating was good at -60^{o} phasing
  - Instability causing high edge density appears to be the reason
- Lithium helps keep edge density relatively low so that the first heating at -30^{o} phasing in D_2 has been obtained
- T_{ihot} of several hundred volts observed for CIII, CVI, and LiII during HHFW. CIII and CVI observed just inside separatrix at ~ 150 cm
- Also, edge rotation appears to be frozen during the RF + NB operation
- These observations hint that energetic edge ion loss could be important and this process needs to be investigated
- Initial startup results will be presented if time permits

NSTX Results Review August 2008

Good Electron Heating Obtained in D_2 at antenna phase of -60^o

NSTX

April 3, 2008



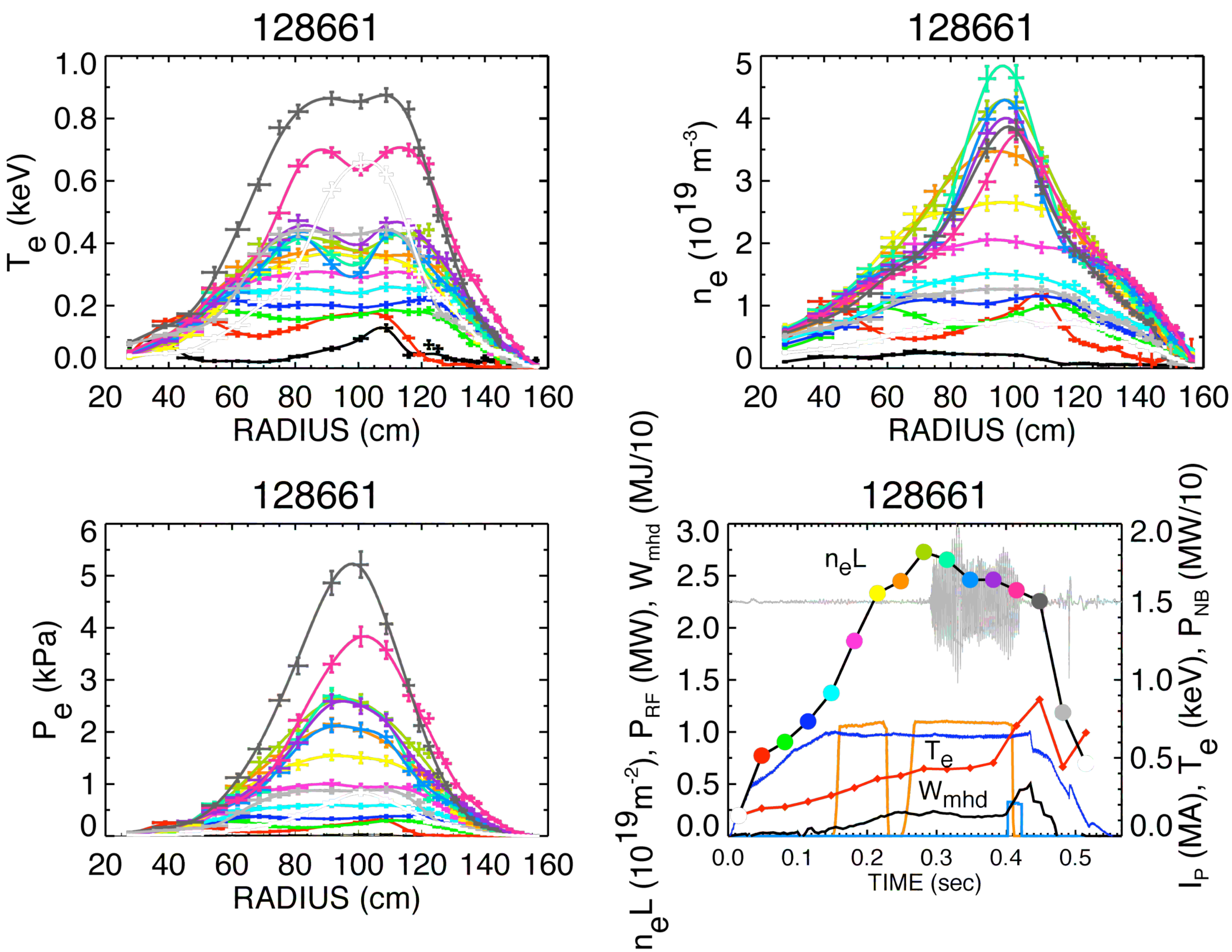
$T_e(0)$ ~ 1.5 keV

for P_{RF} ~ 1.1 MW

- $T_e(0)$ increases almost linearly in time
- NB gives a linear ramp in stored energy - supports later look at CIII velocity

Heating was not initially observed for - 30° phasing in D_2

April 3, 2008

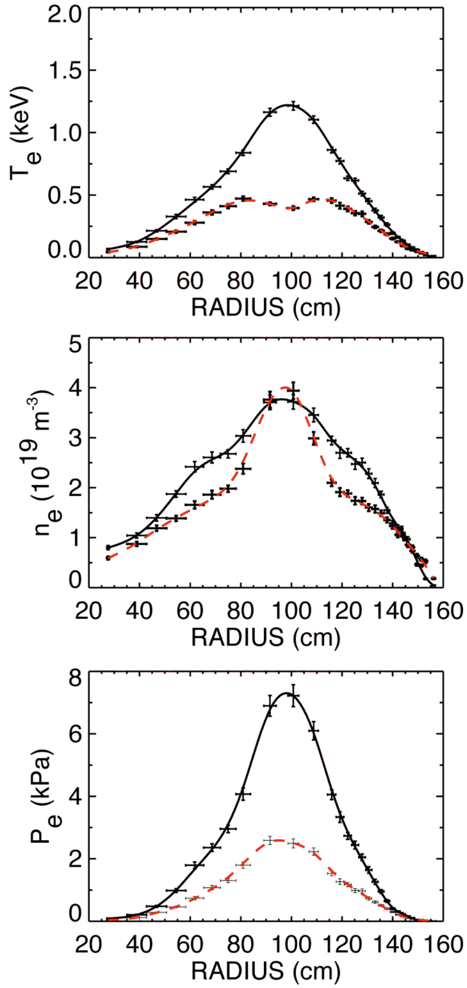


$T_e(0) < 500$ eV for $P_{RF} \sim 1.1$ MW

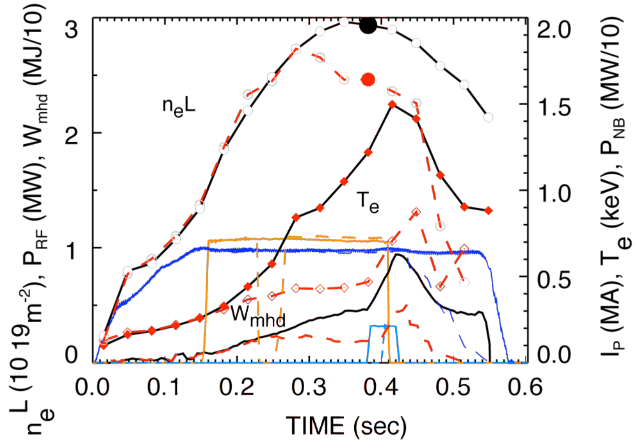
- Instability is strong for this -30° case and may result in the lack of heating

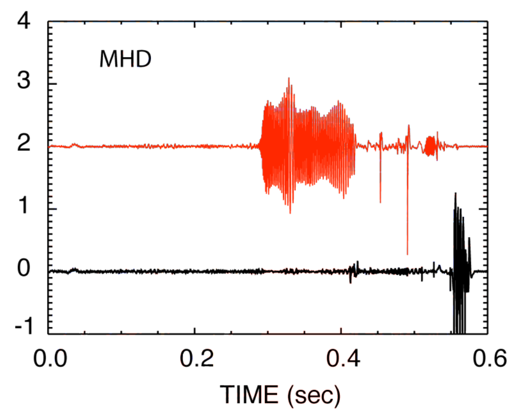
Summary of results with profiles just prior to NB pulse

128663 @0.382 sec,
128661 @0.382 sec



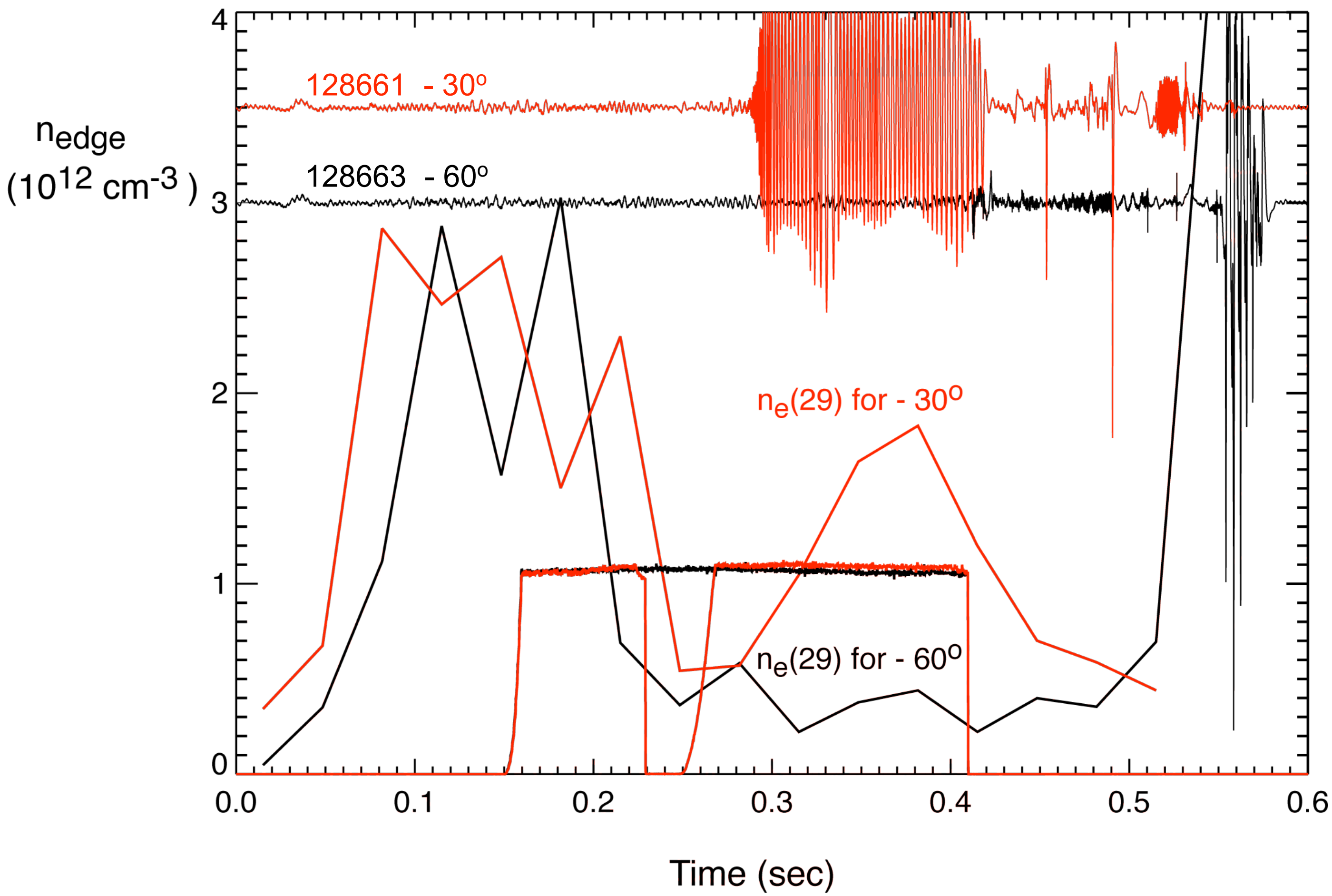
Antenna Phase
- 60° - 30°
128663, 128661





- For the large difference in heating between -60° and -30°, we might expect that the edge density during the instability should be large relative to the onset density

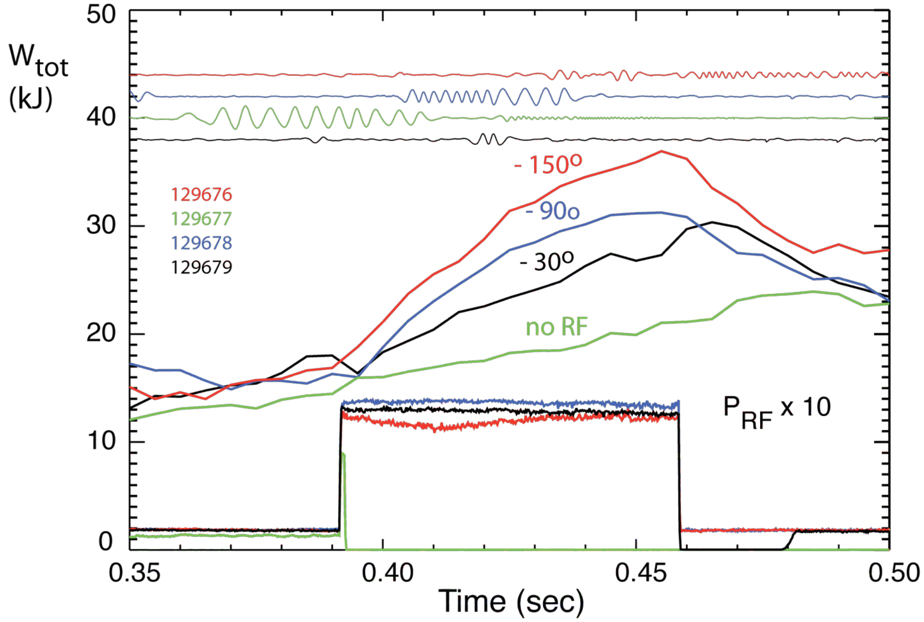
Edge density from Thomson scattering is well above wave onset density during instability

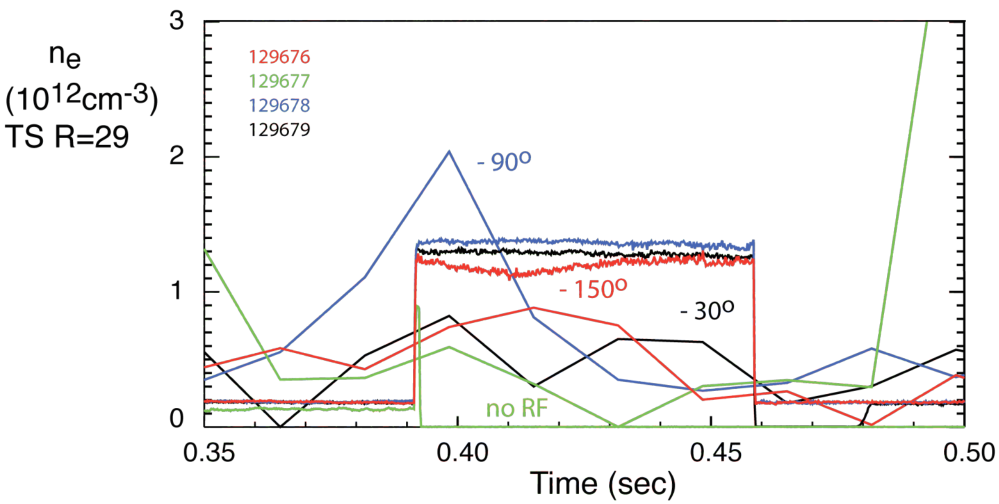


- This result is consistent with our earlier conclusion that relatively high edge density increases edge power deposition

Introduction of Lithium enables sufficient reduction in edge density to provide first observed heating in D_2 at -30° phasing

June 4, 2008





- Heating at -30° is ~ 40% of value at -150°
- Heating at -90° appears to be delayed by early density peak and is possibly affected by instability reduction of confinement

Poloidal heating in edge may eject energetic edge ions

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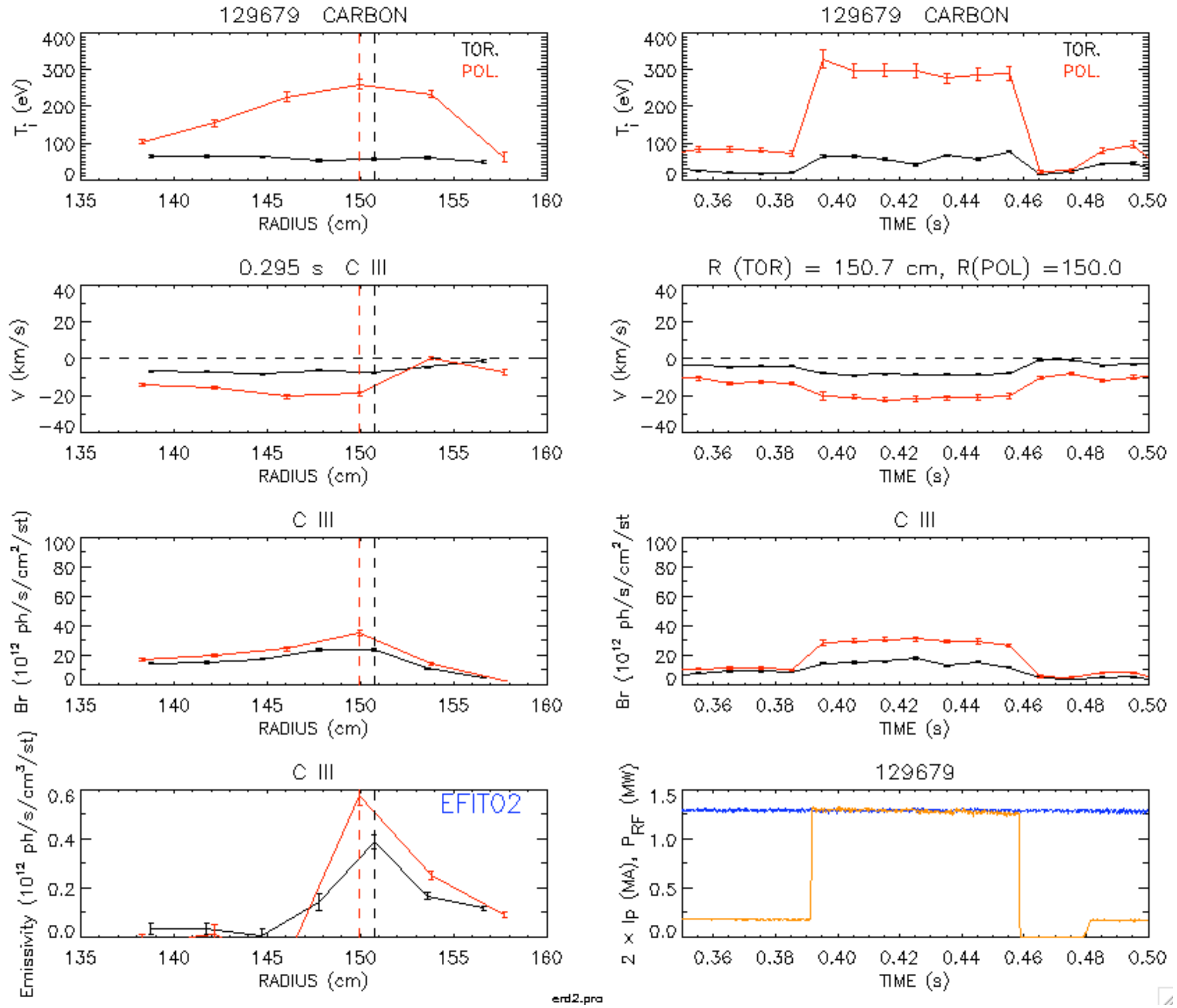
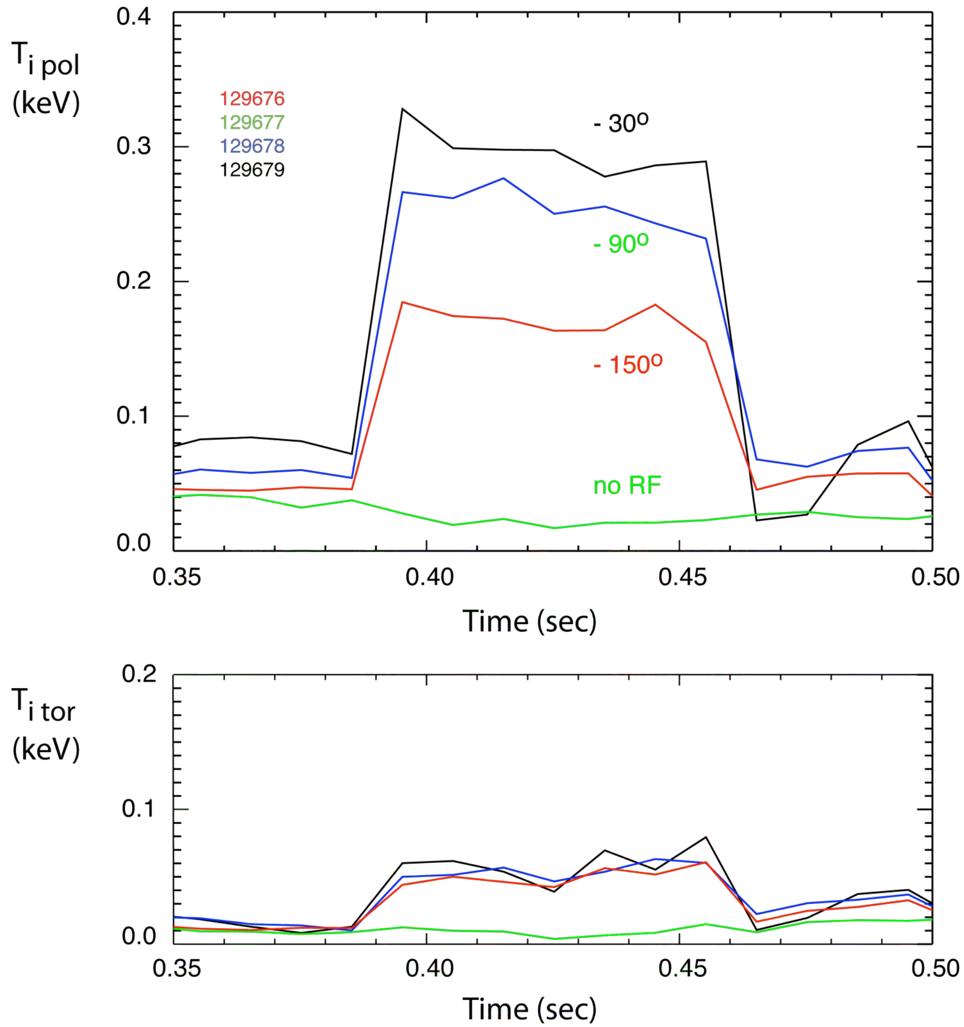
ERD



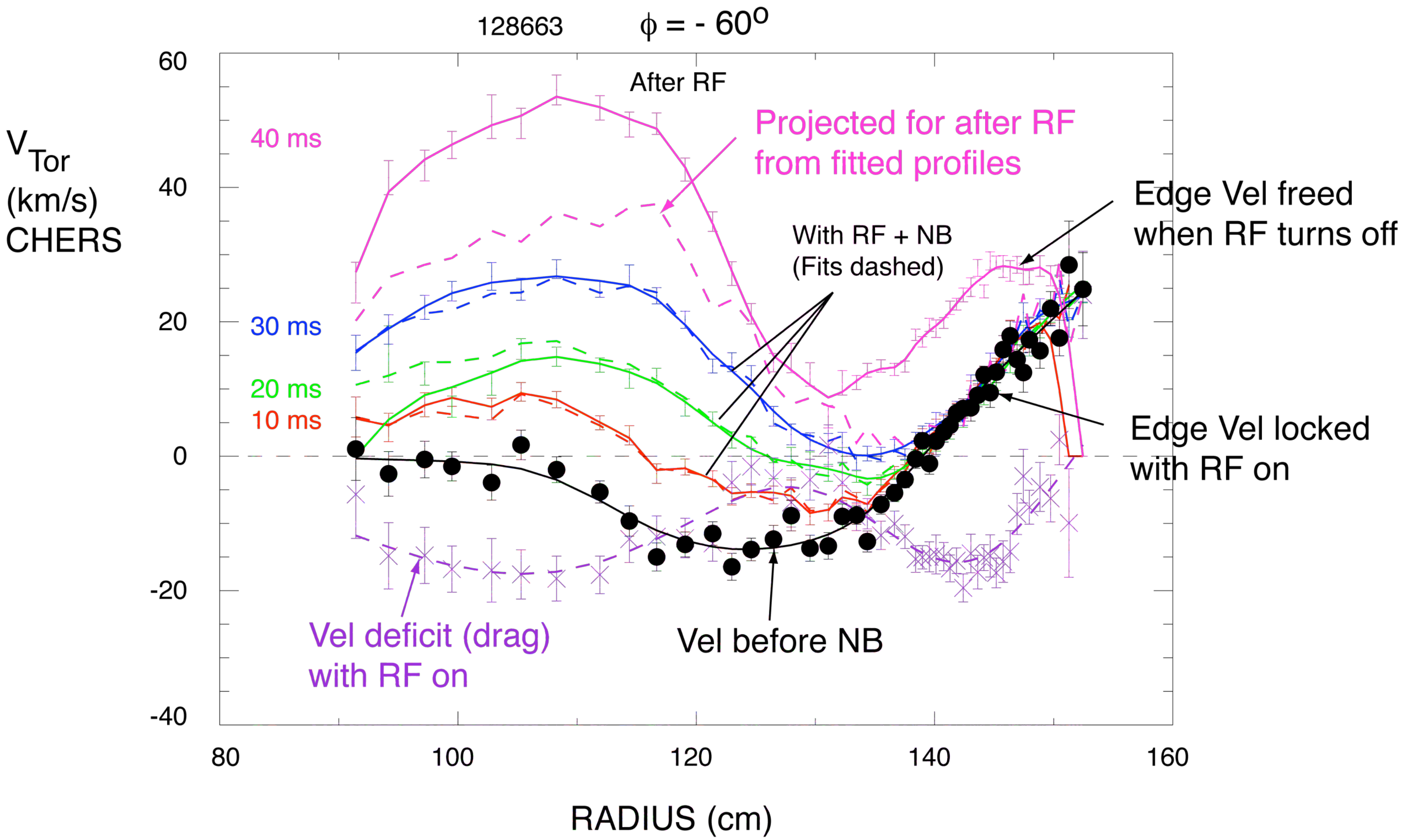
- Edge ions are heated to hundreds of eV: CIII, CVI, LiII, and Helium
- Emission location for CIII and CVI is ~ 150 cm, just inside separatrix
- Edge ion heating may result in loss of energetic ions to SOL and the divertor

Edge ion energy depends on antenna phase



- Energetic ion losses should be greater at lower antenna phase
- Does location of energetic ions change with phase?

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



- 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

June 2-3: XP817

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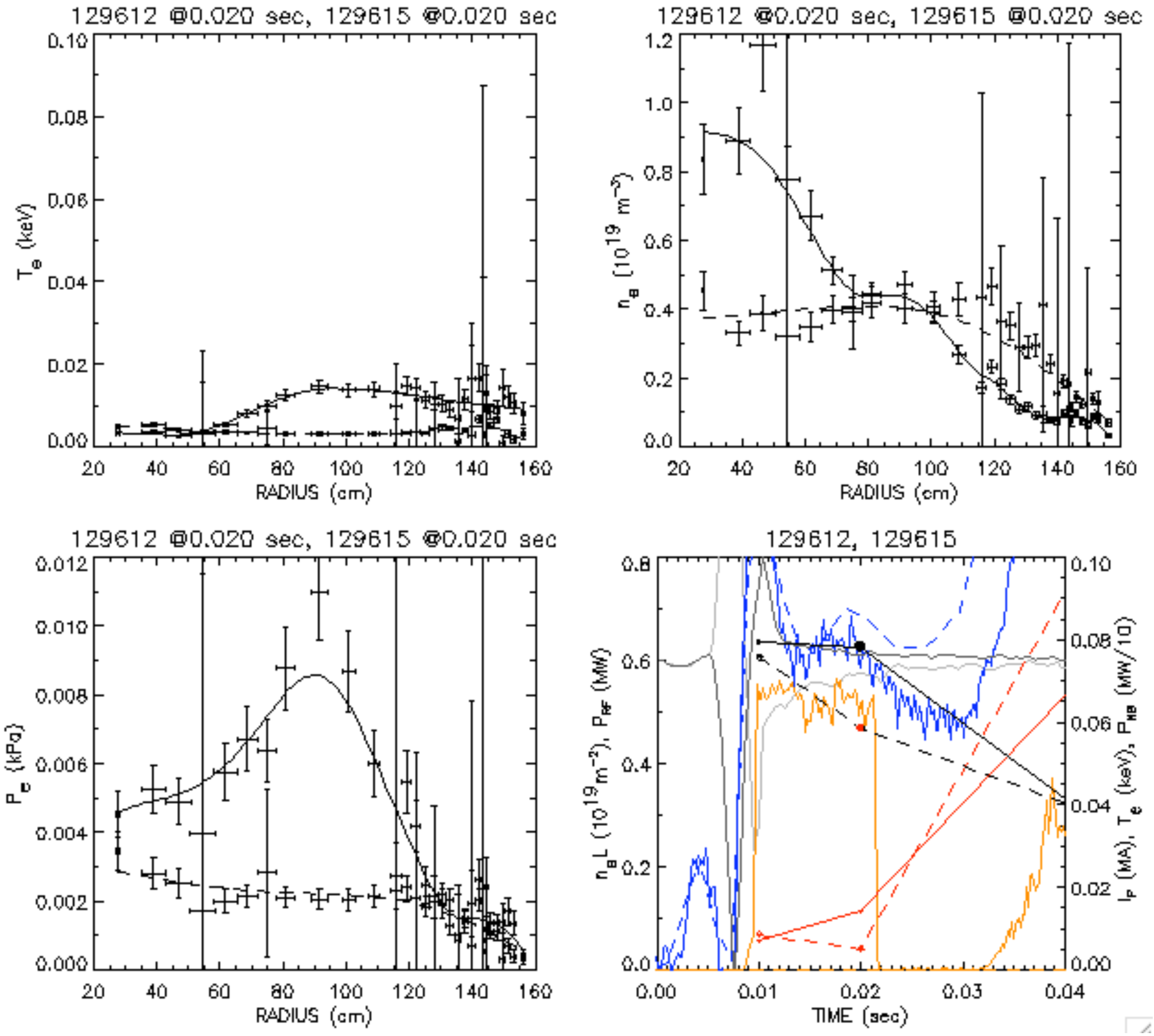
XP817: CHI Startup

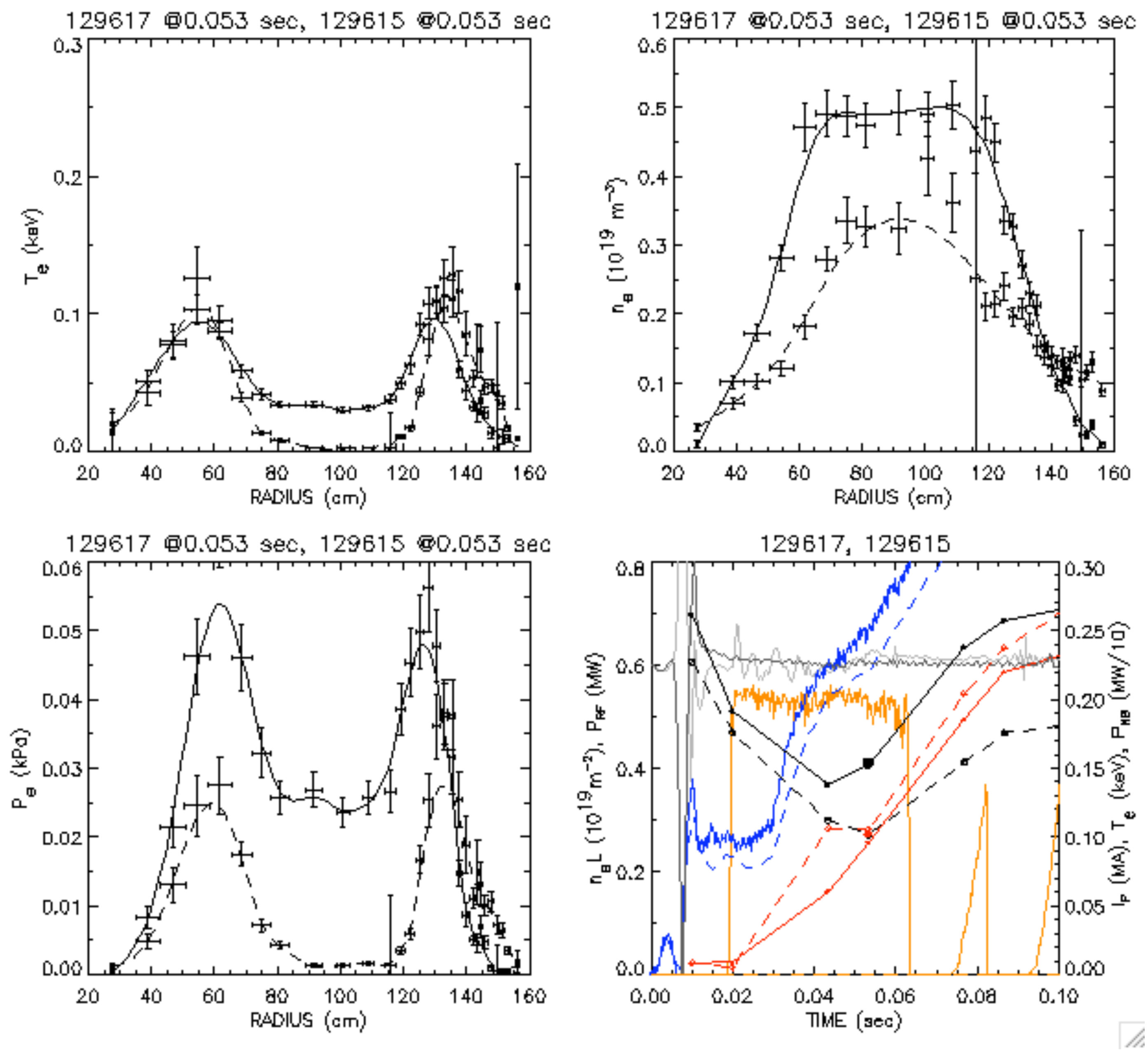
- HHFW applied to startup with CHI-Ohmic combo under XP817
  - Matched to CHI conditions at end of run on June 2.
  - Coupled power to CHI and OH phases on June 3.
    - Coupled ~ 550 kW to transition 10 to 22 msec and heated core from ~ 3 eV to ~ 15 eV at 20 ms.
    - Coupled ~ 550 kW to transition 18 to 64 ms and heated axis (hollow core) from ~ 3eV to ~ 33 eV.
    - Clear heating of ohmic phase. Coupled ~ 1.1 MW from ~ 65 to 120 ms and heated on axis from ~ 140 ev to ~ 700 eV at $n_e(0)$ ~ 6 and ~9 x10^{+12} cm^{-3}, respectively. Suggests that ECH/HHFW could be used to heat up plasma during startup. Rampup in current needs to be simulated to see if it is feasible.

Heating at 20 msec



P_{RF} = 550 kW
9 - 22 msec

Heating at 53 msec



P_{RF} = 550 kW
20 - 64 msec

Heating at 120 msec

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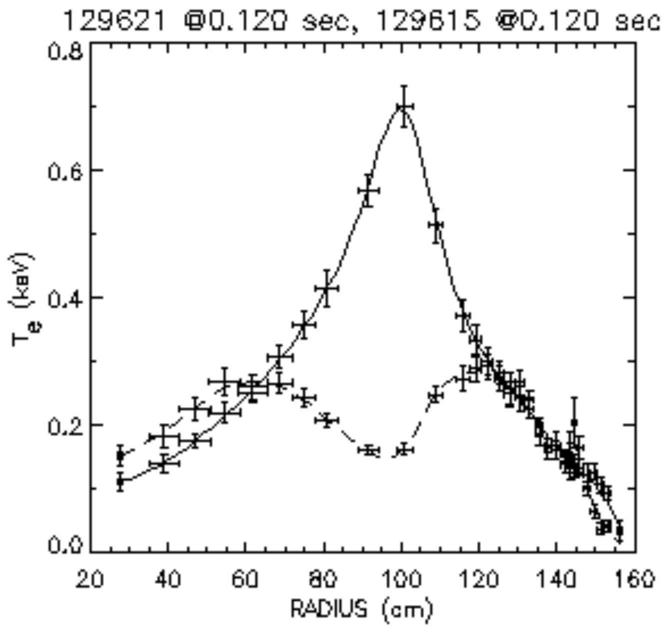

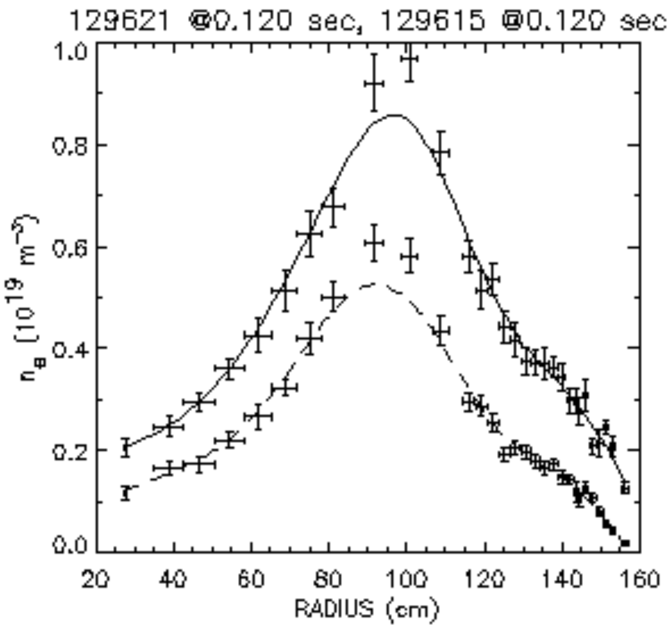

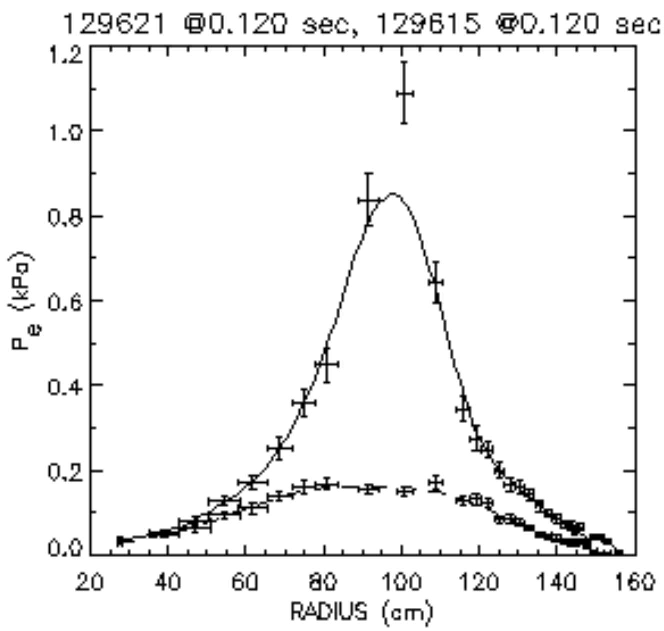

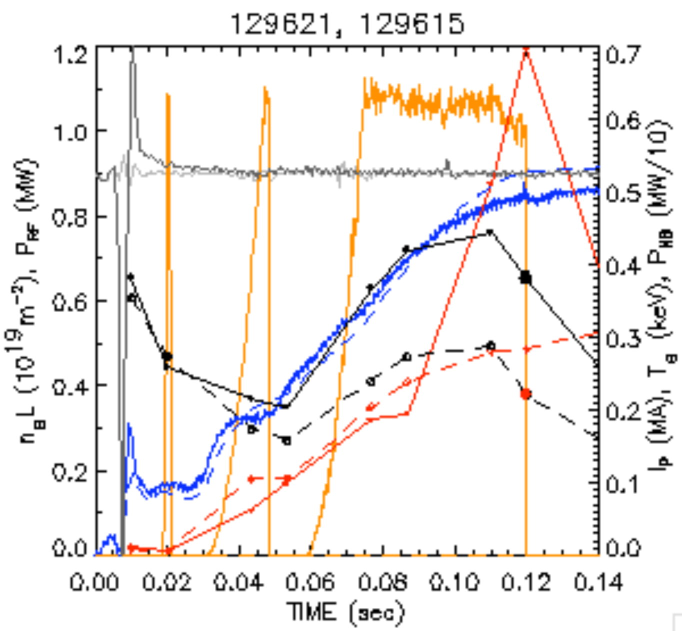

P_{RF} = 1.1 MW
65 - 120 msec