Fast-wave power flow along SOL field lines in NSTX

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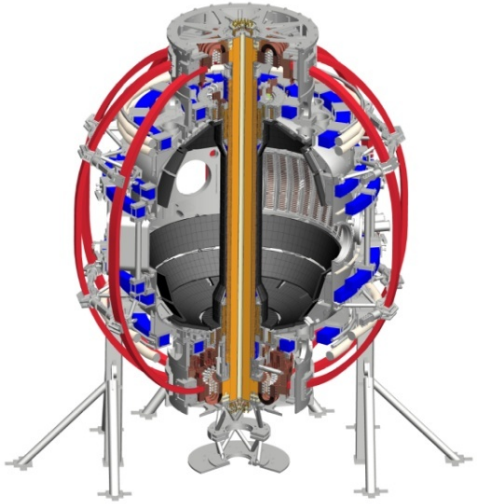
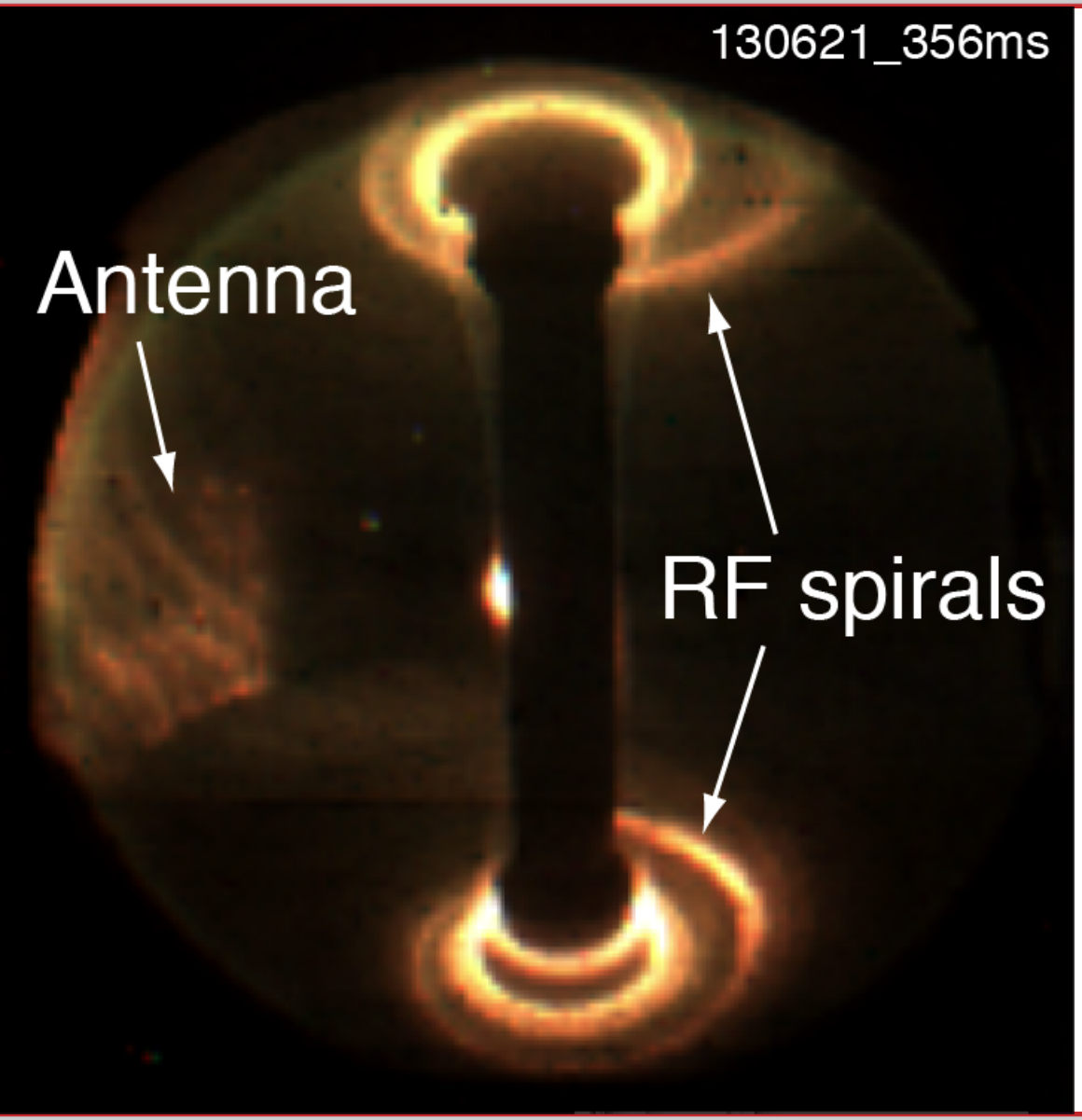


HHFW power lost *directly* to divertor regions along SOL field lines on NSTX



- Lost power deposited in bright spirals on upper and lower divertor
  - IR cameras measure large heat flux in spirals
- Core heating correlates with onset density for perpendicular fast-wave propagation*
  - Enhanced loss when onset density too close to antenna
  - Edge loss up to 60% of coupled RF power

*J.C. Hosea et al., Physics of Plasmas **15** (2008) 056104.

Outline

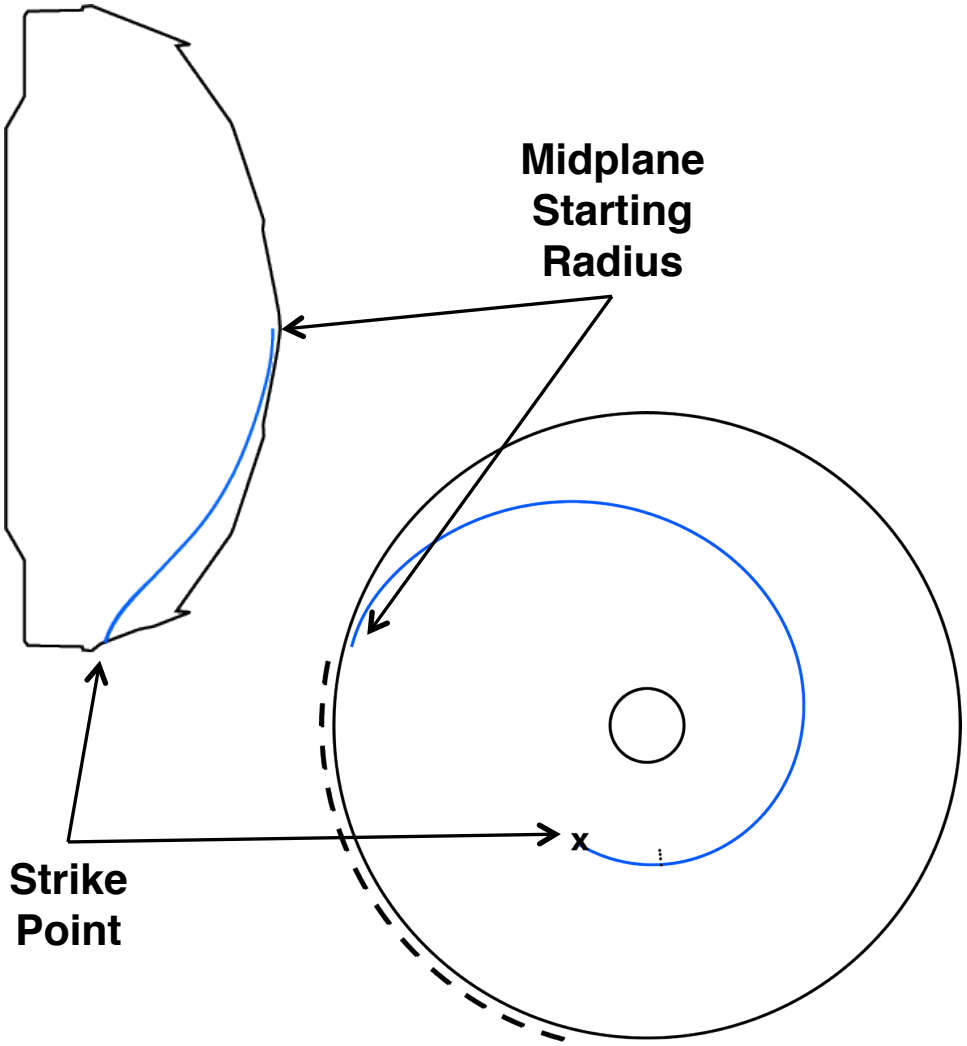
- **Lost HHFW power reaches divertor largely along SOL field lines**
  - Good agreement between field-line mapping and measurements
  - HHFW power lost along all SOL field lines in front of antenna
  - … not just to lines connected to antenna

- **RF-induced heat deposition on lower divertor**
  - RF power deposited in discrete peaks (at Bay I)
  - Location of peaks consistent with field-line mapping

- **Midplane profile of lost HHFW power**
  - Obtained by applying magnetic mapping to divertor heat flux
  - Midplane profile peaks near both antenna and last closed flux surface

- **Midplane loss profile suggests fast-wave propagation in SOL**

Field-line mapping models flow of lost HHFW power

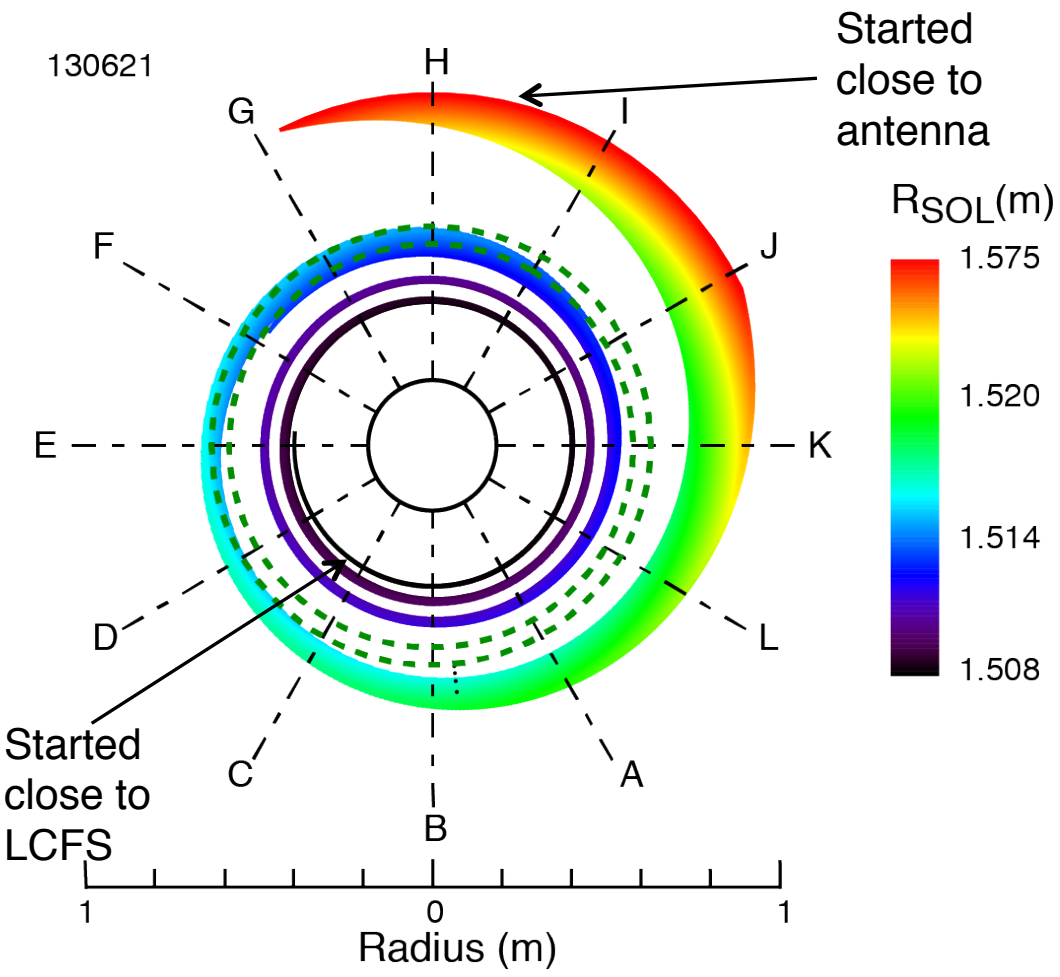


- Start field lines at midplane between antenna and separatrix
- Track field lines until they strike divertor
- Track field lines using SPIRAL code

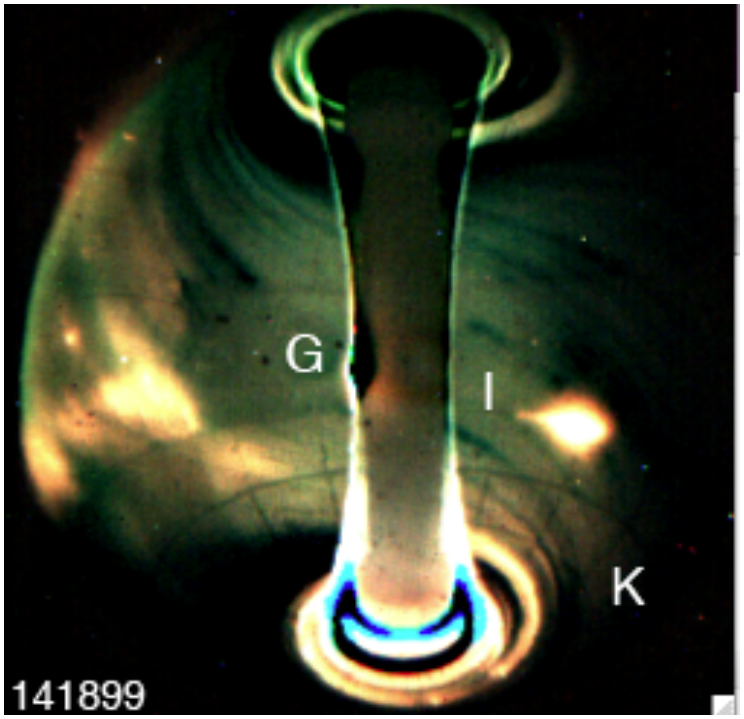
G.J. Kramer et al., 22 IAEA FEC (Geneva, 2008) CD-ROM file IT/P6-3,
G.J. Kramer et al., submitted to Plasma Phys. Cont. F. (2012)

Computed strike points form a spiral that closely matches the observed RF spiral

Strike points on divertor for field lines started at midplane…

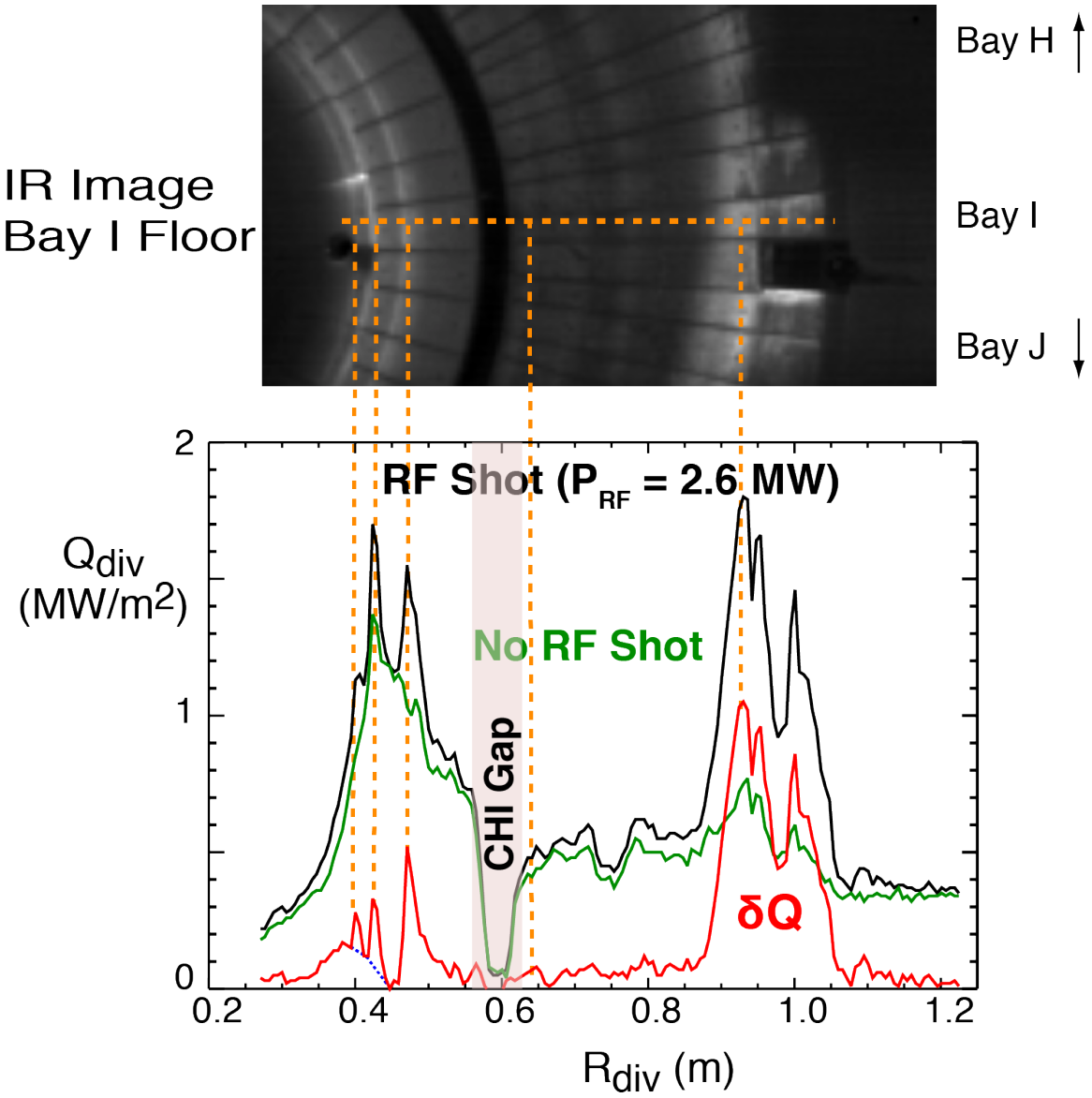


… create spiral pattern close to camera images



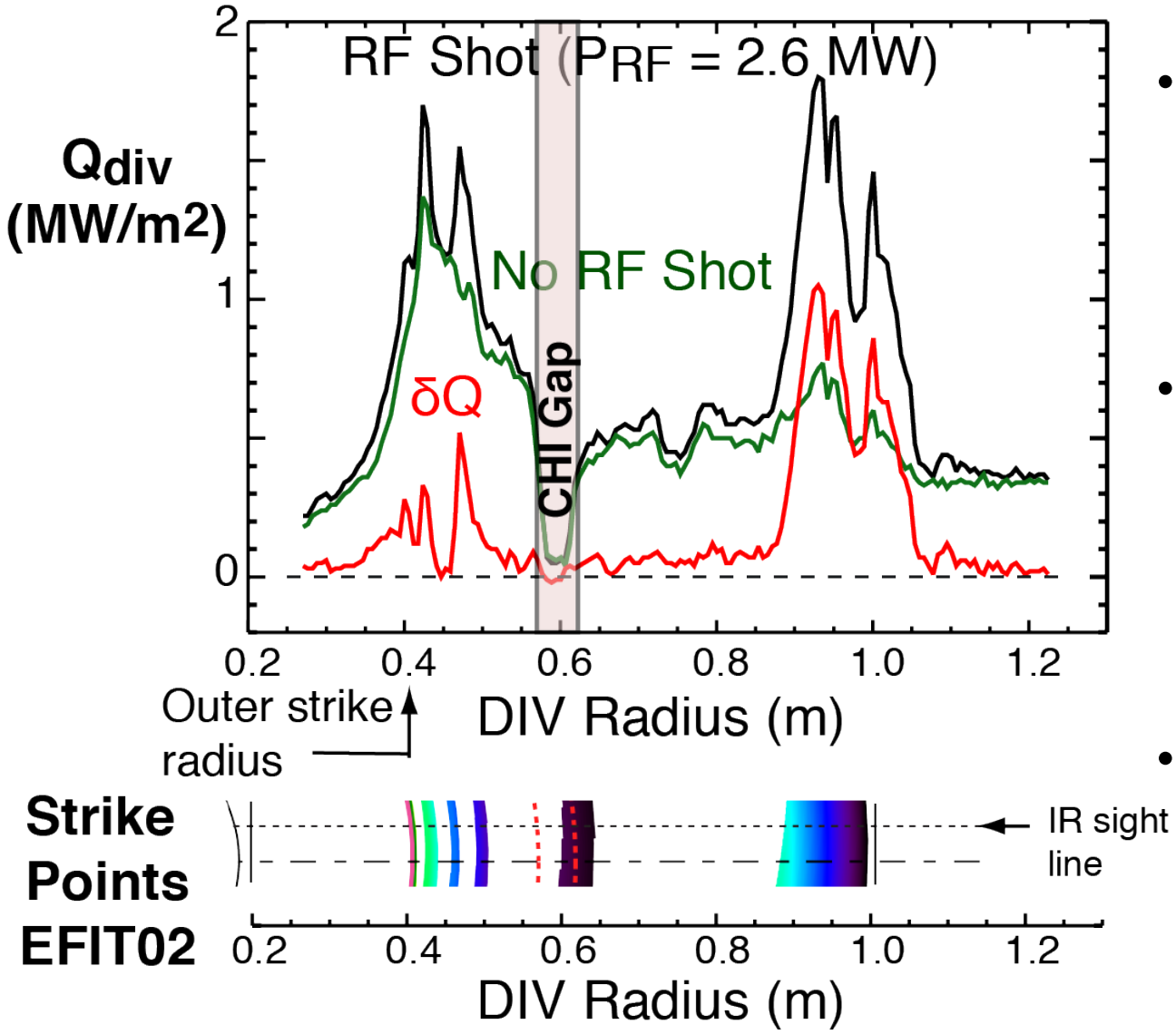
R.J. Perkins et al., Phys. Rev. Lett. 109 (2012) 045001

Divertor IR camera measures strong RF-induced heating



- RF spiral appears in IR image
- Heat profile taken along horizontal line
- RF-induced divertor heating (δQ) in red
  - Shot 135333 with RF (ELMy H-mode)
  - Shot 135334 no RF
  - Difference gives RF heat
- Several RF-induced heat peaks clearly resolved

IR camera data agree with calculated strike points

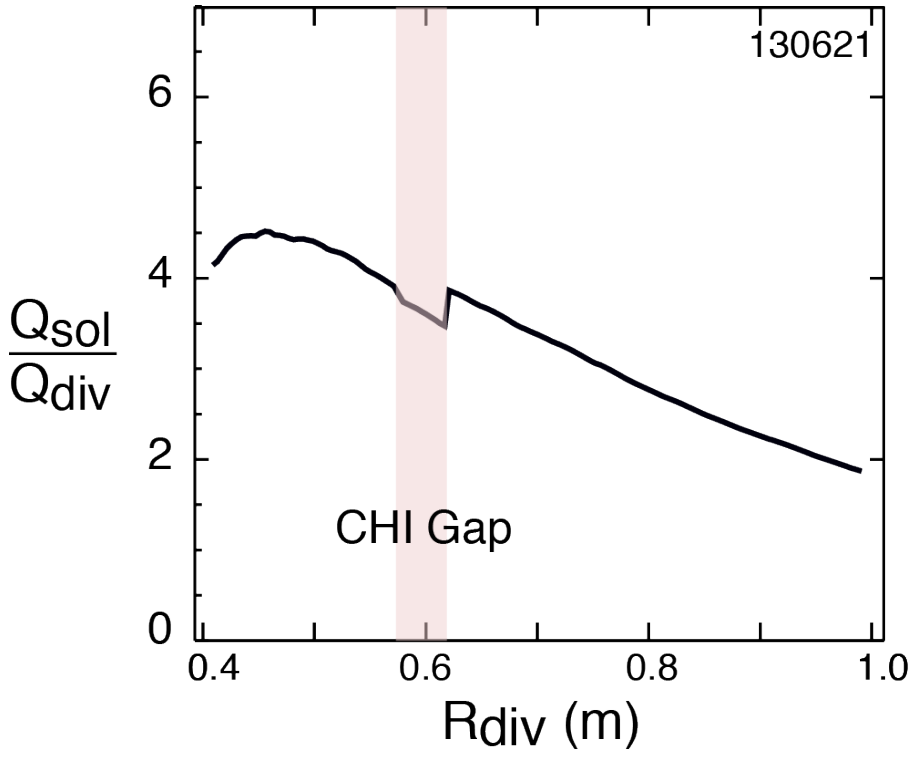


- RF deposits heat at Bay I regions at several radii
- Measured radii of RF heat peaks coincide with strike points computed by SPIRAL
- EFIT02 used here

Hosea PP8.6
Wed. afternoon

Compute HHFW losses at midplane in front of antenna

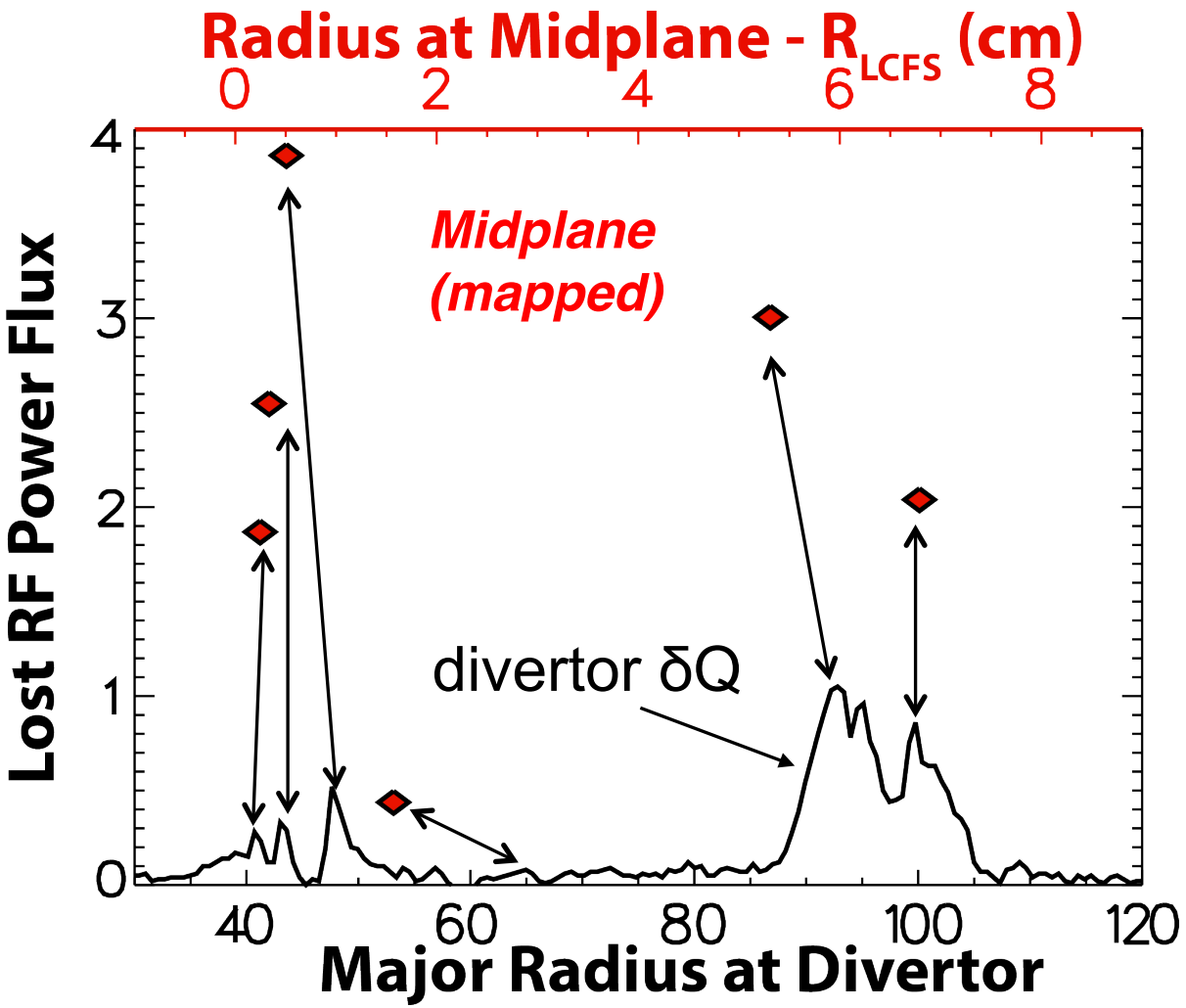
- Apply field-line mapping to RF-induced divertor heat flux
- Flux expansion means losses are greater at midplane
  - particularly close to LCFS
- Can only reconstruct a portion of midplane profile
  - Only have IR data at Bay I
  - Can only reconstruct where spiral passes Bay I



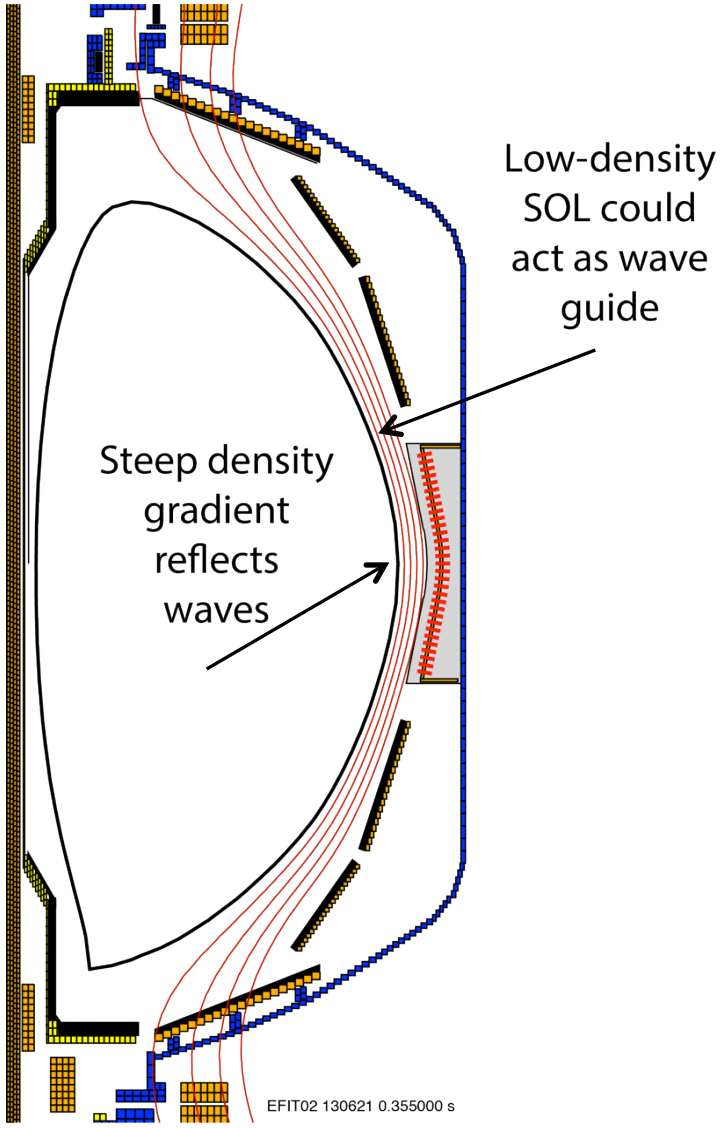
IR Image
Bay I Floor

Lost-HHFW-power profile at midplane Is large near LCFS as well as antenna

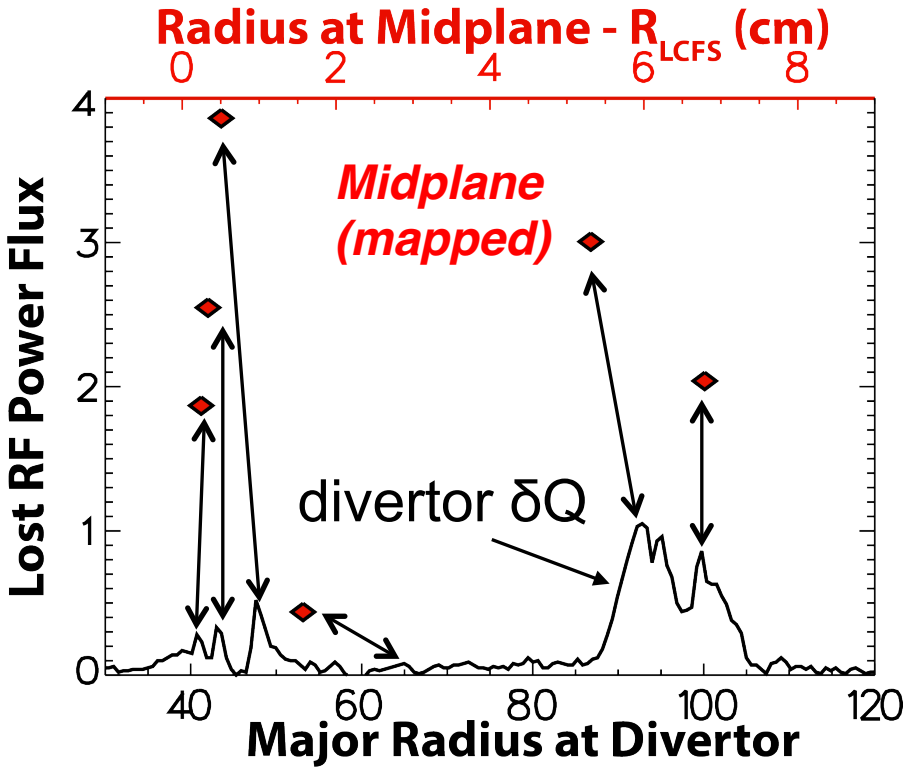
- Midplane profile shows two-peak structure:
  - Peaking of power coupled close to antenna and LCFS
  - Relatively low coupling in between
- Loss mechanism cannot be localized to antenna



Fast-wave propagation in SOL possibly responsible for edge loss



- Loss profile at midplane suggests standing-wave patterns in SOL
- Could be general to fast-wave systems



Future work

- Results provide a benchmark for RF codes
  - Codes should reproduce losses observed experimentally
  - Important for predicting impact on ITER
- Need direct measurements in NSTX-U
  - RF probes needed to confirm presence of RF fields in divertor region
  - Improved IR coverage would help
  - Field-line mapping predicts optimal location for probes
- Increased field strength on NSTX-U favorable for reducing edge losses

Summary

- HHFW power lost to divertor regions along all SOL field lines
  - Losses occur across width of SOL
- Midplane lost power profile is obtained
  - Strong losses along field lines near antenna and LCFS
  - Losses are relatively weak in between
- Results suggestive of fast-wave propagation in SOL
  - Loss profile suggestive of a radial standing wave
  - Could be general to all fast-wave systems