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HHFW Edge Heating Properties for H-mode Plasmas

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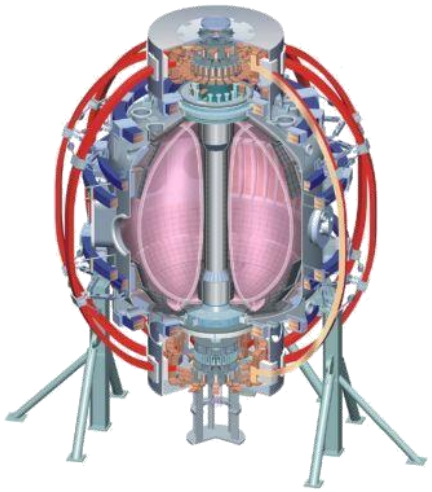

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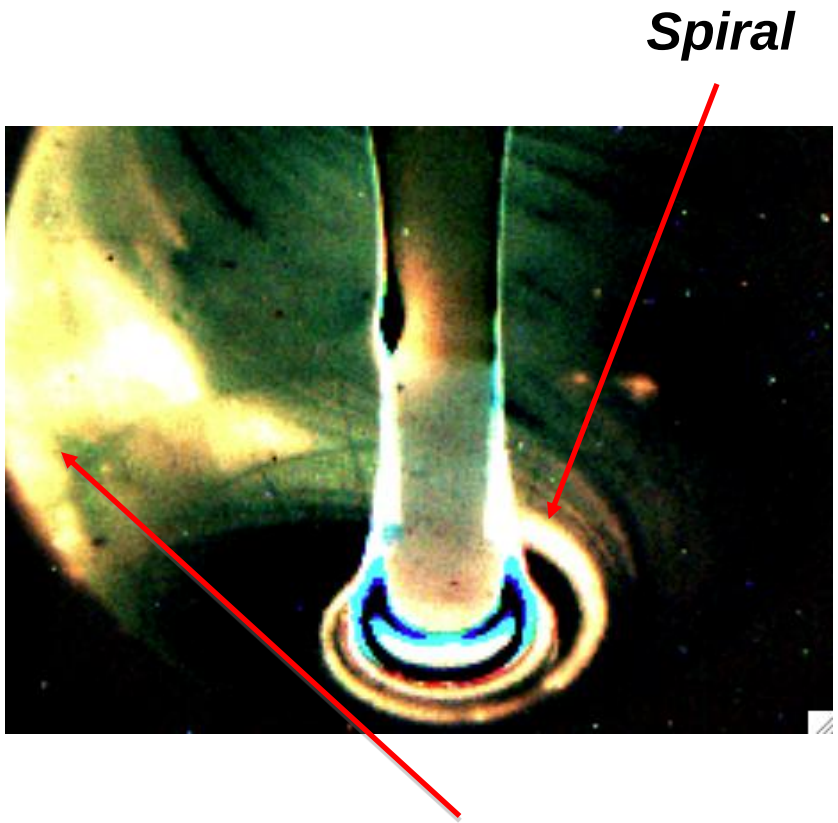
RF edge deposition produces a bright "hot" spiral on the divertor



- IR cameras show strong divertor heating under spiral
  - Edge loss up to ~ 60% of RF power
- Langmuir probes respond strongly to RF when under spiral
- Current to divertor tiles increase when under spiral

Possible mechanisms for spiral and edge loss:

- ✧ Surface waves carrying RF power to the divertor
  - Onset density for perpendicular propagation ($\propto B*k_{||}^2/w$)
- ✧ Direct currents produced by antenna fields

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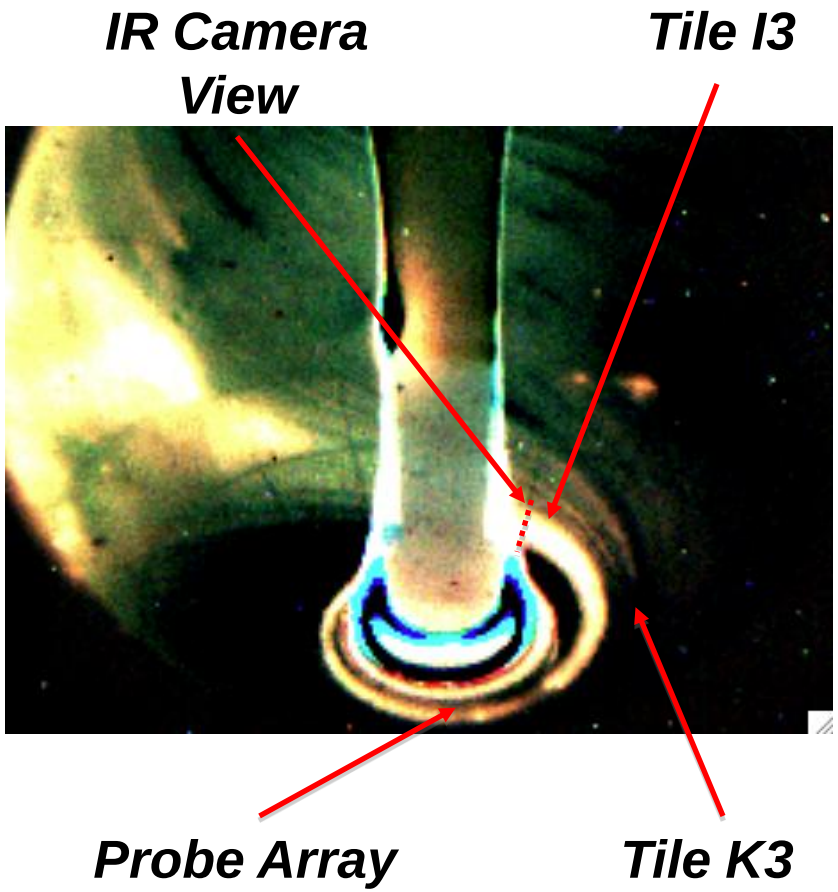

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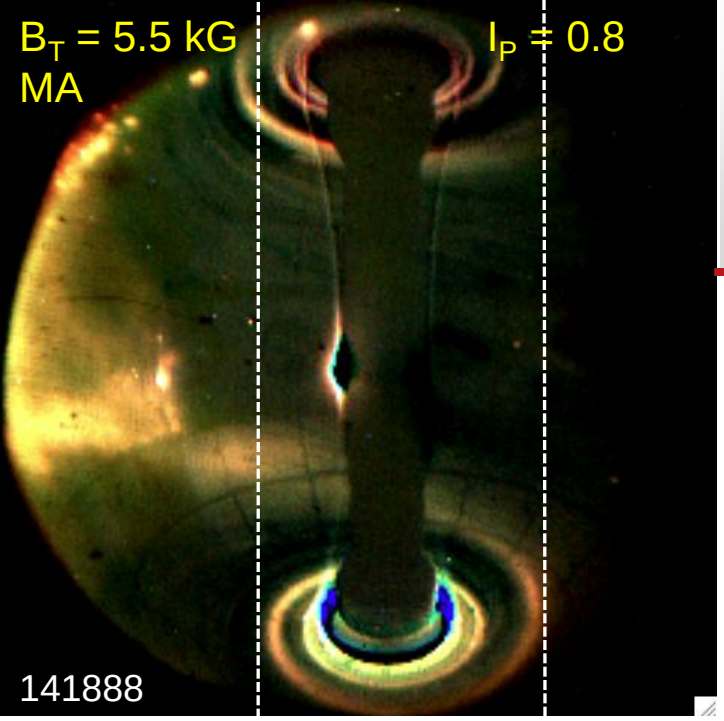
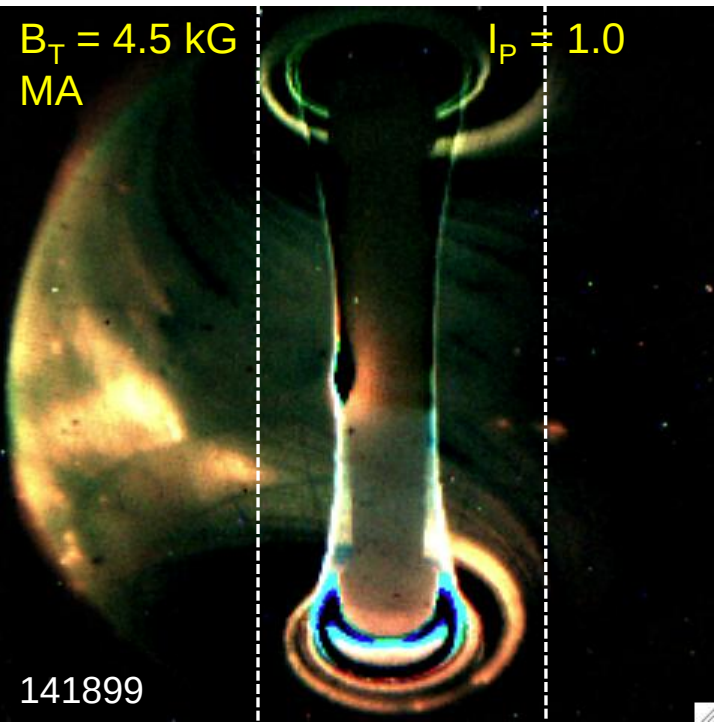
Evidence that RF spiral originates in SOL

- Experimental observations
  - RF spiral moves in response to magnetic pitch
  - Suggests power follows field lines
  - Can sweep RF spiral over diagnostics
- Numerical modeling: field-line mapping from the midplane SOL to divertor
  - Reproduces spiral pattern on divertor
  - Moves with pitch in agreement with experiments
  - Explains trends in diagnostic signals
- Part of spiral comes from the SOL at the midplane… not from the antenna face
  - Consistent with location of onset density for perpendicular wave propagation



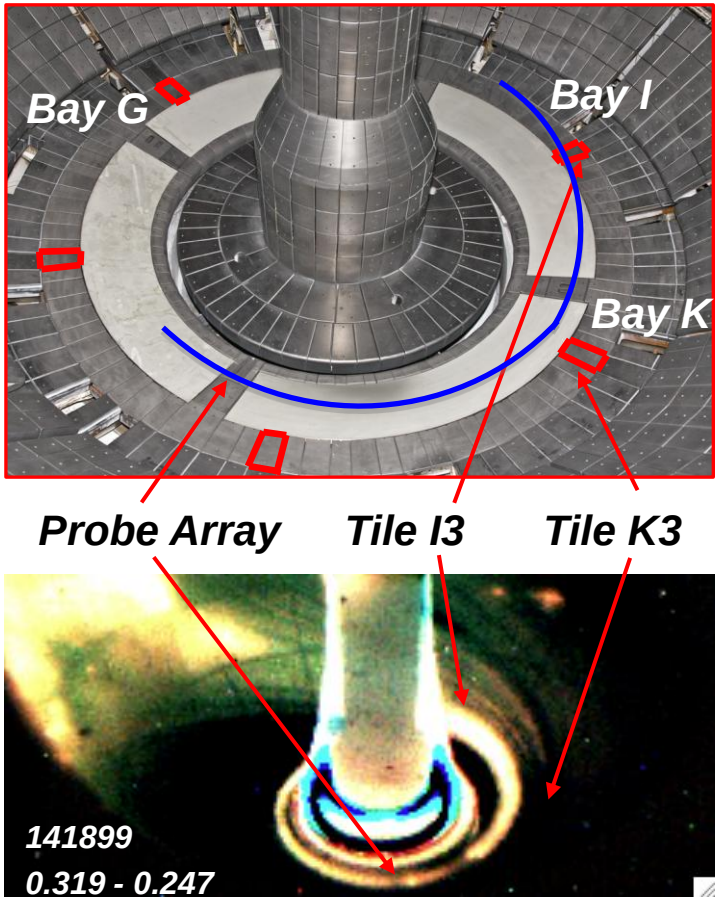


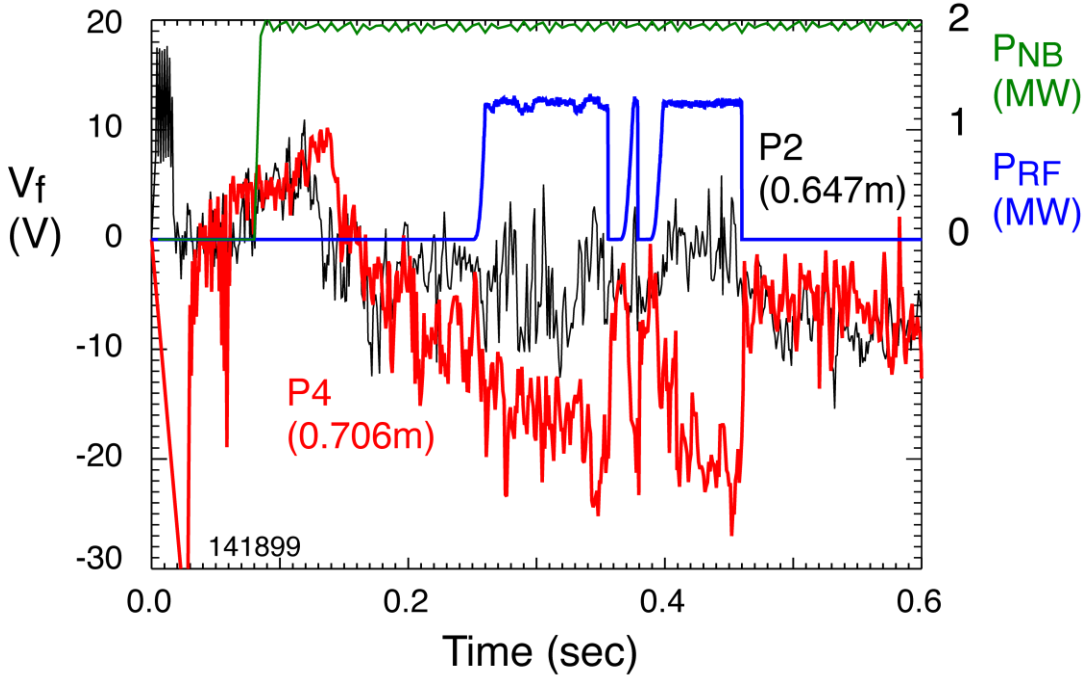
Major radius of RF spiral depends on field pitch

- Radius shifts by ~ 15 cm inward with increased pitch
  - Low pitch: I_P/B_T = 0.8 MA/ 5.5 kG (31˚)
  - High pitch: I_P/B_T = 1 MA / 4.5 kG (42˚)
- Can sweep RF spiral across diagnostics by changing the field pitch
  - Langmuir probes
  - Instrumented divertor tiles

141888 time = 0.312s - bkg 0.247s
141899 time = 0.319s - bkg 0.247s

High field pitch puts spiral over Langmuir probe* 4 but not on other probes a few cm in



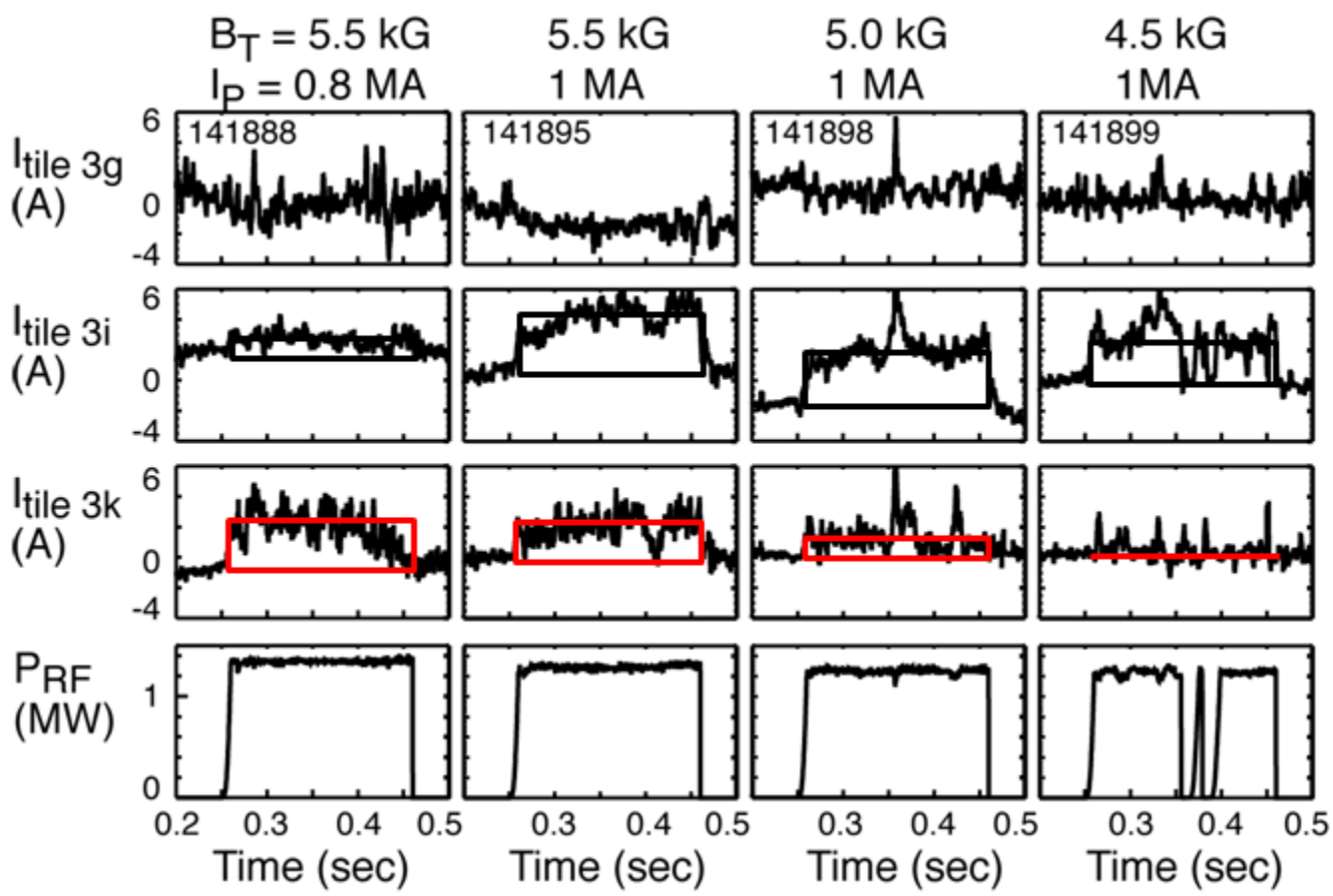


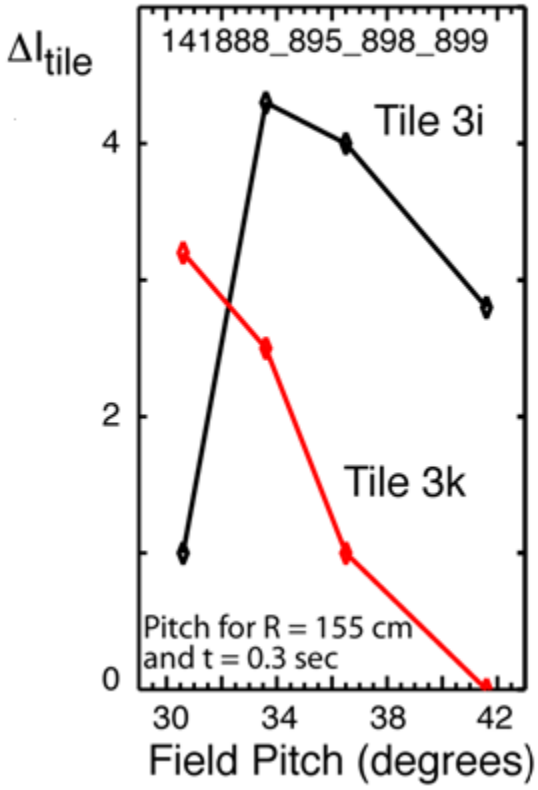
- Langmuir probe P4 floating potential responds strongly to RF
- Langmuir probe P2, 6 cm inboard, has a much weaker response
- RF-induced effects are localized

**** Michael Jaworski, Session GI2 invited talk, Tuesday 10:30***

Current-sensor tiles track movement of RF spiral

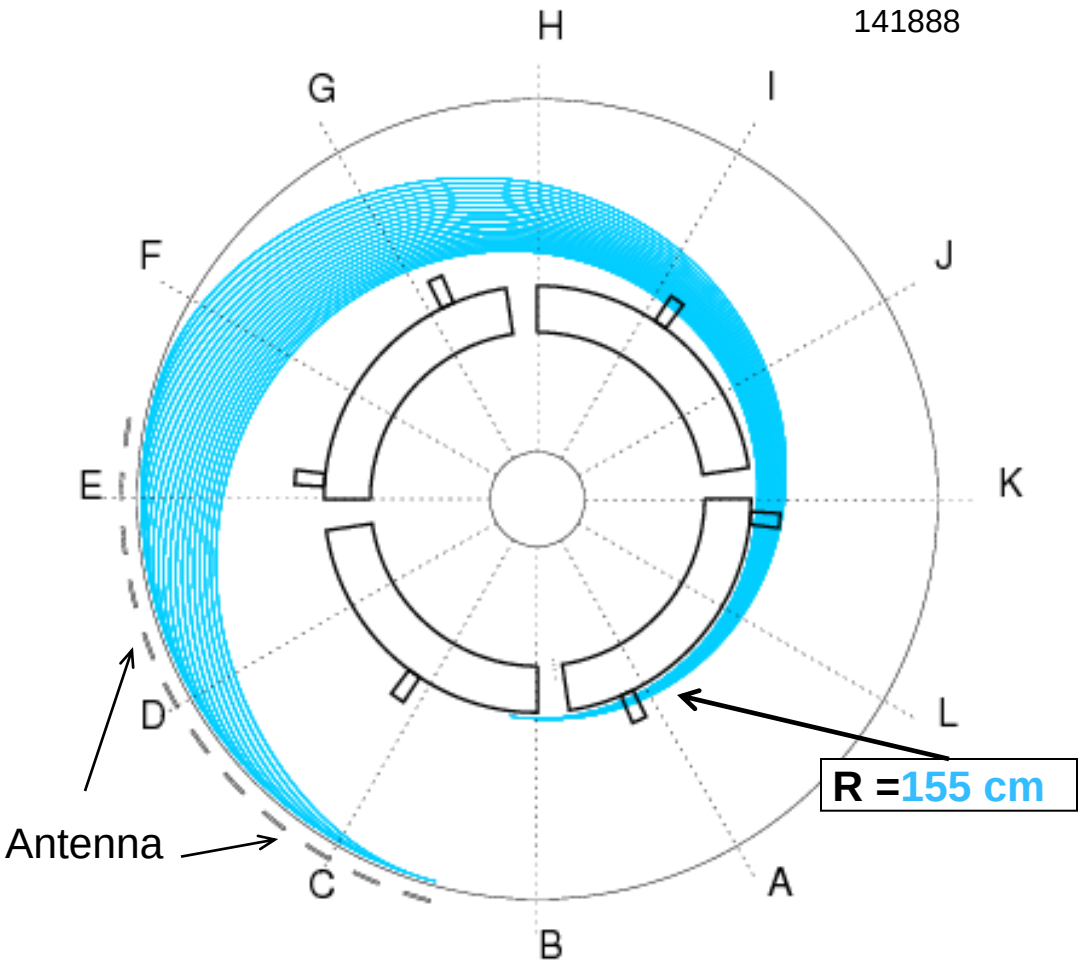
(k_ϕ =-8 m^{-1}/ϕ_{Ant} =-90° , D_2, P_{NB} = 2 MW)





- Bay K tile current decreases as RF spiral moves inward…
- … while Bay I tile current rises

Field-line mapping (SPIRAL code*) models flow of RF power along field to divertor



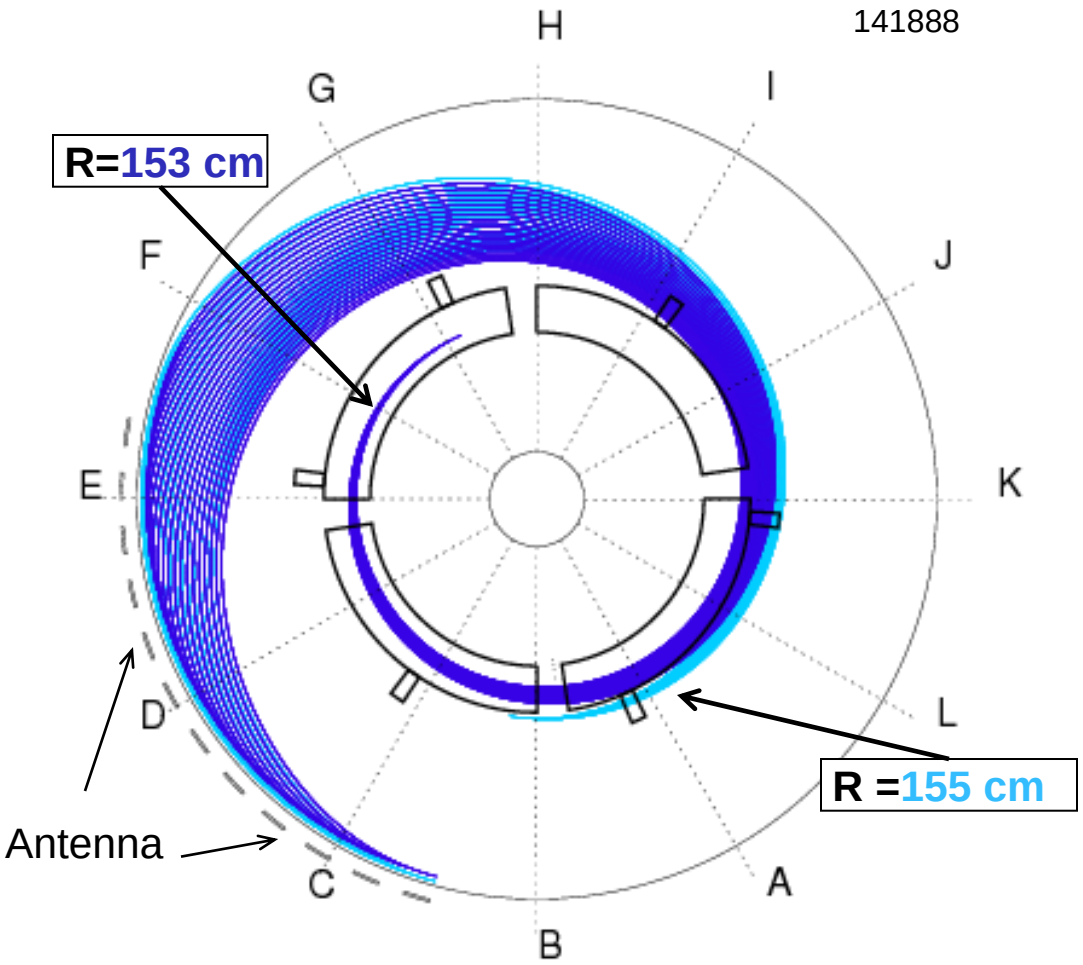
- Follow field lines using SPIRAL
- Start field lines several centimeters off of antenna
- Field lines spiral and focus radially around the center column

At midplane: R_{ANT} = 157.5 cm

R_{LCFS} = 151 cm

*** G.J. Kramer, Session GO4 contributed talk, Tuesday 11:42**

Field-line mapping (SPIRAL code*) models flow of RF power along field to divertor



- Follow field lines using SPIRAL
- Start field lines several centimeters off of antenna
- Field lines spiral and focus radially around the center column
- Field lines started farther into SOL spiral in more

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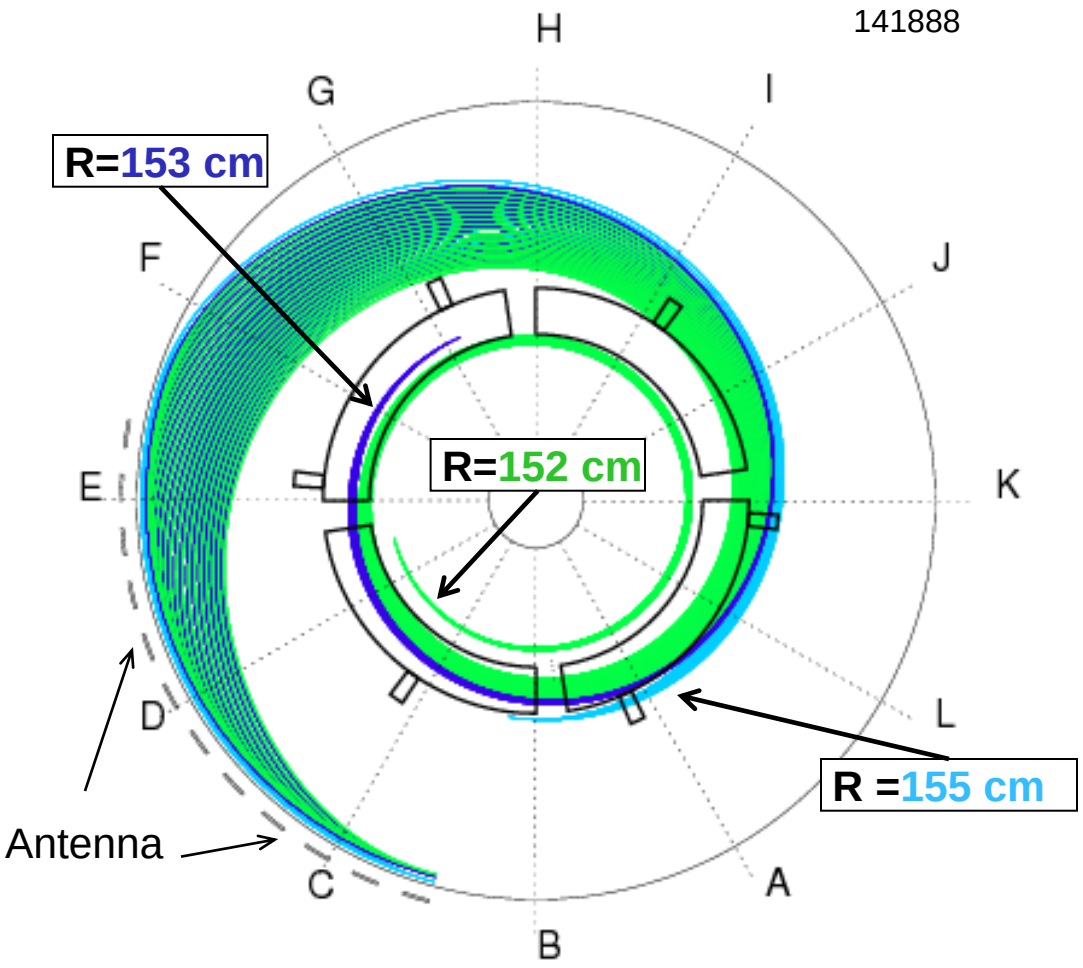

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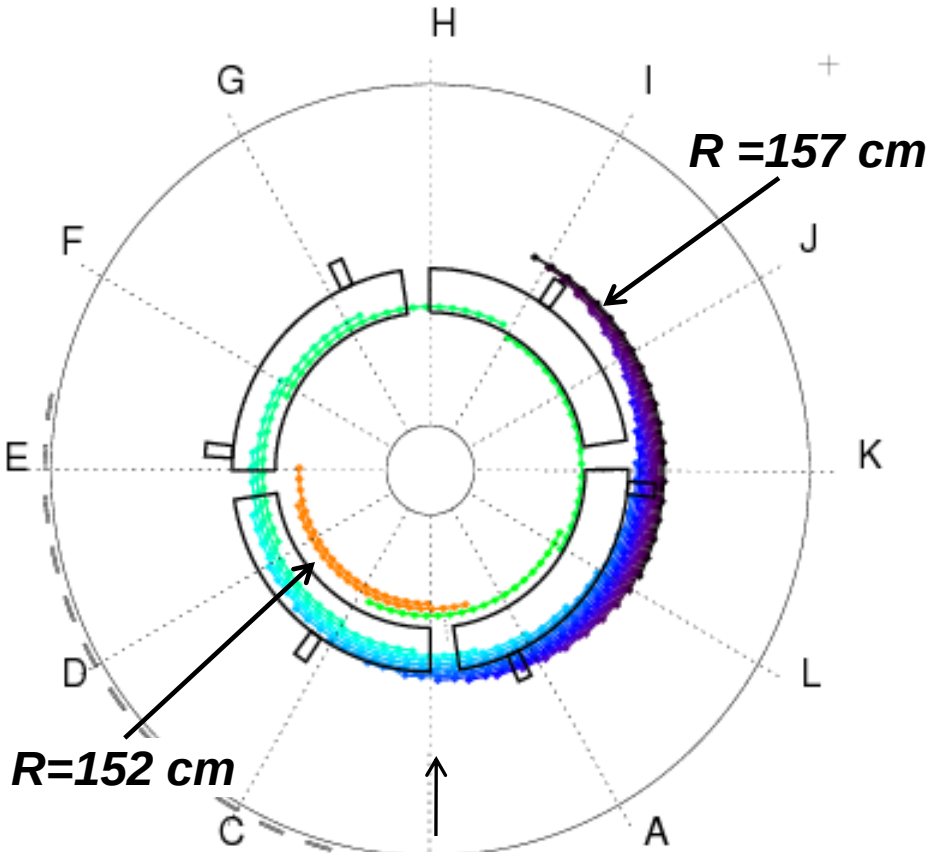
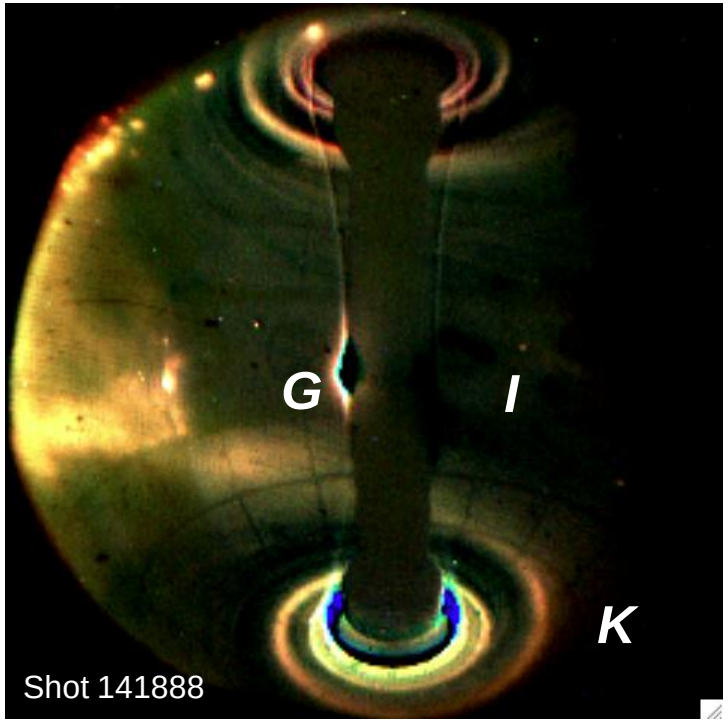
- Follow field lines using SPIRAL
- Start field lines several centimeters off of antenna
- Field lines spiral and focus radially around the center column
- Field lines started farther into SOL spiral in more
- Field lines to probe come from 153 cm at midplane, well away from the antenna

Field-line mapping to the divertor closely matches the observed RF spiral

Strike points on divertor for field lines started at midplane

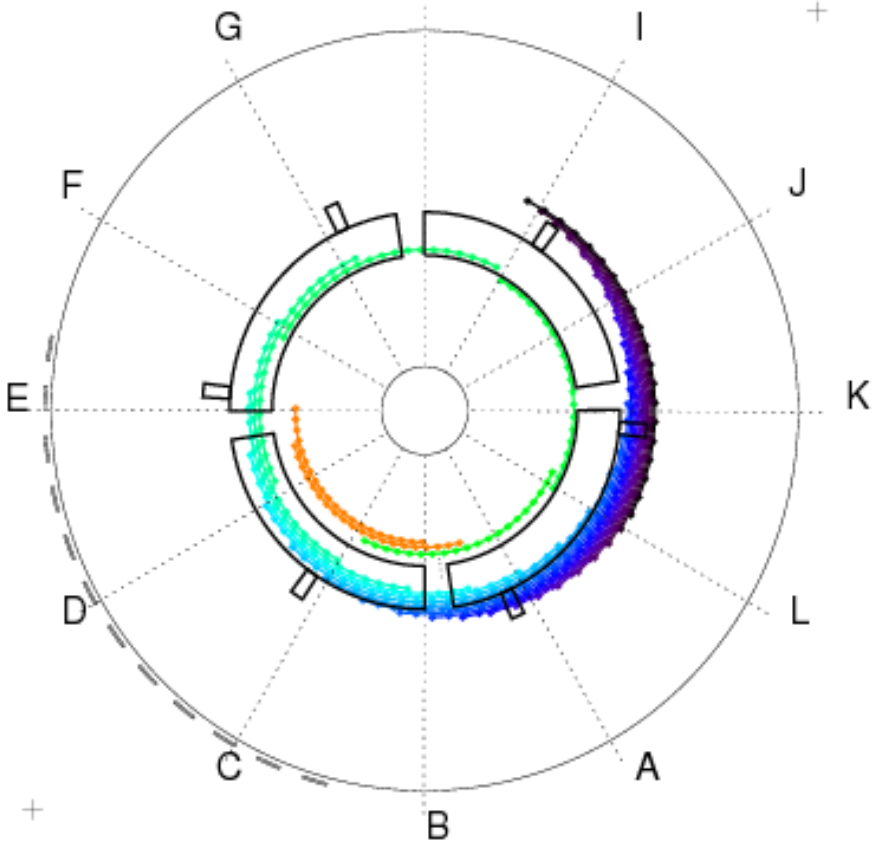


Gives spiral pattern close to camera images

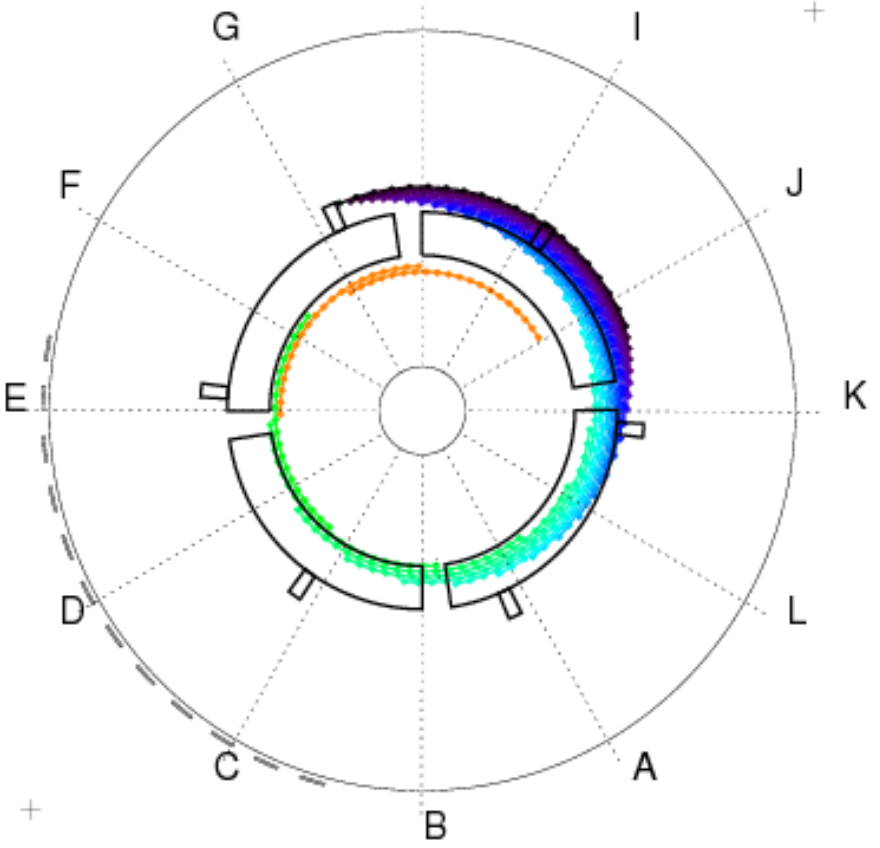


Numerically-generated spiral moves with pitch as observed experimentally

Low Pitch

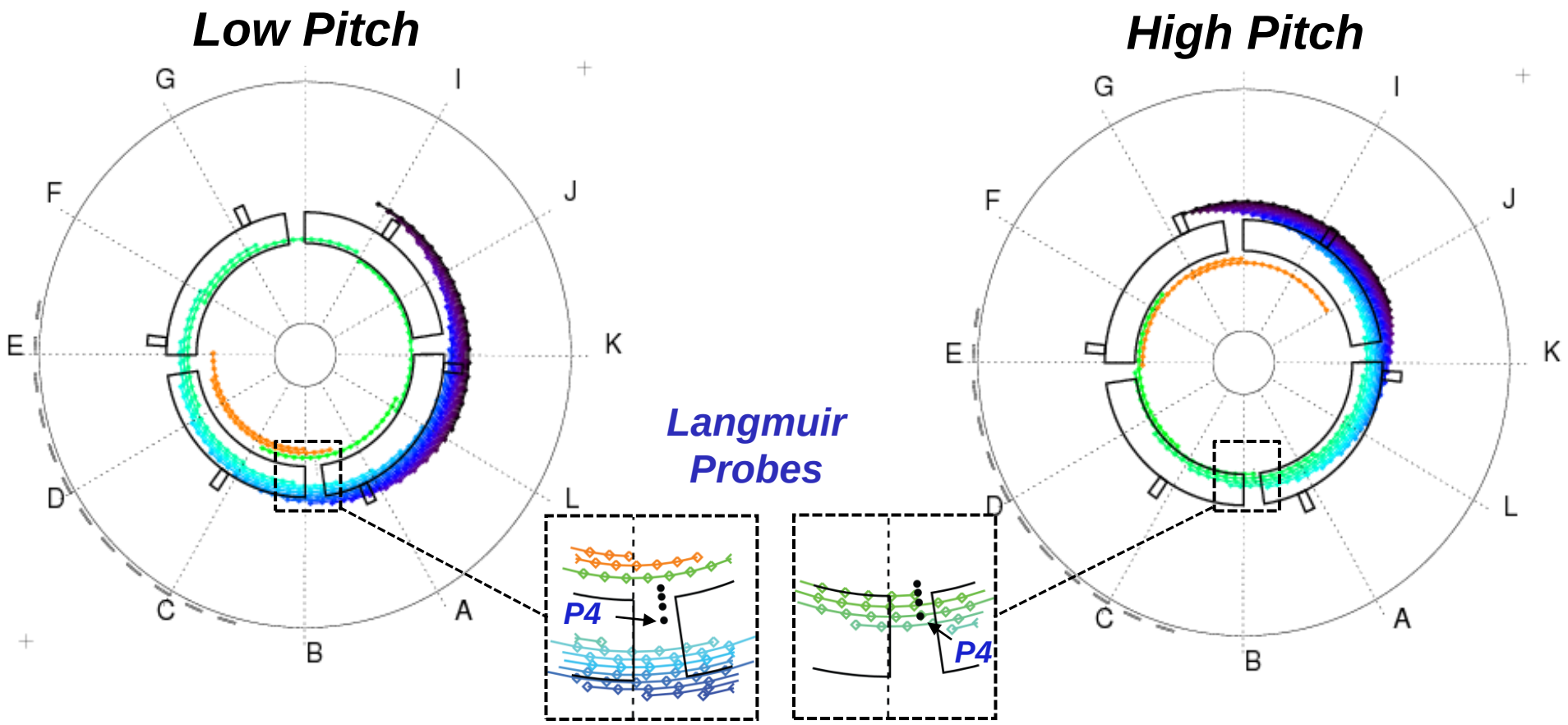


High Pitch



- Spiral rotates counter-clockwise as pitch increases
- As a result, the spiral major radius decreases at any given toroidal location

Modeling indicates that edge RF power propagates along field lines



- Computed strike point spirals match tile and probe measurements
- High field pitch places spiral at probe 4 location
  - Probe connected to SOL 4 cm away from antenna

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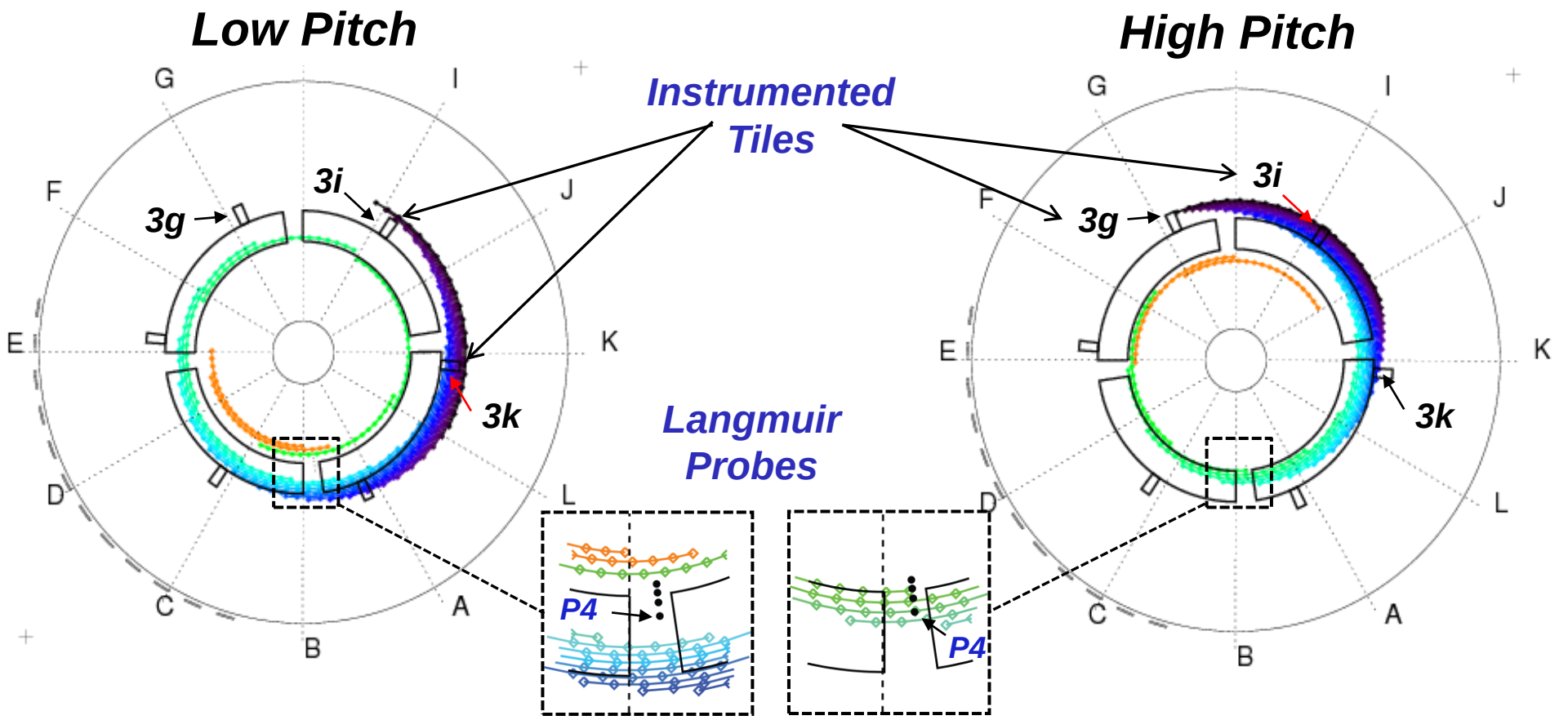

- Computed strike point spirals match tile and probe measurements
- High field pitch places spiral at probe 4 location
  - Probe connected to SOL 4 cm away from antenna
- Spiral goes over tile 3i and off of tile 3k with increasing pitch

Summary

- RF-generated spiral moves with change in magnetic pitch
  - Increased pitch causes major radius to decrease
  - Langmuir probe and divertor tiles show strong RF-response when under the RF spiral
- Field-line mapping reproduces experimental observations
  - Reproduces spiral pattern when field lines from SOL in front of antenna are included.
  - Higher pitch rotates the spiral counter-clockwise
  - Explains movement of spiral over diagnostics
- Much of the RF power-deposition spiral comes from the SOL between antenna and separatrix
  - Could be consistent with location of onset density for perpendicular fast wave propagation