ORNL Contribution to HHFW Heating and CD

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Goals for HHFW System

- Understand and improve the HHFW core propagation and absorption, heating, and current drive efficiency.
- Understand and improve the power propagation through the edge plasma and its deposition in the core.
- Increase the HHFW power and reliability
- Provide heating power to transition from non-inductive startup plasmas to NBI target plasmas.
- Develop ability to deliver power to NBI-driven H modes through L-H transitions.
- Provide a reliable tool for Integrated System Development.

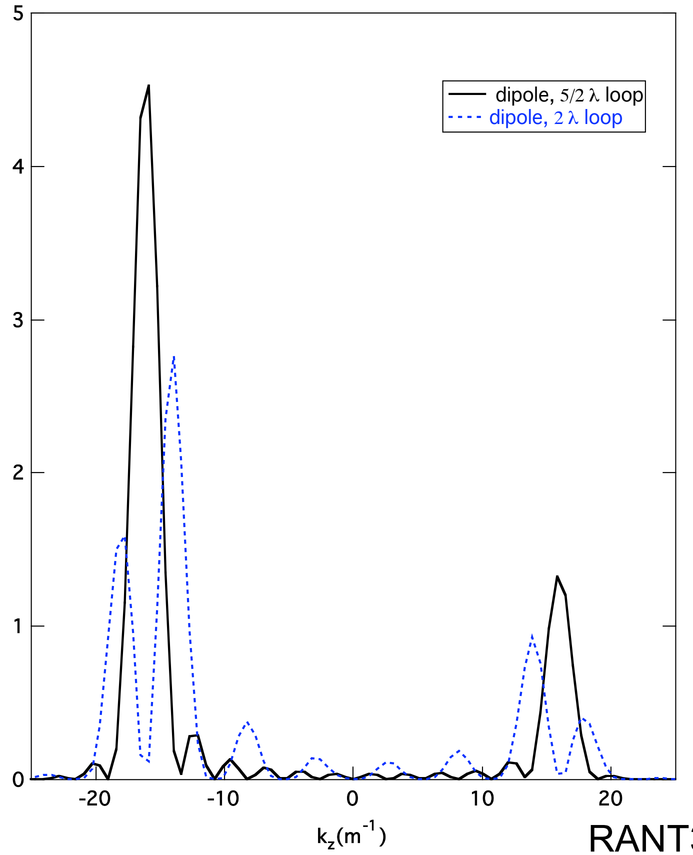
Staged improvements to HHFW System

- Investigate other spectra for improved core heating and current drive efficiency.
- Modify current straps for improved power handling.
- Redesign HHFW antenna array for improved performance and power (6 or 8 strap arrays?).
- Operational improvements
  - Voltage feedback control of power during load transitions.
  - Load feedback control of plasma position
  - Central temperature feedback control of array phasing.
- Improve performance of edge reflectometer
  - Full quadrature measurement of complex phase voltage.

Connecting strap pairs in phase (5/2 λ loops) leads to pure directional spectra at higher k_z

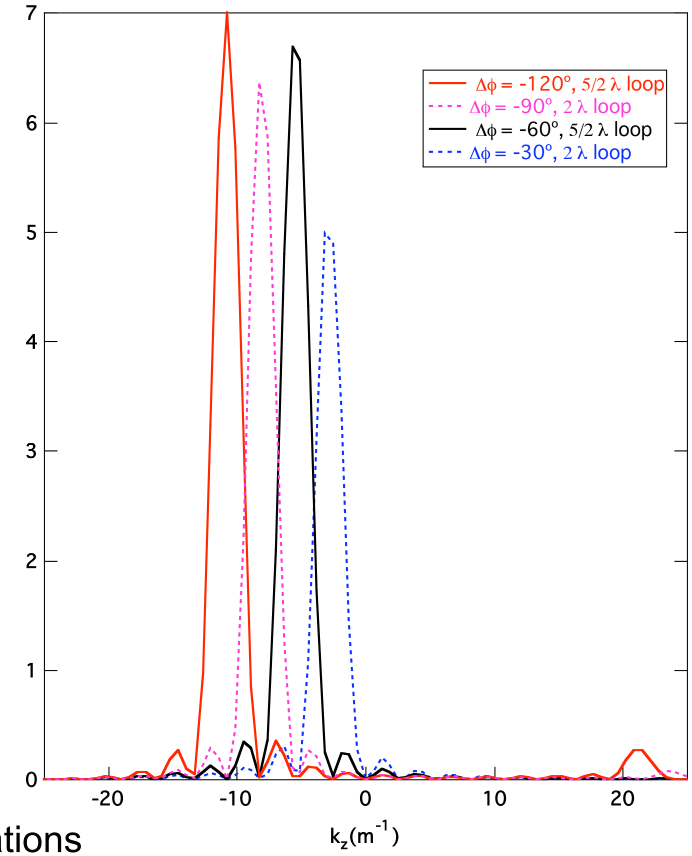
Heating (Dipole) Phasing

2λ connection: peaks at both ±14, 18 m^{-1}
5/2 λ connection: peaks at ±16 m^{-1}



Current Drive Phasing

2λ connection: -8 m^{-1}($\Delta\phi$=-90°), -3 m^{-1}($\Delta\phi$=-30°)
5/2 λ connection: -11 m^{-1}($\Delta\phi$=-120°), -6 m^{-1}($\Delta\phi$=-60°))



RANT3D Calculations

Improve power handling and reliability

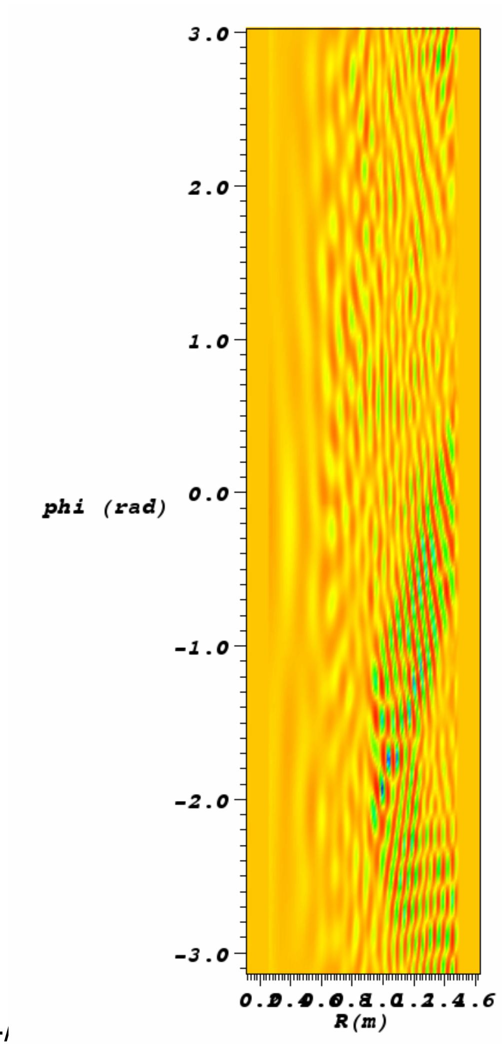
- The plasma loading is typically low for:
  – Array phasing for counter-CD operation.
  – Steep density profiles associated with H-mode.
  – Large antenna-plasma gaps, needed for antenna protection from fast ions when using NBI at low magnetic fields.
- Present current straps are grounded at one end and peak voltages occur at the opposite end of the strap.
- Reliable power capability can be doubled for the same voltage holding on the straps by locating a virtual ground at the center of the strap.
- Fabrication and installation of new straps and doubling the number of vacuum feedthroughs.

HHFW Theory Support

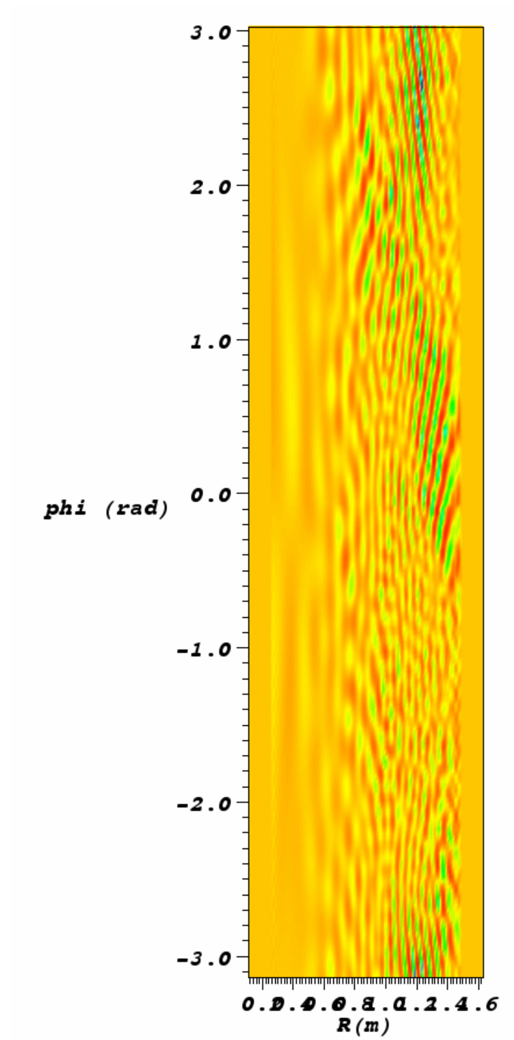
- HHFW Coupling to fast ions
  - Full time-dependent energetic tail evolution including radial diffusion and finite orbit effects.
  - Effects of a second non-Maxwellian ion species
- PDI excitation
  - Develop resonant 3-wave interaction package to study “extended pump”
- Collisionally enhanced absorbtion (AORSA-1D)
- Full Wave Power Propagation Studies in 3D
  - Edge losses, far field sheaths

Wave field in equatorial plane for 81 toroidal modes

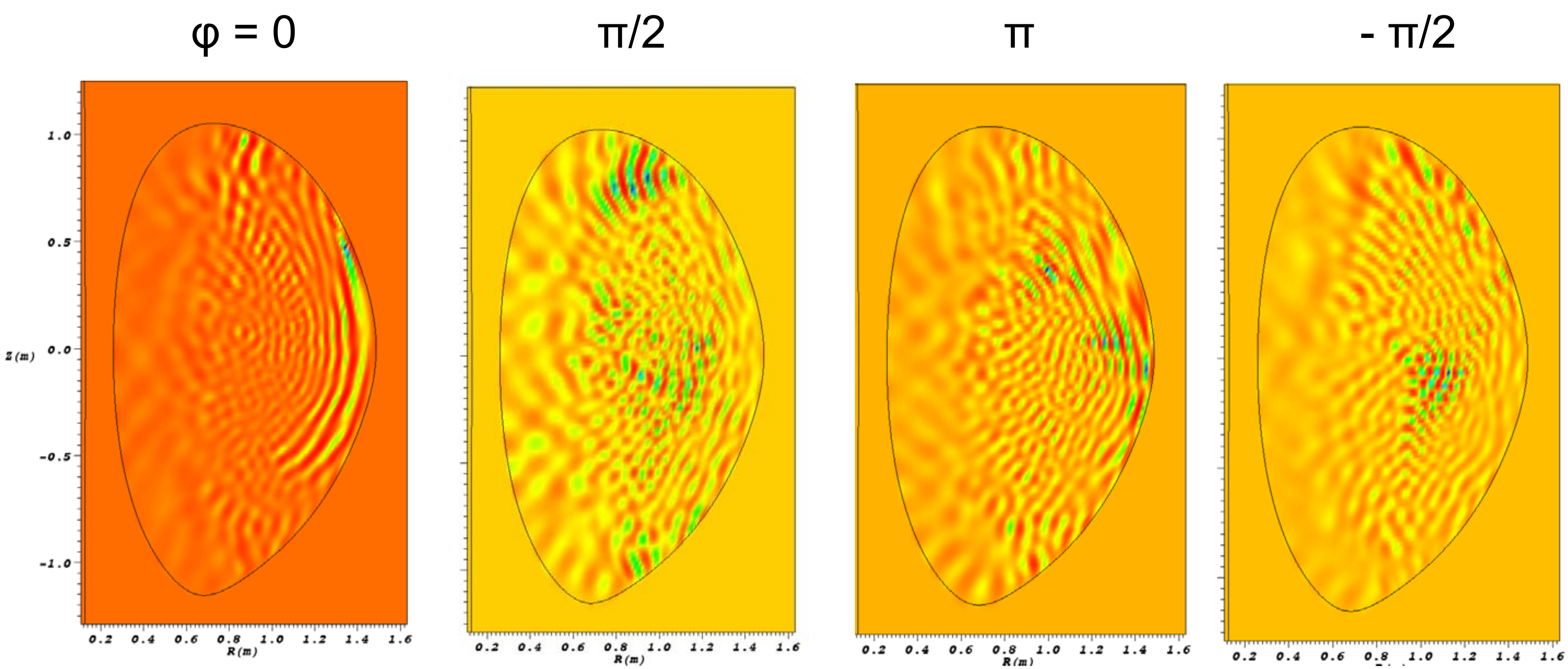
Phase = -90 degrees



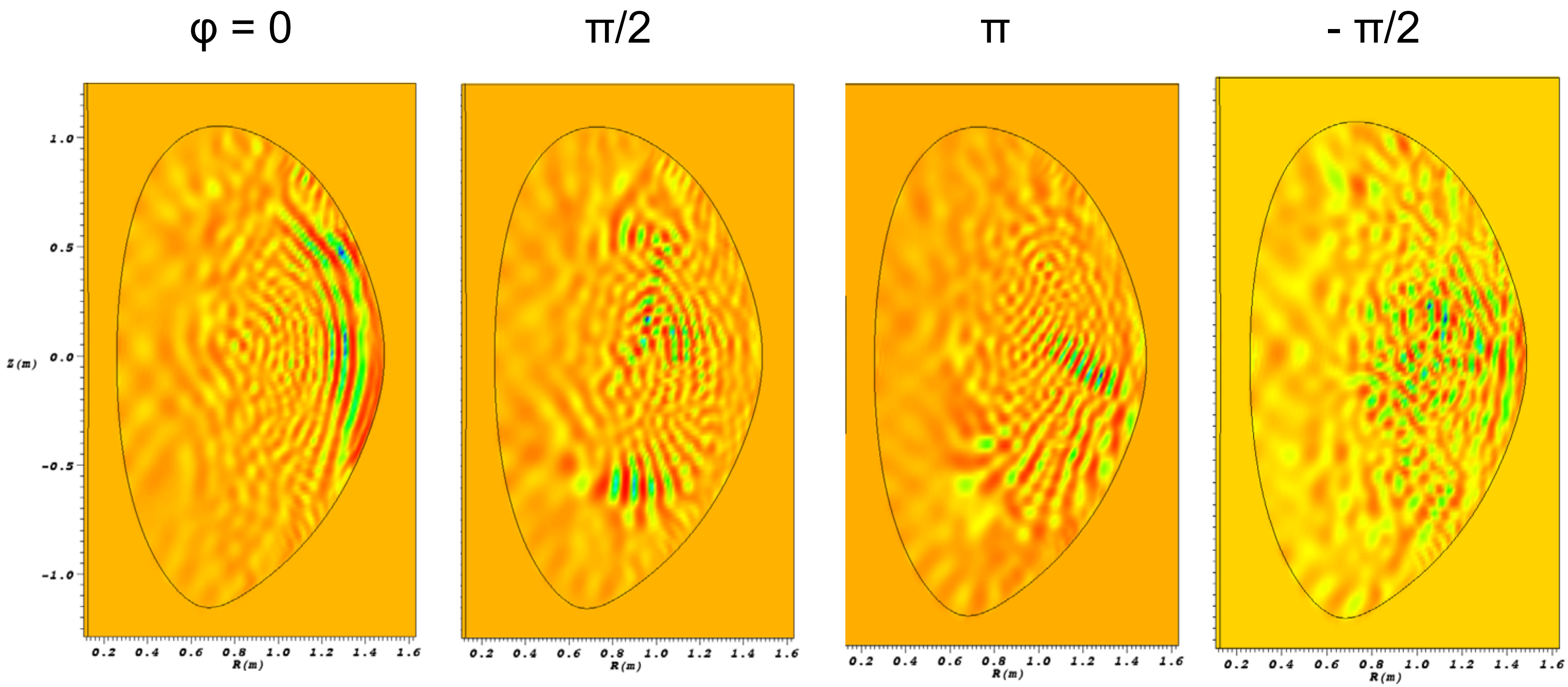
Phase = 90 degrees



Wave field- toroidal cut in the midplane of the antenna for phase angle = -90 degrees

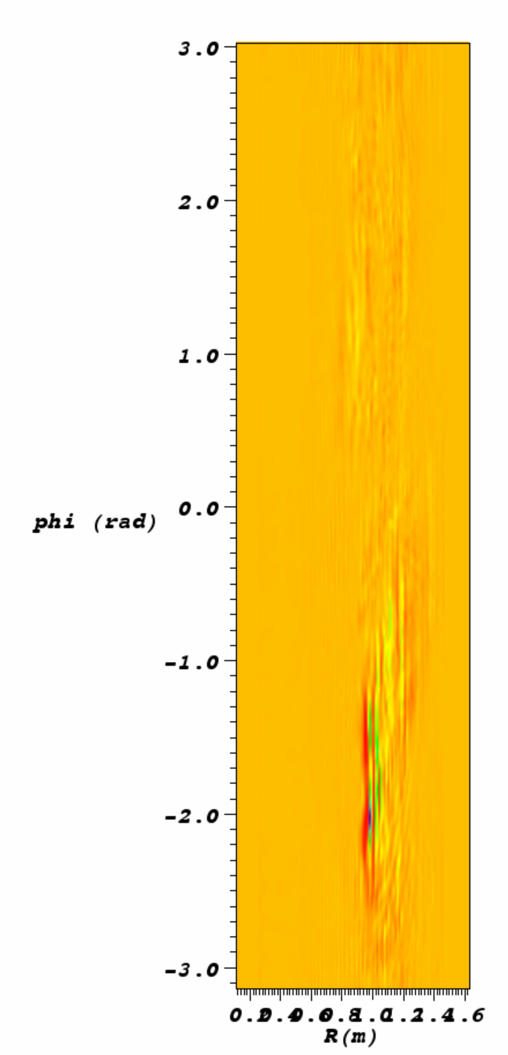


Wave field- toroidal cut in the midplane of the antenna for phase angle = +90 degrees

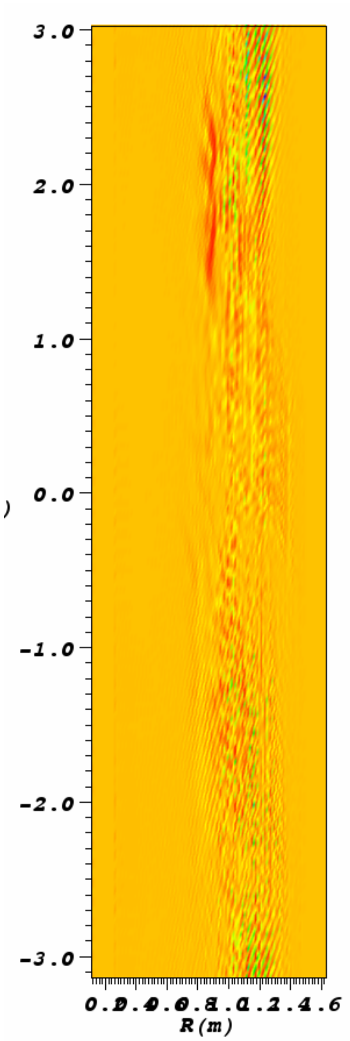


Power absorbed in the equatorial plane

Phase = -90 degrees

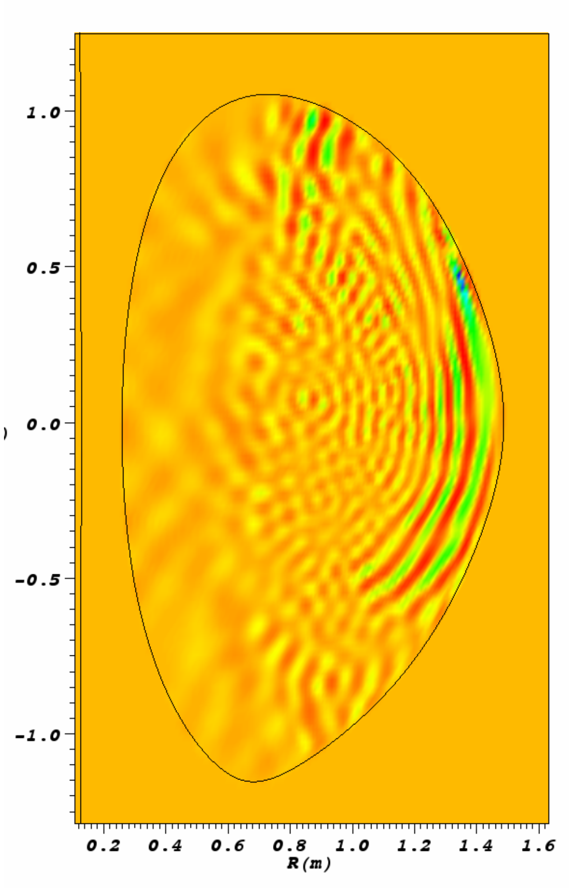


Phase = 90 degrees



Wave field- toroidal cut in the midplane of the antenna

Phase = -90 degrees



Phase = 90 degrees