# *A Core to Edge Model for Radio Frequency Simulations in Tokamaks*

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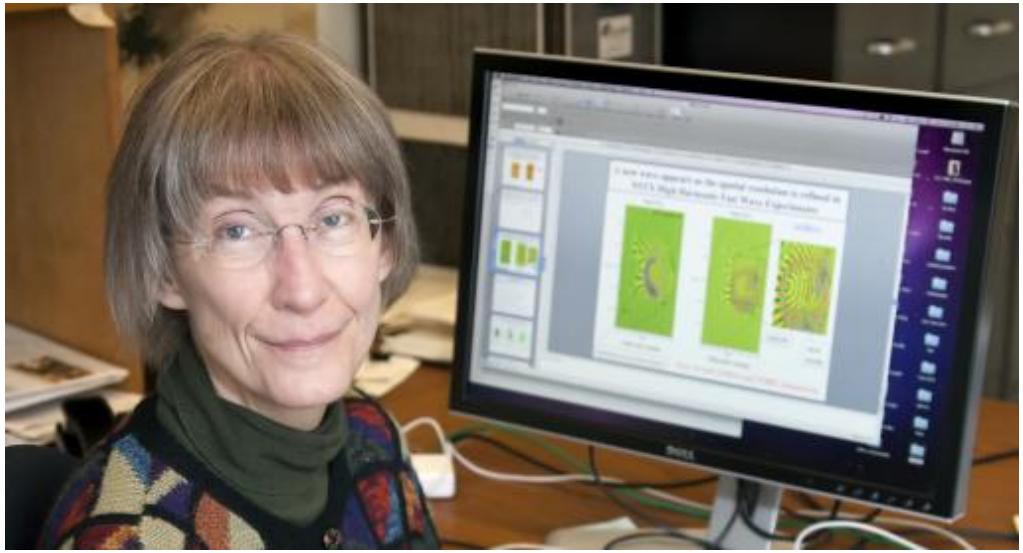
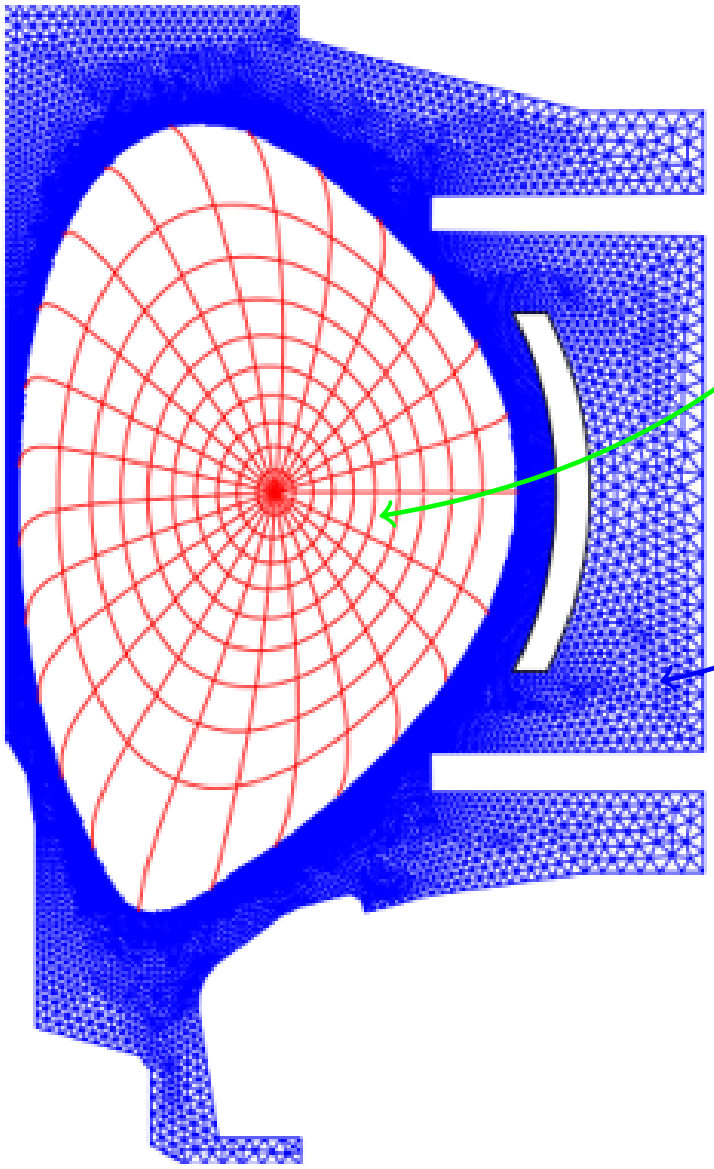
Fisch Symposium, March 28–30 2016, Princeton, NJ

# Cynthia Phillips 1954-2015



# GOAL: INTRODUCING REALISTIC SOL BOUNDARY PLASMAS TO TORIC ICRF SOLVER



- TORIC
  - Well validated solver for hot core plasma
  - Spectral solver, flux aligned mesh
- FEM solver in SOL plasma
  - Complicated geometry
  - Open field lines
- Can we solve two regions separately and connect them later?
- In the simplest form, both core and edge are linear problems$\rightarrow$ Solution can be obtained by linear combination of solutions obtained by different boundary values.

# Mode Matching Technique

- Mode matching method is a particular way of coupling linear systems.
- Calculate the separate solutions in core (in) and edge (out) regions for different modal excitations. Then superimpose the solutions, so that boundary conditions are satisfied.
- Electric fields match for each mode at interface by construction
- Matching magnetic fields in presence of antenna currents given the matching amplitudes.

- $\left(\overleftrightarrow{B}_{\text{in}} - \overleftrightarrow{B}_{\text{out}}\right) \cdot \mathbf{x} = \overleftrightarrow{B}_{\text{ant}}$
- Where $\overleftrightarrow{B}$ is the array of rf magnetic field responses for each electric field boundary condition and Bant is the projection of the antenna created rf magnetic field on the same basis.
- Overhead is approximately a factor of 2:

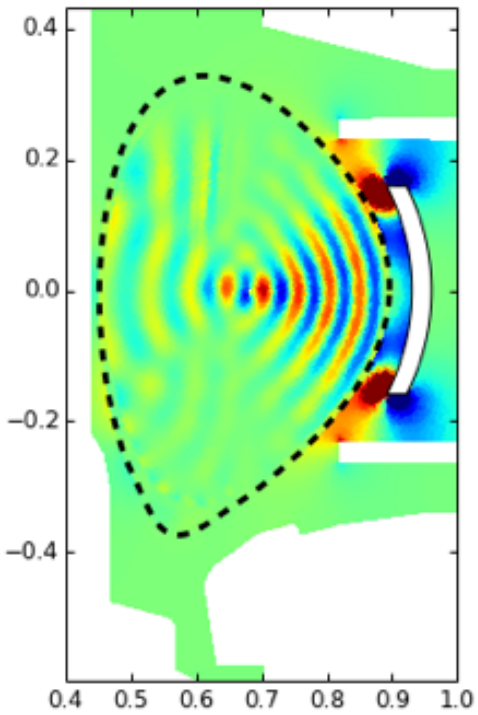
$$\overleftrightarrow{A}\mathbf{x} = \mathbf{b} \quad \text{order } N^3$$

$$\overleftrightarrow{A}\overleftrightarrow{X} = \overleftrightarrow{B} \quad \text{order } 2N^3$$

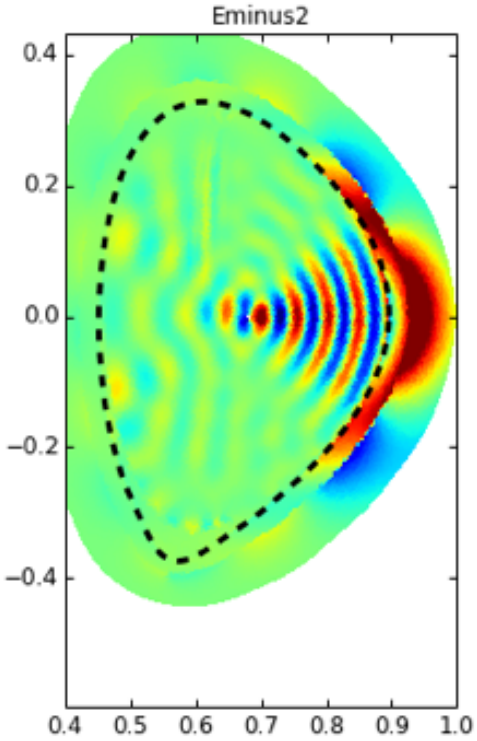
- Changes in B.C. do not require running edge and core codes again.

# Matching algorithm is implemented on the flux coordinates, handling shaped tokamak is straightforward.

TORIC-COMSOL




TORIC standalone




- Test under strong single pass absorption
- Using the same profiles, equilibrium, and antenna source
- Core wave field is very similar, but now with correct edge RF field

# Applications

- Plasma with cold plasma dielectric in edge with refinement of Grad-Shavronov solution and computation of diffusion model for density on open field lines.
- Extensions to HHFW in NSTX, Helicon in DIIID, LHCD in C-Mod
- 3D antenna geometry
- RF sheath boundary condition
- First steps towards whole device model for RF.