NSTX-U

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Advanced RF Codes Supporting HHFW Research on NSTX-U

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for

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Theory & Computation Brainstorming
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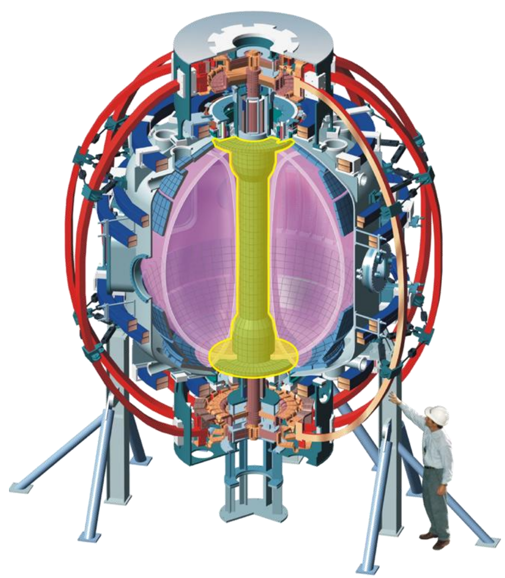

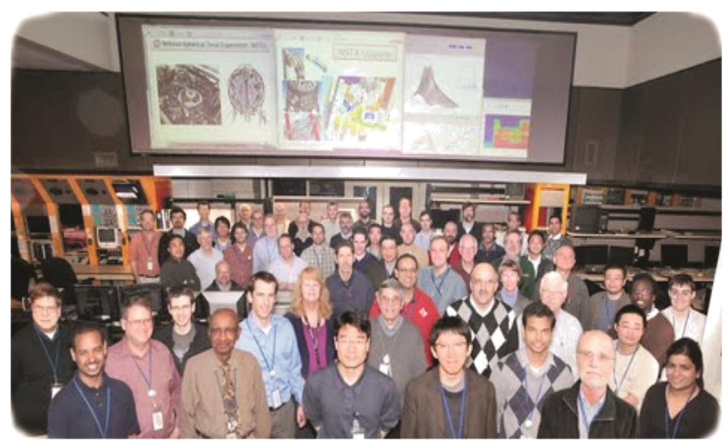

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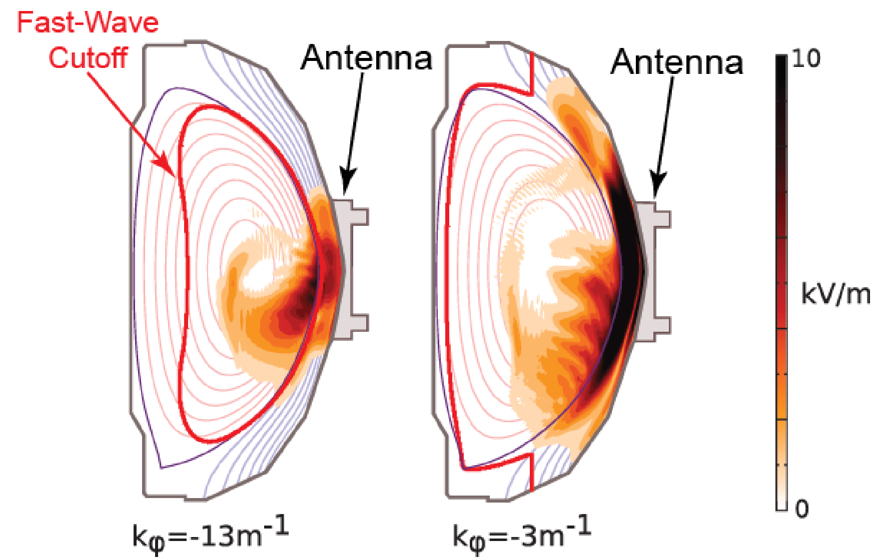
Paths forward for modeling HHFW-edge interactions in NSTX-U plasmas

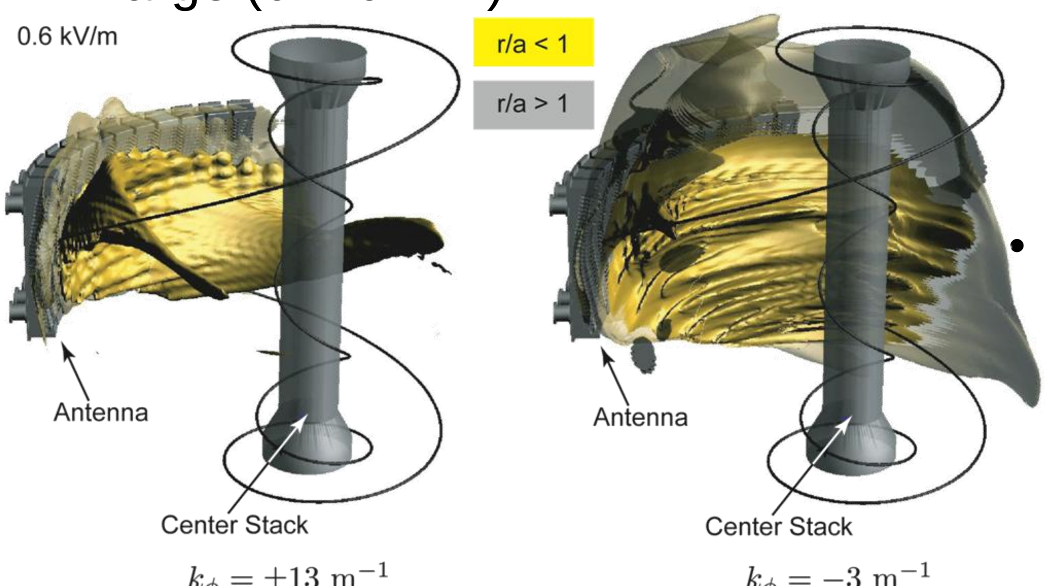
- The spectral solver AORSA has been extended to the wall in NSTX:
  - Uses a realistic wall shape and SOL plasma
  - Employs only a current sheet for the antenna
- Alternately couple core spectral solvers (AORSA and TORIC) to either finite element method (FEM) or particle-in-cell (PIC) codes:
  - FEM codes (for example COMSOL or TOPICA) could accurately describe the 3D solid geometry of the antennas and vacuum vessel
  - PIC codes (for example VORPAL) could be used to simulate nonlinear effects such as RF sheaths or perhaps even PDI
  - Coupling of the edge and core solutions would require advanced algorithmic treatments
- **This work is on-going in the base theory program and RF SciDAC Center and could benefit NSTX-U in the FY2014-18**

AORSA full-wave code with boundary extended to wall and realistic antenna can be used to predict RF power loss in SOL

- Coaxial modes not seen in linear plasma wave dispersion or ray tracing approaches
- Has implications for ITER ICRH, where the distance between the antenna/wall and the separatrix is large (0.1-0.2 m)



2-D AORSA simulation for HHFW on NSTX H-mode shot 130608*



3-D AORSA simulation for HHFW on NSTX shot 130608*

- Future plans call for a quantitative comparison of predicted SOL electric fields with measurements:
  - Requires better resolution in the SOL & including geometry of the antenna & Faraday shield

*D. L. Green, *et al.*, Phys. Rev. Lett. 107, 145001 (2011)

Oak Ridge National Laboratory

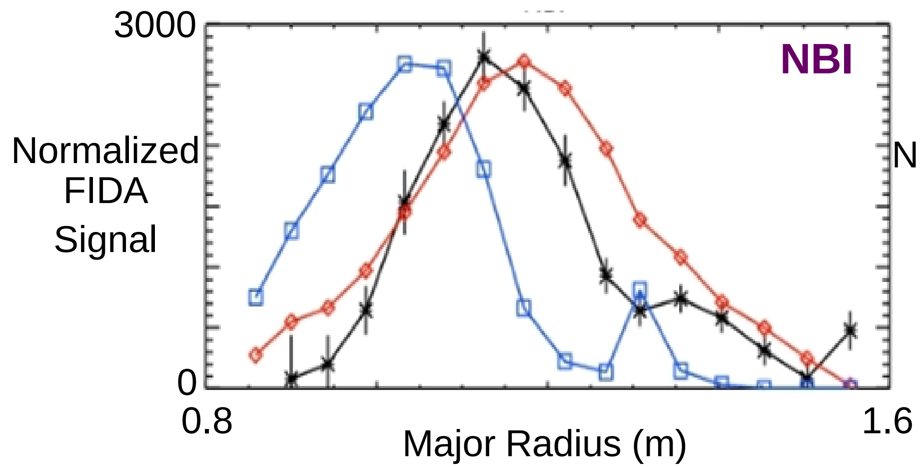
Steps to getting the HHFW heating operator in NUBEAM/TRANSP

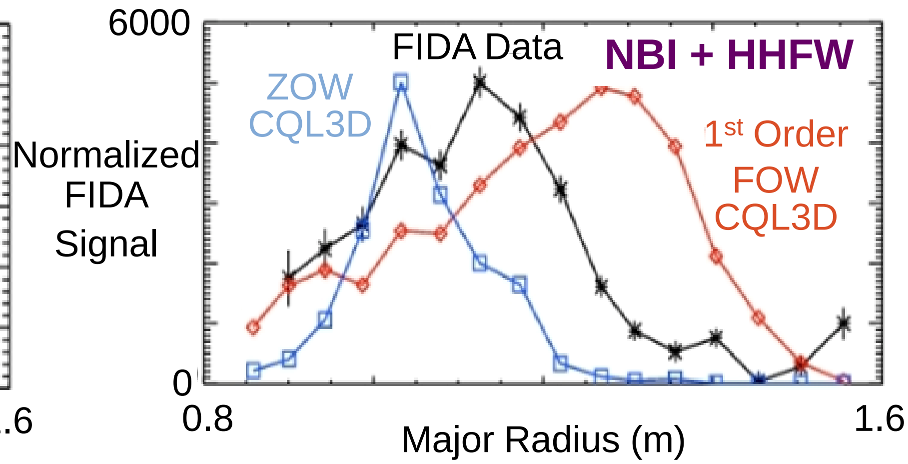
- NUBEAM is a 5-D guiding-center ion orbit integrator with Monte-Carlo operators (e.g., collisions, atomics, etc.)

Adding an HHFW RF operator will require:

1. A Monte-Carlo operator based on the continuum AORSA diffusion coefficients **[DONE]**
2. Implementing this operator in a simple particle code (sMC) for verification with CQL3D: **[Verification with CQL3D in progress]**
   - Essentially sMC is a stripped down NUBEAM, and jumping straight into NUBEAM here would be a mistake
3. Completing the quasi-linear iterative loop by taking the particle code result and creating an AORSA input **[DONE - p2f]**
4. With a verified proof-of-principle in the sMC-p2f-AORSA coupling, apply this to the NUBEAM / TRANSP framework (Specifically to the Cartesian version of NUBEAMs integrator)

Full-orbit, finite-orbit-width (FOW) CQL3D can accurately model neoclassical transport, ion loss & heat flowing to SOL





- First-order FOW CQL3D Fokker-Planck code implemented last year:
  - Good agreement with FIDA for NBI; over estimates radial shift for NBI + HHFW
- Recent results from full-orbit FOW CQL3D show reduced orbit shift:
  - Big differences between predicted HHFW power absorbed by ions and electrons for ZOW (no losses), ZOW (1st order banana loss), and full-orbit FOW CQL3D
- Full-orbit neoclassical transport, an interface to the FIDA fast-ion diagnostic, and modeling of losses to SOL and wall are now being implemented
- Initial tests of full-orbit FOW CQL3D show accurate modeling of fast-ion losses and broader profiles of power absorption and RF-driven current

CompX SM