NSTX-U

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Chapter 7: NSTX-U Wave Heating and Current Drive Research Goals & Plans for FY2014-18

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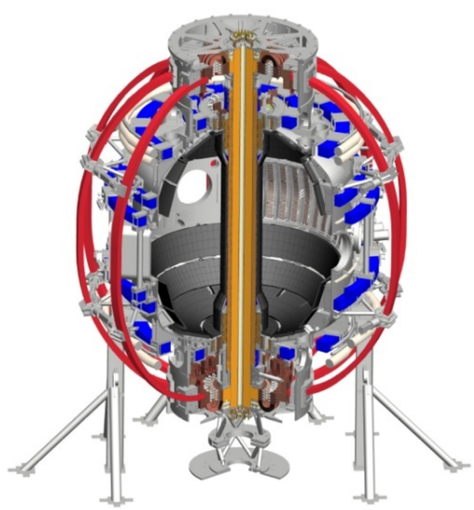

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Chapter 7 Outline

7.1: Overview of Research Thrusts & Plans

7.2: Research Plans

7.3: Timeline for Tool Development

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Research Thrusts to Develop Fully Non-inductive RF+NBI H-modes & Validate Advanced RF Codes

NSTX-U HHFW/EC/EBW Research Thrusts:

- Develop HHFW and EC/EBW heating and current drive for fully non-inductive plasma start-up and H-mode sustainment
- Optimize HHFW current drive in HHFW and HHFW+NBI H-mode plasmas
- Determine the validity of advanced RF codes for NSTX-U RF-heated plasmas and use these codes to predict RF performance in FNSF and ITER

Required research:

- Assess HHFW interaction with neutral beam fast-ions, and develop capability to heat high-power NBI H-modes with HHFW
- Mitigate HHFW power losses in scrape off layer of H-mode plasmas
- Model and implement ECH/EBWH to support plasma startup and local heating and current drive in NBI H-modes
- Develop advanced RF codes that include SOL, realistic antenna geometry and accurately model interaction between the wave fields and NBI fast-ions

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Research Plans for Years 1-2

- Assess performance of 12-strap, double-feed antenna and its compatibility with NBI H-modes [**Hosea**, Perkins, Wilson]*
- Evaluate, study and mitigate RF power flows in the SOL and to the divertors in the H-mode regime [**Hosea**, Perkins, Wilson]
- Heat I_p ~ 300 kA plasma with HHFW power to achieve sustained 100% non-inductive H-modes, and non-inductively ramp I_p with HHFW power [**Taylor**, Raman]
- Study HHFW interaction with NBI fast-ions and model with advance RF codes [**Taylor**, Podestà, LeBlanc]
  - RF modeling predicts a much higher fraction of HHFW power interacting with ions at the higher toroidal fields possible in NSTX-U, compared to NSTX

*coauthor(s), **with lead coauthor in bold**

Research Plans for Years 3-5

- Test high-power ECH system for plasma start-up - assess impact on achieved closed-flux current, discharge pulse-length, and non-inductive fraction [**Taylor**, Raman]

- Utilize HHFW to assist start-up plasma formation and compare to ECH [**Taylor**, Raman]

- Assess impact of HHFW electron heating on NBI current ramp-up [**Taylor**, Raman]

- Simulate and/or mock-up HHFW antenna performance using a reduced number of antenna straps [**Hosea**, Perkins, Wilson]

- Test reduced-strap HHFW system and optimize plasma start-up, ramp-up, and sustainment during NBI H-mode [**Hosea**, Perkins, Wilson]

Research Plans for Years 3-5 – (continued)

- Test 28 GHz (1-2 MW, 1-5s) EBW system with fixed horn for heating studies, and perhaps EBW current drive with a steerable mirror launcher [**Taylor**]
- Pending successful EBW heating results project EBW CD performance to a FNSF/CTF [**Taylor**]

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7.3.1: Theory and Simulation Capabilities [Phillips]

- AORSA-3D full-wave code for HHFW modeling, including SOL and realistic antenna model [**Green**]
- AORSA/ORBIT-RF full-wave/Monte-Carlo code for HHFW modeling of NBI plasmas [**Choi**]
- TORIC full wave code, with SOL model, and SPIRAL code for HHFW modeling [**Phillips**, Valeo, Bertelli, Bonoli, Wright, Kramer]
- GENRAY ray tracing modeling with SOL model and edge fluctuations for HHFW modeling [**Phillips**, Bertelli, Harvey, Bonoli]
- Full finite orbit width CQL3D Fokker-Planck code for HHFW modeling of NBI plasmas [**Harvey**, Petrov]
- Use of DC (Diffusion Coefficient code) for NSTX-U [Harvey]
- GENRAY and TORBEAM ray tracing for ECH modeling [**Harvey**, Bertelli]
- GENRAY/CQL3D for EBW heating and current drive modeling [**Harvey**]
- Upgrade NUBEAM with RF operator for HHFW modeling of NBI plasmas [**Green**]

7.3.2: Diagnostics

- Fast IR for SOL power losses [**Hosea**, Perkins, Wilson]
- Measurements of SOL E-fields during edge power loss [**Hosea**, Perkins, Wilson]
- RF probes in protective tiles above and below antenna to document RF power flow to divertor for comparison to advanced RF codes [**Hosea**, Perkins, Wilson]
- Diagnostic enhancements to measure fast-ion distribution from HHFW acceleration [**Podesta**]
- 10-40 GHz edge reflectometer for HHFW [**Taylor,** Ryan]

7.3.3: Other Facility Capabilities

- Implement compliant attachments between antenna current straps and RF feed throughs to withstand 4x increase in disruption loads [**Hosea**, Ryan, Perkins, Wilson]
- Modifications to NBI armor/limiter to allow HHFW operation with high NBI power [**Hosea**, Ryan, Perkins, Wilson]
- Implement EHO and/or *AE antenna [**Hosea**, Fredrickson, Goldston]
- Modify HHFW antenna to have reduced number of straps [**Hosea**, Ryan, Perkins, Wilson]
- Implement 28 GHz (1-2 MW, 1-5s) EC/EBW heating system with fixed horn [**Taylor**, Ellis]
- Upgrade 28 GHz EBW antenna to metal steerable mirror for EBW heating and current drive studies [**Taylor**, Ellis]