NSTX-U

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PAC-35 Response, SFPS and Ramp-UP

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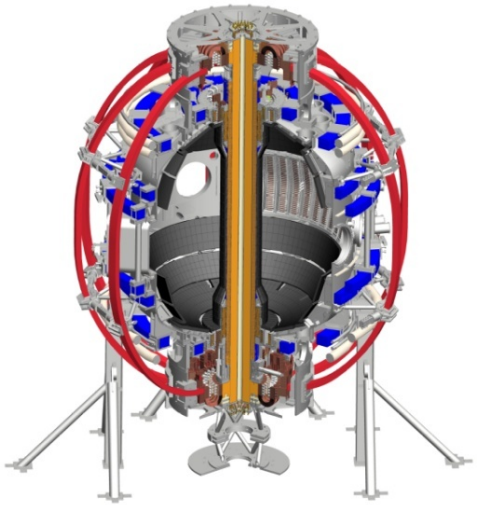

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Solenoid-Free Start-Up and Ramp-Up

One of the most critical issues that must be resolved for an FNSF-ST is that of initiating the plasma and ramping to full current without relying on a solenoid to drive current. The PAC commends the NSTX-U team for addressing this issue using capabilities that are unique to the NSTX-U device.

- Thank you.

The initial current ramp, to approximately 400 kA, will be driven using Coaxial Helicity Injection (CHI). This was demonstrated in NSTX, with as much as 200 kA driven current. Credible scalings predict this should reach 400 kA or more in NSTX-U.

- Yes, we agree

Solenoid-Free Start-Up and Ramp-Up

Previous attempts at handing off the resulting cold plasma to other tools to complete the current ramp (solenoid, fast wave [FWCD], and/or neutral beam current drive [NBCD]) met with limited success.

- Yes, current ramp-up was demonstrated successfully only with the solenoid. While this is the first logical test that needs to be conducted of any new plasma start-up method, it is not FNSF relevant. The real objective is ramping it up with a non-inductive current drive method, which is a high-priority goal of the NSTX-U program.

NSTX-U plans to obtain a 28 GHz gyrotron to heat the electrons in the CHI plasma to a level where these other tools can efficiently drive current.

- Yes, this is necessary to increase the electron temperature of helicity-started plasmas.

Solenoid-Free Start-Up and Ramp-Up

Ultimately, a combination of FWCD and NBCD is planned to complete the current ramp noninductively. There are several challenges involved in the full nonsolenoidal ramp scenario. Previous experience in NSTX has already demonstrated sufficient plasma control to form closed flux surfaces and avoid contact between the CHI plasma and the walls. Also, in the past the NSTX team did not usually mix fast wave and neutral beams as the rf tended to be absorbed by beam ions.

- Yes, we agree

Solenoid-Free Start-Up and Ramp-Up

The plans for the first two years of NSTX-U operation appear to address the right issues. The PAC cautions that sufficient experimental time will need to be made available to develop the current ramp. Early experiments will need to determine the limits of CHI plasma formation, and in particular determine the maximum achievable current without use of the solenoid. Although separate experiments can and should be done to develop a FWCD/NBCD current ramp starting at 400 kA (presumably using the solenoid to get there), a full demonstration of nonsolenoidal startup will have to wait for availability of the 28 GHz gyrotron. The PAC is, however, concerned at the early stage of development of this gyrotron coupled with its importance for the entire current ramp scenario. We urge that this development be expedited as much as possible, as it appears to set the critical path for a full current ramp demonstration.

- Yes, we agree. The experimental work on non-inductive ramp-up will be conducted in parallel with simulations to develop a realistic model for ramping-up CHI-started plasmas starting in FY17. Validation of NBCD is in fact high priority in the development of credible scenario simulations for non-inductive current ramp-up and sustainment. We plan to prepare simulations for variations of the input parameters (like pressure amplitude and peaking factor) of about 30% and use NBCD experiments to validate simulations and to design new, optimized discharges.

Solenoid-Free Start-Up and Ramp-Up

The PAC further commends the NSTX-U team for the extensive effort that is underway to apply modeling tools including NIMROD, TSC, and TRANSP to the problem. We look forward to results of further simulations including more realistic assumptions for fast wave coupled power. These tools will also be very useful for both prediction and interpretation of the upcoming experiments.

- Yes, thank you. Our goal is to develop realistic models to allow extrapolation to a ST-FNSF. We plan to present improved simulation results during the next PAC meeting.