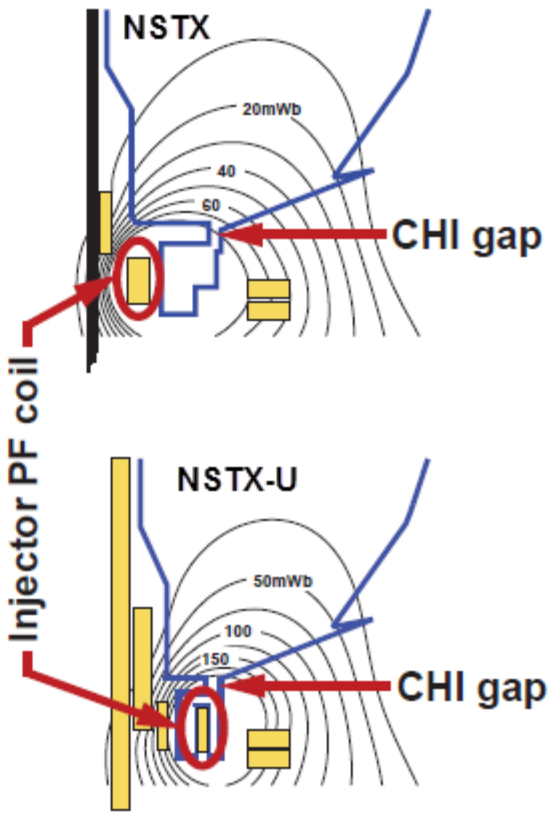
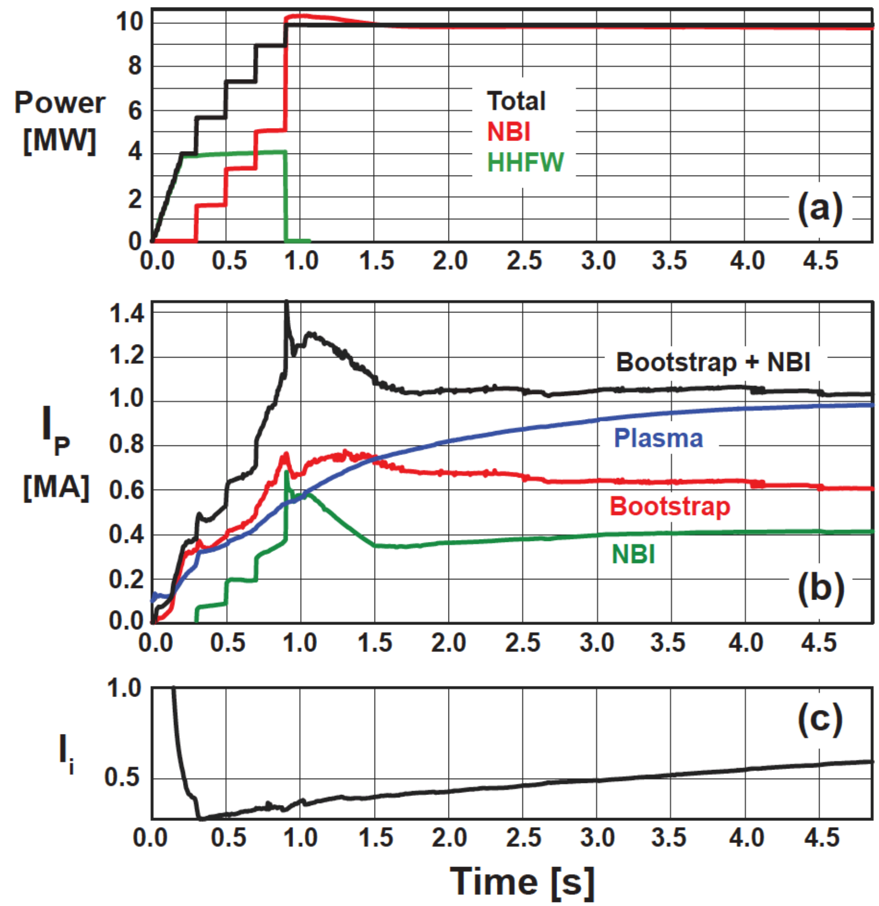
NSTX-U has the Potential for Full Non-Inductive Current Start-up and Ramp-up



Inj. Flux in NSTX-U > enclosed flux in 1MA plasma



TSC Simulations (C.E. Kessel) suggests current ramp-up from a 400kA target to 1MA should be possible in NSTX-U

R. Raman, S.C. Jardin, D. Mueller, et al.,
Theory Needs for SFPS TSG (5 March 2012)

Benefits of Improving Computational Capability for SFPS TSG

- Full Non Inductive start-up and ramp-up is a major goal of NSTX-U
  - Needed to simplify ST/tokamak concept (remove systems not needed during SS operation and minimize auxiliary systems and power input during SS operation)

- For start-up: NSTX-U is configured for CHI Start-up and is now studying the implementation of point source helicity injection for plasma start-up

- For ramp-up: Work by C. Kessel suggests ramp-up from 400kA to 1 MA should be possible

- An improved computational understanding of two specific areas would allow NSTX-U to benefit from the start-up and and ramp-up capabilities and would better position it for more efficient use of experimental run time

- Conditions under which closed flux generation is maximized
  - Injector voltage time history, flux shaping
  - Plasma growth rate and its impact on absorber arcs, impurity radiation and impact on electron temperature
  - Auxiliary heating requirements

- Conditions under which neutral beams are able to ramp the current up to 1MA
  - Level of required initial start-up current and lower limits on electron temperature
  - Upper limits on electron density and its evolution
  - Impact of fast ion driven instabilities on NB current ramp-up
  - Impact of other plasma parameters on NB and NI current ramp-up

Red- SFPS specific   Blue- Also required for Advanced Scenarios TSG

Theory needs for SFPS and Disruption Mitigations Studies

Using resistive 3-D MHD models, determine the conditions for generating flux-surface closure at the end of the injection time, as in the experiment. (e.g. resistive effects, localized magnetic fluctuations). Obtain quantitative comparisons with experiment.

Using 2-D and 3-D MHD models, determine scaling of electron heating and temperature, etc., with injection parameters and electron thermal transport and the resulting effect on plasma current, size, flux-surface closure, etc.

Understand the requirements for current drive by neutral beams in a CHI or point source helicity injection generated target; determine conditions to successfully drive the current (e.g. is additional heating needed?), maximize plasma current, etc.

Understand the scaling of CHI current generation with respect to the amount of injected poloidal flux, divertor flux shape and injector current to allow extrapolation of the process to large devices

Develop a 3-D MHD model of point source helicity injection to understand the physics of current generation in NSTX-U under these very localized helicity injection conditions

Through 2-D axis-symmetric or 3-D MHD models understand the relationship between electrode driven current and impurity generation

Understand the penetration of a high-density gas jet through the energetic SOL region

Blue- Work in progress or planned (Described in subsequent slide and talks by by E.Hooper and F. Ebrahimi)
Red- Little or no work in progress

TSC Simulations in Progress and Planned

a) Assess electron heating of 200kA, low Te plasma by ECH (injection frequency, deposition profile)

b) Assess electron heating, first by ECH and then by HHFW in a resistively decaying 500kA discharge with CHI-like electron density and L-mode confinement

c) Assess NBI current drive in the above discharge as a function of electron density and temperature and for varying NBI parameters, through the ramp-up to 1MA

d) In the above study, replace the 500kA discharge with a CHI started discharge (Full non-inductive start-up and ramp-up simulation)

e) Extend the above study to the NSTX-U vessel geometry, initially to assess CHI current generation potential and then full NI scenario modeling

f) Refine steps d) and e) using improved electron transport model by examining several NSTX discharges through TRANSP simulations

g) Use the SWIM framework in TSC to couple directly to RF codes and to TRANSP for a self-consistent calculation of energy deposition and NBI current drive