Progress on Simulations of Helicity Injection in NSTX

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NSTX Research Forum

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I especially want to acknowledge Carl Sovinec's contributions

- in particular for help in constructing the new grid
- in general for supporting resolution of both physics and numerical issues

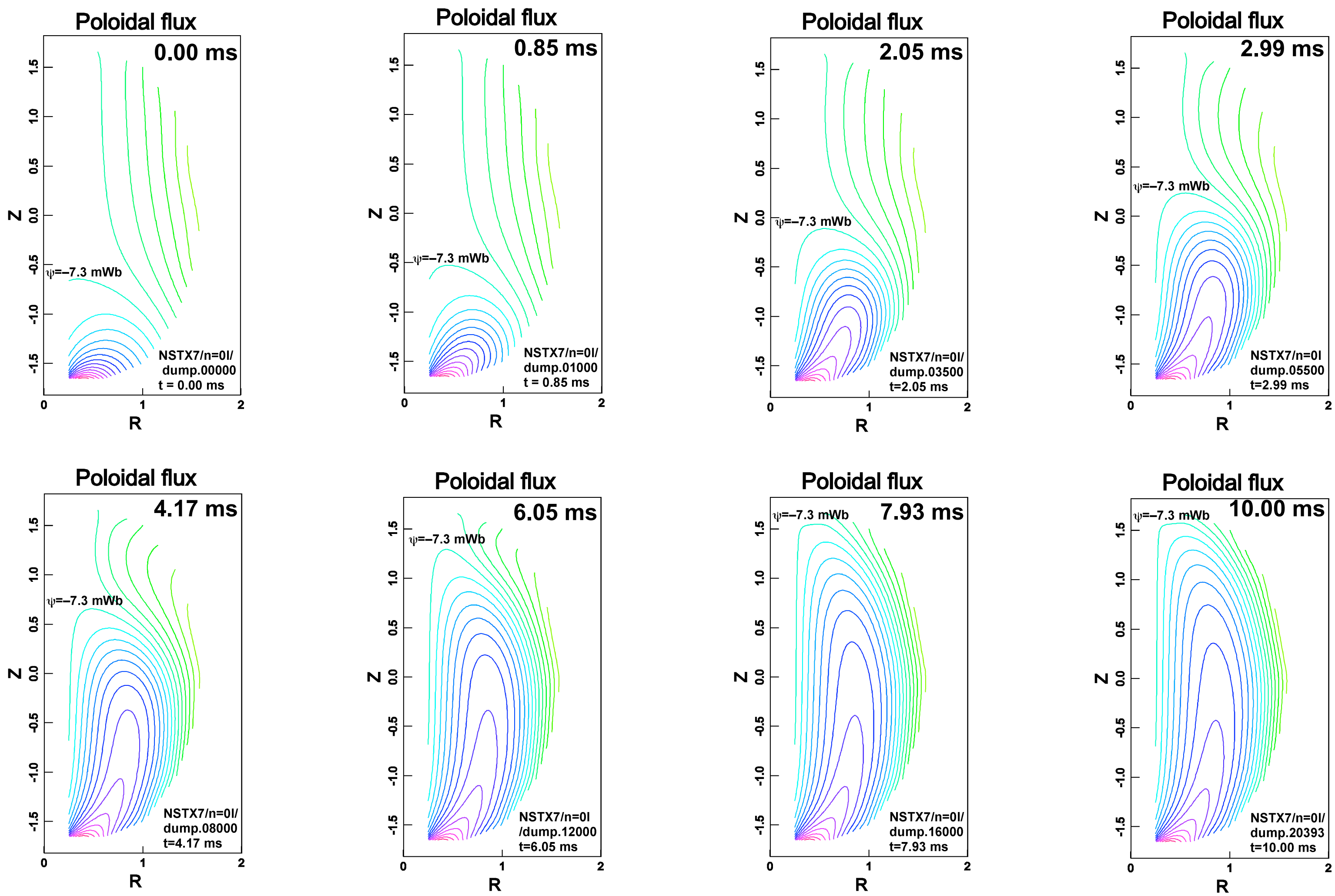
Progress since last report (12/2011)

1. A new grid has been developed for the NSTX boundary including the bends in the central column
   - The original gridding had problems representing the flows and currents near the bends
   - These issues have been greatly reduced with the new grid

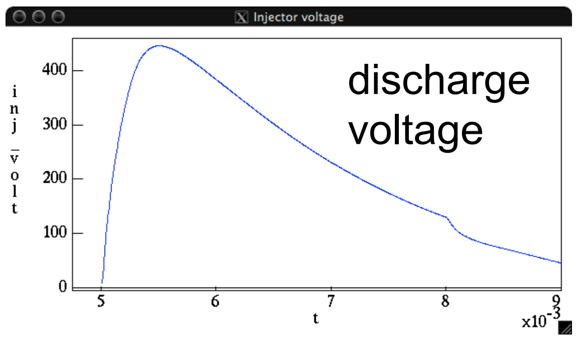
2. A power supply model has been implemented
   - Model includes capacitor bank, transitient suppression circuits, crowbar
   - Voltage is applied across the injection gap
   - Current is measured from the plasma response, and includes the effects of PS impedance

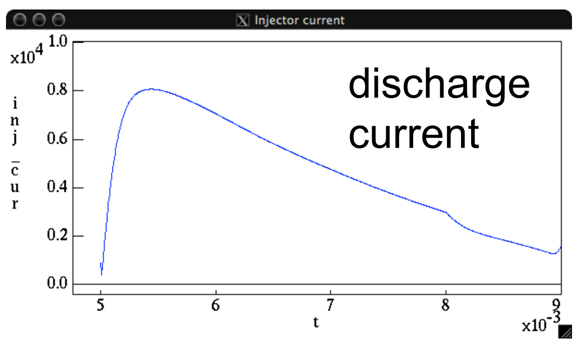
3. Ohmic heating and thermal conductivity along magnetic field lines have been turned on
   - Initial helicity injection calculations yield temperatures consisent with experiment

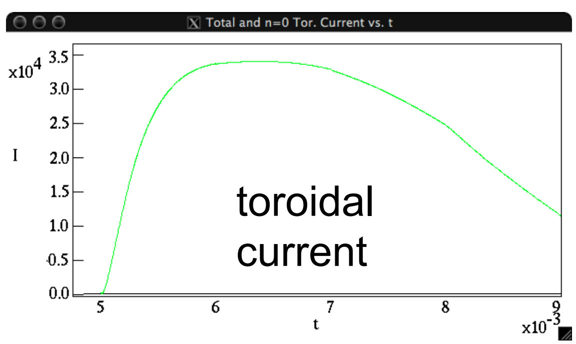
PREVIOUS RESULTS: Poloidal flux expansion – contour plots – during injection: Straight central column

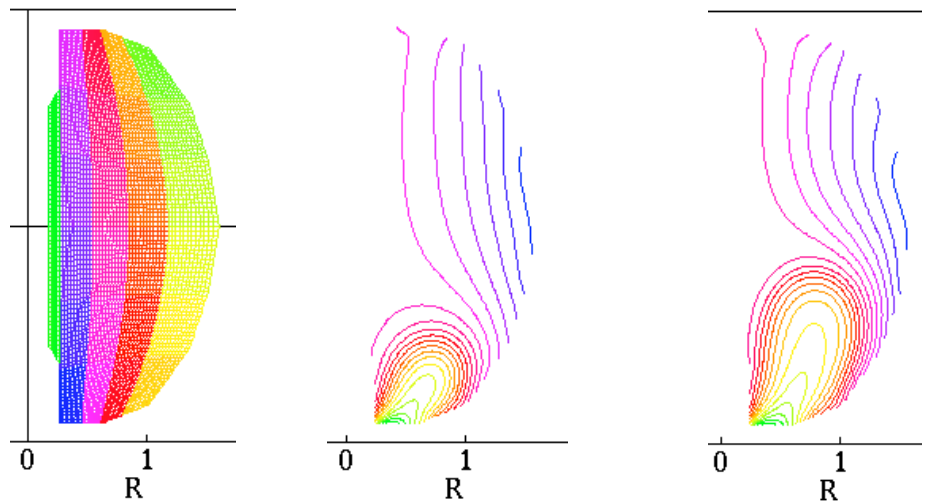


Current drive by power supply — T = const. (≈ 10 eV)









Grid t=5.5 ms t=6.5 ms

(Discharge started at t=5.0 ms)

Note: This simulation used wall boundary-conditions from the file generated by LDRFIT

Fusion Energy Program

Plasma heating

Plasma temperature — determined primarily by:

- **ohmic heating**
- **thermal losses along open field lines to the wall**

$$3n\frac{dT}{dt} \approx \nabla_{\parallel}\left(\kappa_{\parallel} \cdot \nabla_{\parallel} T\right) + \eta_{\parallel} j_{\parallel}^{2}$$

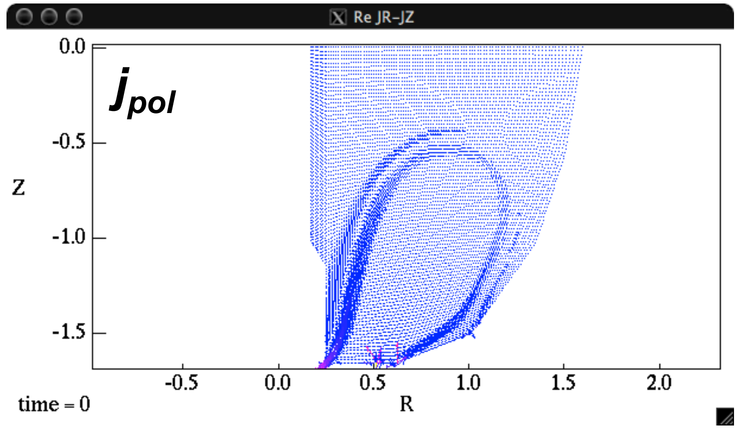
$$\kappa_{\parallel} \sim T^{5/2} / Z_{eff}$$

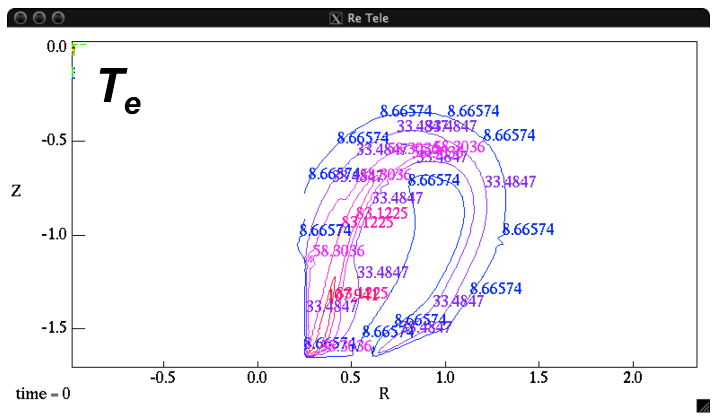
$$\eta_{\parallel} \sim Z_{eff} / T^{3/2}$$

so

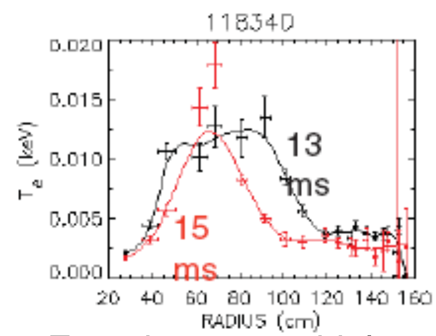
$$T \sim \left(Z_{eff}\, j_{\parallel} \ell\right)^{2/5}$$

with ℓ an effective scale length





Simulation at 0.52 ms: Z_{eff}=1.
T_e is highest (126 eV) near the lower left corner (small R) where poloidal flux tube areas ($2\pi Rw$) are small and $j_{\parallel}$ is large



Experiment at midplane

Simulation temperatures
T_e is consistent with experiment

Fusion Energy Program

Next steps

1. Continue exploration of heating and thermal losses
   Pick “base case” for calculation with wall boundary conditions (LDRFIT)

2. Examine possibility of “pinch-off” of flux-bubble by axisymmetric (resistive) effects

3. Turn on non-symmetric modes

4. Pick experimental discharge for detailed comparison