Neoclassical Theory Developments and Implementation on NSTX

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NSTX Results Review
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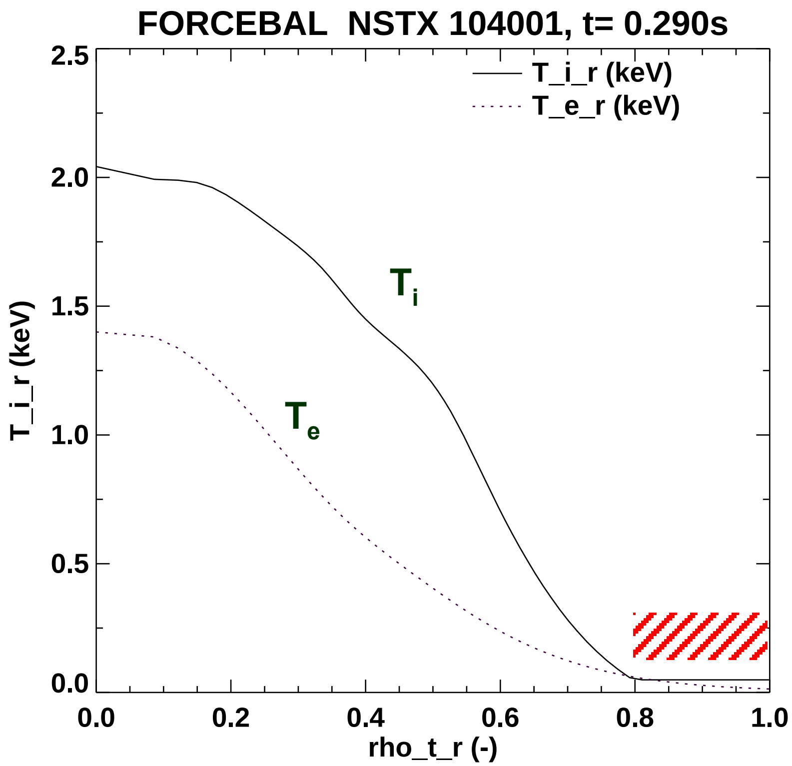
Outline

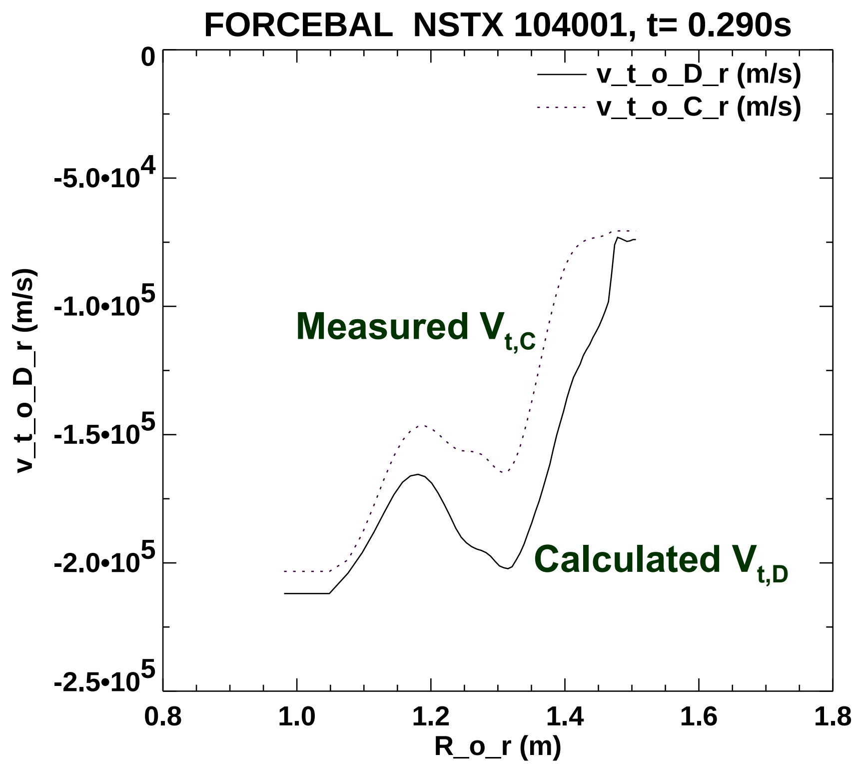
- NCLASS/FORCEBAL installation for NSTX analysis
- Limitations of present analyses illustrated for example NSTX plasma (shot #104001)
  - Implications of high rotation velocities in NSTX
  - Implications of $B_p \sim B_t$ in NSTX
  - Potato orbit effects in NSTX
- Summary

NCLASS/FORCEBAL Installation for NSTX Analysis

- FORCEBAL installation:
  - MDS+ data for EFIT, density and temperature profiles
  - Auxiliary file for CHERS rotation data
  - IDL graphical procedure for viewing results
- TRANSP:
  - Older version of NCLASS
- Planned upgrades of NCLASS:
  - In TRANSP:
    - » Newer version of NCLASS
  - In FORCEBAL:
    - » Potato orbits
    - » Ion orbit loss and the L-H transition
    - » F90 module with dynamic allocation and optional I/O

Reference NSTX Profiles (Shot #104001, 0.29 s)





Neoclassical properties calculated from T in shaded region are likely unreliable

Difference in toroidal rotation expected from species pressure

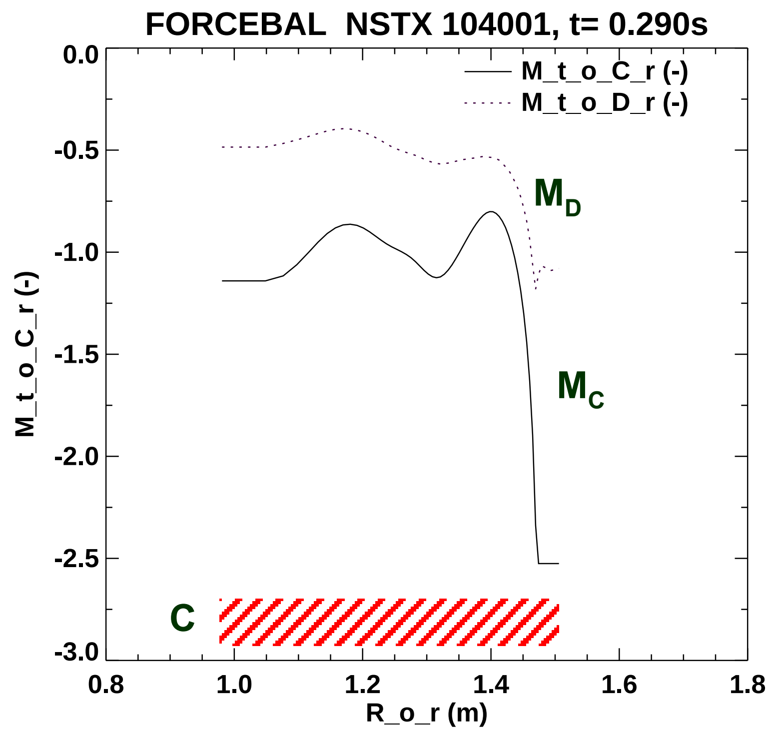
Implications of High Rotation Velocities in NSTX

Deuterium rotation velocity:

- May have to be considered in MHD equilibrium reconstruction

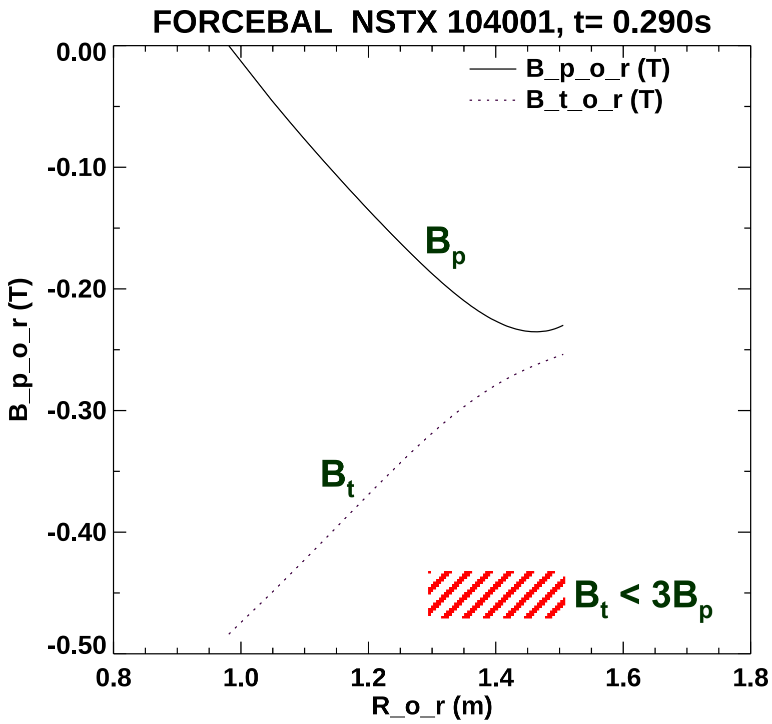
High impurity toroidal Mach numbers:

- Densities peak toward outside from centrifugal effects (as seen in JET)
  - Theoretical model to calculate poloidal distribution was developed by M. Romanelli for JET
- Standard analyses that assume local density is a flux surface quantity are invalid
  - CHERS data must be corrected to obtain impurity profiles, Z_{eff}, transport properties, etc.
  - Lower Z_{eff} reduces Q_{ei}, but probably not enough to explain anomalies in the power balance



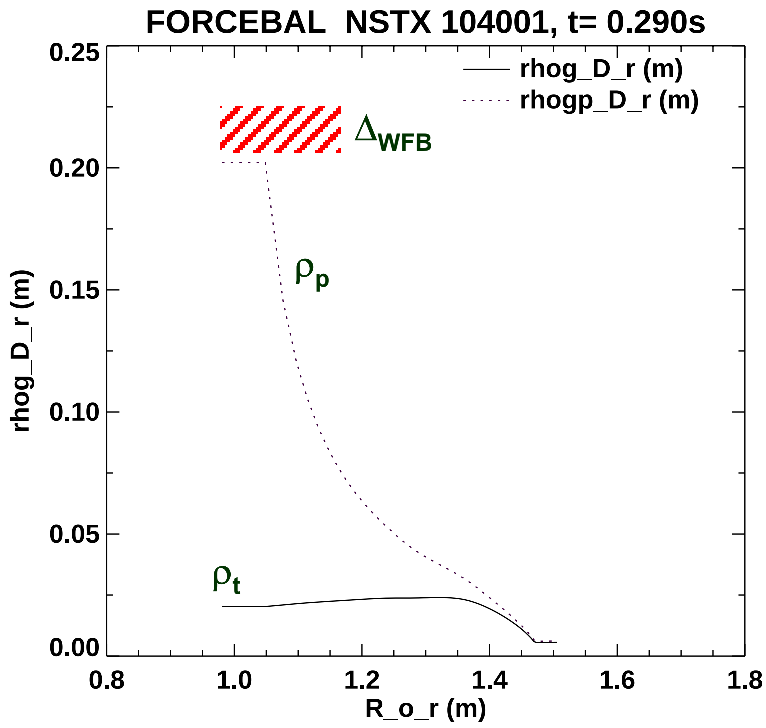
Implications of $B_p \sim B_t$ in NSTX

- **Classical and neoclassical transport processes are comparable**
- **If the L-H transition is driven by orbit losses, the scaling relative to larger A machines would be expected to break**
  - **We have developed modifications to NCLASS to include ion orbit loss driven L-H transitions (**R. Hiwatari, T. Takizuka, K.C. Shaing, W.A. Houlberg, H. Shirai, Y. Ogawa, K. Okano, "Numerical Investigation of Threshold Power by Using L-H Transition Model Based on Ion Orbit Loss," IAEA TCM on H-mode and ITBs, Toki, Sept 2001, to be published in Plasma Phys and Controlled Fusion**)**
  - **Model reproduces B_t, n_e, and I_p scaling of the L-H transition power threshold for standard tokamaks**



Potato Orbit Effects in NSTX

- Width of the 'World's Fattest Banana' (WFB) is 19 cm with $q_0 \sim 1.1$
  - In reversed shear conditions the size grows as $q^{2/3}$
- Potato orbit effects are expected to modify neoclassical transport in the range $0 < \rho < 2\Delta_{WFB}/a$, or $R < 1.35$m, which is most of the core of NSTX
  - NCLASS presently contains an approximate correction for potato orbit effects
  - The theory has been reworked for a more rigorous treatment of the orbits (K.C. Shaing, W.A. Houlberg, P.I. Strand, "Local Potato-Plateau Transport Fluxes and a Unified Plateau Theory," submitted to Phys. Plasmas)
  - We plan to upgrade NCLASS for NSTX applications



Summary

- **FORCBAL/NCLASS installed for NSTX analysis:**
  - **Interface to EFIT and profile data in MDS+**
  - **Graphical interface to results using IDL**
- **Upgrades to NCLASS are dictated by:**
  - **Strong toroidal rotation**
  - **Ion orbit losses at edge for L-H transition studies**
  - **Potato orbit effects**