Goals of NSTX Advanced Scenario and Control TSG

- Study, implement, optimize axisymmetric control techniques.
  - Kinetic and magnetic profiles.
  - Boundary and divertor magnetic geometry control.
  - Vertical position control.
- Combine various tools developed in other TSGs into integrated scenarios.
  - For instance, ELM pacing XPs targeting density control were in ASC.
  - Impurity control for scenario development in FY-10.
- High non-inductive fraction under NB heating has been in ASC.
  - Typically coupled with optimization to high-κ.
  - NBCD is ASC, but details of fast ion transport & redistribution are WEP
  - However
    - RF CD and low-current 100% NI scenarios with HHFW H&CD have historically been in WEP TSG.
    - Maximization of β_N part of ASC, but more in MS.
- Discharge development for the NSTX team (sometimes).

NSTX ASC research was always cross-cutting, and will be even more so in NSTX-Upgrade

Two Overarching Theory/Modeling Needs

- 1: Need advanced control algorithms for boundary shape, divertor geometry, kinetic and magnetic profiles, and divertor heat fluxes.
  - Should include actuator dynamics & saturation.

- 2: In order to tune those control algorithms, need integrated codes with fast, benchmarked models for how sources of particles, momentum, heat and current modify the kinetic and magnetic profiles and free-boundary equilibrium.

Need #1: Models for Scenario Development

- NBCD with *AE modes
  - In the absence of low-f MHD, the neutral beam drive current is apparently classical.
  - At higher values of β_{fast}, *AE modes can lead to redistribution/modification of the fast ion distribution.
  - Theory is needed for when these modes will turn on, and what their effect on the pressure & current profile will be.
  - Need measurements of fast ion distribution (FIDA, neutrons, ssNPA, fusion product detector) and NBCD profile for comparison.
- Prediction of the thermal & momentum transport
  - The bootstrap current depends sensitively on the gradients in the thermal profiles. NBCD depends on T_e/n_e. Global stability depends on rotation.
  - Conversely, the transport, and hence thermal profiles, can be a strong function of the current and rotation profiles
  - Need a model for the thermal and momentum transport and its response to actuators.
  - Include both core & pedestal (and the joining region), including fast-ion MHD leading to transport.
- Need accurate, benchmarked models for HHFW and EBW H&CD within integrated codes such as TRANSP.

Need #2: Realtime Control

- Need a reliable algorithm for the individual and combined control of the current and rotation profiles, along with β_N.
  - The theory of that algorithm should help us to understand to what extent these quantities can be independently controlled given the coupled actuators V_{loop}, P_{inj}, J_{NBCD}, T_{NB} and T_{NTV}.

- More generally, need the ability to test the actual control algorithms in simulations with high degrees of physics fidelity, i.e. flight simulator mode.
  - Could in principle be accomplished by connecting PCS to PTRANSP, CORSICA, or TSC.

- Need the ability to predict the future equilibrium and stability properties of the plasma.
  - Faster than realtime look-ahead of the evolution of the equilibrium
    - (Very) reduced transport models.
  - Stability assessments of those future states (n=0, n=1, ELM?). Future coil currents and boundary shape.
  - Control intervention based on the predictions.