Transport and Turbulence: Guidelines for Five Year Planning

Two main objectives of planning exercise

- Develop/modify long-range research plan to help understand basic toroidal physics better
  - Experiments, diagnostics, analysis methods and tools
- Identify elements of upgrades to facility that will aid in achieving long range research objectives
  - New diagnostics
  - Machine upgrades (additional PF coils, center-stack upgrade, etc.)
  - Heating system upgrades (additional NBI, co- vs ctr-injection, …)

Tie Discussion to IPPA Goals

IPPA Goals as they pertain to the ST specifically

5 year goal: Make a preliminary assessment of the attractiveness of the ST regarding confinement, stability, and high beta operations, and non-inductive operations (to be achieved in 2004-2008 time frame)

10 year goal: Assess the attractiveness of extrapolable, long-pulse operation of the spherical torus for time scales much greater than the current penetration time scales (to be achieved in 2009 time frame)

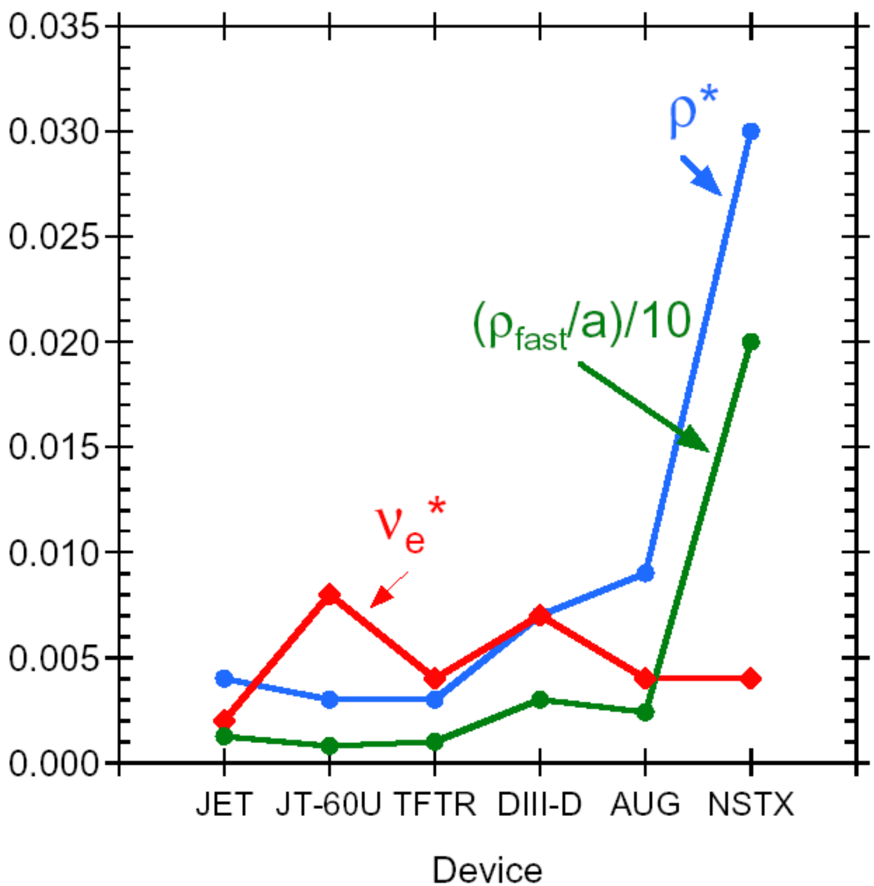
IPPA Science Goal 1: Advance the fundamental understanding of plasmas... and enhance predictive capabilities through comparison of experiments, theory, and simulation

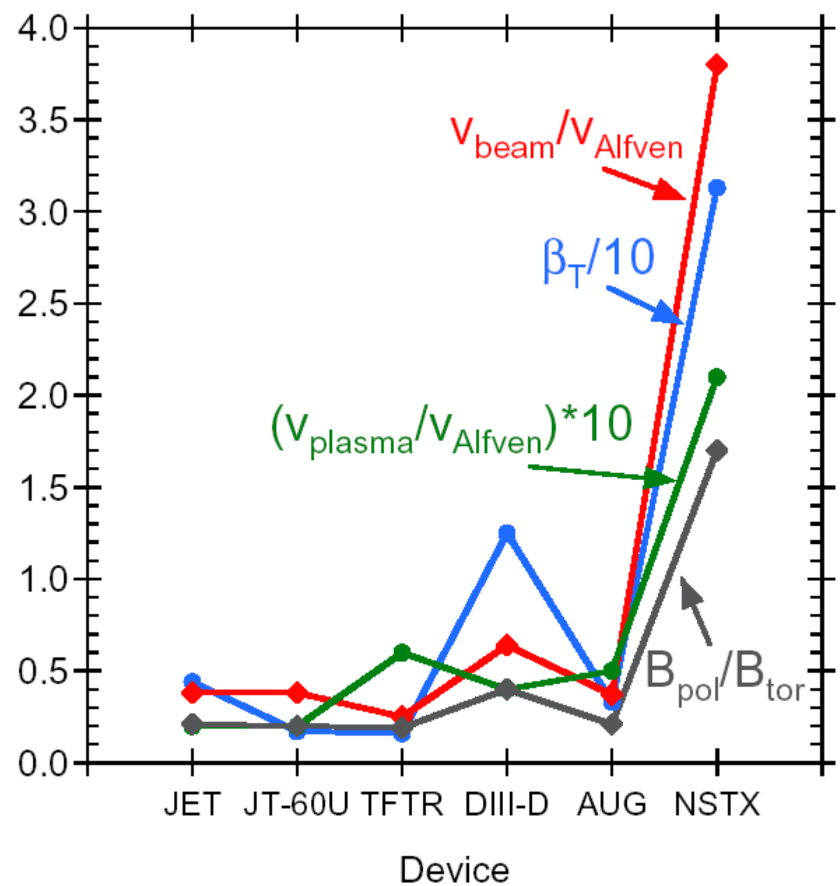
Existing Research Milestones Tied to IPPA Goals

- FY03
  - Control dynamic error fields in strongly rotating plasmas
  - Study SOL fluxes
  - Integrate high-β_t and high τ_E for ~5τ_E
- FY04
  - Measure j(r) modification from RF, NBI, BS
  - Assess long and short wavelength turbulence
  - Avoid or suppress β-limiting modes at high-β
  - Characterize plasma edge and SOL at high-β_t and high τ_E
  - Characterize plasma/fast ion magnetosonic wave interactions
- FY05+ (?)
  - Turbulence <u>suppression</u>
  - Power/particle <u>control</u>
  - Define optimal configuration for NSST

Can We Take Advantage of Unique, Low Aspect Ratio Charactistics of NSTX?

Major differences result from lower B_T, higher relative rotation velocity





Transport/Fast Ion Behavior

ST Features/Theory Issues

- Local $\beta_t \rightarrow 1$ (51% achieved experimentally in core)
  - Electromagnetic effects
- Trapped particle fraction $\rightarrow 1$
  - Validity of fluid treatment of electrons
- $\rho_i/L \sim 0.2$ (near outboard edge); $\rho_i \sim 1$ to 3 cm
  - Validity of spatial scale length ordering
- High ExB flow (>200 km/sec), flow shear (10^5 to 10^6/sec)
  - Effect on μinstability thresholds, turbulence characteristics
  - Dominant (?) role of electron transport
- V_{fast}/v_{Alfven} ~3 to 4
  - Fast ion driven instabilities (Alfvenic modes)
- $\rho_{fast}/a \sim 1/5-1/3$
  - Fast ion confinement, non-adiabatic behavior

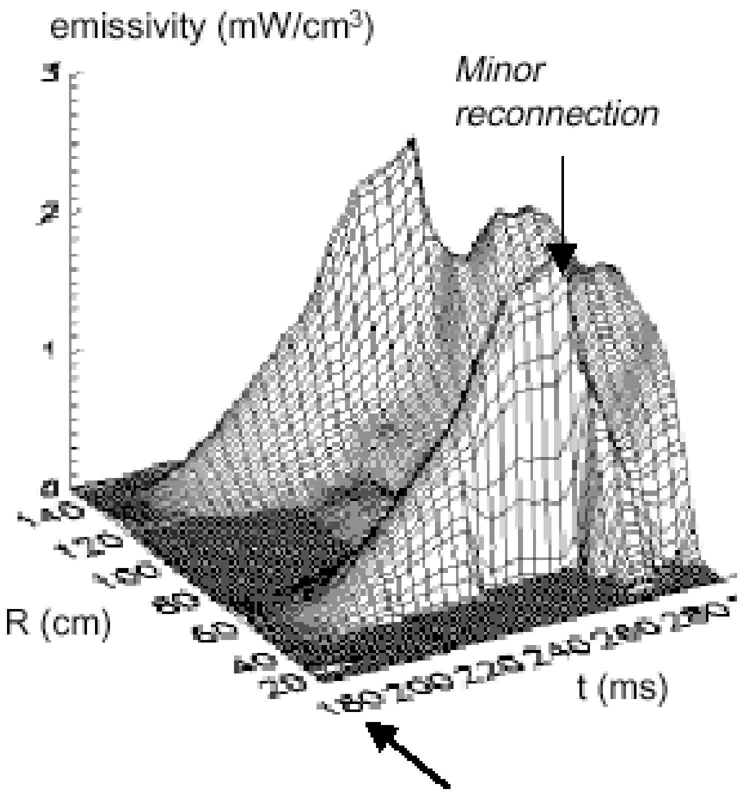
Validity of present gyrokinetic treatment?

Low Ion Transport Observed in Experiment and Supported by Theory

- Role of ion vs electron transport (long vs short-λ turbulence)

Neon puff exp'ts indicate almost no neon penetration to core

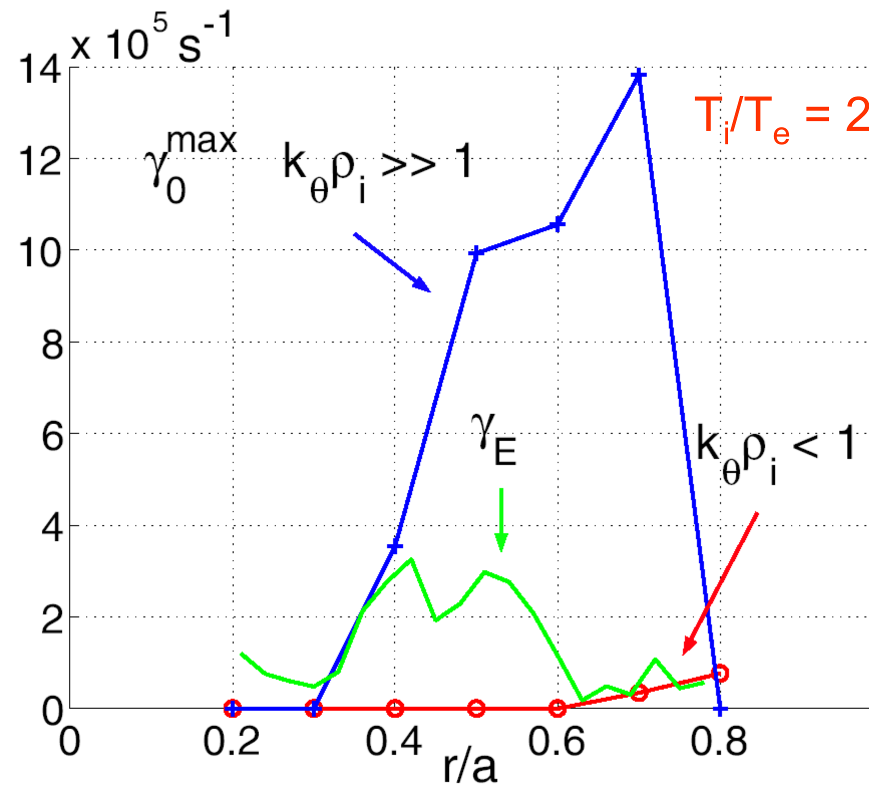
$D \sim 1\ m^2/sec$
close to neoclassical



(D. Stutman, JHU)

GS2 calcs indicated short wavelength modes may dominate transport

Long λ (ITG): $\gamma<\gamma_{ExB}$
Short λ (ETG): $\gamma>\gamma_{ExB}$
High β, T_i/T_e

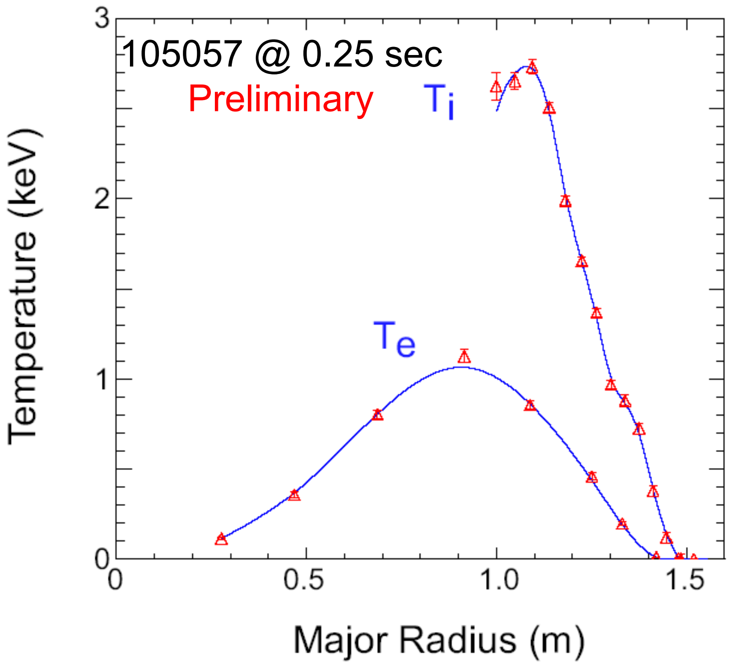


(C. Bourdelle)

NSTX Results Point to New Paths for Describing Transport Properties of Plasmas

High T_i/T_e cannot be supported purely within classical collisional framework

Something more than classical collisional heating and energy exchange may need to be considered in order to properly infer heat diffusivities



Some Possibilities

- Anomalous thermal ion heating
- Heat pinch
- Heating deposition modification

- Considerations for future research
  - Role of ion vs electron transport (anomalous ion htg, heat pinch)
  - Role of E_{radial} (modify through co- vs ctr-injection, impurity injection?)
  - Aspect ratio dependence (intra- vs inter-machine comparisons)
  - Higher TF, I_p operation (benefits of center-stack upgrade?)

- Be imaginative in your thinking about longer-range research goals, and what it would take to achieve them
  - Experiments
  - Diagnostics
  - Analysis methods
  - Facility upgrades (machine, heating systems)