Opportunities for Physics Research on NSTX

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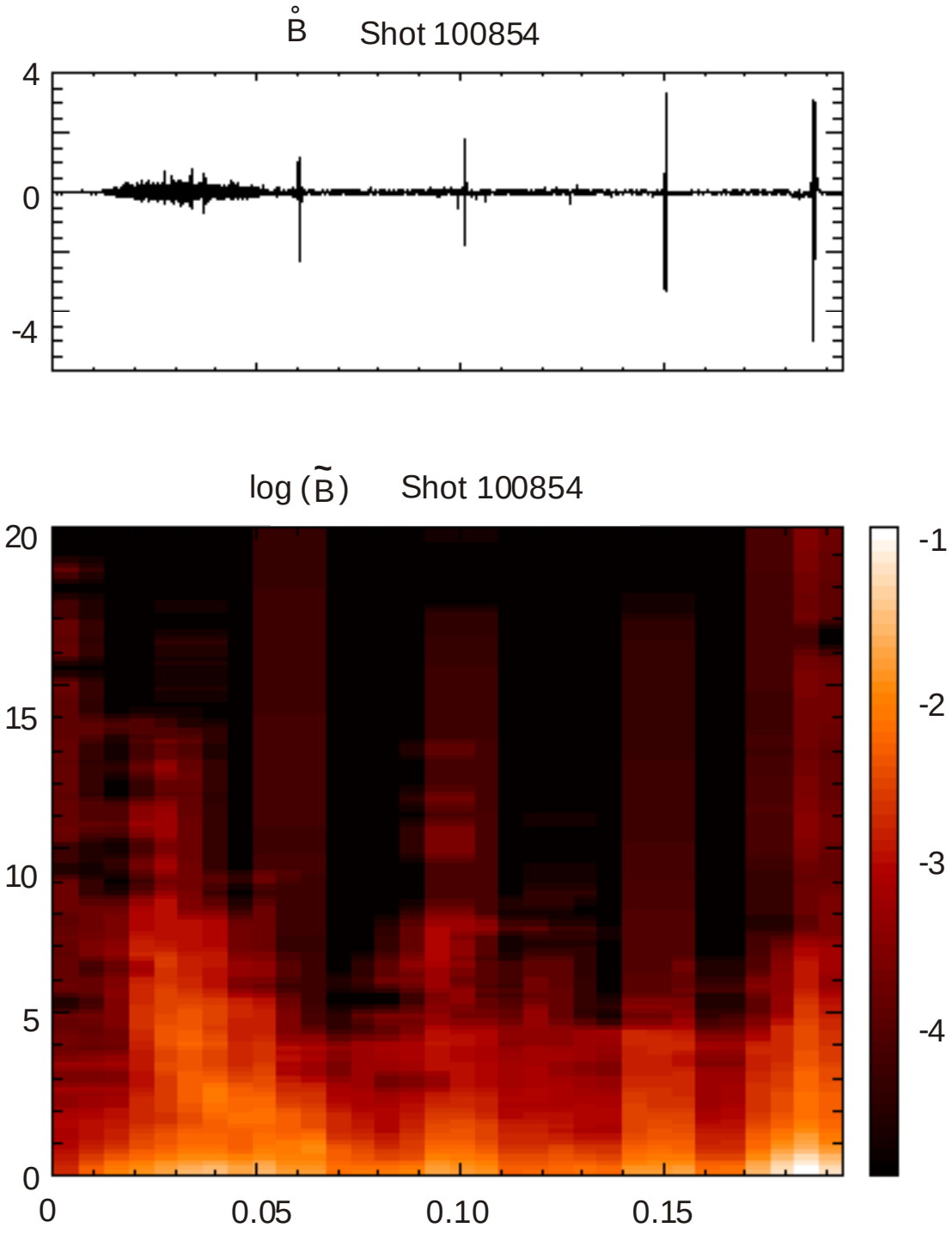
NSTX Physics Issues

- *Near term physics needs guided by existing results and by those anticipated from imminent project upgrades*
- *Some tasks are already underway; all would benefit from further input*
- *Key areas coincide with discussion group topics*
  - *Equilibrium and Stability (MHD)*
  - *Transport and Turbulence*
  - *Energetic Particles*
  - *Heating and Current Drive*
  - *Power and Particle Handling (Boundary Physics)*

Equlibrium and Stability (MHD)

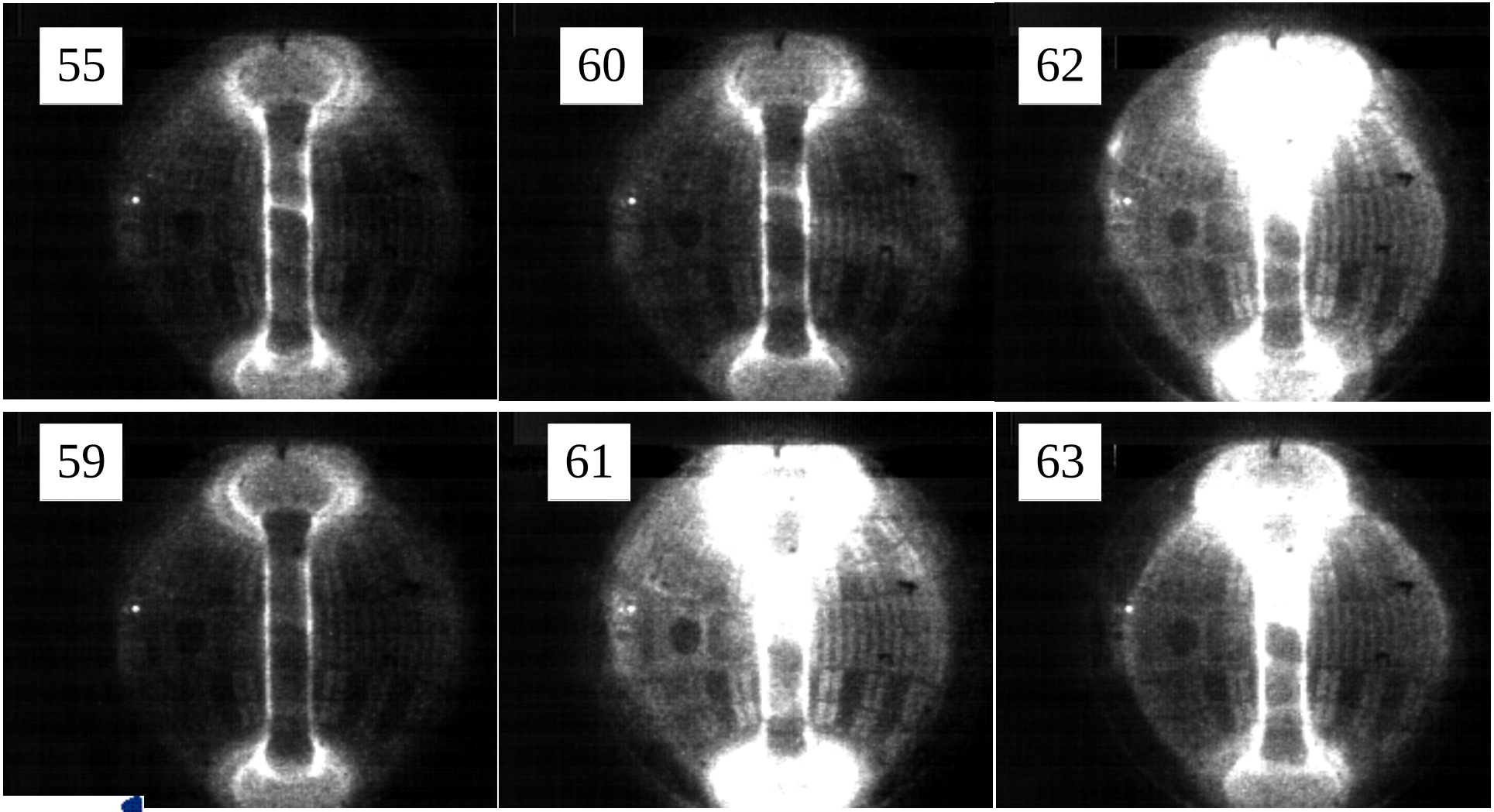
- NSTX discharges exhibit a range of MHD phenomena that influence discharge evolution
  - Oscillatory and locking modes during current ramp up (affected by plasma cleanliness)
  - Possible kink modes near end of current ramp
  - Oscillatory modes associated with density limits
  - Reconnection events responsible for loss of plasma stored energy, current
- Need to study these phenomena within framework of resistive and ideal MHD theory
  - TSC simulations/EFIT reconstructions provide basis for stability studies
- Determination of passive plate electrical configuration for optimizing high-β stability
- Importance of NTMs at high power (high- β)


$\mathring{B}$
Shot 100854
4
0
-4
log ($\tilde{B}$)
Shot 100854
20
15
10
5
0
0
0.05
0.10
0.15
-1
-2
-3
-4
Time (seconds)

Fast Visible Camera Data Shows Large-Scale Distortion of Plasma

NSTX

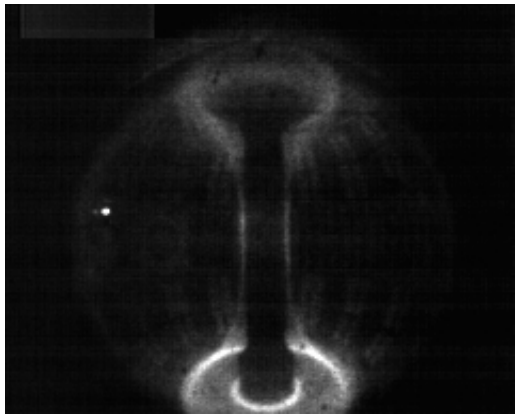
Shot 100843



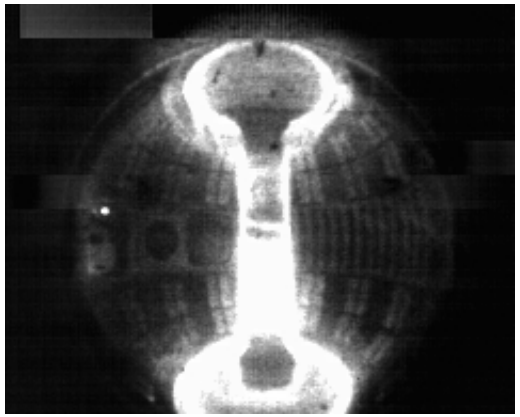
RE Termination of Discharge

NSTX

t=165 msec



t=194 msec



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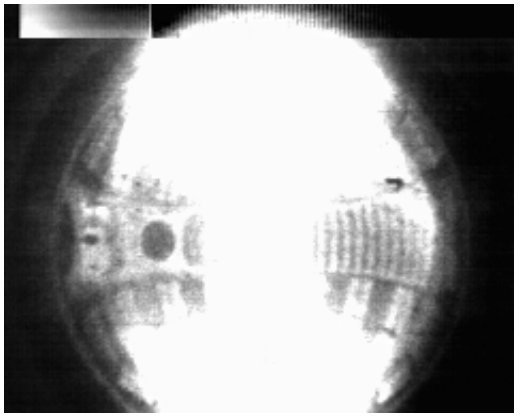
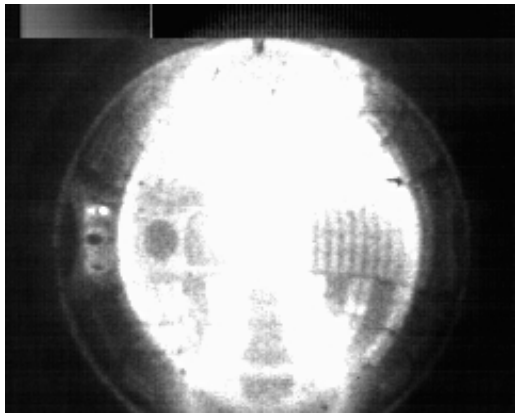
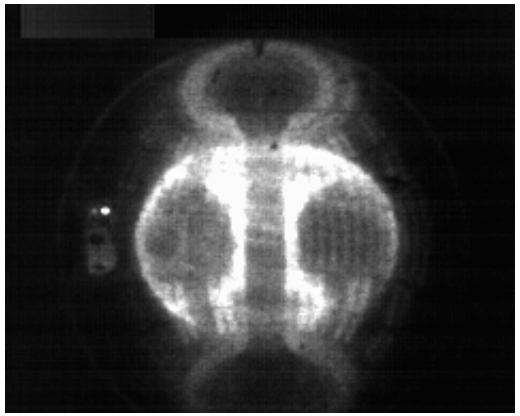


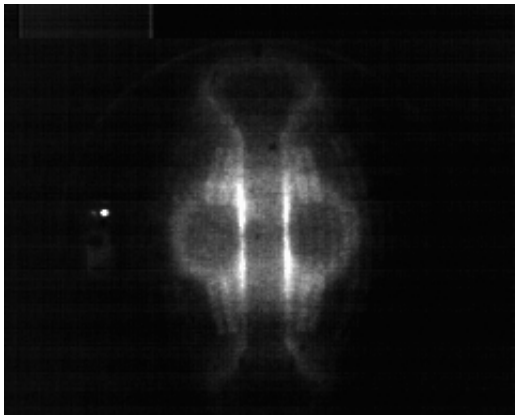
t=196 msec



t=200 msec

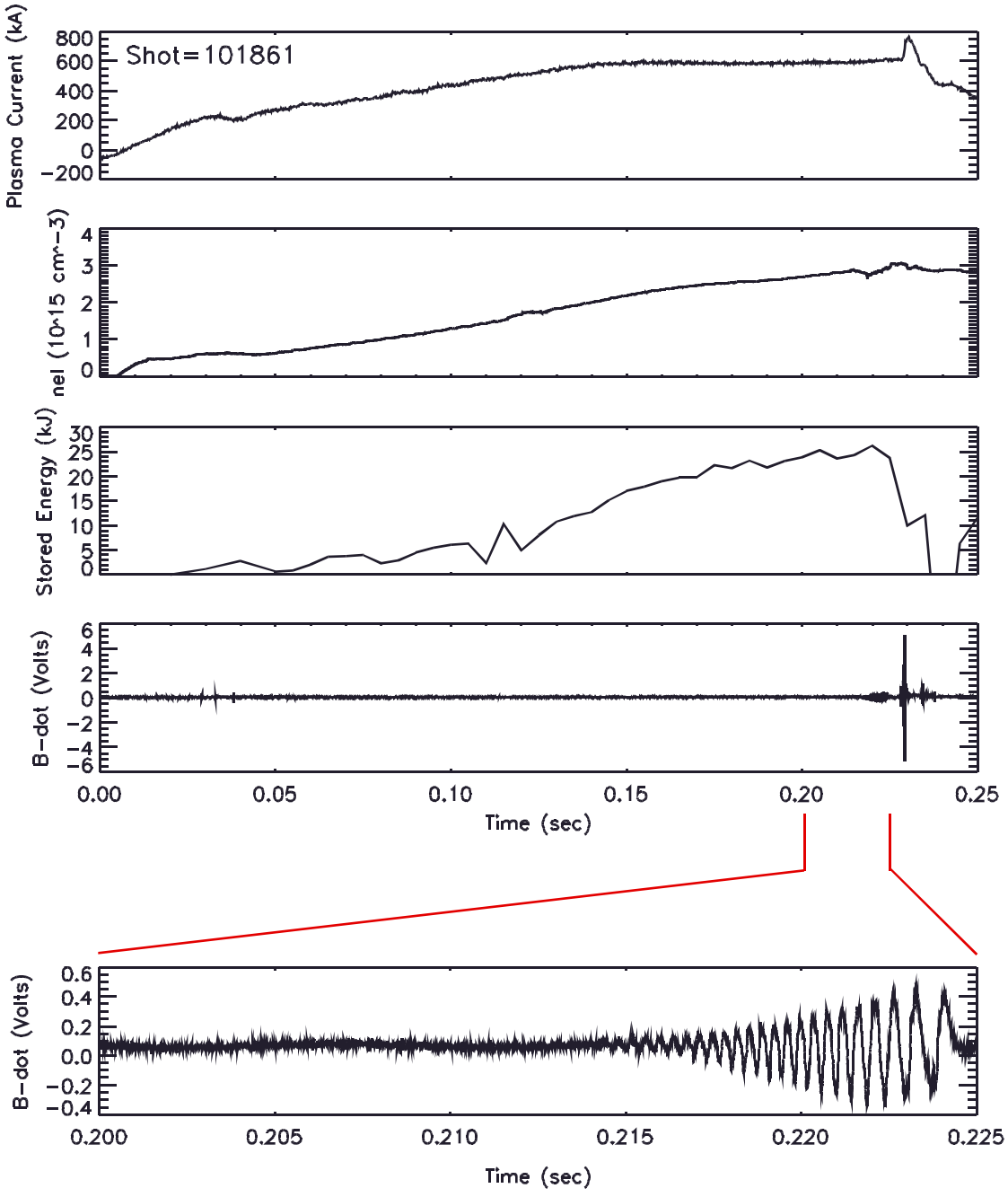


t=215 msec



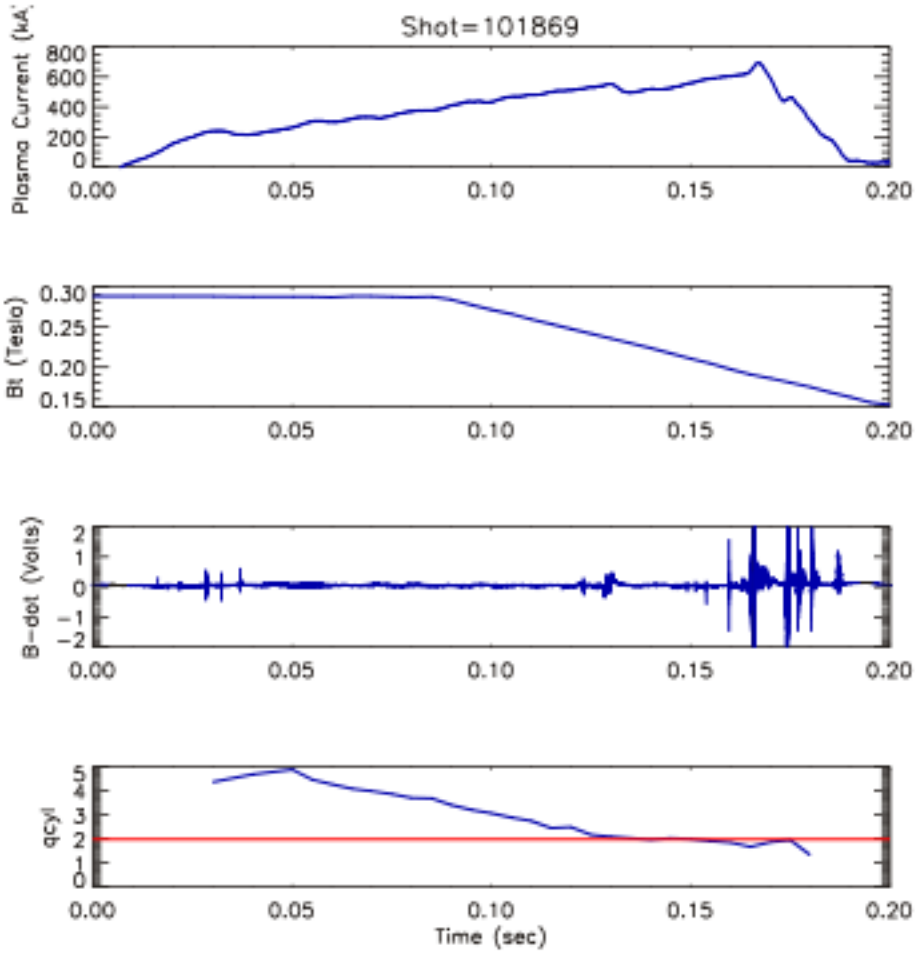
R. Maqueda, G. Wurden (LANL)

Density Limit Characterized by Oscillatory and Locking MHD

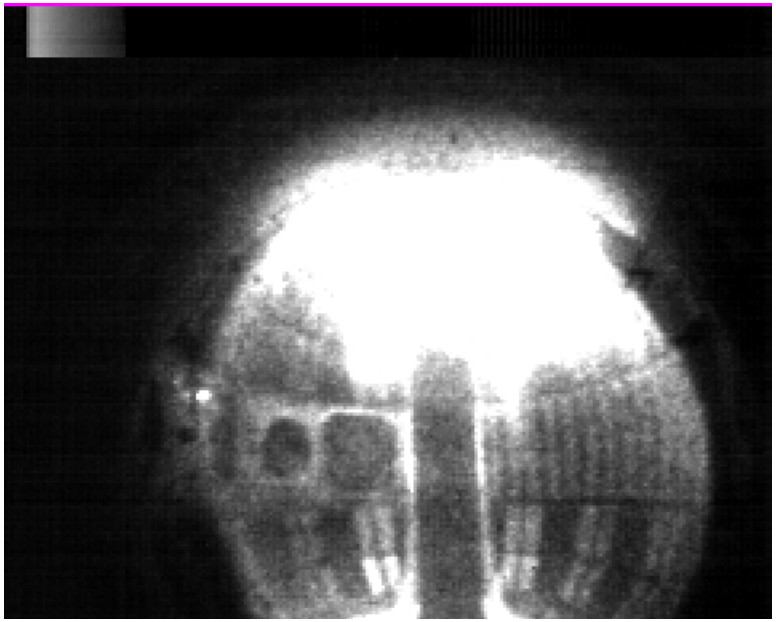


q-Limit Manifest as Kink Induced Disruption

NSTX

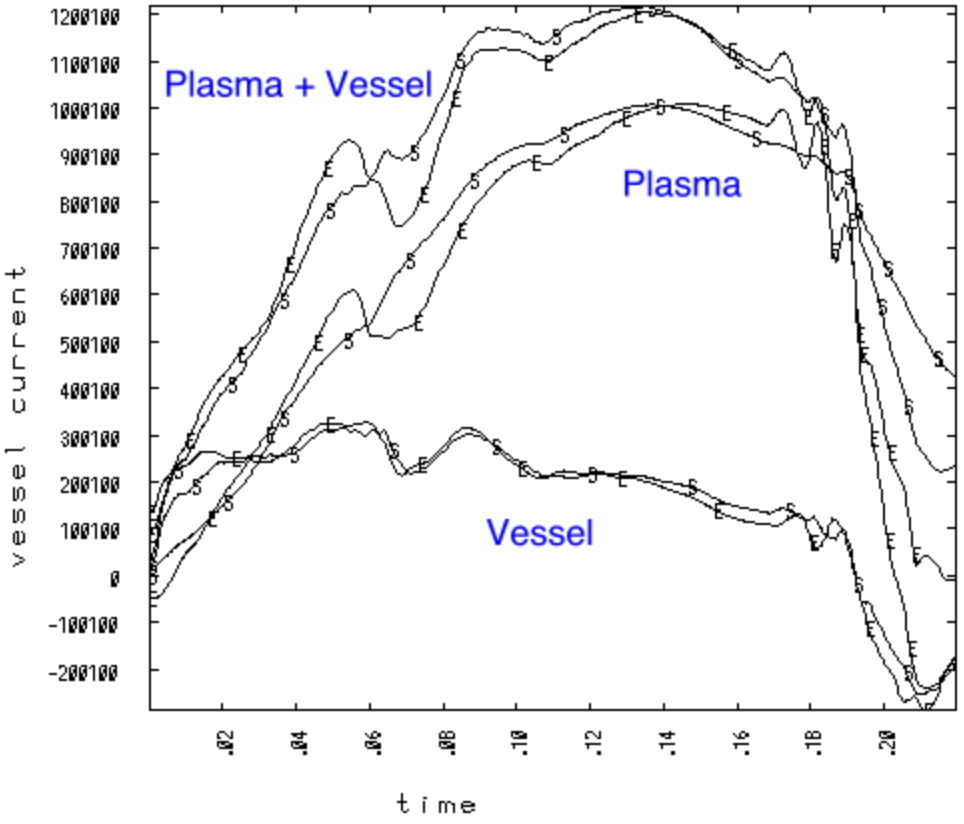


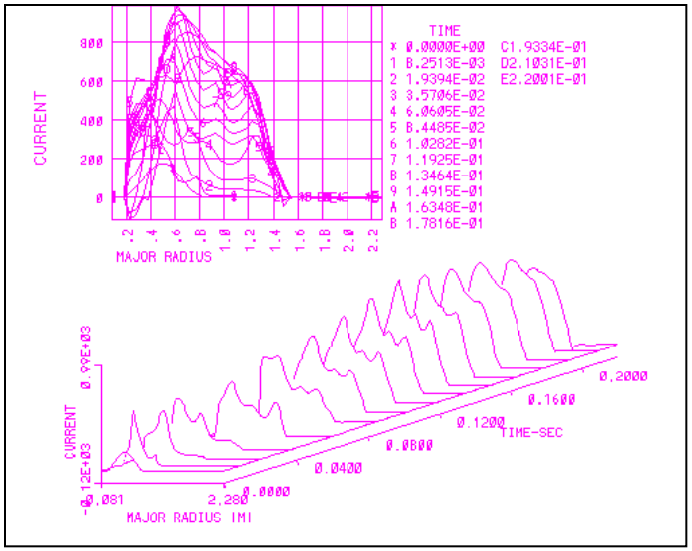
t=168 msec

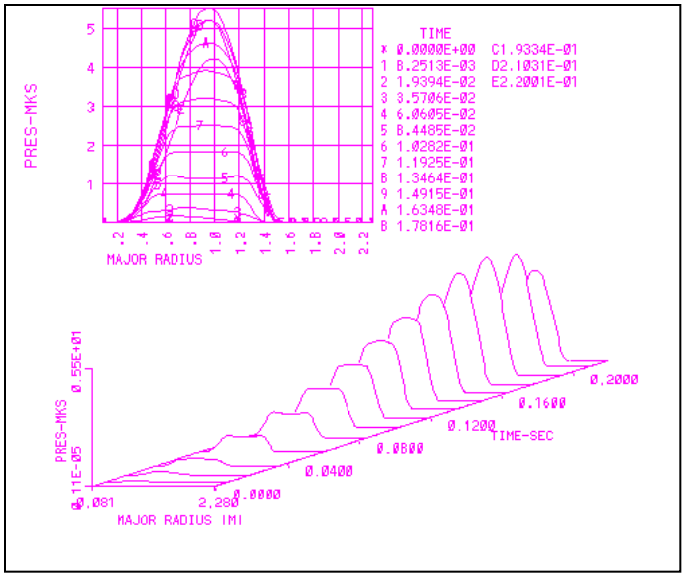


TSC Simulations Reproduce the Plasma Evolution

NSTX







Transport and Turbulence

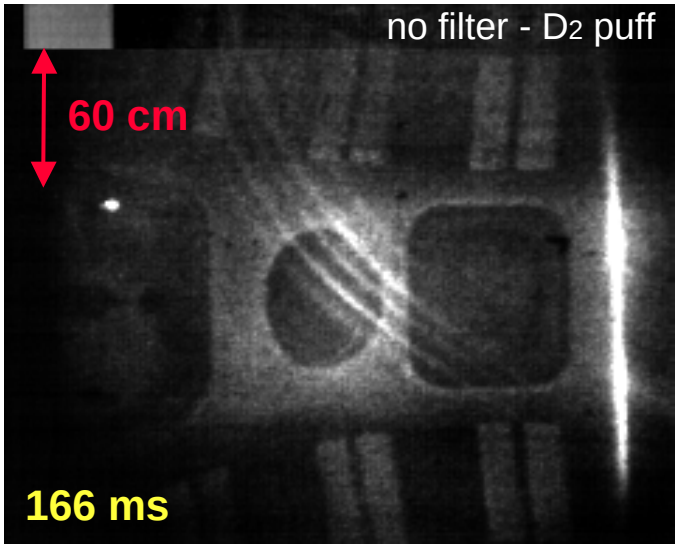
NSTX

- Virtually no profile information yet available; local transport studies premature
- Preliminary observations of edge turbulence (Maqueda and Zweben)
  - Important for H-mode studies, wave coupling, SOL characteristics, CHI current penetration
  - Field aligned density striations observed with visible camera
  - What are expected turbulence patterns and relation to zonal flows?
    - FULL instability code with sheared poloidal rotation
    - Edge turbulence codes (Drake code, BOUT-LLNL, Garching code)

Initial Results on NSTX

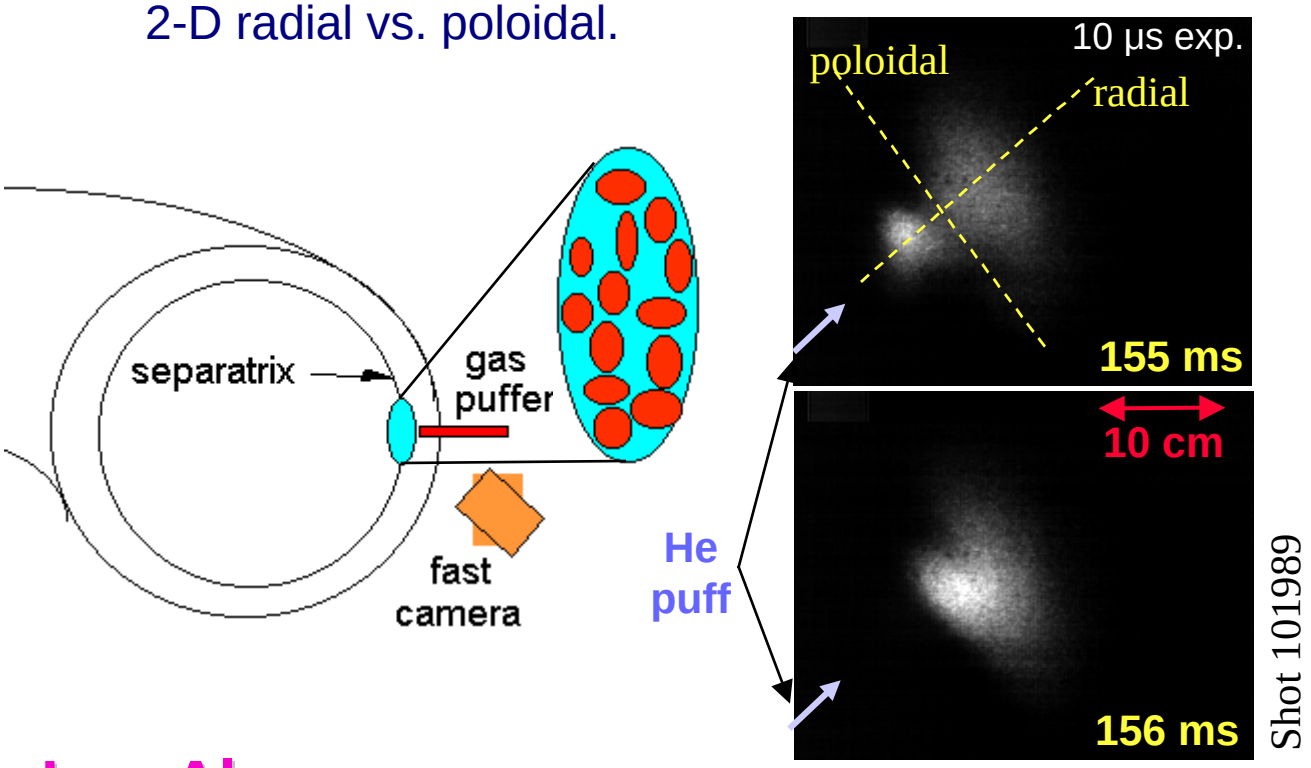
- Turbulent "filaments" of visible light emission are seen in LANL fast framing camera at exposures of 10 μsec.

  - seen in both He & D
  - ~aligned along B
  - λ_{pol} ~ 10-15 cm
  - $k_{pol}\,\rho_s$ ~ 0.1
  - "lifetime" ≤ 50 μsec



Shot 101533

- First results of "**Gas Puff Imaging**" (GPI) of HeI light emission (587.6 nm) viewed along magnetic field, i.e., 2-D radial vs. poloidal.



Energetic Particles

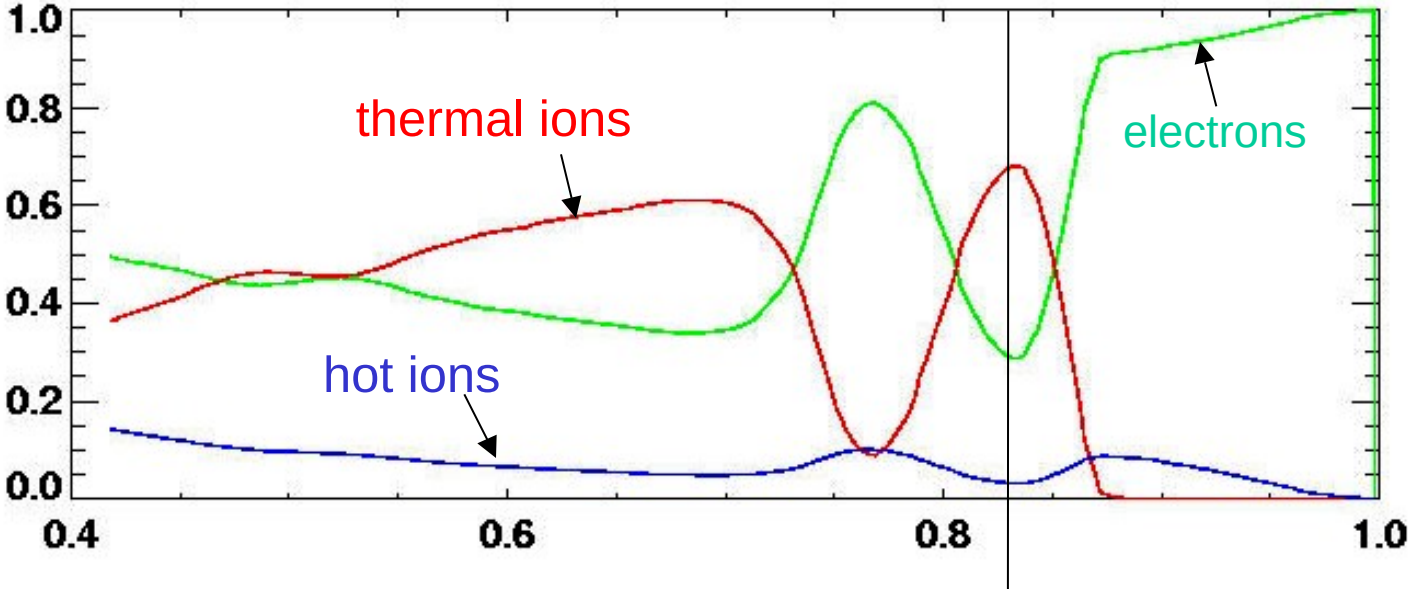
- Develop approach to studying orbits unique to NSTX
  - Fast ion loss detectors
  - Estimates of heating (e.g., TRANSP Monte-Carlo guiding center code with FLR corrections)
    - Use radius of gyration rather than local gyroradius to test for loss
- Power flux to material surfaces (plates, RF antenna) due to classical orbit losses
  - Problematic for 5 sec pulses (?)
- TAE mode studies will be important with introduction of NBI ($v_{NBI} > v_{Alfven}$)
  - Gorelenkov: Losses minimal
  - Jaun: Losses significant

Heating and Current Drive

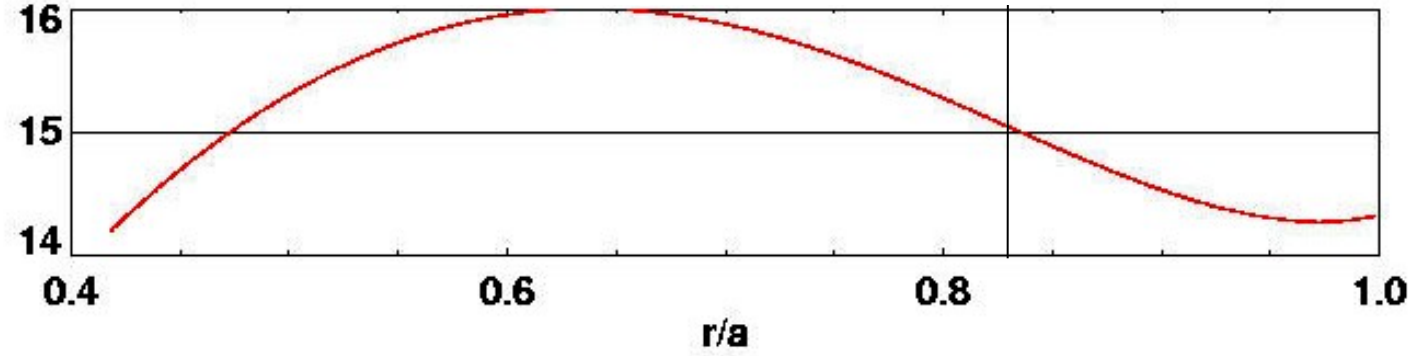
- Develop HHFW heating and current drive package for integration into TRANSP/TSC/EFIT
  - Heating profiles for confinement studies
  - Driven current profiles for equilibrium solutions and current drive accounting
  - Benchmark with measurements
- Effect of energetic and thermal ions on RF absorption
  - Ion damping non-negligible above $T_D(0) \approx 1$ keV
  - Damping on hot ions relatively small (≤5-10%)

NBI ions absorb < 5% of incident HHFW power

Local power absorption fraction (by species)



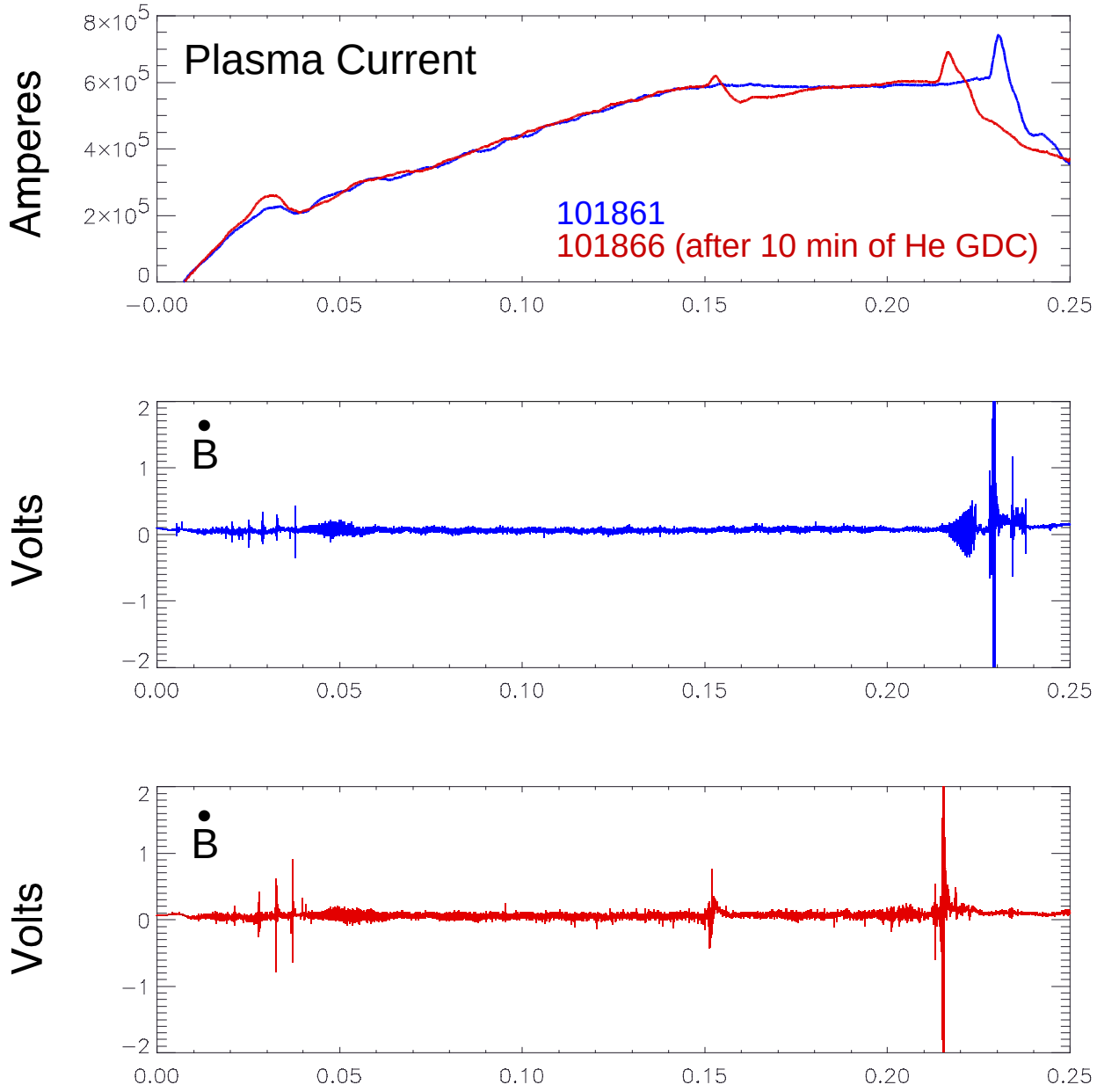
Deuterium cyclotron harmonic number



$T_e(0) = 2.5$ keV, $n_\varphi = 12$, $P_D/P_{TOT} \approx 50\%$

Power and Particle Handling (Boundary Physics)

- Understand effect of impurities on current profile evolution and resulting MHD
- Study effect of increased trapped particle fraction, difference in velocity space distribution on edge modes and SOL widths
- Benchmark models of heat and particle flux in a range of NSTX configurations
  - Effect of short physical connection length and higher trapped particle fraction on $_{\|}T_e$
- Determine importance of "Resistive X-modes"


Amperes
Plasma Current
101861
101866 (after 10 min of He GDC)
Volts
Volts
Time (sec)

Summary

NSTX

- Results to date provide broad basis for input into physics analysis in all topical areas
  - More comprehensive analysis will be forthcoming as additional diagnostics are commissioned
- An important general area of work is to develop scenarios for achieving our Phase II goals of high β (25%) and bootstrap fraction (40%)
  - Preliminary scenarios have been developed with TSC
  - Want to include more recent HHFW, transport models
  - Want to develop model for Co-Axial Helicity Injection current drive