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NSTX

# Summary of the NSTX FY2005 Run


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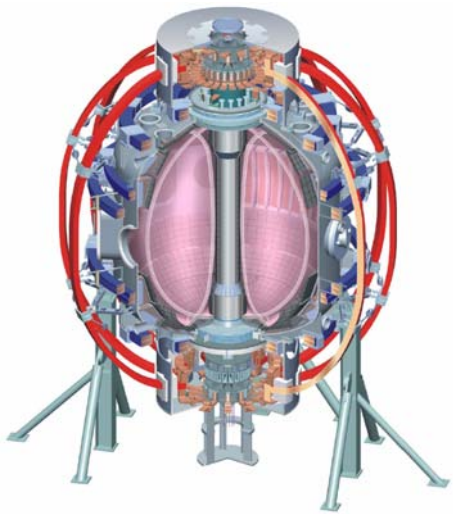
PPPL PRINCETON PLASMA PHYSICS LABORATORY

For the NSTX Team


## NSTX Results Review
## December 12-13, 2005
### PPPL – Princeton, NJ



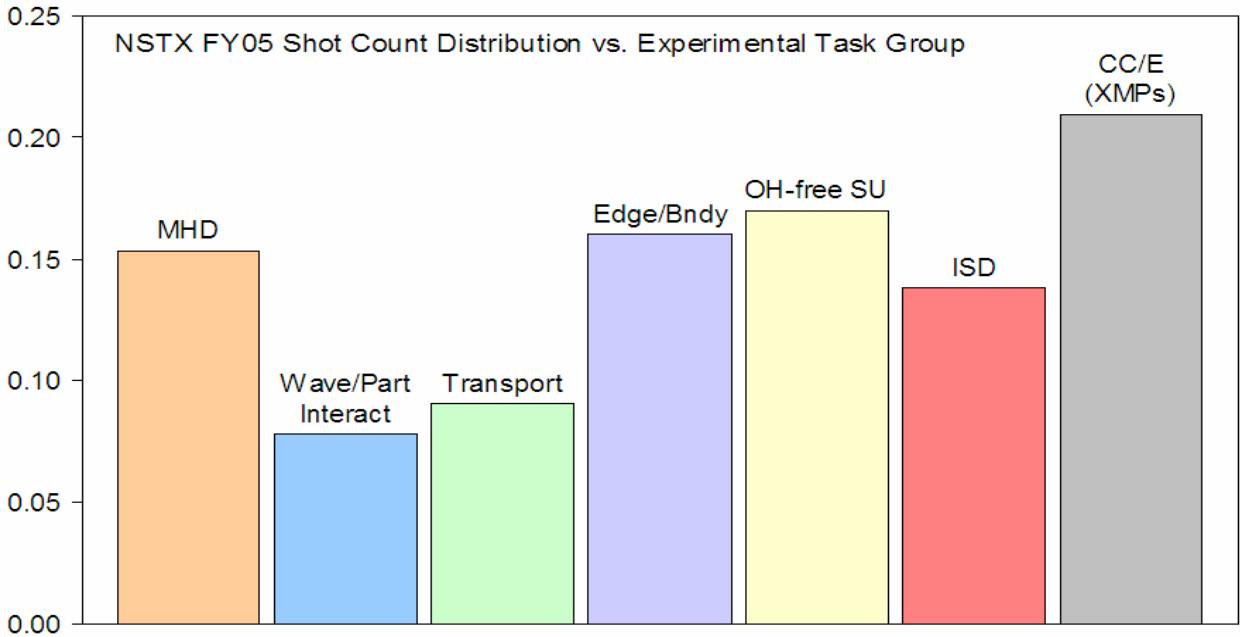

College W&M
Colorado Sch Mines
Columbia U
Comp-X
General Atomics
INEL
Johns Hopkins U
LANL
LLNL
Lodestar
MIT
Nova Photonics
New York U
Old Dominion U
ORNL
PPPL
PSI
Princeton U
SNL
Think Tank, Inc.
UC Davis
UC Irvine
UCLA
UCSD
U Colorado
U Maryland
U Rochester
U Washington
U Wisconsin

Culham Sci Ctr
U St. Andrews
York U
Chubu U
Fukui U
Hiroshima U
Hyogo U
Kyoto U
Kyushu U
Kyushu Tokai U
NIFS
Niigata U
U Tokyo
JAERI
Hebrew U
Ioffe Inst
RRC Kurchatov Inst
TRINITI
KBSI
KAIST
ENEA, Frascati
CEA, Cadarache
IPP, Jülich
IPP, Garching
ASCR, Czech Rep
U Quebec

# FY05 NSTX Plasma Operations Completed Successfully

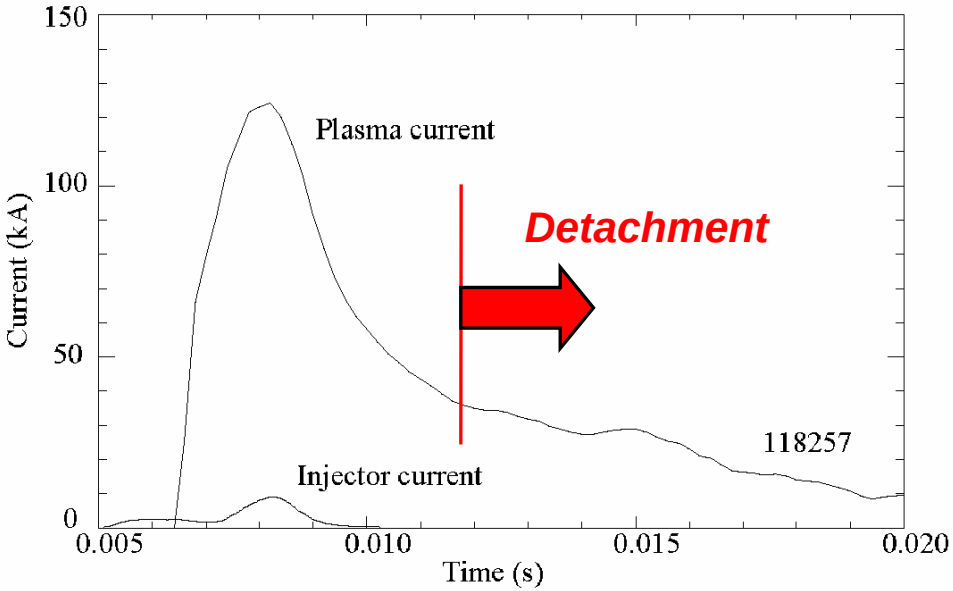
- **FY2005 Joule milestone: 17 weeks**
  - Completed: 18 weeks producing 2221 plasmas.
  - All the facility, diagnostic milestones completed
- **New Research Capabilities Introduced in FY 05**
  - New shortened PF1A divertor coils for high-$\delta$ at high-$\kappa$
  - Error Field / Resistive Wall Mode (EF/RWM) coils powered by Switching Power Amplifier for plasma stability control
  - 8 channel Motional Stark Effect (MSE) current profile diagnostic
  - 10 additional channels of MPTS – diagnose H-mode pedestal
- **New Research Capabilities Commissioned in FY05**
  - Tangential high-k scattering system for electron transport physics
  - Moveable glow probe became operational

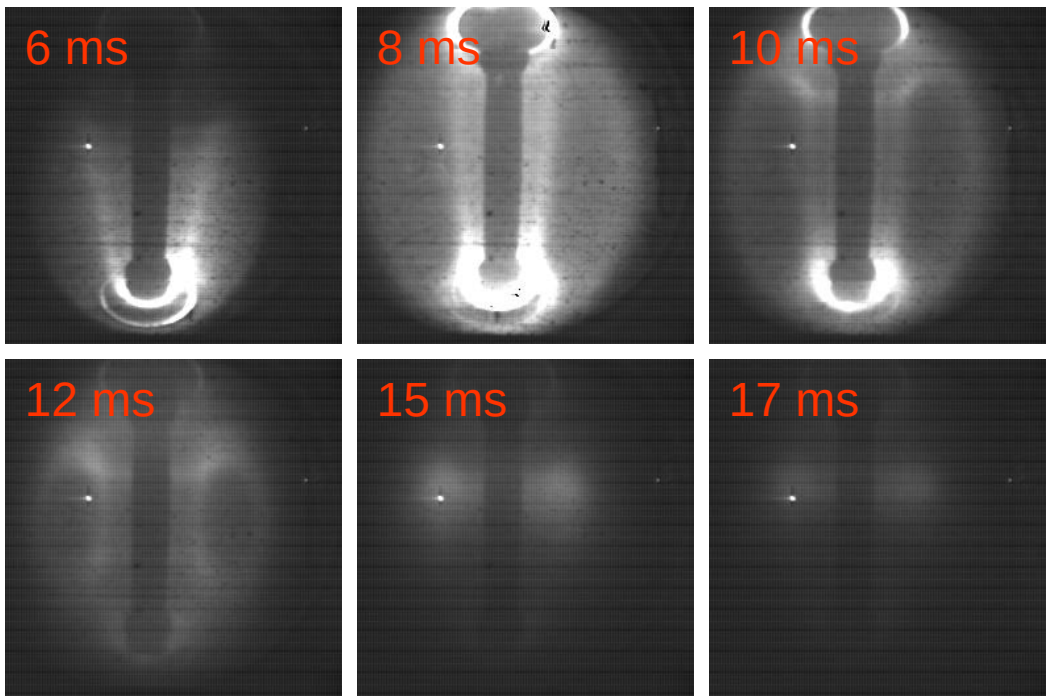
# Shot distribution for FY2005 NSTX run reflects commissioning and usage of many new machine capabilities




- Cross-cutting & Enabling – **MSE calibr.,** HHFW cond., ECH pre-ionization, PCS/rtEFIT
- CHI – **made closed flux!** many shots per run day, took advantage of lack of OH
- Edge/Boundary – **Li pellet injection**, ELM mitig., detachment, rec. probe, SGI, ELM stability
- MHD – **new RWM/EF coils** → RWM & flow damping, β limits with new PF1A, error fields/LM
- ISD – **new PF1A coil → Long pulse DND and LSN**, non-solenoidal ramp-up with HHFW
- Transport – **e-ITB vs. q-shear**, OH H-mode, LH threshold, ion ITB, perturbed e-transport
- WPI – ***AE vs. q and q′**, **modulated HHFW**, HHFW-CD w/ MSE, NPA scan w/ H-mode+MHD
- OH water leak → end-of-run transport and WPI XPs requiring higher TF not performed

# Closed-flux current has been generated using Transient CHI

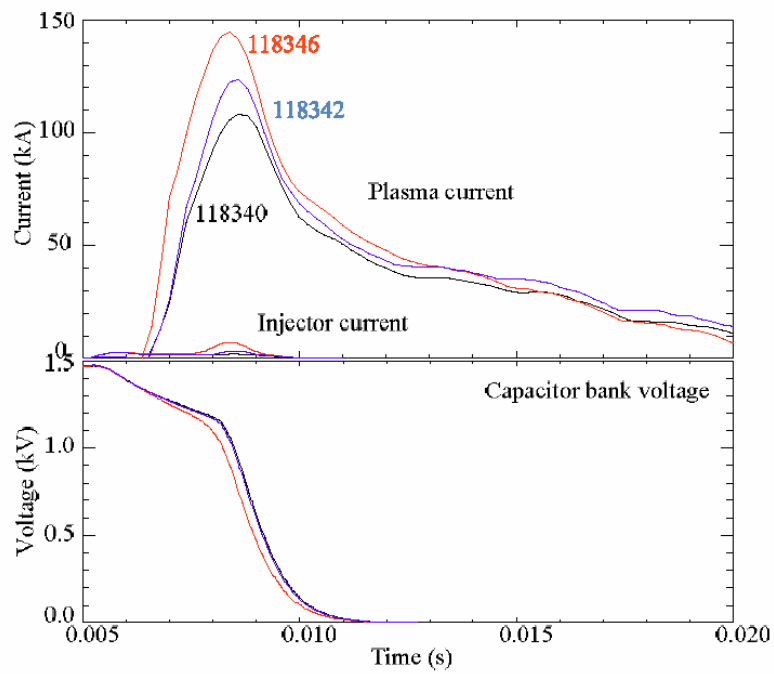


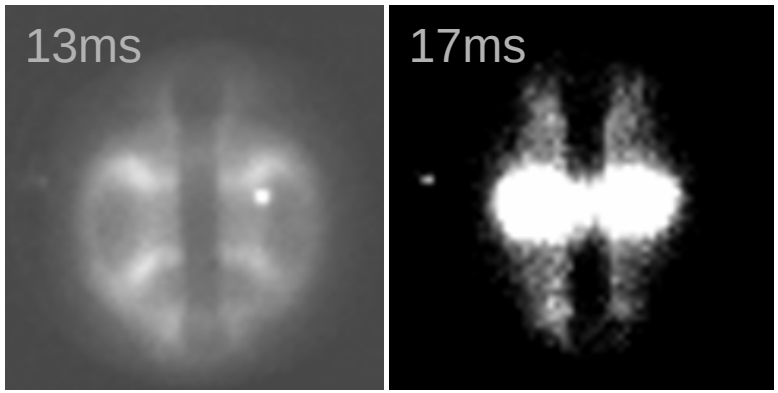



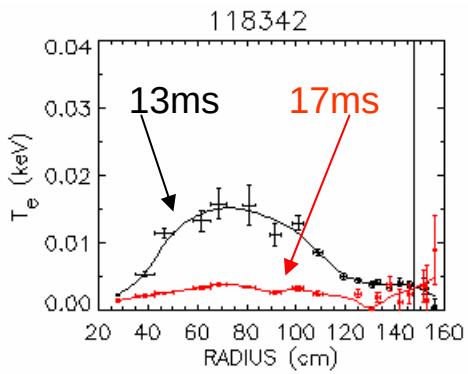

- Plasma current amplified many times over the injected current.
- Camera images at 12 to 17ms shows clear detachment of plasma from injector region

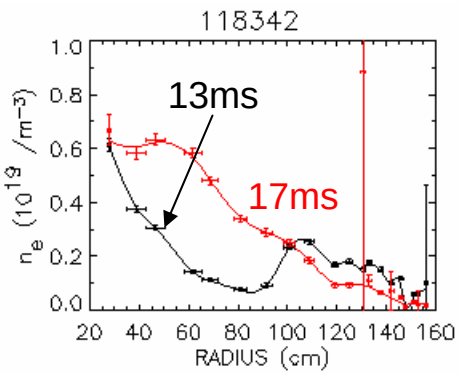
Hiroshima University (N. Nishino) Camera Images: R. Kaita (PPPL)

# Electron kinetic profiles show centrally peaked $T_e$ and inward motion during the current persistence phase



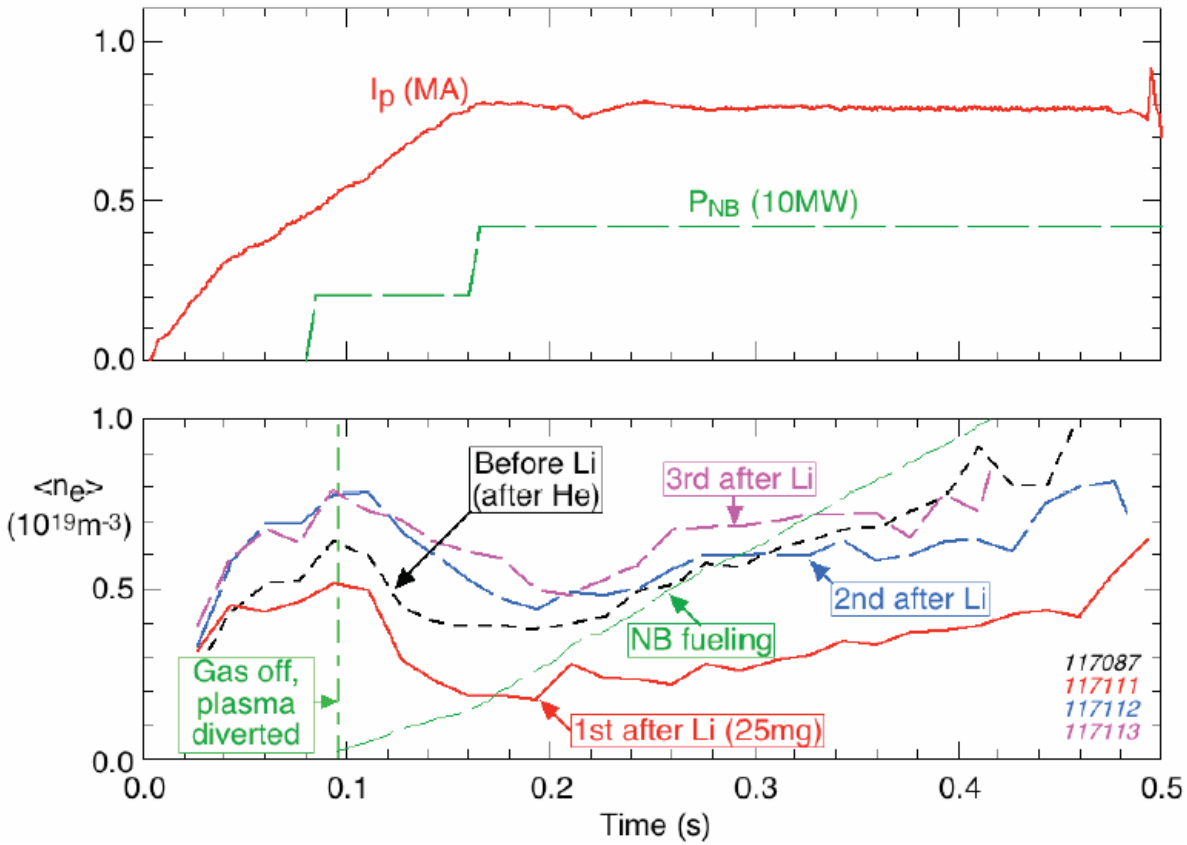

Movement of discharge towards CS seen in the density profile, consistent with the camera image

>60kA of closed flux current generated using Transient CHI

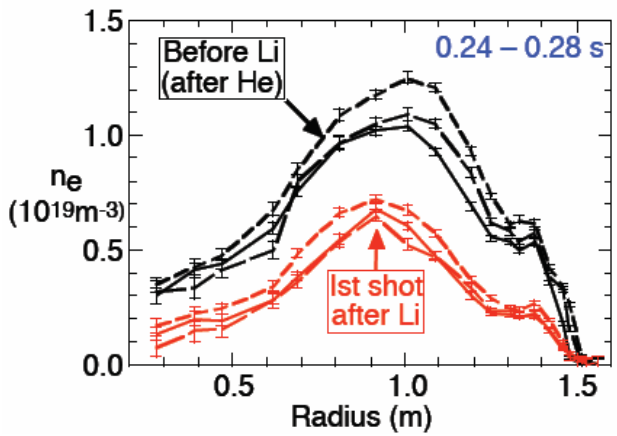
Unambiguous closed flux current generation is clearly demonstrated by these discharges.

Phantom Camera Images: R. Maqueda (Nova Photonics)
Thomson scattering: B. LeBlanc (PPPL)

# Density pumping was achieved using Li deposition on lower divertor - exhibited ×2 decrease in density + peaked e-profiles

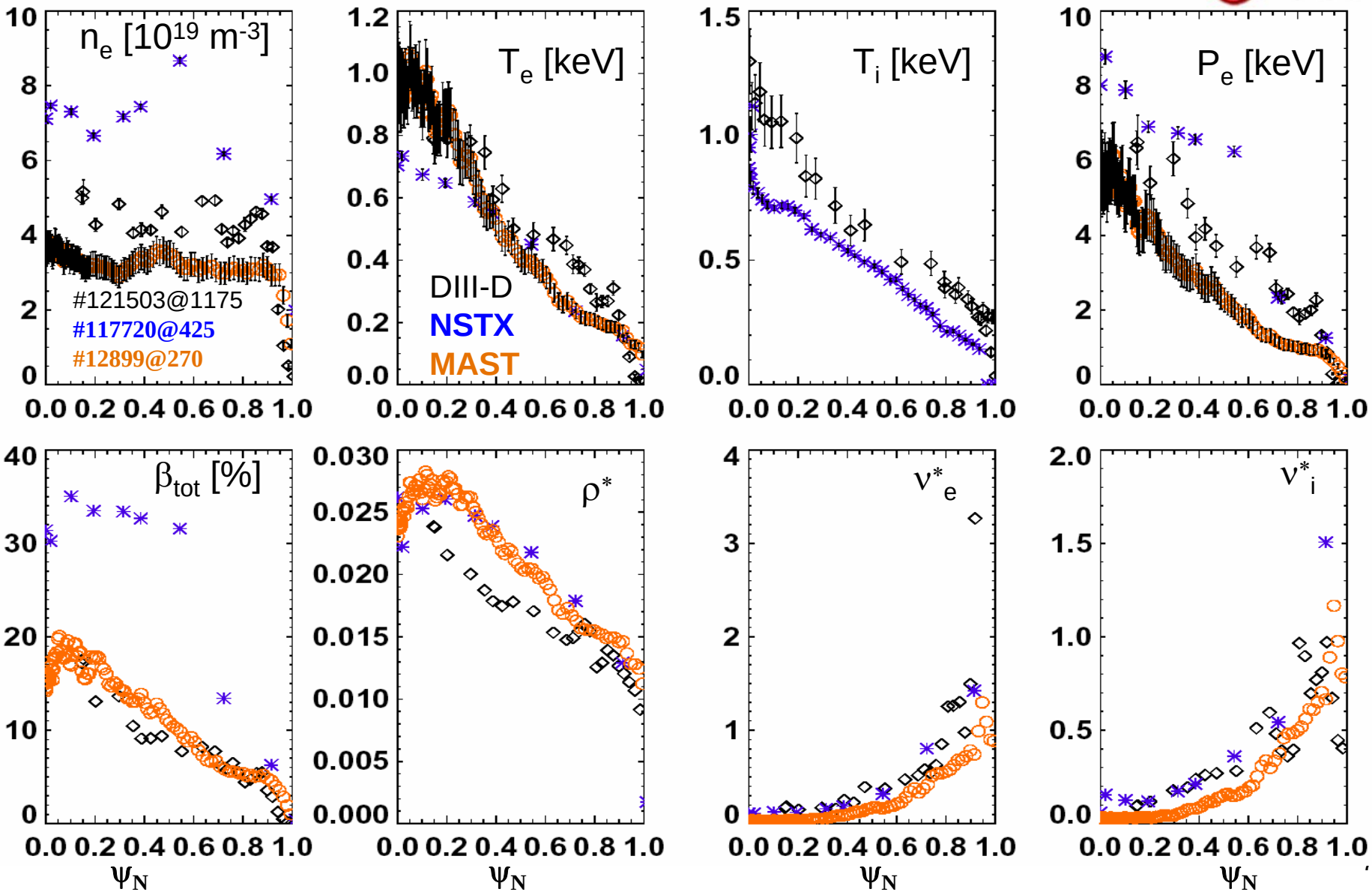



Lower single-null divertor discharges, 0.45T, $D_2$ gas fueled 3.5mg

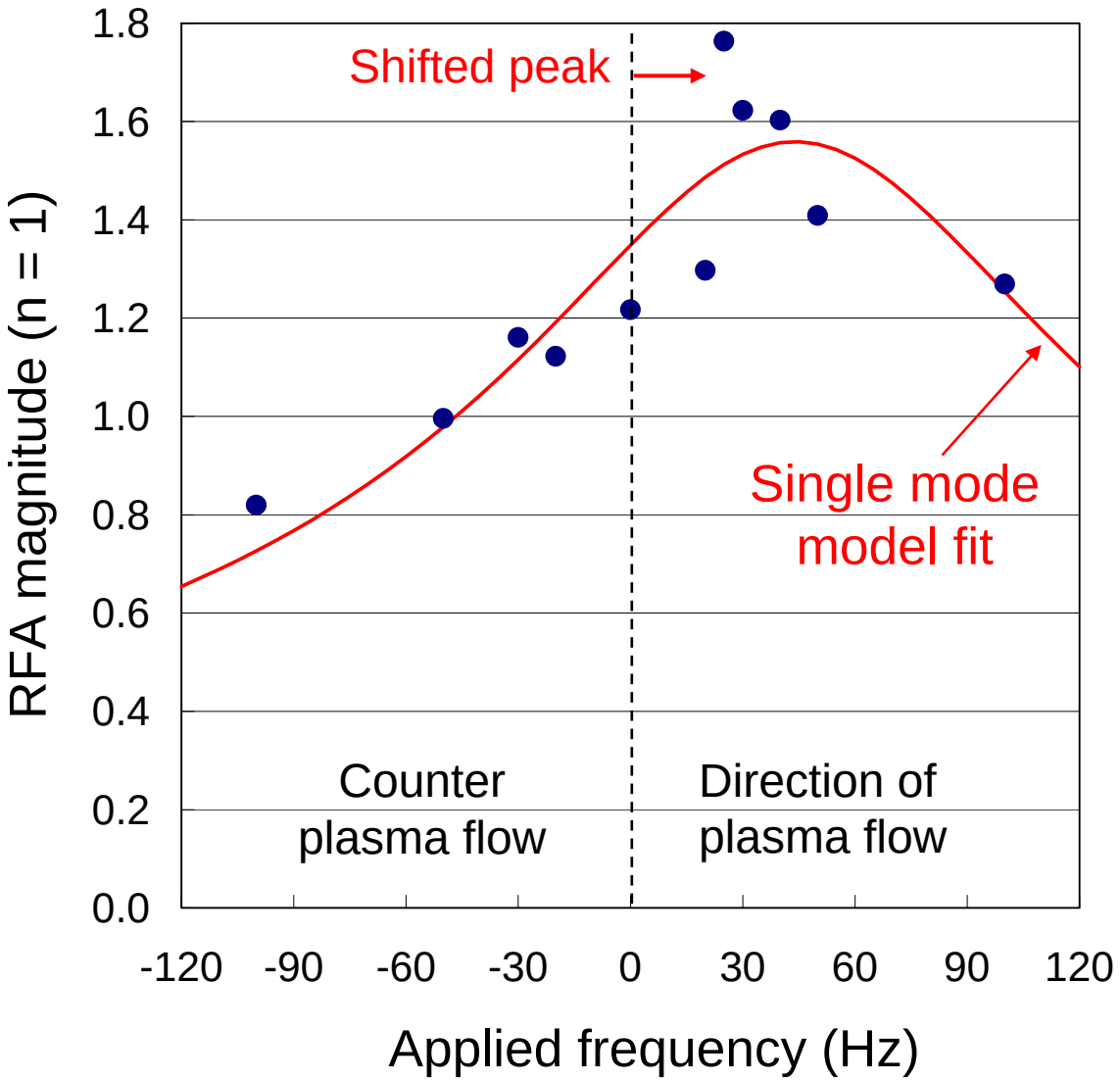



- 25 mg of lithium pumping of edge density saturated after the 3 reference discharges and returned to pre Li wall conditions.
- Expected if most injected gas reacts with the deposited lithium

# DIII-D/MAST/NSTX Pedestal Similarity Experiment obtained profile data to improve understanding of $w_{PED}$ scaling and stability



# RWM spectroscopy experiment measured n=1 resonant field amplification (RFA) dependency on applied field frequency

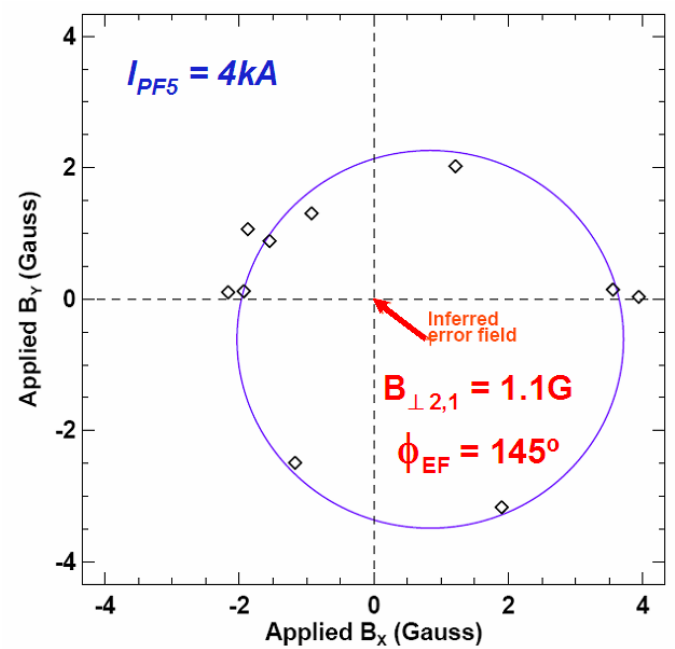



$$RFA = \frac{B_{plasma}}{B_{applied}}$$

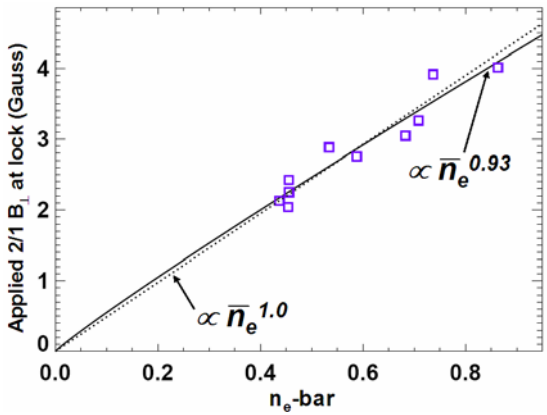
- Applied field phased to create traveling wave in toroidal direction
- Peak in RFA shifted in the direction of plasma flow
  - Peak near 30 Hz
  - Expected by RWM theory / experiment
    - Observed in DIII-D (H. Reimerdes, NF 45 (2005) 368.)

# Error field and locked mode experiments indicate a "non-static" residual error field exists

Measured n=1 error field at low-density

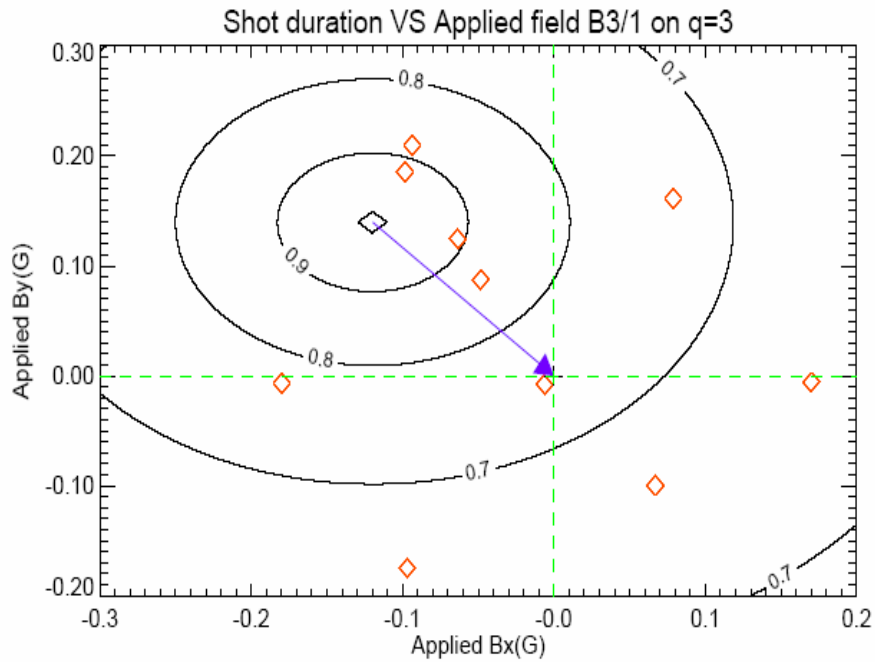



Measured density scaling of locking threshold

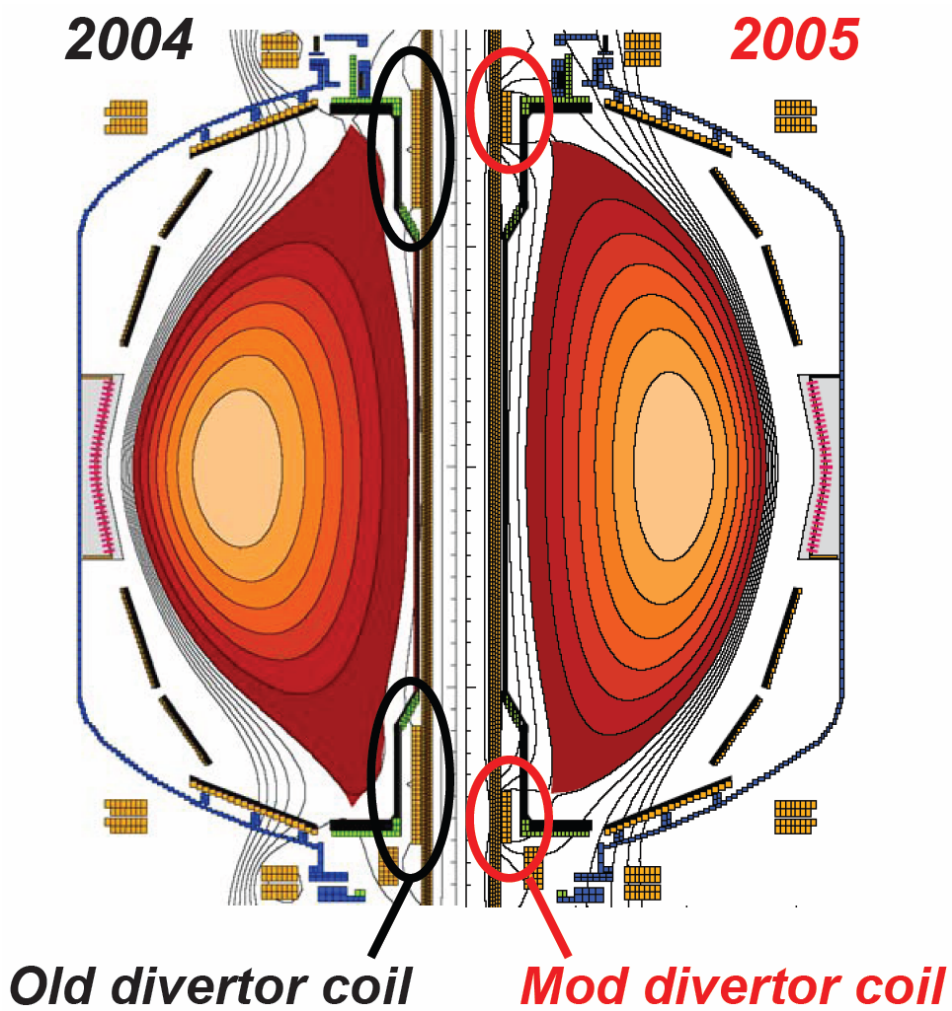


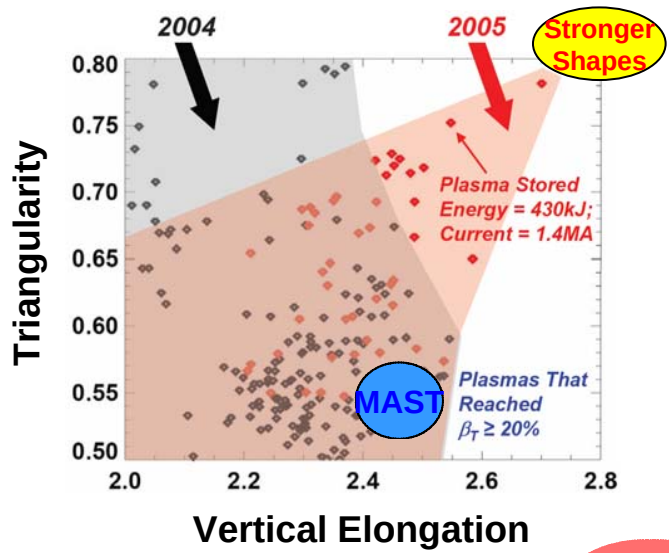

Extended pulse-length with EF correction in high-β discharges prone to disruption

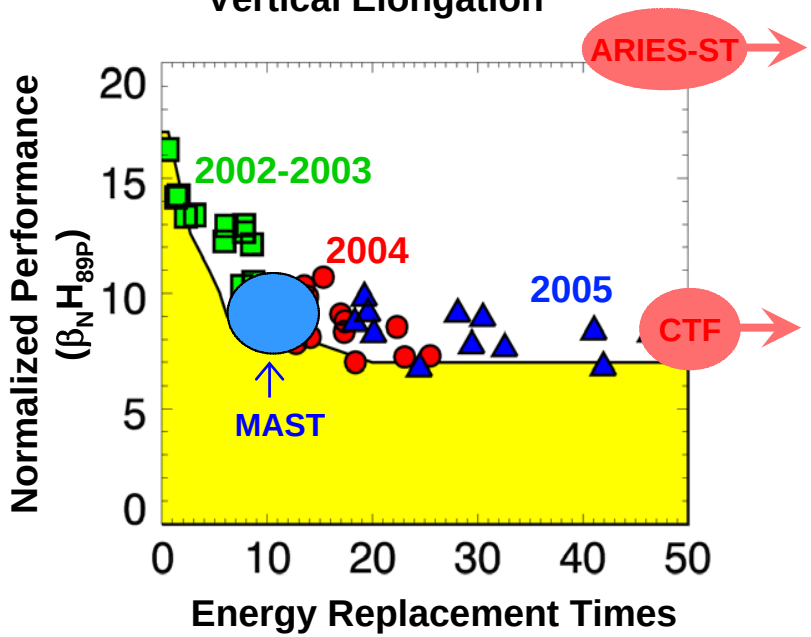
Inferred n=1 error field at high-beta, **and found EF in opposite direction** likely due to TF coil motion $\propto I_{OH} \times I_{TF}$



# New divertor poloidal field coils have significantly enhanced the plasma shaping capabilities of NSTX



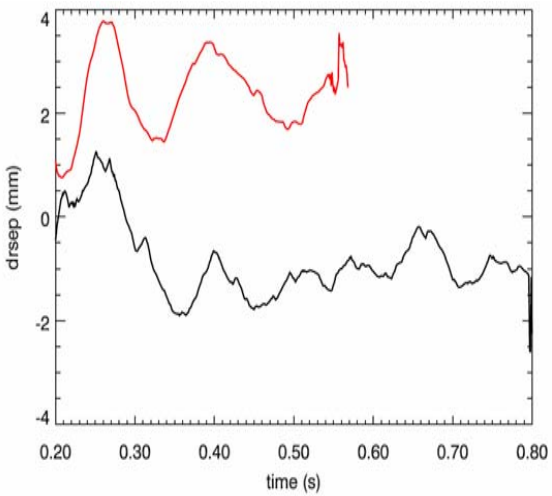



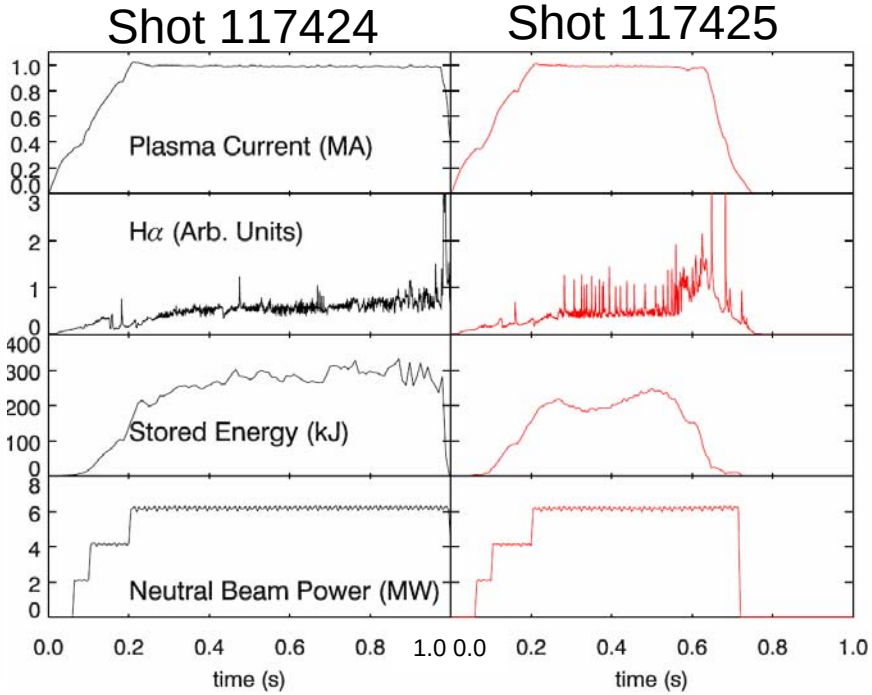
# rtEFIT allows precise control of X-point balance which can significantly affect ELM characteristics

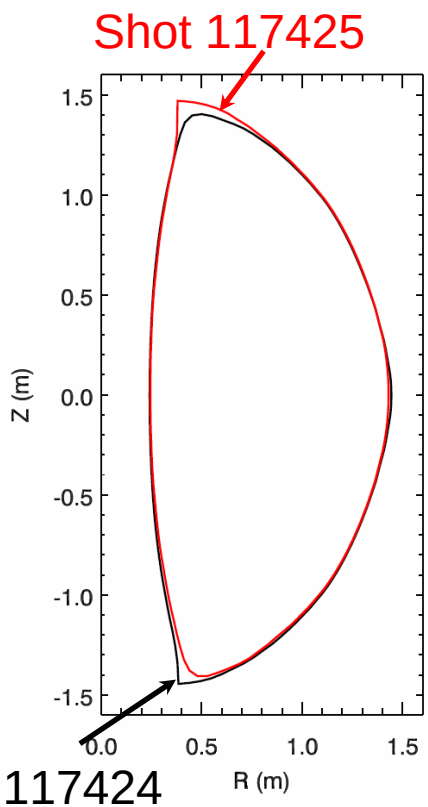
- Very small changes in the plasma boundary reproducibly lead to large differences in ELM behavior

- ELMs have a major impact on performance - controlling them is crucial

$\delta r_{sep}$ (mm) for 117424 (black) and 117425 (red)



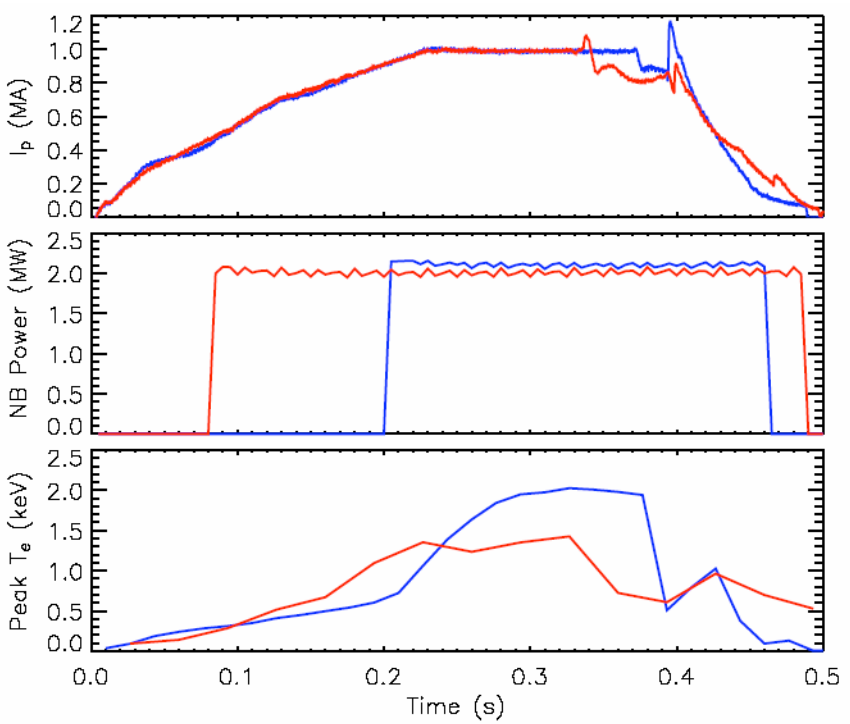



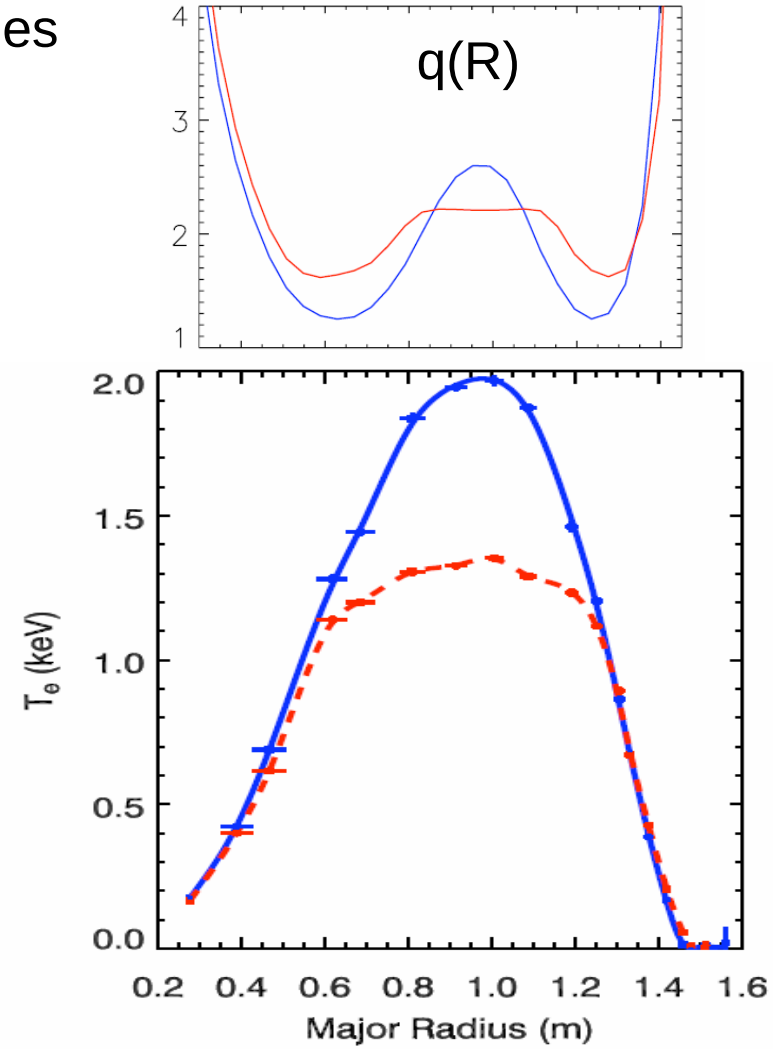




$\delta r_{sep}$ is the radial separation of the flux surfaces which pass through the x-points measured at the outboard midplane

# Improved electron energy confinement correlates with degree of shear reversal - measured with MSE

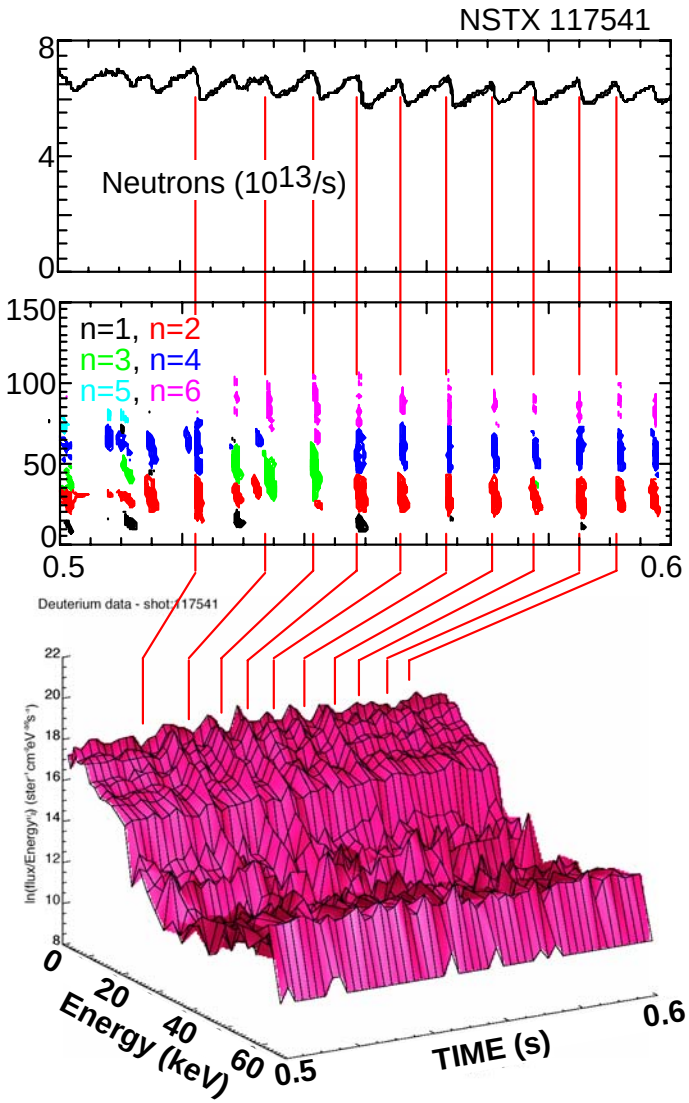
- CS limited 1MA, 4.5kG L-mode discharges
  - nearly DN diverted
- $\tau_E$ = 60-80ms, up to 100ms w/ H-mode



# Impact of EPM/TAE/GAE/CAE on fast ion confinement, heating, and CD under investigation

## Structure diagnosed with Mirnov, reflectometer, SXR, MSE, and f(E) with NPA

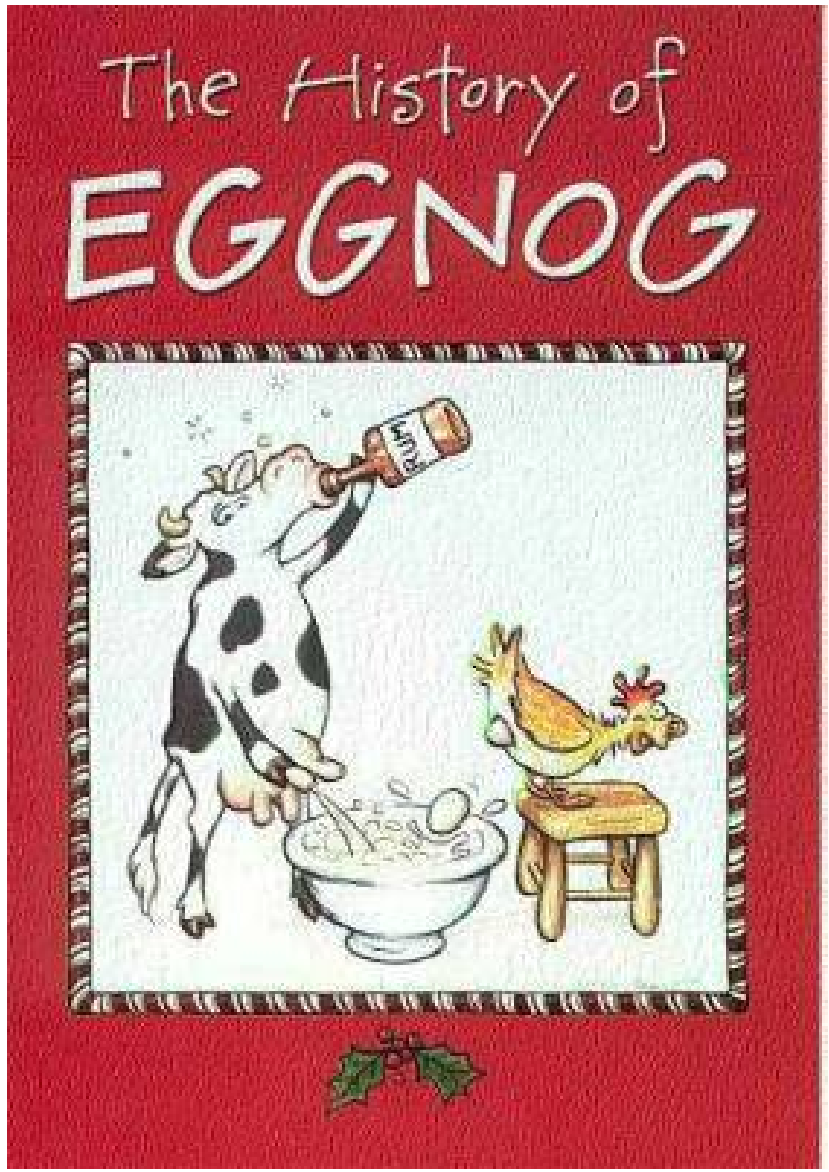



## Example: EPMs

- Strongest modulation is seen for lowest energies; below "half" energy.
- Neutron drops of 10% suggest high energy ions also lost.
- Broad range of energy interaction consistent with bounce-resonances

# Summary

What I felt like drinking after coordinating the FY05 run




Good luck to Roger!

(you're going to need it)