NSTX

Performance of early H-mode PF1B LSN discharges

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NSTX Results Review for FY2004 Run

Princeton Plasma Physics Laboratory
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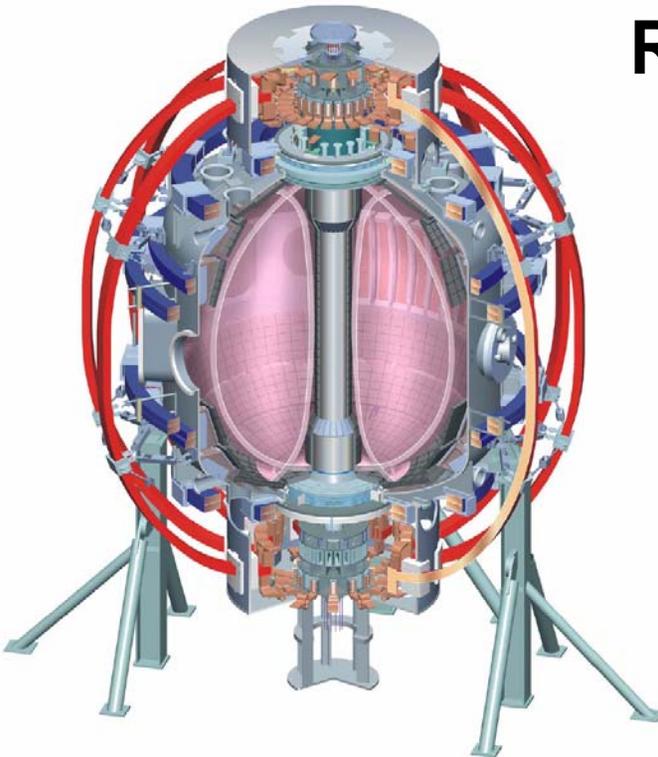
Goals of XPs 432 & 440

- ## XP 432 - Long pulse development in strongly-shaped LSN plasmas
  - **Increase elongation and triangularity using PF1B coil**
  - **Extend LSN long-pulse plasmas from FY02 to lower B_T**
  - Increase plasma current in LSN shape – test β limits

- ## XP 440 - Develop Early H-mode Startup for Access to High q_{min}
  - Generate H-mode transition during I_P ramp
    - Improved confinement raises T_e and BS current
    - Reduces flux consumption, increases q_{min}
  - **Delays J-profile penetration**
  - **Increases pulse length, allows higher current**

Extend long-pulse LSN shape to higher κ & δ

**Record pulse-length shots w/ small ELMs obtained in LSN in FY02**
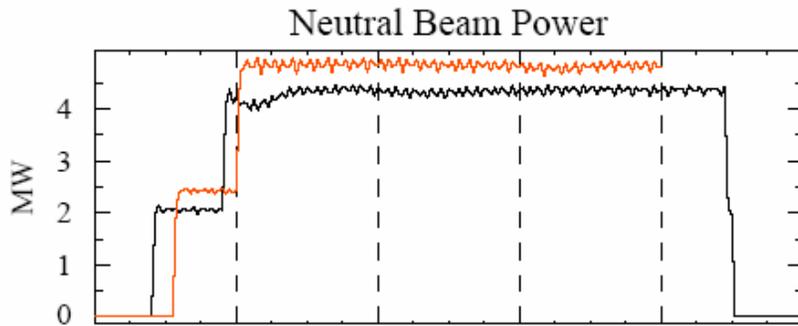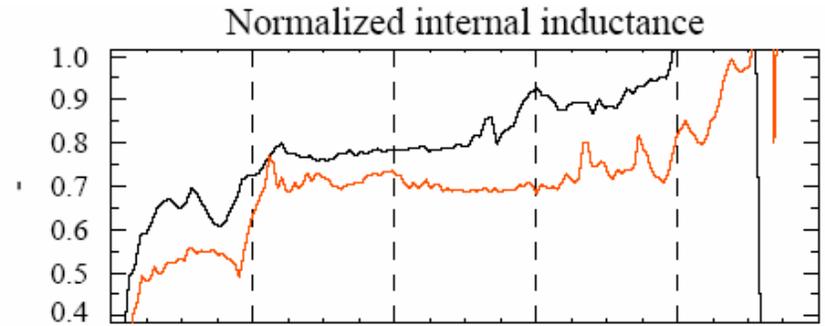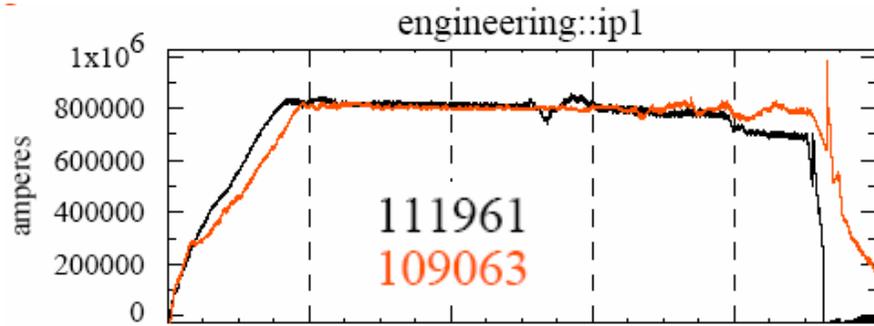
- Need to run at lower TF to extend pulse
  - $\int I^2_{TF} dt$ limit on TF coil
  - Want to raise long-pulse β

- Lower B_T → lower T_e → J profile relaxes faster

- **Need to fix or raise q for good MHD stability**
  - **Raise κ = 2 → 2.4**
  - **Raise δ = 0.4 → 0.55**

- **Use PF1B for high δ_L**
  - **Not used previously**

109070
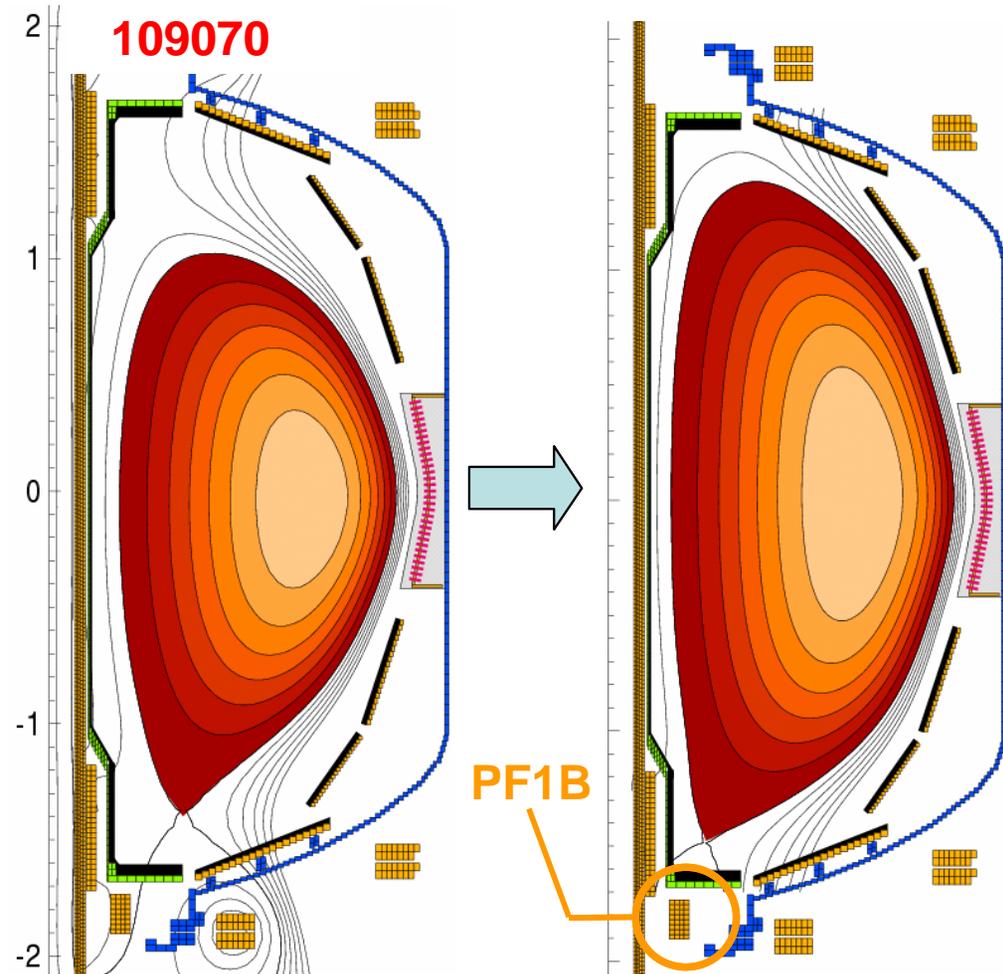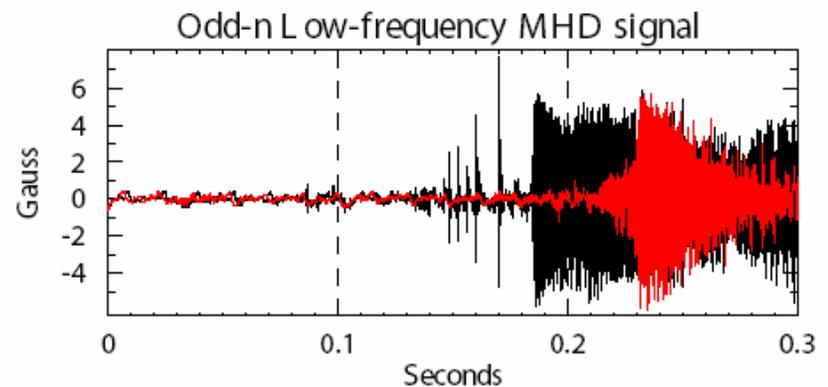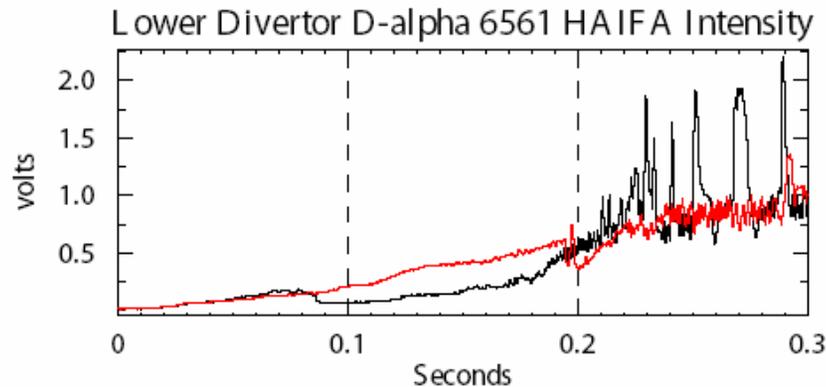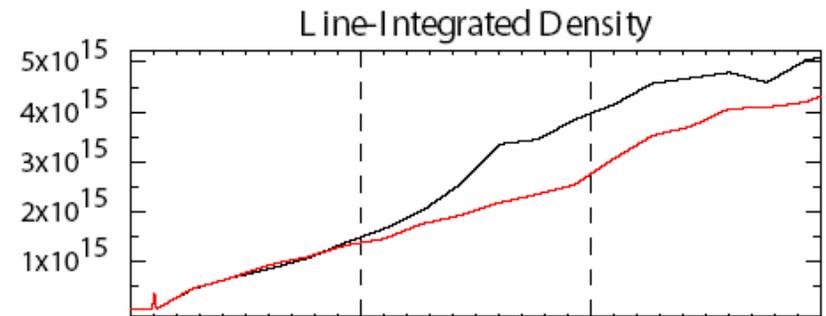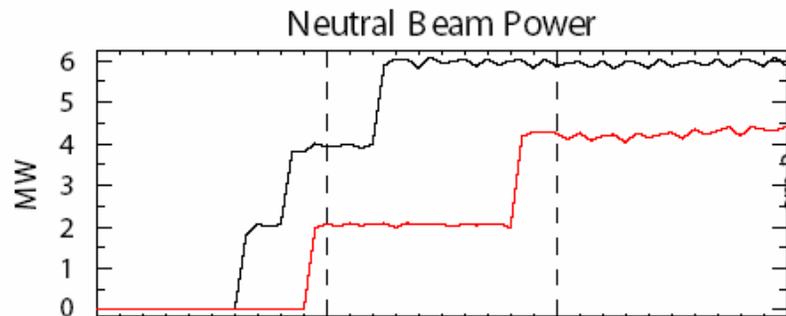
PF1B

Matched performance of 5kG LSN at 4.5kG

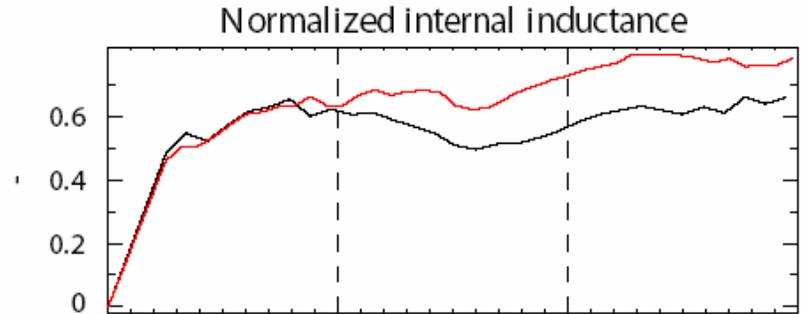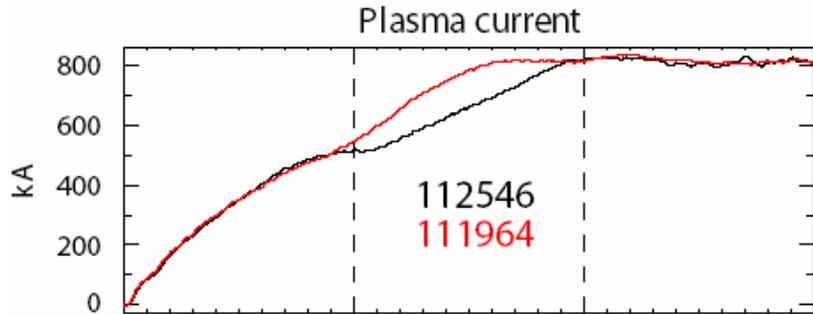**Both discharges affected by n=1 rotating mode that locks near t=700-800ms**
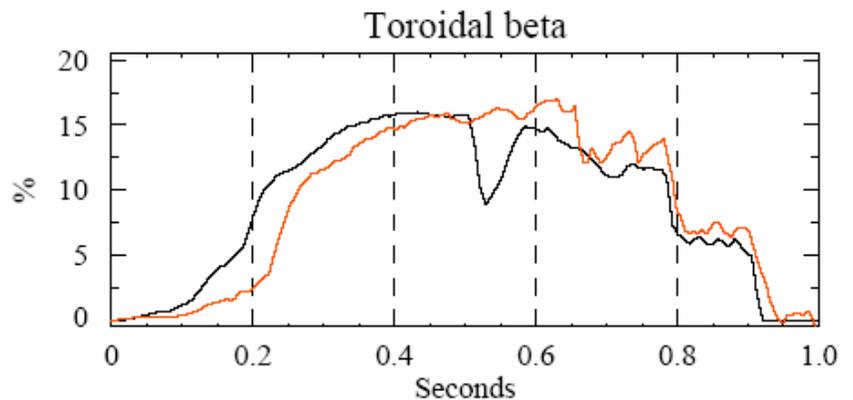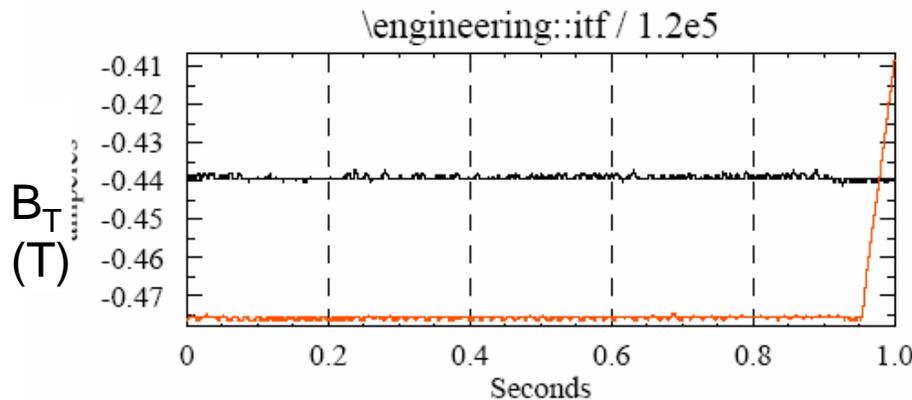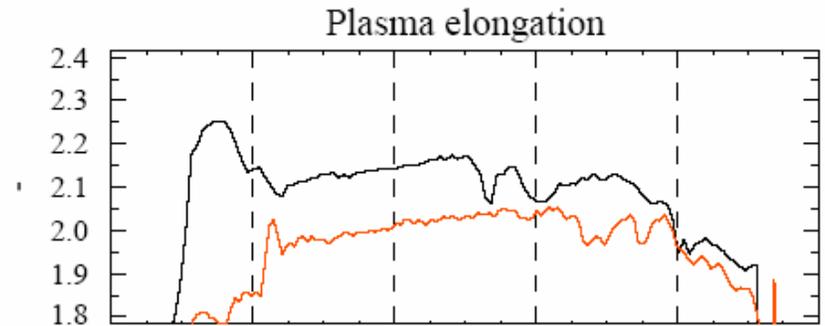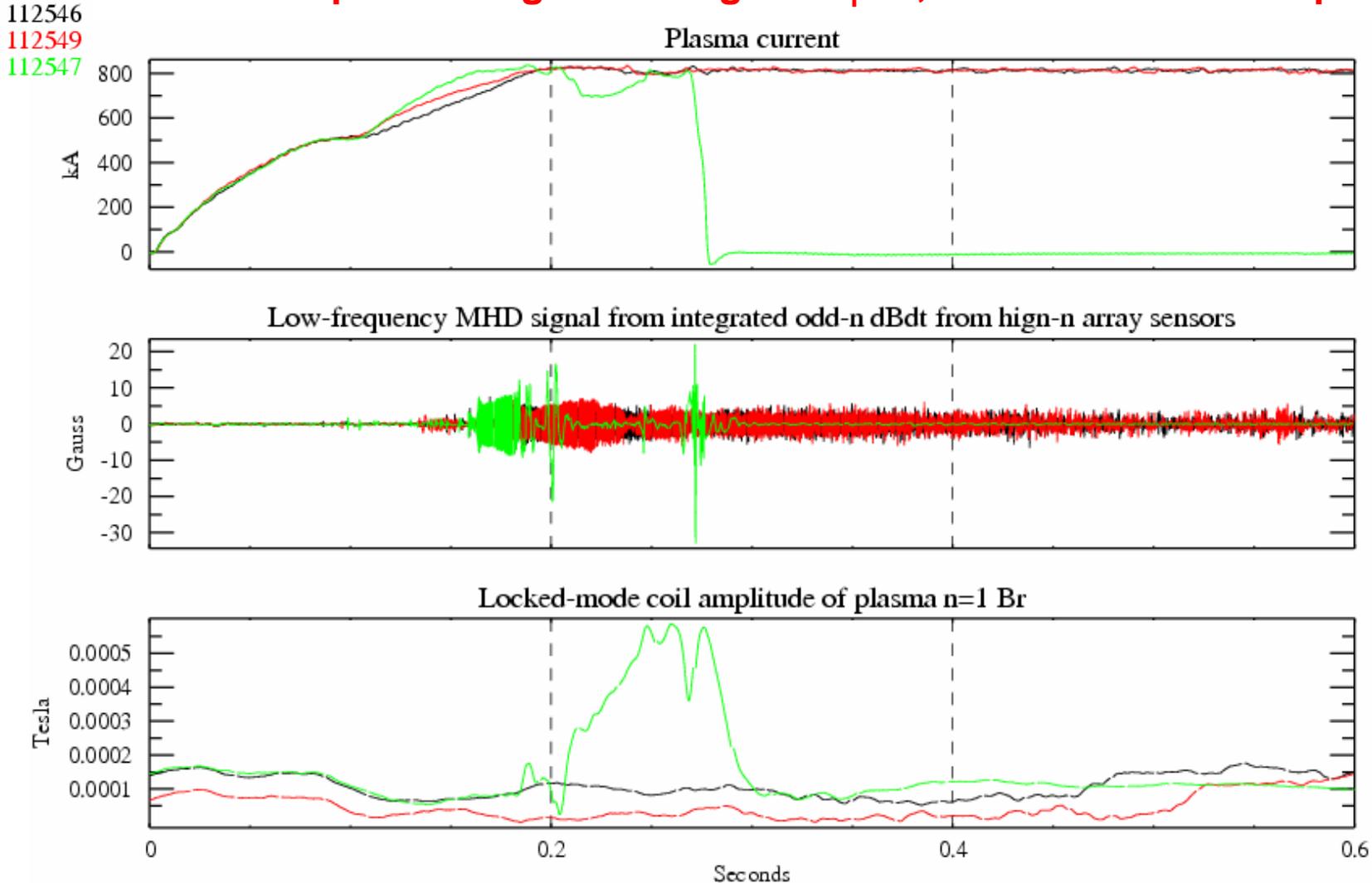
PF1B LSN + I_P pause + early P_{NBI} → early H-mode

- **H-mode triggered @ t=80-90ms by P_{NBI} = 2-4MW**
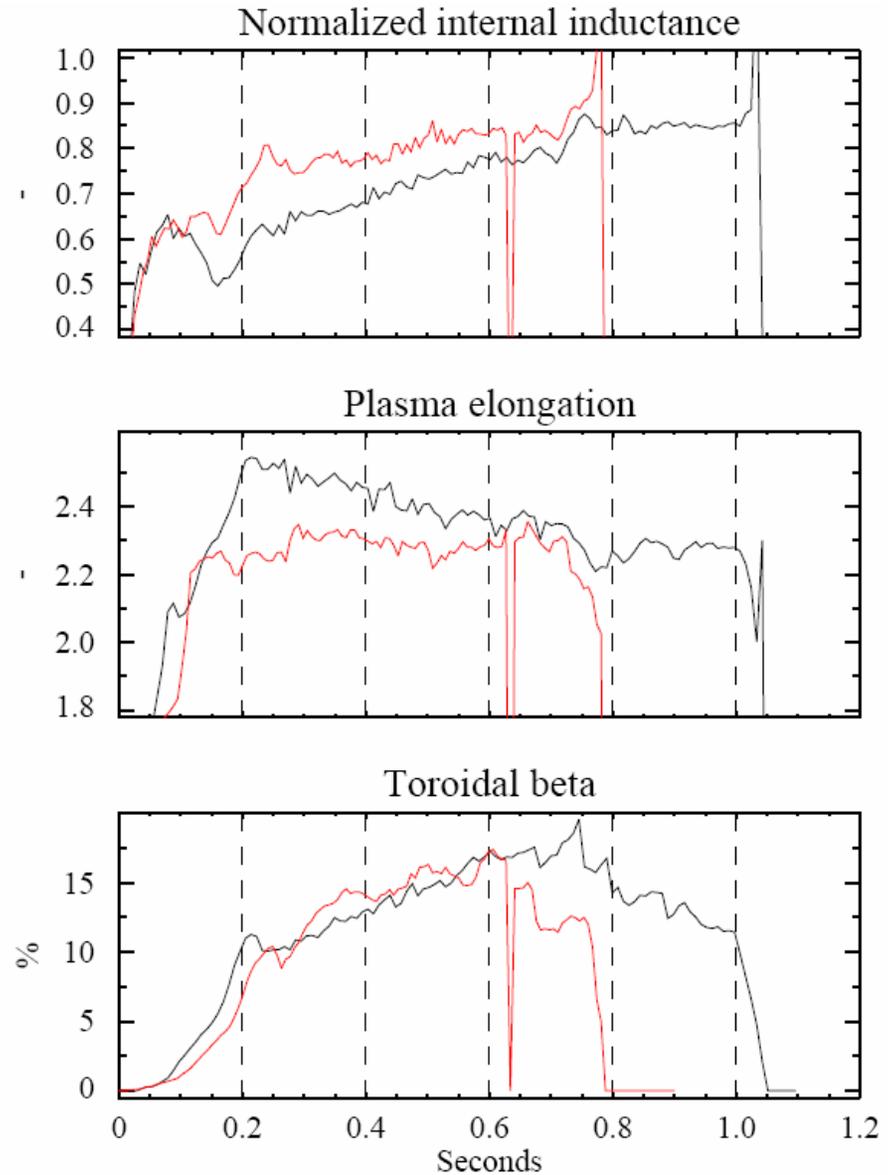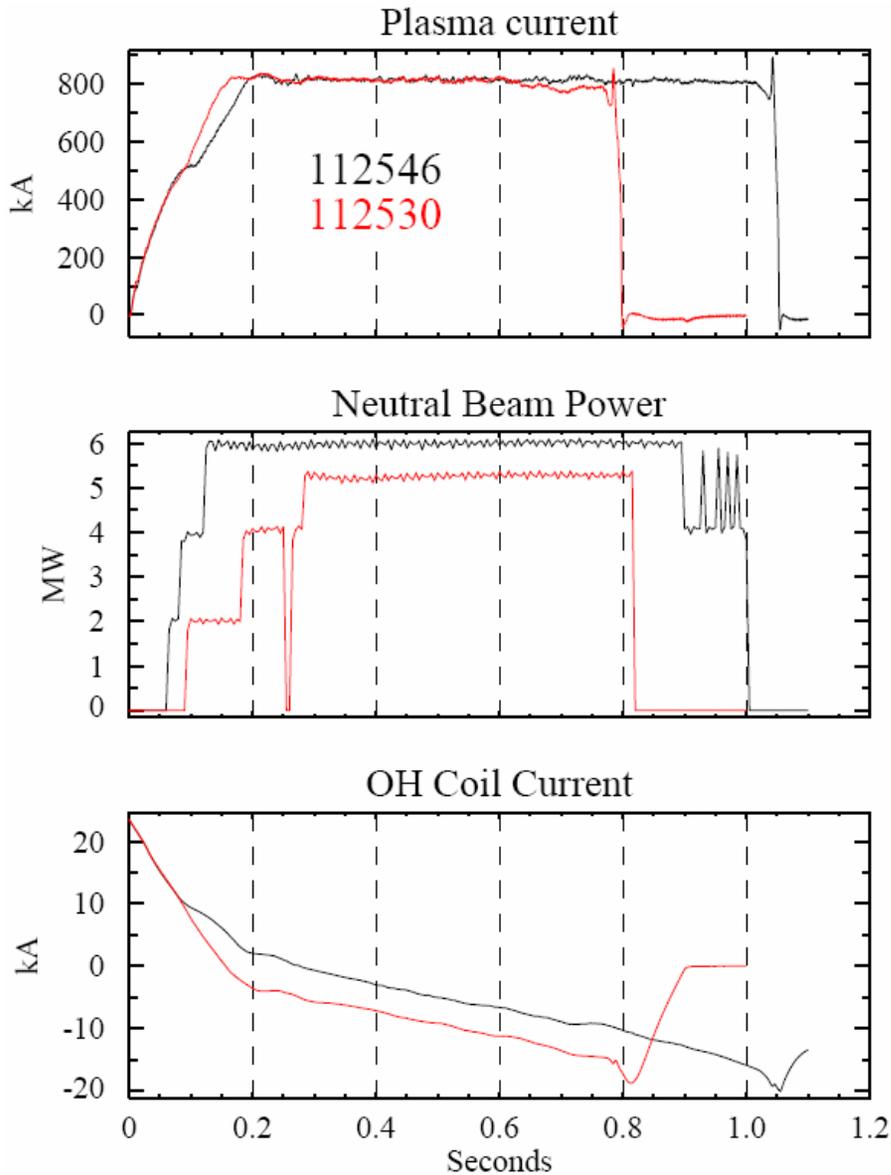- **Broader pressure profile stable (ideally) to increased P_{NBI}**
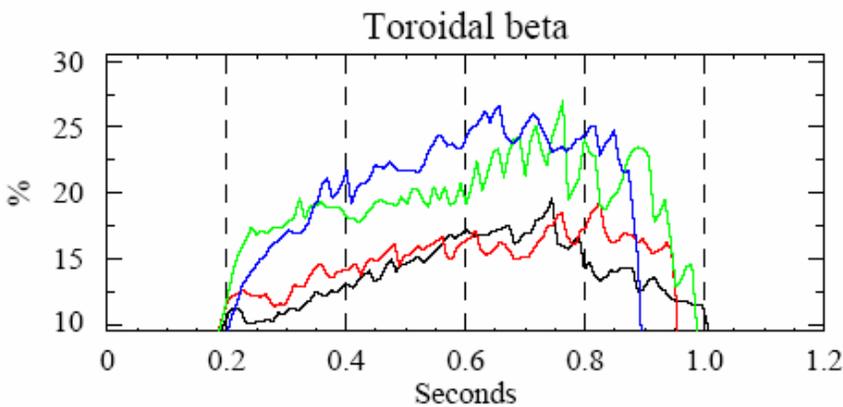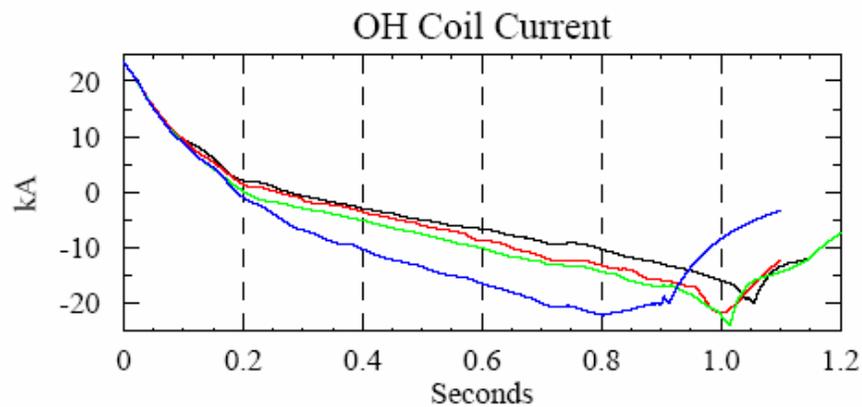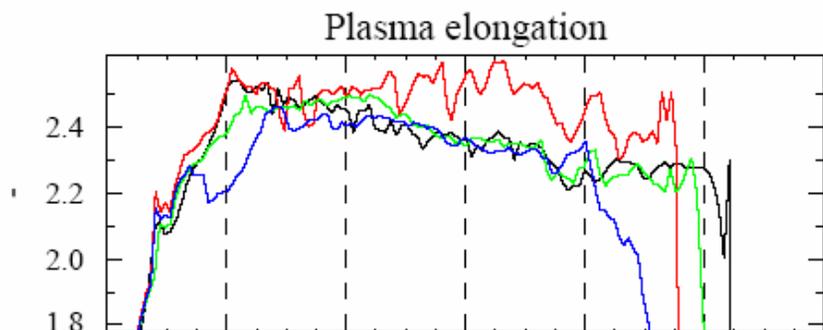
Discharge sensitive to dI_P/dt after H-mode transition
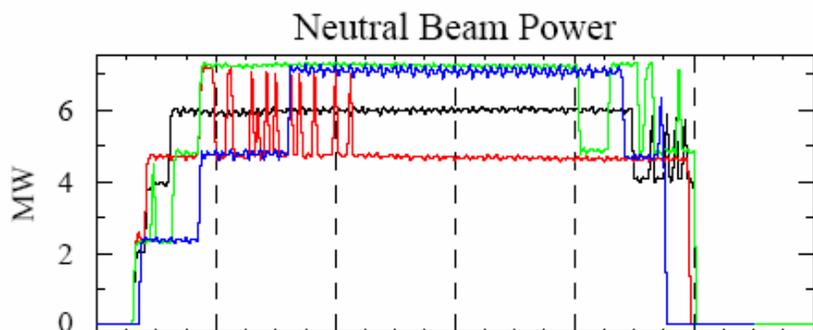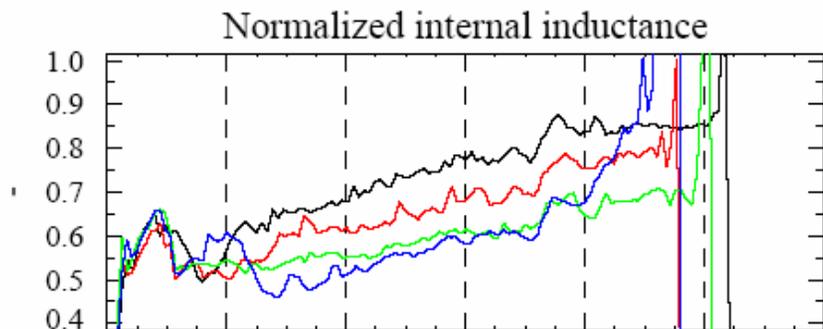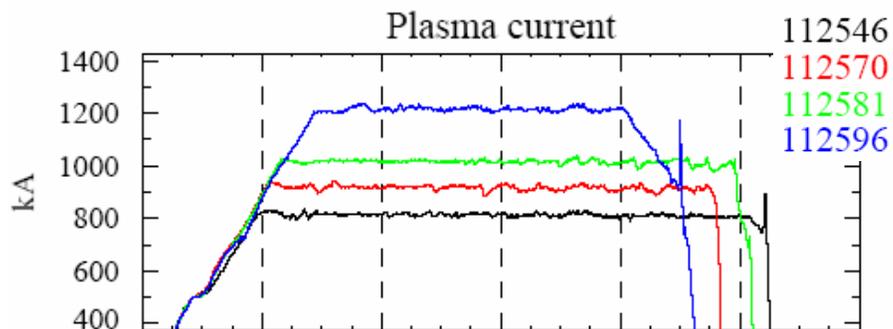
n=1 rotating mode excited @ t=160-180ms in most early H-mode shots

Mode amplitude larger with higher dI_P/dt, mode locks → disruption

Early H-mode extended pulse-length 30% in 1 day

Extended early H-mode to I_P = 1.2MA, 0.5s flat top

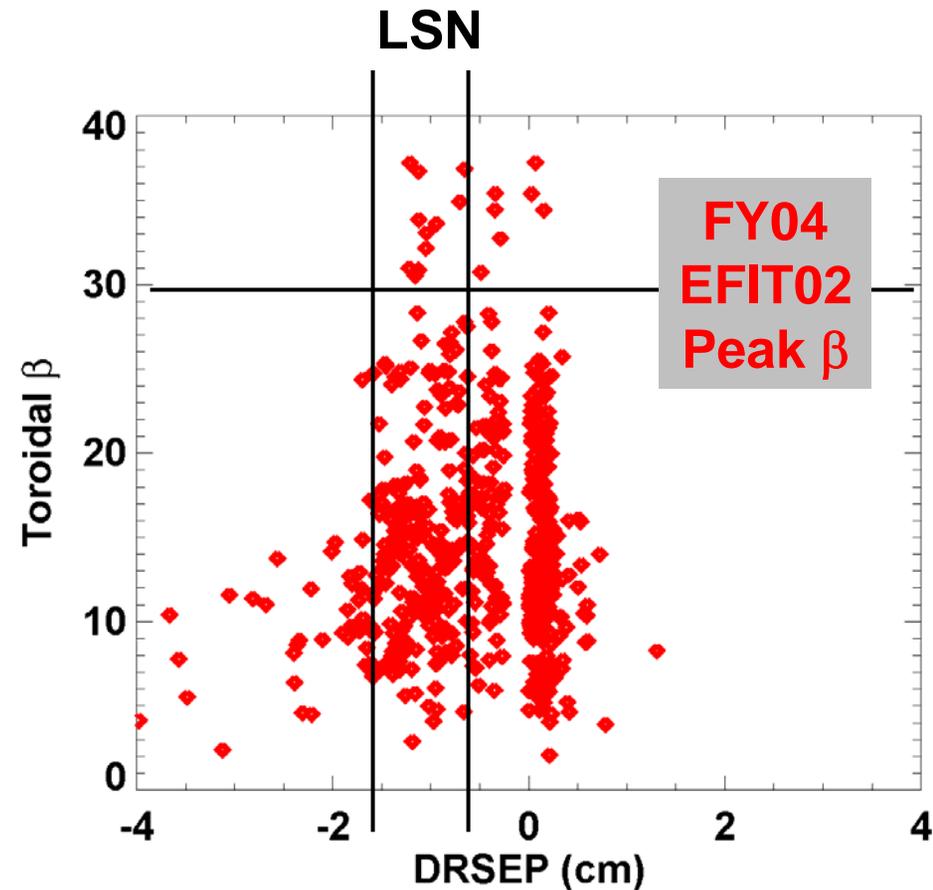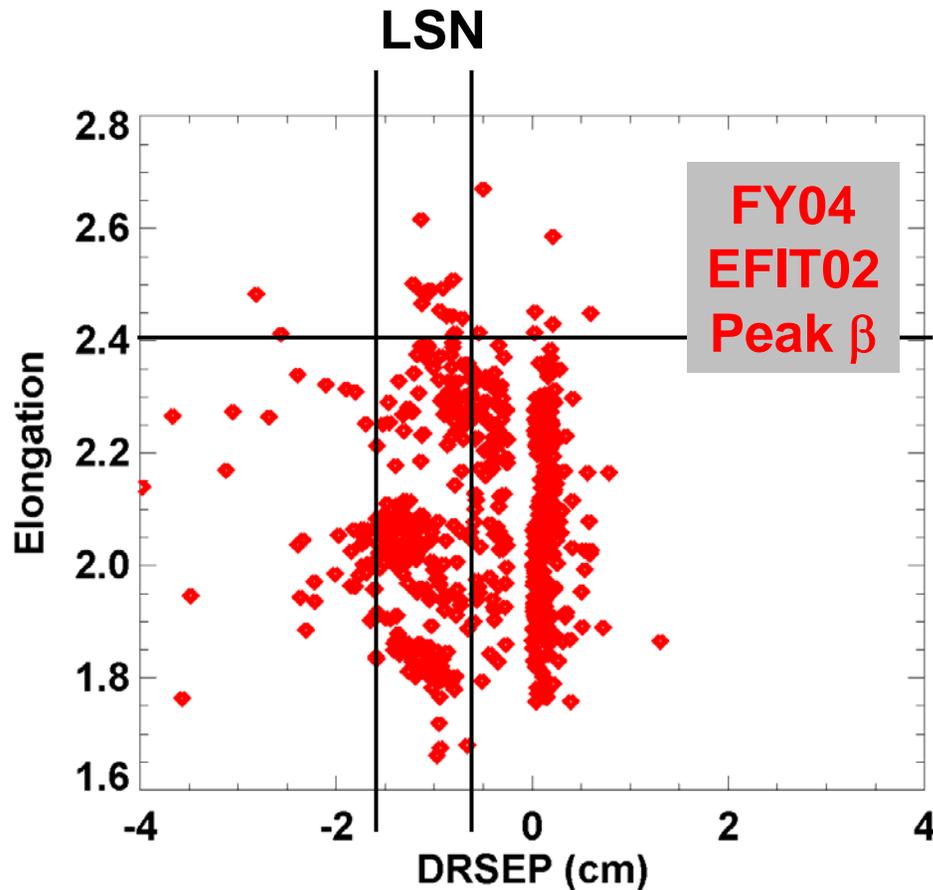# High elongation & β achieved in LSN

Many LSN shots with κ above 2.4

Many shots with κ above 30%

PF1B LSN shape used as high-β target

- Achieved long 1.2MA pulses with **peak β_T $\leq$ 40%** in TF ramp shots (34% TRANSP)
  - Highest β "validated" against kinetics thus far

- Improved resolution (in R, t) charge exchange diagnostic

- Magnetics and SXR show 1/1 mode onset causes β roll-over

112600

I_t, I_p [MA]

P_{NBI} [MW]

H_α [arb]

W_{EFIT}, W_{TRANSP} [MJ]

$\beta_{T,EFIT}$, $\beta_{T,TRANSP}$ [%]

$n_e(0)$, $<n_e>$ [$10^{20}m^{-3}$]

$T_i(0)$, $T_e(0)$ [keV]

Time (s)
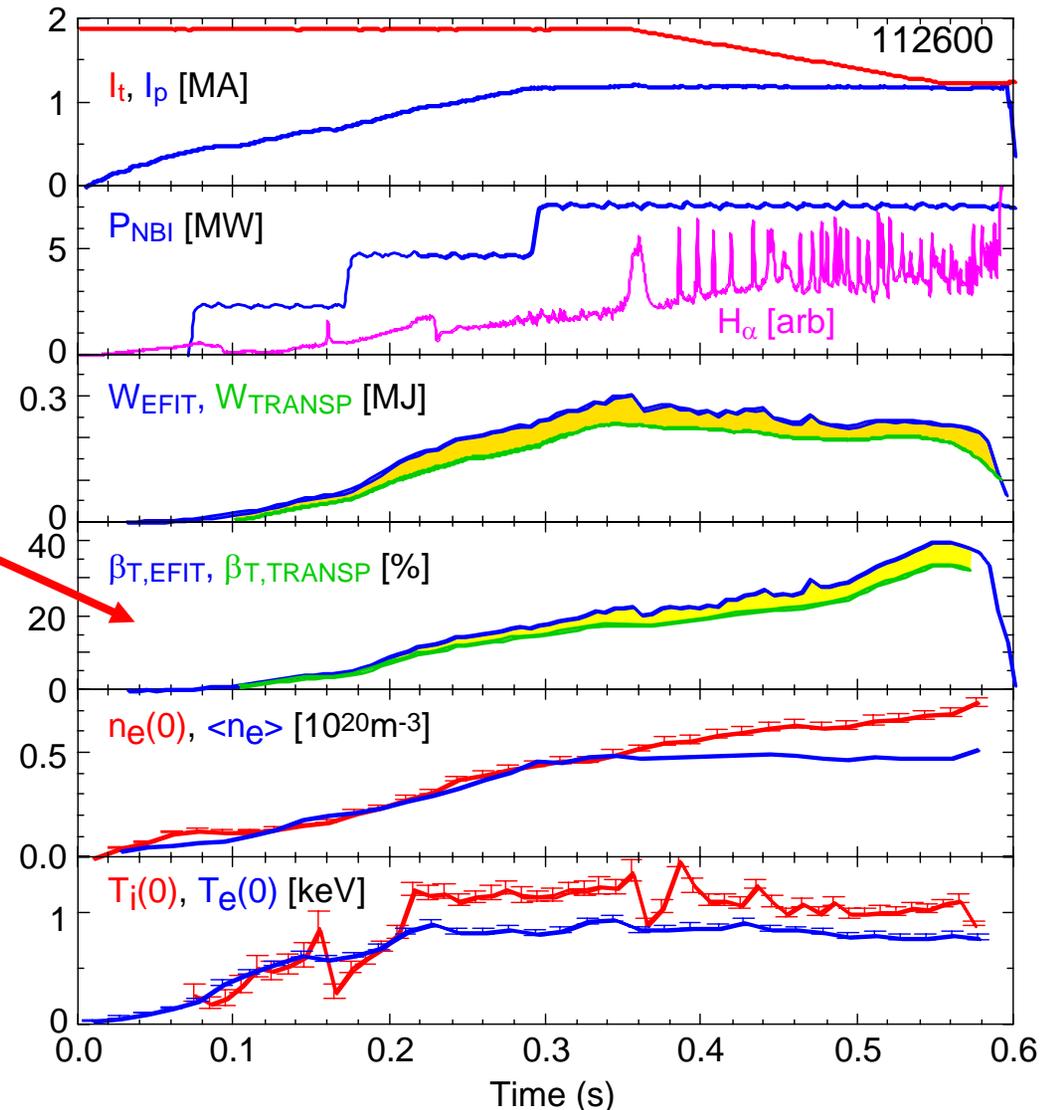
High f_{BS} (likely) achieved at higher β_T

Approximate f_{BS} ($0.5 \times \varepsilon^{\frac{1}{2}}\beta_P$)
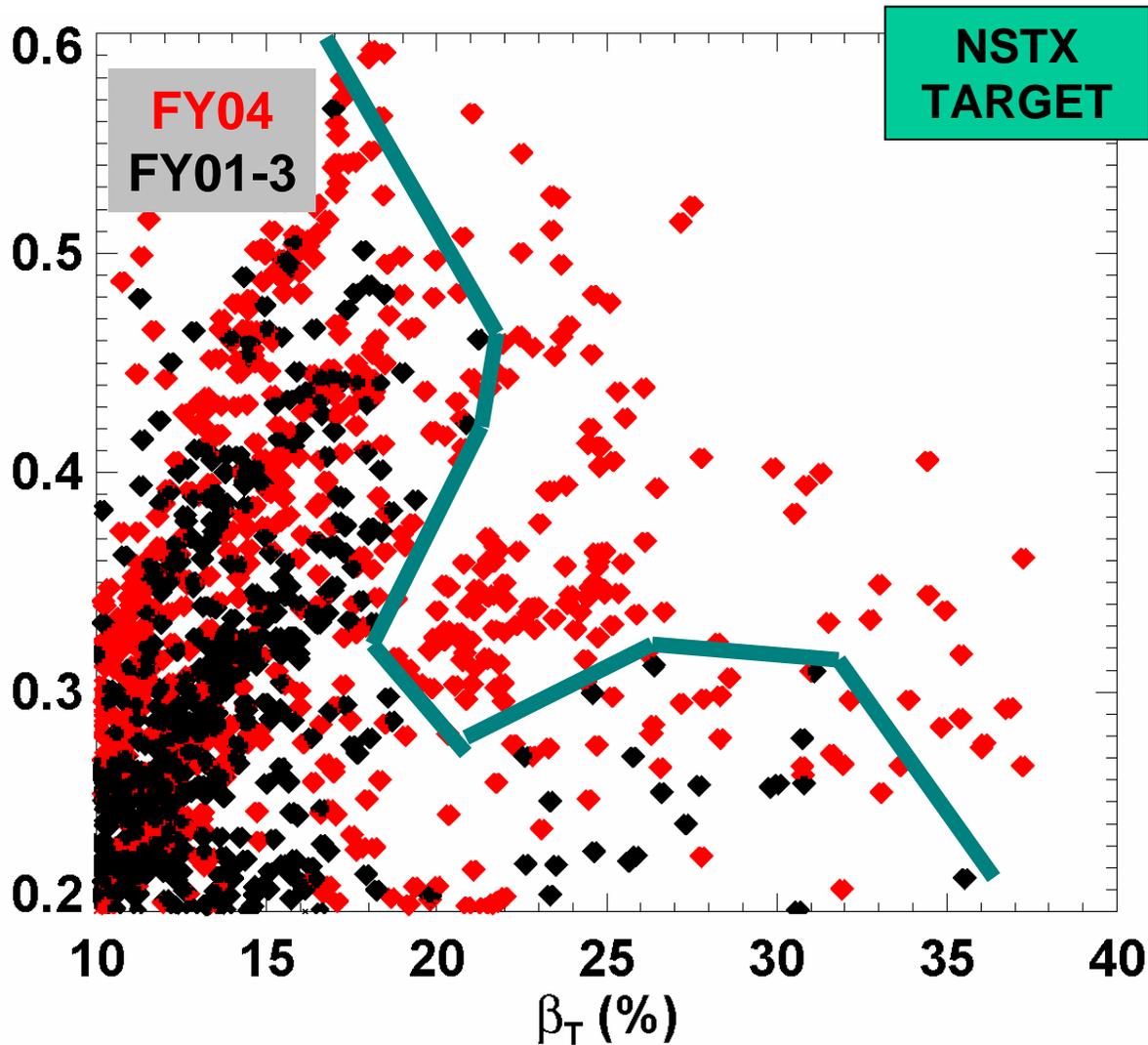
- EFIT02
- Data @ peak β_T
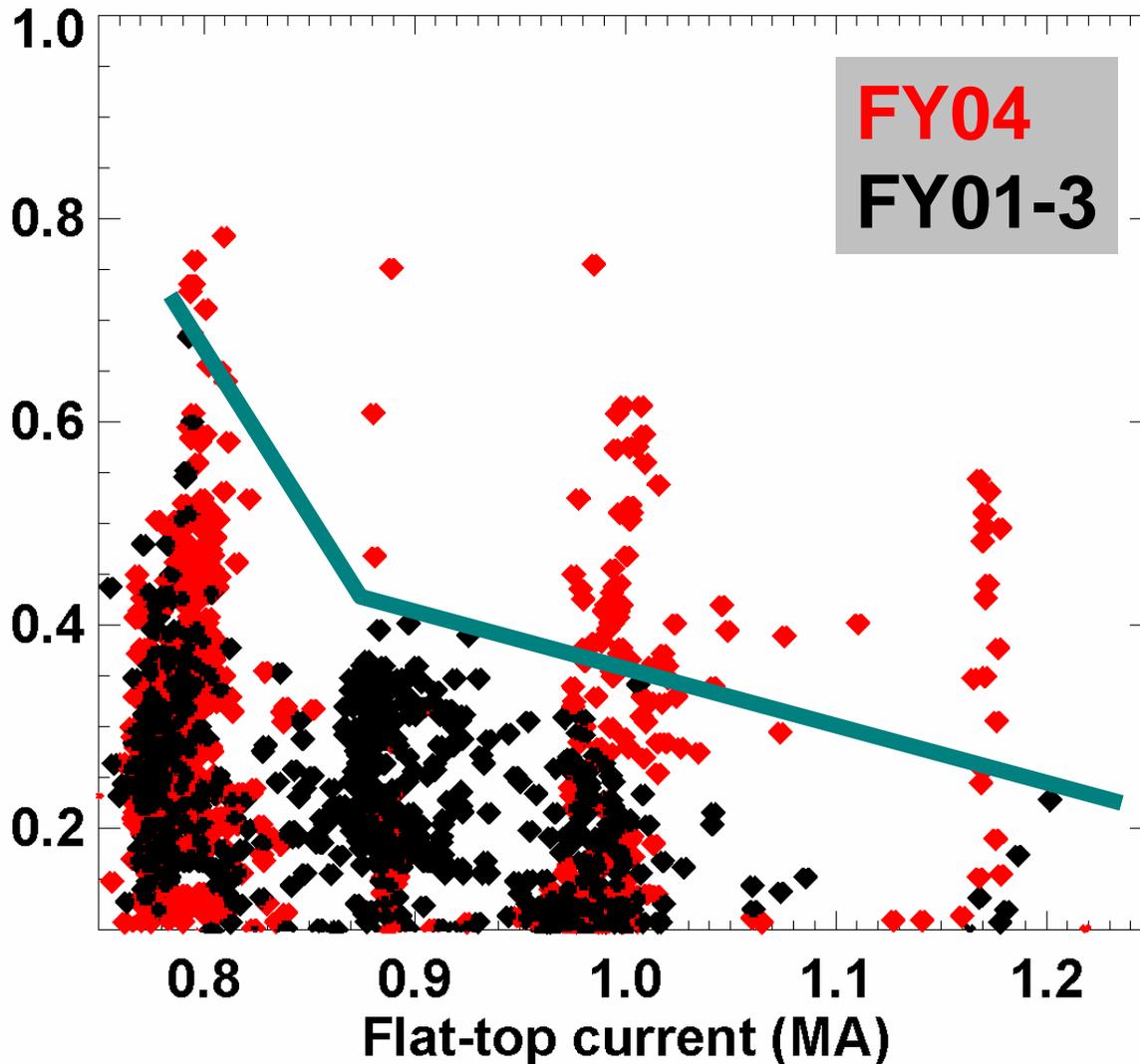- **<u>All shapes</u>**

Flat-top duration doubled for $I_P \geq 0.9\text{MA}$

Flat-top duration (s)

FY04
FY01-3

- EFIT02
- **All shapes**

Summary of results from XPs 432 & 440

- **Development of strongly shaped LSN successful**

- **Early H-mode opened up new operating space**
  - **Record pulse-lengths obtained at high current $\geq$ 1MA**
  - **Long-live MHD activity may be degrading confinement**

- **All shapes achieved high β_T at higher β_P**
  - **Higher elongation key**
  - **Likely higher f_{BS} (need to look at kinetic data)**