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Developments in plasma shaping experiments on NSTX

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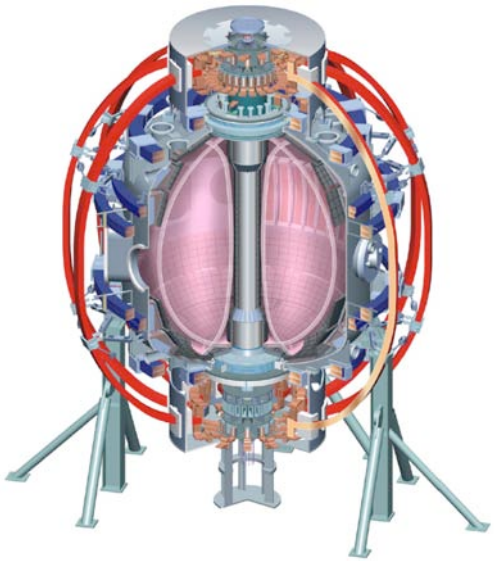
Presented by D. A. Gates

48th Annual meeting of the APS-DPP
October 30 - November 3, 2006
Philadelphia, PA



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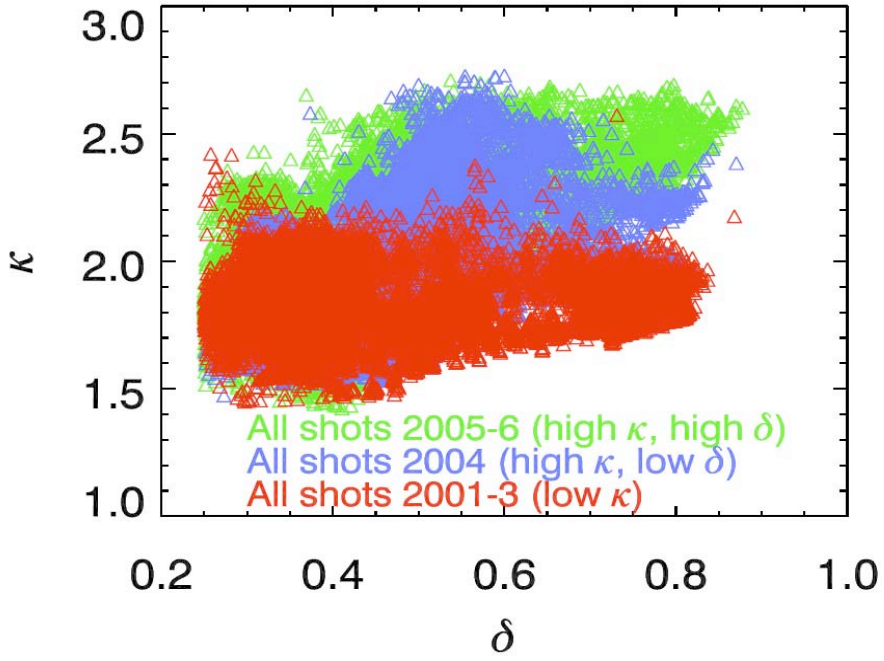
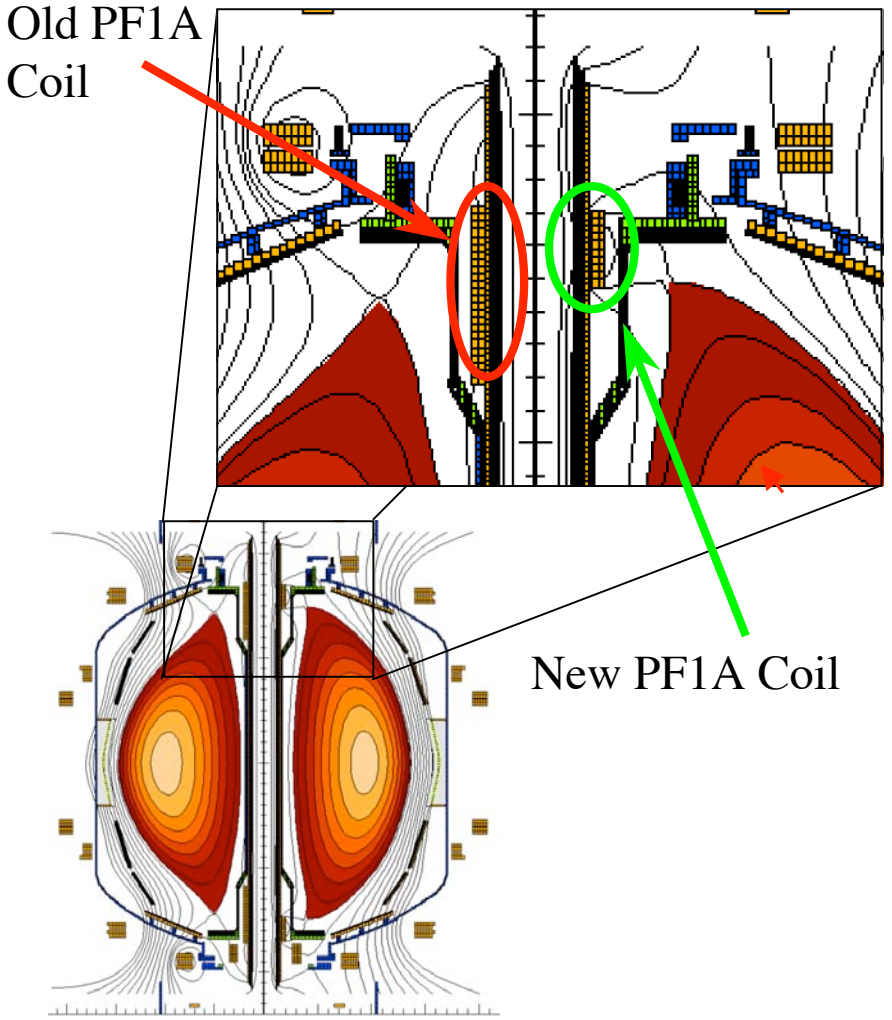
NSTX improvements lead to increased shaping capability

- Control system latency reduction increases κ
- PF coil modification increases δ
- rtEFIT/isoflux improves control reliability

Simultaneously achieved κ and δ
- entire NSTX EFIT database

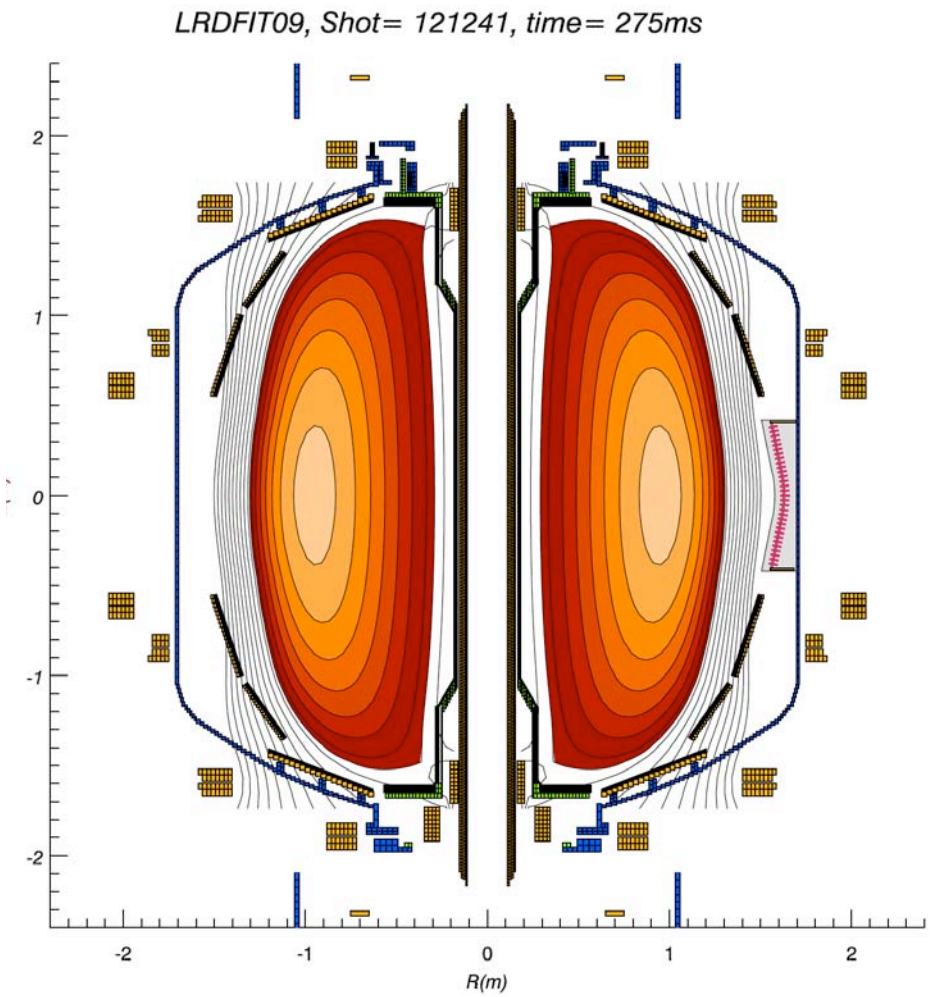




World record plasma shaping

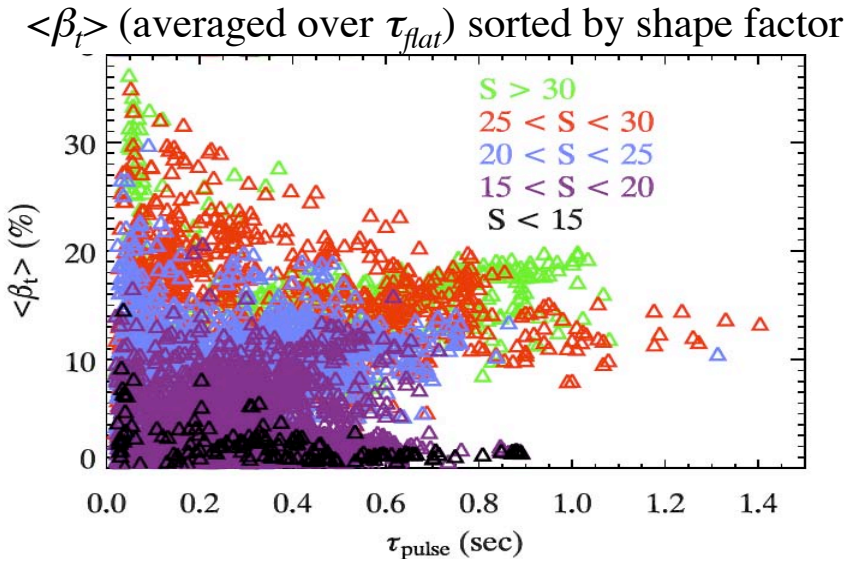
- Elongation 3 achieved on NSTX ($\kappa > 2.8$ for several growth times)
- Shape factor S ($\equiv q_{95}*(I_p/aB_t)$) ~ 41[MA/(m•T)]
- Simultaneously achieved in well controlled discharges
- $l_i \sim 0.35$, very encouraging for steady-state scenarios

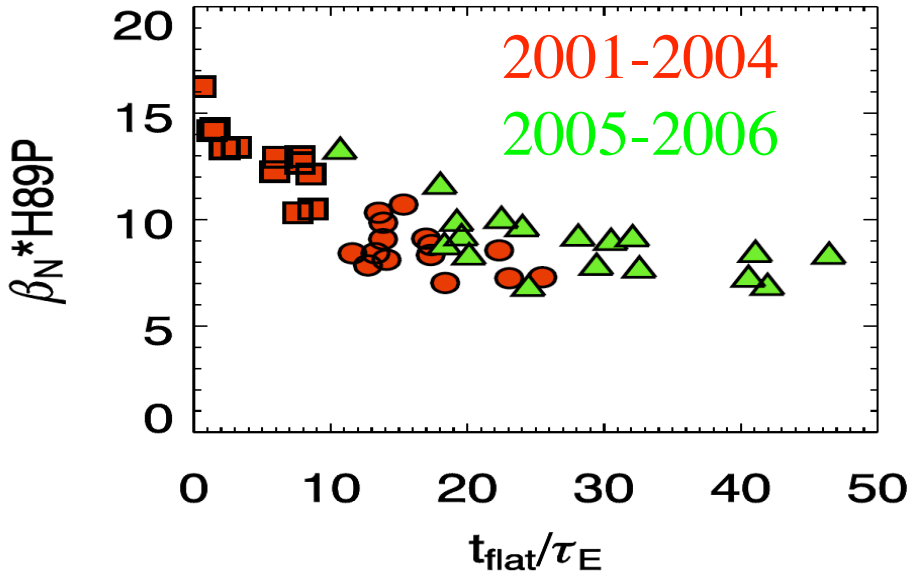
MSE based reconstructions



Plasma performance improves measurably with increased shaping

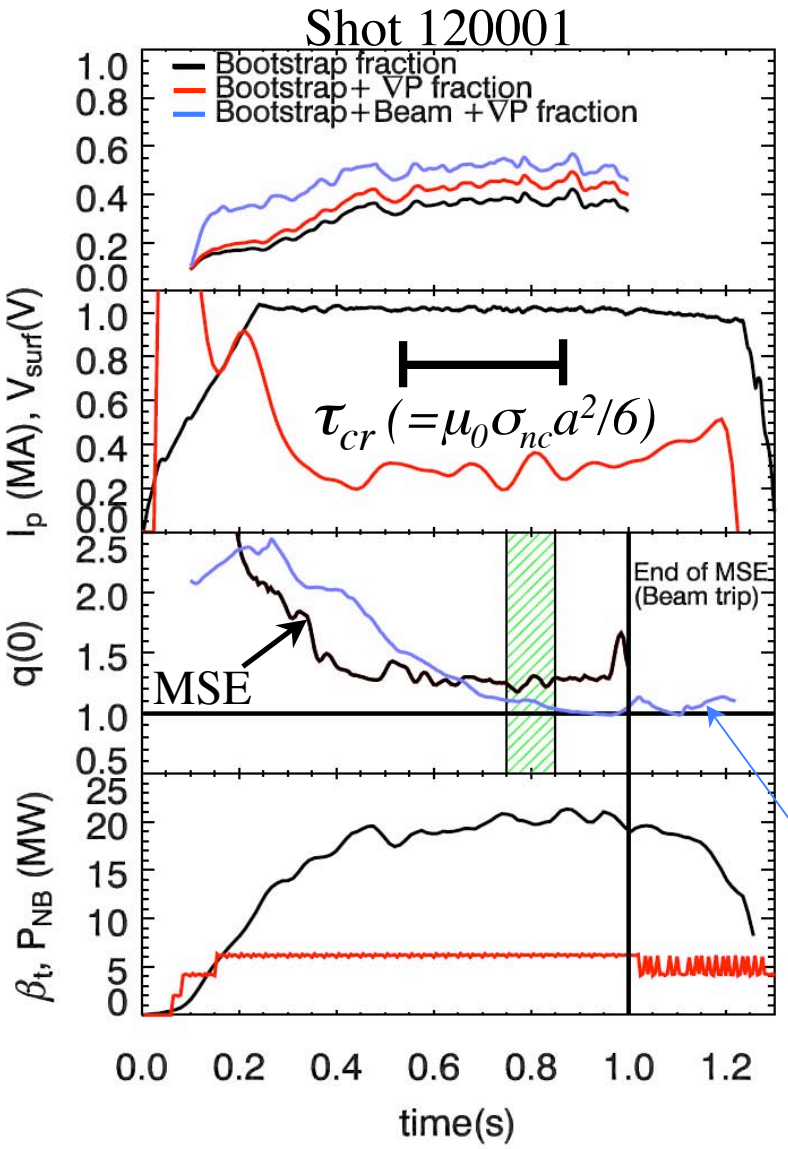
- Shaping is associated with both increased time averaged β_t ($\equiv <\beta_t>$) and increased pulse length
- Pulse length has been extended to ~50*τ_E while maintaining high confinement and β_N
- β_N*H_{89} saturates with pulse extension, similar to tokamak performance



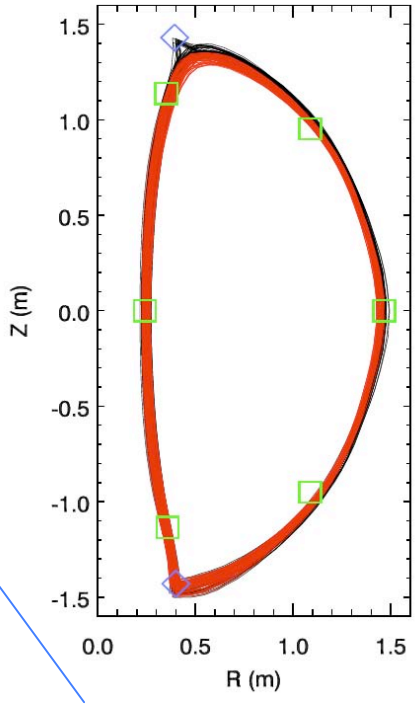


20% β_t sustained for ~ $3\tau_{cr}$

- Long pulse discharge with ~50% non-inductive current, ~80% pressure driven
- Reproducible performance with rtEFIT
- Plasma is not MHD limited
  - limited by available OH flux
- q(0) stays elevated longer than predicted by TRANSP magnetic diffusion calculation,
  - Hybrid mode
  - No tearing mode!



Plasma boundaries for shots 120001 and 121123
From t = 0.3 to t=1s
128 equilibria



TRANSP Magnetic Diffusion calculation

Current profile analysis shows on-axis discrepancy

- Measured kinetic profiles are used to predict the components of the current profile using neoclassical theory
- MSE (+magnetic measurements) is used to reconstruct the total current profile
- Sum of integrated predicted currents agrees within 10% of measured total
- Discrepancy in core current density consistent with observed elevated q(0)

Shot 120001 (0.7s - 0.8s)

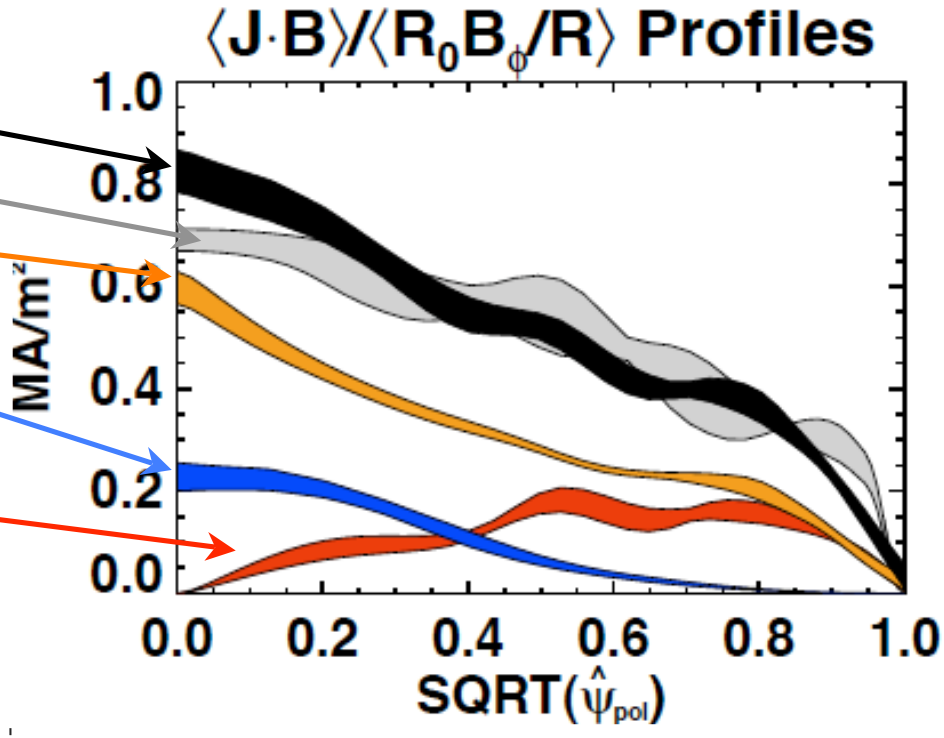
Black - sum of predicted components

Gray - MSE reconstructed total current

Orange - predicted ohmic profile

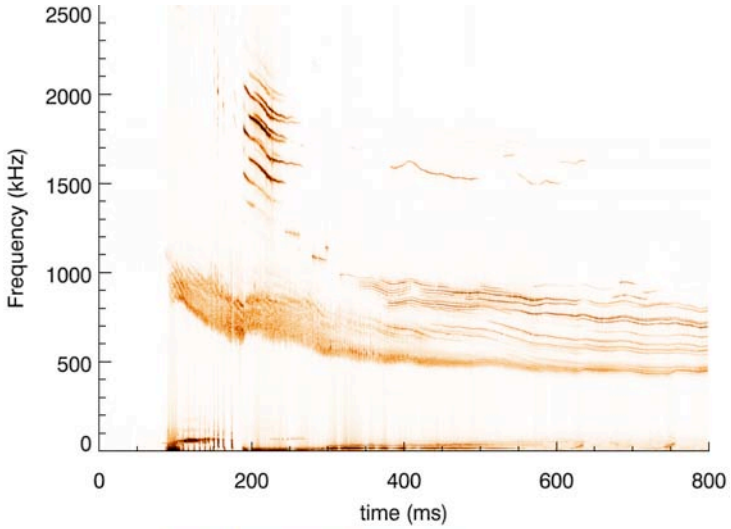
Blue - predicted beam driven current

Red - predicted bootstrap current

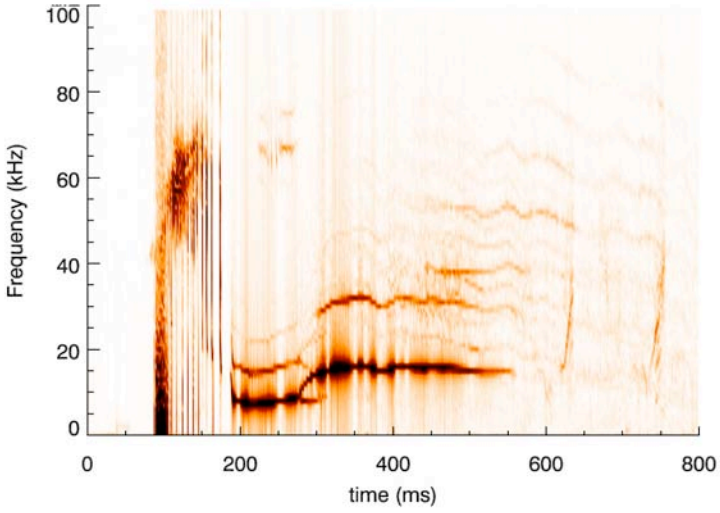


No tearing modes observed during period of elevated *q(0)*

- Higher frequency (CAE/GAE) modes are still observed
- Low level TAEs also observed, but amplitude is decreasing
- Can high frequency modes or small low frequency TAEs explain current redistribution?



Spectrogram of high frequency MHD for shot 120001



Spectrogram of low frequency MHD for shot 120001

Improved control capabilities have led to rapid progress in scenario development on NSTX

- Simultaneously achieved:
  - Record plasma shape factor 41 MA/(m•Tesla)
  - Record plasma elongation $\kappa = 3$, with $\delta = 0.8$
- As expected, shape improves performance
- Achieved $\beta_t \sim 20\%$ for $\sim 3\tau_{cr}$
- General agreement between measured and predicted current profiles with anomaly in the core
- Maintained elevated q(0), without tearing modes