

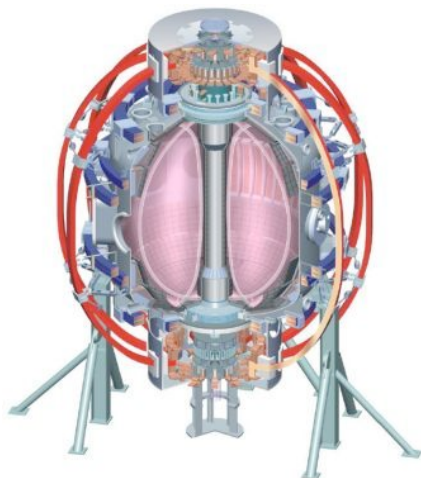
Overview of Results from the FY10 National Spherical Torus Experiment Run

Eric Fredrickson

For the NSTX Team

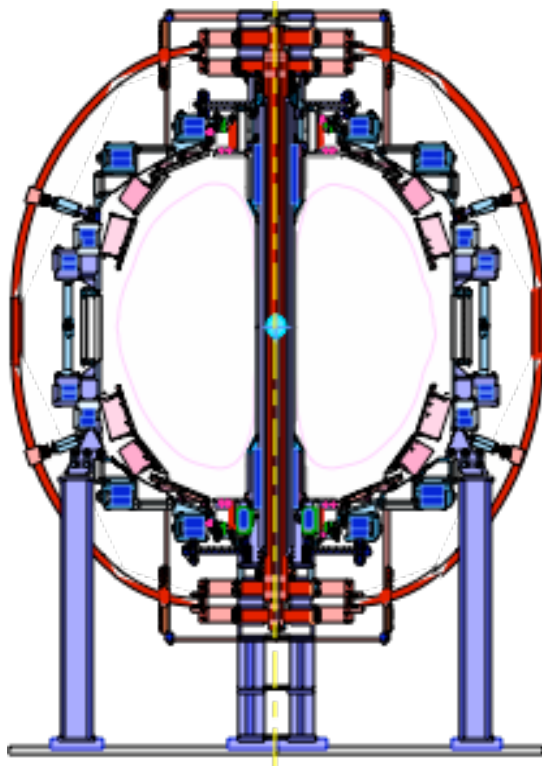
52nd APS-DPP Meeting
Chicago, Illinois, Nov. 8-12, 2010

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NSTX is a midsize Magnetic Confinement Fusion Device, a Spherical Tokamak (ST)



$$R_0 = 0.86 \text{ m}$$

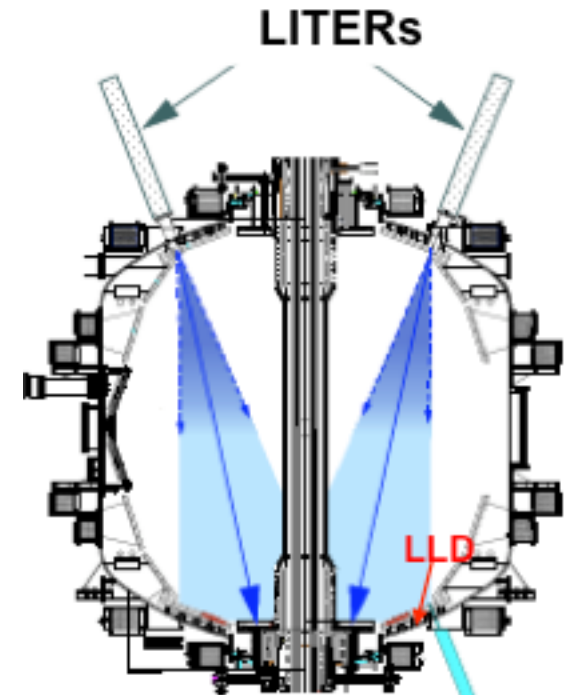
$$a = 0.68 \text{ m}$$

$$B_0 = 0.3\text{-}0.55 \text{ T}$$

$$I_p \leq 1.2 \text{ MA}$$

$$\beta_{\text{tor}} \leq 40\%$$

$$n_e \leq 1 \times 10^{20} / \text{m}^3$$



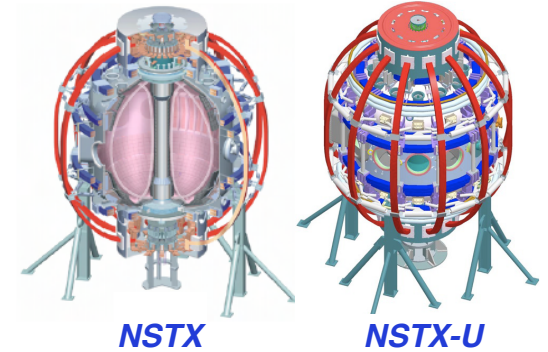
- **New Capabilities for 2010 Campaign:**

- **Liquid Lithium Divertor plates; ELM suppression and D pumping.**
- **Beam Emission Spectroscopy diagnostic; measure turbulence up to 1 MHz.**
- **Fast, two-color IR camera for time-resolved divertor heat flux measurements**

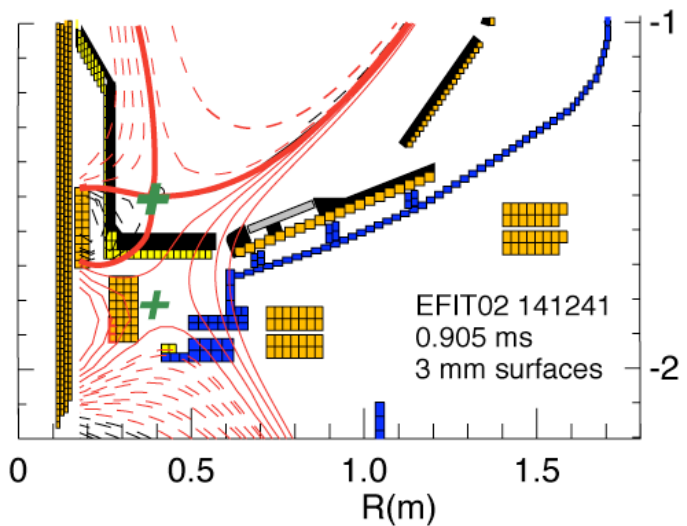
Talk Outline

- 15 weeks of operations
 - Liquid Lithium Divertor Module
 - No Boronization
- Fast, two-color Infra-red camera for divertor heat flux measurements.
- Beam Emission Spectroscopy diagnostic for medium wavelength turbulence studies
 - complements high-k scattering diagnostic
 - 12-channel reflectometer array
- ASC,BP,LR,MS,SFSU,T&T,WPI

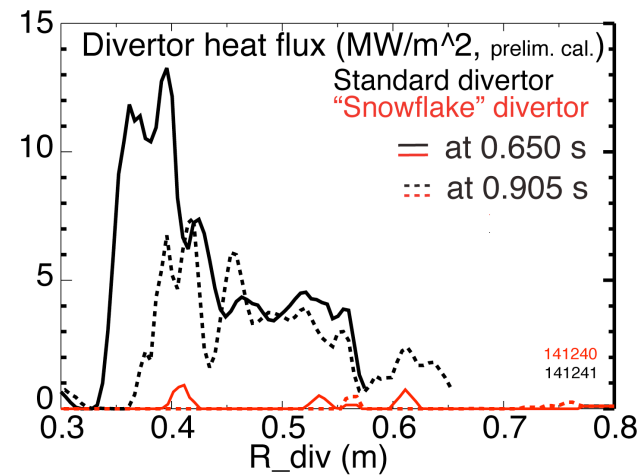
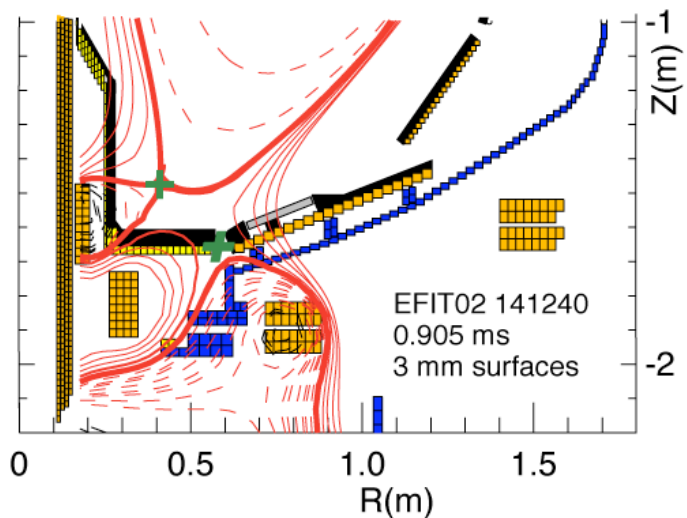
Higher aspect ratio (NSTX-U) discharges demonstrated to reach high $\beta_n (\geq 5)$, $\kappa (\geq 2.6)$



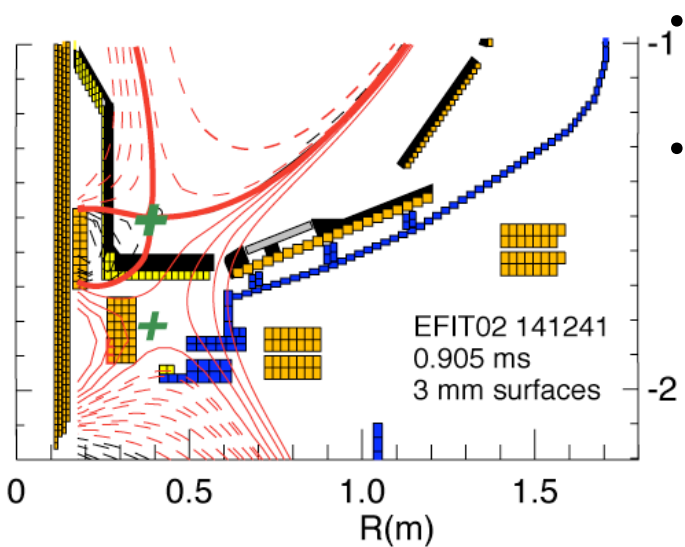
“Snowflake” divertor configurations have been obtained in NSTX with two or three divertor coils



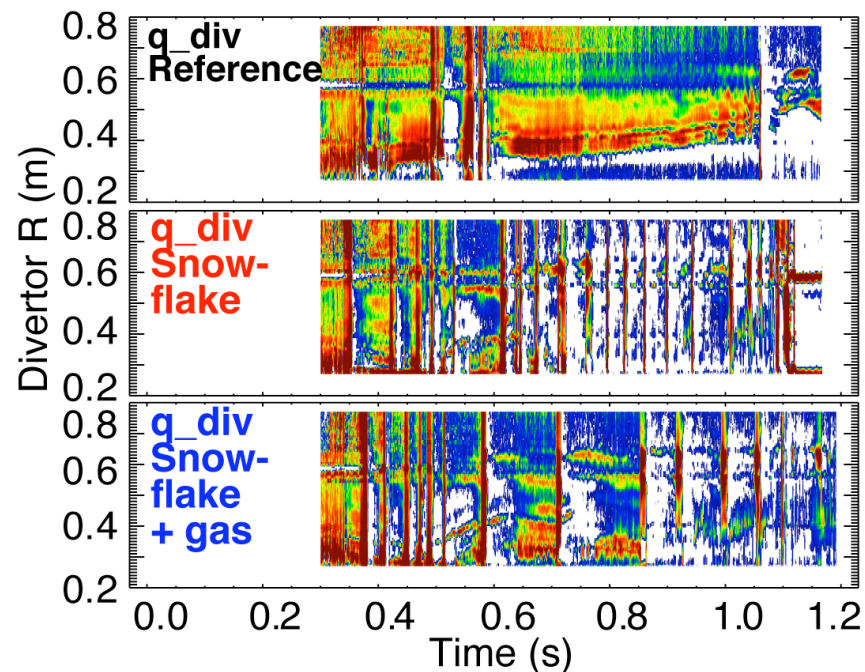
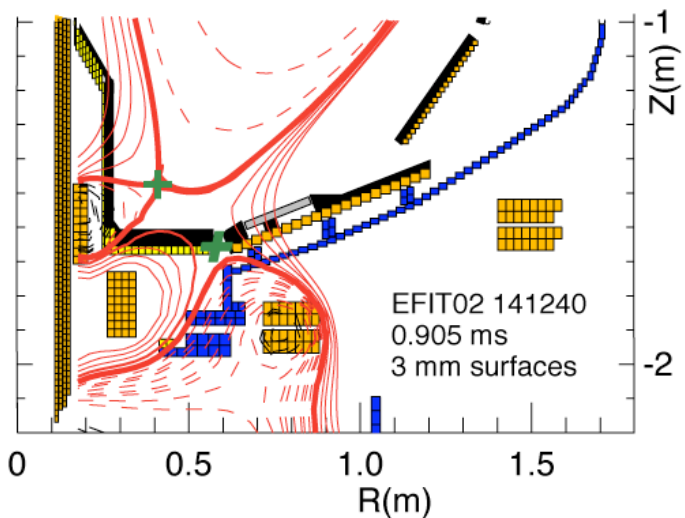
- Standard high- δ divertor configuration is transformed into “Snowflake” divertor with
- Significant reduction of peak heat flux observed in “snowflake” divertor
 - Improved divertor solutions needed to address 2-3x higher input power in NSTX-U
 - Projected peak divertor heat fluxes up to 24 MW/m^2
 - Up to 30 % reduction in Greenwald fraction
 - 3-5 x longer pulse duration



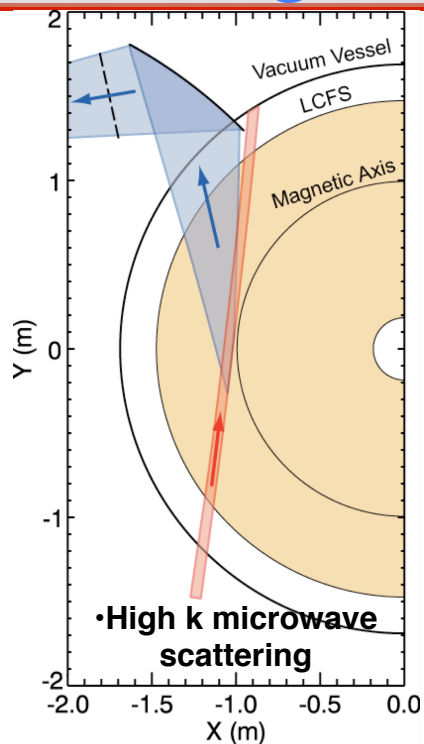
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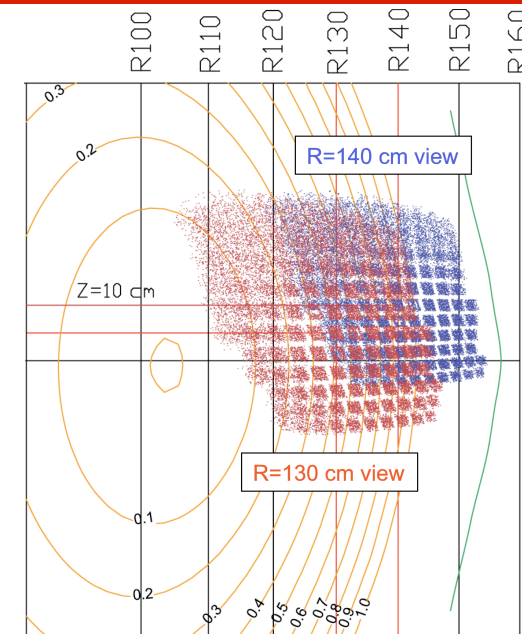
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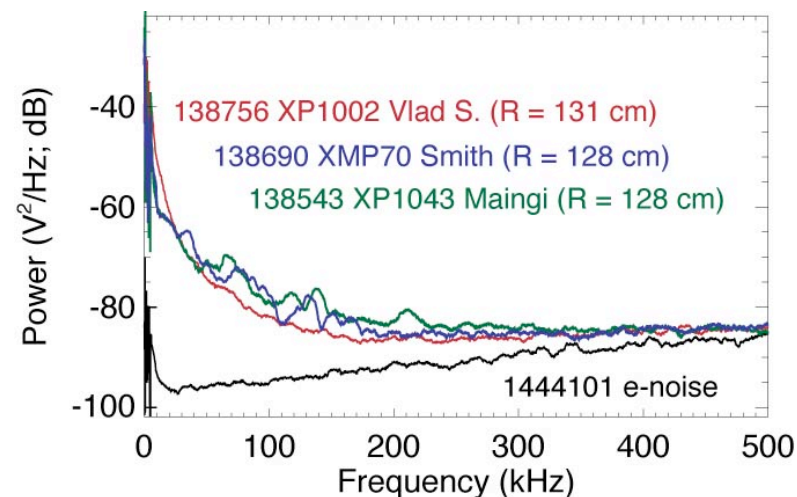
BES measures neutral beam D_α emission to study long wavelength ($k\rho_i < 1$) density fluctuations



- 16 channels in various configurations populated for FY10 campaign
- Diagnostic was used for studies of turbulence and high frequency, coherent Alfvénic activity (TAE, GAE and CAE)

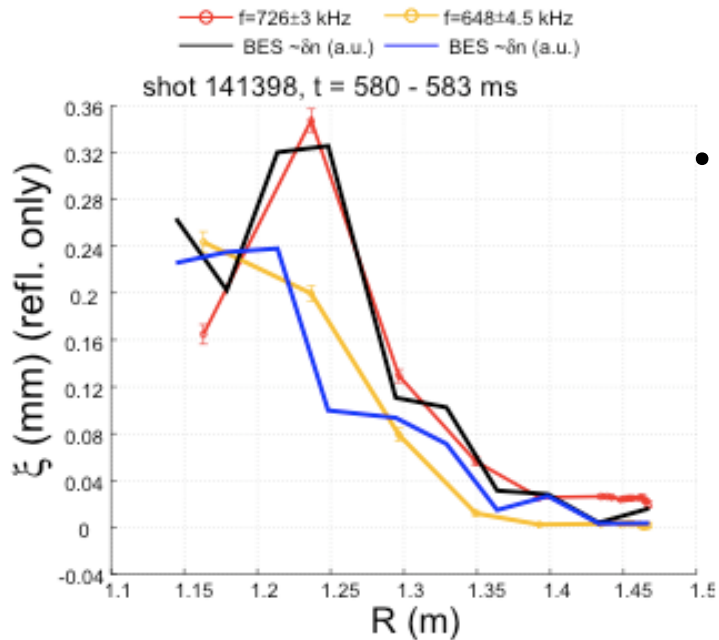


- Turbulent fluctuations detected above diagnostic noise level.
- Channel spacing determines minimum wavelength; complements high-k scattering.
- More localized measurement than 12-channel reflectometer array.

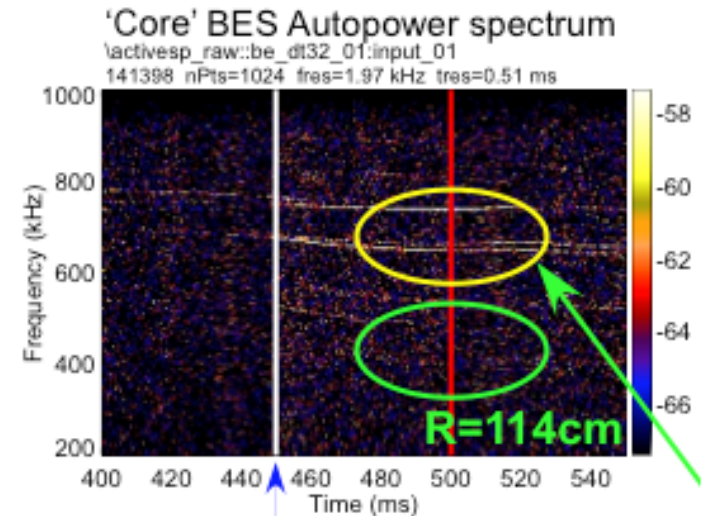


GAE activity has been found to correlate with enhanced core electron transport

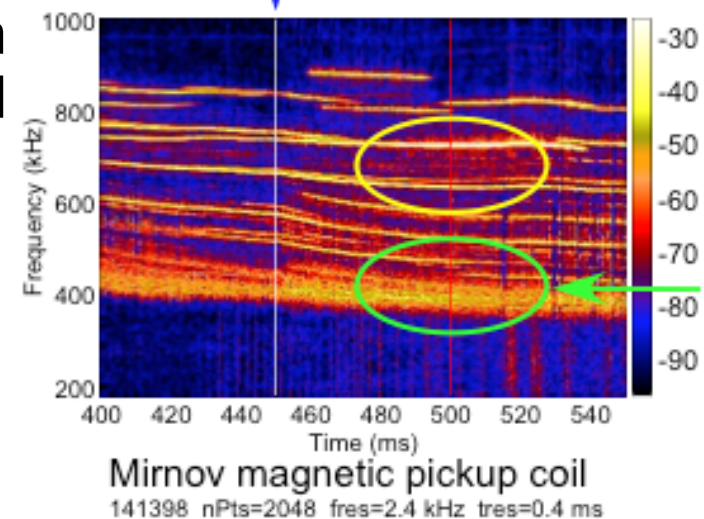
- “Stochastic” transport scales strongly with GAE amplitude ($\sim \alpha^6$)
 - TRANSP estimate for $\chi_e \approx 20 - 60 \text{ m}^2/\text{s}$
 - Direct measurements of mode amplitude needed to test stochastic transport theory
- Stochastic transport scales strongly with amplitude;
 - *strongest modes dominate transport drive*



- Mode profile from reflectometer and BES in rough agreement; BES amplitude not calibrated yet.



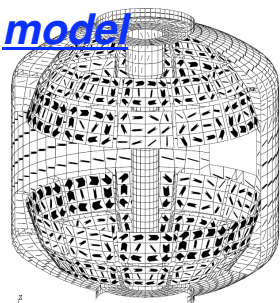
PNBI 4->6MW



New RWM state space controller sustains high β_N plasma

Full 3-D model

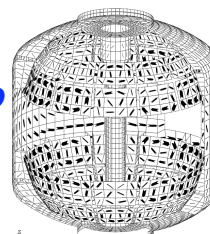
~3000+ states



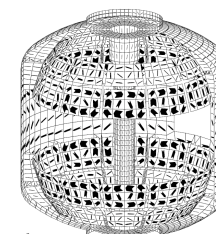
State reduction (< 20 states)

RWM eigenfunction (2 phases, 2 states)

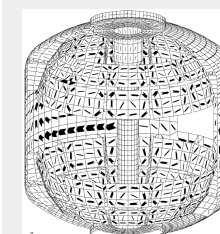
(\hat{x}_1, \hat{x}_2)



\hat{x}_3



\hat{x}_4



truncate

- device R, L , mutual inductances
- instability B field / plasma response
- modeled sensor response

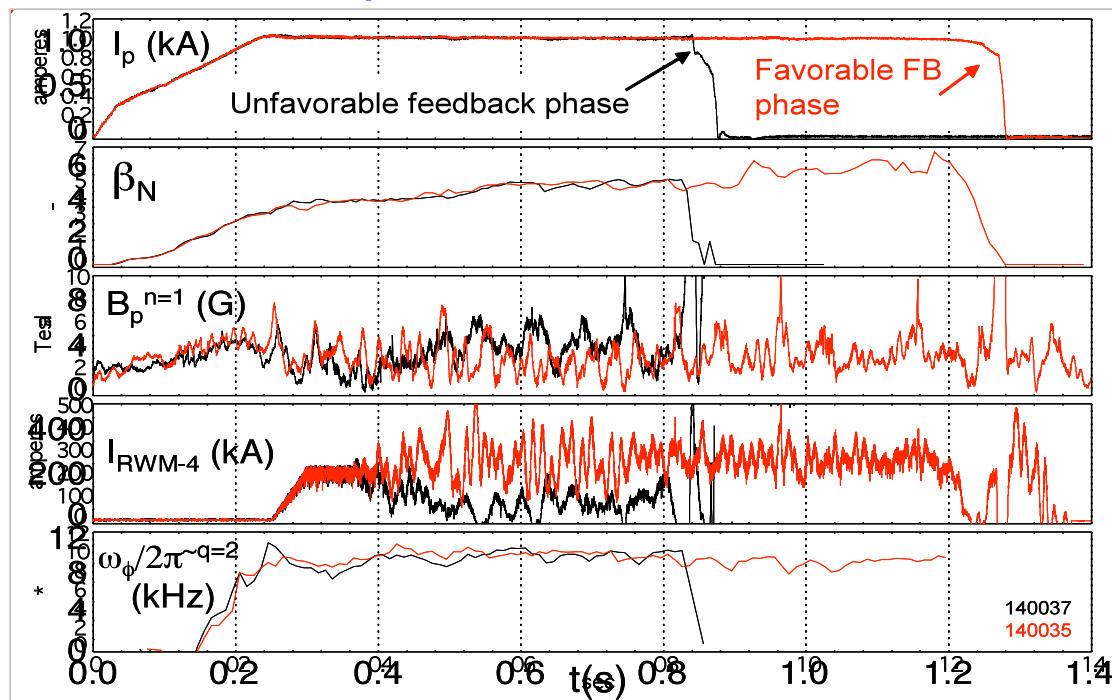
Controller can compensate for wall currents

- Including mode-induced current
- Examined for ITER

Successful initial experiments

- Suppressed disruption due to $n = 1$ applied error field
- Best feedback phase

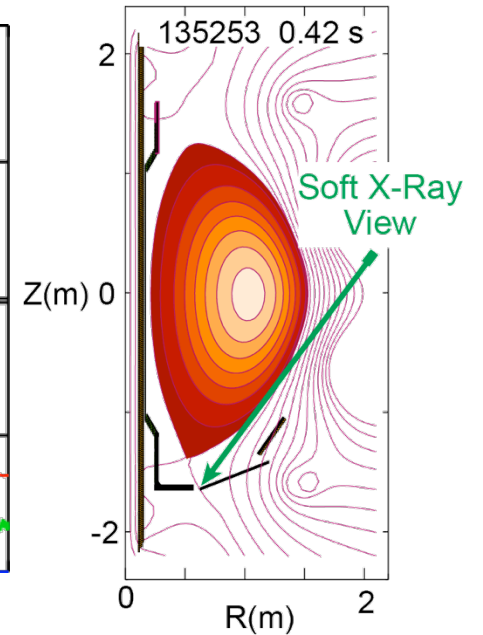
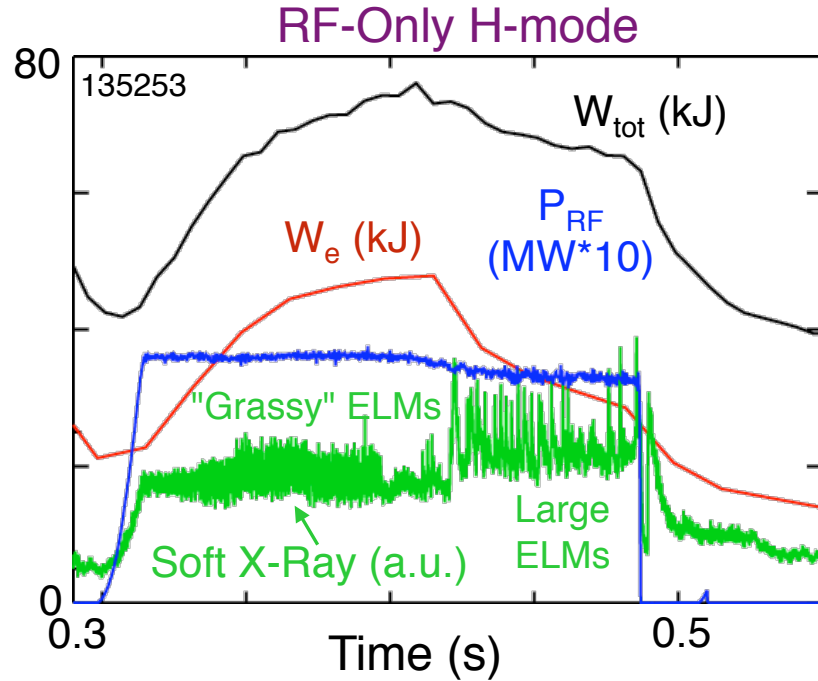
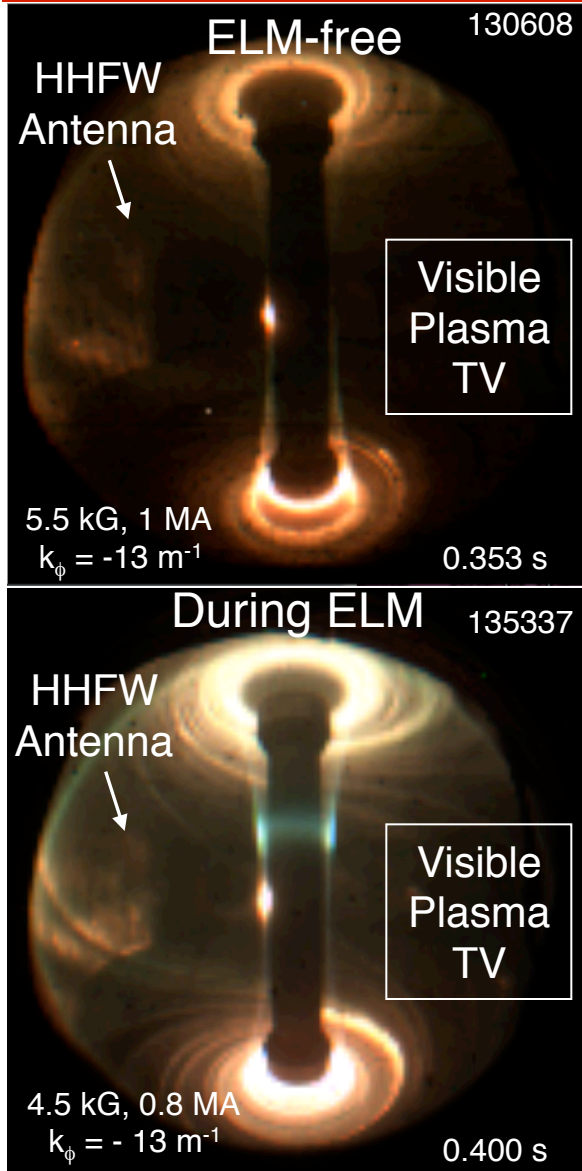
State space feedback with 12



H-mode threshold scaling with X-point B?

- tbd:

Studies of RF power flow to lower divertor found heat flux increased during ELMs

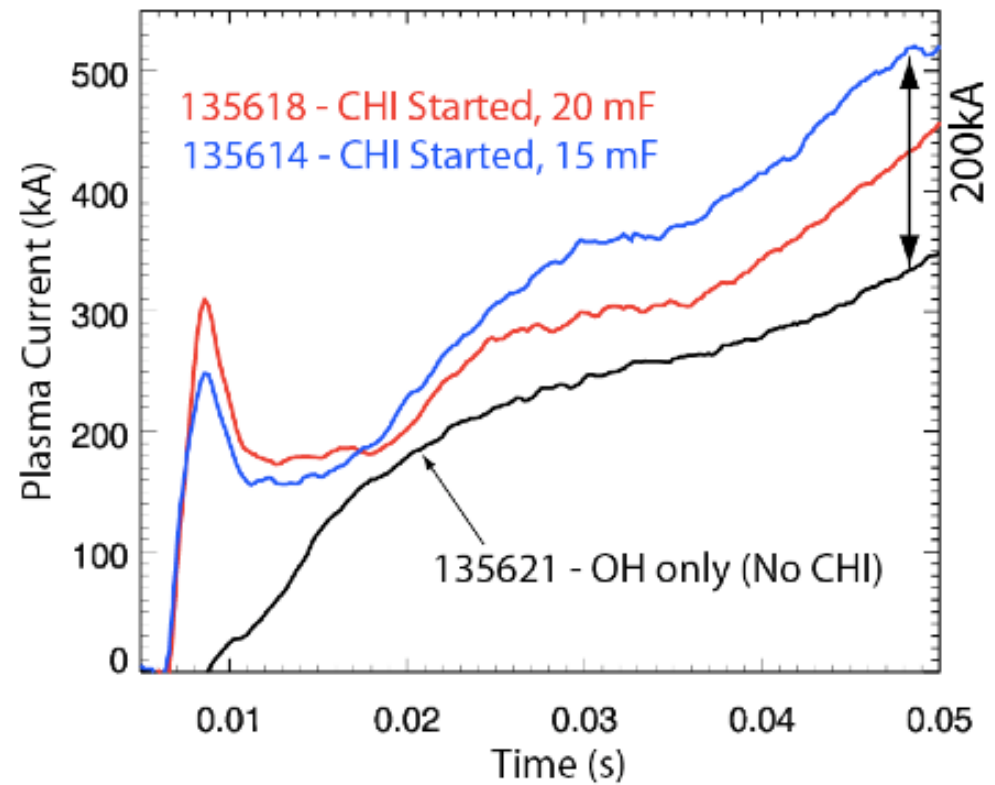


- Extensive lithium conditioning this year significantly degraded antenna performance compared to 2009:
 - $P_{\text{RF}} \sim 1.5 \text{ MW}$ arc-free operation achieved compared to arc-free PRF $\sim 4 \text{ MW}$ by end of 2009 campaign

J. Hosea, et al., Poster BP9.00074, Mon AM

CHI Absorber Arc suppression

- NSTX



Summary

- tbd