NSTX JOHNS HOPKINS UNIVERSITY

Supported by U.S. DEPARTMENT OF ENERGY | Office of Science

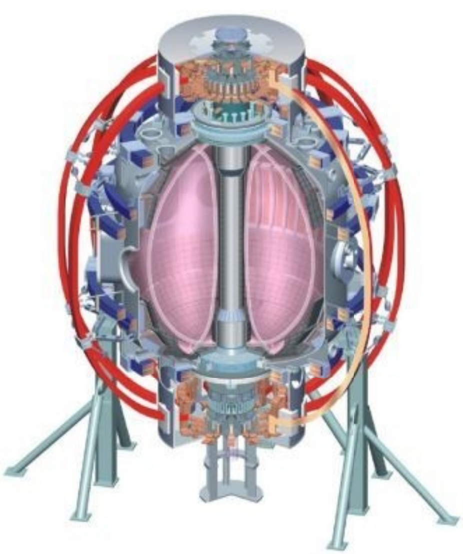
Effects of Global Alfvén Eigenmodes on Electron Thermal Transport in NSTX

Kevin Tritz

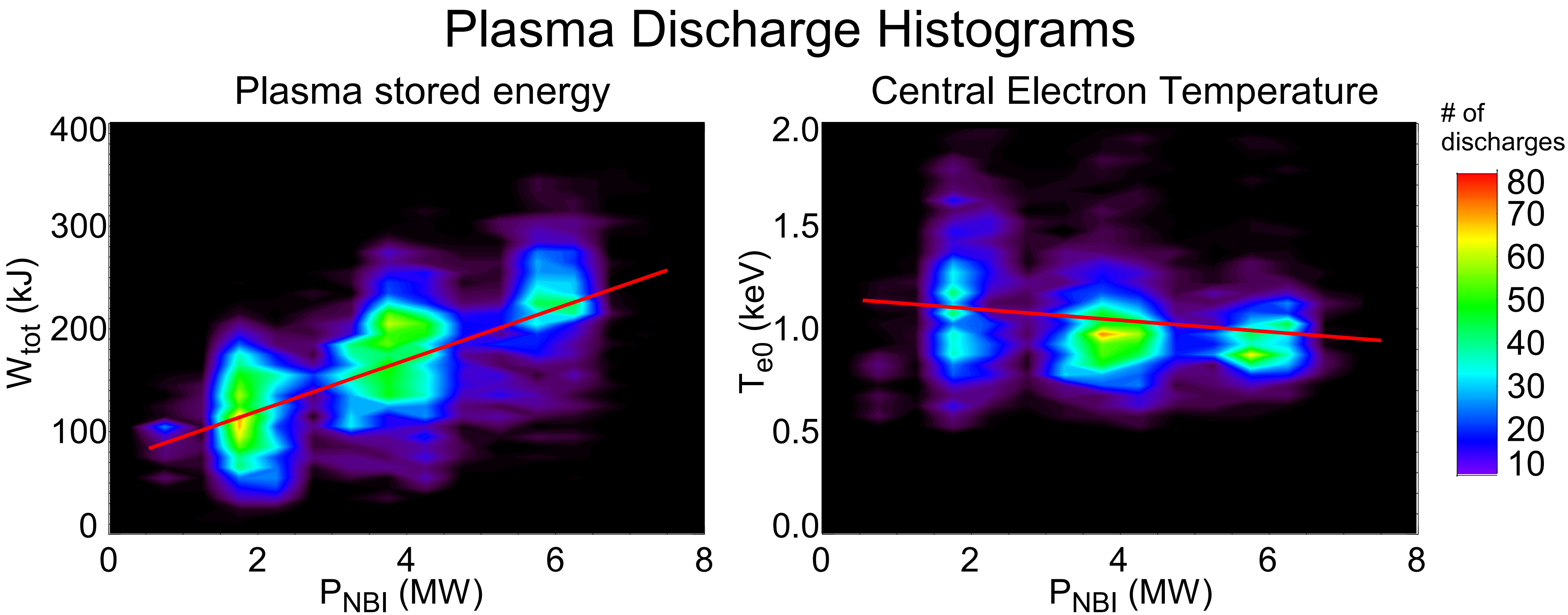
Johns Hopkins University

D. Stutman, M. Finkenthal (*JHU*)
R. Bell, E. Belova, E. Fredrickson, N. Gorelenkov, R. Kaita, S. Kaye, B. LeBlanc, E. Mazzucato, Y. Ren, R. White (*PPPL*)
N. Crocker, S. Kubota, W.A. Peebles (*UCLA*)
R. Fonck, I.U. Uzun-Kaymak, G. McKee, D.R. Smith (*U. Wisc.*)
and the NSTX Team

2010 NSTX Results Review
PPPL 11/30/2010

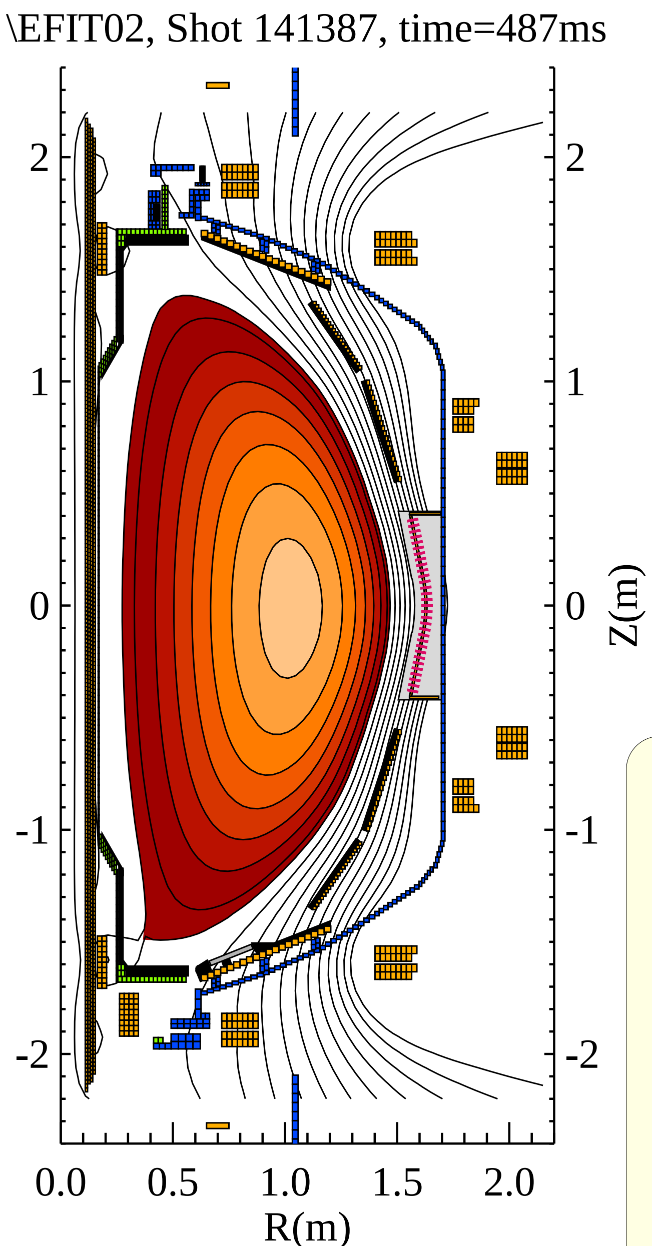


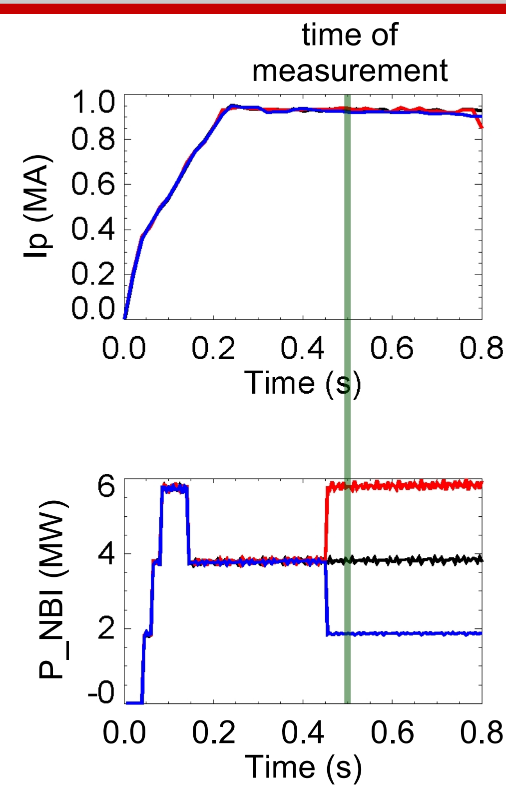
NB power has little effect on T_{e0}



- Database scan of >4000 NBI plasma discharges on NSTX
  - Identify central electron temperature at maximum stored energy
- Large scatter observed, wide range of plasma discharges
- Small but noticeable decrease in T_{e0} vs. P_{NBI}
  - Overall plasma stored energy increases with P_{NBI}

Experimental reference discharges use LSN H-mode with NBI preheat and beam steps for repeatable plasma conditions



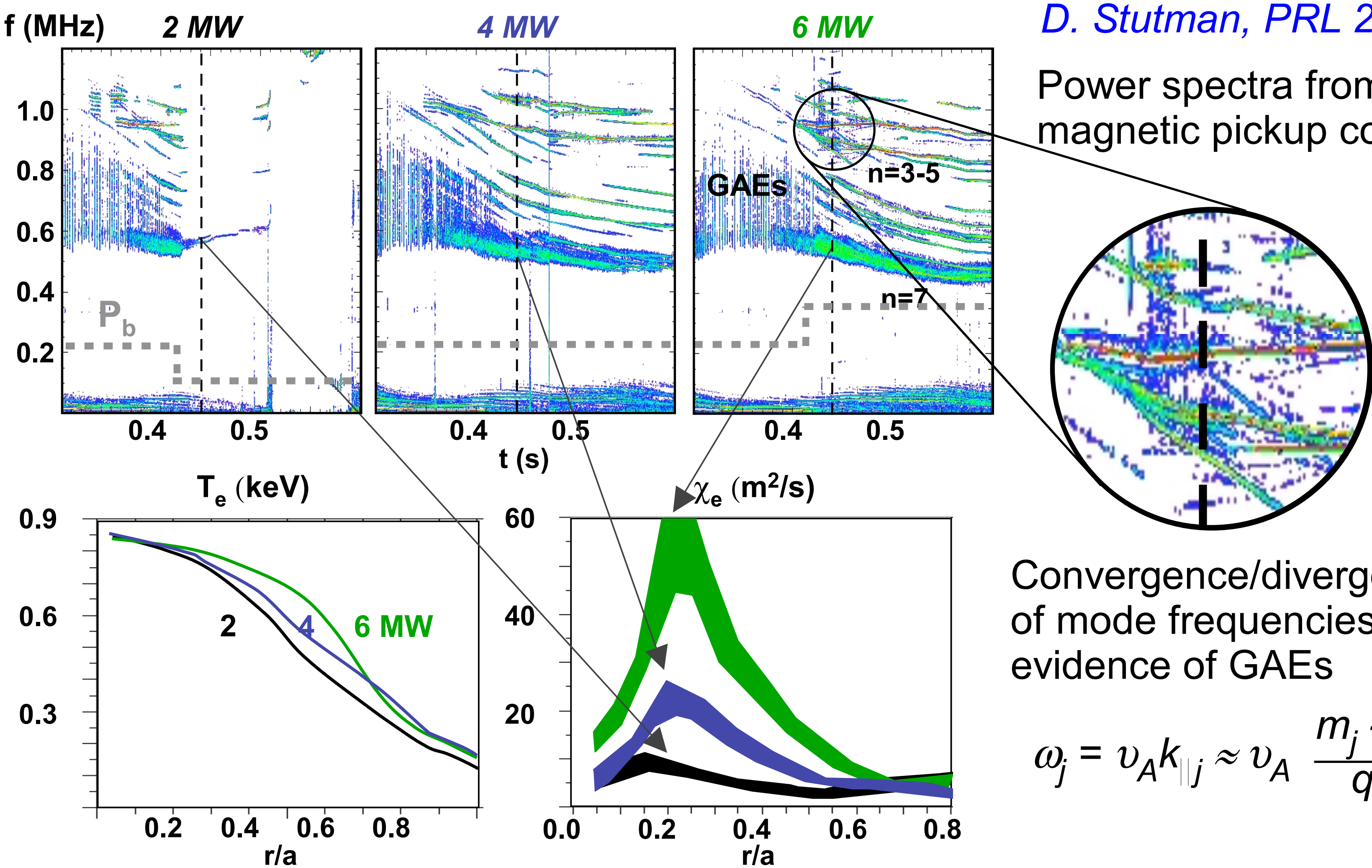


Mag. axis R_{mag}	1.03m
Aspect Ratio A	1.4
Elongation κ	2.4
Triangularity δ	~0.6
Plasma Current I_p	0.9MA
Toroidal Field B_T	0.45T
Pulse Length	~1s
P_{NB} (100keV)	2-6MW
$\beta_{T,tot}$	~15%

- NBI pre-heat used to 'freeze' in current profiles with $q_0 > 1$
- Beam steps at 0.45s used to change input power
- Measurements 50ms later, before relaxation of current profile

GAE modes proposed as possible mechanism for rapid electron thermal transport in plasma core

D. Stutman, PRL 2009



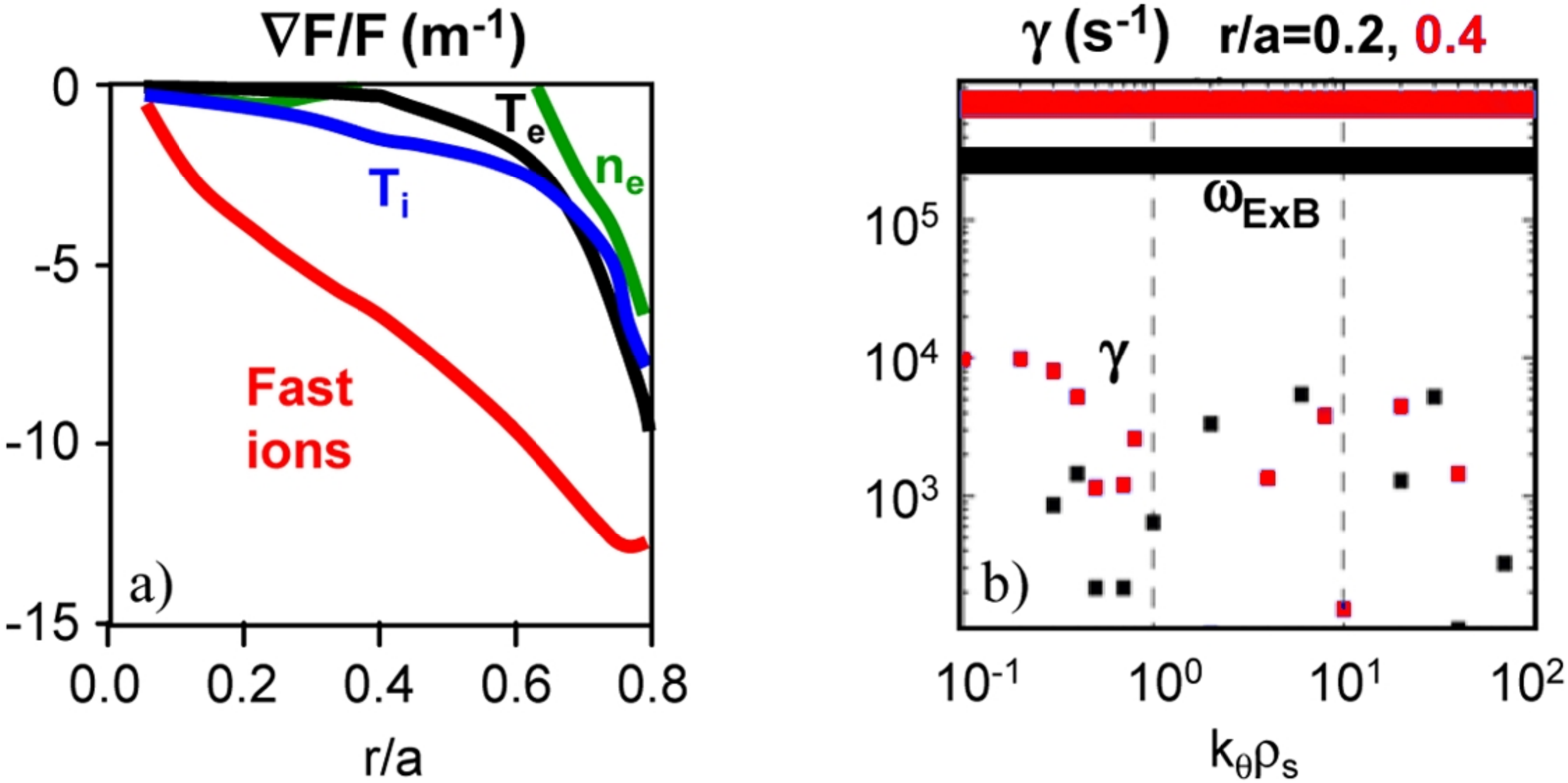
Power spectra from magnetic pickup coils

Convergence/divergence of mode frequencies evidence of GAEs

$$\omega_j = \upsilon_A k_{\|j} \approx \upsilon_A \frac{m_j - n_j q}{qR_0}$$

- GAE activity correlates strongly with P_{NBI} steps and enhanced core electron thermal transport

Flat plasma profiles and high rotation shear suggest suppression of electrostatic turbulence



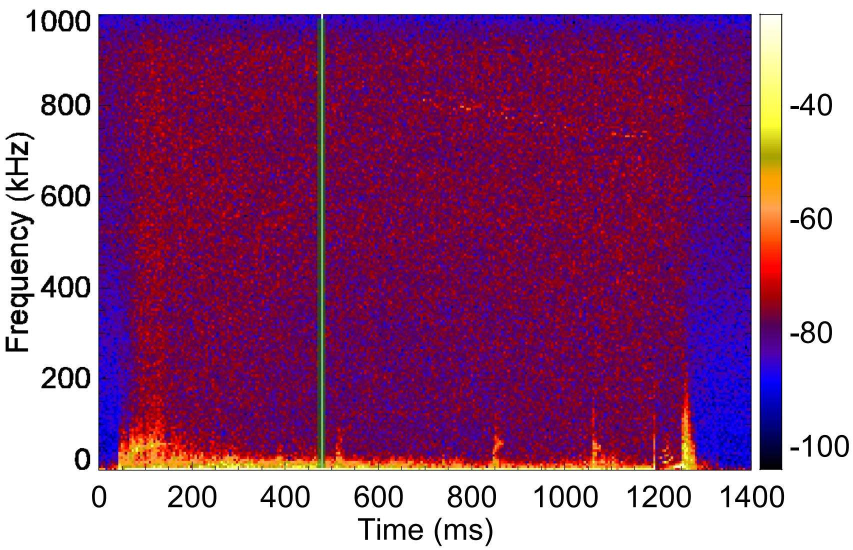
- Linear GS2 calculations show growth rates 20-100x lower than shearing rate in plasma core over high and low-k range

- TRANSP calculated fast ion profile shows gradient which can drive fast ion modes in plasma

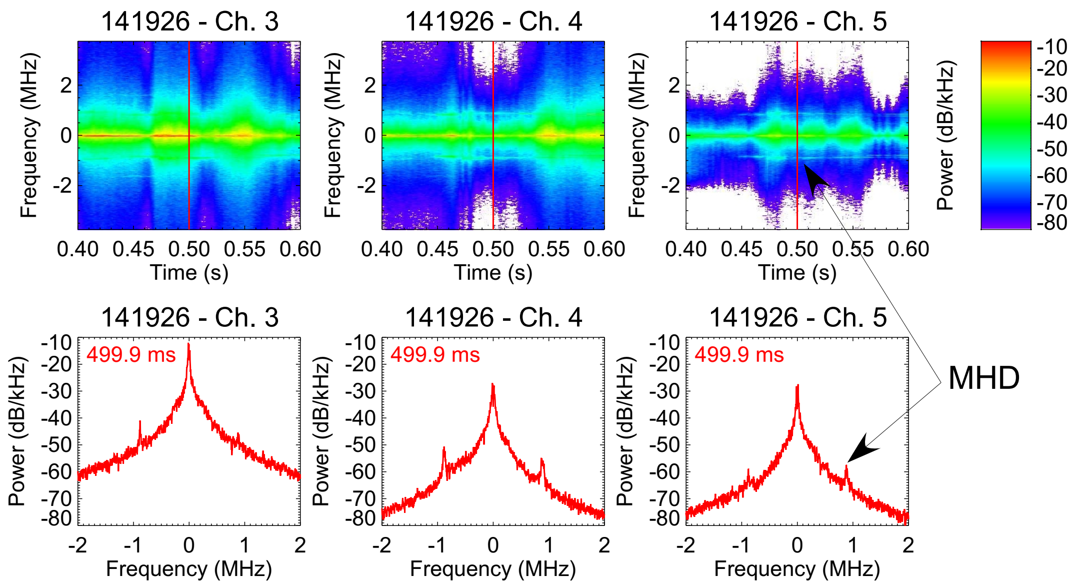
No evidence of short or long wavelength turbulence in core of many NBI-heated discharges in NSTX

Preliminary BES data

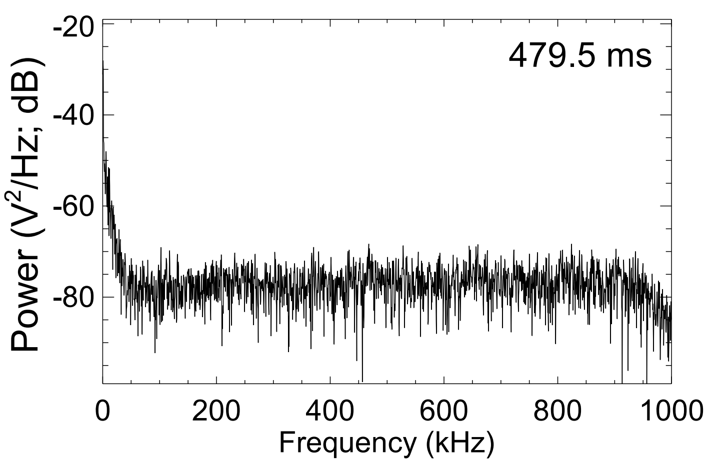
BES Cross-power spectrum R = 117&120cm



High-k fluctuation spectrum R=123cm k_r = 9-16 cm^{-1}

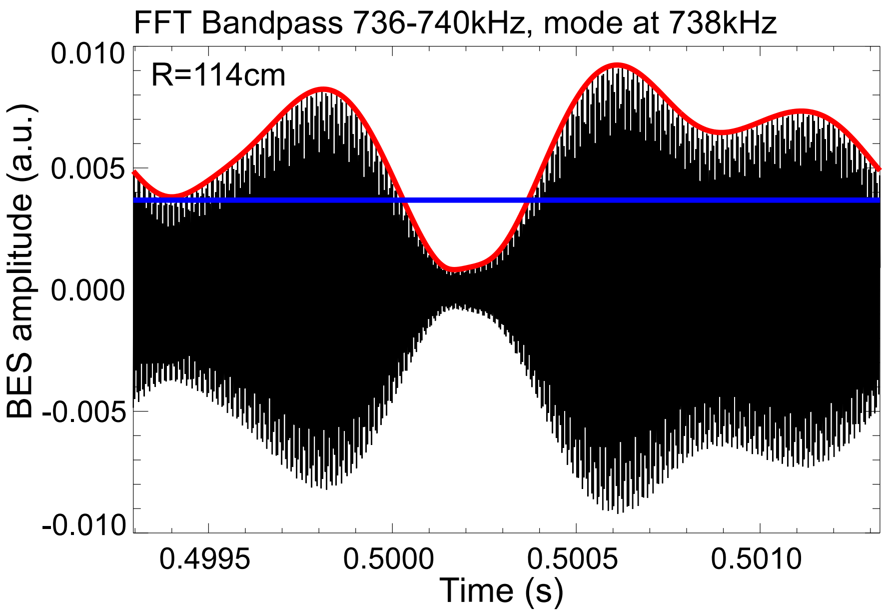


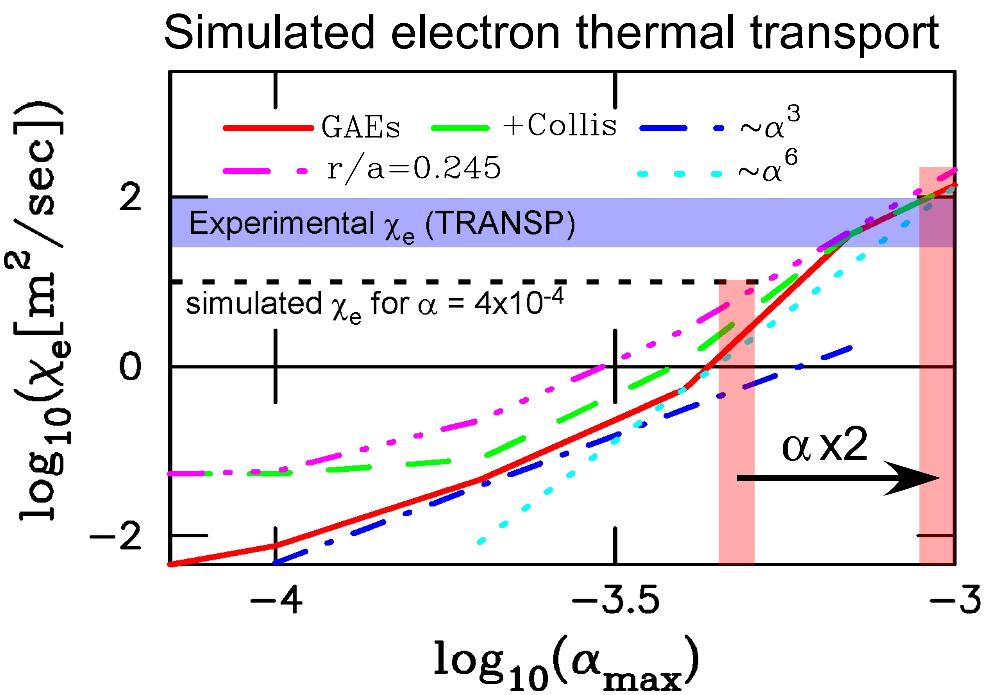
BES Cross-power spectrum R = 117&120cm



- No evidence of broadband low-k turbulent fluctuations on BES
- High-k system also shows little to no broadband high-k activity in plasma (R=123cm)

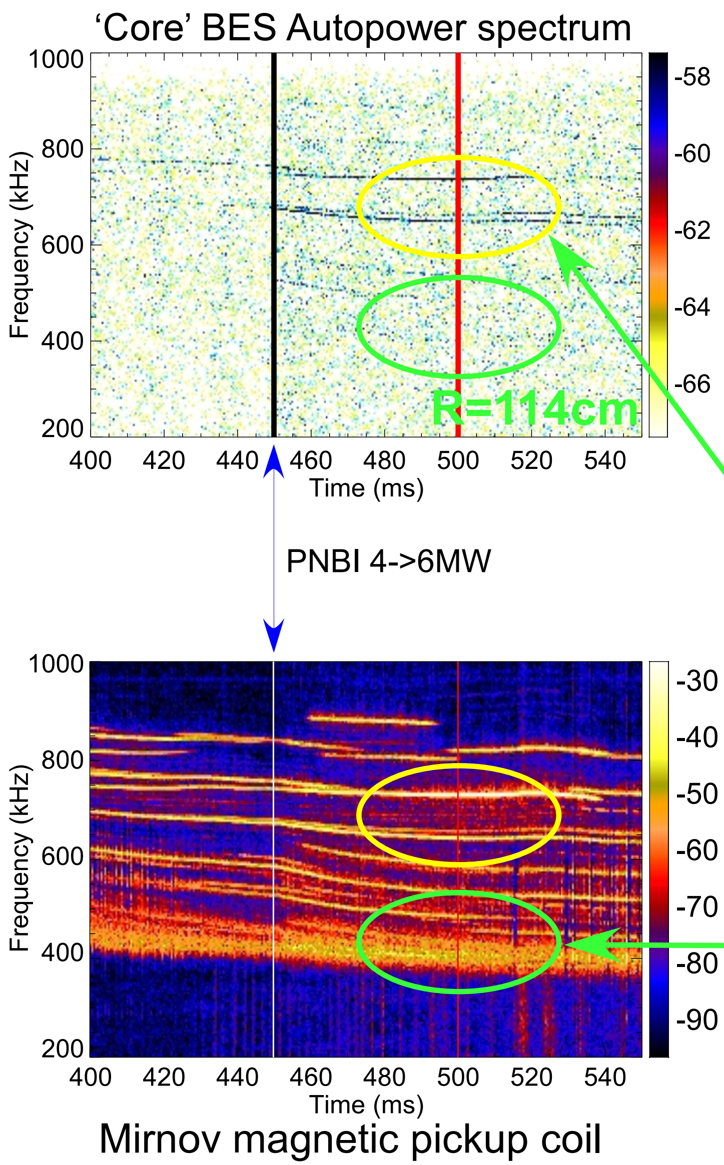
'Bursting' GAE mode activity may strongly affect predicted electron thermal transport

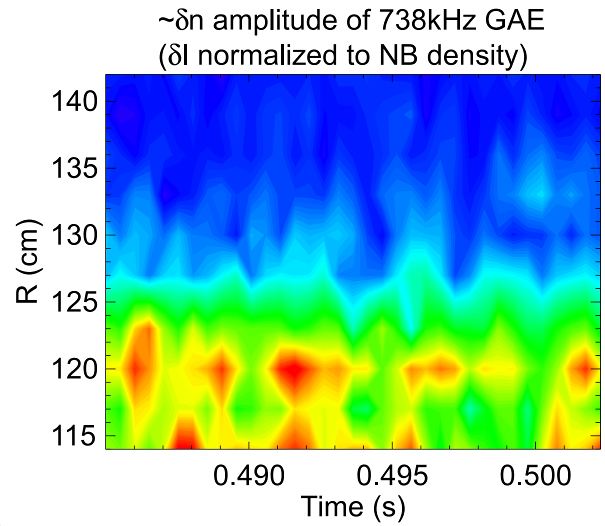


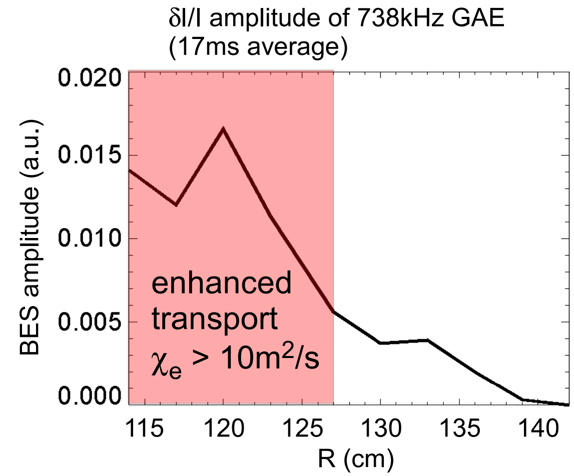


- Strong scaling of transport with α indicates mode amplitude peak values dominate χ_e
- Peak amplitudes ~ x2 to x3 higher than time-averaged, rms values from BES and magnetics
- Calculated electron thermal transport from peak GAE mode amplitudes roughly agrees with experimental TRANSP values

Initial BES measurements show GAE peaking at R~120cm (r/a ~ 0.36) in region of enhanced transport



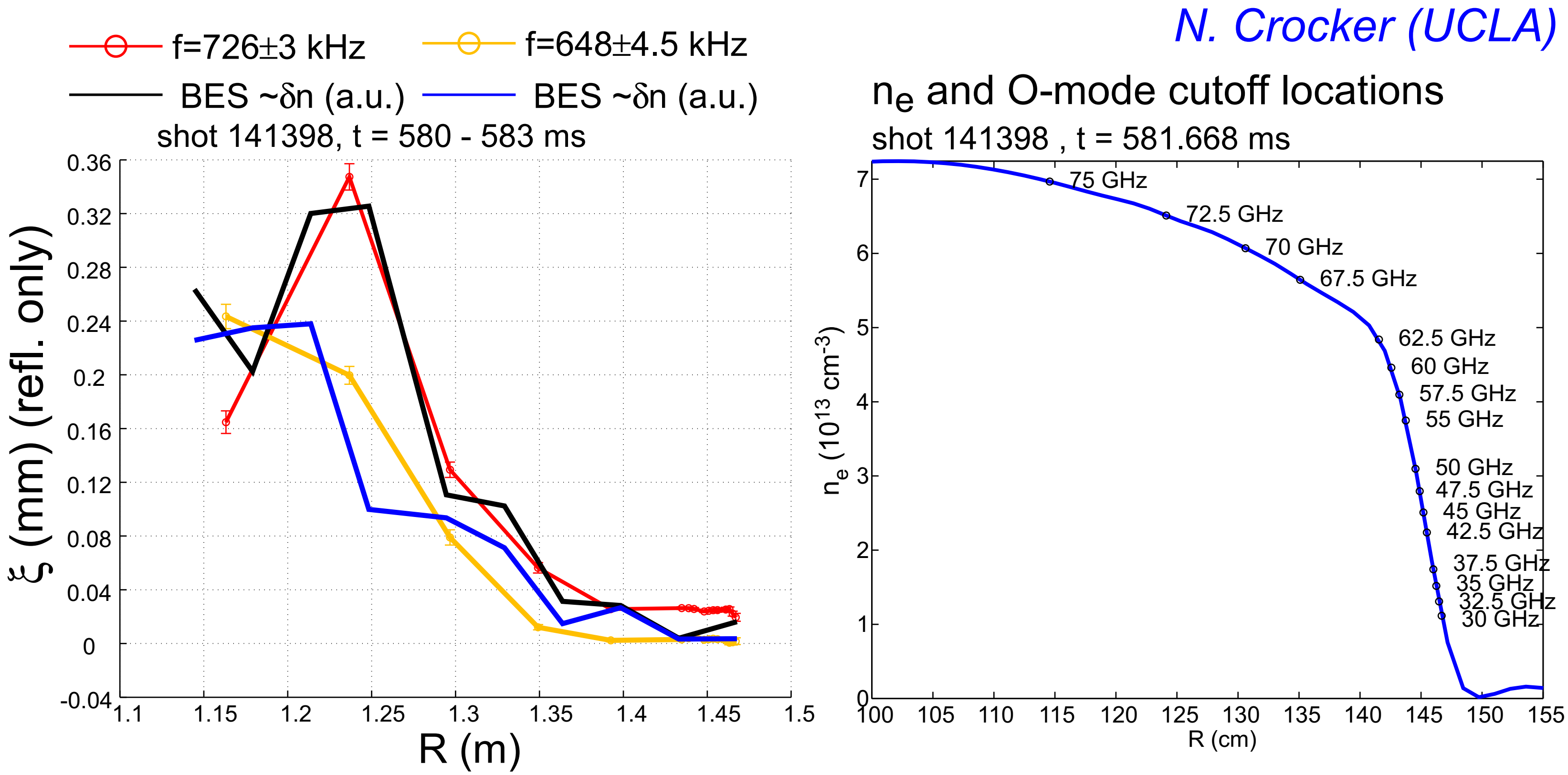




- BES spectrogram shows high-intensity GAE modes R < ~135cm ~ 5-10dB above background
- Mirnov pickup coils reveal additional, lower amplitude modes below BES detector limit

Measured mode displacement profiles from high-frequency reflectometry matches BES profile data

N. Crocker (UCLA) BP9.58



- Displacement of 0.35mm rms ($\zeta/R \sim 4\times10^{-4}$) indicates $\delta n/n \sim 4.5\times10^{-4}$ roughly consistent with high-k in similar discharge
- Raw phase reflectometer signal shows strong 50kHz beating of 700kHz oscillation with maximum amplitude ~0.9mm

Summary

- Flat core profiles and high χ_e not explained with electrostatic turbulence in high power NSTX H-modes
- Strong correlation of GAE activity with NBI power and high electron thermal transport
- Measured GAE mode structure and amplitude roughly consistent with predicted values of transport using ORBIT code

Future Work

- Calibrated amplitude and time history data will be used with ORBIT to further validate predictions of χ_e
- Validation of the HYM code using GAE mode structure and phase measurements
- JHU proposed Ultra-Fast Dual-Energy SXR system will measure poloidal structure of GAE mode, δn_e and δT_e in NSTX-U plasmas