NSTX

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Correlation between Electron Transport and Shear Alfven Activity in NSTX

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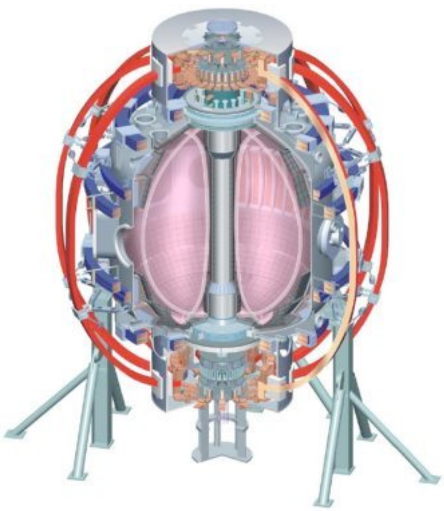

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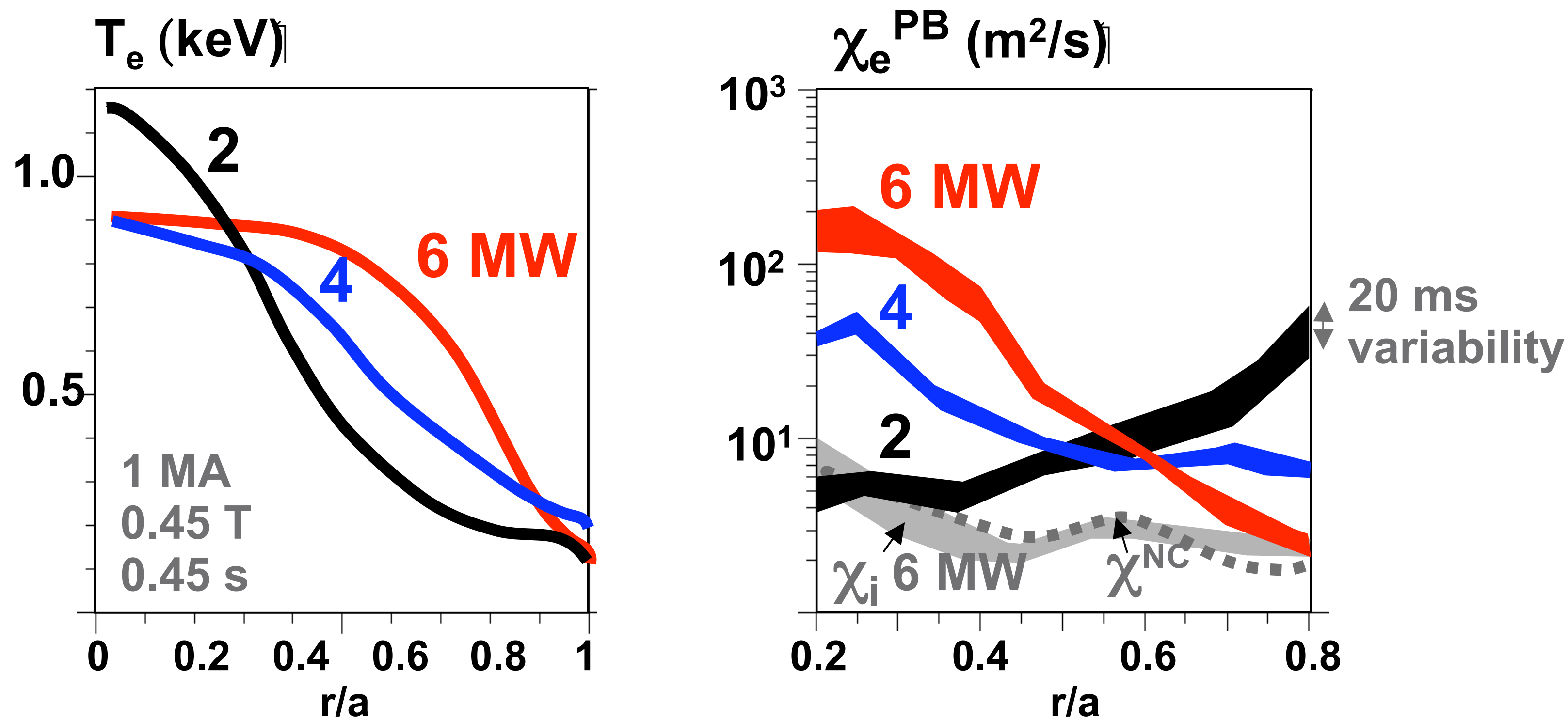
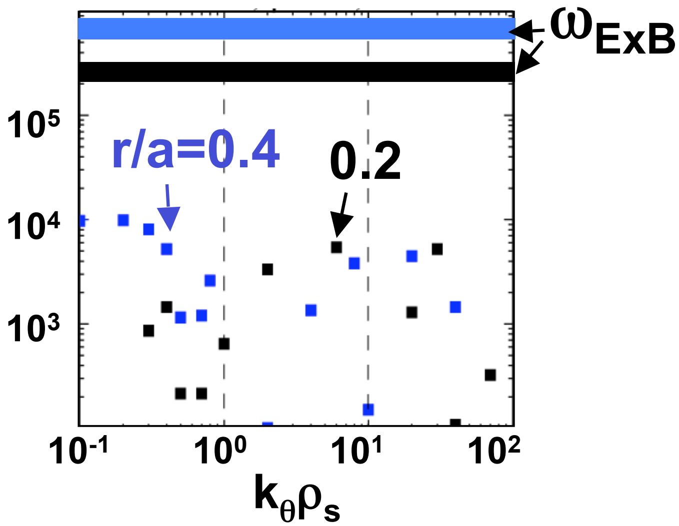
T_e flattens in some NSTX H-modes as P_b increased



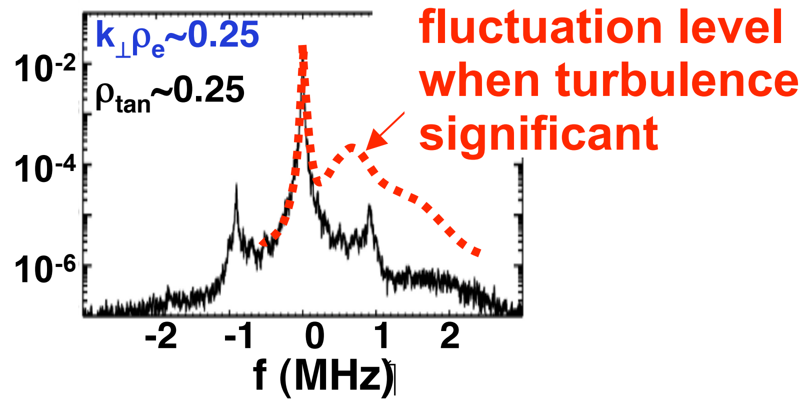
- Not caused by low-f MHD or fast ion (FI) radial redistribution
- $\chi_e^{PB} \geq 10$ m^2/s inside r/a ≤ 0.4, while $\chi_i \sim \chi^{NC}$
- Perturbative experiments support PB transport picture

∇T_e is too low for kinetic instabilities

GS2 growth rates (s^{-1})



High-k power (a.u.)

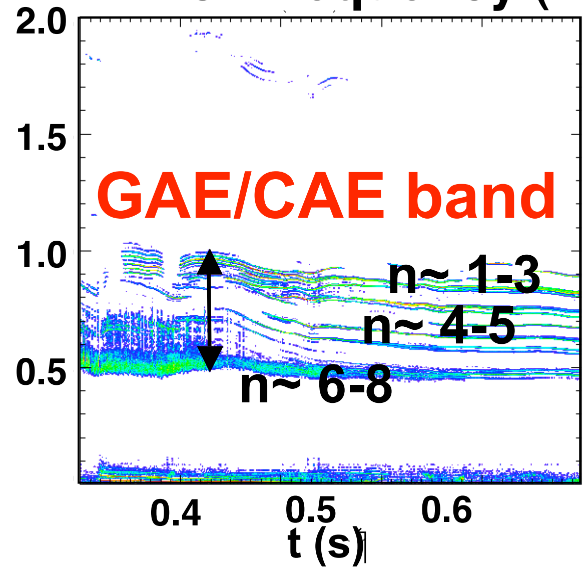


- Weak high-k fluctuations
- Persistent 0.5–1.1 MHz GAE/CAEs

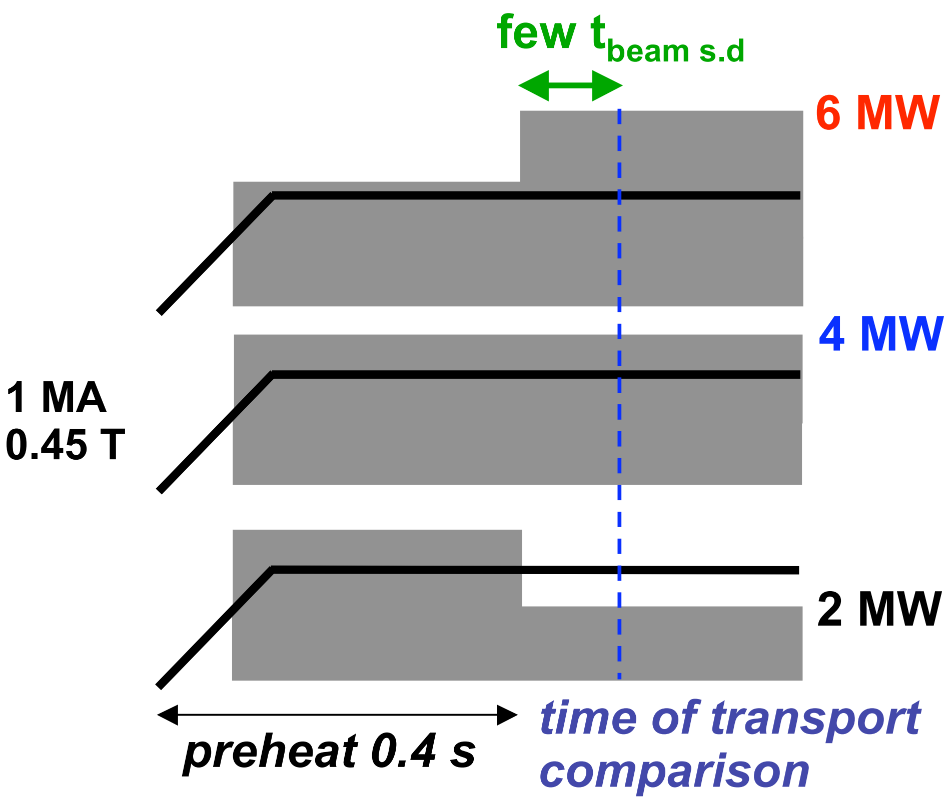
(Global and Compressional Alfvén Eigenmodes)

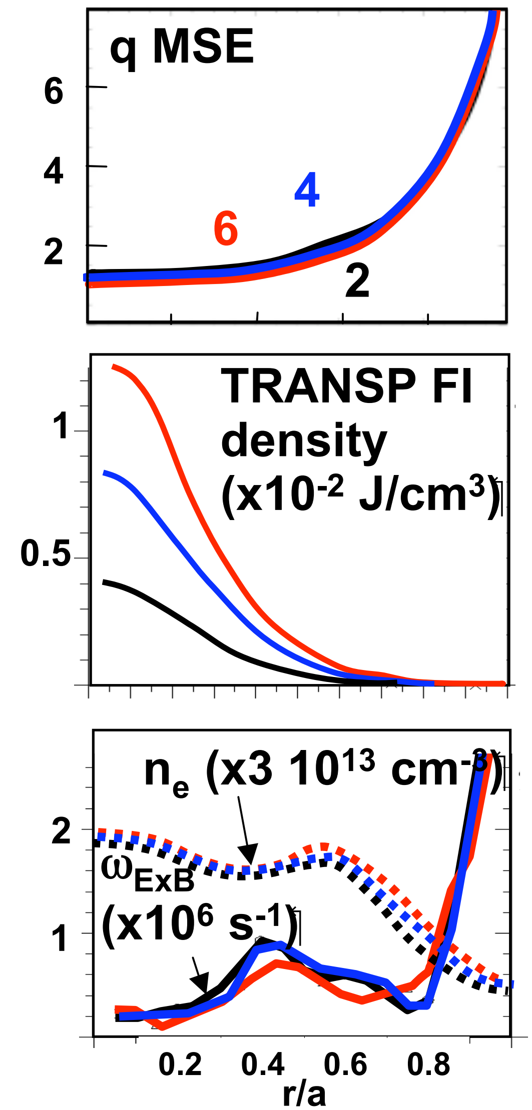
(Gorelenkov et al. NF 2003)

Mirnov frequency (Mhz)



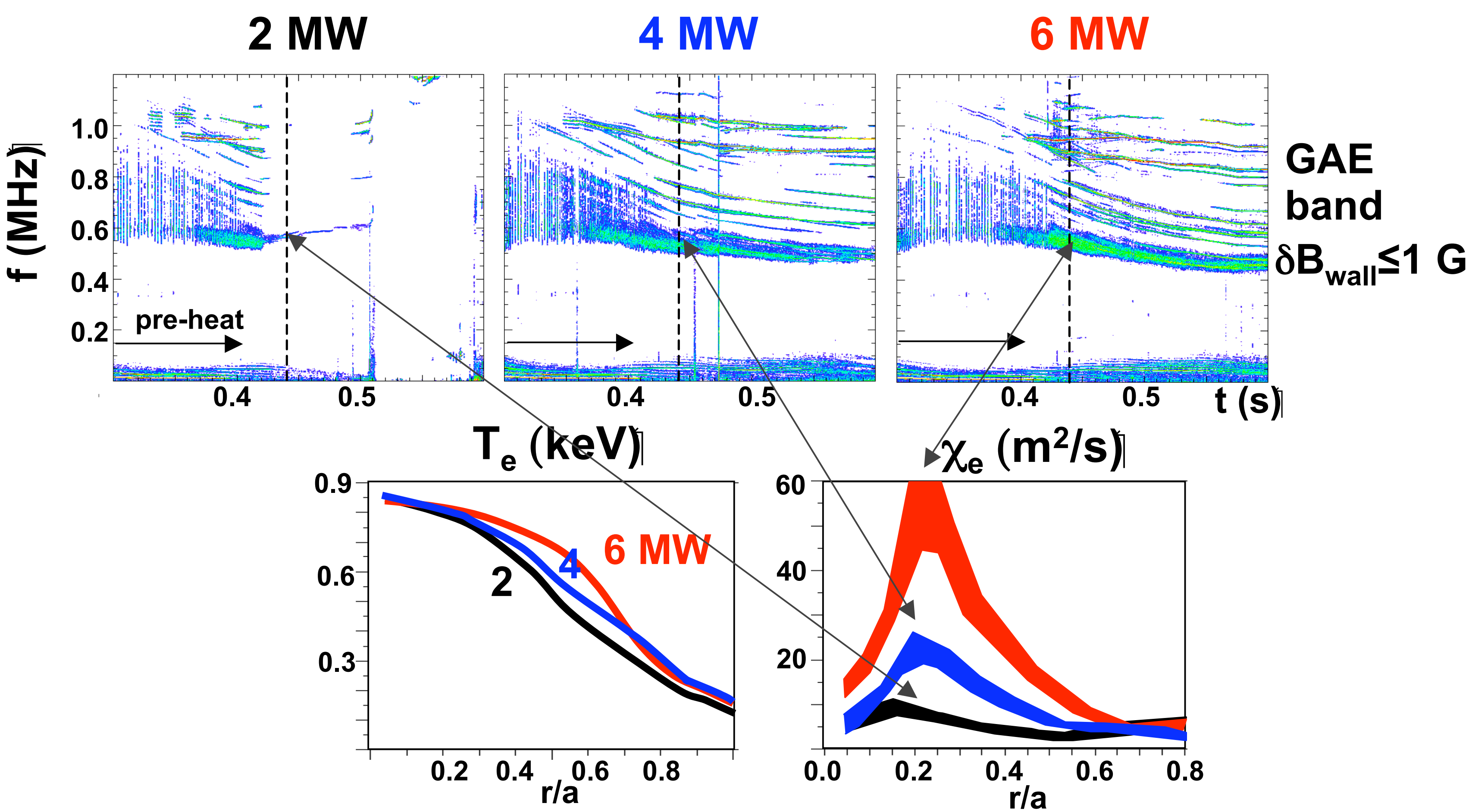
NBI power scan leads to fast ion density change in the core





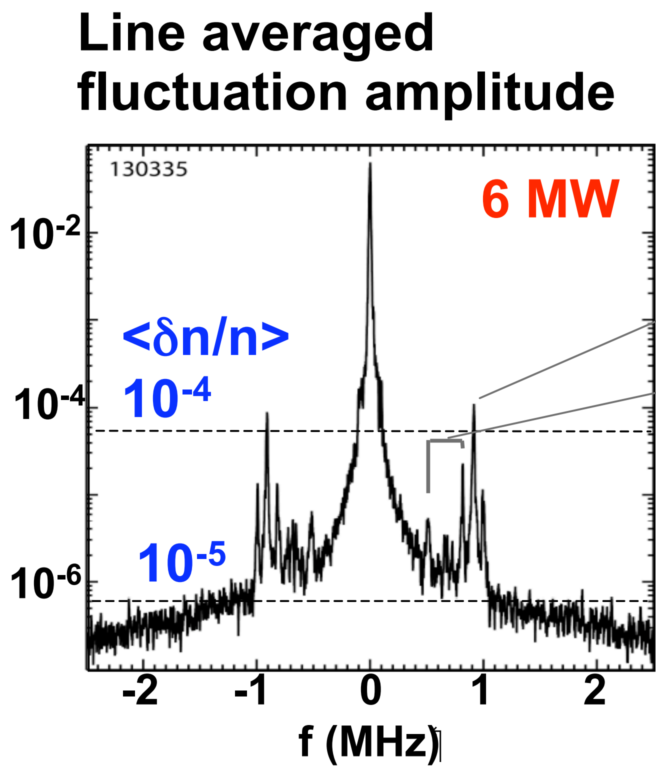
- q 'frozen' by preheating, P_b then stepped
- almost constant q, n_e, ω_{ExB}
- Strong variation in fast ion (FI) density $\Rightarrow$ expected GAE drive

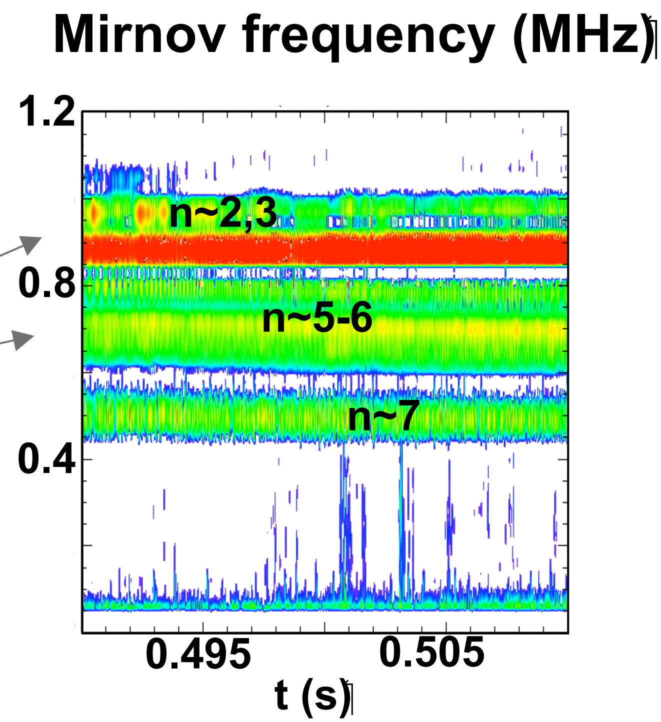
T_e flattening, χ_e increase correlate with GAE intensity



- Plasma with strong GAEs have flat T_e, high central χ_e
- Plasmas with faint/no GAEs have peaked T_e, low χ_e

Interferometry shows significant GAE amplitudes





- High-k diagnostic in interferometric mode at r/a=0.25
- Peak δn_e likely higher, $\delta B_r/B \sim m\delta n_e/n_e\varepsilon$
- Broadband, overlapping GAE character at high P_b

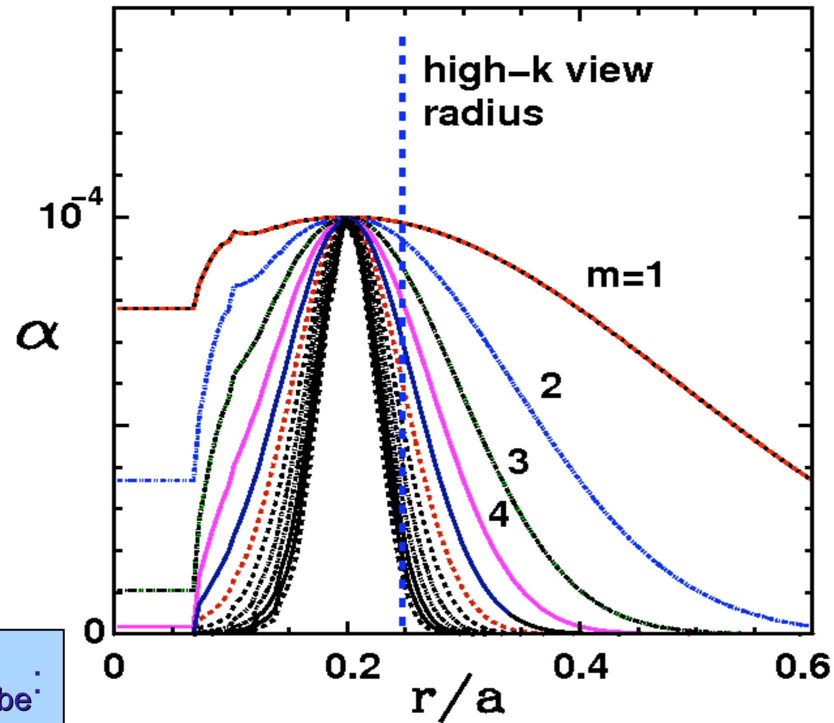
Electrons can resonantly interact with GAEs in NSTX

Characteristic frequencies of thermal species:

- f_{GAE} = ~400–600kHz, but may go higher.
- transit (passing) frequency
  $f_{te} = v_{||}/2\pi qR$ = 2MHz at T_e = 1keV
- bounce (trapped) frequency
  $f_{be} = v_{||}(r/2R)^{1/2}/2\pi qR$ = 560kHz at
  q_0 = 1.25, R = 1m, a = 0.6m, r/a = 0.23
- electron Coulomb scattering frequency
  $\nu_{ce} = 0.7 \times 10^{11}\ \mathrm{sec}^{-1}$, $(\nu_{ee+}\nu_{ie})/\omega_{ce} = 6 \times 10^{-7}$
- thermal ion cyclotron frequency f_{ci} = 3MHz.

GAE frequency equals to trapped electron f_{be}:
resonances are $\omega_{gae} - \omega_{be} = 0$.

Theory for ORBIT:
$\delta B = \mathrm{rot}\,(\alpha^* R_0^* B_0)$



14 GAEs with n = 1 – 8; m is such that f = 400–600kHz are used in guiding center simulations for e-transport.

ORBIT code predicts significant e-transport due to GAEs

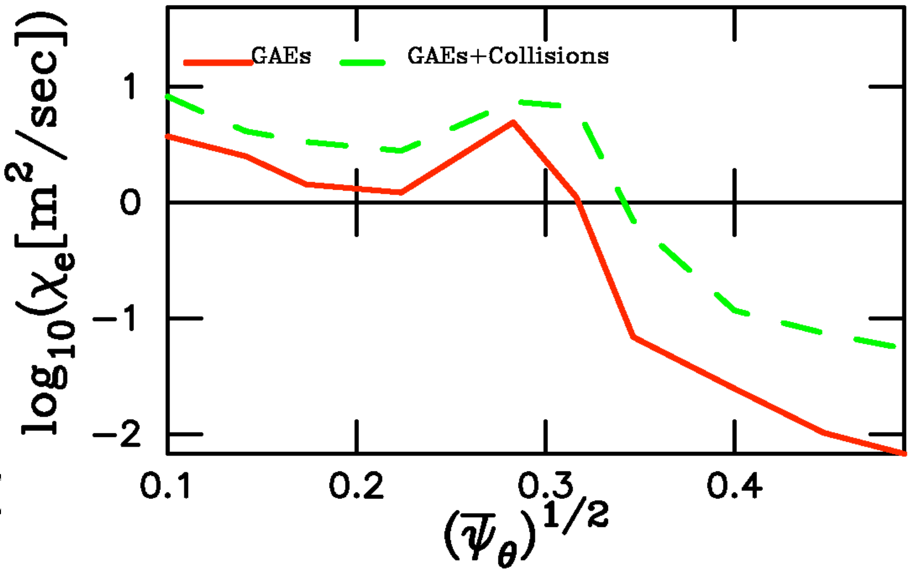
Use ORBIT, guiding center code

Apply to H-mode NSTX plasma

Test e-particle simulations produce thermal electron transport

ORBIT predicts:

$\chi_e > 10 m^2/s$ at $\alpha > 10^{-4}$ ($\delta B_r/B = m \delta n_e / n_e \varepsilon = \sim 10^{-2}$)



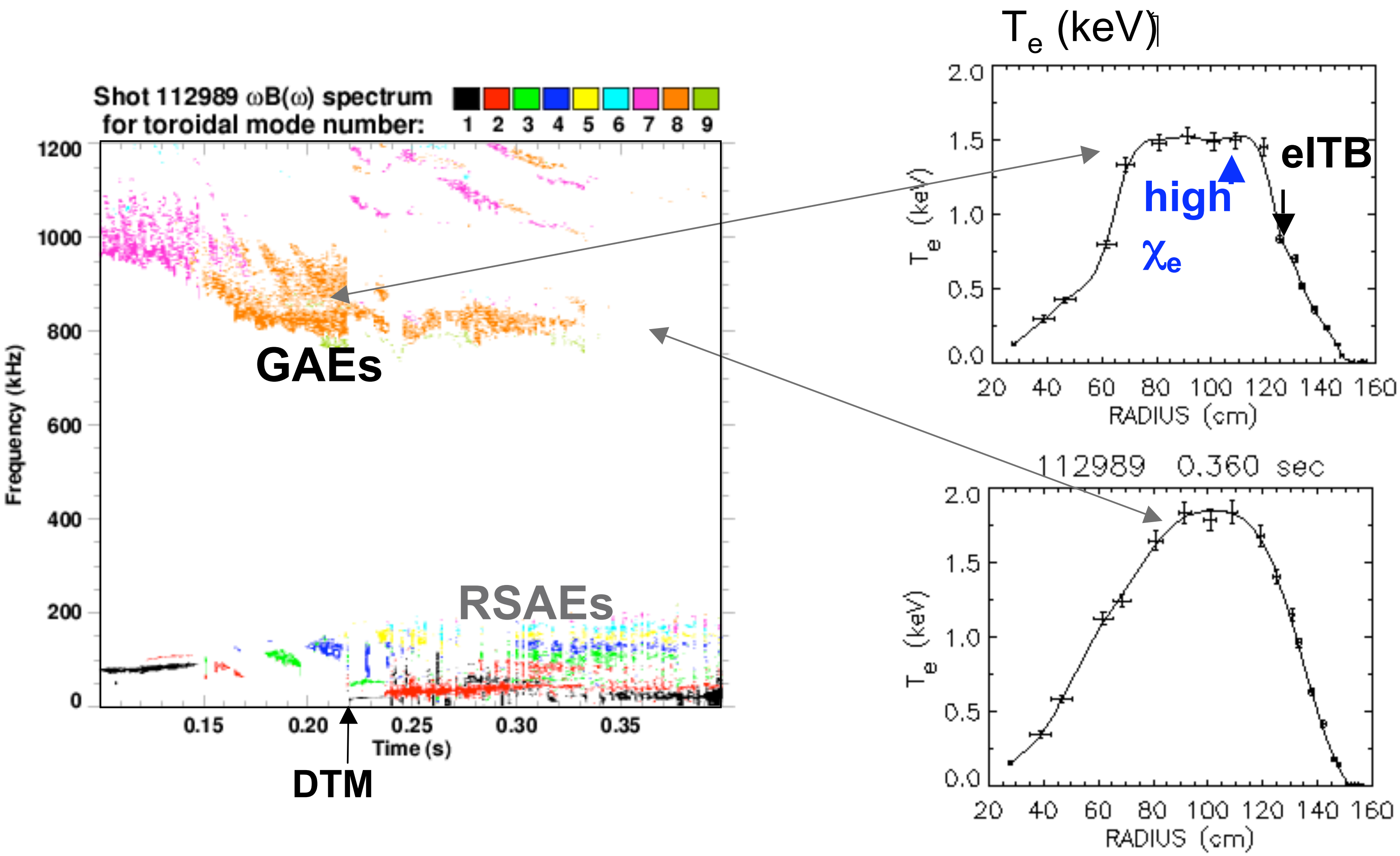
At such perturbation level $\xi_r/R > \alpha\ m / k_{||}\ r = \sim\alpha/\varepsilon = \sim 4{*}10^{-4}$ at r/a=0.25.

This is on the same order as high-k diagnostic measured GAE amplitudes.

Summary

- T_e flattening in NSTX H-modes is observed.
- Flattening correlates with intensity of shear Global Alfvén Eigenmode (GAE) activity.
- GAEs apparent as broadband 0.5–1.1 MHz magnetic and density fluctuations.
- First assessment with ORBIT code, test particle simulations indicates GAEs may resonantly couple with the bulk (~1 keV), primarily trapped electrons.
- χ_e = 10m^2/s for electron heat transport from ORBIT simulations requires $\delta n_e/n_e \sim 10^{-4}$, on the same order as was measured by high-k diagnostic.

GAEs and T_e flattening correlate also in L-modes



- A cause for T_e flattening also inside tokamak eITBs?