

**Study of the correlation between  
GAE activity and electron transport (XP840)**

**Field scaling of electron transport change with  
heating power (XP822)**

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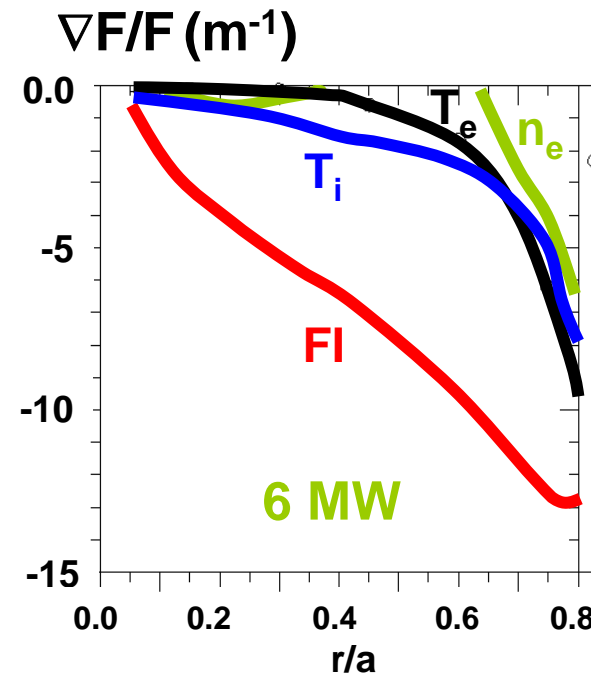
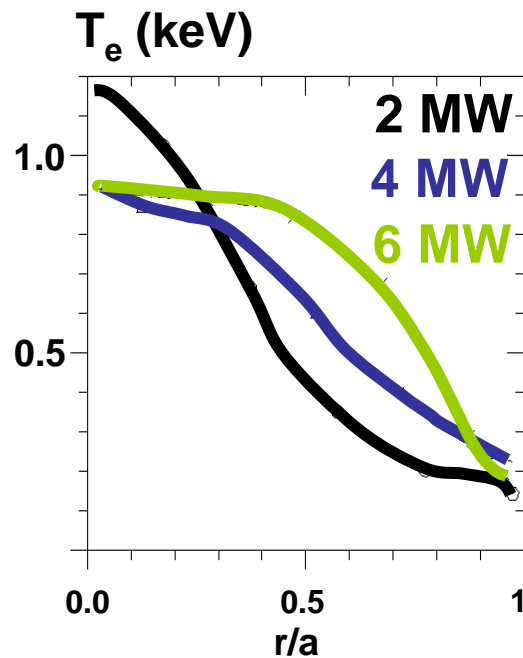
***N. Gorelenkov, E. Fredrickson, S. Kaye, E. Mazzucato***

***PPPL***

**2008 NSTX Results Review**

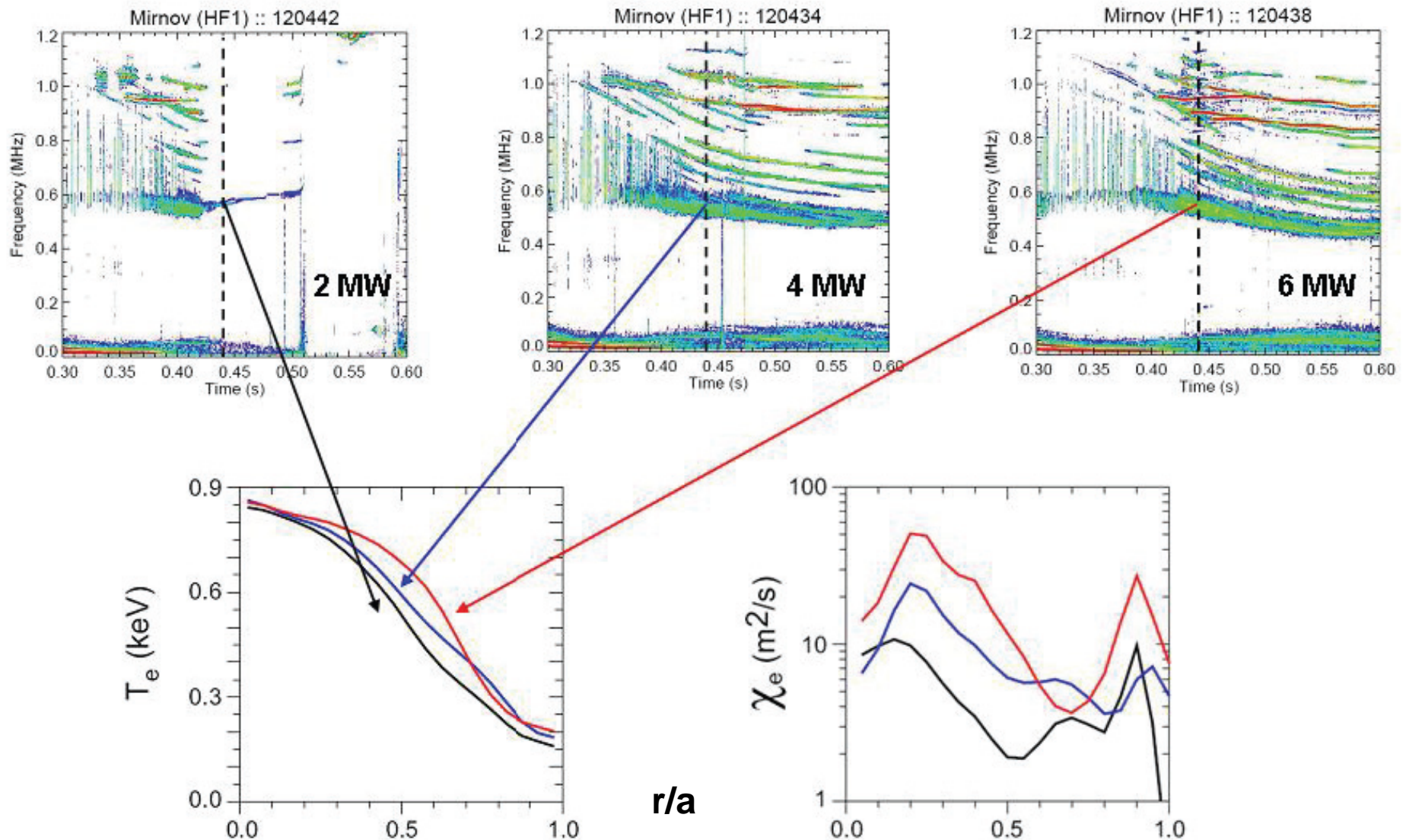
# Motivation: What drives electron transport in flat $T_e$ regimes?

1 MA 4.5 kG H-modes



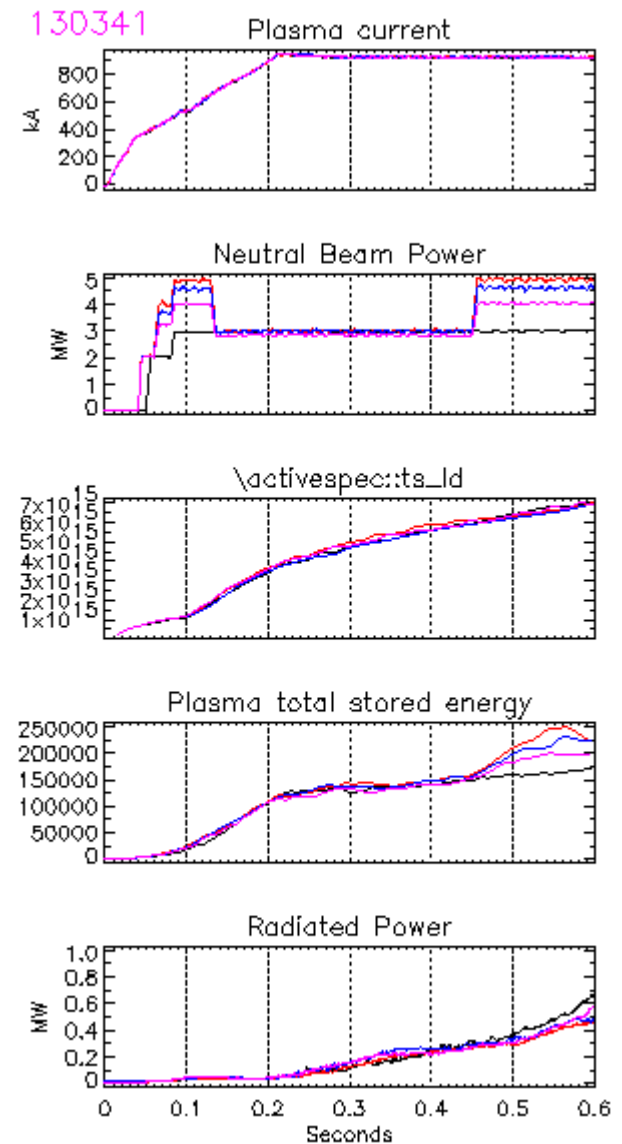
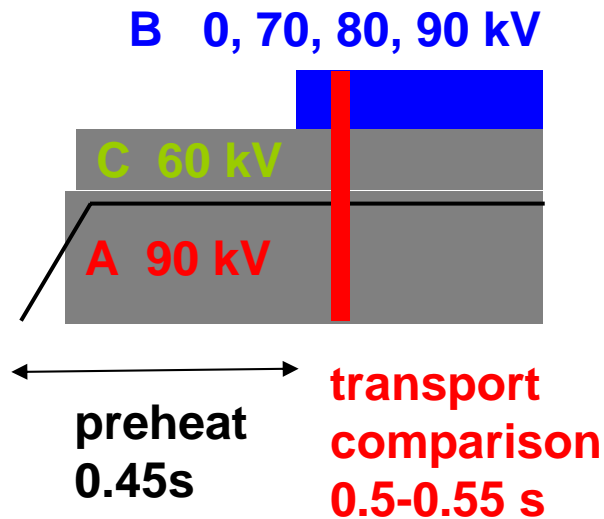
- $T_e$  flattens, central  $\chi_e$  strongly increases with beam power
- $\chi_e \gg D_{\text{imp}}$  suggests stochastic electron transport
- Thermal gradients insufficient for any known instability
- Fast ion gradient only source of free-energy
- Is fast ion MHD (\*AEs) driving electron transport in NSTX?

# Possible relation between electron transport and GAE activity

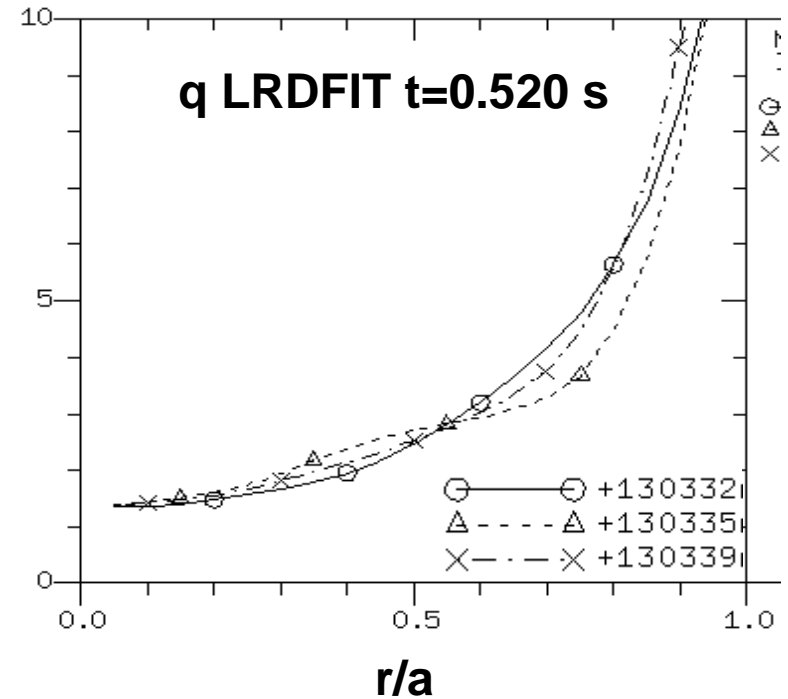
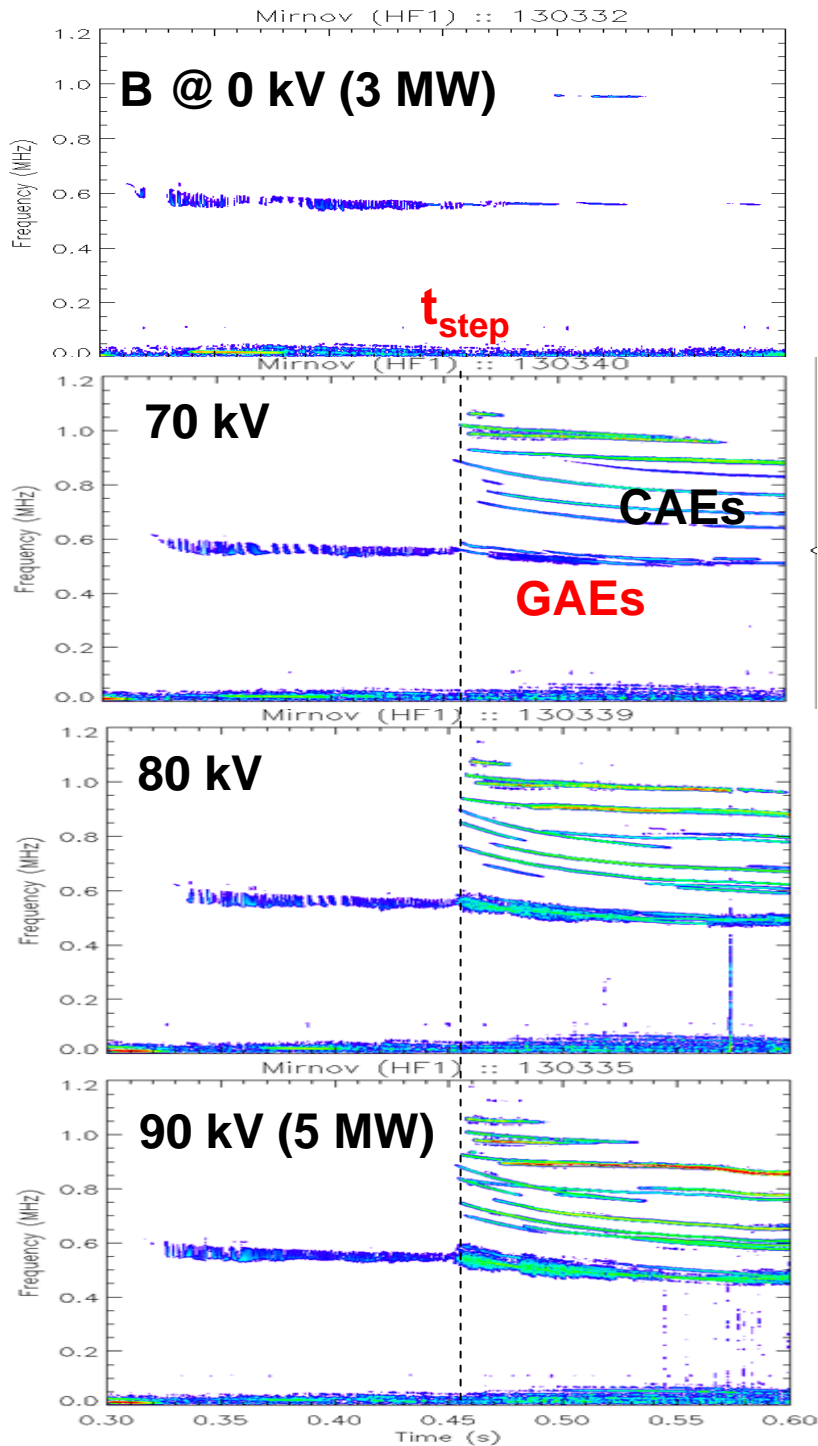


- Correlation seen also in RS L-modes
- GAEs may drive transport of trapped electrons (N. Gorelenkov et al)

# Electron transport/GAE relation further studied in XP840



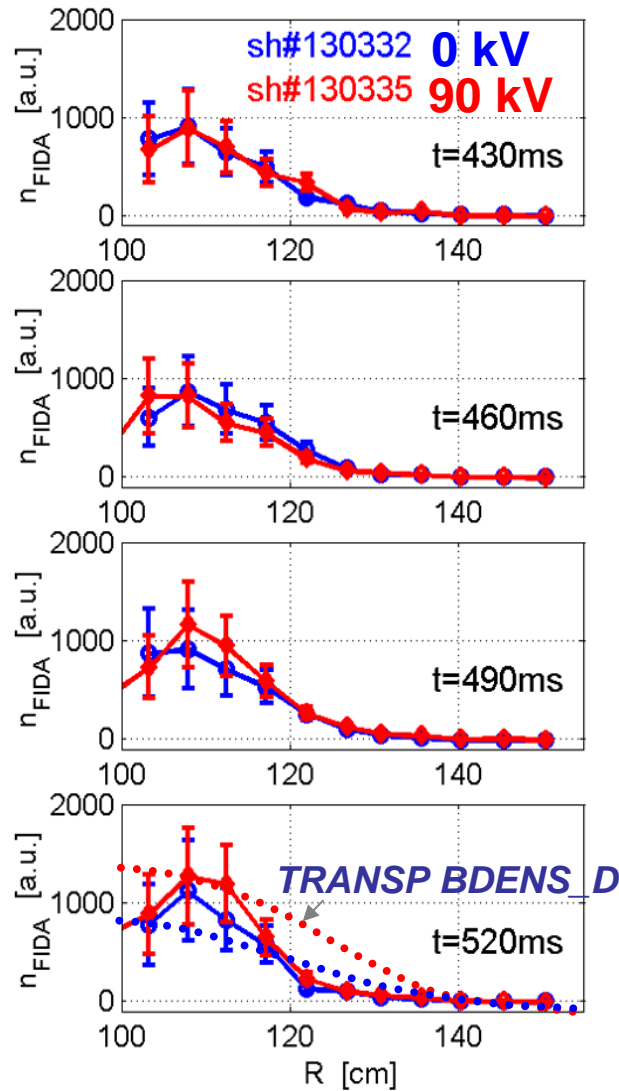
- Experiment:
  - Make AE quiescent H-mode
  - 'Freeze-in' q-profile by preheating
  - Step source B at increasing  $V_b$
- Compare transport at 2-3  $t_{\text{beam slowdown}}$
- Measure GAE  $\delta n/n$  with high-k system



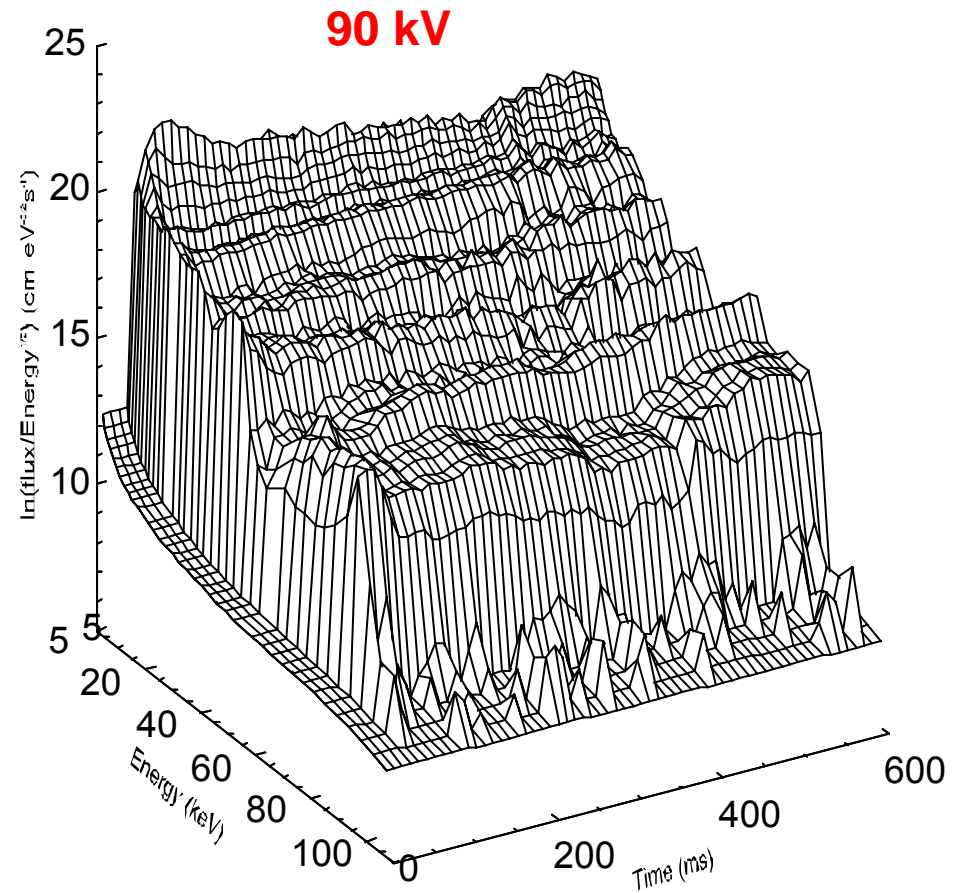
- Progressive increase in GAE amplitude at  $\sim$  constant- $q$
- Negligible low-f MHD, ELMs

# Fast ion distribution likely not much affected by MHD

FIDA (M. Podesta)

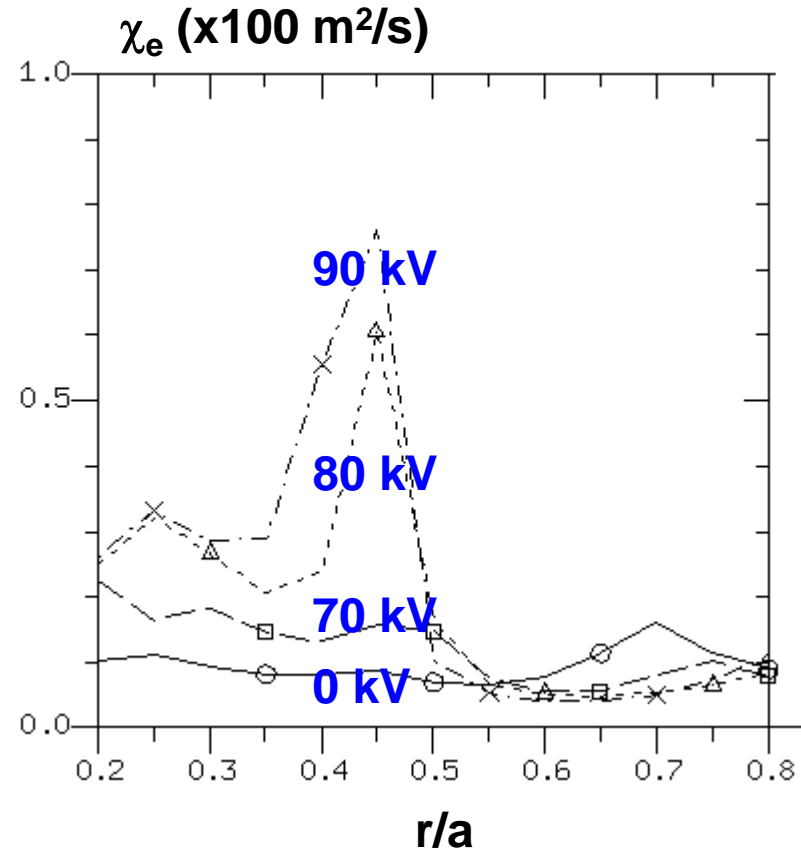
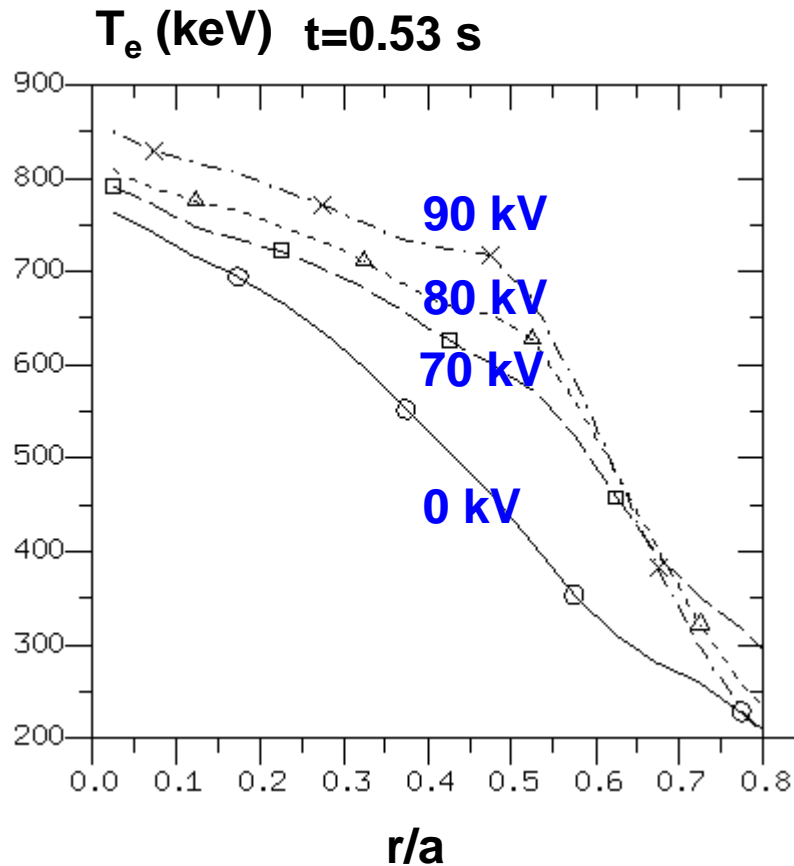


NPA (S. Medley)



- Centrally peaked beam ion density
- No anomalies in NPA spectra
- Some global loss possible (metals)

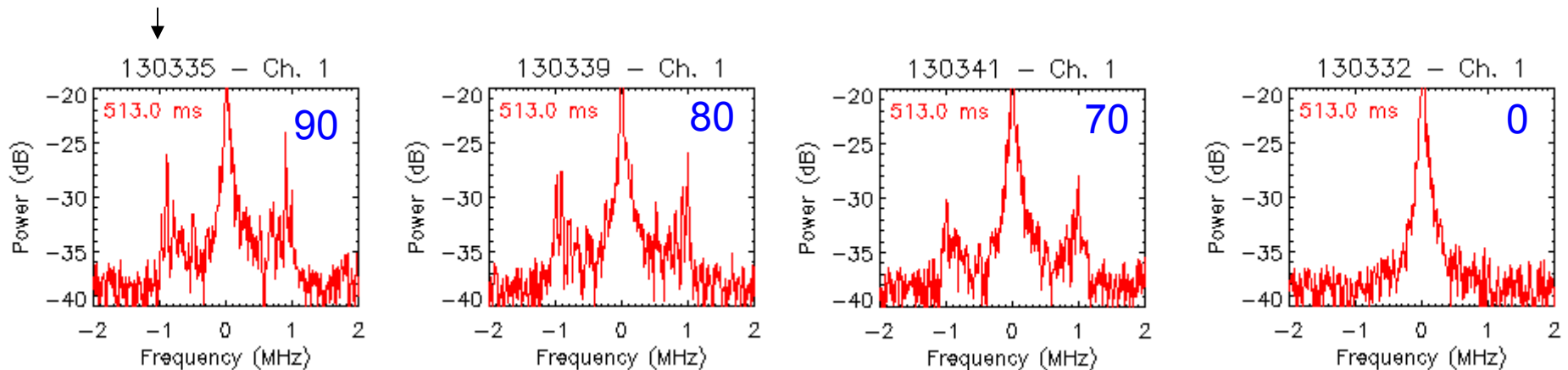
# Central electron transport consistently correlates with GAEs



- Ion transport essentially unchanged ( $\geq$  neoclassical)
- $\sim 20\%$  TRANSP neutron mismatch (prelim.)
- $P_{\text{rad}}$  likely underestimated when metals present ( $\chi_e$  pre-Li  $\ll \chi_e$  post-Li)

# AE $\delta n/n$ estimated by high-k in interferometry mode

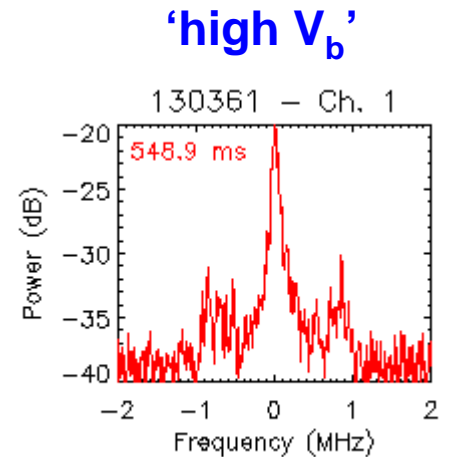
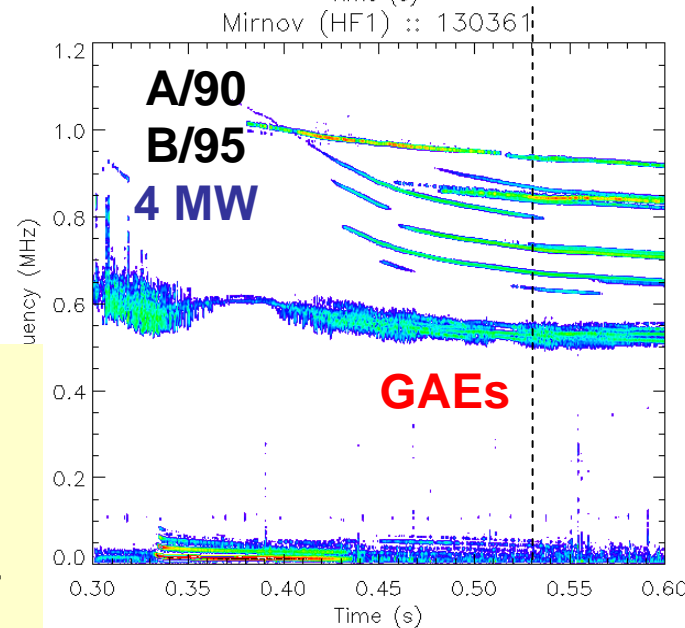
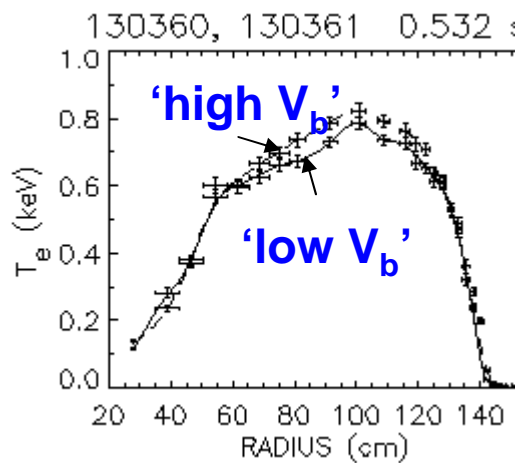
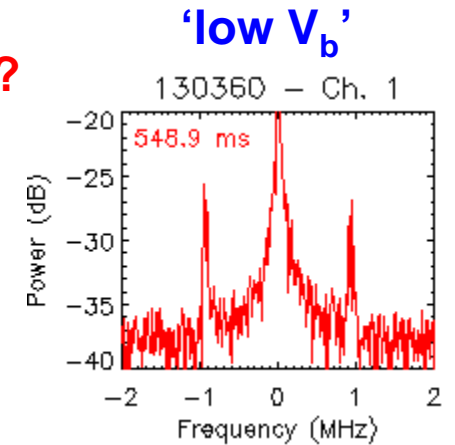
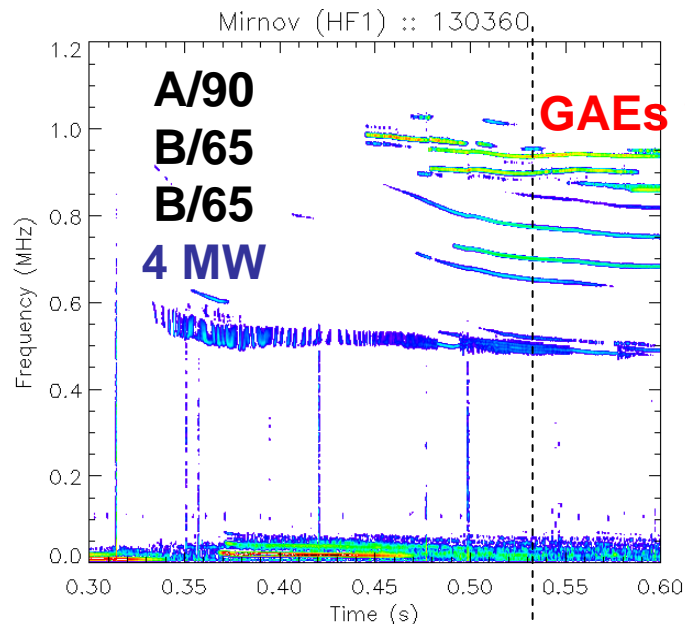
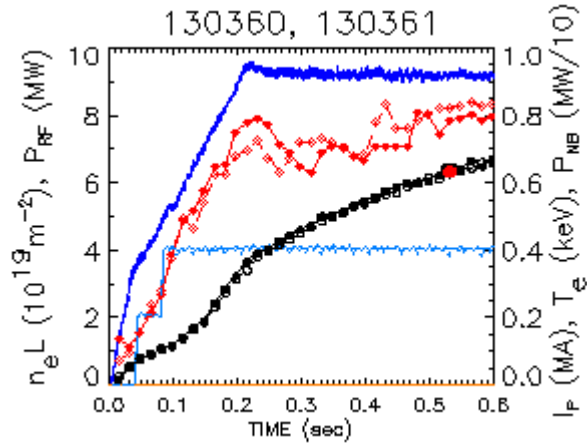
line average  $\delta n/n \sim 4 \times 10^{-4}$  at R=115 cm  
(E. Mazzucato)



- Local  $\delta n/n \lesssim 10^{-3}$  assuming predicted GAE mode extent
- AE amplitude in L-mode also from reflectometry (N. Crocker talk)

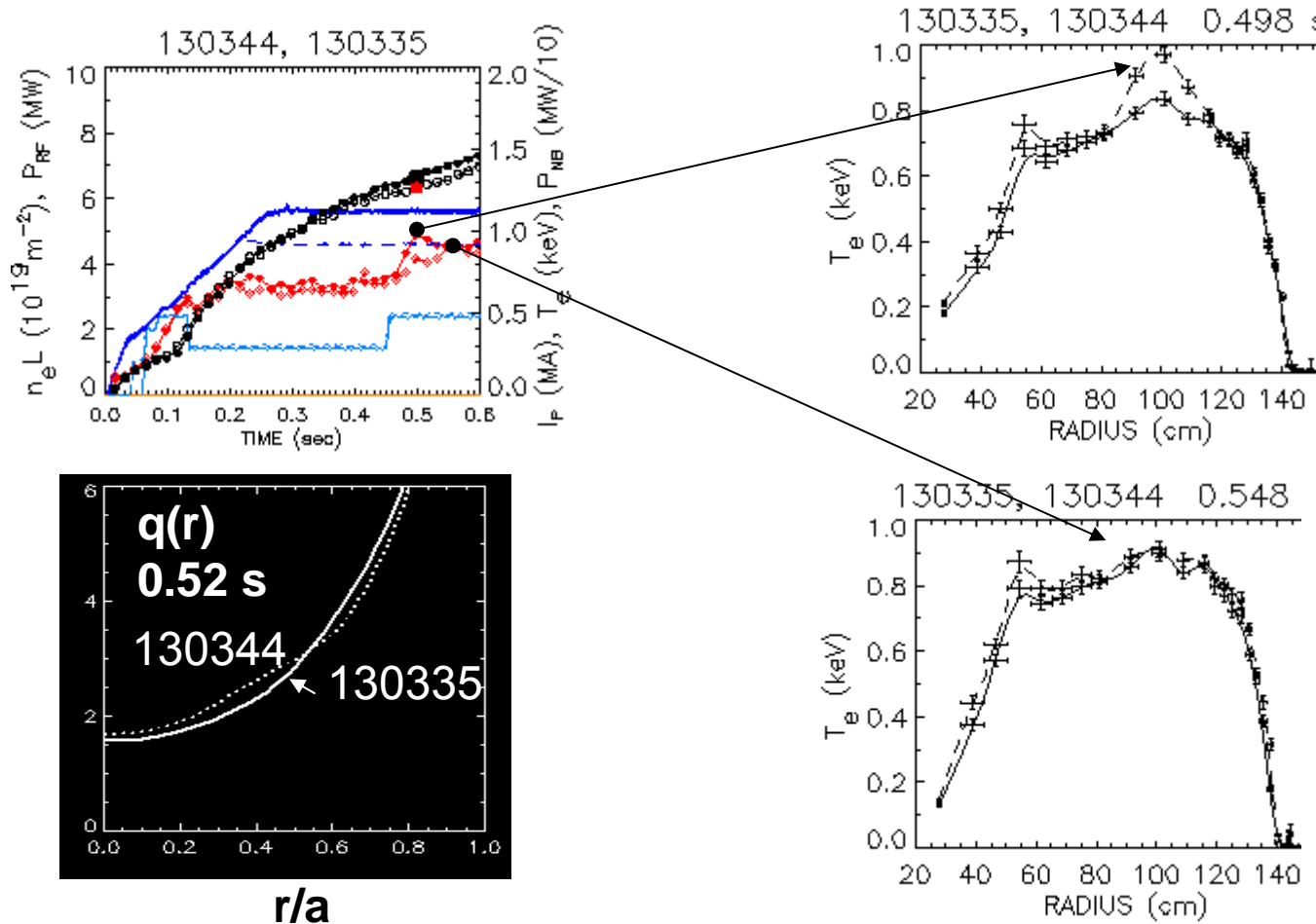


# Plasmas with equal $P_b$ at different $V_b$



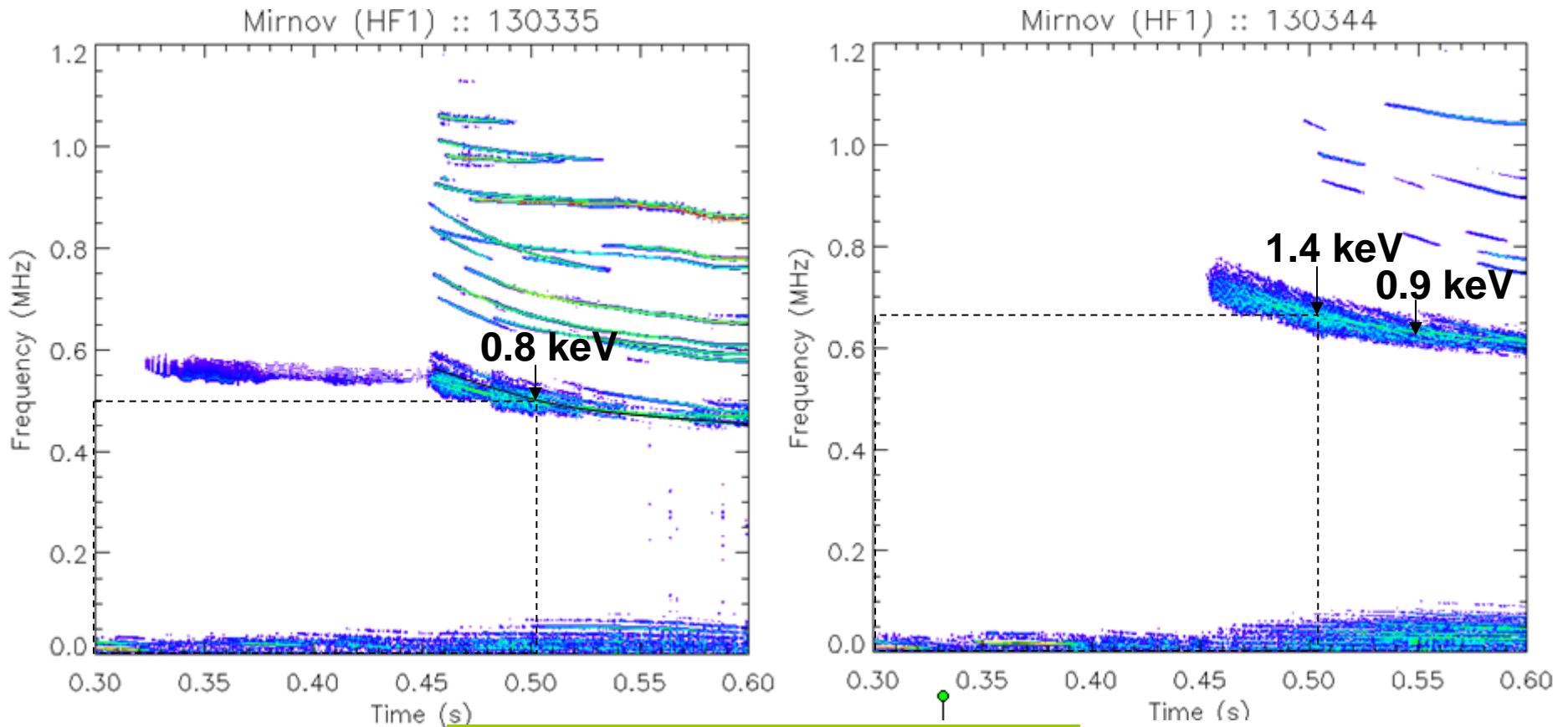
- About 50% higher central  $\chi_e$  at low  $V_b$ , but also stronger GAE (?) activity around 1 MHz
- Some  $q(r)$  differences

# Effect of higher magnetic field



- Low-f MHD quiescent, similar  $q(r)$  shots at 4.5kG/0.9 MA and 5.5 kG/1.1 MA
- $T_e(0)$  transiently peaks at high  $B_t$  ('low rational- $q$ ' effect unlikely)
- Later on slightly broader  $T_e$ ,  $\chi_e$  profile (prelim.)

# Higher GAE frequency might allow $T_e$ peaking at high $B_t$



$$f_{be} = 1/2\pi V_{perp}/qR \sqrt{r/2R}$$

( $r/a=0.2$ ,  $R=1m$ ,  $a=0.8m$ ,  $q_{LRDFIT}$ )

$$E_{res} \sim q^2 f_{be}^2$$

- Broad band of higher frequency GAEs ( $\omega_{GAE} \sim v_A$ ) at high field
- Resonance with higher energy electrons might allow transient  $T_e$  peaking,

# Summary

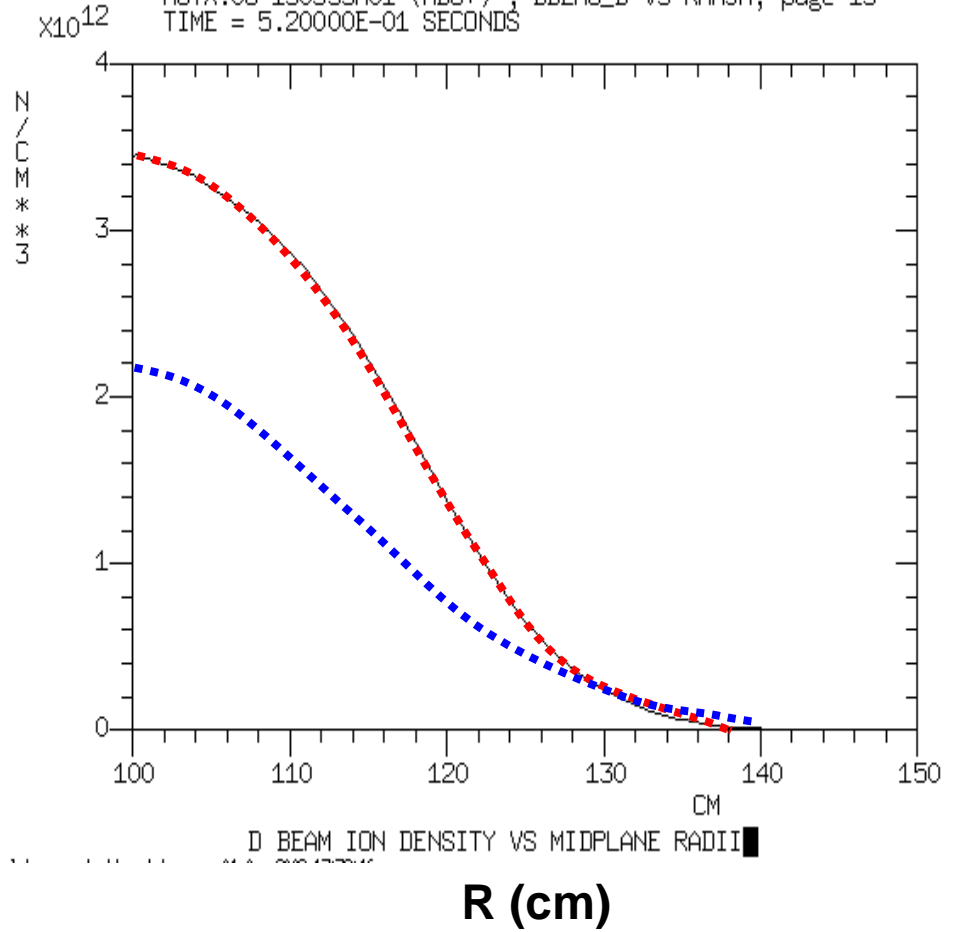
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- Results broadly consistent with hypothesis of GAE driven electron transport
- Clearer cut demonstration needs higher beam power or RF \*AE excitation (present experiments near threshold of highly non-linear effect)
- GAE amplitude in high power H-modes might be relatively high
- Relatively small effect of  $B_t$  on electron transport at fixed-q
- $\chi_i \geq \chi^{\text{neo}}$  makes unnecessary assuming anomalous ion heating in these XPs
- Power balance with metals present, global fast ions loss, possible issues
- Further study important because of likely implications for burning plasmas

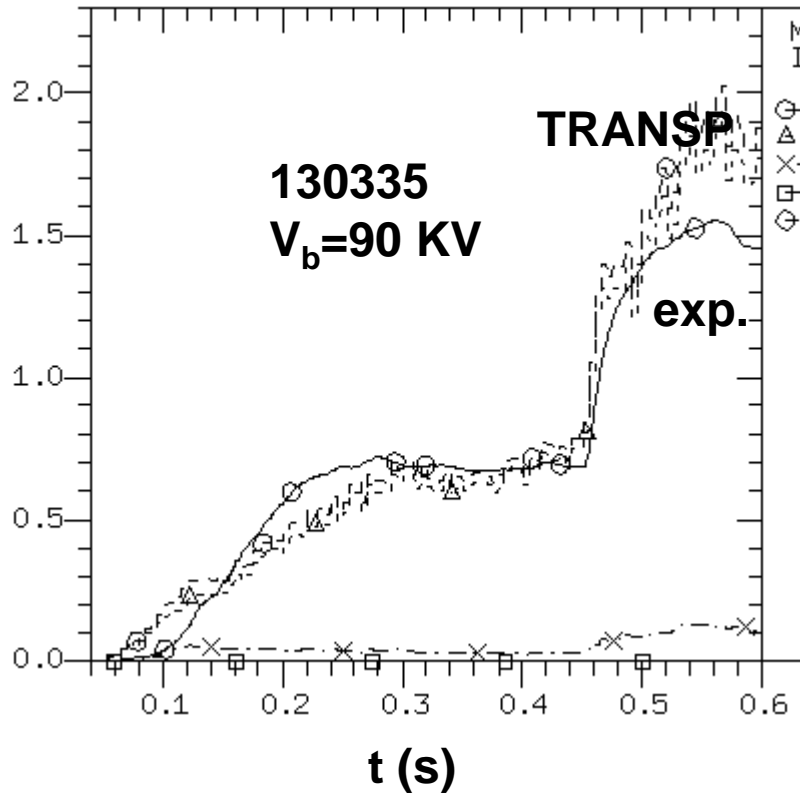
# BACKUP SLIDES

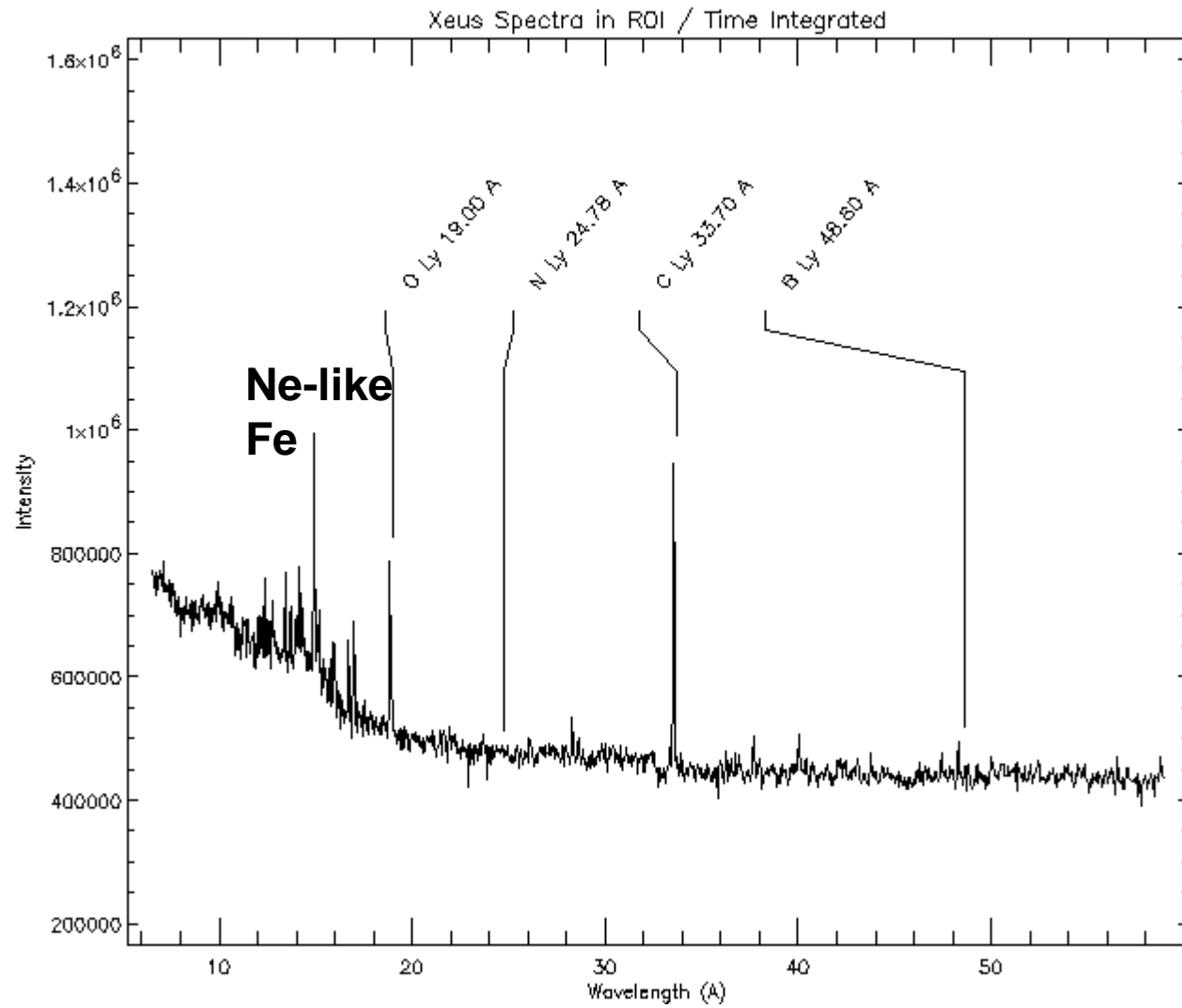
## Beam ion density

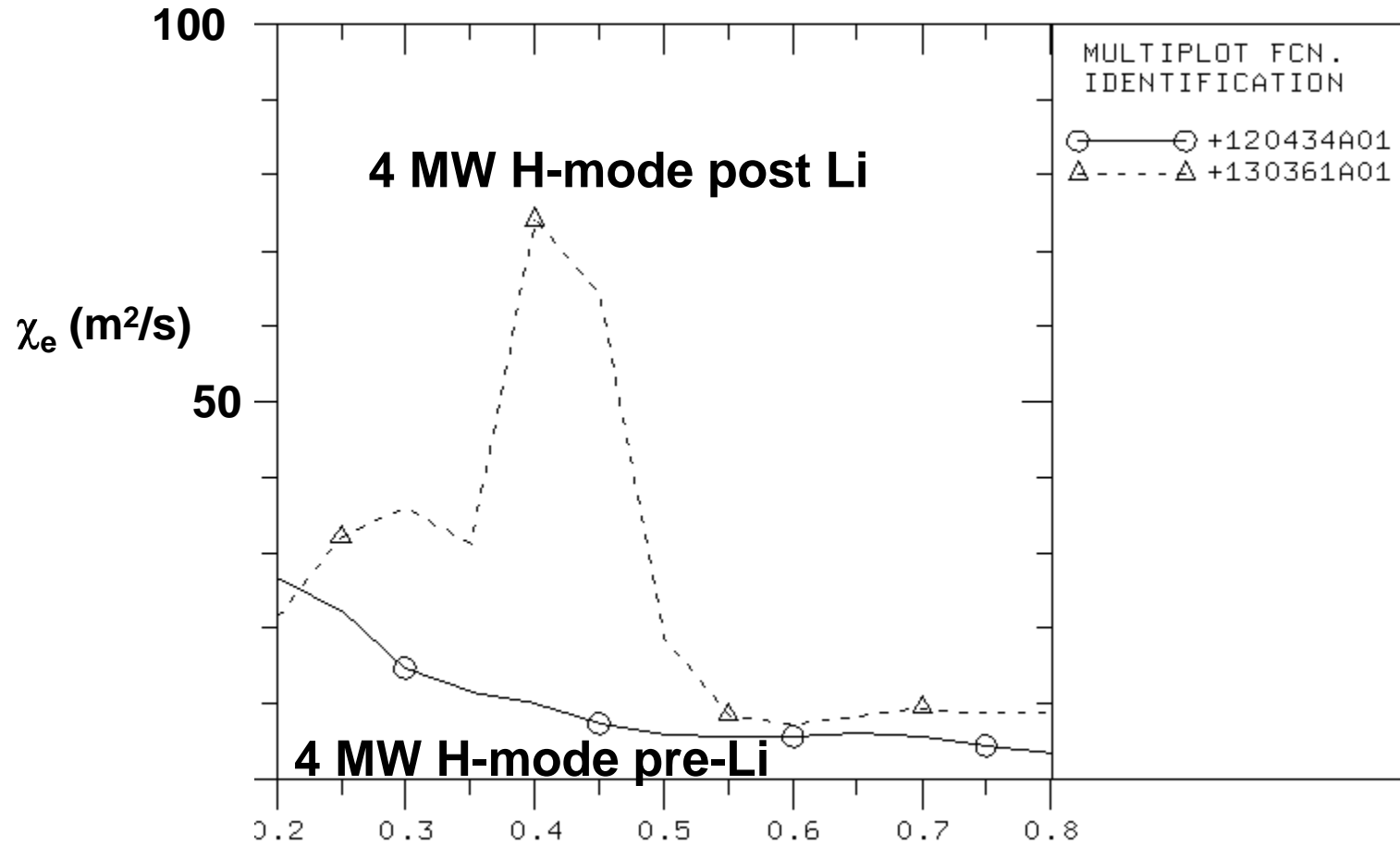
NSTX.06 130335A01 (MDS+) , BDENS\_D vs RMAJM, page 15  
TIME = 5.20000E-01 SECONDS



## Neutrons $\times 10^{14} \text{ s}^{-1}$

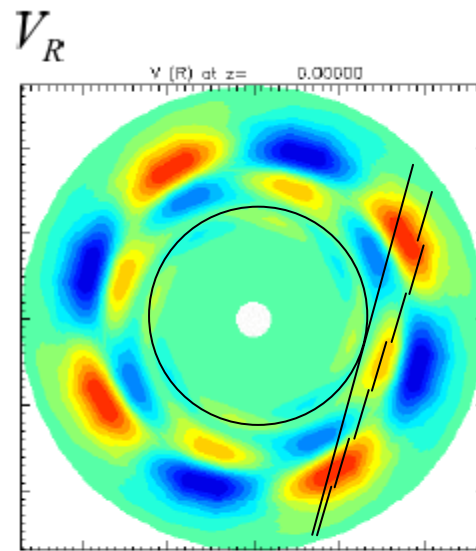






ELECTRON HEAT DIFFUSIVITY (CE) VS XB

by stutman on 28-Jul-2008 21:29:00

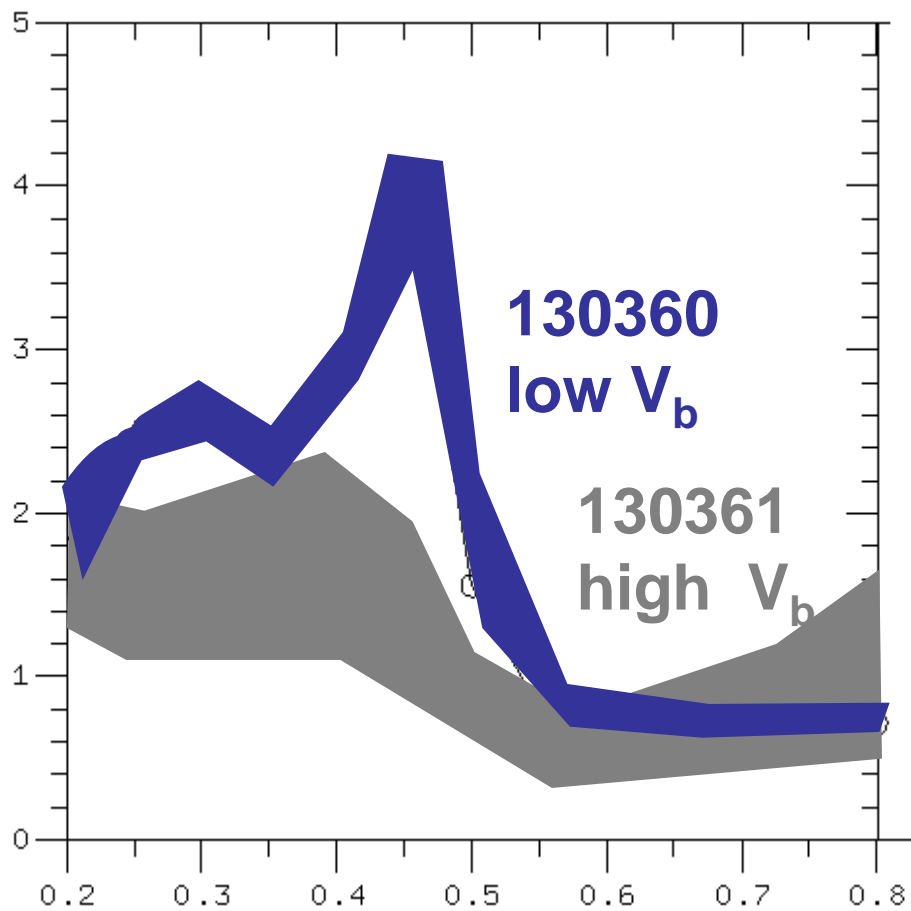


Contour plot of radial component  
of fluid velocity at equatorial plane.

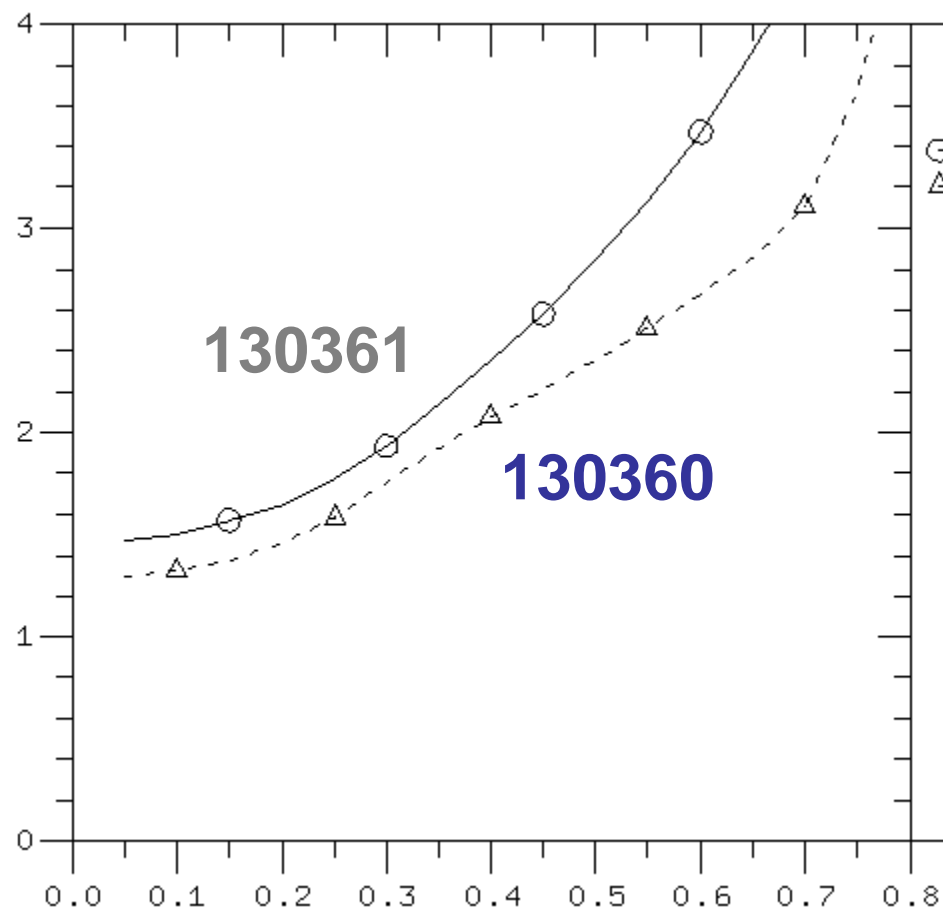
$dn/n \sim 1.5e-3$  in 130335 ( $4e-4$  line integrated)



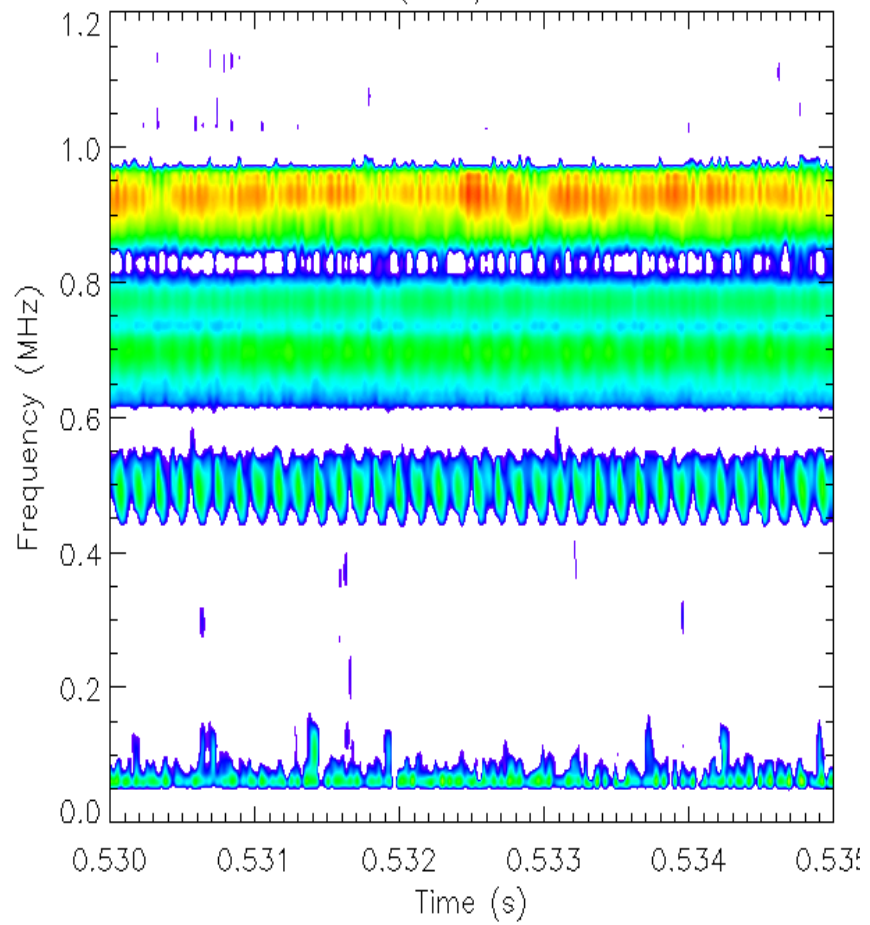
$\chi_e$  ( $\times 10\text{m}^2/\text{s}$ )



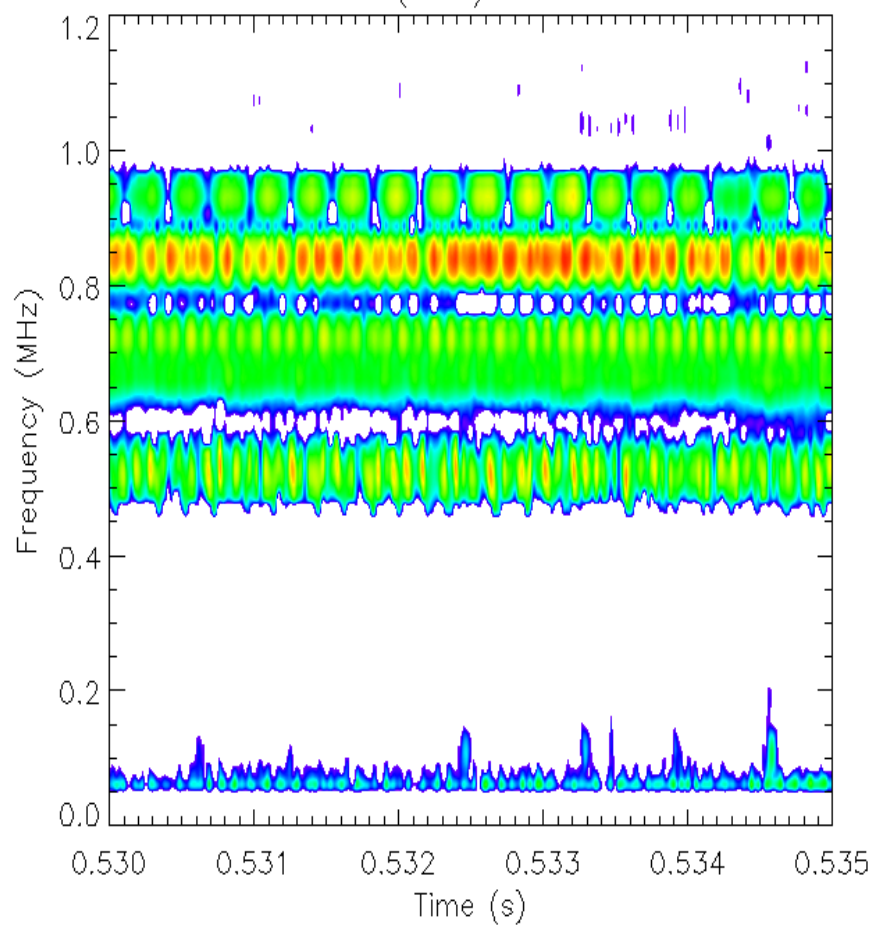
q LRDFIT



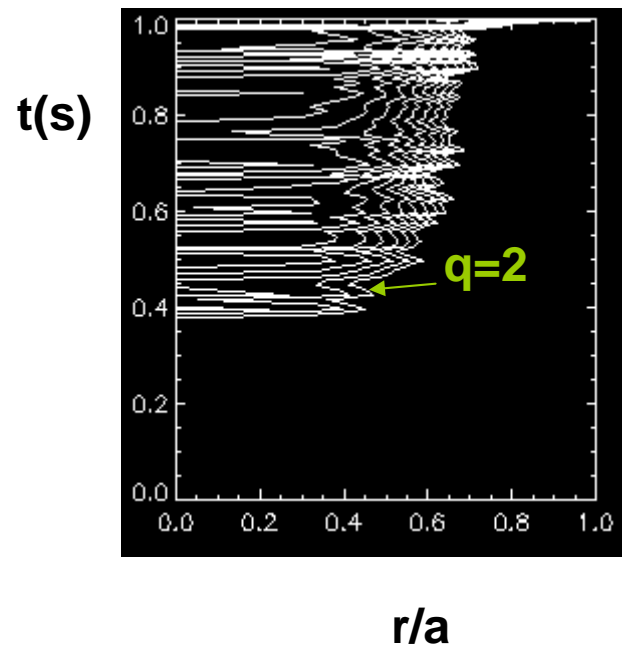
Mirnov (HF1) :: 130360



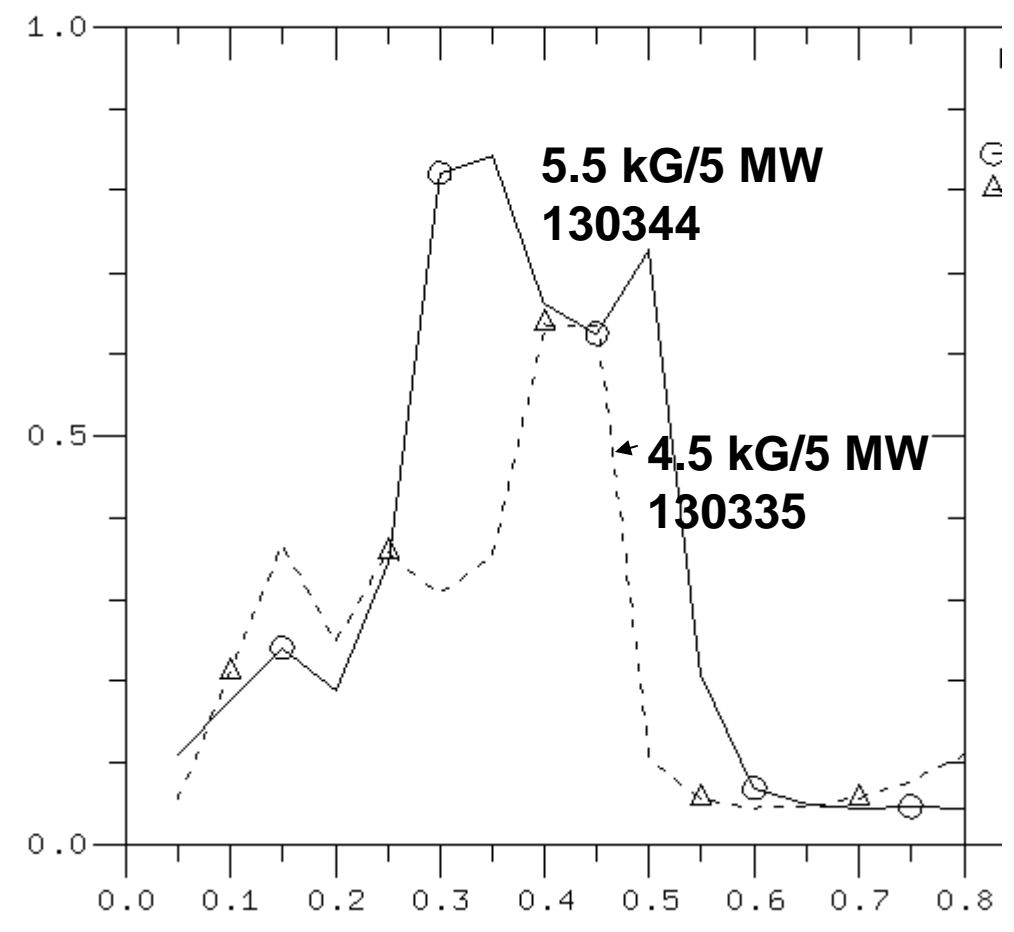
Mirnov (HF1) :: 130361



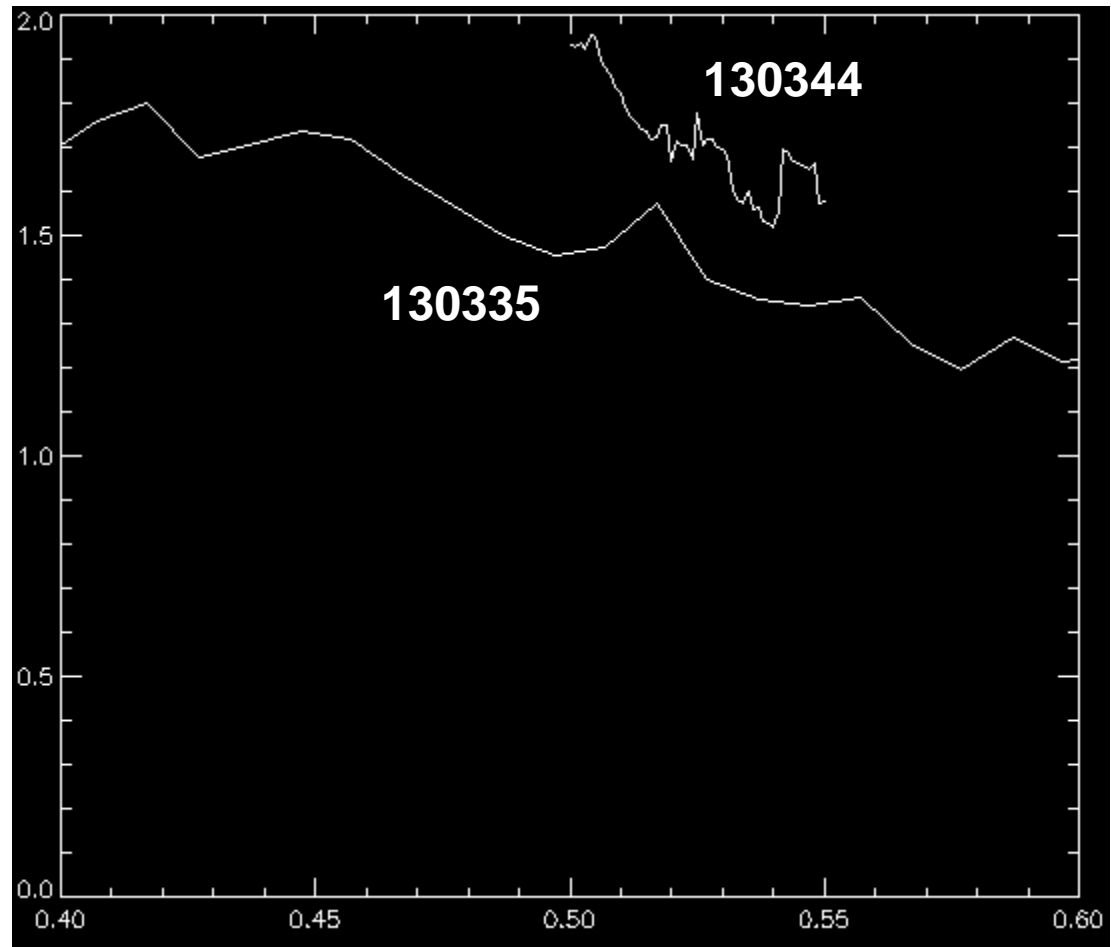
# 130335 q LRDFIT



NSTX.06 130344A01 (MDS+) page 15  
TIME = 5.4000E-01 SECONDS



$q(r/R=0.2)$



$t(s)$

