# Task ‘T13-04: Analyses of the Impact of fast ions on Te measurements’

## Kick-Off meeting 28-02-2013

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**Reference TF leader:**
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# Background: observations (TFTR)

TFTR supershot plasmas (G.Taylor et al.)

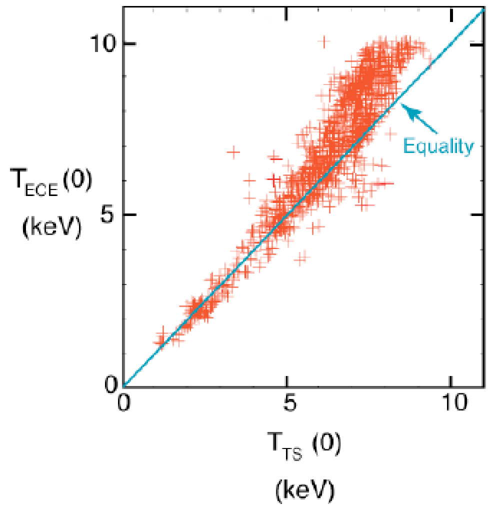
- PPPL report 958412 ( http://www.osti.gov/bridge/)
- PPCF 1989

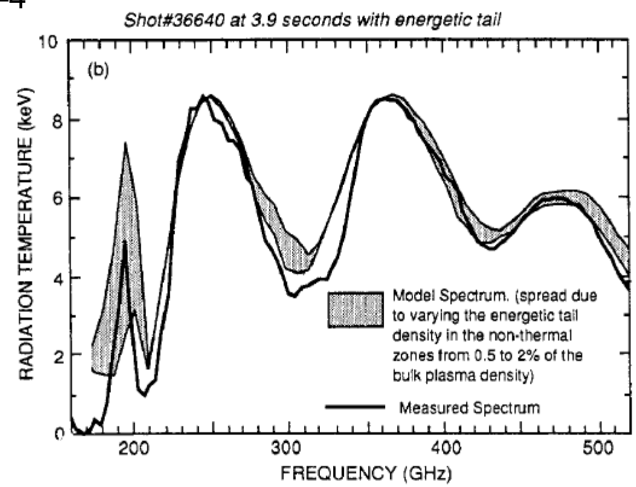
Source of down-shifted ECE within 30 cm of the magnetic axis

non-thermal ECE feature consistent with an energetic electron tail with an energy 40-80 keV, tail density of 0.5-2% of the thermal plasma density (would drive more than the total plasma current if unidirectional)

correlation of the superthermal feature intensity with the peakedness of the electron pressure profile

TFTR NBI heated plasmas 1992-4



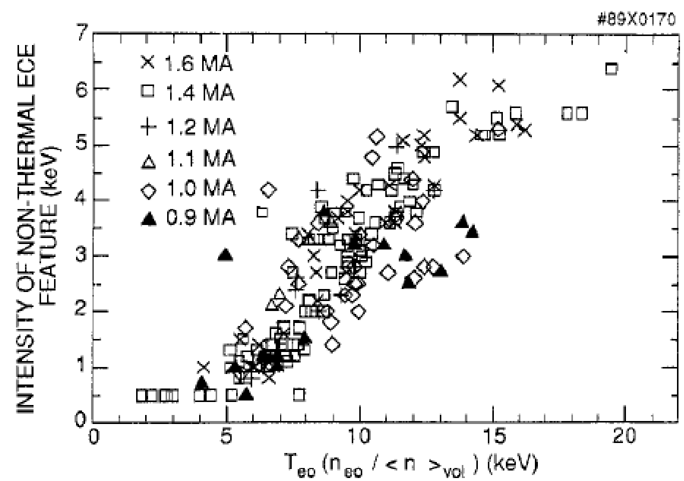




FIG. 14.—Effective radiation temperature of the non-thermal ECE feature versus ($T_{eo}n_{eo}/\langle n_e\rangle_{vol}$); the intensity of the non-thermal ECE feature increases approximately linearly with the product of central electron temperature and density profile peakedness ($n_{eo}/\langle n_e\rangle_{vol}$).

# Background: observations (FTU)

FTU low density, on axis ECRH plasmas (O Tudisco, et al. EPS 2001, EPS 1999)

Oblique ECE spectra provides a scan in the parallel energy of the electron velocity distribution

A deviation from Maxwellian is revealed for near-thermal energy electrons resulting in a 10% overestimation of the peak temperature

This non-Maxwellian contribution to the ECE is important only in the ECRH deposition region

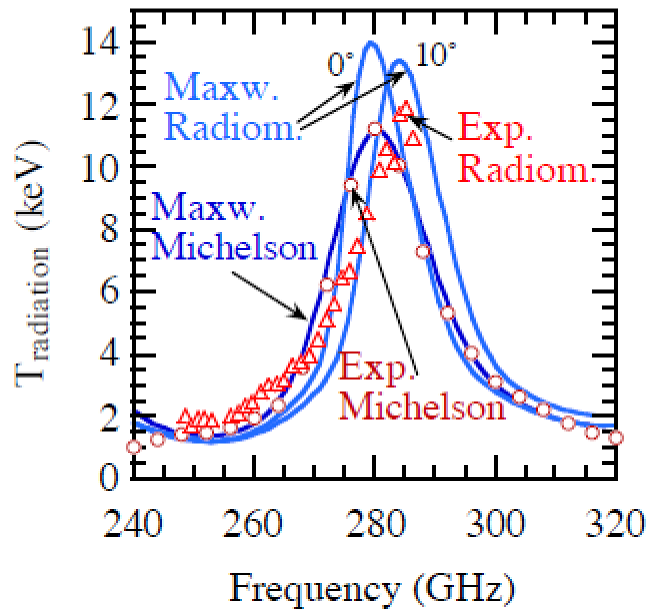
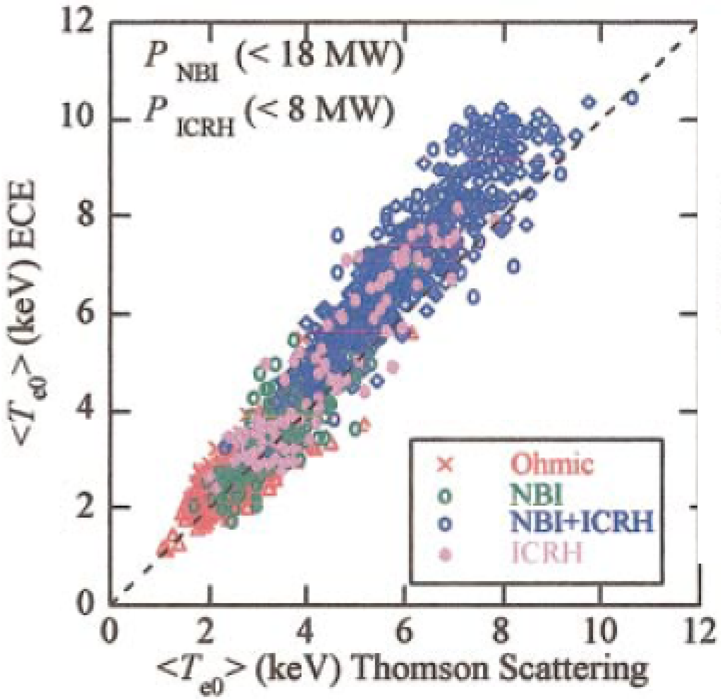


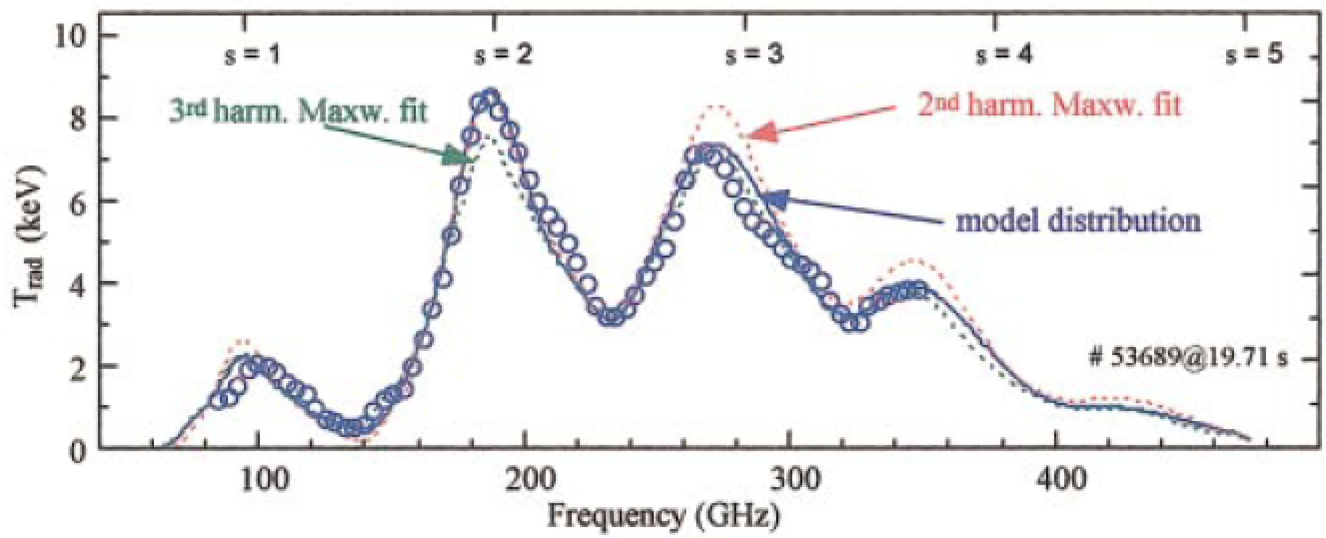

**Fig 4.** *Measured spectra at t = 0.134 s, and simulated ones for the radiometer instrumental parameters (φ = 0°, 10°), computed with the temperature profile obtained over this frequency range from the interferometer and assuming a Maxwellian distribution. Compare with the angular dependence presented in Fig. 2.*

# Background: observations (JET)

JET NBI+ICRH (E de la Luna et al. RSI 2003)




Comparison between central temperatures measured by Thomson scattering (LIDAR) and ECE (Michelson interferometer, second harmonic, X mode), for Ohmic and high-density plasmas with different heating mix, and different values of the toroidal field (2T<Bt<3.4 T).




Measured ECE spectrum shown together with three different fits computed with:

-a Maxwellian distribution function obtained by fitting the second-harmonic (red)

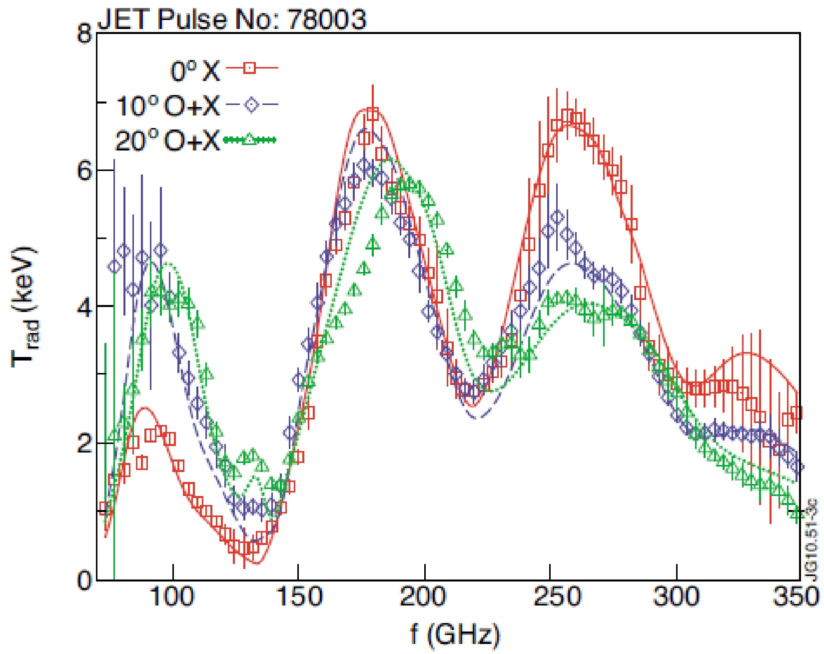
- or the one resonant at the third-harmonic (green),

- and a model distribution function inferred from a consistent fit to the complete-measured spectrum (blue).

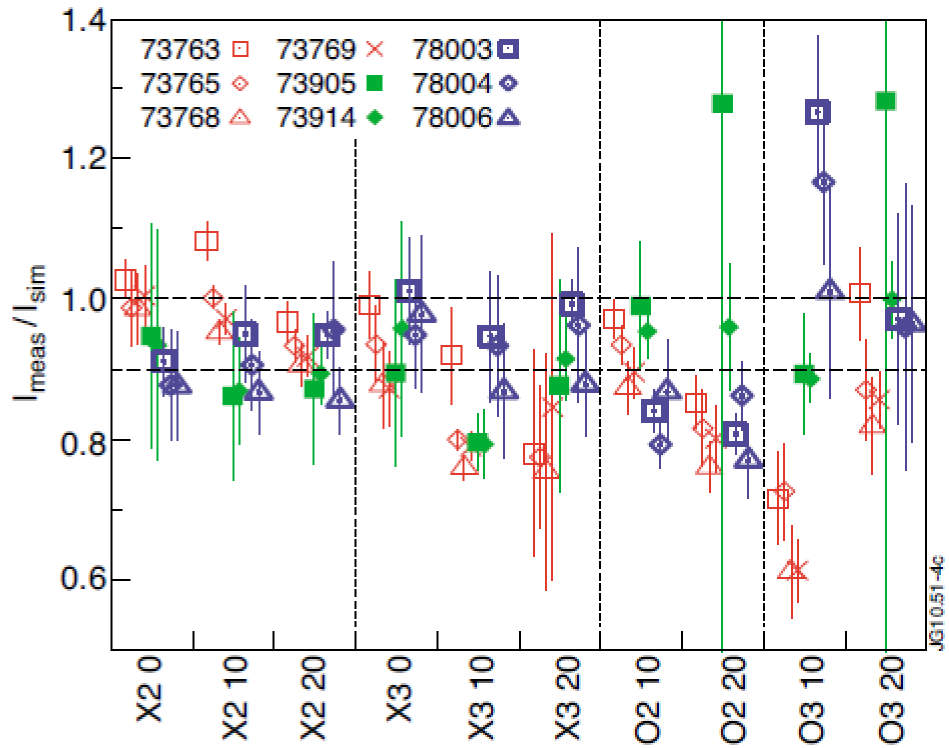
This analysis reveals that the temperature profile deduced from the second-harmonic emission is inconsistent with the one deduced from the third harmonic => the bulk of the distribution function is not well described by a Maxwellian

# Wide band, multi-angular ECE

L.Figini et al. RSI 2010




Model/measurement comparison for pulse 78003.
Oblique spectra are shown as total power O-mode+X-mode spectra.

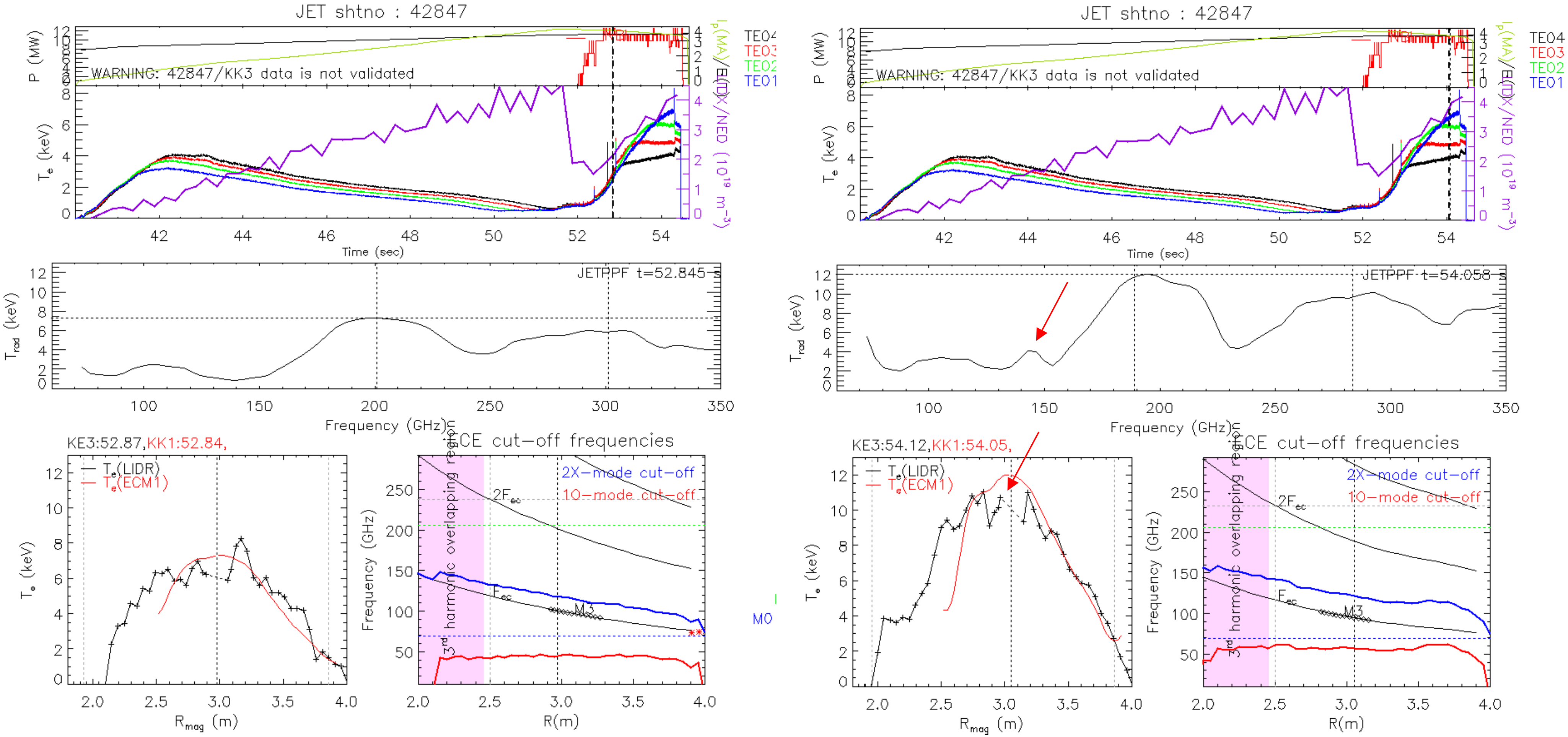



Summary of the measured to simulated intensity ratios evaluated for each pulse on the second and third harmonic peaks of the five measured spectra perpendicular X-mode, 10° and 20° O- andX-modes.

no obvious trend of measured data away from the simulated spectra. Emission at optically thick harmonics second harmonic X-mode X2 and perpendicular third harmonic X-mode is within 10% from the expected value for a Maxwellian plasma.

# Effect of alpha heating (?)

Best in 42847 (60%T), also in 42856, 42840, 42870, 42676
Small in 43011 (92%T) but also present in DD “simulations” at high Te (~ W_dia)



# Background: HRTS analysis

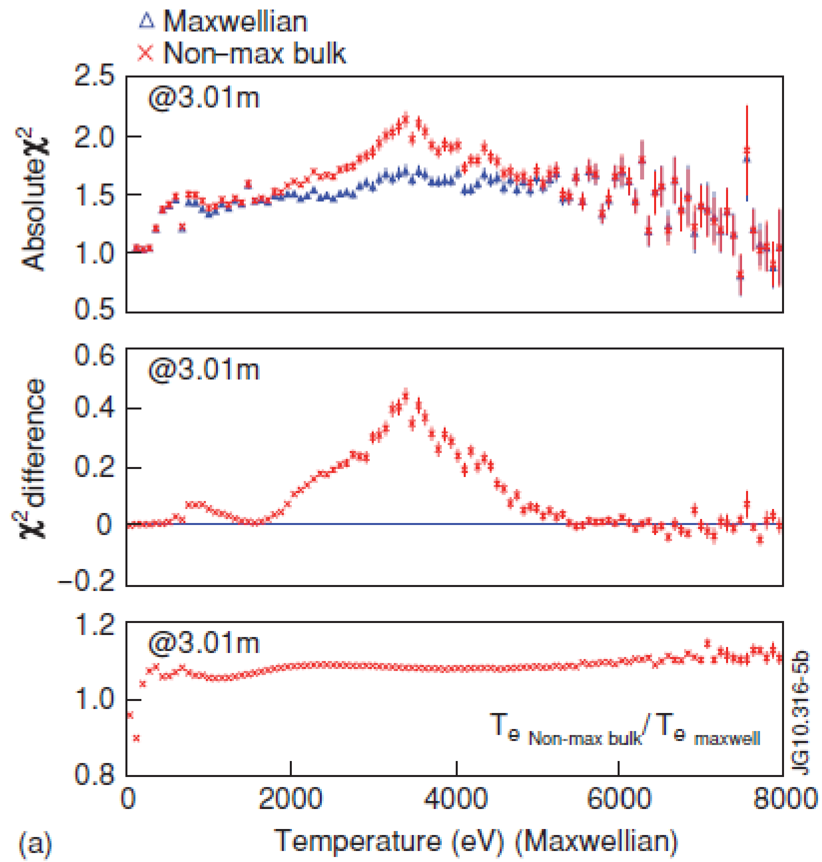
Detecting non-Maxwellian electron velocity distributions at JET by high resolution Thomson scattering (K.V.Beausang et al., RSI 2011)

Chi-square analysis assuming Maxwellian and distorted velocity distribution.

For the current HRTS spectrometer design, the distribution can only be reliably determined in the 1.5–5.5 keV region.

The electron distribution cannot be determined throughout a single discharge

a large number of laser shots from a collection of discharges are required to perform the analysis.




Experimental results showing the comparison of Maxwellian and non-Maxwellian bulk chi-squares from fitting to real HRTS data.

# Background: Alcator C-mode

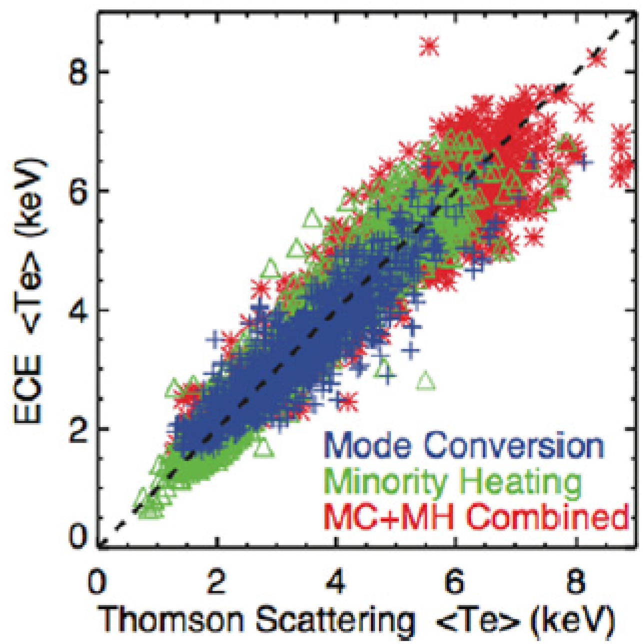
A. White et al., NF 2012: on ECE-TS discrepancy

2 ICRF heating configurations used alternatively or combined:

hydrogen minority ICRH (fast ions transfer energy to plasma via electron drag and collisions with thermal ions)

mode conversion heating (direct electron Landau damping of the mode converted fast wave).

No discrepancy detected!




Central temperature measured with ECE compared with TS. All pairs of ECE and TS data from within the radial range 0.68m< Rmaj < 0.72m are plotted. The paired measurements are made within 1ms of each other, and are separated in radius by less than 1 cm.

# Summary of observations (and ?)

-Effect seen at HIGH Te (>8 keV). More controversial at 6<Te<8 keV

-In presence of fast ions, probably two (possibly combined) effects: downshifted emission (TFTR and JET-DT) and (?) near thermal deviation

-Under strong and direct e heating (ECRH) only near thermal deviation

- Is there a threshold in Te (depending on what?)

- Is there a threshold in Ti, and or ion kinetic

# Objectives for this task (C31-32)

- Review of the status of the tools to investigate the discrepancy
- Construction of a database (much work already done in the past)
  - extensive (as many as possible timeslices) => statistical approach
  - analytical (choice of representative cases to be deeply investigated, including DT plasmas)
- Any opportunity of new data in 2013 ?
  - List of (possibly) related experiments, probe if exp settings can be adapted
- Definition (as much as possible) of the conditions in which discrepancy/deviation might be expected and detected (again, perspective is the DT campaign)
- In case suggest diagnostic “adaptation” (much work done in the past yet)
- What else...?

# Diagnostics techniques / competencies

- Comparison of Te among different diagnostics (ECE, LIDAR/HRTS)
- Simulation of ECE spectra and comparison with
  - 2nd and 3rd ECE harmonics
  - ECE spectra multiple emission angles
- Spectral analysis of HRTS data
- Other diagnostics for Te...?

- ECE(diag. and sim)
- TS/LIDAR
- Diagnostics of fast ions
- Theory. Which mechanism?
- ...Others needed? (ICRH theory?)

# Milestones

| Milestone | # | What | When | Who |
|---|---|---|---|---|
| TF meeting | 1 | presentation | 12/3/13 | |
| tools | 2 | Review of status of diagnostics and analysis tools | 01/04/13 | |
| database | 3 | Definition of the format (which parameters) | 12/3/13 | |
| new exps | 4 | List of interesting ones and exploration of common objectives | 12/3/13 | |
| database | 5 | Build-up (...cont in C31-32) | 01/06/13 | |
| database | 6 | Analysis (...cont in C31-32) | 01/07/13 | |
| summary | 7 | Evaluation of the impact on Te in DT plasmas | 01/03/13 | |
| proposal | 8 | Diagnostics and or analysis techniques: modifications, upgrade... | 01/03/14 | |
| ….. | 9 | …... | | |

# Database

# Related experiments in C31-32