FTU e- fishbones: 2010 proposal

(Post deadline IAEA'10 contribution?)

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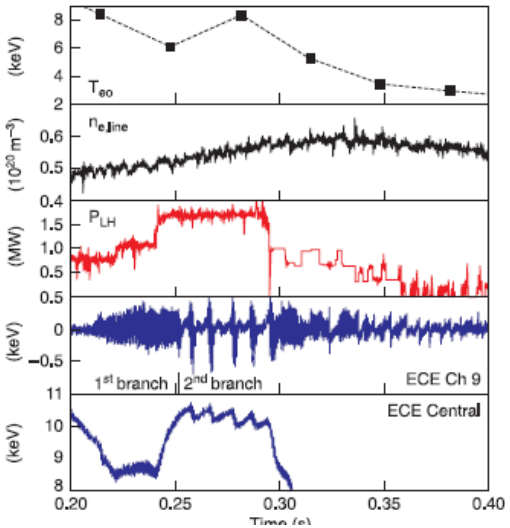
Introduction

- The processes underlying the excitation of fishbone-like internal kink instabilities driven by supra-thermal electrons is analogous to that connected with fast ion induced fishbone.
- Meanwhile, fast electron perpendicular transport due to fishbone-like fluctuations is similar to that of fusion alphas, since both species have small characteristic orbit size compared with the device size; thus, electron-fishbone is an important issue for burning plasma research.
- **FTU results have provided the first evidence of strongly nonlinear behaviours in connection with electron fishbone excitations by LH only and show clear evidence of fast electron redistributions** [Zonca - NF'07].

First FTU results [Zonca et al. NF'07]



#20865 (5.4T, 0.5MA)

FTU experimental results suggest that:

the **level of LH power** input controls the transition from **nearly steady state non linear oscillations (fixed point)** $\Rightarrow$ **to bursting electron fishbone oscillations (limit cycle)**

and that, in the bursting regime, the fishbone is an energetic particle mode well above marginal stability and associated with significant fast electron redistributions, analogous to the fast ion losses that are expected when ion fishbones are excited.

FTU experiments in 2007 [R. Cesario et al. NF'09]

FTU experiments in 2007 were aimed at studying fishbone-like modes with slightly reversed q-profile approaching the condition $q_{min} \approx 1$ and a marginally over-critical population of fast electrons produced by LH.

The results demonstrated the existence of a threshold in power for the observed activity, located between 0.3 and 0.5MW, while FEB data show that the LH-driven fast electron population is affected by electron fishbones, when the *q*-profile meets the condition $q_{min} \approx 1$.

Latest experiment in 2009

Rationale:

- FTU experiments in 2009 were aimed at fully assessing the electron fishbone phenomenology by higher LH power input and different LH power waveforms, necessary for destabilizing modes at $q_{min} \geq 2$.

- High effective supra-thermal electron tail temperatures will produced in FTU via ECRH-LH synergy, yielding high pressure gradients for effective excitation of electron-fishbone in the high frequency range.

Experimental difficulties and results

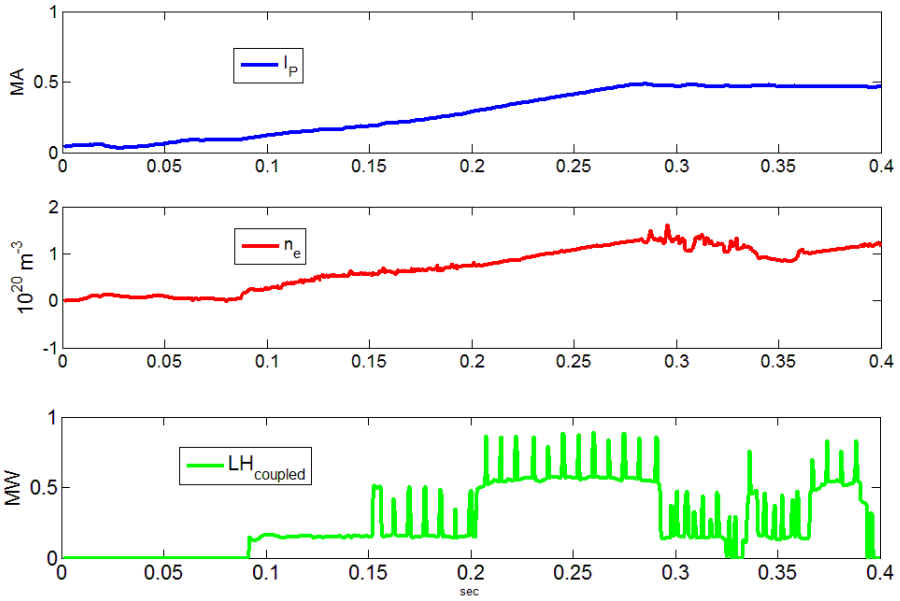
The occurrence of electron-fishbone in FTU is connected with the timing of LH power injection start during the current ramp phase:

⇒ **It has already been possible to couple the available LH power** in the range of 0.3-0.6MW during the plasma current ramp-up, by adopting a change in the FTU switching circuit and utilizing the new favourable operation conditions provided by the lithizated vessel facility.

⇒ ½ session in November 2009, LH power available up to 0.6MW (non enough for LH – ECRH synergy)

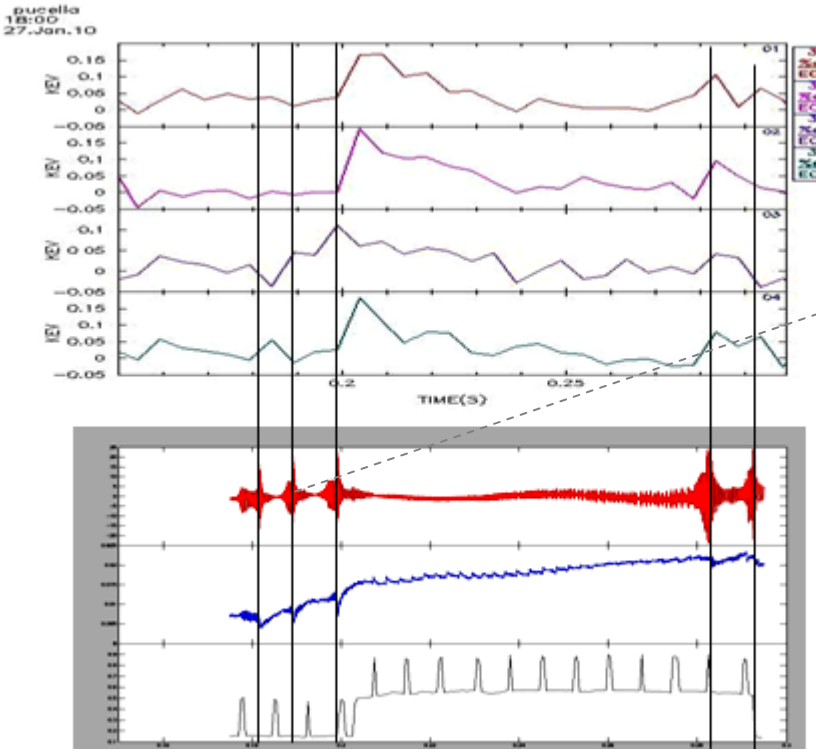
Two “good” shots for the program

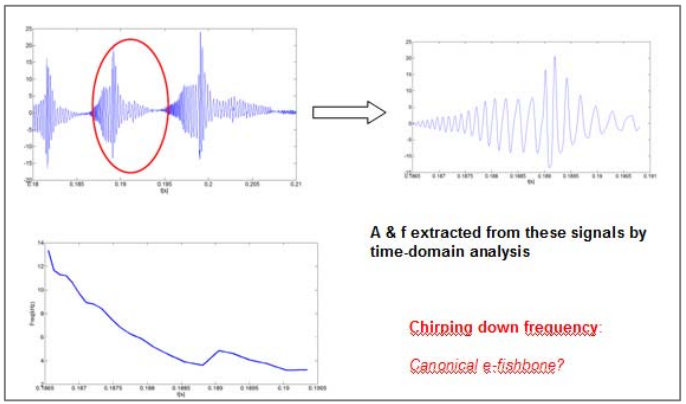
- **Experiment** (reference shot **33287**):
  - Ip=0.5MA, Bt=7.2T,
  - LH injection starts during the current ramp phase (at t=0.11sec) in two steps: ~0.3 MW from 0.11-0.2sec than ~ 0.6MW)



- **Diagnostics:**
  - FEB available
  - ECE (fast) available
  - Equilibrium available
  - SXT not available

Experimental difficulties and results





- Canonical behaviour of fishbones (chirping down in the frequency) but…
- …no clear evidence of supra-thermal emission!

Oscillations due to a change in the current profile? Look at FTU database still in progress

Commenti dopo il de-briefing

• La situazione è resa difficile dalla presenza di fenomeni fishbone-like legati a modi current driven.

• Gli elettroni dovrebbero eccitare modi con n>>1 e questi sì che sarebbero distinguibili dai fenomeni current-driven, che sono quasi esclusivamente a n=1.

• L'idea è di provare ad aumentare la potenza per fare code che permettano di assorbire anche ECH, ma per andare oltre la parte tecnica occorre capire il range giusto di numeri toroidali e quindi di frequenza, e quale sia la diagnostica che può vederli (grandi n non arrivano ai coils con ampiezze significative e ci vuole il riflettometro, o i raggi x se sono abbastanza sensibili).

Proposal in 2010

High effective supra-thermal electron tail temperatures will be produced in next FTU experimental campaigns via ECRH-LH synergy, yielding high pressure gradients for effective excitation of electron-fishbone in the high frequency range.

Next experiments will be aimed at increasing the LH power (**above 0.8MW**), in order to have an effective LH – ECRH synergy

- firstly try during the ramp-up if too complicated (1 exp. day)
- back to steady state condition (1 exp. day)