# Diagnostiche di FTU nelle Overview dal 2005 al 2022

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| Anno | Capitolo |
|---|---|
| 2005 | |
| 2007 | CTS diagnostic studies |
| 2009 | Minor upgrades and future plans |
| 2011 | |
| 2013 | Development of refractometry for density profiles |
| 2015 | Diagnostics:<br>Cherenkov probe<br>Gamma camera<br>Laser induced break down spectroscopy |
| 2017 | Diagnostics:<br>RE imaging and spectrometry<br>Fast infrared camera<br>Triple GEM detector<br>Collective Thomson Scattering<br>Cherenkov probe |

| Anno | Capitolo |
| --- | --- |
| 2019 | Diagnostics:<br>Runaway electron imaging spectroscopy (REIS)<br>Cherenkov probe<br>Laser induced break down spectroscopy (LIBS) |
| 2022 | ✓ Measurements of plasma waves emitted by runaway electrons<br><br>✓ Diagnostics:<br>Laser induced break down spectroscopy (LIBS)<br>Runaway electron imaging spectroscopy (REIS)<br>High resolution saddle coil array<br>Diamond detectors for fast VUV and SX diagnostics |

# Considerazioni varie

- ✓ **Nelle prime Overview ( dal 2005 al 2013)** solo due capitoli vengono dedicati alle nuove diagnostiche : CTS e rifrattometria.

- ✓ **Nelle ultime quattro Overview ( dal 2015**) si trovano dei capitoli dedicati alle diagnostiche, con delle sottosezioni.

  - Alcune delle nuove diagnostiche sono presenti su diverse Overview, indice di ulteriori sviluppi e sicuramente di riscontro positivo.
  - La chiusura di FTU ha interrotto la sperimentazione di alcune diagnostiche (es. diamanti )

# Sommario diagnostiche con capitoli dedicati

- CTS
- Refractometry
- **Cherenkov probe**
- Gamma camera
- **Laser induced break down spectroscopy (LIBS)**
- **RE imaging and spectrometry (REIS)**
- Fast infrared camera
- Triple GEM detector
- Diamond detectors for fast VUV and SX diagnostics

- High resolution saddle coil array
- Measurements of plasma waves emitted by runaway electrons

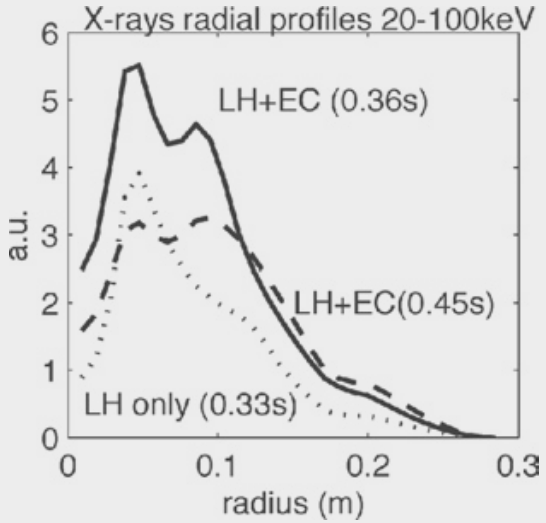
# Overview 2005

Diagnostiche menzionate

- ✓ Nuove
  - Fast Electron Bremsstrahlung FEB
  - Multi-channel interferometer ($CO_2$)
- ✓ Non recenti
  - Reflectometer
- ✓ Da installare
  - Active Beam Diagnostic through Motional Stark Effect

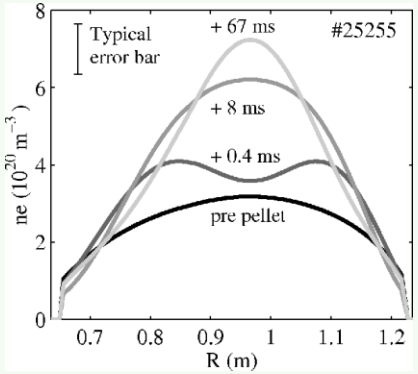
**FEB**

Detection of the Hard X-Ray emission by the fast electron (by LH)
20-200keV
Two cameras (H and V)



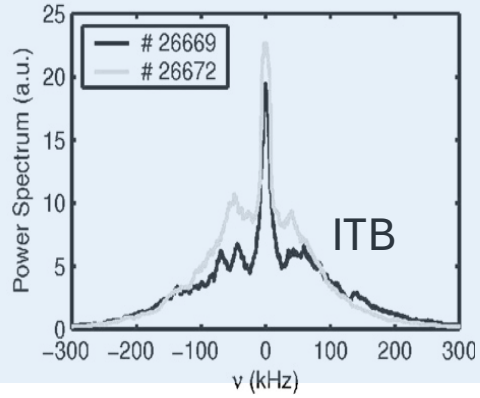

**$CO_2$**

Scanning beam technique on 30 chords
Density Profile @ 50 μ s




**Reflectometer**

Turbolence spectra



# Overview 2007

CTS Test

ITER relevant for fast ion dynamics

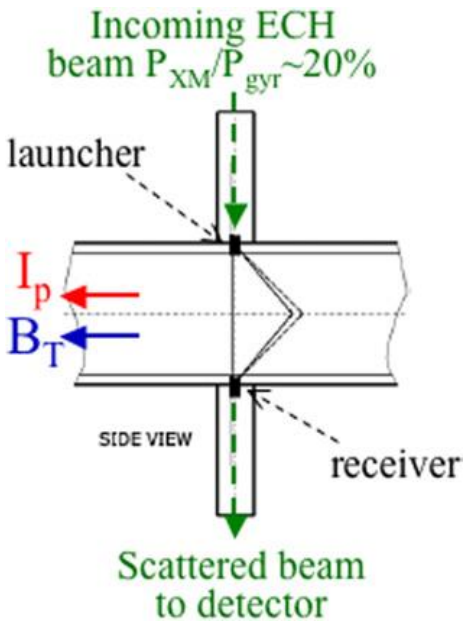
$f_{gyr} < f_{EC}$

X mode

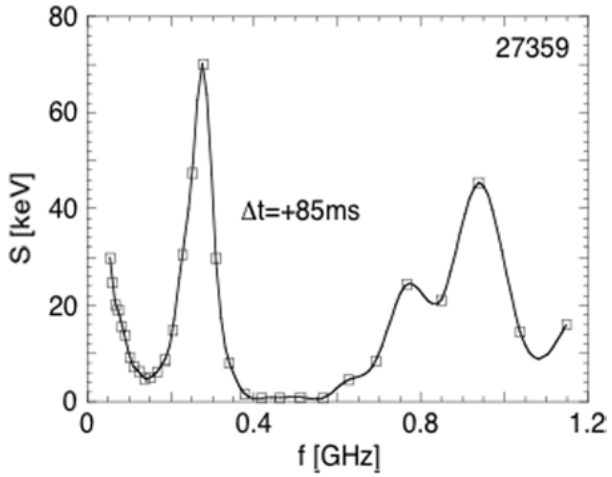
f = 140 GHz

$196 < f_{EC} < 224$ GHz

@ $7 < B_T < 8$ T




Anomalous spectra : non thermal spectra




- Energy much higher than predicted
- Spectra detected also in absence of plasma
- Spurious signal due to the multiple reflessions

Fraction of X mode reflected at the cutoff layer

# Overview 2009

Commissioning on FTU:
- oblique ECE
- refractometer
- MSE

Langmuir probes and TS for dust analysis

FEB signal for the detection fishbones

## Oblique ECE

- possible distortions of the Maxwellian
- supra-thermal electron tail during LHCD o ECRH @ low density

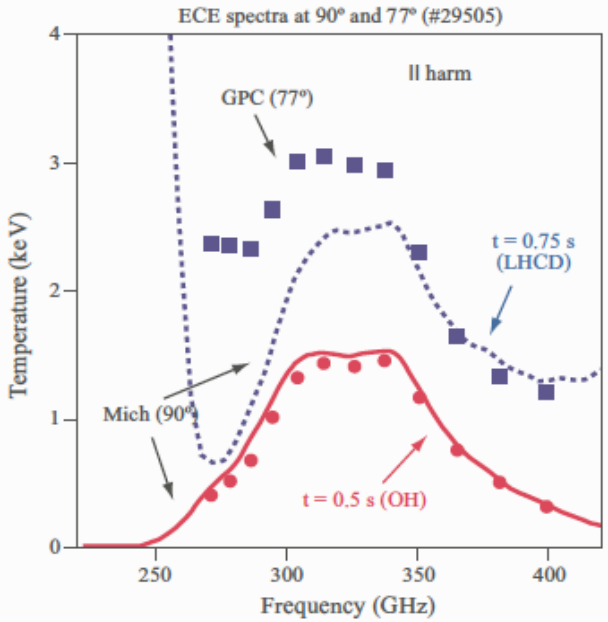



**Figure 12.** ECE emission at 90° (continuous and dotted lines) and 77° (dots and boxes) in OH (continuous line and dots) and LHCD (dotted line and boxes) phase.

## Refractometer

- Good results compared to $CO_2$ interferometers
- Good candidate for density feedback on ITER

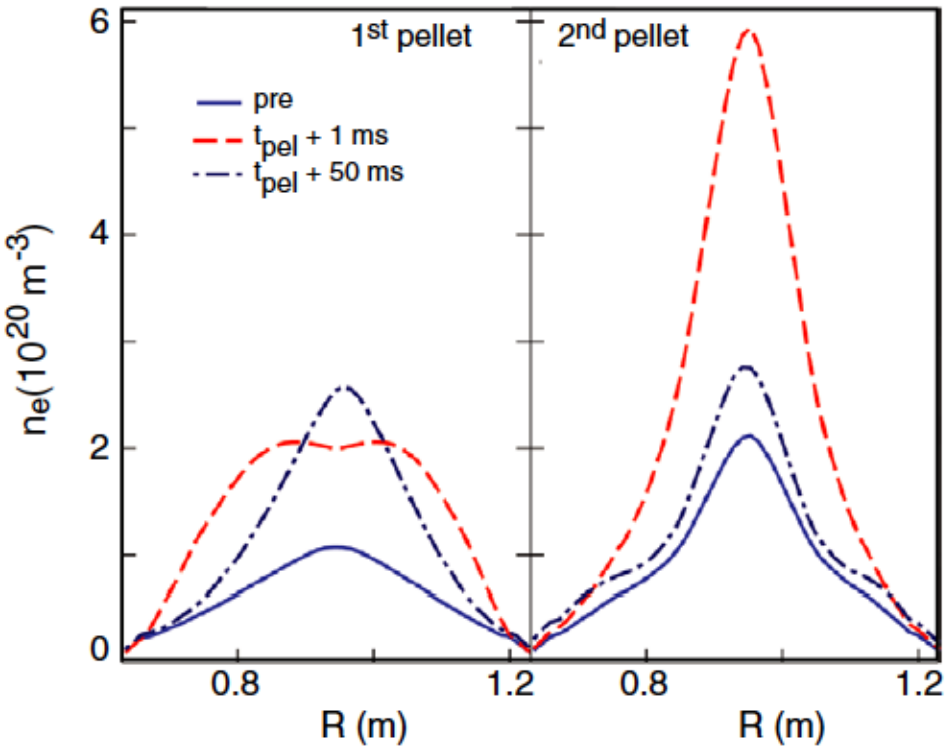
# Overview 2011

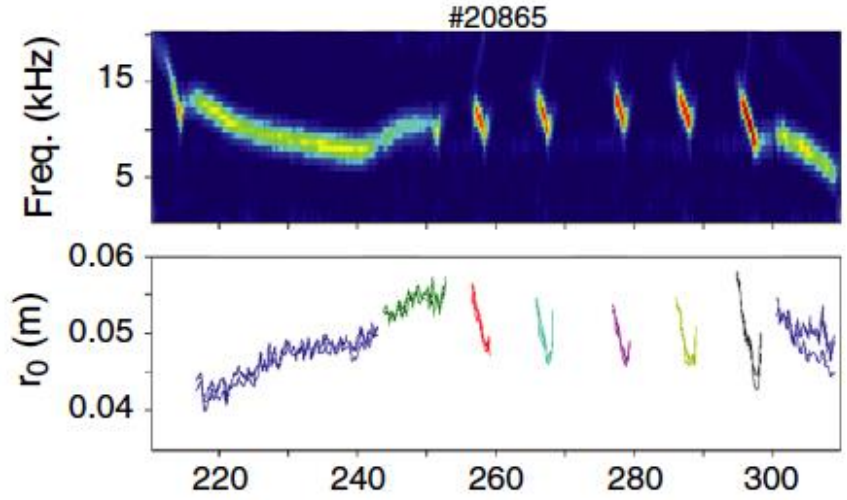
## Inversion of CO2 signals for density profiles

CO2 scanning interferometer is a very powerful tool for studying fast evolution of density profiles and very strong gradients

Density profiles:

- Temporal resolution 62.5μs
- Spatial resolution of 1 cm
- Line integrated density resolution $\Delta ne/ne \approx 2\%$




## A new ECE analysis technique

for studying the mode localization for electron fishbone modes

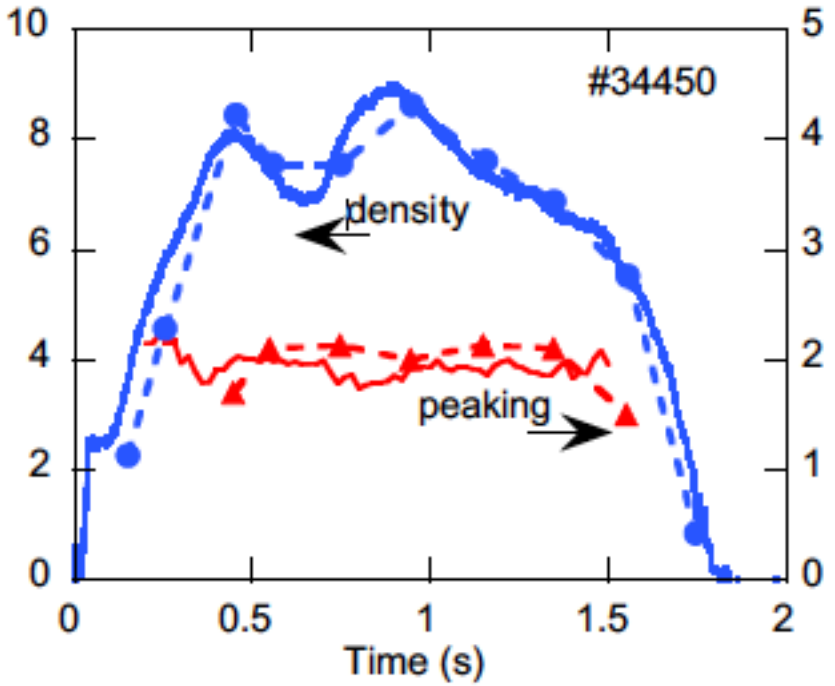
# Overview 2013

## Development of refractometry for density profiles

- A dual-frequency pulsed refractometer at 51.5 GHz and 60.5 GHz
- Transparency window at frequencies of 50–100 GHz
- the time delay is a functional of the density profile that reduces to a simple line average at frequencies well above the cut-off

- The chord-averaged plasma refraction index was measured in a double-pass scheme with a reflection at the inner wall by launching from the low-field side waves

Russian collaboration




**Comparison between interferometer** (solid lines) and from **refractometer** (dashed lines with markers).

# Next step

**Diagnostics in the Overview 2015 until 2022**

**Proposta di scrittura**

- ✓ Paper riassuntivo di circa 5/6 pagine
- ✓ Report ENEA
- ✓ Autori : G. Apruzzese, F. Orsitto e …

Cercasi volontari per la scrittura del paper sulle diagnostiche

# Thank you for the attention and ...