Stato dello sviluppo diagnostiche THz, Enabling Research, Collaborazione con Clarendon Laboratory

WIP 17 Febbraio 2017

Cronistoria & Contesto

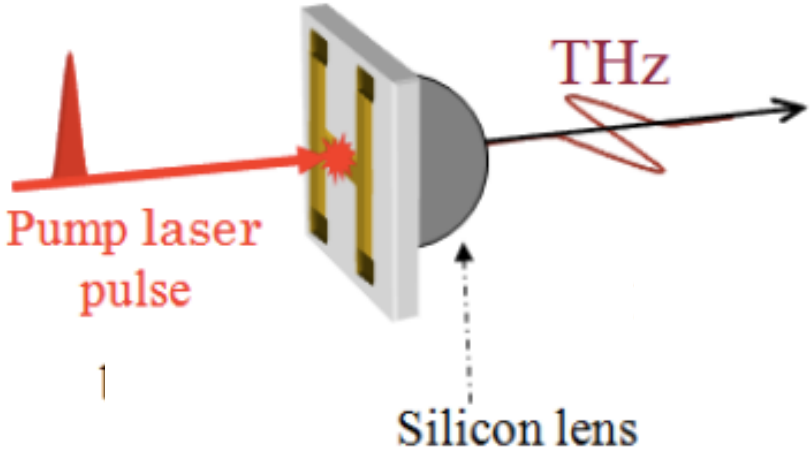
- **Storica tradizione** ECE/mm Frascati (Ascoli, Pieroni, e poi Paolo, Onofrio e gli altri)
- **Milestones:** *FT Michelson, FTU M1, Poly, Heterodyne, AM Reflectometer, JET KK1*
- **Anni 90':** abbandono sviluppo diagnostiche e laboratorio. Perso il treno ITER: ECE all'India!
- **THz-Fusion** project Royal Society (2006/2007)
- Frascati entra nel progetto (MOU 2009)
- UTAPRAD entra nel progetto (2010)
- ER 2014: il THz torna a Frascati

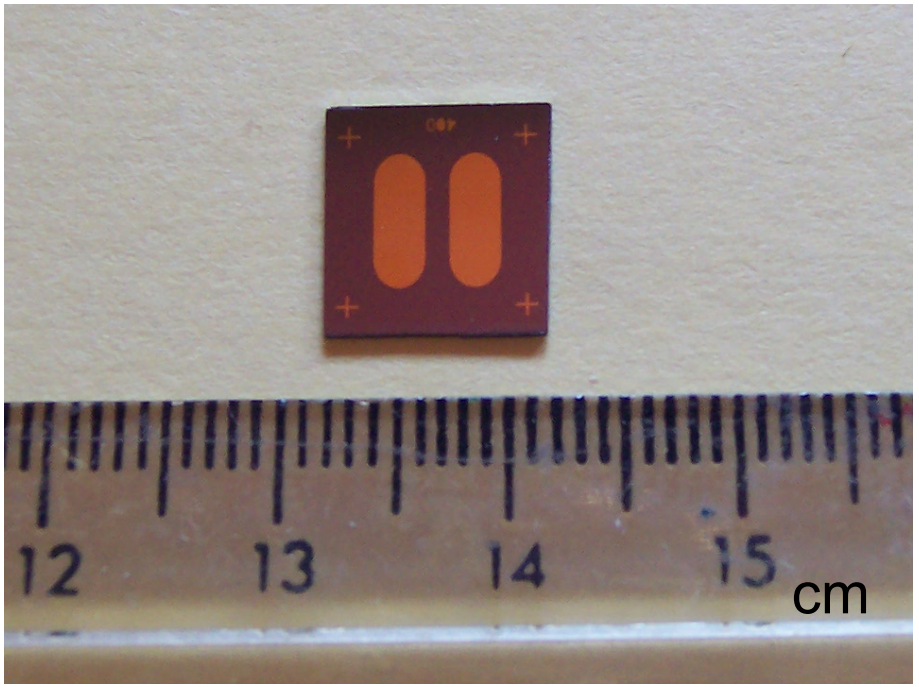
Progressi

- Realizzazione di un Laboratorio “gemello”con Oxford Clarendon, nel framework Enabling Research.
- Fusione con i colleghi ex-UTAPRAD, grande sinergia di competenze e strumentazione.
- Acquisizione di know how per la realizzazione delle diagnostiche e sistemi THz-TDS in generale
- Apertura verso altre applicazioni della metodologia THz-TDS (Materiali, Bio, Arte).

THz for TDS

- Broadband THz pulses generated by photoexcitation of semiconductor targets (GaAs) with 790 nm, fs pulsed laser : spark current.

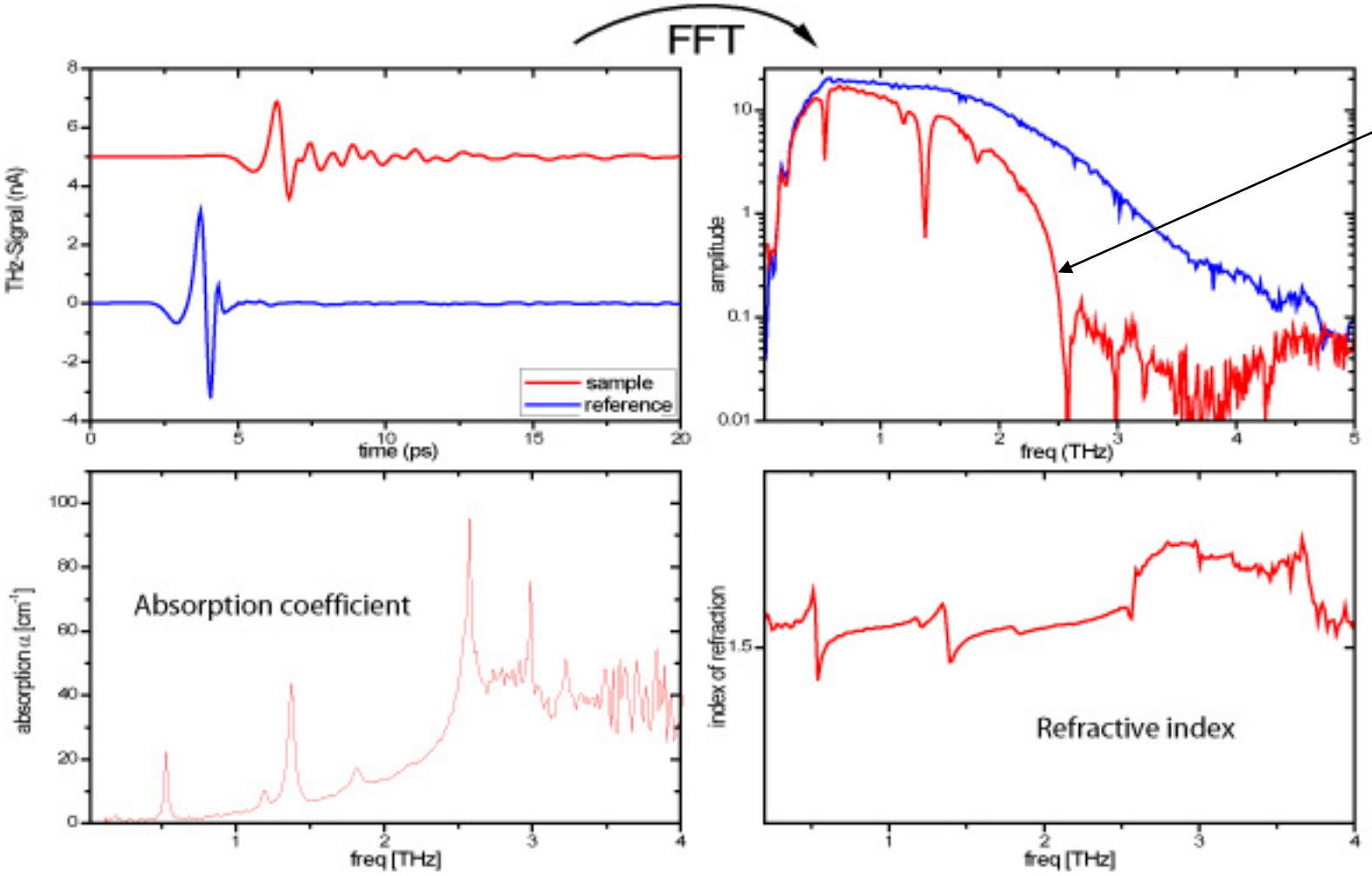




- Frequency range: 200 GHz – 8 THz, spectroscopically covering a range of physical systems, including Tokamak Plasma (lower part of the spectrum).

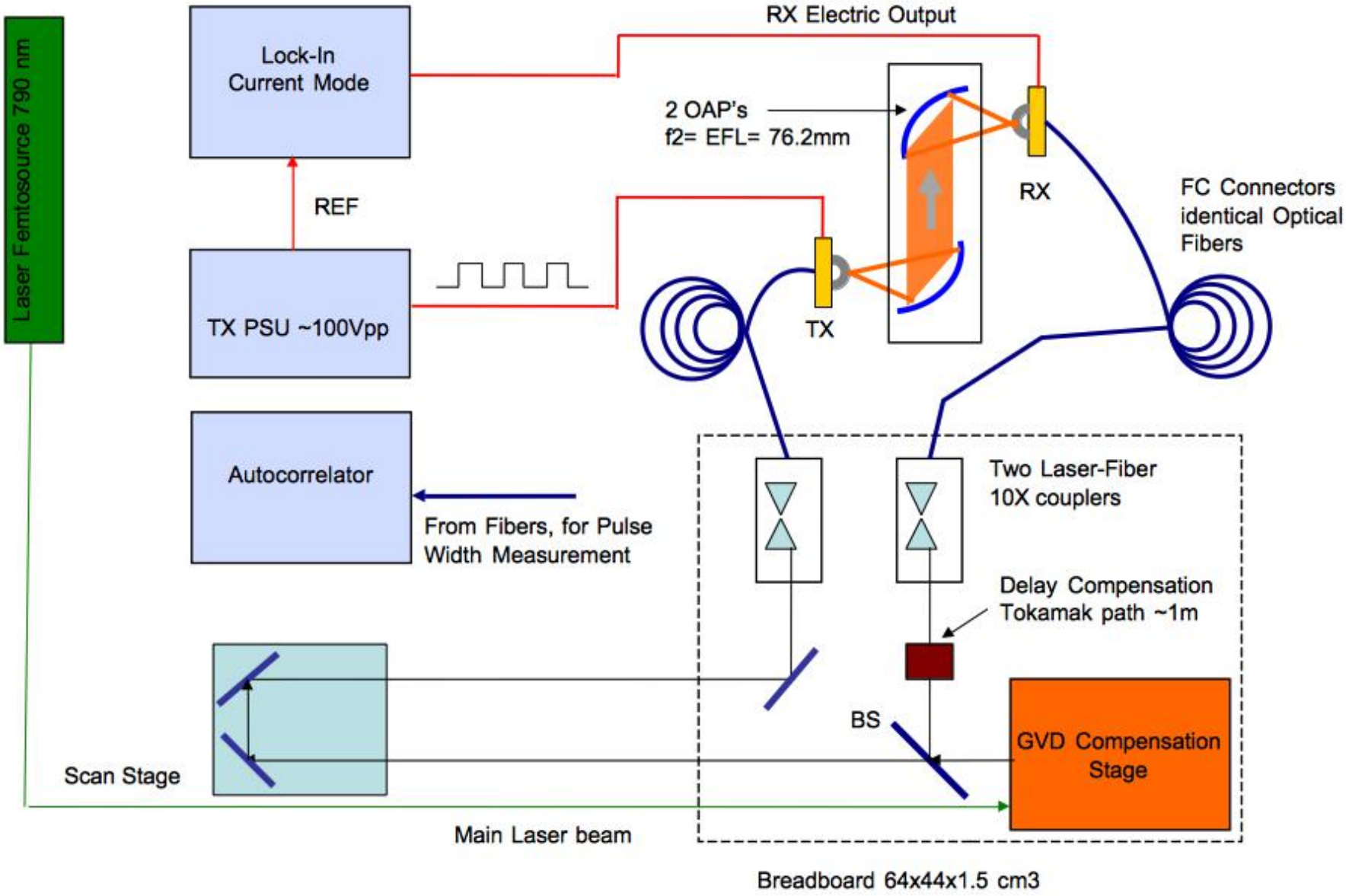
THz TDS

Unique ability to detect the electric field of the THz pulse to yield ***full phase and amplitude information***, an advantage over typical detectors that measure only intensity.



RED: spectrum of a typical dispersive crystal sample.

Full Setup single GVD compressor



Numbers

Ti:Sapphire fs laser (pump laser: diode-pumped Nd:YVO, 4 W beam @ 532 nm)

- **wavelength**: 790 nm
- **duration**: 10 fs
- **Power during pulse**: 700 KW

THz pulse:

Bandwidth: 0.2 – 4 THz

duration: 5 ps (laser pulse 1/100 ps is a delta)

Power: average power 500 mW (conversion efficiency ≈ 0.1%)

The Emitter radiates as a dipole antenna, emitting radiation in a cone

Diagnostics Applications

- Interferometry, in transmission
- Reflectometry
- Measurement of Current Profile with Faraday Rotation @6THz
- ECA/ECE (synchronising the emission with the Laser pulse)

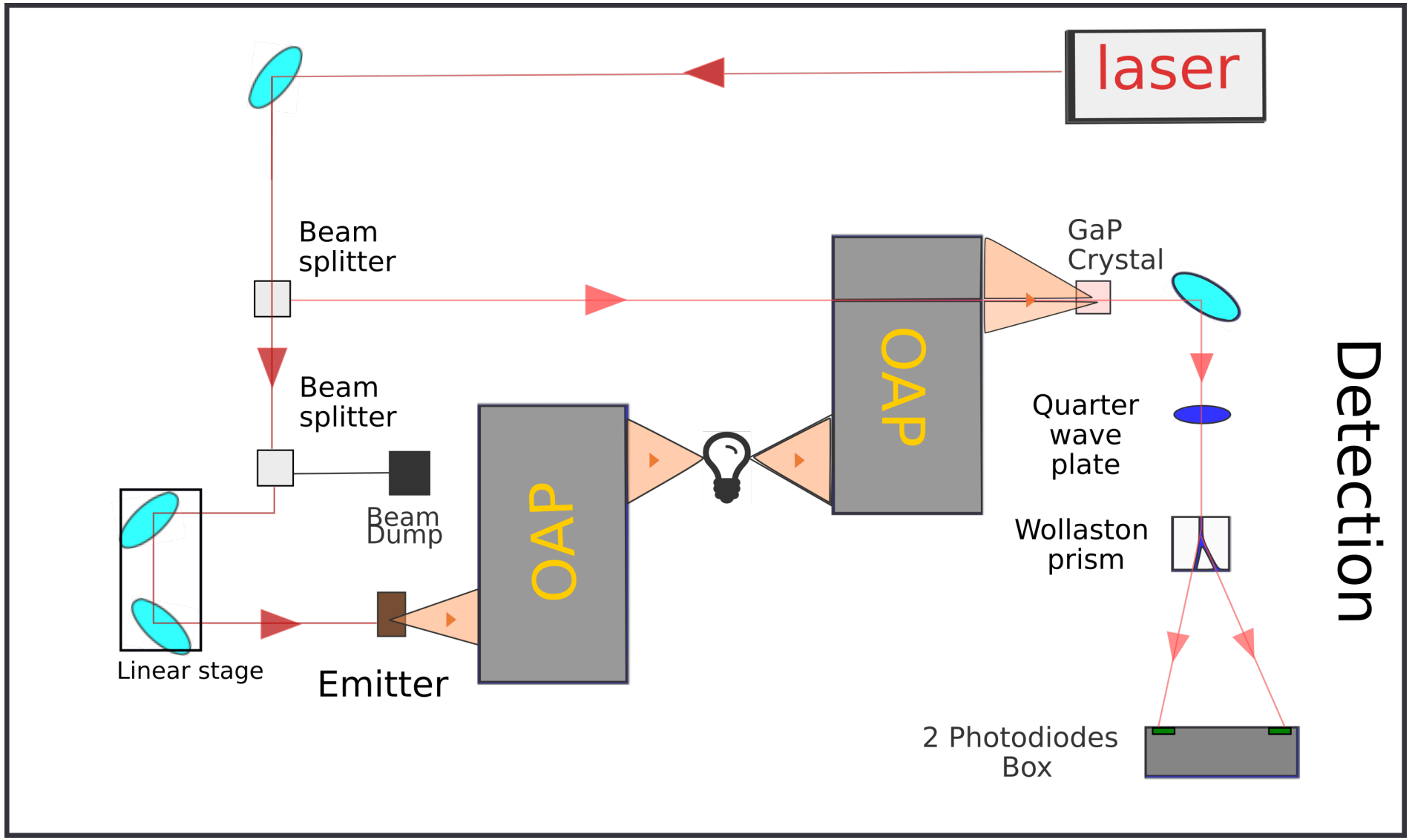
In order to use TDS-THz for plasma diagnostics a number of scientific and technical challenges will be faced: this project is aimed to do it. A few examples:

The geometry of the system will have to be adapted to a Tokamak environment: an optical fiber coupled system is under development for this purpose.

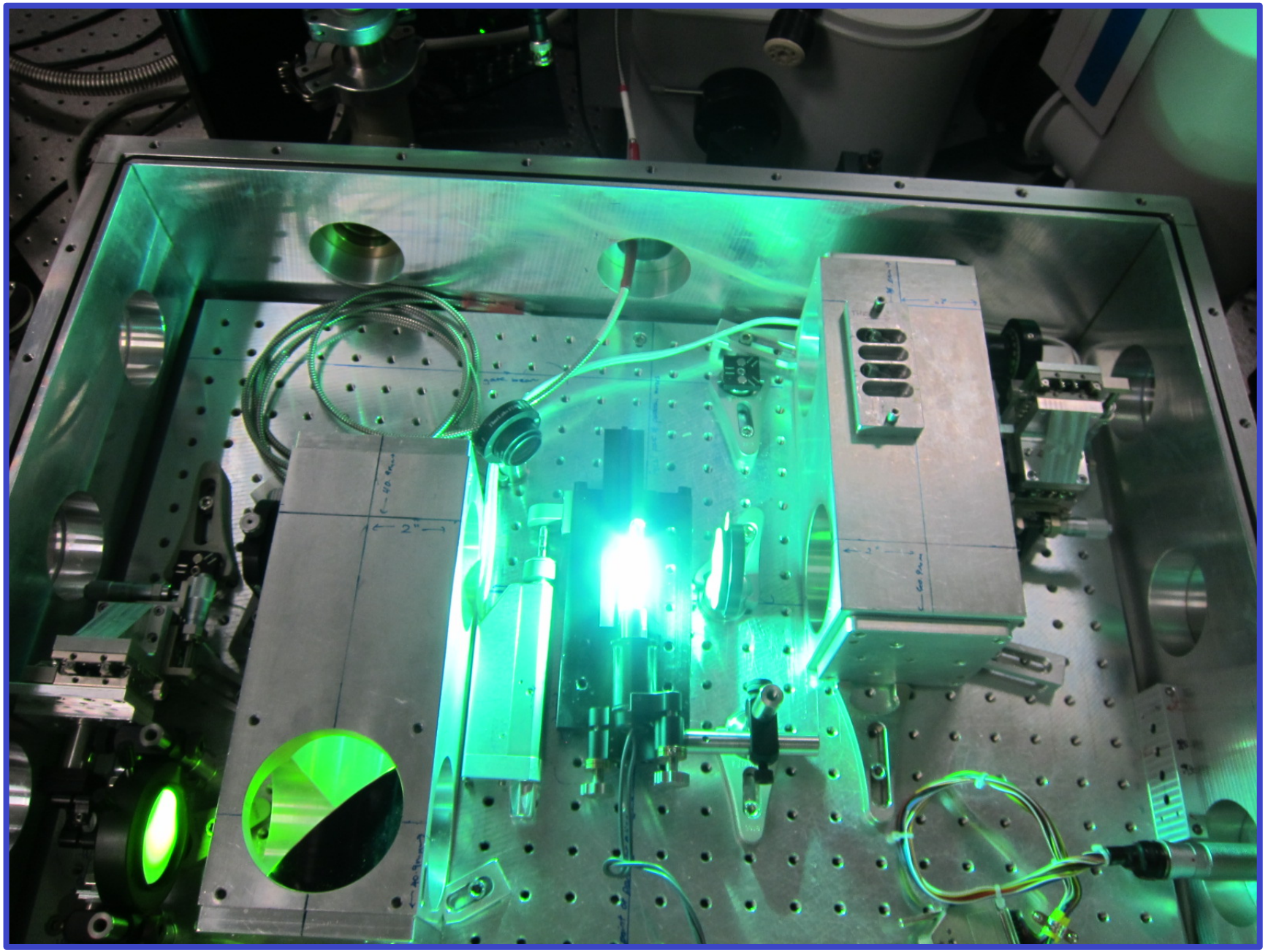
Will the plasma conditions provide enough signal & sensitivity in the required frequency range?

Will it be possible to focus and shape the beams to achieve competitive spatial resolution for each specific measurement, maintaining the alignment under the mechanical stress induced by Tokamak pulse ?

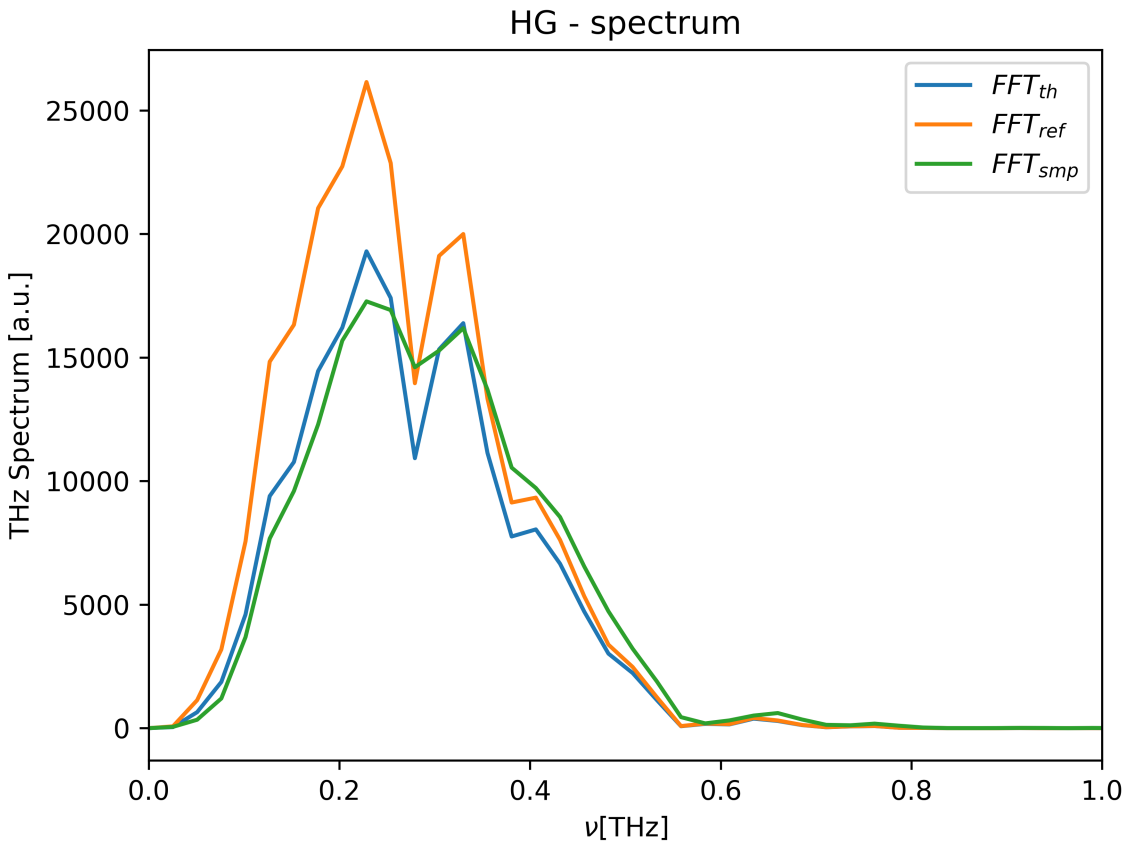
Tabletop plasma measurememements



Tabletop plasma measurememements



Hg lamp HPK-125



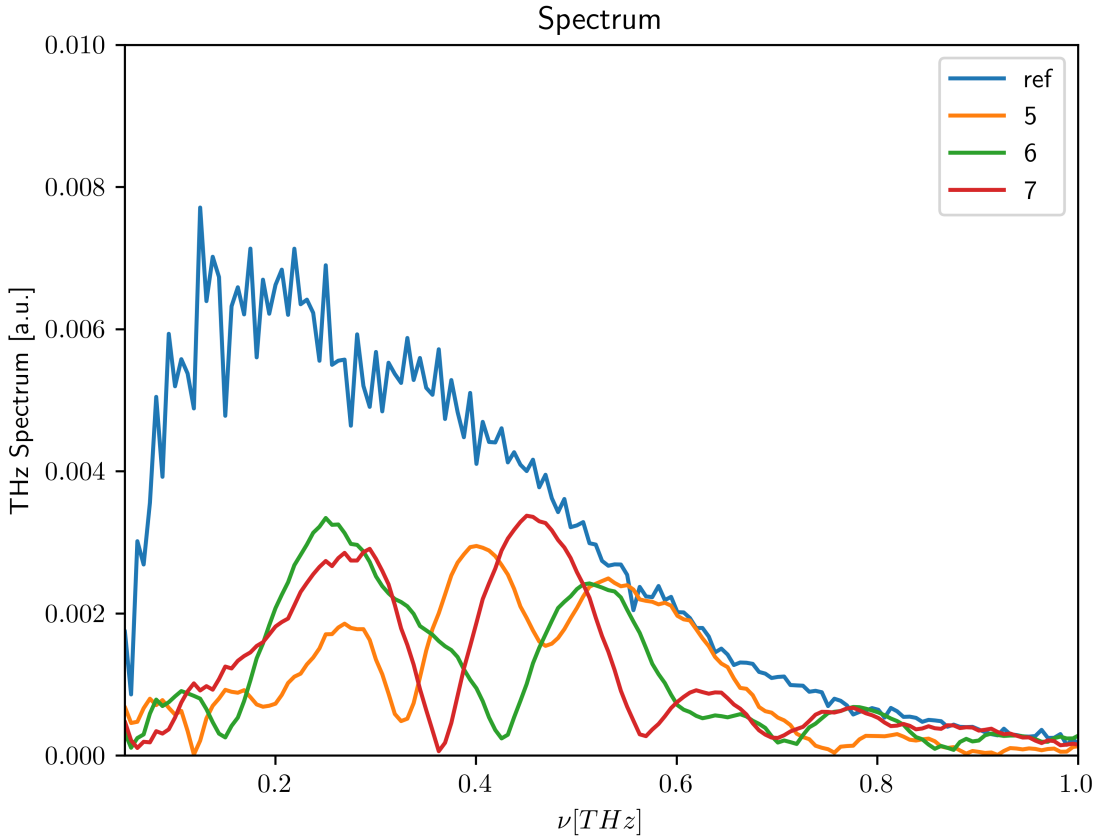
THZ-TDS plasma measurements

Lamp Type	$n_e[10^{20}m^{-3}]$	ν_e [THz]
Hg-HPK125	0.4	1.5
Na-93122E	1.9	0.9
Cs-93105E	4.6	1.7

Table 4: Measured characteristics of Philips spectroscopic lamps n_e is the plasma density ν_e the electron-electron collisional frequency.

(Courtesy G. Galatola, PhD Thesis 2019)

Reflection test: overlap of paper layers: 5, 6 and 7



Novelty and Advantages

- Introduction of cutting edge **THz-TDS** technology in the Tokamak environment.

- Use of compact, room-temperature solid-state devices & optical fibers to ease access and match Tokamak plasma requirements.

- Background rejection of THz-TDS : **High sensitivity**

- Evolution of diagnostics capability, beyond routine plasma density & temperature measurements. A new concept instrument enabling multiple measurements with one single diagnostic tool. Fluctuations, charge density, conductivity, I-profile, with unprecedented resolution.

Attivita’ future

- Test sistematico del sistema Elettro-Ottico

- Test RX & TX lens/fiber testa fotoconduttrice (burning test)

- Decisione relativa al tipo di detector da utilizzare per la diagnostica

- Diagnostic-relevant tests: distanza, SNR, riflessione
  {confronto con CLA+MEX}

- GVD compressor per fibre ottice, decisione finale

- Parametri operativi sistema funzionante

- Progetto costruttivo diagnostica

Con il Contributo di.....

A Doria, E Giovenale, GP Gallerano, P Buratti, O Tudisco, F Bombarda, G. Galatola-Teka, L Senni, A Taschin, Kun-Peng & D Damry (Clarendon) *e molti altri.*