PRESENTAZIONE DI GIUSEPPE GALATOLA TEKA PER ASSEGNO DI RICERCA

THZ-TDS DIAGNOSTICA PER LA FUSIONE E ANALISI DEI MATERIALI

EDUCATION

Università La Sapienza di Roma

- Bachelor Degree: **Physics** with a thesis on "Onde Elettromagnetiche che generano corrente nei Plasmi Termonucleari" at ENEA's Frascati Laboratory under the supervision of Roberto Cesario (MAR 2012);
- Master Degree: **Physics with Condensed Matter Curriculum** with a thesis: "Spettroscopia TeraHertz per Diagnostiche del Plasma" at ENEA's Frascati Laboratory under the supervision of Marco Zerbini (MAG 2015);

Università di Padova

- Ph.D. **Fusion Science and Engineering** on " Development of a fiber optics polarization resolving THz spectrometer for harsh environment diagnostics applications" carried out at ENEA's Frascati Laboratory under the supervision of Marco Zerbini (OTT 2015 - MAR 2019).

WORK EXPERIENCE

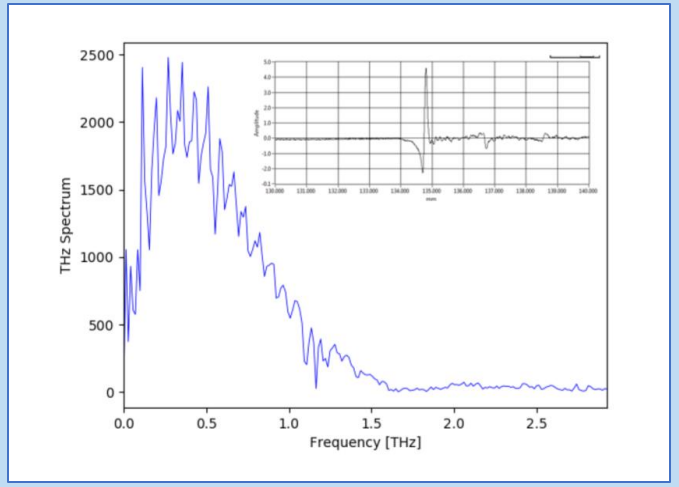
- Industrial Risk analysis and safety regulation for the Chemical and Steelworks industrial field;
- Seveso risk analysis, HAZOP analysis of the industrial process, ATEX directive, C.E. Regulation, etc.

(April 2019 – December 2023)

POST-DOC

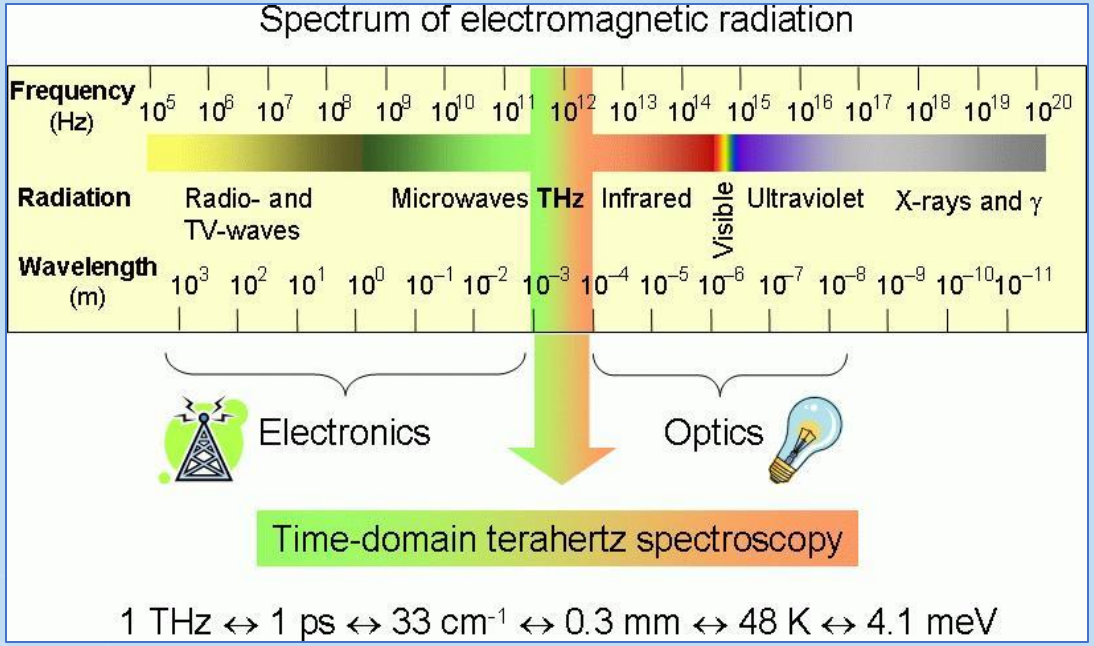
"Sviluppo di una diagnostica del plasma multi-funzionale con tecniche THz-TDS"

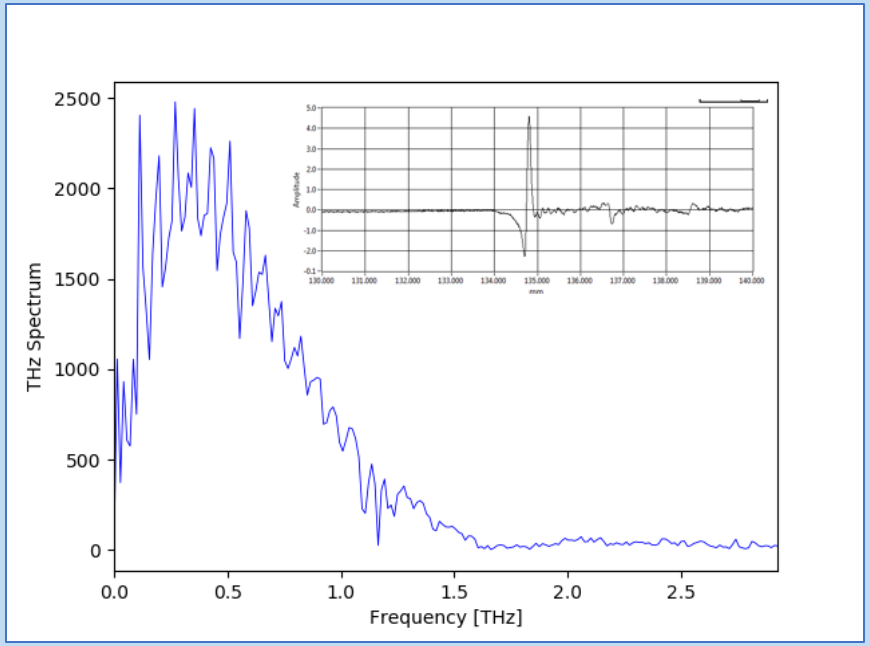
Under the supervision M. Zerbini



THZ RADIATION AND TDS

THz consists of electromagnetic waves within the spectral range usually from 0.3 to 3 Terahertz (THz), 1 mm to 100 µm. Time Domain Spectroscopy utilize pulsed radiation to probe and characterize materials



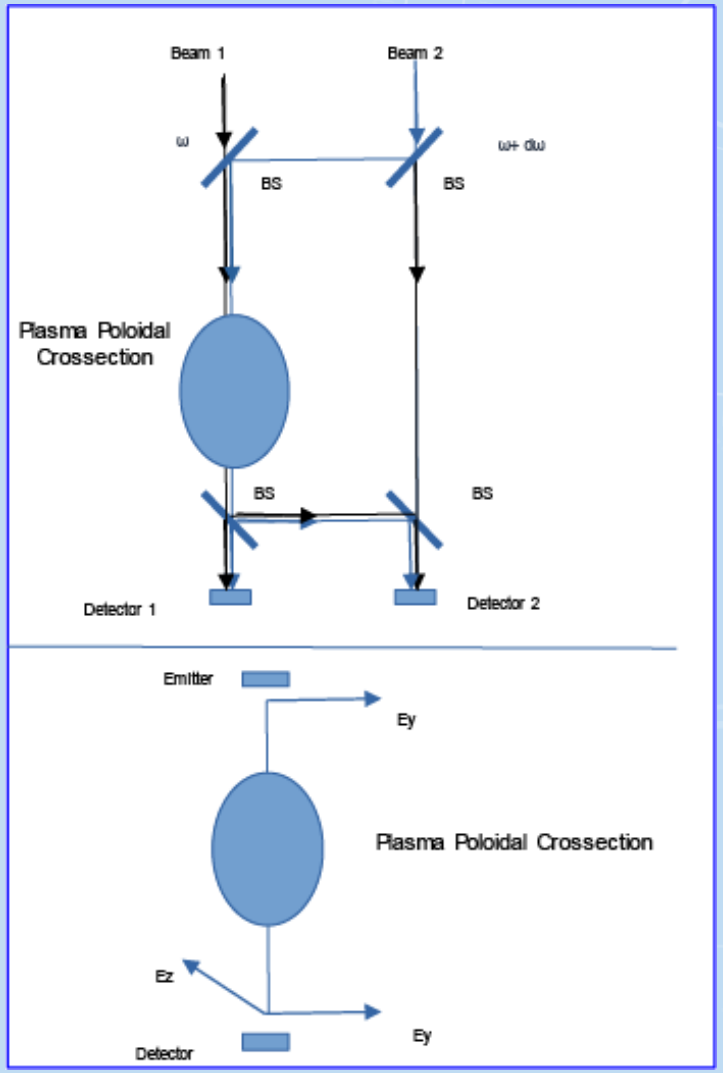


TOKAMAK AND DIAGNOSTICS

INTERFEROMETRY POLARIMETRY REFLECTOMETRY

The Tokamak's plasma exhibits relevant optical properties in the region of the millimetre and sub-millimetre electro-magnetic waves (emw) leading to the development of various diagnostics tools capable of extracting t physical parameters of the dynamics of operation of the Fusion Machine.

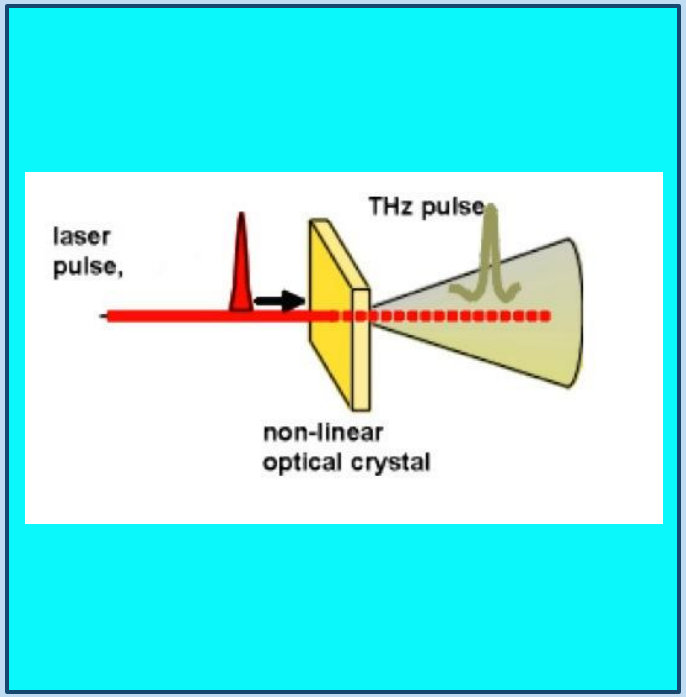
- Recover the index of refraction (and consequently the plasma density) from the phase Shift induced to an E.M.W. from a plasma.
- A magnetized plasma becomes birifrangent and the change in polarization of an EMW can be used To recover the magnetic field
- An EMW propagating in a plasma is reflected at a specified surface of plasma with a special density value (cut-off density)



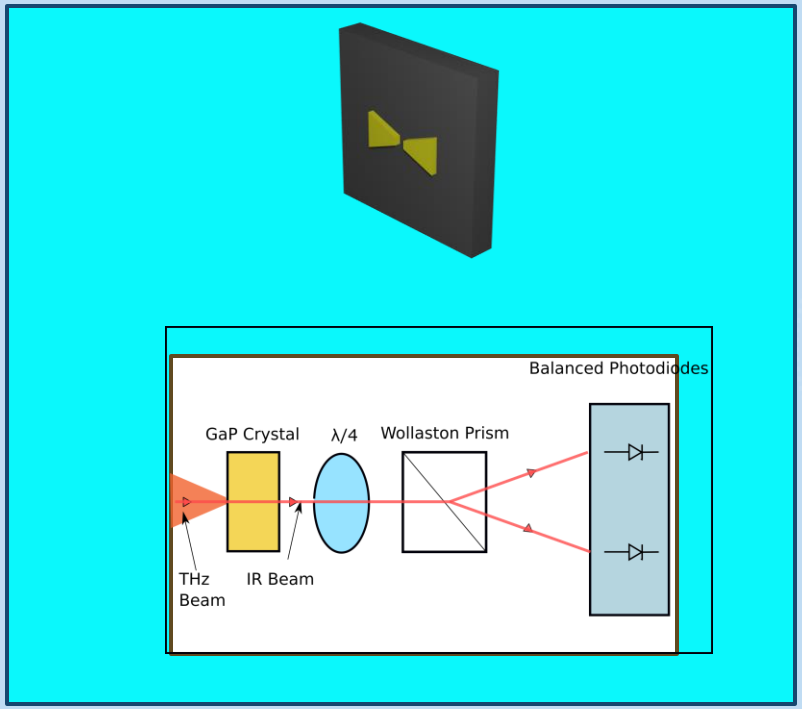
THZ SOURCES AND DETECTORS

The typical bandwidth produced is 5 THz, the power is on the order of tens mW and DR is about 60 DB.

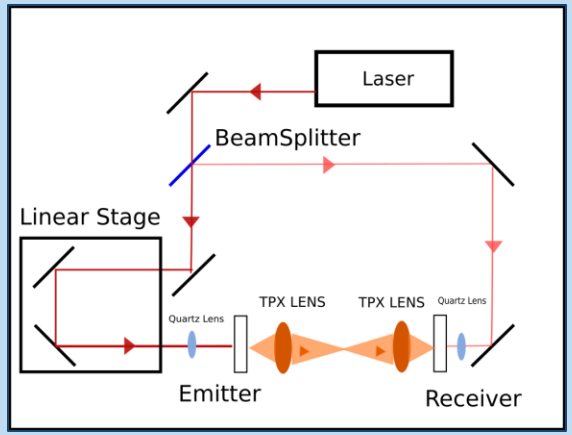
Thz Photoconductive Emitter

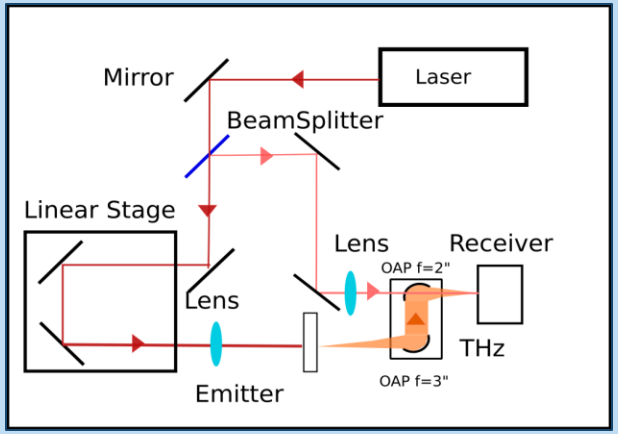


Thz Photoconductive and Electro Optical Detector

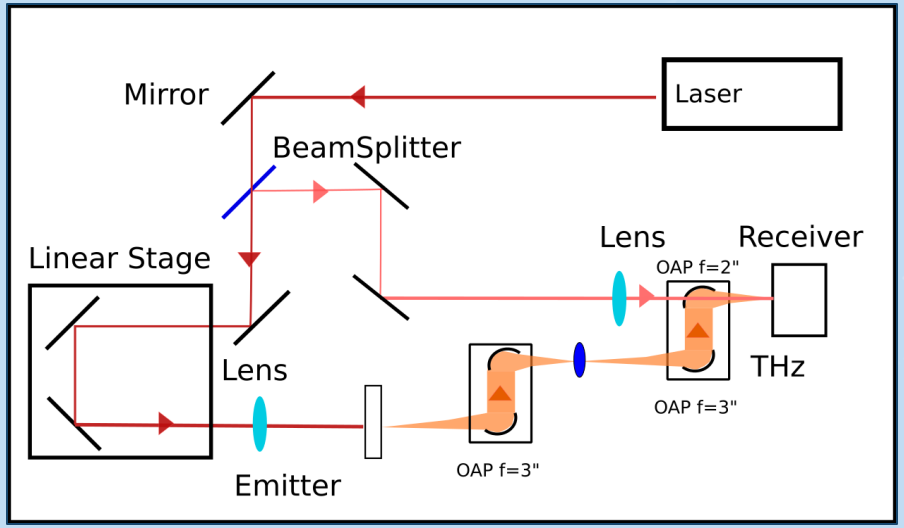


EXPERIMENTAL SET UP: FRASCATI

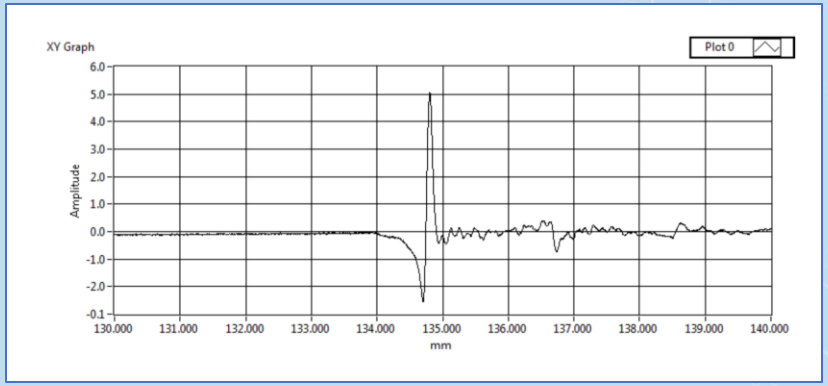


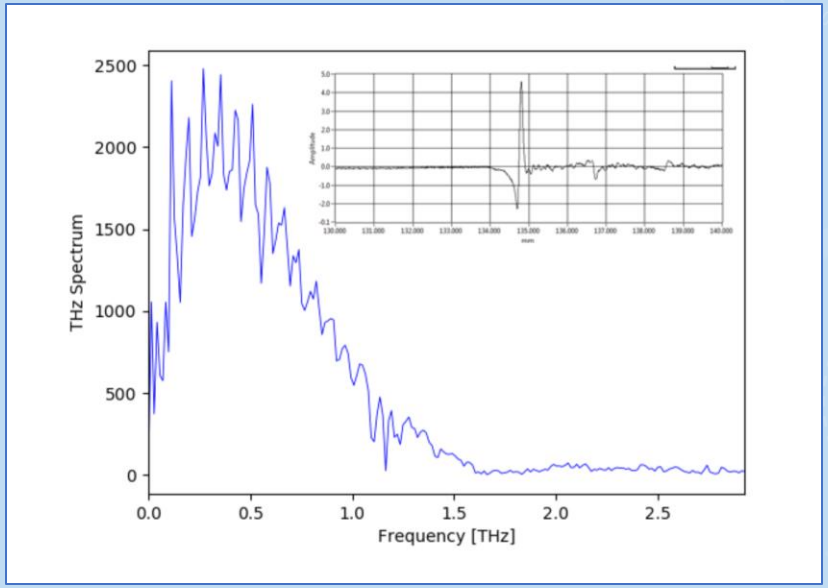


A Ti-Sapphire Mira 800 nm mode-locked laser. The device generates a 170 fs long pulse that is separated into two branches by a beamsplitter the pump branch where the THz pulse is generated and probe branch , where the THz pulse is detected. The linear stage introduces an optical path difference between the source and the detector.



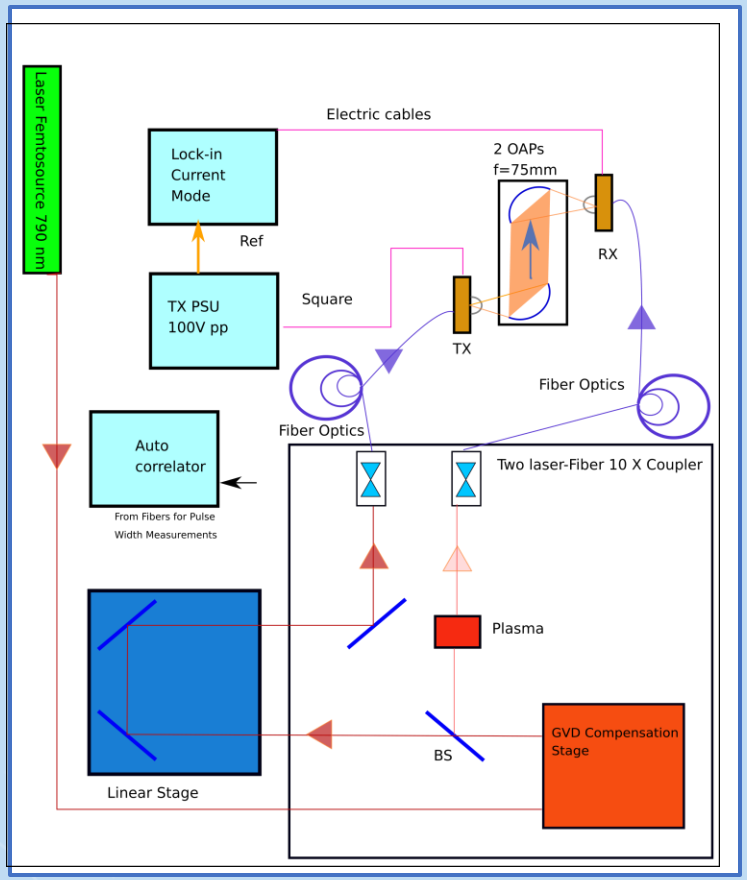
FRASCATI MEASUREMENTS





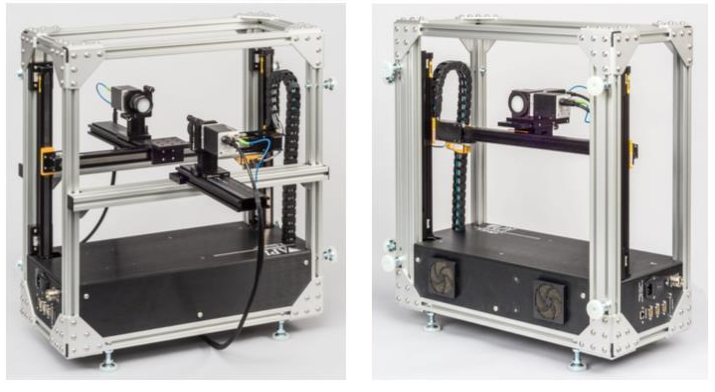
Example of measured pulse with electro optical sampling and relative Fourier Trasform.

OPTICAL FIBER AND OPTICAL FIBER TEST

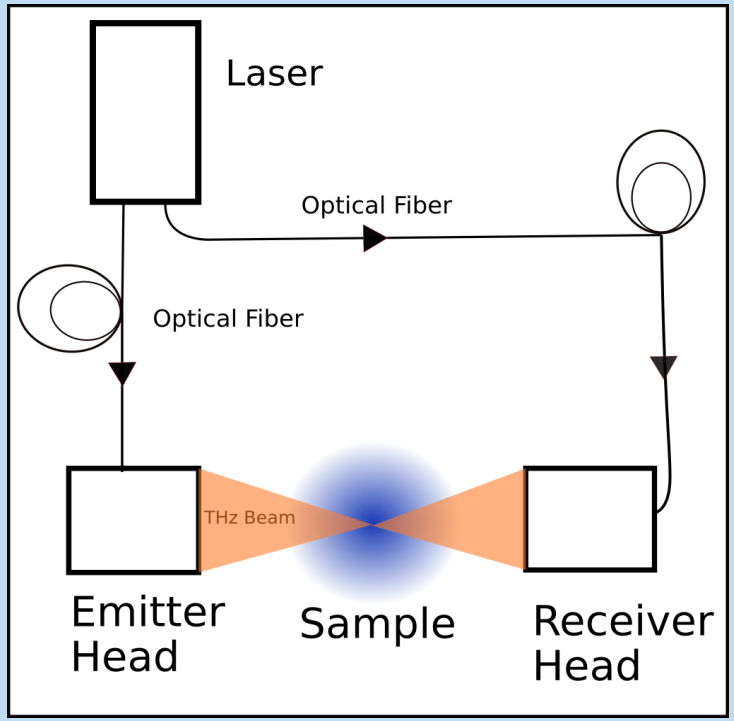


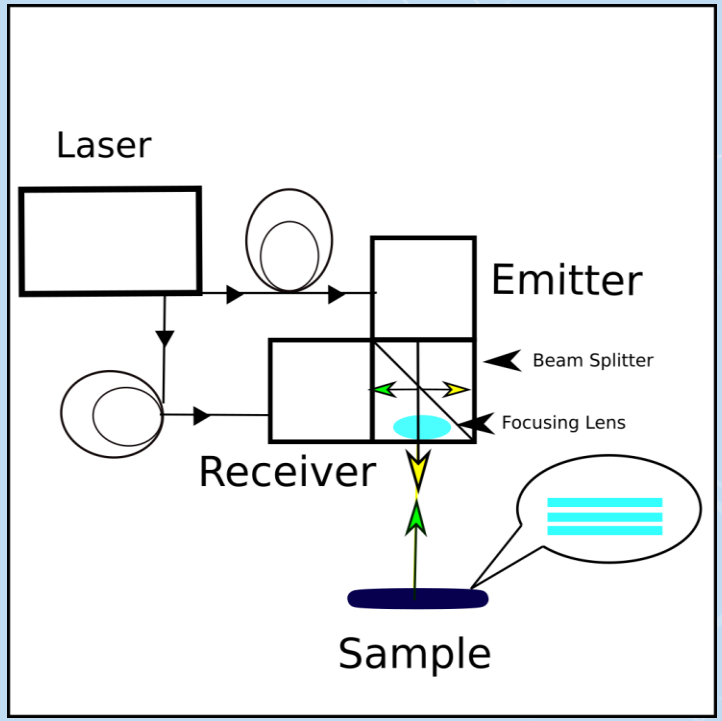
The IR laser radiation can be guided to the THz generation and detection devices by single mode optical fibers for considerable lengths (>10 m).

EXPERIMENTAL SET UP: (MEXICO)



C.I.O. @ Leon (Mexico) experimental Set up Picometrix Two heads, with system lens of focal length of 13.5 cm , one emitter the other receiver, linked to the main seed laser by two 5 meter optical fibers.

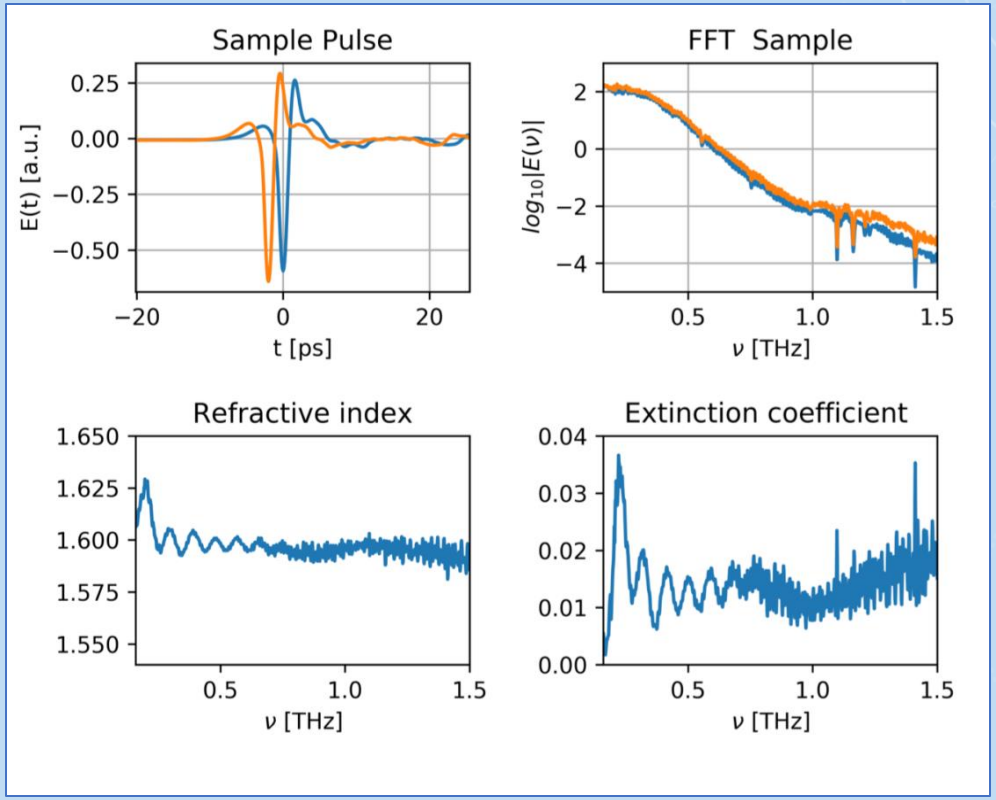




CENTRO DE INVESTIGACIONES EN OPTICA, A.C.

TRASMISSION MEASUREMENT

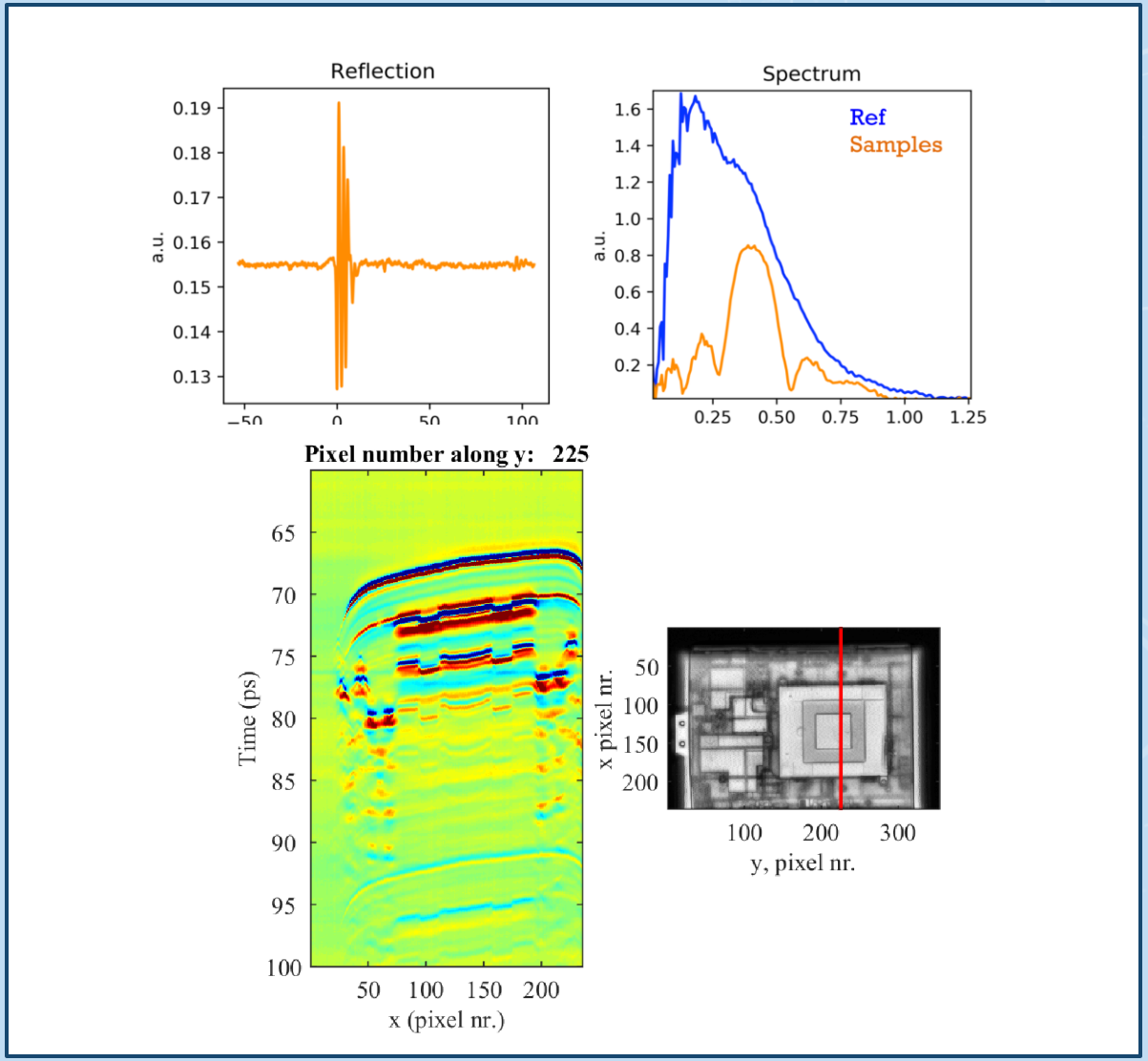
The objective of the measurement is to estimate the index of refraction and the absorption index of a sample of known thickness using THz-TDS. The sample was a disk 1 mm thick, 1 inch wide, 3D printed with Polylactic acid (PLA)



REFLECTION MEASUREMENT

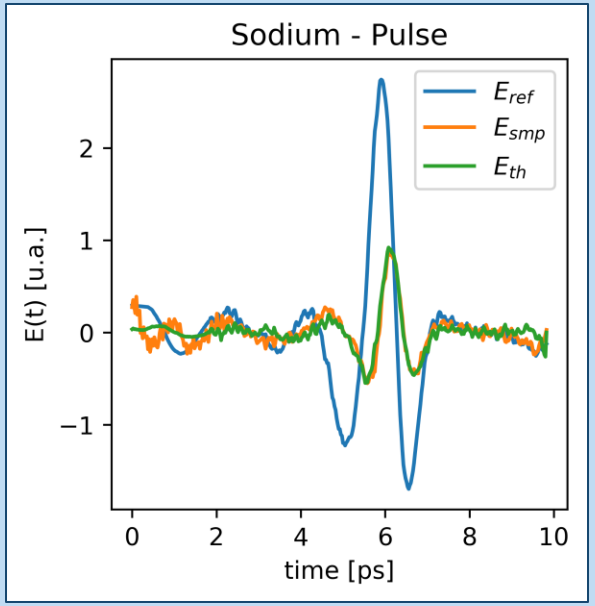
A less complex framework beneficial for studying the different propagation properties of the pulse. The number of planes corresponds to the number of the peaks in the reflected pulse. The travelling time of the pulse corresponds to the distance of each paper;

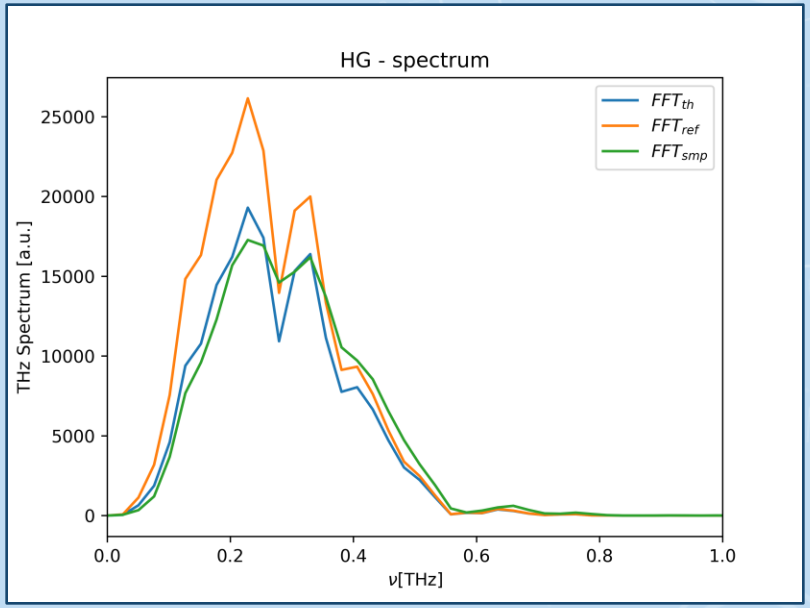
In the case of the X-Y scan output of the electronic device, reflected electric field peak is reconnected to its thickness and index of refraction of the device internal components.



PLASMA MEASUREMENT

Using a simple model for a plasma slab of uniform density in the cold plasma approximation is possible to reproduce the Plasma Transmission Function. Is then possible to deduce the electron density and the electron collision rate.



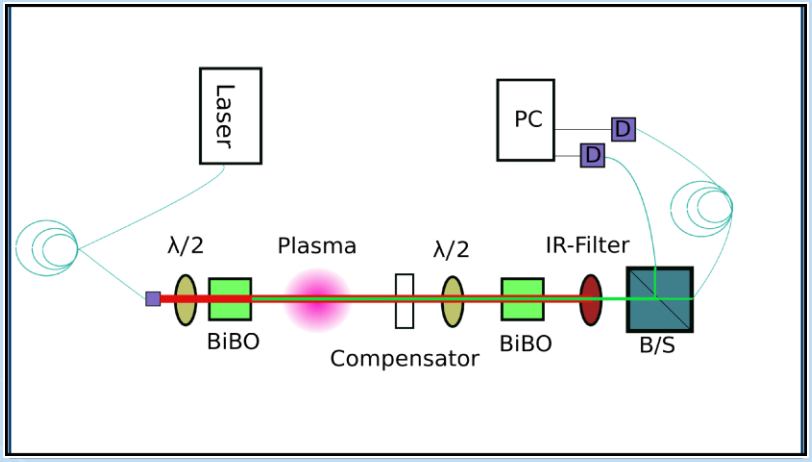


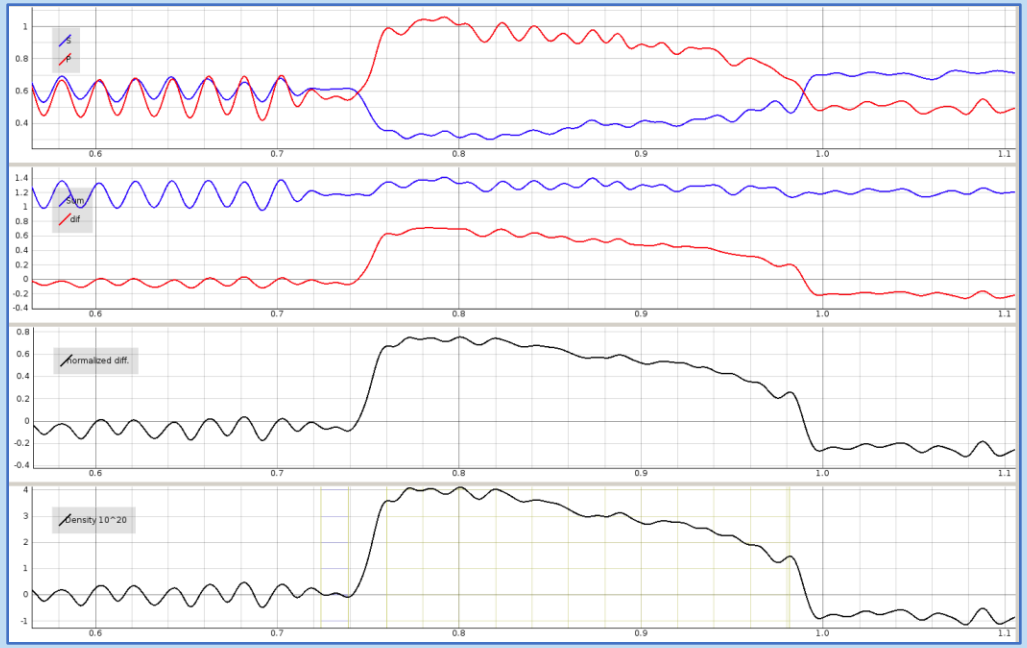
$$H(\omega, n_e, \nu_e) = \frac{S_{smp}(\omega)}{S_{ref}(\omega)} = exp(i\frac{\omega L}{c}(1 - n(\omega, n_e, v_e)))$$

Lamp Type	$n_e[10^{20}m^{-3}]$	$\nu_e[THz]$
Hg - HPK125	0.4	1.5
Na - 93122E	1.9	0.9
Cs - 93105E	4.9	1.3

ELECTRON DENSITY MEASUREMENT OF PROTO-SPHERA PLASMA BY SECOND HARMONIC INTERFEROMETER

Fundamental beam: Nd:YAG CW laser, λ = 1064 nm, P = 300 mW Doubled frequency 532 nm, two color interferometer which strongly reduces the effects of vibrations





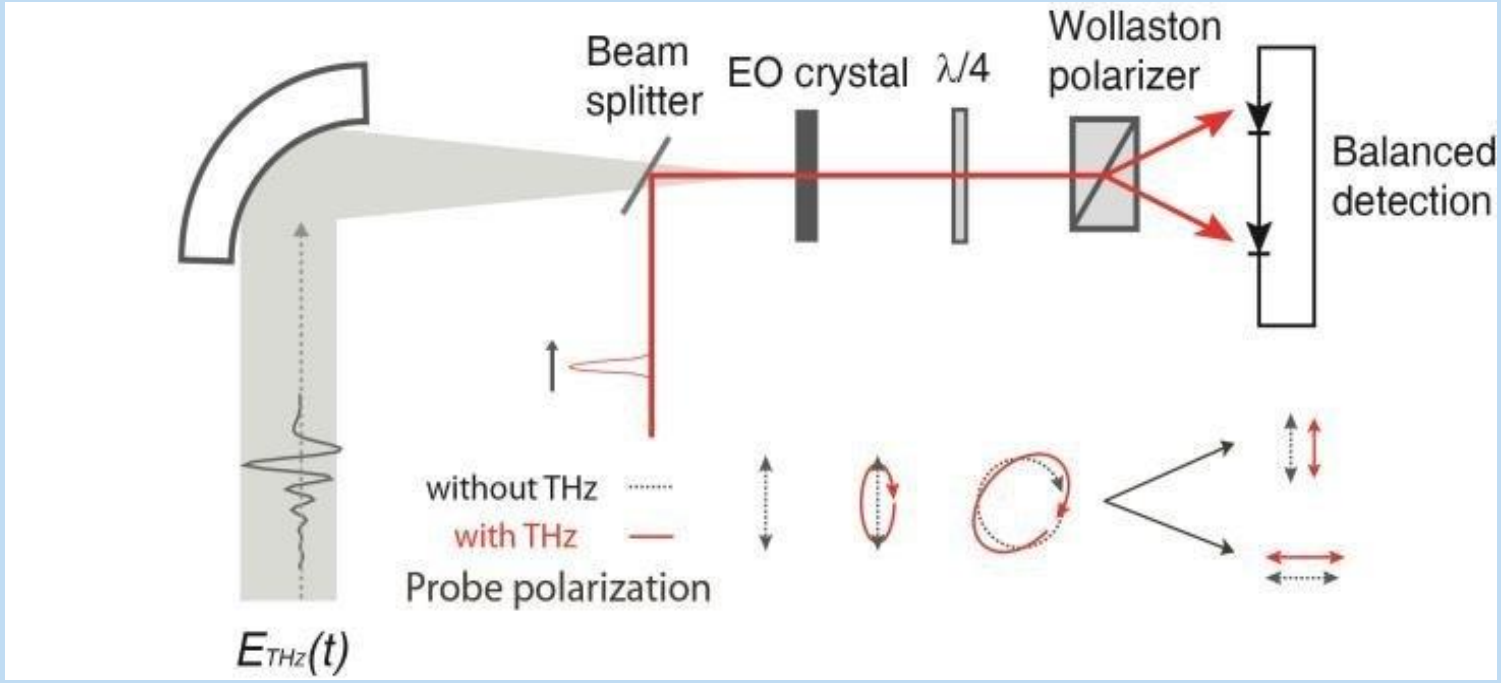
Measured signal of a typical plasma operation Argon #954 at I_e=10kA, equatorial line of view.

PRESENT AND FUTURE WORK

- Diagnostic Relevant Test of Commercial System;
- Participation in experimental campaign and Data Analysis of State of Art Diagnostic in European Tokamaks ;
- THz Diagnostic Design and application;
- THz TDS Material Characterization.


Thank You!

BACKUP SLIDE – EO SAMPLING



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- INDEX OF REFRACTION