

Journées Annuelles PEPR LUMA

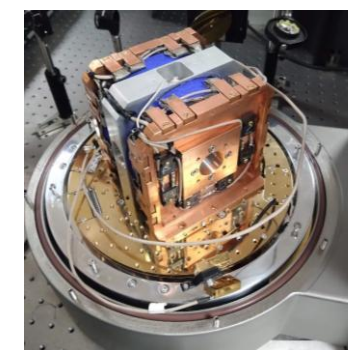
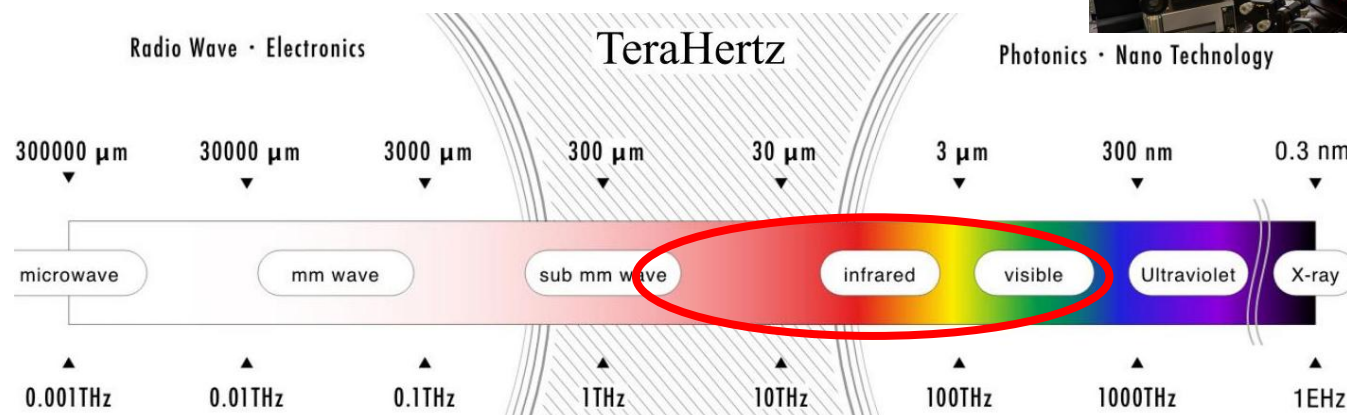


Gwenaelle Vaudel
IMMM femtosecond laser platform
Le Mans

5 femtosecond (fs) laser chains with different but complementary specifications:

gwenaelle.vaudel@univ-lemans.fr

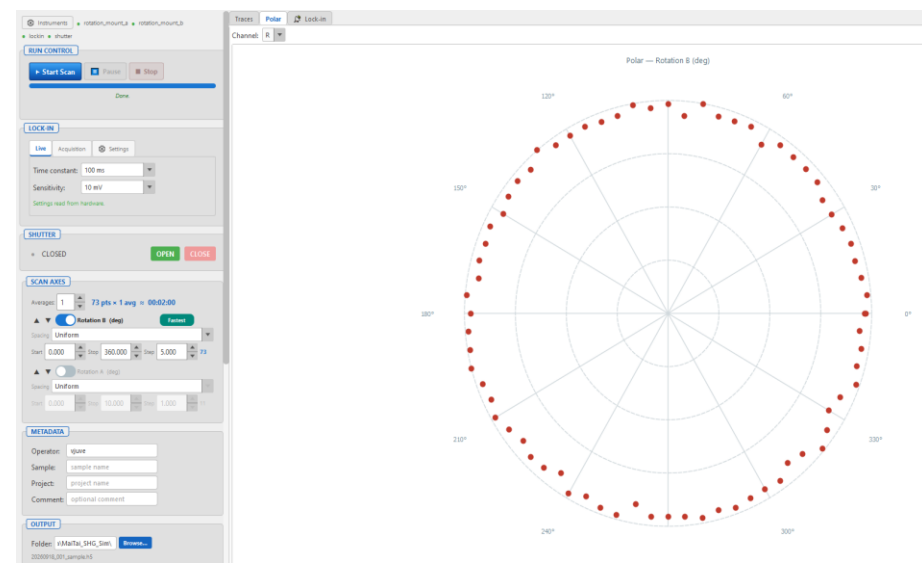
- ➔ Temporal pulsewidth: from 35 fs to 200 fs.
- ➔ Repetition rate/ energy per pulse:
from single shot to 1 kHz @ 5 mJ and to 80 MHz @ 40 nJ.
- ➔ Wavelength: visible up to Mid-IR and THz.
- ➔ Extreme conditions: Temperature down to 4 K
Magnetic fields up to 7 T



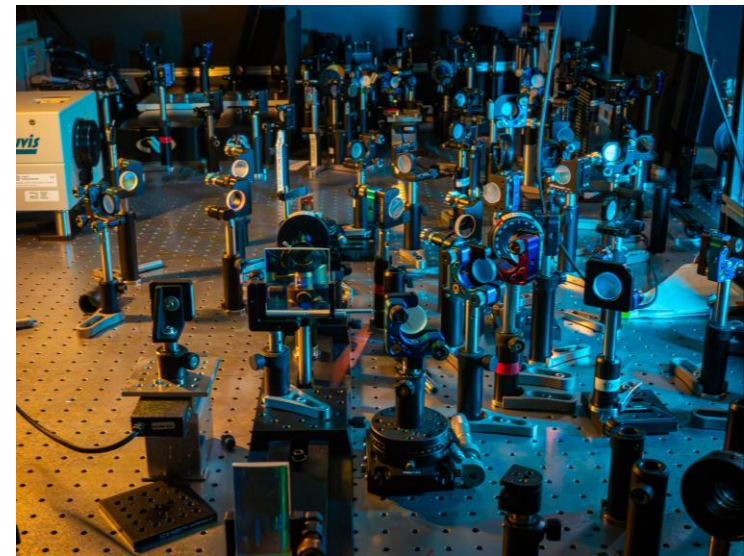
*Optical cryostat
4 K; 7 T*

fs laser chains ➔ Light matter interactions at ultrashort time (fs-ps) scales

Several setups

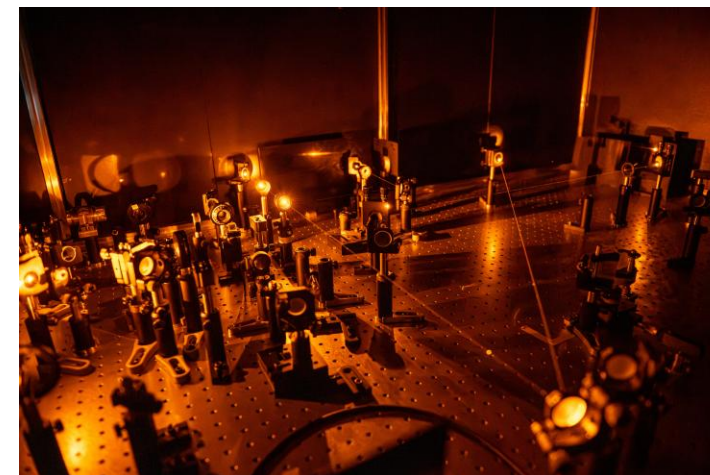
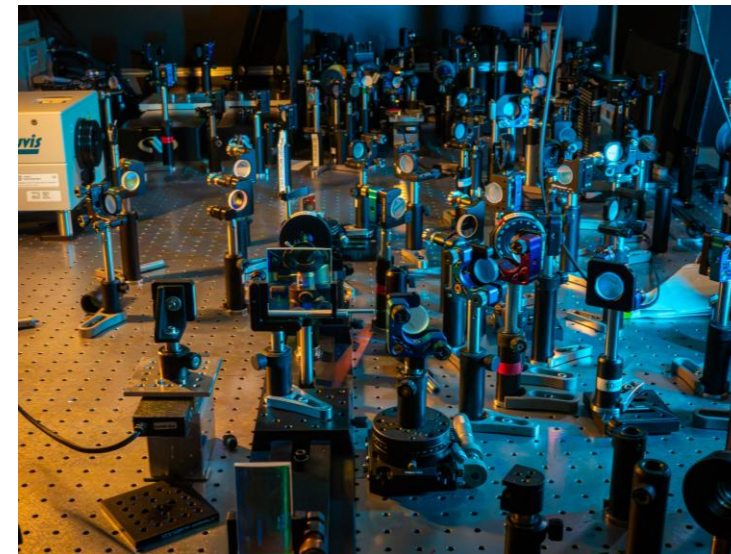
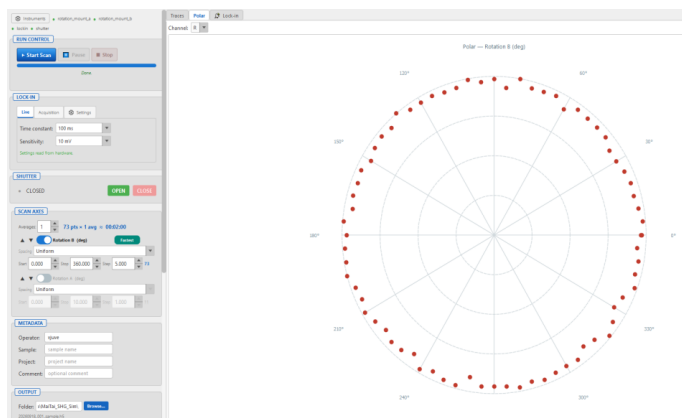


Homemade and scalable
graphical user interface for
acquisition and analysis



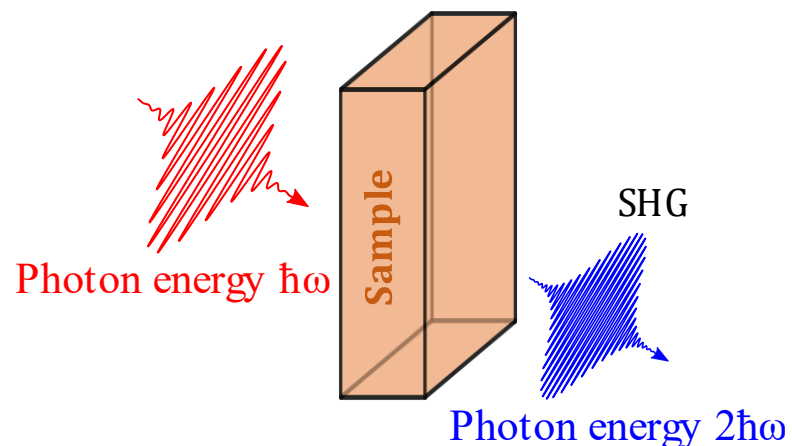
Outline

- ➔ **Emission spectroscopy**
Material exposed to ONE fs laser beam
- ➔ **Ultrafast time-resolved spectroscopy**
TWO fs laser beams: pump and probe
- ➔ **Examples of studies**
- ➔ **Conclusion & perspective**

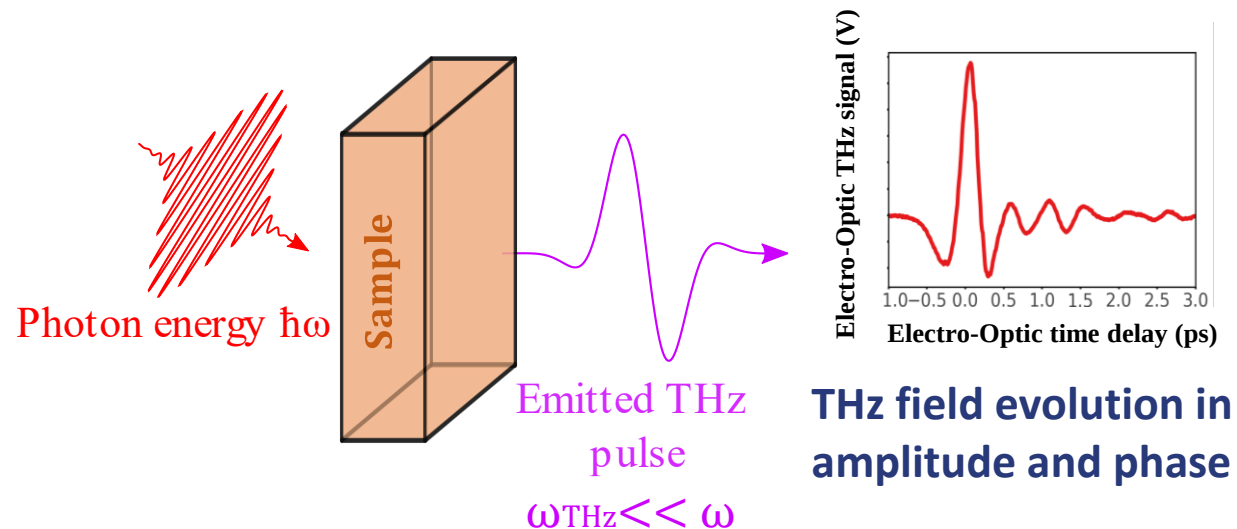


Emission spectroscopies

Second harmonic generation



THz emission spectroscopy



Two complementary techniques to study:

The electronic response of the material

Sensitive to ultrafast dynamics and symmetry

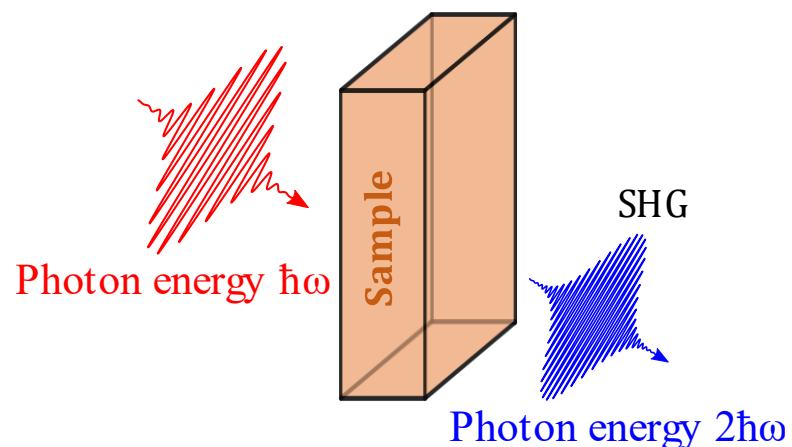
Explore structural and electronic properties of materials

Types of materials : semiconductors, crystals, interfaces, heterostructures, ferroelectrics...

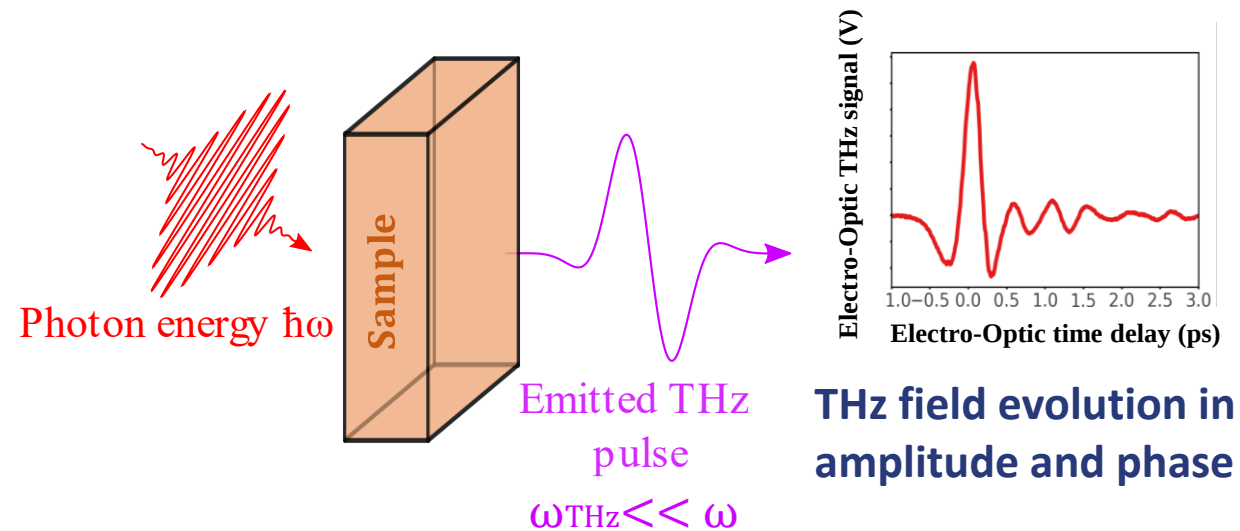
The resonant response of the material

Emission spectroscopies

Second harmonic generation



THz emission spectroscopy



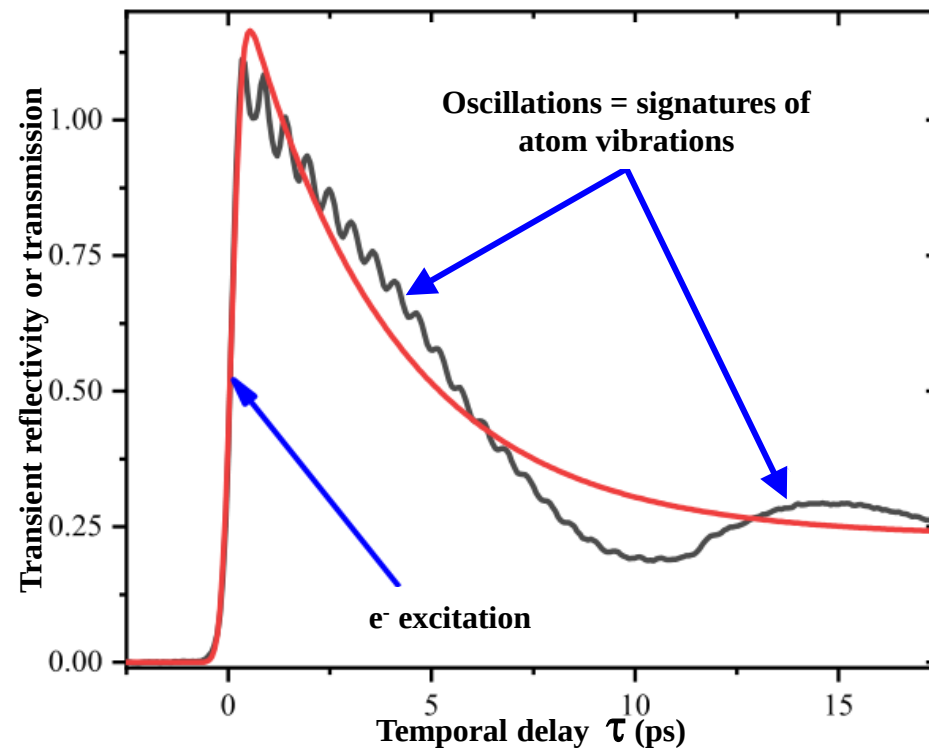
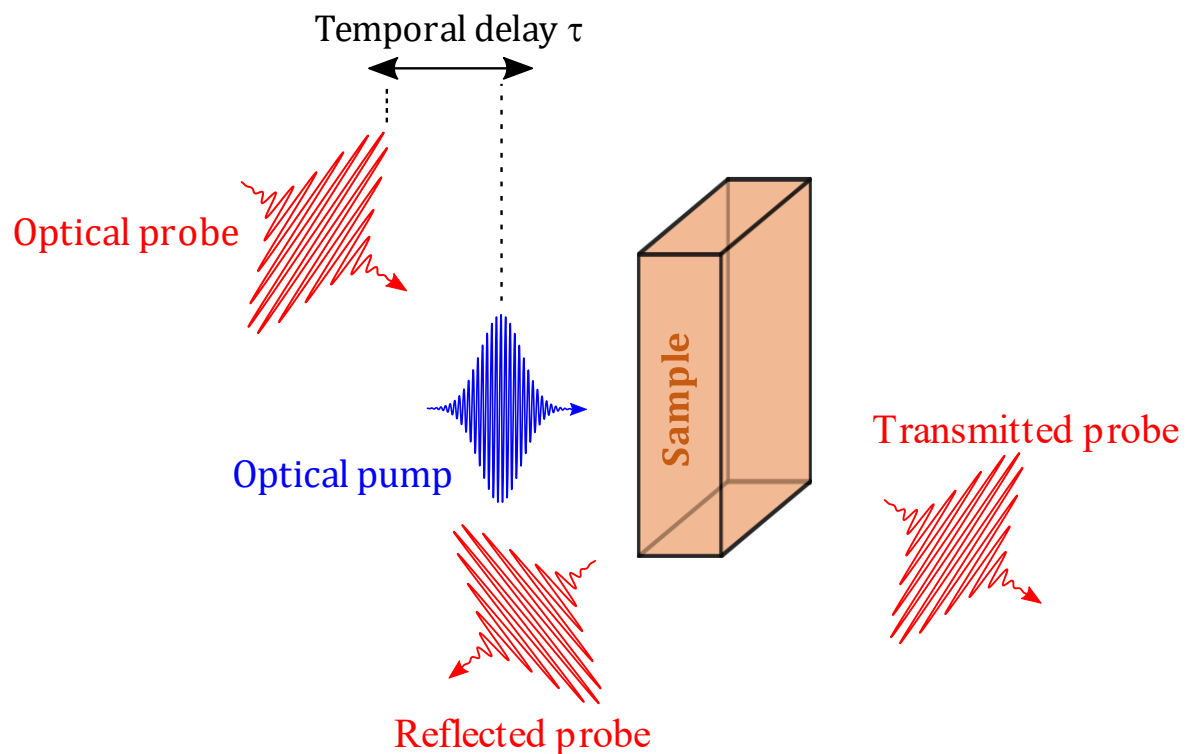
Condensed matter but also **complex/soft matter** or **biological** objects

Fiebig *et al*, J. Applied Physics (2005)
Shen, Annual Review of Physical Chemistry (1989)
Campagnola *et al*, J. Biomedical Optics (2003)

A. El Hamdi ... G. Vaudel ... *et al*, Phys. Rev. B (2024)
A. Levchuk ... G. Vaudel ... *et al*, App. Phys. Lett. (2023)
Z. Abdul-Hadi ... G. Vaudel ... *et al*, to be submitted

Ultrafast time-resolved pump probe spectroscopy

Information on the dynamics, the temporal evolution of photoinduced mechanisms



Typical measured signal

Transient reflectivity/transmission vs temporal delay

Le Mans: long expertise in laser-induced acoustic waves study

V. Gusev, P. Ruello, Appl. Phys. Rev. (2018)

P. Ruello, V. Gusev, ultrasonics (2015)

R. Gu *et al.*, Sci. Adv. (2023)

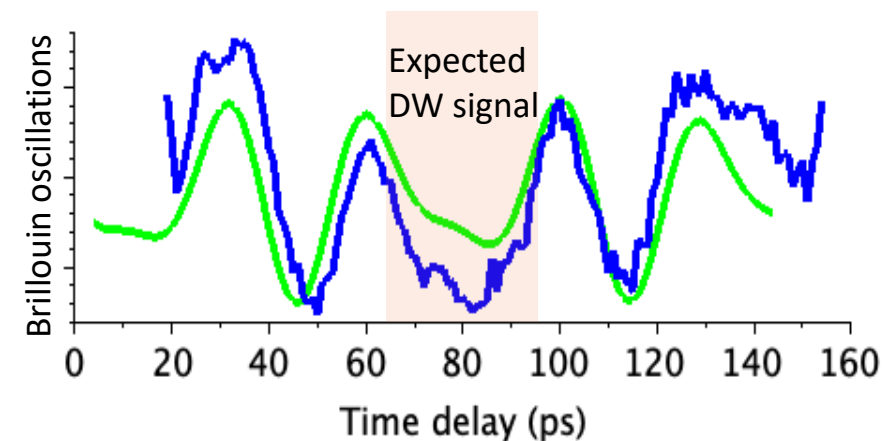
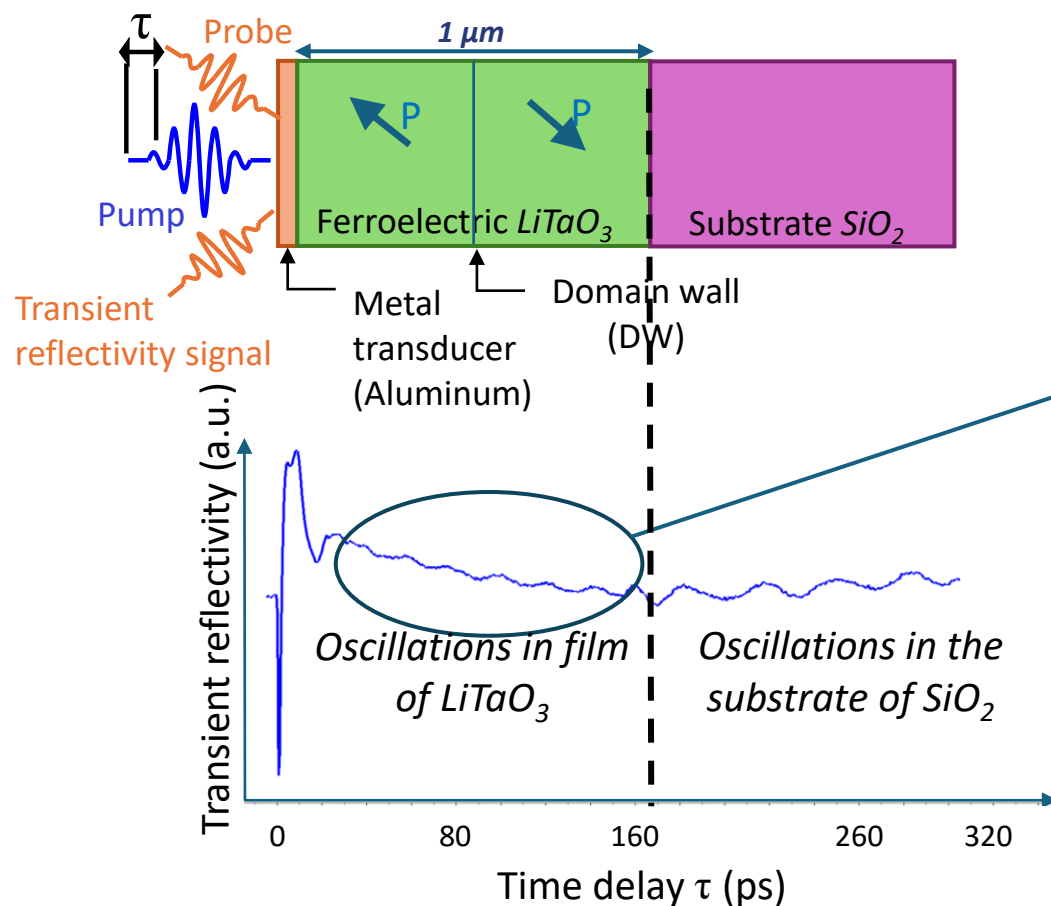
Ultrafast time-resolved pump probe spectroscopy

1st LUMA user



G. Nataf

Problematic : explore a domain wall in depth in a ferroelectric material



Inhomogeneities in the signal $\Rightarrow$ 2 scenarios:

- Signature of the domain wall
- Presence of 2 acoustic modes

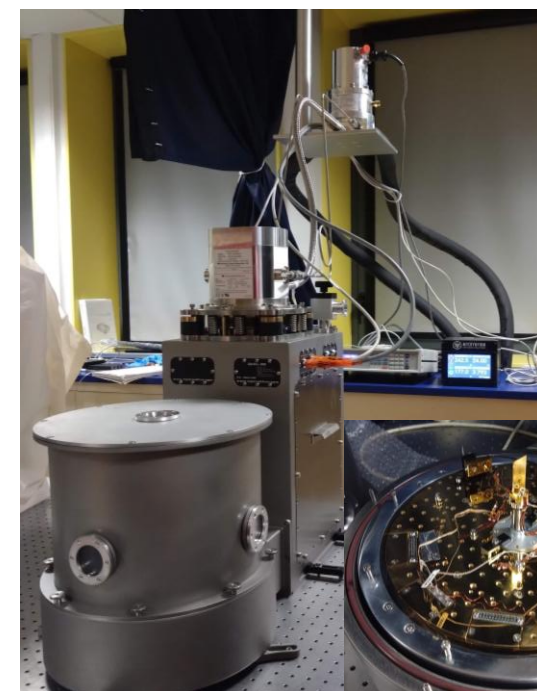
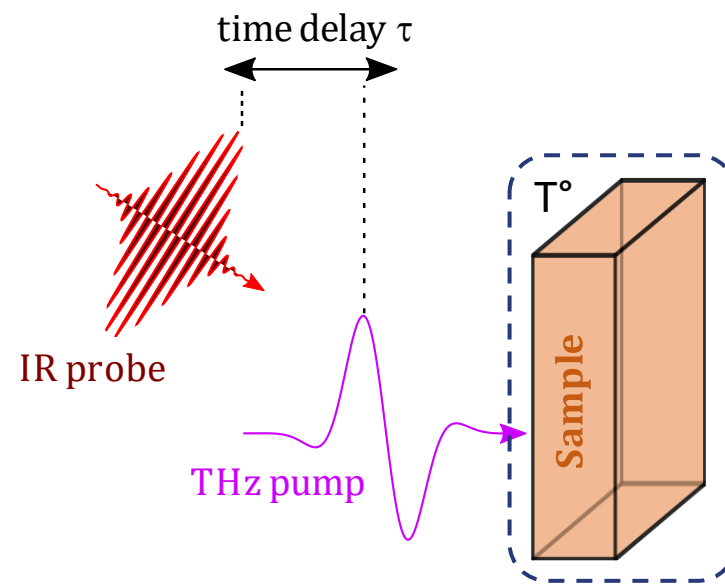
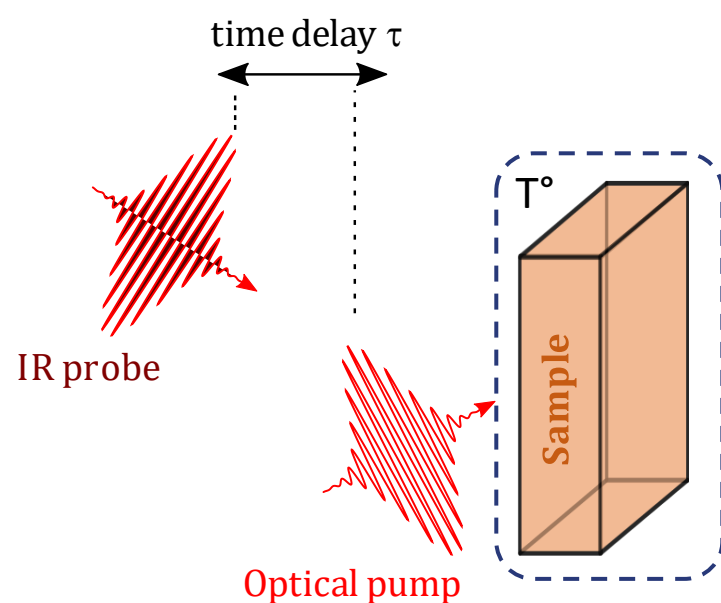
Ultrafast time-resolved pump probe spectroscopy Next LUMA project

Problematic : understand metal-insulator phase transition mechanisms

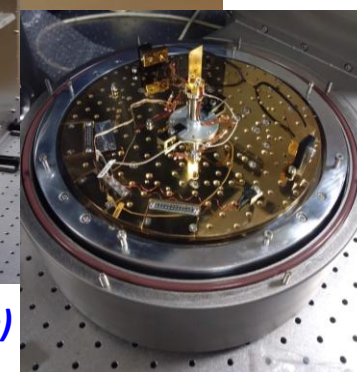
- ➔ Pump-probe experiment with THz and visible either for pump and/or probe
- ➔ At low temperature (10 to 100 K)



M-A. Measson

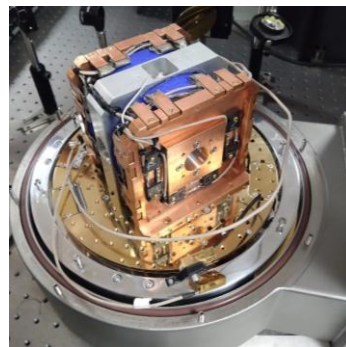
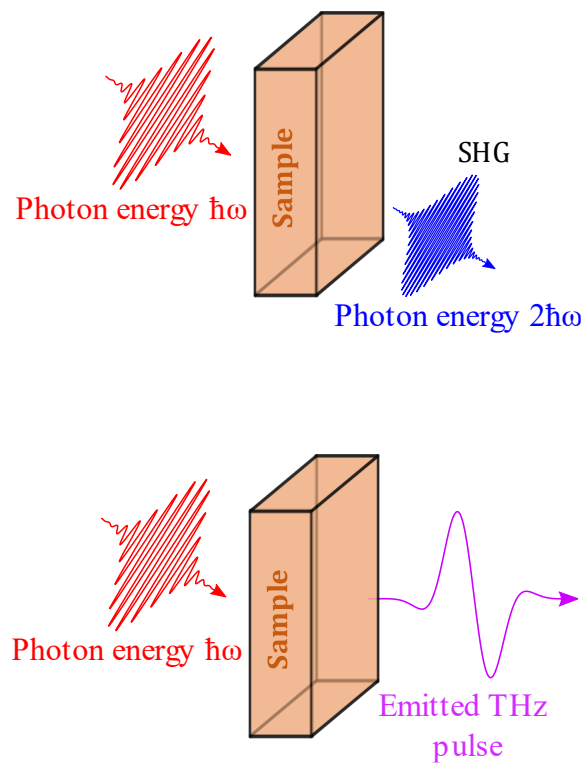


Optical cryostat (He)



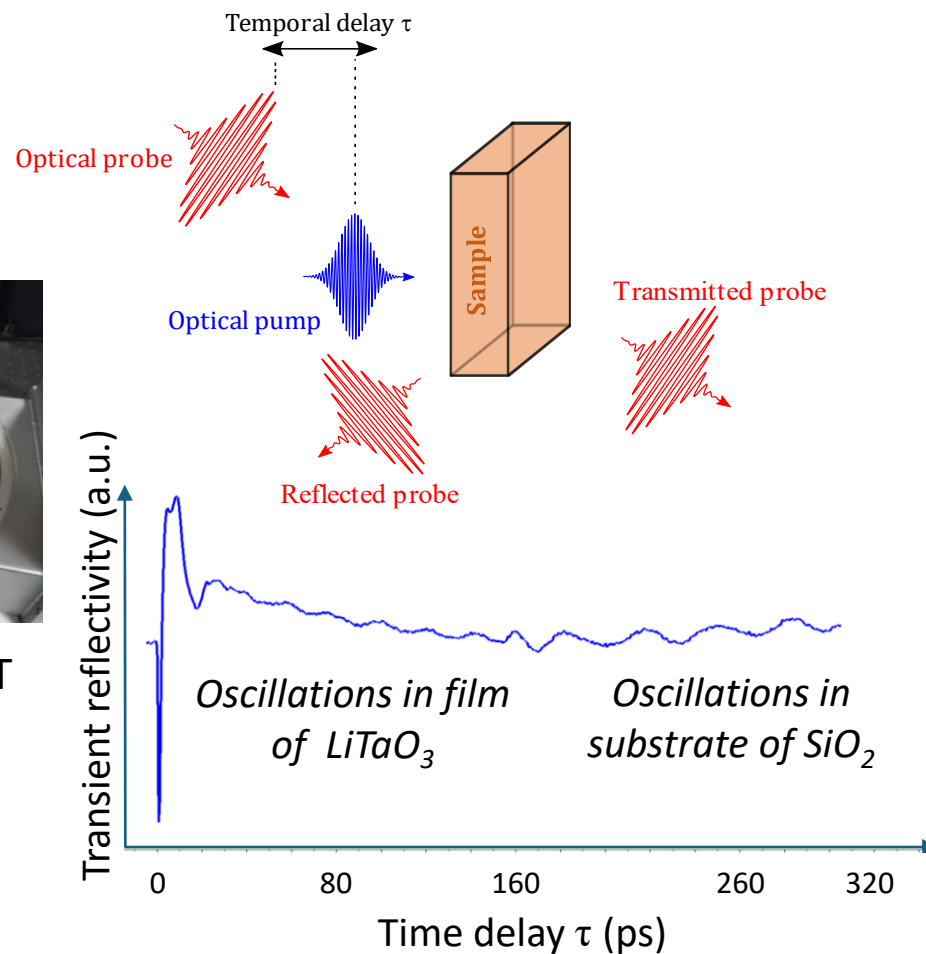
Conclusion

Emission spectroscopies



Up to 4 K; 7 T

Ultrafast time-resolved pump probe spectroscopy



V. Juvé (CR)



M. Weber (MCF)



P. Ruello (Pr)



G. Brotons (Pr)