Center for the Advancement of Natural Discoveries using Light Emission

Experimental setups for temporal shaping of ultrashort pulses and laser-based THz spectrometry

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Ultrafast Beams and Applications
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Outline

The details of the optical schemes for both

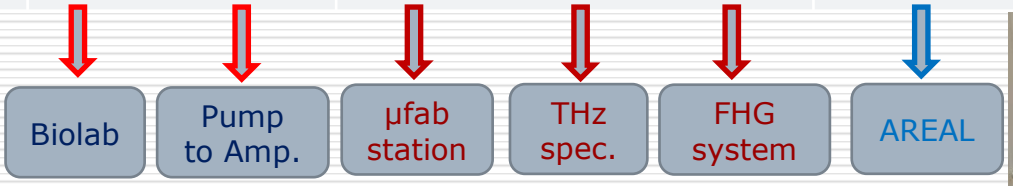
- Delay-line setup for creation of double pulses
- Spectrometer setup for generation and registration of THz radiation

Applications of the double pulses

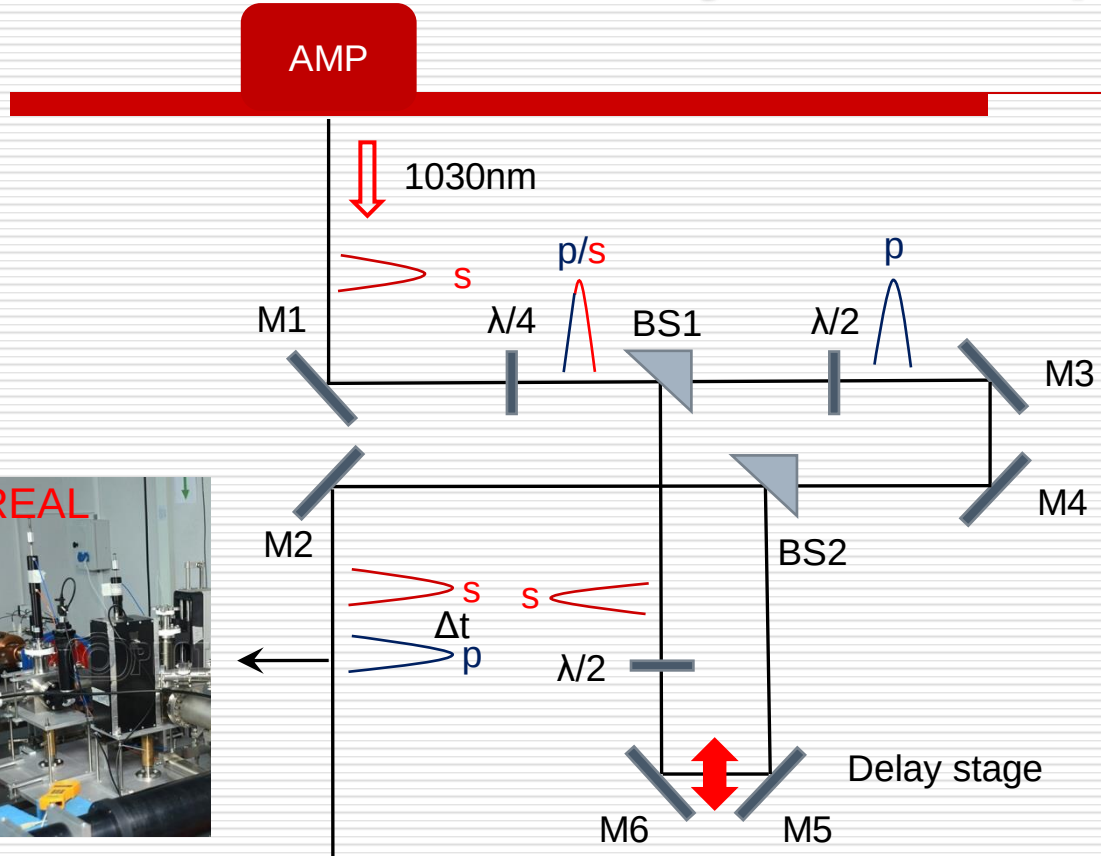
Laser system

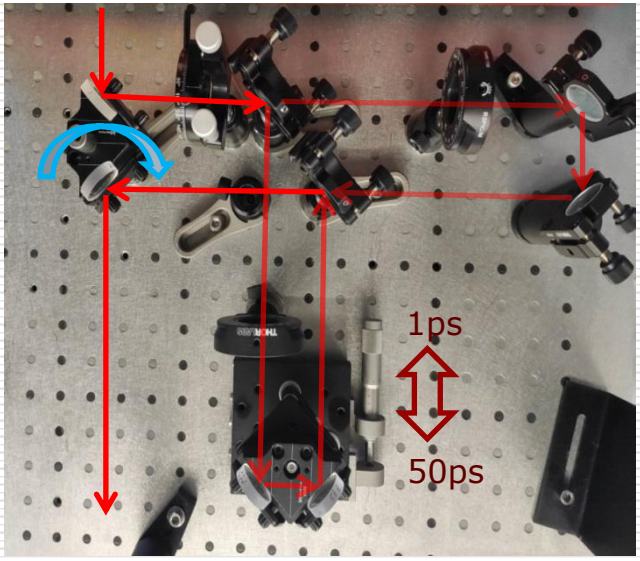
Parameters of the AREAL laser system

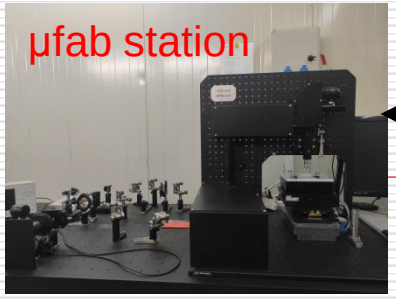
	Oscillator	Amplifier	FHG
Wavelength	1030nm	1030nm	258nm
Pulse duration	250fs	500fs-10ps	500fs-10ps
Repetition rate	50MHz	1kHz-100kHz	1Hz-1kHz
Energy	20nJ	up to 1.8mJ	380μJ



Delay-line setup







Tunable delay: from 0ps up to 50 ps

Pulse power contrast 1:1 to 1:300

Possibility to measure delay

Applications

- to create a two-bunch electron beam on AREAL linac

  opens up a whole range of potential applications and experiments on transient phenomena in irradiated biological and inorganic materials, advanced accelerator concepts, etc

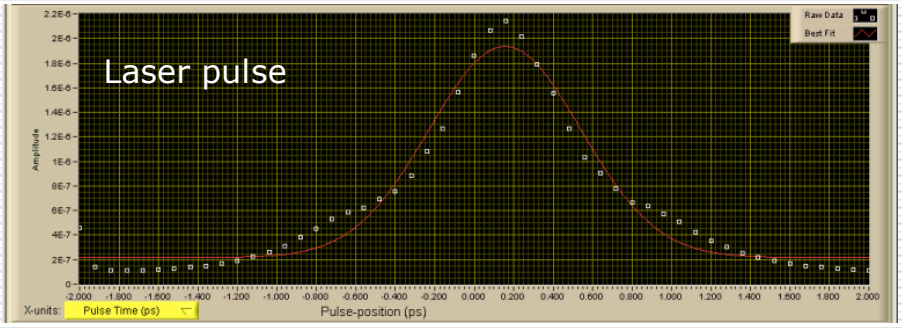
- in the microfabrication station

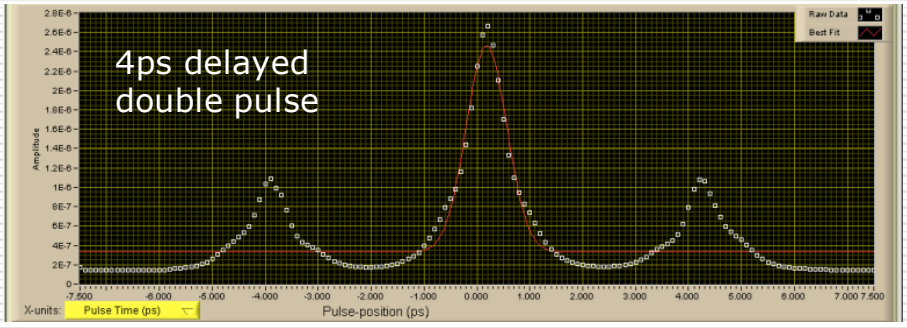
  can find the optimal regimes of the laser processing of materials

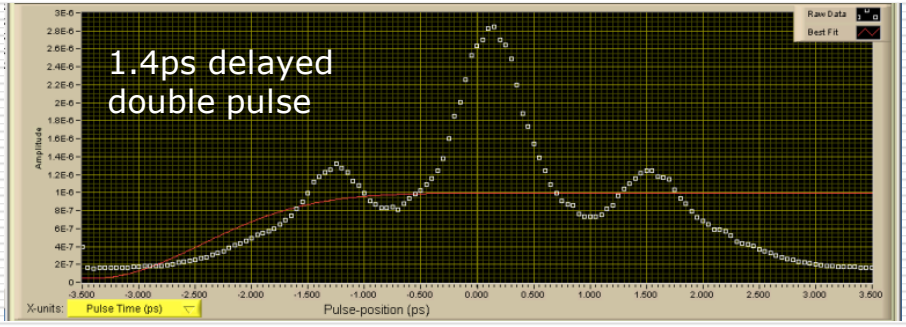
- in THz spectrometer (*air plasma*)

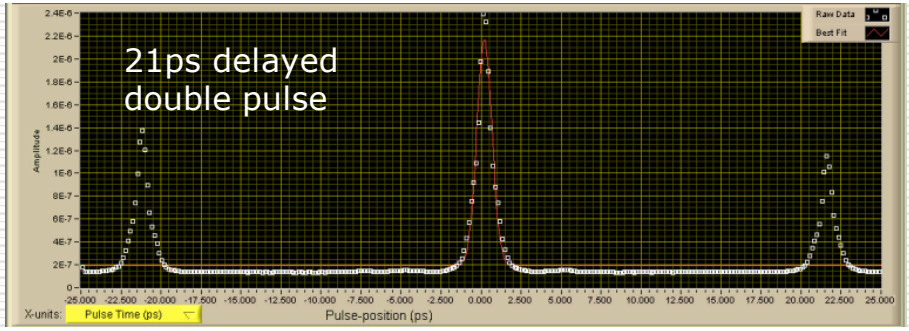
  the higher optical emission intensity of air plasma can be obtained

Autocorrelation measurements









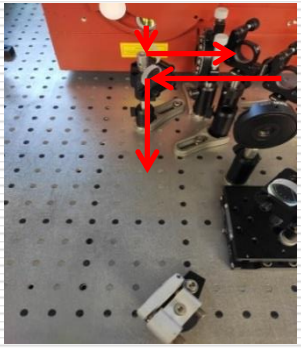
two pulses can interfere if they overlap on one hand and they have the same polarization on the other hand

Delay time **0ps - 50ps**

Pulse power contrast **1:1 - 1:300**

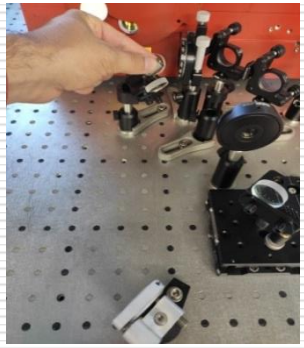
Single and double pulses

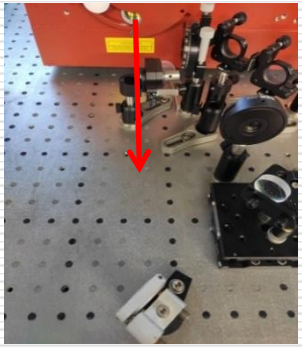
Switchable single and double pulses



Through delay setup:
double pulse

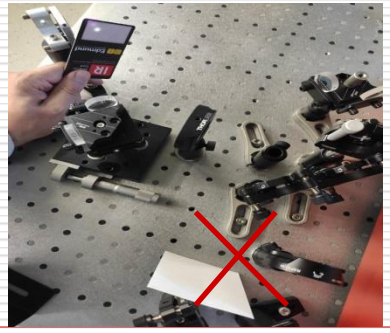
Flipping the mount



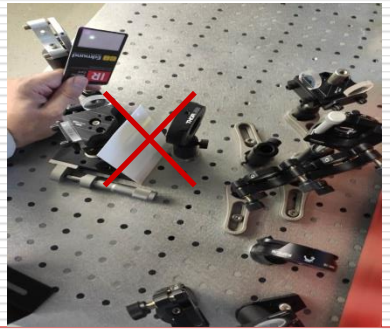


Without delay setup:
laser (single) pulse

Double pulse

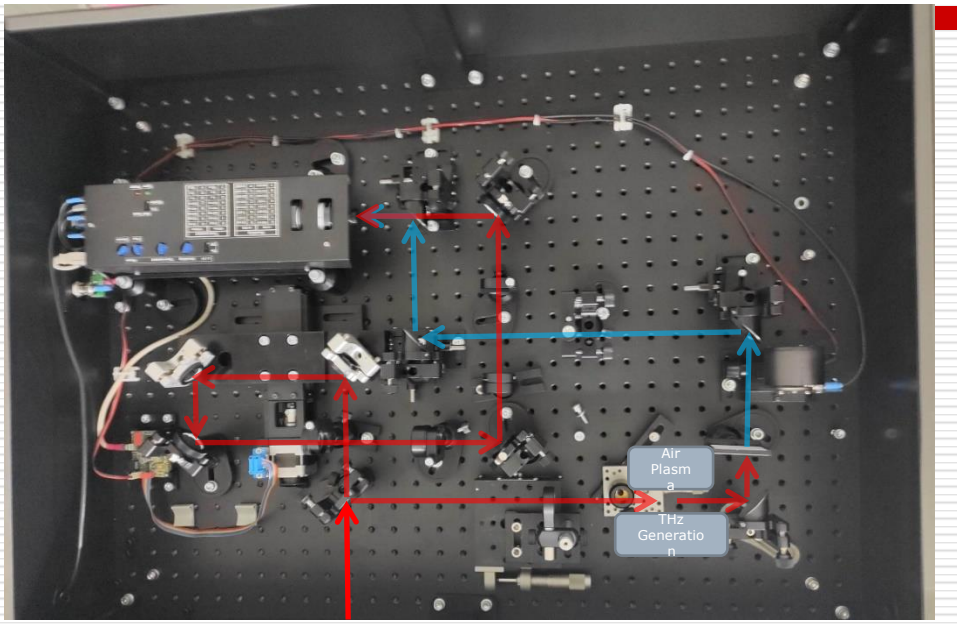


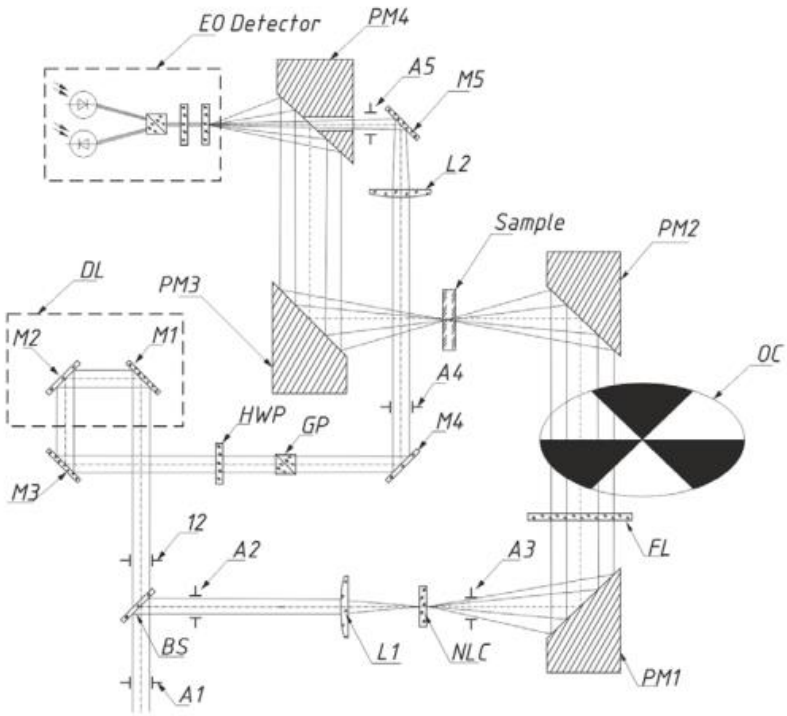
s pulse



p pulse

THz (spectrometer) setup

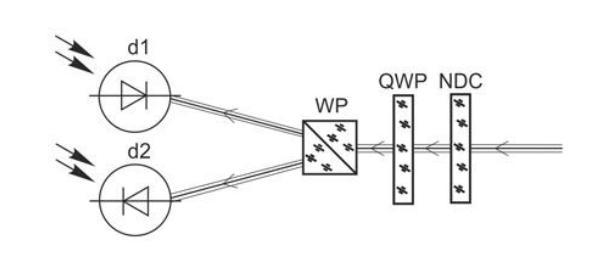




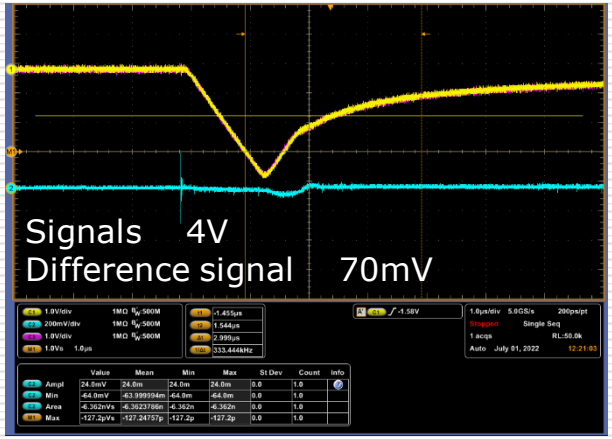
scheme of the THz spectrometer

Generation and detection of THz pulses based on nonlinear interaction of femtosecond pulses with various media are the basis of various THz time-domain spectrometers. This spectrometer is suitable for absorption spectroscopy in the 0.5 THz – 5 THz range.

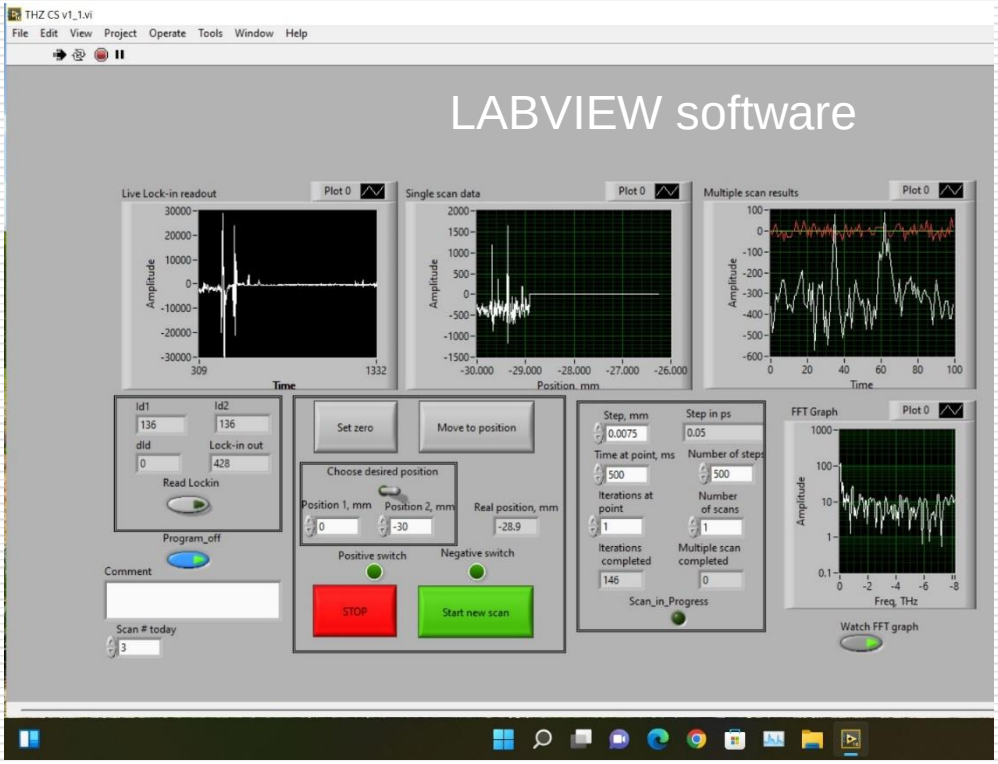
Detection part



detector



Balanced signals
on Oscilloscope



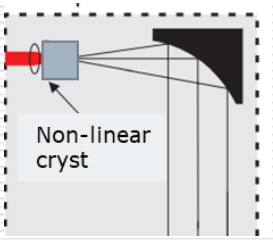
Main program

Laser-based THz generation techniques

Optical rectification

Optical rectification

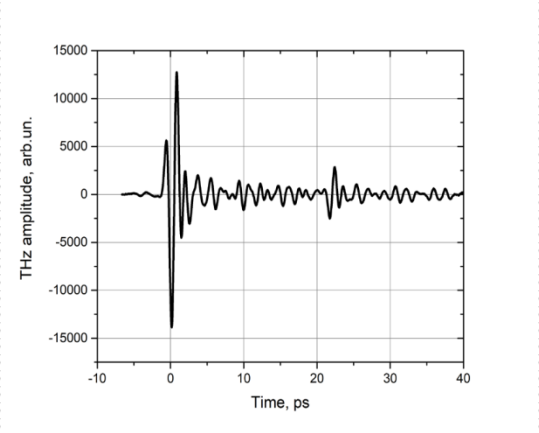
ZnTe, CdTe, LiNbO3 and other NL media



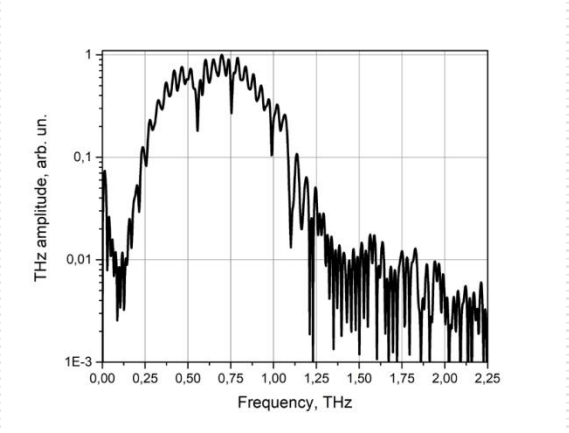
This process is a special case of difference-frequency generation.

Limitations

- *Damage threshold of the crystal*
- *requires precise alignments*
- *due to water vapor THz radiation is significantly attenuated during propagation in the air*



Time profile of emitted THz pulse



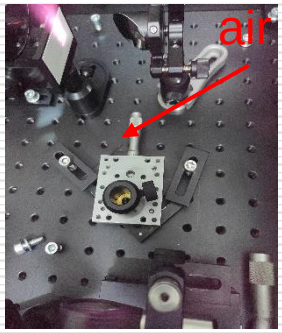
Amplitude spectrum of the THz pulse

Laser-based THz generation techniques

Emission from laser-generated air plasma

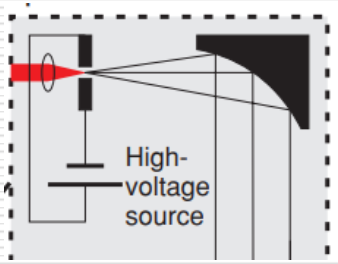
Ponderomotive force plasma emission

Emission due to the spatio-temporal intensity gradient within the plasma



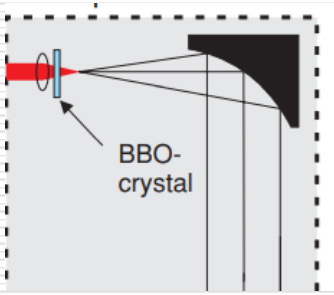
- **The biggest advantage of this method is the damage-free threshold.**
- High-energy pump pulses (several mJ) are usually required
- THz pulse energies of several nJ would be a good result with our laser

External dc bias



- Adding a biased electrostatic field to the plasma is increased the THz radiation intensity.
- the energy of the THz radiation can be in the order of tens of µJs

Opt. 2nd harmonic bias



The oscillating 2nd Harmonic field acts as AC-bias at the focal point to polarize the plasma.

Summary

Delay line setup was configured for creation of double pulses: as a result

- Time delay from 0 ps up to 50 ps
- Arbitrary pulse power contrast 1:1 to 1:300

THz spectrometer setup was developed and configured:

- Experiments of the THz generation are underway.

Thank you