RAPORT ŞTIINŢIFIC INTERMEDIAR

ETAPA DE EXECUTIE NR. 1

CU TITLUL: "Studiul arhitecturii sistemului utilizand analiza propagarii razelor in componentele optice"

Raportul ştiinţific intemediar va cuprinde următoarele documente:

1. Annual Summary Document (pentru ISAB ELI-RO) conform modelului din Anexa 1.A.
2. Indicatori de realizare intermediară, conform modelului din Anexa 1.B.
3. Proces verbal de avizare internă, conform modelului din Anexa 1.C.
4. Procese verbale de recepţie a lucrarilor de la parteneri – fără format impus.

ANEXA 1.A

Annual Summary Document Template

- Group list (physicists, staff, postdocs, students) of the IFIN/HH partner;

IFIN-HH
Senior Researchers Gheorghe Acbas (CS3), Mariana Bobeica (CS3)

- Specific scientific focus of group (state physics of subfield of focus and group's role);

IFIN-HH - *Ultrafast Laser spectroscopy, THz spectroscopy, Physics of Materials and Biophysics, Laser Spectroscopy, Experiments with High Power Lasers with Applications in Biophysics*.

In the first phase of the project, the IFIN-HH group worked on: (1) the evaluation of the technical design of the optical setup in the second region of the proposed design, (2) the CAD drawings of the echelon mirrors, (3) the simulation of the Laser beam transport based on the technical design, (4) the acquisition of the most important optical components for the setup required for the Terahertz spectroscopy, (5) the collaboration with the Japanese manufacturer who worked on the study of the technical feasibility of the echelon mirrors.

- Summary of accomplishments during the reporting period.

a) The completion of the technical design of the optical set-up for THz spectroscopy
b) The simulation of the Laser pulse propagation in polarizing optics
c) The numerical calculations for the estimation of the Laser beam intensity after reflection on all optical components.
d) The acquisition of the optical materials (crystals, parabolic mirrors, polarizers, achromatic quarter wave plate).

2. Scientific accomplishments (max. 3 pages) – Results obtained during the reporting period.

Introduction.

The purpose of the first stage of this project, is to establish the optimum design architecture of the optical setup and to validate the system using ray-tracing. The main requirement is the construction of the echelon mirrors that are the critical components of the instrumentation, which determine the requirements for all the other optical components.

We divided the instrumentation design in three regions:

1. The entrance optics for Laser probe beam, concerned with the Laser beam conditioning (expansion, chirp compensation and apodization).

2. The optics of the detection of tera-hertz (THz) radiation, made from the echelon mirrors, the focalization optics and the electro-optical crystals.

3. The detection system, made from the optics for the probe-beam transport and the CCD detectors.

For the first phase, we worked on the second region,that is the base part of the diagnostics system of the instrumentation. The last region of the detection system is based on the design of the second region. The first region depends on the properties of the Laser probe beam (the dimension, the divergence and pulse duration etc.) so it shall be flexible to allow for its change and adaptations to the different Laser systems that we plan to use.

Starting from the working plan we obtained the following results:

1) The construction of the CAD model of the echelon mirrors.

2) The validation of the system construction feasibility, with the Japanese manufacturer.

3) The simulation of the ray transport of the Laser beams and detection. Starting from this simulation we chose the optimum optical components.

Figure 1 presents the pair of echelon mirrors and their relative position in the optical setup.

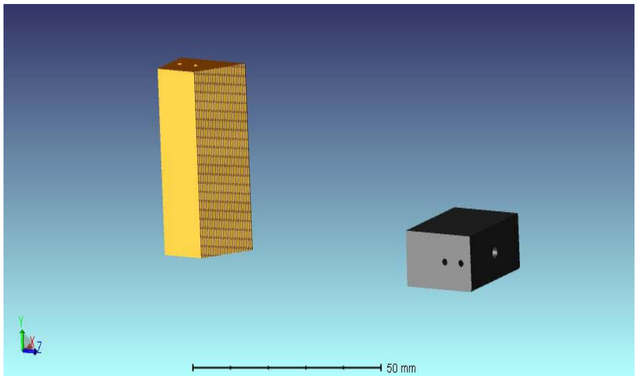
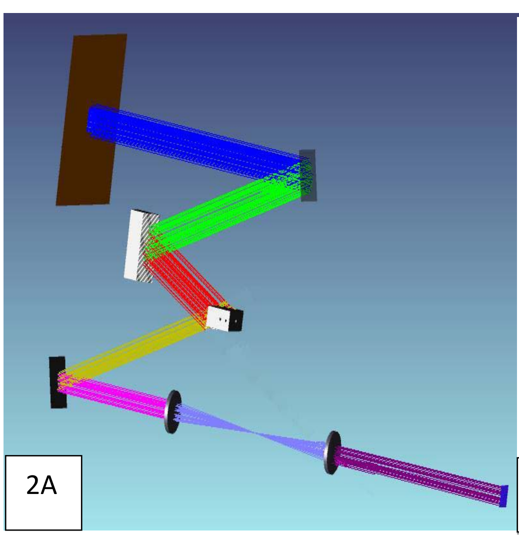


Figure 1. The pair of echelon mirrors. One mirror has 30 steps, 300 µm high and 400 µm wide. The other mirror has 30 steps of 10 µm height and 400 µm width. A Laser pulse, few femtoseconds long, that is reflected on the two mirrors will become an 2D array of 30x30 pulses, with temporal separation of 68 femtoseconds, that offers a temporal probing window of 61 picoseconds.

These mirrors are made from Nickel (Ni), coated with Gold (Au) on the reflecting surfaces. Ultra-precise technology is required for their construction, to assure the required surface planarity (<0.2 μm) and quality of the reflecting surfaces. The mirrors will be built by *Sodick Future Technologies Co Ltd*. from Japan. The Japanese company will validate the construction feasibility of the mirrors. We expect to get an official quotation, after obtaining the export clearance from the company's Legal Department. The pair of etalon mirrors does not only translate in space domain the temporal delay of the mini-beams, but has also the role of a two-dimensional diffraction grating. For this reason, the transport and focusing optics was chosen such that it reduces to a minimum the spectral dispersion and the optical distortions. The simulation of the ray-tracing is presented in figure 2A. To obtain the smallest focus point on the non-linear crystal and a clear, undistorted image on the CCD, we optimized the optical transport system using the software Zemax Optics Studio. The optical components from the focusing system and projection on the CCD were chosen from the optical catalogues. Figure 2B, presents the simulated signal obtained on the CCD detector, where only the coherent which suffers diffraction is considers. One observes that the 30x30 beamlets give a clear image for the entire area of the beam and the diffraction effects are evident on a limited number of pixels, at the intersection of the mini-beams.



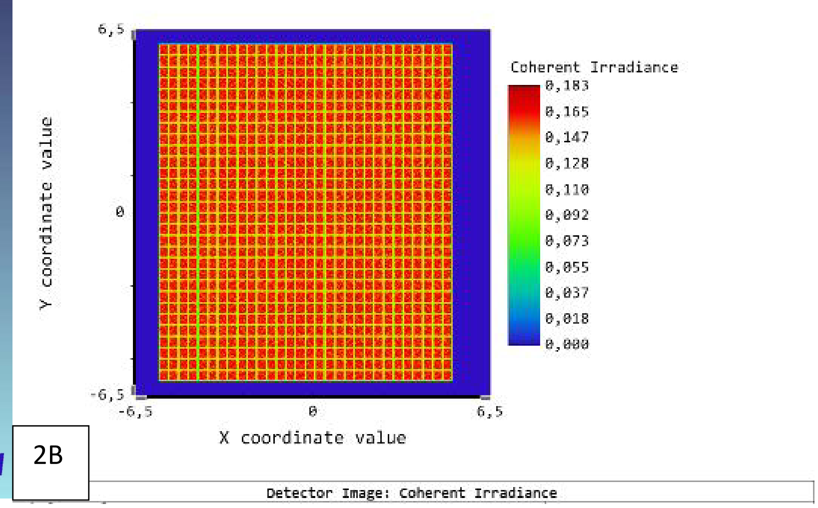


Figure 2A (left panel): The ray-tracing simulation: A Gaussian beam is collimated and truncated using a square slit, to obtain a sufficiently uniform beam along the transversal section that is slightly larger than the small echelon mirror. After its reflection on the echelon mirrors, the beam is passed through a 4-f optical system, that focuses the beam on the electro-optical crystal and then to project the beam on the CCD camera.

Figure 2B (right panel): The simulated image computed on a CCD camera with 2160 x 2160 pixels. Only the coherent part of the beam was used in the simulation.

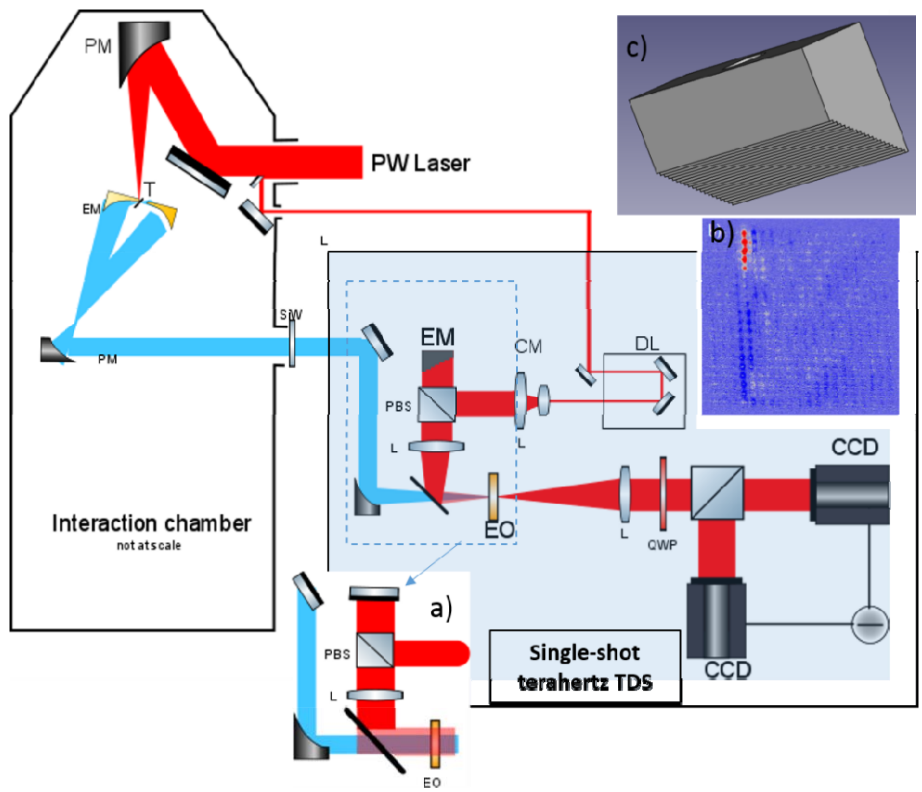


Figure 3. The optical system for the THz spectroscopy.

For the case of the simulated image on a CCD with 2160 X 2160 pixels, one temporal probe from the 900 probes, is projected on an area of 67 x 67 pixels, and the area affected by diffraction is less than 5 pixels. With the above CAD diagrams of the echelon mirrors that need to be built, we performed the simulation of the optics and of the detection systems based on these optical components and the optimum choice of focusing optics.