

**Call: ELI-RO/RDI/DEZ/DFG/2025**

**Project acronym: AMIPulse**

**ELI-NP Thematics:** LSD/I.4 High power lasers diagnostics; LSD/III.5 Artificial Intelligence (AI) for high power lasers; LSD/II.7 Temporal pulse control, Short pulses, Long pulses, Multiple pulses, Pulse shaping

**Annual Summary Document\***

**Year: 1**

Months: 1-2.

**Project Title:** Advanced Metrology of Intense Laser Pulses – AMIPulse

**Project Work Plan** (according to the contract)

**Stage: I. Contracting, technical design, purchase**

**Activities:**

- I.1. Contracting, project starting activities, conceptual design for instruments (CO)
- I.2. Create project web page; prepare the bibliography (CO+P)
- I.3. Technical Design of SRWS (CO)
- I.4. Acquisitions, assembly and preliminary testing of SRWS (CO) – Part I
- I.5. Technical Design of UFOS-FROG (CO)
- I.6. Acquisitions, assembly and preliminary testing of UFOS-FROG (CO) – Part I
- I.7. Technical Design of contrast measurements (CO)
- I.8. Acquisitions, assembly and preliminary testing of contrast measurements (CO) – Part I
- I.9. Acquisition and configuration workstation (P)

**Allocated budget:** 1 000 000 lei

**Realized budget:** 1 000 000 lei

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\* Please fill in all the required items and do not alter the template

1. Cover Page:

- Group list (physicists, staff, postdocs, students);

Name, Surname	Position within the project	Professional degree	Profession
<b>Project Coordinator IFIN-HH</b>			
Dan GH. MATEI	Project director	SR3	Physicist
Cristian ALEXE	Team member	Engineer	Engineer
Tiberiu COMAN	Team member	Physicist	Physicist
Ioan DĂNCUȘ	Key person	SR2	Physicist
Alice DUMITRU	Team member	Engineer	Engineer
Evgeny FILIPPOV	Key person	SR3	Physicist
Tiberius GEORGESCU	Key person	SR3	Physicist
Isabella GHÎȚĂ	Team member	Student	Technician
Alexandra GRIGORE	Team member	Engineer	Engineer
Emilia MATACHE	Team member	Student	Technician
Andrei NAZÎRU	Team member	Engineer	Engineer
Dmitrii NISTOR	Team member	Engineer	Engineer
Andrew OKUKURA	Team member	Physicist	Physicist
Vlad PLEȘANU	Team member	Engineer	Engineer
Ștefan POPA	Team member	Engineer	Engineer
Vlad POPESCU	Team member	Physicist	Physicist
Bianca PREOTEASA	Team member	Engineer	Engineer
Sergiu RUSNAC	Team member	Engineer	Engineer
Denis SANDU	Team member	Student	Technician
Daniel URSESCU	Key person	SR1	Physicist
<b>Partner INCDTIM</b>			
Katalin KOVÁCS	Project responsible	SR1 / R4	Physicist
Ana Maria Mihaela GHERMAN	Team member, key person	SR / R1	Chemical engineer
István Ferenc TÓTH	Team member, key person	SR3 / R2	Physicist
Zsuzsanna BALINT	Team member PhD student	ACS	Physicist
Valer TOȘA	Team member	SR1 / R4	Physicist

- Specific scientific focus of group (state physics of subfield of focus and group's role);  
 IFIN-HH group: non-linear optics, ultrafast technology, experimental setup: install and operate laser beam characterization setup both for spectrally resolved wave-front sensing and temporal characterization methods like FROG, D-scan setup. A novel type of temporal contrast measurement method and corresponding experimental design will be realized based on plasma-mirror FROG technique.  
 INCDTIM group: non-linear optics, modeling laser pulse creation, propagation, focusing, deformation in plasma medium; simulating autocorrelation traces (FROG and D-scan), creating AI tools for the interpretation of experimental measurements.
- Summary of accomplishments during the reporting period.  
 The project has started in 30 October 2025, and the first reporting period has a duration of only 2 months. During this short time interval we report on several important accomplishments:
  - The project contracting process has been completed successfully.
  - The acquisition process of all the IT equipment foreseen for partner INCDTIM has been completed successfully.
  - A kick-off meeting has been organized at ELI-NP with the participation of the full partner team and the key team members from the Coordinator site.
  - The project web page has been created.
  - The acquisition of equipment and materials for IFIN-HH has been initiated.

## 2. Scientific accomplishments – Results obtained during the reporting period.

In this first reporting period which comprised only 2 (two) months, we report on the following scientific accomplishments:

We organized a kick-off meeting during the 2<sup>nd</sup> and 3<sup>rd</sup> of December at the headquarters of the Coordinator at ELI-NP.

During the discussions we identified the methodology for performing the spectrally resolved wavefront sensing measurements. The single-shot measurements will be performed using a mosaic filter in front of the micro-lens array. The multi-shot measurements will be performed with a tunable band-pass filter where two continuously variable edge filters will be combined, while their relative displacement will be continuously tuned and controlled.

We have agreed upon the exact steps of the collaboration between the CO and P. Namely, in the first stage the support from the theoretical / simulation side will be to develop two complementary methods for spectrally resolved wavefront characterization: (1) develop the method where we know in a input plane the laser beam's [intensity and phase] as a pair of information, and calculate the same quantities in the focal plane. (2) Second, the Gerchberg-Saxton (GS) algorithm will be implemented, where the known quantities are the intensity distributions in two distinct planes (name them input and output). The two methods will be cross-checked. This way we propose to have a reliable computational tool for the interpretation and reconstruction of the experimentally measured wave-fronts.

During this first stage we identified several challenges to be solved, namely:

- the exact form of the transfer function for the ultrafast optical switch is not trivial to find;
- the separation of the reference pulse and the gating pulse is a challenge because these are coupled / in convolution.

Concerning the temporal pulse characterization, especially the plasma-mirror FROG (PM-FROG) technique for the temporal contrast measurements, we identified and studied the most recent relevant bibliography.

1. The basic paper we rely on is this: High-Repetition-Rate Targets for Plasma Mirror FROG on Chirped Picosecond Pulses, by Stefan Popa et al. Photonics 12, 533 (2025), where the proof of concept of an ultrafast optical switch based on water pellicle is presented.

Further, the known methods have been investigated, namely the INSIGHT and IMPALA. The relevant studied publications for these are:

2. INSIGHT: Spatio-spectral metrology at focus of ultrashort lasers: a phase-retrieval approach , by A. BOROT and F. QUÉRÉ, Optics Express 26(20), 26444 (2018)

3. IMPALA: Simple few-shot method for spectrally resolving the wavefront of an ultrashort laser pulse, by S. Smartsev et al, Optics Letters 49(8), 1900 (2024)

Other reference papers studied are:

4. Frequency-resolved optical gating for characterization of VUV pulses using ultrafast plasma mirror switching, by Ryuji Itakura et al in Optics Express 23(9), 10914 (2015)

5. Plasma-mirror frequency-resolved optical gating for simultaneous retrieval of a chirped vacuum-ultraviolet waveform and time-dependent reflectivity, by Ryuji Itakura et al. in High Power Laser Science and Engineering, (2016), Vol. 4, e18, 5 pages.

6. Survey of spatio-temporal couplings throughout high-power ultrashort lasers, by A. JEANDET et al in Optics Express Vol. 30, No. 3 / 31 Jan 2022 / Optics Express 3262.

The web page of the project with the essential public information has been designed and is available at <https://www.nipne.ro/proiecte/pn4/projects.html>, section AMIPulse

### 3. Group members (table):

- List each member, his/her role in project and the Full Time Equivalent (FTE) time in project. The FTE formula to be used is:  $FTE = \text{Total number of worked hours} / \text{Total number of hours per reporting period}^\dagger$ ;

Name, Surname	Position within the project	Full-time equivalent	Profession
<b>Project coordinator IFIN-HH</b>			
Dan G. MATEI	Project director	0.09	Physicist
Daniel URSESCU	Key person	0.003	Physicist
Ioan DĂNCUȘ	Key person	0	Physicist
Evgeny FILIPPOV	Key person	0.1	Physicist
Tiberius GEORGESCU	Key person	0.102	Physicist
Cristian ALEXE	PhD student	0.024	Engineer
Tiberiu COMAN	Student	0.03	Student
Alice DUMITRU	PhD student	0.024	Engineer
Isabella GHITĂ	Student	0.014	Student
Alexandra GRIGORE	Team member	0.032	Engineer
Emilia MATACHE	Student	0.027	Student
Andrei NAZÎRU	PhD student	0.032	Engineer
Dmitrii NISTOR	PhD student	0.041	Engineer
Andrew OKUKURA	PhD student	0.022	Physicist
Vlad PLEȘANU	Team member	0.028	Engineer
Ștefan POPA	PhD student	0.046	Engineer
Vlad POPESCU	PhD student	0.022	Physicist
Bianca PREOTEASA	Team member	0.028	Engineer
Sergiu RUSNAC	Team member	0.044	Engineer
Denis SANDU	Student	0.031	Student
<b>Project Partner INCDTIM</b>			
Katalin KOVÁCS	Project responsible	0.151	Physicist
Ana Maria Mihaela GHERMAN	Team member	0.151	Chemical Engineer
István Ferenc TÓTH	Key person	0.149	Physicist
Zsuzsánna BÁLINT	PhD student	0.161	Physicist
Valer TOȘA	Team member	0.104	Physicist

List PhD/Master students and current position/job in the institution.

IFIN-HH team: PhD students: Cristian ALEXE, engineer; Alice DUMITRU, engineer; Andrei NAZÎRU, engineer; Dmitrii NISTOR, engineer; Andrew OKUKURA, physicist; Ștefan POPA, engineer; Vlad POPESCU, physicist;

Zsuzsánna BÁLINT, PhD student, INCDTIM team, scientific research assistant ACS.

### 4. Deliverables in the last year related to the project:

- List of papers (journal or conference proceeding);
- List of talks of group members (title, conference or meeting, date);
- Other deliverables (patents, books etc.).

<sup>†</sup> Total number of hours (for a certain period) = 170 average monthly hours x number of months (e.g., for a full year: 170 hours/month x 12 months = 2040 hours)

The project webpage is available at: <https://www.nipne.ro/proiecte/pn4/projects.html>, section AMIPulse

5. Further group activities (max. 1 page):

- Collaborations, education, outreach.

6. Financial Report (budget usage) for the reporting period (see the Annex).

7. Research plan and goals for the next year.

In the following year, most of the purchases of equipments and materials for the spectrally resolved wavefront sensor (SRWS) and the FROG device built with an ultra-fast optical switch (UFOS) will be finalized.

In what concerns the SRWS, in the first part of the year we will concentrate on the design of the mosaic spectral filter that will be a key component of the SRWS. We expect a lead time of several months, therefore we will have early discussions with several manufacturers, locally and abroad, for determining the best method for production and testing of the filter. In parallel, we will finalize the design for the multi-shot SRWS that uses linearly-variable edge filters, and we expect to conduct initial measurements in the Optics Laboratory of ELI-NP. The data will be provided to the partner INCDTIM for defining the starting conditions for the numerical simulations in the focus of the laser field.

For the UFOS-FROG, we will begin by setting-up the liquid pellicle with the equipment that was purchased this year, and we will determine the optimal parameters for producing a stable pellicle. In the same time, we will finalize the optical set-up for the intersecting line foci. We expect to purchase in the first part of the year the imaging spectrometer required for getting the spectrograms obtained after the interaction of the two ultra-short pulses on the liquid pellicle.

On the numerical simulations and AI software side, the partners at INCDTIM will study the influence of the transfer function used to model the switching behaviour of the liquid pellicle reflectivity.