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DELIVERABLE 5.4

Annual report on implementation of access pilots

- for project months M14-M25 -

Work Package #	5
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Abstract:

This document presents the activities and status of tasks 5.3, 5.4 and 5.5 of IMPULSE for the months 14-25 (December 2021 to November 2022) of the project towards implementation of Access pilot and flagship experiments at the ELI facilities.

IMPULSE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871161.

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
ELI	Extreme Light Infrastructure
ELI-ALPS	ELI Attosecond Light Pulse Source Facility
ELI-BL	ELI Beamlines Facility
ELI-NP	ELI Nuclear Physics Facility
ELI ERIC	ELI European Research Infrastructure Consortium
ISTAC	International scientific technical advisory committee
SFL	Short-focal length
LFL	Long-focal length
CAI	Collective autoionization
ELIMAIA	ELI Multidisciplinary Applications of laser-Ion Acceleration
FLAIM	Flash and ultrahigh dose-rate radiobiology with Laser Accelerated Ions for Medical research
PBCT	Proton boron capture therapy
STC	Scientific and Technical Council
HPLS	High-Power Laser System
LDED	Laser-Driven Experiments Department
VEGA	Variable Energy GammA
GDED	Gamma-Driven Experiments Department
PIC	Project Internal Contact
XUV	Extreme ultraviolet
TPDI	Two-photon double ionization of helium

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1 Introduction

1.1 General aims for the Access pilots

The objective of WP5 is to implement common standards and practices in all areas related to the performance of user access to support the development of ELI as the most advanced user facility in the world in the field of laser-driven science.

Tasks 5.3 to 5.5 are directly supporting this ambition, foreseeing the identification, preparation, and performance of experiments at the three ELI Facilities aiming at demonstrating 1/ the capacity of ELI to deliver best-in-class access conditions, but also 2/ the unique capabilities of the Facilities enabling high-impact science.

During the first year of the IMPULSE project, it has been agreed that two main categories of experiments are to be performed within the framework of IMPULSE, to tackle the above-mentioned aims:

- *Flagship experiments*, aiming at demonstrating to the user community the capacity of ELI to deliver high-impact scientific experiments;
- *Access Pilot experiments*, aiming at testing and demonstrating the capacity of the Facilities to deliver access and run systems on a routine, reliable basis and thus deliver best-in-class access quality.

1.2 Status after the first year of the IMPULSE project

To ensure a common approach to the three tasks 5.3, 5.4 and 5.5, periodic joint meetings were held, with the participation of ELI ERIC representatives and of the task leaders nominated from each facility: D. Charalambidis (ELI-ALPS) for T5.3T.M. Jeong (ELI Beamlines) for T5.4, and D. Doria (ELI-NP) for T5.5.

It has been agreed that the selection of the flagship experiments will be done in a transparent manner individually at each facility, and the selection of the topics was nearing completion at the date of the previous D5.4 Annual report (Nov 2021).

During the first year of the IMPULSE project, the following principles were agreed upon regarding the selection of the flagship experiments:

- The ELI Facilities are ultimately in charge of selecting the proposals;
- The ELI ERIC ISTAC will be consulted on a regular basis to provide strategic advice and recommendations on prioritisation of the proposals. Strictly speaking, the ISTAC will not act as a peer-review committee, but should endorse the proposals by confirming their relevance and high-impact potential;
- The selection process has to be transparent and open to leading user groups. There should be sufficient openness to the user community in putting proposals together.

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Also, during the first year of the IMPULSE project, it was decided that the Access pilot experiments, to be tracked in detail to assess the readiness of the user access workflow and procedures, would be selected among the commissioning experiments involving external expert users (collaborators) and the experiments proposed in the open User calls that are approved following the procedures developed within IMPULSE. At the time of the previous Annual report, the exact date/period for the first ELI ERIC User access call was not yet fixed. All three facilities had ongoing commissioning experiments involving external experts, and ELI ALPS have also had calls for users to assist with commissioning experiments.

The following sections provide the summary of the decisions and activities taken regarding the preparation of the flagship and access pilot experiments during M14-25 of the IMPULSE project.

2 Flagship experiments

2.1 Definition, selection procedure and preparations

Flagship experiments are 'pilot experiments' aiming at demonstrating to the user community the unique capabilities of ELI and its capacity to enable and deliver high-impact experiments.

A short description template was discussed in the T5.3-5.5 joint meetings and then circulated and filled by each Facility with information on the proposed flagship experiment topics in order to gather data to be presented to the ELI ISTAC meeting in December 2021.

The general plans and topical areas for the flagship experiments were shown by the task leaders for each of the ELI facilities in the joint meetings starting in the first year of the project, followed by regular updates on the preparation status. The selection procedures themselves were described in detail in a document finalized in August 2022, upon request of the IMPULSE Steering board (attached to this report as *Annex 1 – "The Selection Process of the IMPULSE Flagship Experiments"*).

More information on the progress during the reported period (M14-25) of the preparations of flagship experiments can be found in the sections below, split between the individual tasks 5.3-5.5 devoted to each of the three ELI facilities. Much of this information can also be retrieved in the content of the report for *Milestone 59 - Phase 2 of the Flagship experiments roadmap achieved*, due in the end of October 2022 (project M24).

A scientific workshop was proposed, with participation from all three ELI facilities, starting from the idea of fostering collaboration between the facilities for the flagship experiments. In September 2022 it was decided that the common preparatory workshop would take place as a satellite meeting of the 2nd IMPULSE Annual Meeting, during the week of November 7-11, 2022. However, following further discussions and recent developments, the workshop was replaced by a review meeting with participation of the management of ELI ERIC and the ELI facilities to be held in conjunction with the IMPULSE Annual meeting. This meeting aims

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to bring together the (scientific) management of the three facilities in order to agree on a concrete commitment towards the performance of the IMPULSE flagship experiments during 2023 and until the end of the IMPULSE project.

2.2 Flagship experiments at ELI-ALPS (Task 5.3)

During the first year of the IMPULSE project, the Scientific Board of ELI ALPS selected two Flagship projects: the "Investigation of correlated electronic dynamics by nonlinear attosecond spectroscopy" (NONLINEARATTO) and the "Time- and Spin-Resolved Momentum Microscopy (TSRMM)". The PI and the performing team and workplan have been identified for both experiments.

The main objective of the **project "NONLINEARATTO"** is the investigation of electronic correlation in simple quantum systems, such as atoms and small molecules by nonlinear spectroscopy in the extreme ultraviolet (XUV) spectral range. The experiments will be based on a new photoelectron/photoion setup for coincidence spectroscopy (Reaction Microscope: REMI) combined with a focusing unit (ellipsoidal mirror) – see Fig. 1. The project, led as PI by Prof. Giuseppe Sansone from the University of Freiburg, will be implemented in the framework of a collaboration between colleagues from MPI für Kernphysik, Heidelberg, University of Freiburg, FORTH and ELI-ALPS.

The project has the following objectives:

a. Characterization of trains and isolated attosecond pulses: comparison between XUV-IR cross correlation and XUV nonlinear autocorrelation techniques
b. Two-photon double ionization of helium (TPDI)
c. XUV-pump-XUV probe attosecond spectroscopy in molecules.

The workplan has been agreed and assumed by the experimental team and collaborators. The first three tasks of the workplan were completed in the end of September 2022 with colleagues from the University of Freiburg coming over to Szeged.

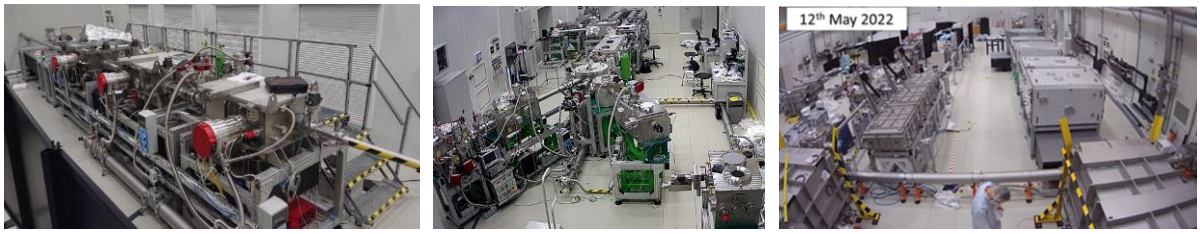

Fig 1 – HR driven 100 kHz gas high-harmonic generation beamline (left), SYLOS driven 1kHz gas high-harmonic generation beamline (centre), SYLOS driven high field interactions: area overview (right).

The **TSRMM project** includes experiments that are considered to challenge the full capabilities of the ELI ALPS surface science end station and its ultrafast, high-flux and repetition-rate light sources (see Fig. 2).

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The project, led as PI by Prof. Martin Aeschlimann from the University of Kaiserslautern, Germany, will be implemented by a collaboration of colleagues from the University of Kaiserslautern, the University of Göttingen, the University of Kiel and ELI ALPS.

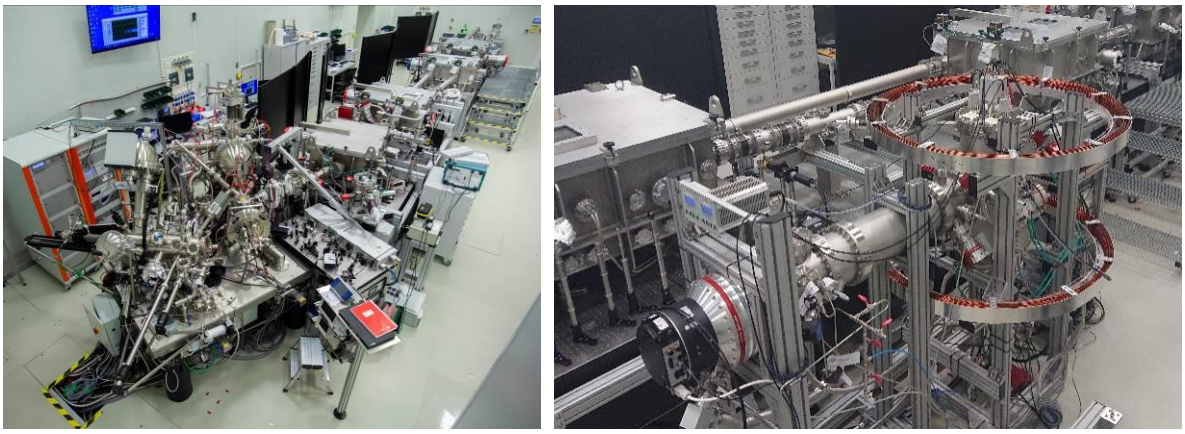

Fig 2 – The NanoEsca end-station coupled to the HR GHHG beamline(left), ReMI/Coltrims end-station (right).

The detailed structure of the activities on the main two sections of the TSRMM project, focusing on *Thin Cobalt film on Gold* and *Dysprosium-Gold surface alloy*, has been decided during the reported period.

Beamtime has already been allocated to the first part of the project TSRMM during the periods 20.06.2021 – 13.09.2021, 19.05.2022 – 20.07.2022 and 08.08.2022 – 29.08.2022.

Fig 3 – The HR Laser (left), the 2PW laser system (center and right right).

2.3 Flagship experiments at ELI Beamlines (Task 5.4)

Based on the available laser parameters expected in 2023, ELI Beamlines has identified three proposals (referred to as 'XUV tuning', 'Multi-LPI-P3', and 'FLAIM' in short) as flagship experiment topics, each of them showing scientific impact and uniqueness of the capabilities of the ELI Beamlines facility. These proposals were introduced to external users during the ELI Beamlines user workshop held in October 2021.

Below are short descriptions (summarized from the previous annual report) and presentations of the current status for each proposal.

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XUV tuning – "Studies of collective dynamics at the nanoscale using intense, tunable XUV pulses from High-Harmonic Generation"

For kHz applications ELI BL proposes in the E1 experimental area this flagship experiment, with associated pilot studies, on the development of the ability to tune the XUV output of the high intensity HHG source by tuning the wavelength of the drive laser (L1 Allegra) for applications in XUV/optical pump-probe experiments, including non-linear XUV-matter interactions. The experiment will be led by Professor Marcel Mudrich from Aarhus University as external PI.

The technical developments for the XUV tuning flagship experiment are progressing well. The core science topics to be addressed are related to "Resonant excitation to investigate collective autoionization (CAI) dynamics of multiply excited pure and doped helium nanodroplets".

A first trial experiment was performed in W24 and 25 of 2021. During this period the basic concepts for the proposed experiment were verified. A second experiment was performed in W44 and 45, 2021 as part of the ELI Beamline Call 2 of open access. During this beamtime proof-of-principle scientific data were obtained that are now being analysed and a first manuscript is under preparation. A third beamtime is expected in 2023. The scheduling of this beamtime is dependent on the scheduling of ELI Call 1 user experiments and the relative priority given to these two objectives. A fourth beamtime may be scheduled in late 2023 or early 2024 to collect complementary data if necessary, or investigate outlook developments if these appear very promising.

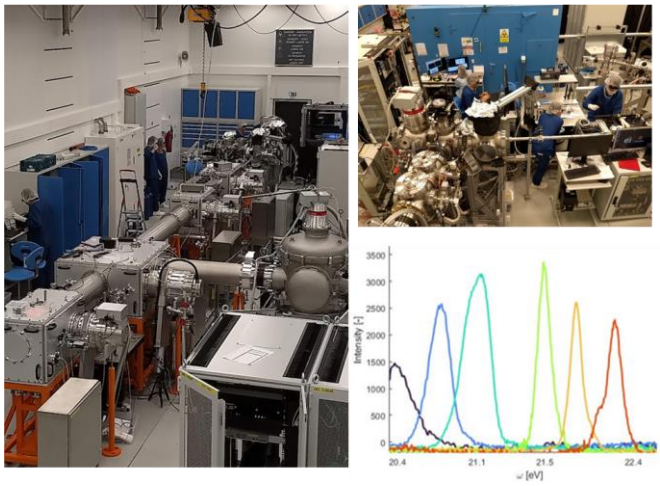

Fig. 4 – Left: The HHG source in ELI Beamlines Experimental hall E1. Top right: The MAC end station use for the XUV tuning experiments. Bottom right: Tuning results for the XUV beam around 21.5 eV

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Multi-LPI-P3 – "Probing dense laser-plasma with ultrafast X-rays and accelerated particles in the context of inertial confinement fusion and laboratory astrophysics"

The P3/E3 proposal is based on sophisticated pump-probe experiments using two synchronized beams to study compressed matter. High-power lasers allow to reproduce extreme states of matter in the laboratory under controlled conditions and study the temporal evolution on the micro- and meso-scale.

The beam time allocation and user calls greatly depend on the laser and facility status. It should be discussed after the final implementation of 10 PW L4 laser beamline and the reliable functionality test on relevant beam transports and diagnostics. Currently the preparation of this proposal is at discussion level with external experts, due to the technical challenge and requirement of high performance and reliable laser parameters.

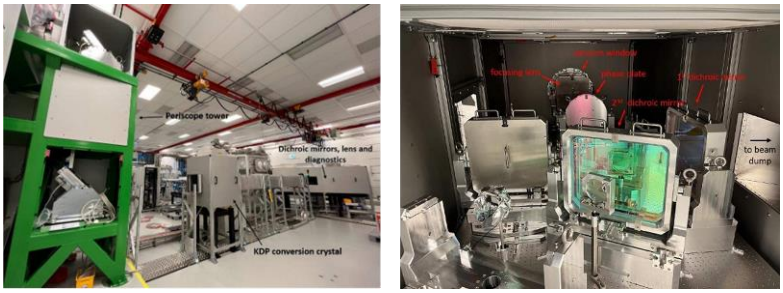

Fig 5 – Left: L4n beam transport and SHG chamber, Right: Dichroic mirror, Beam Diagnostics, Phase Plate beam homogenizer, and focusing lens for L4n beam. The synchronization between L3 and L4n beams has been tested.

FLAIM – "Flash and ultrahigh dose-rate radiobiology with Laser Accelerated Ions for Medical research"

Thanks to the cutting-edge technologies available at ELI-Beamlines, a unique (flagship) experiment in Flash and ultrahigh dose-rate radiobiology with Laser Accelerated Ions for Medical research (FLAIM) can be realized in the experimental hall E4 with the main goal to widen the use of the ELIMAIA beamline in the field of radiobiology and medicine.

The preparation of the flagship experiment requires several important and mandatory steps.

The advanced commissioning of the laser-plasma accelerator, planned in Q4 of 2022, will allow to evaluate the final ion beam parameters to be injected in the ELIMED section of the beamline. In the middle of 2023, the final beamline (including ELIMED) in E4 Hall will be commissioned, and the arrangement of FLAIM flagship experiment will be decided after that.

There will be a dedicated satellite meeting for this experiment during the *2022 ELI user workshop*. The output of the discussion is to agree on final technical requirements from the

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user consortium interested in supporting the preparation and execution of the FLAIM flagship experiment.

Fig 6 – Photo of the ELIMAIA beamline in E4. The main sections of the ELIMAIA beamline (Ion Accelerator and ELIMED) consist of different subsystems: (i) acceleration, collection and diagnostics; (ii) selection, transport and diagnostics; (iii) dosimetry and sample irradiation.

Most of the final stages of the flagship experimental campaigns at ELI Beamlines are planned in 2024. ELI-Beamlines is working on the beamtime plan for 2023 and some of the allocated time for "user assisted commissioning experiments" is intended as initial steps towards the flagship experiments. Both E3-P3 (L4n) and E4-ELIMAIA (L3) are currently offered for user assisted commissioning – the calls are open and published on the ELI-Beamlines webpage.

2.4 Flagship experiments at ELI-NP (Task 5.5)

The Scientific and Technical Council (STC) of ELI-NP has discussed and approved 2 Flagship experiments to be conducted with the High-Power Laser System (HPLS) in the 10PW experimental areas of the facility. The two other initially proposed flagship experiments, based on the VEGA gamma radiation beam, are no longer supported due to the fact that most probably their performance will not be possible by the end of the IMPULSE project.

The main Flagship experiment, "**Investigation of the generation of synchrotron-like radiation from laser-plasma interaction**", led by Domenico Doria from ELI-NP as PI, is about gamma flash generation via foam/aerogel targets, investigating the laser-to-gamma conversion efficiency of the energy and possibly the scaling law for laser powers between 1 and 10 PW. The second Flagship experiment, "**Stimulated emission of long-lived nuclear isomers via X-rays burst**", led by Petru Ghenuche / Klaus Spohr from ELI-NP as PI's, can be considered application/parasitic to the first one. Therefore, the two experiments are foreseen to happen at the same time. The experiment has been tentatively scheduled for March 2023, and it is anyhow likely to be performed during the first half of 2023.

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The implementation of the flagship experiments is in progress and involves different partnerships, among which Helmholtz-Zentrum Dresden-Rossendorf (HZDR) and General Atomics (GA).

In June 2022, as preparation for the 10 PW flagship experiment, an experimental campaign at the E5 area of ELI-NP (1 PW beam area) was carried out to assess the performance of the GA targets and investigate the interaction of the ELI-NP 1 PW laser pulses with these targets. The study had a twofold purpose: characterization of the targets in Target lab of ELI-NP for quality control and testing the performance of our 1 PW laser system.

Following the preparatory beamtime sessions to the time of the writing, improvements in the target fabrication and characteristics (contrast) of the laser pulses are expected to be implemented in the end of 2022 and beginning of 2023. The commissioning of equipment in the foreseen experimental area (E1) is in an advanced stage (see Fig. 4). A delay in the commissioning of the 10 PW focused pulses in the E1 experimental area may postpone the flagship experiment by a few months, but not later than June-July 2023.

Fig 7 – The ELI-NP E1 experimental area (top), Inside of vacuum chamber (bottom-left), and the completed solid target positioning system (bottom-right).

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2.5 Foreseen timeline

The foreseen timeline for the selection, preparation, implementation, performance and reporting of the Flagship experiments is the following:

- November 2022: Discussion and decision among the task leaders and the scientific directors of the ELI facilities regarding the organization of performance of the Flagship experiments; Detailed risk analysis;
- November 2022: Reporting the status of preparation of the proposed Flagship topics to the ELI ISTAC, who will provide feedback and management guidance for the implementation;
- 2023 (started in 2022): Performance of flagship experiments, partial data analysis;
- Jan-Apr 2024: Data consolidation and final reporting (*MS61 – Flagship experiments finalised*).

3 Access pilots

3.1 Categories definition and selection procedure

During the discussions in the first year of the IMPULSE project, the Access pilot category was considered to include two types of experiments: commissioning experiments and Open Access pilots. The *Commissioning experiments* were mainly focusing on testing and demonstrating technology readiness while *Open Access pilots* aim at testing the capacity of ELI to deliver the process of access itself.

However, the debates during the reported period (M14-25), when also the timing of the first ELI ERIC User call [1] became known, lead to the conclusion that it would make much more sense to have the Access pilot experiments selected exclusively among the successful beamtime proposals received from the users. The reasoning behind this conclusion is that for this type of access we have a common policy and workflow, developed within the IMPULSE project, and this allows tracking, evaluating and discussing the feedback of the user access in a common language between all ELI pillars. Moreover, it is very likely that within the timeframe of the IMPULSE project there will be at least one more user access call open by ELI ERIC, allowing also an evaluation of the evolution of our workflow and procedures for access, based on the feedback and improvements after the first call.

During the reported period, the activities within Tasks 5.1, 5.2 and 5.6 of IMPULSE WP5, reported in Deliverable 5.1 – Management procedures and workflows of user offices and access-related processes (due M13 but delayed), D5.2 – Conceptual design report for ELI ERIC user portal (due M18), and D5.5 – Detailed description of training measures and tools for users (due in M18), have lead to the completion of preparation of the first joint ELI ERIC Call for proposals [1], which was also joint by ELI-NP. This common call of the three facilities was opened in June 2022 and had a great success, 47 valid proposals being received from

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the prospective users in the scientific community. Technical committees at each facility evaluated the technical feasibility of the proposals, and currently the scientific peer-review is in progress. Beamtime will be allocated for the selected proposals until April 2023.

The first access pilot experiments will therefore be selected, at least one per facility, among the successful proposals in the first ELI ERIC Call for users [1].

The working group also takes into consideration to perform a comparative study between the user access before the common ELI ERIC workflow was established (e.g., the previous commissioning user calls open by ELI-ALPS, described in the section devoted to ELI-ALPS below) and the user access granted during the ELI ERIC common calls.

As mentioned above, the development for the user access has reached a level of maturity sufficient for finalizing a joint call for user access to the three ELI facilities. While the scientific evaluation of the proposals is performed by a single external committee of experts for ALPS and Beamlines, the technical and safety assessment procedure still needs to be harmonized between the facilities.

3.2 Open access pilot experiments at ELI ALPS

In July 2019 and November 2020 ELI ALPS has opened its 1st and 2nd **Commissioning User Calls** respectively. The main purpose of these calls was to engage the scientific community in the testing and the commissioning of the lasers and instruments through research. One further aim was to improve and validate the procedures set up for user facility operation. These two calls ware continuous calls and all projects underwent peer review through external evaluators, members of the established Review Panel of ELI ALPS. Submission of proposals was online through the ELI ALPS User Office entry point available on the ALPS website. Upon receiving a proposal, a local team was formed, which evaluated the project in terms of technical feasibility, safety and ethical maters. If deemed technically feasible, the proposal was sent to two external evaluators for peer review. The correspondence with the users and evaluators was kept through the ELI ALPS Users Office.

In the two commissioning calls, 23 user teams from 10 countries (CHN, DEN, GER, GRE, NED, BEL, SWE, SUI, FIN) and 8 user teams from Hungary have been hosted by ELI ALPS and more than 4200 user hours have been offered. In November 2021 the 3rd call was be published that included an enlarged pool of technologies that are now available at ELI ALPS.

Based on this extensive user access experience, it will be possible for ELI ALPS to make a comparative study between the user access in the previous commissioning calls and the access provided withing the 1st ELI ERIC call.

Currently, the proposals received by ELI ALPS in this call are in scientific evaluation process, the outcomes being soon due.

3.3 Open access pilot experiments at ELI Beamlines

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The scientific evaluation of the proposals received by ELI Beamlines during the 1st ELI ERIC call for users is ongoing, with the results due soon. ELI Beamlines will select among the successful proposals at least one experiment to be tracked as "open access pilot" within IMPULSE, to evaluate the access process for users. ELI Beamlines collaborates (including within IMPULSE WP5 Task 5.6) with ELI ALPS and ELI-NP for the improvement of the training courses, currently available online on the common User portal for the general (valid in all three facilities) aspects of safety (laser safety, radioprotection, and EHS). These will be extended with localized training courses by each facility.

3.4 Open access pilot experiments at ELI-NP

In the previous D5.4 Annual report, it was foreseen that a first ELI-NP open call for proposals would be started by mid-2022, with beamtime allocated from 2023. Fortunately, also due to the activities performed within IMPULSE WP5 which build links and synergies, IFIN-HH, the home institute of ELI-NP, was able to join ELI ERIC for the first User call, keeping the timing – in June 2022 the first common user proposals call of all three ELI facilities was open. With the unique entry point the ELI User Portal (specified and developed within IMPULSE T5.2) and following the common User access workflow (discussed and developed within IMPULSE T5.1), ELI-NP received 17 proposals, which were evaluated technically by an internal committee. Then, an external panel of experts (Program Advisory Committee, PAC) of ELI-NP completed the scientific evaluation of the proposals during a hybrid meeting held on October 3-4, 2022 in which also the PIs were invited to present and support their proposals.

Based on the PAC recommendations, a decision of the ELI-NP management regarding the actual allocation of beamtime and scheduling is due soon.

At least one of the approved experiments will be selected and tracked as "access pilot" within IMPULSE.

4 Conclusions

The three ELI Facilities have agreed, in the first year of IMPULSE, on a common methodology for the selection of access pilots and flagship experiments – participation of external expert users being foreseen in all these experiments.

During the reported period (months 14-25), the discussions on the benefits that may and should be drawn from the performance of the access pilot experiments have led to the conclusion that these should be selected out of the user-proposed experiments for which beamtime is awarded. The evaluation process of the proposals in the first ELI ERIC user call is ongoing at the time of the writing, so we expect that by the end of 2022 the Access pilot experiments will be selected for all three ELI facilities.

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The scientific topics of the flagship experiments have been identified, together with the performing teams, equipment involved at the facilities and external experts involved. The first evaluation of the risks and mitigation methods is ongoing, and preliminary results give confidence that the selected flagship projects are able to provide high-impact results at each of the ELI facilities within the lifetime of the IMPULSE project. All three ELI facilities have already estimated and proposed periods for allocating beamtime for these projects during 2022 and 2023 (some of the preparatory phases being already completed).

5 References

[1] 1st ELI Call for Users - https://up.eli-laser.eu/call/1st-eli-call-for-users-441745527

6 Annexes

Annex 1 – "The Selection Process of the IMPULSE Flagship Experiments"

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Annex 1

The Selection Process of the IMPULSE Flagship Experiments

Updated: August 8th, 2022

This document summarizes the steps undertaken in the selection process of the IMPULSE Flagship experiments at the ELI facilities, as it has been discussed and agreed in the WP5 joint meetings of Tasks 5.3-5.5, and then approved by the scientific management of each of the three facilities. The selection process had to take into consideration not only the excellent science case of the experiment, but also the time constraints related to the IMPULSE project and related reporting.

Selection process at ELI-ALPS

At ELI-ALPS, two projects have been selected to be implemented under the title of "Flagship experiments" within IMPULSE. These are:

1) "*Investigation of correlated electronic dynamics by nonlinear attosecond spectroscopy*" (**NONLINEARATTO**)" which is a collaborative project between the MPI für Kernphysik, Heidelberg, the Univ. of Freiburg, FORTH and ELI-ALPS.
and
2) "*Time- and Spin-Resolved Momentum Microscopy*" (**TSRMM**) which is a collaborative project between the Univ. of Kaiserslautern, the Univ. of Göttingen and ELI-ALPS.

ELI-ALPS decided that the selection of the projects should be done by the Scientific Board of ELI-ALPS. The Scientific Board discussed all possible options and concluded that the two above mentioned projects would be the flagship projects of ELI-ALPS. The decision was based on:

i) The international reputation of the implementing teams
ii) The scientific merit of the projects
iii) The promotion of the most unique capabilities of ELI-ALPS through these experiments.

Furthermore, both experiments have been presented at the user workshops of ELI-ALPS and international conferences and received notable recognition from the user community and world experts.

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As for i), the consortium of NONLINEARATTO consists of the teams (at MPI and Univ. Freiburg) of two of the worldwide most known scientists in using Reaction Microscope end-station at laser and FEL RIs investigating ultrafast dynamics, the team of colleagues at FORTH that have demonstrated for the first time nonlinear XUV phenomena induced by attosecond pulses as well as the first attosecond XUV-pump-XUV-probe experiments, and the team of ALPS that uniquely provides 1kHz rep rate intense attosecond pulses. The consortium of the TSRMM project consists of two of the most reputable colleagues in ultrafast surface science and the team of ELI-ALPS that operates the most advanced NanoEsca system in the world.

As for ii) both projects are at the very forefront of ultrafast phenomena in gas and condensed phase.

Concerning iii), ELI-ALPS offers a unique combination of high rep rate (1kHz), energetic attosecond pulses that allow for the implementation of kinematically complete coincidence experiments and a unique combination of ultrahigh rep rate (100kHz) attosecond pulses with the best NanoEsca system worldwide, also equipped with the most advanced spin filter. Both unique capabilities of ELI-ALPS are perfectly promoted by the two flagship projects.

Selection process at ELI Beamlines

In 2021, ELI Beamlines had an internal workshop and several follow-up meetings with department heads and chief scientists to collect ideas suitable for Flagship experiments under IMPULSE. After the scientific communication with external users, three topics had been selected for the Flagship experiments by the department heads and chief scientists in ELI Beamlines:

1) *"Studies of collective dynamics at the nanoscale using intense, tunable XUV pulses from High-Harmonic Generation"* (**XUV-tuning**)
2) *"Probing dense laser-plasma with ultrafast X-rays and accelerated particles in the context of inertial confinement fusion and laboratory astrophysics"* (**Multi-LPI-P3**)
3) *"Flash and ultrahigh dose-rate radiobiology with Laser Accelerated Ions for Medical research"* (**FLAIM**)

For the XUV Tuning experiment, the identification of the core external user contribution has been done through the following two main processes:

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- Discussions with representatives from the broader user community during user experiments performed within the framework of the first and second open access calls for experiments in ELI-Beamlines E1 experimental Hall (Call 1 and Call 2), as well as during the preparatory and follow-up phases to these experiments;
- Discussions with representatives from the broader user community during the 2021 ELI-Beamlines user workshop, as well as during the preparatory and follow up phases to that event.

For the Multi-LPI-P3, the selection of the external PI is based on world-recognition in the field of research and track-record expertise. It is based on long-standing collaboration between Dept. 89 and the external PI. The external partner has experience in high-power laser-plasma interaction in the context of High Energy Density Physics (HEDP). The research program of the external partner is perfectly adapted to P3-capabilities. Reliability and technical competences as well as originality of past research was a determining factor in the selection. The details of the flagship experiment (operation, targetry, and diagnostics) are expected to be sorted out in a dedicated workshop in the end of 2022/beginning of 2023.

For the FLAIM experiment, the identification of the user consortium was the result of numerous scientific discussions and past dedicated workshops with ELI potential users, which finally materialized during the ELIMAIA/ELIMED user workshop in October 2021, where there was a dedicated session on this experiment (laser driven ions for radiobiological studies). The core user groups were identified based on world-recognition in the field of laser-plasma ion acceleration and applications in radiobiology, along with their scientific track-records and technical expertise. The user consortium has drafted a short document after the workshop that was used to prepare the slides presented during the IMPULSE meetings. We aim at preparing a more extensive document immediately after an additional workshop to be organized in the near future with such core user groups who have already committed to collaborate both with manpower and specialized equipment during the FLAIM flagship experiment.

Selection process at ELI-NP

The two IMPULSE flagship experiments proposed by ELI-NP are:

1) *"Investigation of the generation of synchrotron-like radiation from laser-plasma interaction"*, aiming for the characterization of the gamma flash emitted from the laser-target interaction for different initial conditions and investigation of the scaling law of the conversion efficiency;

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2) *"Stimulated emission of long-lived nuclear isomers via X-rays burst"*, which is a Nuclear Physics application (the stimulation of long-lived nuclear isomers) of the gamma flash generated in the first experiment.

These two experiments will demonstrate the ability to provide great scientific results of the two facets of ELI-NP's unique infrastructure – reaching unprecedented intensities in the focus of ultra-short pulse lasers and the possibility to perform Nuclear Physics experiments based on the interaction between the laser pulses and targets.
At ELI-NP, internal discussions about the candidate experiments to be featured within IMPULSE project as Flagship experiments started in mid-2021, after the nomination of the task leader for T5.5.
The implementation of the ELI-NP project started, from the scientific point of view, more than a decade ago with a White book, developed by the international scientific community interested in the possibilities open by the new research infrastructure, which then evolved towards the Technical Design Reports (TDR) for the experiments. Among the experiments described in the TDRs (published in 2016), the International Scientific Advisory Board (ISAB) of ELI-NP helped selecting and endorsed the so-called "commissioning experiments", aiming to demonstrate the optimal operation of the laser and gamma beam, the experimental equipment and experimental areas of ELI-NP.
The commissioning experiments are of various degrees of complexity, among them being the ones which ISAB considers "flagship" – experiments of paramount importance to demonstrate the unique capabilities of ELI-NP. These have different timelines foreseen for implementation, depending on the gradual availability of the beams and equipment. These experiments became then, naturally, the candidates when prompted to select the IMPULSE flagship experiments.
Internal discussions were held at the department level and then the proposals were submitted for discussion in the Scientific and Technical Committee (STC) of ELI-NP. In these discussions, the most important factors for the selection were:

- The potential scientific impact of the experiment;
- Involvement of prestigious research teams (collaborators);
- The likelihood that the first (partial) results are available within the timeframe of IMPULSE;
- Risk analysis.

Two experiments based on high power lasers and two based on the high intensity gamma beam were selected, discussed in the IMPULSE T5.3-5.5 joint meetings and presented (together with the proposals of ELI-BL and ELI-ALPS) to the ELI ERIC International Scientific and Technical Advisory Committee (ISTAC) in December 2021. The ISTAC appreciated positively the proposed experiments and endorsed their selection among the IMPULSE flagship experiments.

However, in further discussions at ELI-NP it was concluded that due to the timeline of implementation and commissioning of the VEGA gamma beam system (foreseen to be

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completed in the end of 2023), there is a too high probability that the experiments based on this beam will not be performed within the timeframe of IMPULSE, so it was decided that only the two experiments based on the lasers would be kept as proposals from the ELI-NP pillar.

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