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About THRILL

The THRILL project deals with providing new schemes and devices for pushing forward the limits of research infrastructures (RI) of European relevance and ESFRI landmarks. To do so, the project partners have identified several technical bottlenecks in high-energy high-repetition-rate laser technology that prevent it from reaching the technical readiness level required to technically specify and build the needed devices, and guaranteeing sustainable and reliable operation of such laser beamlines at the partnering RIs. Advancing the technical readiness of these topics is strategically aligned with the long-term plans and evolution of the ESFRI landmarks FAIR, ELI (-BL) and Eu-XFEL, and RI APOLLON, bringing them to the next level of development and strengthening their leading position.

The project is focused and deliberately restricted to three enabling technologies, which require the most urgent efforts and timely attention by the community: high-energy high-repetition-rate amplification, high-energy beam transport and optical coating resilience for large optics. To reach our goals, the major activity within THRILL will be organized around producing several prototypes demonstrating a high level of technical readiness. Our proposal is addressing not yet explored technical bottlenecks – such as transport over long distances of large-aperture laser beams via relay imaging using all-reflective optics – and aims at proposing concrete steps to increase the performances and effectiveness of the industrial community through the co-development of advanced technologies up to prototyping in operational environments.

The project is not only pushing technology, it is also offering an outstanding opportunity to train a qualified work force for RIs and industry. With this in mind, the structure of THRILL promotes synergetic work, fast transfer to industry and integrated research activities at the European level. Access to the RIs will be granted as in-kind contribution.

1 Introduction

The Kick-off meeting for THRILL was planned as soon as possible after the project start, while making sure all management board members could attend after the New Year's break. For this reason, it took place on Jan. 16th 2023 (14:00 -16:00) as an online meeting with the management board members, administrative, technical and legal department staff of the partners.

During the 2-hour meeting the partners agreed to meet regularly during the start phase of the project:

- WP leaders were asked to have technical meetings.
- A technical overview meeting was organized to review the most urgent actions in the projects and review the deliverables due during the first reporting period. So far, no task sees any delay since the work programme has been decided.

As a consequence, the kick-off meeting report is rather the summary of many online meetings and discussions that occurred during the first two months of the project.

2 Progress of WP1&2

In terms of management, the project coordination has been busy with many administrative tasks usual to the start of an EU project. In addition, most tasks related to WP2 could be started swiftly after the recruitment of proper resources in February 2023 by LLE-AISBL/FVB-MBI.

- Consortium agreement

  The THRILL members agreed and signed, upon proposal of the coordinator, on a consortium agreement based on the DESCA model. During the negotiation phase, the agreement model had to be adapted to the partners and many partners made some change requests. Because of the large number and sometimes contradicting change requests, several discussion rounds had to be organized. The whole negotiation took nearly 4 months before the partners agreed on a common text.

- Grant amendment

  The partners agreed to move on with a first amendment to the grant agreement (GA) to include the University of Rochester, which could not participate in the first version of the GA because of technical issues that the partners could solve in the meantime. In addition, the changeover from FZU to ELI-ERIC for the administrative management of ELI Beamlines required this change to be formally included. Note that the partners concerned agreed in a meeting on March 3rd, that GSI will withhold pre-payment for ELI until the changeover is done.

- Website

  The web page preparation has started. The following domain has been reserved: www.thrill-project.eu. At the kick-off meeting, the next steps were presented: to decide on a content management system (Wordpress), find a Wordpress hosting provider as well as a suitable Wordpress theme. Images and texts from all partners were collected. Based on this, the website design process started, including the writing of texts, the selection of images and sketching of the website. A first version of the website will be online in March.

- THRILL Logo

  For the logo, all partners were asked to send in ideas. In a next step, a graphic designer is hired to design the logo and all partners get a vote on the selection of drafts the designer comes up with. As soon as the logo is final, the logo, fonts and colour scheme can be used for the preparation of the communication kit, including PowerPoint templates for slides and

posters as well as templates for brochures and flyers.

- Data management plan

  A procedure was presented for creating a data management plan (DMP) for the project, based on the DMPs of all partners. For this, in a first step, all partners were asked to nominate a contact person familiar with their data policy. In a next step, the contact persons were asked to send their data policies and/or DMPs of their organization. The process of collecting the DMPs is still ongoing.

- Communication tools

  In addition, internal communication tools will be developed further. These include right now:

  - GSI's cloud solution for internal data exchange: seafile server
  - email lists: It has been decided to set up email lists for internal communication.
  - communication guidelines for non-scientific communication

3 WP3 status and start report

The WP3 is a central work package that has a coordination role with the other technical work packages. The first immediate task here is the organization of a workshop with end users at the partner RIs to review their needs and make sure that the goals of the projects match these.

Task 3.1: The organizing committee informed the THRILL consortium about the pre-selected possible venues and dates for the end-user workshop, which will be collocated with the first General Assembly Meeting and the Industry-Board Meeting. The members of the consortium were asked to come forward with possible collisions of the proposed date and alternative suggestions for the venue. The scope of the end-user workshop is to invite potential users of the HEHRR lasers in particular in combination with EU-

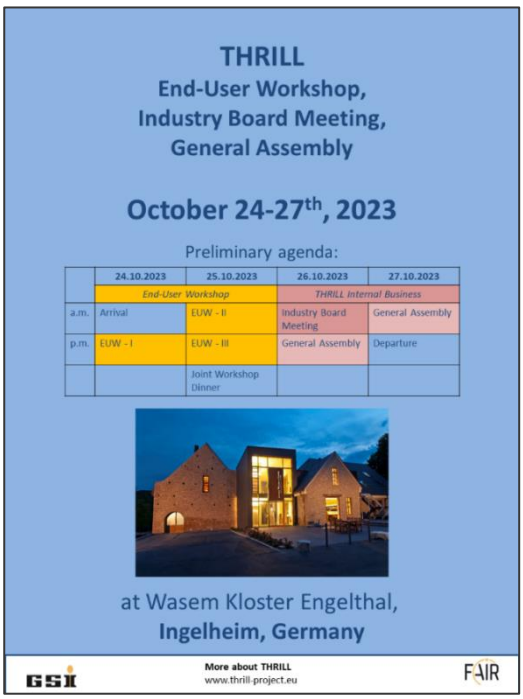

Figure 1 – Flyer for the end-user workshop and THRILL GA meeting

XFEL and FAIR in order to discuss what interesting physics directions will be explored in the future and what laser parameters are necessary in this respect. The workshop will conclude with design goals for the future laser systems at EU-XFEL and FAIR. The end-user board together with the management board will act as the program committee for this workshop. During the kick-off meeting, the consortium received a proposal from the task leader as far as the venue is concerned and the management board members received two weeks to voice concerns on the venue and date.

In the follow-up of the kick-off meeting, the venue was fixed to be Kloster Engelthal (Ingelheim, Germany) and the date of 24-27 October 2023 was agreed on. The first announcement with a rough schedule has been circulated (cf. Fig. 1).

4 WP4 status and start report

WP4 deals with technical developments shared among the partners on the topic of high-energy amplifiers.

Task 4.1: Performance tests of L4 ATON laser amplifiers

The work for this task will be carried out at ELI Beamlines and aims at getting a closer understanding of the critical parameters of the operation of the large-aperture ATON 180 and 300 mm amplifier systems. For this, the wavefront will be measured at the output of each amplifier stage with different cooling flows and shot repetition rates. Currently, the first measurement campaign is planned to finish by September 2023, and a 12-month postdoc position has been granted to S. Vyhlidka from the ATON laser team. The current schedule is in-line with the proposal as reminded from Figure 2.

WP4		2023												2024											
		Period 1												Period 2											
	calendar month	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
	project month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
4.1 Characterization and benchmarking ATON 180 and 300	180mm chain evaluation with different cooling rates and rep. rates									9															
	300mm chain evaluation with different cooling rates and rep. rates													10					4.1						

Figure 2 – Proposed schedule for the task 4.1 activities

Task 4.2: Development and characterization of a 200 mm diameter Pseudo-Active Mirror Disk Amplifier Module

All work will be carried out by Amplitude. Since the proposed amplifier is an up-scaled version of an already existing design, the simulations for gain deposition and cooling performance should be achievable in a few months, followed by the opto-mechanical design and the procurement of components. A fully characterized system is foreseen to be available by mid-2025, as shown in Figure 3. Most of the work will be carried out by Amplitude staff, and so far, no additional hiring is planned.

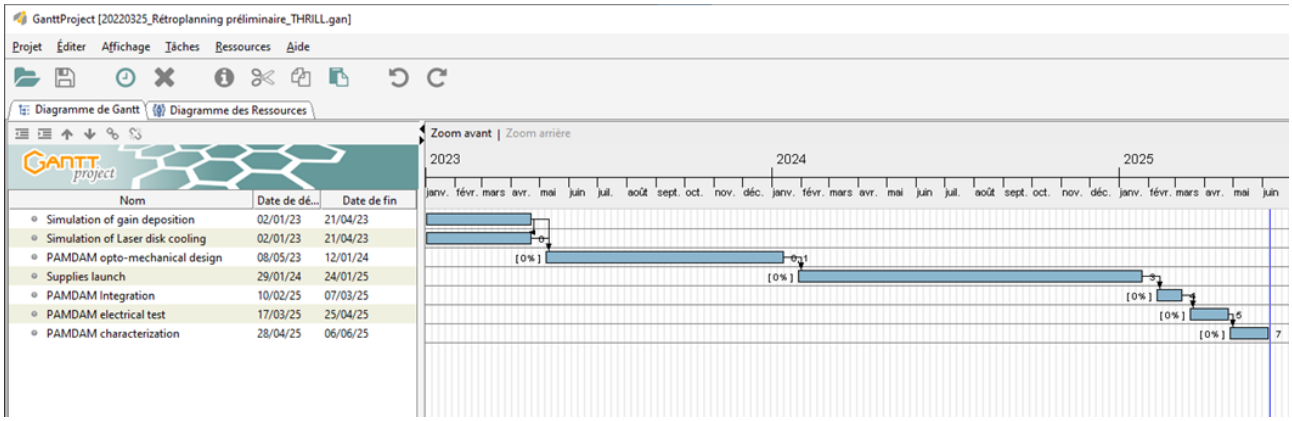

Figure 3 – Proposed schedule for the task 4.2 activities

Task 4.3: Exploration of other large-aperture amplifier concepts

The contributions on task 4.3 were preceded by preparatory discussions with the engineers and researchers contributing to this task. Two sub-tasks, the development of a cooled amplifier housing and the development of a cooled amplifier glass module, have been started years before the THRILL project because of the need for HEHRR amplifiers for several applications at GSI. This greatly facilitates the start of these tasks, and the additional resources (especially work force) will enable a faster progress. A prototype of the cooled amplifier housing will be ready for testing within a few weeks, and the infrastructure (pulsed power as well as a measurement of the amplifier gain with conventional PHELIX laser glass discs) is under preparation in the nhelix2 laboratory at GSI. In addition to the gain measurement, an in-situ measurement of the pump light within the housing at the position of the amplifier glass discs is under preparation.

Work on the cooled glass module is planned to resume soon with the development for a list of required changes on the existing prototype, which will enable further tests.

Both sub-projects will profit from a higher degree of structuring in the form of well-defined

requirements like, e.g., target values for different measurable parameters and system properties. One post-doc (M. Metternich) has been hired for task 4.3 with a contract starting in March 2023, and the possibilities for hiring a CAD/DMU engineer are in discussion with GSI's construction department.

5 WP5 status and start report

The aim is designing and demonstrating beam transport concepts for maintaining good beam quality in large aperture beams throughout the entire system using techniques like relay imaging, active stabilization, machine learning. The work package is divided in 4 tasks:

- Task 5.1 Near Field quality improvement
- Task 5.2 Far Field Stabilization and Control
- Task 5.3 Software AO Integration
- Task 5.4 Machine Learning

The January 6th and March 16th meetings discussed organization and planning. GSI hired a post doc starting March 1st for THRILL WP5. The work will focus on tasks 5.1 and 5.2 at first, and no significant work will happen for tasks 5.3 and 5.4 in the first 12 months. Development started, final material needs are under definition within the team. There are no official milestones / deliverables within the first 12 months.

Task 5.1: Near field quality improvement

Long distance beam propagation in ultrahigh intensity lasers results in serious limitations on the fluence repartition, which is a quantitative measurement of the beam quality. A design for a telescope with reflective optics is ongoing. The integration of this telescope in the Apollon chain is planned to be done end of 2023. Contact to different suppliers for reflective optics are ongoing before launching the public tender hopefully in the next months.

Task 5.2: Far Field Stabilization and Control

For active beam stabilization, the development of the Real-Time Adaptive Optics (RTAO) system has advanced in several aspects: We selected a vendor for a suitable Deformable Mirror (DM) via a public tender and recently purchased the DM. We finalized the assembly of the high-speed wavefront sensor and the Real-Time Computer (RTC) and took part in an in-depth training for the RTAO software "cacao". With this knowledge, we started programming both interfaces to our hardware as

well as evaluation routines to integrate our system with cacao. We allocated laboratory space for the RTAO test bench and started planning the setup.

Concerning the integration of the system at Apollon: We performed injection tests for the witness beam and purchased a suitable light source based on our findings. The planning for the imaging system prior to the 1 PW compressor is advancing and we are entering the design phase in the next weeks.

Tasks 5.4: Machine Learning

The immediate goal of this task is to define an open data-format standard and corresponding acquisition workflow in collaboration with Amplitude.

6 WP6 Kickoff

The main mission of this work package is to develop coatings for sufficiently large apertures necessary for high-energy lasers with high repetition rates. Indeed very large mirrors and electro-optic switching devices ubiquitous to HEHRR lasers require such coatings. In order to ensure sufficiently high damage thresholds of the coatings, LIDT testing will complement the coating activity. The work is effectively divided into 3 tasks as follows:

- Large Area Coatings
- ITO conductive coatings
- LIDT characterization and metrology

Task 6.1: Large Area Coatings

The planning for the ELIAS coating system activation for the first year of the project was presented and discussed. The arrival of the ELIAS vessel is scheduled for autumn 2023 and shortly before that the internal equipment should arrive from the US supplier. The chamber will be equipped for deposition with electron beam evaporation (EBD) systems and resistive evaporation for some metals. Preparatory works have to be done in the meantime, namely the distribution of gasses, cooling circuits, primary vacuum. Additional cryopumps have to be ordered as well as vacuum valves. The ELI team started the necessary procurement procedures for the key items. The laboratory with cleanroom space was prepared.

The initial part of the task (subtask 6.1a) covers the plasma ion source. The presence of the ion

source is imperative when EBD is applied on large area coatings to avoid crazing of surfaces due to large surface stress buildup.

The design and procurement of the ion source prototype was discussed. The largest currently available source on the market is not sufficient in size and maximum power; therefore a new prototype must be realized. However, it was agreed that the Pre-Commercial Procurement initially foreseen for the source is not suitable or even cost effective for this case. For example, it would probably be impossible to secure 2 bids for the PCP process. The procurement of the prototype will proceed using standard procedures.

The related engineering position will be filled during the year before the major systems arrive (ELI).

Task 6.2: ITO conductive coatings

The scope of the task is to develop high damage threshold coatings for electro-optical switching systems. The only currently available crystal at sufficient size and bulk damage threshold is KDP. The longitudinal field will be created by applying a pulse to a transparent conductive coating.

The coating design will be developed and produced including the electrical contacts in collaboration with industrial partners. The detailed analysis of the coating performance will be done by HZDR. The key parameters to be measured will be Transmittance and Reflectance spectra, Group Delay Dispersion, Polarization contrast or e.g. Conductivity.

Task 6.3: LIDT characterization and metrology

Laser Induced Damage Threshold testing will support both tasks 6.1 and 6.2. Ultrafast coatings will be tested within the high vacuum LIDT test setup in ELI with ultrashort as well as nanosecond pulses. The ITO coatings will be tested with help of institutional/industrial partners and potentially verified also in ELI.

The ELI LIDT station has to be upgraded to handle larger number of samples that will be coming from the ELIAS coating system. The schedule of the upgrade is outlined below (Figure 4). Several components have been already received and the design of the new setup has started. The position of the LIDT physicist was filled on 1/3/2023 by Adrien Chauvin.

			2023											
WP6	**calendar month**		1	2	3	4	5	6	7	8	9	10	11	12
	project month		1	2	3	4	5	6	7	8	9	10	11	12
6.3 LIDT testing	LIDT upgr. Design	ELI												
	manufacturing of mechanics	ELI												
	new LIDT controls	ELI												
	integration and tests	ELI												
	Milestone report MS5	ELI											5	

Figure 4 – work plan in 2023 for task 6.3

7 New hires

One of the ambitions of THRILL is training of the next generation of scientists. The kick-off meeting addressed the topic of hiring, which could be problematic in a job market that is booming. The management board agreed to pool information about hiring opportunities and possible candidates. The status of new hiring is the following:

Task	**Type of position**	**status**
WP2	Communication manager	Recruiting procedure finished – new hire started 01. Feb.
3.2a		In progress – position advertised
3.3	PhD student	Candidate found – start in fall 2023
3.4	Postdoc	Recruiting procedure finished – new hire starts 01. April
4.1	Postdoc	Internal job advertisement – candidate started 01. January
4.3	Postdoc	Recruiting procedure finished – new hire started 01. March
5.1 & 5.2	Postdoc	Recruiting procedure finished – new hire started 01. March
6.1	Engineer	In planning for fall 2023
6.3	Physicist	Recruiting procedure finished – new hire started 01. March