



Joint INRS–ELI PhD Program
Advanced laser-driven science and technology
Call for Applicants

Program Highlights

- Access to world-class laser facilities in Europe and Canada
- International research mobility
- Joint PhD supervision by INRS and ELI facilities scientists
- Financial support covering PhD program tuition and fees at INRS, living and mobility expenses (up to four years).

About the Program

Institut national de la recherche scientifique (INRS, Canada) and *Extreme Light Infrastructure ERIC* (ELI) invite applicants for a joint PhD program in advanced laser-driven science and technology.

This unique program combines world-class laser infrastructures in Canada and Europe with strong international mobility. PhD students enrolled at INRS will conduct a significant portion of their doctoral research at ELI facilities (ELI ALPS in Hungary and/or ELI Beamlines in the Czech Republic). The program offers competitive fellowships covering tuition, living expenses, and international research mobility for up to four years.

[INRS](#) is a leading Canadian graduate-level research university in Quebec, exclusively focused on interdisciplinary fundamental and applied research and advanced training across strategic areas such as energy, materials and telecommunications, environment, urbanization and health.

INRS hosts [Advanced Laser Light Laboratory \(ALLS\)](#) a unique national laser-based infrastructure providing a coherent rainbow of light and cutting-edge end-stations to its users. ALLS is a home to most powerful laser in Canada with 750 TW and high repetition rate laser systems to explore novel phenomena in matter with ultrafast tools.

[ELI](#) is a pan-European research infrastructure and consortium hosting some of the world's most powerful and advanced high-power, high-repetition-rate laser systems.



[ELI ALPS](#) in Szeged, Hungary, is a world leading ultrafast photon facility dedicated to generating attosecond-scale bursts of light across a broad spectrum (from terahertz to X-ray frequencies), allowing researchers to probe and control electronic and molecular dynamics at unprecedented temporal resolution.

[ELI Beamlines](#) in Dolní Břežany (near Prague), Czech Republic, is a world leading laser research center operating advanced high-power femtosecond laser systems and secondary radiation and particle sources for multidisciplinary science, from high-field physics and plasma studies to applications in materials science, biology and medical research.

Main Research Topics/Projects

1. Development of High-Power Laser Technologies
2. Ultrafast Molecular Dynamics Imaging
3. High-Field THz Science and Applications
4. Advanced Characterization and Control of Quantum Materials
5. Enhancement of Betatron X-Ray Radiation from Laser–Plasma Accelerators
6. High-Intensity Laser–Matter Interaction and Laser-Driven Nuclear Reactions

Information on research topics and supervisors is attached to the Call. Applicants must select a research topic when applying.

Eligibility

- Master’s degree in physics, engineering, optics/photonics, or a related field
- Strong motivation for high-intensity laser science and advanced photonics research
- English proficiency demonstrated by an English-language degree or minimum B2 CEFR level.

Application and Timeline

Applicants must submit the following to: eli-inrs_phd_program@eli-laser.eu

- Selected research topic (from the list above),
- Motivation letter
- Official transcripts and degree certificates



- Curriculum vitae (maximum 2 pages).

Based on the indicated topic, applicants will relate to potential supervisors. Selected candidates may be invited to an interview.

Timeline and contacts

- Application deadline: **17 April 2026**
Interviews may be conducted on a rolling basis prior to the deadline.
- Fellowship start: Autumn 2026 (earlier start possible in exceptional cases)
- Contacts: eli-inrs_phd_program@eli-laser.eu

Information on Research Topics/Projects and Proposed Supervisors

1. Development of high-power laser technologies

Recent scientific applications require short to ultrashort, intense laser pulses in the 5–15 μm spectral range. However, technologies based on stimulated emission are either immature or non-existent. Such sources are therefore generated through nonlinear processes, particularly difference frequency generation (DFG) of near-infrared beams. The simplest approach so far relies on intrapulse DFG of an ultrashort pump laser, where only fractions of the spectral bandwidth are mixed, resulting in low efficiency.

The candidate will investigate alternative interpulse DFG techniques based on high-power, high-energy picosecond Yb-doped solid-state amplifiers and nonlinear Raman processes for signal tailoring. The project exploits the unique nonlinear response of molecular gases in hollow-core fibers, which exhibits a delayed Kerr effect driven by laser-induced molecular alignment. Rather than matching pulse durations to rotational timescales for maximum broadening, the research targets the Multidimensional Solitary State (MDSS) regime. Driving MDSS with sub-picosecond pulses enhances Raman nonlinearities and intermodal interactions, triggering light self-organization and generating stable, high-energy solitary waves tunable from 1.1–1.3 μm .

These red-shifted waves act as the ideal signal pulse for the subsequent DFG stage. Since the seed originates from a fraction of the main pump pulse, the two are intrinsically synchronized, enabling highly efficient DFG of tunable, few-cycle pulses in the 5–15 μm spectral range.

Supervisors: [François Légaré](#) (INRS)/ [Eric Cormier](#), [Ádám Börzsönyi](#) (ELI ALPS)

2. Ultrafast molecular dynamics imaging

Understanding dynamics and function in molecules of increasing complexity is of fundamental importance in photochemistry with relevance to areas like pharmaceutical development, clean energy and catalysis. Movies of molecular dynamics can be made through pump-probe spectroscopy. The desired dynamics are induced by a pump laser-pulse and from a sequence of snapshots, taken during the subsequent molecular relaxation and dissociation process, a “molecular movie” with femtosecond temporal resolution can be made.

The candidate will perform pump-probe experiments on molecules, and complexes, using femtosecond laser beams at ALLS/INRS and at ELI with laser-driven source of extreme ultraviolet radiation. The diagnostics include photoelectron and photo-ion spectroscopy using time-of-flight detectors or velocity map imaging. One very interesting type of dynamics in molecules to be studied is “roaming”, where the fragment does not dissociate



directly, but roams around the rest of the molecule for an extended period of time. [Endo et al., Science 370, 1072–1077 (2020)].

A similar effect has been observed recently in superfluid He nanodroplets, where excited helium atoms – He* – undergo roaming motion on the droplet surface [Sishodia et al, Sci. Rep. 16, 1321 (2026)].

Supervisors: [Heide Ibrahim](#) (INRS)/[Jakob Andreasson](#) (ELI Beamlines)

3. High-field THz science and applications

Semiconductors are essential technological materials, and their applications are being extended to devices that increasingly operate at THz frequencies, where MV/cm fields drive nonlinear transport and lattice dynamics. In many cases, they are subject to strong electric fields, and it is essential to understand their behavior under such conditions.

The candidate will be involved in THz source development for linear and nonlinear THz spectroscopy using large-area photoconductive antennas (LAPCAs) at the INRS and optical rectification crystals, such as lithium niobate, at ELI. The candidate will perform time-resolved nonlinear spectroscopic studies on semiconductor bulk and thin-film semiconductor samples, such as Ge, InSb, selected alloys and heterostructures, using THz-THz and optical-THz pump-probe techniques.

The work includes data analysis and theoretical simulations to reveal details of the THz-field-induced ultrafast electron and lattice dynamics in the samples.

Supervisors: [Tsuneyuki Ozaki](#) (INRS)/[József A. Fülöp](#) (ELI ALPS)

4. Advanced characterization and control of quantum materials

The extension of angle-resolved photoelectron spectroscopy (ARPES) to the time domain via the pump-probe technique, also known as time-resolved ARPES (TR-ARPES), is a powerful tool for studying ultrafast electron dynamics and many-body interactions in solid surfaces/condensed materials.

The NanoESCA endstation at ELI ALPS is equipped with a photoemission electron microscope (PEEM) and a high-harmonic generation (HHG) beamline, which enable the simultaneous measurement of materials' electronic properties with momentum and spatial resolutions. The TR-ARPES setup at ALLS (INRS-EMT) relies on narrow-bandwidth 6-eV and HHG beamlines to achieve outstanding energy resolution. These two facilities provide complementary working parameters for TR-ARPES studies in terms of photon energy, time and energy resolution, resulting in a combination of instrumental capabilities that is unique worldwide.



The selected candidate will perform experimental work at both facilities, exploring transient electron dynamics and interactions in condensed matter systems on femtosecond-to-attosecond timescales. The goal of this project is to develop optical "knobs" to control the properties of quantum materials, such as topological systems, semiconducting transition metal dichalcogenides, as well as unconventional superconductors.

Supervisors: [Fabio Boschini](#) (INRS)/[Balázs Major](#), [Gyula Halasi](#) and [Laszlo Óvári](#) (ELI ALPS)

5. Enhancement of Betatron X-ray Radiation from Laser–Plasma Accelerators for High-Resolution Imaging and Applications

Laser–plasma accelerators (LPAs) are compact sources of ultrashort, broadband Betatron X-ray radiation with strong potential for high-resolution imaging applications. This PhD project aims to enhance the performance of Betatron X-ray sources through controlled optimization of laser–plasma interaction parameters, electron beam dynamics, and tailored plasma density profiles.

A particular focus will be placed on advanced plasma density tailoring schemes designed to increase X-ray flux, improve source stability, and enhance shot-to-shot reproducibility. The research will primarily utilize the capabilities of the ALLS beamline, while maintaining strong synergy with experiments and diagnostics available at the Gammatron beamline at ELI Beamlines.

In addition to source optimization, the project will investigate applications in high-quality radiography and advanced imaging. Experimental results will be supported by quantitative comparisons with theoretical models and numerical simulations to ensure a comprehensive understanding of the underlying physical mechanisms.

Supervisors: [François Légaré](#), [Sylvain Fourmaux](#) (INRS)/[Uddhab Chaulagain](#) (ELI Beamlines)

6. High-intensity laser–matter interaction and laser-driven nuclear reactions at high repetition rate

Nuclear reactions driven by high-intensity lasers are an emerging research field with strong potential for both fundamental studies and applied research. Laser-driven proton–boron reactions provide a promising platform to investigate nuclear processes in extreme plasma conditions, where the reaction products include energetic alpha particles. Operation in a high repetition rate regime may enable systematic studies of alpha-particle production with improved stability and statistics and may open the way to the exploration



of laser-driven alpha sources for selected applications, such as materials science, and medical research, including radioisotope production.

The PhD candidate will work on high-intensity laser–matter interaction experiments at high repetition rate, focusing on the study of laser-driven proton–boron nuclear reactions and on the detection and characterization of alpha particles generated by these reactions.

The research will be carried out in collaboration between INRS and ELI Beamlines and will include the development of dedicated experimental setups, advanced charged-particle diagnostics, and data analysis supported by numerical modeling to investigate reaction dynamics, alpha-particle yields, and scaling trends in the high repetition rate regime.

Supervisors: [François Légaré](#), [Simon Vallières](#) (INRS)/ [Lorenzo Giuffrida](#) (ELI Beamlines).