

Laser-based Beam Instrumentation R&D within LA³NET

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on behalf of the LA³NET Consortium

Abstract

Within LA³NET, Laser Applications for Accelerators are being developed by an international Network of more than 30 partner institutions from across the world. Laser-based beam instrumentation is at the core of this EU-funded project which will train 17 Fellows during its four year project duration.

Here, we present the consortium's recent research results in beam diagnostics, ranging from development of a laser velocimeter to measurement of the bunch shape with electro-optical sampling in electron accelerators. We also provide a summary of past training events organized by the consortium and give an overview of future workshops, conferences and schools.

Research

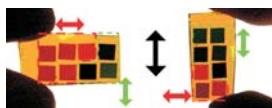
Research within LA³NET is distributed in five different work packages: Laser-based particle sources, laser-driven particle beam acceleration, lasers for beam instrumentation, system integration and lasers and photon detector technology. Here, initial results in beam diagnostics R&D are presented.

Electro-optic Bunch Temporal Profile Monitor

M. Tyrk, A. Gillespie, University of Dundee, UK

Detailed temporal diagnostics of the shortest electron beam bunches pose significant challenges in accelerator beam instrumentation. Electro-optical (EO) methods are a promising approach for single-shot non-intercepting measurement of electron bunches with a time resolution of better than 50 fs. Within LA³NET, teams are planning to measure the 150 fs CLIC main beam bunches to an accuracy of 15-20 fs using a relatively simple laser. A range of alternative materials have been investigated, including GaSe₂, organic crystals such as DAST and MBANP, and novel 'metamaterials' tailored to have the appropriate optical characteristics.

Within the last six months significant progress in the fabrication of silver-doped glass nanocomposites for EO applications in accelerators was made, and dichroism and SHG in these materials was demonstrated - a first step towards implementation as an EO detector material.



Photograph of test samples, images courtesy of U Dundee, MAPS Group

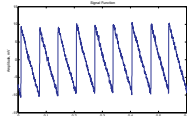
LA³NET Fellow Mateusz Tyrk has been responsible for setting up the recently-purchased Talisker picosecond laser, produced spheroidal nanoparticle distributions within samples by picosecond-pulse laser irradiation at a wavelength of 532 nm and measured their extinction spectra.

Laser Velocimeter

A. Alexandrova, C.P. Welsch, Cockcroft Institute, UK

Gas jets have been successfully exploited for beam instrumentation purposes. For such monitor, it would be highly desirable to have a compact sensor able to record the jet velocity and density profile to understand its dynamics in detail.

A promising option is a velocimeter based on laser self-mixing (SM) which is currently being developed by Alexandra Alexandrova in the QUASAR Group at the Cockcroft Institute, UK.



Example signal received from self-mixing with a mirror as target

In first experiments, ways to receive the right type of signal, to analyze it and understand how to improve its quality and amplitude were investigated. The plot shows results obtained with a mirror as solid target (MOPF03).

Electron Bunch Shape Detection

A. Borysenko, N. Hiller, A.-S. Müller, KIT, Germany

Coherent synchrotron radiation arises when the longitudinal electron bunch length is smaller than the wavelength. Substructures on the electron bunches can then lead to strong „bursting“ in the emission of coherent radiation. The physics behind these effects is still poorly understood, mainly because it is difficult to measure the bunch profile with sufficient temporal resolution.



Photograph of an electro-optic GaP crystal, mounted on its support. Image courtesy of Nicole Hiller, KIT, Germany

Electro-optic measurement uses the linear electro-optic or so called „Pockels“ effect. This effect – usually a change in polarization, which is turned into a change in optical power at a polarizer – can then be measured with a photo detector yielding the bunch signal.

Within a project at KIT an electro-optic system for the new accelerator structure FLUTE is being designed and built up. For this purpose, a system currently being developed for the ANKA light source shall be adapted. In addition, studies into performance limitations with regard to temporal resolution shall be carried out.

Training

Training of all LA³NET fellows will be mostly through specific project-based research realized by the respective host institutions with specific secondments to other partners for specialized techniques and cross-sector experience. In addition, the consortium organizes a number of network-wide events that are open to the wider community.

International Schools

GANIL, France, University of Liverpool, UK and CLPU, Spain

A first international School on Laser Applications at Accelerators was held at GANIL in Caen, France between 15th-19th Oct 2012. 80 participants from inside and outside the LA³NET Consortium were introduced to the state of the art in this dynamic research area. Lectures covered topics such as introduction to lasers and accelerators, beam shaping, laser ion sources, laser acceleration, laser based beam diagnostics and industrial applications.

A week-long School on Complementary Skills was organized for all LA³NET Fellows in March 2013. It covered diverse skills such as presentation techniques, project management, grant applications and peer review. This training was recently identified as „best practice“ by the European Union.

An Advanced School on Laser Applications will be held in September 2014 at CLPU in Spain and cover advanced laser technologies, in particular the combination of different fundamental techniques.

Topical Workshops

Venues across the network

The first LA³NET Topical Workshop covered Laser-based Particle Sources and was held at CERN in February 2013, attracting nearly 50 researchers from Europe and beyond. 10 invited speakers gave 40-minute talks on their current research in this area. An additional 22 delegates delivered shorter oral presentations providing the perfect balance of talks on the generation of electron and ion beams using laser methods. Full details about the workshop can be found on <http://indico.cern.ch>, confID: 212365.

A workshop on Laser Technology and Optics Design will be held at the Fraunhofer Institute for Laser Technology (ILT) in Aachen, Germany between 4th-6th November 2013. It will cover general optics design, provide an overview of different laser sources and discuss methods to characterize beams in details. Participants will be able to chose from a range of topical areas that go deeper in more specific aspects, including tuneable lasers, design of transfer lines, noise sources and their elimination, and non-linear optics effects.

Registration is now open via the project web site.

The 3rd workshop on Novel Acceleration Schemes will be held at HZDR in Dresden, Germany on 28th-30th April 2014 and will cover the latest results in laser and plasma acceleration. The program is currently being finalized and registration will open soon via the project web site.

International Conference on Laser Applications

University of Liverpool, UK

In the final year of LA³NET, a 3-day international conference on R&D in laser applications at accelerators will be organized, with a focus on the methods developed within the network. In addition a Symposium will be organized as an outreach event for the general public.



Photograph from the first LA³NET school, held at GANIL, France

The consortium will award an annual LA³NET cash prize of 1,000 € for an outstanding contribution to the field of laser applications at accelerators to a researcher in the first five years of their professional career. Applications for the 2014 prize can be submitted until 30.6.2014. Full application details can be found on the LA³NET web site.

The network produces a quarterly newsletter and is present in Facebook - in order to subscribe for the former, simply send an email to the coordinator.