FEL R&D within LA³NET

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FEL 2013
26-30 August

Abstract

The detailed diagnostics of the shortest beam pulses in free-electron lasers still pose significant challenges to beam instrumentation. Electro-optical methods are a promising approach for the non-intercepting measurement of electron bunches with a time resolution of better than 50 fs, but suitable optical materials need to be better understood and carefully studied. In addition, adequate timing systems with stability in the femtosecond regime based on mode-locked fibre laser optical clocks, and actively length-stabilised optical fibre distribution require further investigation.

These important problems are being addressed within the broader EU-funded LA³NET project by an international consortium of research centres, universities, and industry partners. Here, an overview of the wider LA³NET project and results from initial studies in FEL-related R&D is presented, together with a description of LA³NET

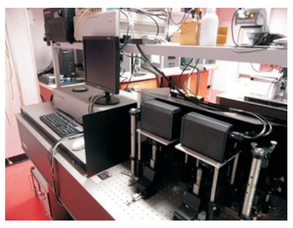
Research

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. Although each fellow works on an independent research project, there are many links between work packages. Below is a description of the project‘s FEL-related research activities to date.

Electro-optic Bunch Temporal Profile Monitor

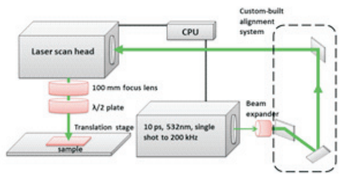
M. Tyrk, A. Gillespie, U Dundee, UK

Detailed temporal diagnostics of the shortest electron beam bunches in FELs 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.



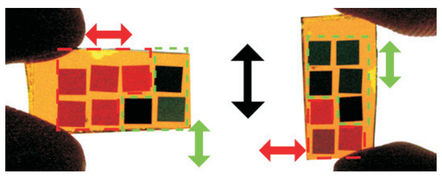
Coherent TALISKER laser and X-Y scanning optics.

Within LA³NET the Dundee-Daresbury Group is working with the CERN compact linear collider project (CLIC), with the intention of measuring the 150 fs CLIC main beam bunches to an accuracy of 15-20 fs, using relatively simple laser systems.



Ultra-short laser configuration for materials processing.

A range of alternative materials to substitute for GaP have been investigated, including $GaSe_2$, organic crystals such as DAST and MBANP, and novel ‚metamaterials‘ tailored to have the appropriate optical characteristics have been developed at the University of Dundee.



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

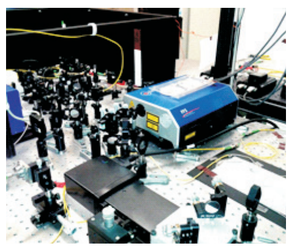
Within the last six months significant progress in the fabrication of silver-doped glass nanocomposites for EO applications in accelerators was made, and dichroism and SHG in these materials was demonstrated - a first step towards implementation as an EO detector material,

LA³NET fellow Mateusz Tyrk has been responsible for setting up and maintaining the recently-purchased Talisker picosecond laser, designed and installed the X-Y scanning system to irradiate samples in a controlled pattern with a measured fluence, produced spheroidal nanoparticle distributions within these samples by picosecond-pulse laser irradiation at a wavelength of 532 nm and measured the extinction spectra of such samples.

Accelerator Timing Monitor with Femtosecond Precision

T. Thakker, S.P. Jamison, ASTeC/STFC, UK

The next generation of accelerators and light sources require timing systems with unprecedented stability and precision for the synchronization of accelerator subsystems, diagnostics and photon experiments.
Proposals and plans for new light sources such as CLARA (MOPSO40) and SwissFEL already require synchronisation to the several femtosecond level.



Photograph of current timing setup at STFC/ASTeC in Daresbury, UK.

Within LA³NET a fellow will be undertaking a project to investigate concepts using nonlinear optical materials with ultra-fast response times to develop beam arrival-time monitors (BAMs) targeted at achieving femtosecond level precision in determining arrival times. These high precision BAMs will form a critical part of the optical timing system, complementing the advancing link stabilisation and contributing to the development of accelerator stabilisation technology for future light sources.

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 and CLPU, Spain

A **first international school** on laser applications at accelerators was held at GANIL in Caen, France between October 15th-19th 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.

An **Advanced School** will be held in **September 2014** at CLPU in Salamanca, Spain and will 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 e.g. 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.

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This project is funded by the European Union under contract PITN-GA-2011-289191

http://www.la3net.eu