R&D into Laser Applications for Accelerators

C.P. Welsch, Cockcroft Institute and The University of Liverpool, UK
on behalf of the LA³NET Consortium

Abstract

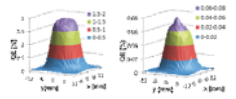
Lasers can be used for the generation of high brightness electron and exotic ion beams, the acceleration of particles with the highest accelerating gradients, as well as for the characterization of many complex particle beams by means of laser-based beam Diagnostics methods. In addition, (free electron) lasers can be used for achieving the highest time resolution and strongest fields for experiments in atomic physics, chemistry and biology, i.e. for studies into the dynamics of some of the most fundamental processes in nature. Without constant progress in laser technology and close collaboration between laser experts and accelerator scientists, many of today's most advanced experiments would simply be impossible.
The LA³NET consortium combines developments into laser technology and sensors with their application at advanced accelerator facilities, for the generation, improvement and optimization of a wide range of particle beams.. This contribution presents some examples from the consortium's broad, yet closely interconnected research program.

Research

The aim of LA³NET is to train early stage researchers (ESRs) in a large spectrum of laser-based applications at accelerator facilities. The projects are closely linked to an overall optimization of existing and future research infrastructures and through these developments the trainees will automatically contribute to and expand the experimental programs at these facilities. Here, selected examples from the network's broad research portfolio are presented.

Cs_3Sb cathodes for the CLIC drive beam photo injector

LA³NET fellow Irene Martini has started investigations into Cs_3Sb photo cathodes that were produced in the CERN photo emission laboratory using the co-deposition technique and recently tested in a DC gun set-up.



: QE map of Cathode #192 before and after measurement at 120 µA.

For measuring the electron beam current a Wall Current Monitor (WCM), a Fast Current Transformer (FCT) and a Faraday Cup (FC) are installed. The above figure shows Quantum Efficiency (QE) maps where scans of the cathode surface with a pencil laser beam have been performed. Although detailed investigations are on-going a possible explanation of this peak might be the laser cleaning process, which is in competition with QE degradation. Similar observations were made previously during high current electron beam production with Cs_2Te and UV laser beams in the same setup. MOPFI058

Electron Bunch Shape Detection

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.

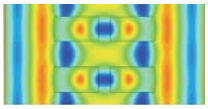
Photograph of an electro-optic GaP crystal, mounted on its support.

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. MOPME014

Fibre optics electron accelerator

Photonic crystals are a promising way to realize an on-chip electron beam source for fundamental radiation biology as they provide a unique combination of nanometre beam size and attosecond-short pulses. There are different candidates for photonic crystal accelerator structures, such as dual-grating structure, photonic crystal fibres and woodpile structure.



Field distribution as calculated with CST Microwave Studio in dual-grating structure.

Within a project in the QUASAR Group the Cockcroft Institute/University of Liverpool, UK simulation work on a new dual-grating structure has recently started. Optimum pillar height and vacuum channel gap are determined in simulation runs. For electric field calculation CST Microwave Studio was used. It can be seen from the figure above that a two side feeding mechanism efficiently decreases the transverse field, i.e. the x-component of the electric field, perpendicular to the direction of travel of the electrons, which is unusable for longitudinal acceleration. A laser wavelength of 1,550 nm and Silicon were chosen for all initial simulations. TUPEA065

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 will organize a number of network-wide events that will be 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. In addition there were study groups, poster sessions and two evening seminars on major international initiatives in the laser and light sources field. The annual LA³NET prize of 1,000 € for an outstanding contribution to the field of laser applications at accelerators by an early stage researcher was awarded to Dr. Sebastian Rothe (U Mainz, Germany).

A second school will be held in **2014** at CLPU in 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 attracting nearly 50 researchers from Europe and beyond. CERN provided the ideal location for the workshop being a centre of expertise on the production of electron beams with photo injectors and resonance laser ionization of radioactive isotopes. This expertise was complemented by the invitation of 10 international renowned speakers to give 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. The following main topics were covered:

- Lasers and photocathodes for high brightness electron beams
- RF and DC photo injectors
- Hot cavity and gas cell ion sources for radioactive ion beam facilities
- Laser systems for efficient resonance ionization
- Optimizing selectivity for RILIS
- In-source spectroscopy of rare nuclides.

The network will organize at least 2 workshops/year-details on our web page.

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 2013 prize can be submitted until 30.6.2013. Full application details can be found on the LA³NET web site.

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

c.p.welsch@liv.ac.uk

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

http://www.la3net.eu