LA³NET

Laser-based Beam Diagnstics for Accelerators and Light Sources

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on behalf of the LA³NET Consortium

Abstract

The Laser Applications at Accelerators network (LA³NET) was selected for funding within the European Union's 7th Framework Programme. During its 4 year duration the project has successfully trained 19 Fellows and organized numerous events that were open to the wider laser and accelerator communities. The network linked research into lasers and accelerators to develop advanced particle sources, new accelerating schemes, and in particular beyond state-of-the-art beam diagnostics.

This poster summarizes some of the research results in laser-based beam diagnostics for accelerators and light sources. It discusses the achievable resolution of laser-based velocimeters to measure the velocity of particle beams, the resolution limits of bunch shape measurements using electro-optical crystals, position resolution of laser wire scanners, and limits in energy measurements using Compton backscattering at synchrotron light sources. Finally, it also provides a summary of events organized by the network and shows how an interdisciplinary research program can provide comprehensive training to a cohort of early career researchers.
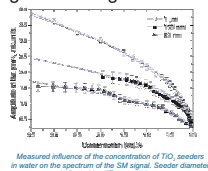
Research

R&D within LA³NET is split into 5 work packages: Laser-based particle sources, laser driven particle beam acceleration, laser-based beam diagnostics, system integration and laser and photon detector technology.

Beam Characterization using Laser Self-Mixing
A. Alexandrova, Cockcroft Institute/University of Liverpool, UK

Project Aims: Investigate the full application potential of laser self-mixing for determining the velocity, density and temperature profile of various solid, fluid and gaseous targets.

Measured influence of the concentration of TiO₂ seeders in water on the spectrum of the SM signal. Seeder diameter indicated by different markers.

Studies carried out:
- Compact laser setup realized for measurement of solid and fluid targets;
- Different seeders and seeder sizes investigated with regards to signal amplitude and dependence on concentration;
- Concept for integration into gas jet setup.developed.

Results: Velocities of up to 100 m/s determined with very good precision and reproducibilty for solid targets. Velocities of liquids measured up to several m/s using different seeders. Measurements gave indication for optimum seeder choice and provided valuable information for future integration into gas jet setup. In a next step gaseous targets shall be studied.
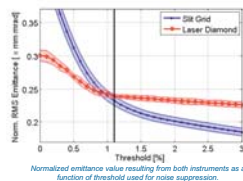
A Laserwire Emittance Scanner for LINAC4
T. Hofmann, CERN, Switzerland

Project Aims: Develop a laserwire scanner that measures the beam profile non-invasively via photo detechment. Optimize for signal strength and dynamic range.

Studies carried out:
- Used a 1080 nm laser with 154 mJ pulse energy, 80 ns length (FWHM), 60 kHz f_{rep} and an M^2 of 1.8 for tests with 12 MeV H⁻ beam and 20 x 20 mm 5 strip polycrystalline diamond detector;
- Determine emittance via laserwise and ‚classic‘ slit-grid method.

Normalized emittance value resulting from both instruments as a function of threshold used for noise suppression.
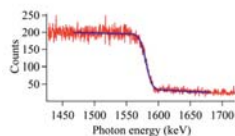
Results: A good agreement between both methods was found and studies have clearly identified optimum threshold value for noise suppression. Tests at 50 MeV and 100 MeV are planned. Electrode design of the diamond detector and its data acquisition readout chain are in the process of being further enhanced for higher angular resolution and faster measurements. Modification of the system is also foreseen so that scans in horizontal and vertical planes will be possible.

Beam Energy Measurements by Compton Backscattering
C. Chang, KIT, Germany

Project Aims: Determine the energy of a stored electron beam from Compton back scattering measurements in a transverse configuration.

Measured CBS spectrum at 1.3 GeV with fit to determine the Compton edge energy. Signal integrated over 120 seconds.

Studies carried out:
- A High Purity Germanium spectrometer was used to determine the energy of the emitted photons at various beam energies.

Results: A compact setup based on a transverse scheme has been successfully tested at ANKA at energies between 0.5-2.5 GeV. Longer acquisition times help further reduce statistical uncertainties in the Compton edge and hence beam energy.

Training

Training of all Fellows was through specific project-based research realized by the host institutions with specific secondments to other partners for specialized techniques and cross-sector experience. In addition, LA³NET organized network-wide events that were open to the wider community.

International Schools
*GANIL, France, University of Liverpool, UK and CLPU, Spain*

An **Advanced School on Laser Applications** was held in **September 2014** at CLPU in Spain and covered advanced laser technologies, in particular the combination of different fundamental techniques (CERN indico: 285698).

Topical Workshops
Venues across the network

The network organized a number of 2-3 day workshops for all Fellows and the wider community. This included a "Scientists Go Industry" workshop where invited speakers from industry presented different career pathways (CERN indico: 318719), information about all workshops including all presentations can be found via the project home page.
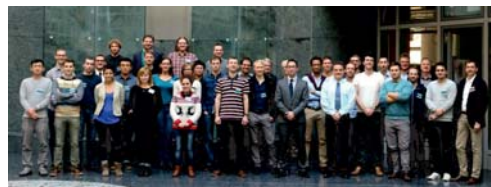
Another **Researcher Careers** Workshop was held in Krakow, Poland on 27 June 2016 (CERN indico: 512574). Later in 2016, a workshop on **Novel Accelerators** (CERN indico: 527727) and one on **Laser Ion Sources** (CERN indico: 546015) will be held between 24-26 October in Paris.

International Conference and Symposium on Laser Applications
University of Liverpool, UK

A 3-day **international conference** on laser applications at accelerators was held **on Majorca in March 2015**. 70 experts discussed the state of the art in the network's R&D areas (CERN indico: 340381).
An **Outreach Symposium** in Liverpool on 26 June 2015 was the project's largest event to date. It gathered several 100s of delegates in the Liverpool Convention Center. Presented posters and videos of all presentations are now available online (CERN indico: 368273).

Details about the upcoming workshops can be found on the network's social media channels, website and in our quarterly newsletter.