DITANET – AN OVERVIEW OF THE FIRST YEAR ACHIEVEMENTS*

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Abstract

Beam diagnostics is a rich field in which a great variety of physical effects are made use of and consequently provides a wide and solid base for the training of young researchers. Moreover, the principles that are used in any beam monitor or detector enter readily into industrial applications or the medical sector which guarantees that training of young researchers in this field is of relevance far beyond the pure field of particle accelerators. DITANET- "DIagnostic Techniques for particle Accelerators – a European NETwork" - covers the development of advanced beam diagnostic methods for a wide range of existing or future accelerators, both for electrons and ions. DITANET is the largest ever coordinated EU education action for PhD students in the field of beam diagnostic techniques for future particle accelerators with a total budget of 4.2 M€. This contribution gives an overview of the network's activities and outlines selected research results from the consortium.

INTRODUCTION

The DITANET project officially started on 1.6.2008 and consists of ten network members and presently 15 so-called associated partners. The training network brings together Universities, research centres, and the industry sector with the aim to jointly train the next generation of young scientists in beam instrumentation. Once all positions have been filled, the network will train 17 Early Stage Researchers (PhD candidates) and 3 Experienced Researchers (normally Postdocs) within its four year duration.

A core idea of DITANET is that all network members interact and collaborate closely, promote the exchange of trainees and staff within the network, and jointly organize training events, workshops and conferences open also to external participants.

The participation of industry is an integral part of the training within DITANET and all partners from industry are included as members of the supervisory board to ensure that industry-relevant aspects are covered in the different projects carried out within the network and to enhance knowledge transfer. In addition, they offer internships to the students from the network to complement the scientific training and thus actively contribute to building the bridge between the academic and the industrial sector.

RESEACH & DEVELOPMENT

DITANET covers all different kinds of particle accelerators from very low energies to present and future high energy colliders, diagnostics for electron as well as for ion beams [1]. This chapter summarizes briefly some of the developments that have been realized already during the initial months.

Beam Tracking Detectors for FAIR

The group of Nuclear Physics at the CNA is one of the institutions responsible for contributing to the design of beam tracking detectors for the Heavy Ion Spectroscopy and Decay Spectroscopy (HISPEC/DESPEC) project, of the low energy branch of FAIR.

In collaboration between CEA (A. Drouart, J. Pançin, M. Kebbiri, M. Riallot) and CNA (B. Fernandez, M.A.G. Alvarez), a mini-Secondary electron Detector (SeD) was constructed and tested. The mini-SeD is a low pressure detector which uses an electron emissive foil and is used as a beam tracking detector. Preliminary tests on the mini-SeD showed that the SeD [2, 3] and the mini-SeD give very similar results in terms of time and position resolution, which implies on having similar resolutions independent on the geometry of the detector

The electric field inside the mini-SeD risks to impact on the performance of the detector. In order to study the behaviour of the electric field, simulations with Femlab [4] have been carried out exploiting the symmetry of the detector.

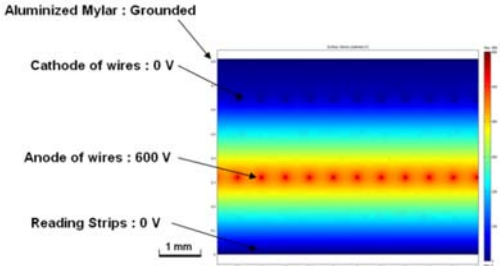

Figure 1: Distribution of the electric field in the mini-SeD as calculated with Femlab.

Fig. 1 shows the resulting distribution of the electric field in the mini-SeD. Optimization of the simulations is presently being carried out.

*Work supported by the EU under contract PITN-GA-2008-215080.
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Investigations into target materials for a low energy pepper-pot emittance measurement

The ion cancer therapy facility HIT in Heidelberg is producing ions (H, He, C and O) from two ECR sources at an energy of 8 keV/u with different beam currents from about 80 µA up to 1.2 mA. Typical sizes for the beam in the LEBT range from are 5–40 mm. Matching the always slightly changing output from the ECR sources to the first accelerating structure, an RFQ, demands a periodical monitoring of the beam emittance. Therefore, a special pepper-pot measurement device is presently being designed, see Fig. 2 for the installation positions. Its central parts are a damage-resistant pepper-pot mask and a vacuum-suitable transparent Scintillator material. The investigation of the material lifetime is done in the first step by computing the maximum intensity the target volume can stand without any radiation damage, shock and heating, the way-finding strategy is SRIM-based. The results will be used to define a set-up for necessary material tests with beam.

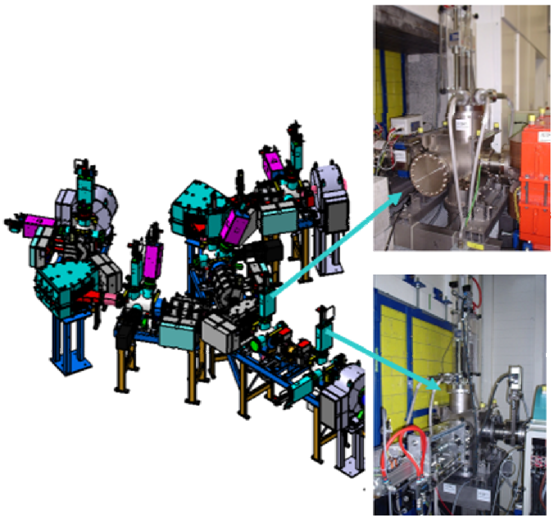

Figure 2: Location of the pepper-pot within the LEBT.

Libera

The required performance of particle accelerators is a constant challenge to applied technologies and operational techniques. Instrumentation Technologies approaches this challenge by combining the individual performance of single instruments and diagnostic tools into an extended global tool that addresses the figures of merit of an accelerator, such as brilliance and luminosity. Important technological innovations that give cutting edge performance are software defined radio, sub-ps synchronization over large distances, super-fast feedback systems and massively parallel real-time data processing.

The Libera family of products includes RF and photon beam position monitor electronics, global orbit and multibunch feedback systems and digital low level RF control and clock distribution. Most recently the Libera Low Level RF stabilisation system was demonstrated at a test set-up of the EMMA FFAG RF system at Daresbury Laboratory. The Libera LLRF provided amplitude and phase stability of 0.005 % and 0.008 deg respectively with 10kW of power at 1.3 GHz. The system is modular covering a range of frequencies from 10's of MHz to 12 GHz, normal conducting or superconducting and different operating modes, pulsed or CW. The system has an architecture that enables networking, logging of large data streams, real-time computing and fast and stable timing and synchronisation.

Radiation hardened CID cameras

The breakthrough Charge Injection Device (CID) 8825D camera is the only solid state color camera capable of operating in radiation environments with no shielding. Unique preamplifier per pixel (PPP) technology offers a low noise image with resistance to radiation damage and tolerance to at least 3 x 10^6 rads total dose gamma along with substantial immunity to radiation induced noise. Cameras are available in NTSC or PAL format and include analogue and digital (USB2.0) output with remote head operation up to 150 meters distance.

Secondary Electron Emission Yield (SEY) and SEM-grid Signal Level in LINAC4.

LINAC4 is the first step of the new LHC injector chain. This linac will accelerate H^- from 45 keV to 160 MeV, intended to replace linac2 as injector for the Proton synchrotron Booster (PSB). During the commissioning phase, emittance measurements will be required at 45 keV, 3 MeV and 12 MeV. For this purpose a slit and grid system is currently being developed. In addition, several SEM-grids will be installed along the linac in order to measure the beam profiles.

Unlike for protons or electrons the signal on the wires depends on several sources (a) secondary emission (SE) caused by H^- entering the wire (b) secondary emission caused by protons and electrons exiting the wire and (c) direct charge deposition of protons and electrons stopped in the wire.

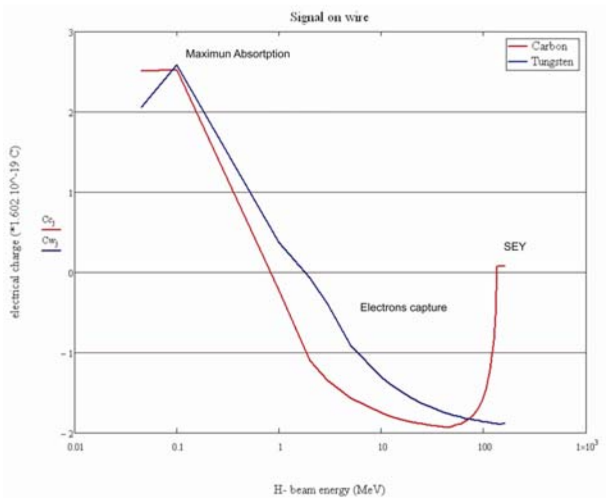

Figure 3: Charge by one particle striking the wire.

The secondary emission yield is described as $Y=\Lambda*dE/dx$, where Λ is a function depending on the wire material and dE/dx is the stopping power of entering or exiting particles. An example of the evolution of the signal induced on the wire was calculated recently and is shown as a function of the H^- energy in Fig. 3.

Beam Profile Monitoring in the USR

The Ultra-low energy Storage Ring (USR) [5] will be one of the key elements of the future Facility of Low energy Antiproton and Ion Research (FLAIR). A neutral supersonic gas jet target shaped into a thin curtain and bi-dimensional imaging of the gas ions created by impact with the projectiles is presently under investigation as a beam profile monitor. Such monitor, as compared to those based on residual gas, allows injection of additional gas (in order to increase the ionization rate) together with efficient evacuation (to keep the required vacuum level elsewhere in the storage ring), due to the high directionality of the supersonic jet [6]; furthermore, it allows simultaneous determination of both transversal profiles and even beam imaging.

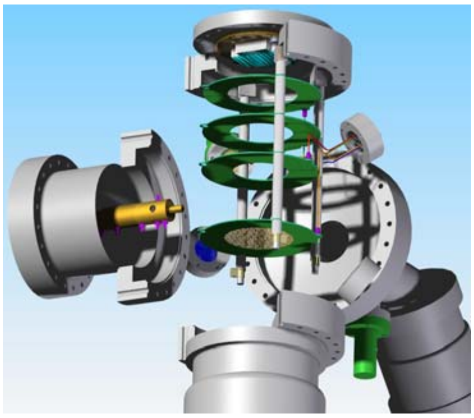

Figure 4: Experimental chamber and extraction system for the density mapping of the supersonic-jet curtain.

A 3D drawing of the monitor's main vacuum chamber including a small electron gun for the characterization of the gas jet is shown in Fig. 4. The vacuum chamber is presently being built and first experimental tests will start later in 2009.

NEW ASSOCIATED PARTNERS

The DITANET consortium was recently complemented by the University of Maryland (USA), Lawrence Berkeley National Laboratory (USA), and the University of Dundee (UK). All new partners were officially integrated during the DITANET School at RHUL and contributed already actively to the lecture program. By participating to the training program of the network's ESRs and ERs and bringing in additional and unique expertise, all three add important value to the network and will further enhance knowledge exchange and secondments of research in this field.

1ST SCHOOL ON BEAM DIAGNOSTICS

From March, 30th - April, 3rd 2009 the first DITANET School on Beam Diagnostics took place at Royal Holloway, University of London. The School was combined with the first DITANET annual meeting and brought together more than 70 researchers from major research centres, Universities and private industry from all over the world.

The School started with an introduction to accelerator physics and the definition of particle beams, before basic beam instrumentation like beam energy, beam current or transverse beam profile measurement were covered. Later the week more advanced topics, like e.g. the monitoring of the machine tune or electron cloud diagnostics were presented. An excursion to Rutherford Appleton Laboratory including visits to ISIS and DIAMOND on Wednesday, April 1st as well as two tutorials and one poster session complemented the broad program.

A particular highlight was a dedicated industry session on the last day where lecturers from Thermo Fisher Scientific, TMD, Thales, ViALUX, and Instrumentation Technologies gave an insight into cutting edge R&D activities in the industry sector with a focus on differences as compared to research in academia.

OUTLOOK

Less than one year after the project start, DITANET has already filled half of the vacant positions with highly qualified young researchers from all over the world. All research projects are making remarkable progress and this paper can only summarize a few developments. The joint organization of the first school on beam diagnostics and in particular the smooth integration of the industry partners showed that DITANET has already become a real network where close collaboration between partners is one of the core ideas.

The network is aiming at organizing a series of topical workshops starting later in 2009 and will hold an advanced school on beam diagnostics in spring 2011 at MSL, Sweden.

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