HIGHLIGHTS FROM BIW08

F. Sannibale, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, U.S.A.

Abstract

The 13th edition of the Beam Instrumentation Workshop (BIW08) took place at the Granlibakken Conference Center on the beautiful shores of Lake Tahoe in California during the first week of May 2008. About 130 participants registered for the workshop. Included in the program during the three and a half days were three tutorials, eight invited and seven contributed oral presentations, and more than 50 poster contributions. A discussion group session and the vendor exhibition simultaneously held with the single day poster session, afforded many opportunities for informal discussion and idea exchange between attendees. During the workshop, the 2008 Faraday Cup Award that recognizes innovative achievements in beam diagnostics was also presented. In this talk, I will present the highlights from BIW08. The overall quality of the contributions was notably high, which made the selection of the topics for this talk quite difficult. Although I endeavoured to produce a balanced choice of highlights, the final list is surely incomplete due to time limitations of the talk, and also it unavoidably reflects my personal point of view and preferences.

INTRODUCTION

When the DIPAC09 Programme Committee proposed me to present a talk and write this contribution on the highlights of the 2008 edition of the Beam Instrumentation Workshop (BIW08), the first question I asked myself was: why a highlights talk?

Several answers came soon to my mind. First, it could be a good way to inform people in the community that did not attend BIW08 on what happened and on what interesting was presented during the workshop. Second, it could stimulate a tighter link between the two main international workshops on beam diagnostics and instrumentation that alternates every other year between Europe and USA. Last but not least (for me), the preparation of the talk and paper would give me a unique chance and opportunity to read and learn from the large number of contributions presented during the workshop.

So I decided to accept the challenge and soon started to work on it. Of course, as everything in this world, there are always drawbacks in every situation, and this one was not an exception. The quality of most of the contributions was significantly high and for obvious time and space limitations only a limited number of highlights could be picked. This made the selection process very difficult. Additionally, even for the selected contributions, only few slides and paragraphs could be used. The forced choice was to describe only general concepts without many details in the attempt of stimulating the reader interest and to refer to the BIW08 proceedings for deeper information.

The selection criteria used in the highlights choice included novelty, originality, broadness of interest, quality of the work and so on. At the same time, when possible and reasonable, an attempt of spreading the choice over different fields, particle species, and geographical locations was done.

Unavoidably, personal interest and bias played a role in the selection as well, and I apologize in advance to the authors of those contributions that have been undeservedly excluded from this incomplete list of highlights.

OLD & NEW IN BIW08

With BIW08, the Beam Instrumentation workshop was at its 13th edition. The structure of the workshop gradually evolved over the years into the present shape that has been pretty much constant over the last editions. BIW08, during the three and half days included 3 tutorial talks, 8 invited and 7 contributed oral talks, plus two special talks. The single poster session included ~ 50 contributions and was held simultaneously with the vendor exhibition in order to facilitate informal discussion and information exchange. The workshop also included a more formal discussion session and the presentation of the 10th Faraday Cup Award, sponsored by Bergoz Instrumentation and assigned by the BIW Program Committee to the authors of innovative beam instrumentation [1].

BIW registered ~ 130 attendees and 9 vendor exhibitors and for the first time in this edition two new initiatives were introduced. Partial financial support for graduate and under-graduate students was offered, and the proceedings of the workshop were published on the JACoW open World Wide Web database [2]. With these initiatives, the BIW Program Committee tried to boost the interest to beam diagnostics in new generations of engineers and physicists, and to facilitate a free and wider diffusion of the workshop publications.

More information on BIW08 can be found elsewhere [3].

CONTRIBUTIONS HIGHLIGHTS

The selected highlights will be presented by loosely following the contribution category, starting with the Faraday Cup Award, going through tutorial, invited and oral contributions, and finishing with posters.

Faraday Cup Award

The 10th Faraday Cup Award was assigned to Suren Arutunian of the Yerevan Physics Institute of Armenia for the invention, construction and successful test of the diagnostic system "A Vibrating Wire Scanner" [4].

Figure 1 shows a 3D view of the core part of the instrument. A metallic wire is stretched through a region where the magnetic field due to a couple of permanent magnets situated on the wire support itself is present.

An oscillating current is then applied to the wire that due the presence of the magnetic field starts to oscillate. The wire is part of a tuned oscillator circuit that drives the oscillation on the natural mechanical resonance of the wire (typically at few kHz). If the cable is now scanned through the beam under measurement, the interaction of the cable with the beam ultimately generates heating with consequent temperature change and dilation of the wire. Such dilation causes a variation in the wire mechanical resonance with frequency shift proportional to the number of particles in that part of the beam that is interacting with the wire. By scanning the wire and recording the frequency shift at each position it is then possible to measure the beam profile.

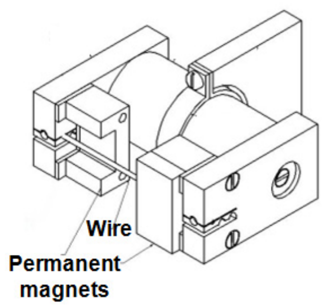

Figure 1: Vibrating wire scanner. Courtesy of S. Arutunian.

The vibrating wire monitor presents a relatively slow response time (tenths of seconds per single position measurement when the system is in air, seconds when in vacuum). On the other hand, it is very sensitive, showing its best performance when measuring low intensity beams and halos. The system has been already successfully tested with ion, proton, electron and photon beams. In a particularly interesting application at the Advanced Photon Source in Argonne, the vibrating wire monitor was used with hard x-ray synchrotron radiation to perform quality beam profile measurements [5]. In such application the monitor was installed in air downstream a thick flange of the storage ring vacuum chamber. The flange absorbed all the synchrotron radiation apart for hard x-ray photons with energy sufficient to go through the thick vacuum flange.

Tutorials

Tutorial talks are a unique characteristic of BIW. The long time allocated for the presentation (75 min plus 15 min of discussion) makes of these contributions something more close to a lecture than to a talk. Speakers are selected among experts on the topic and are requested to explain the matter starting from basics. Tutorials target mainly newcomers and experts from other fields that are interested to learn more about the presented topic, but are actually welcomed and appreciated by most of the attendees.

At BIW08 the three tutorial topics included lasers in beam diagnostics, vacuum technology in accelerators, and digital signal processing using field programmable gate arrays (FPGA). It was quite difficult deciding among the three excellent contributions, but at the end I selected the tutorial on FPGAs by Javier Serrano [6] for the complete and exhaustive presentation and for the importance that the FPGA technology is being assuming in accelerator physics. As a proof of this, a significant number of FPAG applications were presented during the BIW08 poster session [7-10].

In his tutorial Serrano historically introduces the argument, explains the main components and architecture of FPGAs and their functionality. All the design phases and steps that allow transforming abstract ideas into a real digital circuit are clearly described. The focus of the tutorial is concentrated on digital signal processing using FPGAs, which plays a central role in beam diagnostics and instrumentation applications. Special emphasis is also given to the design techniques for a “safe design” that avoids undetermined and/or inconsistent states.

In summary, the tutorial was a comprehensive and clear presentation of the subject, useful to beginners, curious ones but also to the more experts.

Invited Talks

The invited talks were selected by the BIW08 Program Committee at the time when the LCLS, the hard x-ray free electron laser at SLAC, was in the initial part of the commissioning, and the LHC teams at CERN were refining their tools and instruments in preparation for the incoming commissioning. The talks reflected such a situation with an invited by J. Frisch dedicated to the first beam measurements at the LCLS [11], and a couple of talks on two among the “hottest” issues in the design of the CERN collider, “LHC machine protection” by B. Dehning [12], and “radiation damage in detectors and electronics” by R. Lipton [13]. The future of the high energy physics based on accelerators was presented by a motivating talk by M. Zisman with title “future accelerator challenges in support of high-energy physics” [14], while the talk “The CLIC Test Facility 3 instrumentation” by T. Lefevre [15] described the activity of the group at CERN working for demonstrating the technology for future high energy colliders. Two of the talks were reviews of beam diagnostics techniques with are receiving great attention in the community, “electro-optic techniques in electron beam diagnostics”, by J. van Tilborg [16] and “transition, diffraction and Smith-Purcell radiation diagnostics for charged Particle Beams”, by R. Fiorito [17]. The last invited was presented by the author of this paper presenting some new measurement techniques and instrumentation developed at the Advanced Light Source (ALS) in Berkeley [18]. The remaining part of this section includes more details on four of these invited contributions.

In his talk, Frisch, presented a number of impressive measurements at LCLS showing an already high level of beam characterization after a relatively short period of commissioning. Figure 2 shows an example of such measurements where the longitudinal phase space occupied by the beam was measured using in combination a transverse deflecting cavity and a spectrometer. The results were already showing the beam quality that would allow the LCLS to successfully lase at Angstrom wavelengths in spring 2009.

An unexpected presence of coherent radiation at the OTR screens along the linac made those profile monitors diagnostics unusable, and indicated the presence of longitudinal structures in the bunch with characteristic length comparable (and probably shorter) than visible wavelengths. Beam profiles measurements were performed by using wire scanners.

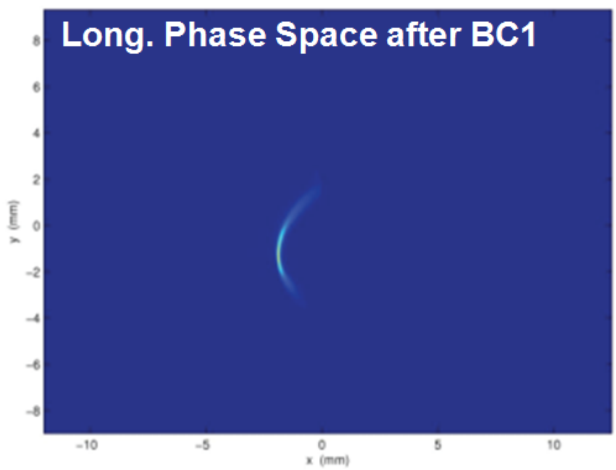

Figure 2: Beam longitudinal phase space measured after the first LCLS bunch compressors. The vertical is the time axis and the horizontal is the energy one. Courtesy of J. Frish.

In his complete and clear review of electro-optic techniques in beam diagnostics, van Tilborg started with a theoretical introduction followed by an extensive description of the different schemes, including time and frequency domain, scanning and single shot applications. Numerous experimental data per each of the schemes were also included.

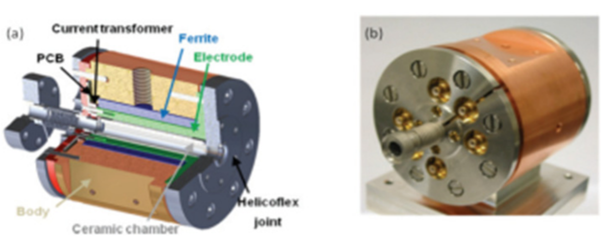

Figure 3: Inductive beam position monitor with 100 nm resolution under development at CTF3. Courtesy of T. Lefevre.

CTF3 facility at CERN has been primarily built to demonstrate by 2010 the key technological challenges for the construction of CLIC a high luminosity 3TeV e+-e- collider based on the "two-beam" accelerator scheme.

Lefevre in his talk pointed out that another major task of CTF3 is to develop and demonstrate the challenging beam diagnostic for the main linac of CLIC. For example, beam position monitors with 100 nm resolution, femtosecond synchronization techniques and high dynamic range beam imaging systems with up to 5 orders of magnitude dynamic range are required. Figure 3 show one of the high resolution beam position monitor under characterization at CTF3.

A novel bunch length monitor developed at the ALS was presented by the author of this paper. In all real accelerator, the longitudinal bunch distribution is never completely smooth and shows a random modulation of the profile. Due to different reasons (longitudinal dispersion, shot to shot variations, etc.) such a modulation changes turn to turn in circular machines, or shot to shot in linear ones. These randomly changing modulations are ultimately responsible for the incoherent radiation emitted by the bunch. If the intensity of the radiation is measured passage to passage it will show random fluctuations as well. It has been shown [19] that the absolute length of the radiating bunch can be measured by measuring the passage-to-passage variance of the radiation intensity in a part of the spectrum where the emission is fully incoherent. The ALS monitor implements this idea in a simple, non-destructive scheme that can be used with any kind of radiation, in both circular and linear accelerators, including those cases where the very short length of the bunches makes difficult the use of other techniques. The monitor was successfully tested at the Advanced Light Source using synchrotron radiation from a dipole [20].

Contributed Orals

Among the contributed oral talks, the one by P. Evtushenko on profile measurements using optical diffraction radiation (ODR) performed at CEBAF [21] is representative of the increasing interest on ODR for performing non-desctructive beam profile measurements. Indeed at BIW08, three contributions concerning ODR based diagnostics were presented. The invited talk by Fiorito [17] offered a complete review of OTR, ODR and Smith-Purcell based diagnostics systems, from both the theoretical and experimental point of view. The mentioned oral contributed by P. Evtushenko, presented instead a number of ODR measurements with a 4.5 GeV and several tens of μA beam at CEBAF. The results showed the potential use of ODR as relative beam size monitor.

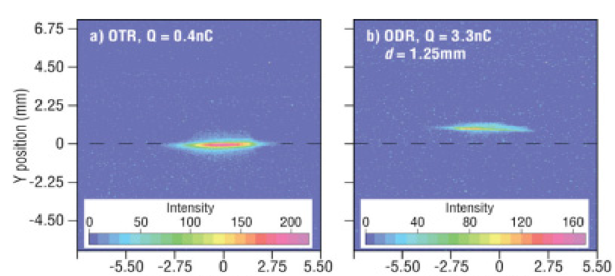

Figure 4: OTR vs. ODR comparison measurement performed at the Advanced Photon Source. Courtesy of A. Lumpkin.

Because of the diffraction radiation characteristics, a significant number of photons in the visible range can be obtained only at high beam energies and high average currents. In their poster contribution [22], A. Lumpkin and collaborators investigated the possibility of using ODR as diagnostic for beams with relativistic gamma factor “down” to the thousand range. Figure 4 shows an example of the ODR measurements performed at the Advanced Photon Source at Argonne.

Posters

Choosing the poster highlights was surely the most difficult task. Among the large number of contributions, I made a first selection that included ten posters [23-32] followed by another one that brought down the number to three.

The contribution by J. Munson and collaborators was selected because of two reasons. First, as the longest paper title I ever saw: “Injection of Direct-Sequence Spread Spectrum Pilot Tones into Beamline Components as a Means of Downconverter Stabilization and Real-Time Receiver Calibration”. Secondly and more seriously, because of the particularly interesting content. They describe a successful bench test at TJNAF of a technique that allows combining a reference/calibration tone with a beam signal without deteriorating the beam signal. In order to do that, a special technique was used. Pseudo-random numbers were generated and used to code the tone signal expanding it into a large number of normal components with individual intensities at the noise level. The coded signal was then combined with a simulated beam signal and sent to a receiver. The signal at the receiver can be used as it is for the beam signal analysis, or by reversing the coding process the tone can be extracted from the signal and used for calibration purposes.

The contribution by T. Hoffman and co-authors, “Beam Quality Measurements of the Synchrotron and HEBT of the Heidelberg Ion Therapy Center”, is representative of the significant activity devoted worldwide to the study and development of cancer therapy accelerators. Beam diagnostics in cancer therapy facilities plays a very peculiar role. Reliability, calibration and precision are obviously mandatory and of paramount importance in such machines. The poster describes the measurements of the carbon beam slow extraction (“spill”) at the Heidelberg facility in Germany. The spill structure is redundantly measured by using ionization chambers, scintillators and beam loss monitors. A “spill pause” is important and used to minimize undesired healthy tissue exposure. If the spill pause does not work properly a fast “RF knock-out” kills the beam within a spill.

The last poster contribution that I want to mention is “Creating a Pseudo Single Bunch at the ALS — First Results” by G. Portmann. In 3rd generation light sources, users performing experiments requiring a long relaxation time are usually satisfied by dedicated special runs where few buckets are filled and several hundreds of ns gaps separate the bunches each other. Portmann and collaborators developed and installed in the ALS ring a fast kicker capable of kicking a bunch every turn (~ 1.5 MHz repetition rate). The kicker pulse duration is less than 80 ns FWHM and allows kicking a single bunch in the middle a ~ 100 ns gap. In this way, such a bunch can be stably set on a displaced orbit. By collimating out the synchrotron radiation from the other bunches on the the regular orbit, a pseudo single bunch operation can be obtained in those beamlines where the displacement is sufficiently large. The paper describes the successful test of the scheme performed at the ALS. Multiple kicker schemes are also presented together with some interesting alternative modes of operation where the beam is kicked every n-th turn.

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