Topical Workshop on Diagnostics for Ultra-Low Emittance Rings (TW-DULER)

Thursday 19 April 2018 - Friday 20 April 2018

Diamond Light Source

Book of Abstracts

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Beam Dynamics for Ultra Low Emittance Rings

Author: Riccardo Bartolini[1]

[1] *Diamond Light Source and John Adams Institute (Oxford University)*

Corresponding Author: riccardo.bartolini@diamond.ac.uk

We review the basic concepts of beam dynamics in ultra low emittance rings including single particle and collective effects. Some emphasis is given to correct implementation of the optics, with the relevant operational issues and diagnostics requirements.

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Recent measurements of linear & nonlinear optics at the ESRF storage ring

Author: Andrea Franchi[None]

Corresponding Author: andrea.franchi@esrf.fr

Different approaches to infer magnet and optics parameters from beam-based measurements at the ESRF storage ring are reviewed. Main results and limits of the established techniques are examined. Possible improvements or alternatives are proposed and discussed in the light of first experimental results. A report on accuracy studies of linear optics measurements, based on both turn-by-turn and orbit data, will be eventually given.

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Fast Quadrupole Beam Based Alignment Using AC Corrector Excitations

Author: Zeus Marti[1]

Co-authors: Ubaldo Iriso [1] ; Gabriele Benedetti [2]

[1] *CELLS-ALBA*

[2] *ALBA-CELLS*

Corresponding Author: zeus@cells.es

The 10kHz fast acquisition BPMs together with an AC excitation of the corrector magnets allow to speed up the beam based alignment process at ALBA. The former approach relies on software synchronization and tango device servers to execute a series of DC corrector magnets and quadrupoles settings designed to avoid the quadrupole hysteresis effects. The approach that we present here is simpler, gives the same level of accuracy and precision and speeds up the measurement by a factor 30. The total measurement time has changed from 5 hours to 10 minutes.

Emittance Diagnostics Workshop Summary / **5**

Summary of the Emittance Measurements Workshop

Author: Ubaldo Iriso[1]

[1] *CELLS-ALBA*

Corresponding Author: uiriso@cells.es

In January 2018, a Topical Workshop on Emittance Measurements for Light Sources and FELs was held at ALBA. This talk will summarise the relevant part for 'rings' by marking current state of the art and pointing out opportunities for further development.

Diagnostics for Injector and Top-Up / **7**

Reduction of perturbations at the injection for the ESRF-EBS

Authors: Eric PLOUVIEZ[1] ; Benoît Roche[1] ; Simon White[1]

Co-authors: Marc Dubrulle [1] ; Mathieu Morati [1]

[1] *ESRF*

Corresponding Author: benoit.roche@esrf.fr

Designing a low emittance ring is generally achieved at the cost of a lower beam lifetime. To ensure a relatively constant current in the ring it is therefore compulsory to use a top-up refill scheme with frequent injections. Unfortunately injections are not completely transparent for users, the pulsed magnets (septa or kickers) induce some perturbation of the beam motion (closed orbit) and beam parameters which is then converted in an emittance increase lasting a few damping time.

In the present machine we have drastically reduced the perturbation at injection thanks to the improvement of the injection kicker system and the addition of several active disturbance cancellation systems. For the ESRF-EBS the perturbation will be reduced even further with a better design of the injection cell. The remaining perturbations to be compensated for will be smaller and it is expected that the systematic perturbation could be cancelled out with a feed-forward compensation. Non-systematic perturbation (due to kickers firing individual jitter) cannot be addressed with a feed-forward scheme and may need a dedicated feedback loop.

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Development and application of the new optical dissector for permanent control of the longitudinal distribution of a beam in cyclic accelerators

Author: Oleg Meshkov[1]

[1] *BINP*

Corresponding Author: o.i.meshkov@inp.nsk.su

A dissector is an electron-optical device designed for measurement of periodic light pulses of sub-nanosecond and picosecond duration. LI-602 dissector developed at BINP is widely used for routine measurements of a longitudinal profile of electron and positron beams at BINP electron-positron colliders and other similar installations. LI-602 provides a temporal resolution of about 20 ps. A new generation of picosecond dissectors based on the PIF-01/S1 picosecond streak tube was created recently. The results of temporal resolution calibration of the new-generation picosecond dissector carried out at the specialized set-up based on a femtosecond Ti:sapphire laser and application of the dissector at BINP accelerators and MLS storage ring will be presented.

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Turn-by-Turn Measurements for Systematic Investigations of the Micro-Bunching Instability

Author: Edmund Blomley[1]

Co-authors: Akira Mochihashi [1] ; Johannes Steinmann [1] ; Marcel Schuh [1] ; Anke-Susanne Mueller [1]

[1] *Karlsruhe Institute of Technology (KIT)*

Corresponding Author: edmund.blomley@kit.edu

While recent diffraction limited storage rings provide bunches with transverse dimensions smaller than the wavelength of the observed synchrotron radiation, this is still challenging in the longitudinal plane. The self interaction of a short electron bunch with its emitted coherent radiation can lead to the micro-bunching instability. Therefore, the bunch compression in storage rings is currently limited to the picosecond range. At KIT, recent detector development enabled the systematic investigation of such an instability on the turn-by-turn level, leading to a better understanding thereof. With this approach, monitoring bunch lengths in the picosecond length and below over long periods of time is possible. Examples of diagnostics developments are the ultra-wideband readout electronics for ultra-fast detectors, KAPTURE, and a ultra-fast line-camera with continuous frame rate in the MHz range, KALYPSO. As a test facility, the Karlsruhe Research Accelerator (KARA) provides an excellent environment for the development and benchmarking of such new diagnostics and transnational access to KARA is supported in the framework of ARIES. Presently, also experiments to characterize the CLIC damping wiggler and to test a novel beam vacuum system within the EuroCirCol project for the future circular collider (FCC) are under way at KARA.

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Bunch-by-bunch diagnostics at BESSY II

Author: Andreas Schälicke[1]

[1] *HZB Berlin, BESSY II*

Corresponding Author: andreas.schaelicke@helmholtz-berlin.de

Already now BESSY II is operated with a complex fill pattern, in order to fulfill many different user-demands simultaneously. Thus, properties like current, bunch size and bunch length vary on a bunch-by-bunch level, which require dedicated diagnostics for the stable operation of the machine. With the advent of BESSY VSR, the variable bunch-length storage ring, bunch resolved diagnostics will become even more important.
The current status of bunch-by-bunch diagnostics at BESSY II is presented, and an outlook to future developments is given.

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Advantages of the pilot tone approach in sub-micron BPM applications for low emittance machines

Authors: Gabriele Brajnik[1] ; Raffaele De Monte[1]

Co-authors: Silvano Bassanese [1] ; Giuseppe Cautero [1] ; Stefano Cleva [1]

[1] *Elettra - Sincrotrone Trieste*

Corresponding Authors: gabriele.brajnik@elettra.eu, raffaele.demonte@elettra.eu

In this contribution, we describe the advantages of the pilot tone compensation technique that we implemented in a new BPM prototype. Injecting a fixed reference tone upstream of cables allows for a continuous calibration of the system, compensating the different behaviour of every channel due to thermal drifts, variations of cable properties, mismatches and tolerances of components.
Another key feature of this approach is that the pilot can be seen as a fixed beam: a parallel and independent demodulation of this signal returns a real-time diagnostic of the system status.
All of these features, combined with long term stability, reduced current dependence, and nanometer-scale accuracy are desirable for BPMs adopted in low emittance machines.
A BPM based on the pilot tone is currently operational in Elettra's storage ring, connected to the global orbit feedback. It is capable of an equivalent RMS noise (@10 kHz data rate) for the pilot tone position of less than 200 nm on a 20 mm vacuum chamber radius, and a long-term stability better than 1 um in a 12-hour window.
Moreover, the possibility to improve further the compensation by means of tone frequency hopping is under investigation.

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High Energy Photon Source BPM digital electronics research

Author: Yufei Ma[1]

[1] *IHEP*

Corresponding Author: mayf@ihep.ac.cn

Abstract
Based on the demand of high energy photo source(HEPS), the goal of digital Beam position monitor(BPM) electronics is to develop a high precision beam control and measurement system, which can make the precise measurement of turn-by-turn (TBT) data, fast acquisition(FA) data, Slow acquisition (SA) data and closed orbit data (COD) data.
The hardware architecture of digital BPM includes analog front electronics (AFE) board, digital electronics (DE) board, the data acquisition and display system in computer. The AFE board mainly pick up analog signal from BPM probe, and AFE fed the processed signal to DE board; In DE board, the analog signal is converted to digital signal first, and then, which are processed with special algorithm in FPGA, at last, the results are transferred to back-end computer. My main research direction is digital electronics hardware circuit and firmware programming. Digital electronics hardware circuit design includes the power supply, clock system, ADC, FPGA, network transmission and other module design; The firmware programming includes the functional configuration of each module in the hardware circuit and the algorithm implementation in the FPGA.
Finally, laboratory tests were carried out with input signal of 499.8MHz and -10db☒Test results show that the turn by turn position resolution is 2.96 um, fast response position resolution is 0.65 um, and closed orbit position resolution is 0.33 um.The test results also demonstrated, the optimized algorithm which has a good performance on the beam position measurement.

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Status of current synchrotron BPM electronics and investigations towards future BPM concepts

Author: Manuel Cargnelutti[1]

[1] *Instrumentation Technologies*

Corresponding Author: manuel.cargnelutti@i-tech.si

Libera Brilliance+ is the third generation of BPM electronics which have been running in several light sources around the world. It's adaptive signal processing based on either frequency or time domain provided flexibility to measure both turn-by-turn and single bunch beam position. Furthermore, the long-term stabilization concept based on the crossbarswitch enabled it to achieve the stability required for the fast orbit stabilization. Lately, the System-on-Chip technology provided means for simplifying the BPM electronics concept, which can be now optimized for specific locations in the machine without big compromises on the performance. Looking at the future Low-Emittance rings and the status of the available technology, it is possible to anticipate some of the possible future needs: for example the capability of bunch-by-bunch position measurements can be an enabler for the control of the beam properties at the bunch level. Other interesting aspects are the alternative long-term stabilization techniques like the pilot-tone and temperature stabilization.
After an overview of the current BPM electronics use-cases and achievements, this contribution will present the investigations and first steps being done towards a future concept of BPM electronics.

BPM technology / **1**

BPM for Co-Propagating Beams

Author: Igor Pinayev[1]

[1] *BNL*

Corresponding Author: pinayev@bnl.gov

There are proposals to utilize the energy recovery linac (ERL) as driver for the light sources with ultra-low emittance. The ERLs have co-propagating beams inside the same vacuum vessel. These beams can have different trajectories, which should be distinguished by beam position monitors (BPM). In this paper we present a concept of a BPM utilizing the phase information for calculation individual position of each of the two beams (accelerating and decelerating). The practical realizations are presented and achievable accuracy is estimated.

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New button-type beam position monitor design for BESSY-VSR

Author: Ji-Gwang Hwang[1]

[1] *Helmholtz-Zentrum Berlin*

Corresponding Author: windy206@hanmail.net

The design study of new button-type beam position monitor (BPM) is performed for a high accuracy bunch-by-bunch BPM system. Particularly it is mainly to compensate the influence of ringing signal which causes the misreading of the beam position of following bunches. The ringing is produced by the combined effect of an impedance mismatching inside the button and trapped TE-mode inside the aluminum-oxide insulator material. In this presentation, we will present design considerations and calculation results.

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Advanced Beam Diagnostic Experiments Using the BPMs at NSLS-II

Author: Weixing CHENG[1]

[1] *NSLS-II, Brookhaven National Laboratory*

Corresponding Author: chengwx@bnl.gov

NSLS-II in-house developed BPM systems provide better than 200nm resolution and sub-micron long-term position stability, combined with the high-temperature stability of the storage ring tunnel, electronic racks, sophisticated support structures and orbit feedback. The talk will start with brief introduction of the NSLS-II BPM button and electronics design and achieved performances. The talk will focus on recent developments based on the BPM electronics enhance the capability for advanced beam measurements, as well as the stable operation of the low emittance storage ring. Examples of such developments, like the BPM gated function, fast glitch detection, AC excitation and beam measurement results will be presented. Future developments like pilot tone calibration and a newer version of electronics will be discussed to continuously improve the stable/reliable operations and beam studies at NSLS-II.

Greater Context of Stability / **21**

The Stability Task Force at MAX IV

Author: Brian Jensen[1]

[1] *MAX IV Laboratory*

Corresponding Author: brian_norsk.jensen@maxiv.lu.se

The work on stability for MAX IV took speed around 2010 and has since been an important factor in calculations and designs for buildings, supports and the components of accelerators and beam-lines. The stability work is now in a different phase, where observations of stability and instabilities emerges. This is the reason for establishing the MAX IV Stability Task Force in 2016. I will give a summary of the early work and summarize the philosophy behind setting stability tolerances at MAX IV. The civil engineering concepts developed for the project is shown. Some methods and policies, which we need to use, in order to maintain our stability, will be described. Realizing the risk of sub optimization, a “holistic” approach was taken in order to ensure accelerator performance: stability, alignment precision, vacuum and maintenance. The MAX IV solution to this challenge is presented as well as lessons learned in retrospect. Resent results from the characterization of stability at the lab will be presented, showing how the philosophy works. Some methods, tools, and possibilities for stability characterization will be described. Finally, I will list some of the projects that are running and some, which I think should be run, in order to assure our future operations.

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Experience with Hydrostatic Levelling Systems at Diamond

Author: Ian Martin[1]

[1] *Diamond Light Source*

Corresponding Author: ian.martin@diamond.ac.uk

In this talk we review measurements obtained with a Hydrostatic Levelling System (HLS) at Diamond. Two versions have been installed, the first of which ran along the length of a single beamline, and the second followed the full circumference of the storage ring inside the tunnel. The construction of the Diamond facility, details of the HLS system, results from both systems and experience gained are all discussed.

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APS Upgrade Fast Orbit Feedback and Beam Stabilization R&D

Author: Glenn Decker[1]

Co-authors: Nicholas Sereno [1] ; John Carwardine [1] ; Robert Lill [1] ; Ned Arnold [1]

[1] *Argonne National Laboratory*

Corresponding Author: decker@aps.anl.gov

The APS upgrade entails a complete replacement of the APS storage ring with a multi-bend achromat lattice, resulting in a reduction in natural emittance by more than a factor of 50, nominally to 42 pm-rad. This will reduce the horizontal beam size at insertion device source points to below 15 microns rms, and the vertical beam size to below 3 microns at 10% coupling. An extensive R&D program was initiated in 2013 to address limiting technologies supporting the APS-U, one such involving deployment of a suite of diagnostic and feedback capabilities encompassing two sectors of the present APS. This included 16 modernized sets of beam position monitor (BPM) electronics, a high-power hard x-ray BPM, 8 prototype fast steering corrector power supplies, a feedback controller operating at 22 kHz sample rate, in-tunnel hydrostatic floor level monitors, and capacitive proximity sensors monitoring the horizontal and vertical displacement of critical in-tunnel rf BPM pickup electrodes and x-ray BPM detectors. A description of the instrumentation and summary of key results will be presented.

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The SLS 2.0 Upgrade Project and some Considerations about Beam Instrumentation

Author: Volker Schlott[1]

[1] *Paul Scherrer Institut*

Corresponding Author: volker.schlott@psi.ch

SLS 2.0 is the upgrade Project of the Swiss Light Source (SLS) at the Paul Scherrer Institut in Villigen, Switzerland. The new 7-bend achromat lattice will reduce the natural emittance by a factor of ~40 providing higher brightness and coherent photons for the users.
This contribution shortly introduces the SLS 2.0 project and summarizes the first considerations about beam instrumentation and electron as well as photon beam stability.

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Overview HEPS beam diagnostics and the efforts on beam instrumentation R&D

Authors: Yanfeng Sui[1] ; Jianshe Cao[1] ; Junhui Yue[1]

[1] *IHEP*

Corresponding Author:

High Energy Synchrotron Photon Source（HEPS）is an ultra-low emittance light source, of which the energy is 6 GeV and the beam current is 200mA. There are many challenges in hardware design and fabrication. As to beam instrumentation, sub-micron level beam position measurement system, synchrotron light measurement system based x-ray and the feedback system including FOFB, TFB and LFB should be considered firstly, furthermore, common instrumentation such as beam current measurement and beam loss monitors are also studied. Many efforts are made in home-made beam position electronics and synchrotron light measurement system based on KB mirror. The R&D status and discussion of those system will be reported in this paper. The preliminary design of HEPS instrumentation will be presented also.