IMPROVEMENTS ON THE PHOTON BEAM DIAGNOSTICS AT ELETTRA

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Abstract

Elettra, the italian third generation SR source, was commissioned in 1993. Since then a great effort has been spent to develop a diagnostic system on the photons delivered to the users. At first were designed and installed traditional photon beam position monitors (PBPM) for insertion device (ID) beamlines only. Then, operational experience showed that these devices were not suitable for orbit feedback operations. So, in the last years a different approach has been taken working in two different directions. On one side a new design has been adopted for undulator PBPM and a first prototype has been successfully commissioned, while on the other hand PBPMs for bending magnet (BM) beamline have been also developed. Besides, a dedicated branch line from BM has been designed for further on-line SR parameters analysis. A description of the detectors developed, their instrumentation and highlights are presented together with an analysis on their impact on beam stability improvements. Progress to date and future plans are then investigated with a particular attention on the integration with the conventional accelerator instrumentation for orbit feedback.

1 INTRODUCTION

1.1 The Standard Storage Ring Diagnostics

The SR electron orbit is usually monitored by the so-called rf-BPM. These devices are placed in convenient sites along the SR vacuum vessel and together allow depicting a realistic behaviour of the electron orbit centre along the SR. But the rf-BPMs, so necessary for the daily operational life of a SR, have some properties that complicate their use for precise orbit measurement. In particular, from the experimental user point of view, they do not give back an absolute position measurement but only a relative one. So there are no real high accuracy correlations between the rf-BPMs outputs and the photon beam position with respect to the beamline alignment. In fact they are fixed to the vacuum pipe and suffer from its mechanical motion that causes fictitious beam motions. Such motions are caused by temperature changes in the vacuum chamber due to temperature variations inside the SR tunnel, cooling water temperature or beam current. Only more sophisticated rf-BPM, recently developed and mounted on dedicated supports, are mechanically decoupled from the vacuum vessel and minimize this effect [1]. Moreover, both the high frequency signals which are collected from the pick-up electrodes and the non linear electronic devices used for their handling, will introduce errors that may be seen as fictitious beam motions.

2 DIAGNOSTICS FOR UNDULATOR RADIATION

2.1 The Traditional PBPM for Undulator Beamlines

The most popular non-destructive PBPMs are based on blades, which intercept the fringes of the beam and photoemit electrons. The position of the beam centre and the angle of emission are then computed from the photocurrents measured. At Elettra each Front-End (FE), fed by IDs, has a PBPM system installed [2]. The PBPMs are so useful in beam diagnostics for their high sensitivity in position and in angle particularly. A continuous beam monitoring may be done for each beamline and it gives a stability parameter of the radiation provided (fig.1). Besides, data archiving allows off-line analysis and beam stability statistics. Unfortunately, these PBPMs are highly sensitive to any orbit perturbation in the upstream and downstream dipoles. In fact, their radiations contaminate the undulator position data. So, it is difficult to use them within any orbit feedback system.

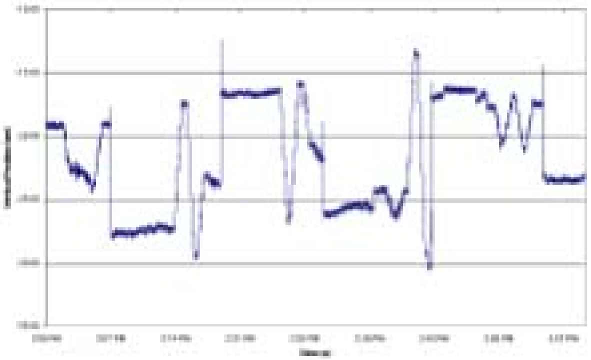

Figure 1: Photon beam stability monitoring at the undulator beamline 7.2 with the new PBPM.

2.2 The Novel PBPM for Undulator Beamlines

In order to overcome the PBPM limitations, a new generation of PBPM for undulator is currently under development [3]. This novel detector has been designed to perform a drastic reduction of both spatial and energy integration with respect to the traditional device. It collects the information coming from a limited portion of the blade and from a small photon energy bandwidth centred on an undulator harmonic. This effect is obtained collecting the electrons photo-emitted by a set of blades hit by the photons. An electron energy analyser, coupled to each blade, performs the energy selection over the electrons. A first prototype has been designed and built. Its commissioning is undergoing and its first results look very promising. The dipole radiation contamination has been cut off down to 0.1% as predicted. Moreover the position sensitivity has increased of a factor 2 due to the high selectivity in energy. This innovative device opens new perspectives for enhancing orbit feedback effects on the undulator beam stability. This is a key point because, usually, the undulators fed the most expensive and advanced experimental chambers where the stability is of paramount importance for scientific results.

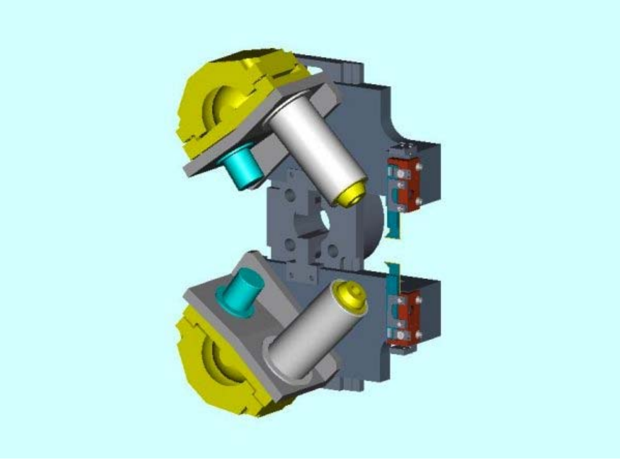

Figure 2: The Layout of the Photon Beam Position Monitor for Undulator Radiation.

3 DIAGNOSTICS FOR DIPOLE RADIATION

3.1 The Dipole Light Port at Elettra

At Elettra any beamline feds by dipole radiation has been designed with no dedicated diagnostics. Later, operational experience showed that a distributed monitoring system on the real displacement of the photon beam inside each beamline would be useful both for alignment purposes and for orbit feedbacks. Besides, experience in many SR facilities shows how a conventional PBPM, based on photoemission, is reliable and repeatable when it operates with the dipole radiation.

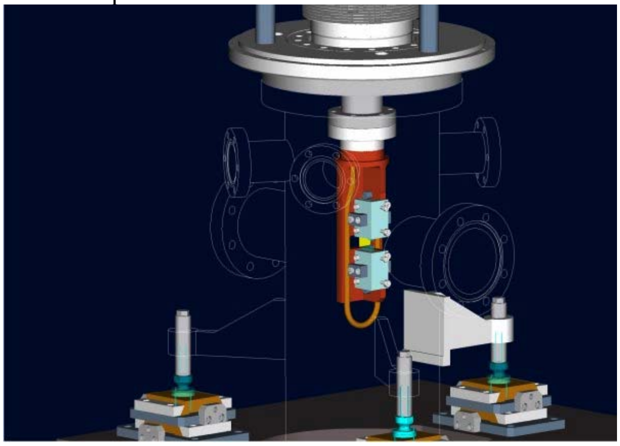

Figure 3: The Layout of the Photon Beam Position Monitor for Dipole Radiation.

So, starting from the standard FE layout, a diagnostic system has been designed. It is fully compatible with the existing FE structure and it does not interfere with its operations. A diaphragm with three holes provides each Elettra SR light port from a dipole magnet. They cut the angular dispersion of the photons to 2mrad vertically and 6mrad horizontally. The external holes define the portion of the dipole radiation for two beamlines, while the central one is unused. This feature allows designing a central branch-line dedicated for diagnostics. Moreover, some UHV chambers suitable to support a PBPM device provide each beamline. So, each BM front-end might be equipped with PBPMs only or with a dedicated diagnostic branch-line.

2.3 A Dipole Branch-line for Diagnostics

A first diagnostic branch-line from dipole has been designed and is currently under commissioning. It is based on a layout already used in other SR facilities [4]. The active elements are two PBPM for BM radiation and a Pin-hole-Array Imaging System (PAIS). The PBPMs provide a reliable detection of the vertical beam position and of the vertical beam angle. Besides, the PAIS provides further information on the beam dimensions and on the beam emittance. The PBPM layout is based on two pair of TZM blades placed on the vertical plane and insulated by BeO sleeves. The second pair of blades is shifted with respect to the first of a certain gap depending on the FE design. This gap permits the auto-calibration of the detector without any movement.

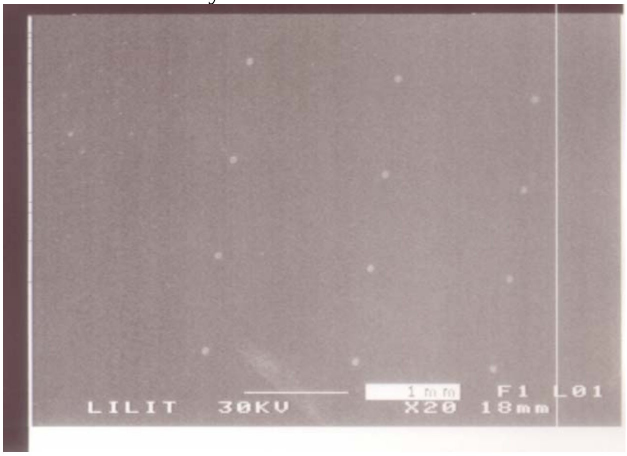

Figure 4: The Pinhole Array Imaging System (PAIS), developed at Elettra, by Deep X-Ray Lithography.

The Pinhole Array Imaging System (PAIS) is a simple extension of a pinhole camera system. Instead of a single pinhole our system integrates on a copper foil fifty equi-spaced holes. They are obtained by X-ray lithography with a diameter of 50 micrometer. The Deep X-ray Lithography group at Elettra [5] is developing a fast prototyping process for low resolution (feature size > 10 _m) structures with maximum aspect ratio of ~ 10:1. A chromium mask is replicated using standard UV lithography in a 35 mm thick photo resist layer coated on a kapton foil with a Chromium/gold base plating. Kapton offers the advantages of being transparent and resistant to X-ray and very cheap compare to the standard X-ray mask membrane (Be, Diamond, SiN). Gold is then electrodeposited in the holes left in the developed resist in thickness up to 25 _m. This X-ray mask is then used to expose resist thickness up to 2 mm and either Ni, Au or Cu can be electrodeposited to fabricate the final metal part. The PAIS allows measuring the main characteristics of the BM light as source sizes, vertical opening angle, position of the source and emission angle [6]. In order to evaluate the source sizes, we have to collect data due to the X-rays as, for the diffraction limit, any imaging caption at lower energies would decrease the effective system resolution. So, a dedicated water-cooled filter foil cuts low energies photons. Then a phosphor is coupled to the filter and a CCD camera collects the images coming out from the pinhole array. These images are also usable for monitoring the transverse and longitudinal beam instabilities.

4 INSTRUMENTATION FOR PBPM

4.1 A Floating & Smart Transimpedence Amplifier

Both traditional and novel PBPMs collect signals from electrodes, which may be biased up to some kV. A standard smart instrumentation, called Picolite, has been developed for current measurements on biased electrodes. Each module has two independent channels that can measure currents ranging from 1pA to 1mA. The inputs are provided by a triaxial connector, which allows a double signal shielding. Picolite is a smart instrumentation as it is based on 2 micro controllers for each channel and has a 16bit ADC for on board digital conversion. As the output is fully digital, an analog service output is also provided. Each channel has a HV input connector for the electrode polarization. Two models are currently available: the **S50x** and the **S300x**, the first allows a maximum biasing voltage of 500V while the latter of 3000V. Each module is housed in a 3U high cabinet compatible with 19" Euro-mechanics rack, and up to 4 Picolite modules may be mounted into a single 3U high rack for a total of 8 channels. Picolite is provided with its 3U high rack and its power supply unit. Each channel has auto-ranging and auto-offset capabilities, which allow a safe stand-alone usage. Besides, each channel is provided by a standard serial interface for controls and data acquisition through a host computer. Moreover, a fast digital data acquisition path is available for real time applications while a further slot is available in the rack for an embedded DSP controller board suitable for fast calculations. High sensitivity and low noise are the major highlights of the instrument. Its operational commissioning, with the PBPM for undulator beamline, shows an overall system sensitivity of 0.1 um.

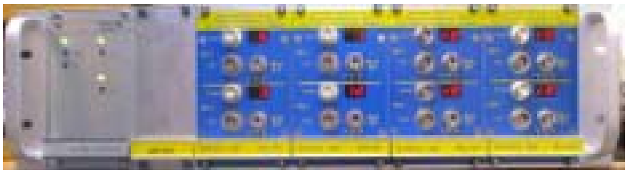

Figure 5: The 8 Channels Instrumentation Crate for PBPM Data Acquisition.

4.2 Real Time Data Processing for Feedbacks

As our main interest on PBPM relies on feedback system improvements, we need a fast real time calculation unit for handling all the processes. A first system, based on a commercial CompactPCI board (cADC64 from Innovative Integration with a TMS320C32 floating-point DSP on board from Texas Instruments capable of up to 60MFLOPS/30MIPS) is presently under development. On-chip peripherals include two flexible 32-bit counter/timers, a bi-directional sync serial port, eight 16-bit A/D converters and 16 general purpose digital I/O. The capabilities of this high performance data acquisition board allow sampling eight diagnostic signals with a frequency up to 100KHz. This board has the capability to compute the data and to send the corrections directly to the actuators.

5 CONCLUSIONS

Brief summaries about last developments and trends in photon beam diagnostics at Elettra have been presented. Different SR sources require different detectors while a common hardware and software platform for data acquisition is preferable. Photon beam diagnostics looks very promising for integrating conventional storage ring diagnostics. In particular it might support a user-oriented policy that would take care of the real beam quality provided to experimental station. A strong effort has been spent to overcome past PBPM limitations and to allow their future integration in both local and global feedbacks. First results are particularly promising but for covering all the Elettra light ports further investments are needed. A European cooperation, between SR facilities, on these topics may help to cut the development costs and allows a faster upgrade of the existing systems.

6. REFERENCES

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