ABSTRACT

• With swap-out injection and a third-harmonic bunch lengthening cavity, time domain diagnostics will be beneficial tools for optimisation of the Advanced Photon Source Upgrade (APS-U) electron storage ring.

• In the present work, we present plans for time-domain X-ray and visible photon diagnostics for the APS-U.

• Particular emphasis is given to implementation of visible light streak cameras and X-ray bunch purity monitors as time domain photon diagnostics.

MOTIVATION

• Several user programs take advantage of the pulsed time-of-arrival of X-rays corresponding to the storage ring fill pattern.

• We plan to provide temporal photon beam diagnostics for the optimisation and diagnostics of APS-U accelerator operations.

• We outline the time distribution of photons for beamlines at APS-U. Proposed techniques for time-domain photon diagnostics are summarised. Finally, we describe the proposed changes to the existing beamline configuration to employ these diagnostics.

FILL PATTERN AND BUNCH PROFILE

• Fill patterns of the APS are controlled by the radiofrequency (rf) of the main rf cavities (352 MHz), and the storage ring circumference (1104 m). This accommodates 1296 buckets.

• At present, APS operates three fill patterns for user operations.

• Either 24, or 324 bunches equally-spaced, or a camshaft fill (‘hybrid mode’, 1 + 8 x 7), with 1 bunch, and 8 trains of 7 bunches spaced at 2.84 ns [1].

• For APS-U, a 48-bunch mode and 324-bunch mode are foreseen, with 324 bunches operating in bunch trains with ion-clearing gaps and guard bunches [2].

BEAMLINE GEOMETRY

• An elevation view of the beamline front end is illustrated in Fig. 1, and schematically in Fig. 2.

Figure 1: Profile of components in 35-8M front end [3]. The longitudinal coordinate z is with respect to the bending nominal bending magnet photon source point. (a) Existing APS configuration. (b) Proposed APS-U configuration. For APS-U, a section of the visible light telescope, the pinhole aperture assembly and pinhole camera will be removed.

Figure 2: Schematic illustration of 35-8M beamline in plan view [4]. (a) 35-8M for APS operations. For daily operations, the outboard branch line serves a pinhole camera for imaging, M1 mirror for visible synchrotron radiation. Time-correlated single photon counting is performed in hutch C using the inboard X-ray branchline. (b) Proposed APS-U configuration. Future capability for a pinhole camera on outboard branch line. Visible light transport and X-ray photon counting for bunch purity monitoring will be preserved.

TIME DOMAIN PHOTON DIAGNOSTICS

• Bunch Length Measurement

  – Operation of APS-U higher harmonic cavity to lengthen the bunch results in a bunch distribution that potentially departs significantly from a Gaussian approximation [5].

  – This motivates experimental techniques to measure the bunch temporal profile without assumption about the bunch shape.

  – For APS-U, bunch length measurements will be performed using a visible light streak camera [6].

  – The streak camera can be synchronised with the third subharmonic of the storage ring main rf frequency (117 MHz), derived from the APS-U timing and synchronisation system [7].

• Bunch Purity Monitor

  – At APS, time-correlated single photon counting of hard X-rays is employed to measure bunch purity [8, 9].

  – This capability will be preserved in order to measure bunch purity of the APS-U storage ring.

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