Title	***SR photon monitor upgrade***			
Project Requestor	Bingxin Yang			
Date	02/22/2008			
Group Leader(s)	Glenn Decker			
Machine Manager	Louis Emery			
Category	Accelerator Improvement			
Content ID*	APS_XXXXXX	Rev.	ICMS_Revision	ICMS Document Date

*This row is filled in automatically on check in to ICMS. See Note [1]

Description:

Start Year (FY)	**2009**	**Duration (Yr)**	**4**

Objectives:

Upgrade goals in electron beam size measurement at two locations in Sector 35. (1) RMS resolution: 5 micrometer at ID source and BM sources; (2) imaging frequency: 1 kHz or higher; and (3) digital video upgrade for emittance measurements to cover the dynamic range corresponding to 1 – 100 mA stored beam.

Improve availability of beam data to timing users and experiments: (1) An APD-based online bunch phase / length / longitudinal profile monitor will make the waveform available as EPICS process variables. (2) The existing APD-based bunch purity monitor will be improved to provide 10^8 to 10^9 contrast between a filled bucket to the next bucket, in order to support the Booster bunch cleaning initiative. (3) During hybrid fill operations, many timing users use the 16-mA super bunch exclusively for their experiment, which has a different bunch length, energy spread, beam divergence, and source size. A bunch-resolved emittance monitor will be implemented to supply online information about this bunch.

Benefit:

A high transverse resolution measurement of the beam size is important to support the development of low vertical coupling / high brightness synchrotron radiation source. One source of user x-ray flux fluctuation is the x-ray beam size and/or divergence fluctuation seen by the user beamline. A high-speed centroid motion of electron beam may also be perceived as size fluctuation by detectors averaging over many bunches and turns. A high-resolution and high-frequency beam size measurement system is crucial in sorting out the cause of beam size fluctuations and helping the eventual corrections of the fluctuation. Digital video upgrade will increase the effective dynamic range of cameras from the current 6-bit to 10 – 12 bit, covering beam current ranges from 1 mA to 100 mA.

The APS timing users have come to demand more detailed information on bunch longitudinal profile, in addition to bunch length and phase. Since these quantities drifts slowly over the run of several days, it is suitable to provide them on line to help users interpret their experimental data. In addition, this monitor allows archival of photon bunch phases during operations and machine studies. Such information will help diagnose problems with rf timing system or user timing system. Finally, large dynamic range and constant availability of the new system also help accelerator studies.

Risks of Project: See Note [2]

None. The new systems will be implemented in steps to supplement / replace the existing emittance monitor.

Consequences of Not Doing Project: See Note [3]

With improvement of the centroid stability below 1 kHz, it is increasingly difficult to improve user beam quality without the assurance that the beam size is stable and is accurately measured. In other words, not knowing whether user beamline output fluctuation is due to centroid or size change makes it very difficult to make further improvement. Without digital video upgrade, the current-dependent beam size measurement has been performed using increasingly larger slits openings to compensate for lower x-ray intensity level for low currents, making data interpretation more difficult.

APD-based bunch purity monitor has been upgraded successfully in FY06-07 to provide bunch purity measurements with signal-to-noise ratio better than 10^11 for buckets far away from the filled ones. The contrast for the bucket adjacent to the main bucket, referred to as +1 bucket, still needs to be improved. This improvement is necessary to support the initiative to implement a Booster bunch cleaning system.

The APS timing users have become more sophisticated since the start of the light source: the interpretation of their experiments is affected by the details of the bunch length, size, and sometimes, transverse and longitudinal profiles, which drifts slowly during storage ring operations. Without simultaneous measurements of these beam parameters with their experiments, interpretation of the data will be subject to errors and possible artifacts.

Cost/Benefit Analysis: See Note [4]

Zone plate optics has been used in Spring8 and Photon Factory successfully for beam size measurements with micrometer resolution. It is the most reliable way known today to achieve the resolution goal. High speed imaging and beam size measurements require further analysis to find approaches matching the time structure of the APS storage ring.

APD-based bunch purity monitor has been proven to be a cost-effective tool for bunch purity measurements with signal-to-noise ratio exceeding 10^11 for buckets far away from the main. Our first effort will be based on this tested platform.

APD-based bunch length measurement using correlated photon counting has been tested in FY08 using a loaner unit from a vendor. Its resolution is adequate for continuous longitudinal bunch profile measurement of the 16-mA bunch. Its cost is low compared with the streak camera system and it will actually save money by reducing operation hours of expensive streak cameras.

Description:

The high resolution imaging optics will be based on x-ray zone plate / achromatic optics. A simple channel-cut crystal monochromator at the 35BM, lower power than the ID line, will be the first step to get the first high resolution image. The ID beamline will use a simple diamond double crystal monochromator with very limited wavelength range. These images will give us beam size information at two points ninety degrees apart in betatron phase.

The existing APD-based bunch purity monitor will be upgraded for better time resolution and higher count rate. A visible light APD-based bunch length measurement using correlated photon counting will be installed in 35-BMB lab. At this time, the resolution of this techniques is limited by the sensor, APD or PMT. We will evaluate APD's from multiple vendors for best performance.

We will build a bunch-resolved emittance monitor and put it online. A test using existing hardware will be performed first, to evaluate most cost-effective approaches. It will likely be based on gated camera or APD detectors.

Funding Details

Cost: ($K)
Use FY08 dollars.

Year	AIP	Contingency
1	140	10%
2	140	10%
3	140	10%
4	140	10%
5		
6		
7		
8		
9		
Total	560	56

Contingency may be in dollars or percent. Enter figure for total project contingency.

Effort: (FTE)

The effort portion need not be filled out in detail by March 28

Year	Mechanical Engineer	Electrical Engineer	Physicist	Software Engineer	Tech	Designer	Post Doc	Total
1	0.25		0.3	0.2	0.3	0.25		1.3
2	0.25		0.3	0.2	0.3	0.25		1.3
3	0.25		0.3	0.2	0.3	0.25		1.3
4	0.25		0.3	0.2	0.3	0.25		1.3
5								0
6								0
7								0
8								0
9								0

---

[1] **Notes:**

ICMS. Check in first revision to ICMS as a *New Check In*. Subsequent revisions should be checked in as revisions to that document i.e. C*heck Out* the previous version and C*heck In* the new version. Be sure to complete the *Document Date* field on the check in screen.

[2] **Risk Assessment.** Advise of the potential impact to the facility or operations that may result as a consequence of performing the proposed activity. Example: If the proposed project is undertaken then other systems impacted by the work include ... (If no assessment is appropriate then enter NA.)

[3] **Consequence Assessment.** Advise of the potential consequences to the facility or to operations if the proposal is not executed. Example: If the proposed project is not undertaken then ____ may happen to the facility. (If no assessment is appropriate then enter NA.)

[4] **Cost Benefit Analysis.** Describe cost efficiencies or value of the risk mitigated by the expenditure.

Example: Failure to complete this maintenance project will result in increased total costs to the APS for emergency repairs and this investment of ___ will also result in improved reliability of ____. (If no assessment is appropriate then enter NA.)