Overview of
Possible Technical Specifications and Schedule for an APS Upgrade

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Introduction

This document outlines possible technical specifications for an APS upgrade. The accelerator changes discussed here are only part of the overall science-driven upgrade plan, which will also include many innovations to beamlines and insertion devices. While the purpose of the upgrade is to enable dramatically improved experiments, we put a premium on preserving existing experimental capabilities with minimal disruption. Two different approaches are being considered: a replacement of the existing storage ring accelerator; or an augmentation of the present injection systems by an energy recovery linac (ERL) which would then utilize the existing storage ring in a single pass mode.

Boundary Conditions

While the upgrade will deliver revolutionary capabilities, it will take time for the user community to take full advantage of these new specifications. To minimize disruption, a premium is placed on preserving at all times the present APS capabilities .

The following will be maintained to the extent possible for either approach:

1. Will utilize the existing APS storage ring tunnel
2. Beam energy will be at least 6 GeV, but with a goal of 7 GeV.
3. Existing beamlines will be preserved
4. Existing beam stability will be maintained

If the approach taken is a replacement of the storage ring

1. Beamlines will be able to continue operation with no changes to equipment, if that is desired, and without any reduction in performance.
2. Existing capabilities for bunch patterns will be preserved, including single bunch current of up to 16 mA in hybrid mode.

If the approach taken is an ERL injector

1. Delivered flux will be maintained (in high flux mode).
2. The storage ring will be able to run in its present “storage ring mode” for as long as is necessary after the ERL has been commissioned.

Potential New Capabilities

By virtue of major changes to the accelerator complex, APS proposes to develop innovative x-ray sources with unique and unsurpassed capabilities. Two options are being considered for a storage ring replacement, and several ERL layouts are being considered. The

capabilities/qualities that we envision supporting with each are noted below:

Storage Ring Replacement, providing low emittance lattice:

1. Significantly reduced horizontal beam emittance, to below 1 nm.
2. Increased beam current, to at most 200 mA.
3. Controlled short x-ray pulses tunable from tens to a few picoseconds, available at a few sectors using rf transverse chirping scheme.
4. Enhanced coherent imaging, particularly, with larger imaging area available at a few sectors using rf transverse chirping scheme.
5. Extended straight section length to support innovative sources, such as,
    a. Variably-polarized high-energy x-rays.
    b. Variably-polarized intermediate-energy x-rays with rapidly-changing helicity.

Storage Ring Replacement, providing additional ID beamlines:

1. Reduced horizontal emittance (~1.5nm)
2. Increased beam current, to at most 200 mA.
3. 2.1 m straight section parallel to existing BM line provides capability of ID beamline for all BM beamlines
4. Three pole wiggler could be provided for BM beamlines that wish to retain bending-magnet-like source
5. Lattice provides space for third ID per sector.

ERL

The ERL layouts all produce comparable beam for injection into the existing storage ring. We indicate the parameters that we anticipate in Table 1 for three different modes of ERL operation: High Flux; High Coherence; and Ultrashort Pulse. The values are from G. Hoffstaetter, FLS2006.

Mode →	***High Flux***	***High Coherence***	***Ultrashort Pulse***
Average current (mA)	100	25	1
Rep. rate (MHz)	1300	1300	1
Bunch charge (pC)	77	19	1000
Emittance (pm)	22	6	365
RMS bunch length (ps)	2	2	0.1
RMS momentum spread (%)	0.02	0.02	0.4

Table 1

ERL layouts fall into two basic categories: placement of the ERL inside the storage ring enclosure, and placement of the ERL outside. The primary difference is that the ERL layouts outside the storage ring utilize a straight (i.e., not folded or recirculating) linac, and provide space for long undulators and the potential for an FEL upgrade.

Incorporating these options into the facility is a challenging task and requires extensive changes to the accelerator complex, as well as considerable research and development.

Schedule and Operational Impact

An upgrade of this magnitude will clearly impact APS operations, though every effort will be made to limit this impact. If the upgrade involves a replacement of the storage ring, the anticipated schedule and operational impact are:

1 APS user time will be scheduled as it is now (three ~1650 hour runs per year, and three shutdowns) until the start of the project.
2 The shutdown will begin after a 2013 run, perhaps later, no sooner.
3 The shutdown for installation will last 12 months, followed by a two month commissioning period.
4 The first year of operation will be scheduled as four 1100 hour operational periods and four shutdowns. The first two of these operational periods will be considered commissioning runs with availability expected to be better than 75%.
5 We would expect to be back to three operational runs and three shutdowns with availability greater than 90% and MTBF greater than 24 hours in year two after the shutdown.

If the upgrade utilizes the ERL approach most of the work would be away from the accelerator complex. The work that impacts the accelerator, such as the relocation of utilities, would be done during normal shutdowns (each of which is about one month in duration) leading up to construction. The final shutdown, in which the ERL is "spliced" into the existing APS complex will be minimized, although the impact will depend on which of the layouts would be implemented. Details of the ERL installation into the APS complex are still being studied. As noted earlier, the existing injector complex would be retained. After the shutdown in which the ERL is connected to the storage ring, we would plan on providing periods of standard operation with beam from the existing injector interspersed with periods of ERL commissioning.

Upgrade Concept

Descriptions of the upgrade concepts can be found at: **Storage Ring Options** and **Accelerator Systems**