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REMOVAL AND INSTALLATION PLANNING FOR THE ADVANCED LIGHT SOURCE - UPGRADE PROJECT *

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Abstract

The ALS-U project is a proposed upgrade to the Advanced Light Source (ALS) at Berkeley Lab that aims to deliver diffraction limited performance and an increase of the beam brightness by two orders of magnitude for soft x-rays compared to the current ALS facility. The storage ring design utilizes a nine-bend achromat lattice, with reverse bending magnets and on-axis swap-out injection from an accumulator ring. This paper will describe the preliminary plans for the installation of a new accumulator ring (AR) in the existing tunnel, and for the removal and replacement of the existing storage ring (SR). The AR will be installed during regular maintenance shutdowns while the ALS continues to operate. The current ALS will be shutdown for a nominal twelve month darktime period, consisting of 9 months of SR removal and installation activities, followed by three months of commissioning.

INTRODUCTION

Since the ALS was commissioned in 1993 it has developed into a premier user facility for soft X-rays. Currently, there are 43 beamlines providing more than 2,100 users each year with light capabilities extending from infrared to harder X-rays. The proposed ALS-U project will provide a soft X-ray source that is up to 1,000 times brighter than today's capabilities, whilst generating a significantly higher fraction of coherent light in the soft x-ray region than is currently available at the ALS [1]. In September 2018, the project's conceptual design was approved by the Department of Energy (CD-1), which authorized the start of the detailed engineering and design work.

In order to achieve the new target brightness for the x-ray source, the storage ring lattice was optimized to reach a stored beam emittance of 70 pm rad, thereby requiring the addition of an accumulator ring to the accelerator complex [1]. The accumulator ring accepts beam from the existing ALS booster utilizing a standard off-axis injection technique. The accumulator acts as a damping ring and is designed to deliver a similar emittance as the current ALS storage ring of 2nm rad. Its extracted low emittance beam is then injected on axis into the new multibend achromat storage ring. Figure 1 shows a 3D-CAD model rendering of the proposed ALS-U accelerator complex. In parallel to the accelerator construction the optical beamlines will be reconfigured as needed, to match to the new source points of the storage ring. Additionally, two new beamlines will be installed to take full advantage of the upgraded light capabilities. Following commissioning, and during early operations, the project will bring existing and new scientific beamlines back online in a staged approach.

During operation the upgraded ALS storage ring will contain 10 bunch trains while the accumulator ring will contain one bunch train. A fresh accumulator bunch train will be periodically swapped-out with a bunch train of the storage ring to maintain its nominal 500mA stored beam. The accumulator ring continues to accumulate fresh charge from the booster ring until the next swap-out injection. This operation mode requires a complex transfer line/beam injection area to transfer the beam from the booster to the accumulator ring, from the accumulator ring into the storage ring and from the storage ring into the accumulator ring. The transfer line area requires careful physics and engineering optimization, to enable installation whilst providing access for subsequent maintenance activities in this heavily congested area.

Limiting the scientific down time of the ALS user program is an important objective for the ALS Upgrade project and a driver for the engineering design and installation strategy. The planning of the installation process is aimed to minimize the time required to install and align the equipment in the tunnel by maximizing the amount of integration work that can be done outside the tunnel. This paper focuses on the current plans for the installation of the new accumulator ring, removal of the existing accelerator components and their auxiliary systems, and site preparation. We only briefly describe the conceptual installation plans of the new storage ring.

ALS-U REMOVAL AND INSTALLATION OVERVIEW

The removal and installation effort will be conducted in three phases:

1. Upgrades to end-of-life ALS utilities as part of ongoing facility improvements starting in 2019, ensuring compatibility with the site preparations necessary for the AR installation.

2. The installation of the accumulator ring prior to darktime, which will be executed over several years starting in 2020, and continue until darktime. Preliminary commissioning of the AR will be completed before the darktime.

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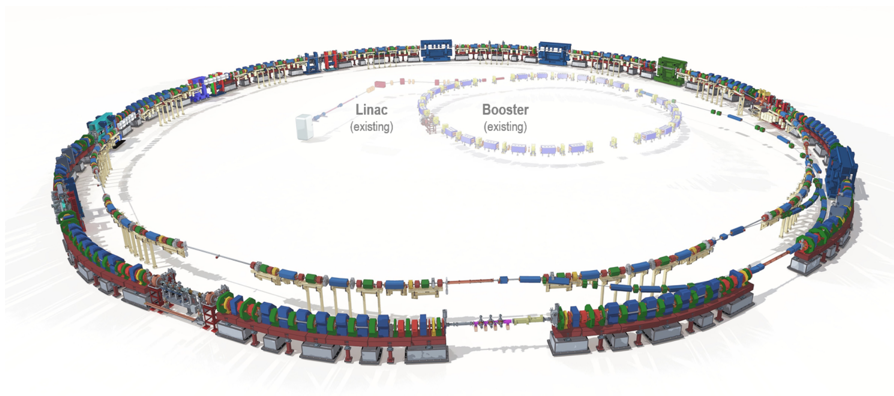

Figure 1: 3D-CAD model of the ALS-U accelerator complex.

3. The removal of the ALS storage ring and its auxiliary accelerator components and the installation of the new ALS-U storage ring during the twelve months darktime. This darktime includes three months for the recommissioning of the injector system (injection linac, booster, and accumulator ring) and the commissioning of the new storage ring. In the current project plan, the darktime is proposed to start in July of 2024 and conclude in July of 2025.

INSTALLATION OF THE ACCUMULATOR RING

As described above, the accumulator ring will be installed while the existing ALS continues to operate at its nominal 5000 hours/year. The AR will be located in the upper section of the inner tunnel shielding wall. This wall is cast-in-place concrete and part of the building foundation, which limits vibration levels and is seismically adequate to support the added weight of the accumulator (about 70 metric tons). The accumulator elevation is located high enough (2m above the tunnel floor) to allow egress through the existing tunnel labyrinths, in compliance with building code. The elevated position, together with the overall limited space in the accelerator tunnel, makes maintenance and installation activities challenging, and needs to be considered as part of the design requirements. The preliminary design model for the accumulator ring mounted on the inner shielding wall is shown in Fig. 2. The accumulator ring will be installed in a staged approach utilizing regular maintenance shutdowns of the ALS. In the first phase the existing utilities and the air conditioning system distribution ducts that are currently located on the inner shielding wall will be relocated to create the necessary space for the accumulator installation. In the next phase LCW cooling lines and wireways for the AR are installed on the wall followed by the support structures.

To minimize the assembly effort inside the tunnel a rigorous workflow has been developed to thoroughly test each component before it is accepted for pre-staging into raft modules where magnets, vacuum chambers, and diagnostics are integrated and functionally tested in an off-site assembly area. All components will be precision aligned to each other fiduzialized to the raft. In addition, the vacuum assembly between rafts will be tested and preliminary vacuum level established to ensure a smooth installation process in the tunnel minimizing unexpected interferences. In effect, in the tunnel, only seven components (rafts/magnets) for each sector will need to be aligned, greatly reducing the assembly and alignment time in the tunnel. The support structure and

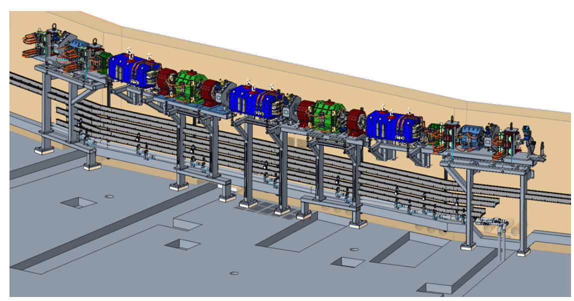

Figure 2: Model of one accumulator ring sector mounted on the tunnel wall.

the accelerator components are designed in a modular way for maximum flexibility during installation. One sector of the accumulator ring consists of four pre-aligned rafts and three dipoles as shown in Fig. 2.

Similarly the LCW cooling distribution and electrical cable-routing to all magnet coils and diagnostics devices will be completed and tested on the raft level. This approach simplifies the electrical and mechanical integration of the sector during installation. It reduces the time to connect the rafts to the main LCW system, and the numbers of cable terminations to be completed in the tunnel. In addition, the majority of the accumulator magnets are energized in series simplifying the cable routing. The remaining corrector magnet power supplies, independently driven focusing elements, vacuum systems, and diagnostic electronics, will be distributed in 3 standard height racks per sector, with the cables locally routed through wall penetrations into wireways mounted below the accelerator structure as shown in Fig. 2. Similarly to the mechanical components, electrical system

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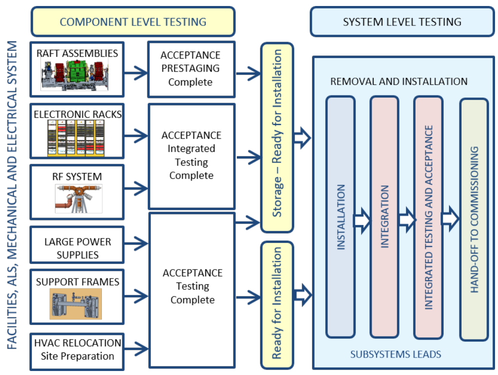

Figure 3: Hand-off workflow from the component level to pre-installation, installation, integrated testing and commissioning.

components and controls will be tested as before they are accepted for installation. The racks will be pre-populated and qualified before they are released for installation in the accelerator facility. Figure 3 shows the general process and acceptance workflow for the accumulator ring, and a similar approach is also applied for the storage ring installation as described below.

REMOVAL AND INSTALLATION OF THE STORAGE RING

To minimize the required assembly time in the tunnel, the SR components are mounted on raft assemblies that are pre-aligned and independently tested before they are released for installation in the tunnel, much like the accumulator ring. Figure 4 shows the conceptual design of the storage ring and its support structure. Since the accumulator will remain in

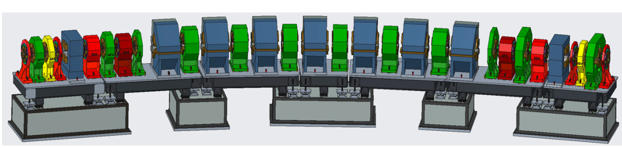

Figure 4: Model of one storage ring sector.

place during the SR removal and installation effort some preparation work for the storage ring cable routing must be completed during the AR installation, to avoid interference. In the current facility, each sector is fed by two floor trenches and one LCW utility trench. In order to route the additional cables needed to power the nine-bend achromat two additional floor trenches fed by six new cable penetrations per sector need to be completed before the accumulator structure is anchored to the floor. Six months prior to the darktime the facility will be prepared for the nine months removal and installation activities. Three egress points have been identified, that can be utilized to move equipment out of the tunnel via ground transportation, as shown in Fig. 5. Selected beamlines will be decommissioned prior to darktime to clear these egress paths.

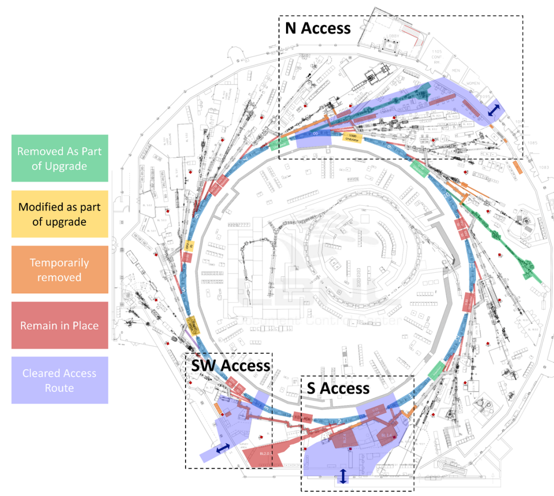

Figure 5: The ALS facility with the egress points indicated.

Once the ALS accelerator facility shuts down at the beginning of the extended darktime, the SR and pit equipment removal sequence can start immediately. Initially, electrical equipment will be de-energized and lock-out/tag-out (LOTO) applied. The accumulator ring and its auxiliary components, the storage ring RF system, some insertion devices as well as most front-ends will remain in place and will be protected before the removal activities can start. All other storage ring components, racks, and cables will be removed and replaced. The new cables will be routed from the pit area through the two existing and new additional trenches on the floor.

A combination of ground transportation and overhead crane will be used to remove the old storage ring components. Removal and installation processes will be developed with a focus on methods that allow activities to be conducted in parallel, while minimizing overall in-tunnel activity. For the electronic equipment in the pit, only the overhead crane is a viable option since the inner shielding wall is cast-in-place with only a small removeable section, that is rather inaccessible. Therefore, electronic racks and power supplies will be staged near a common pick-up point for the crane, where they will be transported in a few shifts. In total about 400 tons of equipment will be removed and replaced. During the darktime four crews in the tunnel and four crews in the pit area will work in parallel in four quadrants to clear and prepare the floor space for installing the SR concrete support plinths and equipment racks. Similar to the removal, a combination of ground conveyance and overhead crane will be used to install the new SR components into the tunnel.

REFERENCES

[1] C. Steier *et al.*, "Status of the Conceptual Design of ALS-U", in *Proc. 9th Int. Particle Accelerator Conf. (IPAC'18)*, Vancouver, Canada, Apr.-May 2018, pp. 4134–4137. doi:10.18429/JACoW-IPAC2018-THPMF036