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STATUS OF THE ALS-U ACCUMULATOR RING INSTALLATION

D. Leitner*, A. Lodge, C. Bullock, J. Caddick, D. Fuller, T. Griesemer,
E. Lee, K. McCombs, E. Newman, M. Quiogue, S. Spillane, R. Stitt,
K. Chow, J. Niu, J. Bohon, D. Robin, C. Steier, W. Waldron
Lawrence Berkeley National Laboratory, CA, USA

Abstract

The ALS-U project is an upgrade to the Advanced Light Source (ALS) at the Lawrence Berkeley National Laboratory that aims to deliver diffraction-limited X-ray beams with an increased beam brightness of two to three orders of magnitude for soft X-rays compared to the existing ALS facility. A nine-bend achromat lattice Storage Ring (SR) and a three-bend achromat Accumulator Ring (AR) will be installed in the facility. The project has recently received federal approval to start construction for the new SR. The AR has received early funding and is currently being installed in the ALS facility during its regularly planned shutdowns. This paper describes the status of the accumulator ring installation.

ALS-U PROJECT STATUS

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 hard X-rays. The ALS-Upgrade (ALS-U) project will provide a soft X-ray source that is up to 1,000 times brighter than today's capabilities, while generating a significantly higher fraction of coherent light in the soft X-ray region than is currently available at the ALS. In November 2022, the project's final design was approved by the Department of Energy (CD-3 approval), which authorized the start of fabrication, assembly and installation. The ALS-U Project will replace the existing SR with a new nine bend-achromat ring that delivers ultra-low-emittance electron beams that generate fully diffraction-limited X-ray light. To achieve this performance goal, the upgraded facility requires the installation of a full energy Accumulator Ring (AR) and its corresponding transfer lines that will deliver the beam to the new SR. The AR will accept beam from the existing ALS booster utilizing a standard off-axis injection technique. The AR will act as a damping ring and will stack multiple injections for preconditioning the beam. A fresh AR bunch train will be periodically swapped-out with a bunch train of the storage ring to maintain its nominal 500 mA stored beam [1]. The operation mode requires a complex transfer line area to transfer the beam from the booster to the accumulator ring (BTA), from the accumulator ring into the storage ring (ATS), and from the storage ring into the accumulator ring (STA). This transfer line area requires careful physics and engineering optimization, to enable installation while providing access for subsequent maintenance activities in this heavily congested area.

The AR is on a fast-track schedule having already received its approval for construction in September of 2019. Since the AR is located on the inner wall of the ALS accelerator tunnel, it can be installed while the existing ALS continues to operate prior to Dark Time (DT) [2].The 12-month Dark Time is defined as the period during which no X-ray beam will be available for ALS experimental users. During DT the ALS storage ring will be replaced by the ALS-U nine-bend achromat ring. Figure 2 shows a 3D-CAD model rendering of the ALS-U accelerator complex.

Figure 1: Pictures of the inner wall in 2019 and 2023 - ready to receive accelerator components.

AR INSTALLATION

The Accumulator Ring (AR) is installed on the inner wall of the existing ALS tunnel. To preserve egress the nominal beam height is set to 2 m above the tunnel floor. The installation takes place over several years (from 2020 to 2025)

* dleitner@lbl.gov

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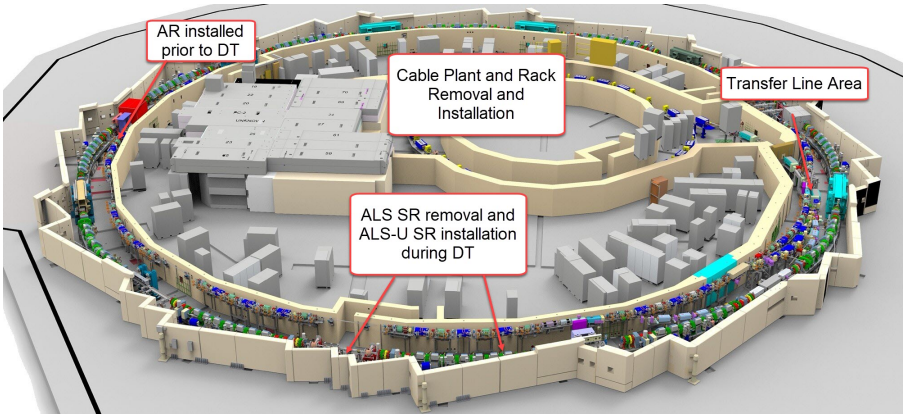

Figure 2: 3D-CAD model of the ALS-U accelerator complex.

during regular maintenance shutdowns. Therefore, the AR must be compatible with operating the existing ALS Storage Ring as well as the new ALS-U Storage Ring (SR). In addition, it is designed so that the two rings can operate independently from each other.

Site Preparation

In the first installation phase (to be completed in summer of 2023) all utilities and existing ALS infrastructure were reconfigured (HVAC system, Radiation Safety System, Fire suppression, tunnel light system) in order to prepare the tunnel for the additional accelerator. With the inner wall cleared, support structures, cables trays and LCW routing were added (2021-2023). Figure 1 shows the inner wall prior and as the site preparation nears completion. In addition, 58 electronics racks, the AR RF system, an independent fiber optics network and controls distribution, and a cable plant are currently being added to support the AR operation.

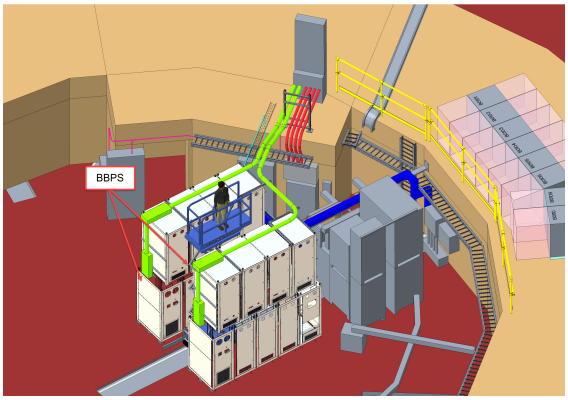

Figure 3: 3D CAD rendering of the Booster syncrotron pit with the new booster bend power supply.

BOOSTER RING

The injector system of the ALS will be utilized by the ALS-U with a slightly increased energy from 1.9 GeV to 2 GeV. To achieve this energy, the booster synchrotron power supply will be replaced with a high-precision and more efficient power supply consisting of two power converters that are connected in series with the center connection tied to the ground. Figure 3 shows a CAD rendering of the new power supply that will be installed in the summer of 2023. Due to space constraints the 18 power supply racks are arranged in two rows and vertically stacked. This power supply layout was customized by the vendor to adhere to the unique demands of ALS-U.

AR SECTOR INSTALLATION

A major challenge for the Project are the space constraints inside the tunnel and the limited access to the tunnel. To minimize the assembly effort inside the tunnel, pre-aligned raft assemblies have been developed that integrate magnets, vacuum chambers, and diagnostics devices as well as localized cooling and cabling routing. Figure 4 shows a picture of one of the five different raft assemblies for an AR sector as it is lifted into the tunnel.

The ALS tunnel roof is segmented into 82 roof blocks which can be individually lifted for direct access to the tunnel utilizing a building crane. However, in several areas roof access is impossible due to previously installed equipment on the tunnel roof. Therefore, we have developed specialized tooling for both crane-based and based-ground installation.

Crane-based Installation

Figure 4 shows the integrated raft with a custom C-frame attached. This C-frame lifting fixture allows for installation close to the wall without interfering with existing sprinkler pipes, conduits, and smoke detectors.

Ground-based Installation

A customized lifting cart was developed in order to install AR components with the roof blocks in place. Its capacity of 1100 kg covers the heaviest AR rafts and dipole magnets. An customized off-the-shelf scissor lift is used for the vertical lift and linear actuators are used to translate the components horizontally onto the supports (Fig. 5). Alignment features on the top platform of the cart allow for precise positioning during installation. With an integrated air caster system, the

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cart can be easily maneuvered and positioned throughout the tight tunnel aisle. After a successful prototyping phase, the ground installation proved to be more efficient and faster than the crane installation since it eliminates the time consuming roof block removals. Therefore, the majority of the AR will be installed using ground installation.

Figure 4: Raft 2 assembly is lifted into the ALS tunnel.

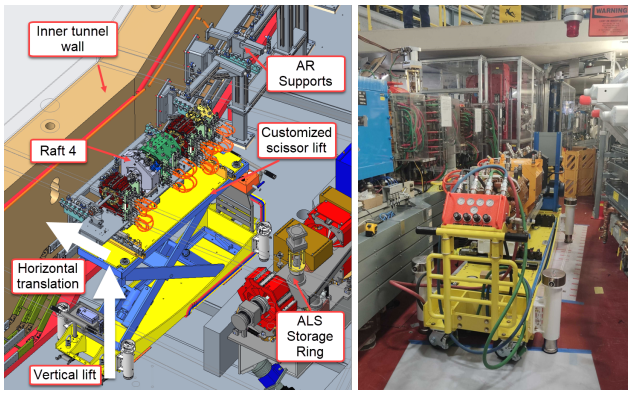

Figure 5: CAD rendering of the customized scissor lift as raft 4 is translated onto the AR support.

TRANSFER LINE AREA

The transfer line area is a highly congested area where the booster ring connects to the downstream accelerators. During the initial commissioning of the accumulator ring (AR) befor DT the existing Booster-To-Storage (BTS) transfer line will be branched-off at one of the existing BTS dipoles to enable injection into the AR via the Booster-To-Accumulator (BTA) transfer line. During the DT, two additional transfer lines will be added; the Accumulator-To-Storage (ATS) and the Storage-To-Accumulator (STA). Figure 6 shows the final configuration with the new ALS-U SR and the additional transfer lines added. Due to the very limited space all installation activities for this area will be done using the building crane. Specialized lift fixtures and tooling and a preset installation sequence are needed. We are currently in the final design phase where we optimize this area for accessibility, alignment, and maintainability.

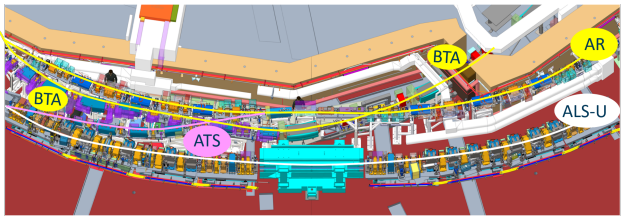

Figure 6: 3D rendering of the transfer line area after DT (BTA, ATS). The STA is further down stream and not shown.

CONCLUSION

The status of the ongoing AR installation was presented. Early commissioning for the AR is planned for 2025 about six months prior to the beginning of the Dark Time. Once the SR is added, the complete accelerator complex will be commissioned and transitioned to operations.

ACKNOWLEDGMENTS

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