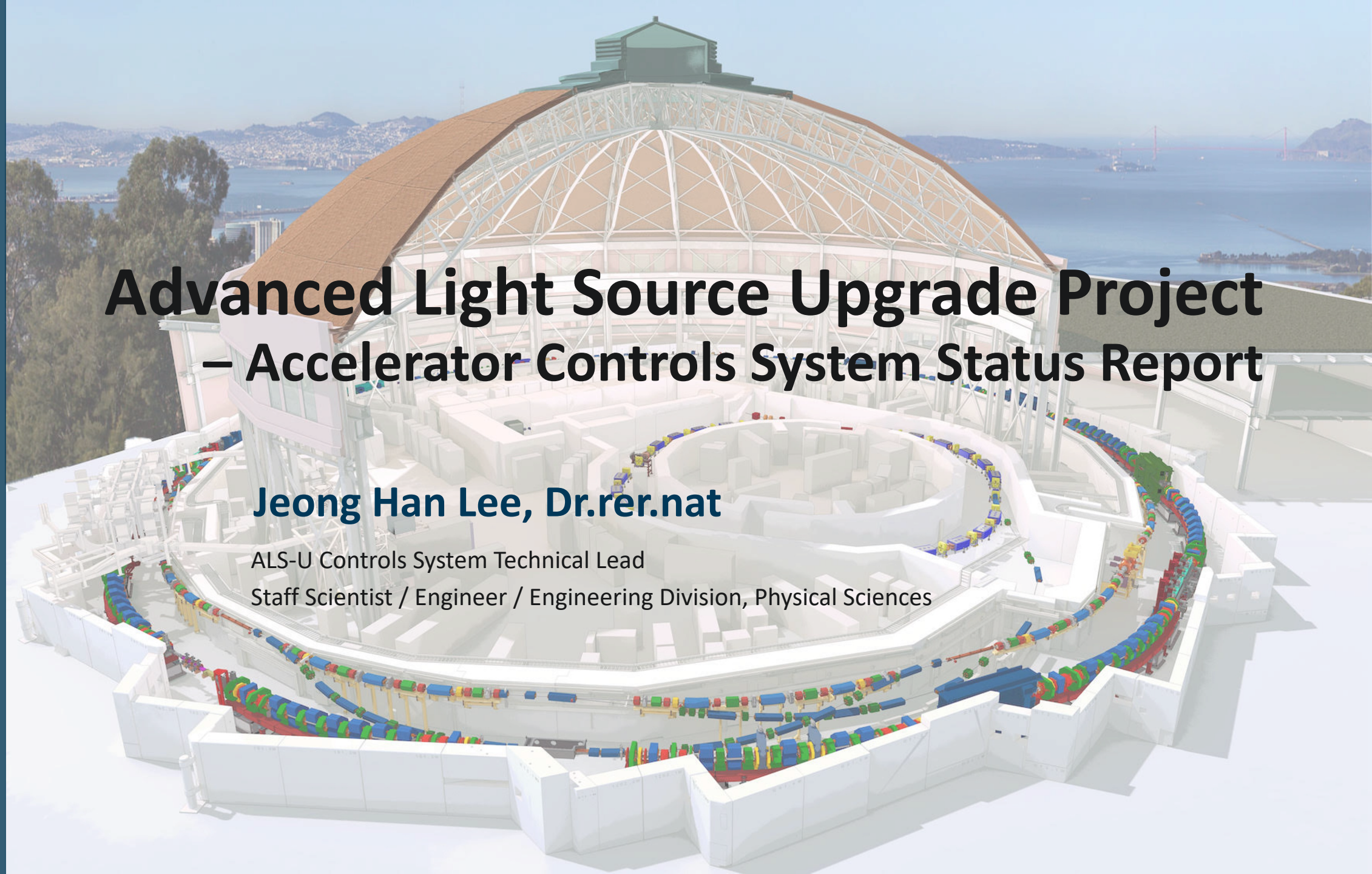
U.S. DEPARTMENT OF ENERGY
Office of Science

BERKELEY LAB

ALS-U
ADVANCED LIGHT SOURCE



Advanced Light Source Upgrade Project
– Accelerator Controls System Status Report

Jeong Han Lee, Dr.rer.nat

ALS-U Controls System Technical Lead

Staff Scientist / Engineer / Engineering Division, Physical Sciences

2024 EPICS, Pohang, South Korea | April 17, 2024

Brief LBNL Intro

Radiation Lab is the beginning of the Lawrence Berkeley National Laboratory (LBNL, LBL, Berkeley Lab)

Established in **1931** by the University of California (UC), the laboratory is sponsored by the United States Department of Energy and administered by the UC system. Ernest Lawrence, who won the Nobel prize for inventing the cyclotron, founded the Lab and served as its Director until his death in 1958. (Wikipedia, access 2024-04)

Oppenheimer (Courtesy of WB)

These pictures will be removed after this (offline) presentation


NOBEL LAUREATES


EARLY CYCLOTRONS


Ernest Orlando Lawrence
BERKELEY NATIONAL LABORATORY


LAWRENCE ACCEPTS THE NOBEL PRIZE

Brief Speaker Intro

Jeong Han Lee, Dr.rer.nat.
ALS-U Job: Technical Lead for Controls (~ 13 FTE)
Institution: LBNL
Staff Scientist and Engineer

Experience

- 22+ years of international accelerator facilities work experience (MAMI-Germany, RISP-South Korea, ESS-Sweden, and Jefferson Lab & LBNL - the United States)
- Experimental Nuclear Physics – Parity Violation for the Data Acquisition and Detector System, SW Data Analysis Framework based on ROOT, and Compton Backscattering Polarimeter Chicane Design and Construction.
- 8+ years Accelerator Controls Group Leader at RISP and LBNL
- 4+ years Hardware Integration Work Package Lead at ESS (Realtime and Embedded Linux, DAQ, MTCA, Timing, Network, EPICS SW architecture, E3 architect)
- 13+ years EPICS Collaboration Works and Contributions
- Published 2 Nature, 12 PRL, 10+ JACoW, and other international journal and conference papers and serves as a peer reviewer of NIM A.

Brief Speaker Intro

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ALS-U Job: Technical Lead for Controls (~ 13 FTE)
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Staff Scientist and Engineer

Old Man

Advanced Light Source Upgrade Project

ALS-U will deliver a world-leading light source on schedule and budget that provides users with bright, high-coherent-flux soft x-rays unmatched by any other facility

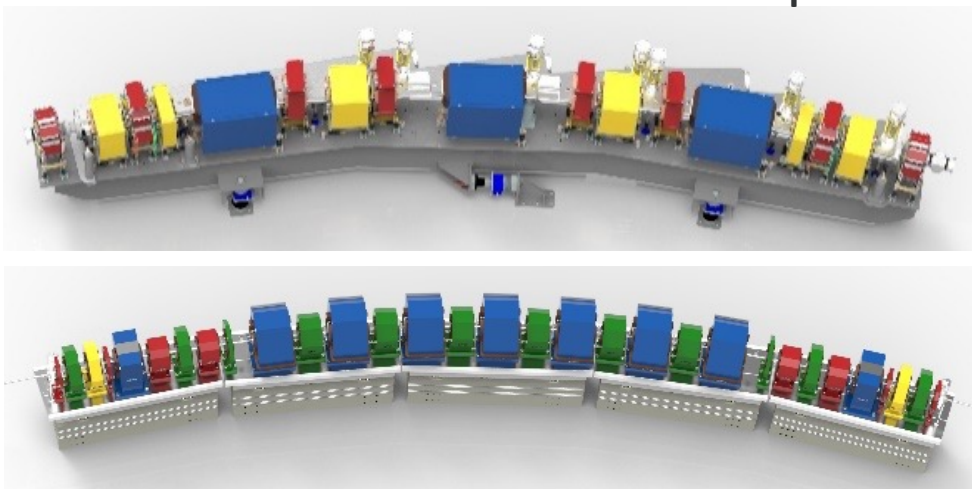
High-level goals:

- Achieve an increase in brightness and coherent flux of soft x-rays (@1 keV) of at least 2 orders of magnitude beyond today's ALS capabilities
- Develop a set of world-class experimental capabilities that will push the frontiers in soft x-ray science and maintain ALS leadership in this area
- Provide infrared and hard x-ray capabilities comparable to present-day ALS

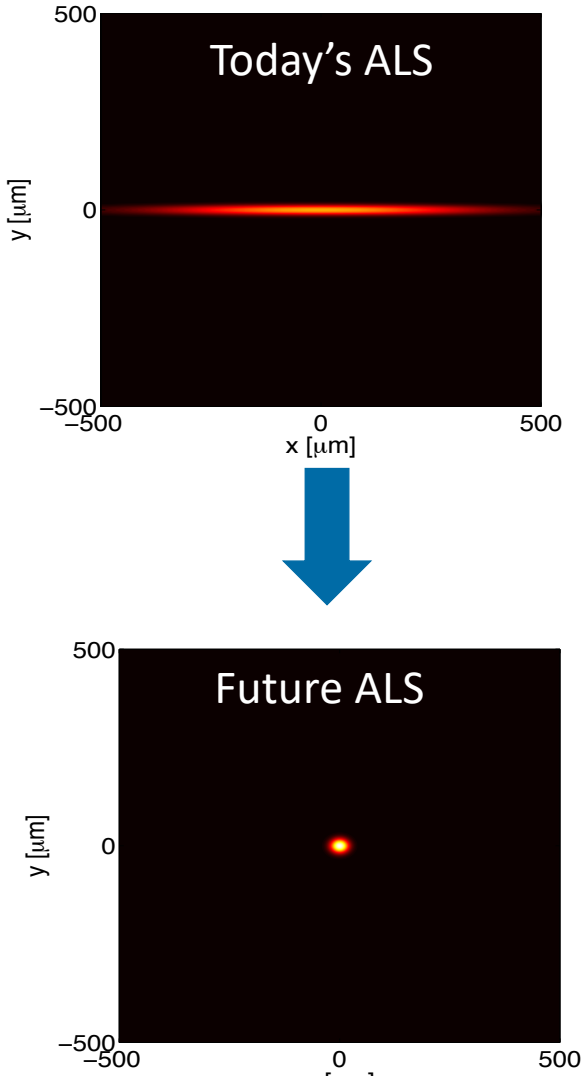
Today's ALS
- 30 years, 40+ beamlines
- 2100+ users/year
- 16,000+ publications

Future ALS (aka ALS-U)
- next 25 years

A SR Sector Arc Area Comparison



Electron Beam Profiles



ALS-U Project Scope

Major items:

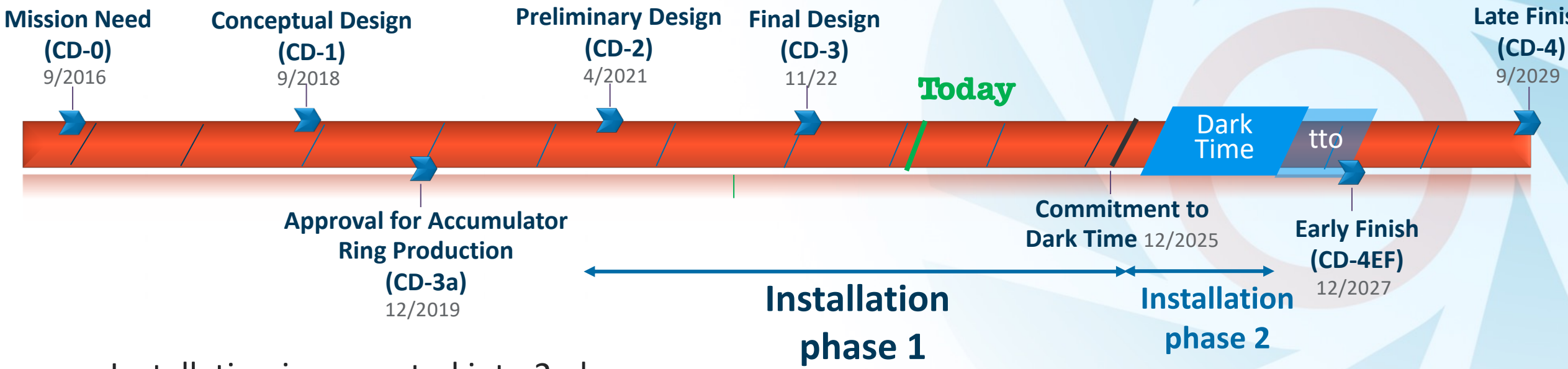
- New 2-GeV, high-brightness storage ring fed by a new full-energy accumulator ring and transfer lines in the existing ALS storage-ring tunnel
- 6 high-field bends and realignment of bend-magnet beamlines
- Adding a suite of 2 feature world-leading undulator beamlines
- Seismic/ALARA shielding upgrade: to improve seismic safety and minimize dose rates

ALS-U Key Performance Parameters (KPPs)

Performance Measure	Threshold	Objective
Storage ring energy	≥ 1.9 GeV	2.0 GeV
Beam current	> 25 mA	500 mA
Horizontal emittance	< 150 pm rad	< 85 pm rad
Calculated brightness at 1 keV	> 2.0×10^{19}	2.0×10^{21}
Number of feature MBA beamlines installed	2	≥ 2

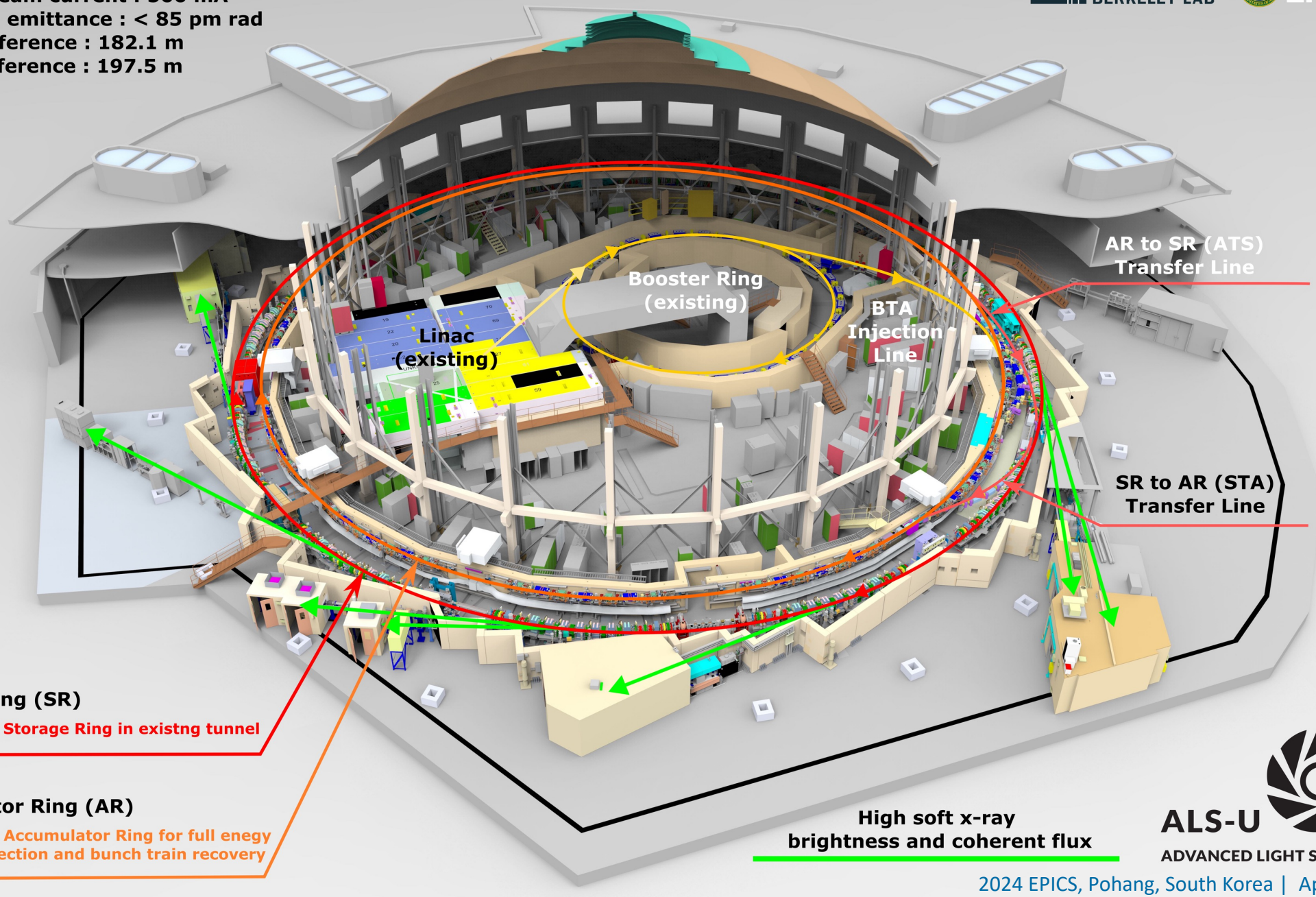
- The threshold KPPs are the minimum parameters against which the project's performance is measured at completion (CD-4)
- The objective KPPs describe the technical goals of the project

ALS-U Project Timeline



- Installation is separated into 2 phases
  - Tunnel prep and accumulator ring installation and testing conducted during planned summer and winter ALS shutdowns that began in winter 2021
- Dark Time is scheduled to be one year in duration starting in June 2026 followed by a 6-month transition to operations (tto) where beamlines are brought online
- Commitment to Dark Time – at least 6 months prior to the start of dark time
- Postponed early finish by ~9 months since CD-3 to from April 2027 to Dec 2027
  - 20 months of schedule contingency remain, which is sufficient

Storage ring energy : 2.0 GeV
Electron beam current : 500 mA
Horizontal emittance : < 85 pm rad
AR circumference : 182.1 m
SR circumference : 197.5 m



Storage Ring (SR)

New 2.0 GeV Storage Ring in existng tunnel

Accumulator Ring (AR)

New 2.0 GeV Accumulator Ring for full enegy swap-out injection and bunch train recovery

High soft x-ray brightness and coherent flux

ALS-U
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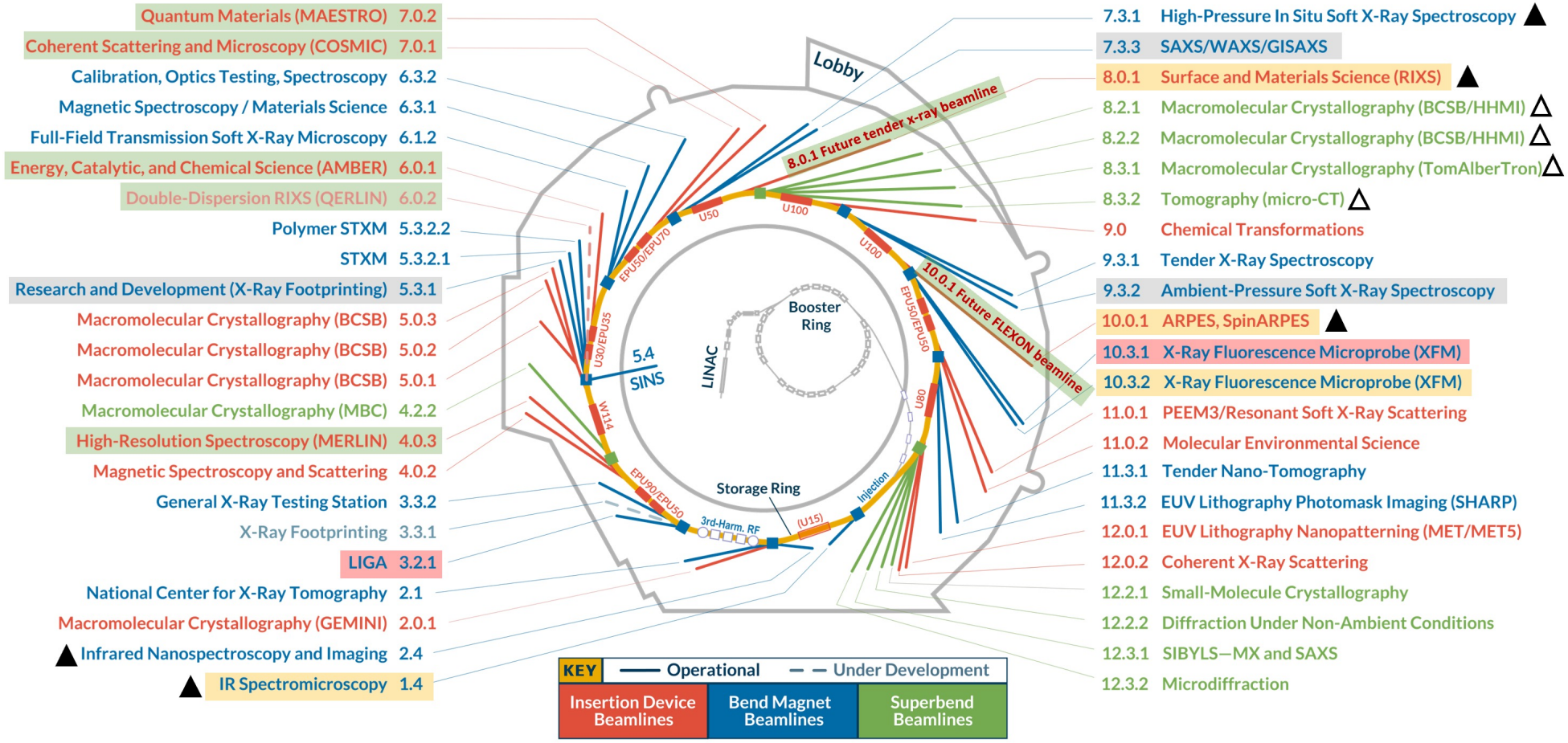
ALS/ALS-U Beam Lines

https://als.lbl.gov/als-u/als-u-beamline-impacts/



Post-ALS-U operational status legend

- Beamline upgrade/expanded capabilities
- Beamline closed; capabilities will be migrated/expanded elsewhere
- Beamline closed
- Beamline closed; under consideration for post-ALS-U reopening/upgrade
- ▲ Beamline will turn off before the dark time
- △ Beamline *may* turn off before the dark time

A Typical Controls System Scope

What

Carry / take all monitor, control, accelerator model-based calculated signals (data) from one place to another through network environment

Where

All accelerator subsystems and operations subsystems. In addition, partially experiment, safety, and conventional facility

How

Achieve a rock-solid control, interactive / non-interactive automation, and user-friendly operation environment

ALS-U Controls scope

Global Controls

Machine Protection System
- PLC-based Slow Interlock (ms)

Motion Control
- Servo / Stepper Motion (Omron – Delta-Tau server, EtherCAT clients)

Software High Level and Data Acquisition (DAQ) System

Software and middleware services (EPICS)

Infrastructure
- Controls Network – aka Operational Technology Network
- Rack - Rack temperature controller, water leak and smoke detection system
- Temperature monitoring system (TC and PRTD)
- Asset Management System (AMS) : QR Label, Scanner, Web, RESTful API

Subsystem Controls

Vacuum System

Power Supply System

Magnet System

Beam Diagnostic System

Facility/Radiation Safety System

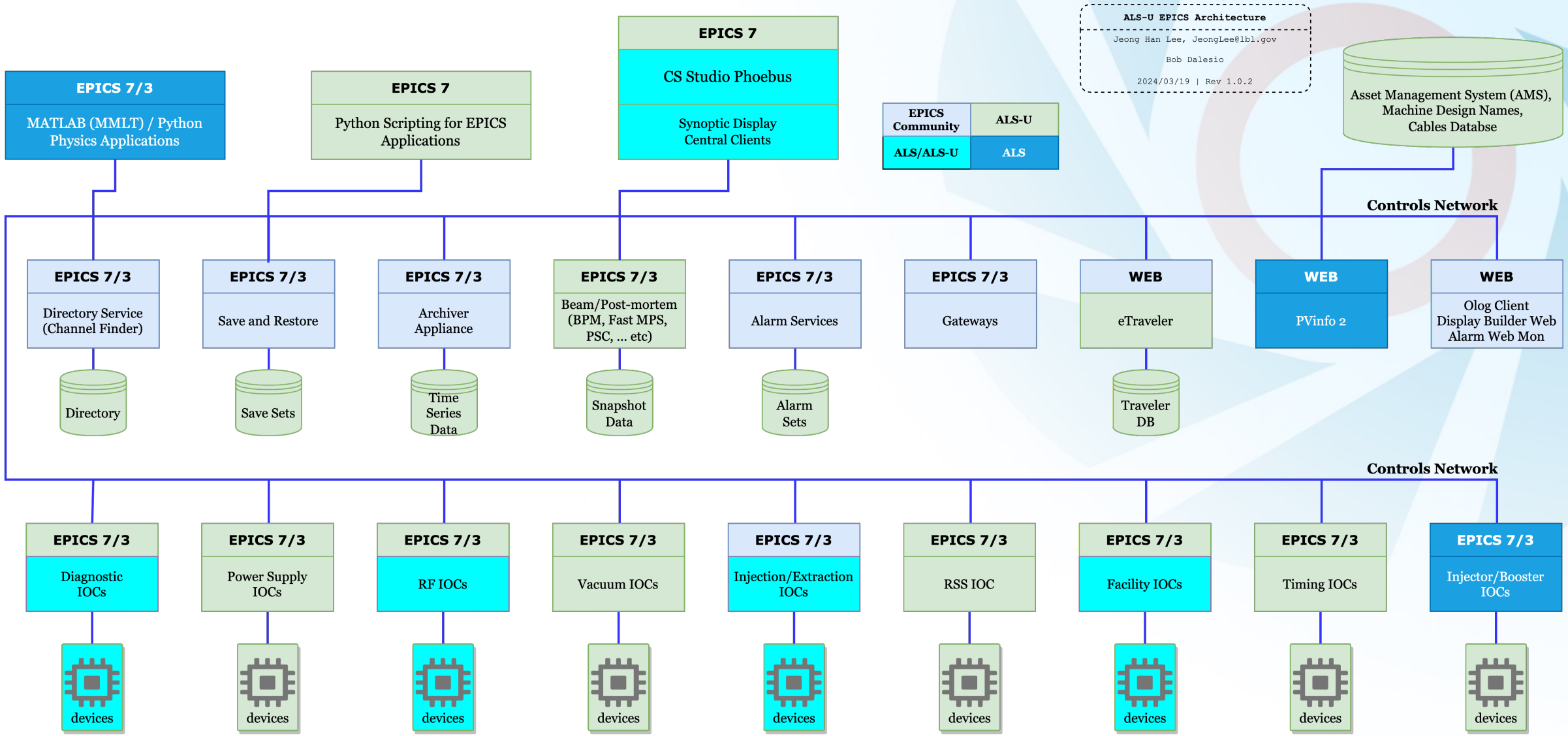
Radio Frequency System

Injection/Extraction System

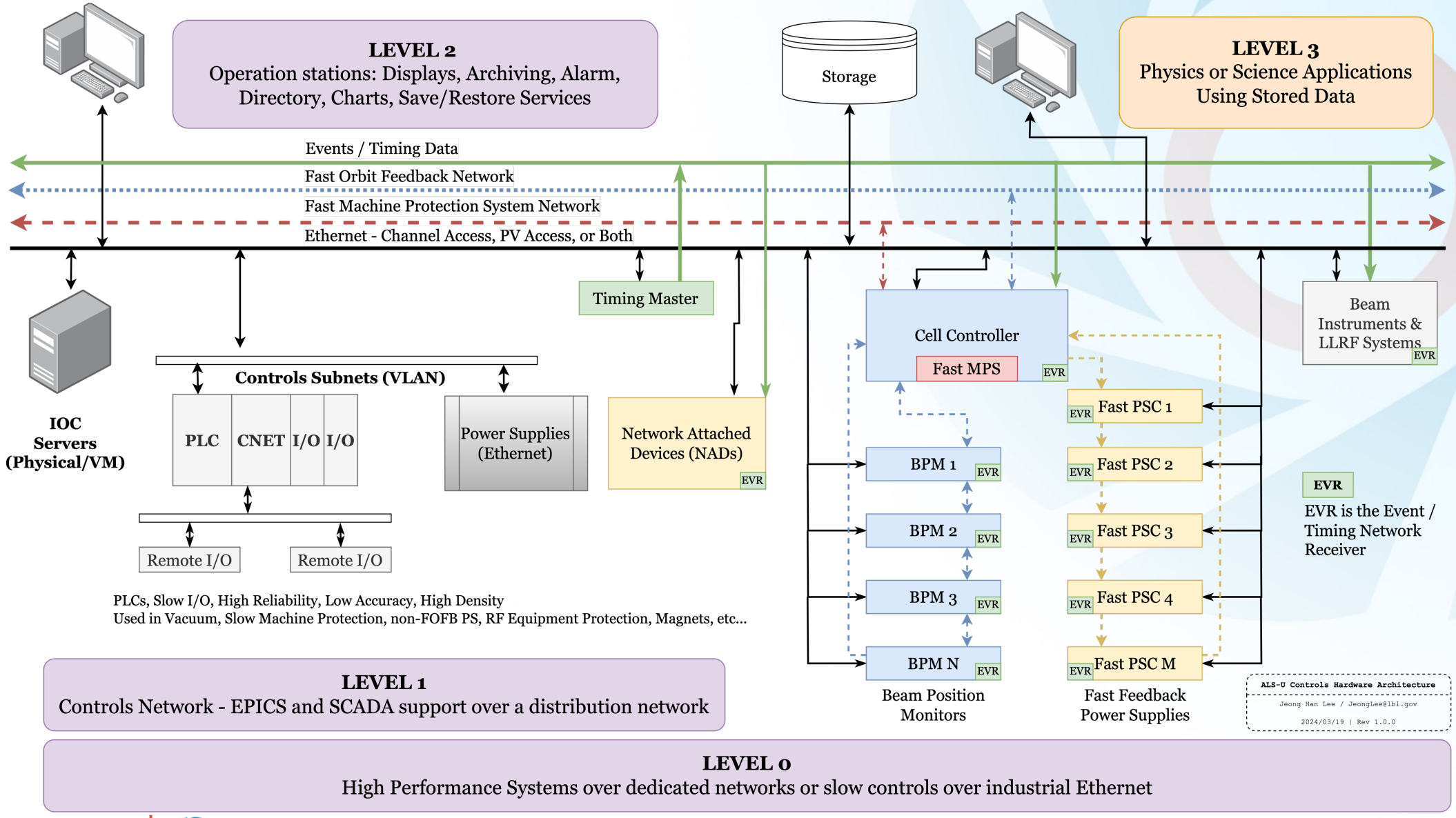
Quality Assurance

Operation

Controls Software Architecture



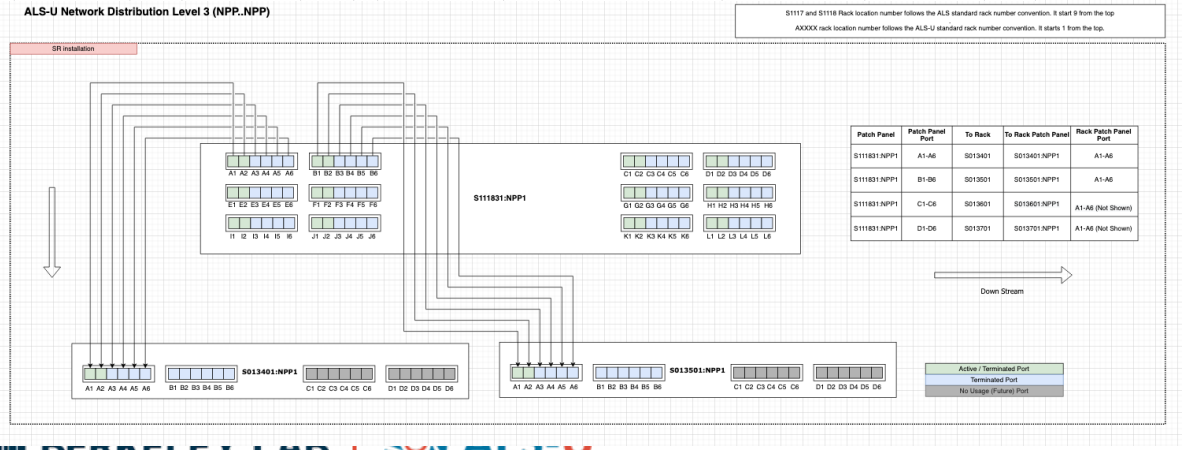
Controls Hardware Architecture

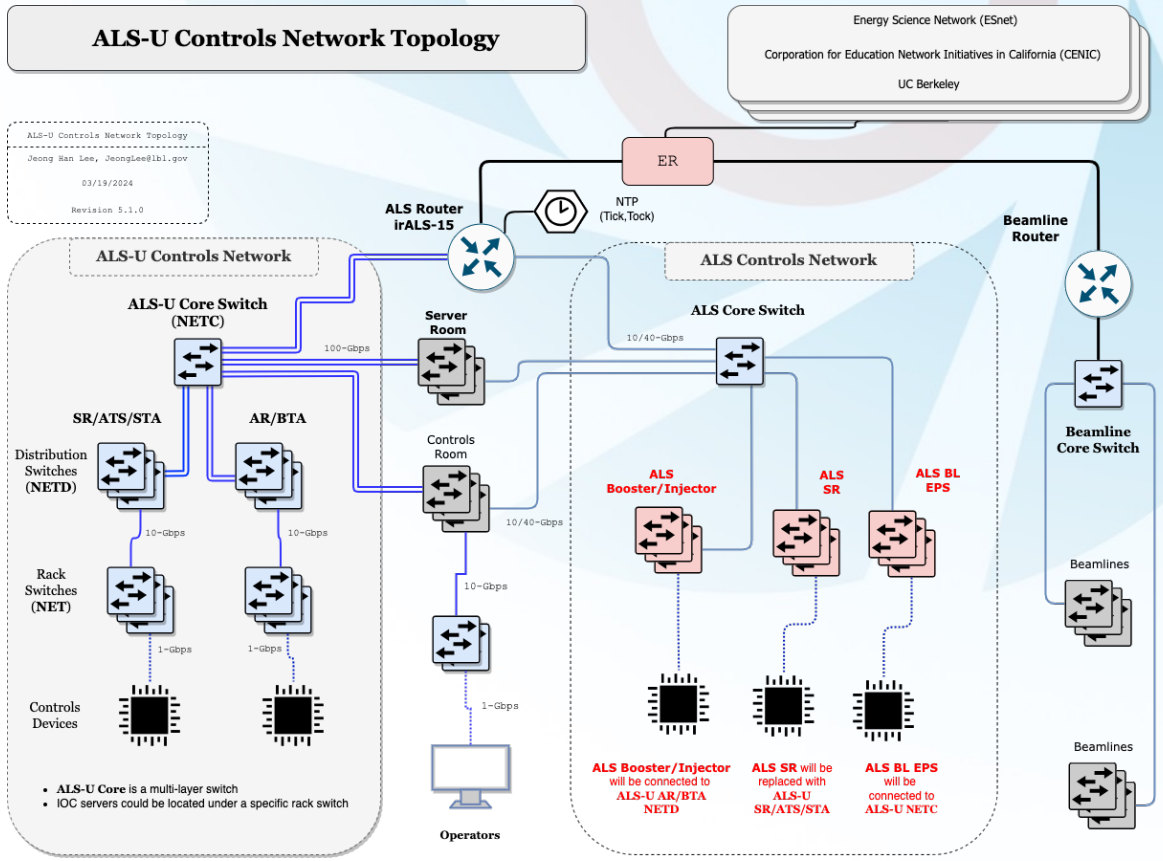


Controls Network

- Decouple from the ALS network / Move the new ALS-U network after Darktime
- Network device port counts 2000+, Single Mode Fiber Distribution
- Estimated Overall Data Traffic: NETC (56+ Gbps), NETD (43+ Gbps), NET (5+ Gbps)
- For the network design and security models, we follow the NIST Special Publication (NIST SP 800-82) such as the Guide to Industrial Control Systems Security (Rev 2) and Guide to Operational Technology Security (Rev 3) since 2021

SR	S111716:NPP1	C3/D3	S111824:NETD3	u1/u2	S111824:NETD3	d37	S111845:NPP8:A1	ATS120101:NPP1:A1	ATS120103:NET1	u1	PS rack
SR	S111716:NPP1	C4/D4	S111826:NETD4	u1/u2	S111826:NETD4	d37	S111845:NPP8:A2	ATS120101:NPP1:A2	ATS120103:NET1	u2	
SR							S111845:NPP8:A3	ATS120101:NPP1:A3			
SR							S111845:NPP8:A4	ATS120101:NPP1:A4			
SR							S111845:NPP8:A5	ATS120101:NPP1:A5			
SR							S111845:NPP8:A6	ATS120101:NPP1:A6			
SR	S111716:NPP1	C3/D3	S111824:NETD3	u1/u2	S111824:NETD3	d38	S111845:NPP8:B1	ATS120401:NPP1:A1	ATS120403:NET1	u1	C&I rack
SR	S111716:NPP1	C4/D4	S111826:NETD4	u1/u2	S111826:NETD4	d38	S111845:NPP8:B2	ATS120401:NPP1:A2	ATS120403:NET1	u2	
SR							S111845:NPP8:B3	ATS120401:NPP1:A3			
SR							S111845:NPP8:B4	ATS120401:NPP1:A4			
SR							S111845:NPP8:B5	ATS120401:NPP1:A5			
SR							S111845:NPP8:B6	ATS120401:NPP1:A6			
SR	S111716:NPP1	C3/D3	S111824:NETD3	u1/u2	S111824:NETD3	d39	S111845:NPP8:C1	ATS120501:NPP1:A1	ATS120503:NET1	u1	Vac rack
SR	S111716:NPP1	C4/D4	S111826:NETD4	u1/u2	S111826:NETD4	d39	S111845:NPP8:C1	ATS120501:NPP1:A2	ATS120503:NET1	u2	
SR							S111845:NPP8:C3	ATS120501:NPP1:A3			
SR							S111845:NPP8:C4	ATS120501:NPP1:A4			
SR							S111845:NPP8:C5	ATS120501:NPP1:A5			
SR							S111845:NPP8:C6	ATS120501:NPP1:A6			
SR	S111716:NPP1	C3/D3	S111824:NETD3	u1/u2	S111824:NETD3	d40	S111845:NPP8:D1				





Slow MPS

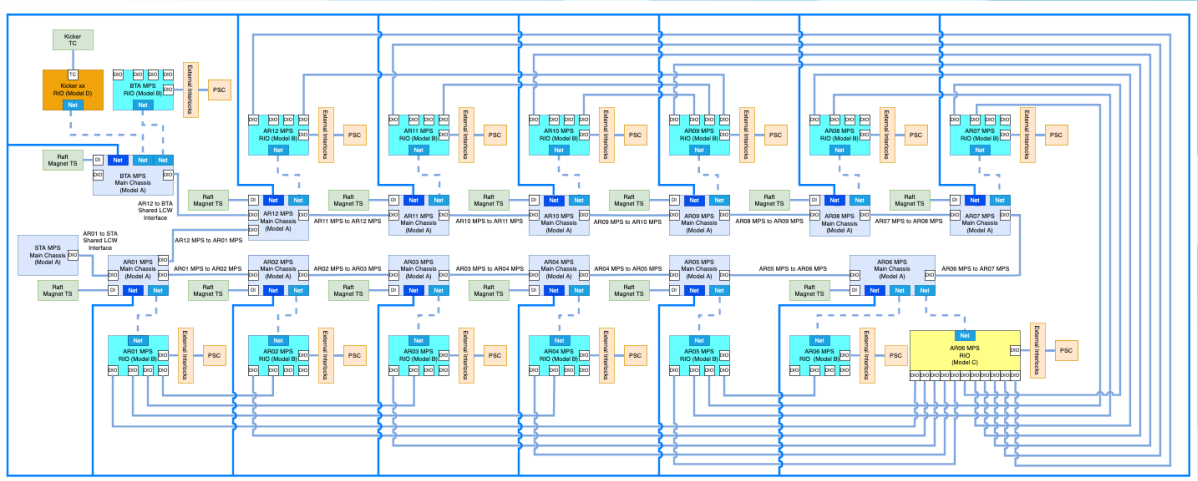
- Allen-Bradley PLC L320ER family with the latest RS Studio version

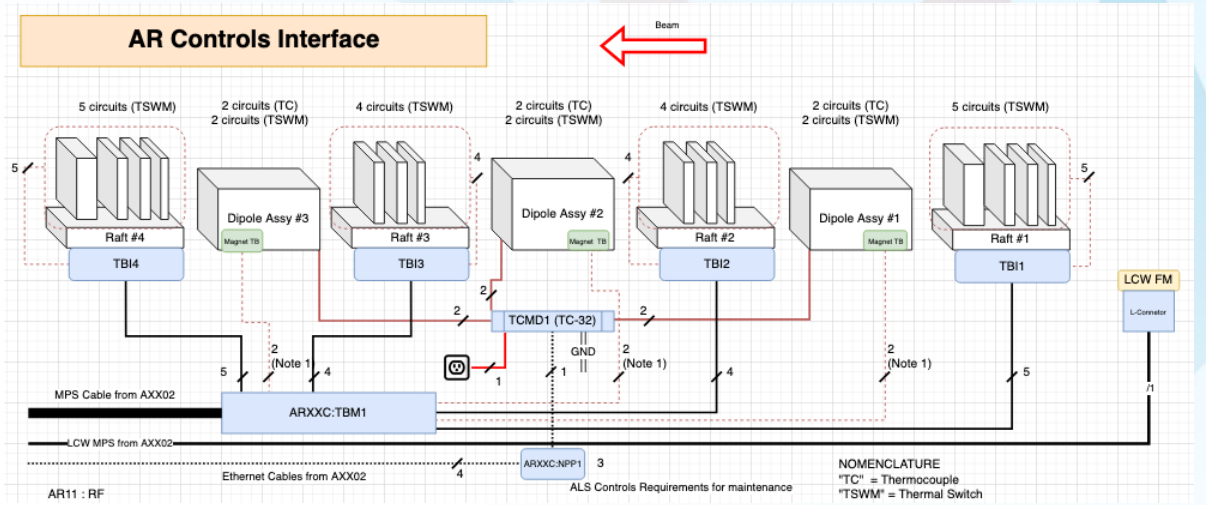
- Main PLC (MPS A) and Remote IO Chassis Topology to cover AR/BTA requirements across subsystems (Magnet, Pre-staging, Inj/Ext, Power Supply)

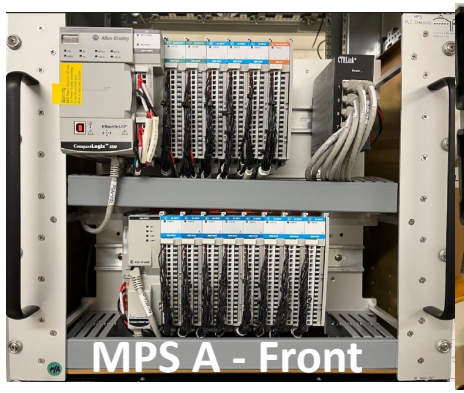
- AR MPS Design will cover the SR Slow MPS also with an additional RIO (MPS E)

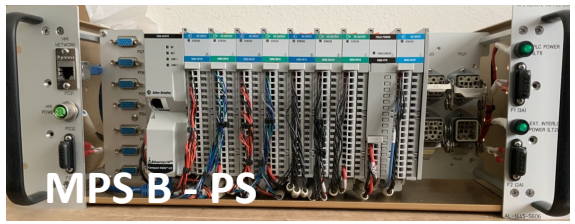
- Various level diagrams for plug-to-plug cable mapping and detailed I/O mapping between PLC IO and a physical signal

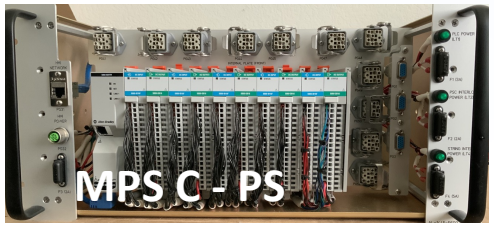
- Terminal blocks for AR magnet thermal sensor interfaces

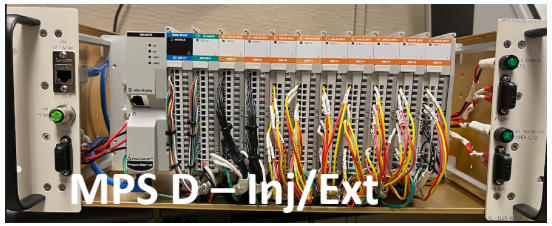






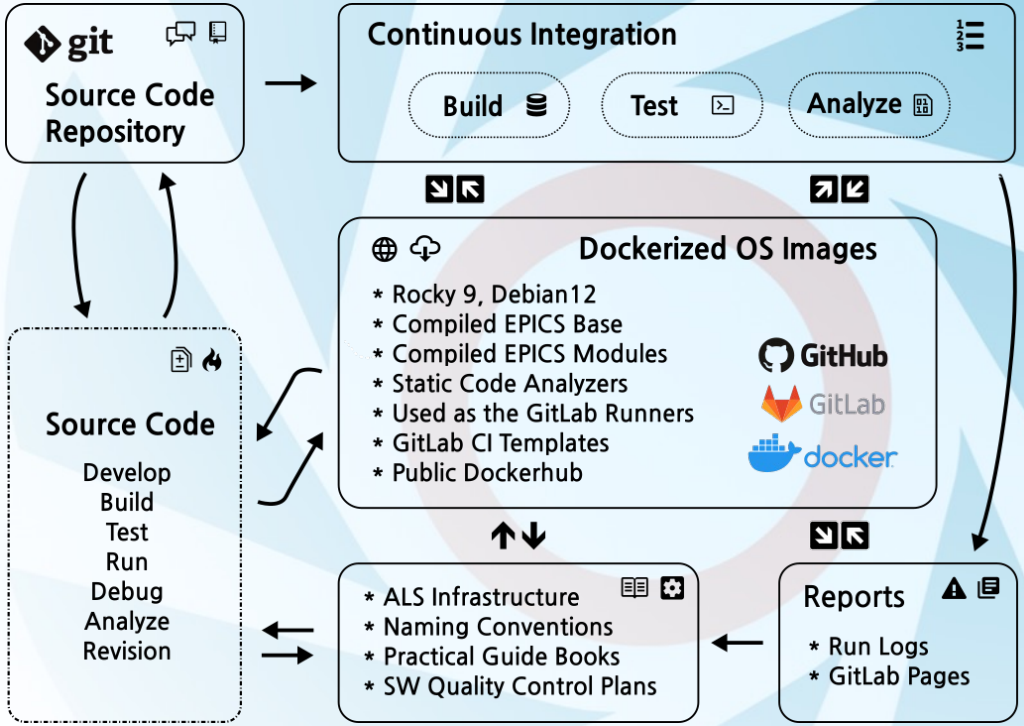


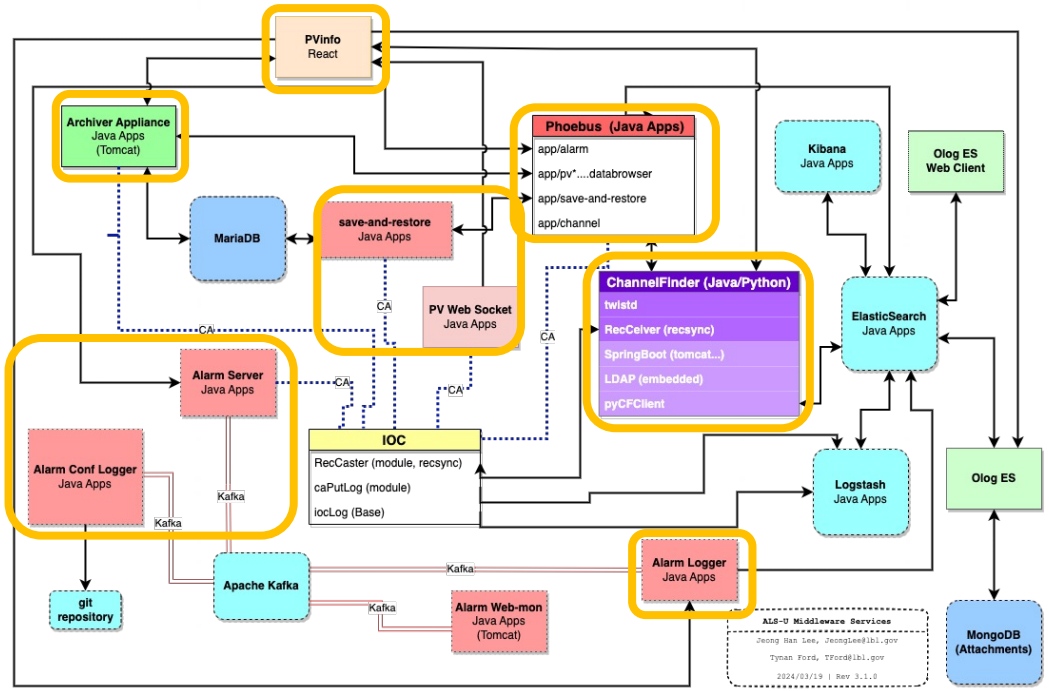




Controls Software

- Released ALS-U EPICS environment 1.0.0 for the AR production
  - Rocky 9.2 and Debian 12 are official supported Linux
  - Include various SW quality checkers (shellcheck, splint, cppcheck, gcovr, flawfinder, static code analyzer pmd) in Docker images for Continuous Integration
- ALS GitLab is the source code repository and a central place where we work. We work very closely together to build this environment.
- The entire workflow at https://git.als.lbl.gov/ is running since 2021!





Key Middleware Services

- Phoebus
- ChannelFinder
- Archiver Appliance
- Alarm Services
- Save-and-Restore
- PV Web Socket
- PVInfo

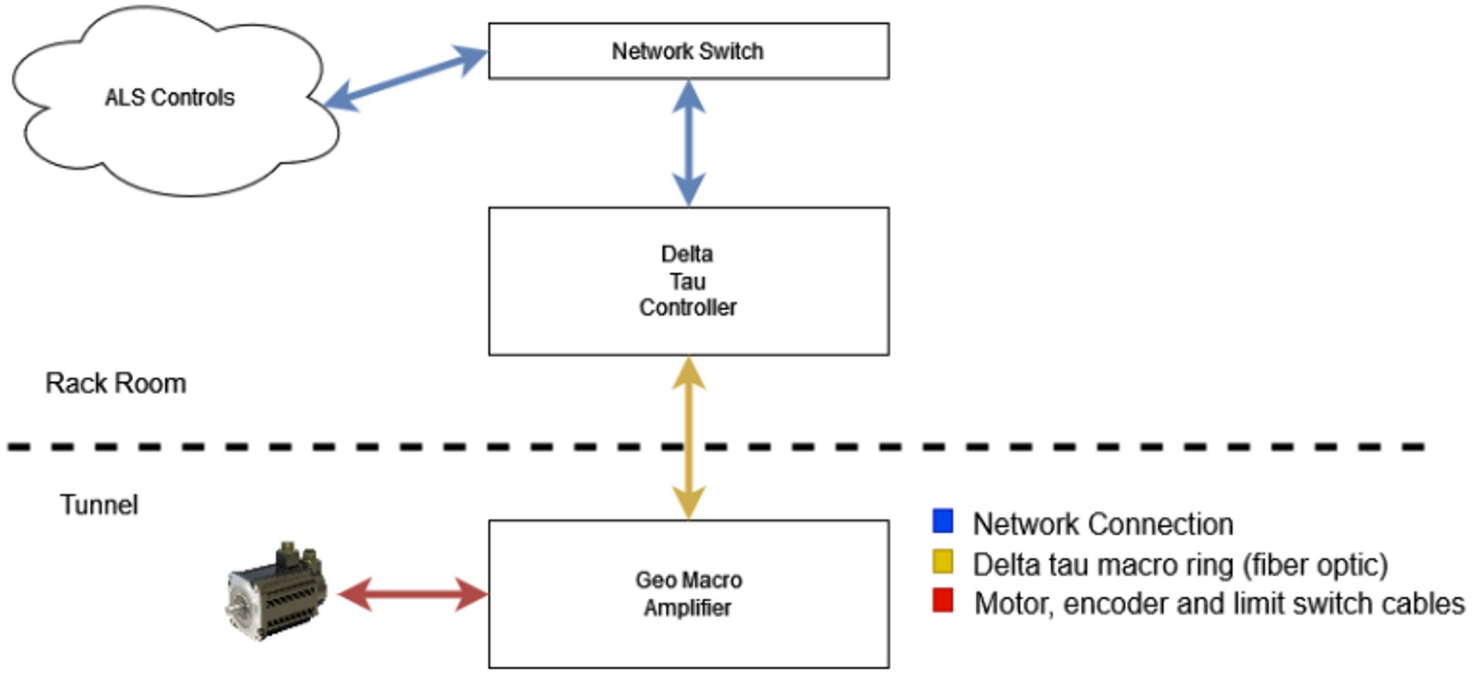
- EPICS Community Middleware Services
- Collaboration with the ALS Controls team to use the same environment
- Phoebus, ChannelFinder, and Archiver Appliance are ready for the AR production
- Alarm Services and Save-and-Restore configuration and study in progress
- Work with the EPICS collaborators intensively

ALS-U Motion

- *Stepper Motion Control Supports (no resources from ALS, end of life hardware, and so on), work with Osprey to find a feasible solution studies during 1.5 years*

- **After 1.5 year study, we finalized the ALS-U Motion Architecture to compatible with ALS motion and EPICS SW architectures.**

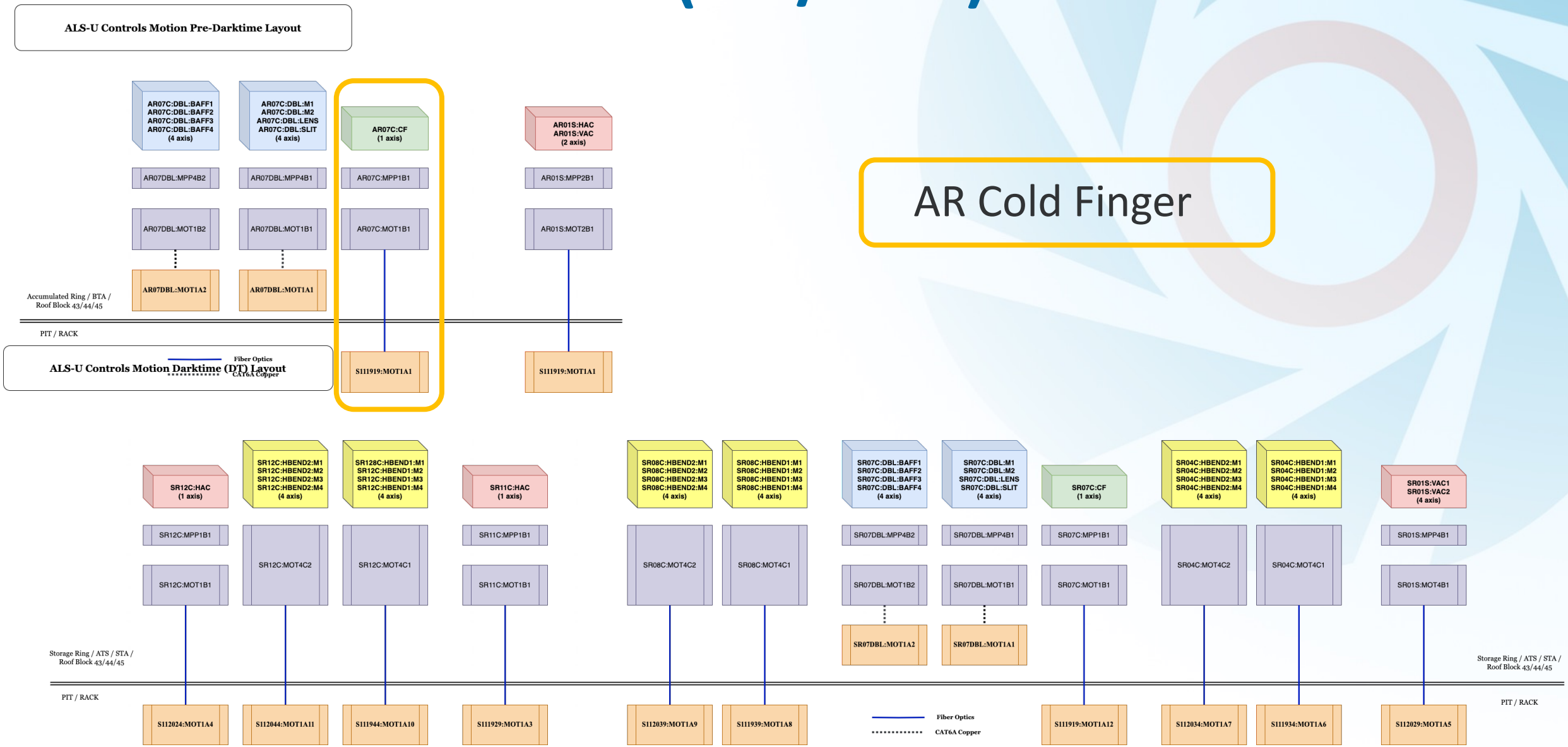
The following figure shows the current ALS motion architecture.



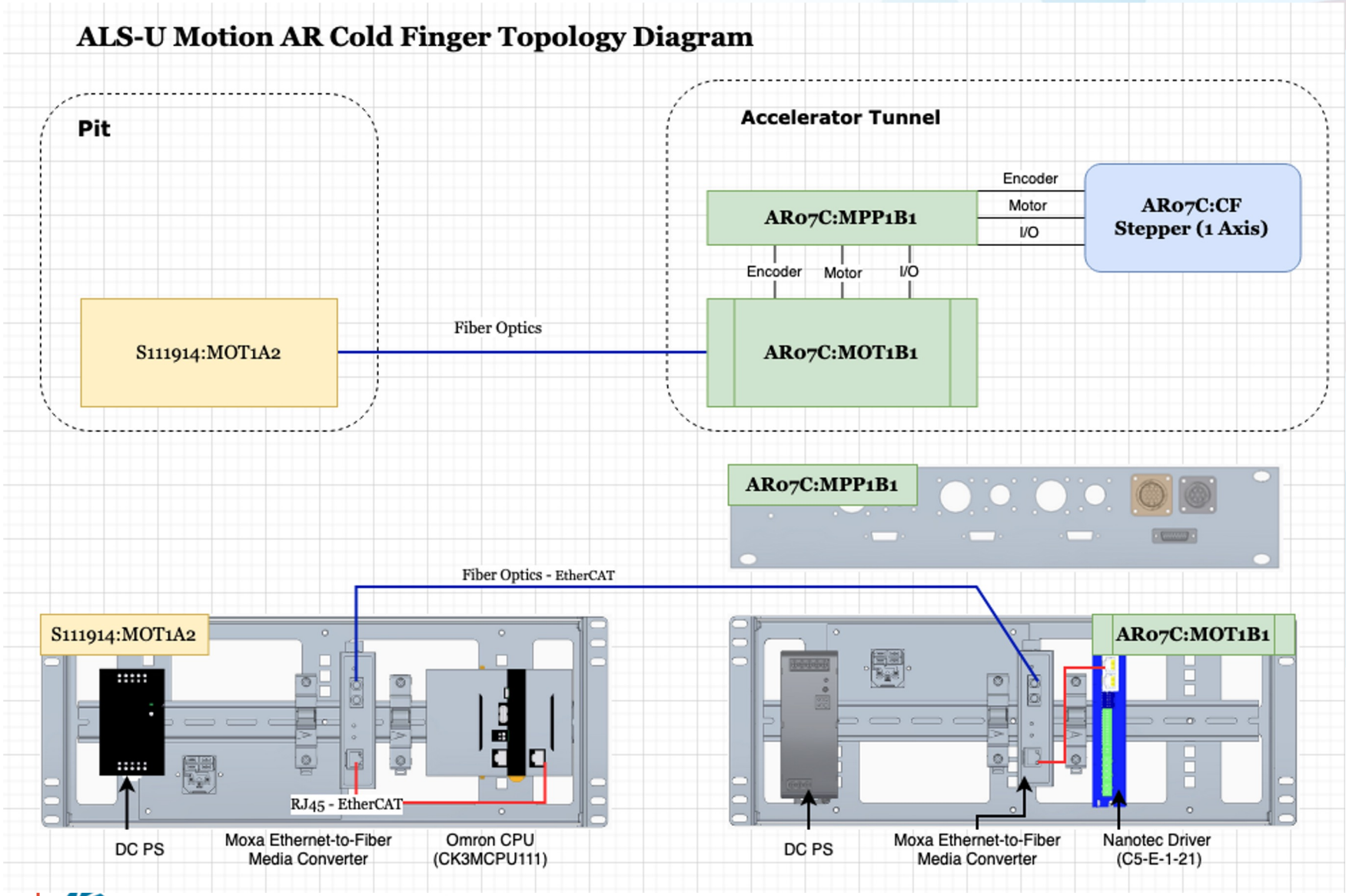
ALS Motion Architecture

We focus on finding feasible solutions to meet the ALS-U motion requirements and keeping the ALS architecture as close as possible to market available protocol, which is reliable and sustainable for the next two decades. Moreover, we aim to make a modularized solution per each axis, so we can scale up that module to cover potential multi-axis requirements without losing the design strategy.

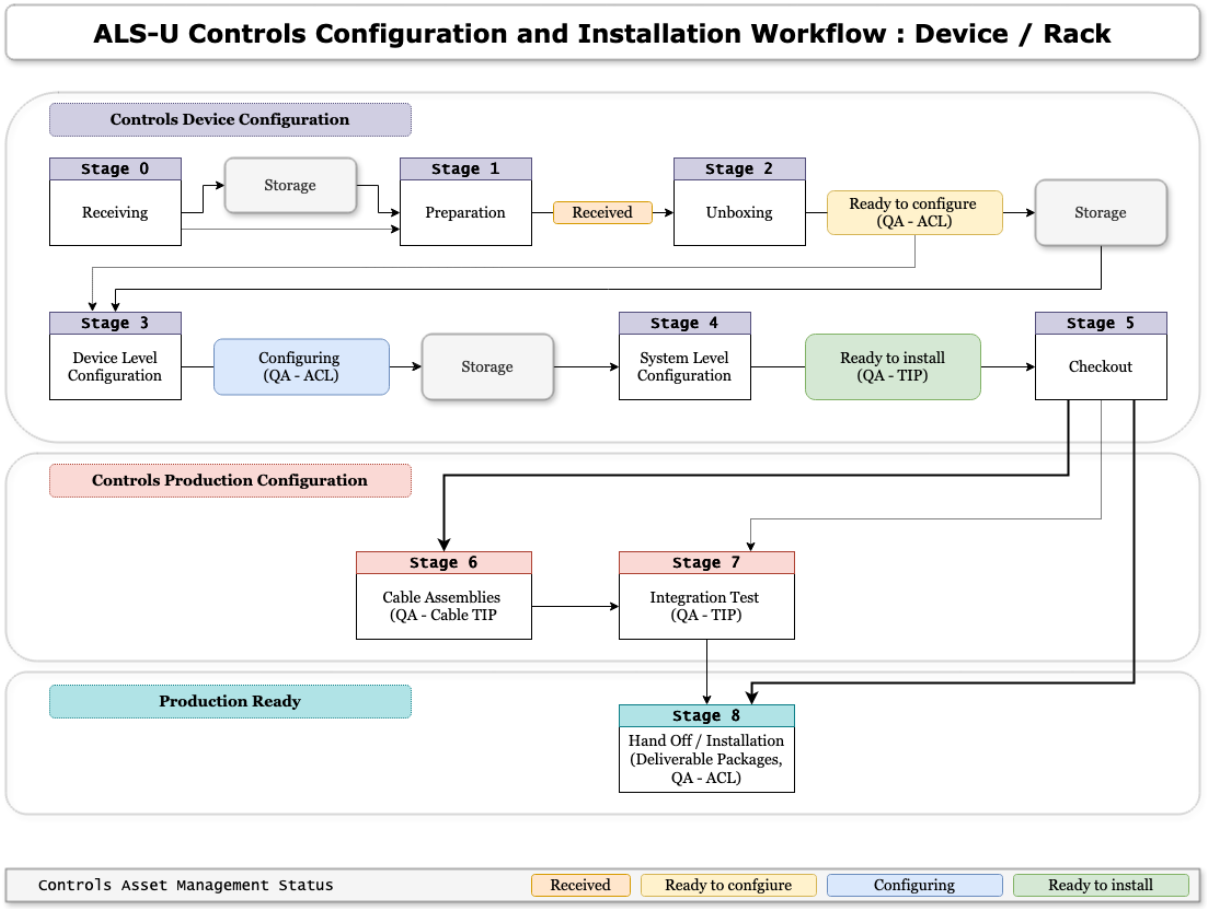
ALS-U Motion Racks (Pit / DBL)

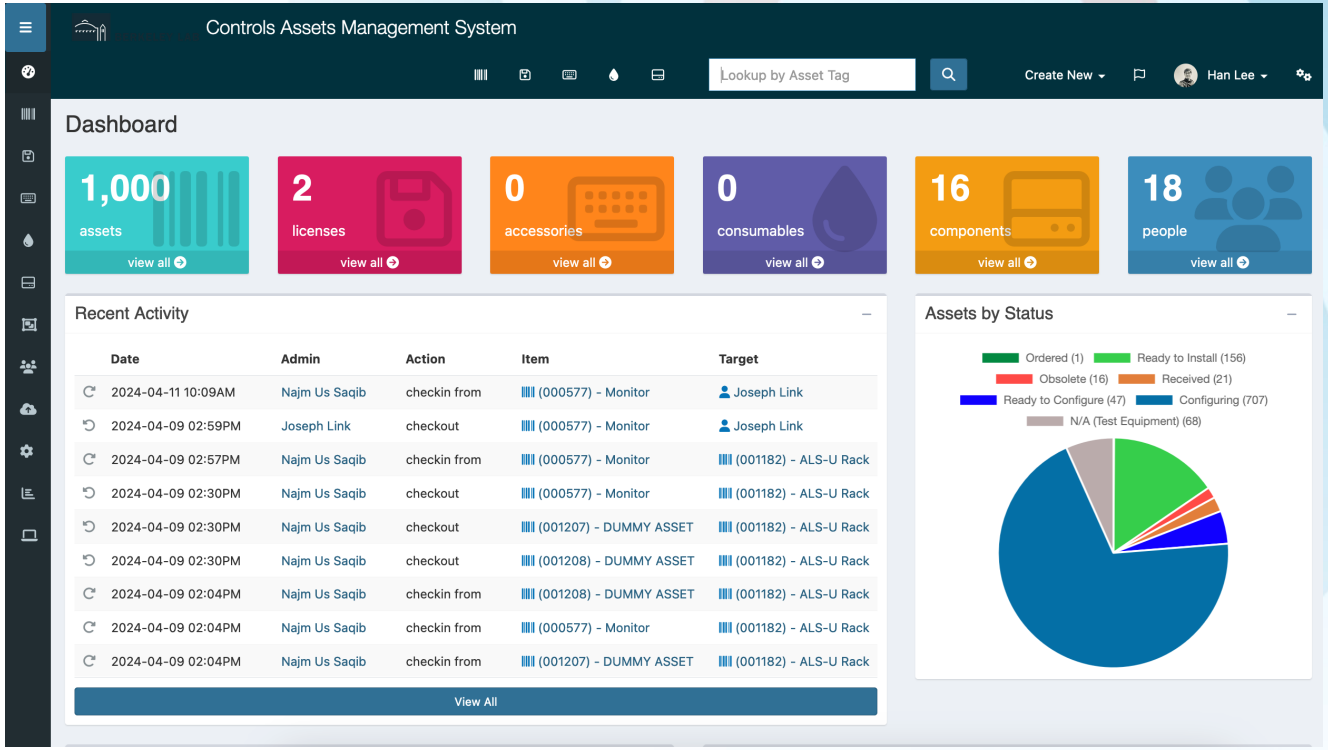


ALS-U Motion : AR CF Topology (An example)



Asset Management System (AMS)





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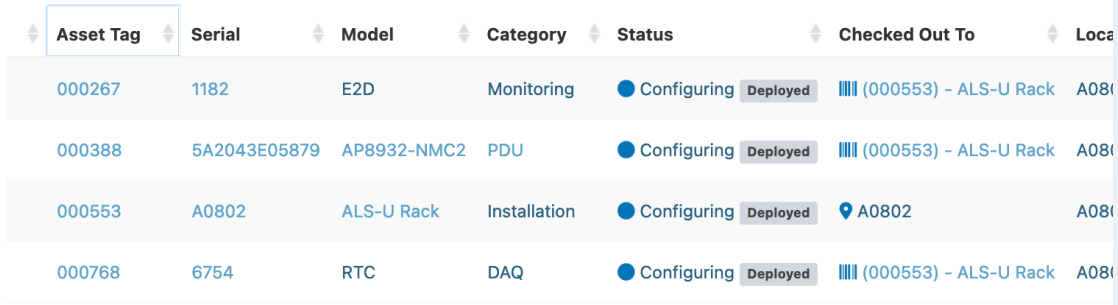

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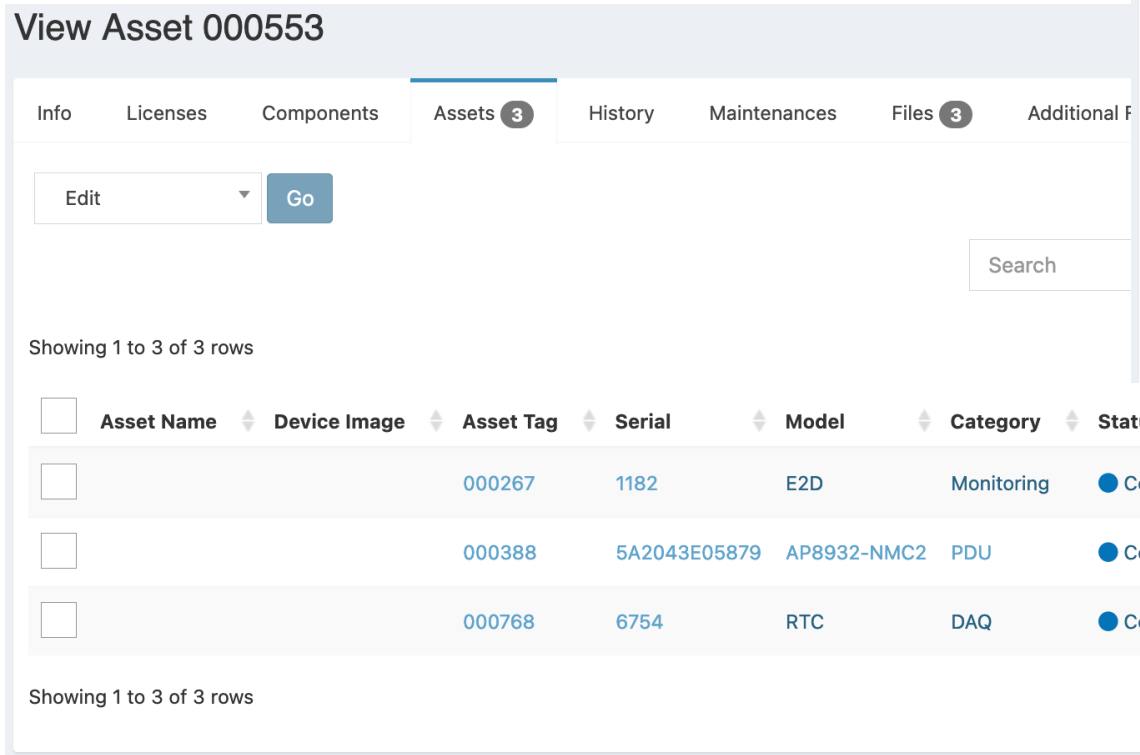
000388	5A2043E05879	AP8932-NMC2	PDU	Configuring Deployed	(000553) - ALS-U Rack	A08(
000553	A0802	ALS-U Rack	Installation	Configuring Deployed	A0802	A08(
000768	6754	RTC	DAQ	Configuring Deployed	(000553) - ALS-U Rack	A08(



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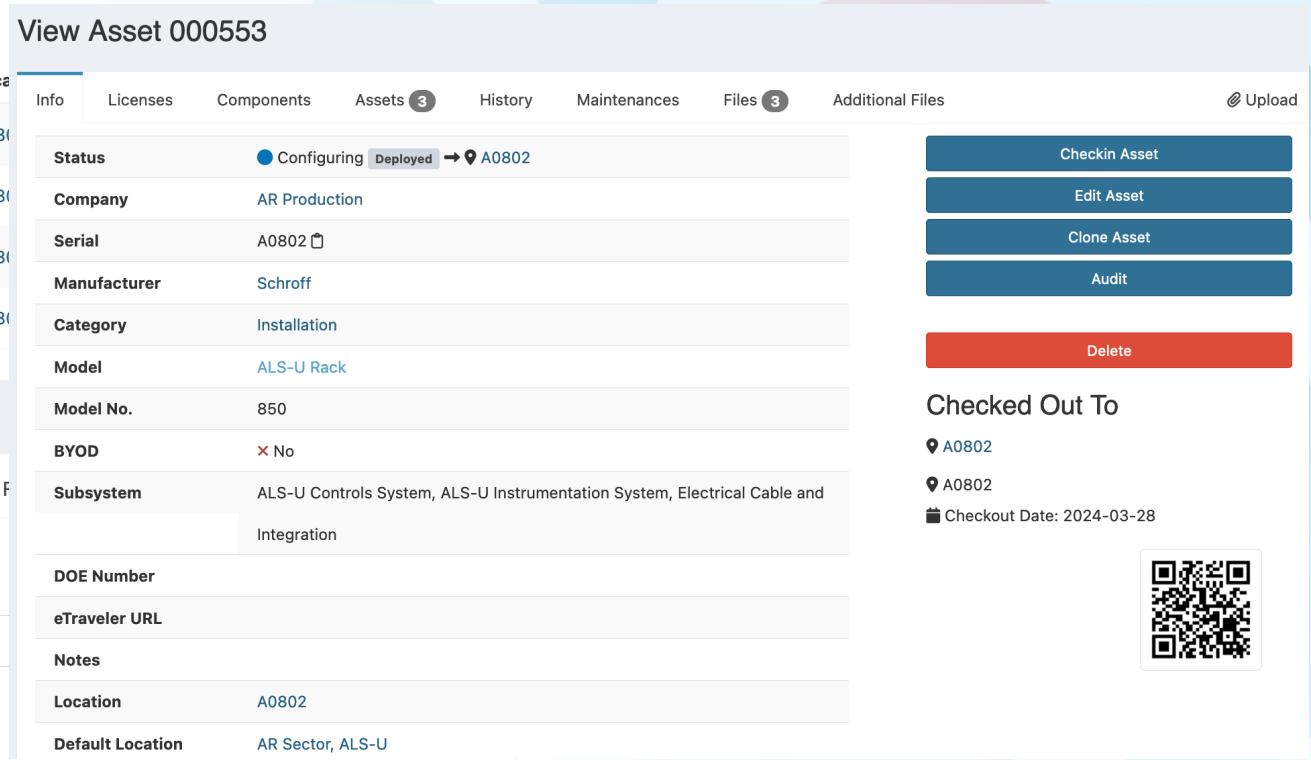

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Company	AR Production
Serial	A0802
Manufacturer	Schroff
Category	Installation
Model	ALS-U Rack
Model No.	850
BYOD	✕ No
Subsystem	ALS-U Controls System, ALS-U Instrumentation System, Electrical Cable and Integration
DOE Number	
eTraveler URL	
Notes	
Location	A0802
Default Location	AR Sector, ALS-U

Checkin Asset

Edit Asset

Clone Asset

Audit

Delete

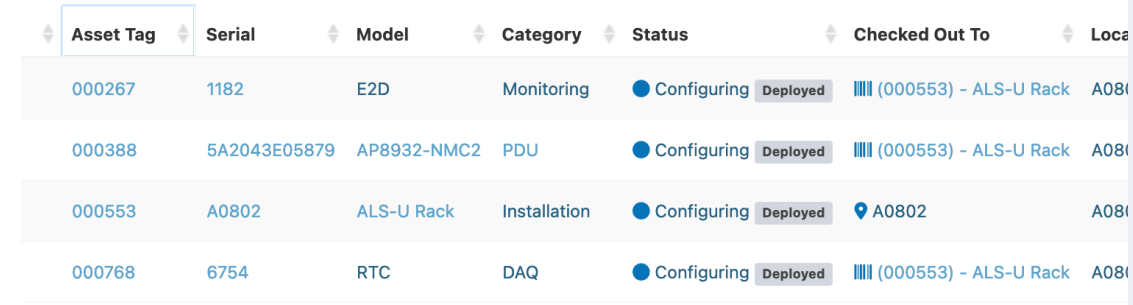
Checked Out To

A0802

A0802

Checkout Date: 2024-03-28

Asset Management System (AMS)



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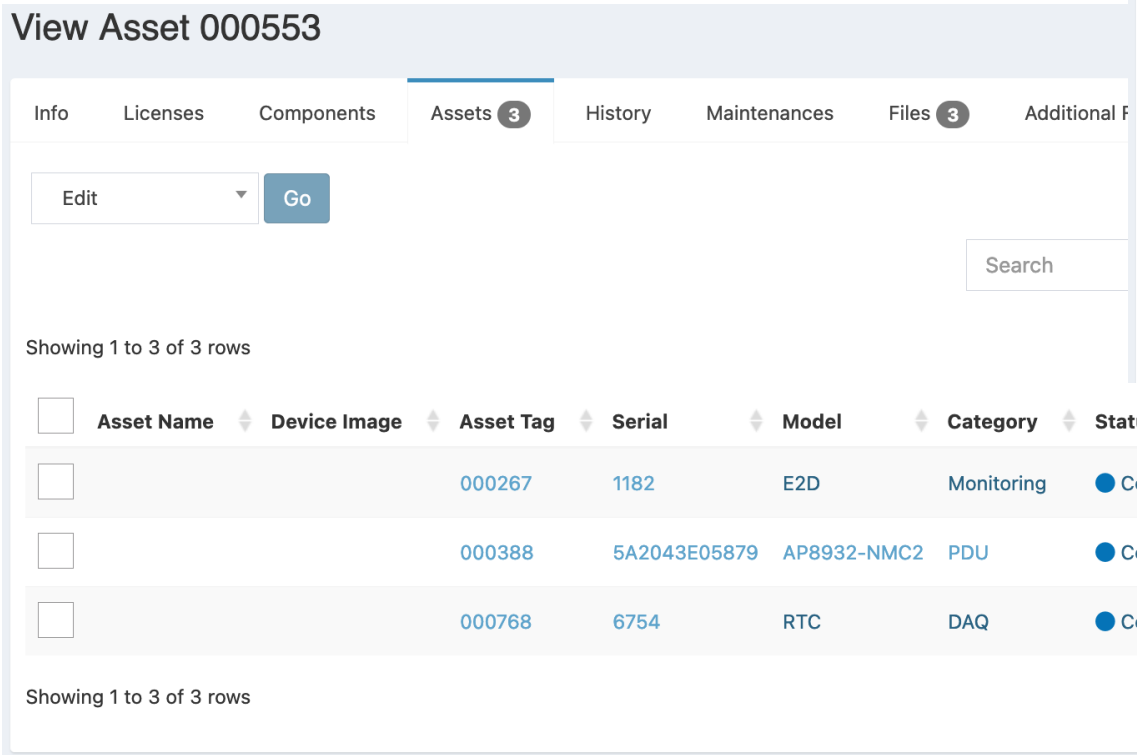

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		000768	6754	RTC	DAQ	Configuring Deployed	(000553) - ALS-U Rack	

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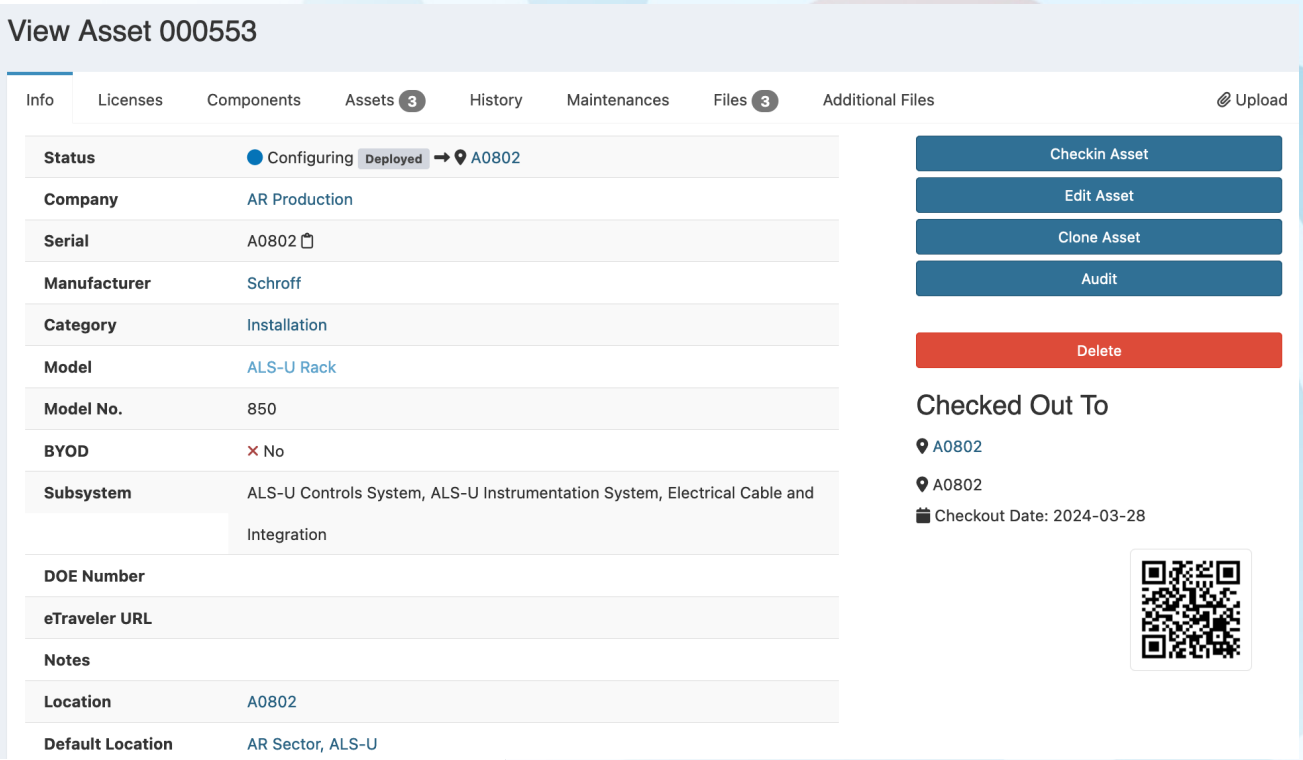

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Info | Licenses | Components | Assets 3 | History | Maintenances | Files 3 | Additional Files | Upload

Status	Configuring Deployed → A0802
Company	AR Production
Serial	A0802
Manufacturer	Schroff
Category	Installation
Model	ALS-U Rack
Model No.	850
BYOD	✕ No
Subsystem	ALS-U Controls System, ALS-U Instrumentation System, Electrical Cable and Integration
DOE Number	
eTraveler URL	
Notes	
Location	A0802
Default Location	AR Sector, ALS-U

Checkin Asset

Edit Asset

Clone Asset

Audit

Delete

Checked Out To

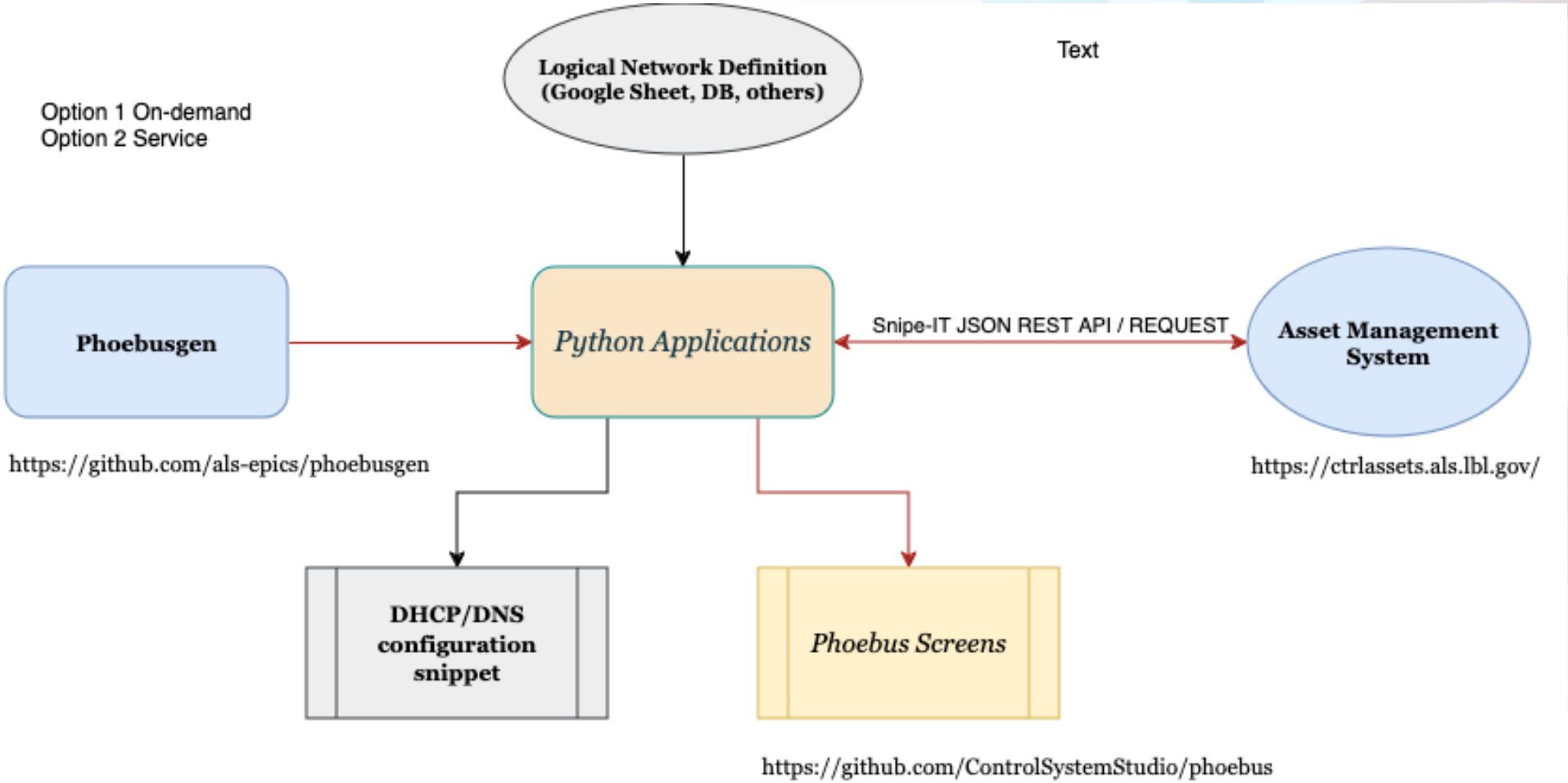
A0802

A0802

Checkout Date: 2024-03-28

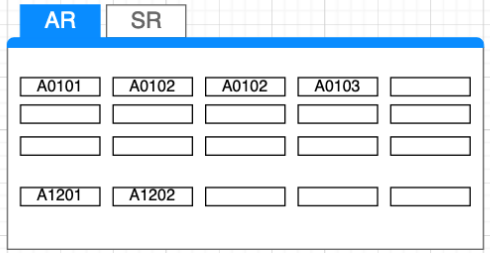
Asset Management System (AMS)

Asset Management System (AMS)

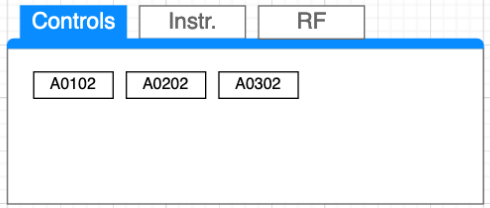


Asset Management System (AMS)

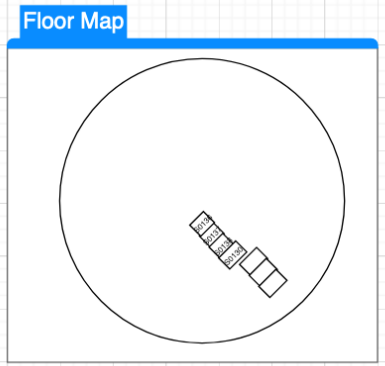
Phoebus Screen 1



Phoebus Screen 2



Phoebus Screen 3

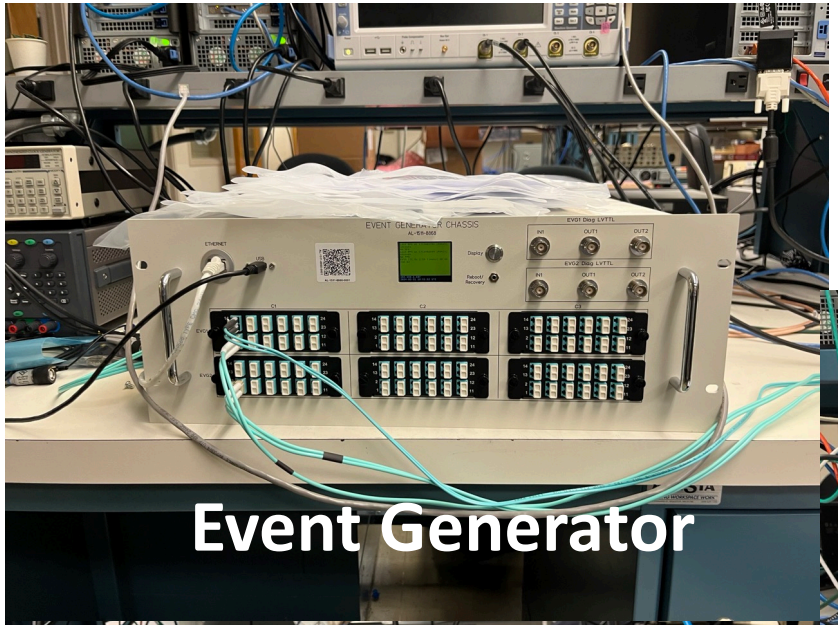


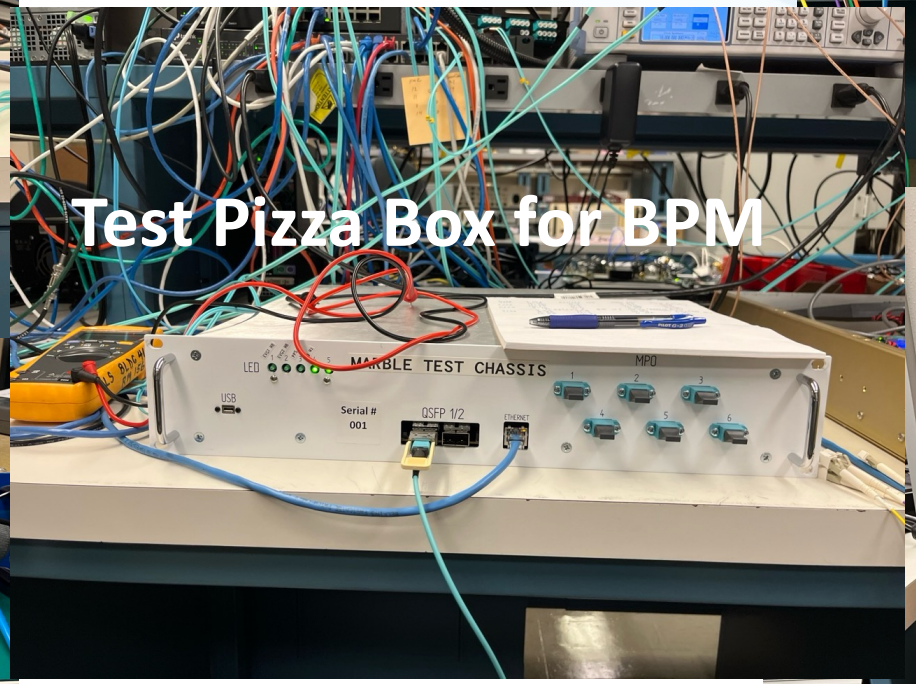
A0802
NET : EX3400-24T
DCPS
MPSA
DCDS
EVR
BLM
NPCT
DMM
BCM
E2D
RTC
PDU

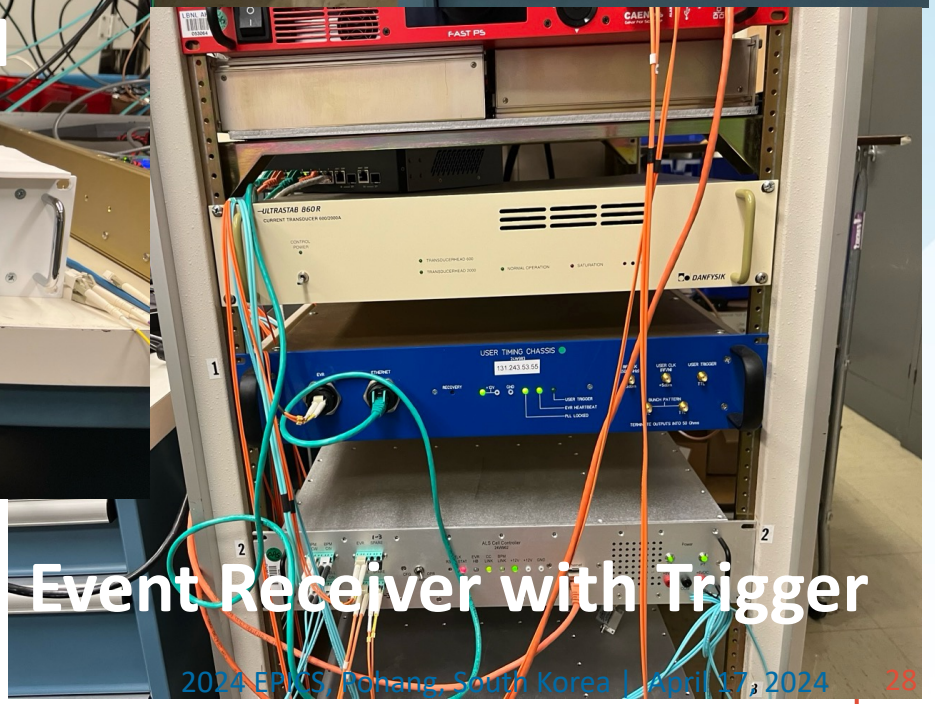
- Rack Name (Parent)
- NAME : DEVICE Model (dynamic* PVs)
- Each unit (Child asset) has all static information and dynamic* PVs from IOC if exists
  - Asset Tag
  - Serial Number
  - Model
  - Firmware
  - IP address
  - Subnet mask
  - Gateway
  - MAC Address

(dynamic* PVs) : Future expansion

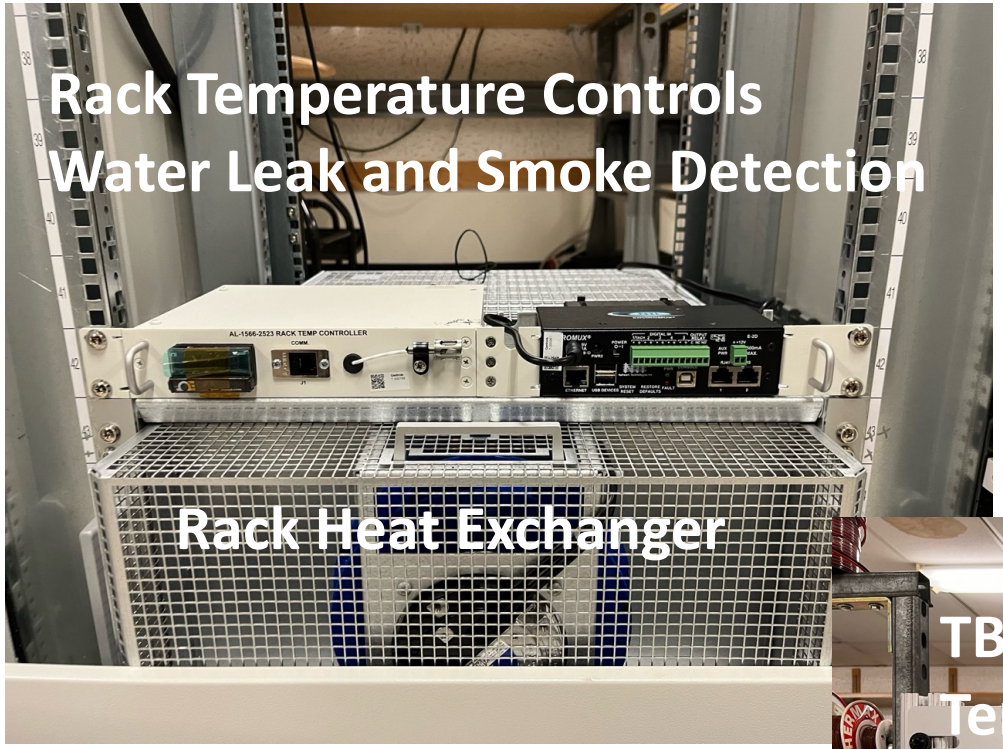
ALS-U Hardware

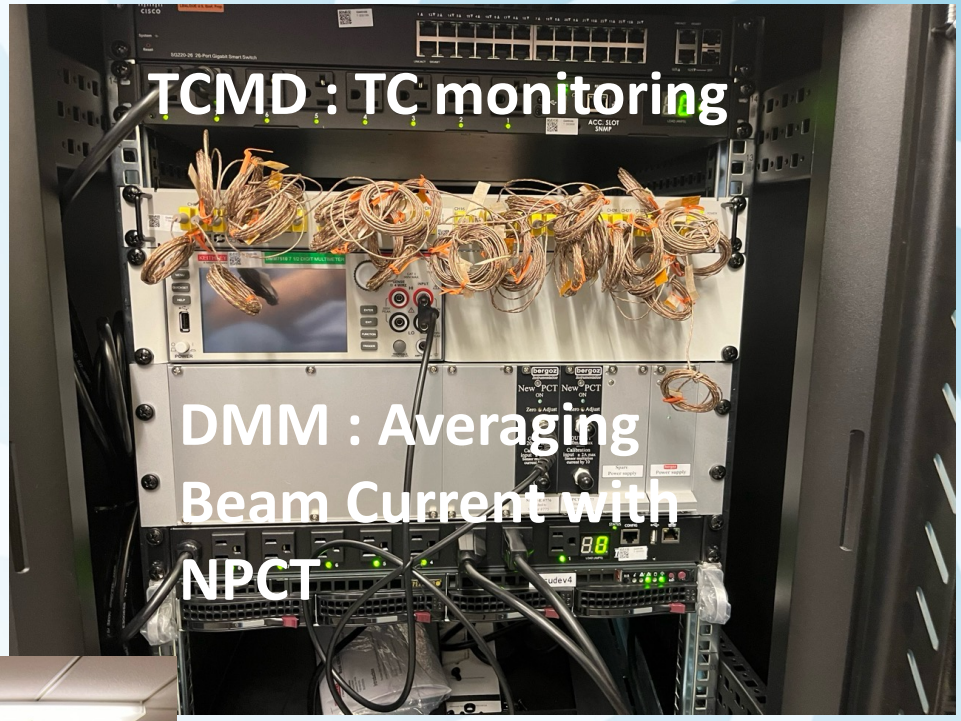


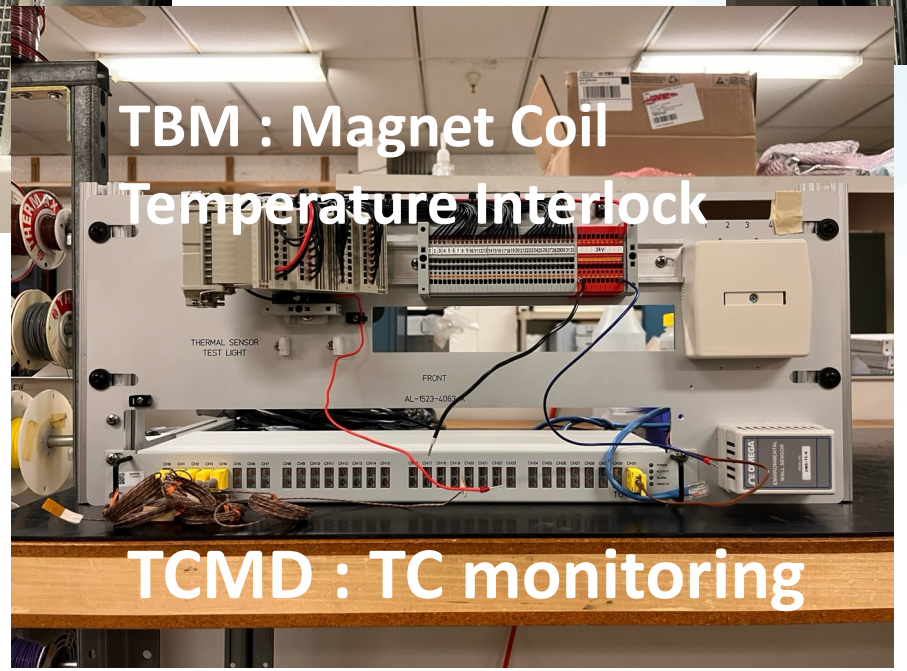


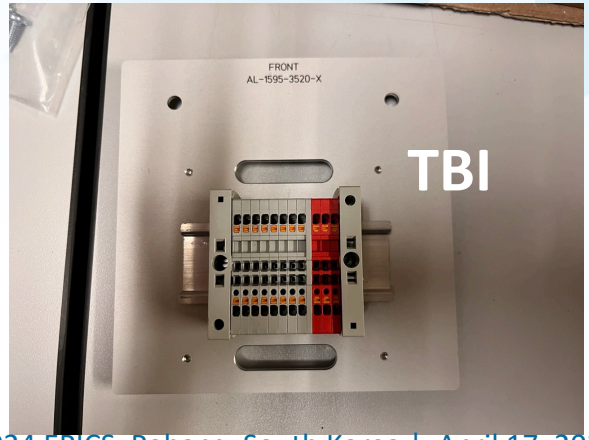


ALS-U Hardware









ALS-U Hardware

Lesson Learned?

We found we have zero clearance, and random orientation for the FM cable, so we had to find additional L-Shape cable adaptor. Please engage your design at early stage of the mechanical and plant design.

Lesson Learned?

We received the vendor (Schroff/nVent) with the rack frame grounding on the left.

We fixed it rightly!

Be aware about the vendor QC/QA engineering

Lesson Learned?

- Grounding on a painted surface (Schroff / nVent)
- not enough tolerance on mounting rails, so we cannot mount


Thank you!
감사합니다!
Let the Light In ALS-U!