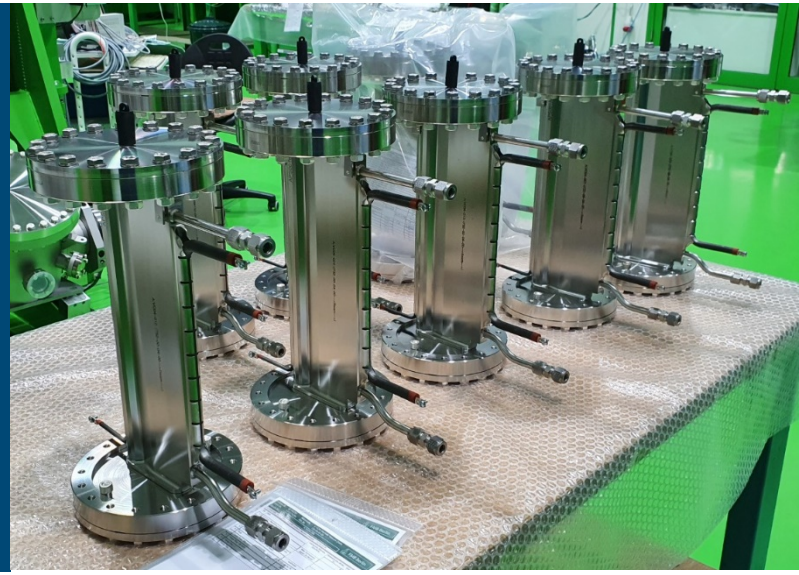
APS Upgrade Project Status Update



A set of the first production batch (40 total) of keyhole vacuum chambers prior to shipment from the vendor.

R. Hettel, APS-U Project Director

APS All Hands Meeting

April 28, 2021

Overall

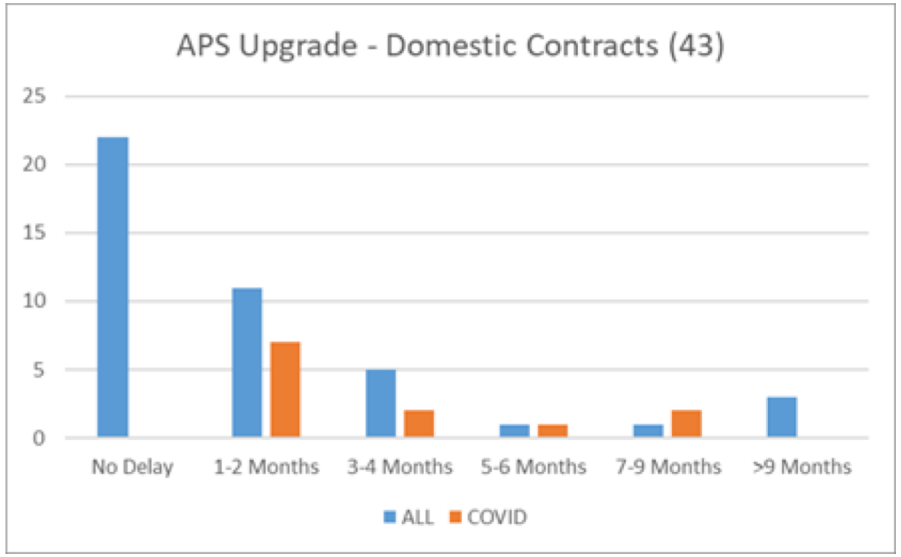
- As of March 2021 the Project is 50% complete by cost, 70% by cost + obligations. Cumulative CPI = 0.99, SPI = 0.93. However FY21 SPI = ~0.86, largely due to COVID impact.
- Project (for this stage) has good cost and schedule contingency
- 920 out of 1321 storage ring magnets are on site, many received and measured; many power supplies, BPM electronics, etc. have been also received
- A horizontal injection scheme has been chosen in place of the vertical scheme.
- On-site work continues for receipt, inspection, and assembly as items arrive.
- Offsite Bldg. 981 now becoming fully functional for project work.
  - Deliveries, equipment setup and assembly efforts allowed to proceed as needed
  - Over 3000 components currently in storage in the facility – many more to come!
- Placing procurements and vendor management remains a high priority
  - 28-ID enclosure fixes and transport work to be completed within days; 25-ID enclosure work in progress with estimated completion in May
  - Main enclosure contract has been awarded -- with a 10-M$ impact on contingency. Details of the schedule are still being worked out
  - Critical path vacuum chamber production is being very closely tracked
  - Seeing some supply chain delays for miscellaneous contracts (e.g. global chip shortage)

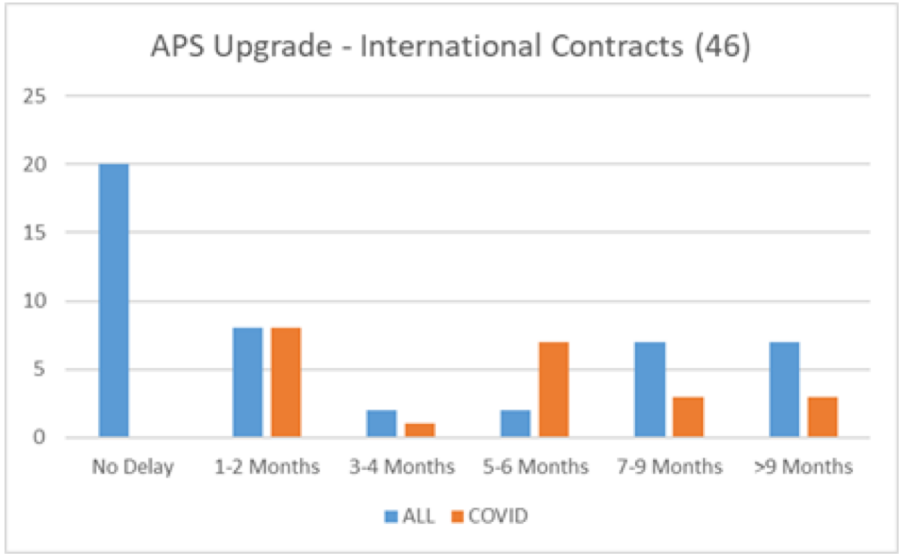
COVID and the APS Upgrade

- On-site work continues on receipt, inspection, assembly of components as they arrive
  - Work is tracked and authorized weekly for commencement and continuation
  - ESH presence is on-site daily for oversight and assistance
  - Work includes acceptance tests for magnets, power supplies, high voltage pulsers, BPM electronics, planar undulators, SCU, Bunch Lengthening System test, feedback kicker parts testing, use of off-site space, and practice plinth / module assembly work.
- (At least) one member of APS-U management on site every day. In the end there is not a substitute for this level of communication.
- Photon Sciences (and the APS-U) continue using a 2 shift 'cohort' model of staffing to minimize staff contact / interactions. Illinois rates rising. On site requests are under increased scrutiny.
- Project work continues using video conferencing.
- Project continues to assess the potential impact of COVID on schedule and cost (using actual data coupled with Monte Carlo scenario simulations) and communicates the findings with DOE/BES. Potential impacts include changes in darktime schedule, CD-4 schedule and total project cost (TPC).

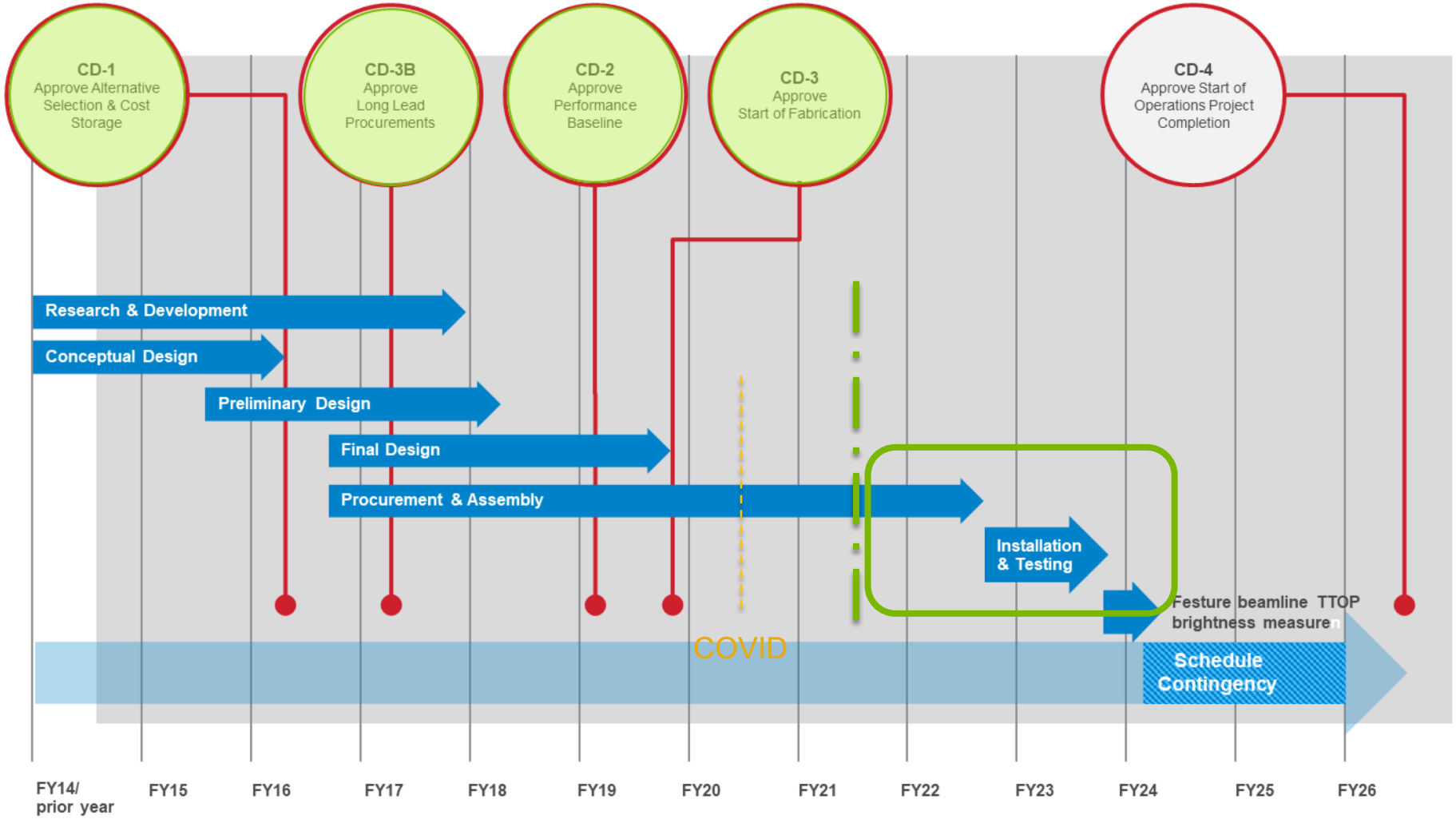
Vendor Impacts

- ‘Partial’ schedule impacts due to COVID are shown
- Vendors are trying. European impacts are large at the moment.
- What-if including all vendor input underway. Potential schedule delay for the start of downtime is being assessed.
- Discussions on impacts ongoing w/ stakeholders





APS-U Schedule (original)



Schedule from now to the end of the project, including the start of the darktime, is being re-evaluated in light of the COVID pandemic – on our supply chain / vendor deliveries and our local work requirements.

APS-U by the Numbers

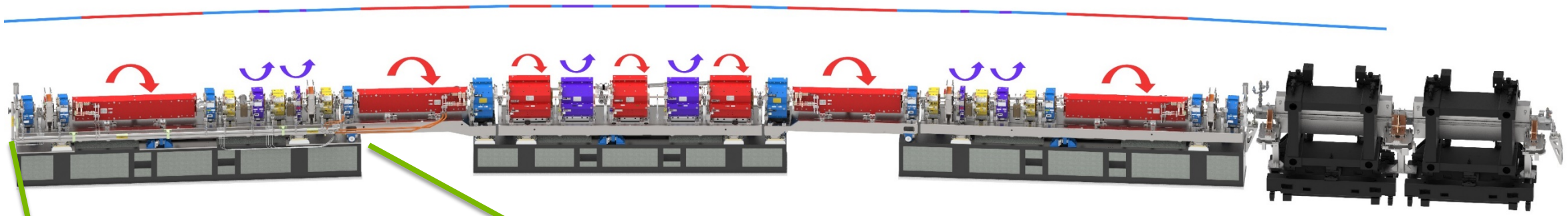
Storage Ring	Insertion Devices	Front Ends	Beamlines
1,321 Magnets	11 Phase Shifters/Supports	470 Tables/Supports	36 Enclosures
4,640 Vacuum Components	48 Canted Magnets/Supports	162 Shutters	61 Mirrors
120 Modules	33 Corrector Magnets	108 BPMs	28 Instruments
80 Support Plates	800 Vacuum Components	162 Masks	23 Monochromators
2,245 Power Supplies	68 Power Supplies	116 Collimators	9 Transports
400 Power Supply Controllers	4 Superconducting Undulators*	19 High Heat Load Front Ends	22 Compound Refractive Lens
560 RF BPM Electronics	43 Planar Insertion Devices**	16 Canted Front Ends	13 Enhanced Beamlines
200 Module Assemblies	12 Revolver Devices***	20 Bending Magnets	9 Feature Beamlines

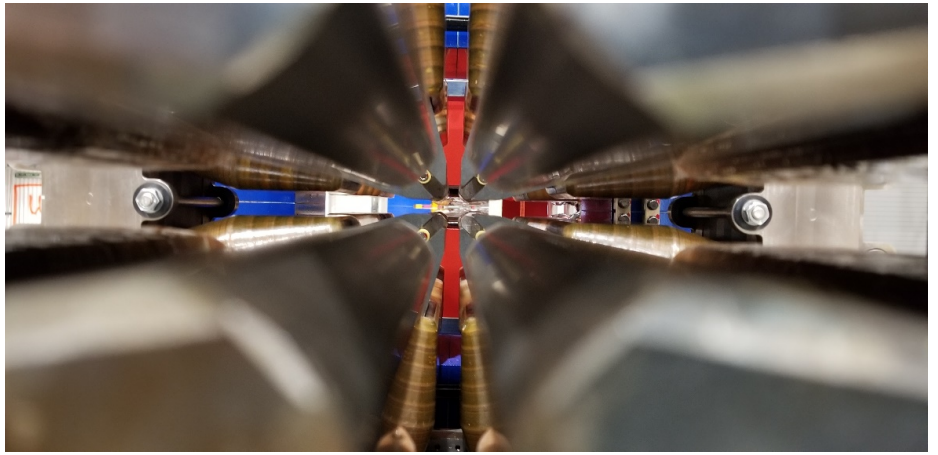
* 2 different periods, 3 different core lengths
** 9 different periods
*** 2 different periods

Practice assembly of DLM-A Plinth and magnets in bldg. 375

- The 1st plinth assembly (concrete/metal base and associated machined plate) and associated 11 magnets was assembled
- Alignment data taken before / after the mounting; 30 μm alignment tolerance achieved
- Process will be repeated not just for alignment, but also for workflow, etc.

First DLM-A Plinth and magnets in bldg. 375





Power Supplies

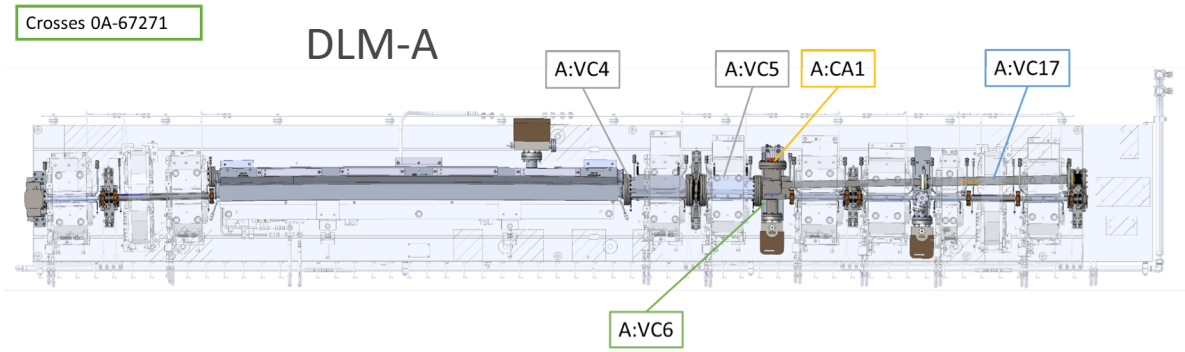
Power Supply Pre-Installation Testing

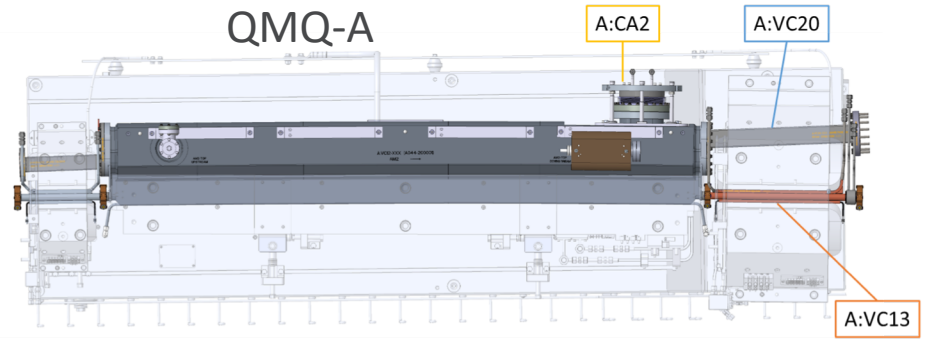
- Completed CAENels unipolar power supplies designated electrical equipment inspection (DEEI) and quality assurance (QA) inspection of the 30 first articles received from the vendor:
  - 10 DCU-100, 100 A converters
  - 10 DCU-200, 200 A converters
  - 10 DCU-300, 300 A converters
  - 84 production units recently received

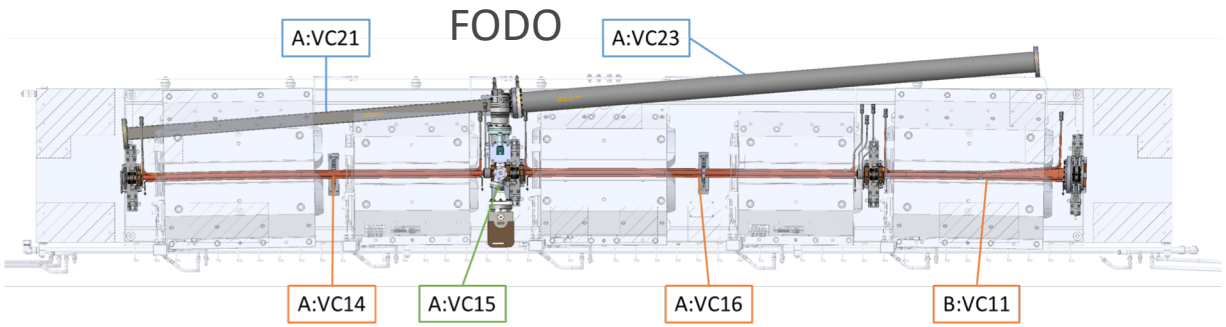
Unipolar power supply converter cabinets and the units under test in elevated-temperature room

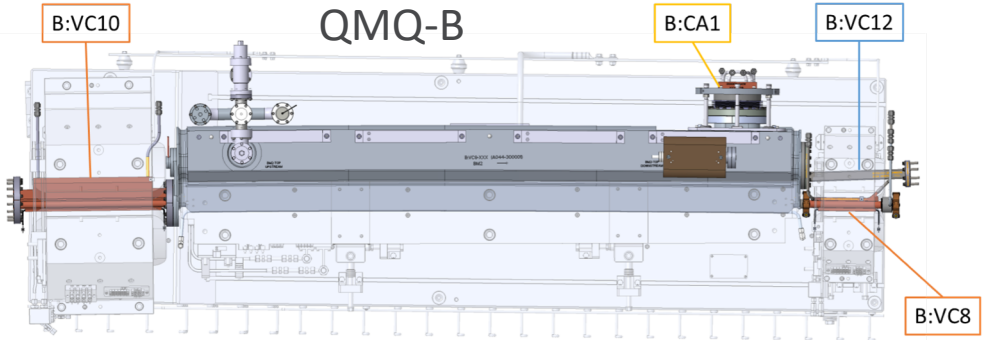
Bipolar relay rack loaded with 16 bipolar power supplies, and the raw power supplies installed in elevated-temperature testing room.

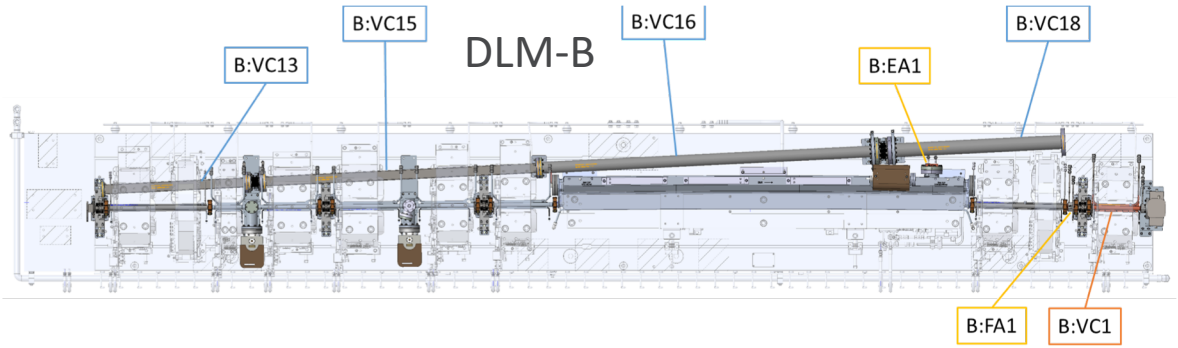
Vacuum System





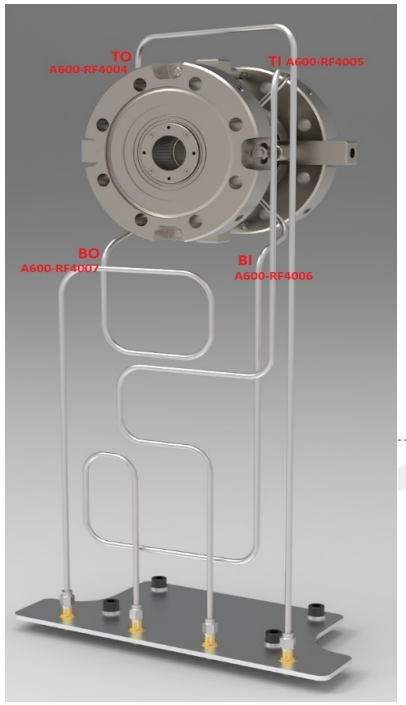






Vacuum System

Keyhole chambers



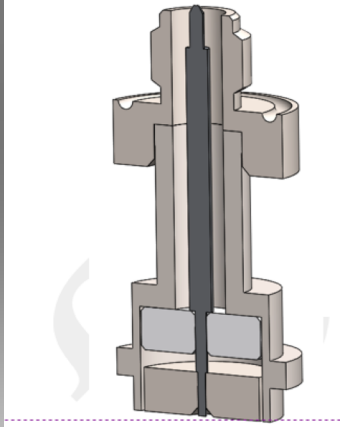
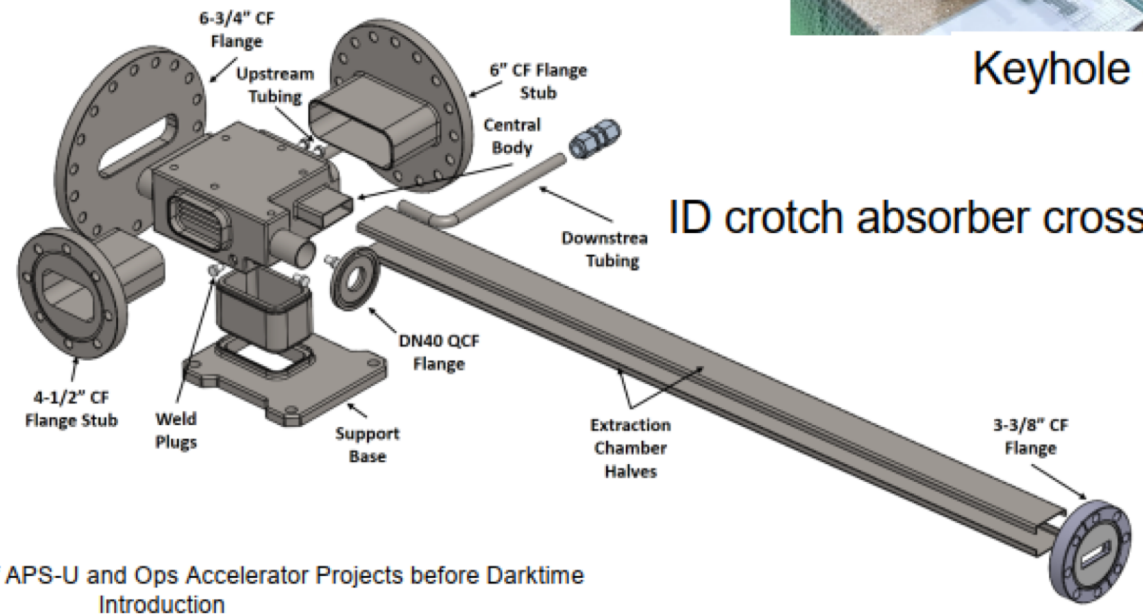


Figure 7: MDC-ISI's initial proposal for BPM feedthroughs.

BPM assembly, button feedthru, RF finger liner



ID crotch absorber cross

tion of APS-U and Ops Accelerator Projects before Darktime Introduction

Figure 10: A silver-plated Glidcop rf liner.

Controls, Diagnostics and Interlocks

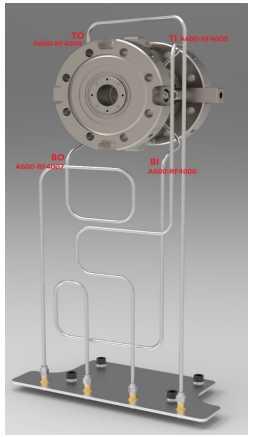
Controls:

- Detailed specification and design of this complex system is ongoing
- Network components in procurement
- Successful upgrade of PLC-based vacuum valve controllers
- Much progress on CDB implementation
- Staffing successfully increased
- Much much more

VVC chassis with upgraded CPU processor, power supply, and touchscreen.

Diagnostics:

- 112 out of 140 Libera B+ BPM processors accepted; remaining due soon
- SPARC single pass injected beam monitors selected
- BPM cabling specified
- Bunch Monitor uses ALS design
- DCCT specified and in procurement
- Beam Size Monitor FDR completed
- HLS FDR completed



ITech BPM processors

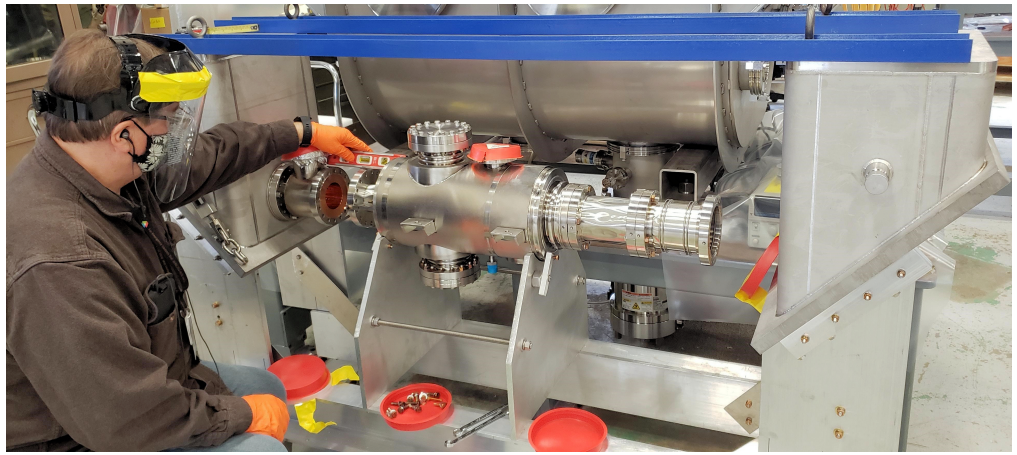
Interlocks:

- 2nd BPLD chassis completed
- Radiation safety: more radiation monitors, BTS BESOCM, top-up injection safety interlock in process
- Ops handing ACIS modifications

MPS units

BLS and Feedback Systems

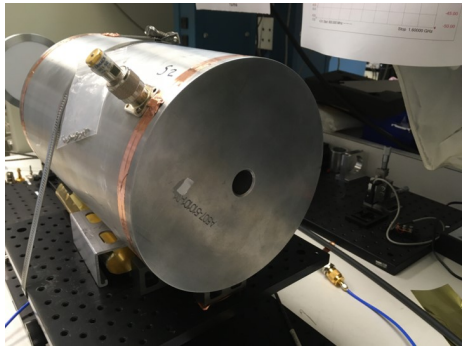
Bunch Lengthening System



A mock assembly of several of the components to be installed on the inside of the BLS cryomodule.

- First cold cavity tests completed
- Cryo system design complete
- Helium refrigerator due in early 2021

Helium tank installation
for bunch-lengthening system



Aluminum Longitudinal Feedback Kicker (LFB) model undergoing impedance testing.

Fast Orbit Feedback

- Work on this state-of-the-art system continues.

Transverse Feedback

- Final Design Review was held.
- DIMTEL processor in procurement.
- Kicker will be the same as injection decoherence kicker.

Longitudinal Feedback

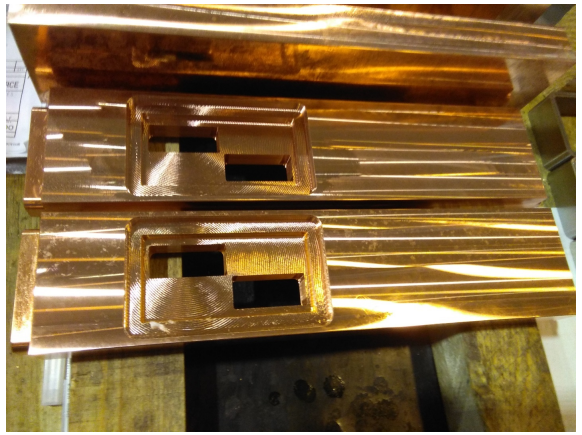
- Final Design Review was held.
- DIMTEL processor with direct energy sensing
- The 1st-article 500 W power amplifier is undergoing factory acceptance test at the vendor.
- Al kicker model tested successfully

Front Ends and Insertion Devices

- The front end assembly of tables has commenced in Building 981.
- All the FE masks needing explosion bonding has been completed. CINEL has completed delivery of all canted exit masks and is working on the canted GRID XBPM masks fabrication.
- First article canting magnet assemblies completed by Tesla.
- Fabrication of 9 out of 13 revolver GSM completed by ANL central shops.
- Two 1.9m long core has been successfully impregnated with epoxy resin.
- Test insertion of the cold mass into cryostat has been successful
- SCU controls instrumentation rack has been assembled. Programming is on-going in preparation for testing in the horizontal cryostat.

Assembly work beginning at the 981 clean room

CU Front End Safety Shutters assembled in 981



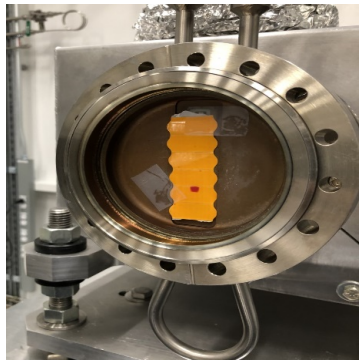
Canted ID GRID masks prior to brazang

First impregnated 1.9m long SCU ID core

First article Canting Magnets ready for shipping

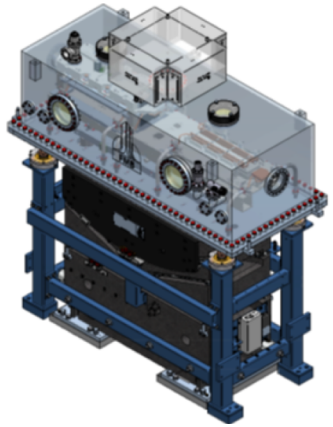
Experimental Systems

- The vertical DCM for Polar has been awarded to CINEL, France
- A new photon shutter design for multiple beamlines has been completed.
- Installation of shielded enclosures for ASL (25-ID) has resumed.
- First beam delivered to 28-ID-B enclosure. Beamline has been configured for measurement and testing for APS-U.
- Support stage for 9-1-1T for Polar beamline complete
- The three single crystal monochromators for CHEX beamlines has been awarded to JJ Xray, Denmark
- Final Design Reviews of 3DMN (3-5-21) and Atomic (3-18-21) was completed.

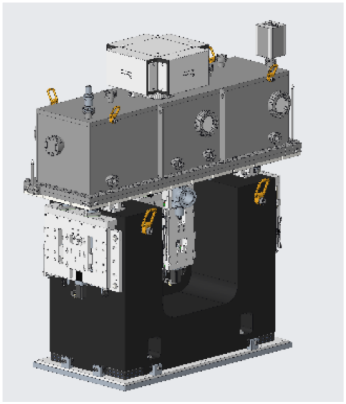


First beam in 28-ID-B

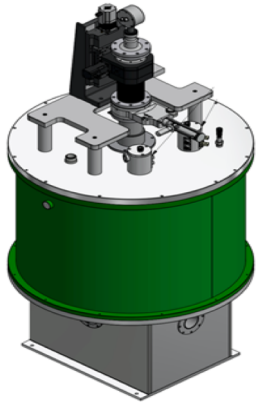
25-ID-D enclosure installation



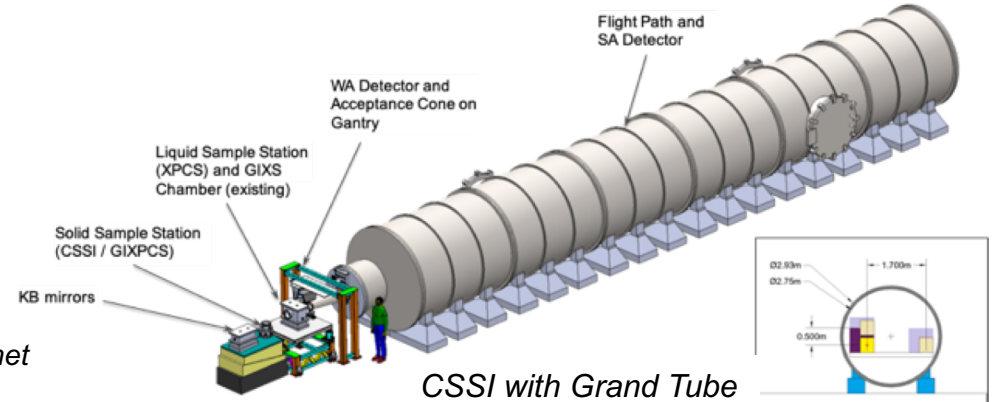
19-ID ISN primary mirror system



4-ID Double focusing mirror system designed by Axilon



Preliminary design of 9-1-1 T magnet system for Polar beamline

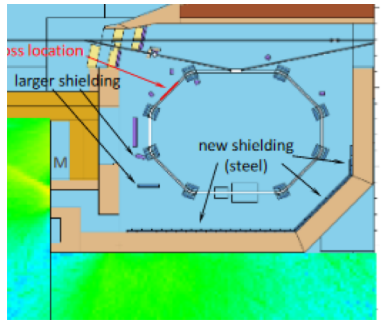


CSSI with Grand Tube

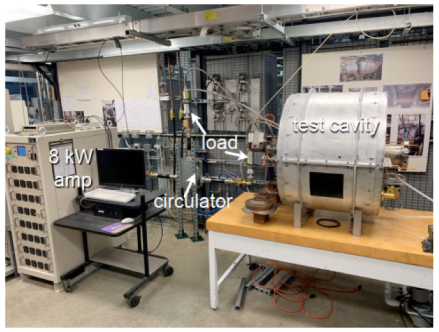
Injector Systems

Progress on:

- 352 MHz ring RF waveguide reconfiguration plans
- Timing and synchronization system
- Injector LLRF
- PAR, Booster and BTS studies for high charge operation (largely by AOP)
- PAR 12th harmonic RF amplifier upgrade to 8 kW (high charge operation)
- Booster high power RF coupler (high charge operation)
- PAR shielding enhancement

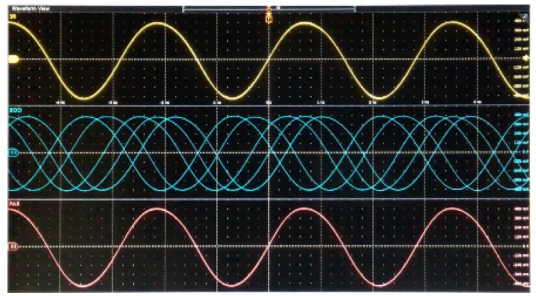


PAR shielding enhancement and panel lifting cart

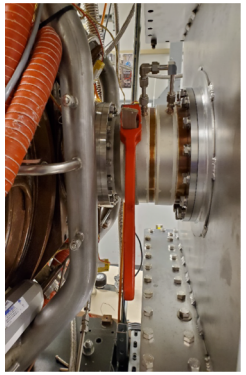


PAR 8 kW RF amplifier under test

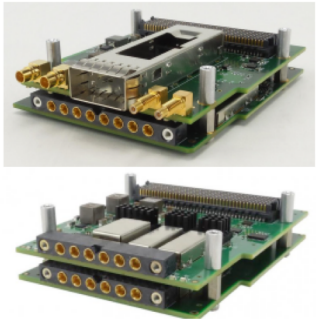
Injection timing system: Storage ring (yellow), booster (blue), and PAR (red) rf traces. The booster is at a different frequency; hence its trace is out of sync but beam transfer is still possible



Booster high power cavity coupler attached to test cavity



- Booster and PAR LLRF systems will be upgraded to digital
- µTCA for flexibility & scalability
  - A-D and D-A boards by VadaTech in testing
- Strong collaboration with SNS (Eric Breeding)
- Rf design & EPICS interface in house.
- Proof of principle setup in PAR
- FDR January 2021

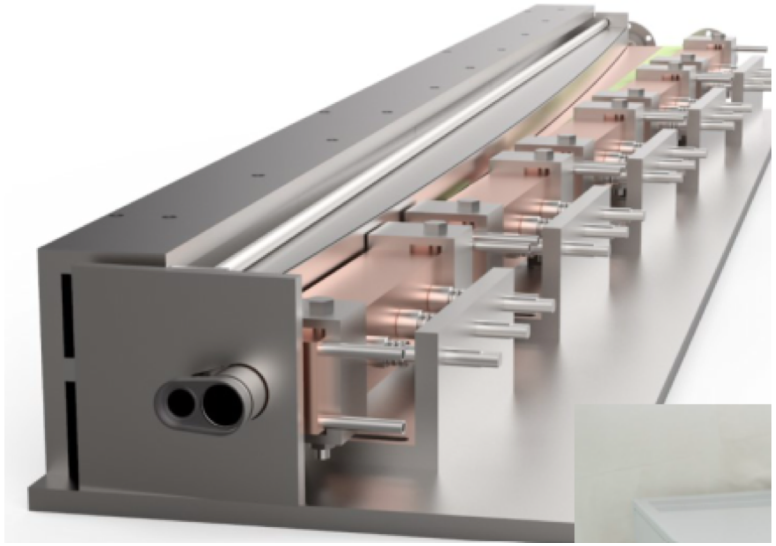


Injection Scheme

Argonne NATIONAL LABORATORY
Advanced Photon Source Upgrade

Septum Magnets

- Lambertson DC septum (vertical injection) was delivered to Argonne From FNAL on January 19.
- Physics has determined that leakage fields are acceptable from a beam dynamics perspective.
- Horizontal pulsed septum design near completion
- Final decision on injection scheme formalized: _**horizontal**_ injection will be used



Pulsed Horizontal Injection Septum Magnet model

Record of Decision on the Injection Method for the APS-U Storage Ring

APS-U Document #:	WBS Number:	Revision:	ICMS Content ID:	Date Issued:
APSU-2.01.06-RD-024	U.U2.01.06/ U.U2.03.03.06/ U.U2.03.04.04	0	APSU_2175768	2/26/2020

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Approvals for this document will be required from:

Mohan Ramanathan –APS-U Associate Project Manager for Experimental Systems and IDs
Glenn Decker – APS-U Associate Project Manager for Accelerator Systems
Elmie Peoples-Evans – APS-U Deputy Project Manager
Tom Fornek – APS-U Project Standards and Verification
Jim Kerby – APS-U Project Manager
Bob Hettel –APS-U Project Director

Record of Decision – Horizontal Injection chosen

- A group of experts was consulted via email the week of February 15, 2021, with follow-up meetings involving these individuals on February 23, 24, and 25, 2021.
- Vertical Risks: NEG coating of 6 x 8-mm, 2-m stored beam chamber needs development effort that can't be met by LBNL at this time (but possible with an extended schedule), concerns about chamber vacuum even if coated.

Long Beamline Building (LBB)

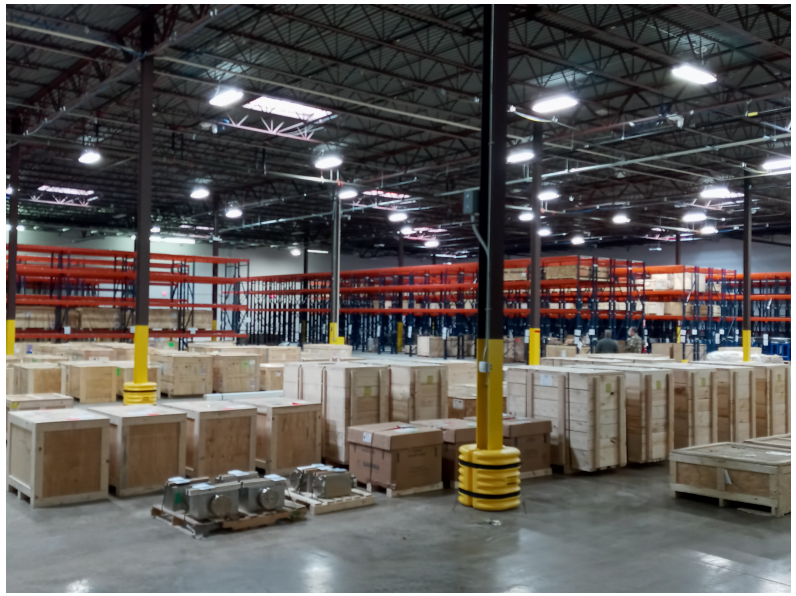
- Cellular fill pour onsite has been completed.
- Framing, pouring of foundations, and installation of rebar has started in the month of March..
- Pouring of frost walls at the ISN corridor has been completed.
- Pouring of thickened slabs at ISN enclosure has begun
- Installation of underground plumbing has also begun and will continue into the month of April.

Framing and foundation for the HEXM area. ISN is the back

Site Photo from March 19, 2021 showing poured cellular fill

Cellular fill for the ISN corridor and Enclosure area

Offsite Bldg. 981 (100,800 sq.ft.)



- Storage underway.
- The Module Assembly area is completed with five DLM/FODO assembly stations, each consisting of a certified retractable ISO7 (Class 10,000) clean room and load tested 3-ton overhead crane.
- An additional two QMQ assembly stations have been outfitted, each with a load tested 5-ton gantry crane.
- Component storage racks have been installed and rack locations set up with quick response (QR) codes tied to the APS-U Component Database (CDB).

First FODO module was delivered to Building 981 and moved into our assembly station clean room using the Hilman Traksporter system.

Ramp up in technical support

Technicians:

- Magnet inspection – 2
- Accelerator vacuum – 1
- SI- 1
- Power supplies – 1 starting in May
- Insertion devices – 2
- Inventory coordination - 5
- Magnetic measurements - 2
- Front ends/Beamlines - 5
- Controls – 1 starting in May
- Module assembly – 2 starting in May
- S&A -3 (2 support beamlines)

Engineers:

- BLS – 1
- S&A - 1
- SCUs – 1

Will continue to ramp up in SI/PS/vacuum/module assembly/beamlines...

APS-U is also funding 3 GEM Students that will do work for XSD and AES

FY21 Milestone List

No	Milestone	Schedule Date	Forecast Date	Actual Date	WBS
1*	Offsite building beneficial occupancy approved	15-Dec-20		30-Nov-20	U2.01 Management
2	Final Design Reviews Complete: Power Supply Controllers and Diagnostics (full list in criteria)	31-Dec-20		19-Nov-20	U2.03 Accelerator
3	Approve initial metrology plan for characterizing mirror systems	31-Jan-21		22-Jan-21	U2.04 Experimental Systems
4*	Vertical vs Horizontal Injection scheme decision made	28-Feb-21		26-Feb-21	U2.03 Accelerator
5	Final Design Review Meetings Done: Storage Ring RF, Injector LLRF, and multiple Feature Beamline Instruments (full list in criteria)	31-Mar-21		18-Mar-21	U2.03 Accelerator U2.04 Experimental Systems
6	Removal and Installation Cable Plant Plan: major systems cables loaded into cable design tool with initial routing	30-Apr-21	30-Apr-21		U2.03 Accelerator
7	Awards completed: High Heat Load Monochromators (8 units)	30-May-21	30-May-21		U2.04 Experimental Systems
8*	Unipolar Power Supplies - 1st 30 units acceptance testing successfully completed	18-Jun-21		10-Apr-21	U2.03 Accelerator
9*	Long Beamline Building Concrete Foundations Complete	25-Jun-21	25-Jun-21		U2.04 Experimental Systems
10*	SCU 1st article assembly first cold test complete and documented	31-Jul-21	2-Sep-21		U2.05 Front End / Insertion Devices
11*	Complete BPM electronics delivery and acceptance	31-Jul-21	31-Jul-21		U2.03 Accelerator
12	ARR and commissioning plan Readiness Review Progress Review complete	15-Aug-21	15-Aug-21		U2.01 Management
13*	**First Assemblies complete:** **3 SR magnet module production assemblies complete** **70 ID Front End table assemblies complete** **23 Insertion Devices tuned**	**15-Aug-21**	**15-Aug-21**		**U2.03 Accelerator** **U2.05 Front Ends / Insertion Devices**
14*	MS-L2-0041 Magnets Q1-Q6 67% (320) received	14-Sep-21		18-Dec-20	U2.03 Accelerator

* - vendor dependent
bold - critical path
*** - multiple vendors involved.

6. Reviewed in the past month. Verifying we have met all criteria to achieve milestone.
7. Bids expected end of April. Milestone completion dependent on quality of bids.
10. Review of SCU schedule held April 2nd. Path forward to achieve milestone finalized April 12th, progress follow-up scheduled for April 26th.
13. Vendor delays leading to concerns on achieving this milestone before the end of FY21.

Major Outstanding Issues

- Manage COVID impact and all the disruptions it causes as best as possible – manage vendor contracts for timely deliveries
- New beamline enclosure installations are being delayed due to COVID-19; working to mitigate this and the threat to the beamline completion schedule
- Update project baseline schedule to address COVID impacts; expected to converge shortly
- Define Radiation Protection system for injecting with beamline stoppers open (task team in place; radiation monitors on bend beamlines, BTS BESOCM, magnet interlocks likely)
- Finalize SAD and ASE; prepare for ARR (task team in place)
- Complete final designs on time (being carefully managed)

Upcoming

- APS-U/APS Interface Gap Workshop Closeout, week of May 3
- ARR status reviews in April/early May and September
- DOE Status Review scheduled for October 24, preceded by Director's Review
  - Major topics include downtime schedule potentially COVID cost and schedule impacts on TPC and CD-4

Summary

- The APS-U project is progressing well: ~70% complete by cost and commitments with many issued contracts and delivered components. Funding is adequate and reasonably secure.
- The Project is being managed for successful delivery of baseline scope; no added scope as yet.
- We have 0.93 SPI and 0.99 CPI, Some schedule delays related to the COVID-19 impact on vendor production and to delays in system design completion and getting procurements out the door. Close attention is being given to manage this situation, for example by expediting vendor schedules and continual assessment of the COVID-19 impact.
- The project is well-staffed with some hires yet to be made; technician staff will be ramped up as we move to acceptance, testing and assembly.
- Risk mitigation plans are in place.
- The project is working well with APS Ops and has good relationships with ANL, DOE and the User community.
- APS-U webpage for recent information: https://www.aps.anl.gov/APS-Upgrade
- Conducting the project in a safe manner is a high priority.

Thanks to all!