



# **Closeout Report on the DOE/SC CD-1 Review of the**

## **Advanced Photon Source Upgrade (APS-U) Project**

**Argonne National Laboratory**

**September 22-24, 2015**

**Kin Chao**

**Committee Chair**

**Office of Science, U.S. Department of Energy**

<http://www.science.doe.gov/opa/>



1. **Conceptual Design:** Is the conceptual design for the new storage ring sound and likely to meet the specified technical performance requirements? Will the new and upgraded beamlines be able to exploit the new X-ray source and fulfill the mission need?
2. **Scope:** Is the project's scope sufficiently well-defined to support the preliminary cost and schedule estimates?
3. **Cost and Schedule:** Are the cost and schedule estimates sufficiently well-defined and of adequate maturity to support the point cost estimate of \$734M and to establish a new cost range for the project? Are there adequate scope, cost, and schedule contingency to execute the project?
4. **Management:** Is the project being properly managed at this stage? Does the management team possess the skills, expertise and experience necessary to successfully deliver the project? Has the management team met all the prerequisite requirements for CD-1 approval? Is the project ready for CD-1?
5. **Environment, Safety, and Health:** Is environment, safety, and health being properly addressed given the project's current stage of development?



# Review Committee Participants

## Kin Chao, DOE/SC, Chairperson

### SC1

#### Accelerator Physics

- \* David Robin, LBNL
- Mikael Eriksson, MAX IV
- John Schmerge, SLAC

### SC2

#### Accelerator Systems

- \* Karen White, ORNL
- Will Oren, TJNAF
- Jim Rose, BNL
- Jim Sebek, SLAC

### SC3

#### Experimental/Beamline

- \* David Fritz, SLAC
- Alex Hexemer, LBNL
- Zhong Zhong, BNL

### SC4

#### Front Ends / Insertion Devices

- \* Toshi Tanabe, BNL
- Michael Rowen, SLAC
- Sasha Temnykh, Cornell U

### SC5

#### Accelerator Removal / Installation

- \* Richard Boyce, SLAC
- Benjamin Scott, SLAC
- Steve Virostek, LBNL

### SC6

#### Environment, Safety and Health

- \* Mike Andrews, FNAL
- Jim Floyd, LBNL

### SC7

#### Cost and Schedule

- \* Steve Meador, DOE/SC
- Carolyn Galayda, SLAC
- Simona Rolli, DOE/SC

### SC8

#### Project Management

- \* Kem Robinson, LBNL
- Frank Crescenzo, DOE/BHSC
- Lori Plummer, SLAC
- Adam Bihary, DOE/FSO

### Observers

- Harriet Kung, DOE/SC
- Jim Murphy, DOE/SC
- Ed Stevens, DOE/SC
- Phil Kraushaar, DOE/SC
- Peter Lee, DOE/SC
- Ron Lutha, DOE/ASO
- Frank Gines, DOE/ASO

- Pepin Carolan, DOE/FSO
- Jerry Kao, DOE/ASO

### LEGEND

- SC Subcommittee
- \* Chairperson

**COUNT: 26 (excluding observers)**



**Mikael Eriksson (MAX-IV), David Robin (LBNL) , John Schmerge (SLAC)**

1. **Conceptual Design:** Is the conceptual design for the new storage ring sound and likely to meet the specified technical performance requirements?

**Yes**, the baseline lattice meets the specified technical performance requirements.

2. **Scope:** Is the project's scope sufficiently well-defined to support the preliminary cost and schedule estimates?

**Yes**, based upon the accelerator physics requirements the project scope is sufficiently well defined to support the preliminary cost and schedule estimates

### 2.1.2 Comments

- The APS-U accelerator team has demonstrated the possibility for the US to reclaim the world leadership position in hard x-ray sources
- Realigning the injector to match the RF frequency appears to be the less disruptive than realigning the ID straights. However it is important to better understand the scope, cost, risk, and benefits of the booster realignment as compared with realigning the ID straights.
- The impact of smaller apertures could be further studied. In particular the use of coupled bunch feedback systems to increase the single bunch thresholds perhaps allowing smaller apertures
- Commissioning strategies should be experimentally tested.

### 2.1.2 Comments

- Alternative RF frequencies (such as 117Mhz) have some attractive features
  - Longer bunches, less IBS, lower emittance, longer lifetimes, etc.
- The choice of optimal beam energy depends on the photon energy. It appears that a lower beam energy, such as 5 GeV, would result in a higher performance below 30 keV.
- The combination of reduced energy, reversed bends, lower RF frequency, and smaller vacuum apertures could result in significantly improved performance such as emittance as low as 30 pmrad



### **2.1.3 Recommendations**

- The project is ready to proceed to CD-1
- A tradeoff study should be made between 5 and 6 GeV operation and its implication on maximizing scientific output before CD-2.
- Before choosing a final lattice take sufficient time to evaluate the benefits of the alternative lattices (reverse bends, lower RF frequencies, and narrower vertical apertures) to maximize scientific output CD-2.



## SC 2 Subcommittee

**K. White/ORNL, W. Oren/TJNAF, J. Rose/BNL, J. Sebek/SLAC**

1. Conceptual Design: Is the conceptual design for the new storage ring sound and likely to meet the specified technical performance requirements??

Yes

2. Scope: Is the project's scope sufficiently well-defined to support the preliminary cost and schedule estimates?

Yes

**Accelerator Systems: Ready for CD-1**





## 2.2 General

### ■ Findings

- The project provided documents and presentations detailing the conceptual design and preliminary cost and schedule for the accelerator subsystems
- The project has leveraged experience gained from APS, ANL and several other laboratories for design and planning
- R&D scope is well targeted to reduce identified risks

### ■ Comments

- Overall, planning and R&D are well advanced for this stage of the project
- The project has done a good job applying lessons learned to their planning
- Staff is very experienced in their subject areas, many are matrixed from APS
- Some labor profiles have less technician effort and more engineering effort than expected during the time when equipment is received, tested and prepared
- Labor profiles seem to eliminate most designer effort after final design is complete which may not provide enough designer resource to properly “as-built” drawings



## **RF**

### ▪ **Findings**

- Existing RF system will be used with minimum modifications; 16 cavities will be reduced to 12
- Existing waveguide, interlocks and LLRF will be modified to work with the new topology
- High power RF systems and cavities are viewed as capable of meeting the voltage and power requirements of APS-U

### ▪ **Comments**

- Amplitude and phase tolerances of the fundamental RF system were not presented
- There is no reason to think the APS-U requirements could not be met with the existing system, but it cannot be verified at this point

### ▪ **Recommendations**

- Specify the fundamental RF phase and amplitude jitter requirements linked to photon beamline requirements and compare to the known system performance prior to CD-2



Team Members: Alex Hexemer (LBNL) & Zhong Zhong (BNL)

1. Conceptual Design: Is the conceptual design for the new storage ring sound and likely to meet the specified technical performance requirements? **NA**

Will the new and upgraded beamlines be able to exploit the new X-ray source and fulfill the mission need?

Regarding the beamlines, we cannot make a definitive determination at this time since the new beamlines have not been selected and the upgrades not been defined in detail. The total resources allocated to these areas, however, should allow for this.



2. Scope: Is the project's scope sufficiently well-defined to support the preliminary cost and schedule estimates?

The high-level scope is well-defined (6 new beamlines, 2 major upgrades, generic enhancements) but the detailed scope is not. The generic cost and schedule model presented is reasonable and well-justified.



- **Recommendations**

- Complete the beamline selection process before CD-2 (recommend at least ~ 6 months before). This selection will better define the function of the components/systems and thus the scope. The development efforts (detector, optics, etc.) and storage ring design should explicitly tie to these choices.
- Complete a detailed beamline-by-beamline analysis of what needs to be changed to maintain current performance, including bend magnet beamlines and computing requirements, before CD-2. This will determine the requirements and scope.
- Define/execute a process to determine/justify the investment breakdown between new flagship beamlines and general upgrades to maximize the science impact of the project.
- Study the shielding implications for the existing beamlines of the APS-U, especially those that will substantially increase in flux.
- Study existing bending magnet beamlines with multiple branches: side branches may not be served well by the 3-PW. Implications of multiple source points of the dipoles & 3-PW, especially for imaging BM beamlines, should be evaluated.

**The project is ready to proceed to CD-1**



**Team members: Michael Rowen (SLAC) & Sasha Temnykh (Cornell Univ.)**

1. Conceptual Design:

- Is the conceptual design for the new storage ring sound and likely to meet the specified technical performance requirements? **YES**
- Will the new and upgraded beamlines be able to exploit the new X-ray source and fulfill the mission need? **Conditional yes. The beamlines have not been defined or insertion devices selected, but with correct selection of ID's and beam lines the mission needs will be met.**

2. Scope:

- Is the project's scope sufficiently well-defined to support the preliminary cost and schedule estimates? **YES. The choice of injection scheme could affect the preliminary cost and schedule estimates.**



- **Recommendations**

- Examine the possibility of further reducing the minimum gap of IDs.
- Further optimize the 3PW design to minimize the beam emittance increase.
- Develop more automated tuning method for standard IDs.
- Evaluate collimation scheme for protection of the IDs against radiation induced damage caused by particles scattered from the electron beam.

Ready for CD-1

→ Complete by the Director's CD-2 review.



1. Conceptual Design: Is the conceptual design for the new storage ring sound and likely to meet the specified technical performance requirements? **With respect to Removal and Installation, Yes the conceptual design is sound and will meet specifications.** Will the new and upgraded beamlines be able to exploit the new X-ray source and fulfill the mission need? **NA**
2. Scope: Is the project's scope sufficiently well-defined to support the preliminary cost and schedule estimates? **Yes, although the costs are within multiple L2 WBS elements**





## **2.5 Accelerator Removal and Installation**

### **2.5.3 Recommendations**

1. Develop the 12 month shutdown schedule in P6 in sufficient detail to be able to identify critical path in the parallel work processes through commissioning. Complete by the Director's CD-2 review
2. Project should fix the downtime start date as far in advance as possible (1+ years) and maintain that date to allow appropriate timing for Users and to acquire and train removal & installation teams. Move up the Readiness for Installation review timeline as much as practical
3. Costs for Removal and Installation are covered in multiple WBS codes, which is likely to cause issues in tracking costs and with project management. Reconfiguring the WBS to group installation work is recommended. Complete by the Director's CD-2 review

**The Project is ready for CD-1**



5. Environment, Safety, and Health: Is environment, safety, and health being properly addressed given the project's current stage of development? **Yes**

• **Findings**

- The Preliminary Hazard Analysis has been developed
- The Preliminary Security and Vulnerability Assessment Report is in place
- The Project is presently utilizing the ANL Integrated Safety Management System
- The Preliminary Quality Assurance Plan has been developed
- The NEPA strategy has been issued and determination of Categorical Exclusion (CX) was issued by the DOE Argonne Site Office on July 20, 2015
- The Photon Sciences ESH/QA Coordinator currently acts as the ESH/QA Manager for the APS-U Project
- The Accelerator Systems Division ESH/QA Coordinator currently provides field support to the APS-U Project
- The Project has committed to hiring a ESH Manager and QA Manager prior to CD-2



- **Recommendations**
  - The interim Project ESH Manager should be a member of the APS-U Integrated Project Management Team
  - Update the PHAR to reflect project specific activities, hazards, and mitigations including a more defined analysis process for defining risk levels by CD-2
  - Project should continue to move forward in hiring both the ESH Manager and QA Manager positions and integrate them into the Project Management Team before CD-2
  - The Project is ready for CD-1



**Subcommittee 7: S. Meador DOE/SC; Carolyn Galayda, SLAC; Simona Rolli, DOE/HEP-FSO**

- 2. Scope: Is the project's scope sufficiently well-defined to support the preliminary cost and schedule estimates? **Yes****
  
- 3. Cost and Schedule: Are the cost and schedule estimates sufficiently well-defined and of adequate maturity to support the point cost estimate of \$734M and to establish a new cost range for the project? **Yes, point estimate is reasonable. A cost range has been developed, but upper end appears optimistic for this stage of the project.** Are there adequate scope, cost, and schedule contingency to execute the project? **Yes, just adequate at this stage...more to do on the way to CD-2 to ensure all forms of contingency are adequate.****



- Project Documentation is in good shape for CD-1 (Including Assumptions Document, design definition, good supporting documentation for cost and schedule estimates)
- Cost and schedule estimating processes/systems well defined (CAM Notebook)
  - Benchmarking is good practice; some relevant benchmarks although limited
  - Beamline model as a costing tool looks reasonable/practical
  - Work to mature the bases of all estimates
  - Reevaluate escalation rates at CD-2
- Schedule is funding and technically limited
  - Many near critical path activities
  - Schedule for shutdown activities just fits; risk associated with shutdown delays or extension should be closely monitored and regularly reassessed
- Proposed funding profile is based on project assumptions; continue to work with BES to establish a reasonable, achievable profile
  - In addition, working toward CD-2 the project should develop a detailed spending plan to increase flexibility to address CRs or other budgetary delays



- While project risks are defined, and managers seem to understand key risks; in addition or in support of planned risk retreat, should consider holding one or more risk workshops similar to practice adopted by US ITER, LCLS II, and LBNF/DUNE
- Schedule contingency appears adequate for this stage; cost contingency appears just adequate for this stage; and scope contingency is very limited – project should work to ensure all forms of contingency are adequate at CD-2
- Cost range is narrow for a project at this stage; the upper end is optimistic
- Good pre-project planning but worry about general market conditions, competition with key vendors, uncertainty with cost of partner lab contributions
- Experienced WBS managers/SMEs; many with prior project and CAM experience
- Experienced Project Controls Managers and Staff with good working relationship with CAMs



1. Continue ongoing efforts in refining cost and schedule estimates
2. Consider convening risk workshop (Jan 2016)
3. Consider increasing upper end of cost range to 30% of the preliminary point estimate (Nov 2015)



- 4. Management: Is the project being properly managed at this stage? Does the management team possess the skills, expertise and experience necessary to successfully deliver the project? Has the management team met all the prerequisite requirements for CD-1 approval? Is the project ready for CD-1?**

*Yes. The committee finds that the project is being properly managed at this stage. The project management team possesses the skills, expertise and experience necessary to successfully deliver the project. This management team has met all of the prerequisite requirements for CD-1 and the project is ready for CD-1.*



## Comments (1)

- The APS-U project management team is strong, capable, motivated and fully engaged
- Argonne Lab is fully committed to the success of the APS-U project and has made the project its highest priority in practice as well as in word
- The APS-U project and ANL have established strong advisory and review structures and mechanisms
- The projected project management resources and costs in the budget appear reasonable for the maturity and uncertainty of the project estimate.
- The project management team has met all the prerequisite requirements for CD-1 approval.
- The project team has a good understanding of what is needed and priorities for getting to CD-2

## Comments (2)

- Overall, the schedule is realistic, but the budget authorization (BA)/budget obligations (BO) in years FY2017-19 are challenging. This might be mitigated if the procurement of non-critical path items can be delayed
- Provided that the project gets CD-3b as presently scheduled, CD-2 approval could slip without affecting the installation or completion date of APS-U
- The PPEP is ready for CD-1. The APS-U project should consider including in the PEP the delivery of WBS elements as well as KPPs for project completion well prior to CD-2
- Partner lab engagements need to be solidified as soon as possible, but they aren't required for CD-1
- During the preparation for CD-2, the project should examine time-phased risk-based contingency needs as early as feasible.
- The project and ANL need to clarify the payment of Procurement and other ANL provided resources prior to CD-2

## Comments (3)

- The APS-U approach to the disposal of the old storage ring components simplifies project planning and execution. Although it is formalized in the MOU between APS-U and ANL, it should also be codified in the PEP prior to CD-2 as well.
- Quality Assurance functions need to be staffed as soon as possible in order to minimize technical, cost and schedule risk on the procurements
- The committee stresses the importance of close continuous communication between, and colocation of, the technical and procurement parts of the project team
- As the project has stated, comprehensive market analysis, vendor prequalification, and identifying critical supplier resources should be completed soon after CD-1
- The project should not underestimate the additional schedule risks of foreign supplier deliveries which are further compounded by QC, importation, and customs.

## Comments (4)

- Beamline selection needs to proceed as quickly as possible. While not required for CD-1, it will impact the project's ability to accurately develop a baseline.
- The project should pursue establishing a specialized resource sharing contract with Fermilab in order to reduce schedule risk during removal and installation
- Upon review, the removal of the storage ring seems quite aggressive and the project might benefit by having millwrights and riggers walk the ring with the engineers planning the removal.
- Care should be exercised to ensure the KPPs appropriately cover the project scope as deemed appropriate
- The productivity cost of the loss of beam time to 5000 users during the year of dark time should be estimated and held as backup for discussion with the alternatives analysis.



## Recommendations

1. Proceed with obtaining CD-1
2. Prior to CD-2, consider putting the disposition and disposal of the old SR components including any funds that might be obtained from recycling into the PEP.
3. Solidify partner lab engagement as far in advance of CD-2 as possible.