

Advanced Photon Source

APS Beamline Final Design Report Guide

(May 2023)

The Final Design Report (FDR) describes the total beamline design at approximately 90% completions of design engineering effort. At the final design level, the engineering and design work should be mature that the beamline layout and individual instruments have been designed in detail. The approved FDR will be the document of record of the approved design. As such, for a complete reference, the FDR is to include each of the sections listed below, even if those that were unchanged from the PDR. Final designs of shielding components and systems will be files and made available to facility maintenance personnel.

The FDR will identify changes from the Preliminary Design Report (PDR) or an FDR Update will identify changes from a previously approved FDR. If the design review committee (PDRC) finds that the designs are substantially different from the previous approved designs, the DALD-X-ray Operations approval will be sought for the change.

An electronic copy of the report is to be submitted to the PSC Design Review Committee for review and DALD-Operations for approval (see Appendix B for documents typically included with submission). Appendix B has a FDR Checklist that is available for use by a beamline design review committee.

Beamline readiness reviews will confirm that the installed hardware is consistent with the approved FDR.

Content of a Beamline Final Design Report

0. Introduction (background material for reviewers)
 - 0.1. To provide context for reviewers, a **brief** statement describing the programs to be supported by the beamline and beamline facilities.
 - 0.2. Description of beamline optics – typically this will have been previously reviewed as part of the justification for the scientific program. A link to proposal or optics design reviews is appropriate.
 - 0.3. Provide high-level schedule milestones (e.g., dates for shielded enclosure constructions, conventional constructions, PSS validation, shielding validation, network installation, and first beam).
1. Changes From the Approved PDR
2. Beamline Layout:
 - 2.1. Plan view on a standard sector ([s04859_2.dwg](#)) including
 - 2.1.1. Shielding enclosures and beam transport
 - 2.1.2. Identification of optical components

- 2.1.3. Support facilities (e.g., control areas, equipment racks, equipment, utilities)
 - 2.1.4. Life Safety Code compliant aisles and egress routes
 - 2.1.5. Locations of PSS hardware
 - 2.2. Elevation view with identification of optical components
3. Ray Traces Drawings:
 - 3.1. Identify type of radiation to be propagated (white, monochromatic, or "pink") in each portion of the beamline. Ray traces are to be provided for all operating modes and compliant with [Standard APS Beamline Ray Trace Drawings \(APS 1192967\)](#);
 - 3.2. Clear identification of each known non-compliance on the drawing. If a waiver has been granted for the non-conformance, provide a copy of the waiver document or a link to the document.
4. Component Reference Table:

Complete Component Reference Table, [template \(APS 1253836\)](#) and see Appendix A):

 - 4.1. List all radiation safety system (RSS) components (radiation protection credited controls) and their function (e.g., shutter, stop, mask, collimator, enclosure, transport,)
 - 4.2. Provide survey and alignment requirements for each RSS component
 - 4.3. Include a link to a drawing for each RSS component
 - 4.4. Include component operational requirements (e.g., water flow)
5. RSS Component Drawings and Specifications:
 - 5.1. Assembly drawings, detailed enough to show functionality including materials, and dimensions critical to shielding performance (e.g., thickness of shielding materials, and dimensions and locations of shielding)
 - 5.2. Performance specifications and thermal analysis for high heat load components as appropriate
 - 5.3. Identify shielding that conforms and shielding that does not conform to the [Guidelines for Beamline and Front-End Radiation Shielding Design at the Advanced Photon Source \(ANL/APS/TB-44\)](#). If a waiver has been granted for non-conforming shielding, provide a copy of the waiver document or a link to the document.
 - 5.4. Identify shielding that is a new design (i.e., not previously reviewed and approved for use on a beamline) or if being used in a manner differently from what it had been approved for (e.g., a RSS component being used with a different ID than it was approved for). For new designs or new uses provide analysis demonstrating the shielding meets the same design criteria as described in TB-7 [Guide to Beamline Radiation Shielding Design at the Advanced Photon Source \(TB-7\)](#) and [Bremsstrahlung Scattering Calculations for the Beam Stops and Collimators in the APS Insertion-Device Beamlines \(TB-20\)](#)
6. Personnel Safety System (PSS) and Administrative Controls
(Layout drawings include location of PSS hardware, e.g., control panels, search buttons, etc.)
 - 6.1. Identify PSS interlocked components

- 6.2. Identify RSS components that need administrative control, and describe the administrative control procedure;
 - 6.3. Provide a logic table that describes the configuration of the beamline components for different modes of operation, e.g., monochromatic, white, station pass-through, etc. and the required status of the beamline components to define the access to each experimental station (i.e., station secured no personnel access, personnel access permitted to station, or station administratively off-line).
7. Survey and Alignment Plan:
- 7.1. Provide fiducialization, survey and alignment plan and identify any special alignment requirements
8. Engineered Safety Systems
- Identify installed beamline engineered safety systems. The Design Safety Checklist found in Appendix C may assist the Project Leader in identifying planned safety systems. Iterate experiment-specific safety systems are reviewed as part of the experiment safety assessment)
- 8.1. Identify systems that can be pressurized, pressure relief required
 - 8.2. Identify if LN₂ is plumbed into an enclosure, ODH monitoring required
 - 8.3. Mitigation plans for other hazards mitigated with installed engineered controls including: chemical hazards, Class IIIb and Class IV lasers, biological hazards, hazardous materials storage, toxic and hazardous gas exhaust or handling systems, fire hazards, etc.
9. Equipment Protection System requirements:
- 9.1. Confirm that the beamline is in compliance with the [Beamline Vacuum Policy \(APS 1410422\)](#) or if a waiver(s) has been granted by the APS Mechanical Operations and Maintenance Group Leader provide a copy or link to the waiver
 - 9.2. Provide a description of the EPS, including:
 - 9.2.1. Identify EPS monitored components
 - 9.2.2. EPS design logic and interface requirements.
10. Special Facility Requirements:
- 10.1. Identify special, (i.e., those beyond the capacities described in [APS Sector Layout: Utilities, etc. \(ANL/APS/TB-9\)](#) conventional facilities requirements.
 - 10.2. Identify special IT facility requirements (TBD standard or menu)
 - 10.3. Provide conventional construction designs.

References:

- [Development of a New Beamline of Significant New Capability \(APS 2013652\)](#)
- [APS Beamline Preliminary Design Report Guide \(APS 2013650\)](#)

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Appendix A: Sample Beamline Component Reference Table Form

The Component Reference Table identifies each RSS component, as well as non-RSS components requiring AES Survey & Alignment or connection to EPS. Sample template:

NN-ID Beamline Component Reference Table¹

RSS Tag Bar Code	Component Description	Reference Drawing/ ICMS Content ID #	Position ²			Alignment tolerance +/-			Optical Aperture		Shielding Aperture		Material [Thickness (mm)]	PSSEPS Water Flow Rates (gpm)			Source Limits / FEA	Notes
			X (mm)	Y (mm)	Z (m)	dx (µm)	dy (µm)	dθ (mrad)	H (mm)	V (mm)	H (mm)	V (mm)		Nominal	Minimum	Maximum		
1 NN-ID-A-F-01	FE Exit Mask ¹																	
2 NN-ID-A-F-01	FE Exit Collimator ¹																	
3																		
4																		
5																		
First Branch Line																		
6																		
7																		
8	Monochromator ¹																¹ Notes, as needed, e.g., specify Mono offset	
9																		
Second Branch Line																		
10																		
11																		
12																		
13																		

Enclosures

Enclosures	Type	Drawing No in ICMS
NN-ID-A	White Beam Enclosure	APS_XXXXXXX
NN-ID-		APS_XXXXXXX
NN-ID-		APS_XXXXXXX
NN-ID-		APS_XXXXXXX

Source Type: Dual Collimator Undulators

Location	Period	Length	Minimum Gap (Software Limit)
Upstream			
Downstream			

Legend

	Component not in PSS or EPS Water Flow
	Beamline component, not part of RSS
	Front End component, for reference only

¹ See HHLFE/CUFE CRT APSU_XXXXXXX

² Coordinate System
X= horizontal (+ outboard), Y= vertical (+ up), Z = along beam direction from center of straight section.
X and Y position relative to the nominal white beam centerline. Masks and collimators referenced to the aperture center.

For each component in the table, the following information should be provided, as appropriate and if available:

1. RSS identification numbers for radiation safety shielding (typically this will be assigned when readied for installation).
2. Reference to a drawing and/or specification of the component at a level of detail that shows how it operates and critical dimensions.
3. alignment specification of the component position in three dimensions using a right-handed local coordinate system originating at the source:

x — transverse, specified relative to white beam,
positive/negative = outboard/inboard

y — elevation, specified relative to white beam,
positive/negative = above/below

z — longitudinal, specified relative to source

The position should be given in units of millimeters for x and y, and in units of meters for z; apertures are assumed to be centered on and parallel to the beam unless otherwise noted. When there is a discrepancy between the z distance of a component in the ray traces compared to the CRT, please add a comment to that component's notes column of the CRT.

Using a right-hand rule coordinate system, a positive (negative) vertical offset indicates that the component is to be placed above (below) the white beam. A positive (negative) transverse offset indicates the component is to be placed outboard (inboard) with respect to the storage ring. The definition of the local beamline coordinate system gives the positions of all RSS components with respect to white beam showing immediately any pink beam or mono beam vertical offsets.

Caution: In the special case of horizontal branch lines, the point at which the branch line starts shall be the origin of a separate and new local right-handed coordinate system. This fact needs to be documented in the table by indicating the coordinate of the new origin in the frame of the white beam system, the angular deviation in mrad with a positive angle specifying an outboard rotation away from the storage ring center. If this is a mono beamline the y-offset at the new origin will show that. In addition, any special or unusual alignment requirements such as unique alignment tolerances, or apertures that are not centered on or parallel to beam, should be noted.

The z-distance specified in the RSS table is defined as the distance between the source point and the upstream edge of the component determined by the seam between the flange of the RSS component and the adjacent upstream beam element. The Project Coordinator provides the z-positions tolerances; +/- 5 mm is typical.

4. RMS tolerances of the component position.

The tolerance information should be specified in units of micrometers for x and y, and in units of millimeters for z.

5. Shielding and optical aperture dimensions.

6. Material used for shielding or masking.

7. Nominal and minimum cooling water flow requirements.

8. Source power limits

Appendix B – Example - Beamline Design Documentation List

1. Design Reports:

CDR	Conceptual Design Report	APS_XXXXXXX
PDR	Preliminary Design Report	APS_XXXXXXX
FDR	Final Design Report	APS_XXXXXXX
FDR Update	Final Design Report Update	APS_XXXXXXX

2. Design Reviews:

BDRSC Docket No.	Subject of Review	Approval
TNyy-00n	Xxx Beamline CDR Review	APS_XXXXXXX
TNyy-00n	Xxx Beamline PDR Review (includes link to ICMS folio with reviewed materials)	APS_XXXXXXX
TNyy-00n	Xxx Beamline FDR Review (includes link to ICMS folio with reviewed materials)	APS_XXXXXXX

3. Beamline Layouts:

Floor plan	Beamline Layout: Final Beamline Layout and Elevation View	APS_XXXXXXX

4. Ray Trace Drawings:

Synchrotron	Synchrotron Ray Trace Drawings	APS_XXXXXXX
Bremsstrahlung	Bremsstrahlung Ray Trace Drawings	APS_XXXXXXX

5. User PSS Requirements Document

PSS requirements	Safety Interlocks User Requirement's Document	APS_XXXXXXX
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Appendix C – Sample Design Safety Checklist

Checklist to be completed by the Project Lead

Project Title: _____ Date: _____

Beamline: _____ Project Leader: _____

Check if an update of a previously submitted checklist

BRC docket number: _____ (format TNyy-nnn, number assigned by BRC Chair)

Indicate safety hazards mitigated by beamline designs, either mitigated with engineered controls or require administrative controls to safely deploy the designs. (Transient, experiment-specific systems and components, reviewed through the experiment safety review process, are considered to be not in the scope of the review.)

Check one		Hazard	Reference and comments
In project scope	Not in scope		
		radiation safety shielding	
		laser system	
		mechanical/structural hardware	
		electrical – including utility power distribution	Not in scope if plugged into a standard outlet
		Safety Interlocks including PSS and ACIS	
		Convectional construction,	Includes utility distributions of electricity and piping; construction of a walls or installation of room partitions; and facility modifications
		fire and egress	
		pressurized system	
		exposure to chemicals or hazardous materials	including toxic or hazardous gas exhausts
		radioactive materials	
		fire	

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		cryogenics	Including hard plumbed crogenic fluid supplies
		biohazard	
		High temperatures	

Appendix D - Beamline FDR Checklist

Beamline: _____

Review Chair: _____ PDRC docket number: TNyy-00n

Date: _____ Status: _____

Design Report Records:

CDR	Conceptual Design Report	APS_XXXXXXX
PDR	Preliminary Design Report	APS_XXXXXXX
FDR	Final Design Report	APS_XXXXXXX
FDR Update	Final Design Report Update	APS_XXXXXXX

Design Standard	compliant	Not compliant	NA	Criteria (at a preliminary level)	notes
				0. Design report includes a scope and schedule summary	
				0.1. Programs identified	
				0.2. Optics described	
				0.3. Schedule milestones	
				1. Identification of Design Changes from the Approved PDR.	
				2. Beamline Layout submitted:	
standard sector s04859_2.dwg				2.1. Beamline plan on standard sector footprint shows:	
				2.1.1. Shielded enclosures and beam transport	
				2.1.2. Optical components identification	
				2.1.3. Support facilities	
Life Safety Code NFPA 101 and DOE waiver				2.1.4. Egress routes and aisle ways	
				2.1.5. PSS hardware	
				2.2. Elevation with optical components identified	
Ray trace standard APS				3. Ray Traces Drawings submitted:	

Design Standard	compliant	Not compliant	NA	Criteria (at a preliminary level)	notes
procedure 43-00105;					
				3.1. Raytraces for all modes provided	
				3.2. Non-compliances with the raytrace standard identified and waivers provided as needed	
template (APS 1253836)				4. Component reference table submitted:	
				4.1. RSS components listed	
				4.2. Survey and alignment requirements for RSS provided	
				4.3. RSS drawings provided	
				4.4. Component operational requirements provided.	
				5. RSS Component Drawings and Specifications submitted including:	
				5.1. Assembly drawings, showing functionality materials, and shielding critical dimensions	
				5.2. Performance specifications and thermal analysis as appropriate	
Guidelines for Beamline and Front-End Radiation Shielding Design at the Advanced Photon Source (ANL/APS/TB-44).				5.3. Identify shielding that conforms or does not conform to APS standard (TB-44) and waivers for non-conforming shielding	
				5.4. New designs or new uses for shielding designs identified	
				6. PSS plans provided:	
				6.1. Safety interlocked hardware identified	

Design Standard	compliant	Not compliant	NA	Criteria (at a preliminary level)	notes
				6.2. Shield administrative controls	
				6.3. Interlock logic tables provided	
				7. Survey and alignment plan submitted	
See Appendix C checklist				8. Engineered Safety Systems	
				8.1. Pressure systems identified and safety plans provided	
				8.2. Cryogenic systems identified and safety plans provided	
				8.3. Other Engineered safety system plans provided	
				9. EPS	
Beamline Vacuum Policy				9.1. Confirmation of compliance with vacuum policy and MOM GL-approved waiver for any non-compliance.	
				9.2. EPS description, components, interfaces, and log, provided	
				10. Special Facility Requirements	
APS Sector Layout: Utilities, etc. (ANL/APS/TB-9)				10.1. Special conventional facilities plans provided	
				10.2. Special IT facility plans provided	
				10.3. Conventional Construction plans provided	