Component Database for the APS Upgrade

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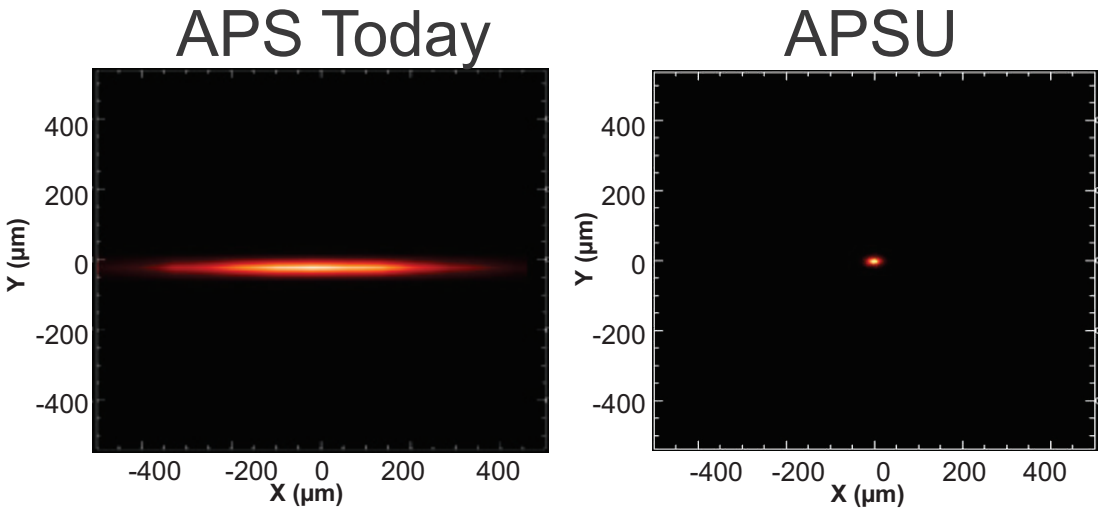
The APS Upgrade: The World's Leading High-Brightness Hard X-Ray Storage Ring

The APS Upgrade is a **next-generation** x-ray synchrotron:

- Optimized for hard x-rays
- Incorporating advanced beamlines, optics and detectors
- 'Round' source ideal for imaging

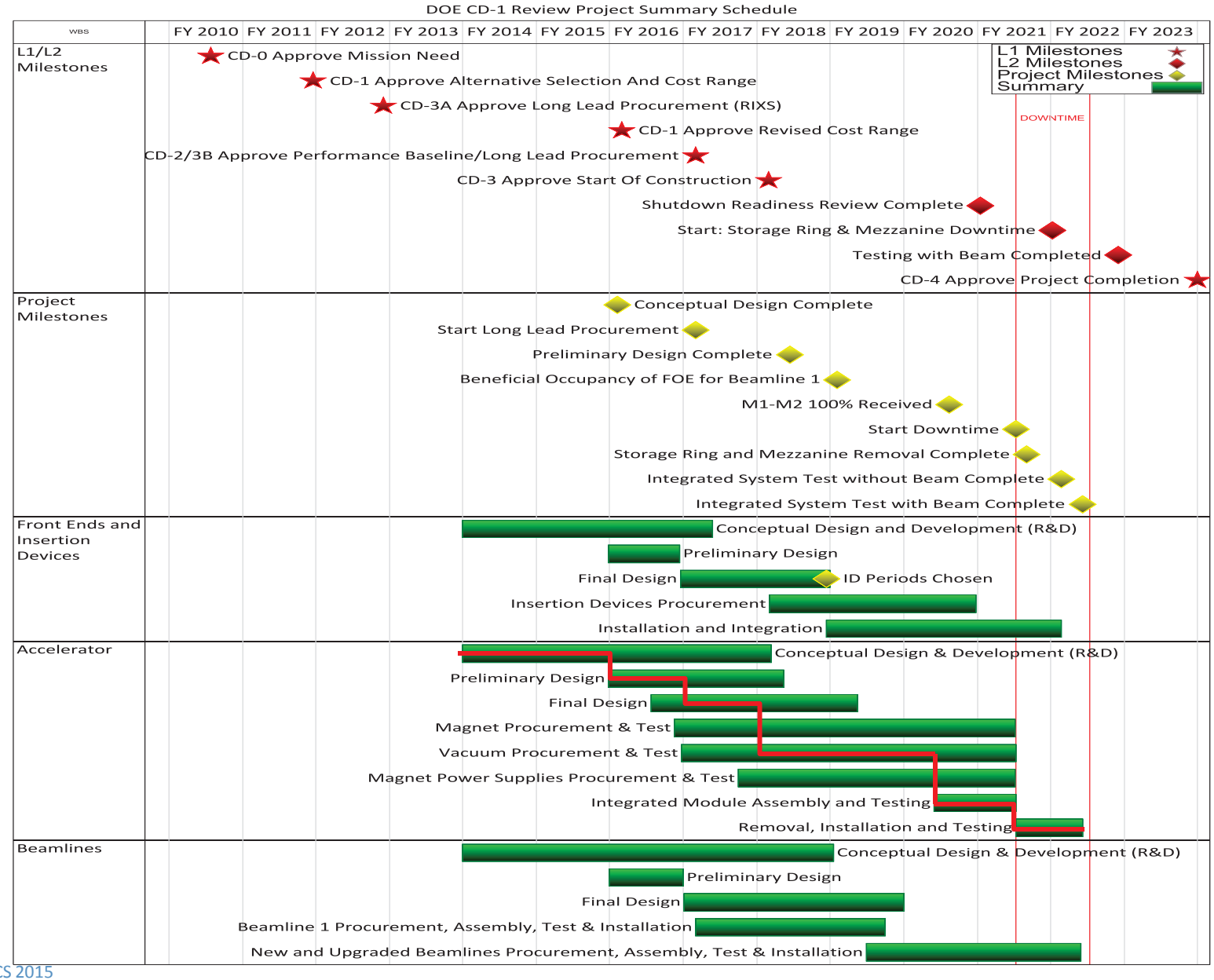
World's brightest storage ring light source above 4 keV



Technical Features

- 6 GeV, 200 mA, swap-out injection
- Circumference 1100 m
- Multi-bend achromat (7 bend) lattice
- High-brightness, ultra-low emittance (e_x, e_y) 50-60, 5-50 pm
- Diffraction limited vertical emittance to 15 keV, horizontal emittance to 2 keV
- 35 insertion device straight sections
- Flexible operation: High-brightness and timing modes, round and flat beams
- >30 world-class ID beamlines upon commissioning

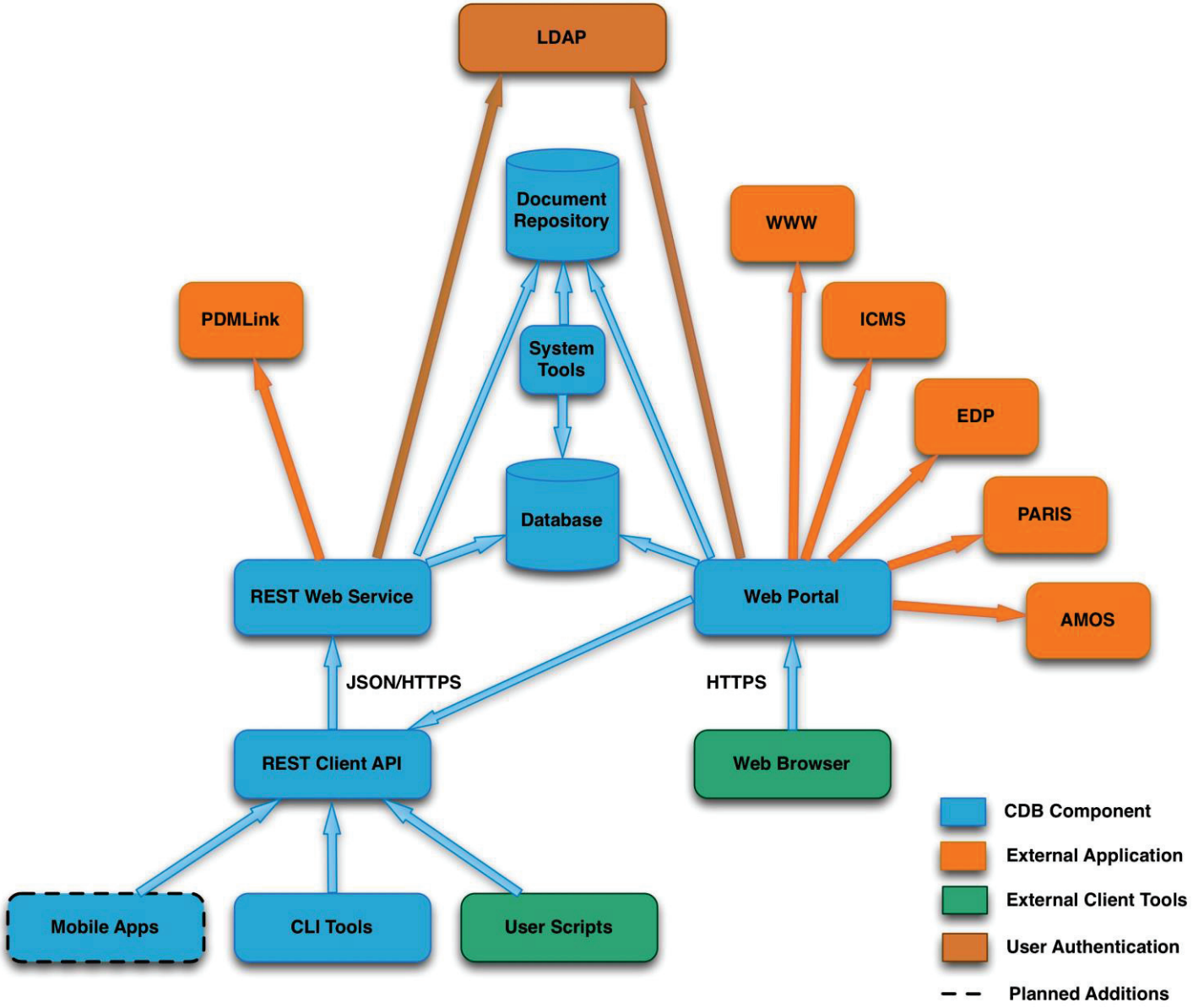
APS Upgrade High Level Schedule



Why a Component Database?

- APSU Project: will replace the existing storage ring with a multi-bend achromat (MBA) lattice
- Very aggressive one-year schedule for removal, installation and testing is planned
- Component Database (CDB) aims to aid in the management of the thousands of components to be installed in such a short time
- Goals:
  - Identify, document, track, locate and organize components in a central database
  - Provide links and interfaces to other commonly used software systems ("If you know one piece of information, you can find everything else.")

Component Database System Components



User Interfaces

- Users can access the system via:
  - Web Portal
  - REST Web Service (Python and Java APIs)
  - Command Line Interfaces (built on top of Python APIs)
- All client interfaces use SSL, and allow both read and write access
- Write access requires authentication and authorization (based on UNIX-like permission system)

Technology Stack

- Database: MySQL
- Web Portal: GlassFish
- Java EE: JSF (PrimeFaces), JPA
- REST Web Service: CherryPy
- Python ORM: SQLAlchemy

System Functionality

CDB Schema

Components
- Properties
  - Name, Model #, WBS Reference
  - Vendors, Owner
  - Links to documentation, etc.

Designs
- A group of components to fulfill particular requirement: What component goes where?
- Design elements use naming convention (e.g., S01A:BPM1)
- Designs can include other designs
- Designs reflect the **Bill of Materials** to be installed
- Properties
  - Name, Owner, WBS Reference
  - Links to documentation, etc.

Component Instances


- Tracked by QR ID #
- Properties
  - Status (Failed, Operational, etc.)
  - Record of Inspections/Tests/Calibrations
  - Location

Property Value Histories | **Design Elements**

Property Values | **Property Types** | **Users**

Locations | **Component Types** | **Logs** | **...**

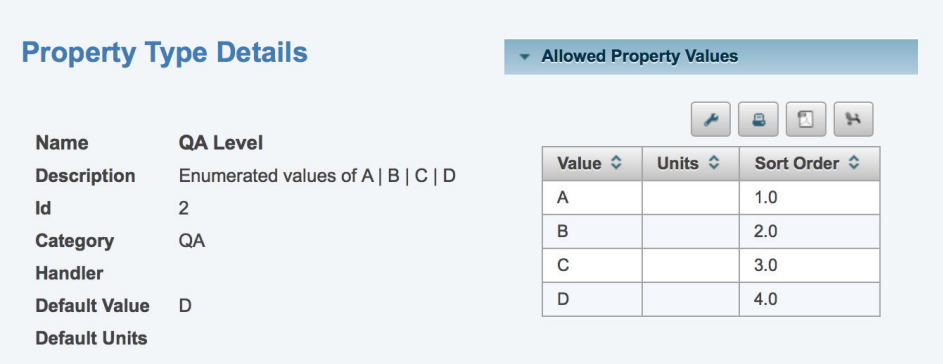
Document/Drawing Repositories
- PDMLink / Vault / SharePoint
- ICMS / EDP / Shared File Systems

Other Applications
- PARIS
- AMOS

Component Inspection Sheets & Component Measurements
- Forms / Data Files / Analysis Scripts

Properties

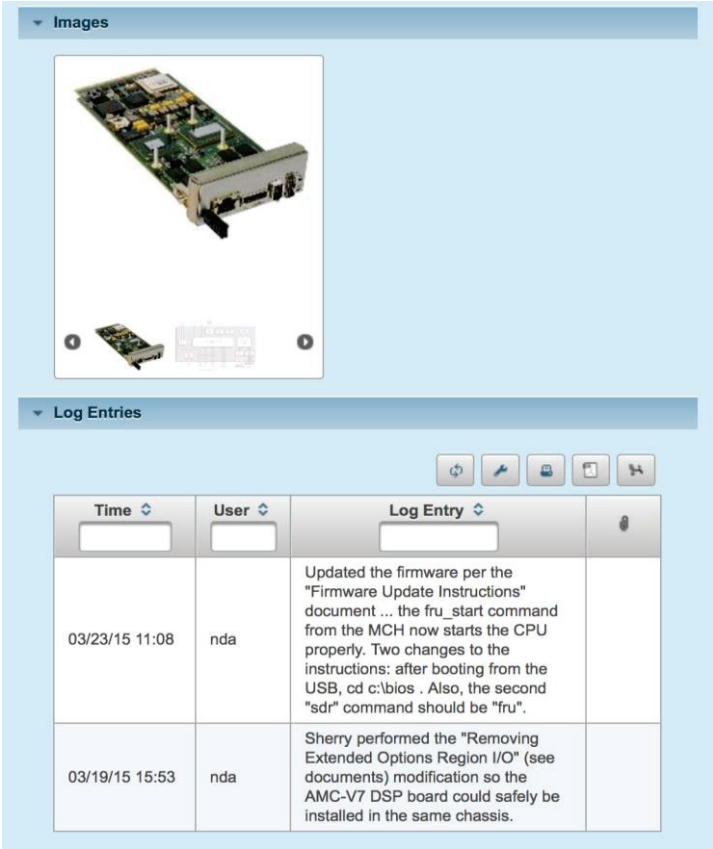
- Properties provide a flexible mechanism for capturing object-dependent information.
- They are associated with individual components, component instances, designs, and design elements.



- Examples: QA Level, Drawing, Electrical Inspection, etc.
- Property types may be associated with a restrictive set of “allowed” property values.
- Property types may be linked to unique “handler” class, which enables different view or edit modes in the Web Portal, or integration with an external system
- A time-stamped history of each property value is kept to provide a historical log of each property

Other Notable Features

- The “Component Catalog” will contain all components to be used on the MBA
  - Components are associated with “types” (magnet, ADC, vacuum chamber, etc.)
  - “Types” are grouped into categories
- Chronological log entries for each component, component instance, design



- Users are members of CDB-defined groups; write permission for owner or group
- QR-codes only contain component instance #, no other information
- Extensive system search capabilities

Web Portal: Component Instance Details View

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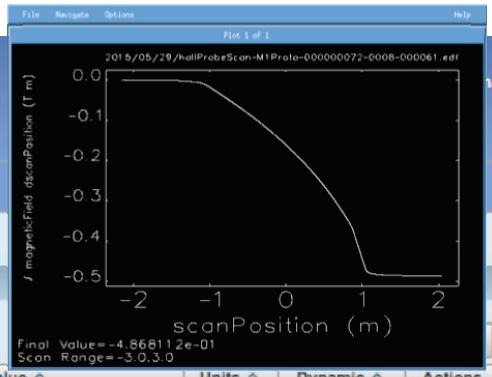
Component Database Portal

Name: Not Logged In
User

Home | Components | Component Instances | Designs | Locations | Property Types | Sources | Users | Search | Login



Component Instance Details

QR Id	000 000 072
Component	M1 dipole pre-prototype [Magnet Component:Magnets]
Tag	First Unit (from Fermilab)
Serial Number	GDCA001
Location	MM1
Location Details	
Description	
Id	81
Owner User	cease
Owner Group	MED
Created By	nda
Created On	Thu Apr 23 14:16:32 CDT 2015
Modified By	carwar
Modified On	Fri Jul 10 15:30:20 CDT 2015
Group Writeable	true

Return

▸ Images

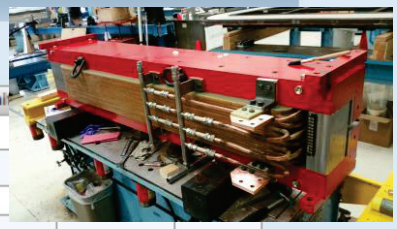
▸ Log Entries

Component Instance Properties

Type	Tag	Value	Units	Dynamic	Actions
Measurement (plot)	Field Measurement	document.1199866487895911175.pdf			
Measurement (plot)	Field Integral	document.3918100351477500121.pdf			
Measurement (plot)	Field Integral vs X	document.270949675286297729 3.pdf			
Documentation URI	M1 Inspection Doc Folder	https://apsshar...n_Documentation			

Component Properties

Type	Tag	Value
Magnet Measurement Procedure	Measurement Run Plan	https://apsshar...an_Rev3.0a.docx
Image		
Documentation URI	Core Assy Dwgs	https://apsshar...mbly%20PDFs.pdf
Documentation URI	SharePoint Folder	https://apsshar...net%20Prototype



Future Plans

- Addition of design instances
- Incorporate relationships between design elements (e.g. powered-by, controlled-by, etc.)
- Develop ability to capture cable connections
- Investigate integration with several DISCS modules (e.g., Travelers, Cables, Naming, …)
- Investigate possibilities for adding graphical interfaces to CDB

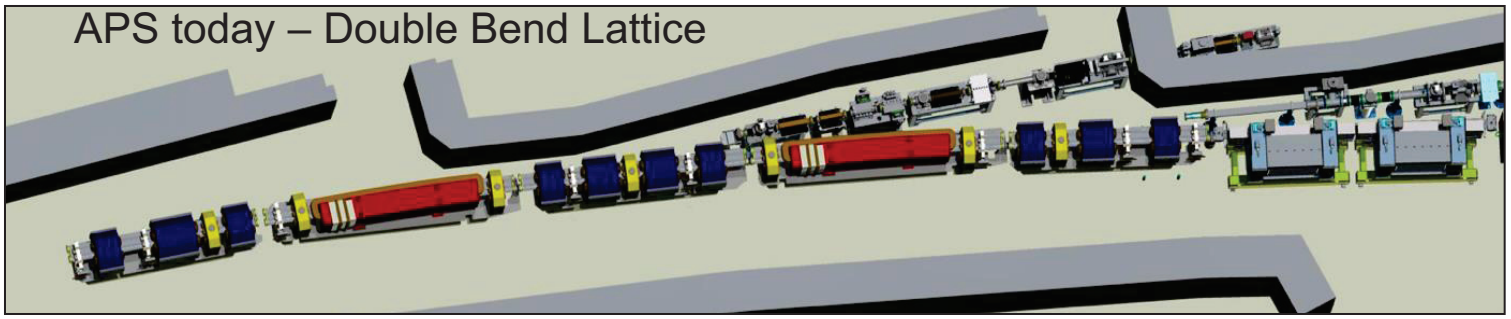
Conclusion

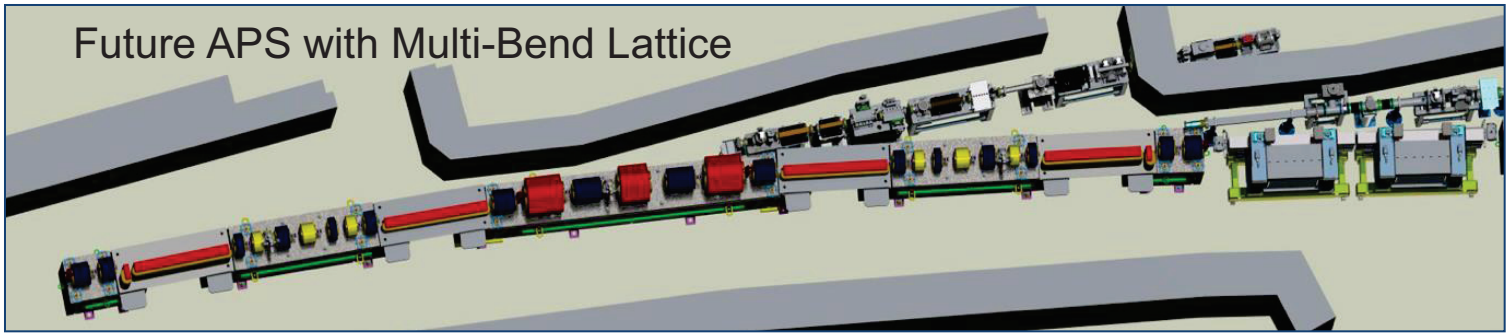
- Component Database application has the potential to capture a complete Bill of Materials for the new APSU accelerator well before the installation timeframe
- This will facilitate careful planning and tracking of the construction and installation process, a prerequisite for an ambitious APSU schedule
- Success will depend on management support, early availability, user feedback and quick turnaround for user-requested features

Additional Slides

APS Upgrade Multi-Bend Achromat Lattice Concept

~50-fold reduction in horizontal emittance





$$\varepsilon_x = C_L \frac{E^2}{N_D^3}$$

E = Beam energy (E = 6 GeV for APS MBA)
N_d = Number of dipoles per sector (N_d = 7 for APS MBA)

J. Murphy, BNL-42333.

APSU Technical Specifications

	APS-U Timing Mode	APS-U Brightness Mode	APS Now	Units
Beam Energy	6	6	7	GeV
Beam Current	200	200	100	mA
Number of Bunches	48	324	24	
Effective Emittance	47	68	3100	pm-rad
Emittance Ratio	1	0.1	0.013	
Horizontal Beam Size (rms)	18.2	21.8	274	μm
Horizontal Divergence (rms)	2.6	3.1	11.3	μrad
Vertical Beam Size (rms)	10.8	4.1	10.8	μm
Vertical Divergence (rms)	4.4	1.7	3.7	μrad
Brightness - 20 keV	90	203	0.6	(*)
Pinhole Flux - 20 keV	185	211	20.1	(#)
Coherent Flux - 20 keV	87	195	0.6	10^{11} photons/sec
Single-Bunch brightness - 20 keV	188	63	2.6	(&)

(*) 10^{20} photons/sec/0.1%BW/mm^2/mrad^2
(#) 10^{13} photons/sec in 0.5x0.5 mm^2 pinhole at 30 m
(&) 10^{18} photons/sec/0.1%BW/mm^2/mrad^2

Comparison of APSU to Other Light Sources (Early 2020s)

Parameter		APS Present	APS Upgrade	ESRF-II	SPring8-II	Petra-III	NSLS-II	MAX-IV	Sirius
Energy [GeV]		7	6	6	6	6	3	3	3
Current [mA]		102	200	200	100	100	500	500	500
Emittance, Horizontal [pm]		3113	67	142	99	1000	800	302	275
Brightness (*)	8 keV	1	88	61	43	4.1	3.7	13.9	22.7
	20 keV	1	336	164	137	2.9	0.8	5.2	8.1
	80 keV	1	382	154	127	1.0	0.01	0.4	0.3
Flux Density (*) (#)	8 keV	1	4.6	3.9	1.8	1.8	0.4	2.0	1.7
	20 keV	1	10.4	7.7	4.1	1.4	0.1	0.6	0.5
	80 keV	1	10.4	7.5	3.9	0.1	0.0	0.0	0.0
Coherent Flux	8 keV	9.3	813	562	398	38	34	129	211
(10^{11} ph/s)	20 keV	0.6	198	97	81	2	0	3	5
Single Bunch Brightness @ 8 keV (*)		1	25.5(&)	1.5	5.1	0.3	0.1	1.9	3.1
Flux for 10 nm focus @ 8 keV (*)		1	88	61	43	4	4	14	23

(*) Relative to present APS performance

(#) Flux Density is through a 0.5 x 0.5 mm aperture at 30 m

(&) APS-U 48 bunch timing mode

No light source now operating, under construction or planned can match all of APS-U's technical capabilities

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