

APS Upgrade Overview and Status

Stuart Henderson

Director, APS Upgrade Project

APS Users Organization/Partner User Council Joint Meeting

September 16, 2014



Outline

- Recent Events and News
- Project Status
- Near-term Plan
- Beamline selection process discussion

Recent Events – DOE/SC/BES Briefing – Aug. 27

- We were presented with a set of Tough Questions from BES in late July, to focus preparations for the Briefing
 - Science case, community engagement, technical case, management team, scope/cost/schedule, procurement, alternatives, ...
- Formed Science Case Team
- Pre-meeting review with Bill Madia – Aug. 13
- Dry-runs with UChicago, Jim Decker
- DOE/SC/BES Briefing – August 27

Science Case Team

- We have formed a Team with responsibility for working with the community to further develop and articulate the Science Case
- While the initial focus was on the briefing, we appreciate that the Science Case Development will be an ongoing activity extending throughout the life of the Project
- Members:
 - APS: S. Streiffer, G. Srajer, D. Haeffner, L. Young, S. Henderson, G. Shenoy, C. Jacobsen, D. Vine, J. Freeland
 - ANL: P. Fenter, P. Fuoss
 - P. Evans (U. Wisconsin)
 - O. Shpyrko (UC San Diego)
 - J. Kirz (LBNL)
 - M. Sutton (McGill U.)
 - ANL Communications: T. Kunz, E. Austin
- These members will be reaching out to and working with the community to develop the case

Briefing Topics

- Science Case
- Scientific Community Support
- Competitive Landscape
- APS-U Concept and Technical Performance
- Project Team
- APS-U Project Formulation
 - Scope, cost, schedule
 - Installation
 - Procurement and Partnerships
- Communications

Next Steps – Near Term

- Feedback was positive and supportive overall; we convincingly addressed most of the issues and concerns
 - We received feedback on the rest, principally related to the Science Case and Alternatives Analyses
- We will work with BES to refine the Science Case, which will be built around a set of high-impact science examples, showing how those relate to the everyday world (national need) and why they need the Upgrade
- We will complete the answers to Tough Questions, including analysis of several alternatives
 - Alternatives are not ‘just’ light sources, but include other scientific endeavors the US taxpayer could spend our money on
- It is very important that we effectively articulate the transformational opportunities enabled by the Upgrade, and convincingly explain why there is urgency around APS-U, and why it should be the highest priority

Next Steps - Mid Term

- In consultation with the program, we are proceeding with our FY15 R&D plan and getting “CD-1 ready” by Q2 FY15.
- We are well advanced for a Project not yet at CD-1; Preparation for the August 27 briefing included extensive development of
 - Technical Design
 - Scope
 - Cost and Schedule
 - Installation Planning
- While further developing the science case for APS-U, in parallel we want to make use of this time to mature the conceptual design, advance the R&D program, cost estimate, resource loaded schedule, risk analysis, and so-on, so that we are well prepared once we get the green light
- We need to develop the best possible project, gain confidence in our design and our plans to make the APS-U case bullet-proof...and we need to do this with urgency

Next Steps – Mid Term

We will stand up our advisory committee structure and plan for a complete set of top to bottom reviews in December

- Machine Advisory Committee reviewing the technical aspects of the accelerator design
- Experimental Systems Advisory Committee reviewing the technical aspects of the beamlines, optics, detectors
- Project Management Advisory Committee reviewing the project management aspects of the APSU Project

We will then be in a strong position for a DOE Office of Project Assessment review.

For internal planning purposes, we are working toward a CD-1 Review in Q2 FY15

Comparison of APS-U to other light sources worldwide in early 2020s

Parameter	APS	APS Upgrade		ESRF-II	SPring8-II	Petra-III	NSLS-II	MAX-IV	Sirius	
	Present	Hi-Bright	48 Bunch							
Energy [GeV]	7	6	6	6	6	6	3	3	3	
Current [mA]	102	200	200	200	100	100	500	500	500	
Emittance, Horizontal [pm]	3113	67	48	142	99	1000	800	302	275	
Brightness (*)	8 keV	1	88	51	61	43	4.1	3.7	13.9	22.7
	20 keV	1	336	144	164	137	2.9	0.8	5.2	8.1
	80 keV	1	382	152	154	127	1.0	0.01	0.4	0.3
Flux Density (*) (#)	8 keV	1	4.6	4.1	3.9	1.8	1.8	0.4	2.0	1.7
	20 keV	1	10.4	9.1	7.7	4.1	1.4	0.1	0.6	0.5
	80 keV	1	10.4	9.0	7.5	3.9	0.1	0.0	0.0	0.0
Coherent Flux (10^{11} ph/s)	8 keV	9.3	813	472	562	398	38	34	129	211
	20 keV	0.6	198	85	97	81	2	0	3	5
Single Bunch Brightness @ 8 keV (*)	1	6.5	25.5	1.5	5.1	0.3	0.1	1.9	3.1	
Flux for 10 nm focus @ 20 keV (*)	1	336	144	164	137	2.9	0.8	5.2	8.1	

(*) Relative to present APS performance

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

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

Preliminary consideration of project scope

- New, 4th-generation multi-bend achromat storage ring lattice in existing tunnel
- Doubling of the ring stored beam current
- New insertion devices for 35 sectors optimized for brightness and flux
- New and upgraded Front-Ends
- Suite of 3 new and 3 upgraded beamlines designed for best-in-class performance with MBA source properties
- Optics for remaining beamlines to make full use of MBA source properties
- Improved beam stability
- **Well-defined** installation and testing period is a **key deliverable**
 - **External review found the present ~12-month plan achievable**
 - Given the central importance of minimizing APS unavailability, the APS Upgrade will require a very different strategic approach from typical installations

Beamline Scope in the Upgrade

- There are four elements of project beamline scope which must eventually be baselined
- At present these have only been evaluated in a generic sense for costing purposes:
 - New beamlines (3 included for costing)
 - Beamlines which receive major upgrades (3 included for costing)
 - Beamlines which receive minor upgrades (a ~\$30M package of optics and detector improvements included for costing)
 - Insertion devices: assumes a number of superconducting undulators, reworked PM undulators to account for reduction in storage ring energy, revolver undulators and so on, for costing
- It is worth pointing out that the cost for beamline technical scope in the present formulation of APS-U is similar to that in the previous formulation
- All ID beamlines will have new and/or upgraded front-ends (HHLFE), including next-generation (“GRID”) x-ray bpm system, etc.
- All beamlines will benefit, but choices will have to be made on new beamlines, major upgrades, minor upgrades and ID selection

Beamline Selection Process Discussion

- We will be developing a process and would appreciate your input
- While the process is not yet developed, there are nevertheless several guiding principles which have been identified:
 - Open call for proposals
 - Transparent, science-based decision process described in advance
 - Incorporate the project's boundary conditions (cost, schedule, no conventional construction)
 - Incorporate long-term strategic priorities of APS
 - Make use of APS-U's strengths and unique capabilities
 - Major investments should deliver beamlines that are world-leading and best-in-class
 - Evaluation and ranking by SAC and experimental systems advisory committee members

Request for Information, and Discussion

- With respect to upgrades of existing beamlines and ID selection, a first step is understanding what is needed to make best use of MBA lattice capabilities
 - We will be sending out a one-page template to the CATS to gain information on their 5-year strategic plan and what they would need to optimize their capabilities and performance in the MBA-era (also carrying out assessments of APS beamlines)
 - The more specific the responses the more useful it will be for our planning purposes
- At this point we would appreciate your feedback and advice on the process of beamline selection, ID selection and upgrade proposal evaluation
- Comments, Questions, Discussion?

Finally....

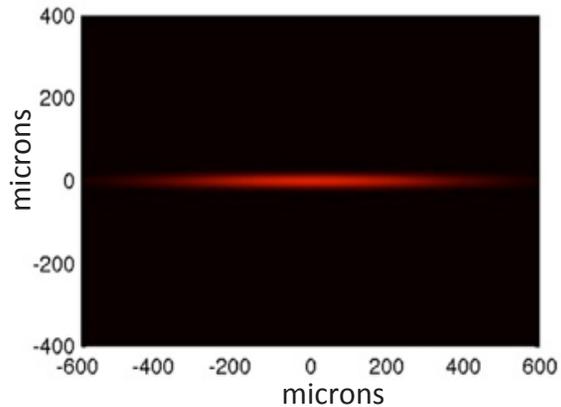
- Recent and Upcoming Workshops
 - *APS Upgrade Workshop on Coherent Imaging*, Sept. 6, 2014
 - *Synchrotron Environmental Science VI*, Sept. 11-12, 2014
 - *Workshop on high-pressure time-resolved synchrotron techniques*, Sept. 25- 27, 2014
 - *Diffraction Limited Storage Ring Workshop*, Nov. 19-21, 2014
 - *Full Field Imaging*, Jan 19-20, 2015
- Your advice and support is extremely important to us
- We will be counting on your support as we continue to make the case that an upgraded APS is an essential 21st century tool for 21st century science



Backup

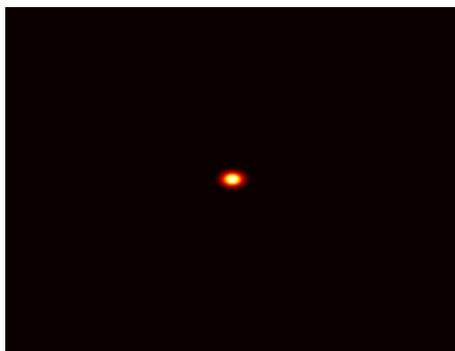
Implementation of an MBA lattice and optimized IDs dramatically enhances APS performance as a hard x-ray source

APS Now

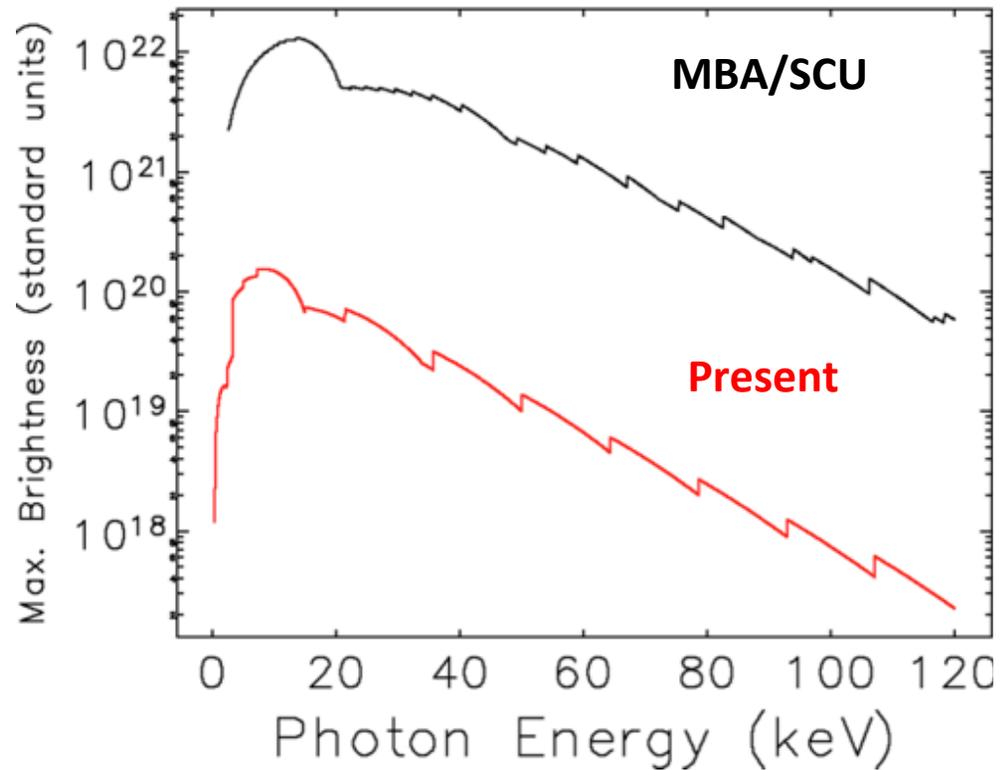


Particle Beam Profiles

APS MBA



1 mm

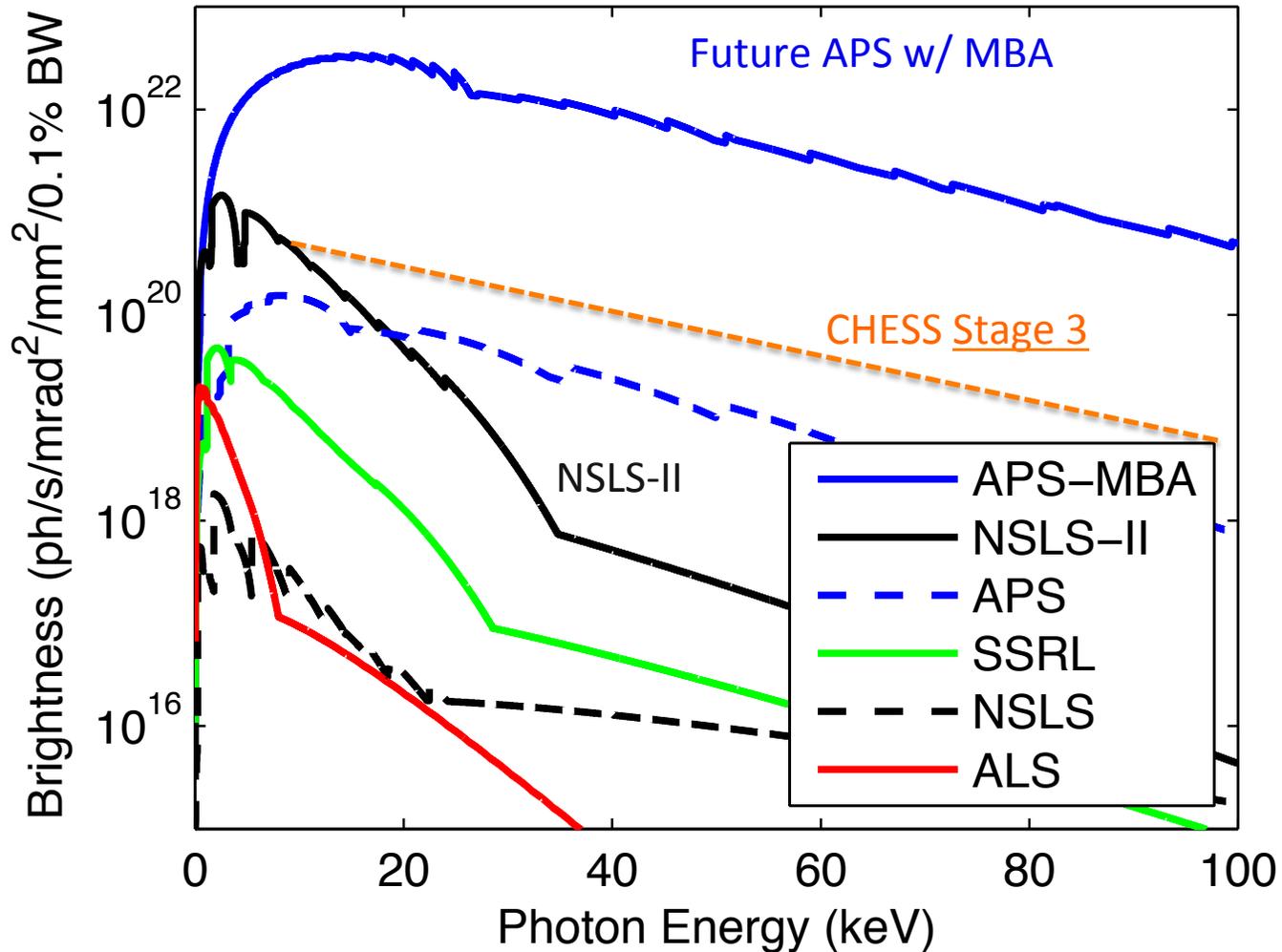


Parameter comparisons: APS today vs APS MBA Upgrade*

Quantity	Symbol	Units	APS Now	APS MBA Timing Mode	APS MBA Bright. Mode
Beam Energy	E	GeV	7	6	6
Beam current	I	mA	100	200	200
Number of bunches	N_b		24	48	324
Bunch duration	σ_t	ps	34	70	18
Bunch spacing	T_b	ns	153	77	11
Bunch rep. rate	f_b	MHz	6.5	13	88
Emittance ratio	$K = \epsilon_y / \epsilon_x$		0.013	1.0	0.1
Horizontal emittance	ϵ_x	pm	3100	46	65
Horizontal beam size	σ_x	μm	275	17.8	21.2
Horizontal beam divergence	σ_x'	μrad	11	2.6	3.1
Vertical emittance	ϵ_y	pm	40	46	7
Vertical beam size	σ_y	μm	10	10.2	4.0
Vertical beam divergence	σ_y'	μrad	3.5	4.3	1.6

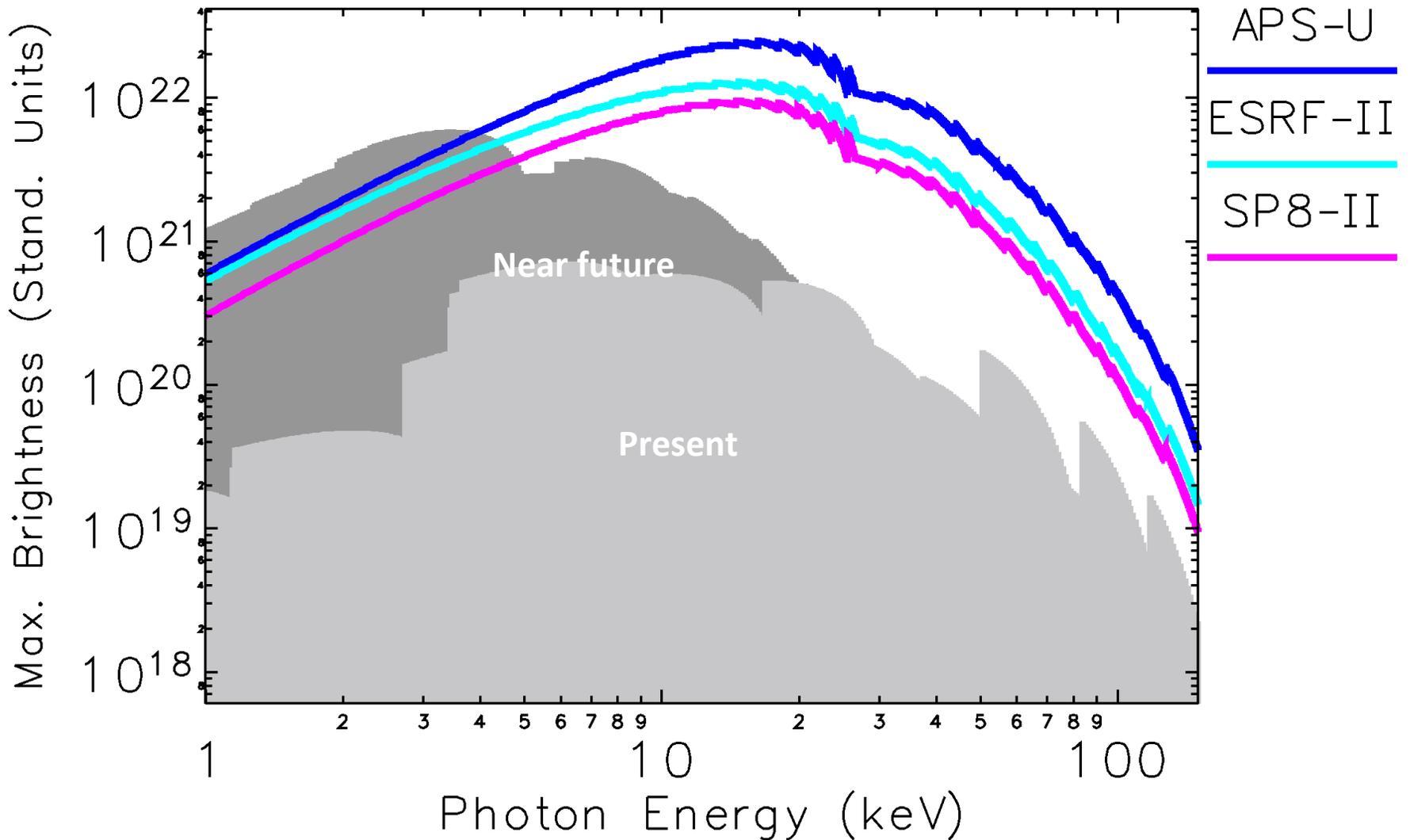
*H7BA-TwoSector-nux95-nuy36-3PW-Version4
Courtesy M. Borland

APS: High energy star in US x-ray facility constellation



Brightness vs. x-ray energy at top beamlines among BES synchrotron facilities, including approximate CHES Stage 3 upgrade per Cornell's web page

APS-U Will Deliver World-Leading Performance



Curves for APS, ESRF and SP8 upgrades based on present designs, and assume identical undulators