

APS Upgrade Update

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APS Users Monthly Operations Meeting

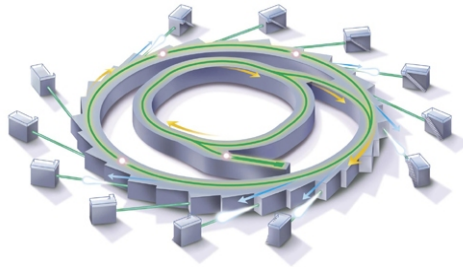
28 August 2013

BESAC Future Light Sources Review, July 2013

BESAC Light Sources Charge

- January 2, 2013– Bill Brinkman charged BESAC to provide advice on the future of photon sources and science, which will require formation of a panel of experts and a workshop and will consider both new science opportunities and new photon source technologies in parallel. The specific charge includes:
 - Assessment of the grand science challenges that could best be explored with the current and possible future SC light sources.
 - Evaluate effectiveness of the present SC light source portfolio to meet these grand science challenges.
 - Enumerate future light source performance specifications that maximize the impact on grand science challenges.
 - Prioritized recommendations on which future light source concepts and the technology behind them are best suited to achieve these performance specifications.
 - Identify prioritized R&D initiatives to accelerate the realization of these future light sources in a cost effective manner.
- This BESAC report should be delivered by July 15, 2013.

Grand Challenge Science on Diffraction-Limited Storage Rings



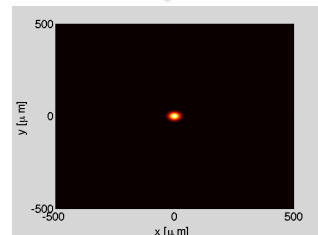
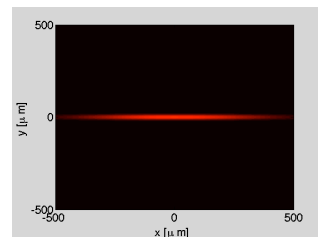
A consensus report on future opportunities from scientists at
ALS, LBNL
APS, ANL
NSLS-II, BNL
SSRL, SLAC
together with a broad community of scientists
at laboratories and universities.

BESAC Subcommittee on Future Light Sources: July 10-12, 2013

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Recent Advances Enable Ultra-Bright Rings

- Storage ring light sources have not reached their practical limits of brightness and coherence.
- Dramatic improvements are on the horizon due to transformational advances in accelerator design.
- **What's Changed:**
 - Tightly-packed multi-bend achromat lattices via new magnet and vacuum technology.
 - Success of top-up, better understanding of storage ring scaling, advances in simulation, optimization, and alignment.
- **Outcome:**
 - High confidence that diffraction-limited rings are feasible.
 - International community is now upgrading existing facilities and building new facilities with diffraction limited capability that will enable new science.



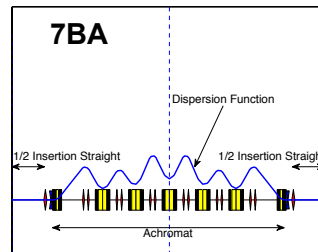
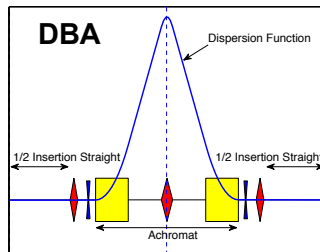
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Multi-bend Achromats Pave the Way to the Diffraction Limit

Lattice design evolution from double- and triple-bend achromats (DBA, TBA) to multi-bend achromats: increase N_D .

$$\varepsilon_x = C_L \frac{E^2}{N_D^3}, \quad \varepsilon_x \underbrace{\propto}_{\text{Fixed E}} \frac{1}{C^3}$$

C_L = lattice constant
 N_D = # dipoles
 C = Circumference



Strong Focusing and Low Dispersion

First used for MAX-IV.

D. Einfeld *et al.*, Proc. PAC 95, Dallas TX



Multi-bend lattices are becoming a reality:

- MAX-IV (Sweden), pioneering, under construction
- Sirius (Brazil) just started construction
- Plans for ESRF (France), SPring-8 (Japan), BAPS (China), and SLS (Switzerland)

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Planning at APS

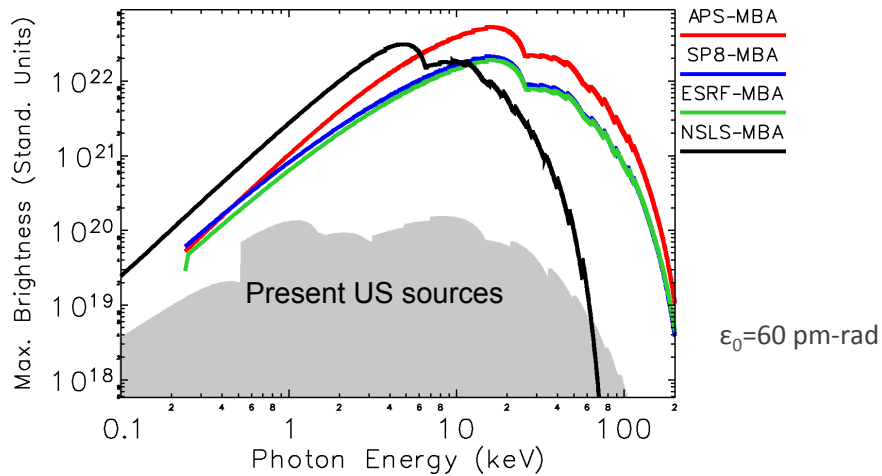
Recommendation of BESAC Future Light Sources Review:

"The very large, diverse U.S. user population presently utilizing U.S. storage rings represents a major national resource for science and technology. It is essential that the facilities this science community relies on remain internationally competitive in the face of the innovative developments of storage rings in other countries. Such developments include diffraction-limited storage rings with beamlines, optics, and detectors compatible with the 10^2 - 10^3 increase in brightness afforded by upgraded storage rings."

APS is working with DOE to evaluate the incorporation of MBA technology into the ongoing APS Upgrade project



Opportunity for APS: World-Leading Brightness



MBA lattice offers major improvements in brightness, coherent flux needed for nanoprobe, coherent imaging and dynamics

Community Engagement Plan

- **August:**
 - Initial evaluation of impact on the Upgrade and draft White Paper on incorporating MBA lattice into APS Upgrade

<http://www.aps.anl.gov/Upgrade/Documents>
- **September:**
 - Engage user community, APS staff and other Labs in evaluating opportunities and organizing October workshop
- **October 21-22:**
 - Workshop to optimize incorporation of MBA into APS-U, including science opportunities for all communities
- **November 6-7:**
 - APS Scientific Advisory Committee review of Workshop report

Workshop on Science Opportunities with MBA Lattice

Monday, October 21

9:00-11:30 *Plenary Session*

MBA sources overview: scientific opportunities and global perspective

Source properties of a potential MBA lattice at the APS

Optics, detector, and instrumentation developments for high brightness x-ray sources

1:00-5:00 *Breakout Sessions*

Scanning Probe Imaging

Coherent Diffraction and Phase Contrast Imaging, XPCS

Timing and Dynamics

Interface and Single Crystal Diffraction

Structural and High Energy Scattering, SAXS

Spectroscopy and Inelastic Scattering

Macromolecular Crystallography

Tuesday, October 22

9:00-11:00 *Breakout Discussion and Report Preparation*

11:00-12:00 *Workshop Reports and Plenary Discussion*

1:30-4:30 *Workshop Reports and Plenary Discussion cont.*



Goals for the Workshop

- *Inform the APS community concerning the properties of an MBA low-emittance lattice being considered in the APS Upgrade.*
- *Gather input on the new science opportunities offered by such a source.*
- *Address how our current suite of beamlines map onto these envisioned science opportunities, and what new capabilities are needed.*
- *Explore the technical advances in optics, detectors, and undulators that are required to realize these science opportunities.*
- *Identify areas that require R&D efforts to achieve the ultimate performance from an MBA x-ray source.*

Input from the user community and APS staff essential





Summary

- Recent report by the BESAC recommended evaluating “multi-bend achromat” (MBA) technology that provides 100x brightness improvements
 - High coherent flux, high intensity focusable to smallest (e.g. nanometer) spots
 - Maintains advantages of rings: high flux ($\sim 10^{14}$ - 10^{15} photons/sec), stability and capacity
 - Essential to remain world-leading
- We will work with DOE Office of Science and the scientific community to study incorporating an MBA lattice into the APS Upgrade project
- Workshop on Science Opportunities is scheduled for October 21-22
 - We are working on organizational details
- Workshop report will be reviewed by SAC and subsequently incorporated in a proposal to the Office of Science
- Incorporation of the MBA lattice in the APS Upgrade offers transformational scientific opportunities

