NSLS-II

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Brookhaven National Laboratory
NSF Panel on Light Source Facilities
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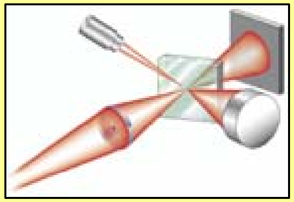
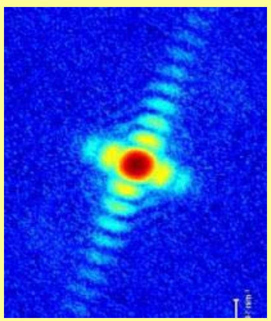
High Level Description of NSLS-II

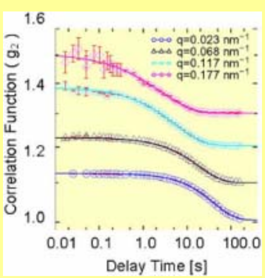
New Capabilities



Nanoprobes



Diffraction Imaging



Coherent Dynamics

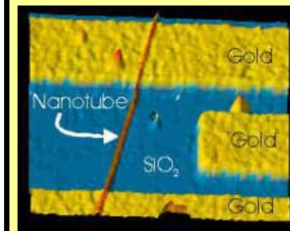
Highly optimized x-ray synchrotron delivering:

- extremely high brightness and flux
- very small beams with exceptional beam stability
- suite of advanced instruments, optics, & detectors

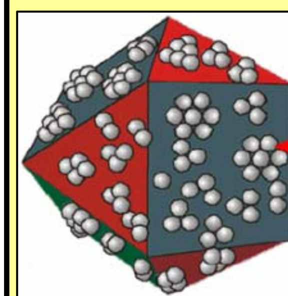
Together, these:

- provide outstanding performance and flexibility from the far-IR to the very hard x-ray regions to support diverse scientific needs
- enable the study of materials properties and functions with unprecedented spatial (~ 1 nm) and energy (~ 0.1 meV) resolutions and sensitivity (single atom)

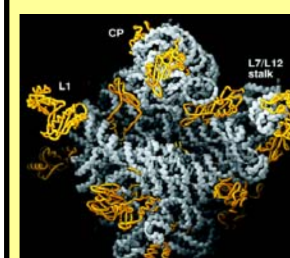
New Science



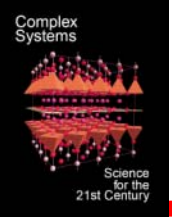
Nanoscience



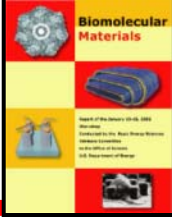
Nanocatalysis



Life Science



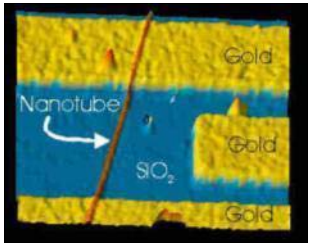
What Research will NSLS-II Enable?



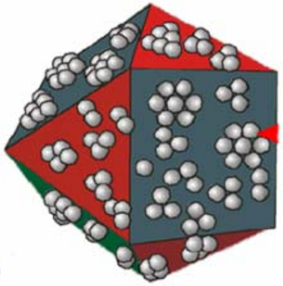
Structure & properties/functions

Observe fundamental material properties with nanometer-scale resolution and atomic sensitivity

- Physical, chemical, electronic, and magnetic structure of nanoparticles, nanotubes and nanowires, e.g. new electronic materials that scale beyond silicon
- Designer catalysts, e.g., in-situ changes in local geometric, chemical, and electronic structure of active catalytic site in real-time and under real reaction conditions



Molecular Electronics



Nanocatalysis

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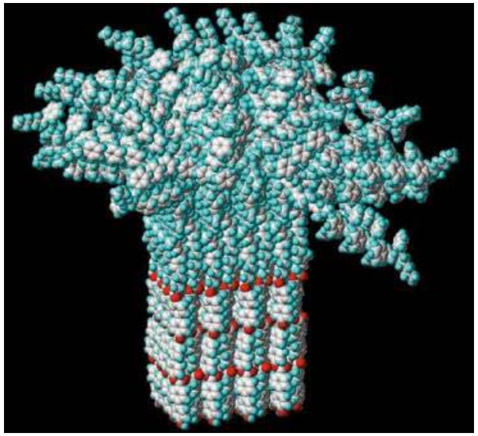
Self-assembly

Understand how to create large-scale, hierarchical structures from nanometer-scale building blocks

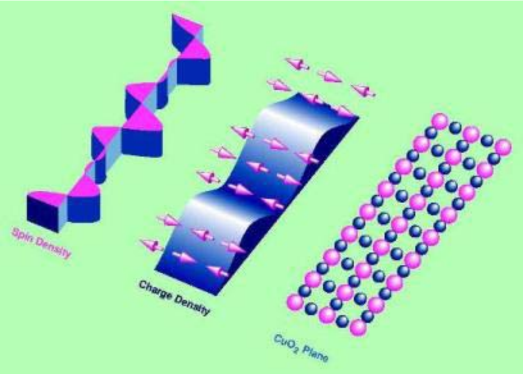
- Interactions between nanoscale building blocks
- Kinetics of nanoscale assembly
- Structure of hierarchical materials from nanometers to microns
- Mechanisms of directed assembly (by templating or external fields)
- Molecular interactions in nano-confined environments



Emergent behavior

Probe nanometer-scale materials that display emergent behavior

- Direct 3D imaging of domain structures and dynamics, e.g., in random field magnets and spin glasses
- Colossal magnetoresistance for high-sensitivity magnetic sensors or high-density information storage
- Dynamics of charge and spin stripes in high temperature superconductors



Charge and spin stripes in complex oxides

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Project Scope

Accelerator Systems

- Storage Ring (~ ½ mile in circumference)
- Linac and Booster Injection System

Conventional Facilities

- Ring Building w/ Operations Center and service buildings (~ 341k gsf)
- Laboratory/Office Buildings (LOBs) to house beamline staff & users (~71k gsf)
- Reuse of existing NSLS office/lab space for NSLS-II staff

Experimental Facilities

- Initial suite of 6 insertion device beamlines and instruments
- Capable of hosting at least 58 beamlines

R&D

- Advanced optics for achieving 1 nm and 0.1 meV
- Nanopositioning and mirror metrology

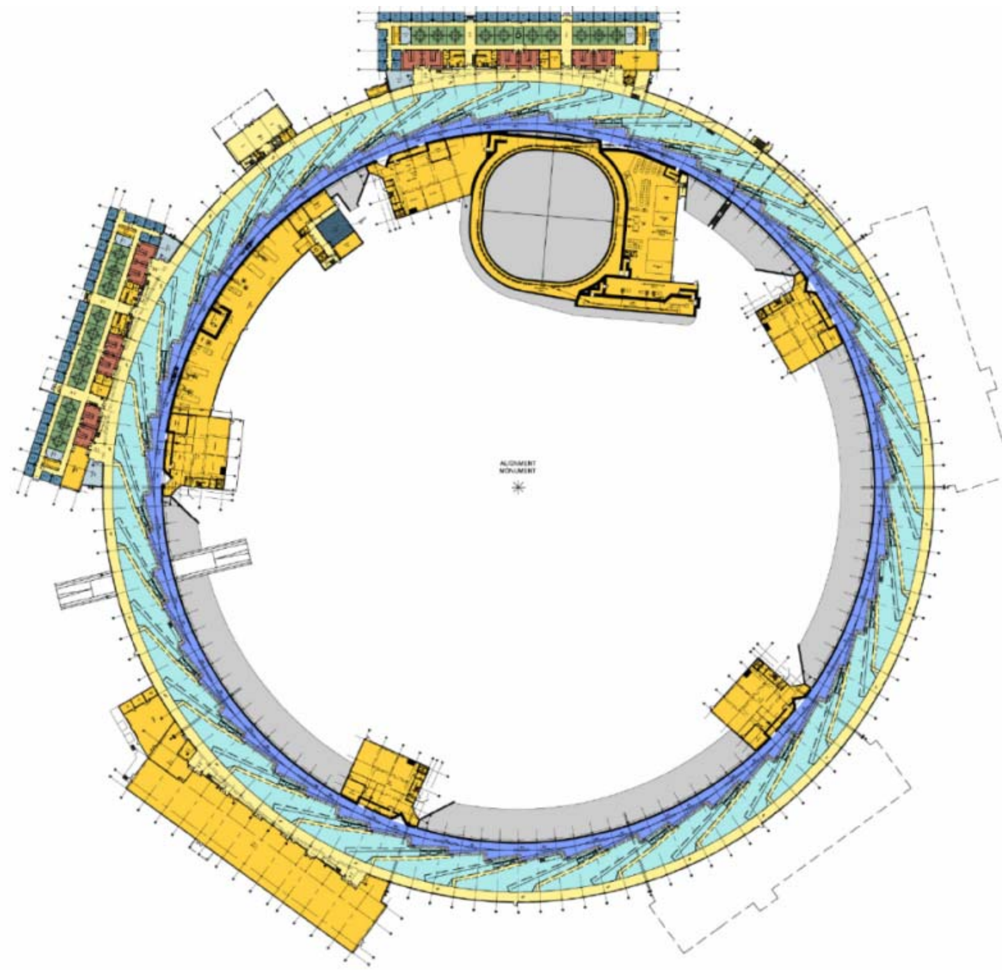
NSLS-II Design

Design Parameters
- 3 GeV, 500 mA, top-off injection
- Circumference 791.5 m
- 30 cell, Double Bend Achromat
  - 15 long straights (9.3 m)
  - 15 short straights (6.6 m)

Novel design features:
- damping wigglers
- soft bend magnets
- three pole wigglers
- large gap IR dipoles

Ultra-low emittance
- $\varepsilon_x, \varepsilon_y$ = 0.6, 0.008 nm-rad
- Diffraction limited in vertical at 10 keV

Pulse Length (rms) ~ 15 psec



NSLS-II Performance

Very broad spectral coverage

Far-IR through very hard x-rays

Very high brightness

$> 10^{21}$ p/s/0.1%/mm^2/mrad^2 from ~ 2 keV to ~ 10 keV

Very high flux

$> 5\times10^{15}$ ph/s/0.1%bw from ~ 500 eV to ~ 10 keV

Very small beam size

$\sigma_y = 2.6\ \mu m$, $\sigma_x = 28\ \mu m$

$\sigma'_y = 3.2\ \mu rad$, $\sigma'_x = 19\ \mu rad$

Top-off operation

Current stability better than 1%

NSLS-II Beamlines

19 straight sections for undulator beamlines

- Fifteen 6.6 m long low-β and four 9.3 m long high-β
- Highest brightness sources from UV to hard x-ray

8 straight sections for damping wiggler beamlines

- Each 9.3 m long high-β
- Broadband high flux sources from UV to hard x-ray

27 BM ports for IR, UV and Soft X-rays beamlines

- Up to 15 of these can have three pole wigglers for hard x-rays

4 Large Gap BM ports for far-IR beamlines

At least 58 beamlines
More by canting multiple IDs per straight
Multiple hutches/beamline are also possible

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For comparison, NSLS has 65 operating beamlines

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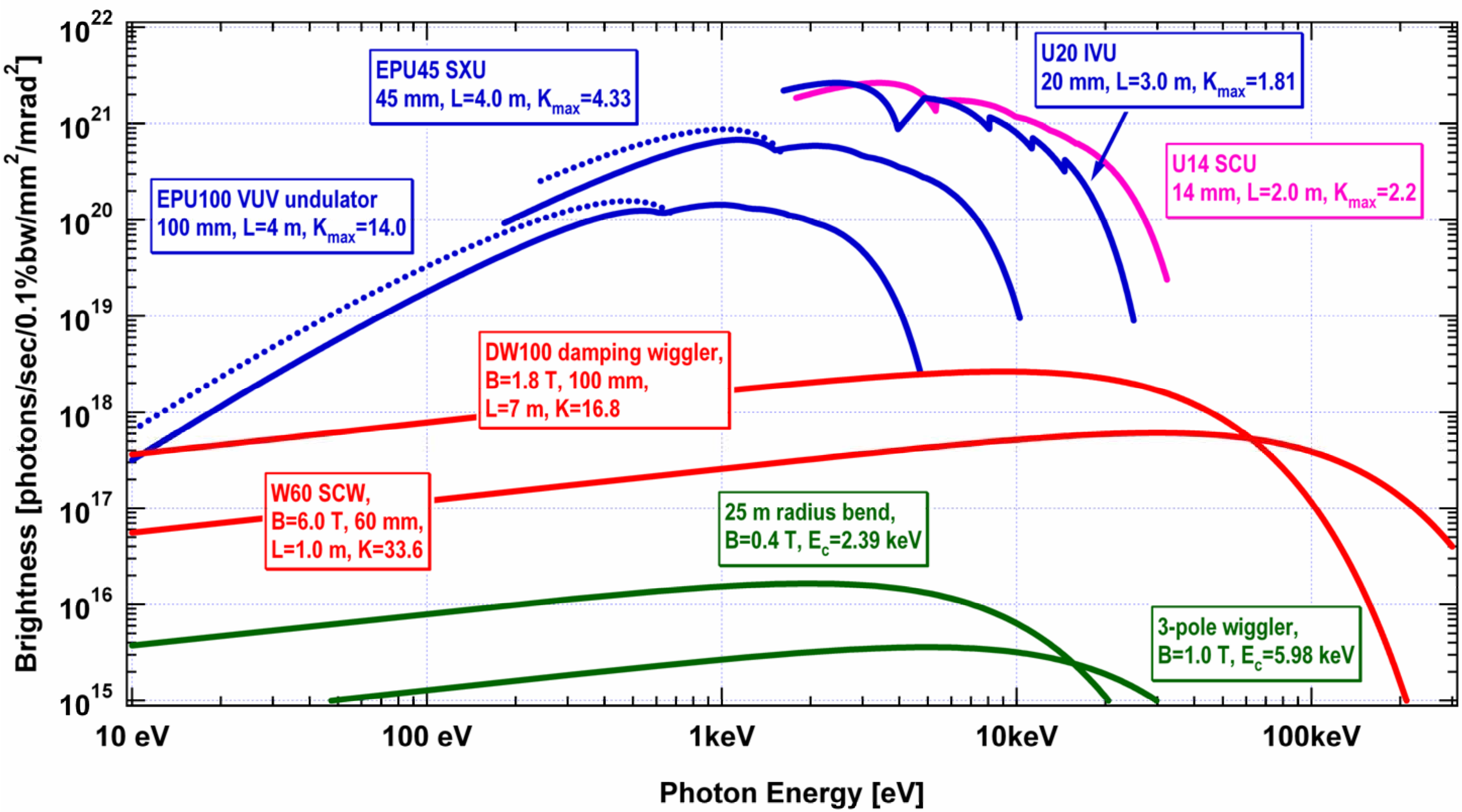
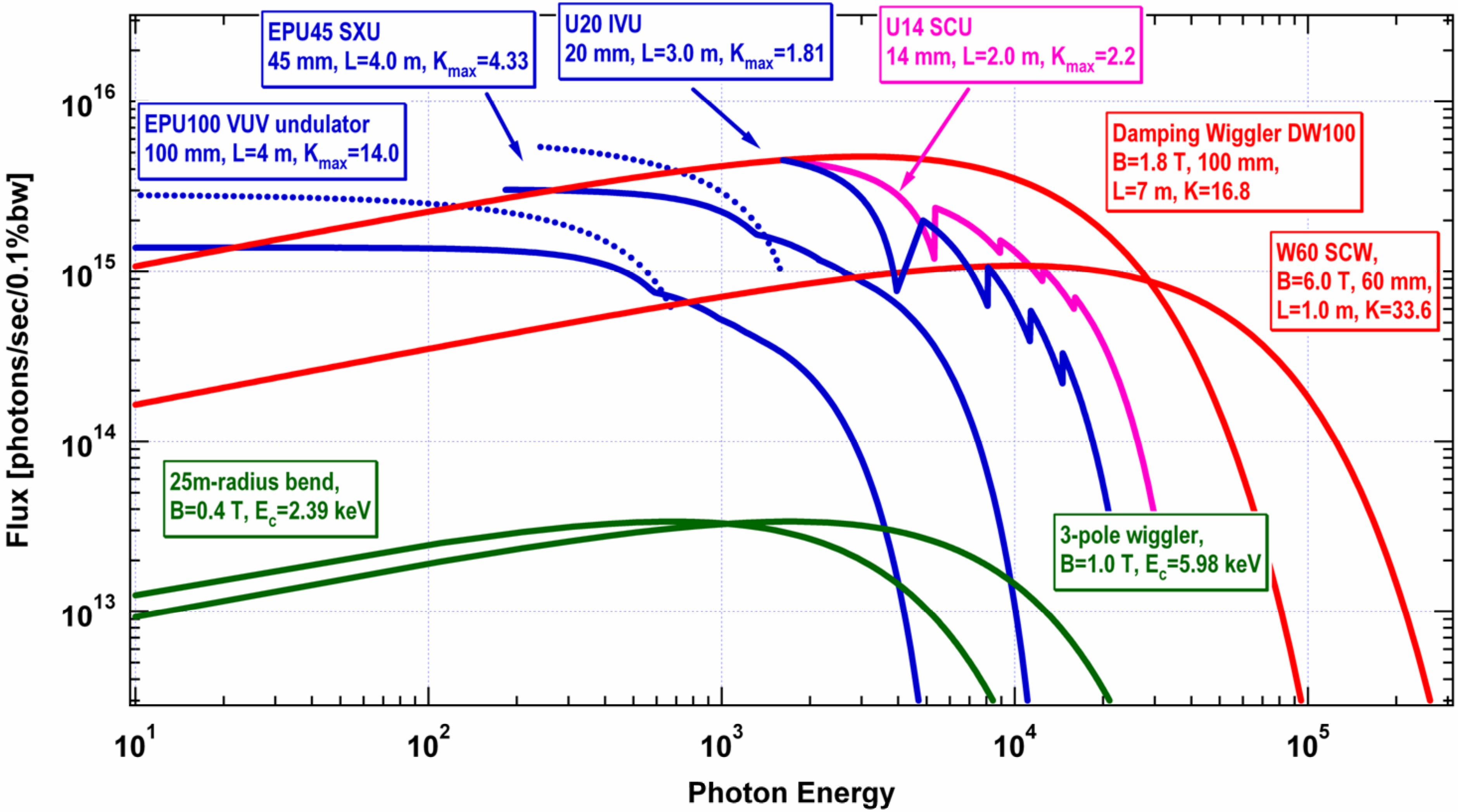
Radiation Sources: Brightness

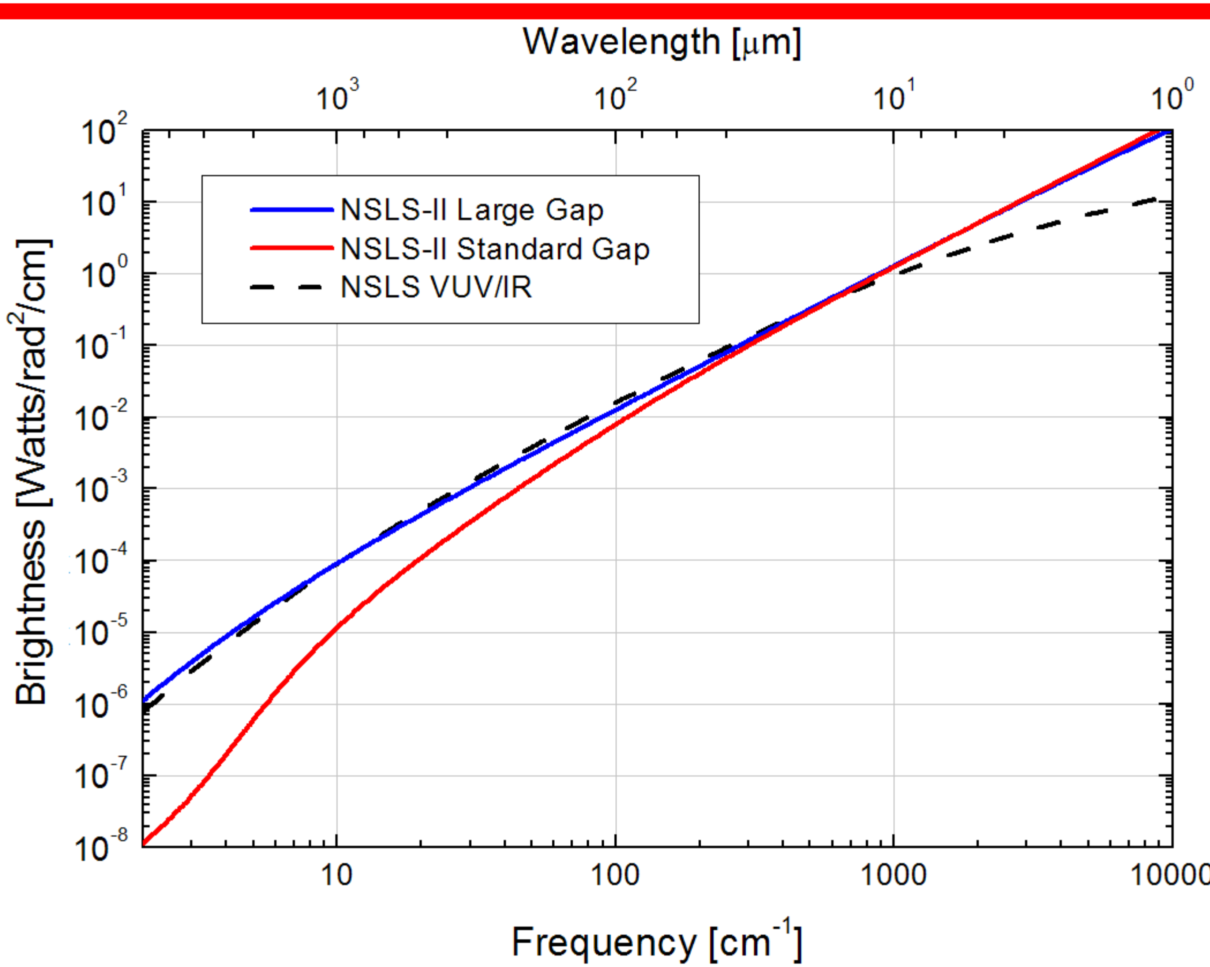


Radiation Sources: Flux



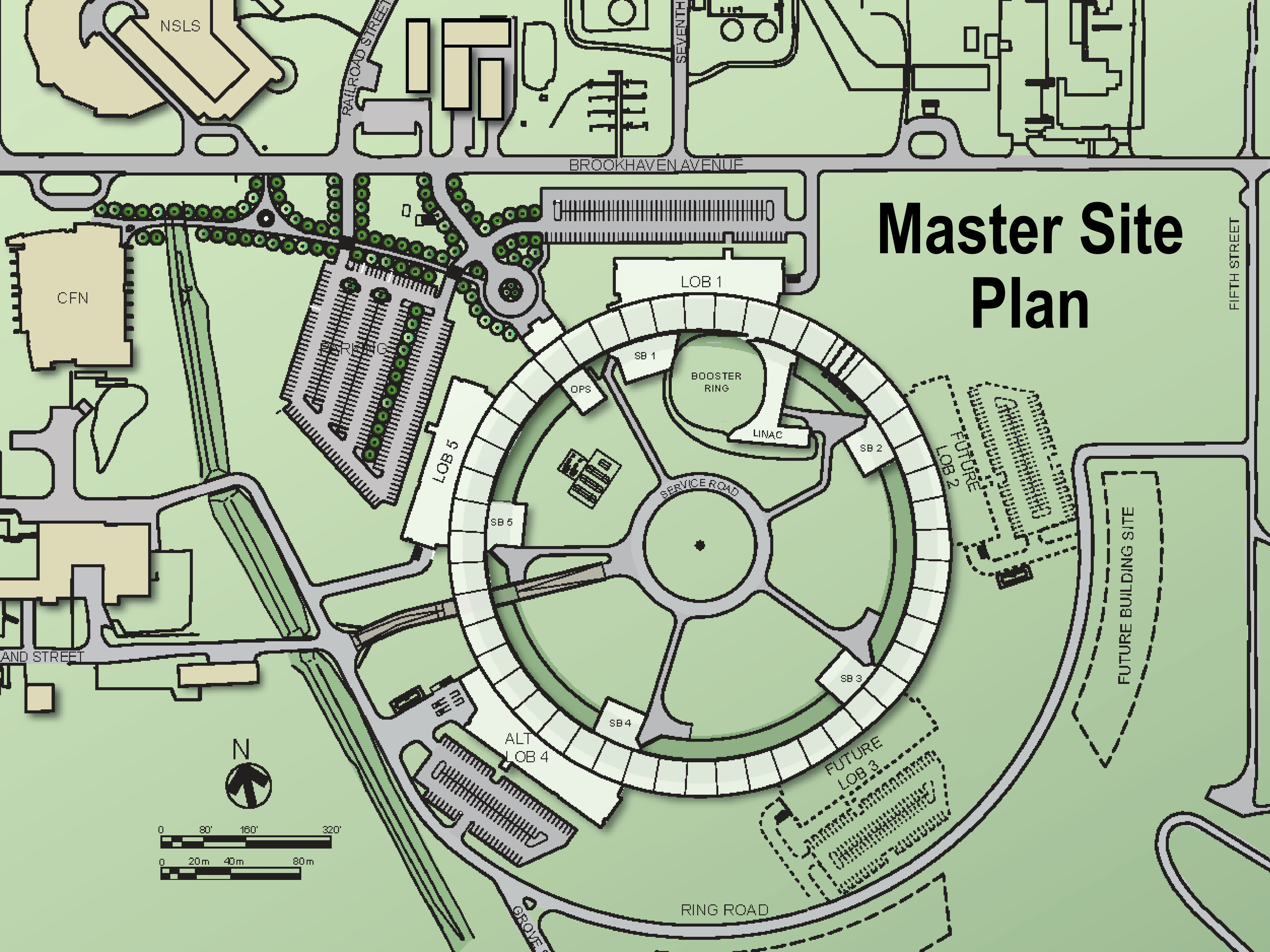
(Flux per horizontal milliradian for broadband sources)

Radiation Sources: Infra-Red

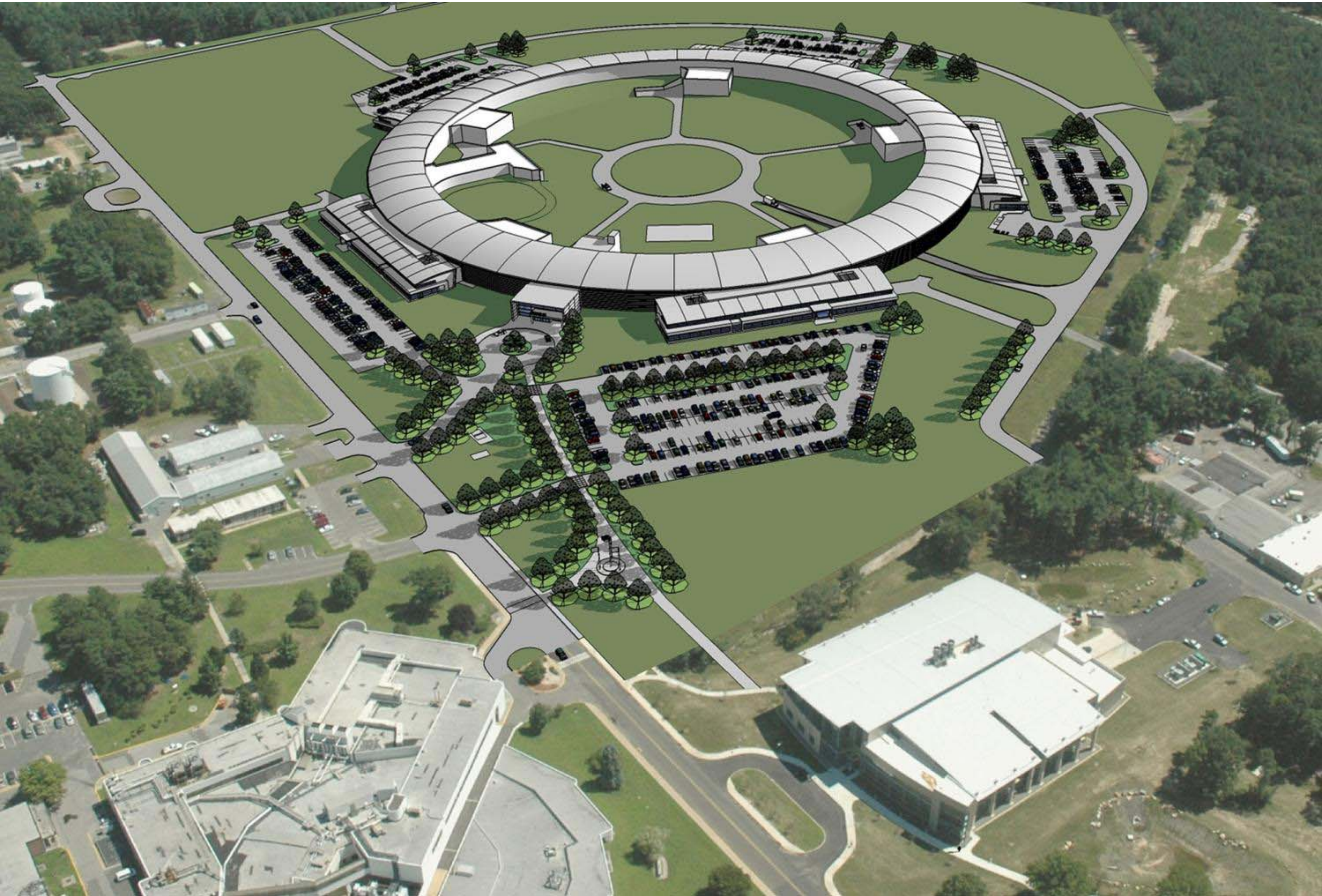


Standard gap BMs provide excellent mid and near IR sources
Large gap (90 mm) BMs provide excellent far-IR sources

Master Site Plan



Rendering of NSLS-II

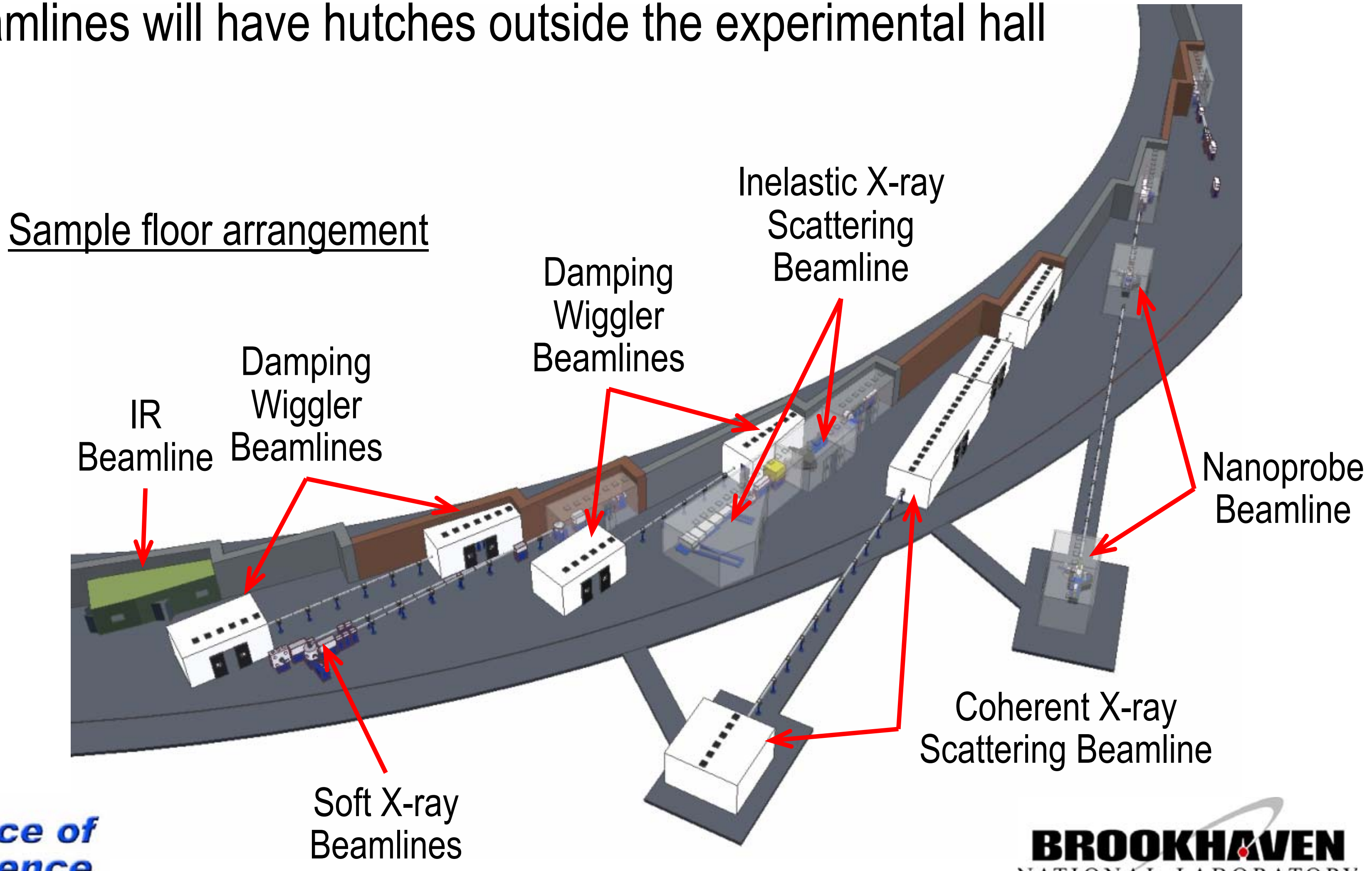


Laboratory Office Buildings

- Three in base scope (22,800 sf each) – Each serves six sectors
  - 72 offices w/ conference space, interaction areas, lavs, showers
  - 6 labs – optimized for shared use
  - Shipping/Receiving/Storage area & chemical storage area
  - Future addition of 2 more LOB's as facilities builds out
- Egress provided for personnel and large items at each LOB
  - Loading area with exterior roll-up door
  - Double-door from each lab onto the experimental floor
  - Rolling access to all beamline areas

Experimental Floor

- Designed to minimize sources and propagation of vibrations
- Long beamlines will have hutches outside the experimental hall



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NSLS-II Strawman Beamline Distribution

Possible distribution among beamline categories (and compared to existing NSLS)

	NSLS-II			NSLS		
Type	**IDs**	**BMs**	**Total**	**IDs**	**BMs**	**Total**
IR/UV/Soft X-ray Spectroscopy	1	8	9	3	7	10
X-ray Spectroscopy	4	4	8	0	9	9
Soft Matter/Biophysics Scattering	4	1	5	0	8	8
Hard Matter/Strongly Correlated Scattering	7	1	8	3	5	8
Powder/single crystal/high P/optics	5	4	9	3	8	11
Imaging/micro-probe	3	8	11	2	7	9
Macromolecular Crystallography	6	3	9	2	8	10
TOTAL	30	29	59	13	52	65

N.B. NSLS-II distribution includes some canting (principally, damping wigglers) and also leaves 3 straights unassigned.

Beamline Acqusition Strategy

FUNDING	BEAMLINES
NSLS-II Project	6 insertion device beamlines to be built by construction project as initial suite for physical sciences
NSLS-II Early Operations	~ 20 bending magnet beamlines transferred from NSLS to NSLS-II
DOE-BES MIE*	~ 16 insertion device beamlines for DOE-BES relevant missions
Non-DOE sources	~ 5 Insertion device beamlines and ~ 11 bending magnet beamlines for non-DOE-BES missions

* MIE = Major Item of Equipment

Project Beamlines

Goal: To provide a minimum suite of insertion device beamlines to meet physical science needs that both exploit the unique capabilities of the NSLS-II source and provide work horse instruments for large user capacity.

- The beamlines are:
  - Nanoprobe (1 nm)
  - Inelastic x-ray scattering (0.1 meV)
  - Soft x-ray coherent scattering and imaging
  - Hard x-ray coherent scattering and SAXS
  - Powder diffraction (damping wiggler source)
  - EXAFS (damping wiggler source)

Phased Transition to NSLS-II Operations

Transition from NSLS to NSLS-II

- Continue operations of NSLS until NSLS-II operational (CD-4)
- NSLS and NSLS-II staff merge to operate NSLS-II

Beneficial Occupancy of Experimental Floor (Feb 2012)

  - Enables early operations funding
- Use early operations funding to transfer selected NSLS beamlines to NSLS-II to ensure significant capacity at start of operations
- Primarily techniques with high demand, high productivity
- Mainly occupy 3-pole wigglers and soft-bends
- Expect to transfer about 20 beamlines, accommodating > 1300 users/yr

Early Project Completion (June 2014) / CD-4 (June 2015)

  - Start of Full Operations
  - All commissioning goals have been achieved

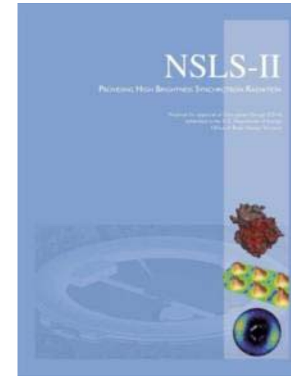
Joint Photon Sciences Institute (JPSI)

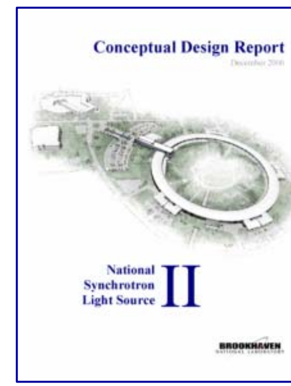
- A new initiative in photon sciences to leverage the unique capabilities and internal science programs of NSLS-II
- Brings together interdisciplinary teams in collaborative projects, forging synergistic relationships that enable new science
- Incubator of high risk techniques & applications, requiring broad array of expertise and supporting technology
- New York State is providing $30 million for the JPSI building

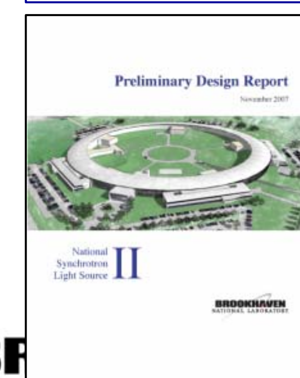
Mission:

- Develop and enhance scientific programs that best utilize NSLS-II
- Develop enabling technologies to support JPSI programs
- Serve as a gateway for NSLS-II
- Educate and train the next generation of leaders in synchrotron research

User Community Input on NSLS-II







NSLS-II Advisory Committees

Project Advisory Committee

Experimental Facilities Advisory Committee

Accelerator Systems Advisory Committee

Conventional Facilities Advisory Committee

NSLS-II User Workshop (July 17-18, 2007)

More than 450 attendees from 130 different institutions

OSTP: John Marburger
DOE: Pat Dehmer (BES)
Pedro Montano (BES)
Susan Gregurick (BER)
NIH: Charles Edmonds (NIGMS)
Alan McLaughlin (NIBIB)
Michael Marron (NCRR)
Amy Swain (NCRR)
NSF: Guebre Tessema

Pat Dehmer announcing the award of CD-1

John Marburger addressing the audience

NSLS-II User Workshop

First Day Plenary Session

- Described conceptual design and status of project
- Highlight talks on physical and life sciences and user access models
- Described process for beamline development at NSLS-II
- Described Joint Photon Sciences Institute
- Described plans for transitioning from NSLS to NSLS-II

Second Day Breakout Sessions

Technique-based Sessions

- **Hard x-ray Nanoprobe**
- **Soft Coherent Scattering and Imaging**
- **Powder Diffraction**
- Macromolecular Crystallography
- Liquid Interfaces
- **Inelastic X-ray Scattering**
- **Hard Coherent and XPCS/SAXS**
- **XAFS**
- Bio-SAXS
- Photoemission Spectroscopy

Science-based Sessions

- Life Sciences
- Catalysis
- Environmental Science
- High-Pressure
- Strongly Correlated Electrons
- Magnetism
- Radiometry and Metrology
- Soft Condensed Matter

Upcoming Strategic Planning & Beamline Workshops

Technique-Based Workshops

• XPCS and Microbeam SAXS	Jan. 10-11
• X-Ray Absorption Spectroscopy	Jan. 16
• Powder Diffraction	Jan. 17-18
• Soft X-Ray Scattering	Feb. 4
• Inelastic X-Ray Scattering	Feb. 7-8
• Nanoprobe Beamline	Feb. 15

Scientific Strategic Planning Workshops

• Life Sciences	Jan. 15-16
• Materials Science and Engineering	Jan. 17-18
• Earth and Environmental Sciences	Jan. 22-23
• Chemical and Energy Sciences	Feb. 1
• Hard Condensed Matter and Materials Physics	Feb. 5-6
• Soft and Biomolecular Materials	Feb. 11-12

Key Milestones

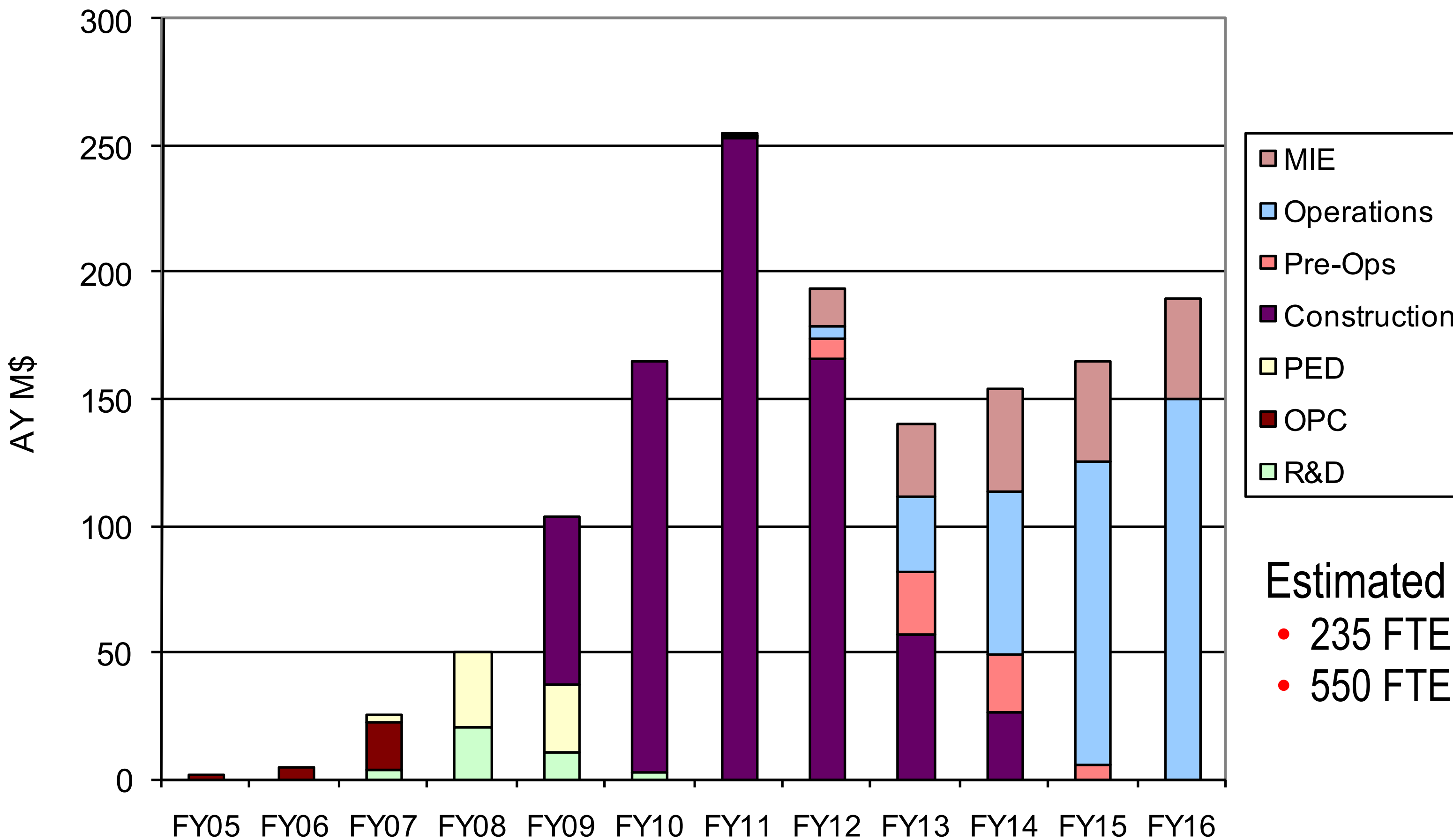
Aug 2005	**CD-0**, Approve Mission Need	(Complete)
Oct 2006	Complete EA/FONSI	(Complete)
Nov 2006	Complete Conceptual Design Report, Preliminary Baseline	(Complete)
Dec 2006	Review, Preliminary Baseline	(Complete)
Jul 2007	**CD-1**, Approve Alternative Selection and Cost Range	(Complete)
Oct 2007	Complete Preliminary Design Report, Performance Baseline	(Complete)
Nov 2007	Review, Performance Baseline	(Complete)
Dec 2007	**CD-2**, Approve Performance Baseline	(Complete)
Oct 2008	Begin Site Prep	
Jan 2009	**CD-3**, Approve Start of Construction	
Jun 2009	Issue Ring Building Notice to Proceed	
Mar 2010	Contract Award for Booster System	
Feb 2011	Ring Building Pentant #1 Beneficial Occupancy	
Feb 2012	Beneficial Occupancy of Experimental Floor, Start of Early Operations Funding	
Aug 2013	Conventional Facilities Construction Complete	
Oct 2013	Start Accelerator Commissioning	
Jun 2014	Early Project Completion; Ring Available to Beamlines	
Jun 2015	**CD-4**, Project Completion	

NSLS-II Cost Baseline ($M)

Project Management	53
Accelerator Systems	242
Conventional Facilities	241
Experimental Facilities	73
Total Construction Cost Baseline	609
Contingency (30% of Constr. Cost Baseline)	183
Total Estimated Costs (TEC)	**792**
R&D and Conceptual Design	60
Pre-Operations	50
Contingency (20% of Pre-ops)	10
Other Project Costs (OPC)	**120**
Total Project Costs (TPC)	**$ 912**

Funding Profile with Operations & MIE

TPC = $912M TEC = $792M (including 30% contingency)



Estimated operating staff:

- 235 FTEs w/ no beamlines
- 550 FTEs w/ 57 beamlines

Note: Operations & MIE funding are not part of TPC

Summary

- Novel design w/ outstanding performance and flexibility from the far-IR to the very hard x-ray. A range of sources matched to various scientific needs.
- Baseline scope provides substantial experimental capability
- Have plan for transition from NSLS and reuse of experimental and conventional facilities from NSLS
- Community is fully engaged in optimizing overall facility utilization