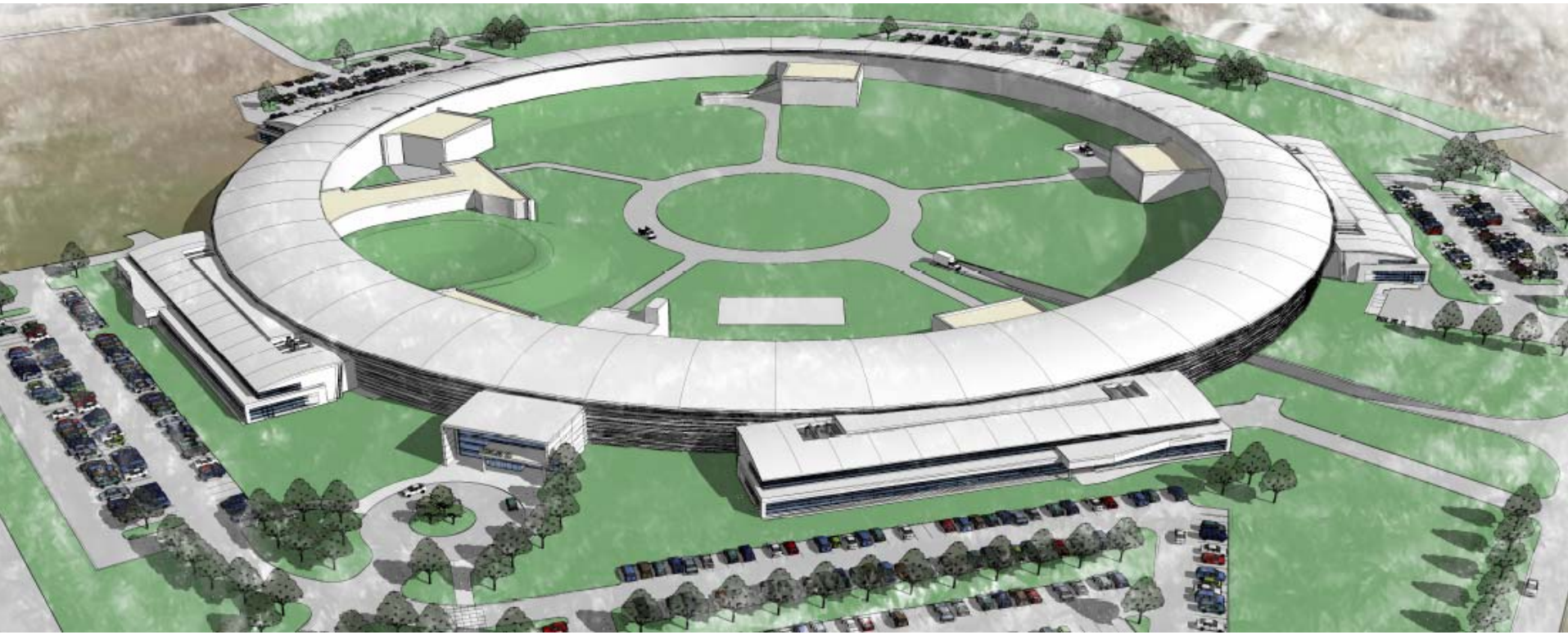
NSLS-II Overview



John Hill
Experimental Facilities Division Director
NSLS-II
Soft Matter and Biomolecular Materials workshop Feb 11th 2008

Office of Science
U.S. DEPARTMENT OF ENERGY

BROOKHAVEN NATIONAL LABORATORY
BROOKHAVEN SCIENCE ASSOCIATES

NSLS-II Flyover

NSLS-II Design

Design Parameters

- 3 GeV, 500 mA, top-off injection
- Circumference 791.5 m
- 30 cell, Double Bend Achromat
  - 15 high-β straights (9.3 m)
  - 15 low-β straights (6.6 m)

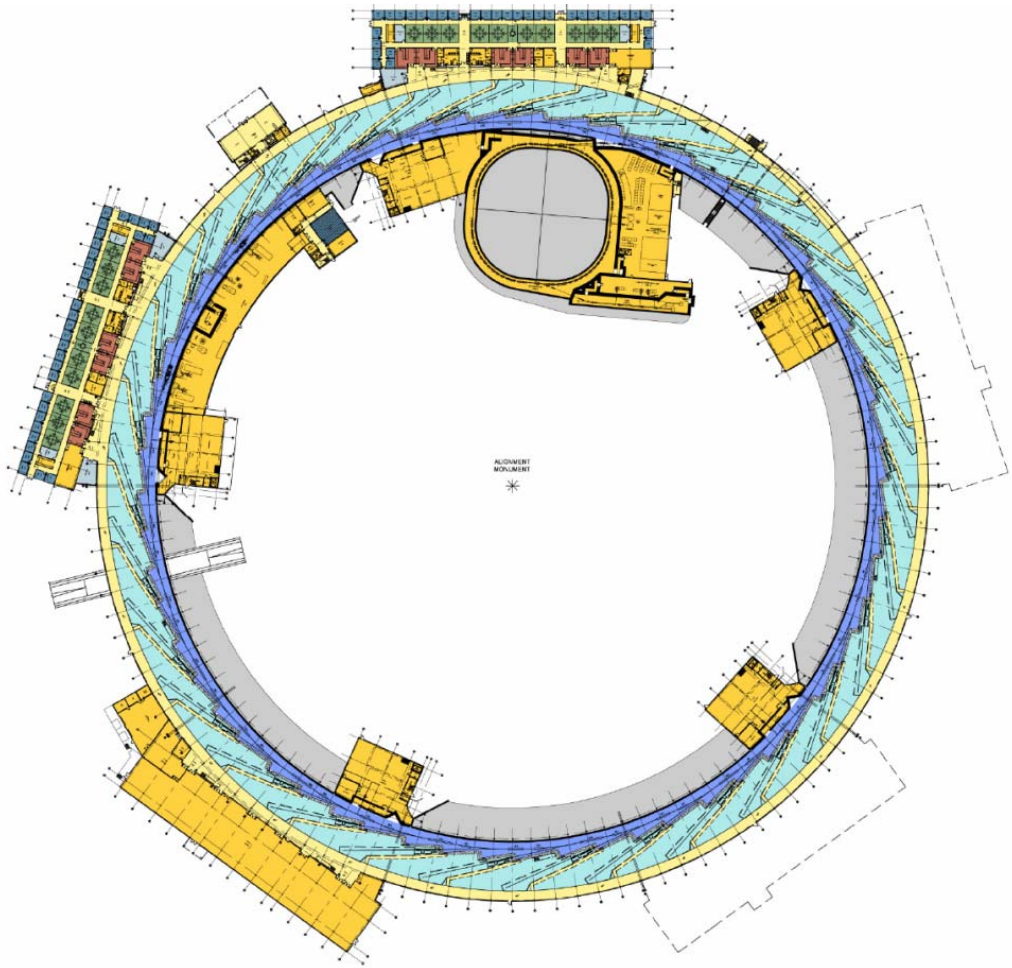
Novel design features:

- damping wigglers
- soft bend magnets
- three pole wigglers
- large gap IR dipoles

Ultra-low emittance

- ε_x, ε_y = 0.6, 0.008 nm-rad
- Diffraction limited in vertical at 10 keV
- 2.6 μm x 28 μm (low-β)

Pulse Length (rms) ~ 15 psec



NSLS-II Beamlines

19 straight sections for undulator beamlines

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

8 straight sections for damping wiggler beamlines

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

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

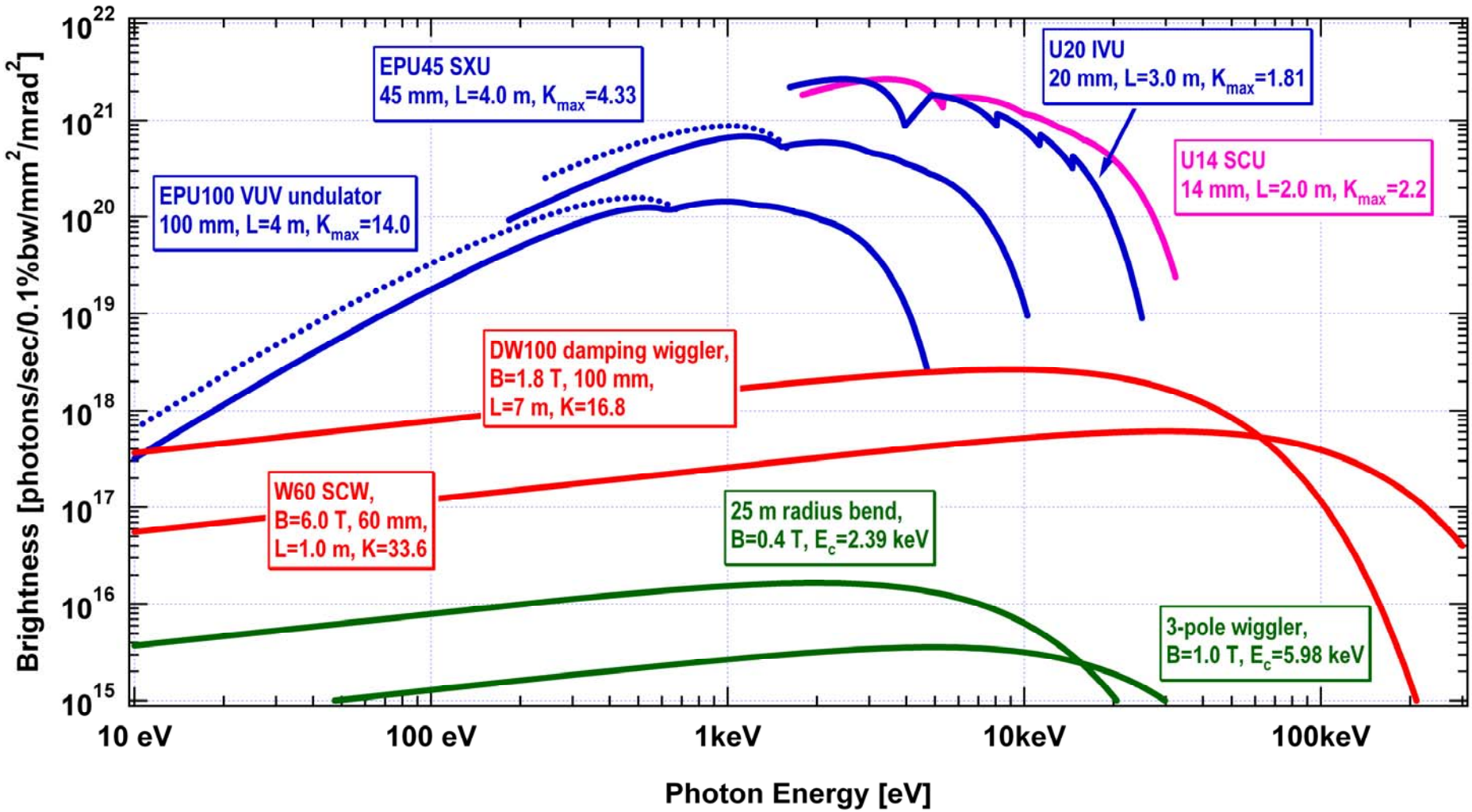
- Or three pole wigglers for hard x-rays

4 Large Gap BM ports for far-IR beamlines

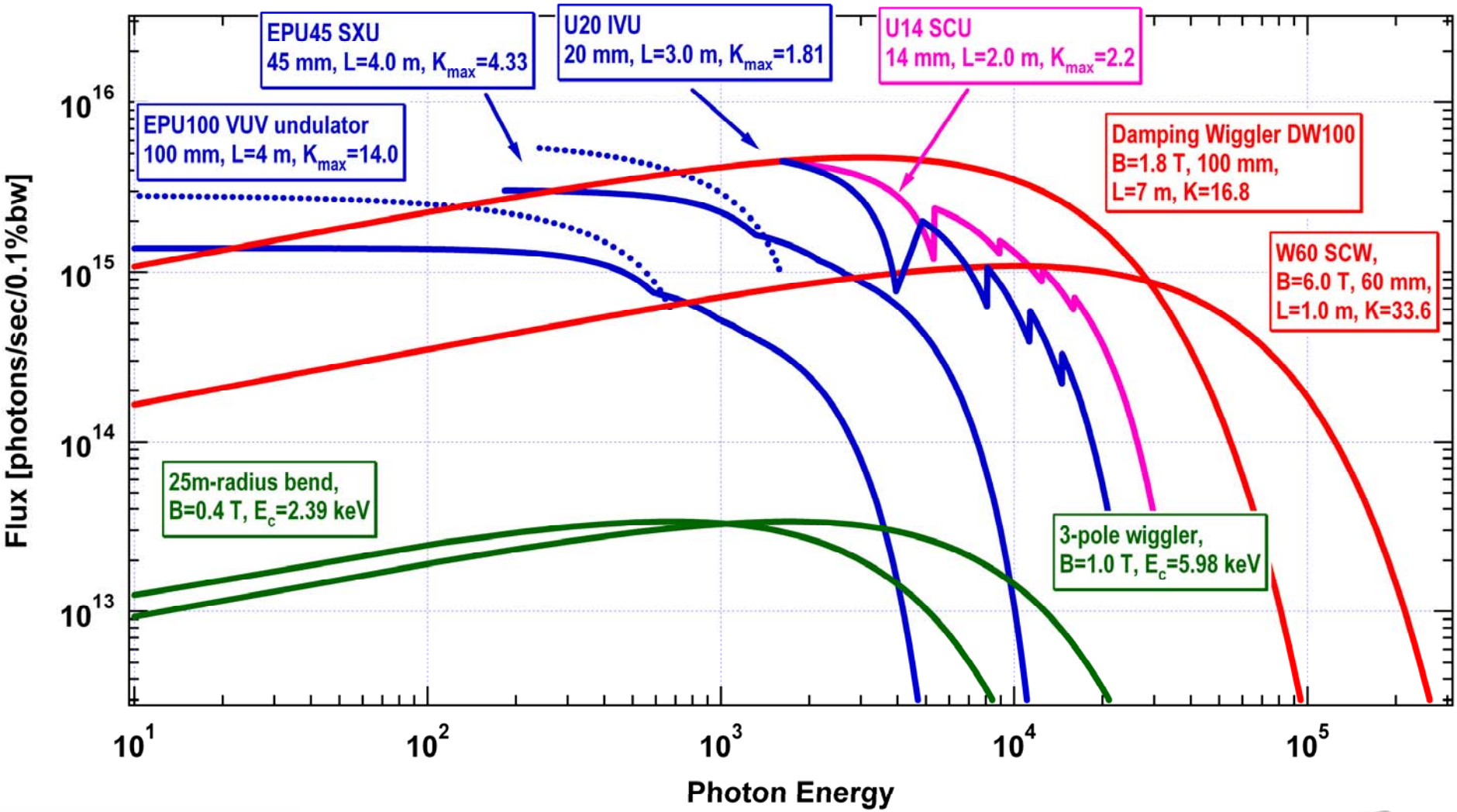
At least 58 beamlines
More by canting multiple IDs per straight
Multiple hutches/beamline are also possible

For comparison, NSLS has 65 operating beamlines

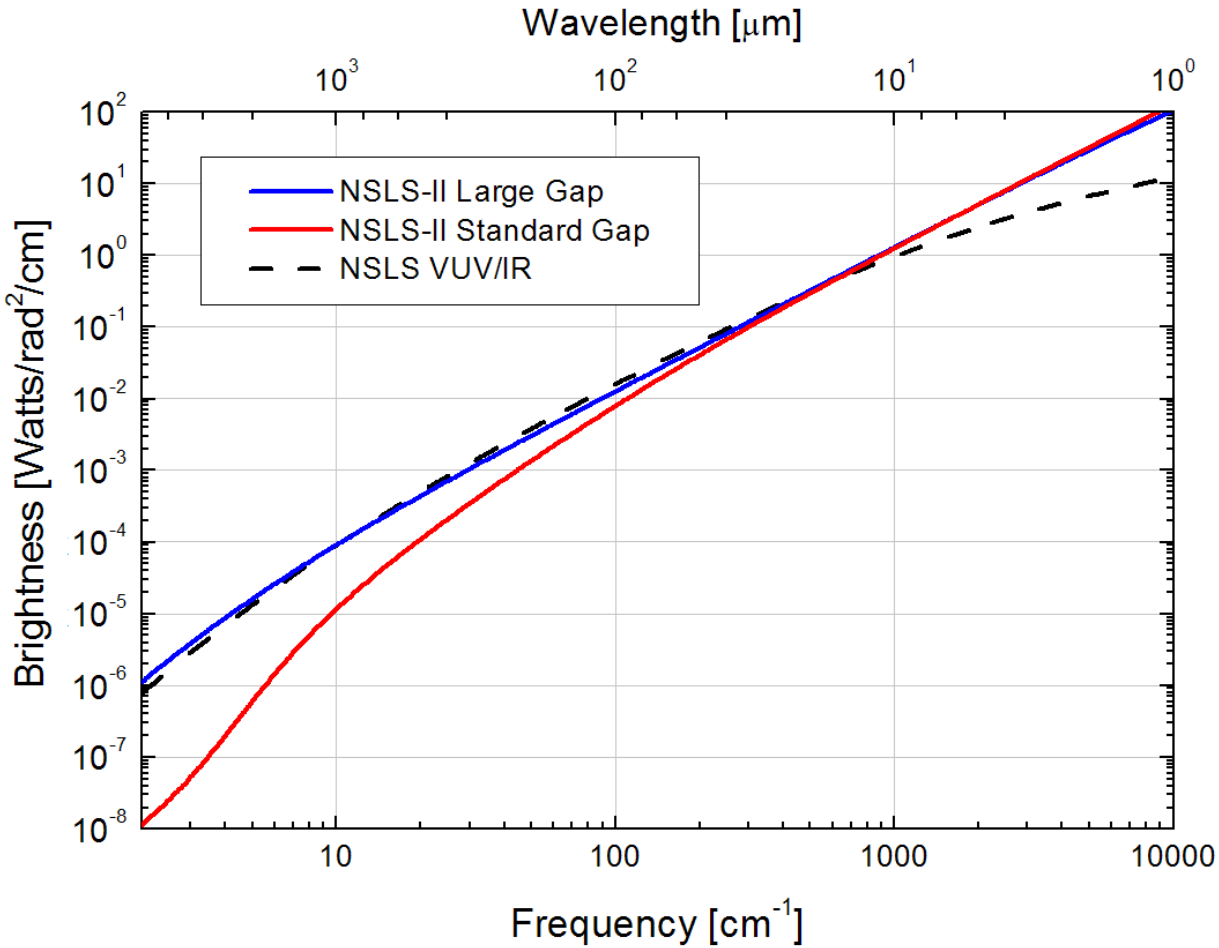
Radiation Sources: Brightness



Radiation Sources: Flux

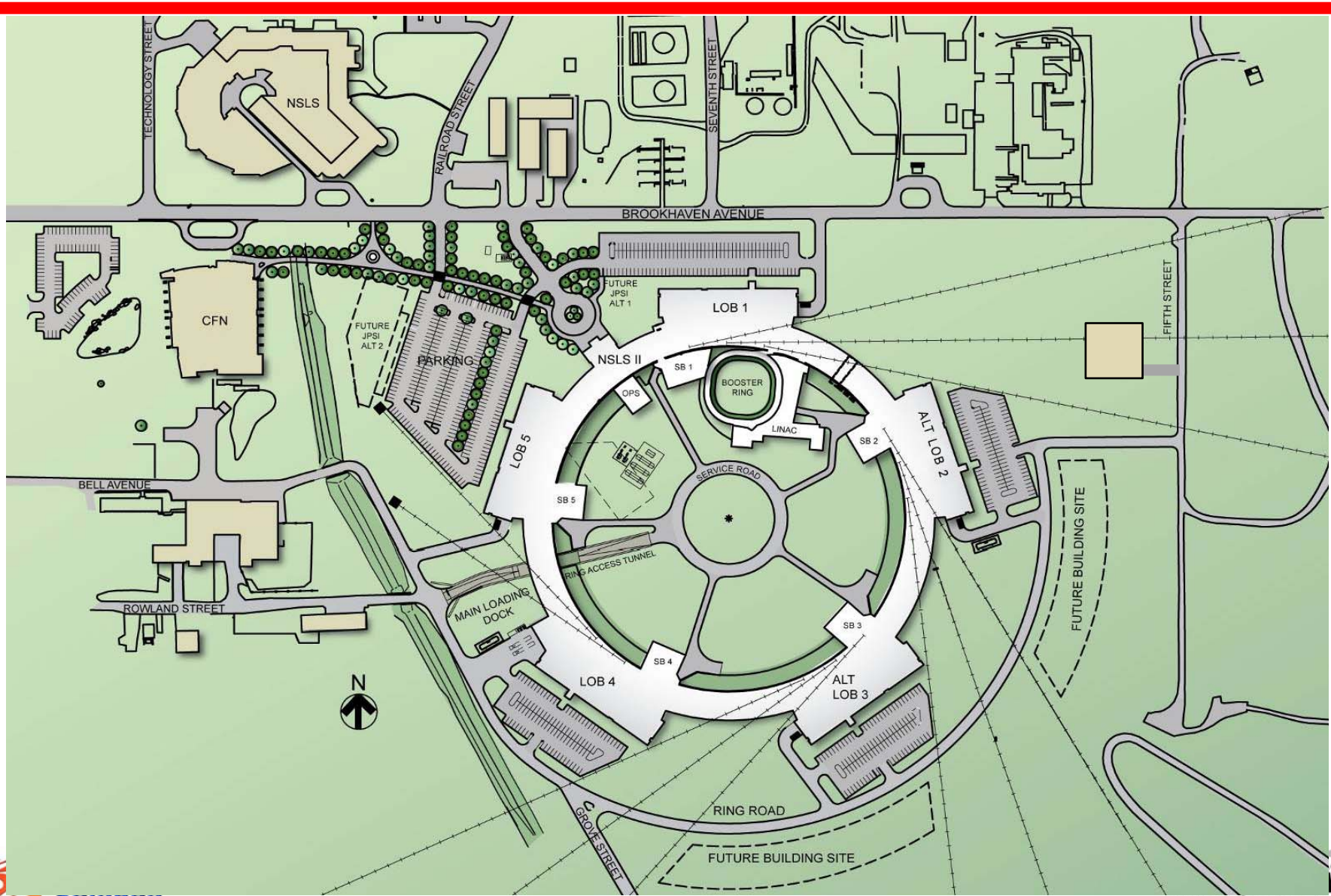


Radiation Sources: Infra-Red



- World leading IR extracted from Bend Magnets
- Large gap dipoles (90 mm) boost performance in far-IR

Master Site Plan



Lab-Office Building

Total = 23,800 gsf

Labs = 480 nsf

Lab Office Building - each nominally has:

- 72 Offices
- 6 labs
- Machine shop
- 4 Conference Rooms
- Loading/storage area

Key Milestones

Aug 2005	CD-0, Approve Mission Need	(Complete)
Oct 2006	Complete EA/FONSI; Internal Advisory Committee Reviews	(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 Performance Measurement Baseline	(Complete)
Nov 2007	Review, Performance Baseline	(Complete)
Dec 2007	CD-2, Approve Performance Baseline	(Complete)
Dec 2008	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	
Aug 2013	Conventional Facilities Construction Complete	
Oct 2013	Start Accelerator Commissioning	
Jun 2014	Early Project Completion; Ring Available to Beamlines	
Jun 2015	CD-4, Approve Start of Operations	

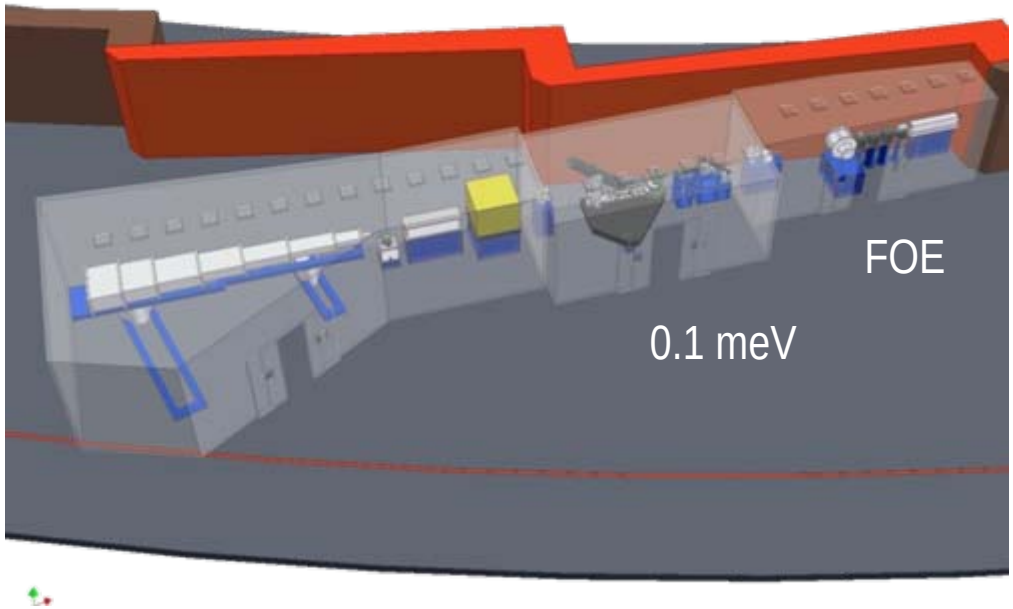
Project Beamlines

Project 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:

• Inelastic x-ray scattering (0.1 meV)	U20 undulator
• Nanoprobe (1 nm)	U20 undulator
• Soft x-ray coherent scattering and imaging	EPU45 undulator
• Hard x-ray coherent scattering and SAXS	U20 undulator
• Powder diffraction	Damping wiggler
• XAS	Damping wiggler

IXS Beamline



- U20 source, operating at 9.1 keV, high β straight
- Requires new optics schemes (R+D)

Science Mission

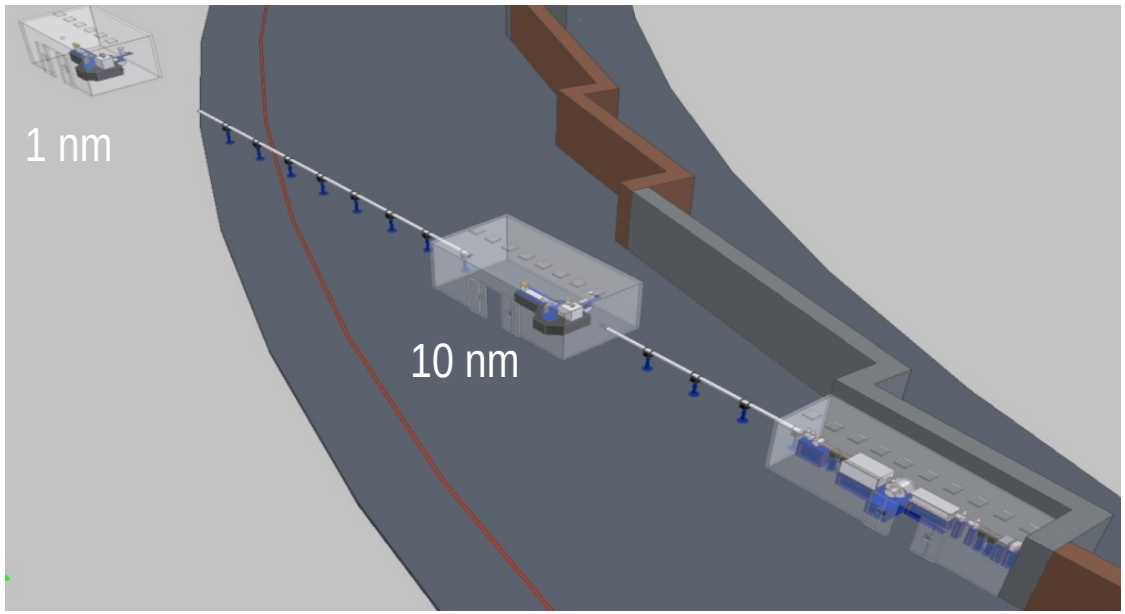
- Visco-elastic behaviors and relaxation processes of disordered systems and complex fluids
- Collective modes in lipid membranes and other biological systems
- Phonons in single crystals, surfaces, thin films, high pressure systems, small samples, strongly correlated systems …

0.1 meV Endstation

- Scan range ~ 100 meV
- Q-resolution 0.01 – 0.04 A^{-1}, up to 8 A^{-1}
- Spot size < 5 μm (v) x 10 μm (h)

World-leading resolution, 0.1 meV, opens up new regimes of dynamics

Nanoprobe Beamline



- U20, 1 nm spot size. Operating at 4.3 – 30 keV, low-β straight. Remote endstation (outside experimental hall)
- Requires new optics schemes (R+D)

World-leading resolution, 1 nm opens up new regimes of study

Science Mission

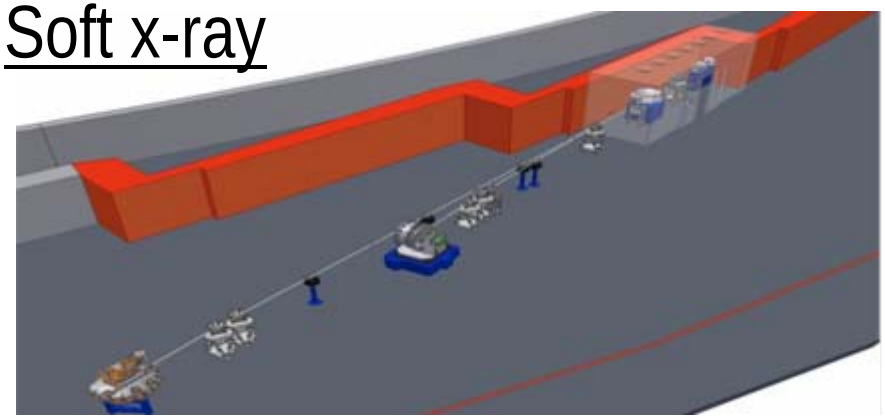
- Structure and function of catalytic nanoparticles
- Strain in buried interfaces
- Structure of single molecule devices

Endstation

- Fluorescence scanning nanoprobe
- Full field imaging capability
- Nanodiffraction capability
- Cryo-sample environments

Coherent X-ray Scattering Beamlines

Soft x-ray



- EPU (low-β), operating at 200 to 2000 eV

- Mesoscopic imaging (magnetic domains, large cells)
- Nanomagnetism, buried interfaces
- Time correlation spectroscopy

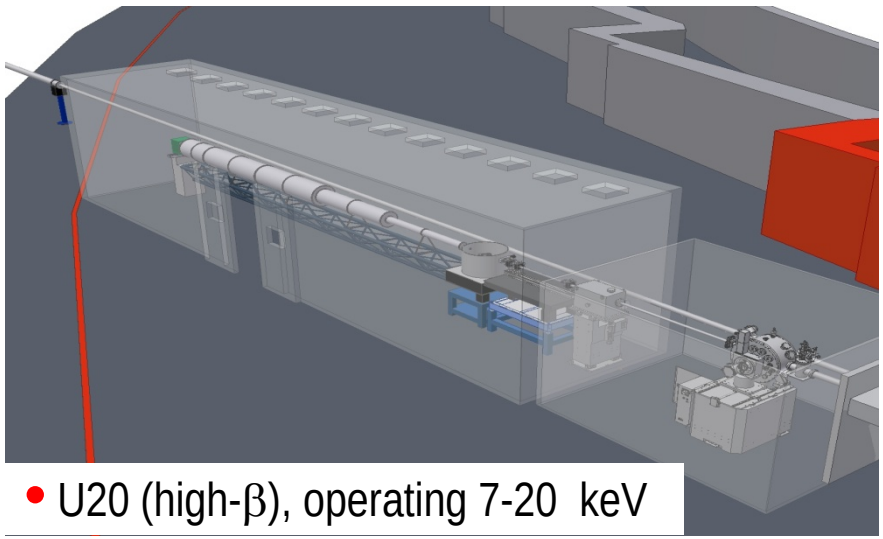
Fast switching of circularly and linearly polarized modes

Spot size < 4 μm x 4 μm

Flux 10^{12} – 2 x 10^{13} depending on resolution

1 T field for magnetic measurements

Hard x-ray



- U20 (high-β), operating 7-20 keV

- X-ray Photon Correlation Spectroscopy: dynamics of soft matter systems
- Small Angle X-ray Scattering

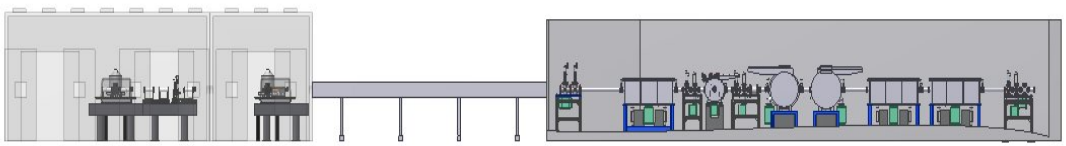
Heavily pixelated detector

Mono and “pink” beam modes

10 m flight path

Wiggler Beamlines

XAS



- 90 mm wiggler (high β straight), 5-90 keV

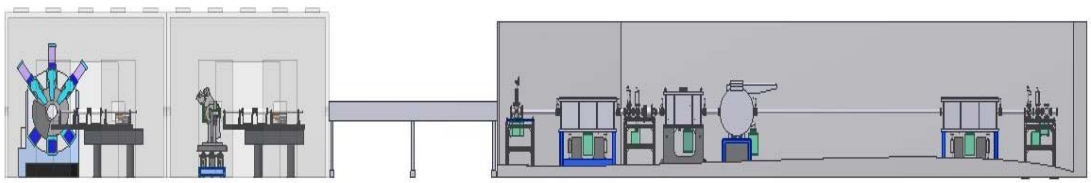
- Bulk XAS and micro-EXAFS
- Materials science and catalysis
- Nanomaterials research
- Environmental science and geology

$4x10^{12}$ in 1 micron spot for micro-XAS

Diamond anvil cell capability

In-situ capabilities, high energy-resolution mode

Powder



- 90 mm wiggler (high-β straight) 20–100 keV

- High-resolution scattering and in-situ PDF
- Materials science, nanomaterials, chemistry, pharmaceuticals, microstructure, residual strain…

0- 50 A^{-1} q-range

Spot size < 1 μm for DAC work

4 – 4000 K sample temperature range

Robotic sample changer

Beamline Development

All beamlines to be developed using **Beamline Advisory Teams**

- Small teams formed by submitting a Letter of Interest (reviewed by EFAC)
- Propose scientific mission and technical requirements for beamline
- Facility hires beamline staff, designs & builds beamlines
- BAT meets every 6 months, working closely with the facility to advise them during design, construction, commissioning, and early operations
- Represent a particular User community
- Report to XFD Director

Letters of Interest

A brief proposal (10 page limit) from the BAT. Contains:

1. **The scientific case for the beamline.**

   Key scientific drivers for this beamline. How does NSLS-II impact this field. What unique capabilities will it provide and which scientific questions will these address?

2. **The technical requirements and specifications of the beamline.**

   What requirements flow from the scientific justification? (q-ranges, energy resolution, sample environments, need to take full undulator beam…).

3. **How does it meet the needs of the user community?**

   Documentation of User demand for the beamline. User workshops held. White papers written. Appendix: containing a list of supporters/potential users (not included in page count)

4. **What source does it need and why?**

   Discussion of performance and high level parameters. Choice of straight section.

5. **Summary of Team members and their expertise.**

   Brief description of what each member brings to the team.

   Appendix: One page bio for each member (not included in page count)

Letters of Interest

- Letters of interest may also propose a suite of beamlines to meet a particular need.
- Such LOIs should lay out overall scientific case for the suite and address how each of the particular beamlines meets a component of the scientific mission.
- Expectation is that such LOIs would be rare and that single BATs would not encompass disparate beamlines.

LOIs (continued)

For non-DOE-BES funded beamlines, for which external funding will need to be secured, NSLS-II will require a detailed Memorandum of Understanding (MOU) be developed between NSLS-II and the Partner User group.

This will ensure that all the requirements of the facility are met, including

1) Policy requirements regarding beamline development and flow of funding, user access, and operations models

2) Technical, staffing, and scientific requirements.

In cases where a funding proposal is to be submitted to an external agency, it will be necessary for the BAT to gain the approval of NSLS-II before submitting to a funding agency.

Criteria for Beamline Selection

- Excellence of scientific case and engagement of user community in its articulation
- Best-in-class performance, with characteristics well matched to NSLS-II source (meets or exceeds relevant world-wide benchmarks, based on realistic simulations)
- Technical feasibility of reaching scientific objectives
- Alignment with overall utilization of facility
- Quality of team

Letter of Interest (cont.)

Following the blessing of the LOI by the EFAC, the project would then assign resources to work with the BAT to develop the following:

1. Pre-Conceptual Design for Beamline

   Provides preliminary BL layout. More detailed requirements and specifications for the beamline. Identifies any particular design challenges that are beyond current state-of-the-art.

   - This already exists for the project beamlines.

2. Preliminary Cost Estimate

   Developed on the basis of the pre-conceptual design.

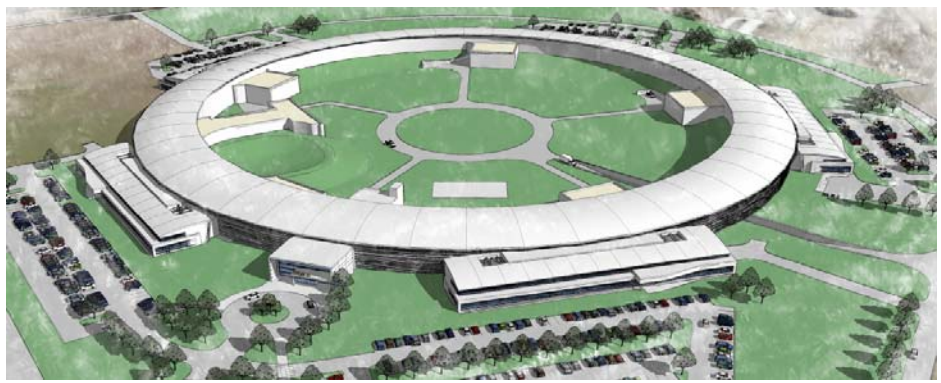
   - This already exists for project beamlines.

3. Alignment with NSLS-II Strategic Plan.

   Addresses the question of how this capability would fit in with the strategic vision for the facility. Interactions with other beamlines and other user communities, synergies, etc.

Timeline

• LOI for 6 project beamlines	March 30th 2008
• EFAC review	April 2008
• Oral presentations to EFAC	May 5th – 7th 2008
• Recommendation by EFAC	May 2008
• Next round of LOIs due	August 31st 2008
• EFAC review	Sept 2008
• Oral presentations to EFAC	Oct 2008
• Recommendation by EFAC	Oct 2008

Summary

- NSLS-II will provide a superb source of extremely bright photons over a wide energy range
- It is a near ideal source for many techniques including nanoprobe, SAXS, GISXAS, imaging…, etc, offering big increases in performance over existing sources
- The facility is looking to you, the users, for input and advice on the design, construction and operation of the beamlines.
- This workshop (and others to follow) is one mechanism for this.
- Beamline Advisory Teams will formalize this.