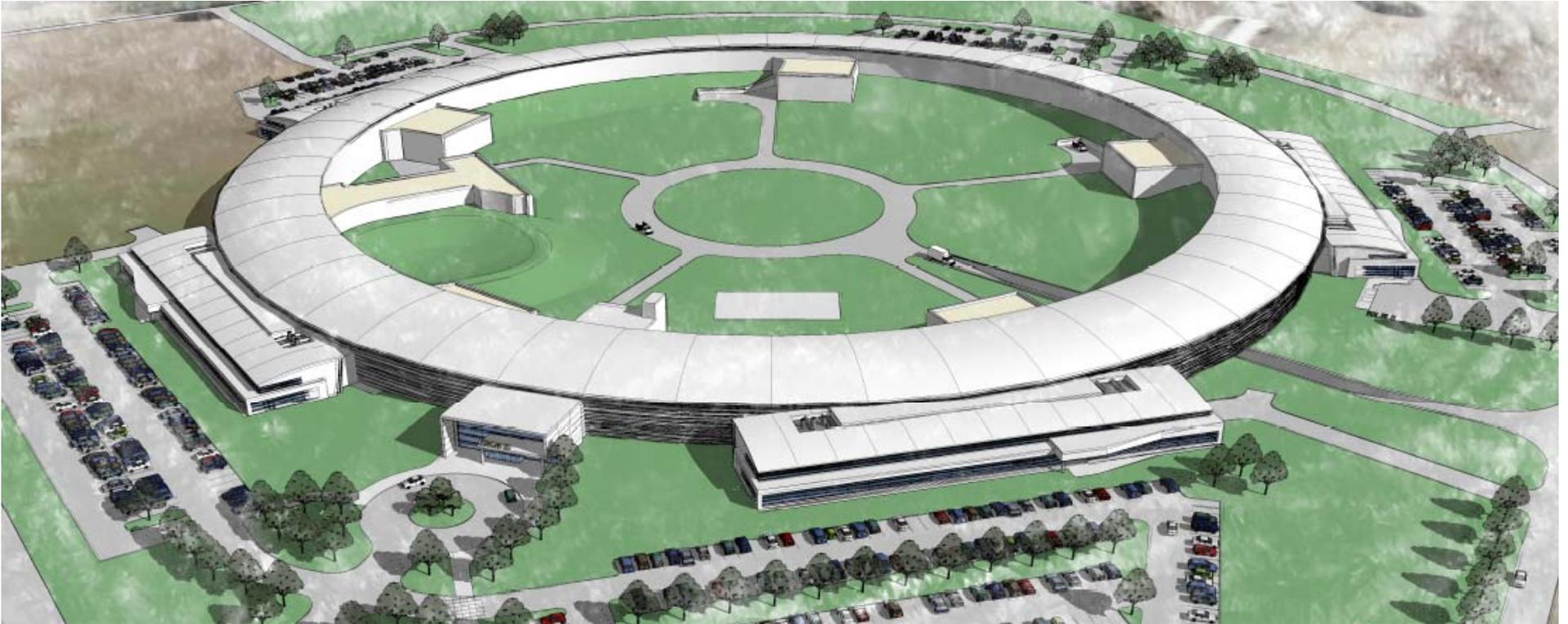


# NSLS-II Overview

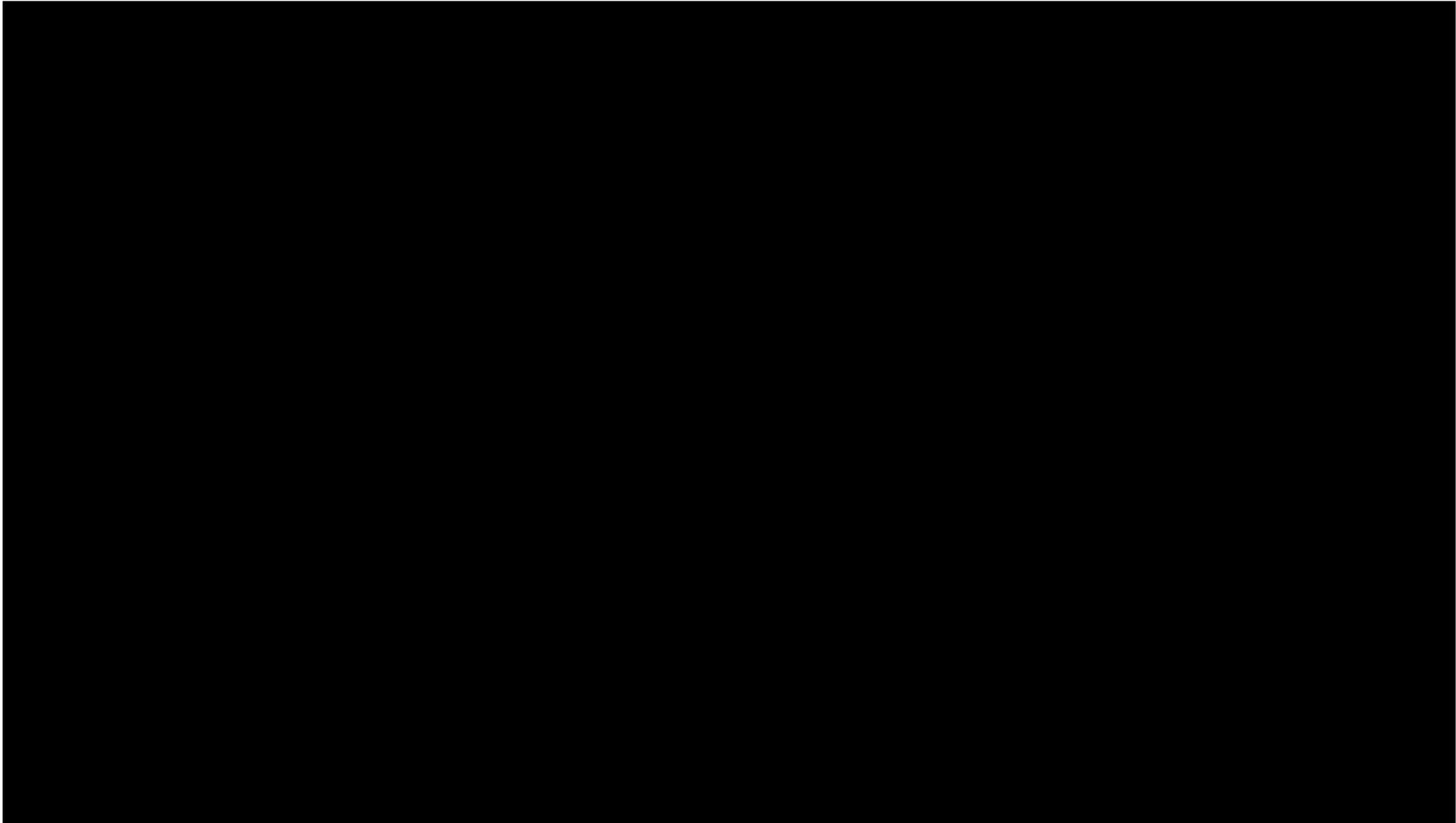
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John Hill  
Experimental Facilities Division Director  
NSLS-II  
Life Sciences workshop Jan 15<sup>th</sup> 2008

# NSLS-II Flyover

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# NSLS-II Design

## Design Parameters

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

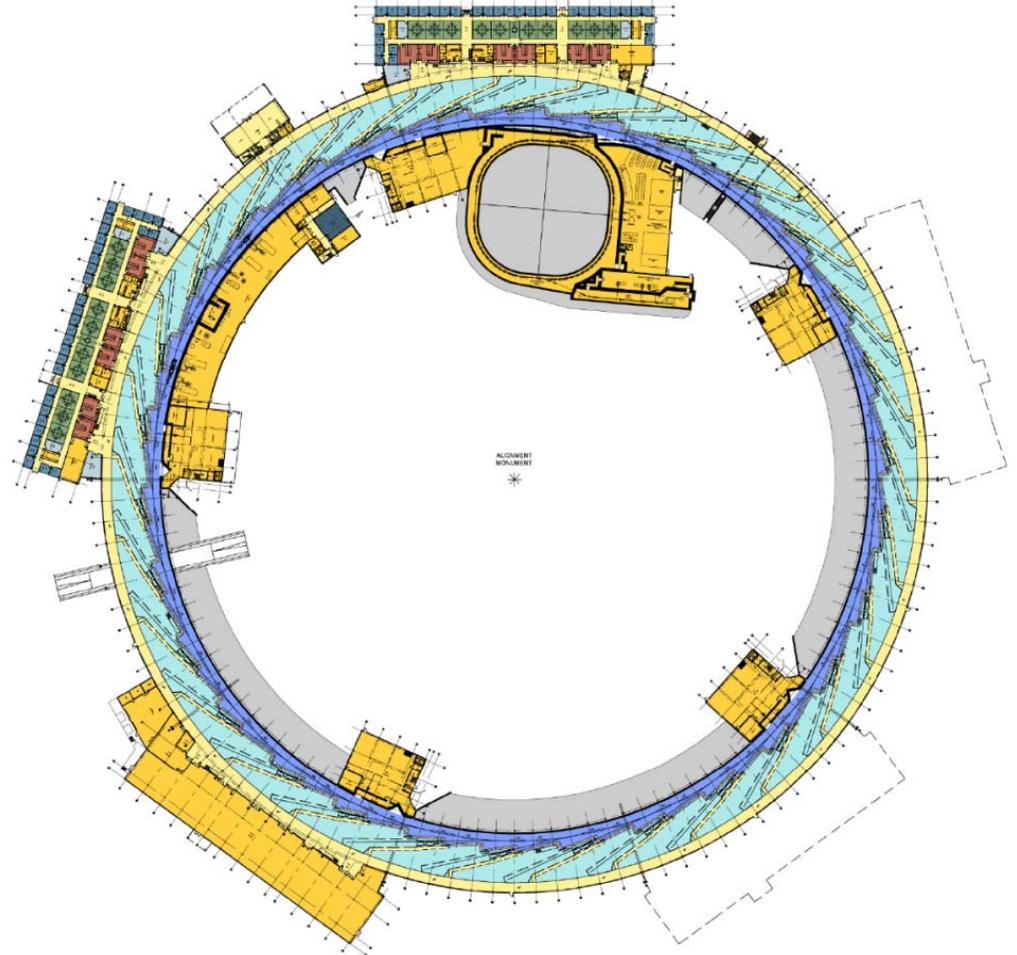
## Novel design features:

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

## Ultra-low emittance

- $\epsilon_x, \epsilon_y = 0.6, 0.008$  nm-rad
- Diffraction limited in vertical at 10 keV
- $2.6 \mu\text{m} \times 28 \mu\text{m}$  (low- $\beta$ )

Pulse Length (rms) ~ 15 psec



# NSLS-II Beamlines

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## 19 straight sections for undulator beamlines

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

## 8 straight sections for damping wiggler beamlines

- Each 9.3 m high- $\beta$
- 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

For comparison, NSLS has 65 operating beamlines

# NSLS-II Performance

---

## Very broad spectral coverage

- Far-IR through very hard x-rays

## Very high brightness from 10 eV to 20 keV

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

## Very high flux from 10 eV to 20 keV

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

## Very small beam size

- $\sigma_y = 2.6 \mu\text{m}$ ,  $\sigma_x = 28 \mu\text{m}$
- $\sigma'_y = 3.2 \mu\text{rad}$ ,  $\sigma'_x = 19 \mu\text{rad}$

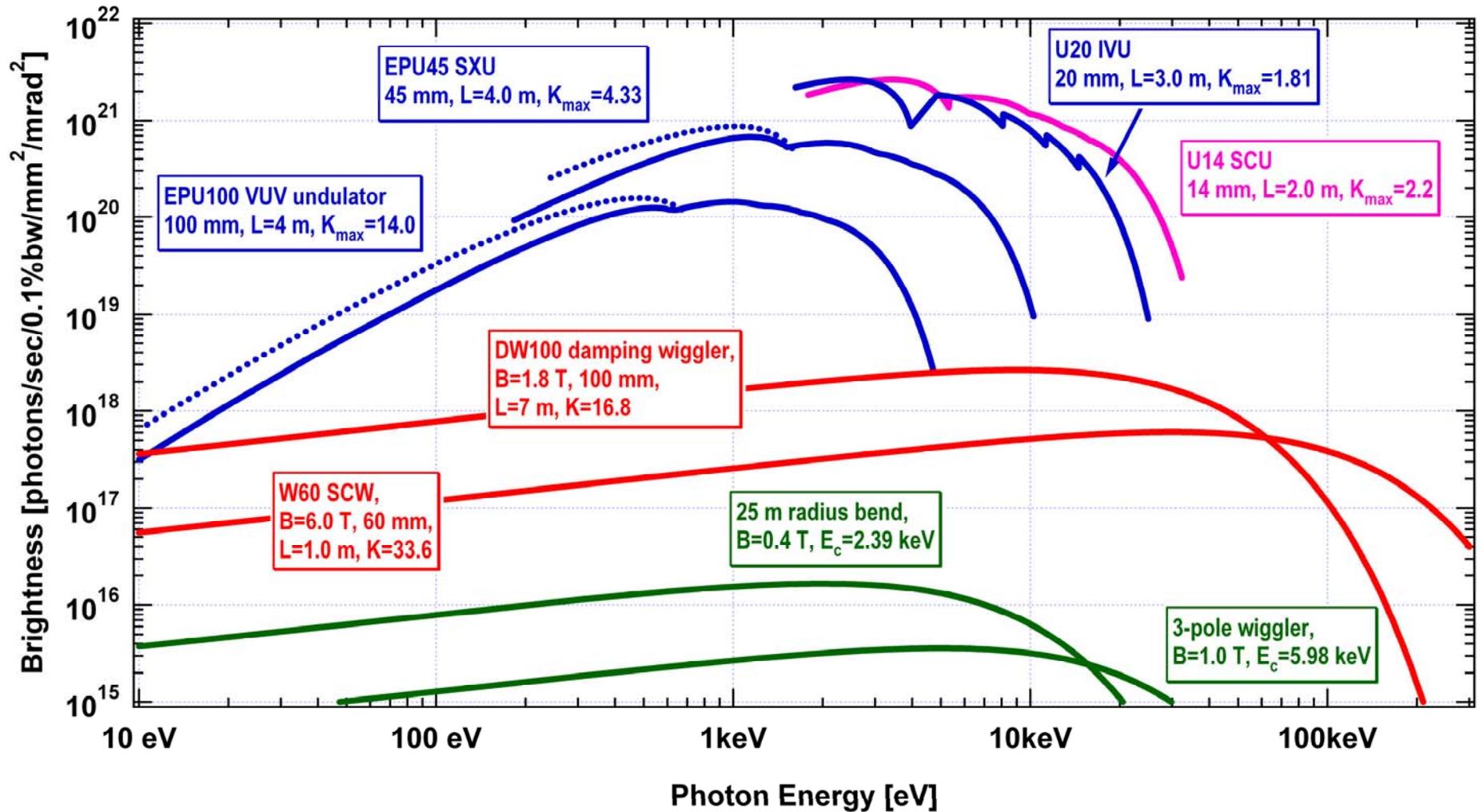
## Top-off operation

- Current stability better than 1%

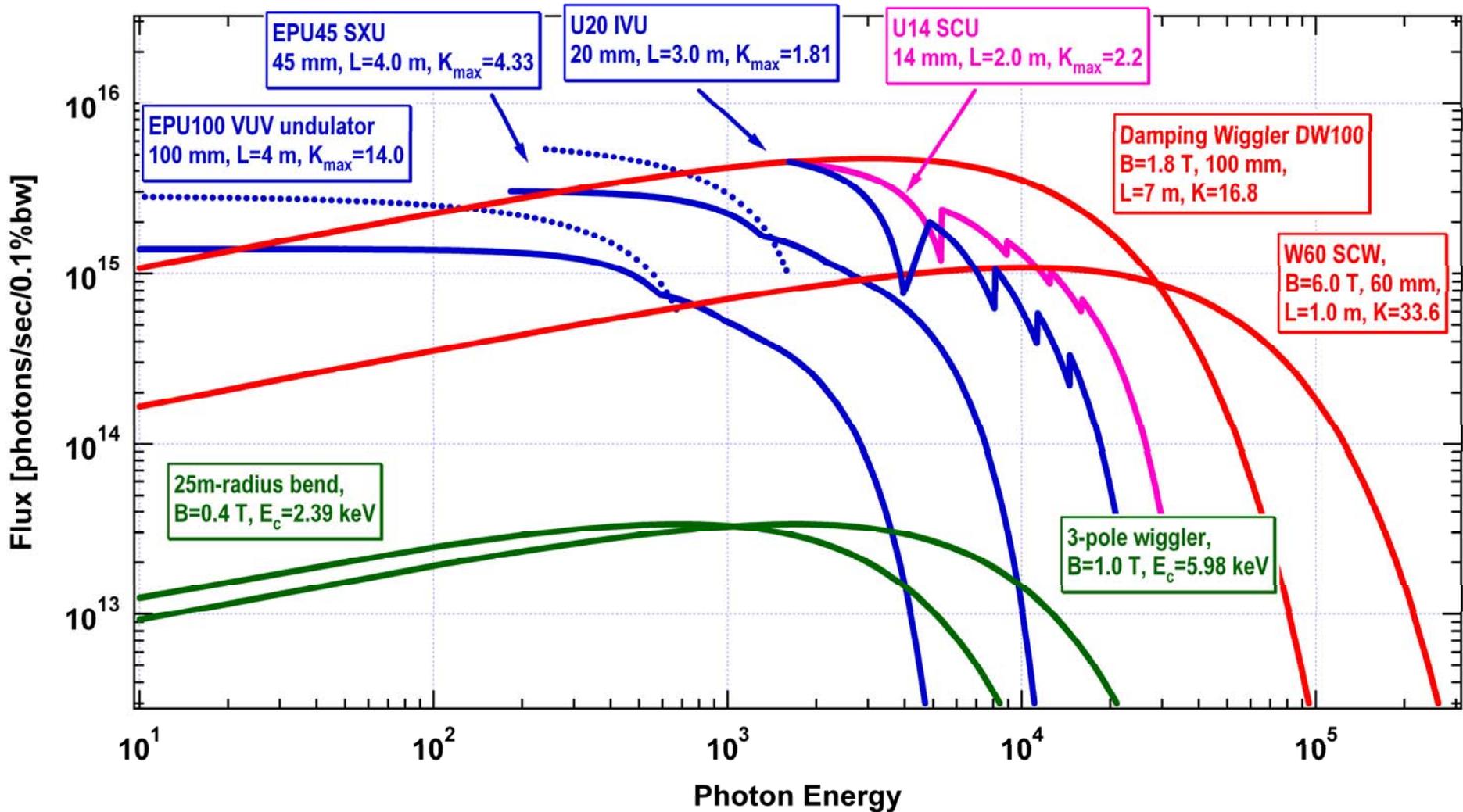
27 straight sections available for insertion device beamlines

31 BM or Three Pole Wiggler ports available for beamlines

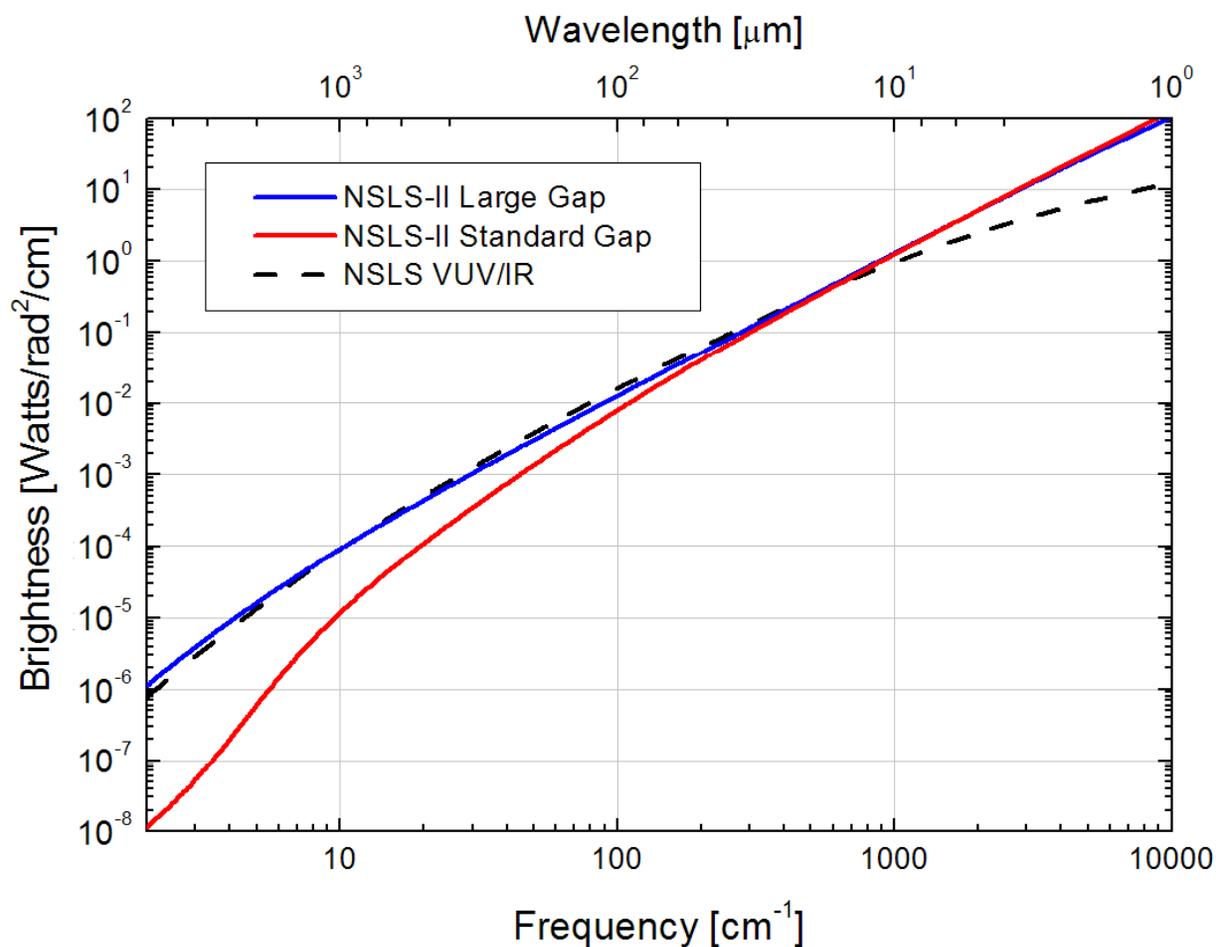
# Radiation Sources: Brightness



# Radiation Sources: Flux

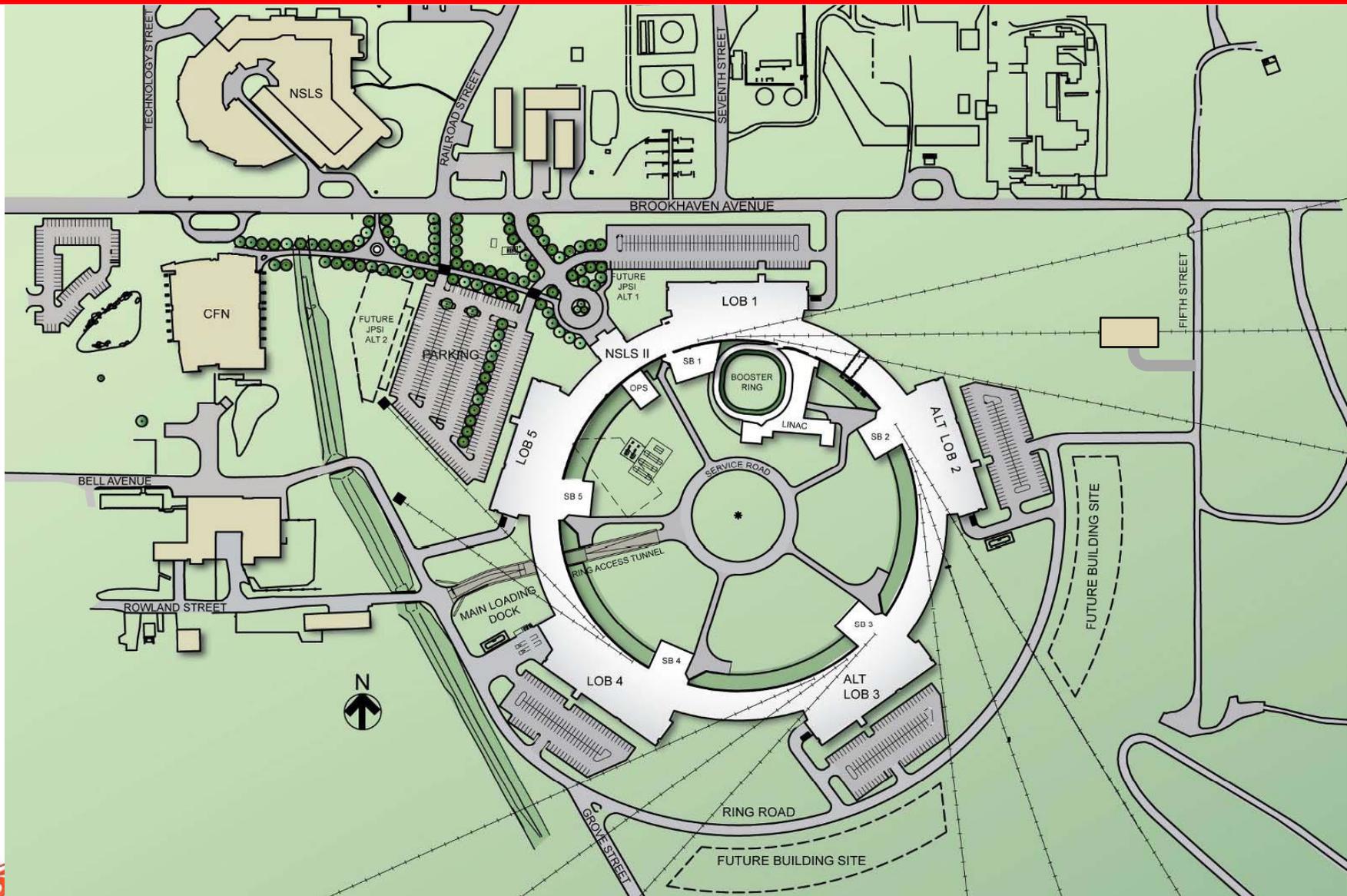


# Radiation Sources: Infra-Red



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

# Master Site Plan



# Lab-Office Building



Lab Office Building - each nominally has:

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

# Key Milestones

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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	

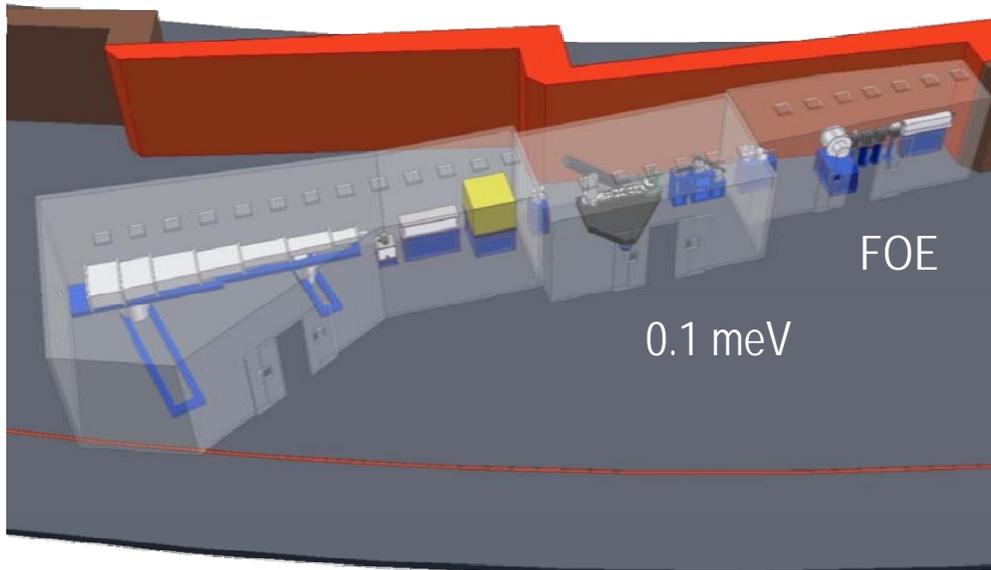
# Project Beamlines

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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  $\beta$  straight
- Requires new optics schemes (R+D)

## Science Mission

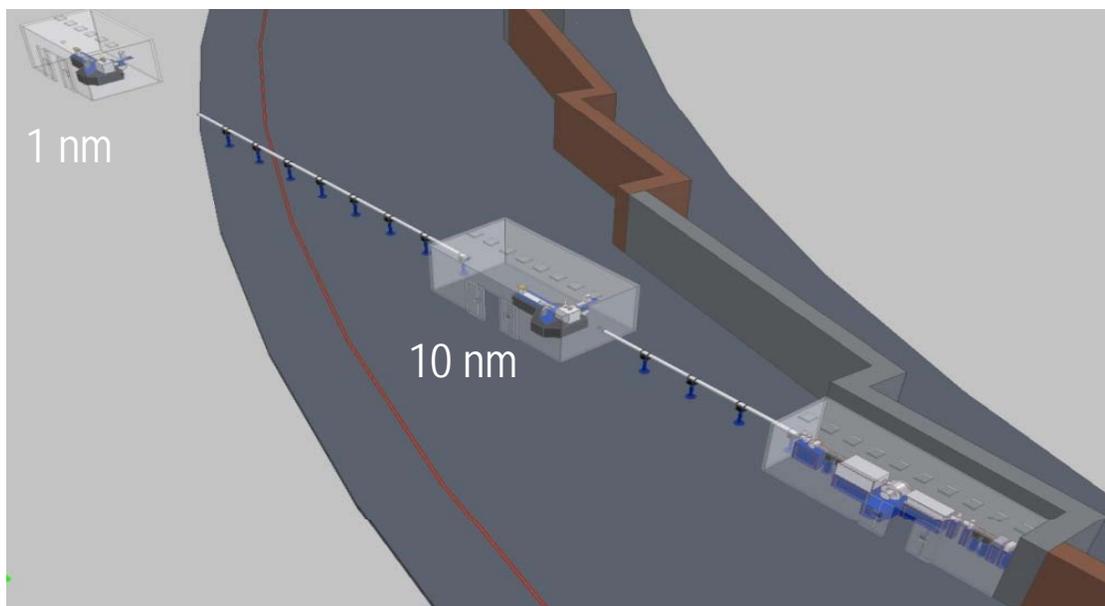
- Visco-elastic behaviors and relaxation processes of disordered systems and complex fluids
- Collective modes in lipid membranes and other biological systems
- Phonons in single crystals, surfaces, thin films, high pressure systems, small samples, strongly correlated systems
- ...

## 0.1 meV Endstation

- Scan range ~ 100 meV
- Q-resolution 0.01 – 0.04  $\text{\AA}^{-1}$ , up to 8  $\text{\AA}^{-1}$
- Spot size < 5  $\mu\text{m}$  (v) x 10  $\mu\text{m}$  (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- $\beta$  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

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## Soft x-ray



- EPU (low- $\beta$ ), operating at 200 to 2000 eV

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

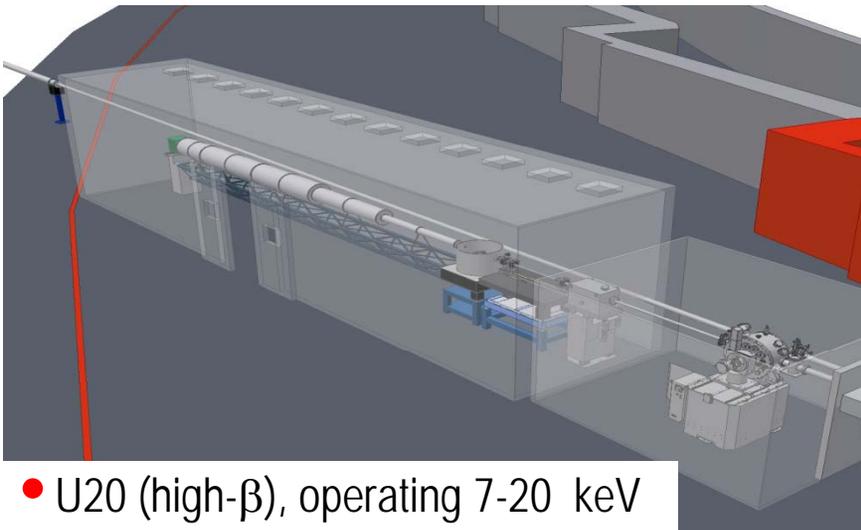
Fast switching of circularly and linearly polarized modes

Spot size  $< 4 \mu\text{m} \times 4 \mu\text{m}$

Flux  $10^{12} - 2 \times 10^{13}$  depending on resolution

1 T field for magnetic measurements

## Hard x-ray



- U20 (high- $\beta$ ), operating 7-20 keV

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

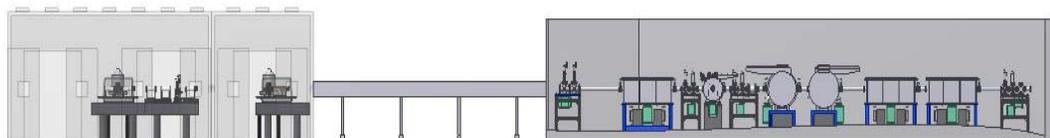
Heavily pixelated detector

Mono and "pink" beam modes

10 m flight path

# Wiggler Beamlines

## XAS



- 90 mm wiggler (high  $\beta$  straight), 5-90 keV

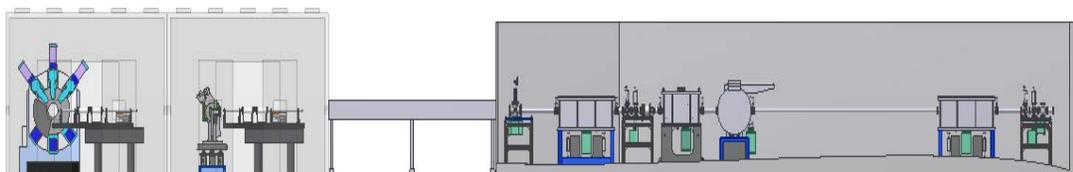
- Bulk XAS and micro-EXAFS
- Materials science and catalysis
- Nanomaterials research
- Environmental science and geology

$4 \times 10^{12}$  in 1 micron spot for micro-XAS

Diamond anvil cell capability

In-situ capabilities, high energy-resolution mode

## Powder



- 90 mm wiggler (high- $\beta$  straight) 20–100 keV

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

0- 50  $\text{\AA}^{-1}$  q-range

Spot size < 1  $\mu\text{m}$  for DAC work

4 – 4000 K sample temperature range

Robotic sample changer

# Beamline Development

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

- Small teams formed by submitting a Letter of Intent (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

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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

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- 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.

# Criteria for Beamline Selection

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- 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

Same criteria used regardless of funding source

# Letter of Interest (cont.)

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Following the blessing of the LOI by the EFAC, the project would then assign resources to work with the BAT for BES funded beamlines 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.

# LOIs (continued)

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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 BAT.

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.

# Timeline

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

# Summary

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- NSLS-II will provide a superb source of extremely bright photons over a wide energy range
- It is a near ideal source for PX, imaging, SAXS, etc, 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.
- The Beamline Advisory Teams will formalize this.

