The NSLS-II Project

Steve Dierker
Associate Laboratory Director for Light Sources, NSLS-II Project Director
HAXPES Workshop
May 20, 2009

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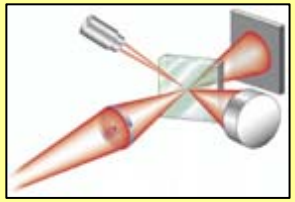
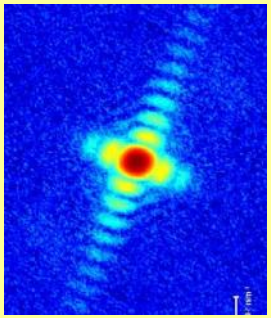
High Level Description of NSLS-II

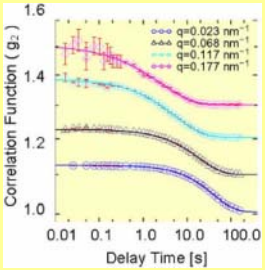
New Capabilities



Nanoprobes



Diffraction Imaging



Coherent Dynamics

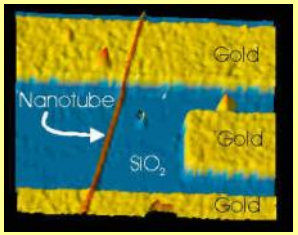
Highly optimized x-ray synchrotron delivering:

- extremely high brightness and flux
- exceptional beam stability
- suite of advanced instruments, optics, and detectors that capitalize on these special capabilities

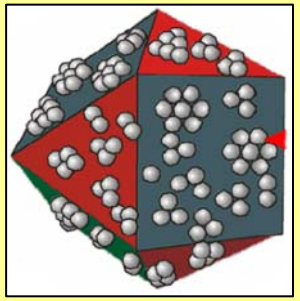
Together, these enable

- ~ 1 nm spatial resolution
- ~ 0.1 meV energy resolution
- single atom sensitivity

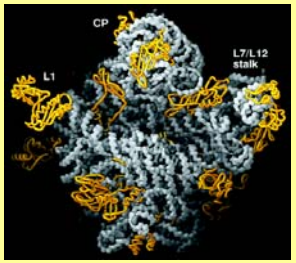
New Science



Nanoscience



Nanocatalysis



Life Science

Project Scope

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

Conventional Facilities
- Ring Building and Service Buildings
- Laboratory/Office Buildings (LOBs) to house beamline staff & users
- 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
- Advanced insertion devices

NSLS-II Design Features

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)

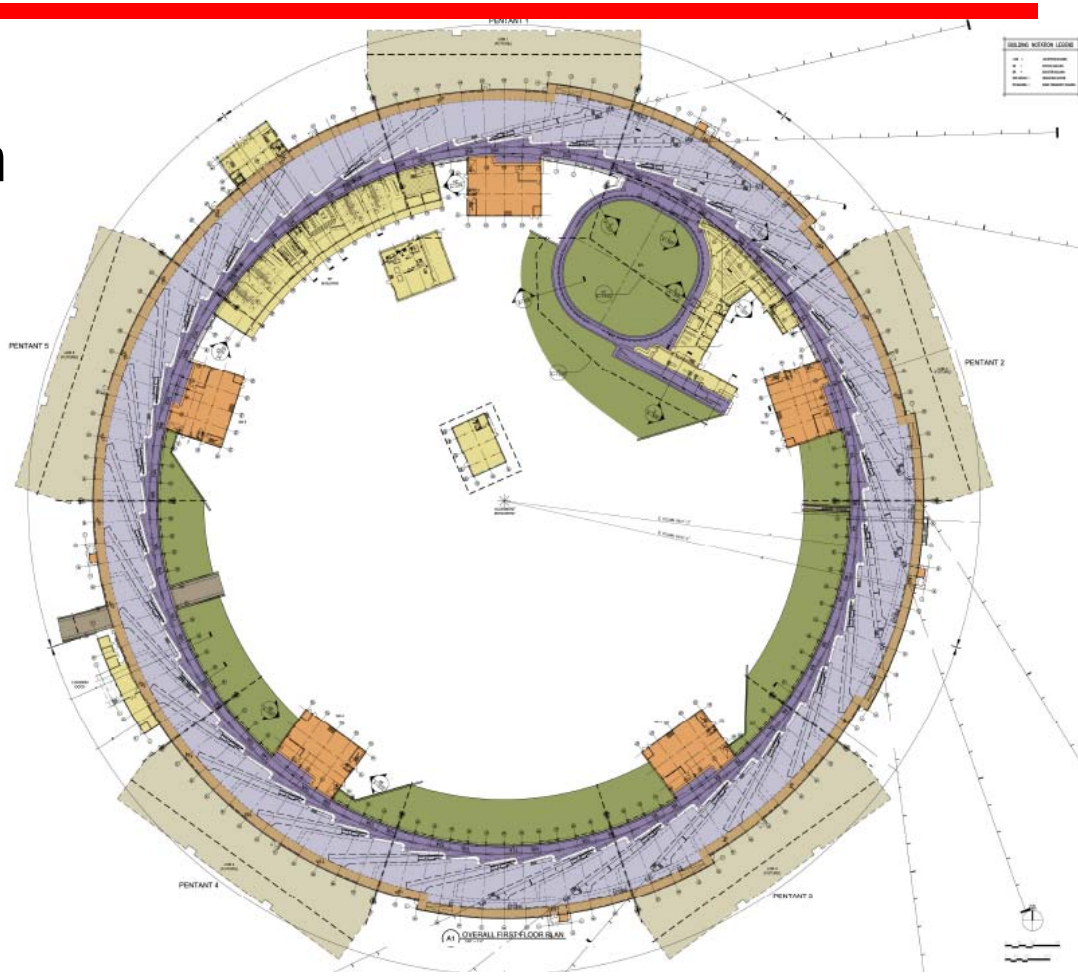
Novel design features:

- 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 12 keV
- Small beam size: σ_y = 2.6 μm, σ_x = 28 μm, σ'_y = 3.2 μrad, σ'_x = 19 μrad

Pulse Length (rms) ~ 15 psec



NSLS-II Beamlines

19 straight sections for undulators

- 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 wigglers

- 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

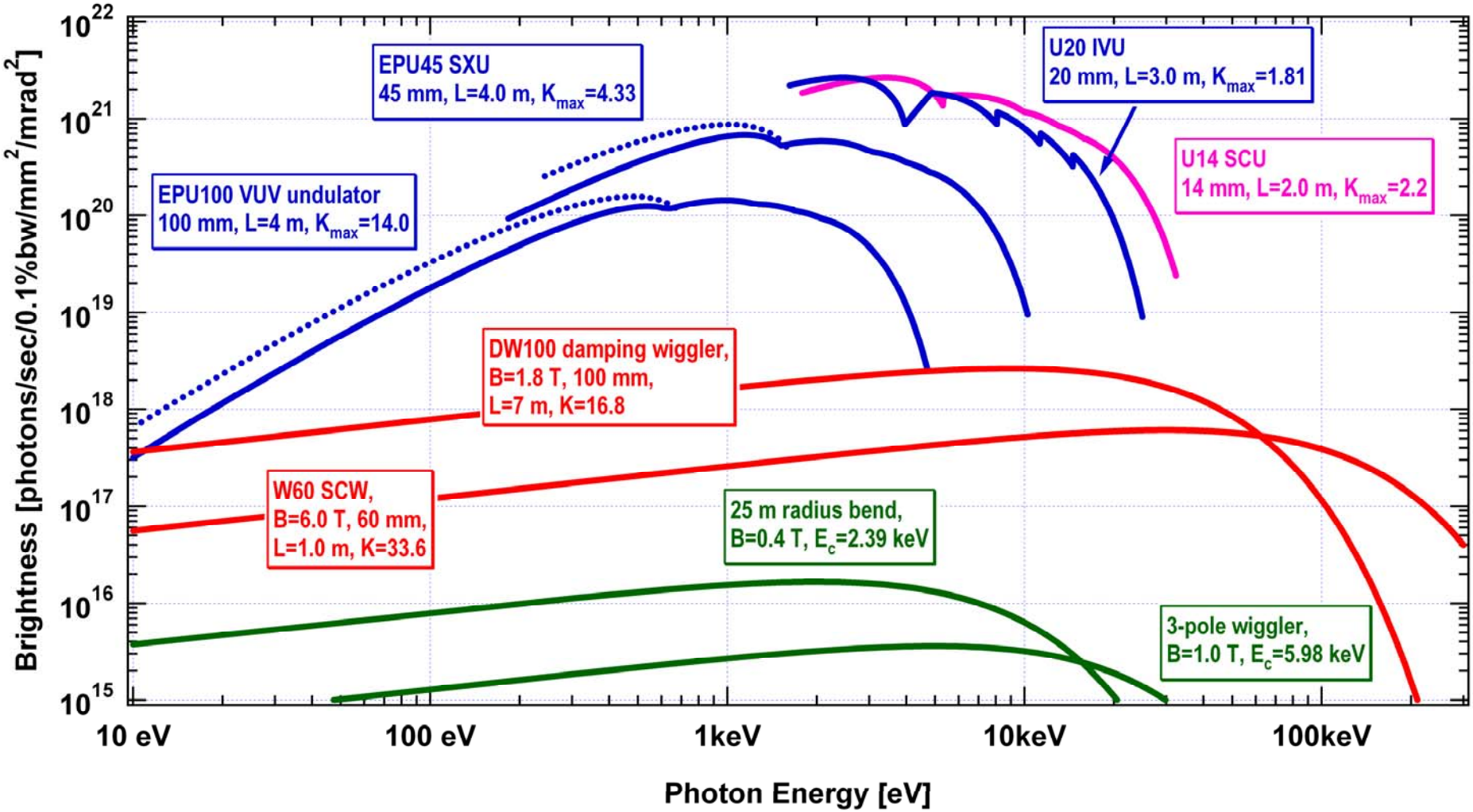
- These can also have three pole wigglers for hard x-rays

4 Large Gap BM ports for far-IR

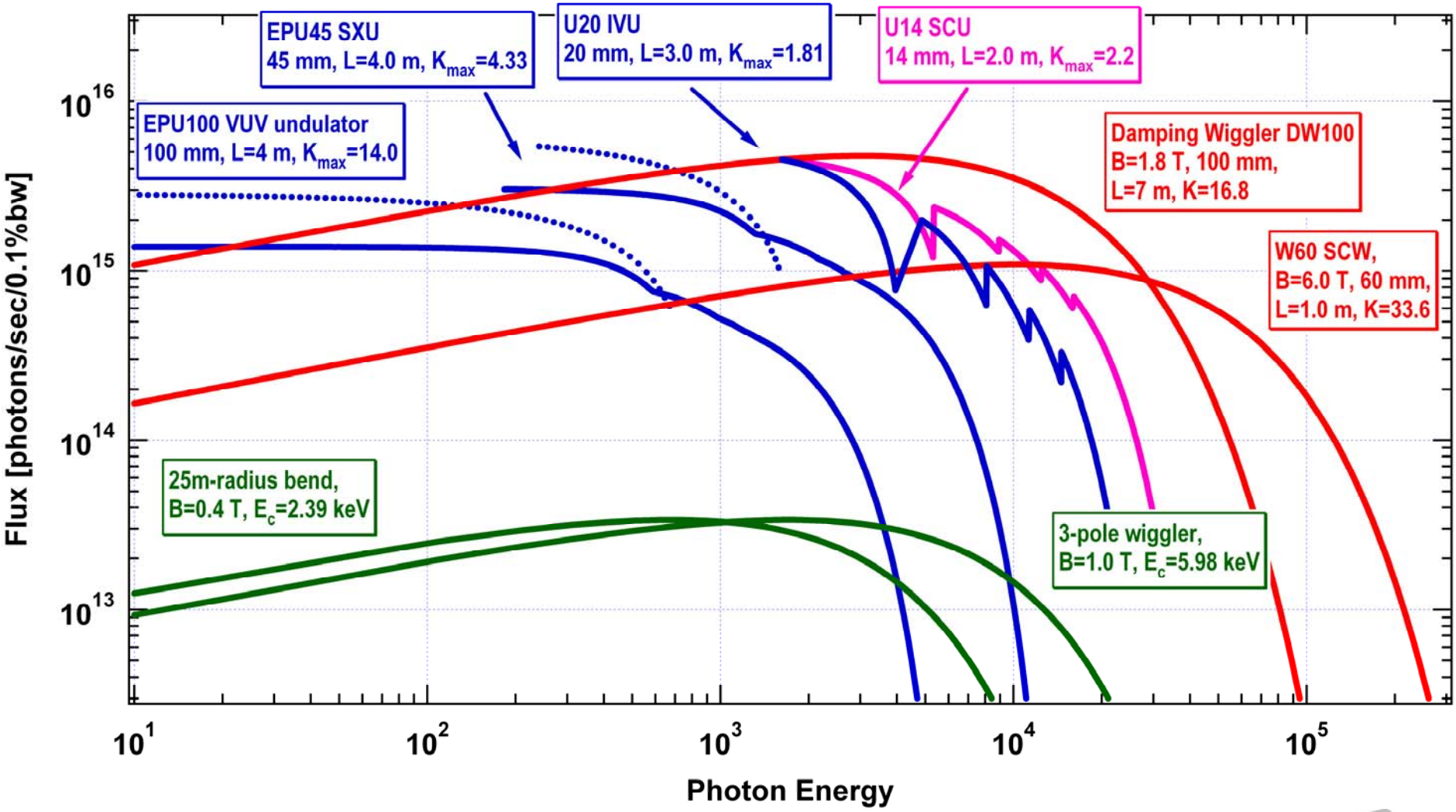
At least 58 beamlines
More beamlines by canting multiple IDs per straight
Multiple end-stations/beamline are also possible

For comparison, NSLS has 65 operating beamlines

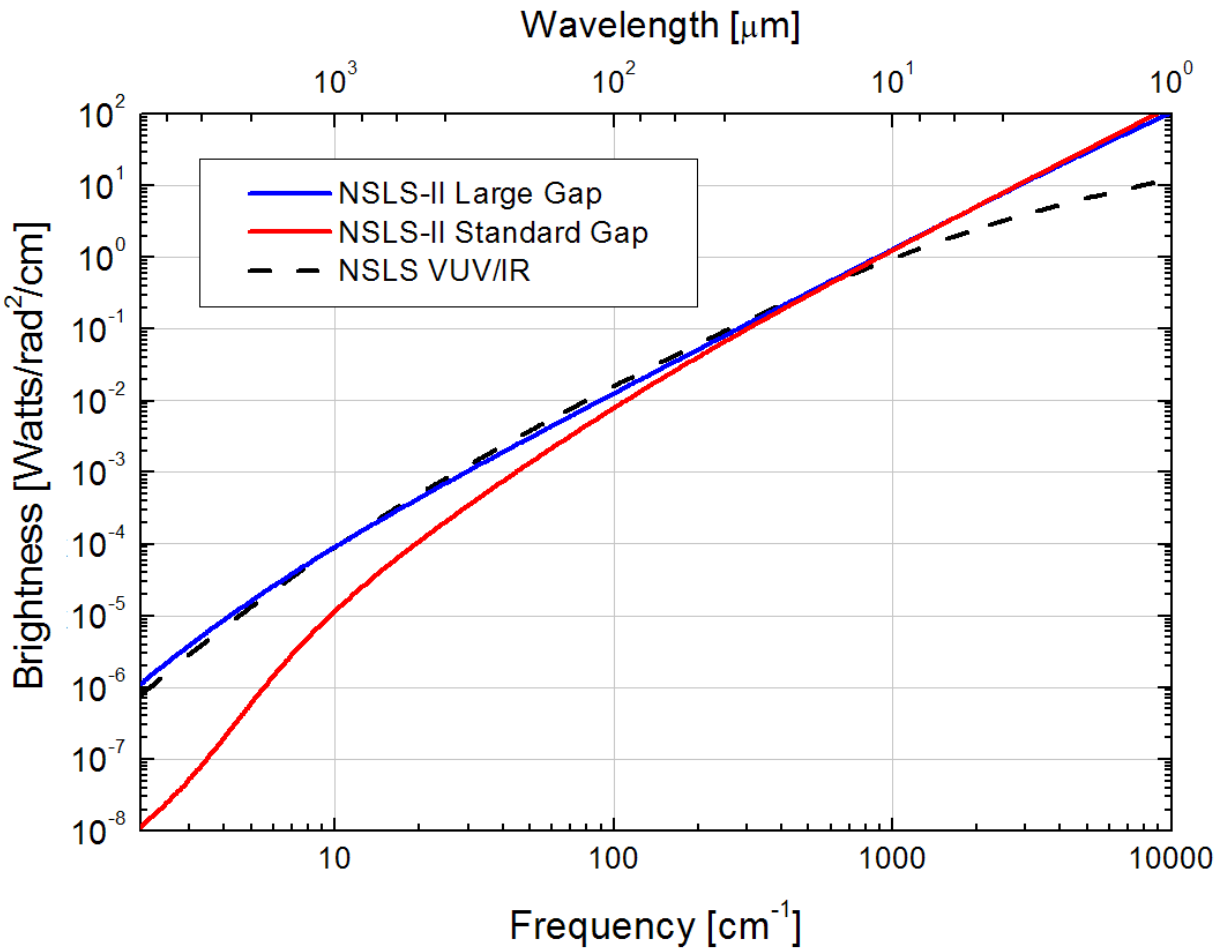
Radiation Sources: Brightness



Radiation Sources: Flux



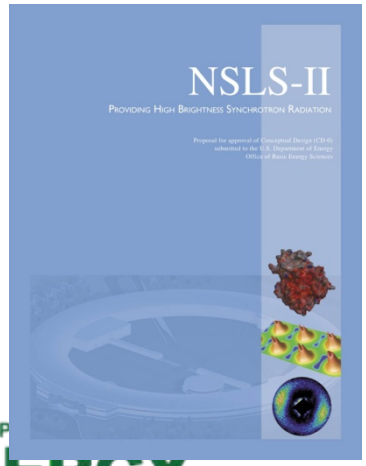
Radiation Sources: Infra-Red

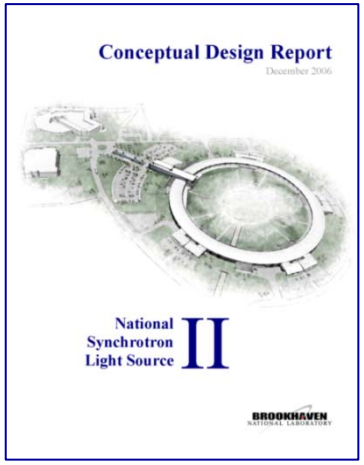


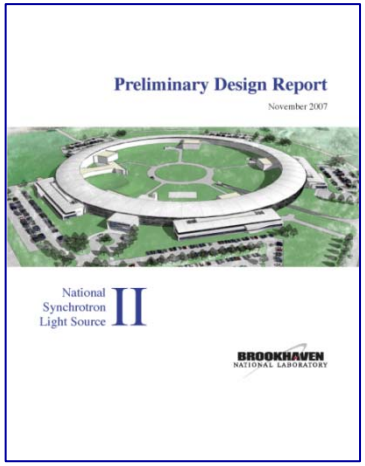
- World leading IR extracted from Bend Magnets
- Large gap dipoles (90 mm) boost performance in far-IR

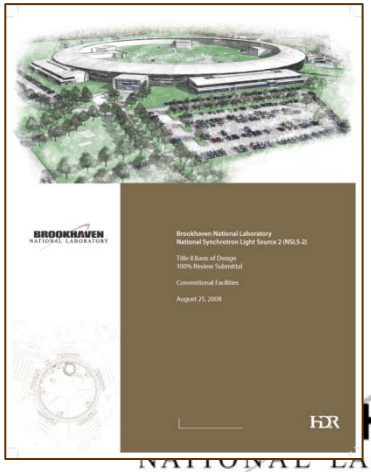
Key Project Milestones

Aug 2005	CD-0, Approve Mission Need	(Complete)
Jul 2007	CD-1, Approve Alternative Selection and Cost Range	(Complete)
Jan 2008	CD-2, Approve Performance Baseline	(Complete)
Jan 2009	CD-3, Approve Start of Construction	(Complete)
Feb 2009	Contract Award for Ring Building	(Complete)
Aug 2009	Contract Award for Storage Ring Magnets	
Mar 2010	Contract Award for Booster System	
Feb 2011	1st Pentant Ring Building Beneficial Occupancy; Begin Accelerator Installation	
Feb 2012	Beneficial Occupancy of Experimental Floor	
Oct 2013	Start Accelerator Commissioning	
Jun 2014	Early Project Completion; Ring Available to Beamlines	
Jun 2015	CD-4, Approve Start of Operations	



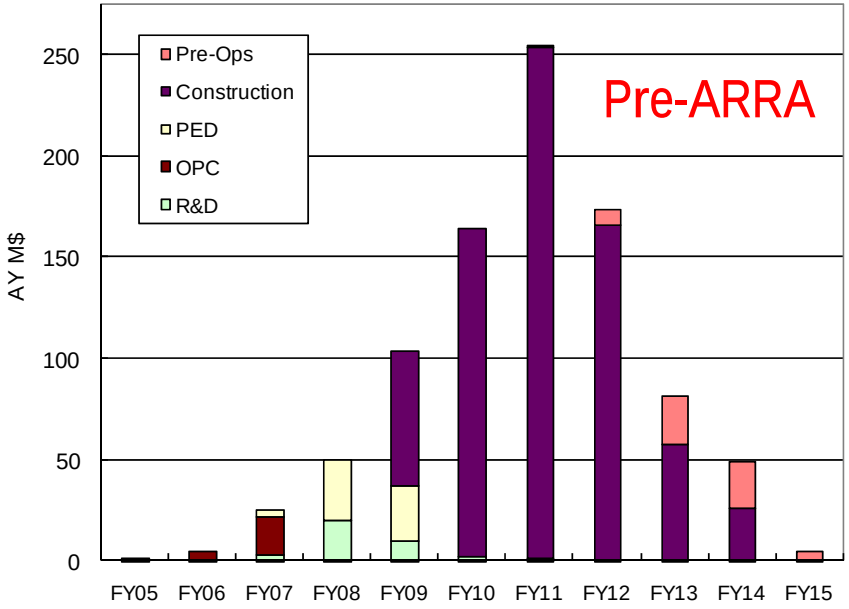


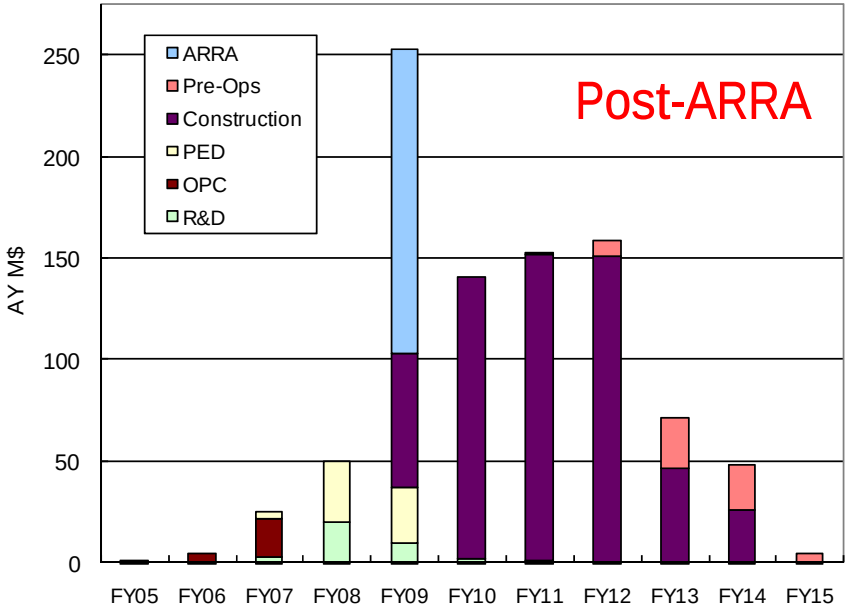




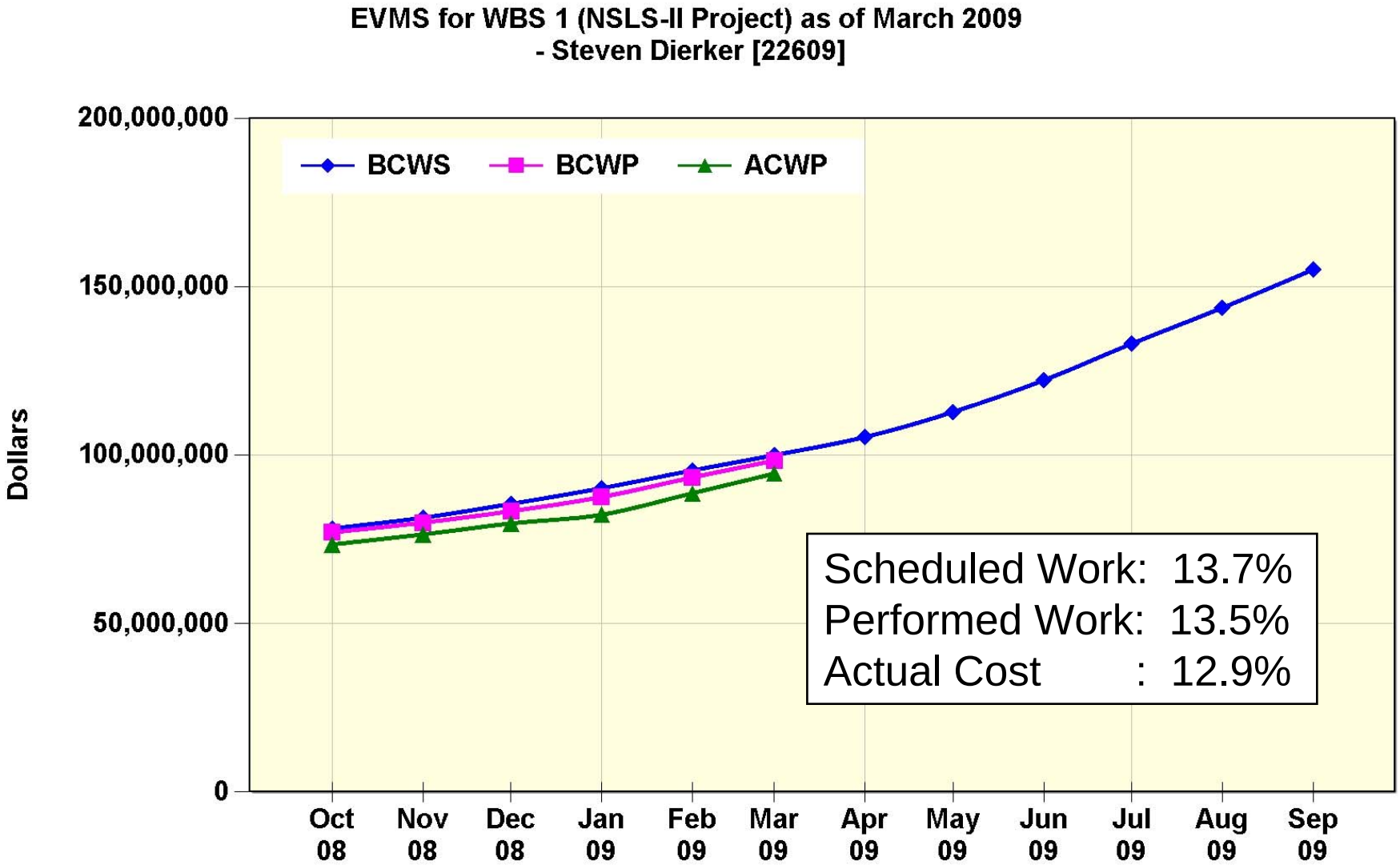
Project Funding

- FY09 Omnibus Bill passed on March 12 included $103M funding for NSLS-II
- Stimulus bill provided $150M additional funding allocation for NSLS-II project: TPC remains same ($912M) but profile changed
  - Accelerates Ring Building, LOBs, Chilled Water, Electrical Substation, Unit Substations
  - Front loaded profile: exactly what we need





On Budget and On Schedule



NSLS-II Management Team

Steven Dierker
Associate Lab Director for Light Sources
Project Director

Aesook Byon
Deputy Project Director

James Yeck
Assistant Project Director for
Conventional Construction

Satoshi Ozaki
Senior Project Advisor

Ferdinand Willeke
Accelerator Division

Qun Shen
Experimental Facilities Division

Wayne Hendrickson
Associate Project Director
for Life Sciences

Martin Fallier
Conventional Facilities Division

Diane Hatton
Project Support Division

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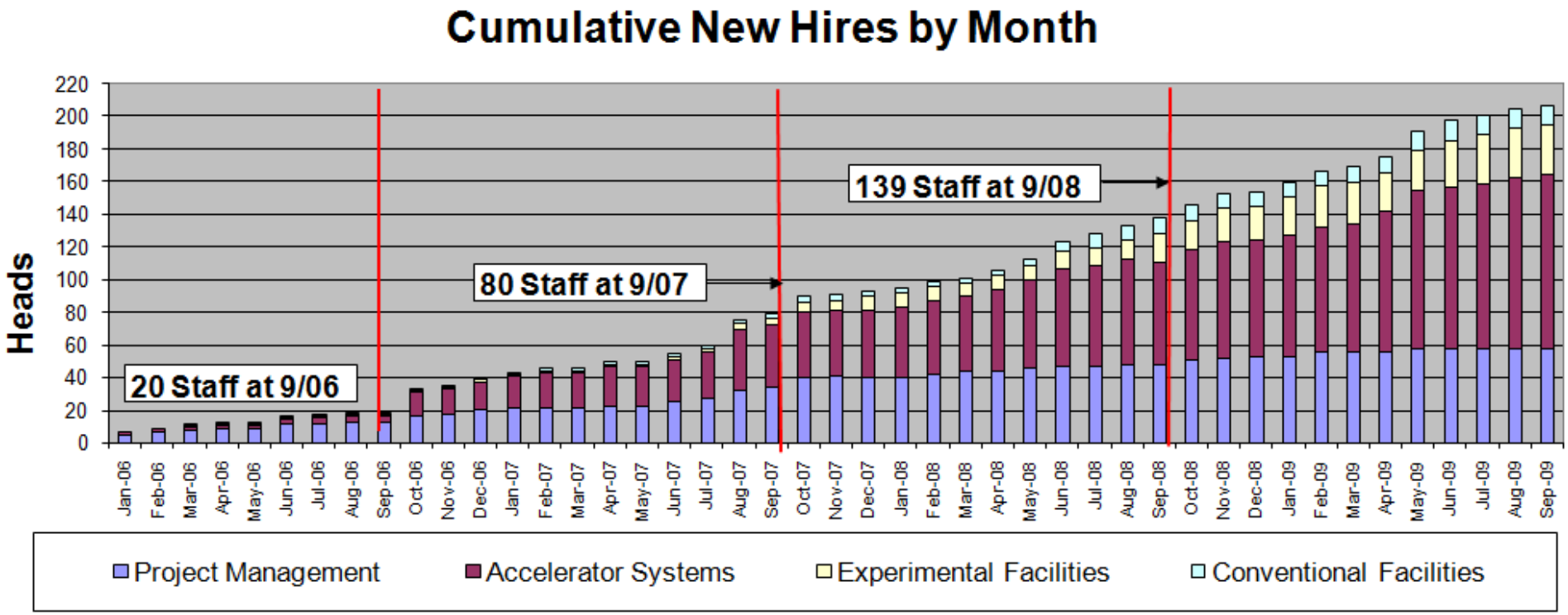
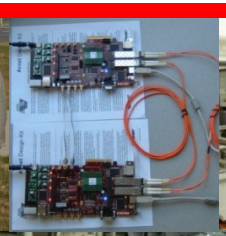
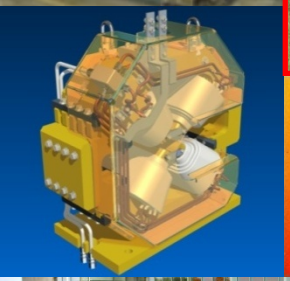
Progress on NSLS-II Staffing

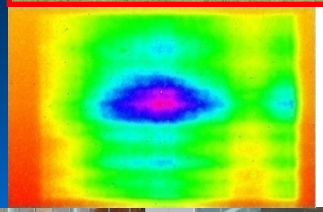
- Total hires now at 207
- 20 Open Requisitions with 8 offers in process

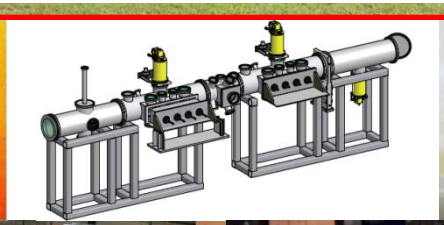


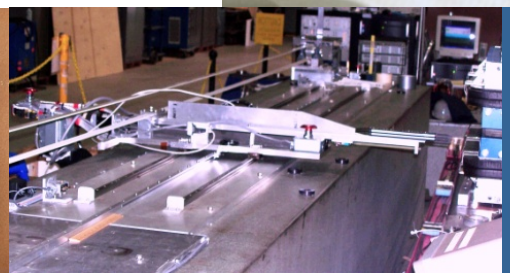
Great Progress

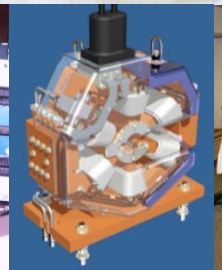






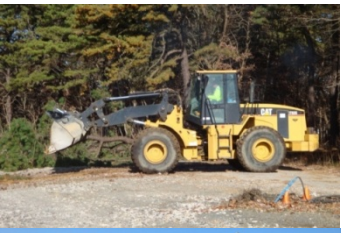






Conventional Facilities Progress

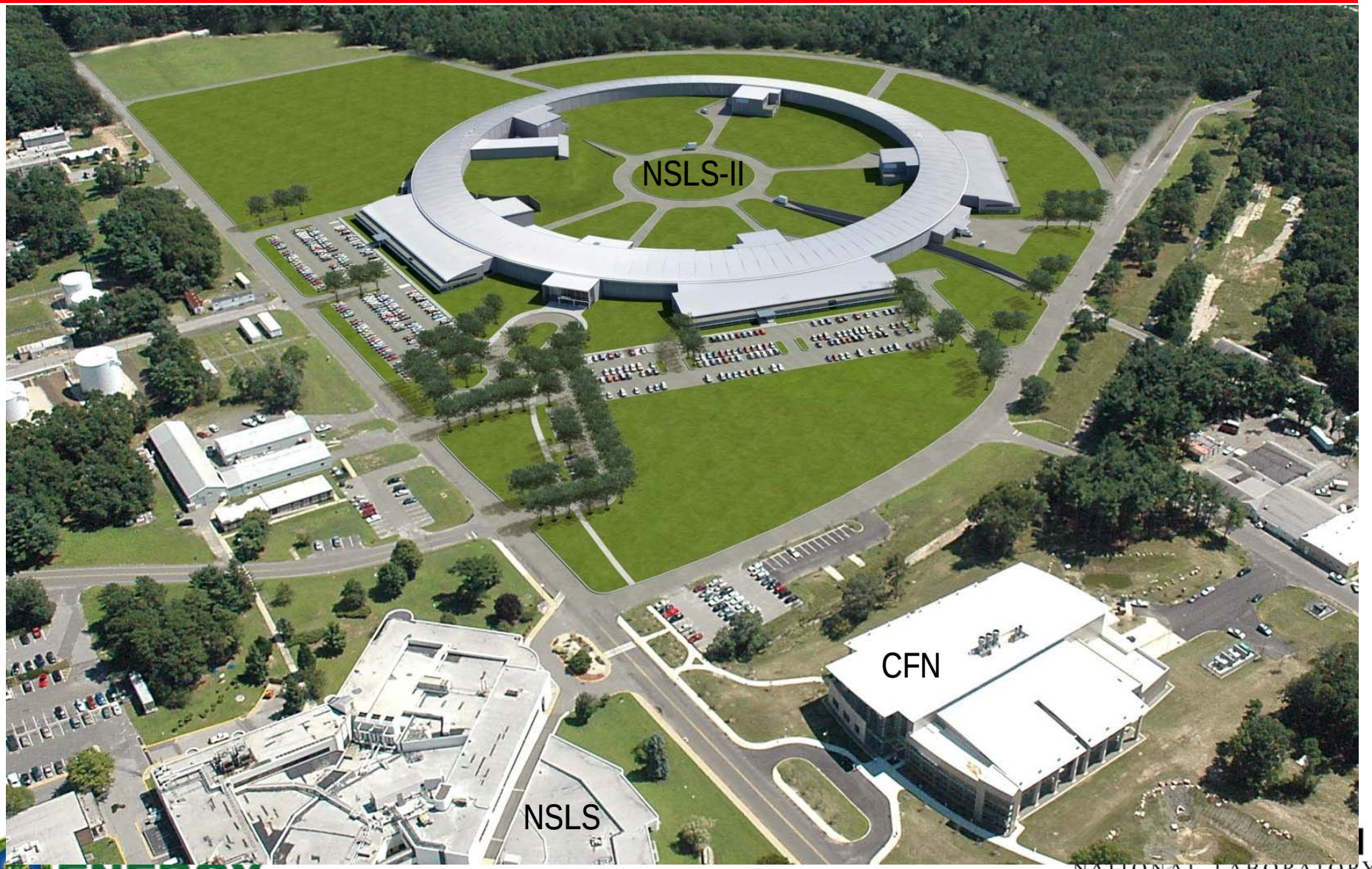
- Ring building bid package released to industry on Oct 1, 2008
- General Contractor bids received December 5
- Torcon, Inc was selected as the General Contractor for the Ring Building construction
  - Price consistent with baseline - enables retirement of significant risk



Contract Signing – February 18, 2009

- Site Preparation completed Feb 17

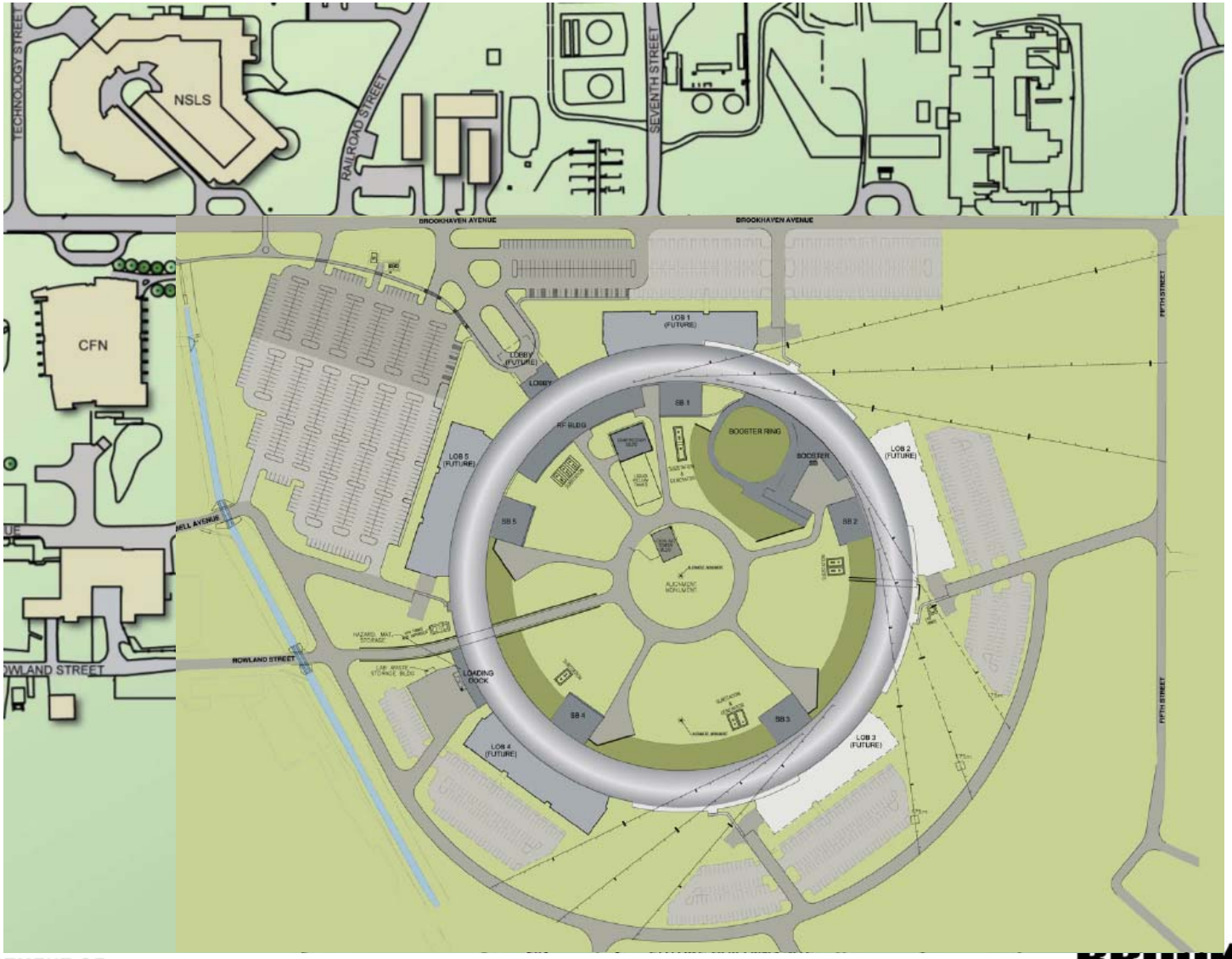
Aerial View



Construction Site Work Underway

Construction webcam at http://www.bnl.gov/nsls2/webcam/

Site Plan



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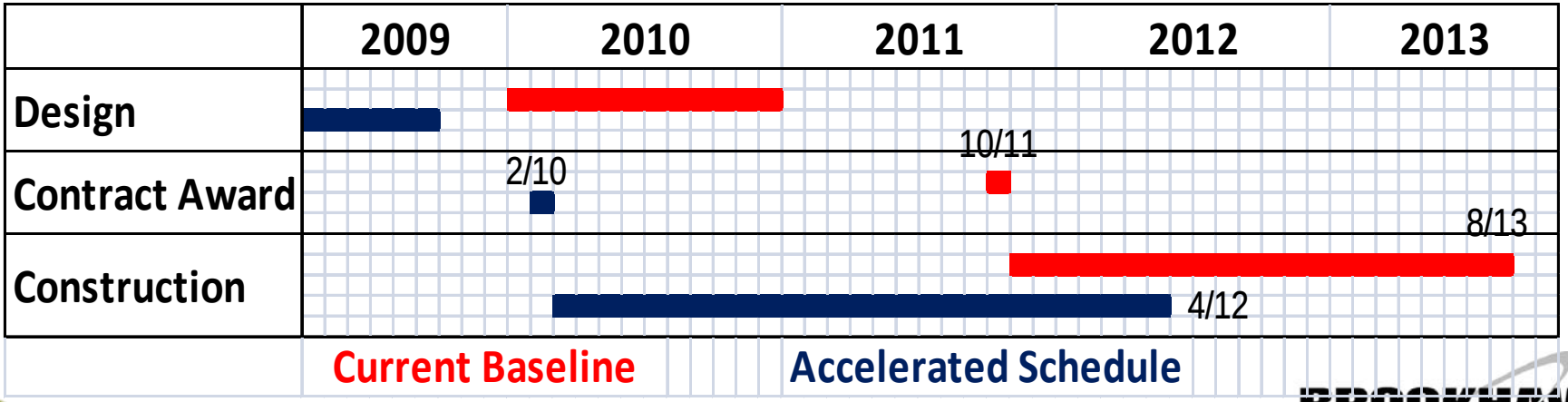
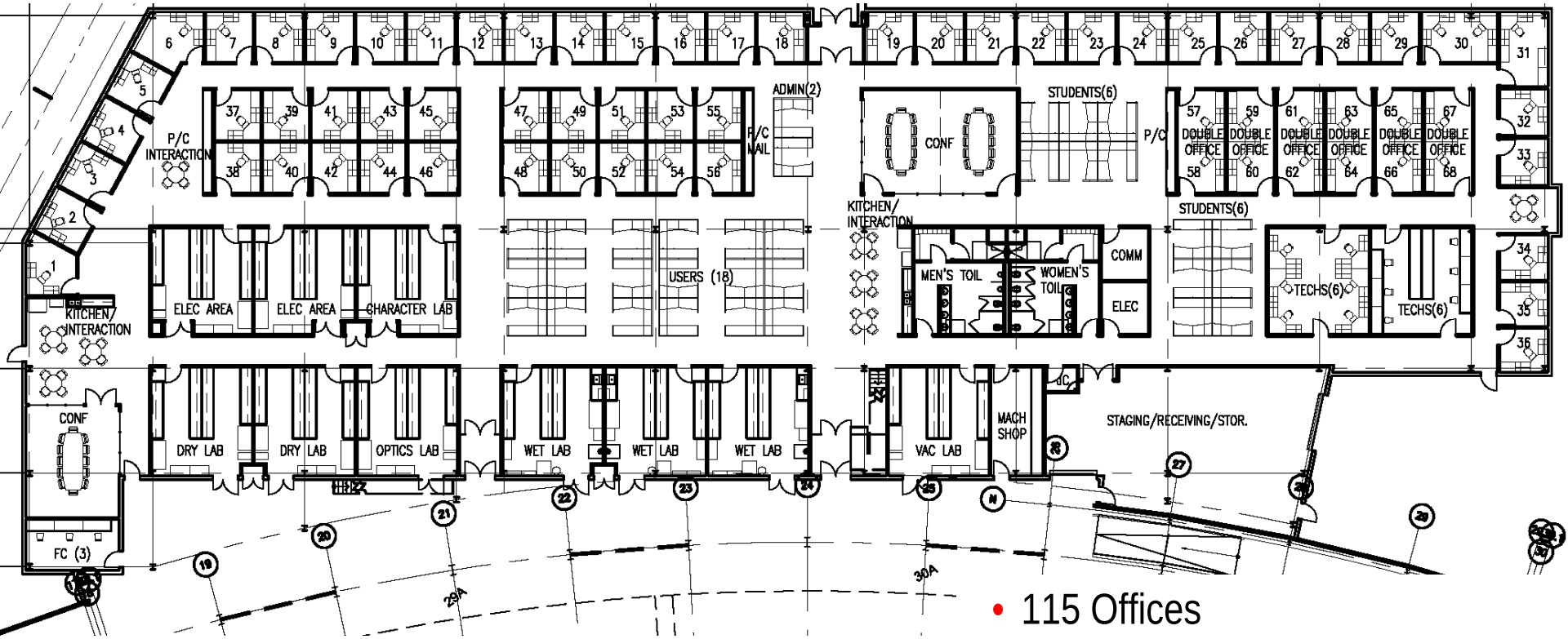
Advancing LOB Design

- Design paused after conceptual design phase
- Ring Building Contractor has indicated ideal time for LOB start would be mid FY10 from standpoint of constructability as well as efficiency
- Advancing LOB design and construction
  - To improve constructability and efficiency
  - To capitalize on current market conditions
  - To fulfill (comply) ARRA justification (requirement)
  - To minimize risks and challenges during commissioning & early operations of accelerator and beamlines



Lab-Office Building: Optimized Design

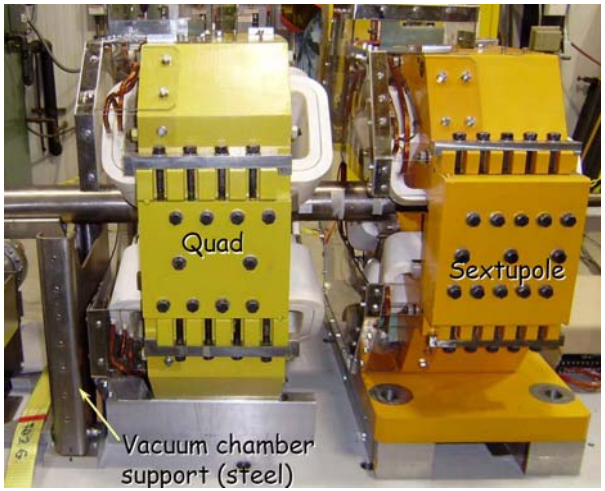


	Baseline	Optimized
Offices	8,206 ft^2	11,000 ft^2
Labs	2,883 ft^2	6,000 ft^2
Other space	12,910 ft^2	17,000 ft^2
Total Size	24,000 ft^2	34,000 ft^2

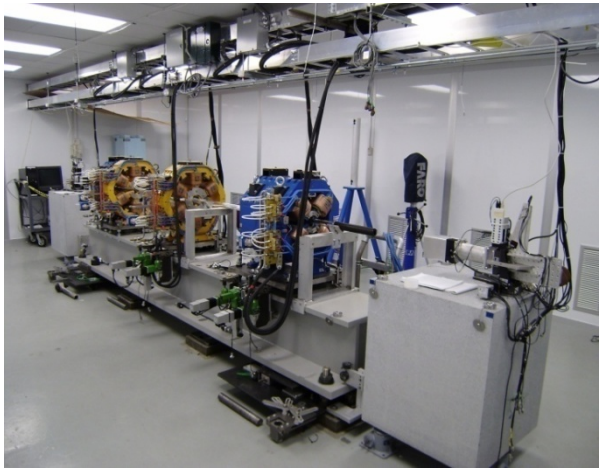
- 115 Offices
- 10 labs
- Machine shop
- Conference Rooms
- Interaction Areas
- Loading/storage area

Accelerator Systems Progress

- Storage Ring
  - All prototype magnets completed & met performance spec
  - Magnet RFP released; contract award by mid-August
  - Support Systems, girder positioning tests completed successfully
  - Vacuum 2nd dipole vacuum chamber prototype successfully bent
- Electrical Systems
  - Circuit schematics completed and component tests underway
- Instrumentation
  - Prototype of High Stability BPM stand assembled
  - BPM Electronics & controls requirements developed
- Insertion Devices
  - Development of Bldg 832 for ID-Lab laboratory underway
  - Technical docs for damping wiggler design contract prepared
  - Simulations of NSLS-II Elliptically Polarized Undulator (EPU)



Magnet Measurements at BNL


Environmental Room for
Magnet Alignment on Girders

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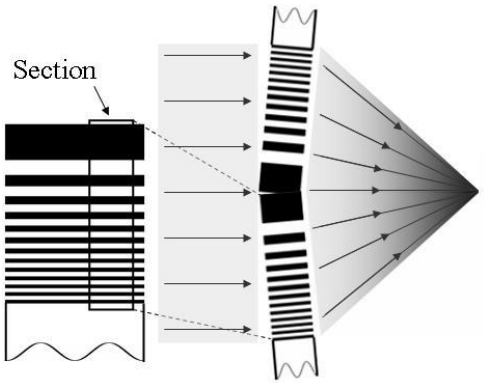
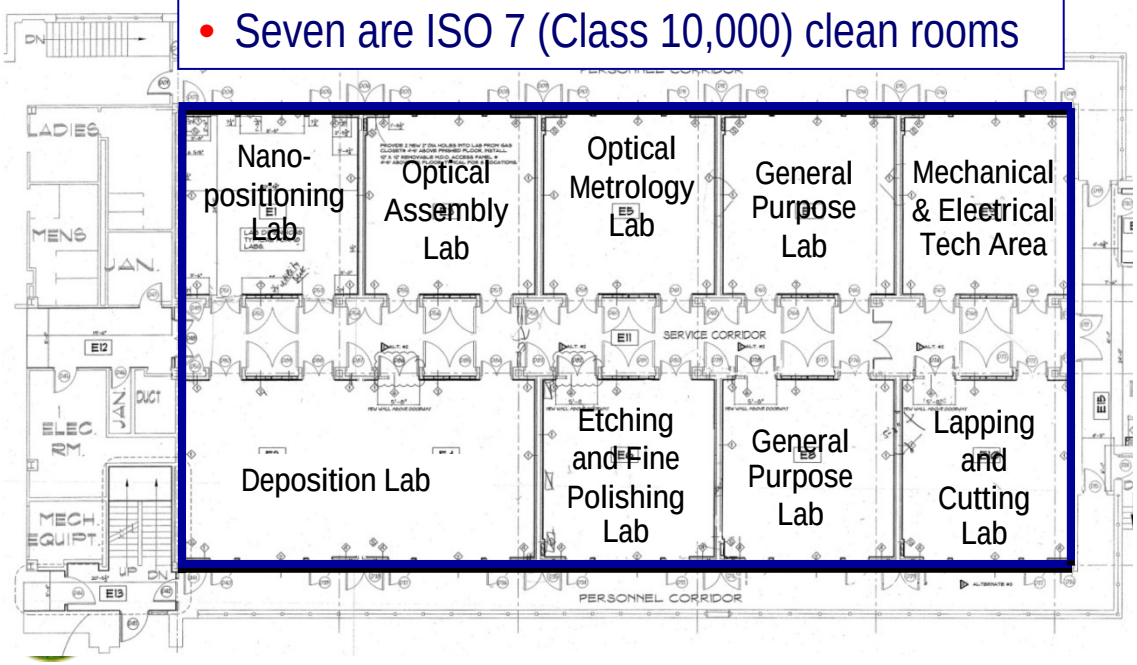
Experimental Facilities R&D Program

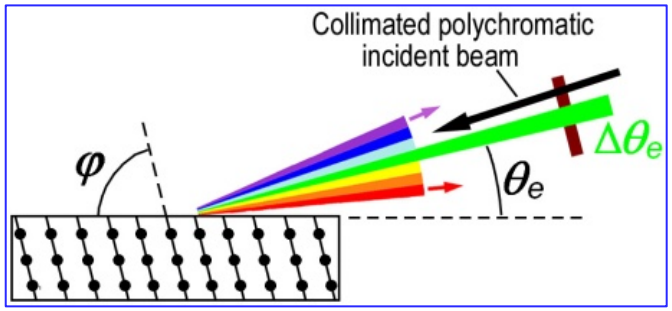
- 1 nm focusing optics and nanopositioning
- 0.1 meV high-resolution optics
- X-ray beam position monitors
- Optical figure control (heat load, metrology)



Yan, Conley, Lima, Chu (NSLS-II); Maser, Macrander, Rose, Stephenson, et al. (ANL)

- Nine R&D labs (5,200 ft^2) have been created in the east wing of Bldg 703
- Seven are ISO 7 (Class 10,000) clean rooms





Cai, Huang, Honnicke, Keister, Coburn, Struble (NSLS-II); Shvyd'ko (APS)

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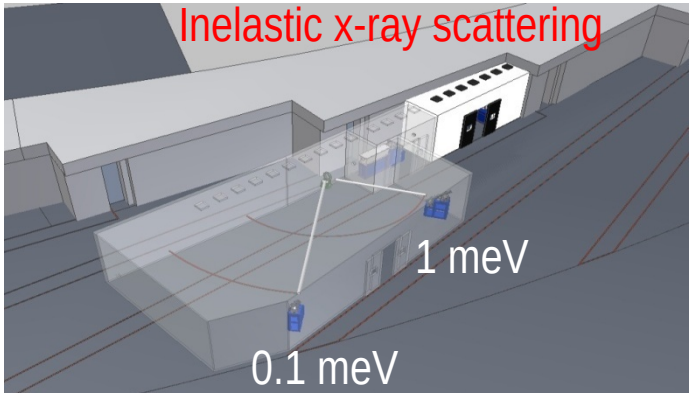
Beamline Acquisition Strategy

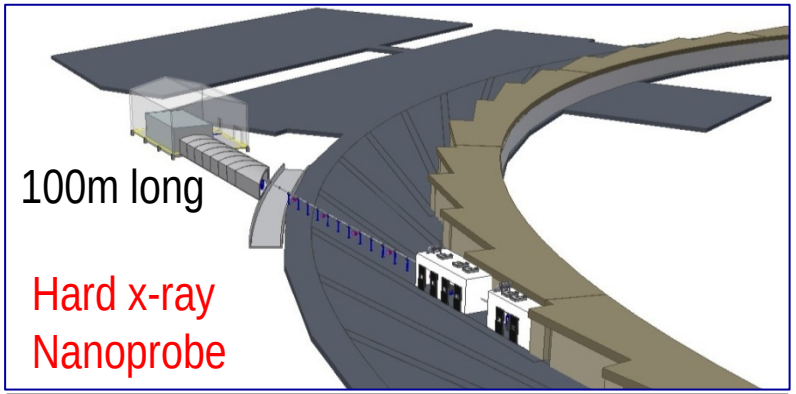
FUNDING	BEAMLINES
BES – Project	6 insertion device beamlines in base project scope
BES – Early Operations	~ 20 bending magnet beamlines transferred from NSLS to NSLS-II, using NSLS-II early operations funding
BES – MIE	~ 16 insertion device beamlines
Non-BES	Life Science beamlines and other non-BES missions

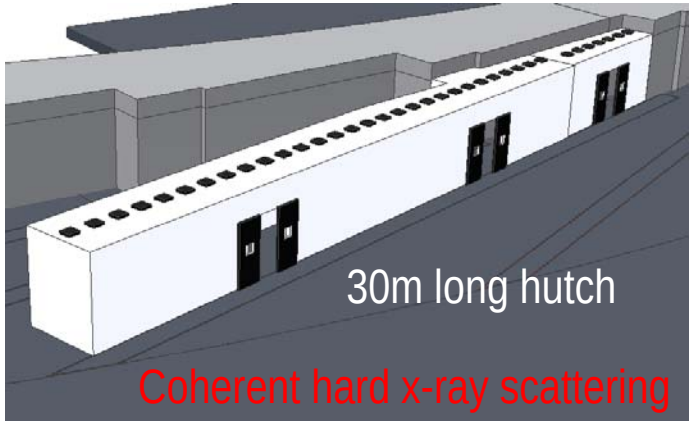
Project Beamlines: LOI Reviews & Decisions

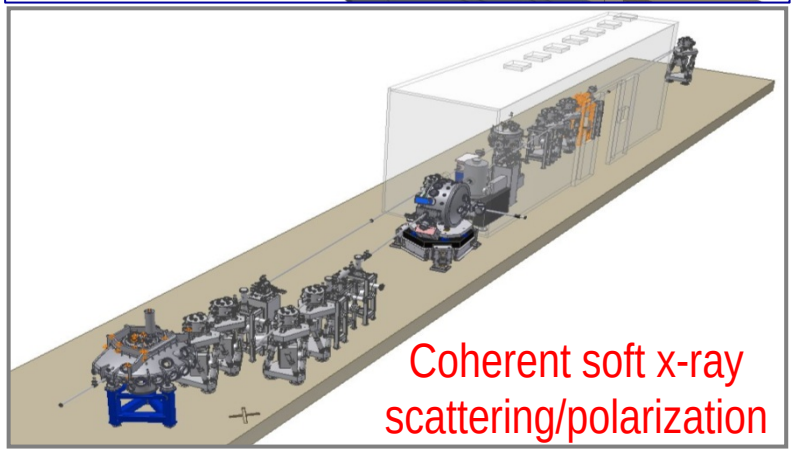
- Beamline and strategic planning workshops held January-March 2008
- Received 11 Letters of Interest (LOIs) from groups wanting to form Beamline Advisory Teams (BATs) for the project beamlines
- LOIs were reviewed by external reviews and Experimental Facilities Advisory Committee (EFAC). EFAC met May 5-7, 2008 and heard presentations from all 11 LOIs. EFAC report received June 2008.
- NSLS-II carefully evaluated the EFAC rankings and recommendations, and additional information in submitted LOI, external peer reviews, oral presentations and dialog at the EFAC meeting, as well as reviewers' comments at technical and project reviews, and overall project priorities.
- Final decision on project beamline selection was communicated with DOE program office and announced at end of August 2008.

Six Project Beamlines at NSLS-II

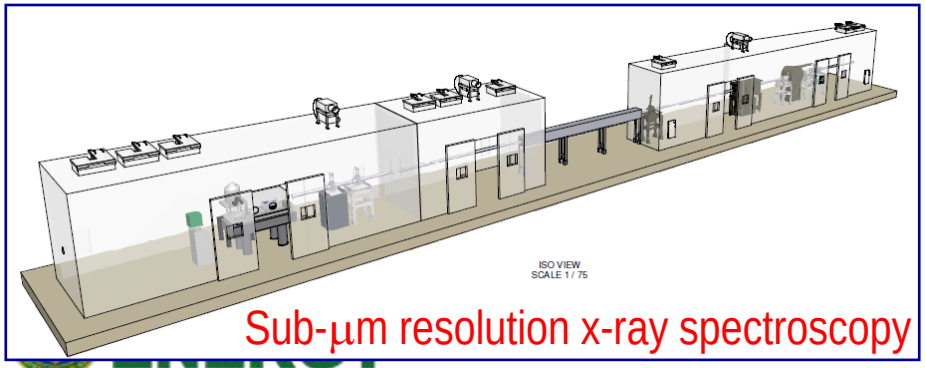


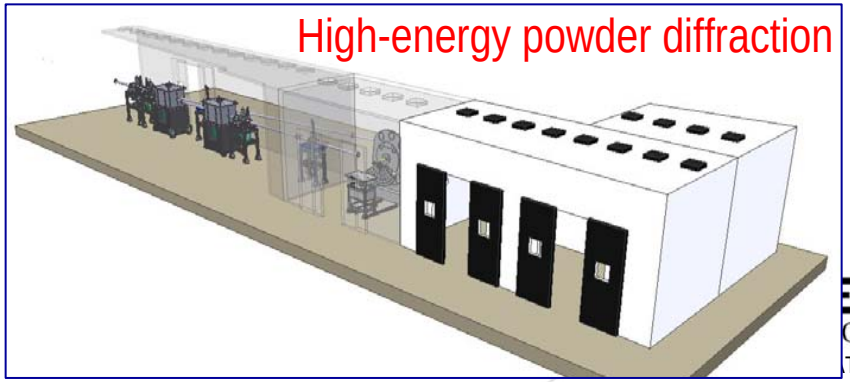






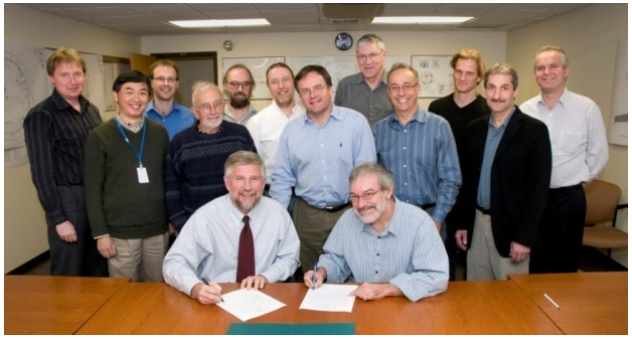
- Initial suite of insertion device beamlines
- Unique, world-leading characteristics
- Meet the needs of user community
- Enable new science



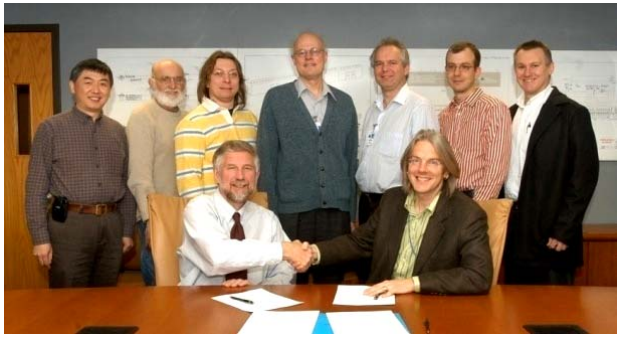


BAT Meetings

- All Beamline Advisory Teams (BATs) have completed first official meetings:
  - Good progress made on scientific and technical scopes
  - Beamline conceptual designs in progress



SRX BAT, October 30, 2008



XPD BAT, November 24, 2008

IXS BAT, December 5, 2008

CHX BAT, December 9, 2008

CSX BAT, January 8, 2009

HXN BAT, January 26, 2009

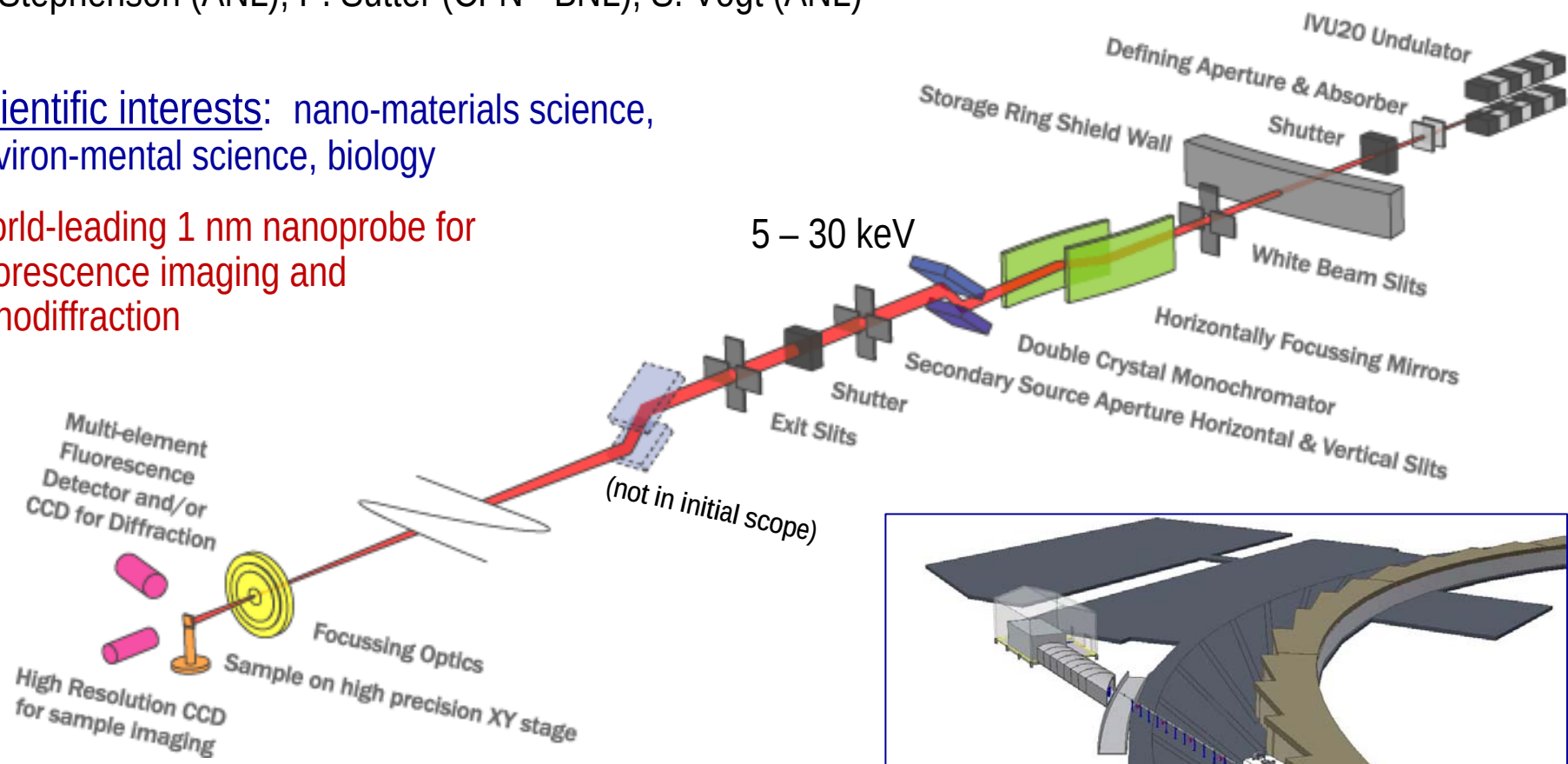
Hard X-ray Nanoprobe

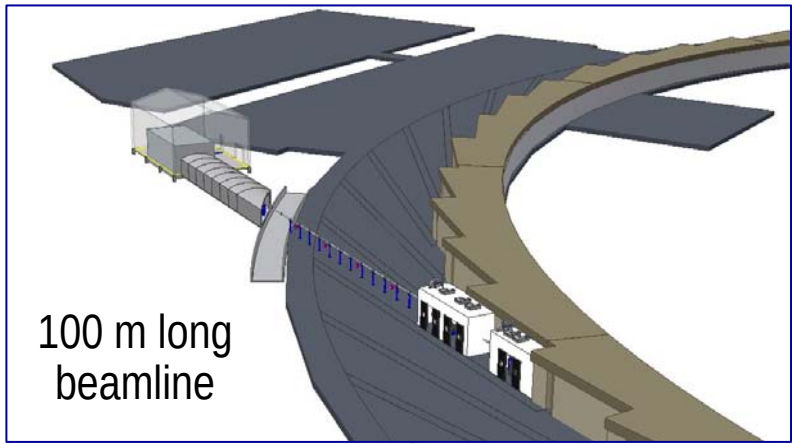
BAT members

C. Noyan (Columbia) – Chair; D. Bilderback (Cornell); C. Jacobsen (SBU); T. Lanzirotti (U. Chicago); B. Stephenson (ANL); P. Sutter (CFN - BNL); S. Vogt (ANL)

Scientific interests: nano-materials science, environ-mental science, biology

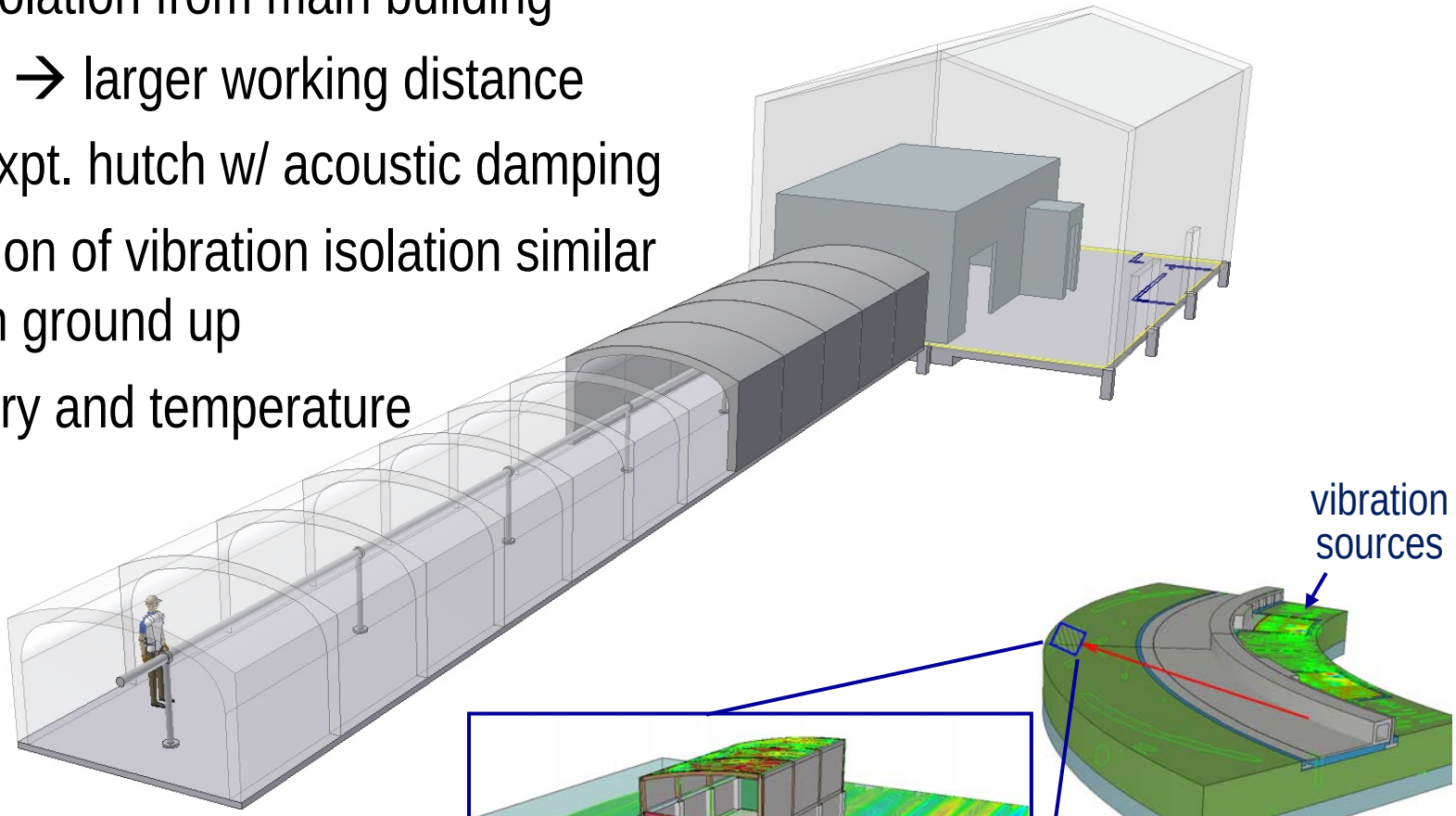
World-leading 1 nm nanoprobe for fluorescence imaging and nanodiffraction

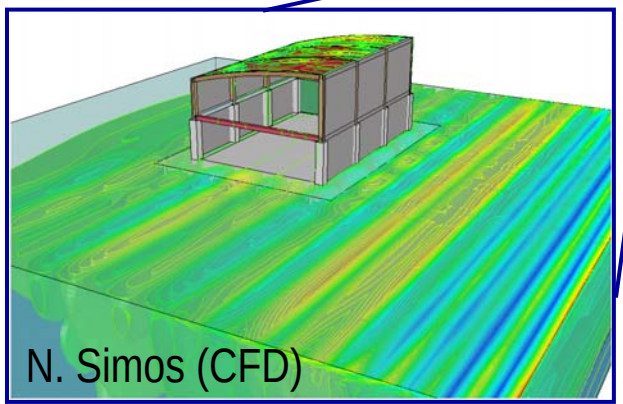




Hard X-ray Nanoprobe in Satellite Building

- Vibration isolation from main building
- 100 m long → larger working distance
- Concrete expt. hutch w/ acoustic damping
- Consideration of vibration isolation similar to EM, from ground up
- Air-lock entry and temperature stability
- ……

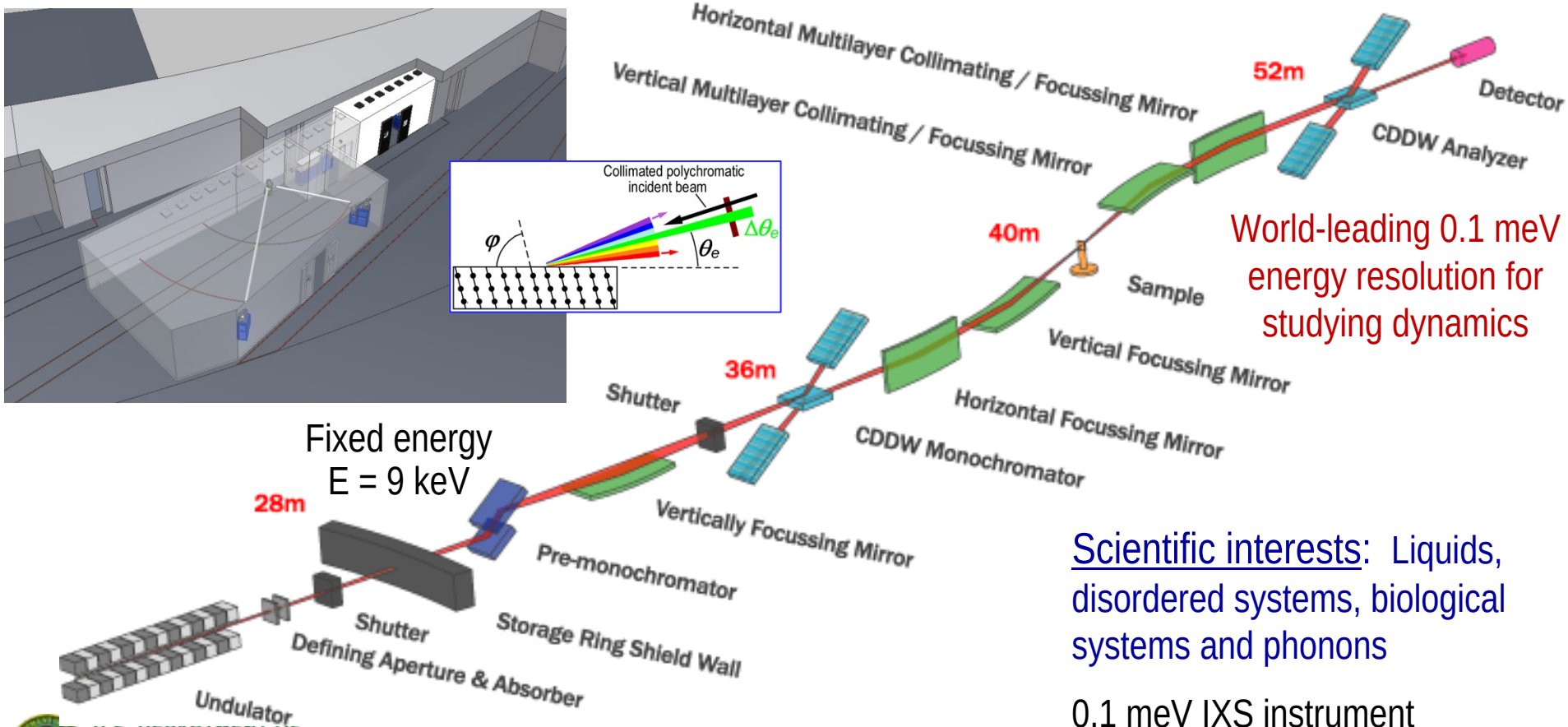




Inelastic X-ray Scattering

BAT members

C. Burns (WMU) – Chair; S-H. Chen (MIT); A. Cunsolo (APS, ANL); M. Krisch (ESRF); H-K. Mao (CIW); T. Scopigno (U. Rome); S. Shapiro (CMPMSD, BNL); Y. Shvyd'ko (APS, ANL)



Fixed energy
E = 9 keV

World-leading 0.1 meV energy resolution for studying dynamics

Scientific interests: Liquids, disordered systems, biological systems and phonons

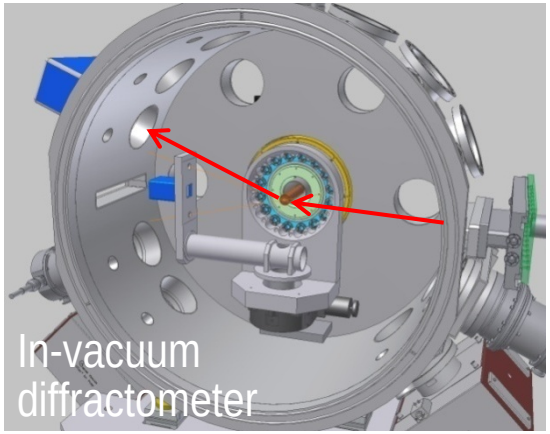
0.1 meV IXS instrument

U.S. DEPARTMENT OF ENERGY

Coherent Soft X-ray Scattering & Polarization

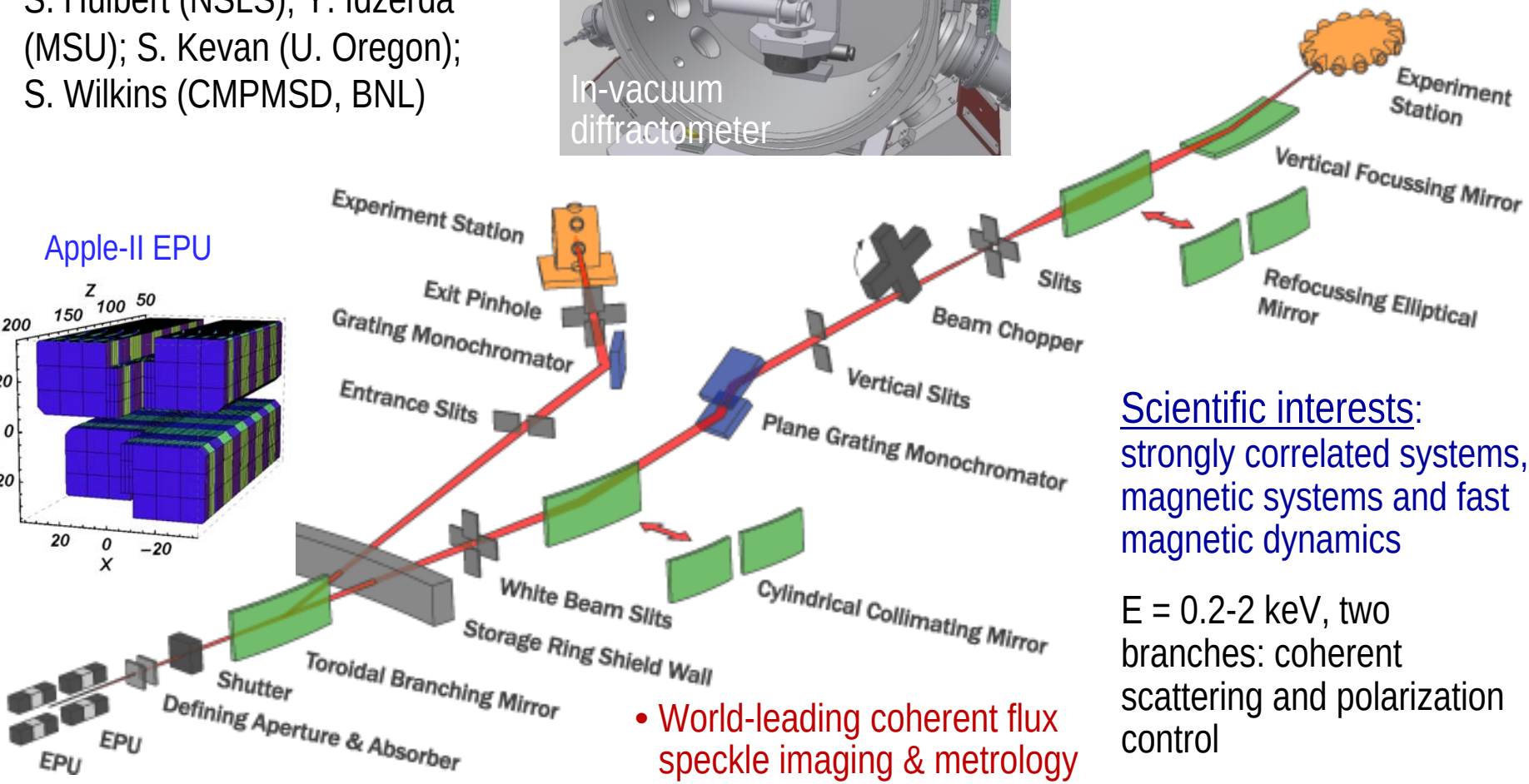
BAT members

C. Sanchez-Hanke (BNL) – Chair; H. Ade (NCSU); D. Arena (NSLS); S. Hulbert (NSLS); Y. Idzerda (MSU); S. Kevan (U. Oregon); S. Wilkins (CMPMSD, BNL)



Fast (1 kHz) circular polarization switching by beam chopper and focusing optics for XMCD

Apple-II EPU



Scientific interests: strongly correlated systems, magnetic systems and fast magnetic dynamics

E = 0.2-2 keV, two branches: coherent scattering and polarization control

- World-leading coherent flux speckle imaging & metrology

Coherent Hard X-ray Scattering

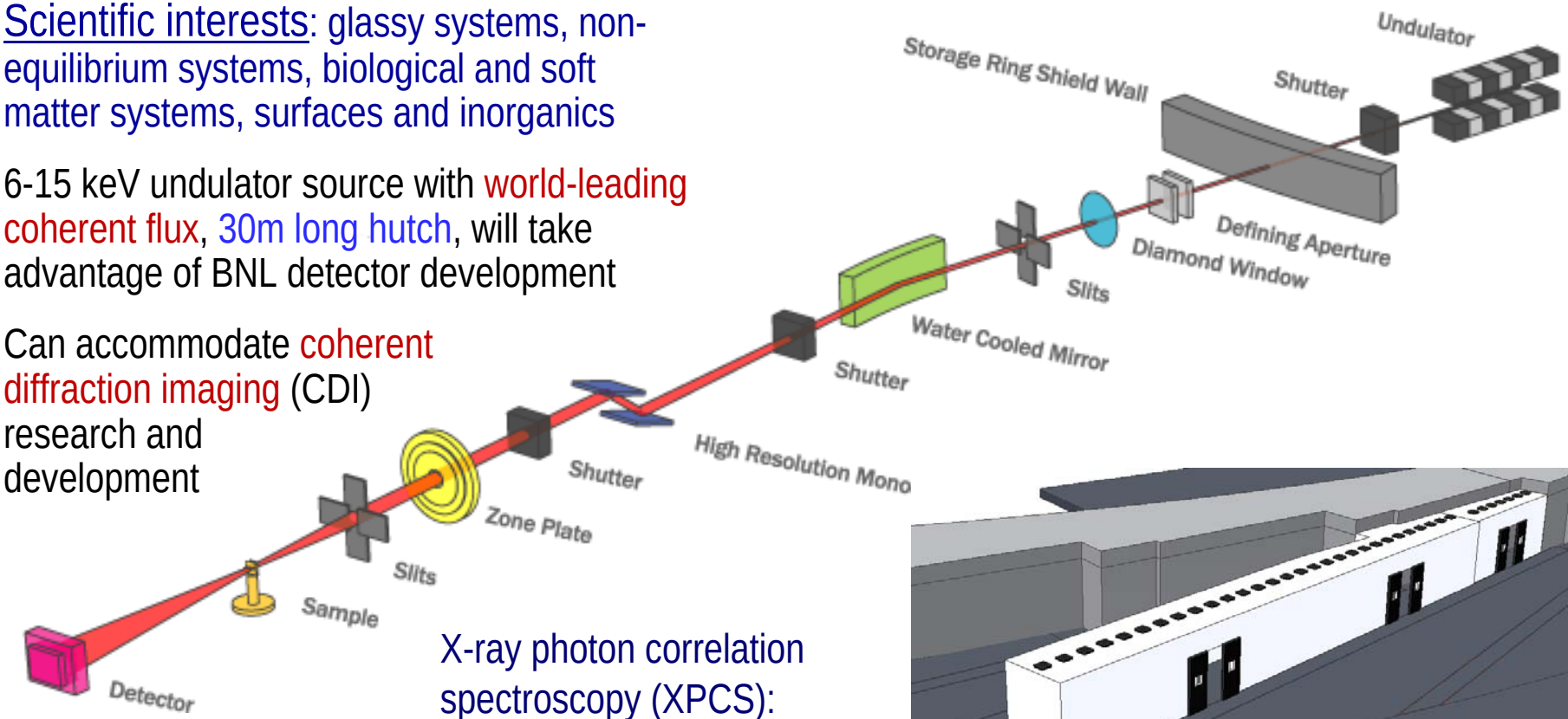
BAT members

B. Leheny (JHU) – Chair; K. Ludwig (BU); L Lurio (NIU); S. Mochrie (Yale); L. Pollack (Cornell); A. Robert (SLAC); A. Sandy (APS, ANL); O. Shpyrko (UCSD); M. Sutton (McGill U.)

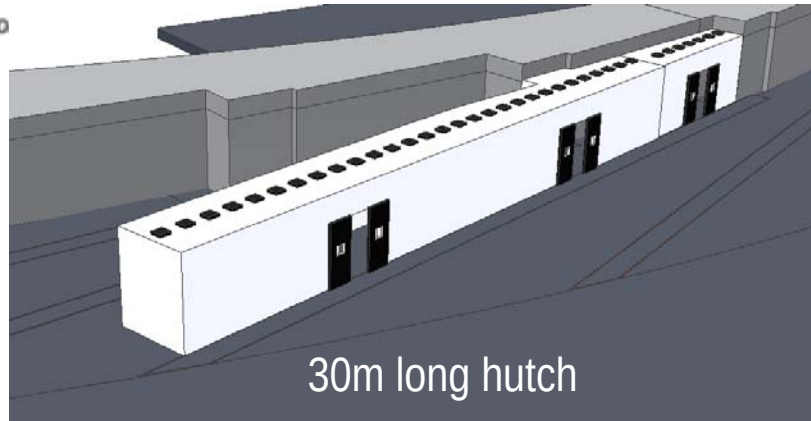
Scientific interests: glassy systems, non-equilibrium systems, biological and soft matter systems, surfaces and inorganics

6-15 keV undulator source with world-leading coherent flux, 30m long hutch, will take advantage of BNL detector development

Can accommodate coherent diffraction imaging (CDI) research and development



X-ray photon correlation spectroscopy (XPCS): 20x coherent flux => 400x faster dynamics



U.S. DEPARTMENT OF ENERGY

X-ray Powder Diffraction

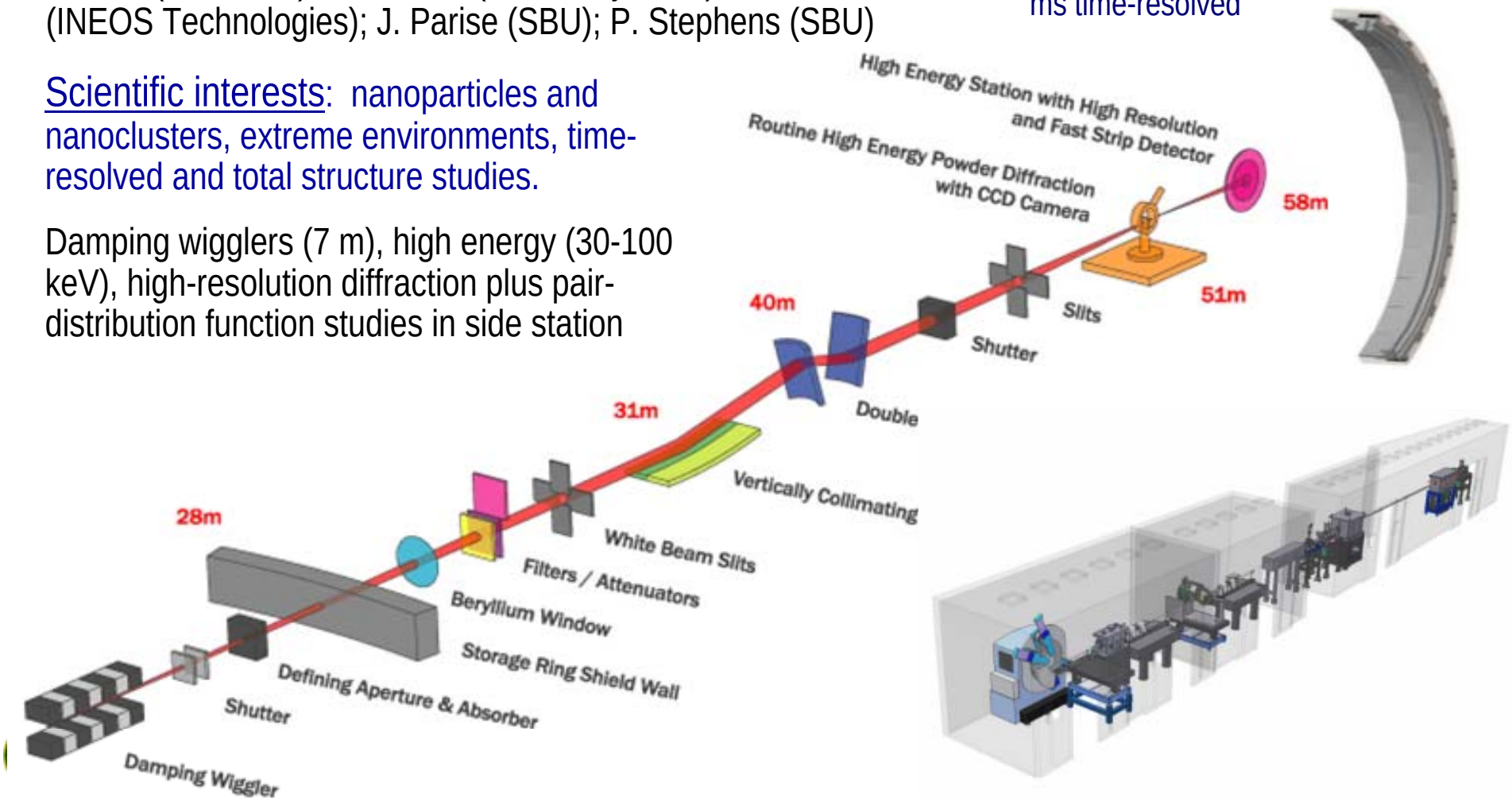
BAT members

S. Billinge (Columbia/BNL) – Chair; P. Chupas (APS, ANL); L. Ehm (SBU/BNL); J. Hanson (Chemistry, BNL); J. Kaduk (INEOS Technologies); J. Parise (SBU); P. Stephens (SBU)

Scientific interests: nanoparticles and nanoclusters, extreme environments, time-resolved and total structure studies.

Damping wigglers (7 m), high energy (30-100 keV), high-resolution diffraction plus pair-distribution function studies in side station

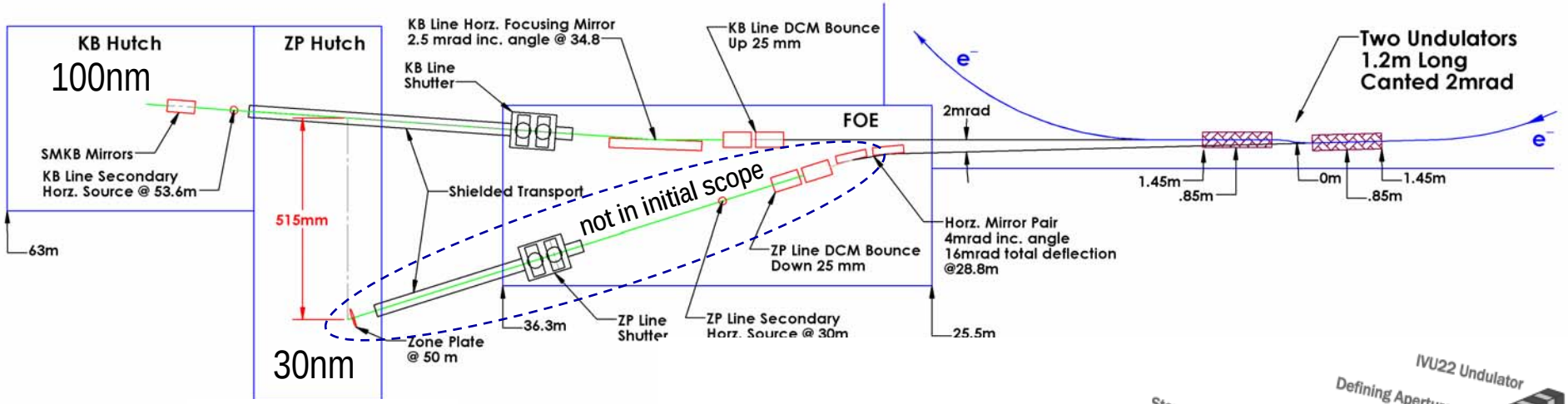
- Multi-crystal analyzer array for high-resolution
- 7000 element strip detector for ms time-resolved



Sub-micron Resolution X-ray Spectroscopy

BAT members

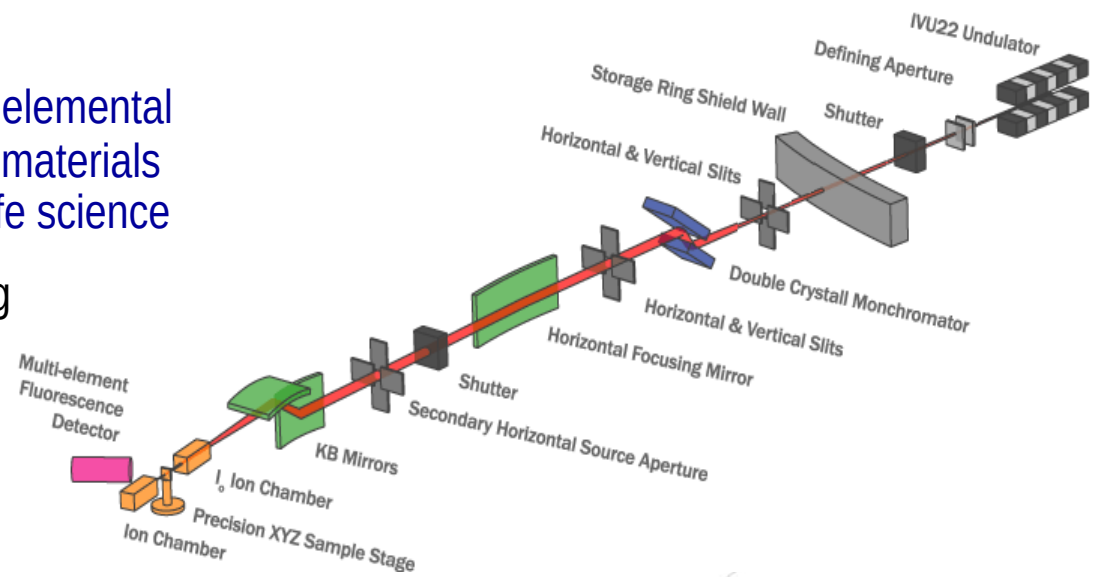
T. Lanzirotti (Chicago) – Chair; S. Sutton (Chicago); S. Vogt (ANL); G. Woloschak (NU); K. Jones (BNL); M. Rivers (Chicago); P. Eng (Chicago); L. Miller (NSLS); J. Fitts (BNL); P. Northrup (BNL); R. Reeder (SBU)



Scientific interests: submicron imaging of elemental distribution in chemical and energy science, materials science, earth and environmental science, life science

Undulator beamline 2 – 25 keV. Mostly using XRF imaging. KB 100 nm main branch and FZP 30 nm side branch (not in initial scope)

World-leading x-ray brightness in 100x100 nm^2 focal spot size



Start of Construction Ceremony

- Please join us for a special ceremony to celebrate the start of construction of the National Synchrotron Light Source II (NSLS-II)
- The event will take place at BNL on Monday, June 15, 2009, starting at 10:30 AM