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Planned Beamline Developments at NSLS-II

Mark Beno

APS - XSD

SC2.4 Experimental Facilities Subcommittee

Mark Beno, Argonne National Laboratory
Zahid Hussain, Lawrence Berkeley National Laboratory
Jörg Maser, Argonne National Laboratory
Piero Pianetta, Stanford Linear Accelerator Center

Experimental Facilities Overview

Steve Dierker, Qun Shen

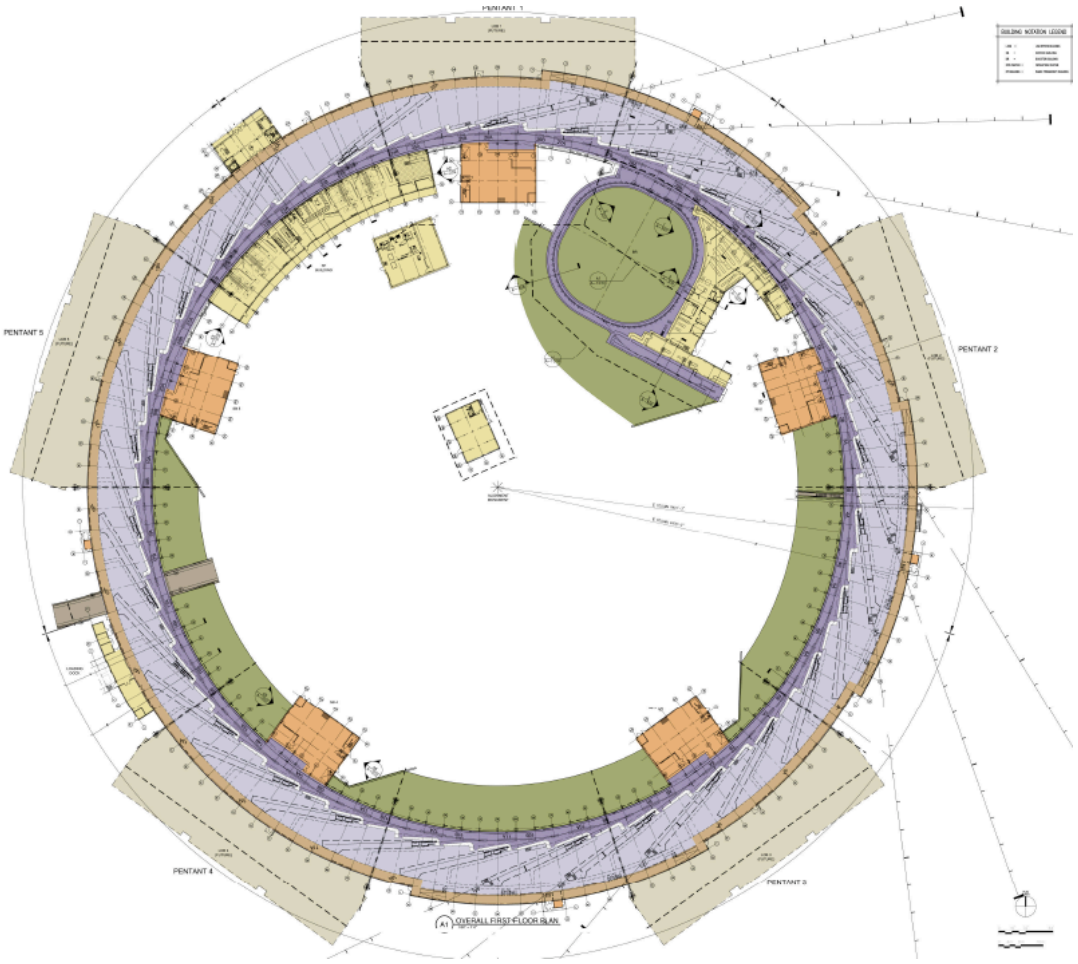
NSLS-II CD-3 DOE Review

September 30 – October 2, 2008

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

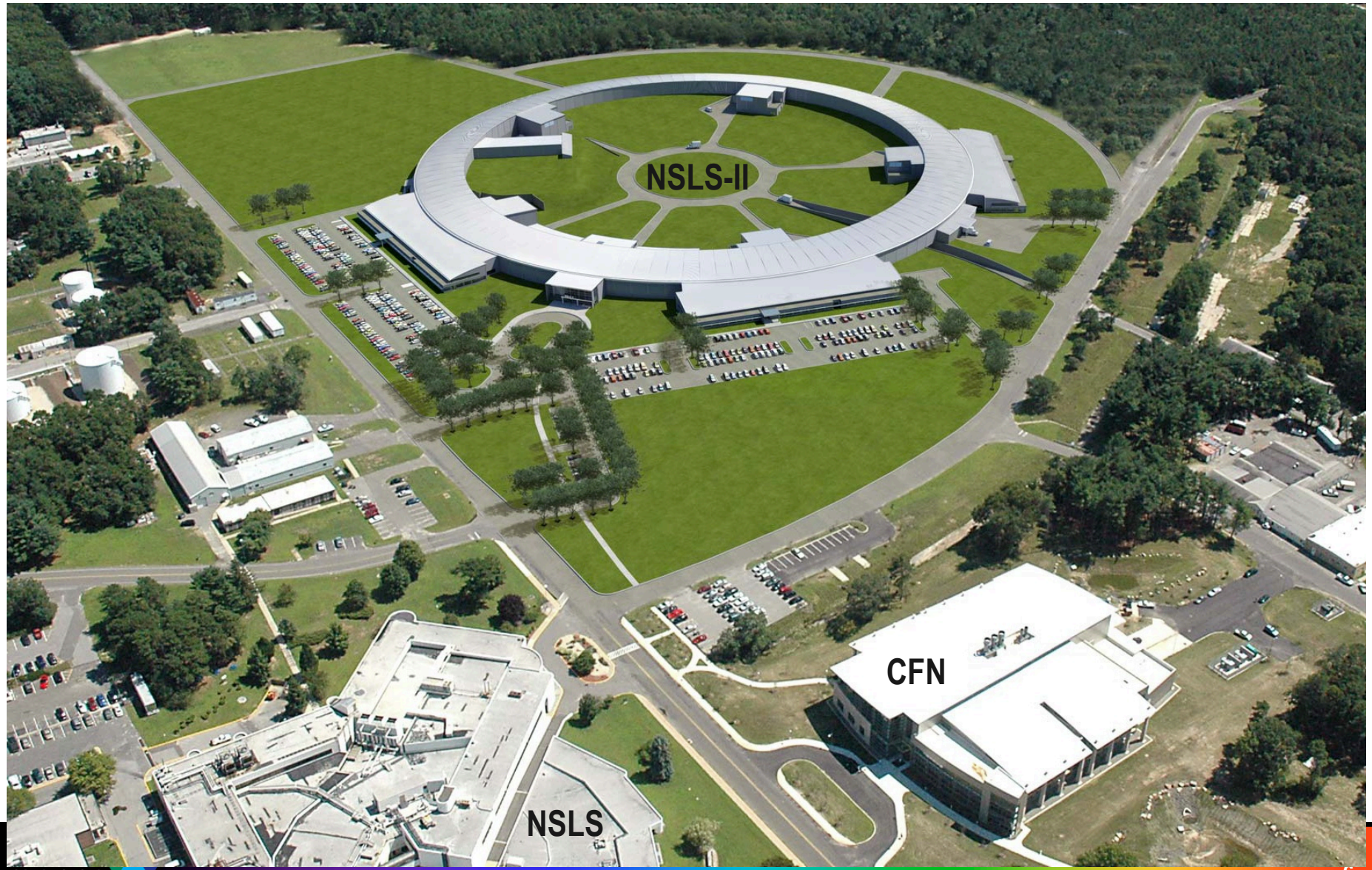
- These can also have three pole wigglers for hard x-rays

4 Large Gap BM ports for far-IR

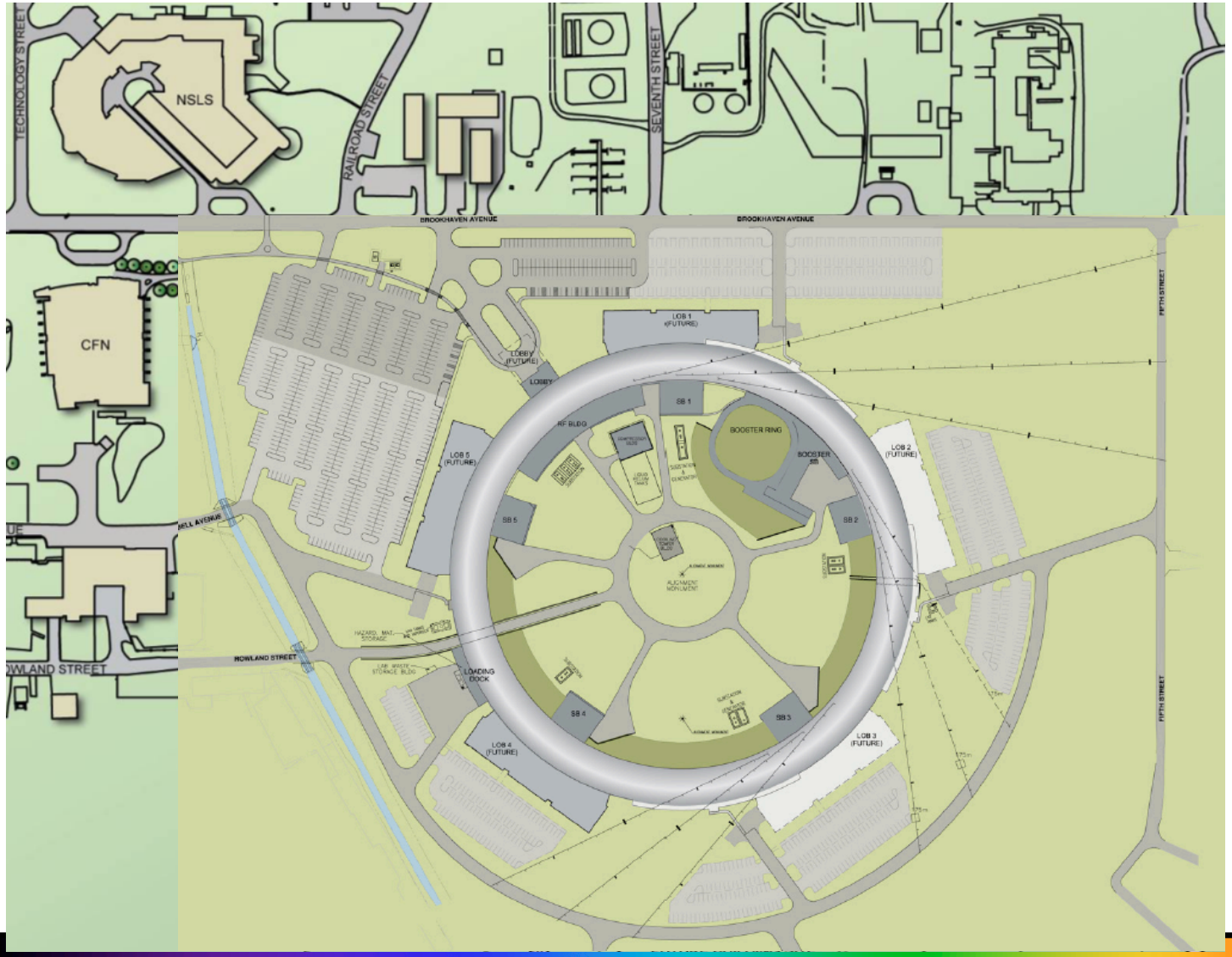
At least 58 beamlines
More beamlines by canting multiple IDs per straight
Multiple end-stations/beamline are also possible

For comparison, NSLS has 65 operating beamlines

Aerial View: NSLS-II, NSLS & CFN

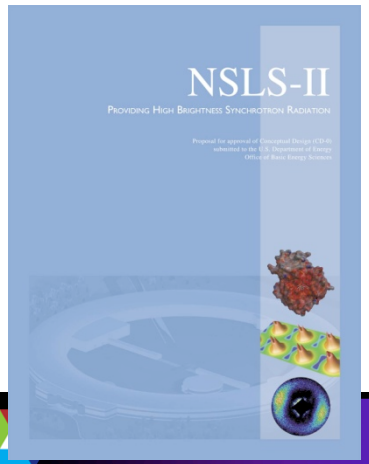


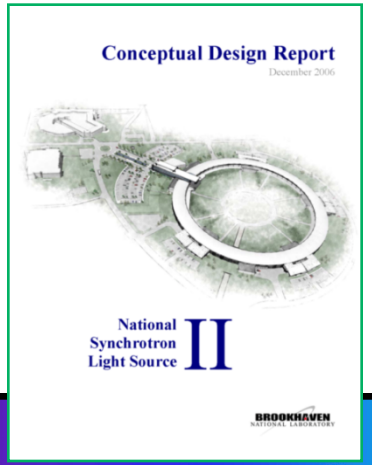
Site Plan

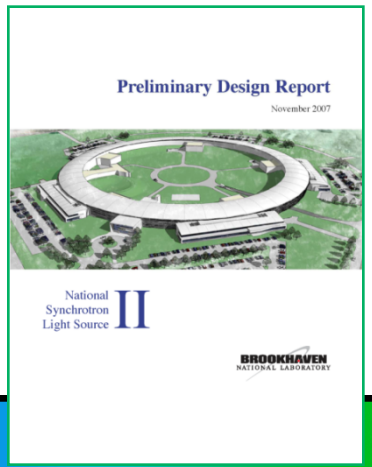

NSLS
CFN
TECHNOLOGY STREET
RAILROAD STREET
SEVENTH STREET
BROOKHAVEN AVENUE
BELL AVENUE
HOWLAND STREET
FIFTH STREET
LOB 1 (FUTURE)
LOBBY (FUTURE)
LOBBY
SB 1
RF BLDG
BOOSTER RING
BOOSTER SB
LOB 2 (FUTURE)
LOB 5 (FUTURE)
SB 5
SB 2
HAZARD MAT. STORAGE
LOADING DOCK
SB 4
SB 3
LOB 4 (FUTURE)
LOB 3 (FUTURE)

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)
Dec 2008 **CD-3**, Approve Start of Construction
Feb 2009 Contract Award for Ring Building
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







Experimental Facilities Scope

- WBS 1.04: All phases of specification, design, procurement, installation, and commissioning of the six insertion device beamlines and instruments included in the project scope. Includes activities associated with planning the fully built-out facility, interacting with the user community.
- WBS 1.06.03: Integrated testing and pre-operations
- WBS 1.02.02: R&D in support of experimental facilities.

Project Beamlines

- Project beamline decision process by NSLS-II management included careful evaluations of the following:

  - submitted Letter of Interest (LOI)
  - external peer reviews
  - oral presentation and dialog at EFAC meeting May 2008
  - ranking of all LOIs by EFAC and EFAC recommendations
  - reviewers' comments at technical and project reviews, and
  - overall project priorities.

- Project beamlines are:

  - Inelastic x-ray scattering (IXS)
  - Hard x-ray nanoprobe (HXN)
  - Coherent hard x-ray scattering (CHX)
  - Coherent soft x-ray scattering (CSX)
  - High-energy X-ray powder diffraction (XPD)
  - Submicron resolution x-ray spectroscopy (SRX)

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

User Workshops and LOIs

- 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 and subsequent 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.

Expt. Fac. Advisory Comm. (EFAC)

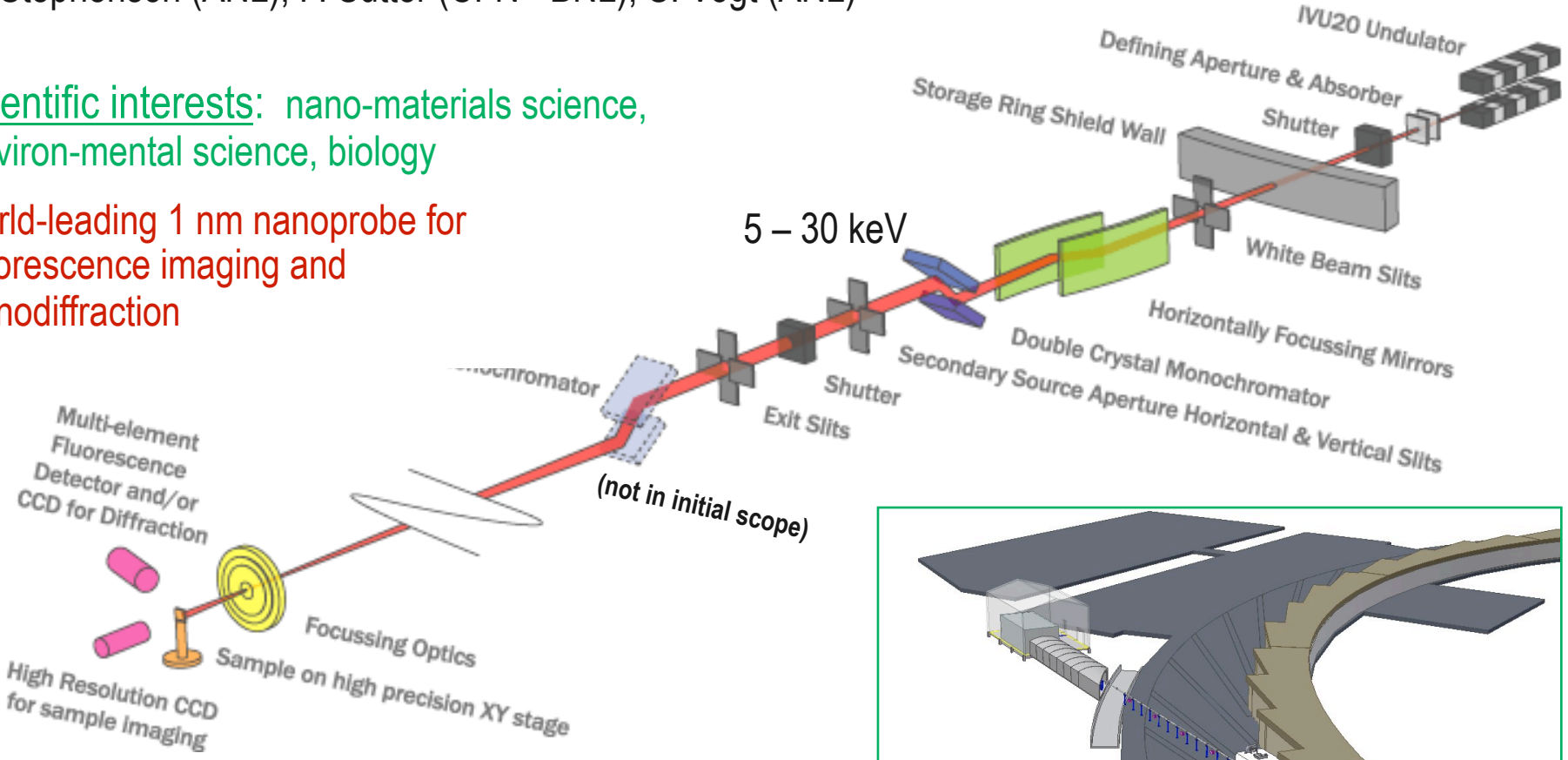
Hard X-ray Nanoprobe

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)

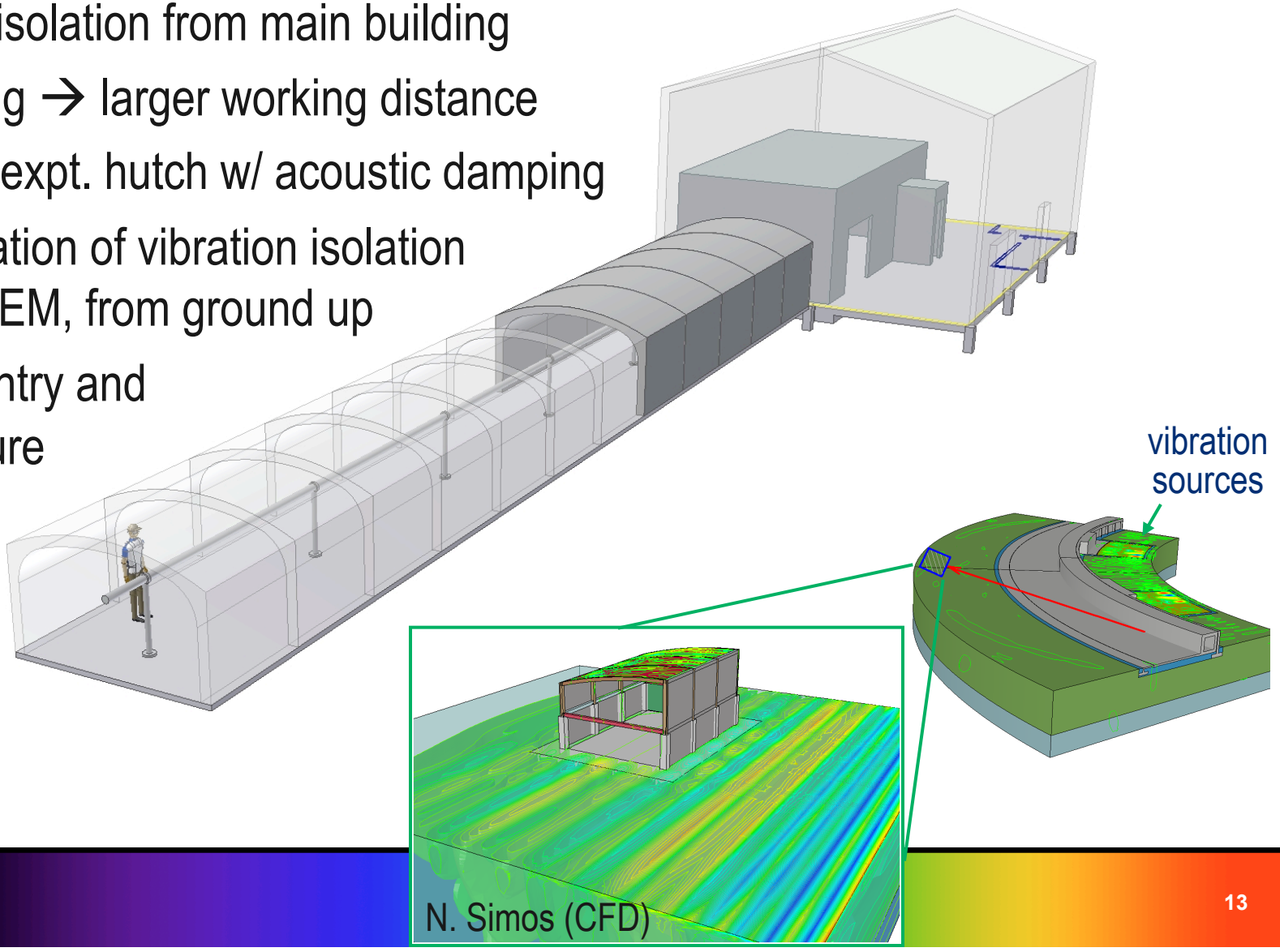
Scientific interests: nano-materials science, environ-mental science, biology

World-leading 1 nm nanoprobe for fluorescence imaging and nanodiffraction



Hard X-ray Nanoprobe in Satellite Building

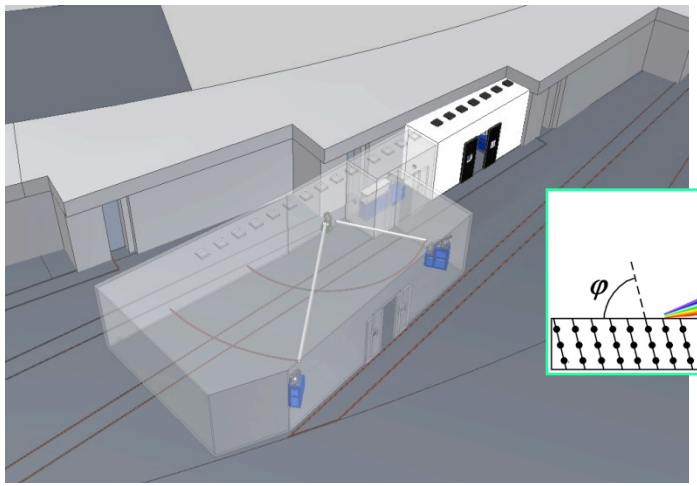
- Vibration isolation from main building
- 100 m long → larger working distance
- Concrete expt. hutch w/ acoustic damping
- Consideration of vibration isolation similar to EM, from ground up
- Air-lock entry and temperature stability
- ……

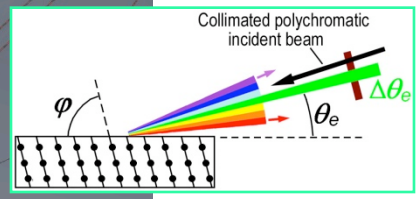


Inelastic X-ray Scattering

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

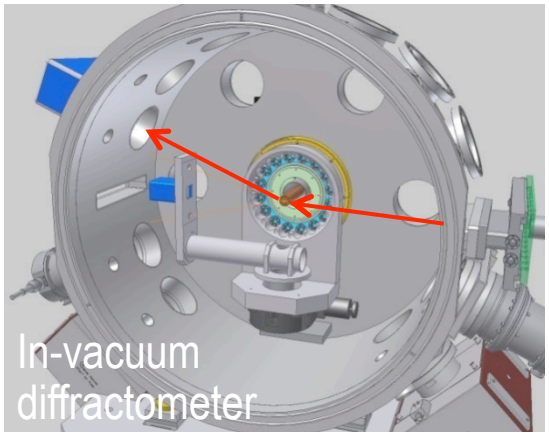
Scientific interests: Liquids, disordered systems, biological systems and phonons

0.1 meV IXS instrument

Coherent Soft X-ray Scattering & Polarization

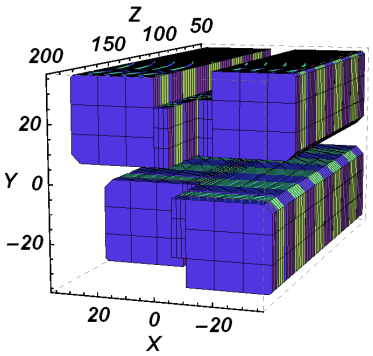
BAT members

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



- World-leading coherent flux speckle imaging & metrology

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

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

Coherent Hard X-ray Scattering

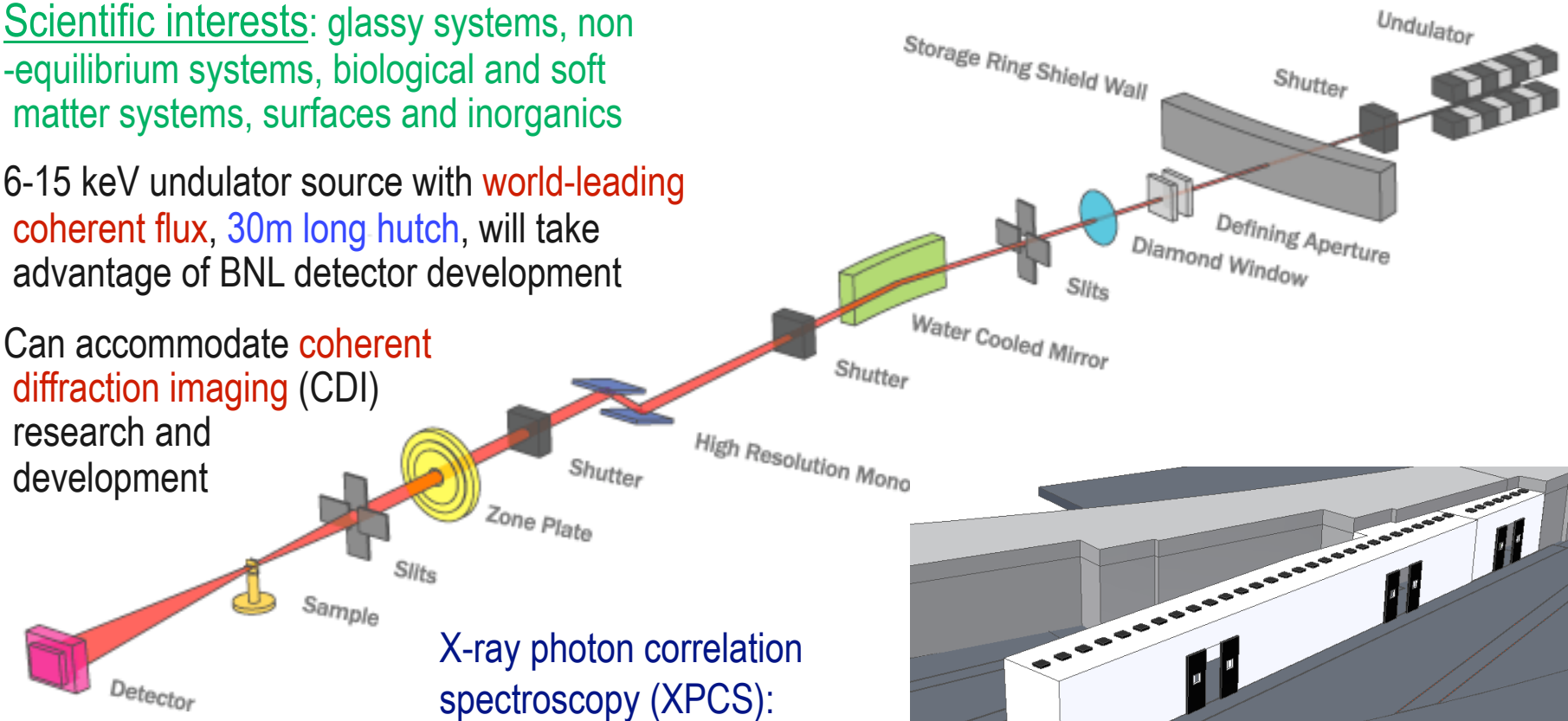
BAT members

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

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X-ray Powder Diffraction

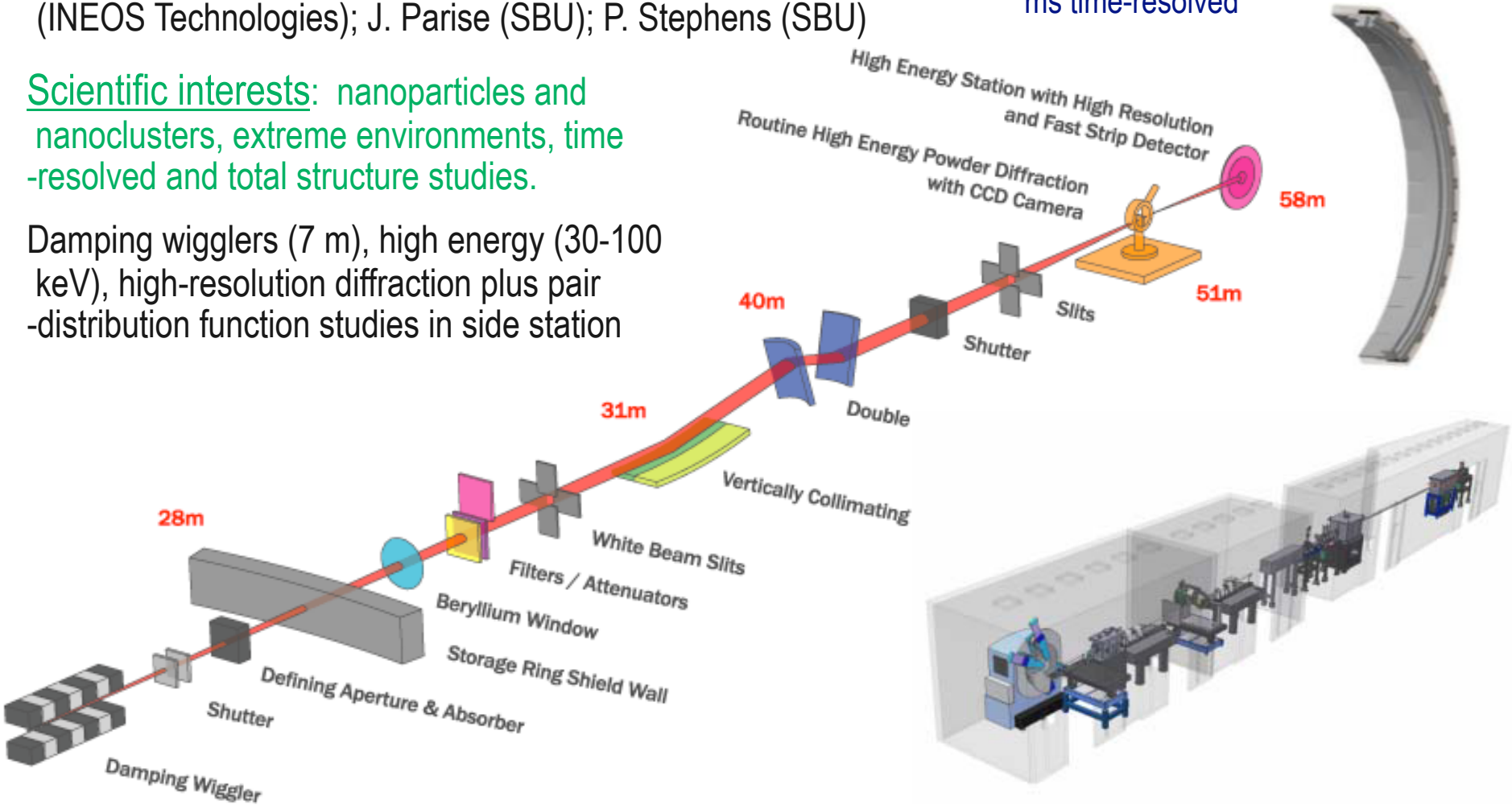
BAT members

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)

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

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

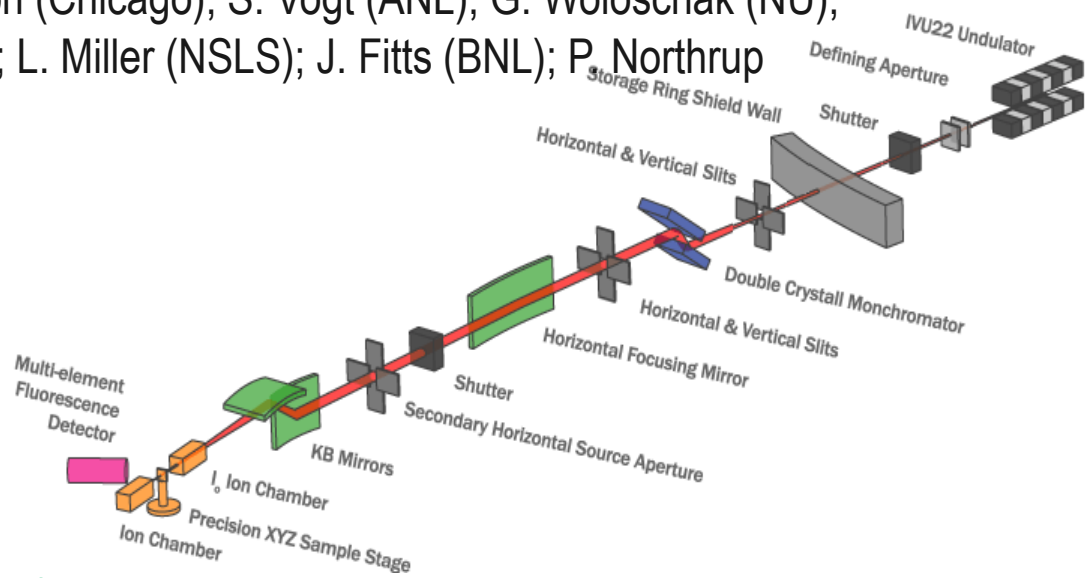
Damping wigglers (7 m), high energy (30-100 keV), high-resolution diffraction plus pair-distribution function studies in side station



Sub-micron Resolution X-ray Spectroscopy

BAT members

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



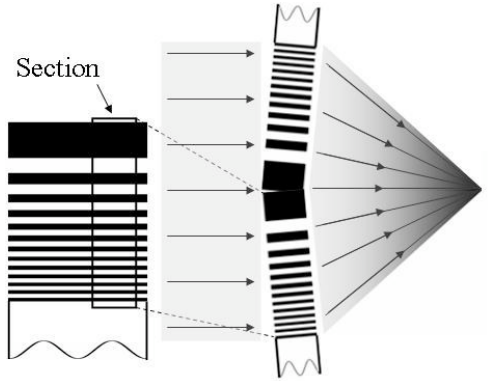
Scientific interests: submicron imaging of elemental distribution in chemical and energy science, materials science, earth and environmental science, life science

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

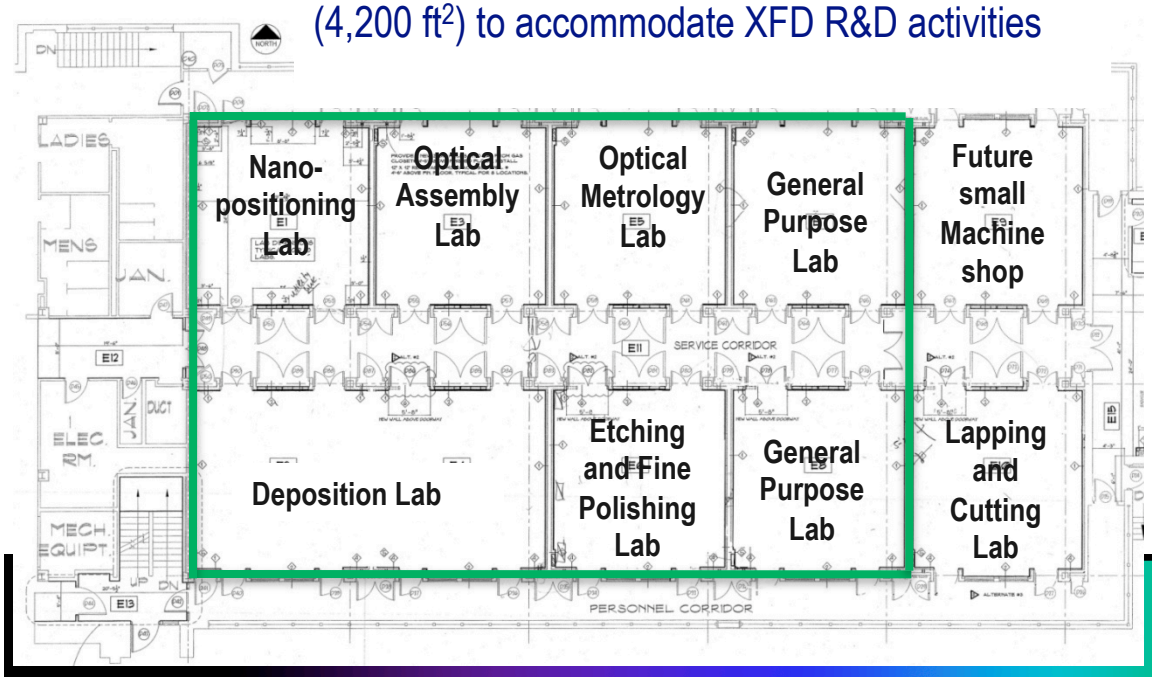
Experimental Facilities R&D Program

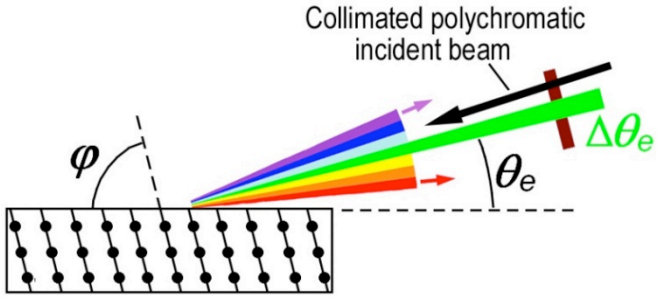
- 1 nm focusing optics and nanopositioning
- 0.1 meV high-resolution optics
- X-ray beam position monitors
- Optical figure control (heat load, metrology)



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

The east wing of Bldg.703 is under renovation
Seven labs to be ISO 7 (Class 10000) cleanrooms (4,200 ft^2) to accommodate XFD R&D activities

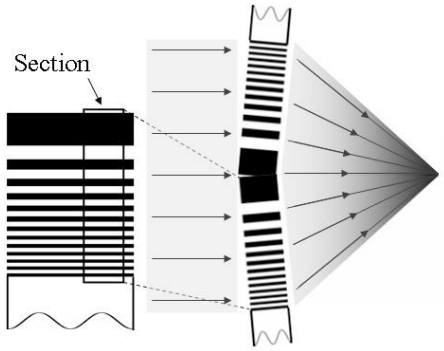




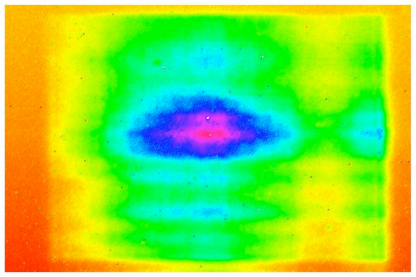
Cai, Huang, Honnicke (NSLS-II) Shvyd'ko (APS)

1 nm Optics R&D

Multilayer Laue Lenses (in collaboration with CNM/APS/MSD at Argonne)

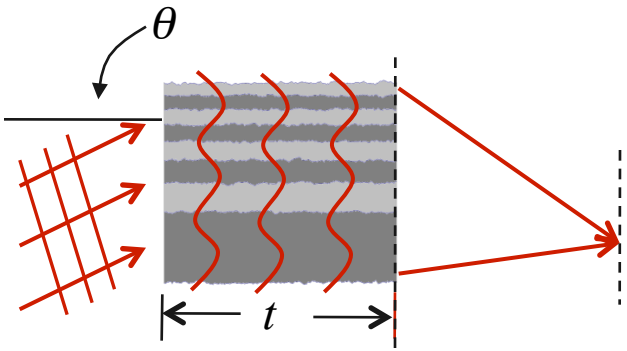


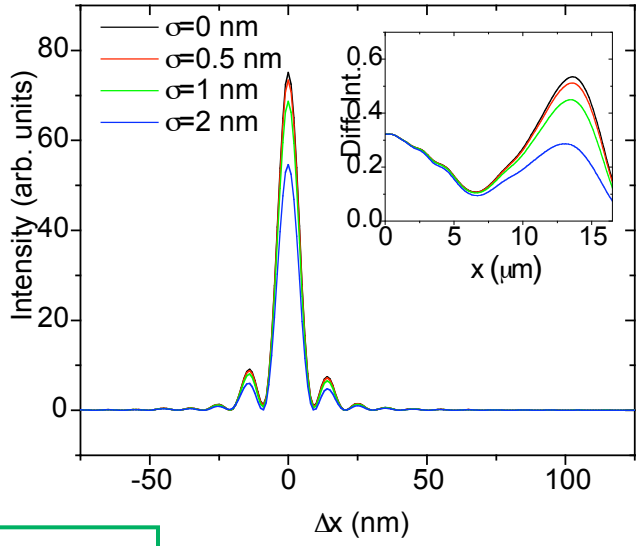
Yan, Conley, Maser, Macrander, Rose, Stephenson, et al.



1st far-field image of 2D MLL tested at APS 26-ID

Effect of interfacial roughness: 19.5 keV, 5 nm MLL, t=10 μm





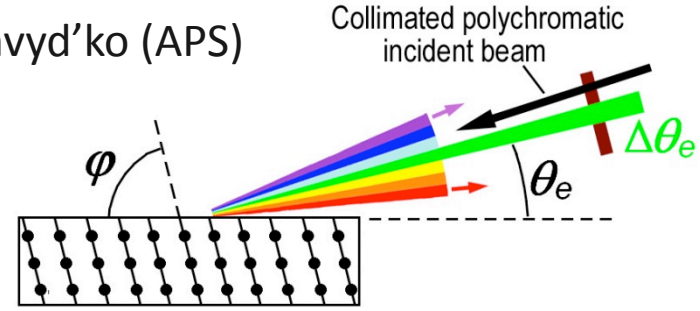
Key Research Areas:

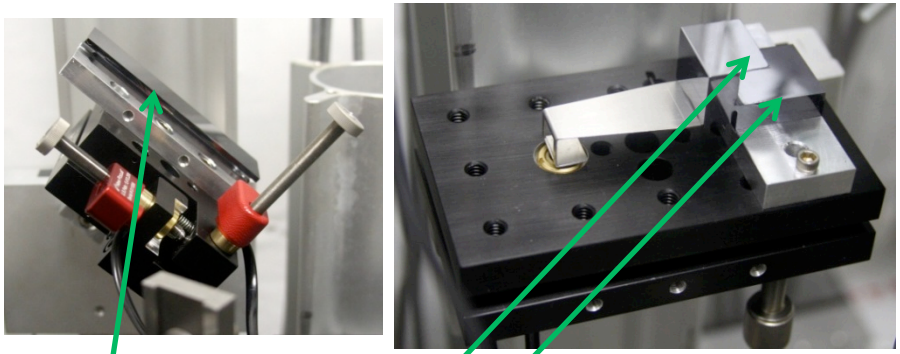
1) Fabrication of 1 nm outermost zone MLLs
2) Metrology of layer placement
3) Focus spot characterization
4) Fabrication of "wedged MLLs"

More on 1 nm R&D in XFD Breakout Session

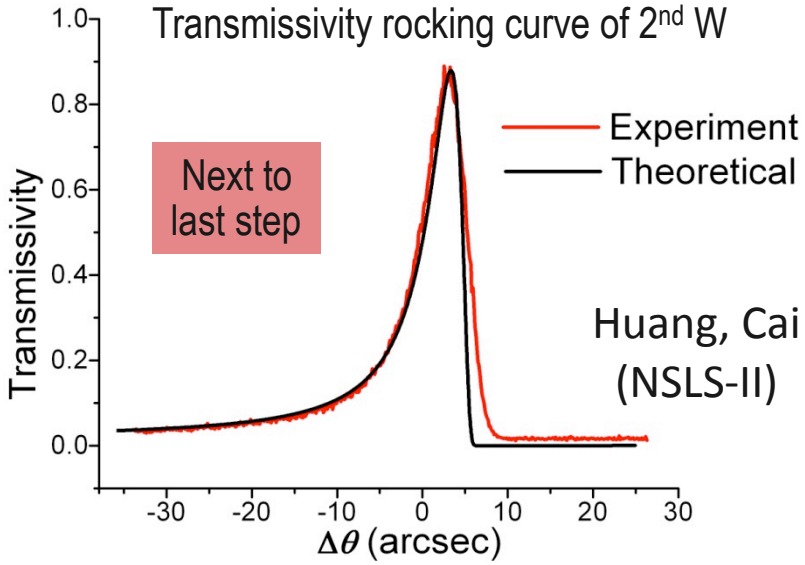
0.1 meV Progress: Testing CDW optics

Shvyd'ko (APS)





Analyzer-monochromator combination setup



Next steps:

- Fabricate, assemble and test temperature controlled enclosures.
- Design "Comb Crystal" to significantly shorten D crystals (proposed by Yuri Shvyd'ko). Investigating cutting methods.
- Develop dedicated R&D beamline at NSLS.

More on 0.1 meV R&D in XFD Breakout Session

Current Cost Baseline Is Unchanged

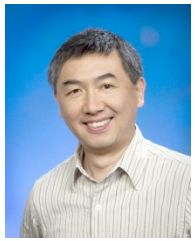
XFD WBS Level 3	Budget (K$)
1.02 R&D	
1.02.02 Experimental Systems R&D	19,167
1.04 Experimental Facilities	
1.04.01 Experimental Facilities Management	4,513
1.04.02-04, 06-07 Standard Components	1,801
1.04.05 User Instruments (6 beamlines)	66,221
1.06 Pre-operations	
1.06.03 Experimental Facilities - Pre Ops	3,824

→ $19.2M

$76.3M

- Added engineer and tech support during installation and testing. Total effort for beamline construction is 28.5 FTE-years/BL (was 23.1 in original estimate)
- Revised estimate for Nanoprobe satellite bldg. and beam-transport tunnel
- Adjustments have been made in initial beamline endstation instrumentation to offset increased cost due to added labor
- We are confident that the initial scope of all beamlines can be met within baseline XFD non-R&D budget of $76.3M

Experimental Facilities Organization

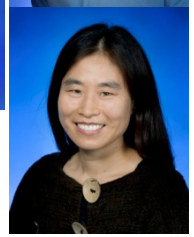

EXPERIMENTAL FACILITIES
Q. Shen
DIVISION DIRECTOR

BEAMLINE &
INTERFACE MANAGER **A. Broadbent**

Administrative Support L. Rogers
Administrative Support - R. Robinson

14 new hires in FY08






NANOPROBE BEAMLINE
A. Broadbent (I)
GROUP LEADER

R. Conley
J. Biancarosa
K. Evans-Lutterodt (M)
E. Lima
H. Yan

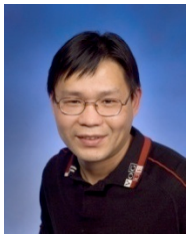
HARD X-RAY COHERENT BEAMLINE
A. Fluerasu
GROUP LEADER

L. Berman (M)
L. Yang (M)

Beamline Support Group
A. Broadbent
GROUP LEADER

O. Chubar
K. Kaznatcheev
L. Miceli
M. Carlucci-Dayton
P. Yoon
M. Loftus (A)
S. Coburn (M)





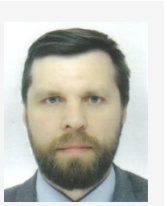

INELASTIC BEAMLINE
Y. Cai
GROUP LEADER

X. Huang
M. Honnicke
Z. Zhong (M)

SOFT X-RAY COHERENT BEAMLINE
A. Broadbent (I)
GROUP LEADER

C. Sanchez-Hanke (M)
S. Hulbert (M)
L. Carr (M)
D. Arena (M)





POWDER BEAMLINE
A. Broadbent (I)
GROUP LEADER

D.P. Siddons (M)
L. Berman (M)

SRX BEAMLINE
A. Broadbent (I)
GROUP LEADER

P. Northrup (M)