

# **NSLS-II Final Design Review**

## ***Beamline for Materials Measurement – BMM***

***February 8, 2017***

***Dan Fischer***

*Leader Synchrotron Science Group*

*Materials Measurement Science Division*

*Material Measurement Laboratory*

***National Institute of Standards and Technology***



***“Promote Innovation and Enhance US Industrial Competitiveness”***

# ***NIST NSLS-II Partner Beamlines***

## ***NIST Synchrotron Science Group***

***Stationed at NSLS-II***

Ray Browning

Dan Fischer

Zugen Fu

Cherno Jaye

Barry Karlin

Johnny Kirkland

Bruce Ravel

Conan Weiland

Joe Woicik

Eliot Gann (NRC)

Nick Quackenbush (NRC)

w/Jean Jordan-Sweet (IBM)

w/Ron Jones MML/NIST Liaison

w/Ruben Reininger (SAS)

## ***NSLS-II***

Andy Broadbent

Zhong Zhong, Howard Robinson

John Fabijanac

Greg Fries

Chris Stebbins

ID, FE, EPS, Controls, Safety  
Groups

## ***FMB Oxford (UK)***

Andrew Fairley

Scott Mowat

FMB Team

# People create opportunities !



# 35 year NIST NSLS I/II Partnership

## Need

Development and optimization of advanced materials and innovative devices by U.S. industry requires measurement of electronic, chemical, and spatial structure at the nanoscale

## NIST NSLS-II Partner Beamline Suite

\$40M+ investment, started in 2009

### Spectroscopy Soft and Tender(SST) Beamlines

- 100 eV to 7.5 keV in a single experiment (common focus in 2 stations, rare capability)
- 2 full-field microscopes micro to nanoscale (unique magnetic projection design, SBIRs)

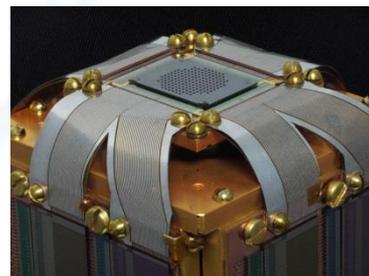
### Beamline for Materials Characterization(BMM)

Hard X-ray Absorption Spectroscopy and Diffraction 4.9 keV to 22 keV

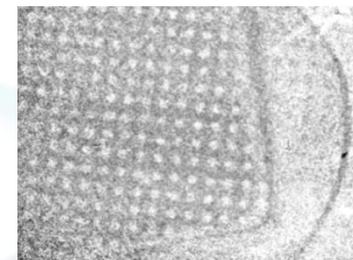
Synchrotron Science Group (9) at BNL

## NSLS-I Achievements and Impact

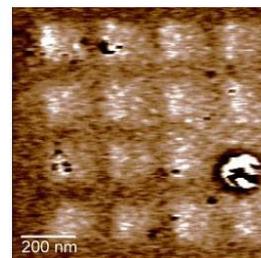
- Spectroscopy beamlines that span the entire periodic table (90 experiments/year; 110 users)
- State-of-the-art X-ray and electron detectors
- In-situ capabilities for “real” samples/conditions



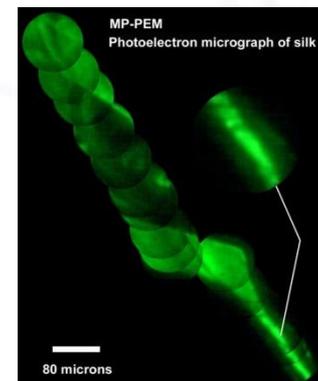
*NIST  $\mu$ -calorimeter  
X-ray detectors*



*Chemical imaging of  
designer photo voltaics*



*Ferroelectric  $\text{SrTiO}_3$   
thin film on Silicon*



*Photoelectron image of silk*

## Customers and Partners:

25 private, 14 public, 25 academic



# NIST NSLS-II Spectroscopy Beamline Suite spanning the entire periodic table (FY17)

*“We develop and apply new synchrotron X-ray measurement methods to establish structure-function relationships for advanced materials design”*

## Spectroscopy Soft and Tender (SST 1 and 2)

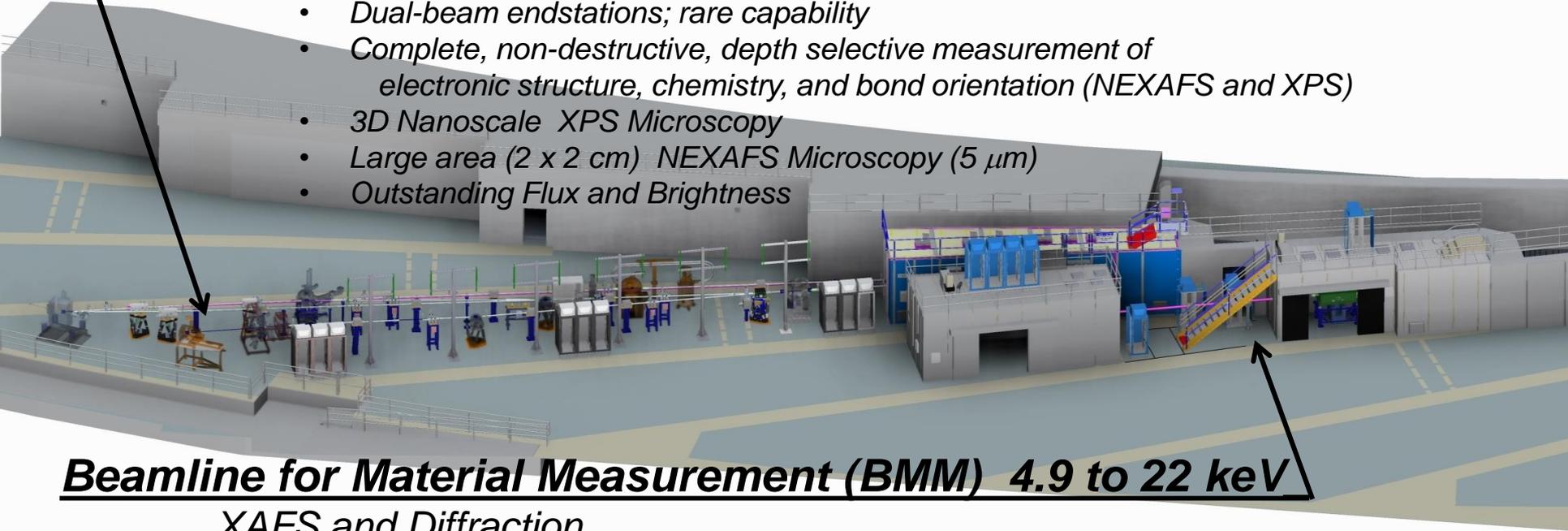
### *Soft and Tender Beamlines*

- 100 eV to 7.5 keV x-ray energy range
- Dual-beam endstations; rare capability
- Complete, non-destructive, depth selective measurement of electronic structure, chemistry, and bond orientation (NEXAFS and XPS)
- 3D Nanoscale XPS Microscopy
- Large area (2 x 2 cm) NEXAFS Microscopy (5  $\mu\text{m}$ )
- Outstanding Flux and Brightness

## Beamline for Material Measurement (BMM) 4.9 to 22 keV

### *XAFS and Diffraction*

- High flux: dilute samples, quick scanning for chemical reactions
- Focused beam: XAFS thin films, XAFS scan imaging
- High-energy resolution for enhanced chemical speciation
- 6-circle goniometer for high-resolution specular and non-specular diffraction



# SST and BMM User Communities

**SST**: NEXAFS, HAXPES, XPS, Microscopy    **BMM**: XAFS, Diffraction

**Communities or industries served**: inorganic and organic microelectronics, plastics, chemical / catalysis, biomaterials, batteries, environmental materials.

**Established User Community**: informed and prepared for operations

25 Academic, 25 Industrial,  
14 National Laboratory Groups



# BMM Scope

- FOE and Experimental Hutches
- Mechanical and Electrical Utilities
- EPS
- PPS
- Source: TPW
- Front End
  
- Photon Delivery System with controls (FMB-O)
- End stations: XAS (NIST), DAFS, Diffractometer (NIST/IBM)
- Data acquisition and end station controls (NIST)

# BMM construction project

*NSLS-II direct involvement in all aspects of construction, true partnership*

Andy Broadbent: NSLS-II Partner Beamline Portfolio Manager

Zhong Zhong and Howard Robinson : NSLS-II NIST Partner Beamline

John Fabijanic: NSLS-II Designer

NIST/BNL Interagency Agreements fund BNL purchase and construction

IDs testing and integration; Straights and Front Ends (NSLS-II Groups; ID, FE, EPS, Controls)

Hutches/Common systems (NSLS-II Utilities)

Photon Delivery Systems – NIST Direct Purchases

Ruben Reininger optical designs, mirror specs

FMB Oxford BMM beamline mechanics, Diagnostics, DCM, mirrors, and installation



Experimental Stations – State of the art from NSLS-1

BMM – XAS (fully instrumented), DAFS, 8-circle Huber goniometer

# BMM Schedule

**All activities finish May 31, 2017, IRR in June**

SST12 and BMM Partner Beamlines - 2016 December Draft		IPD - Summary Schedule			02-Feb-17 09:51		
Activity ID	Start	Finish	FY2016	FY2017	FY2018		
			FY16	FY17	FY18		
<b>BMM Management</b>	02-Mar-15 A	21-Jul-17					
<b>BMM Design</b>	02-Mar-15 A	28-Sep-17					
<b>BMM Construction</b>	01-Oct-12 A	22-May-17					
<b>BMM Hutches</b>	02-Mar-15 A	22-May-17					
<b>BMM Utilities - Mechanical</b>	01-Feb-16 A	20-Jan-17					
<b>BMM Utilities - Electrical</b>	01-Feb-16 A	30-Nov-16 A					
<b>BMM EPS</b>	25-Apr-16 A	24-Apr-17					
<b>BMM PPS</b>	25-Apr-16 A	11-May-17					
<b>BMM Front End</b>	01-Apr-15 A	29-Mar-17					
<b>BMM Source TPW</b>	01-May-15 A	26-Jan-17					
<b>BMM Controls</b>	02-Nov-15 A	05-May-17					

# **Photon Delivery System**

## **History FMB-O BMM FDRs at NSLS-II**

### **(minutes, action items and responses posted)**

- Sept. 2, 2015 – BMM FDR: 18 action items
  - June 29, 2016 – NIST approves
- Sept. 13, 2016 FMB-O contract amendment  
Secondary Bremsstrahlung shielding and other shielding, diagnostics, and in-situ mono crystal change
- Nov. 29, 2016 FMB-O FDR: 13 action items
  - Dec. 21, 2016 NIST approves

# BMM Layout: Experimental Hutch and FOE



## **View of 6BM from the roof of 5ID-C**

Hutch construction was completed in December 2015.

# BMM Layout: Monochromator, Mirrors, and Diagnostics

**M1  
(collimating mirror)  
in front end**

**Monochromator  
Si (111), (311)**

**M2 (focusing mirror)  
M3 (harmonic rejection)**

**XAS station**

**XRD station**



**3PW and FE**

Installed in  
Dec shutdown

In hand (crystal cage  
to be replaced)

**Mirrors (3), diagnostic  
modules(3), transport  
pipe: delivered and  
installed by May**

Temporary XAS table  
being reconfigured now

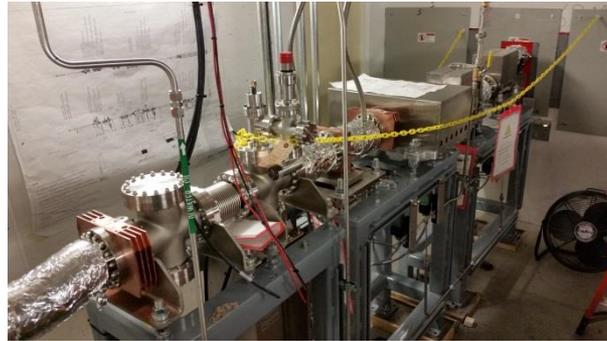
Goniometer in the hutch

# BMM TPW / FE/M1 Installation

LN2 system



FE shutters



TPW



**M1 Mirror System  
- a very tight installation!**

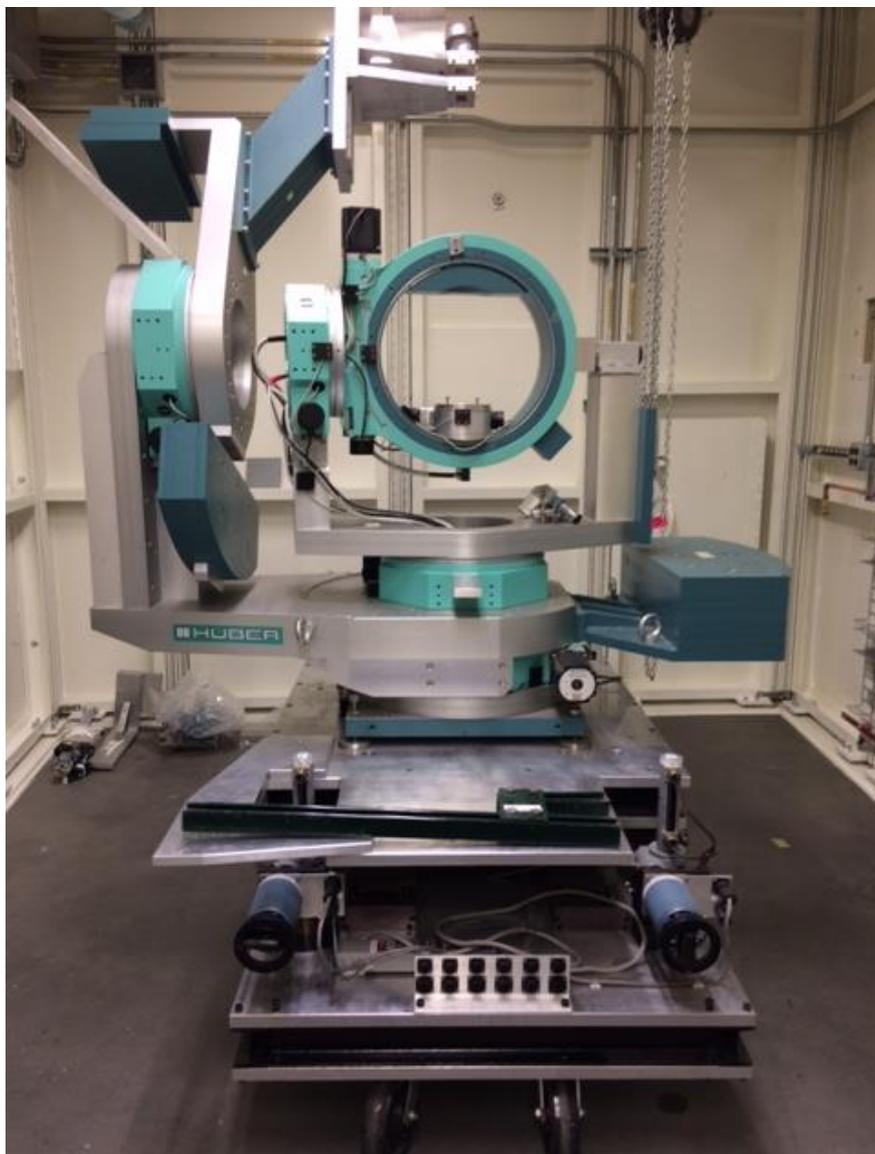


# BMM construction

- **Current Status:**
  - Hutches and Utilities all complete including the ODH and the LN2 systems, and the exhaust system (installed Dec 2016).
  - Front End (except Be window) and Three Pole wiggler installed successfully in Dec 2016 shutdown.
  - FMB-O installation of M1 in FE completed December 2016, needs minor finishing work during a maintenance day.
  - Beamline shutter installed in Dec 2016.
  - PPS installation complete, certification required. EPS in progress.
  - Radiation shielding calculations in progress.
- **Photon Delivery System and End Station**
  - Partial installation of FMB-O equipment (M2, M3, DCM, some controls) planned for Feb 2017.
  - Final installation of equipment covered under the contract amendment to occur in Apr 2017.
  - Cable pulling mainly complete.
  - End station equipment (XAFS table and diffractometer) assembly in progress.
- FDR on 8 Feb 2017.
- IRR in June 2017



# BMM X-Ray Diffraction End Station



Huber psi 6-circle + anal/detec stage  
(Huber 4-circle with offset chi as secondary diffractometer)



Hi-res XYZ stage (encoded Micos PP30)

## Detectors



Dectris Mythen 1-D



Dectris Pilatus 100K 2-D

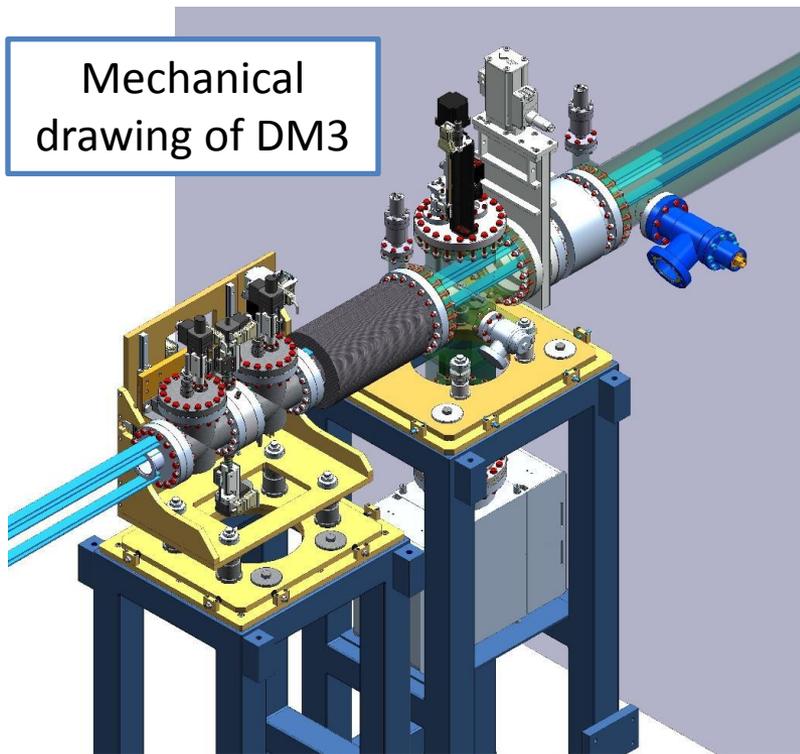


HERMES 1-D



APD and Bicron 0-D

# BMM Operating Modes: optimization for XAS and XRD Expts.



The various settings of M2 (bendable cylinder) & M3 (flat) result in five distinct operating modes, each with a distinct height and pitch entering the end station.

Commissioning and operations must consider this configurational variability. Automation for moving between modes is essential.

DCM Mono: Si(111), Si(311)

Mode	Mirrors	Energy	Angle	Beam quality	Height (XAS)	Height (XRD)
A	M2	>9 keV	3.5	Spot/line focus	1538.3	1538.3
B	M2+M3	<7 keV	5	Spot/line focus	1439.1	1397.0
C	M2+M3	<9 keV	3.5	Spot/line focus	1468.9	1439.4
D/E	M3	>7 keV	3.5	Large beam	1551.7	1551.7
F	M3	<7 keV	5	Large beam	1521.9	1509.3

# BMM Safety

## ***BMM is a NIST NSLS-II Partner Beamline***

**Safety for Partner and Facility Beamlines is identical from conception, construction, commissioning and operations; this includes policies, training, equipment and procedures.**

- Andy Broadbent and Zhong Zhong (Howard Robinson) ensure that the NIST Partner Beamlines design and construction are fully compliant with all NSLS-II safety policies and practices.
- Dan Fischer (Lead Beamline Scientist) develop, monitor, and maintain safe operating conditions within the beamline during commissioning and operations.
- NSLS-II fully funds, designs, constructs, maintains and tests the beamline personnel protection systems.
- The NIST group has excellent safety track record of compliance, cooperation, and collaboration spanning 33 years of construction and operation of beamlines at NSLS.

