# SUB-MICRON RESOLUTION X-RAY SPECTROSCOPY (SRX)

BROOKHAVEN NATIONAL LABORATORY

NATIONAL SYNCHROTRON LIGHT SOURCE II

## SCIENTIFIC SCOPE

The SRX beamline at sector 5-ID is a versatile but optimized tool for studies in many scientific areas, such as materials science, life science, energy science, art conservation, physical and chemical sciences, environmental, geo-, earth, and planetary sciences. It enables X-ray fluorescence imaging and spectroscopy with sub-µm spatial resolution at an X-ray flux of $10^{13}$ ph/sec at 4.65 – 25 keV. Future plans include a second endstation with sub-100 nm resolution at $10^{11}$-$10^{12}$ ph/sec.

## BEAMLINE CHARACTERISTICS

**TECHNIQUES:**

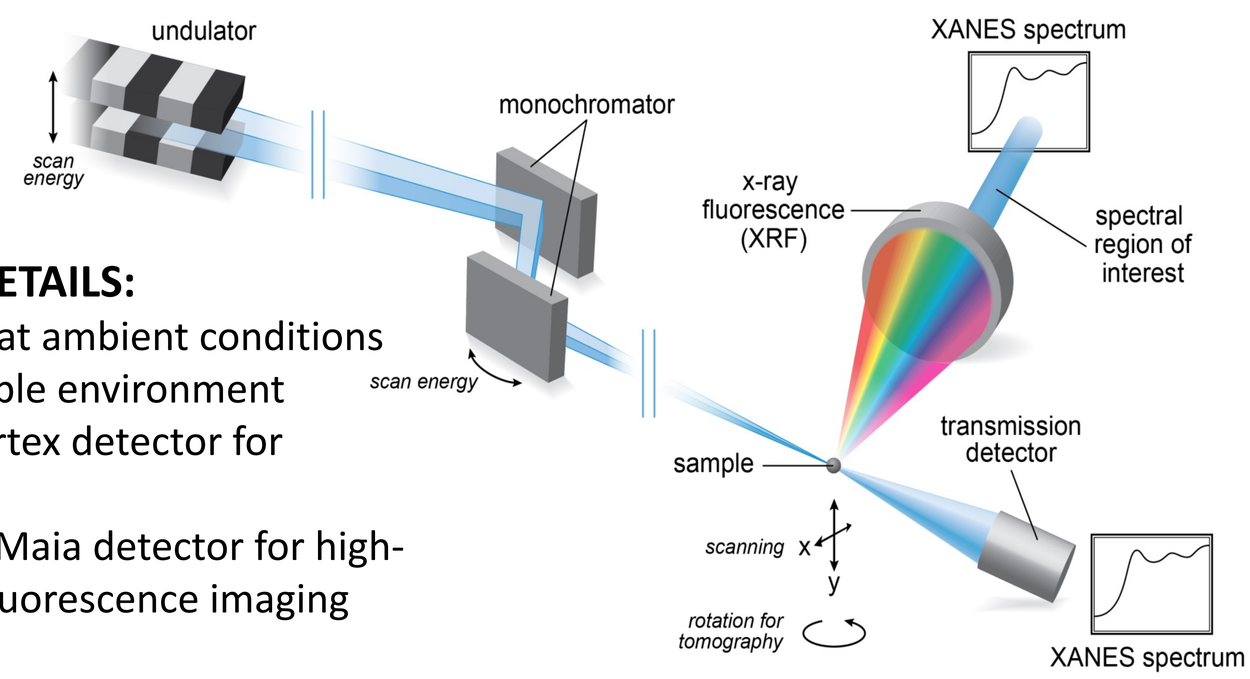
- 2D scanning X-ray fluorescence imaging at a focal spot size of < 1 µm in an energy range of 4.6-25 keV using KB mirror optics and either a vortex or the 384-element Maia detector.
- XANES and EXAFS spectroscopy with a focal spot size size of < 1 µm in an energy range of 4.6-25 keV.

**SRX at NSLS-II:**

- Analysis of chemical and physical heterogeneities in materials to determine elemental composition, oxidation states, and coordination.
- Spectromicroscopy analysis on materials for instance from geosciences, battery research or art conservation will all enhance current understanding of reactions and processes on the sub-µm length scale.

**ENDSTATION DETAILS:**

- Sample in air at ambient conditions
- Versatile sample environment
- 3-element vortex detector for spectroscopy
- 384-element Maia detector for high-speed X-ray fluorescence imaging




## Overview

**PORT:** 5-ID

**SOURCE**: Undulator (IVU21)

**ENERGY RANGE**: 4.65 – 25 keV

**ENERGY RESOLUTION**: $\Delta E/E = 10^{-4}$

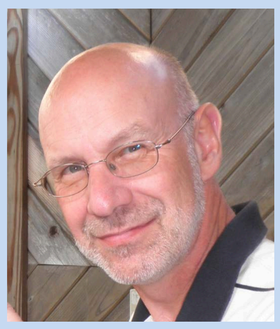
**SPATIAL RESOLUTION**: sub-1 µm

**BEAMLINE STATUS:** Open to users

**BEAMLINE PHONE:** 631.344.1605

**BEAMLINE WEBSITE:** https://www.bnl.gov/nsls2/beamline/5-ID

## Beamline Staff



**Juergen Thieme**
Lead Beamline Scientist

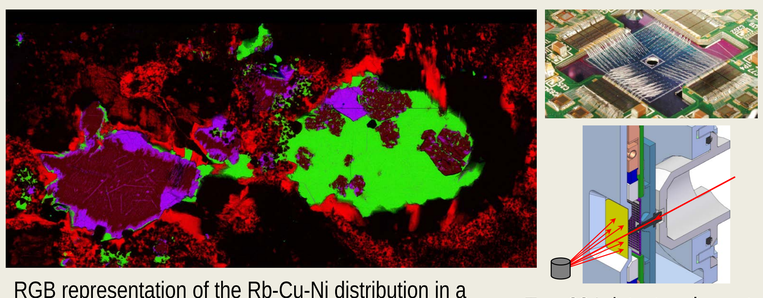
**Garth Williams**
Beamline Scientist

## Apply for Beam Time

Beamlines at NSLS-II are available to all scientific researchers through a peer-review proposal process. For more information, see the NSLS-II Users' Guide at:

**www.bnl.gov/ps/userguide/**

## SCIENTIFIC APPLICATIONS



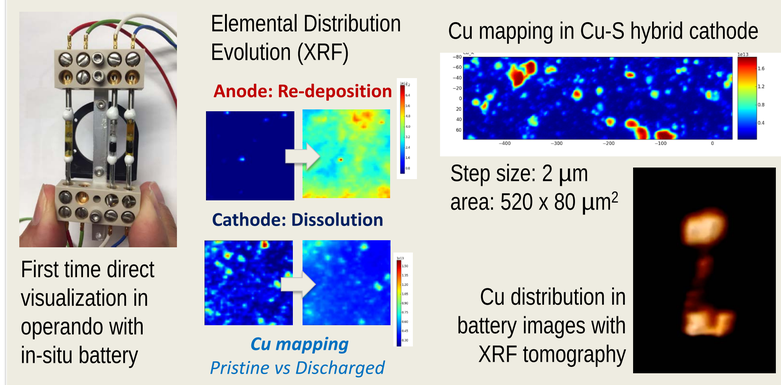
RGB representation of the Rb-Cu-Ni distribution in a mineral sample from Noril'sk. The image has been taken using the Maia detector: 10.5x5.1mm², 3751x1822 pixel, 0.8 ms dwell time, total acqusition time 1.5 hours.

Top: 384 detector elements wire-bonded to ASICS. Bottom: Detector setup.

### Element co-localization in minerals

*With: Margaux LeVaillant (CSIRO, Aiustralia)*

Goal: Explain the formation of minerals, here in Noril'sk, the world's largest mining resource for nickel. The Maia detector has been used to scan a large area in search of small and distributed inclusions, to see which mineral phases they are associated, and to try and understand the genetic processes.

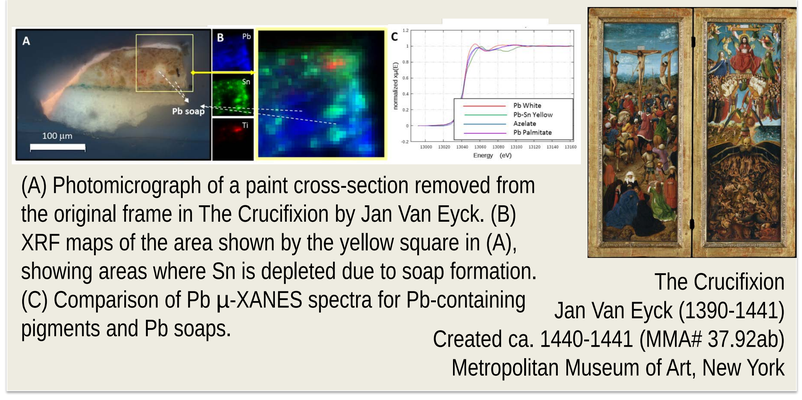



First time direct visualization in operando with in-situ battery

### In Operando Study on Future Energy Storage Materials

*With: Hong Gan (Sustainable Energy, BNL)*

Goal: Addressing the critical challenge in Li-S batteries, the low conductivity of the S cathode. It can be improved by using a capacity-contributing hybrid cathode: CuS-S. In operando study of a critical issue: The dissolution of Cu and its re-deposition.




(A) Photomicrograph of a paint cross-section removed from the original frame in The Crucifixion by Jan Van Eyck. (B) XRF maps of the area shown by the yellow square in (A), showing areas where Sn is depleted due to soap formation. (C) Comparison of Pb µ-XANES spectra for Pb-containing pigments and Pb soaps.

The Crucifixion
Jan Van Eyck (1390-1441)
Created ca. 1440-1441 (MMA# 37.92ab)
Metropolitan Museum of Art, New York

### The Structure and Coordination Environment of Lead Soaps

*With: Silvia Centeno (Metropolitan Museum of Art, New York)*

Goal: Understand lead soap formation mechanisms, how it can be arrested and prevented. Initial studies using (XANES) show that lead pigments and lead soaps can be distinguished from each other. XRF mapping shows elemental segregation (Sn vs Pb) in soap forming regions.