HIGH ENERGY ENGINEERING X-RAY SCATTERING (HEX)

BROOKHAVEN NATIONAL LABORATORY

NATIONAL SYNCHROTRON LIGHT SOURCE II

SCIENTIFIC SCOPE

Brookhaven Lab is designing and constructing a hard X-ray beamline, HEX, that will provide intense high-energy X-rays produced by a superconducting wiggler source to advance energy storage technologies. Using state-of-art imaging and diffraction probes, researchers will be able to map the three-dimensional structure of energy storage materials in real time and under actual operating conditions. Benefits will include a greater ability to integrate renewable energy into the grid, reductions in carbon emissions, and more efficient storage and use of energy. HEX is sponsored by NY State.

BEAMLINE CHARACTERISTICS

TECHNIQUES:

- Energy Dispersive X-Ray Diffraction (EDXRD)
- Wide (XRD) and small angle (SAXS) monochromatic angle dispersive diffraction
- Pair Distribution Function measurements (PDF)
- phase-contrast imaging
- Tomography (CT)/radiography

HEX at NSLS-II:

- HEX will consist of three independently operating branches, A, B1 and B2 in tandem, and C, with B and C being white-beam compatible.
- HEX will substantially surpass the operating performance of other EDXRD x-ray facilities in the country and the end station capabilities will be tailored for attacking and solving of fundamental/technological problems.

ENDSTATION DETAILS:

- Large, >7 mrad wiggler fan will allow three independent branches
- 3D visualization under real operating conditions
- Satellite building and concrete B2 hutch for propagation phase contrast, which requires large distance to source
- Large field of view (esp. vertical) for imaging

Overview

PORT: 27-ID

SOURCE: Superconducting wiggler, 4.3 T, 70 mm period

ENERGY RANGE: 25-150 keV

ENERGY RESOLUTION: $\Delta E/E = 10^{-3}$

SPATIAL RESOLUTION: 1 micron

FIELD OF VIEW FOR IMAGING: 100 mm (H) X 15 mm (V)

BEAMLINE STATUS: Design

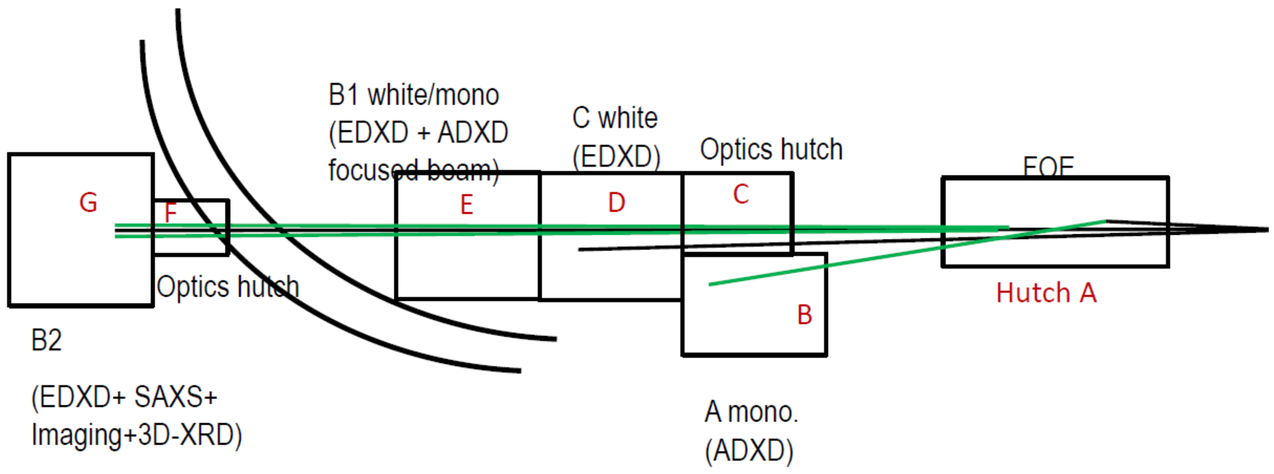
AVAILABLE TO USERS: Expected in 2022

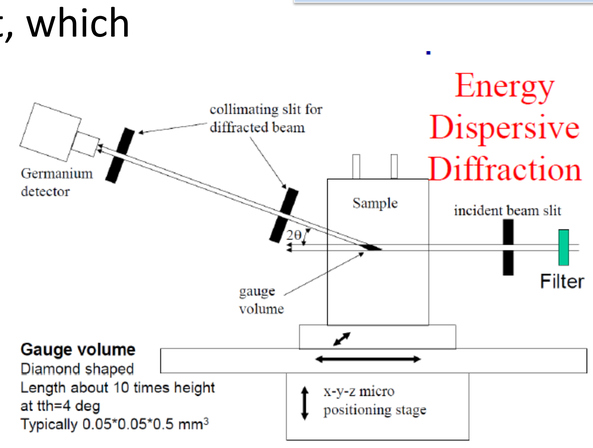
BEAMLINE WEBSITE: www.bnl.gov/nsls2/beamline/27-ID

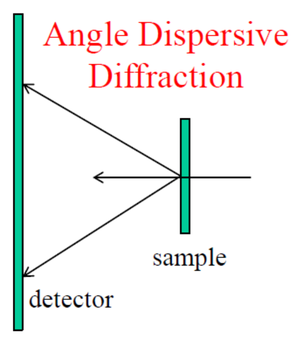
Beamline Staff

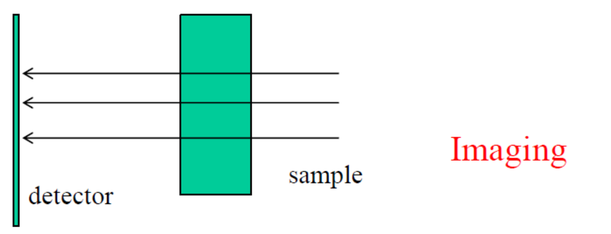
Zhong Zhong
Lead Beamline Scientist

HEX Beamline Layout



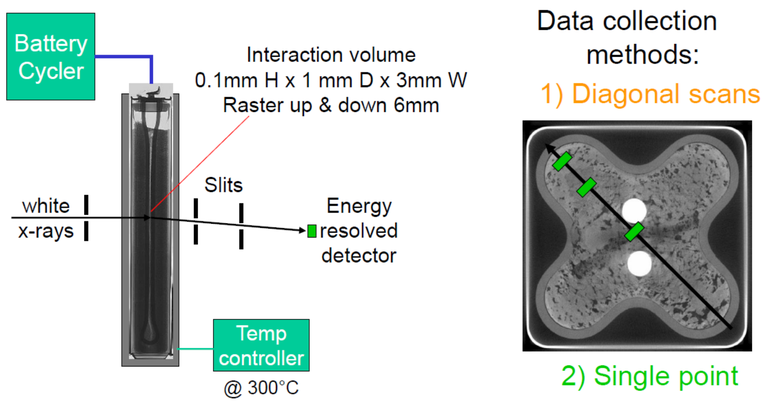






SCIENTIFIC APPLICATIONS

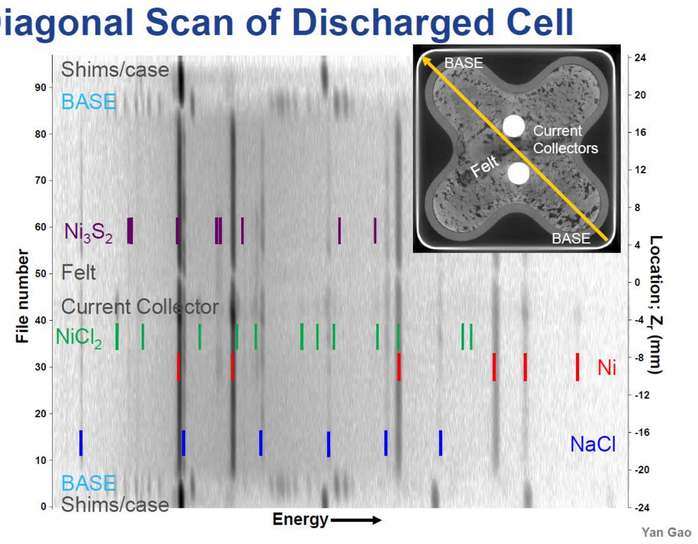
In-situ XRD Diffraction From Na-MCl_2 cells



J. Rijssenbeek, Y. Gao, Z. Zhong, M. Croft, N. Jisrawi, A. Ignatov, T. Tsakalakos, *J. Power Sources* **196** (2011) 2332–2339

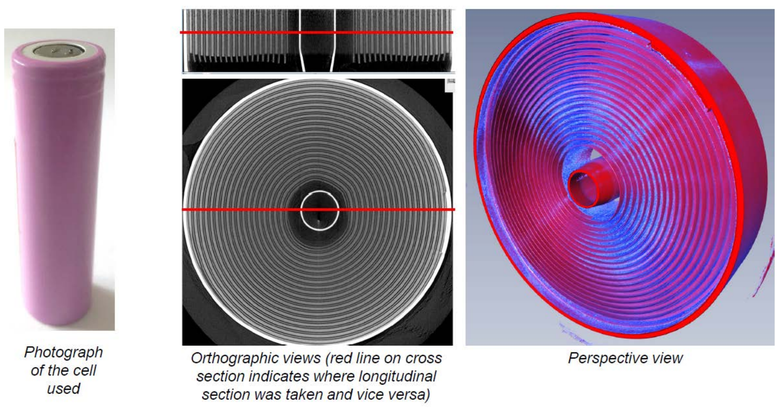
- In-situ EDXRD allows observation of reactions deep inside full-size cells.
- Promising technique for studying battery technologies and other "buried" processes

Diagonal Scan of Discharged Cell



- Good spatial and temporal resolution
- Yields reaction rate and mechanistic information

CT of a steel-encased Li-Ion Battery



TESLA motor battery, imaged at 70 keV at BMIT (Canada), Courtesy CLS Industrial Science

- Imaging can be performed before diffraction study
- CT guides placement of EDXRD gauge volume inside the sample