Optimization of Large-Scale Imaging with Scanning Electron Microscopy

Vivian Shi
Bard College at Simon's Rock

Eric W. Roth, Dr. Reiner Bleher
Material Science and Engineering, Northwestern University

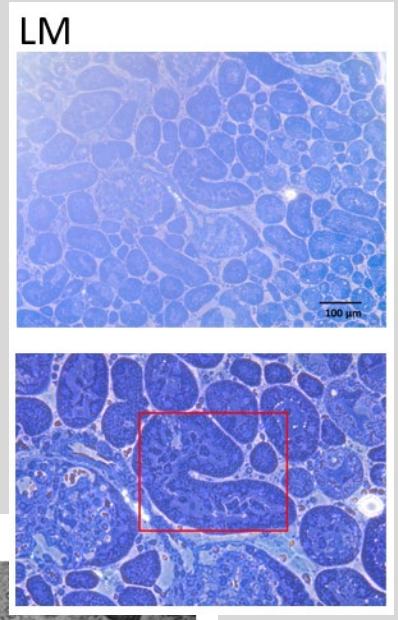
SHyNE Soft and Hybrid Nanotechnology Experimental Resource
THE UNIVERSITY OF CHICAGO
NSF
Northwestern University

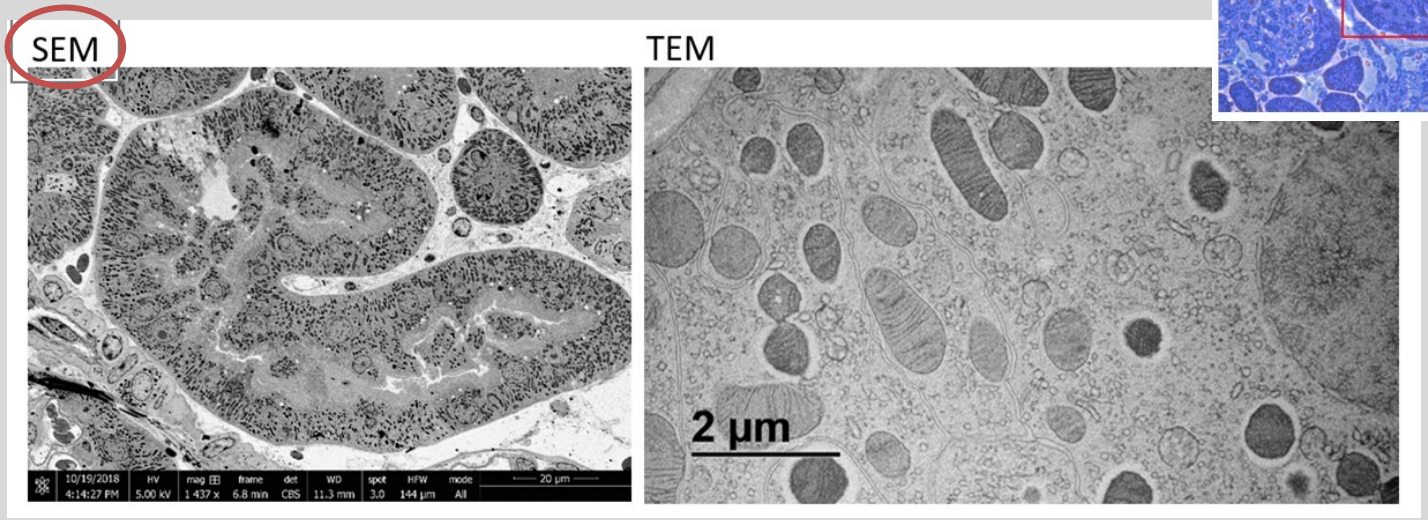
Imaging with Electrons

- Scanning Electron Microscope (SEM)
- Transmission Electron Microscope (TEM)

Comparison of light microscopy (LM) and electron microscopy images of sections of mouse kidney.

Images provided by Dr. Reiner Bleher, Northwestern University.





Large-Scale Imaging with SEM

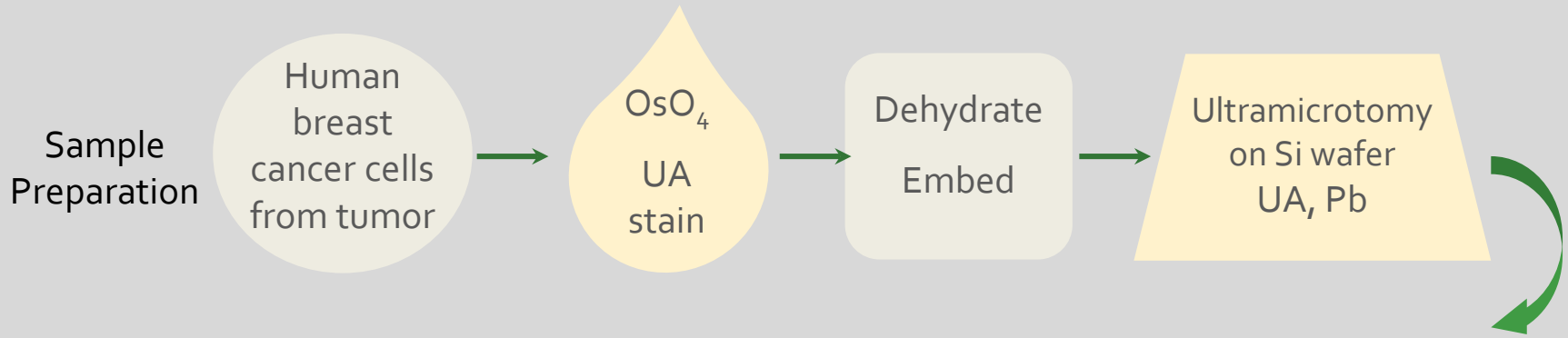


Image Quality

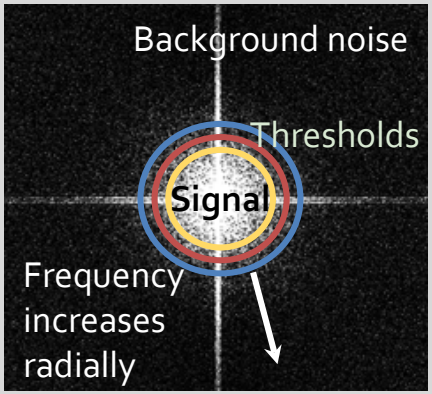
Signal to Noise Ratio (SNR)

$$\mathrm{SNR} = 10 \cdot \log_{10} \left[\frac{\sum_{0}^{n_x-1} \sum_{0}^{n_y-1} [r(x,y)]^2}{\sum_{0}^{n_x-1} \sum_{0}^{n_y-1} [r(x,y) - t(x,y)]^2} \right]$$

$$\left[\frac{\text{Average signal power}}{\text{Average background noise power}} \right]$$

Spatial Resolution

Fourier-based method



Cropped FFT power spectrum with thresholding

GATAN

How do we get the highest quality image?

Approach

Quanta FEG 650 SEM

Acceleration Voltage

Spot Size

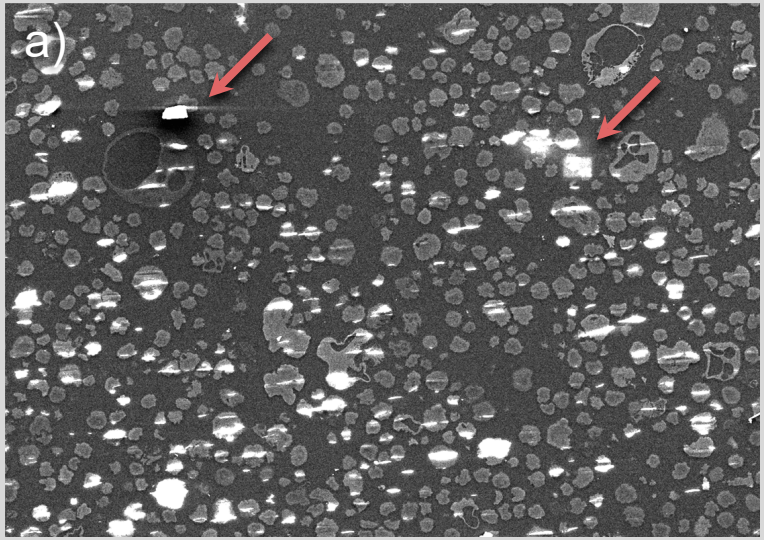
Dwell Time

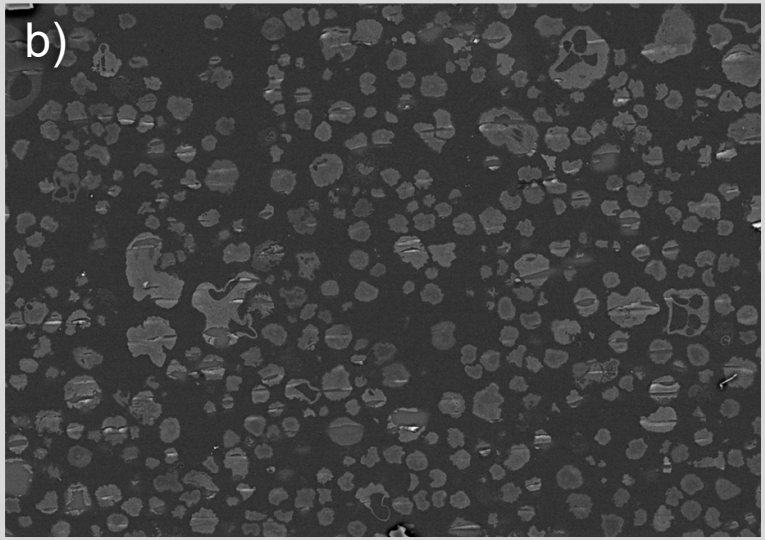
Working Distance

Image Processing + Analysis

SE vs. BSE

- Secondary electrons (SE): surface topography
- Backscatter electrons (BSE): material composition



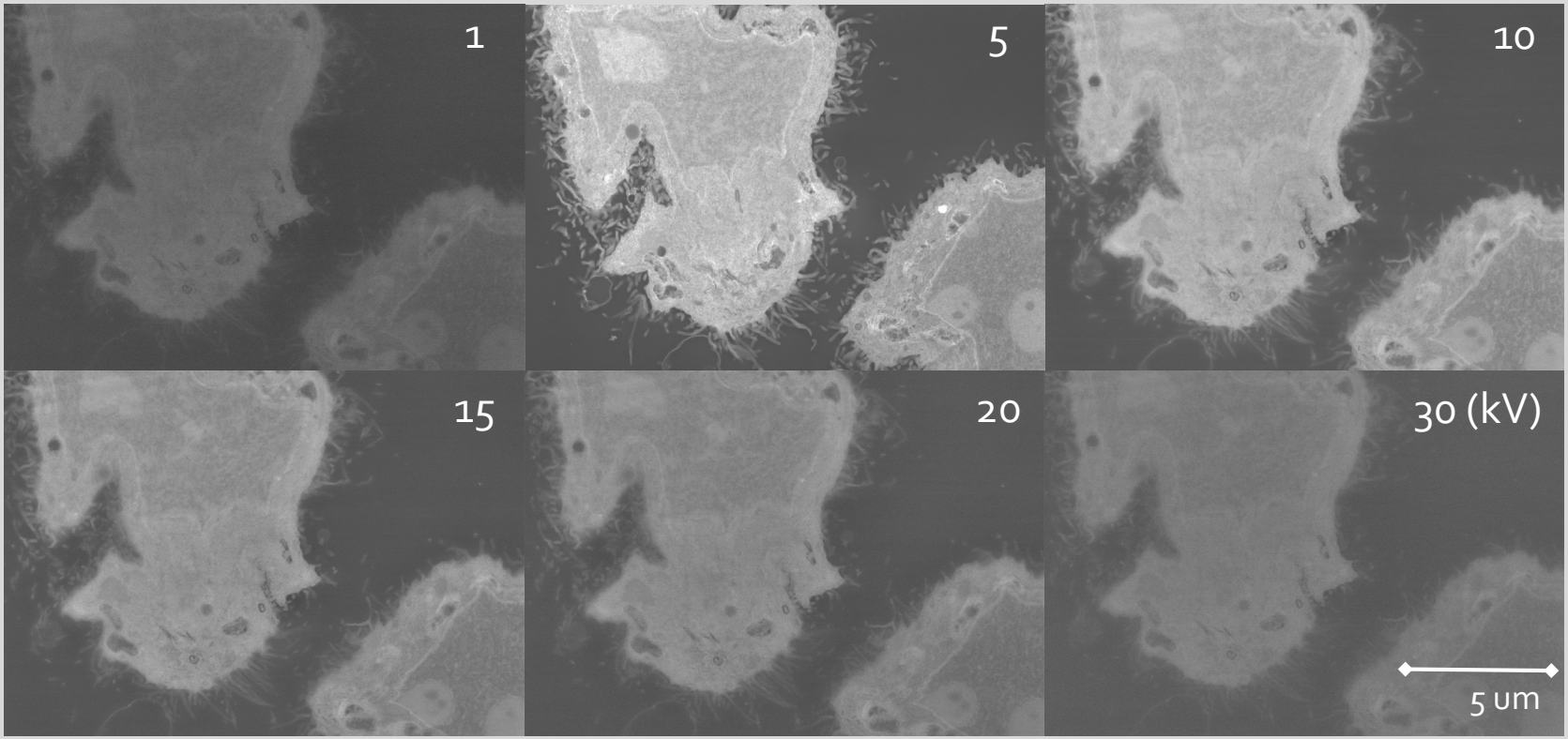


Human breast cancer cells from tumor

SE (left) vs BSE (right)

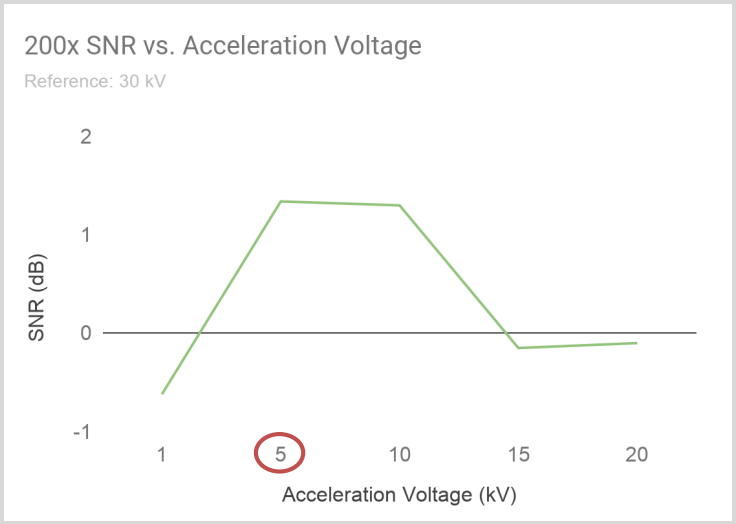
20 kV, 200x (cropped)

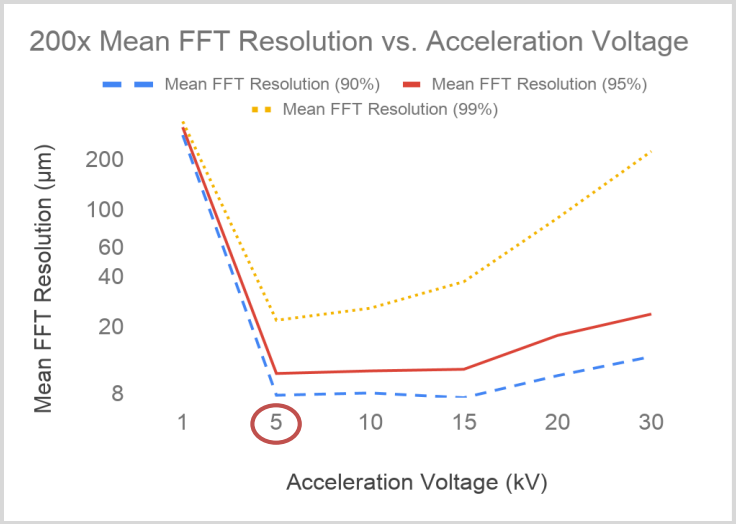
Results: Acceleration Voltage

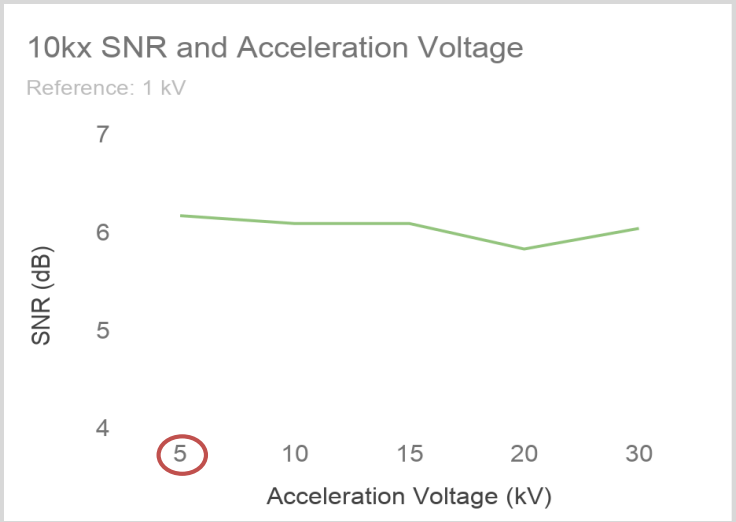


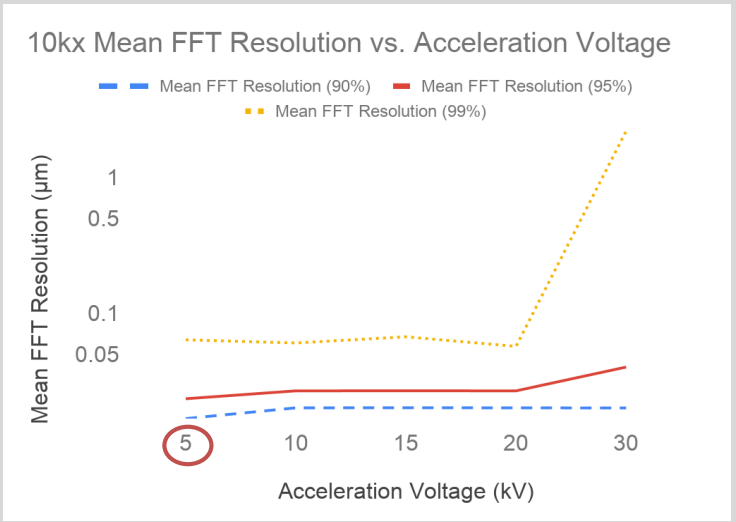
BSE 10kx: 30 µm aperture, 3.5 spot size, 5 µs dwell time,
10 mm working distance, contrast adjusted

Results: Acceleration Voltage

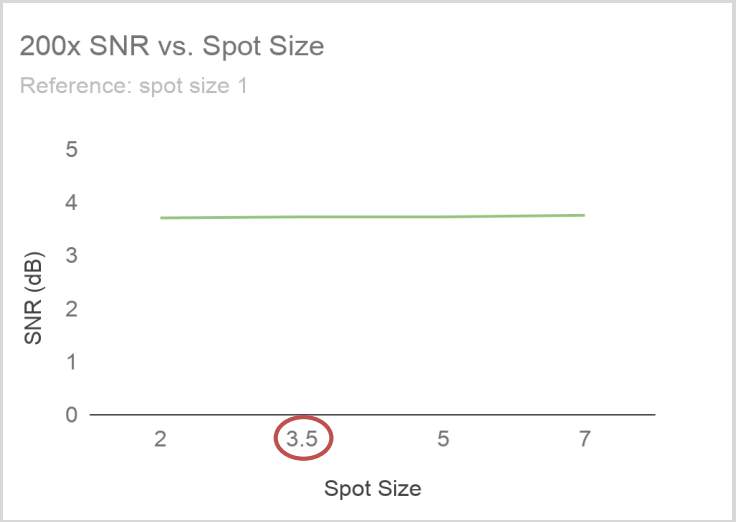


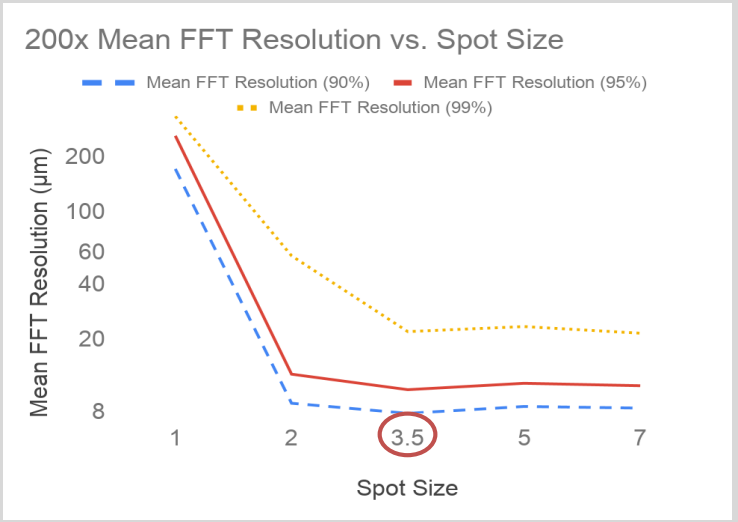


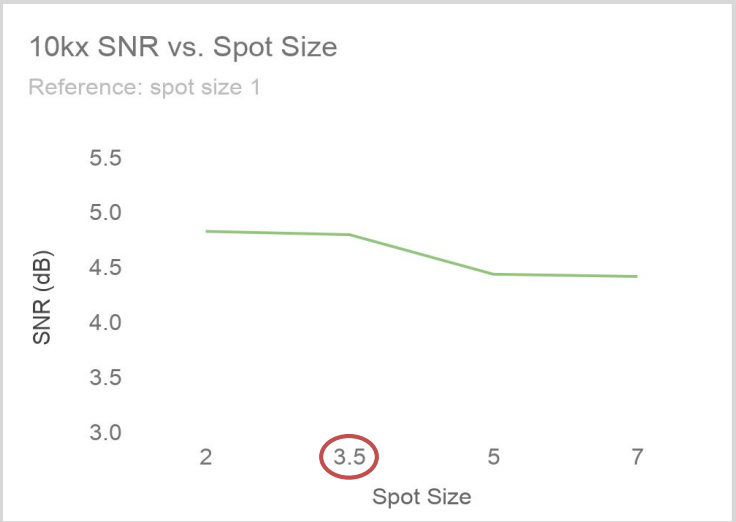


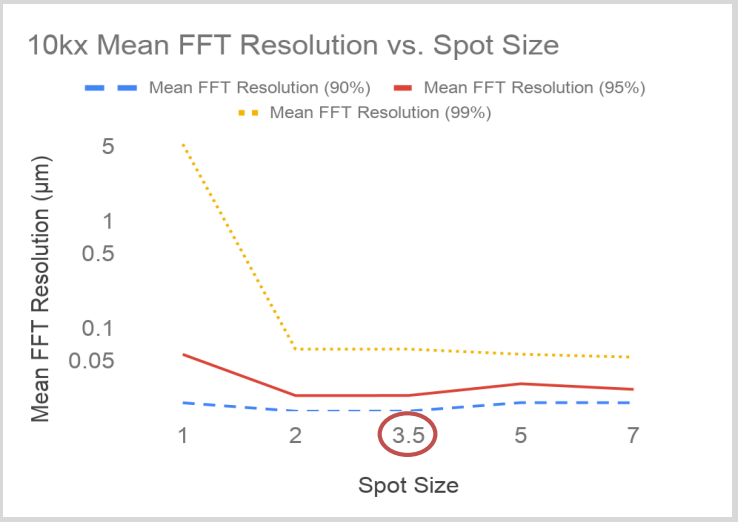


Results: Spot Size

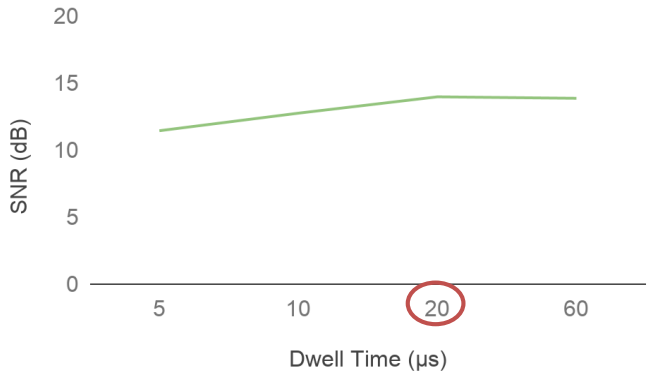


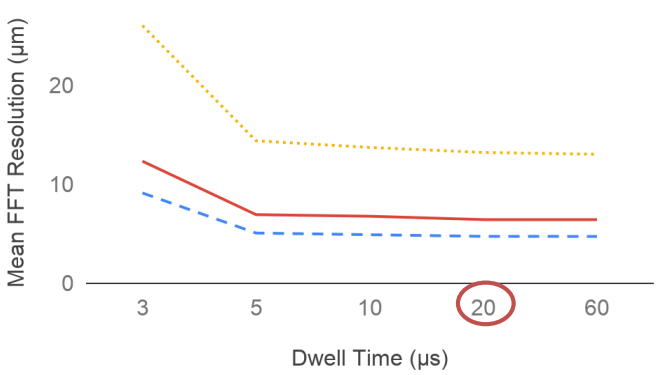


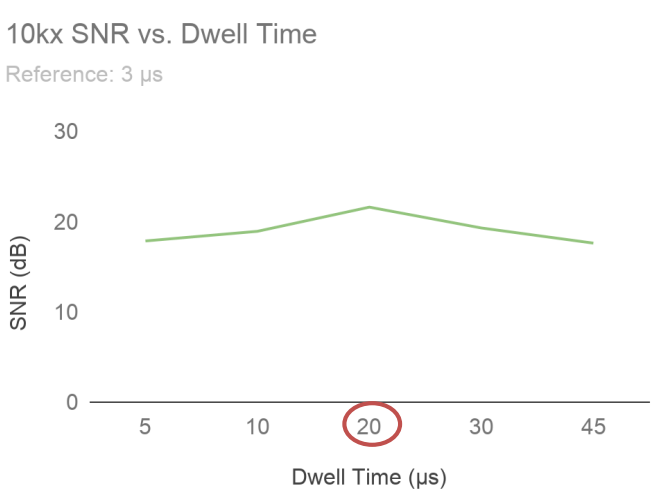


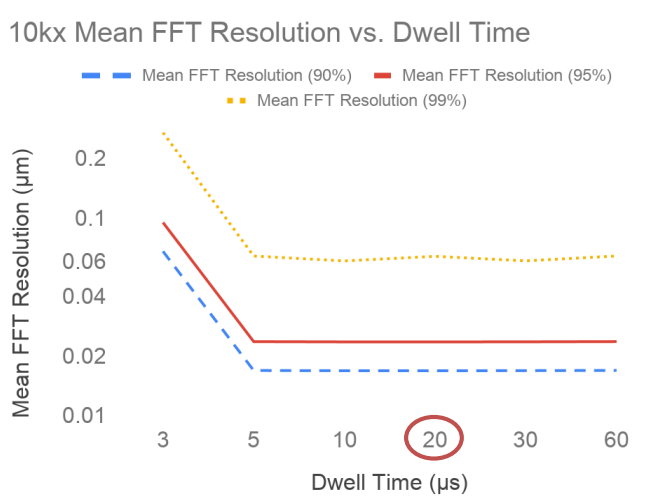


Results: Dwell Time

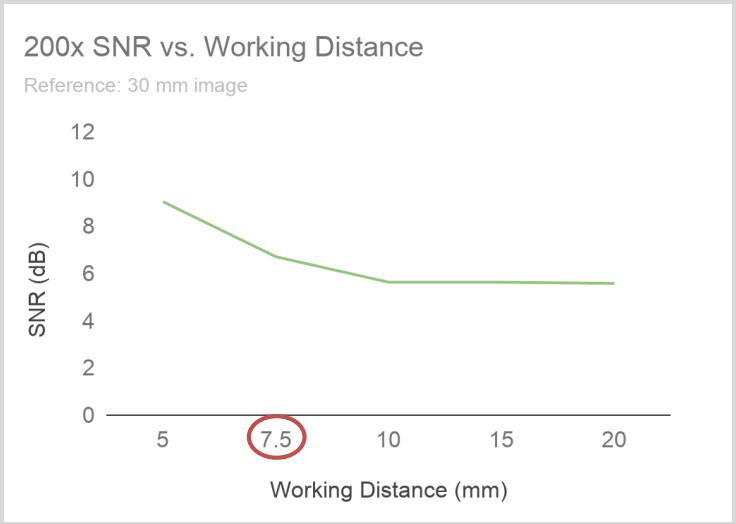


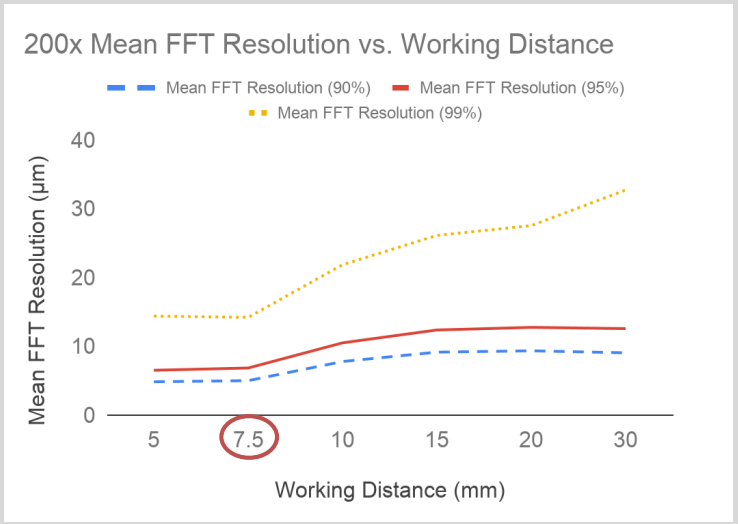


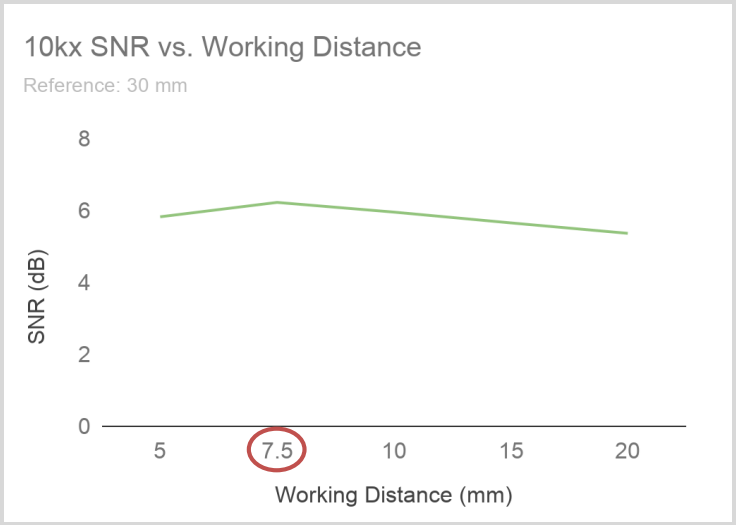


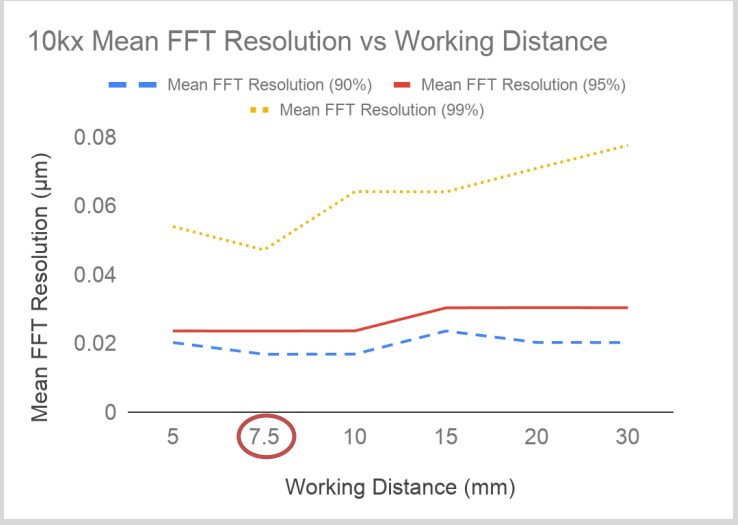


Results: Working Distance

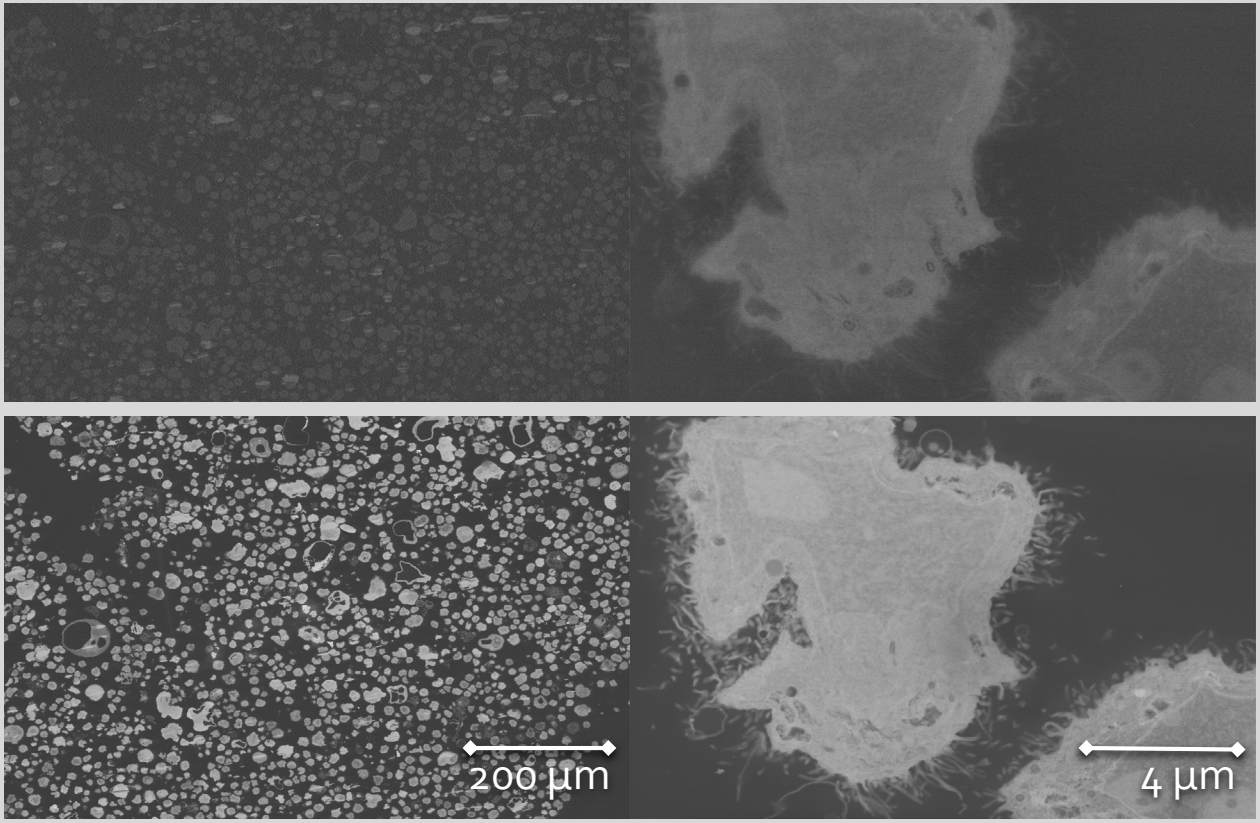








Final Images

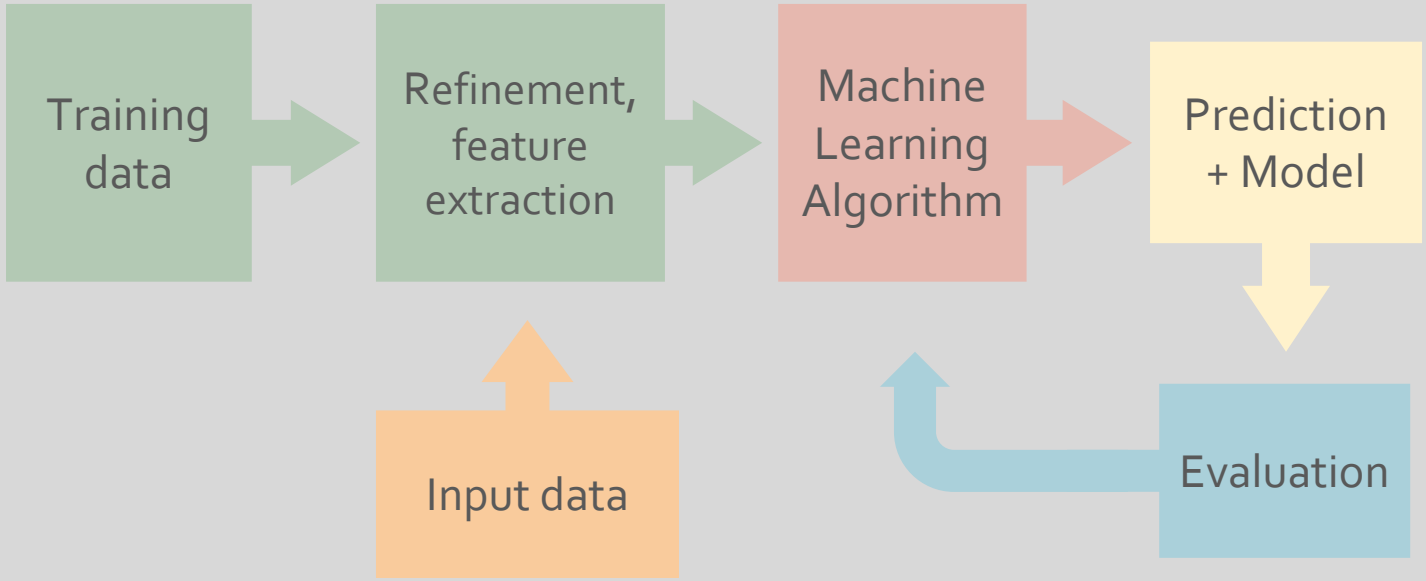


Human breast cancer cells from tumor 200x (left), 10kx (right)

(top) 1 kV, 3.5 spot size, 5 µs dwell time, 10 mm working distance
(bottom) 5 kV, 3.5 spot size, 20 µs dwell time, 7.5 mm working distance

Future Work

➢ Process of optimization→ **Machine learning**



➢ Other quality metrics: **contrast transfer function (CTF)**

Acknowledgements

SHyNE Resource, Northwestern University
NNCI REU ECCS-1542205

Eric W. Roth, mentor
Dr. Reiner Bleher, faculty supervisor
Dr. Ben Myers, program supervisor
Tirzah Abbott, microscope specialist