AMI-II: Direct Detector Data Analysis

SLAC NATIONAL ACCELERATOR LABORATORY

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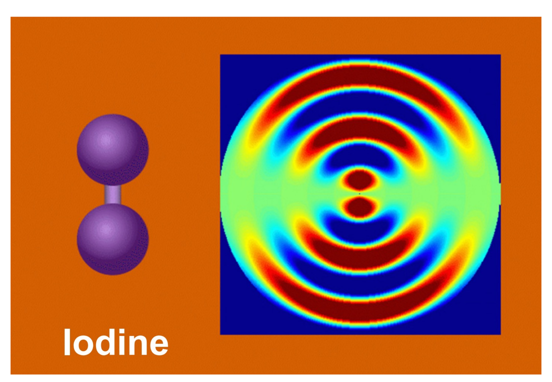
Introduction

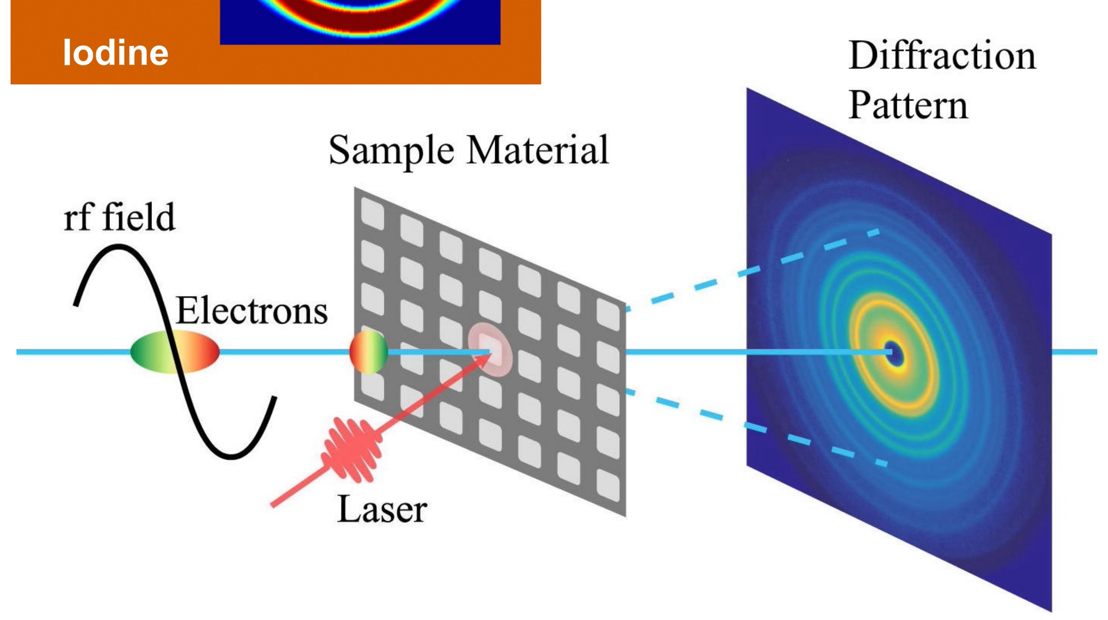
Ultrafast Electron Diffraction

- Study of time-resolved, ultrafast atomic, molecular, and structural dynamics
- Ultrafast Electron Diffraction (UED) initiative
- Pump-probe, glean information about dynamic changes

Pump-Probe Technique

- Laser pulse (pump) incident on a material, exciting it resulting in alterations
- Electron beam (probe) measure and quantify the effect of the excitation
- Interaction with the sample causes electron diffraction in the probe
- Signals recorded using charge-couple device (CCD) cameras
- Adjust time interval between the two pulses to obtain a succession of diffraction patterns.



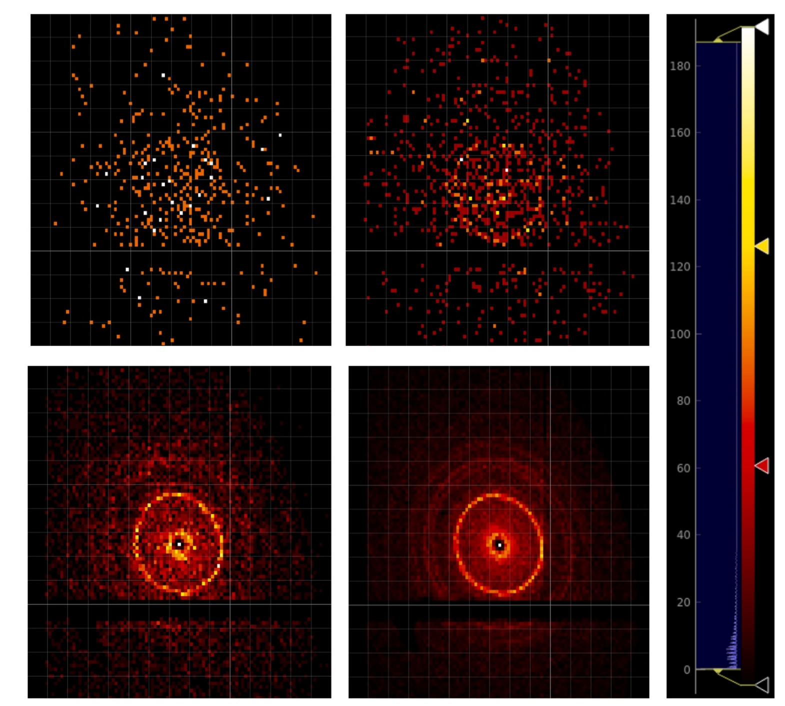


Diffraction Pattern

Blobfinding

- Optimize experimental parameters, camera diagnostics
- Electron hits should be observed in no less than 4 pixels
- Sum of clusters fit to Landu distribution

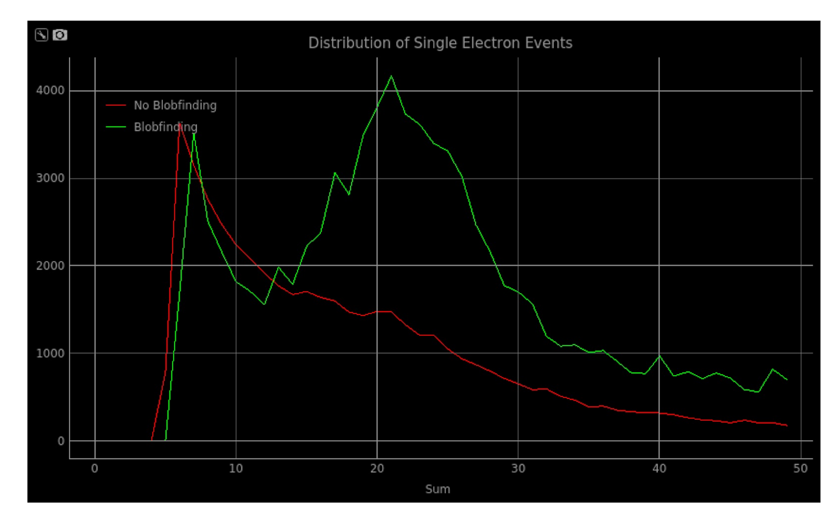
1. Locate single pixels exceeding threshold
2. Sum cluster values, must exceed acceptance threshold
3. Plot coordinates/intensity of clusters to visualize diffraction pattern
4. Plot histogram of electron counts against sum



Accumulation of electron hits forming the diffraction pattern in AMI-II

Single Pixel Filtering

- Analyze un-clustered pixels
- Reject pixels below threshold
- Continuous distribution with a small bump due to the electron signal
- Lacks additional filter placed on events from blobfinding
  1. Counts must exceed threshold → noisy pixels excluded
  2. High intensity adjacent pixels must exist such that sum exceeds another threshold → events in 2+ pixels counted once

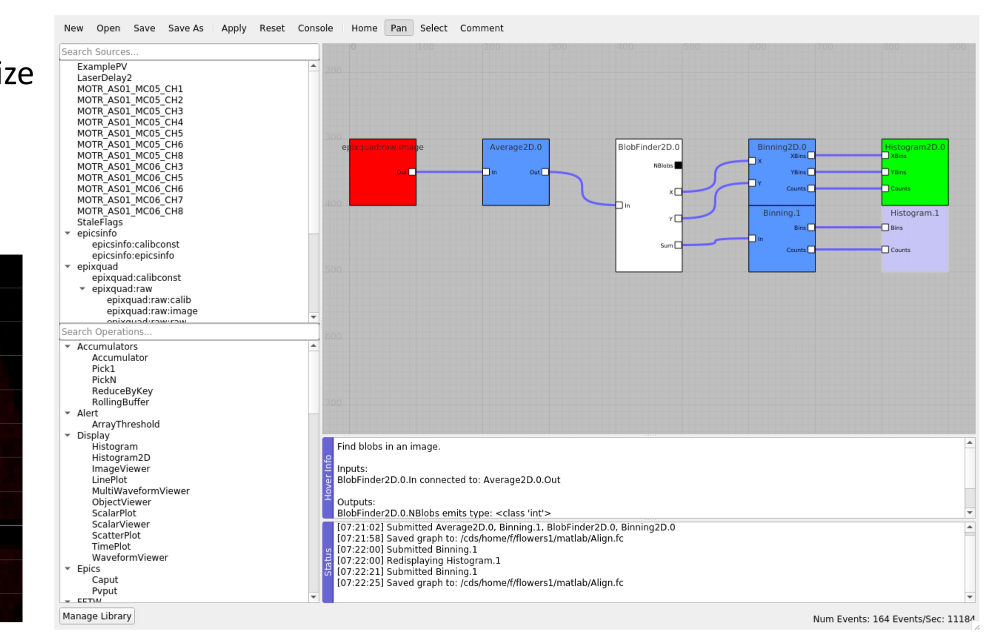


Distribution of single electron events with and without blobfinding

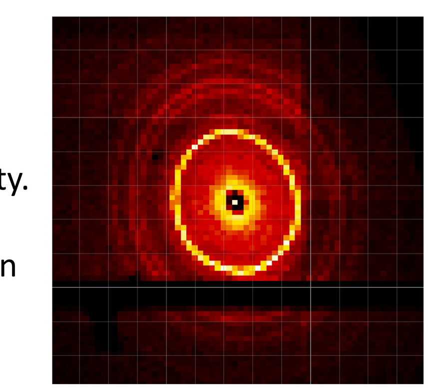
Data Analysis

Alignment

- Near-live image of diffraction pattern to maximize intensity
- Parameter optimization
- Flowchart: choose from sources & operations



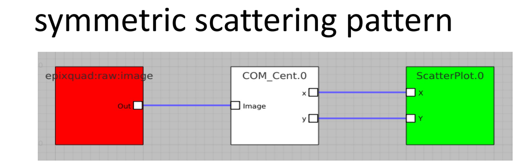
note how the rings are more defined, and much higher in intensity. Allows for easier differentiation between similar diffraction patterns



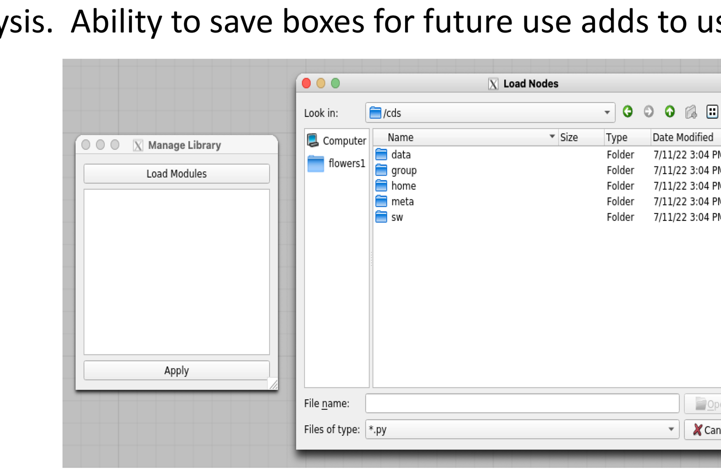
Reusable Boxes

Highly customizable, which enables advanced levels of analysis. Ability to save boxes for future use adds to user convenience and is an attractive feature.

- Create boxes for more complicated analysis
- Define inputs, function, outputs
- New center find box: determine center of a centrally symmetric scattering pattern



- Import .py file from directory, load module into AMI
- Box saved for future use



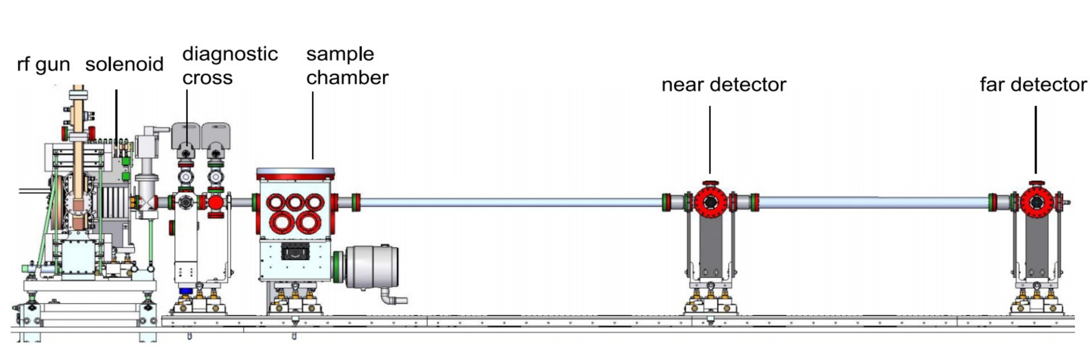
Imaging System

Mega Electron-Volt UED

- Performance increased using MeV sources, MeV UED developed at SLAC
- Beam recorded by two detectors

1. P43 phosphor screen & Andor iXon Ultra 888 EMCCD
2. ePIX detector - direct electron detecting

	No Image Burn	Quantum Efficiency	Reciprocal Space Resolution	Wavelength Compatibility
Phosphor-Based	✗	✗	✗	✗
Direct Detector	✓	✓	✓	✓

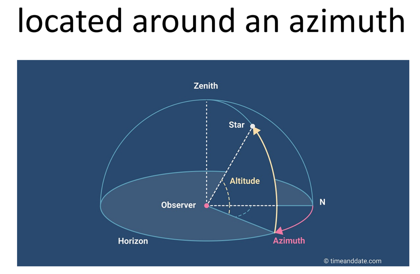


Schematic of the MeV UED beam line at SLAC's ASTA facility

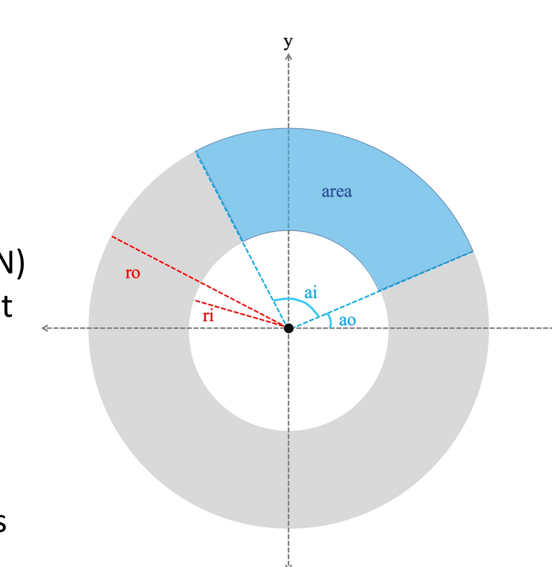
Future Projects

Radial/Azimuthal Integration (RoiArch):

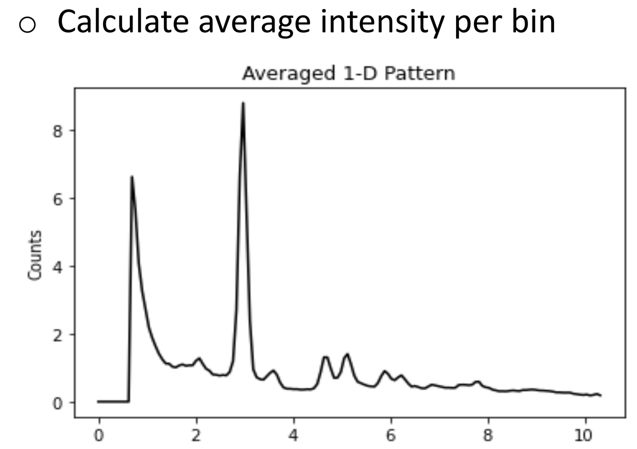
Calculate the circular azimuthal average -- the arithmetic mean of data points located around an azimuth

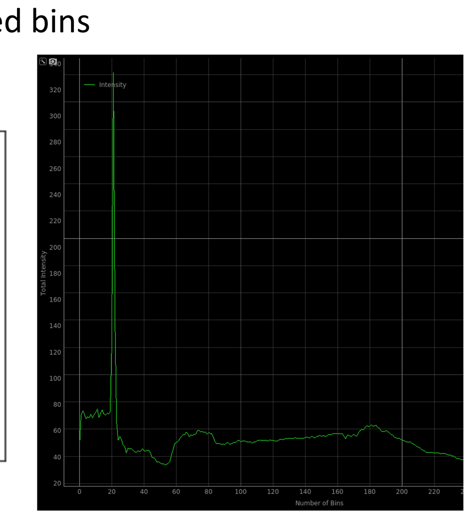


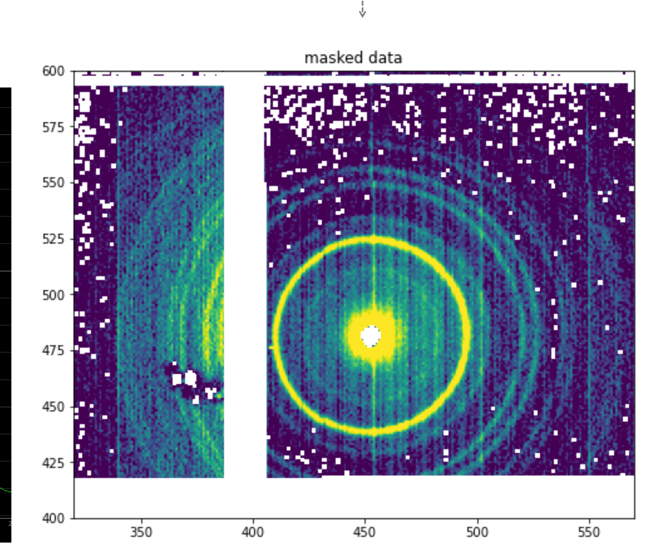
Azimuth: Angle between a reference direction (N) and a vector from the origin to a point of interest (star) projected onto the same plane as the reference direction.



- Input inner radius ***ri*** and outer radius ***ro*** to define the width of the ring
- Input starting angle (from x-axis) ***ao*** and ending angle (from ao) ***ai***, specifies the arc area between the two concentric circles
- Divide area into the number of specified bins
- Calculate average intensity per bin







Conclusion

Like	Dislike
Immediate results, optimize time available with equipment	Lacking documentation
Separation of "sources" and "operators" works effectively	Sometimes slow/glitchy
Conceptually straightforward	Only been tested on old data

Thoughts:

- Built in operators handy, but sometimes limiting
- Easier to rely on "Python Editors" before developing an intuition for AMI

Next Steps:

- Test on new electron data once UED back on
- Develop more defined/efficient method of benchmarking data

Acknowledgments

Mentor: Alexander Reid, MeV-UED Instrument Lead Scientist

Group: MeV-UED