Overview

Guns and Voltage

Lens Systems

Detectors
Why Electrons?

Pros

- Small wavelength
- Can be focused

Cons

- Damages sample
  - worse with faster electrons
- Poor penetration
  - better with faster electrons

They’re the worst option, except for everything else
Concept check: electron guns

• What are the 3 main kinds of electron guns? What are the advantages and disadvantages of each?

• What is the difference between spatial coherence and temporal coherence?

• What is the “high tension”?

• How fast are the electrons moving at our usual voltage range?
Typical Voltages & Configurations

- 80 - 120 keV
  - E.g. Joel J1230, Tecnai T12
  - Tungsten or LaB$_6$, CCD or CMOS non-DD
  - High contrast, robust, fast
  - Screening room temp or cryo samples
Typical Voltages & Configurations

- 200 keV
  - E.g. Tecnai F20, Talos, Arctica, Glacios
  - FEG, direct detector or non-direct detector
  - Versatile – screening or high resolution (sub-3 Å)
  - Usually cryo
Typical Voltages & Configurations

- 300 keV
  - E.g. FEI Polara, Titan Krios
  - FEG, Direct detector, energy filter, etc.
  - Highest resolution (sub-2Å)
  - Hopefully no screening
• What are the three main lens systems in an electron microscope?
• What are the special names given to the three independent sets of deflectors?
• What is “hysteresis”? 
• What is a “crossover”?
Electron Lenses

• Focus
• Magnify
• Rotate
<table>
<thead>
<tr>
<th>Detectors</th>
<th>Photon Converted</th>
<th>Direct Sensing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CCD</strong> (Charge Coupled Device)</td>
<td>![green checkmark]</td>
<td>![orange question mark]</td>
</tr>
<tr>
<td><strong>CMOS</strong> (Complementary Metal Oxide Semiconductor)</td>
<td>![green checkmark]</td>
<td>![green checkmark]</td>
</tr>
</tbody>
</table>
Detectors

From Anchi Cheng

Photon Converted

Direct Sensing

phosphor
fiber optic plate

CCD

CMOS

CMOS
Detector Quantum Efficiency

From Ben Himes on Twitter @B3naminHimes

Direct detector on our Krios

Direct detector on our F20

CMOS – Photon converted
On our T12 & F20
Hybrid Pixel Array Detectors

• The next detector for cryo-TEM?
• Now used regularly in x-ray diffraction

**Pros**: Great DQE, 10 kHz frame rate

**Cons**: Large (75 μm pixel vs 5 μm), Small viewing area – 1030 x 514

https://www.dectris.com/technology/hybrid-photon-counting/direct-detection
Hybrid Pixel Array Detectors

K2 Summit (super-resolution)  
K2 Summit (counting)  
DE-12  
Falcon II  
Falcon I  
F416  
US4000

DQE

Fraction of Nyquist

Dectris EIGER X 1M

40 keV  
60 keV  
80 keV  
100 keV  
120 keV

Fraction of Nyquist
Practicals & Journal Club

- Tomorrow’s practical: meet here at 3:30 for our microscope anatomy practical
- Journal clubs: for-credit students will present.

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Presenters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan 22</td>
<td>Comparison of original and modern plunge freezing techniques (Adrian et al. 1984 &amp; Razinknov et al. 2016)</td>
<td>Marriah Green, Ruby Froom</td>
</tr>
<tr>
<td>Feb 12</td>
<td>Beginning of the Resolution Revolution (Liao et al. 2013)</td>
<td>Zhengshan Hu, Vinay Kumar Sapuru</td>
</tr>
<tr>
<td>Feb 19</td>
<td>HIV trimer controversy and Einstein from noise (Mao et al. 2013 &amp; Henderson 2013 &amp; van Heel 2013)</td>
<td>Rafal Piwowarczyk, Pedro Gutierrez, Natalie McArthur</td>
</tr>
</tbody>
</table>