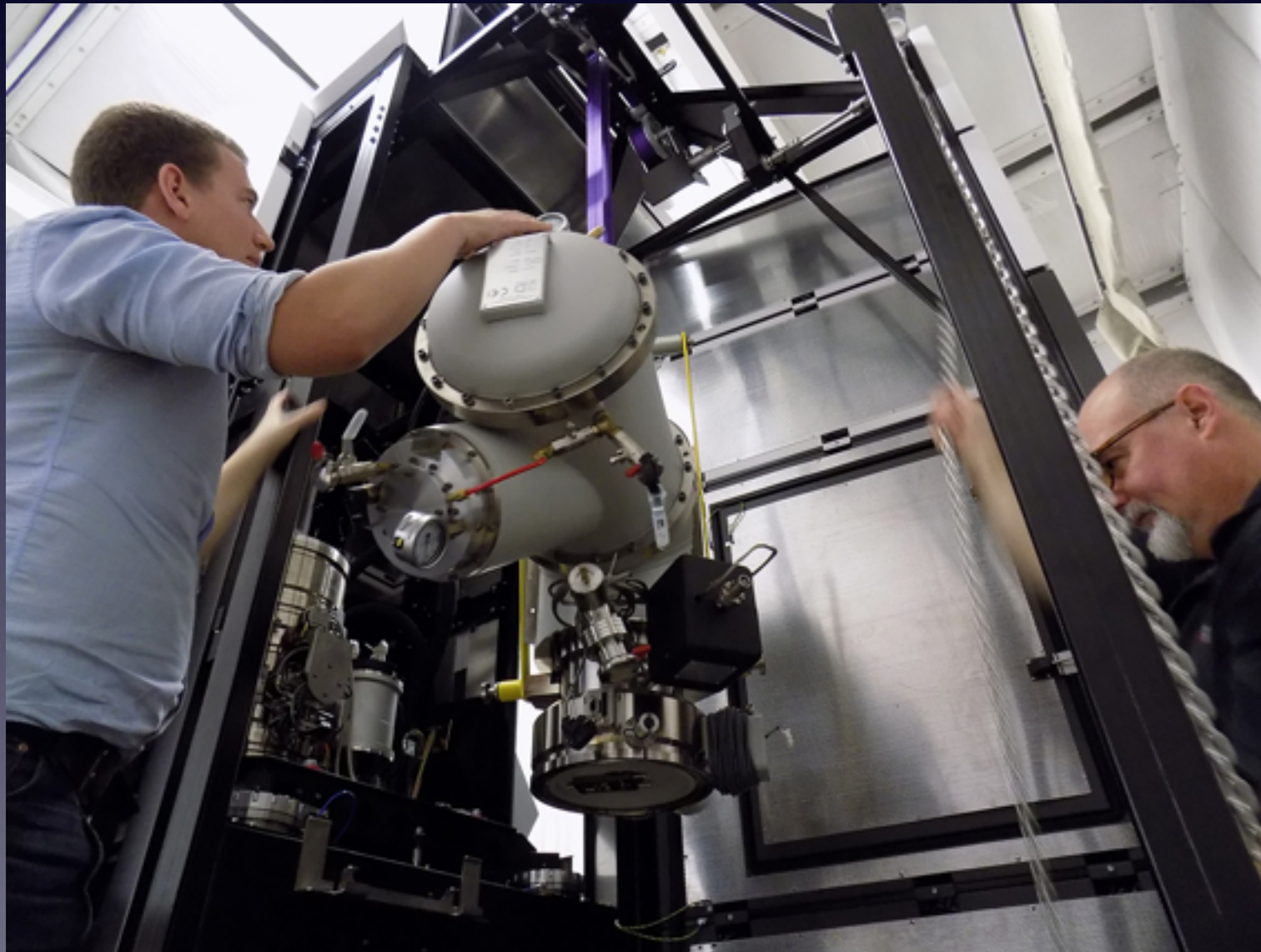


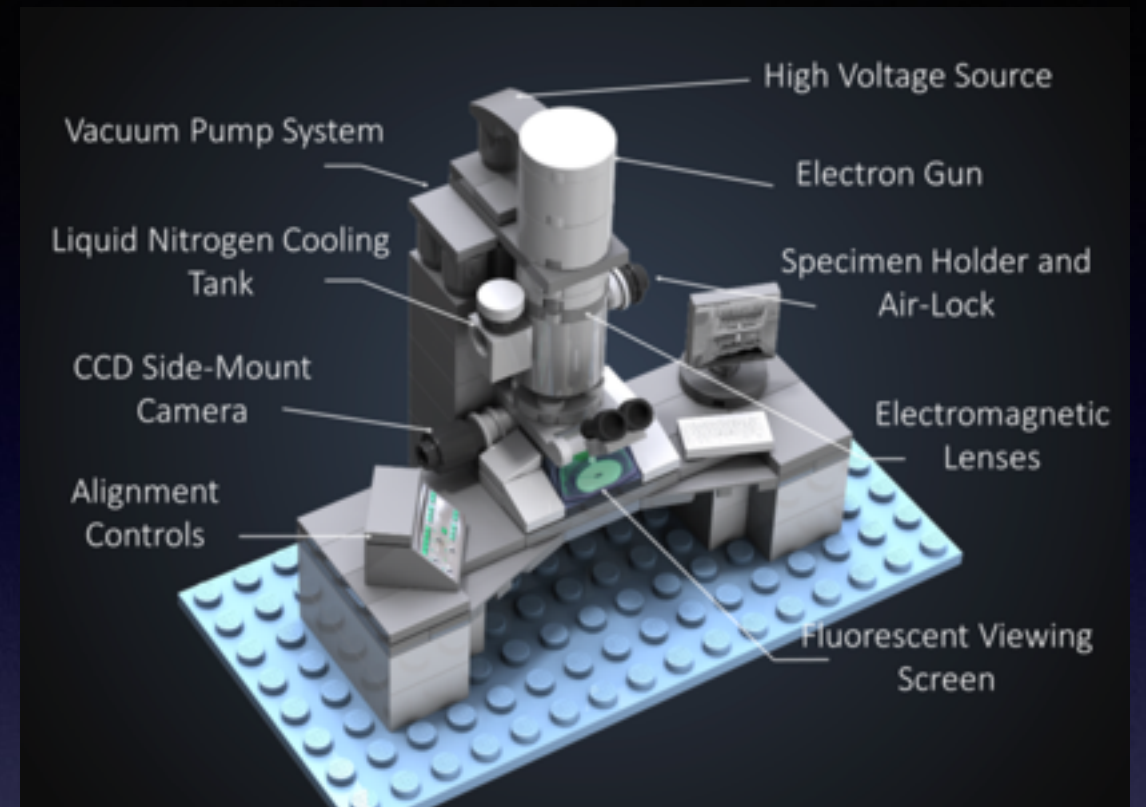
# Supplementary to Basic anatomy of the electron microscope

Anchi Cheng

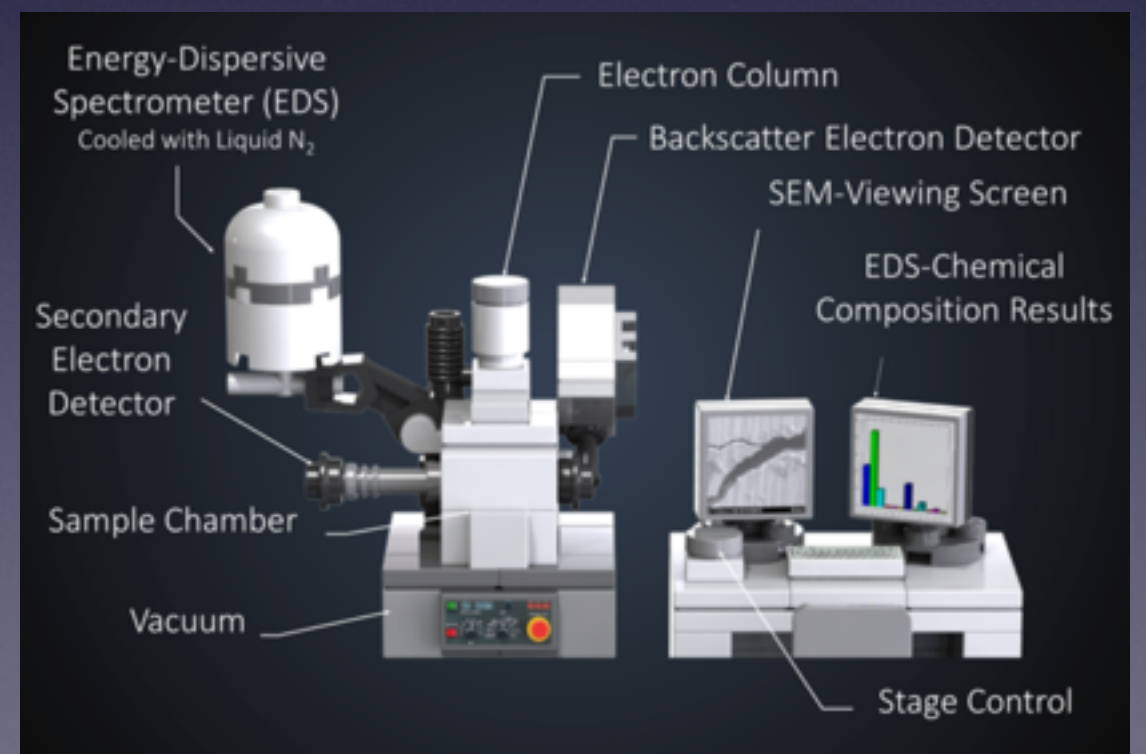


# What we will add

- Different TEMs
- Scope Alignment
- Direct Detection Camera
- SEM anatomy



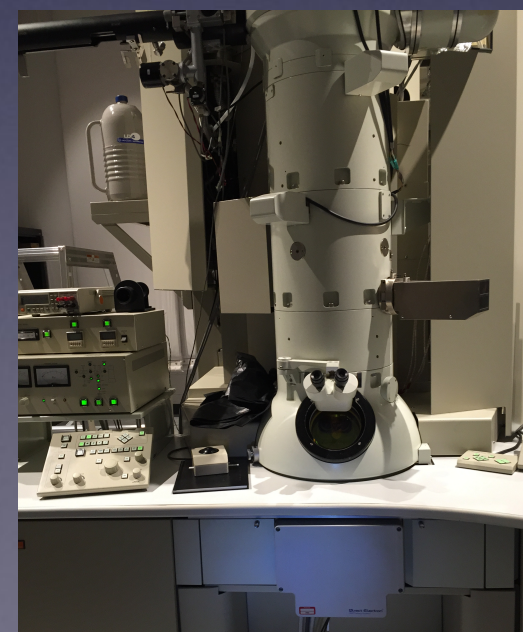
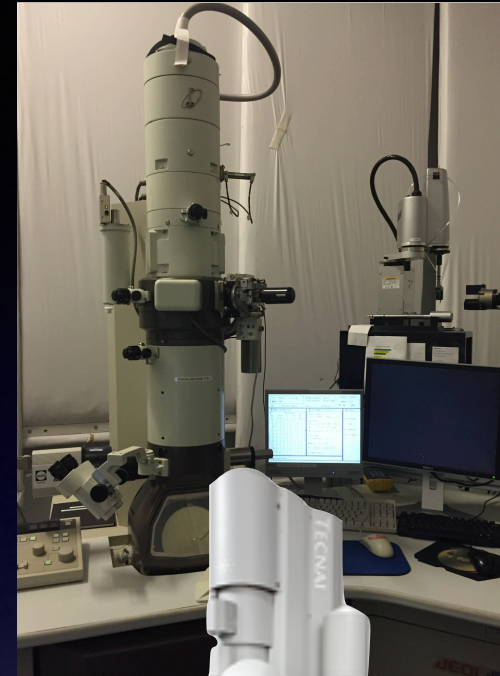
<https://ideas.lego.com/projects/102281>



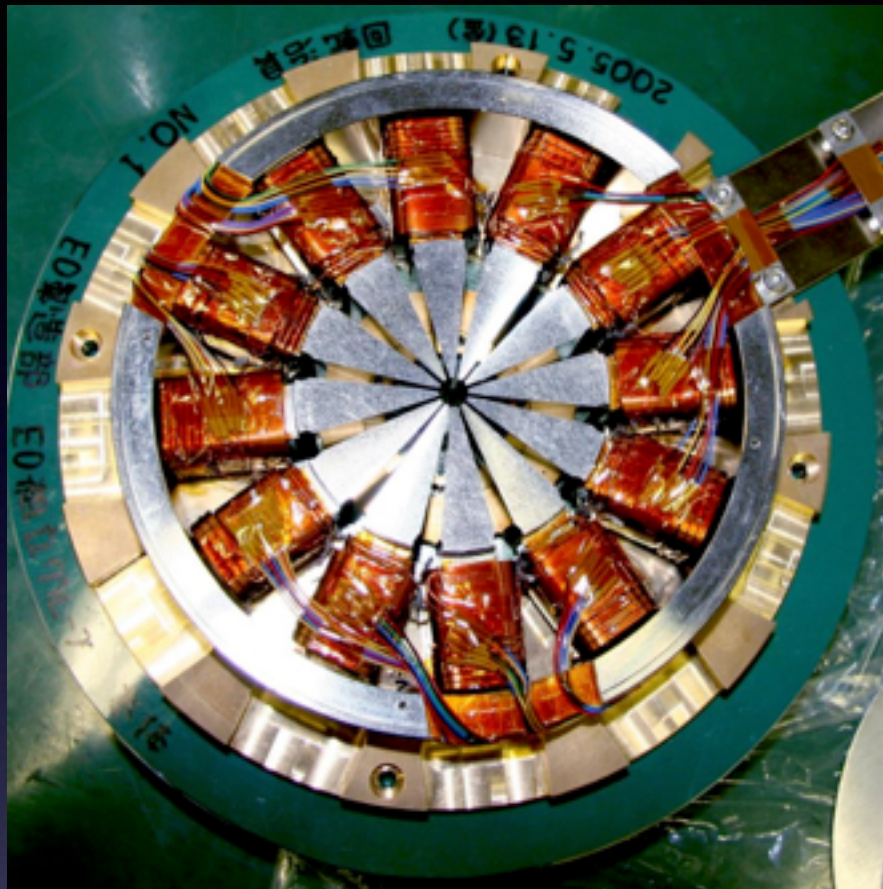


# TEMs used in cryo-EM

- 80-120 kV: JEM 1230; Tecnai T12
  - W or LaB6
  - High contrast & robust
- 200 kV: JEM 2100F, Tecnai F20, Talos, Artica
  - FEG
  - 4 Å resolution (2016)
- 300 kV: JEM 3200FSC, Krios, Polara
  - FEG
  - Smaller effect on unwanted lens aberration
  - 2.5-3 Å resolution (2016)



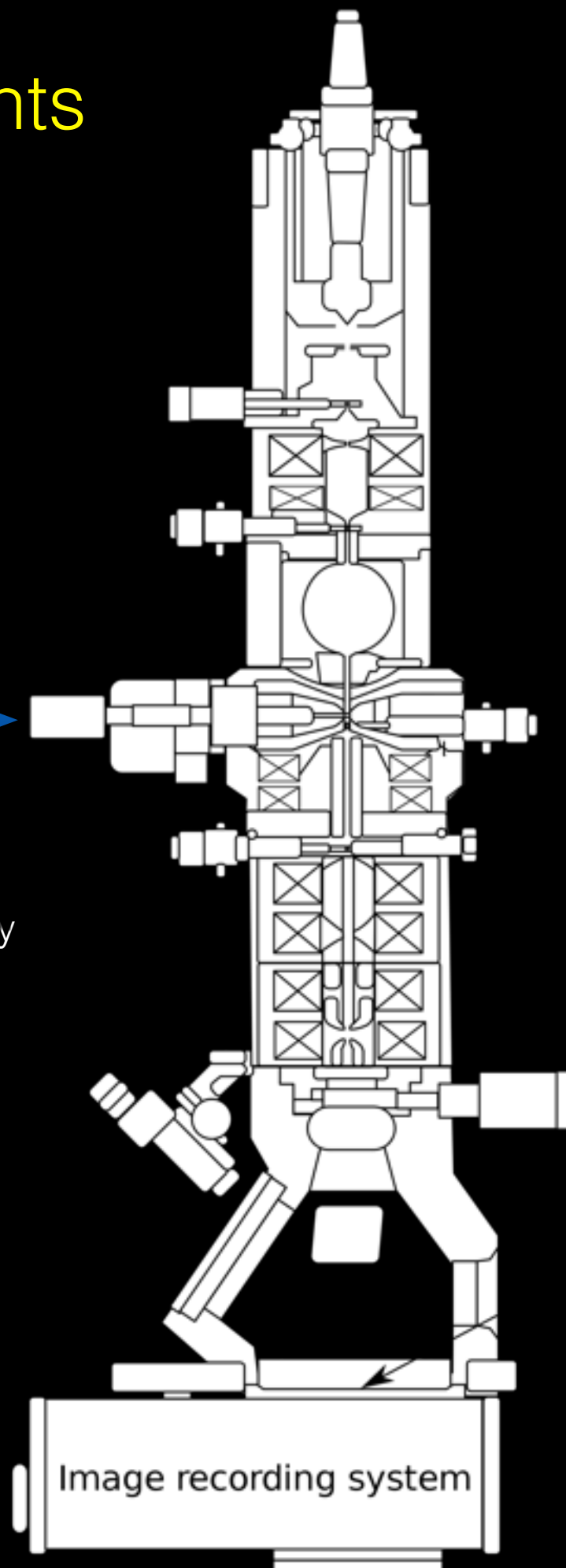
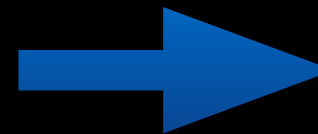
# Microscope Components



[https://en.wikipedia.org/wiki/Scanning\\_transmission\\_electron\\_microscopy](https://en.wikipedia.org/wiki/Scanning_transmission_electron_microscopy)

Filament	Energy Distribution ( $\Delta E$ )
Heated tungsten	2.5 eV
LaB <sub>6</sub>	1.5 eV
Warm FEG	1.0 eV
Cold FEG	0.25 eV

[http://www.snaggledworks.com/em\\_for\\_dummies/gun.html](http://www.snaggledworks.com/em_for_dummies/gun.html)

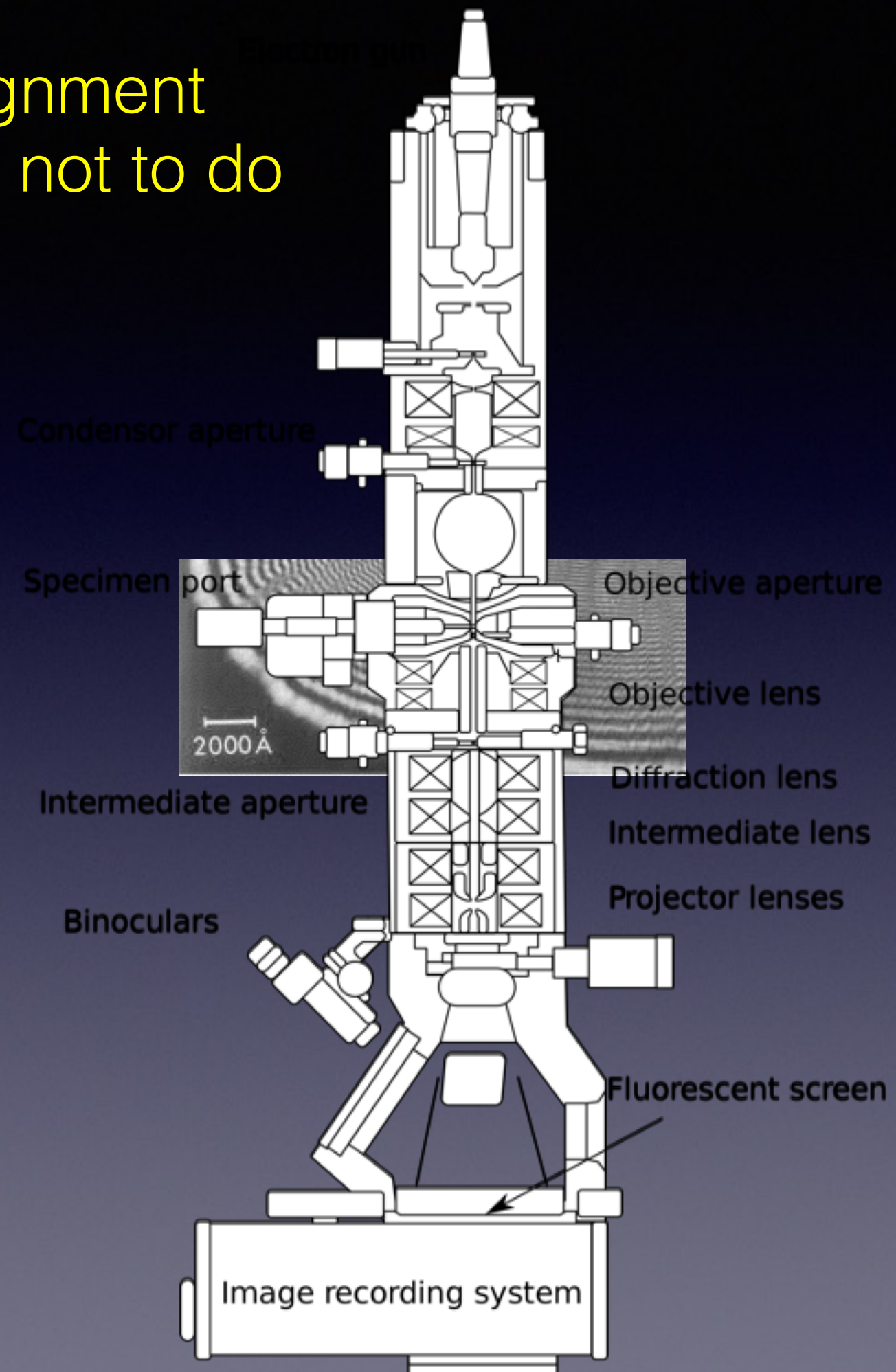




# Microscope Alignment

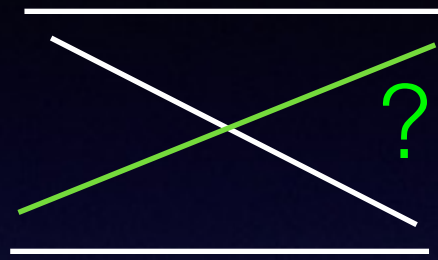
## What to do & what not to do

- Do:
  - Start at eucentric height and focus
  - Check if it is already good before attempt
  - Align from top to bottom
- Not to do:
  - ~~Align without a way to undo~~
  - ~~Align when TEM is not stable (i.e., temperature)~~

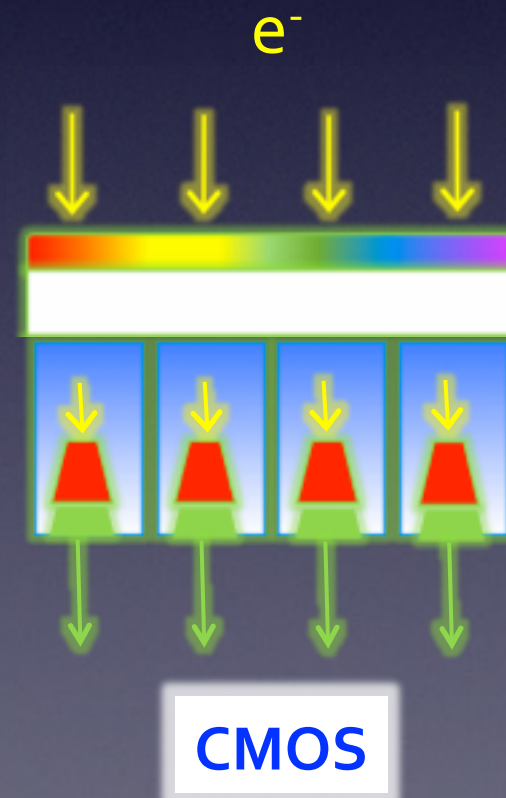
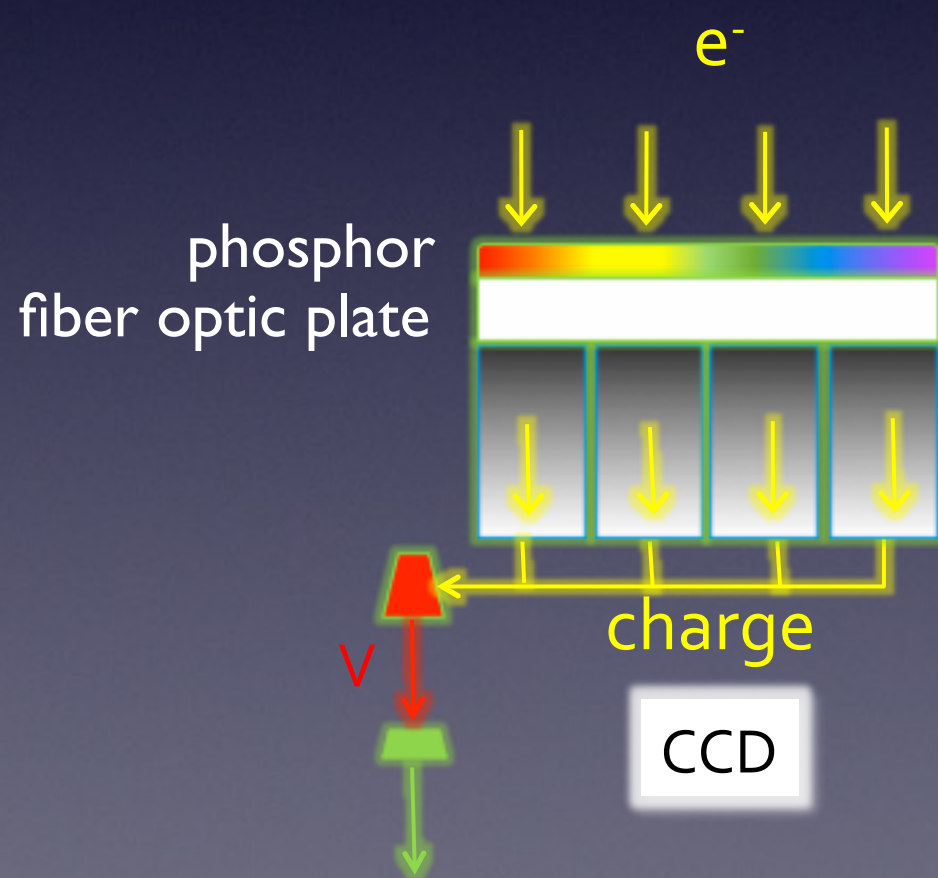


# Digital Cameras for TEM

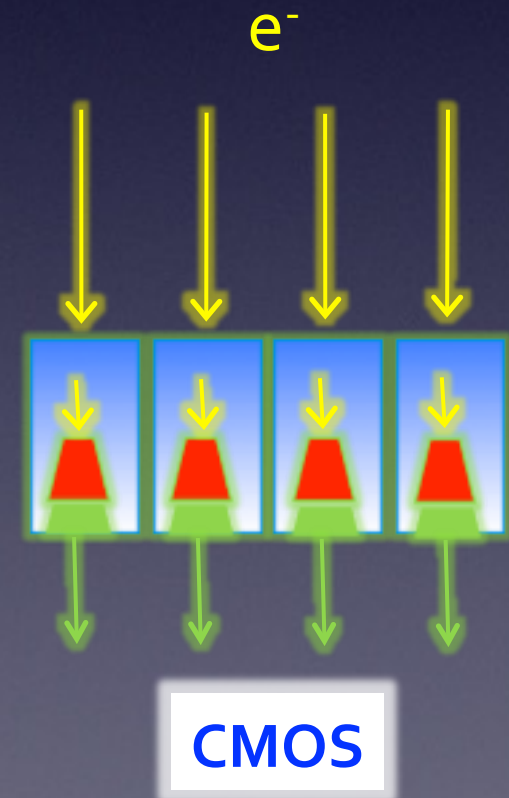
- Photon converted
- Direct sensing



- **CCD** Charge Coupled Device
- **CMOS** Complementary Metal Oxide Semiconductor



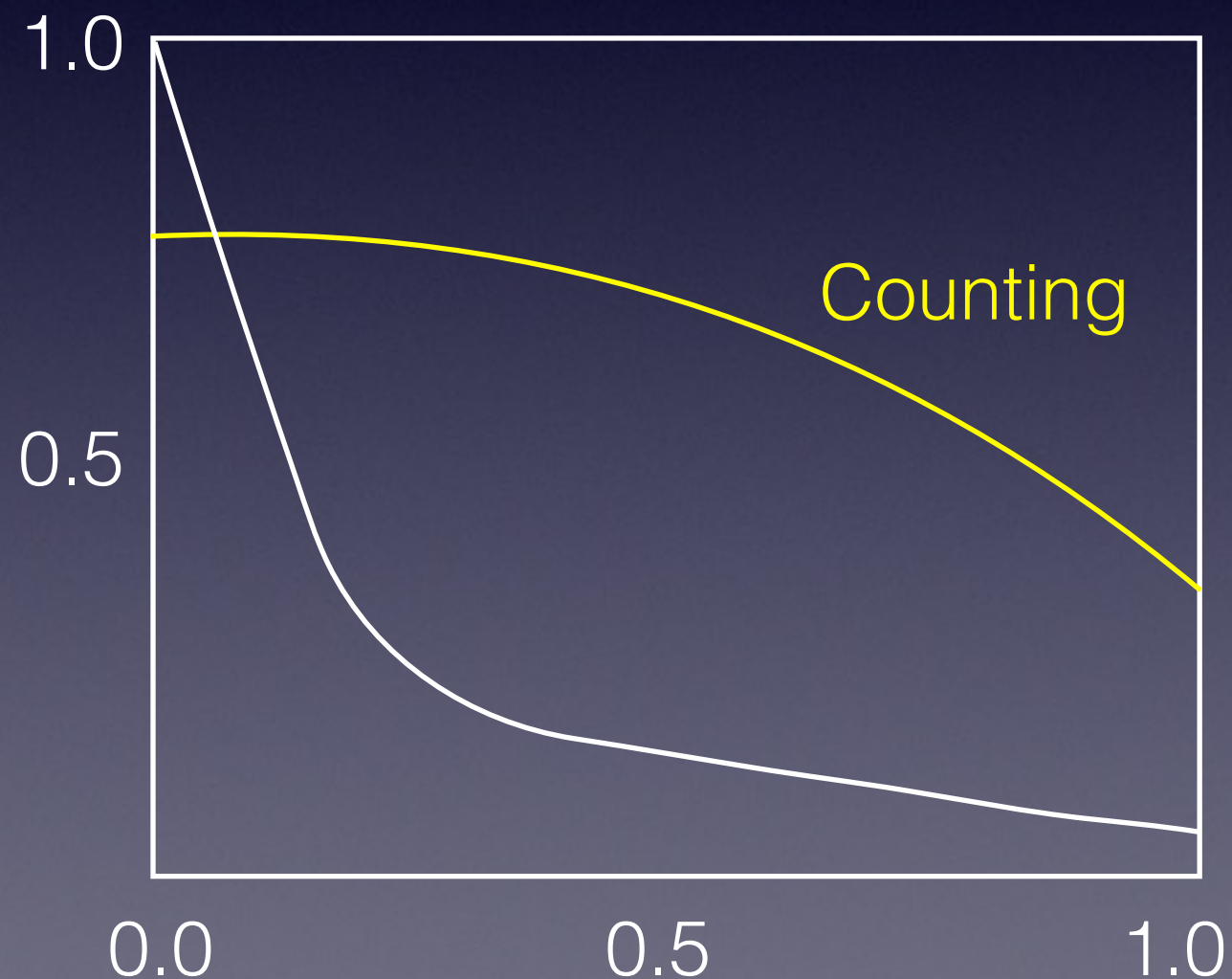
high dose rate



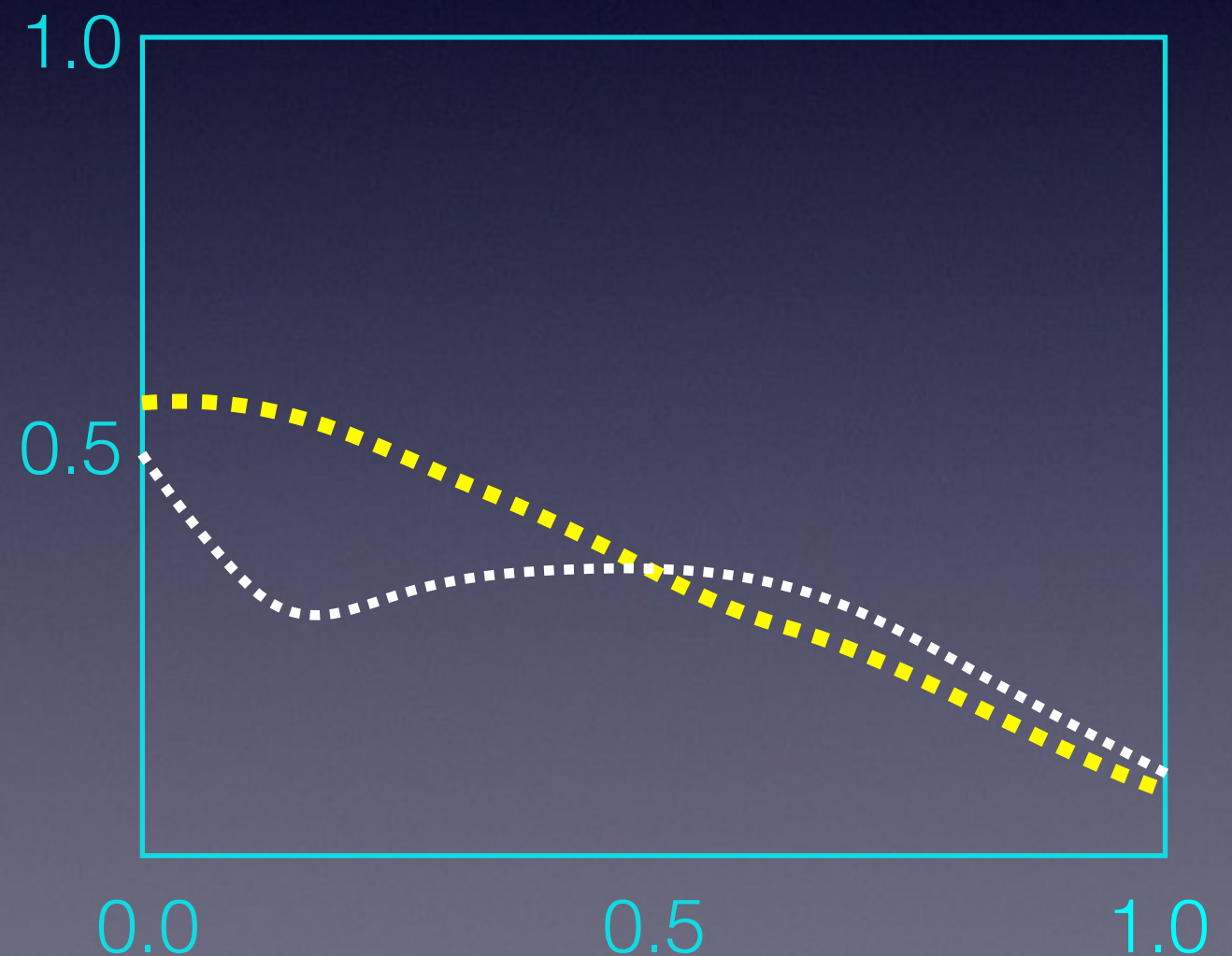
Direct Detectors

# Detector Performance Characterization

- MTF (Modulation Transfer Transform)
  - contribute to signal envelope
- DQE (Detector Quantum Efficiency)
  - S/N over spatial frequency range



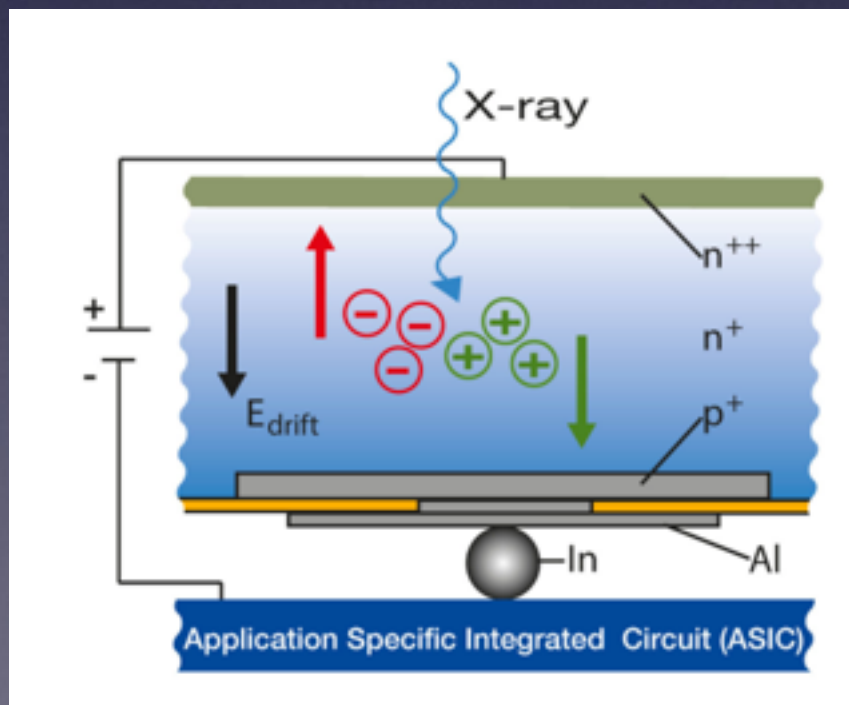
Nyquist Frequency





# Next Detector for cryo-TEM ?

- Hybrid Pixel Array Detector ?
  - Dectris X 1M (3000 Hz, almost perfect DQE, 75  $\mu\text{m}$  pixel)
  - Gruene\_et\_al (2018) Angewandte\_Chemie
    - DOI: 10.1002/anie.201811318



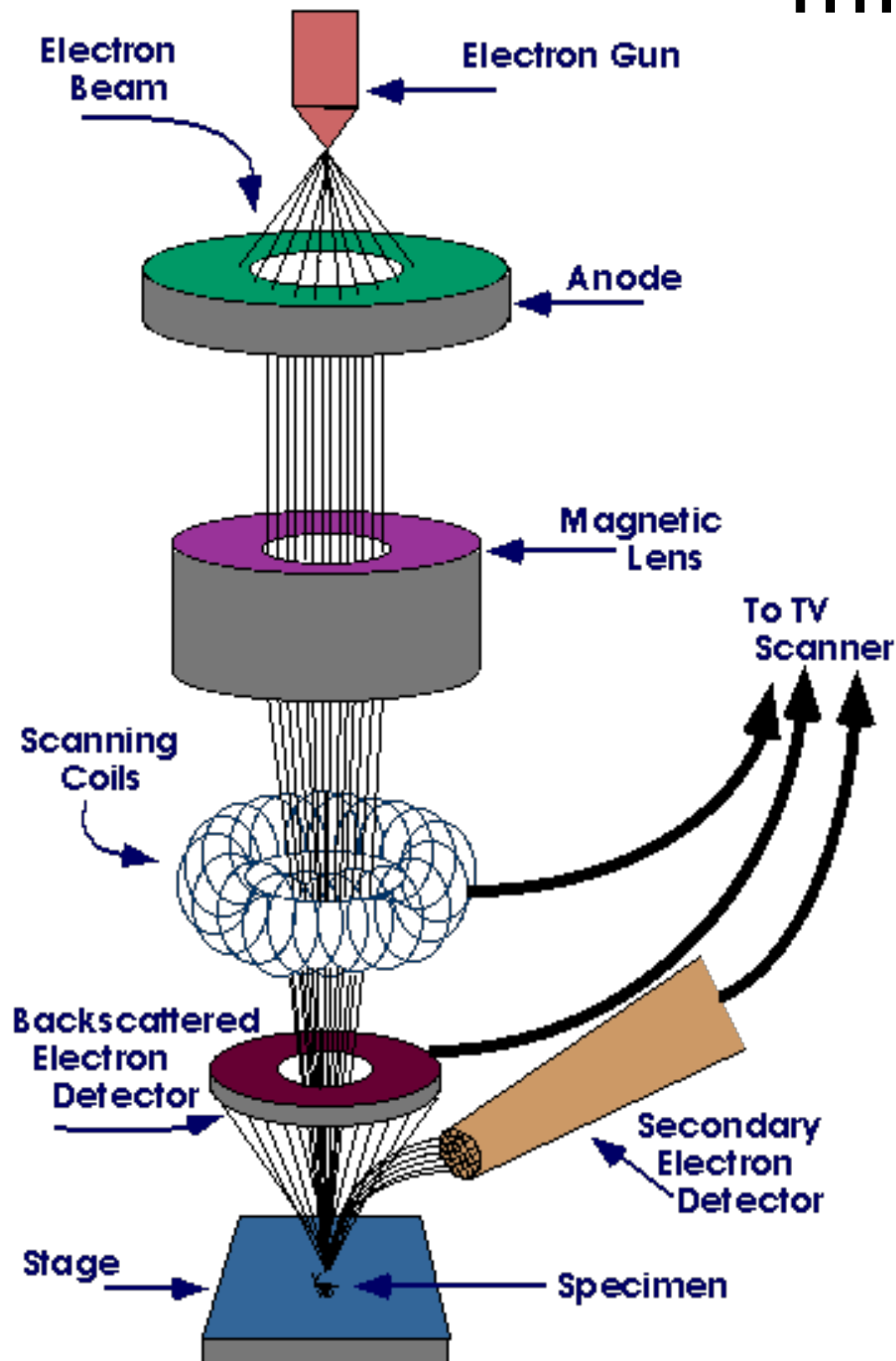
Trapped in the electric field  
that reduces the point spread



# Recommended Reading

- Instrument Manual
- Light and Electron Microscopy
  - E. M. Slayter and H.S. Slayter (**ISBN-13:** 978-0521339483)
- Internet

# Basic anatomy of a scanning electron microscope



Electron gun: range from tungsten filaments in lower vacuum SEMs to FEGs which need modern high vacuum SEMs

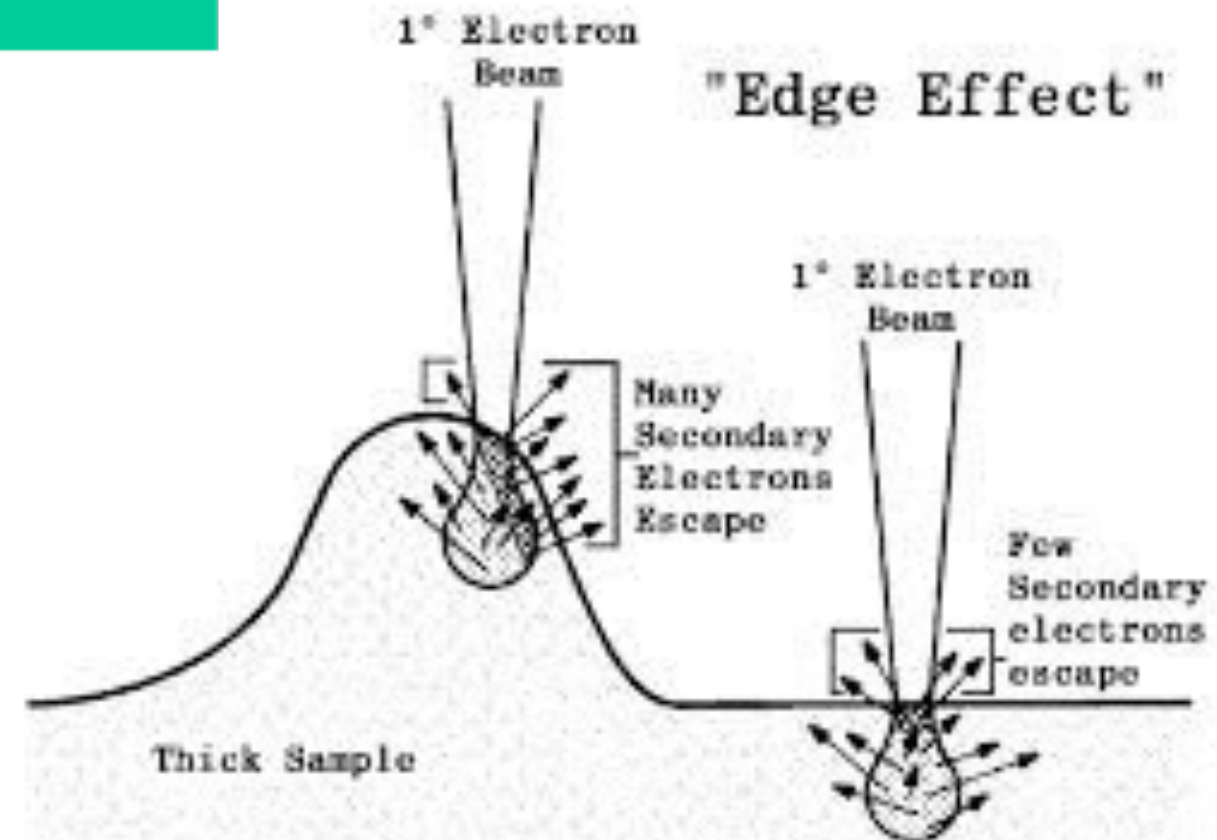
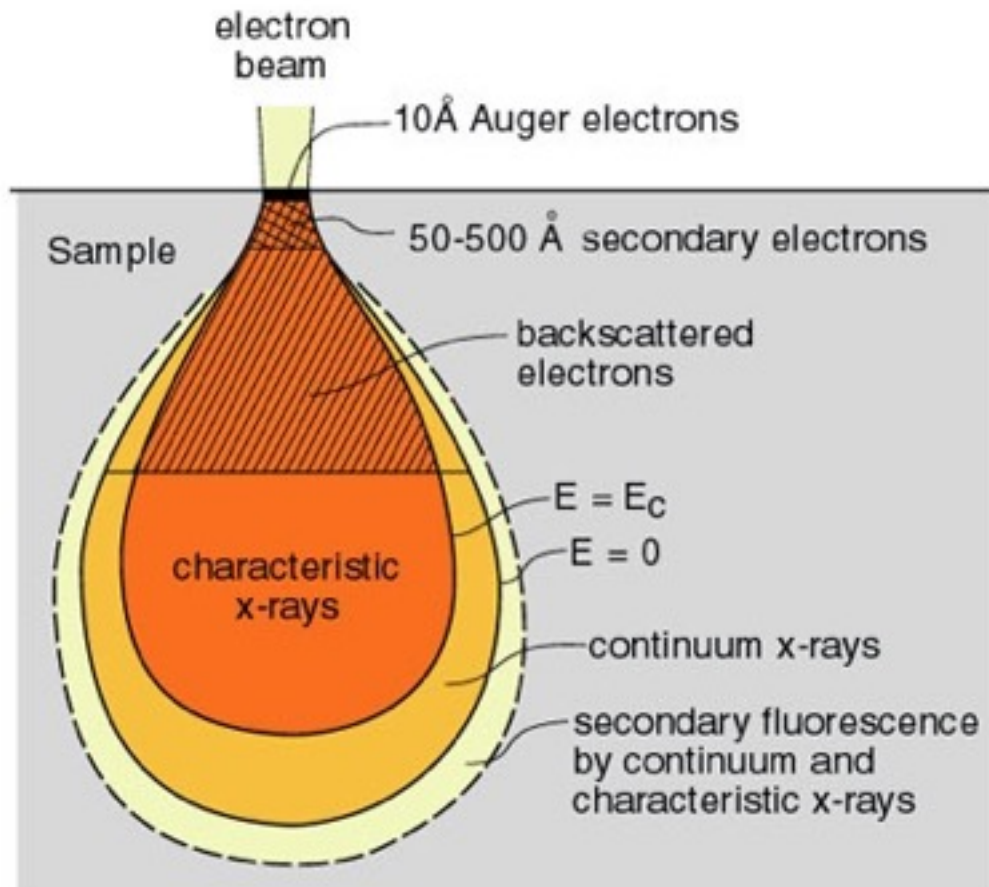
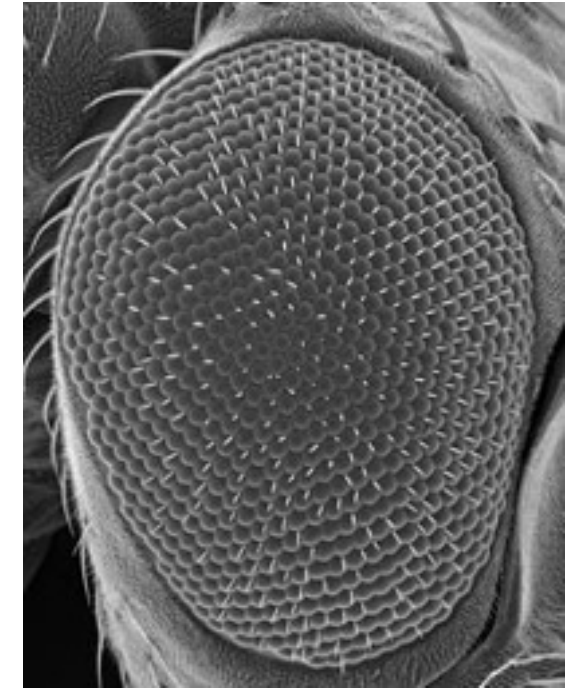
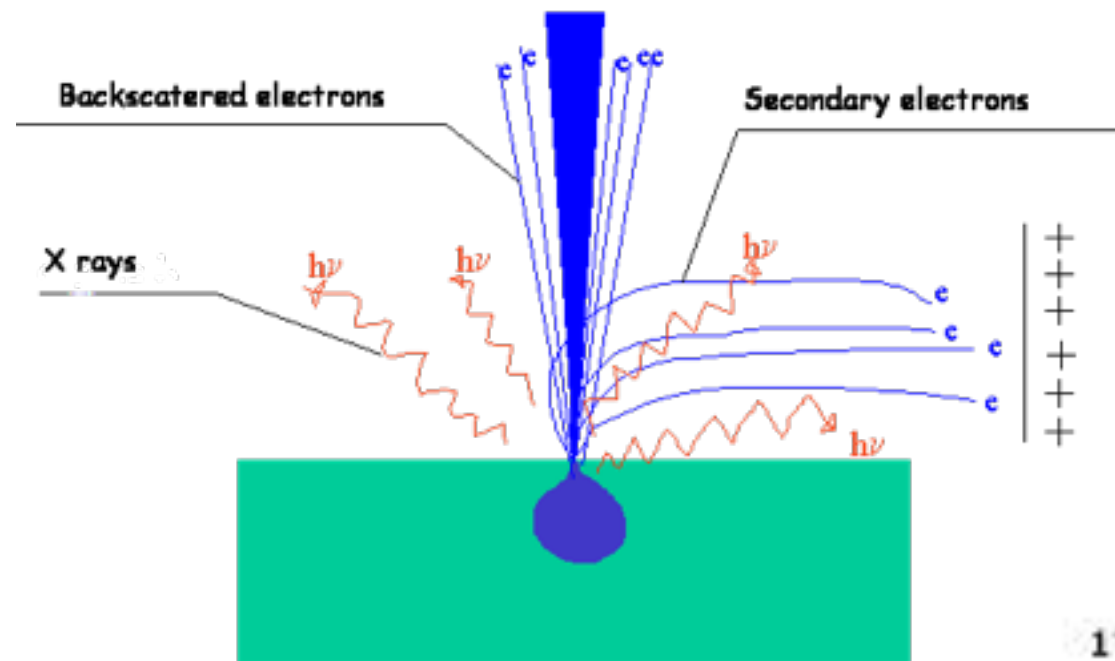
Beam energy: 0.2 - 40 keV is focused by a condenser lens system into a spot of 0.4 - 5 nm

Beam is deflected by very fast scanning coils and rasters the sample surface

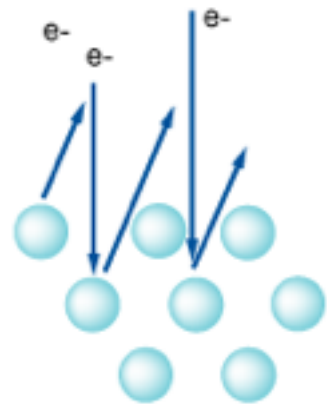
Typical resolution of SEM is between 1 and 20 nm where the record is 0.4 nm



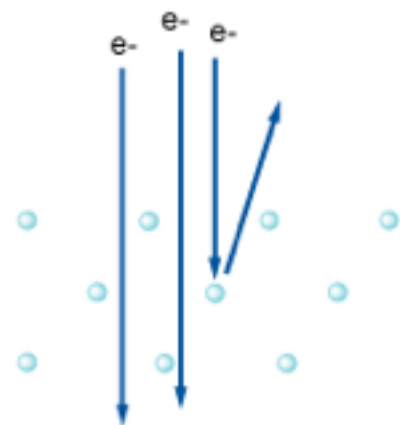
# Basic anatomy of a scanning electron microscope - beam sample interactions and image formation



# Basic anatomy of a scanning electron microscope - beam sample interactions and image formation



Titanium  
atomic number 22



Silicon  
atomic number 14

