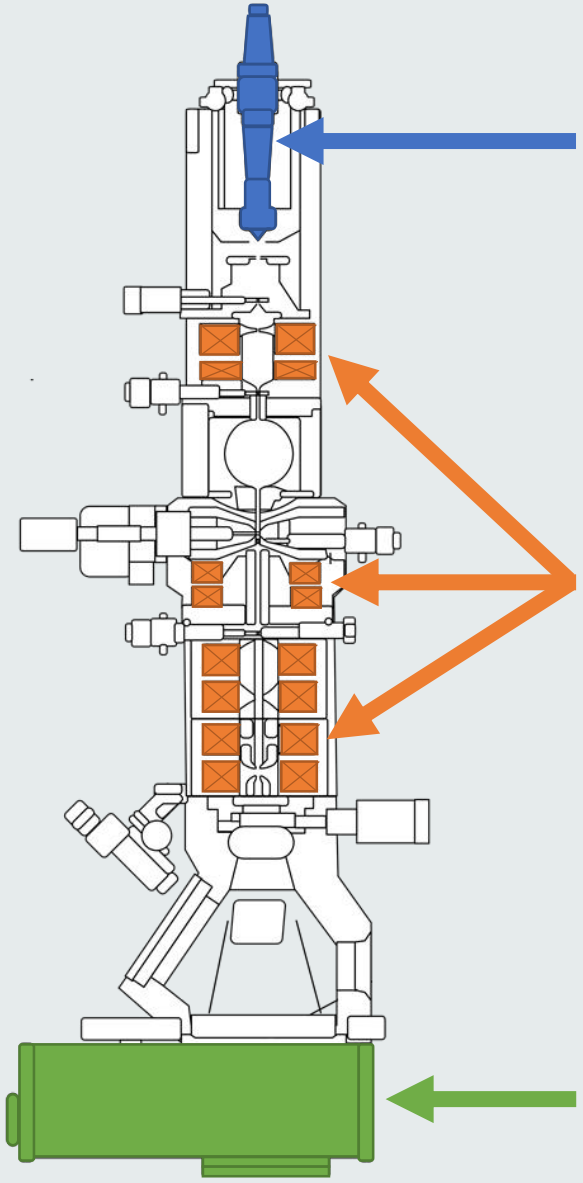
Basic anatomy of an electron microscope

SEMC Winter EM Course

January 13th, 2020

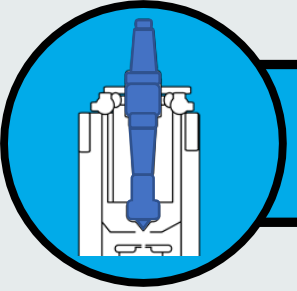
Overview



Guns and Voltage

Lens Systems

Detectors



Why Electrons?

Pros

Small wavelength

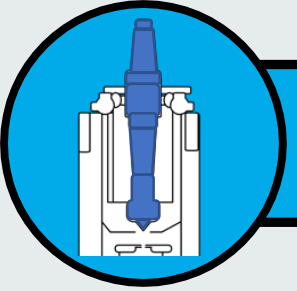
Can be focused

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

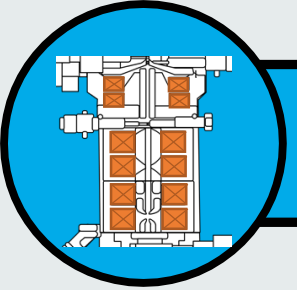
- 200 keV

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

Typical Voltages & Configurations

- 300 keV

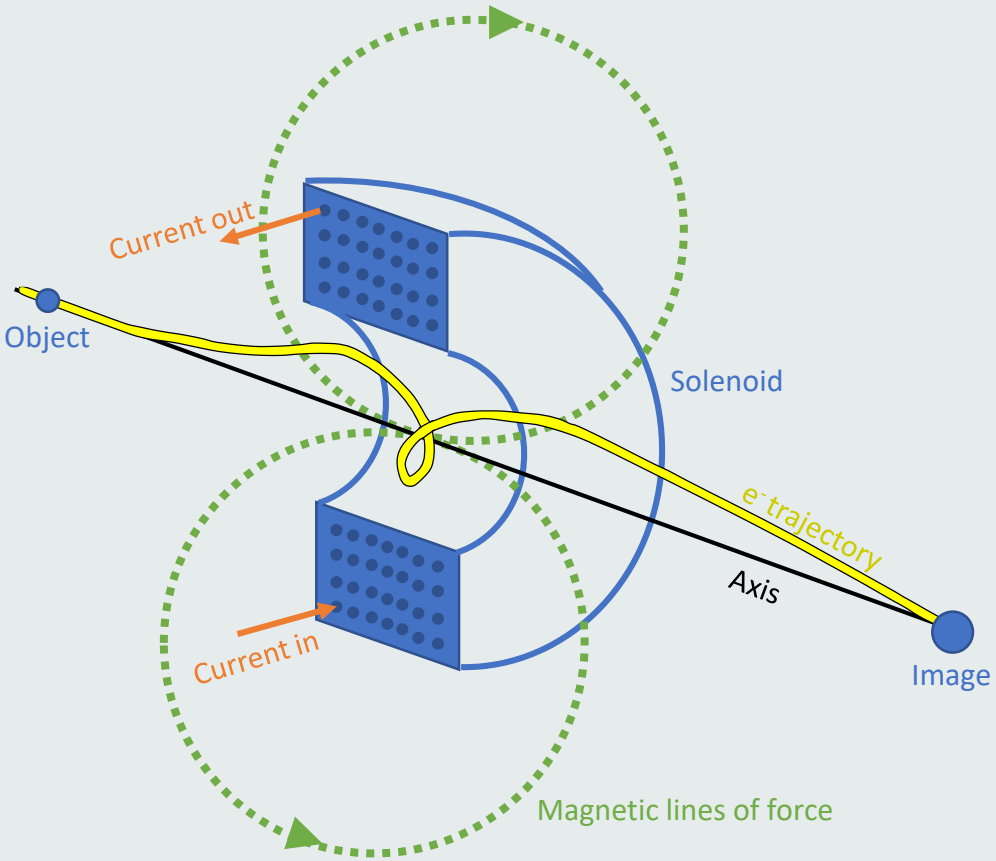
- E.g. FEI Polara, Titan Krios
- FEG, Direct detector, energy filter, etc.
- Highest resolution (sub-2Å)
- Hopefully no screening



Electron Lenses

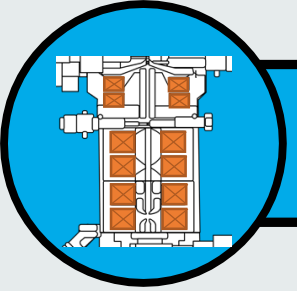
- What are the three main lens systems in an electron microscope?
- What are the special names given to the three independent sets of deflectors?
- What is “hysteresis”?
- What is a “crossover”?

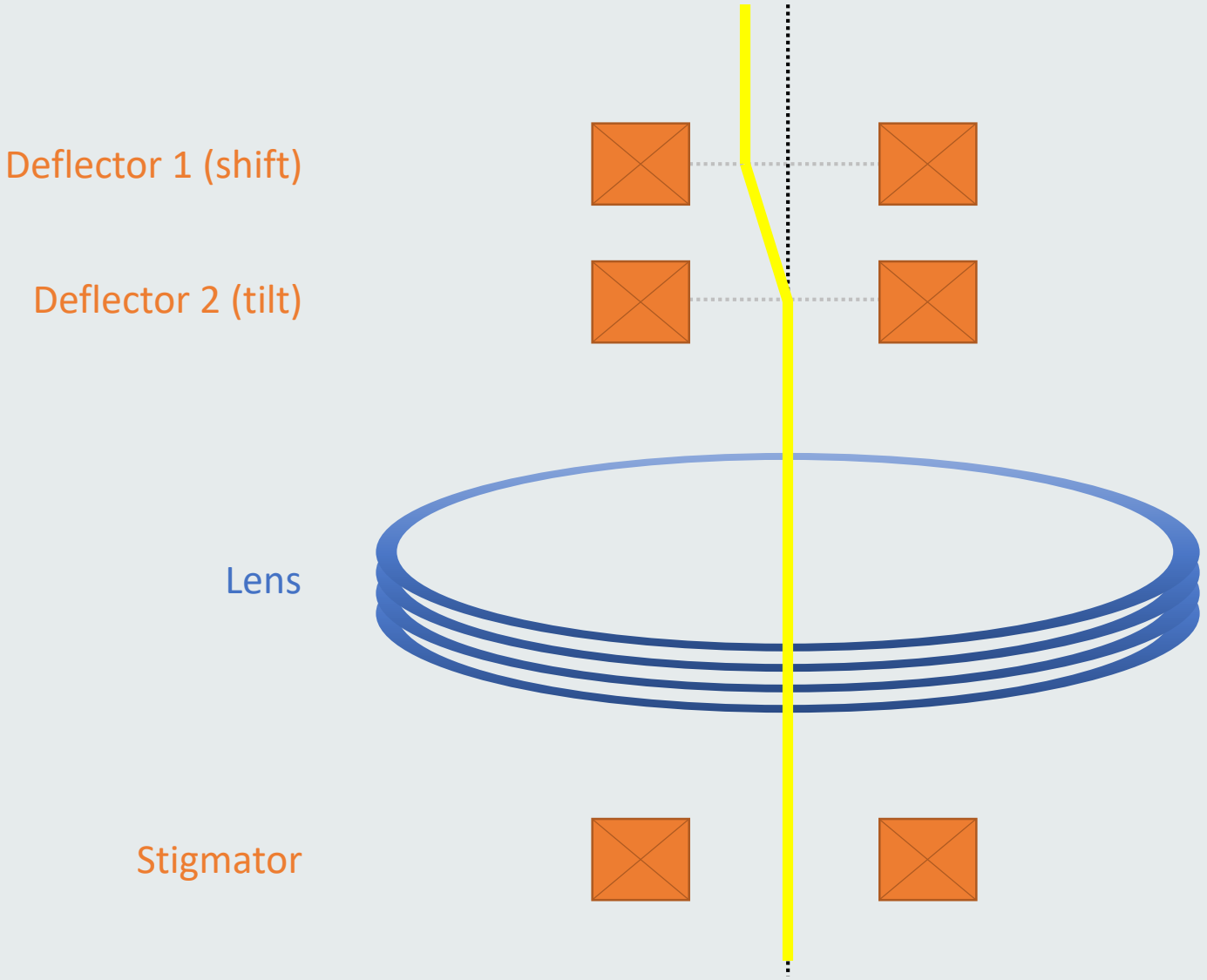
Electron Lenses

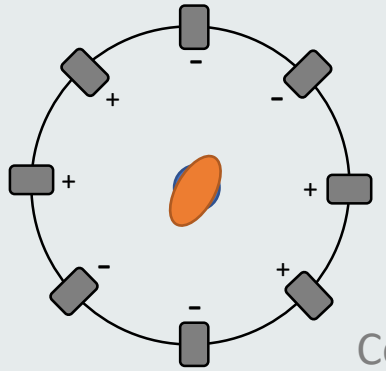


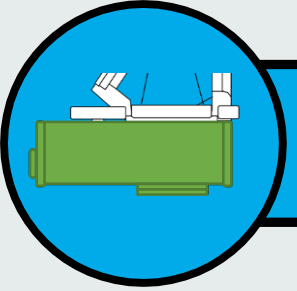
- Focus
- Magnify
- Rotate

Lens Systems





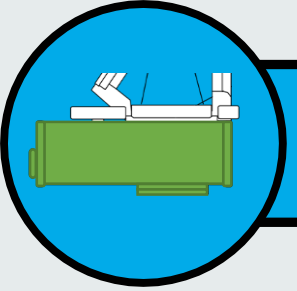


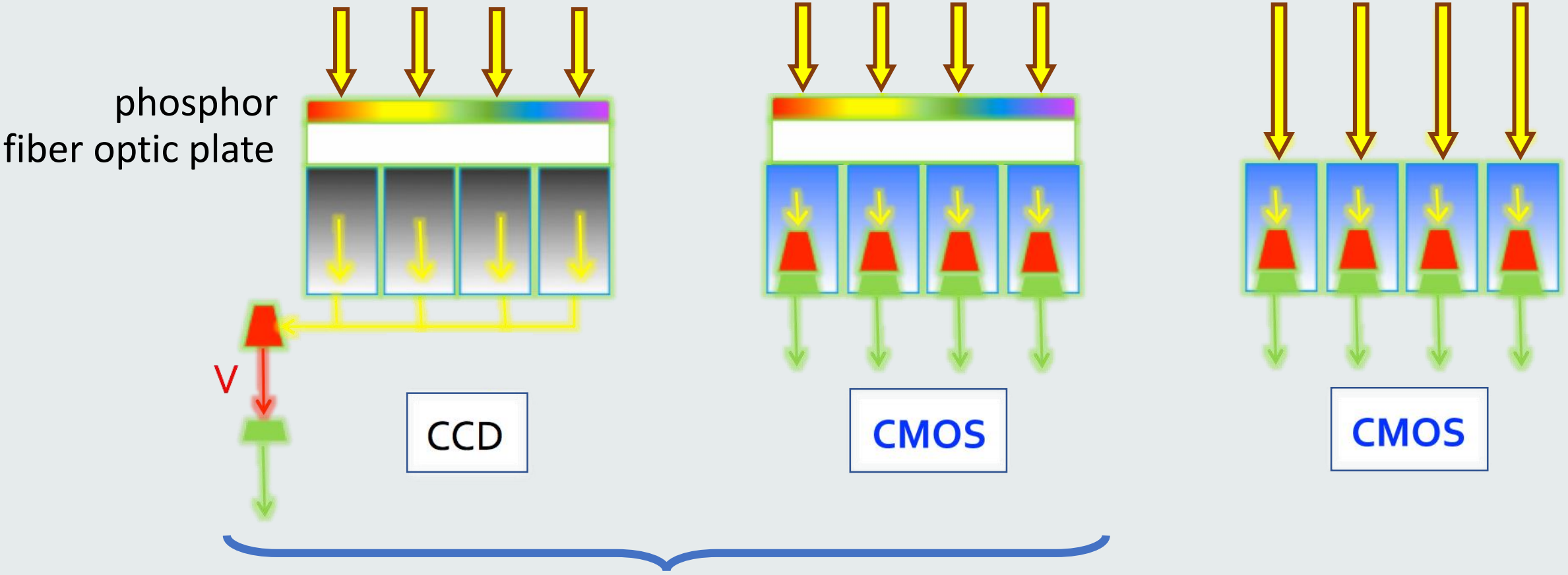


Detectors

	Photon Converted	Direct Sensing
CCD (Charge Coupled Device)	✓	?
CMOS (Complementary Metal Oxide Semiconductor)	✓	✓

Detectors



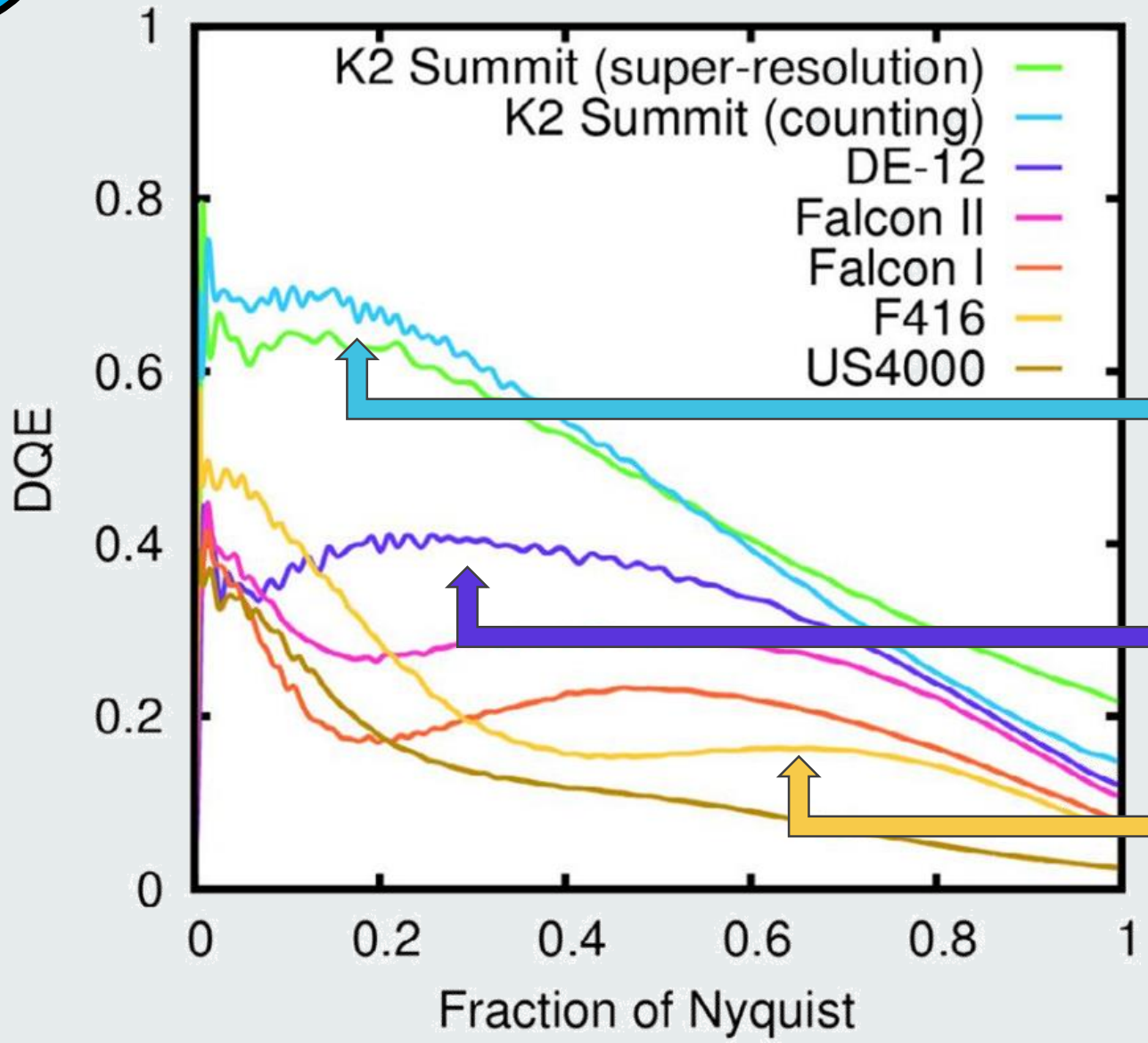


From Anchi Cheng

Photon Converted

Direct Sensing

Detector Quantum Efficiency



Direct detector on our Krios

Direct detector on our F20

CMOS – Photon converted
On our T12 & F20

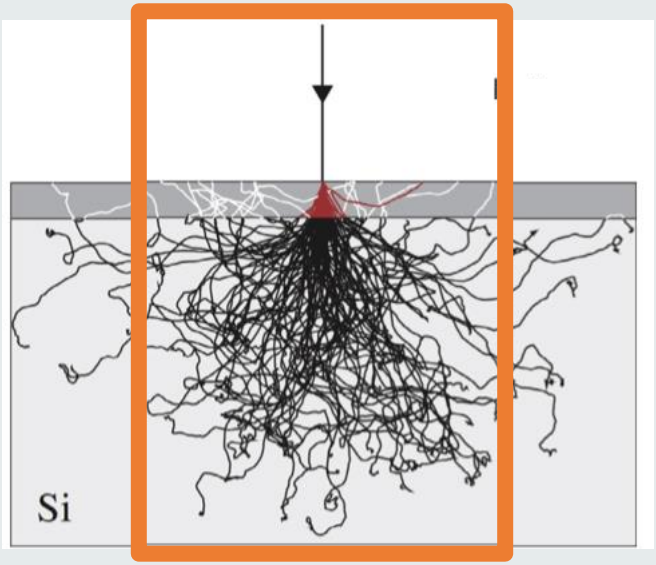
From Ben Himes on Twitter @B3naminHimes

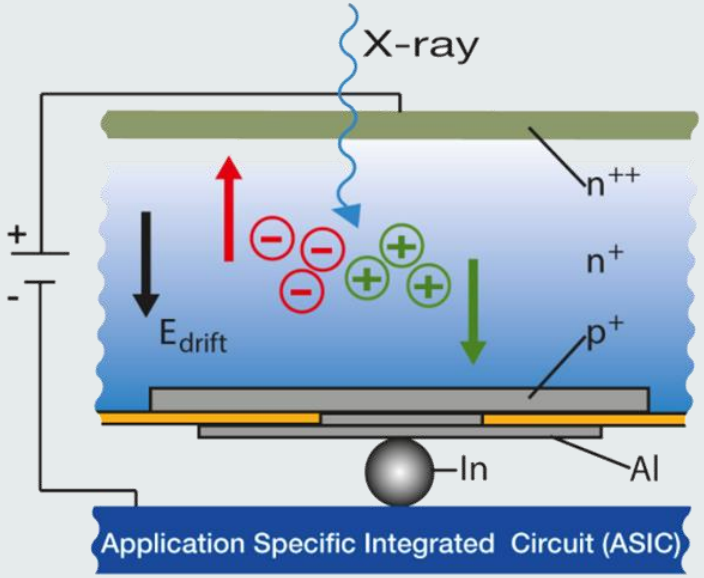
Hybrid Pixel Array Detectors

- The next detector for cryo-TEM?
- Now used regularly in x-ray diffraction
- Used in Gruene 2018, *Angewandte Chemie* & Peet 2019, *Ultramicroscopy*

Pros : Great DQE, 10 kHz frame rate

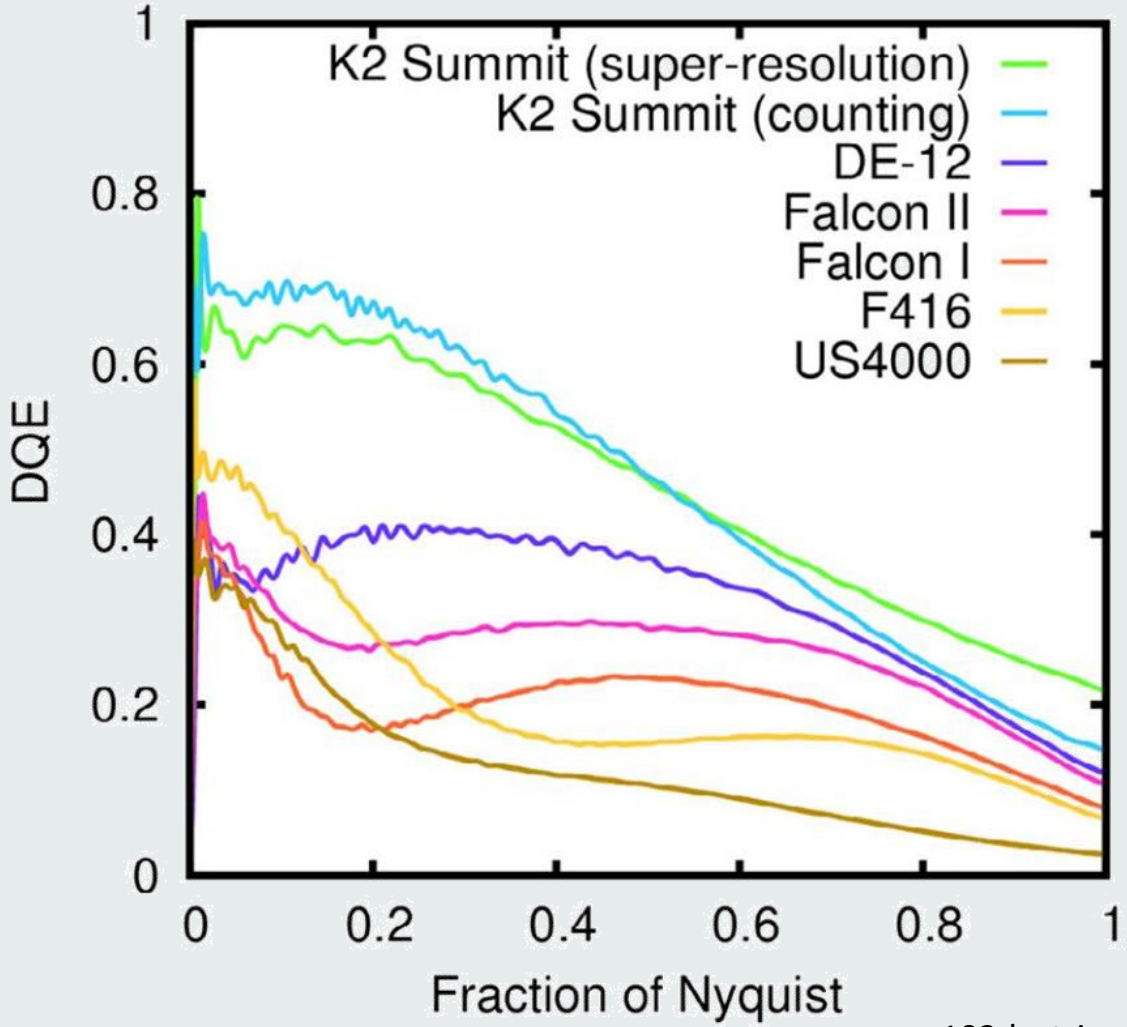
Cons : Large (75 µm pixel vs 5 µm),
Small viewing area – 1030 x 514

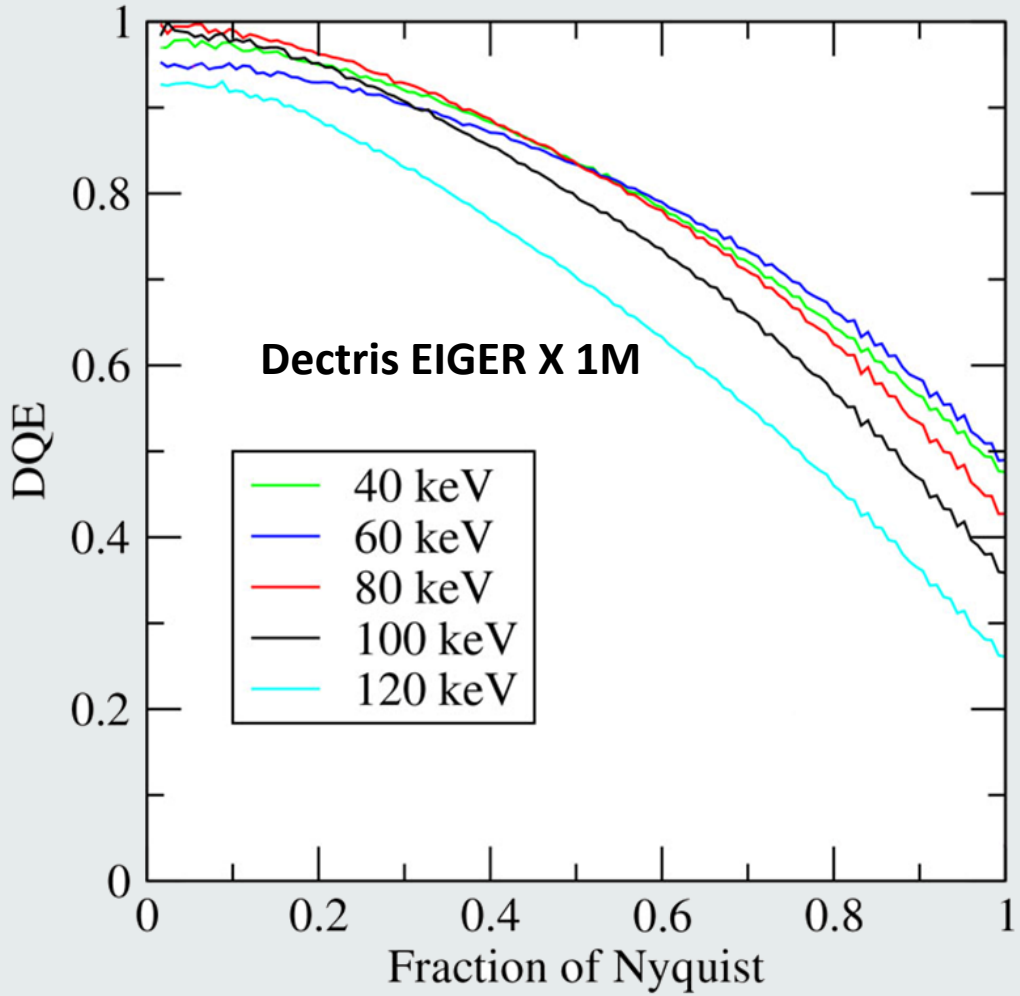




https://www.dectris.com/technology/hybrid-photon-counting/direct-detection

Hybrid Pixel Array Detectors





103dectris.com/company/news/newsroom/success-story-details/electrons-are-the-new-photons

Practicals & Journal Club

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

Jan 22	Feb 5	Feb 12	Feb 19
Comparison of original and modern plunge freezing techniques (Adrian et al. 1984 & Razinknov et al. 2016)	The best voltage for EM (Peet et al. 2019 & Naydenova et al. 2019)	Beginning of the Resolution Revolution (Liao et al. 2013)	HIV trimer controversy and Einstein from noise (Mao et al. 2013 & Henderson 2013 & van Heel 2013)
Marriah Green, Ruby Froom	Bryce Delgado, Evan Seitz, Ayat Yaseen	Zhengshan Hu, Vinay Kumar Sapuru	Rafal Piwowarczky, Pedro Gutierrez, Natalie McArthur