Direct Electron Detectors

not just the latest new toy: game changing

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1. how to select the best microscope parameters
2. how to pre-process frames: what does/doesn't work
3. how to assess the data quality
4. usability of cameras/interfaces
5. how do we handle data tsunami
6. what would we like in a next generation camera?

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Wah Chiu (Baylor)	DE cameras
Carsten Sachse (EMBL)	comparison of Falcon 2/K2
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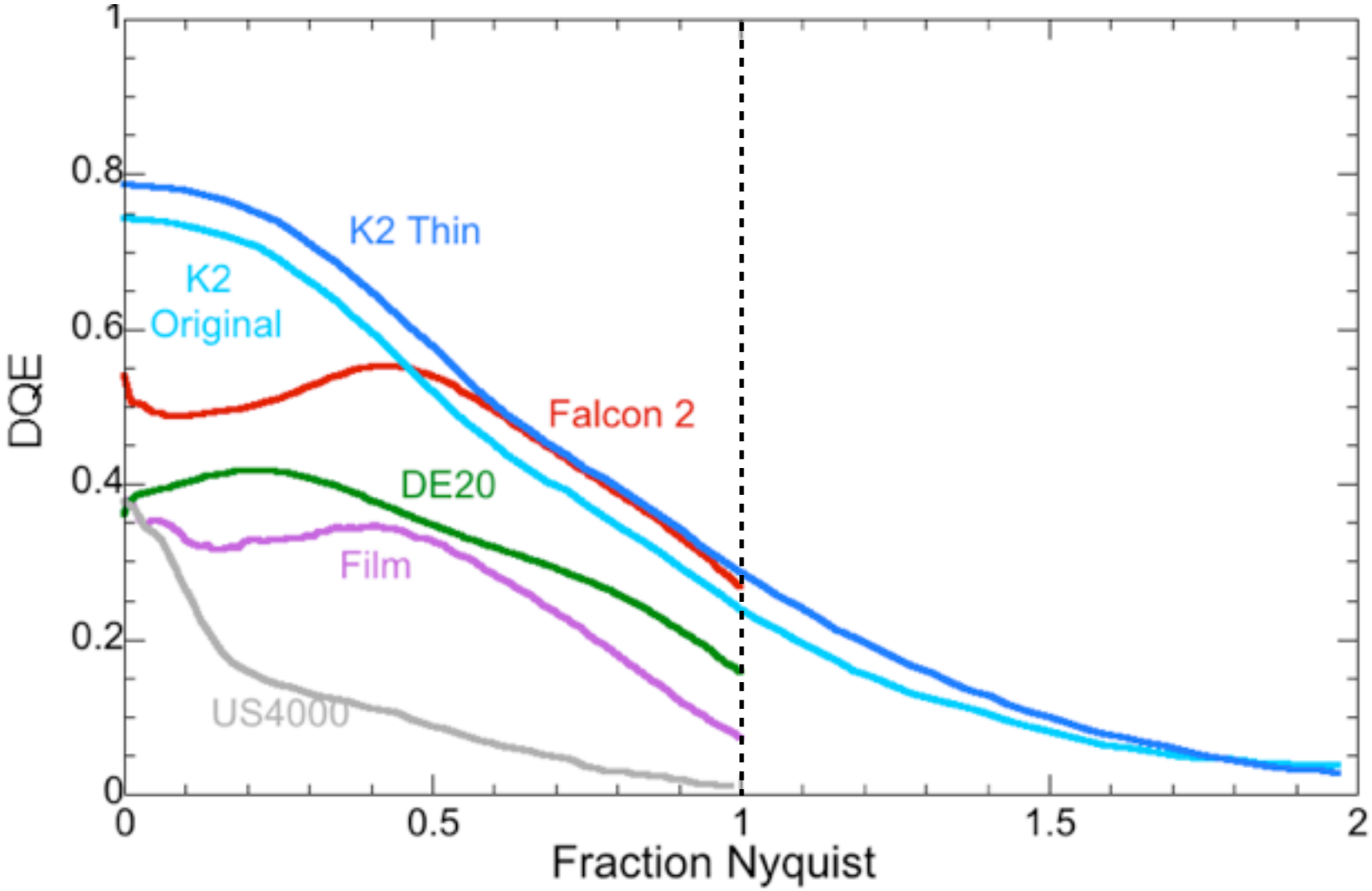
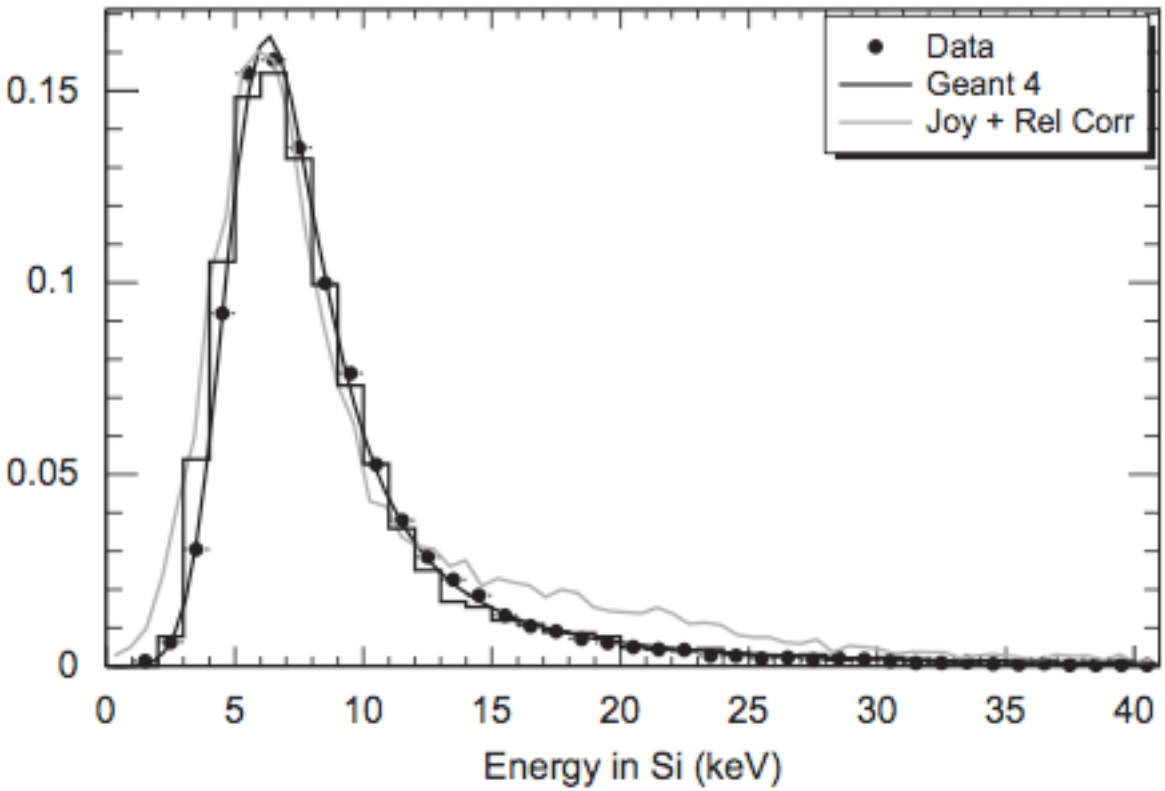
all Direct Detectors provide a huge leap forward



high sensitivity, minimal effective read out noise, high frame rates (10-40 fps)

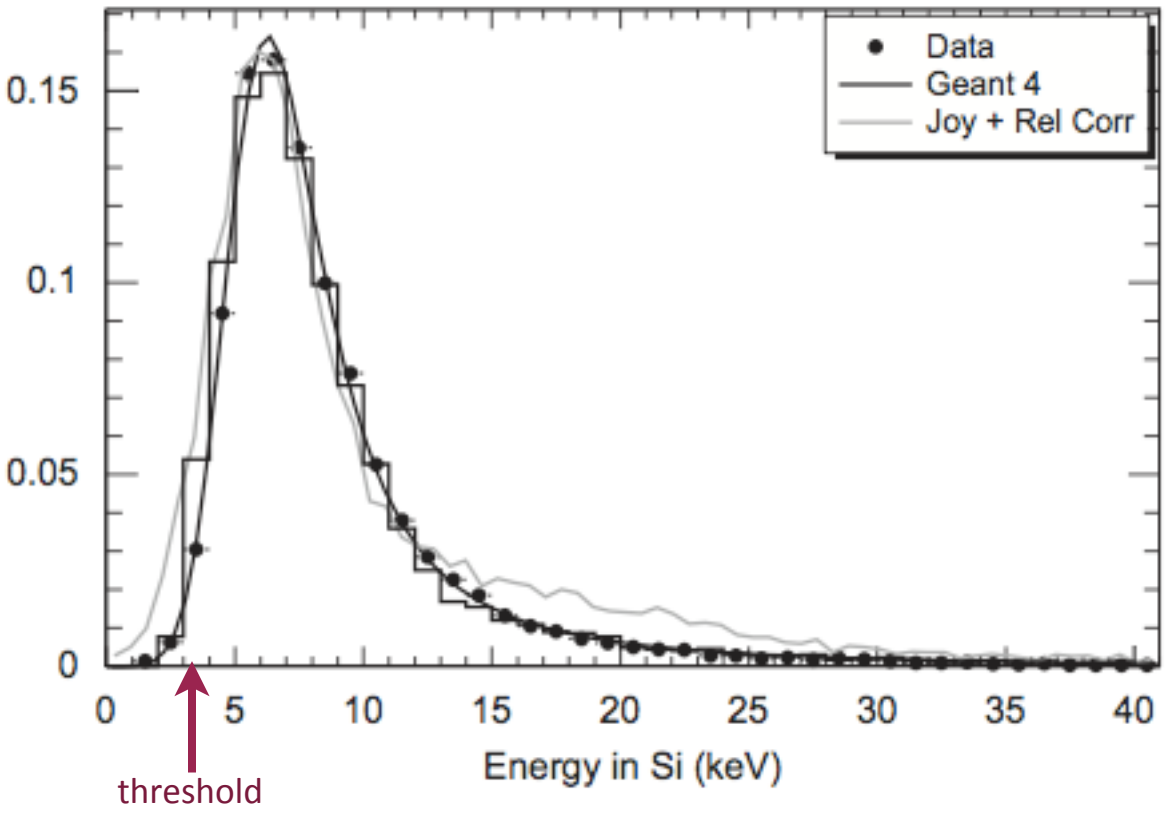
McMullan et al, 2014, Paul Mooney

Landau noise:
a problem for all integrating detectors



wide range of signal registered for each electron event
reduces DQE
significant contributor to image noise

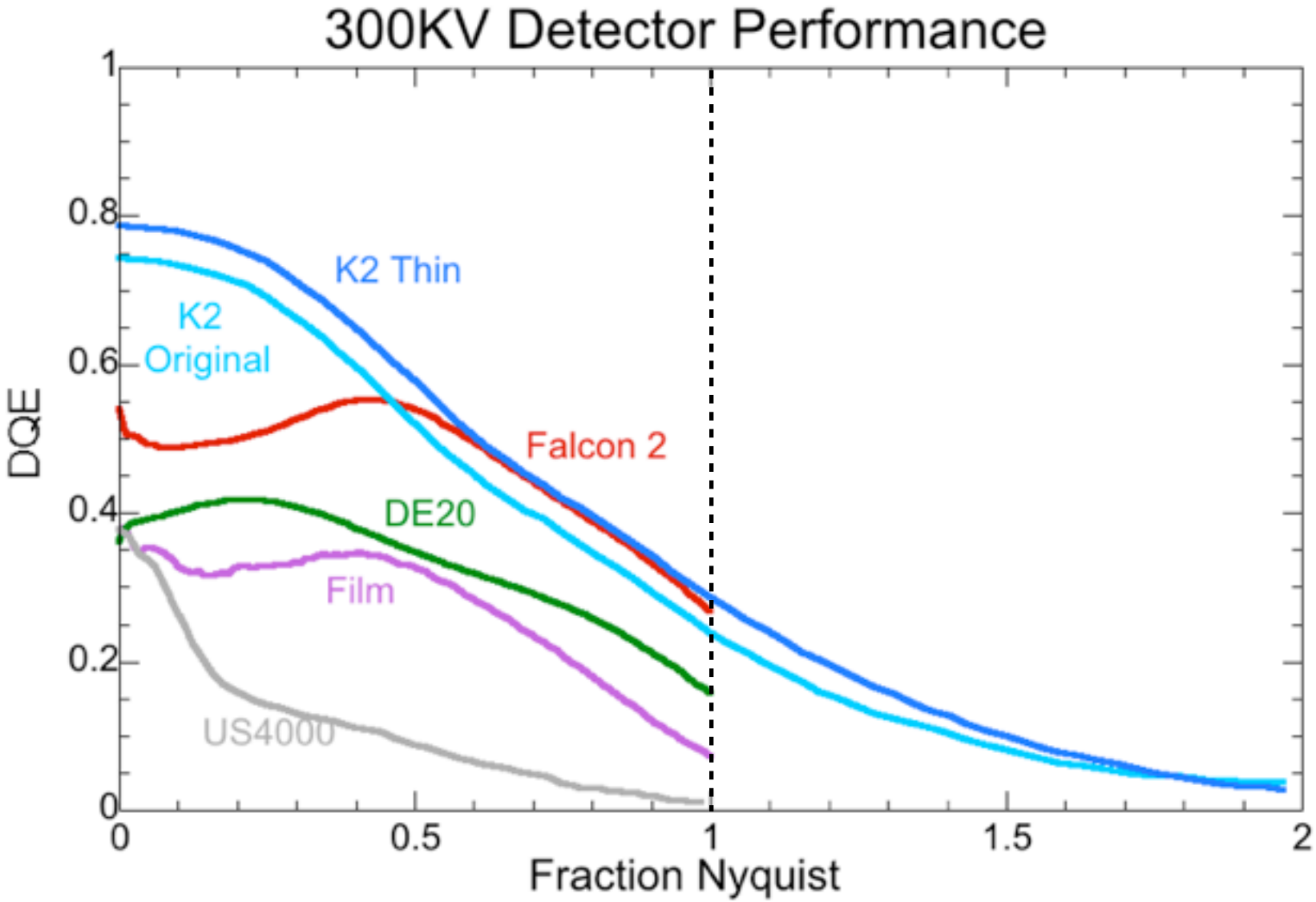
Landau noise:
a problem for all integrating detectors



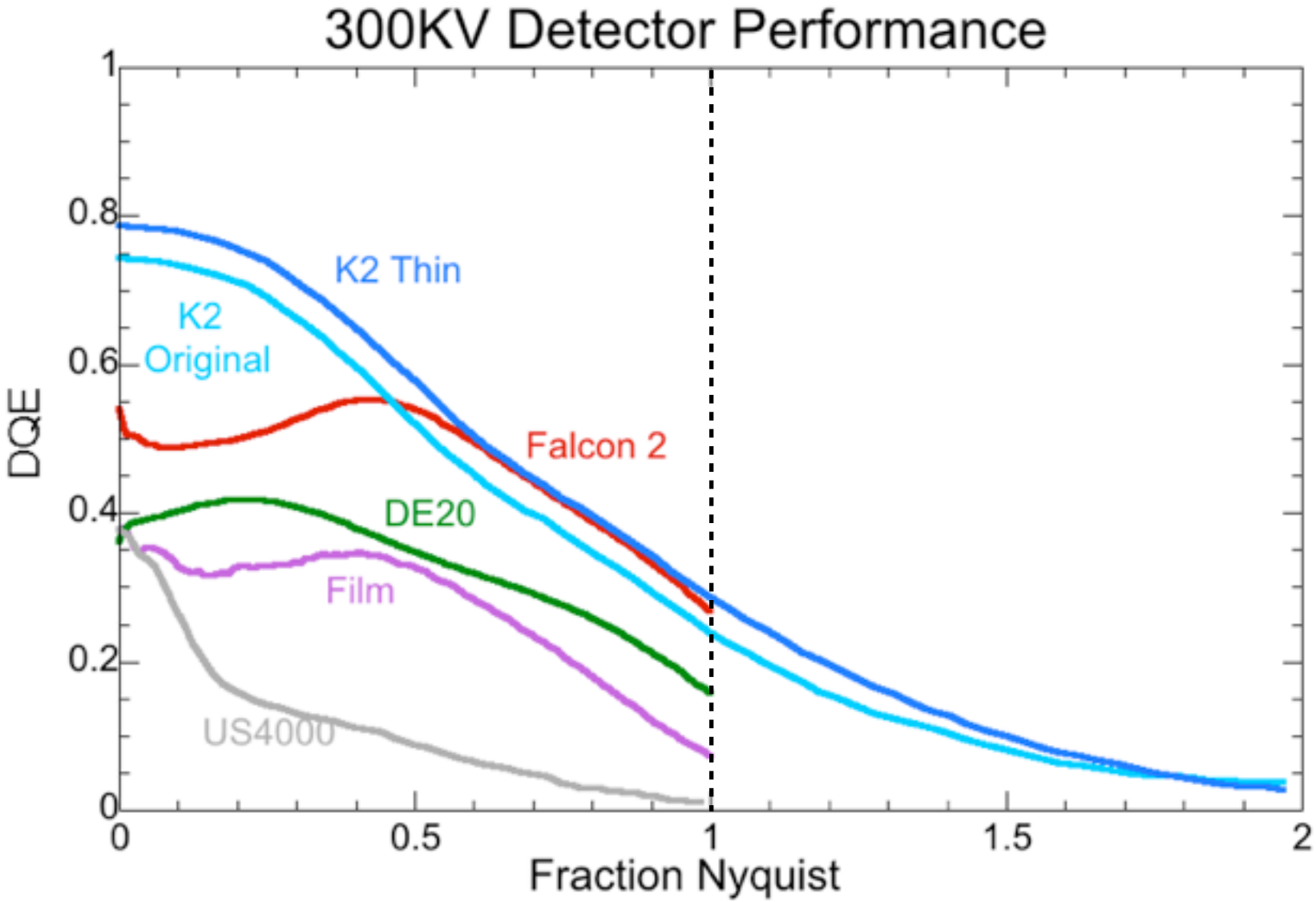
greatly improved DQE

virtually eliminates noise

centroid interpolation => super-resolution



McMullan et al, 2014Paul Mooney



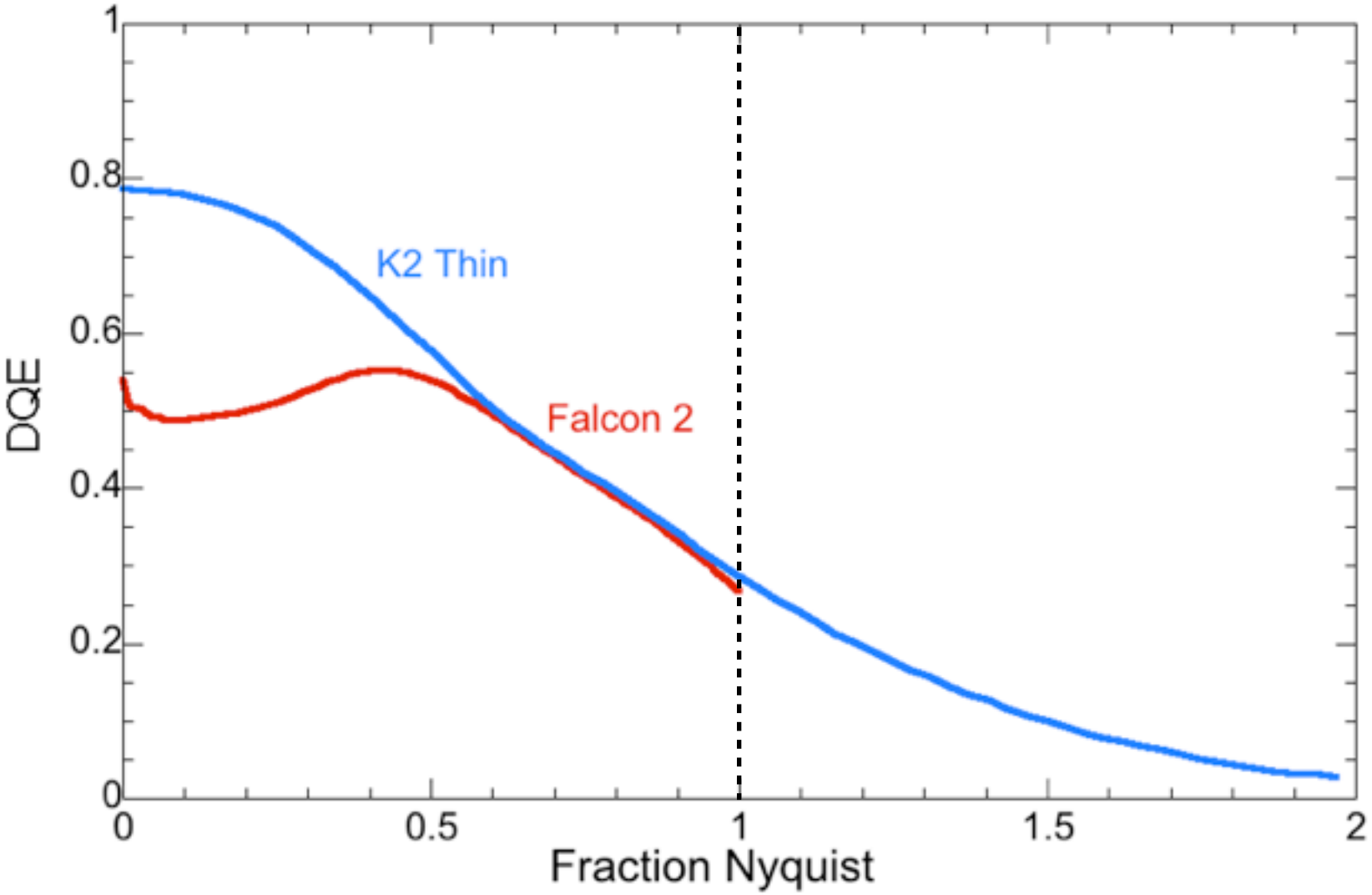
all have significant transfer at physical Nyquist => noise aliasing (JR point)

K2: super-resolution can provide some extra area (25% lower mag), aliasing suppression

K2: coincidence losses reduce QE at dose rates above 8 e^-/pix/sec

McMullan et al, 2014

“only need K2 for particles smaller than 400KDa”



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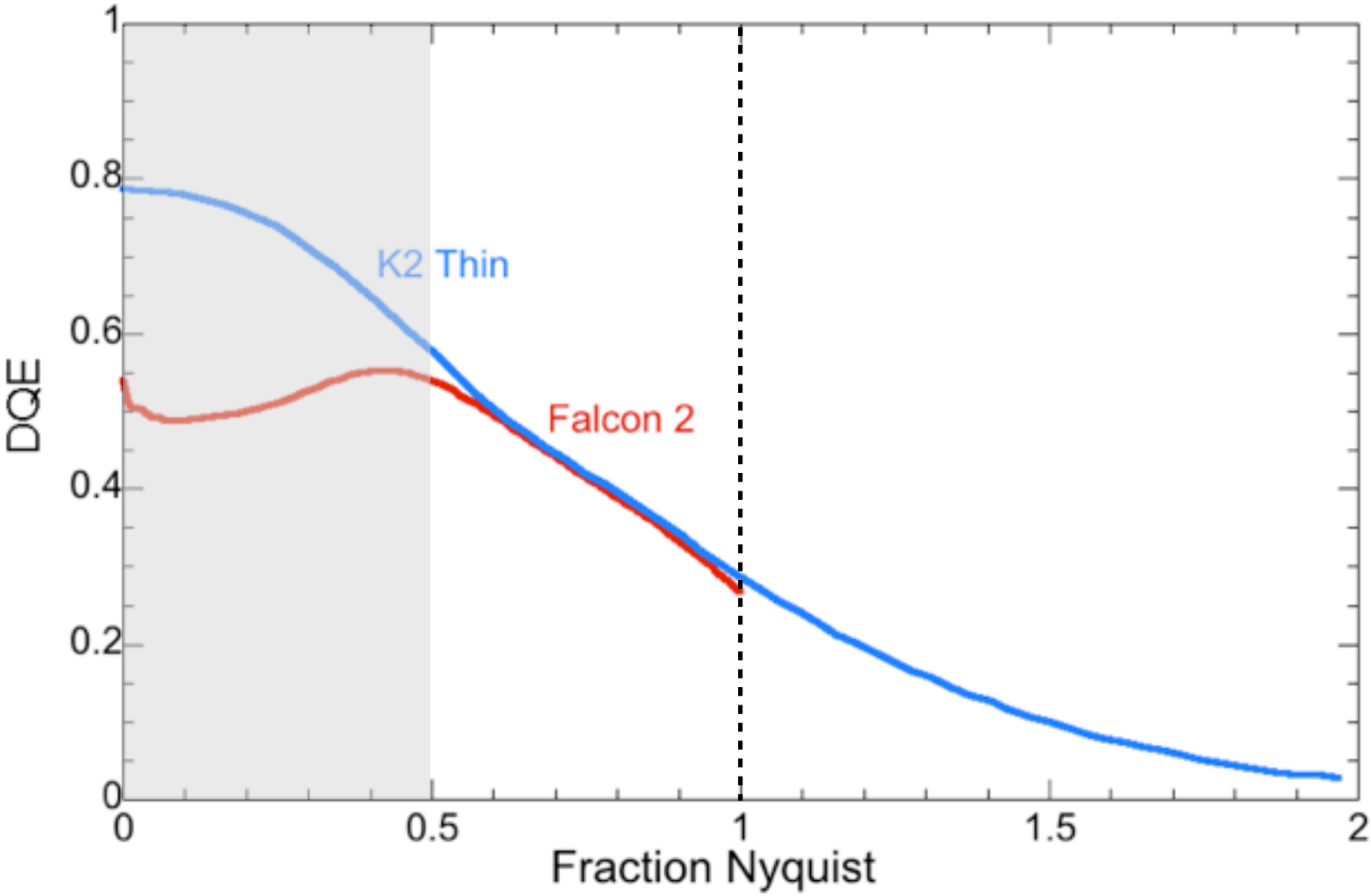

information to 5-8Å used for all aspects of frame, particle alignment, classification, etc
better information there, better for all samples
higher DQE lower noise, better for dose fractionation => better classification, etc

Data Tsunami from movies

counted movies, only need to count to 4-6

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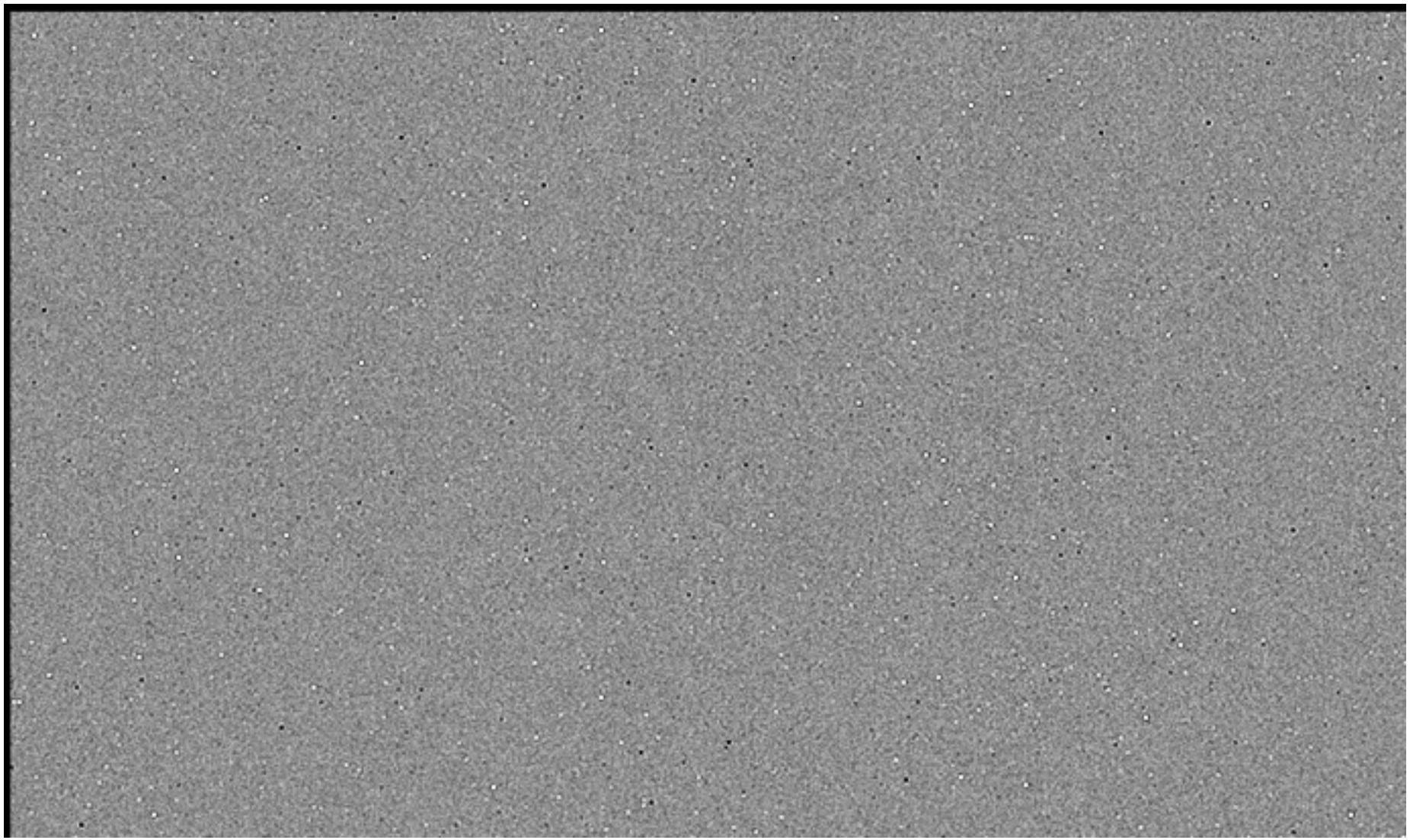
Gatan offers 8 bit mode, we compress to 4 bit (8X reduction)

not gain corrected, or bad pixel fixed

we store gain and bad pixel list in extended header

correct on fly, during frame alignment on GPUs, so fast

All CMOS detectors have noisy pixels, but more apparent with counting

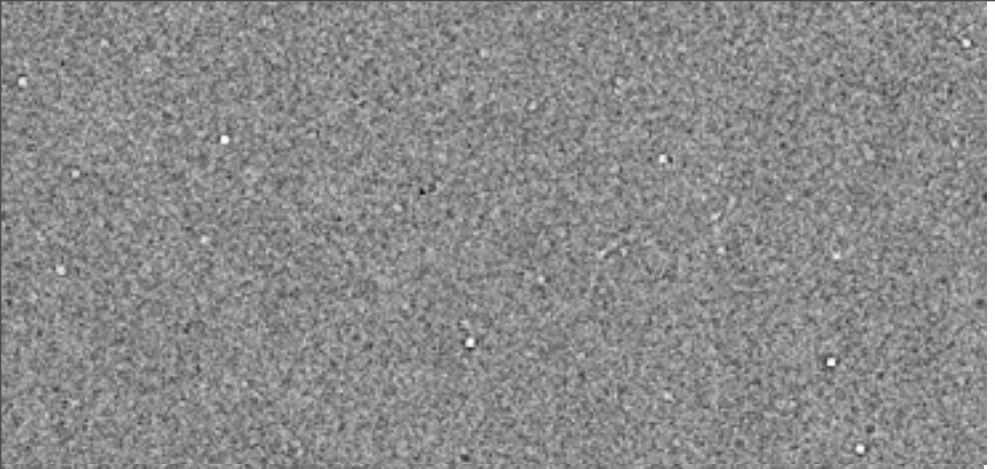


Summation of 150 stacks (4500 0.2 sec frames) yields a strong pattern of spots.

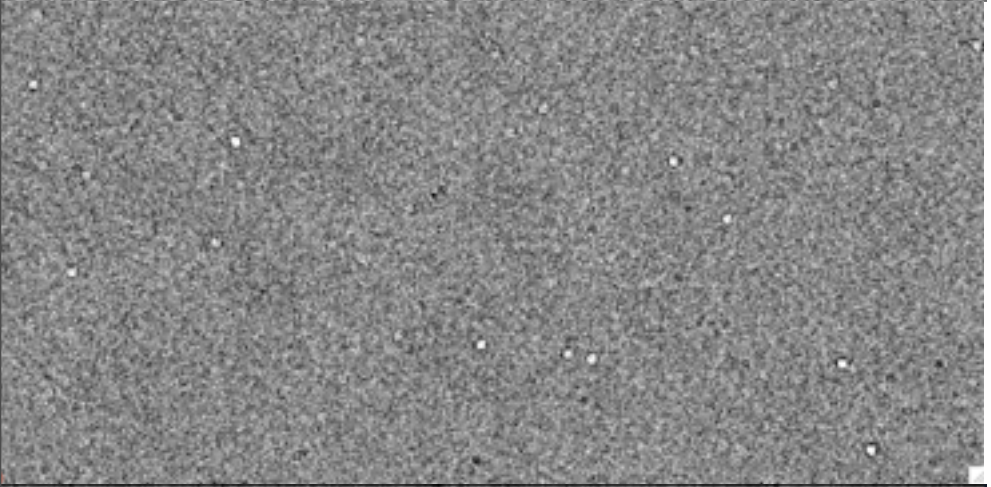
undetectable in individual frames or single stacks

Klim Verba
Shawn Zheng

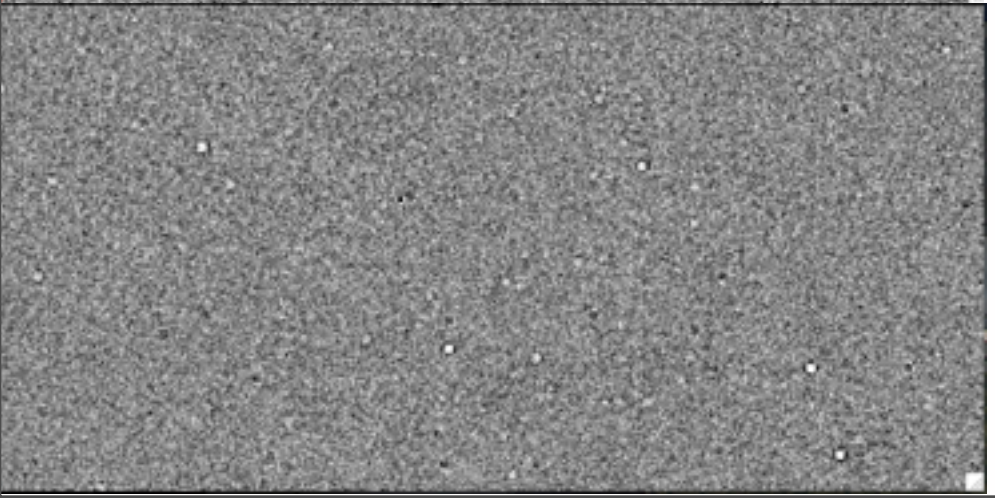
Readily apparent in sum of 10 Stacks



Sum of stacks 1-10



Sum of stacks 11-20



Sum of stacks 21-30

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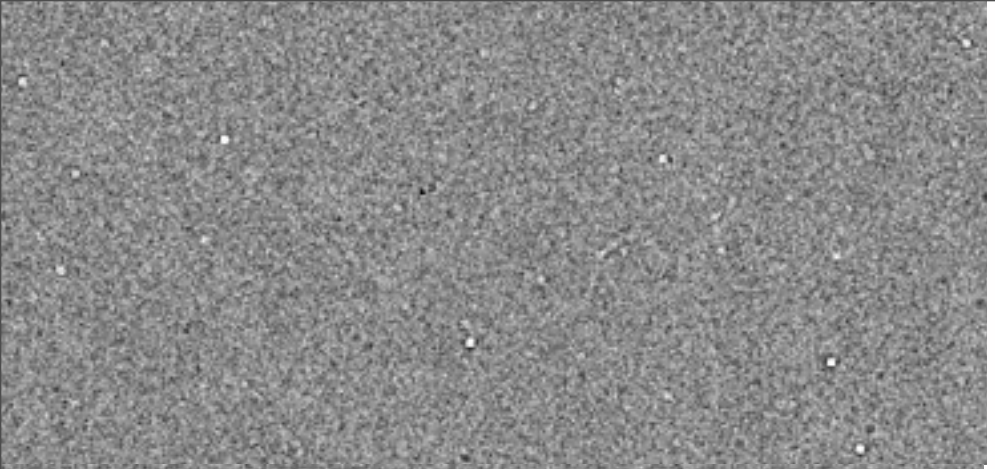

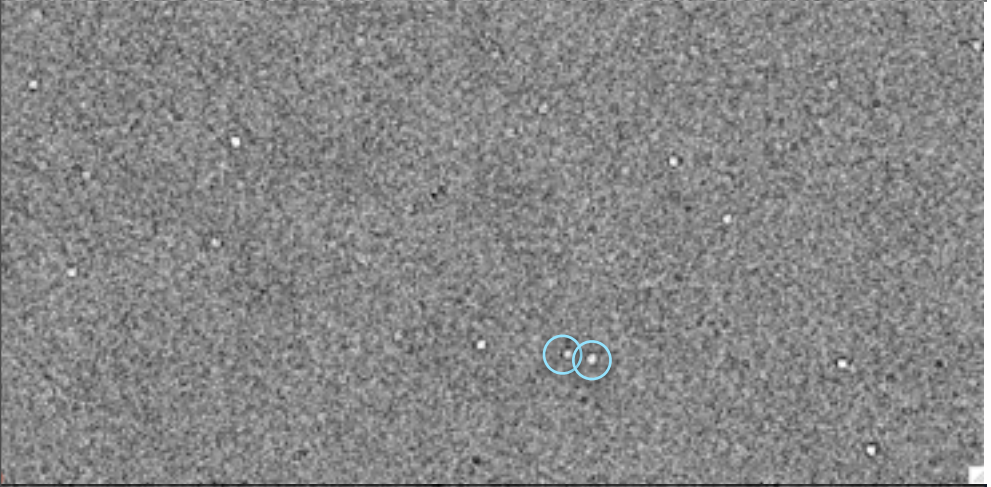

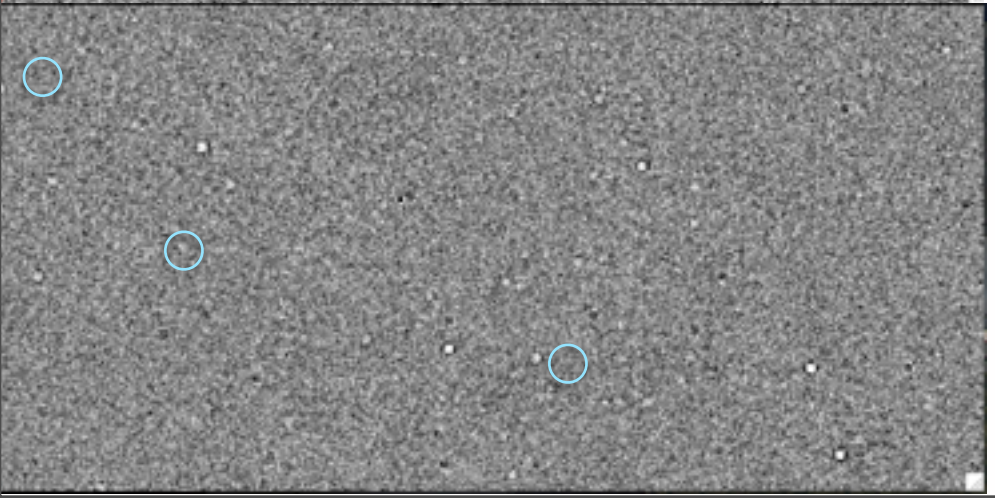

Readily apparent in sum of 10 Stacks

Spots are not consistent over time

Sum of stacks 1-10

Sum of stacks 11-20

Sum of stacks 21-30

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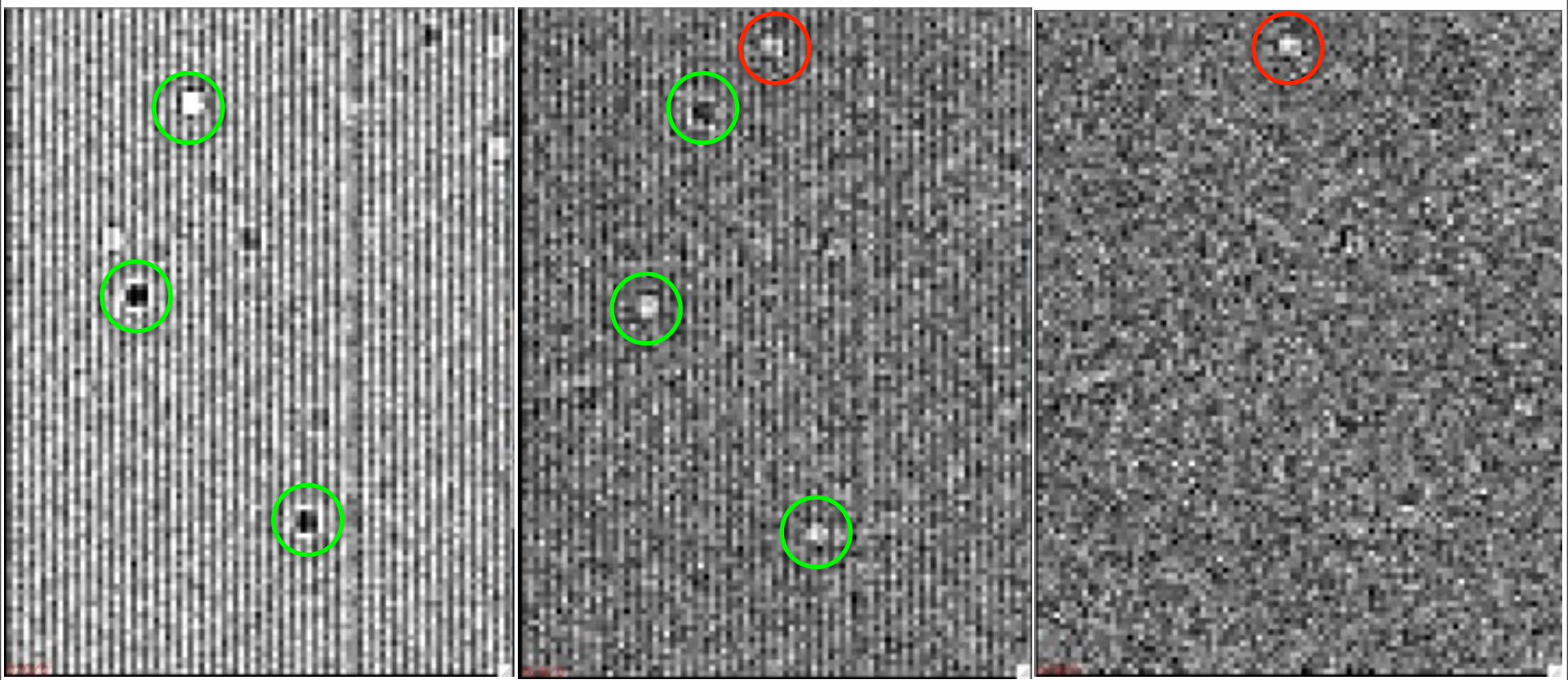
Gain reference is not responsible for the defects but is actually fixing a lot of faulty pixels.

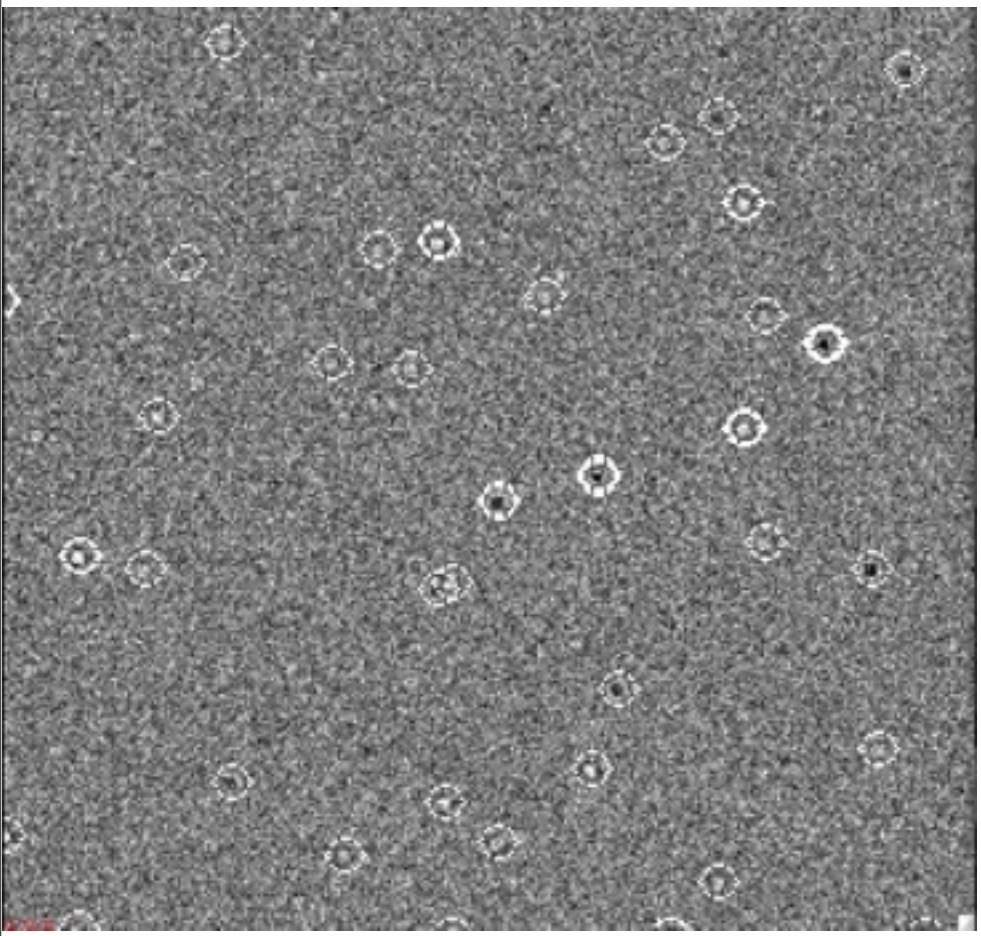
Green circles - spots which are on the camera chip, and which are corrected on the gain reference (hence contrast inversion)
Red circles - spot which is on the gain reference corrected sum, and which is not on the gain reference itself.

Gain Reference | Uncorrected Sum | Reference corrected sum

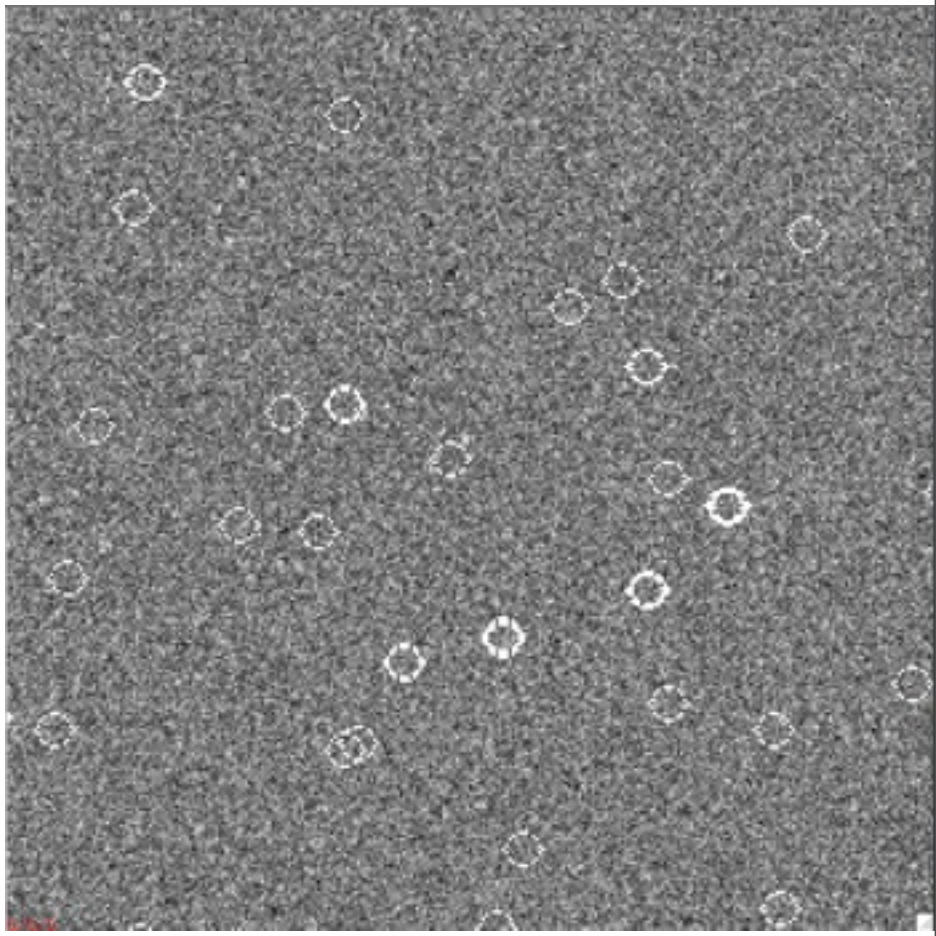


Need to determine and fix from actual data

Pre Correction



Post Correction



we have gpu code that does this efficiently
can integrate with frame alignment

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