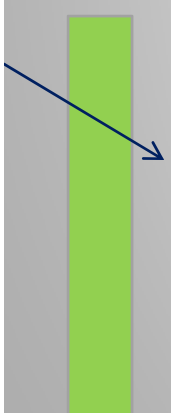
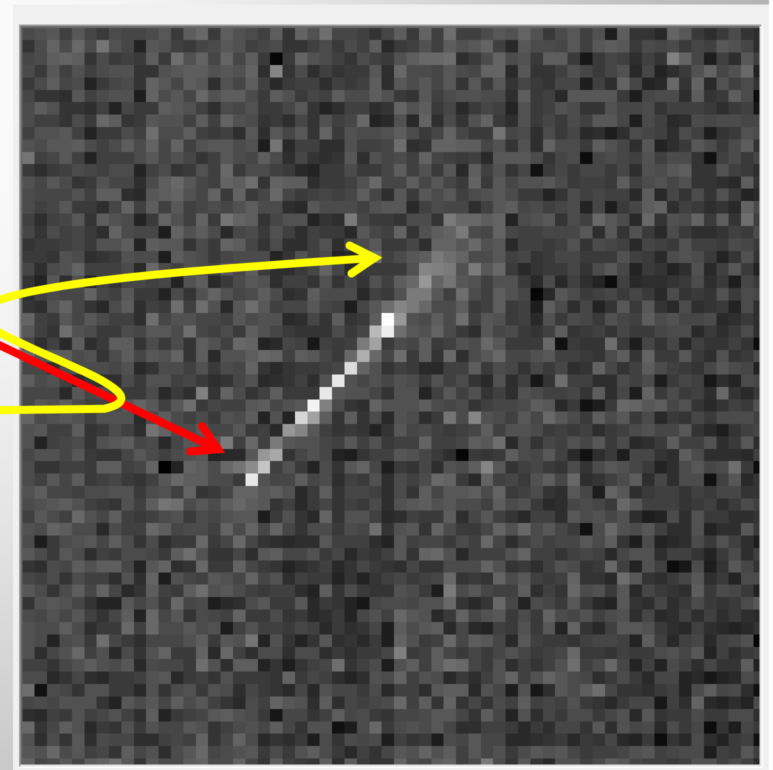
FastCCD Status – Oct. '08

- Up to the ALS shutdown (Sep. '08) we saw that
  - The FCCD responds to light
  - The FCCD can indeed readout in 5 ms
- The problem that showed up when looking for mono-energetic x-rays was that we didn't see a peak
  - Suspicion: we are somehow not fully depleting the CCD
- Look at cosmic rays
  - Makes sense – CCD is vertical, so we see cosmic rays that go through the CCD at some angle
  - Expect little diffusion near the front (where the CCD structure is) and a bit more at the back
  - **But** – these are 30 μm pixels and when fully depleted, diffusion is 5 μm !?

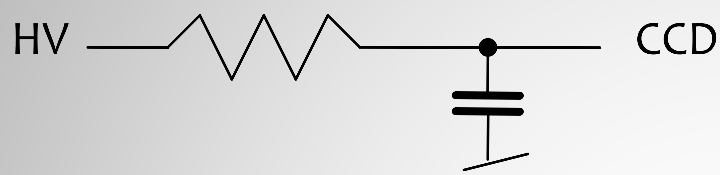




Everything in these slides is at a 1.6 μs horizontal cycle time – i.e. 5 ms readout

Problem Identified (time for me to retire)

- HV bias has RC filter

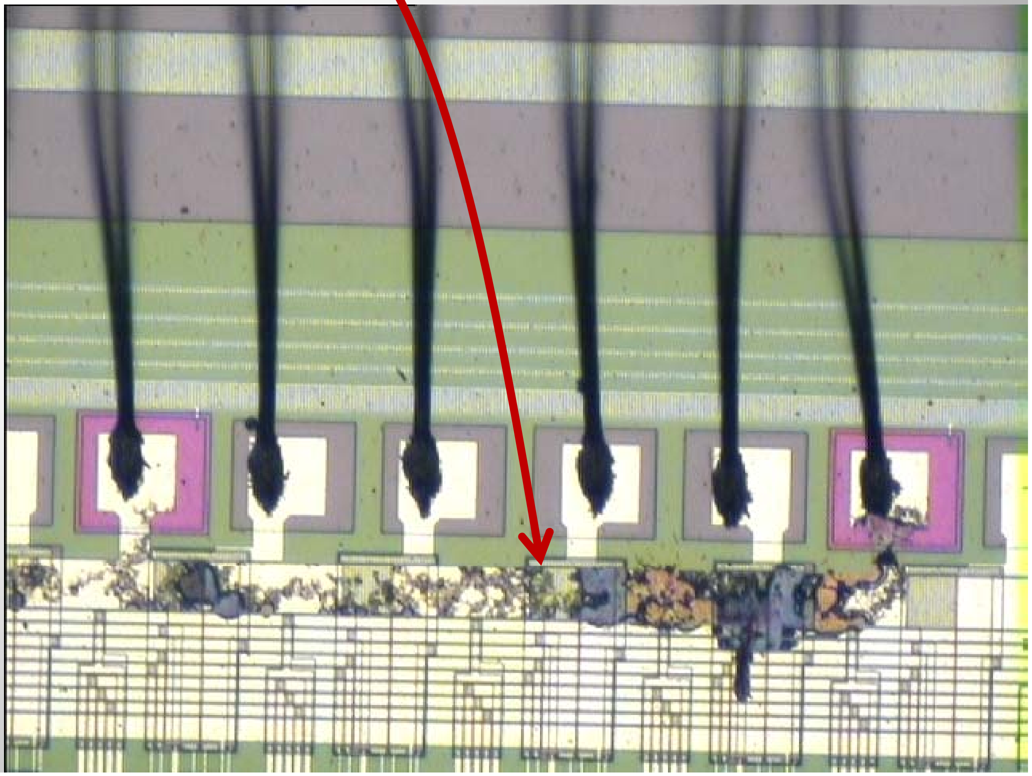


- I had specified 1 MΩ for the resistor. But there is current flow in the guard ring structure (doesn't get to the imaging matrix – so we don't "see" it, but it causes IR drop)
- 1 MΩ too high – IR drop meant that we were **NOT** depleting the CCD

- Change the resistor and fix the problem

ZAP!

- Filter resistor replaced
- Fire the system back up
  - But we've always had vacuum "issues"
  - What vacuum is safe to run at?
- We destroyed the CCD
  - SNAP had similar experience due to condensation
  - We're now adopting the SNAP 'rule' **– no cooling if the vacuum is not $\leq 10^{-5}$**

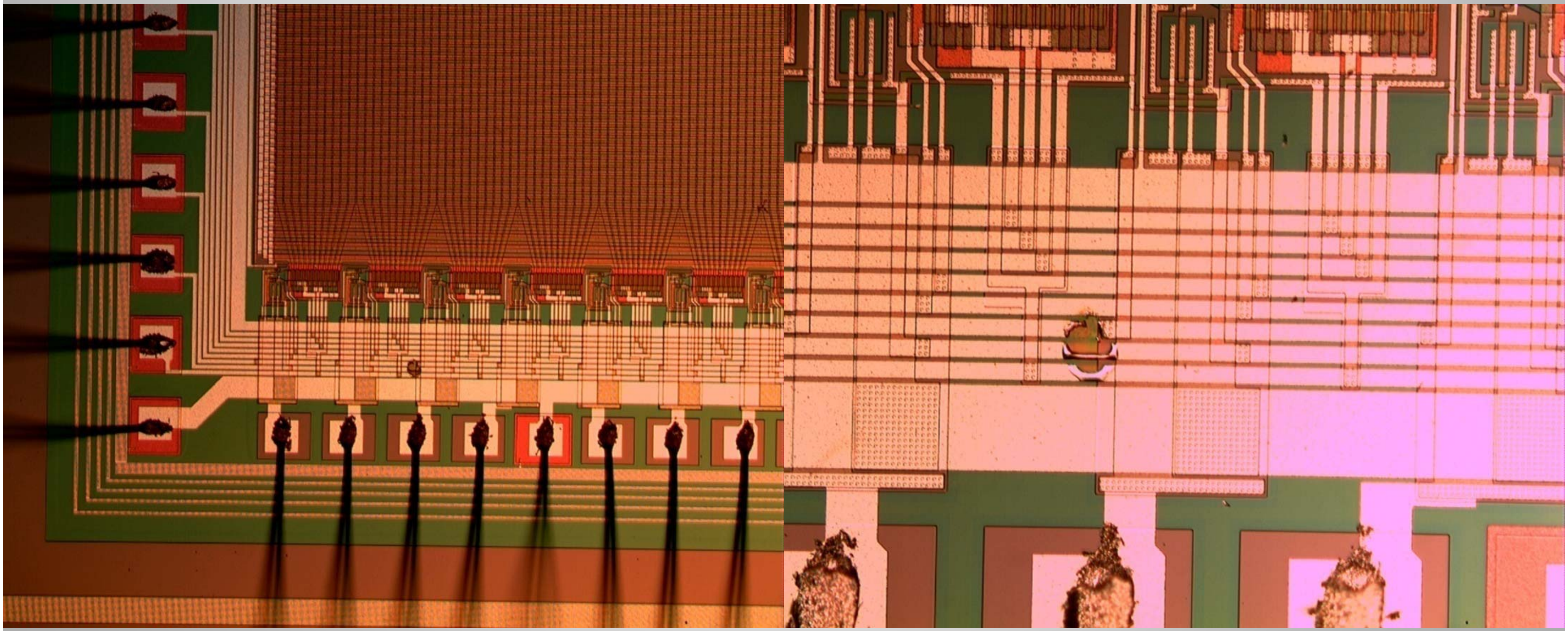


- Mount another CCD
  - This took some time

ZAP^2!

◆ Reset Gate on ONE half of the CCD started to draw excessive current

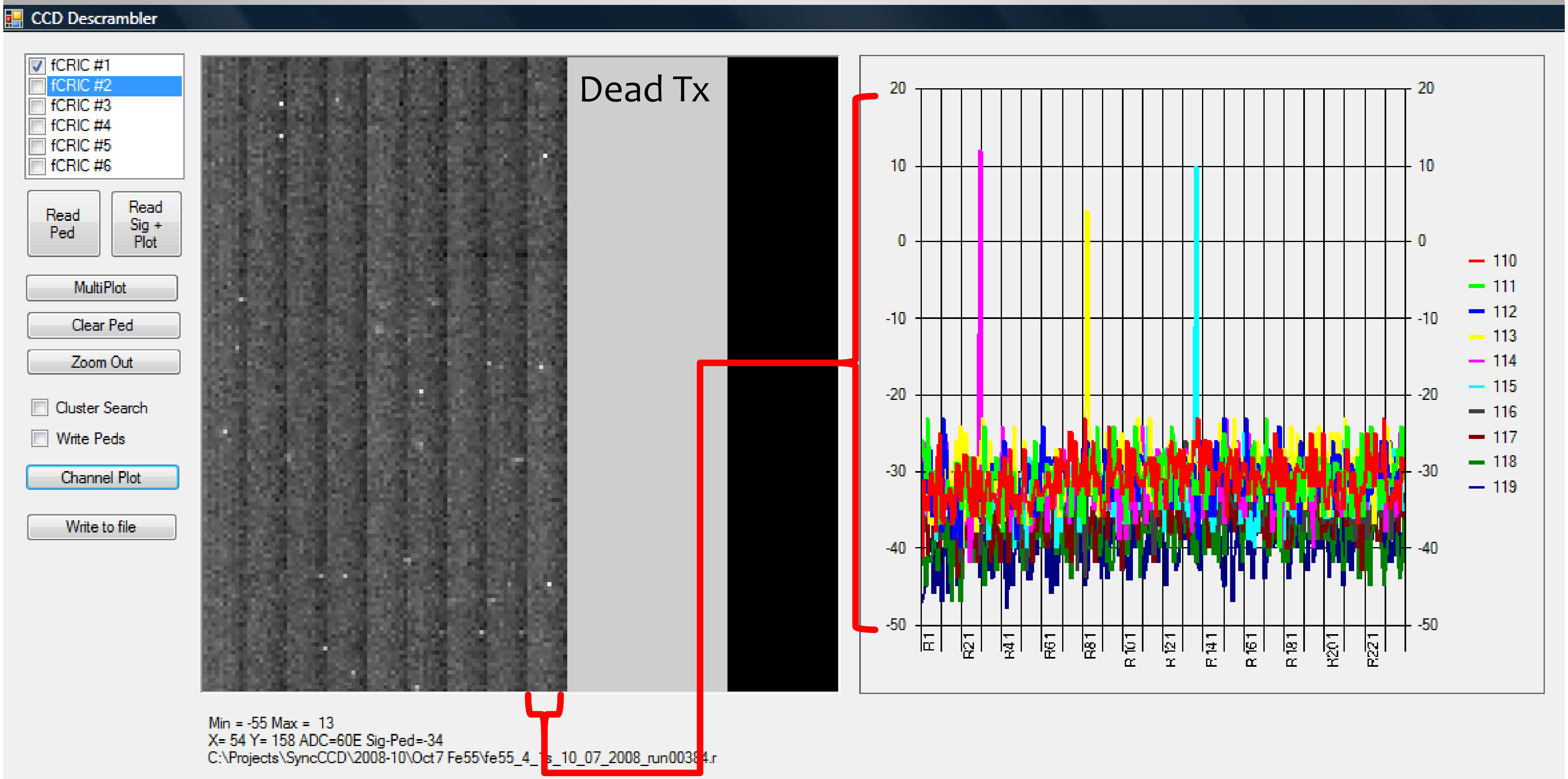
- Damage observed on CCD
- Shorted tantalum cap on clock module
- Did cap take down CCD or vice versa?



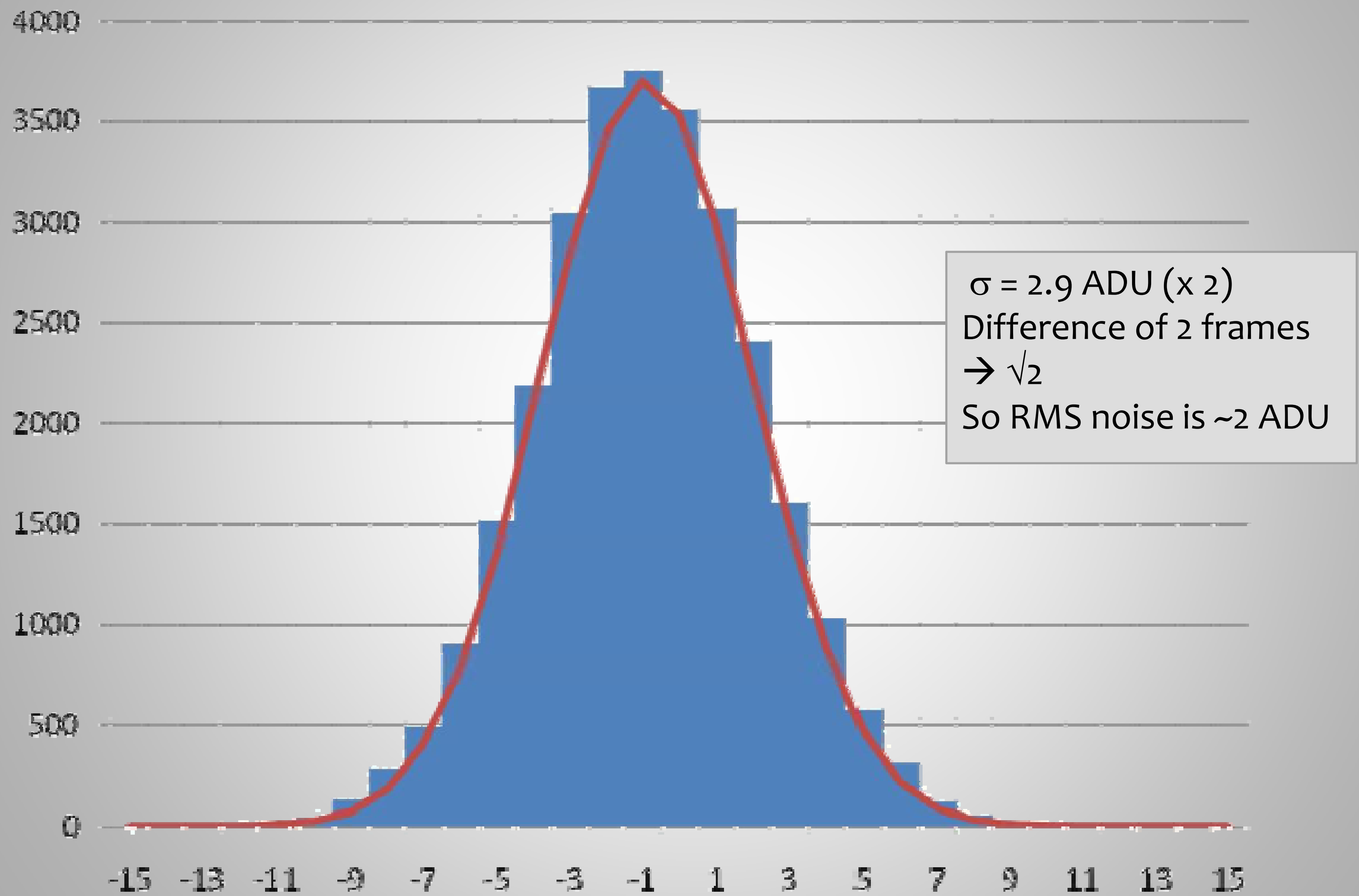
Symmetry is good!

- We are only able to read one half (i.e. one data module)
  - This will probably only be resolved when we visit Argonne
- Substrate is “symmetric” → so rotate it by π
  - 2 of the 3 fCRICs on that side are dead
  - 1 of the readout links on the working fCRIC is dead
  - So, pathetic that we are, that’s still 12 columns
- Fe^{55}
  - 6 second integration at -50C, so a bit of leakage current noise
  - Forced on x2 setting

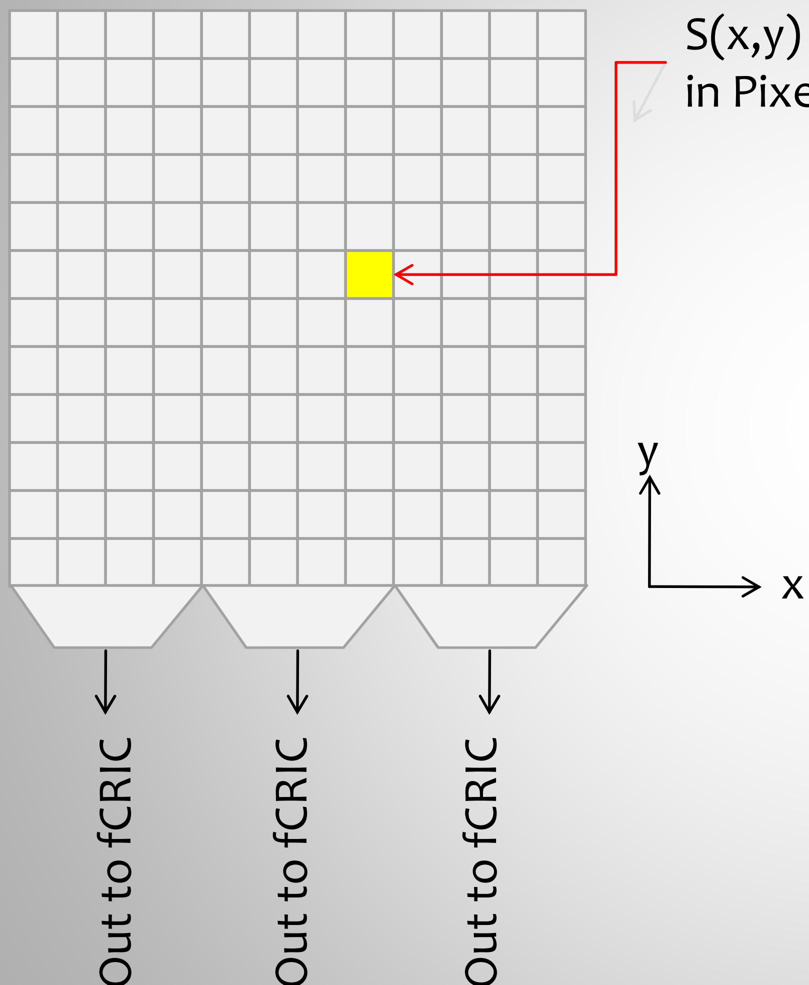
Encouraging



Noise (difference of 2 successive dark images)



Signal - method



- If S(x,y) – S(x,y-1) > THRESH then Pixel(x,y) is a seed pixel
- Use column average

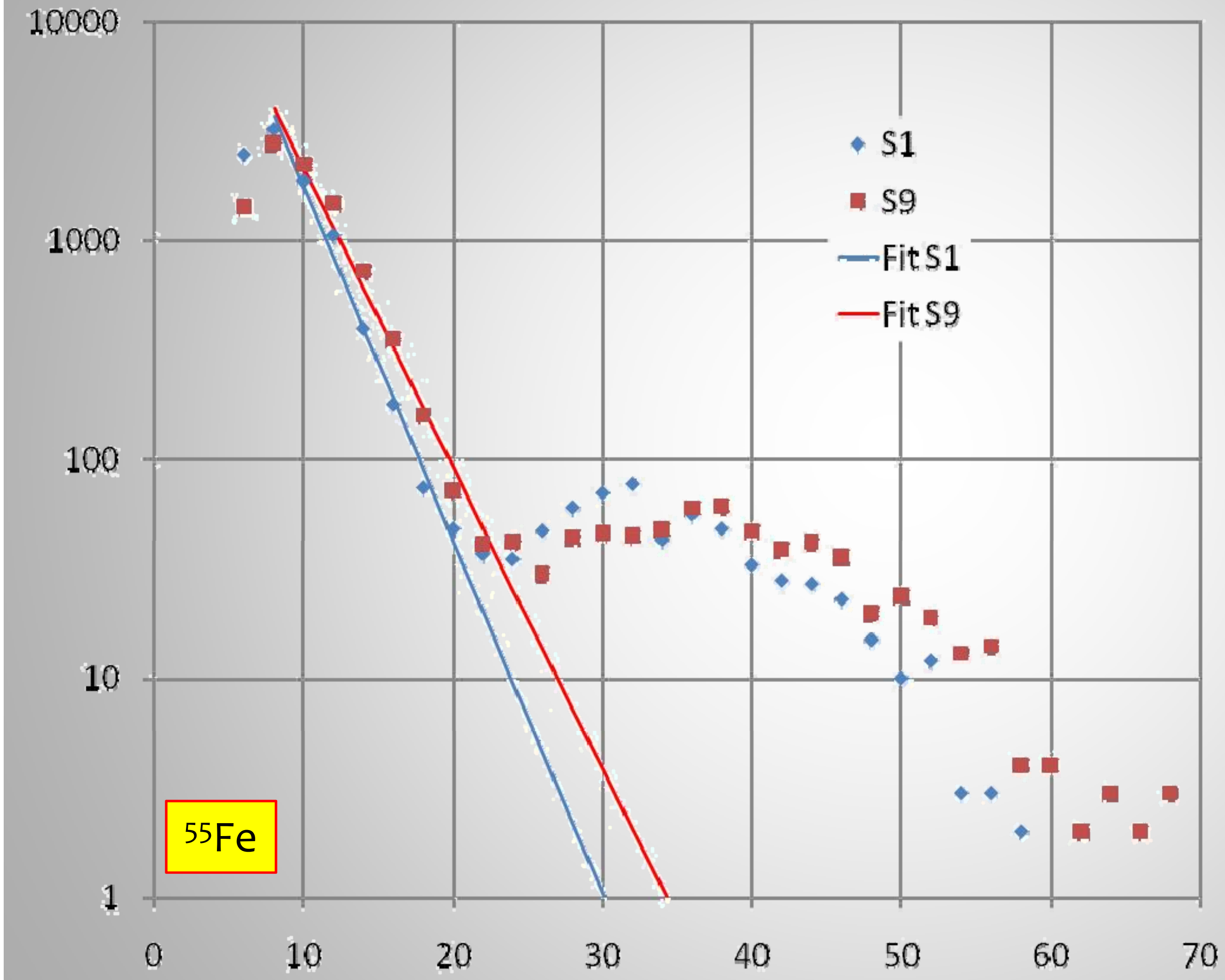
$$Ped(x) = \frac{1}{N}\sum_{y} S(x,y)$$

as the pedestal

- $S_1 = S(x,y) - Ped(x)$
- $S_9 = \sum_{x,y=-1}^{+1} S(x,y) - 3\sum_{x=-1}^{+1} Ped(x)$
- If $S_1/S_9 > R_{MIN}$ AND

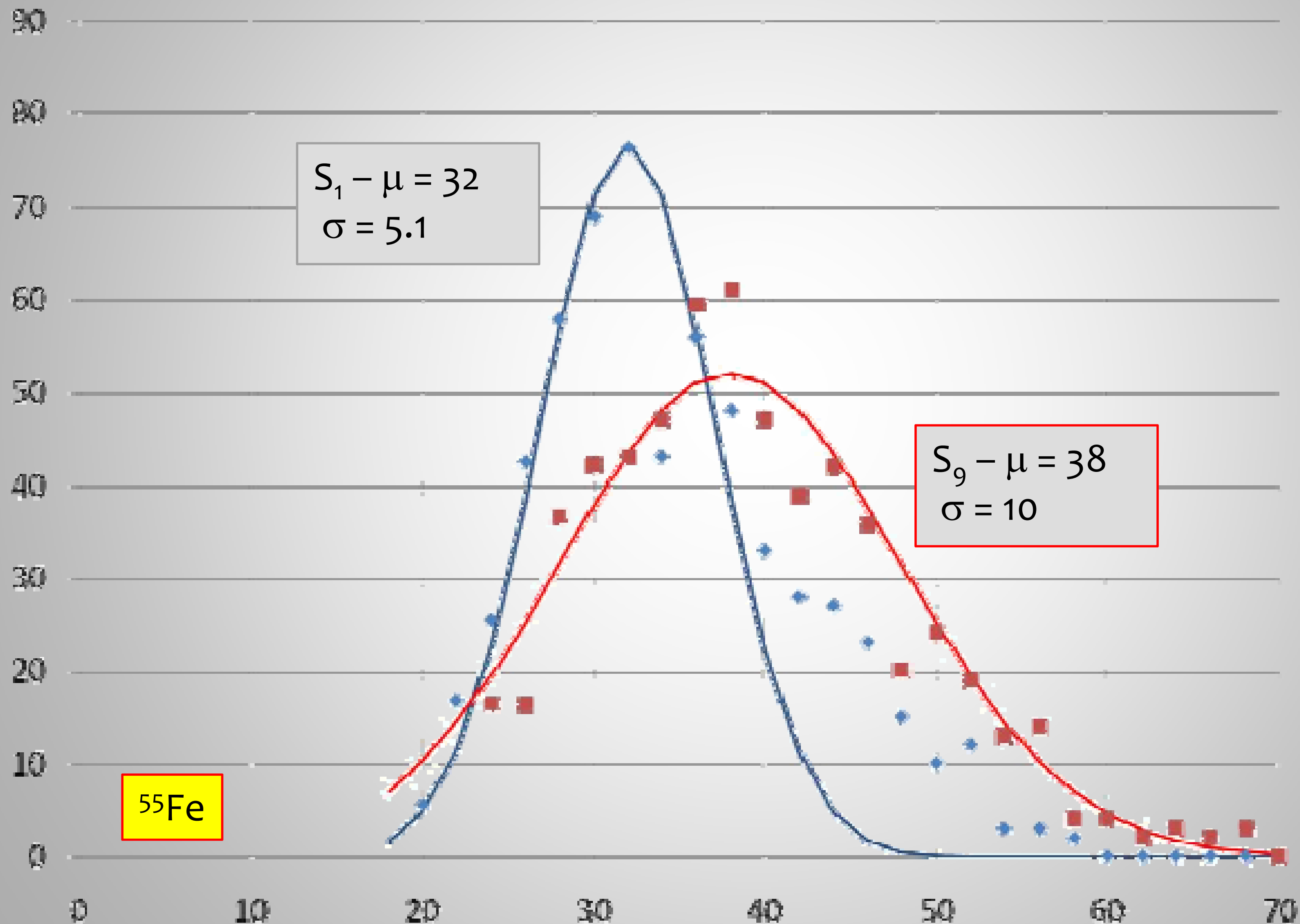
$S_1/S_9 < R_{MAX}$ then record event

Now the spectrum has a peak



- Prior to 1 MΩ resistor replacement, there was no peak in the spectrum – just an exponential tail
- Peak for S_1 and S_9 are quite similar (as one would expect for giant 30 μm pixels – as opposed to nano-scale 10 μm SNAP pixels)
- Subtract the exponential fits

Subtract exponential tail

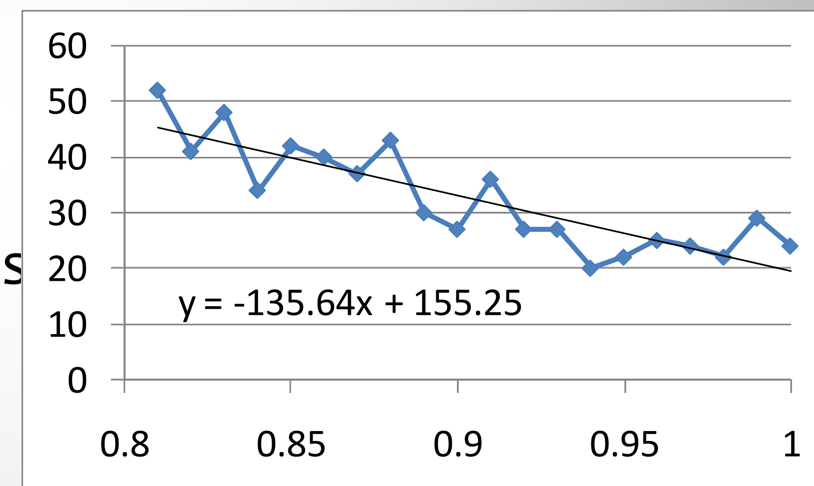


Discussion – (1)

- On x2 scale
  - 0.5 V FS, Gain = 2, 12-bit quantization → 1 ADU = 0.5 V/2/2^{12} = 61 μV
  - Noise ~ 2 ADU → 120 μV. Expect 30 – 40 μV
  - Need to repeat signal measurement at colder temperatures and noise measurement at shorter integration times (is increased noise due to leakage current?)
- ^{55}Fe (5.9 keV) = 38 ADU
  - 5.9 keV → 1640 e^- → 1 ADU = 43 e^-
  - 61 μV/ADU → 1.4 μV/e–
    - But Bill Kolbe measured 3.5 μV/e–
    - ^{55}Fe on x1 scale has a peak at ~½ the number of ADU
  - Factor of 2 gain confusion
- S_1 has σ = 5 for ^{55}Fe and σ = 2 for noise, →
  - Noise ~ 300 eV (should be ~8x less)
  - σ(^{55}Fe) [minus noise] ~ 660 eV (too high)

Discussion – (2)

- Looking at S_1 (rather than S_9) because of added noise in S_9
- Cut on 80% < S_1/S_9 < 100%
- Correcting S_1 by S_1/S_9 introduces noise
- Plot shows $N(S_1/S_9)$ → linear
- So the pulse height distribution 2 slides ago should be the convolution of δ functions at 5.9 (and, smaller, 6.5 keV), the "resolution" (noise + Si) and the plot on the right (assuming that the noise in S_9 is zero-mean)

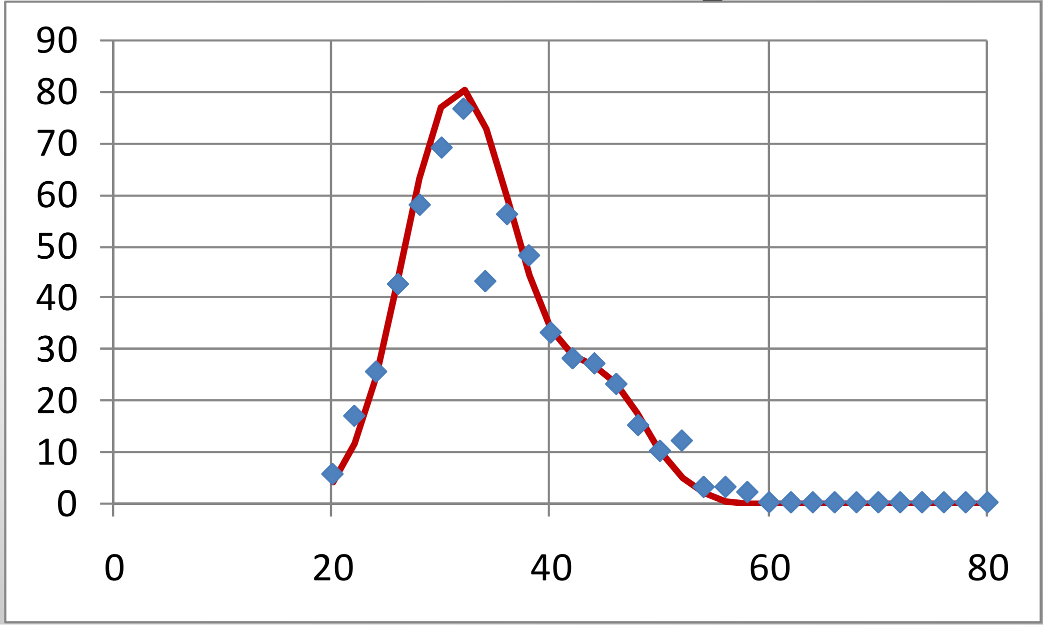


Discussion – (2½)

- An explanation that makes sense (but which I don't understand) would be if there were an *offset* – so that zero energy does not go through zero
- Assume 3.5 μV/e– (as measured before)
  - With an offset such that the 5.9 keV peak is where it is observed to be
- Assume ~10% ratio of 6.5 keV Mn K_β to 5.9 keV Mn K_α
- Then, with a resolution of σ = 4 ADU, and using the convolution described above, one obtains the following:

Data minus exp. background

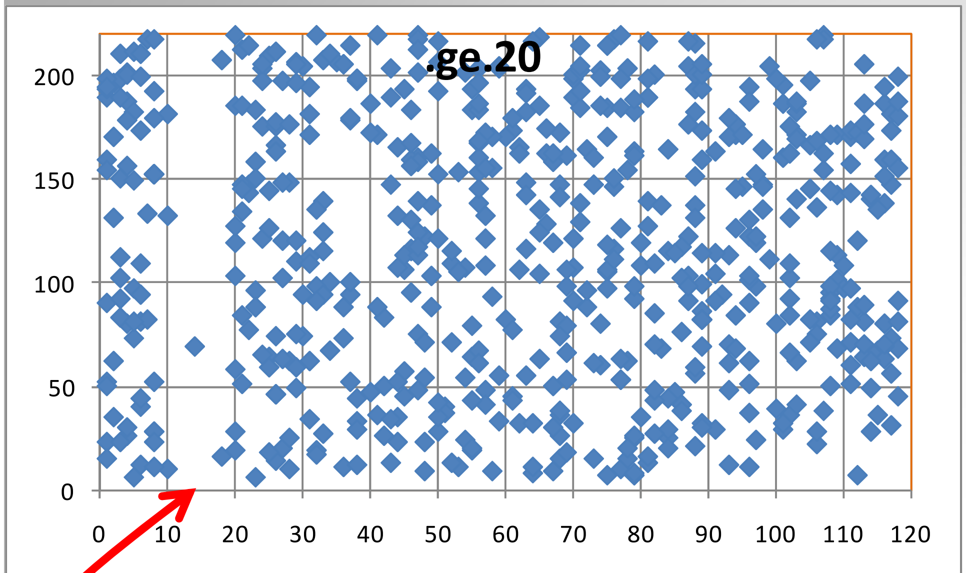
Fit – assuming
1. Gaussian σ = 4 ADU
2. 3.5 μV/e–
3. Offset of 3 keV
4. Convolution as above



Discussion – (2¾)

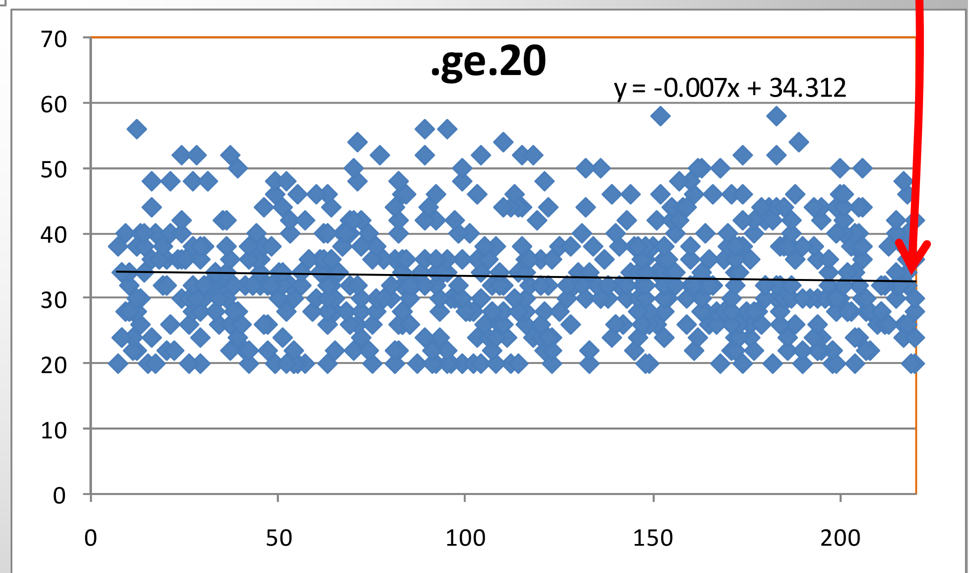
- If this (an offset) were indeed the case then
  - The gain would make sense
  - The noise would be 150 e^- (still not great, but better)
  - The overall resolution would be 300 e^-
- CTE is unlikely to be the explanation (looks ok)
  - And the column-by-column gain variation we saw with light does not seem to be there with ^{55}Fe

Discussion – (3)



- Hit distribution
  - Plot x,y for $S_1(x,y) > 20$
- Looks like there is one dead channel (10 columns)
- fCRIC? CCD?

- Poor (or lazy) man's CTE
  - Plot S1 for all S1 > 20 vs. y position (i.e. row number)
  - Fit to a straight line
  - Slope should be ≤ 0 (CTE ≤ 1)
- Slight negative slope. CTI? Statistics?
  - In any case, not a disaster



Next measurements

- Now that the bias is correct – noise (dark images) vs T and t
  - Integration times of 10, 20, 50, 100, 200, 500, 1000, 2000, 5000 ms as a function of temperature from -40 to -100 (or even colder)
- ^{55}Fe at -100C (for 6 s integration) and more statistics (both x1 and x2)
- Eventually a look at different energies on 5.3.1 to see if there *is* an offset