Simple RBI Shot Noise Measurement/Interpretation

Richard Crisp
rdcrisp@earthlink.net
www.narrowbandimaging.com
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Overview

- Basic plan is to take reference darks and to take pre-flooded darks and to reduce and analyze the data to determine the impact of the RBI flood on dark shot noise
- Very important!
  <u>Ensure all measurements taken in dark: cannot accept any light leaks</u>

Reference Darks

- Power up camera from cold start
- Set operating temperature to -35C. If not possible to reach -35C then try -30C. Once camera reaches temperature (as measured by Maxim DL) then wait 15 minutes
- Take three darks of 15 minutes.
- Warm up camera: then cool to 10C warmer than before (ie, if were running at -35C, then cool down to -25C for this test). Let wait for 15 minutes to stabilize once cooled down
- Take three more darks of 15 minutes

RBI Darks

- Cold start camera as before. Pick the same operating temperature as before (ie -35C)
- Let wait 15 minutes after reaching temperature.
- Open shutter and shine incandescent flashlight into sensor area and flood thoroughly with no filter in place. Two to three seconds is enough.
- Flush twice by taking two bias frames of 1x1 binning.
- Then take a 15 minute dark.
- Repeat light flood/bias-flush followed by another 15 minute dark. Take three darks total at this temperature using this method
- Now warm camera to room temperature. Wait 15 minutes and then cool down to second operating temperature from the reference dark collection (ie -25C). Wait 15 minutes at this temperature to stabilize.
- Then perform the flood/bias-flush/15minute dark operation three times as before.

We now have the required data: pick the cleanest two darks for each operating point for analysis

Data Reduction Theory

- Each dark so-captured will contain three noise components: read noise, dark fixed pattern noise and dark shot noise. Mathematically they are added in quadrature:

$$Total\_noise =$$

$$\sqrt{Read\_noise^2 + \ Dark\_Fixed\_pattern\_noise^2 + Dark\_shot\_noise^2}$$

- If you measure the standard deviation of a 100 x 100 selection box in the middle of the dark frame you are measuring the TOTAL NOISE with all three components.
- What we want to learn is how the dark shot noise changes for the reference case and the flood/flush case.

- **We need to learn the read noise and remove the dark fixed pattern noise to determine the dark shot noise**

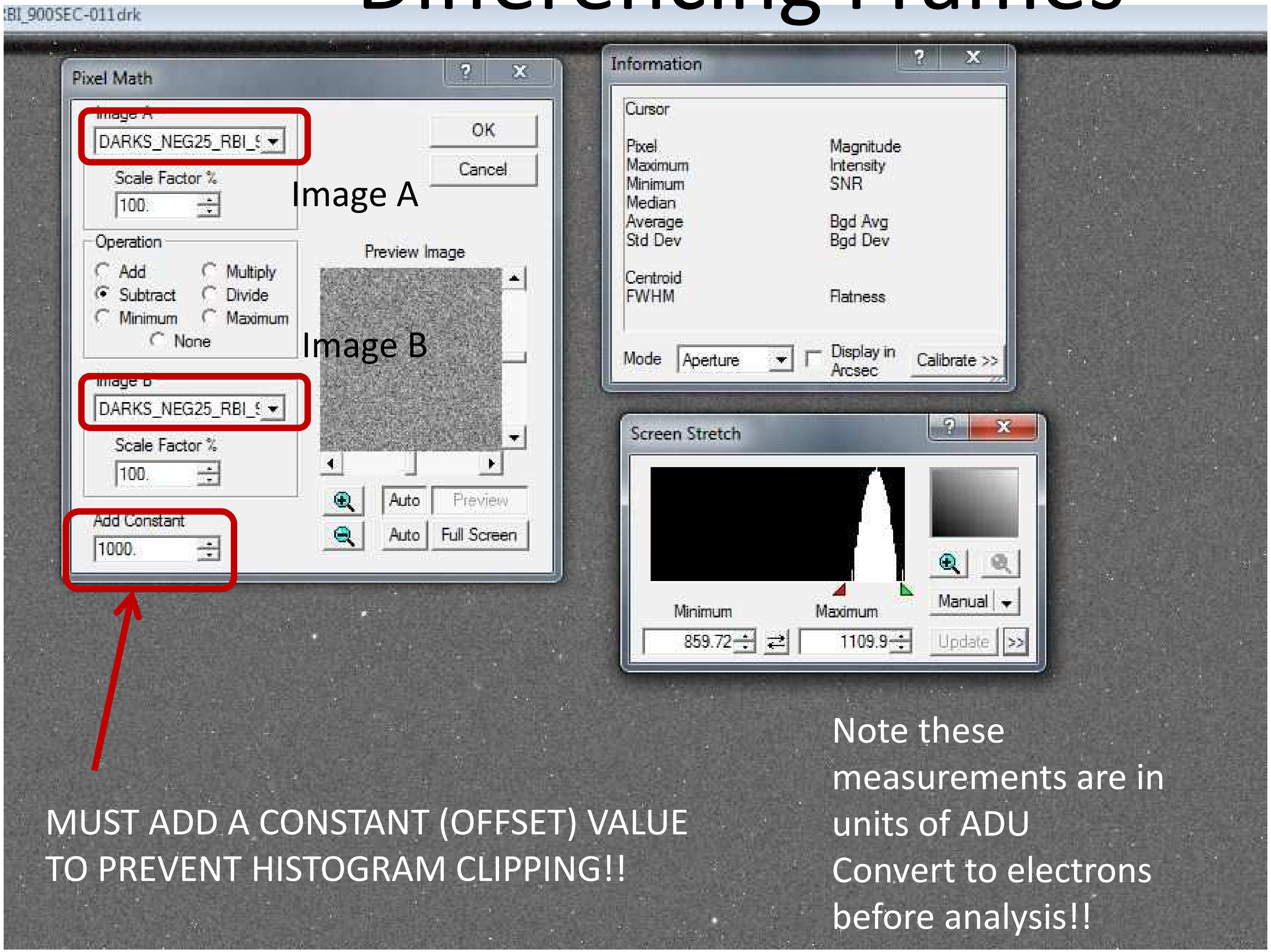
Data Reduction

- Perform a Photon Transfer Characterization on the camera to accurately measure the read noise. Alternatively FLI measures the read noise so you can use their reported value.
- If you take the difference of two identical dark frames and measure the standard deviation of a 100x100 box in the middle, the result will be the SQRT(2) * the total noise devoid of the fixed pattern term: differencing the frames removes the dark fixed pattern noise
- We can determine the dark shot noise using this equation:

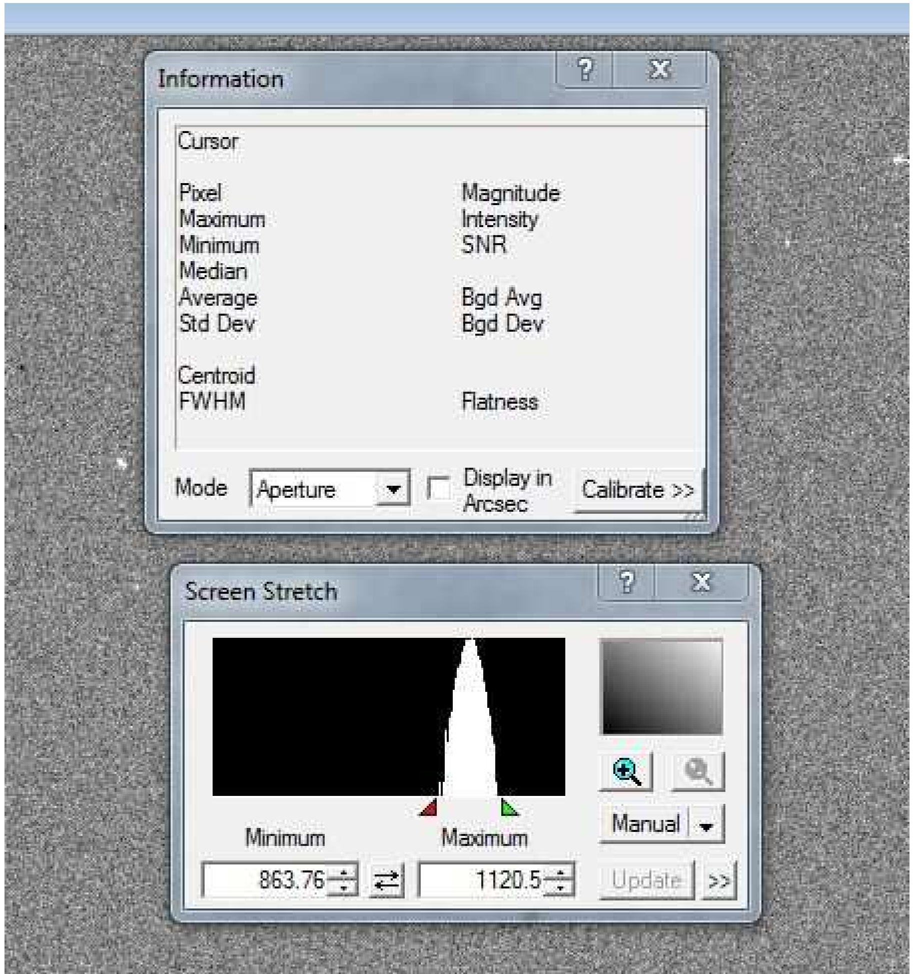
$$Dark\_Shot\_Noise = \sqrt{0.5 * (standard\_deviation)^2 - read\_noise^2}$$

It is imperative that a consistent set of units to be used in the calculation. I suggest working in units of electrons since the read noise is customarily expressed in those units by manufacturers

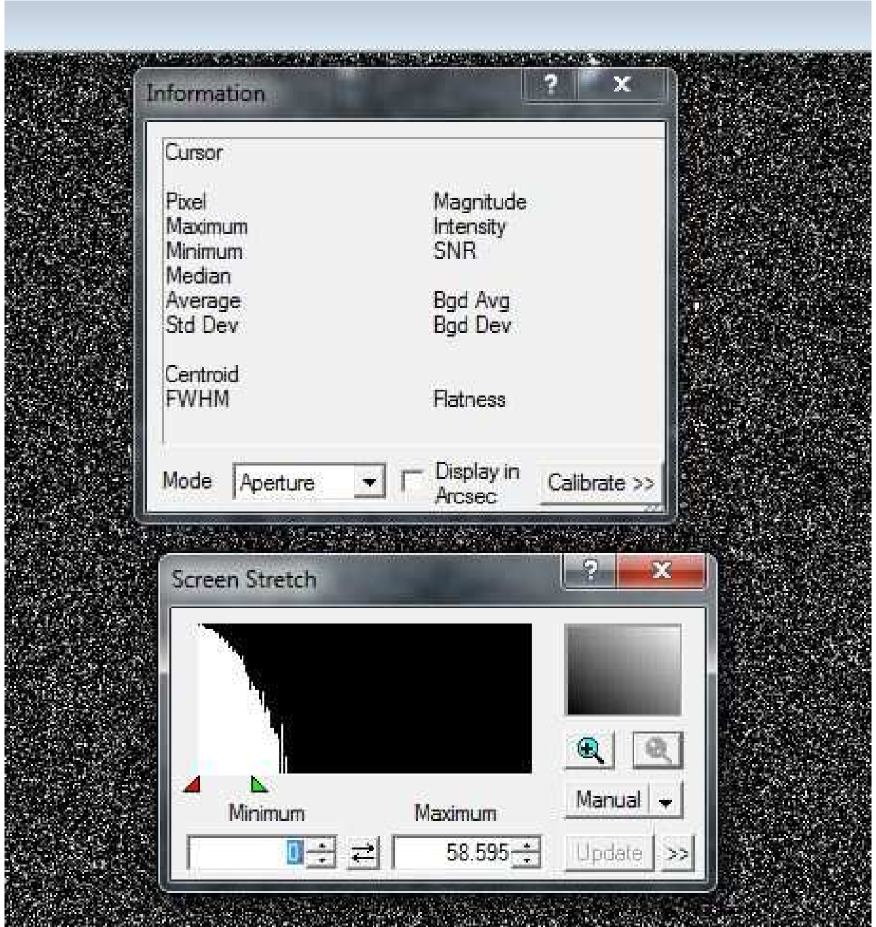
Differencing Frames



Proper Frame Differencing Result

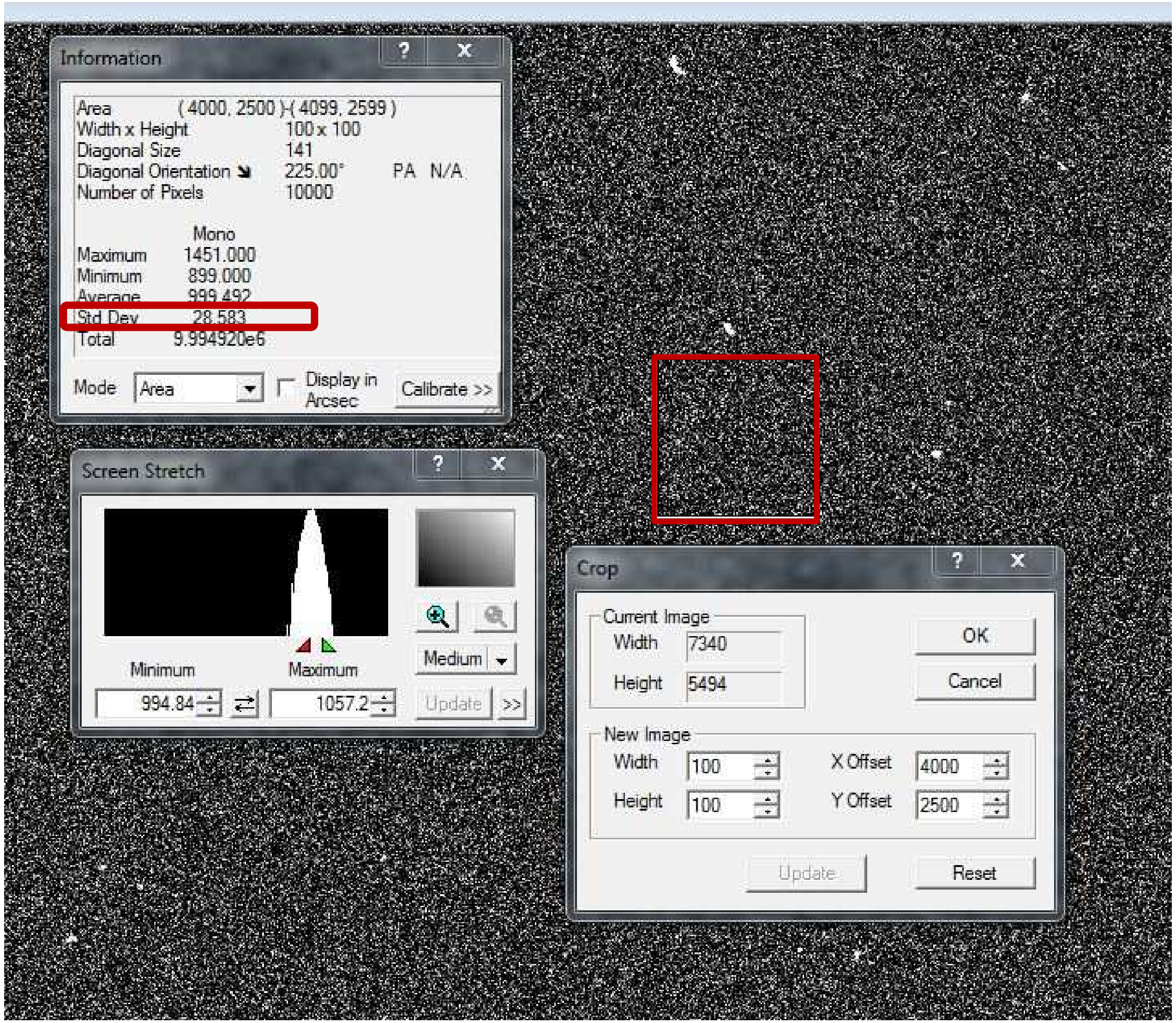


Proper differencing using offset



Bad differencing: no offset used: distorts histogram by clipping

Measuring Standard Deviation



Standard_deviation = 28.583 ADU

Convert to electrons
Gain = 0.9 e-/ADU

Total Noise w/o DFPN:

0.9* 28.583 * 1/sqrt(2) = 18.19 e-

Read Noise = 11.7e- (from PTC)

Dark Shot Noise = Sqrt (18.19^2 – 11.7^2)
=13.92 e-

Interpreting results

- This particular camera (KAF39000M operated at -25C for 15 minutes with RBI Flood) shows 13.92 e- of dark shot noise for a 15 minute RBI-mitigated image. The read noise of this camera was measured to be 11.7 e- so a 15 minute exposure at -25C using RBI mitigation shows dark shot noise basically matching the read noise. That says the 15 minute exposure is a reasonable exposure duration for this camera operated with RBI mitigation at -25C

Reference PTC for PL39000M