

# Calculating Camera Gain

## Background

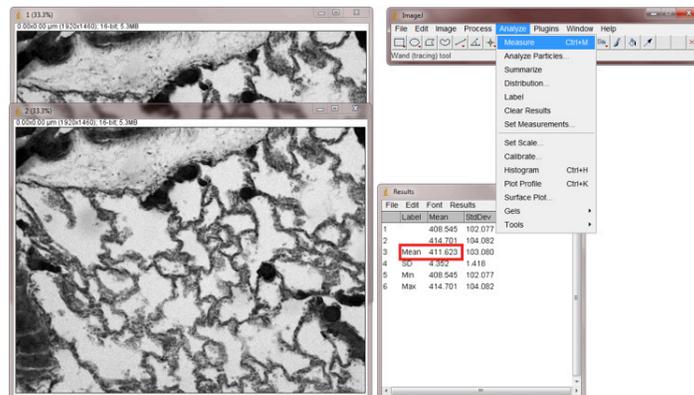
When the amount of light entering a camera is linearly increased, the response of the camera in grey levels should also linearly increase.

The gain represents the quantization process as light incident on the detector is processed and quantified. It varies from camera to camera depending on electronics and individual properties but it can be calculated experimentally. If a number of measurements are made and plotted against each other the slope of the line should represent the linearity of the gain.

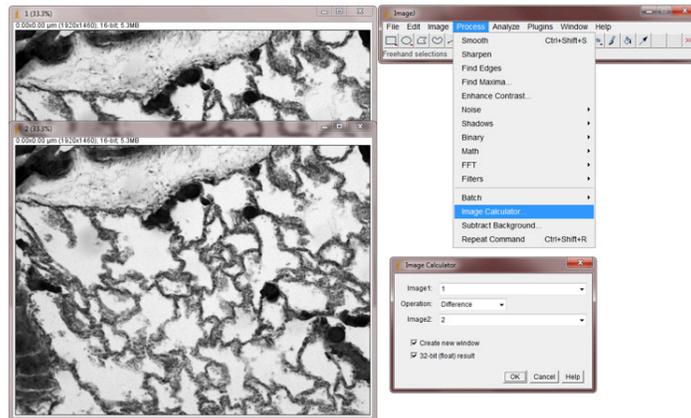
## Method

Camera system gain is calculated by a single point mean variance test which calculates the linear relationship between the light entering the camera and the cameras response to it. To perform this test:

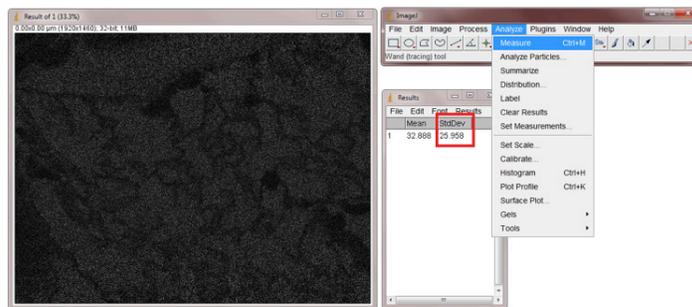
1. Take a 100-frame bias stack with your camera like in the document *Calculating Camera Bias* and measure the mean bias
2. Take 2 frames of any image using the same light level with a 5ms exposure time
3. In ImageJ, Measure the means of both images and average them. We'll call this  $\text{Mean}_{\text{Image1, Image2}}$



4. Calculate the difference between the two images by selecting Image Calculator from the Analyze menu. Select the two frames and Subtract, you will need to float the result. Press OK to generate the diff image.



5. Measure the Standard Deviation of the diff image, we'll call this Standard deviation<sub>Diff image</sub>.



6. Calculate the variance of the two images with the following equation:

$$\text{Variance}_{\text{Image 1, Image 2}} = \frac{\text{Standard deviation}_{\text{Diff image}}^2}{2}$$

7. Calculate the gain from the variance using the following equation, remember to remove the previously calculated bias:

$$\text{Gain} = \frac{(\text{Mean}_{\text{Image 1, Image 2}}) - \text{bias}}{\text{Variance}_{\text{Image 1, Image 2}}}$$

Gain is represented as e-/grey level.

8. Repeat this process with 10ms, 20ms and 40ms exposure times to check that the gain is consistent across varying light levels.

9. You can also use the single-point mean variance (gain) calculator provided by Photometrics on the website: <https://www.photometrics.com/resources/imaging-tools/mean-variance-calculator.php>