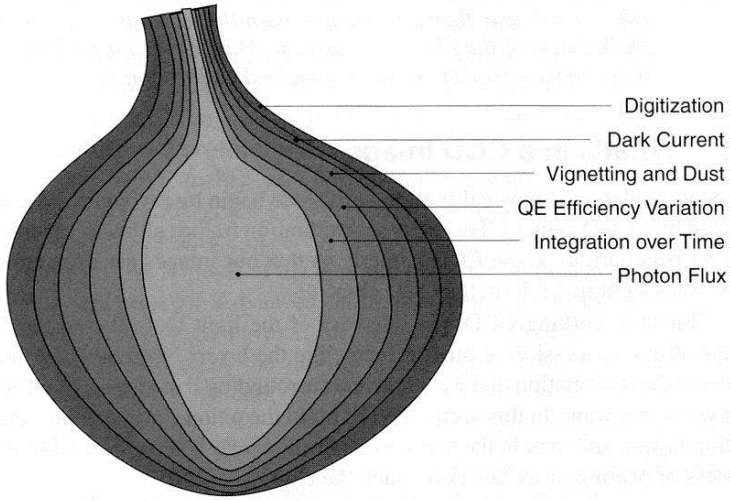
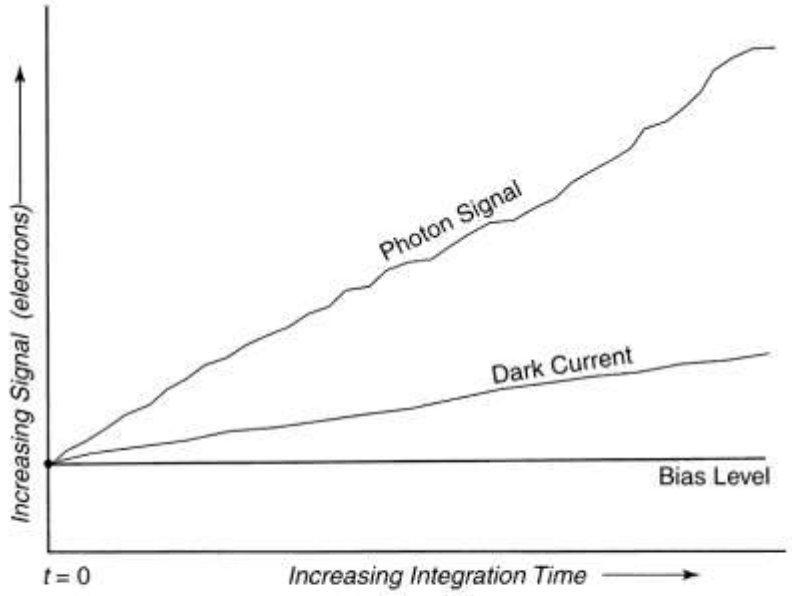
Basic Image Processing

Noise: Calibration

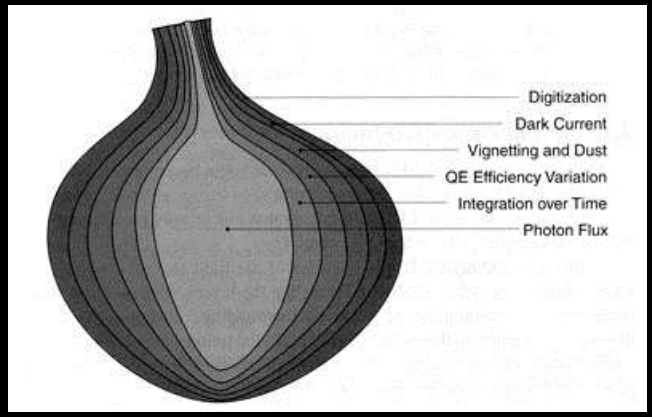


CCD information is layered like an onion, with the data that you really want—the flux of photons—hidden away in the innermost layer. To retrieve the photon flux, you must peel away unwanted signals and factors that influence the signal from the CCD. This process is called image calibration.

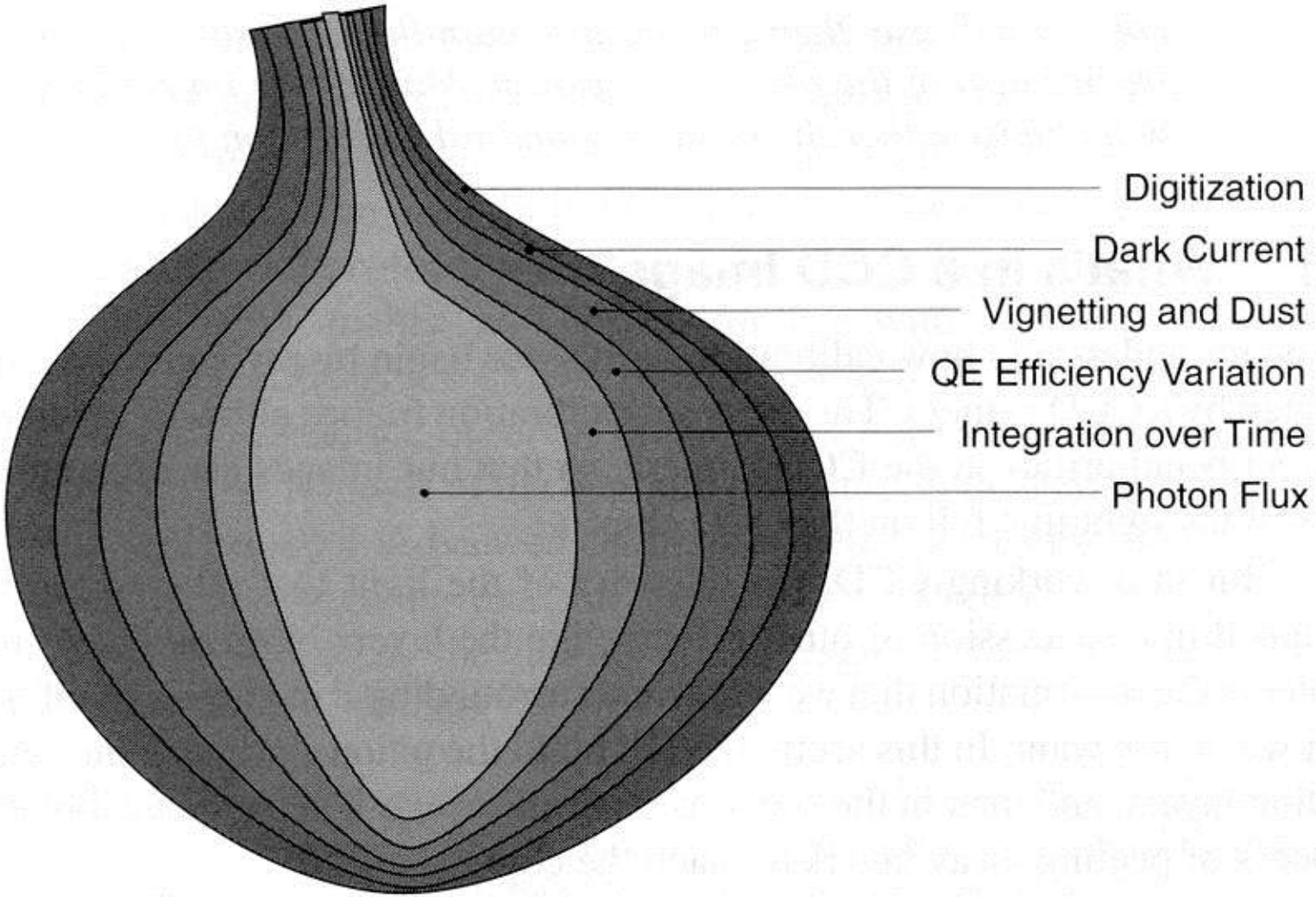


During an integration with a CCD, the bias remains constant, the dark current increases, and photoelectrons accumulate. At the end of the integration, you only know the total signal. To find the average photon flux, you must subtract both the bias level and the dark current from the total signal.

HOW to win the battle against **NOISE**



- Noise is uncertainty.
- Noise is often counter-intuitive: *it may not behave as you expect*.
- Anything that increases noise *is bad for the image*.
- When in doubt, *follow the rules*, not your intuition!



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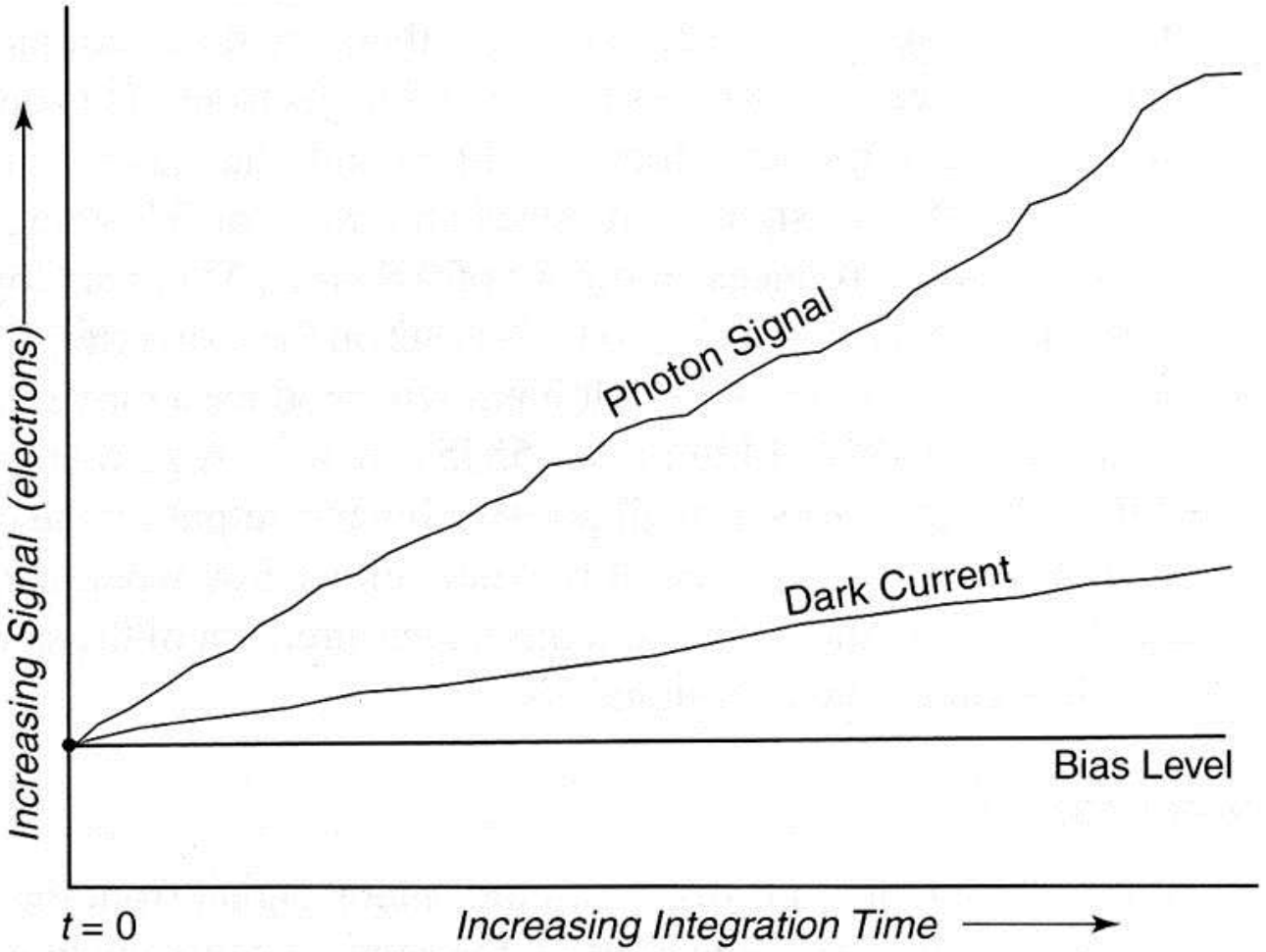

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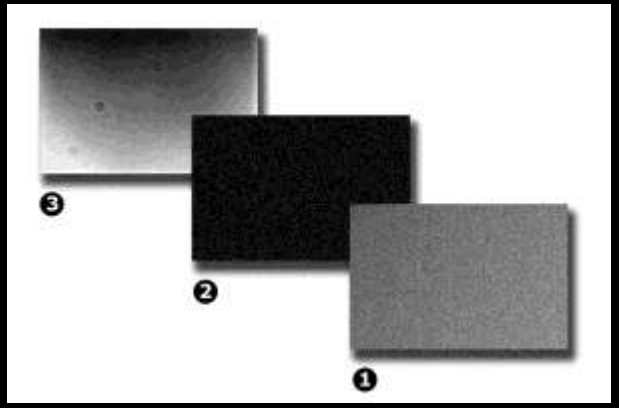
Image Calibration/Reduction



- BIAS Frames
- DARK Frames
- FLAT-FIELD Frames
- Use statistical combine (e.g. MEDIAN SUM) to clean up outliers (e.g., cosmic ray hits)

All calibration/reduction frames:

- Remove system noise
- Add random noise!

Bias Frames

- Bias records initial state of each pixel
- Bias frames are optional. Use when:
  - Scaling darks
  - Compensating for pedestal
- More bias frames = less noise added to final image
  - 8 frames recommended minimum;
  - 50 are not too many!

All frame types add random noise. Don't use bias frames unless you need them.

Dark Frames

- Darks record end state of each pixel at the completion of the exposure
- Darks record thermal noise (dark current)
- Not all cameras require darks
- For lowest noise, always take darks that match the light image's:
  - Exposure time
  - Temperature
- Take 8 **or more** darks for lower noise.
- **ALWAYS** take at least 3 darks!

Scaling Dark Frames

- Never scale a shorter dark to a longer light
- May result in hot/cold pixel leftovers
- Take large numbers of darks to lower noise contribution of scaled darks (8-72!)

Scaling darks also scales random noise. Don’t scale darks unless you accept the noise penalty.

Evaluating Flats

- The only way to know how good a flat is to apply it to an image
- A flat is a good one if it:

  Leaves the image background flat (*except for light pollution gradients!)*

Flat Problems

- Uneven illumination
- Direct illumination of diffuser
  - Moonlight on diffuser
  - Sunlight on diffuser
  - Light from your white T-shirt reflecting on diffuser – etc.
- Off-axis light
  - Bright spots on diffuser
  - Back illumination (light entering at back of scope or through camera)
  - Internal reflections from ambient light sources

Flat-field Frames

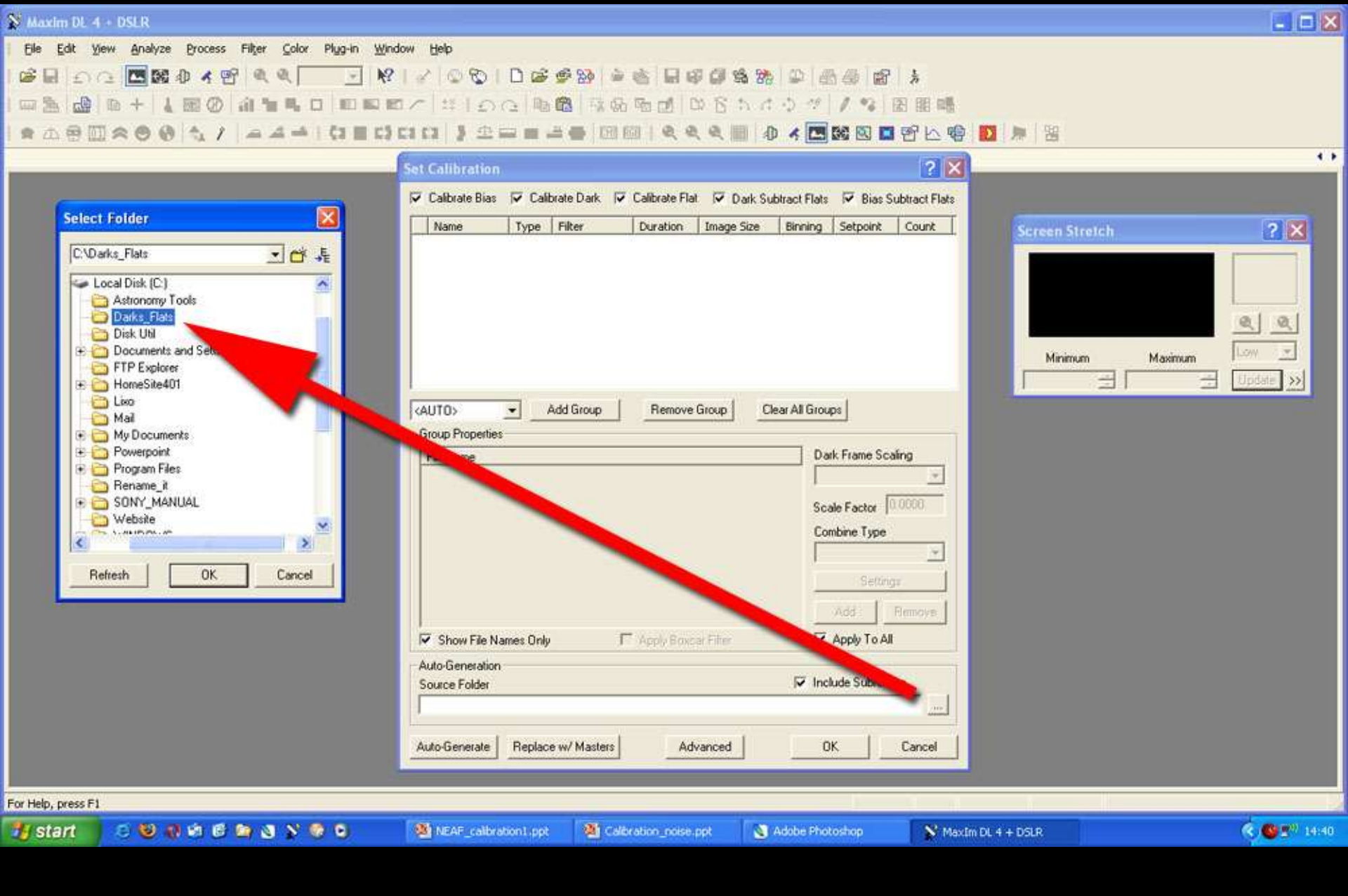
- Most difficult type of calibration frame to do right
- Unlike bias/dark, requires significant operator skill
- Sky flats accurate
- Diffuser flats easy
- Sky flats through a diffuser give you best of both approaches

Calibration Libraries

- Libraries average out changes in sensor response
  - *Take a large number of images*
  - *Use images from multiple nights*
- Calibration images get out of date over time
  - Keep library up to date with recent images
  - Throw out old images
  - Periodically subtract old from new measure change and verify usefulness

Calibration Libraries

Maxim DL/CCD 4.56



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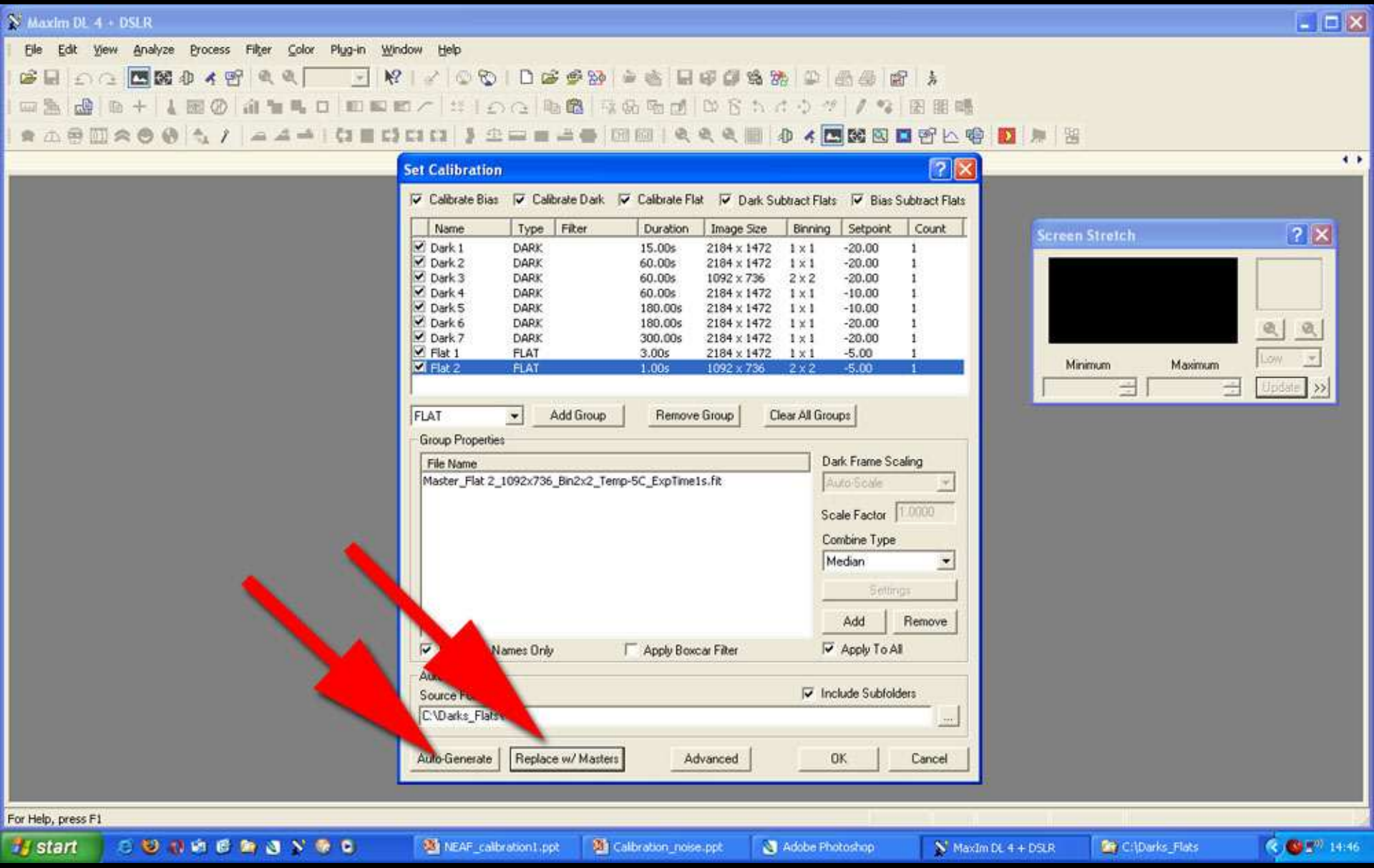

Calibration Libraries