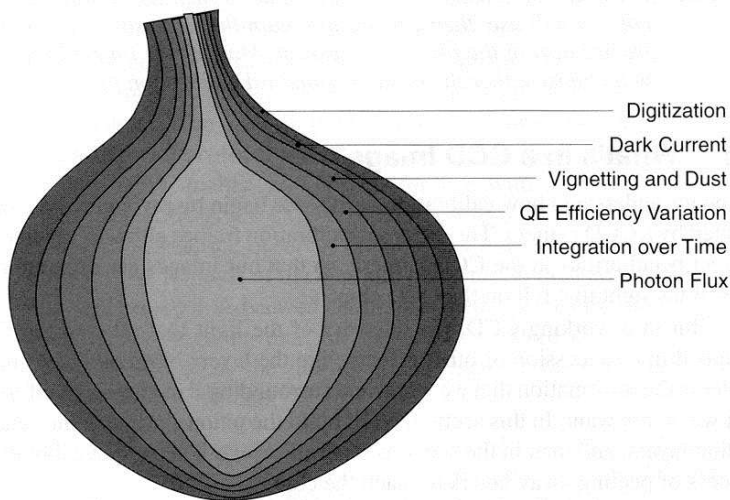
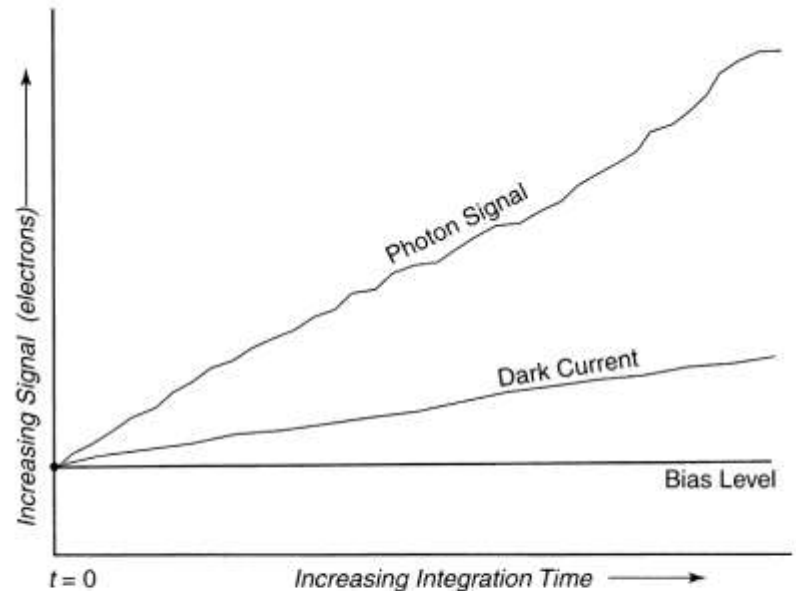


Basic Image Processing

Noise: Calibration



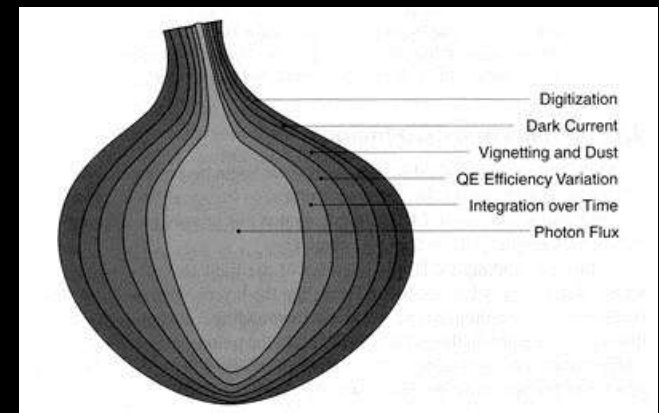
CCD information is layered like an onion, with the data that you really want—the flux of photons—hidden away in the innermost layer. To retrieve the photon flux, you must peel away unwanted signals and factors that influence the signal from the CCD. This process is called image calibration.

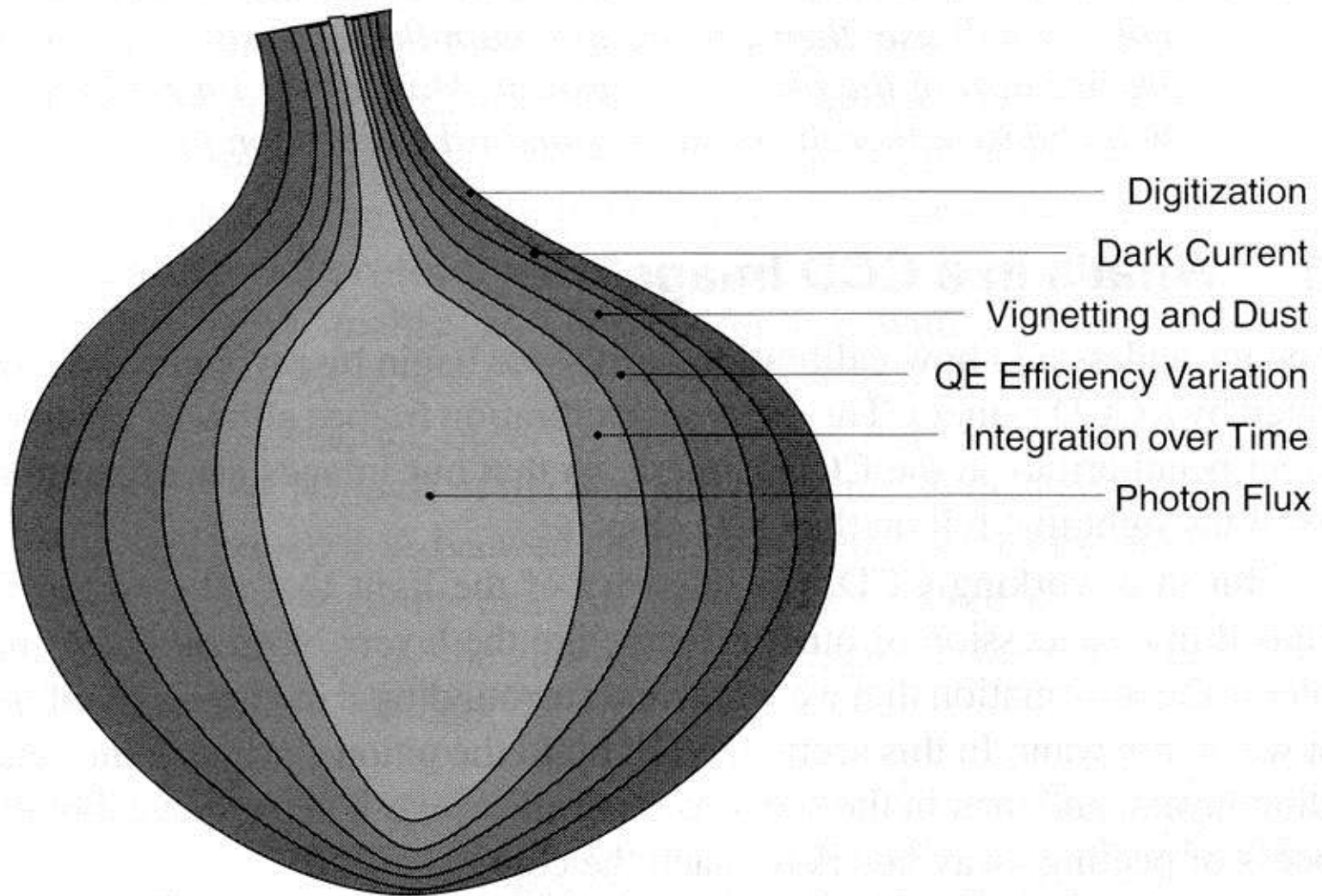


During an integration with a CCD, the bias remains constant, the dark current increases, and photoelectrons accumulate. At the end of the integration, you only know the total signal. To find the average photon flux, you must subtract both the bias level and the dark current from the total signal.

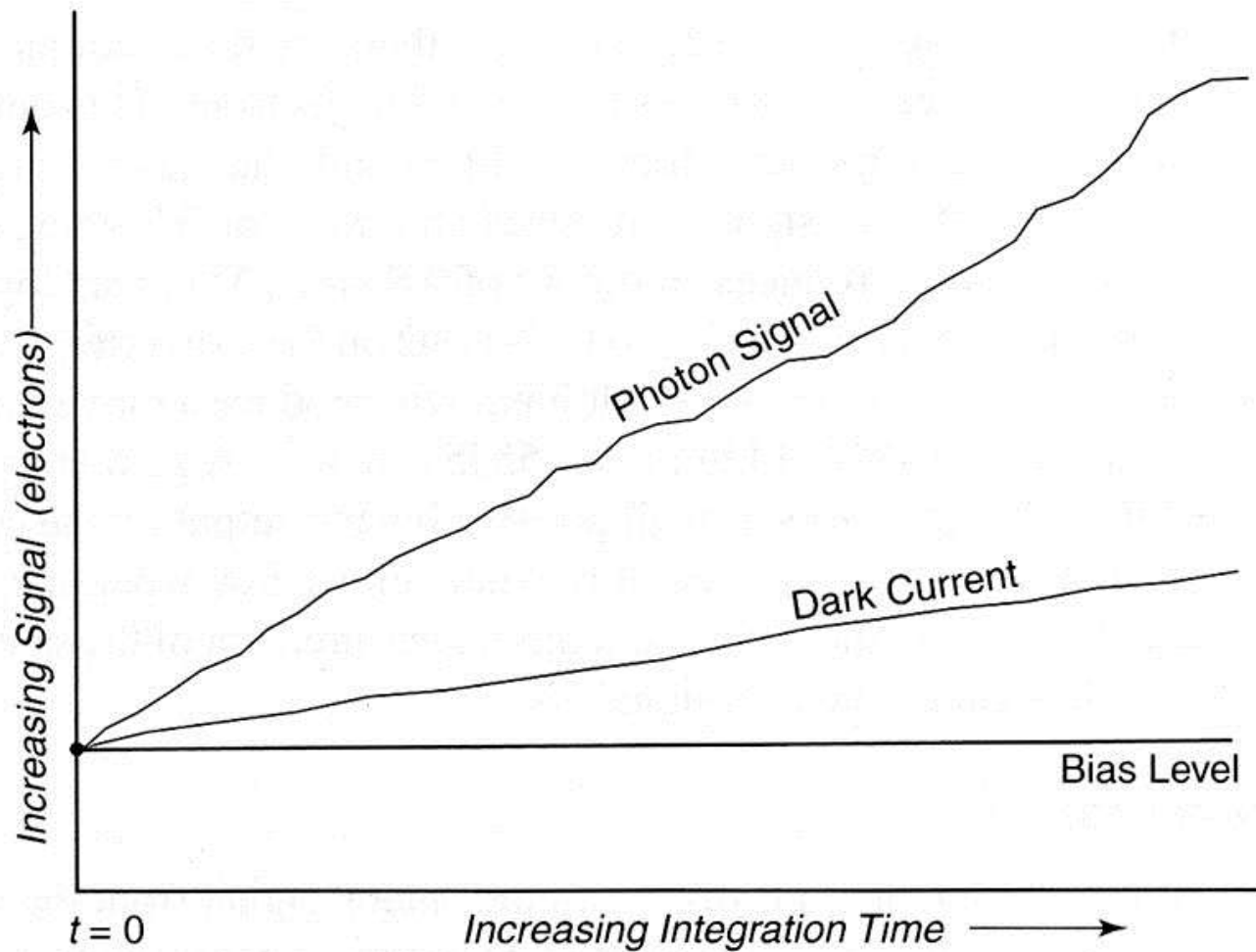
HOW to win the battle against **NOISE**

- 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!





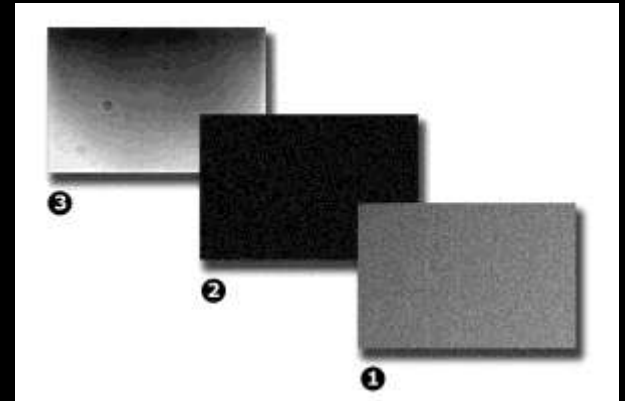
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Image Calibration/Reduction

- **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

The screenshot displays the Maxim DL 4 + DSLR software interface. The main window shows a menu bar (File, Edit, View, Analyze, Process, Filter, Color, Plug-in, Window, Help) and a toolbar. Three dialog boxes are open:

- Select Folder:** A file explorer window showing the directory structure of the local disk (C:). The folder **Darks_Flats** is selected, and a red arrow points to it.
- Set Calibration:** A dialog box for configuring calibration settings. It includes a table with columns: Name, Type, Filter, Duration, Image Size, Binning, Setpoint, and Count. Below the table are buttons for **Add Group**, **Remove Group**, and **Clear All Groups**. The **Group Properties** section includes a text field for the group name, a **Dark Frame Scaling** dropdown menu, a **Scale Factor** input field (set to 0.0000), and a **Combine Type** dropdown menu. There are also **Settings**, **Add**, and **Remove** buttons. At the bottom, there are checkboxes for **Show File Names Only**, **Apply Boxcar Filter**, and **Apply To All**. The **Auto-Generation** section includes a **Source Folder** field and a checked **Include Sub...** checkbox. Buttons at the bottom include **Auto-Generate**, **Replace w/ Masters**, **Advanced**, **OK**, and **Cancel**.
- Screen Stretch:** A dialog box for adjusting the screen stretch. It features a black preview window, **Minimum** and **Maximum** input fields, a **Low** dropdown menu, and an **Update** button with a right arrow.

At the bottom of the screen, the Windows taskbar is visible, showing the Start button and several open applications: NEAF_calibration1.ppt, Calibration_noise.ppt, Adobe Photoshop, and Maxim DL 4 + DSLR. The system tray on the right shows the time as 14:40.

Calibration Libraries

The screenshot displays the Maxim DL 4 + DSLR software interface. The main window shows the 'Set Calibration' dialog box, which is used to configure calibration files. The dialog includes a table of calibration files and several configuration options.

Name	Type	Filter	Duration	Image Size	Binning	Setpoint	Count
Dark 1	DARK		15.00s	2184 x 1472	1 x 1	-20.00	1
Dark 2	DARK		60.00s	2184 x 1472	1 x 1	-20.00	1
Dark 3	DARK		60.00s	1092 x 736	2 x 2	-20.00	1
Dark 4	DARK		60.00s	2184 x 1472	1 x 1	-10.00	1
Dark 5	DARK		180.00s	2184 x 1472	1 x 1	-10.00	1
Dark 6	DARK		180.00s	2184 x 1472	1 x 1	-20.00	1
Dark 7	DARK		300.00s	2184 x 1472	1 x 1	-20.00	1
Flat 1	FLAT		3.00s	2184 x 1472	1 x 1	-5.00	1
Flat 2	FLAT		1.00s	1092 x 736	2 x 2	-5.00	1

The 'Set Calibration' dialog also features a 'Group Properties' section with the following settings:

- File Name: Master_Flat_2_1092x736_Bin2x2_Temp-5C_ExpTime1s.fit
- Dark Frame Scaling: Auto-Scale
- Scale Factor: 1.0000
- Combine Type: Median
- Settings: [Settings]
- Add: [Add] Remove: [Remove]
- Apply Names Only: Apply Boxcar Filter: Apply To All:
- Source Path: C:\Darks_Flats [Include Subfolders:
- Buttons: Auto-Generate, Replace w/ Masters, Advanced, OK, Cancel

A 'Screen Stretch' dialog is also visible on the right side of the screen, showing a black image and controls for Minimum, Maximum, and Update.

Red arrows point to the 'Replace w/ Masters' button in the 'Set Calibration' dialog.

For Help, press F1

Calibration Libraries

