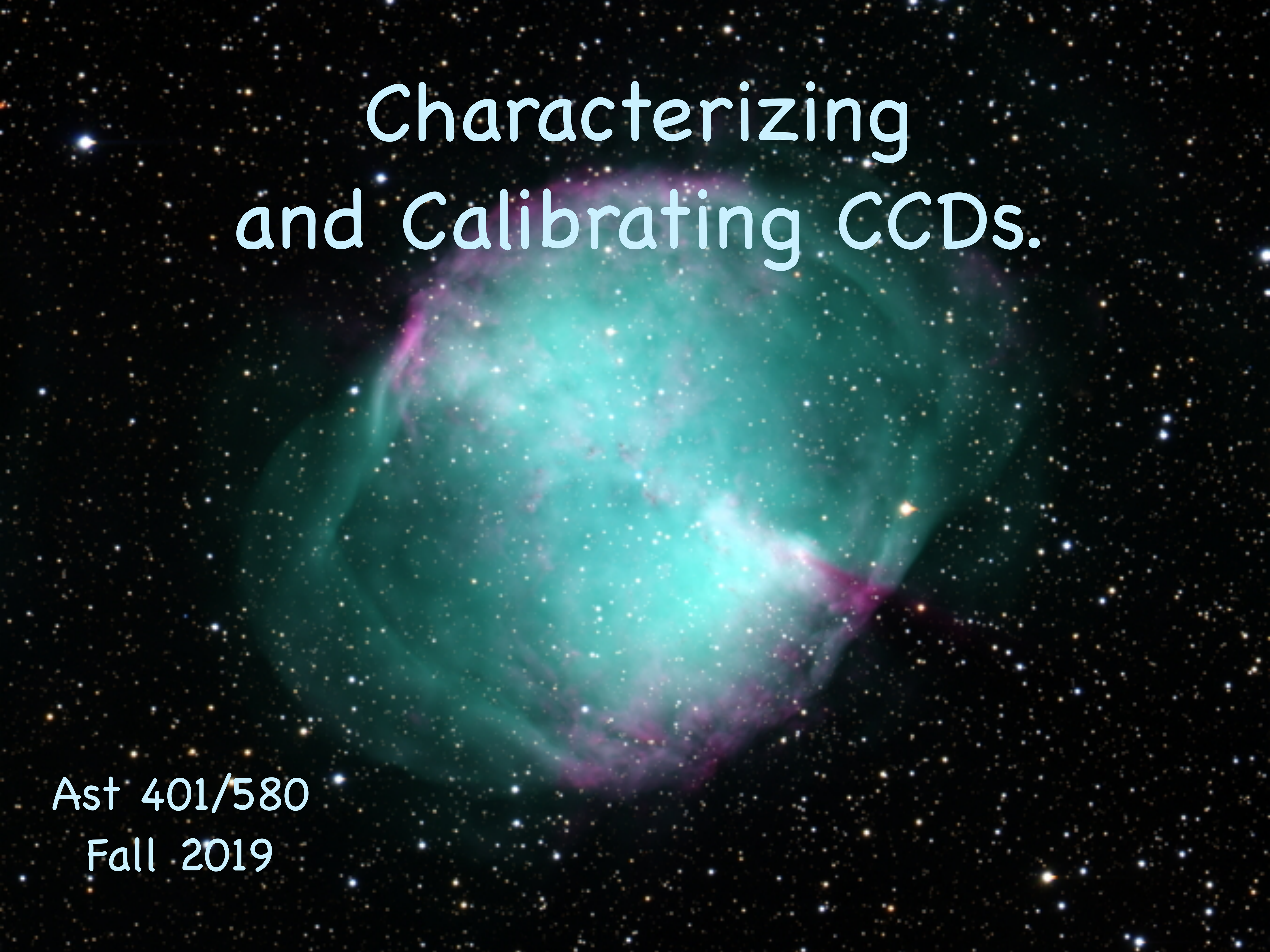


Characterizing and Calibrating CCDs.

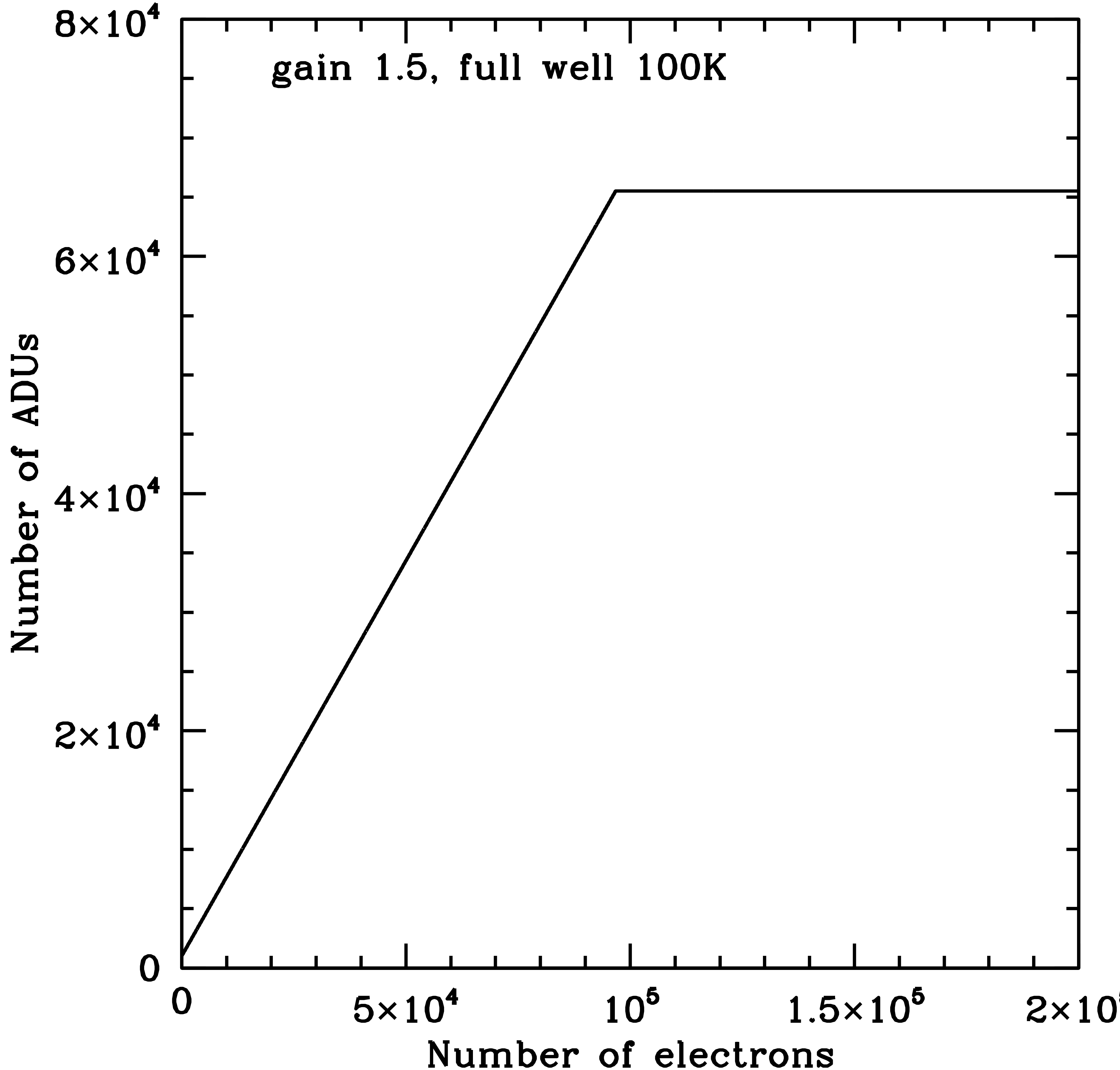
Ast 401/580
Fall 2019

Read noise and gain

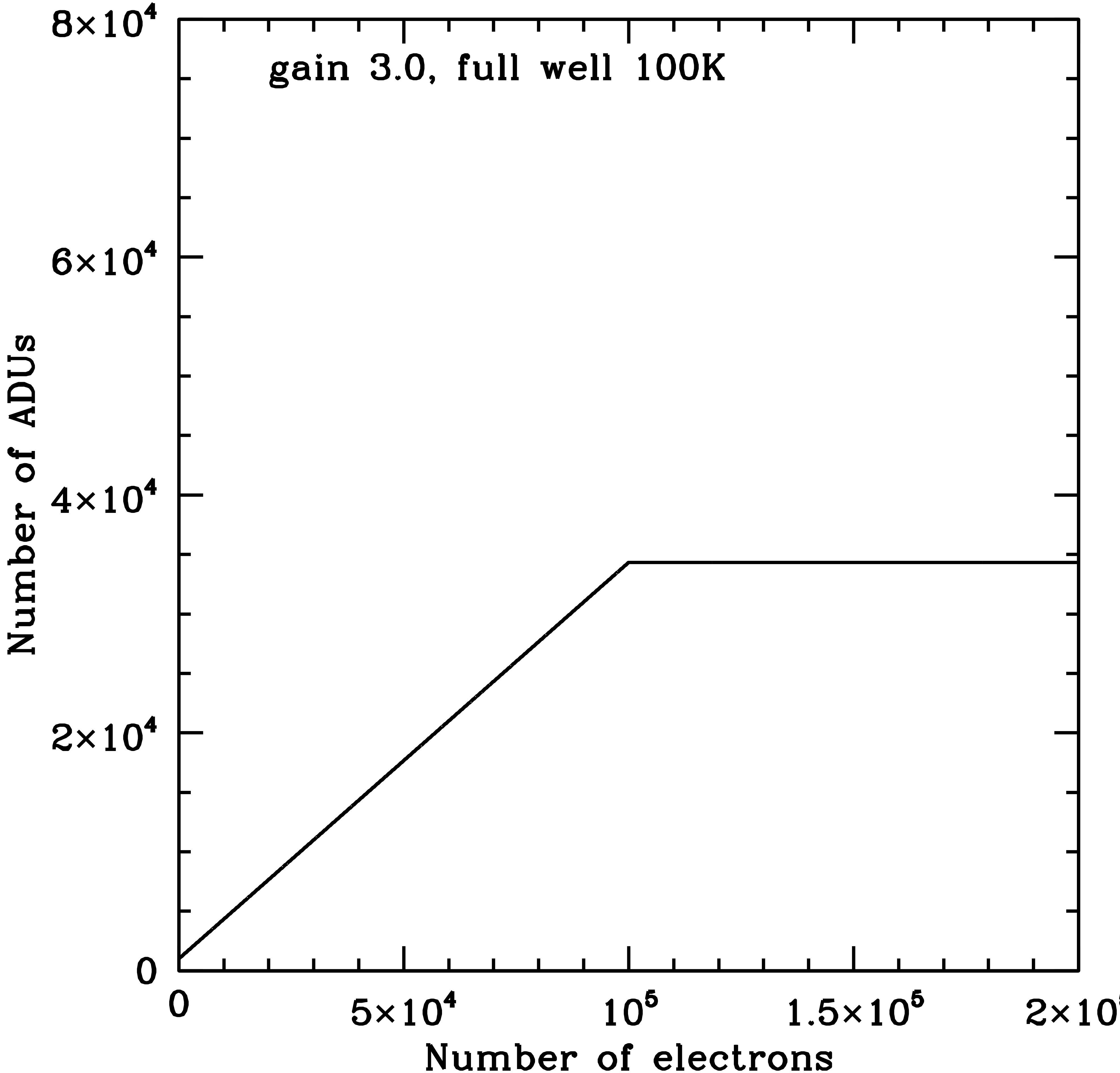
- Read-noise and gain
  - Most modern CCDs have <10e readnoise; 6e is typical.
  - Gain tells you the number of e/ADUs
- You should always measure this yourself for fun during your run.

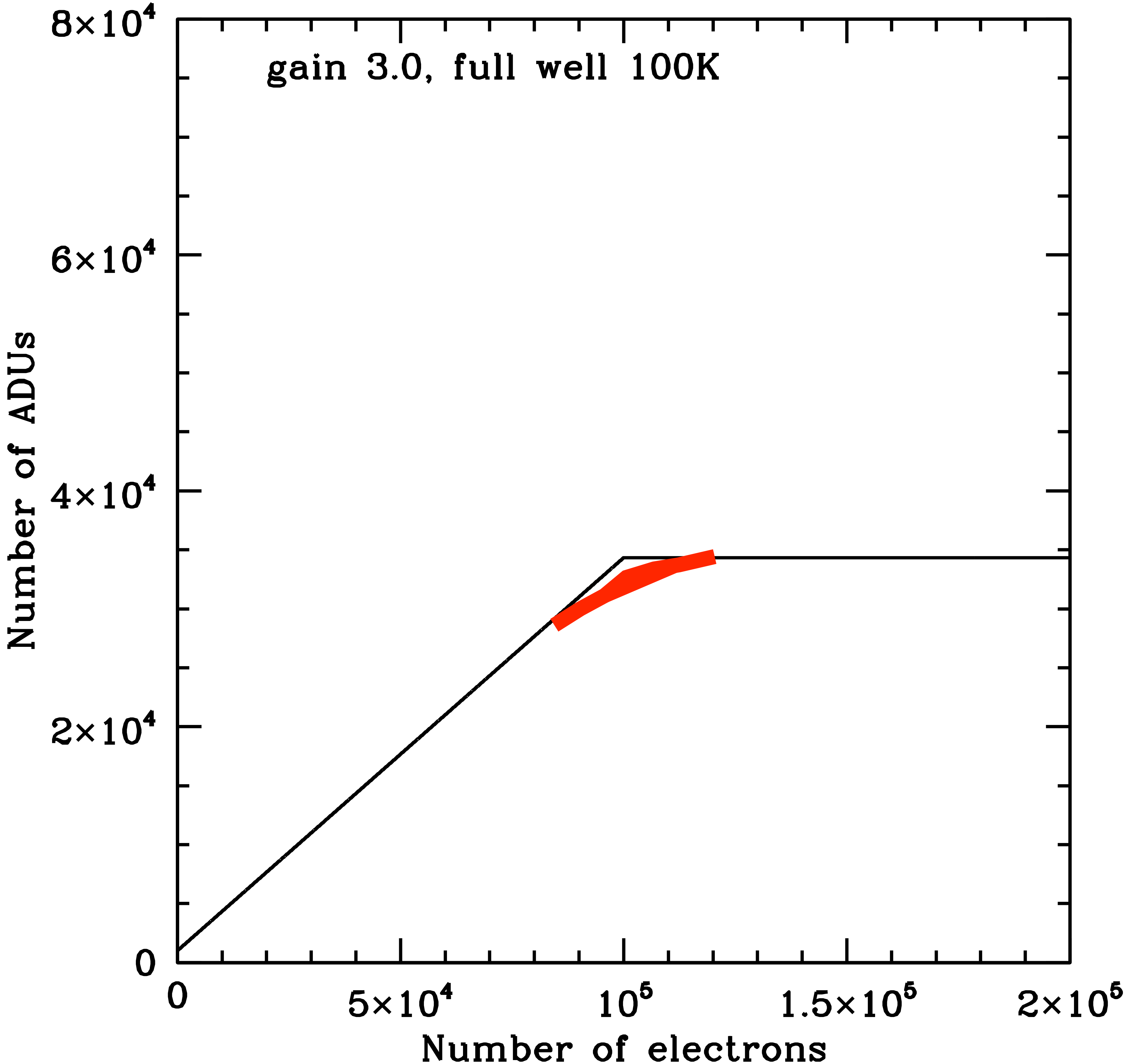
Full well and linearity range

- Where and why are you going to saturate?
  - Full-well capacity of CCD is typically 80,000-120,000e- (depending upon manufacturer and pixel size). Smaller pixel sizes usually mean full well is smaller.
  - If your gain is 1.0 e/ADU, you will "saturate" when your signal gets to 65,535.
  - If your gain is >=2 you will likely go non-linear a bit before you reach the full well.



gain 1.5, full well 100K
Number of ADUs
Number of electrons
0
2×10⁴
4×10⁴
6×10⁴
8×10⁴
0
5×10⁴
10⁵
1.5×10⁵
2×10⁵


gain 3.0, full well 100K
Number of ADUs
0
2×10^4
4×10^4
6×10^4
8×10^4
0
5×10^4
10^5
1.5×10^5
2×10^5
Number of electrons



gain 3.0, full well 100K
Number of ADUs
Number of electrons
0
2×10^4
4×10^4
6×10^4
8×10^4
0
5×10^4
10^5
1.5×10^5
2×10^5

Full well and linearity range

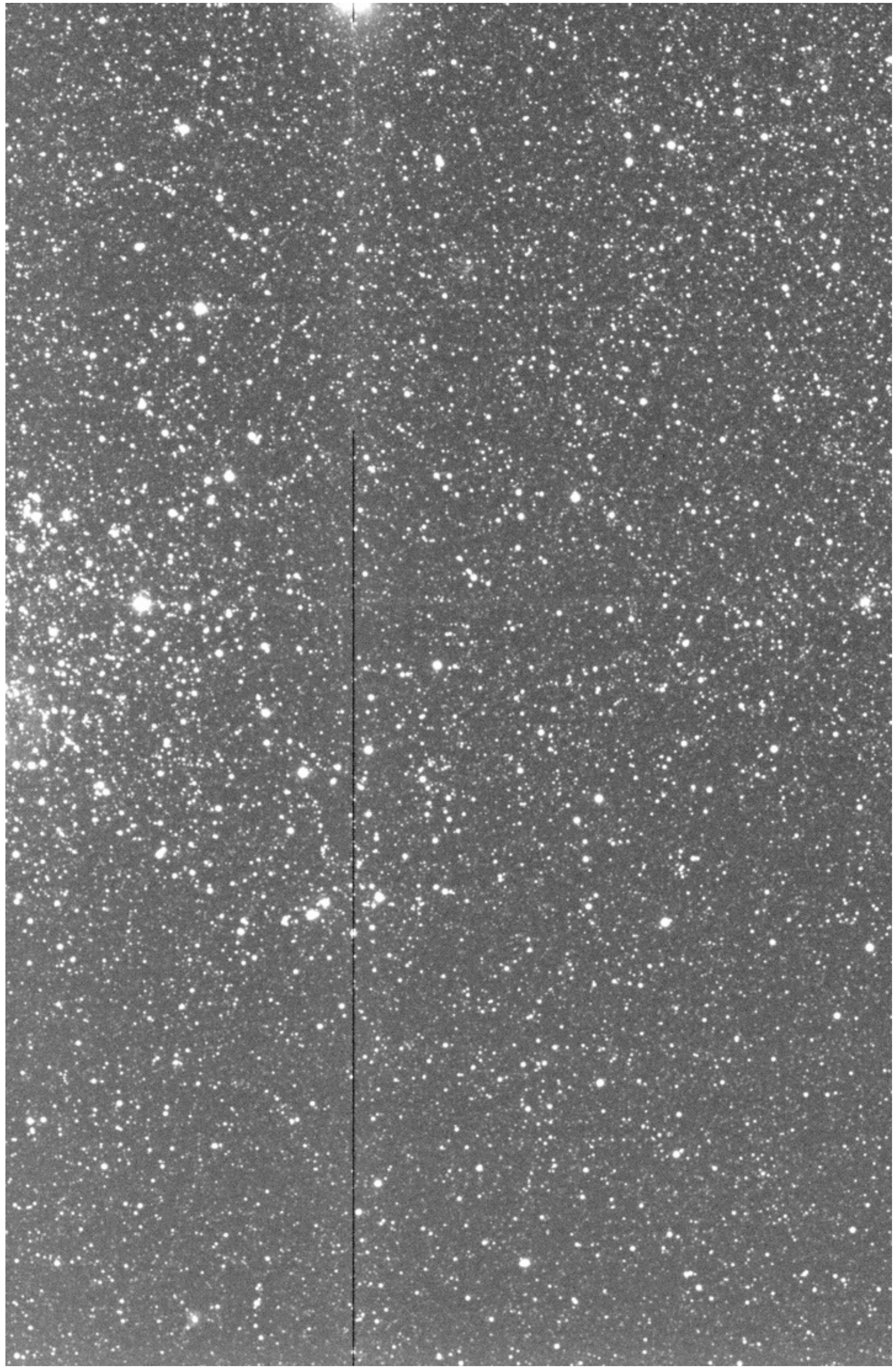
- This has all assumed that you are using a modern 16-bit A/D converter. There are still some 15-bit A/D converters around in which the largest number you can get out is 32,767.

Bias level

When a CCD is read out through a "bias voltage" is added to the amplifier output. Why? Simple! You're only going to get positive numbers. You don't want the read-noise to have any chance of taking you into negative territory. This is often overdone; i.e., bias level may be 1000 ADUs even though the read noise is only a few ADUs.

Cosmetics

- What are the cosmetics like? Are there bad columns, or non-linear areas?
  - Can measure this yourself using short vs long exposures.
  - Sometimes cosmetic issues (such as bad columns) are REALLY obvious.



DQE as a Function of Wavelength

- DQE=Detector Quantum Efficiency. If 10 photons fall on the CCD, how many get absorbed and how many of them bounce off?
- Depends a lot on what sort of anti-reflective (AR) coating has been applied!

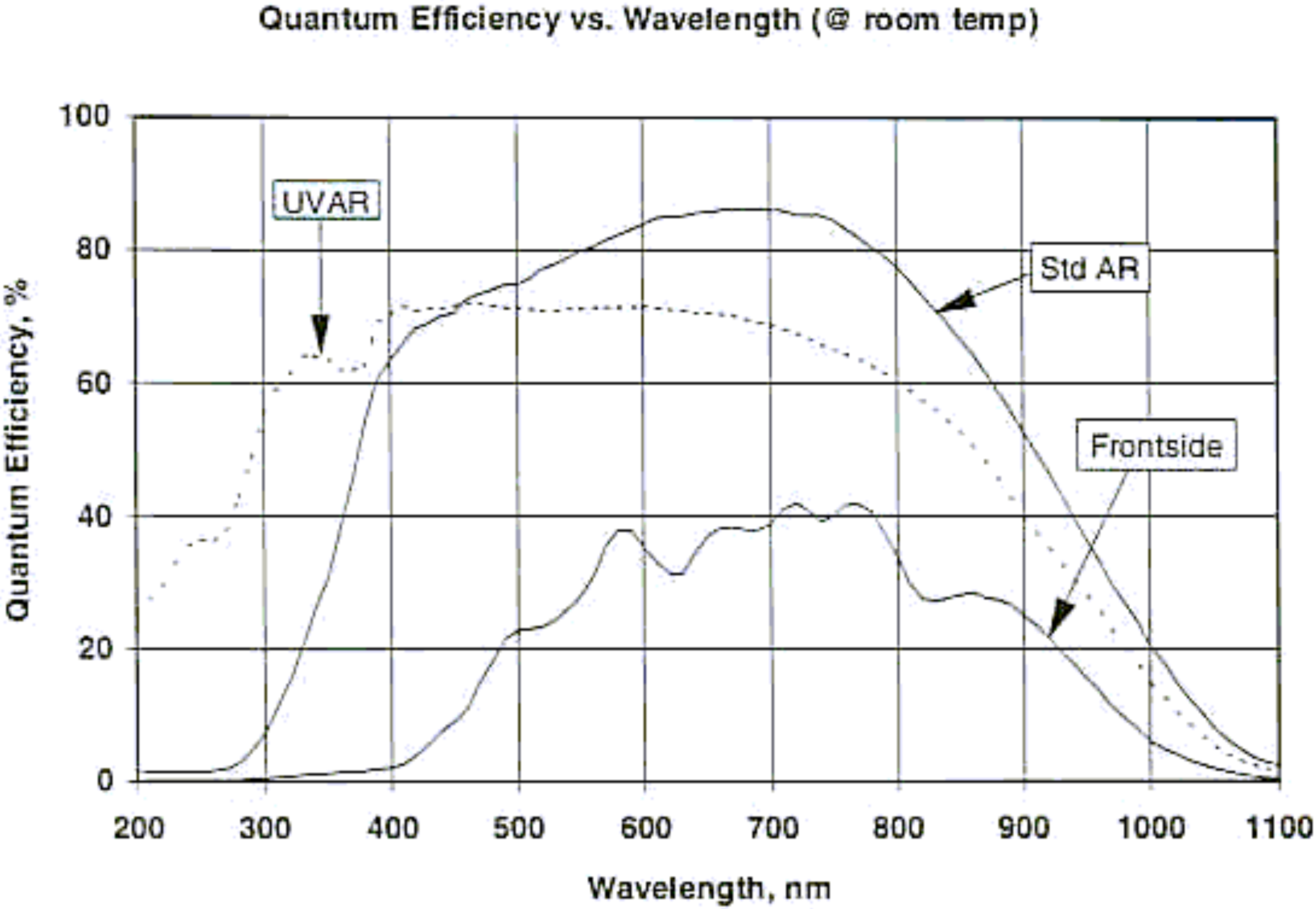


FIGURE 7 *Typical QE curves*

Read out time

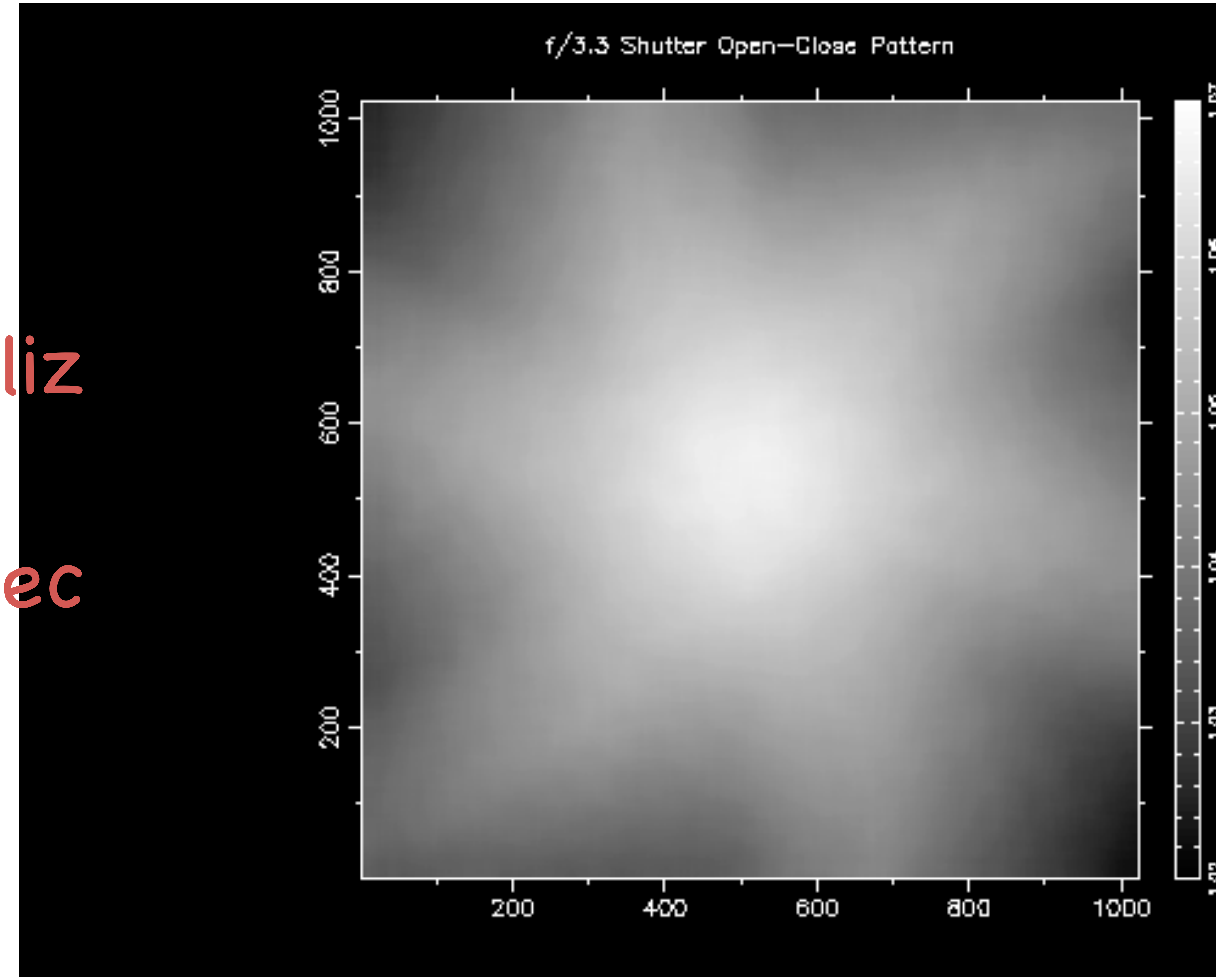
- What is the read-out time? This allows you to know whether your should bring a good book along with you, and/or how many twilight flats you will be able to get.

Minimum Exposure time for the Shutter

- How good is the shutter? Is it an iris shutter or a double-blade shutter? What is the shortest exposure you can make and still achieve <<1% uniformity?
- This is also very important for knowing what to do about twilight exposures.

Minimum Exposure time for the Shutter

Example: Uniblitz shutter
0.5 sec / 10 sec



Minimum Exposure time for the Shutter

- Open/close time of 30 millisecs. So, want exposure times of 5 seconds or more:
- $30 \times 10^{-3} / 5 = 0.6\%$

Pixel scale: should you bin?

- Pixel scale
  - For spectroscopy, will want to know dispersion and wavelength range, but same idea.
- Sometimes the pixel scale is silly for your application: for instance, the Perkins 72-inch PRISM has a scale of 0.4"/pixel. The seeing typically 2.0". So, FWHM is going to be 5 pixels.

Decisions, decisions…

- 1) To bin or not to bin? Is it nobler in the mind…
- Binning means taking 2 x 2 pixels (say) and making them one big fat pixel.
- Is the resolution worse? Or just the scale?

Pixel scale: should you bin?

- Advantages:
  - Shorter readout times (by about a factor of 3, not 4).
  - Deeper full wells! Sometimes this helps to have a very large dynamic range.
- Disadvantages:
  - Scale is down a factor of 2. Sometimes this matter, and sometimes it doesn't—resolution!
    - ★ Do you still satisfy the Nyquist sampling?

Choosing a gain

In some CCD cameras you get to specify the gain (basically set by how fast you're reading out the array; surprise!). Some considerations:

a) You want to sample the read-noise. If the read-noise is 30e-, it made sense to have a gain of 10. If the read-noise is 6, it makes sense to have a gain of 2-ish.

b) You want to map the full well of the chip (100,000 e-?) to the full range of the A/D converter (65,535-1000, say)--->1.5-ish.