1) Let’s try to put together many of the observational/Poisson issues that have been addressed recently in class, along with a dash of magnitudes. Suppose you use an 8.4-meter diameter telescope (one side of the LBT) to observe a star with magnitude $V = 21.0$ and further suppose the collected light falls on a single noiseless photon-counting detector with quantum efficiency equal to 0.5 at all wavelengths.

a) In a 60 second measurement how many photons are detected? You might want to know that a zero magnitude star produces $3.6 \times 10^{-8}$ erg/s/cm$^2$/nm at the V-band wavelength and that the V-band filter is 80 nm wide.

b) Assume no sky background. At what signal to noise ratio is the star detected in this 60 second observation?

c) Suppose that instead of a single detector the light of the star is falling on a CCD array with 20 um pixels. The telescope focal ratio is f/5. The seeing is 1.0” FWHM.

i) What is the angular size of an array pixel? You might as well quote the focal plane scale of the telescope in arcseconds/mm while you are at it.

ii) If the sky background is 21.0 mag/arcsec$^2$ in the V band will the sky emission degrade the quality of the detection compared with the photon counting detector? Said another way, how different is the signal-to-noise ratio in a 60 sec exposure compared with b) above. You will have to make a crude assumption about how many pixels are “under” the star star image. Just be explicit (and more or less accurate) about the number of pixels you choose to use. Assume the read noise is zero for this part.

iii) Now include a read noise of 6 electrons RMS for the same observation. Does the read noise degrade the signal-to-noise ratio in a 60 sec exposure or are the star and background so dominant that the SNR doesn’t change.

iv) If the seeing degrades to 2.0” FWHM how does the SNR improve or degrade?