



# **Photon Numbers & Rates for Tip/Tilt cameras**

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## Revisions

<i>REV</i>	<i>DATE</i>	<i>AUTHOR</i>	<i>COMMENTS</i>
0.1	2005/09/22	D Buscher	First draft

## Some photon numbers:

From Nathalie's plot (INT-402-MIS-0034, fig 2), then a 16th magnitude star will give about 10000 photons per second (depends a little on the dichroic being used), i.e. 20photons in a 2msec exposure. The light will be spread out over a region of approximately 1 arcsec FWHM, i.e. 5x5 pixels. Thus the photon rate is 0.8 photons/pixel/exposure. For true photon counting, it would be nicer to have fewer photons per pixel per exposure than this, which could be done either by making smaller pixels or by reading them more often. The former would compromise the NAS field of view; hence higher frame rates are desirable if possible.

A 0 magnitude star is  $2.5 \cdot 10^6$  times brighter, giving a photon rate of  $2 \cdot 10^6$  photons per pixel per exposure. No existing camera will allow this. Assuming a full well of 200,000 electrons, we can observe stars fainter than about magnitude 2.5. Probably ok. We can observe brighter stars by getting rid of photons, but this is hard to do without introducing an offset in the tilt due to e.g. the refraction through a filter etc.

## Photon Rates:

The Andor iXon camera quotes an un-amplified read noise of 62e rms at a 10MHz pixel rate. This means that when the photon rate goes above about 4000 e/pixel/exposure, it is worth switching off the multiplication, since the multiplication noise is then  $\sqrt{4000}$  electrons, i.e. slightly more than the read noise. This photon level corresponds to a magnitude of about 6.75, i.e. any star you can see with the naked eye will be better with the gain switched off.

The gain has to be turned **\*down\*** but not off at lower photon rates, because the amplifier has a full well of 800,000e and a max gain of 1000, i.e. 800 counts/pixel/exposure will overwhelm it at full gain. Therefore at least 3 gain settings will be needed: unity gain, mid gain (perhaps  $\sqrt{1000} \sim 30?$ ), and max gain=1000.