Detector Selection Document

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January 30, 2014

1. Goal

This document discusses four detector options for ARCTIC that fulfill the SRD and engineering requirements. The process included looking at both pre-packaged and bare detectors. It was determined out of the scope of this document to fully discuss the extra incurred cost of pre-packaged detectors on the design of the instrument.

Table 1:: CCD Statistics

CCD	E2V CCD231	STA4150	Fairchild CCD6161	Andor IKon 936
Pixel Size	15μm	15μm	15μm	13.5μm
Pixels	4096 x 4112	4096 x 4096	4096 x 4097	2048 x 2048
Imaging Area	61.4mm^2	61.4mm^2	61.44 x 61.455mm	27.6mm^2
Gain	2.6e-/ADU	NA	NA	NA
Dark Current	3e$^-$/pixel/hour	3e$^-$/pixel/hour	0.6e$^-$/pixel/hour	0.006e$^-$/pixel/hour
Readout Noise	2-5	3 - 6	10	2.9 7.0
Readout Rate	50KHz - 1MHz	100KHz -1MHz	Up to 1MHz	Up to 5MHz
Cost	$114,000	$55,000	NA	NA

2. Pre-Packaged systems

Two pre-packaged systems where investigated. The first was an Andor Technology camera. Their best option was the iKon series camera, specifically the 936 model. This is the largest detector model that Andor provides. The detector size for this camera is 27.6mm^2. With good readout speed, low noise, and a host of user selectable features this would be a good choice, with the exception of the CCD size.

The second pre-packaged system was from Spectral Instruments. The 1100S camera is customizable with several CCD options; the two investigated are the E2V CCD231-84 and the Fairchild CCD486. As of writing this Fairchild is not longer producing deep depletion devices. The closest analog to the CCD486 is the front illuminated CCD6161. They are both 61mm^2 devices with 15 micron pixels with good dark current and fast readout. They differ in the detector type. The E2V is back side illuminated, deep depletion while the Fairchild is a front side illuminated (although it does have better QE). The cost for the pre-packaged E2V option is $249K and with the Fairchild option it is $163K. These options are both very expensive and would require special adapters to fit ARCTIC.

3. Bare CCD Packages

The two bare ccd packages are both comparable on specs although packaged differently. The biggest differences between the two are the coatings, packaging, and thinning. These will most likely be the deciding factor. The two CCD choice are between E2V and STA. E2V is a global company with a good reputation while STA is smaller company with a great deal of history developing CCDs. STA manufactures their CCDs through DALSA with Mike Lesser at ITL performing the thinning and coatings.

Each CCD has very comparable statistics. They can both be readout between 100MHz and 1KHz with nearly the same read noise. The read noise for E2V is claimed to be less, but when connected to the Leach controller it is only slightly better than the STA chip. Both CCDs have the same imaging size, with the same pixel size, and similar readout architecture. One difference comes after the silicon. The E2V chip does not come with a built-in pre-amp board while STA includes the pre-amp as part of their packaging. They claim that this is to produce consistency in readout between chips, as well as control/minimize the read noise between systems. For the ARCTIC instrument having the pre-amp included makes design of the dewar much simpler.

The E2V chip would require using a Leach designed pre-amp board. This board is then sandwiched between a retainer and the cold plate. The design of this is not overly difficult but it can lead to bonding problems. If anything comes loose then the CCD can pull away from the cold plate and warm. This is unlikely but still a risk. The STA chip has the CCD and pre-amp bonded to the same packaging. A couple bolts are all that is necessary to couple the cold plate to the CCD package.

The other large differences, aside from the packaging, are the coatings of each CCD. E2V offers several coatings from a blue sensitive to a red sensitive option, see figure 1. The selection of coatings offered by STA seem more developed, figure 2. These coatings are designed more of astronomical research than generic industrial CCD usage. The two most likely choices for coating will be the broadband or multi coating options, figures 3 and 4, respectively. The red portions of the coatings are very similar but STA has significantly increased throughput blue-ward of 700nm. Figure 4 also shows a new theoretical coating currently under development at ITL. ITL has just finished coating a piece of bare silicon and is studying the 1-R properties to tune the coating. I expect that it will be better than the curve added to figure 4 since that line is simply based on conversation about the coatings instead of actual test data.

Fringing is the last big difference in chip qualities. E2V employees an anti-fringing technology to decrease the fringing below 2%. This is an additional $4K, included in the cost seen in table 1. STA on the other hand controls fringing through substrate thickness. They offer two thicknesses, 19μm and 30μm. The thicker silicon will decreasing fringing to less than 2%.

4. Recommendation

Several CCD choices have been presented but one shows properties that will increase the scientific effectiveness of this instrument. It is my recommendation to go with the STA4150 CCD with the new multi coating. This chip will produce low noise images while increasing the total throughput of the system. This chip is half the price of the E2V CCD due to minimized overhead at STA. The cost difference might instigate a conversation on whether to purchase a back-up chip. A partially functional engineering grade is on the order of $20K - $30K, while a low grade science CCD would be $43K. Although it seems like a good idea to purchase a back up chip I cannot recommend this option. During installation STA has offered to lend an engineering grade chip for a short time period. The only other purpose of a back-up chip would be if the main CCD was damaged sometime over the instrument lifetime. If this were to occur it would seem more practical to purchase a newer technology CCD rather than have something of lower grade that can be installed quickly to get the instrument back online. This may mean a down instrument for several months, but it seems that the benefit for the long term operation of the instrument would be greater.

The lead time on the STA chip is unknown due to the new coating. STA has as silicone run in a couple months with thinning and coating moving forward as per the ITL queue. The revised schedule for this instrument does not need to have CCD installed until the fall of 2014. Ordering the CCD within the next month would be prudent to secure it in time. I have already placed a holder for one chip to be manufactured this year but STA is awaiting our managements final decision to proceed further.

Fig. 1.—: E2V Coating Choices

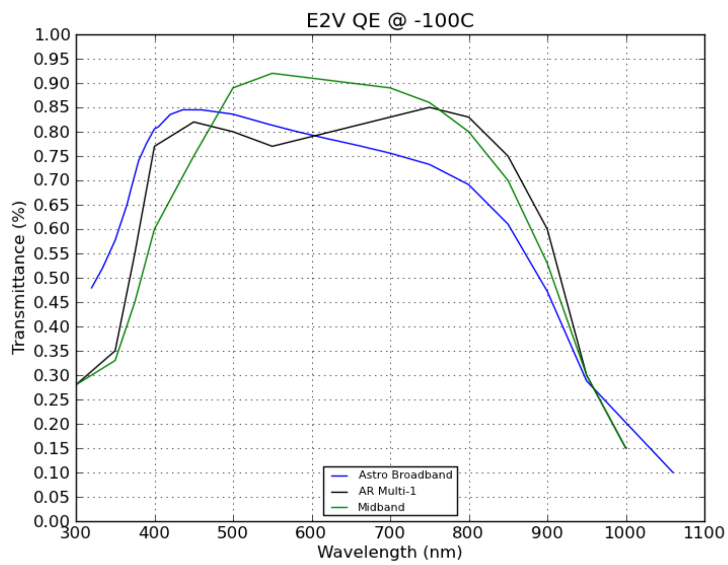

Fig. 2.—: STA Coating Choices

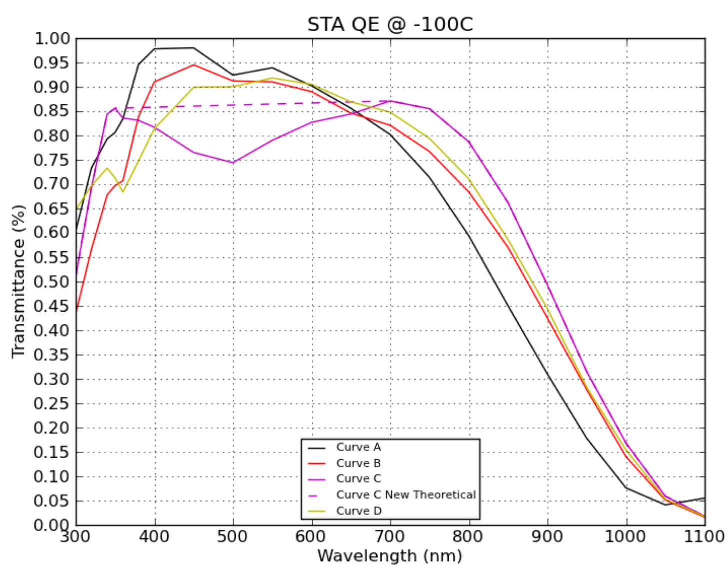

Fig. 3.—: Broadband Coating Comparison

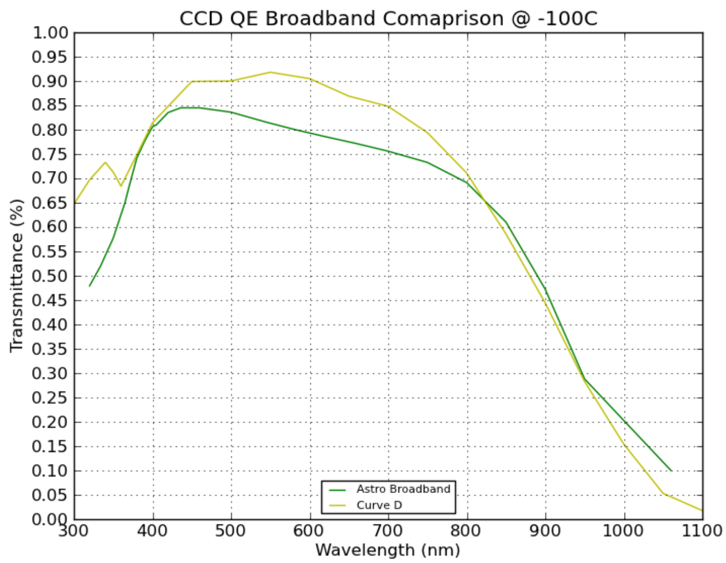

Fig. 4.—: Multi Coating Comparison