

## **KOSMOS System Design 3.01**

**Title:** Initial CCD Selection for KOSMOS  
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### **Introduction**

This document describes the initial “down-select” of the KOSMOS CCD detector, including selection criteria and a summary of the relevant information.

### **Selection Process and Criteria**

The optical re-design of OSMOS for use on the Mayall telescope requires specification of the detector pixel scale. Otherwise, the optical designed is forced to carry on parallel efforts for multiple potential detectors. This specification can be revisited once an initial optical design is produced, if that seems advisable.

Beyond that, the choice of detector vendor or specific detector need not be made at this point, although an overview of the options is presented below. Although, theoretically, there might be cost savings in standardizing on a single detector or vendor for all three CCD purchases funded through ReSTAR, in reality there appear to be no such savings. In addition, the project schedules are different enough that placement of a single order is difficult if not impossible. (Cost savings might be significant if CCDs were procured through a foundry run of some sort, but a foundry run could not be done on the schedules required for the Mosaic or Hydra upgrades.)

### **Pixel Scale**

The choice of pixel scale is dictated by several considerations:

- A physically larger pixel scale is somewhat easier to design a camera for, assuming a fixed pixel scale on the sky. For the desired pixel scale (0.36 arcsec), a 15-micron physical pixel requires an approximately  $f/3$  camera. This suggests pixel scales significantly less than 15 microns are undesirable.
- A physically larger pixel scale may not fit into a universal dewar if the array is 4k pixels in at least one dimension. The maximum size depends on the array packaging as well. We know we can accommodate a dimension for the array itself of ~60 mm; anything much larger than this will require a review of the dewar design. This implies considerable caution in selecting pixels >20 microns.
- A physically larger pixel has greater cross-section to cosmic rays.
- Ideally, the same or similar pixel scales should be available from more than one vendor. Selection of a pixel scale available from a single vendor essentially selects that vendor as well. This may be acceptable if the vendor has an excellent

track record for on-time and in-spec delivery, but it should be recognized as a potential source of risk

There are several vendors – E2V, Fairchild, STA, and LBNL who can provide 4k x 4k or 2k x 4k detector with 15-micron pixels. There is no other pixel size with the same variety of vendors. Furthermore, the only other pixel sizes available as commercial products are significantly smaller, which complicates the optical design and offer few advantages.

*We therefore choose a physical pixel size of 15 microns. This choice will be revisited if, and only if, the optical design study reveals significant problems with the choice.*

## **Vendor Selection**

There are several considerations associated with vendor choice. These are:

- Price. Given the overall cost of the project, and the need to buy only one detector, detector costs is not a primary driver. The commercial devices range from ~\$75K to ~\$130K; the LBNL device may be free but has costs associated with re-packaging and controller (Torrent) modifications.
- Schedule. Assuming the detector purchase is initiated soon after the design review in June, 2010, there is a period of about a year to deliver the detector without impacting the overall project schedule. The LBNL chip would be needed sooner to support Torrent development, but it might be possible to work with a device that has not been re-packaged for such work. It therefore appears that any of the vendors can meet our schedule.
- Performance. This is more complicated, and discussed further below. In essence, E2V, Fairchild, and STA produce roughly similar devices which can have their wavelength response “tuned” by appropriate coatings; the LBNL device is a thicker, red-sensitive CCD. E2V also makes a deep-depletion device. All the devices appear to be capable of producing low read noise with fairly quick read-out times. Fringing (and therefore spectrograph stability) is an issue in the red for all but the thick devices.
- Other issues. As noted, the LBNL device requires an additional development effort. The Fairchild CCDs have (some) history of failing when cooled too far.

### *Performance – Wavelength Response*

One key property is wavelength response. The table below presents a summary, where the data are taken from (a) E2V data sheets, (b) ESO measurements for a cold Fairchild device and (c) data provided by LBNL. The E2V deep-depletion data are similar to the standard device curves for the mid-band and (probably) 2-layer coatings, except in the red where response is better. Note that most of the numbers in the table below were taken from plots by eye, and should not be considered accurate to better than ~2% in QE or ~10 nm in wavelength. The data for the various E2V device/coating combinations illustrate how device thickness and coating affect wavelength response. All of the vendors (except LBNL) offer some variety of coatings.

**Table 1 – CCD Wavelength Response**

Device	85% QE Range	80% QE Range	50% QE Range	Peak QE
E2V, Std Astro Mid-Band	470-680 nm	460-730 nm	380-840 nm	92%
E2V, DD Astro Mid-Band	470-750 nm	460-800 nm	380-910 nm	92%
E2V, Astro 2-Layer	none	420-500 nm & 650-825 nm	360-920 nm	83%
E2V, DD Astro BB	none	400-580 nm	330-880 nm	85%
E2V, DD Astro ER1	570-810 nm	540-840 nm	420-920 nm	92%
Fairchild (blue)	400-680 nm	390-710 nm	330-840 nm	91%
LBNL	550-960 nm	500-970 nm	380-1010 nm	95%

The Fairchild devices tend to have better blue response and poor red responses (70% QE around 760 nm), while the LBNL devices have excellent response in the far-red but fall off in the blue (70% QE point about 450 nm). This suggests that neither device is the best choice for the primary detector, especially since the Fairchild devices fringe badly in the red.

*Selection Options*

The best option for a single detector would seem to be an E2V deep-depletion device, probably with the mid-band coating (or something similar biased a bit more to the blue). The alternative would be to go with a more blue-sensitive detector (possibly Fairchild) as the commissioning device and then implement the LBNL device later on.

Fortunately, this decision need not be made final until the design review. The time up until the design review should be used to:

- Get a clearer understanding of the device properties, including compilation of information from STA.
- Understanding whether resources exist to implement two detectors on a realistic time scale, or just one. The second detector would be commissioned after the instrument plus first detector, but within 6-12 months.
- Verifying whether all the detectors under consideration can fit in a universal dewar, as well as verifying that the optical design does not require modification of the universal dewar.

As a place-holder, the most expensive option (4k x 4k E2V device, \$115K) should be retained. This should be revisited as the optical design progresses.

**Versions**

<b>Version</b>	<b>Date</b>	<b>Changes</b>
1	Dec. 22, 2009	First draft
2	April 7, 2010	Released, no changes from version 1