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The Large Binocular Camera of LBT
The focal plane detectors

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1. Introduction

We describe the characteristics of the array of the Large Binocular Camera, that will equip the prime focus of the LBT telescope [Ragazzoni *et al.*, 2000]. Two different cameras are planned for the LBT primary foci. Apart from the wavelength coverage (one optimized for the "UV-blue" range and the other for the "red" one), they are very similar from the opto-mechanical point of view.

Three types MAT (*Marconi Applied Technologies*, ex EEV) of detectors have been chosen to allow both the scientific data acquisition and the control of the intrument: an array of four MAT 42-90 (4.6K?2.5K) chips cover the corrected field (? = 27 *arcmin*) with a sampling of 0.23 arcsec/pixel providing the scientific image, while two MAT 42-10 will be used to acquire short exposure images for tracking and wavefront control.

We are still evaluating the possibility to place another small chip, like the MAT06-02, for a real time low order aberration corrections.

2. The detectors placement

The four scientific MAT 42-90 chips are mounted on an invar plate as shown in fig. 1. This plate has been directly machined by MAT with the holes for the electrical connectors and for the orientation register needed to align the detectors.

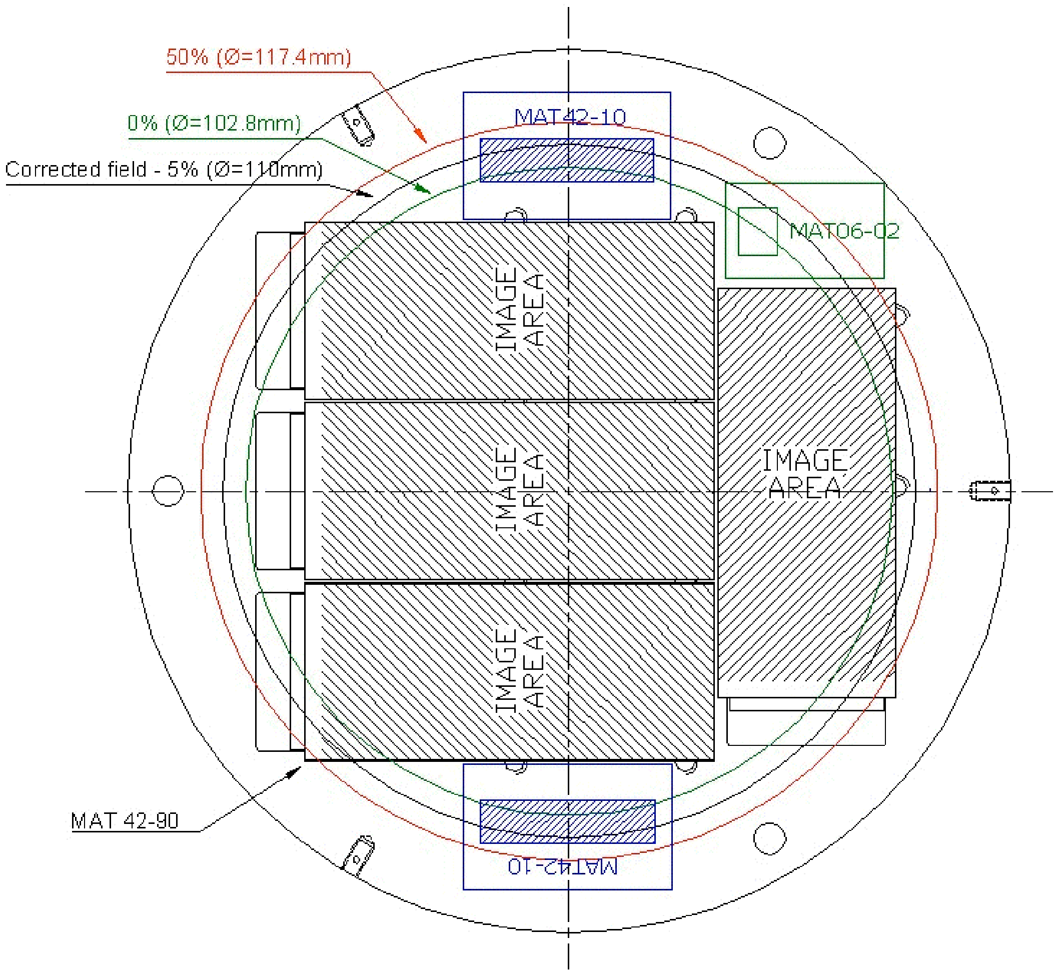

Fig. 1: *The array arrangement at the focal plane. The size of corrected field and vignetting areas for the BLUE channel are also reported.*

The corrected fields have a diameter of 110*mm* and 108.2*mm* for the blue and red channel respectively and the four MAT42-90 chips cover about the 75% of these useful areas. As shown in figure 1 there is a 5% of energy loss, in the blue channel at the edge of the corrected field, while in the red channel this percentage of vignetting is well outside from the corrected area.

The two MAT 42-10 chips will be placed at the two sides of the scientific array, mostly inside the corrected field to, and we are also investigating the opportunity to use also the small area near the fourth chip for installing a small MAT 06-02 chip for on-line wavefront analysis.

3. The MAT 42-90 detector

These cryogenic three side buttable sensors (fig. 2) are widely used in astronomy for the construction of large mosaics [Baulade *et al.*, 2000 - McLeod *et al.*, 1998]. They actually represent the "state of the art" of the MAT technology being characterized by a very low readout noise (?5e$^-$ at 1MHz readout speed) and a high quantum efficiency up to about 90%.

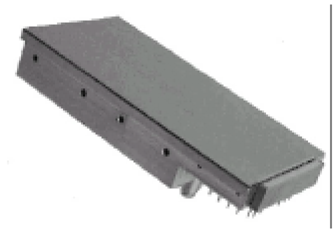

Fig. 2 : *The EEV 42-90 chip.*

Two sets of four 42-90 grade-1 detectors were ordered following these requirements:

- ? QE > 85% at peak
- ? Charge Transfer Efficiency > 99.999%
- ? Read Out Noise < 5 electrons at 1MHz
- ? Dead Pixels < 1350
- ? Column Defects < 6
- ? Surface roughness < 7 ?m peak to valley

The last requirement (see fig. 4) is imposed by the very fast focal ratio of the camera ($F_{\#}$=1.41) and is needed to keep the nominal optical quality (80% of the energy in one pixel) of the image all over the focal plane.

We have received all the eight 42-90 chips for both channels. The electrical and mechanical samples have been used to make the preliminary tests and set up of the blue channel camera. In the table 1 and figure 3, the QEs of the chips we have received are listed and plotted.

CCD sn	350 nm	400 nm	500 nm	650 nm	900 nm	1000 nm
Blue channel array						
8341-16-3	53.8	81.3	85.4	78.8	28.3	-
8351-18-4	56.1	83.7	88.2	80.1	27.3	-
9283-4-5	53.8	81.1	83.8	76.8	27.4	-
9283-1-4	56.3	77.7	80.5	75.0	28.3	-
Red channel array						
9434-17-3	-	-	95.1	96.7	57.0	13.2
9434-16-5	-	-	82.8	90.2	53.2	11.8
9434-15-3	-	-	84.3	90.6	51.5	11.2
9434-15-4	-	-	87.4	95.7	54.4	12.2

Tab. 1: *Quantum Efficiency of the scientific sensors.*

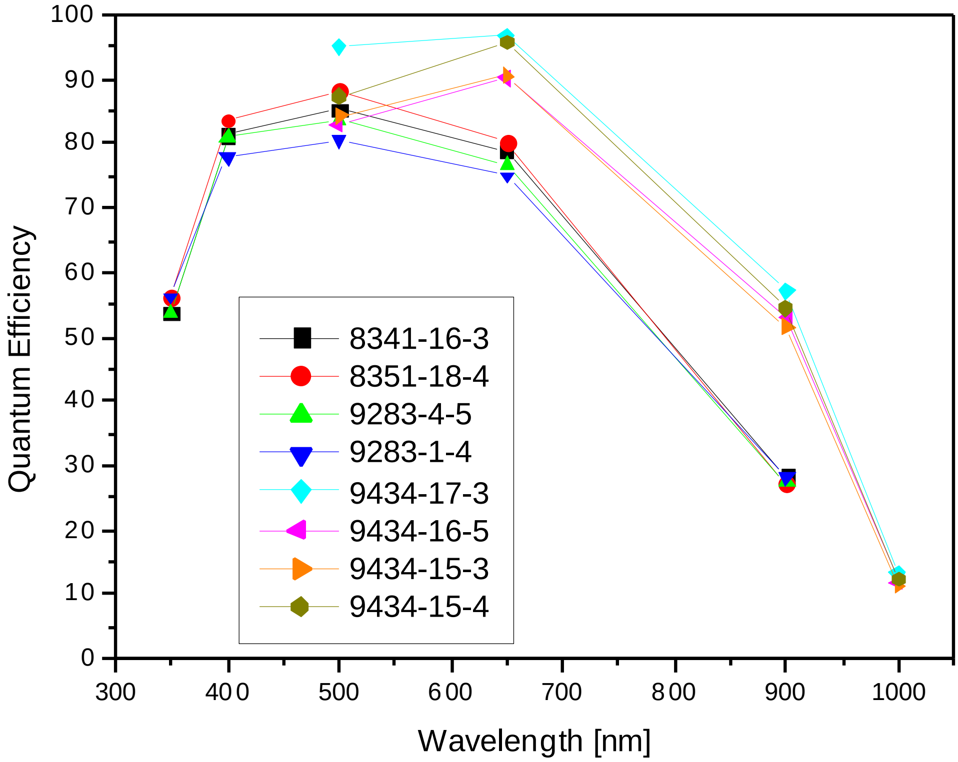

Fig. 3: *Plot of the Quantum Efficiency of our scientific 42-90 detectors.*

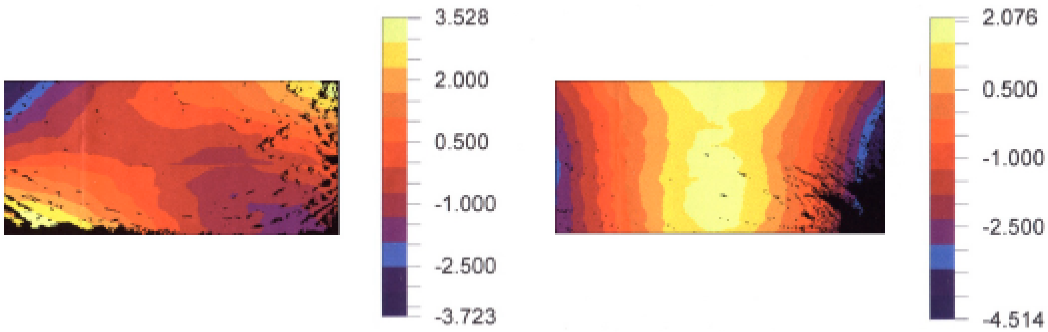

Fig. 4: *The surface of two scientific detectors (9434-17-03, 9434-16-5); units are in ? m.*

The four detectors of the array are cooled down to 170*K* by using a LN_2 cryostat [Speziali *et al.*, 2002] to reach a low dark current of <1.5 e^-/*min* (according to the data sheets of the 42-90 chips). Even increasing the operative temperature by 5*K* (fig. 5) the dark value increases to 5 e^-/*min* still well below the expected photon noise of a scientific exposure. In the best cases the dark signal can be one order of magnitude lower. Therefore, due to the good thermal stability of +/- 2*K* of the cryostat itself, we do not expect to use an active temperature stabilization.

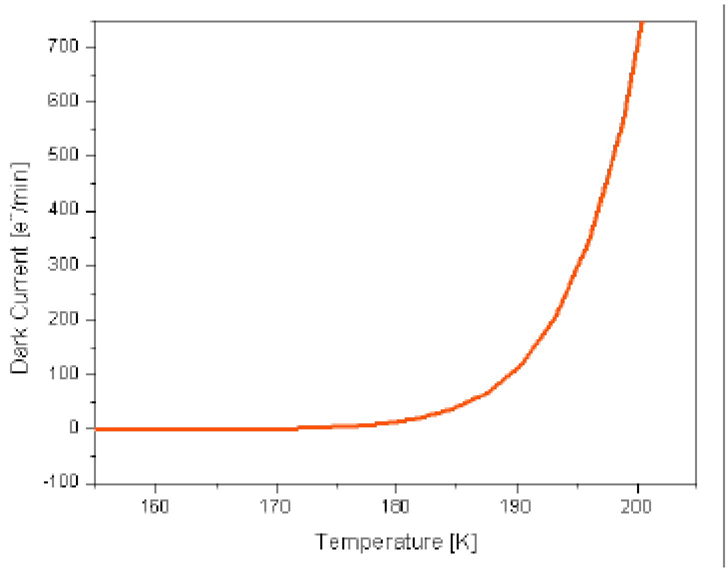

Fig. 5: *The estimated dark current vs temperature of the 42-90 chip.*

4. The MAT 42-10 chips

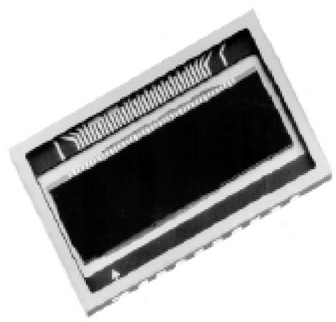

Fig. 6: *The MAT 42-10 chip.*

This chip is a frame transfer CCDs. and will be will be used for guiding, realtime focusing and high order wavefront analisys. The refresh time of this system will be about 1Hz.

We performed a simulation of the images given by the 42-10 chips to evaluate the sampling time needed to track a field star. Conservatively, we considered 1 *arcsec* of seeing, and we requested a centroid determination accuracy better than 0.02 *arcsec*. Because of the position of the trackers on the same focal plane of the science array, the attenuations and bandwidths of the science filters have been considered. Taking into account the broadband typical response of the QE (see fig. 7), we ran the simulation using stars in with a magnitude range from 15 to 20 and the results are shown in Table 2:

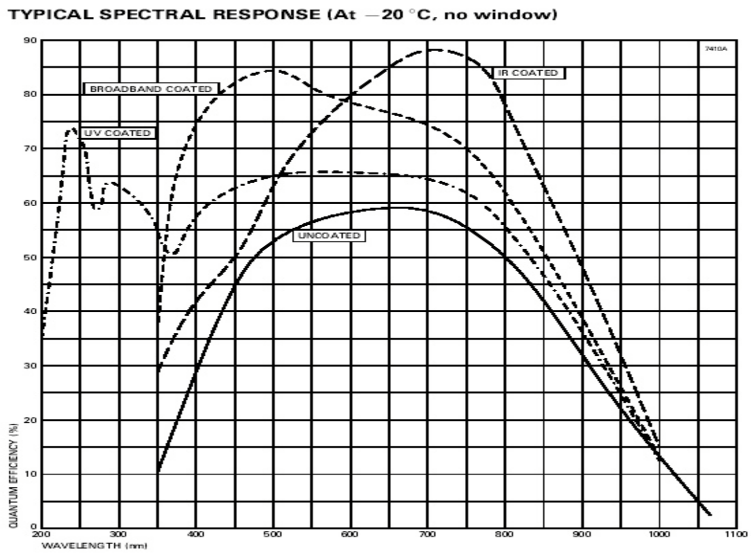

Fig. 7: *The Quantum Efficiency of the MAT 42-10.*

Mag	*Texp[s]*	*Ns/deg²*	*Det. stars*
$M_V = 18$	1	*709*	>1
$M_V = 19$	1	*1100*	>2
$M_V = 20$	2	*1640*	>3
$M_B = 18$	1	*458*	? 0.5
$M_B = 19$	1	*724*	>1
$M_B = 20$	2	*1090*	>2

Tab. 2: *The expected exposure times of MAT42-10 for different magnitudes in V and B bands. In the third column are reported the star counts/deg^2 from the Bahcall model at the North galactic pole. The last column reports the number of stars detected using two chips MAT 42-10.*

The total sky coverage of the 2 trackers is about 4.5 squared *arcmin.* Therefore combining the chip performance, the area and the number of star in one squared degree following the Bahcall model, we expect to find at least one reference star with $M_V = 19$ or $M_B = 20$ at high galactic latitude. In the latter (and worst) case the refresh time of the tracking loop will be around 2 seconds.

In the U band, due to the lack of bright star, we may consider to slightly offset (<15°) the pointing by modifying the paraxial angle when a fast tracking loop using a bright (Mag.U <18) star will be needed.

5. The Wavefront analisys

Two modality of wavefront analisys are planned for the LBC to best exploit the funcionalities of the active primary mirror of LBT.

We are planning to make a real time wavefront analisys acquiring a defocused PSF at the edge of the field by means of a CCD MAT 02-06 (380 x 280 pixels) installed about 0.2 - 0.3 *mm* below the optical focal plane. We espect with this mall chip to detect always, with an integration time less than 20-30 sec, a defocused star bright enough to be recorded with a good S/N for the computation of the low order aberrations (tip-tilt, defocus, coma, astigmatism).

An *off line* analisys will be performed using a peculiar beam splitter (fig. 8) applied to the edge of the MAT 42-10 trackers. In this case when a star is centered on its face, two images of the source are produced on the CCD giving an extrafocal and an intrafocal PSF of the same star. Both PSF will cover several pixels yielding the opportunity to extract the high order aberrations for a primary mirror fine tuning. The expected loop time is about 10 sec. with a 15 or 16 Mag. star.

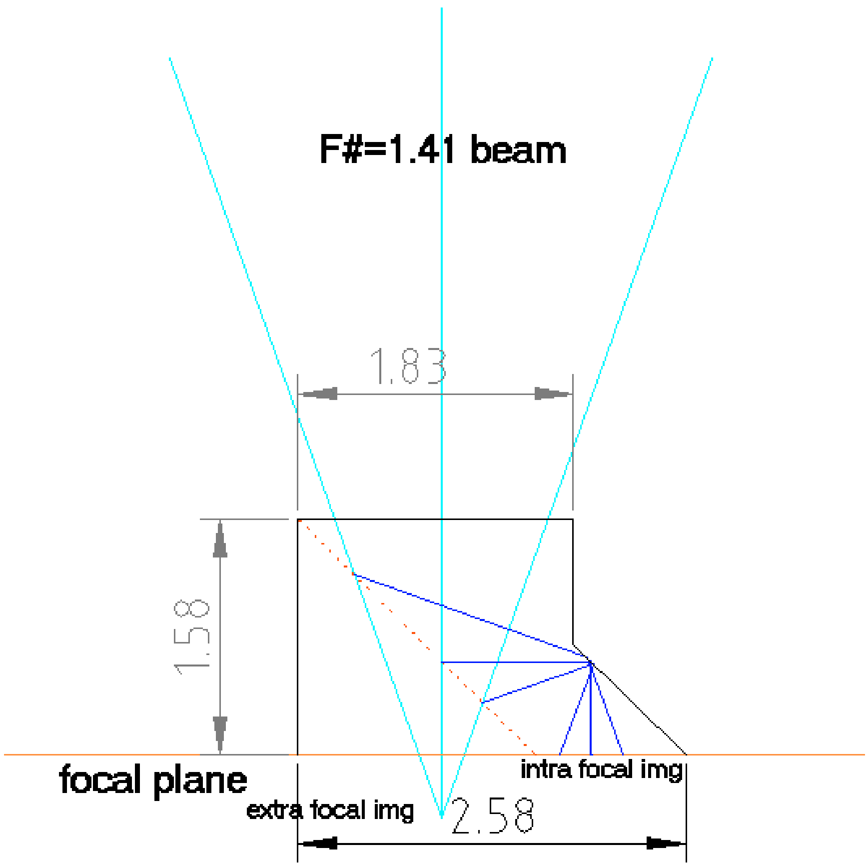

Fig. 8: *The beam splitter for the high orders WF analisys*

6. References

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