The MOONS red sensitive optical detector, illuminated by an F 0.95 optics

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ABSTRACT

The MOONS instrument [1] features spectrographs with simultaneous wavelength coverage between 0.64 and 1.8 µm.
To achieve the **highest sensitivity** in the red wavelength range of **0.64 to 0.95 µm, optical LBNL fully depleted CCDs** will be used to complement the infrared detectors.
This paper describes critical points **in the implementation of those detectors**, which feature the following key parameters:

a.) format of 4k x 4k pixels with 15 µm pixelsize;
b.) illuminated by an F 0.95 camera optics;
c.) flat to less than 10 µm (peak to valley);
d.) operate at around 133 K to minimize radiation;
e.) RON of about 2e-;
f.) optimized PSF properties such that charge diffusion is minimized
g.) minimized side effects with respect to conventional detectors
h.) integrated into a Schmidt camera design

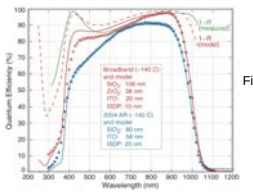
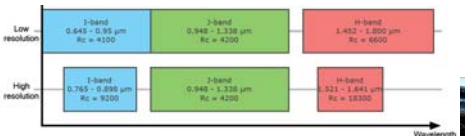


Figure 1: QE response of the LBNL detectors [2]

A. THE MOONS SPECTROGRAPH AT THE VLT

(3rd Gen. Instrumentation)



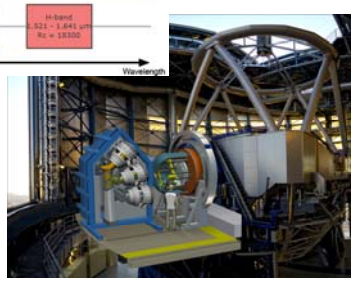


Figure 2:
(Top) MOONS features simultaneous spectroscopy in low/medium and high resolution in the sketched wavelength bands with optical CCDs up to 950 nm. Infrared detectors serve the upper bands [4].
(Right) Artistic Impression of the MOONS instrument on the VLT [3]

A1. MOONS Optical Layout

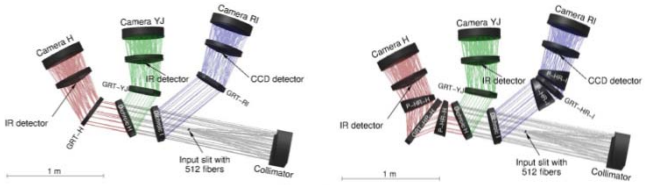
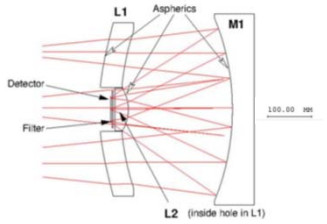


Figure 3: Medium-resolution spectrograph [5] High-resolution spectrograph

A2. Schmidt Camera & integrated detector



A3. Example Spectrum

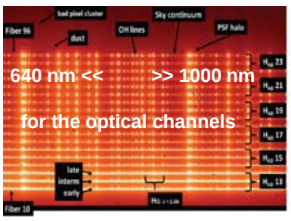
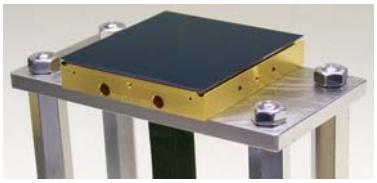


Figure 4: (Left) Schmidt Camera with detector integrated into optics [5] & Incidence Angle on CCD; (Right) Simulation of a MOONS spectrum on the detector, spectra are dispersed in horizontal direction (three CCD lines per fibre signal with five lines gap to the next). [6]

B. Optical 4k x 4k Detectors of LBNL:



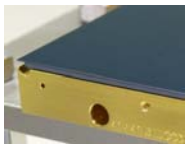


Figure 5: (Left) LBNL 4k x 4k CCD [2] Close-up of bond-wire section

? Any feedback on the side effects especially for spectroscopy ?
? Which side-effects of fully depleted CCDs have I overlooked for spectroscopy ?
? Which ones would you like to eliminate for spectroscopy from a user point of view ?
? Which ones do not matter for spectroscopy, or can be easily calibrated out ?
Please contact: oiwert@eso.org

C. MOONS Detector Unit inside the Schmidt Camera

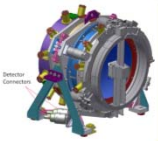


Figure 6: Camera unit and Detector Unit (rear view)

Figure 7: Detector Unit on spider

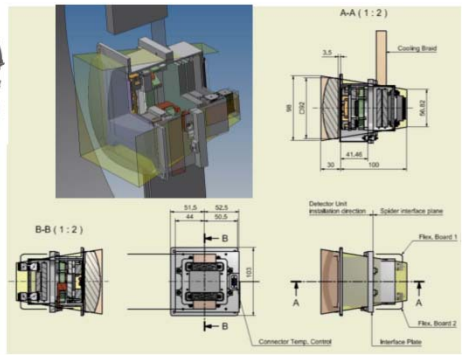


Figure 8: The Detector unit in 3D view and sectional views, featuring a cryogenic preamplifier

D. SIDE-EFFECTS OF FULLY DEPLETED CCDs & Conclusions / Questions for the application in MOONS (Spectroscopy)

D1. Absorption depth / Optimum thickness of MOONS detector

The requirement for highest QE at 950 nm implies the use of a detector with 250 µm thickness and full depletion with backside bias voltage.

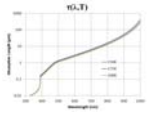
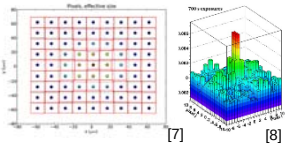


Figure 9: Absorption Depth of Si

D2. Brighter fatter effect / effective change in pixelsize and PSF

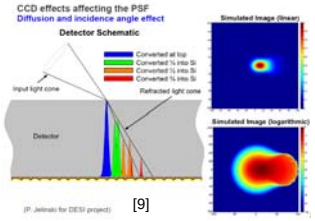


[7] [8]

How important is this effect in spectroscopy versus direct imaging ?
Would a subtraction of calibration data in spectroscopy lead to similar problems ?
Correction for spectroscopy ?

Figure 10: Brighter fatter effect: Effective Pixelgrid / Correlation

D3. Light incidence angle, wavelength dependent conversion depth, collection and wavelength dependent focussing



[9]

Difference for PSF between imaging and spectroscopy:
What is the practical experience as function of wavelength ?
Is the detector always 'telling' us the optimum focusing itself ?
Calculation with high accuracy ?
Can the wavelength range of a spectrograph be covered with identical focus ?

Figure 11: Incidence Angle and wavelength dependent collection

D4. Edge glow & roll-off / Useful area

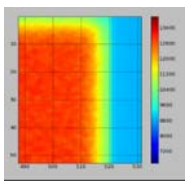


Figure 12: Edge roll-off [10]

The edge effects are tolerable for MOONS, if the useful area is limited to a slightly smaller detector format than physically available.

D5. Tree-ring effect

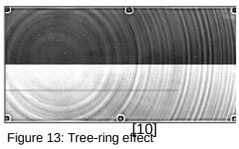


Figure 13: Tree-ring effect [10]

This effect is stationary and removable through flat-fielding, therefore should not matter much for spectroscopy. Comments ?

References:

[1] http://www.roe.ac.uk/~ciras/MOONS/VLT-MOONS.html
[2] LBNL data
[3] Credit STFC
[4] M. Cirasuolo et al.: "MOONS: the Multi-Object Optical and Near-infrared Spectrograph for the VLT", SPIE Vol. 9147, 2014
[5] E. Oliva et al.: FDR MOONS Optical Design Report
[6] G. Li Causi et al.: "Virtual MOONS, a focal plane simulator for the MOONS thousand –fiber NIR spectrograph", SPIE Vol. 9147, 2014
[7] P. Astier et al.: "The brighter fatter effect and pixel correlations", BNL Workshop Nov. 2013
[8] A. Rasmussen: "LSST Sensors: How will dark energy be constrained with lensed photo-conversions ?", BNL Workshop Nov. 2013
[9] J. Guy, "Spectral extraction of BOSS fully depleted CCD data", BNL Workshop Nov. 2013
[10] P. O'Connor, "Spot Scan Probe of Edge and Midline Effects in Fully-Depleted CCDs", BNL Workshop Nov. 2013

ACKNOWLEDGMENTS

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