# Slicing the Universe

## CCDs for MUSE

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*MUSE, the Multi Unit Spectral Explorer, is a 2nd generation instrument for the VLT. It is built by a consortium of European institutes and ESO. MUSE consists of 24 Integral Field Units each equipped with its own cryogenically cooled CCD head. The detector size is 4096x4096 with 15 µm pixels.*
*In this paper we discuss the requirements for the CCDs and give an overview of the design status of the detector system. Because of the large number of units the complexity of each unit has to be reduced to save cost and man power and increase reliability. We present a novel preamplifier to be used inside the very compact detector head with pulse tube cooling and show how ESO's New General detector Controller (NGC) is adapted to this application.*

## 1. Overview

MUSE is an integral field spectrometer mounted at the Nasmyth focus of one of the VLT telescopes. The Fore Optics (FO) splits a large field of view into 24 sub-fields. 24 Integral Field Units (IFU) provide the spectral decomposition of the sub fields. The IFUs include an Image Slicer Subsystem (ISS), Spectrometer Subsystem (SPS) and an Instrument Detector Subsystem (IDS). The spectral coverage of MUSE is 465 to 930 nm.

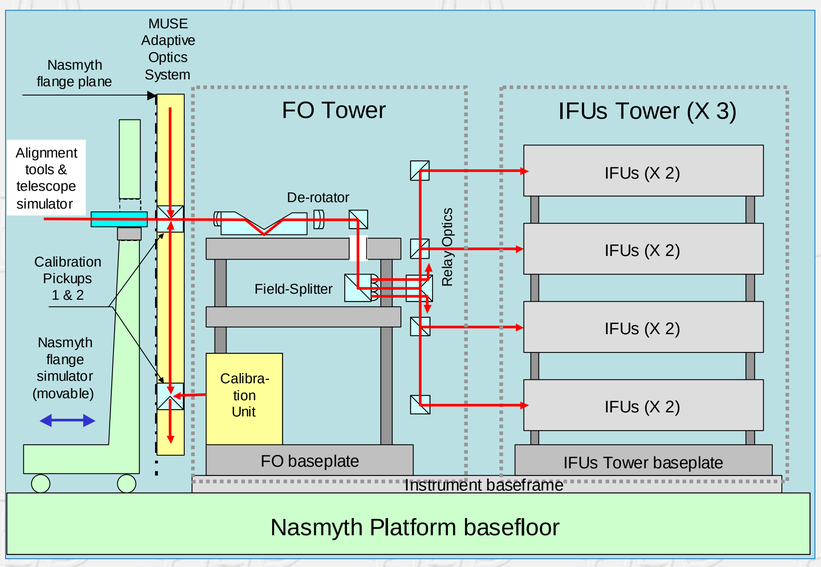


**Figure 1:** MUSE Optical Configuration

## 2. Cryogenics

The 24 detectors are housed in 24 separate cryostats which are cooled using separate low frequency Pulse Tube Heads (PTH). The 24 PTHs are powered using two Coolpack 6000 compressors from Leybold. The design is driven by the tight space and weight constraints of MUSE. Figure 2 shows a prototype of the new compact CCD head, which will also be the standard head for future ESO instruments.

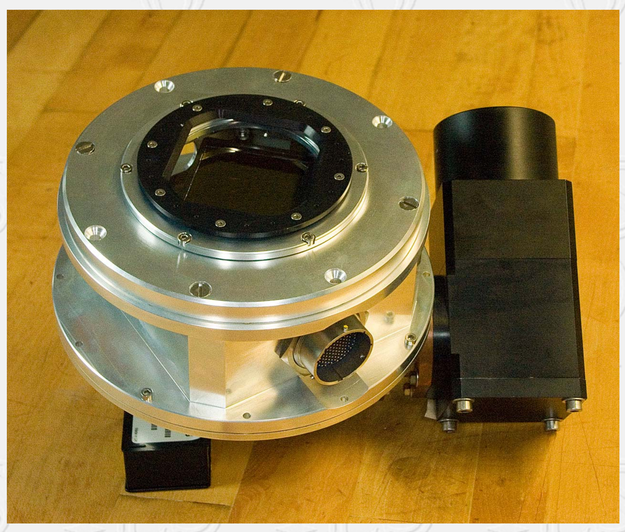

**Figure 2:** CCD head prototype

## 3. CCD Head Electronics

The first buffer stage for the CCD outputs is a cascode stage with two low noise JFETS Q1 and Q2 (Figure 2). The advantage of this circuit is a gain two times higher compared to a single buffer. As a benefit the circuit delivers a true differential output signal. L1 is a common mode choke to improve noise immunity (Figure 3).

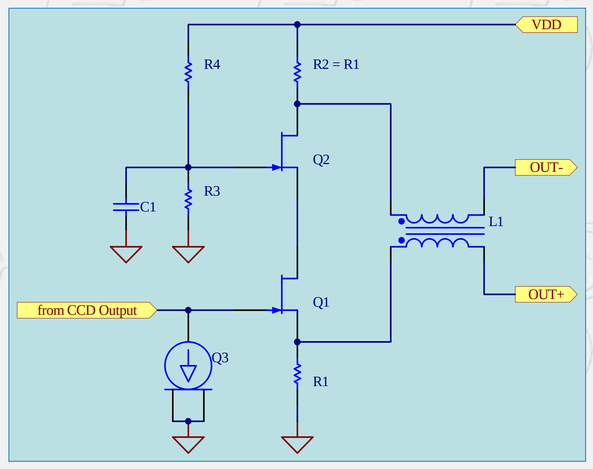


**Figure 3:** Cascode CCD Buffer Stage

## 4. Detector Controller

ESO's New General detector Controller (NGC) will be used for MUSE. NGC has been selected because of it's compact size and low power consumption. Each of the 24 CCDs is driven by a single board containing 4 video channels, 20 bias and 16 clock sources. One controller unit will contain 4 such boards (Figure 4). In total 6 NGCs are required.

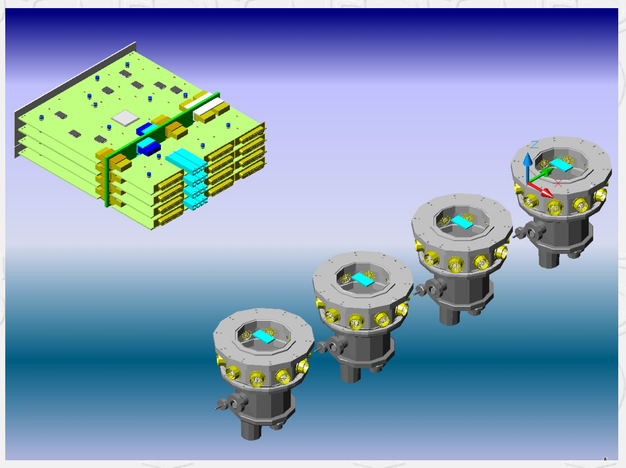

**Figure 4:** NGC configuration

## 5. CCD Requirements

Table 1 below shows the preliminary requirements for the most important CCD characteristics. Given the faintness of the science targets, the detector QE is of prime importance. Special attention is given to the redder ($\lambda$ > 0.6 µm) part of the spectral range where the QE should be optimized.

Constraints on the chip flatness are due to the camera aperture (f/1.9) and expected image quality.

**Table 1:** Preliminary detector requirements

| Item | Value | Remarks |
|---|---|---|
| Detector format | 4096 x 4096 or 2x 2048 x 4096 | |
| Detector dimensions | 61.4 x 61.4 mm$^2$ | |
| Pixel size | 15 x 15 µm$^2$ | |
| QE 465 – 570 nm | 85% min; 90% goal | |
| QE 610 – 800 nm | 85% min; 90% goal | |
| QE 800 – 930 nm | 60% min; 70% goal | |
| PRNU | < 10% | Peak-to-peak |
| Fringing | < 10 % | Peak-to-peak of avg. sensitivity |
| Fringe stability | < 1% | Within 24 hours |
| Flat field stability | < 1% | Per night |
| Readout time | Goal:1 min; max: 3 min | 4-port readout |
| Readout noise | < 4 e- RMS | @ 50 kpix/sec |
| Binning capability | 4 x 4 | Without increase of noise |
| Dark current | < 2 e-/pix/h | |
| Charge transfer efficiency | > 0.999995 | |
| Linearity | < 1% | Up to 50,000 e- |
| Full well | > 100,000 e- | |
| Blooming full well | > 200,000 e- | |
| Charge diffusion | < 0.1 pixel | FWHM equivalent gaussion convolution |
| Surface flatness | < 20 µm pp | |
| Cosmetics | Science grade | Number of defects TBD, no bright or dark columns. |