The MUSE Detector System

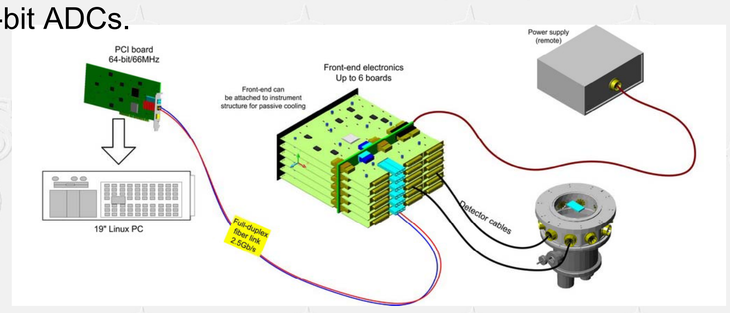
Roland Reiss, Sebastian Deiries, Jean-Louis Lizon, Gero Rupprecht
European Organisation for Astronomical Research in the Southern Hemisphere

Instrument

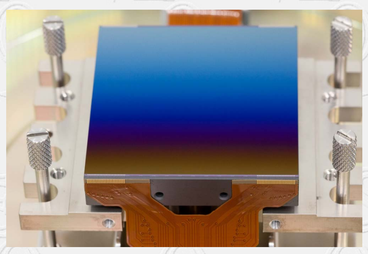
MUSE is an integral field spectrometer to be mounted on the Nasmyth platform of one of the VLT UTs. The Fore Optics (FO) splits a large field of view into 24 sub-fields. 24 Integral Field Units (IFU) provide the spectral decomposition of the sub fields. Each IFU includes its own Instrument Detector Subsystem (IDS). The spectral coverage is 465 to 930 nm.

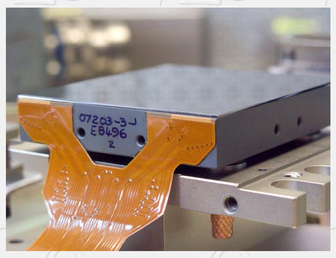
Instrument Detector System (IDS)

The Detector Controller (ESO's Next General detector Controller NGC) consists of a total number of 24 Front-end Basic Boards (FEBs) in four 6-slot housings. Each FEB contains sequencer, bias and clock circuitry and a 4-channel video video chain with clamp/sample circuit and 16-bit ADCs.



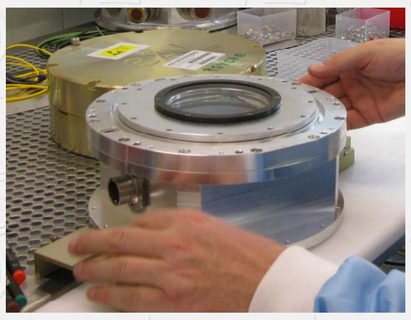
Detectors





The detectors for MUSE are manufactured by *e2v technologies*. The design is based on the 4Kx4K deep depletion backside illuminated CCD231-84. As the MUSE spectrographs have a fixed spectral format the CCDs have been coated with a graded anti-reflection coating.

The picture to the right shows a detector head after assembly.



Summary of detector properties

The table below lists the key properties of the MUSE detectors. The values have been confirmed by measurements from three out of 24 science grade devices.

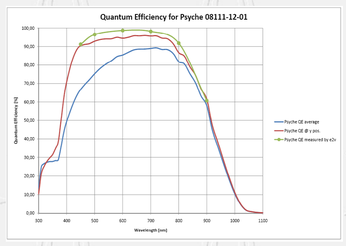
Item	Value
Type	e2v CCD231-84, deep depletion, backside illuminated, graded AR coating
Format	4096x4112, 4 outputs + 4 dummy outputs
Pixel size	15 x 15 µm^2
Noise	< 3e$^-$RMS @ 100kpix/sec < 4e$^-$RMS @ 200kpix/sec < 5e$^-$RMS @ 500kpix/sec
Readout time	< 10sec @500kpix/sec (4 ports)
Linearity error	< ± 0.4% @ 100kpix/sec
Quantum efficiency	> 90% (460..780nm) > 60% @ 900nm > 40% @ 930nm
AR coating	Graded coating, matched to MUSE spectral coverage (465..930nm)
Dark current	< 3 e$^-$/pix/hour @ 163K
CTE	> 0.999995 (v/h) (e2v data)
Point Spread Function	See figure on the right
Package	SiC, 4-side buttable, two flex boards with 37-pin Micro D connectors
Flatness	< 20µm peak-to-valley, including package tolerances.
Operating temperature	163K

Summary

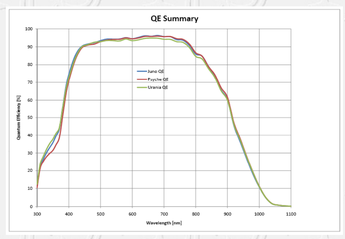
MUSE (Multi Unit Spectroscopic Explorer) is a second generation instrument for the VLT. It is built by a consortium of European institutes and ESO. MUSE consists of 24 Integral Field Units each equipped with its own cryogenically cooled CCD head. The detectors used are deep depletion e2v CCD231-84 with 15 µm pixels and 4096x4112 active pixels. After passing FDR in early 2009 the MUSE Instrument Detector System (IDS) is now in the production phase.
The poster gives an overview of the complex MUSE IDS including detector controllers, the cryogenic and vacuum system and the precision assembly of CCDs into the 24 detector heads.
We present results from the characterization of the first science grade e2v CCDs. These CCDs have a graded anti-reflection coating which is matched to the MUSE spectrographs.

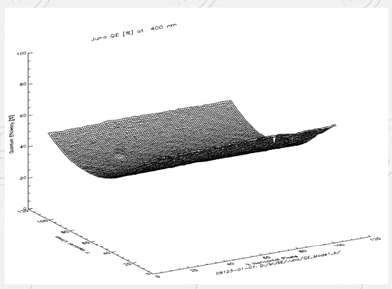
Detector Results

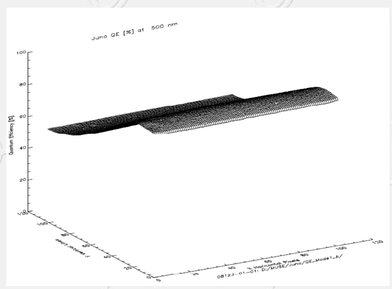
So far three out of 24 science grade CCDs have been fully characterized. On the figure to the right the quantum efficiency (QE) of CCD „Psyche“ is shown. The red (ESO) and green (e2v) curves show the QE at the „optimum“ position of the graded AR coating. The blue curve is the QE averaged over the whole device.

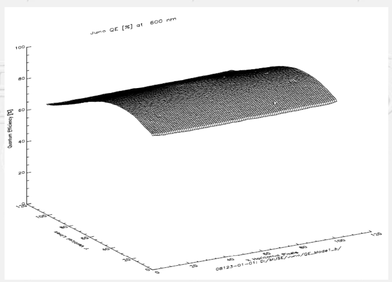


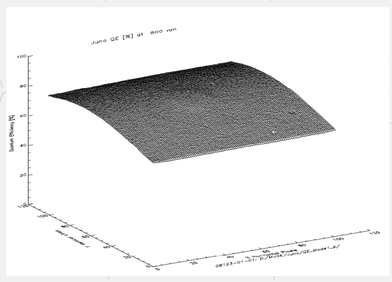
This plot shows the „optimum position“ QE of three different devices („Juno“, „Psyche“ and „Urania“). The close match of QE values is quite remarkable.





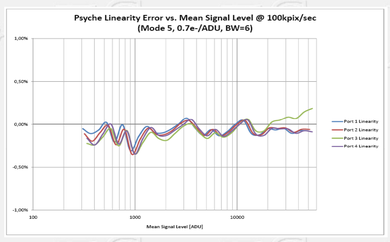


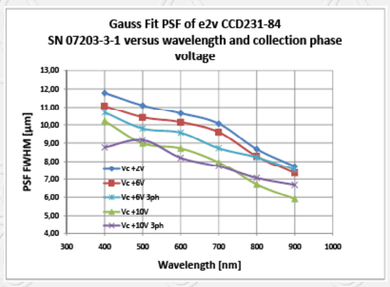




The „surface“ plots above illustrate the effect of the graded AR coating over the whole imaging area at 400, 500, 600 and 800nm.

The figure to the right shows the linearity error of the four output ports of CCD „Psyche“ within a range of approx. 140 to 40,000 e$^-$ at binning of 4x4.

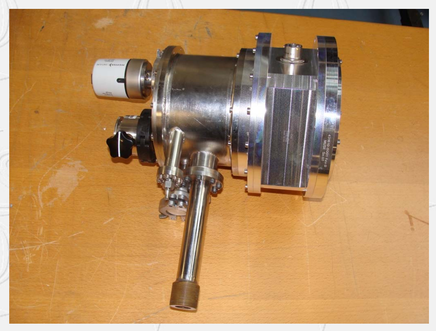




PSF values measured with CCD231-84 at different collecting phase voltages. With kind support from Mark Downing, ESO.

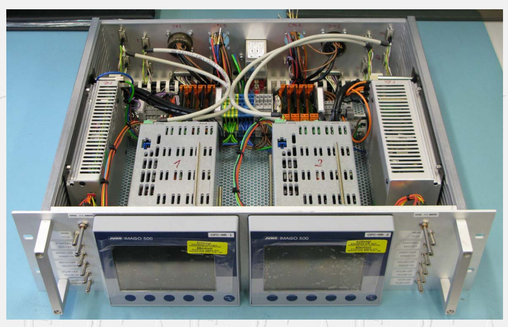
Vacuum and Cryogenic System (VCS)

Each of the 24 detectors is mounted in its own Detector Vessel (DV). Cooling is done with LN2 using a Continous Flow Cryostat (CFC).

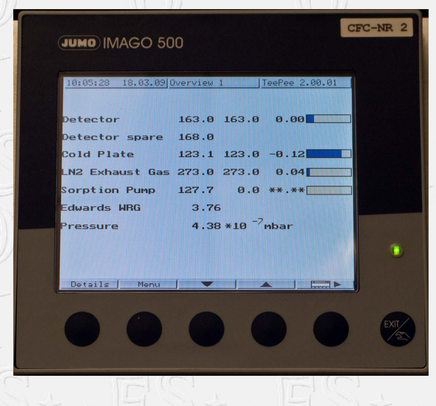


The thermal control of the 24 detector heads and cryostats is handled by a unit named „TeePee“. TeePee is based on an industrial Program Controller (JUMO Imago 500). One TeePee contains two Imago 500 and controls and monitors two detector vessels.

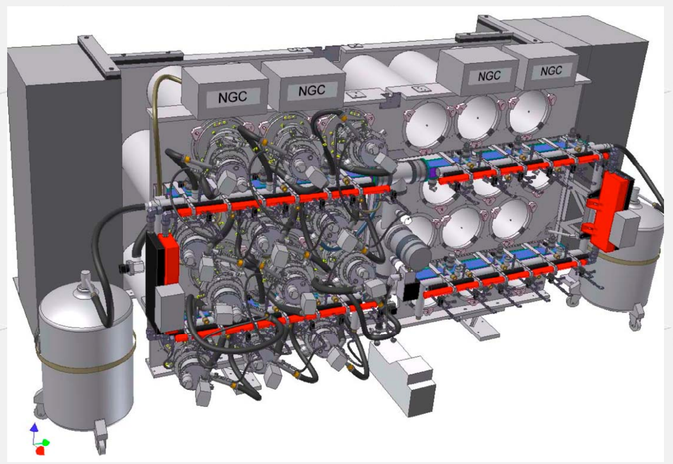
TeePee (right) is made from industrial components (controller, power supplies, solid state relays).



The Imago 500 (right) controls and monitors
- Detector temperature
- Cold plate temperature
- N2 exhaust gas temperature
- Sorption pump temperature during regeneration
- Vacuum pressure (Edwards WRG)



There are numerous interlocks for temperature and pressure to guarantee detector safety. All TeePees are connected via Profibus-TP to a master controller (Siemens PLC)



The drawing above shows the Instrument Main Structure with 12 out of 24 Detector Vessels installed. The four 6-slot NGCs are on top, the blue parts are the vacuum lines. The red pipes collect the N2 exhaust gas which is used to flush the instrument. The grey lines are for LN2 distribution. The control electronics (TeePees) are located in the cabinets to the left and right.
The picture below shows LN2 and vacuum distribution lines currently beeing integrated in the ESO assembly hall.