Detector Progress Report March 2014

Detector status

- Aquarius hardware installation at MPIA
- Software work for DCS and DRS integration
- First measurements and results from the Aquarius FLT110 FPA:
  detector mask and thermal background,
  signal correlation and photon transfer curve,
  quick look on mechanical vibrations.
- Detector situation (Aquarius)
- Next steps

Aquarius hardware installation at MPIA

- Aquarius eng./sci. detector installed in the N band cryostat, mechanical, thermal and electrical integration is finished, remote access from Bonn is established.
- MATISSE-specific readout modes were tested (multiple sub-windows, CDS with extra reset, external trigger).
- Detector was tested cold at different temperatures (7-9 K) and bias voltages were optimized (improved linearity, see below).
- Handover from ESO with documents on approval: „ICD for AQUARIUS cryogenic detector setup“ and „AQUARIUS Detector Operational Recommendations“.

Software work for DCS and DRS integration

- Integration of new readout modes (acquisition process and sequencer scripts provided by ESO)
- Image recording as binary FITS tables with use of the MATISSE DCS
- Template tests of

  MATISSE_gen_cal_det: detector characterization template

  MATISSE_gen_cal_im_basic: daily template for detector health and external noise

  MATISSE_gen_cal_im_extended: monthly template for detector health

  MATISSE_gen_cal_im_remanence: yearly template for remanence measurement

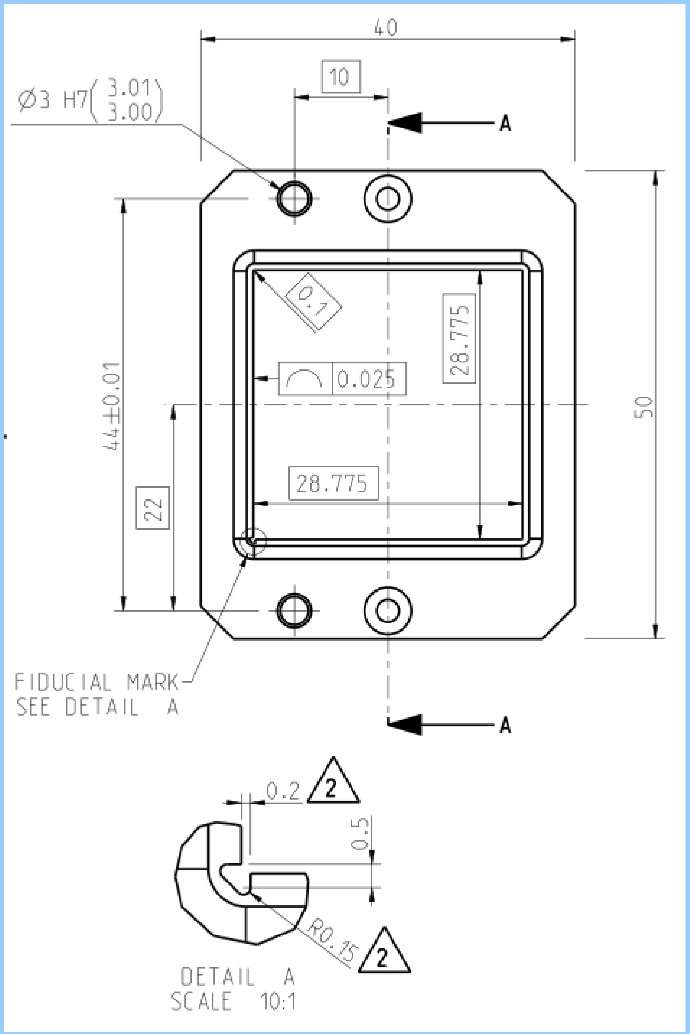
The tests include the readout modes, NGC-triggers (TIM-Board), periodic shutters (TIM-Board) and the FITS-File storage.

Measurements of the Aquarius FTL110 FPA – Setup conditions

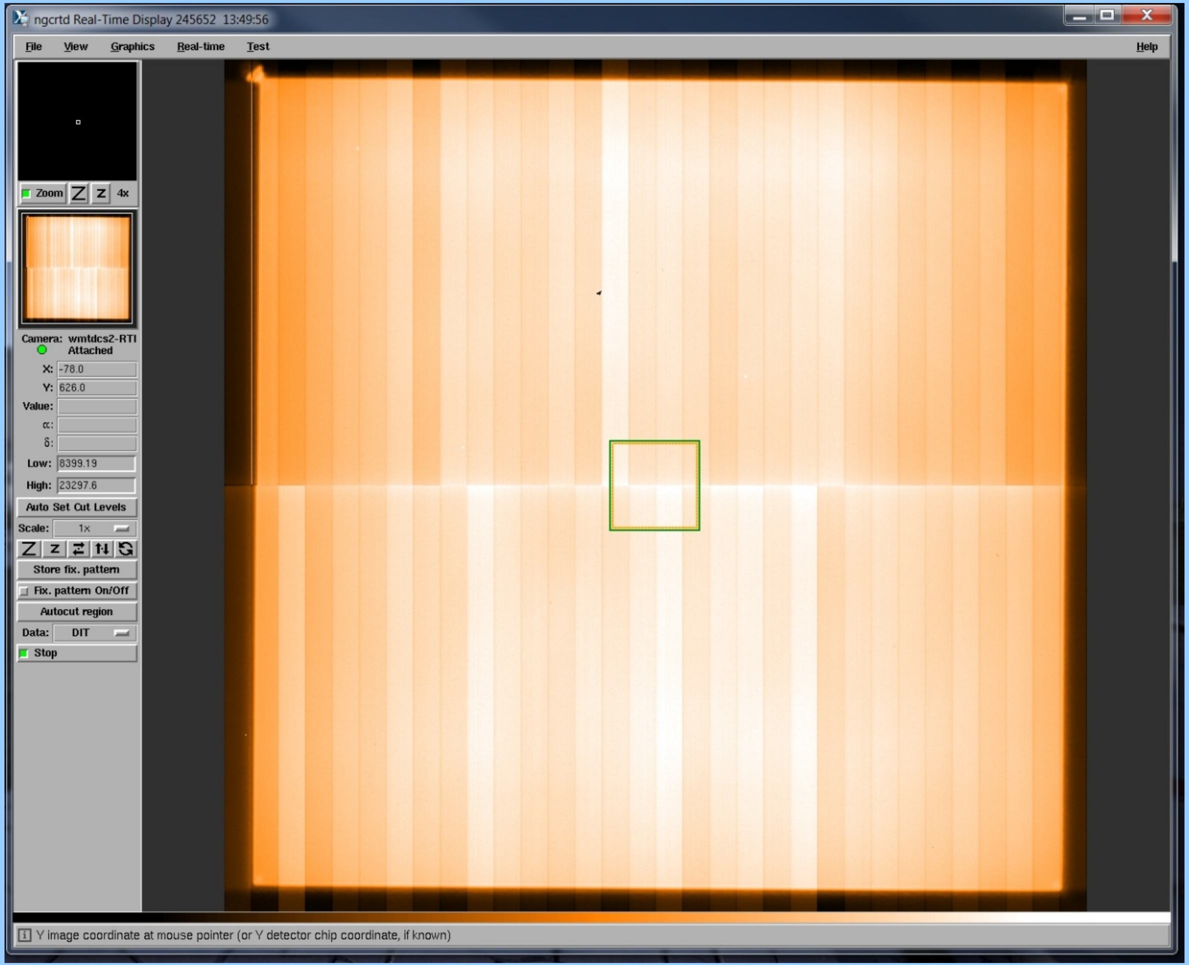
Setup conditions for the measurements:

- detector mask,
- thermal background of the cryostat and dark

Aquarius FTL110 FPA: detector mask

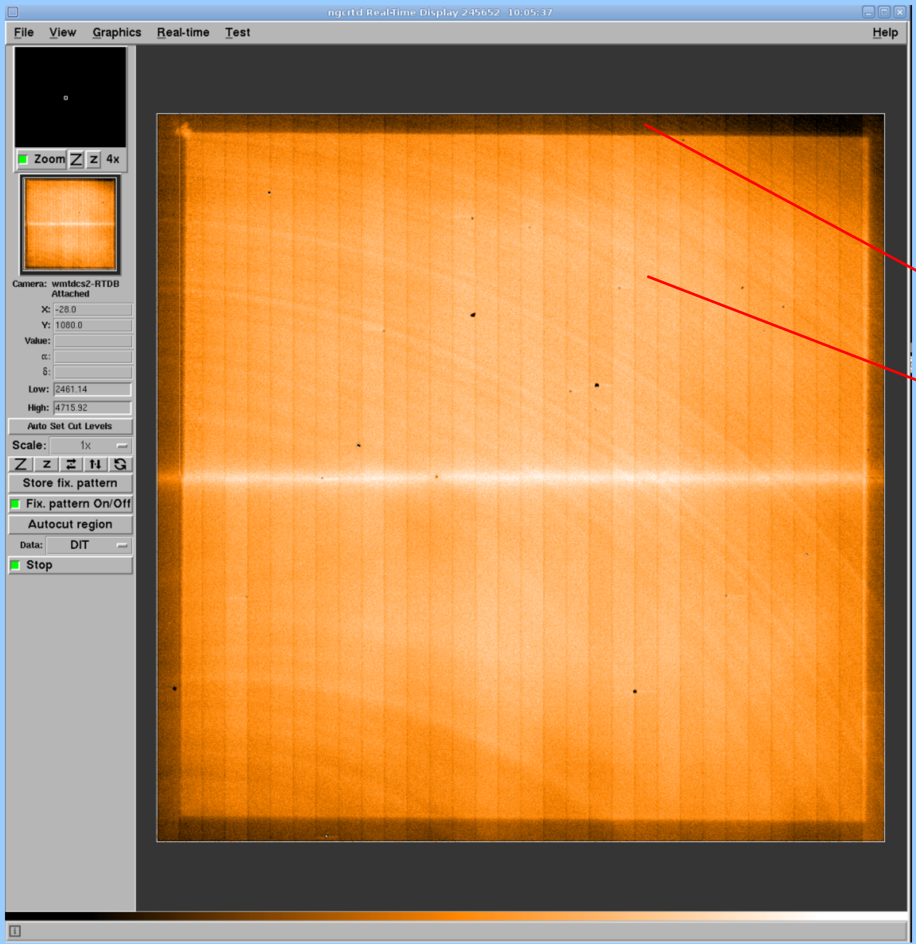


Detector mask, distance to detector surface: ~0.4 mm

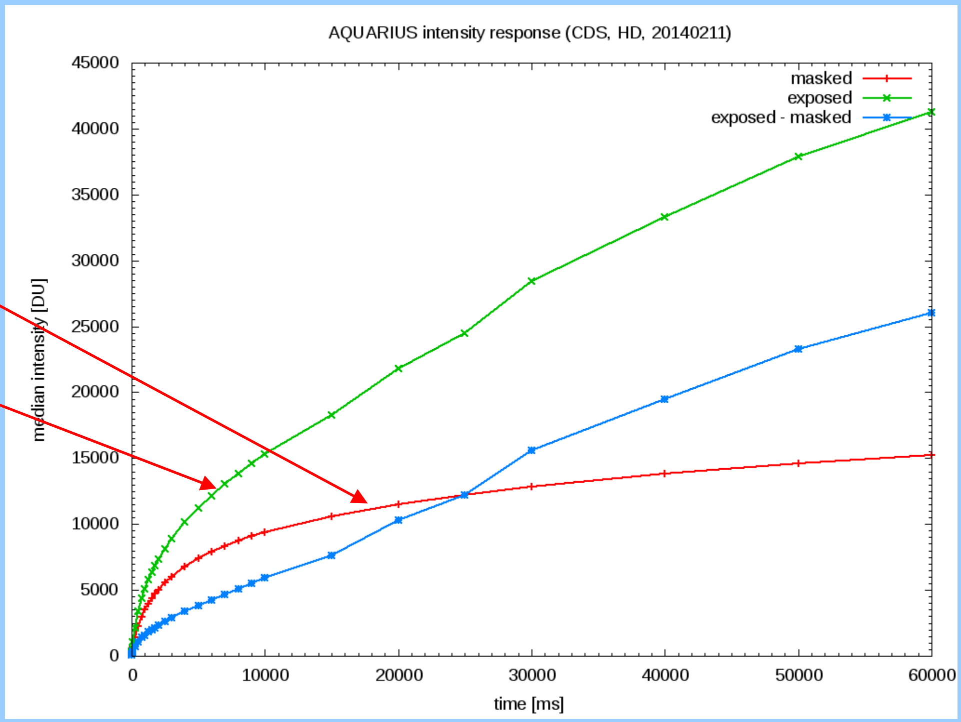


Detector raw image with mask on RTD

Aquarius FTL110 FPA – thermal background



Thermal background radiation inside the N band cryostat



Thermal background radiation 0 – 60 sec.: detector output signal in the masked area (red) and other parts (green). The difference (blue) gives ~ 400 DU/sec., or 8000 photo-electrons per second per pixel, or:

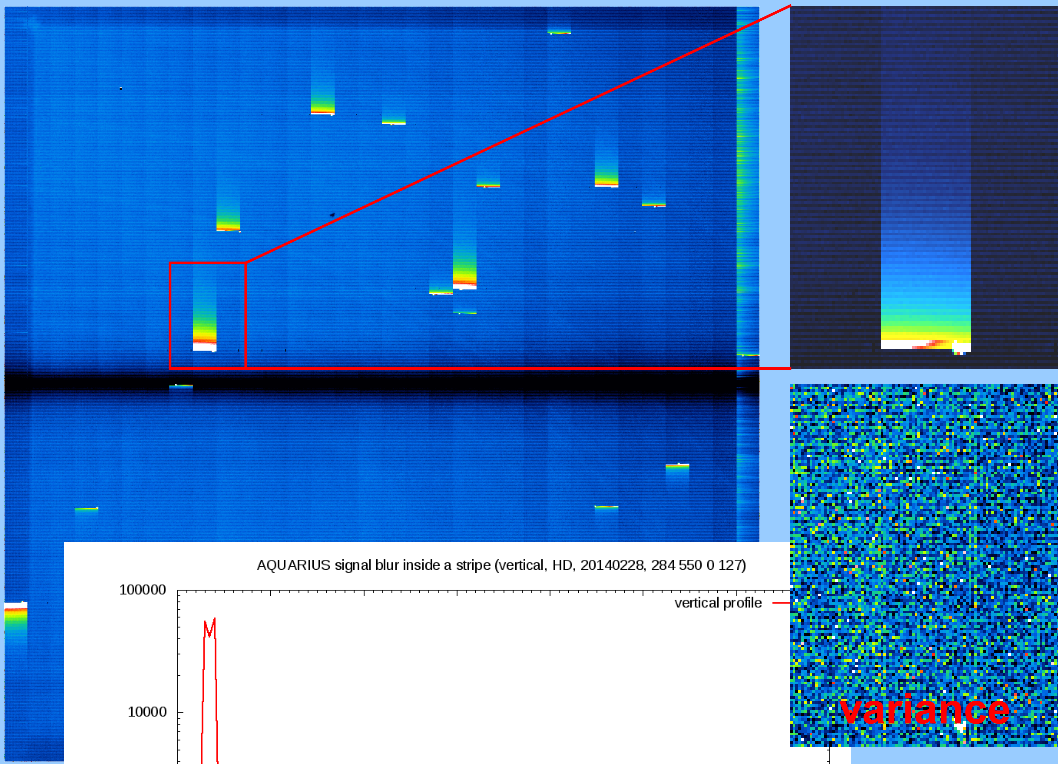
~240 e- / 30 ms / pixel (below RON)

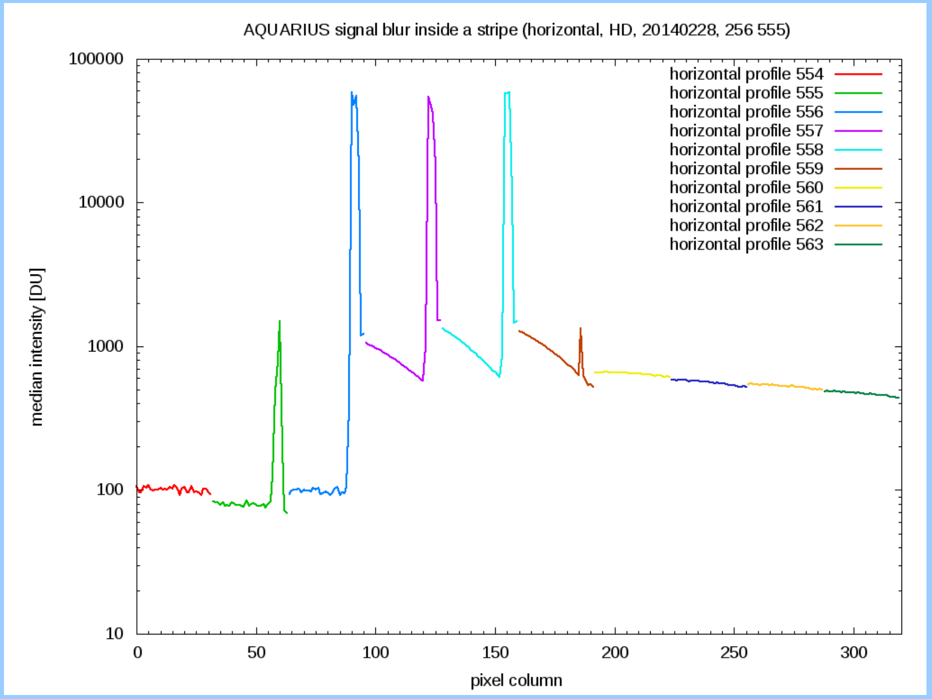
Measurements of the Aquarius FTL110 FPA – Signal Correlation (CDS readout)

Types of signal correlation:

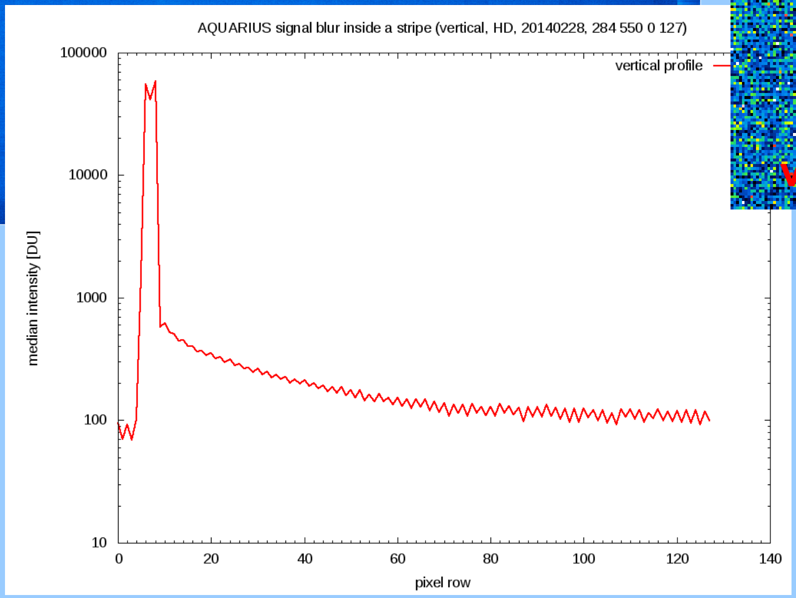
- Signal blur within the output stripes
- Crosstalk between the 64 output stripes
- Remanence
- Spatial correlation of neighbouring pixels (row and column)

Aquarius FTL110 FPA – signal blur within one of the output stripes (CDS readout)





Series of concatenated horizontal cuts



Vertical cut through insert

Aquarius FTL110 FPA – crosstalk between the 64 output stripes

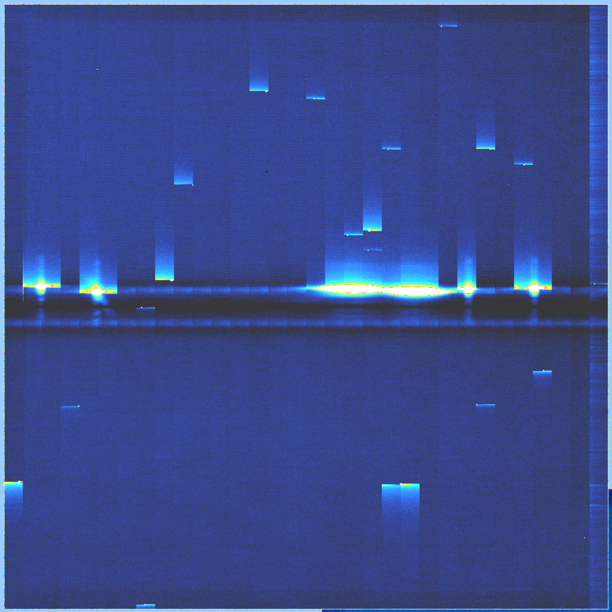
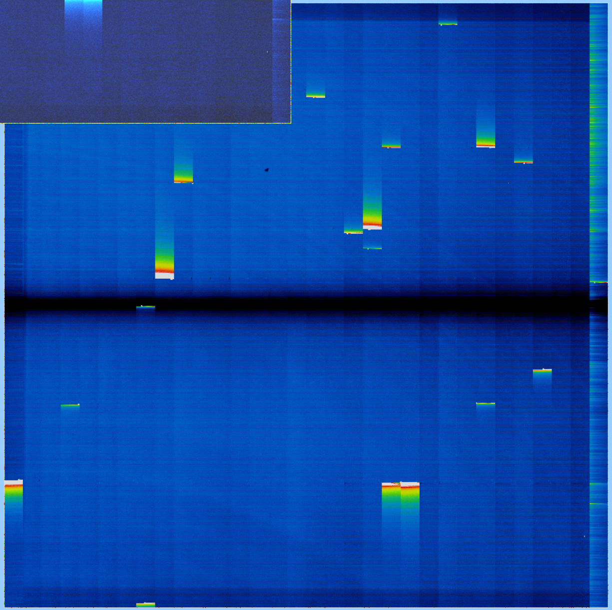
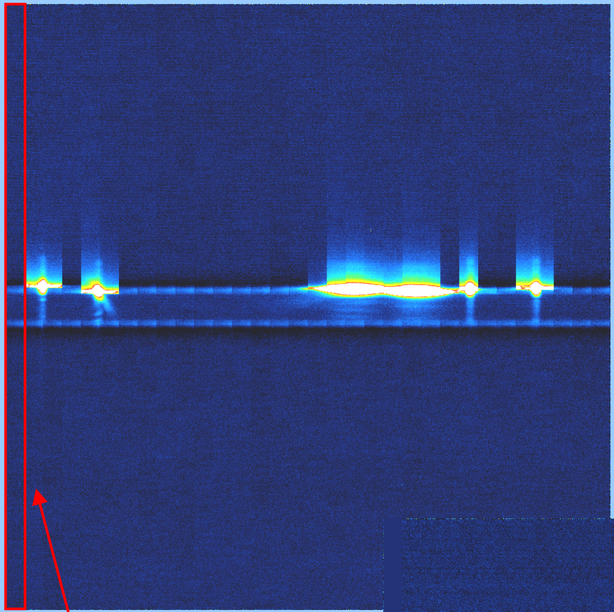


Image of the illuminated shifted pinhole and the photometric channels (no dispersion, 12.5 ms DIT)

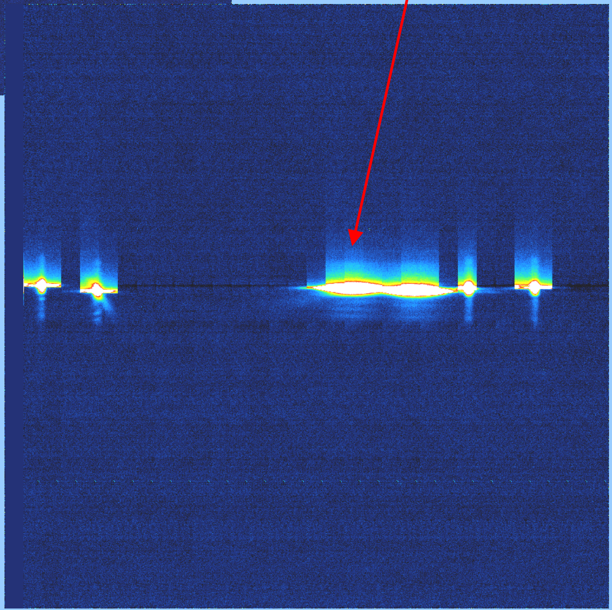


Right: Image of the mean dark



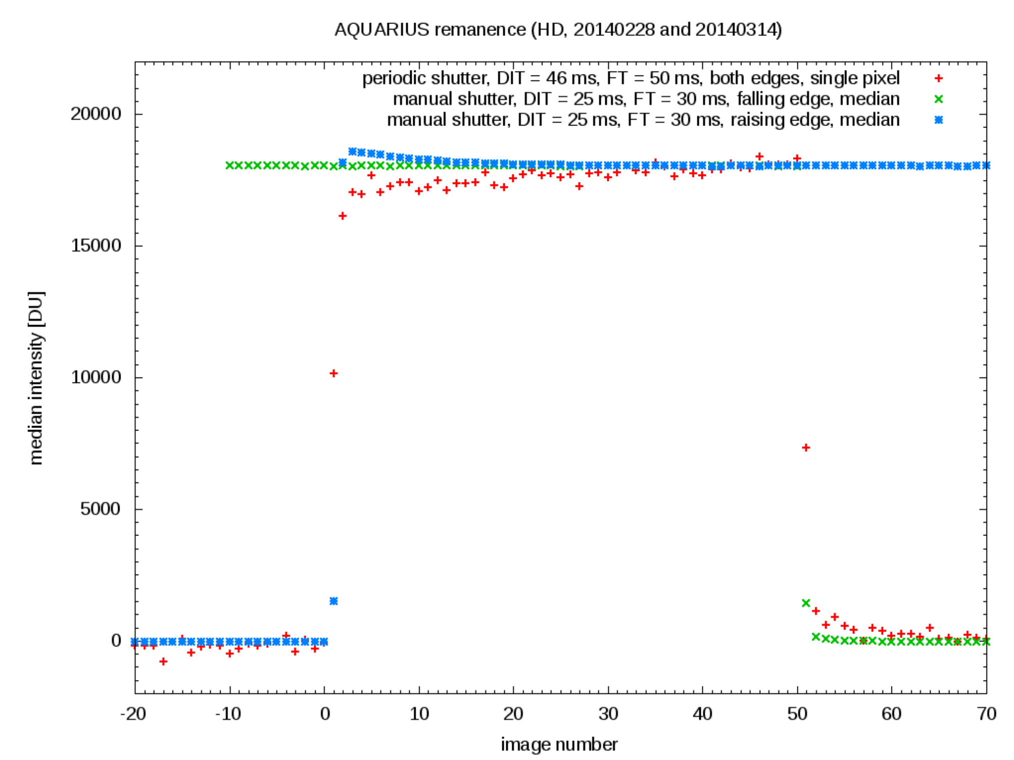
Left: Mean dark subtracted from the left image (illuminated shifted pinhole)

Right: Intensity profile of the left stripe of the masked area subtracted from all other stripes



remaining artefacts

Aquarius FTL110 FPA – Remanence



Remanence: 8%
(blue+green)
Red: under investigation

Remanence or temporal correlation of one pixel (red) or a small area (green and blue)

Aquarius FTL110 FPA – Inter-pixel crosstalk

Pixel-to-pixel crosstalk or spatial correlation in row and column direction

How we measure crosstalk: auto-correlation of flatfield data

SW tool: MATISSE_gen_cal_im_extended

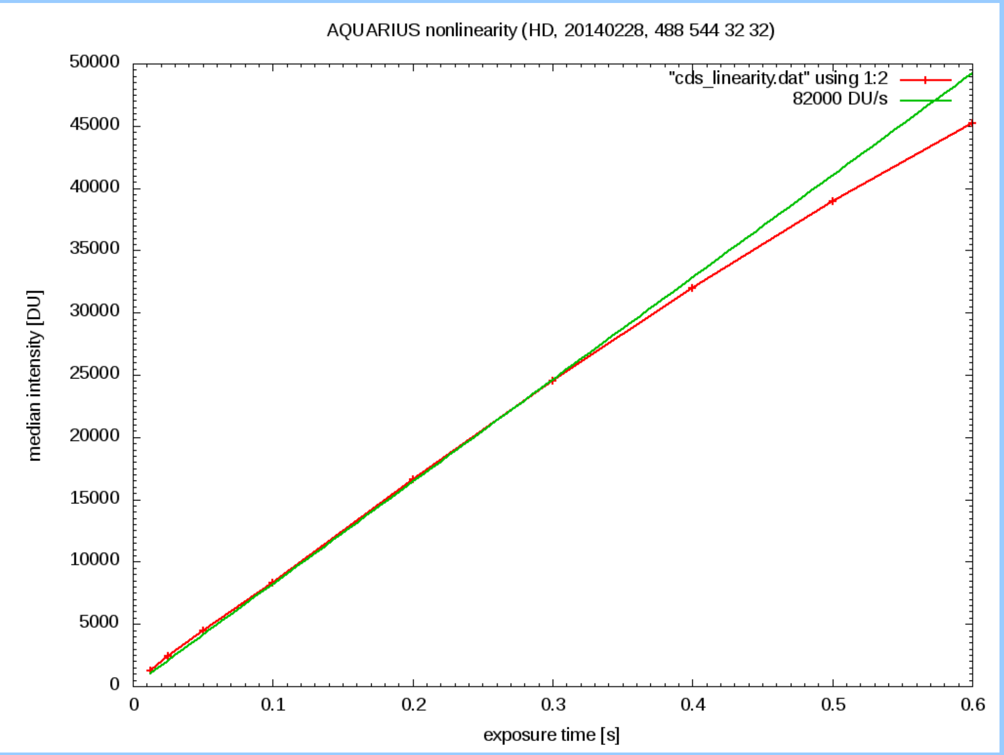
Results: none due to the filter wheel problems,
previous measurements: < 5% in row, <10% in column direction

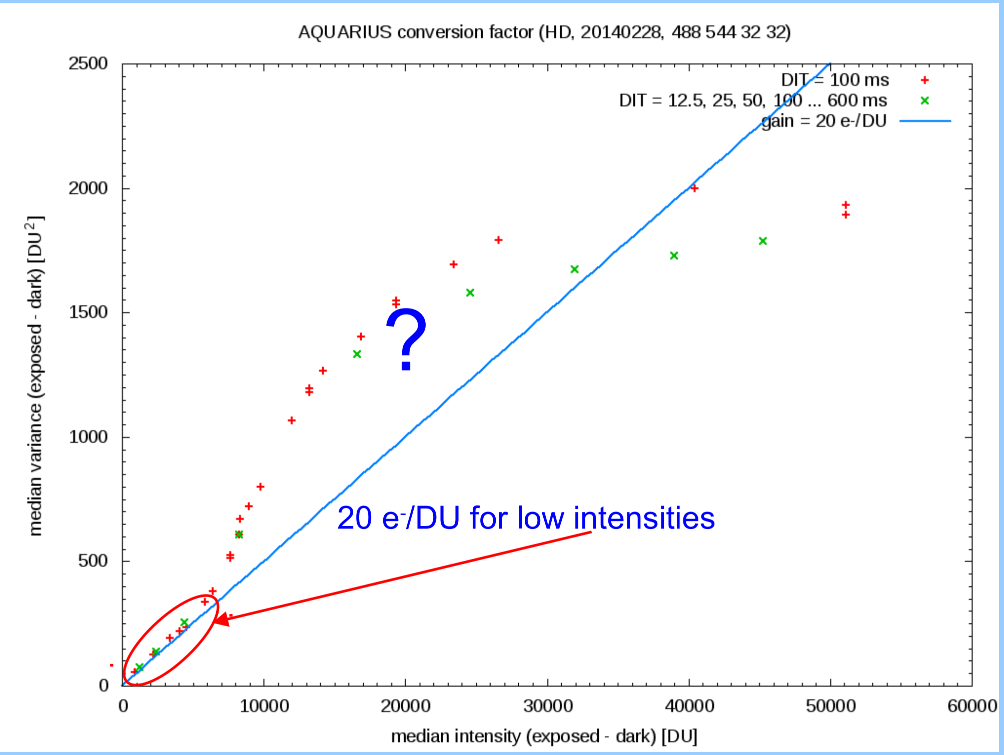
Measurements of the Aquarius FTL110 FPA – Conversion factor (from e^- to DU)

Measurements for the conversion factor:

- DIT vs. signal output: linearity measurements
- Photon transfer curve (variance vs. signal)
- Full well and max. detector output signal
- Detector unit cell capacitor and electronic gain

Aquarius FTL110 FPA: Linearity and conversion factor





Detector signal vs. DIT (left) and signal variance vs. signal (right)

CDS with DITs ranging from 12.5 ms to 600 ms.
The linearity curve looks quite nice, however the variance does not follow the signal (assumed: photon noise).

Aquarius FTL110 FPA – conversion factor (2)

From electrons to DUs, different methods

1. Photon transfer curve – ambiguous, see previous plot.

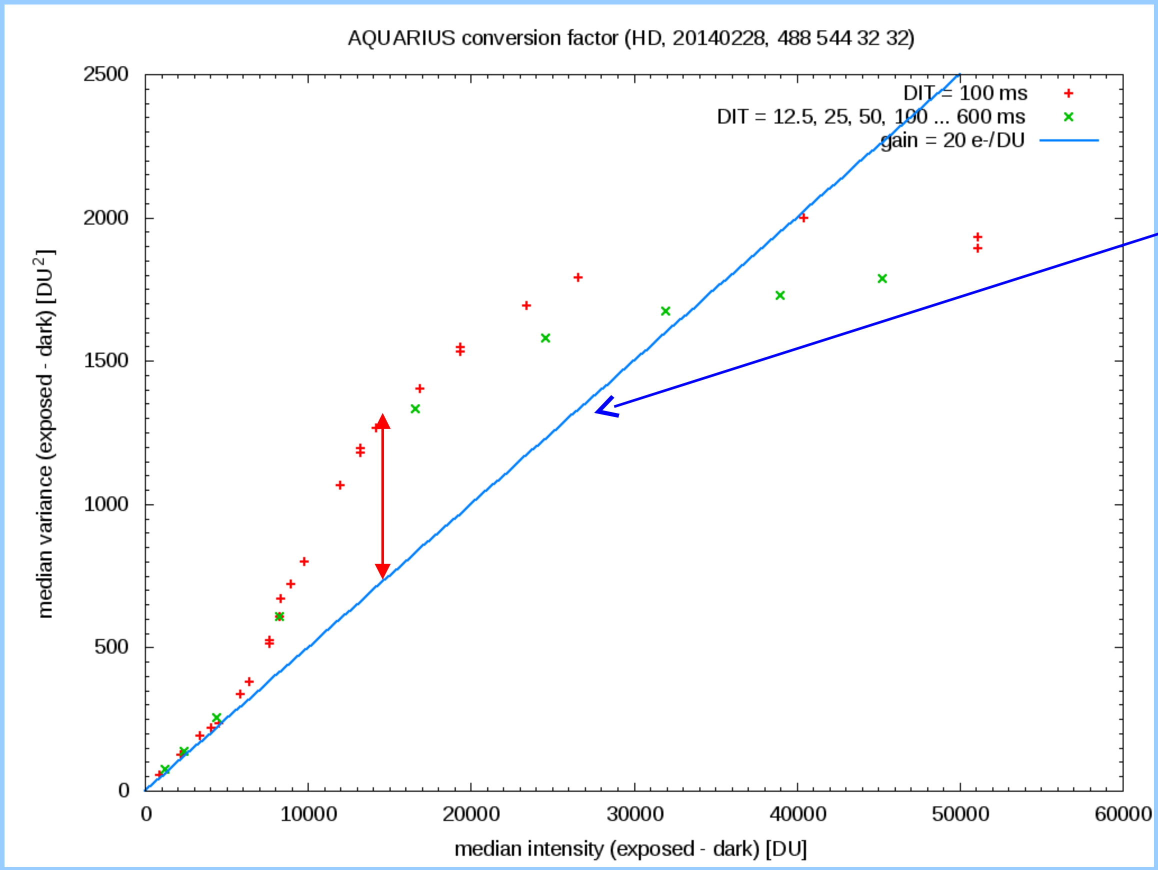
2. Max. detector output signal for detector full well:
   Aquarius full well: 1E+06 e^- (from Raytheon data sheet, no measurement)
   max. detector output signal: 50.000 DU (measured),
   division gives → **20 e^- / DU**

3. Detector unit cell capacitor + electronic gain (preamp, ADC, etc.):
   a) U = Q/C, Q(electron) = 1.6E-19 C, C(unit cell) = 156 fF
   → 1 µV per electron at the detector output

   b) preamp electronic gain: 3x, ADC range: 65536 DU for 4V input signal

   Calculation: 1E-06 V x 3 x 65536 DU / 4V ≈ 0.05 DU per electron → **20 e^- / DU**

Aquarius FTL110 FPA – conversion factor (3)



Variance against signal. Additional noise term to the photon noise.

Assumption: The conversion factor is about 20 e^{-}/DU.

1. We can calculate the mean number of photo-electrons in a detector pixel.

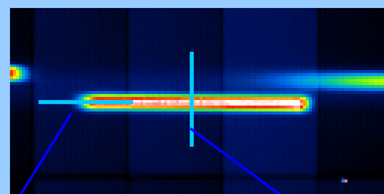
2. The noise in the detector images is photon noise + additional noise. The SNR can be degraded by a large factor. However: the data was not recorded in the way we will do it for MATISSE!
The measurements have to be repeated in the MATISSE context and environment and simulate the chopping.

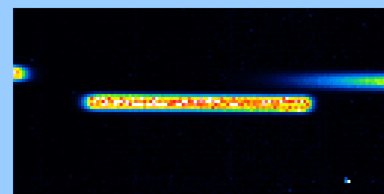
Aquarius FTL110 FPA – mechanical vibrations

Internal mechanical vibrations between the spatial filter slider or the photometric slider and the detector

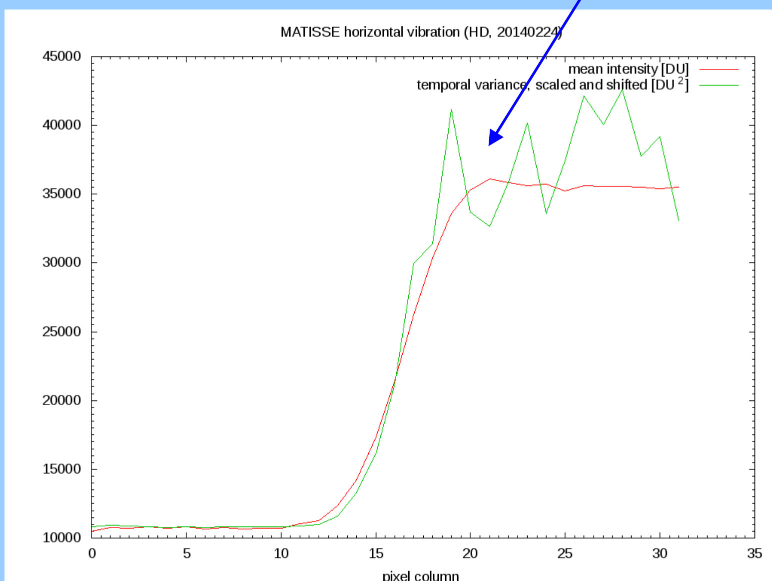
How we tried to measure vibrations: differences between intensity and variance from high contrast images (sharp object edges, series of a large number of images)

mean signal intensity →

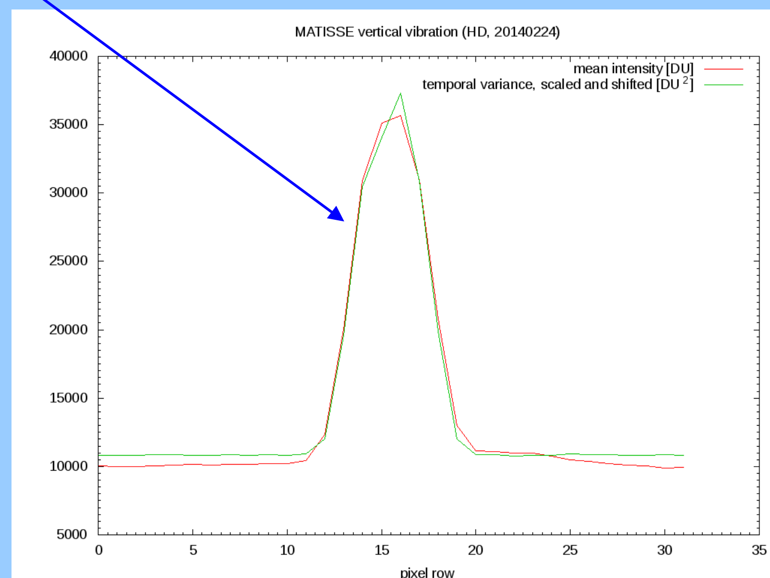




← variance



cut in horizontal direction



cut in vertical direction

Aquarius detector situation: delays? best detector?

- **Delays due to additional detector tests in Heidelberg?**

  10 of 13 foreseen days were used for the HW integration (this includes the MUX replacement) + some remote access time, the SW integration (DCS+templates, detector characterization) will probably take 5 + 15 days as planned, no additional tests are presently foreseen.

- **Did we select the best detector for MATISSE?**

  Aquarius detector delivery from Raytheon to ESO: 6 detectors were delivered,

  2 went into VISIR,

  1 is an eng.grade, which we tested over the last 2 years,

  2 were sent back to Raytheon to be replaced (non-linearity aspects of the MUX),

  1 was delivered to MATISSE.

- **The Aquarius detector we got from ESO is the best one out of 4.**
- **The remaining two VISIR detectors were reported to have strong ELFN (as all other four).**
- **If Raytheon would replace two detectors, we would have the chance to get one of them, or keep the one we have now.**

Next steps

- DCS and template tests started, to be finished
  These are pure SW tests, no useful data is expected for further analysis.

- Detector characterization (for MRR5)
  Preparation:
  - increase the „blackbody plate“ temperature to achieve higher flatfield intensities. This is a result from preliminary flatfield tests.
  - use of a temperature controller and heater resistors to achieve ~80 ºC. At 60 ºC first tests showed temperature differences on the blackbody plate of ~0.5 ºC.
  - filter wheel operation required