



We Must be MAD



Pushing FIERA to its Limits

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MAD (Multi conjugate Adaptive optics Demonstrator) is an MCAO pathfinder experiment for both Overwhelmingly Large (OWL) 100-m class telescopes and ESO VLT 2nd generation instrumentation.

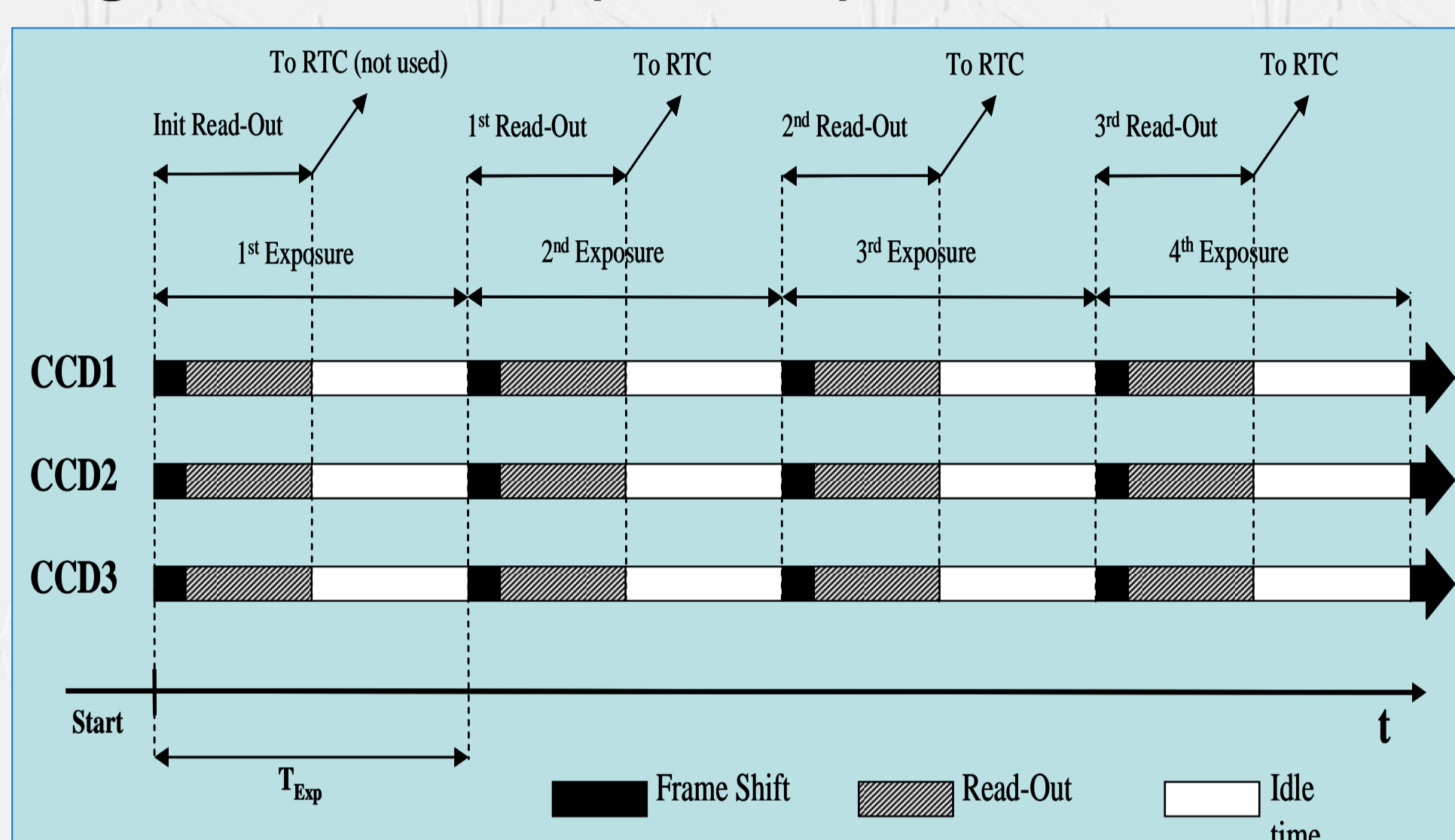
MAD's Wave Front Sensor (WFS) employs five thermo-electrically cooled e2v CCD39-01 devices operating in two modes: The Multi Shack-Hartmann (SH) WFS consists of three CCDs with 80x80 pixels each which are read in parallel at up to 400 frames per second delivering a pixel rate of 4.8 Mpix/sec at lowest noise.

The Layer Oriented (LO) WFS is made up with two CCDs of the same type but both detectors are read simultaneously with different frame rates and binning factors using a single FIERA controller.

The paper shows the concept of both the SH and LO wave front sensors and gives first performance results from laboratory tests. We report on tricks used to implement and speed up the clock patterns and the lessons learned during the development phase.

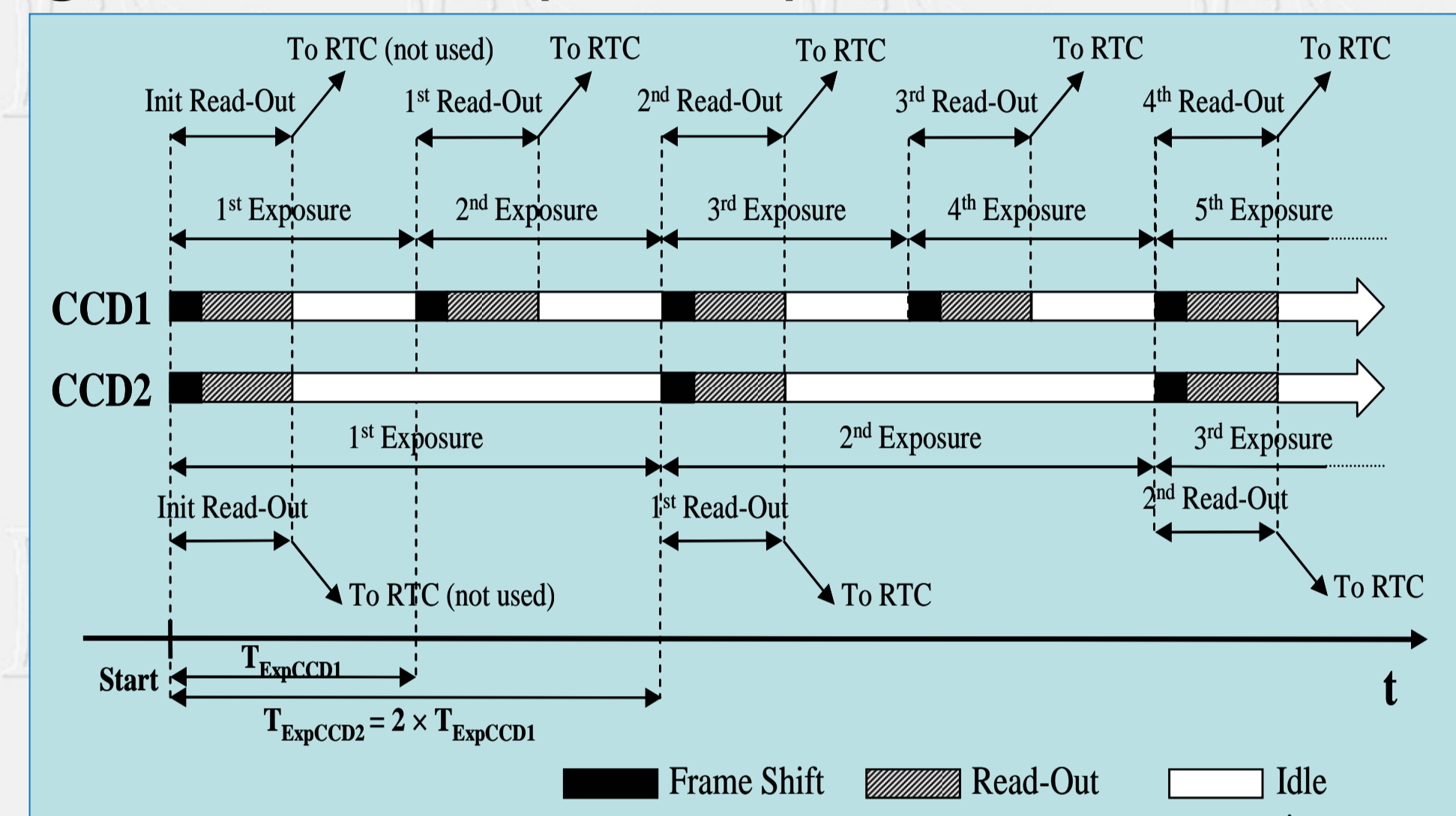
Shack-Hartmann WFS (SHWFS)

- 3 CCDs are read synchronously at the same frame rate (up to approx. 400Hz).
- The binning factors are the same for all 3 SHWFS CCDs (either 1x1 or 2x2).
- 12 video channels (3x4), 625 kpix/sec/channel
- Region-of-Interest (window) is 64x64.



Layer Oriented WFS (LOWFS)

- 2 CCDs are read synchronously, but with different frame rates!
- The binning factors are different for the 2 LOWFS CCDs (2x2 and 4x4).
- 8 video channels (2x4), 625 kpix/sec/channel.
- Region-of-Interest (window) is 80x80.



Limitations of FIERA sequencer:

- Length of subpattern limited to 1024
- Repetition count limited to 1024
- FIERA adds delay to very short subpatterns

```
sequence_TST
pixel_x 192
pixel_y 64
{
  frame_transfer 40 1;
  pixel_dump 84 1;
  repeat 32
  {
    line_shift 1 1;
    pixel_dump 1 1;
    read_025 1x3 1;
    pixel_dump 10 1;
  }
}
```

exec_time [usec]	delay [usec]
1000	0
700	9
700	1

Solution:

- Combine two short patterns to save overhead

Disadvantage:

- Number of prescan pixels fixed.

```
sequence_TST
pixel_x 192
pixel_y 64
{
  frame_transfer 40 1;
  pixel_dump 84 1;
  repeat 32
  {
    line_shift_dump 1 1;
    read_025 1x3 1;
    pixel_dump 10 1;
  }
}
```

exec_time [usec]	delay [usec]
88	0
18	2
71	2

Mechanical constraints

- Size of head limited to 96 x 68 x 30 mm³.
- Electrical connections must be mechanically very flexible!

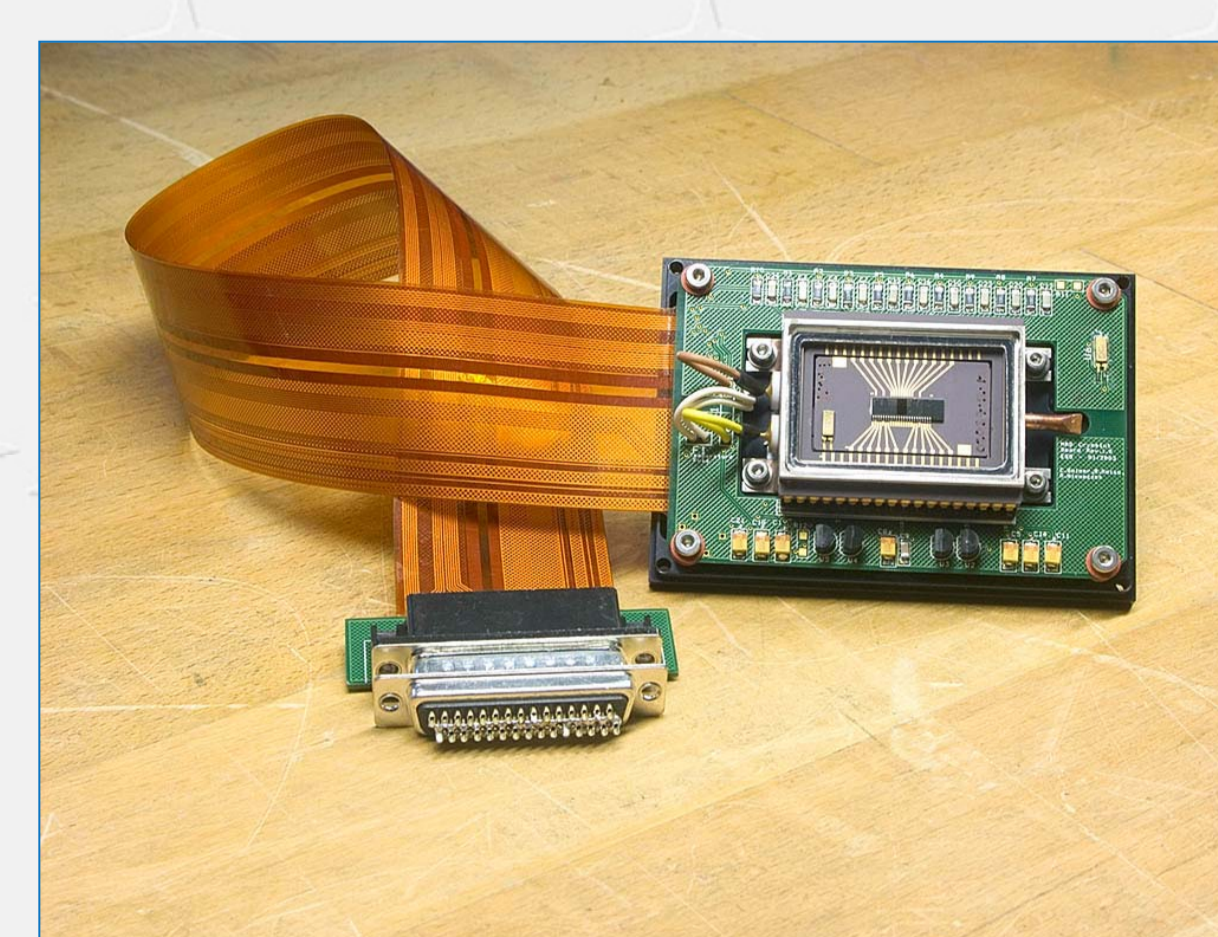
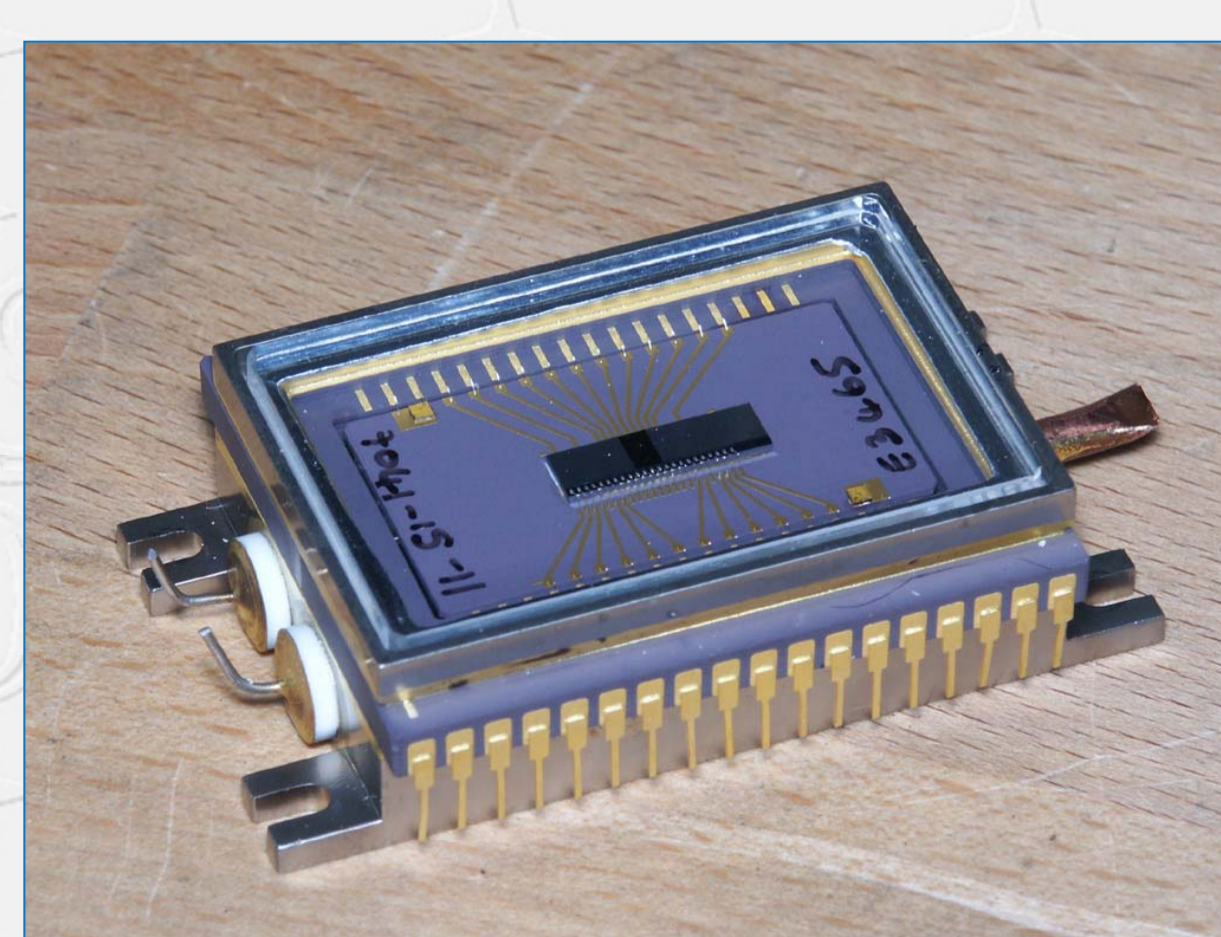
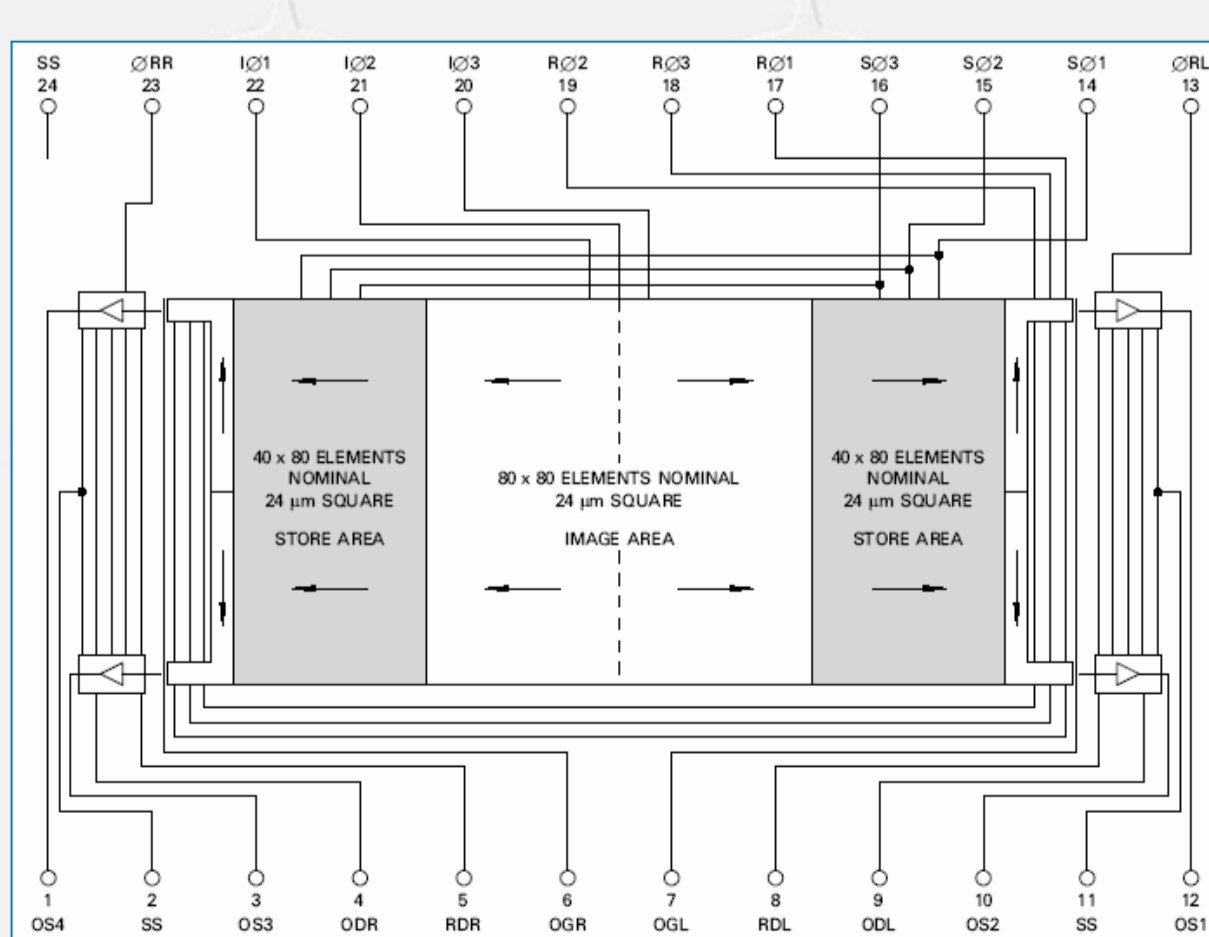


Figure 1: CCD39 functional diagram

Figure 2: CCD39 Peltier package

Figure 3: Rigid-flex PCB

Figure 4: CCD housing

Performance Data (SHWFS)

- Frame rate 400 Hz (64 x 192 pixels).
- Average pixel rate 4.9 Mpixel/sec.
- Burst pixel rate 7.5 Mpixel/sec.
- Noise @ 400Hz approx. 6 e-RMS.

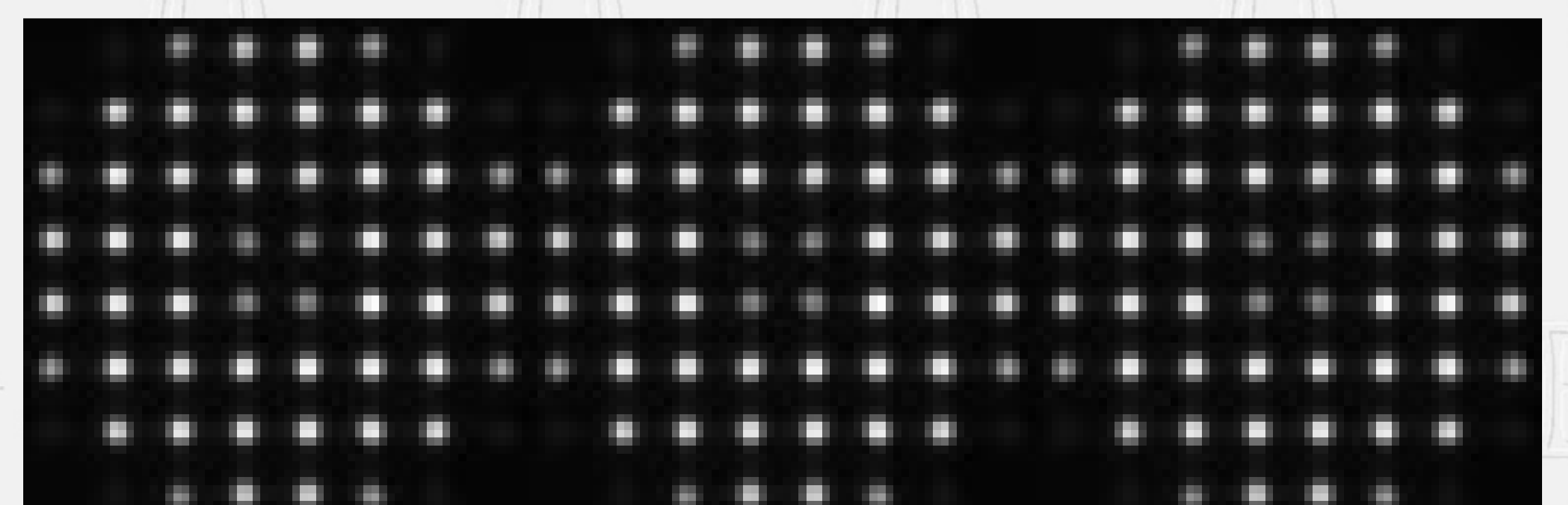


Figure 5: Sample image SHWFS (3 x 64 x 64 pixel)