Future Developments of Infrared Controllers at ESO

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Next Generation IR Detectors

Detector	Format	Outputs	Pixel Time	Frame Time	Baud Rate
			[μs]	[ms]	Gbaud
Hawaii-2RG MBE HgCdTe	2Kx2K	32	0.2	26	2.6
Si:As BIB	640x480	32	0.3	2.8	1.7
ORION 2Kx2K InSb	2Kx2K	64	1.5	100	0.7
Adaptive optics sensors	256x256	32	0.2	0.41	2.6

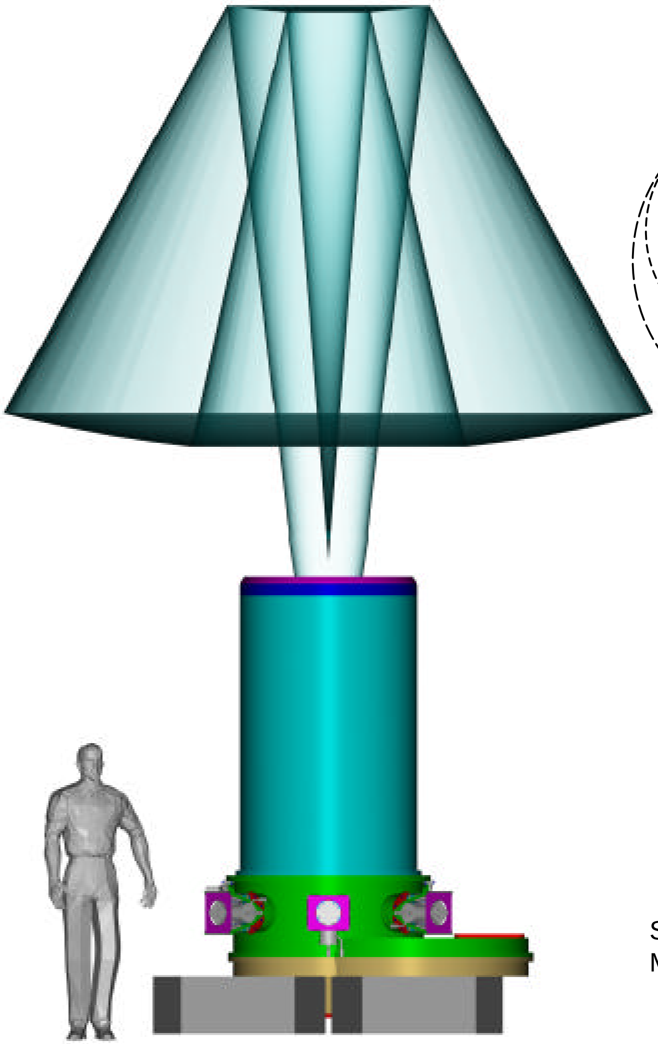
- need 5 MHz 16 bit ADC's
- need 3 Gbaud fiber link

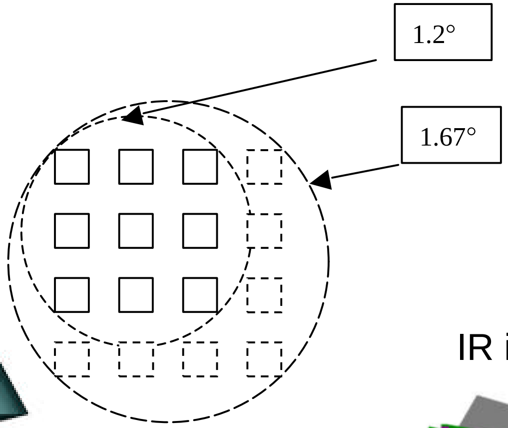
Future Requirements for IRACE

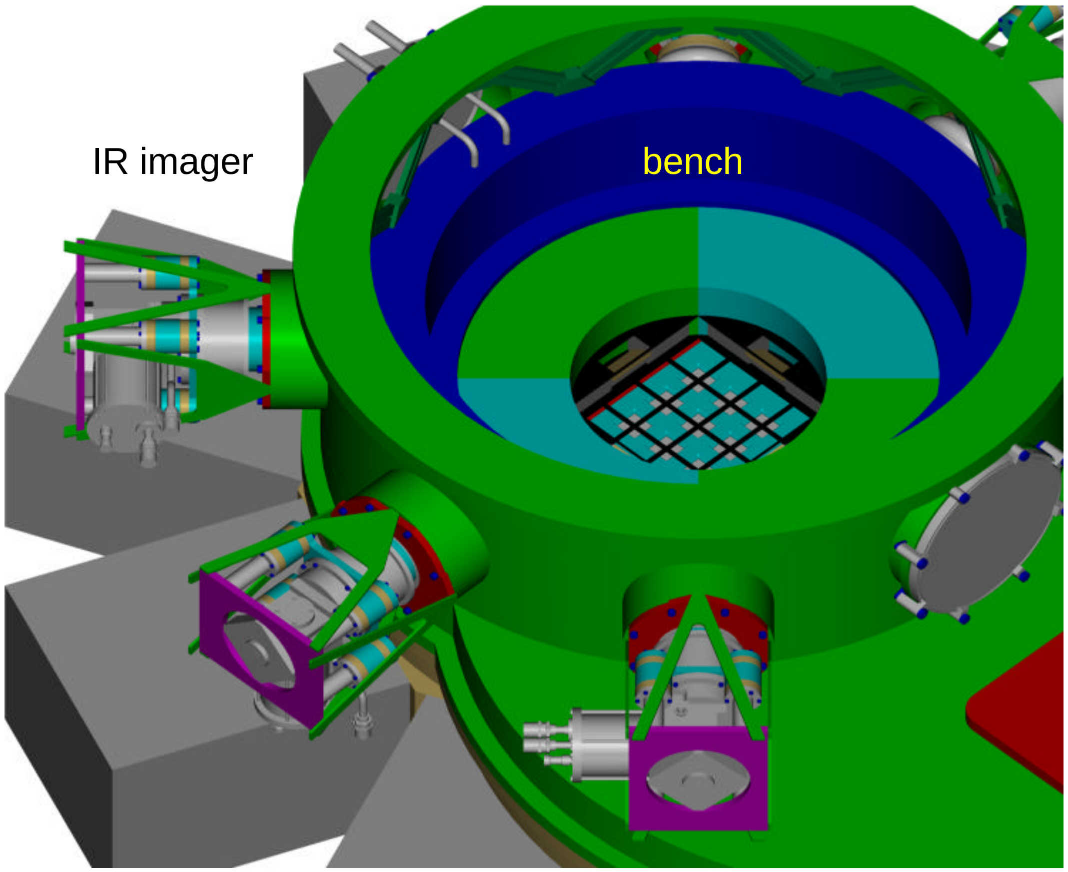
- Large format mosaics of 4x4x2Kx2K IR arrays each having >= 32 parallel video outputs (VISTA)
- Subpixel sampling by digital filter in EPLD
- Reference unit cells for true differential signal chain
- Interpolated digital clamp of reference unit cell
- Embedded real time pre-processing in high level programming language such as IDL (cosmic ray rejection)
- Guiding on science frame
- diagnostics , self test of acquisition system, on line help
- Audio DAC’s to control clock slopes ?
- Put detector front end in ASIC close to focal plane

Large Format : VISTA

- 4 meter telescope, field 1.67 deg
- mosaics of 4x4x2Kx2K IR arrays







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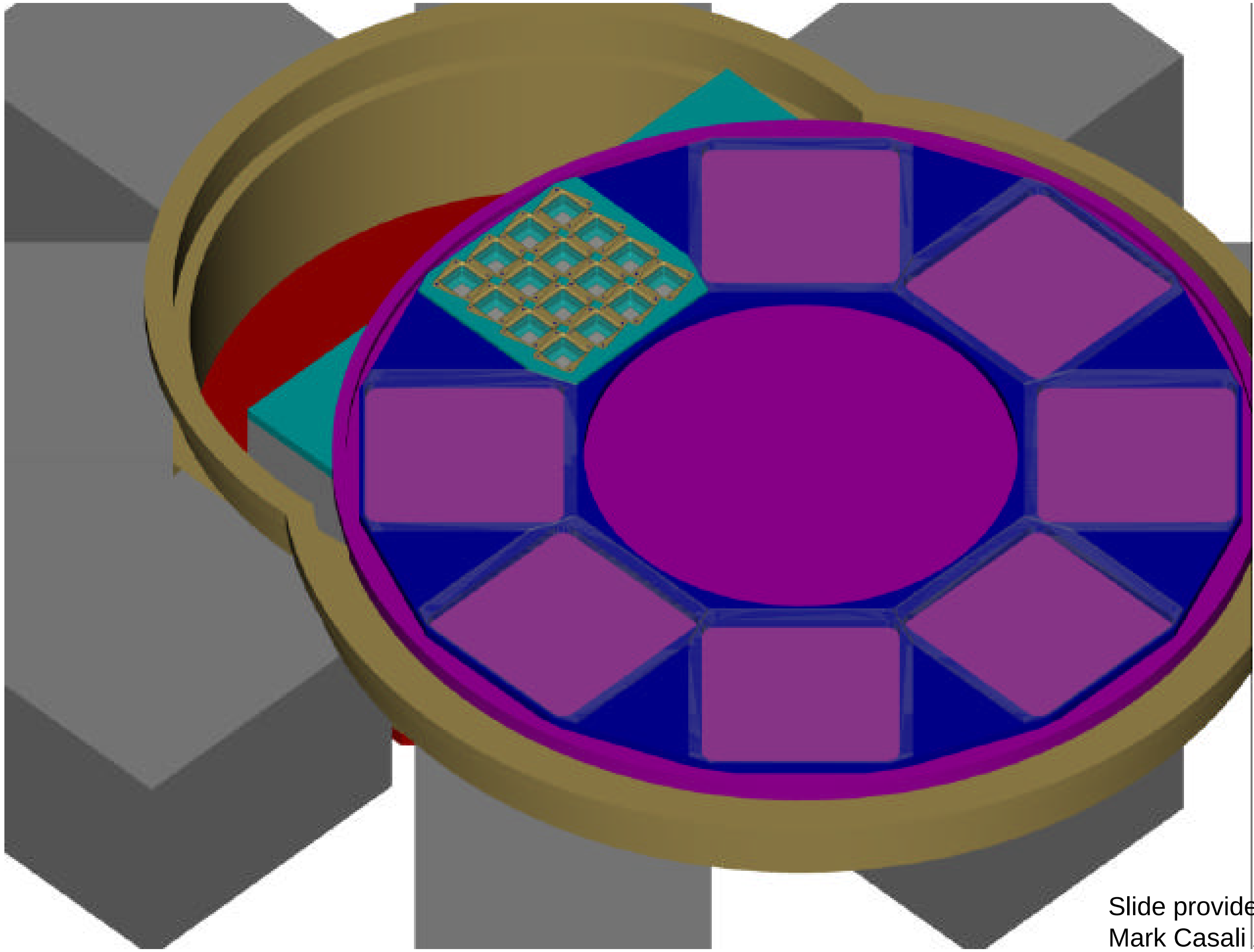
Large Format: VISTA



- eight filter units, each containing sixteen filters, each 54mm square
- with HAWAII2 mux use four quadrants for tracking,guiding and wave-front sensing
- with HAWAII2-RG use guiding feature built into detector

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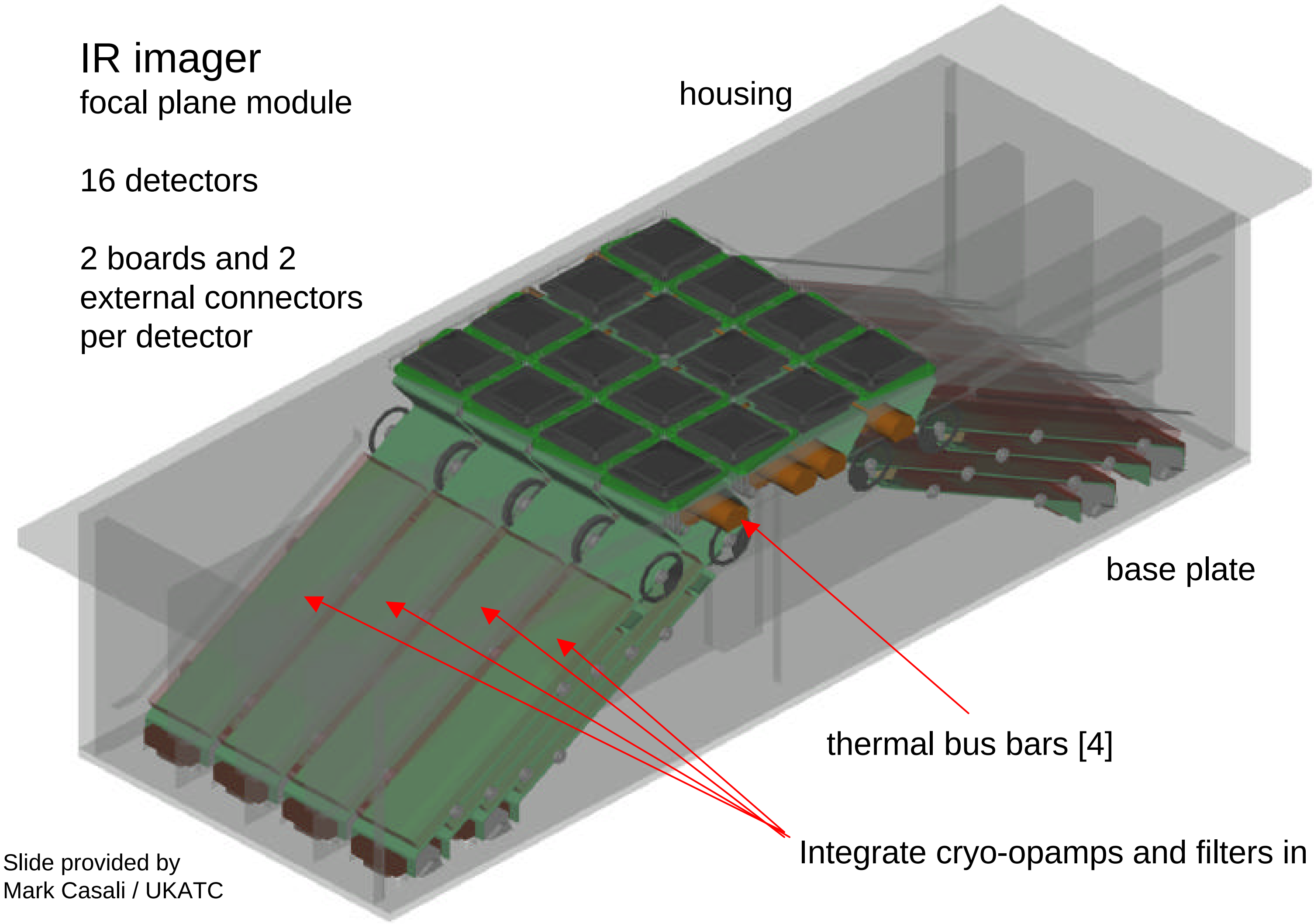
VISTA focal plane

IR imager
focal plane module

16 detectors

2 boards and 2 external connectors per detector



- 16 2Kx2K arrays each having 32 parallel outputs
- 512 channel IRACE system
- readout time 1.3 s

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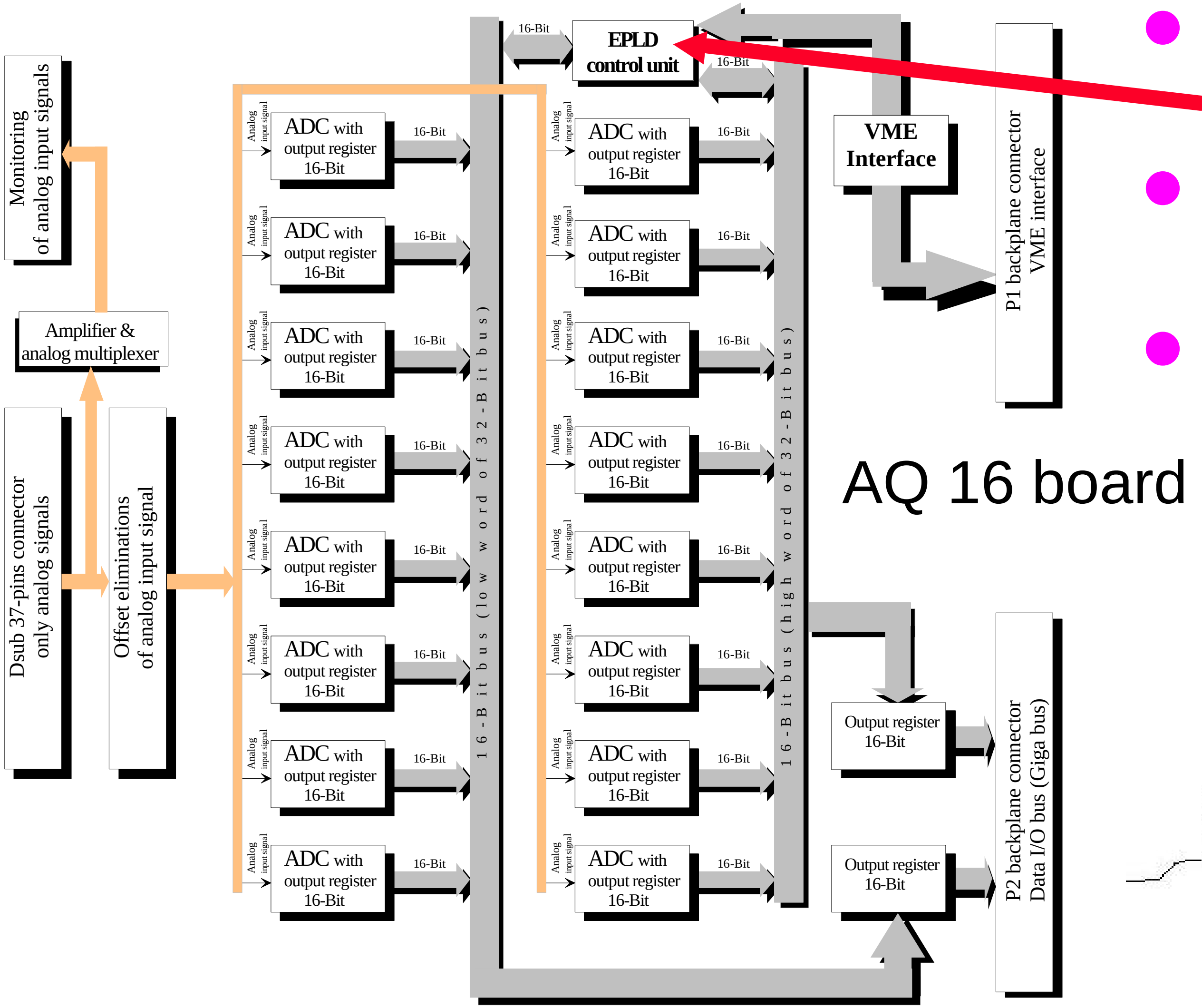
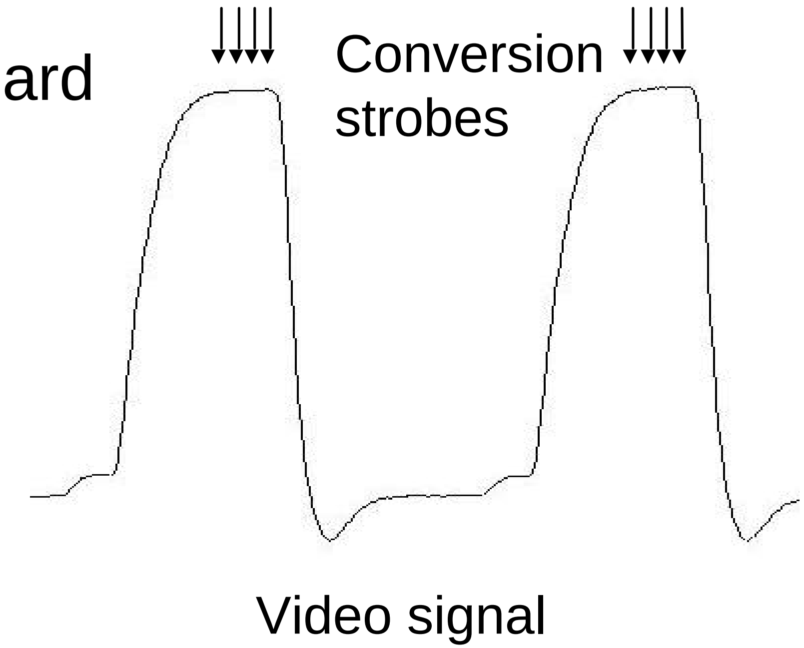
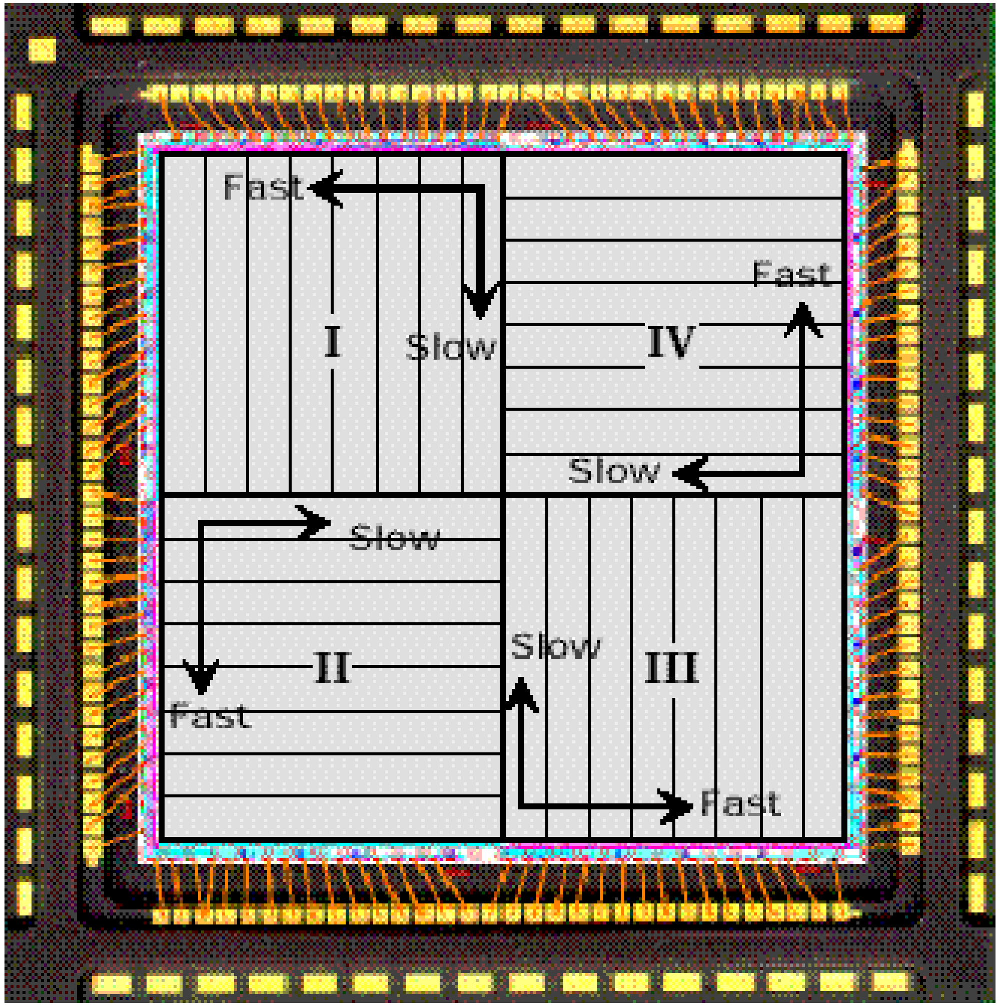
Digital filter in EPLD of AQ16



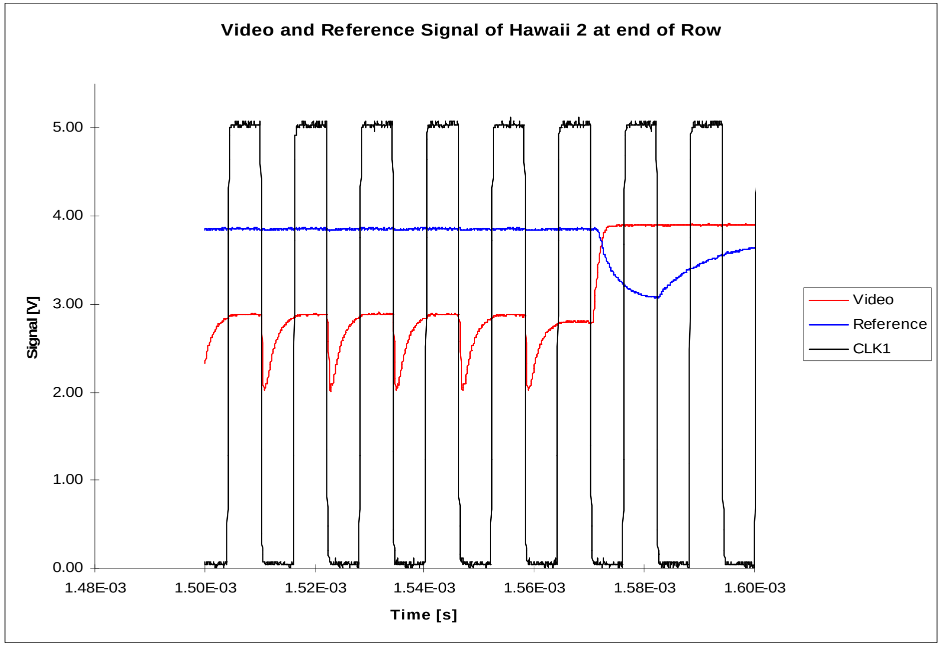
- process subpixel samples in EPLD
- parallel processing 1 processor /AQ board
- digital filter of video signal



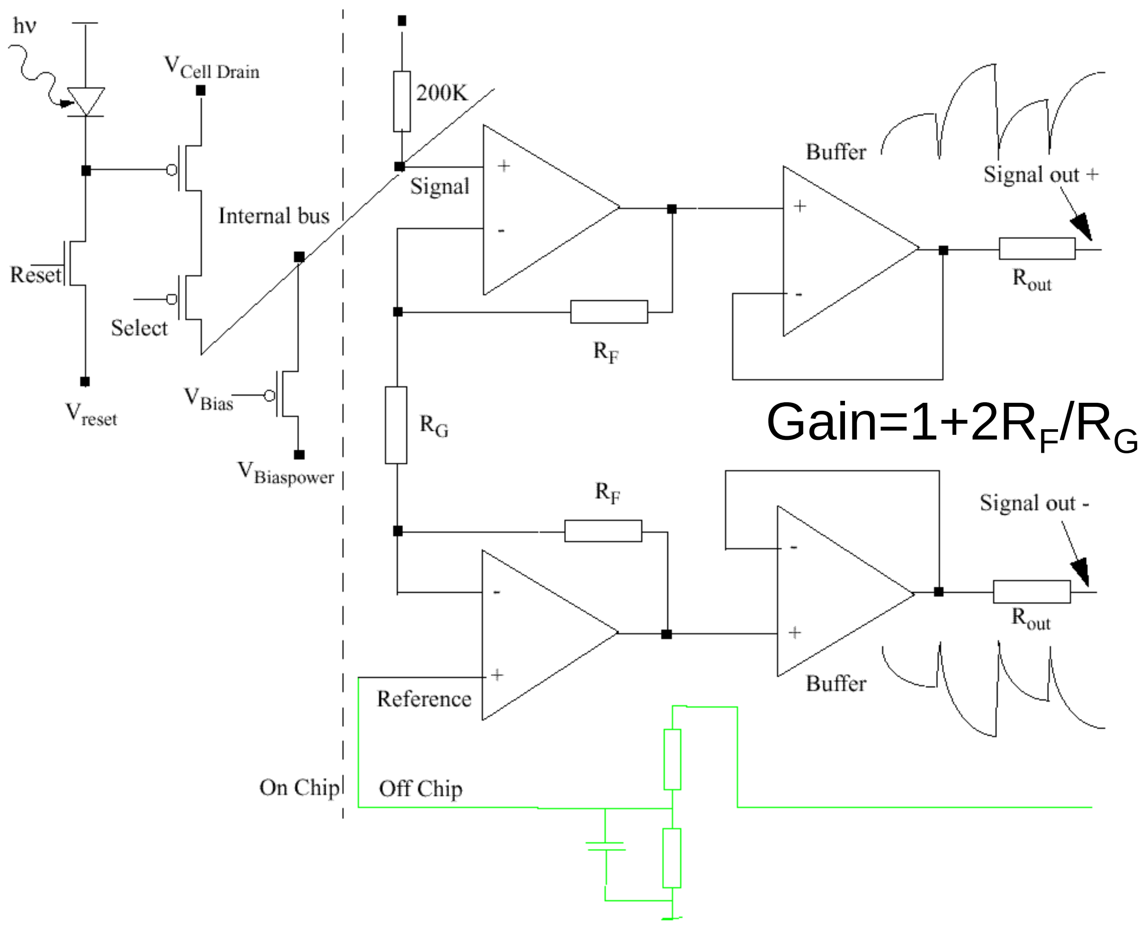
Reference unit cell (Hawaii2)



- 8 video outputs / quadrant
- 128 pixels in fast direction
- reference pixel for thermal drift is 129 th pixel on 9 th output
- 36 channels / detector required

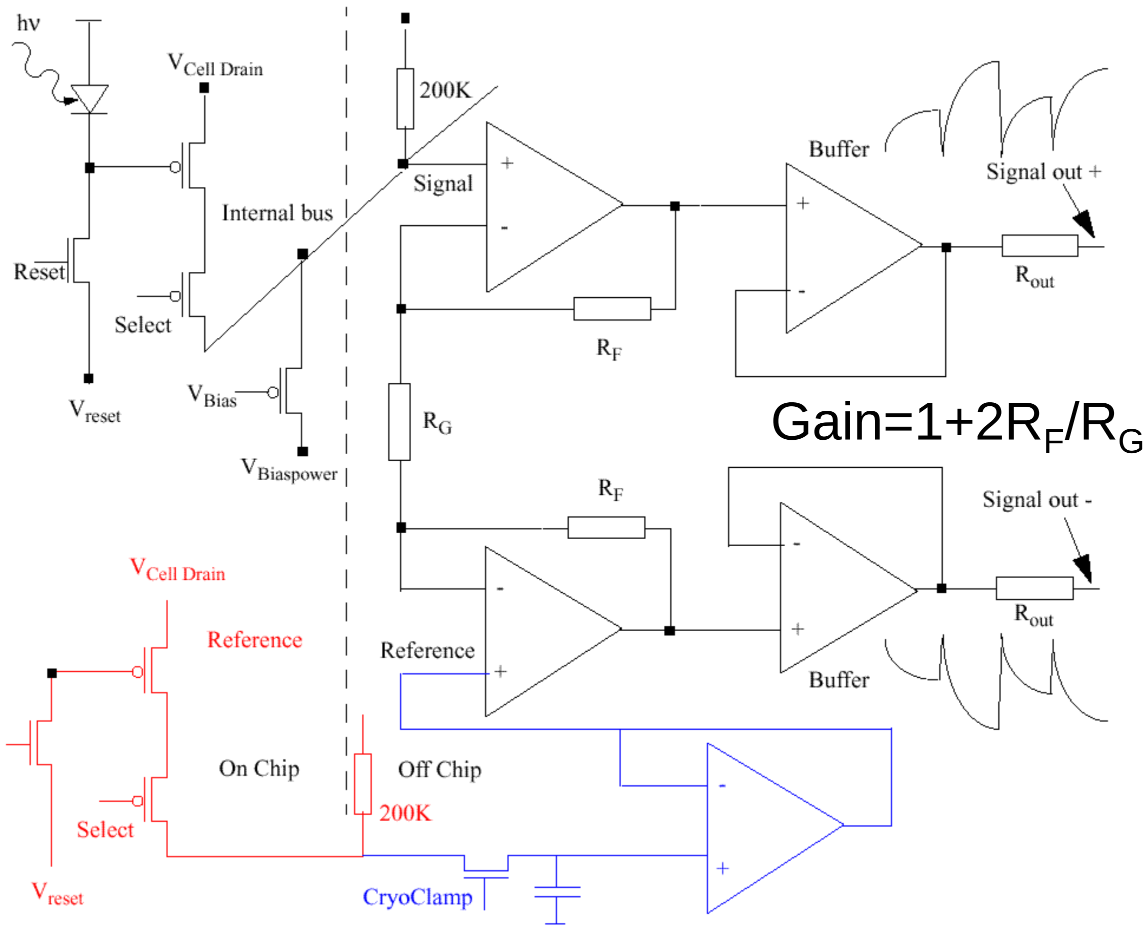


External reference with Hawaii1



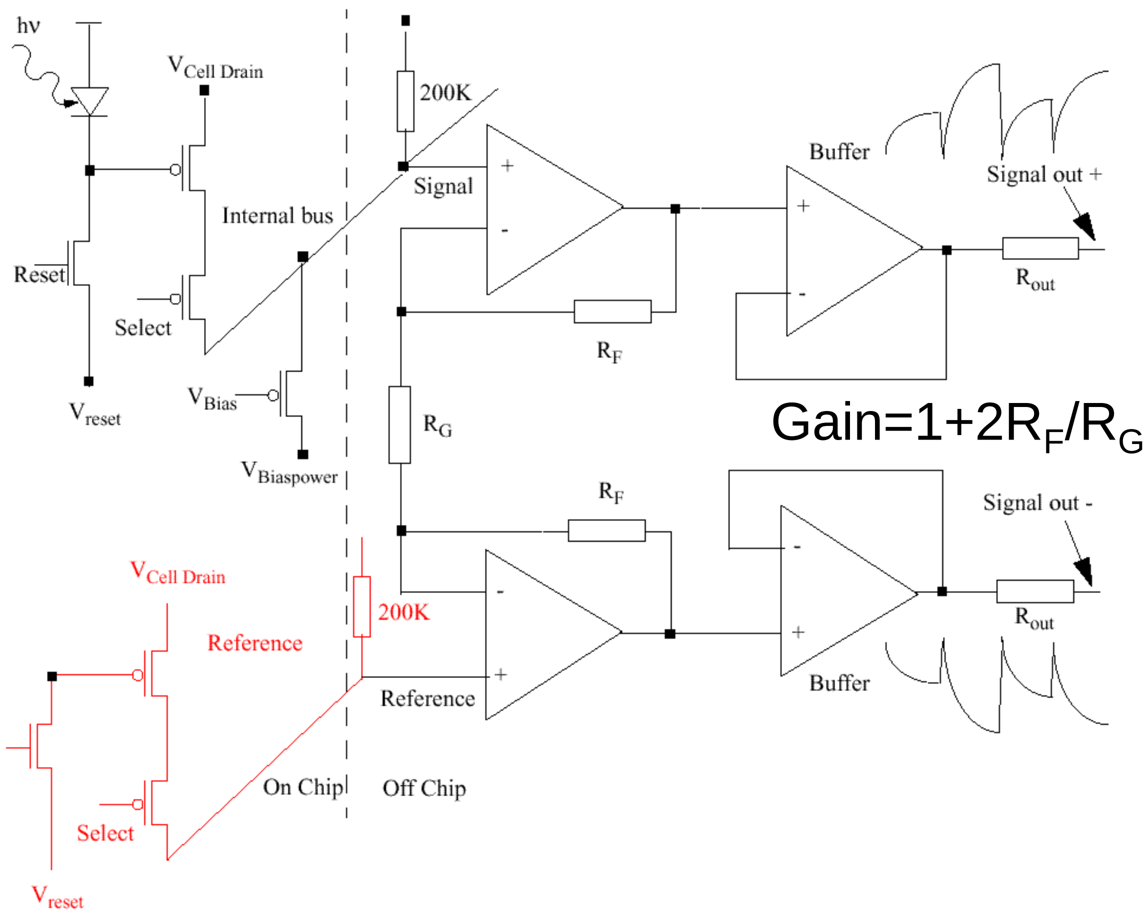
- No reference output provided on chip
- external reference has to be used

On chip reference cell of Hawaii2



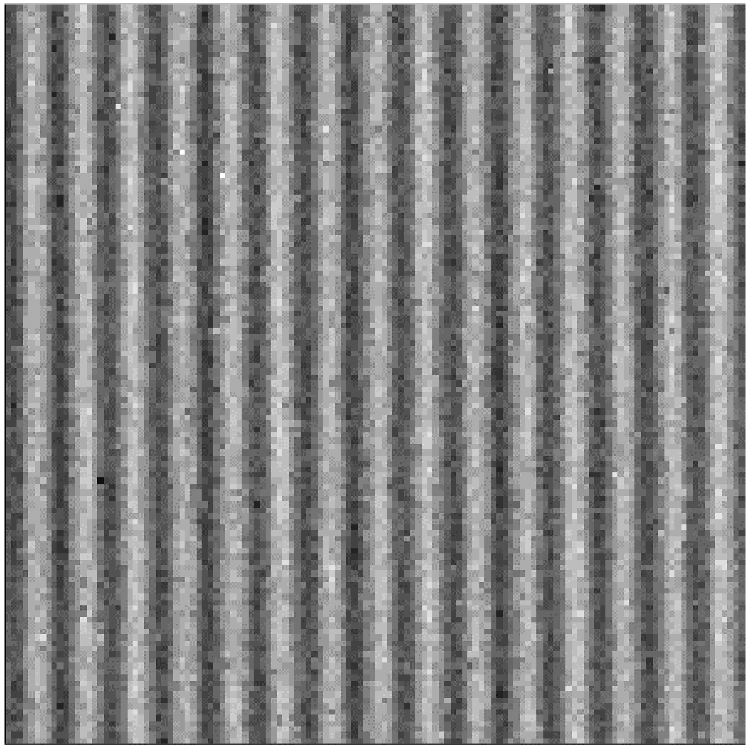
- reference pixel for thermal drift compensation and suppression of pickup is 129 th pixel on 9 th output
- reference pixel not available while reading pixels
- clock first to reference pixel
- clamp reference pixel with cryogenic sample and hold
- read pixels of row with clamped voltage at reference input of cryo-opamp

On chip reference cell of Hawaii2-RG



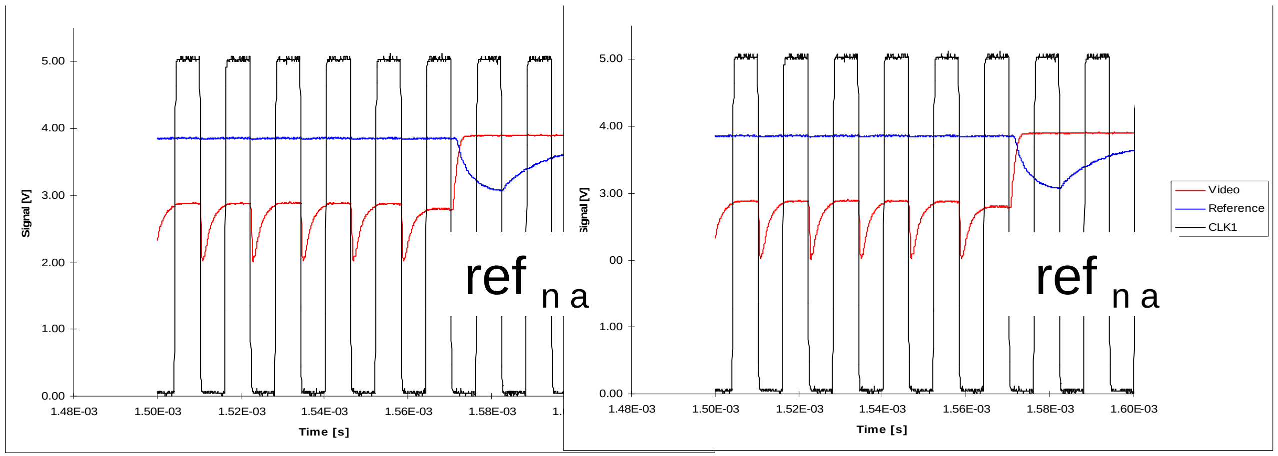
- reference pixel for thermal drift compensation and suppression of pickup on 9 th output, but
- reference pixel available while reading pixels
- read pixels of row with voltage of reference cell at reference input of cryo-opamp
- best suppression of noise pickup

50 Hz pickup of Hawaii2 without clamp of reference

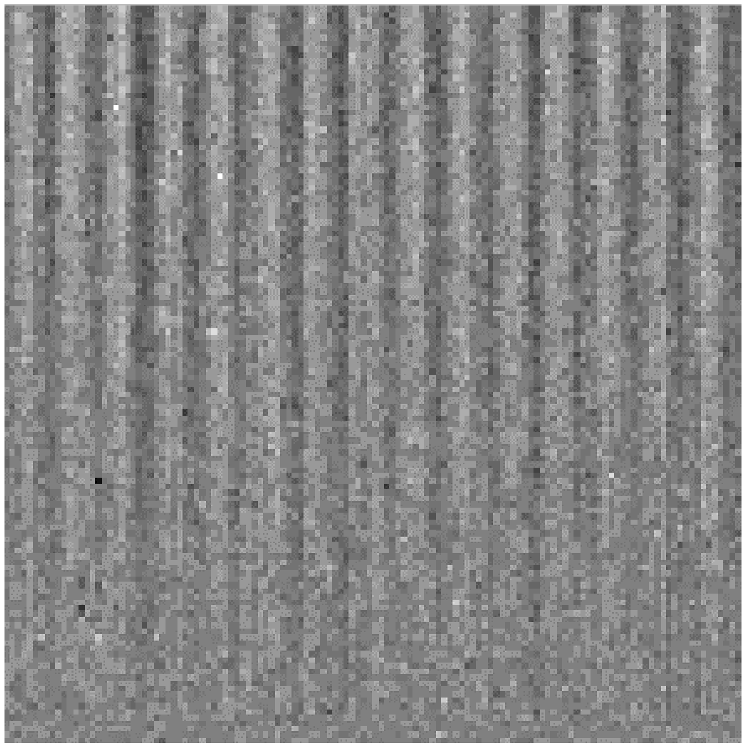


- multiple sampling reduces readout noise and requires lower pickup noise
- Clock each row once and read once
- reference output (129 th pixel on 9 th output) is not used
- 32 channels / detector required

Row n-1 Row n

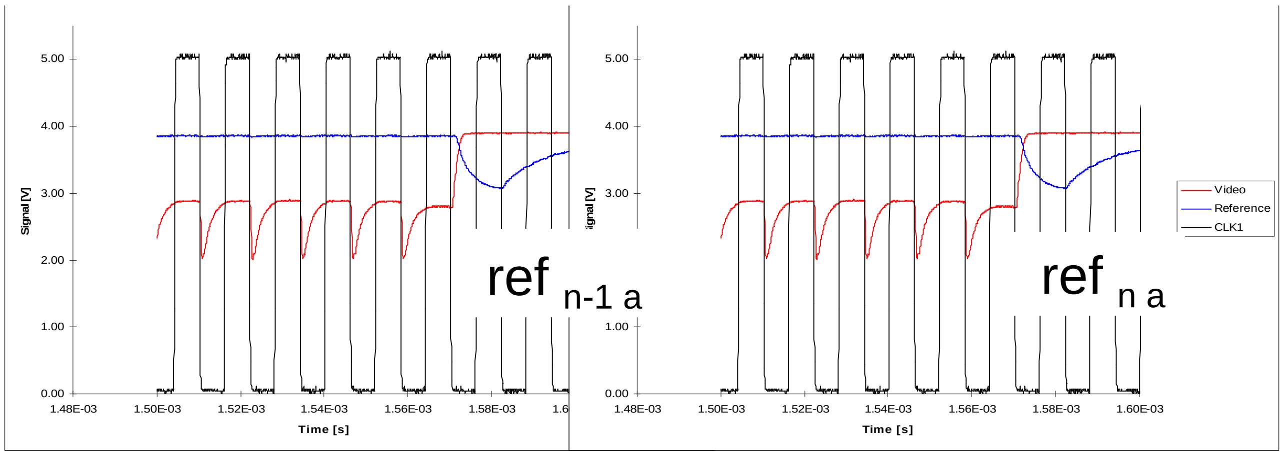


50 Hz pickup of Hawaii2 with digital clamp

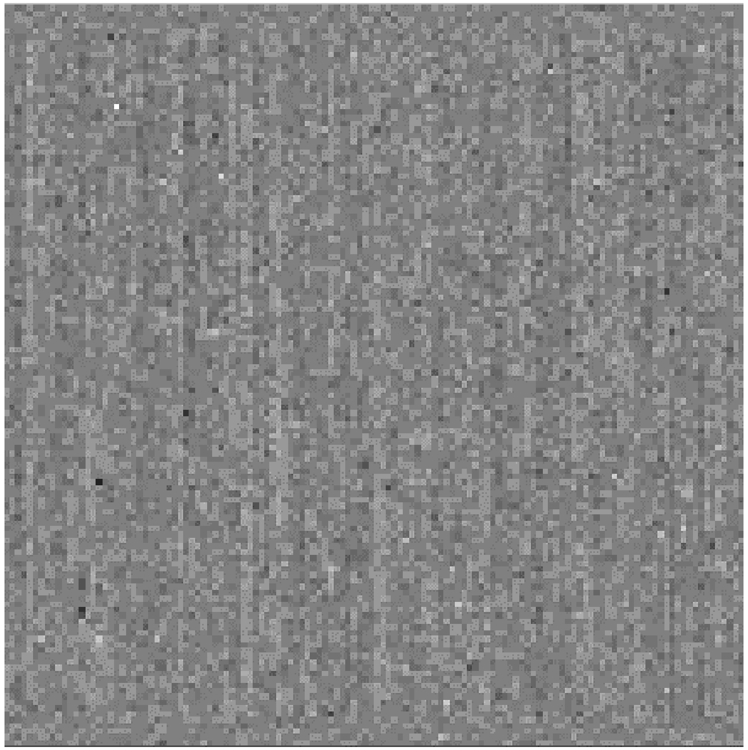


- Clock each row once and read once
- read reference after reading row and and subtract reference signal for each pixel
  $sig_{nk} = pix_{nk} - ref_{na}$
- 36 channels / detector required

Row n-1 Row n

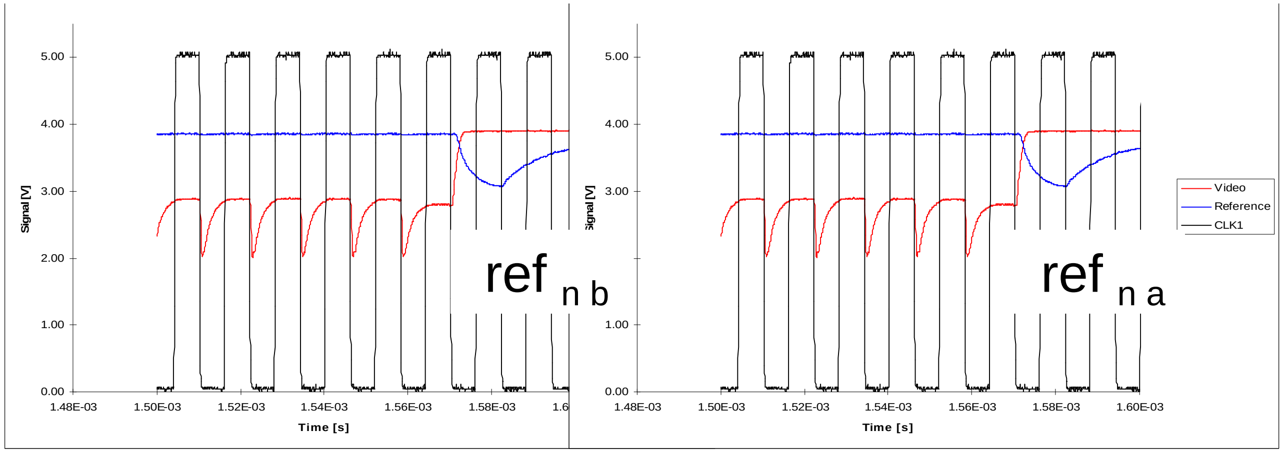


50 Hz pickup of Hawaii2 with interpolated digital clamp



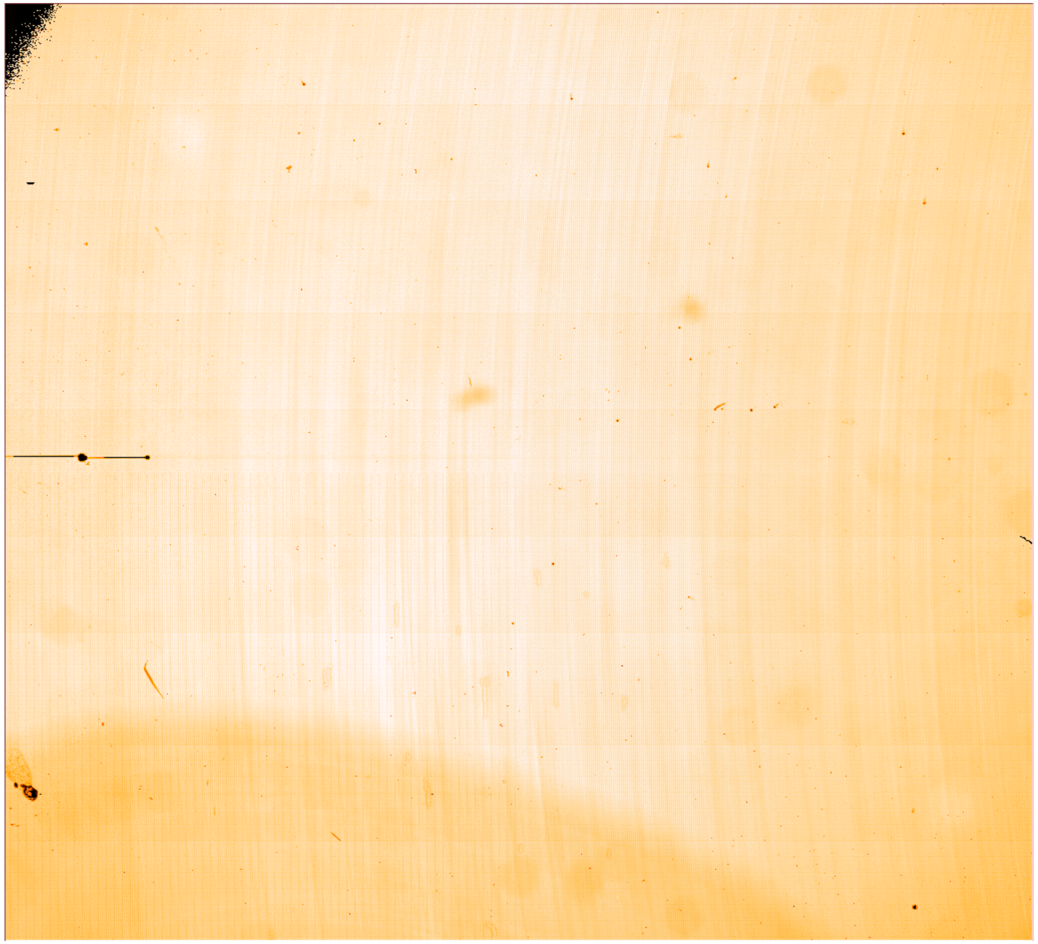
- Clock each row twice and read once
- read reference before and after reading row and interpolate reference signal for each pixel
  $sig_{nk} = pix_{nk} - (ref_{nb} - (ref_{nb} - ref_{na})*(k-1)/127)$
- 36 channels / detector required
- reference allows rejection of low frequency pickup and compensation of thermal drifts

Row n   Row n

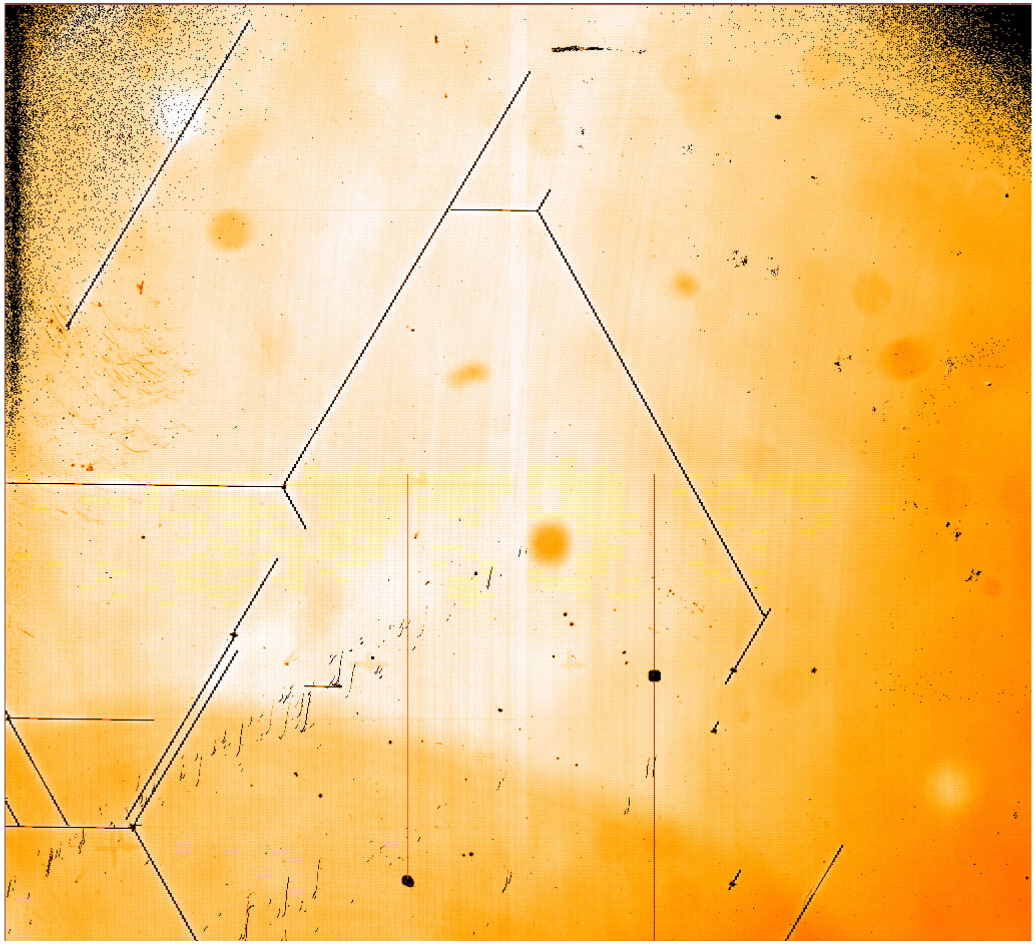


Aladdin #3 & #4

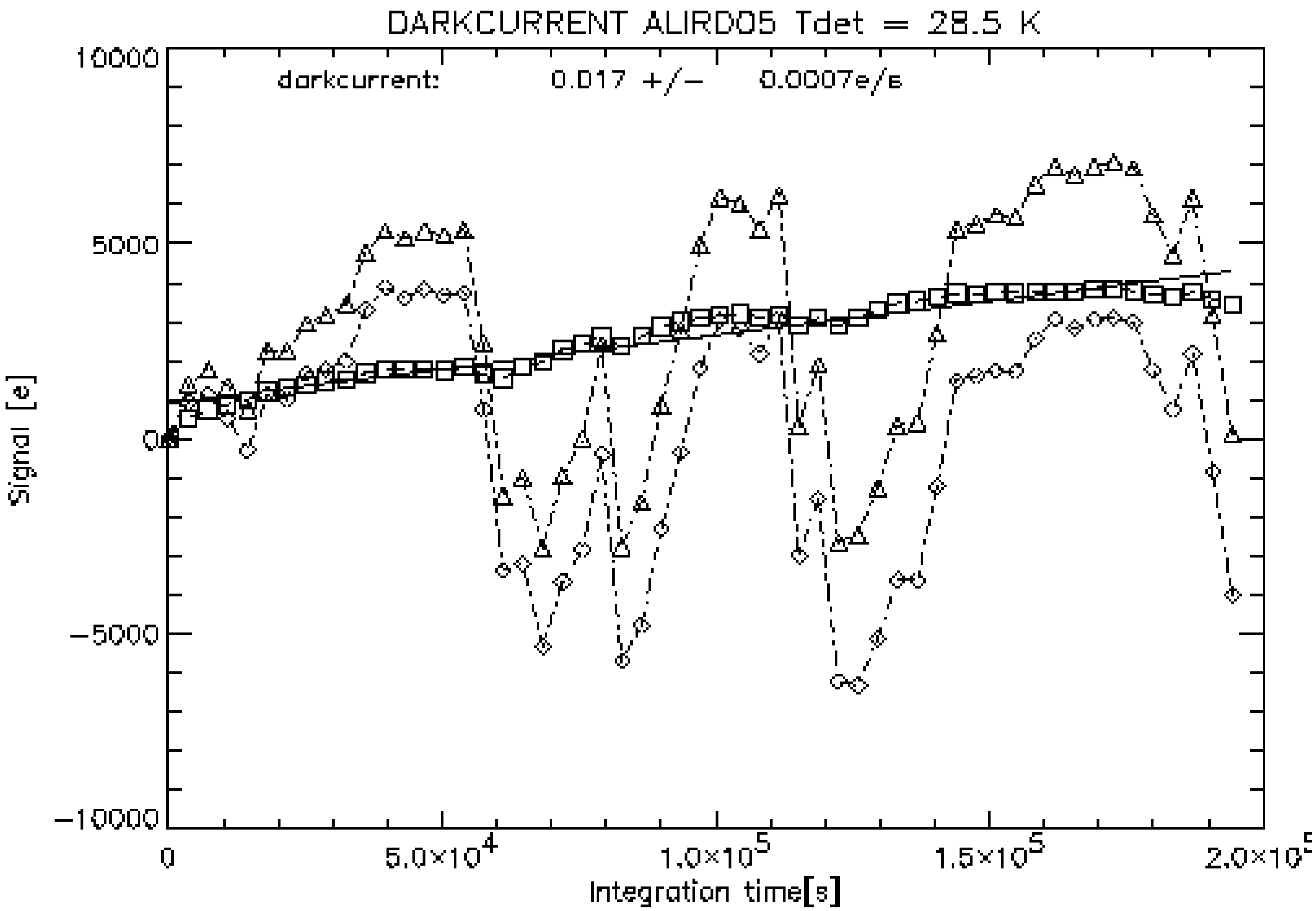
#5: QE H = 0.82 (ISAAC)
darkcurrent = 0.017 e/s



#4: QE H = 0.86
darkcurrent = 0.004 e/s

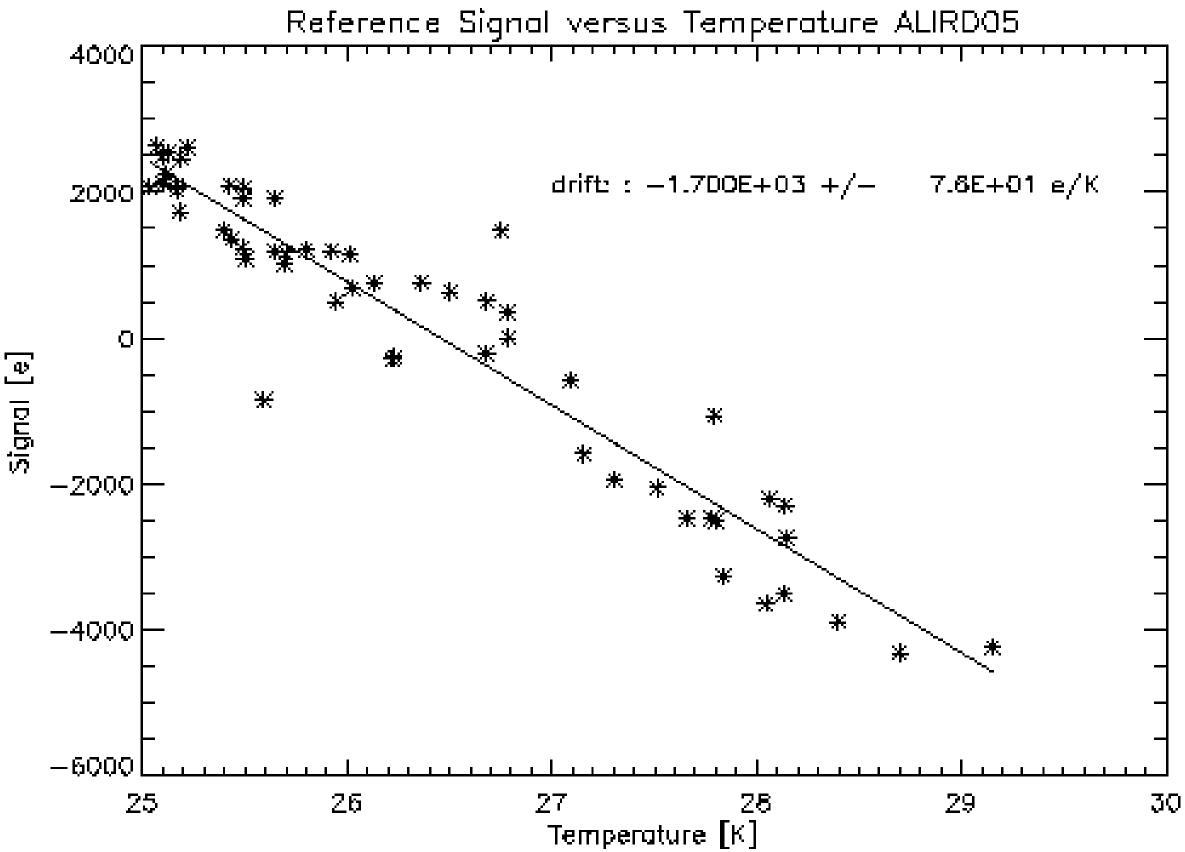


Monitor temperature drift using dead pixels



- Triangles: measured integration ramp
- Diamonds: dead pixels
- Open In bump bonds are used to monitor drifts
- Squares: drift corrected integration ramp
- darkcurrent at 28.5 K: 0.017 e/s/pixel

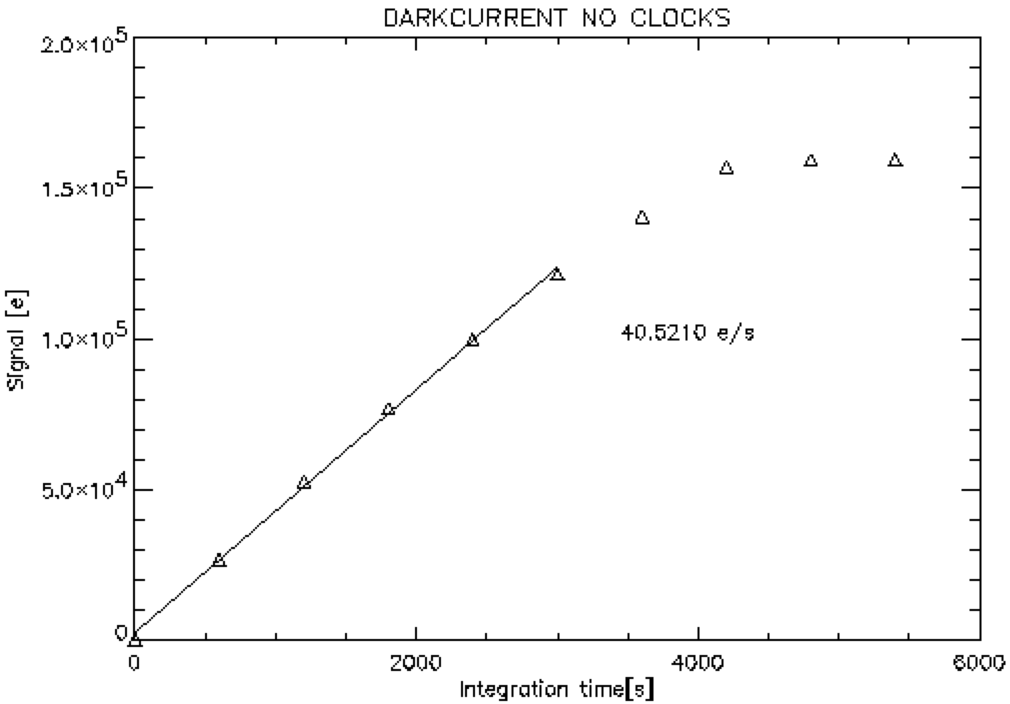
Temperature drift of dead pixels in Aladdin array



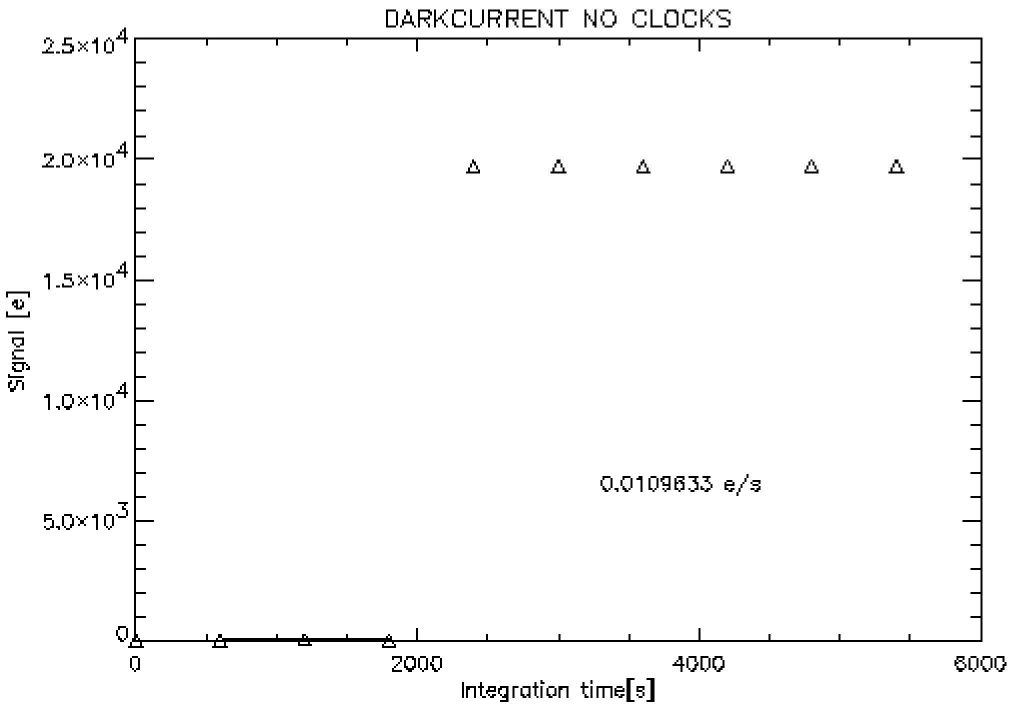
- Temperature drift: 1700 electrons / K
- required temperature stability of array: 6 mK
- temperature drift will be monitored with reference unit cell of Hawaii-2RG

Elimination of cosmic rays by multiple sampling

Warm pixels
continuous integration ramp



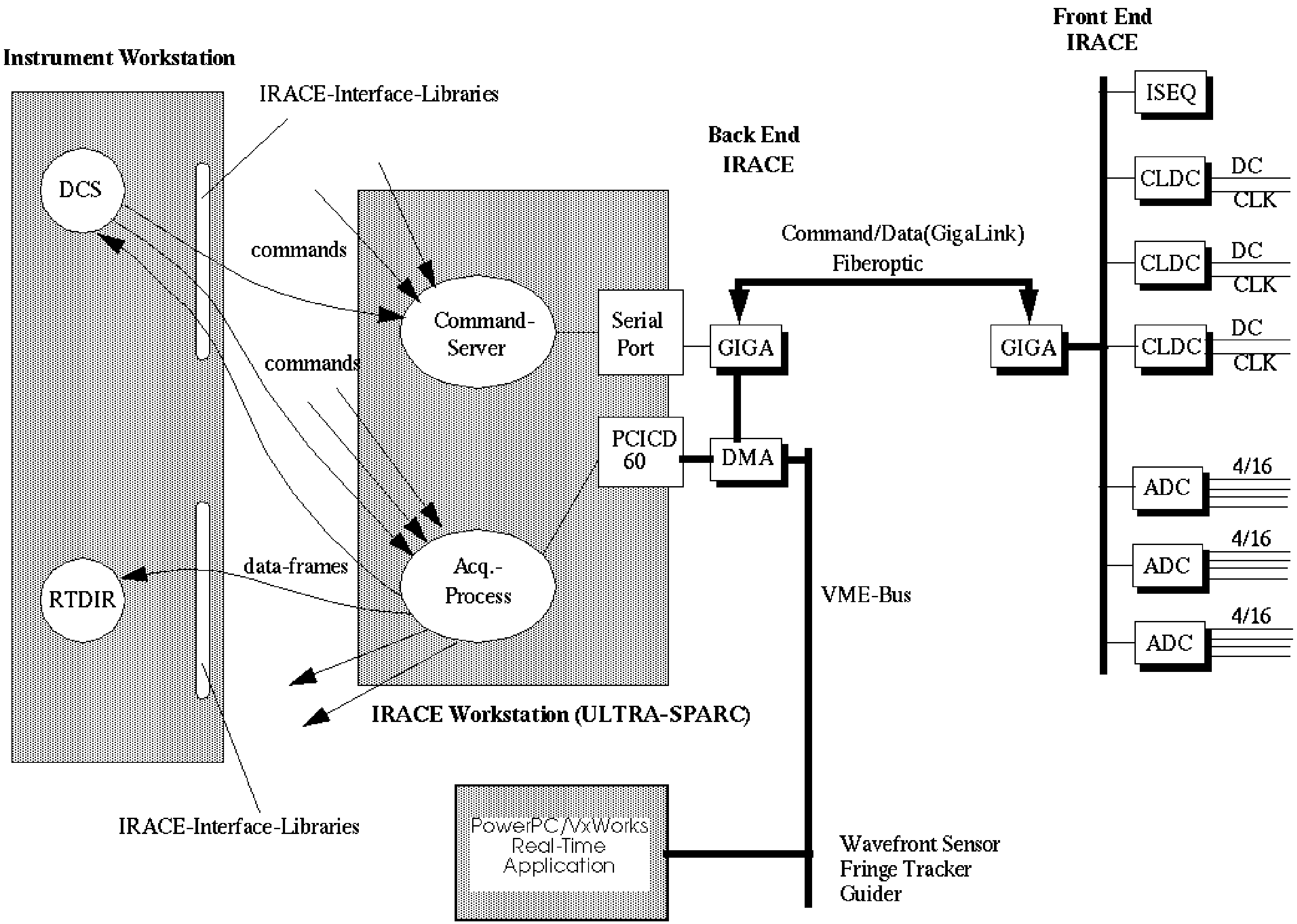
Cosmic rays create charge burst
and step in integration ramp



Cosmic Ray Correction

- At Paranal (altitude 2600 m)
  2038 pixels / hour are hit
- maximum charge injected by comic ray
  ~ 2E4 electrons < full well (1E5 electrons)
- correction by multiple nondestructive sampling and real time processing in IRACE number cruncher using idl routines
- at present more warm pixels than cosmics, but arrays may improve (MBE)

Parallel Processing of Detector Data in IRACE



- mark digitized video signal with different headers
- process video signal in IRACE number cruncher (ULTRA-SPARC) for science frame
- process subwindow in PowerPC on VME bus for real time applications

Conclusion

- Mosaics of 2Kx2K arrays are coming
- need 5 MHz 16 bit ADC's and 3 Gbaud fiber link
- use of unit cell reference for true differential signal chain
- more real time image processing with faster processors
- General purpose ASIC needed for ground based applications