NOTCam as a test bed for NTE

STC-meeting, La Palma, 15/4-2015
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Outline of talk

- NTE IR-spec and IR-ima detectors will be Hawaii-2 RG arrays
- An infrared detector controller is needed
- Status of NOTCam array controller
- Hawaii-1 versus Hawaii-2 RG array
- Testing in NOTCam: pro's and con's
- Requirements
- Estimate of the work load required at the NOT

NTE IR arm – Hawaii-2RG arrays

- NOTCam: 1k x 1k x 18 µm Hawaii-1 HgCdTe (Mer-Cad-Tell)
- NTE: 2k x 2k x 18 µm $\lambda_c \sim 2.5$ µm Hawaii-2 RG arrays (SPEC and IMA)

- NTE with two new IR arrays needs a working IR detector controller
- Existing H2RG array controllers (SIDECAR/Teledyne, IRACE/ESO, MPIA RO electronics/CalarAlto, …?)
- Copenhagen CCD3COMM IR variant (does not exist yet)

Challenge: Write and test a completely new IR controller package for NTE (CUO)

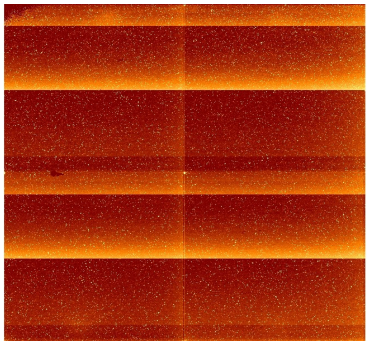
Why testing in NOTCam?

- Time constraints for the NTE
- IR array + new(!) IR controller testing is time-consuming
- Real tests are done in a vacuum vessel and at T < 80 K
- Performance is best tested with telescope, on sky (pick-up noise, std stars)
- Good to know array performance for NTE
- The H2RG array is already ordered – arrival expected in May
- A potential gain for NOTCam

What is in it for NOTCam users?

- NOTCam has been waiting for a controller upgrade since 2001 (!)

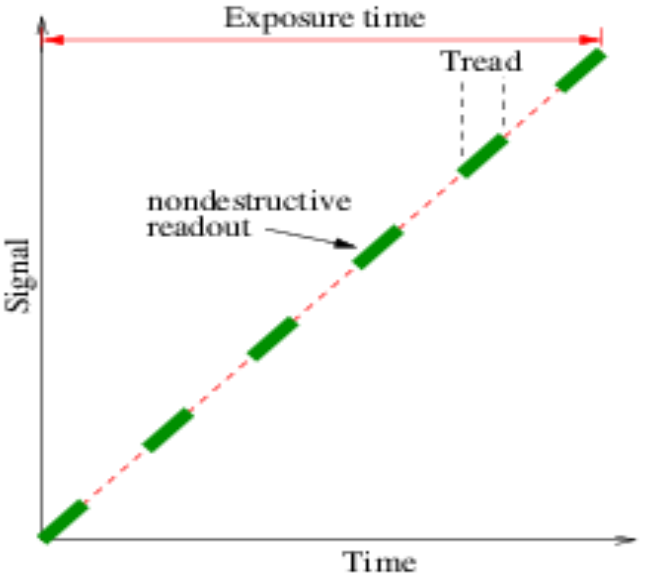
- Out-of-spec features:



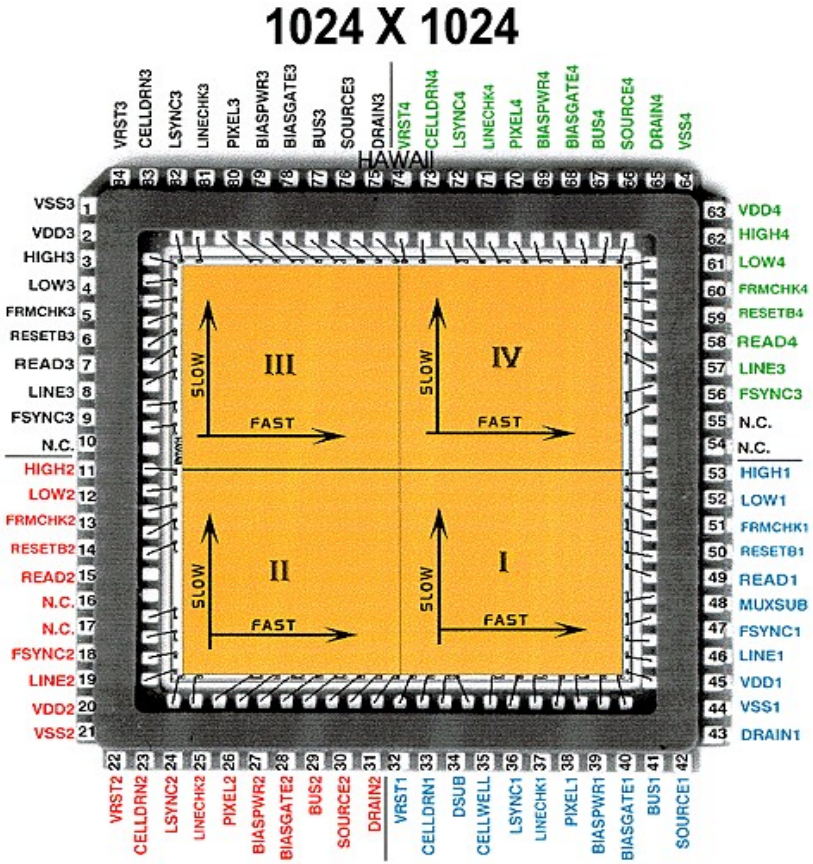
long **readtime** (3.6 s vs. specified to 1 s)
can not abort an exposure
dead columns at the start of each quadrant
crazy darks

- Minimum exposure time = **readtime**
  (continuous reading, cycle time = 2 x **readtime**)

- If shorter, then you need **the shutter** (!)
  time = **readtime** + expt + **readtime** + oh
  NOTCam overheads are tremendous!



Hawaii-1

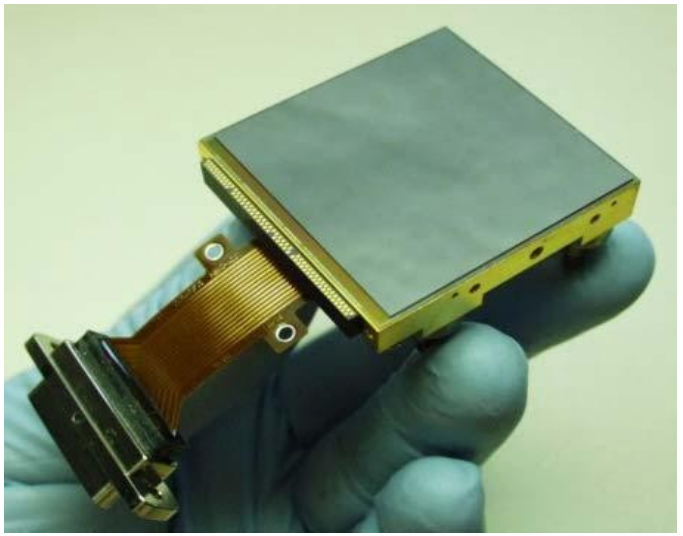


NOTCam: 512^2 pix/3.6s ~ 70 kpix/s
Readnoise ~ 8-9 e

Hawaii-2RG

- 2048 x 2048
- Substrate removed
- 1, 4, or 32 readout ports (programmable)
- Reference pixels
- Guide window
- Full-frame readout-rates

  < 0.1 Hz to 80 Hz
- Readnoise: 7 – 25 e (DCS)



Examples of H2RG arrays in use

Hawk-I/VLT

- 4 readout ports, 100 kpix/s,
  full frame readtime = 10.6s
- RN ~ 12 e (DCS)
- RN ~ 5 e (N=10, multiple reads)
- Min. exptime = 1.7 s
- Min readtime = 1.7s, cont. read
- Overhead = 8s

Omega2000/CalarAlto

- 320 kHz clock rate
- Min. exptime:
  (2048 x 2048 / 32 ports) * 2/320kHz
  = 0.8 s

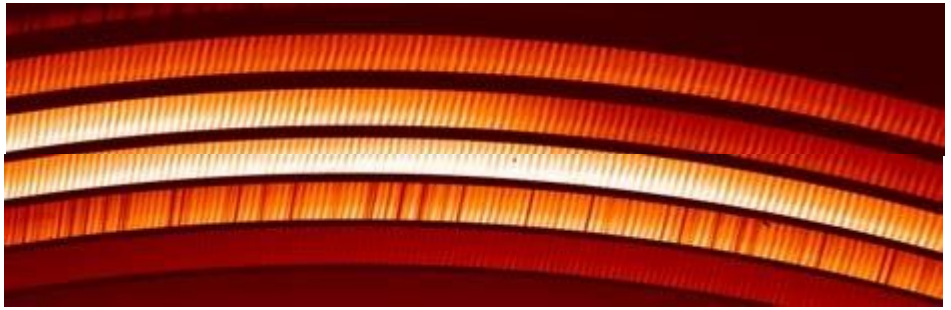
X-Shooter IR arm

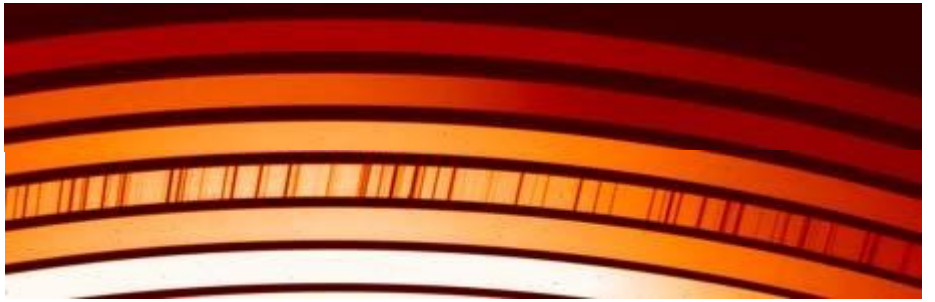
- 4 readout ports?,
  full frame readtime =
- RN ~ 25 e (DCS)
- RN ~ 8 e (expt > 300s, N > ?)
  readtime = 1.46 s?
- Min single exptime =0.66s
  Ramp-sampling only mode
- QE = 85%
- Bright star limit: H = 3 mag

Improvements for NOTCam

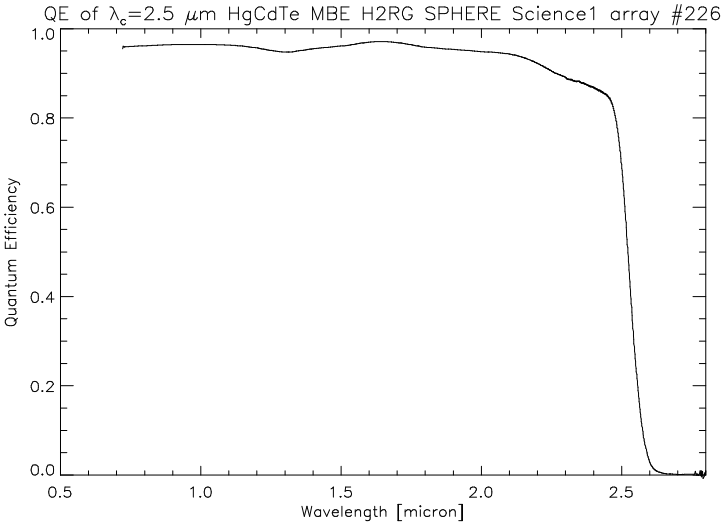
- NOTCam fringe level is at ~15% peak-to-peak

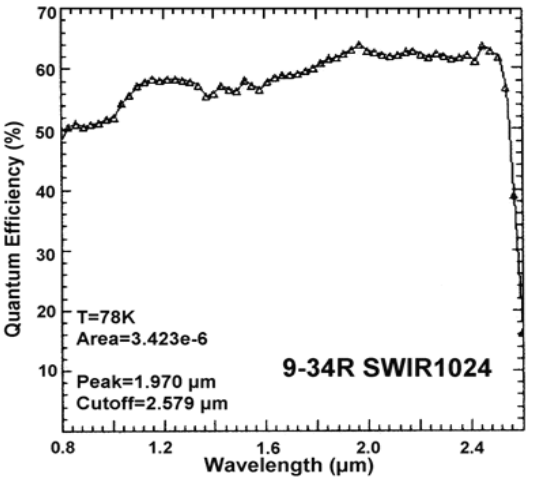
  fringes + flexure = problem!
- New generation H2RG are fringe-free (CdZnTe substrate removed)





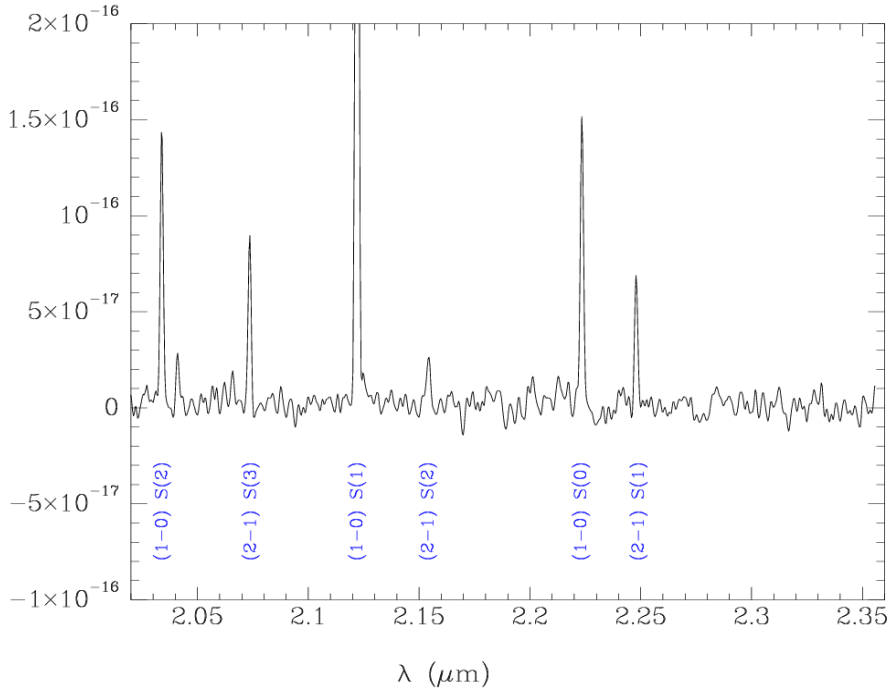
- QE ~ 85%

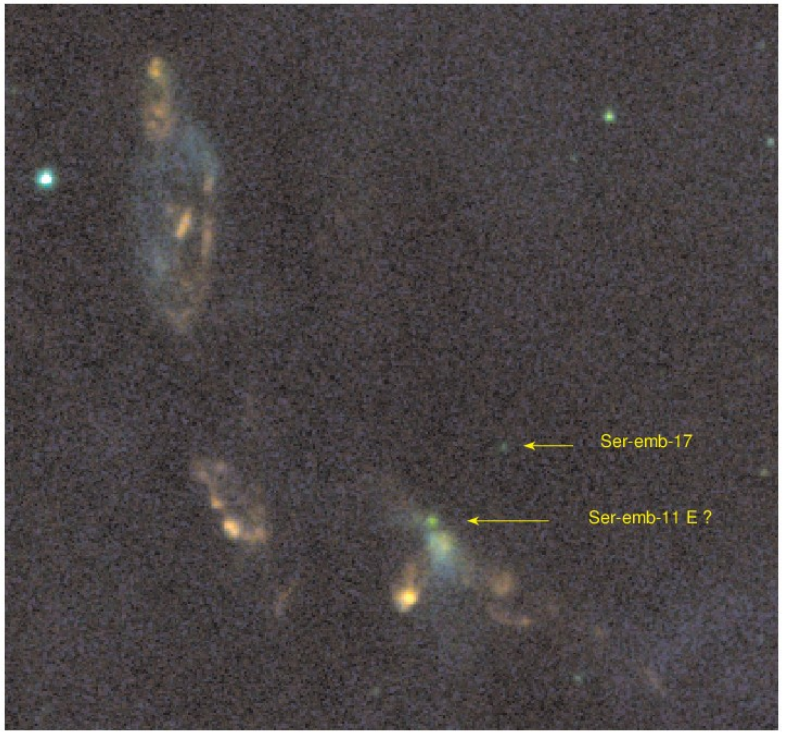




Extra gain for NOTCam - I

- NOTCam can do **K-band spectroscopy** – not available with NTE

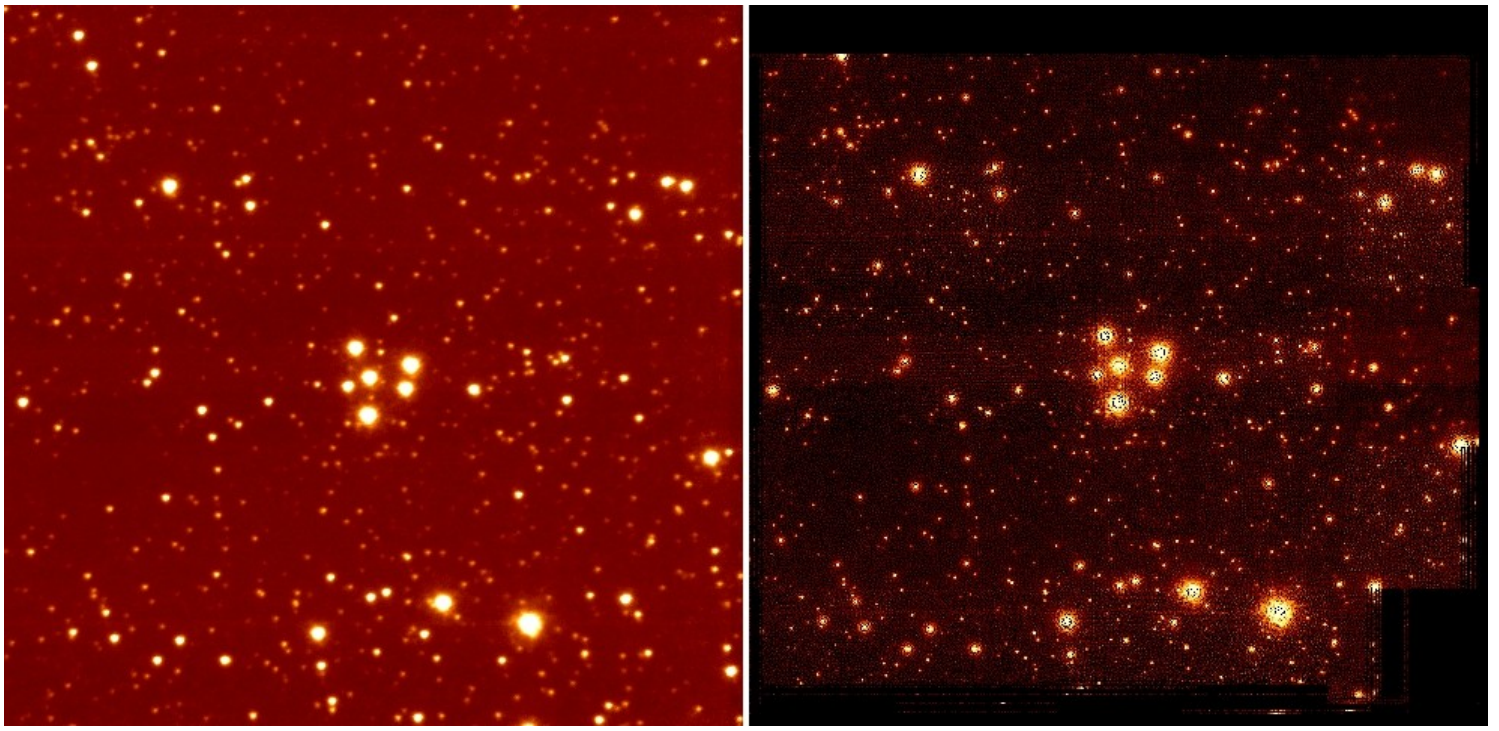




Embedded protostellar jet (Djupvik et al., in prep)

Extra gain for NOTCam - II

- **High-resolution (0.078”/pix) imaging** with the HR camera (not with NTE)



R. Schödel, IAA,

ERC Consolidator Grant
Holography technique for image restoration
Hawk-I/VLT and NOTCam/NOT

NTE vs NOTCam requirements

- NTE focuses mainly on spectroscopy – NOTCam BB imaging (90% of use)
  low background vs. high background application
  different requirements wrt read noise and data acquisition speed
- For spectra: reading in strips is preferred
- For fast imaging: 4 quadrants with center windowing is preferred
- Risk of saturation and persistence higher for BB imaging ?
- Mainly long exposures vs. mainly short exposures

Requirements on DAS speed

NOTCam capabilities must be improved or equal (not worse)

- Already specified in detail for a **NOTCam controller upgrade** in a 34 page document we wrote in 2012, for the Hawaii-1 array

  http://www.not.iac.es/instruments/development/IR_user_requirements.pdf

- Data acquisition rate **must** be improved !
- Minimum exposure time:

  Now: 0.6s (shutter) and 3.6s (no shutter)

  Importance: saturation & charge persistence

  Required: 1s, if not possible, then shutter must be programmed
- Maximum full frame readout time:

  Now: 3.6s (4 read ports, 73 kpix/s)

  Required: 1s (32 ports: 131 kpix/s, 4 ports: ~ 1Mpix/s ?)

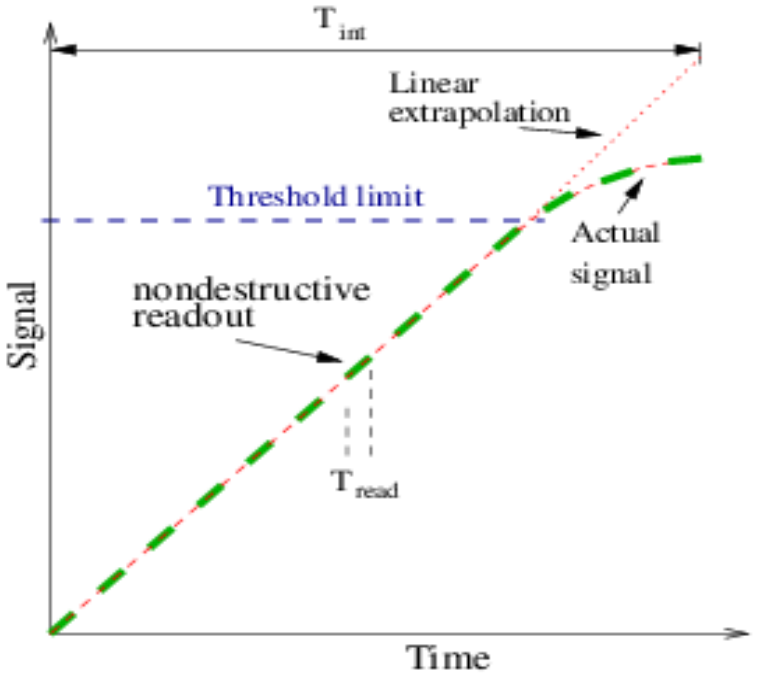
General requirements

- Read noise: TBD Now: 8-9 electrons
- No controller induced features

  Now: dead columns, no abort, dark level jumps
- Include detector temperature control Now: none
- Preferentially reading 32 outputs, not only 4
- Include threshold limited integration (TLI, add figure)
- Ramp-sampling and fowler-sampling read modes
- Options to set the read speed (fast mode with more read noise)
- Windowing to improve speed?
- How to configure and use the H2RG guide window?

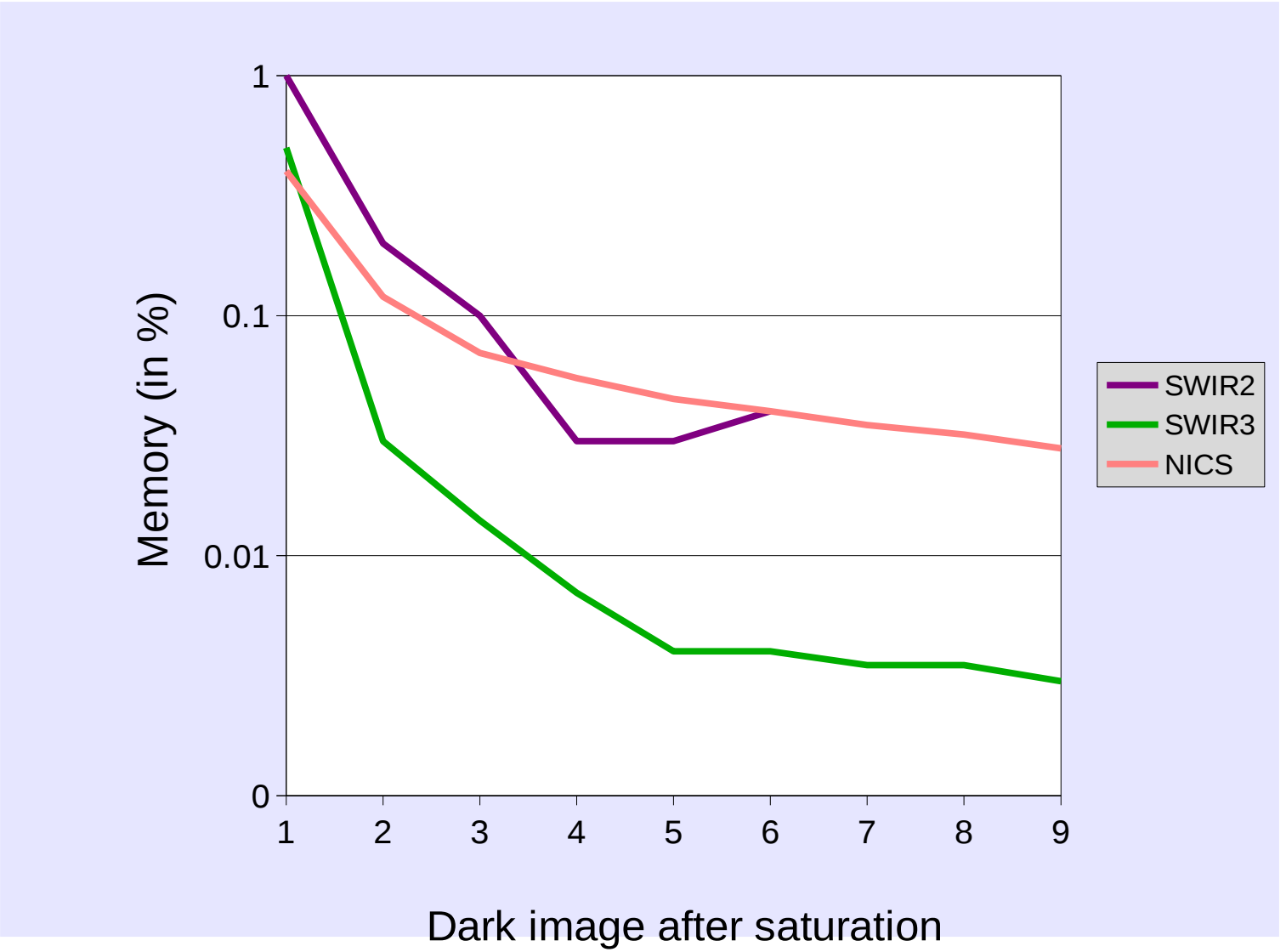
Before stating requirements more technical info is needed

Threshold Limited Integration



To be applied to the linear Regression analysis on Ramp-sampling readout

Persistence / memory



NOTCam work to do

- Physically larger detector (detector flange replacement)
- Controller box (cable length issue?)

- Off-telescope testing (CUO and NOT)
- Commissioning (tech time)
- Different data format and higher data rate
- Current data acquisition system must be modified (sequencer)
- New post-processing tools (reset subtraction, linear regression etc.)
- All Quality Control procedures and scripts need a major upgrade
- New models of: 1) the optical distortion, 2) non-linearity, 3) illumination corr.
- All data reduction software (notcam.cl) need a major upgrade

Modifications, risks and cost

- NOTCam must(?) be sent to CUO – unavailable at NOT (how long?)
- Teledyne technical document arrives only when the array arrives
- Potential problems/delays with new IR controller (to be expected)
- Device dependent: QE, read noise, persistence effect

Conclusions

- Mutual benefits for NOTCam users and the NTE project
- BUT: risk of delays & non-availability of NOTCam
- ALSO: risk of getting a non-optimal controller for NOTCam

- Must specify requirements on the controller for use in NOTCam
  - document to be made (GC, AAD), pending Teledyne technical sheet
- Agreement between NOT and NTE
- Foresee a substantial work load on NOT staff

References

- Djupvik, Cox, Clasen, Augusteijn, 2012

  IR User Requirements for a new Controller for NOTCam
- Finger et al. 2008

  Performance evaluation, readout modes and ... of HgCdTe HAWAII-2RG mos aic arrays
- ESO X-Shooter manual
- ESO Hawk-I manual
- Gemini GSAOI Detector Characteristics
- Storz et al. 2012
  Standard modes of MPIA's current H2/H2RG-readout systems
- Young et al. 2012

  Using ODGWs with GSAOI: Software and Firmware Implementation Challen ges