



# Infrared Detector Test Facility at ESO

Detector Development Workshop

17 February 2022

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(on behalf of FIAT team)



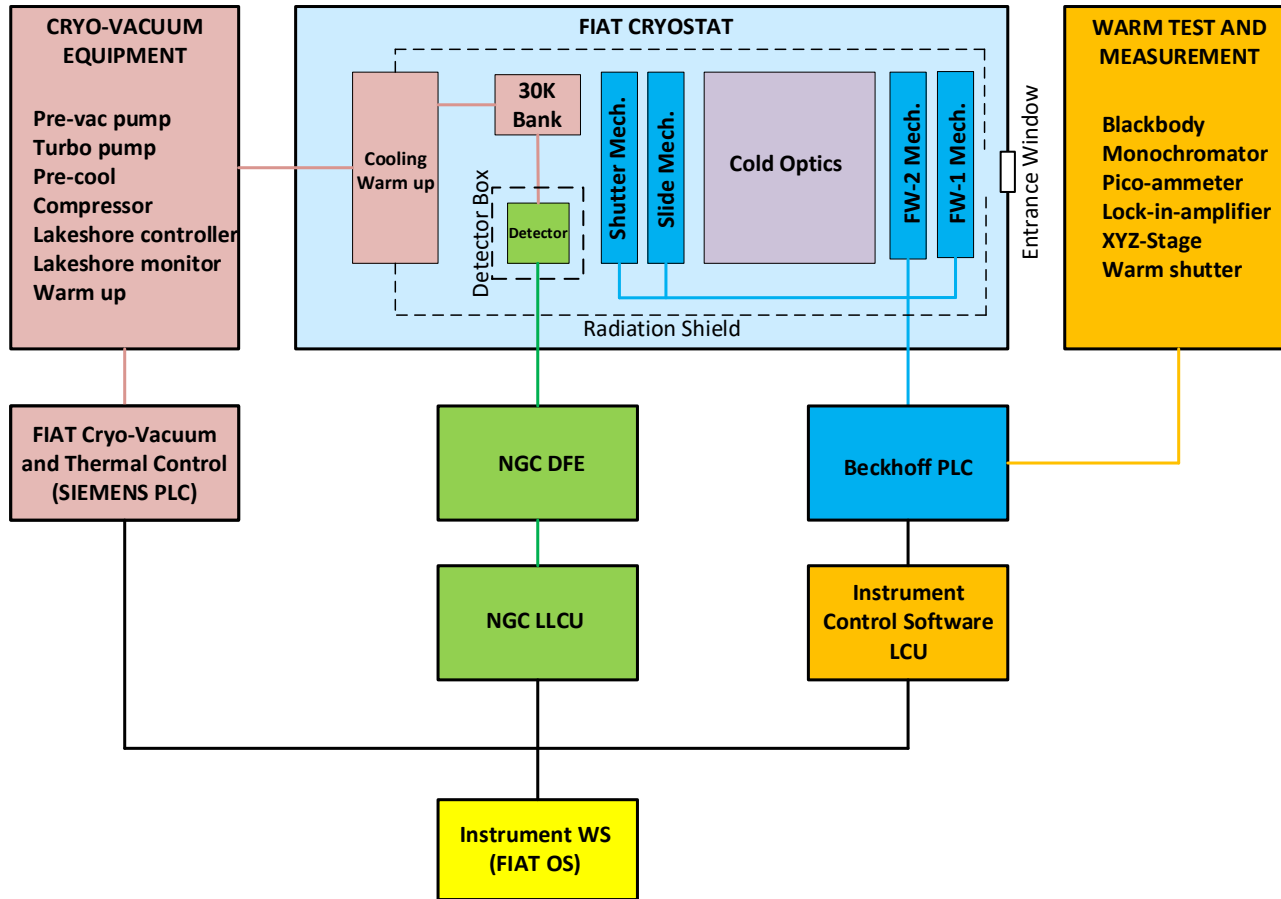
# FIAT - Objectives

## ■ NIR detector test facility

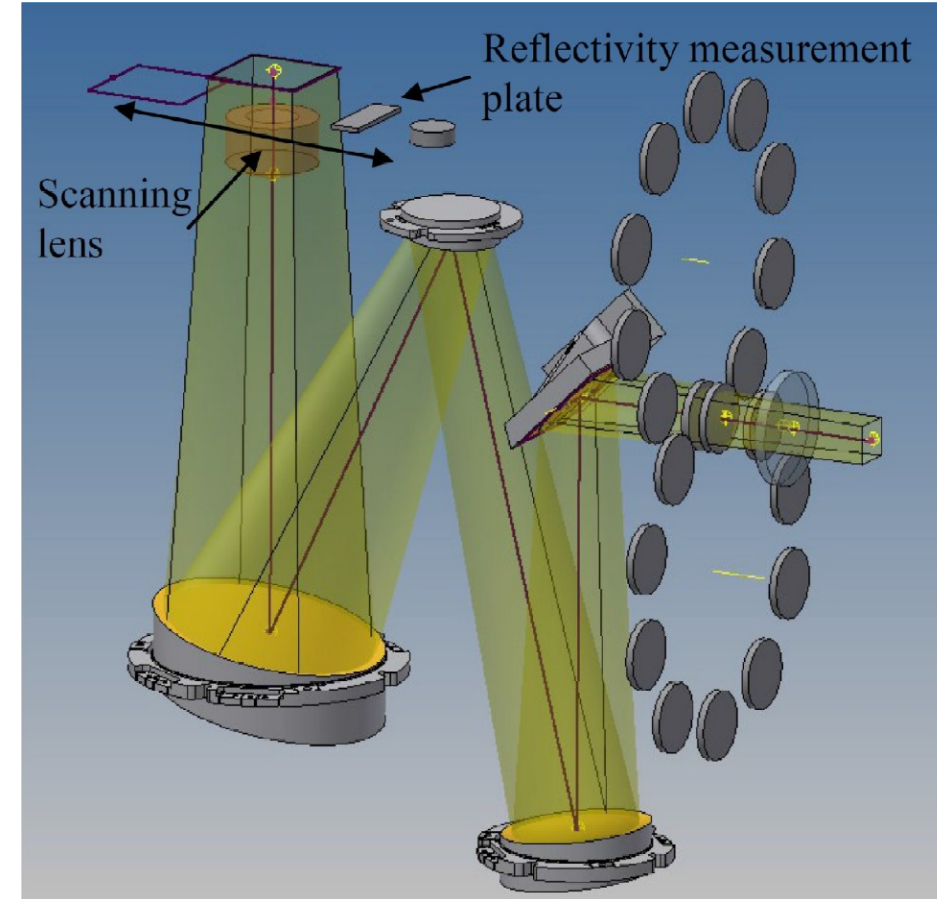
- Characterize all ELT and future VLT Infrared Arrays up to  $5.3\mu\text{m}$
- Conjugated object image focal plane - Full field of view  $\sim 66\text{mm}$  square
- Ultra low background - Detector limited dark measurements
- QE measurements through a set of passband filters up to  $5.3\mu\text{m}$
- Intra-pixel scan and surface reflectivity measurements
- ESO VLT standard cryogenics, electronics and software tools
- Characterisation data in ESO science data archive



# FIAT Block Diagram



FIAT Functional Block Diagram



FIAT Optical Path - Magnification ~2.6



# User Control Interface

**FIAT Vacuum and Cryostat Controller** **Cryostat Overview** 10/28/2021 9:36:26 AM

**Idle** 10/25/2021 1:42:39 PM

evacuation stopped 10/25/2021 1:42:39 PM

**Temperature too low cannot repressurize** 10/25/2021 2:21:32 PM

0 820 501 1 History

**System Pressure** +2  
Low 9.55 · 10 mbar

**Detector**  
293.00 K -0.0 K/min  
291.34 K 0.0 K/min

**PID loop**  
Active automatic  
Output = 0.0 %  
Setpoint = 110.00 K

**Interlock registries**

0	Temperature to
1	PVV status
2	TMP status
3	ACP status
4	None
5	None
6	None
7	None

**Emergency Stop**

Vacuum LS218 Connection OK Warmup ON

Pre Cooling ON 293.00 K 293.02 K Warm

Pre Cooled Current Average 0.02132 K STD Long Term Warm

He CCC ON Detector Interlock Bypassed

Cooled LS336 Connection OK Emergency Pumping

Operational Man. Control Enabled

Start Warmup Stop Warmup Start Evacuation Stop Evacuation

Repressurize Precooling Disabled

Copper Mass Stabilization Inactive Start Precooling Start CoolDown Stop CoolDown

CM Setpoint [K] 110.00 110.00 CM Setpoint LK336 - Ou Enter Operational Status Exit Operational Status

Timers Overview Engineering LakeShore Long Term trends Temperature trends Pressure trends Sequences Thresholds Interlock Thresholds





# Instrument Control Software

- Beckhoff PLCs for Instrument Control Software
  - Cryo-mechanisms
  - Blackbody
  - Monochromator
  - Pico-ammeter
  - Lock-in amplifier
  - Warm shutter
  - Monitor instrument temperature, pressure

FIAT ICS Control - @wfiat

File ICS Devices LCU Maintenance Tools Std. Options Help

State: **ONLINE** idle Op. mode: **LCU simulated** ICDFBs **OK**

Motors \ Lamps/shutters \ Sensors \ Monochromator \ Black Body \ Pico & Lock-in

<input type="checkbox"/> lens	<b>ONLINE</b>	Open	0	Open
<input type="checkbox"/> msh	<b>ONLINE</b>	Closed	3.118560	Closed
<input type="checkbox"/> linx	<b>ONLINE</b>		25.00003	
<input type="checkbox"/> liny	<b>ONLINE</b>		8.000031	
<input type="checkbox"/> linz	<b>ONLINE</b>		25.00003	
<input type="checkbox"/> filt1	<b>ONLINE</b>	CLOSED	0	CLOSED
<input type="checkbox"/> filt2	<b>ONLINE</b>	OPEN	0	OPEN

Risk of collision: NONE

Command Feedback Window Options

```
08:25:57 STOPSIM > REPLY/ L Successfully put device: S7_CRYO in requested mode
08:26:11 ONLINE > INVOKED "-function S7_CRYO"
08:26:14 ONLINE > REPLY/ L OK
```

SETUP STOP

FIAT ICS Control - @wfiat

File ICS Devices LCU Maintenance Tools Std. Options Help

State: **ONLINE** idle Op. mode: **LCU simulated** ICDFBs **OK**

Motors \ Lamps/shutters \ Sensors \ Monochromator \ Black Body \ Pico & Lock-in

<input type="checkbox"/> sensor1	<b>ONLINE</b>	<b>SIM</b>			
Alarm:	OFF	Door:	CLOSED	Ready:	NO
ACH1:	99.99	ACH2:	99.99	ERROR:	0
STATUS:					
<input checked="" type="checkbox"/> S7_CRYO	<b>ONLINE</b>				

COA:	288.60	M4:	292.00	FLTWHEEL:	291.80
SHUTTER:	293.00	RADSHIELD:	291.20	COPPMASS:	292.40
COOLDN:	292.00	WARMUP:	291.90	COATCH:	291.70
CRYVAC:	1039.49	PREVAC:	1533.01	STATE:	0.00
TMP:	OFF	PREVAC:	OFF	COLDHD:	OFF
PVALVE:	OFF	VVALVE:	OFF	LNVALVE:	OFF
TDETA:	291.56	TDETB:	291.13	TDETC:	291.99
TDETD:	293.00	HTR1PUR:	31.20	HTR2PUR:	0.00
HTR1RNG:	2.00	HTR2RNG:	0.00	SETP_1:	293.00
SETP_2:	500.00	Alarm:	OFF	CMPID:	OFF
CMSETP:	0.00	CMout:	0.00		

Command Feedback Window Options

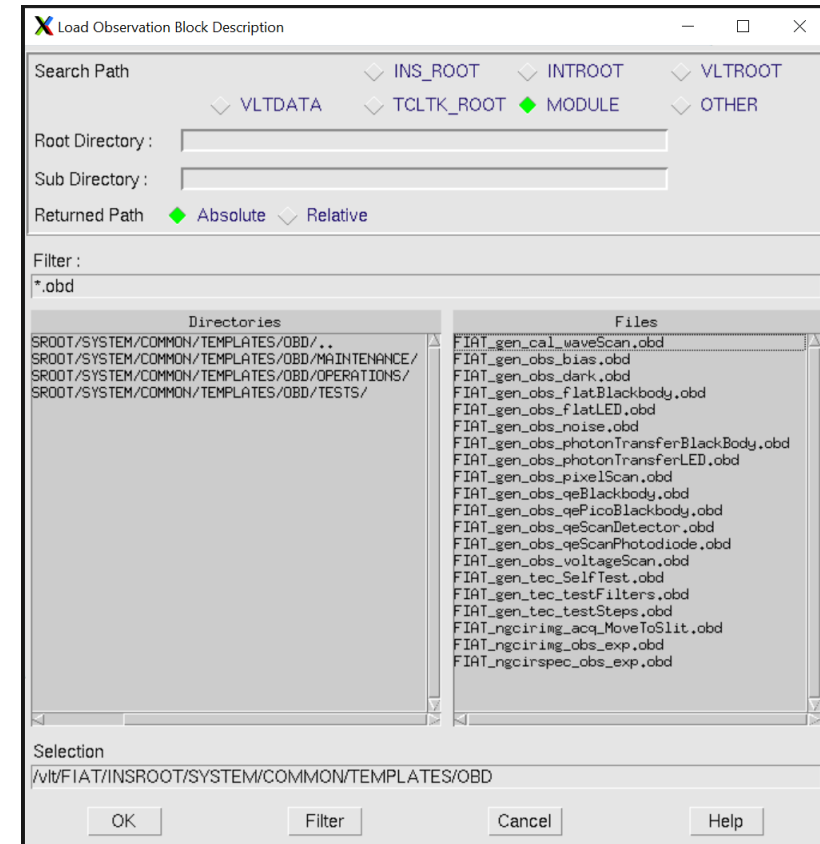
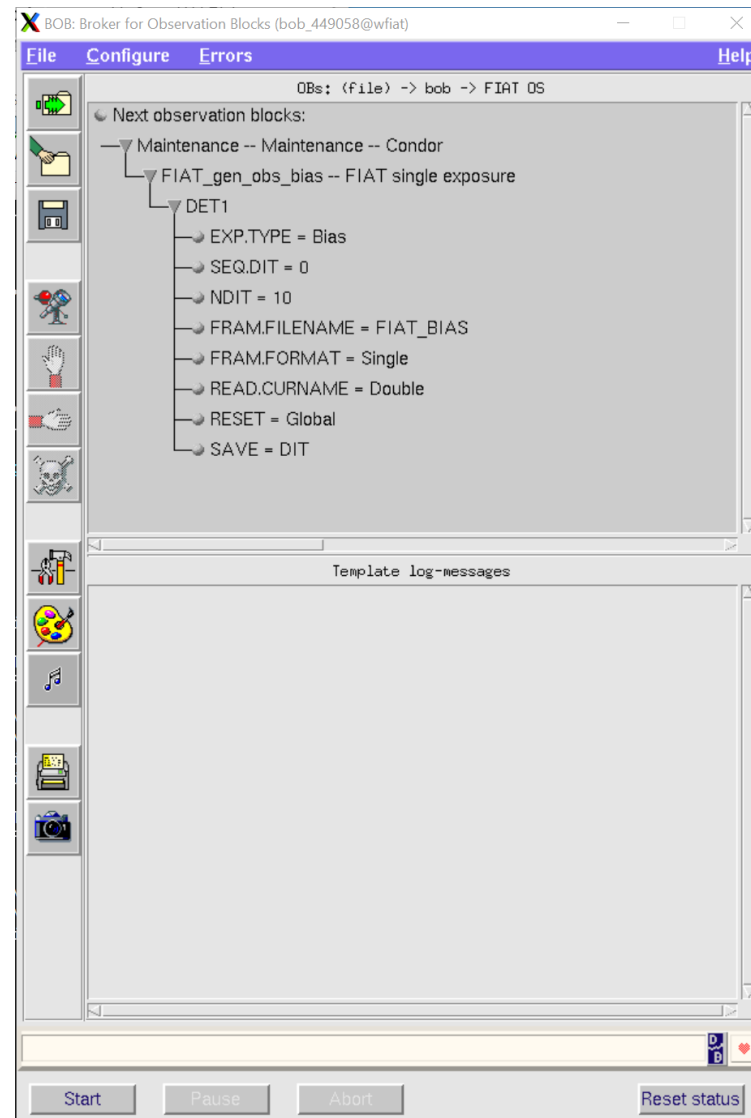
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```

SETUP STOP



# Observation Software

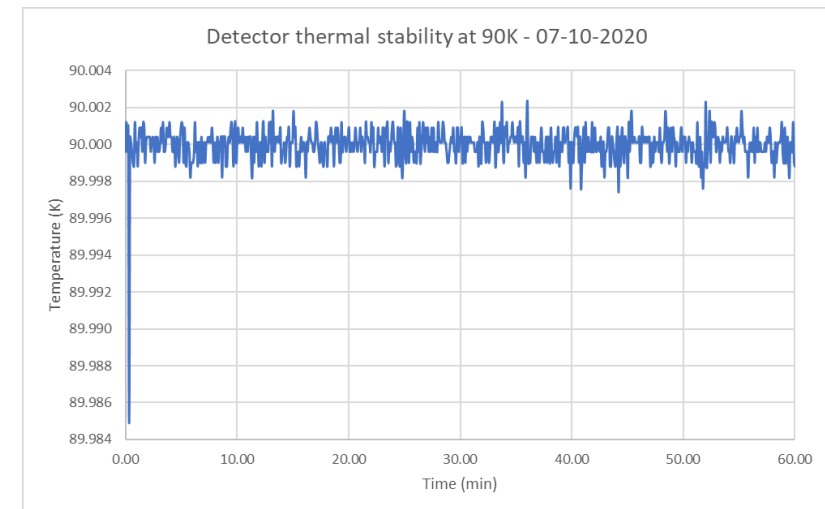
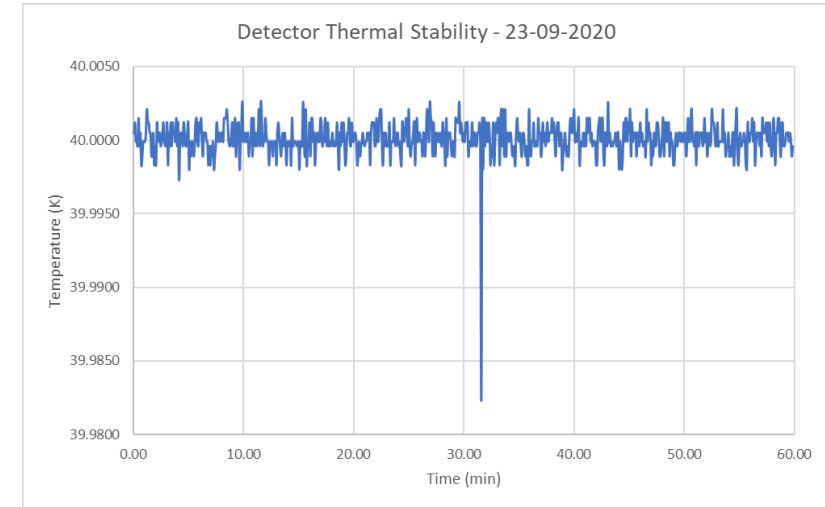
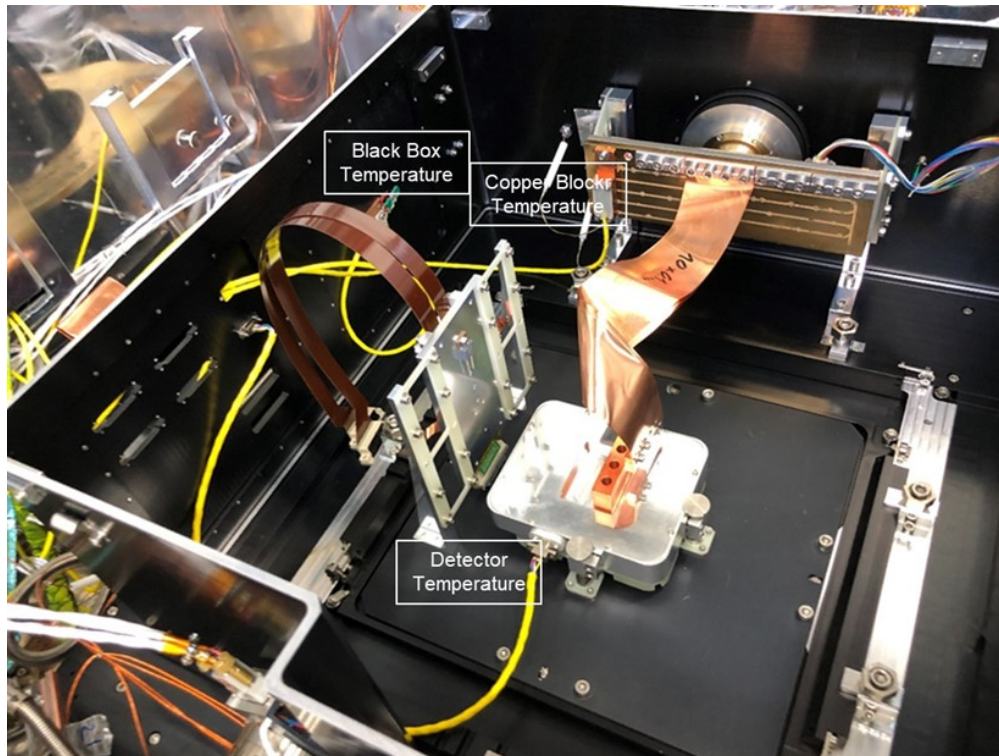
- VLT standard observation software
  - Several templates to collect data
  - Instrument configuration information into FITS headers
- Data into ESO science data archive



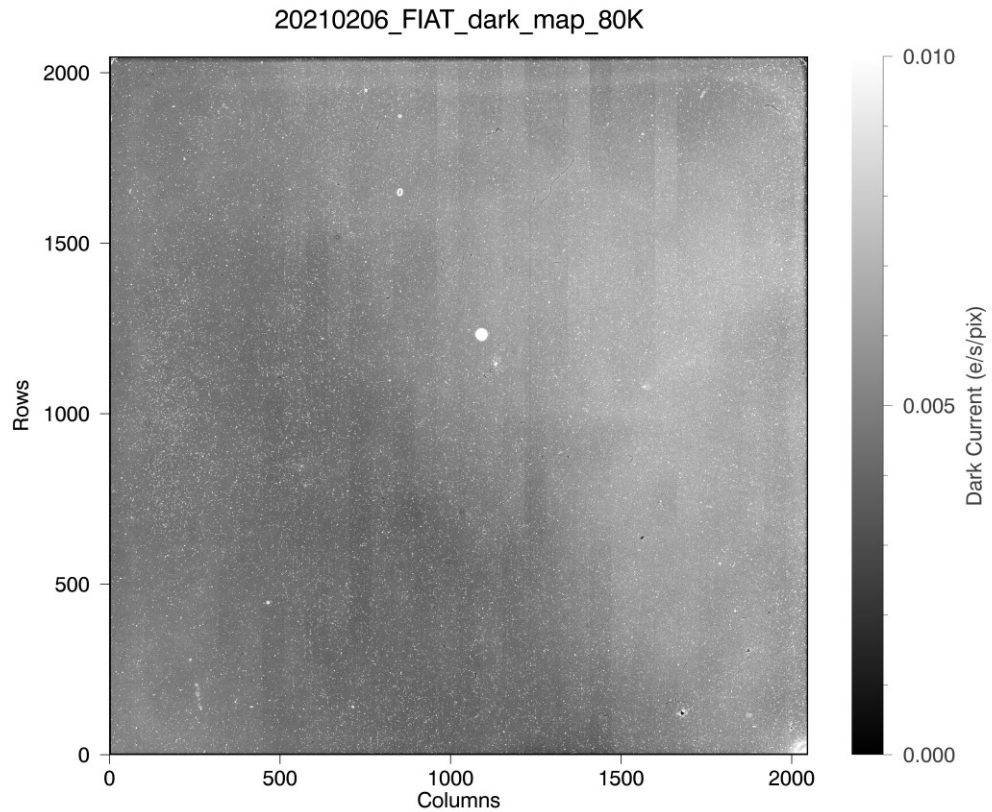
# Detector Thermal Control

## ■ Detector Temperature Control by Lakeshore Controller

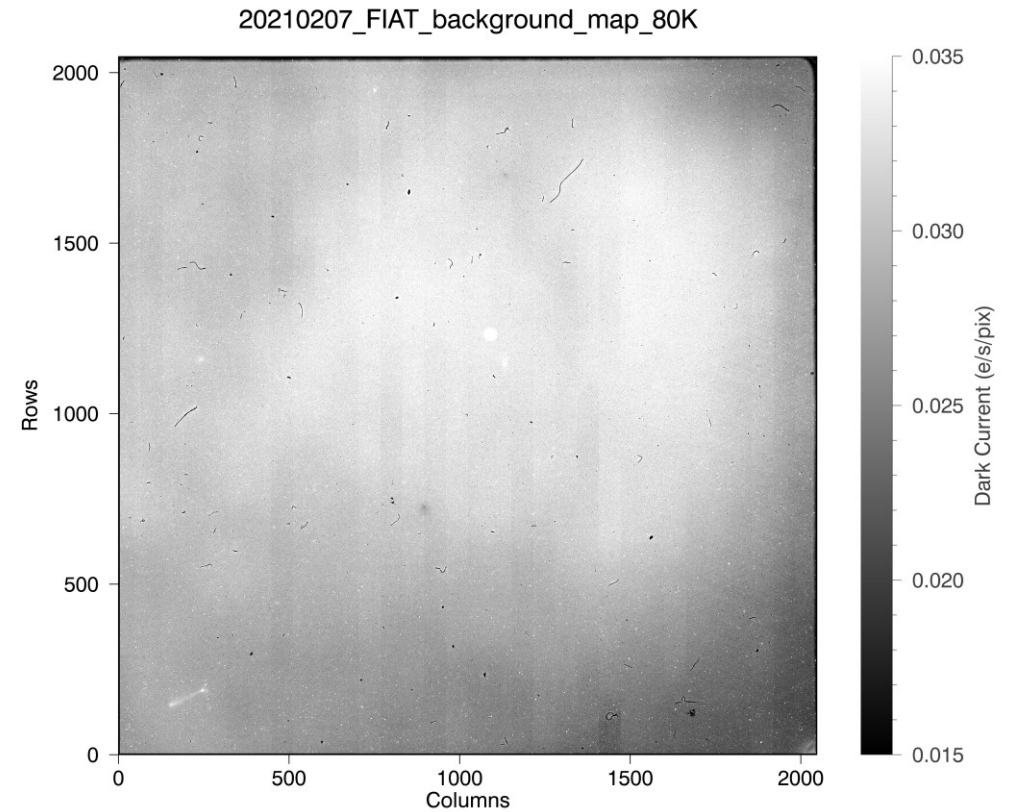
- Minimum 40K, Maximum = 110K
- Copper mass follows detector setpoint with a specified  $\Delta T$



# Thermal Background



Thermal background –  $0.006\text{e-/s/pix}$   
(cold shutter closed)



Instrument background –  $0.025\text{e-/s/pix}$   
(cold shutter open)

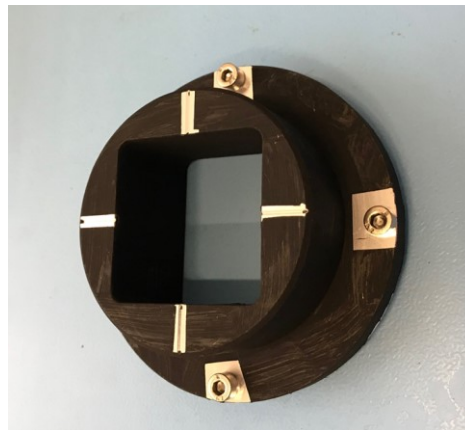


# Optical Illumination - Straylight

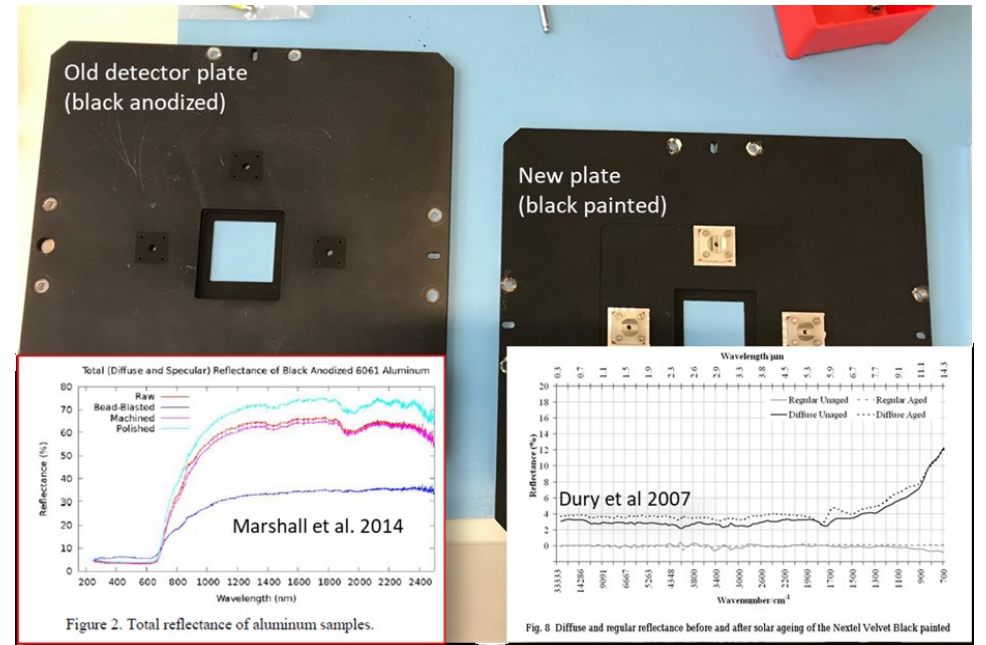
- Extended blackbody source provides uniform illumination at detector plane
- Additional baffle reduce straylight from warm field of view
- Painted surfaces rather than anodized surfaces



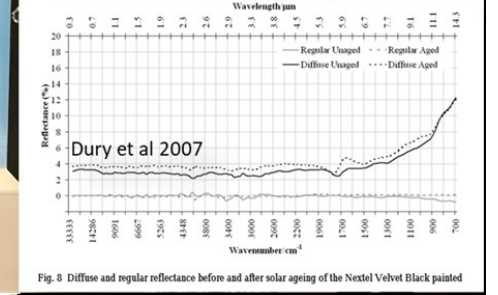
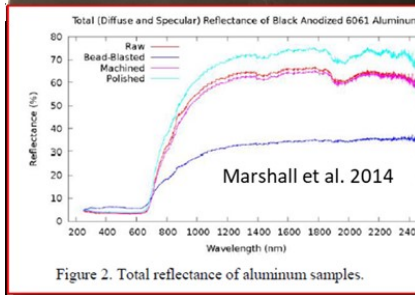
Extended blackbody source at object plane



Entrance baffle reduce straylight from warm FoV



Painted surfaces reduce scattered light

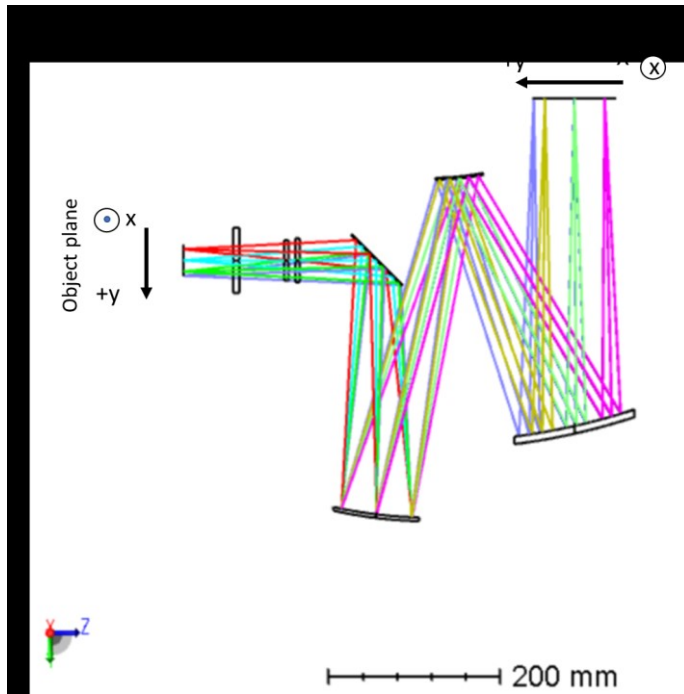


# Optical Illumination - Gradient

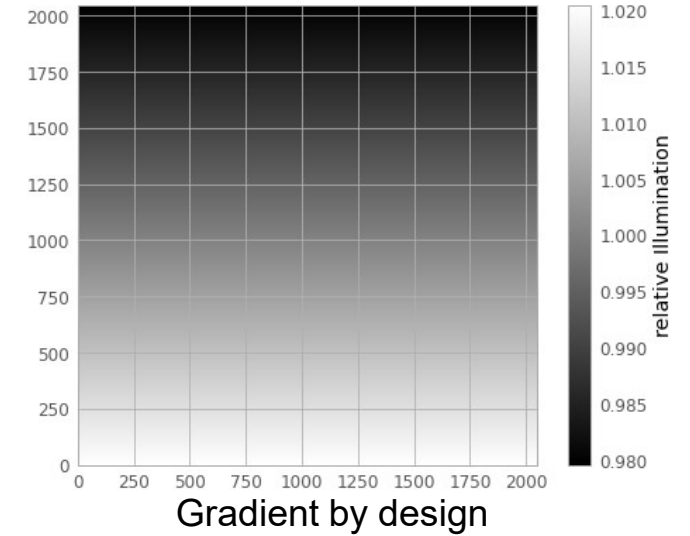
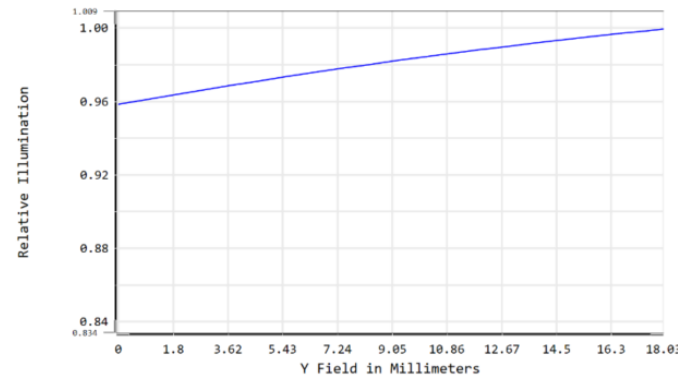
## ■ Illumination Correction

- Inherent illumination gradient by design
- Detector gain spatial variation

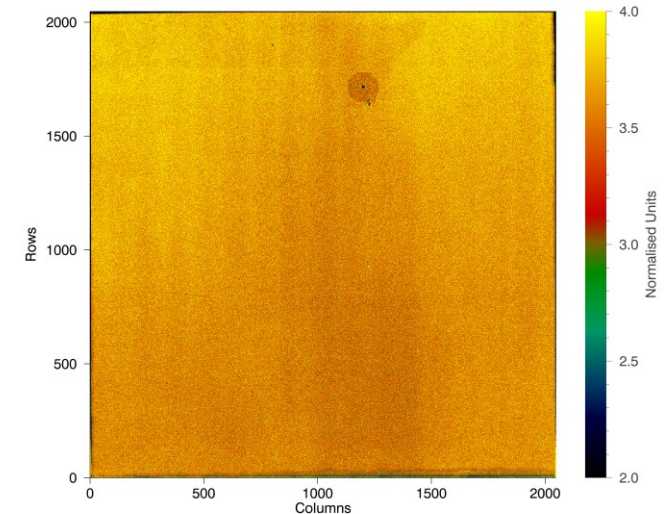
## ■ Residual illumination gradient ~ 5%



FIAT Optical design and illumination gradient



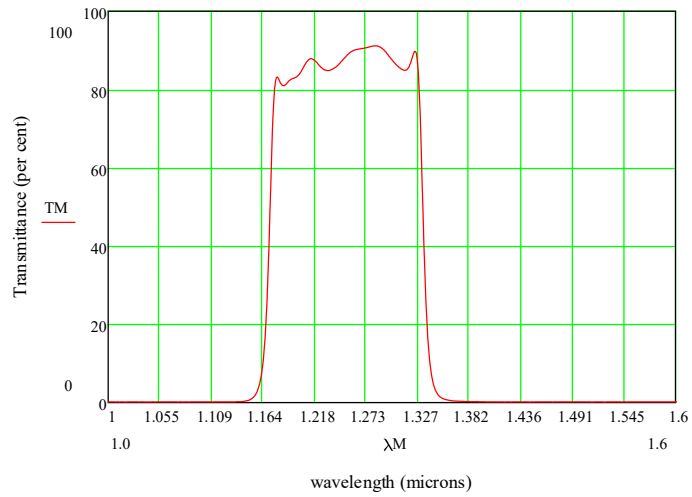
Gradient by design



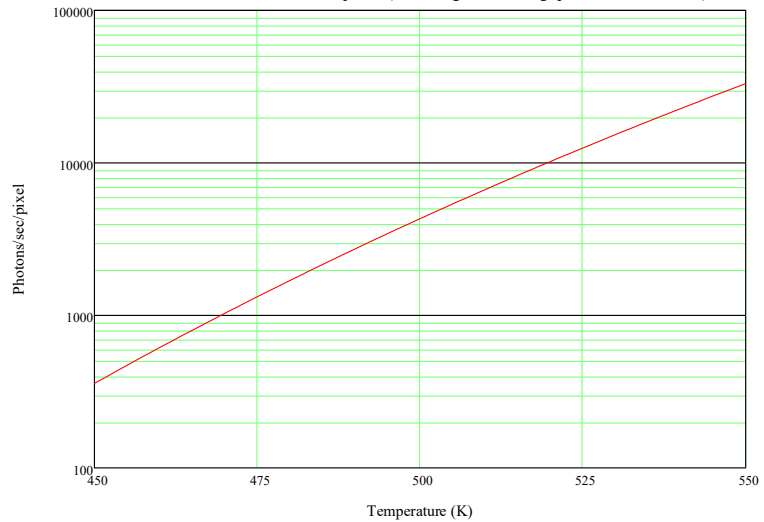
Detector gain variation

# Radiometry

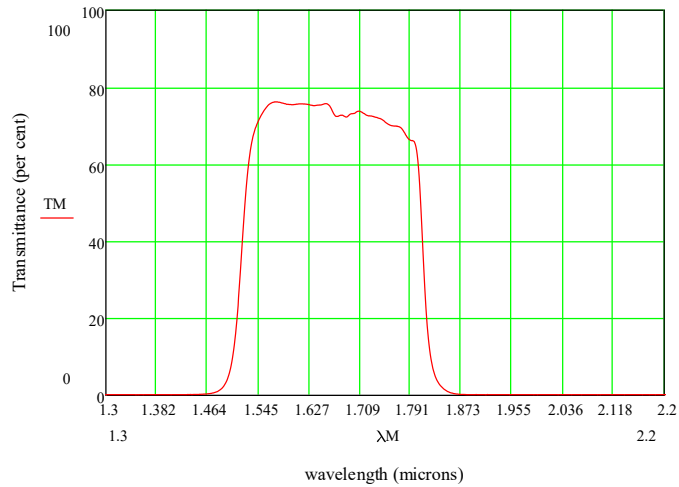
## Js - Band



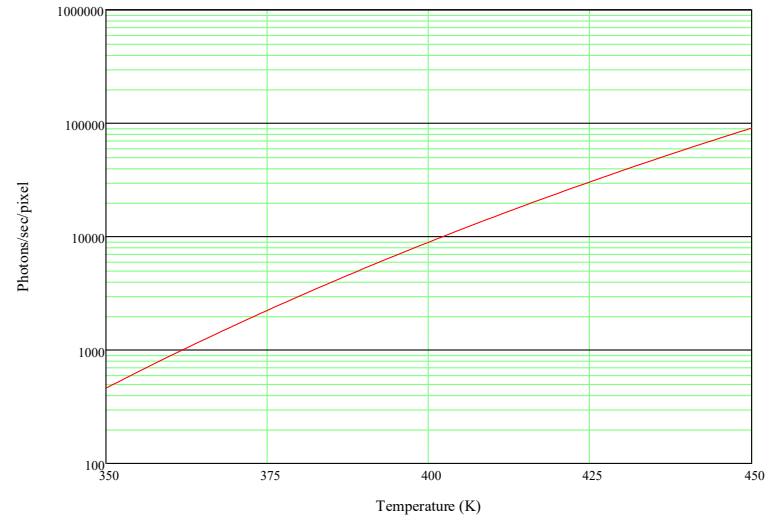
Js band irradiance at detector plane (assuming 90% throughput and exit f#15.66)



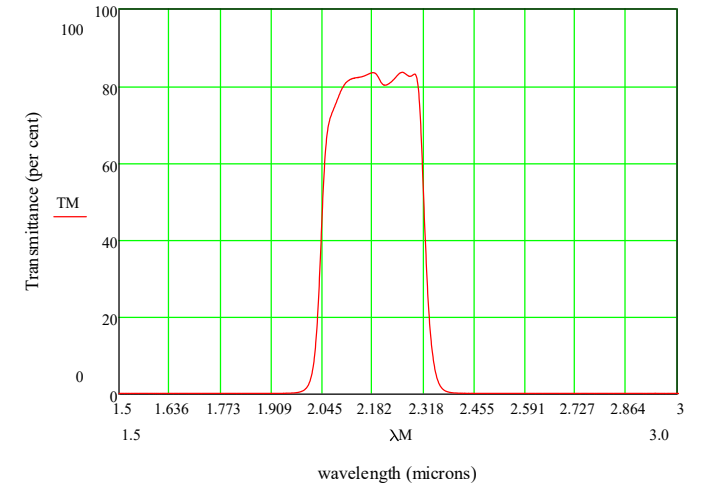
## H - Band



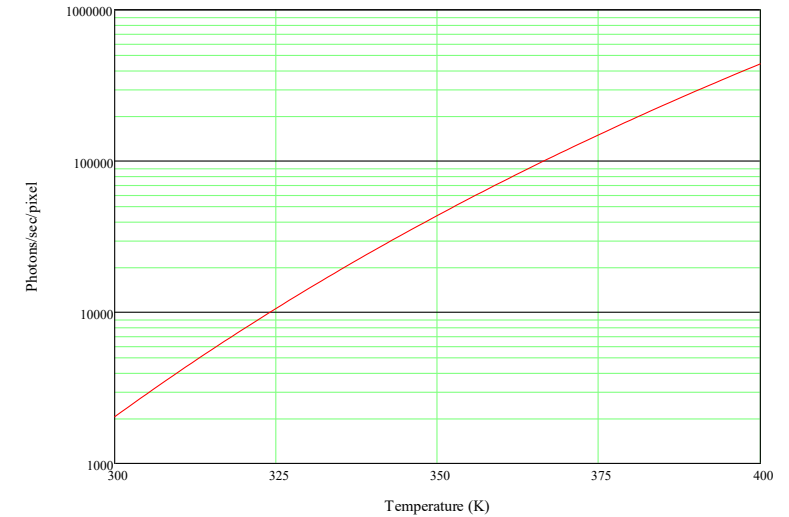
H band irradiance at detector plane (assuming 90% throughput and exit f#15.66)



## Ks - Band

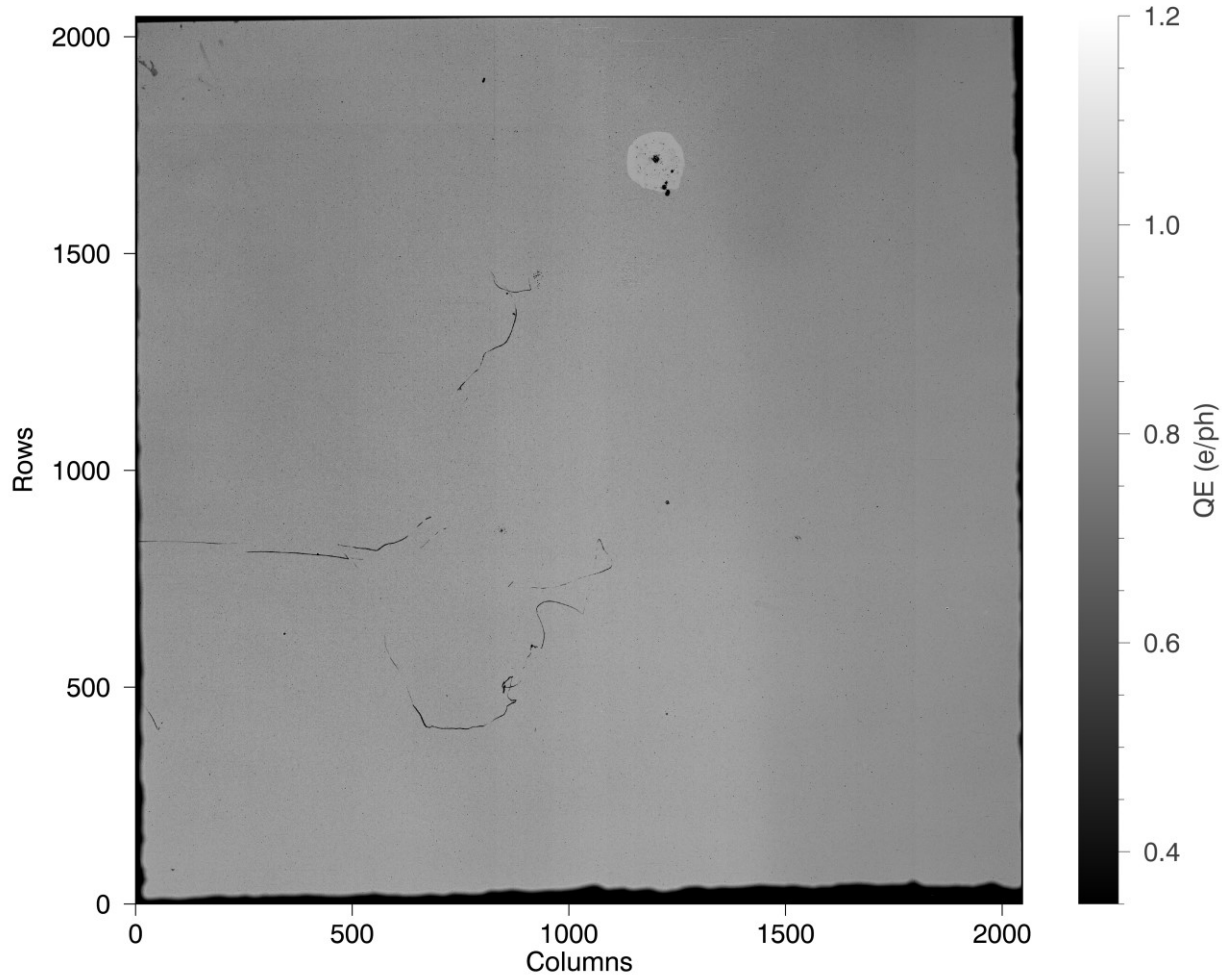


Ks band irradiance at detector plane (assuming throughput of 90% and exit f#15.66)

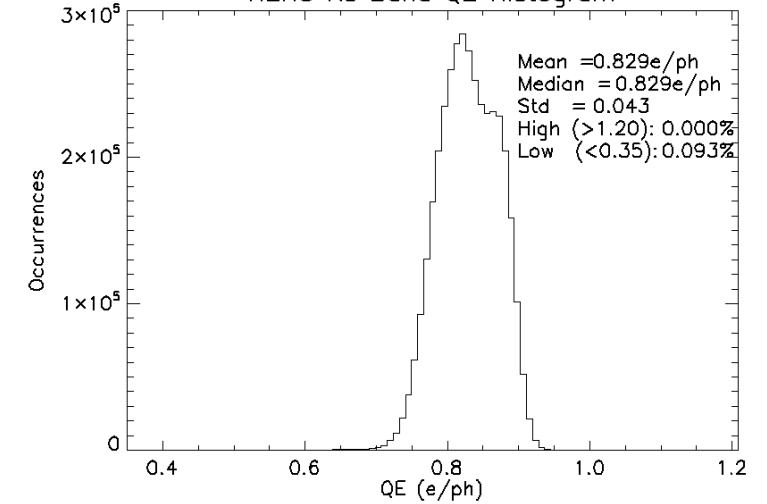


# EN20052 QE – Ks Band

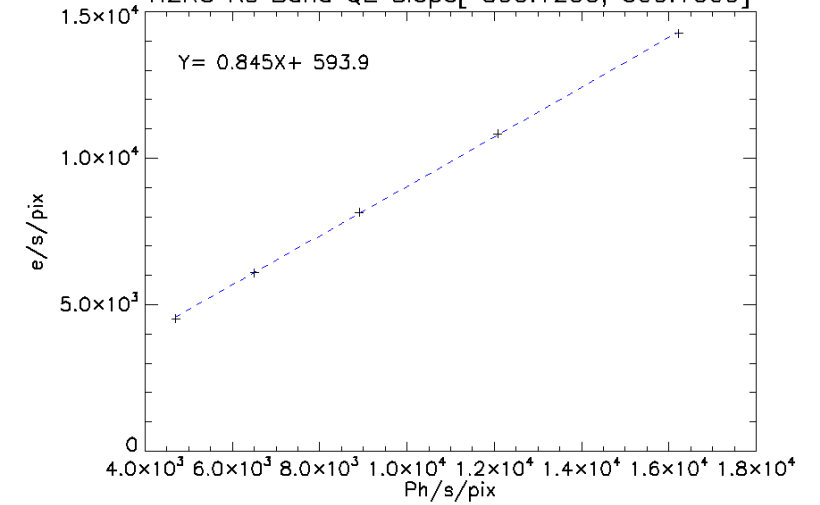
H2RG Ks Band QE Bitmap



H2RG Ks Band QE Histogram

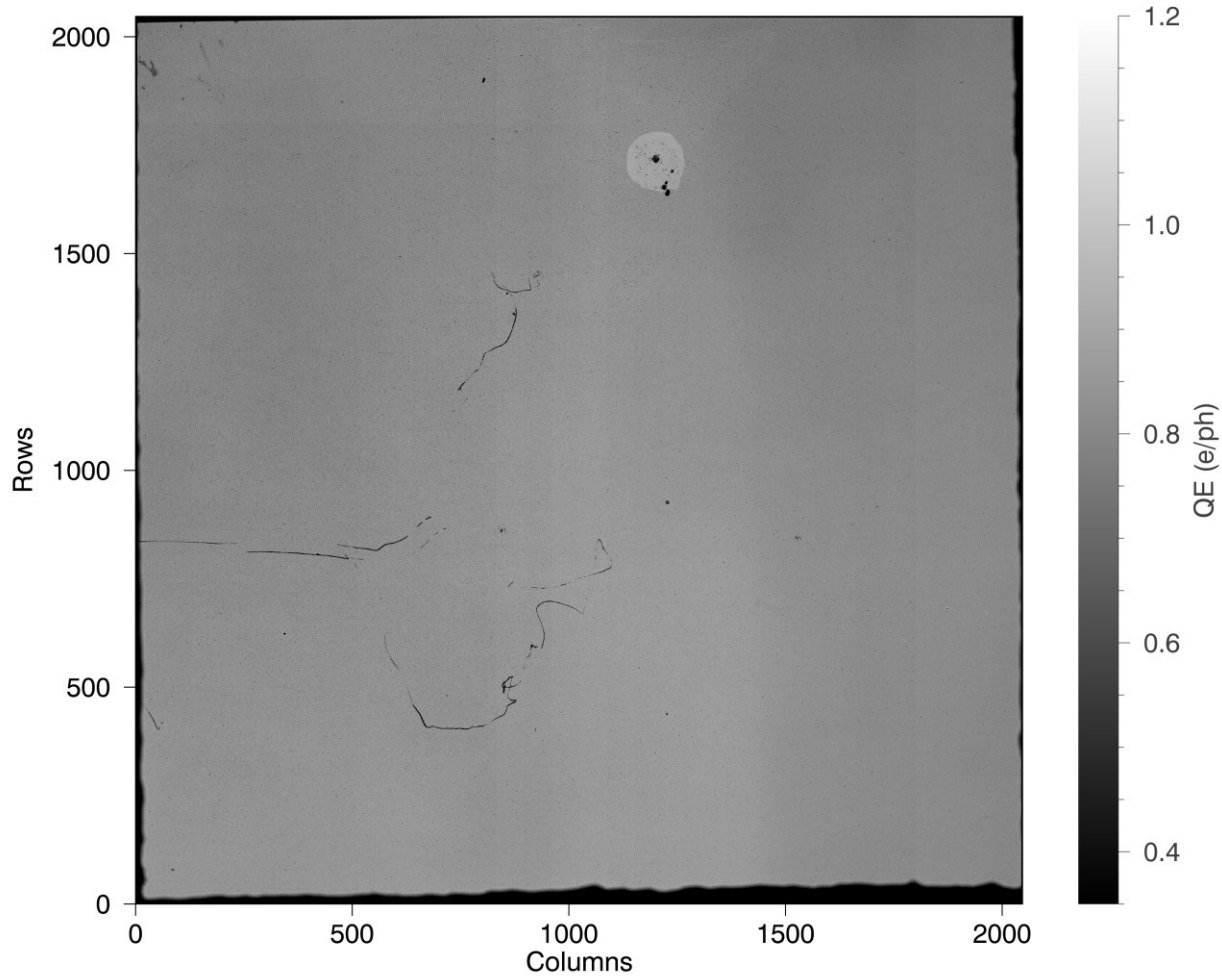


H2RG Ks Band QE Slope [ 800:1200, 600:1000 ]

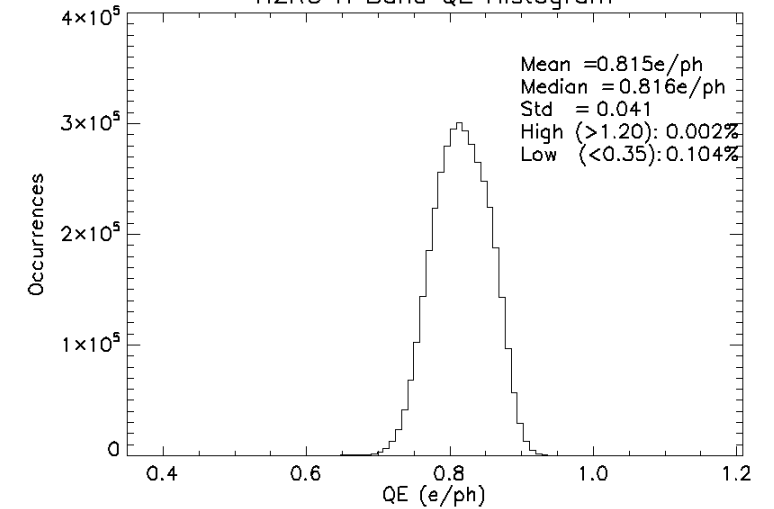


# EN20052 QE – H Band

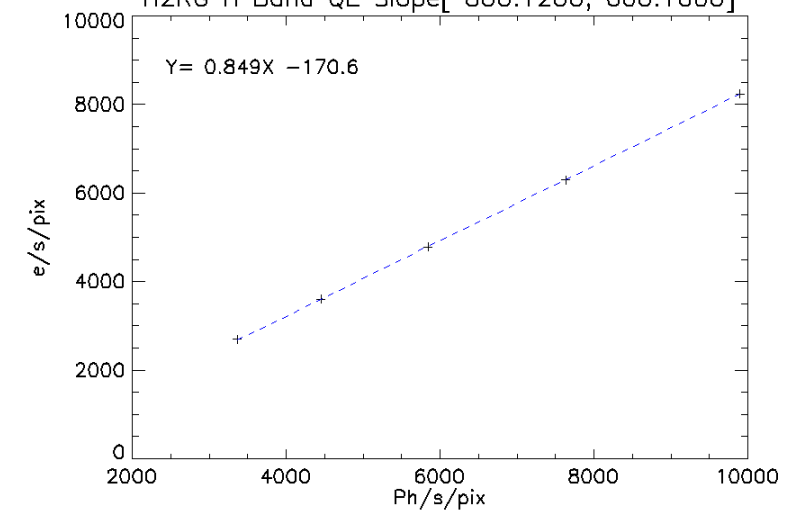
H2RG H Band QE Bitmap



H2RG H Band QE Histogram

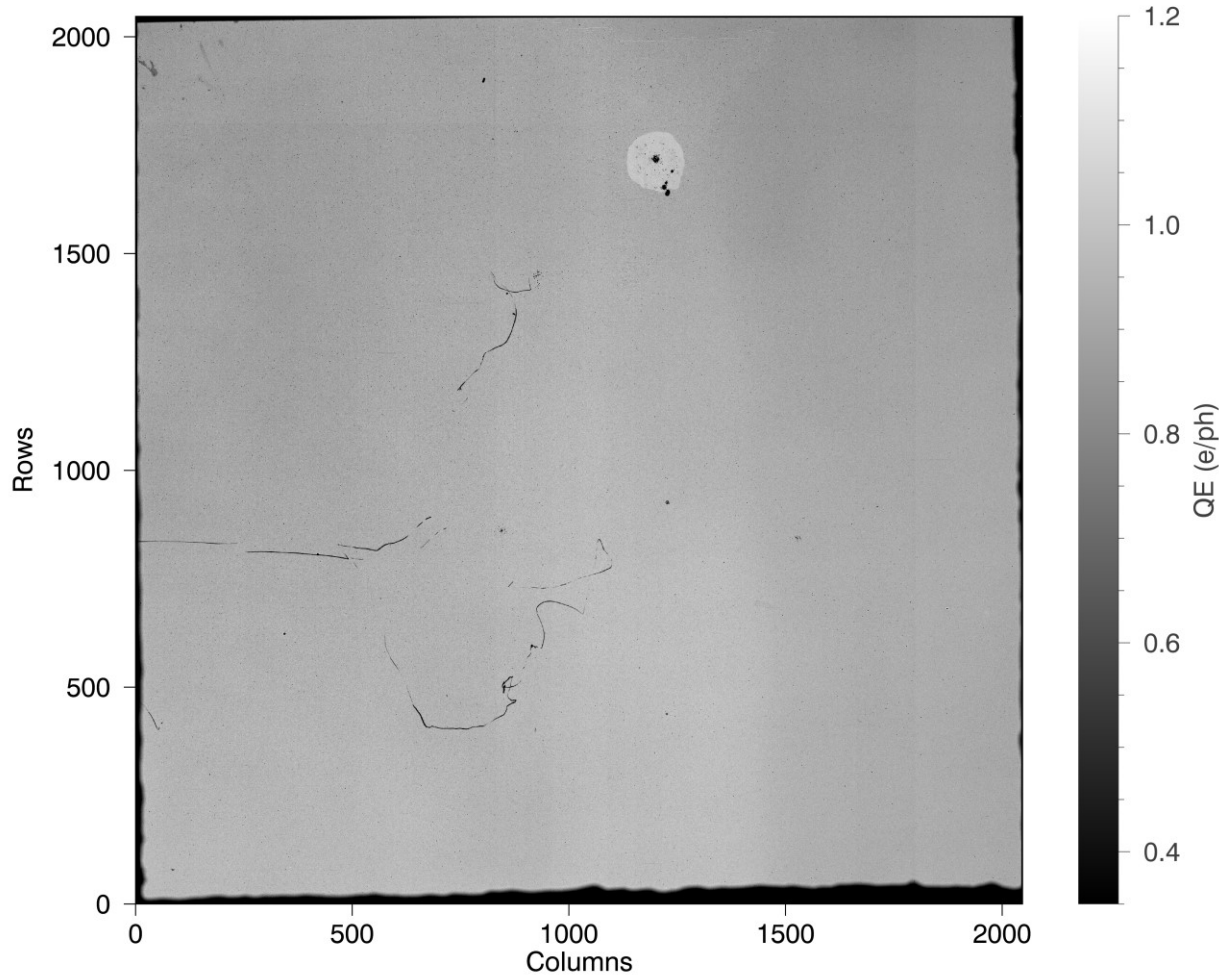


H2RG H Band QE Slope [ 800:1200, 600:1000 ]

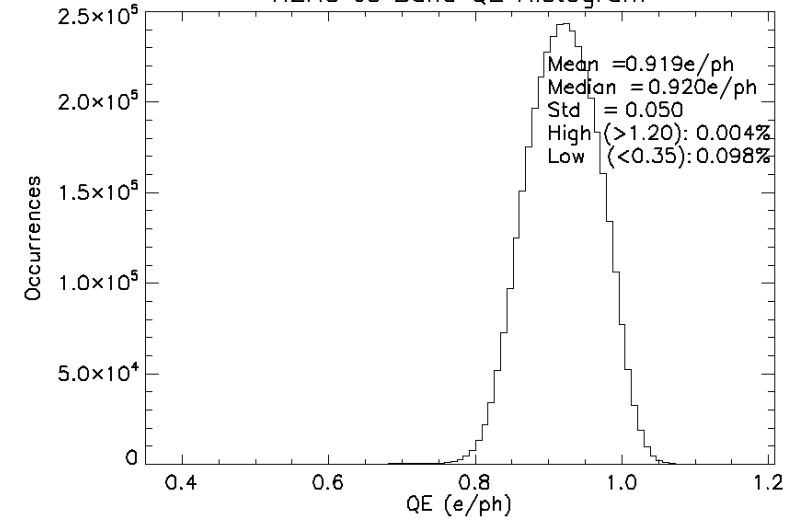


# EN20052 QE – Js Band

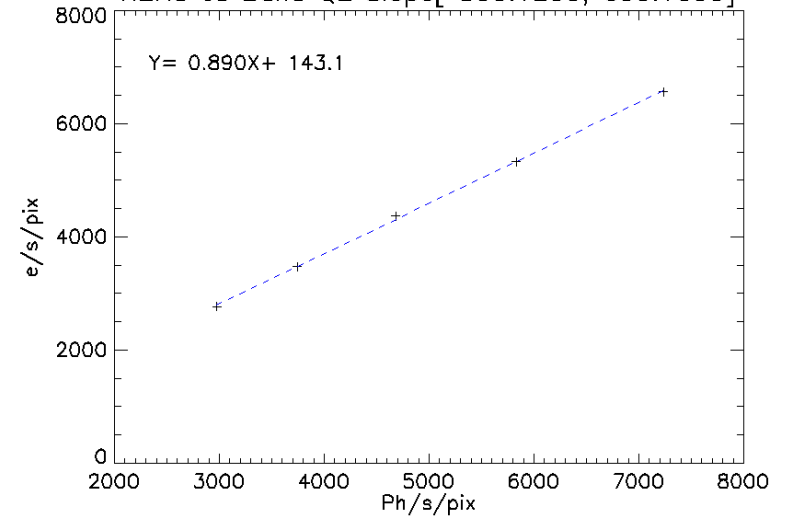
H2RG Js Band QE Bitmap



H2RG Js Band QE Histogram



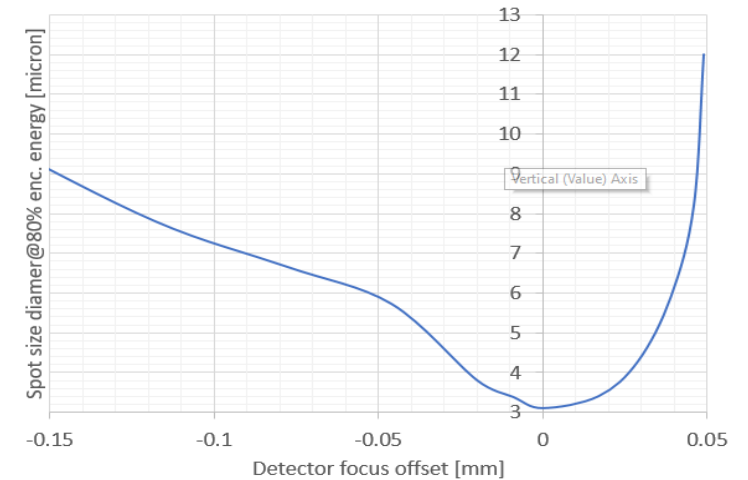
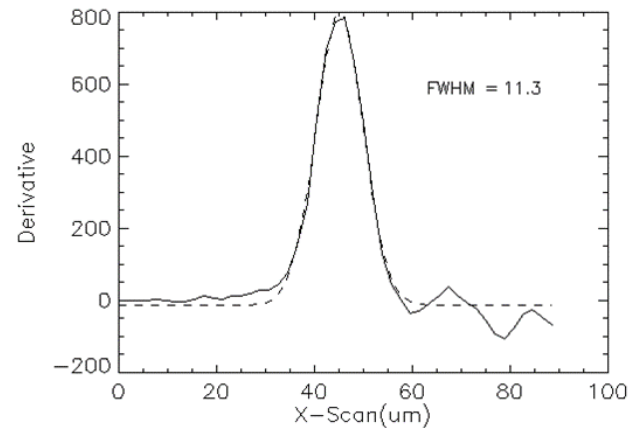
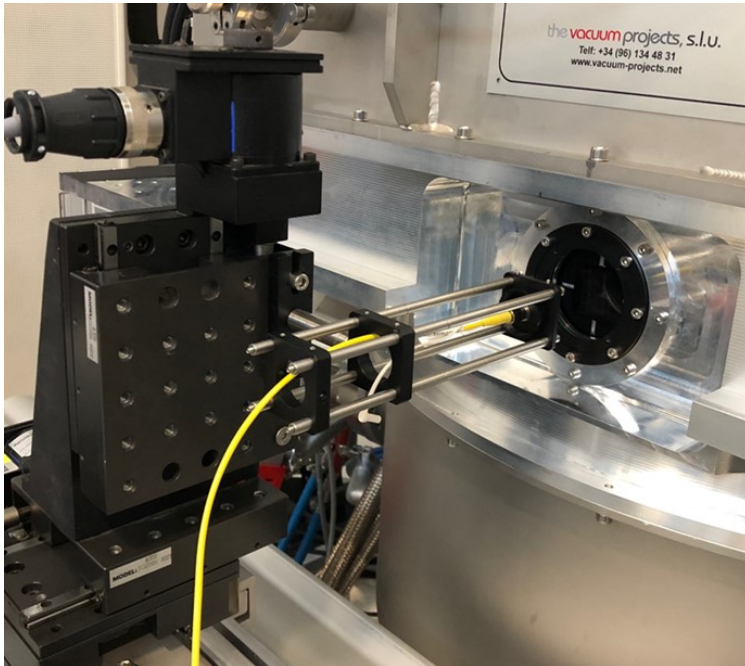
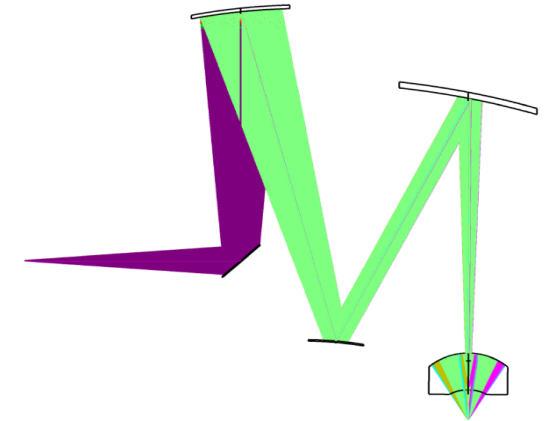
H2RG Js Band QE Slope [ 800:1200, 600:1000 ]



# Intra-pixel Spot Scan

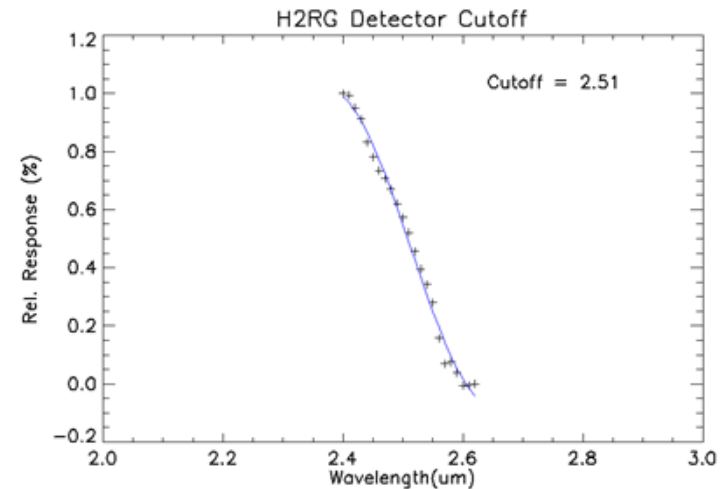
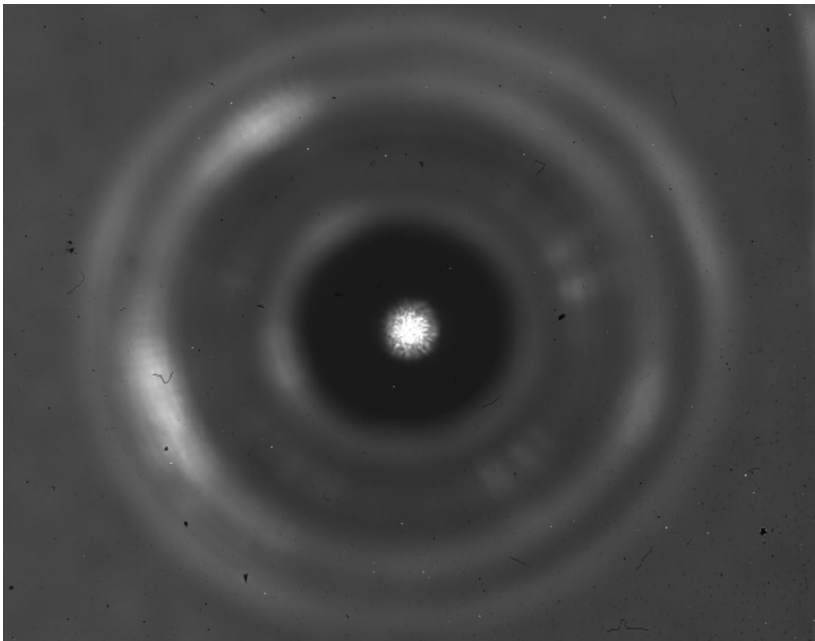
## Pixel Lens

- Very limited FoV for best spot quality
- Detector stage is not motorized, so focus compensation in the object plane requires the detector to be positioned within  $\pm 30\mu\text{m}$  from its nominal focus position
- Need to get this correct with a few iterations



# Detector Cut-off

- Fiber coupled to monochromator
  - Scanned over a small wavelength range around the detector cut-off
  - Assumed the throughput of the monochromator and fiber constant



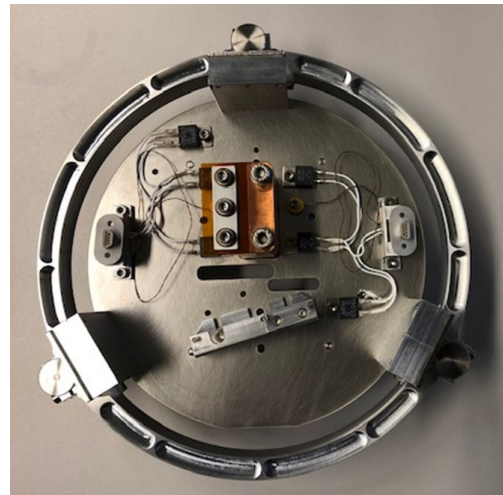


# H4RG Test Setup

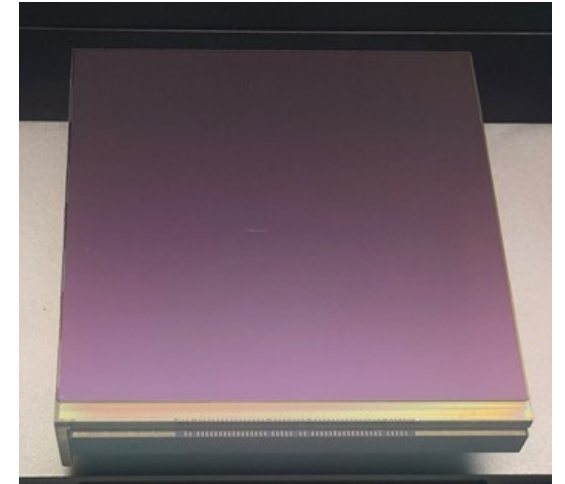
- H4RG testing underway
  - Warm tests with multiplexer completed
  - Eng. H4RG is being installed for cold testing



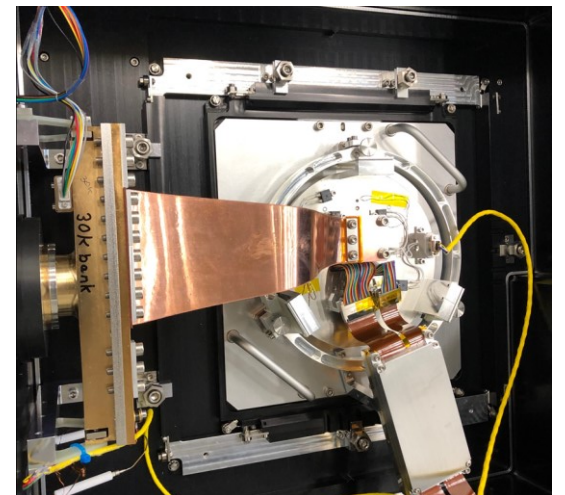
H4RG warm test setup



H4RG mount for FIAT



H4RG-15 (2.5µm cut-off)



H4RG mounted in FIAT