

QE measurement on CHEOPS flight spare (FM1) CCD47-20-13351-10-09

Peter Verhoeve

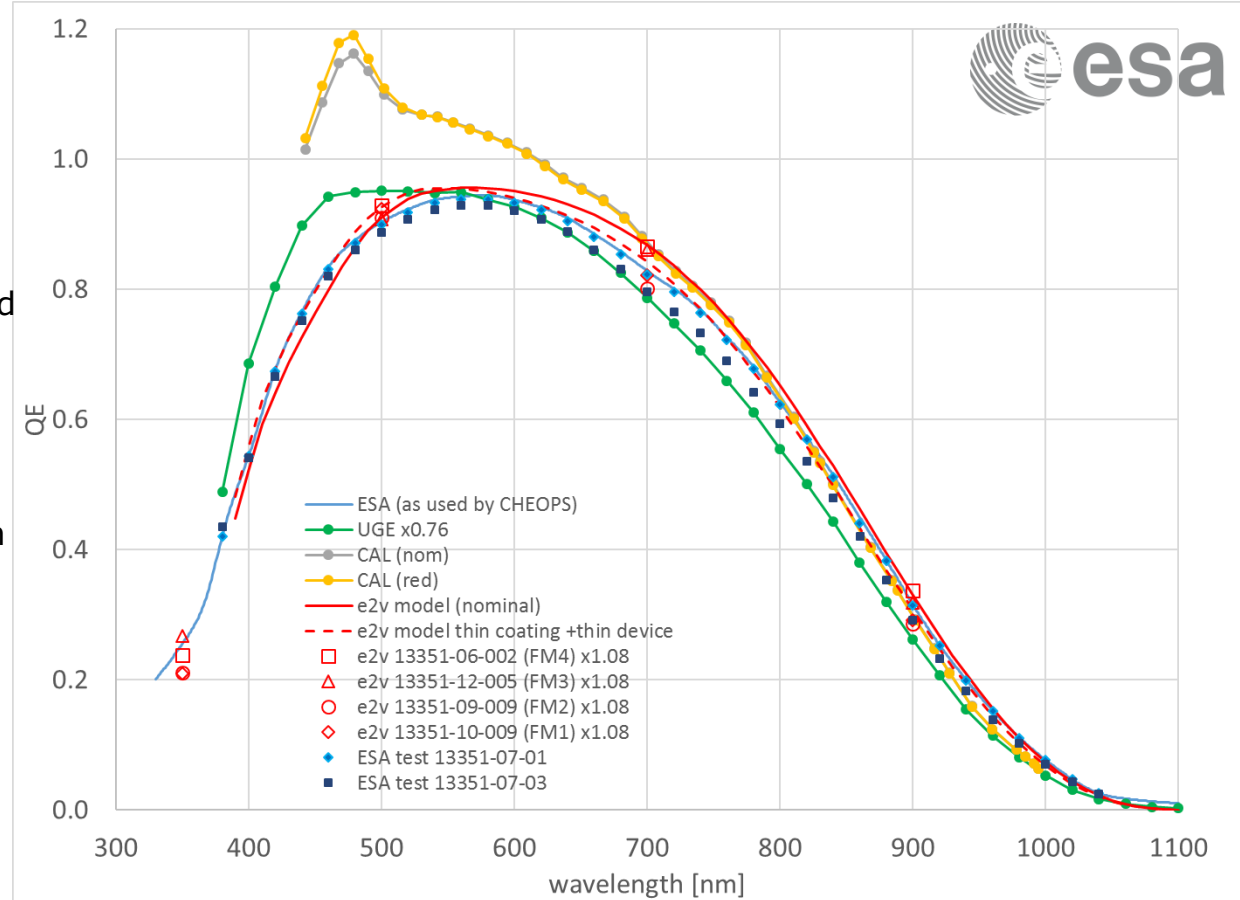
09/04/2020

ESA-SCI-FIV-CHP-HO-0002

background

History

- Top 4 curves are as provided by Adrien Deline, email 22-10-2018
- The ESA curve is based on measured data for 13351-07-01 (EM)
- $\times 0.76$ for UGE curve: to match max predicted QE
- $\times 1.08$ for e2v measured values from data sheets: to reflect e2v's "QE revision" TN
- CHEOPS FM = FM2



UGE FM1 & FM2 test reports (NOT latest versions)

CHEOPS-UGE-SYS-TR-119

Issue: 1 Revision: 2, 11. Sep. 2015, Page: 50/51

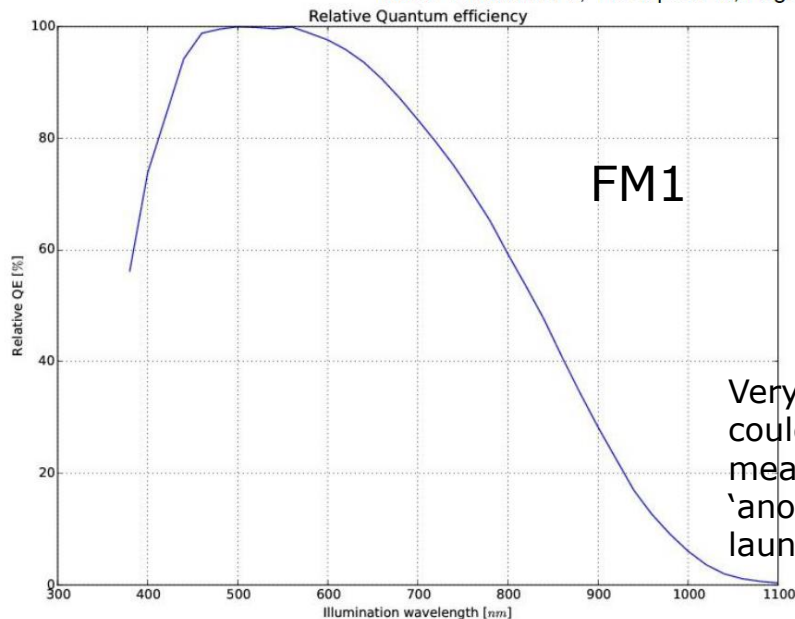


Figure 4-38: Relative quantum efficiency

CHEOPS-UGE-SYS-TR-120

Issue: 1 Revision: 0, 27. Oct. 2015, Page: 52/52

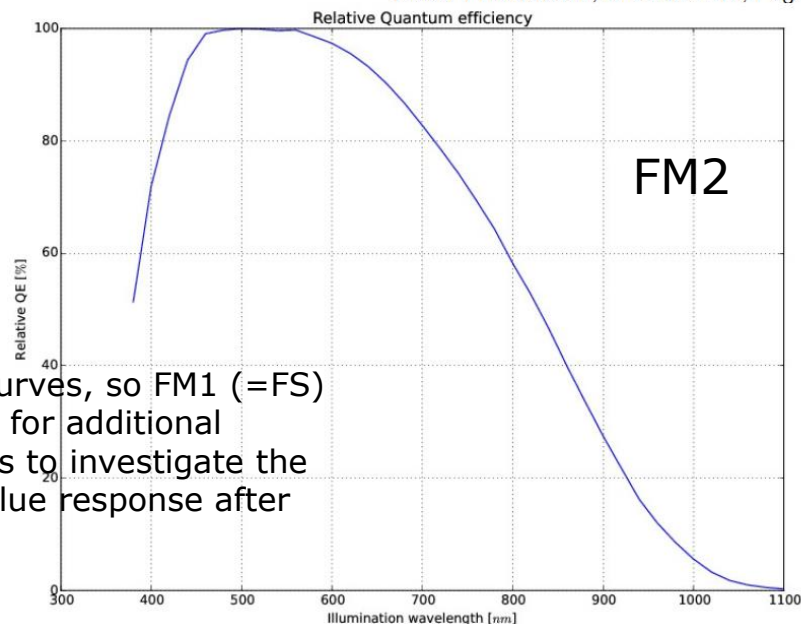


Figure 4-40: Relative quantum efficiency

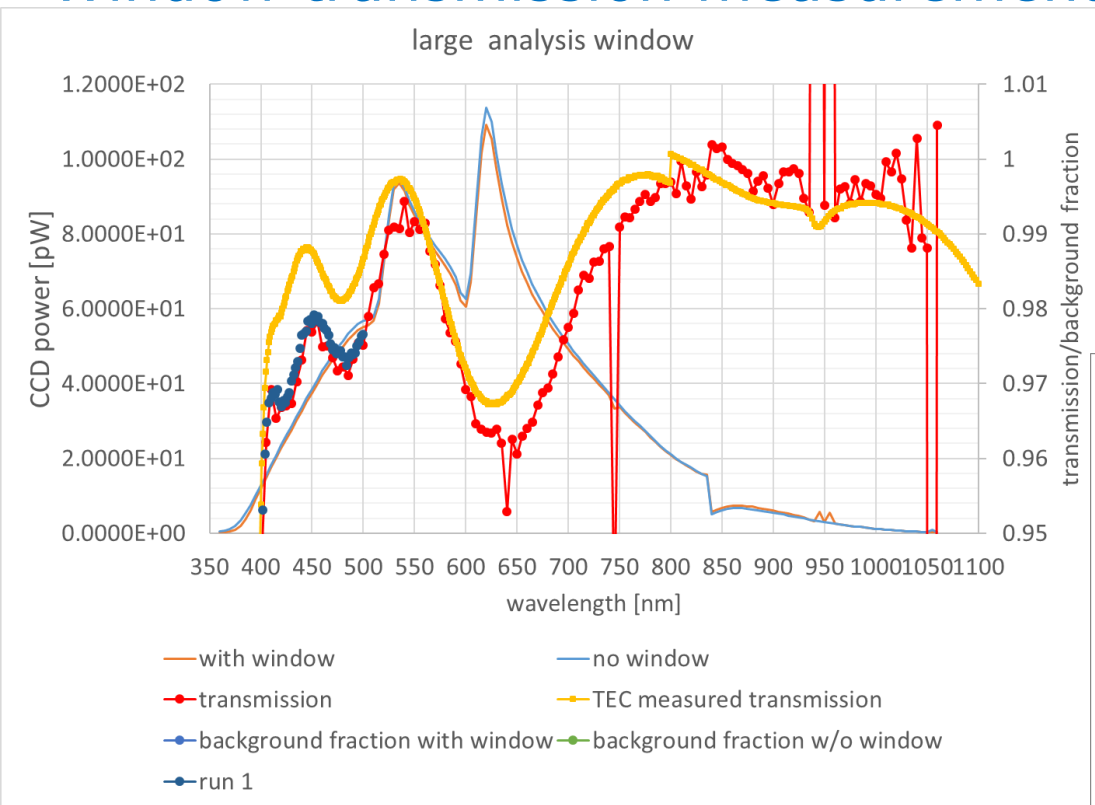
Very similar curves, so FM1 (=FS) could be used for additional measurements to investigate the 'anomalous' blue response after launch

QE measurement on CHEOPS FLIGHT SPARE device

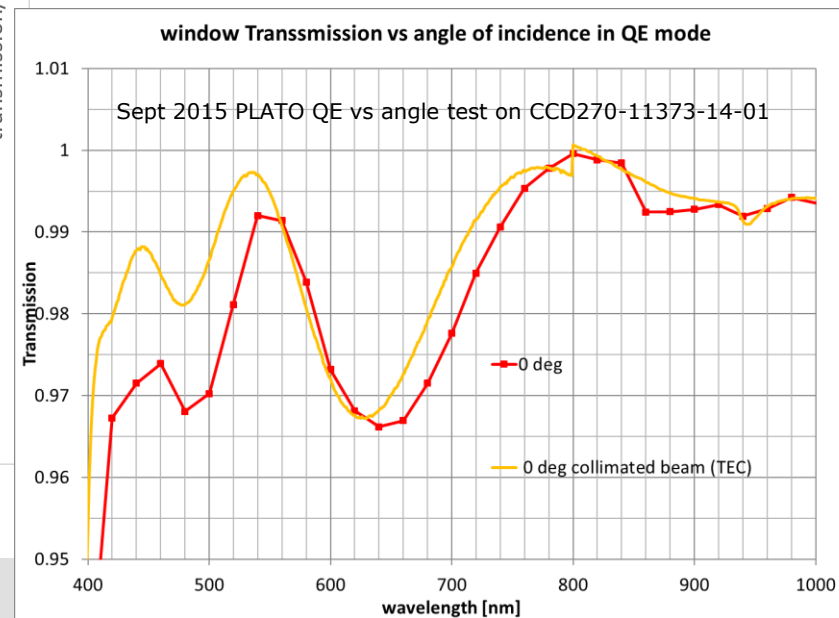
CCD47-20-13351-10-09

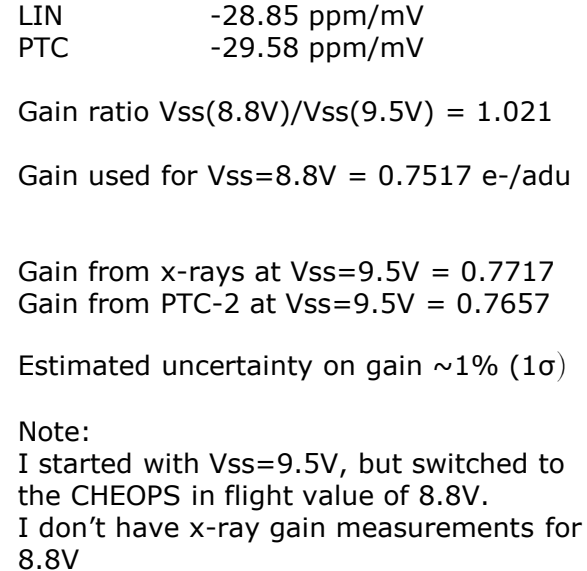
(FM1)

Window transmission measurement during FM1 test



- This test was with 4x higher incident power
- Results for <500nm is the same to within 0.2%
- Results are also very similar to sept 2015 results to within 0.3%
- Largest difference with TEC normal incidence curve ~0.7%
- Will use the red curve



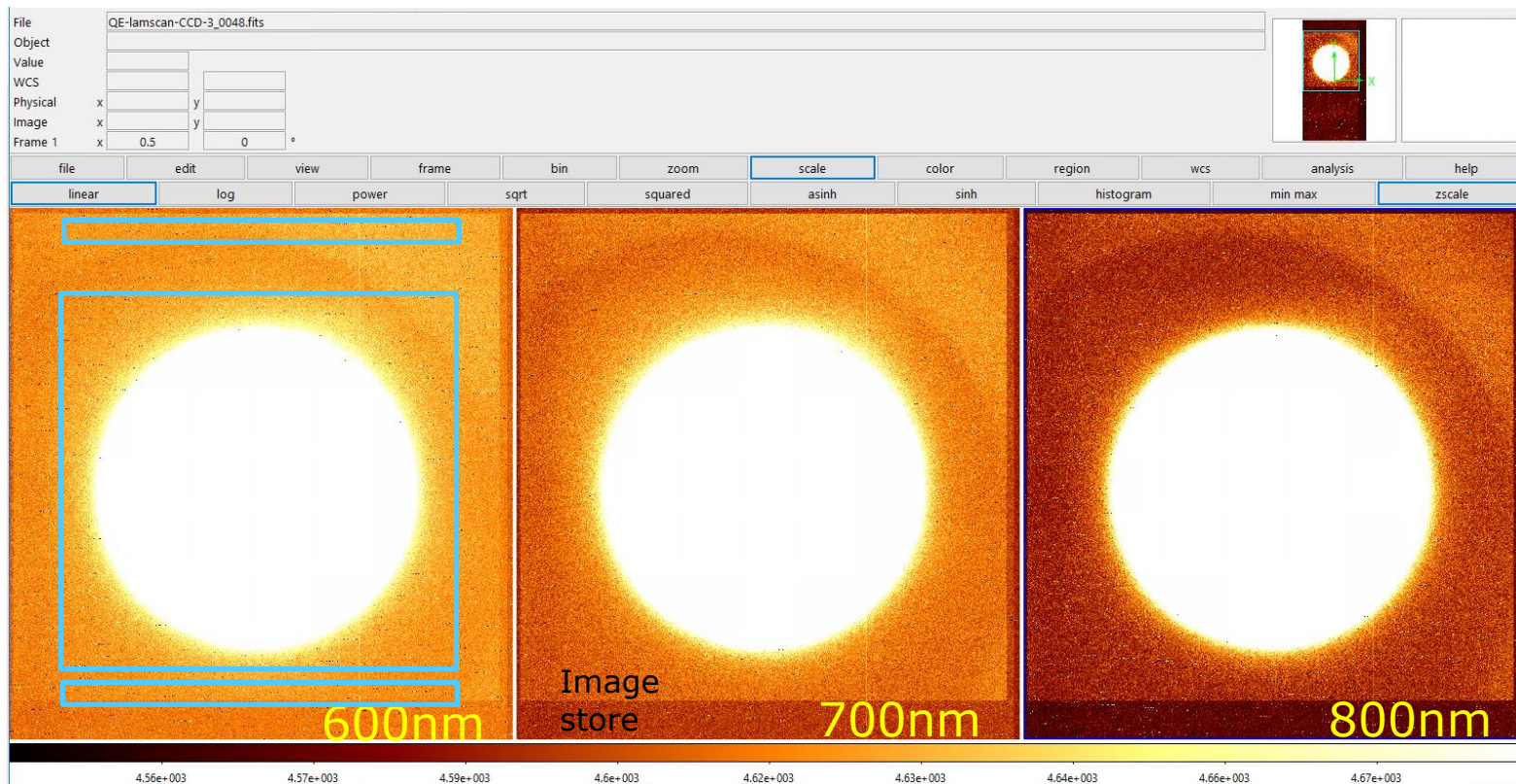


Spot on CCD 4mm aperture (1)

Scale: linear

Two areas for
background
subtraction,
one target area

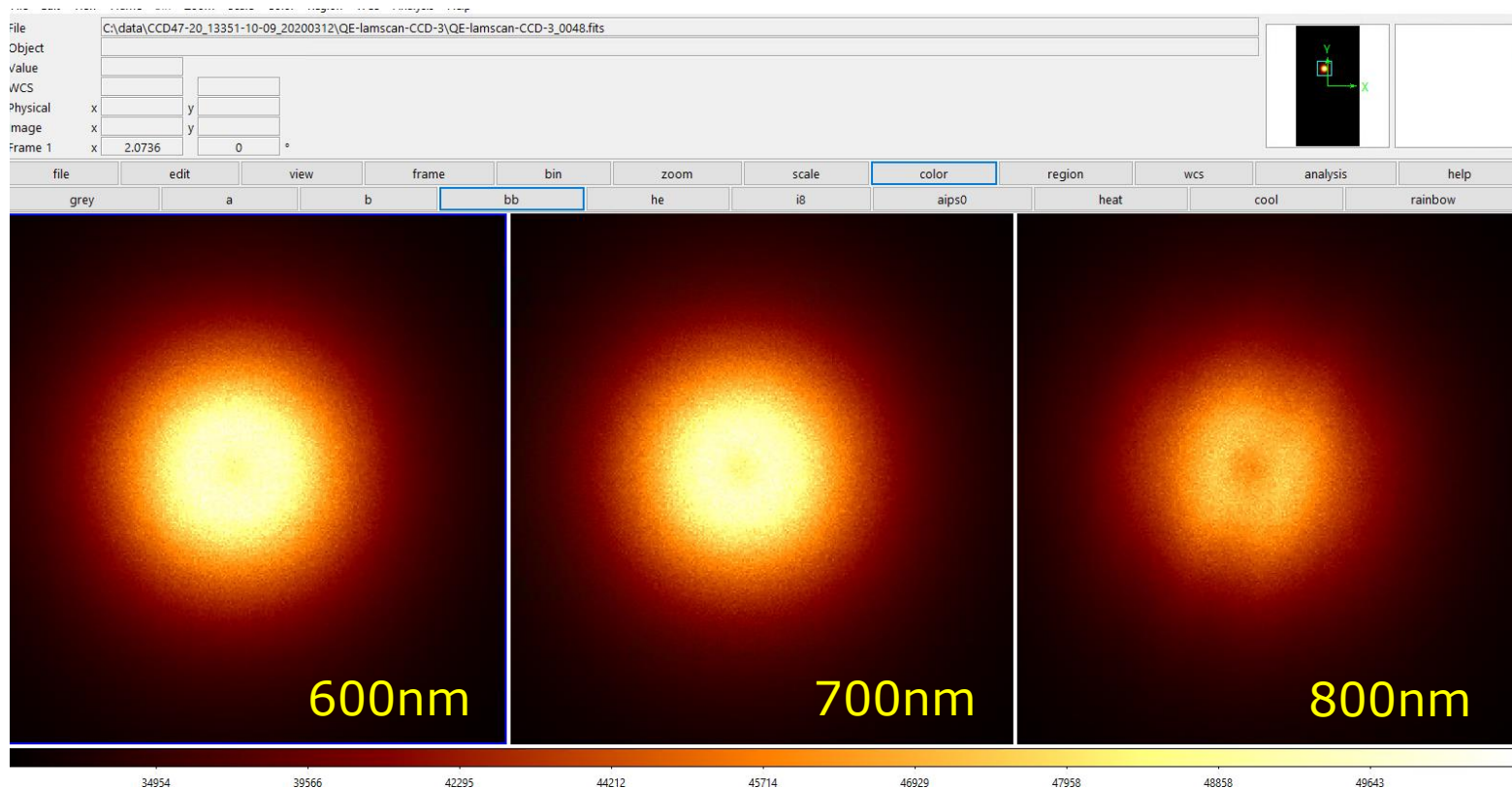
Contrast
between image
and store
indicates
background
level



Spot on CCD 4mm aperture (2)

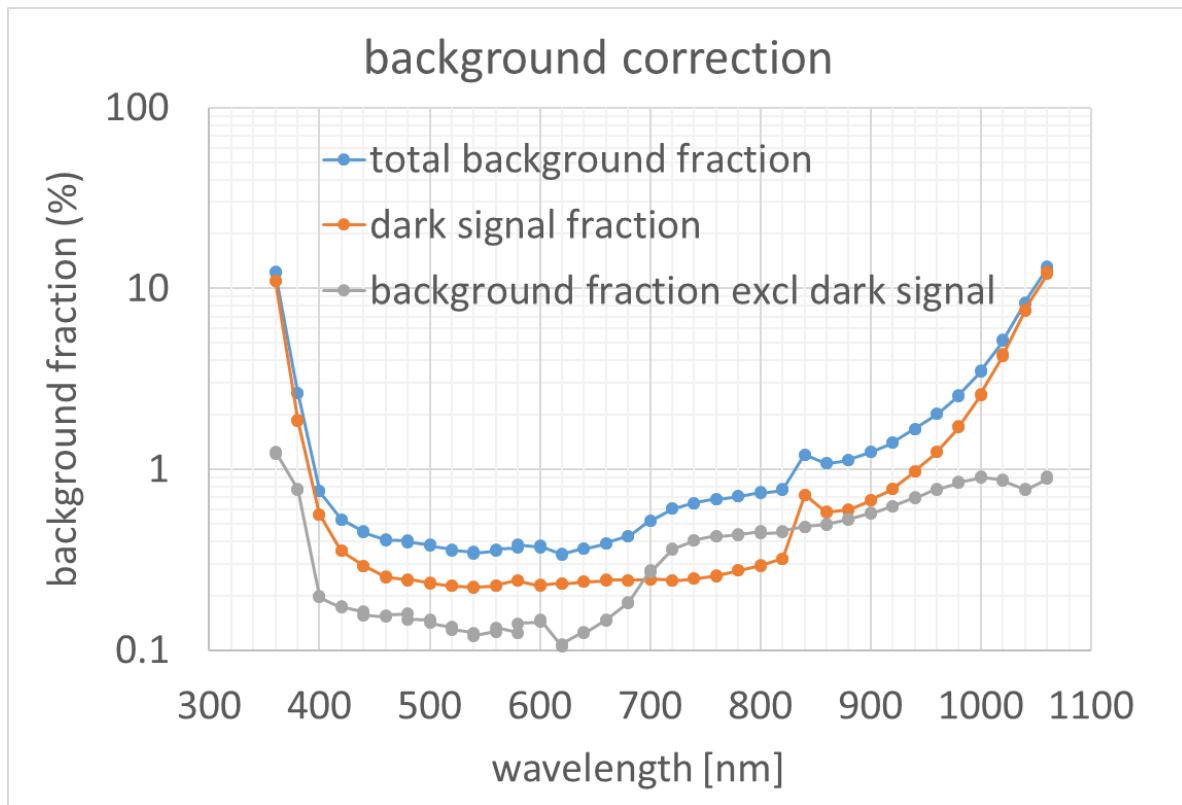
Scale: power

All intensities
<50000 adu

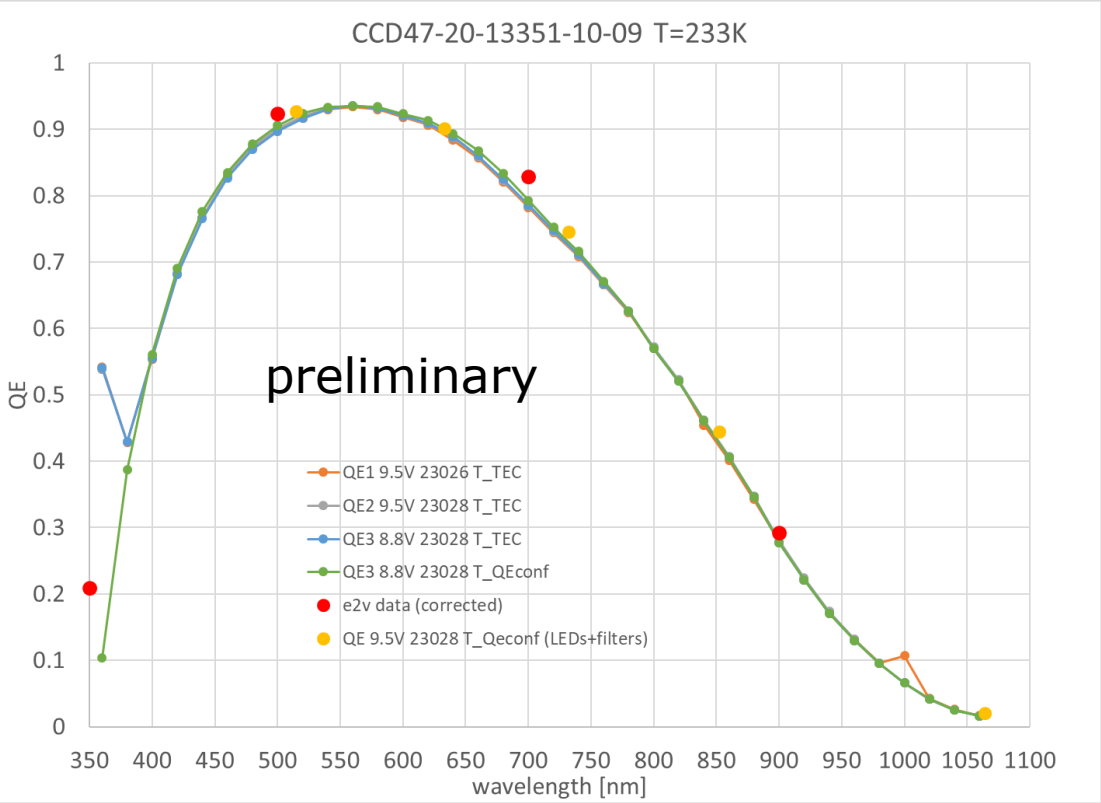


Background correction

- Background includes dark current and stray light
- It is assumed that dark and stray light are uniform across the image area
- Dark signal dominates over most of the wavelength range
- the background correction is $<1\%$ over most of the wavelength range



QE results for different configurations



- Results for 8.8V and 9.5V are very similar
- Using the measured window transmission in the QE test configuration is assumed correct, but does not make a lot of difference
- Using LEDs+filters instead of monochromator gives similar results
- Corrected e2v measurements are significantly higher, especially at 700 nm:

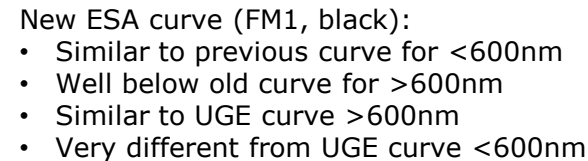
lambda	e2v	ESA	ratio
500 nm	0.923	0.907	1.018
700 nm	0.829	0.793	1.045
900 nm	0.292	0.277	1.054

- Uncertainties ESA (1 σ):
 - CCD gain: 1%
 - Optical calibration: 1%
 - CCD measurement: 1%
 - Optical measurement: 1%
 - TOTAL: 2% (between 450-890nm, larger outside)
- Uncertainties e2v:

Contributing Factor	Variation Limit	Equivalent Influence (%) 1 σ Width				Notes
Wavelength (nm)		350	500	700	900	
Repeatability of Measurement	σ	0.87	1.35	1.31	1.15	1.3.
Temperature Uncertainty	σ	0.05	0.01	0.02	0.12	2.4
Shutter Uncertainty	+/- 2ms	0.08	0.08	0.08	0.08	8
Optical Cal Uncertainty	σ	5.87	3.07	3.07	5.87	
Amplifier Gain & Error	σ	1.92	1.92	1.92	1.92	5
C/V Error (excl. repeatability)	σ	1.91	1.91	1.91	1.91	7
Combined Standard Uncertainty	1 σ (%)	6.53	4.31	4.30	6.57	
Expanded Uncertainty	+/-3 σ (%)	10.38	9.60	9.55	10.62	6

Table 11 - Q.E. Measurement Uncertainties





Translating FM1 results to FM2 (= in flight)

lambda	e2v results		ratio
	FM1=FS	FM2=FM	
	13351-10-09	13351-09-09	
350 nm		0.211	0.990
500 nm	0.923	0.909	1.015
700 nm	0.829	0.808	1.026
900 nm	0.292	0.287	1.019

- FM2 ~2% lower than FM1
- This is probably insignificant, given the e2v uncertainties on the previous slide, but w/o optical cal uncertainty)
- Recommend to use the new curve for FM2 as is, but with slightly larger uncertainty: adding an extra 2% uncertainty term to the ESA budget

results

sa

wavelength[nm]	QE (FM1)	1sigma error FM1	1sigma error if used for FM2
1060	0.015967	0.0012	0.0012
1040	0.024953	0.0015	0.0015
1020	0.041806	0.0019	0.0020
1000	0.066019	0.0021	0.0025
980	0.095081	0.0025	0.0032
960	0.1295	0.0034	0.0043
940	0.170579	0.0045	0.0057
920	0.220974	0.0058	0.0073
900	0.276746	0.0073	0.0092
880	0.346169	0.0069	0.0098
860	0.405758	0.0081	0.0115
840	0.46041	0.0092	0.0130
820	0.520438	0.0104	0.0147
800	0.56985	0.0114	0.0161
780	0.626385	0.0125	0.0177
760	0.670649	0.0134	0.0190
740	0.71617	0.0143	0.0203
720	0.752471	0.0150	0.0213
700	0.792571	0.0159	0.0224
680	0.833492	0.0167	0.0236
660	0.867807	0.0174	0.0245
640	0.893542	0.0179	0.0253
620	0.913201	0.0183	0.0258
600	0.923397	0.0185	0.0261
580	0.933805	0.0187	0.0264
560	0.93505	0.0187	0.0264
540	0.933058	0.0187	0.0264
520	0.923655	0.0185	0.0261
500	0.90551	0.0181	0.0256
480	0.877499	0.0175	0.0248
460	0.834775	0.0167	0.0236
440	0.776513	0.0205	0.0258
420	0.690584	0.0183	0.0229
400	0.560831	0.0217	0.0244
380	0.387065	0.0201	0.0216
360	0.103961	0.0075	0.0078

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