XMM-Newton Optical & UV Monitor (OM) Calibration

Simon Rosen
ESAC

Users Group Meeting
May, 2019

Outline

- OM SUSS4 catalogue
- Time-dependent sensitivity degradation monitoring
- Jupiter depletion patch monitoring
- Time-dependent boresight update
- Calibration forward look

Release of Serendipitous UV Source Survey V4.1 ("the OM Catalogue")

- Version 4: SUSS4.1, released in December 2018 (available via XMM XSA)
- All public observations up to July 2017

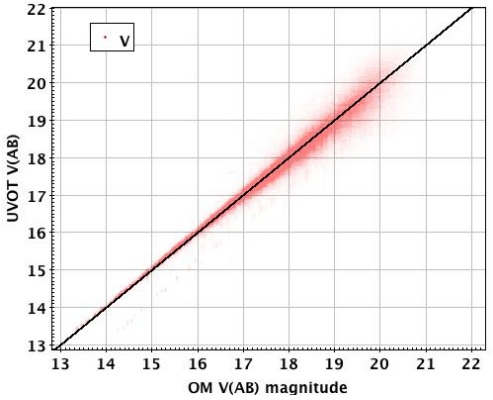
- Full reprocessing with SAS 17:
  - photometry of sources detected in mosaic and stacked images
  - inclusion of time-dependent sensitivity corrections

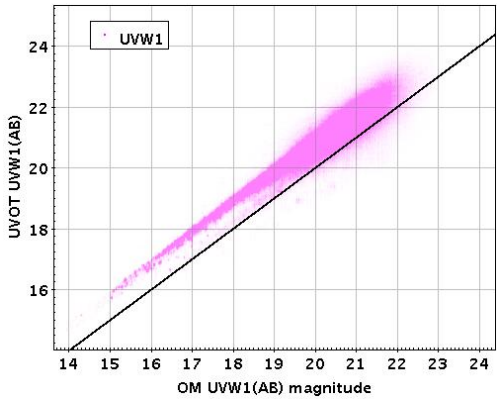
- 8.18×10^6 detections of 5.5×10^6 unique sources, from 9749 XMM-Newton pointings
- 4.45×10^6 detections with UV data (3.05×10^6 unique sources)

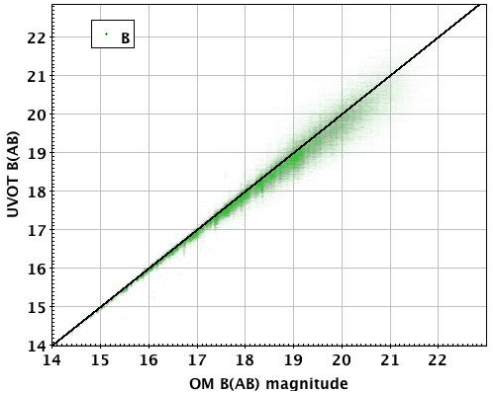
- Source variability from multiple pointings (1.04×10^6 sources observed > once)

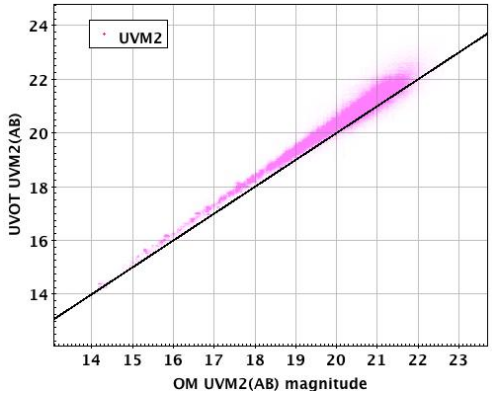
- 82% of cleanest, point-like OM sources have a match in GAIA DR2 catalogue
  - 98% of those are within 2", median offset 0.45"

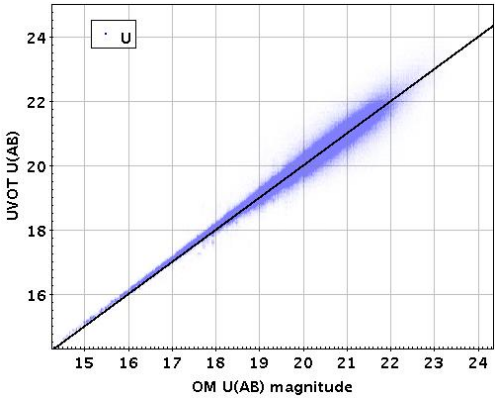
Comparison of XMM OM and Swift UVOT photometry – good agreement

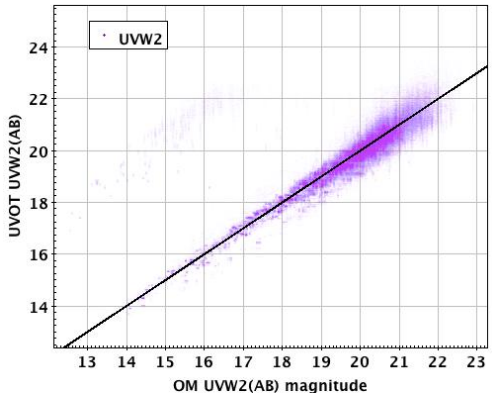








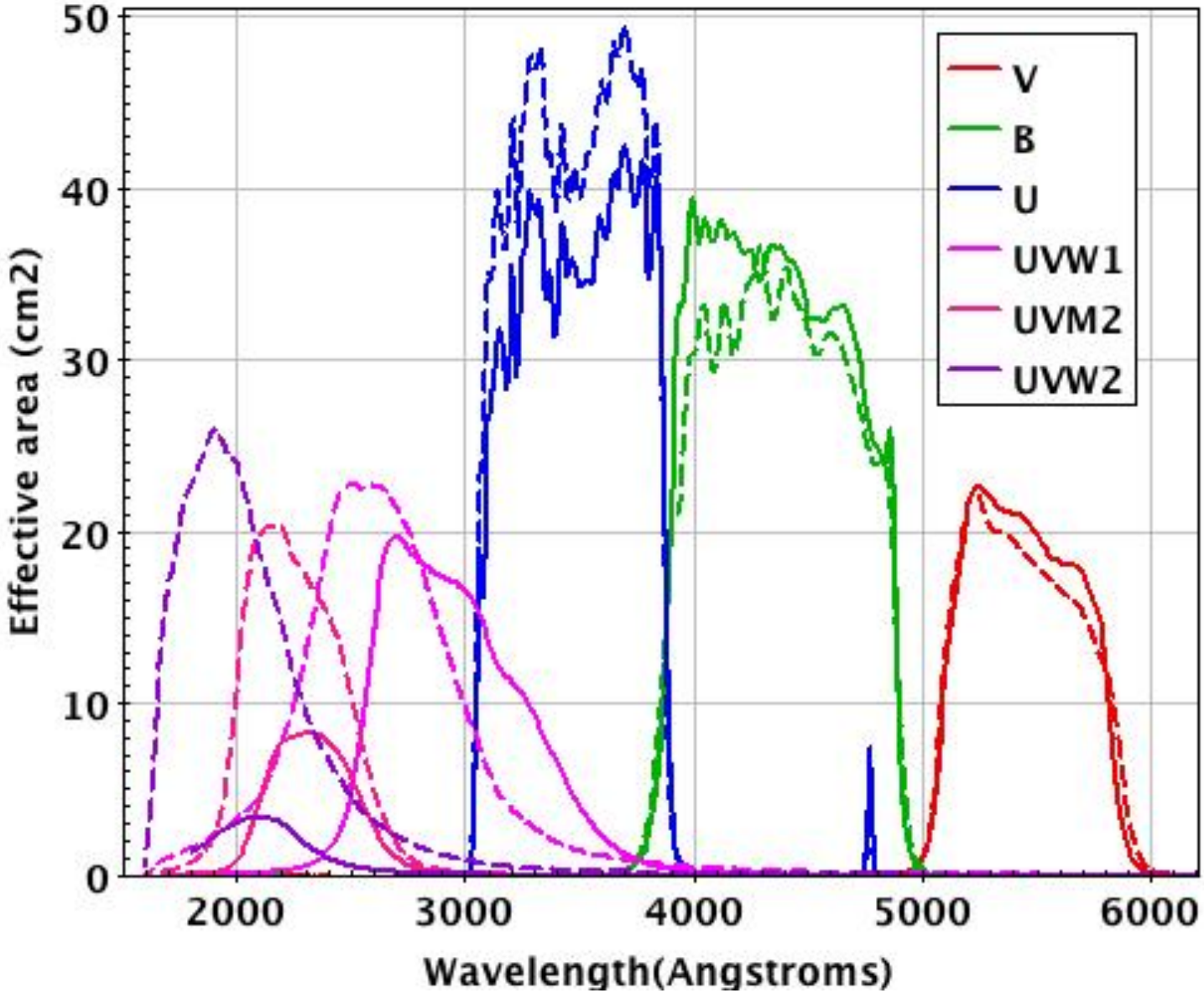




- OM v UVOT (AB mag)
- Generally good agreement – almost OM=UVOT

  (see also data from A. Breeveld in Yershov, V.N., 2014, Astr. & Space Science, 354, 97.)
- UVW1 notable different
  - double pronged
  - due to rather different filter profile
- Other filter differences – similar cause

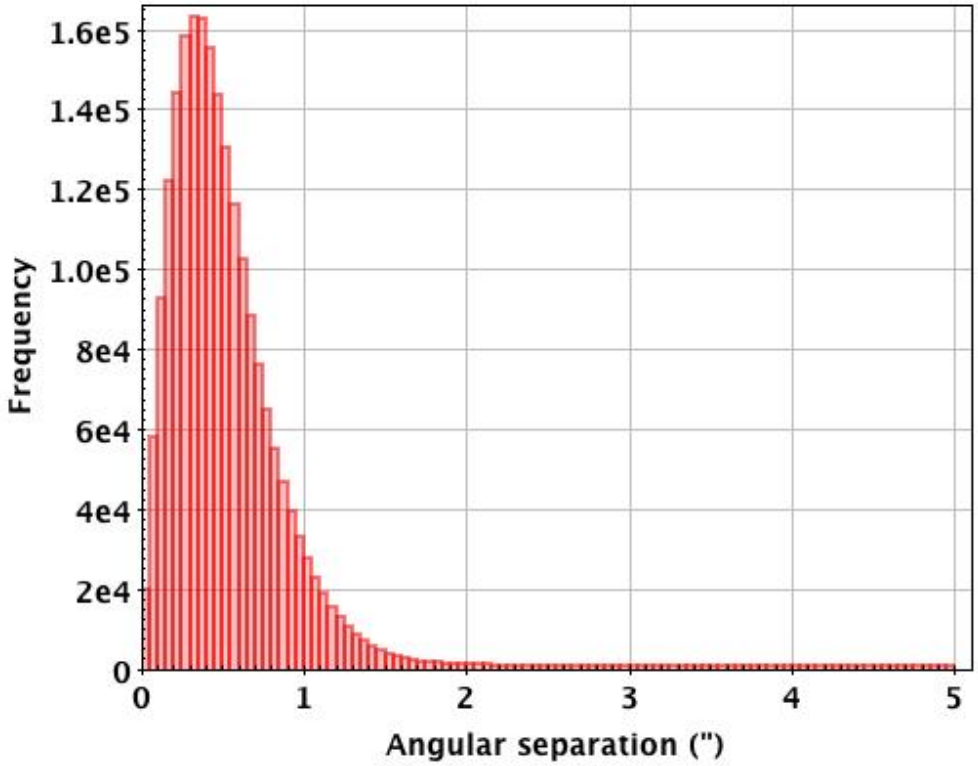
Comparison of XMM OM and Swift UVOT photometry – good agreement



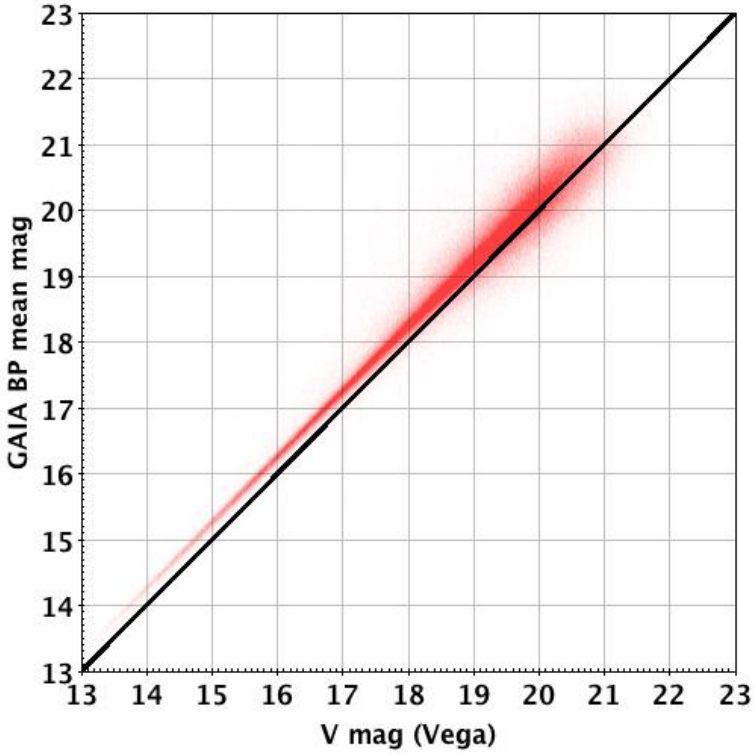
OM (solid)
UVOT (dashed)

OM-GAIA comparisons

OM* source offsets from GAIA matches

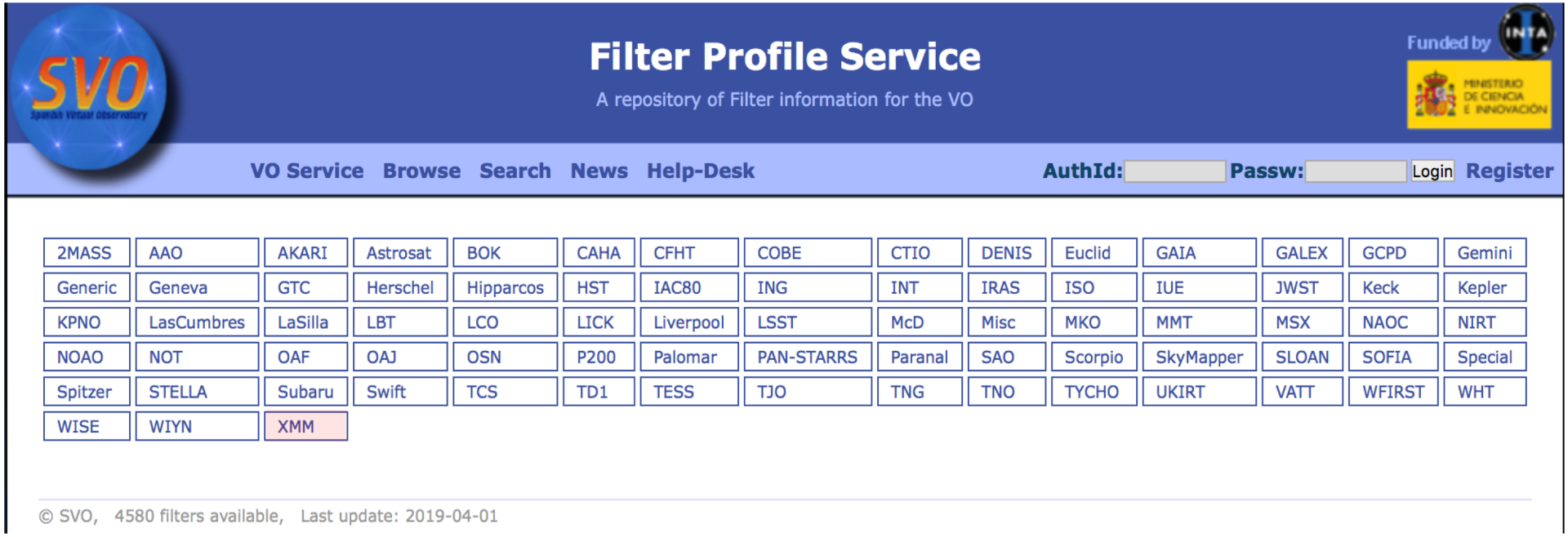


OM*(V) / GAIA (BP mag)



** Clean, point like OM sources*

XMM OM filter data in SVO filter service



http://svo2.cab.inta-csic.es/theory/fps/

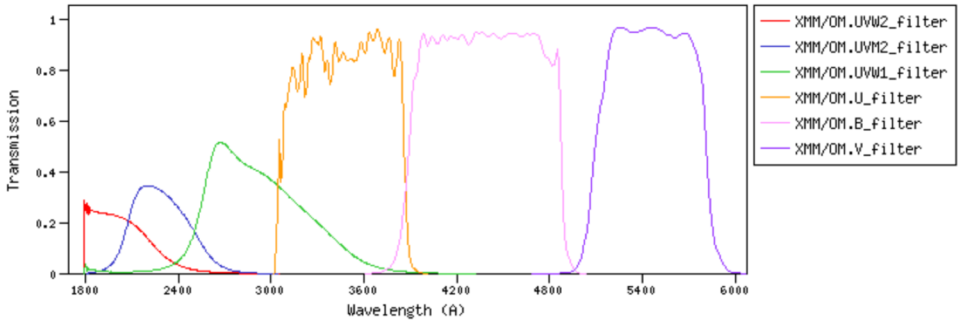
XMM OM filter data in SVO filter service

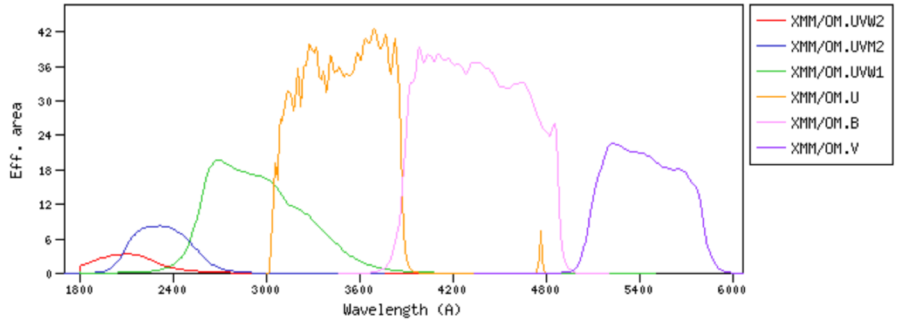
XMM filters:

Filter ID	λ_{mean}	λ_{eff}	λ_{min}	λ_{max}	W_{eff}	ZP (Jy)	Obs. Facility	Instrument	Description
XMM/OM.UVW2_filter	2066.6	2042.1	1790	2892	435.5	738.9	XMM	OM	XMM OM UVW2 filter transmission only
XMM/OM.UVW2	2175.3	2144.9	1800	3246	498.3	766.3	XMM	OM	XMM OM UVW2 filter full effective area
XMM/OM.UVM2_filter	2303.8	2283.8	1821	2919	461.9	773.9	XMM	OM	XMM OM UVM2 filter transmission only
XMM/OM.UVM2	2347.2	2327.6	1884	2994	478.1	781.1	XMM	OM	XMM OM UVM2 filter full effective area
XMM/OM.UVW1_filter	2947.4	2934.3	1795	4034	744.0	1044.8	XMM	OM	XMM OM UVW1 filter transmission only
XMM/OM.UVW1	2978.8	2971.0	2189	4060	795.3	1065.0	XMM	OM	XMM OM UVW1 filter full effective area
XMM/OM.U_filter	3488.8	3515.7	3022	3948	675.1	1480.5	XMM	OM	XMM OM U filter transmission only
XMM/OM.U	3503.2	3534.6	3020	4782	651.1	1506.0	XMM	OM	XMM OM U filter full effective area
XMM/OM.B	4365.4	4332.4	3719	4964	926.4	4056.7	XMM	OM	XMM OM B filter full effective area
XMM/OM.B_filter	4397.8	4361.9	3729	4969	910.2	4055.0	XMM	OM	XMM OM B filter transmission only
XMM/OM.V	5437.6	5412.1	4932	5963	666.4	3637.3	XMM	OM	XMM OM V filter full effective area
XMM/OM.V_filter	5463.4	5437.8	4943	5977	699.6	3620.7	XMM	OM	XMM OM V filter transmission only

Filter Plots (using a common λ range)

(Plot them zoomed to their own λ range)





XMM OM filter data in SVO filter service

XMM/OM.UVW1_filter

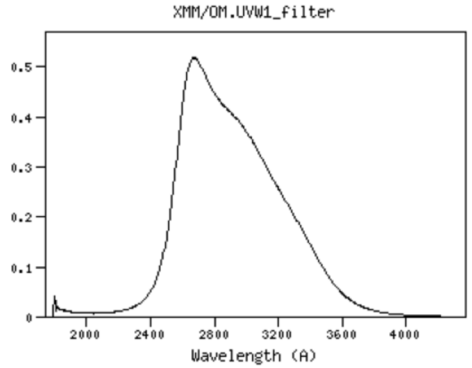
Filter Description

Filter ID (?) :	XMM/OM.UVW1_filter
Description (?) :	XMM OM UVW1 filter transmission only
Phot.System (?) :	XMM
Detector Type (?) :	Photon counter
Band Name (?) :	UVW1
Obs. Facility (?) :	XMM
Instrument (?) :	OM
Comments (?) :	------

Mathematical properties

Property	Calculated	Specified	Unit
λ_{mean} (?) :	2947.35	-------	(Angstrom)
λ_{cen} (?) :	2914.67	-------	(Angstrom)
λ_{eff} (?) :	2934.34	-------	(Angstrom)
λ_{peak} (?) :	2680.00	-------	(Angstrom)
λ_{pivot} (?) :	2895.37	-------	(Angstrom)
λ_{phot} (?) :	2972.69	-------	(Angstrom)
λ_{min} (?) :	1795.00	-------	(Angstrom)
λ_{max} (?) :	4033.62	-------	(Angstrom)
W_{eff} (?) :	743.98	-------	(Angstrom)
FWHM (?) :	732.34	-------	(Angstrom)
A_f/A_V (?) :	1.86	-------	()

Transmission curve



Data file: ascii, VOTable

Reference for filter response: XMM-Newton Users handbook

Calibration properties

Vega System

Property	Specified	Calculated	Unit
Zero Point (?) :	-------	3.638e-9	(erg/cm2/s/A)
	-------	1044.79	(Jy)
ZP Type (?) :	Pogson		
PhotCal ID (?) :	XMM/OM.UVW1_filter/Vega		

AB System

Property	Specified	Calculated	Unit
Zero Point (?) :	-------	1.264e-8	(erg/cm2/s/A)
	-------	3631.00	(Jy)
ZP Type (?) :	Pogson		
PhotCal ID (?) :	XMM/OM.UVW1_filter/AB		

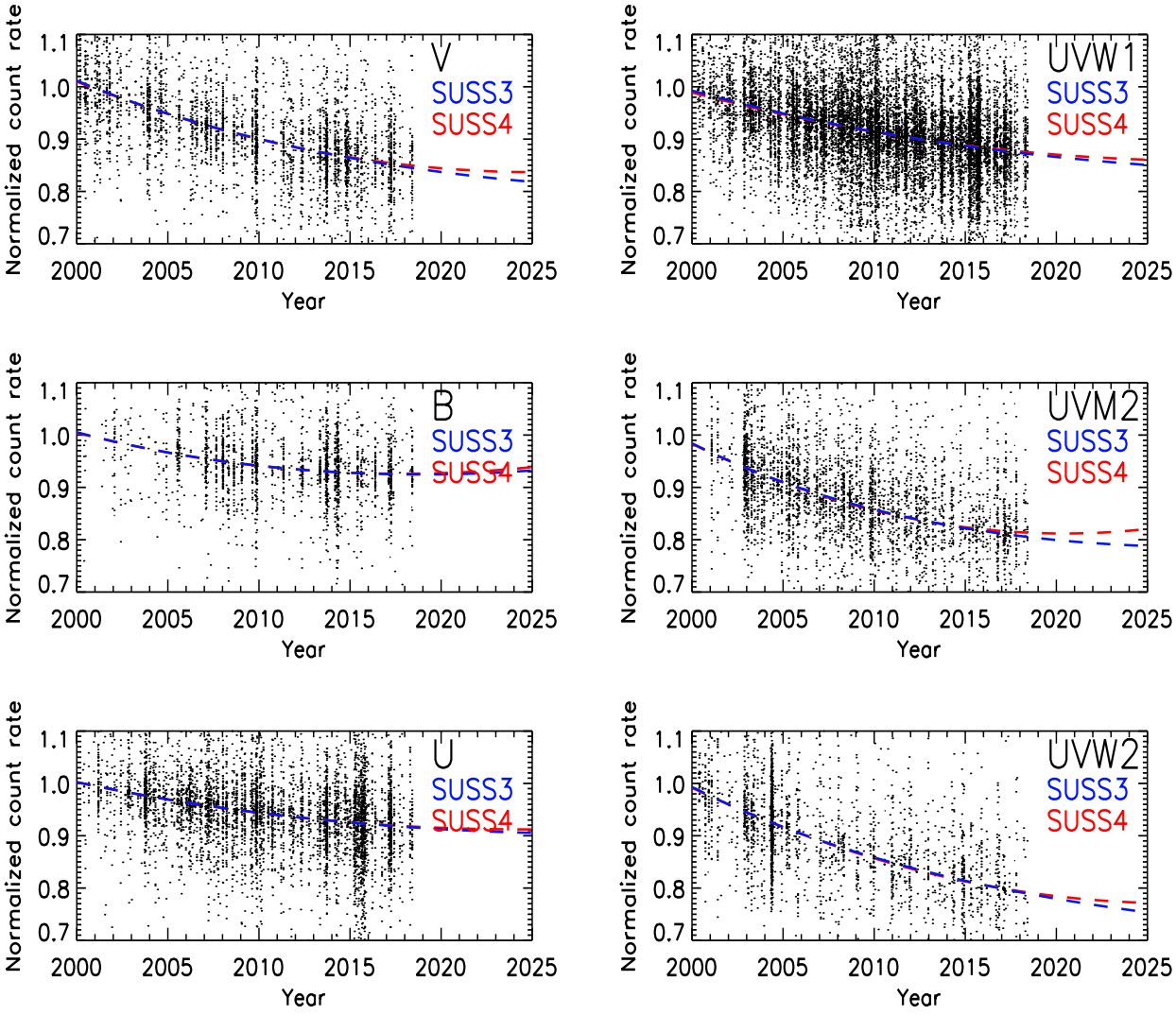
ST System

Property	Specified	Calculated	Unit
Zero Point (?) :	-------	3.631e-9	(erg/cm2/s/A)
	-------	1042.86	(Jy)
ZP Type (?) :	Pogson		
PhotCal ID (?) :	XMM/OM.UVW1_filter/ST		

Filter added: 2019-03-29 10:51:34
Last update: 2019-03-29 12:58:09

OM time-dependent sensitivity degradation

OM time sensitivity degradation (SUSS4)



OM throughput

Filter	Current	Expected in 2030
V	0.85	0.84
B	0.92	0.92*
U	0.92	0.92
UVW1	0.88	0.85
UVM2	0.81	0.81*
UVW2	0.78	0.73

** Set at current values due to fitted function turnup.*

From multiply-observed (>5x) OM SUSS4.1 catalogue sources

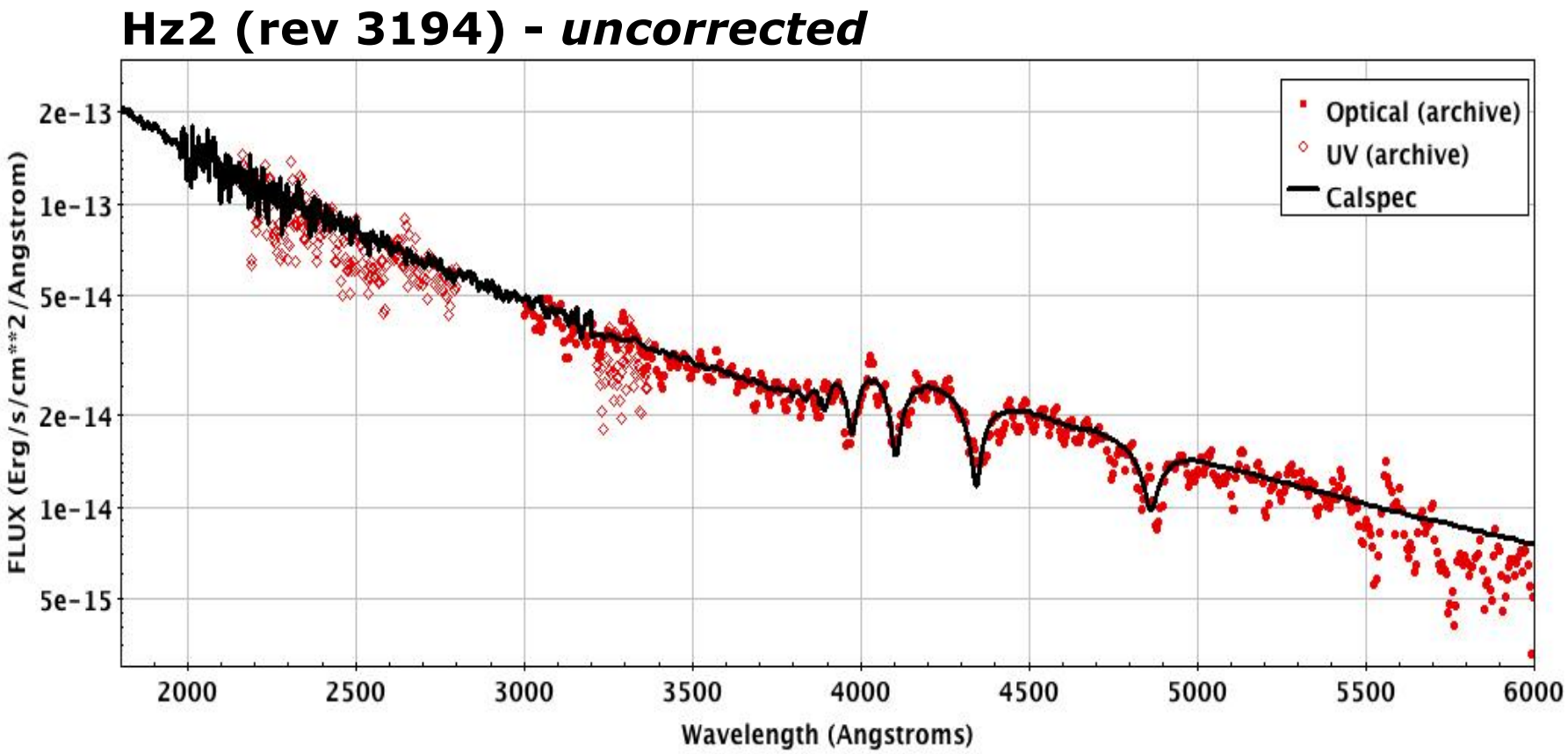
First implementation of time-dependent sensitivity degradation for the grisms

Year	UV_Grism	V_Grism
2000	1.00	1.00
2002	1.01	1.01
2004	1.02	1.02
2006	1.04	1.02
2008	1.05	1.03
2010	1.07	1.04
2012	1.08	1.04
2014	1.10	1.05
2016	1.12	1.06
2018	1.13	1.07
2020	1.15	1.07

Implemented in OM_GRISMCAL_0005

Accommodated by changes to OM grism SAS software

First time-dependent sensitivity degradation implemented for Grisms



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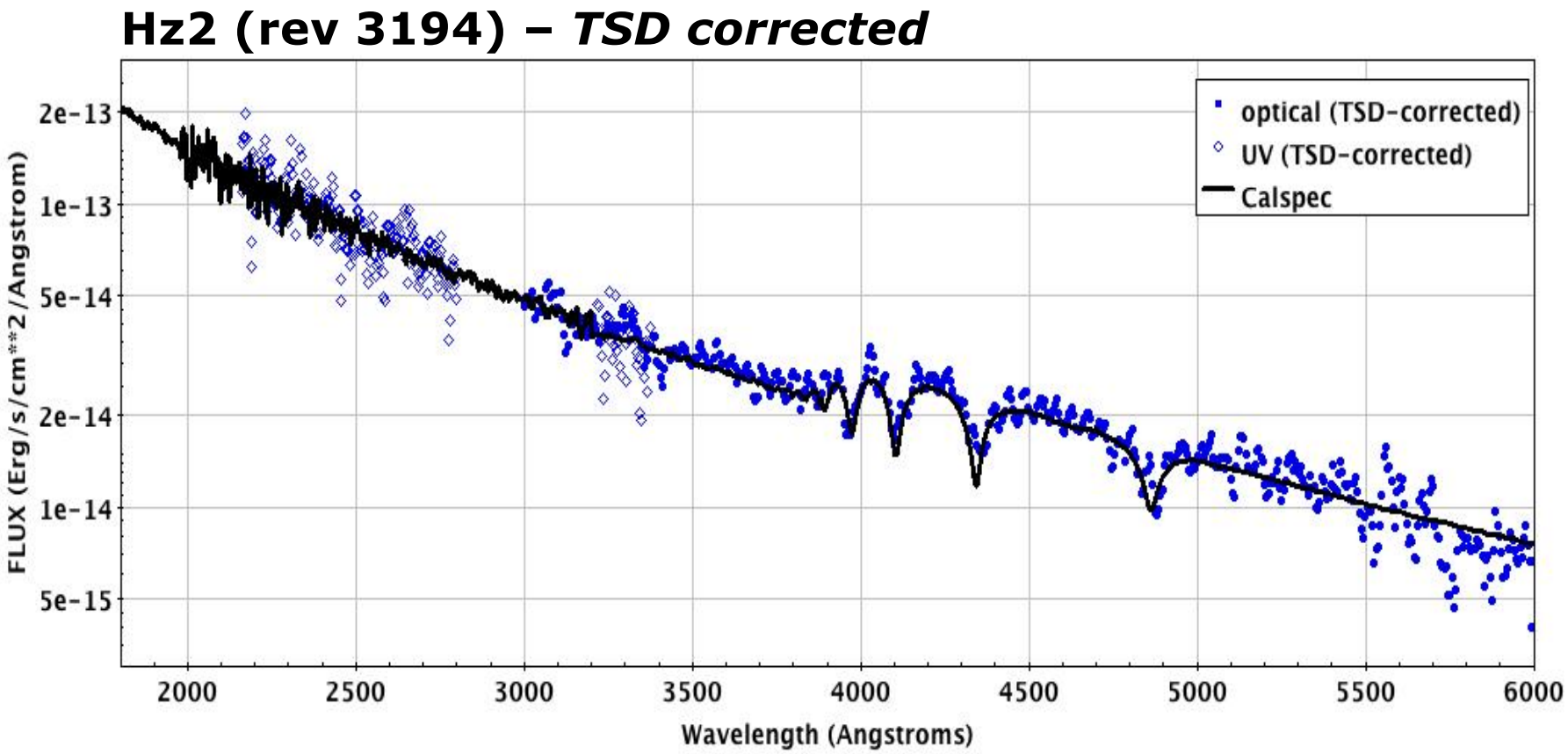
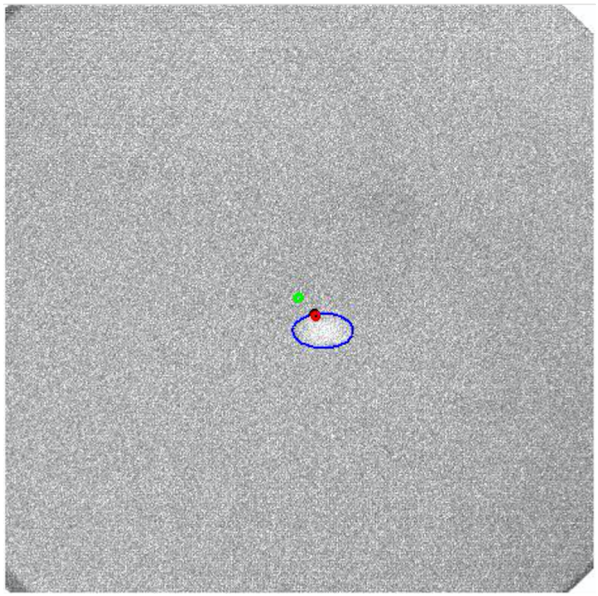
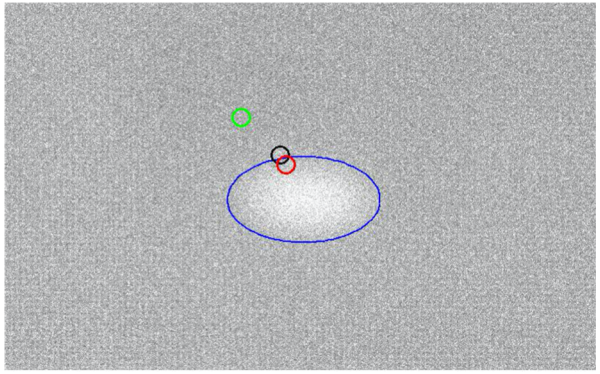


Update on the Jupiter depletion patch

Flat field image
(full frame)



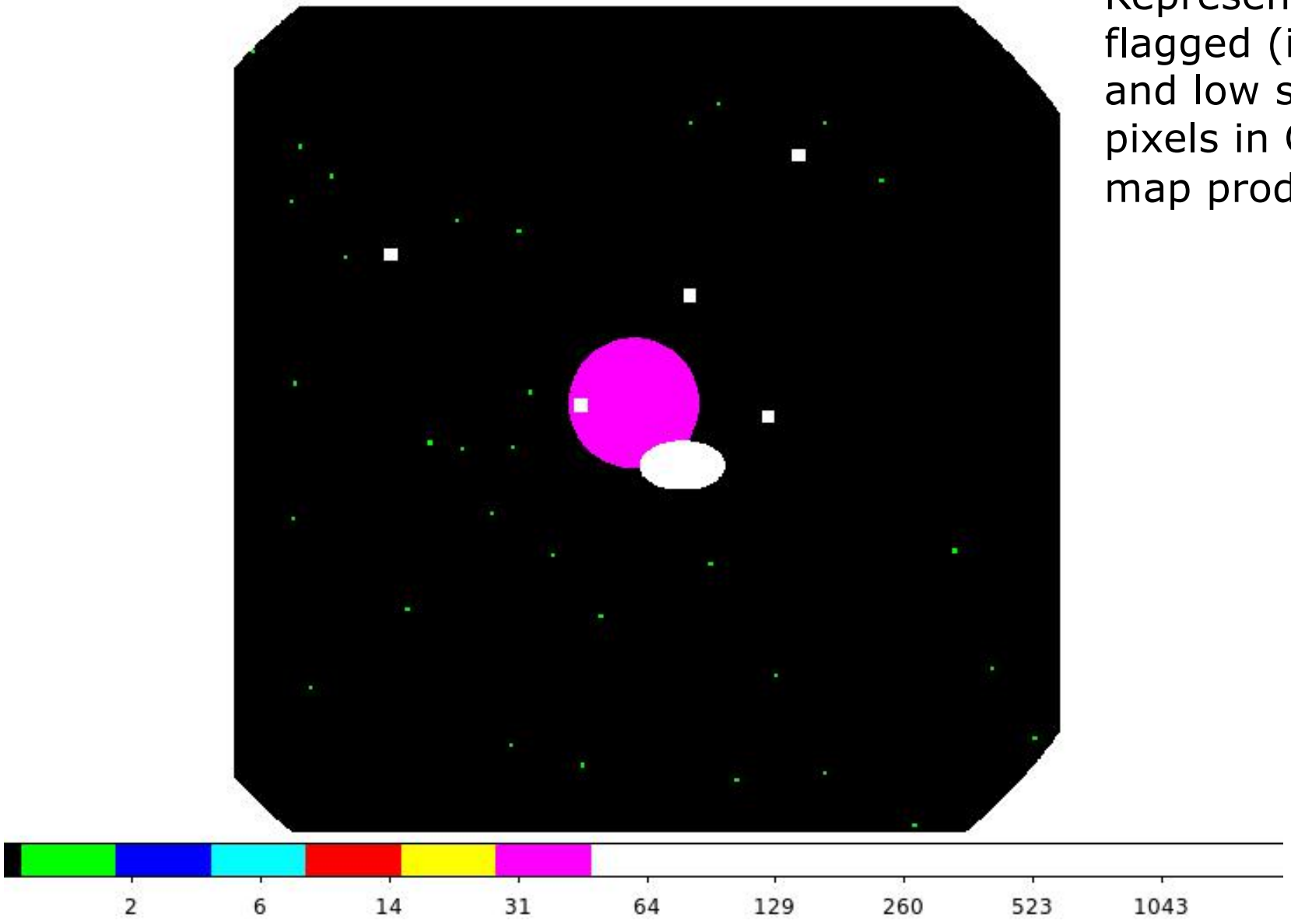
Zoom



Accidental observations of Jupiter (16 July 2017)

- Elliptical lower sensitivity patch ~105” x 60” (~0.5% of FoV), up to ~ -35% (in V)
- Affected area flagged in the Bad Pixels CCF
  - Updated with new badpixel characterization
  - Distinguishes low sensitivity from bad pixels
  - New CCFs: OM_BADPIX_0007+0008

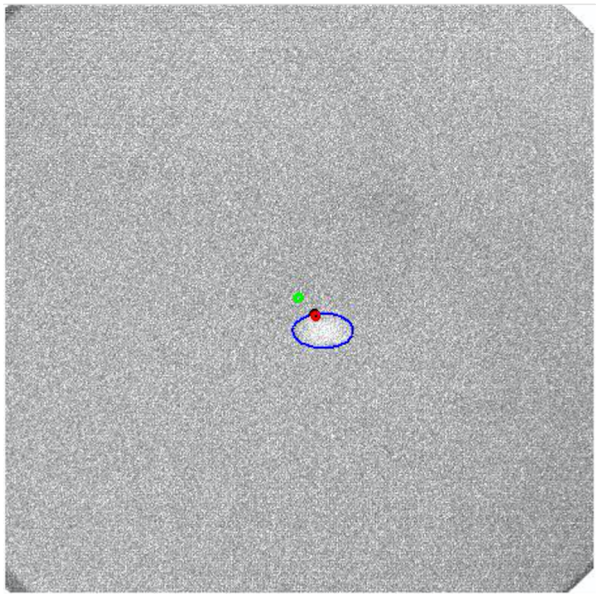
Update on the Jupiter depletion patch



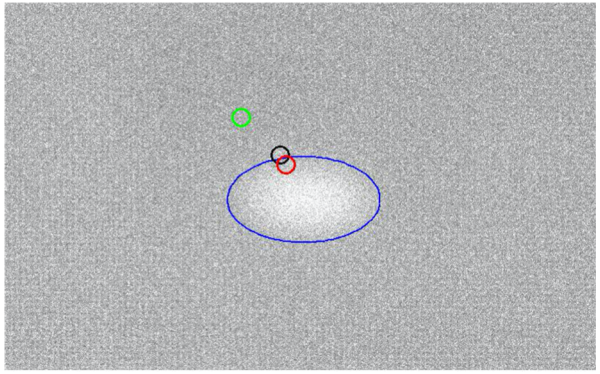
Representation of flagged (including bad and low sensitivity) pixels in OM quality map products.

Update on the Jupiter depletion patch

Flat field image
(full frame)



Zoom



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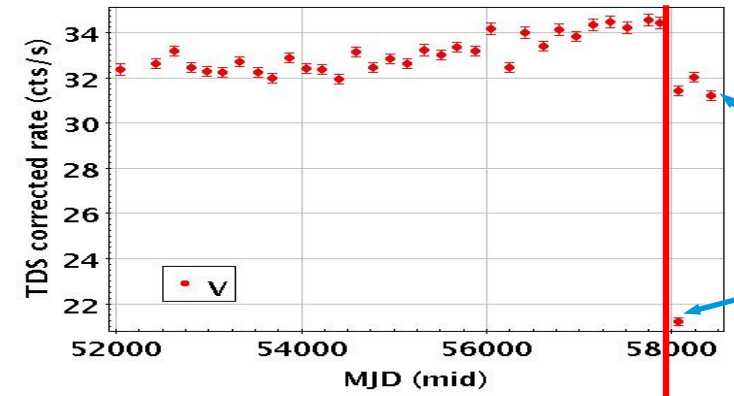
- Affected area flagged in the Bad Pixels CCF
  - Updated with new bad pixel characterization
  - Distinguishes low sensitivity from bad pixels
  - New CCFs: OM_BADPIX_0007+0008
- pn boresight (typical target position) centred outside the Jupiter depletion patch bad pixels
- Routine standard star observations made at pn boresight since event

Impact on targets at pn boresight

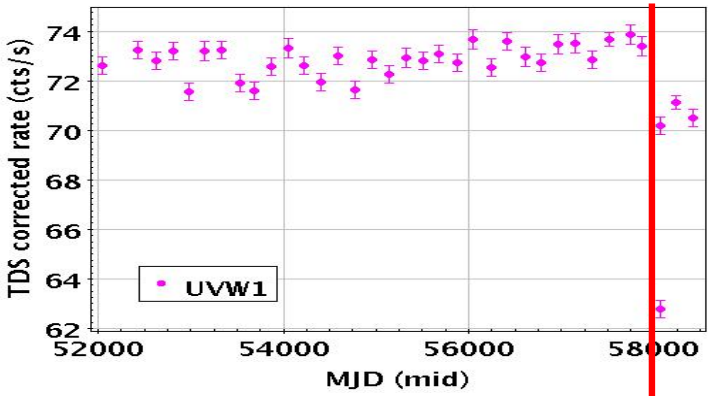
BPM 16274



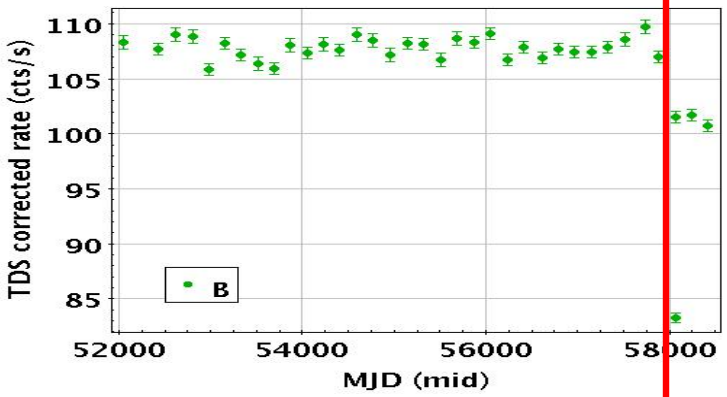
V

pn boresight
-4.8%

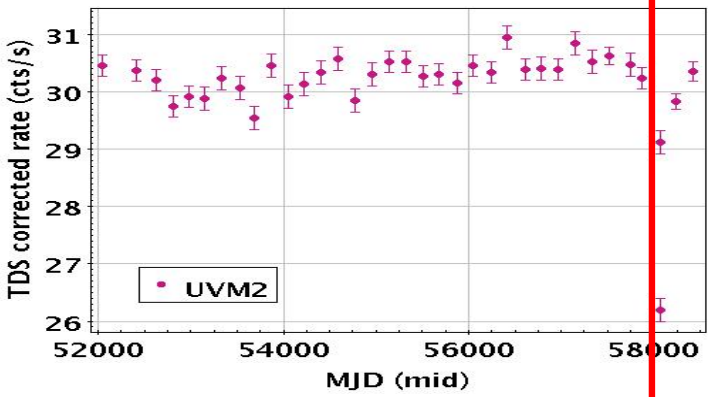
patch centre
-36%



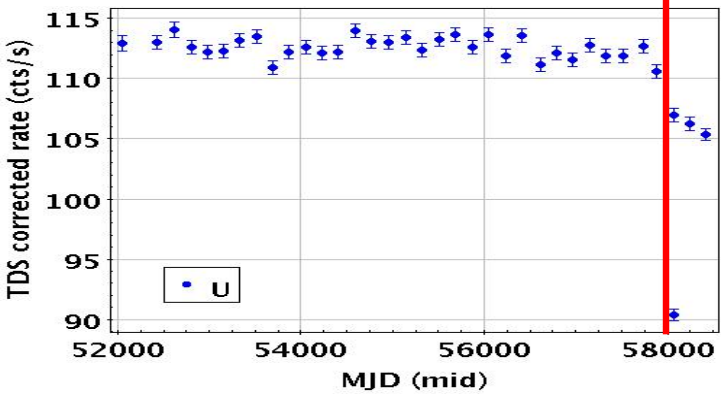
W1
-- 3.3%



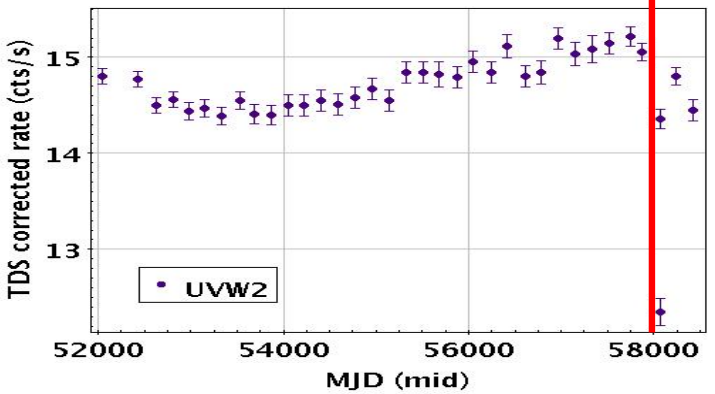
B
-- 6.0%



M2
-- 2.3%



U
-- 5.5%



W2
-- 1.4%

Impact on targets at pn boresight

In summary

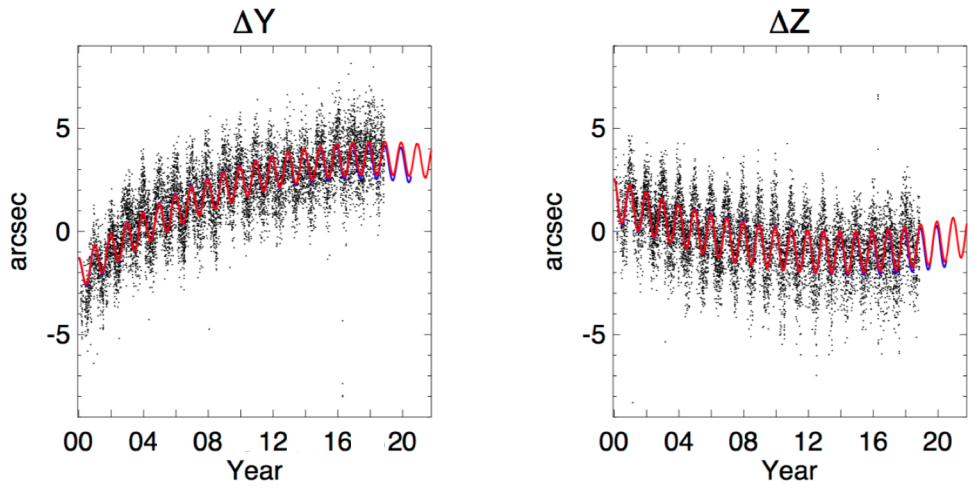
- Patch sensitivity appears stable
- There is a small ($\lesssim$ 6%) degradation at pn boresight
  → users informed via XMM-Newton March 2019 newsletter

Ongoing monitoring

- New NRCO of BPM16274 just performed (source well outside patch), contemporaneous with RCO observation at the pn boresight
  - immediate comparison of the in/out of patch count rates
  - monitoring long-term time-dependent sensitivity via standards again

Updating the time-dependent boresight

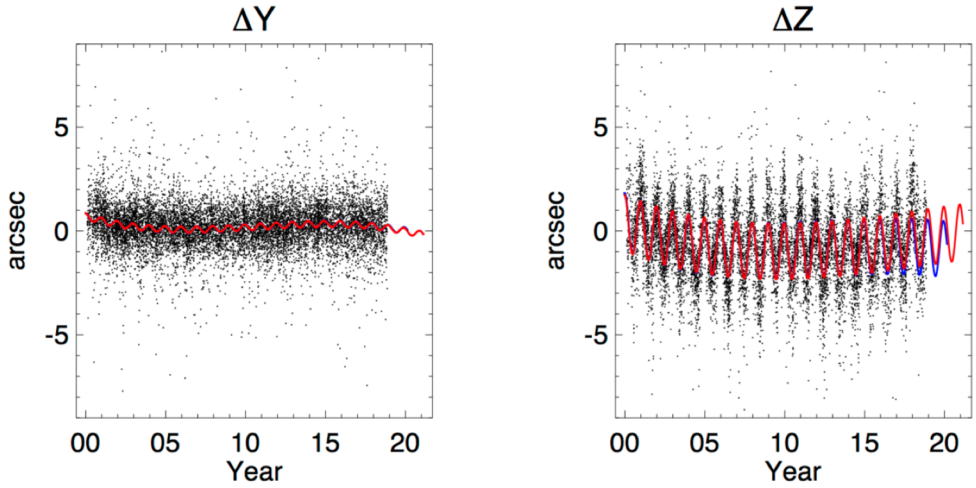
OM



$$\Delta = (P_1 + P_2 \times T + P_3 \times T^2) + P_4 T^3) + P_5 \times \cos[2\pi \times (T - P_6)/P_7)]$$

Instrument/coordinate	P_1	P_2	P_3	P_4	P_5	P_6	P_7
EPIC/Y	+0.70	-0.64×10^{-3}	$+2.0 \times 10^{-7}$	-1.7×10^{-11}	+0.15	−13.58	364.0
EPIC/Z	+0.38	-0.87×10^{-3}	$+1.7 \times 10^{-7}$	-7.8×10^{-12}	+1.35	−8.28	364.8
OM/X	−1.57	$+1.03 \times 10^{-3}$	-1.01×10^{-7}		−1.02	−11.25	364.5
OM/Y	−2.04	$+1.66 \times 10^{-3}$	-1.23×10^{-7}		+0.81	−11.82	364.1

EPIC (P. Rodriguez)



- Update (v29) of time-dependent boresight using latest data
- OM information from
  - catalogue cross-correlations (from pipeline processing)
  - field acquisition
- Long-term trend + annual variation
- Improves astrometry where catalogue cross-correlations not possible

A forward look

- Monitoring and updates from routine calibration, esp. time-dependent sensitivity degradation
- Small flux steps in photometry between
  - sub-exposures obtained in default imaging mode
  - fast-mode exposure segments obtained during default imaging mode
  - fast-mode photometry arising from exposure-exposure drift of off-centred sources
- Jupiter depletion patch
  - Exploration of approaches to correct photometry of sources within the reduced sensitivity patch