Instrument	EPIC MOS	EPIC pn	RGS	OM
Bandpass	0.15-12 keV	0.15-15 keV	0.35-2.5 keV (1)	180-600 nm
Orbital target vis. (2)	5-135 ks	5-135 ks	5-135 ks	5-145 ks
Sensitivity (3)	~10^{-14} (4)	~10^{-14} (4)	~8×10^{-5} (5)	20.7 mag (6)
Field of view (FOV)	30' (7)	30' (7)	~5'	17'
PSF (*FWHM/HEW*) (8)	5"/14"	6"/15"	N/A	1.4"-2.0"
Pixel size	40 μm (1.1")	150 μm (4.1")	81 μm (9×10^{-3} Å) (9)	0.476513" (10)
Timing resolution (11)	1.5 ms	0.03 ms	0.6 s	0.5 s
Spectral resolution (12)	~70 eV	~80 eV	0.04/0.025 Å (13)	350 (14)

Optical & UV Monitor

(OM)

on-board

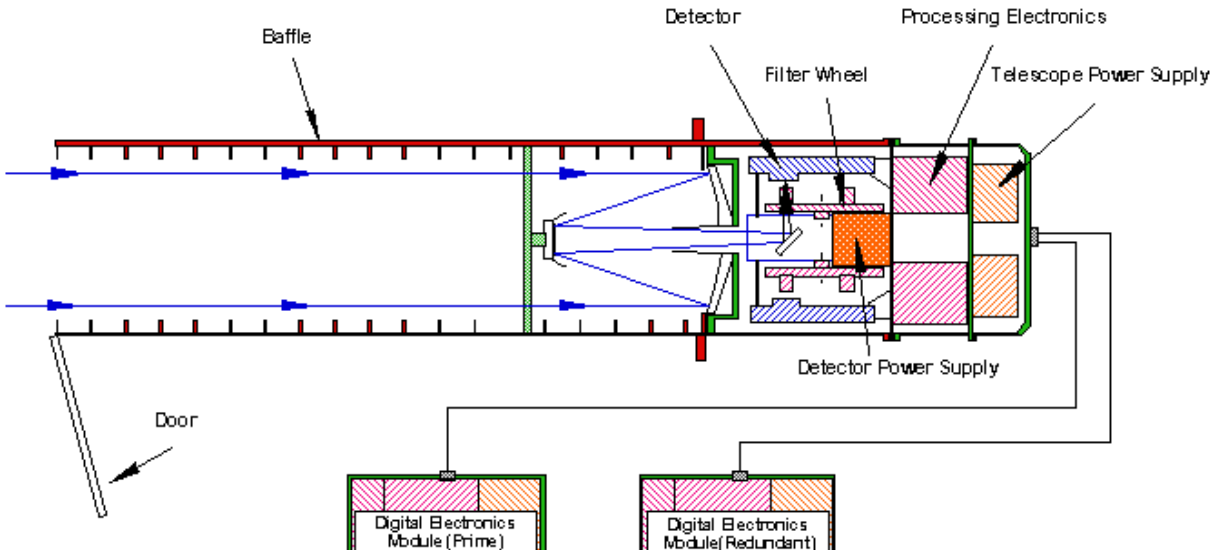
XMM-Newton

Antonio Talavera

XMM-Newton Science Operation Centre, ESAC, ESA

OM: Instrument Description

- cm Ritchey-Chretien telescope
- cal ratio of f/12.7 and focal length of 3.8 m
- tal coverage between 170 nm and 650 nm of a 17 arcmin square field of view
- ter wheel with 11 apertures: one blanked off, six broad band filters (U, B, V, VW1, UVM2 and UVW2), one white, one magnifier and two grisms (UV and optical)
- etector: micro-channel plate intensified CCD (2048 x 2048 pixels final format)



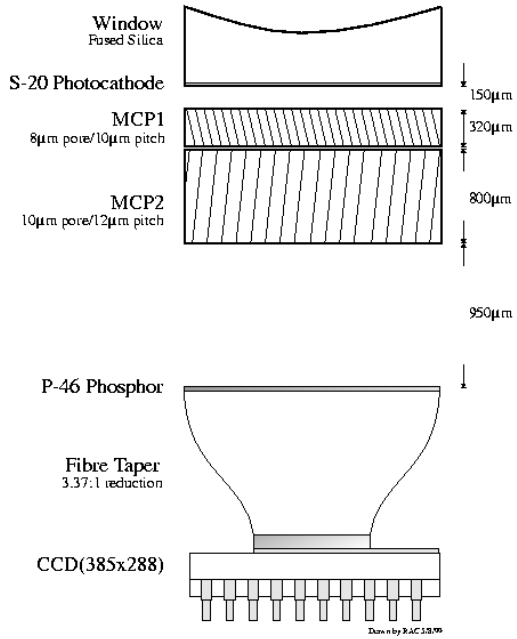
OM: Instrument Description

Detector: micro-channel plate intensified CCD with 384 x 288 physical pixels (Active area 256x256). Amplification: 10^5

Photon events centroided to 1/8 physical pixel (2048 x 2048): 0.5”

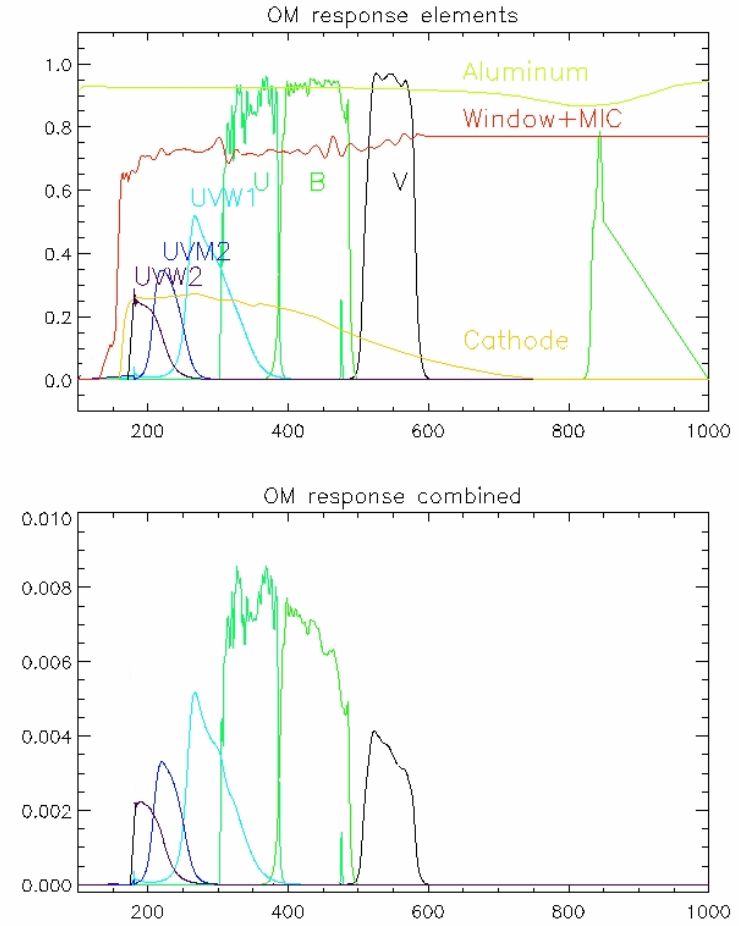
“Shift and Add” mechanism to compensate S/C drift or jitter

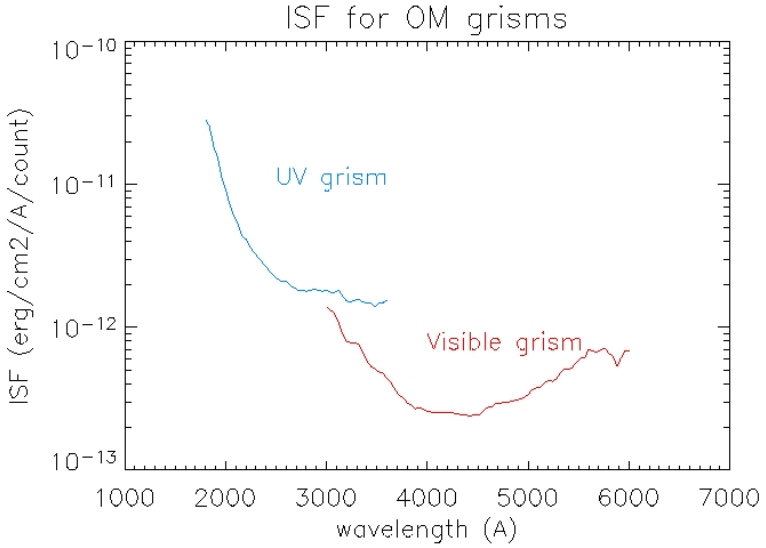
Fast event timing: 500 ms in fast mode



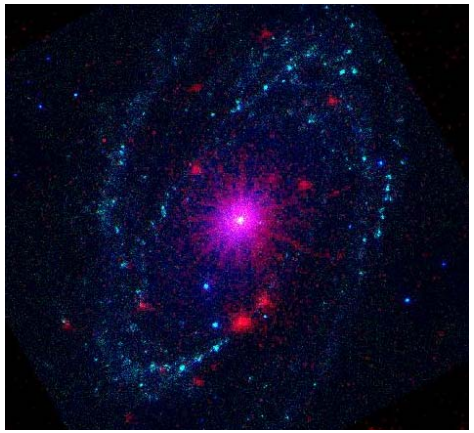
Schematic Structure of Detector Head

OM: filters & grisms

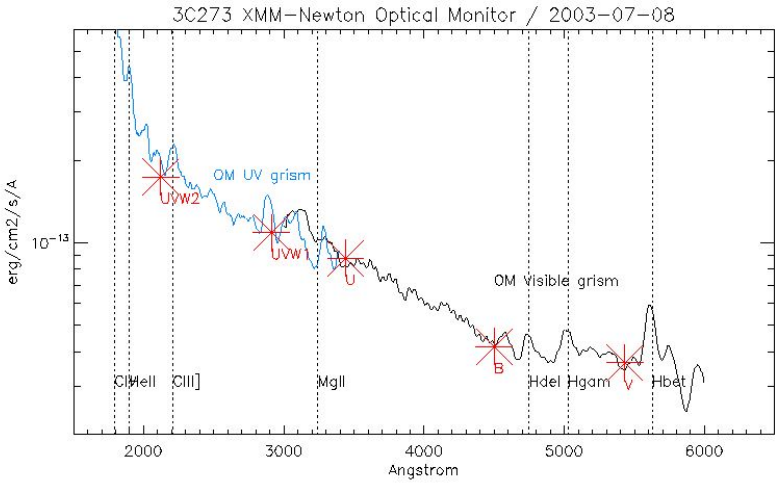




OM: some examples

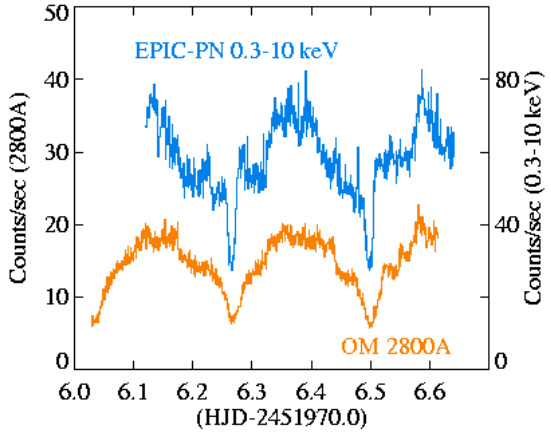


Spectral energy distribution with grisms and filters

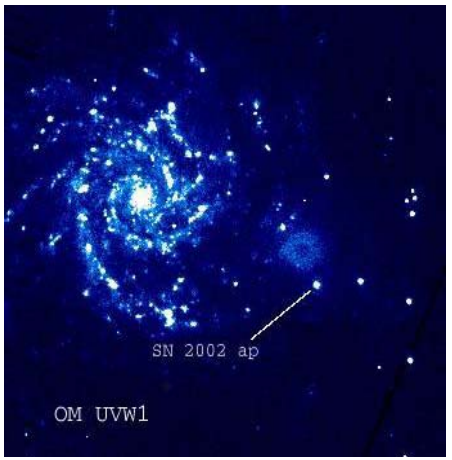


-ray light

2-371)



SN 2002p



OM: performance

l limiting magnitude:
igma in 1000 s

ter	Spectral type				
	B0	**A0**	**G0**	**K0**	**WD**
	19.8	19.8	19.7	19.7	19.7
	21.0	20.8	20.2	19.9	20.6
	21.8	20.4	19.6	18.6	21.2
W1	21.1	19.2	17.6	15.4	20.5

OM UV grism sensitivity:
detected flux (erg/cm2/s/A)

Detection	**Exposure time (s)**	
level	**1000**	**5000**
1-σ	1.0 10^{-14}	4.6 10^{-15}
3-σ	4.0 10^{-14}	1.6 10^{-14}
10-σ	2.4 10^{-14}	7.0 10^{-14}

DM: operational configuration with filters

o basic modes:

- Imaging
- Fast mode (< 512 pix)

Default image

Default image + fast mode

User defined windows (up to 5 windows, 2 in fast mode)

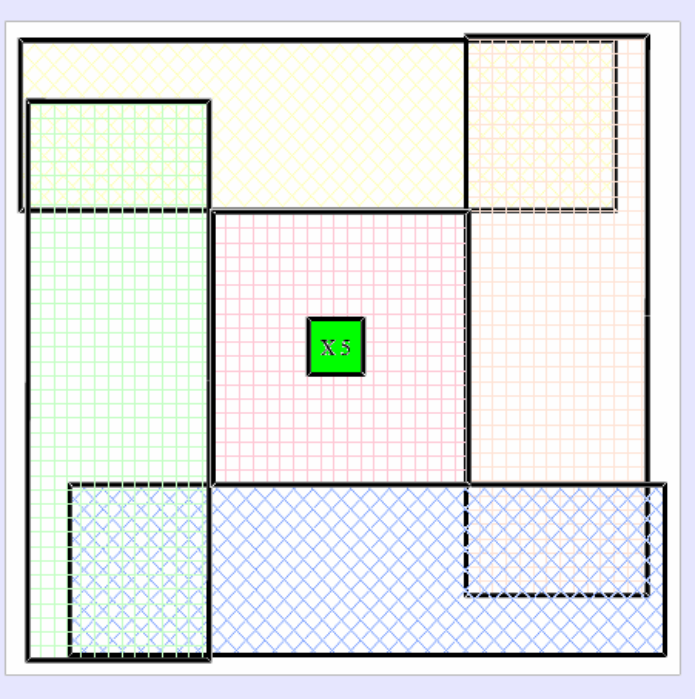
Full-Frame Low-Resolution
1024 x 1024 1” pixels

Full-Frame High-resolution
2048 x 2048 0.5” pixels

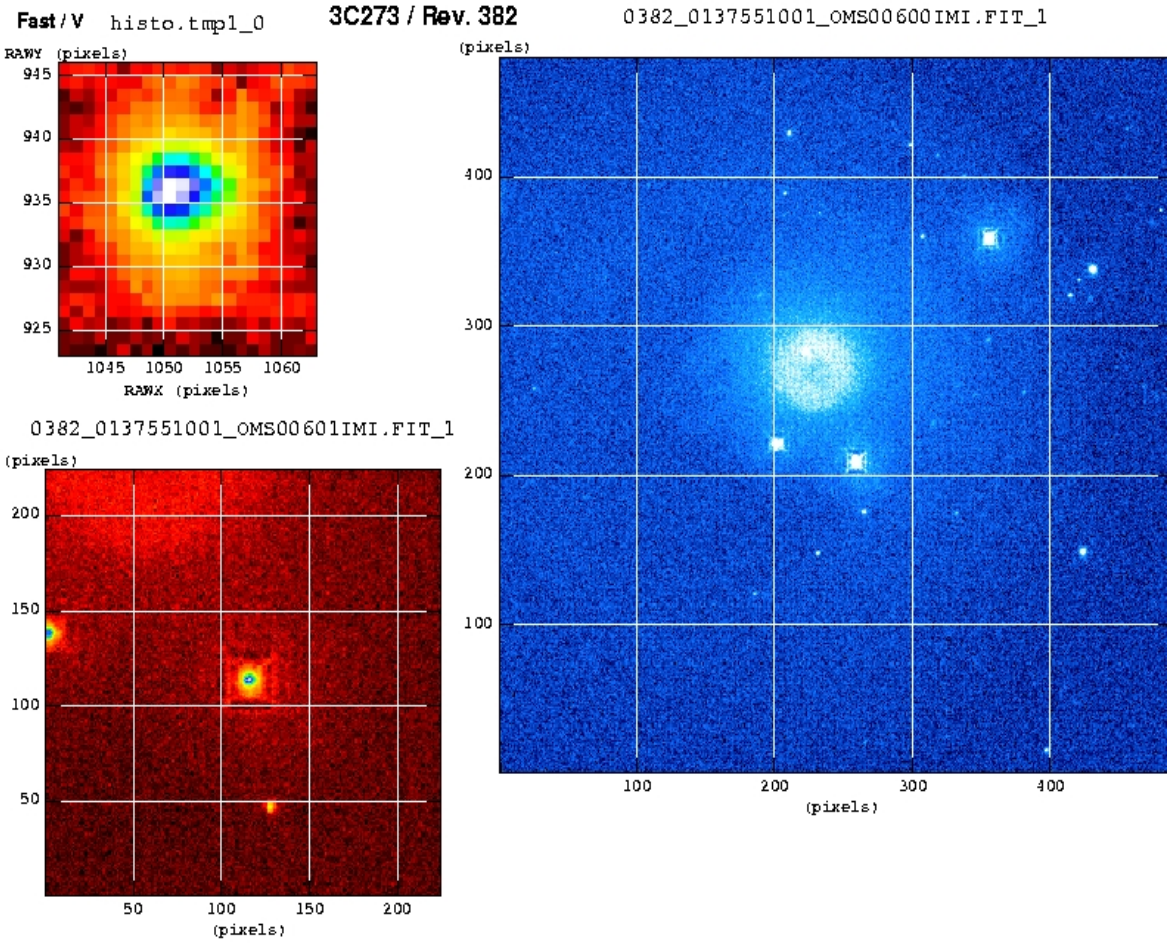
Total number of pixels is limited

Fast window: 22 x 23

Default configuration:

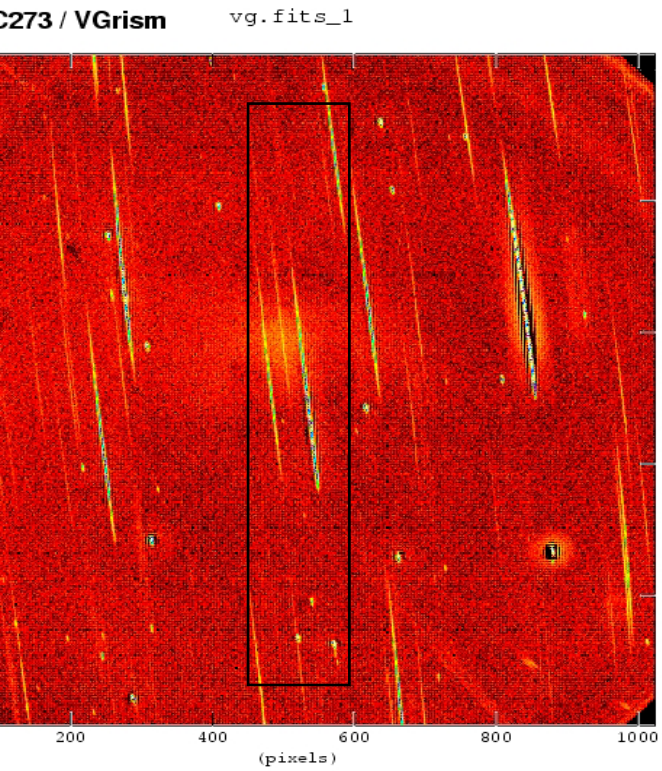


Optical Monitor: default windows

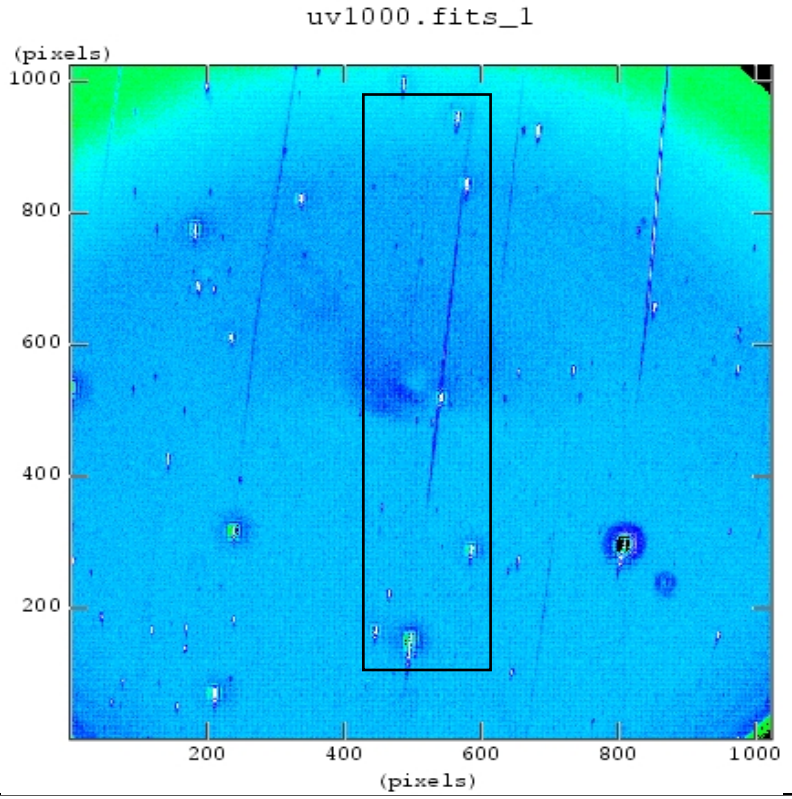


OM: operational configuration with grisms

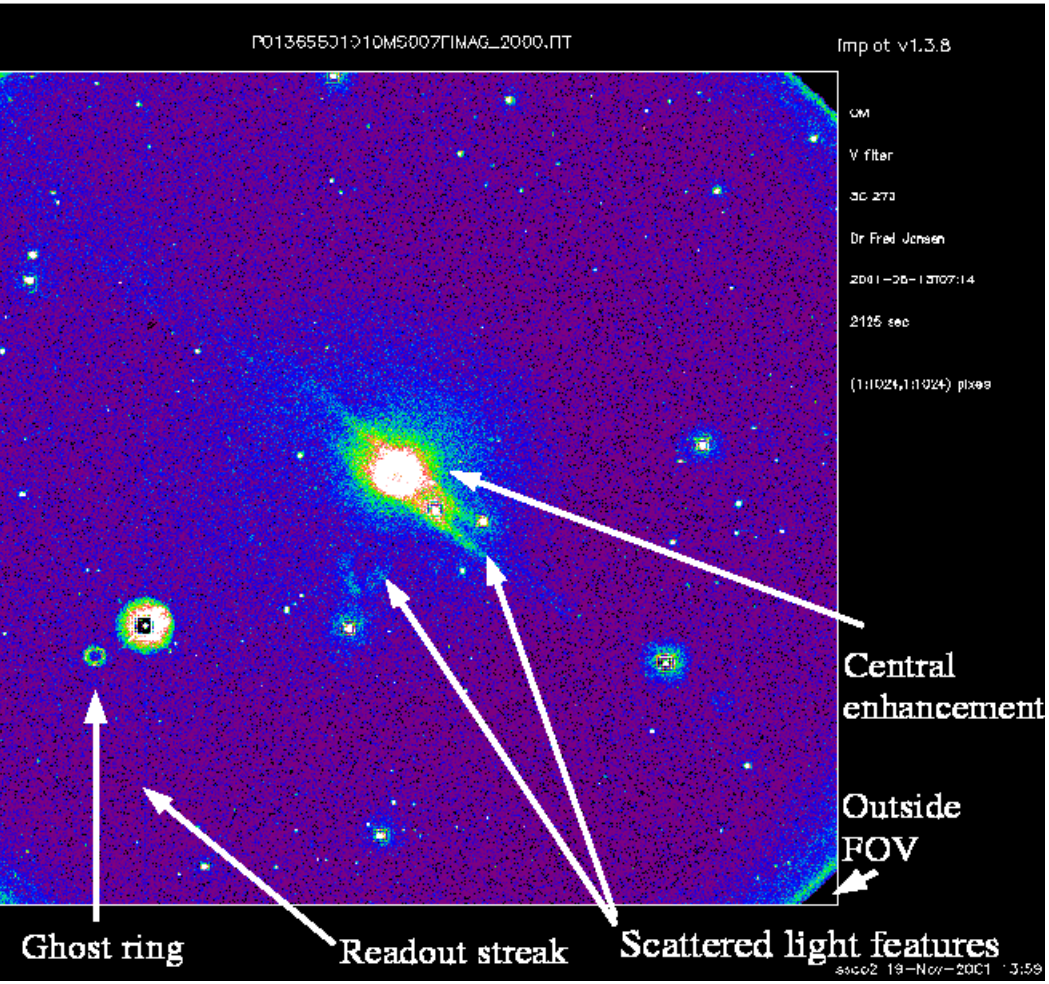
- Single object spectroscopy:
  target at the boresight



- Field spectroscopy:
  all objects in the f.o.v.



Artifacts in OM images



- Straylight loops
- Central bright patch
- Gost images
- Streaks

ptical Monitor (and all XMM-Newton) data

All data are processed, corrected and calibrated with the Science Analysis System (SAS).

Then they go into the XMM-Newton Science Archive (XSA):

http://xmm.esac.esa.int/xsa/

ptical Monitor data processing: what is it?

trumental corrections

strometry(filters & grisms):

- **Geometric distortio**
- ➢ ***X,Y linearized posit***

notometry:

- **aperture**
- **PSF**
- **coincidence losses and dead time**
- **time sensitivity degradation**

- **geometry:distortion, rotation**
- **spectral extraction**
- ➢ ***spectrum count rate vs. position***

All corrections and calibrations are included into OM data processing through corresponding SAS algorithms & CCFs

SAS RESULTS CAN BE USED DIRECTLY FOR SCIENTIFIC INTERPRETATION

II) Calibration

- **Astrometry:**

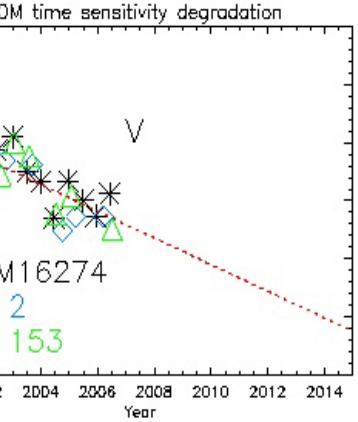
om X,Y to R.A. & Dec

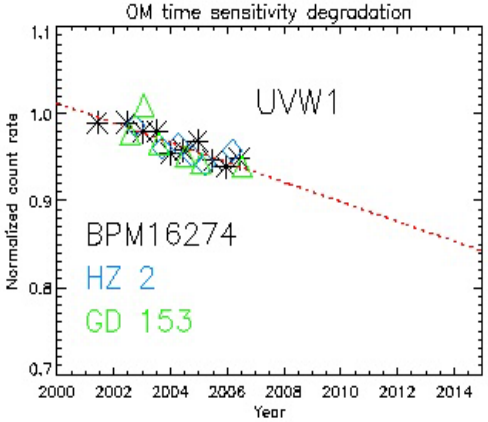
metry:

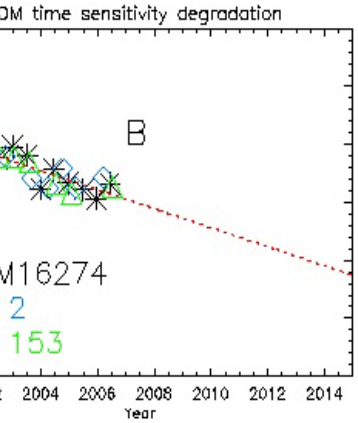
om count rate to magnitude, andard UBV, color indices, AB magnitude

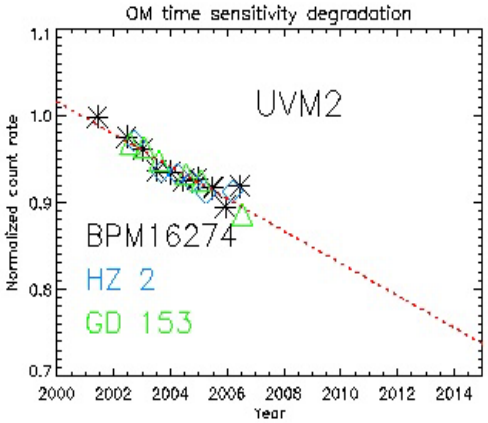
- ➢ ***light curve***
- ➢ ***from count rate to absolute flux filter***

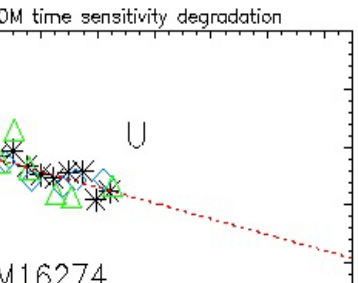
- ➢ ***from position to wavelength***
- ➢ ***from count rate to absolute flux vs. wavelength***

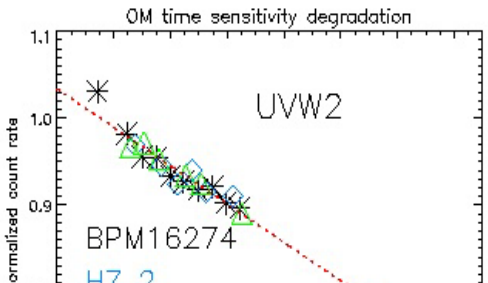












OM time sensitivity degradation

Sensitivity loss in 2015:

- **U, B, V, UVW1 : < 15 %**
- **UVM2, UVW2 : < 30 %**

OM data reduction with SAS: accuracy

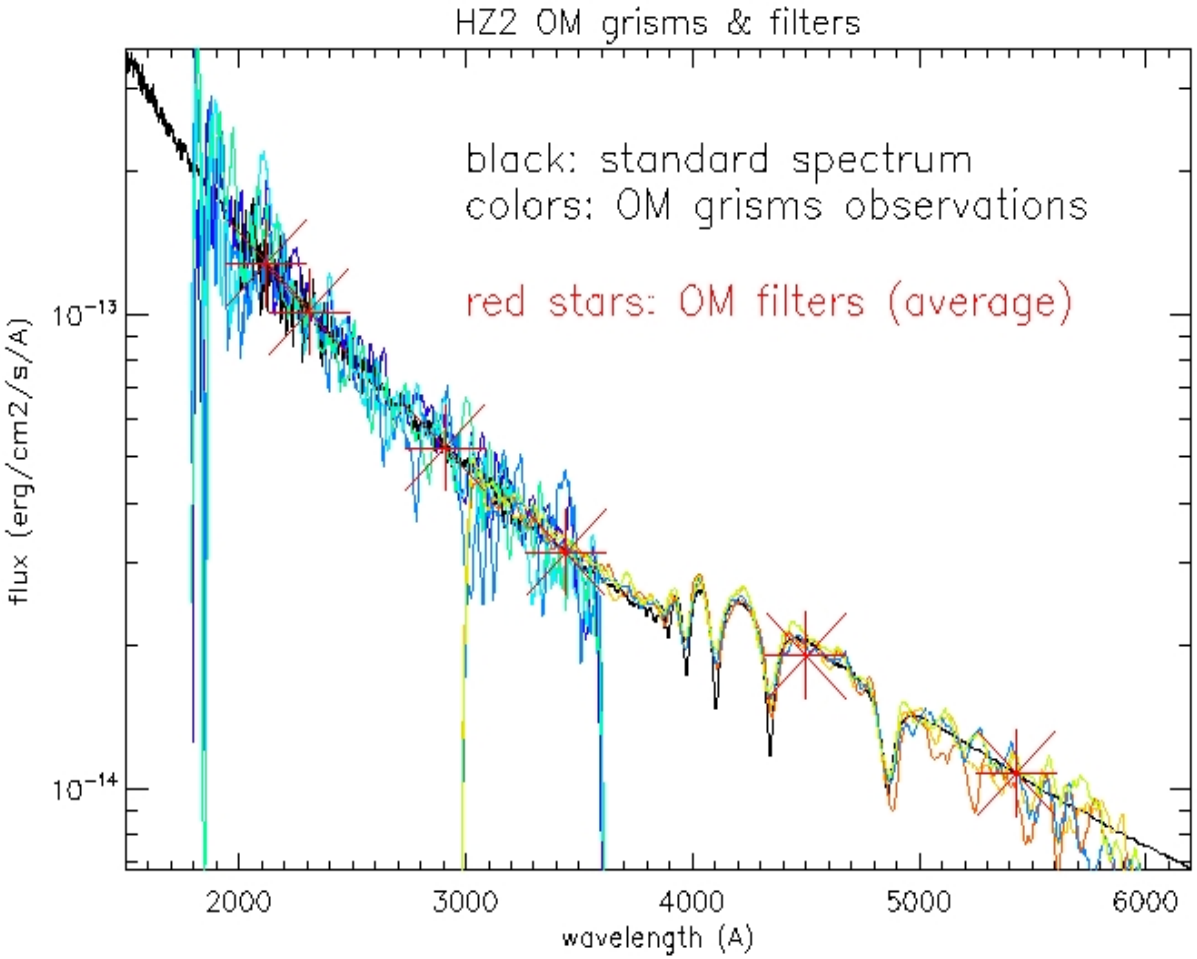
trometric precision (image photometry):
RA_off = - 0.22 ± 1.8 arcsec Dec_off = - 0.40 ± 2.1
mit is 0.7" due to residual distortion and catalogue uncertainties)

otometric precission:
0.02mag (2%) for MS stars
0.04mag (4%) for MS stars in U filter (due to Balmer discontinuity effects)
10% for non Main Sequence stars
absolute flux: errors < 10% (up to 2% depending on spectral type)

sms spectra:
wavelength: internal accuracy: 7A (UVgrism), 15A(Vgrism) / possible 10 A shift
wavelength across f.o.v.: up to 50A shift
spectral resolution: 15A for UVgrism (worst in Vgrism)
absolute flux: better than 10% (up to 20% at edges of spectral range)

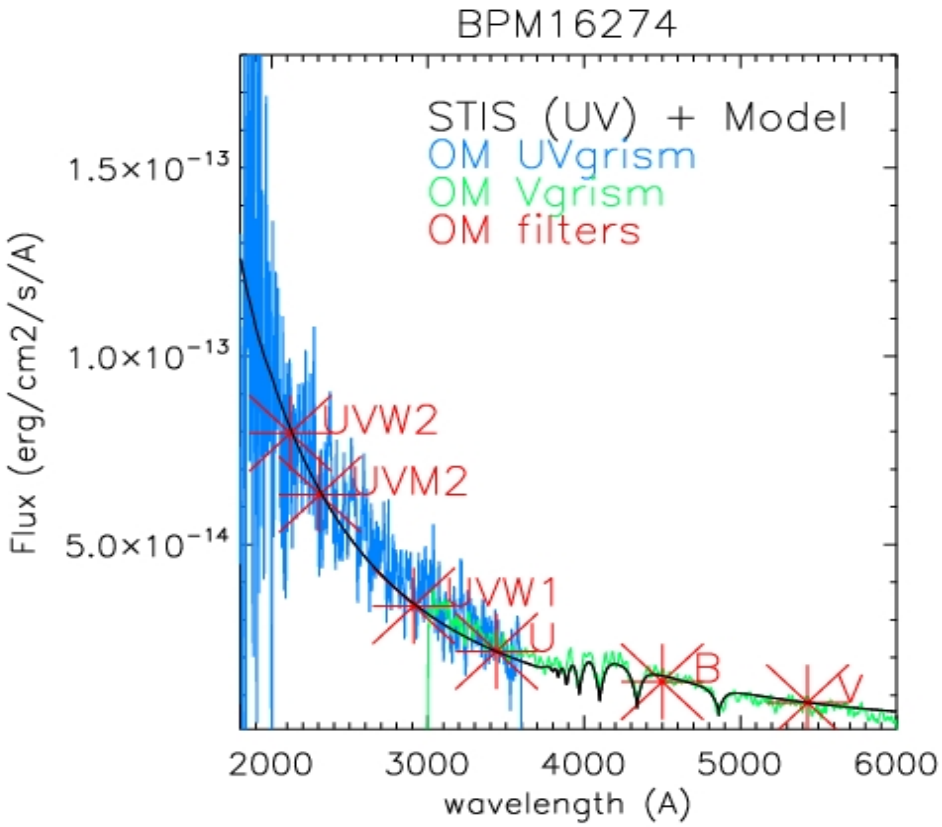
oss-calibration: grisms and grisms versus filters: EXCELLENT (10%)

OM data reduction with SAS

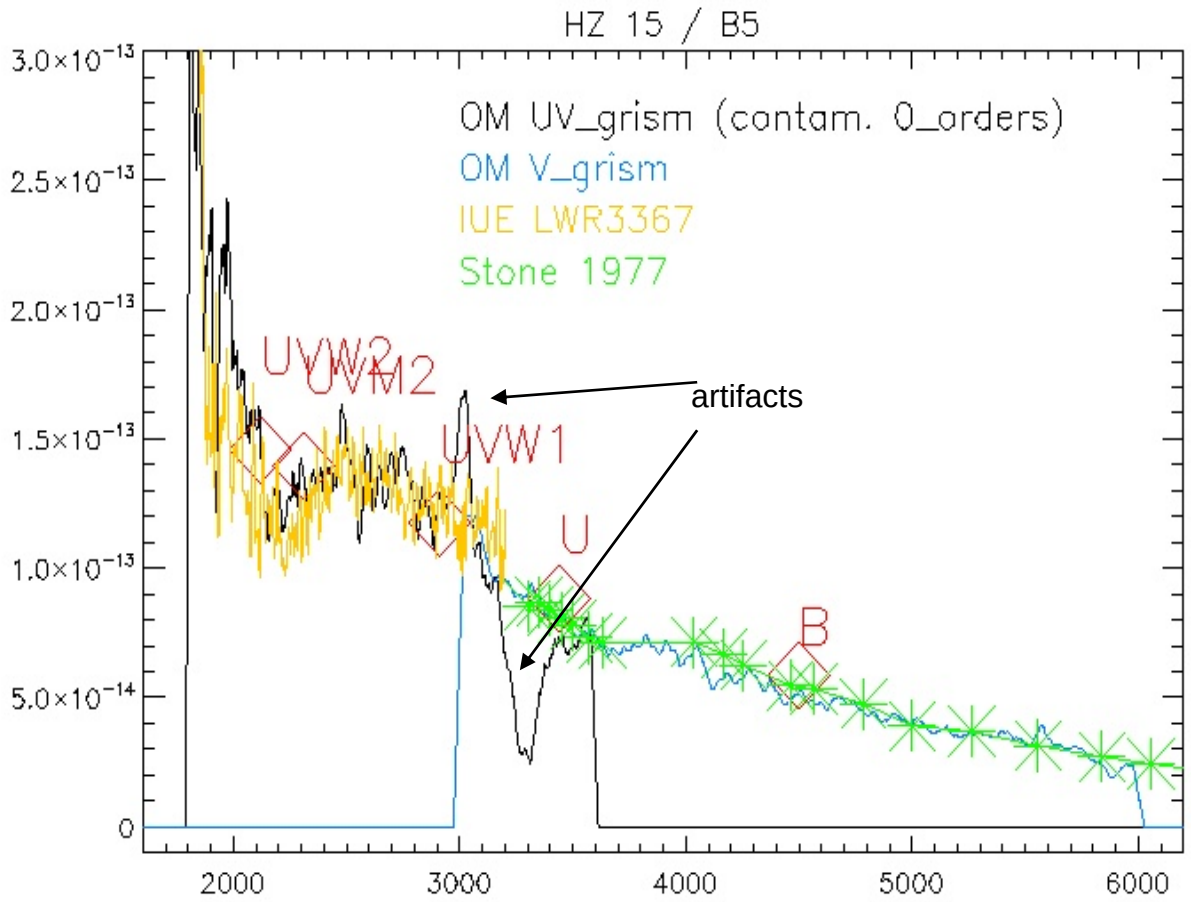


OM data reduction with SAS

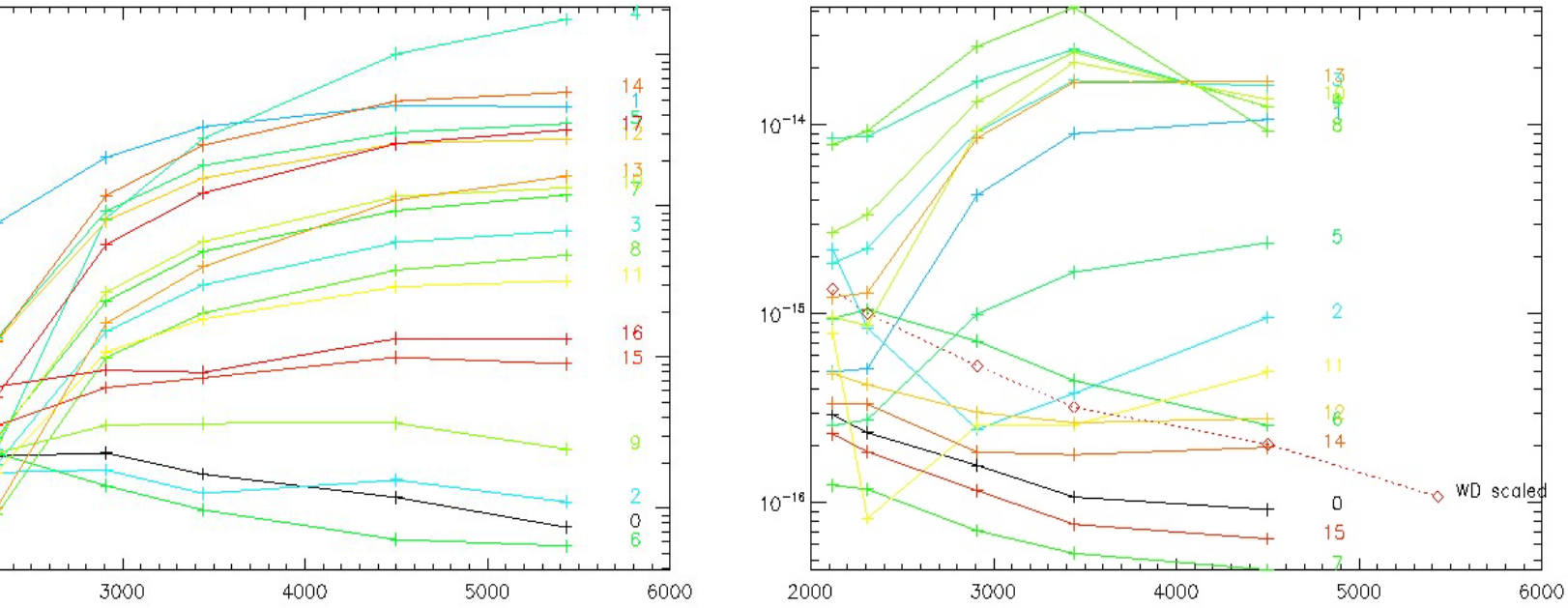
M16274



OM data reduction with SAS

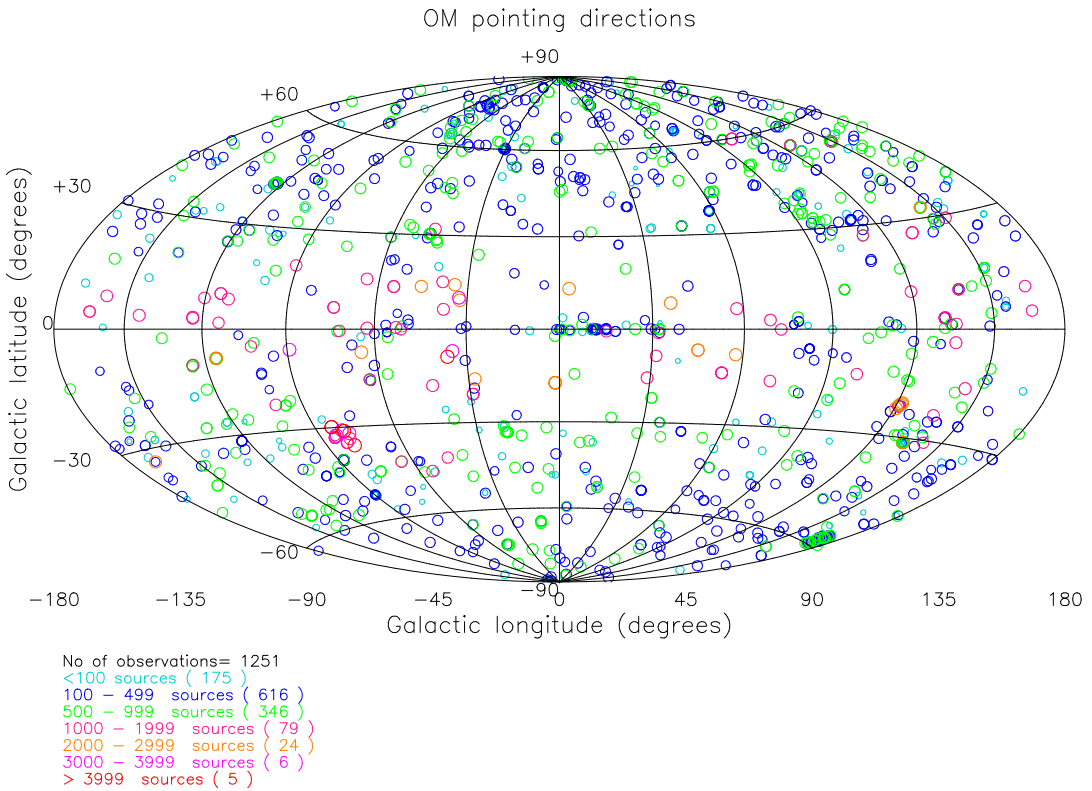


OM data reduction with SAS

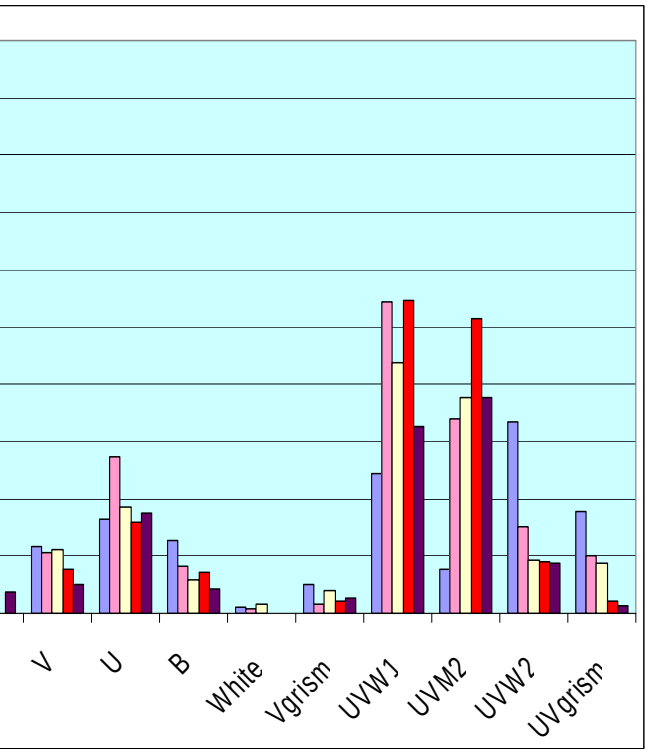


Spectral Energy Distribution of objects in the OM f.o.v.

OM Catalogue: available soon



OM usage: Preferred Filters



From rev. 42 to 1343 there were 15384 OM exposures with filter non-blocked

9699 exposures with one of the UV filters

OM usage: publications

l papers :

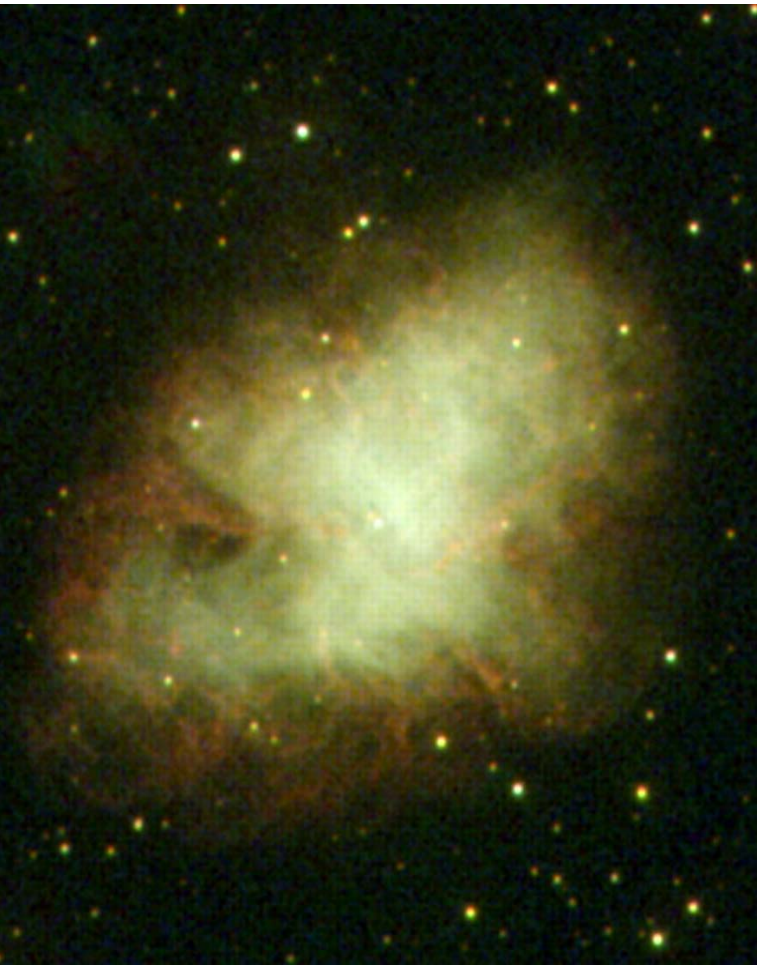
2001 - 11 papers
2002 - 8 papers
2003 - 12 papers
2004 - 31 papers
2005 - 27 papers
2006 - 32 papers

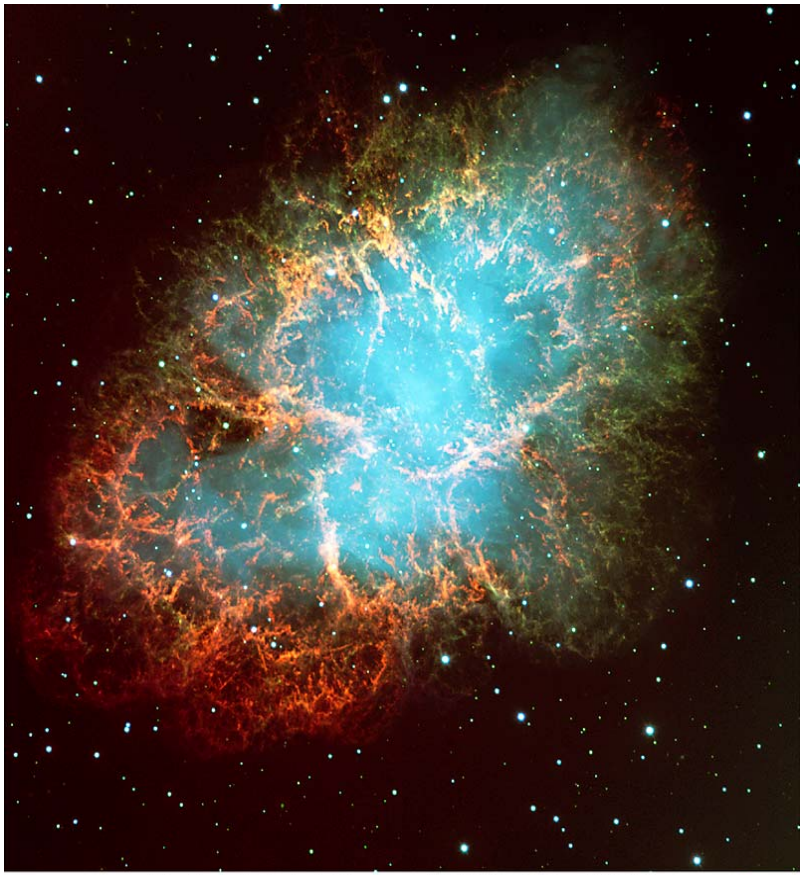
Total = 121 up to Dec. 2006

refereed papers with “OM” or “Optical Monitor” in the Abstract, i.e.
n OM data very relevant for the paper (ADS).

refereed papers with “OM” or “Optical Monitor” in the Title (ADS).

The Crab: OM(231, 291,344 nm) versus VLT(429,657, 673 nm)

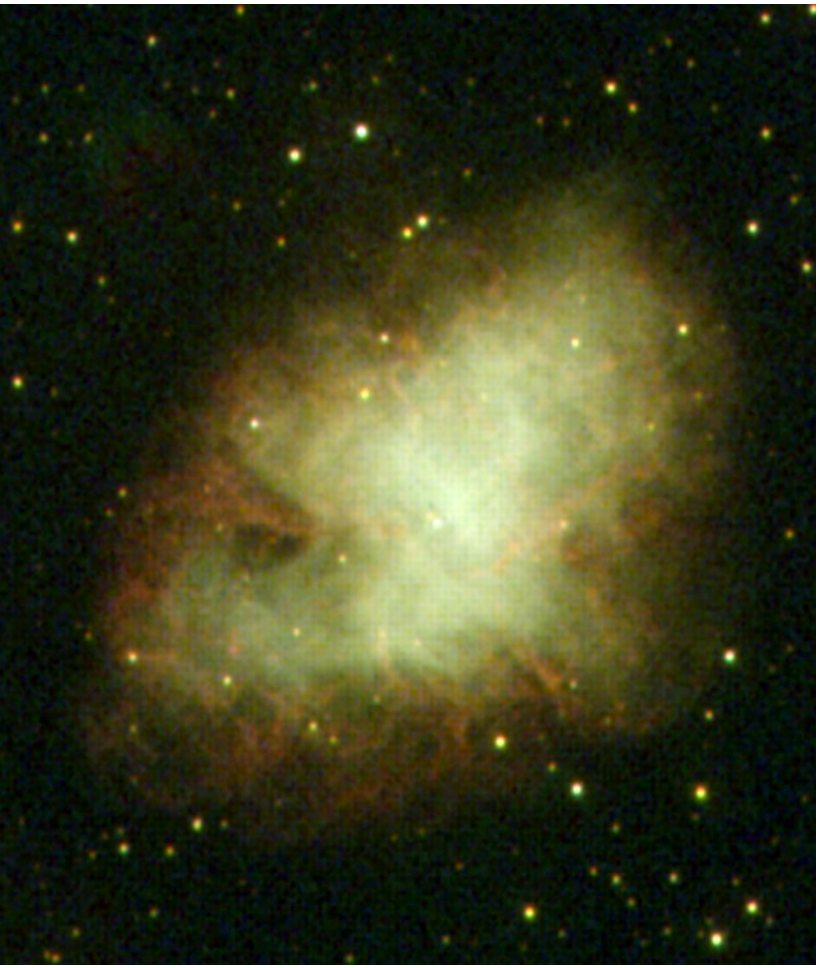




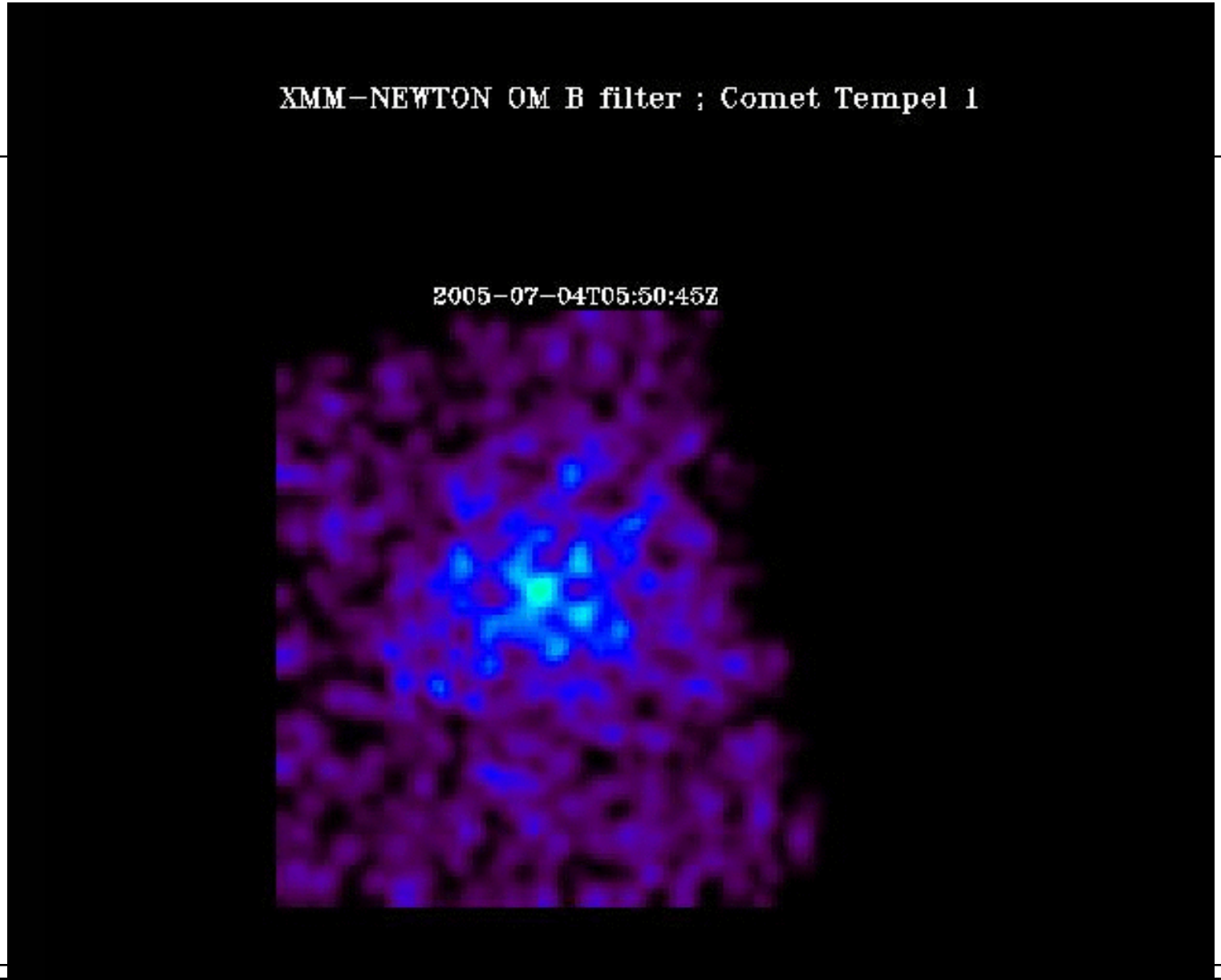
The Crab Nebula in Taurus (VLT KUEYEN + FORS2)

ESO PR Photo 40f/99 (17 November 1999)

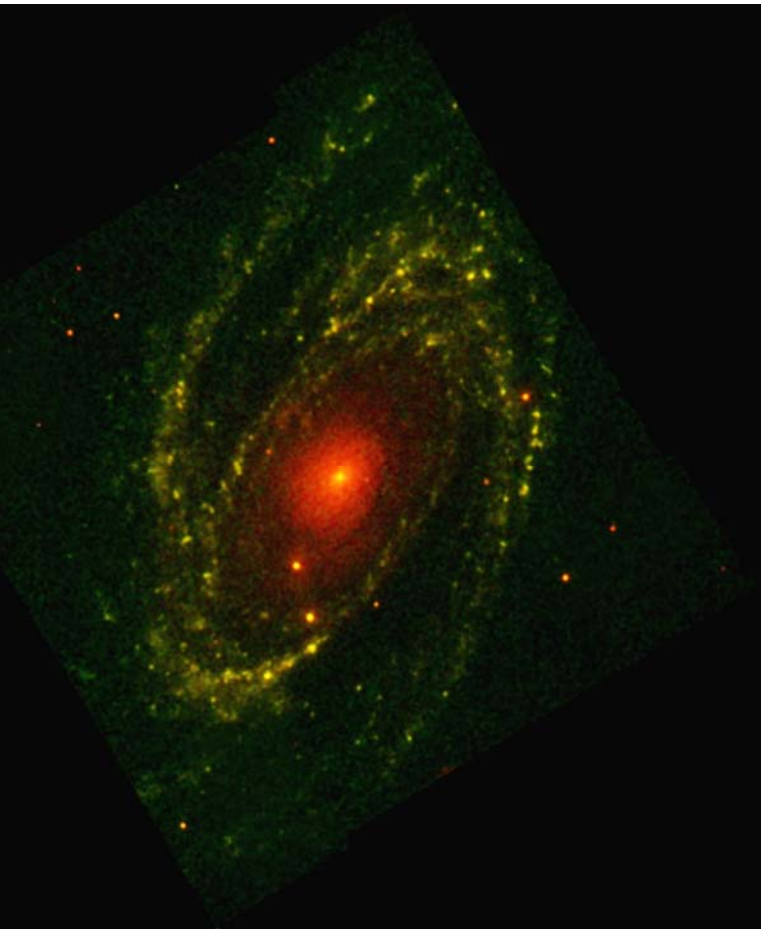
The Crab: OM(231, 291,344 nm) versus composite X_opt_radio



OM filter	Count rate	AB mag	AB Flux (erg/cm2/s/A)
UVW2	0.12	18.84	7.05e-16
UVM2	0.29	18.74	6.49e-16
UVW1	1.89	17.88	9.11e-16
U	5.18	17.40	1.00e-15


XMM-NEWTON OM B filter ; Comet Tempel 1
2005-07-04T05:50:45Z

M81: OM(231, 291,344 nm) versus Galex



OM photometry: zero points

oints for Zero epoch

finition of the zero point (magnitude giving one count per second) can be given as:

Zero_point = m_vega+2.5*alog10(countrate_vega)

he count rate of Vega is obtained through simulations

oints for OM instrumental system (at zero epoch)

2	**19.2429**	**18.1979**	**17.2038**	**15.7724**	**14.8667**
	B	**U**	**UVW1**	**UVM2**	**UVW2**

oints, corrected to Johnson UBV are:

3 19.2661 18.2593)

AB magnitude system for OM

ut spectrum of 1 erg/s/cm2/hz gives a photon rate in each filter, n_phot.

e zero points in AB system are defined as:

Zero_point = - 48.60 - 2.5 * log(1./n_phot)

Zero points in AB system for OM (at zero epoch)

9230	19.0809	19.1890	18.5662	17.4120	16.5719
V	B	U	UVW1	UVM2	UVW2

M counts to flux conversion based in white dwarfs

nt rate to flux conversion (from WD's)

uvw2	uvm2	uvw1	u	b	v
2120.	2310.	2910.	3440.	4500.	5430.
5.71e-15,	2.20e-15,	4.76e-16,	1.94e-16,	1.29e-16,	2.49e-16

This gives erg/cm2/s/A

relative errors (stdev/mean) are :

uvw2	uvm2	uvw1	u	b	v
0.054	0.0401	0.068	0.042	0.068	0.013

M counts to flux conversion from White Dwarfs versus Pickles and BPGS spectral libraries

es library

Filter	A0V	B0V	F0V	G0V	K0V	M0V	Vega
V	2.50E-16	2.48E-16	2.52E-16	2.54E-16	2.56E-16	2.65E-16	2.50E-16
B	1.36E-16	1.16E-16	1.41E-16	1.53E-16	1.60E-16	1.81E-16	1.34E-16
U	1.71E-16	1.94E-16	1.80E-16	1.83E-16	1.88E-16	2.01E-16	1.70E-16
UVW1	4.96E-16	4.72E-16	4.96E-16	4.51E-16	3.88E-16	1.09E-16	4.86E-16
UVM2	2.20E-15	2.14E-15	2.10E-15	1.84E-15	1.66E-15	n.a.	2.19E-15
UVW2	6.06E-15	5.56E-15	7.15E-15	6.05E-15	5.76E-16	n.a.	5.88E-15

S library

Filter	A0V	B0Ib	F0IV	G0V	K0V	M0V
V	2.48E-16	2.50E-16	2.50E-16	2.55E-16	2.56E-16	2.61E-16
B	1.29E-16	1.17E-16	1.38E-16	1.44E-16	1.55E-16	1.80E-16
U	1.66E-16	1.97E-16	1.77E-16	1.88E-16	1.85E-16	1.94E-16
UVW1	4.79E-16	4.76E-16	4.84E-16	5.02E-16	5.15E-16	3.14E-16
UVM2	2.15E-15	2.17E-15	2.18E-15	2.27E-15	2.02E-15	1.42E-15
UVW2	5.56E-15	5.25E-15	6.14E-15	6.50E-15	6.34E-15	2.46E-15

WD's

2.49E-16
1.29E-16
1.94E-16
4.76E-16
2.20E-15
5.71E-15

OM fluxes in AB system

n_phot is the number of photons produced by 1 erg input
ectrum, then 1/n_phot is the rate to flux conversion factor (in
equency space).

Count rate to flux conversion in AB system (frequency)

uvw2	uvm2	uvw1	u	b	v
2120.	2310.	2910.	3440.	4500.	5430.
3.535e-27	3.937e-27	1.360e-27	7.663e-28	8.465e-28	2.459e-27

This gives erg/cm2/s/hz

te that the effective frequency of a filter can be any within
e filter range since the flux is constant. Even if we are in
equency space, we can characterise the filter by its effective
velength.

OM fluxes in AB system

an then convert these factors to lambda space by multiplying by
lambda**2) and we get:

Count rate to flux conversion in AB system (lambda)

uvw2	uvm2	uvw1	u	b	v
2120.	2310.	2910.	3440.	4500.	5430.
5.70e-15	2.21e-15	4.82e-16	1.94e-16	1.25e-16	2.50e-16

his gives erg/cm2/s/A

surprisingly, if we compare these last factors with the ones
ved directly from WD's fluxes, we have:

1.002	0.994	0.988	0.999	1.029	0.995

OM Astrometry

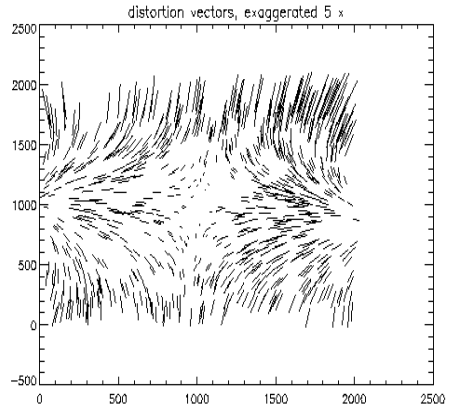
Geometric distortion

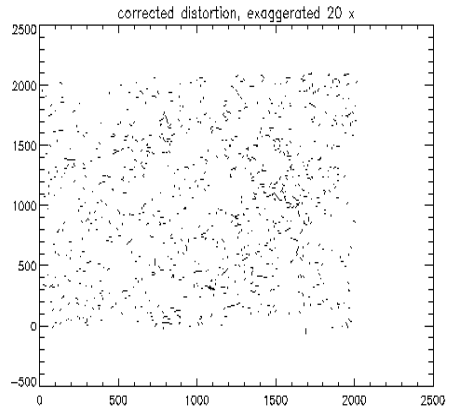
- distortion map derived from OM image using more than 800 stars
- it corrects positions to 0.7” rms error

SAS provides RA & Dec for all sources detected in OM images - from X_Y, AHF (star tracker) & boresight information.

Additional cross-correlation (in SAS) with USNO catalogue allows us to improve the coordinates:

- Using the new boresight:
  - RMS offset from USNO < 1.5”





OM grisms calibration

velength calibration:

- F-type stars: HD 221996, HD 224317 (V & UV grisms, low & high resolution)
  HD 13499, HD 13434 (V & UV grisms, low resolution, across FOV)
  (Field stars at different positions in FOV (V & UV grisms))
- White dwarfs with Hydrogen lines (BPM 16274, GD50,…) (for V-grism)

x calibration:

- Spectrophotometric standard stars (WD):

  GD 153, HZ 2

sms distortion:

- 3C273
- other science observations

OM grisms calibration: wavelength

e wavelength scale: anchor point → *zero order*

asuring zero-order position: it can be predicted for User Def. observing windows,
(with less accuracy for full frame images),
and then refined by centroiding algorithm

avelength range:

Vis-grism: 3000 - 6000 A

UV-grism: 1800 - 3600 A (second order contamination)

(the range could be extended, but not the flux calibration)

avelength scales

: lambda (A) = 991.778 + 1.8656 X + 0.0007713 X^2 (X : pixels from zero order)

s: lambda (A) = 200.898 + 5.626 X

internal error: < 7 A (UV)

global shift due to zero order position: about +/- 10 A

OM grisms data calibration: wavelength

avelength scale variations across f.o.v.:

HD 13499 offset observations and field stars in fflr science observations:

- ***Wavelength shift on right hand part of the image: up to 50 A***

esolution : limited by mod_8

UV grism: better than 15 A @ 2600 A (from NGC 40 observations)

V grism: worst than UV

Mod_8 is stronger in V grism (because of higher response)

OM grisms data calibration: flux

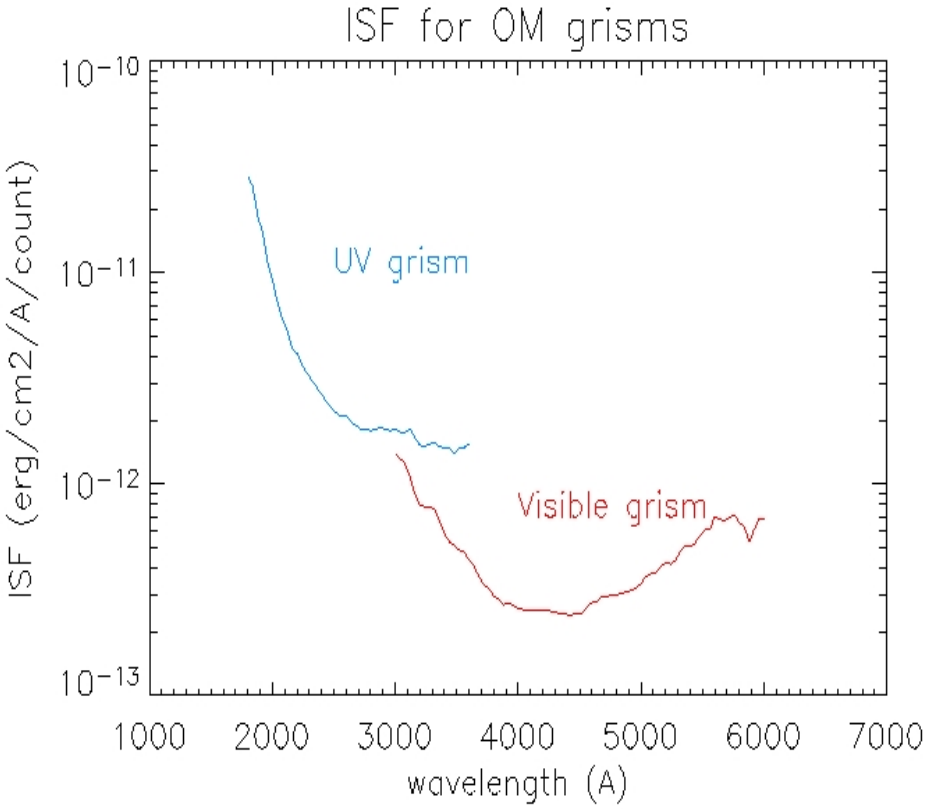
lux scale:
nverse Sensitivity Function (ISF)
ISF(λ) = Fstd (λ) / CRstd (λ)
Fobs(λ) = CRobs(λ) x ISF (λ)

ux accuracy: around 10% (slightly rst at long wavelength end of grism)

V and V common range: excellent reement!!!

B, U, UVW1, UVM2, UVW2 rsus Grisms: excellent reement!!!

me sensitivity variation: not rrected yet



Optical Monitor calibration: what's new?

onse matrices for OM:

- **UVW2, UVM2, UVW1, U, B, V filters**
- **UV and V grisms**