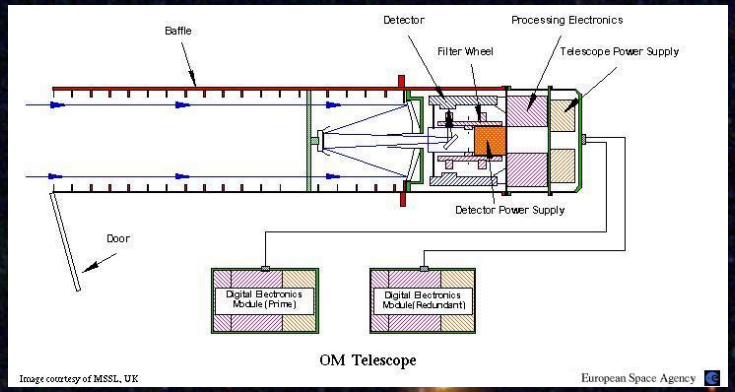
XMM-OM at 20

XMM 20 years celebration, ESAC December 2019



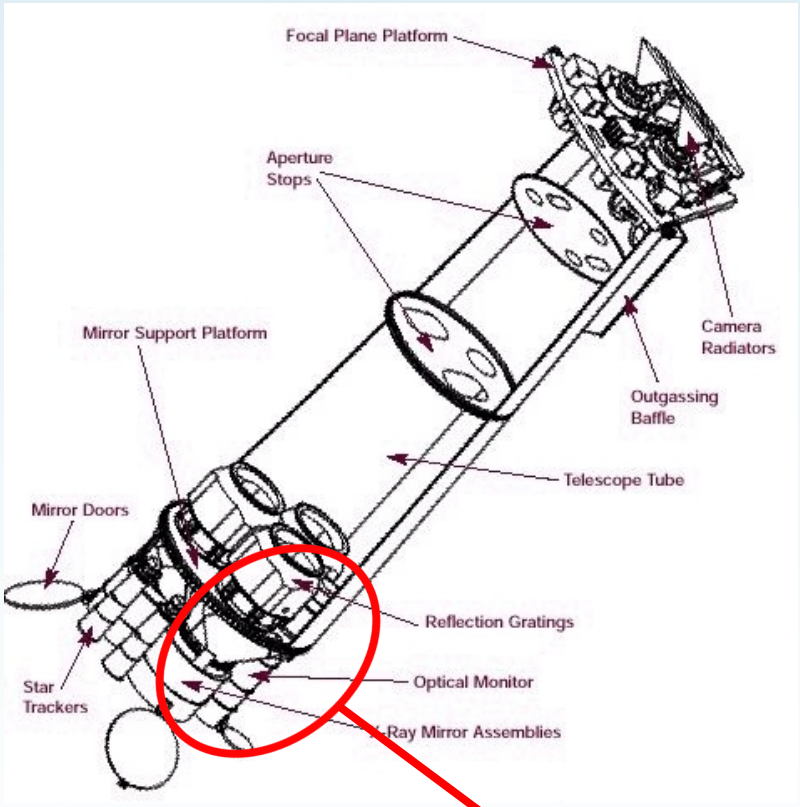
Mat Page, MSSL-UCL
on behalf of MSSL and ESAC OM teams

Contents:

- Contribution from Keith Mason
- XMM-OM basics
- The detector
- What is XMM-OM being used for?
- OM descendants
- Instrument health and the next 10 years.

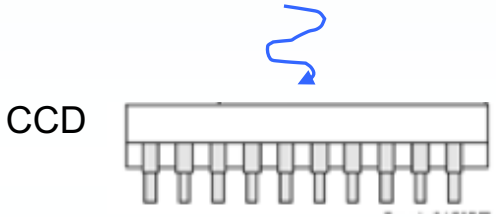
XMM-OM basics

- 30cm telescope
- Co-aligned with X-ray instruments
- Microchannel-plate-intensified CCD detector
- Photon counting.
- On-board image tracking
- 6 broad band filters u,b,v,uvw1, uvm2, uvw2
- UV and optical grisms
- PSF is about 2” FWHM in the UV, about 1.5” in the optical.

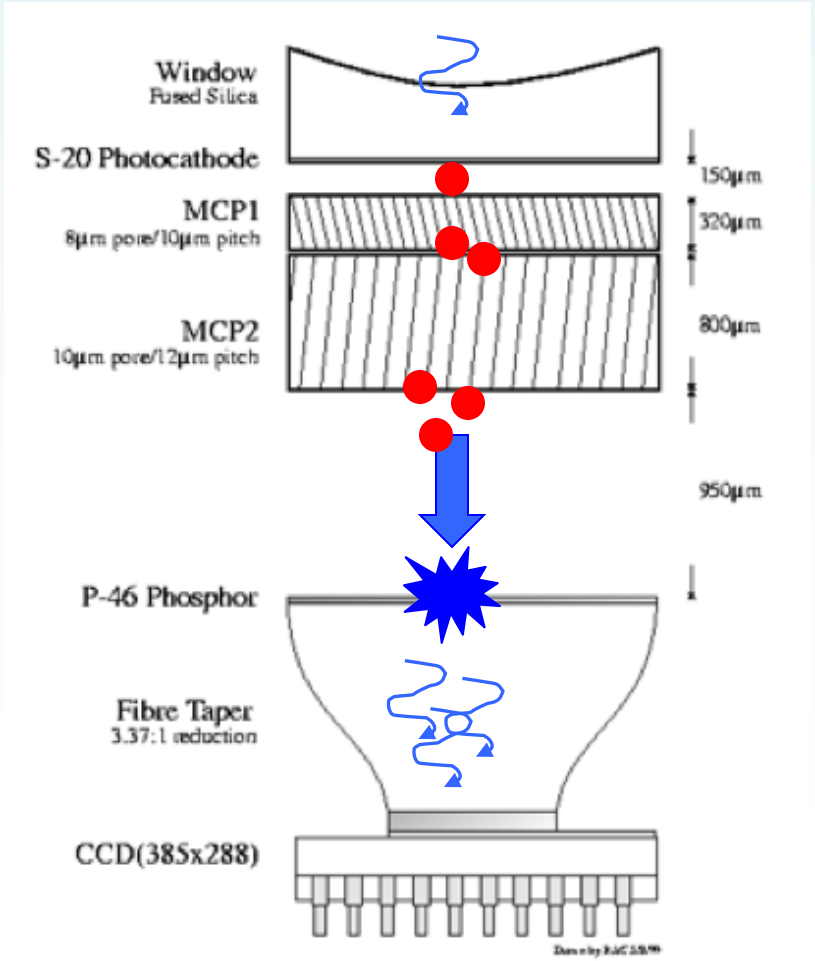


XMM-OM detector: it's not just a CCD camera

EPIC or RGS



OM

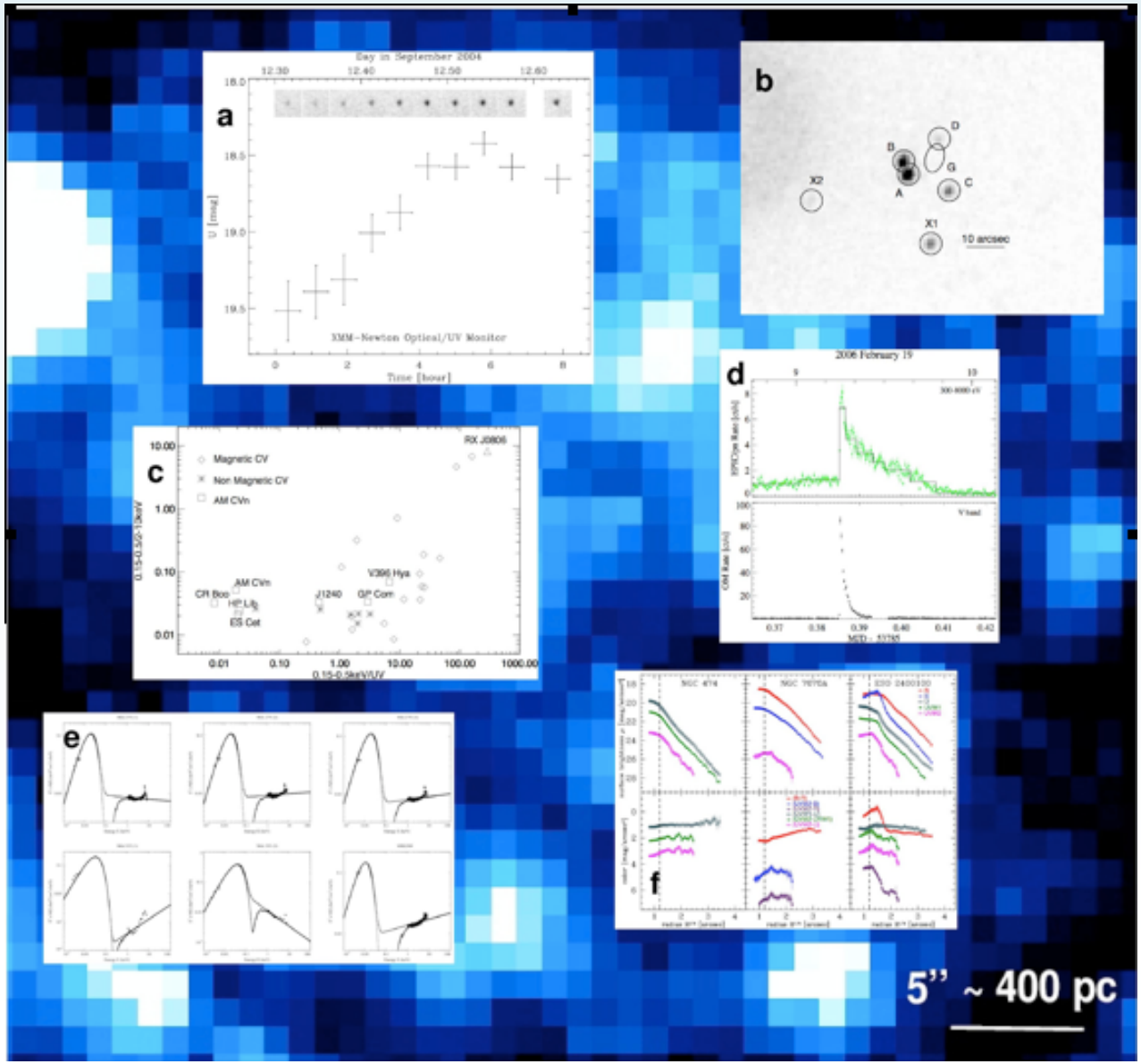


What has XMM-OM been used for?

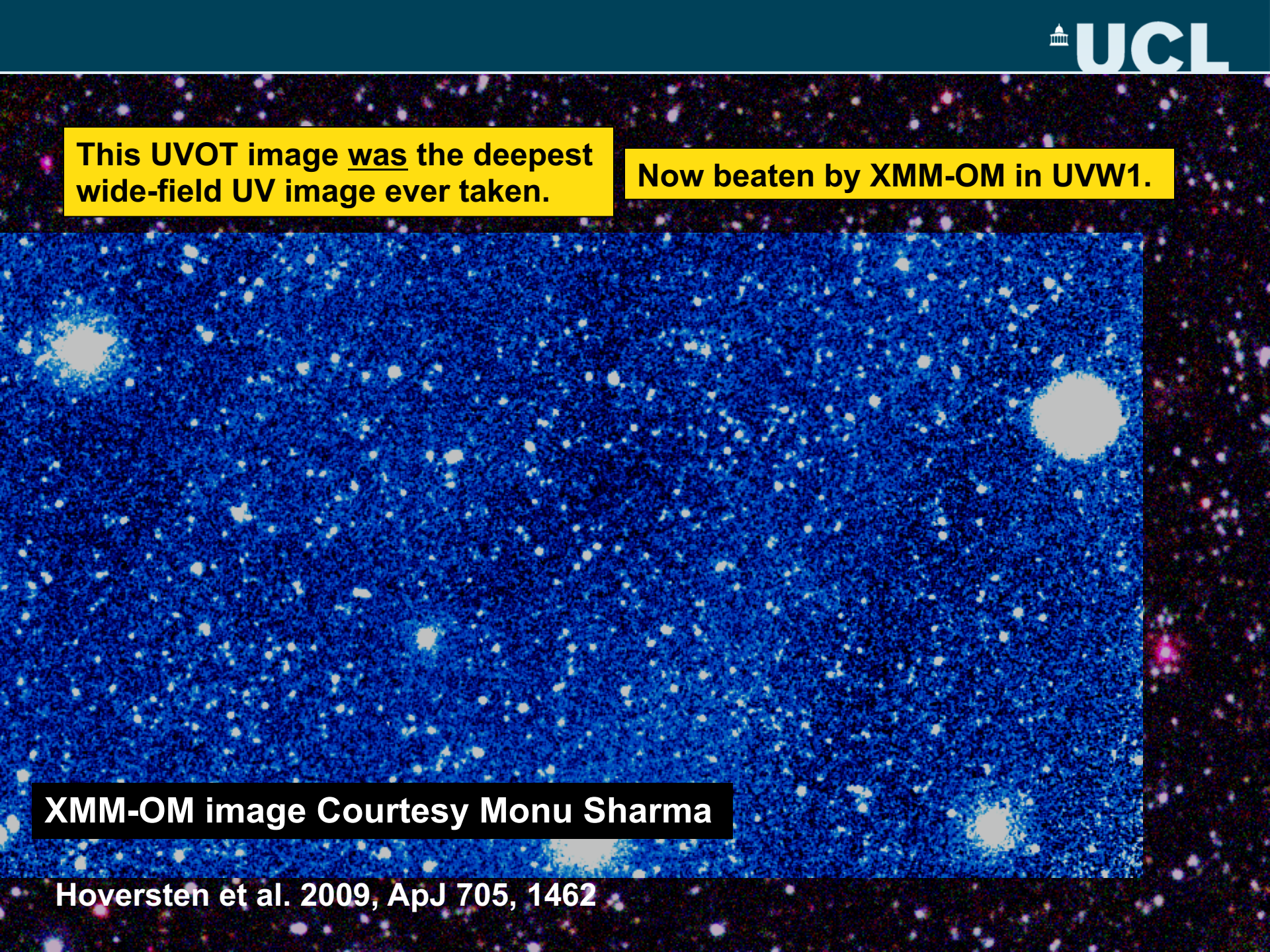
- Measurement of water molecules in Comets
- First gamma-ray burst UV afterglow
- Instantaneous SEDs of AGN
- Reverberation mapping of AGN
- Eclipse measurements of X-ray binaries
- Accretion patterns in magnetic CVs
- Star formation in galaxy clusters
- Impulsive emission in stellar flares
- Star formation in active and normal galaxies
- UV galaxy surveys
- Accretion onto T-Tauri stars
- Quasar cosmology
- Identifying millisecond pulsars

What hasn't XMM-OM been used for?

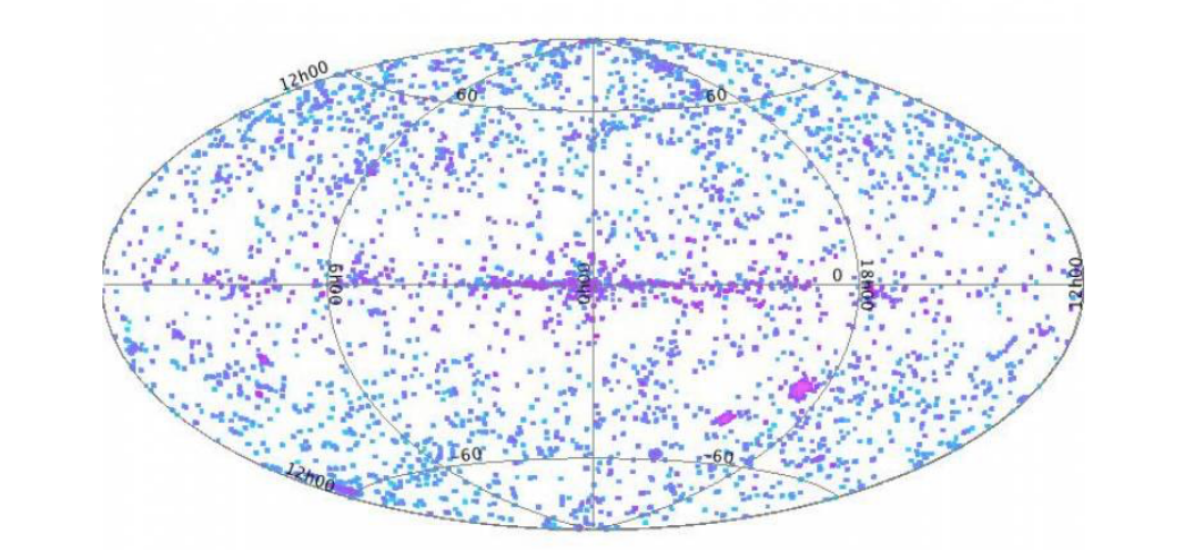
A flavor of XMM-OM diverse uses



a) OM lightcurve of the brown dwarf 2MASS J0414 showing a 1 magnitude change in U-band brightness, likely due to an accretion event from a circumstellar disk,' (Grosso et al. 2007, A&A 468, 557). b) XMM-OM image of the gravitationally lensed quasar SDSS J1004+4112 (Lamer et al. 2008, A&A 454, 493). c) UV/X-ray colours are used to diagnose the accretion disk dominance in CV stars (Ramsay et al. 2006, A&A 457, 623). d) fast mode XMM-OM observations record the rapid optical rise of a 6-magnitude stellar flare in the ultracool dwarf LP 412-31 (Stelzer et al. 2006 A&A 460, L35). e) UV observations from XMM-OM are used to determine Eddington ratios and bolometric corrections for AGN (Vasudevan & Fabian 2008, MNRAS 392, 1124). f) UV luminosity and colour profiles of shell galaxies (Trinchieri et al. 2008 A&A 489, 85). Underlying image: XMM-OM UVW2 image of the young star clusters surrounding the nucleus of M99 (Soria & Wong 2006, MNRAS 372, 1531).


This UVOT image was the deepest wide-field UV image ever taken.
Now beaten by XMM-OM in UVW1.
XMM-OM image Courtesy Monu Sharma
Hoversten et al. 2009, ApJ 705, 1462

XMM-Serendipitous UV Source Survey.

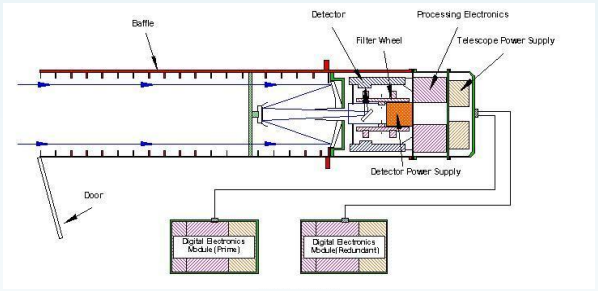


- Lets face it, not every X-ray astronomer knows how to deal with optical/UV images.
- So the MSSL and ESA team produce a high-level catalogue of XMM-OM optical and ultraviolet sources.
- Latest version (released 2018) is XMM-SUSS 4.1.
- > 5.5 million sources, reliable multi-band photometry.
- I used to tell people how useful the catalogue is.

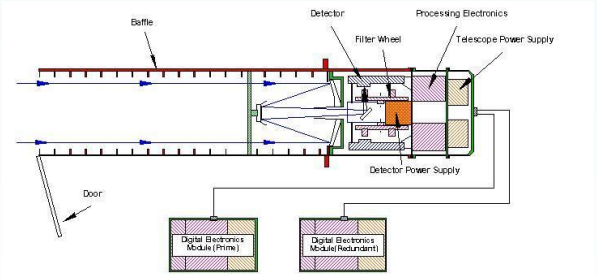
…now people tell *me* how useful the catalogue is!

Imitation is the sincerest form of flattery!

XMM-OM

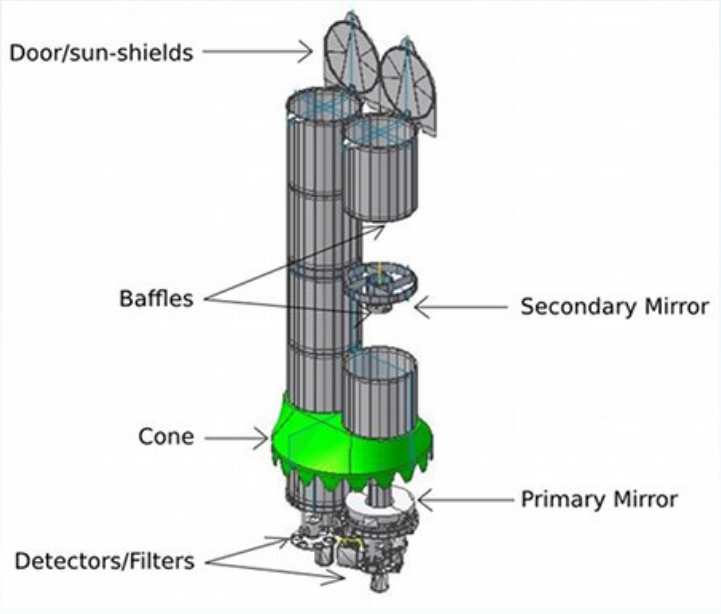


UVOT



- Copy built for NASA Swift
- Higher UV throughput
- More capable data processing unit and higher telemetry
- In orbit for > 15 years

UVIT



https://uvit.iiap.res.in/Instrument

- Carried on Astrosat
- Larger telescopes
- MCP intensified like XMM-OM
- CCD -> CMOS
- Night-time only

XMM-OM condition after 20 years

- XMM-OM continues to function nominally.
- Though its not perfect:
  - Throughput declined by 10-20% (depending on filter) over 20 years.
  - It has a low sensitivity spot near the boresight because of accidental Jupiter observation.
- Producing excellent science.

XMM-OM is in good shape.

OM and the next 10 years of operation

- The filter wheel mechanism is a critical system as it has moving parts and a limited life.
  - At the current rate of filter wheel rotation it should reach its specification in about 7 years time.
  - But identical filter wheel on UVOT passed that number of rotations years ago, and is still working.
- There is some redundancy in the electronics.
  - For example, there are more temperature sensors than absolutely necessary.
- OM also has a **complete** system (filter wheel, electronics, detector) held in cold redundancy
  - The change is made by rotating a 45° beam steering mirror under stepper motor control to direct the light through a separate filter wheel to a separate detector.
  - Only the primary and secondary mirrors and beam steerer are common.
- **Prospects for XMM-OM look good, just like XMM-Newton.**

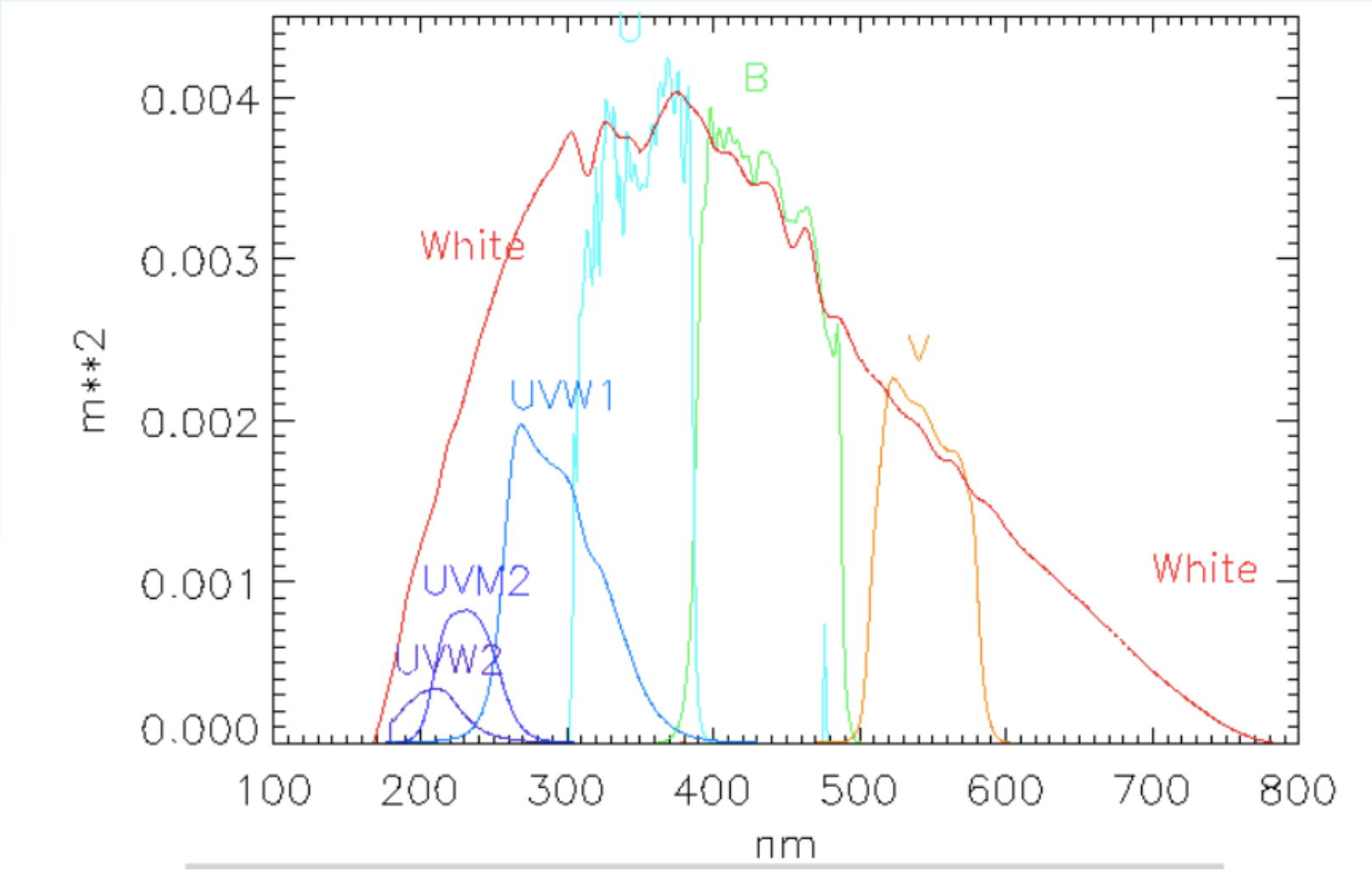
Concluding remarks

- XMM-OM is being used for a wide variety of applications.
- Superb science coming from it.
- Similar instruments have been deployed on Swift and Astrosat, but their X-ray telescopes much smaller.
- So XMM-OM + EPIC or RGS combination is unique to XMM-Newton.

- ATHENA won't carry anything equivalent.
- So make the most of the next 10 years of XMM-OM!

Backup slides follow

XMM-OM imaging passbands



OM survey observations

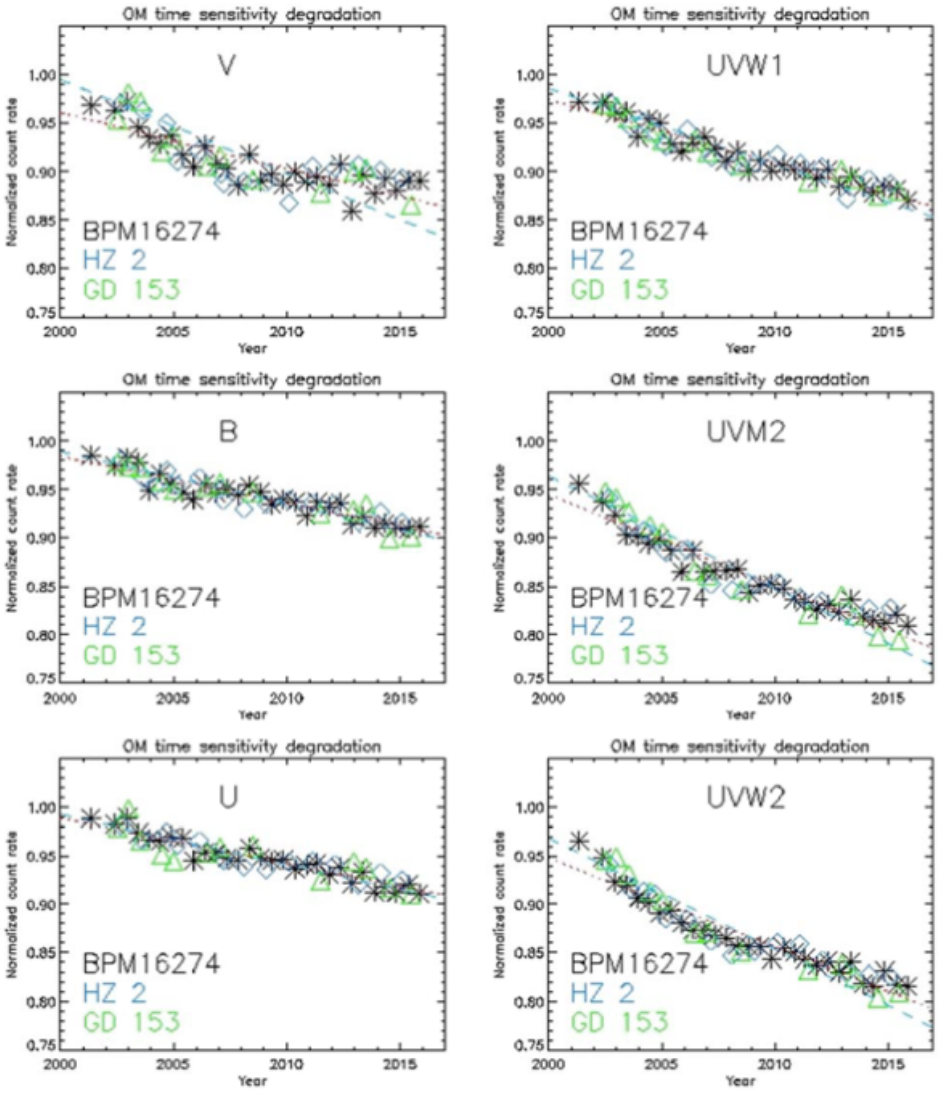
- A lot of people here already know how to get good science from OM with UV imaging fast photometry, or whatever.
- But I know that there are some people in the audience that have no idea what to do with XMM-OM.
  - Extragalactic survey folks are especially bad.
  - Its not very big compared to Keck or GTC or Subaru or VLT.
  - Its **UV** imaging capabilities (<3000A) **infinitely** better though!

- XMM-OM's sweet spot is 2700A UVW1 filter*.
- Throughput is good in this band (not as true at shorter wavelengths).
- Long exposures in full-frame low-resolution (1") mode are very efficient.**

*** That's about 0.006 keV for really hardcore X-ray astronomers.**

**** Follow this advice, and you will get factor~2 more UVW1 photons than original XMM-OM pre-launch prediction!**

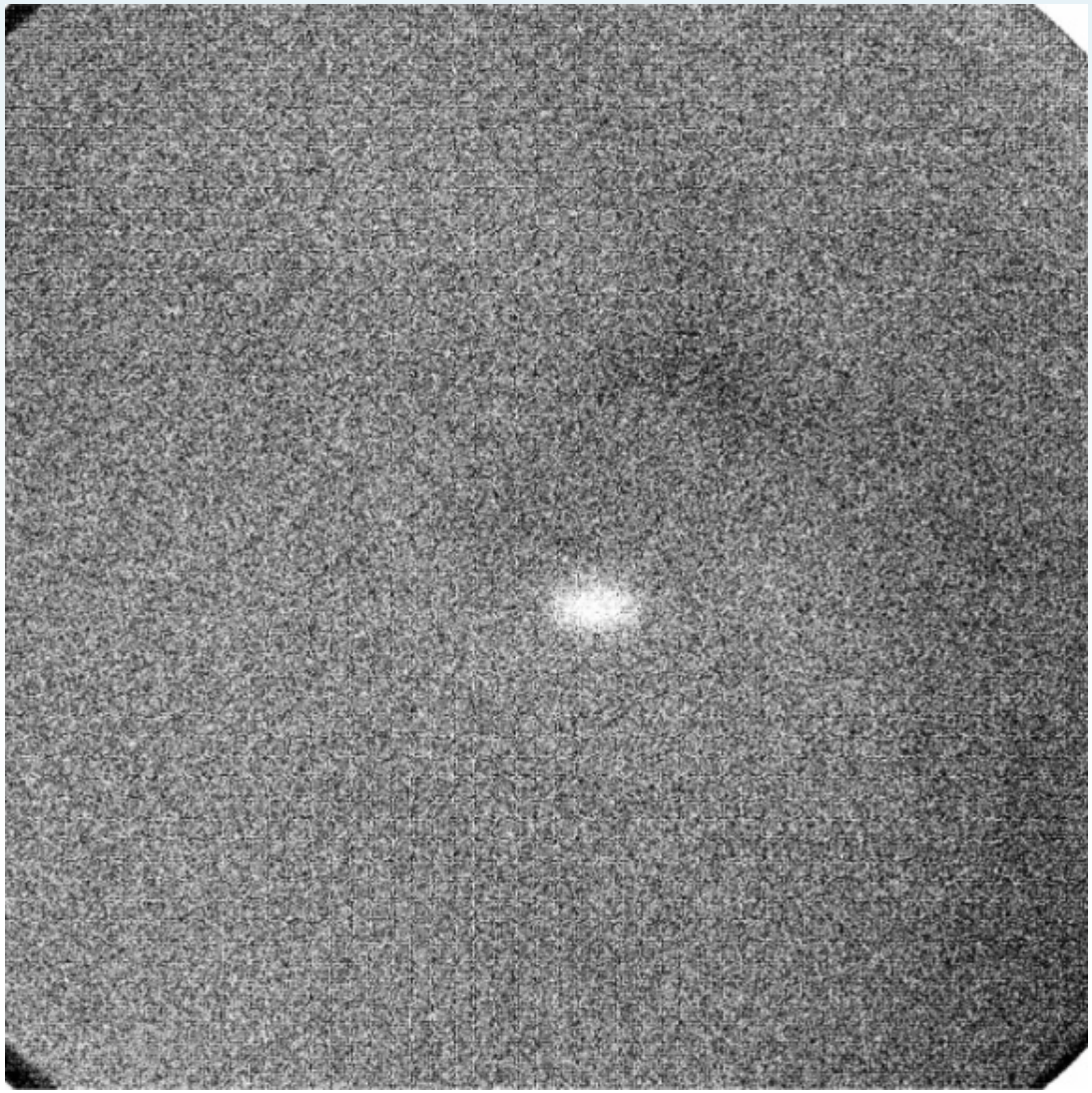
Evolution of the instrument sensitivity



- There is a slow decline in sensitivity of the XMM-OM, by 0.5-1% per year.
- This is calibrated, and dealt with by the analysis software.

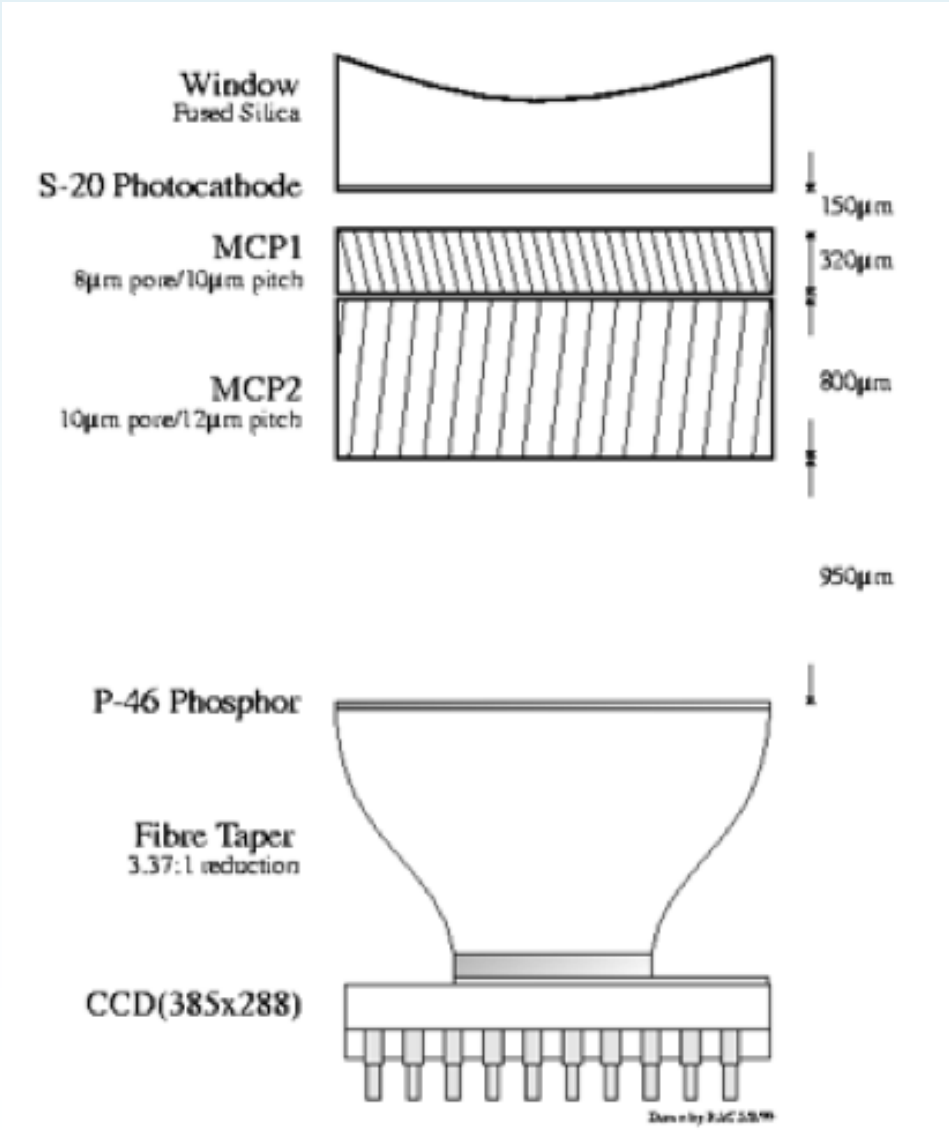
July 2017: Jupiter observation.

- Jupiter was accidentally observed with XMM-OM in July 2017.
- It is many magnitudes brighter than the safe bright source limit.
- The image is a flat-field taken using the on-board LED after the incident.
- Take care with post-July-2017 images.



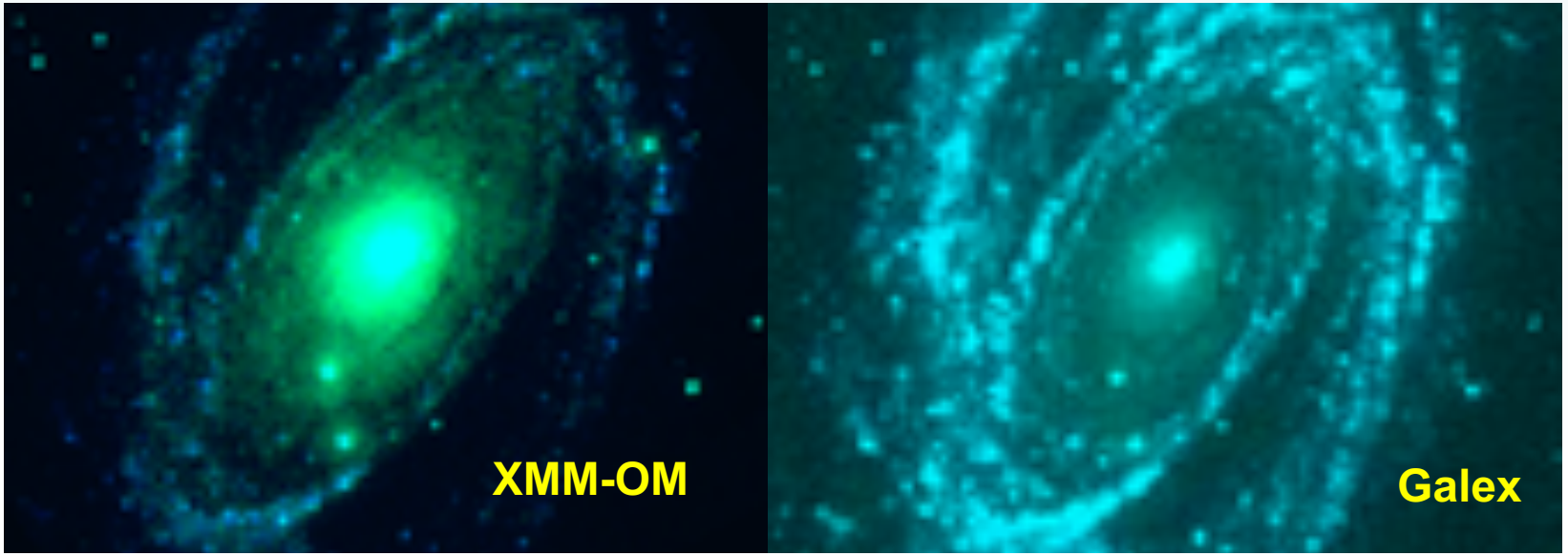
XMM-OM detector

- It's NOT just a CCD camera.
- Photocathode with multi-MCP intensifier.
- 3rd generation photon-counting camera, follows IPCS, HST FOC.
- Counts photons one at a time.



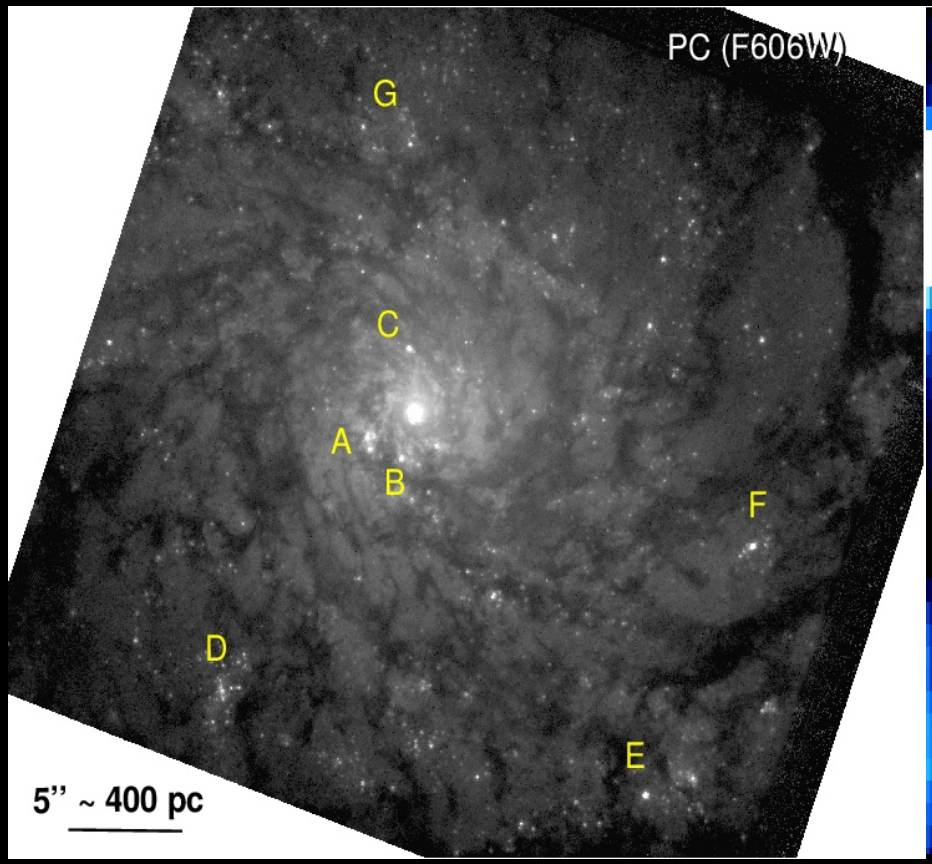
UV capable observatories comparison

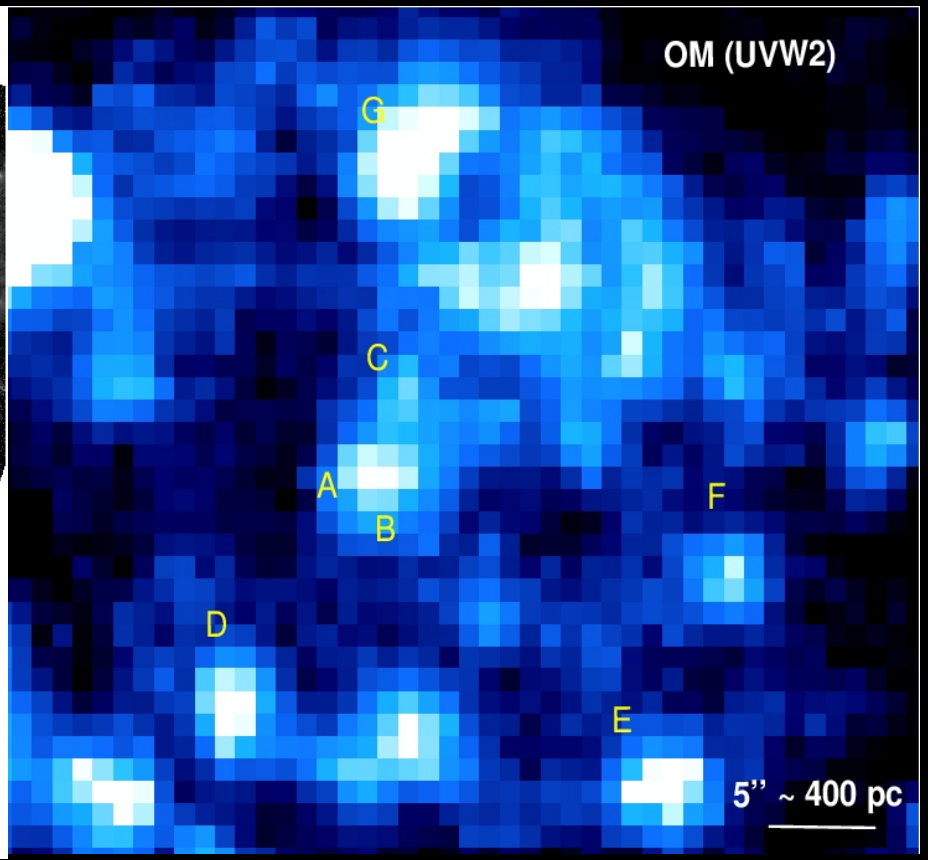
	XMM-OM	UVOT	Galex
FWHM	2.0”	2.2”	5”
FOV	17x17’	17x17’	80’ diam
Range (A)	1700-6000	1700-6000	1350-2750
Aeff(2700A)	20cm^2	30cm^2	60cm^2



Nice example:

Soria et al. 2007, ULXs and star formation in M 99





OM UV imaging used to work out the ages of the star clusters.
No young stars in the nuclear star cluster!