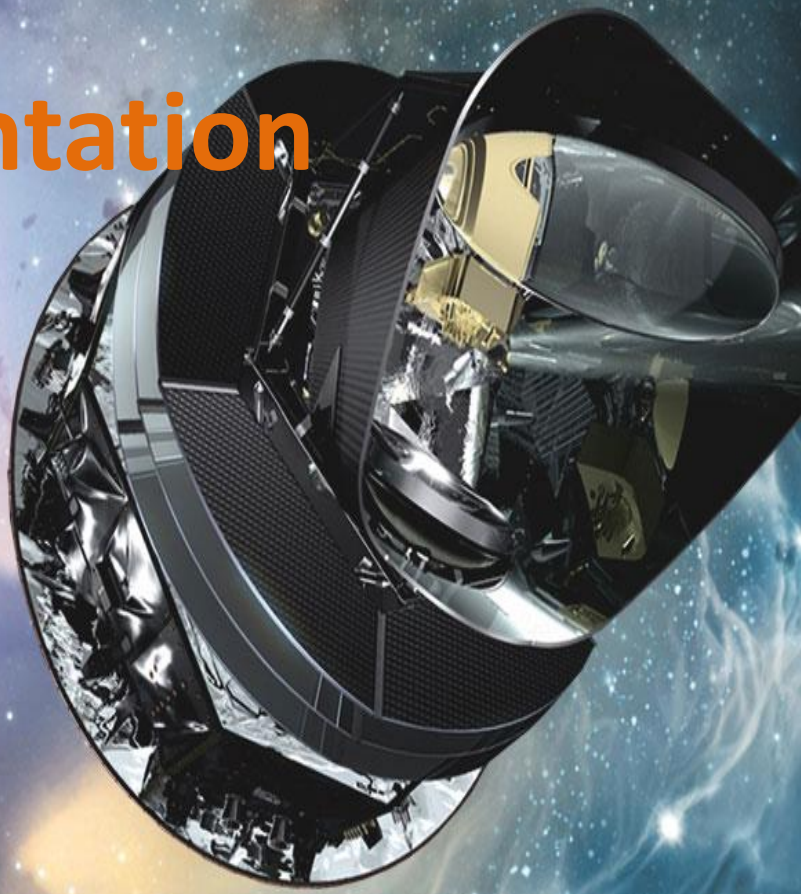
Space Instrumentation

ELEC-E4220 (5 cr)

Teachers: Anne Lähteenmäki

Esa Kallio

Guests



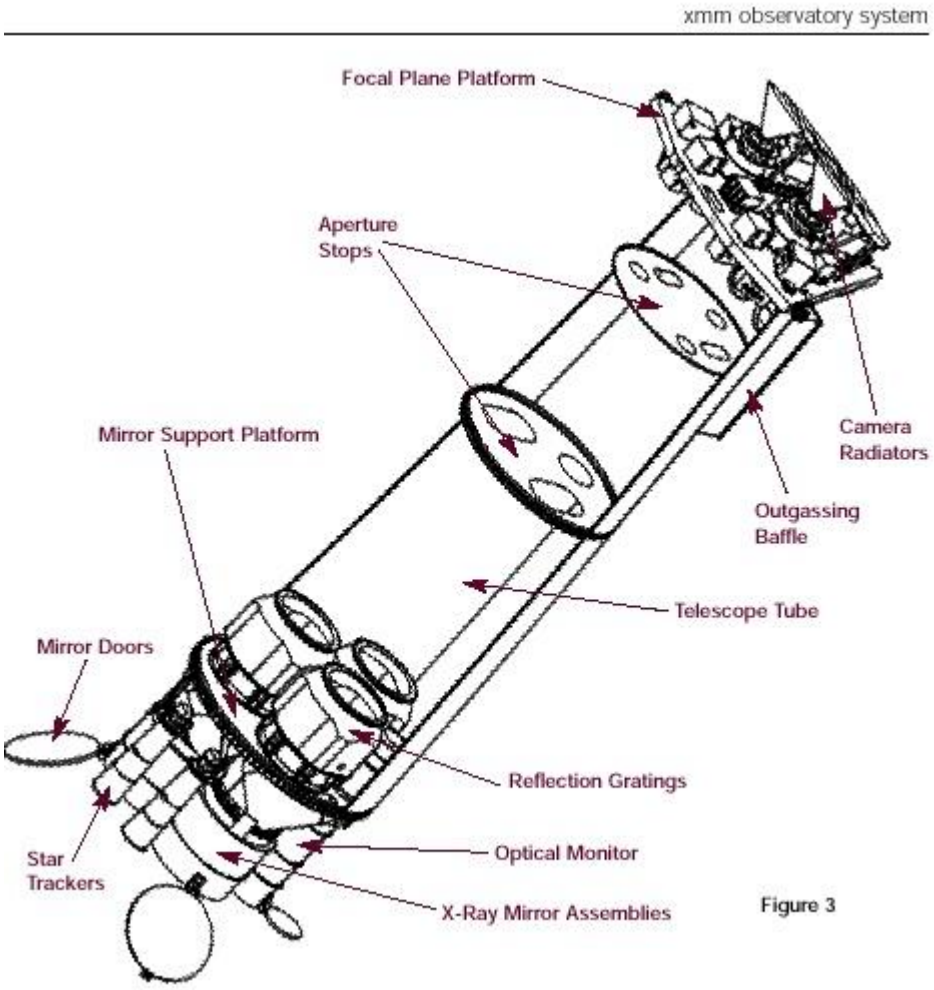
Today 1.12.2020

- Two (short) introductions:
  - How do I get observing time with a satellite? Case study: XMM-Newton.
  - UV astronomy.
- Peer-assessment and how to do it.

ESA

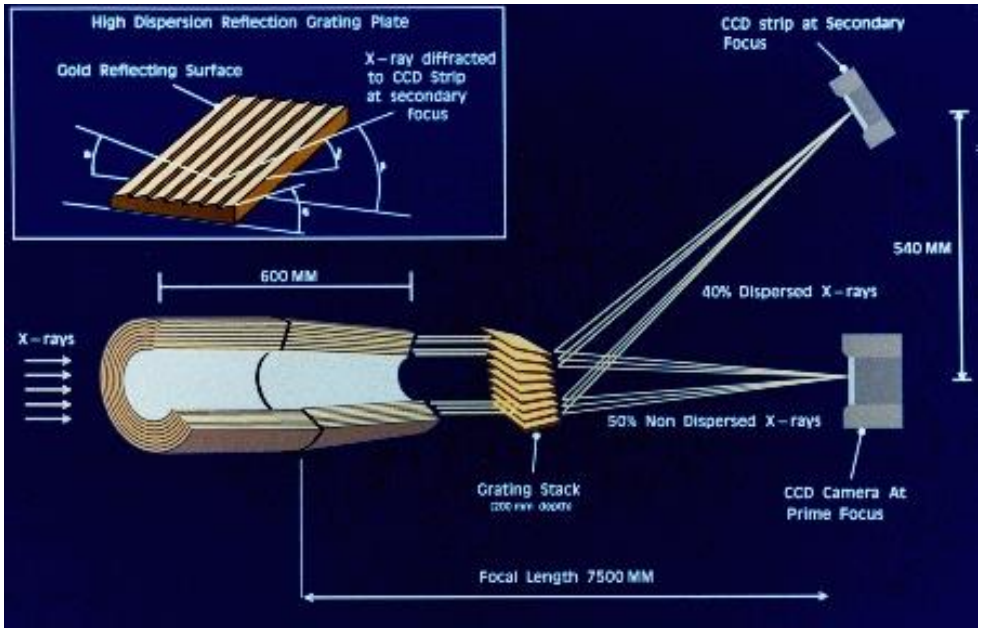
XMM-Newton (launched 1999)

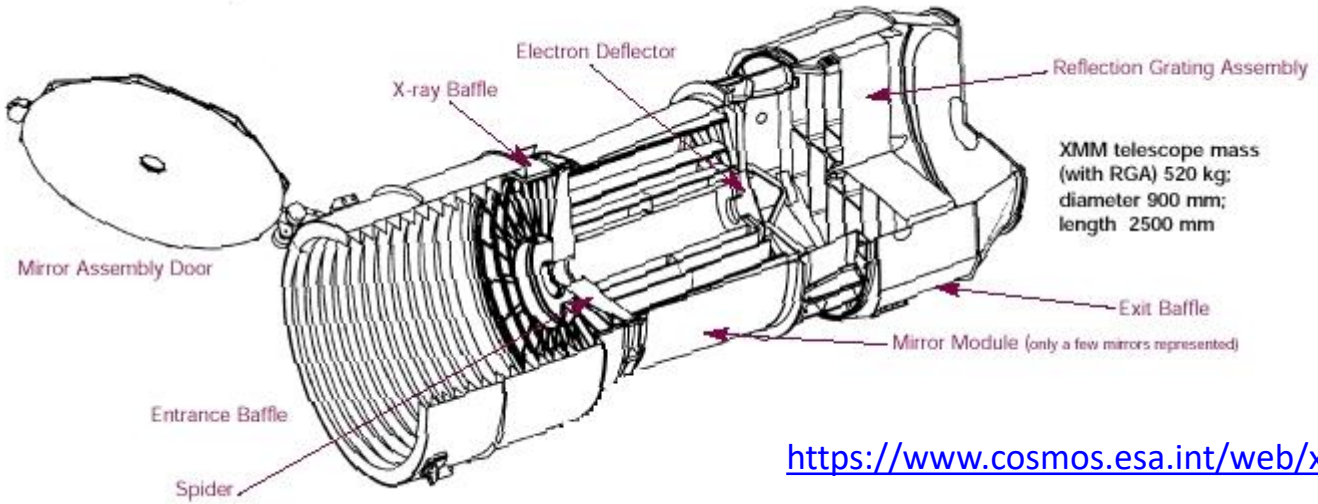
- Service module
- Mirror support platform
- Telescope tube (6.8 m)
- Focal plane assembly



XMM telescopes

- 3 telescopes with FOV 30', resolution 6" (FWHM)
- 58 nested mirrors
  - Nickel and gold
  - 30 – 70 cm in diameter
  - 0.47 – 1.07 mm thickness
  - 1mm separation

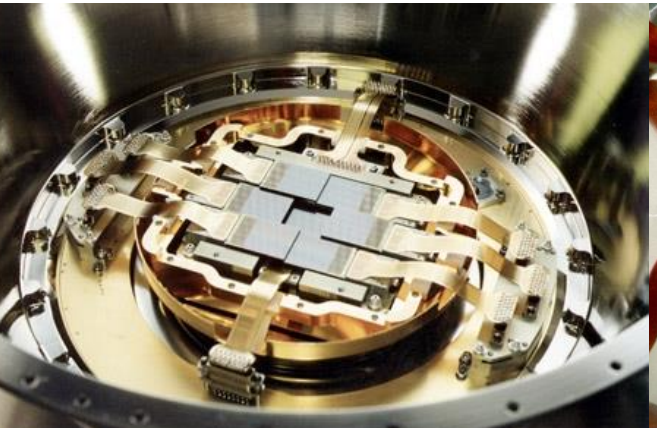
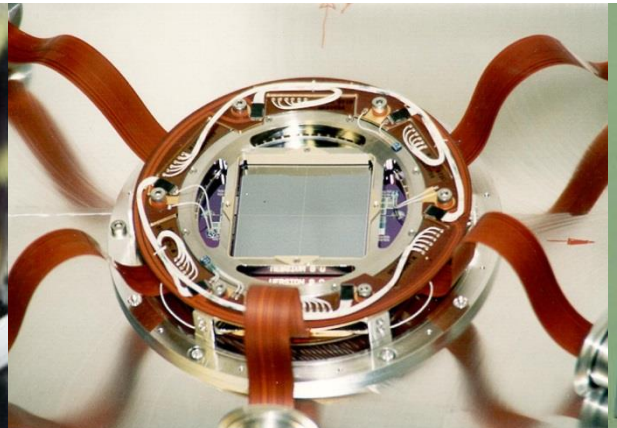
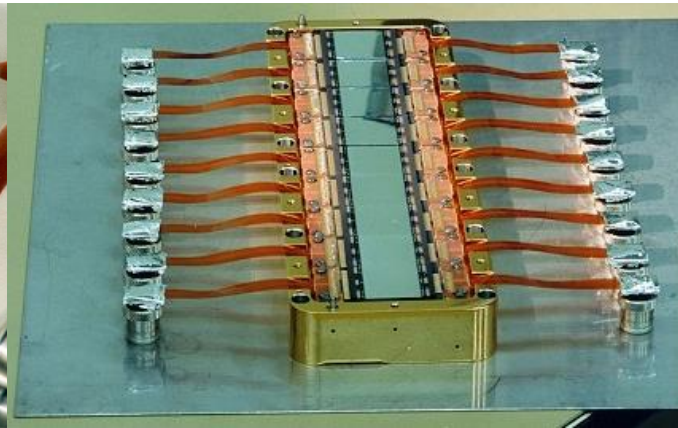




https://www.cosmos.esa.int/web/xmm-newton/technical-details

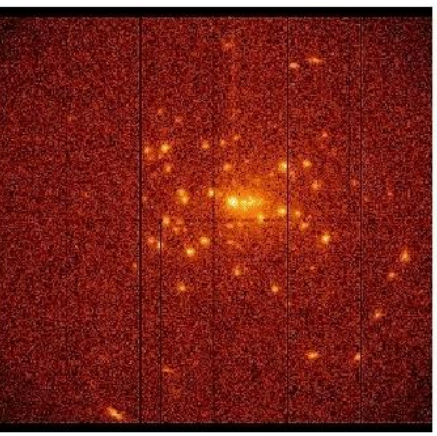
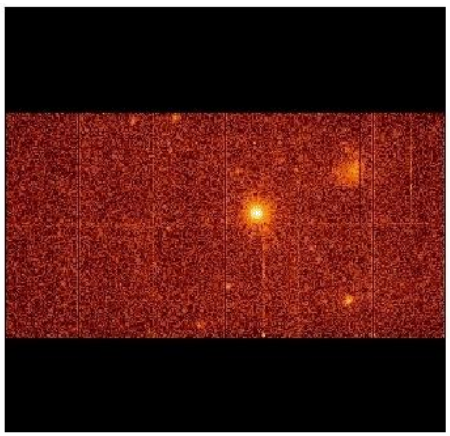
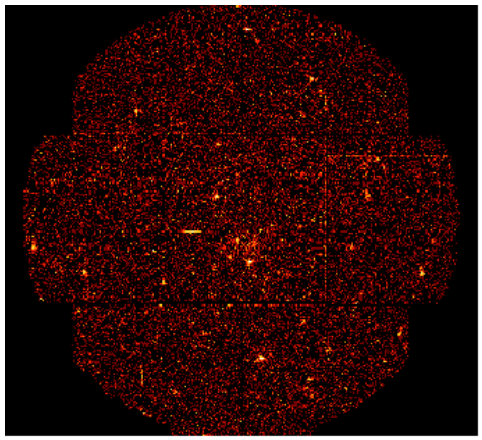
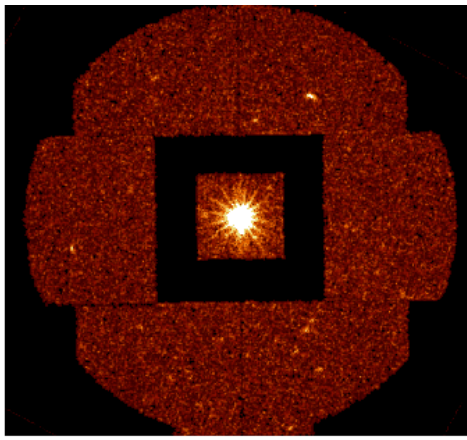
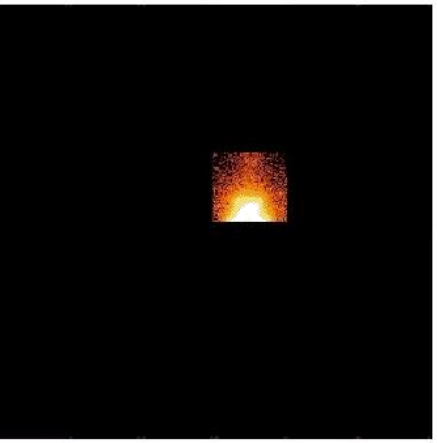
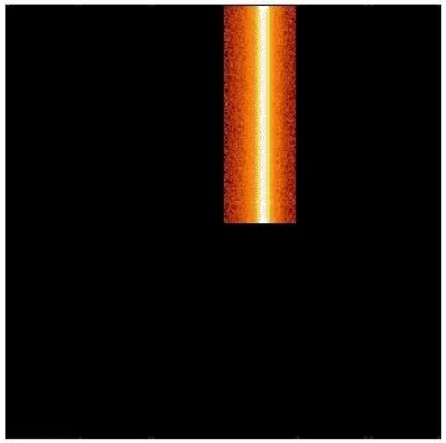
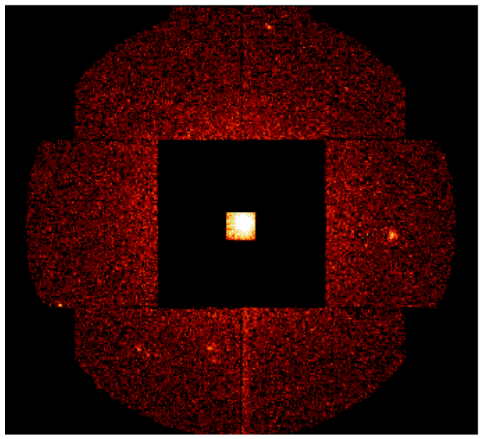
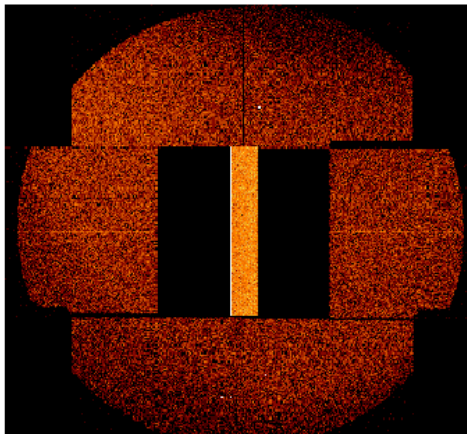
XMM instruments

- European Photon Imaging Camera (EPIC): 3 CCD cameras
  - 2 Metal Oxide Semi-conductor (MOS) CCD arrays (MOS cameras)
  - pn CCD (pn camera)
  - 0.15 – 15 keV
  - Energy sensitive CCDs provide also spectroscopy
  - Operating temperature -100 °C
- Reflection Grating Spectrometers (RGS): 2 reflection grating arrays and CCDs
  - 0.33 – 2.5 keV
  - Operating temperature -80°C

EPIC science modes

Full Frame	Large Window
Small Window	Timing

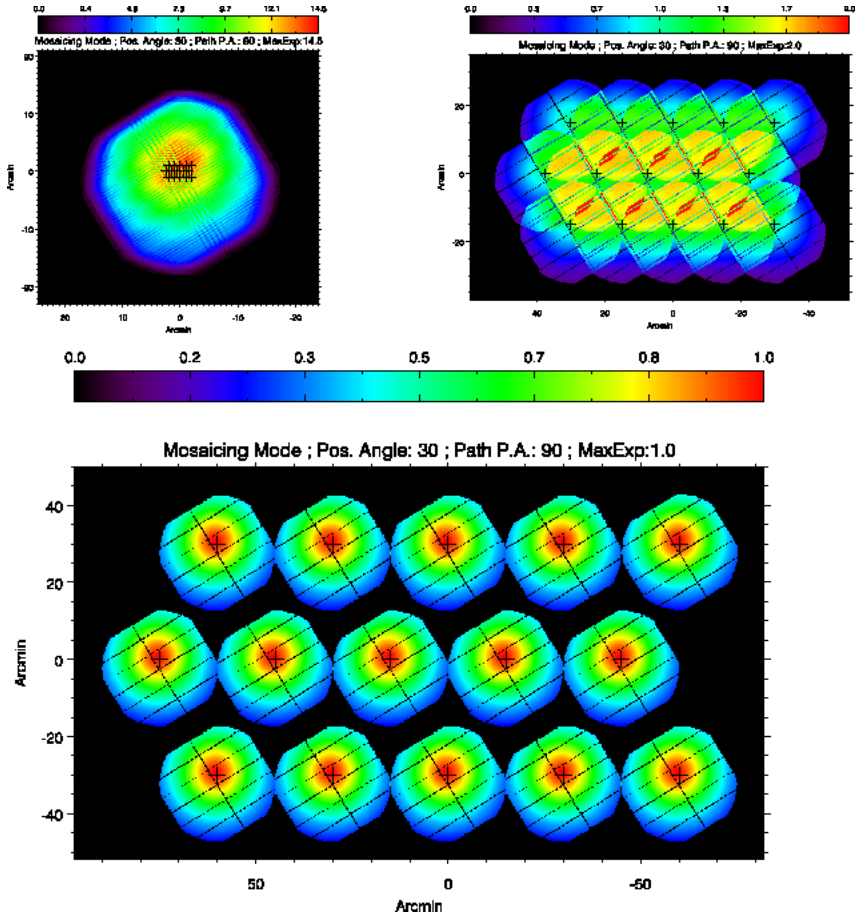









pn

MOS

Additional observing modes

Mosaic mode for large fields

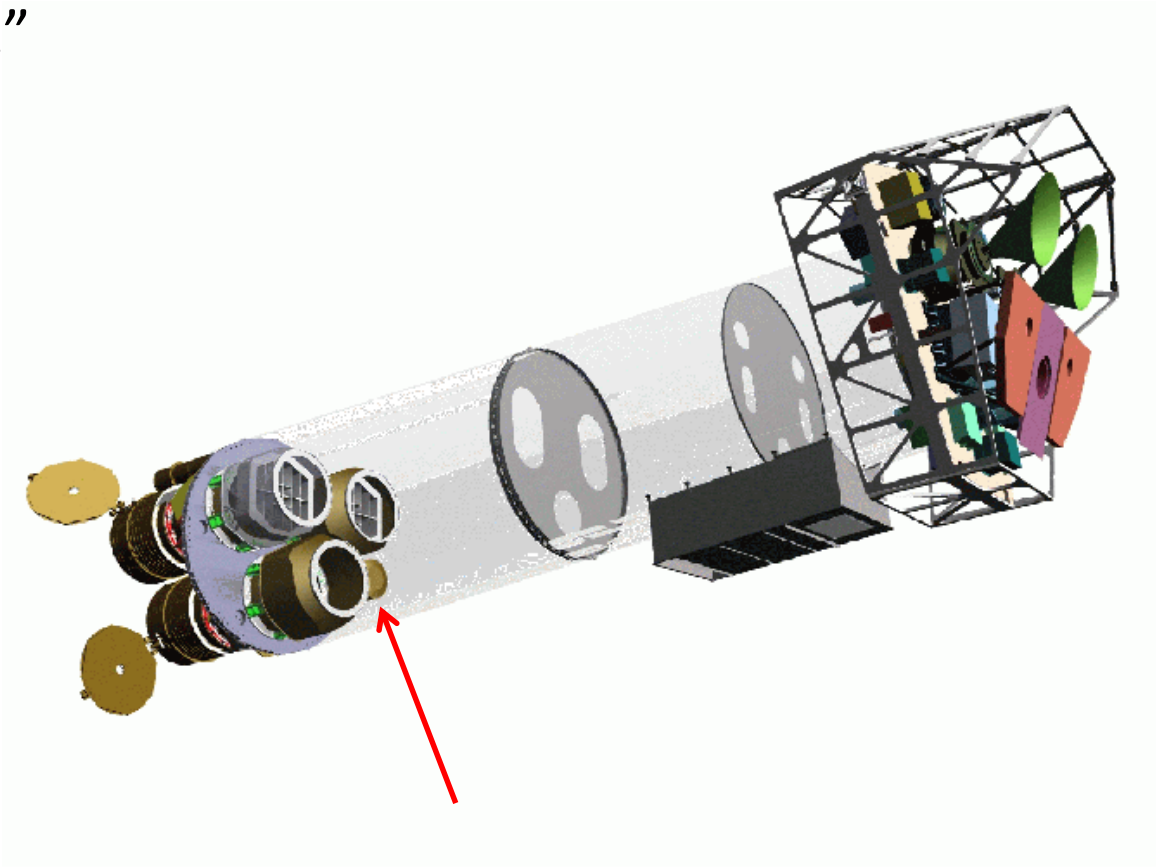


RGS Multipointing mode

– 5 different pointings to eliminate the coincidence of photons of certain energies always hitting the same (bad) pixels of the detectors.

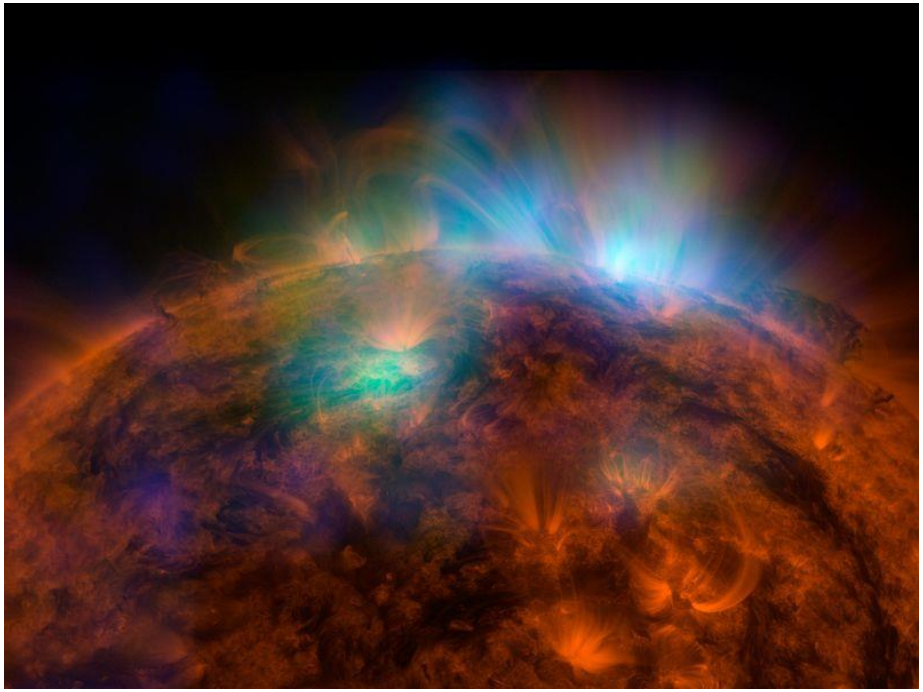
Optical monitor (OM)

- 30 cm optical/UV telescope
- 180 – 600 nm
- Resolution approx. 1”



EPIC Radiation Monitor Subsystem (ERMS)

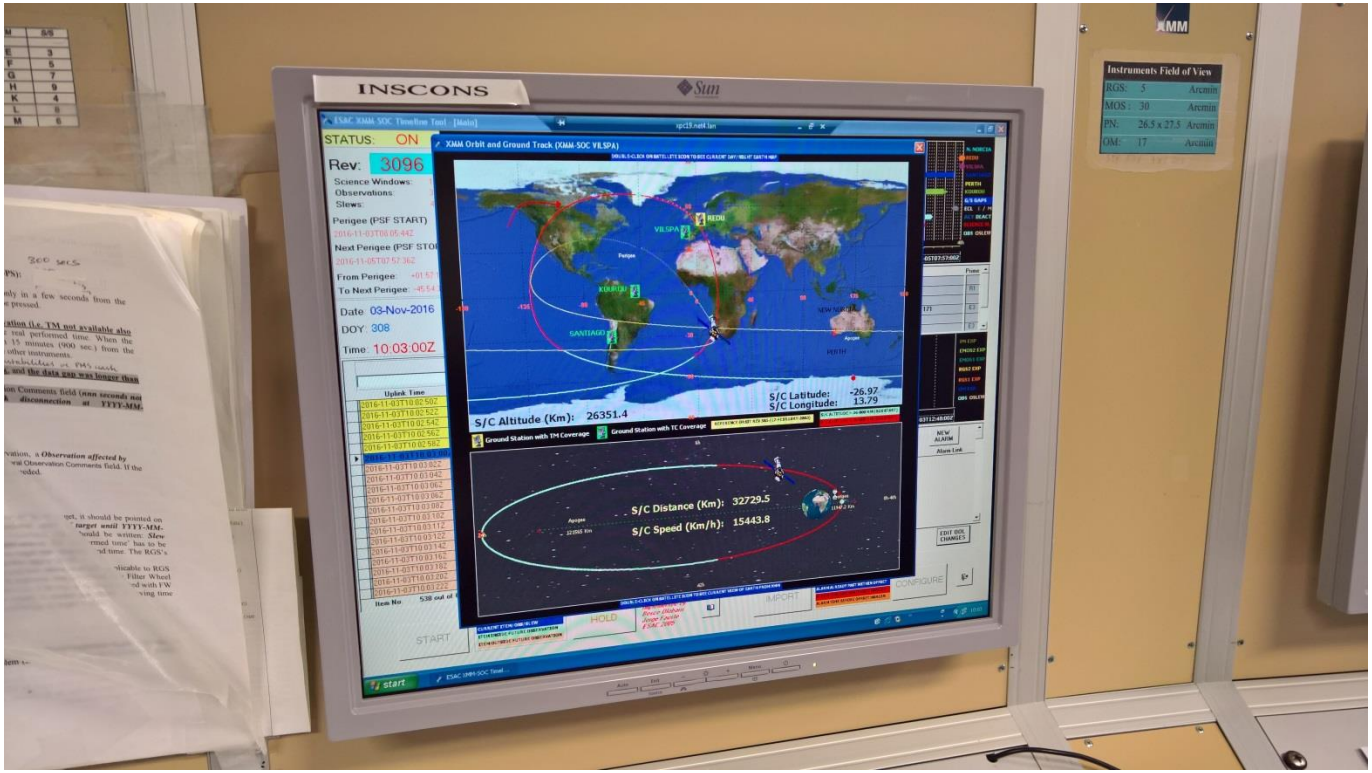
- Monitors the total radiation amount of the satellite
  - Radiation belts.
  - Solar flares.
- If a threshold is exceeded, instruments are put in a safe mode.



NuSTAR+SDO

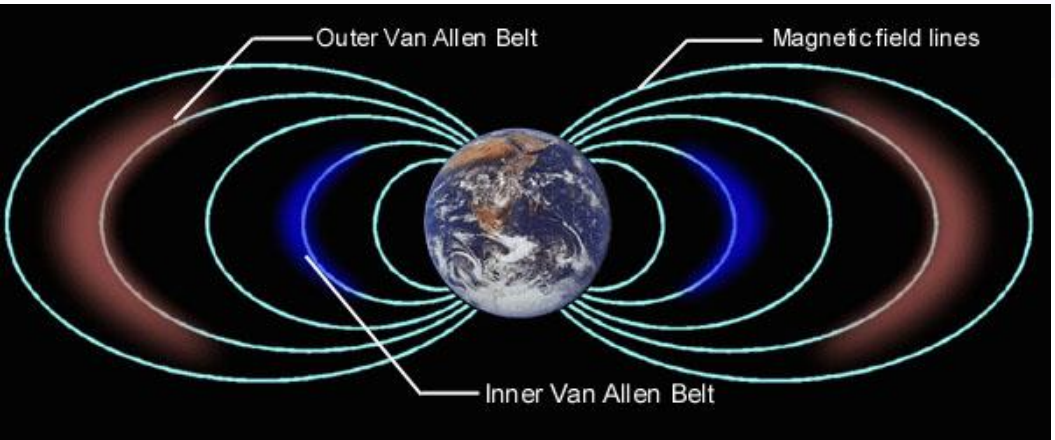
XMM orbit

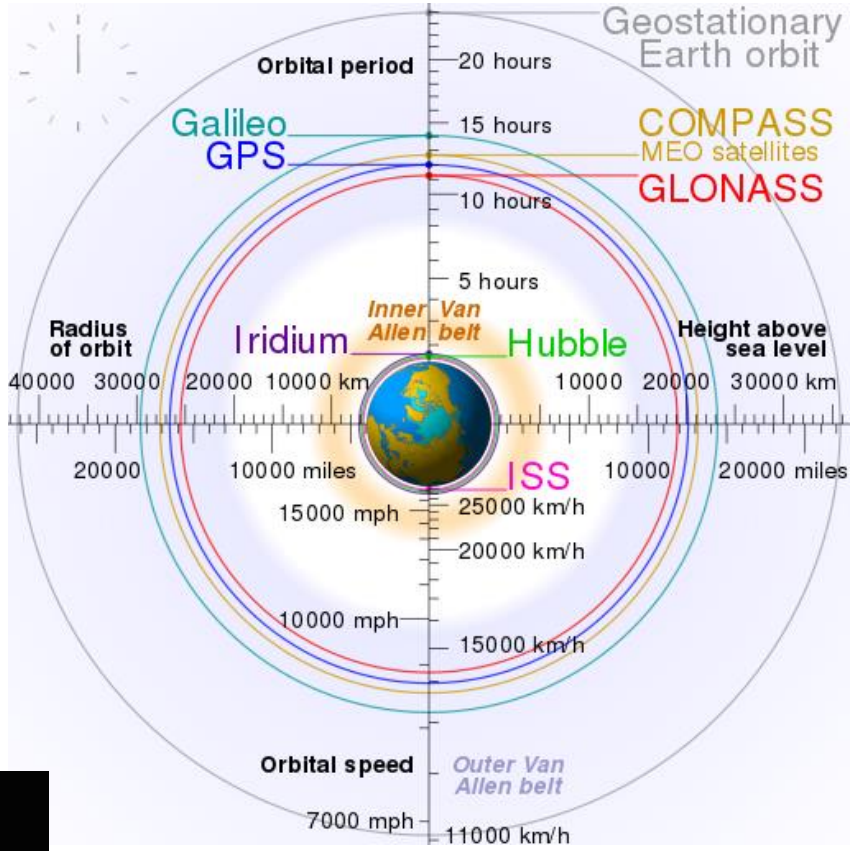
- Orbit length approximately 48 hours
- Perigee < 10 000 km
- Apogee approx. 100 000 km
- Eccentricity > 0.8



Radiation background

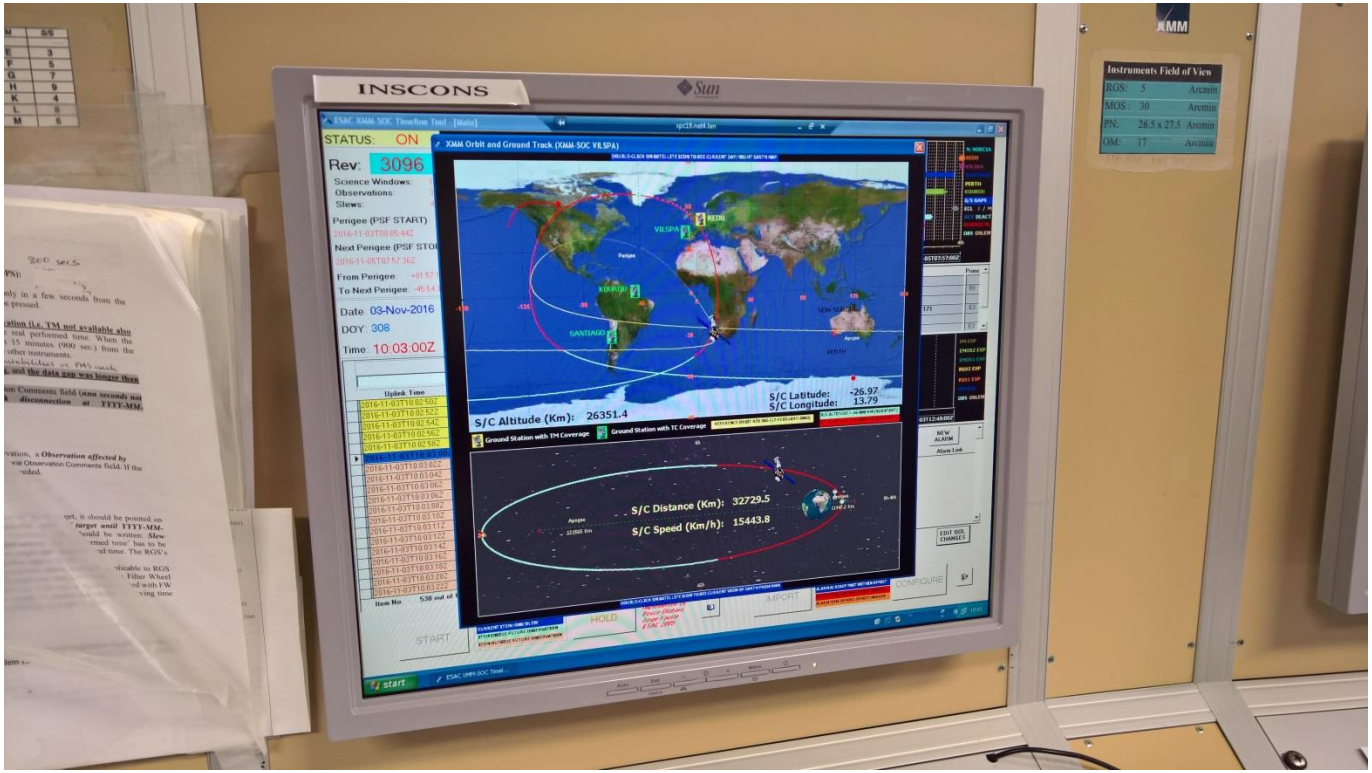
- Radiation from the Earth's magnetosphere causes high background and can ruin observations.
- Sensitive instruments closed during high background (also solar flaring!), no observations can be made at all.





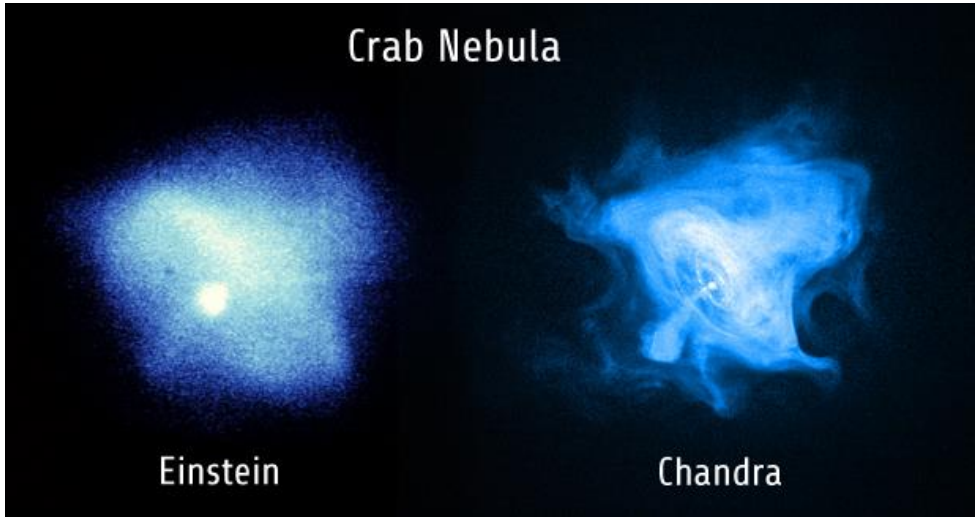
Cmglee, Geo Swan

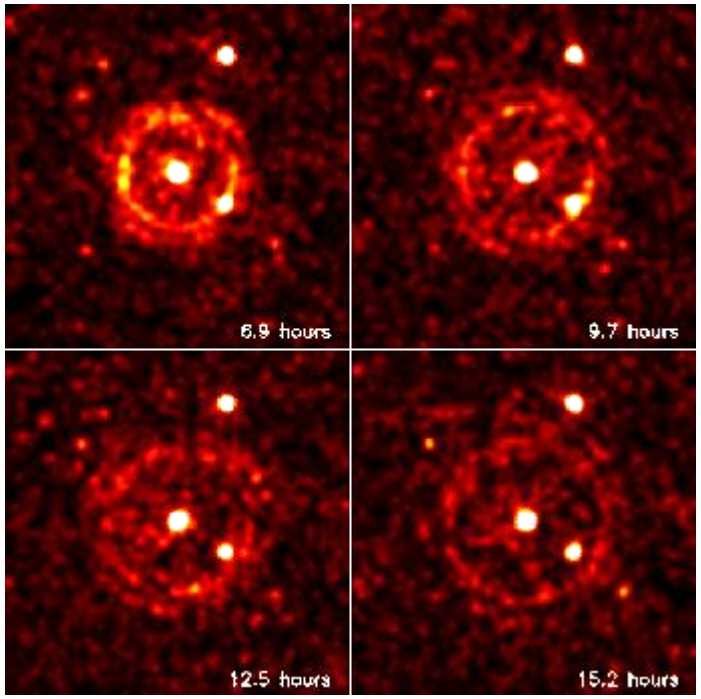
- Approximately 60% of observing time available during low levels; a minimum satellite height for good quality observations is > 46 000 km which corresponds to observing time of 132 ks per orbit.
- Low background levels needed for fainter sources
  - What can you do? Increase observing time. Repeat observations.



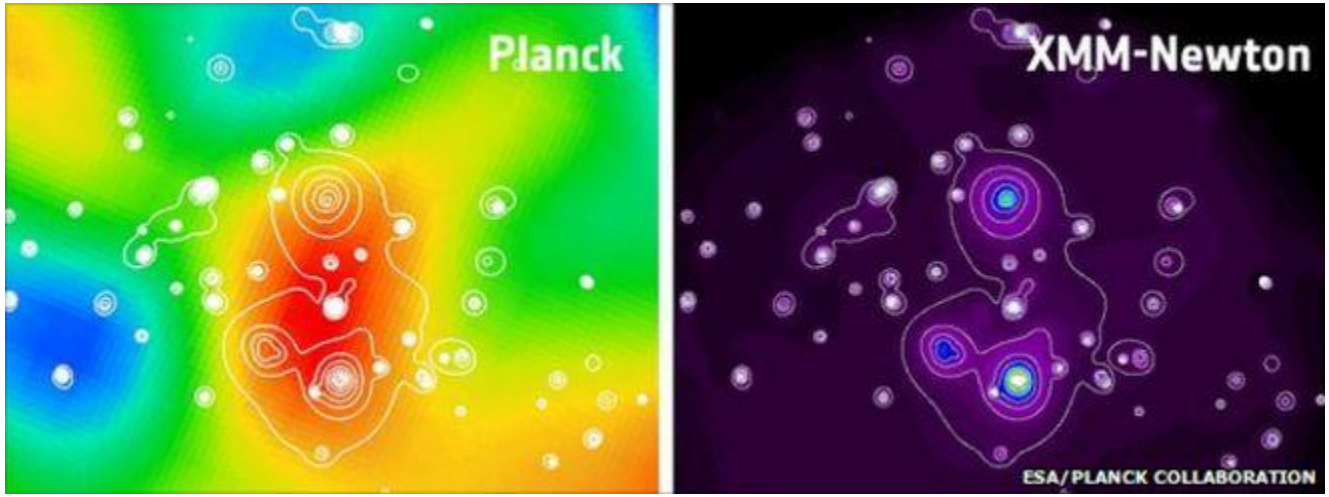
XMM-Newton operations room at ESAC

X-ray imaging



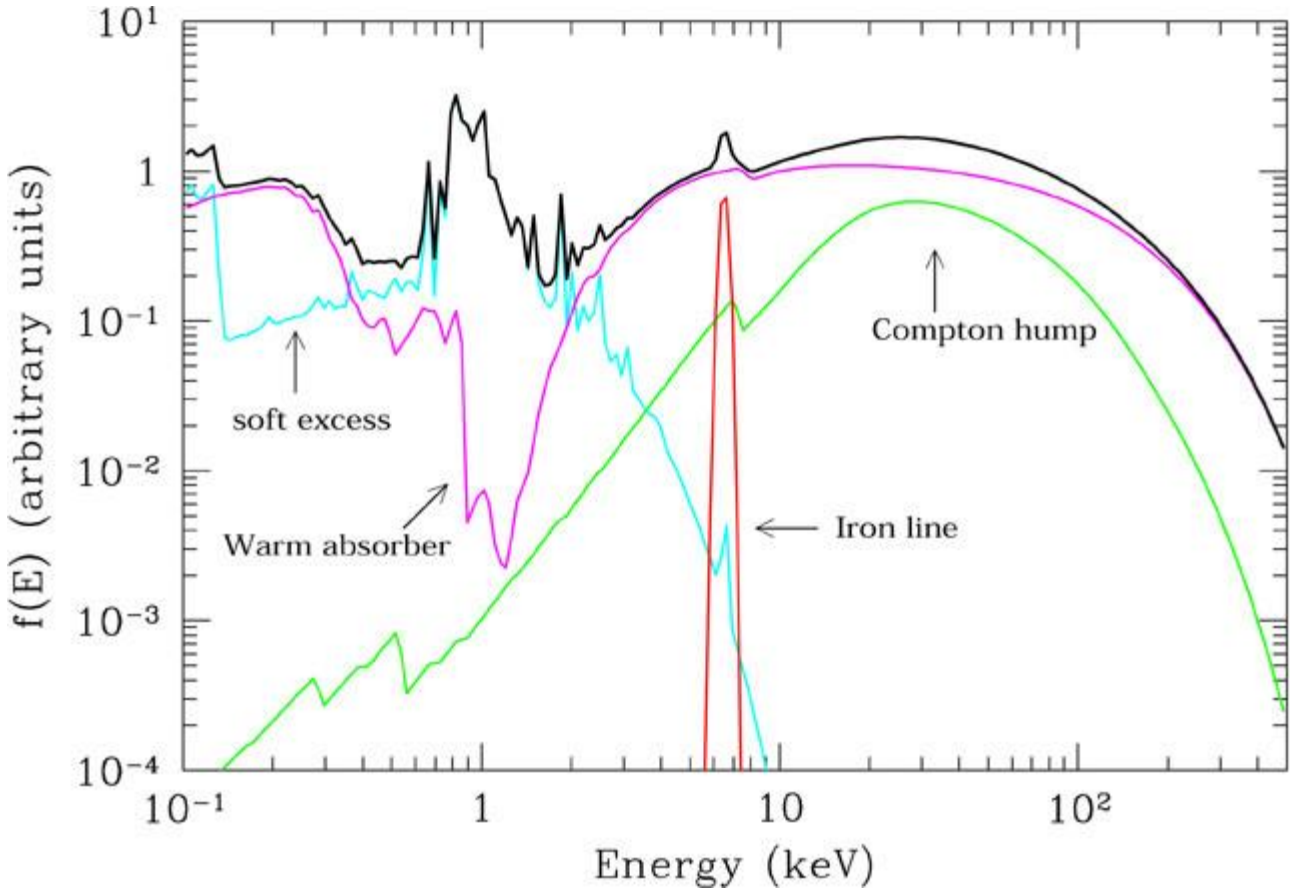


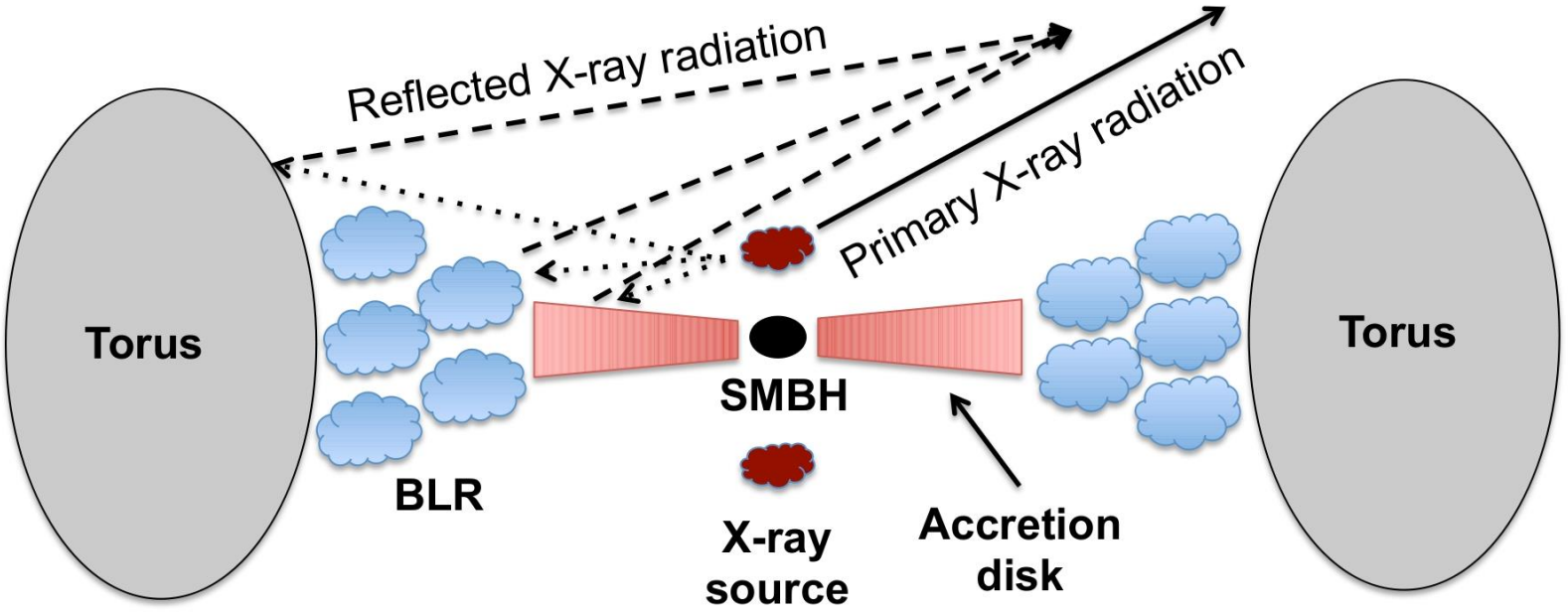
Gamma-ray burst (XMM)



Supercluster

X-ray spectra of active galactic nuclei

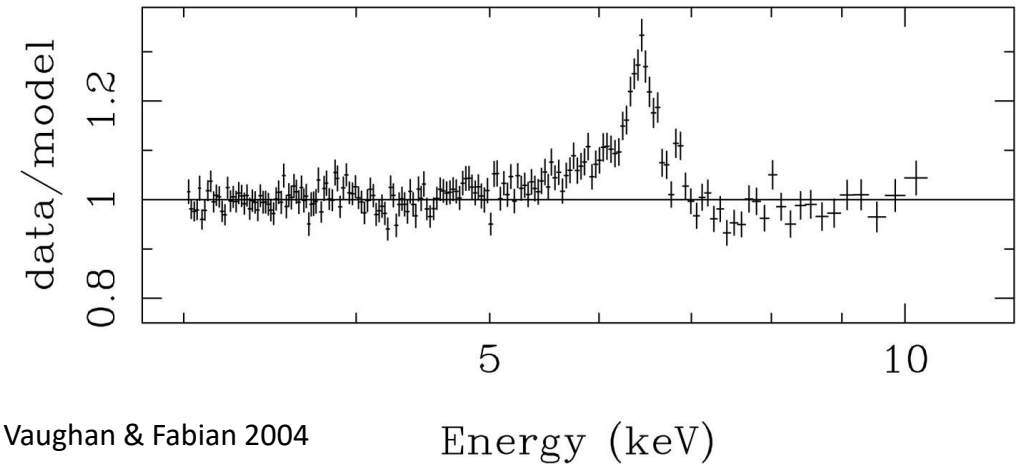




www.isdc.unige.ch/~ricci/Website/AGN_in_the_X-ray_band.html

X-ray reverberation mapping

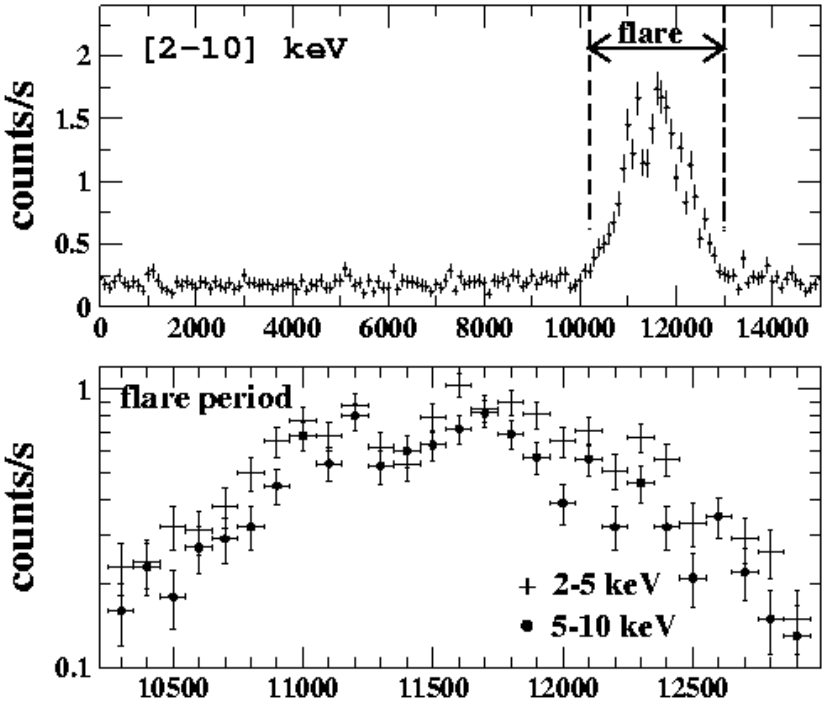
- An intense X-ray source close to the black hole illuminates the accretion disk and the iron line brightens: time lags between the direct continuum and reflected X-ray components.
  - Broad Fe K line at 6.4 keV
- Relativistic reverberation!
  - Very close to the supermassive black hole.
  - Distance calculated from the time lag indicates that the X-ray source is some distance above the accretion disk.
  - Also the black hole spin can be measured.



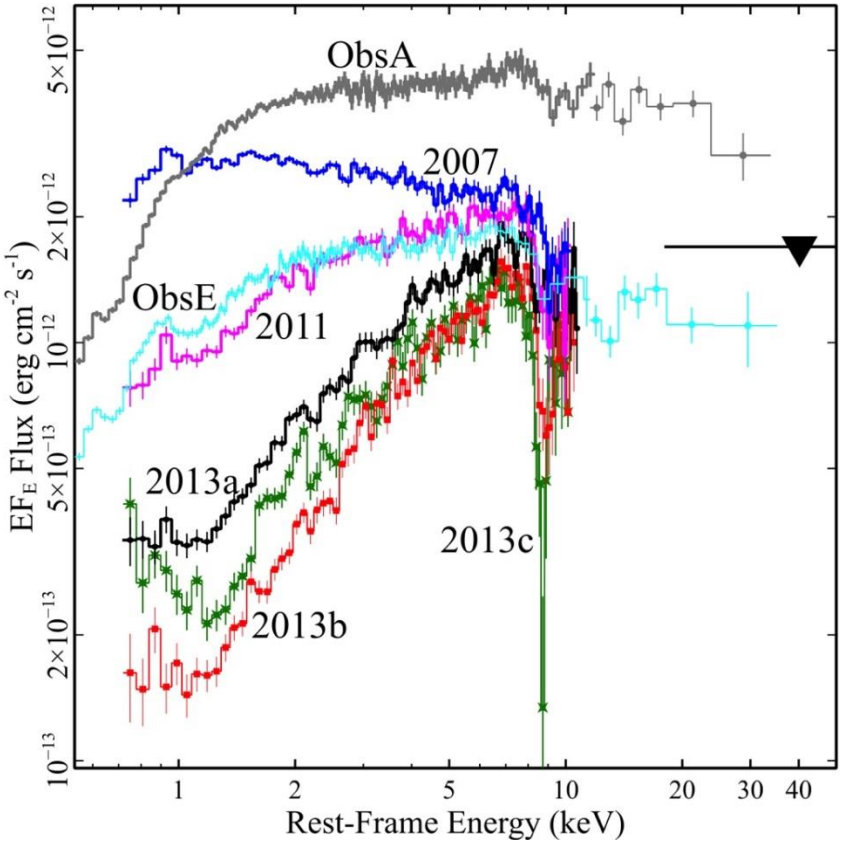
Vaughan & Fabian 2004

X-ray timing / variability

- Variability from fractions of a second to years
  - Light curves
  - Spectral variability



Sgr A*; Porquet et al. 2003



PDS 456; Matzeu et al. 2016

Observing with an X-ray satellite

- For an observatory-type satellite you need to apply for observing time.
  - Observatory vs.survey satellite
- Getting observing time is not trivial
  - Satellite facilities are expensive.
  - Oversubscription rates are high, lots of competition.
  - Only the best proposals get observing time.
  - Good science case with justification + a feasibility study!

- XMM: 1800EUR/ksec
- Chandra: 7700EUR/ksec
- Metsähovi radio telescope 115 eur/h -> 38 EUR/ksec.

Applying for observing time

- A call for proposals usually once a year : *Announcement of Opportunity (AO)*
  - The process will take several months. Deadlines for various instruments are spread throughout the year.
  - Planning for multifrequency campaigns is demanding.
- You need to specify what you want to do and why, and how you are going to do it. Is it technically feasible with the instrument you are suggesting?
  - Template with a page limit.
  - Additional software needed (for simulations etc)?
  - Check for existing observations.
  - Is this the best possible instrument for this purpose?

Observing time allocation case study: XMM-Newton

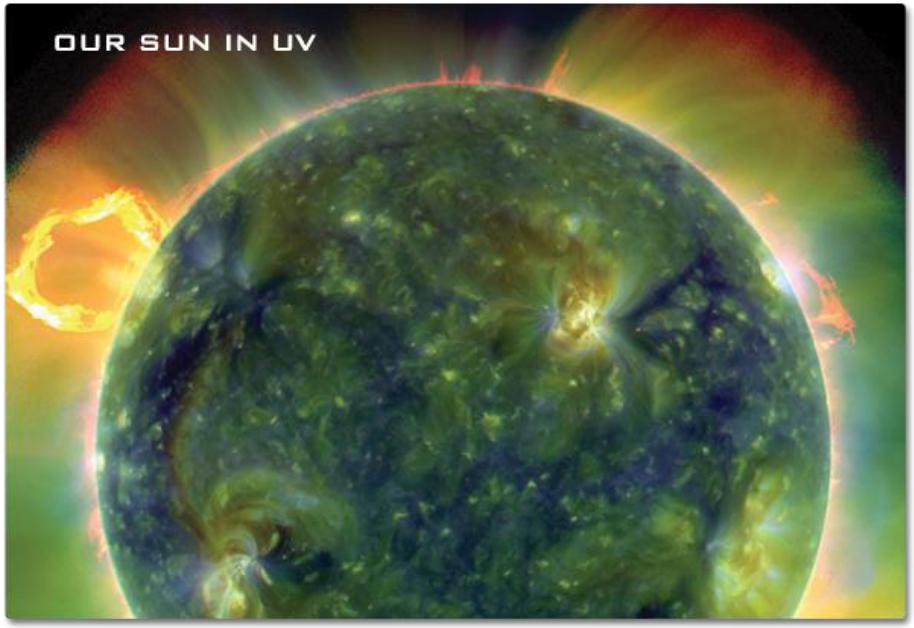
- Observing time allocation committees (OTACs) in each topic area decide what will happen to your proposal. …
- … (continues as a live narrative only, no slides available)

UV astronomy

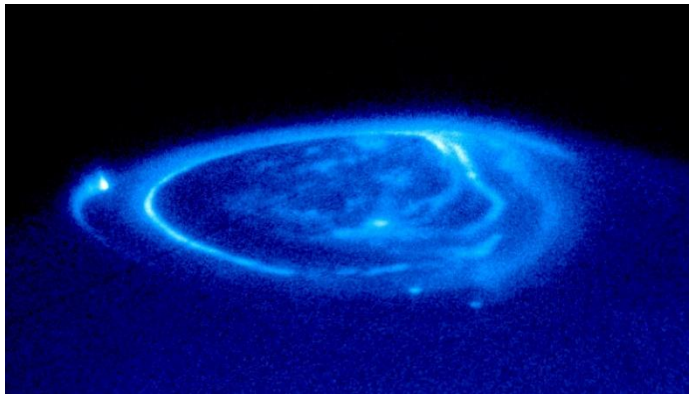
Ultraviolet radiation

- 10 nm – 400 nm
- UV-C, UV-B, UV-A

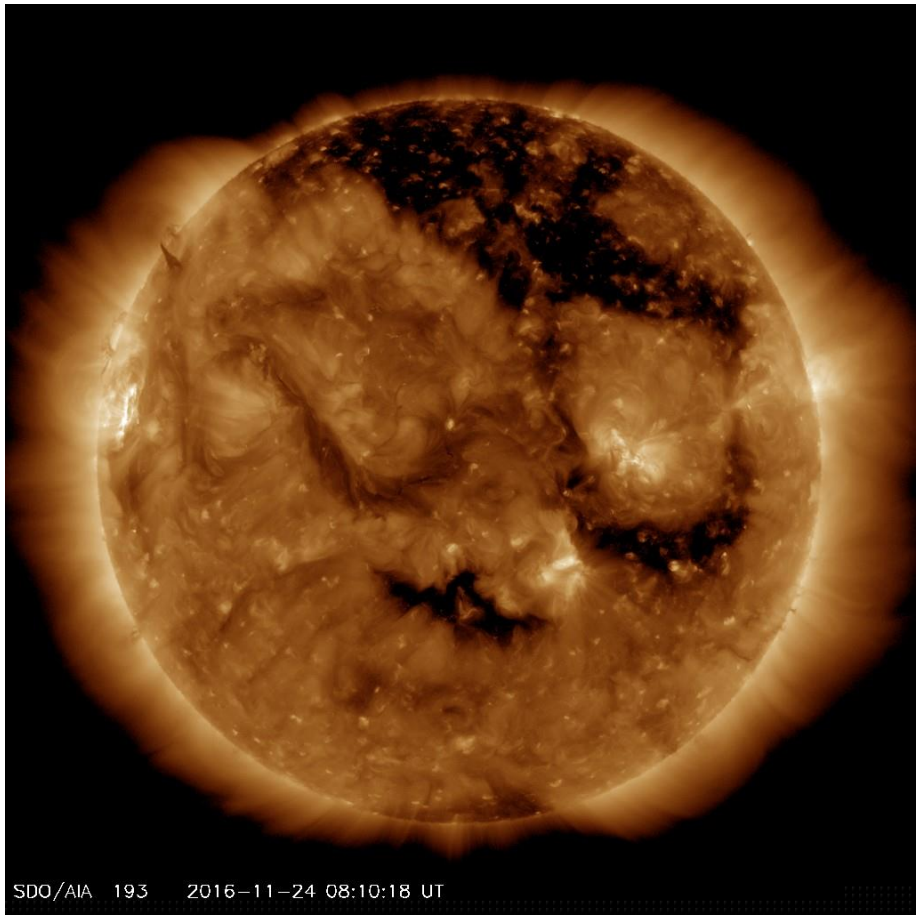
- The Sun
- Young & hot stars
- Galaxies (via star formation)

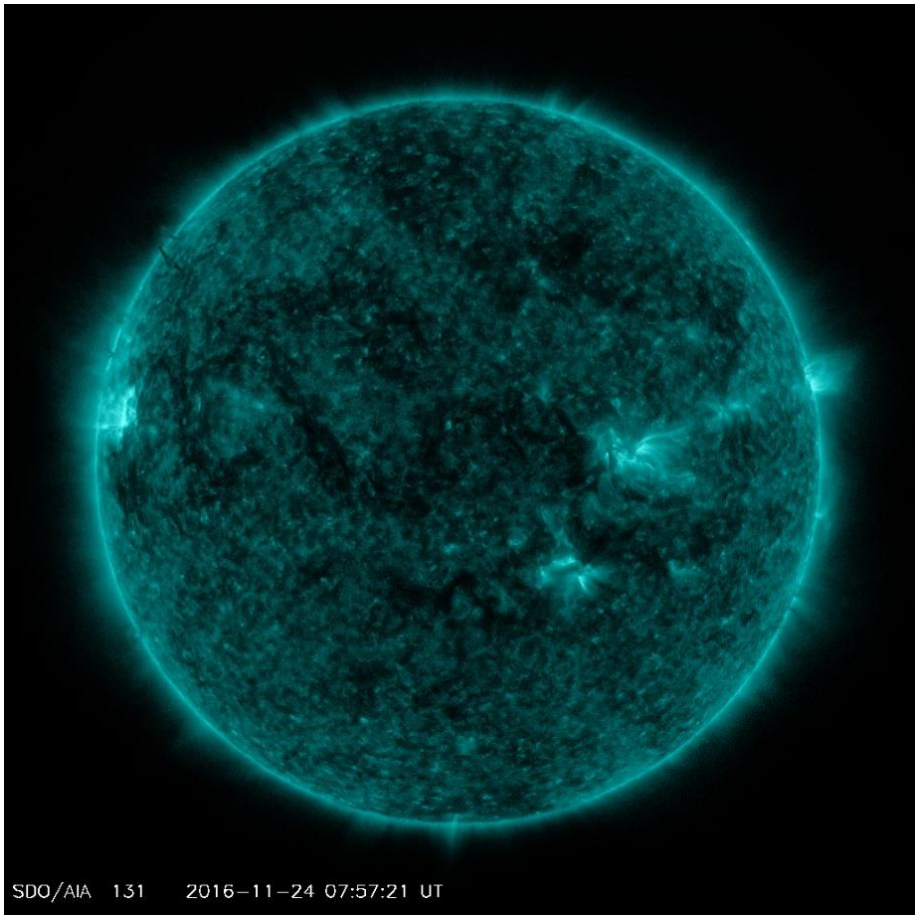


NASA/SDO/AIA



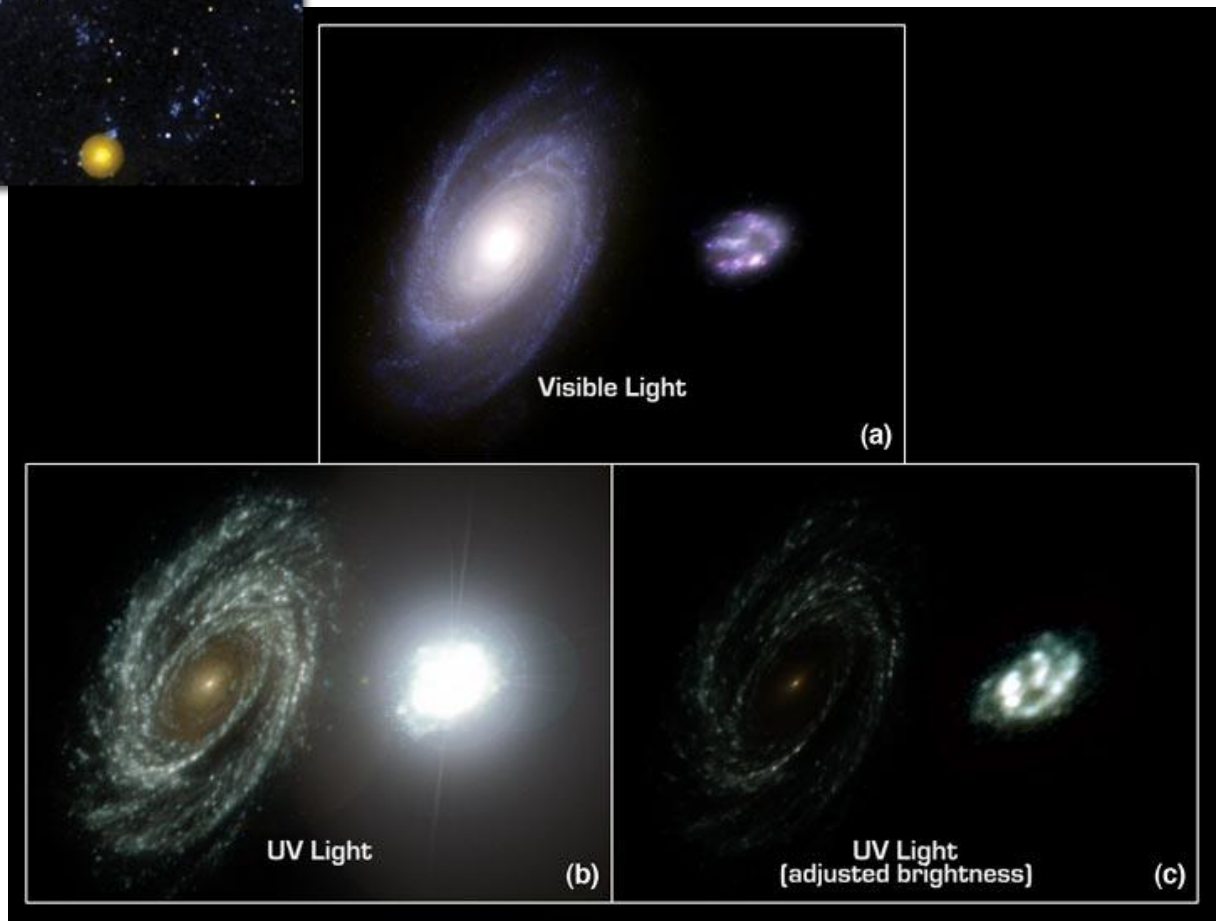
Hubble





http://sdo.gsfc.nasa.gov/data/

GALEX; NASA/JPL-Caltech

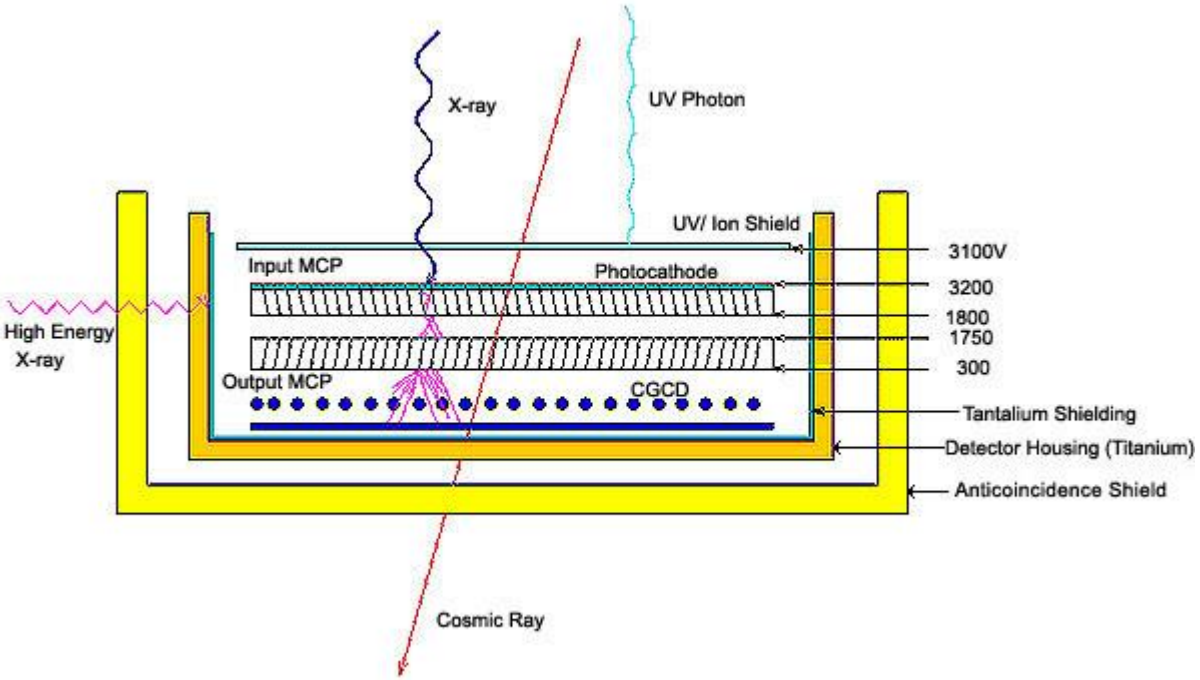


UV satellites

- Dedicated missions: IUE, EUVE, GALEX; SOHO, SDO…
- UV instruments onboard other missions: Hubble, XMM, Swift…
- Imaging, spectra.

- Optical-type telescopes, X-ray type telescopes.
- X-ray type detectors
  - Microchannel plates
  - CCDs
  - Future technologies: electron-bombarded CCDs, photoconductive detectors based on GaN and GaAlN

- Microchannel plates
  - Channels, coated with special material, through a lead glass plate.
  - Electrons freed by X-rays or UV photons interact with the material.
  - Positional information: which channel was activated.



Chandra High Resolution Camera (HRC)

Project reports & peer-assessment

Project report

- Reminder: report includes
  - an introduction and background section (for example, what has been done before in this area, why this topic was chosen, what are the goals of the project, why is it important…).
  - the main findings (for example, what is the project about, how will the goals be achieved, which technologies, orbits, etc have been chosen, how will these support the project, what is the outcome/results of the project…). Use as many sections as needed.
  - the arguments why certain solutions were chosen.
  - conclusions/summary, estimate of future work and possibilities.
  - references.

- Figures and images are fine, but do not try to fill the report with them. Only use illustrations that you think are necessary and useful.
- Simulations and videos can be included in the report (links).
- 5 to 10 pages (A4, normal font size and line spacing).
- Report deadline 14.12. at 9.00 in MyCourses. **Late submissions NOT ALLOWED.**

Peer-assessment

- Peer-assessment opens automatically in MyCourses immediately after the report deadline (14.12. at 9.00).
- Deadline 21.12.2020 at 09.00.

- Everyone reads and evaluates two reports
  - Assessment criteria rubric (max 20 points).
  - Open feedback.
  - You get max 5 points for your assessment work.

- It’s about learning how to evaluate, how to write better reports, how to give feedback. It’s not only about assessing others, it’s also a tool for self-assessment.

Student contribution	Points	Comments
Assignments	3 x 5 = 15 in total	3 assignments, maximum of 5 points each.
Project plan	10	
Project report	20	
Peer-assessment	5	Points are given for the quality of the assessment.

Peer-assessment will be checked by the teacher to make sure that the evaluation is consistent and fair. It usually is anyway, even without checking!

Assessment criteria (TBC!)

- Assessment rubric in which you can choose how many points you give, based on certain criteria (NB. There will be changes in the rubric until peer-assessment opens), for example:
  - Definition of the mission and its goals
  - Content
  - Organization and clarity
  - References
- Open feedback

Examples (TBC!)

References (0-3*): *Is all material properly referenced?*

Referencing seems complete to me: 3

Adequate referencing with most references in place: 2

Some essential referencing but a lot clearly missing: 1

No references or seriously unfinished referencing: 0

Examples (TBC!)

Organization and clarity (0-3*?*)*: Is the report well-organized and easy to read? Is it focused or does it contain superfluous materials? Is the length and number of figures/tables appropriate? Are figures illustrative?*

Report is well-organized and easy to read. It focuses on the topic at hand and does not contain superfluous materials. The length is appropriate. The figures and tables are appropriate and illustrative. This is a very good/excellent report. : 3

The report is organized and contains most essential items required. It is mostly focused, with appropriate figures. The length is appropriate. This is a satisfactory/good report: 2

The report could be very short and/or without proper structure. Figures and tables are inadequate and/or confusing. The text may additionally wander from focus and concentrate on inessential topics, or it does not contain all that is required. This is a sufficient report.: 1

The report is very short and unfinished, and does not contain much anything required. This is an insufficient report. (Please do not submit any of these :)): 0

Giving open feedback

- Constructive!
- Do not compare, do not be judgemental or aggressive.
- It should be useful and help in writing better reports.
- Be specific rather than too general, give examples what kind of things would make the report better
  - *”This is bad”* vs. *”Writing also about zzyyxx would improve this a lot”*
- Be (also) positive
  - *”This is bad”* vs. *”That is really nicely written, but this could be improved by zzyyxx”*

ELE's 2021 Summer jobs

Open for application 8 Dec 2020!

Follow ele.aalto.fi for updates
and learn more about the research areas and the research groups in the department of Electronics and Nanoengineering

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