Aos ministrantes de disciplinas de graduação no presente semestre

Como representantes da Comissão de Avaliação Didática e de Disciplinas, ficamos encarregadas de distribuir os formulários de avaliação a serem preenchidos pelos alunos.

Solicitamos a todos que nos avisem sobre as melhores datas para suas turmas. para que tenhamos o maior número possível de alunos presentes.

Em geral, o dia da última prova é a melhor ocasião, mas outras datas também podem ser definidas, caso o(a) colega assim preferir.

Aguardamos sua proposta de data para depois combinarmos os detalhes.

(Favor encaminhar sua resposta para astronomia@iag.usp.br)

Atenciosamente,

Jane e Vera

Revise schedule

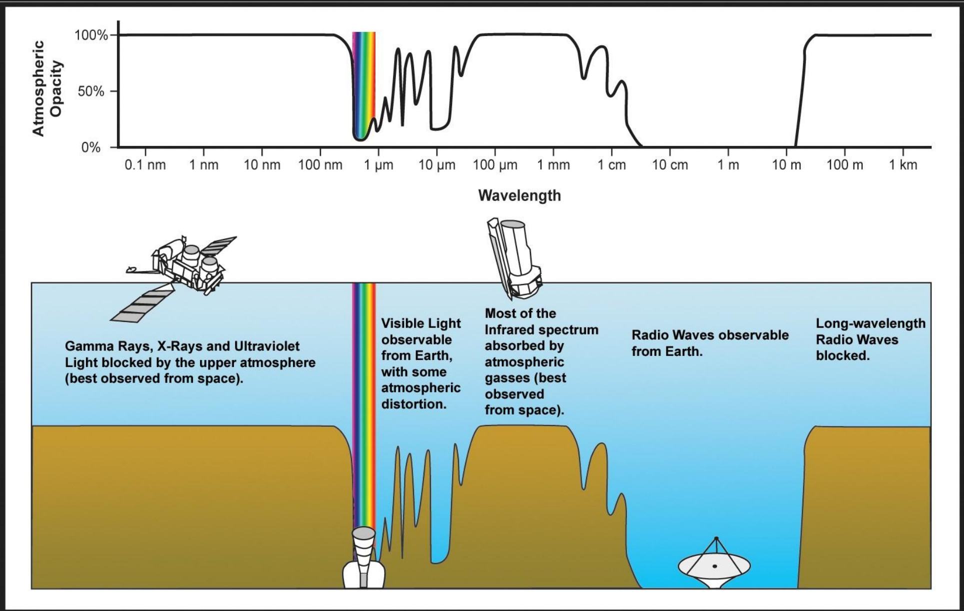
AGA0414
Space Based Observations

Prof. Alessandro Ederoclite

This is where I get out of my comfort zone.

Why do we go to space?

1. Get rid of atmosferic absorption
2. Optical imaging at diffraction limit
3. In situ observations



https://en.wikipedia.org/wiki/File:Comet_67P_on_19_September_2014_NavCam_mosaic.jpg

Btw, Starlink!

Elon Musk @elonmusk

Follow

Replying to @varunversion1 @Erdayastronaut @SpaceX

There are already 4900 satellites in orbit, which people notice ~0% of the time. Starlink won't be seen by anyone unless looking very carefully & will have ~0% impact on advancements in astronomy. We need to move telelscopes to orbit anyway. Atmospheric attenuation is terrible.

Johnny Greco @johnnypgreco · May 27

"We need to move the telescopes to orbit anyway. Atmospheric attenuation is terrible." Now there's a billion dollar idea. How come we never thought of that astronomy friends?

IAU Statement on Satellite Constellations

https://www.iau.org/news/announcements/detail/ann19035/

Who goes to space?

Currently, few countries have the mean to send payload to space:

- USA (NASA)
- Russia (Roscosmos)
- ESA
- China (CNSA)
- India (ISRO)
- Japan (JAXA)
- Brazil - Projeto Jupiter

https://en.wikipedia.org/wiki/Ariane_5

The pros and cons of space

Pros

- Space missions can bring unique results

Cons

- Space is dangerous
- No screwing up
- Flying a mission is expensive
- Space missions need to stay within size and weight (not necessarily budget)
- Space agencies are difficult to deal with
- Missions can have dramatic failures (e.g. explode during launch,...)

Technology for Space

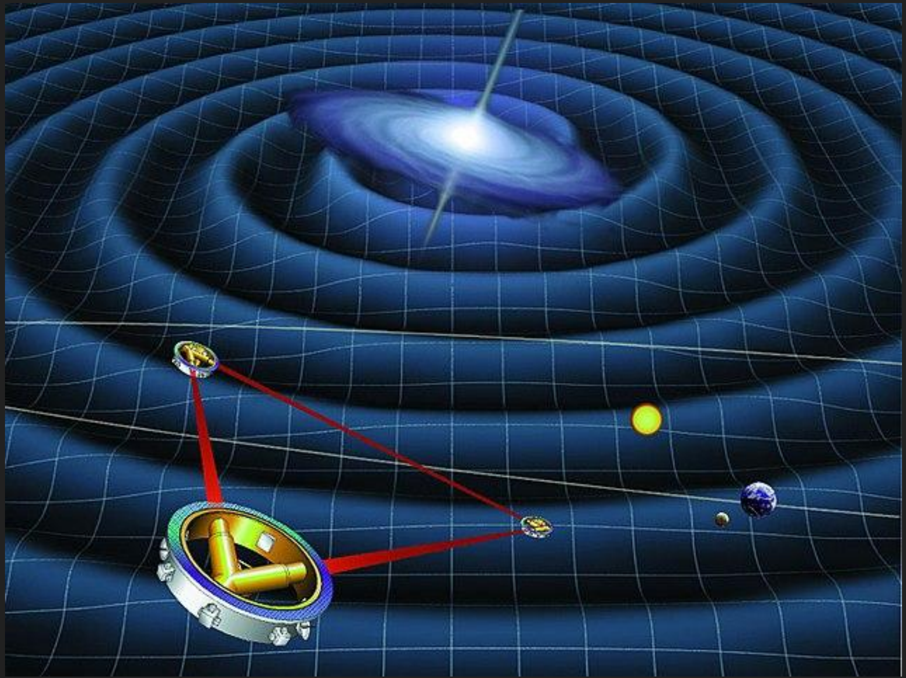
Most large missions are based on reliable hardware and software.

The legend of the Russian pencil.

Some missions are “pathfinders” or technology demonstrators.

Most missions are unique and even their science instruments are unique.

This causes little reproducibility of some observations (e.g. GALEX and WISE).



https://en.wikipedia.org/wiki/Laser_Interferometer_Space_Antenna

Getting out of the atmosphere

You need a spaceship

Vibrations during launch. Think of your polished mirror or the alignment of the spectrograph.

Size and weight are a big deal. Your telescope needs to fit the cargo of your vector (rocket or shuttle).

Price! (~22,000 US$/kg)

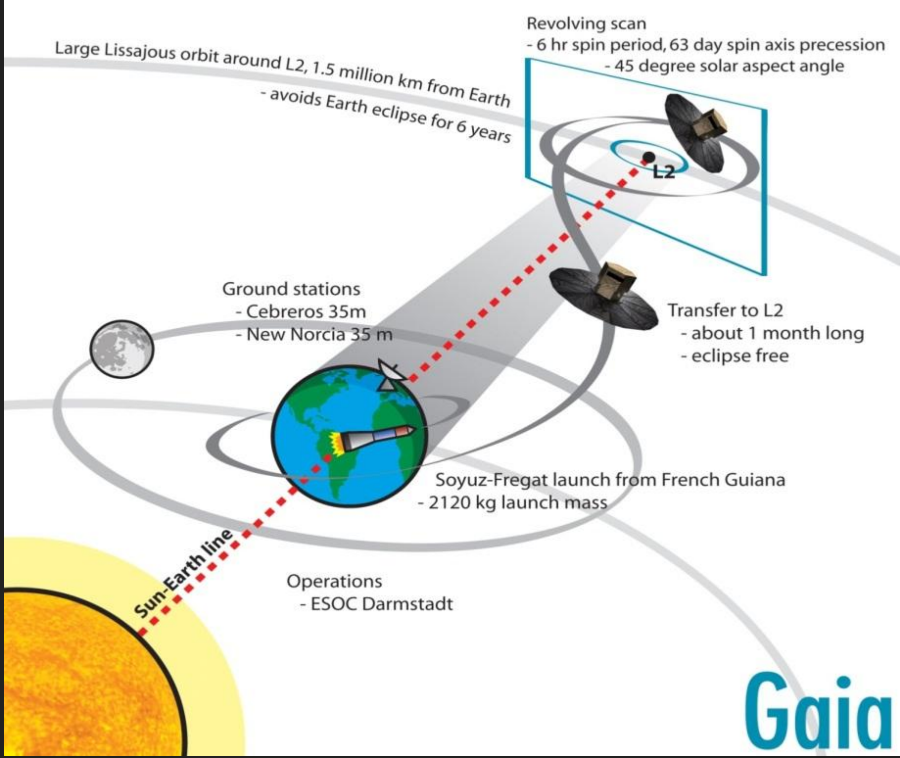
https://en.wikipedia.org/wiki/Soyuz_(rocket_family)

Flight Dynamics

You need to keep your spacecraft “on track”

People’s favourite places:

- Low Earth orbit (HST)
- Wondering about (Pioneer, Voyager, Rosetta, New Horizon,...)
- L2
- https://youtu.be/-AIbD2WxyN8



Science Operations

How do you point towards an object? (either use thrusters or reaction wheels)

You can not send an astronomer to operate the telescope… unless you do it in Villafranca del Castillo (Spain).

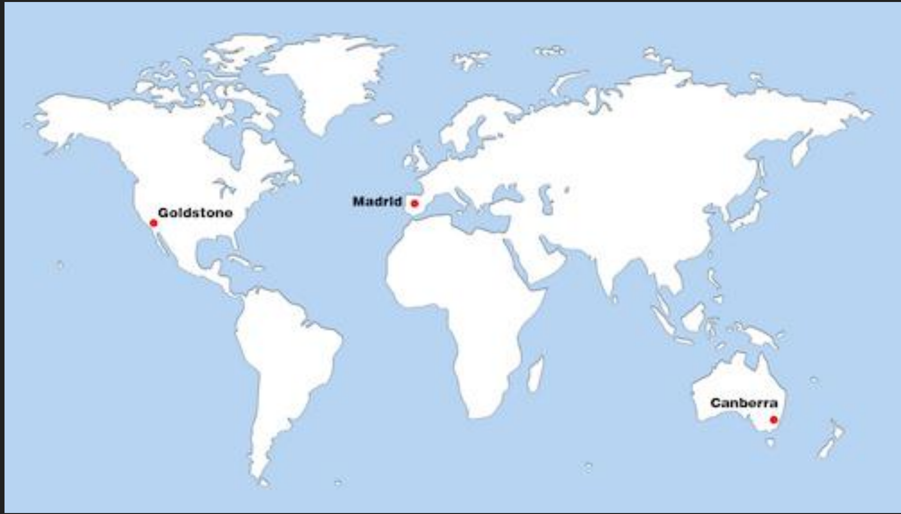
Most operate in “queue mode”.

http://sci.esa.int/iue/2424-iue-storm-signals/?fbodylongid=988

Communications

You need to send both telemetry and science data to Earth.

NASA has a “Deep Space Network”.



https://spaceplace.nasa.gov/dsn-antennas/en/

A few famous missions

There are many more than you know

Missions/Telescopes vs Observatories

Missions

- Dedicated science case
- Defined observing strategy
- Publish a catalogue at the end of the mission

Observatories

- Multi-purpose
- (Almost) anyone can apply to get observations
  - Instrument teams have reserved time/targets
- Publish data through an archive (typically data become public after a given time)

International Ultraviolet Explorer

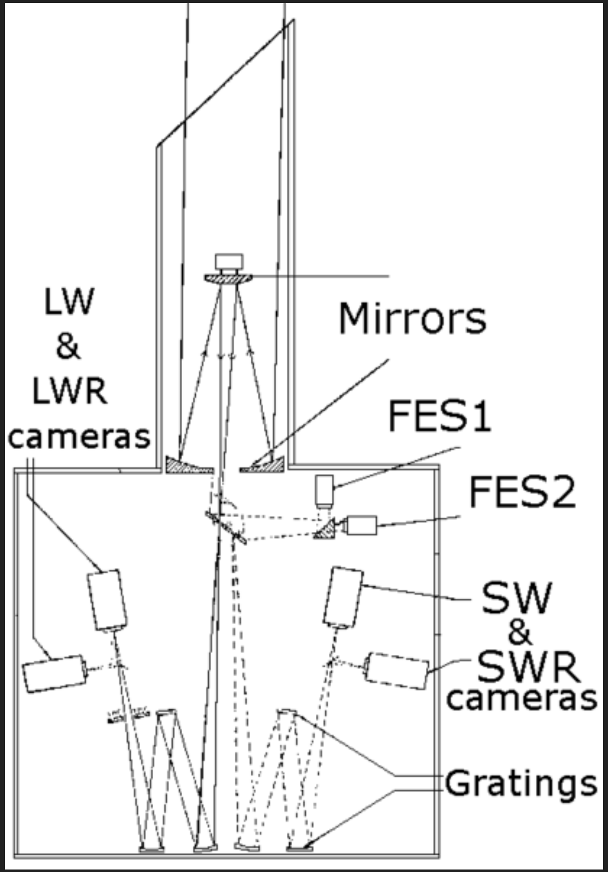
Telescope: Ritchey-Chretien

Diameter: 45cm

Focal ratio: f/15

Instruments:

- 115nm-198nm echelle spectrograph
- 180nm - 320nm echelle spectrograph



http://sci.esa.int/iue/

https://en.wikipedia.org/wiki/International_Ultraviolet_Explorer

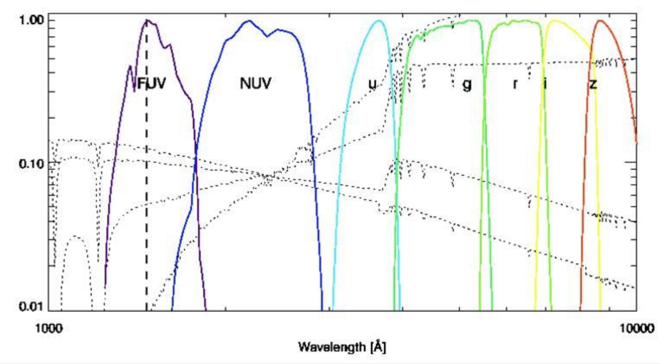
GALEX

Telescope: Ritchey-Chretien

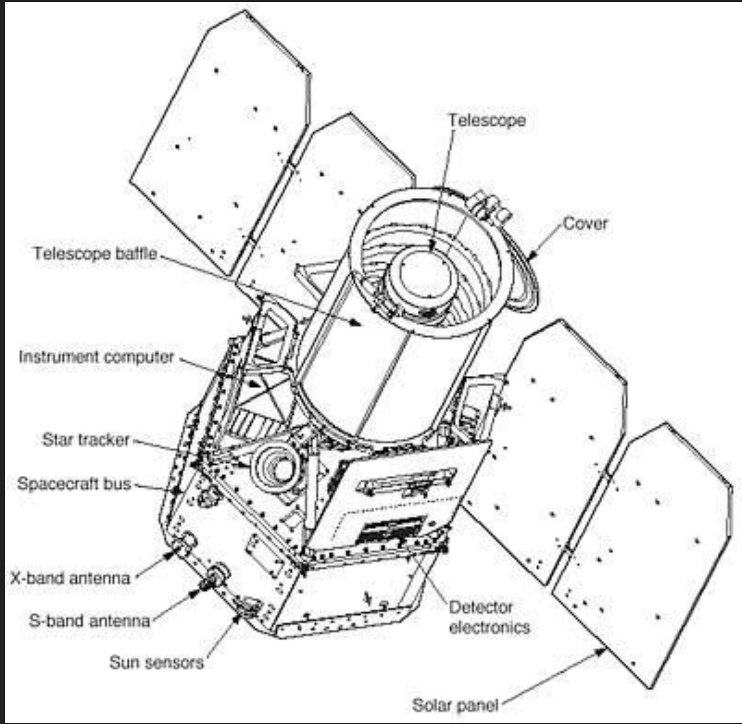
Diameter: 50cm

Focal ratio: f/6

2 filters: NUV & FUV



http://www.galex.caltech.edu/



https://en.wikipedia.org/wiki/GALEX

https://spaceflightnow.com/pegasus/galex/030424galex.html

Hubble Space Telescope

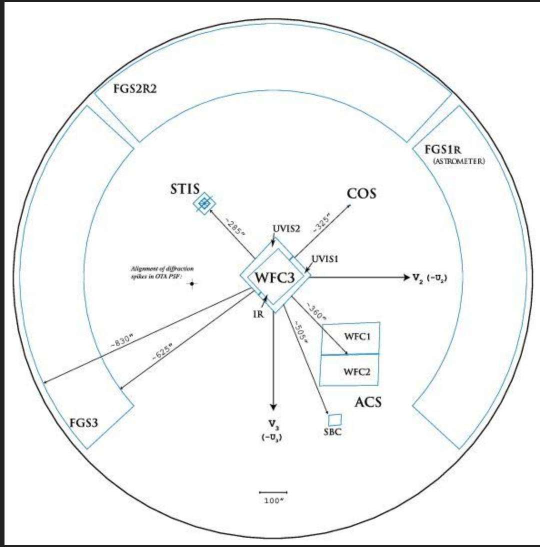
Telescope: Ritchey-Chretien

Diameter: 2.4m

Focal ratio: f/24

Current Instrumentation:

- ACS - Advanced Camera for Surveys
- COS - Cosmic Origins Spectrograph
- FGS - Fine Guidance Sensor
- WFC3 - Wide Field Camera 3



http://www.stsci.edu/hst/wfc3/documents/handbooks/currentIHB/c02_instr_descript3.html

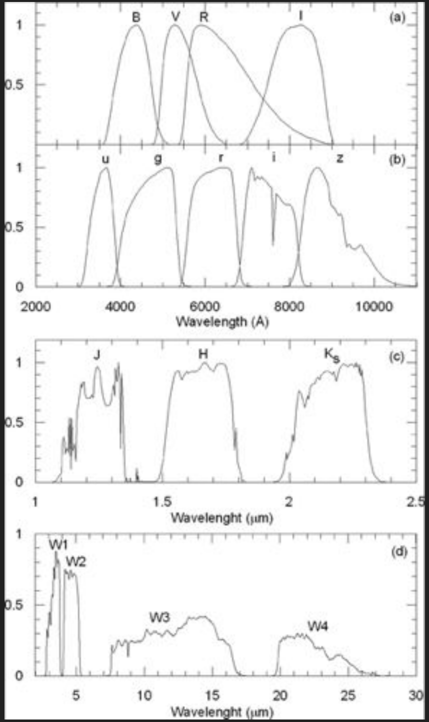
https://en.wikipedia.org/wiki/Hubble_Space_Telescope

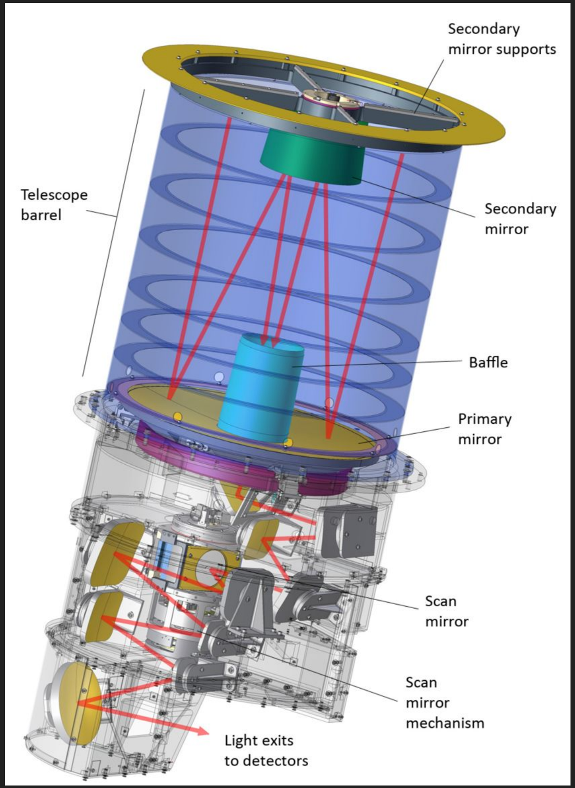
https://www.nasa.gov/mission_pages/hubble/main/index.html

Wide-field Infrared Survey Explorer

Diameter: 40cm

FoV = 47’





https://en.wikipedia.org/wiki/Wide-field_Infrared_Survey_Explorer

https://www.nasa.gov/mission_pages/WISE/main/index.html

http://www.planetary.org/multimedia/space-images/charts/wise-telescope-design.html

Herschel Space Observatory

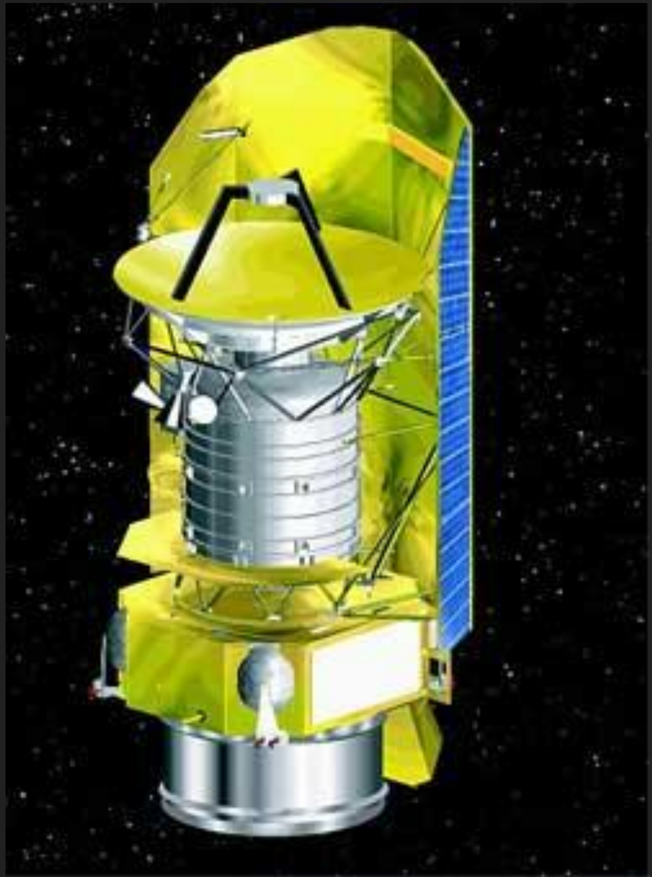
Telescope: Ritchey-Chretien

Diameter: 350cm

Focal ratio: f/8.7

Instruments:

- HIFI - Heterodyne Instrument for Far Infrared
- PACS - Photodetector Array Camera and Spectrometer
- SPIRE - Spectral and Photometric Imaging Receiver



http://sci.esa.int/herschel/ https://en.wikipedia.org/wiki/Herschel_Space_Observatory

X-ray astronomy

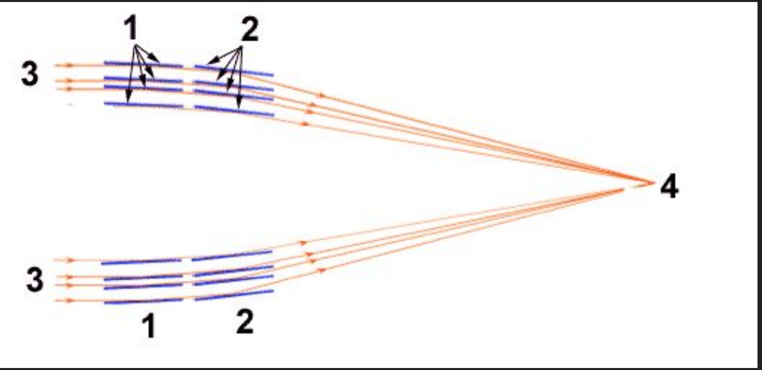
Focussing X-rays
Detecting X-rays

Focussing X-rays

Some high-energy missions use calorimeters and do not need focussing.

X-rays tend to go through matter (remember the hand of Röngten's wife?).

Hans Wolter (1952) designed the "grazing mirrors".



https://en.wikipedia.org/wiki/Wolter_telescope

https://en.wikipedia.org/wiki/XMM-Newton

X-ray detectors

CCDs :-)

X-ray photons produce enough electrons that one can measure their energy directly!

Uhuru

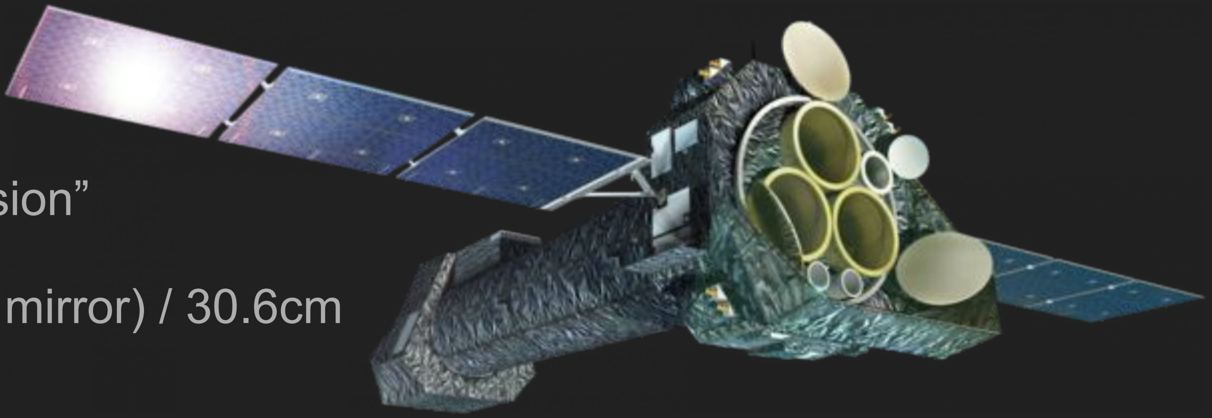
FIrst satellite for X-ray astronomy

Lauched by the San Marco Base (Kenia)

https://heasarc.gsfc.nasa.gov/docs/uhuru/uhuru.html

https://en.wikipedia.org/wiki/Uhuru_(satellite)

XMM/Newton



“X-ray Multi Mirror Mission”

Diameter: 70cm (outer mirror) / 30.6cm (inner mirror)

Focal: 7.5m

Spatial resolution: 5 - 14 arcsec

Spectral coverage 0.1-12 keV (0.1-12nm)

http://sci.esa.int/xmm-newton/

Instruments:

- EPIC - European Photon Imaging Camera
- RGB - Reflection Grating Spectrometer

https://en.wikipedia.org/wiki/XMM-Newton

Chandra

Diameter: 1.2m

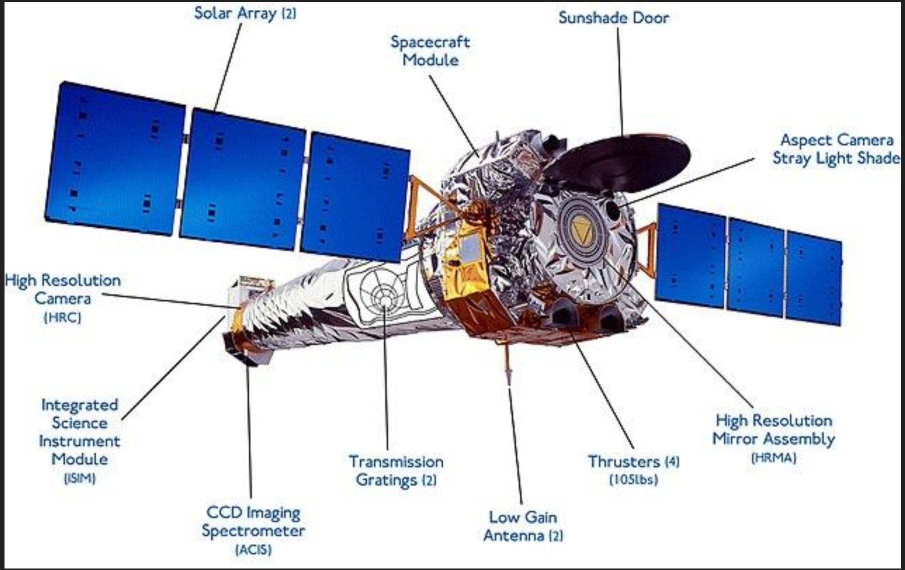
Focal length: 10m

Resolution: 0.5 arcsec

Spectral resolution: 40-2000

Instruments:

- ACIS: Advanced CCD Imaging Spectrometer
- HRC - High Resolution Camera
- HETG - High Energy Transmission Grating
- LETG - Low Energy Transmission Grating



https://en.wikipedia.org/wiki/Chandra_X-ray_Observatory https://www.nasa.gov/mission_pages/chandra/main/index.html

Neil Gehrels *Swift* Observatory

Instruments:

- BAT - Burst Alert Telescope
- XRT - X-Ray Telescope
  - Diameter 30cm
  - Focal: 3.5m
- UVOT - Ultraviolet/Optical Telescope
  - Diameter: 30 cm

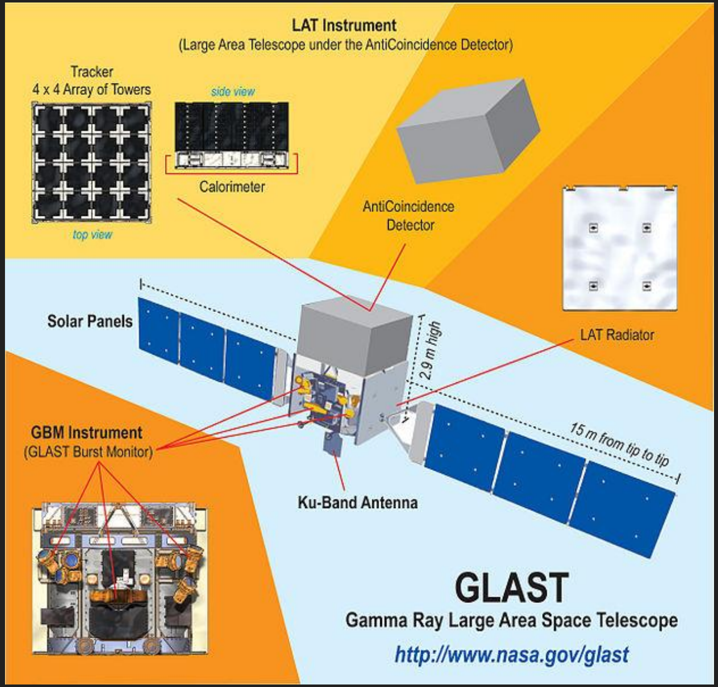
https://en.wikipedia.org/wiki/Neil_Gehrels_Swift_Observatory

https://swift.gsfc.nasa.gov/

Fermi (the mission once known as GLAST)

Instruments:

- GBM - Gamma-ray Burst Monitor (FoV - all sky not blocked by Earth)
- LAT - Large Area Telescope (Fov ~ 20% of sky)



https://en.wikipedia.org/wiki/Fermi_Gamma-ray_Space_Telescope https://www.nasa.gov/content/fermi-gamma-ray-space-telescope

INTEGRAL

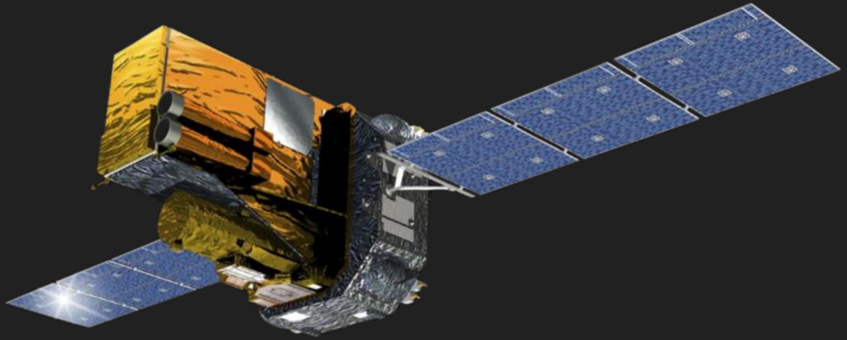
“Coded mask telescope!”

Diameter: 3.7m

Focal length: 4m

Instruments:

- IBIS - Imager on Board the INTEGRAL Satellite (15 keV - 10MeV); angular resolution 12 arcmin
- SPI - SPectrometer for INTEGRAL (15 keV - 10MeV); spectral resolution 450



https://en.wikipedia.org/wiki/INTEGRAL

http://sci.esa.int/integral/

...next time

Yet another attempt to meet in the IT lab to learn how to reduce spectroscopic data.

Between me feeling sick and the strikes, we have missed two or three lectures. I am happy to do one or two extra ones during this month, but you need to tell me when.