Observing from Space

Orbits, constraints, planning, coordination

Integral

XMM-Newton

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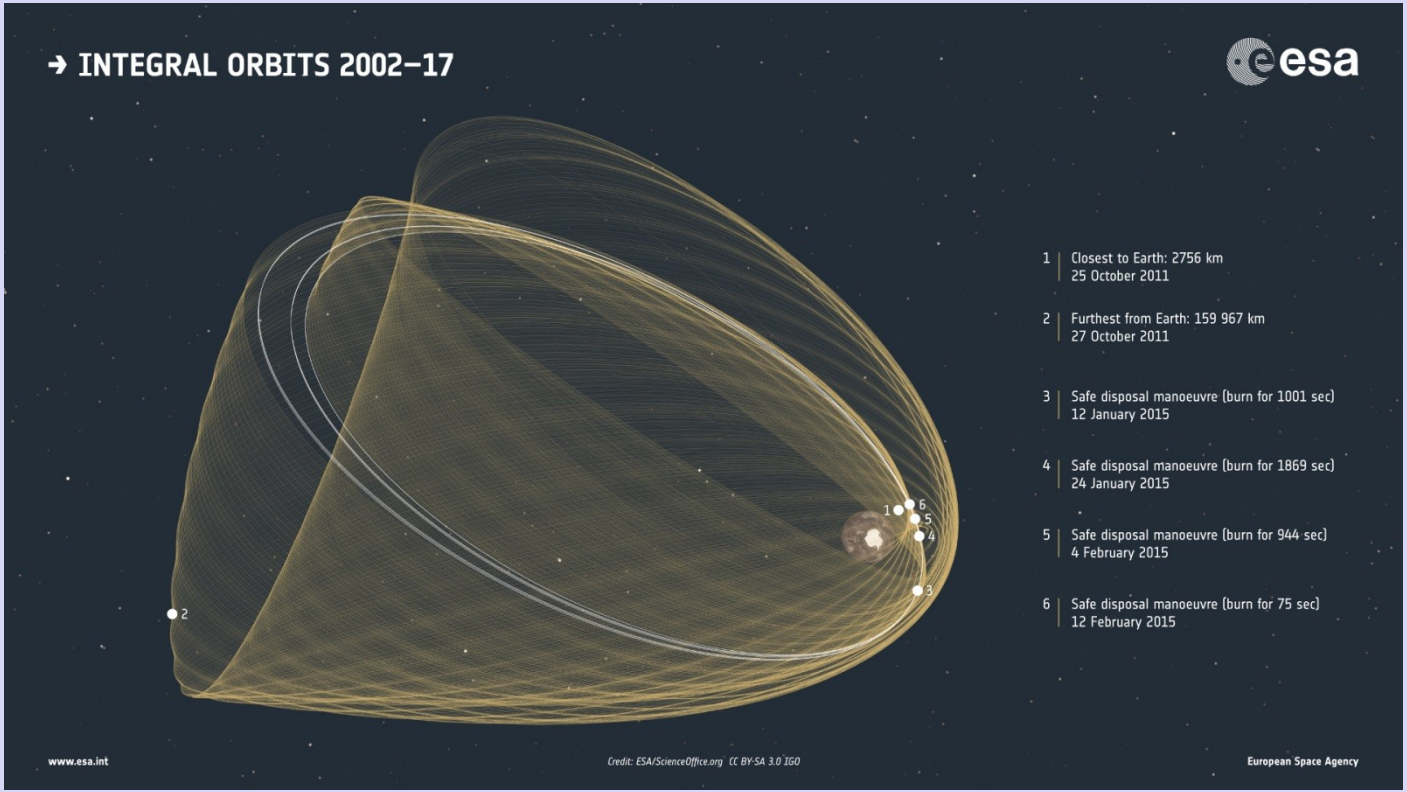
On behalf of the

Integral and XMM-Newton Science Operations Centres

Observing from Space - Orbits

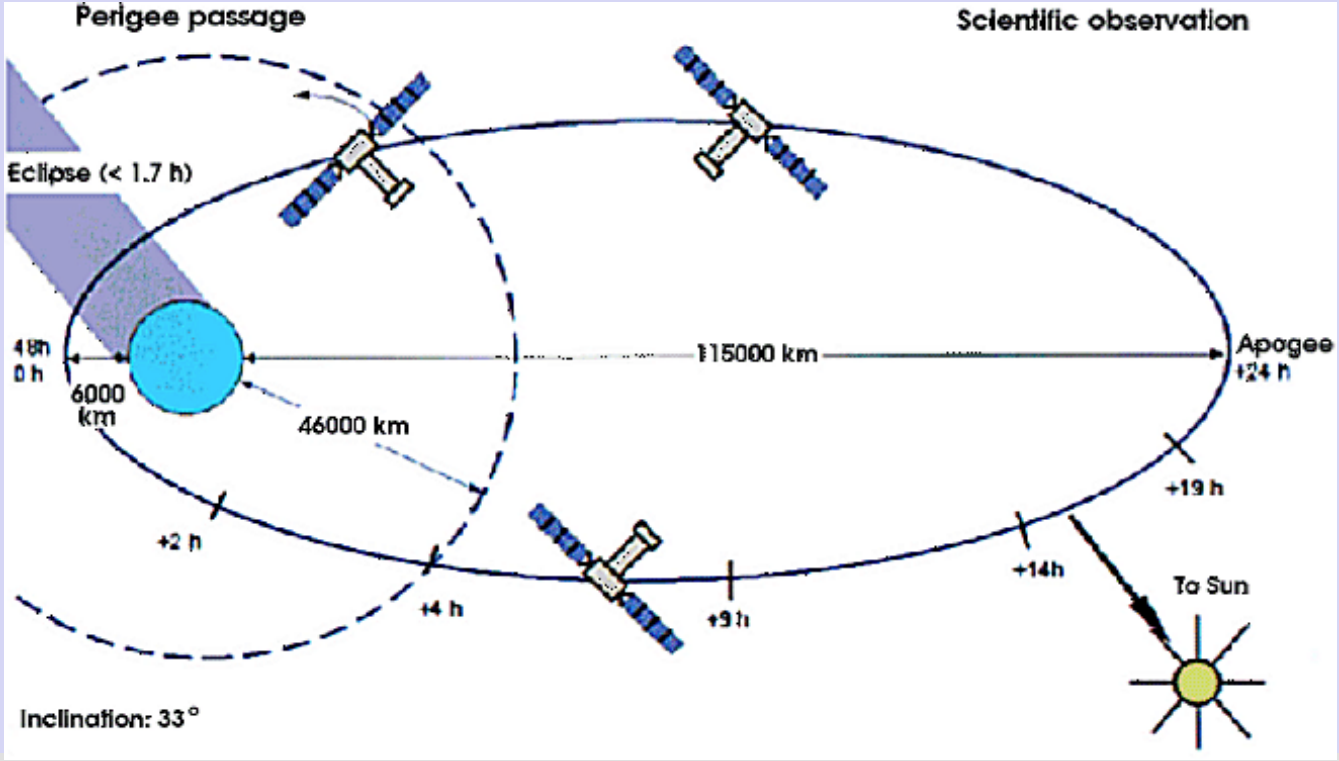


http://sci.esa.int/integral/59688-integral-fifteen-years-in-orbit/

Observing from Space - Orbits

Highly elliptical Earth orbit:

XMM-Newton, Integral, Chandra

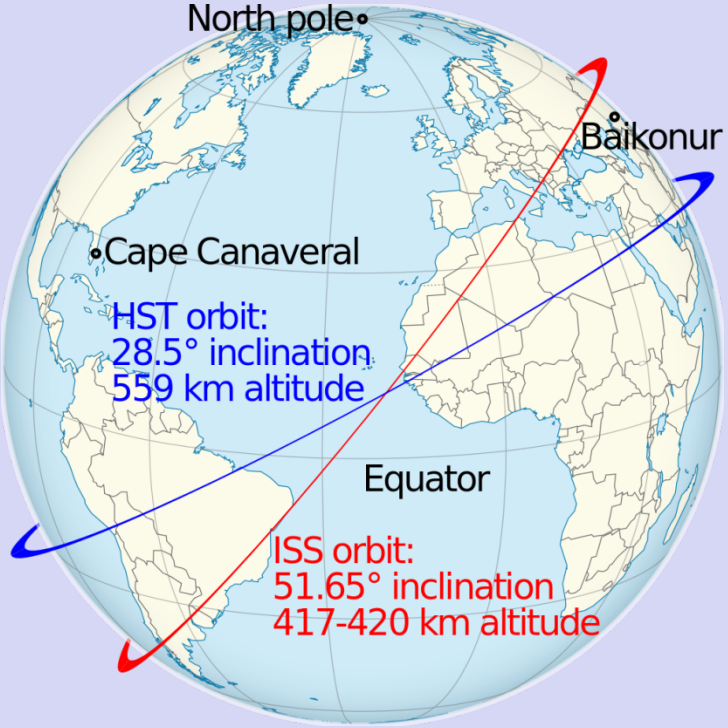


Observing from Space - Orbits

Low-Earth orbit:

~1.5 hour, examples:

Hubble Space Telescope
Swift
NuSTAR
Fermi



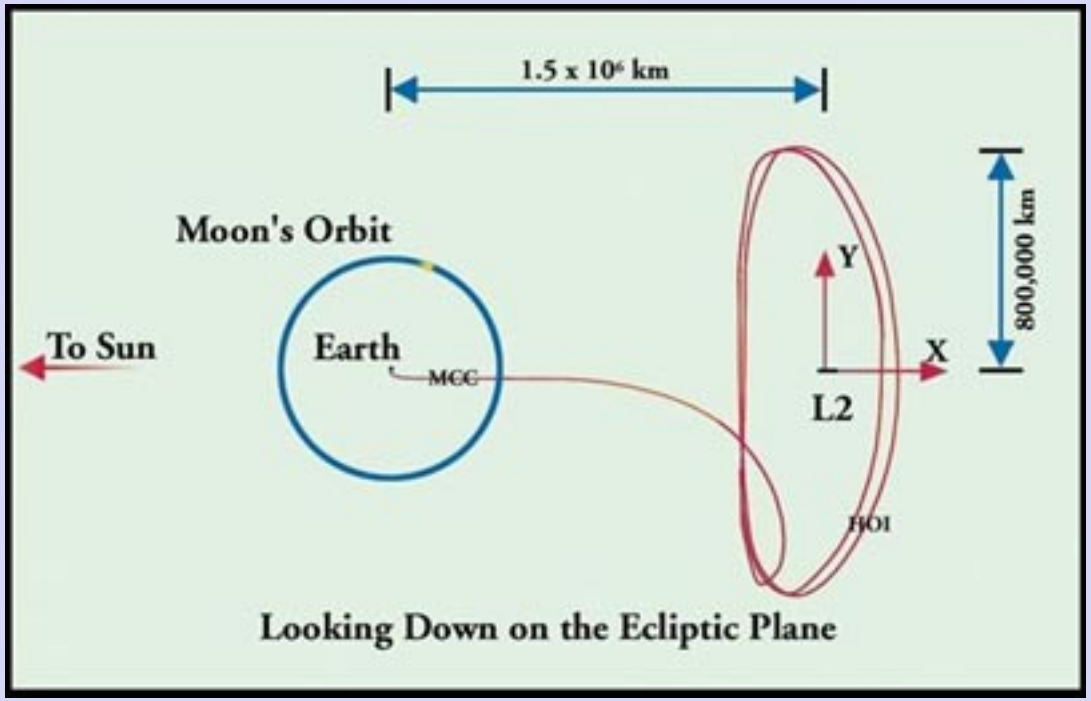
Earth blocking, especially low declination objects

⇒Only short snapshots of a few 100s possible
⇒No long uninterrupted observations
⇒Only partial overlap with Integral/XMM possible

Observing from Space - Orbits

Orbit around Lagrange point L2

past:
Herschel
Planck



future:
James Webb
Athena

present: Gaia

Observing from Space – Constraints

Motivations for constraints:

- Safety of space-craft and instruments
- Contamination by bright optical/X-ray sources or straylight from them
- **Functionality of star Tracker**
- **Power supply (solar panels)**
- **Thermal stability (avoid heat from the sun)**
- **Ground contact for remote commanding and downlink of data**

Space-specific constraints in bold orange

Observing from Space – Constraints

Examples for constraints:

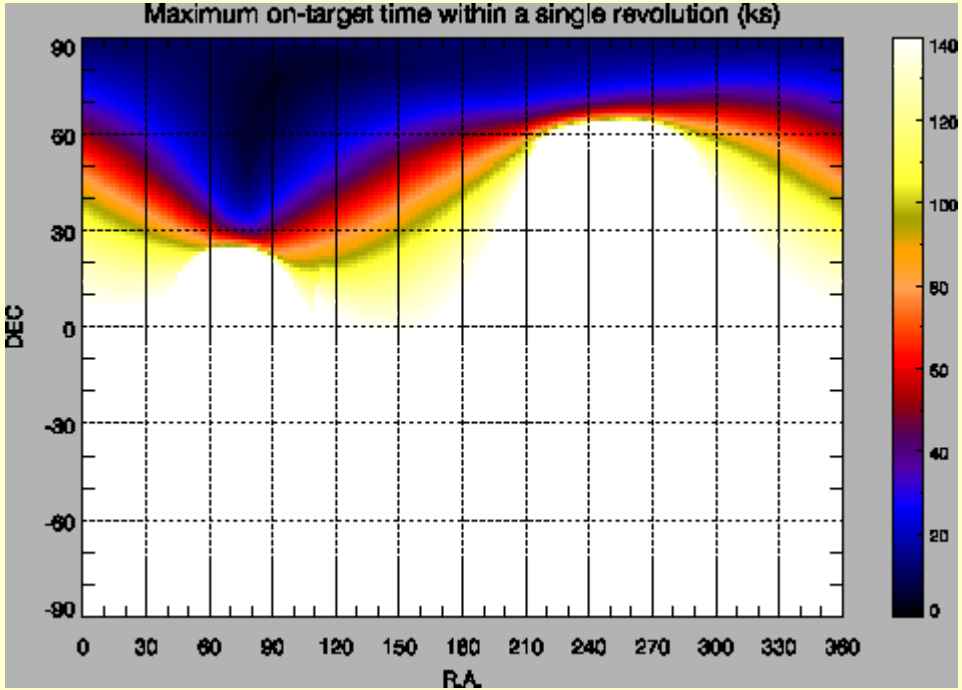
- No observations while passing through **radiation belts**
- **Orientation** of space craft to sun
- **Large avoidance** angles around Sun and **anti-Sun**, Moon, Earth, Bright planets
- **No slewing over Moon and Earth** (planets ok)
- **Availability of ground stations**
- **No commanding during ground-station handovers**
- Down times during maintenance

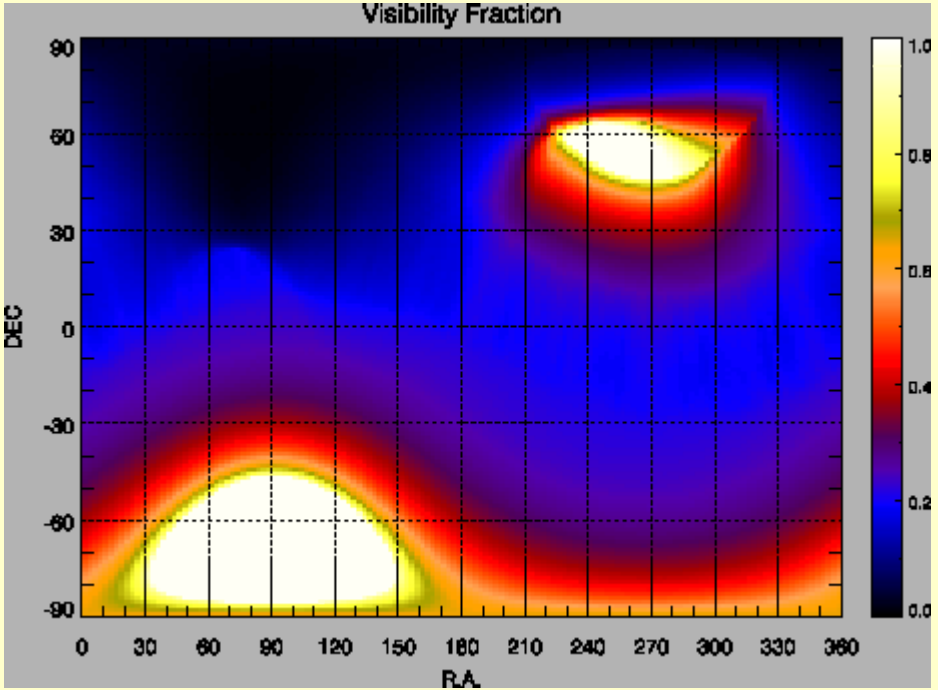
Some constraints only known a short time in advance
=> Flexibility with long-term planning

Space-specific constraints in bold orange

Observing from Space – **Observing** Constraints

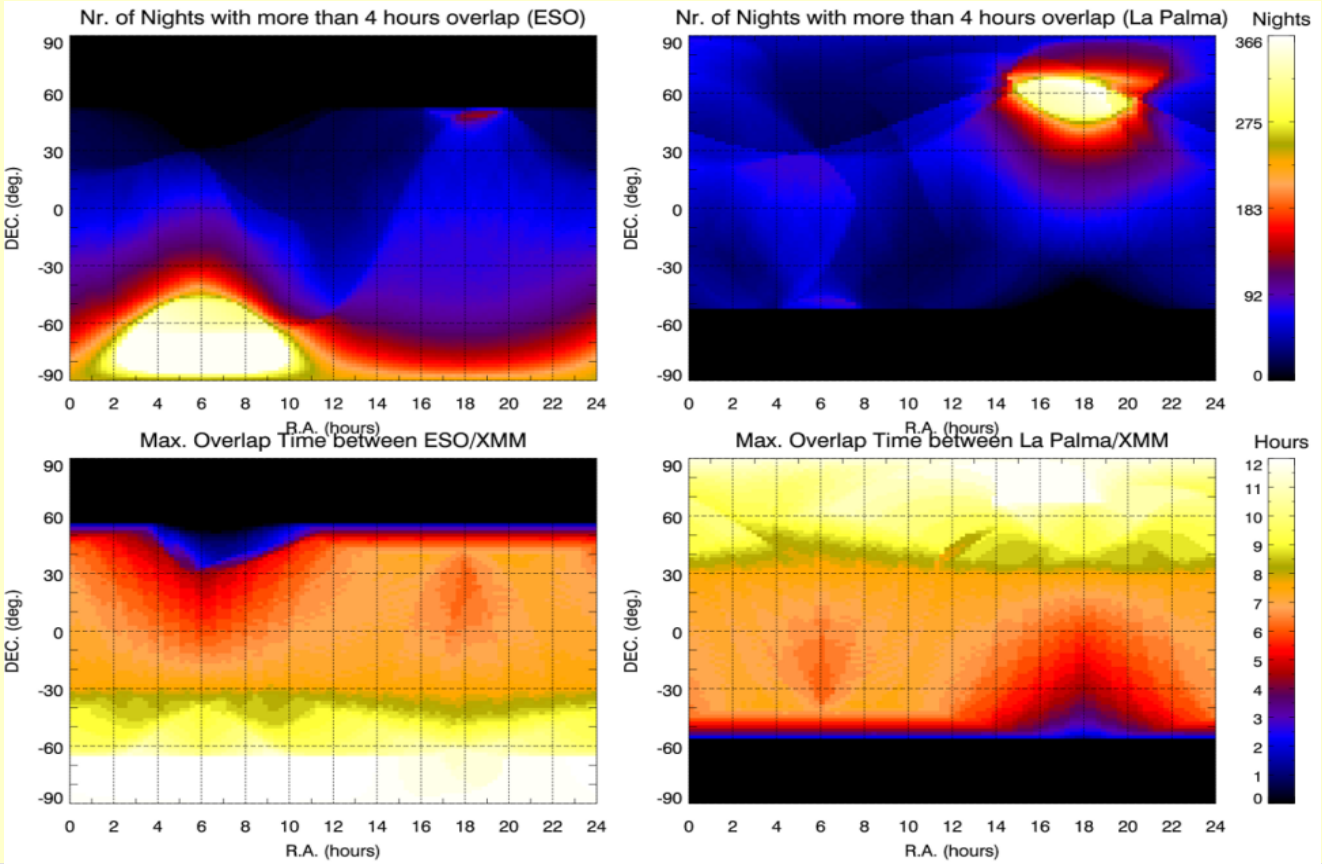
XMM-Newton





Observing from Space – **Observing** Constraints

XMM-Newton++



Observing from Space – Long-term Planning

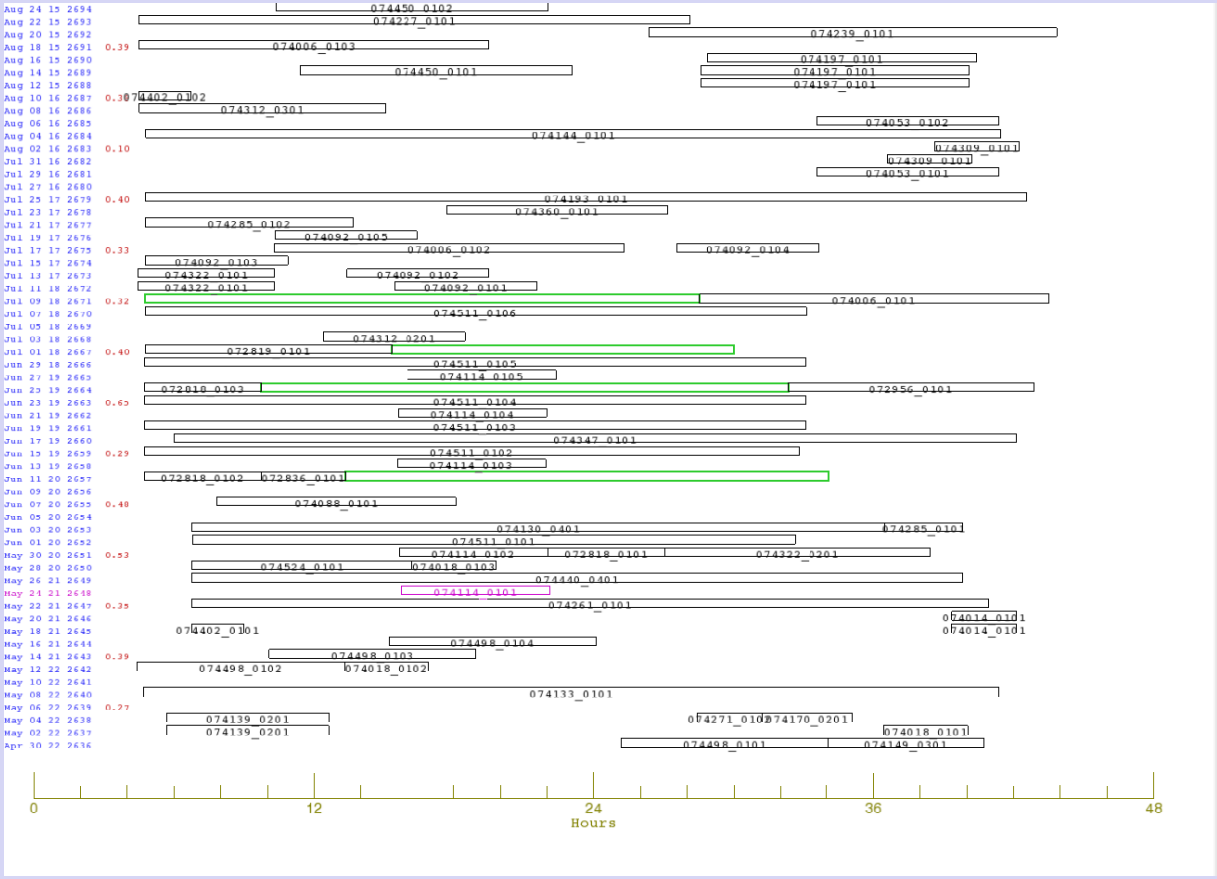
Announcement of Opportunity (AO) calls etc
=> pool of observations per pre-defined time interval (1 year)

All to be observed before end of observing cycle

- Make sure to observe before end of respective visible windows
- Satisfy scientific constraints
- Allow flexibility to accommodate Targets of Opportunity observations

Celestial constraints can be predicted
But: some information not available yet
e.g., times of ground station contacts

Observing from Space – Long-Term Planning



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074006_0104	NGC1068	54000	0 NS
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074018_0101	CPD_-28_2561	13000	0 NS
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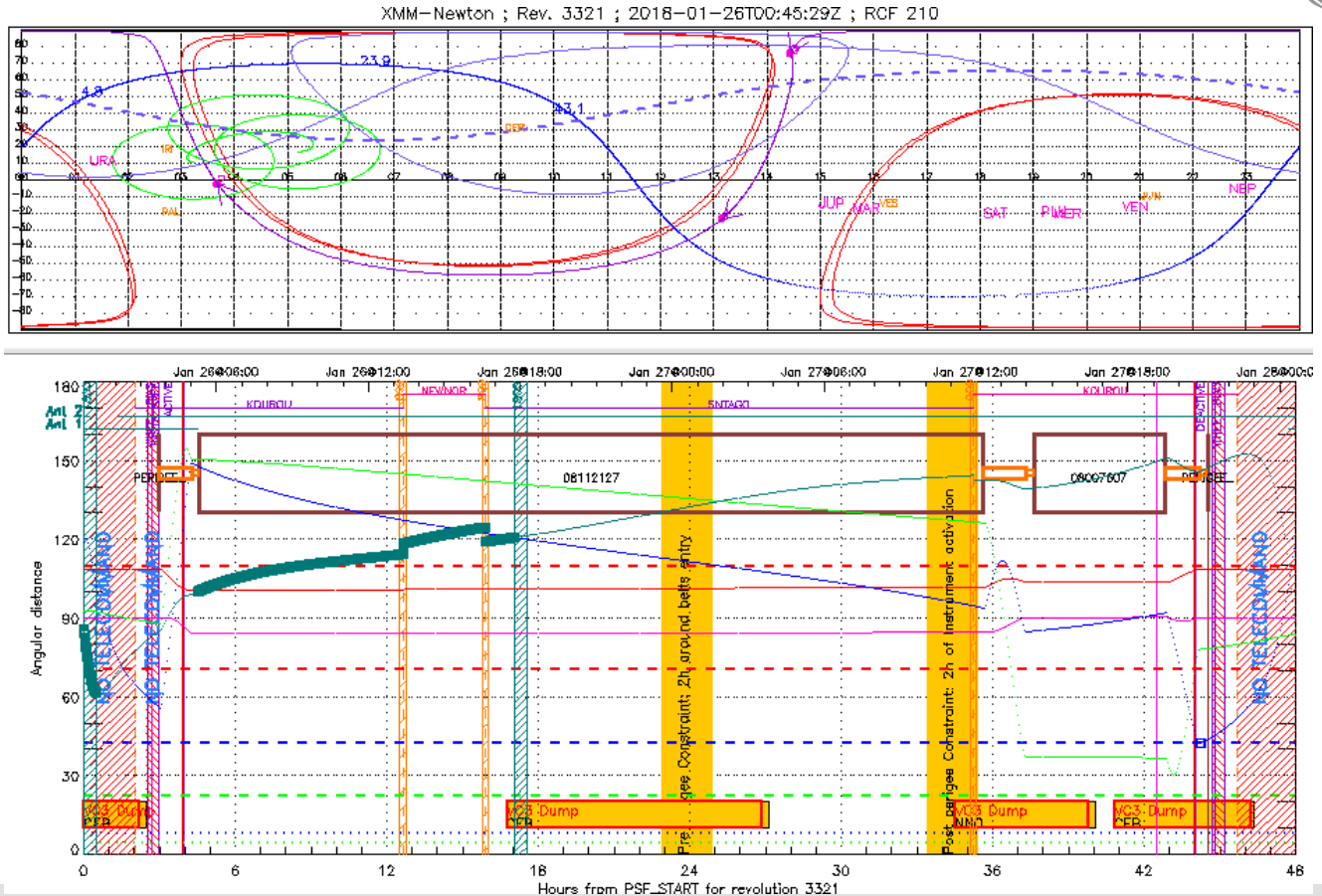
Observing from Space – Long-Term Planning

Strategies:

- Always plan as soon as possible as observations may fail and need time for repetition
- Document margins of tolerance
- Leave enough flexibility (accommodate ToOs)
- Plan coordinated observations after most time-critical observations

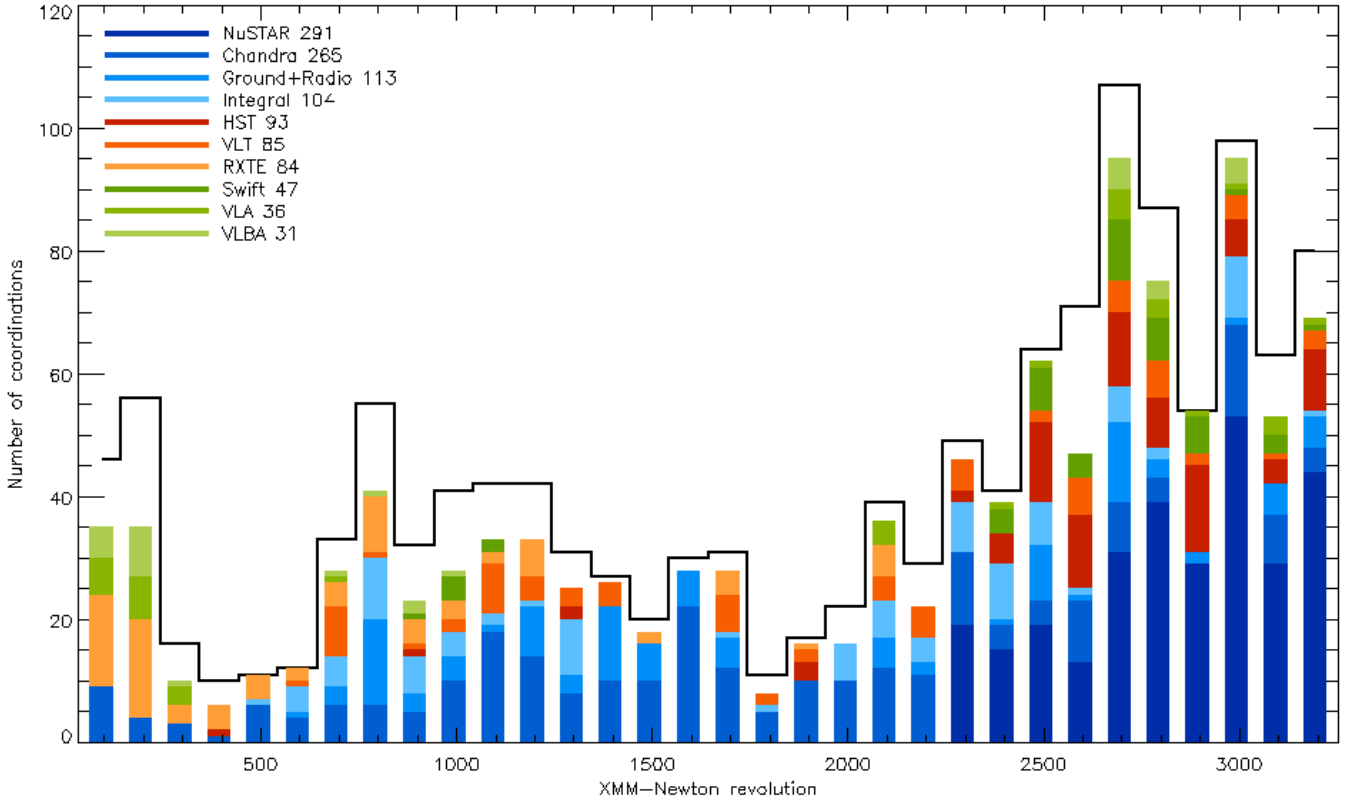
To some degree can be automated (e.g. APSI)

Observing from Space – Scheduling



Observing from Space – Coordination

Evolution for XMM-Newton



Observing from Space – Coordination with other observatories

Types of coordinated observations

- Joint Programmes (not necessarily all joint observations are coord.)
- Initiatives by Principal Investigators
- Anticipated triggered observations (e.g., X-ray binaries with known outburst cycles)
- Unanticipated Targets of Opportunity (e.g., GRB, GW, SN)

Strategies:

- Coordinated observations, after time-critical observations planned
- Determine available observing slots of own facility
- Present available slots to other facility/-ies and determine overlap
- Some agreements may contain the more flexible observatories to follow the scheduling of the less flexible ones

Observing from Space – Coordination with other observatories

Strategies:

- Before planning coordinated observations, need to have all time-critical observations planned
- Determine available observing slots of own facility
- Present available slots to other facility/-ies and determine overlap
- Some agreements may contain the more flexible observatories to follow the scheduling of the less flexible ones

All done manually

- Works well with small number of observations and facilities
- Not always optimal slots found

=> **Couldn’t coordination of any number of observations and facilities within a given time interval be automated?**

Observing from Space – Long-Term Planning

- Specific required times (e.g. planet transients)
- Fixed spacing (e.g., multiple observations of same phase)
- Maintenance activities
- Targets with limited visibility
- Coordinated observations
- Needs to be updated in case of high-impact modifications in response to triggered observations

Main differences

XMM-Newton:

Only internal planning and only containing time-critical observations

~30% of mandatory exposure time (A+B targets)

Integral:

Public Long-Term plan containing all mandatory observations