A Long Lifetime As Challenge

Presentation for the SCIENCE OPERATIONS 2013 Conference

Norbert Schartel

XMM-Newton Project Scientist, ESA, ESAC, Spain

10 September 2013

A Long Lifetime Of Astronomical Satellites As Challenge

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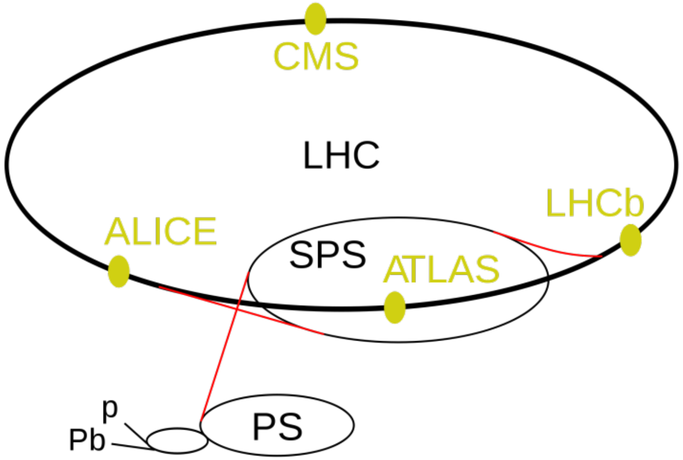
Content

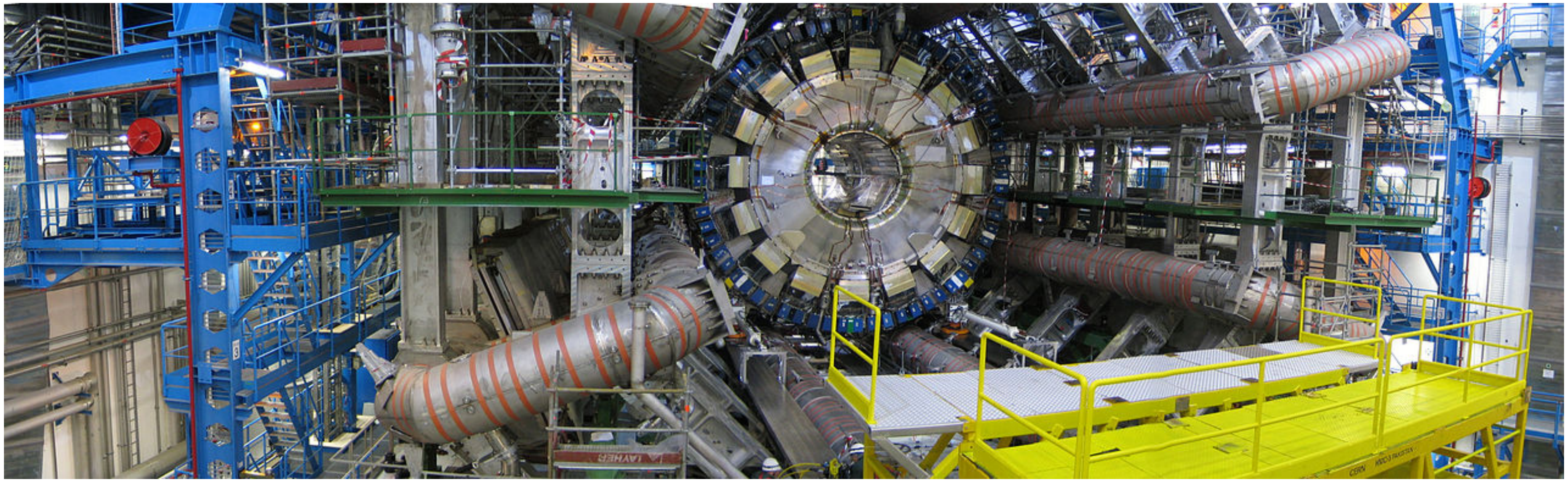
Content:

- Two aspects of research
- Lifetime of astronomical facilities
- Robotic missions
- Robotically maintained space telescopes
- Experiences with operations
    - Community support
    - Calibration
    - Software
- Conclusions

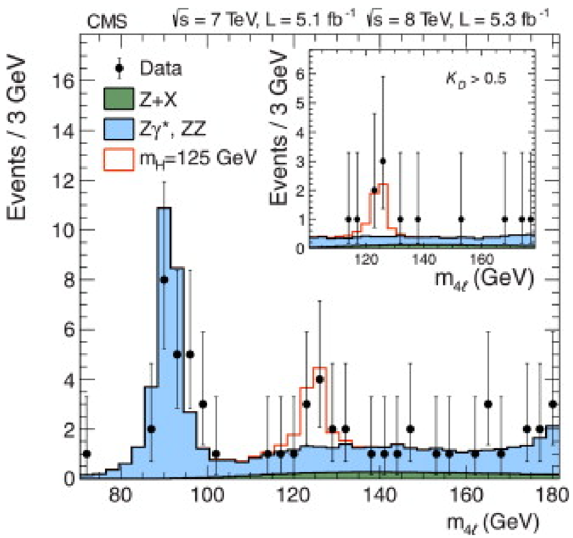
Two aspects of research?

Instrument dominated research





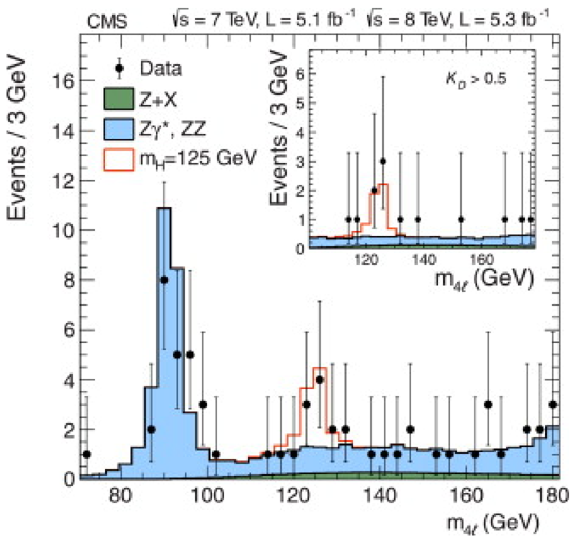
Instrument dominated research



Distribution of the four-lepton invariant mass for the ZZ→4ℓ analysis. The points represent the data, the filled histograms represent the background, and the open histogram shows the signal expectation for a Higgs boson of mass mH=125 GeVmH=125 GeV, added to the background expectation. The inset shows the m4ℓm4ℓ distribution after selection of events with KD>0.5KD>0.5, as described in the text.
S. Chatrchyan et al., Physics Letters B, Volume 716, Issue 1, 17 September 2012, Pages 30–61

- Knowledge:
  - confirmation of the Higgs Boson
  - mass, spin ..

Instrument dominated research



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- **Knowledge:**
  - confirmation of the Higgs Boson
  - mass, spin ..
- **Understanding:**
  - ?
  - dark matter?, dark energy?, new physics?

Object dominated research

LETTER

doi:10.1038/nature12168

A Jurassic avialan dinosaur from China resolves the early phylogenetic history of birds

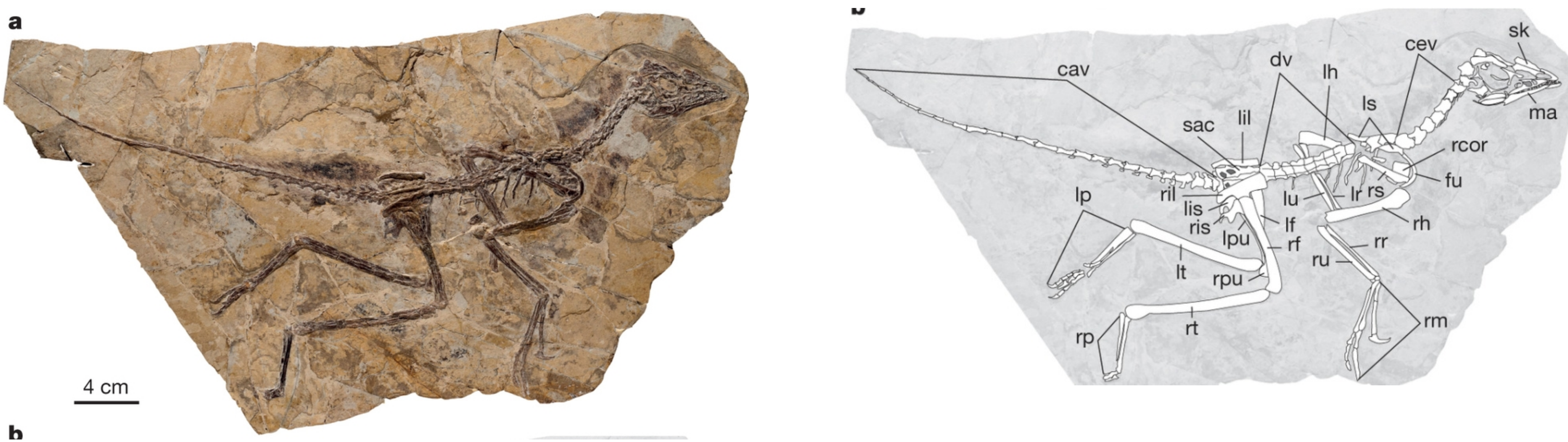
Pascal Godefroit[1], Andrea Cau[2], Hu Dong-Yu[3,4], François Escuillié[5], Wu Wenhao[6] & Gareth Dyke[7]

Nature 498, 359-362

The recent discovery of small paravian theropod dinosaurs with well-preserved feathers in the Middle–Late Jurassic Tiaojishan

premaxilla is long, slender and contacts the nasal, excluding the maxilla from the external naris; in *Archaeopteryx* and *Anchiornis*, the maxillary

a



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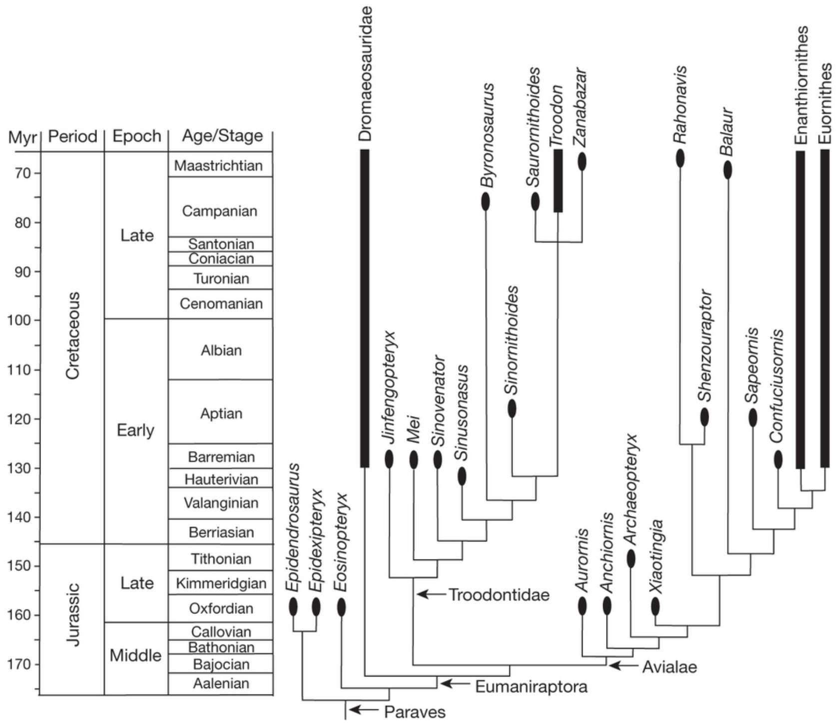
Object dominated research

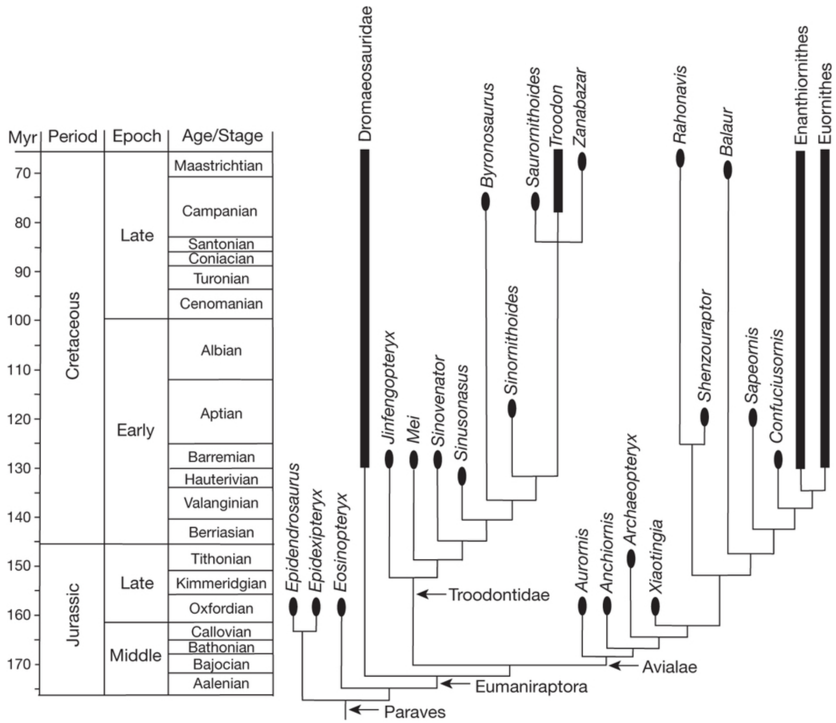


Nature 498, 359-362

Knowledge:

- new & complete skeleton of a new paravian from the Tiaojishan Formation of Liaoning Province, China

Object dominated research



Nature 498, 359-362

- **Knowledge:**
  - new & complete skeleton of a new paravian from the Tiaojishan Formation of Liaoning Province, China
- **Understanding:**
  - phylogenetic analysis: five major consequences, e.g. single origin of powered flight within Paraves; the early diversification of Paraves and Avialae in the Middle–Late Jurassic period.

Reality

- Understanding grows by a combination of object dominated research and instrument dominated research

- In general the more developed a discipline is, the more object dominated is the research

➔ We need long-lasting facilities, which at the same time are flexible enough to adopt to new technologies

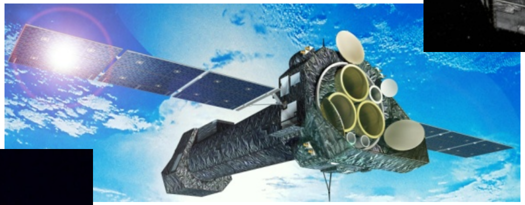
➔Difficult for space missions

Lifetime of astronomical facilities

1961...

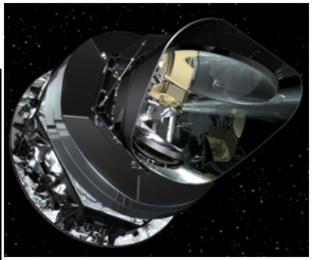
1999...

1990...



1999...

2009 - 2013



2009–
2012/13

1977-
1979

Lifetime of astronomical facilities

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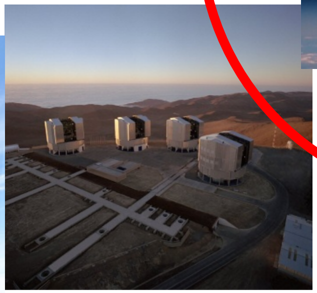

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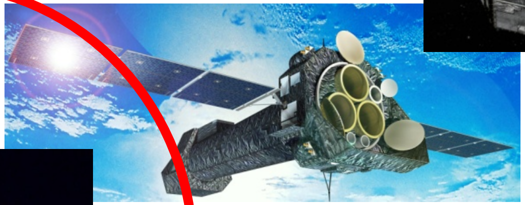

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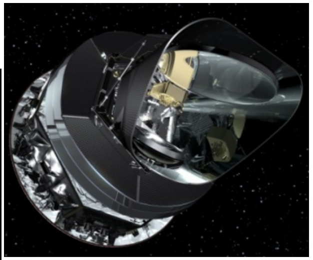


2009–
2012/13

1977-
1979

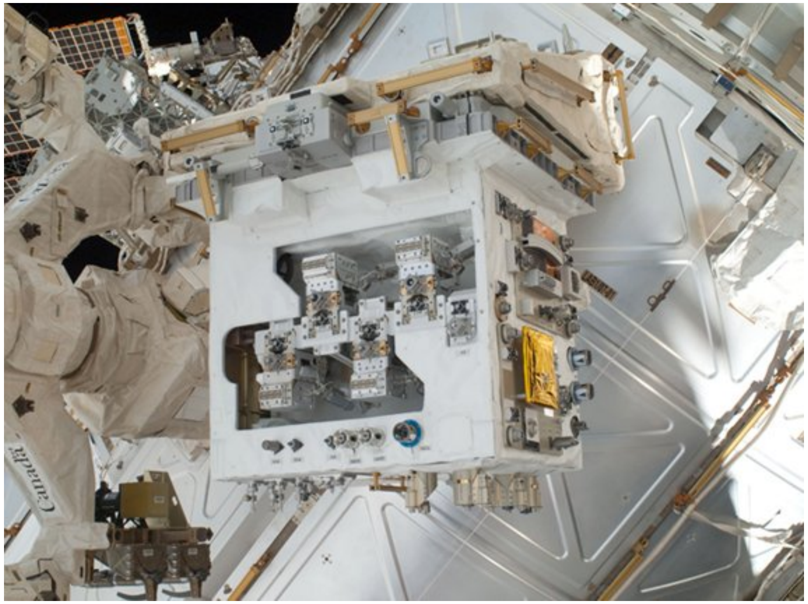
HST

- HST is the only spacecraft designed for maintenance
- Five servicing missions (SM 1, 2, 3A, 3B, and 4) were flown by NASA space shuttles, the first in December 1993 and the last in May 2009:
  - Repair of components which had failed
  - Replacement/Change of instruments

Can Robots be a Solution?

Robotic Refueling Mission

- The Robotic Refueling Mission is an International Space Station demonstration that proves the tools, technologies and techniques to refuel and repair satellites in orbit - especially satellites not designed to be serviced.RRM gives NASA and the emerging commercial satellite servicing industry the confidence to robotically refuel, repair and maintain satellites in both near and distant orbits - well beyond the reach of where humans can go today.

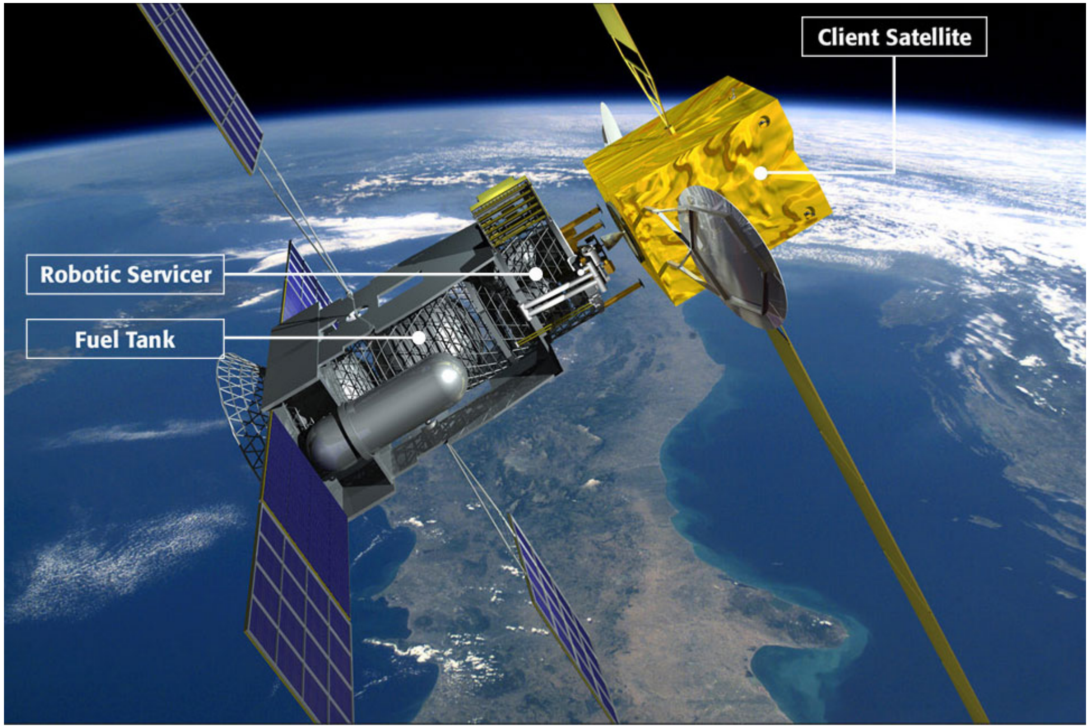


Special Purpose Dexterous Manipulator

- Dextre, Special Purpose Dexterous Manipulator (SPDM), is a two armed robot, or telemanipulator, which is part of the Mobile Servicing System on the International Space Station (ISS), and extends the function of this system to replace some activities otherwise requiring spacewalks. It was launched March 11, 2008 on mission STS-123.Dextre is part of Canada's contribution to the ISS

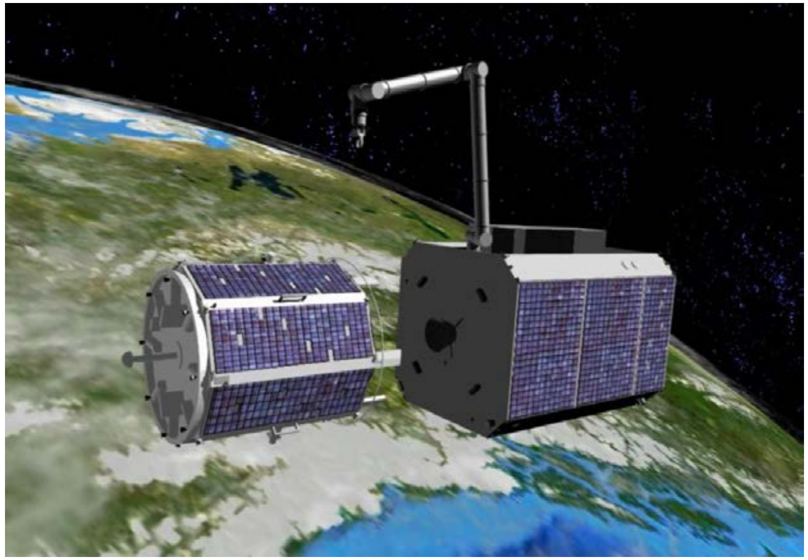
Space Infrastructure Servicing

- Space Infrastructure Servicing (SIS) is a spacecraft being developed by Canadian aerospace firm MacDonald, Dettwiler and Associates to operate as a small-scale in-space refueling depot for communication satellites in geosynchronous orbit. Intelsat is a requirements and funding partner for the initial demonstration satellite which, as of March 2011, was planned to be launched in approximately 2015.
- MDA put the launch plans on hold in November 2011 pending finding a second launch partner, beyond Intelsat.



Deutsche Orbital Servicing mission (DEOS)

- DEOS is the first German servicing mission DEOS. The main goals of this mission are the rendezvous with and berthing of a non-cooperative and tumbling spacecraft by means of a manipulator system accommodated on a servicing satellite, the docking of the spacecraft via a dedicated docking device and servicing tasks in the coupled configuration as well as the controlled de-orbiting / re-entry of the spacecraft's coupled configuration in the Earth's atmosphere at the end of the mission.



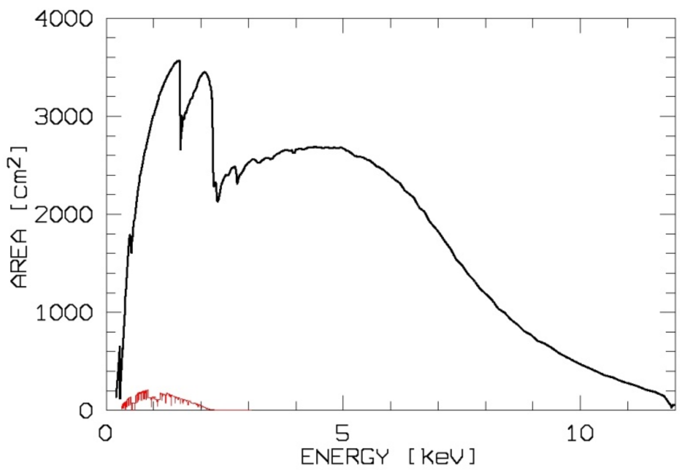
- Can robots be the solution?

- (Industry is already willing to invest in this direction!)

Instruments

- Telescopes develop much slower than instruments

- Micro-calorimeter Spectrometers in X-rays:

- 

N. Schartel, 2012, AN 333, 209

Robotically Maintained Space Telescopes

1. Spacecraft designed for a long lifetime (60y) and for robotic maintenance
2. Robotic Service Missions (repair, refuel, exchange of instruments)

Operations

- Operations for missions with a long lifetime is very challenging
- A main issue is the expectation on cost reduction

Long Lifetime versus Operations: Involvement of Scientific Community

- XMM-Newton had a very high involvement of the Community
- SSC, EPIC-team, RGS-team, OM-team
- Analysis Software, pipeline software, pipeline processing, observation screening, catalog production, calibration, instrument performance monitoring and S/W operations

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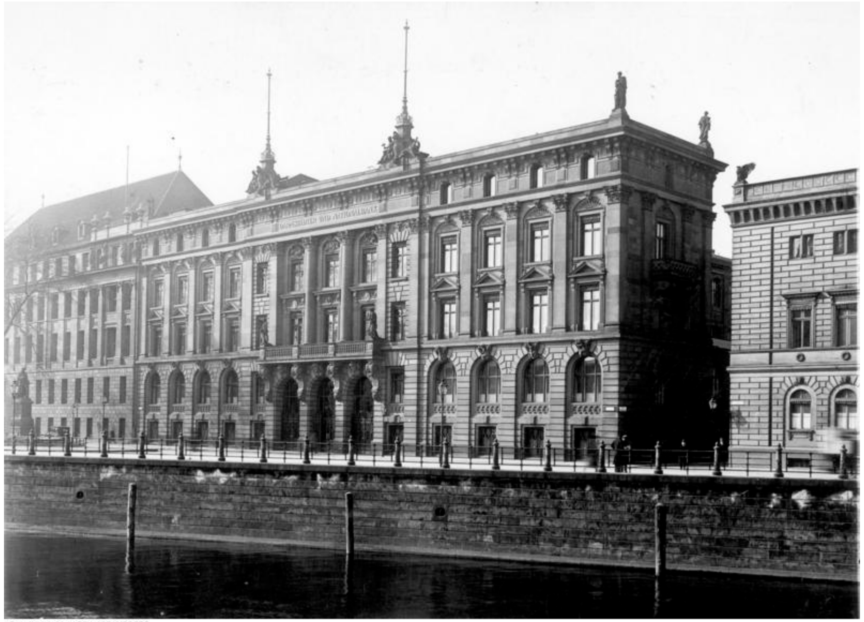

Bundesarchiv, Bild 183-H28575
Foto: o.Ang. | 1925

Berlin 1925, The headquarters of the „Darmstädter und Nationalbank“ at Schinkelplatz Nr. 1–4

→ Great Depression before WWII

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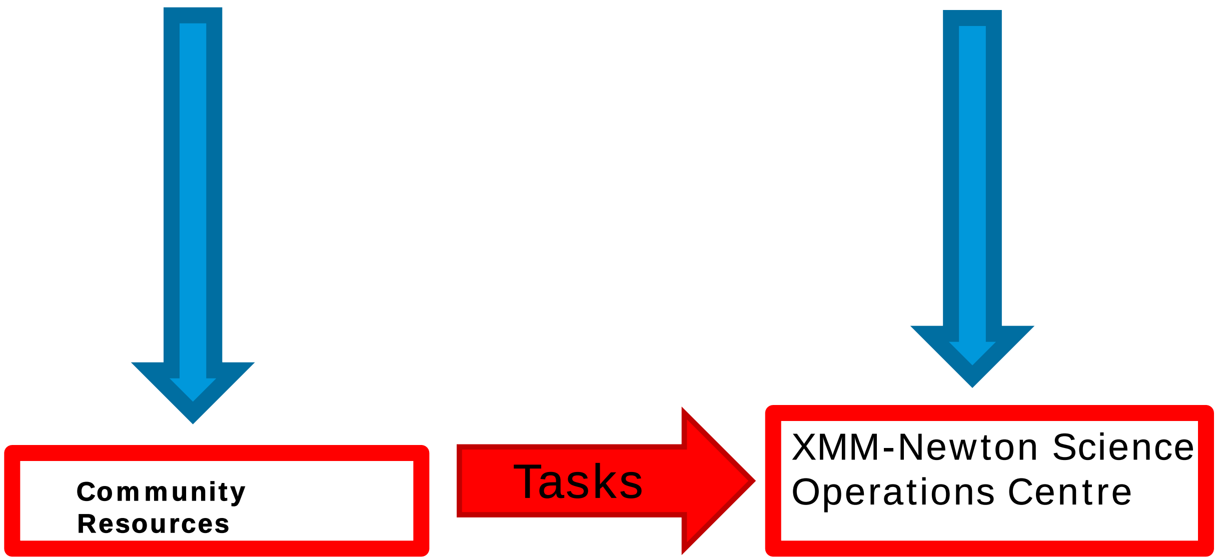
- Short against Long
- Short commitments of funding agencies against the long lifetime of the space craft

Long Lifetime versus Operations: Involvement of Scientific Community

Community Resources

XMM-Newton Science Operations Centre

Long Lifetime versus Operations: Involvement of Scientific Community



Long Lifetime versus Operations: Involvement of Scientific Community

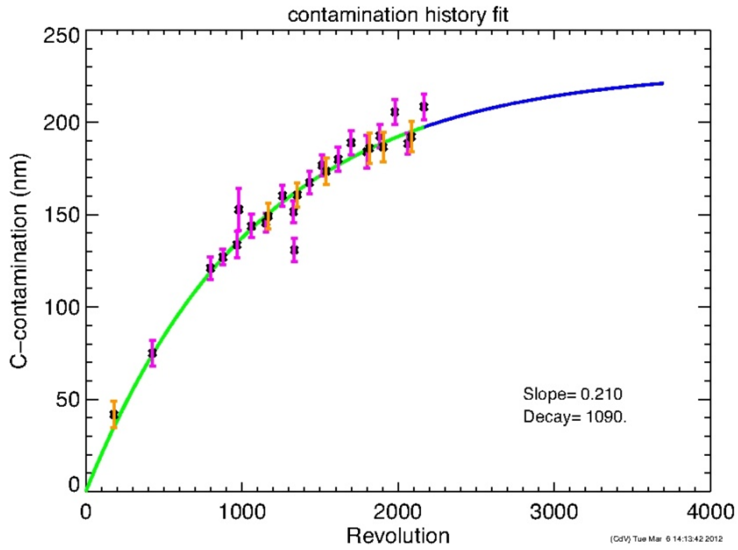
- To overcome the “Short against Long” loop, there must be a mechanism of “return”, such that a support of a mission is attractive for scientists (and institutes) itself independent from a third party
- Direct funding of tasks agreed on?
- Return in form of observing time?
- But no tax system!

Long Lifetime versus Operations: Calibration

- Calibration challenges for a mission with long lifetime:
- Instruments are ageing

Long Lifetime versus Operations: Calibration

- Calibration challenges for a mission with long lifetime:
- Instruments are ageing ➔ re-calibration, but often also requires a much more complex description of the modeling (absorption in RGS, non-linear change in gain ..



Courtesy C. de Vries, SRON, Utrecht

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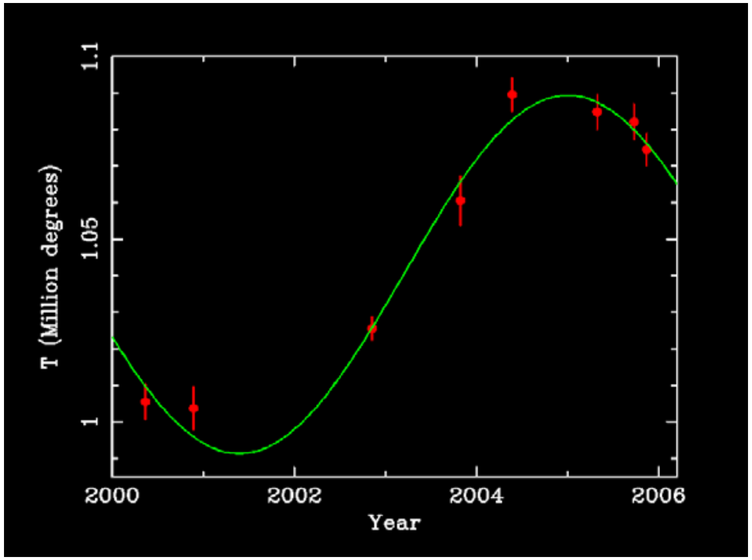
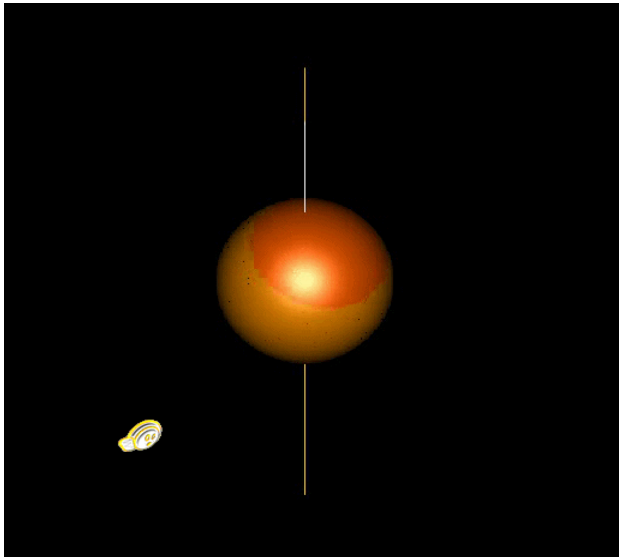


F. Haberl et al., 2006 A&A 451, L17



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- More data for general analysis

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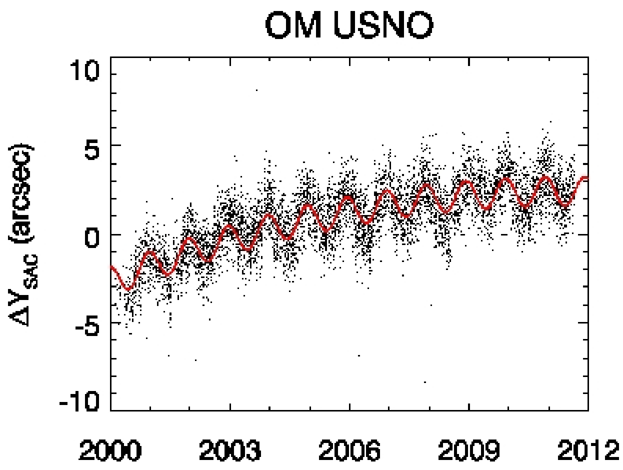
- More data for general analysis ➔ causes new calibration requirements (1-year periodicity in off-set of source position)



Courtesy P. Rodriguez, ESAC, Spain

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- More data for general analysis ➔ periodicity (1 year) in off-set of source position
- Longer observations

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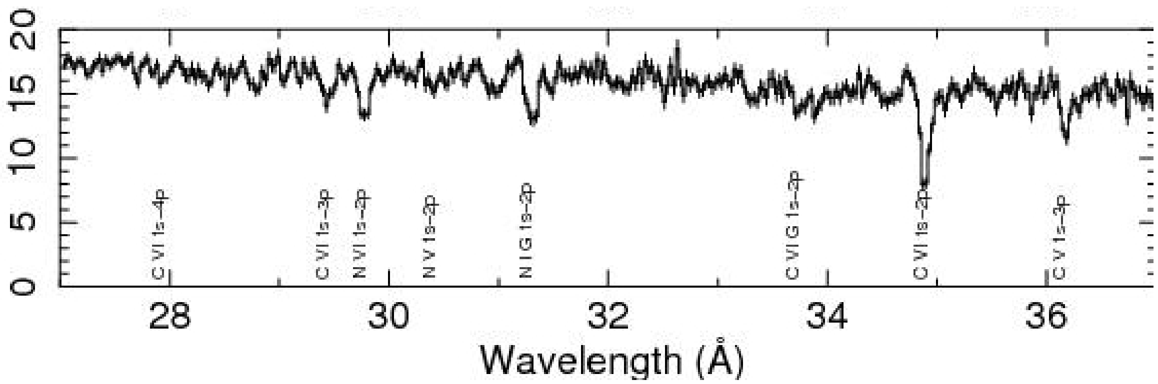
- More data for general analysis ➔ periodicity (1 year) in off-set of source position
- Longer observations ➔ higher statistics ➔ increases the requirements on calibration (30 – 100 ks versus large programs with 500 ks)



600 ks spectrogram of Mrk 509
J. S. Kaastra, et al., 2011, A&A 534, 37

Long Lifetime versus Operations: Calibration

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➔ A long lifetime, implying much more and much longer observations, implies intrinsically much higher calibration standards

Long Lifetime versus Operations:

- In 1992:
  - I bought a TV

Long Lifetime versus Operations: Software

- In 1992:
  - I bought a TV,
  - And I was analyzing ROSAT spectra for my Ph.D. using EXSAS

Long Lifetime versus Operations: Software

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Guess what is working today?

Long Lifetime versus Operations: Software

- A long lifetime is extremely challenging for software?

➔ I do not see a convincing concept

- Software requires permanent maintenance
- However, after only(?) 10 years significant issues are occurring implying re-engineering of software, re-writing of tasks and packages
  - Bad behavior/evolution of programs
  - Repeated transfer of maintenance
- Data format, fits, seems to be reasonably established for a long lifetime
- F-tools (but very basic), rtops (NASA)

Conclusions

Long lifetime in space:

- **Scientifically strongly motivated**
- **Technically visible with robotic maintenance and upgrade**
- **Operations are a major challenge** (that could be overlooked by technicians and need also planning ahead)