XMM-Newton: Status and Perspectives

Treasures Hidden in High-Energy Catalogues

22 May 2018

IRAP, Toulouse, France

Norbert Schartel

Extensions

- ESA extensions:
  - Every two years comparing all missions: 2 + 2 schemata:
  - 2 years operations financed
  - 4 years planning envelope (indicative extension)

- Summer/autumn 2018 next confirmation & extension:
  - Operations up to end of 2020
  - Planning envelope up to end of 2022

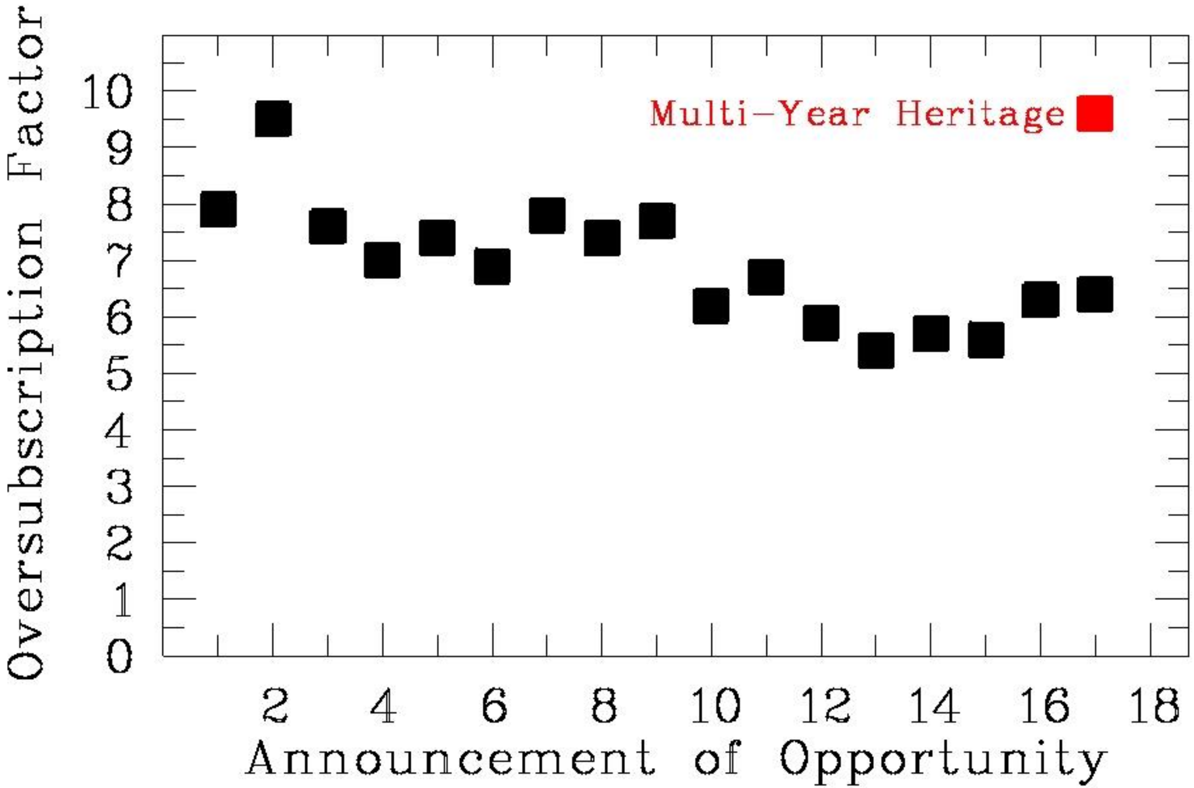
Spacecraft Status

- Spacecraft status is very good
- ESA has scheduled the next Mission Extensions Operation Review 5 June 2018.
- All important systems are running on their primary unit, i.e. full redundancy
- Currently 44 kg of fuel remain with usage of around <2.7 kg per year.
- The solar array is generating around 1800 W (used between 800-1350W)
- All other systems susceptible to wear are in good condition

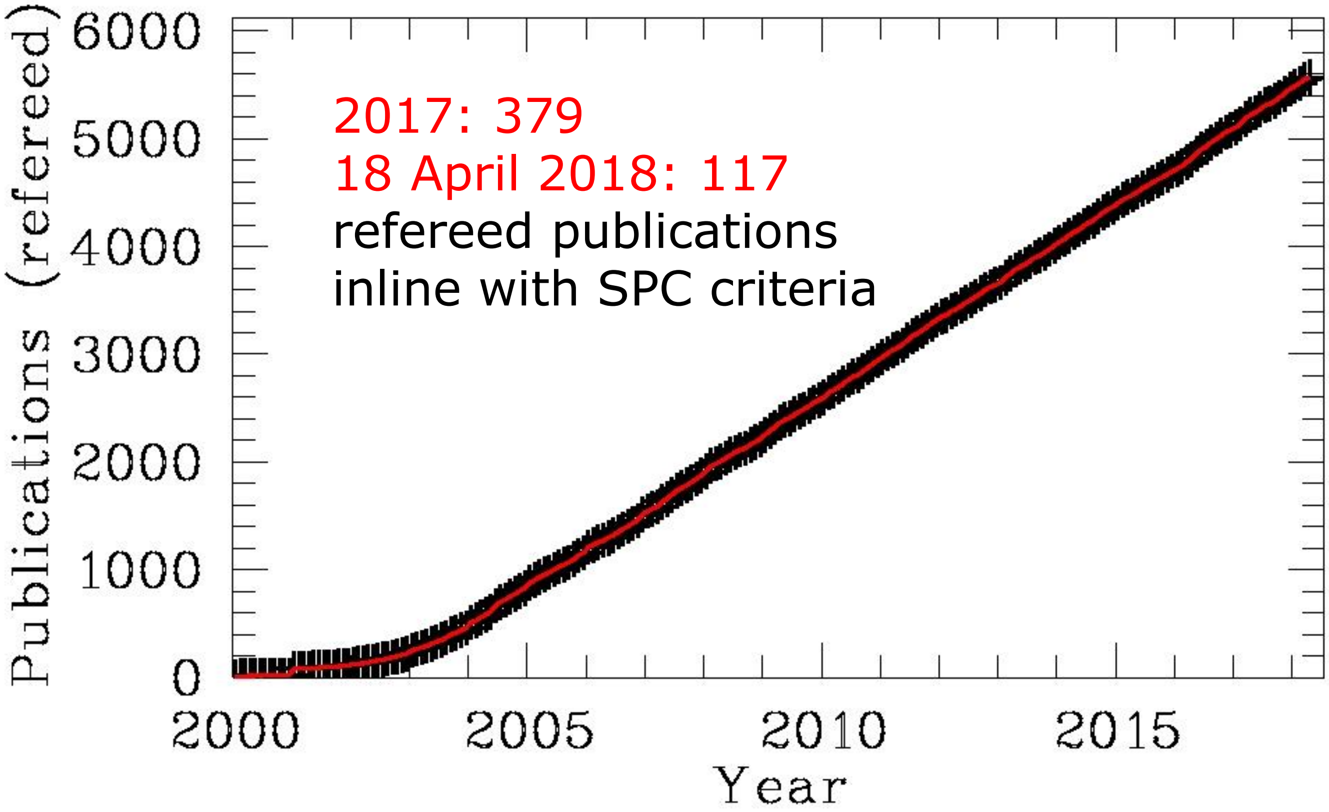
Some key figures

- Users:
  - Large Community: 1500 - 2000 scientists
  - All scientific areas are covered, from comets and planets up to the most distant quasars & cosmology
  - Vast majority of users are “external” to the XMM-Newton project, (they do not belong to instrument institutes nor to the Survey Science Centre)
- Observatory type mission:
  - Scientific programme is defined by the community through annual calls for observing proposals & peer review processes (OTAC)
  - Active support to users enhances observatory scientific productivity
    - up-to-date documentation, helpdesk, observations enhancement, scheduling & coordination with other facilities, rapid ToO implementation, continuous improvement of data analysis SW(SAS), calibration, pipeline & archives, SAS threads, conferences, public outreach…
- Observatory improvements regularly prioritised by Users’ Group

Oversubscription remains high



Publications II



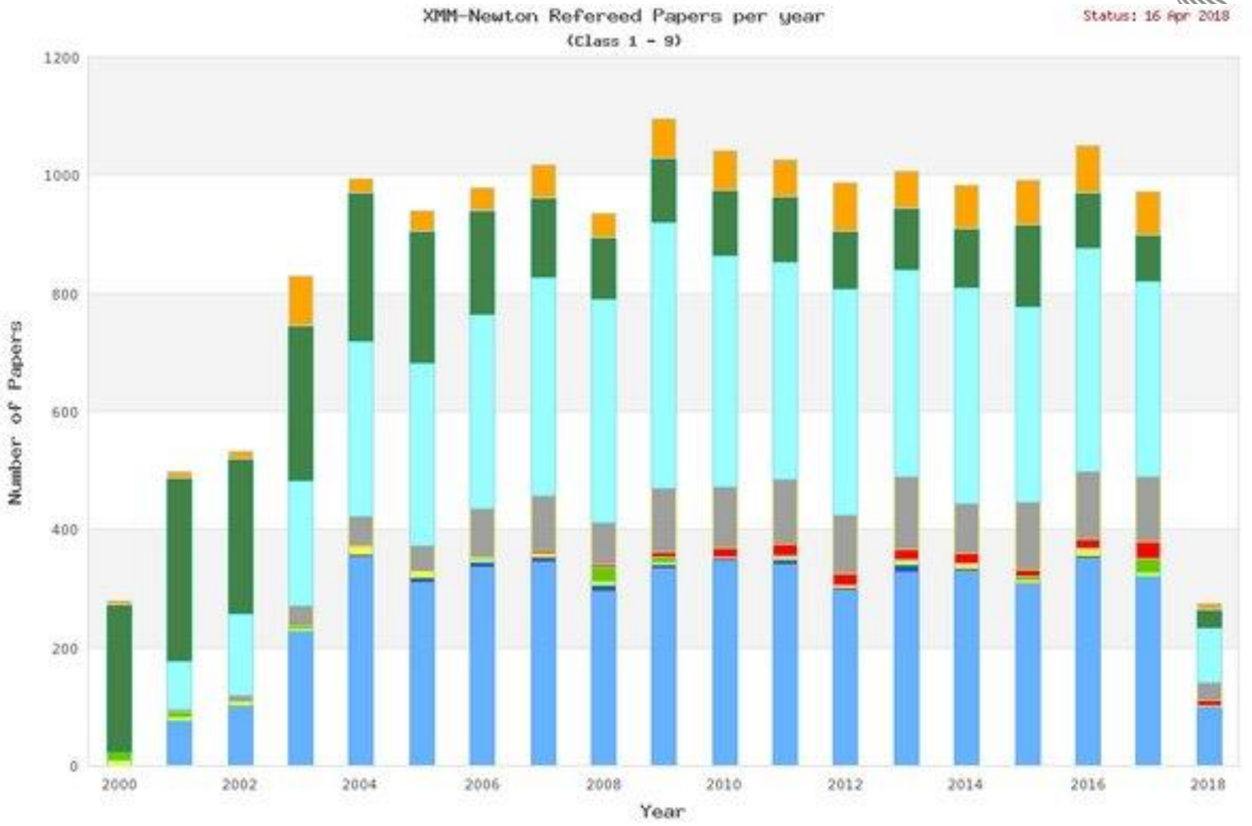
2017: 379
18 April 2018: 117
refereed publications
inline with SPC criteria

Publications

XMM in Name
Mentions XMM
XMM & Citation
Uses Others

--- AWG ---

Uses Products
Describes
Predicts
Catalogue
Uses Data



XMM-Newton: The Next Decade

Outcome of Workshop: Structural Points I

1. Increased importance of Target of Opportunity observations
2. Increased importance of (simultaneous) multi-wavelength /multi-messenger observations
3. Importance of very large project (>2 Ms)

4. And combinations of 1., 2. and 3.

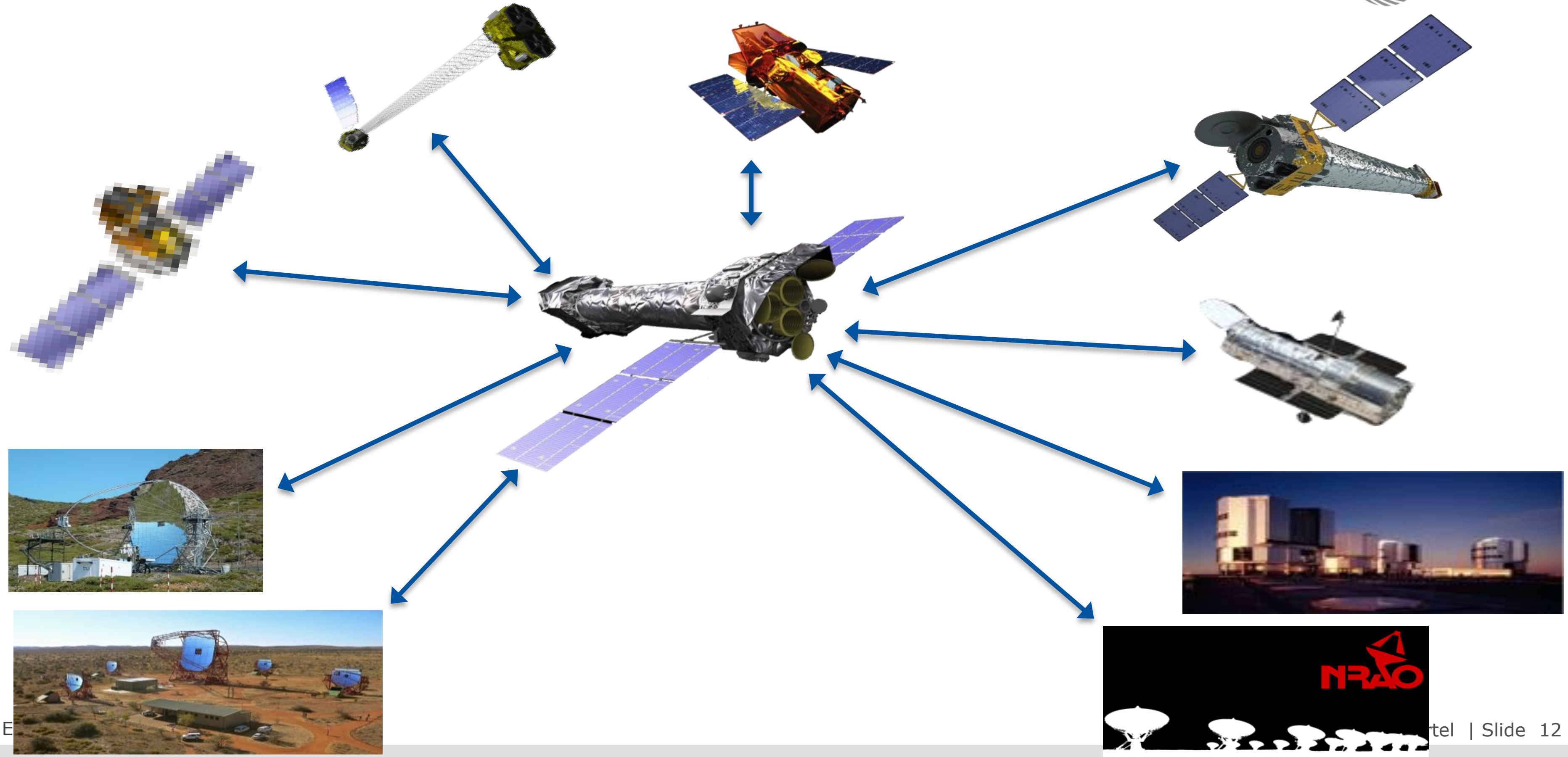
Outcome of Workshop: Structural Points II

- Importance of very large projects (>3Ms)
- Multi-Year-Heritage Programs introduced in AO17 (➔ next AO 20)
  - 3.4 Ms AGN evolution
  - 3.0 Ms Planck clusters as cosmological probe
- in future: Euclid deep fields

- Increased importance of Targets of Opportunity (TOO)
  - Examples: Zwicky Transient Factory, LSST, eRosita, Einstein
  - Gravitational Wave events will be public (2019)
  - Introduce trigger probability in proposals, i.e. acceptance of more anticipated TOO proposals

Outcome of Workshop: Structural Points IV

- Increased importance of (simultaneous) multi-wavelength /multi-messenger observations
  - Chandra (**+LP 300ks -> 1Ms**)
  - Radio (**NRAO**)
  - JWST (from 2. JWST AO)
  - TeV **Magic & HESS**


NRAO

AO 18 Preparation I

- Planned key milestones (public since 9 January 2017, XMM-Newton Newsletter#205 & SOC web-pages):
  - Announcement: 21 August 2018
  - Due date for proposals: 5 October 2018 (12:00 UT)
  - Final approved programme: mid December 2018
  - Second phase submission: 8 January – 1 February 2019
  - Start of observations: 1 May 2019
- 6 Scientific categories / 13 Panels in total / 66 scientists
- OTAC chairperson: Prof. Peter Schneider, University Bonn, Germany
- OTAC panel chairpersons are asked not to participate on new LP

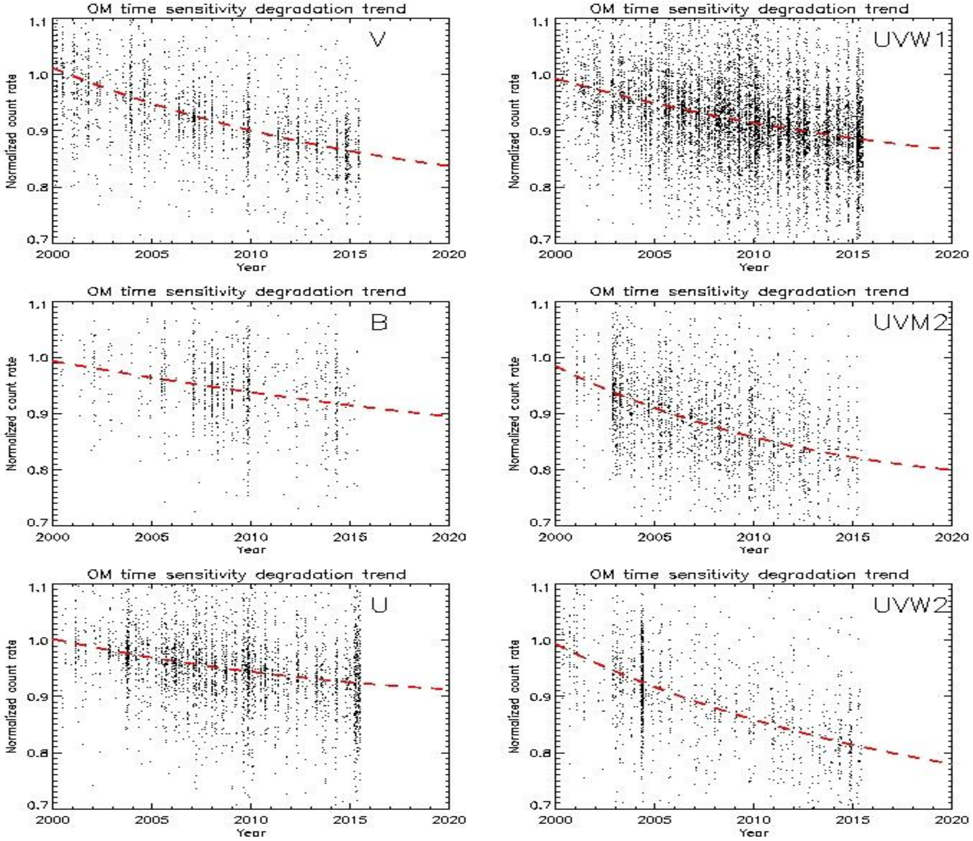
AO 18 Preparation II: Comments and Changes

- Multi-Year Heritage Program (MYHP) offered in AO17.
  ➔ We should aim to offer a MYHP in AO20

- TOO - Comment: Gravitational Wave Events (2019+) alerts will be freely distributed (no MoU)

- Changes:
  - Large Programs: up to 4 Prime Investigators (AO18 or AO19)
  - TOOs: Trigger likelihood
  - New Joint programs:
    - Magic (150 ks)
    - HESS (150, ks)
    - NRAO/VLT (150ks, TBC)
  - **Large Programs: NO constrain on the requested time**

Status of OM (Optical Monitor = Opt/UV Telescope) I



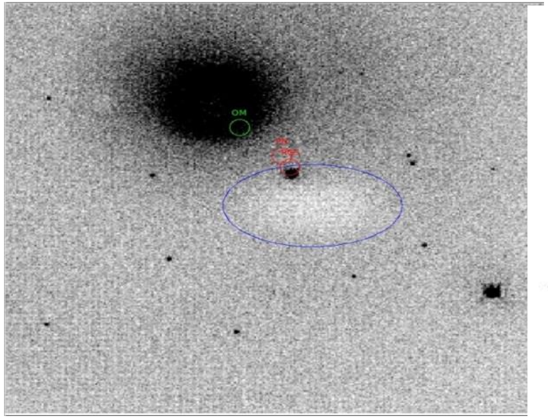
OM throughput:

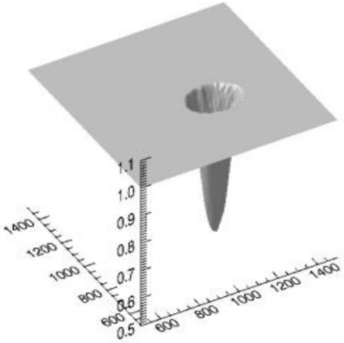
Filter	Current	Expected in 2030
UVW2	0.79	0.73
UVM2	0.81	0.79
UVW1	0.87	0.84
U	0.92	0.90
B	0.92	0.86
V	0.85	0.81

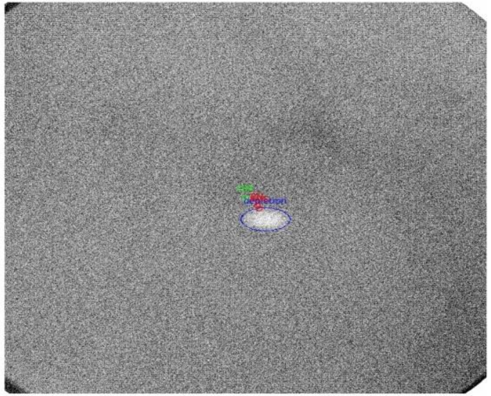
No impact on scientific return (difficulty in seeing faint sources is offset by the fact that one can leave OM turned on when there are bright prime targets or off-axis sources)

Courtesy A. Talavera, ESAC

Status of OM (Optical Monitor = Opt/UV Telescope) II



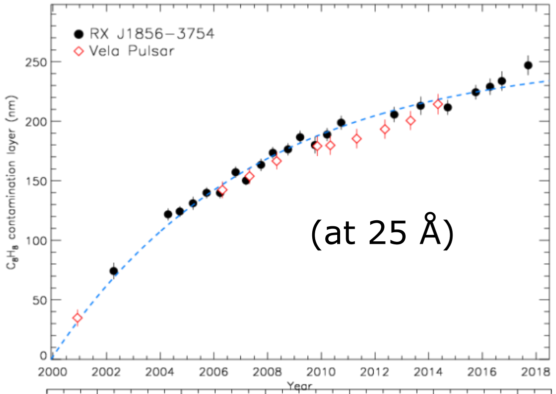


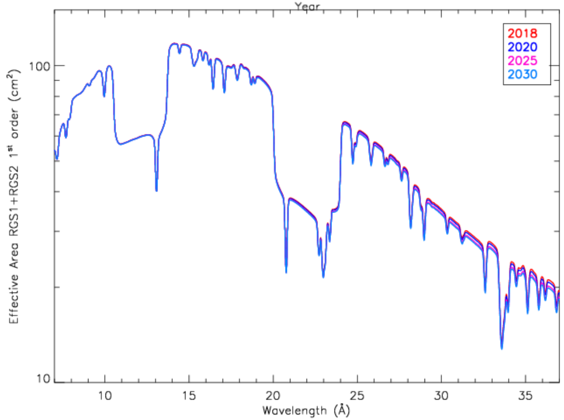


Jupiter was accidentally observed in July 2017 with the V filter :

- a low sensitivity depletion patch appeared in the OM detector: ~160 x 80 pix^2
- RGS boresight is depleted (5% in V filter)
- the depletion level is wavelength dependent
- it is stable (54 % in flat field)
- the affected area is flagged in the Bad Pixels CCF

Status of RGS (Reflection Grating Spectrometer

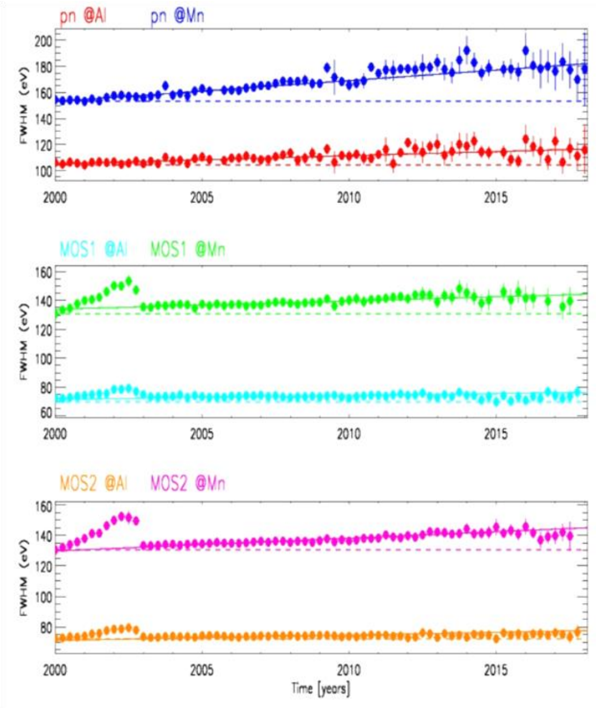




- Expectation for RGS until 2030
  - carbon contamination building-up very slowly
    ➔ effective area will have decreased by 2030 at most by 6% (at 25Å)
  - number of hot columns and pixels stable
    ➔ effective area effected by hot columns/pixels well below 1%
  - Early failure of two CCD chains in year 2000
    ➔ Very unlikely to be repeated following operational modifications
  - RGS2 switched to single-node from double node readout to avoid ADC problem (in 2007)
    ➔ Nothing similar seen in RGS1

Courtesy R. Gonzalez-Riestra

STATUS OF EPIC (CCD Imagers - 3)

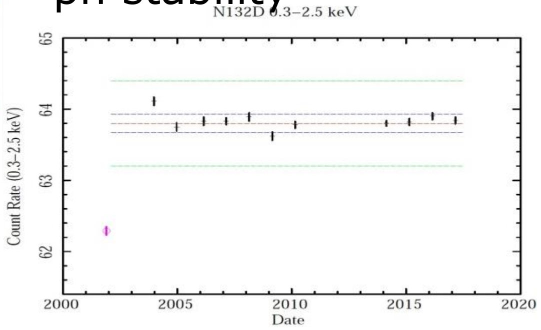


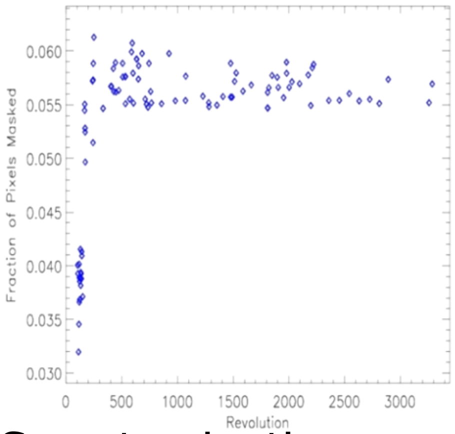
Courtesy M.Smith, M.Stuhlinger, M.Guainazzi

FWHM (eV)

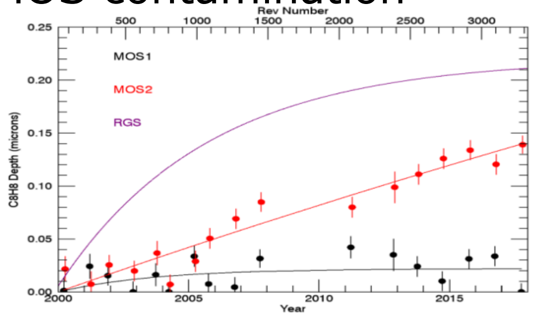
	2000	2018	2030	
pn Al K_{α}	106	117	124	**(1.49 keV)**
pn Mn K_{α}	153	182	201	**(5.90 keV)**
MOS1 Al K_{α}	72	76	79	**(1.49 keV)**
MOS1 Mn K_{α}	134	144	151	**(5.90 keV)**
MOS2 Al K_{α}	71	78	82	**(1.49 keV)**
MOS2 Mn K_{α}	130	145	155	**(5.90 keV)**

pn stability





MOS contamination



Courtesy M. Stuhlinger

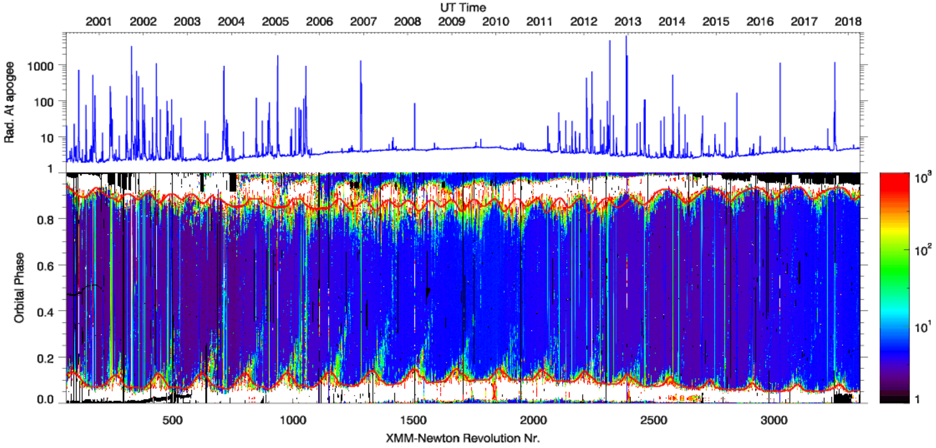
Courtesy A. Pollock and M. Guainazzi

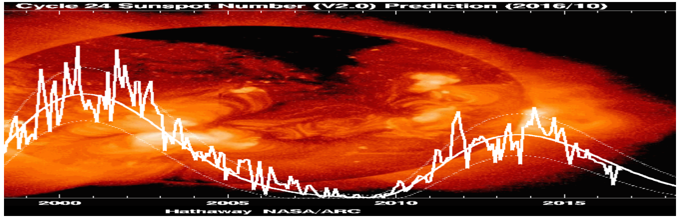
Courtesy S. Sembay & R. Saxton

For Extension I

- Antenna availability and predictability?

- SPACON merger
  - SPACONs are not trained in instruments
  - Observing efficiency
  - TOO
  - Joint program reliability





Requirement for Extension Case V

- Calibration
  - Aging instruments require update and new calibration methods
  - Many calibration requirements (e.g. effective area) were never fulfilled
  - Significant progress in overall X-ray calibration due to new missions (NuSTAR off-mirror observations)
  - Current scientific question do not tolerate calibration discrepancies

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DOCUMENT

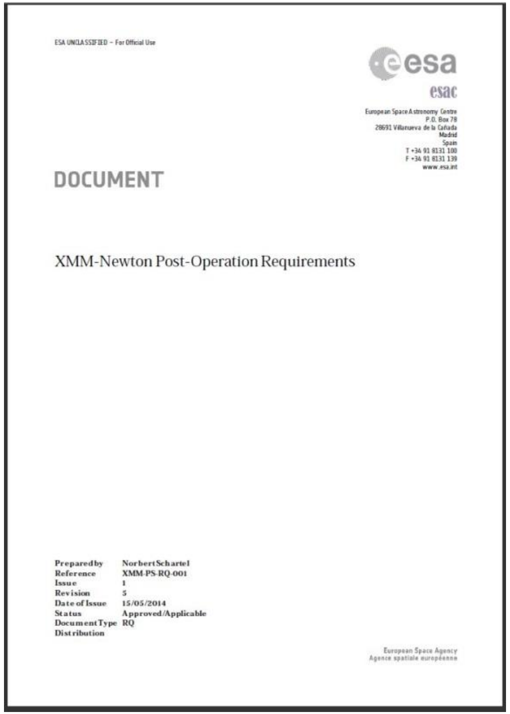
XMM-Newton Calibration Requirements

Prepared by	Norbert Schartel
Reference	XMM-PS-RQ-002
Issue	1
Revision	0
Date of Issue	019/06/2015
Status	Approved
Document Type	RS
Distribution	

European Space Agency
Agence spatiale européenne

Requirement for Extension Case VI

- Post-Operations Preparations
- Maintainable maintenance for next decade
  - Roadmaps
  - Pipeline
  - SAS / Risa



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DOCUMENT

XMM-Newton Post-Operation Requirements

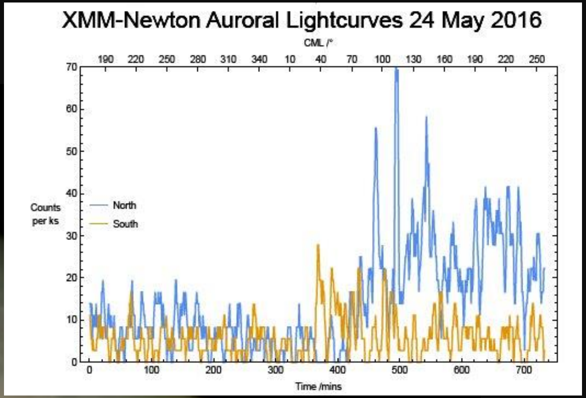
Prepared by	Norbert Schartel
Reference	XMM-PS-RQ-001
Issue	1
Revision	5
Date of Issue	15/05/2014
Status	Approved/Applicable
Document Type	RQ
Distribution	

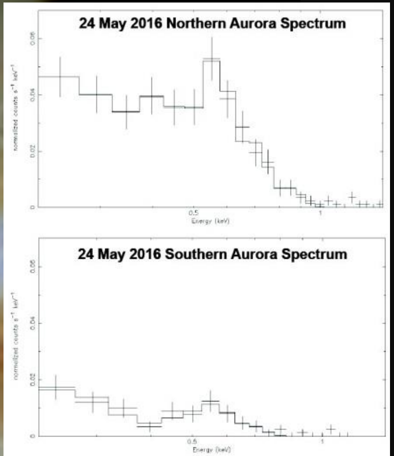
European Space Agency
Agence spatiale européenne

Conclusions

- **XMM-Newton continues to be scientifically extremely productive**
  - **360 refereed papers per year make use of XMM-Newton data**
- **XMM-Newton continues to have extremely high scientific potential for addressing open questions and doing new science and discoveries, especially in combination with new and soon-to-come facilities**
- **XMM-Newton continues to have unique capabilities**
- **XMM-Newton and it's instruments are ageing:**
  - **however, there are no issues which would affect the scientific output <u>assuming appropriate monitoring, calibration and maintenance work and mitigation measurements</u>**
  - **albeit the intrinsic risk of space based missions can not be mitigated (e.g micro-meteorites)**
- **<u>Antennas and SPACON Merger must reestablish highest efficiency and reliability of observations</u>**
- **The scientific output can only be kept at the current level if the quality of the scientific user support (from AOs to scheduling, calibration, analysis software, helpdesk) can be maintained**
- **Spearhead science requires continuation of specific efforts, like coordinated observations, triggered & TOOs, calibration**

The independent pulsations of Jupiter's northern and southern X-ray auroras





Jupiter's northern X-ray aurora is concentrated into a hot spot.

The X-ray emission demonstrates that the hot spot is produced by oxygen, sulphur and/or carbon ions that are undergoing charge exchange.

-Observations failed to reveal a similar feature in the south

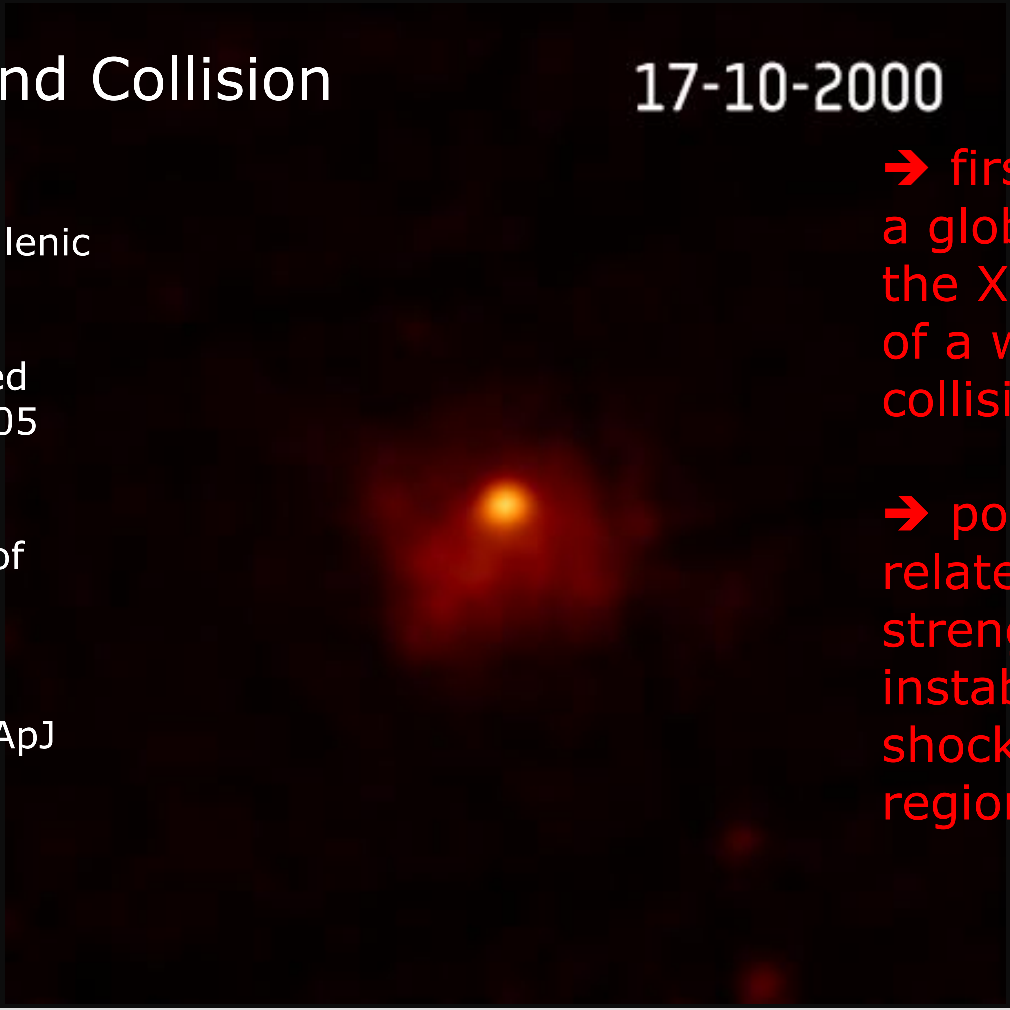
XMM-Newton and Chandra campaigns show that Jupiter's northern and southern spots each exhibit different periodic pulsations and uncorrelated changes in brightness

➔ highly energetic, non-conjugate magnetospheric processes sometimes drive the polar regions of Jupiter's dayside magnetosphere.

in contrast to current models of X-ray generation for Jupiter

Dunn et al., 2017, Nature Astronomy 1, 758

A Changing Wind Collision



HD 5980 is a massive system in Small Magellenic Cloud

- light curve unchanged between 2000 and 2005

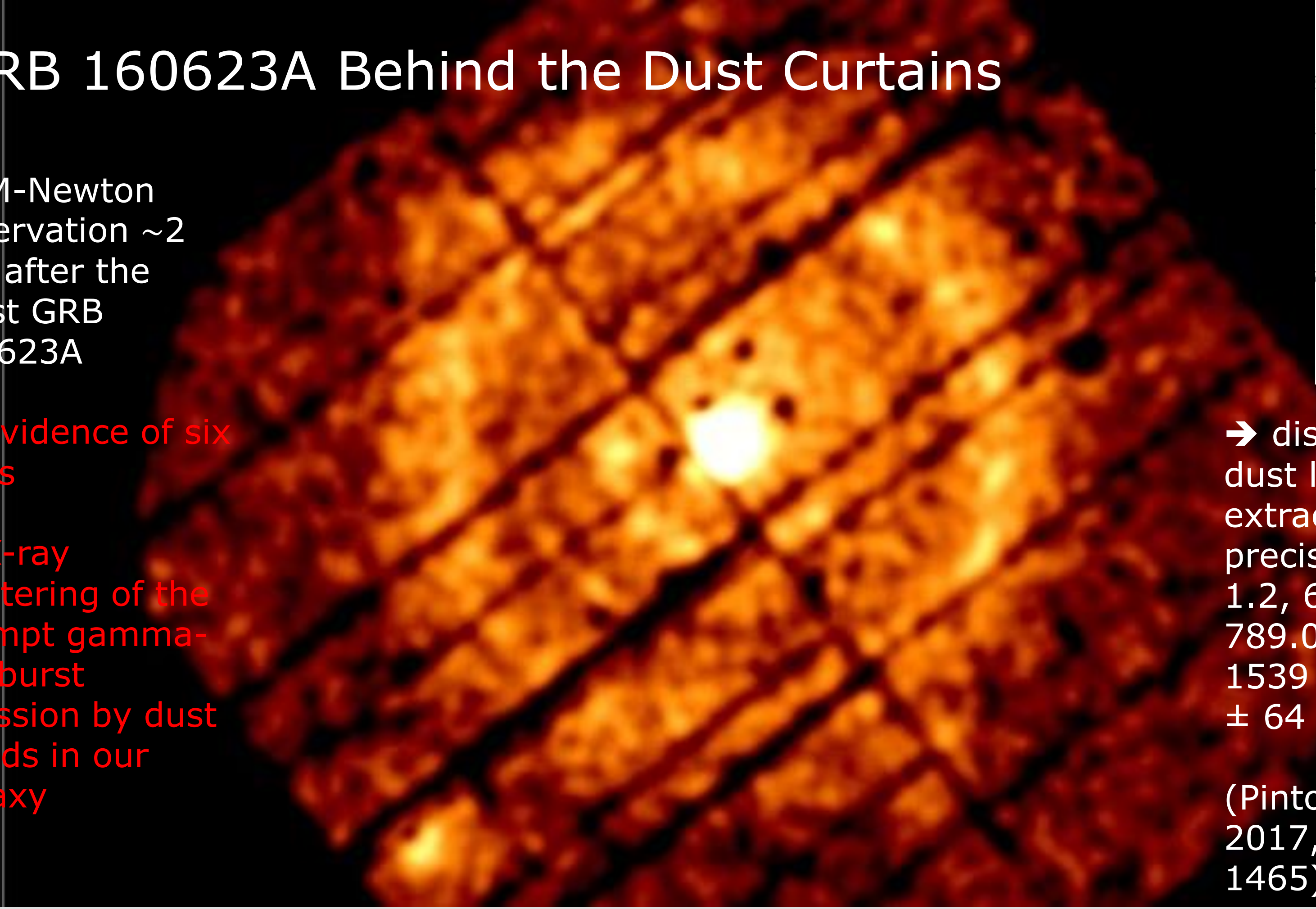
- X-ray flux has now increased by a factor of ~2.5

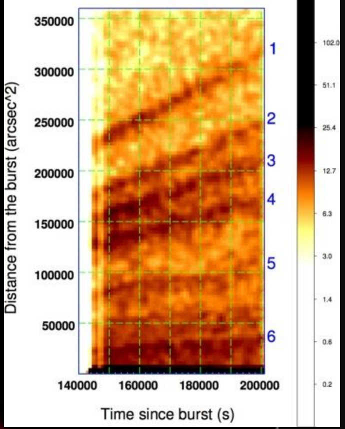
(Y. Nazé et al., 2018, ApJ 853, 164)

➔ first detection of a global change in the X-ray emission of a wind–wind collision

➔ possibly be related to varying strength of thin-shell instabilities in shocked wind regions

GRB 160623A Behind the Dust Curtains





XMM-Newton observation ~2 day after the burst GRB 160623A

➔ evidence of six rings

➔ X-ray scattering of the prompt gamma-ray burst emission by dust clouds in our Galaxy

➔ distances of the dust layers with extraordinary precision: 528.1 ± 1.2, 679.2 ± 1.9, 789.0 ± 2.8, 952 ± 5, 1539 ± 20 and 5079 ± 64 pc

(Pintore, F. et al., 2017, MNRAS 472, 1465)

A strongly truncated inner accretion disc in the Rapid Burster

The neutron star (NS) low-mass X-ray binary (LMXB), the Rapid Burster shows Type II X-ray bursts.

Swift, NuSTAR and XMM-Newton observations during 2015 outburst:

➔ broad Fe K line can modelled using relativistic reflection models

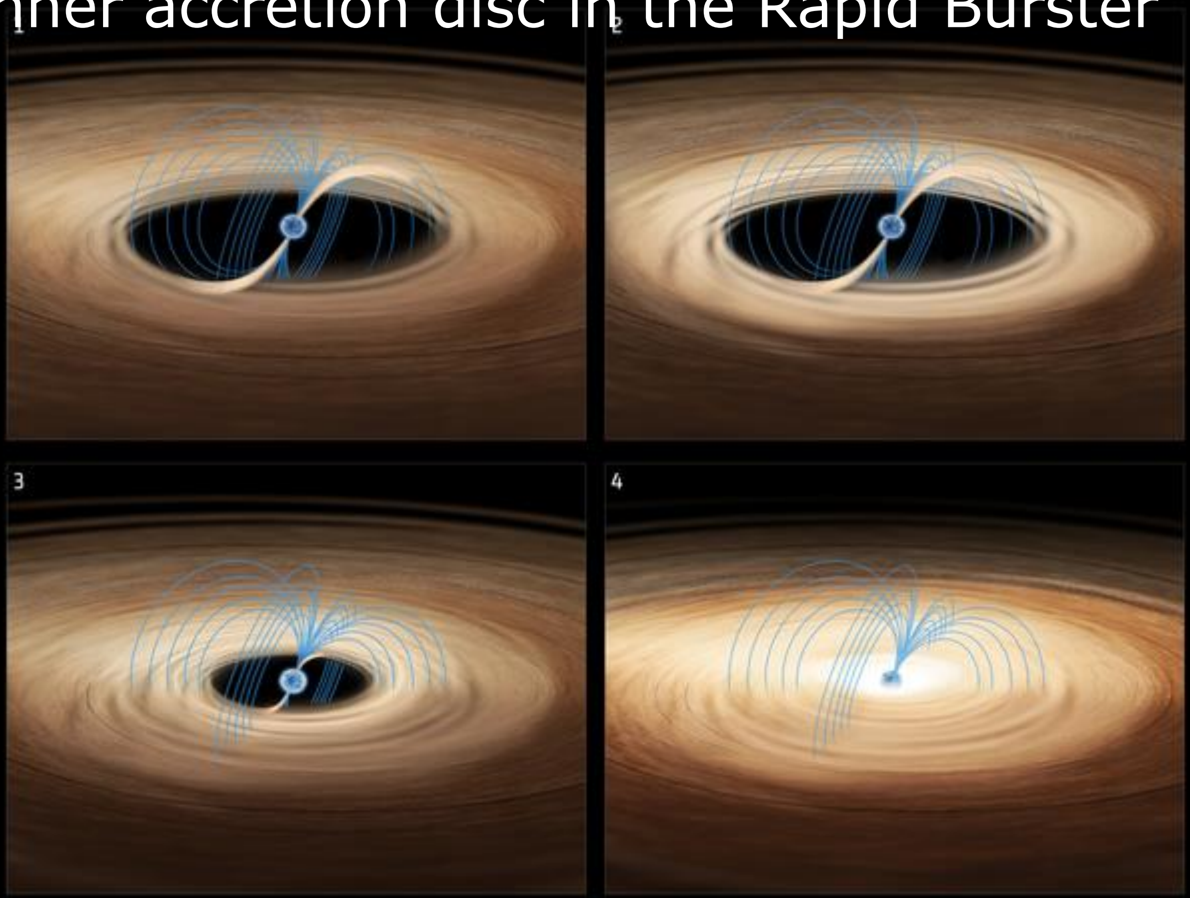
➔ strongly truncated disk at ~41.8 gravitational radii (~87 km),

➔ magnetospheric Type II burst

➔ strongly disfavours instabilities at the innermost orbit

➔ B = $6.2 \pm 1.5 \times 10^{8}$ G, i.e. larger than typically inferred for NS LMXBs

J. van den Eijnden et al., 2017, MNRAS 466, L98



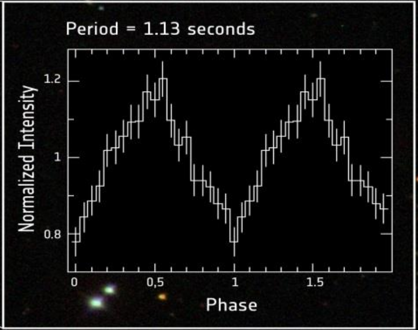
An accreting pulsar with extreme properties drives an ultraluminous X-ray source in NGC 5907

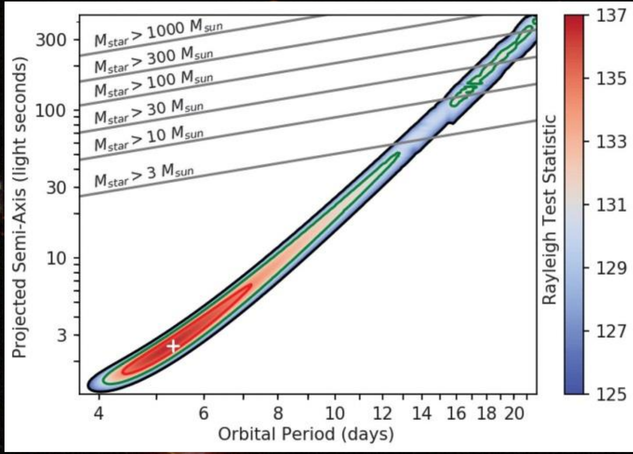
Ultraluminous x-ray sources (ULXs) shine brighter than any x-ray source in our Galaxy.

ULXs are usually modelled as stellar-mass black holes (BHs) accreting at very high rates or intermediate-mass BHs.

XMM-Newton and NuSTAR observations:

➔ NGC 5907 ULX is an neutron star (NS)
➔ spin period evolves from 1.43 s in 2003 to 1.13 s in 2014.
➔ isotropic peak luminosity of ~1000 × Eddington limit
➔ standard accretion models fail to explain its luminosity, even assuming beamed emission,
➔ strong multipolar magnetic field can describe its properties.
➔ other extreme ULXs might harbour NSs.





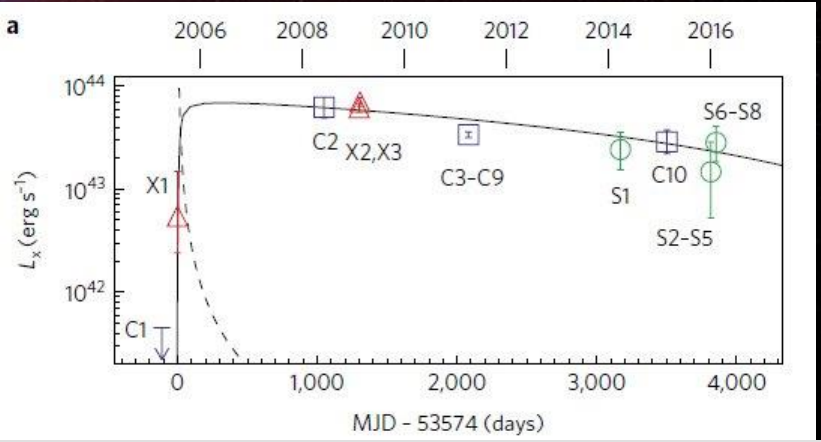
G.L. Israel, 2017, Science 355, 817

A likely decade-long sustained tidal disruption event

XMM-Newton, Chandra and Swift observations:

➔ discovery of a super-long (>11 years) luminous X-ray flare from the nuclear region of a dwarf starburst galaxy.
➔ fast rise within ~4 months
➔ X-ray luminosity persistently high at around the Eddington limit
➔ a tidal disruption event

D. Lin et al., 2017 Nature Astronomy, 1, 33

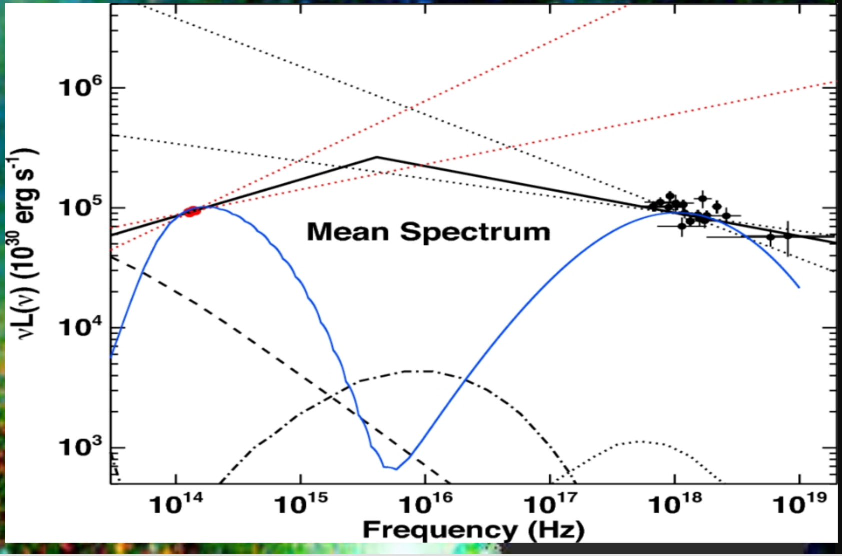


A powerful flare from Sgr A* confirms the synchrotron nature of the X-ray emission

- multiwavelength monitoring campaign of Sgr a* with XMM–Newton, NuSTAR and SINFONI
- first fully simultaneous observations in near-infrared (NIR) and X-rays of a very bright flare of Sgr A*

Ponti et al., 2017
MNRAS 468, 2447

➔ synchrotron emission with a cooling break



The red and black points show the mean NIR and X-ray (XMM–Newton and NuSTAR) emission during a flare. The dotted red and black straight lines show the uncertainties on the determination of the NIR and X-ray power-law slope, respectively. The solid line shows the best-fitting synchrotron with cooling break model.

The response of relativistic outflowing gas to the inner accretion disk of a black hole

Gas outflows from AGNs release huge quantities of energy into the interstellar medium, potentially moderating the growth of their host galaxy.

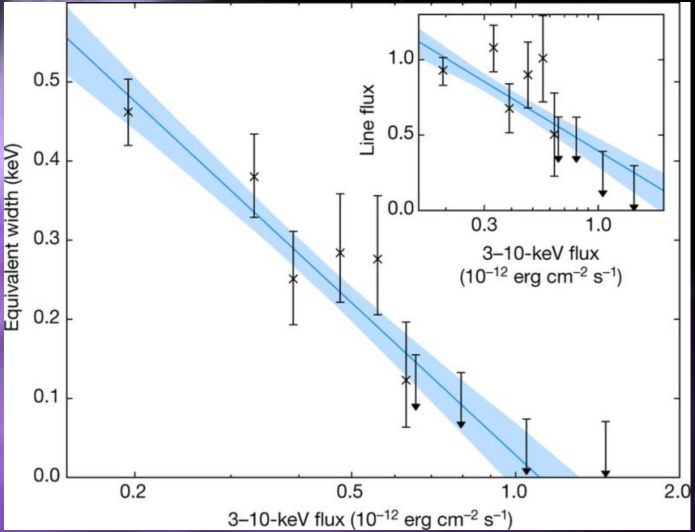
XMM-Newton observations of the narrow line Seyfert-1 galaxy IRAS 13224-3809:

➔ extreme ultrafast gas flow in the X-ray spectrum

➔ 0.236 ± 0.006 times the speed of light (71,000 km/s)

➔ absorption is strongly anti-correlated with the emission of X-ray

➔ X-ray emission from within a few gravitational radii of the black hole is ionizing the disk wind hundreds of gravitational radii further away as the X-ray flux rises.

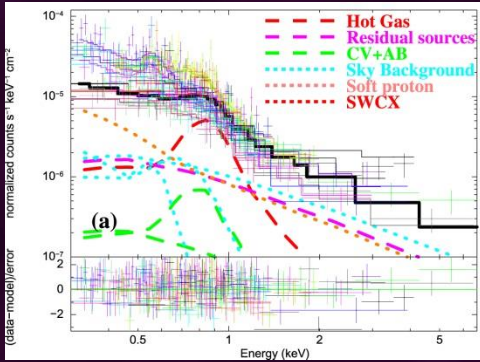


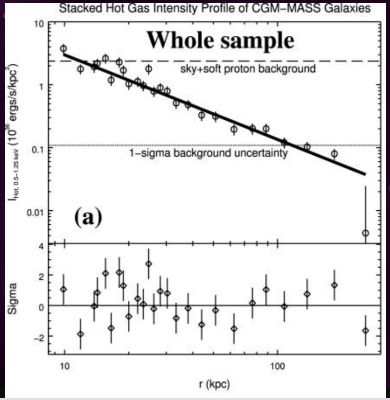
M. L. Parker, et al., 2017
Nature 543, 83

Baryon Budget of the Hot Circumgalactic Medium (CGN) of Massive Spiral Galaxies

The baryon content around local galaxies is observed to be much less than is needed in Big Bang nucleosynthesis.

Simulations indicate that a significant fraction of these "missing baryons" may be stored in a hot CGM around massive galaxies





- stacking X-ray observations of six local massive spiral galaxies
- density profile can be characterized by a single power law
- hot CGM accounts for 8±4% of the baryonic mass expected for the halos

➔ hot baryons within the virial radius of massive galaxy halos are insufficient to explain the "missing baryons."

J.-T. Li et al., 2018 ApJ 855, L24