Welcome & Introduction

Natalie Webb
On behalf of the XMM2ATHENA team:

Welcome to Toulouse and to the workshop!
Small constraint, please sign in to the meeting every day – thank you!
LOC identifiable by the red circle on their badge
Wifi: Eduroam recommended. Alternatively, individual connections available at welcome desk
Presentations via central computer where possible – upload pdf of your slides
Possibility to connect to the zoom and present from your own computer
Posters, coffee breaks & lunches in the Gervais de Lafond room – next door
Restricted access to the remainder of IRAP (unless accompanied)
Hybrid meeting, please use the microphone when asking questions
For remote participants, please keep microphone muted when not speaking
For remote participants, please raise hand to ask a question or post in chat
For all participants, please be respectful to everyone
For speakers, time slots include 5 minutes for questions, try to stick to time
Dinner Wednesday, Mas de Dardagna, limited places, require ticket, 55€
drinks included, pay at restaurant
• The Research Institute for Astrophysics and Planetary Sciences (IRAP)
• 320 people, ~120 researchers, ~80 engineers, ~50 postdocs, ~50 PhD students
• Three sites, Roche & Belin in Toulouse and at Tarbes (Pic du Midi)
• Situated next to the French Space Agency (CNES) and University of Toulouse III
• Wide range of research: plasma physics, solar system, the Sun, stars, interstellar medium, astro-chemistry, compact objects, astroparticle physics, fundamental physics, galaxies, cosmology, signal processing
• Strong instrumental development, i.e. SPI/integral, radiation monitors/XMM-Newton, ECLAIRs/SVOM and X-IFU/ Athena
A BIT ABOUT TOULOUSE

France

Tououlouse

Pyrenees

Marseille

Italy
The XMM-Newton Survey Science Centre (XMM-SSC) was selected by ESA to ensure that the scientific community can exploit XMM-Newton data.

Responsibilities:

Development of much of the science analysis system (SAS)

Pipeline processing of all XMM-Newton observations <2012

Follow-up/identification of the XMM-Newton serendipitous sky - the XID Programme

Compilation of the Serendipitous Source Catalogue.
This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101004168

4XMM-DR13

983948 detections, 656997 unique sources
353538 (36%) sources with spectra & lightcurves
91763 extended sources
≤90 detections/source

Covers 1328 sq. deg of sky

Release: 12th June 2023

(Webb et al. 2020)
The XMM-Newton Survey Legacy for Athena and Beyond Workshop
February 26-29 2024

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XMM2ATHENA : APRIL 2021-SEPTEMBER 2024

XMM-Newton

Athena

1999 - ..... 2037-......

http://xmm-ssc.irap.omp.eu/xmm2athena/
• XMM-Newton observing the X-ray, ultra-violet & optical sky for >24 yrs
• Astronomy has evolved, rarely look at individual sources, but populations
• No longer use a single wavelength, but multi-wavelength and multi-messenger information to help understand the X-ray sources
• Moving into era of time domain astronomy
• Requires operating observatories differently
• New software + methods needed to accompany emerging astronomy
• To be used by next generation X-ray observatory, Athena
• XMM2ATHENA brings together the XMM-Newton SSC, key members of the Athena Science ground segment + members of the X-ray community
CONSORTIUM

CNRS/IRAP, Toulouse
CEA, Saclay
CNRS/ObAS, Strasbourg
UC/IFCA, Santander
ULEIC/Leicester
UCL/MSSL
AIP, Potsdam
MPG/MPE, Garching
NOA, Athens
• New classification software (naive Bayes classifier)
• Improved software for source detection in stacked data
• Machine learning algorithm to determine photometric redshifts
• Software to detect (very) short term and long term variability
• XMM-Newton alerts
• Improved sensitivity estimator
• New outreach material
• Train the next generation of X-ray astronomers
• Methodology and software ready for Athena
New XMM-Newton catalogue, 5XMM-DR15 in 2025 containing:

- Re-reduction of all data with improved software and calibration
- Single stacked catalogue using source detection reaching deeper fluxes
- Upper limits
- Identifications of all XMM-Newton X-ray, UV and optical sources
- Other multi-wavelength/messenger counterparts to X-ray sources
- Photometric redshifts
- Fits to spectra, including sources with just 5 flux bands
- Physically motivated (type/z) spectral fits for best spectra
- (Very) short term and long term variability
- Methodology and software ready for Athena
SCOPE OF THE MEETING

- Discuss the format and accessibility of X-ray and multi-wavelength catalogues
- Understand the uses of the catalogues and the needs of the user
- Adapting to time domain astronomy
- Investigating new source classification and machine learning techniques
- Learn about new software and methods
- Discuss upcoming missions, software and tools
- Reflect on the importance of outreach/diversity in astronomy

Aim to provide better catalogues and software in the future
SUMMARY

• XMM2ATHENA will allow XMM-Newton archival data to be fully exploited
• XMM2ATHENA is providing additional functionality & more complete catalogues
• New version of sensitivity estimator, FLIX
• New catalogues of spectral fits for all sources, classifications, etc already out
• 4XMM-DR14 currently being prepared, 5XMM expected for 2025
• XMM2ATHENA will prepare the X-ray community for future X-ray missions
• XMM2ATHENA is helping to make astronomy more accessible to the public
• Knowledge of XMM-Newton & X-ray observatories passed on to next generation
Aimed at final year undergraduate/post-graduate students
- General relativity
- Compact objects
- Gravitational waves
- Friedman-Lemaître-Robertson-Walker metric & cosmology
Currently available in French, soon in English & Spanish
Printed and electronic versions available
Estimate of the carbon footprint of astronomical research infrastructures

2022, Nature Astronomy, Volume 6, p. 503-513

Jürgen Knödlseder¹, Sylvie Brau-Nogue², Mickael Coriat¹, Philippe Garnier¹, Annie Hughes¹, Pierrick Martin¹ & Luigi Tibaldo¹

worldwide active astronomical research infrastructures currently have a carbon footprint of 20.3±3.3 MtCO₂ equivalent (CO₂e) and an annual emission of 1,169±249 ktCO₂e yr⁻¹ corresponding to a footprint of 36.6±14.0 tCO₂e per year per astronomer. Compared with contributions from other aspects of astronomy research activity, our results suggest that research infrastructures make the single largest contribution to the carbon footprint of an as-

Findings include:
- Operations are ~1-2 % of carbon footprint of typical space based mission
- More comprehensive exploitation of data limits carbon footprint

=> Longevity of XMM-Newton coupled with intense archive exploitation reduces carbon footprint of X-ray astronomy in Europe

Note: average carbon footprint / European / year : ~8 tCO₂e

²
FLIX SENSITIVITY ESTIMATOR

- New interface
- Improved code
- Processing time halved
- No further time-outs
- Accepts large requests

http://flix.irap.omp.eu/

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SPECTRAL FITS

- Bayesian fitting (BXA, Buchner+14)
- Simple fit to all extracted spectra
- Fit to stacked spectra
- Fit to all sources, even without extracted spectra
- Classified sources with photometric redshifts: physically motivated fits

All catalogues available: [http://xmm-ssc.irap.omp.eu/xmm2athena/](http://xmm-ssc.irap.omp.eu/xmm2athena/)

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<tr>
<th>Class</th>
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<tr>
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<tr>
<td>CVs</td>
<td>bremsstrahlung</td>
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</tbody>
</table>

![Histogram and distribution plots](image)
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CLASSIFICATIONS

Classifications of each X-ray source in 4XMM-DR12

- Classification of OM sources
- Classification of 630347 sources in 4XMM-DR12
  - Revisited naive Bayes classification
  - Based on 15 criteria pertaining to spatial, spectral, and timing properties + multiwavelength counterparts
  - Outlier measure used to identify objects of other nature

Tranin et al. (2022 & 2023)
The XMM-Newton Survey Legacy for Athena and Beyond Workshop
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PHOTOMETRIC REDSHIFTS

- Will provide photometric redshifts for all extragalactic sources
- Pipeline based on MLZ-TPZ (Carrasco Kind & Brunner, 2013)
- SDSS, PanSTARRS & DES photometry
- Compared to redshifts from spectroscopy
• Code developed to find very rapid, faint transients
• Good at finding variability in sources where no lightcurve extracted (thus no variability evaluation – 64% of 4XMM)
• 7529 previously detected sources now shown to be variable
• A few tens of new sources discovered (neutron star candidates, stars, …)
• Gupta et al. (to be sub.), Pastor Marazuela et al. (2020)
LONG-TERM TRANSIENTS & ALERTS

- Many objects vary on months to years timescales (supernovae, ULXs, TDEs, changing look AGN, gravitational wave events, X-ray & CV outbursts)
- Code developed to find long term transients (baseline 30 years)
- Uses 6 additional X-ray catalogues+XMM upper limits
- 0.5 long-term transients (> factor 5) detected per day
- Majority are unknown sources
- Of known objects, the majority are from galaxy centres (TDEs, Changing look, etc)
- Rare objects found (Quintin et al. 2021 & 2023)
- Quasi-real time alerts could be provided

Simbad Counterparts

- XRB: 8.4%
- Galaxy: 15.7%
- Star: 10.4%
- Unknown: 17.1%
- Not In Simbad: 28.2%
- Not Checked: 20.2%
Welcome to CLAXSON!
(Classification of X-ray Sources for Novices)

CLAXSON is a platform designed to identify new objects observed in the X-ray sky with the European Space Agency X-ray telescope XMM-Newton. Be the first to find new supermassive black holes, stars, galaxies and other exotic objects in observations taken over the last 20 years, and help astronomers unravel the mysteries of the X-ray sky.

Aim: use identified sample for better classification using Tranin et al. (2022) method
Teaches about objects and how to identify them
Uses wisdom of crowds (20 IDs to identify source)

http://xmm-ssc.irap.omp.eu/claxson/index.php?

Many talks and events at local, national and international level
Numerous outreach activities in different participant’s countries
Papers published
Follow us on Facebook and Twitter