The XMM-Newton Survey Science Centre SSC

Mike Watson & Natalie Webb

XMM-Newton SURVEY SCIENCE CENTRE

XMM-Newton 20th Anniversary
10 - 11 December 2019, ESAC

Topics

- Introduction to SSC and brief history
- SSC roles in XMM project
  - science analysis software
  - pipeline science processing
  - serendipitous catalogue creation
  - follow-up identification programme
- Current status: restructuring and new catalogues
- Future

Survey Science Centre (SSC)

- SSC Consortium formed in 1995, competitive bid for SSC activities in response to ESA AO
- Selected by ESA in early 1996, activities started in April 1996
- Funded by national agencies

Original rôle of SSC (as defined in *ESA XMM Science Management Plan ESA/SPC(88)20, **01-Jun-88**), Section 4.4.1.*)

"The role of the Survey Scientist is to provide both expert support to ESA on the general concept and to provide the software system for analysis of the XMM database. The Survey Scientist will undertake the systematic analysis of all archive data leading to the production of catalogues of all serendipitous sources detected by XMM."

List of Investigators

Survey Scientist

Dr M G Watson	University of Leicester, UK

Co-Investigators

Dr M Arnaud	Service d'Astrophysique, CEA/DSM/DAPNIA, Saclay, France
Dr J Ballet	Service d'Astrophysique, CEA/DSM/DAPNIA, Saclay, France
Dr M Boer	CESR, Toulouse, France
Dr Th Boller	Astrophysikalisches Institut Potsdam, Germany
Dr M S Cropper	MSSL, University College London, UK
Prof R S Ellis	Institute of Astronomy, Cambridge, UK
Prof A C Fabian	Institute of Astronomy, Cambridge, UK
Dr F Genova	Centre de Données astronomiques de Strasbourg, France
Prof G Hasinger	Astrophysikalisches Institut Potsdam, Germany
Dr R G McMahon	Institute of Astronomy, Cambridge, UK
Prof K O Mason	MSSL, University College London, UK
Dr C Motch	Observatoire de Strasbourg, France
Dr M Pakull	Observatoire de Strasbourg, France
Dr W Pietsch	Max-Planck Institut für extraterrestrische Physik, Germany
Dr G C Stewart	University of Leicester, UK
Dr W Voges	Max-Planck Institut für extraterrestrische Physik, Germany
Dr R S Warwick	University of Leicester, UK

Associate Scientists

Dr T Maccacaro	OAB, Italy *(Chair of Associate Scientists)*
Dr X Barcons	University of Santander, Spain
Dr M S Elvis	Harvard-Smithsonian CfA, USA
Dr K Sekiguchi	NAO, Tokyo, Japan
Dr J-M Vreux	Université de Liège, Belgium
Dr D Worrall	University of Bristol, UK

Key Personnel

Dr J P Pye	University of Leicester, UK *(Project Manager)*
Dr J P Osborne	University of Leicester, UK *(Science Analysis Team Leader)*
Dr C Page	University of Leicester, UK *(Data ProcessingTeam Leader)*

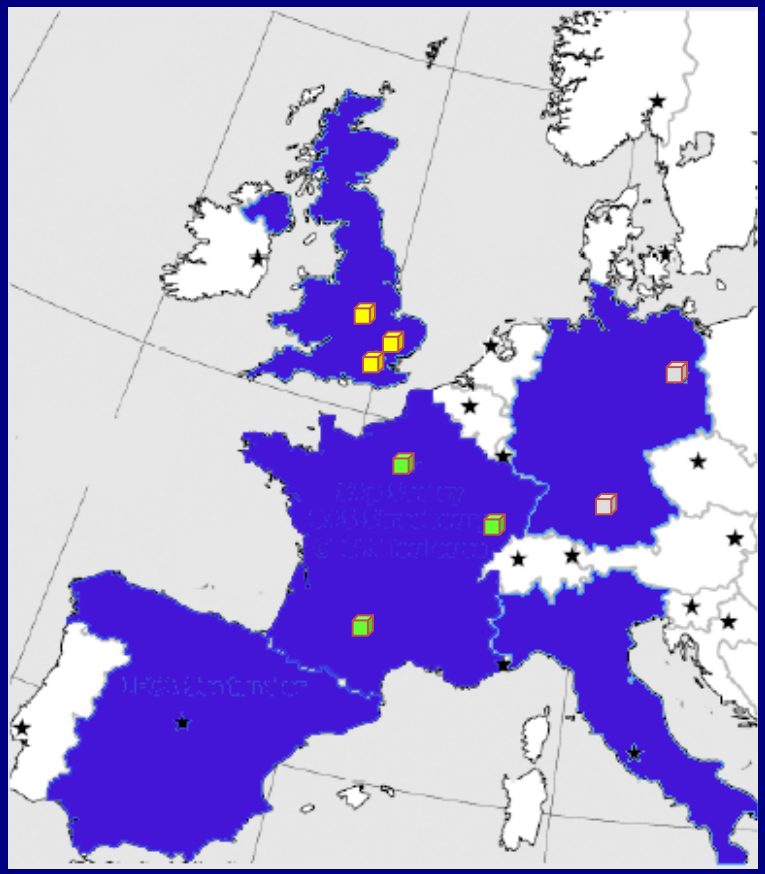
SSC Consortium (1996)

University of Leicester (UK)
MSSL (UK)
IoA Cambridge (UK)

SAp/CEA/Saclay (France)
CESR Toulouse (France)
OAS Strasbourg (France)

AIP Potsdam (Germany)
MPE Garching (Germany)

+ Associate Scientists



SSC Consortium (2002)

30 FTE at peak

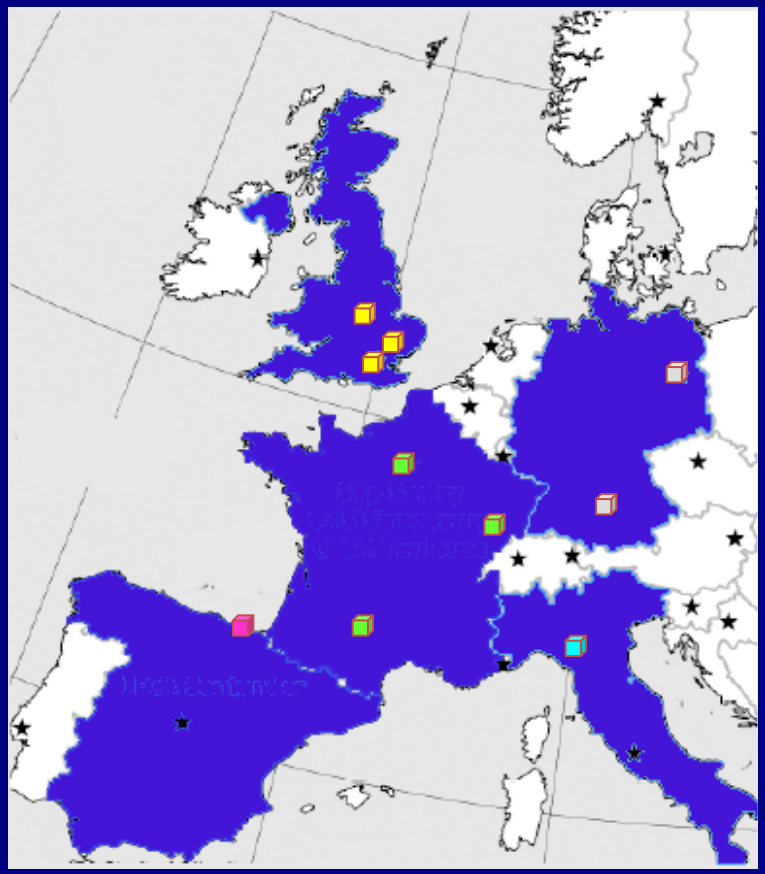
University of Leicester (UK)
MSSL (UK)
IoA Cambridge (UK)

SAp/CEA/Saclay (France)
CESR Toulouse (France)
OAS Strasbourg (France)

AIP Potsdam (Germany)
MPE Garching (Germany)

IFCA Santander (Spain)
OAB Milano (Italy)

+ Associate Scientists



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SSC Consortium (2019)

University of Leicester (UK)
MSSL (UK)

DAp/CEA/Saclay (France)
IRAP Toulouse (France)
OAS Strasbourg (France)

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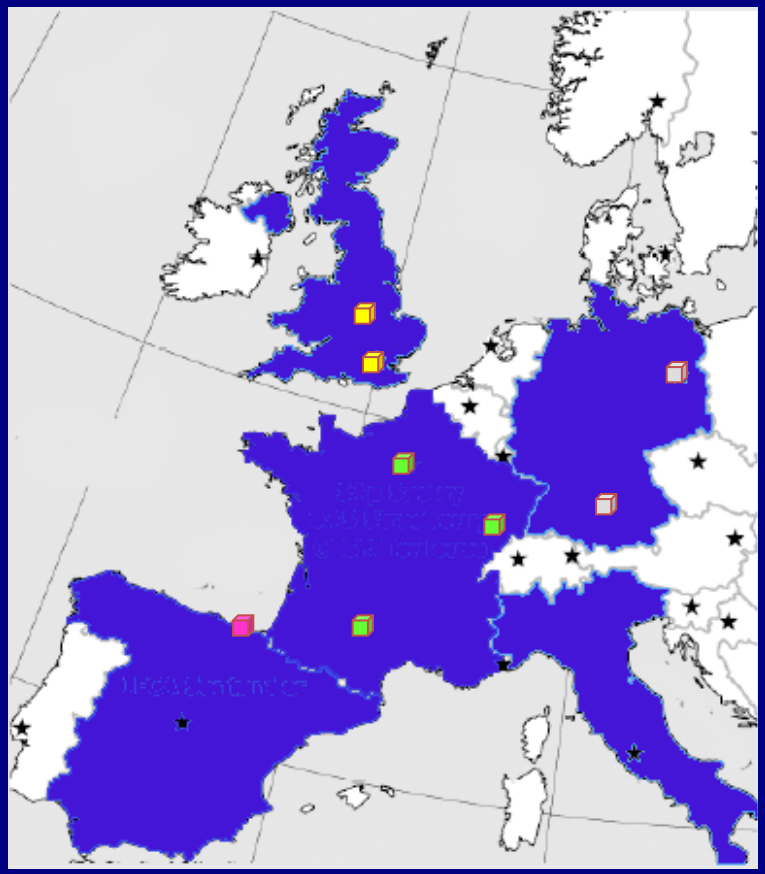

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Main SSC roles in XMM-Newton

Science Analysis Software (SAS)

- provision and maintenance of science analysis software for all XMM-Newton instruments
- **task shared with ESA SOC and instrument teams**

SSC >70% of SAS
C++ 452K lines
Fortran 627K lines

Pipeline Processing & Reprocessing

- standardised processing of all XMM-Newton science data
- data products → science archive @SOC (XSA) → observer and archival users
- SSC provided processing infrastructure, all processing operations and quality control

Catalogue creation

- serendipitous X-ray source catalogues from every EPIC observation (+ OM catalogues)
- catalogues based on pipeline processing

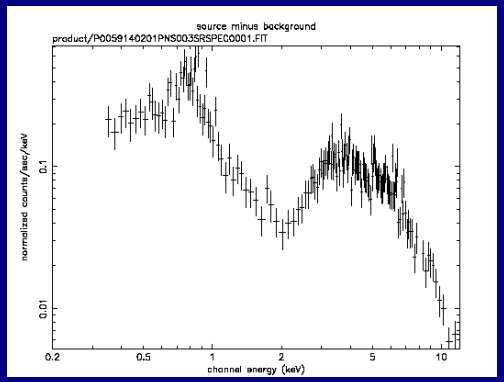
XID Program

- large-scale follow-up and identification program for selected samples of serendipitous X-ray sources

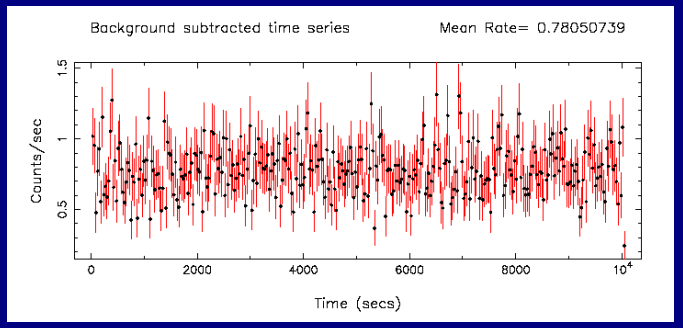
Pipeline processing

- SSC operated the XMM-Newton science pipeline from 2000 – 2012
  - thereafter transferred to ESA SOC
  - *2 new datasets per day, every day*
  - 1-2 week turn-around time at SSC
  - substantial operations and system engineering & management task
  - substantial quality control (data screening) activities for each observation
- Produced set of standard products for all 6 instruments
  - distributed to observers and incorporated into archive (XSA)

X-ray spectrum



time series



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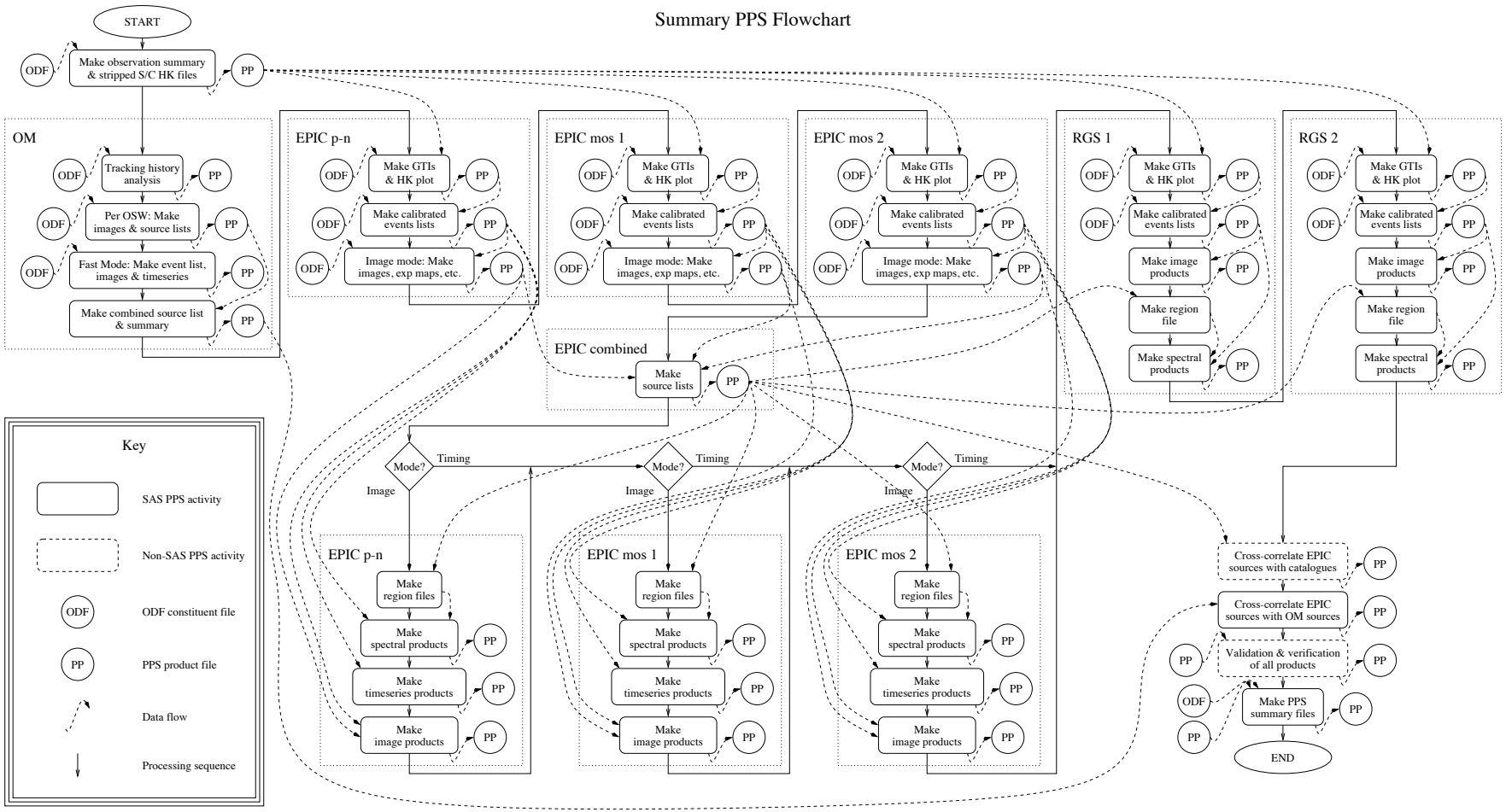
Simplified processing flowchart



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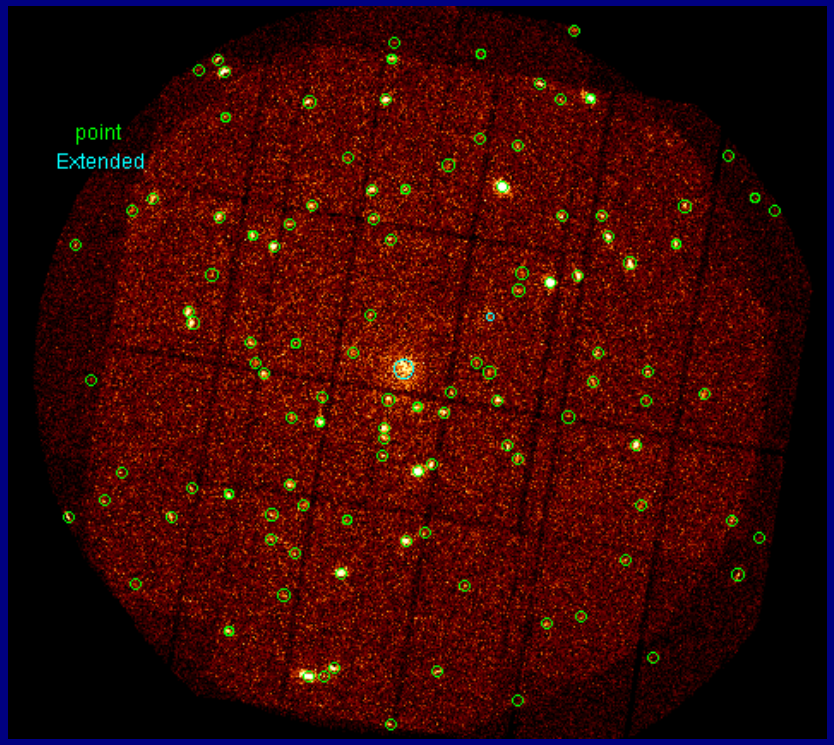
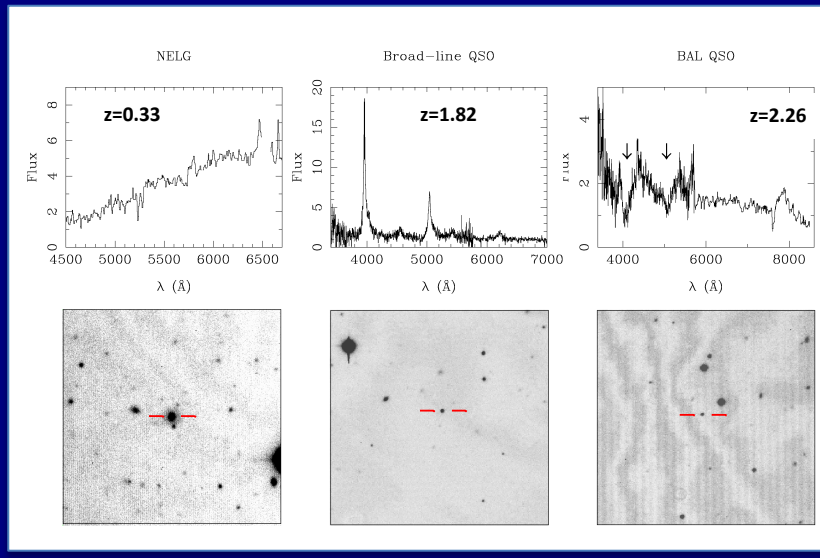
SSC Serendipitous Source Catalogues

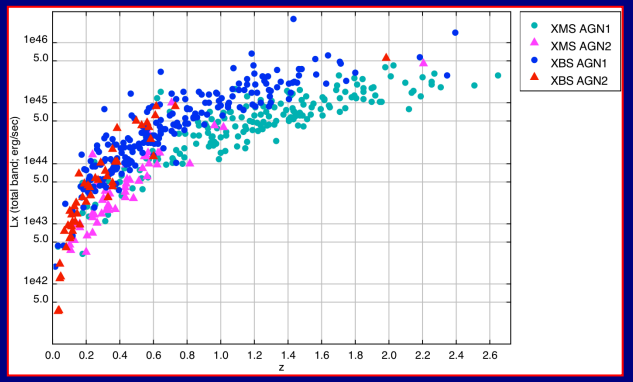
- Each XMM EPIC observation detects 50-200 new* X-ray sources
- Serendipitous source catalogues created from each observation
- Careful quality control and catalogue characterisation
- First catalogue (1XMM) in 2003
- Latest catalogue (3MM-DR9) in 2018 contains ~500K sources



SSC XID Program

- Extensive X-ray source follow-up and identification program
  - carefully selected samples
  - optimise value of XMM serendipitous survey for community
  - *statistical* identifications for the whole XMM-Newton serendipitous catalogue
  - 5-10 observing runs per year (whole SSC XID) ~1999-2010
  - spectroscopic IDs for >2000 XMM sources
  - deep multi-colour imaging data for ~20000 XMM sources





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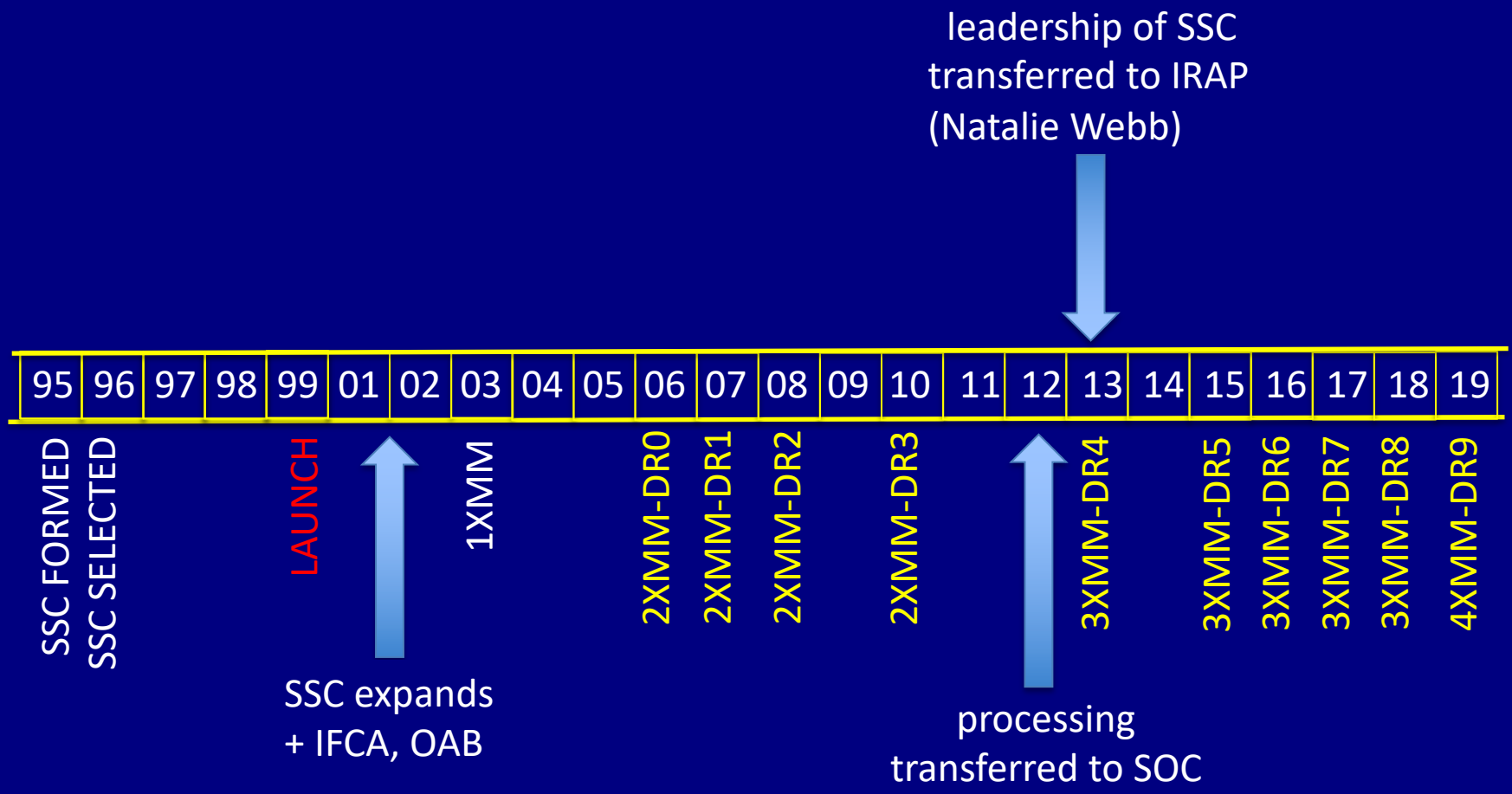
SSC history: 24 years!



Continuity and enhancements

- Continued SAS task development + support
- Continued data products screening
- Ongoing source identification activities
- Enhancement of catalogue servers
- Continued input into OM catalogue (SUSS)
- Continued input into SAS + pipeline development via monthly SAS-CCB & SASWG meetings
- Regular telecons & consortium meetings
- New SSC webpages http://xmmssc.irap.omp.eu/ and outreach pages

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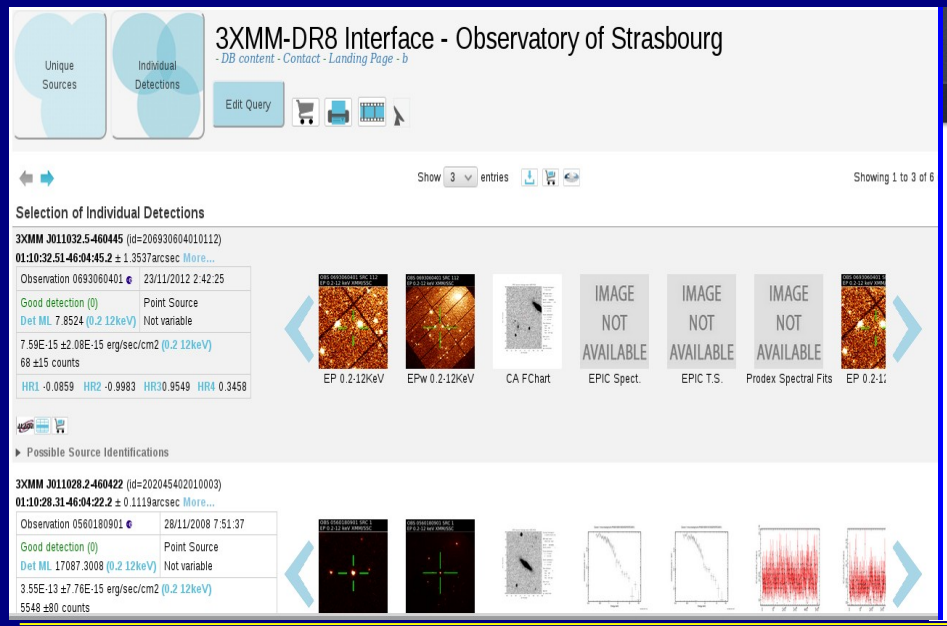
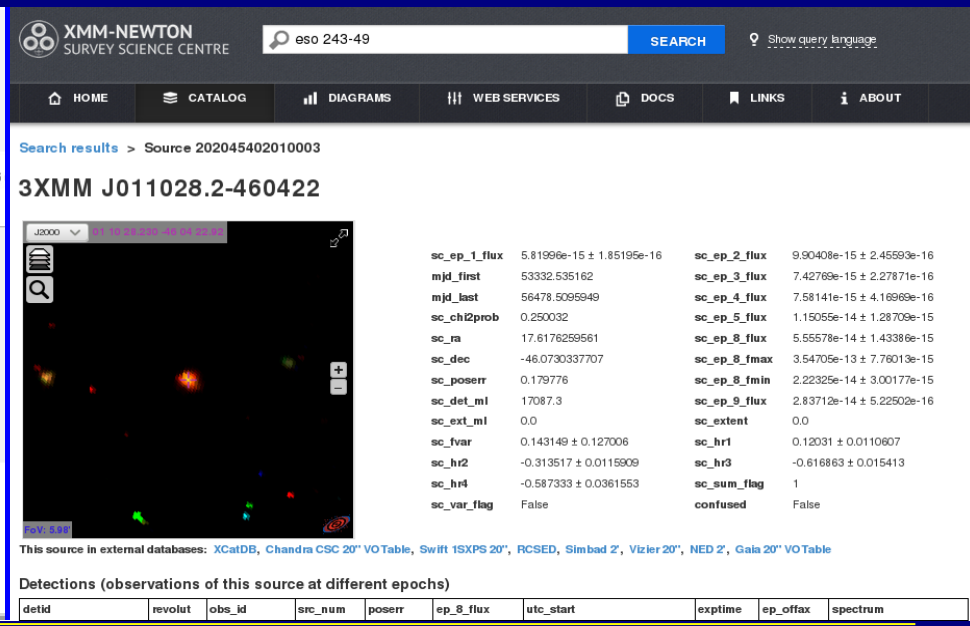
Catalogue

- New incremental version of 3XMM yearly (Rosen, Webb, Watson et al. 2016)
- Latest version, 3XMM-DR8 (16 May 2018, 775153 detections)
- 3XMM-DR8 accessed at IRAP by 2100 people from 87 countries
- Introduced the stacked catalogue (3XMM-DR7s)
- New catalogue server since 2014 (spectral fitting, lightcurve extraction, ...)
- Successful international workshop on high energy catalogues





New for 4XMM-DR9

- improved calibration & software
- pn lightcurves binned to seconds resolution
- background now calculated with smoothing method (not spline)
- KS test also used to evaluate variability (on non-binned data)
- systematic position for poscorok=F improved to 1.29” (from 1.5”)
- new columns: EP EXTENT ML, SC EXTENT ERR, pileup eval., KS test results
- improved methodology to calculate SC_EXTENT and FVAR
- improved pile-up estimate
- radio to gamma-ray SEDS
- sky exposure to be provided for all catalogue
- update to upper limit server, FLIX

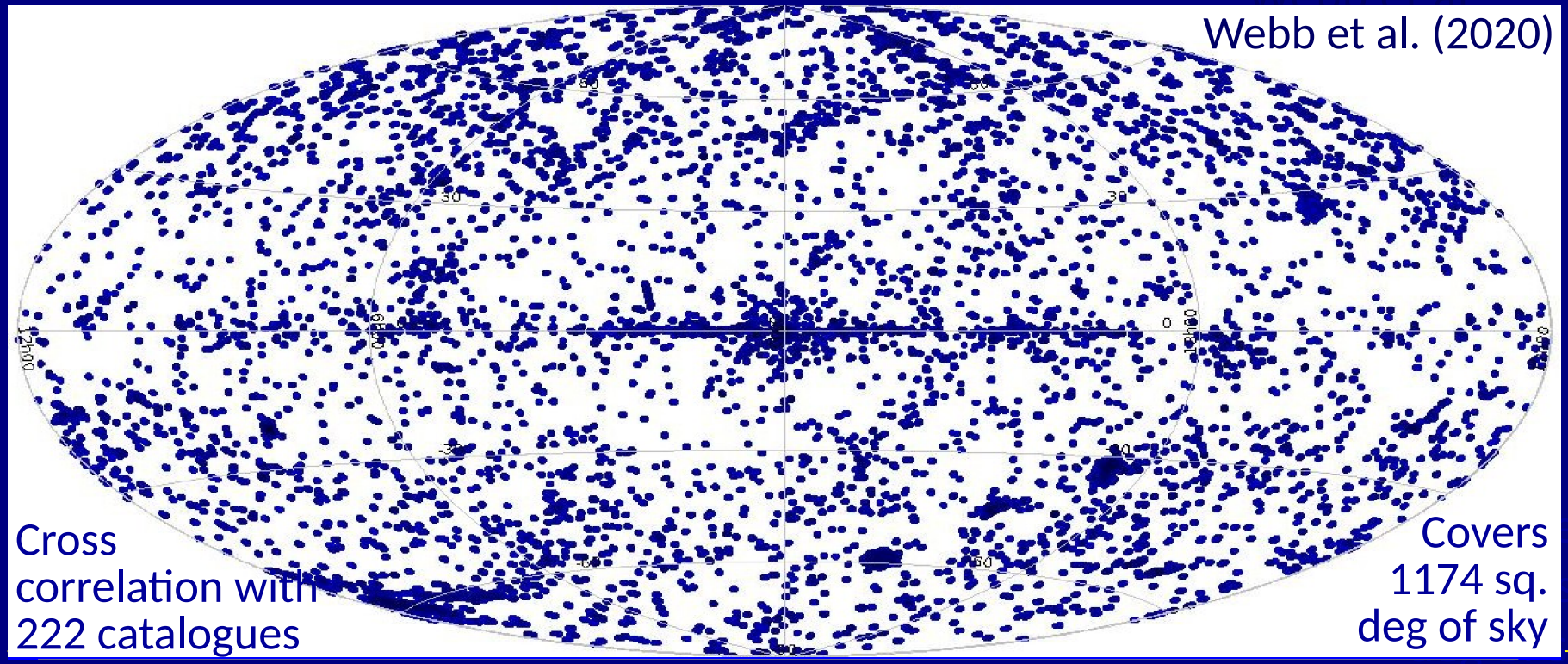
4XMM-DR9

3 February 2000 – 1 March 2019

810795 detections, 550124 unique sources - detected up to 69 times

288282 (36%) sources with spectra and lightcurves

76999 extended sources



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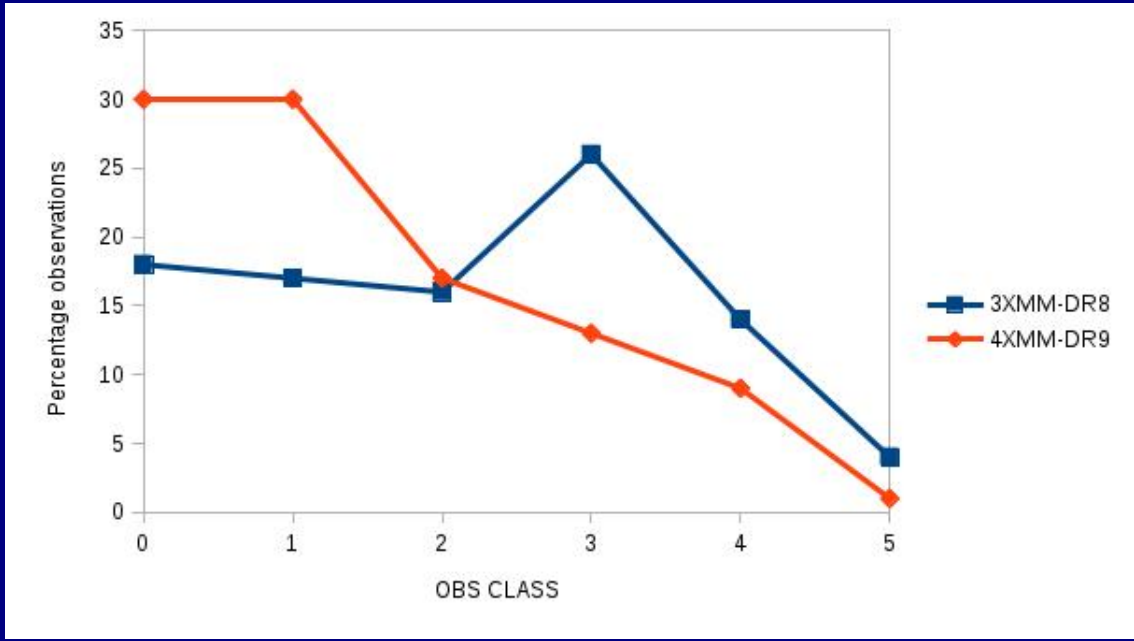
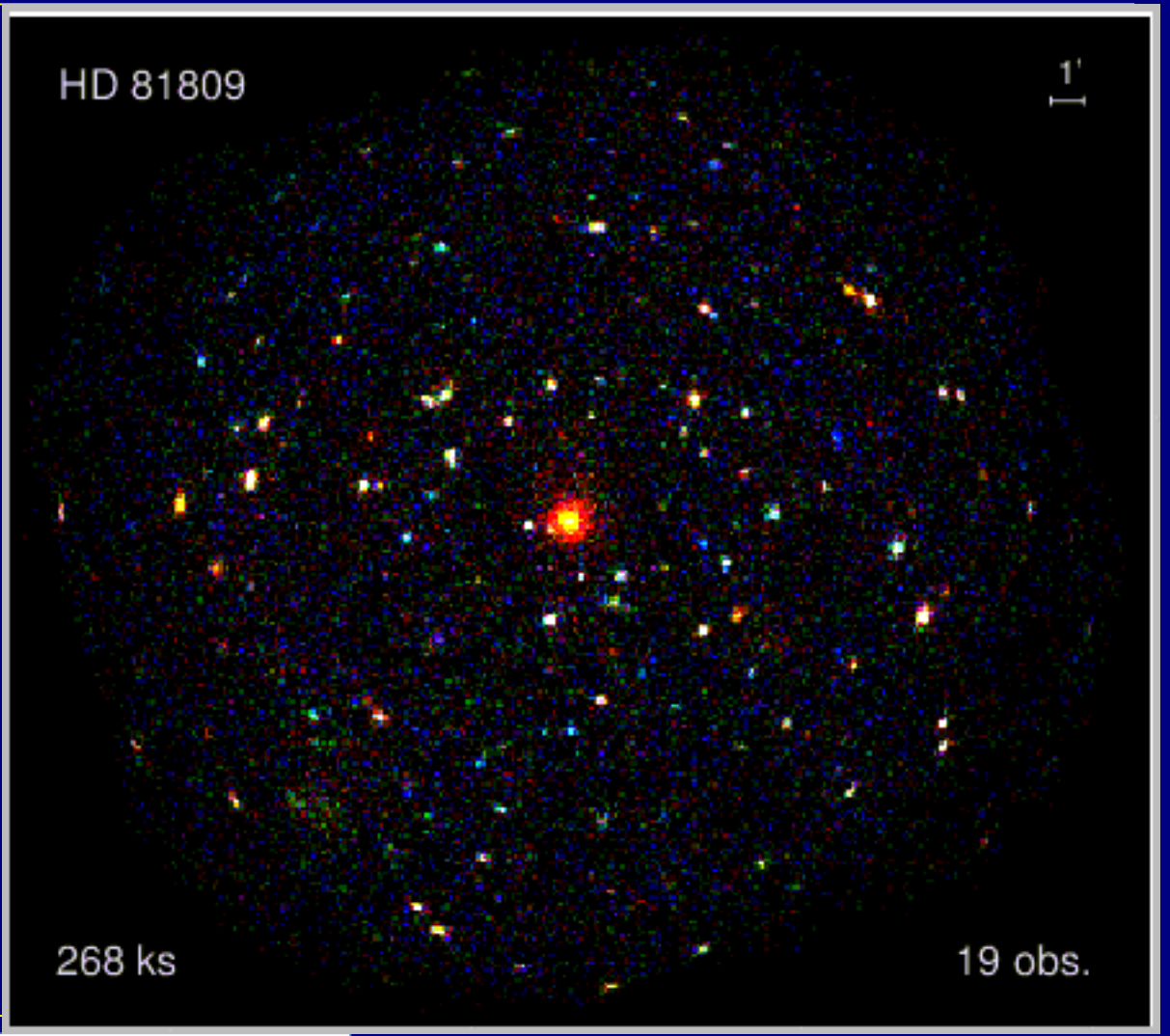
4MM DR9



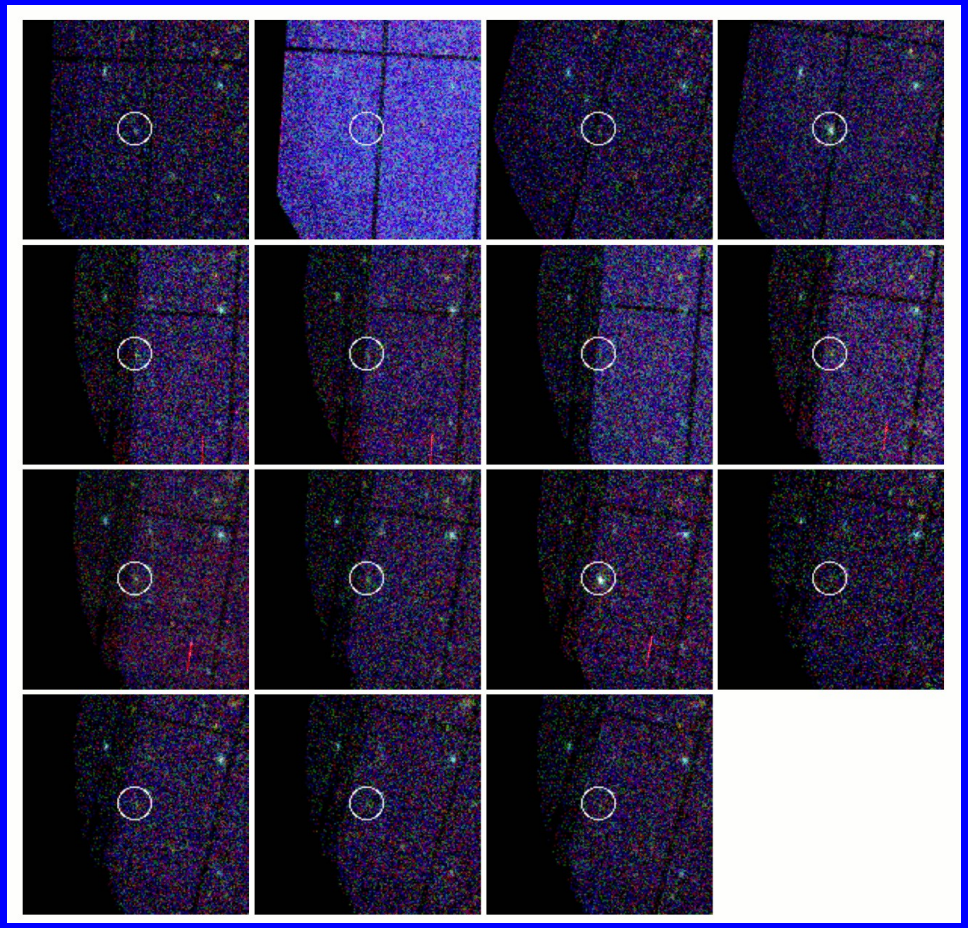
Obsclass	Quality
0	bad area = 0%
1	0% < bad area < 0.1%
2	0.1% < bad area < 1%
3	1% < bad area < 10%
4	10% < bad area < 100%
5	bad area = 100%

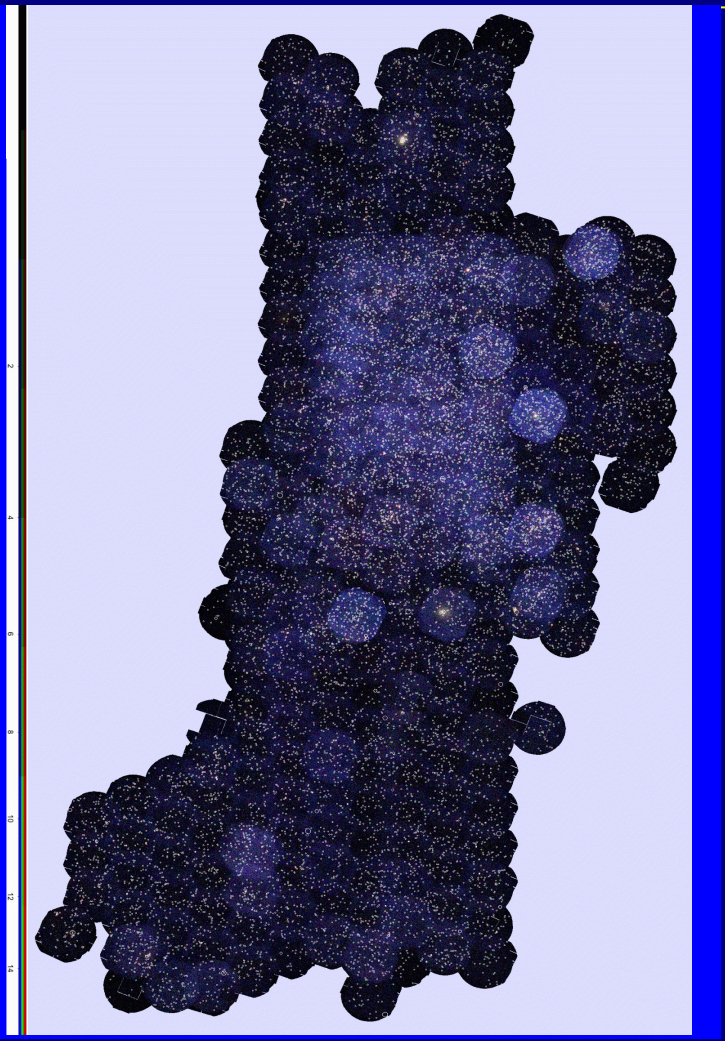
4XMM-DR9s

- 1329 stacks
- 6604 observations
- 288191 sources
- 20% new sources with respect to 4XMM-DR9



4XMM-DR9s





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Summary and future

- Good quality software to reduce all XMM-Newton data
- Reliable pipeline to reduce XMM-Newton data automatically
- Provided a good quality X-ray catalogues widely used by the community
- Provided a complimentary catalogue of ultra-violet and optical sources
- Provided repositories and databases in which to search and exploit the catalogue data and multi-wavelength follow-up data
- Produced a series of well cited papers
- Continued manpower available in the SSC
- Continued collaboration and synergy with the SOC

- Yearly incremental versions of 4XMM
- 5XMM expected for ~2025
- Exploit the time domain capacity of XMM-Newton
- Continue to provide XMM-Newton legacy products over the lifetime of XMM

Ready for the next decade of XMM-Newton

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