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# The XMM-Newton Survey Science Centre SSC

**Mike Watson & Natalie Webb**



XMM-Newton 20<sup>th</sup> Anniversary  
10 - 11 December 2019, ESAC

# Topics

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- 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)

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- 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 Processing Team Leader*)



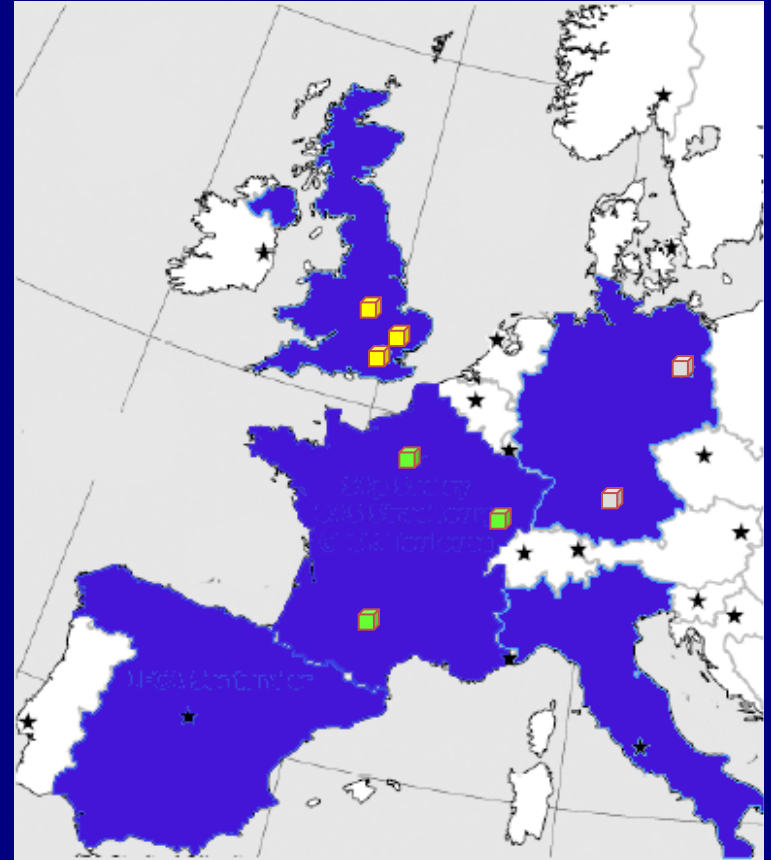
# SSC Consortium (1996)

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

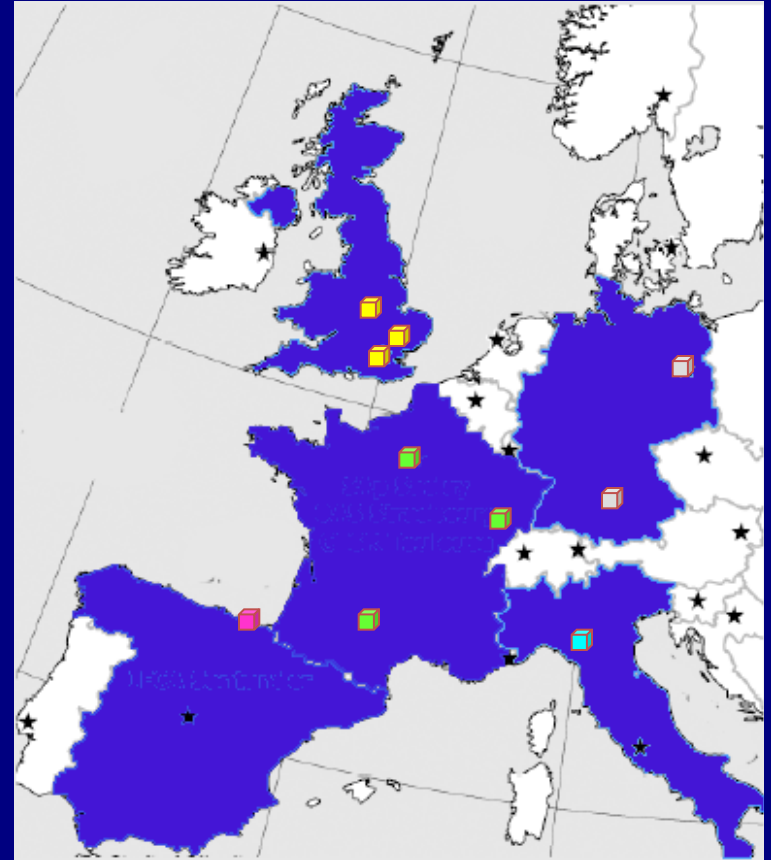
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IFCA Santander (Spain)  
OAB Milano (Italy)

+ Associate Scientists



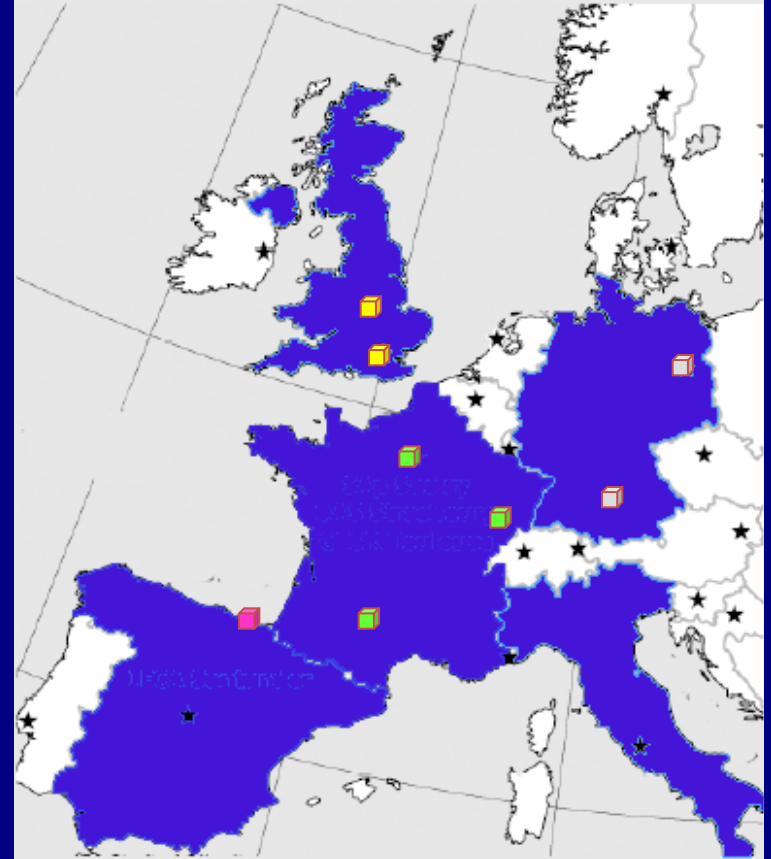
# SSC Consortium (2019)

*University of Leicester (UK)*  
*MSSL (UK)*

*DAP/CEA/Saclay (France)*  
**IRAP Toulouse (France)**  
*OAS Strasbourg (France)*

*AIP Potsdam (Germany)*  
*MPE Garching (Germany)*

*IFCA Santander (Spain)*



# 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

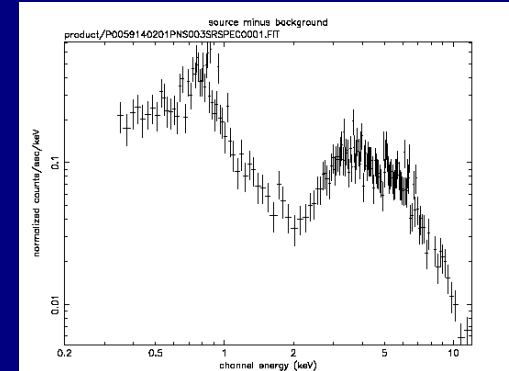
## XID Program

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

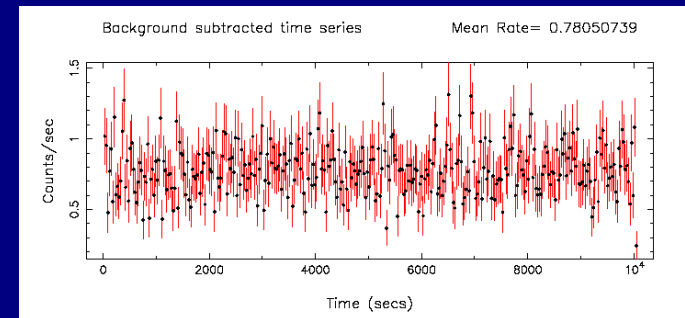
# Pipeline processing

- 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**

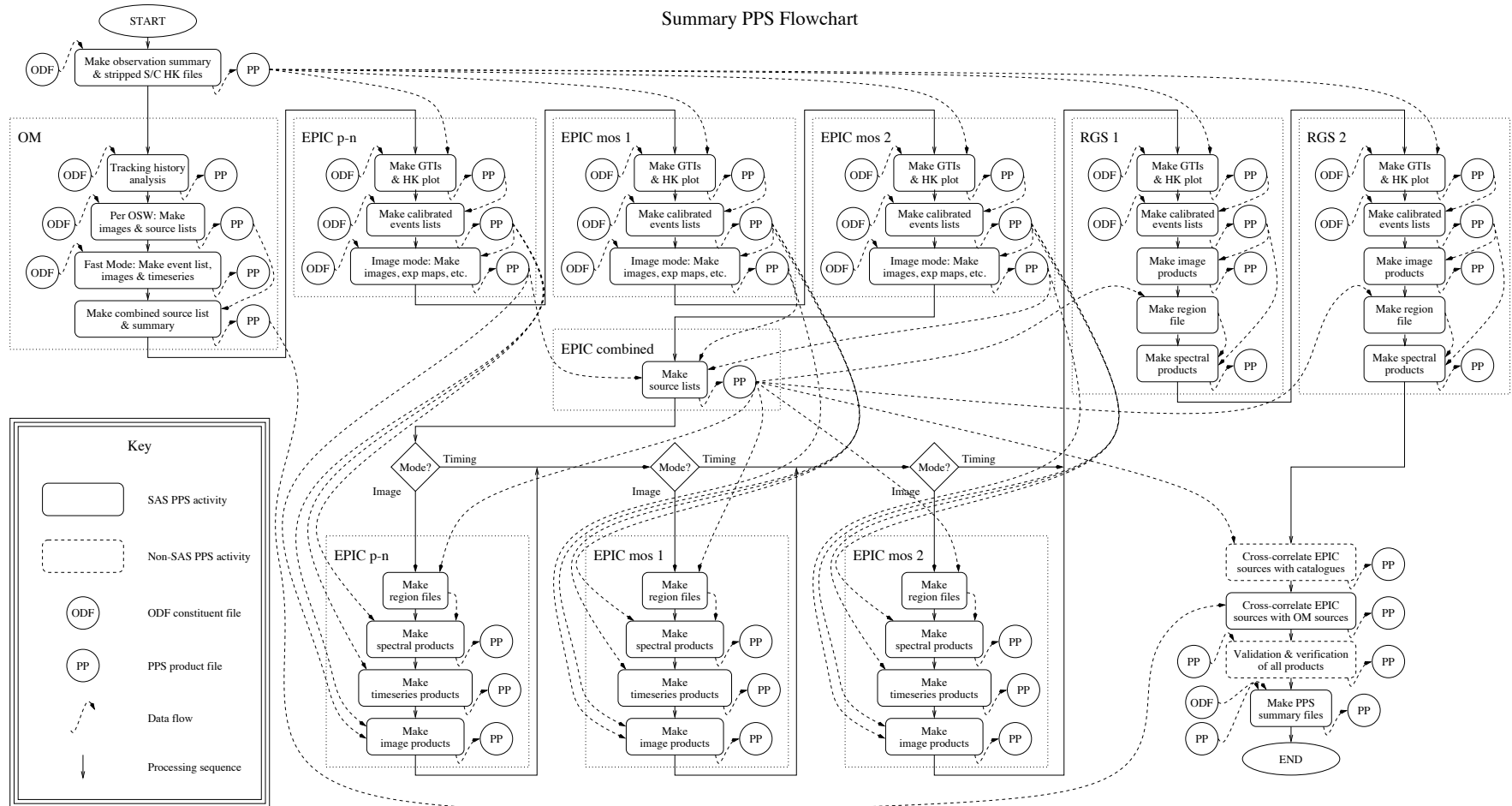


**time series**



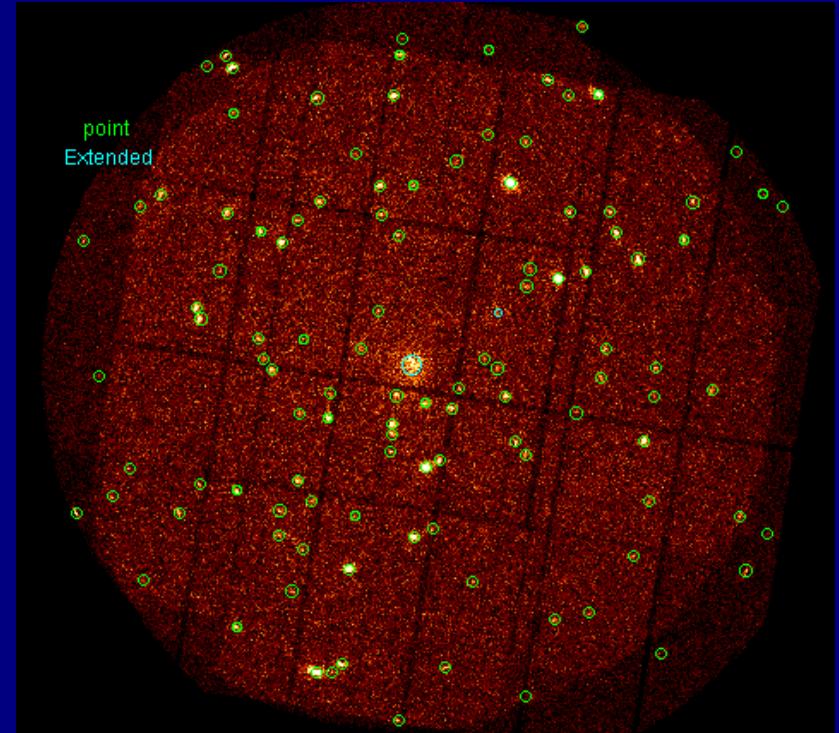
# Simplified processing flowchart

Summary PPS Flowchart



# SSC Serendipitous Source Catalogues

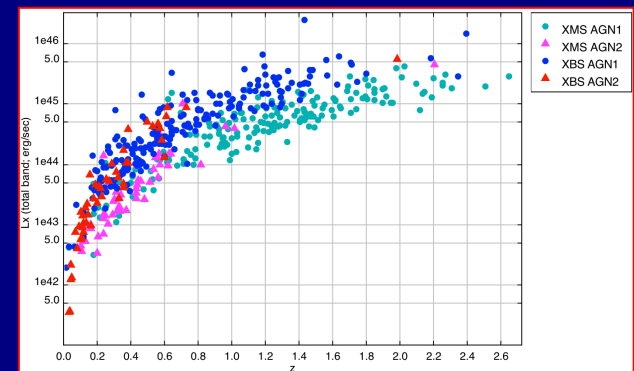
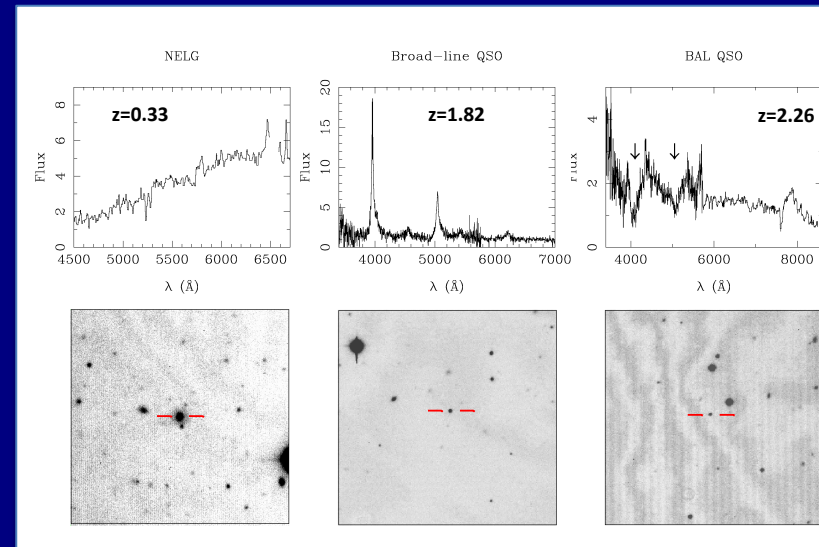
- Each XMM EPIC observation detects 50-200 new\* X-ray sources
- Serendipitous source catalogues created from each observation
- Careful quality control and catalogue characterisation
- First catalogue (1XMM) in 2003
- Latest catalogue (3MM-DR9) in 2018 contains ~500K sources





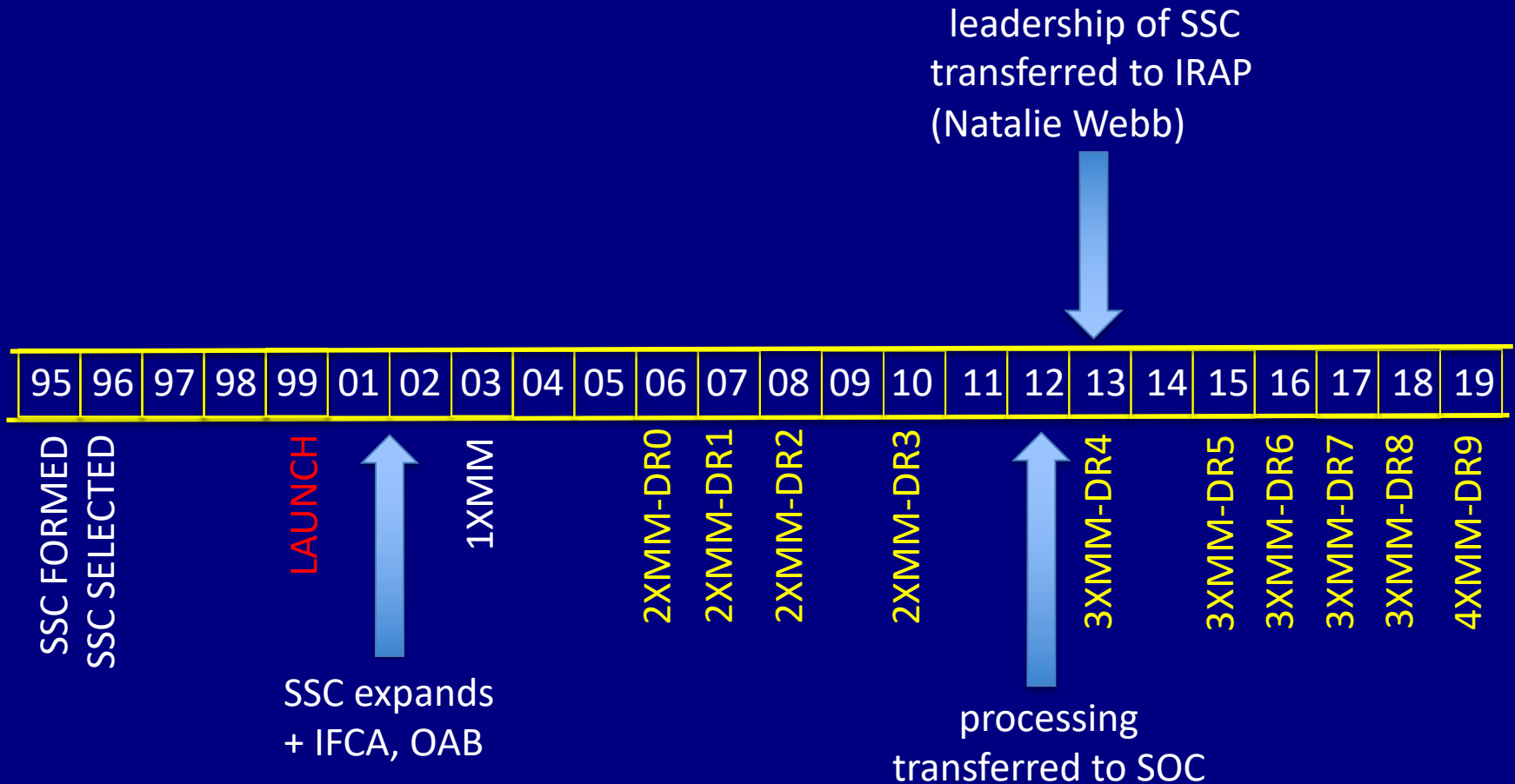
# SSC XID Program

- 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



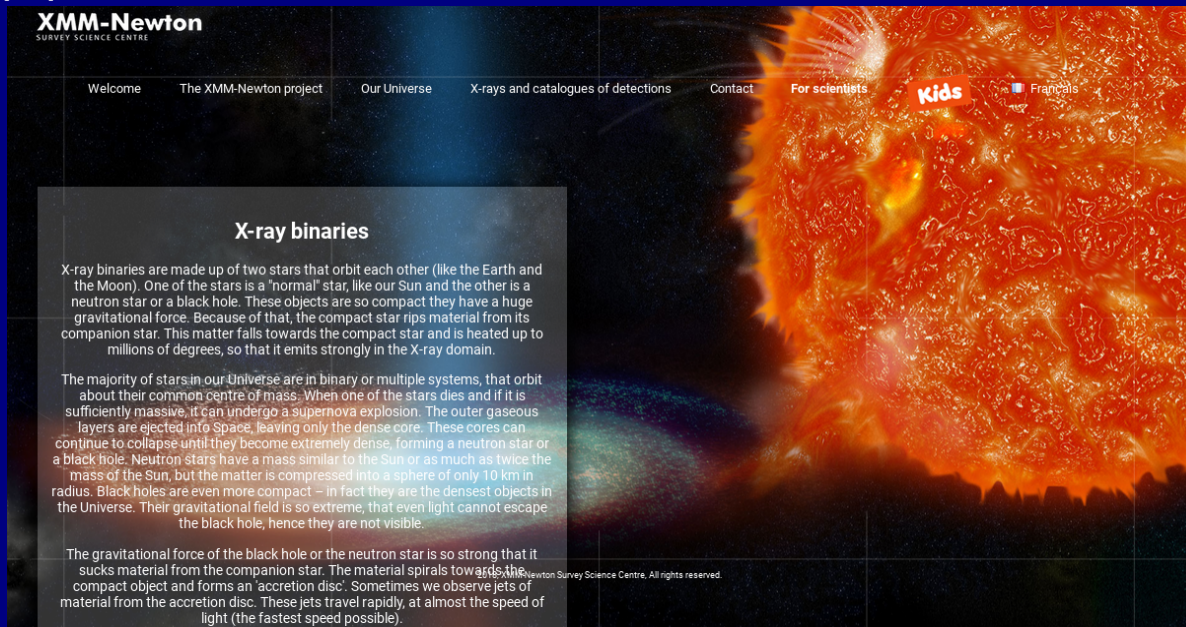


# SSC history: 24 years!



# 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



# 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

3XMM-DR8 Interface - Observatory of Strasbourg  
- DB content - Contact - Landing Page - b

Unique Sources Individual Detections

Edit Query

Show 3 entries Showing 1 to 3 of 6

Selection of Individual Detections

3XMM J011032.5-460445 (id=206930604010112)  
01:10:32.51-46:04:45.2 ± 1.3537arcsec [More...](#)  
Observation 0693060401 23/11/2012 2:42:25

Good detection (0) Point Source  
Det ML 7.8524 (0.2 12keV) Not variable  
7.50E-15 ± 0.08E-15 erg/sec/cm2 (0.2 12keV)  
68 ± 15 counts  
HR1 -0.0859 HR2 -0.9983 HR3 0.9549 HR4 0.3458

EP 0.2-12keV EPw 0.2-12keV CA FChart EPIC Spect. EPIC T.S. Prodex Spectral Fits EP 0.2-1

IMAGE NOT AVAILABLE IMAGE NOT AVAILABLE IMAGE NOT AVAILABLE

Possible Source Identifications

3XMM J011028.2-460422 (id=202045402010003)  
01:10:28.31-46:04:22.2 ± 0.1119arcsec [More...](#)  
Observation 0560180901 28/11/2008 7:51:37

Good detection (0) Point Source  
Det ML 17.087 3008 (0.2 12keV) Not variable  
3.55E-13 ± 7.78E-15 erg/sec/cm2 (0.2 12keV)  
5548 ± 80 counts

EP 0.2-12keV EPw 0.2-12keV CA FChart EPIC Spect. EPIC T.S. Prodex Spectral Fits EP 0.2-1

XMM-NEWTON SURVEY SCIENCE CENTRE

eso 243-49

SEARCH

Show query language

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Search results > Source 202045402010003

3XMM J011028.2-460422

12000

5.81996e-15 ± 1.85195e-16  
53332.535162  
56478.5095949  
0.250032  
17.6176269561  
-46.0730337707  
0.179776  
17087.3  
0.0  
0.143149 ± 0.127006  
-0.313517 ± 0.0115909  
-0.587333 ± 0.0361553  
False

sc\_ep\_1\_flux  
mjd\_first  
mjd\_last  
sc\_ch2prob  
sc\_ra  
sc\_dec  
sc\_poserr  
sc\_det\_ml  
sc\_ext\_ml  
sc\_fvar  
sc\_hr2  
sc\_hr4  
sc\_var\_flag

9.90408e-15 ± 2.45593e-16  
7.42769e-15 ± 2.27871e-16  
7.58141e-15 ± 4.18686e-16  
1.15055e-14 ± 1.28709e-15  
5.56578e-14 ± 1.43386e-15  
3.54705e-13 ± 7.76013e-15  
2.2325e-14 ± 3.00177e-15  
2.83712e-14 ± 5.22502e-16  
0.0  
0.12031 ± 0.0110807  
-0.616863 ± 0.015413  
1  
False

sc\_ep\_2\_flux  
sc\_ep\_3\_flux  
sc\_ep\_4\_flux  
sc\_ep\_5\_flux  
sc\_ep\_6\_flux  
sc\_ep\_8\_fmax  
sc\_ep\_8\_fmin  
sc\_ep\_9\_flux  
sc\_ext  
sc\_hr1  
sc\_hr3  
sc\_sum\_flag  
confused

This source in external databases: XCatDB, Chandra CSC 20" VO Table, Swift 1SXPS 20", RCSED, Simbad 2", Vizier 20", NED 2", Gaia 20" VO Table

Detections (observations of this source at different epochs)

detid	revolut	obs_id	src_num	poserr	ep_8_flux	utc_start	exptime	ep_offax	spectrum
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# New for 4XMM-DR9

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- 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

4XMM-DR9

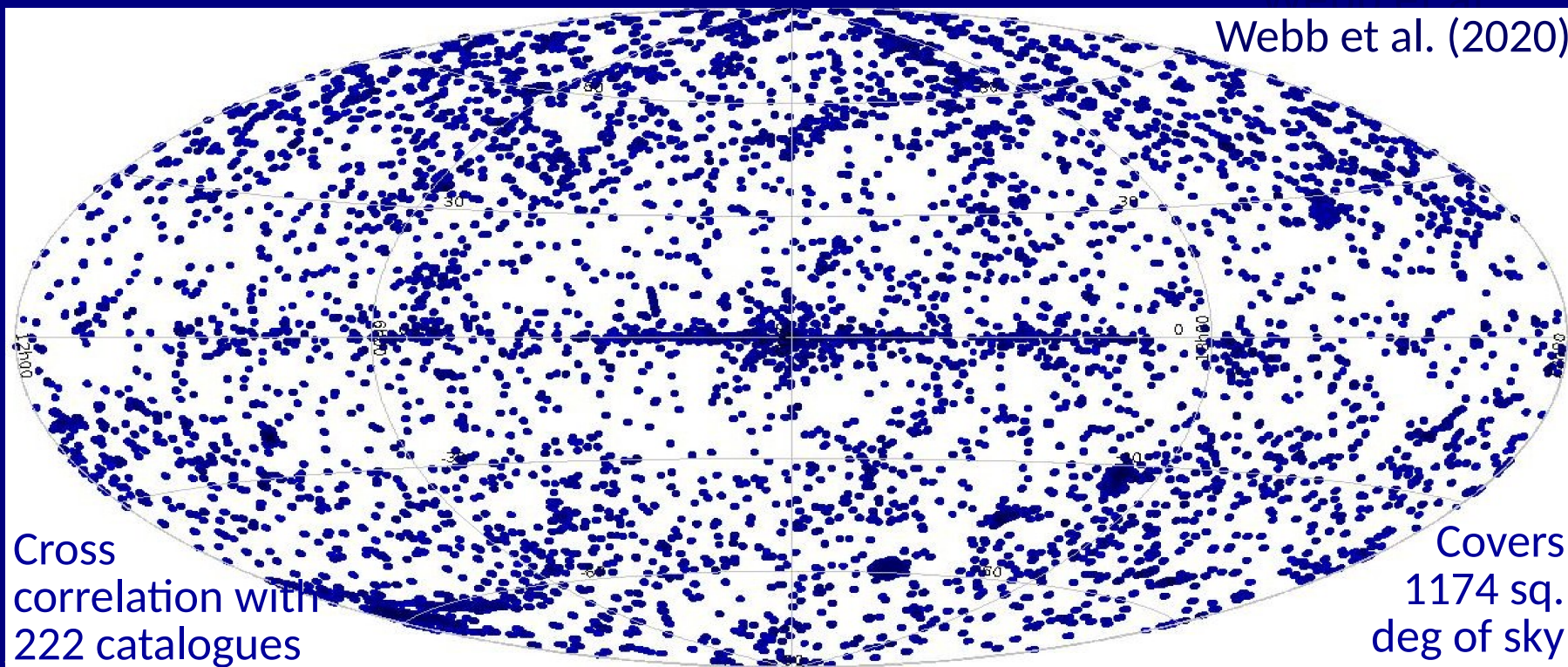
3 February 2000 – 1 March 2019

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

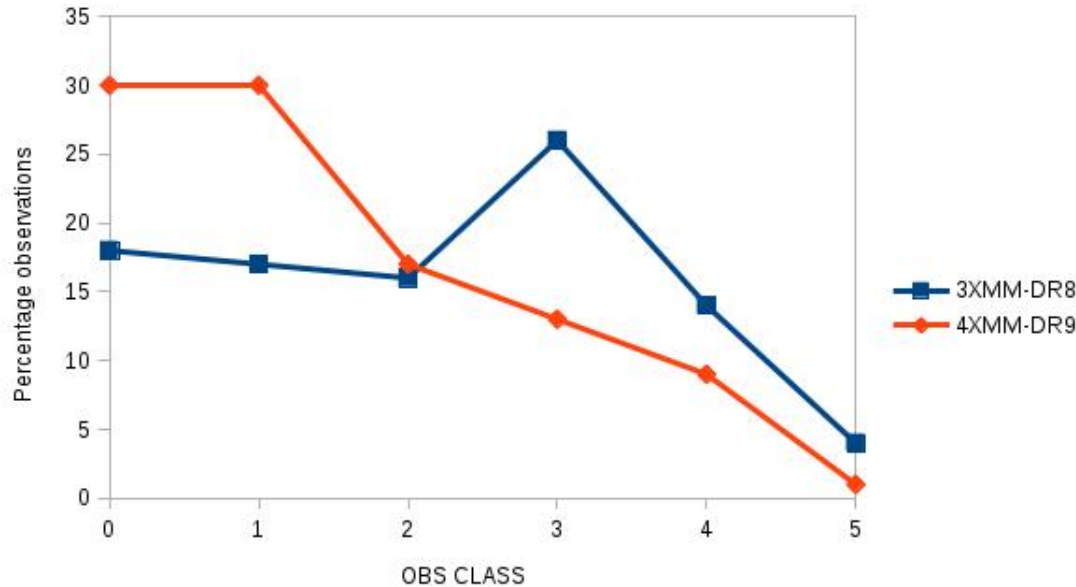
288282 (36%) sources with spectra and lightcurves

76999 extended sources

Webb et al.  
Webb et al. (2020)



# 4MM DR9

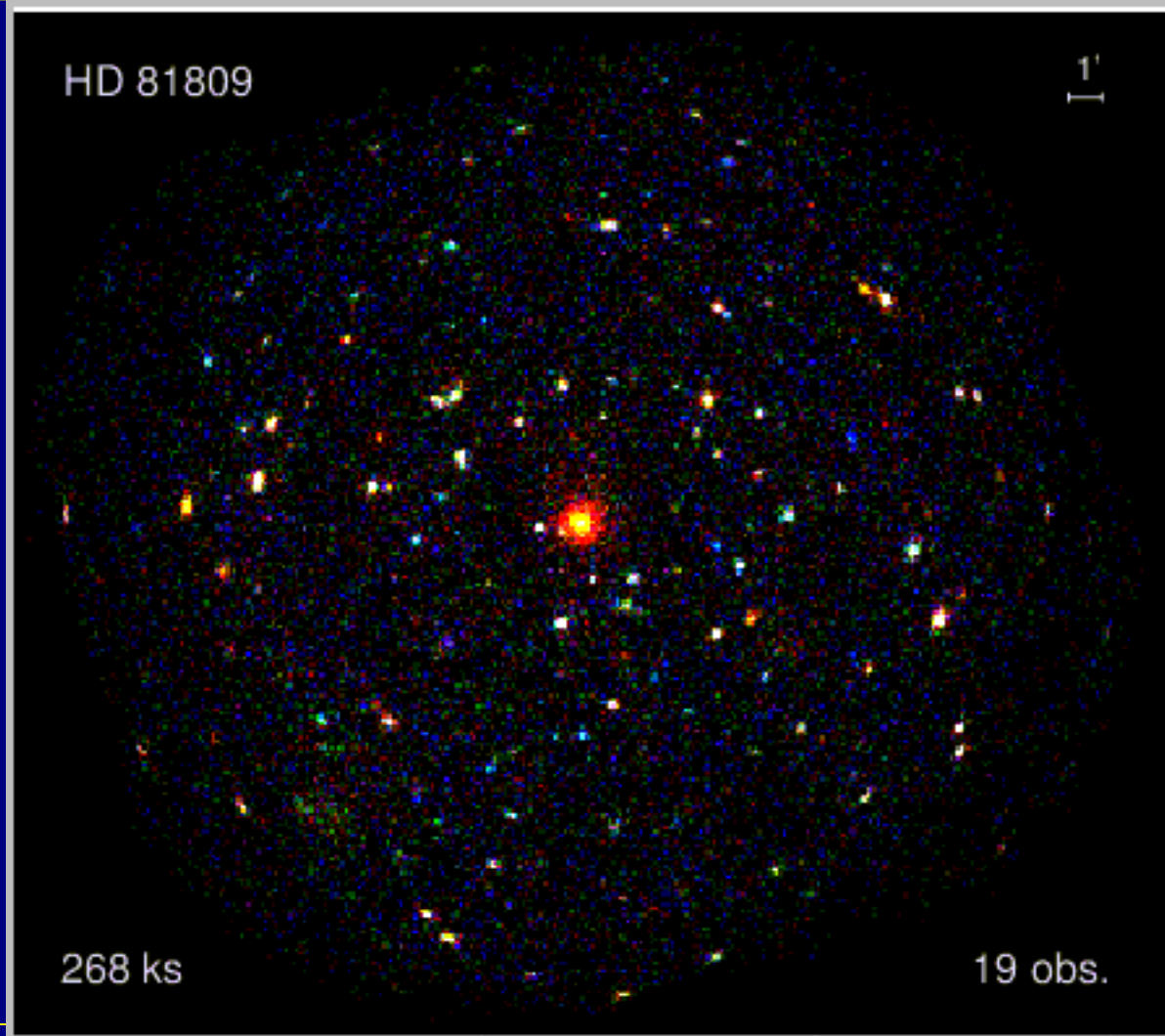


Obsclass	Quality
0	bad area = 0%
1	0% < bad area < 0.1%
2	0.1% < bad area < 1%
3	1% < bad area < 10%
4	10% < bad area < 100%
5	bad area = 100%

# 4XMM-DR9s

4XMM-DR9

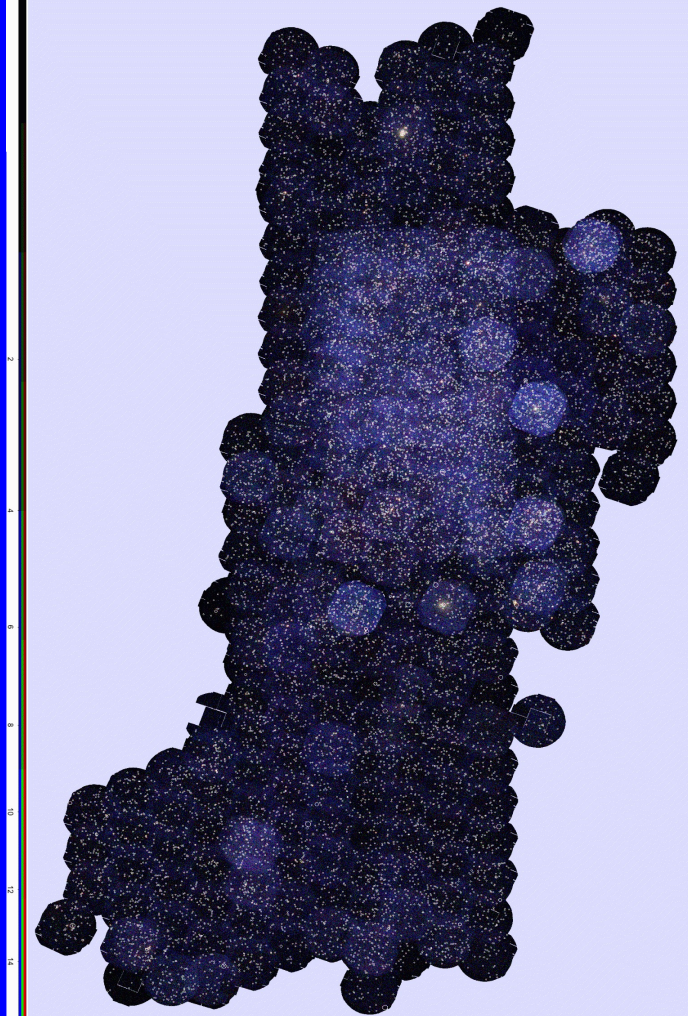
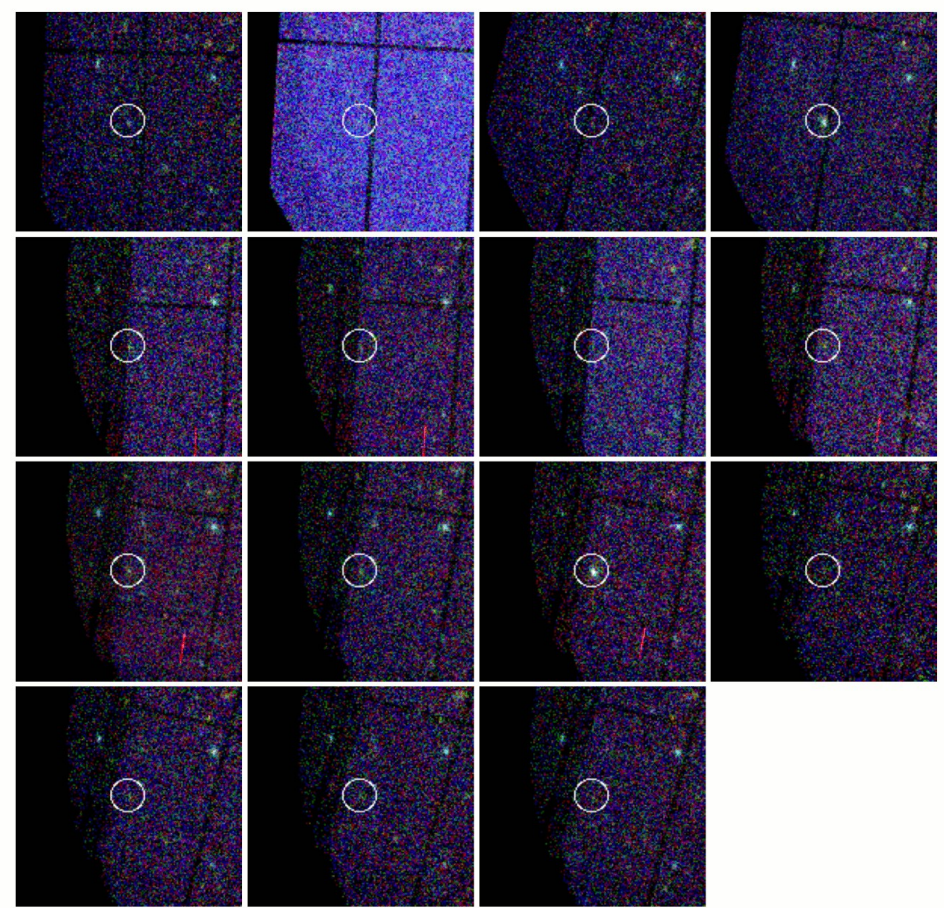
- 1329 stacks
- 6604 observations
- 288191 sources
- 20% new sources with respect to 4XMM-DR9





# 4XMM-DR9s

~~4XMM-DR9~~





# Summary and future

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- 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

