
High energy data, Catalogues & Data archives

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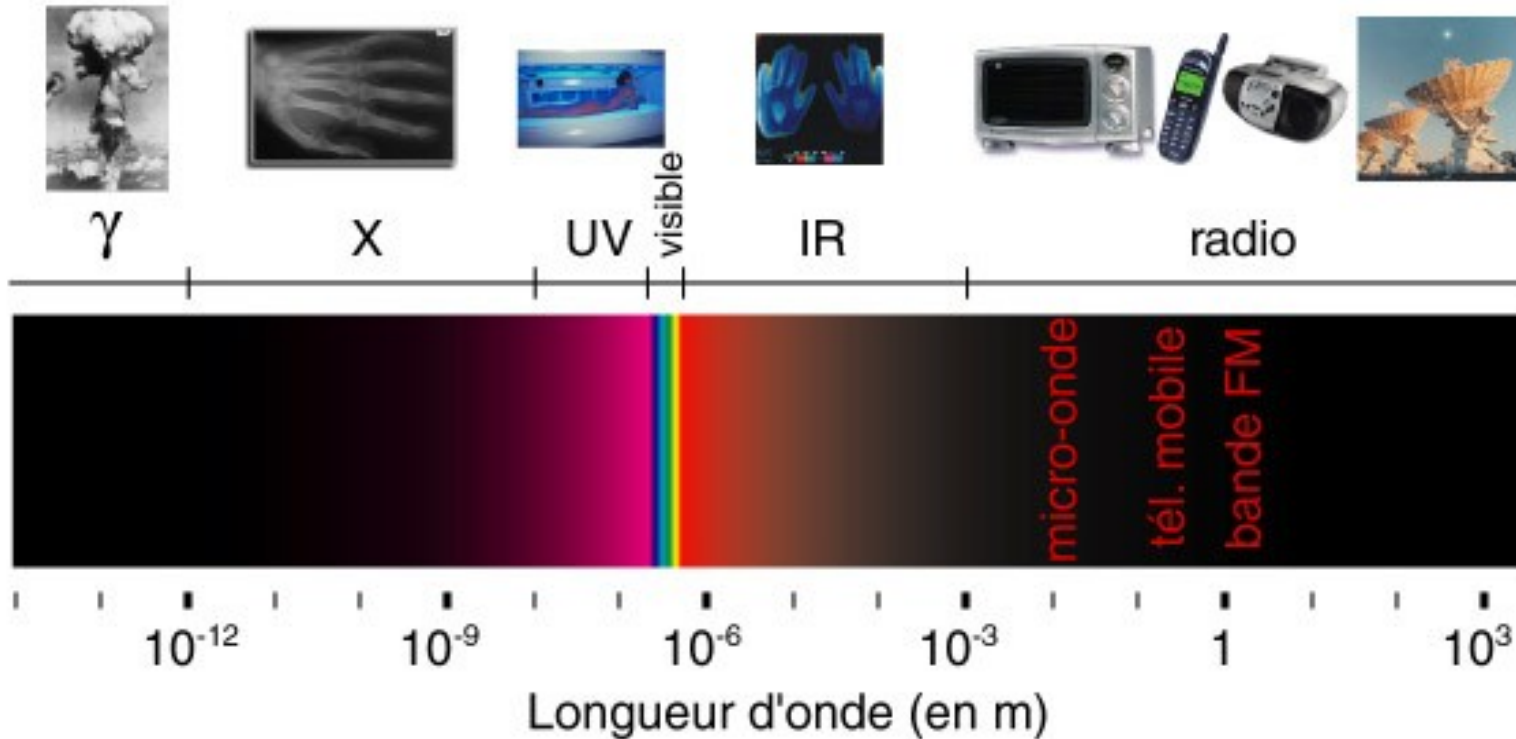


Outline

- 1) High energy data and FITS data files
- 2) High energy data reduction steps, detection of point sources
- 3) High energy data archives/catalogues
- 4) Exploiting high energy archival data on line or with the software "Topcat"

High Energy data

What is high energy ?



Optical
 4×10^{-19} J

X-rays
 $> 2 \times 10^{-17}$ J

Electron volt
(eV)
 1.6×10^{-19} J

$$c = \nu \lambda$$

$$E = h\nu n$$

$$(E = hc/\lambda l)$$

c = speed of light in vacuum (3.00×10^8 m s⁻¹)

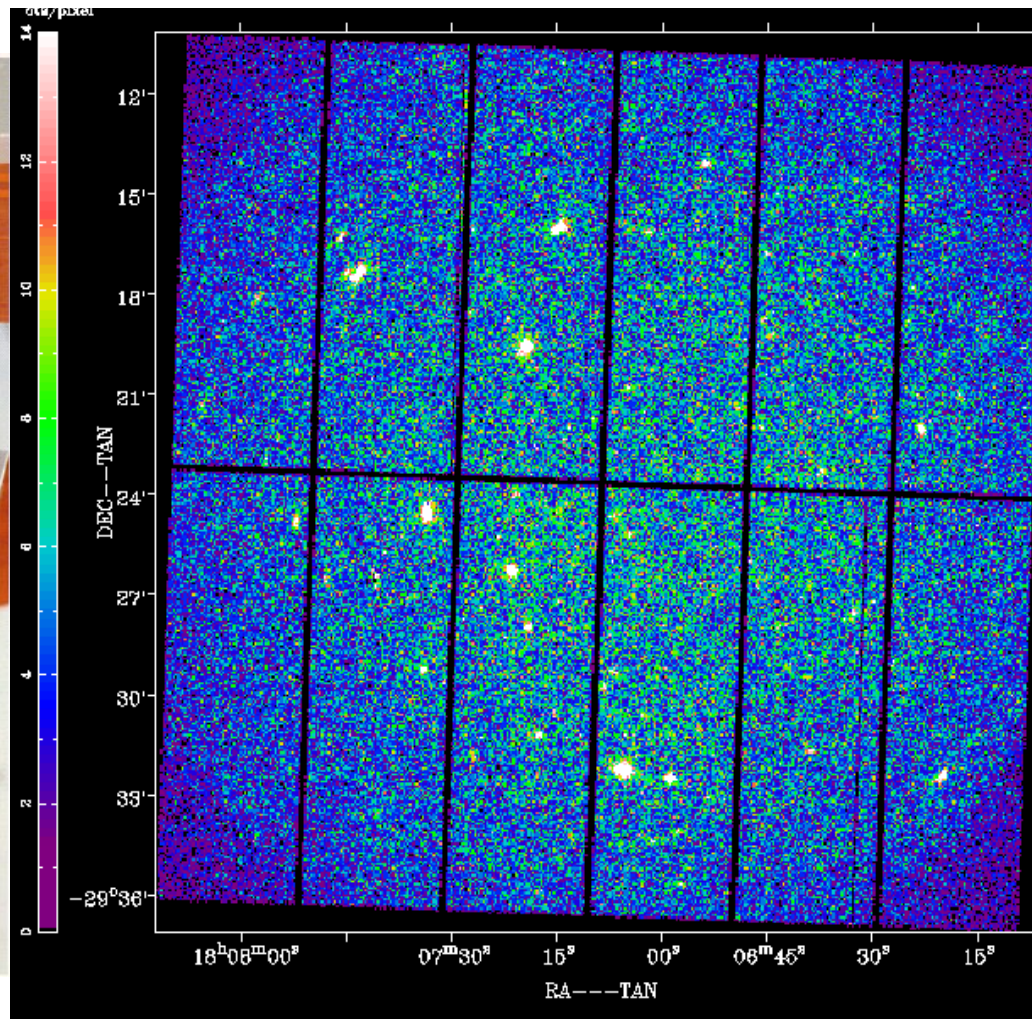
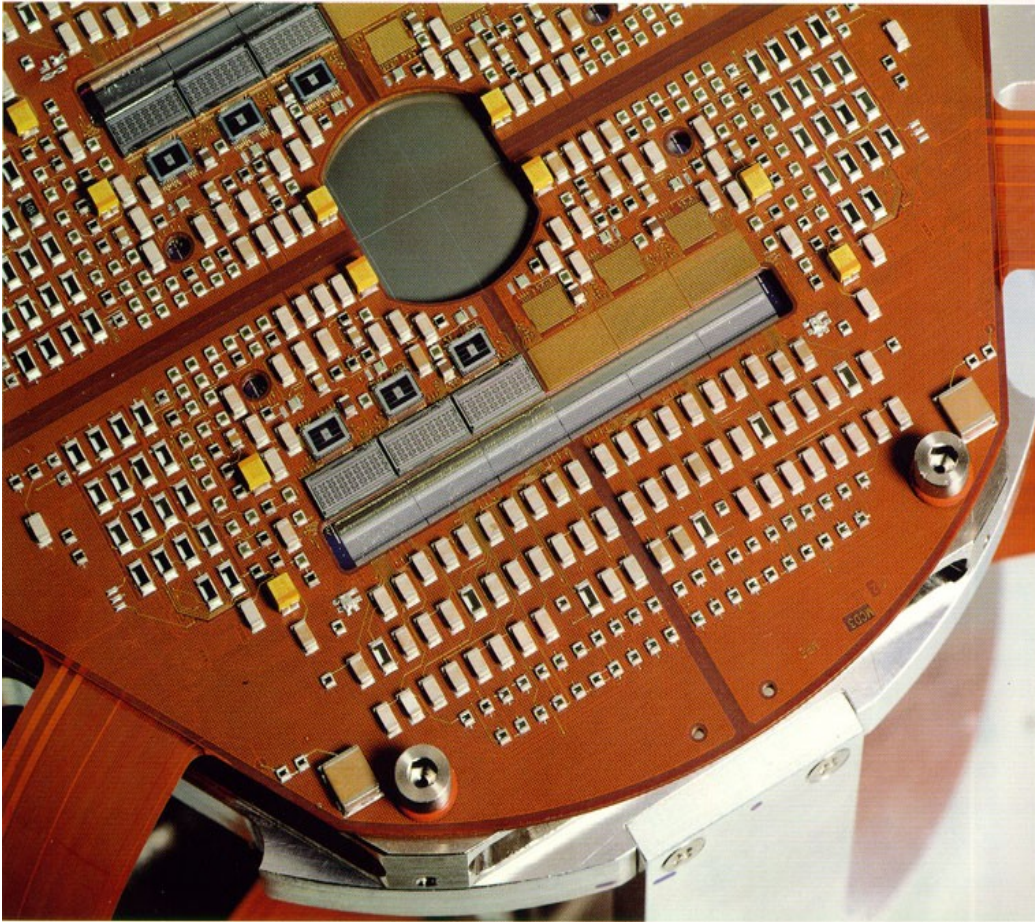
ν = frequency

λ = wavelength

E = energy

h = Planck constant (6.6×10^{-34} J s)

High Energy data



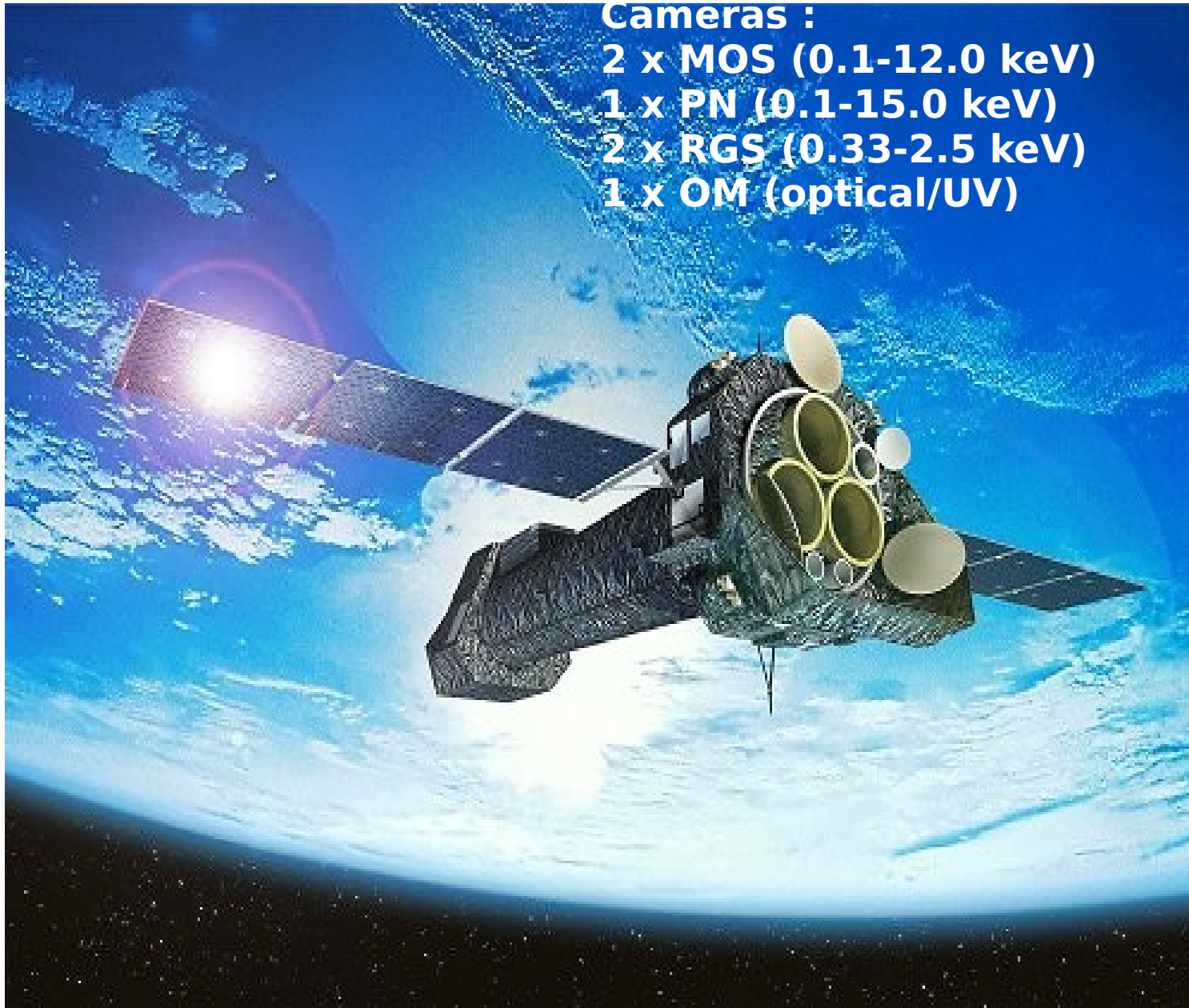
Know photon: Position on CCD
 Time of arrival
 Energy

High Energy data

X-ray detectors are photon-counting => two main consequences:

- X-ray astronomy is an intrinsic Poissonian science – scientific products can have a few or even zero events in large ranges of their parameter spaces
- The event is characterised by:
 - position on the detector
 - “pulse height”, which is related to the X-ray energy of the incoming photon in a complex and generally non-linear way
 - arrival time at the spacecraft
 - event “shape” (used to separate X-ray events from particles)
 - CCD number, and other secondary attributes (you don’t generally have to worry about)

Example : XMM-Newton



High Energy data

From observation data file (example XMM-Newton data):

emframes on auxiliary file, event file and external GTI file (if any), to create a frame file and a CCD/node specific GTI file

badpix to add BADPIX extension to event file. If bad pix file exists, it is used instead of the CAL calls for the non-uplinked bad pixels.

emevents on event list, offset/variance & frame file, to create new event list

gtialign on external GTI file and event file

gtimerge to merge resulting aligned GTI and the CCD/node GTI.

attcalc (attitude correction) on new event list, filling the X/Y columns.

emenergy on new event list, filling the FLAG, PHA and PI columns.

The event list

File Edit Tools Help

TIME RAWX RAWY DETX DETY X Y PHA PI FLAG PATTERN PAT_ID PAT_SEQ CCDNR

Select D I I I I J J I I J B I B B
 All s pixel pixel 0.05 arcsec 0.05 arcsec 0.05 arcsec 0.05 arcsec channel eV
 Invert Modify Modify Modify Modify Modify Modify Modify Modify Modify Modify Modify Modify Modify

1	2.873553184715E+08	15	142	-3418	3792	27837	28609	56	432	0	2	5121	0	1
2	2.873553185031E+08	29	81	-4648	8765	28182	33720	124	890	0	2	5121	0	1
3	2.873553185090E+08	24	140	-4170	3961	28548	28907	1077	5611	0	0	0	0	1
4	2.873553186078E+08	42	57	-5646	10759	28817	35858	767	3952	0	0	0	0	1
5	2.873553185756E+08	24	118	-4186	5785	28246	30705	364	1907	0	0	0	0	1
6	2.873553186103E+08	34	144	-5043	3611	29469	28714	1073	5652	0	0	0	0	1
7	2.873553186446E+08	54	19	-6668	13934	29270	39162	302	1533	0	0	0	0	1
8	2.873553186391E+08	13	60	-3261	10554	26504	35240	860	4300	0	0	0	0	1
9	2.873553186888E+08	9	71	-2930	9621	26341	34264	798	4009	0	0	0	0	1
10	2.873553187408E+08	45	38	-5917	12391	28800	37512	314	1632	0	0	0	0	1
11	2.873553187889E+08	32	44	-4888	11870	27877	36820	1019	5063	0	0	0	0	1
12	2.873553188425E+08	63	131	-7421	4697	31621	30198	179	988	0	0	0	0	1
13	2.873553188314E+08	64	139	-7469	3998	31791	29518	625	3433	4	0	0	0	1
14	2.873553189489E+08	56	75	-6837	9315	30242	34643	29	152	2097152	0	0	112	1
15	2.873553189541E+08	52	103	-6521	6994	30335	32303	446	4540	0	2	5121	0	1
16	2.873553191227E+08	56	88	-6821	8259	30410	33601	1648	8609	0	0	0	0	1
17	2.873553191289E+08	54	143	-6701	3725	31082	29115	679	4306	0	1	5121	0	1
18	2.873553191173E+08	22	175	-4054	1064	28939	26034	1219	6445	0	0	0	0	1
19	2.873553192505E+08	38	115	-5326	6020	29328	31135	276	1490	0	0	0	0	1
20	2.873553192389E+08	7	183	-2769	379	27793	25135	1811	9855	0	3	5121	1	1

Go to: Edit cell:

Cleaning X-ray data

Filter for high background (soft proton flares):

Create a binned lightcurve of data above 10 keV (*evselect*)

```
MOS : (PI>=10000)&&(PATTERN==0)&&(#XMMEA_EM)
```

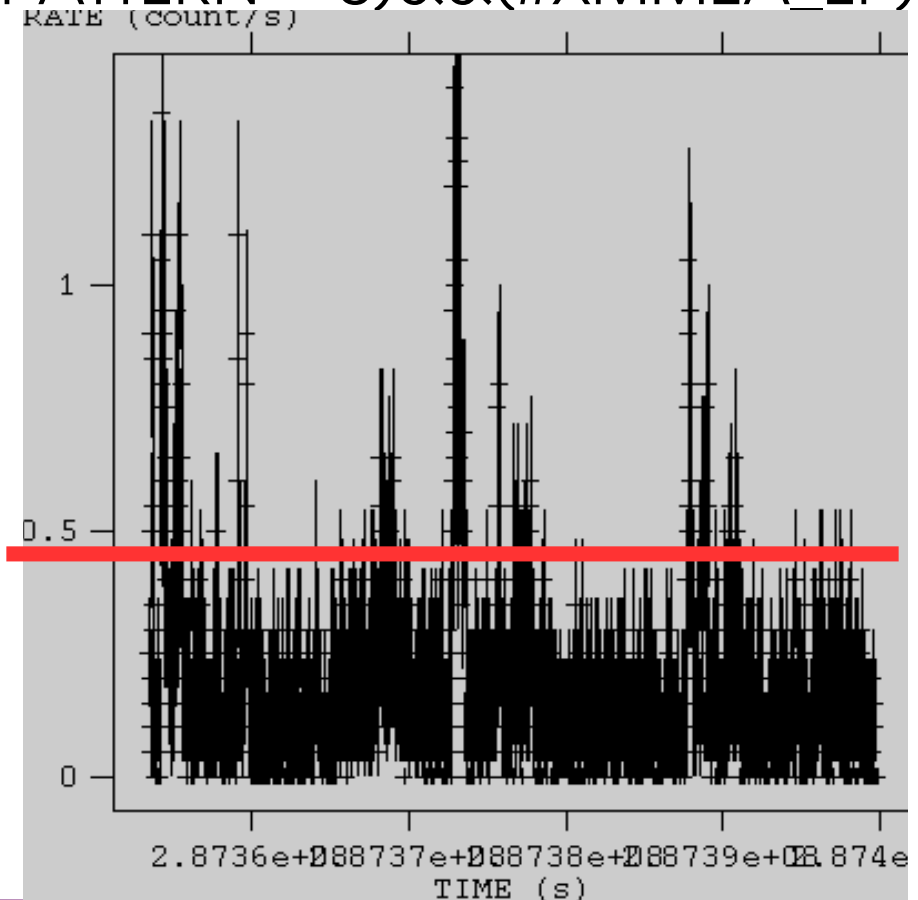
```
pn : (PI in (10000:12000))&&(PATTERN==0)&&(#XMMEA_EP)
```

Identify count rate above which the background is not low and stable

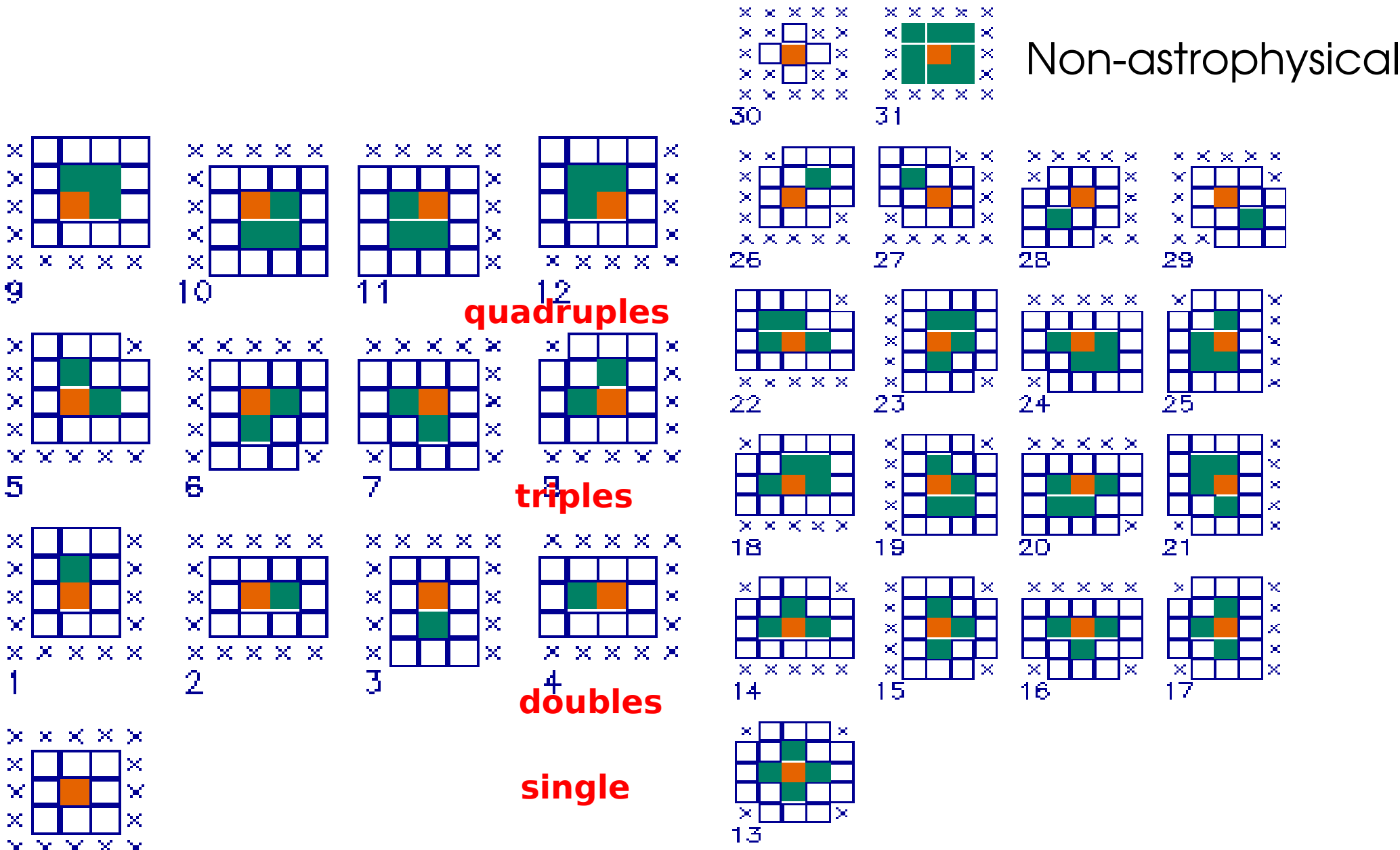
Create good time intervals (*tabgtigen*)

Filter for good time, X-ray patterns, etc (*evselect*)

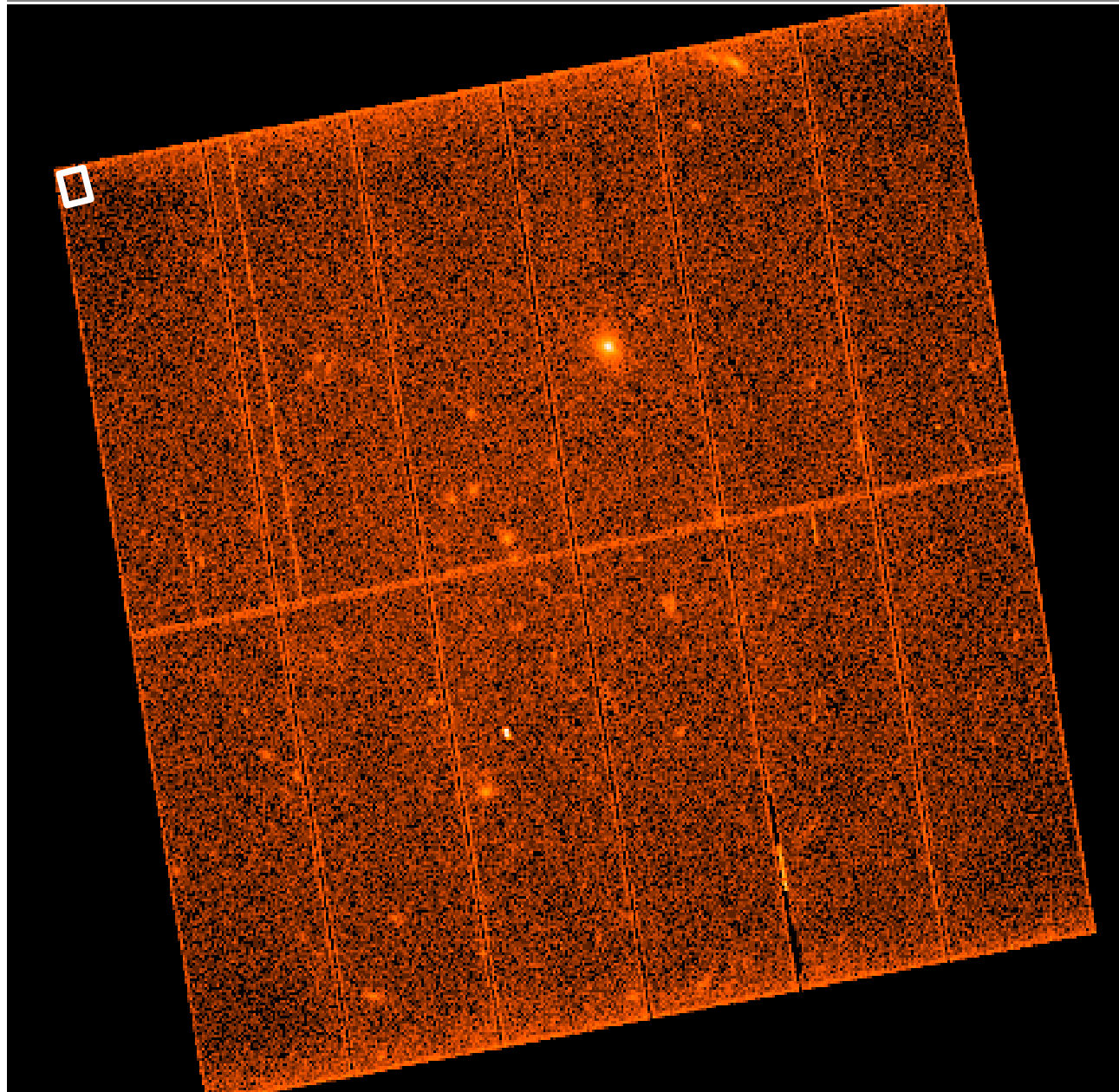
```
MOS : (PATTERN<=12)&&(#XMMEA_EM)  
&&GTI(m1.gti,TIME)&&(PI in (200:12000))
```



Astrophysical and non-astrophysical patterns



X-ray source detection



X-ray source detection

edetectchain

eexpmap	creation of exposure maps	attitude file, event list, image	exposure maps	eboxdetect (map mode)	box detection using background maps	images, exposure maps, detection mask, background maps	map detect source list
emask	creation of detection masks	exposure map	detection mask				
eboxdetect (local mode)	sliding box detection	images, exposure maps, detection mask	box detect source list	emldetect	maximum likelihood fitting	images, exposure maps, background maps, map detect list	final source list
esplinemap	creation of background maps	image, exposure map, detection mask, local box list	background map	esensmap	creation of sensitivity maps	exposure map, detection mask, background map	sensitivity map

Alternative : *ewavelet*, based on a Mexican hat wavelet algorithm

Catalogues

The majority of observatories today provide some form of catalogue of detections

They cover all wavelengths and contain a variety of information

Catalogues are useful for :

- Quick access to data products (fluxes, spectra, images, etc)
- Finding new objects
- Population studies
- Cross correlation for multi-wavelength studies

Existing catalogues at :<http://vizier.u-strasbg.fr/viz-bin/VizieR>
- 14465 catalogues

Any one catalogue is usually provided in >1 format

Catalogue formats

Catalogues are often provided in tabular form (fits, csv, text)

These tabular forms can be manipulated with :

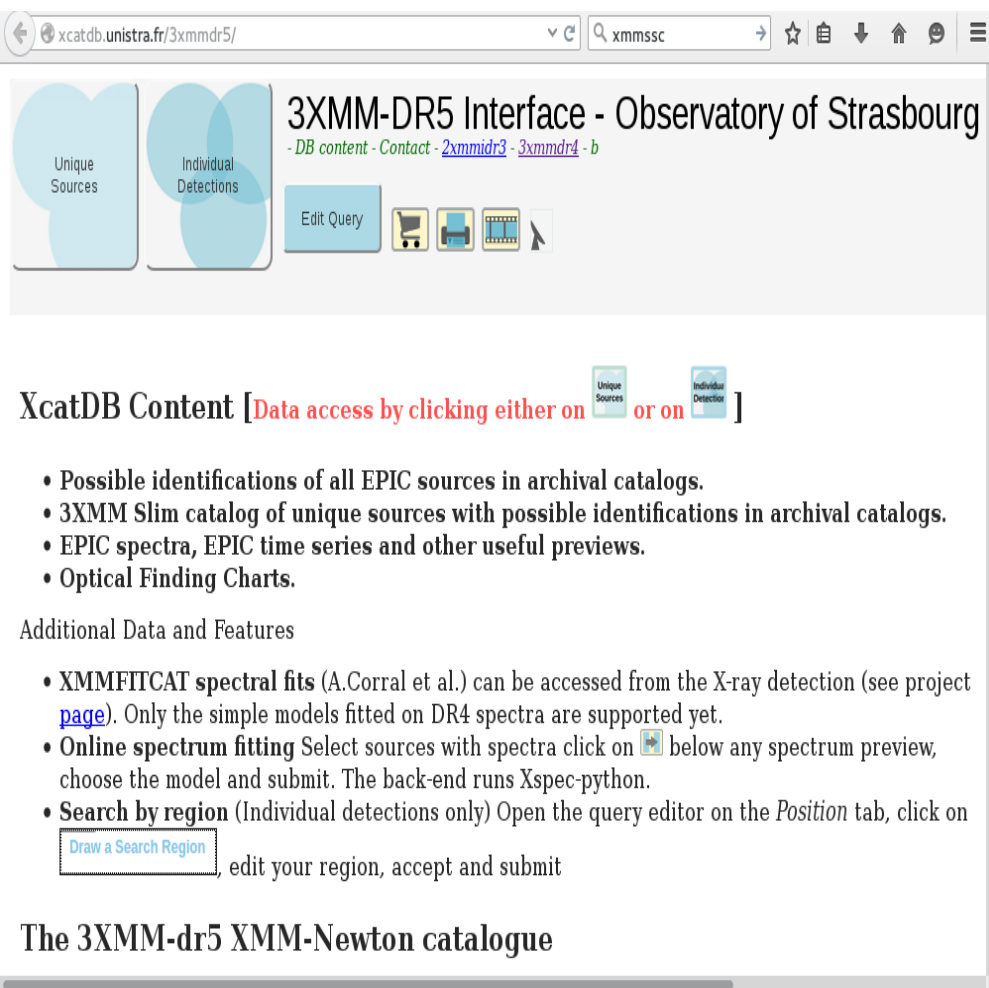
- sql scripts
- ftools
- excel (or similar)
- dedicated software such as Topcat/Stilts
- scripts (python, c, idl,)
- many, many other things !!!



This allows you to have complete freedom to access all aspects of the catalogue

Catalogue formats, example : 3XMM

Alternatively they can be accessed via online archives, e.g. :



3XMM-DR5 Interface - Observatory of Strasbourg
- DB content - Contact - [2xmmidr3](#) - [3xmmidr4](#) - b


Unique Sources Individual Detections

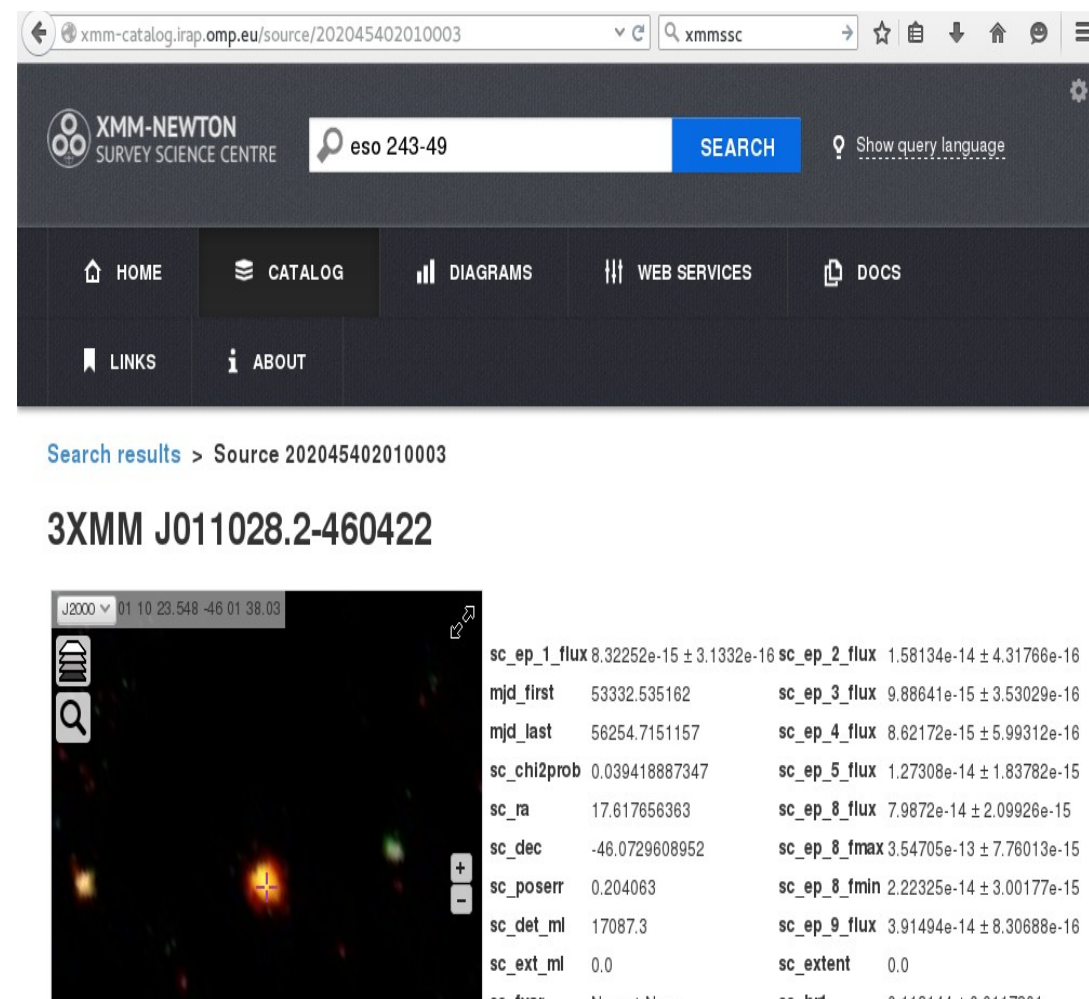
Edit Query

XcatDB Content [Data access by clicking either on Unique Sources or on Individual Detections]

- Possible identifications of all EPIC sources in archival catalogs.
- 3XMM Slim catalog of unique sources with possible identifications in archival catalogs.
- EPIC spectra, EPIC time series and other useful previews.
- Optical Finding Charts.

Additional Data and Features

- XMMFITSAT spectral fits (A.Corrál et al.) can be accessed from the X-ray detection (see project [page](#)). Only the simple models fitted on DR4 spectra are supported yet.
- Online spectrum fitting Select sources with spectra click on  below any spectrum preview, choose the model and submit. The back-end runs Xspec-python.
- Search by region (Individual detections only) Open the query editor on the *Position* tab, click on [Draw a Search Region](#), edit your region, accept and submit



XMM-NEWTON SURVEY SCIENCE CENTRE

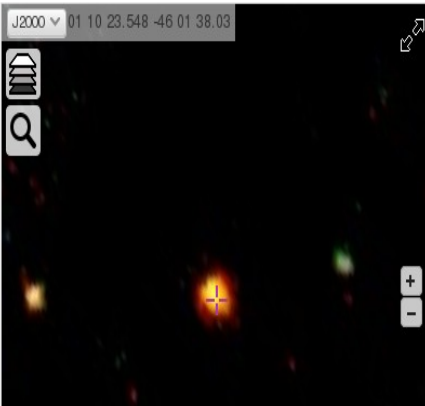
eso 243-49 SEARCH Show query language

HOME CATALOG DIAGRAMS WEB SERVICES DOCS

LINKS ABOUT

Search results > Source 202045402010003

3XMM J011028.2-460422



sc_ep_1_flux	8.32252e-15 ± 3.1332e-16	sc_ep_2_flux	1.58134e-14 ± 4.31766e-16
mjd_first	53332.535162	sc_ep_3_flux	9.88641e-15 ± 3.53029e-16
mjd_last	56254.7151157	sc_ep_4_flux	8.62172e-15 ± 5.99312e-16
sc_chi2prob	0.039418887347	sc_ep_5_flux	1.27308e-14 ± 1.83782e-15
sc_ra	17.617656363	sc_ep_8_flux	7.9872e-14 ± 2.09926e-15
sc_dec	-46.0729608952	sc_ep_8_fmax	3.54705e-13 ± 7.76013e-15
sc_poserr	0.204063	sc_ep_8_fmin	2.22325e-14 ± 3.00177e-15
sc_det_ml	17087.3	sc_ep_9_flux	3.91494e-14 ± 8.30688e-16
sc_ext_ml	0.0	sc_extent	0.0

Inside the catalogues

In general :

- unique identification of each detection
- position of detection
- error on position
- source extension
- time/date of observation
- measure of the quality of the detection
- measure of flux/magnitude in one or several bands
- error on the flux/magnitude

Can also include :

- unique source identification
- spectral/timing products
- measure of the spectra/variability
- images
- tentative source identification
- observing conditions

...and many other products !

Example the XMM-Newton catalogue : 3XMM-DR5



Released 28th April 2015

	3XMM-DR5	3XMM-DR4	Increment
Number of observations	7781	7427	354
Number of 'clean' observations (i.e., observation class < 3)	4735	4553	182
Observing interval	03-Feb-00 -- 20-Dec-13	03-Feb-00 -- 08-Dec-12	1 year
Sky coverage, taking overlaps into account (≥ 1 ksec exposure)	877 sq.deg	794 sq.deg	83 sq.deg
Number of detections	565962	531261	34701
Number of 'clean' detections (i.e., summary flag < 3)	456904	432321	24673
Number of unique sources	396910	372728	24182
Number of 'cleanest' (summary flag = 0, not in high-background fields) extended detections	9082	7698	1384
Number of detections with spectra	133032	123867	9165
Number of detections with timeseries	133025	123860	9165
Number of detections where probability of timeseries being constant is $< 1 \times 10^{-5}$	4668	4612	56

Access to 3XMM-DR5

On the XMM-Newton Survey Science (SSC) webpages :

<http://xmmssc.irap.omp.eu>

But also at :

XSA at ESA's XMM-Newton SOC : <http://xmm.esac.esa.int/xsa/>

XCAT-DB at the SSC institute, Observatoire Astronomique, Strasbourg : <http://xcatdb.unistra.fr/3xmmdr5>

LEDAS at the SSC institute, University of Leicester :

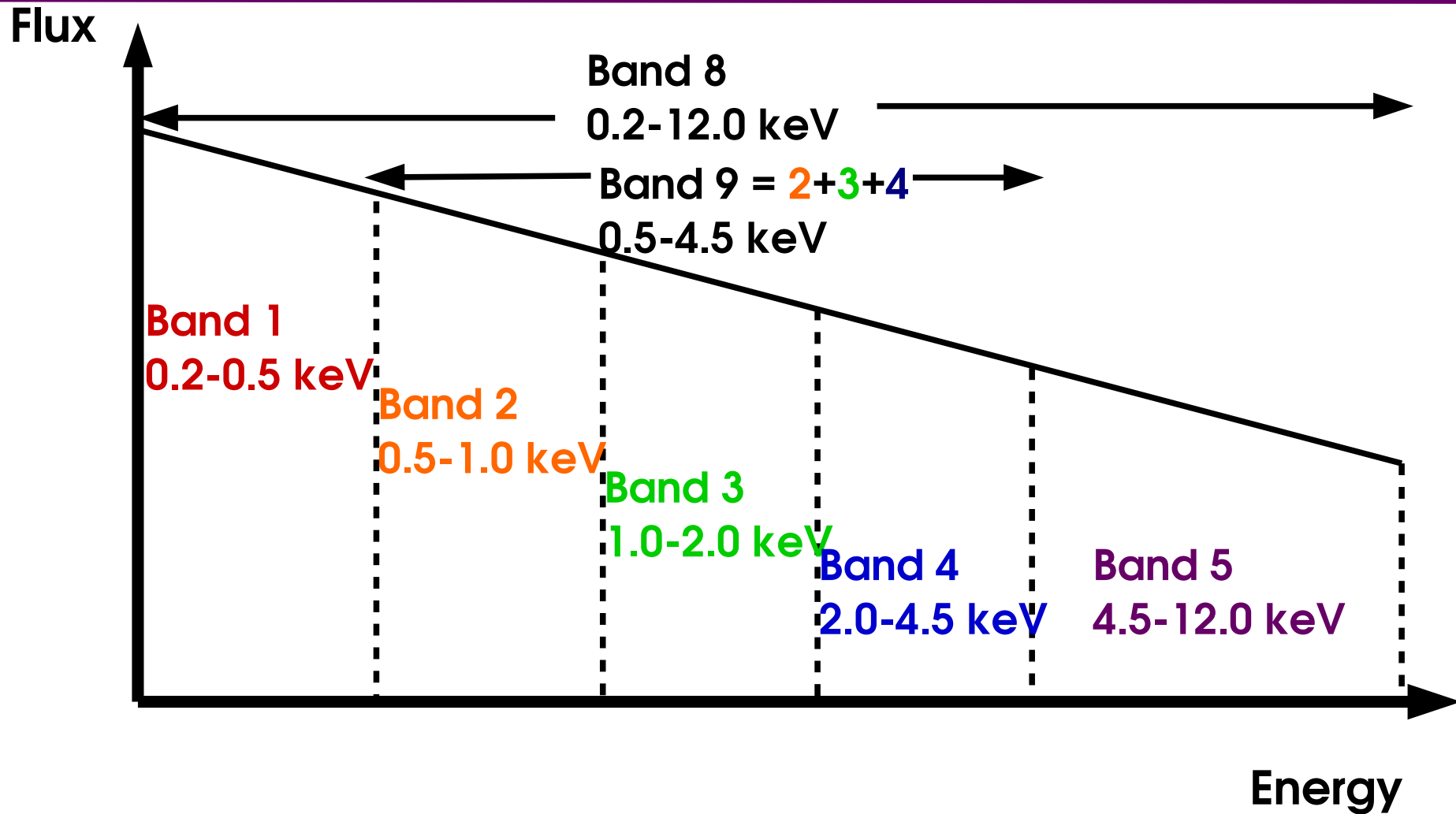
<http://www.ledas.ac.uk/>

Browse at HEASARC NASA GSFC :

<http://heasarc.gsfc.nasa.gov/db-perl/W3Browse/w3browse.pl>

The IRAP catalogue server XSA : <http://xmm-catalog.irap.omp.eu/>

3XMM bands and hardness ratios



$$HR_i = \frac{\text{Band}_{i+1} - \text{Band}_i}{\text{Band}_{i+1} + \text{Band}_i}$$

HR = hardness ratio

Using the online data archives

<http://xmm-catalog.irap.omp.eu/>

Provide a 3XMM-DR5 source name or do a cone search

e.g. 3XMM J133129.6+110755

or : cone('13 31 29.6 +11 07 55', '1deg')

or search categories of sources (CVs, ULXs, ...)

Visualise : Image (XMM and other catalogues)

Source parameters (flux in different bands, date obs., ...)

Fit spectrum

Visualise/extract lightcurve

Cross correlate with other catalogues

Topcat – Tool for Operations on Catalogues And Tables

- Allows to view table and meta-data
- Perform statistics on data
- Create plots of data
- Match/concatenate tables
- Perform functions (conversions, arithmetic, format change, ...)
- Use virtual observatory data/software
- Link several virtual observatory services together

Using Topcat to manipulate the XMM catalogues

- Retrieve 3XMM-DR5 at : <http://xmmssc.irap.omp.eu/>



The XMM-Newton SSC | The XMM-Newton Catalogue | The X-ray Identification project | Software and tools | Restricted access

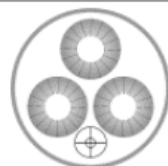


The catalogues

- 3XMM DR5
- 3XMM DR4
- 2XMMi - DR3
- 2XMMi - DR2
- 2XMM - DR1
- 2XMMp - Data pr



The XMM-Newton SSC | The XMM-Newton Catalogue | The X-ray Identification project | Software and tools | Restricted access



XMM-Newton
SURVEY SCIENCE CENTRE

Warning: Browsing these web pages with intern

The XMM-Newton Survey Science Centre was s
data accumulated by the ESA cornerstone miss
to access the catalogues that we have produ

The latest from the XMM-Ne

- **May 2016:** Update to the [XMM-Newton sp](#)
3XMM-DR5.
- **April 2016:** If you are interested in having
- **March 2016:** [Photo](#) from the 29th XMM-N
- **February 2016:** A new version of the Sci

Please read the [Watchouts](#) section before using the catalogues.

3XMM_DR5cat_v1.0.fits.gz	FITS binary	468 MB	MD5: a6b2288dadae4af80a87adfcde9bbee	full binary catalogue; recommended for more in-depth studies (includes information of all detections)
3XMM_DR5cat_v1.0.csv.gz	CSV	510 MB	MD5: e2f2140a2c8f61465d0a35e77e7519ca	full ascii catalogue
3XMM_DR5cat_slim_v1.0.fits.gz	FITS binary	51 MB	MD5: 95b412d8ff9d3fec6d30d719907dd973	reduced binary catalogue, suited for studies of unique sources (individual detection information is not included)
3XMM_DR5cat_slim_v1.0.csv.gz	CSV	57 MB	MD5: 0b3376af2abf08e226a62c224e3eef1d	reduced ascii catalogue

For convenience, there are suitable SQL CREATE statements available for use with a relational DBMS in order to load the data in CSV format:

- [load 3xmmdr5cat_v1.0.sql](#)
- [load 3xmmdr5cat_slim_v1.0.sql](#)

Scroll down to :

Natalie Webb

Astroparticle physics school, OHP, May 2016

Topcat – plot the 3XMM-DR5 catalogue

How many detections in 3XMM-DR5 ?

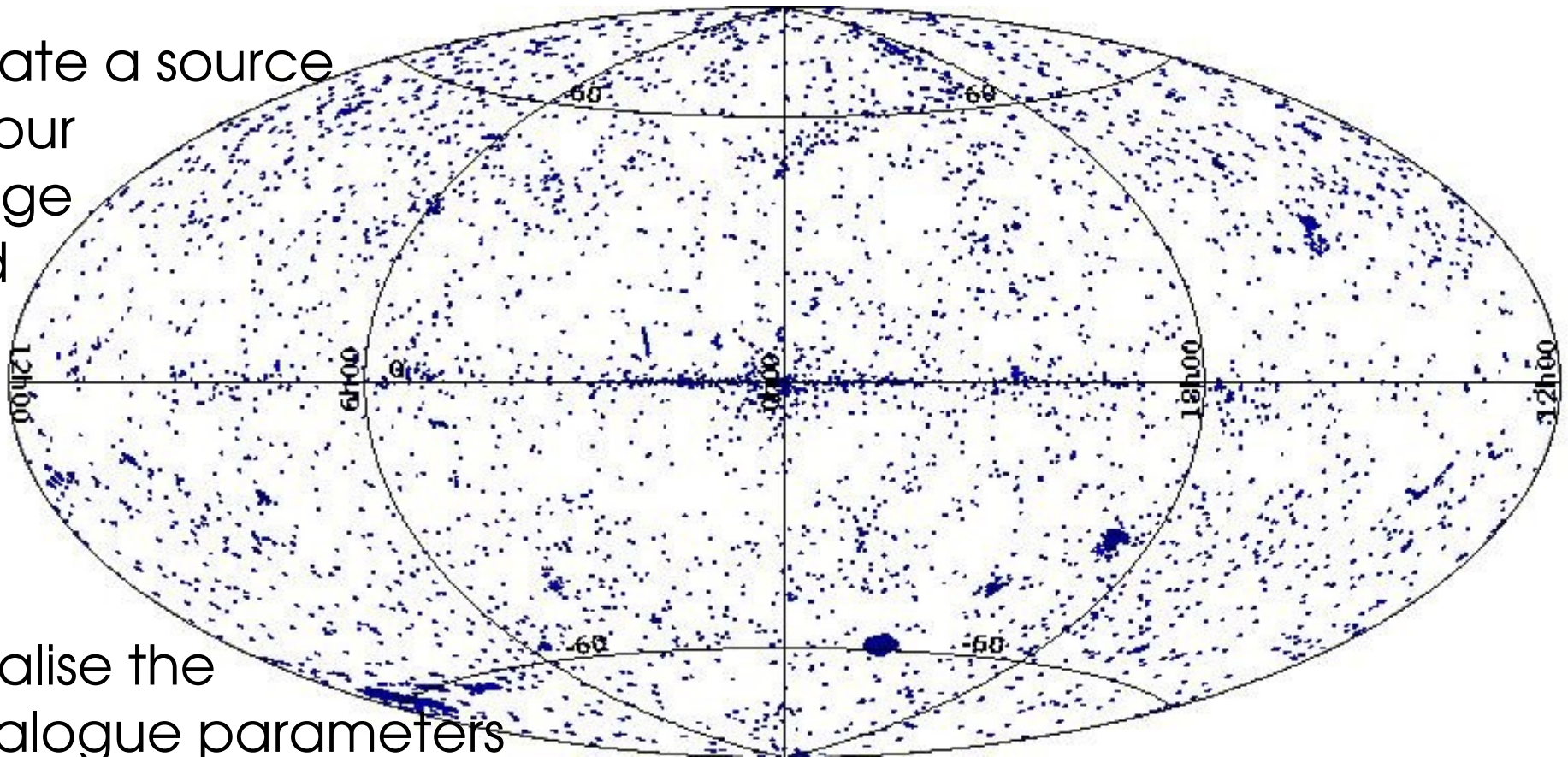
How many unique sources in 3XMM-DR5 ?

What is the mean number of detections of a source ?

What is the maximum number of detections of a source ?

Plot the whole catalogue in a Hammer-Aitoff projection :

Locate a source
in your
image
and

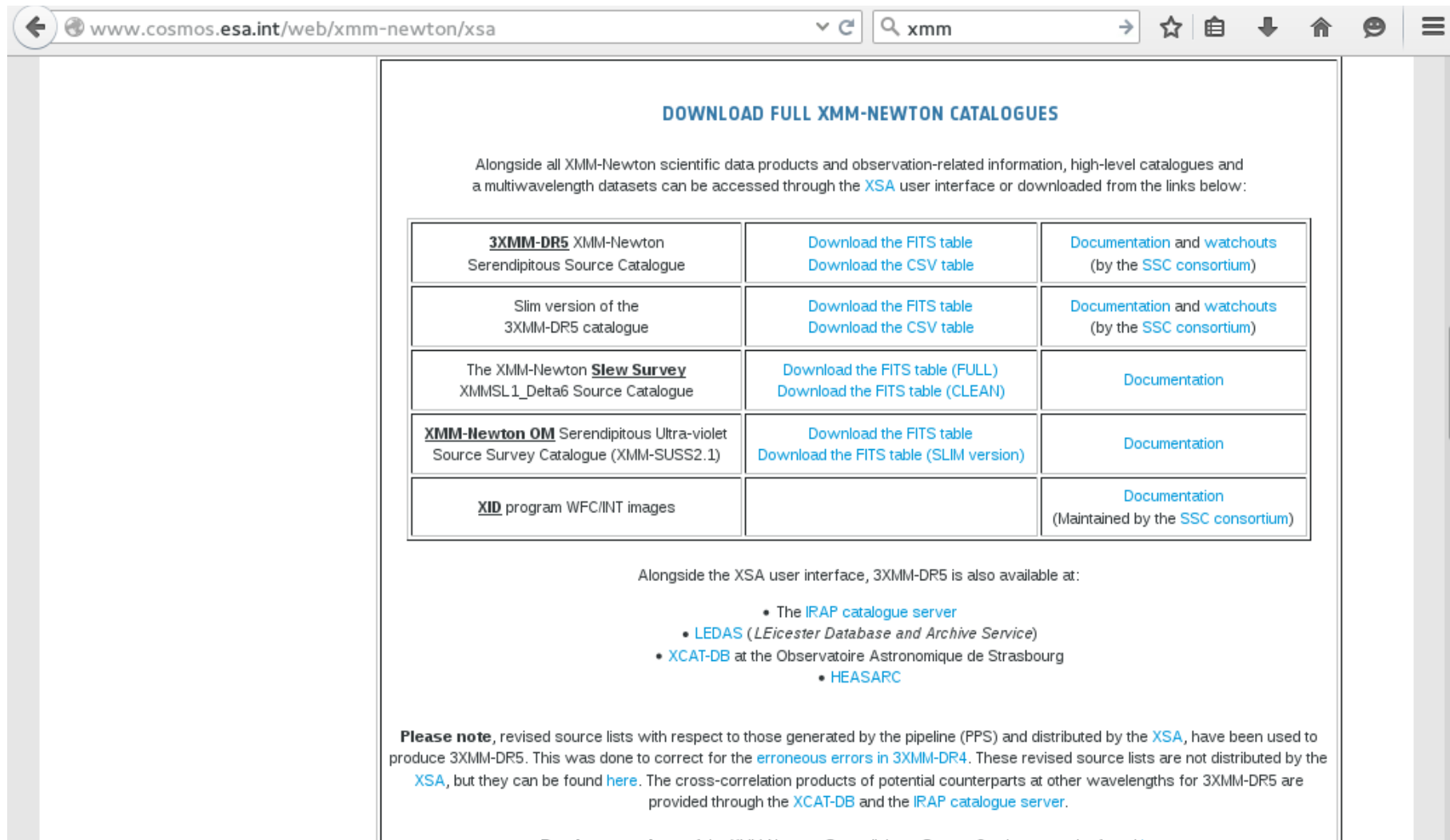


visualise the
catalogue parameters

Retrieve OM catalogue : SUSS 2.1

<http://www.cosmos.esa.int/web/xmm-newton/xsa>

Scroll down to :



The screenshot shows a web browser window with the URL www.cosmos.esa.int/web/xmm-newton/xsa. The page title is "DOWNLOAD FULL XMM-NEWTON CATALOGUES". Below the title, there is a paragraph explaining that high-level catalogues and multiwavelength datasets can be accessed through the XSA user interface or downloaded from the links below. A table provides download links for several catalogues:

3XMM-DR5 XMM-Newton Serendipitous Source Catalogue	Download the FITS table Download the CSV table	Documentation and watchouts (by the SSC consortium)
Slim version of the 3XMM-DR5 catalogue	Download the FITS table Download the CSV table	Documentation and watchouts (by the SSC consortium)
The XMM-Newton Slew Survey XMMSL1_Delta6 Source Catalogue	Download the FITS table (FULL) Download the FITS table (CLEAN)	Documentation
XMM-Newton OM Serendipitous Ultra-violet Source Survey Catalogue (XMM-SUSS2.1)	Download the FITS table Download the FITS table (SLIM version)	Documentation
XID program WFC/INT images		Documentation (Maintained by the SSC consortium)

Below the table, it states: "Alongside the XSA user interface, 3XMM-DR5 is also available at:" followed by a bulleted list:

- The [IRAP catalogue server](#)
- [LEDAS](#) (*LEicester Database and Archive Service*)
- [XCAT-DB](#) at the Observatoire Astronomique de Strasbourg
 - [HEASARC](#)

Please note, revised source lists with respect to those generated by the pipeline (PPS) and distributed by the XSA, have been used to produce 3XMM-DR5. This was done to correct for the [erroneous errors in 3XMM-DR4](#). These revised source lists are not distributed by the XSA, but they can be found [here](#). The cross-correlation products of potential counterparts at other wavelengths for 3XMM-DR5 are provided through the [XCAT-DB](#) and the [IRAP catalogue server](#).

Previous versions of the XMM-Newton Serendipitous Source Catalogue can be found [here](#).

Topcat – match 3XMM-DR5 sources to SUSS 2.1 sources

How many 3XMM-DR5 and SUSS sources match to 1" ?

Plot the matching sources on the Hammer-Aitoff plot

Determine the source parameters – try to identify a source of your choice

Select all matched sources with a U magnitude brighter than 18th

Try out some of the functionality described at

<http://www.star.bris.ac.uk/~mbt/topcat/> under Features

Ideas

- Upper limit servers, e.g. http://www.ledas.ac.uk/flix/flix_dr5.html
-