The XMM-Newton spectral-fit database

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The project (XMMFITCAT)

- ESA (PRODEX) funded project carried out by the X-ray group at NOA in collaboration with the XMM-Newton Survey Science Centre (XMM SSC) in the University of Leicester.
- **Goal:** Use the spectral data from the XMM-Newton Serendipitous source catalogue (latest version 3XMM-DR4) to construct a database of spectral-fitting results.
  - Construct samples of X-ray sources according to spectral properties.
  - Pinpoint “peculiar” sources.
  - Get X-ray properties of samples selected at other wavelengths.

3XMM-DR4 spectral data

- **3XMM-DR4** is the largest catalogue of X-ray sources built to date. Photometric information for more than 500,000 detections of ~ 370,000 sources.
- **3XMM-DR4** also contains pipeline extracted spectra and acillary matrices for detections with EPIC net (background subtracted) counts > 100 counts in 0.2-12 keV: 120,000 detections, ~ 85,000 unique sources.

- **XMMFITCAT:** only 3XMM-DR4 spectra with > 50 cts in 0.5-10 keV per instrument and exposure.

>114,000 detections, ~78,000 unique sources

Spectral models

- The aim of the database is not to find the “best-fit model” (limited number of models), but to obtain a representation of the spectral shape as good as possible.
- Six models implemented (most commonly observed spectral shapes), and three energy bands defined.

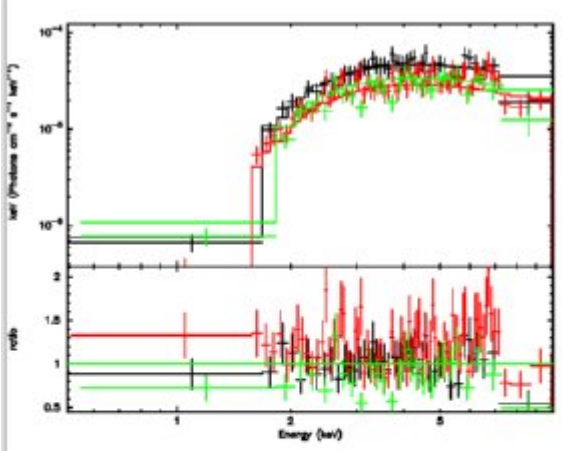
<table>
<tr><th>Energy range (keV)</th><th colspan="2">3XMMDR4 bands</th><th colspan="2">XMMFITCAT bands</th></tr>
<tr><td>0.2 - 0.5</td><td>1</td><td></td><td colspan="2"></td></tr>
<tr><td>0.5 - 1.0</td><td>2</td><td rowspan="5">Total</td><td rowspan="2">Soft</td><td rowspan="4">Full</td></tr>
<tr><td>1.0 - 2.0</td><td>3</td></tr>
<tr><td>2.0 - 4.5</td><td>4</td><td rowspan="2">Hard</td></tr>
<tr><td>4.5 - 10</td><td rowspan="2">5</td></tr>
<tr><td>10 -12</td><td></td><td colspan="2"></td></tr>
</table>

Spectral models

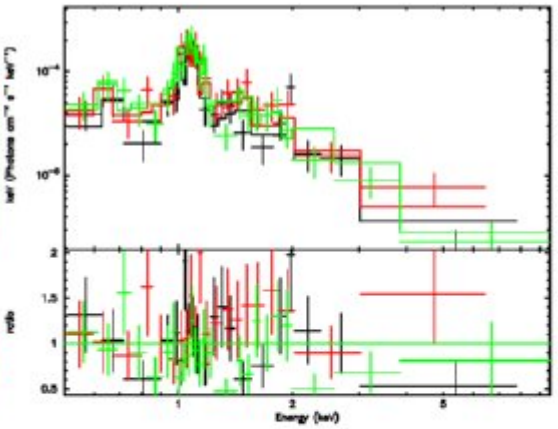
- Simple models are applied to all detections:
  - **Absorbed power-law** in **Full**, **Hard**, and **Soft** bands: Γ, N_H, Norm
  - **Absorbed thermal model** in **Full** and **Soft** bands: N_H, kT, Norm
  - **Absorbed black-body model** in **Soft** band: N_H, kT, Norm.

- Complex models are applied if EPIC counts > 500 counts, and only in the **Full** band.
  - **Thermal plus power-law**: N_{H1}, kT, Norm1, N_{H2}, Γ, Norm2
  - **Black-body plus power-law**: N_H, kT, Norm1, Γ, Norm2
  - **Double power-law**: N_{H1}, $\Gamma 1$, Norm1, N_{H2}, $\Gamma 2$, Norm2

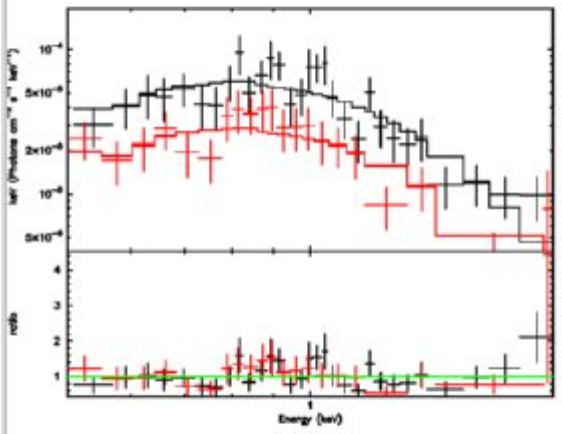
WAPO



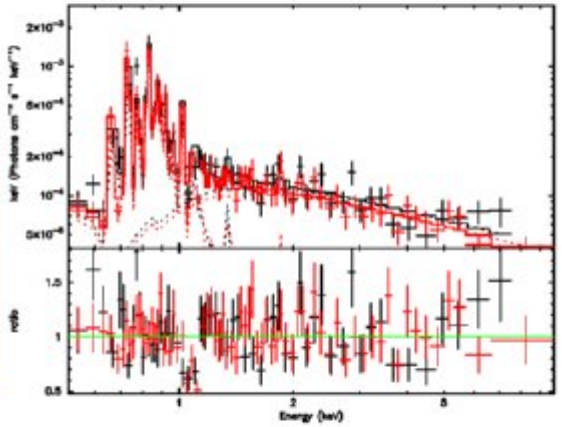
WAMEKAL



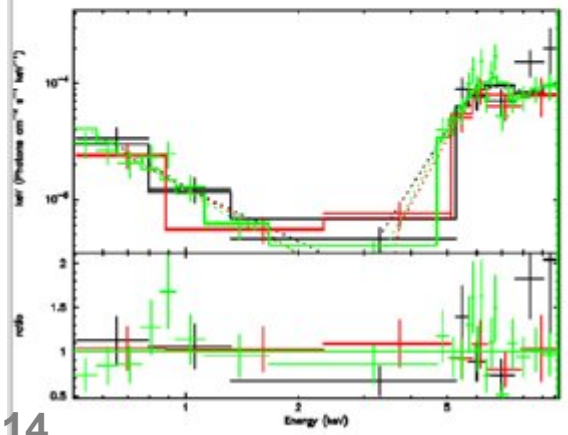
WABB



WAMEKALPO



WAPOPO



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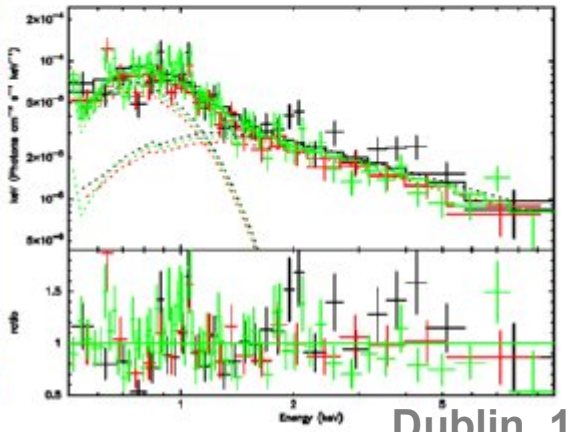

Automated fitting

- **Each detection fitted separately -> spectral-fitting results for each detection, not for each source.**
- All models are applied to all detections (depending on number of counts).
- For each model, best-fit parameters and errors are computed (90% level); and fluxes and errors (90% level, in each XMMFITCAT energy band); an estimate of goodness of fit.

Automated fitting - Goodness of fit

- `Xspec` 12.7.1, C-stat ➔ no goodness of fit.
- `Goodness`: performs a number of simulations and returns the percentage of simulations that gives a lower value of the statistic. As a guide to the user: **acceptable fit if `goodness` < 50%, preferred model: the simplest one with the lowest `goodness` value.**
- Also provided χ^2 as a test statistic, when using C-stat as fit statistic (goodness < 50 $\Leftrightarrow$ $\chi^2_c < 1.5$).

XMMFITCAT

- **Output:** one row for each source detection, and 214 columns containing information about the observation, a summary of the spectra-fitting, and spectral-fitting results for each spectral model applied (best-fit parameters and errors, fluxes, and goodness of fit)
- ~ 18% of sources: multiple observations with spectra: spectral variability studies.

IAUNAME	DETID	SRCID	OBS_ID	SRC_NUM	SRC_HEX	SC_RA	SC_DEC	T_COUNTS	H_COUNTS	S_COUNTS	GNH	A_FIT	P_MODEL
3XMMJ000548.6+200150	1833	19268	0600540501	65	0041	1.45289	20.03057	59.16699	-99.	-99.	0.03516	☑	1
3XMMJ000548.8+200627	1836	7186	0101040101	14	000E	1.45339	20.10758	96.23369	-99.	80.12826	0.03564	☐	0
3XMMJ000548.8+200627	1837	7186	0600540601	9	0009	1.45339	20.10758	580.6626	139.84521	437.29176	0.03564	☑	0
3XMMJ000548.8+200627	1838	7186	0306870101	7	0007	1.45339	20.10758	255.86811	70.98639	181.71661	0.03563	☑	0
3XMMJ000548.7+201513	1839	13087	0600540601	104	0068	1.4532	20.25367	79.26334	50.03315	-99.	0.03649	☑	0
3XMMJ000548.8+200627	1840	7186	0600540501	9	0009	1.45339	20.10758	422.29079	100.01115	320.50835	0.03564	☑	0
3XMMJ000549.5+201308	1845	7101	0600540601	10	000A	1.45629	20.21902	668.22002	179.17344	484.68514	0.03628	☑	0
3XMMJ000549.5+201308	1846	7101	0306870101	4	0004	1.45629	20.21902	390.1877	103.21101	284.48779	0.03628	☑	0
3XMMJ000549.5+201308	1848	7101	0101040101	11	000B	1.45629	20.21902	164.87083	-99.	124.67539	0.03628	☑	0
3XMMJ000549.5+201308	1849	7101	0600540501	8	0008	1.45629	20.21902	519.88876	108.72877	406.54006	0.03628	☑	0
3XMMJ000550.0-344757	1855	18222	0404910101	15	000F	1.4585	-34.79917	95.76618	-99.	64.51116	0.01318	☑	0
3XMMJ000550.4-343742	1861	33310	0404910101	18	0012	1.46033	-34.6285	87.80419	-99.	62.66844	0.01329	☐	0
3XMMJ000550.7+201716	1864	7812	0306870101	14	000E	1.46166	20.28797	236.87845	112.47384	121.87379	0.03665	☑	0
3XMMJ000550.7+201716	1865	7812	0101040101	17	0011	1.46166	20.28797	110.29757	-99.	68.56283	0.03665	☑	1
3XMMJ000550.7+201716	1866	7812	0600540601	33	0021	1.46166	20.28797	282.75284	142.658	138.45195	0.03665	☑	0
3XMMJ000550.7+201716	1867	7812	0600540501	31	001F	1.46166	20.28797	123.73808	51.90408	70.41663	0.03665	☑	0

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3XMM-DR4

IAUNAME	DETID	SRCID	OBS_ID	SRC_NUM	SRC_HEX	[illegible]	SC_DEC	T_COUNTS	H_COUNTS	S_COUNTS	GNH	A_FIT	P_MODEL
3XMMJ000548[illegible]+200150	1833	19268	0600540501	65	0041	1.4521	20.0[illegible]857	59.16699	-99.	-99.	0.03516	☑	1
3XMMJ00[illegible]548.8+200627	1836	7186	0101040101	14	000E	1.45339	[illegible].10758	96.23369	-99.	80.12826	0.03564	☐	0
3XM[illegible]000548.8+200627	1837	7186	0600540601	9	0009	1.45339	20.[illegible]758	580.6626	139.84521	437.29176	0.03564	☑	0
3X[illegible]MJ000548.8+200627	1838	7186	0306870101	7	0007	1.45339	20.10[illegible]58	255.86811	70.98639	181.71661	0.03563	☑	0
[illegible]XMMJ000548.7+201513	1839	13087	0600540601	104	0068	1.4532	20.2536	79.26334	50.03315	-99.	0.03649	☑	0
3XMMJ000548.8+200627	1840	7186	0600540501	9	0009	1.45339	20.10758	422.29079	100.01115	320.50835	0.03564	☑	0
3XMMJ000549.5+201308	1845	7101	0600540601	10	000A	1.45629	20.21902	668.22002	179.17344	484.68514	0.03628	☑	0
3XMMJ000549.5+201308	1846	7101	0306870101	4	0004	1.45629	20.21902	390.1877	103.21101	284.48779	0.03628	☑	0
3XMMJ000549.5+201308	1848	7101	0101040101	11	000B	1.45629	20.21902	164.87083	-99.	124.67539	0.03628	☑	0
3[illegible]MJ000549.5+201308	1849	7101	0600540501	8	0008	1.45629	20.2190[illegible]	519.88876	108.72877	406.54006	0.03628	☑	0
3X[illegible]MJ000550.0-344757	1855	18222	0404910101	15	000F	1.4585	-34.79[illegible]17	95.76618	-99.	64.51116	0.01318	☑	0
3XMM[illegible]00550.4-343742	1861	33310	0404910101	18	0012	1.46033	-34[illegible]285	87.80419	-99.	62.66844	0.01329	☐	0
3XMMJ000[illegible]50.7+201716	1864	7812	0306870101	14	000E	1.46166	[illegible].28797	236.87845	112.47384	121.87379	0.03665	☑	0
3XMMJ000550.[illegible]201716	1865	7812	0101040101	17	0011	1.46[illegible]	20.28797	110.29757	-99.	68.56283	0.03665	☑	1
3XMMJ000550.7+201[illegible]	1866	7812	0600540601	33	0021	1.46166	20.28797	282.75284	142.658	138.45195	0.03665	☑	0
3XMMJ000550.7+201716	1867	7812	0600540501	8	001F	1.46166	20.28797	123.73808	51.90408	70.41663	0.03665	☑	0

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Fit summary

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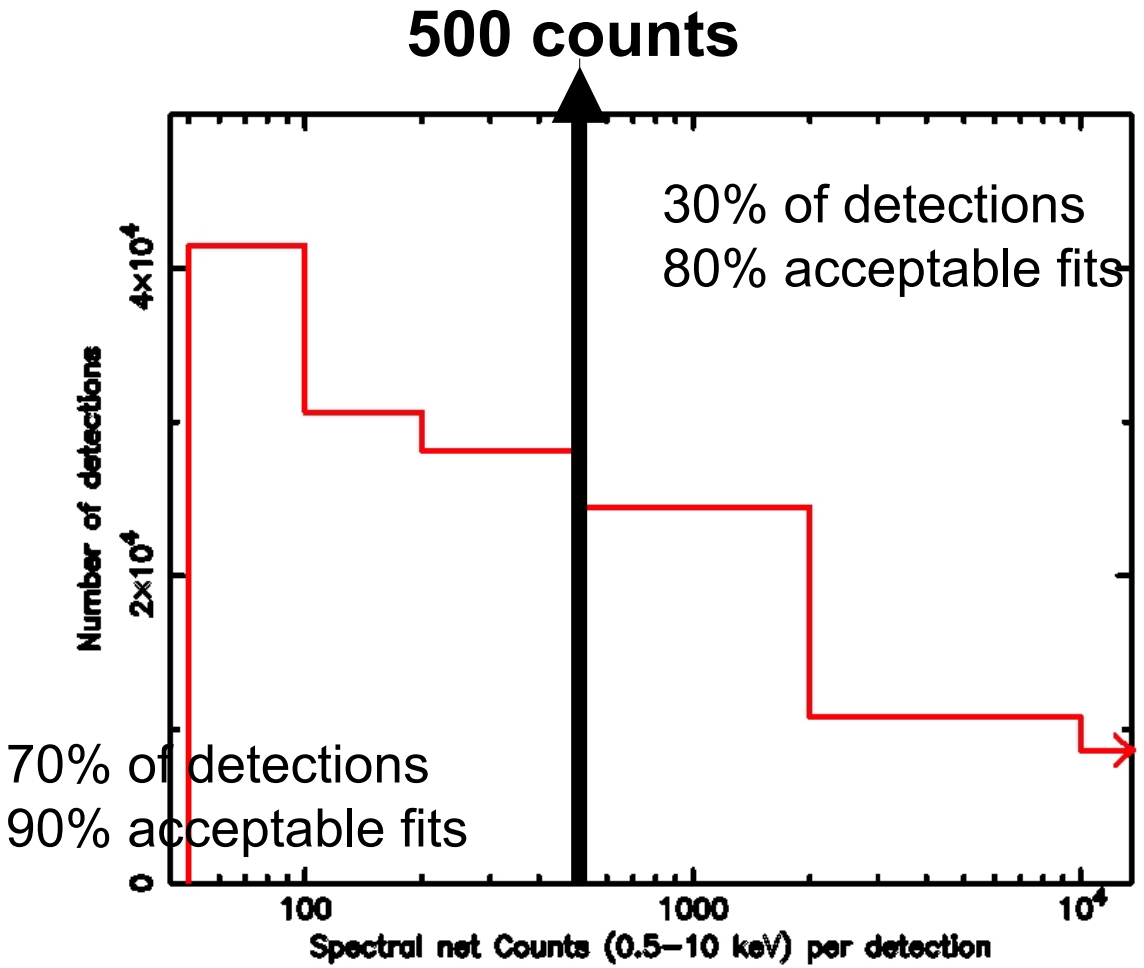
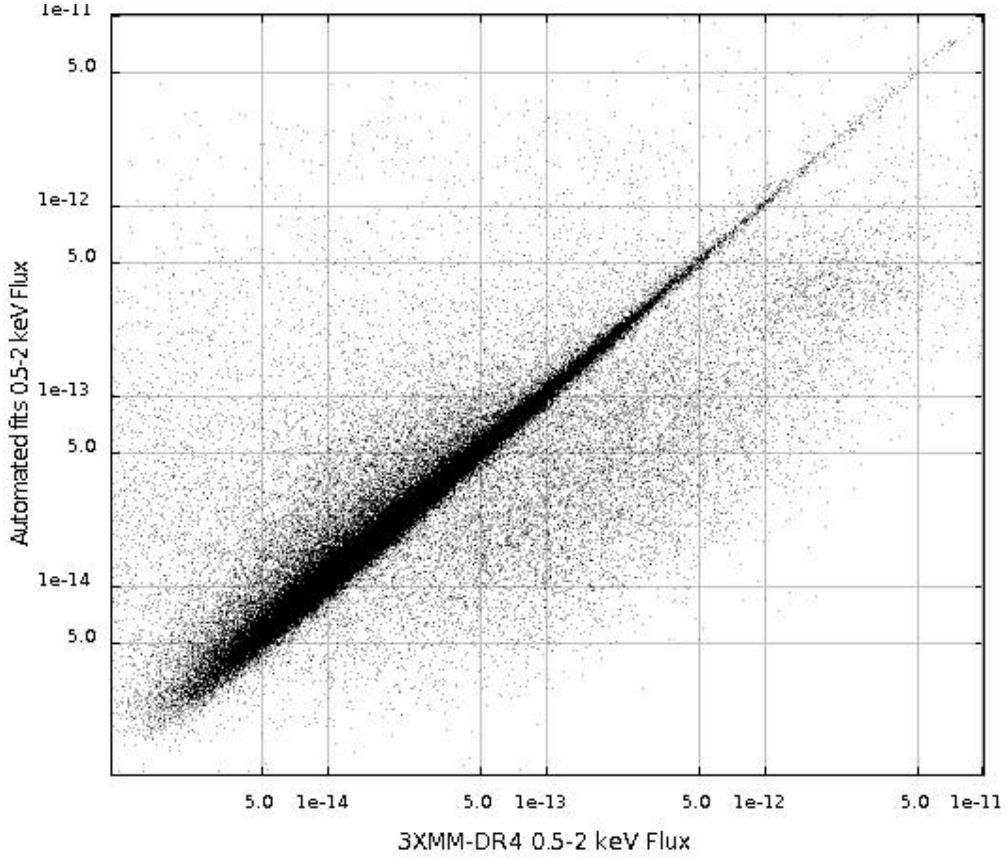
Results



Less than 1% of detections missing one fit due to errors.

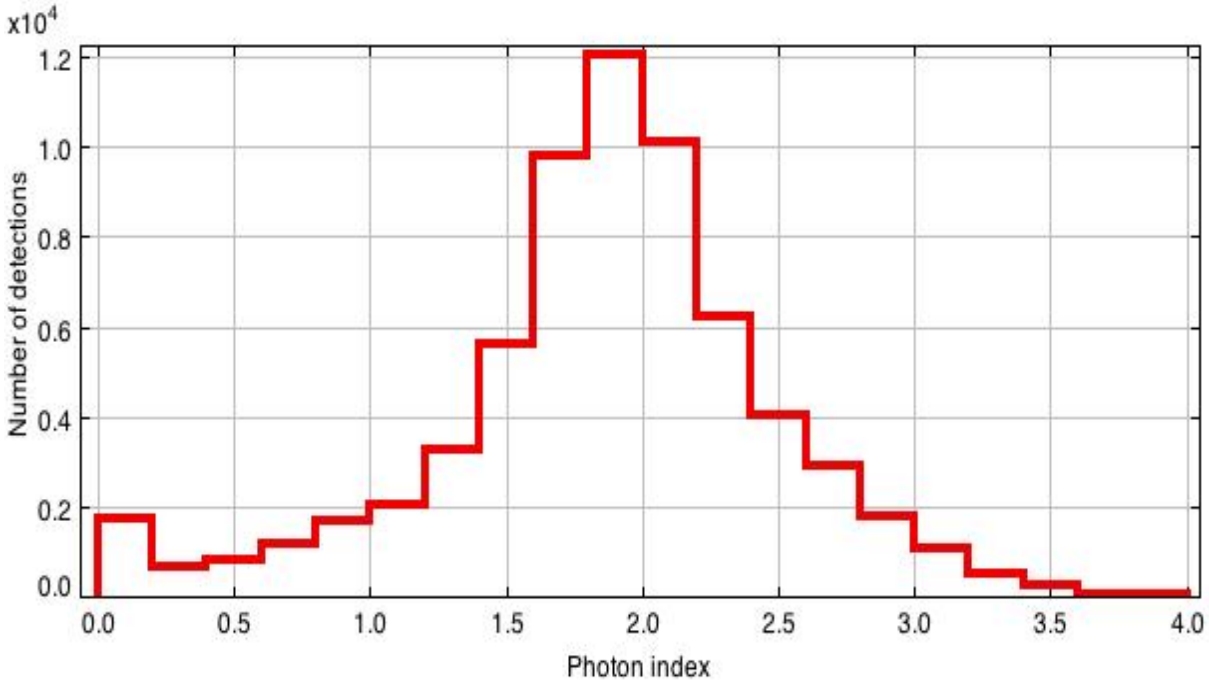
Acceptable fits even for large number of counts.

Results

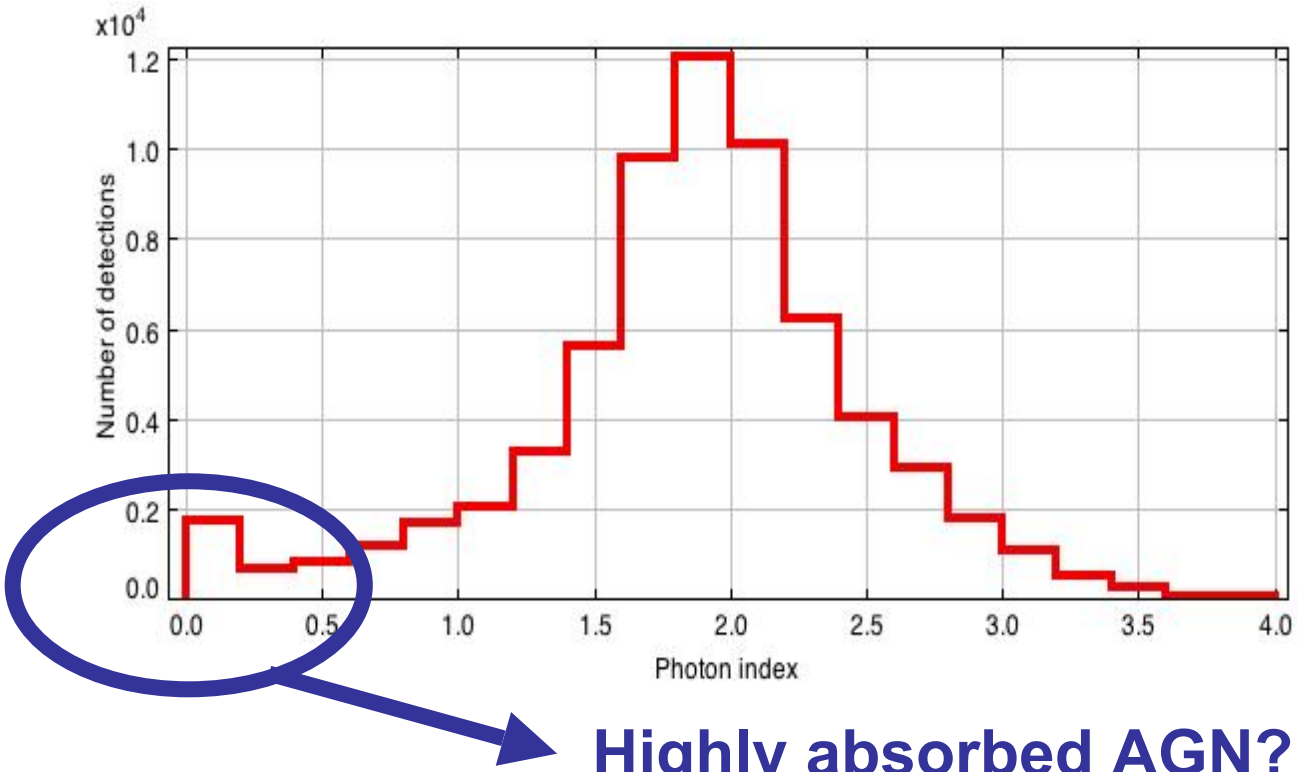


Consistent within errors for ~ 70% of the detections. Significant differences: power-law with a steep photon index, or thermal model.

Results


x10^4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Number of detections
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Photon index

Results



Highly absorbed AGN?

(I. Georgantopoulos talk yesterday)

Access

- Full database (FITS table) from 3XMM-DR4 released on March 2014 (and documentation).

http://xraygroup.astro.noa.gr/Webpage-prodec/index.html

- LEDAS (Leicester Database and Archive Service): query capabilities. 3XMMspectral.
- XCAT-DB: query and spectral-fitting visualisation tool.

http://xraygroup.astro.noa.gr/Webpage-prodec/index.html

XMM-Newton spectral-fit database

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- Catalogue description
- XMM-SDSS sample
- Seminars
- Publications
- Related links
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Summary

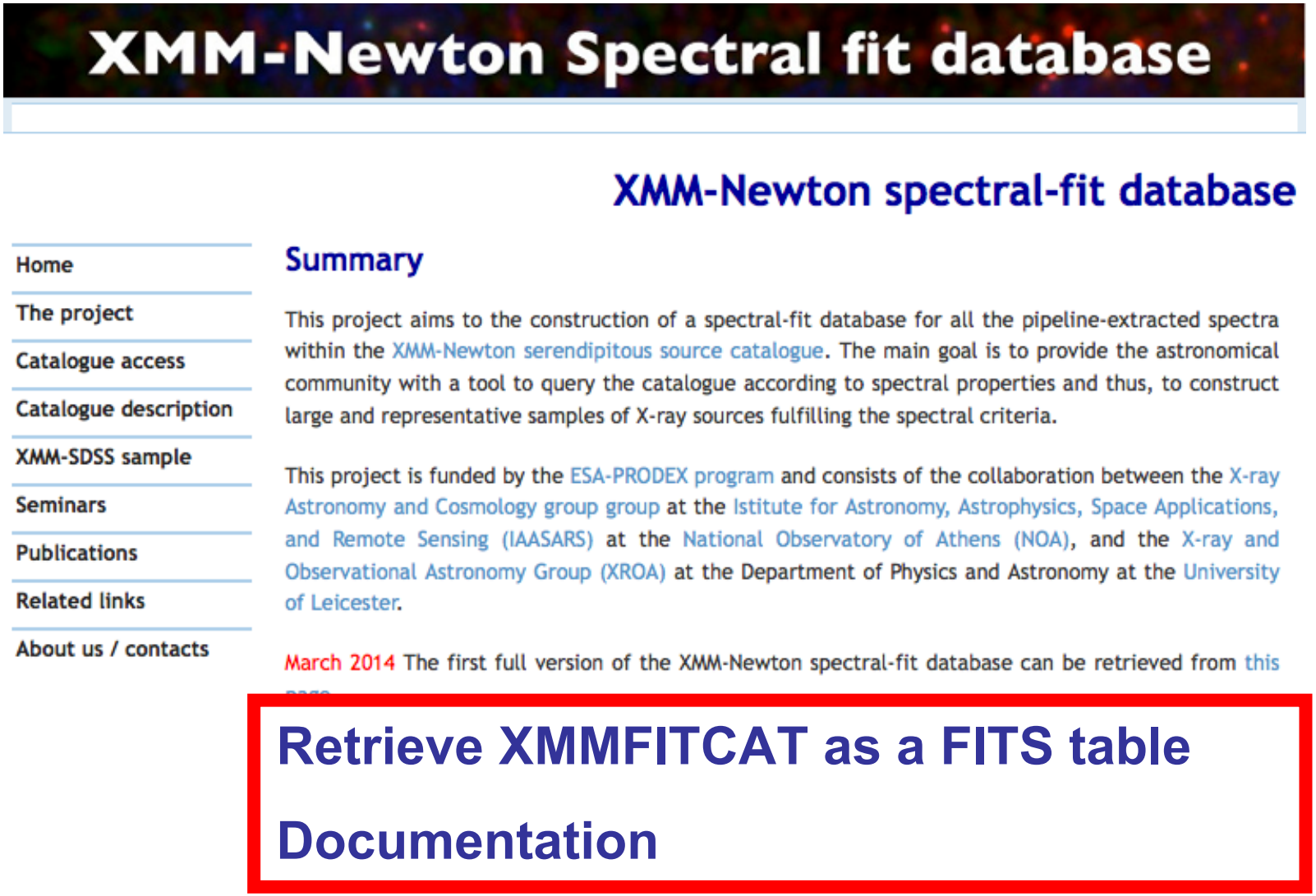
This project aims to the construction of a spectral-fit database for all the pipeline-extracted spectra within the XMM-Newton serendipitous source catalogue. The main goal is to provide the astronomical community with a tool to query the catalogue according to spectral properties and thus, to construct large and representative samples of X-ray sources fulfilling the spectral criteria.

This project is funded by the ESA-PRODEX program and consists of the collaboration between the X-ray Astronomy and Cosmology group group at the Istitute for Astronomy, Astrophysics, Space Applications, and Remote Sensing (IAASARS) at the National Observatory of Athens (NOA), and the X-ray and Observational Astronomy Group (XROA) at the Department of Physics and Astronomy at the University of Leicester.

March 2014 The first full version of the XMM-Newton spectral-fit database can be retrieved from this page.

March 2014 The spectral-fitting results corresponding to a XMM/SDSS cross-correlation can be retrieved from this page.

http://xraygroup.astro.noa.gr/Webpage-prodec/index.html



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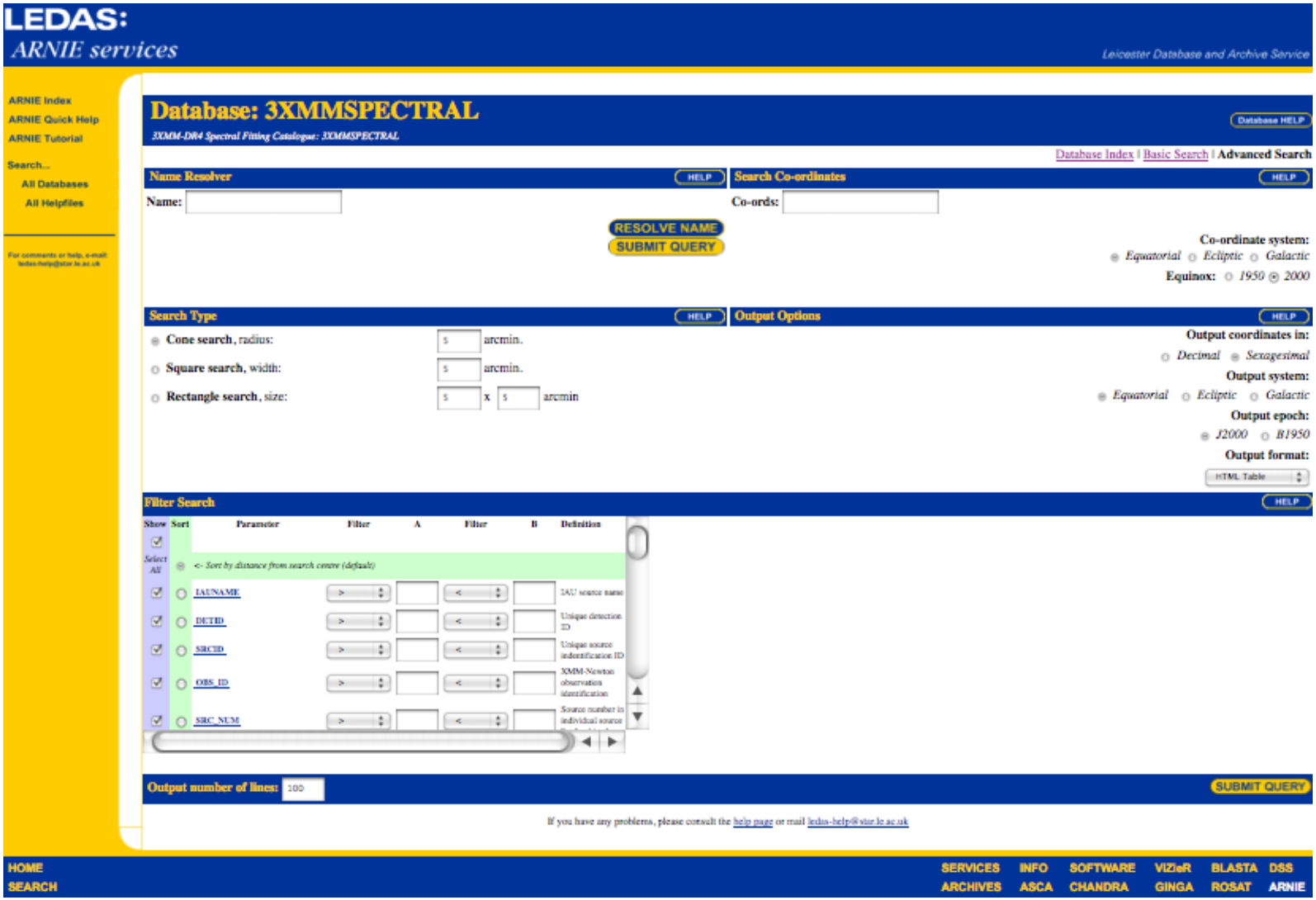
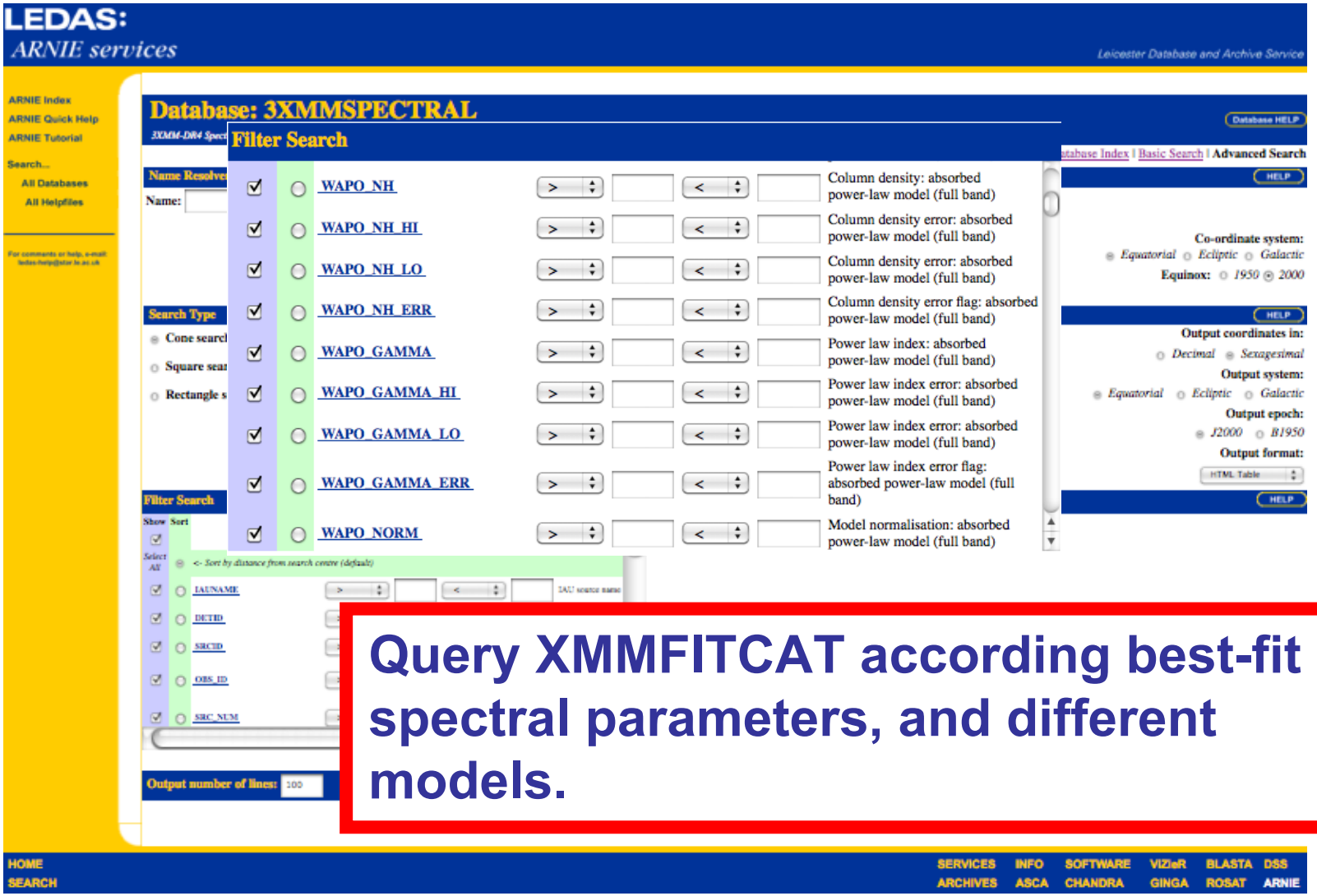
http://www.ledas.ac.uk/arnie5/arnie5.php?action=advanced&catname=3xmmspectral



http://www.ledas.ac.uk/arnie5/arnie5.php?action=advanced&catname=3xmmspectral



Query XMMFITCAT according best-fit spectral parameters, and different models.

Access

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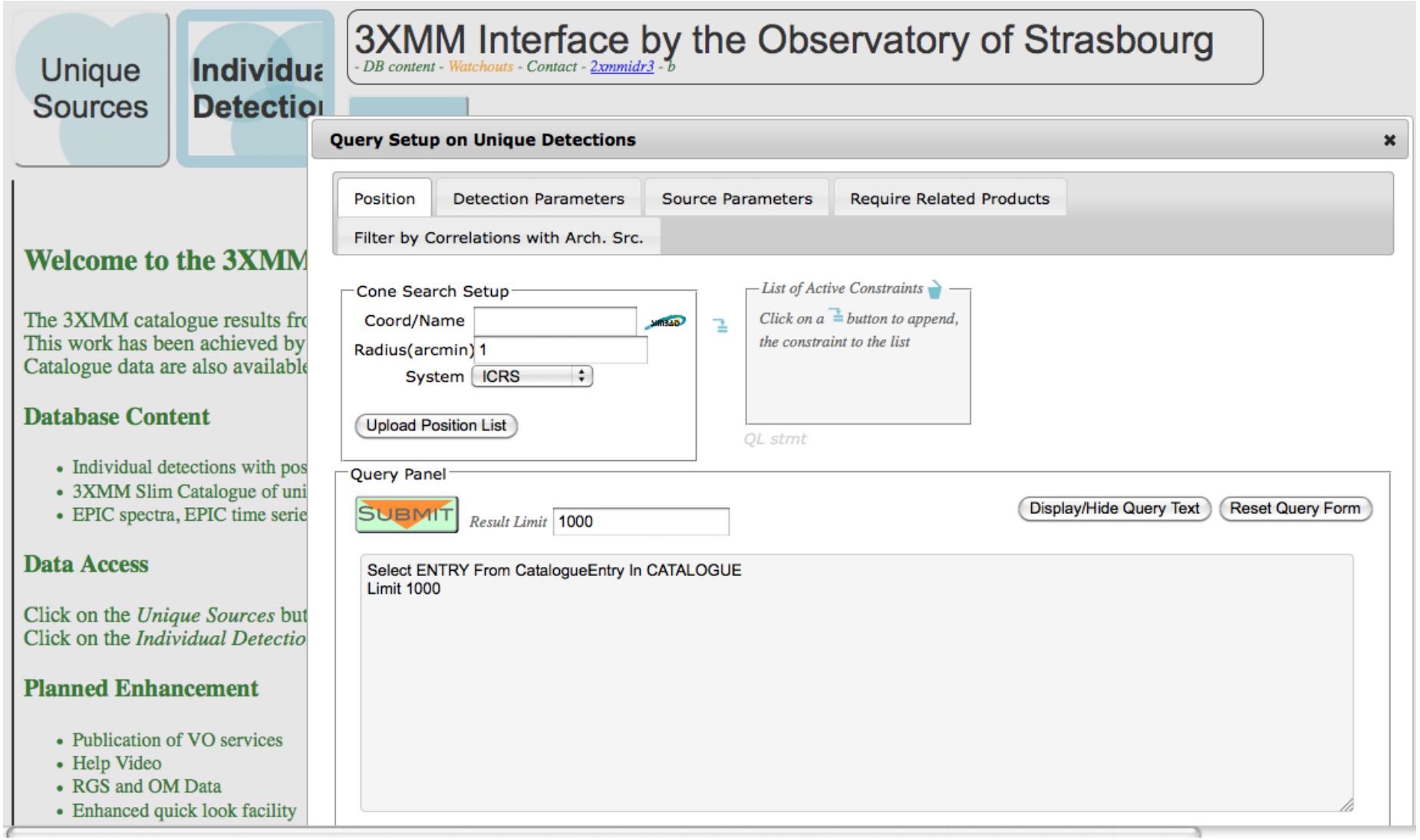
- LEDAS (Leicester Database and Archive Service): query capabilities. 3XMMspectral.
- XCAT-DB: query and spectral-fitting visualisation tool **(soon).**

http://xcatdb.unistra.fr/3xmm/ **(soon)**



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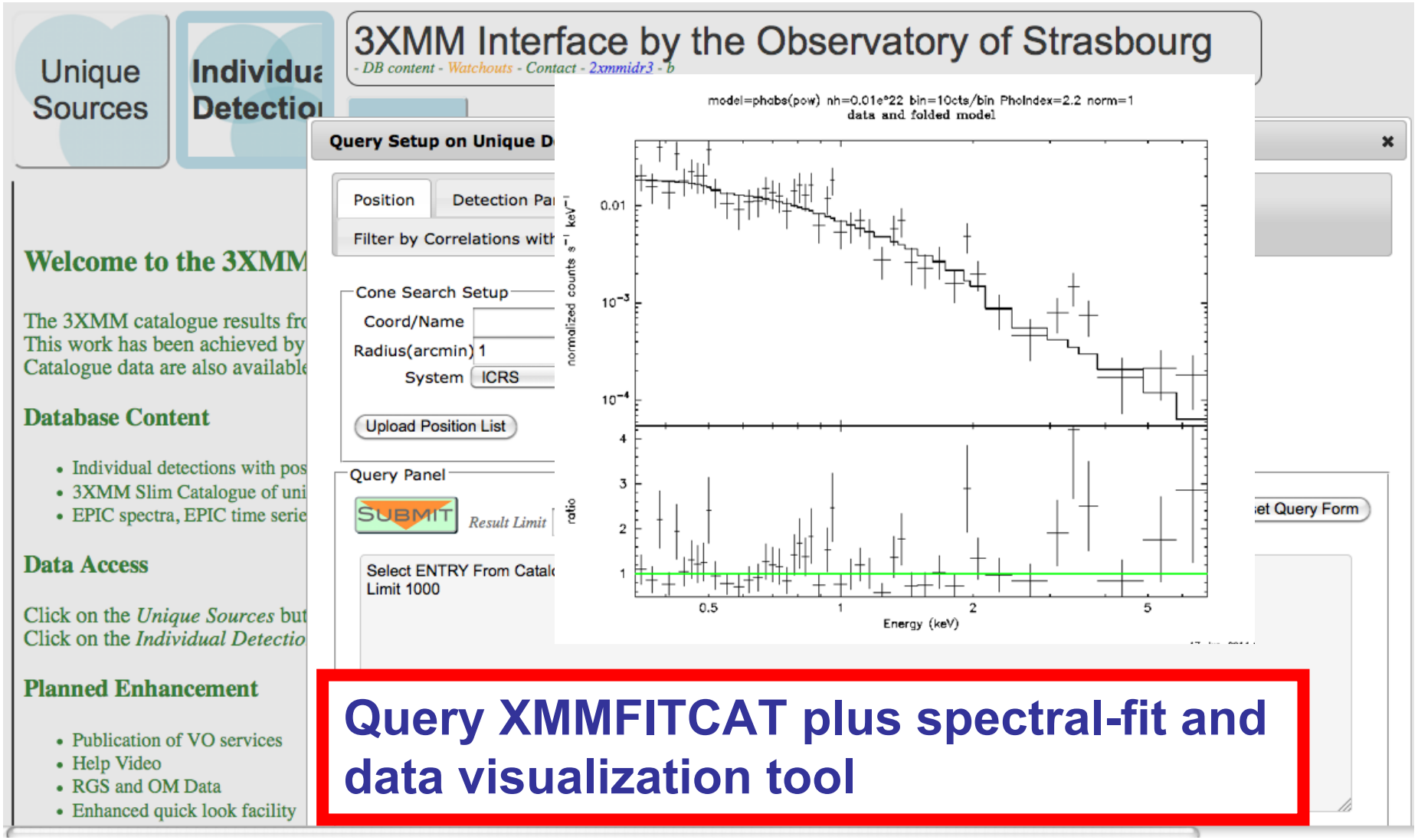

XMM/SDSS

http://xraygroup.astro.noa.gr/Webpage-prodec/index.html

- Spectral-fitting results from XMM-Newton SDSS-DR7 cross-correlation (Georgakakis & Nandra 2011)
- Detected in the hard band (2-8 keV): ~14,000.
  - Sources with redshifts available ~ 8000 (spectral fits modified to include redshift effects)
  - Sub-sample with spectroscopic redshifts used in selection of highly absorbed AGN (Corral et al., submitted; Fe Kα emission line fitting included; **I. Georgantopoulos talk yesterday**)

Summary

- Construction of XMMFITCAT from 3XMM-DR4 completed, catalogue released to the public.
- Plus additional results from a XMM/SDSS cross-correlation also released.
- Working on catalogue paper.

- **Future:** spectral-fitting results will be included in future versions of the XMM-Newton Serendipitous Source catalogue. Athena, eROSITA ?