



# MOCs in Arches

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# Arches at a Glance

<http://www.arches-fp7.eu>



New tools will be developed for cross-correlation with extensive archival resources, producing well-characterised multi-wavelength data in the form of spectral energy distributions for large sets of objects. We plan to create high reliability source crossidentifications extracted from the best archival astronomical catalogues so as to cover the widest range in wavelength. These cross-matches will then be used to build fully calibrated spectral energy distributions (SEDs). Most importantly, we will validate the quality of these products by using them in the framework of a small number of pilot projects tackling forefront astrophysical topics, providing the route for further enhancement.

ARCHES will considerably increase the usability and research potential of the XMM-Newton X-ray catalogue, enhancing it with key multi-wavelength resources and distributing these results to the international community.

32 months starting from 01/2013

Strasbourg, Santander, Madrid, Potsdam and Leicester



# The ARCHES Project

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- 3XMM catalogue enhancement
  - Remove suspicious detections
  - Flag sources in order to improve their reliability
  - Merge multiple detections
- **Accurate cross correlation with the 3XMM sources in all energy ranges (radio to  $\gamma$ )**
  - **Focus of the present topic**
- Building SEDs for 3XMM sources
  - Likely other connections with VO standards
- Checking the results on real science cases.



# Cross Correlation with the 3XMM

## 1. Selection of the candidate catalogue

- Make sure that all 3XMM sources are in the footprints of catalogues covering all wave lengths.
- Computing intersection between 3XMM and these catalogues.
  - Catalogues intersect but without correlation -> upper limit values.
  - upper limit values can not be inferred from the absence of correlations returned by a simple cross match.
- Need catalogue footprints.

## 2. Multi-catalogue cross match

- François Xavier's job. *-out of the present topic-*



# Candidate Catalogue Selection

- **Get of all Vizier catalogues intersecting with the 3XMM.**
  - Query by MOCs
- **Select among these catalogues those which are potentially interesting**
  - Interesting information on magnitudes, flux and counts from Radio to gamma.
- **The most interesting catalogues will be selected later by coverage and both photometric and position accuracy**
  - The goal is to get for each 3XMM source counterparts extracted from a catalogue set with the best balance between WL coverage, 3XMM overlapping and position accuracy



# Operating Mode

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- 1. Make the 3XMM footprint**
- 2. Computing the intersection between the 3XMM and all Vizier tables**
- 3. Table selection by UCD**
- 4. Compute which sources are in MOCS**
- 5. Computing the fraction of the 3XMM area covered by each catalogue**
- 6. Checking astrometric and photometric accuracy**

- **Computed with STILTS**
  - Use of the *pixfoot* function
- **Resolution fixed to 6.87" (healpix level 9)**
  - Good enough to compute intersections between catalogues
- **Stored in a fits file**
  - Notice that the 3XMM footprint is very fragmented

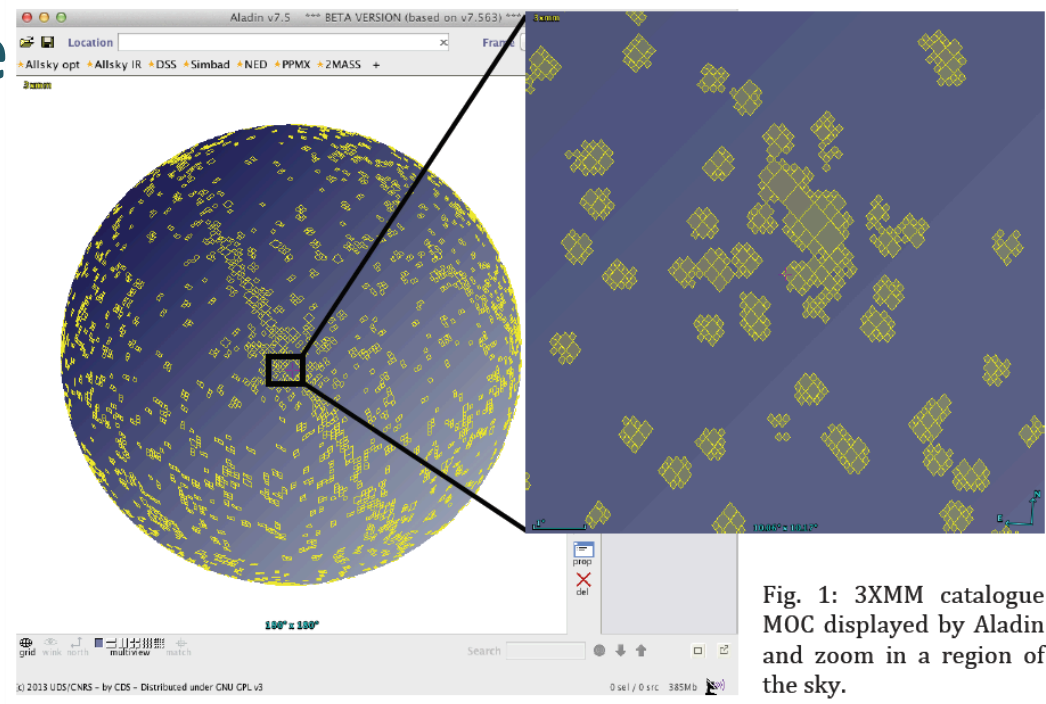


Fig. 1: 3XMM catalogue MOC displayed by Aladin and zoom in a region of the sky.



# Intersection Between the 3XMM and Vizier Tables

- **Get the MOCs for all the 12237 (at that time) Vizier catalogues**
  - Available at the CDS MocServer
  - HTML/JS page hacked to avoid tens of thousands clicks.
- **Using the MocServer to generate the MOCS of all intersection**
  - A few seconds
  - 10636 Vizier Catalogue intersect with 3XMM
- **Delivery of 10636 MOCS ( $3XMM \cap$  Catalogue)**
  - Output in ASCII in the current prototype (open issue)





# MocServer (feedback)

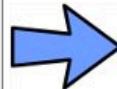
## MocServer

Returns ASCII MOCS

12237 MOCs loaded (107MB)  
(loaded in 2168ms by Tomcat server)

- 1972)  [J/ApJ/566/880/table2](#) (69 cells)
- 1973)  [J/A+AS/80/149/table1](#) (1231 cells)
- 1974)  [J/MNRAS/404/1005/9c/cont](#) (549 cells)
- 1975)  [J/ApJS/89/85/table6](#) (5 cells)
- 1976)  [J/AJ/143/121/table3](#) (0 cells)
- 1977)  [J/AcA/48/147/smc/sc](#) (27 cells)
- 1978)  [J/ApJS/205/6/table1](#) (104 cells)
- 1979)  [J/A+A/344/943/table1](#) (2 cells)
- 1980)  [J/ApJS/66/387/table1](#) (119 cells)
- 1981)  [VII/103/catalog](#) (160 cells)
- 1982)  [J/ApJS/160/272/table1](#) (109 cells)
- 1983)  [J/ApJS/89/57/table5](#) (948 cells)
- 1984)  [J/A+AS/125/419/table5](#) (113 cells)
- 1985)  [3xmm](#) (39904 cells)
- 1986)  [J/MNRAS/398/91/table1](#) (5 cells)
- 1987)  [J/other/IBVS/4433/table1](#) (95 cells)
- 1988)  [II/203A/table1](#) (514 cells)
- 1989)  [J/MNRAS/417/114/table2](#) (4 cells)
- 1990)  [J/ApJ/660/239/table1](#) (12594 cells)
- 1991)  [J/A+A/451/1053/table1](#) (64 cells)
- 1992)  [J/MNRAS/378/179/catalog](#) (124 cells)
- 1993)  [II/230/catalog](#) (5157 cells)
- 1994)  [J/ApJ/546/694/table1](#) (1 cells)
- 1995)  [GAIA/GUMS/MW](#) (48 cells)
- 1996)  [J/MNRAS/385/1749/bin](#) (51 cells)

1



3xmm  
intersects 10636 catalogs/surveys  
(computed in 306ms)

- 2)  [J/A+A/454/895/stars](#) (26 cells)
- 3)  [I/313/lqrf](#) (56820 cells)
- 4)  [J/A+A/542/A66/YSOs](#) (44 cells)
- 5)  [IX/6/data](#) (641 cells)
- 6)  [J/A+A/528/A36/tablea](#) (16 cells)
- 7)  [J/MNRAS/401/257/stars](#) (97 cells)
- 8)  [J/MNRAS/325/1002/table1](#) (132 cells)
- 9)  [J/A+AS/104/271/table2](#) (71 cells)
- 10)  [J/A+A/520/A42/table5](#) (10 cells)
- 11)  [J/ApJS/177/39/list](#) (16 cells)
- 12)  [VIII/16/mrcj2000](#) (12000 cells)
- 13)  [J/AJ/123/269/table2](#) (10 cells)
- 14)  [J/AJ/128/1558/table1](#) (111 cells)
- 15)  [J/MNRAS/412/423/galaxies](#) (59 cells)
- 16)  [J/A+A/379/564/stars](#) (62 cells)
- 17)  [J/A+A/385/67/tablea3](#) (1 cells)
- 18)  [J/ApJ/692/422/sample](#) (58 cells)
- 19)  [J/AJ/108/2338/table1](#) (275 cells)
- 20)  [J/ApJS/147/1/table2](#) (5 cells)
- 21)  [J/MNRAS/365/401/table3](#) (27 cells)
- 22)  [J/MNRAS/276/57/table1](#) (333 cells)
- 23)  [J/MNRAS/402/2792/table2](#) (64 cells)

2



Intersection:  
3xmm ∩  
J A+A 454 895 stars

3

A possibility of filtering the input catalogues by UCDs would be very helpful

```
#HPXMOC
{"8": [283286, 572153],
 "9": [1492993, 1492995, 1705982, 1705983, 2953997, 2953998, 2953999]}
```

4

Provide directly a MOC (ex: 3/128 4/345-510):

or J2000 coordinates (ex: 10.34 +23.12):



# Table selection by UCD

- **Some table intersection with the 3XMM are not all useful.**
  - No relevant photometric parameters e.g.
- **Selection of catalogues of interest by UCDs**
  - Catalogue with information on magnitude in different energy range
  - Need to be properly implemented (TAP service e.g.)
  - Requires queries on the catalogue descriptions.
  - Cannot be done before the MOC generation because the MultiMoc has no UCD filtering option.
- **6700 catalogues selected**
  - 8584 catalogues selected, but some have information in multiple energy bands

UCD	# catalogues
em.gamma	59
em.X-ray	764
em.UV	193
em.opt	4.566
em.IR	1.806
em.mm	226
em.rad	970



# Sources in MOCS

- Can be done with STILTS, but requires MOC in FITS format
  - Conversion of all MOCS in FITS using the Aladin API (hack)
- Delivery of one table per VizieR catalogue with the 3XMM sources contained in its MOC (not a cross match)
  - Source X + pos + ID

TOPCAT(8): Table Browser

Table Browser for 8: B\_avo.rad\_catalog.fits

	SRCID	SC_RA	SC_DEC	inmoc	CatName
1	22022	188,96278	62,13851	<input checked="" type="checkbox"/>	B_avo.rad_catalog
2	4335	188,97145	62,17698	<input checked="" type="checkbox"/>	B_avo.rad_catalog
3	9062	188,98002	62,15014	<input checked="" type="checkbox"/>	B_avo.rad_catalog
4	7951	188,98384	62,26564	<input checked="" type="checkbox"/>	B_avo.rad_catalog
5	22361	188,98424	62,20544	<input checked="" type="checkbox"/>	B_avo.rad_catalog
6	12633	188,98436	62,13408	<input checked="" type="checkbox"/>	B_avo.rad_catalog
7	352951	188,98956	62,17321	<input checked="" type="checkbox"/>	B_avo.rad_catalog
8	8803	189,02116	62,33686	<input checked="" type="checkbox"/>	B_avo.rad_catalog
9	60377	189,02269	62,11509	<input checked="" type="checkbox"/>	B_avo.rad_catalog
10	352811	189,02369	62,19685	<input checked="" type="checkbox"/>	B_avo.rad_catalog
11	50305	189,02444	62,14392	<input checked="" type="checkbox"/>	B_avo.rad_catalog
12	352823	189,02782	62,1652	<input checked="" type="checkbox"/>	B_avo.rad_catalog
13	25331	189,02828	62,26411	<input checked="" type="checkbox"/>	B_avo.rad_catalog
14	22842	189,03136	62,25085	<input checked="" type="checkbox"/>	B_avo.rad_catalog
15	51520	189,04612	62,15069	<input checked="" type="checkbox"/>	B_avo.rad_catalog
16	4250	189,0464	62,37475	<input checked="" type="checkbox"/>	B_avo.rad_catalog
17	55774	189,04802	62,36381	<input checked="" type="checkbox"/>	B_avo.rad_catalog
18	5503	189,05017	62,19415	<input checked="" type="checkbox"/>	B_avo.rad_catalog
19	4239	189,05065	62,32817	<input checked="" type="checkbox"/>	B_avo.rad_catalog
20	350796	189,06503	62,10509	<input checked="" type="checkbox"/>	B_avo.rad_catalog
21	55442	189,06665	62,18528	<input checked="" type="checkbox"/>	B_avo.rad_catalog
22	61170	189,06773	62,25364	<input checked="" type="checkbox"/>	B_avo.rad_catalog
23	8671	189,0711	62,16976	<input checked="" type="checkbox"/>	B_avo.rad_catalog
24	4203	189,07501	62,27633	<input checked="" type="checkbox"/>	B_avo.rad_catalog
25	350864	189,07533	62,26403	<input checked="" type="checkbox"/>	B_avo.rad_catalog
26	4963	189,07726	62,18742	<input checked="" type="checkbox"/>	B_avo.rad_catalog
27	11333	189,07972	62,24494	<input checked="" type="checkbox"/>	B_avo.rad_catalog
28	350870	189,08155	62,2603	<input checked="" type="checkbox"/>	B_avo.rad_catalog
29	350873	189,08192	62,26511	<input checked="" type="checkbox"/>	B_avo.rad_catalog
30	350849	189,08986	62,26742	<input checked="" type="checkbox"/>	B_avo.rad_catalog



# Fraction of 3XMM area covered by each catalogue

- **Attach a sky coverage to each VizieR catalogue**
  - Could help for the final selection catalogue
- **It could be helpful to have a sky coverage per galactic latitude or other parameters.**
  - Could be done with IDL from “source in MOC “ files
  - Relevant for science cases. Doing the galactic science in the galactic plane only e.g.

TOPCAT(2): Table Browser

Table Browser for 2: 3XMM\_intersection\_tables\_IR.lis

Catalog	3XMM_cover...	Title	Bibcode
8 I/297/out	1,	NOMAD Catalog (Zacharias+ 2005)	2004AAS...205.4815Z
15 I/315/out	1,	UCAC3 Catalogue (Zacharias+ 2009)	2010AJ...139.2184Z
16 I/317/sample	1,	The PPMXL Catalog (Roeser+ 2010)	2010AJ...139.2440R
18 I/322A/out	1,	UCAC4 Catalogue (Zacharias+, 2012)	2012yCat.1322....0Z
37 II/246/out	1,	2MASS All-Sky Catalog of Point Sources (Cutri+ 20...	
11 I/305/out	0,999	The Guide Star Catalog, Version 2.3.2 (GSC2.3) (S...	
14 I/312/sample	0,999	PPMX Catalog of positions and proper motions (R...	2008A&A...488..401R
62 II/311/wise	0,999	WISE All-Sky Data Release (Cutri+ 2012)	2012yCat.2311....0C
6 I/289/out	0,884	UCAC2 Catalogue (Zacharias+ 2004)	2004AJ...127.3043Z
5 I/280B/ascc	0,858	All-sky Compiled Catalogue of 2.5 million stars (K...	2001KFNT...17e.409K
1710 J/PASP/122/1437/table15	0,844	All-sky spectrally matched Tycho2 stars (Pickles+...	2010PASP...122.1437P
1772 VI/135/table15	0,844	All-sky spectrally matched Tycho2 stars (Pickles+...	2010PASP...122.1437P
1753 V/136/tycall	0,838	Teff and metallicities for Tycho-2 stars (Ammons...	2006ApJ...638.1004A
1792 VII/233/xsc	0,75	The 2MASS Extended sources (IPAC/UMass, 2003...	2006AJ...131.1163S
1703 J/PASP/120/1128/catalog	0,731	Calibrated griz magnitudes of Tycho star (Ofek, 2...	2008PASP...120.1128O
10 I/304/out	0,605	Carlsberg Meridian Catalog 14 (CMC14) (CMC, 20...	
31 II/241/out	0,541	2MASS Catalog Intermediate Data Release (IPAC/...	
1 B/denis/denis	0,54	The DENIS database (DENIS Consortium, 2005)	
60 II/307/wise	0,517	WISE Preliminary Data Release (Cutri+ 2011)	2011yCat.2307....0C
43 II/275/fsr	0,504	IRAS Faint Source Reject Catalog (IPAC 1992)	
1754 V/136/tycdwarf	0,49	Teff and metallicities for Tycho-2 stars (Ammons...	2006ApJ...638.1004A
54 II/297/irc	0,425	AKARI/IRC mid-IR all-sky Survey (ISAS/JAXA, 2010)	2010A&A...514A...1I
17 I/320/spm4	0,35	SPM 4.0 Catalog (Girard+ , 2011)	2011AJ...142...15G
1806 VIII/90/first12	0,35	The FIRST Survey Catalog, Version 12Feb16 (Beck... 1997ApJ...475..479W	
1711 J/PASP/122/1437/table16	0,334	All-sky spectrally matched Tycho2 stars (Pickles+...	2010PASP...122.1437P



# Astrometric & Photometric Accuracy

- Go to ADS, ArXiv .....
- A similar job has been done for the XMM pipeline (ACDS)

- 220 catalogue queried
- Selected by hand by M Pakull
- Cross match results included within de delivered products
- Accessible through the XCatDB

<http://xcatdb.unistra.fr>

Filter by VizieR Keywords    Filter by Catalogue Names    Filter by ...

**astronomy**

- Abundances
- AGN
- Binaries:cataclysmic
- BL\_Lac\_objects
- Blue\_objects
- Clusters\_of\_galaxies
- Galaxies

**mission**

- AKARI
- ASCA
- Chandra
- Einstein
- EUVE
- FAUST
- Hipparcos

**wavelength**

- EUV
- IR
- optical
- Radio
- UV
- X-ray

Query Panel

**SUBMIT**    Result Limit: 1000

```
Select ENTRY From CatalogueEntry In CATALOGUE
HavingCounterpartsWith {
  "wavelength=UV"
}
```



# Database

[prototype](#)

**saada** ArchesCatDB XMM>ENTRY>Slim3XMMEntry

about

Previous Next Show 10 entries Showing 1 to 10 of 100 entries

Access	Position	Error (arcsec)	Name	Rel : XmmToVizierCat
	00:00:09.82-25:19:20.3 (s)	±1.9665	3XMM J000009.8-251920	2 links

**Source Detail** ✕

◀▶ **TABLE ENTRY 3XMM J000009.8-251920 - 00:00:09.82-25:19:20.3**



- ▼ Native Data
- ▶ Mapped Data
- ▼ Relation XmmToVizierCat

Search:

Access	Table	Rel : VizierCatToMoc	Rel : VizierToUcd	rad	mm	IR	opt	UV	Xray
	B_wds_wds.fits	1 links	23 links	0.0000	0.0000	0.0000	1.0000	0.0000	0.000
	B_denis_denis.fits	1 links	74 links	0.0000	0.0000	1.0000	1.0000	0.0000	0.000

Showing 1 to 2 of 2 entries



## What next

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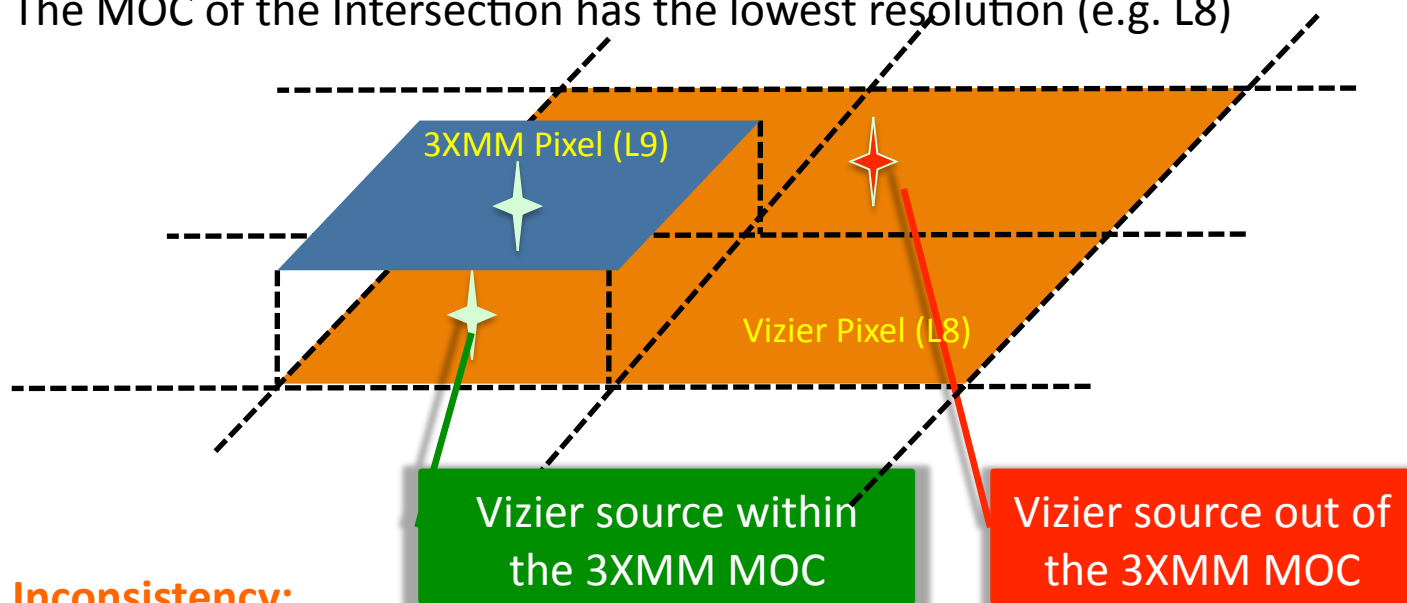
- **Compute cross correlation with identification probabilities**
  - FX Pineau
- **Generate SED for all 3XMM sources having a counterpart covering all the EM spectrum**
- **Put the results online**



# Healpix Resolution Issue

- If the 2 catalogues have a different healpix resolutions

- The MOC of the Intersection has the lowest resolution (e.g. L8)



- **Inconsistency:**

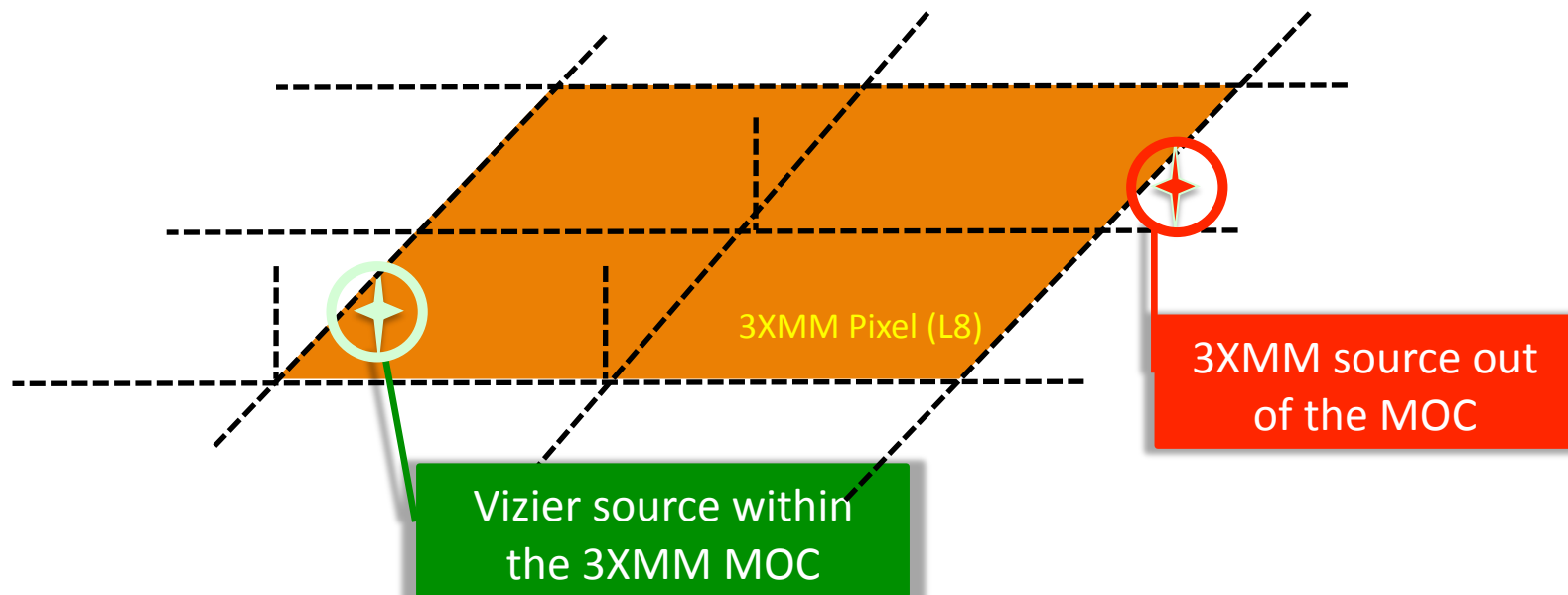
- Let's take a source (red) which belongs to the intersection but not the 3XMM footprint.
- AS it doesn't belong to the 3XMM footprint, so it should not be in the intersection.
- Although it IS in the intersection.

- No solution yet to this issue.

- Degrading the 3XMM Moc: **too bad**
- Re-compute on demand some Vizier MOCs with the right resolution: **takes time?**



- **The MOCs do not take in account the errors**
  - The healpix pixels only contain the sources having their barycentre into it.
    - The footprints should be a little bit extended to include side sources.
  - That could be easily fixed for circular errors with the Healpix library.
  - But things are getting worse with ellipsoidal errors .....





# Querying by UCDs

- Querying catalogues by UCDs is not straightforward.
  - Requires un good knowledge of the vocabulary

Tap Nodes

Show 10 entries

name
phot.mag.sb;em.opt.R;meta.modelled
phot.flux;em.opt.R
phot.mag;em.opt.R
phot.mag.sb;em.opt.R
phot.mag;em.opt.R;arith.diff
phot.mag;em.opt.R;instr.fov
phot.flux.density.sb;em.opt.R
phot.flux.density;em.opt.R

Showing 1 to 8 of 8 entries Previous Next

Select What Where Plain Text Query Job Control

Result Limit  
100

```
SELECT DISTINCT metaviz.STATucd.name
FROM metaviz.STATucd
WHERE metaviz.STATucd.name LIKE 'phot%em.opt.R%'
```



# Conclusions

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- **This catalogue selection couldn't be achieved without both MOCs tools and UCDs.**
  - Let's say without the VO tools
- **Some issues require improvement**
  - ≠ resolutions
  - Errors handling
  - Conditional catalogue coverage
- **This work might give some idea for a future Web service doing the same job in a more general case.**