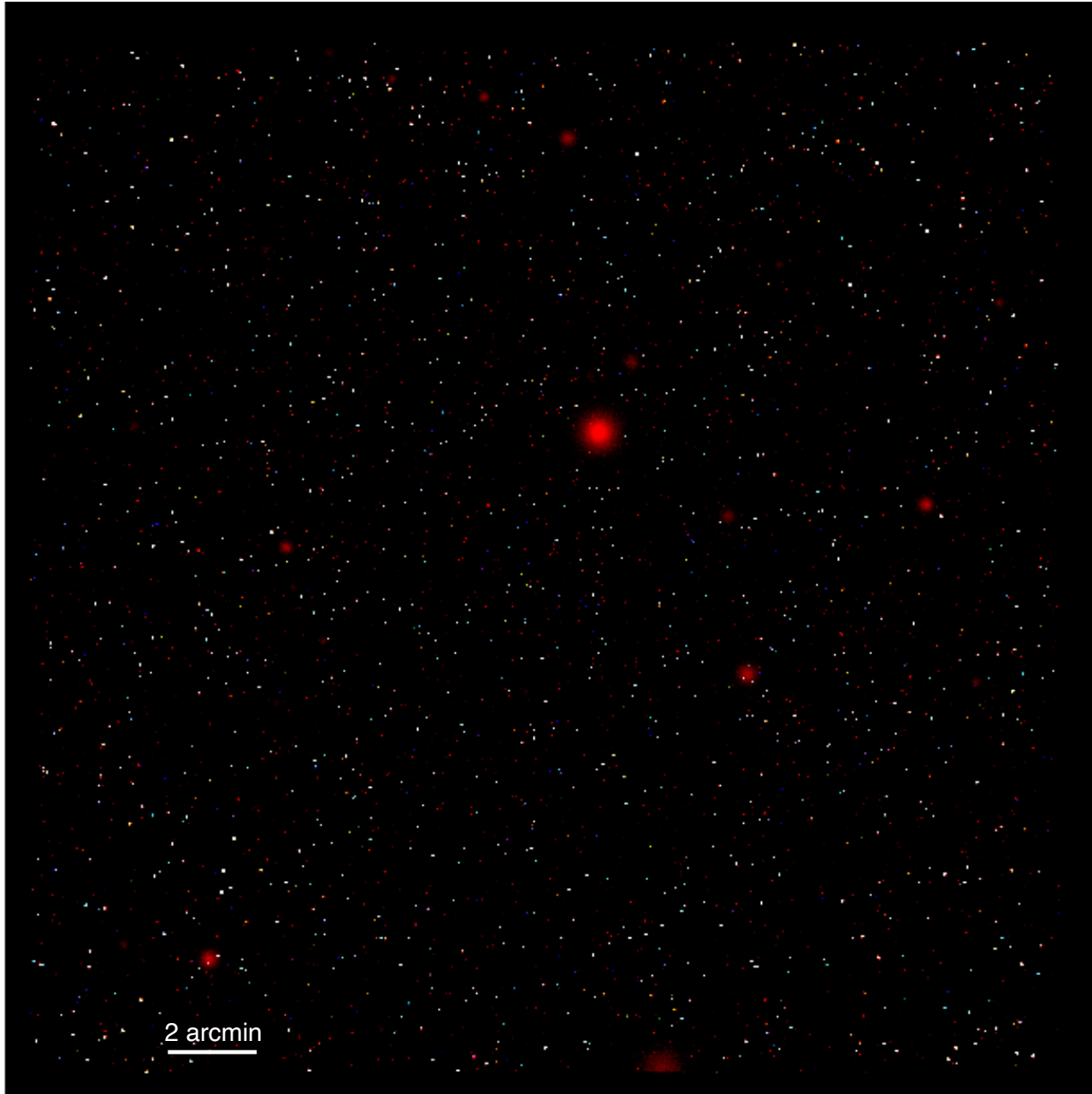


Understanding the AGN population: X-ray surveys



X-rays as a strategic tool in AGN analysis

X-ray emission contributes only to $<10\%$ to AGN bolometric luminosity. However, X-ray emission offers an unique point of view in the AGN analysis. In fact, X-ray offer the...

Donley et al. (2008, 2012); Ballantyne et al. (2011) Comastri et al. (2011); Georgantopoulos et al. (2013); Lanzuisi et al. (2015); Buchner et al. (2015)

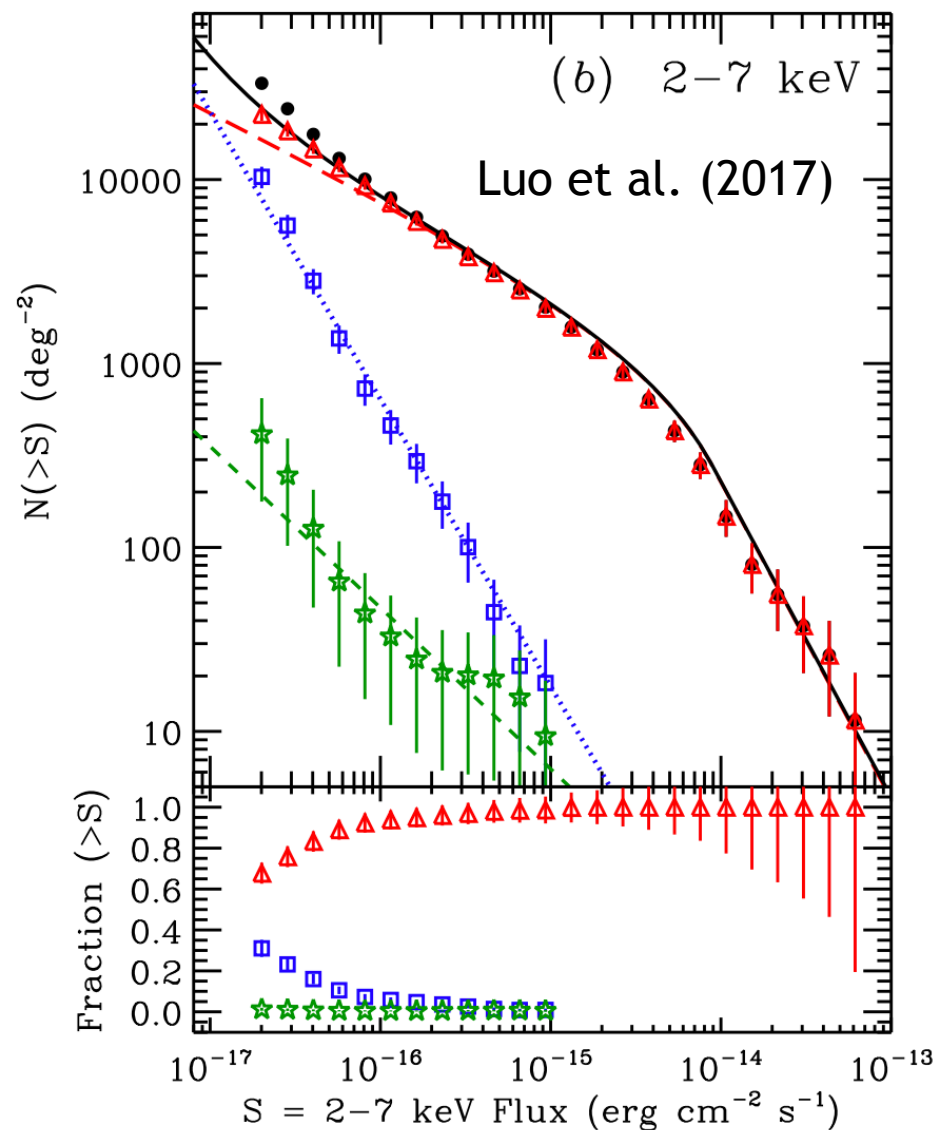
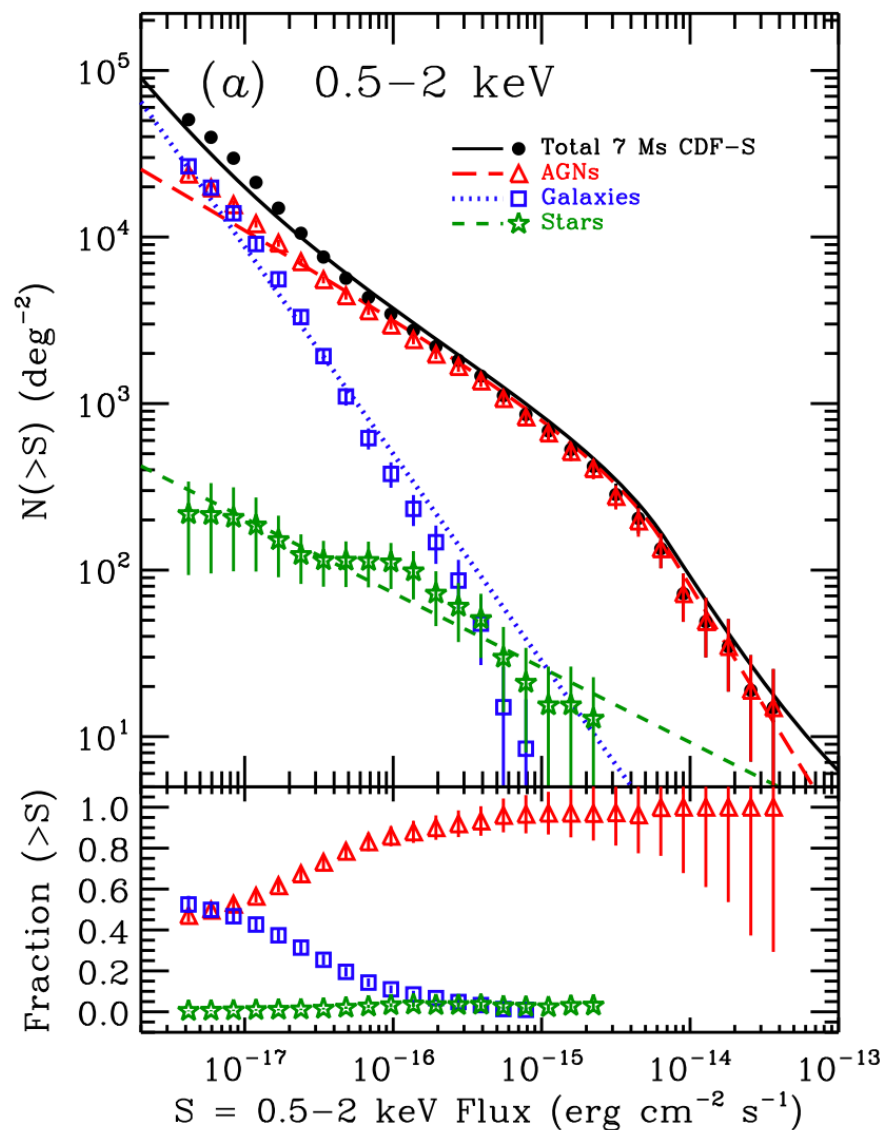
X-rays as a strategic tool in AGN analysis

X-ray emission contributes only to $<10\%$ to AGN bolometric luminosity. However, X-ray emission offers a unique point of view in the AGN analysis. In fact, X-ray offer the...

1. *cleanest* AGN selection: negligible SF contamination, both in terms of single objects ($L_x > 10^{42}$ erg s $^{-1}$ safely identifies AGN) and of integrated population (galaxy contribution to total X-ray emission becomes significant only at the flux limit of the deepest surveys).

Donley et al. (2008, 2012); Ballantyne et al. (2011) Comastri et al. (2011); Georgantopoulos et al. (2013); Lanzuisi et al. (2015); Buchner et al. (2015)

X-rays as a strategic tool in AGN analysis



(top panel: Luo et al. (2017), Lanzetta et al. (2015), Buchner et al. (2015))

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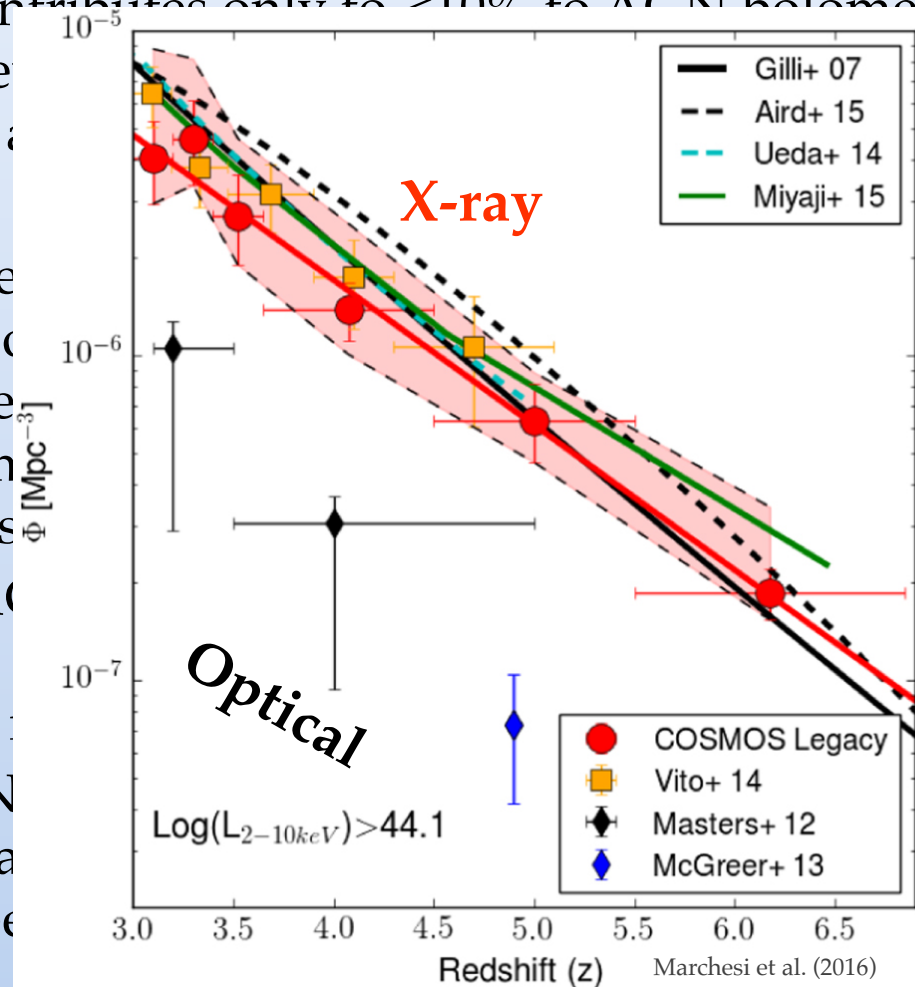
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3. *less biased* AGN selection: less strong obscuration effect at >2 keV. Sampling a class of obscured sources (up to $N_H \sim 10^{24}$ cm $^{-2}$) which cannot be detected by optical surveys.

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X-rays as a strategic tool in AGN analysis

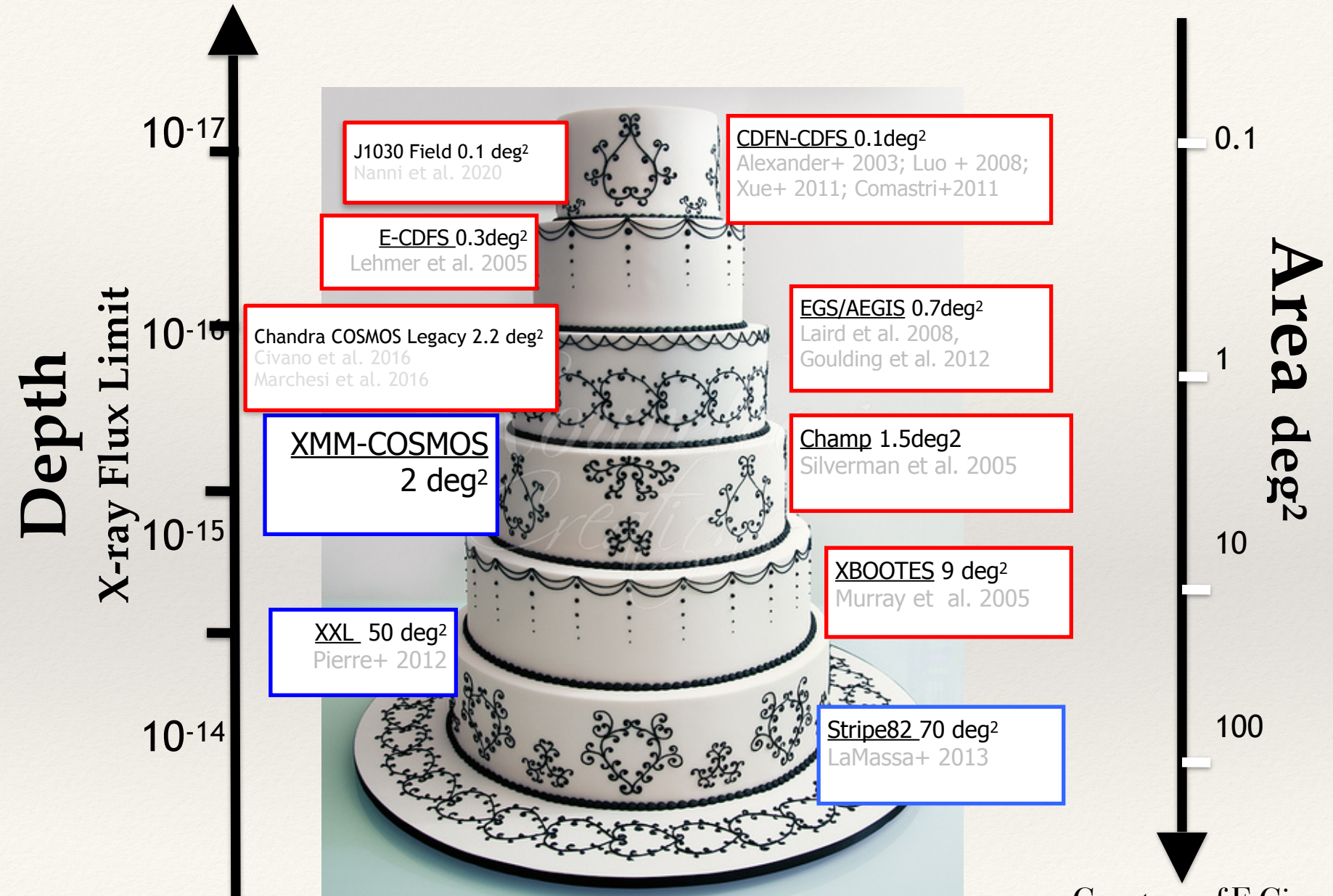
X-ray emission contributes only to $\leq 10\%$ to AGN bolometric luminosity. However, in the AGN view in the AGN

1. *cleanest* AGN selection in terms of single component and of integrated emission become deepest surveys
2. *less luminous* AGN magnitude less contamination,
3. *less biased* AGN selection keV . Sampling a which cannot be



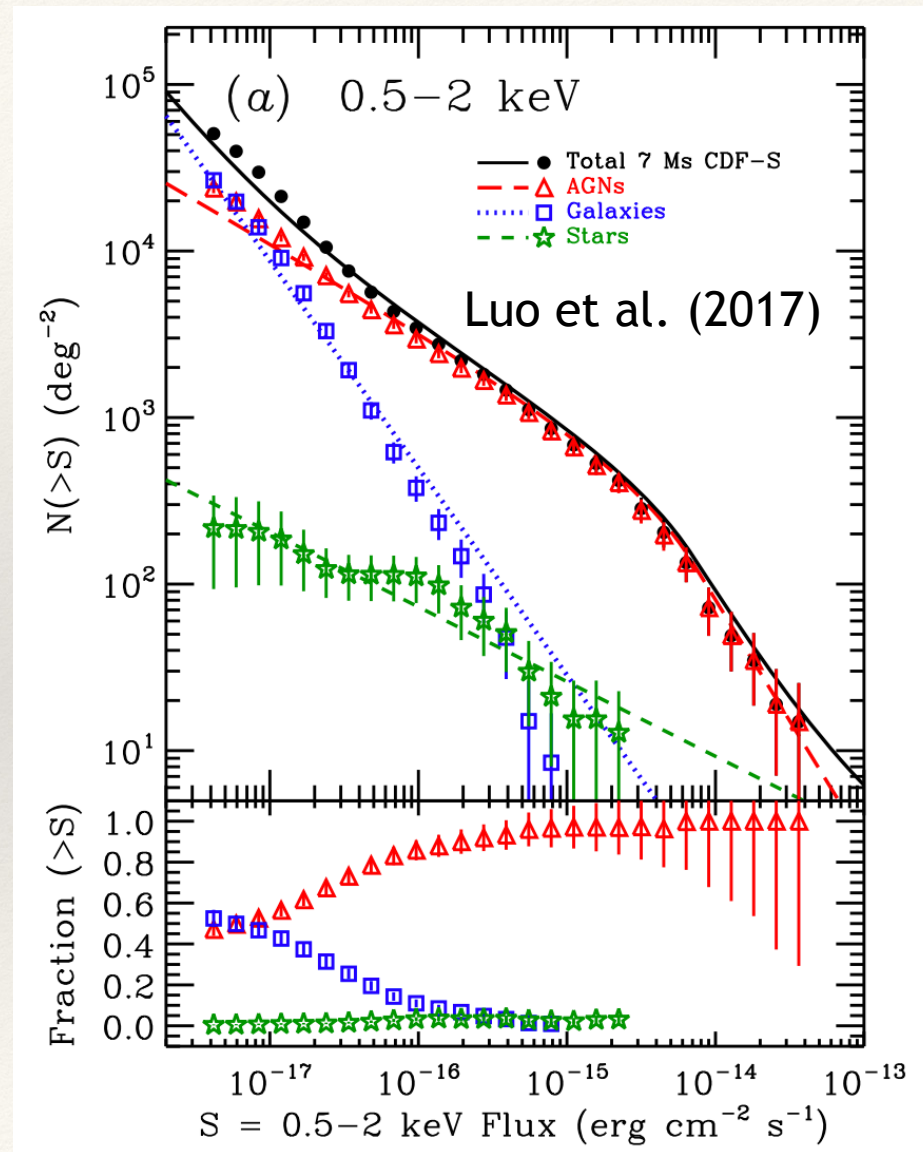
Donley et al. (2008, 2012); Ballantyne et al. (2011) Comastri et al. (2011); Georgantopoulos et al. (2013); Lanzuisi et al. (2015); Buchner et al. (2015)

The X-ray surveys wedding-cake strategy

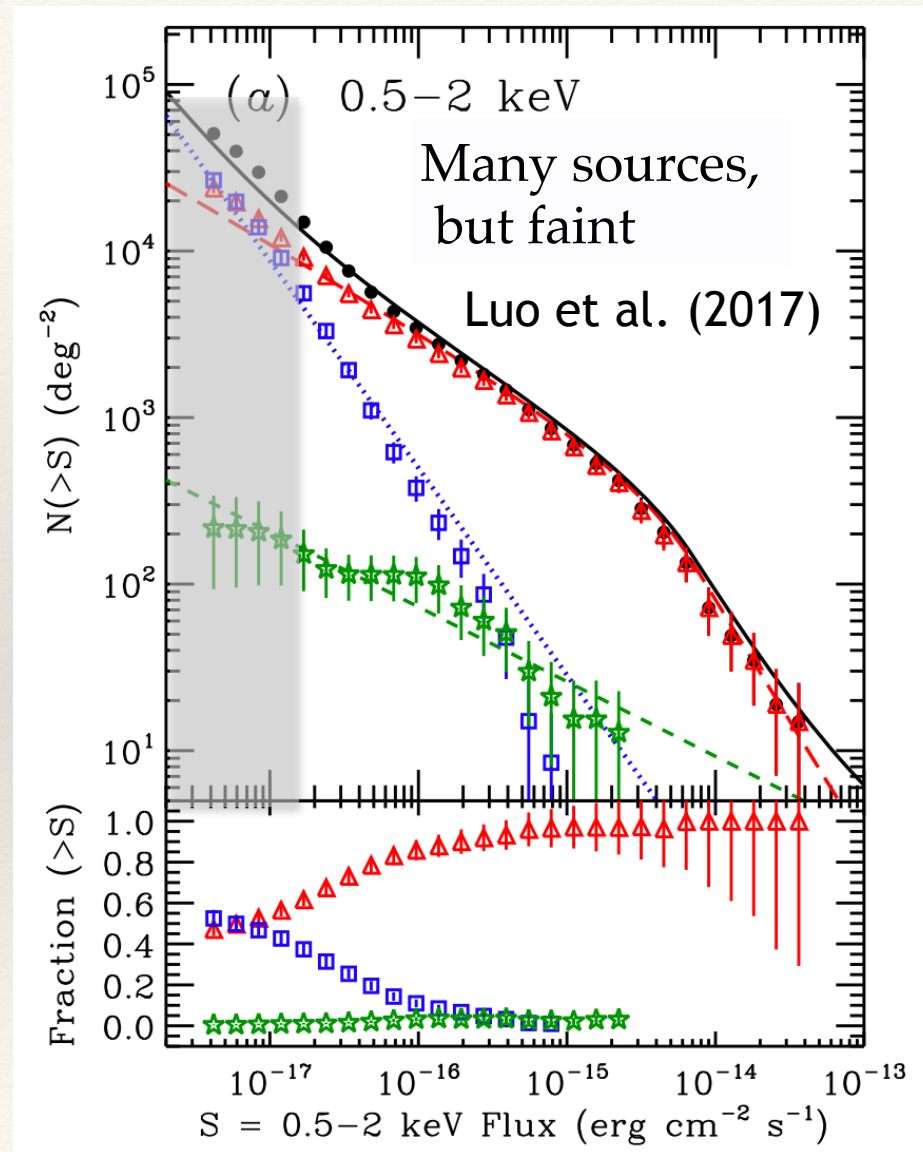


Courtesy of F.Civano

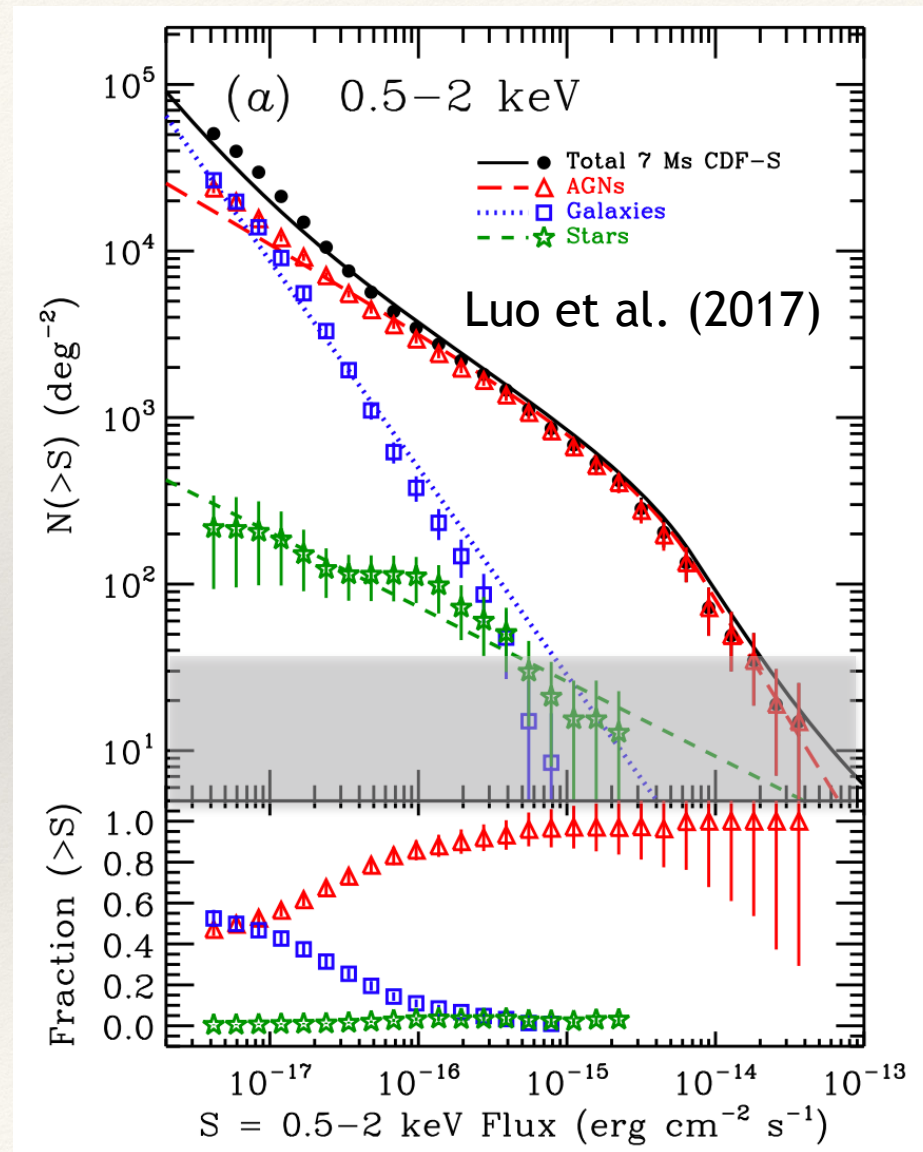
Different surveys for different science



Different surveys for different science

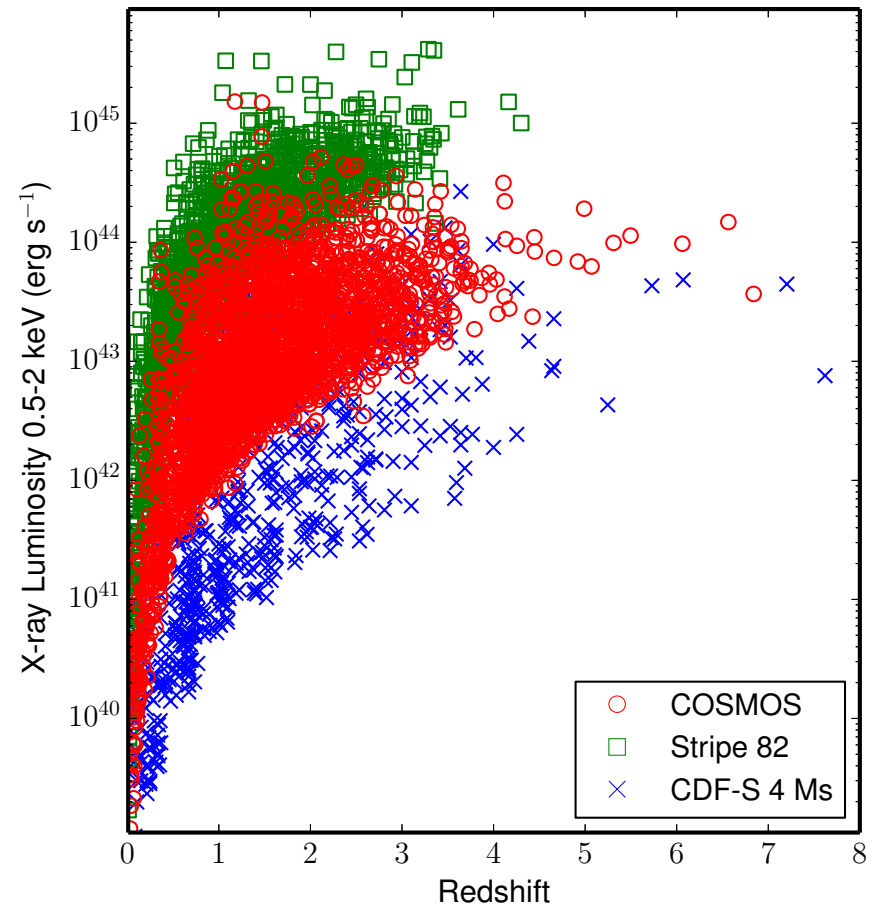
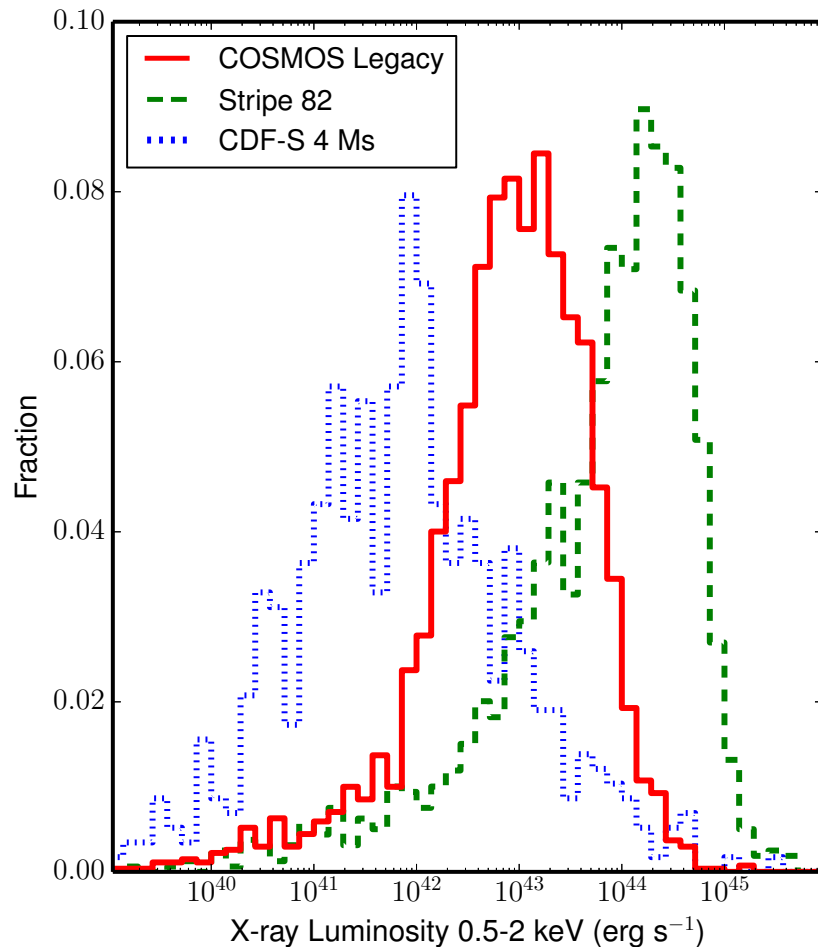


Different surveys for different science



Extremely
bright, but
rare

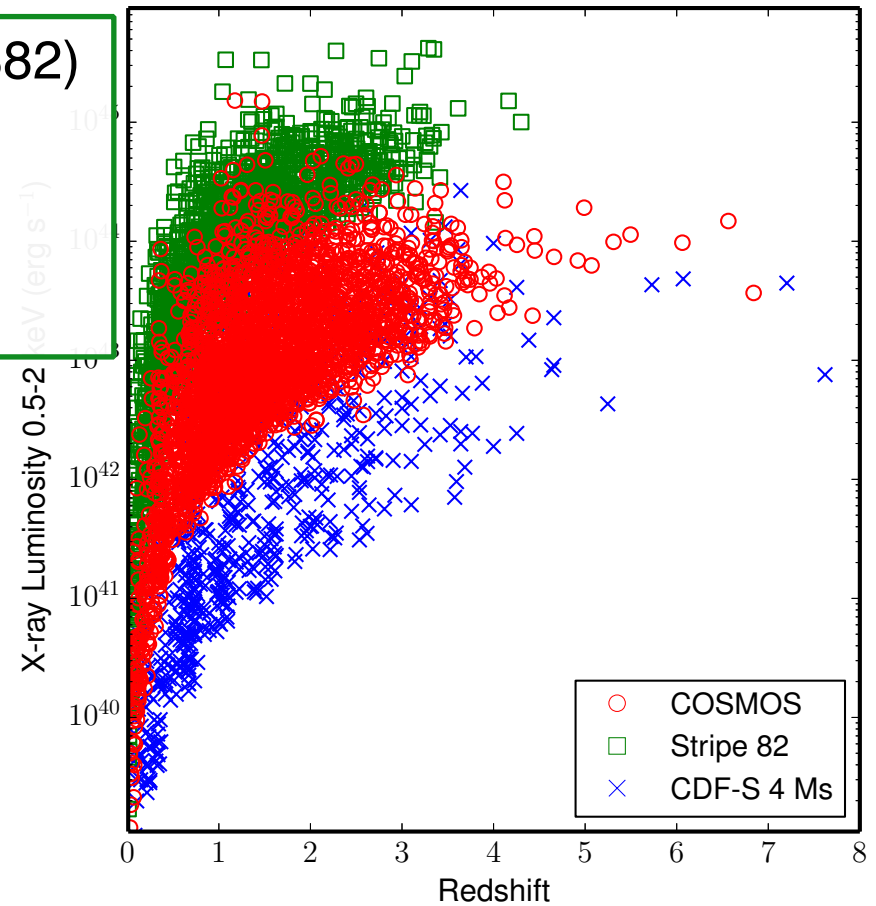
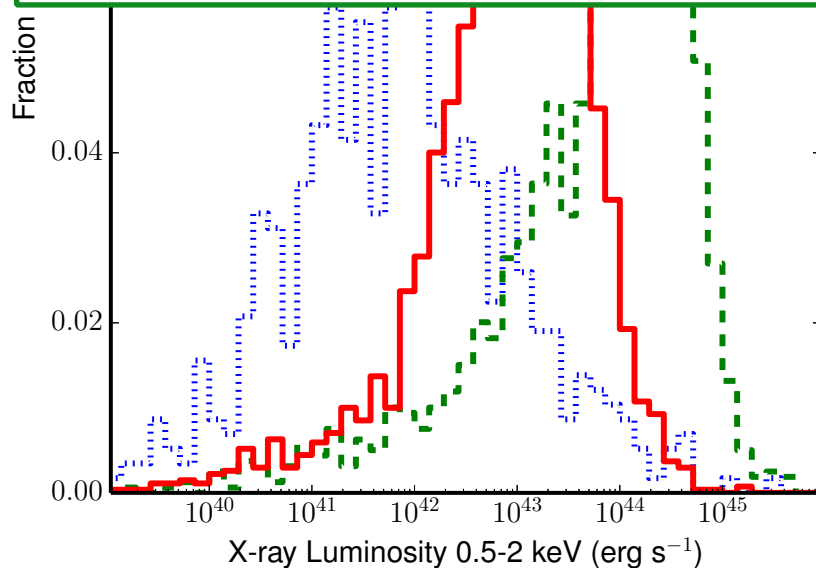
Different surveys for different science



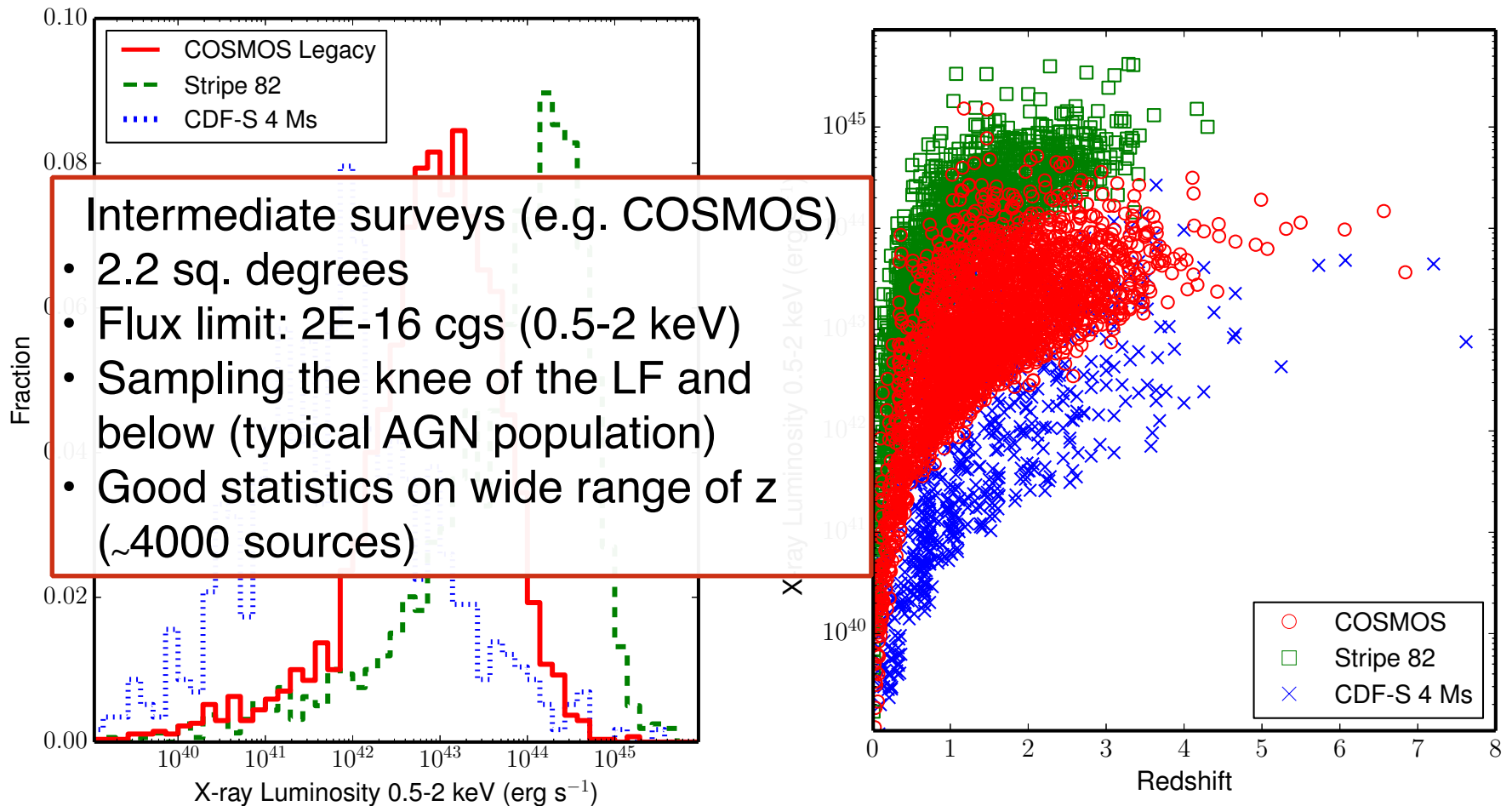
Different surveys for different science

Large area, shallow surveys (e.g., S82)

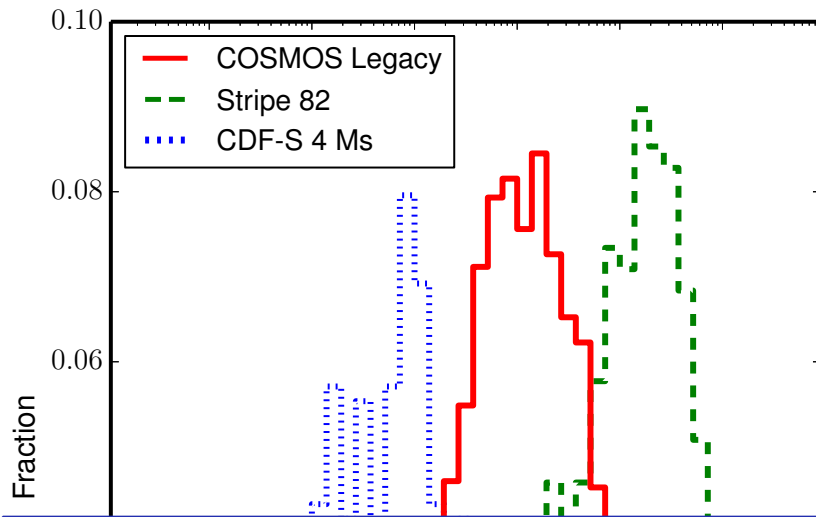
- 70 sq. degrees
- Flux limit: $9E-16$ cgs (0.5-2 keV)
- Looking for rare objects
- Missing low-luminosity objects



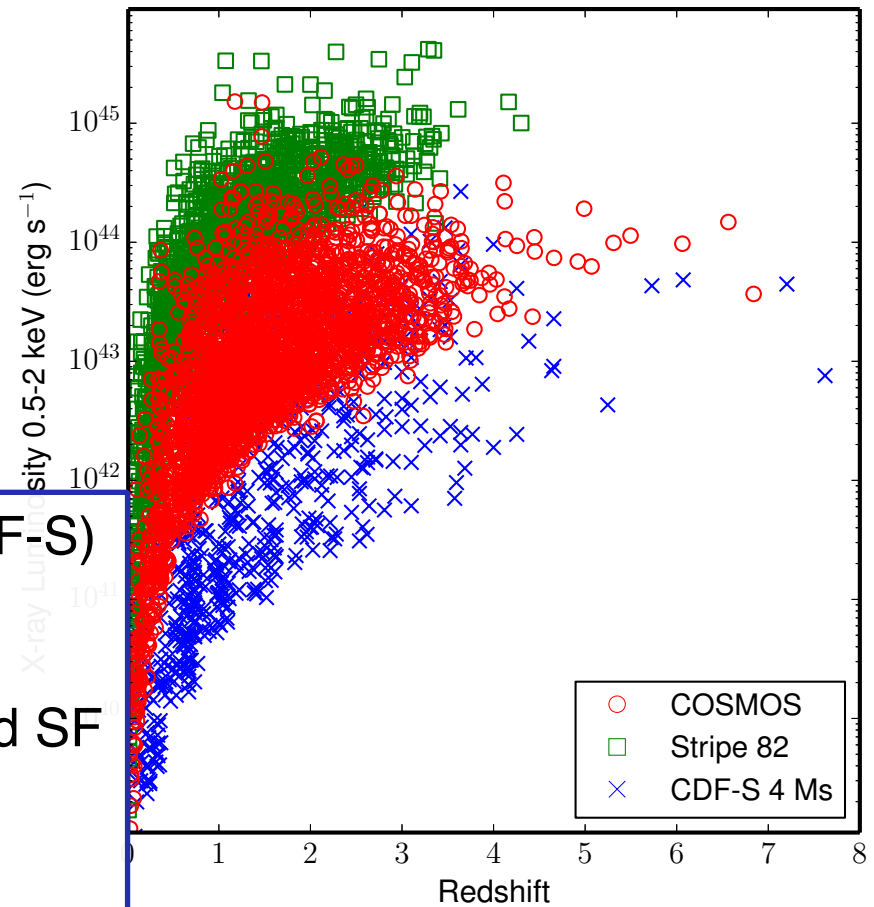
Different surveys for different science



Different surveys for different science



- Deep, pencil beam surveys (e.g. CDF-S)
- 0.1 sq. degrees
 - Flux limit: 6E-18 cgs (0.5-2 keV)
 - Detection of low luminosity AGN and SF galaxies
 - Smaller number of objects (~1000 sources)



Chandra Deep Field-South (CDF-S)

≈ 7 Ms *Chandra* exposure (last obs. at March 2016)

≈ 3 Ms *XMM-Newton* exposure

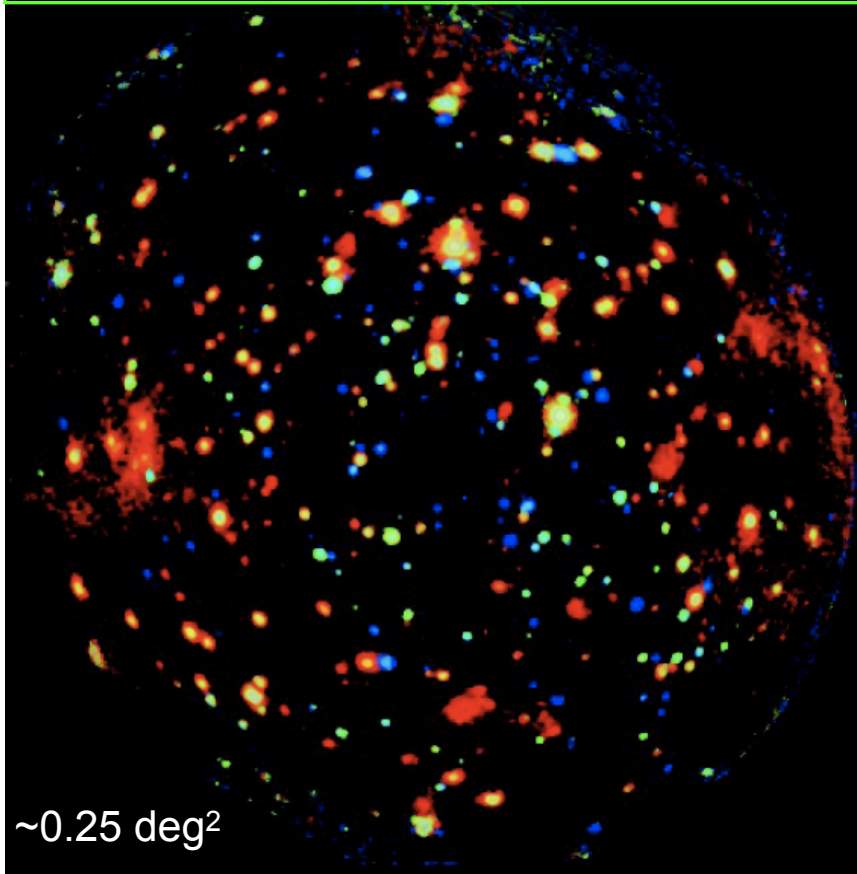
Deep multi-wavelength coverage

One of the legacy fields (no deeper field for the next 20 yrs)

Chandra: good on-axis PSF (i.e., excellent angular resolution) and low background
→ Sensitive to faint and distant AGN

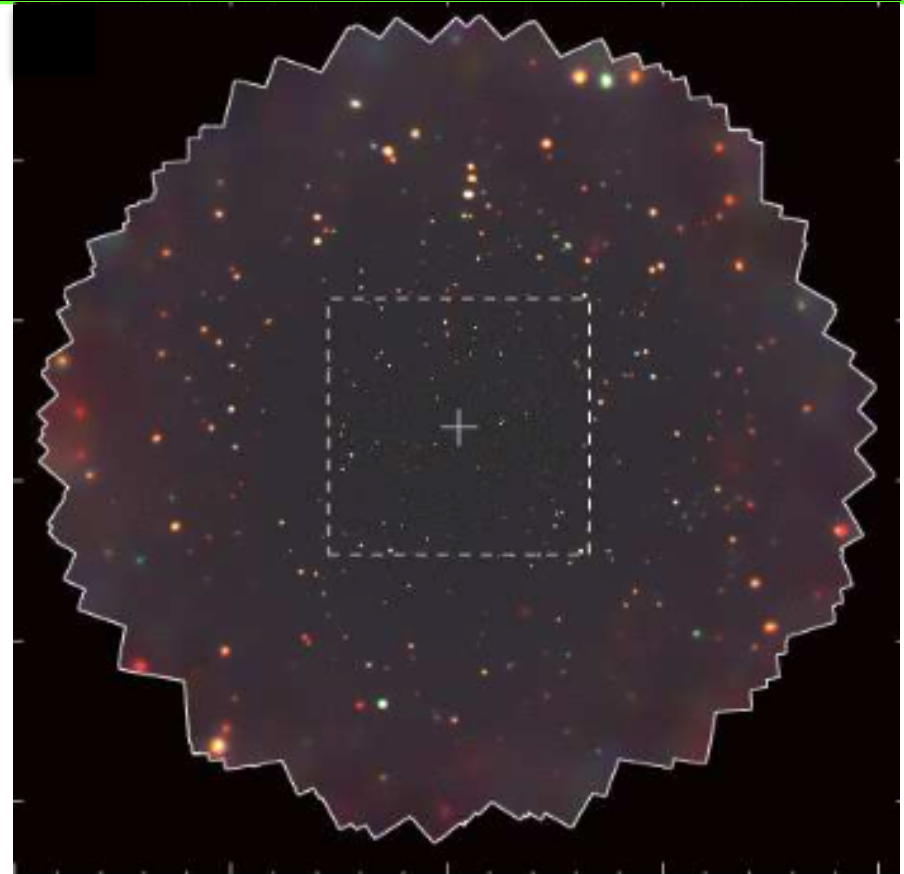
XMM-Newton: larger effective area (hence photon statistics), but much worse angular resolution and higher background
→ Better for X-ray spectroscopy of relatively bright AGN

The deepest X-ray field: CDF-S



XMM-CDFS 3 Ms survey
(PI: A. Comastri; Ranalli+13)

$F(2-10\text{keV}) \approx 6.6 \times 10^{-16} \text{ erg/cm}^2/\text{s}$



Chandra-CDFS 7 Ms survey
(PI: R. Giacconi, W.N Brandt; Xue+11, Luo+17)

$F(0.5-2\text{keV}) \approx 6.4 \cdot 10^{-18} \text{ erg/cm}^2/\text{s}$

Capable of probing the high- z Universe with some photon statistics

This Lab Outline

- 1. Build the source catalog:** From a mosaic made of 4 long CDFS exposures which will be provided to you, perform source detections with different parameter setups. Visualise the outputs and cross-match sources with the official 7Ms source catalog.
- 2. Explore the source catalog:** For one of the newly produced catalogs, produce some relevant plots, and compare quantities with those reported in the 7Ms source catalog
- 3. Analyse the data products:** Fit the X-ray spectra of a few, particularly interesting sources.

Lab Outline

1) Build the source catalog

Lab Outline

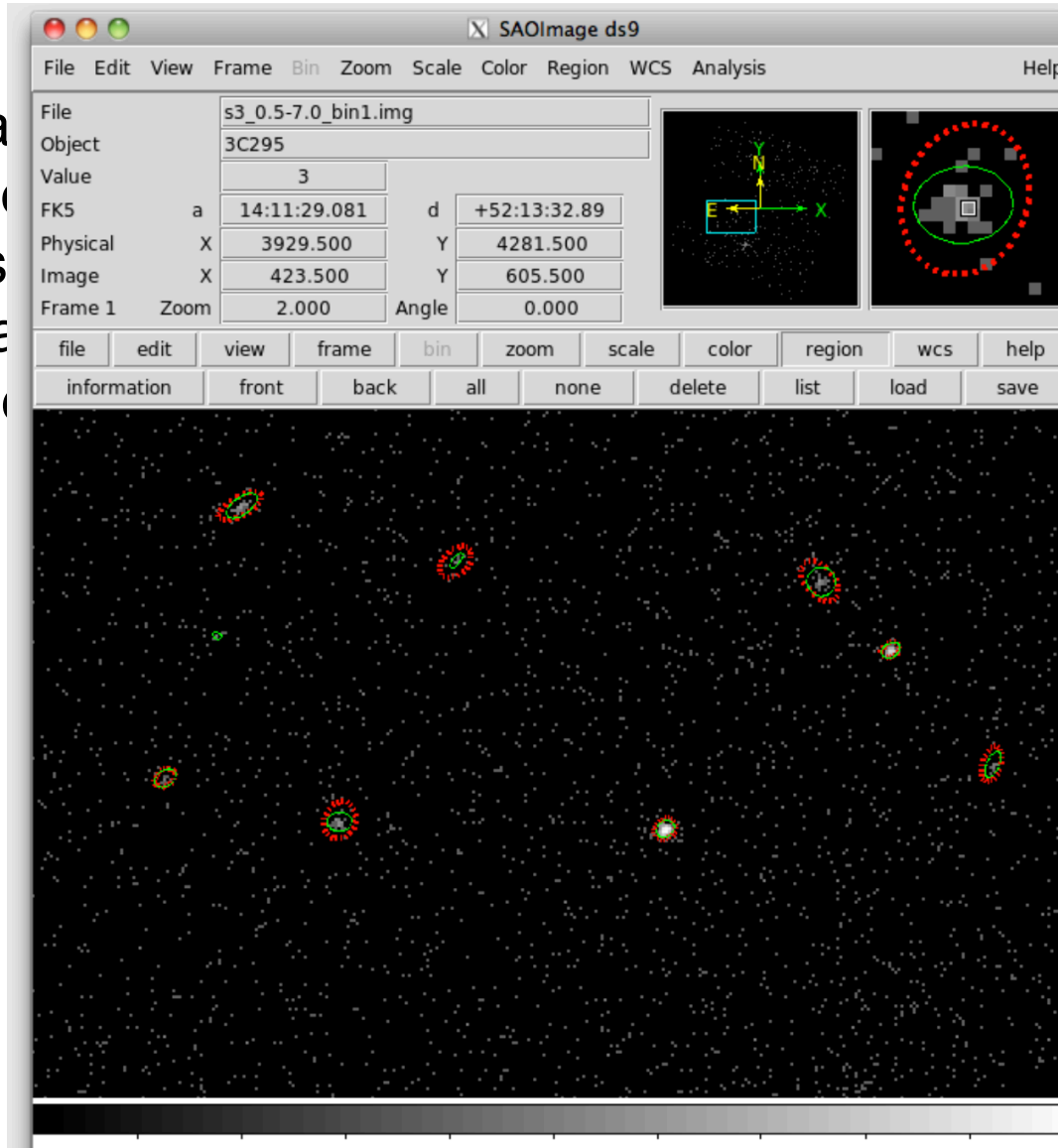
1) Build the source catalog

- a. Run the wavdetect tool to search sources in your observations, using different significance thresholds (i.e., your detections can be more or less reliable; test $1\text{E-}6$ vs $1\text{E-}4$) and different maximum wavelet scales (stop at 5.6 or at 11; important if there are extended sources and for objects in the external part of the field).

Lab Outline

1) Build the source catalog

- a. Run the wavelet transform using different scales to find more or less compact sources and wavelet scales.

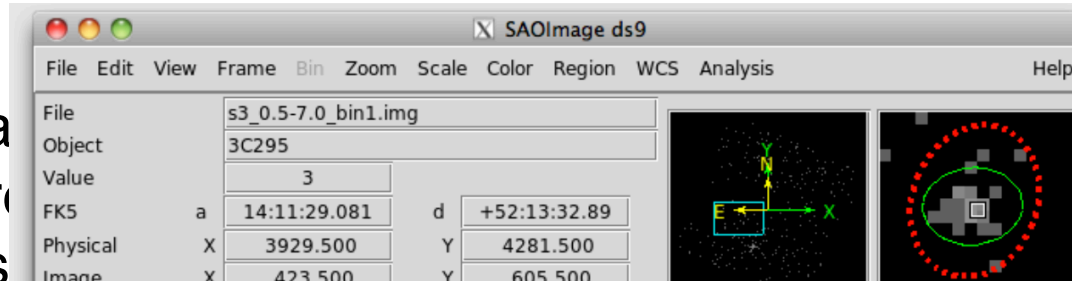


observations, functions can be maximum are extended d).

Lab Outline

1) Build the source catalog

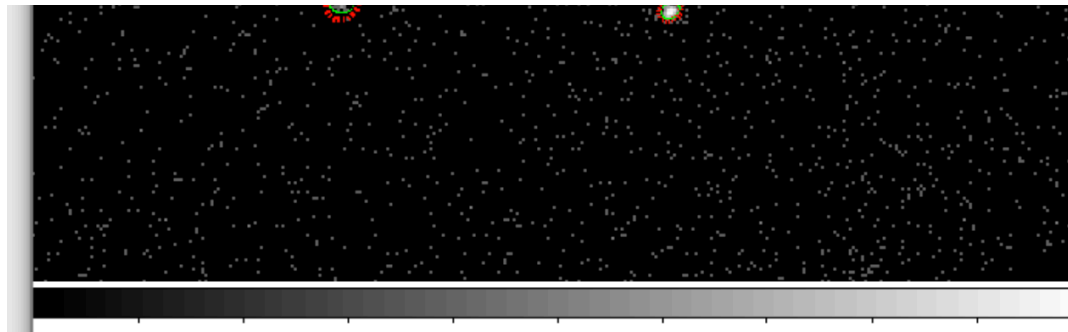
a. Run the wavdetect using different parameters more or less



observations, positions can be determined to maximum

```

unlearn wavdetect
pset wavdetect infile=CDFS_4obs_merged_057keV_bin1.fits
pset wavdetect outfile=CDFS_4obs_merged_057keV_wavdet_1em6_src.fits
pset wavdetect scellfile=CDFS_4obs_merged_057keV_wavdet_1em6_cellimage.fits
pset wavdetect imagefile=CDFS_4obs_merged_057keV_wavdet_1em6_reconstructed.fits
pset wavdetect defnbkgfile=CDFS_4obs_merged_057keV_wavdet_1em6_normbkg.fits
pset wavdetect regfile=CDFS_4obs_merged_057keV_wavdet_1em6.reg
pset wavdetect ellsigma=3.0
pset wavdetect sigthresh=1e-6
pset wavdetect scales="1 1.4 2 2.8 4 5.6 8 11"
pset wavdetect expfile=CDFS_4obs_merged_broad_thresh.expmap
pset wavdetect psffile=CDFS_4obs_merged_broad_thresh.psfmap
wavdetect clobber+ verbose=3
    
```



Lab Outline

1) Build the source catalog

- a. Run the wavdetect tool to search sources in your observations, using different significance thresholds (i.e., your detections can be more or less reliable) and different maximum wavelet scales (important if there are extended sources and for objects in the external part of the field)
- b. Cross-correlate the source lists generated in the previous steps with the official 7 Ms Chandra source catalog in the CDF-S (Luo et al. 2017), using various cross-matching radii.
 - Compute the fraction of 7Ms sources found in the 4-observation mosaic using different thresholds ($1\text{E-}6/1\text{E-}4$) and matching radii (1/2/3").
 - For your source list which has the largest number matches within 2" with the 7 Ms CDF-S catalog, compute the number of sources detected in the 4-observation mosaic and not in the 7Ms catalog, and study their properties (e.g., number of counts, source significance, position in the field of view...) and their visual appearance: what are the possible explanations for their detection in the your shorter-exposure mosaic?

Lab Outline

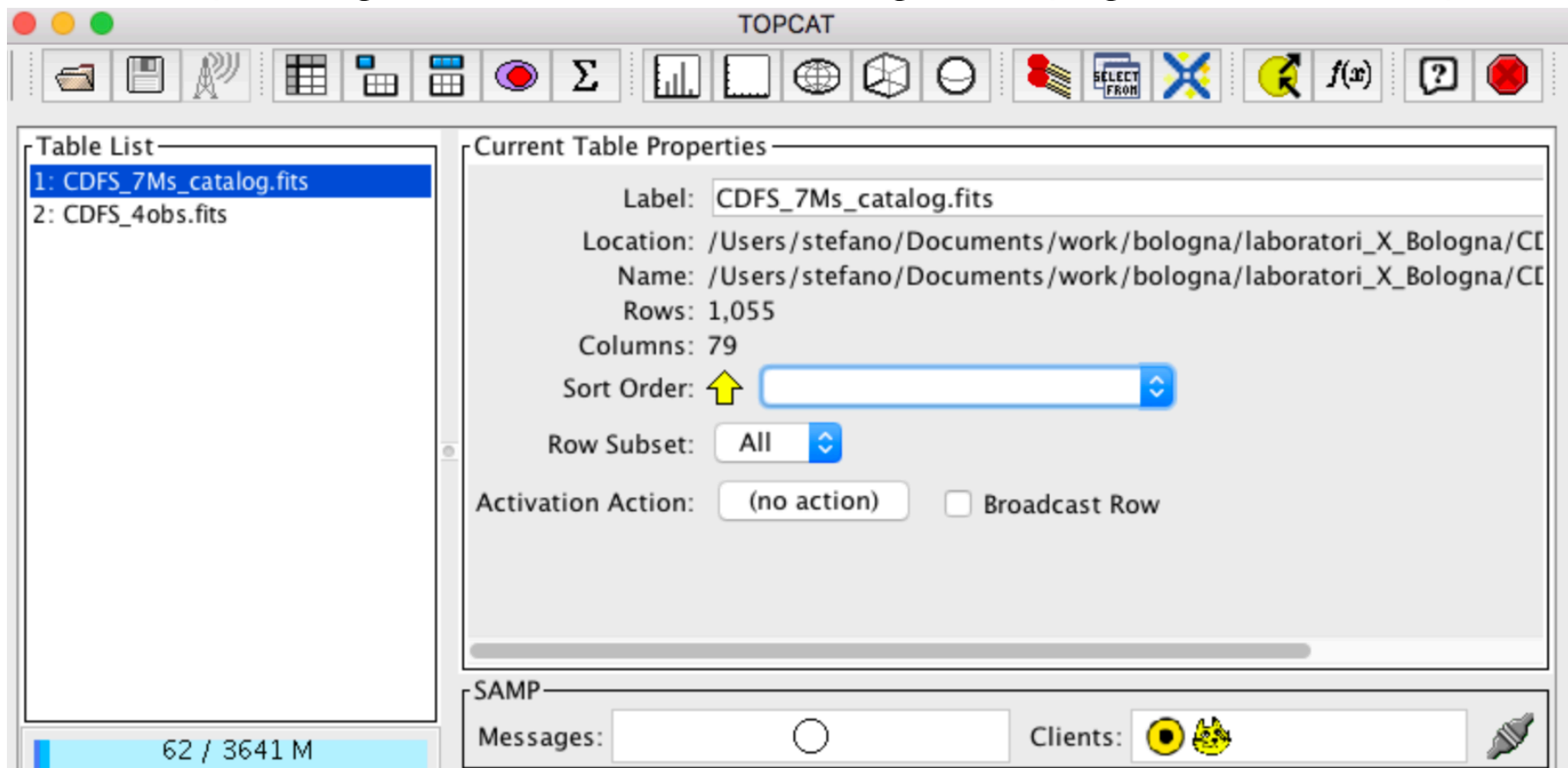
1) Build the source catalog

Cross-correlate the source lists generated in the previous steps with the official 7 Ms Chandra source catalog in the CDF-S (Luo et al. 2017), using various cross-matching radii (e.g., 1,2,3 arcsec)

Lab Outline

1) Build the source catalog

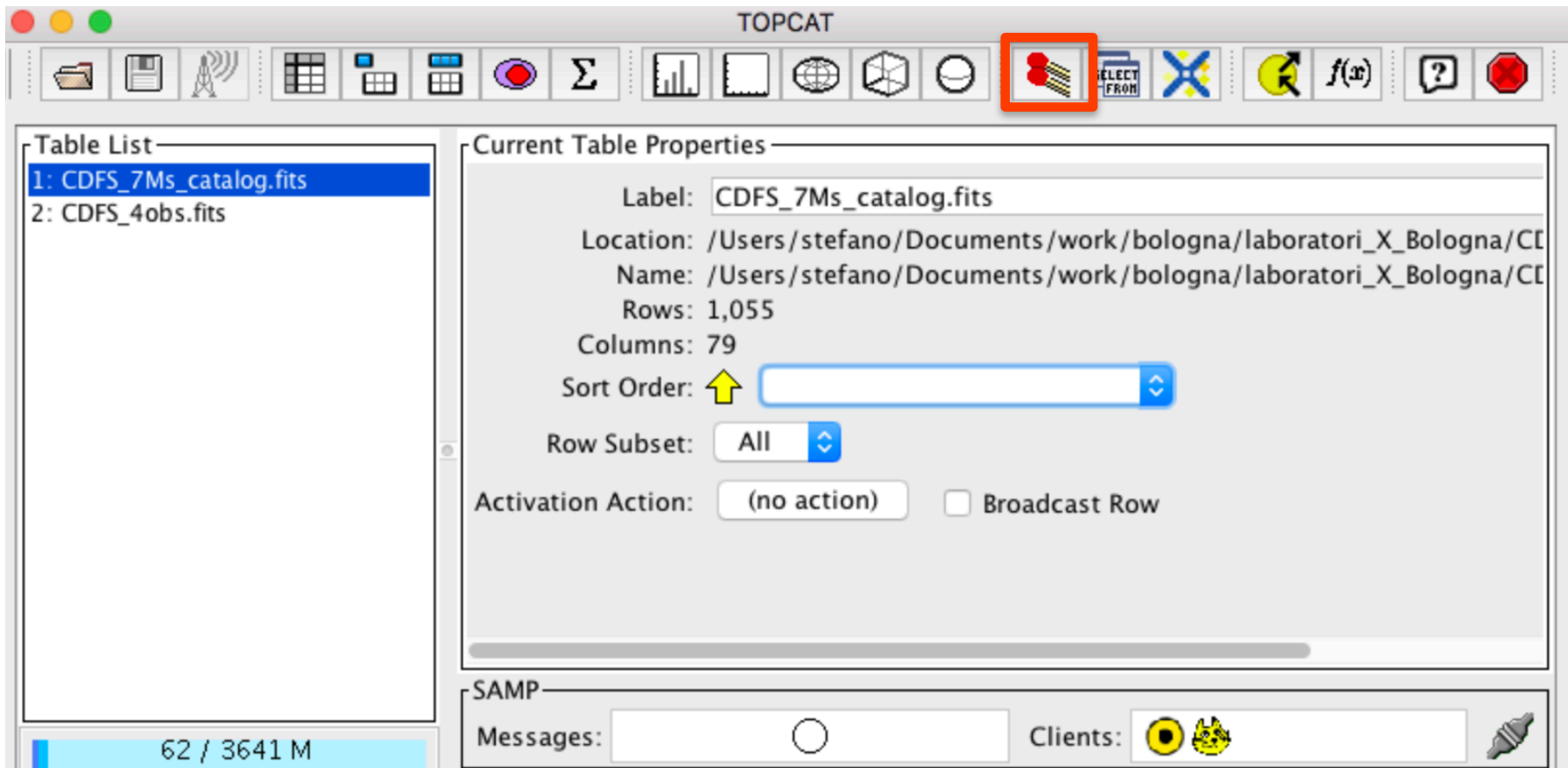
Cross-correlate the source lists generated in the previous steps with the official 7 Ms Chandra source catalog in the CDF-S (Luo et al. 2017), using various cross-matching radii (e.g., 1,2,3 arcsec)



Lab Outline

1) Build the source catalog

Cross-correlate the source lists generated in the previous steps with the official 7 Ms Chandra source catalog in the CDF-S (Luo et al. 2017), using various cross-matching radii (e.g., 1,2,3 arcsec)



1) B

Cross-correlate the
with the official 7
al. 2017), using v

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previous steps
e CDF-S (Luo et
1,2,3 arcsec)

The screenshot displays the 'Match Tables' application window. On the left, a 'Table List' pane shows two tables: '1: CDFS_7Ms_catalog.fits' (selected) and '2: CDFS_4obs.fits'. The main area is divided into sections for 'Match Criteria', 'Table 1', 'Table 2', and 'Output Rows'. The 'Match Criteria' section has 'Algorithm' set to 'Sky' and 'Max Error' set to '2.0' in 'arcsec'. The 'Table 1' section has 'Table' set to '1: CDFS_7Ms_catalog.fits', 'RA column' set to 'RA' in 'degrees', and 'Dec column' set to 'DEC' in 'degrees'. The 'Table 2' section has 'Table' set to '2: CDFS_4obs.fits', 'RA column' set to 'RA' in 'degrees', and 'Dec column' set to 'DEC' in 'degrees'. The 'Output Rows' section has 'Match Selection' set to 'Best match, symmetric' and 'Join Type' set to '1 and 2'. At the bottom, there are 'Go' and 'Stop' buttons, a 'Messages' pane, and a 'Clients' pane showing two active clients. A status bar at the very bottom indicates '62 / 3641 M'.

Match Tables

Match Criteria

Algorithm: Sky

Max Error: 2.0 arcsec

Table List

1: CDFS_7Ms_catalog.fits

2: CDFS_4obs.fits

Table 1

Table: 1: CDFS_7Ms_catalog.fits

RA column: RA degrees

Dec column: DEC degrees

Table 2

Table: 2: CDFS_4obs.fits

RA column: RA degrees

Dec column: DEC degrees

Output Rows

Match Selection: Best match, symmetric

Join Type: 1 and 2

Go Stop

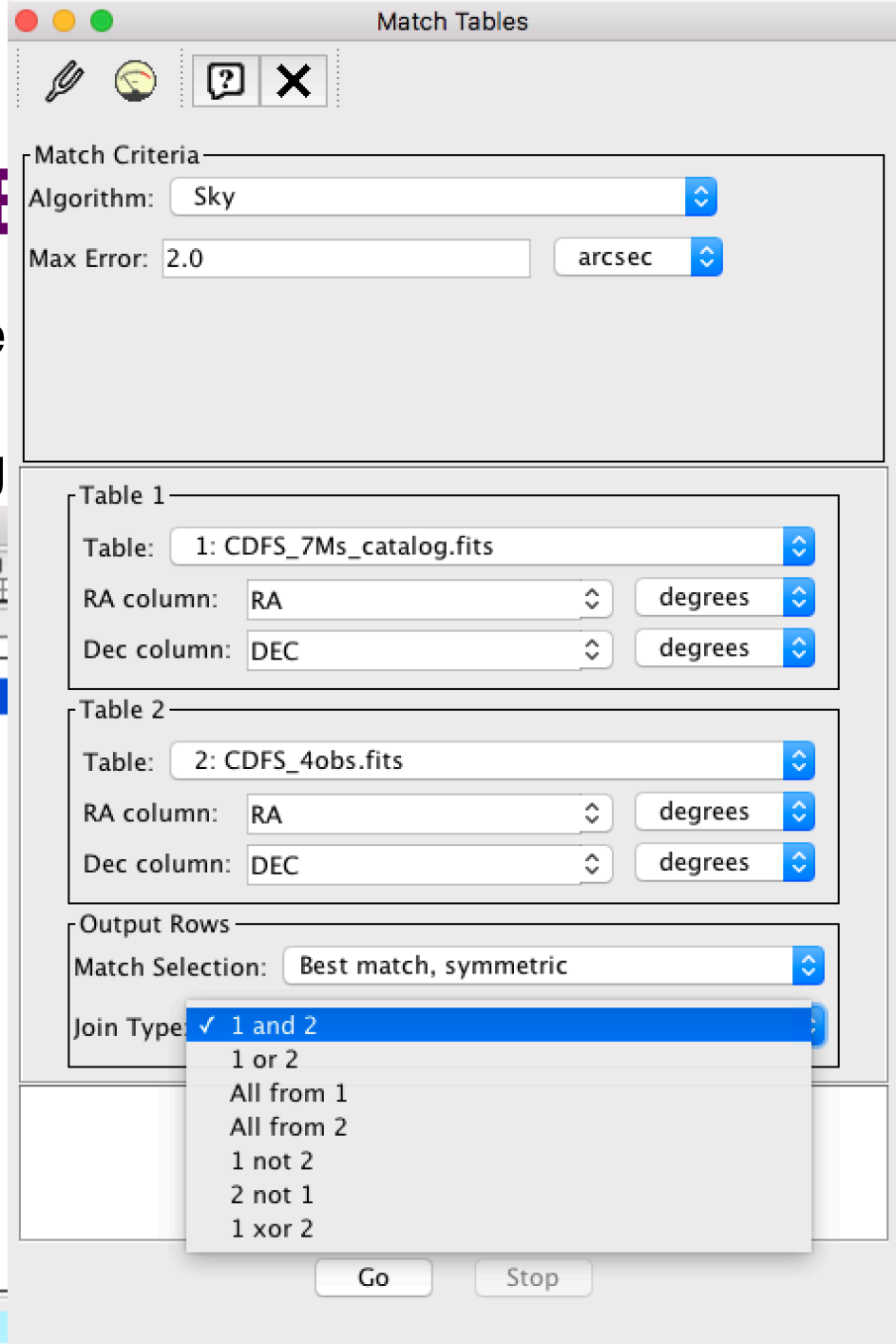
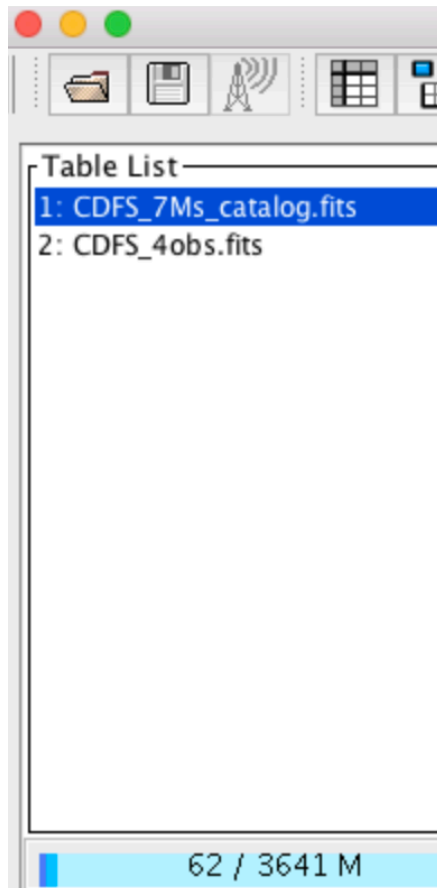
Messages:

Clients:

62 / 3641 M

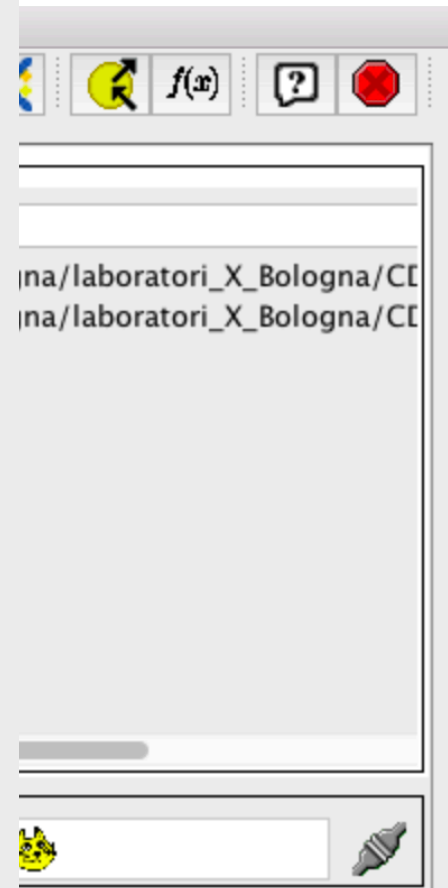
1) E

Cross-correlate
with the official
al. 2017), using



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vious steps
CDF-S (Luo et
,2,3 arcsec)



Lab Outline

2) Explore the source catalog

Lab Outline

2) Explore the source catalog

- a. Choose one of the catalogs you built (e.g., the one with largest number of matches with the CDF-S 7 Ms one) and produce some plots (number of counts vs. source significance, vs. exposure time, vs. positional uncertainty, etc.)

Lab Outline

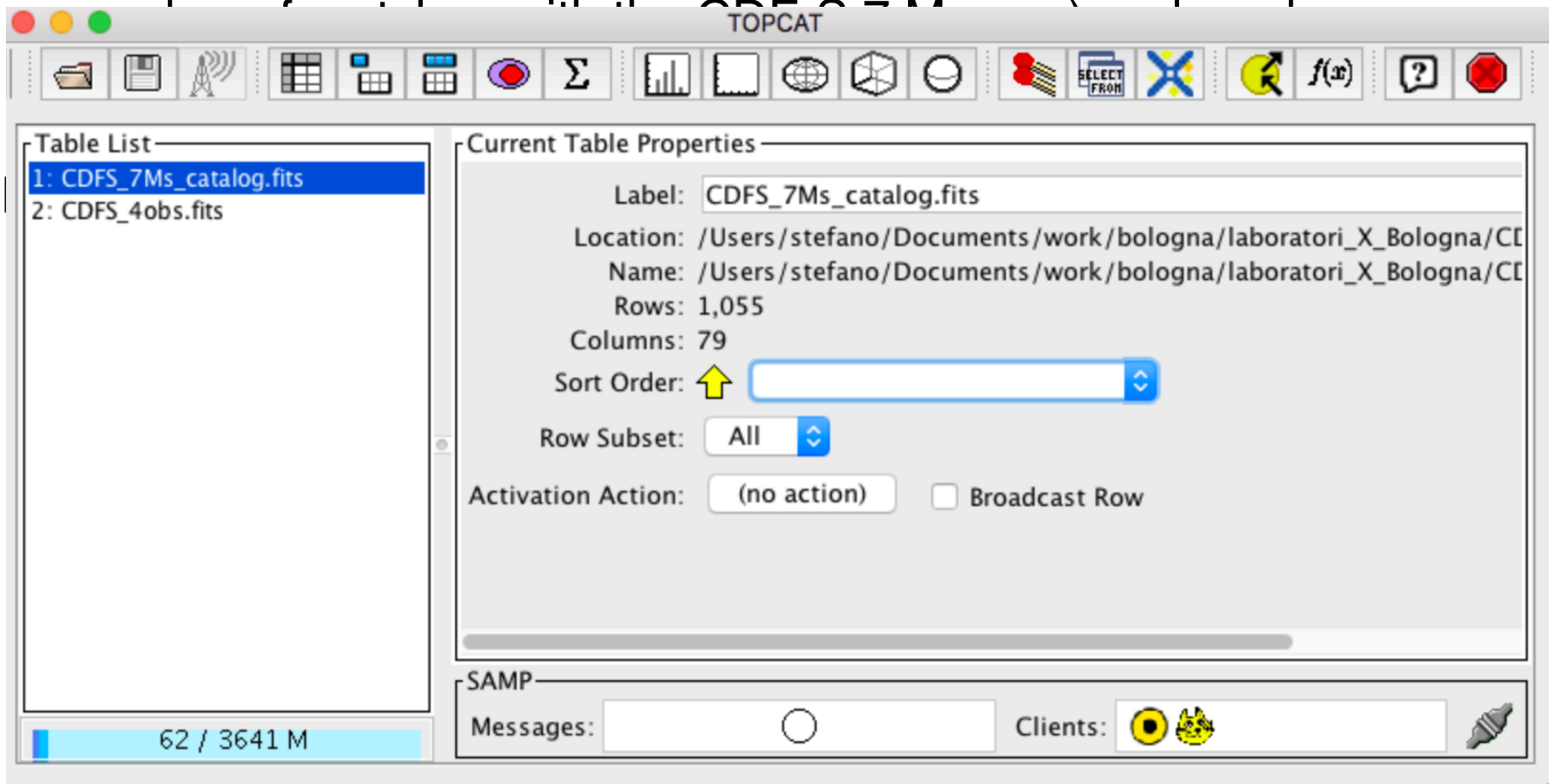
2) Explore the source catalog

- a. Choose one of the catalogs you built (e.g., the one with largest number of matches with the CDF-S 7 Ms one) and produce some plots (number of counts vs. source significance, vs. exposure time, vs. positional uncertainty, etc.)
- b. For the sources associated with the 7Ms source catalog, produce the redshift distribution histogram, L_x vs. z plot, etc.

Lab Outline

2) Explore the source catalog

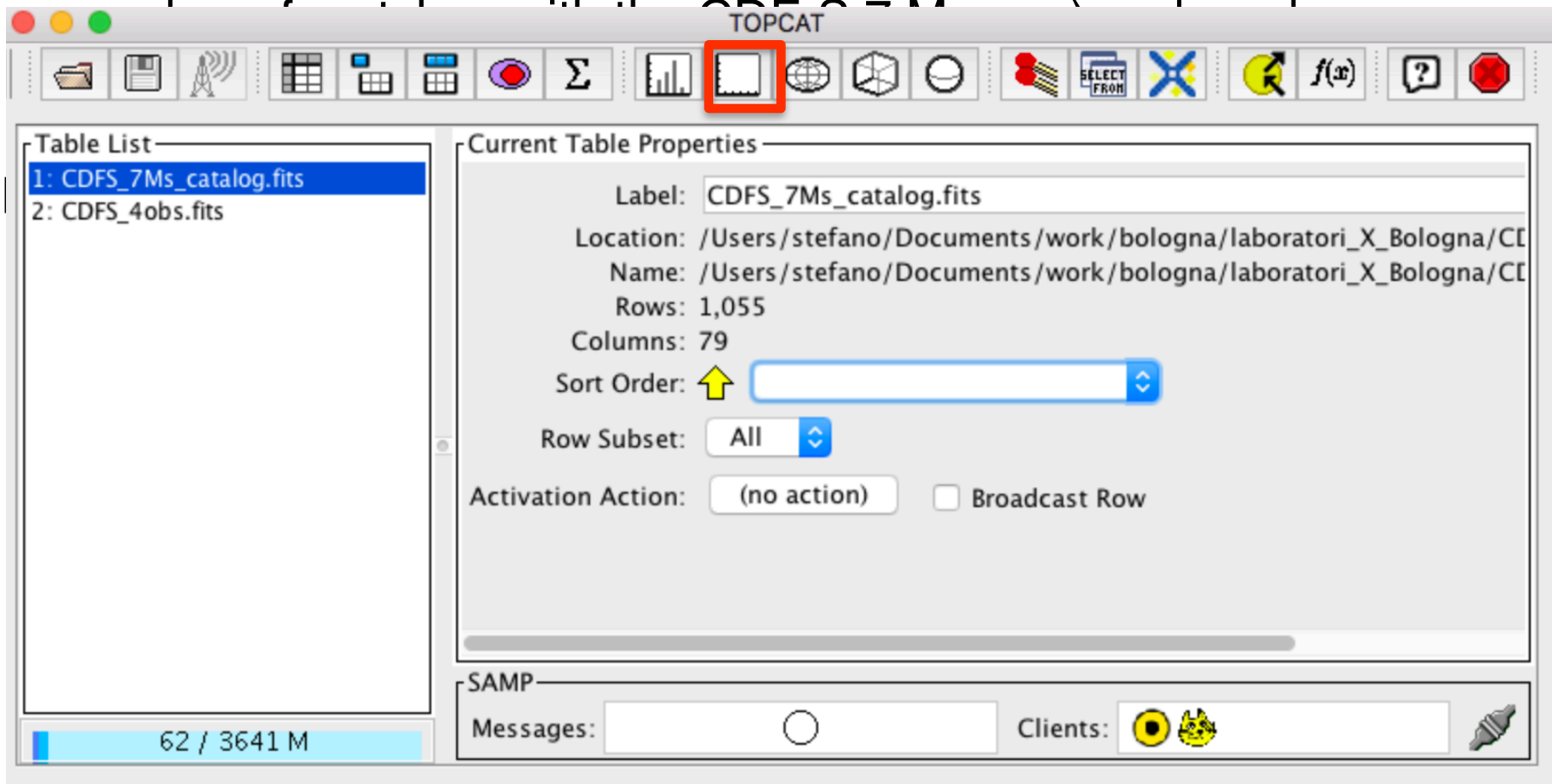
a. Choose one of the catalogs you built (e.g., the one with largest



Lab Outline

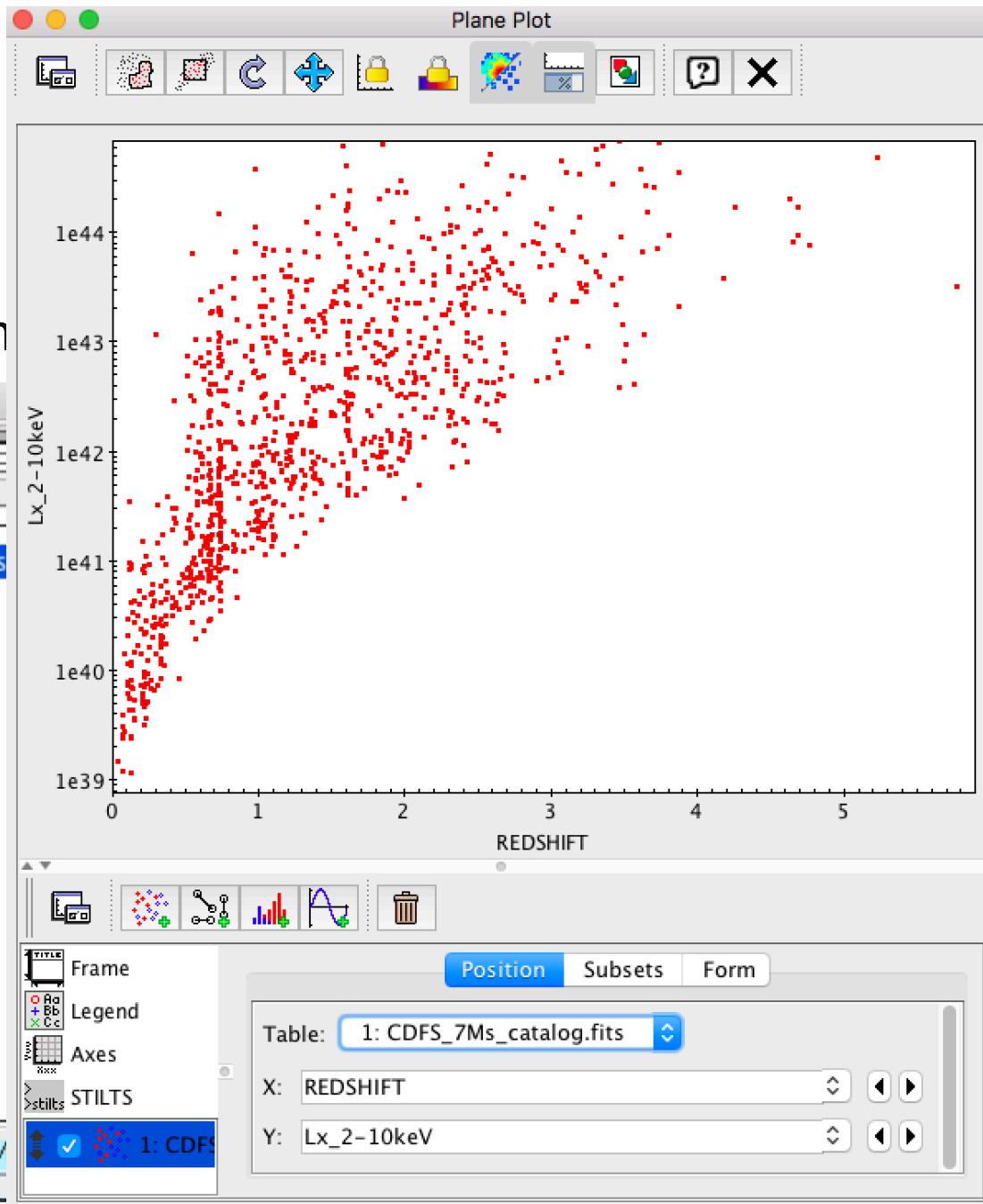
2) Explore the source catalog

a. Choose one of the catalogs you built (e.g., the one with largest



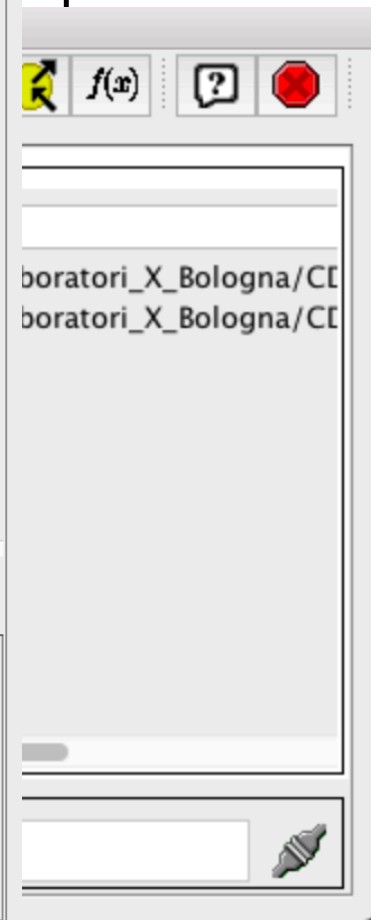
2)

a. Choose on



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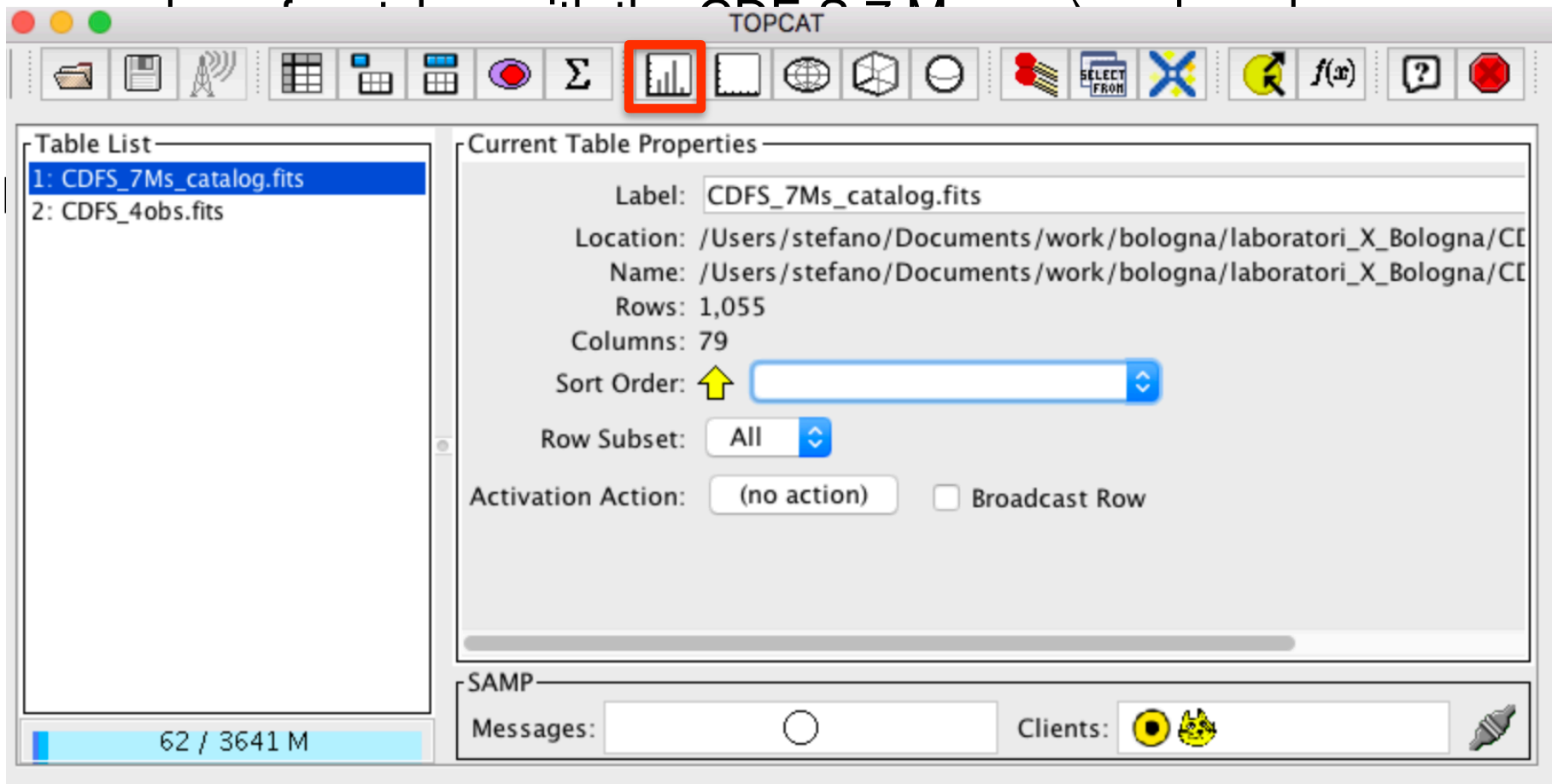
th largest



Lab Outline

2) Explore the source catalog

a. Choose one of the catalogs you built (e.g., the one with largest

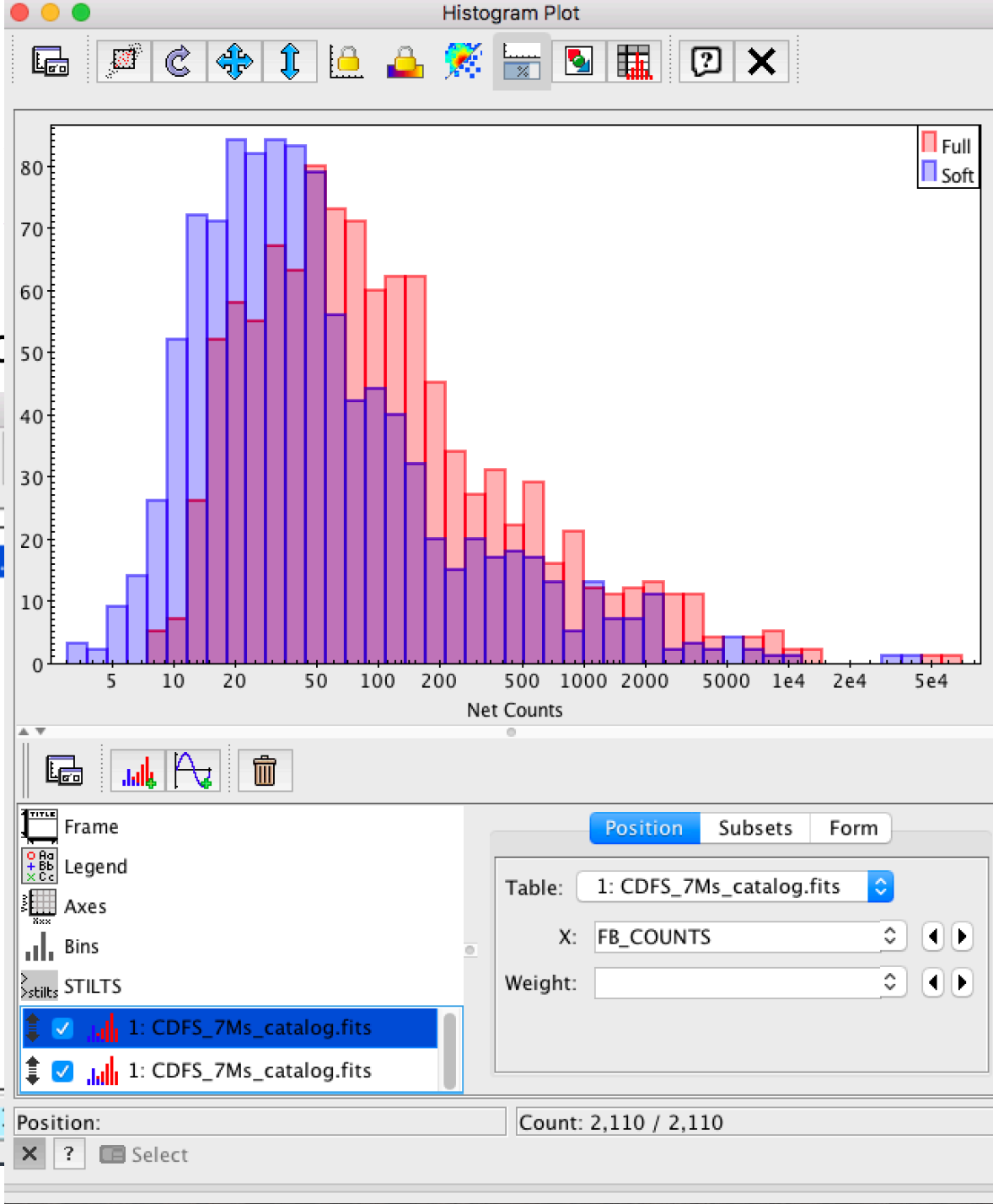


2

a. Choose c

og

largest



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atori_X_Bologna/CC

Lab Outline

2) Explore the source catalog

- a. Choose one of the produced catalogs and produce some plots (number of counts vs. source significance, vs. exposure time, vs. positional uncertainty, etc.)
- b. For the sources associated with the 7 Ms source catalog, produce the redshift distribution histogram, L_x vs. z plot, etc.
- c. Repeat the operation done in b. after creating subsamples of sources from the 7 Ms source catalog (e.g., spec- z vs phot- z ; low vs high band-ratio...). Are there any noticeable trends?

Lab Outline

2) Explore the source catalog

a. Choose one of the produced catalogs and produce some plots

The screenshot shows the TOPCAT software interface. The title bar reads 'TOPCAT'. The toolbar contains various icons for file operations, data manipulation, and visualization. A red box highlights the 'Plot' icon (a circle with a dot). The 'Table List' on the left shows two tables: '1: CDFS_7Ms_catalog.fits' (selected) and '2: CDFS_4obs.fits'. The 'Current Table Properties' panel on the right displays the following information:

- Label: CDFS_7Ms_catalog.fits
- Location: /Users/stefano/Documents/work/bologna/laboratori_X_Bologna/CF
- Name: /Users/stefano/Documents/work/bologna/laboratori_X_Bologna/CF
- Rows: 1,055
- Columns: 79
- Sort Order: [dropdown menu]
- Row Subset: All [dropdown menu]
- Activation Action: (no action) ☐ Broadcast Row

The status bar at the bottom shows '62 / 3641 M' on the left, 'Messages: [empty box]' in the center, and 'Clients: [empty box]' on the right.

VS

Lab Outline

2) Explore the source catalog

a. Choose one of the produced catalogs and produce some plots

The screenshot shows the TOPCAT software interface. A 'Table List' on the left contains two entries: '1: CDFS_7Ms' and '2: CDFS_4obs'. The 'TOPCAT(5): Row Subsets' dialog box is open, displaying a table of row subsets for the file 'CDFS_7Ms_catalog.fits'. The table has four columns: 'ID', 'Name', 'Size', and 'Fraction'. It shows one subset with ID '_1', Name 'All', Size 1055, and Fraction 100%. The dialog box has a toolbar with various icons, including a green plus sign which is highlighted with a red square. The main window shows a 'Table List' on the left and a 'SAMP' section at the bottom with 'Messages' and 'Clients' fields. The status bar at the bottom indicates '62 / 3641 M'.

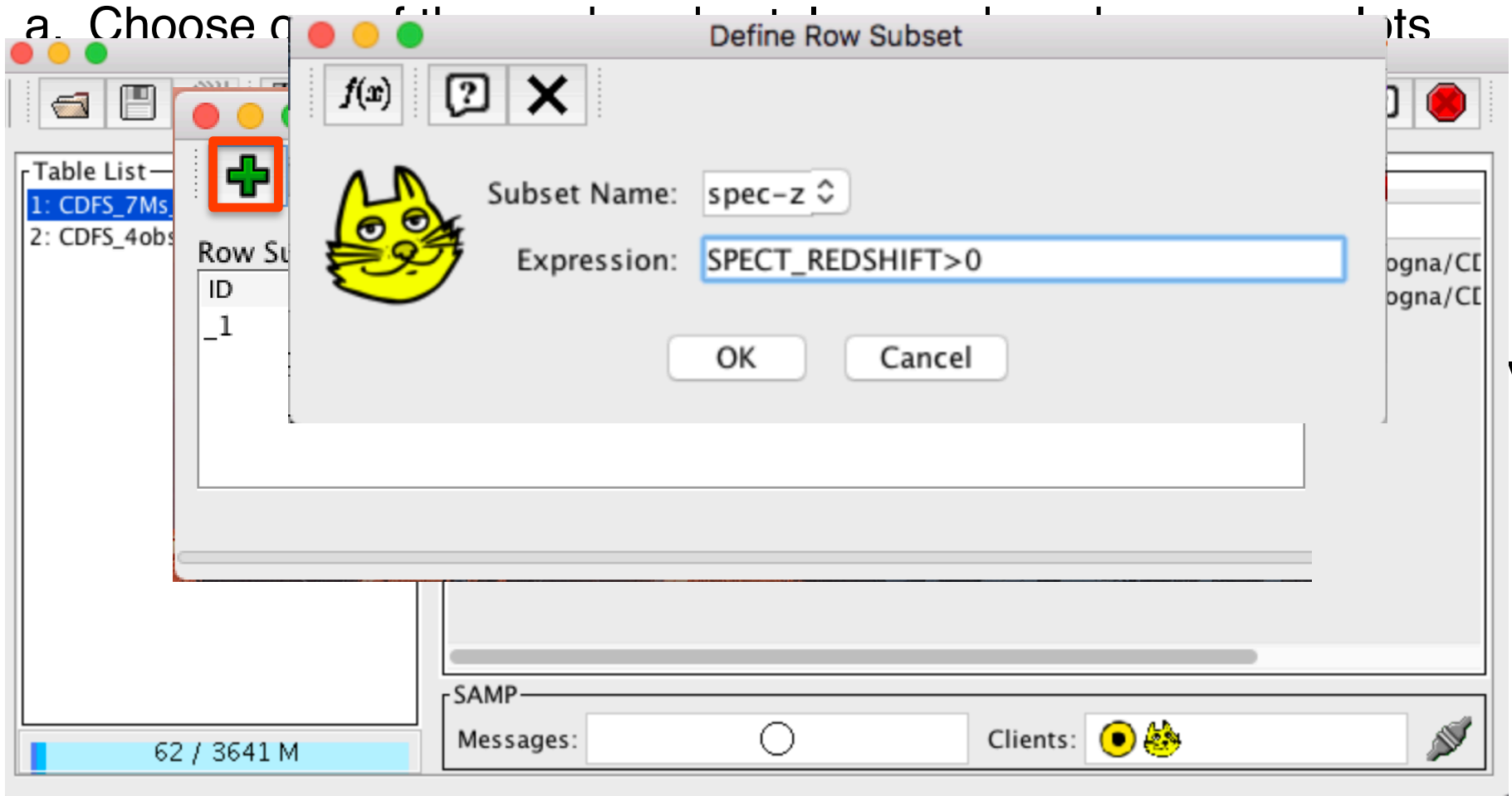
ID	Name	Size	Fraction
_1	All	1055	100%

VS

Lab Outline

2) Explore the source catalog

a. Choose a



The screenshot shows a software interface with a 'Define Row Subset' dialog box open. The dialog box has a title bar with standard window controls (red, yellow, green buttons). Below the title bar are three icons: a function symbol $f(x)$, a question mark, and a close button. The main area of the dialog contains a yellow cat icon on the left. To the right of the cat, there is a 'Subset Name' field with the text 'spec-z' and a dropdown arrow. Below that is an 'Expression' field containing the text 'SPECT_REDSHIFT>0'. At the bottom of the dialog are 'OK' and 'Cancel' buttons. In the background, a 'Table List' panel is visible on the left, showing two tables: '1: CDFS_7Ms' and '2: CDFS_4obs'. A red box highlights a green plus icon in the 'Table List' panel. The bottom of the interface shows a status bar with a progress indicator (62 / 3641 M), a 'SAMP' section, a 'Messages' field, and a 'Clients' section with two cat icons.

Define Row Subset

Subset Name: spec-z

Expression: SPECT_REDSHIFT>0

OK Cancel

Table List

1: CDFS_7Ms

2: CDFS_4obs

Row Su

ID

_1

62 / 3641 M

SAMP

Messages:

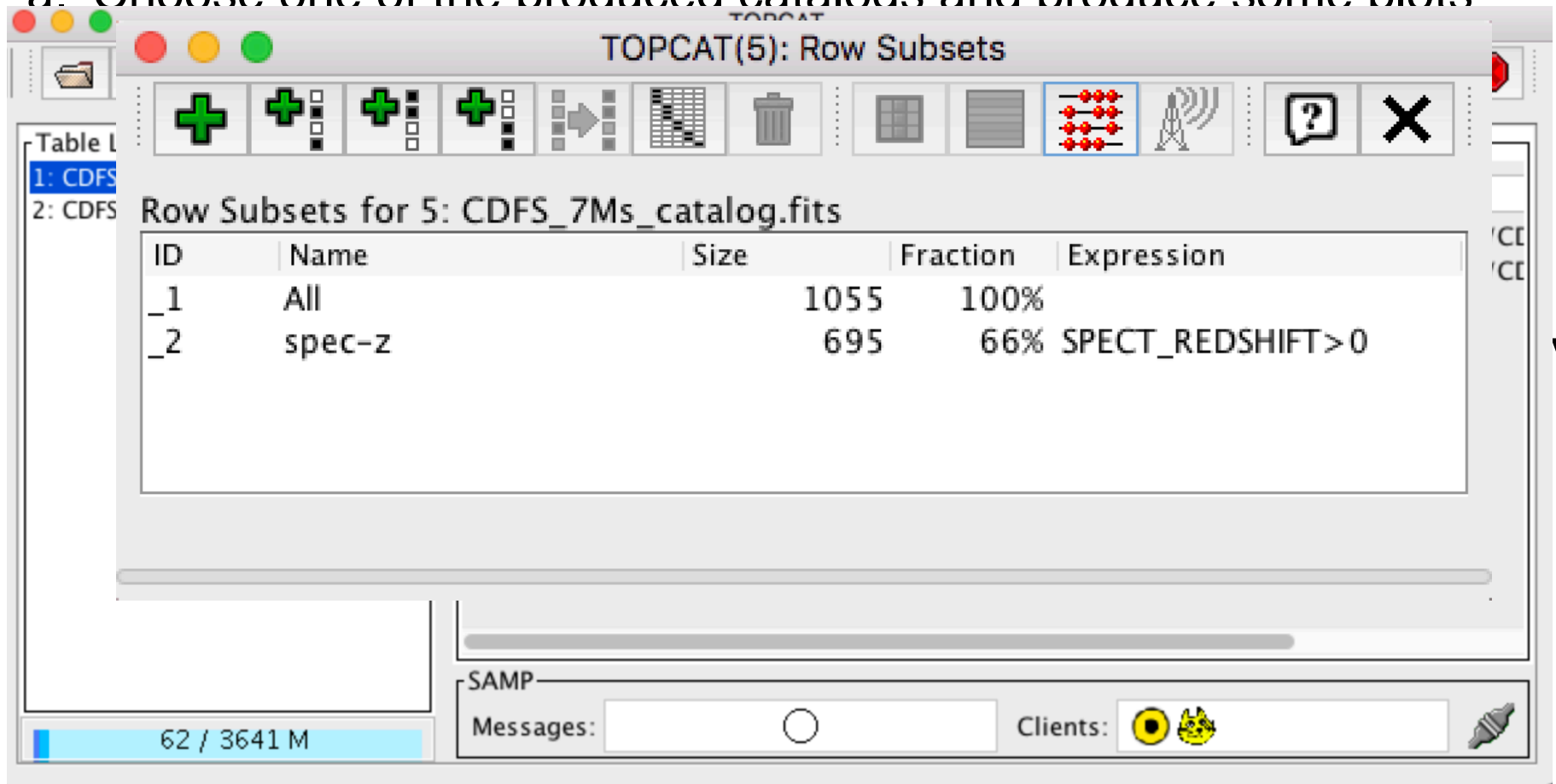
Clients:

VS

Lab Outline

2) Explore the source catalog

a. Choose one of the produced catalogs and produce some plots




TOPCAT(5): Row Subsets

Row Subsets for 5: CDFS_7Ms_catalog.fits

ID	Name	Size	Fraction	Expression
_1	All	1055	100%	
_2	spec-z	695	66%	SPECT_REDSHIFT>0

62 / 3641 M

SAMP Messages: Clients: 

VS

Lab Outline

2) Explore the source catalog

a. Choose

The screenshot shows a software interface with a 'Define Row Subset' dialog box open. The dialog box has a title bar with standard window controls (red, yellow, green buttons). Below the title bar are three icons: a function symbol $f(x)$, a question mark, and a close button. The main area of the dialog features a yellow cat icon on the left. To its right, the 'Subset Name' field contains 'phot-z' and the 'Expression' field contains 'REDSHIFT>0 & !_2'. At the bottom of the dialog are 'OK' and 'Cancel' buttons. In the background, a 'Table List' panel is visible on the left, showing two tables: '1: CDFS_7Ms' and '2: CDFS_4obs'. A red box highlights a green plus icon in the table list. The bottom status bar of the application shows '62 / 3641 M' on the left, a 'SAMP' section with a 'Messages' field and a circular indicator in the center, and a 'Clients' section on the right showing two cat icons and a small icon of a plug.

Define Row Subset

Subset Name: phot-z

Expression: REDSHIFT>0 & !_2

OK Cancel

Table List

1: CDFS_7Ms

2: CDFS_4obs

Row ID

_1

62 / 3641 M

SAMP

Messages:

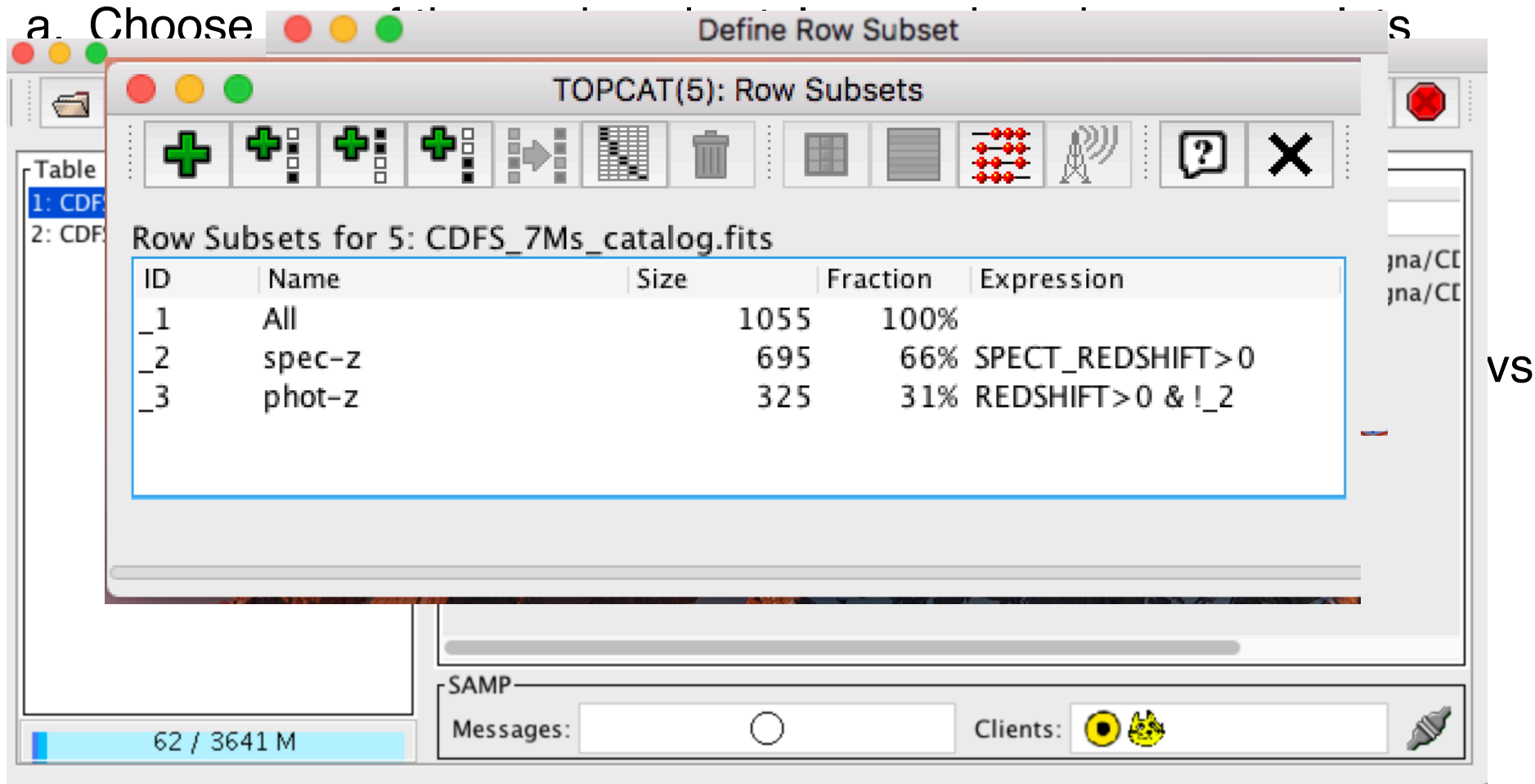
Clients:

VS

Lab Outline

2) Explore the source catalog

a. Choose



Define Row Subset


TOPCAT(5): Row Subsets

Row Subsets for 5: CDFS_7Ms_catalog.fits

ID	Name	Size	Fraction	Expression
_1	All	1055	100%	
_2	spec-z	695	66%	SPECT_REDSHIFT>0
_3	phot-z	325	31%	REDSHIFT>0 & !_2

SAMP

Messages:

Clients: 

62 / 3641 M

VS

Lab Outline

2) Explore the source catalog

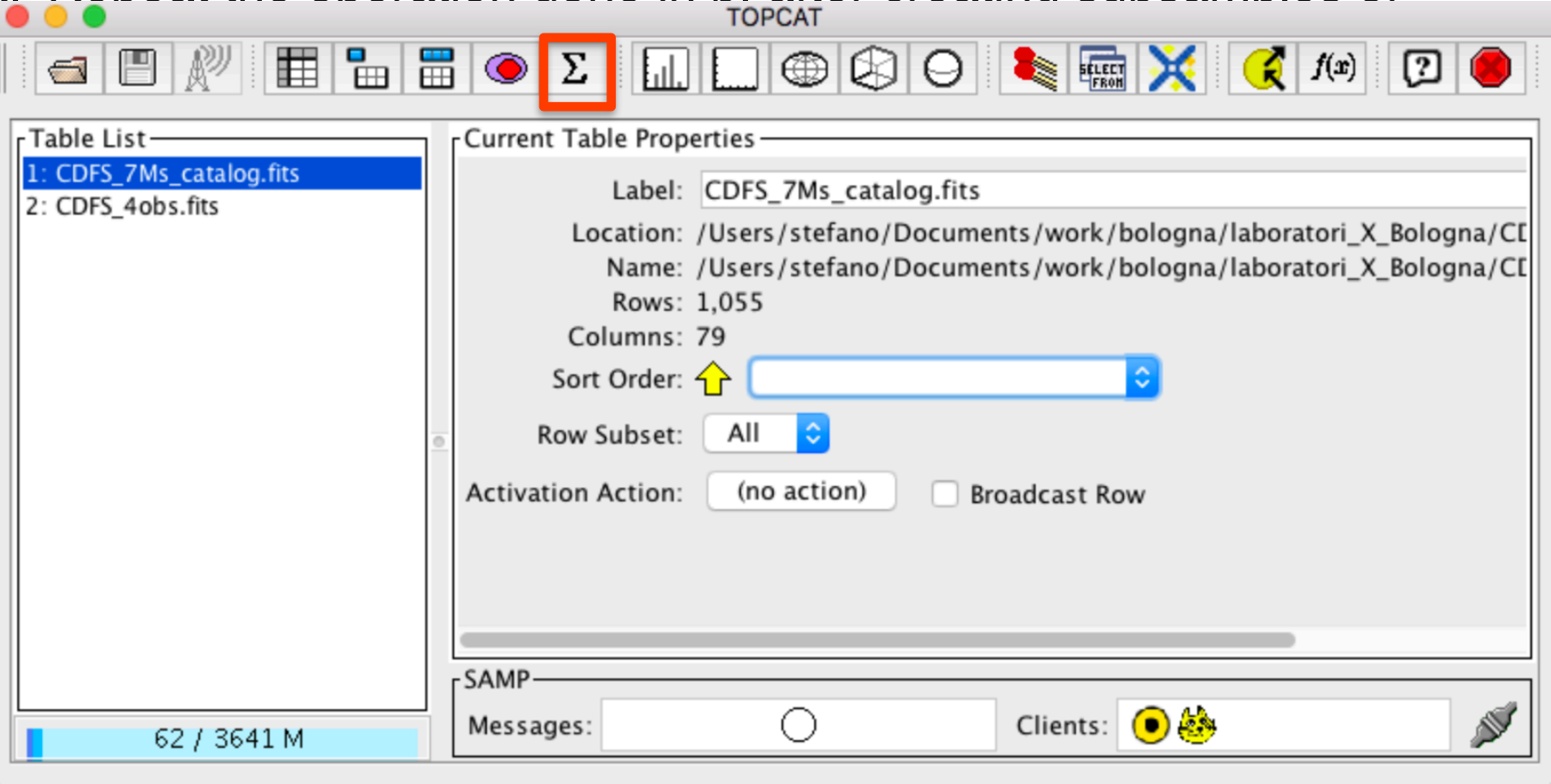
- a. Repeat the operation done in b. after creating subsamples of sources from the 7 Ms source catalog (e.g., spec-z vs phot-z; low vs high band-ratio...). Are there any noticeable trends?
- b. The trends can also be quantified using the Topcat statistics tool.

Lab Outline



2) Explore the source catalog

a. Repeat the operation done in b. after creating subsamples of

b.



The screenshot shows the TOPCAT software interface. The title bar reads "TOPCAT". The toolbar contains various icons, with the summation symbol (Σ) highlighted by a red square. The "Table List" panel on the left shows two tables: "1: CDFS_7Ms_catalog.fits" (selected) and "2: CDFS_4obs.fits". The "Current Table Properties" panel on the right displays the following information for the selected table:

- Label: CDFS_7Ms_catalog.fits
- Location: /Users/stefano/Documents/work/bologna/laboratori_X_Bologna/CF
- Name: /Users/stefano/Documents/work/bologna/laboratori_X_Bologna/CF
- Rows: 1,055
- Columns: 79
- Sort Order: 
- Row Subset: All 
- Activation Action: (no action) ☐ Broadcast Row

The bottom status bar shows "62 / 3641 M" on the left and "SAMP" on the right, which includes "Messages:" with a circular progress indicator and "Clients:" with two icons (a yellow circle and a yellow cat head).

Lab Outline

2) Explore the source catalog

a

b

TOPCAT(5): Row Statistics

Row Statistics for 5: CDFS_7Ms_catalog.fits

Name	Mean	SD	Minimum	Max
VLA_DEC	-5.7216	11.2414	-27.9885	
VLA_20_CM_MAG	3.84106	7.57468	0.	
SPECT_REDSHIFT	1.0809	0.784943	0.034	
SPECT_REDSHIFT_FLAG			INSECURE	
REF_SPECT_REDSHIFT	10.6576	6.54157		2
PHOT_REDSHIFT_L10	0.542863	0.848864	0.	
PHOT_REDSHIFT_R11	1.03203	0.749643	0.	
PHOT_REDSHIFT_H14	1.07511	0.787236	0.	
PHOT_REDSHIFT_S14	0.82387	0.80083	0.	
PHOT_REDSHIFT_S15	0.809108	0.814808	0.	
PHOT_REDSHIFT_S16	0.936187	0.826658	0.	
REDSHIFT	1.08991	0.776239	0.038	
REF_REDSHIFT				H14
REDSHIFT_NEG_ERR	0.002921	0.02576	0.	
REDSHIFT_POS_ERR	0.00354	0.026326	0.	

Subset for calculations:

- All
- spec-z
- phot-z

Lab Outline

2) Explore the source catalog

- a. Choose one of the produced catalogs and produce some plots (number of counts vs. source significance, vs. exposure time, vs. positional uncertainty, etc.)
- b. For the sources associated with the 7Ms source catalog, produce the redshift distribution histogram, L_x vs. z plot, etc.
- c. **OPTIONAL:** Select a few sources, then use the PIMMS Online tool (<https://cxc.harvard.edu/toolkit/pimms.jsp>) to compute the count rate-to-flux correction factor, using the photon index available in the catalog. Does it match the one used in the catalog?

Lab Outline

2) Explore the source catalog

PIMMS v4.11a: with ACIS Pile up and Background Count Estimation

Input		Output	
<input checked="" type="radio"/> Count Rate	<input type="radio"/> Flux	<input type="radio"/> Count Rate	<input checked="" type="radio"/> Flux
Mission: CHANDRA-Cycle 11 ▼		Flux: Absorbed ▼	
Detector/Grating/Filter: ACIS-I/None/None ▼			
Input Energy: 0.5 to 2 keV		Output Energy: 0.5 to 2	

Model:	Galactic NH:	Redshift(z):	Redshifted NH:	Photon Index:	Count Rate:
Power Law ▼	7E19 cm**2	0	0 cm**2	1.7 N=AE**-a	1E-2 cts/s

CALCULATE CLEAR HELP

[PIMMS Prediction:](#)

6.383E-14
erg/cm**2/s absorbed flux

Lab Outline

2) Explore the source catalog

PIMMS v4.11a: with ACIS Pile up and Background Count Estimation

Input		Output	
<input checked="" type="radio"/> Count Rate	<input type="radio"/> Flux	<input type="radio"/> Count Rate	<input checked="" type="radio"/> Flux
Mission: CHANDRA-Cycle 11 ▼		Flux:	
Input Energy: 0.5 to 2 keV		Output Energy: 0.5 to 2	

Detector/Crating/Filter:

What happens changing the mission Cycle?

Model: Power Law ▼	Galactic NH: 7E19 cm**2	Redshift(z): 0	Redshifted NH: 0 cm**2	Photon Index: 1.7 N=AE**-a	Count Rate: 1E-2 cts/s
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CALCULATE

CLEAR

HELP

PIMMS Prediction:

6.383E-14

erg/cm**2/s absorbed flux

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The screenshot shows the TOPCAT software interface. The title bar reads "TOPCAT". The toolbar contains various icons for file operations, data manipulation, and visualization. The "Table List" panel on the left shows two tables: "1: CDFS_7Ms_catalog.fits" (selected) and "2: CDFS_4obs.fits". The "Current Table Properties" panel on the right displays the following information for the selected table:

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- Name: /Users/stefano/Documents/work/bologna/laboratori_X_Bologna/CF
- Rows: 1,055
- Columns: 79
- Sort Order: (indicated by a yellow arrow icon)
- Row Subset: All
- Activation Action: (no action) ☐ Broadcast Row

The "SAMP" panel at the bottom shows "Messages:" and "Clients:" with icons for network connectivity.

c.

Lab Outline

2) Explore the source catalog

- a. Choose one of the produced catalogs and produce some plots (number of counts vs. source significance, vs. exposure time, vs. positional uncertainty, etc.)

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The screenshot shows the TOPCAT software interface. The title bar reads "TOPCAT". The toolbar contains various icons for file operations, data manipulation, and visualization. A red box highlights the "Table List" icon in the toolbar. The "Table List" panel on the left shows two tables: "1: CDFS_7Ms_catalog.fits" (selected) and "2: CDFS_4obs.fits". The "Current Table Properties" panel on the right displays the following information for the selected table:

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- Rows: 1,055
- Columns: 79
- Sort Order:
- Row Subset: All
- Activation Action: (no action) ☐ Broadcast Row

The bottom status bar shows "62 / 3641 M" and "Messages: Clients:

c.

Lab Outline

2) Explore the source catalog

a. Choose one source sign

b.

c. Table List
1: CDFS_7Ms_cata
2: CDFS_4obs.fits

TOPCAT(3): Table Columns

Table Columns for 3: CDFS_7Ms_catalog.fits

Δ	Index	Visible	Name	\$ID	Class	Units	Description	Dataty
0		<input type="checkbox"/>	Index	\$0	Long		Table row index	
1	1	<input checked="" type="checkbox"/>	SOURCE_SAMPLE	\$1	String			char
2	2	<input checked="" type="checkbox"/>	XID_SOURCE_NUMBER	\$2	Long			long
3	3	<input checked="" type="checkbox"/>	NAME	\$3	String			char
4	4	<input checked="" type="checkbox"/>	ALT_NAME	\$4	String			char
5	5	<input checked="" type="checkbox"/>	RA	\$5	Float	DEGREE		float
6	6	<input checked="" type="checkbox"/>	DEC	\$6	Float	DEGREE		float
7	7	<input checked="" type="checkbox"/>	LII_1	\$7	Float	DEGREE		float
8	8	<input checked="" type="checkbox"/>	BII_1	\$8	Float	DEGREE		float
9	9	<input checked="" type="checkbox"/>	LOG_MIN_NS_PROB	\$9	Float			float
10	10	<input checked="" type="checkbox"/>	LOG_MIN_FP_PROB	\$10	Long			long
11	11	<input checked="" type="checkbox"/>	ERROR_RADIUS	\$11	Float	ARCSEC		float
12	12	<input checked="" type="checkbox"/>	OFF_AXIS	\$12	Float	ARCMIN		float
13	13	<input checked="" type="checkbox"/>	FB_COUNTS	\$13	Float	CT		float
14	14	<input checked="" type="checkbox"/>	FB_COUNTS_NEG_ERR	\$14	Float	CT		float
15	15	<input checked="" type="checkbox"/>	FB_COUNTS_POS_ERR	\$15	Float	CT		float
16	16	<input checked="" type="checkbox"/>	SB_COUNTS	\$16	Float	CT		float
17	17	<input checked="" type="checkbox"/>	SB_EXPOSURE	\$61	Float	S		float
18	18	<input checked="" type="checkbox"/>	SB_COUNTS_NEG_ERR	\$17	Float	CT		float
19	19	<input checked="" type="checkbox"/>	SB_COUNTS_POS_ERR	\$18	Float	CT		float
20	20	<input checked="" type="checkbox"/>	HB_COUNTS	\$19	Float	CT		float
21	21	<input checked="" type="checkbox"/>	HB_COUNTS_NEG_ERR	\$20	Float	CT		float
22	22	<input checked="" type="checkbox"/>	HB_COUNTS_POS_ERR	\$21	Float	CT		float
23	23	<input checked="" type="checkbox"/>	SOURCE_FLAG	\$22	String			char

62 / 3641 M

SAMP

Messages:

Clients:

nts vs.



_Bologna/CT
_Bologna/CT

Lab Outline

2) Explore the source catalog

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62 / 3641 M

SAMP

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Lab Outline

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17	17	<input checked="" type="checkbox"/>	SB_EXPOSURE	\$61	Float	S		float
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23	23	<input checked="" type="checkbox"/>	SOURCE_FLAG	\$22	String			char

62 / 3641 M

SAMP

Messages:

Clients:

Lab Outline

2) Explore the source catalog


a. Choose one
source sign

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1: CDFS_7Ms_cata
2: CDFS_4obs.fits

Define Synthetic Column

$f(x)$? X

 Name: SB_COUNTRATE

Expression: toFloat(\$16/\$61)

Units:

Description:

UCD: no UCD


Index: 19



OK Cancel

21	21	<input checked="" type="checkbox"/>	HB_COUNTS_NEG_ERR	\$20	Float	CT	float
22	22	<input checked="" type="checkbox"/>	HB_COUNTS_POS_ERR	\$21	Float	CT	float
23	23	<input checked="" type="checkbox"/>	SOURCE_FLAG	\$22	String		char

62 / 3641 M

SAMP

Messages: 

Clients:  

3. Analyse the data products: spectral fitting

Fit *Chandra* spectra for at least one source whose properties suggest potential interesting outcome (e.g, high-z, high obscuration based on hardness ratio...).

XID	Luo17	Source coordinates	z	Opt. Class + Info
551		03:32:29.85 -27:51:05.71	3.700	NL (Comastri+11)
746		03:32:39.66 -27:48:50.64	3.064	NL (Vito+13)
730		03:32:38.91 -27:57:00.48	0.298	NL
242		03:32:13.24 -27:42:40.96	0.605	NL

IDs reported in the spectral files we provide

All spectra and response matrices are provided

3. Analyse the data products: spectral fitting

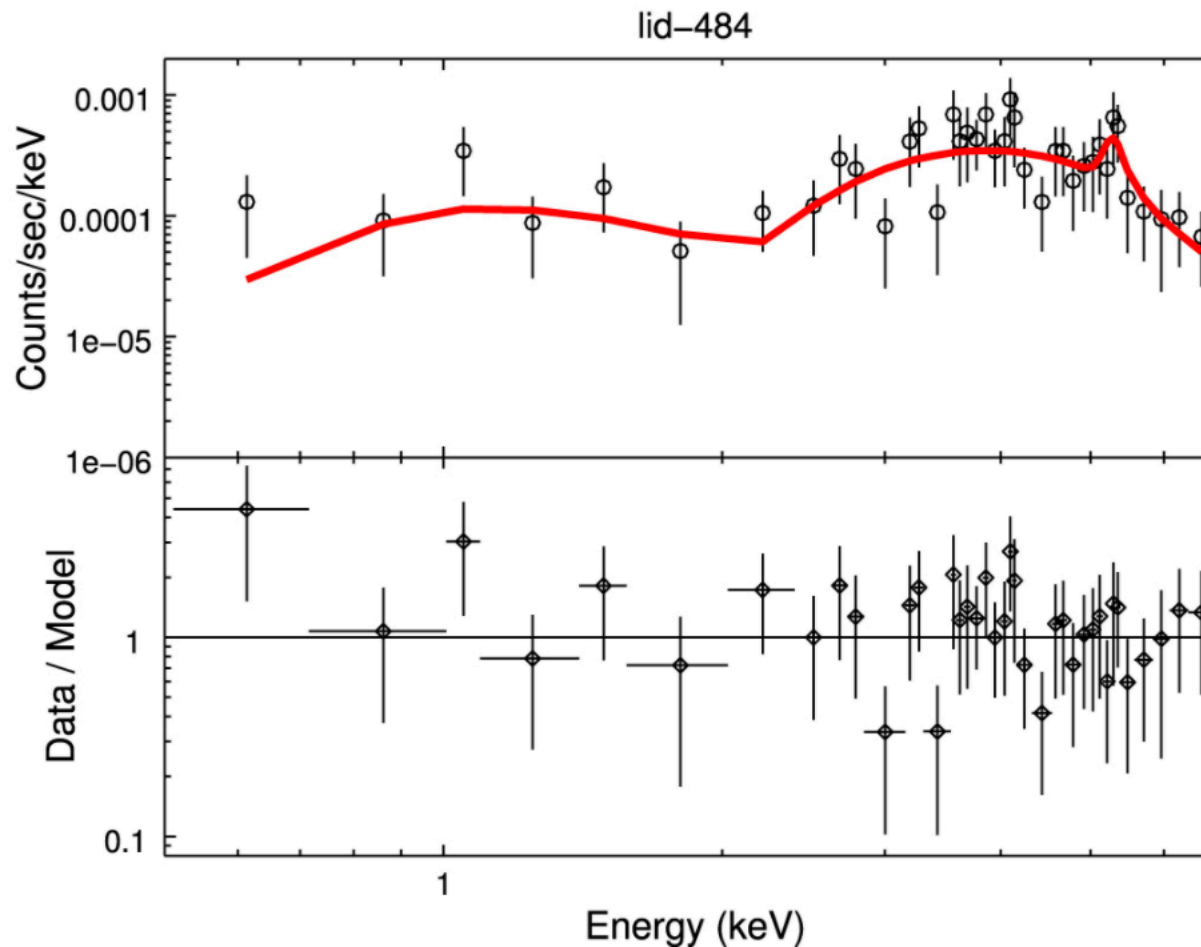
Spectral analysis pipeline

1. Choose one of the four sources
2. Group the spectra (*grppha*) accordingly to the quality of the data
3. Load spectra in XSPEC
4. Define a spectral model and fit it to the data. Step by step approach: starting with an absorbed power law, then adding additional components (e.g., secondary power law to account for scattered emission, Gaussian to model Iron line at 6.4 keV...)
5. Once a physically justified model is obtained, save the X-ray spectral parameters (including errors) and produce confidence contours

PLAN (III)

OPTIONAL

- a. Re-run the procedure for a second source, better if at a different redshift range.



Main publications

- Xue Y.Q. et al. 2011, ApJS, 195, 10 **4 Ms Chandra source catalog.**
- Vito F. et al. 2013, MNRAS, 428, 354 **High-redshift AGN population in the CDF-S.**
- Luo B. et al. 2017, ApJ Suppl., 228, 2 **The Chandra Deep Field-South Survey: 7 Ms Source Catalogs.**

Command list: wavdetect

```
punlearn wavdetect
pset wavdetect infile=CDFS_4obs_merged_057keV_bin1.fits
pset wavdetect outfile=CDFS_4obs_merged_057keV_wavdet_1em6_src.fits
pset wavdetect scellfile=CDFS_4obs_merged_057keV_wavdet_1em6_cellimage.fits
pset wavdetect
imagefile=CDFS_4obs_merged_057keV_wavdet_1em6_reconstructed.fits
pset wavdetect defnbkgfile=CDFS_4obs_merged_057keV_wavdet_1em6_normbakg.fits
pset wavdetect regfile=CDFS_4obs_merged_057keV_wavdet_1em6.reg
pset wavdetect ellsigma=3.0
pset wavdetect sigthresh=1e-6
pset wavdetect scales="1 1.4 2 2.8 4 5.6 8 11"
pset wavdetect expfile=CDFS_4obs_merged_broad_thresh.expmap
pset wavdetect psffile=CDFS_4obs_merged_broad_thresh.psfmap
wavdetect clobber+ verbose=3
```