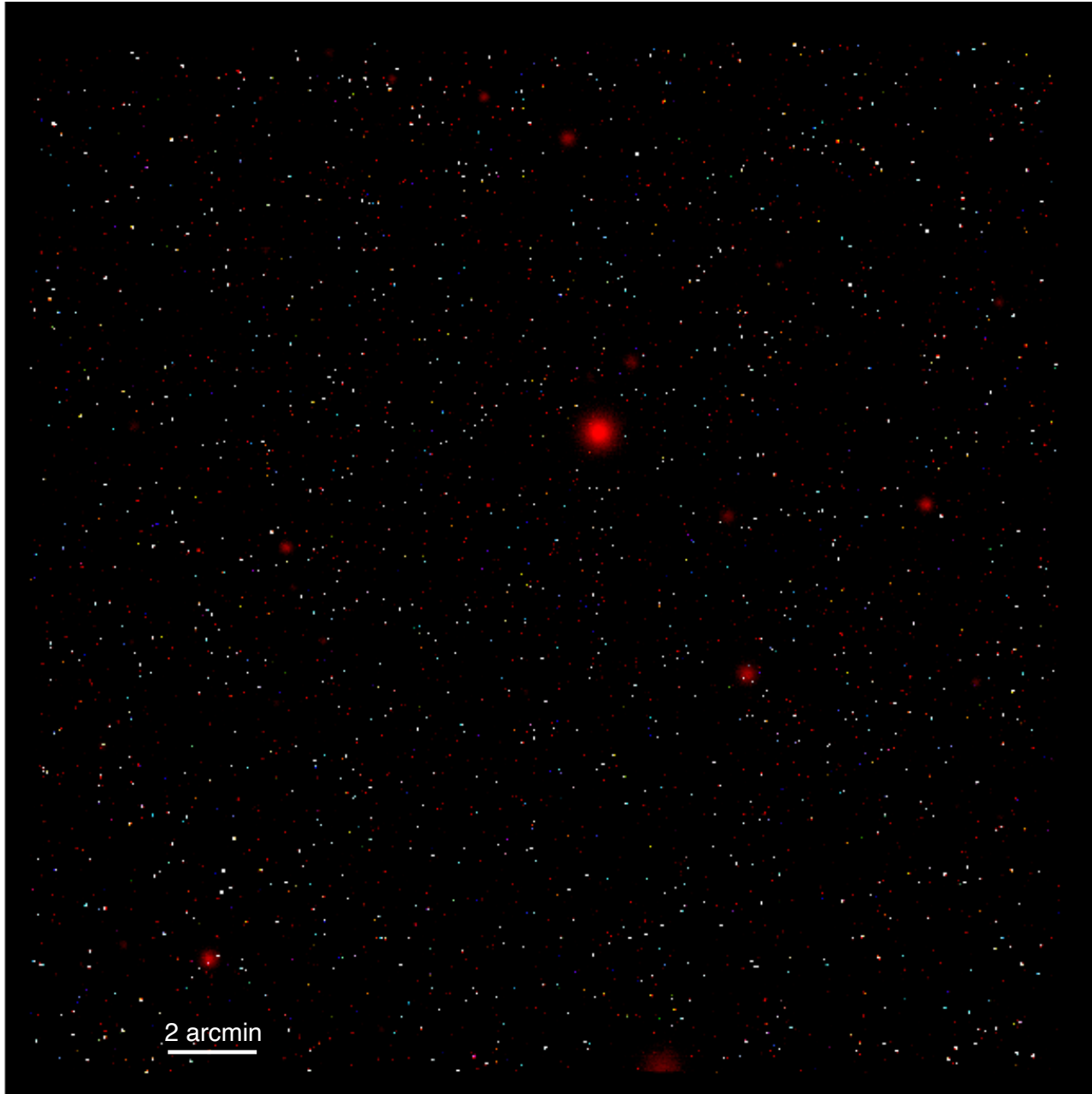


Understanding the AGN population: X-ray surveys



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...

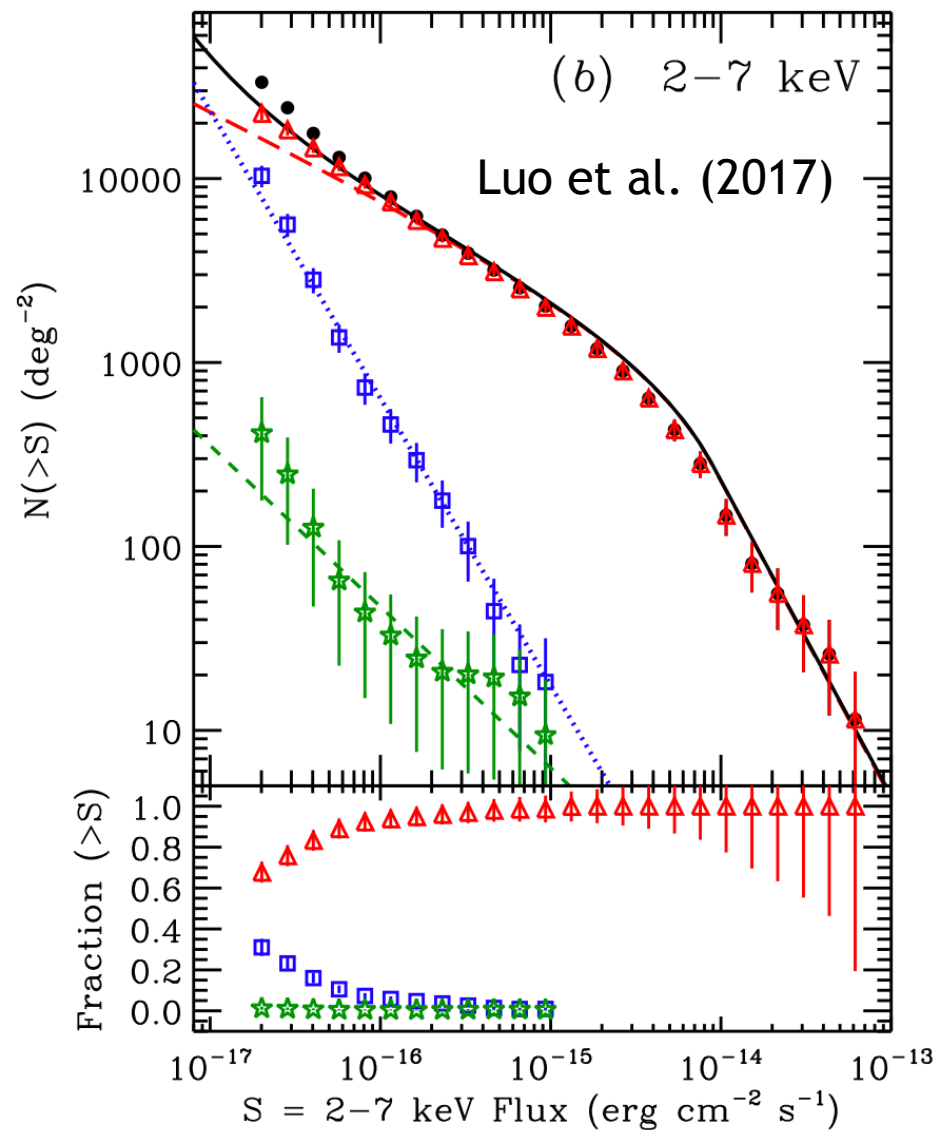
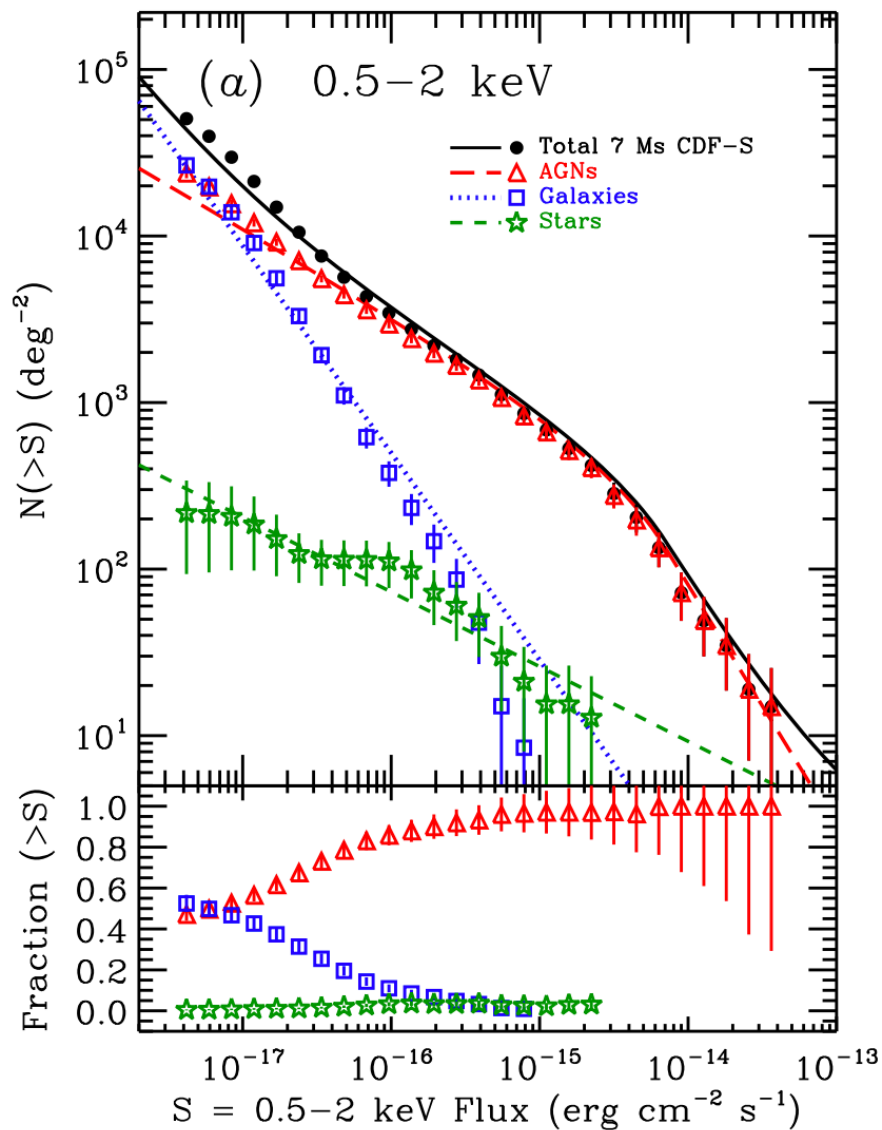
Donley et al. (2008, 2012); Ballantyne et al. (2011) Comastri et al. (2011); Georgantopoulos et al. (2013); Lanzuisi et al. (2015); Buchner et al. (2015)

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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).

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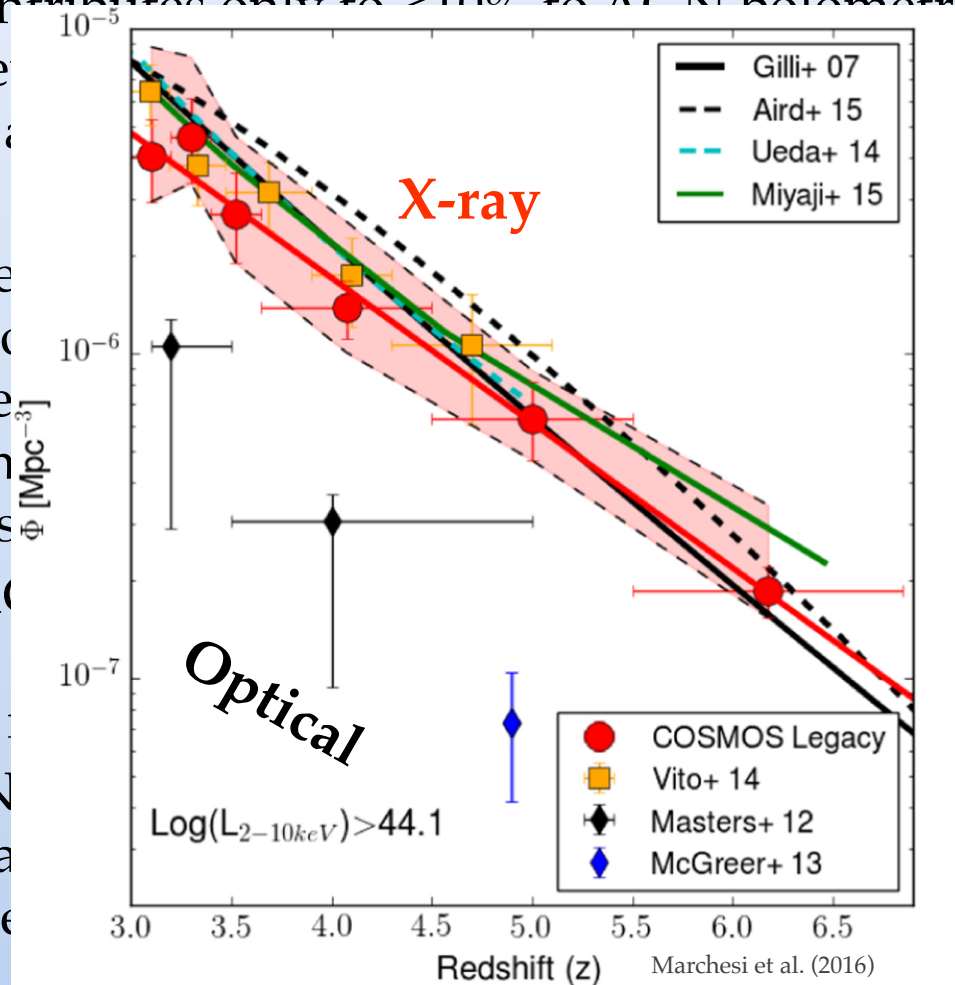
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3. *less biased* AGN selection: less strong obscuration effect at >2 keV. Sampling a class of obscured sources (up to $N_H \sim 10^{24}$ cm^{-2}) which cannot be detected by optical surveys.

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X-rays as a strategic tool in AGN analysis

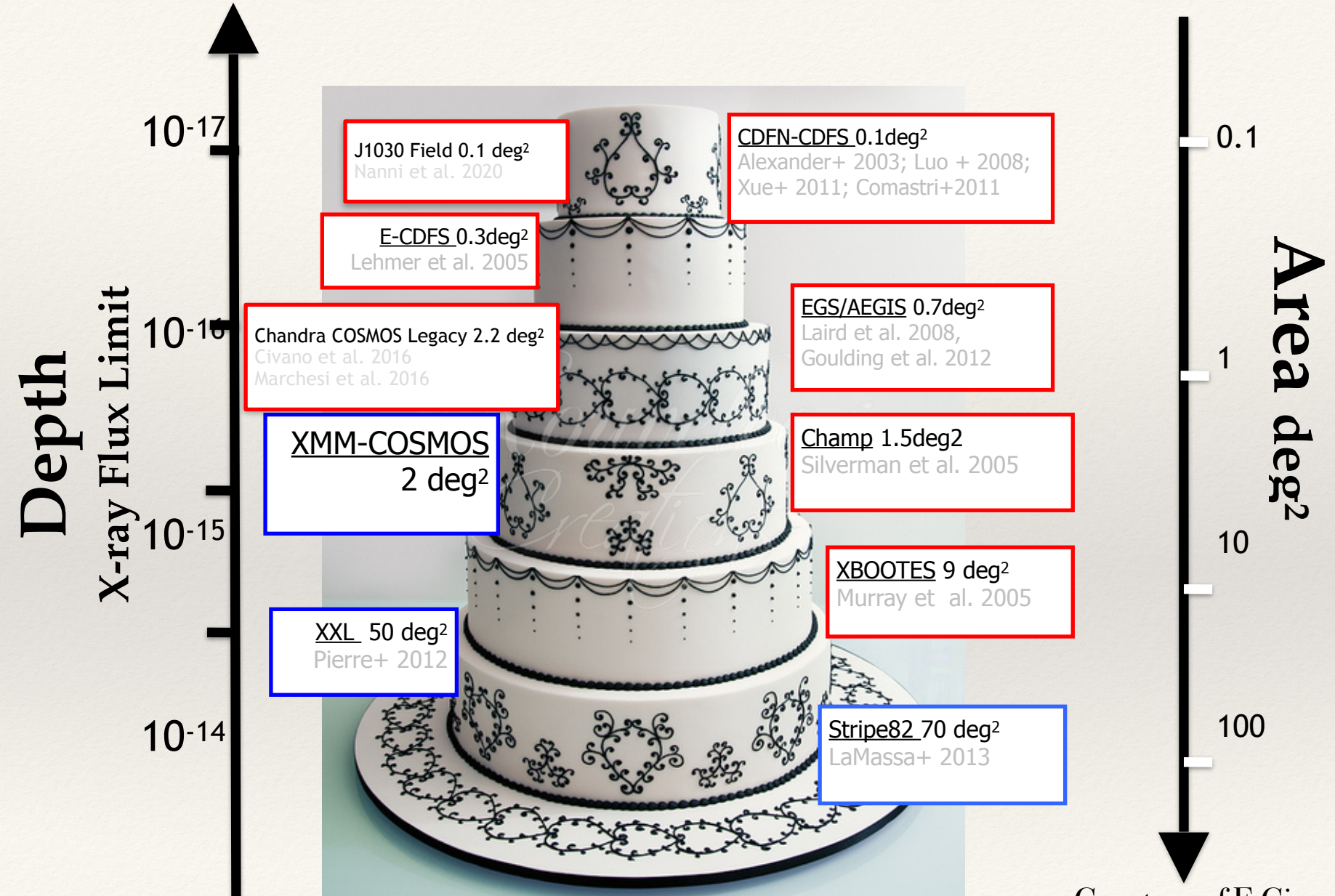
X-ray emission contributes only to $\sim 10\%$ to AGN bolometric luminosity. However, in the AGN view in the AGN...

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



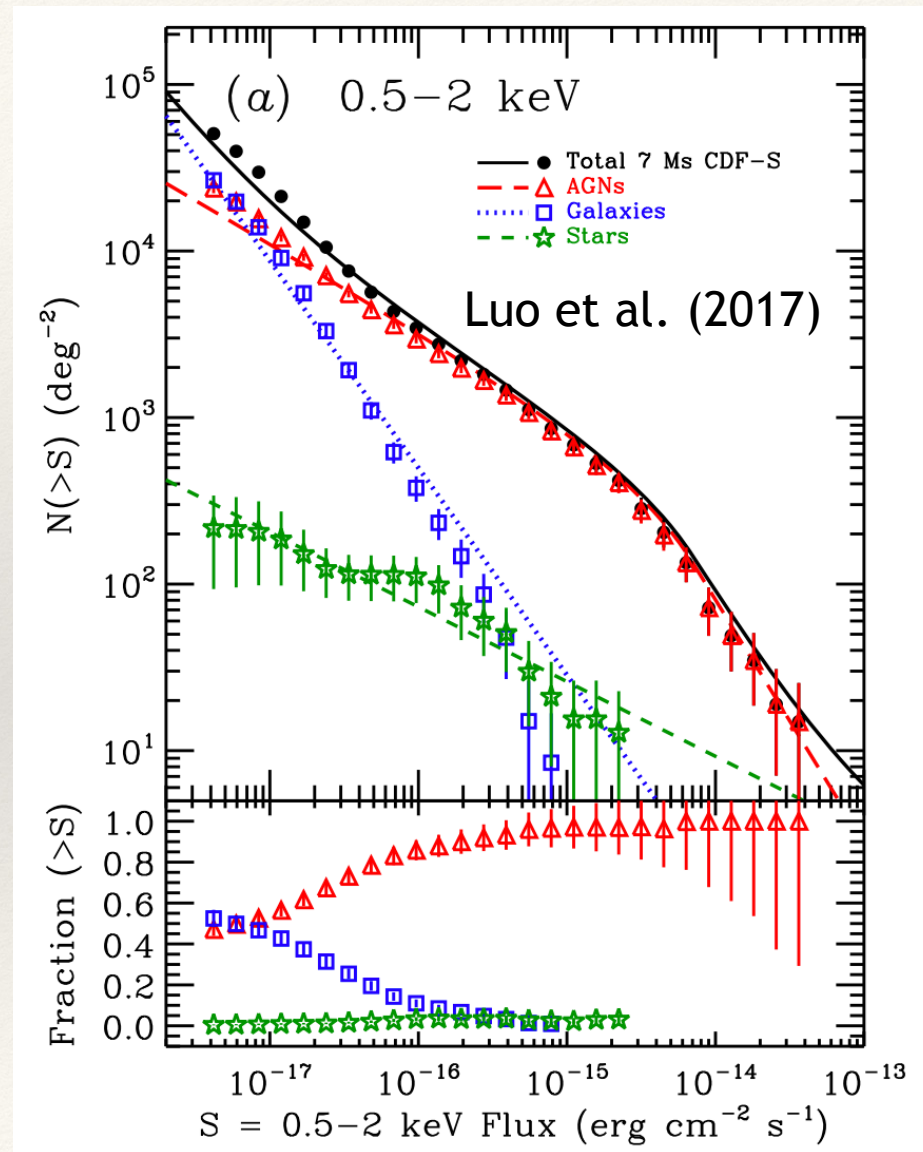
Donley et al. (2008, 2012); Ballantyne et al. (2011) Comastri et al. (2011); Georgantopoulos et al. (2013); Lanzuisi et al. (2015); Buchner et al. (2015)

The X-ray surveys wedding-cake strategy

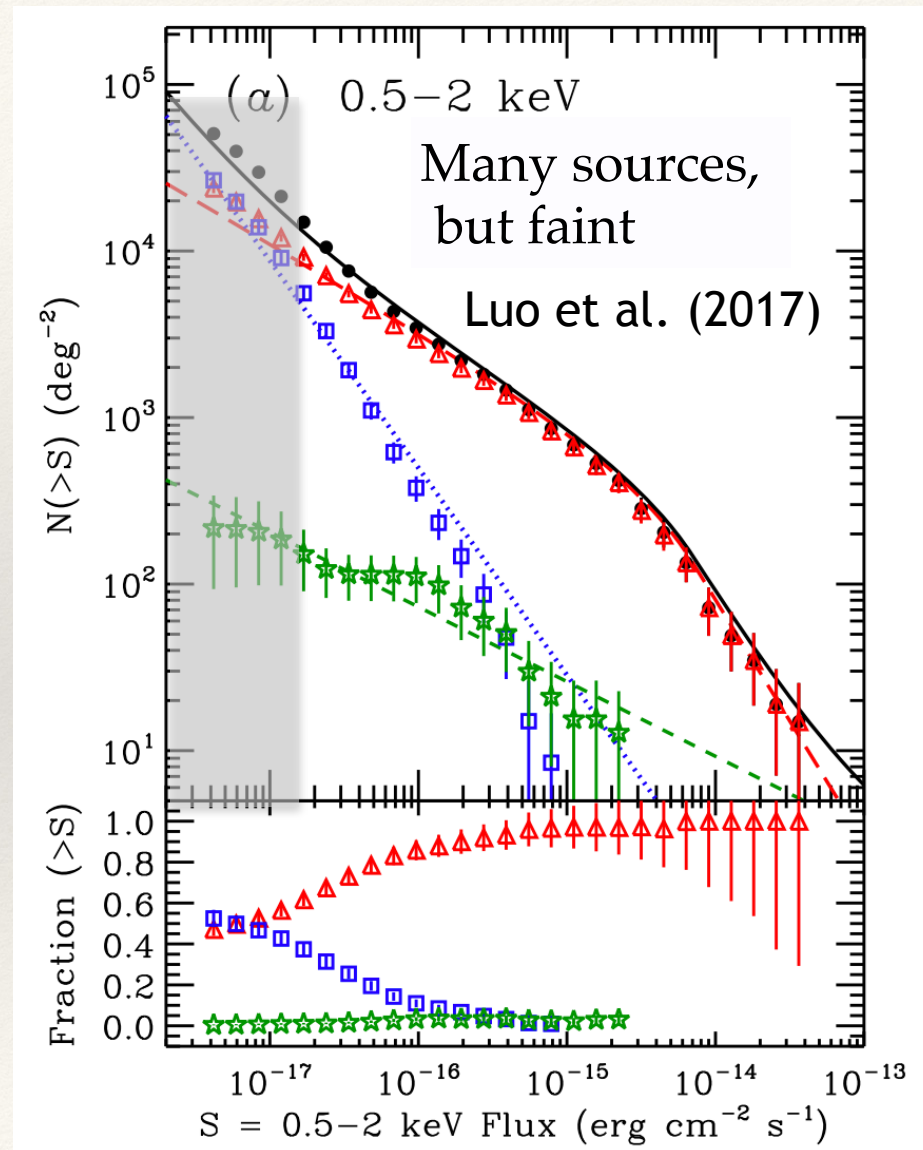


Courtesy of F.Civano

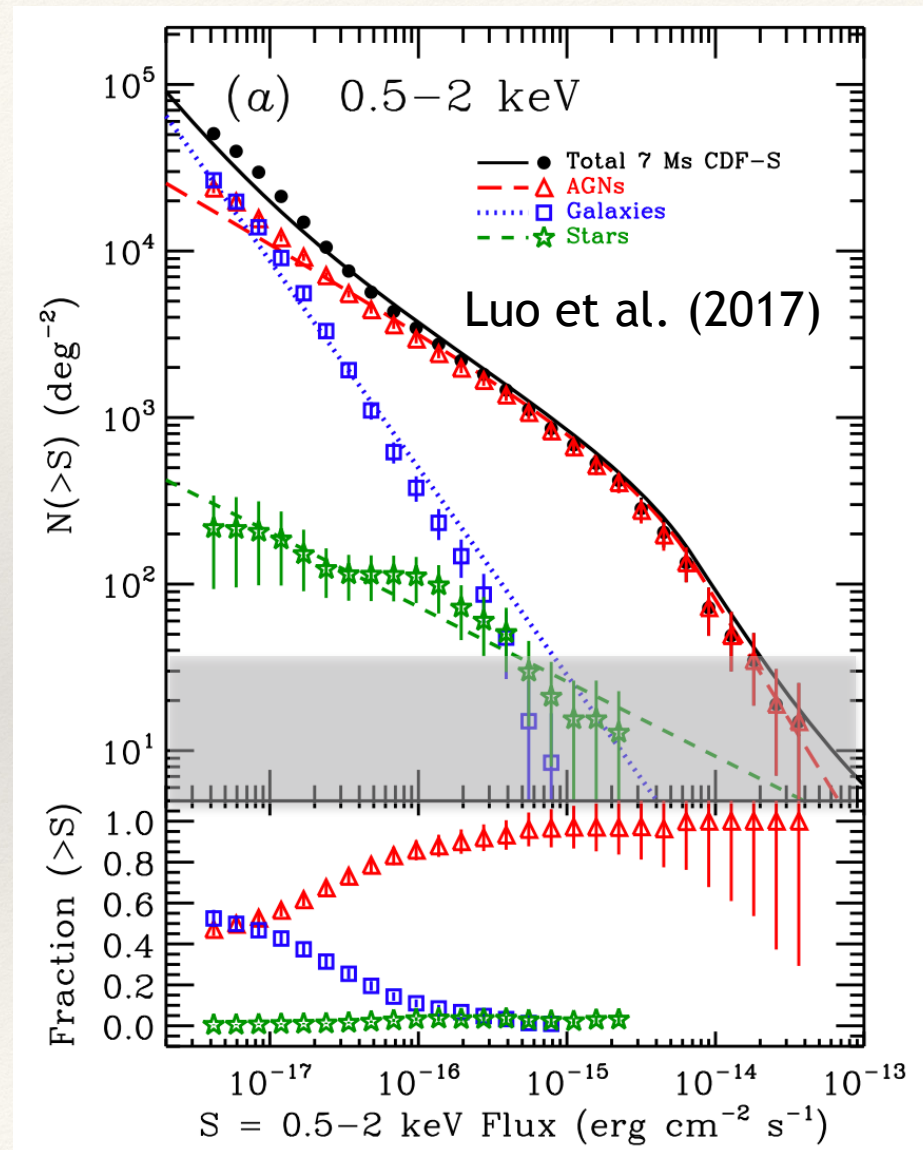
Different surveys for different science



Different surveys for different science

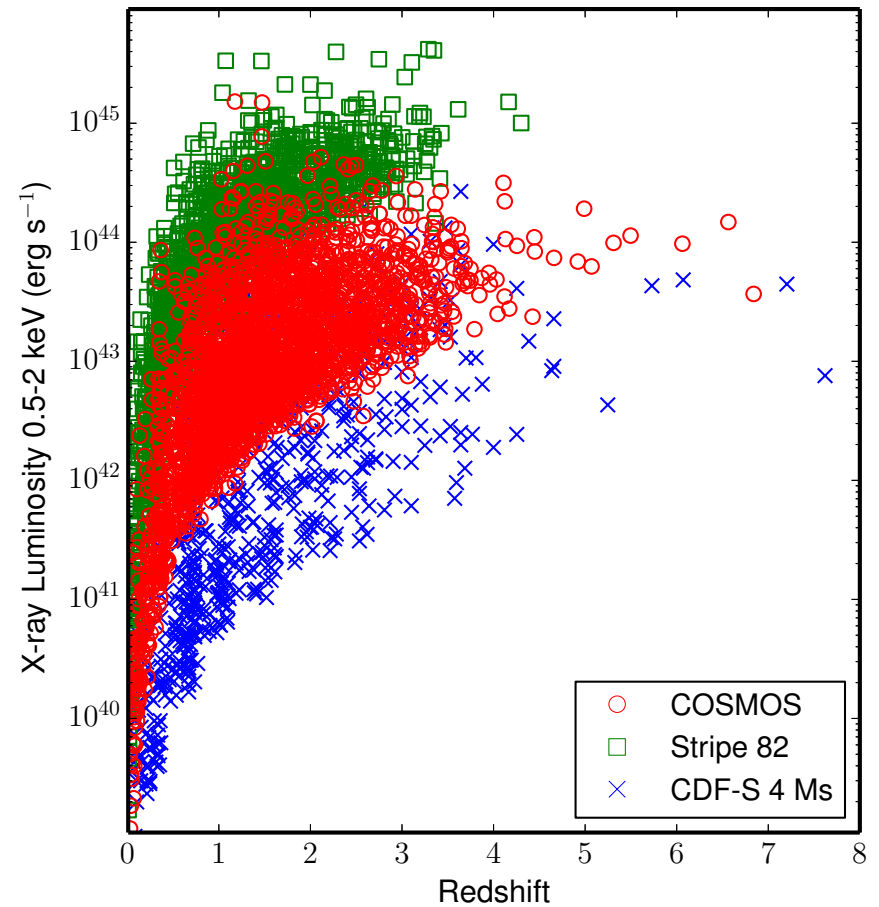
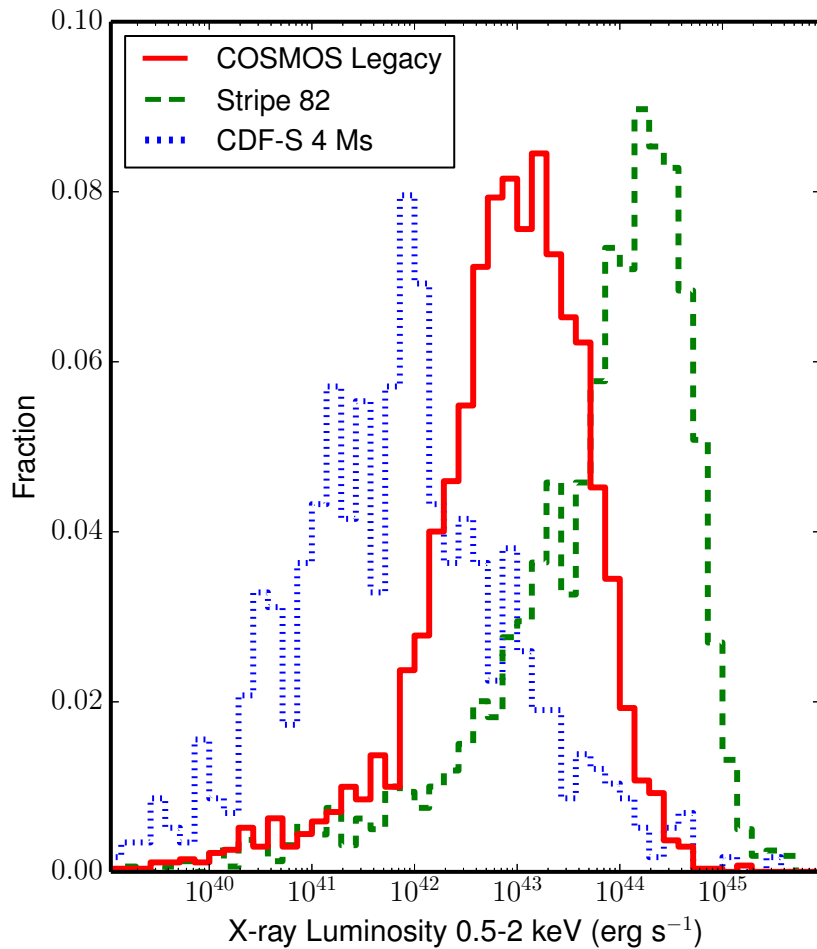


Different surveys for different science



Extremely
bright, but
rare

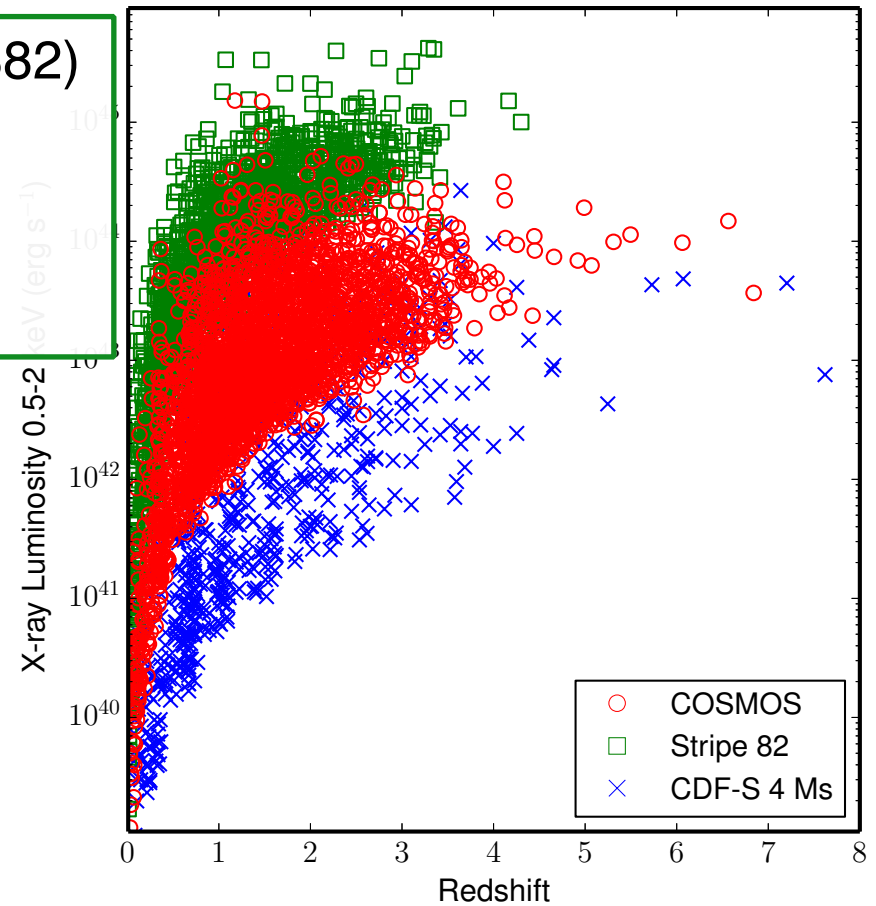
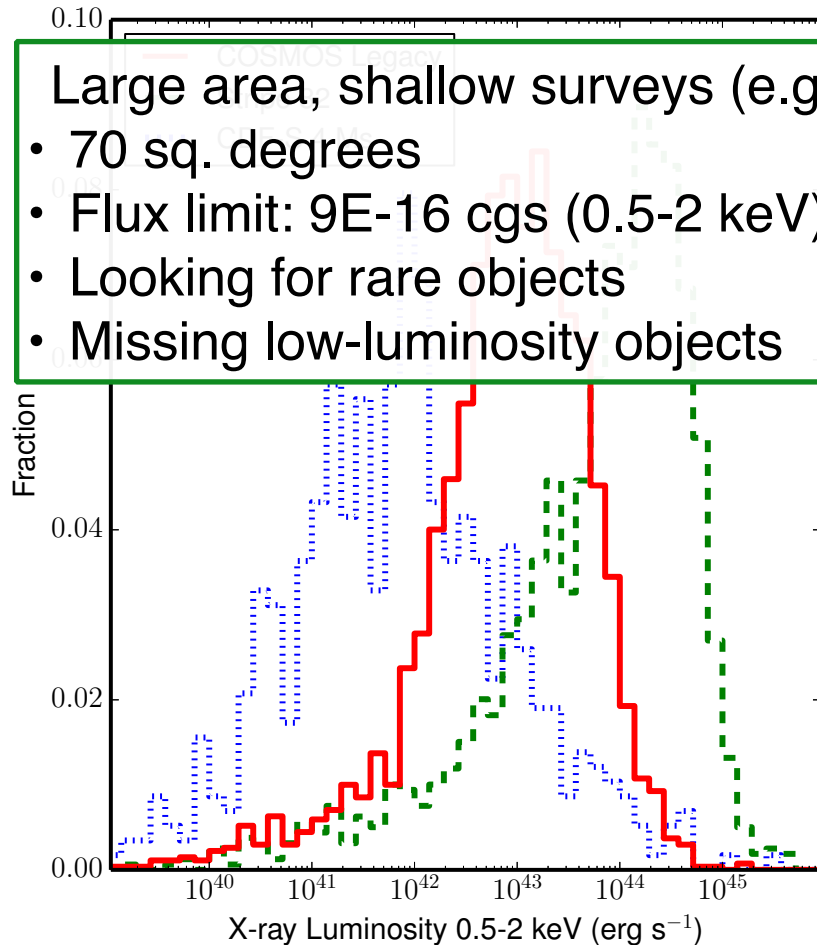
Different surveys for different science



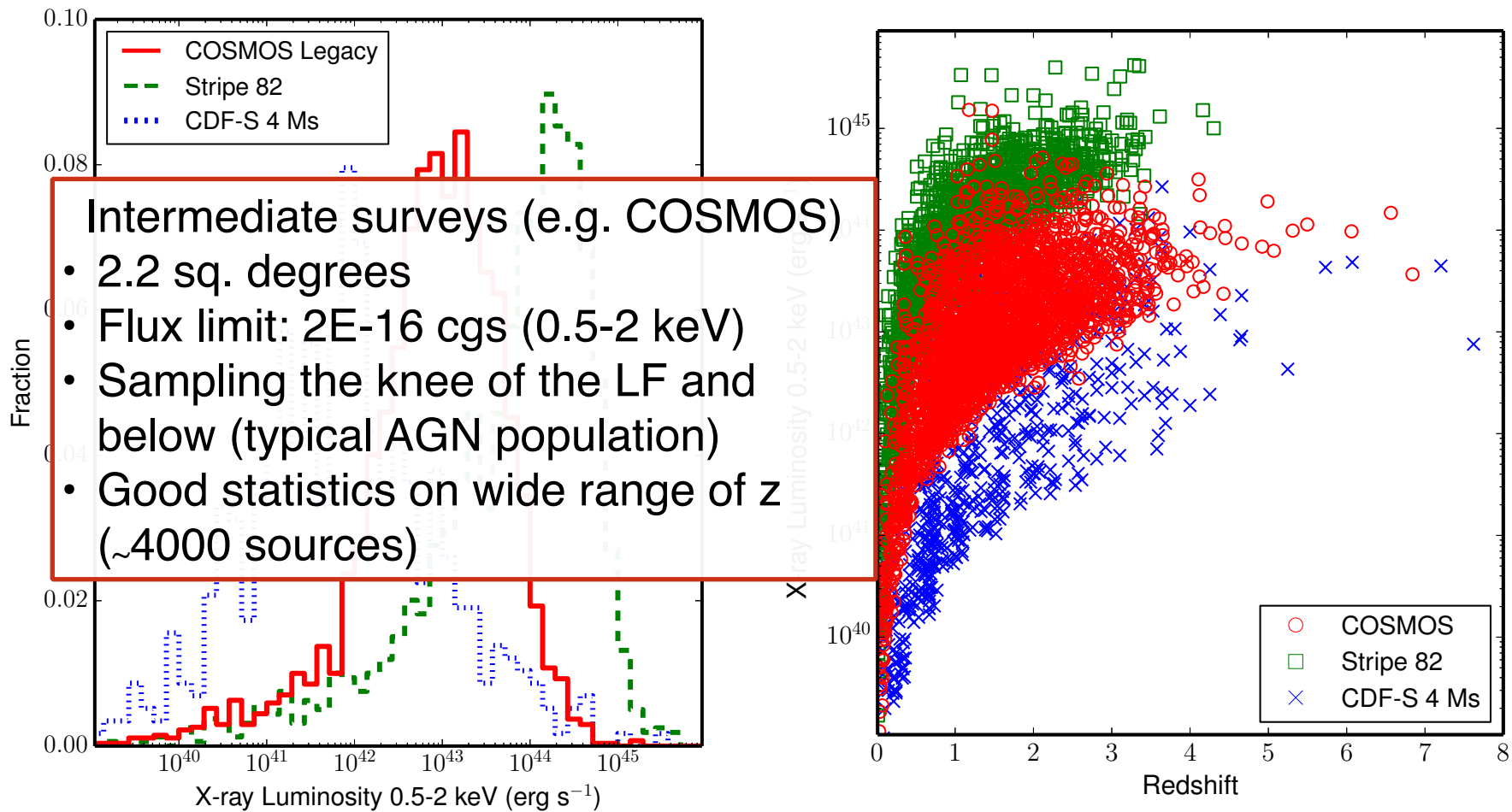
Different surveys for different science

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

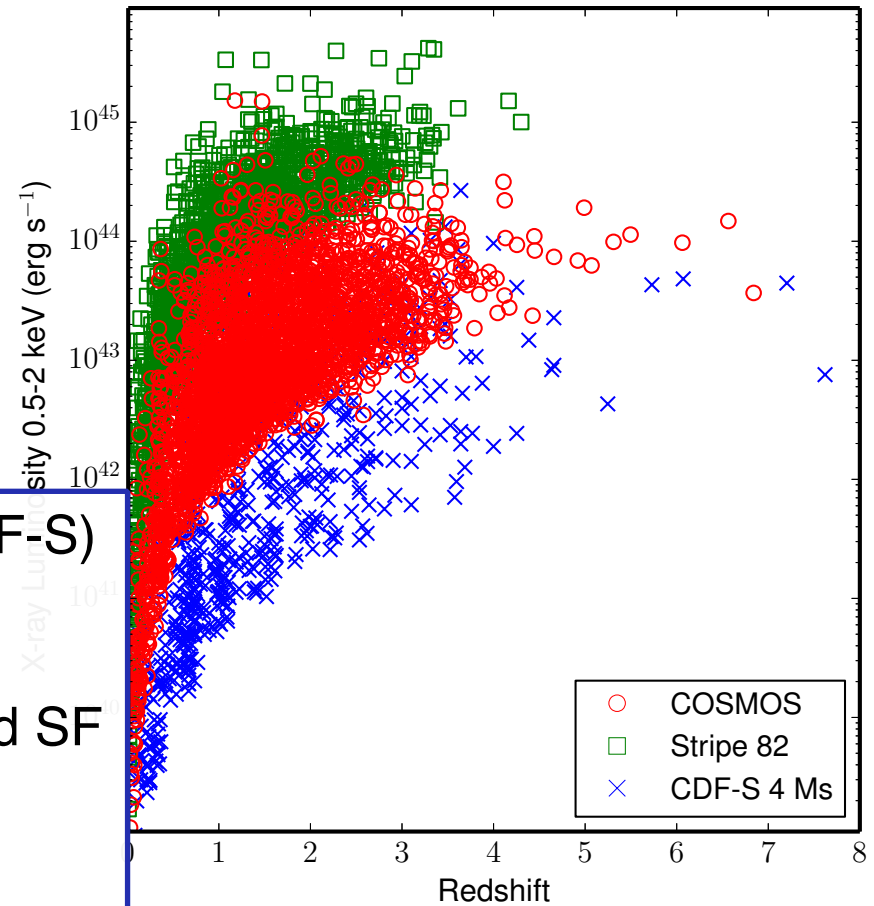
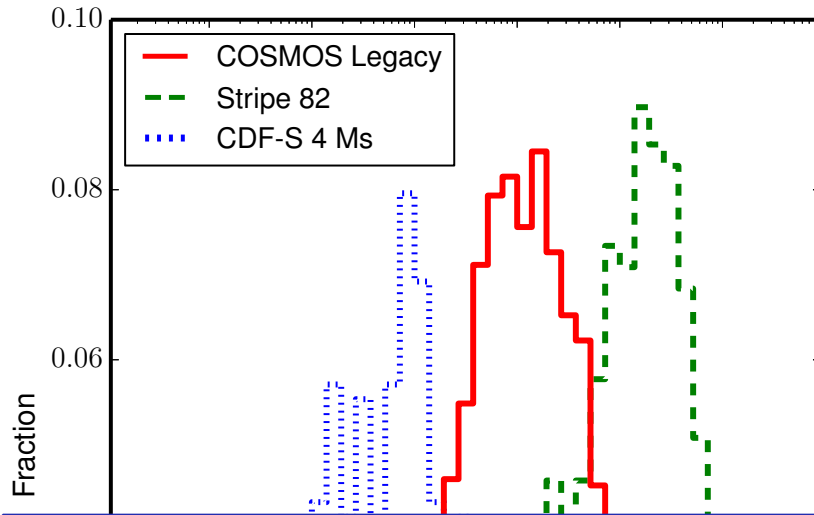
- 70 sq. degrees
- Flux limit: $9E-16$ cgs (0.5-2 keV)
- Looking for rare objects
- Missing low-luminosity objects



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)**

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

≈3Ms *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

This Lab Outline: Exploring the deepest existing X-ray survey

In this lab, you will explore the Chandra Deep Field 7 Ms survey; deepest X-ray field currently existing, and learn how to study and characterize a population of sources through the investigation of their properties (as reported in catalogs)

- 1. Understand the parameters affecting the source catalog:** We will provide you with a series of catalogs performed using different detection parameter setups over 500 ks out of the 7 Ms of observations of the Chandra Deep Field. You will cross-match the sources in this low-exposure catalogs with those in the official 7Ms source catalog, using different criteria.
- 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) Explore different source catalogs

- a. We ran for you the Chandra CIAO **wavdetect** tool to search sources in a set of observations, using two different **significance thresholds** (i.e., your detections can be more or less reliable; **sigthresh=1E-6; 1E-4**)

```
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
```

Lab Outline

1) Build the source catalog

b. Cross-correlate the two catalogs

(CDFS_4obs_merged_057keV_wavdet_1em4_src.fits; CDFS_4obs_merged_057keV_wavdet_1em6_src.fits) 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 the different catalogs and different matching radii (1/2/3”).
- Then, for both catalogs and using a cross-matching radius of 2”, compute the number of sources detected in the 500 ks 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 shorter-exposure mosaic?

Lab Outline

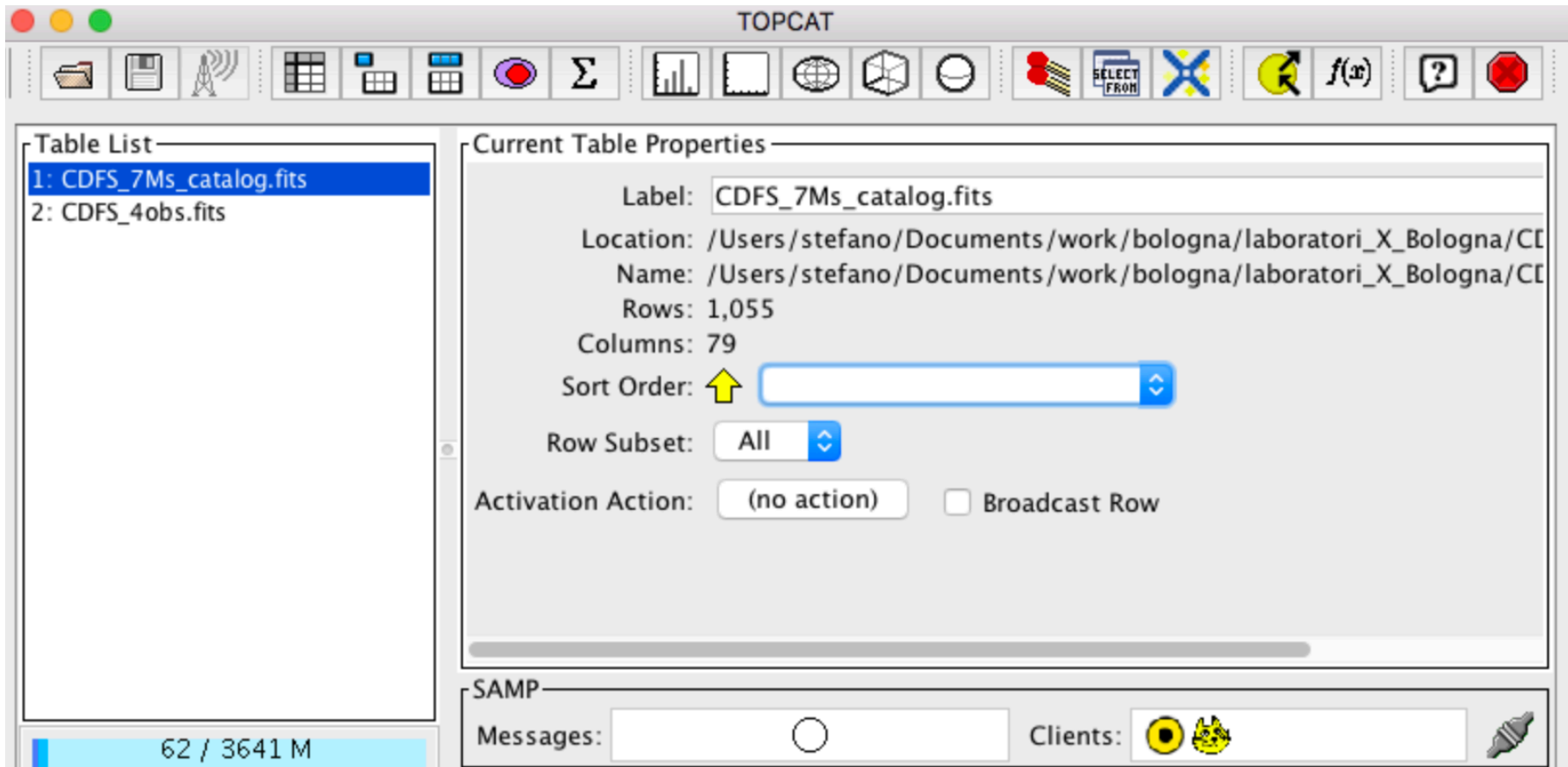
1) Build the source catalog

Cross-correlate the source lists obtained in the short-exposure mosaic 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 obtained in the short-exposure mosaic 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)



The image shows a screenshot of the TOPCAT software interface. The window title is "TOPCAT". The interface is divided into several sections:

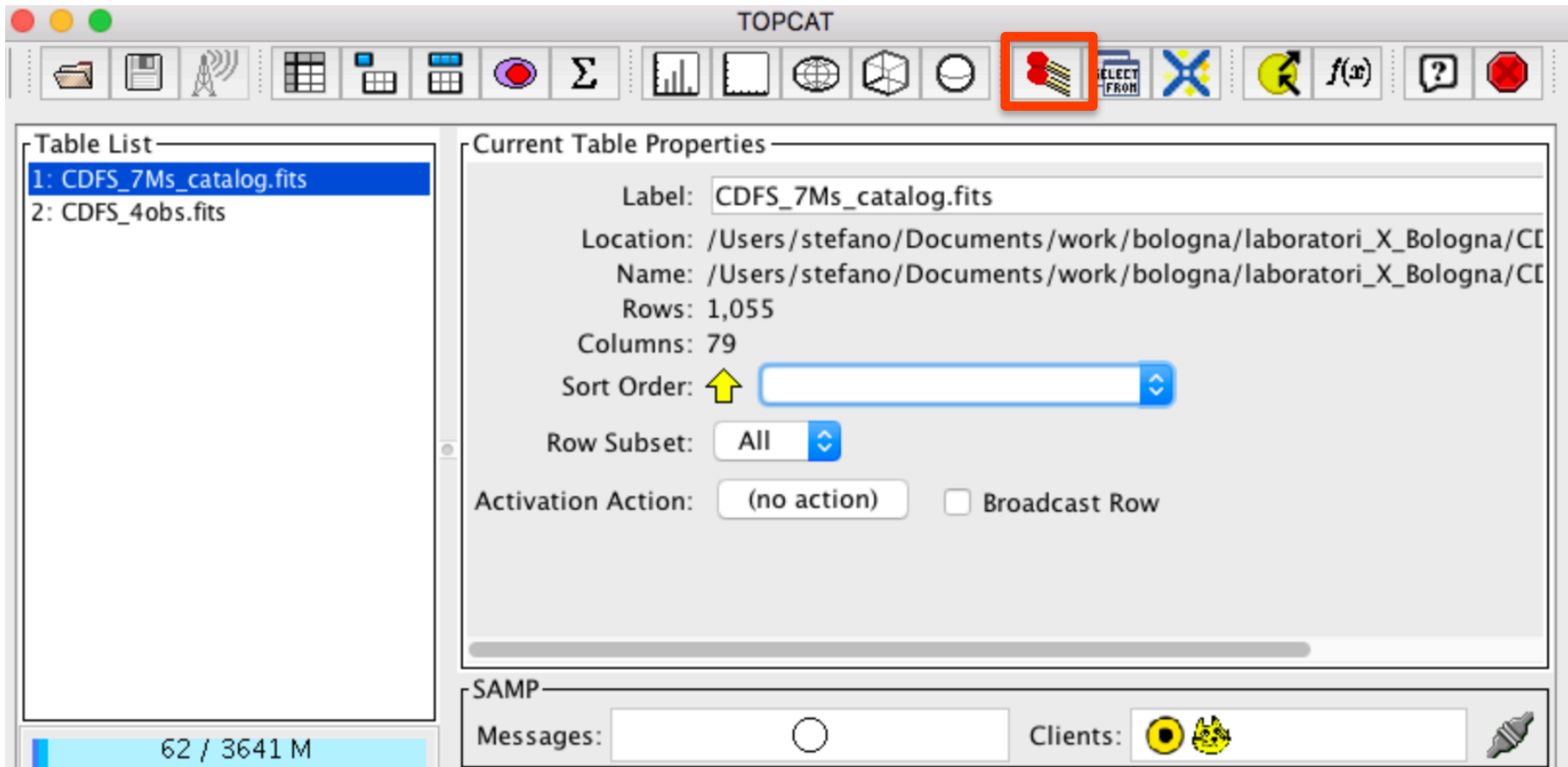
- Table List:** A list of tables is shown on the left. The first table, "1: CDFS_7Ms_catalog.fits", is selected and highlighted in blue. The second table is "2: CDFS_4obs.fits".
- Current Table Properties:** A panel on the right displays the properties of the selected table:
 - Label: CDFS_7Ms_catalog.fits
 - 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: A dropdown menu with an upward-pointing yellow arrow.
 - Row Subset: A dropdown menu set to "All".
 - Activation Action: A button labeled "(no action)" and a checkbox for "Broadcast Row" which is currently unchecked.
- SAMP:** A section at the bottom of the interface for connecting to other software via SAMP. It includes a "Messages:" field with a circular icon and a "Clients:" field with two icons (a yellow circle and a yellow robot head).
- Status Bar:** At the bottom left, a blue bar displays "62 / 3641 M".

The interface also features a toolbar at the top with various icons for file operations, data visualization, and table manipulation.



Lab Outline

1) Build the source catalog

Cross-correlate the source lists obtained in the short-exposure mosaic 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)



The screenshot shows the TOPCAT software interface. The title bar reads "TOPCAT". The toolbar contains various icons, with a red circle highlighting the "Cross-match" icon (two overlapping circles). The main window is divided into two panes:

- Table List:** Contains two entries:
 - 1: CDFS_7Ms_catalog.fits
 - 2: CDFS_4obs.fits
- Current Table Properties:** Displays details 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

At the bottom, the status bar shows "62 / 3641 M" and a "SAMP" section with "Messages:" and "Clients:" fields.

1) B

Cross-correlate the
with the official 7 I
2017), using vario

alog

exposure mosaic
CDF-S (Luo et al.
arcsec)

Match Tables

Match Criteria

Algorithm: Sky

Max Error: 2.0 arcsec

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:

Table List

- 1: CDFS_7Ms_catalog.fits
- 2: CDFS_4obs.fits

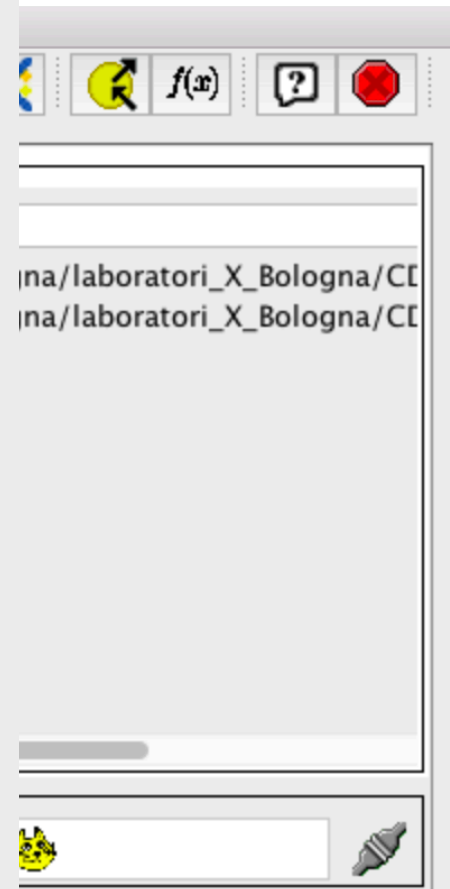
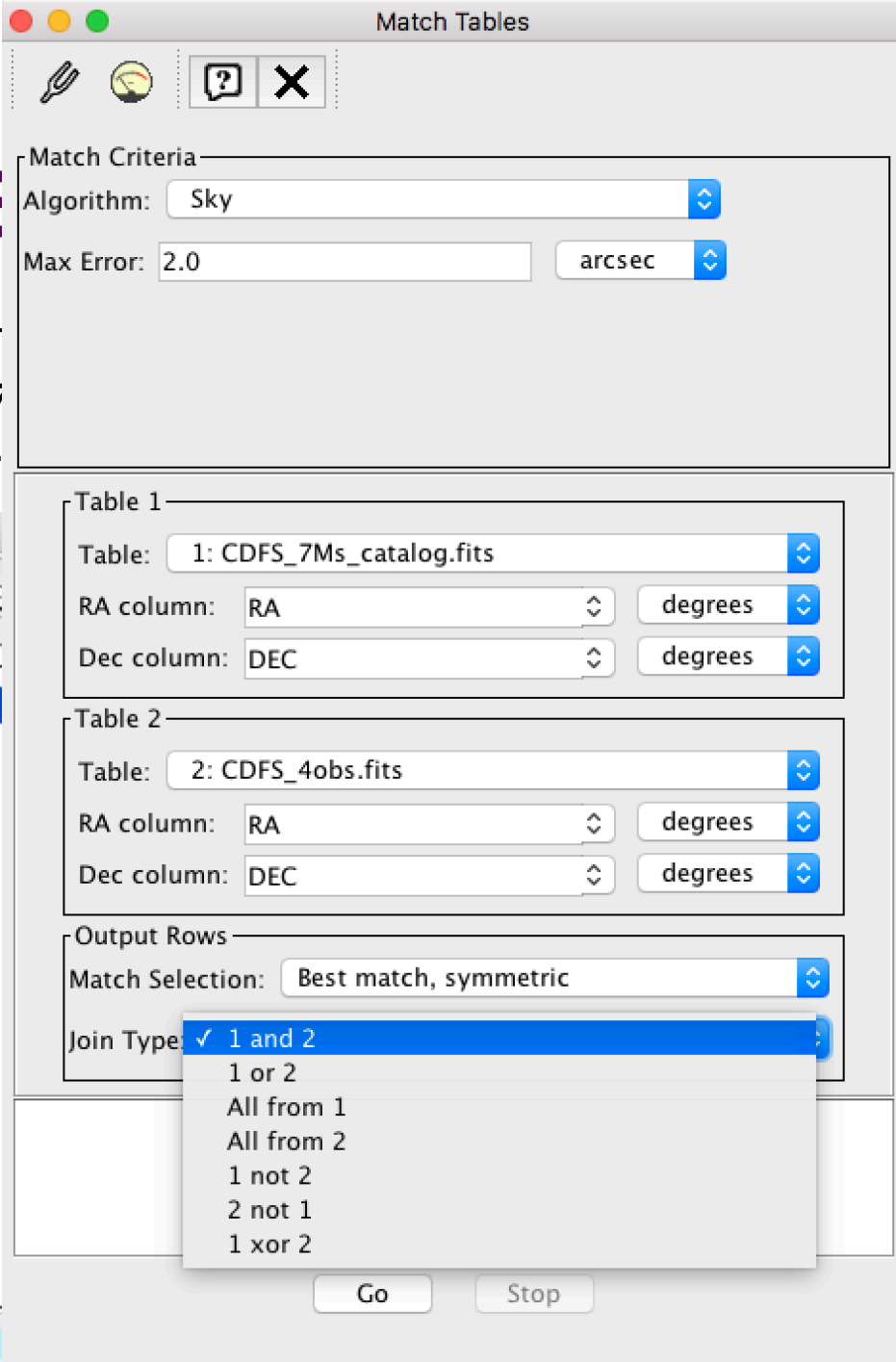
62 / 3641 M

1) E

Cross-correlate with the official 7 (2017), using var

log

xposure mosaic
DF-S (Luo et al.
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

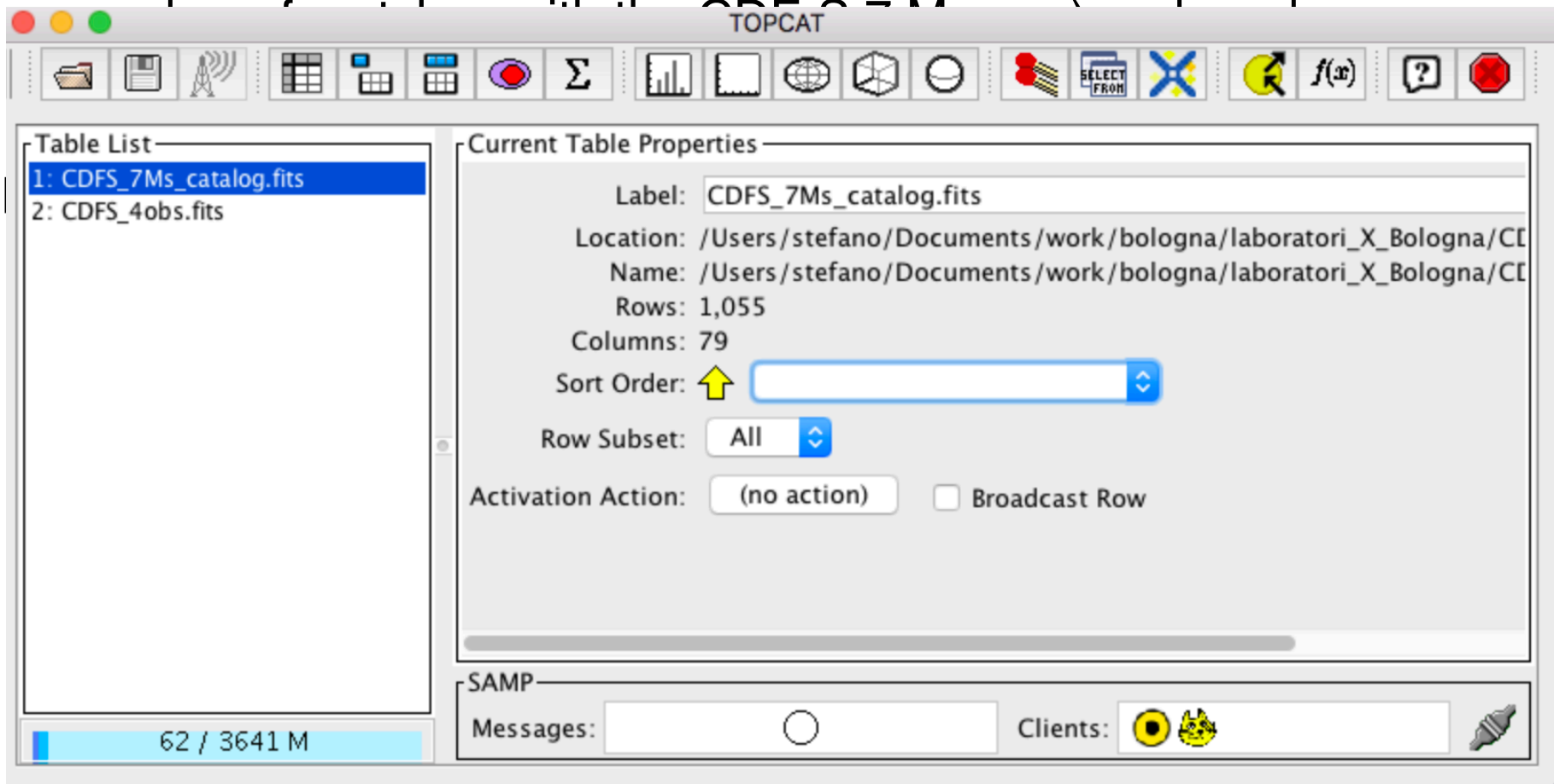
2) Explore the source catalog

- 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



The screenshot shows the TOPCAT software interface. The window title is "TOPCAT". The interface is divided into several sections:

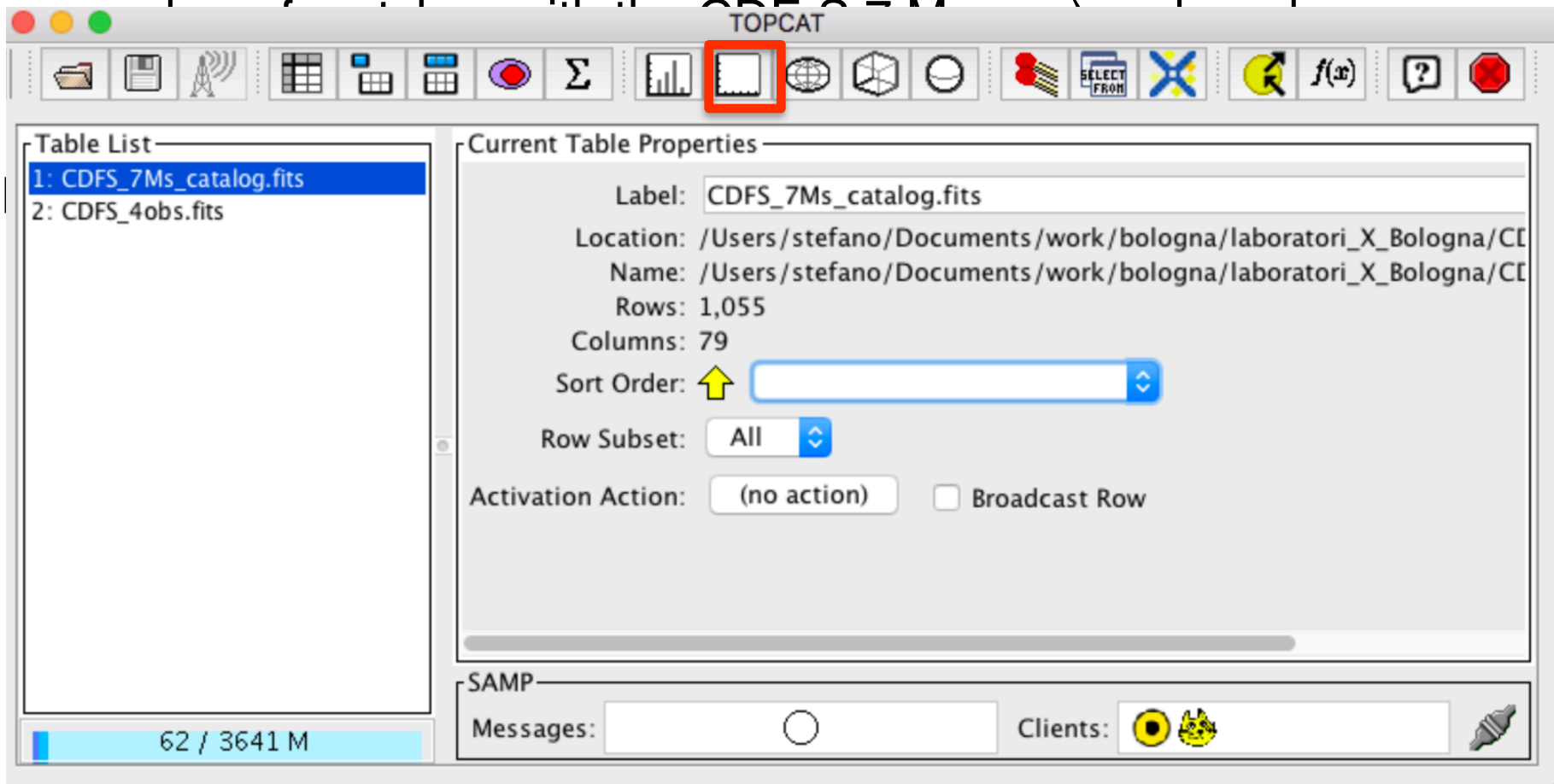
- Table List:** A list of tables is shown on the left. The first table, "1: CDFS_7Ms_catalog.fits", is selected and highlighted in blue. The second table is "2: CDFS_4obs.fits".
- Current Table Properties:** A panel on the right displays the properties of the selected table:
 - Label: CDFS_7Ms_catalog.fits
 - 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: A dropdown menu with an upward-pointing yellow arrow.
 - Row Subset: A dropdown menu set to "All".
 - Activation Action: A button labeled "(no action)" and a checkbox for "Broadcast Row" which is currently unchecked.
- SAMP:** A section at the bottom of the window. It includes a "Messages:" field with a circular indicator and a "Clients:" field showing two active clients (represented by yellow and black icons).
- Status Bar:** At the bottom left, it displays "62 / 3641 M".

The top of the window features a toolbar with various icons for file operations, data visualization, and navigation.

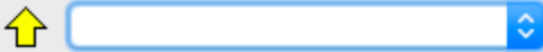

Lab Outline



2) Explore the source catalog

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



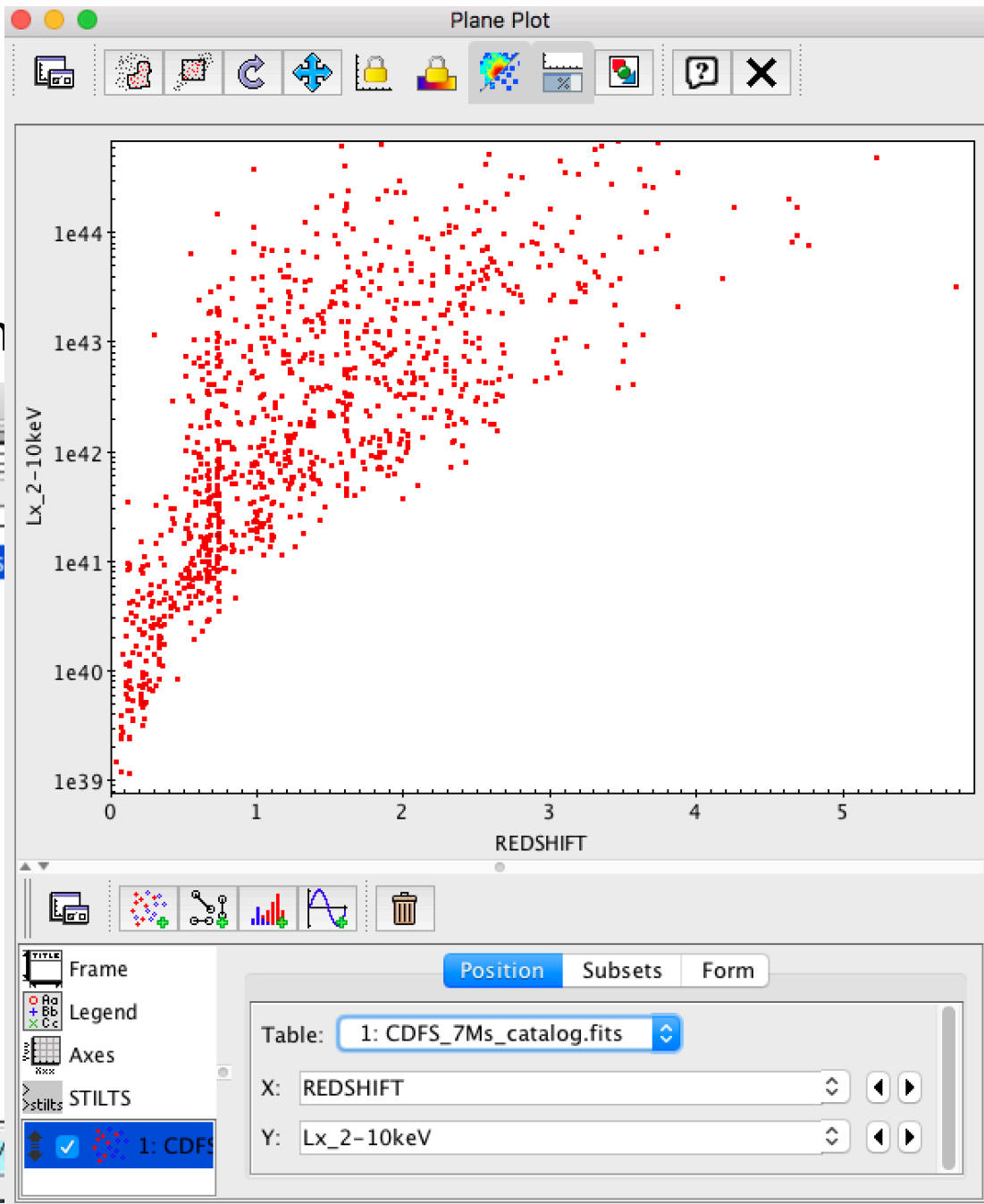
The screenshot shows the TOPCAT software interface. The title bar reads "TOPCAT". The toolbar contains various icons, with a red box highlighting the "Table List" icon. The "Table List" panel on the left shows two tables: "1: CDFS_7Ms_catalog.fits" (selected) and "2: CDFS_4obs.fits". The "Current Table Properties" panel on the right displays the following information:

- 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 status bar at the bottom shows "62 / 3641 M" on the left and "Messages:  Clients: 

2)

a. Choose on



log

th largest

Table List

- 1: CDFS_7Ms_catalog.fits
- 2: CDFS_4obs.fits

62 / 3641 M

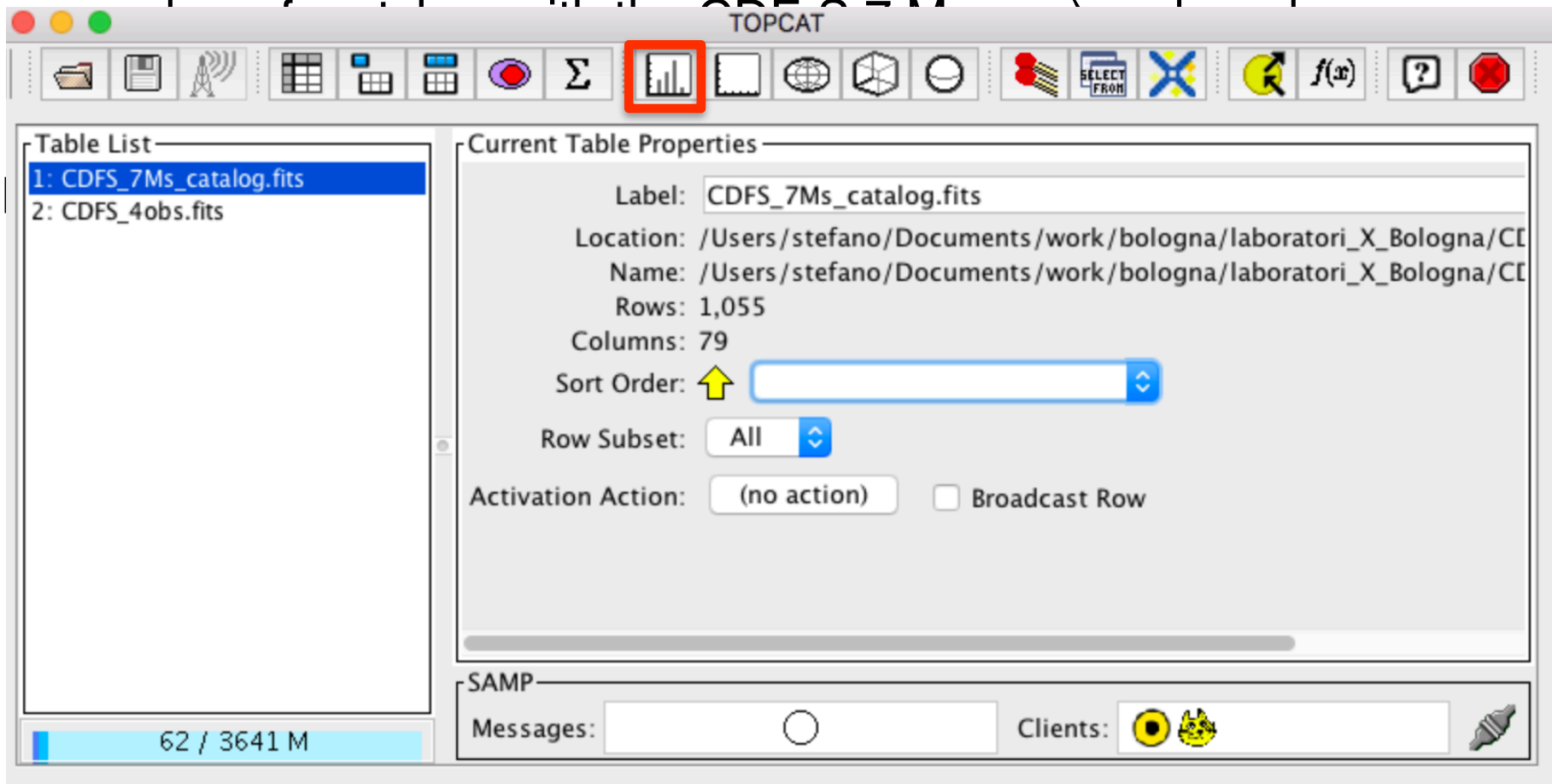
boratori_X_Bologna/CC

boratori_X_Bologna/CC

Lab Outline

2) Explore the source catalog

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



The screenshot shows the TOPCAT software interface. The title bar reads "TOPCAT". The toolbar contains various icons, with a bar chart icon highlighted by a red box. The main window is divided into two panes:

- Table List:** A list of tables with "1: CDFS_7Ms_catalog.fits" selected (highlighted in blue) and "2: CDFS_4obs.fits" below it.
- Current Table Properties:** A panel showing details 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: A dropdown menu with a yellow arrow pointing up.
 - Row Subset: A dropdown menu set to "All".
 - Activation Action: A button labeled "(no action)" and a checkbox for "Broadcast Row" which is unchecked.

At the bottom of the window, there is a "SAMP" section with a "Messages:" field and a "Clients:" field containing two icons (a yellow circle and a yellow cat face).

62 / 3641 M

2

a. Choose c

og

largest

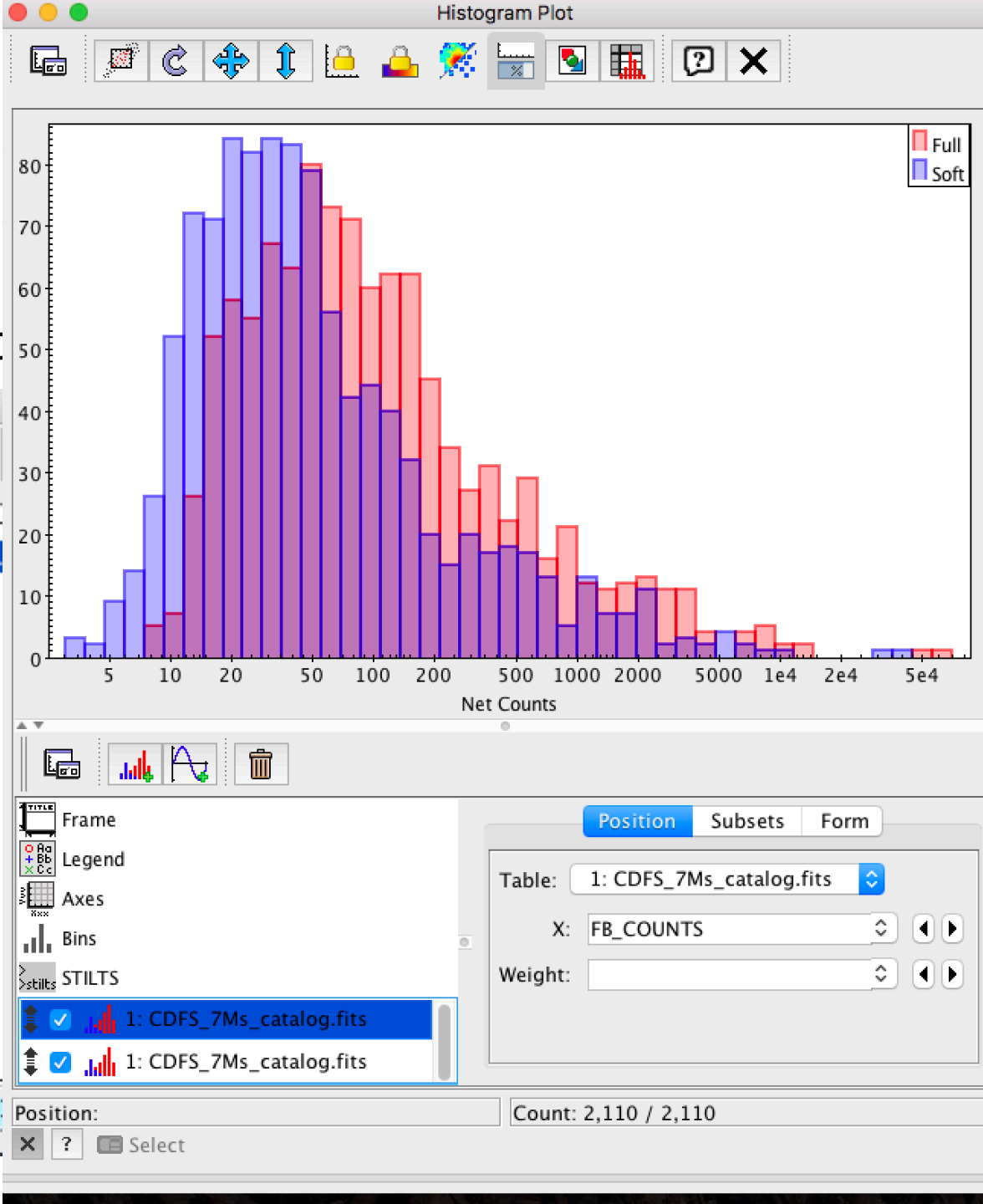


Table List

- 1: CDFS_7Ms_catalog.fits
- 2: CDFS_4obs.fits

62 / 364

$f(x)$?

atori_X_Bologna/CC
atori_X_Bologna/CC

Select

Position Subsets Form

Table: 1: CDFS_7Ms_catalog.fits

X: FB_COUNTS

Weight:

Position: Count: 2,110 / 2,110

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, with the 'View Table' icon (a purple circle with a red dot) highlighted by a red square. The 'Table List' on the left shows two tables: '1: CDFFS_7Ms_catalog.fits' (selected) and '2: CDFFS_4obs.fits'. The 'Current Table Properties' panel on the right displays the following information:

- Label: CDFFS_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

At the bottom, the 'SAMP' section shows 'Messages: [input field]' and 'Clients: [radio buttons]'. The status bar at the bottom left indicates '62 / 3641 M'.

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'. A 'Row Subsets' dialog box is open, titled 'TOPCAT(5): Row Subsets'. The dialog shows a table of row subsets for the file 'CDFFS_7Ms_catalog.fits'. The table has four columns: 'ID', 'Name', 'Size', and 'Fraction'. The first row is '_1', 'All', '1055', and '100%'. The dialog also features a toolbar with various icons, including a green plus sign highlighted with a red box. At the bottom of the main window, there is a status bar showing '62 / 3641 M', a 'SAMP' section with 'Messages:' and 'Clients:' fields, and a yellow radiation warning icon.

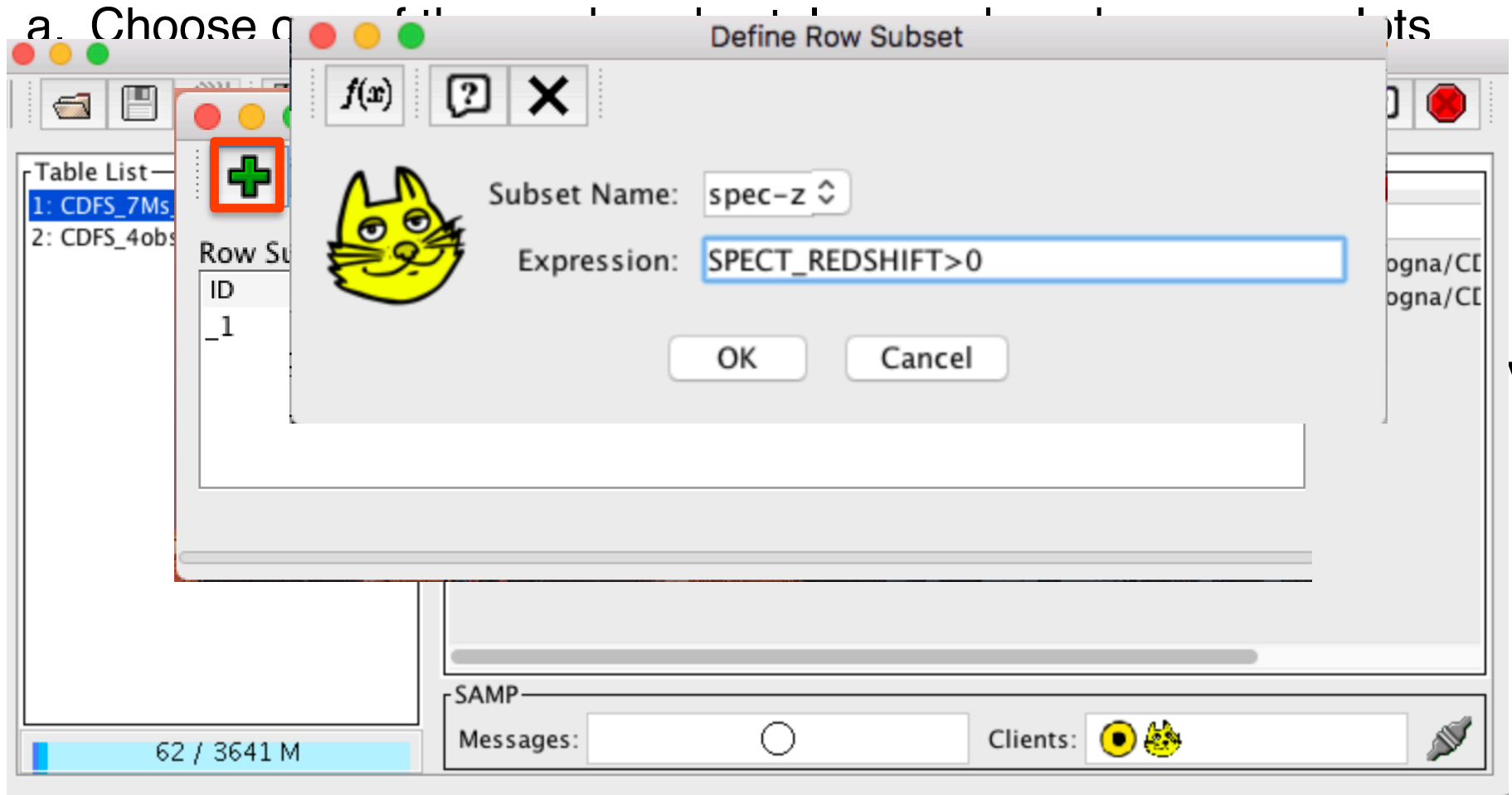
ID	Name	Size	Fraction
_1	All	1055	100%

VS

Lab Outline

2) Explore the source catalog

a. Choose a...



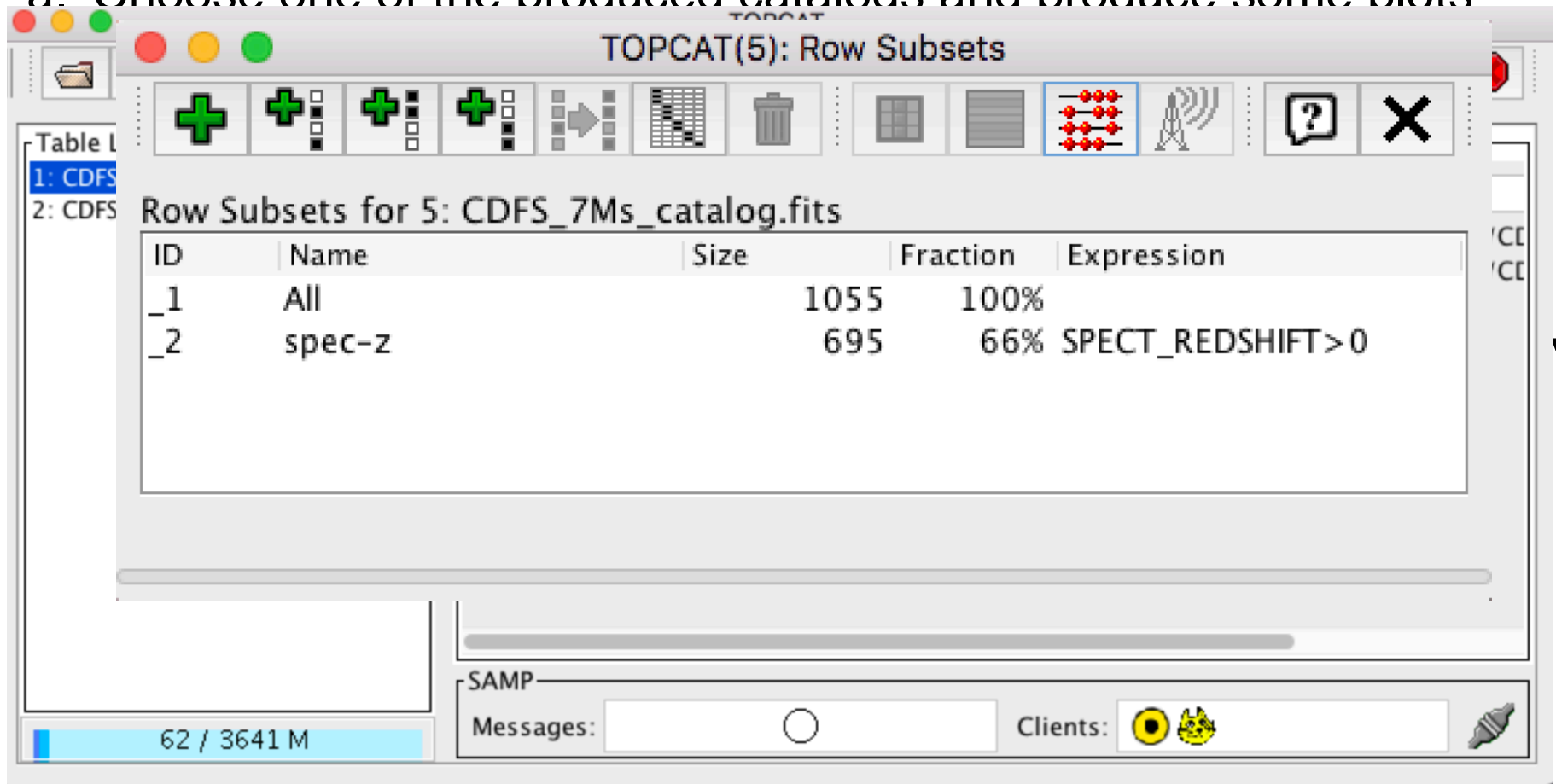
The screenshot shows a 'Define Row Subset' dialog box in a software application. The dialog features a yellow cat icon on the left. The 'Subset Name' field contains 'spec-z' and the 'Expression' field contains 'SPECT_REDSHIFT>0'. There are 'OK' and 'Cancel' buttons at the bottom. In the background, a 'Table List' window is visible with a green plus icon highlighted by a red box. The status bar at the bottom shows '62 / 3641 M' and 'Clients: [yellow circle] [yellow cat icon]'.

VS

Lab Outline

2) Explore the source catalog

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



The screenshot shows the TOPCAT(5) Row Subsets window. The title bar reads "TOPCAT(5): Row Subsets". The window contains a toolbar with various icons for adding, deleting, and filtering row subsets. Below the toolbar, the text "Row Subsets for 5: CDFS_7Ms_catalog.fits" is displayed. A table with the following data is shown:

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

At the bottom of the window, there is a status bar with a memory usage indicator showing "62 / 3641 M", a "SAMP" label, a "Messages:" field with a circular icon, and a "Clients:" field with two yellow icons.

VS

Lab Outline

2) Explore the source catalog

a. Choose

The screenshot displays a software interface with a 'Define Row Subset' dialog box in the foreground. The dialog box features a yellow cat icon on the left, a 'Subset Name' field containing 'phot-z', and an 'Expression' field containing 'REDSHIFT>0 & !_2'. Below the expression field are 'OK' and 'Cancel' buttons. In the background, a 'Table List' is visible with two entries: '1: CDFS_7Ms' and '2: CDFS_4obs'. A red box highlights a green plus sign icon in the background interface. At the bottom of the window, a status bar shows '62 / 3641 M', 'Messages', and 'Clients' with two cat icons.

VS

Lab Outline

2) Explore the source catalog

a. Choose

Define Row Subset

TOPCAT(5): Row Subsets

Row Subsets for 5: CDFFS_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

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SAMP

Messages: Clients:

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.

TOPCAT

Table List

- 1: CDFS_7Ms_catalog.fits
- 2: CDFS_4obs.fits

Current Table Properties

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

SAMP

Messages:

Clients:

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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: 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
<input type="radio"/> Flux Density		<input type="radio"/> Flux Density	
Mission:	Detector/Grating/Filter:	Flux:	
CHANDRA-Cycle 11 ▾	ACIS-I/None/None ▾	Absorbed ▾	
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
<input type="radio"/> Flux	<input type="radio"/> Flux Density	<input type="radio"/> Flux Density	
Mission: CHANDRA-Cycle 11 ▾	Detector/Crating/Filter: What happens changing the mission Cycle?	Flux:	
Input Energy: 0.5 to 2 keV		Output Energy: 0.5 to 2	

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

Lab Outline

2) Explore the source catalog

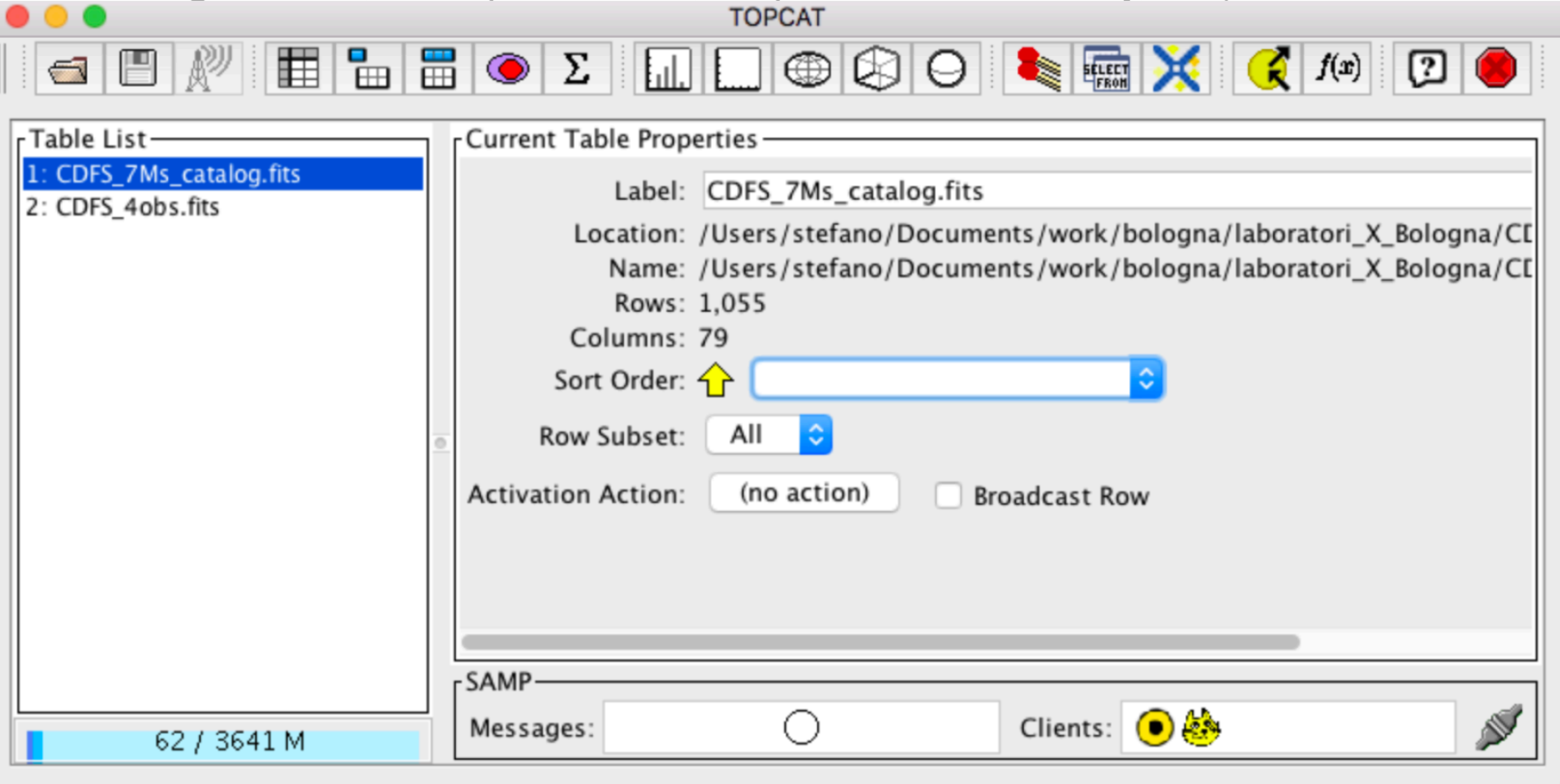
- a. Choose one of the produced catalogs and produce some plots (number of counts vs. source significance, vs. exposure time, vs. positional uncertainty, etc.)
- b. For the sources associated with the 7Ms source catalog, produce the redshift distribution histogram, L_x vs. z plot, etc.
- c. **OPTIONAL:** 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

- 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.




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 main window is divided into two panes:

- Table List:** A list of tables with "1: CDFS_7Ms_catalog.fits" selected.
- Current Table Properties:** A panel showing details 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: A dropdown menu with an upward arrow icon.
 - Row Subset: A dropdown menu set to "All".
 - Activation Action: A button labeled "(no action)" and a checkbox for "Broadcast Row".

c.

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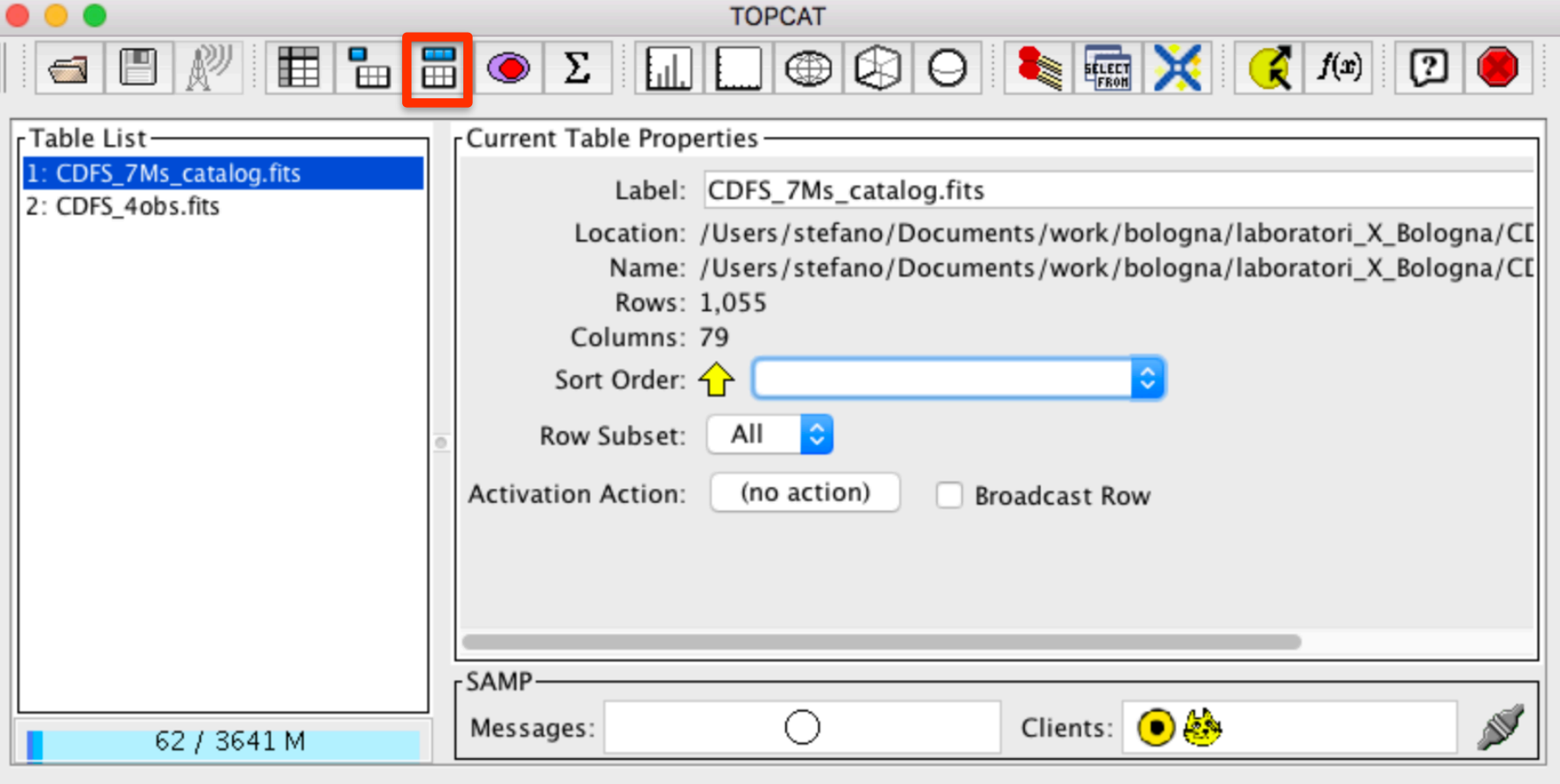
Messages: Clients: 

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.



c.

Table List

- 1: CDFS_7Ms_catalog.fits
- 2: CDFS_4obs.fits

Current Table Properties


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

SAMP

Messages:




Clients:  

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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


SAMP



Messages:



Clients: 


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nts vs.


 



 


 



 



 


 



 



 



 



 



 


 



 

Lab Outline

2) Explore the source catalog

a. Choose one source sign

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

c.

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

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SAMP

Messages:

Clients:

nts vs.

_Bologna/CC

_Bologna/CC

Lab Outline

2) Explore the source catalog

a. Choose one source sign

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

c.

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:

Lab Outline

2) Explore the source catalog

a. Choose one source sign

b.

c. Table List
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

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

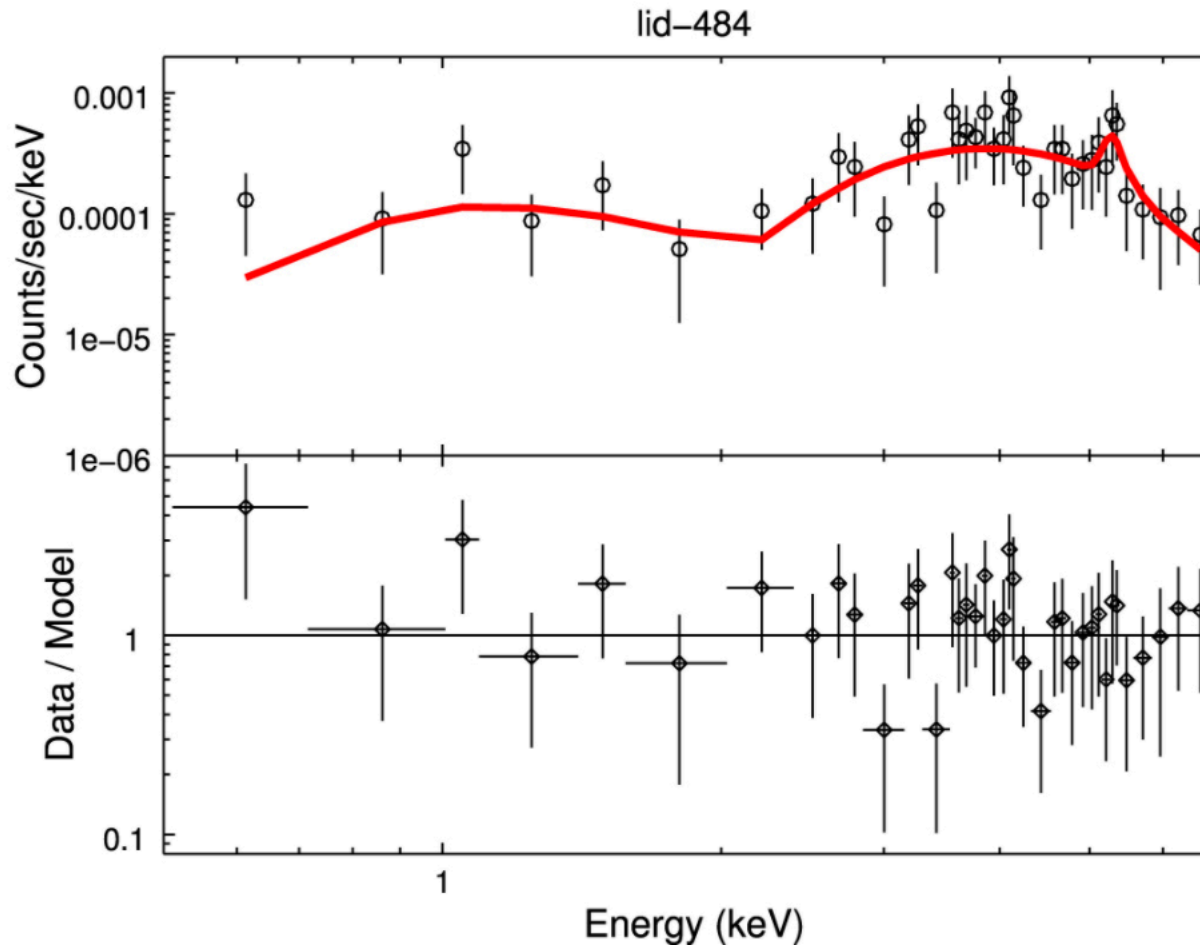
Spectral analysis pipeline

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

- 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.**