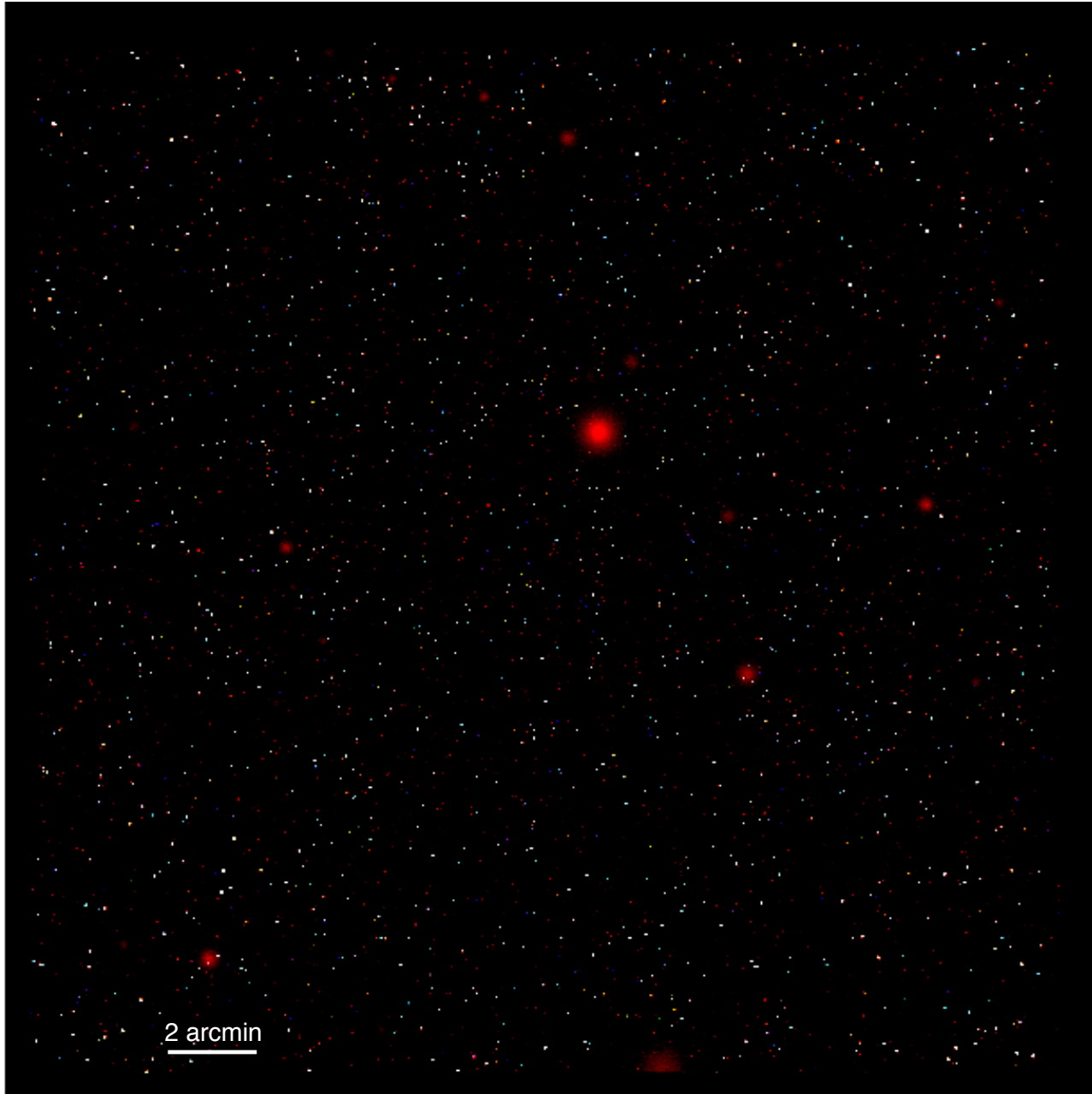
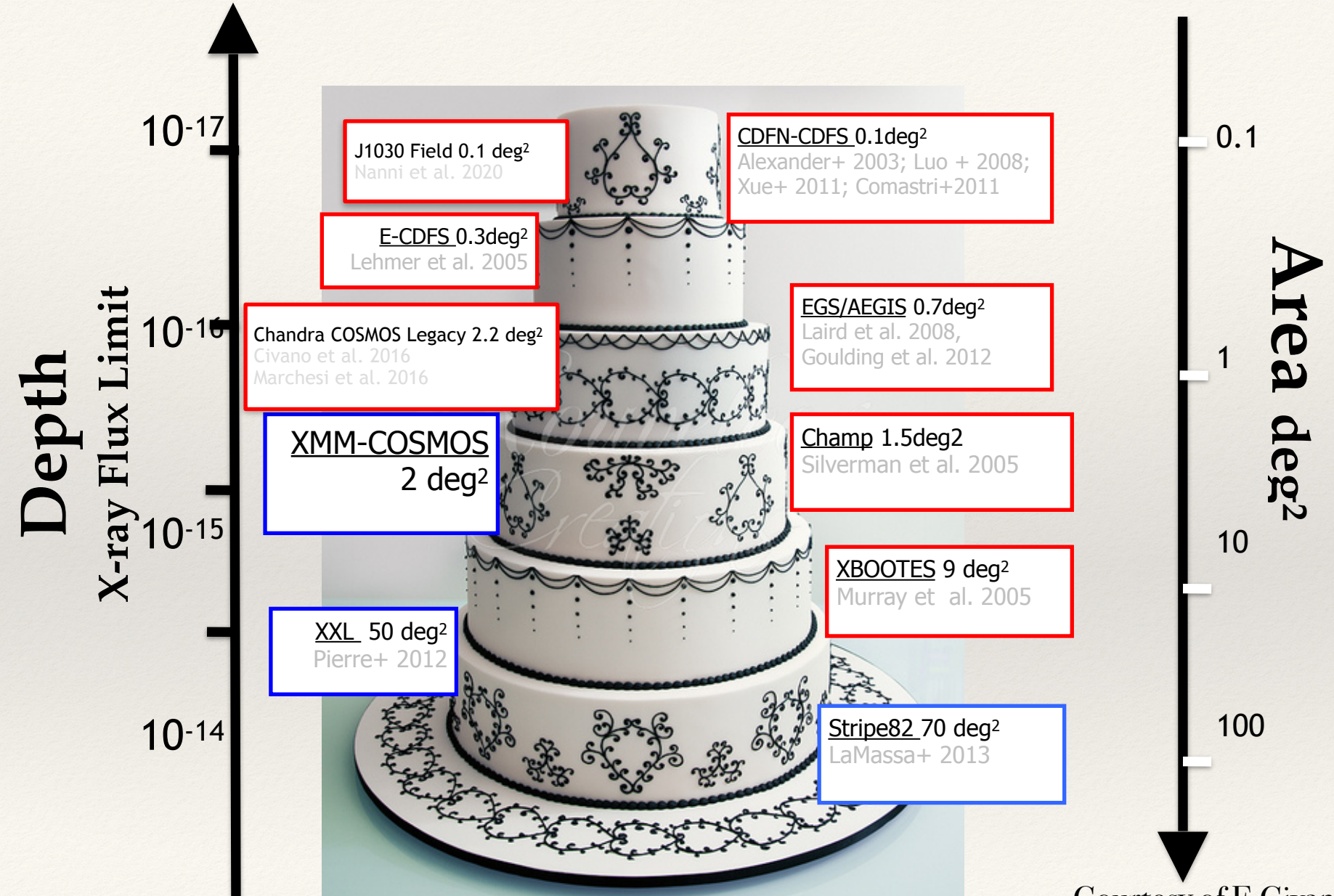


Understanding the AGN population: X-ray surveys

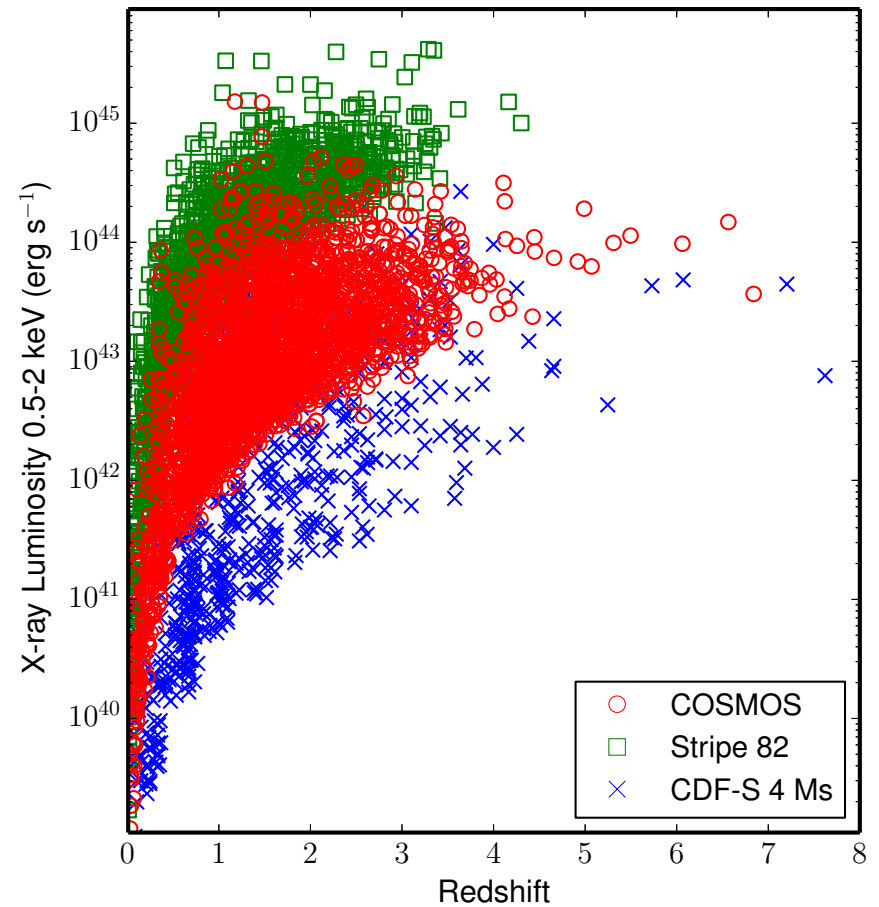
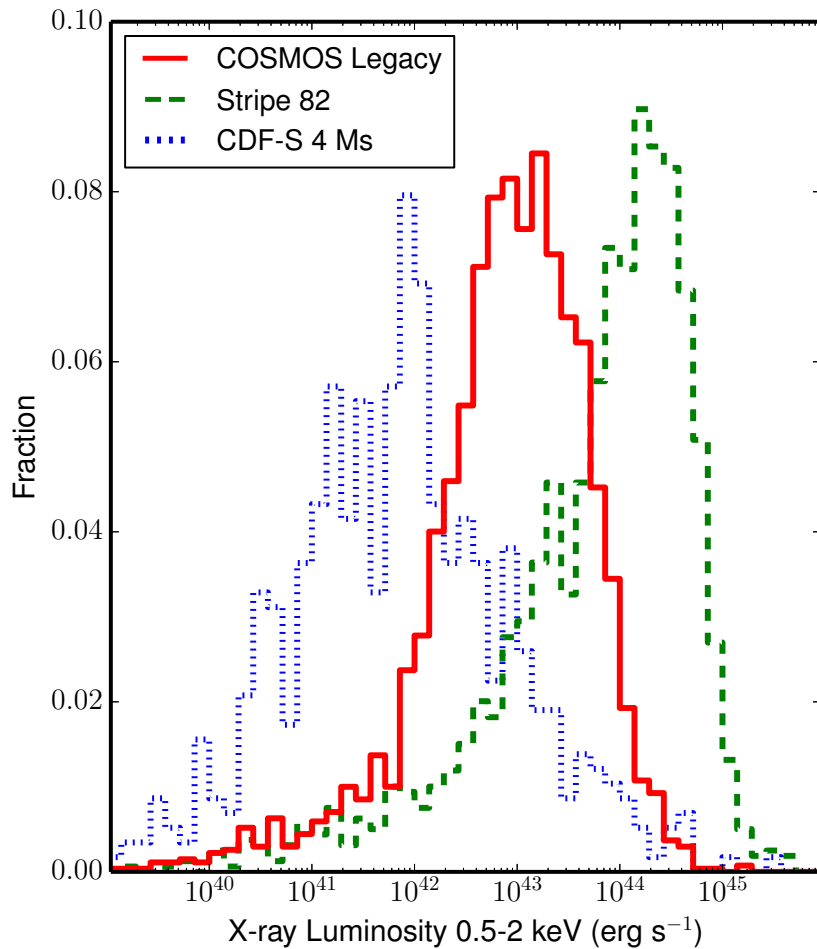


The X-ray surveys wedding-cake strategy



Courtesy of F.Civano

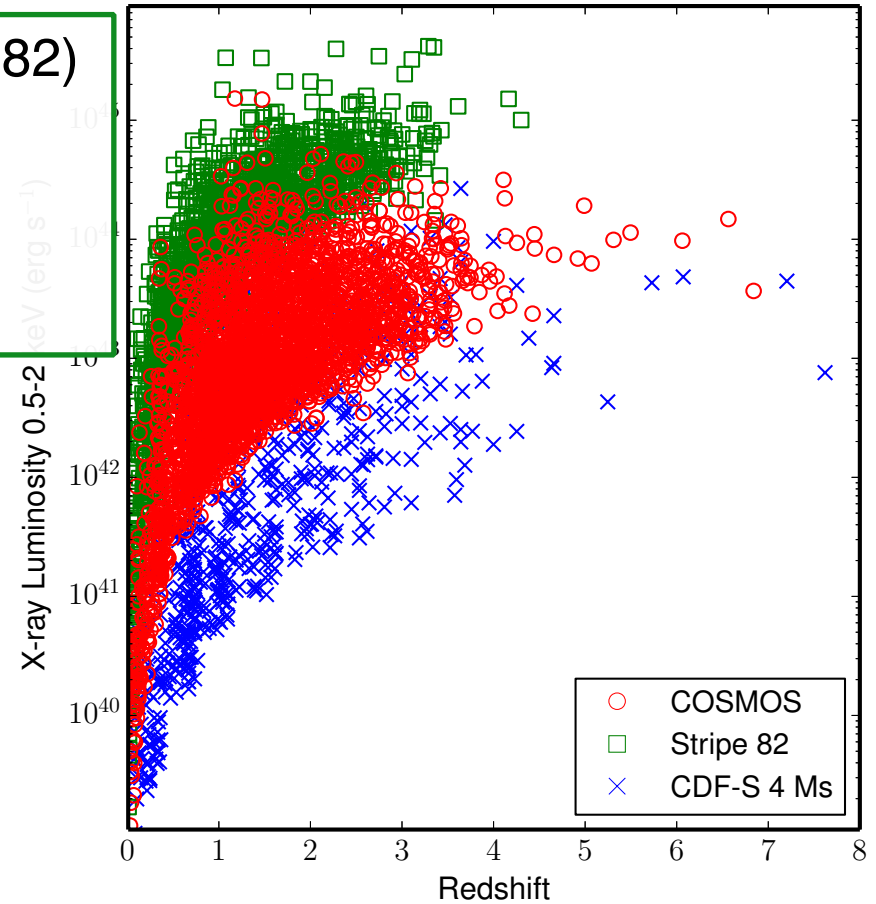
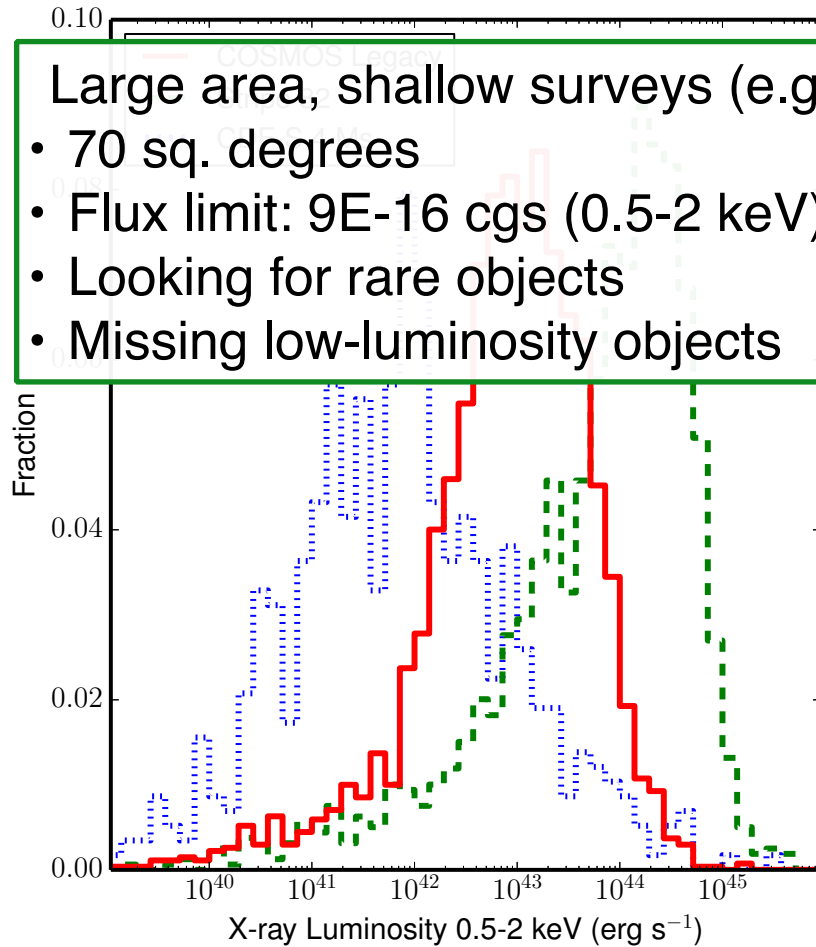
Different surveys for different science



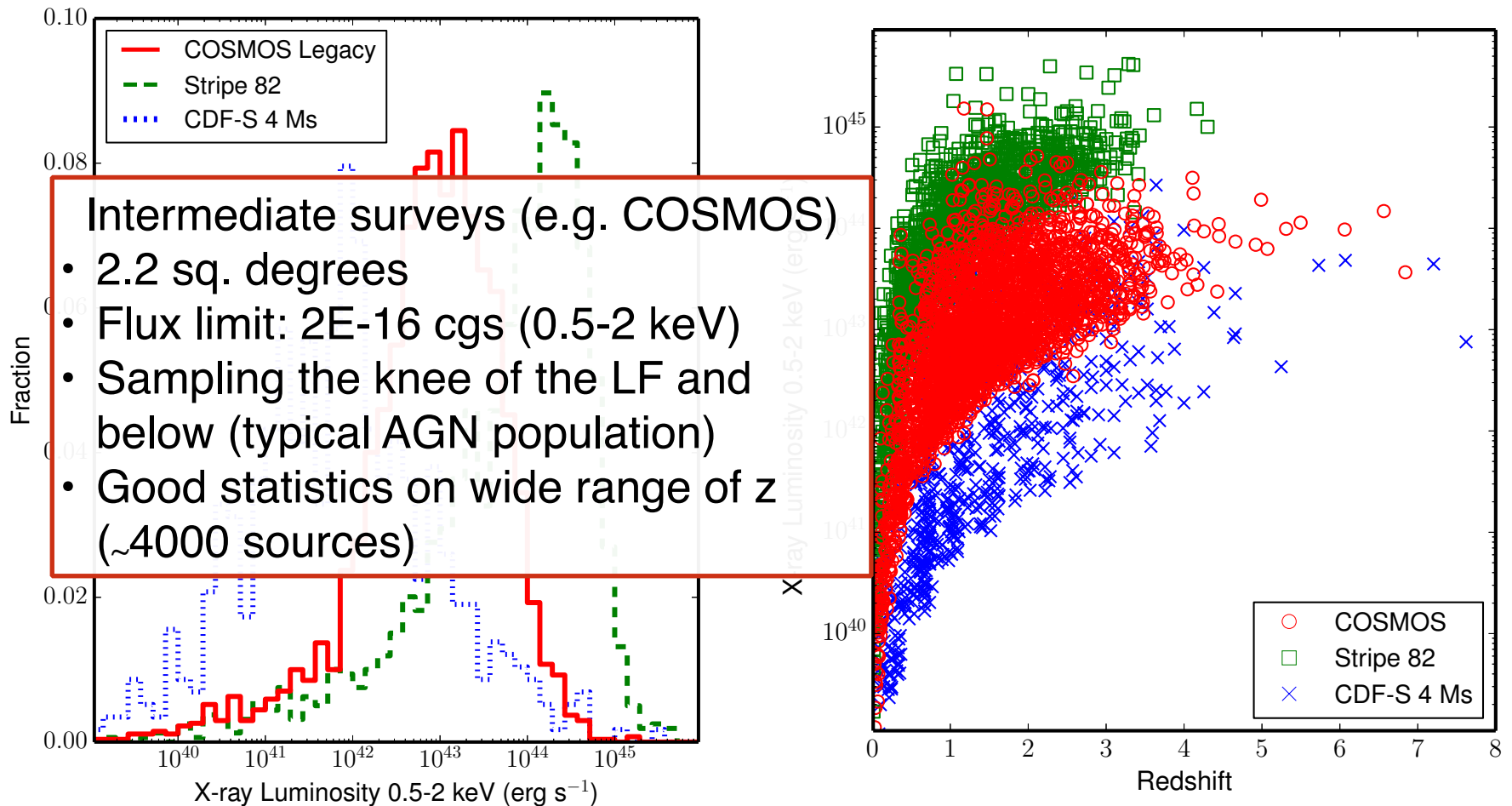
Different surveys for different science

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

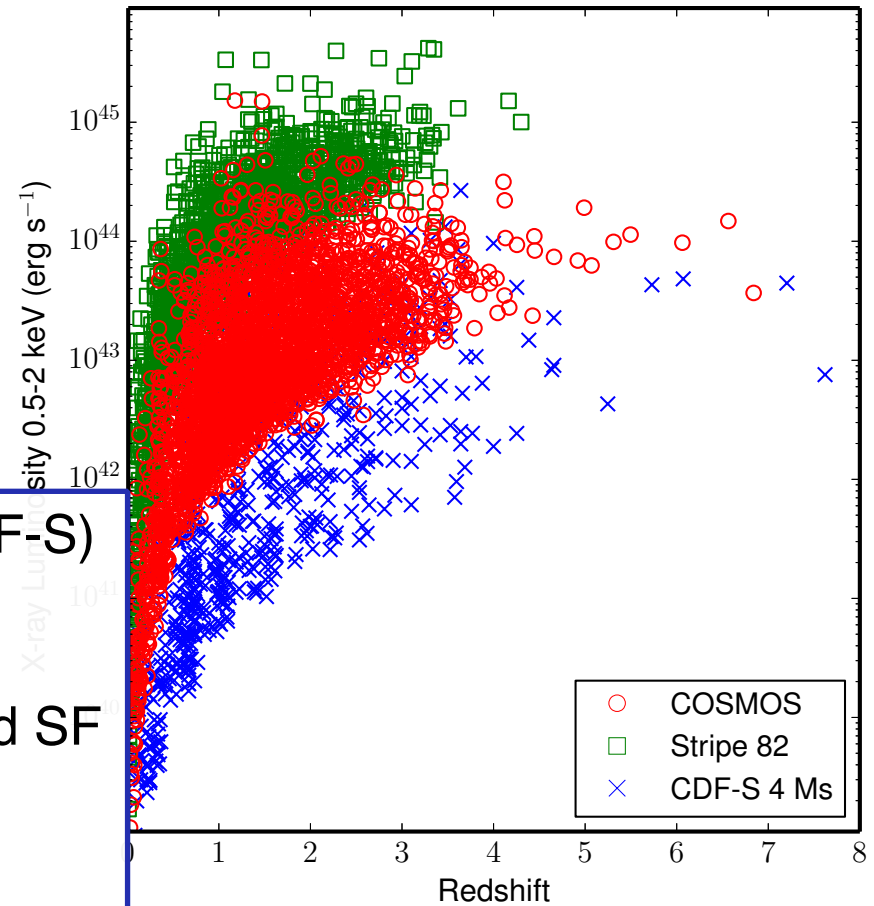
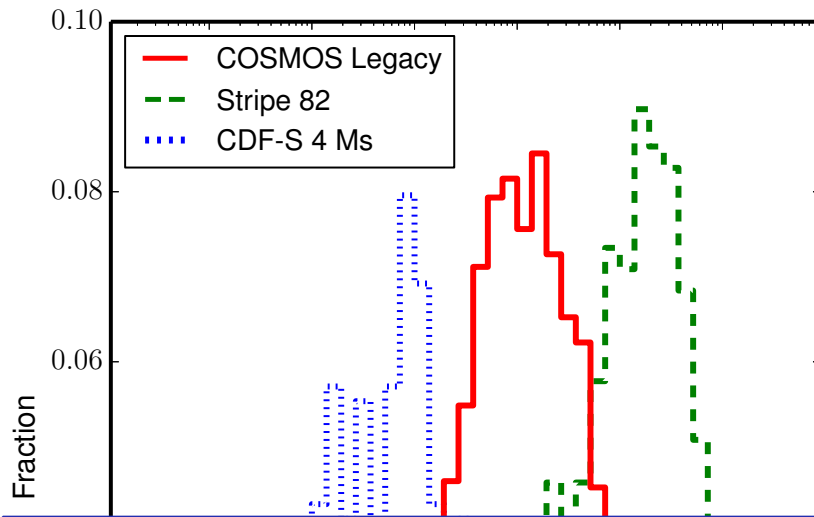
- 70 sq. degrees
- Flux limit: $9E-16$ cgs (0.5-2 keV)
- Looking for rare objects
- Missing low-luminosity objects



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)

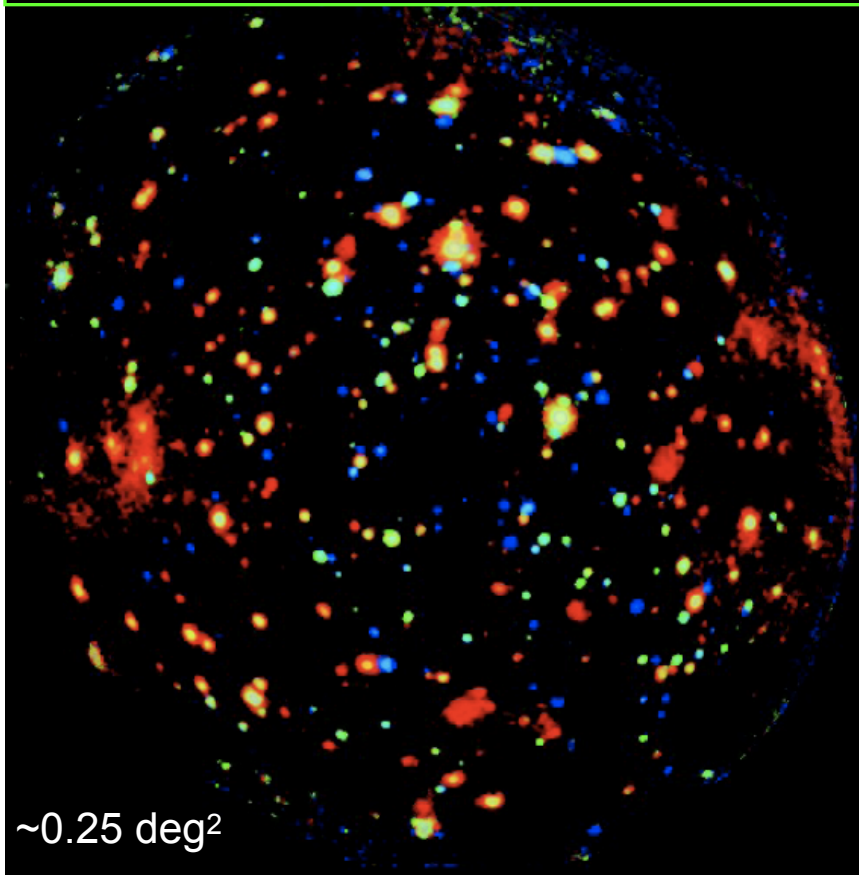
Chandra: good on-axis PSF (i.e., excellent angular resolution) and low background

→ Sensitive to faint and distant AGN

XMM-Newton: larger effective area (hence photon statistics), but much worse angular resolution and higher background

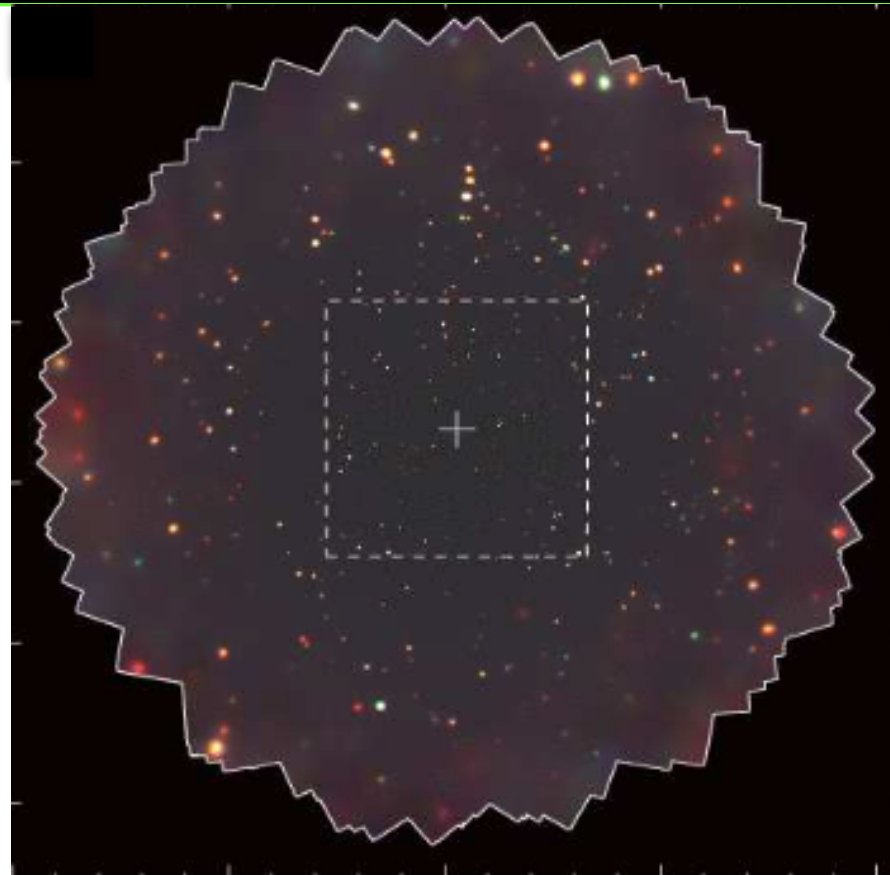
→ Better for X-ray spectroscopy of relatively bright AGN

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:** Produce a mosaic using 4 long CDFS exposures and provide source detections with different setups. Visualize 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

- a. Reprocess with `chandra_repro` four different Chandra observations of the CDF-S. Generate all data products (event files, exposure maps...) that are needed to perform a source detection using the `merge_obs` tool.

Lab Outline

1) Build the source catalog

- a. Reprocess with `chandra_repro` four different Chandra observations of the CDF-S. Generate all data products (event files, exposure maps...) that are needed to perform a source detection using the `merge_obs` tool.

```
punlearn merge_obs
pset merge_obs infile=@infile.lis
pset merge_obs outroot=CDFS_4obs
pset merge_obs asolfiles=@asol.lis
pset merge_obs badpixfiles=@bpix.lis
pset merge_obs maskfiles=@mask.lis
pset merge_obs parallel=yes
pset merge_obs nproc=4
pset merge_obs units=time
pset merge_obs bands=broad
pset merge_obs xygrid=0.5:8192.5:1,0.5:8192.5:1
pset merge_obs psfecf=0.9
pset merge_obs psfmerge=exptime
merge_obs
```

Lab Outline

1) Build the source catalog

- a. Download and combine four different Chandra observations of the CDF-S. Generate all data products (event files, exposure maps...) that are needed to perform a source detection using the `merge_obs` tool.

Lab Outline

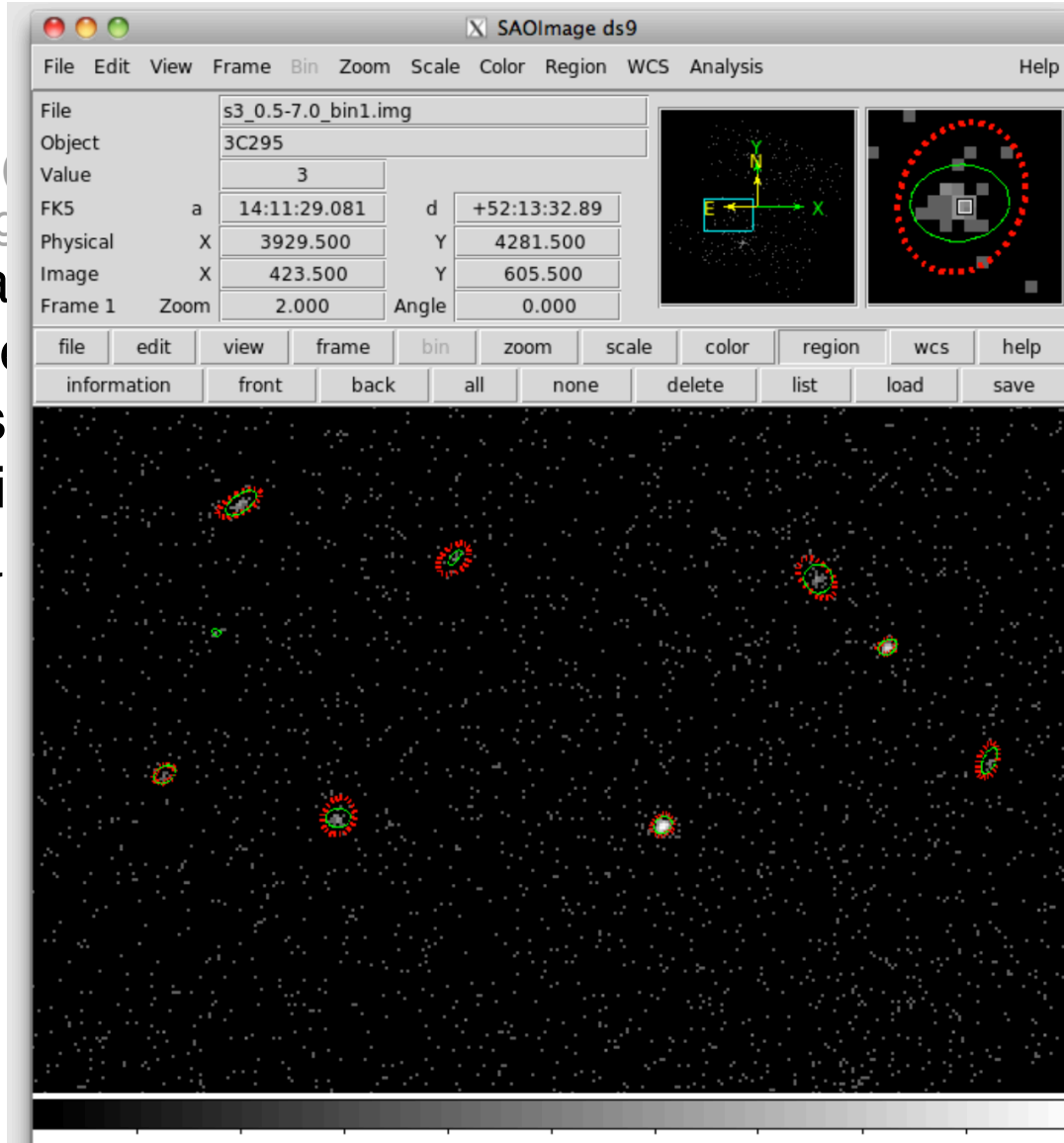
1) Build the source catalog

- a. Download and combine four different Chandra observations of the CDF-S. Generate all data products (event files, exposure maps...) that are needed to perform a source detection using the `merge_obs` tool.
- b. 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).

Lab Outline

1) Build the source catalog

- a. Download and process data products (using detection using
- b. Run the wavelet transform using different scales (important in external pa



DF-S. Generate all
orm a source

ervations,
ctions can be
scales
cts in the

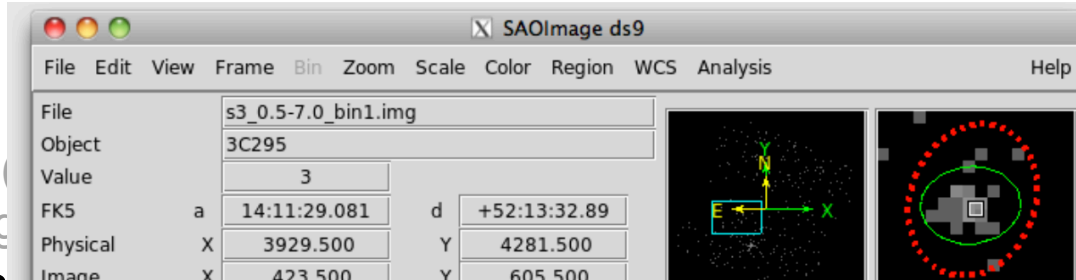
Lab Outline

1) Build the source catalog

a. Download and
data products (e.g.,
detection using

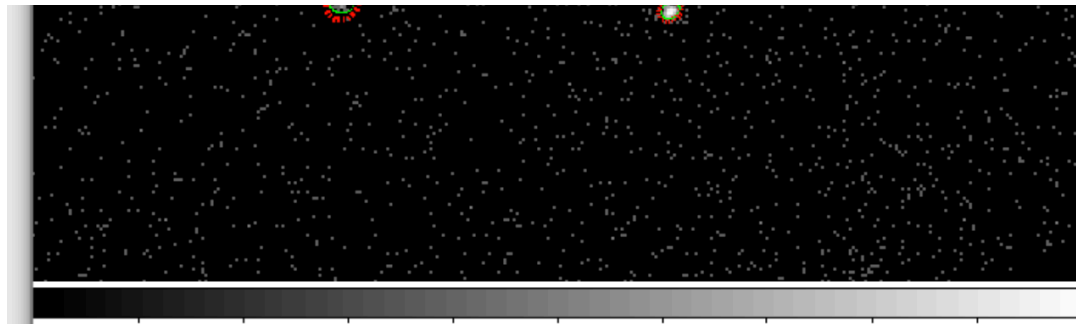
b. Run the wavelet

```
python learn_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 defnbgfile=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
```



DF-S. Generate all
form a source

equations



Lab Outline

1) Build the source catalog

- a. Download and combine four different Chandra observations of the CDF-S. Generate all data products (event files, exposure maps...) that are needed to perform a source detection using the `merge_obs` tool.
- b. 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)
- c. 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 ($1E-6/1E-5/1E-4$)/scales (5.6/8/11)/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 visualize them: what are the possible explanations for their detection in the your shorter-exposure mosaic?

Lab Outline

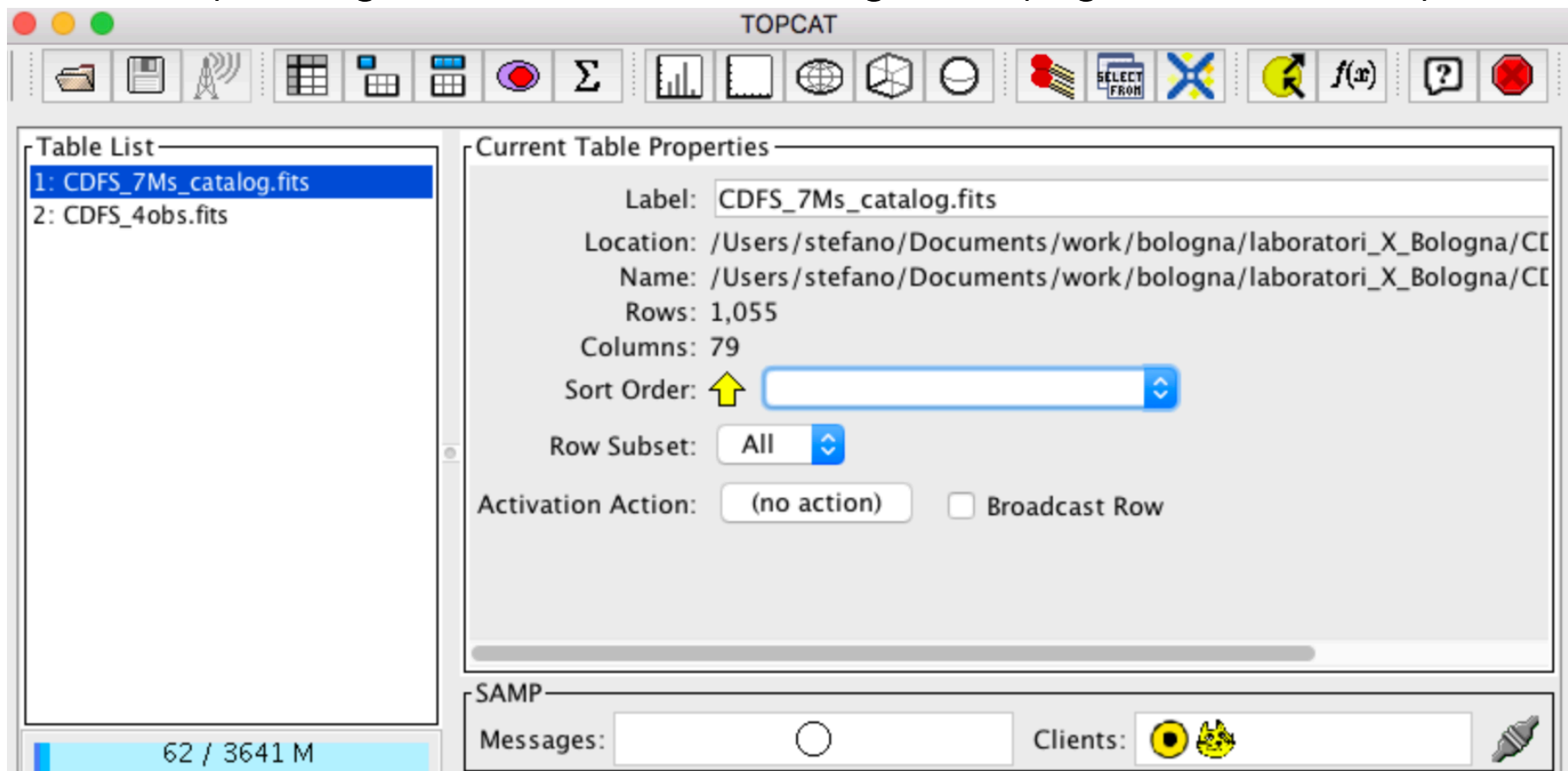
1) Build the source catalog

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)



The screenshot displays 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:

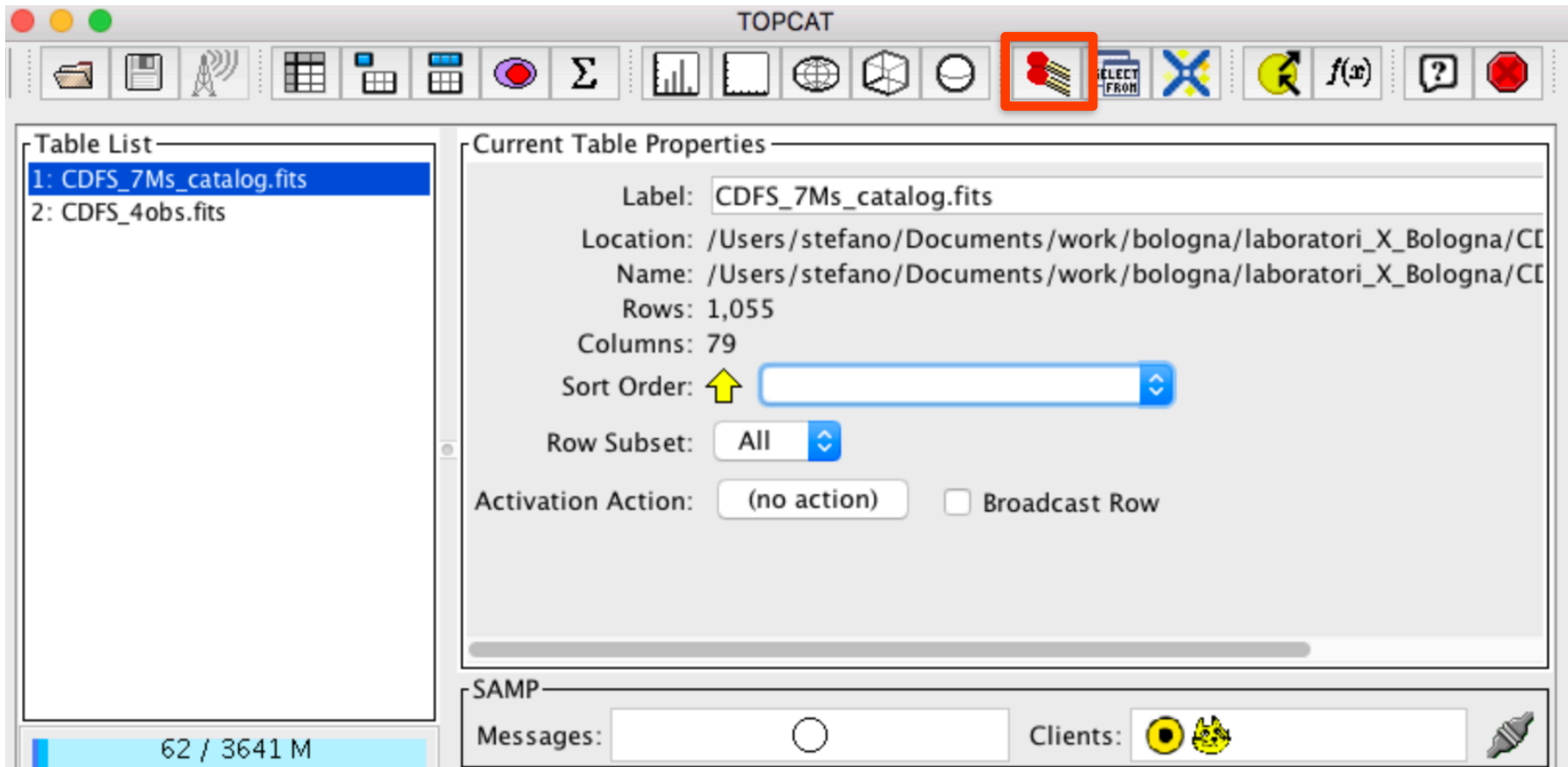
- Table List:** Shows a list of tables. The first table, "1: CDFFS_7Ms_catalog.fits", is selected and highlighted in blue. The second table is "2: CDFFS_4obs.fits".
- Current Table Properties:** Displays the following information for the selected table:
 - Label: CDFFS_7Ms_catalog.fits
 - Location: /Users/stefano/Documents/work/bologna/laboratori_X_Bologna/CF
 - Name: /Users/stefano/Documents/work/bologna/laboratori_X_Bologna/CF
 - Rows: 1,055
 - Columns: 79
 - Sort Order: A dropdown menu with an upward-pointing 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.

At the bottom of the window, there is a status bar showing "62 / 3641 M" and a "SAMP" section with "Messages:" and "Clients:" fields.



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)



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:** 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: 
 - 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
al. 2017), using v

alog

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

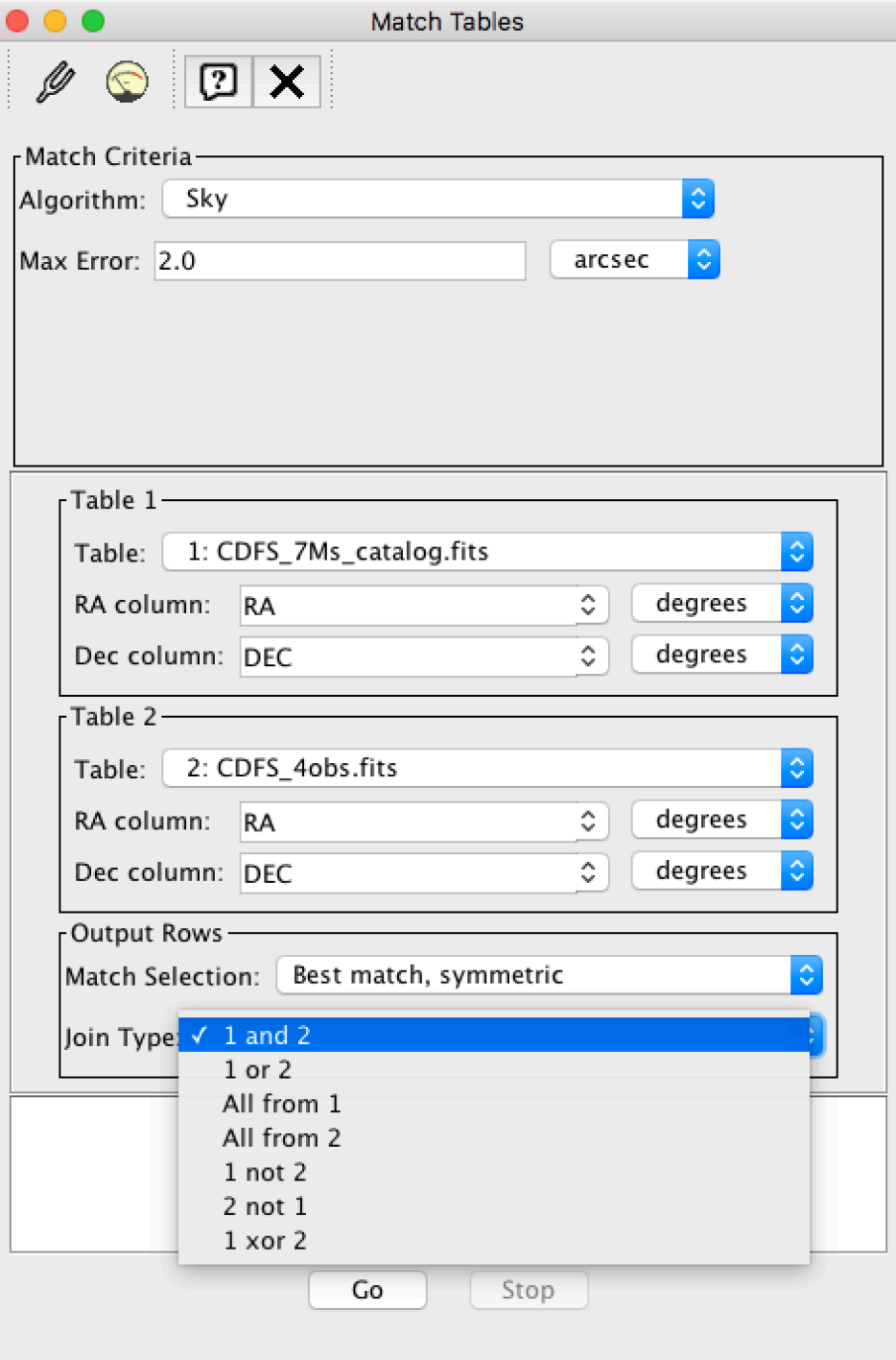
62 / 3641 M

logna/laboratori_X_Bologna/CF

logna/laboratori_X_Bologna/CF

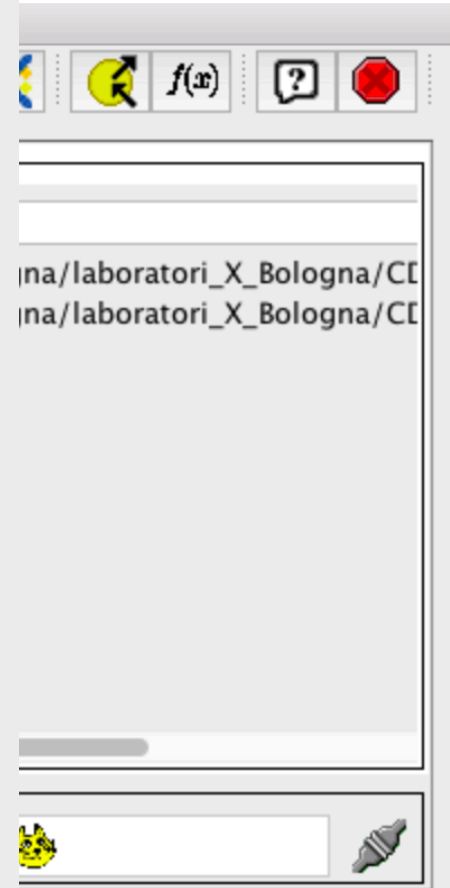
1) E

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



log

vious steps
CDF-S (Luo et al. 2017), using
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

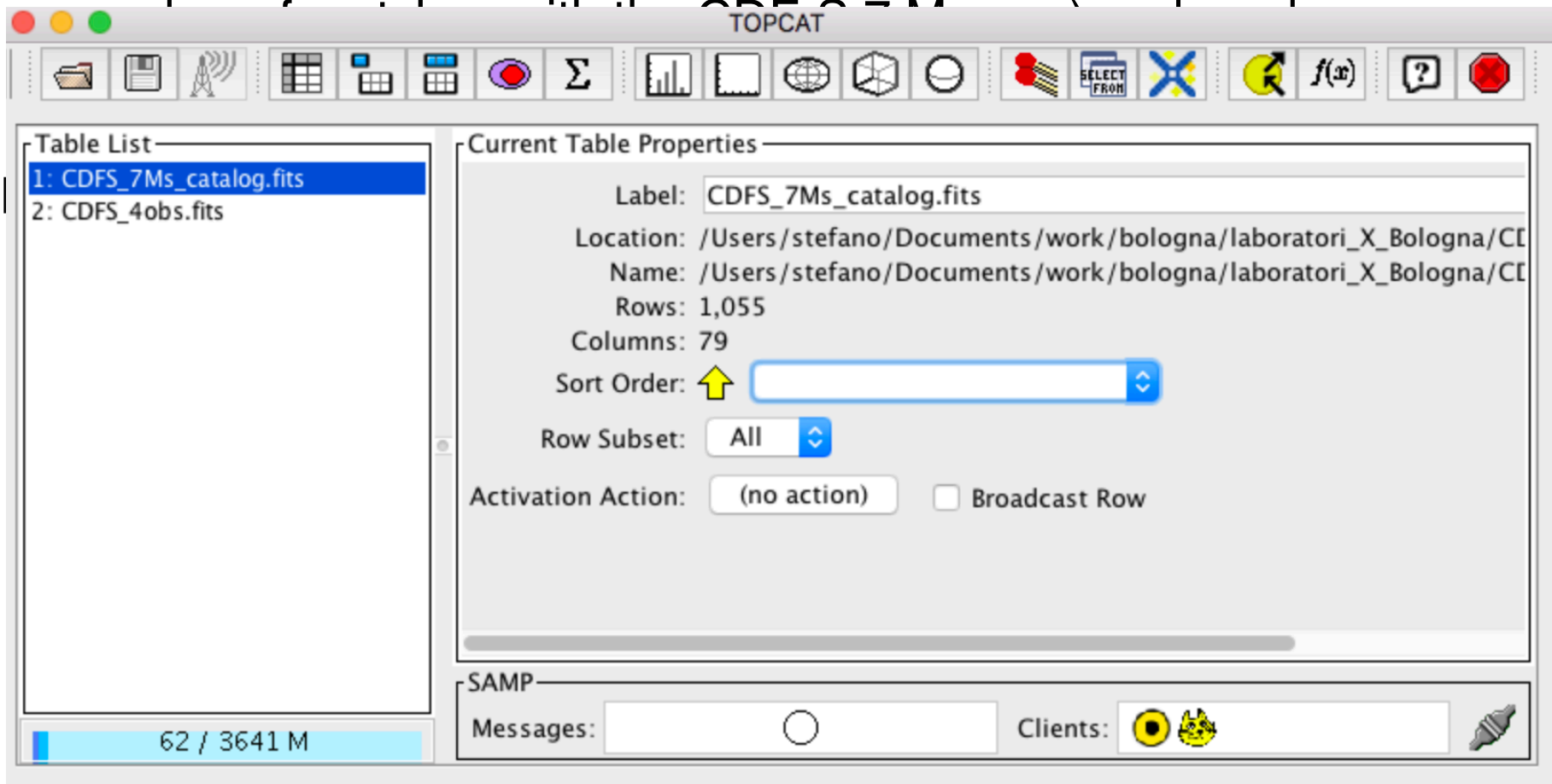
2) Explore the source catalog

- 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



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

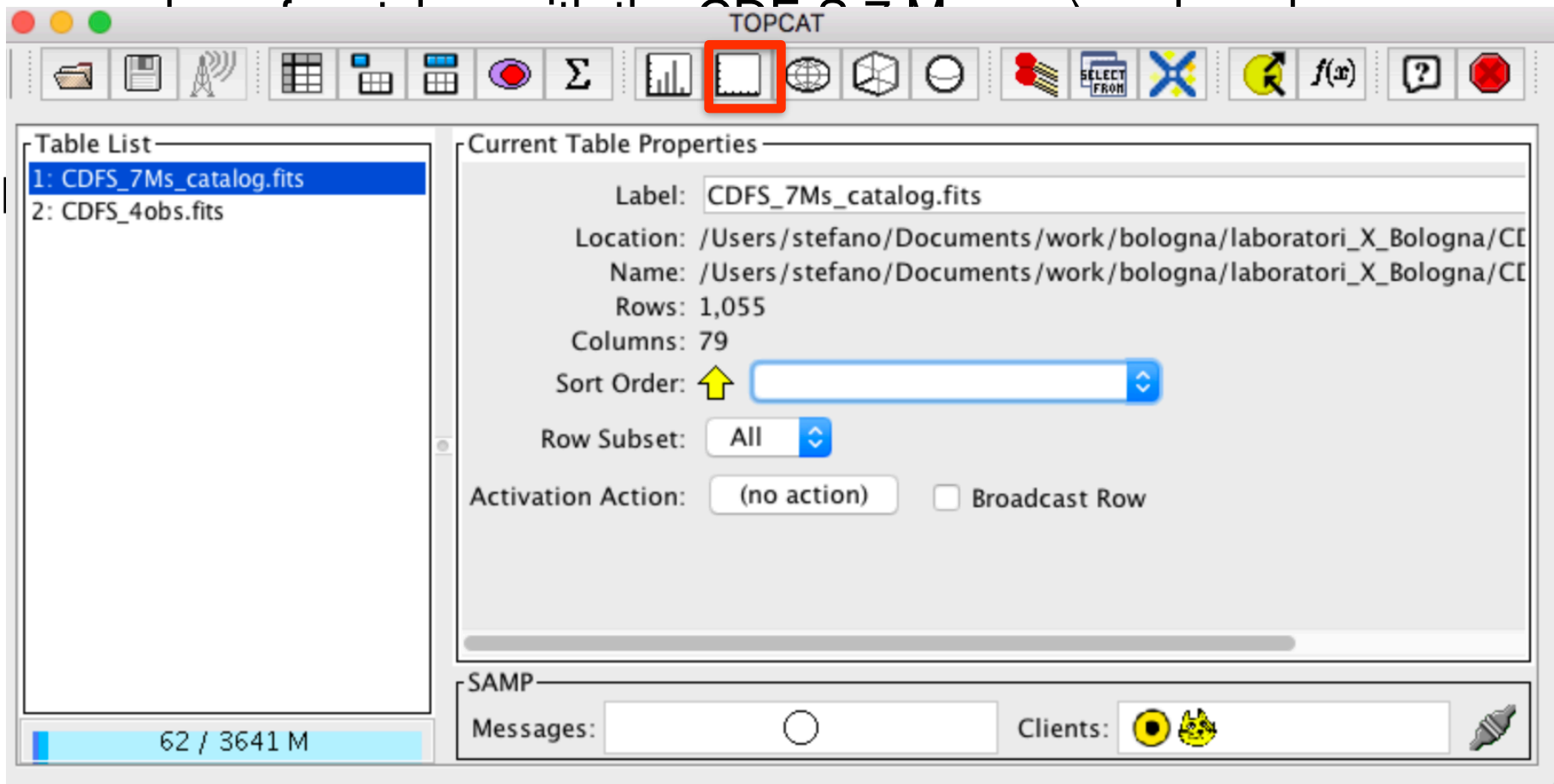
- Table List:** A list of tables with "1: CDFS_7Ms_catalog.fits" selected.
- Current Table Properties:** A panel showing details for the selected table:
 - Label: CDFS_7Ms_catalog.fits
 - Location: /Users/stefano/Documents/work/bologna/laboratori_X_Bologna/CF
 - Name: /Users/stefano/Documents/work/bologna/laboratori_X_Bologna/CF
 - 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".
- SAMP:** A section at the bottom showing "Messages:" and "Clients:" with icons for a yellow circle and a yellow cat.
- 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 manipulation, and visualization.

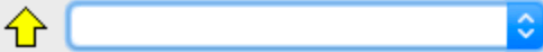

Lab Outline



2) Explore the source catalog

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



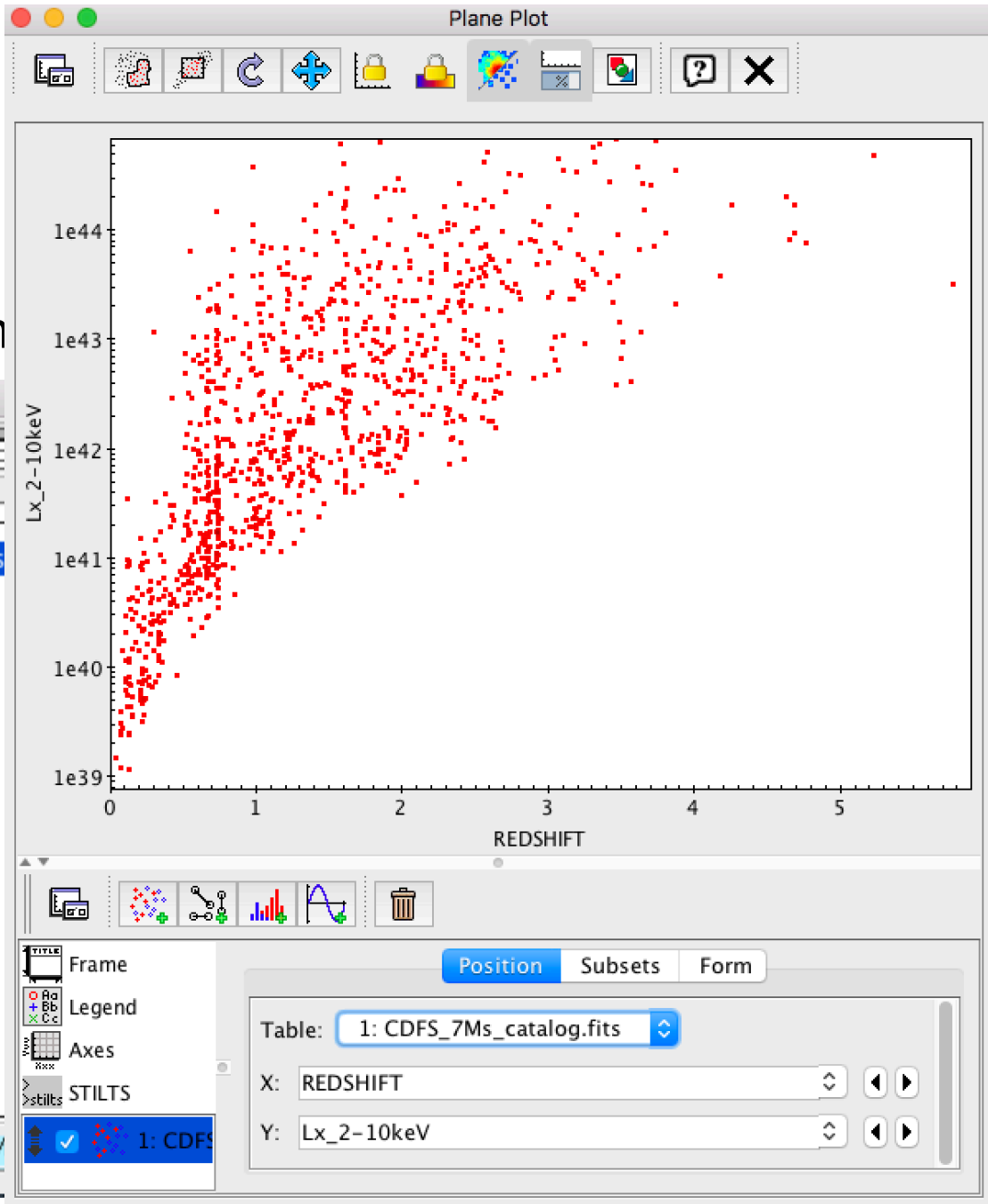
The screenshot shows the TOPCAT software interface. The title bar reads "TOPCAT". The toolbar contains various icons, with a red box highlighting the "Table List" icon. The "Table List" panel on the left shows two tables: "1: CDFS_7Ms_catalog.fits" (selected) and "2: CDFS_4obs.fits". The "Current Table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

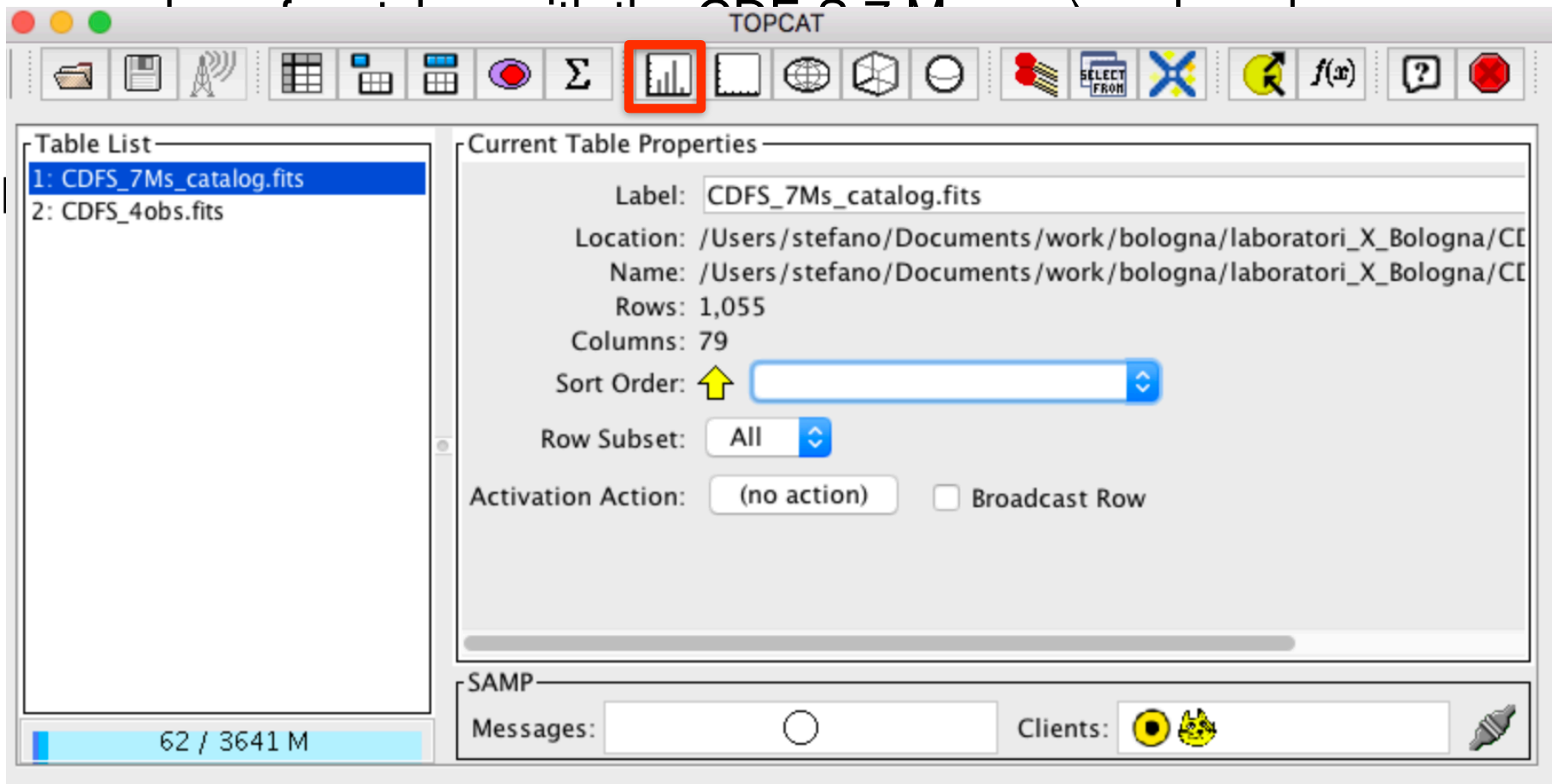
The "Table List" window displays a list of files. The first file, "1: CDFS_7Ms_catalog.fits", is highlighted in blue. Below it is "2: CDFS_4obs.fits". At the bottom of the window, a status bar shows "62 / 3641 M".

The control panel window features a toolbar with a function icon labeled "f(x)", a help icon, and a red stop icon. Below the toolbar, there is a text area containing the text "boratori_X_Bologna/CC" and "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



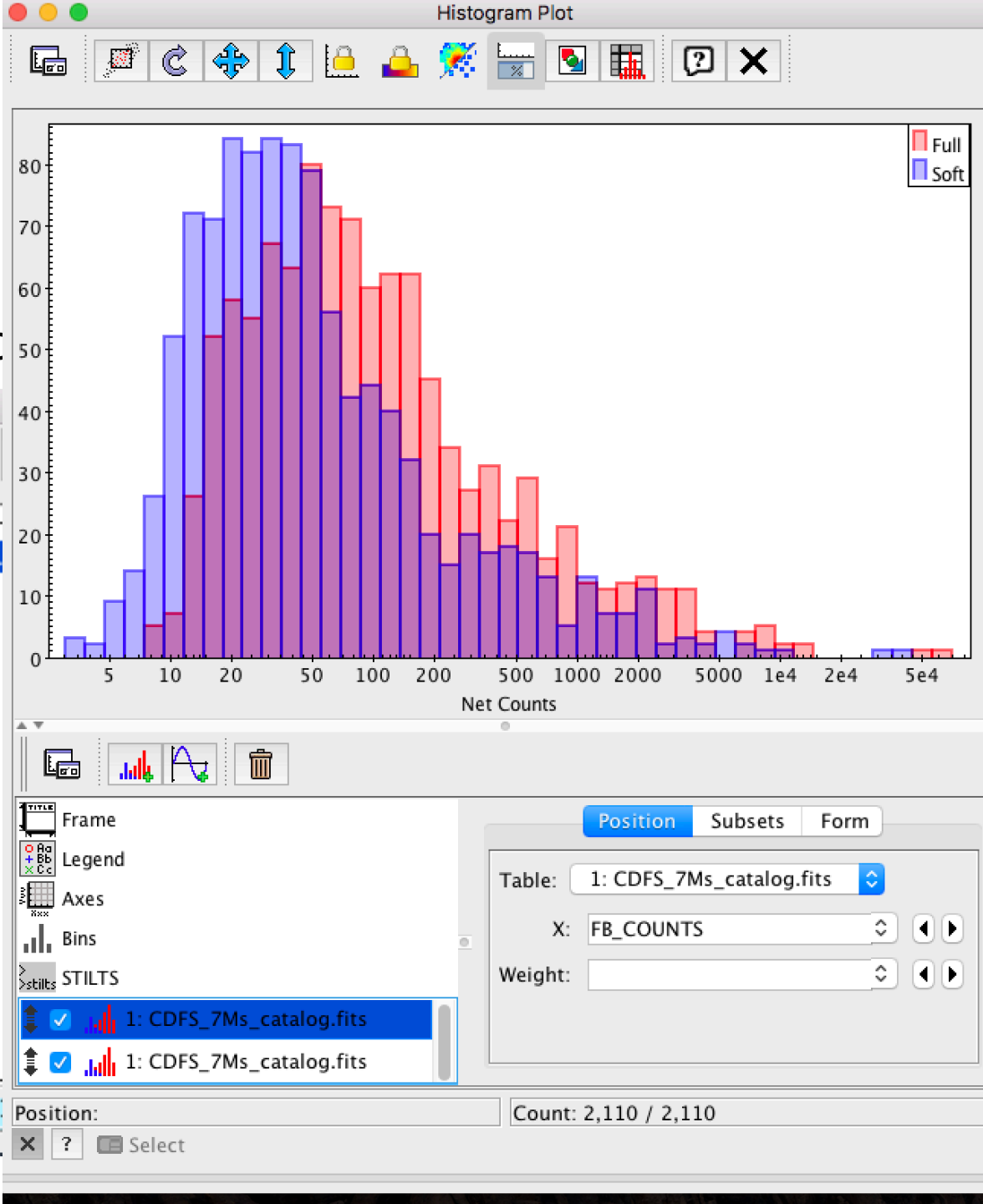
The screenshot shows the TOPCAT software interface. The title bar reads "TOPCAT". The toolbar contains various icons, with a bar chart icon highlighted by a red box. The "Table List" panel on the left shows two tables: "1: CDFS_7Ms_catalog.fits" (selected) and "2: CDFS_4obs.fits". The "Current Table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



og

largest

$f(x)$?

atori_X_Bologna/CC

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, 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: 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

At the bottom, the 'SAMP' section shows 'Messages: [input field]' and 'Clients: [radio buttons]'. A status bar at the bottom left indicates '62 / 3641 M'. The text 'VS' is written to the right of the interface.

Lab Outline

2) Explore the source catalog

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

TOPCAT

TOPCAT(5): Row Subsets

Table List—
1: CDFS_7Ms
2: CDFS_4obs

Row Subsets for 5: CDFS_7Ms_catalog.fits

ID	Name	Size	Fraction
_1	All	1055	100%

SAMP—
Messages: [input field] Clients: [radio buttons]

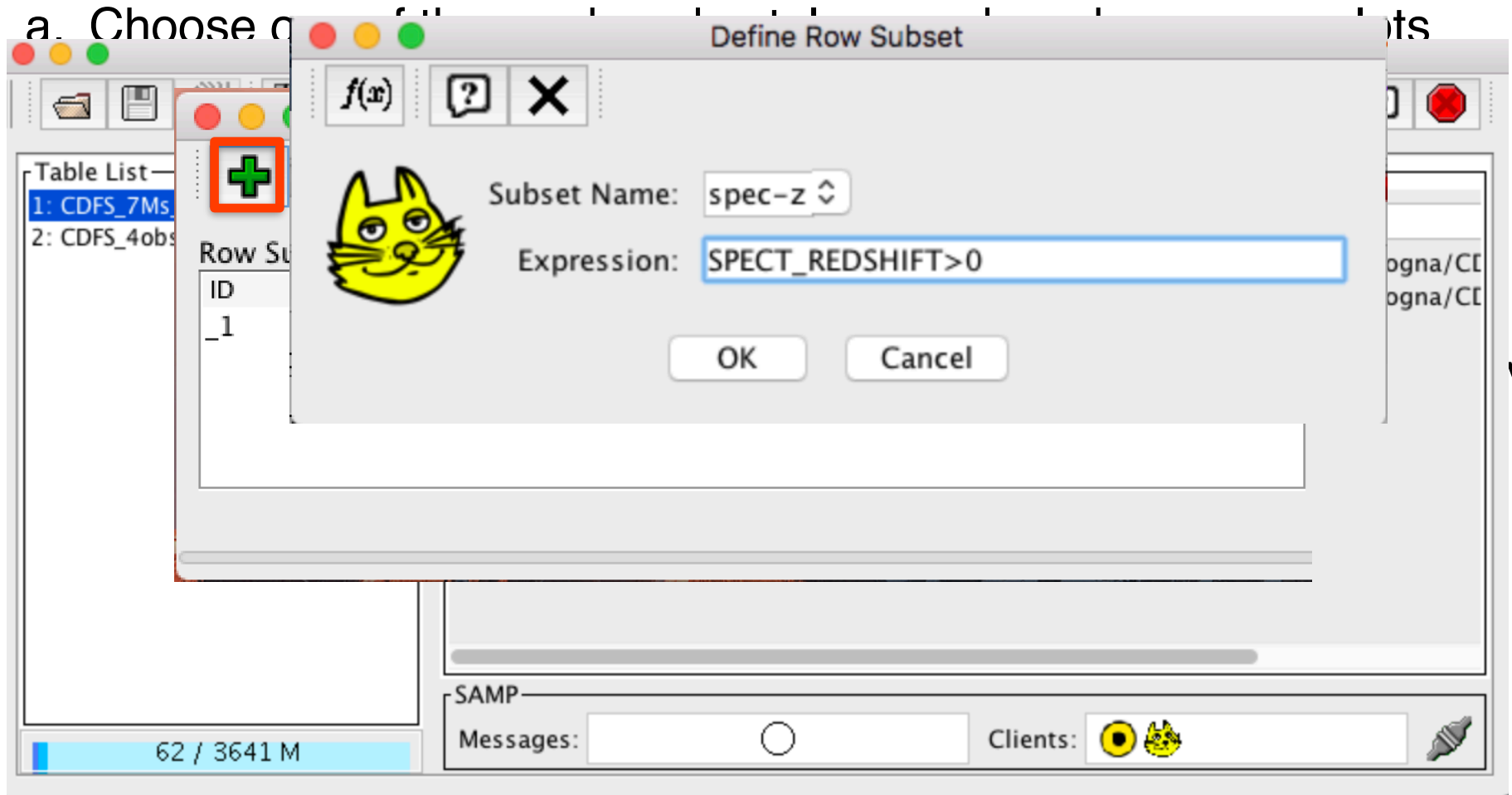
62 / 3641 M

VS

Lab Outline

2) Explore the source catalog

a. Choose a...



The screenshot shows a software interface with a 'Define Row Subset' dialog box. The dialog box has 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]'. The text 'VS' is visible on the right side of the image.

Table List

- 1: CDFS_7Ms
- 2: CDFS_4obs

Row Su

ID

_1

Define Row Subset

$f(x)$? X

Subset Name: spec-z

Expression: SPECT_REDSHIFT>0

OK Cancel

SAMP

Messages: [] Clients: [yellow circle] [yellow cat icon]

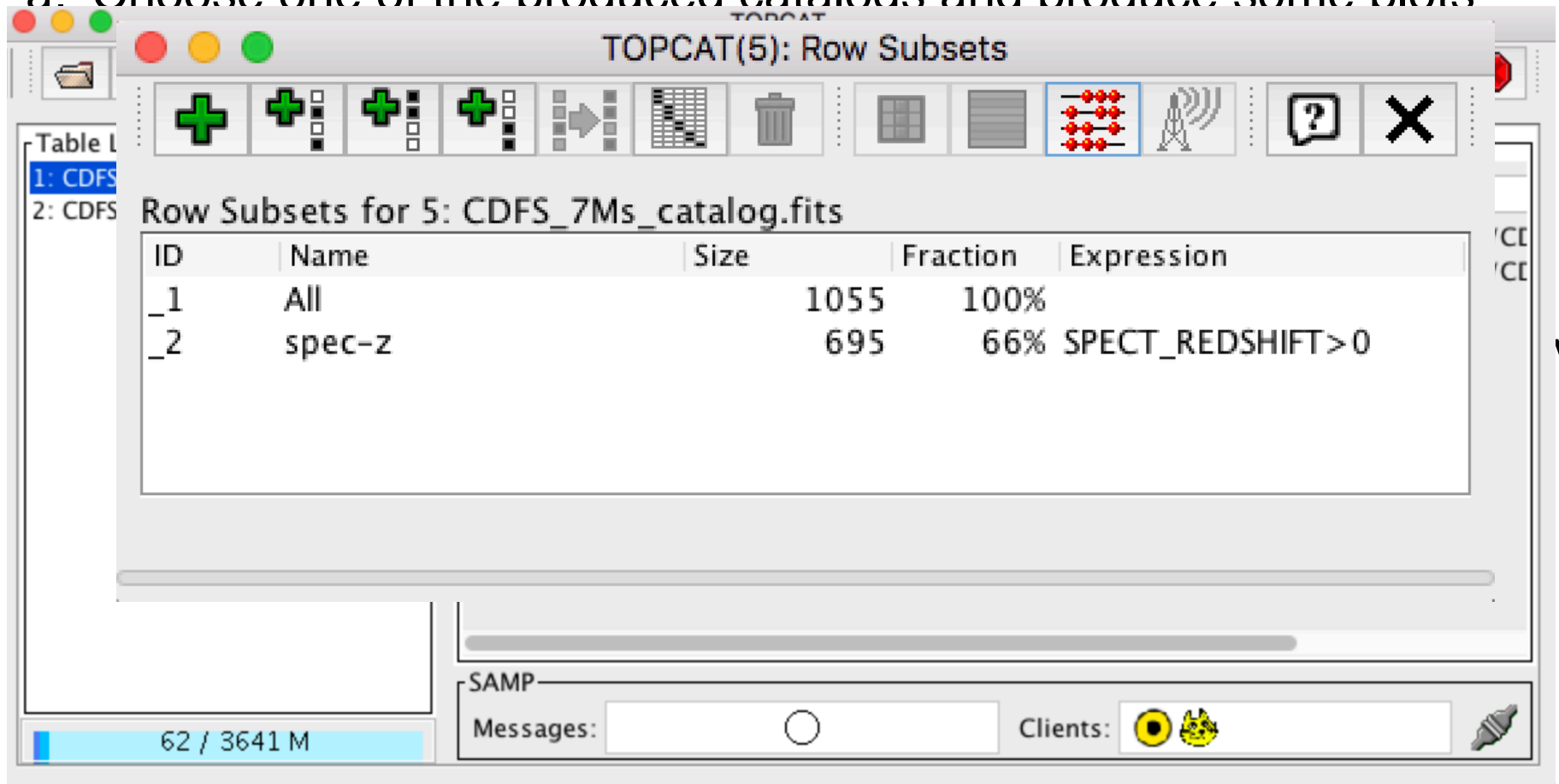
62 / 3641 M

VS

Lab Outline

2) Explore the source catalog

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



The screenshot shows the TOPCAT(5) Row Subsets window. The title bar reads "TOPCAT(5): Row Subsets". The main area displays "Row Subsets for 5: CDFS_7Ms_catalog.fits" with a table of subsets. The table has columns for ID, Name, Size, Fraction, and Expression. Two subsets are listed: "_1" (All, Size 1055, Fraction 100%) and "_2" (spec-z, Size 695, Fraction 66%, Expression SPECT_REDSHIFT>0). The interface includes a toolbar with various icons for adding, deleting, and plotting. At the bottom, there is a status bar showing "62 / 3641 M" and a "Messages" section with a "Clients" area containing two icons.

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

VS

Lab Outline

2) Explore the source catalog

a. Choose

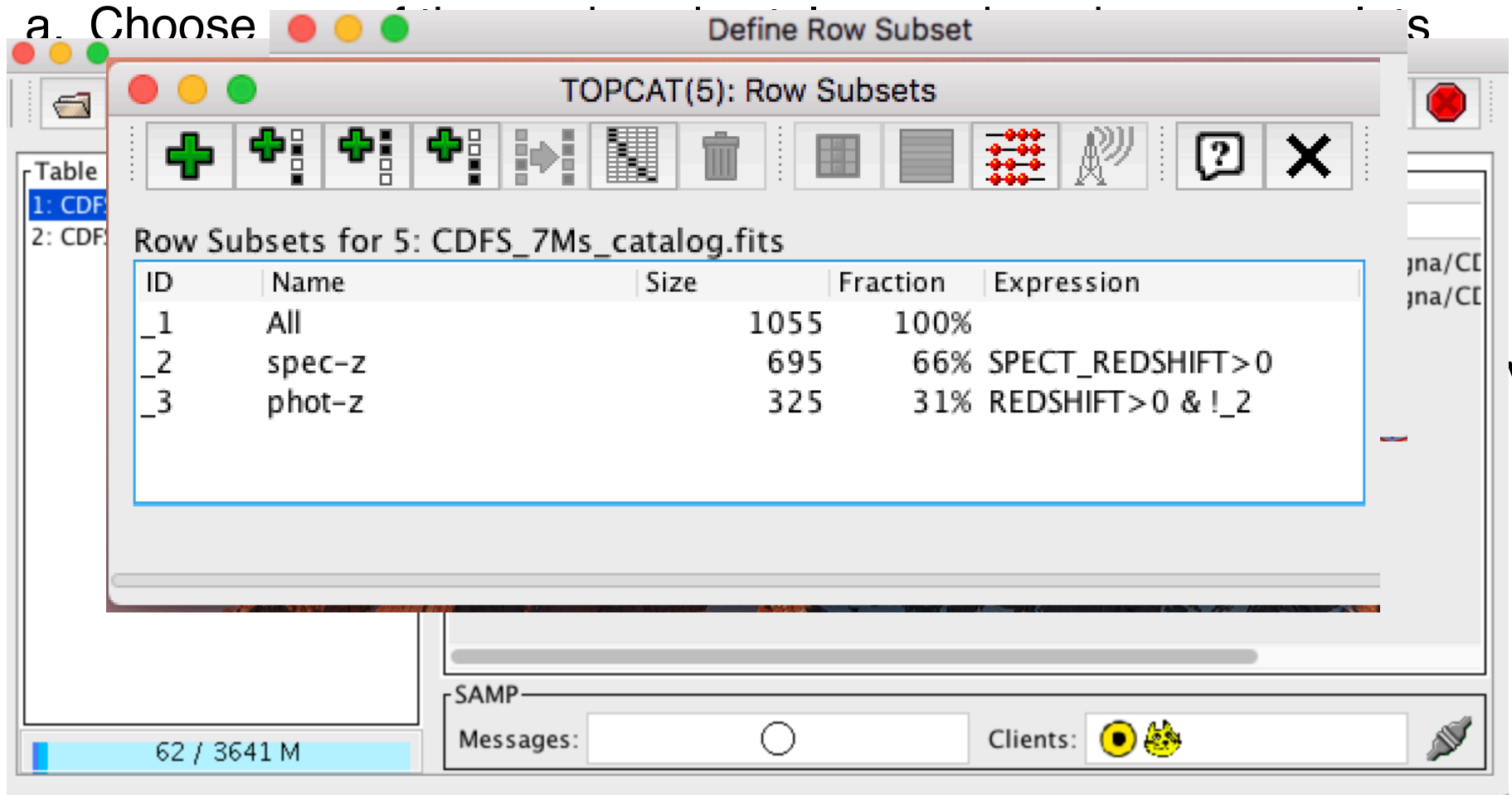
The screenshot displays a software interface with a 'Define Row Subset' dialog box in the foreground. The dialog box features a yellow cat icon on the left, a 'Subset Name' field containing 'phot-z', and an 'Expression' field containing 'REDSHIFT>0 & !_2'. Below the fields are 'OK' and 'Cancel' buttons.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

VS

Lab Outline

2) Explore the source catalog

a. Choose



The screenshot shows the TOPCAT software interface. A window titled "TOPCAT(5): Row Subsets" is open, displaying a table of row subsets for the file "CDFFS_7Ms_catalog.fits". The table has five columns: ID, Name, Size, Fraction, and Expression. The data is as follows:

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

Below the table, there is a status bar showing "SAMP" and "Messages: [] Clients: []". The bottom left corner of the window displays "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.

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:

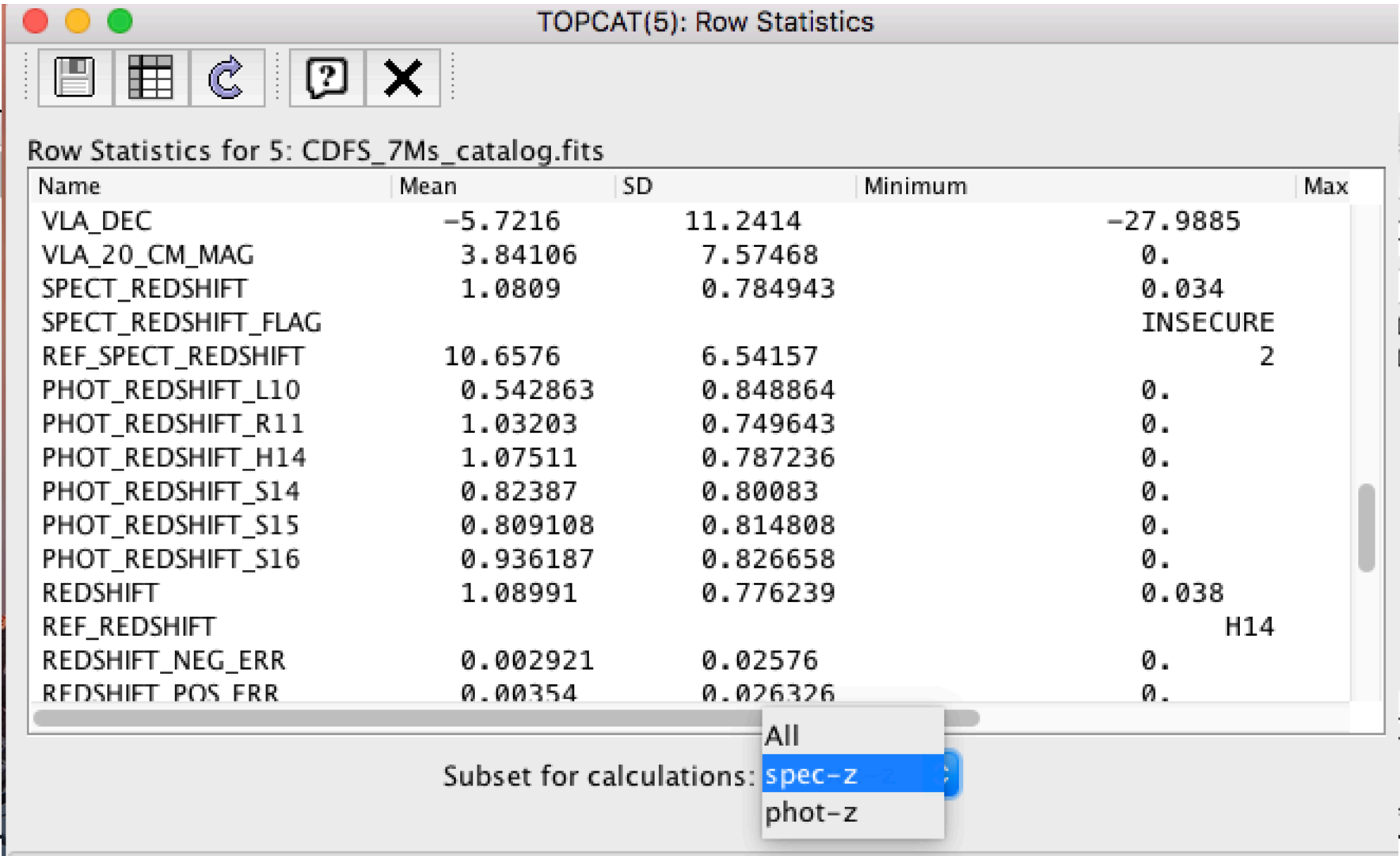
62 / 3641 M

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. 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.

Lab Outline

2) Explore the source catalog

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

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

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

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
------------------------------	---	--------------------------	--	---	-------------------------------------

CALCULATE CLEAR HELP

PIMMS Prediction:

6.383E-14

erg/cm**²/s absorbed flux

3. Analyse the data products: spectral fitting

Fit *Chandra* spectra for sources 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

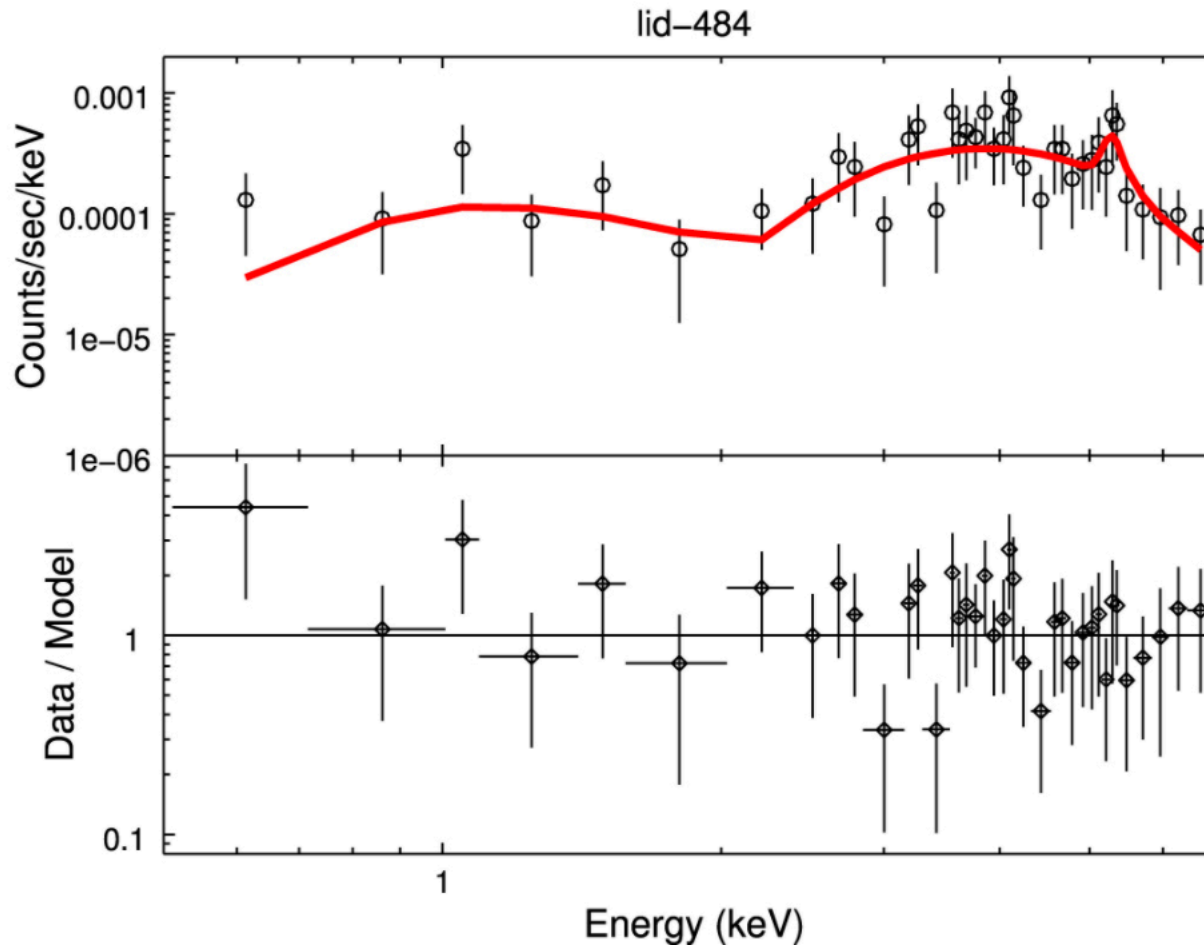
Spectral analysis pipeline

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
5. Once a physically justified model is obtained, save the X-ray spectral parameters (including errors) and produce confidence contours
6. Check for further components (to lower the data/model residuals) – Return to point 3

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.**

Command list: merge_obs

```
punlearn merge_obs
pset merge_obs infile=@infile.lis
pset merge_obs outroot=CDFS_4obs
pset merge_obs asolfiles=@asol.lis
pset merge_obs badpixfiles=@bpix.lis
pset merge_obs maskfiles=@mask.lis
pset merge_obs parallel=yes
pset merge_obs nproc=4
pset merge_obs units=time
pset merge_obs bands=broad
pset merge_obs xygrid=0.5:8192.5:1,0.5:8192.5:1
pset merge_obs psfecf=0.9
pset merge_obs psfmerge=exptime
merge_obs
```

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_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
```