# X-ray spectral analysis of AGN in the *Chandra* Deep Field South (CDF-S) using the 4Ms *Chandra* and the 3Ms XMM-*Newton* data. Analysis of the background in the *Chandra* deep exposure

Lab X – AA2013-14
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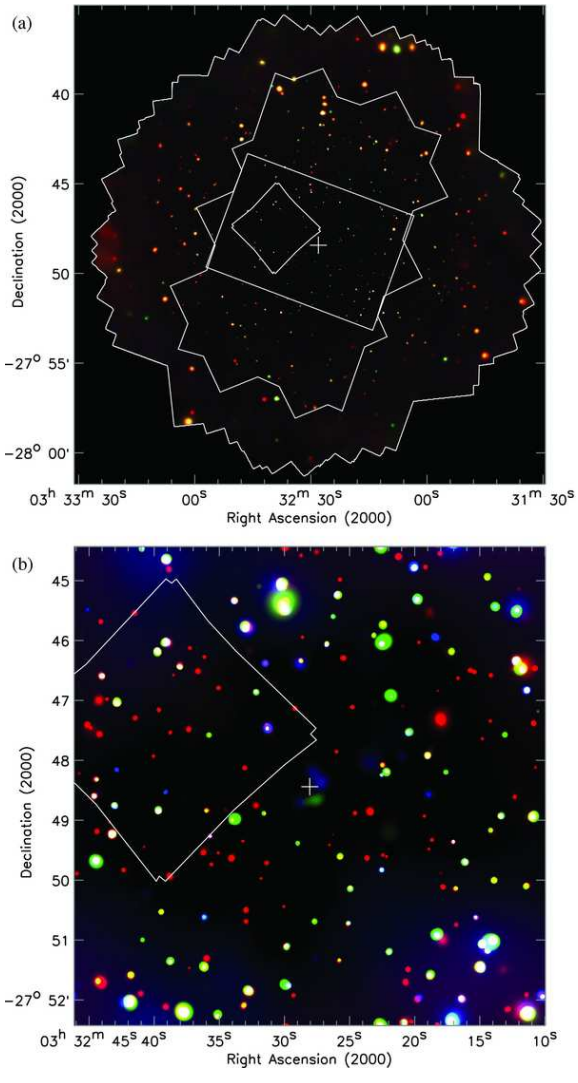
27 Nov 2013

# Outline

# The 4 Ms CDF-S




Xue+11

- Exposure $\sim$ 4 Ms
- Covered Area $\sim$ 464 arcmin$^2$
- 740 X-ray point-like sources (Xue+11)

**Chandra pros:**

1. Excellent angular resolution (FWHM$\sim$0.5 arcsec on-axis)
2. Low background

$\downarrow$

- Sensitive to very faint point-sources
- High signal$-$to$-$noise ratio (SNR)

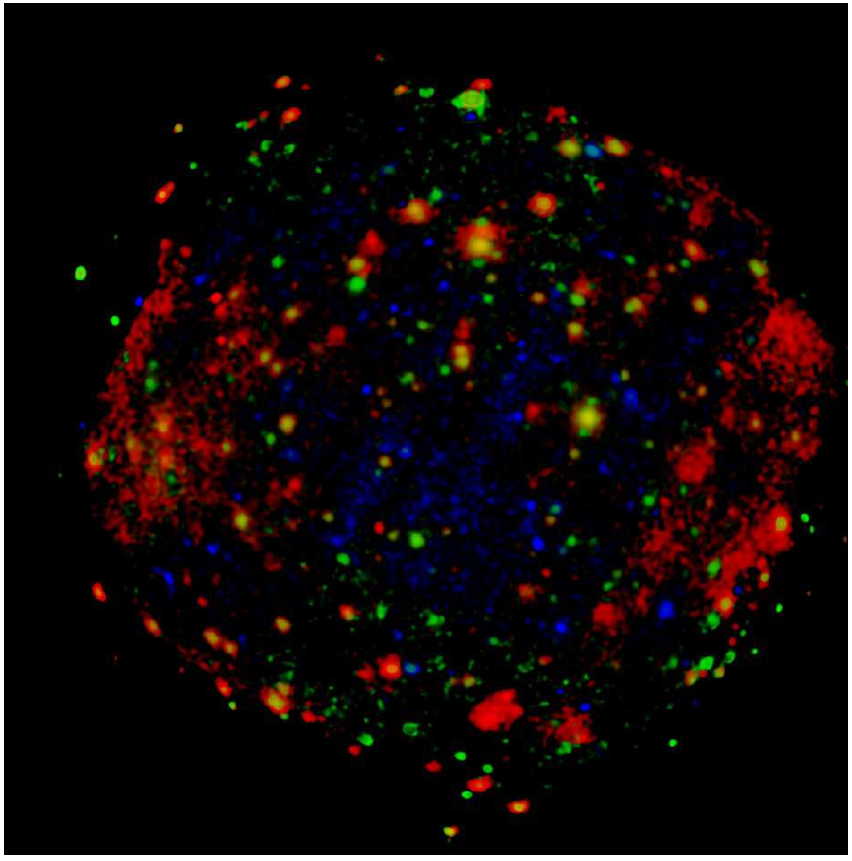
**Chandra cons:**

1. Low effective area wrt XMM-Newton

$\downarrow$

- Lower number of counts

# The XMM Deep Survey in the CDF-S



Ranalli+13

- Exposure $\sim$ 3 Ms (pn, mos1, mos2)
- Area encompasses the 4 Ms CDF-S

**XMM pros:**

1. Large effective area

$\downarrow$

- Large photon-counting statistics (good for "bright" and/or extended sources)

**XMM cons:**

1. Worse spatial resolution than *Chandra*
2. High (and quite complex) background

$\downarrow$

- Very faint sources not detectable (source confusion is a problem)
- Possibly low SNR

# Main goals

1. Fit *Chandra* spectra for two sources (i.e., excluding XID_Xue11=198) and the XMM spectra (all EPIC cameras) for one of these two sources; compare the spectral results

2. Fit the *Chandra* background spectrum using a phenomenological model (and focusing on the emission lines)

# 1. Fit *Chandra* and XMM spectra

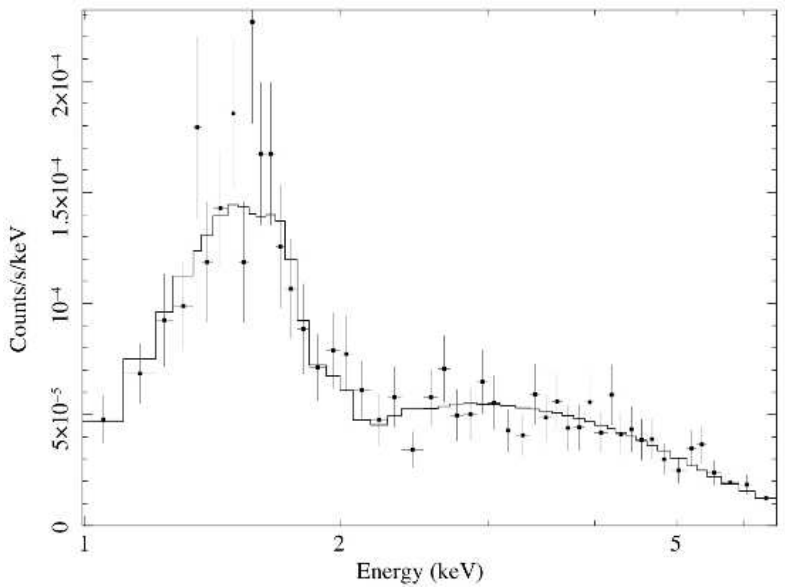
**Fit Chandra spectra for 2/4 sources (i.e., excluding XID_Xue11=198) and the XMM spectra (all EPIC cameras) for one of these two sources; compare the spectral results**

| XID_Xue11 | XID_XMM | Source coordinates | z | Opt. Class + Info |
|---|---|---|---|---|
| 412 | 144 | 03:32:29.86 -27:51:06.1 | 3.700 | NL (Comastri+11) |
| 546 | 180 | 03:32:39.68 -27:48:51.1 | 3.064 | NL (Vito+13) |
| 533 | 48 | 03:32:38.93 -27:57:00.9 | 0.298 | NL |
| 193 | 289 | 03:32:13.25 -27:42:41.3 | 0.605 | NL |
| 198 | – | 03:32:13.86 -27:42:49.3 | 0.735 | NL (close to Xue=193) |

Source and bkg spectra, ARF and RMF files provided.

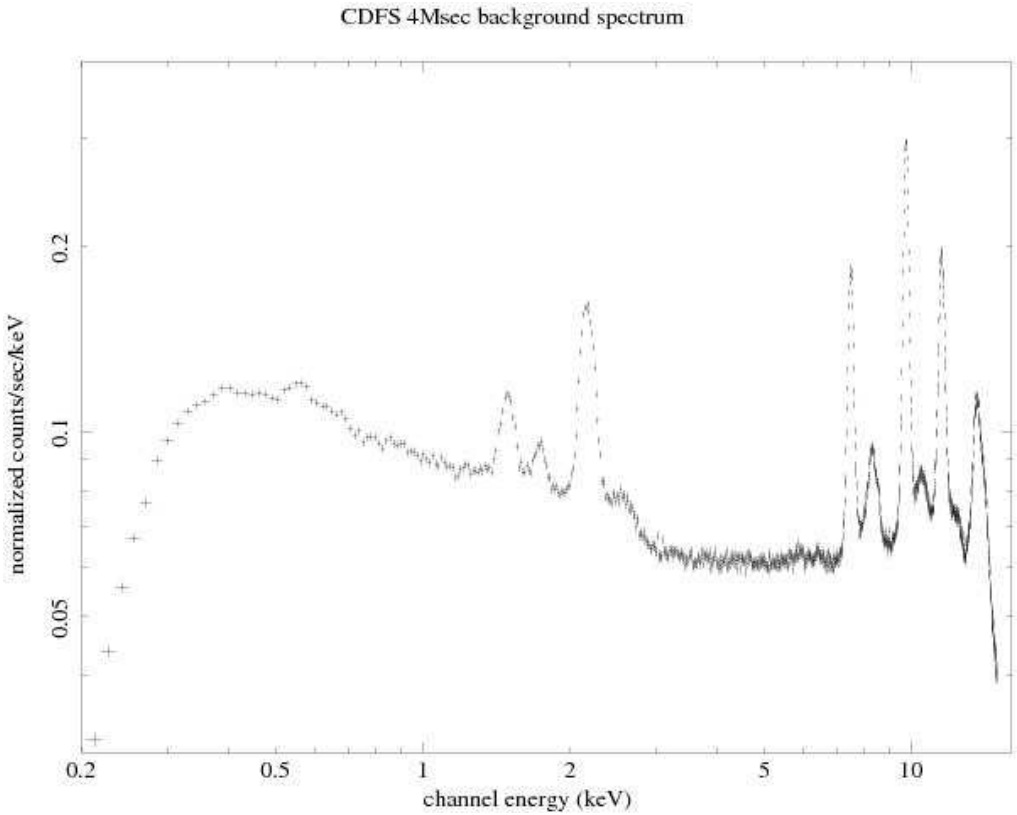
# 1. Fit *Chandra* and XMM spectra

1. Group the spectra (*grppha*; mind the statistics!).
2. Load spectra in XSPEC.
3. Define a spectral model (one or more component if required) and fit.
4. Once a (physically) reasonable fit is obtained, save the spectral parameters (with errors), produce confidence intervals.
5. Possibly try another model (return to point 3).
6. Compare results from *Chandra* and XMM spectra (for one source).



# 2. Fit the *Chandra* background

**2. Fit the Chandra background spectrum using a phenomenological model (and focusing on the emission lines)**




Fiore+12 provides the list of the emission lines
Source and bkg spectra, ARF and RMF files provided.

# 2. Fit the *Chandra* background

Two main components: cosmic bkg (unresolved sources, thermal emission from the local Bubble, etc.), particle-induced bkg (responsible for the fluorescent lines; local effect, *ergo* not vignetted)

Same approach as before.

Fit with a phenomenological model ("what you fit is what you see")

# Optional work(s)

1. Fit some of the remaining Chandra/XMM spectra
2. Verify the X-ray spectral differences between XMM_ID=289 and XID_Xue11=193+198 (effects of source confusion)
3. Extract the spectrum of a *Chandra* source using an approximate method

# 1. Fit the remaining spectra

## 1. Fit some of the remaining Chandra/XMM spectra

| XID_Xue11 | XID_XMM | Source coordinates | z | Opt. Class + Info |
|---|---|---|---|---|
| 412 | 144 | 03:32:29.86 -27:51:06.1 | 3.700 | NL (Comastri+11) |
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| | | | | |
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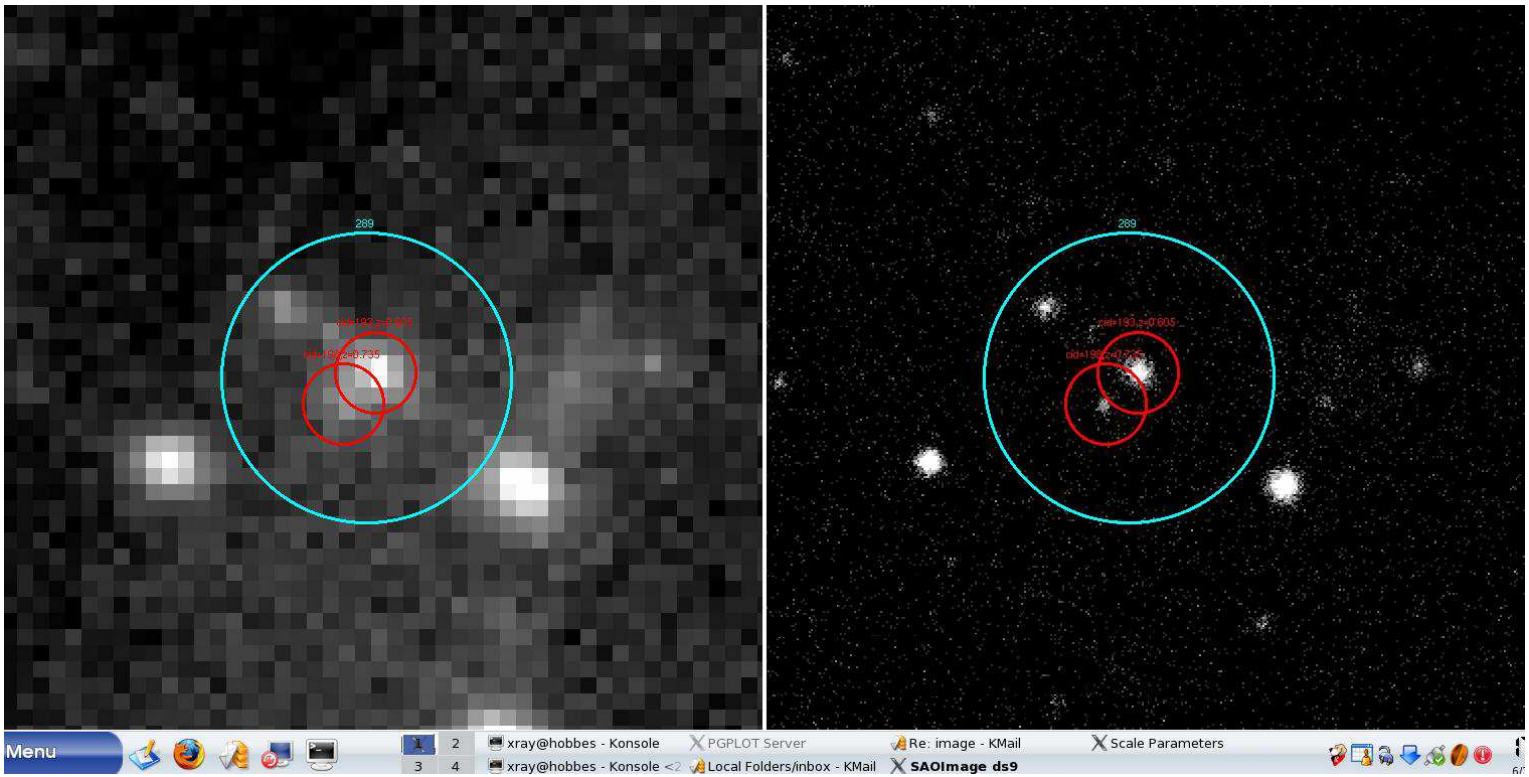
Source and bkg spectra, ARF and RMF files provided.

# 2. XID193 + XID198 = XMM289 ?

**2. Verify the X-ray spectral differences between XMM_ID=289 and XID_Xue11=193+198**




Source and bkg spectra, ARF and RMF files provided.

# 3. Extract the spectrum of a *Chandra* source

**3. Extract the Chandra spectrum for one source (with already analyzed spectrum) using an approximate method, i.e. starting from the merged 4 Ms data. Compare the spectral results obtained from the analysis of the properly extracted spectrum with those derived adopting this approximate spectral extraction**

1. Select and save source and bkg regions on the merged image in ds9
2. Extract the spectra
3. Fit the source spectrum in XSPEC
4. Compare the (nominally wrong) results with those obtained in the correct way (extracting the spectra from the single observations and adding them with proper weights)

A written guide will be provided

# Bibliography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  Introduction to heavily obscured AGN in XMM-CDFS and focus on the AGN at z=3.700.

- 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: X-ray spectra and LogN-LogS.

- Ranalli P. et al. 2013, A&A, 555, A42

  The XMM deep survey in the CDF-S III. Point source catalogue and number counts in the hard X-rays.

- Fiore F. et al. 2012, A&A, 537, 16

  Faint high-redshift AGN in the CDF-S and their XLF. Modeling the Chandra background.

- Tozzi P. et al. 2006, A&A, 451 457

  X-ray spectral analysis of the CDF-S sources using 1Ms Chandra data.

- Norman C. et al. 2002, ApJ, 571, 218

  Focus on the preliminary Chandra data of the obscured AGN at z=3.700.