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The Compton-thick AGN fraction from the deepest X-ray spectroscopy in the CDF-S

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Compton-Thick AGN

- A high percentange of AGN are highly obscured, some of them by extreme column densities over 10^{24} cm^{-2}, the Compton-Thick (CT) AGN.
- Detecting and characterizing this population is key to study the growth of SMBH across cosmic time.
- There are several multi-wavelength techinques so search for CT AGN, but X-rays remain the most capable of ensuring their CT nature either by measuring these large column densities directly form their X-ray spectra, or by the detection of a high EW Fe Kα line.

- To be able to detect them and extract information from their X-ray spectra at high redshifts, we need very deep observations, such as the 7Ms observation of the Chandra- Deep Field South (CDF-S). Many previous works on CT AGN in the CDF-S: Tozzi+06, Comastri+11 Georgantopoulos+13, Buchner+14, Brightman+14...

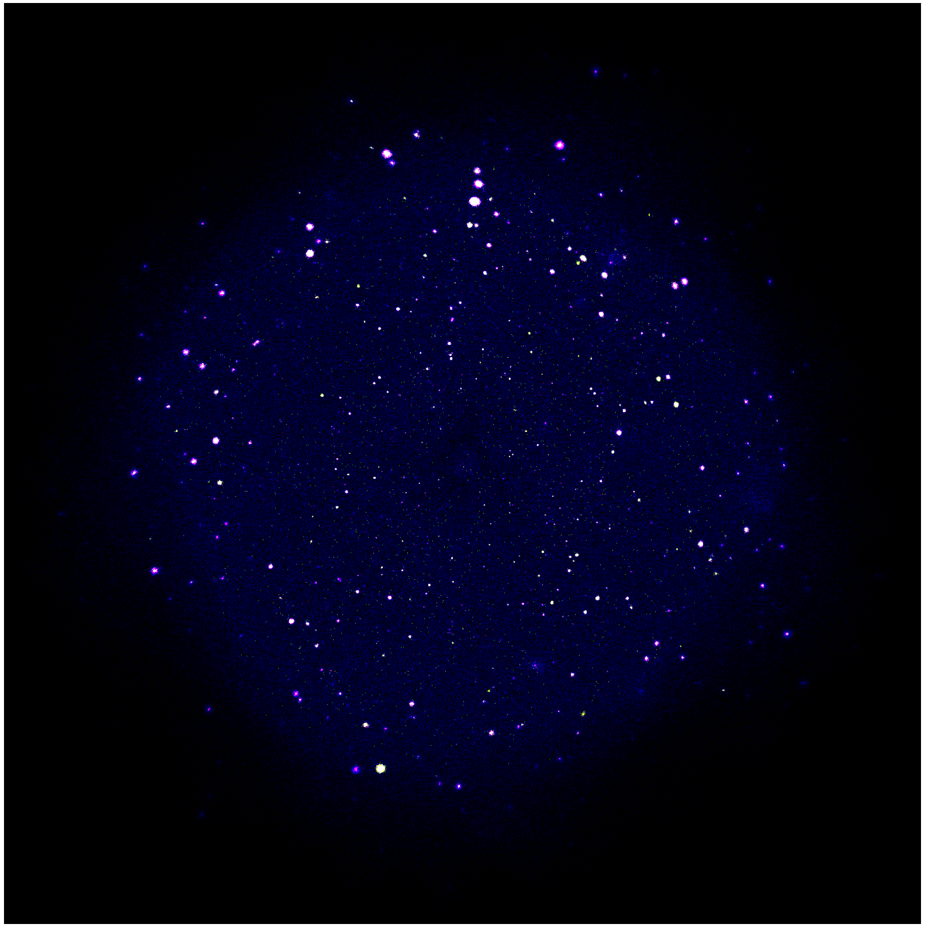
This work

- We are NOT looking for the best-fit model for all the detected X-ray sources within the CDF-S.
- We are NOT trying to classify sources as CT or not CT.

- We are optimising selection criteria to pinpoint highly absorbed sources by using automated spectral fitting, so that they can be applied to large samples and relatively low quality X-ray spectra.
- Then, we derive the probabilities of an AGN being CT, and use these probabilities in further analyses.
- Trying to devise a method as less model-dependent as possible.

Chandra Deep Field South

- Deepest X-ray observation to date
  - XMM-Newton 3Ms catalogue: Ranalli+13
  - Chandra 7Ms catalogue: Luo+17
- To ensure a spectral quality as good as possible, we restricted this analysis to the sources detected the hard (2-8 keV) band in the 2Ms (Luo+08).

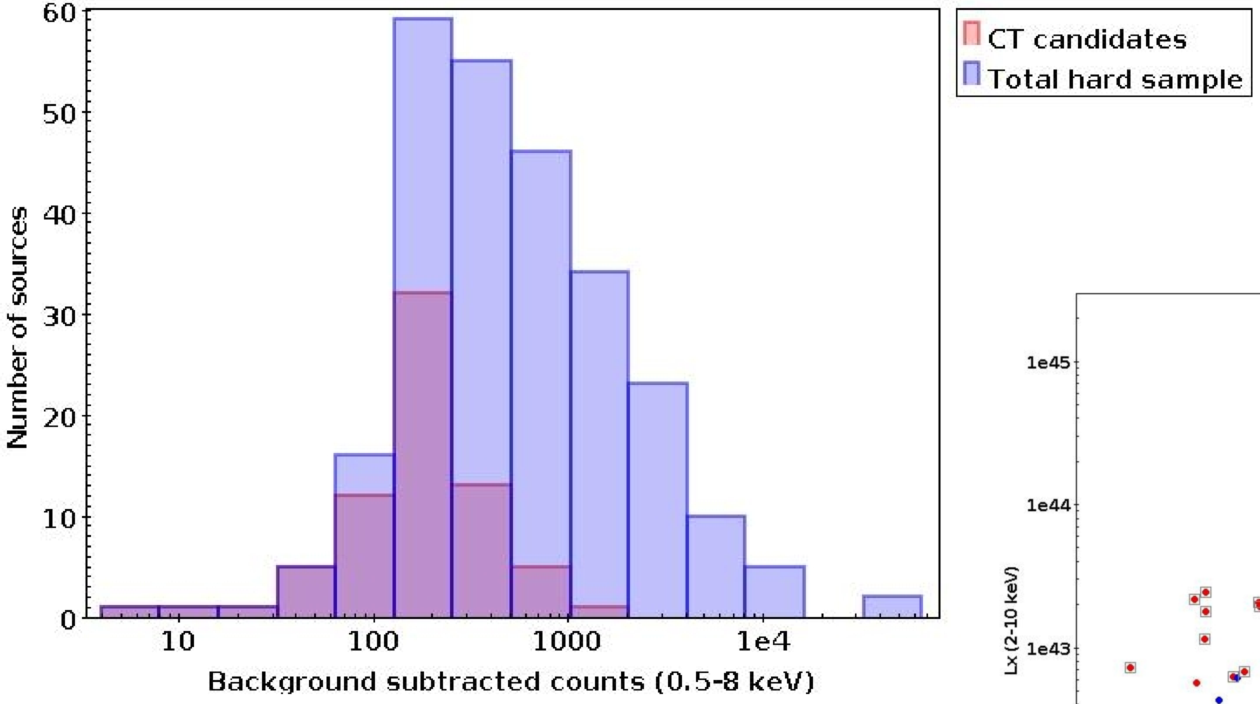


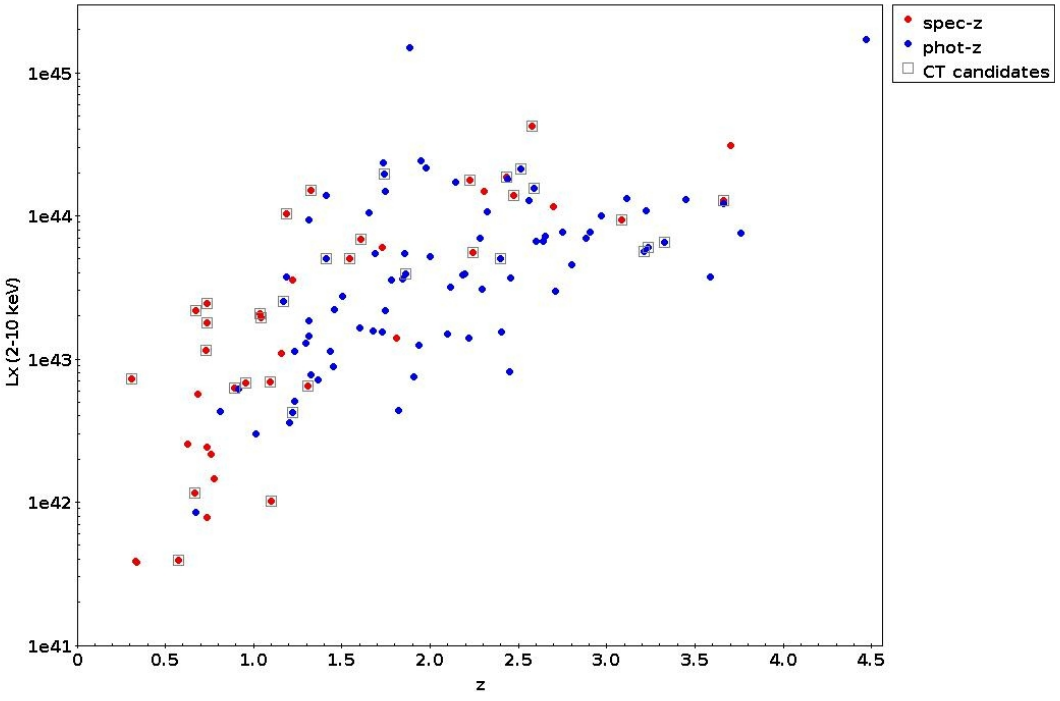
CDF-S 7Ms Chandra image (E. Pouliasis)

S_{limit}(2-8 keV) ~ 1.3×10^{-16} erg cm^{-2} s^{-1}

Sample

265 sources in Luo+08 hard sample **257** with redshifts (252 in Luo+17 7Ms catalogue)
(**177 spectroscopic**, **80 photometric**, Hsu+14)





Automated selection

- **Selecting highly absorbed sources (not only CT) by fitting simple models** (Xspec, cstat): absorbed (double)power-law plus gaussian emission line.
- Parameters for selection: N_H, photon index 2-10 keV (rest-frame and observed), line EW: **more than 60 AGN** selected as candidates, still optimising:
  - From simulations (**preliminary results**), and from XMM-Newton data on known CT AGN (Corral+14): **80-90% of selected sources are highly absorbed (N_H>10^{23} cm^{-2}), and we don't miss any CT AGN because of the selection.**
  - We do miss CT AGN because of data quality (**simulations, preliminary results**), not only during the automated selection but also by using more physically realistic models:
    - Below ~ 100 counts in 2-8 keV we could be missing up to 9% of CT AGN (up 5 sources in our sample) .
    - Between 100-250 counts we could be missing 1-2% of CT AGN (up to 2 sources in our sample).
- **Work in progress:**
  - More simulations still running to get better statistics.
  - Implementing Murphy&Yaqoob+11 **mytorus** for the simulations.

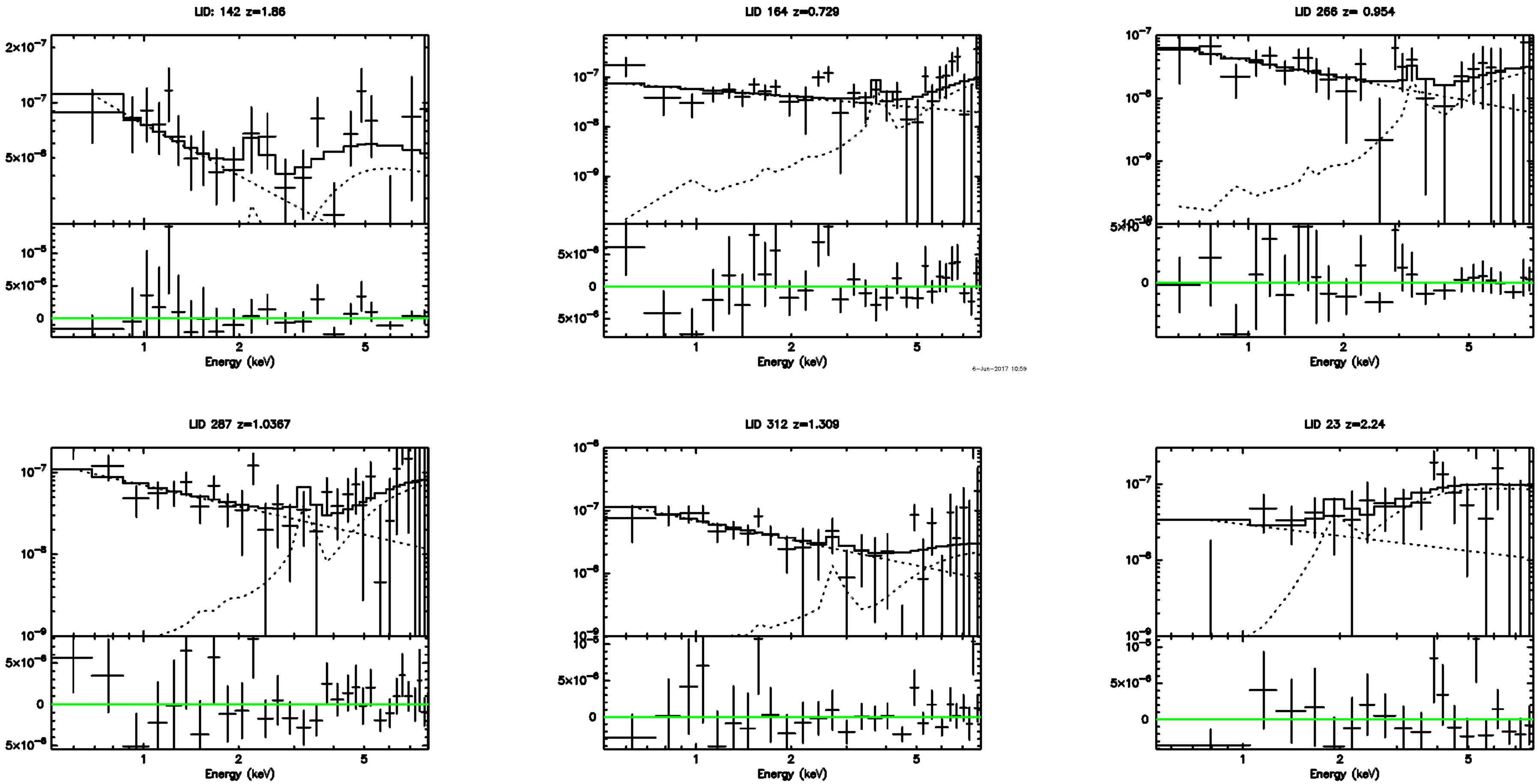
Bayesian analysis

- See **Akylas+16**: we apply a appropriate model for CT AGN to the selected candidates (Brightman&Nandra+11) torus model:

  zpo+torus(oa:60º,inclination:80º)

- Markov Chain Monte Carlo (MCMC) to derive the probability distributions for all parameters → $P(N_H>10^{24})$ = probability of being CT, P(CT).
- **37 of selected candidates have probabilities > 10% (19 with P(CT) > 90%).**
- **Now each one “weights” its P(CT).**

New "looking CT” AGN

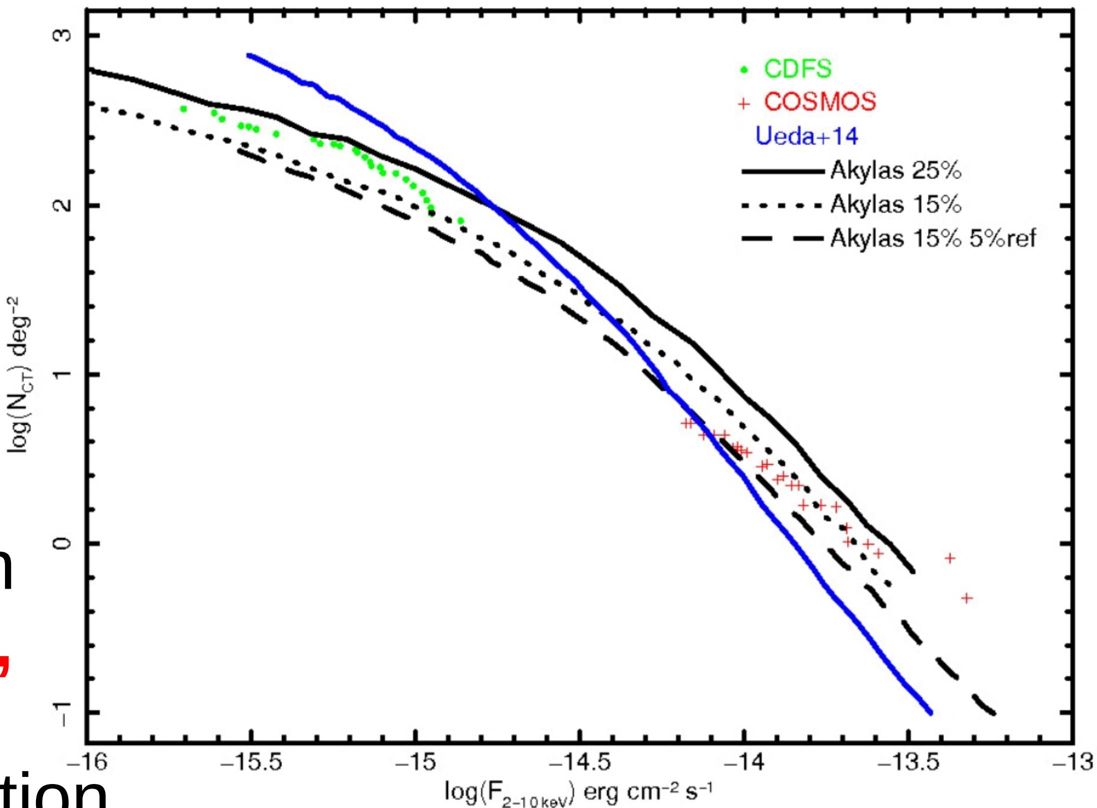


CXB models

We build the logN-logS for our 37 candidates weighting them by their P(CT)

Comparing with CXB synthesis models: **CT fraction over 25%**
- Ueda+14: 50% CT, moderate amount of reflection.
-Akylas+12:
    25% CT and no reflection
    15% CT and no reflection
    15% CT and 5% of reflection

Data: **COSMOS (Lanzuisi+15),** CDFS (this work)



Akylas+16 showed smaller fraction for local CT AGN: **redshift dependence?**

Summary and results

- Using the 7Ms spectral data for the 2Ms detections allow us to carry out spectral analyses down to low fluxes:
  - We applied a highly efficient selection technique for highly absorbed AGN that can be applied to larger samples.
  - We don’t classify CT AGN, but derive a probability of being CT.
  - Using these probabilities and comparing with CXB models, our results favour a CT fraction of ~ 25%, but amount of reflection/simulations results still have to be taken into account.
  - For more details and comparison between high and low redshift CT AGN **see Georgantopoulos talk on Wednesday.**