Finding distant clusters: NIR requirements for follow up to complement XXL Survey and other approaches

by

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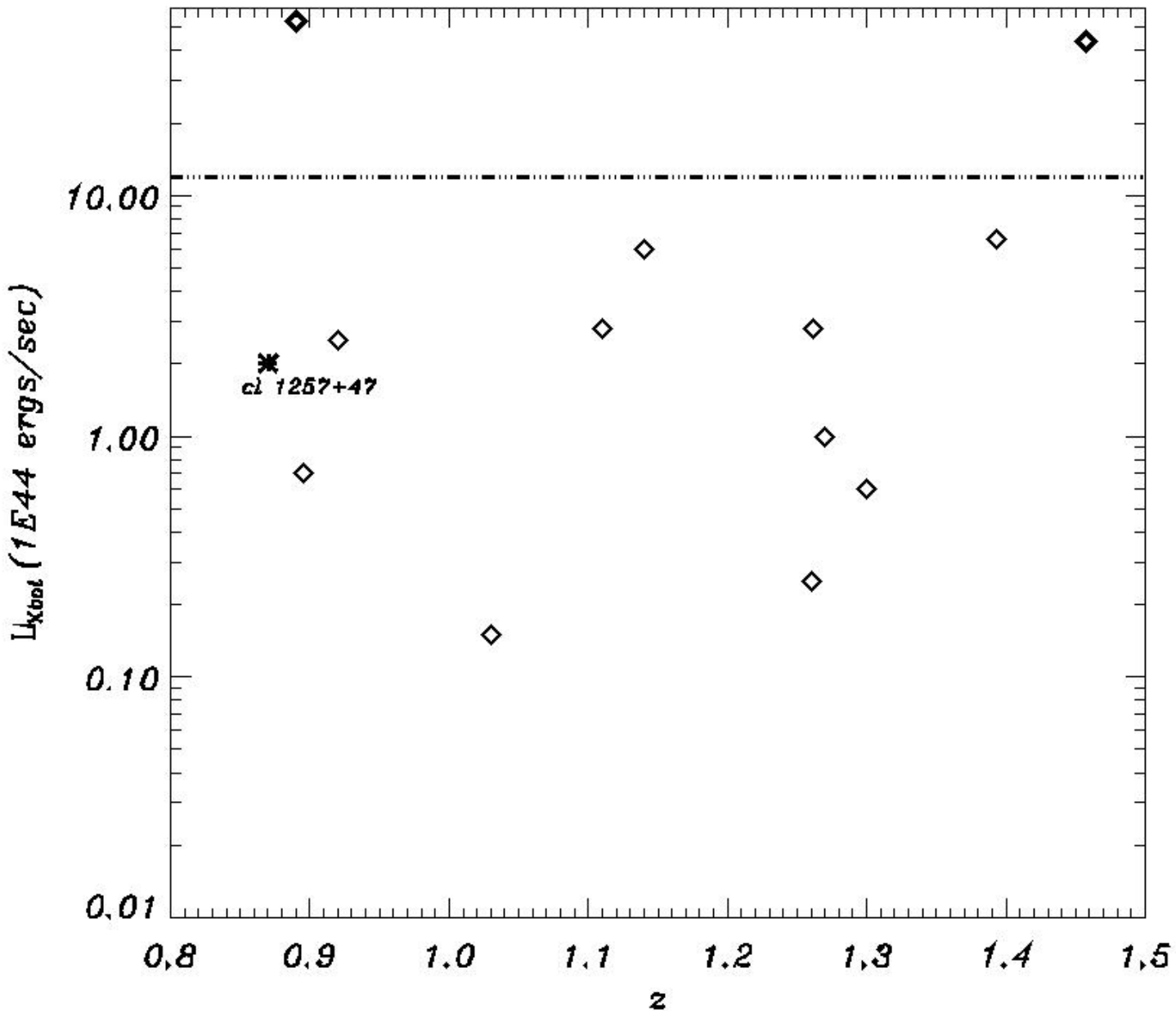
This talk is based on our experience with using the ROSAT data to find distant clusters.

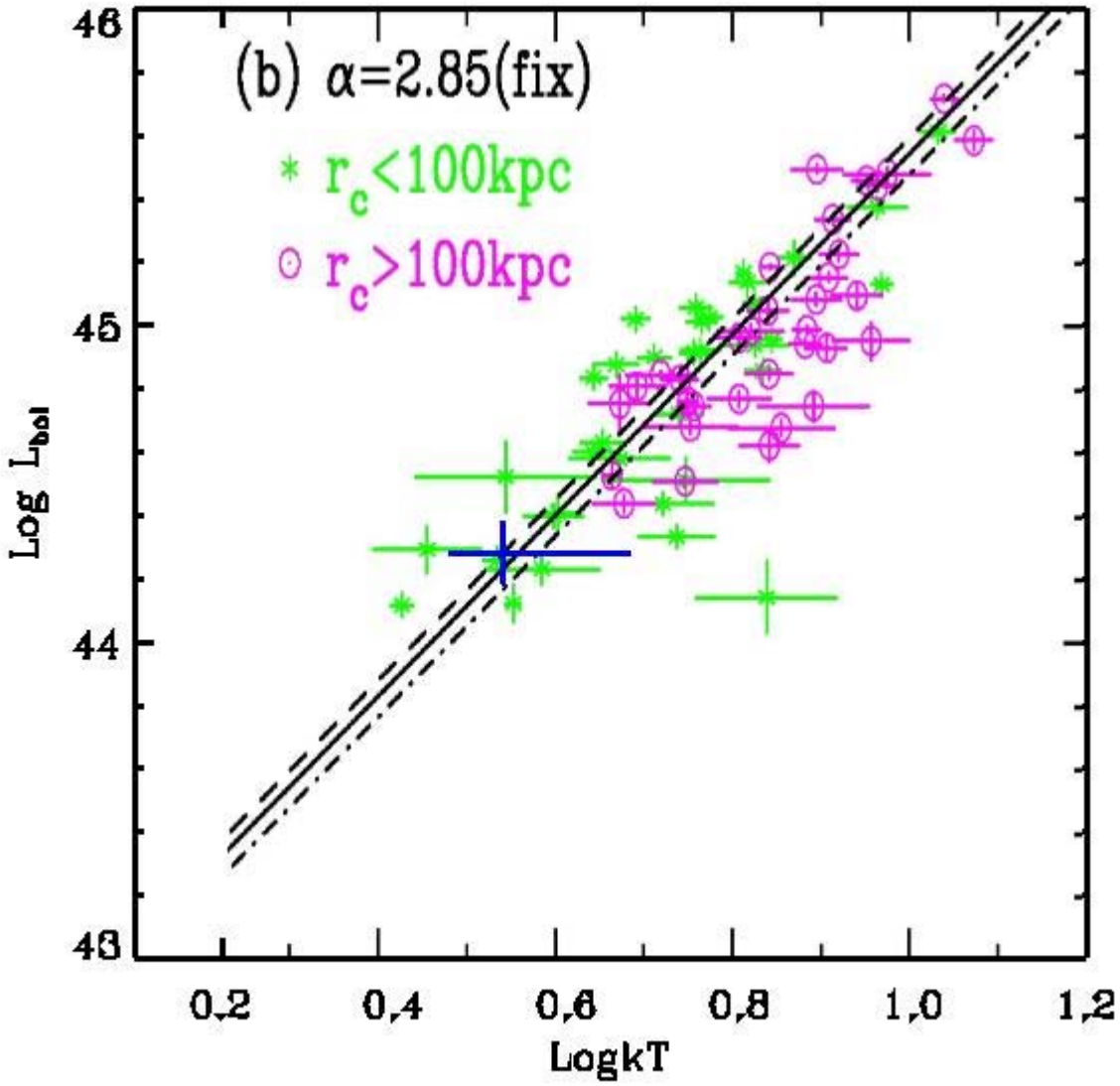
We complemented the ROSAT data with a NIR follow-up to identify distant clusters for further X-ray study

=> I present what we suggest would be nice to do with large ground based telescopes plus XMM-Newton in regards to the study of distant cluster of galaxies

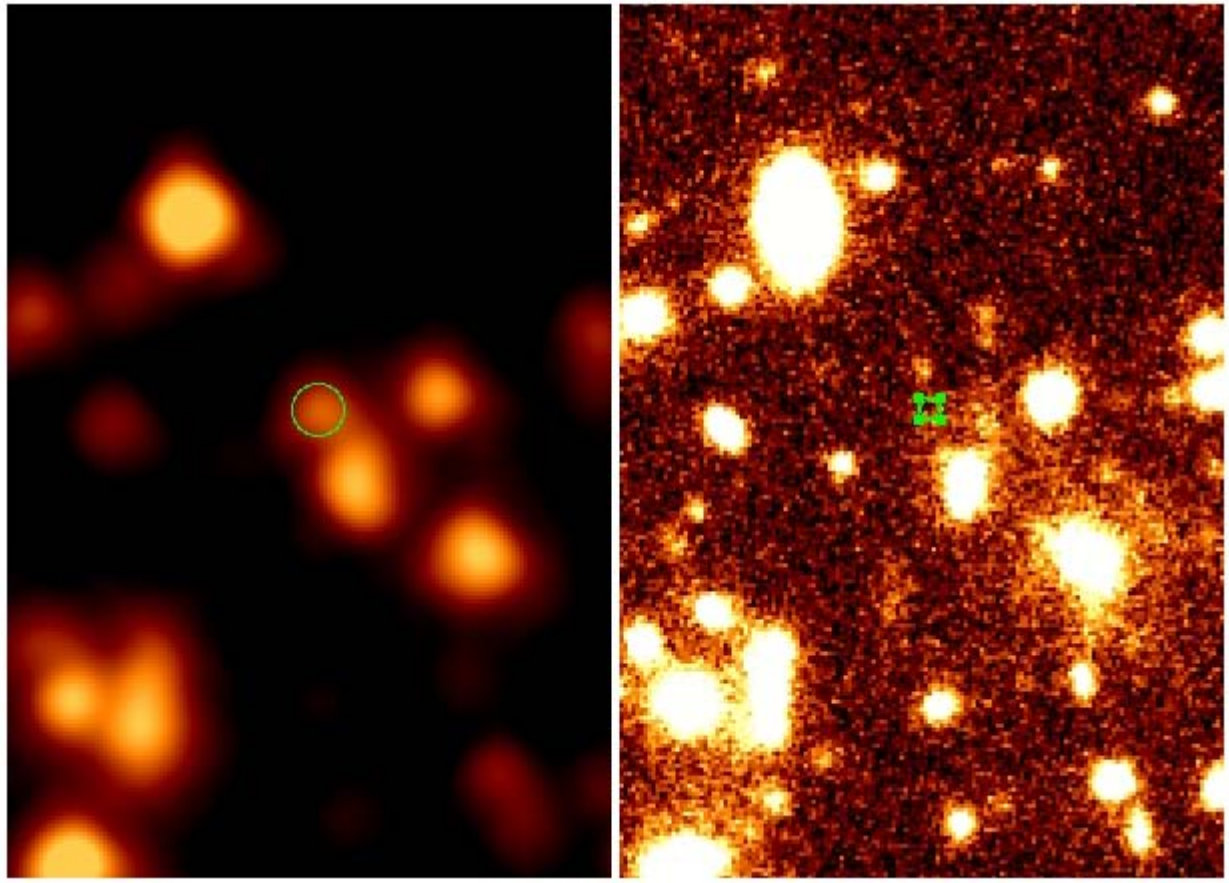
First a little background



Is this cluster (blue cross) already fits on line by z = 0.9; all the rest are below z = 0.56; from Ota, N. et al 2006



Also great for finding super distant galaxies and possibly X-ray emitting AGNs



3.6 um IRAC object ~18 i'-faintest can detect is ~25.5

Extended SHARC Survey: The Process

All sources where image quality is too poor to detect possible extent and object > 3 sigma
~ 3,400
select only those with no object within 3' (generous 3 sigma error) in NED or DSS => 37

+ 2 with no R (3.5 m, 10 min exposure) but probably extended

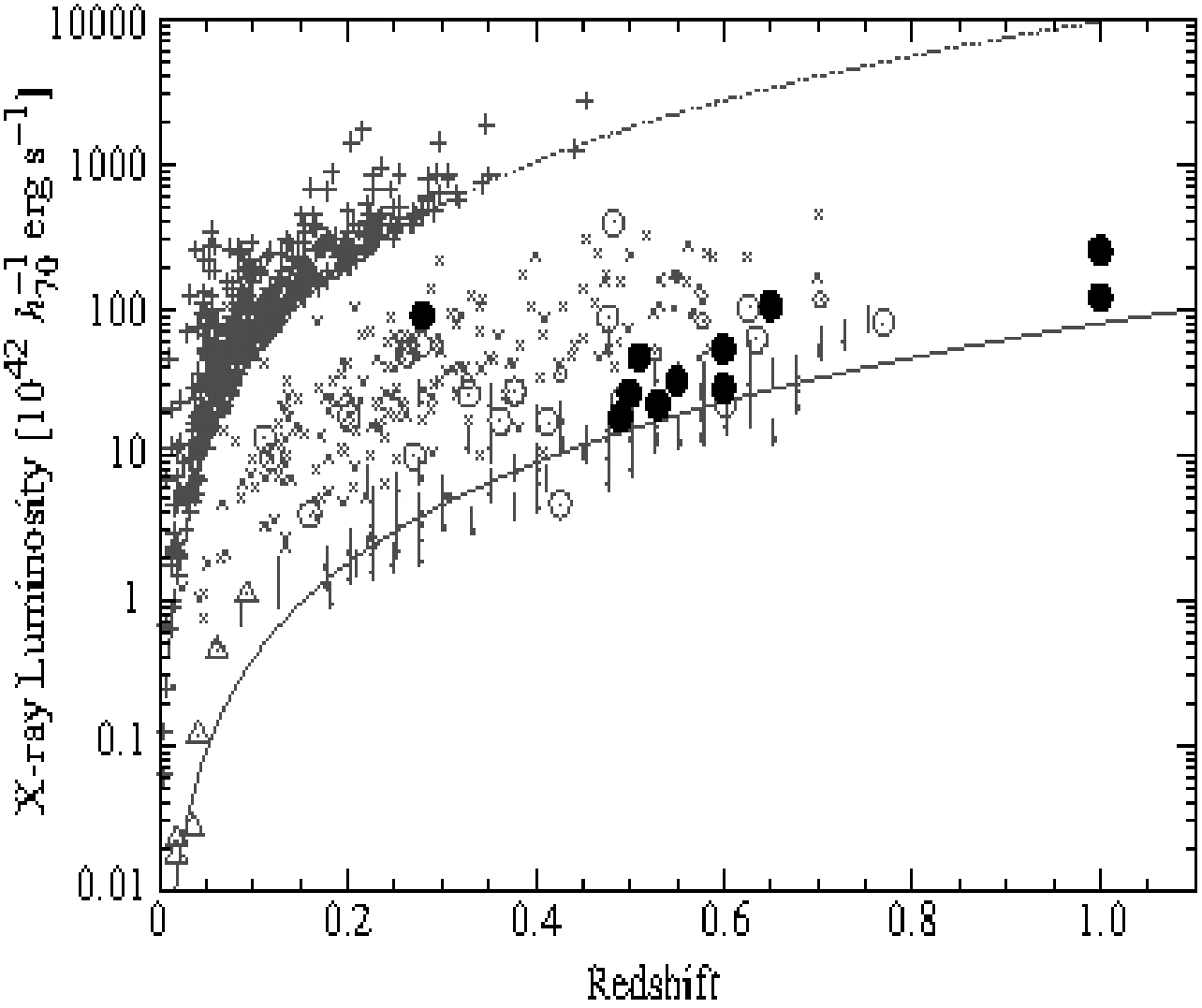
Follow-up with i, R, and some J and K

Found: 5 clusters (one not see in X-rays) with measured z => 2 at about 0.6, 2 at 0.5, and 1 at 0.9.
Possible clusters (9) with photo-z between 0.5 and ~1 [5 @ 0.55, , 2@ 0.65, 2 @ 1]

=total possible = 14/37 ~ 1/3 of original candidates interesting and about 1/10 z ~ 1 (rounding 0.9 to 1)

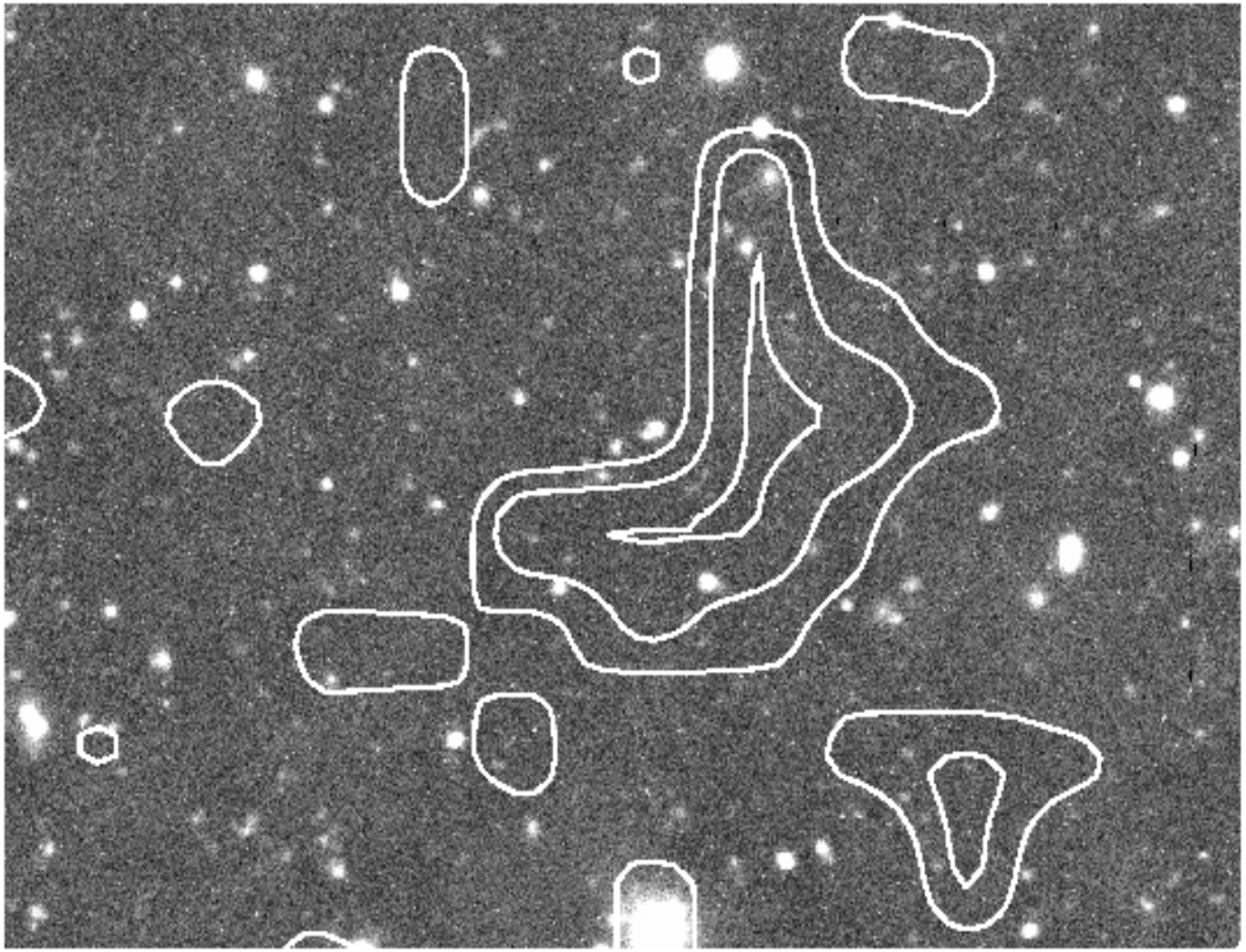
Some tid-bits from our survey or, why NIR with a targeted X-ray survey is good

Us = big black dots compared to CHAMPS (open circles are CHAMPS extended sources) about the same!



+ Are clusters from REFLEX; x, X-ray ROSAT 160 sq deg; vertical lines/arrows, X-ray upper limits to optically identified candidates

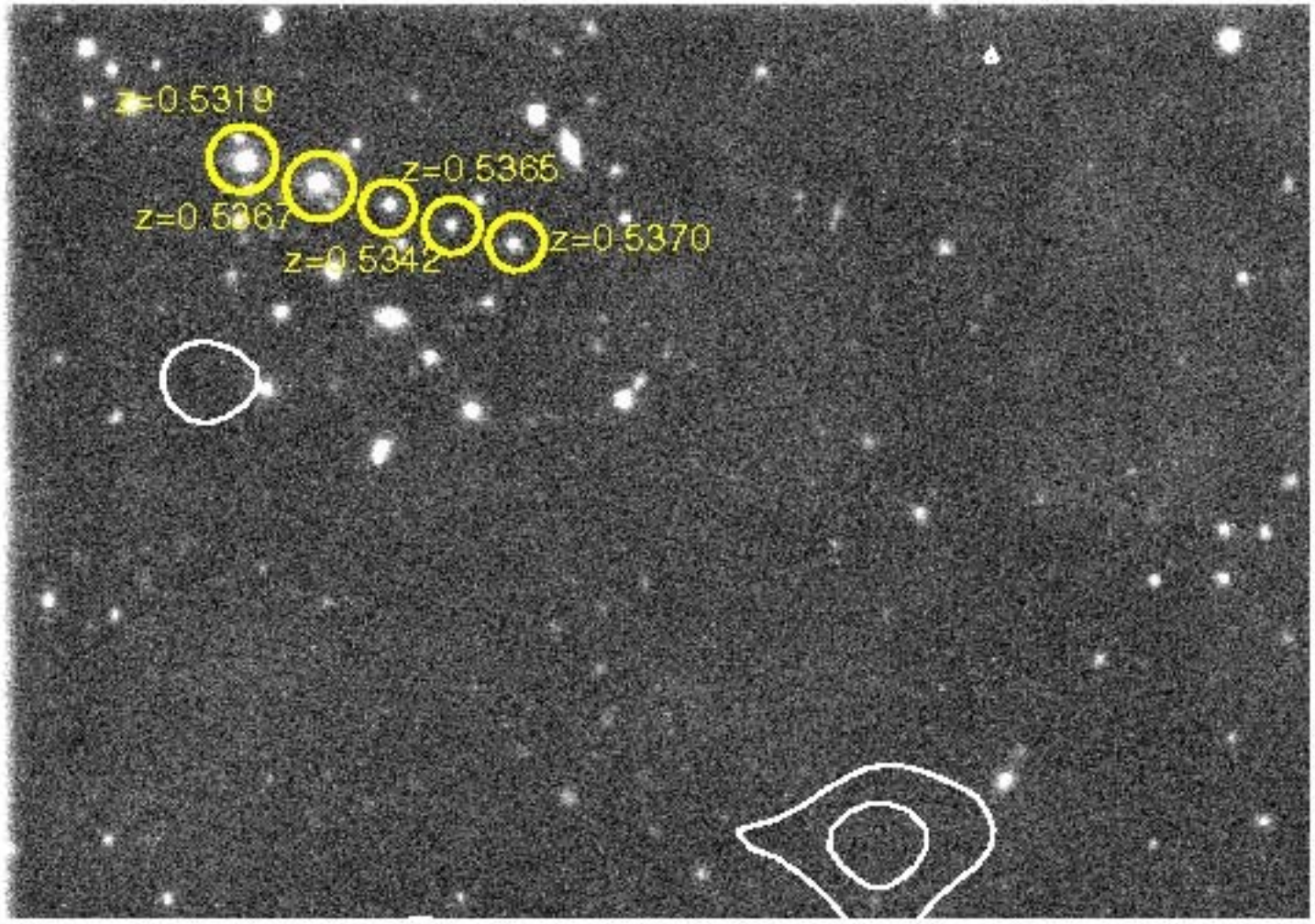
Possibly extended and nearly blank, very faint i'-band field (mag 23.5 limit) => Likely a z > 1 cluster 2.7 x 2 arc min FOV



DEC

RA

Example of an X-ray dark cluster at z = 0.53



DEC

RA

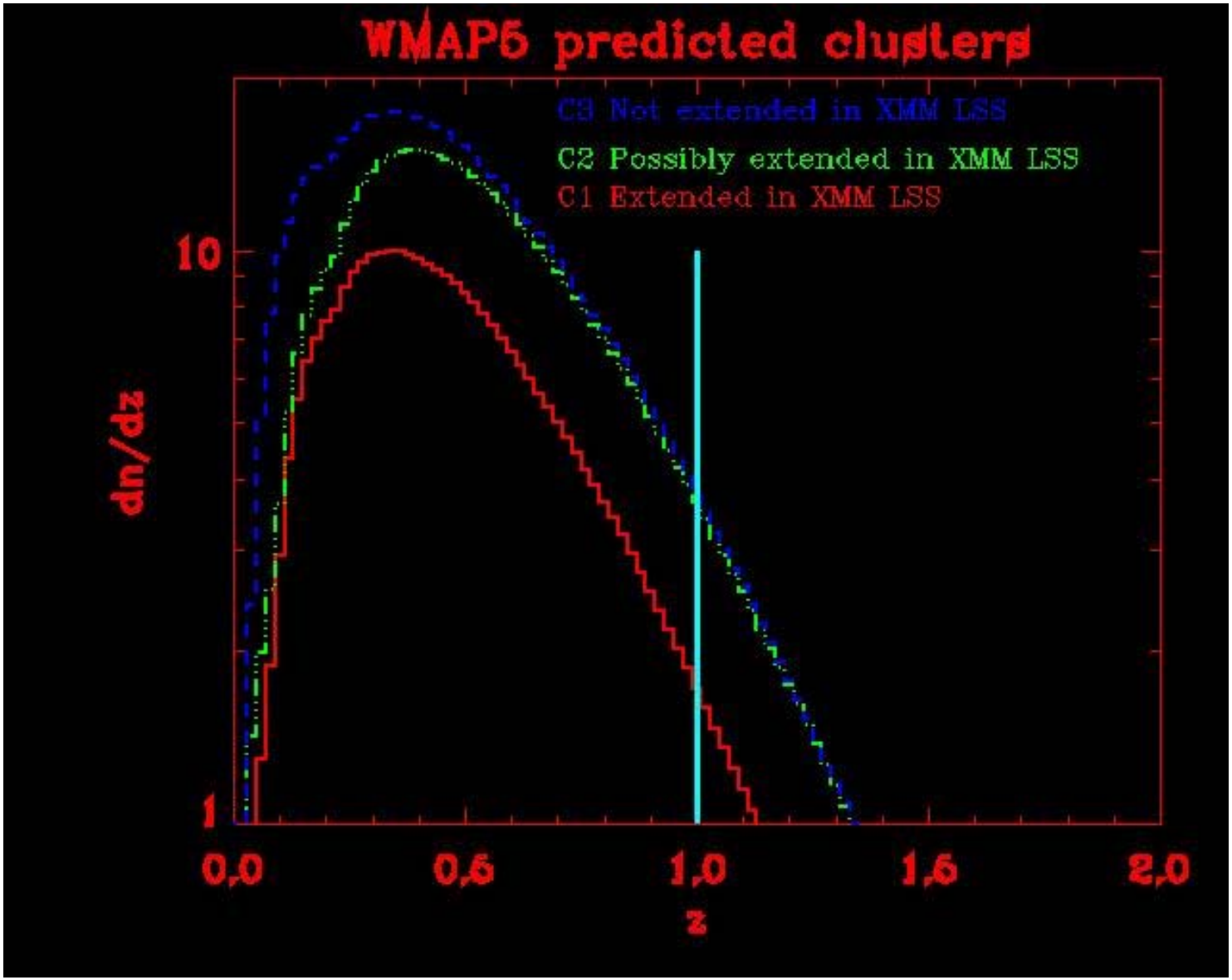
3.5 x 2 arc min field i-band complete to about i'~23.5

We now discuss 2 X-ray selection choices for XMM

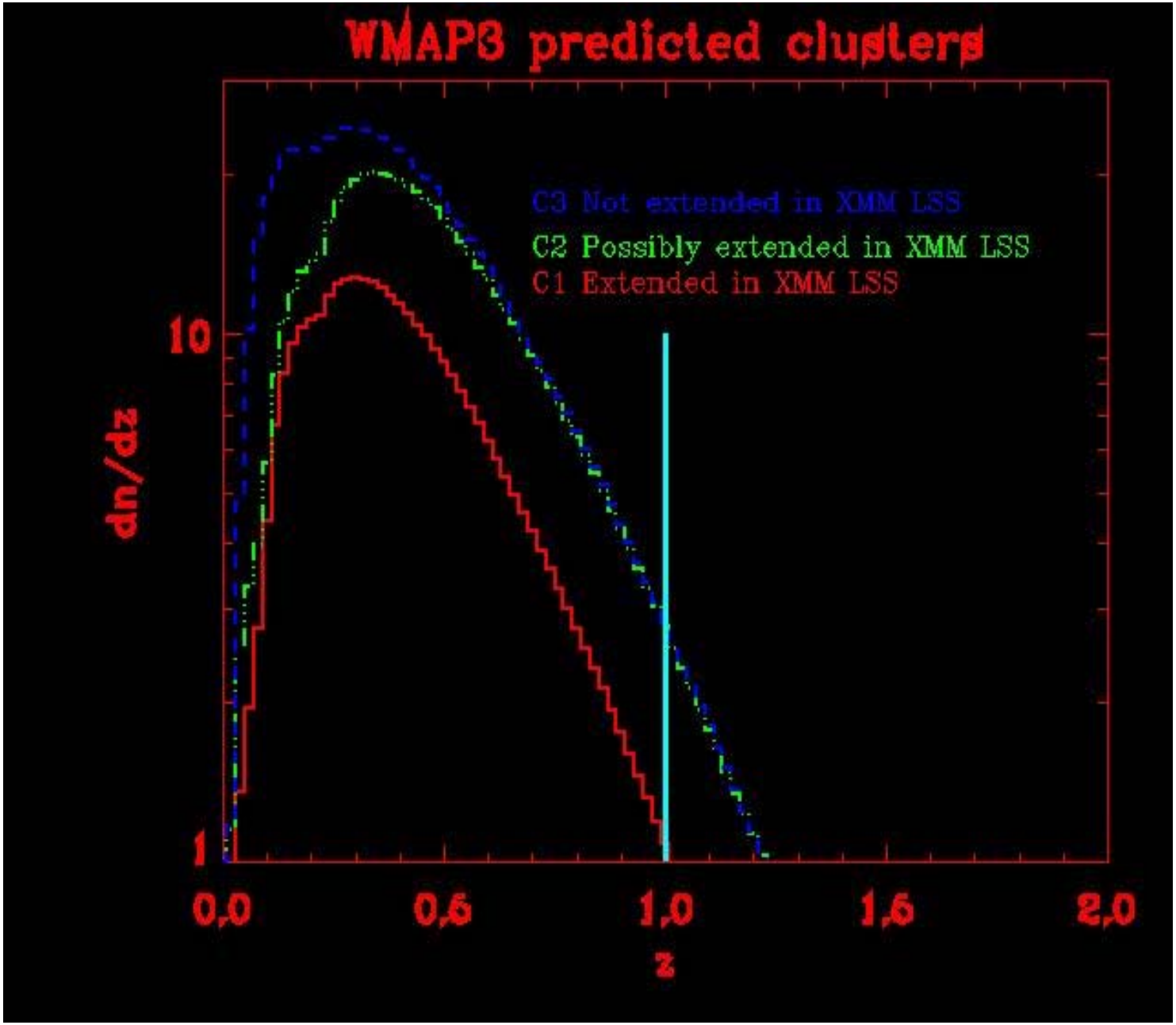
(1) XXL Survey with 10ksec/pointing and 100 sq degrees, from Florian Pacaud: he estimates between 150 and 250 C1+C2 (extended plus possibly extended candidates) will be found with z > 1

=> Follow up 150 minimum exposures in i-band, preferred r, k as well to get a better z estimate

Can see going as low as z = 0.5 for comology Using XXL and Theory (Florian Pacaud) WMAP5 vs WMAP3, next slide



Using XXL and Theory (Florian Pacaud) WMAP3



=> **We see three things comparing WMAP3 and WMAP5 :**

(a) C1s won't find many z >1 compared to C3 (or C2)

(b) There is some sensitivity to cosmology but really need times 10 to get reasonable statistics for this

(c) Going down to about z = 0.5 is interesting since it allows better statistics for gaining insights to Cosmology

And yet we need more observing time afterwards in order to get more than possible extent from X-ray observations (or wait for XEUS??)

Suppose instead, one uses the about 100 sq degrees (clean observations) that already exist!

Then from Florian Pacaud, we expect for z > 1, 50-80 total candidates with as many as 20-35 C1!

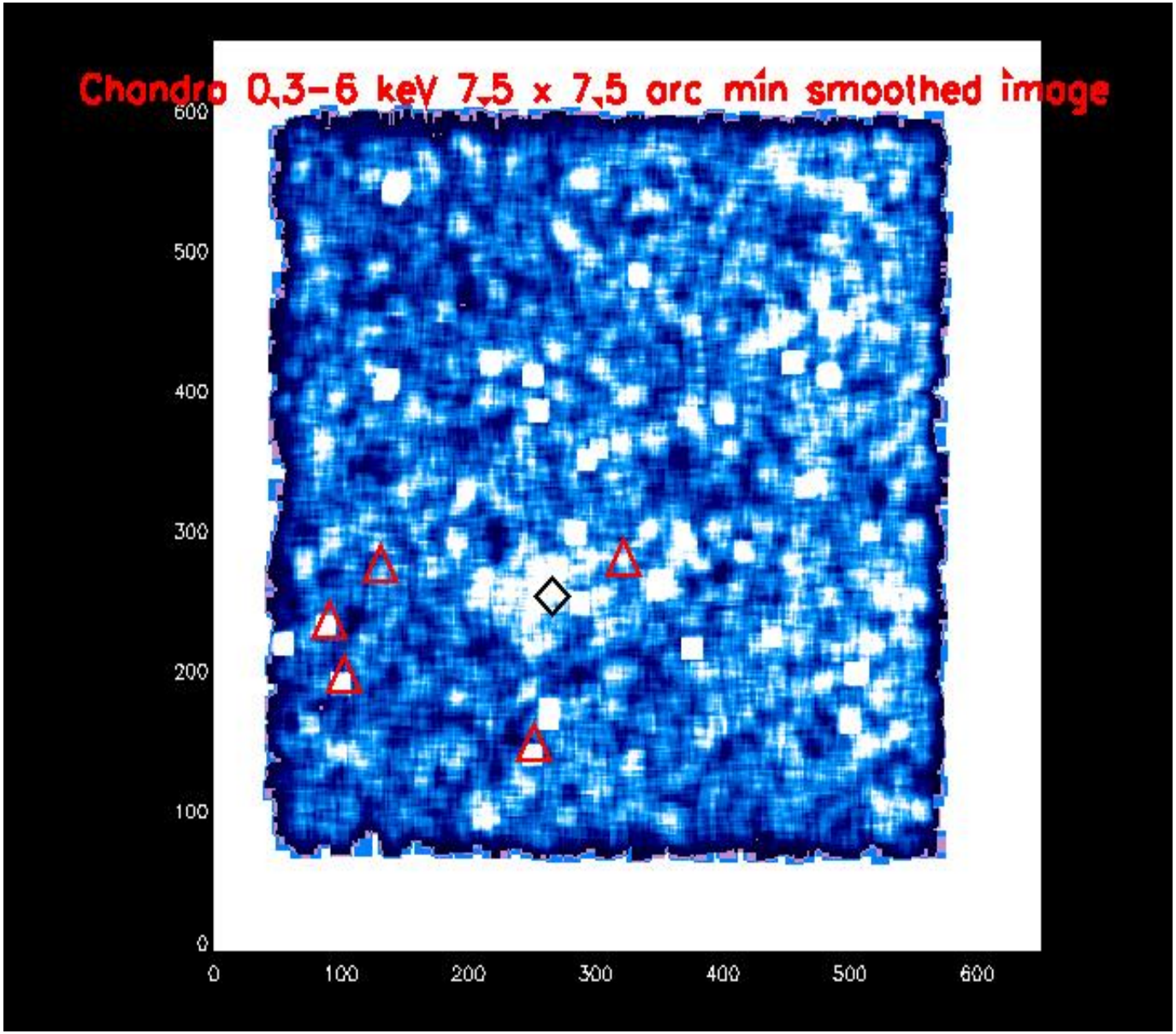
=> Propose 40 ksec good data (assuming typical loses then 100ksec per target) follow-up of these better than blank fields because we centre the objects.

Do the project in two stages: (a) just the C1s while spend more NIR time on C2+C3, and then (b) continue with C2+C3 with about 10-15 cluster per year!

Get kTs , redshifts and element (Fe) abundances!

Plus lots of background X-ray AGNs and possibly some even lensed as super high z

Here are some examples of possibly very distant X-ray emtting AGNs that could have been magnified



Black Diamond, z = 0.9 cluster; Red triangles faint (~25 i') or invisible in i-band Gemini, but bright in Irac1,2 (mag ~ 18) Spitzer = z > 10?

Conclusions:

1. No matter how you do a next generation survey, NIR is useful, and it will even uncover X-ray dark clusters

2. Both an XXL survey or a targeted archive-based survey will find about 50-100 z > 1 clusters

- **The XXL will require no advance « thinking » or analysis and be contiguous, but it will be shallow**
- **The targeted survey requires thinking in advance, but yields a richer data set**
- **Don't neglect down to z = 0.5!**
- **The 1.0-1.5 z range seems to be where clusters have matured in X-rays and with a targeted sample of 50-100, we'll have good enough statistics to well model « how and why » they become X-ray bright**
- **If I could « hijack » XMM, HST and Spitzer and some 4-8 meter ground based telescopes, I'd look at 1,000 known (optically) rich clusters with z > 0.4 with all of these and derive gravitational lens masses and find many many distant galaxy (or AGN) candidates (era for the era of re-ionization and BH formation studies) as well as get a measure of w and w'.**