The XMM-LSS and the CFHTLS

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Plan

1 Clusters :

Detection in the X-ray

Identification with the CFHTLS

Cosmological applications

2 The XMM/CFHTLS catalogue

PART I

CLUSTERS

Survey GOAL

Construct a cluster sample out to z~1
with controlled selection effects
suitable for cosmological studies

➔ It seems that now,
at least in the X-ray,
we master the selection effects

The XMM-LSS design

The XMM-LSS Survey

Goal :

cluster ξ in two redshift bins for the first time

~ 900 clusters out to z~1

has fixed the XMM-LSS survey characteristics:

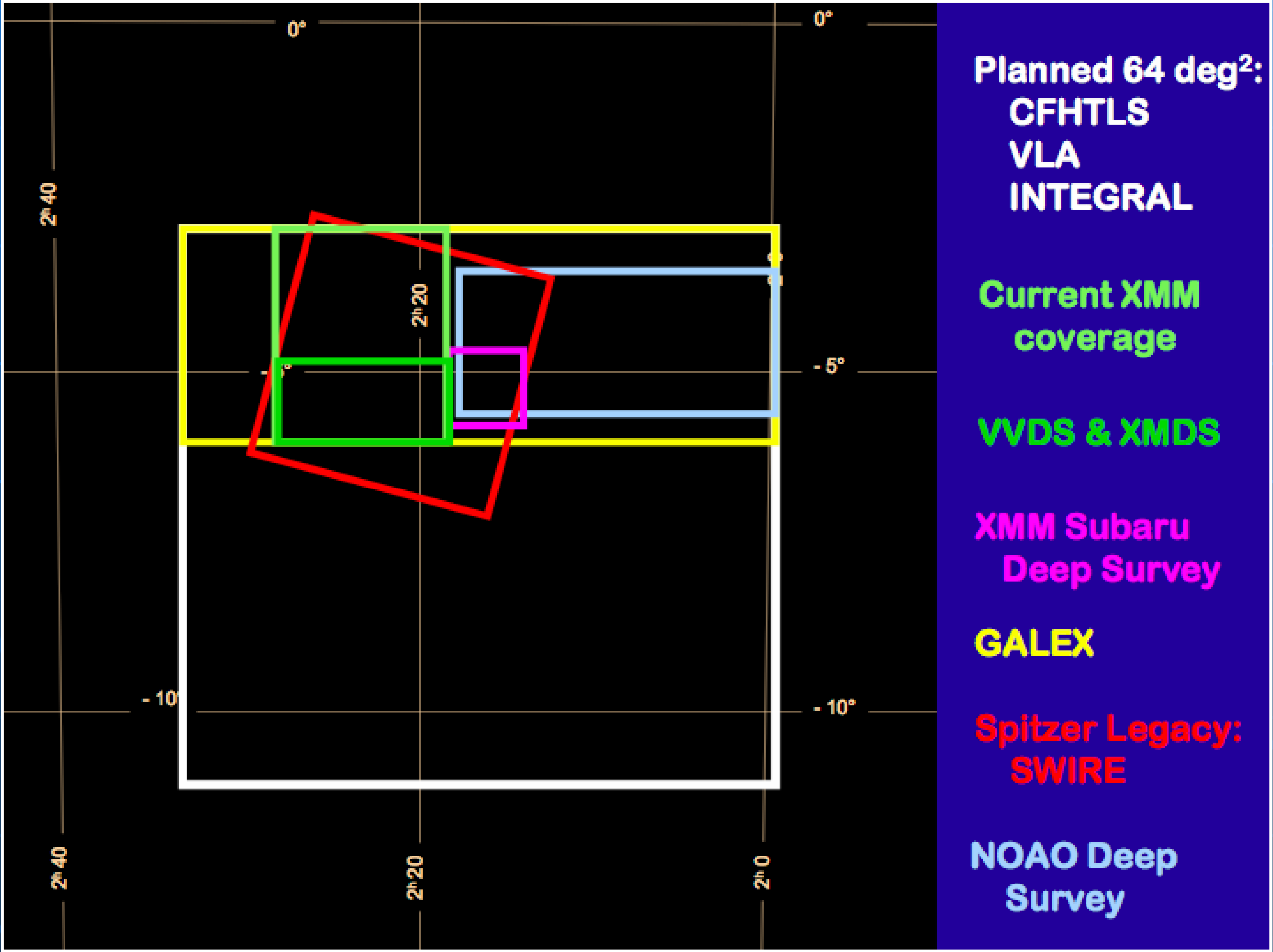
a 8x8 deg2 area covered by 10 ks XMM pointings.

⇒ sensitivity 5 10^{-15} erg/s/cm^2 in the [0.5-2] keV band

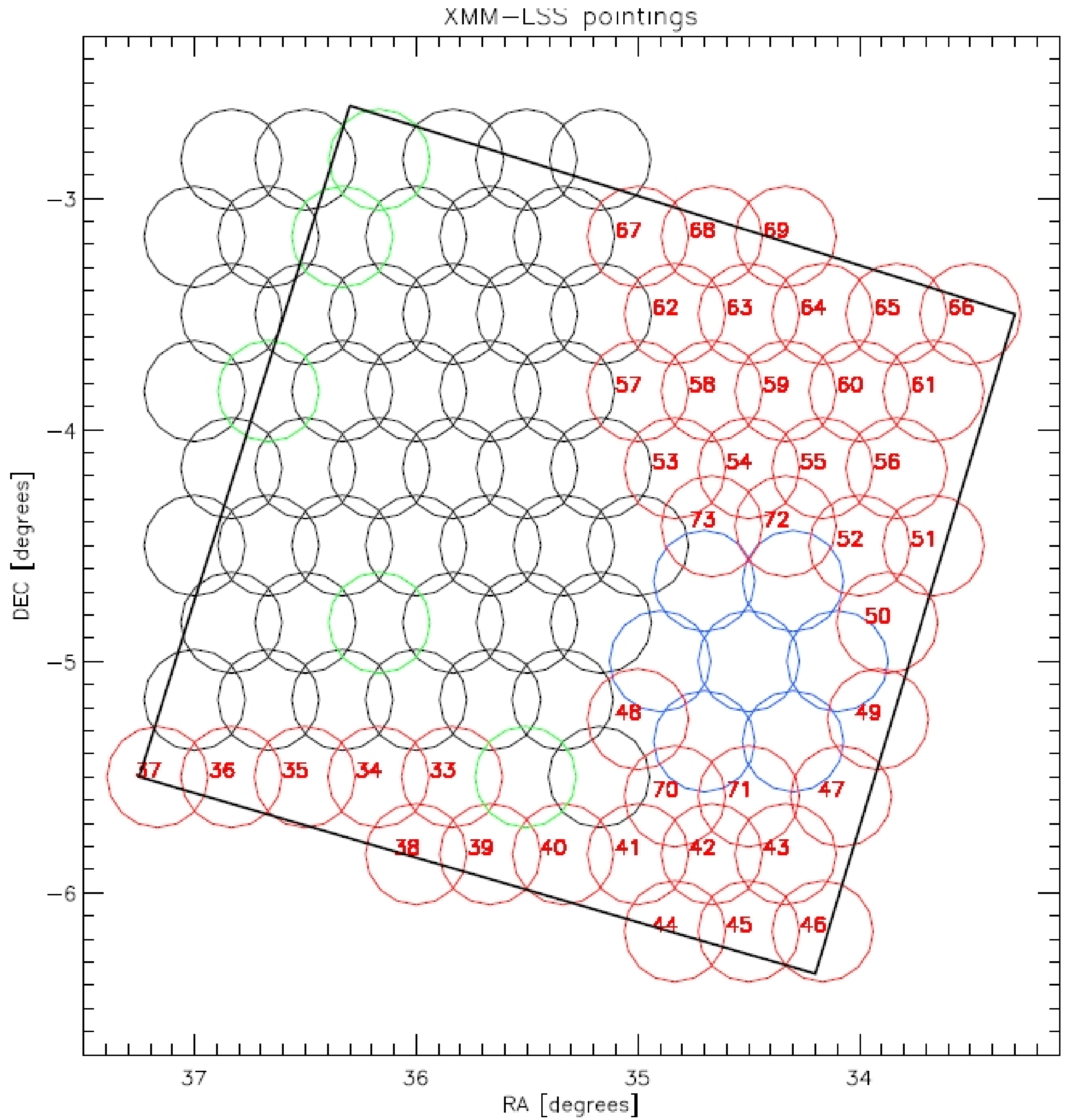
The XMM-LSS Field = W1

X-ray data status: - Received - received - received - ($5deg^2$)

- AO5 Large Program - accepted - (10 deg2)



The XMM-LSS / CFHTLS / SWIRE 10 deg2 field : an XMM Large Programme



XMM pointings :

- . Done
- . To be redone
- . Subaru DS (done)
- . To be done in 2006-2007

Square = SWIRE 10deg2 field Scuba 2 Legacy

Concept

XMM observations

Optical imaging with the **CFHT Legacy Survey**

- Optical ID
- Spectro with **FORS, VIMOS, NTT**
  Or **photo-z**
- **Cluster and QSO** ξ

- **Weak lensing mass determination**

COSMOLOGY

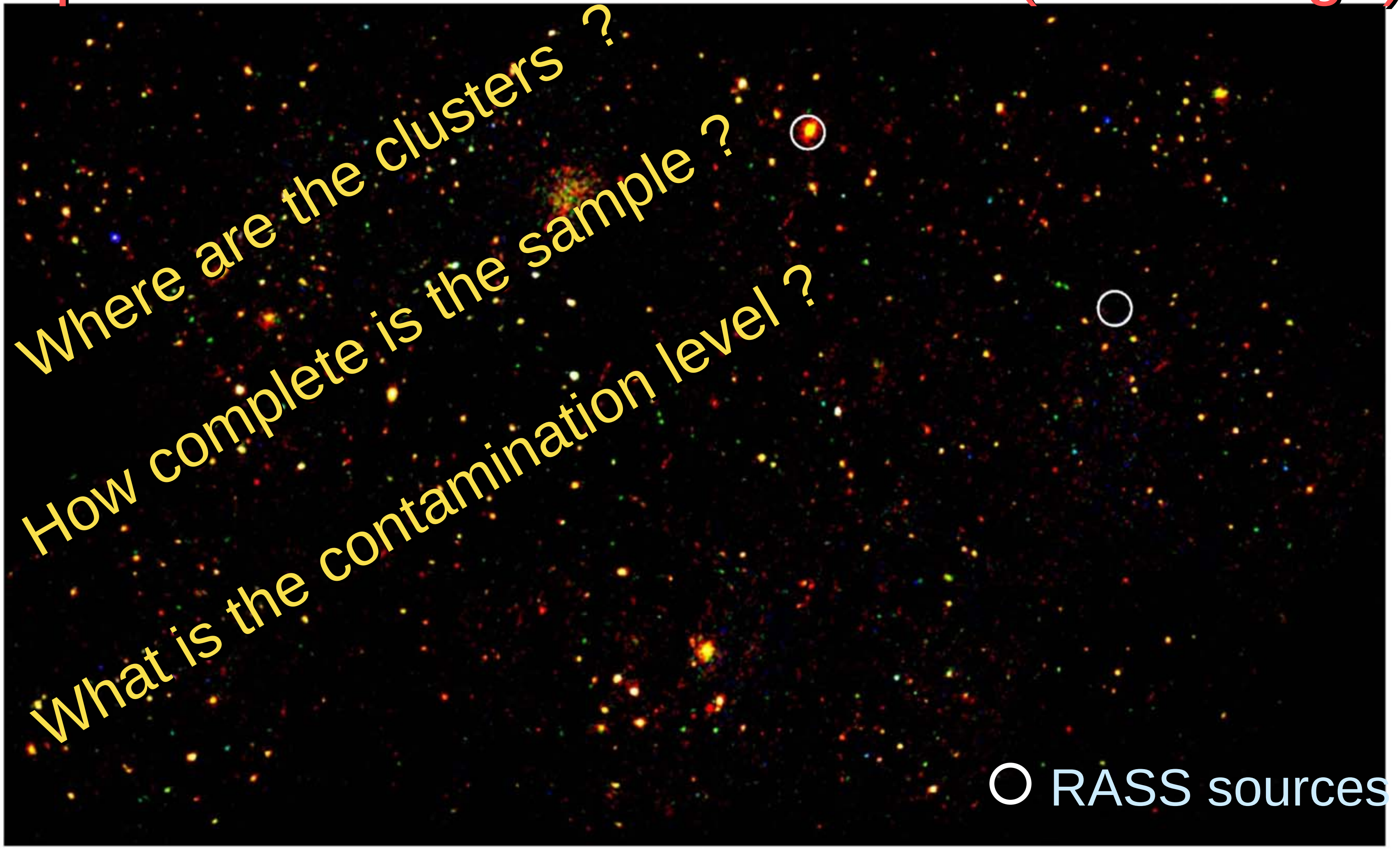
A new era is open with XMM

Detecting clusters

and

monitoring the selection function

A piece of the XMM-LSS mosaic (2 x 1 deg^2)



10 ks exp. red [0.3-1] keV green [1-2.5] keV blue [2.5-10]keV

The problem of cluster detection

...

critical for cosmological interpretation !

What's the problem ?

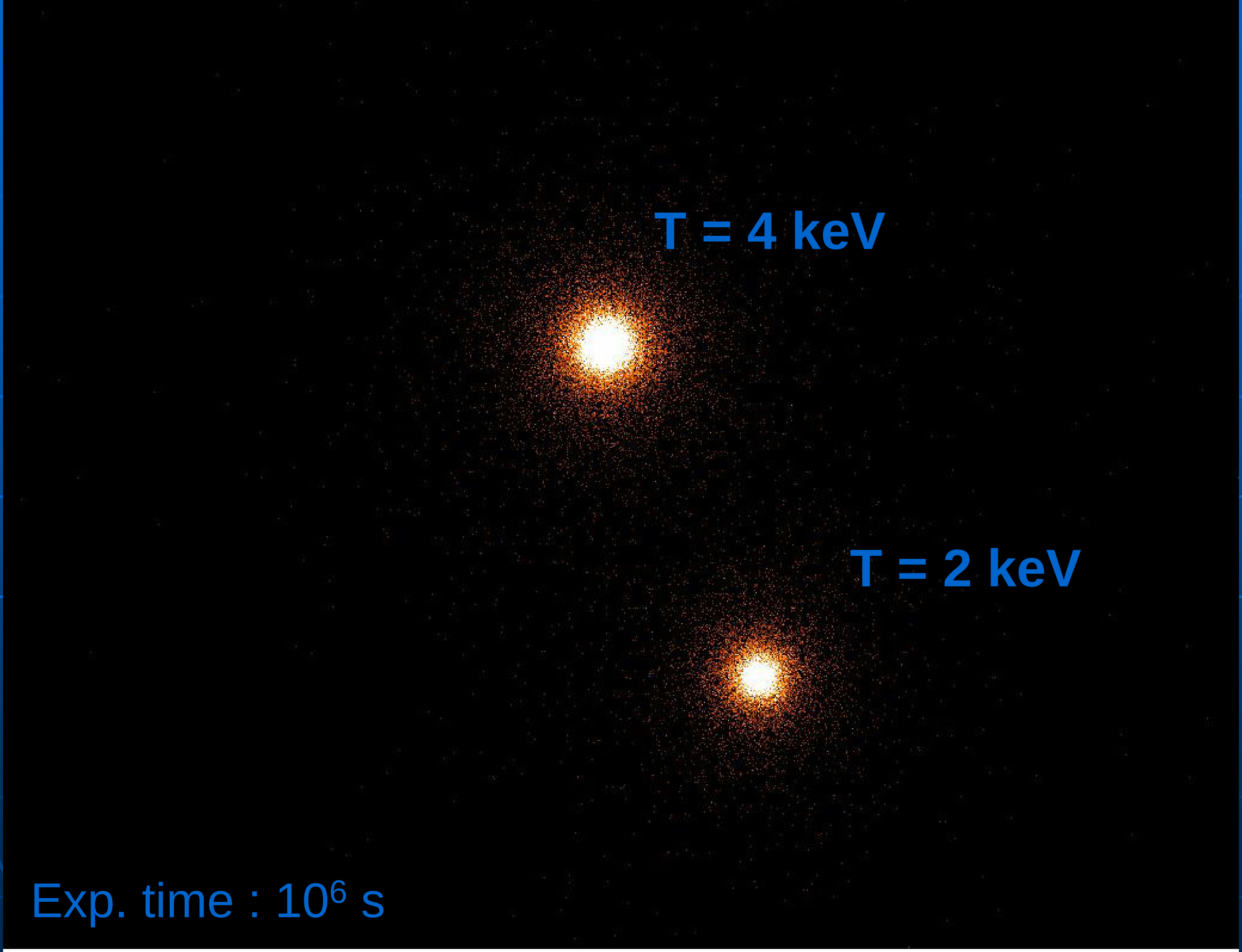
For $0.1 < z < 1$, 20'' < Rc < 100''.

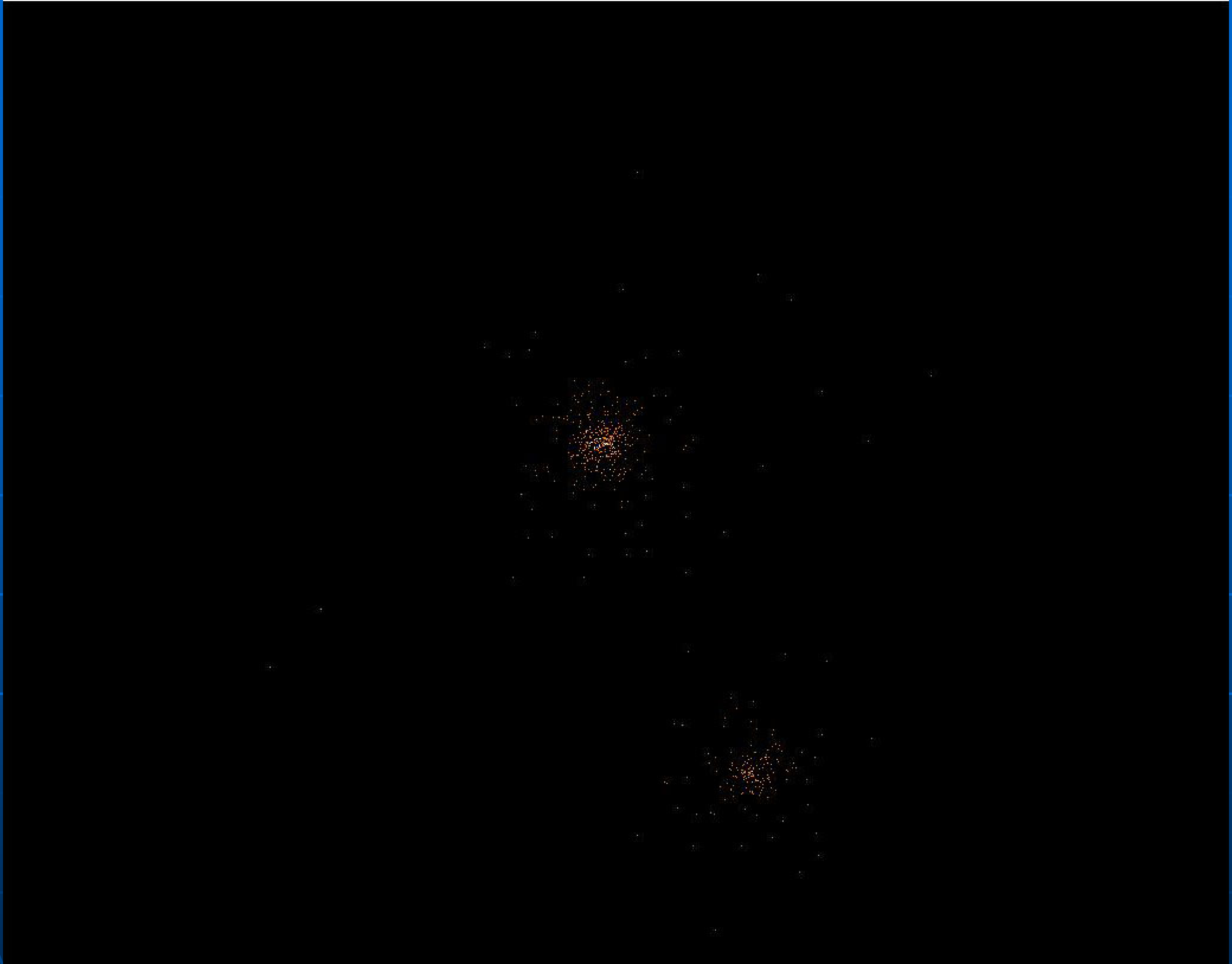
⇒ Detecting extended sources (PSF ~ 6'')

For a typical source, we receive 1 photon / min.

⇒ Detection is a very specific task as we are in the Poisson regime.

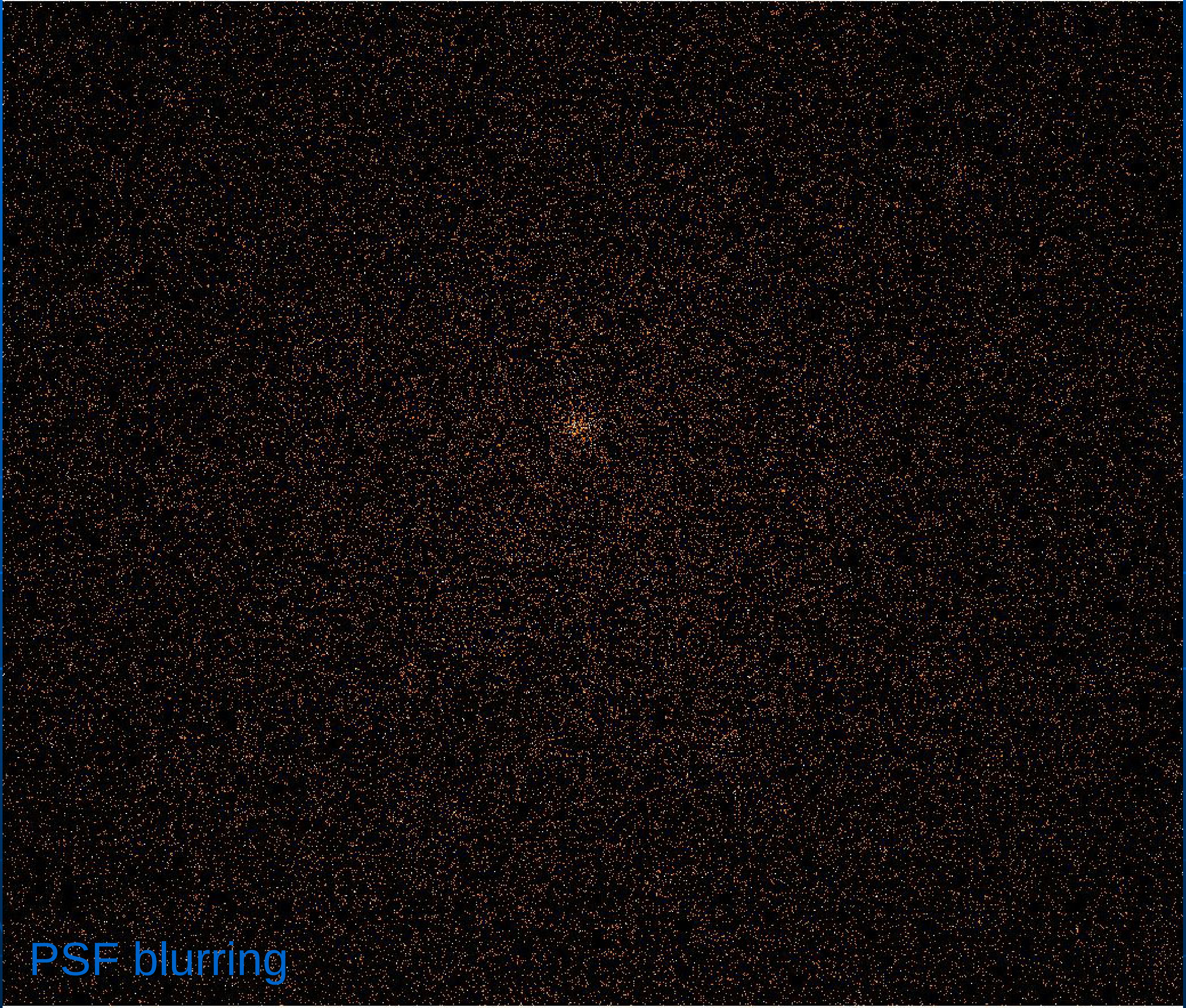
Simulation example: two clusters at z=0.5

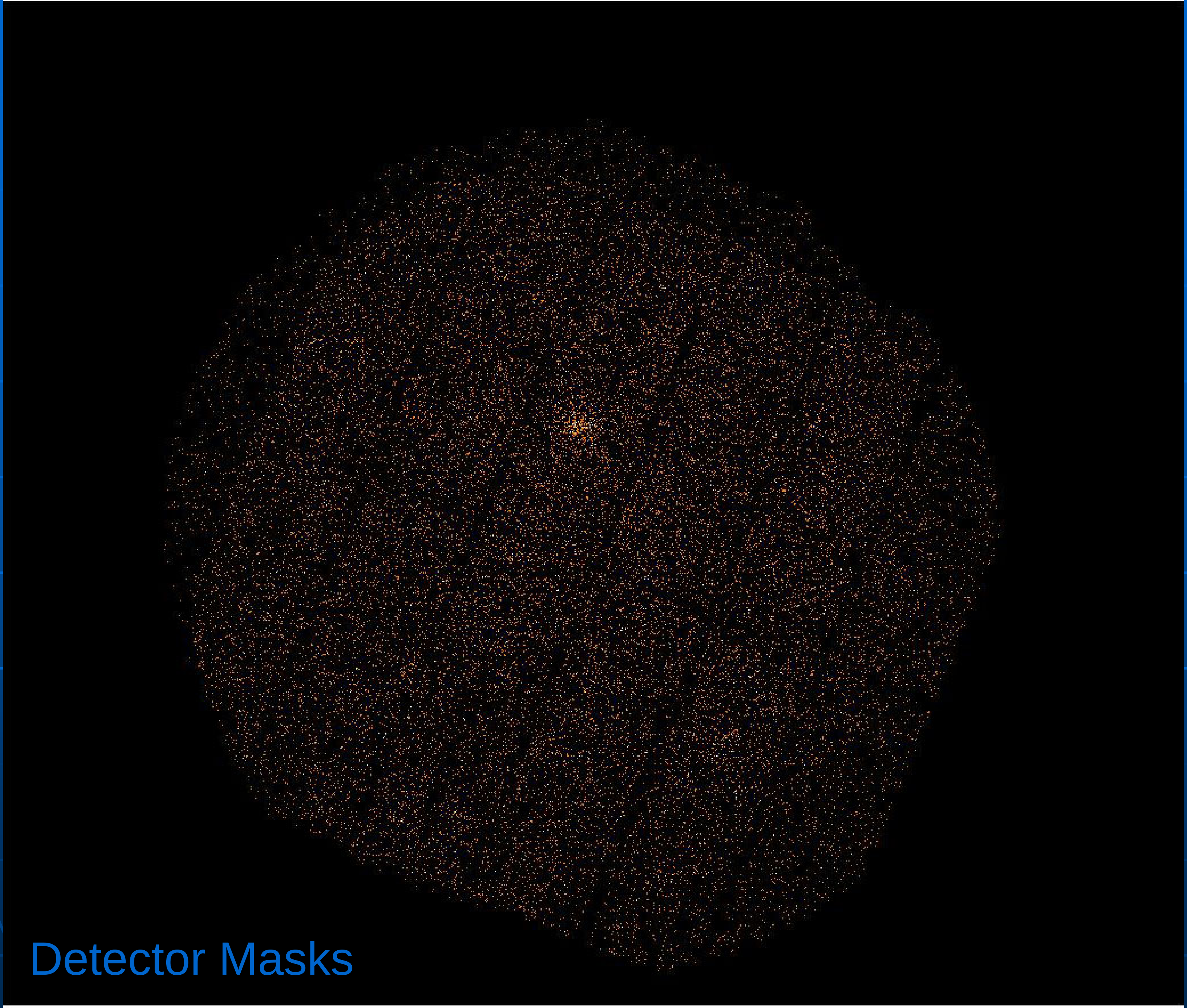


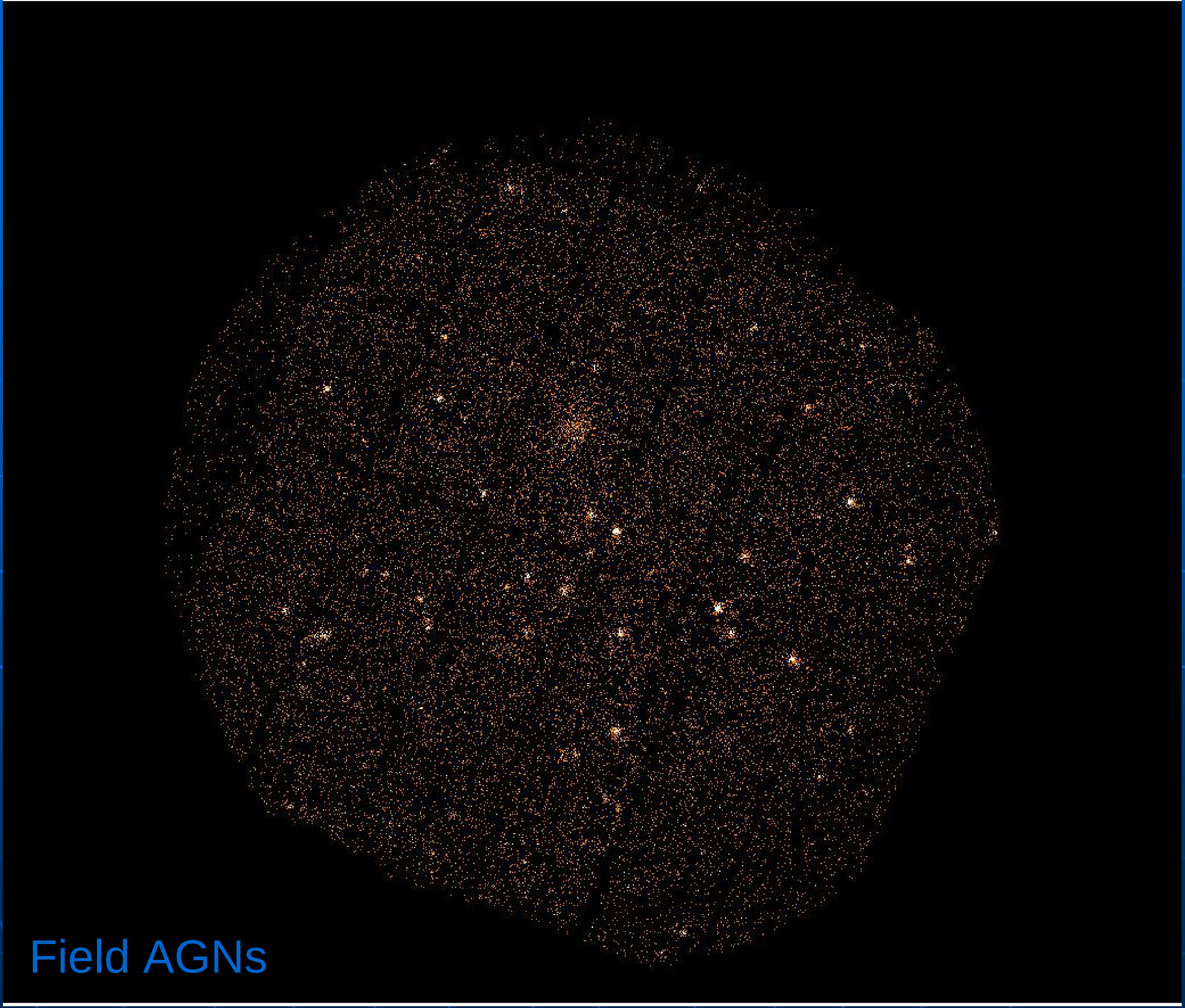


Exp. time : 10^4 s

Particle and photon background


PSF blurring


Detector Masks


Field AGNs

The XMM LSS pipeline

-1- Image filtering in wavelet space

➔ source detection at a low level

-2- Maximum likelihood analysis

➔ **Test 2 source models**: **point** & β-**profile**

➔ Final catalogue:

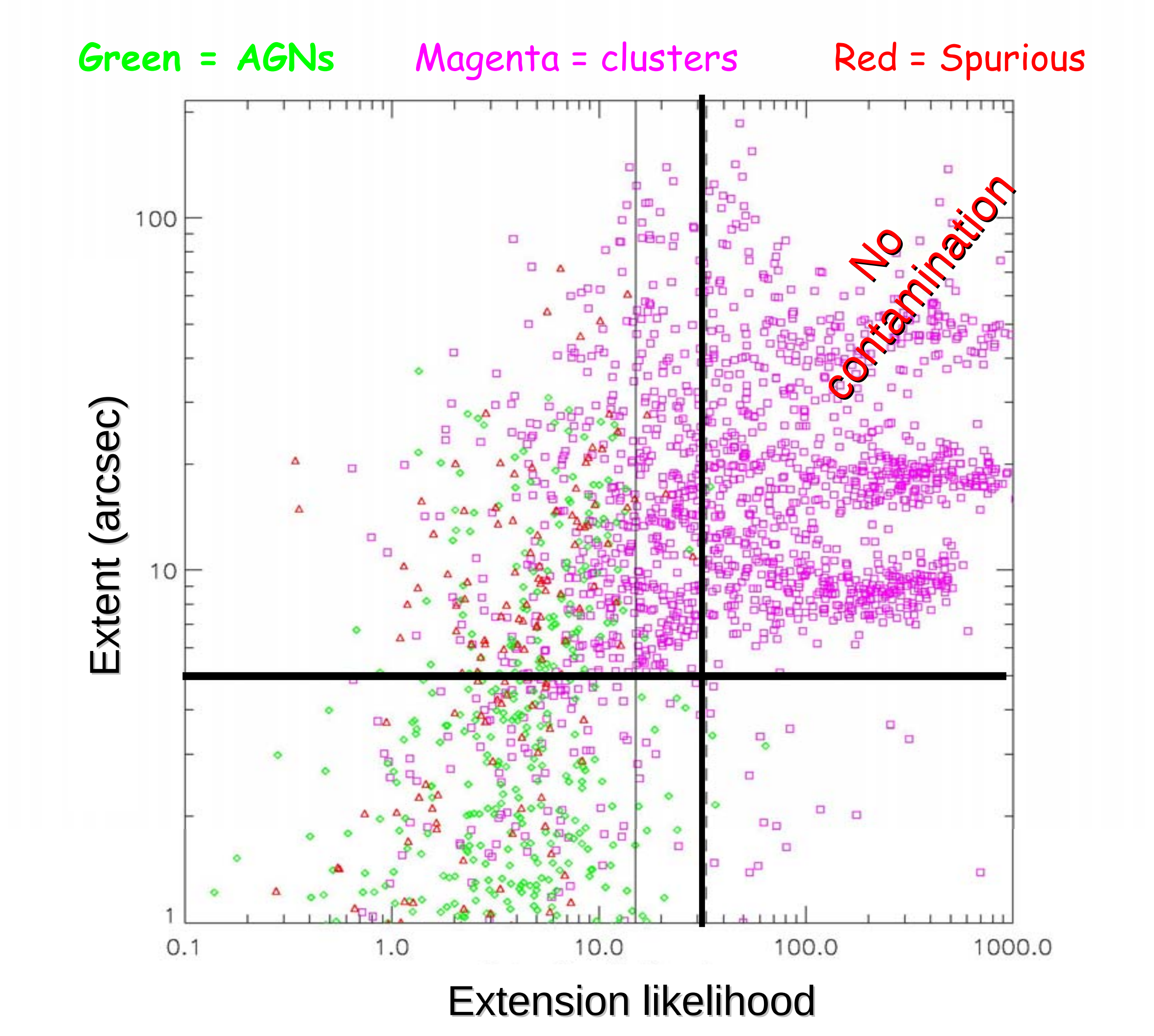
- Count-Rate and Extent
- Detection Likelihood
- Extent Likelihood
- ... etc

Designed and tested using extensive in-situ simulations

Pacaud et al 2006

The cluster selection process

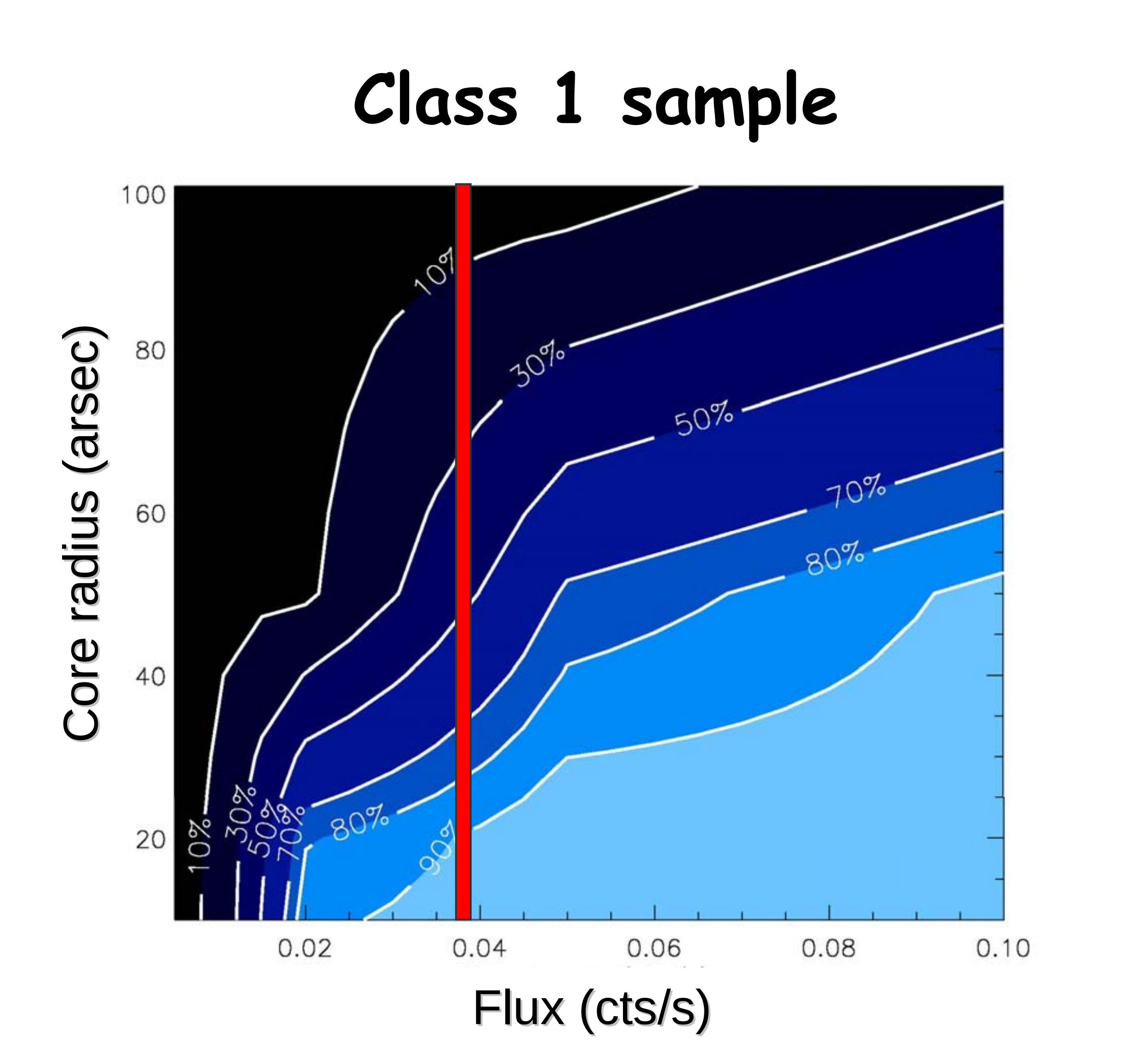
3 classes of extended sources



- Class 1 (C1):
  ~ 7/deg^2
  no contamination
- Class 2 (C2):
  ~ 5 more / deg^2
  + 5 false detec.
  50% contamination
- Class 3 (C3):
  other clusters
  15-20/deg^2

Pacaud et al 2006

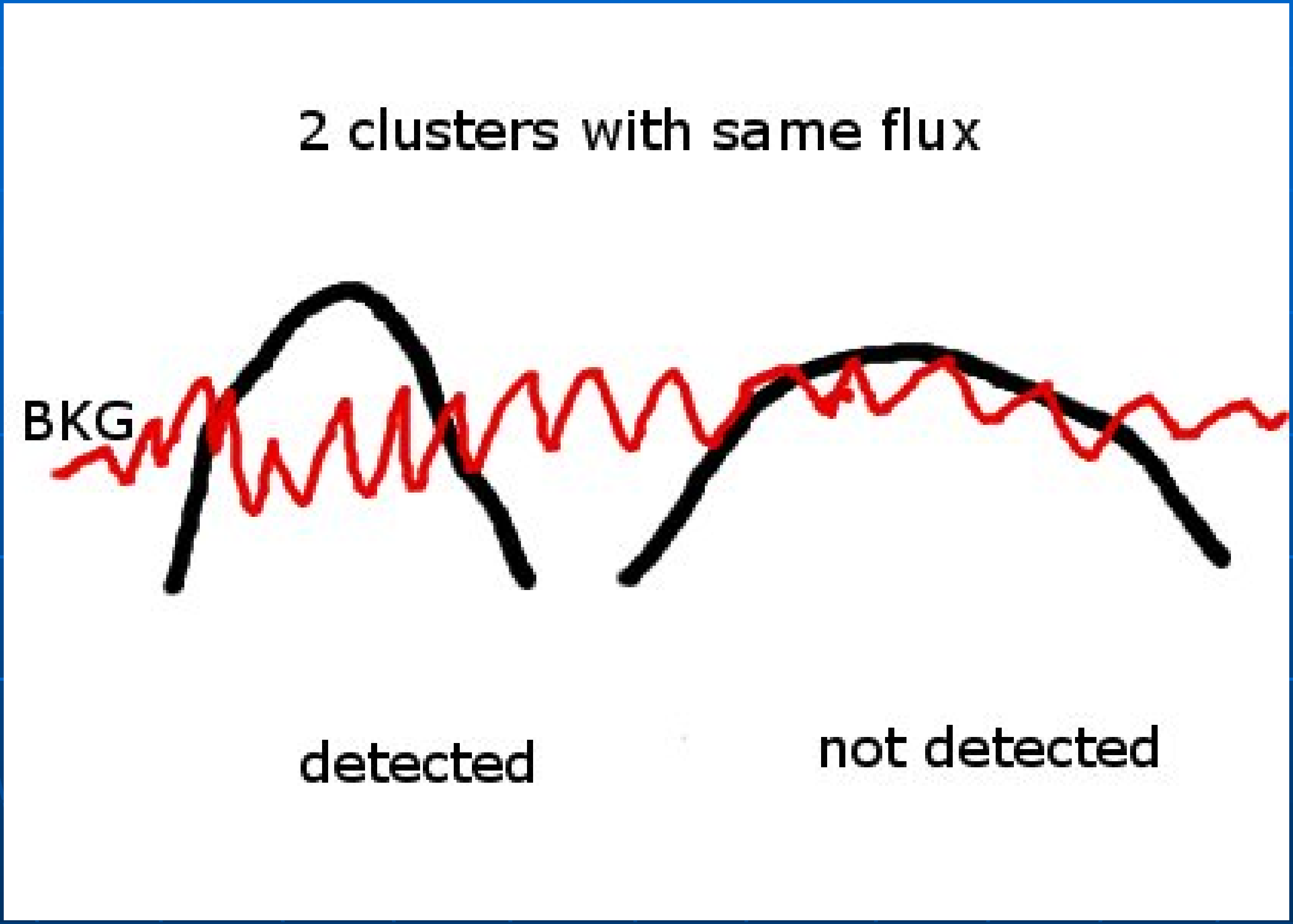
Detection rates



Not a flux limit !

Pacaud et al 2006

Not a flux limit

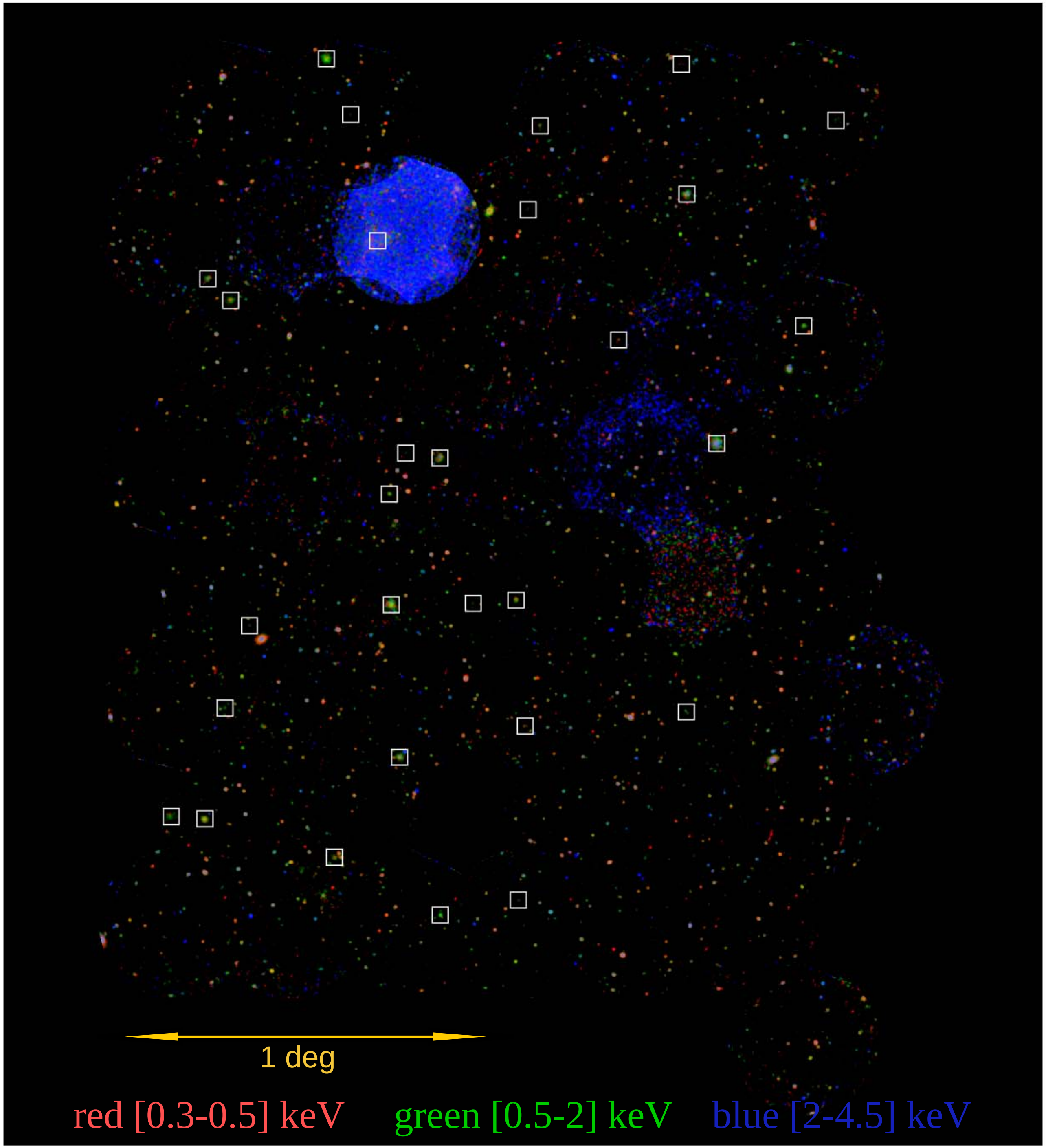


~ surface brightness limited

Constructing the sample

The C1 sample

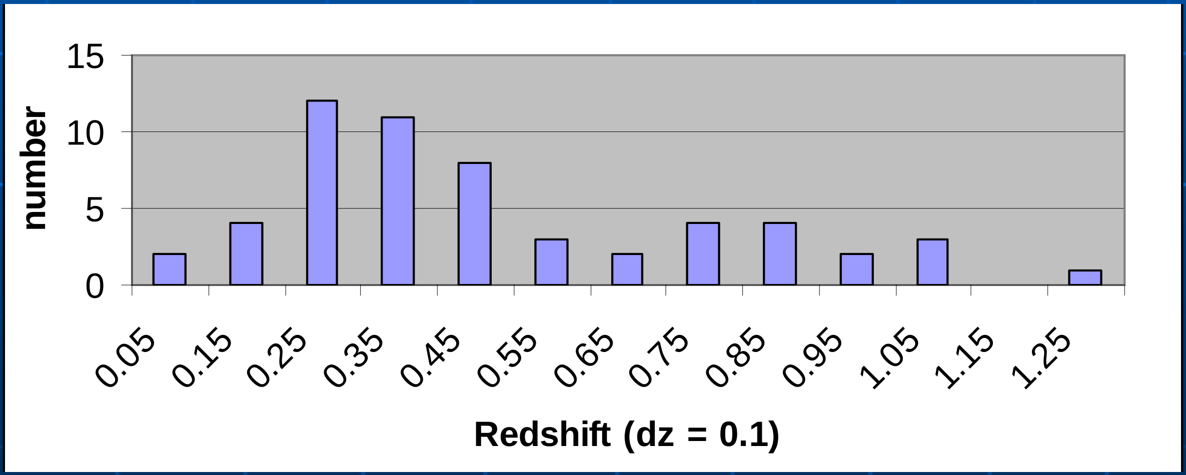
Pacaud et al, in prep.



The cluster Catalogue

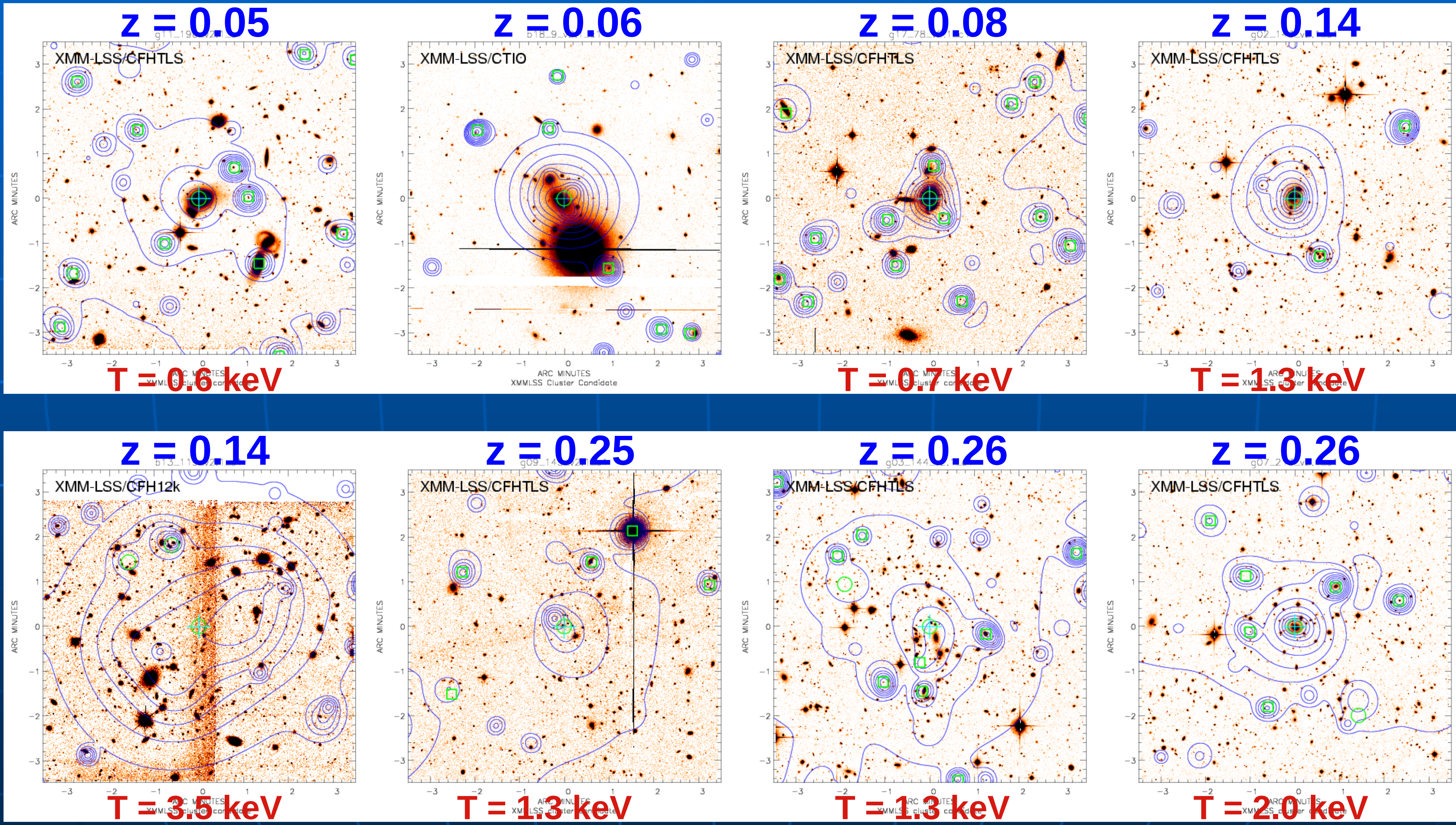
- Results over the first 5deg^2 (~4.1 usable):
  29 C1, 41 C2 candidates

- Result of 3 seasons of spectroscopic follow-up:
  (2002,2003,2004@NTT,VLT,Magellan)
  => ~ 60 confirmed clusters (26, 8)



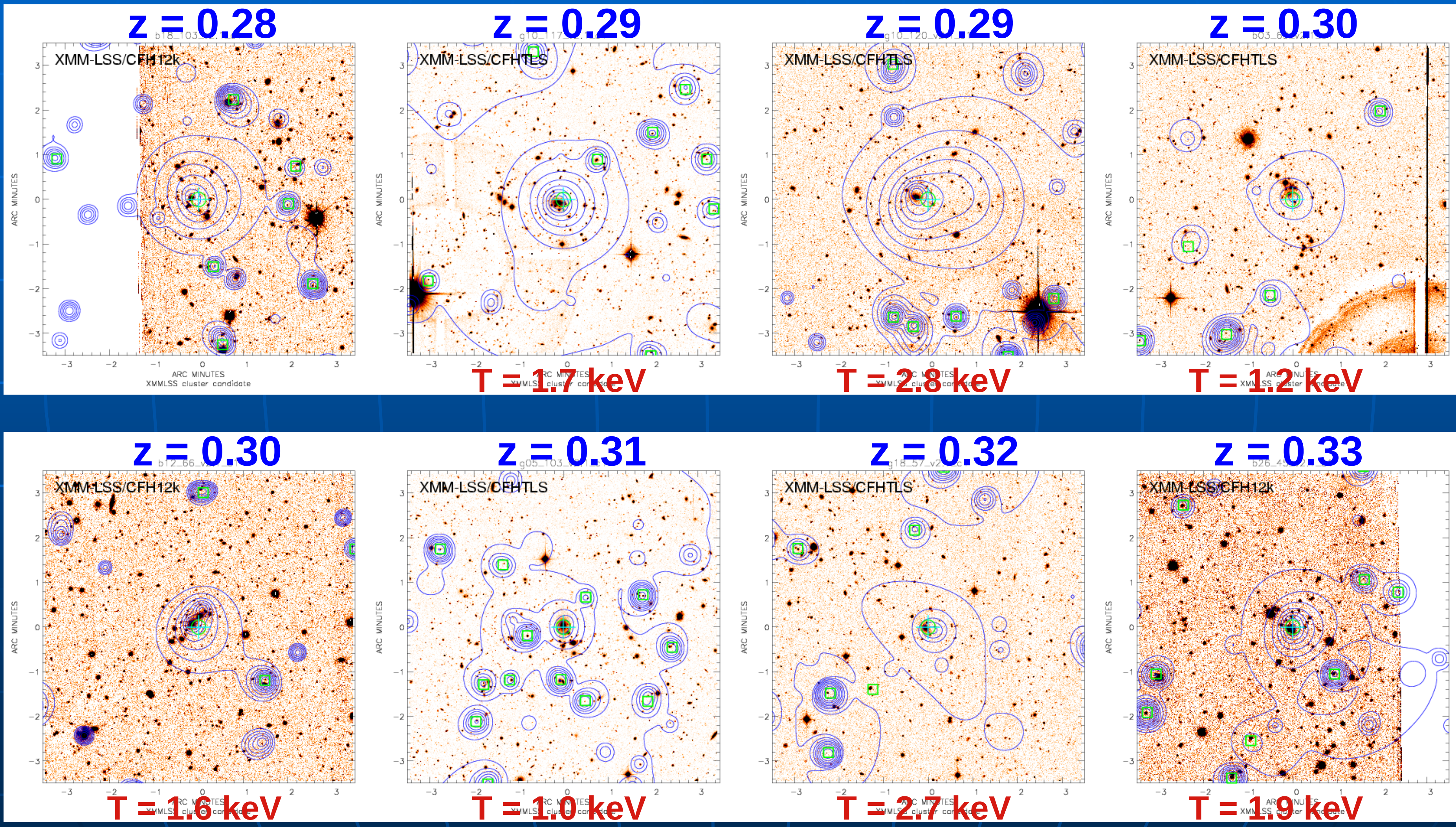
The C1 cluster sample (z < 0.3)

Small volume, high sensitivity ⇒ low T



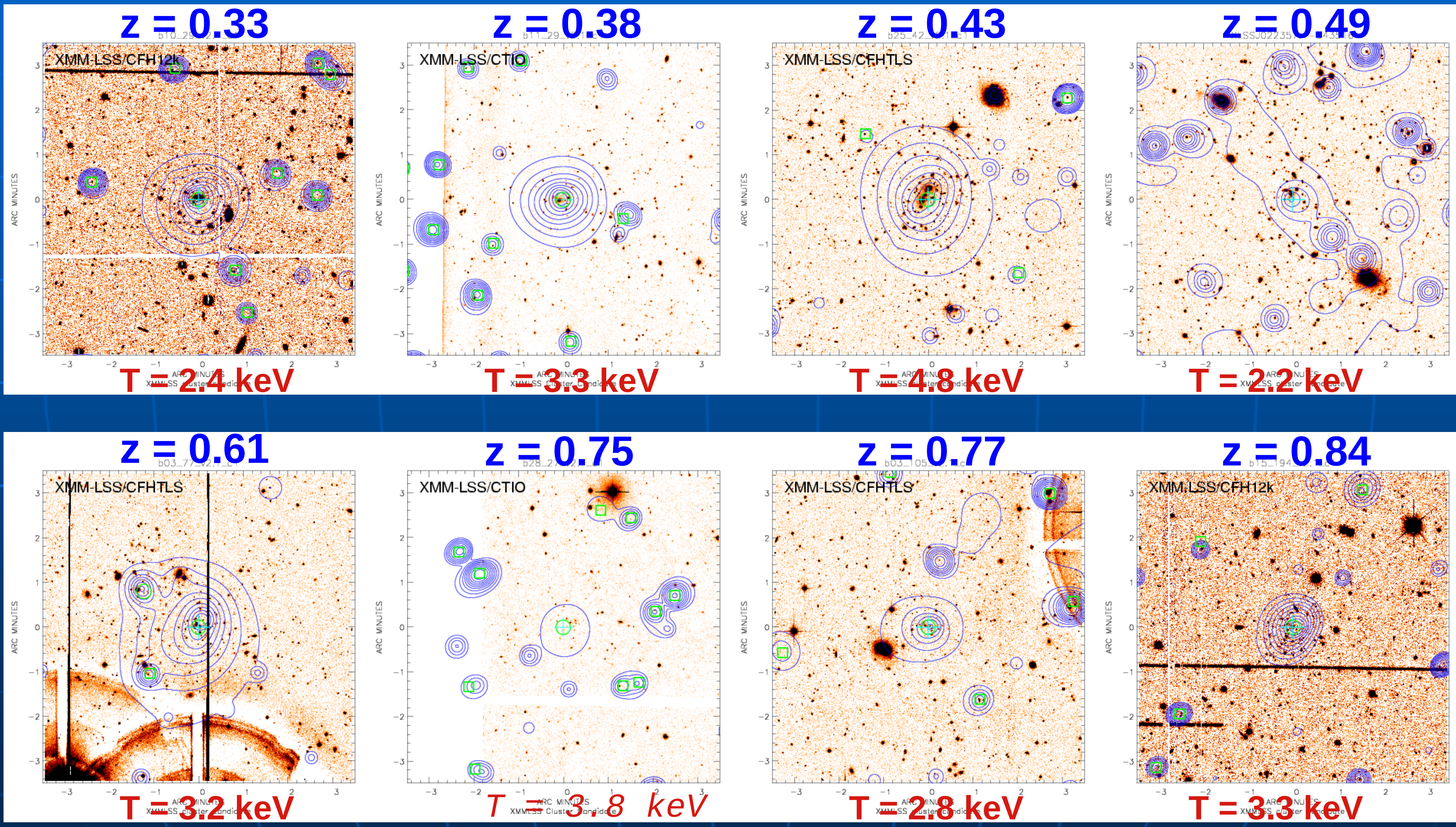
The C1 cluster sample (z ~ 0.3)

… and 1 < T < 3 keV bulk of XMM-LSS population

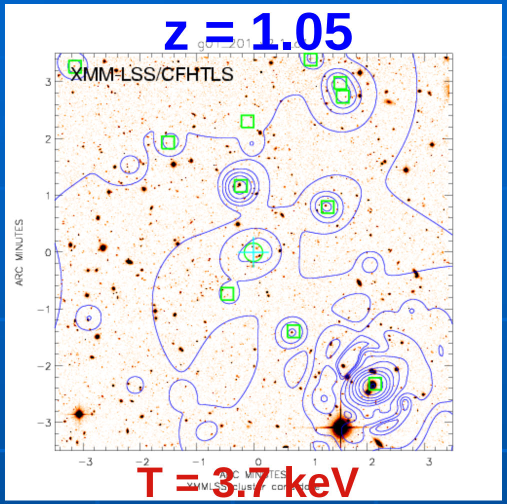


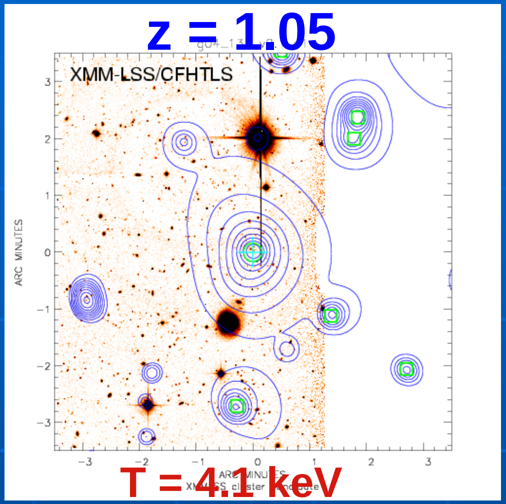
The C1 cluster sample (0.3 < z < 1.0)

… finally detecting clusters

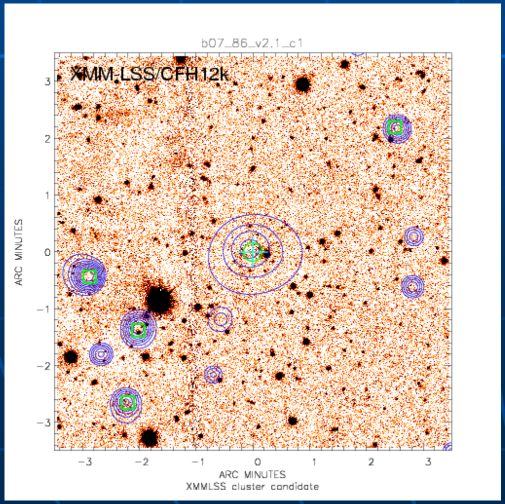


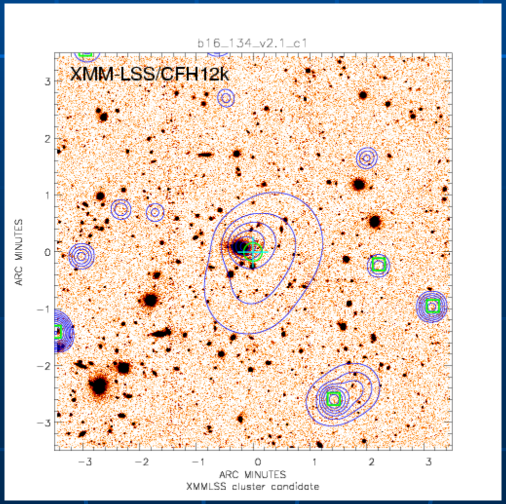
The C1 cluster sample (z > 1.0)

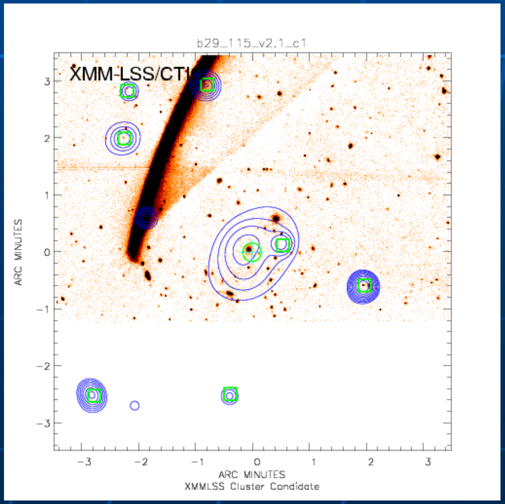




Pending sources …



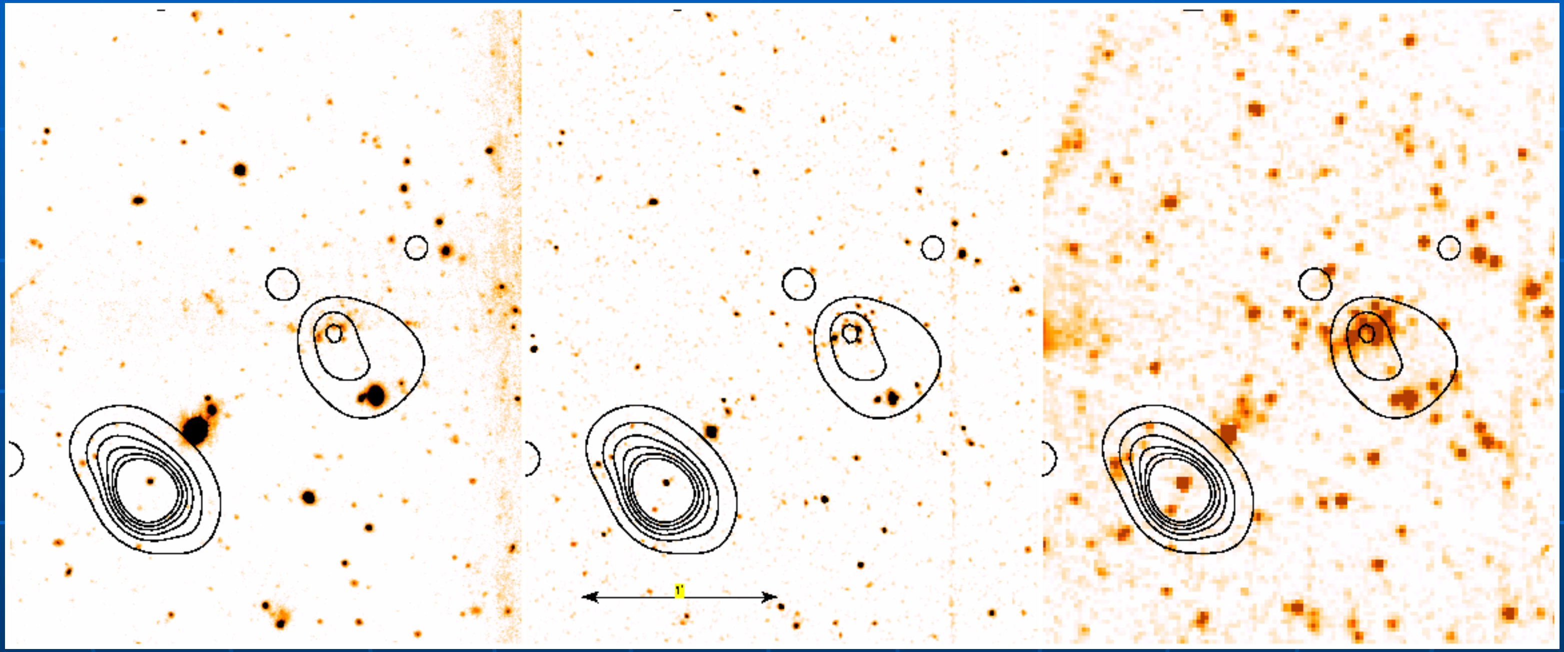




Distant cluster search (example)

measured z = 1.22

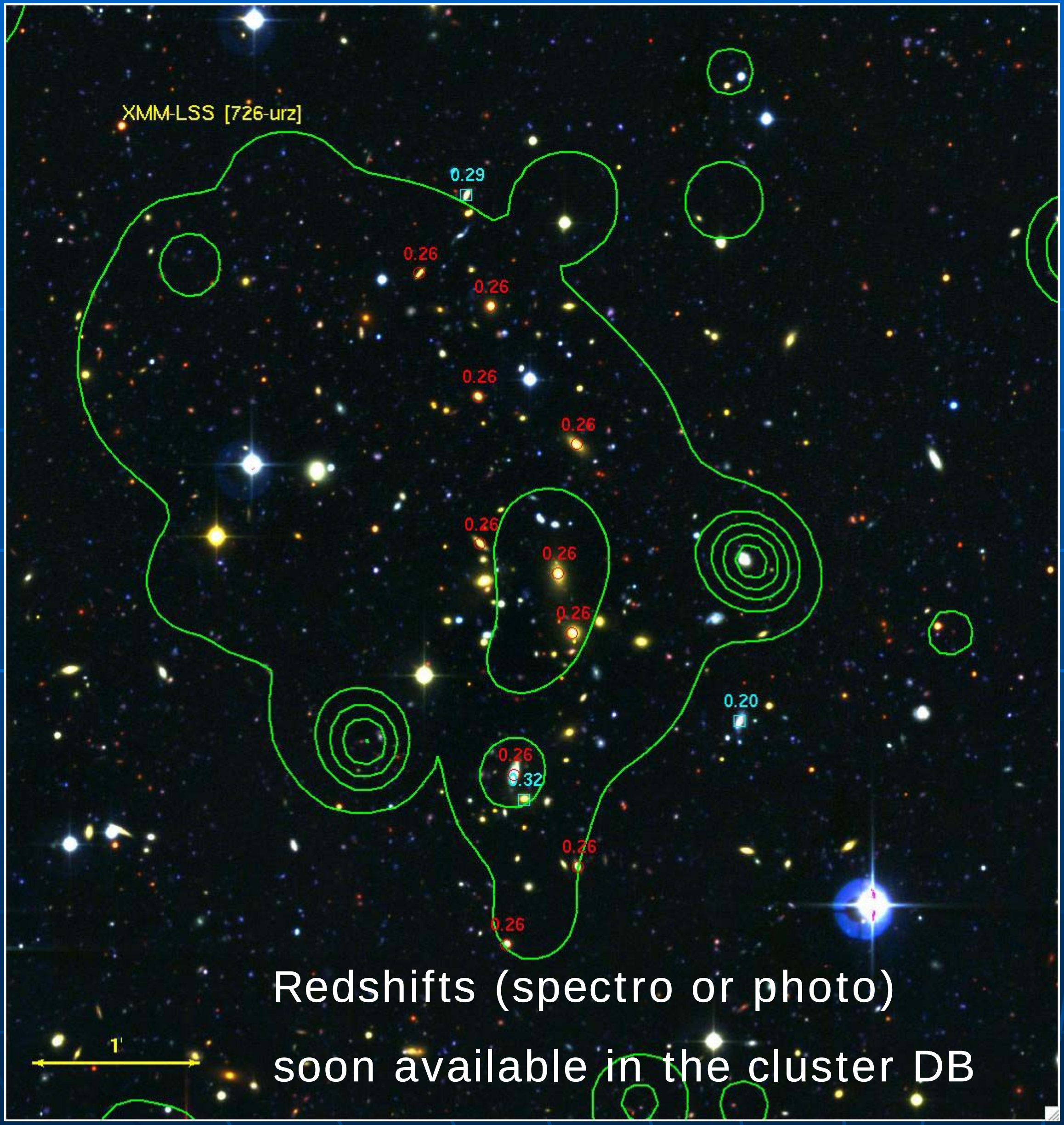
XLSSC-046 (C2)



I (CFHT) K (NTT) 3.6 μm(Spitzer)

Bremer et al 2006

The cluster DB : L3SDB



Redshifts (spectro or photo) soon available in the cluster DB

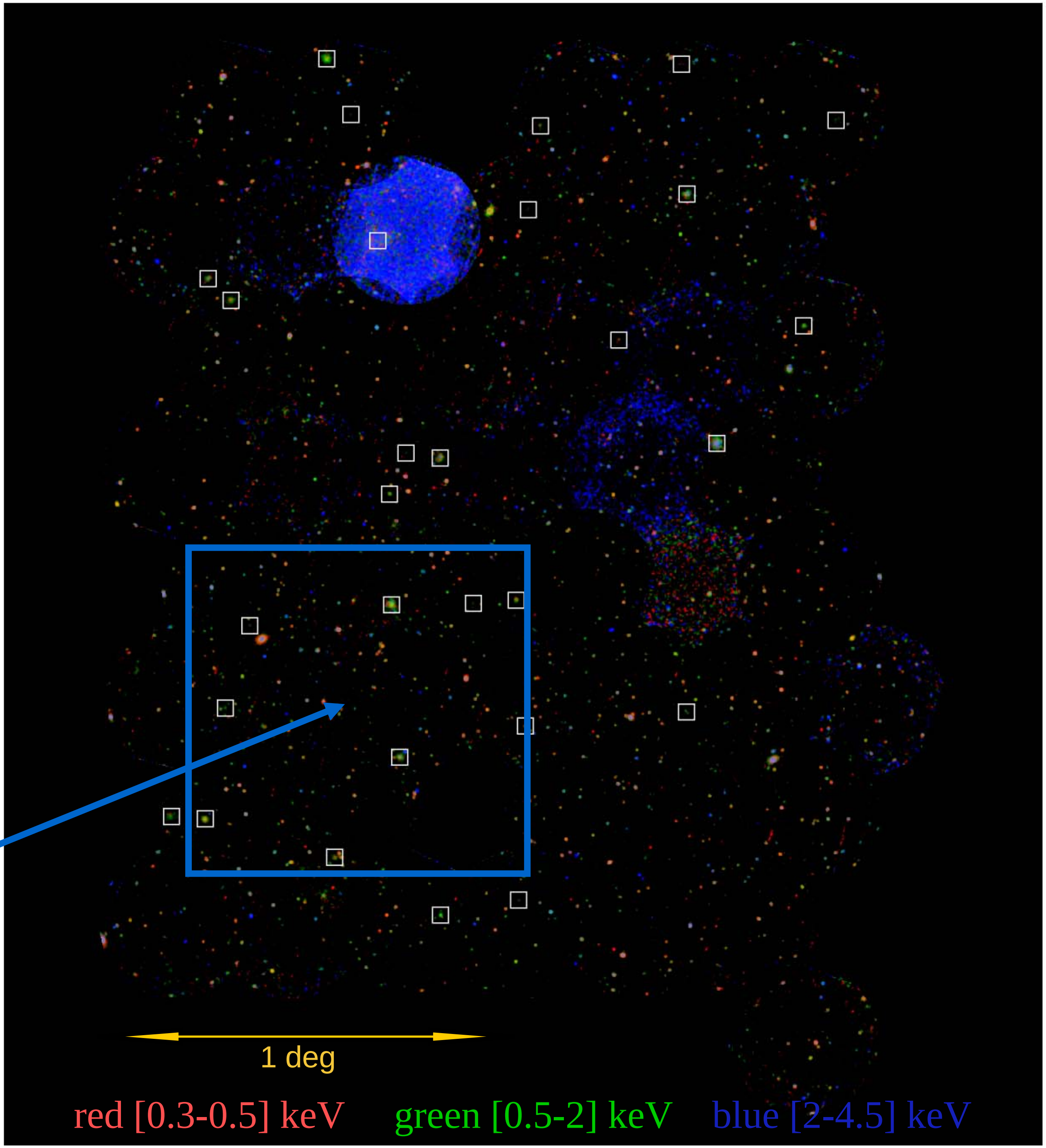
AVAILABLE NOW

- -X-ray images
- -CFHTLS images
- -X-ray spectra
- -X-ray profiles
- - Cluster redshifts

Constraining the cluster scaling laws

The D1 area

Here !



The D1 sub-sample

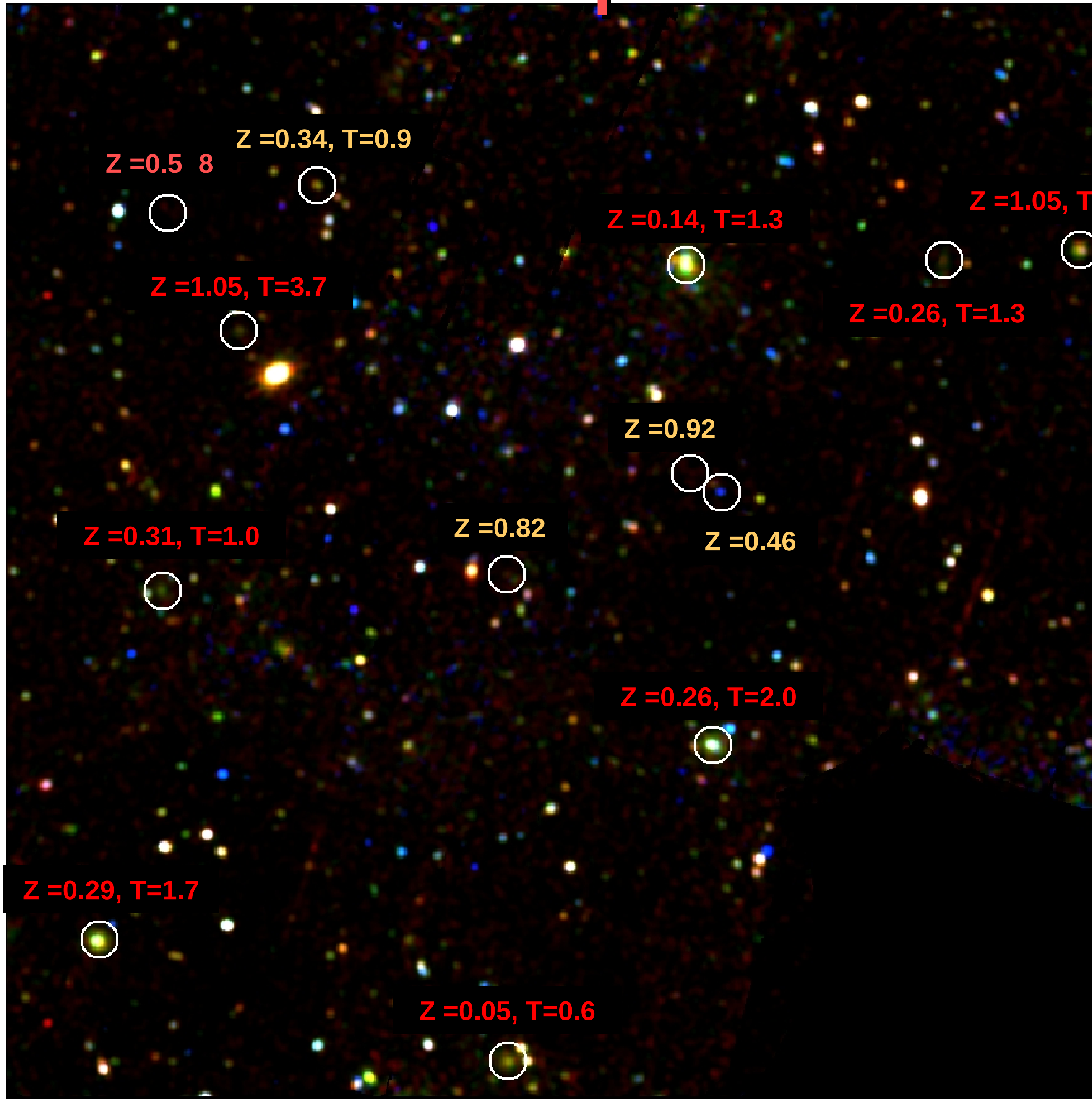
1 deg^2 - 20ks
CFHTLS Deep
VVDS

8 C1

1 C2

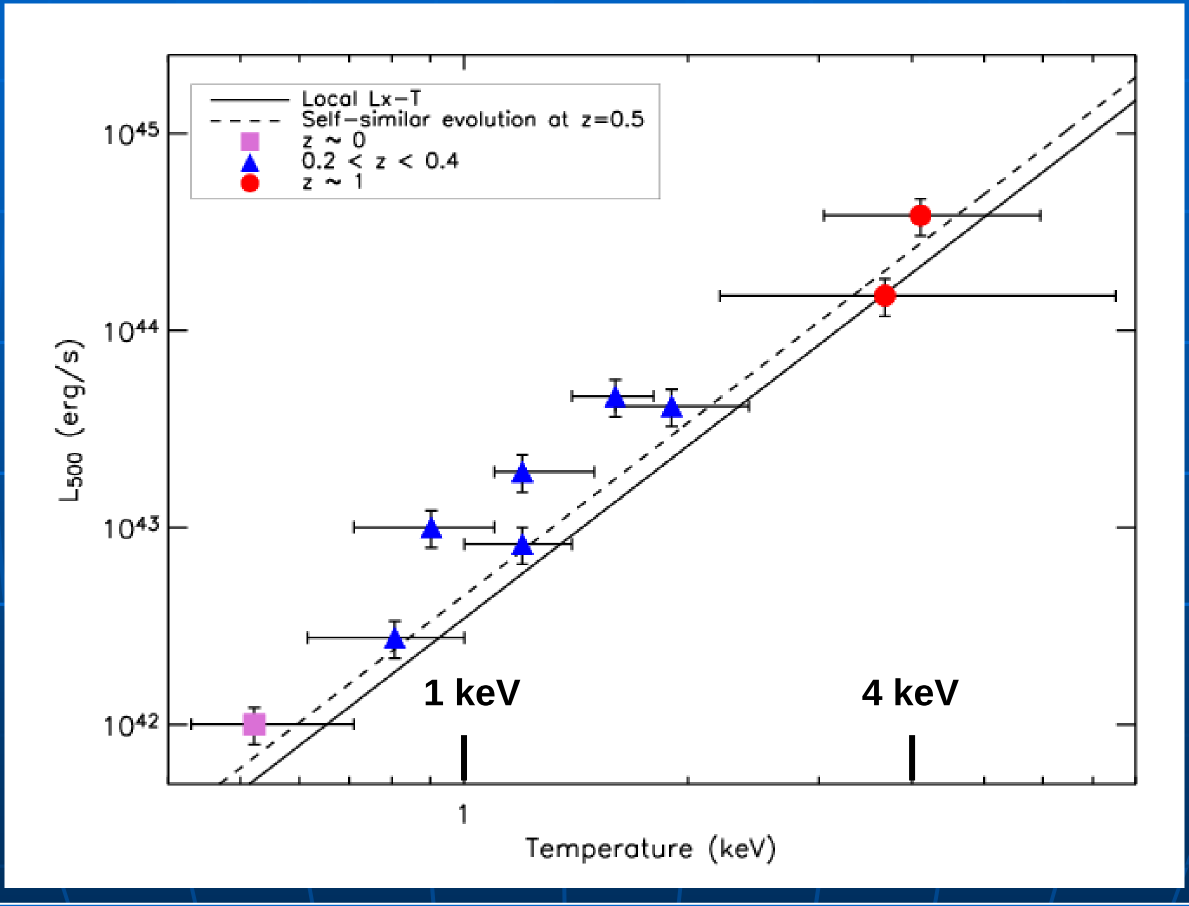
4 C3

Pierre, Pacaud, Duc et al. 2006



The D1 L-T relation

The first L-T relation for intermediate redshift groups



L-T at z=0

L-T at z=0.5 (self-similar evolution)

Pierre, Pacaud, Duc et al. 2006

Cosmological modelling

Cosmological modeling

- ΛCDM + P(k) (WMAP+BBKS)
- Mass Function (Sheth & Tormen 1999)
- Halo profile model (NFW 1995 + Bullock et al 2001)
- M_{500}-T relation (Arnaud et al 2005)
- L-T relation (Arnaud & Evrard 1999)

+

- Redshifted plasma model (APEC)

$\Rightarrow$ Fluxes (M,z)

- Convolution with XMM response

$\Rightarrow$ Count-rate

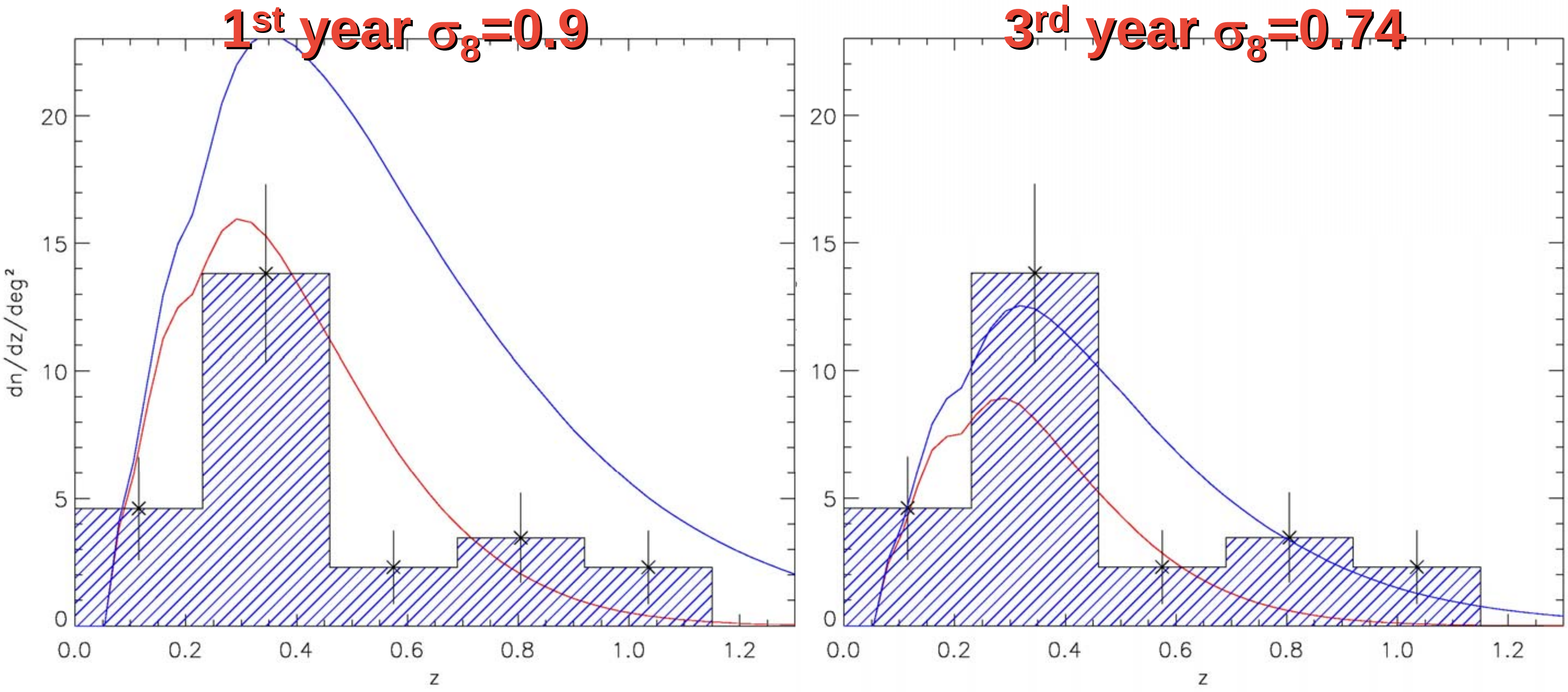
- β-profile (β=2/3 and Rc=180kpc)

$\Rightarrow$ Folding with simulated detection rates

... and finally dn/dz !

The C1 redshift distribution

… compared with WMAP 1st and 3rd year



Self-similar evolution

No scaling evolution

Pacaud, Pierre, 2006 subm.

FUTURE

Insights from other wavelengths:

Weak lensing

Sunyaev-Zel'dovich effect

S-Z observations of the XMM-LSS field

- APEX-SZ survey :
  - Resolution: 50'' @ 150 GHz
  - Coverage: 4 clus./deg^2 over the whole field
  - Sensitivity: 10μK (y = 5.10^{-4} arcmin^2)
- OCRA :
  - Resolution: 70'' @ 30 GHz
  - Coverage: pointed observations
- AMIBA (interferometer):
  - Resolution: ~ 10'' @ 95 GHz
  - Coverage: pointed observations

All about to start !

Combining wavelengths

- Joint analysis of number density and space distribution of clusters using X, S-Z, and optical methods

  (i.e. with differing selection process)

- Use the joint X-ray/S-Z data sets to get insights into the evolution of the ICM physics

- Get mass information from the weak lensing survey on the CFHTLS data

- **The redundancy between the various observables allows:**
  - **Calibration of the mass-observables relations**

    AND
  - **Constraints on the cosmology**

Conclusions

Summary I

- With 10^4s d'XMM we detect ~ 12 clusters/deg^2
  - ~ 3 times more than with the ROSAT DS
  - Soon ~120 amas in the SWIRE region (10deg^2)
  - Cosmological constrains from the cluster distribution out to z~1

- We detect the group population at $0.3 < z < 0.5$ for the first time
  - building blocks of the z~0 clusters
  - The L-T relation provides major information on baryon physics

Summary II

For the first time, self calibration of a cluster survey:

- Flux limit is no longer viable
  - The class system allows us to control larger samples
- We abandon the F(L) evolution approach
- We model the observed n(z) from P(K)

Further multi-λ studies including:

- APEX-SZ
- CFHTLS weak lensing

➔

- Improved understanding of the ICM Physics
- Toward a precision cosmology

Summary III : CFHTLS contribution to cluster studies

- CFHTLS is necessary to identify the XMM and APEX cluster detections
- Cluster photo-z are mandatory for any further study

  CFHTLS is very promising

  (cf H. Aussel)
- CFHTLS weak lensing mass information is essential for cosmology

Recent cluster publications

- The XMM-LSS survey: The X-ray pipeline and the survey selection function
  Pacaud et al., 2006, MNRAS 372, 578

- The XMM-LSS survey: A complete X-ray sample over the D1 CFHTLS area
  Pierre et al., 2006, MNRAS 372, 591

- The XMM-LSS survey: the C1 cluster sample and its cosmological applications
  Pacaud et al (subm.)

All cluster data available at L3SDB : http://l3sdb.in2p3.fr:8080/l3sdb

PART II

The 90% remaining point-sources

On-going activities

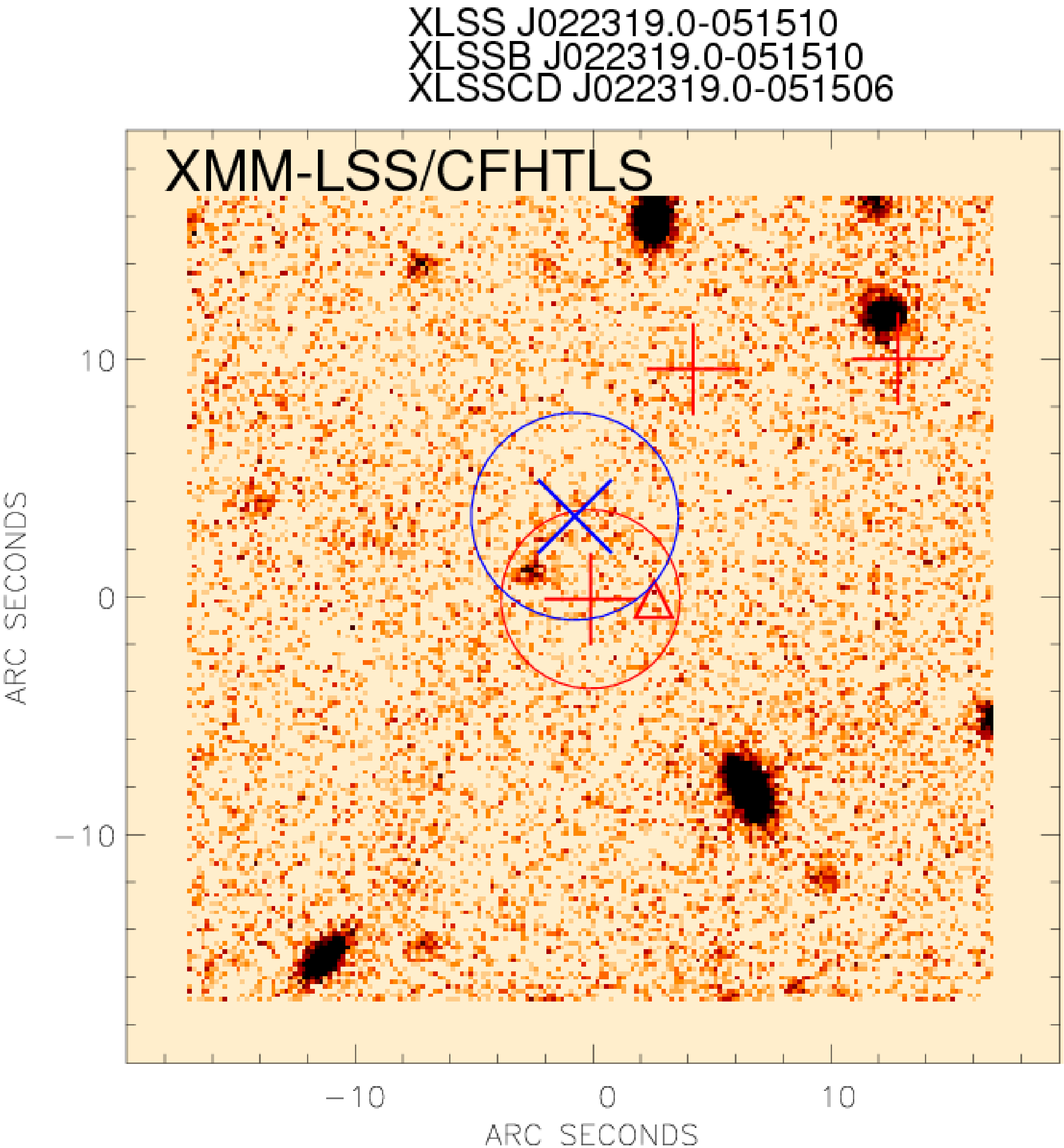
- Multi-λ studies : XMM/SWIRE/CFHTLS
- Angular correlation

The W1 XMM-LSS/CFHTLS catalogue

- XMM source lists in 2 bands:
  - [0.5-2] & [2-10] keV
  - 3300 sources
- Band-merged catalogue
- Full X-ray images

- CFHTLS associated data for each source
  - within 6”: u,r,g,i,z catalogue
  - 40”x40” stamp image

- **SWIRE/CFHTLS catalogue : public!**



XMM-LSS / CFHTLS STAMPS

+ soft sources

x hard sources

Recent AGN publications

- The XMM Large-Scale Structure Survey: properties and two-point angular correlation of point sources

  Gandhi et al., 2006, A&A 457, 393

- Obscured and unobscured ANG in a hard subsample of the XMDS survey

  Tajer et al (subm.)

- The XMM-LSS catalogue: X-ray sources and associated optical data

  Pierre et al (subm.)

All X/optical data available in Milano :

http://cosmos.iasf-milano.inaf.it/~lssadmin/Website/LSS/Query/

FIN