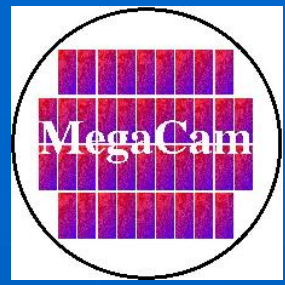
The XMM-LSS cluster sample and its cosmological applications



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The XMM-LSS survey: the First Class cluster sample over the initial 5 deg^2 and its cosmological modelling ∗

F. Pacaud[1,15]†, M. Pierre[1,15], C. Adami[2], B. Altieri[3], S. Andreon[4], L. Chiappetti[5], A. Detal[6], P.-A. Duc[15], G. Galaz[7], A. Gueguen[1], J.-P. Le Fèvre[8], G. Hertling[7], C. Libbrecht[6], J.-B. Melin[9], T. J. Ponman[10], H. Quintana[7], A. Refregier[1,15], P.-G. Sprimont[6], J. Surdej[6], I. Valtchanov[3], J. P. Willis[11], D. Alloin[15], M. Birkinshaw[12], M. N. Bremer[12], O. Garcet[6], C. Jean[6], L. R. Jones[10], O. Le Fèvre[2], D. Maccagni[5], A. Mazure[2], D. Proust[13], H. J. A. Röttgering[14], G. Trinchieri[4]

Cosmological interpretation of cluster samples

TOOLS: dn/dz, 2-pt correlation function ...

-1- Whatever the detection wavelength:

- The samples must be complete and uncontaminated
- The selection function must be well understood

-2- Evolution of cluster [physics] plays a key role in the detectability of [X-ray] clusters

➔ Detailed simulations are necessary

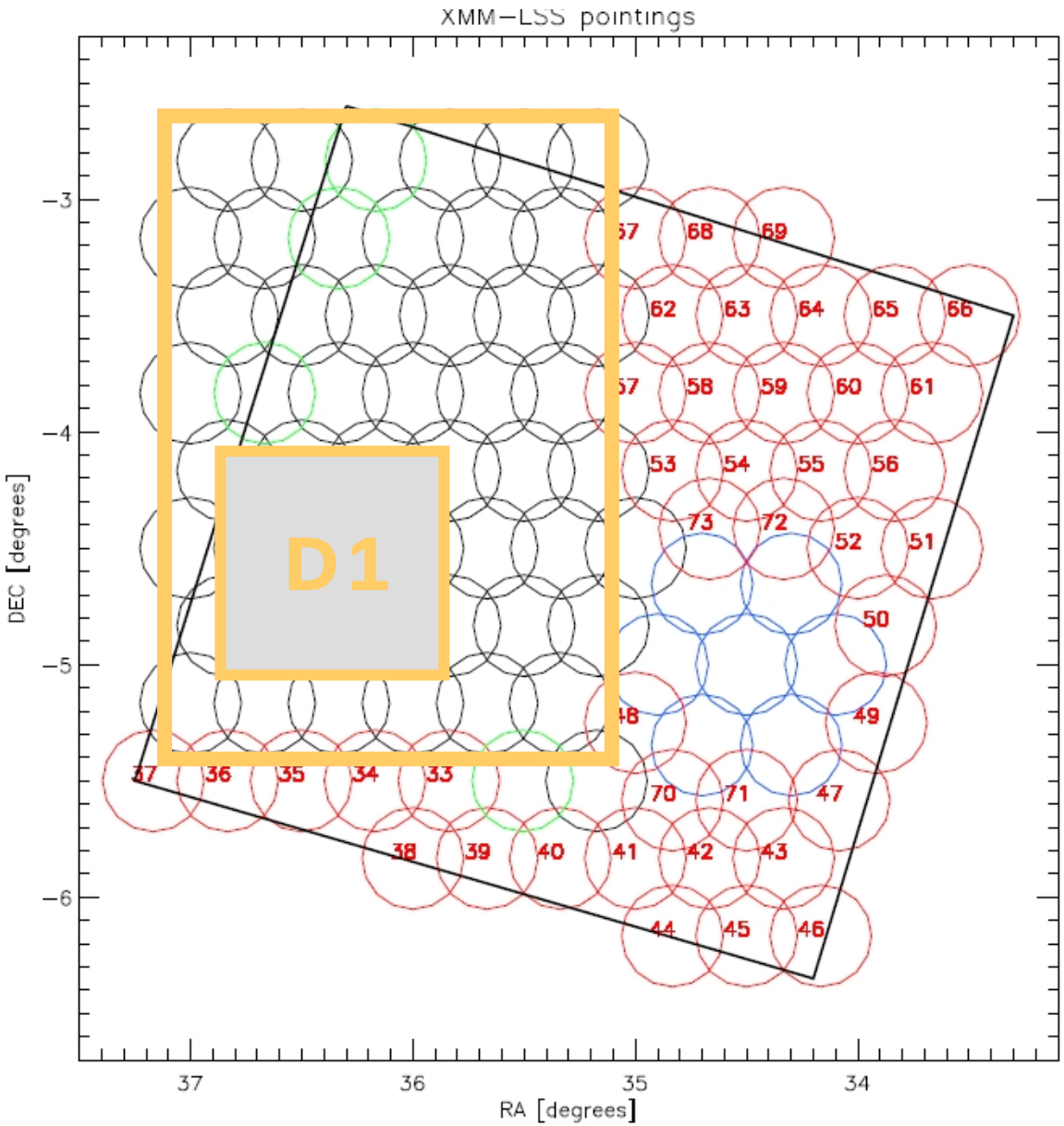
Plan of the talk

1. The XMM-LSS survey
2. Cluster detection and the selection function
3. The sample and its cosmological interpretation
4. XMM-LSS is also ~ 3000 AGN in multi-λ
5. Public releases
6. The future

1. The XMM-LSS survey

The XMM-LSS/CFHTLS/SWIRE 10 deg2 field :

an XMM Large Programme



W1 CFHTLS field

72 x 10 ks (GO)

19 x 20 ks (GT)

7 x 50 ks (SDS)

Square =

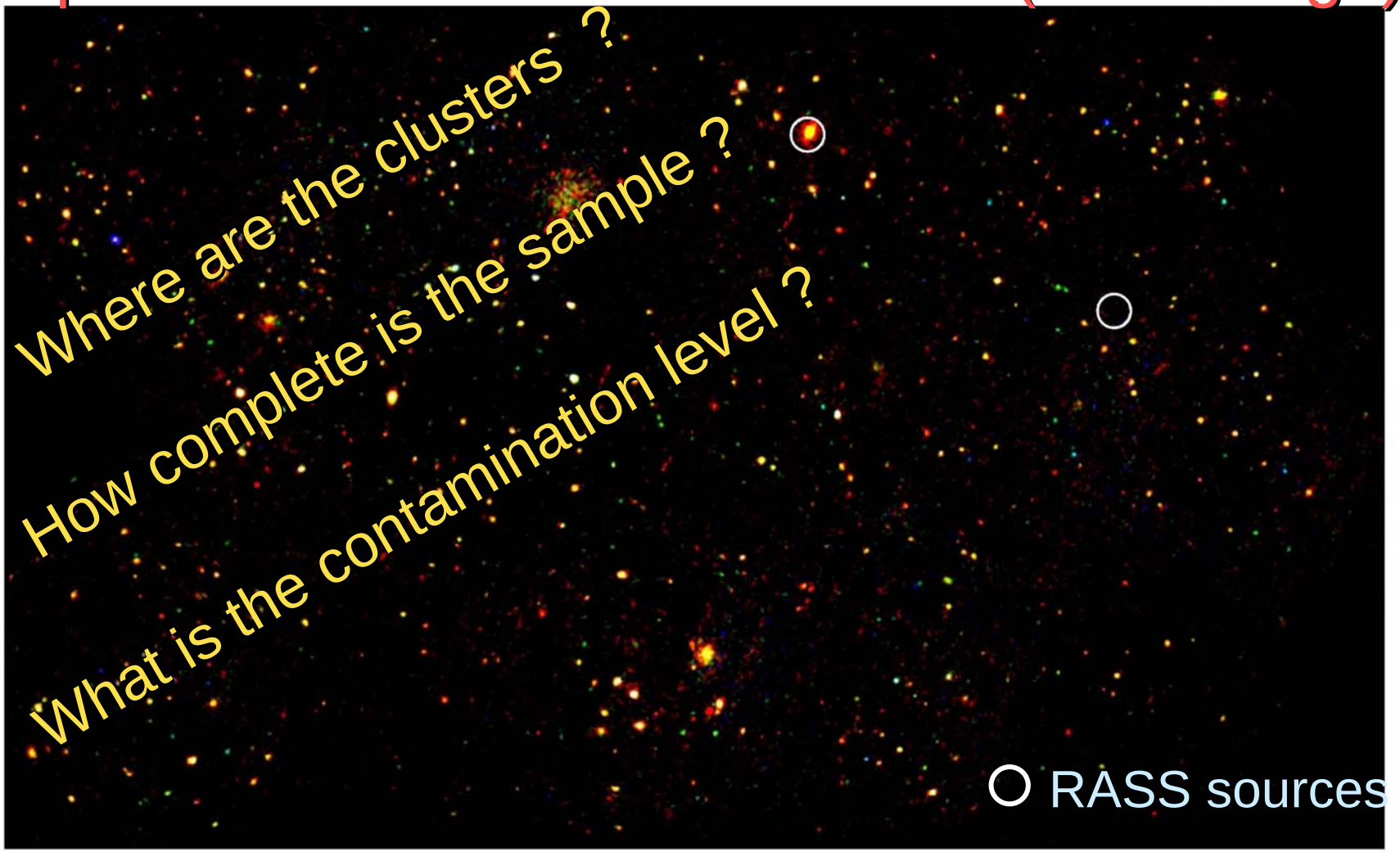
SWIRE 10deg2 field

UKIDSS, Herschel

Scuba 2 Legacy

VLA, INTEGRAL,GALEX

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

2. Cluster detection and the survey selection function

The problem of cluster detection

For z in [0.1-1], 20'' < Rc < 100''.

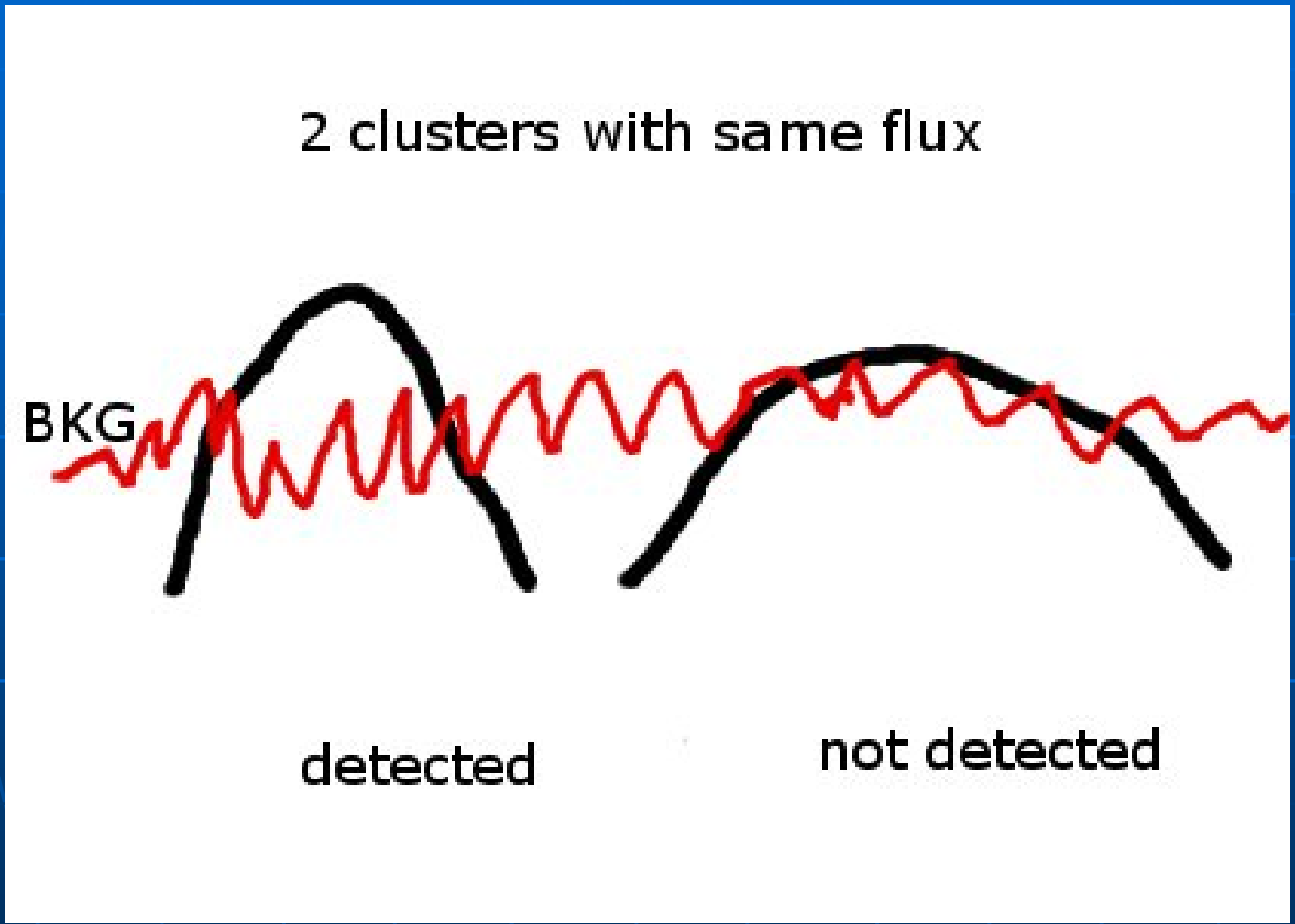
$\Rightarrow$ Detecting extended sources (PSF ~ 6'')

Clusters have 50-500 photons

$\Rightarrow$ Detection is a very specific task :
we are in the Poisson regime.

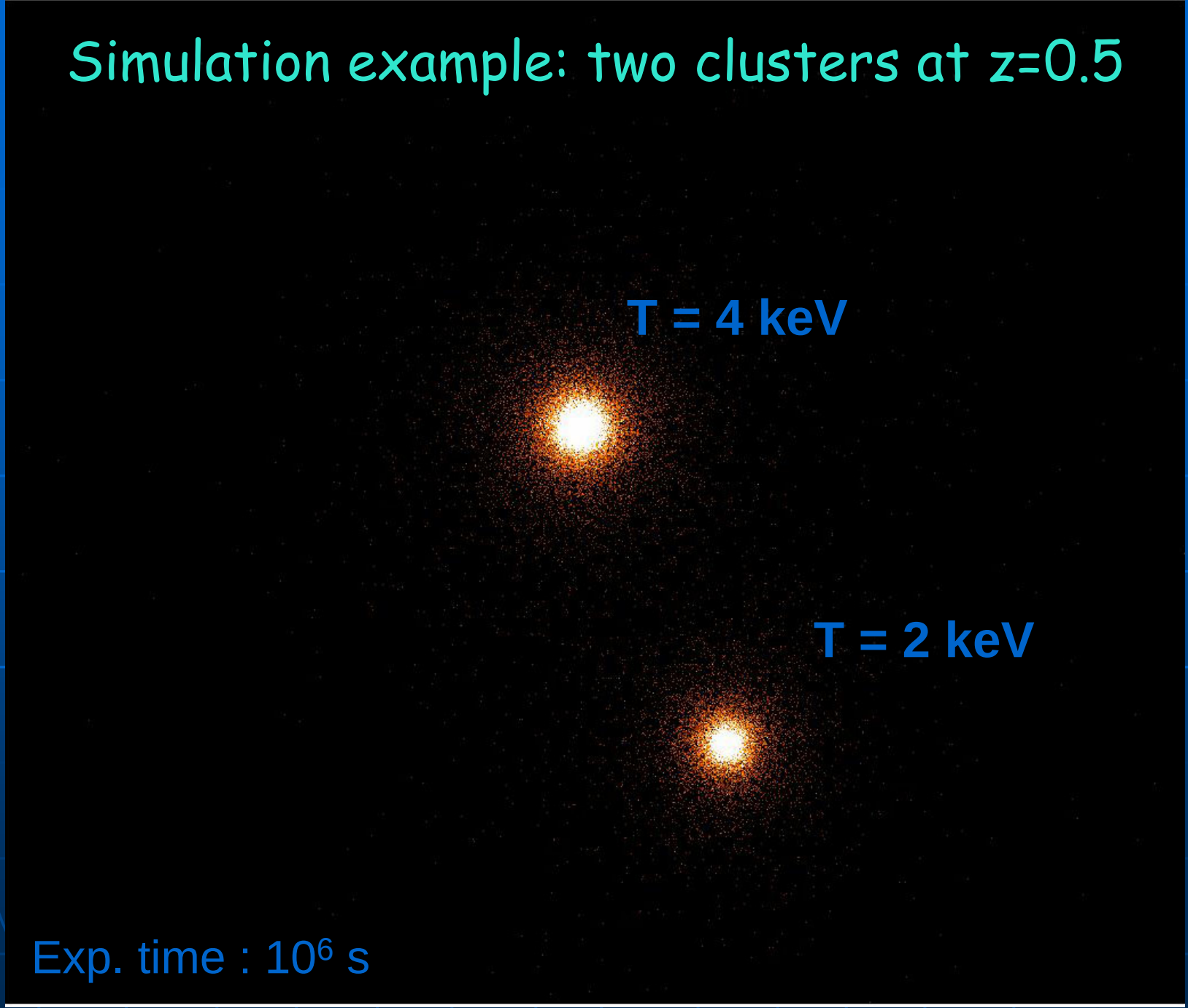
For XMM-LSS: no confusion problem

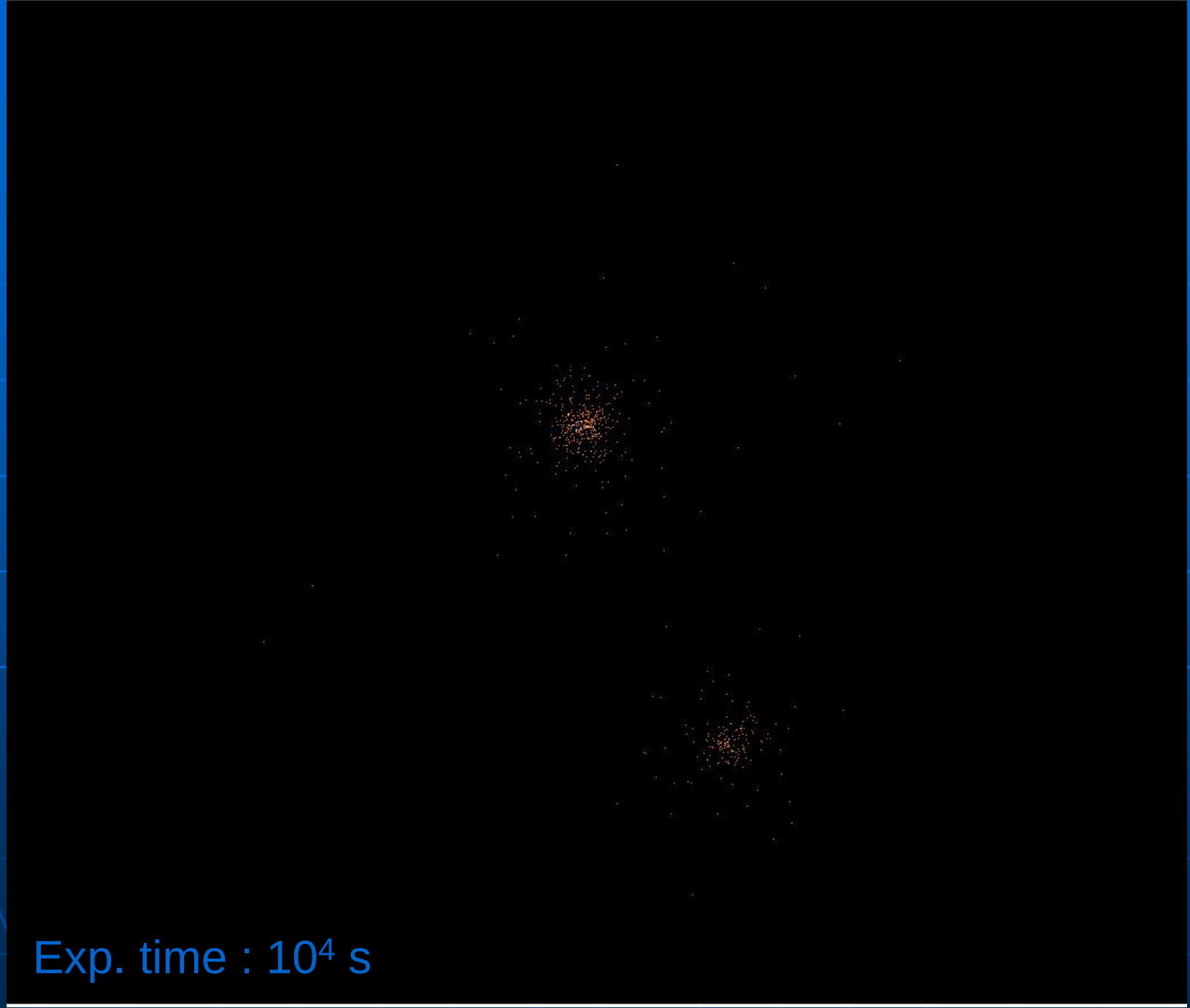
Not a flux limit



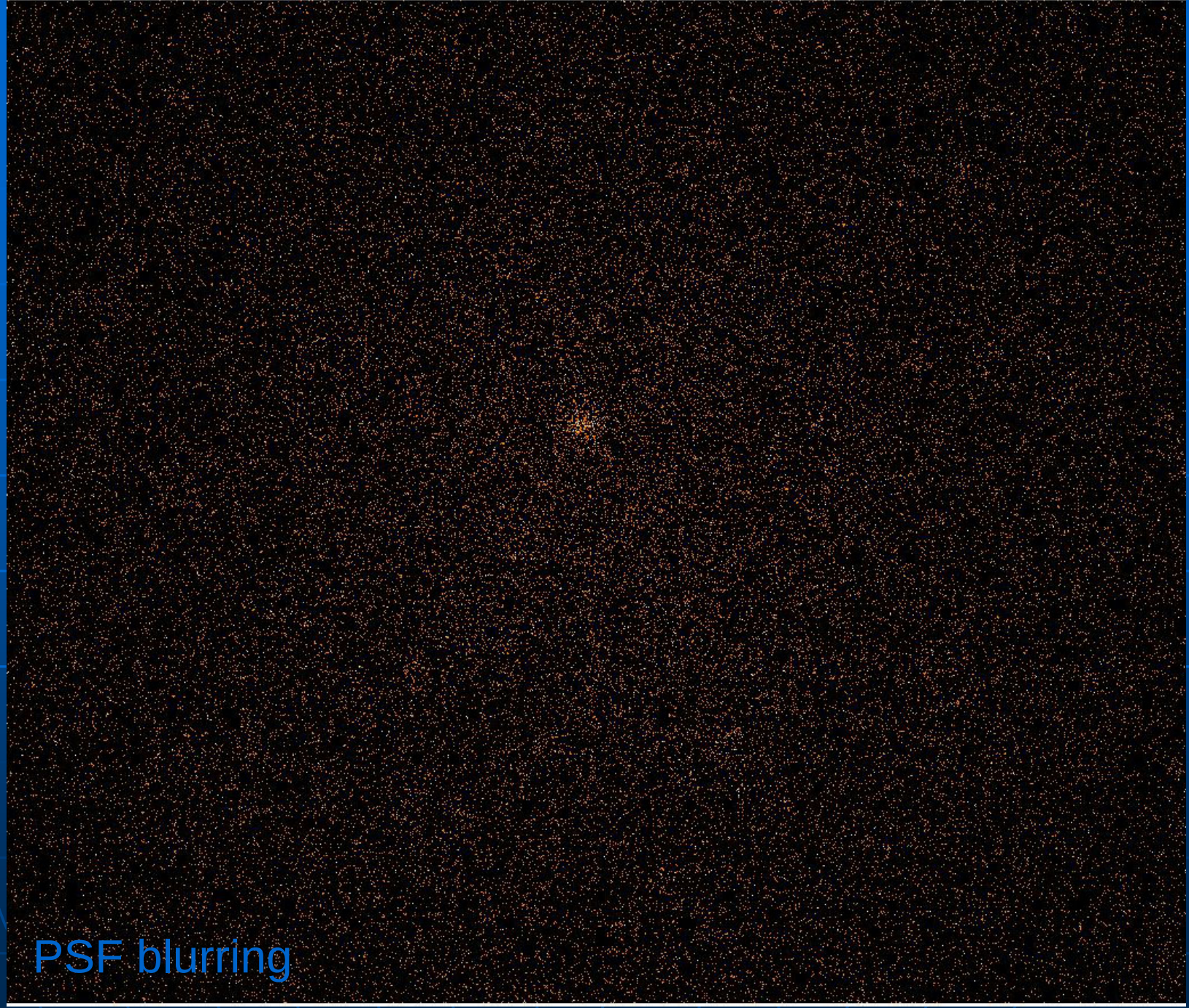
~ surface brightness limited

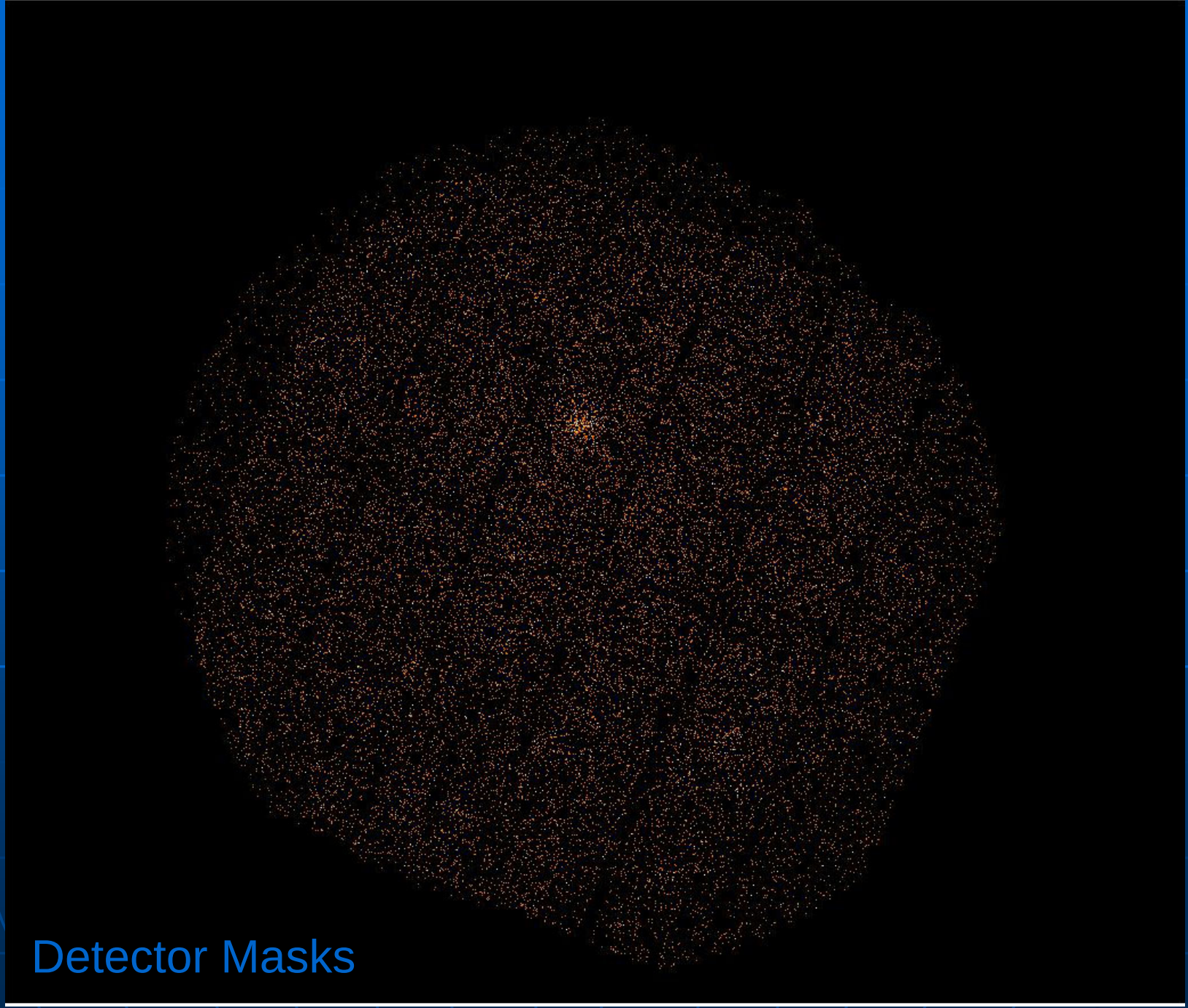
Simulation example: two clusters at z=0.5



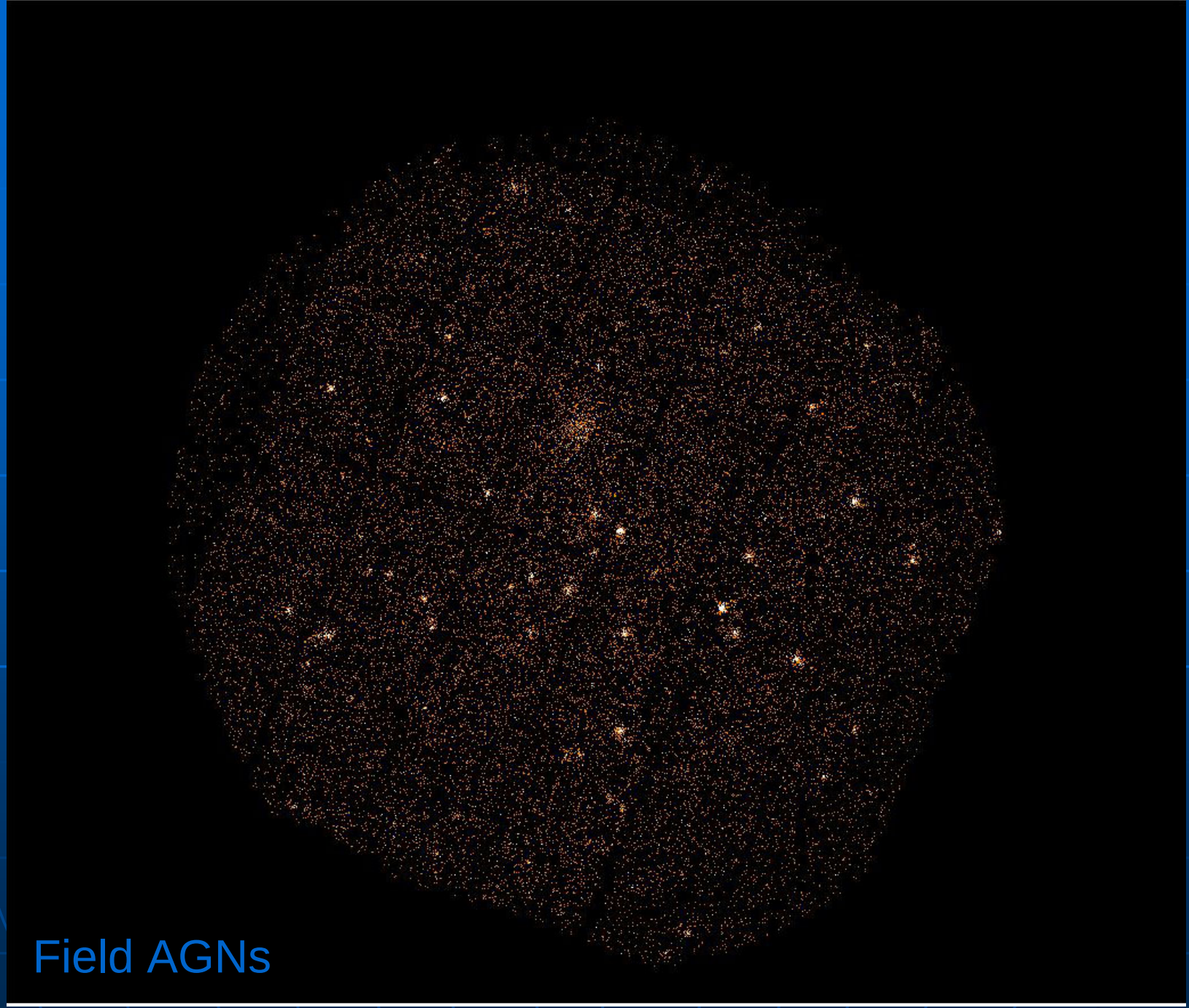

Exp. time : 10^4 s


Particle and photon background


PSF blurring



Detector Masks



Field AGNs

The 2-step 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

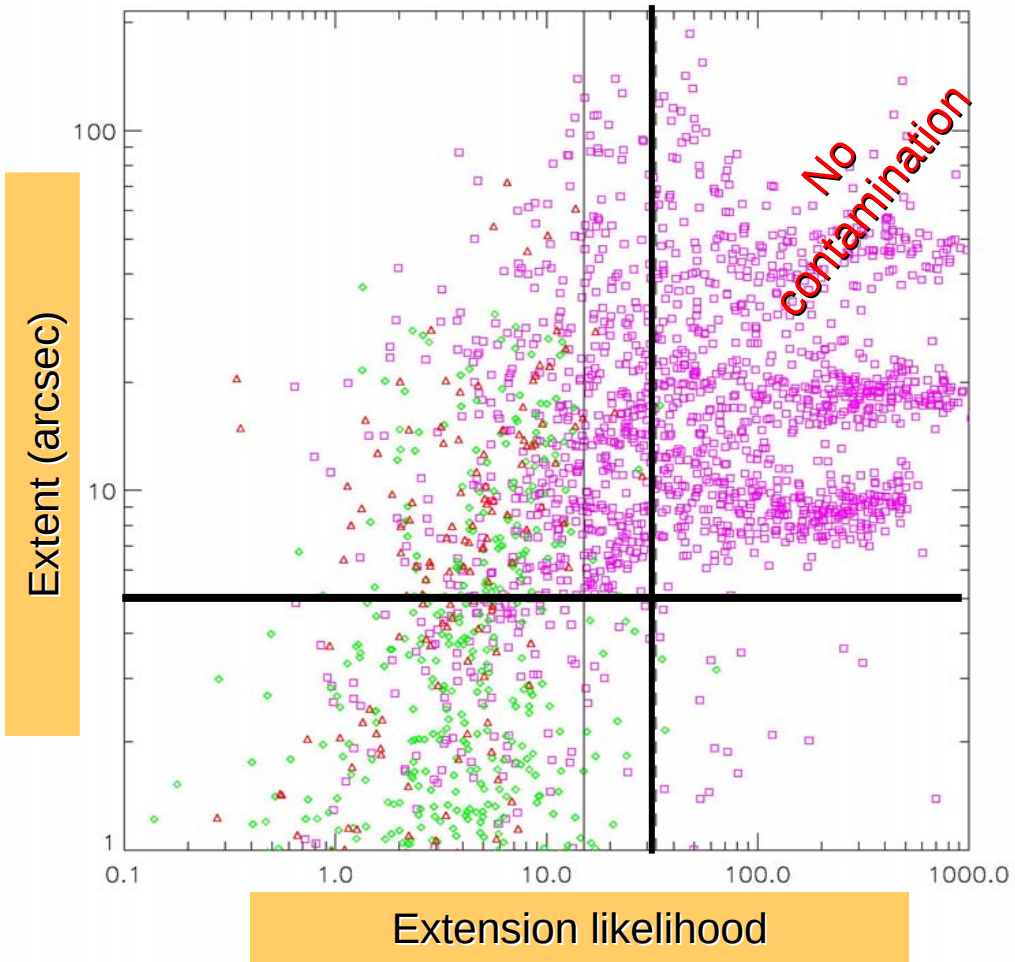
Designed and tested using extensive in-situ simulations

Pacaud et al 2006

The cluster selection process

3 classes of extended sources

Green = AGNs Magenta = clusters Red = Spurious

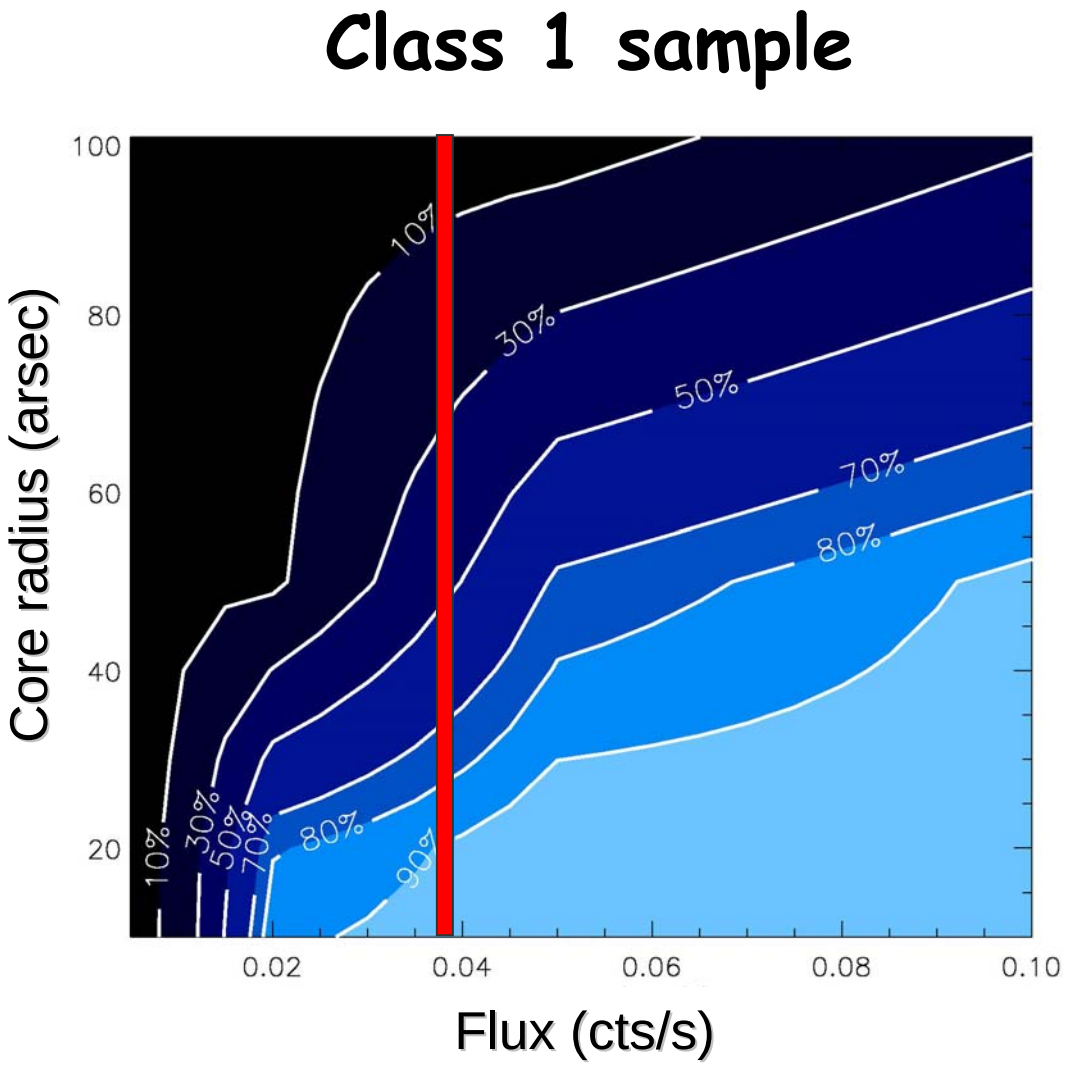


- Class 1 (C1):
  ~ 6/deg^2
  no contamination
- Class 2 (C2):
  ~ 5 more / deg^2
  + 5 false det.
  50% contamination
- Class 3 (C3):
  other clusters
  15-20/deg^2

Pacaud et al 2006

Detection rates

Not a flux limit !



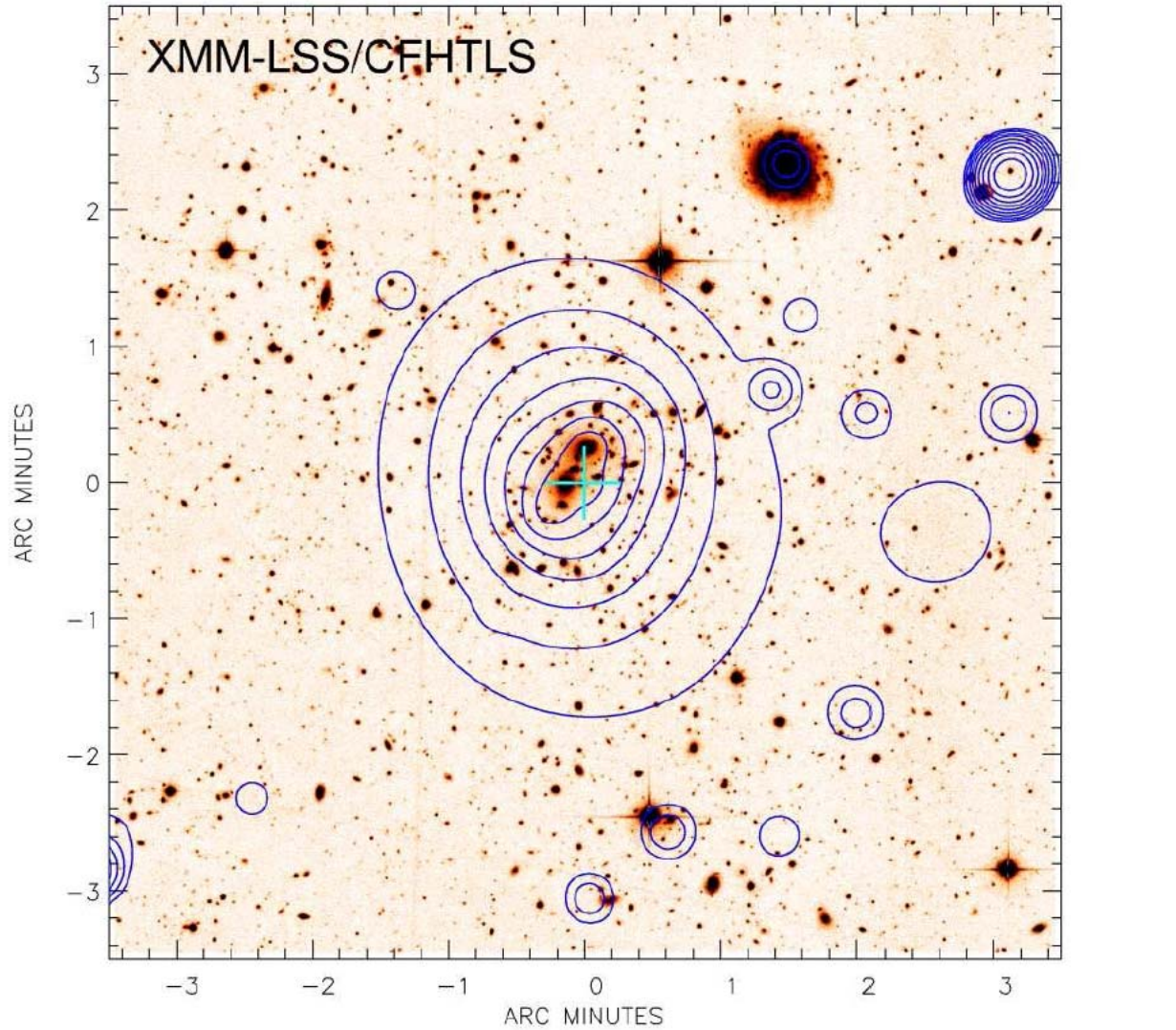
Pacaud et al 2006

The hottest cluster:

XLSSC-06

T = 4.8 keV

z = 0.43



Cluster physical quantities

After the selection, each cluster undergoes an interactive :

- Spectral fitting
  → Tx
- Profile fitting
  → Lx

3. The cluster sample and its cosmological modelling

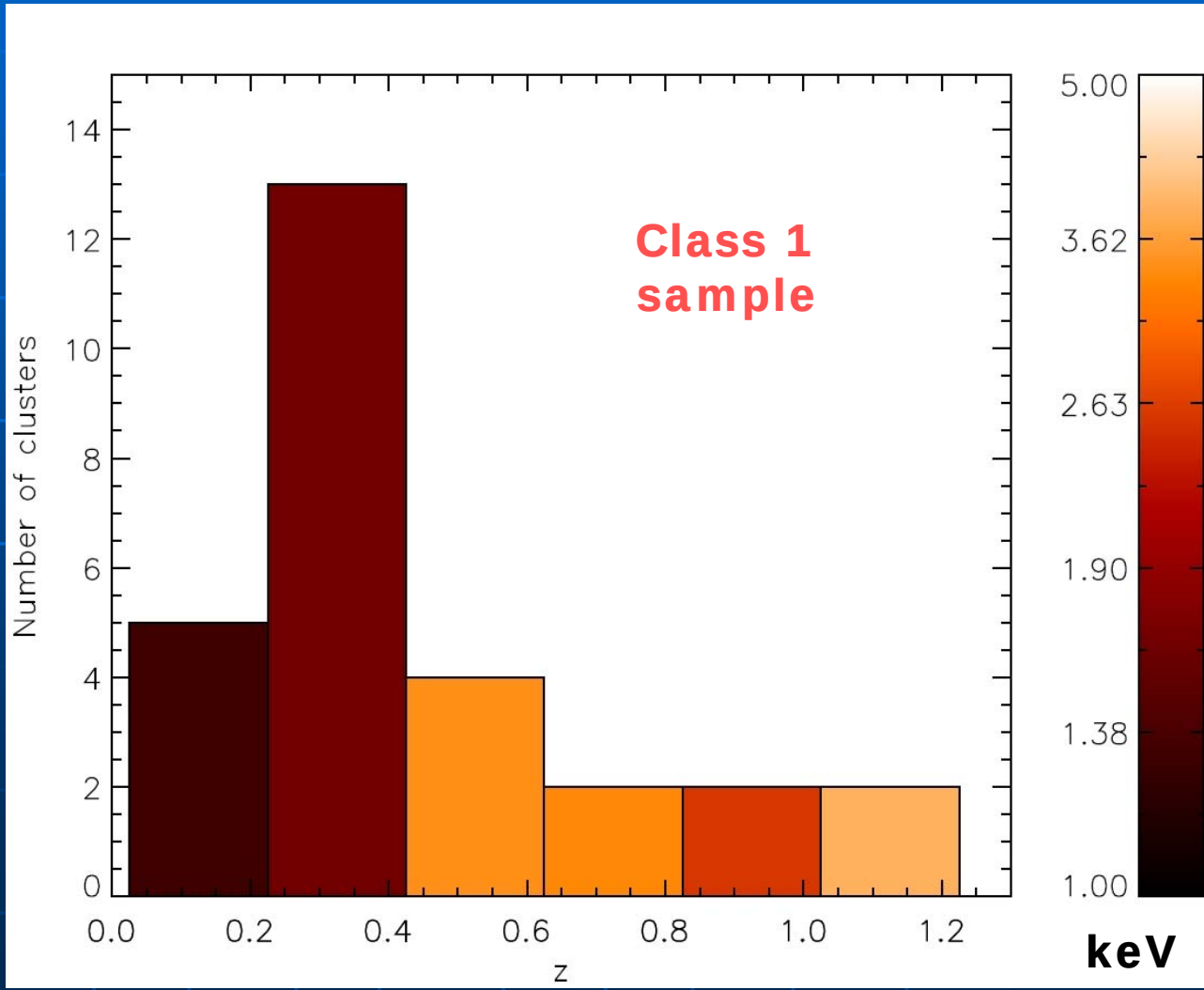
The current sample over 5 deg2

~ 60 spectro. confirmed

28 with controlled selection, upon purely X-ray criteria

➔contamination~0

C1: ➔



Cosmological modeling of *dn/zn*

- **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)

⇒ Fluxes (M,z)

- **Convolution with XMM response**

⇒ Count-rate

- **β-profile (β=2/3 and Rc=180kpc)**

⇒ Folding with simulated detection rates

... and finally dn/dz !

Cosmological modeling of *dn/zn*

- **ΛCDM + P(k)** **(WMAP+BBKS)**
- **Mass Function** **(Sheth & Tormen 1999)**
- **Halo profile model** **(NFW 1995 + Bullock et al 2001)**
- **Critical: M_{500}-T relation (z) ?**
- **L-T relation (z) ?**

+

- **Redshifted plasma model** **(APEC)**

⇒ Fluxes (M,z)

- **Convolution with XMM response**

⇒ Count-rate

- **β-profile (β=2/3 and Rc=180kpc)**

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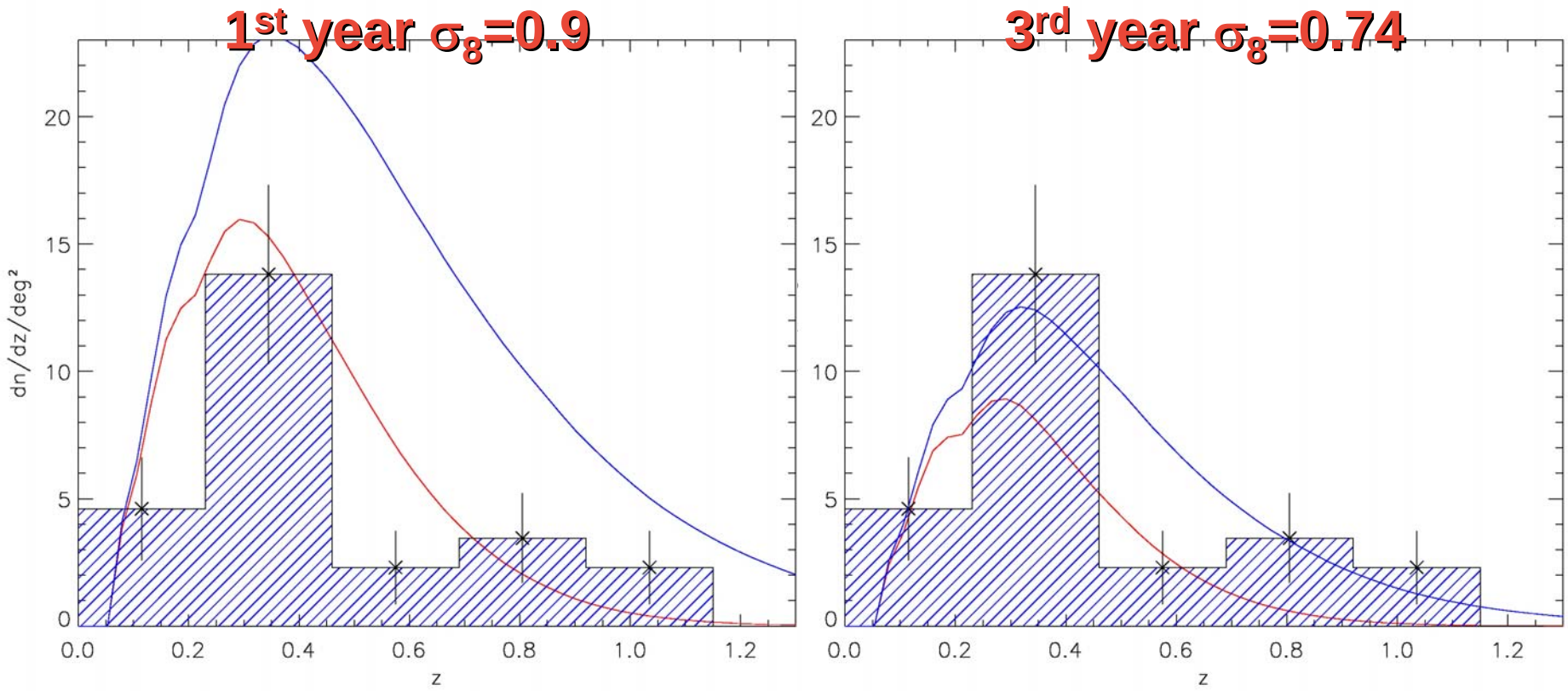
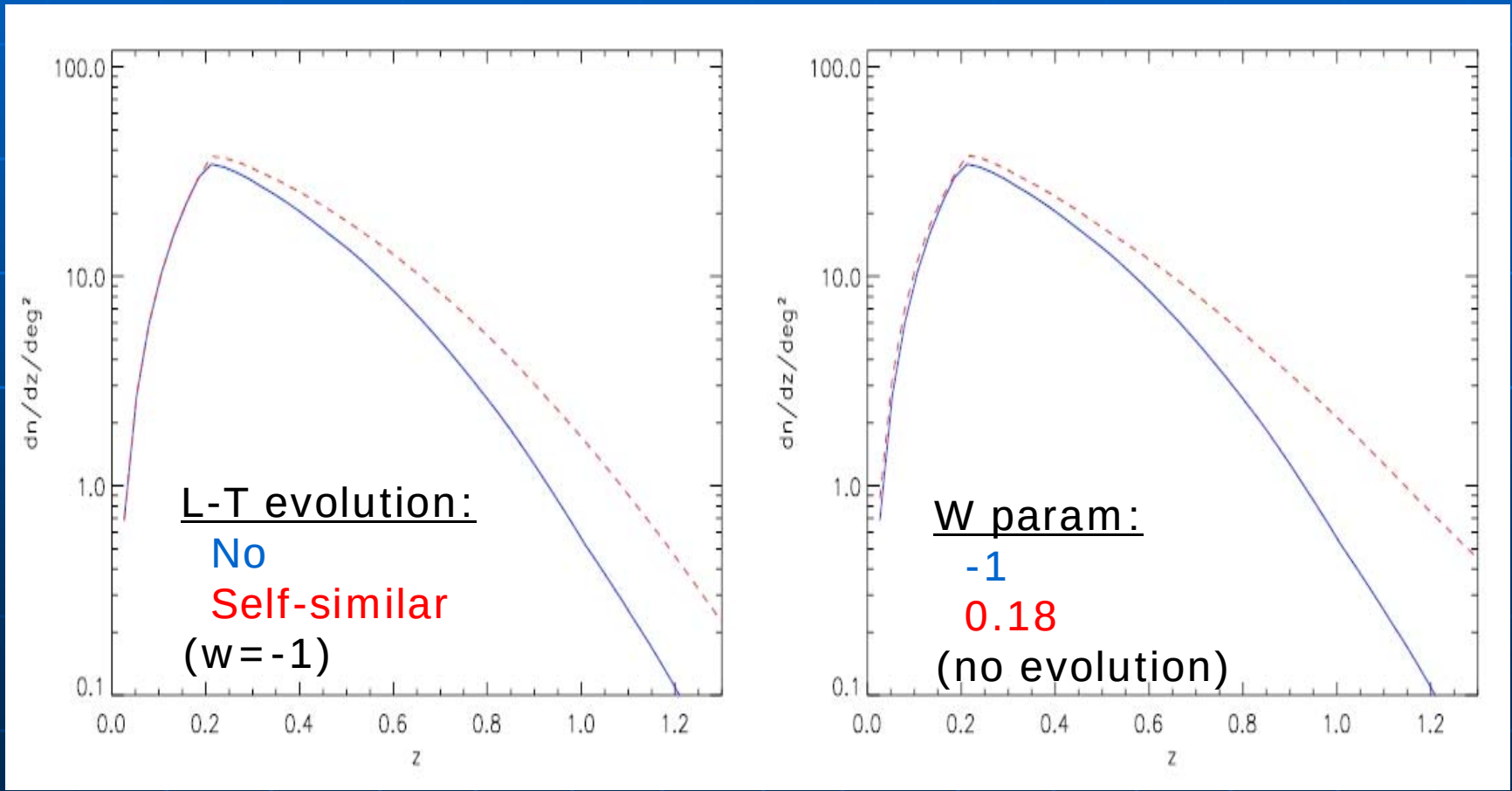
… and finally dn/dz !

The C1 redshift distribution

... compared with WMAP 1st and 3rd year



Influence of the scaling laws and equation of state of the DE



To break the degeneracy we need to

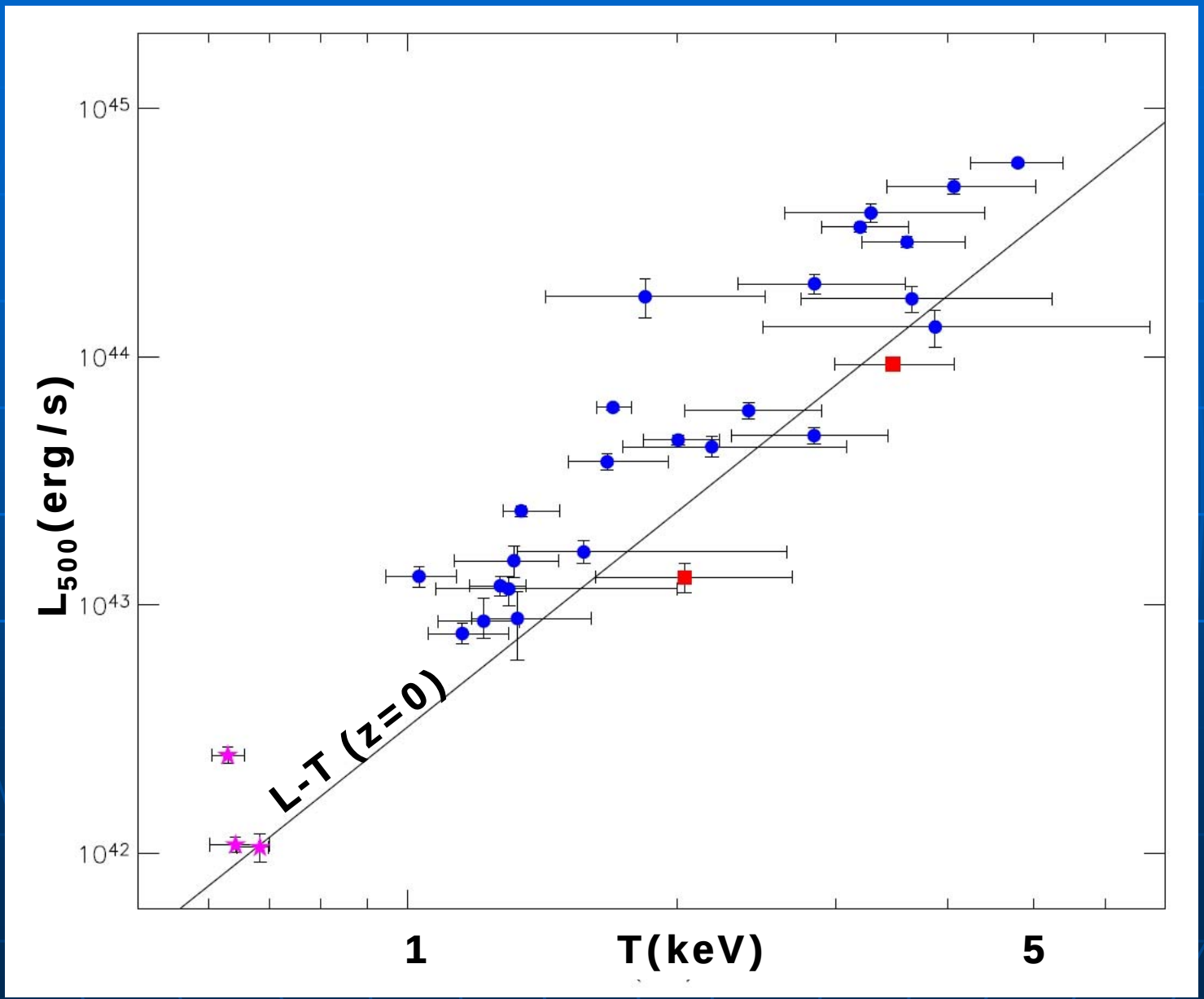
1) Determine the evolution of

T-L_X & M-T_X

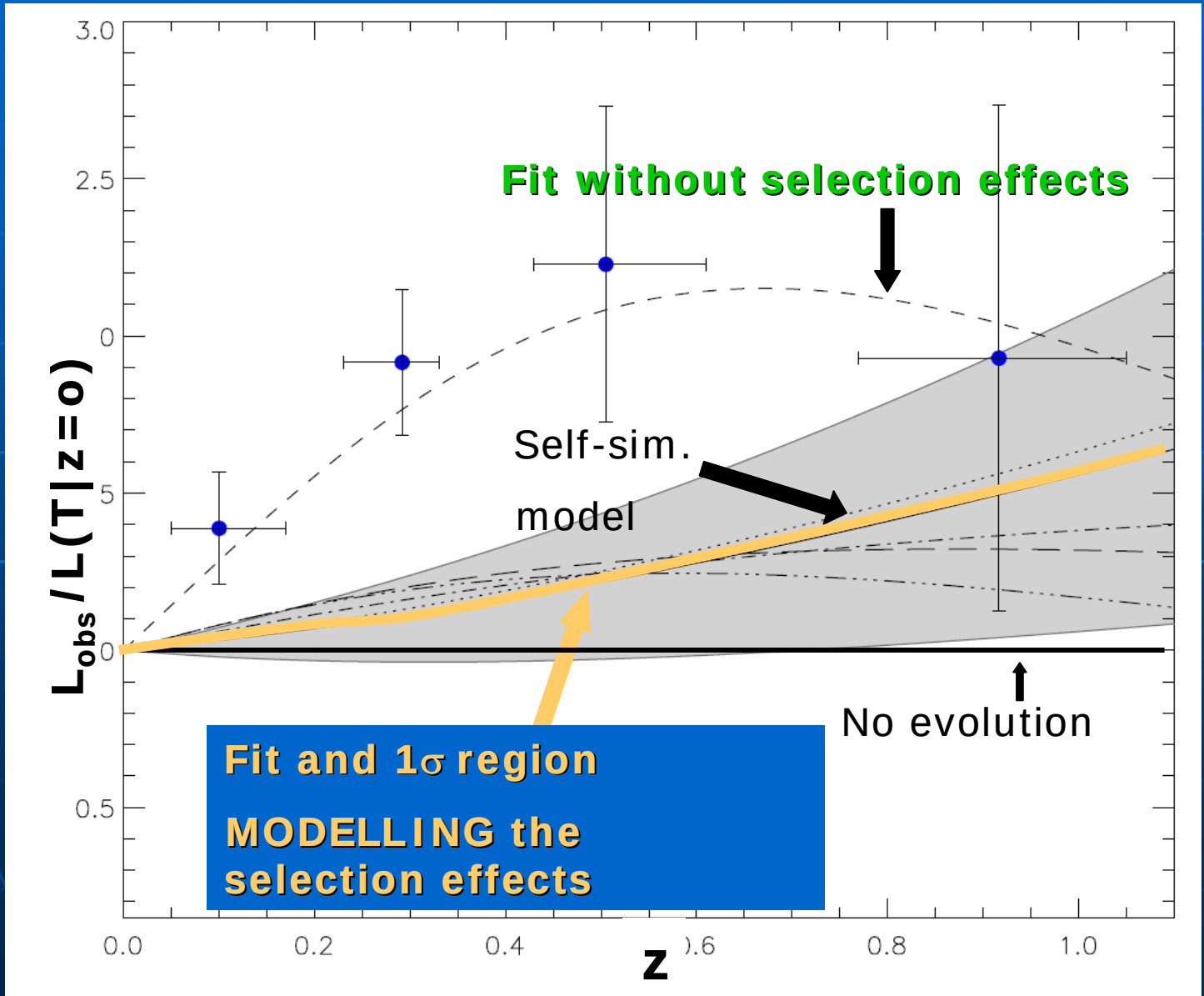
2) Or, in a more compact form

a mass-observable(z) relation:

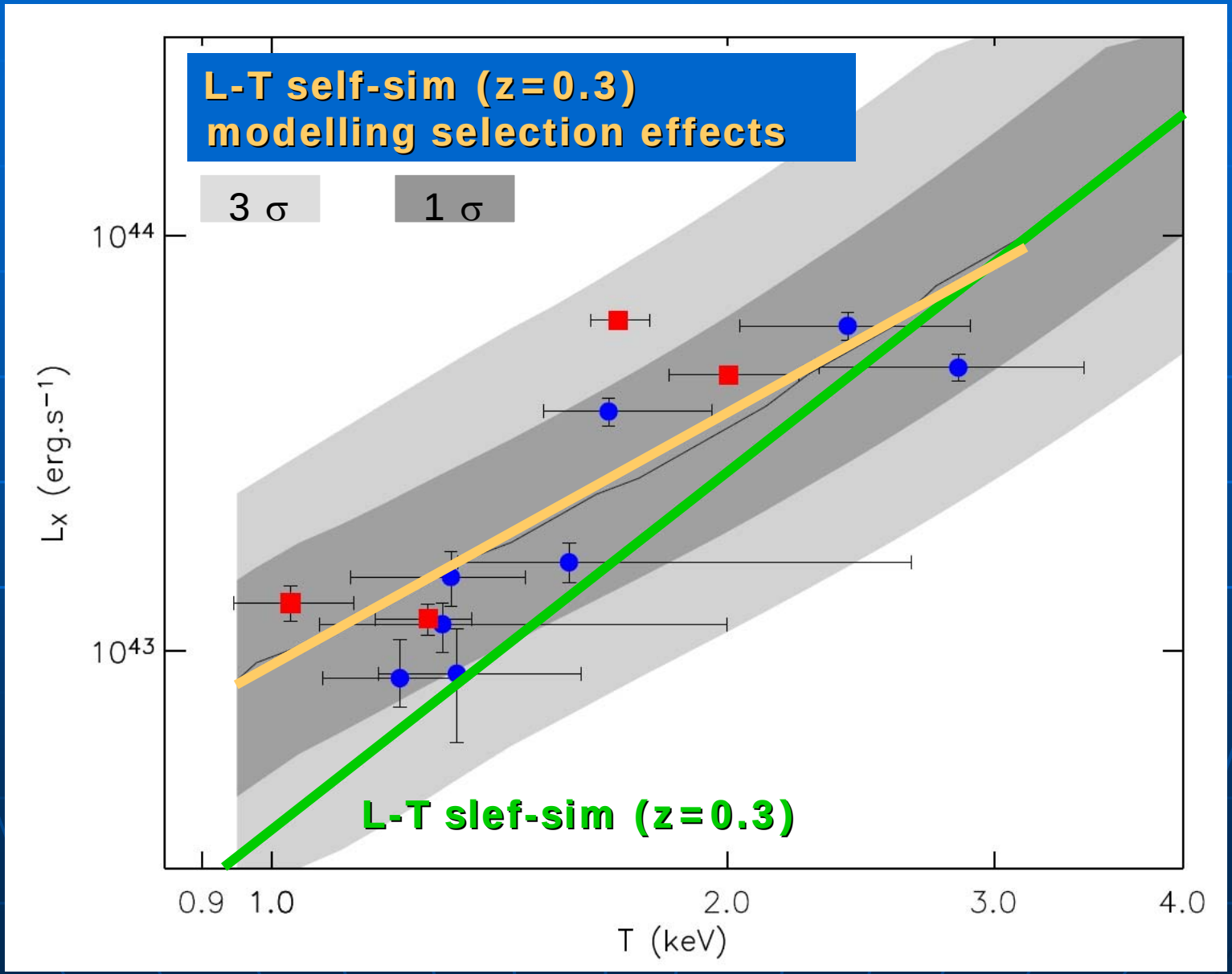
here ***$M(F_X, z)$***


10^{45}
10^{44}
10^{43}
10^{42}
L_{500}(erg/s)
L-T (z=0)
1
T(keV)
5

First time with XMM-LSS !



Zooming into the 0.2<z<0.4 interval



Evolution of L-T according to:

Ref.	power of (1+z)
Vikhlinin et al. (2002)	1.5 ± 0.3
Novicki, Sornig, & Henry (20	2.1 ± 1.1
Ettori et al. (2004)	0.6 ± 0.3
Lumb et al. (2004)	1.5 ± 0.3
Kotov & Vikhlinin (2005)	1.8 ± 0.3
Maughan et al. (2006)	0.8 ± 0.4
C1 clusters with $0.1 < z < 0.4$ (14 sources)	2.3 ± 0.8
C1 clusters with $0.4 < z < 1.1$ (10 sources)	1.3 ± 0.5
All C1 clusters above $z = 0.1$ (24 sources)	1.5 ± 0.4

T: XMM & Chandra

But

Samples from Rosat

Result

- The current sample is compatible with:
  - Concordance cosmology
  - Self-similar cluster evolution

5. Public releases

- The C1 cluster catalogue over the first 5 deg2

  Pacaud et al 2007

  - Z_{spec}, L, T, M
  - X-ray an optical images

- The full source catalogue over the first 5 deg2

  Pierre et al 2007

  - 2 bands
  - Associated CFHTLS g,r stamps

- The low-frequency radio catalogues

  Cohen et al 2003, Tasse et al 2006

- SWIRE, CFHTLS, UKIDSS are public

5. AGN in the XMM-LSS

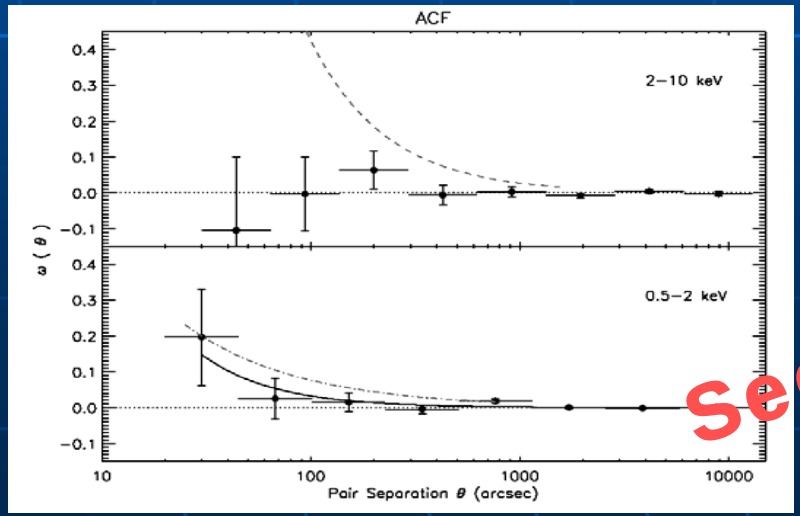
largest single deep X-ray field
unique multi-λ coverage over 10 deg2
~ 300 sources/deg2 down to 4E-15 in [0.5-2] keV

Spatial distribution of faint X-ray sources over a single area of 5 deg^2

! 1st time !

2-pt correlation function:

- In [0.5-2] keV ~ 1100 sources : significant clustering
- In [2-10] keV ~ 410 sources : no clustering



Gandhi et al. (2006)

See poster 1 by Garcet

Testing the AGN unified scheme optical vs X-ray classification

- **99 spectroscopically identified X-ray AGN in [2-10] keV band** (R<22 mag)

➔ **Mismatch:**

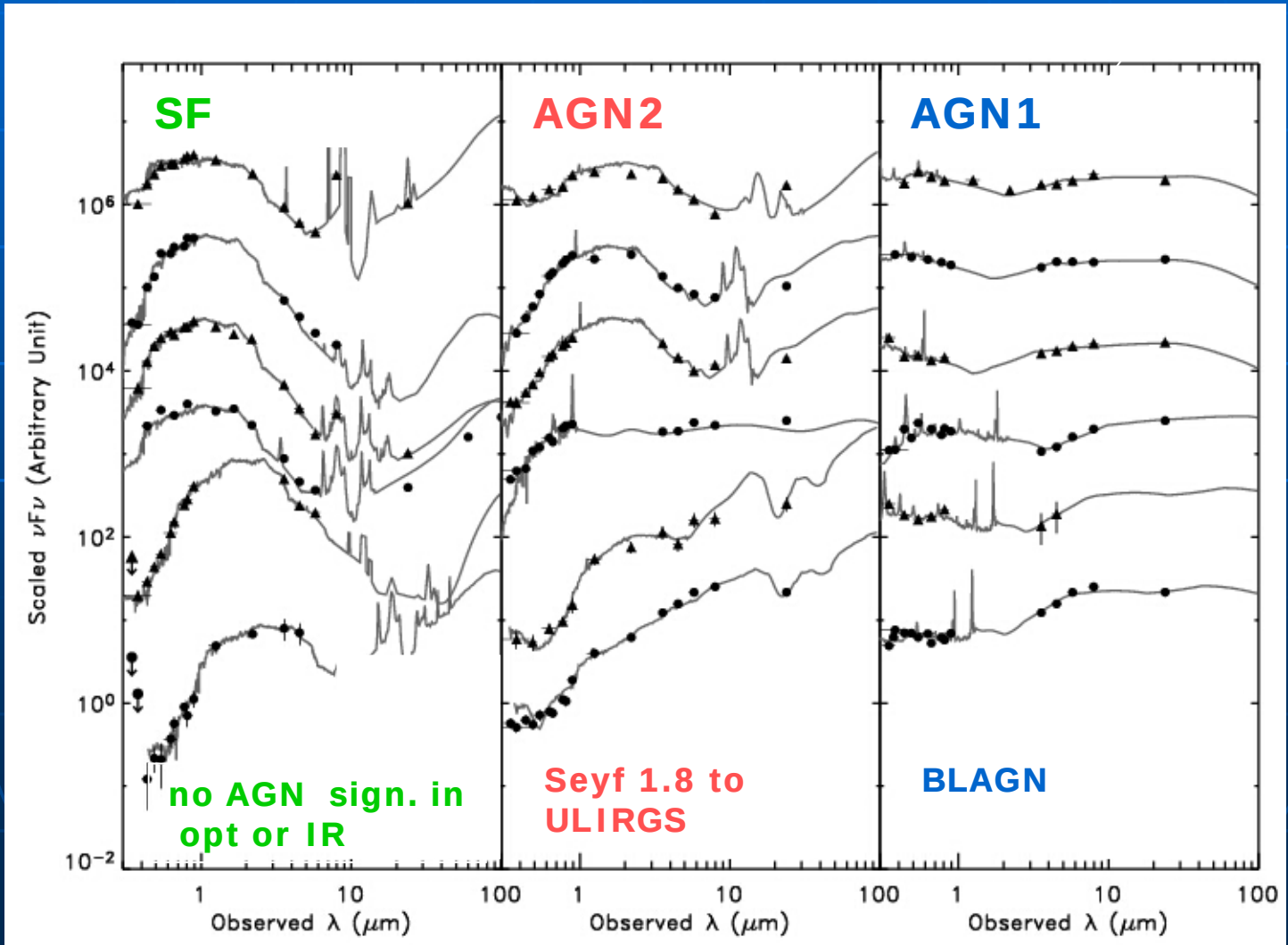
- **25 unabsorbed AGN** lacking broad emission lines in their optical spectra (dilution effects)
- **7 Absorbed AGN** showing broad emission lines in their optical spectra (large dust grains within the torus and/or a low dust-to-gas ratio)

opt \ X	Type I	Type II	N
Type 1	54	7	61
Type 2	25	13	38
N	79	20	**99**

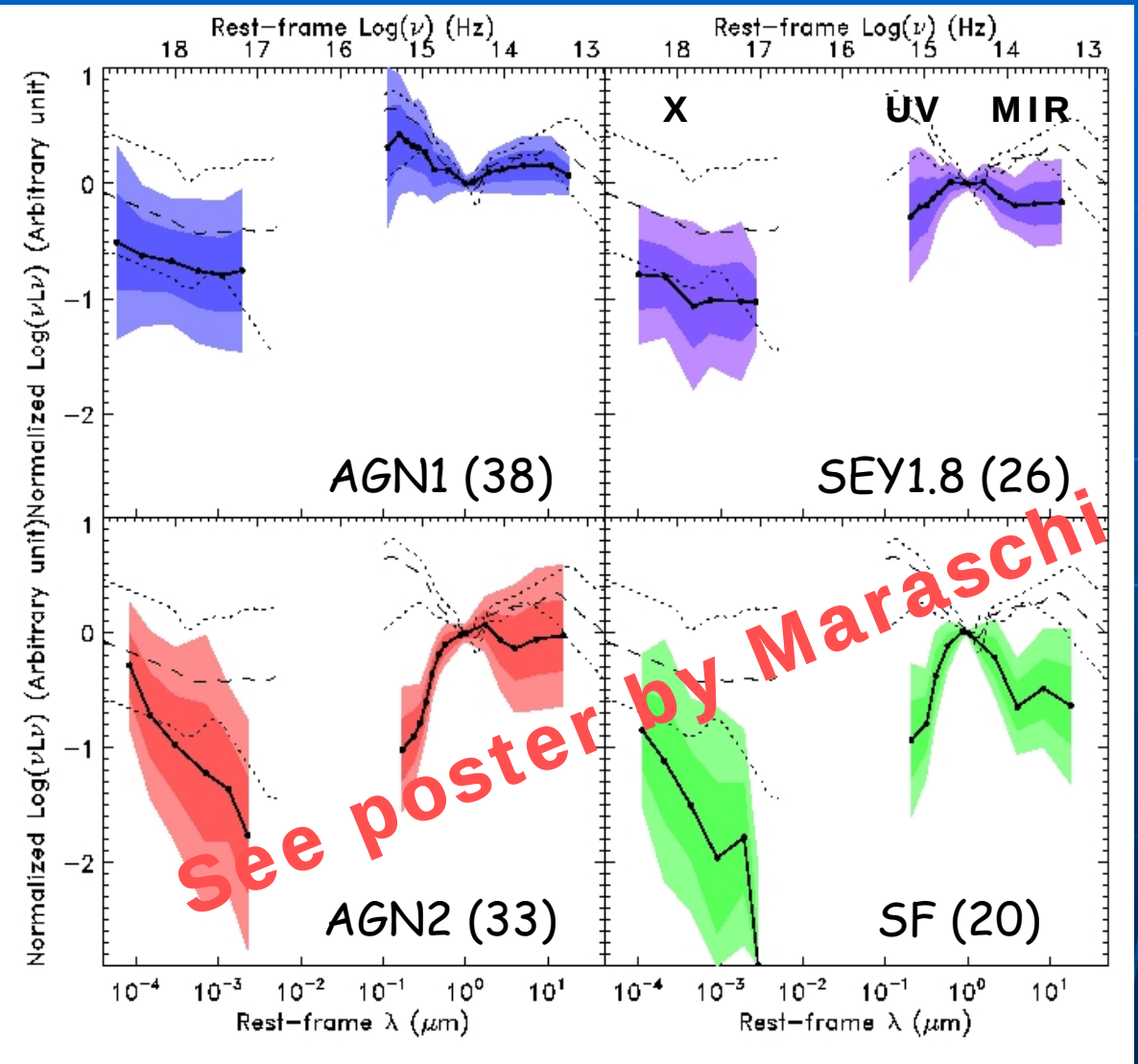
See poster 2 by Garcet

Garcet et al subm.

From optical to MIR: AGN classification + photo-z estimates from SED fits



From X-ray to MIR:



See poster by Maraschi

the SED properties are continuous through the various classes

Polleta et al 2007

6. Near future

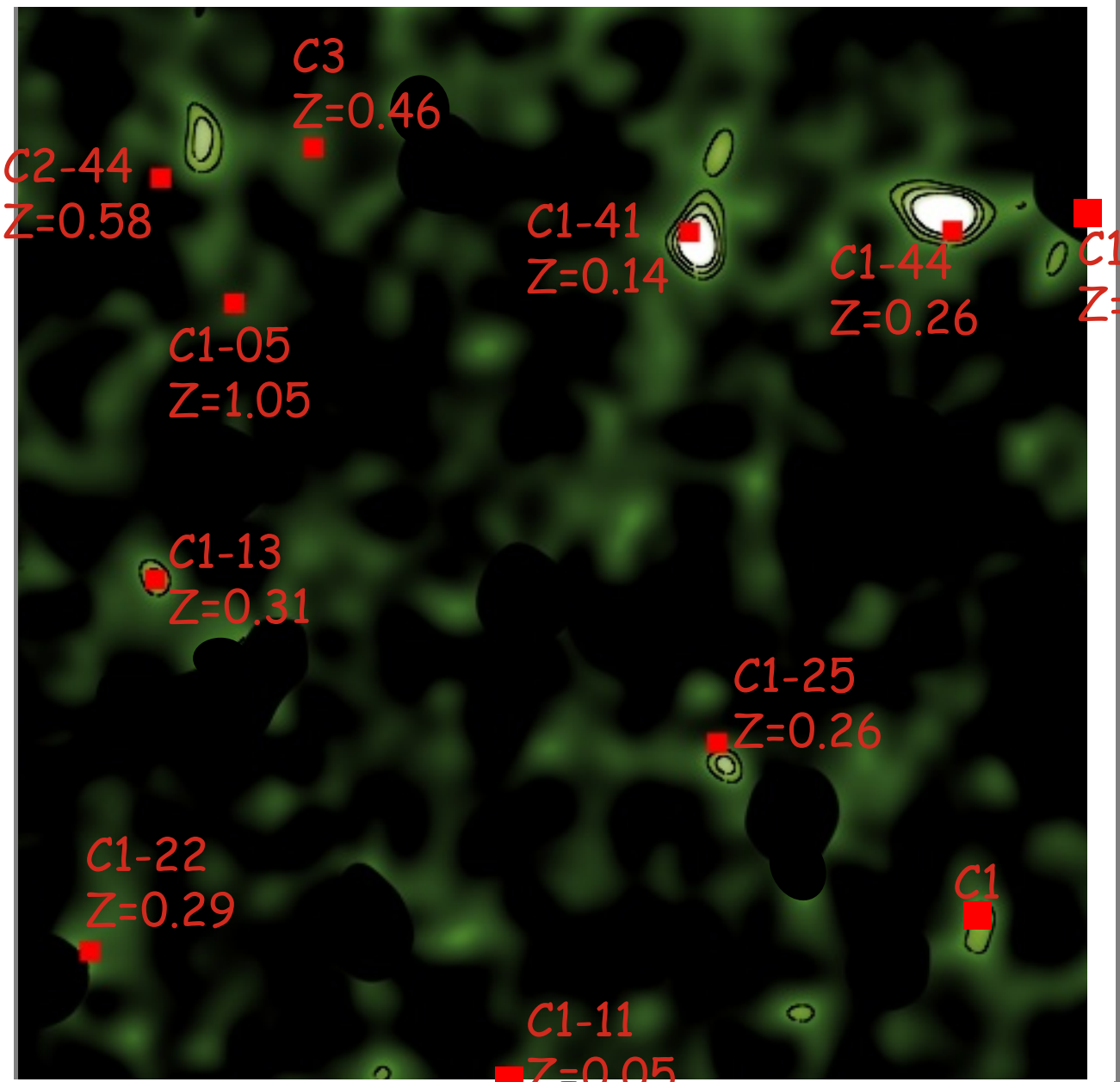
Toward cluster masses ...

WEAK LENSING map D1 area

Paulin et al in prep

KSB

XMM-LSS Clusters
(Pierre et al. 2006)



Comparison with

Gavazzi & Soucail 2006

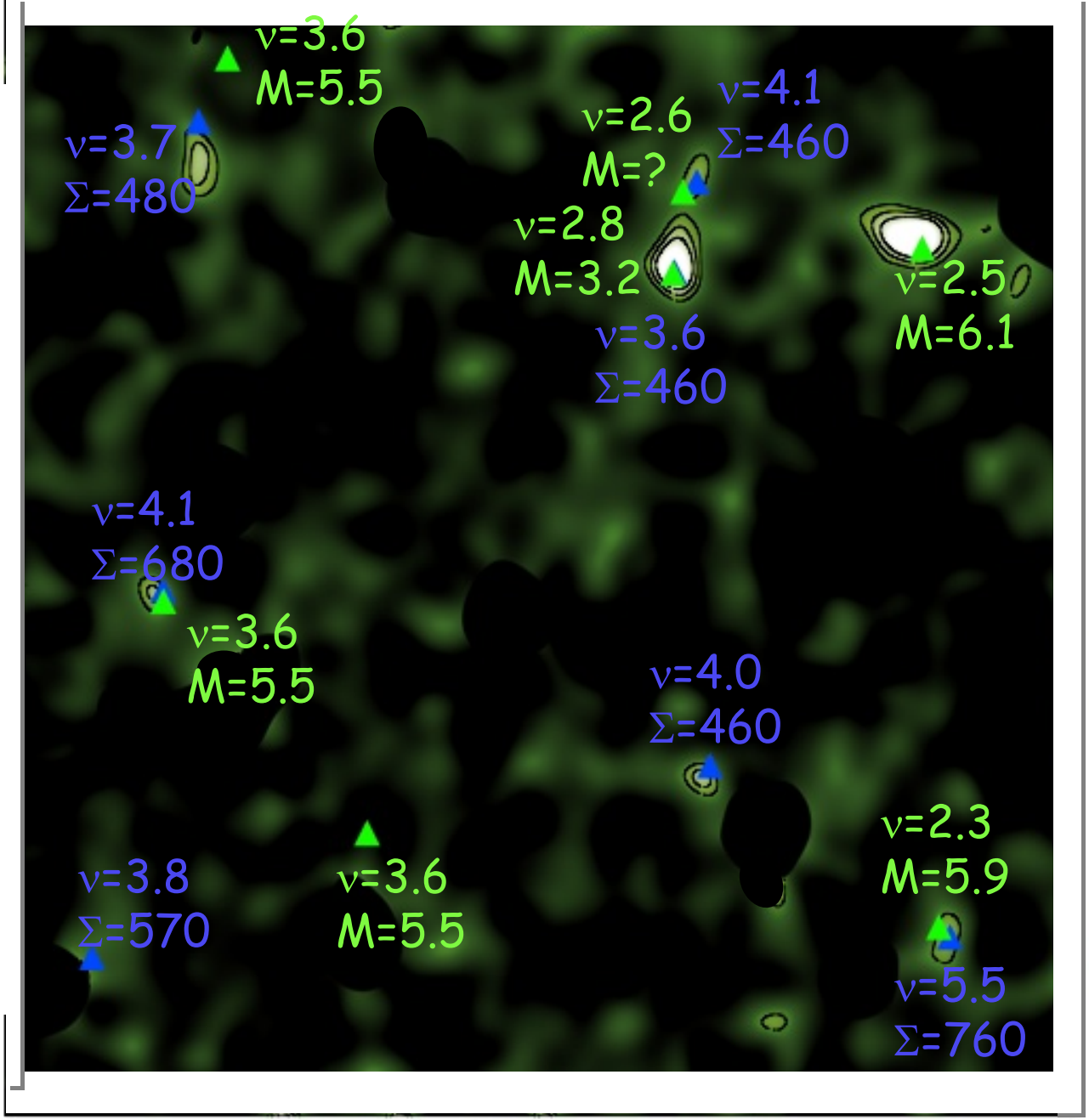
KSB

ν: S/N
Σ: velocity dispersion for an isothermal sphere model (in km.s^{-1})

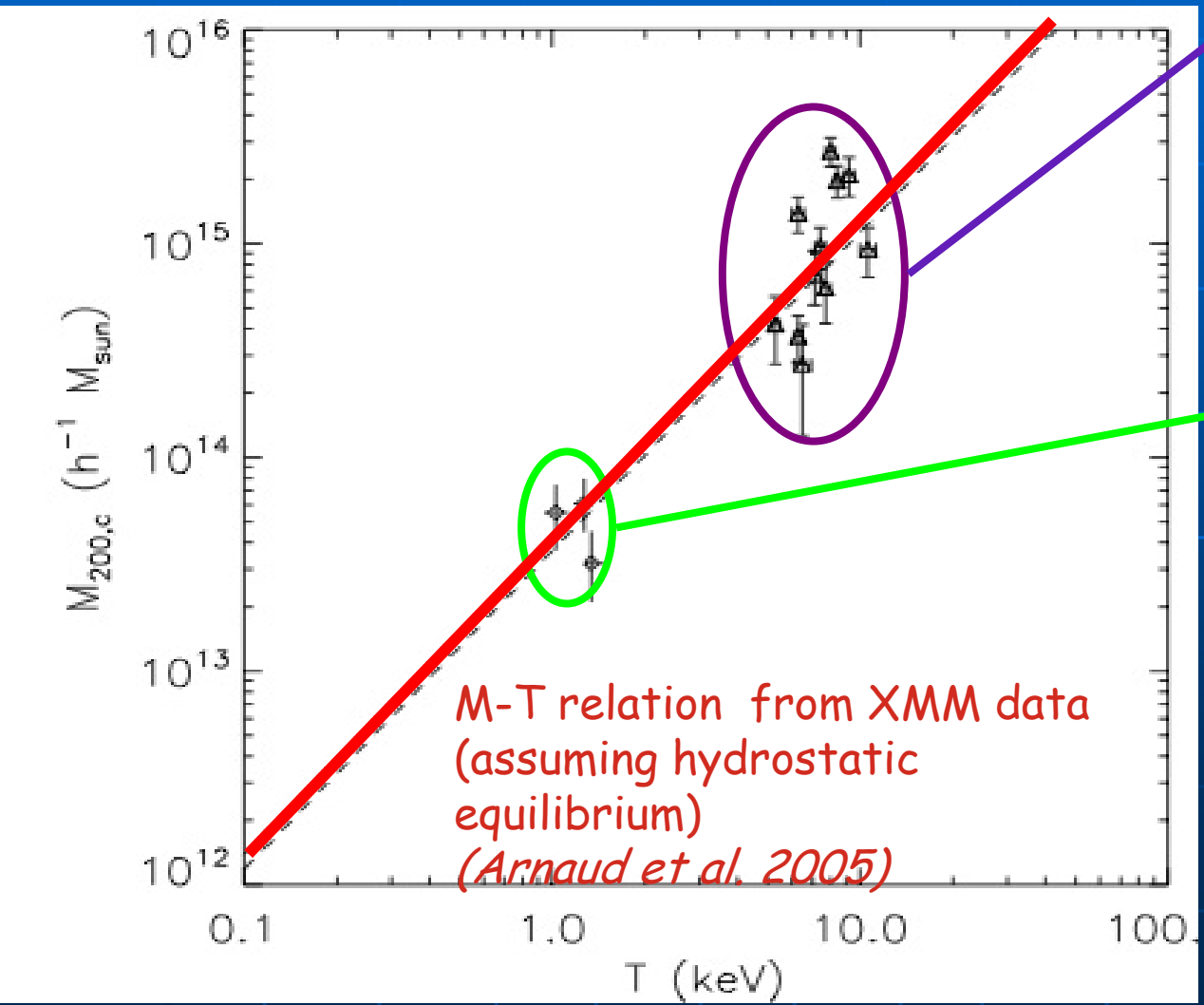
Berge et al in prep

Shapelets

ν: S/N
M: mass in unit of h^{-1}x10^{13}M$_{sun}$



The $M_{lensing}$ - T_x relation



(Bardeau et al. 2007)

CFTHLS-D1, weak lensing with Shapelets and XMM-LSS Tx

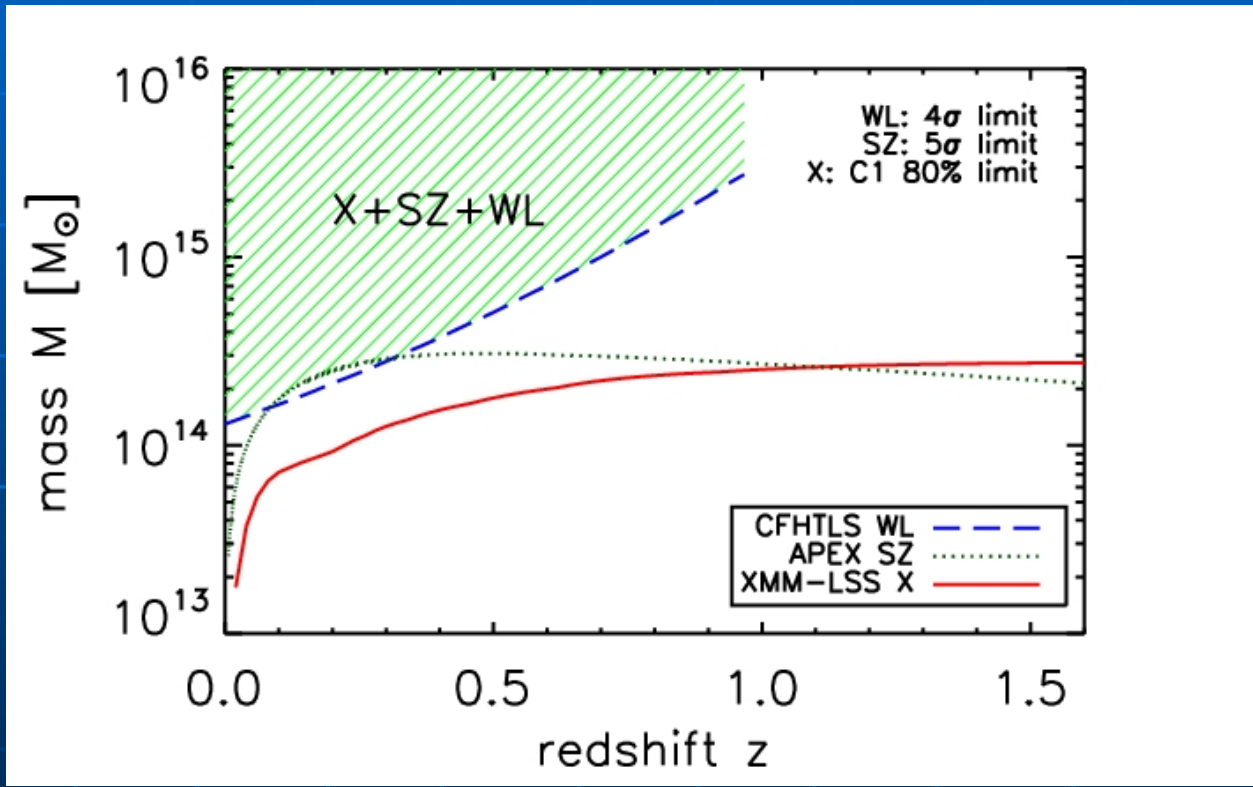
Berge et al in prep

Near future: S-Z + WL + X

3 independent MASS measurements

Better constraints on cluster physics

thus, on cosmology!



Workshop announcement to examine:

- Science arguments for a 100-200 deg2 survey with XMM … for the Next Decade
- Observing and processing requirements
- Associated optical and S-Z surveys

→ Rendez-vous à Paris, January 2008

FIN