Cluster cosmology in XXL format

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XMM – Next Decade
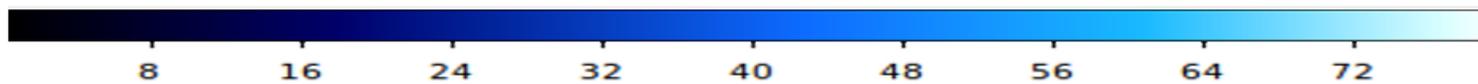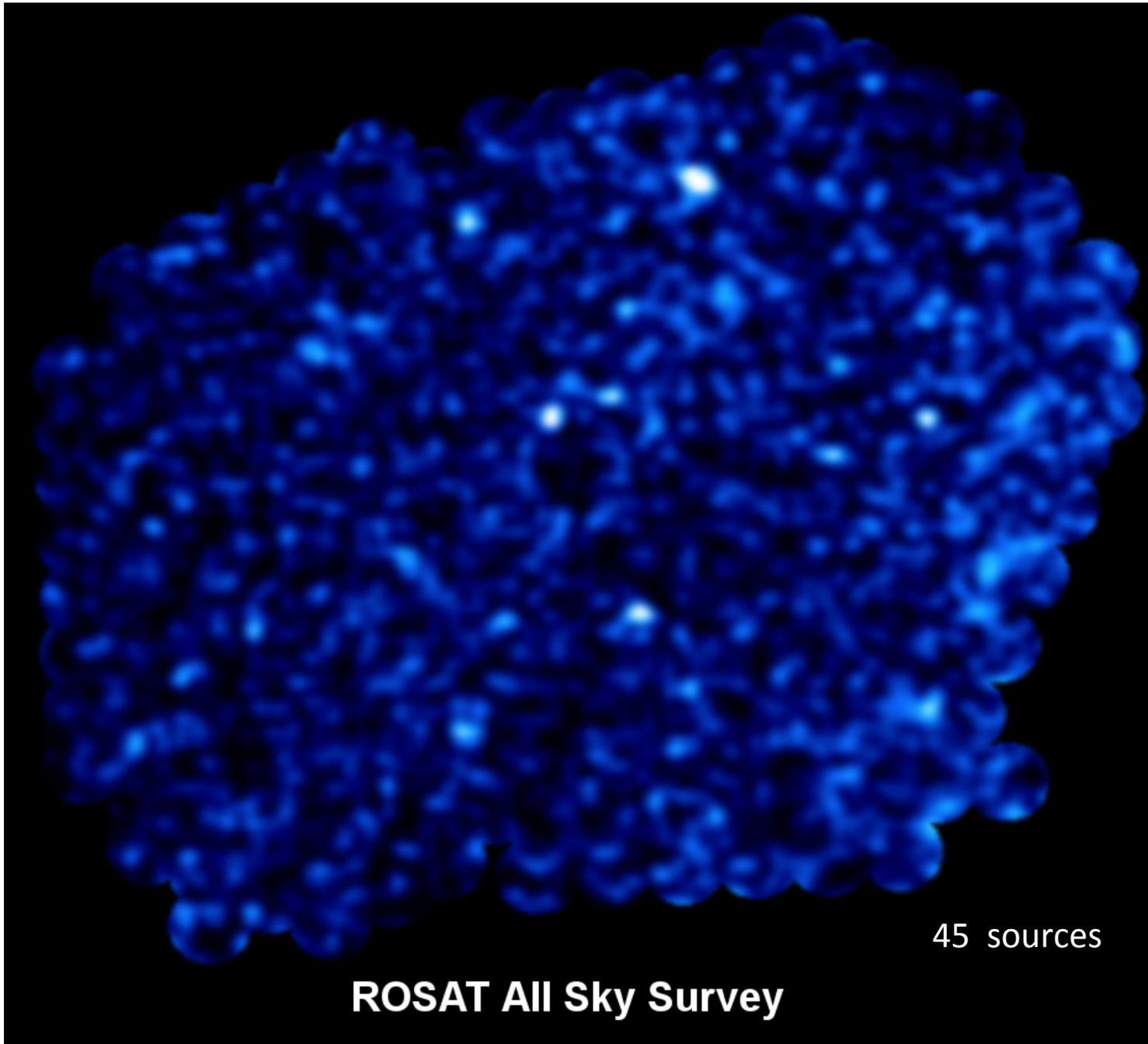
The XXL survey
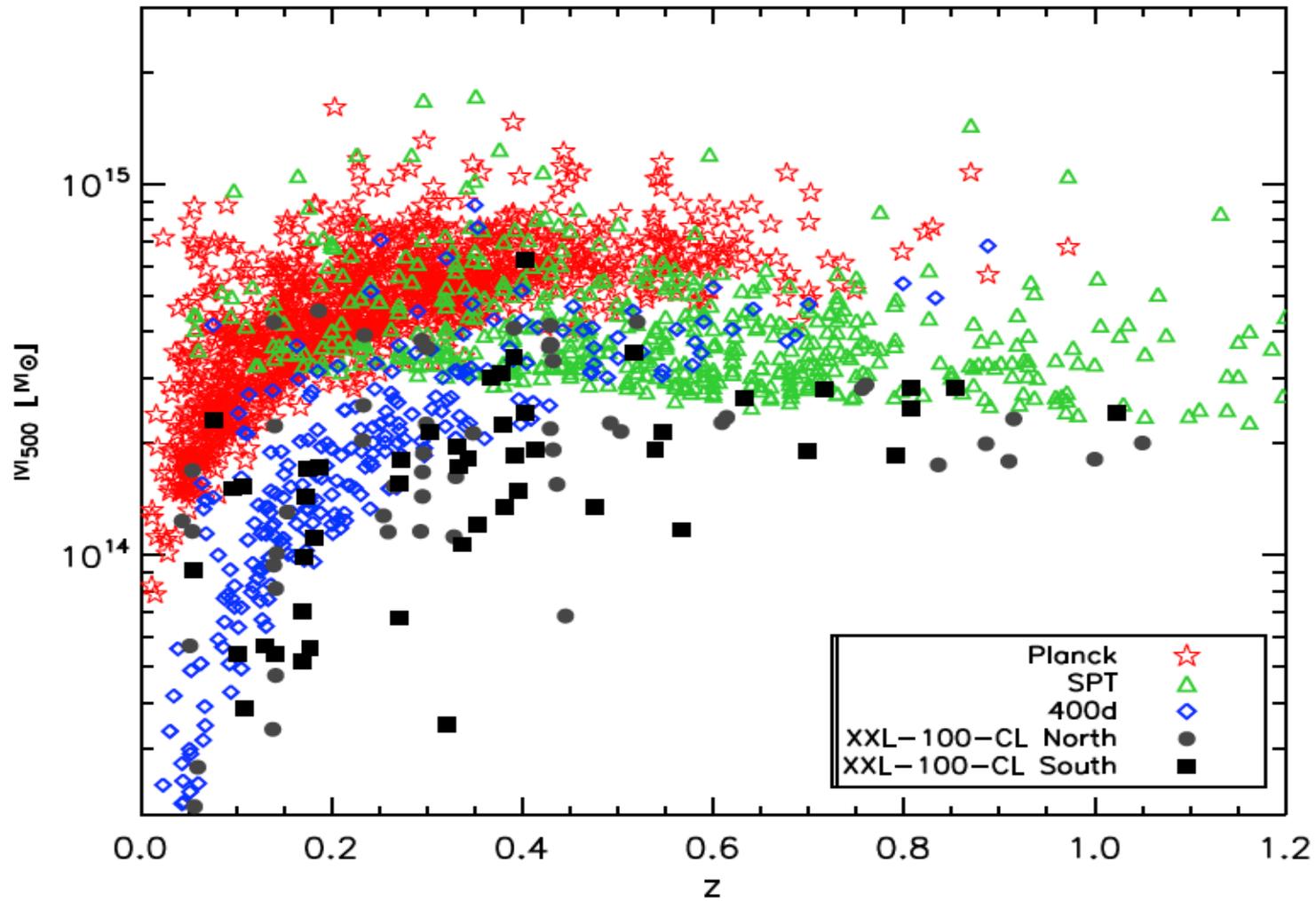## XMM VLP

- 2 x 25 deg^2 areas
- 6.9 Ms – 452 XMM observations   2011-2013
- Some 100 scientists
- ESO LP and numerous associated surveys from UV to 74 MHz

- **December 2015, first series of papers**
  - 14 refereed articles   A&A special issue
  - brightest 100 clusters released (spectro z, L , T)
  - brightest 1000 AGN released (z, multi-λ)
  - XMM images released

200
clusters

12 000
AGN

XMM-XXL South

0.59	0.88	1.4	2	2.9	3.9	5.2	6.6	8.2	

45 sources

ROSAT All Sky Survey
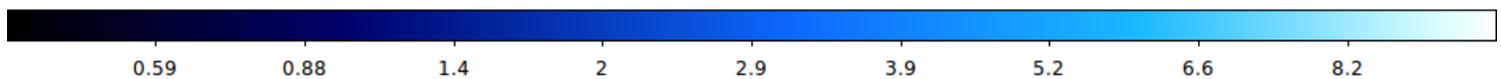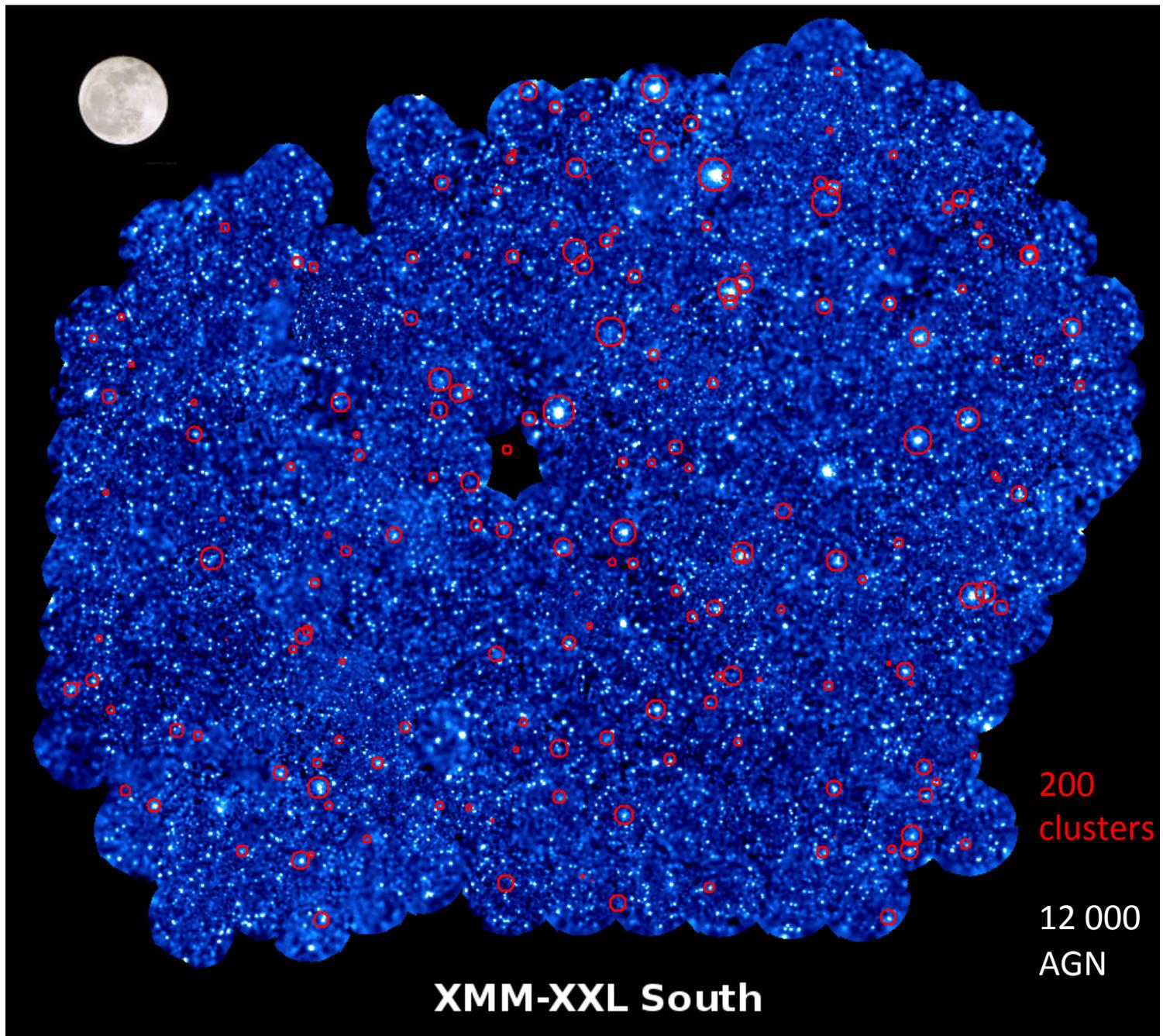
Cluster mass range

XXL paper II   Pacaud, Clerc et al, A&A in press

Main results (clusters)

- We find 17 (40)% less clusters than expected from WMAP9 (Planck)

- The measured cluster evolution is compatible with self-smilar

- . . . but strongly dependent on the slope assumed for the z ~ 0 relations
➔ we favour internal calibration of the SR
➔ the precise knowledge of the cluster selection function (including scatter) is critical for any SR and evolutionary study (not only for cosmology!)

- Do visit :
  - Our website: http://irfu.cea.fr/xxl
  - Our databases: clusters (Lyon) and AGN (Milan)

Second (and final) series of XXL papers by the end of 2018

- Full cluster catalogue (z_{spec}, X parameters) : 450 objects

- Full AGN catalogue (z_{spec} z_{phot}, X and multi-λ parameters): 25 000 objects

- Cluster selection functions

- Cosmological analyses and many others
- ➔ Stay tuned!

# Great potential for XRB studies
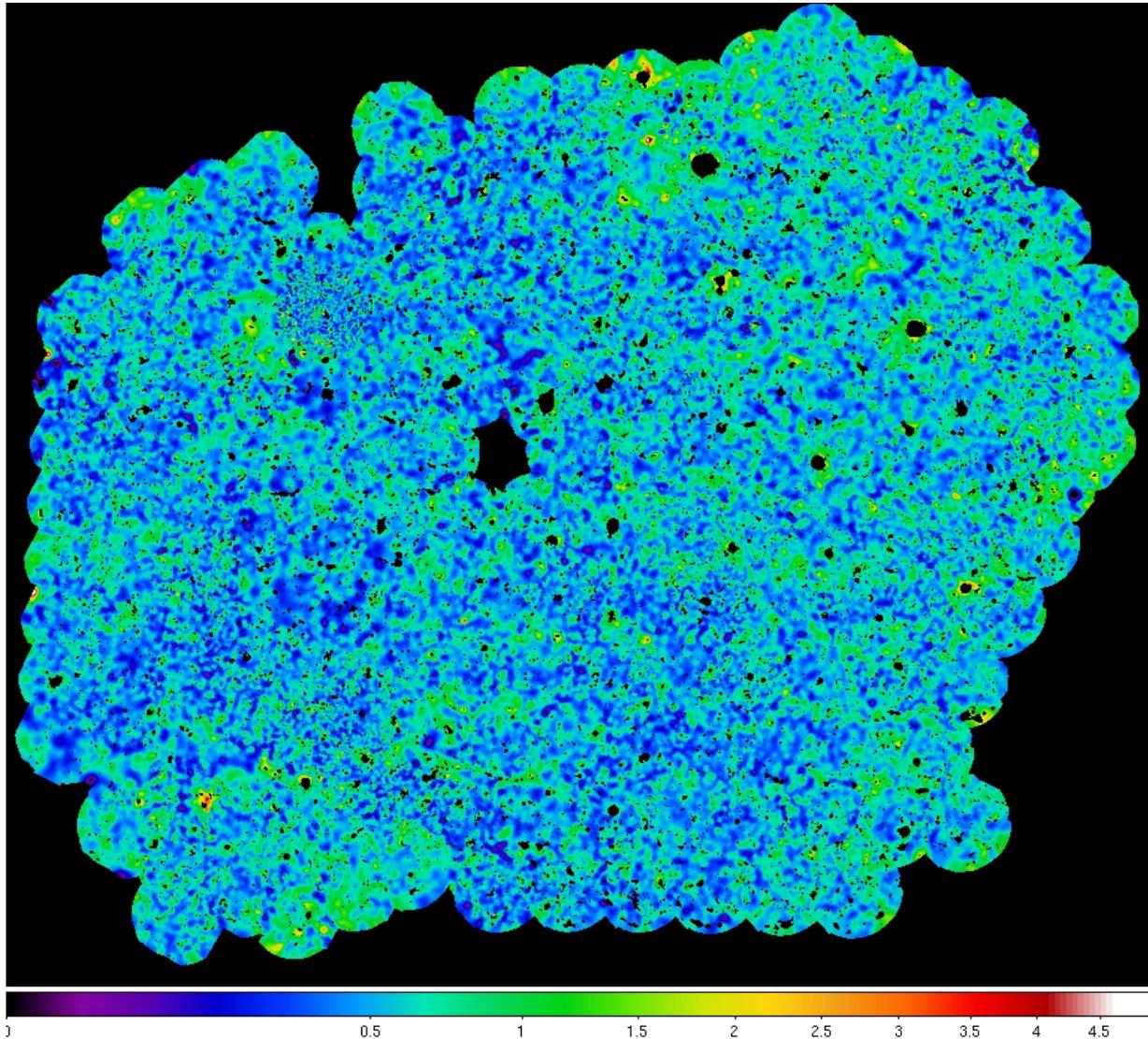
- Sources subtracted

- Exposure Correction of the Count

- Minus
Particle and Soft
Proton Backgrounds
Image

(Snowden 2016)

XCLASS project

- XXL is great for LSS studies:
  - ξ improves the constraints by a factor of 2

- But we can enlarge our statistical sample
  - **Processing of all XMM high galactic latitude observations (cut to 10 ks and 20 ks chunks)**
  - ~ 4000 observations
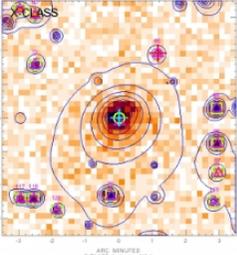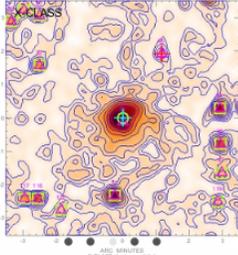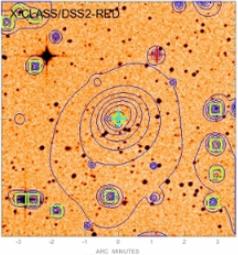 - ~ 3000 cluster candidates

Clerc et al .

Visit the
XCLASS DB

http://xmm-lss.in2p3.fr:8080/l4sdb

60

30
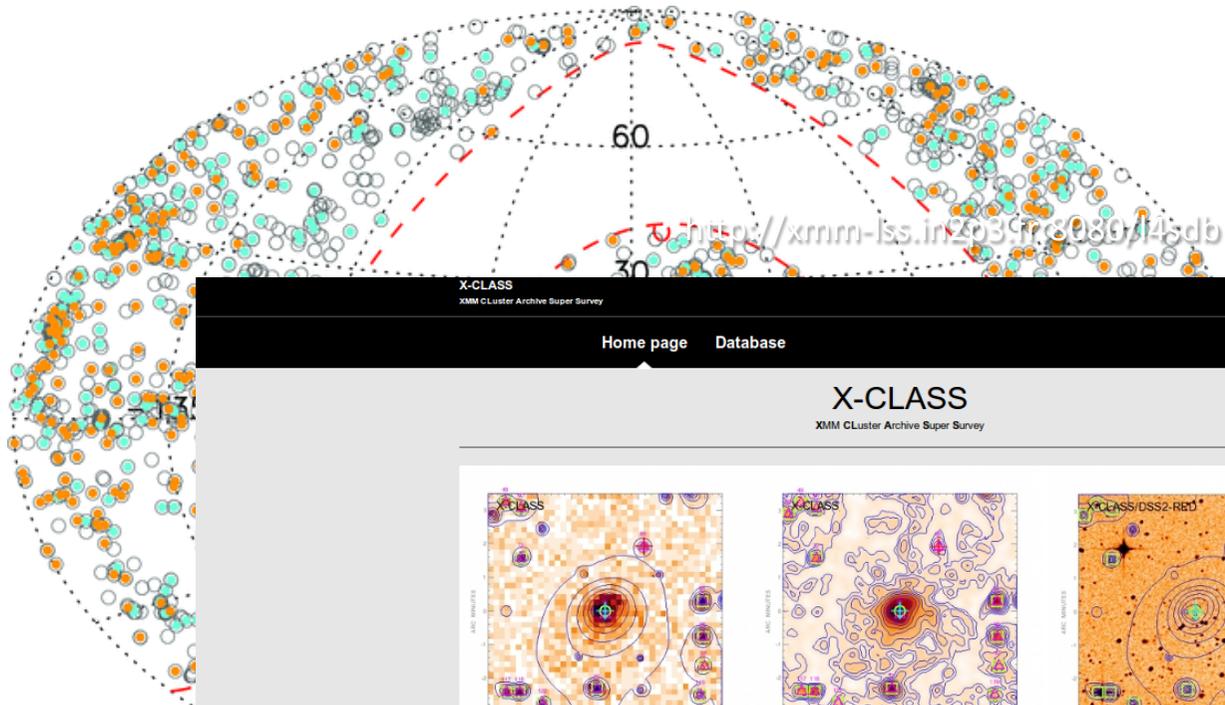
X-CLASS

XMM CLuster Archive Super Survey

The XMM CLuster Archive Super Survey is an X-ray galaxy cluster search in XMM-Newton archival data.

This webpage provides access to the X-CLASS catalogue through a dedicated database (» link).
On your first visit you will be asked to choose a login and password which will grant you access to the catalogue. It is immediate and no other information is required !
Contact: Jean-Paul Le Fèvre (» e-mail)

Database overview
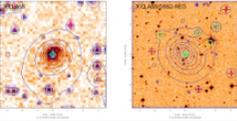
X-ray and optical images
Raw and spatially filtered X-ray images are given for each entry in the catalogue. An optical image (POSS-II) is also provided.

Nasa Extragalactic database cross-identification
For each cluster in the catalogue we provide the list of objects listed in the NED (» link) for which redshift information is available and within 3 arcmin of the X-ray centroid.
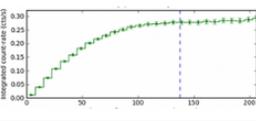
Detailed information about the X-ray data
Images of the XMM pointings and corresponding information about flare removal procedure are accessible for each catalogue entry. Count-rate measurements in several energy bands can also be retrieved for each cluster, along with corresponding plots.

Related publications :
Clerc et al 2011b, arXiv: 1109.4441

FUTURE:

Doing cluster cosmology
without masses

"χ^2"

Cosmology (ΛCDM,...)
$$\frac{dn}{dM \, dz \, d\Omega}$$

Up

Estimated mass distribution

Selection effects M(z) ?

Scaling laws, HE...
➔ Individual masses

T_X, Mgas(r), Y_X, T_X(r)

+redshifts

X-ray observables:
Count-rates in given bands and errors
ICM spectrum

Bottom

Top

Cosmology (ΛCDM,...)

$$\frac{dn}{dM\,dz\,d\Omega}$$

Scaling laws

$$\frac{dn}{dz\,dT\,dL\,d\Omega}$$

X-ray observables (count-rates)

X-ray selection function

⊗

$$\frac{dn}{d\mathrm{CR}\,d\mathrm{HR}}$$

RAW
X-ray fluxes & colours

Down

X-ray observables:
Count-rates in given bands and errors
ICM spectrum

"χ^2"

- CR in [0.5-2] keV   ~ Magnitude
- HR = [1-2]/[0.5-1]   ~ Colour
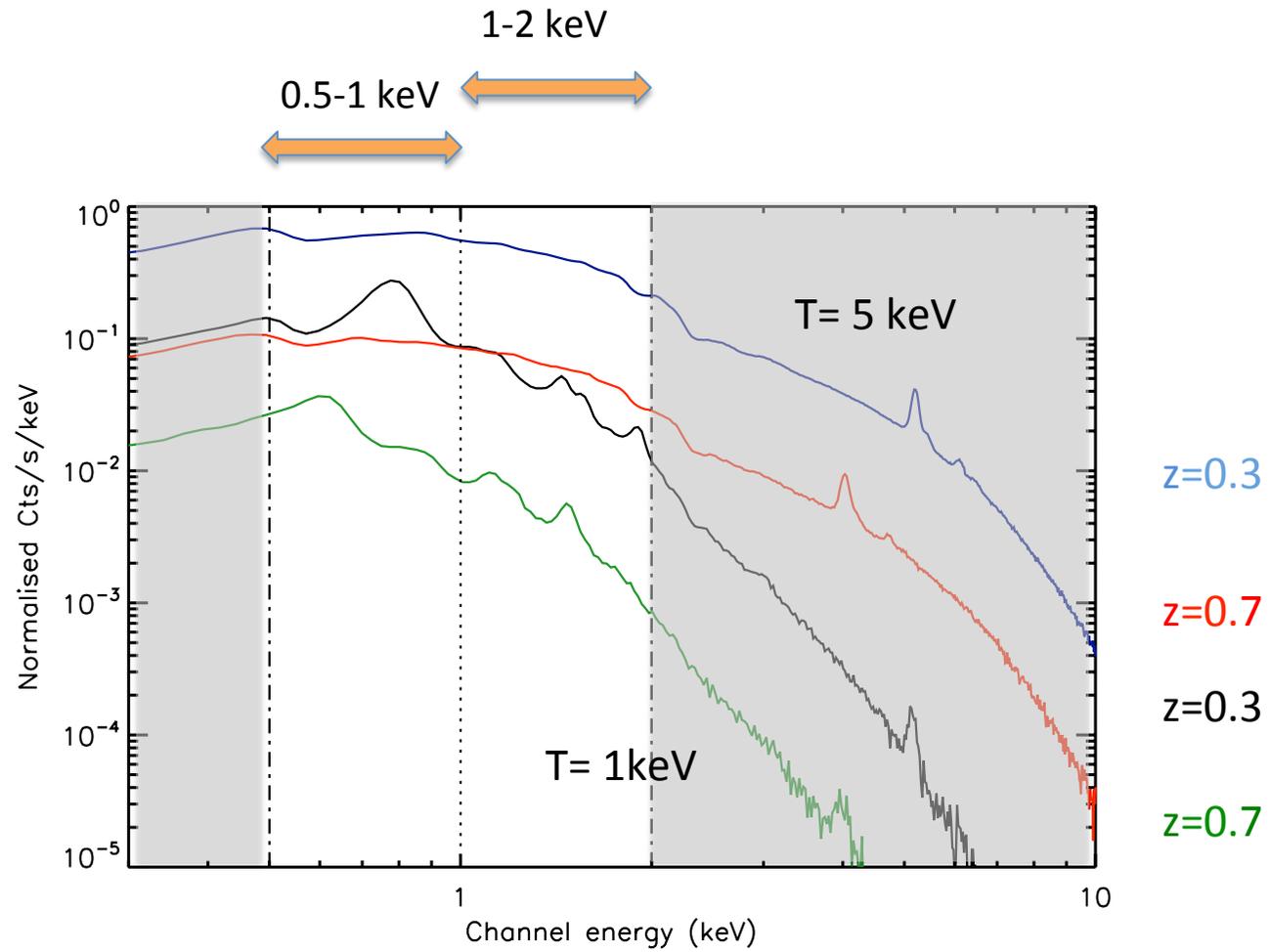
X-ray colour-magnitude diagrams

[1-2] keV / [0.5-1] keV hardness ratio (HR)
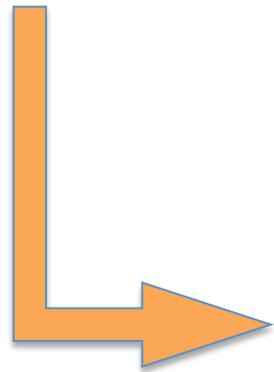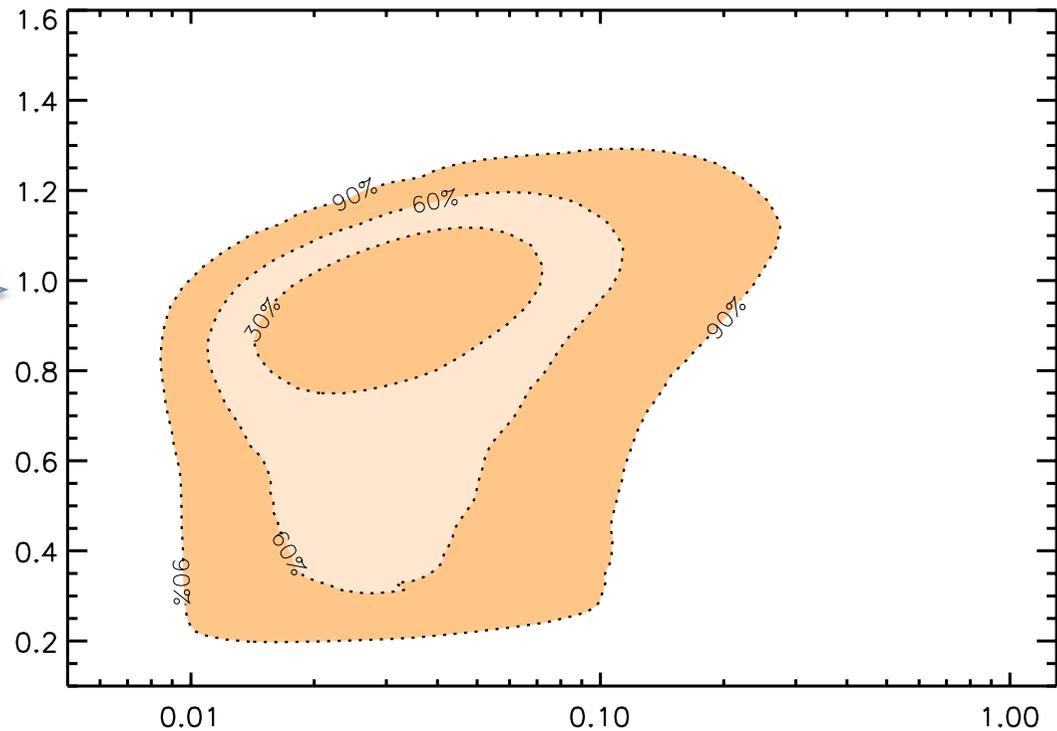
Diagram computed for :
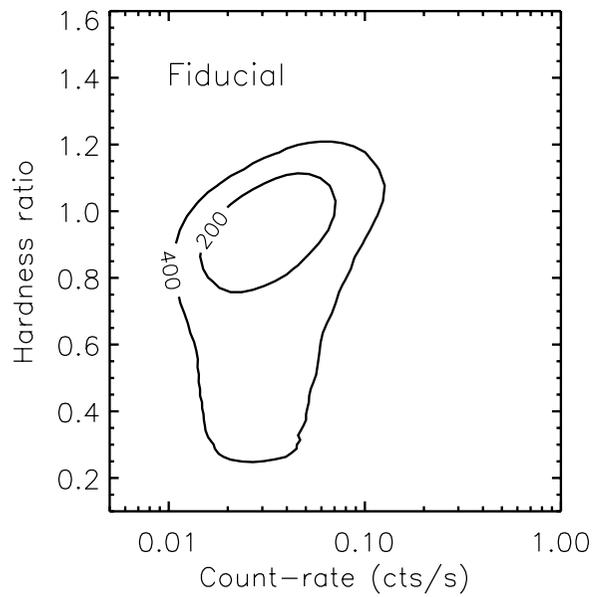   WMAP5 cosmology
    C1 selection
    Local cluster scaling laws
    Self-similar evolution

100deg2

[0.5-2] keV Count-rate (CR, cts/s)

Non standard cosmology

Non self-similar evolution

Fiducial

$\Omega_m + 20\%$

$\gamma_{z,MT} = -1$

400

200

400

800

600

800

600

1000

Hardness ratio

Count-rate (cts/s)
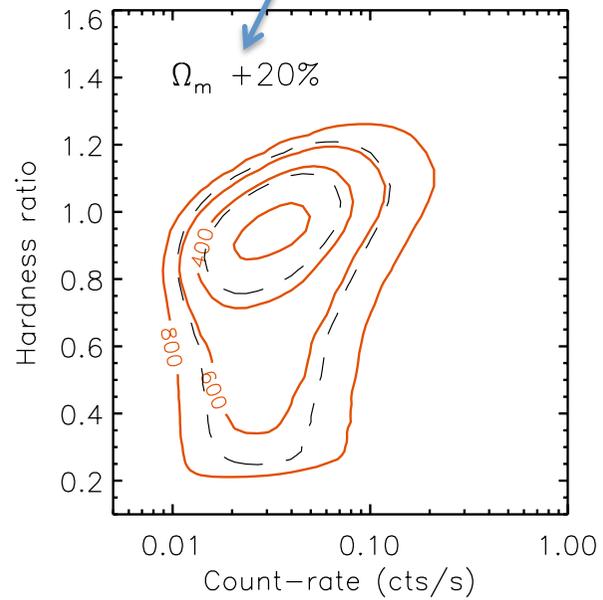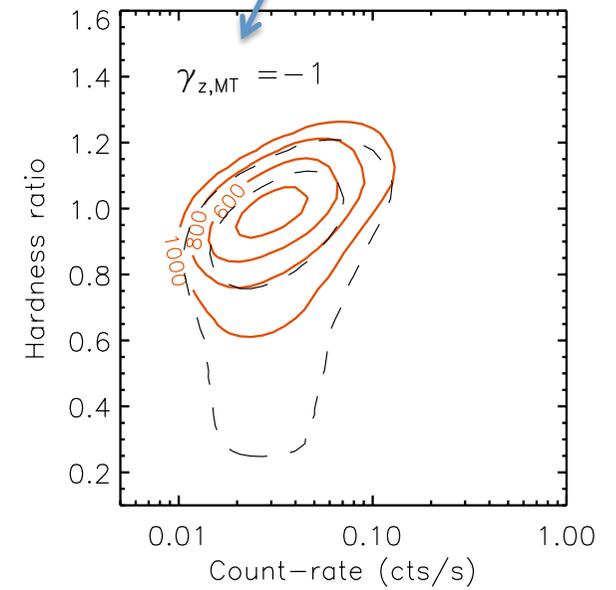
Method evaluated by *Clerc et al 2012*
(Fisher analysis)

Recent developments

Pierre, Valotti, Clerc et al
(to be submitted)

ASpiX based on XDD

New features

- The four observables: CR − HR − Rc − z

- Fisher analysis => toy model to
  - simulate cluster catalogues
  - test the impact of errors, scatters, area
  - search for possible degenerate solutions

Principle

Project the 2-D theoretical dn/dM/dz population

into the 4-D CR-HR-Rc-z observed parameter space

Set of explored parameters

	fiducial	main
Ω_m	0.23	x
σ_8	0.83	x
X_c	0.24	x
γ_{ML}	0	
γ_{MT}	0	
w_o	-1	x
w_a	0	

A few results

Preliminary conclusions

- Current accuracy predicted for 100 deg2:
    - Ω_m ~ 5%
    - σ_8 ~ 2%
    - X_c < 1%
    - w_o ~ 8%

➜ Slightly better than dn/dM/dz with 50% mass error !
and much faster and simpler!

Of course, sample variance is not (yet) taken into account here

FUTURE

Create XDDs directly on the fly, from simulations

- by-pass all current scaling relation related problems:
  - morphology (cc, relaxed-unrelaxed…)
  - hydrostatic vs lensing masses
  - Intrinsic scatter in the scaling relations
  - evolution

  - no external calibration sample needed

➔ What matters, after all, is only **the physics** that is put in the simulations

CONCLUSION

- GREAT opportunity for an XMM XXL^2 survey until 2028

- Compelling science cases

- All tools (processing and cosmo) are in place

- Unique X-ray Sky Atlas (unrivalled sensitivity and resolution)

- Huge legacy value

If you are interested in this idea:

Join the Mykonos prospective meeting, next June