Cluster detections in large multiband imaging surveys

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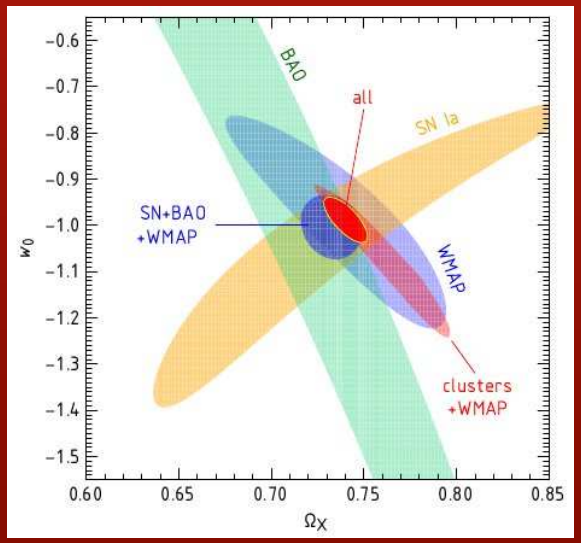
Main collaborators:

- Christophe Adami
- Christophe Benoist
- Emmanuel Bertin
- Alberto Cappi
- Jean Coupon
- Olivier Ilbert
- Isabel Márquez
- Sophie Maurogordato
- Tabatha Sauvaget
- Melville Ulmer

Why search for clusters?

- Clusters are interesting objects *per se*
- Cosmological interest: cluster counts give constraints on cosmological parameters



Vikhlinin et al. 2009, ApJ 692, 1060

The data

CFHTLS u*, g′, r′, i′ or y, z′ bands

- Mazure et al. 2007: Deep 1 field

- Adami et al. 2010:
  - Deep fields: Deep 2, Deep 3 and Deep 4
  - Wide fields (34 deg^2): Wide 1, Wide 3 and Wide 4 from data release 4

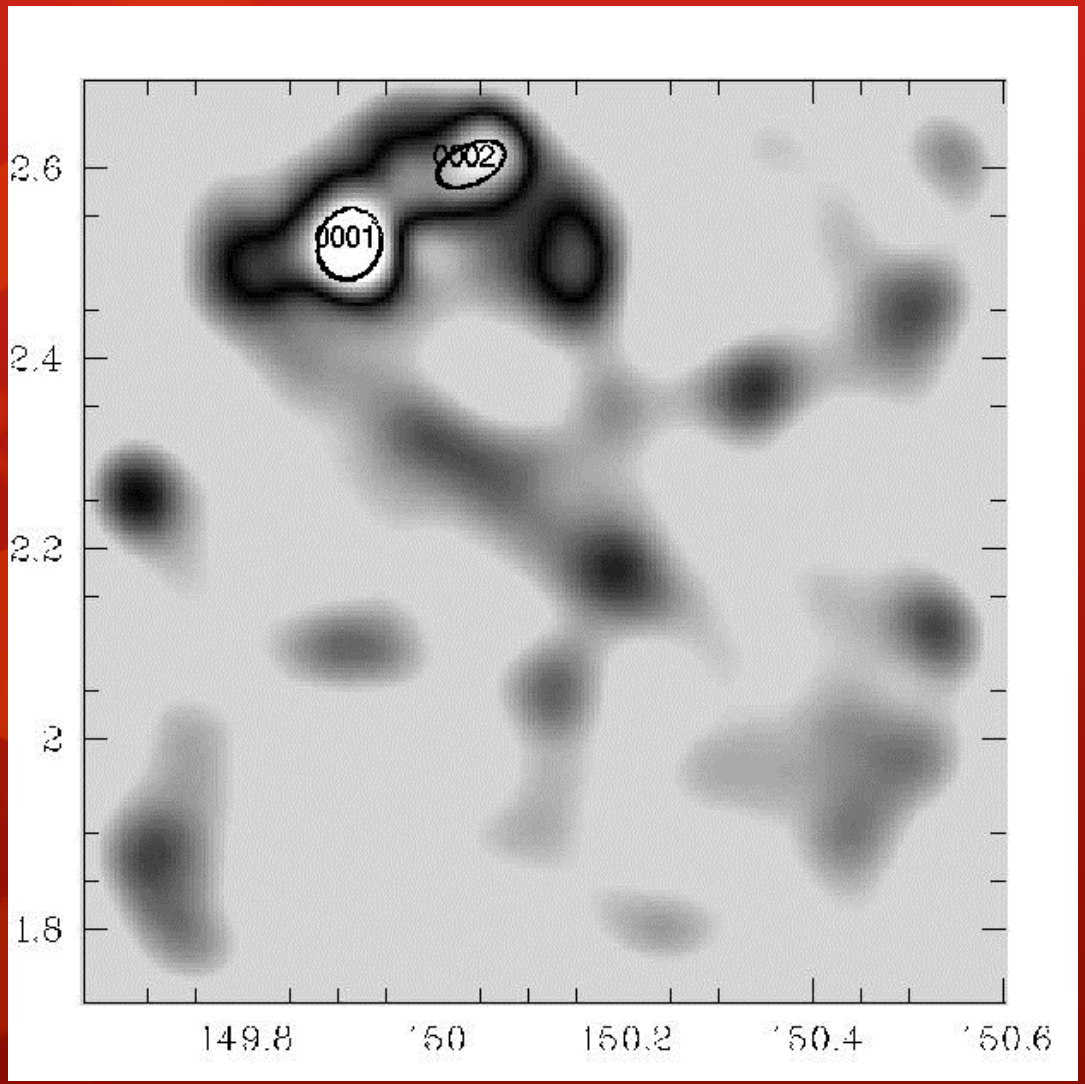
- Durret et al. 2011:
  - Wide fields (154 deg^2) from data release 6 cut at $z' \leq 22.5$

SDSS Stripe 82

- 270 deg^2
- 5.4 10^6 galaxies with $z_{phot} \leq 0.75$ (z_{phot} from Reis et al. 2012, ugriz magnitudes from Annis et al. 2011)

Our cluster finder in a nutshell: AMACFI (Adami & Mazure Cluster FInder)

- Apply magnitude limits to galaxy catalogues to avoid incompleteness effects
- Estimate photometric redshifts for all galaxies with LePhare (O. Ilbert, J. Coupon)
- Build galaxy density maps in photo-z bins of 0.1 incremented by 0.05 based on an adaptive kernel technique
- Detect structures in these maps with SExtractor at a chosen significance level (3σ, 4σ, 5σ, 6σ, 9σ)
- Assemble the structures detected with a friends-of-friends algorithm (minimal spanning tree)



Example of a density map:

CFHTLS Deep 2 field in the [0.65-0.75] redshift bin

Two candidate clusters detected at 6σ

Validation on Millennium simulation

- Validate method by applying same procedure to the Millennium simulation (modified to be comparable to our data)
- Estimate masses as a function of detection threshold
- Estimate percentages of fake detections as a function of redshift and of detection threshold
- Estimate errors on cluster positions

CFHTLS: a few results

Adami et al. (2010)

- 1200 cluster candidates
- Cluster candidates at $z \geq 1$: 141 at 3σ, 31 at 6σ

Durret et al. (2011)

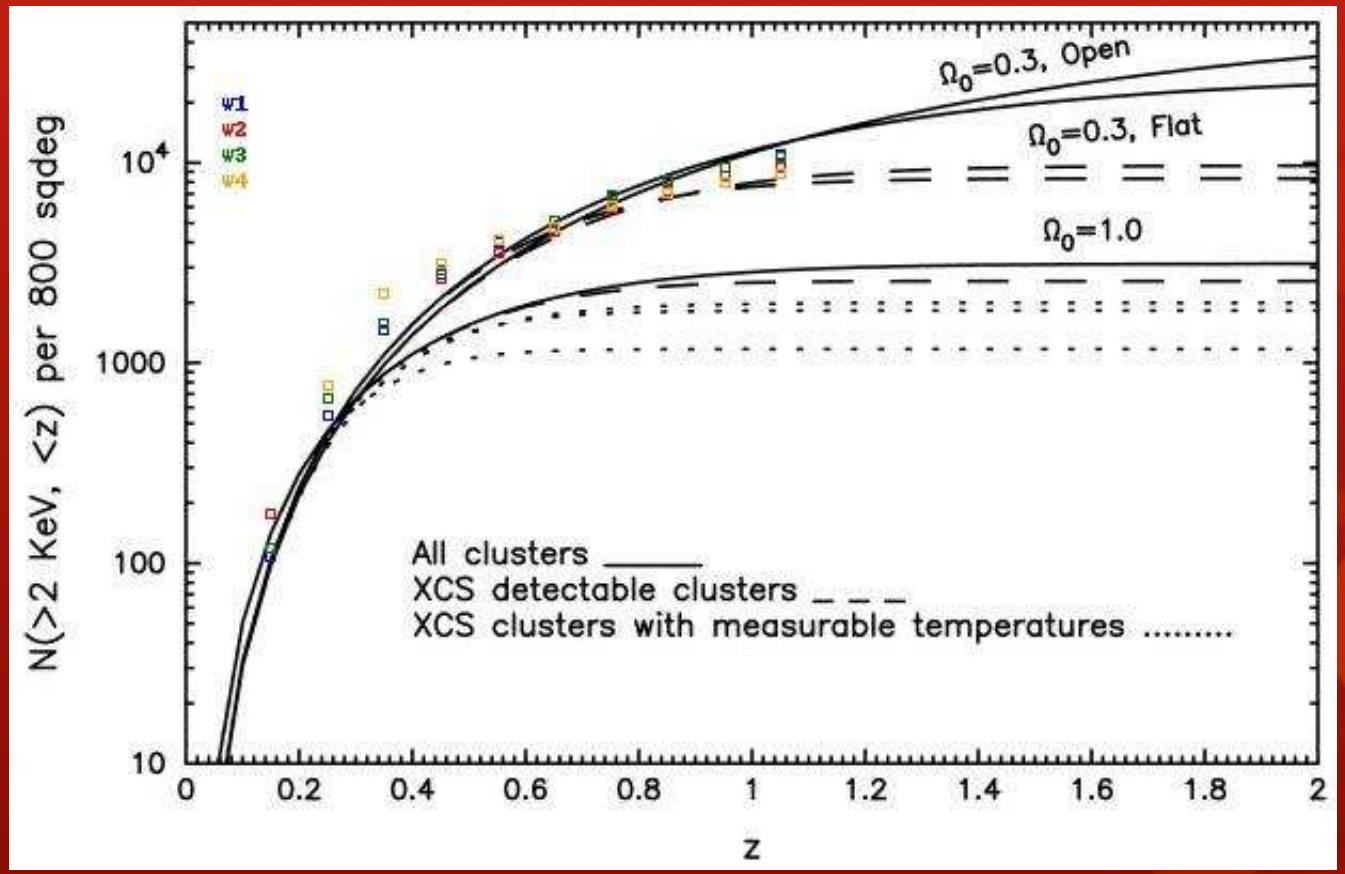
- 4061 cluster candidates, redshift range $0.2<z<1.15$,

masses between 1.3 10^{14} and 1.3 10^{15} M_{solar}

- Cluster candidates at $z \geq 1$: 821 at 3σ, 32 at 6σ

- These cluster candidates have typical cluster properties (colour-magnitude relation, luminosity function)

Redshift distribution of the clusters detected at ≥ 4σ in all the Wide fields



Romer et al. 2001, ApJ 547, 594

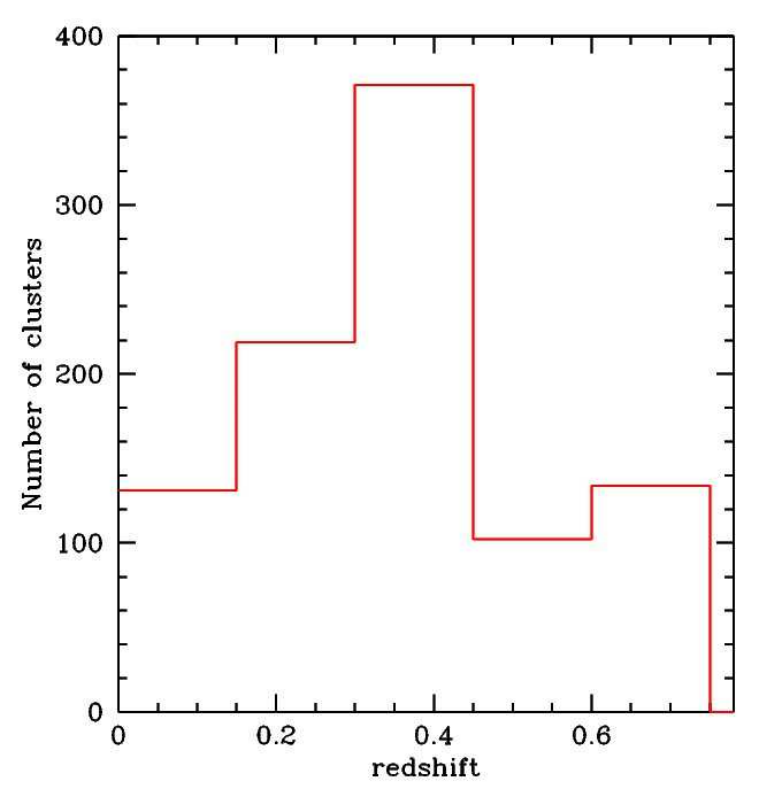
In progress: full analysis of all the CFHTLS candidate clusters (Maurogordato et al. in preparation)

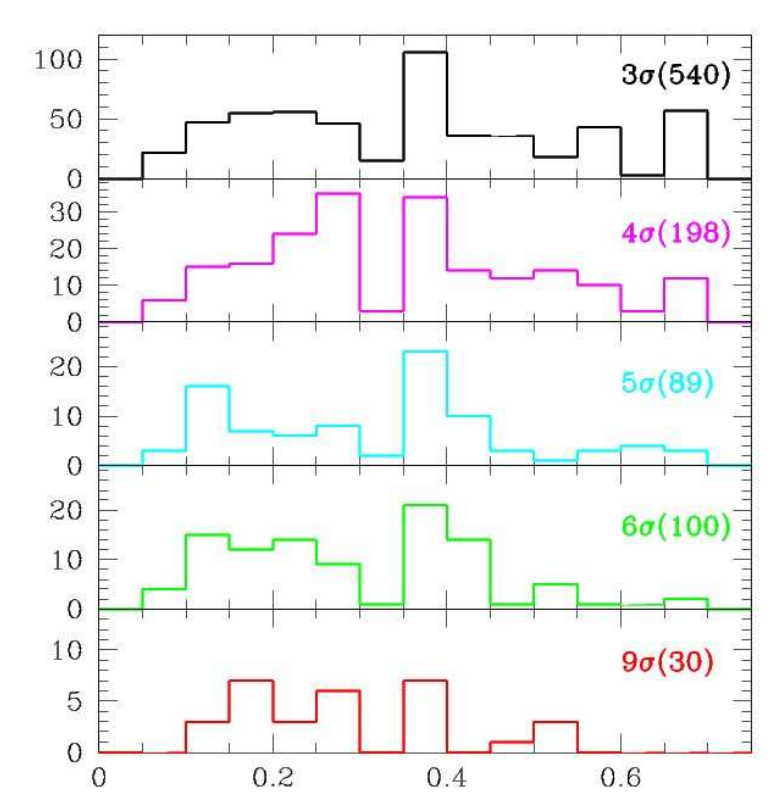
Properties of candidate clusters stacked by redshift or mass (significance level of detection):

- colour-magnitude relations
- galaxy luminosity functions and Schechter function fits

Large scale structure around candidate clusters

SDSS Stripe 82:
957 candidate clusters at z≤0.75

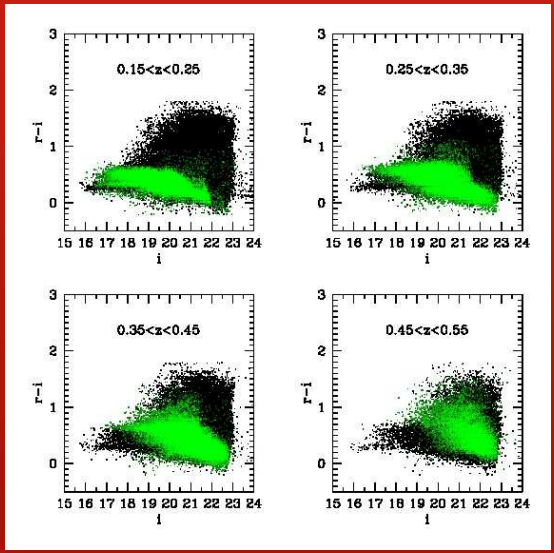




Durret et al. in preparation

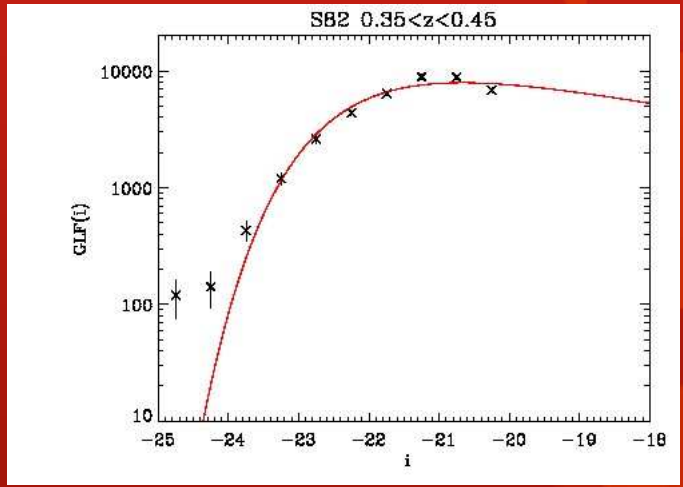
Stripe 82 clusters stacked in redshift bins

Colour-magnitude diagrams



Black: all galaxies within 2 Mpc radius
Green: galaxies within 2 Mpc and z cluster ± 0.1

Galaxy Luminosity Functions



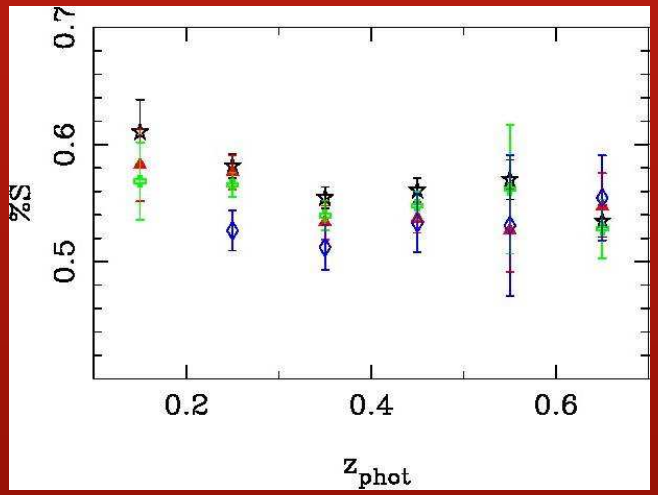
Galaxy luminosity function of stacked clusters in the 0.35<z<0.45 redshift bi n

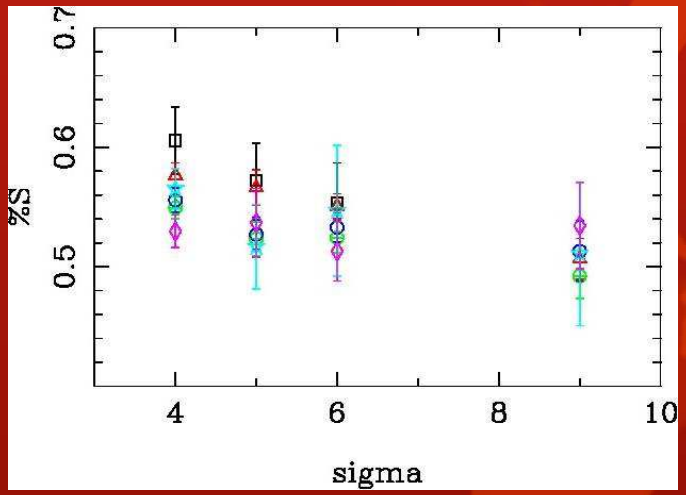
The properties of stacked clusters are similar to those of clusters

75% of the clusters we detect at 4σ and above are also detected by

Geach et al. (2011), MNRAS 413, 3059

Morphological analysis of cluster galaxies in the Stripe 82





Percentage of late-type galaxies in stacked clusters as a function of redshift (left) and significance level/mass (right) of cluster detection

No strong variation

AMACFI was applied to mock catalogues as part of the Euclid cluster finder challenge

- Main present limitation: the spatial resolution
- Need to cut the original catalogue in smaller overlapping zones
- Needs to be to parallelized
- To analyse 100 deg^2 mock catalogue, ~100 hours computing time!
- Compromise difficult to find between computing time, and catalogue completeness and purity

A few conclusions

- An important fraction of our candidate clusters are likely to be real clusters
- Analysis of properties of stacked clusters is under way
- Candidate clusters could be correlated with X-ray data
- Application of AMACFI to mock catalogues for Euclid cluster finder challenge: analysis of completeness and purity in progress
- AMACFI can be applpied to other large surveys (NSLS)