

XMM Clusters through DECam Eyes

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University of Sussex

Ripples in the Cosmos, July 23rd 2013



DARK ENERGY
SURVEY



Collaborations Funding Agencies Observatories DES:UK partners

XMM Clusters through DECam Eyes

On behalf of the XCS-DES-SV team:
36 members of DES; 22 members of XCS

Especially:

Philip Rooney; Jeeseon Song; Chris Miller;
Shantanu Desai

XMM Clusters through DECam Eyes

Thanks also to the dozens of scientists and engineers who built and commissioned DECam; upgraded the Blanco telescope; and developed the data management systems

Overview

- The Dark Energy Survey
- The XMM Cluster Survey
- Bringing XCS and DES together

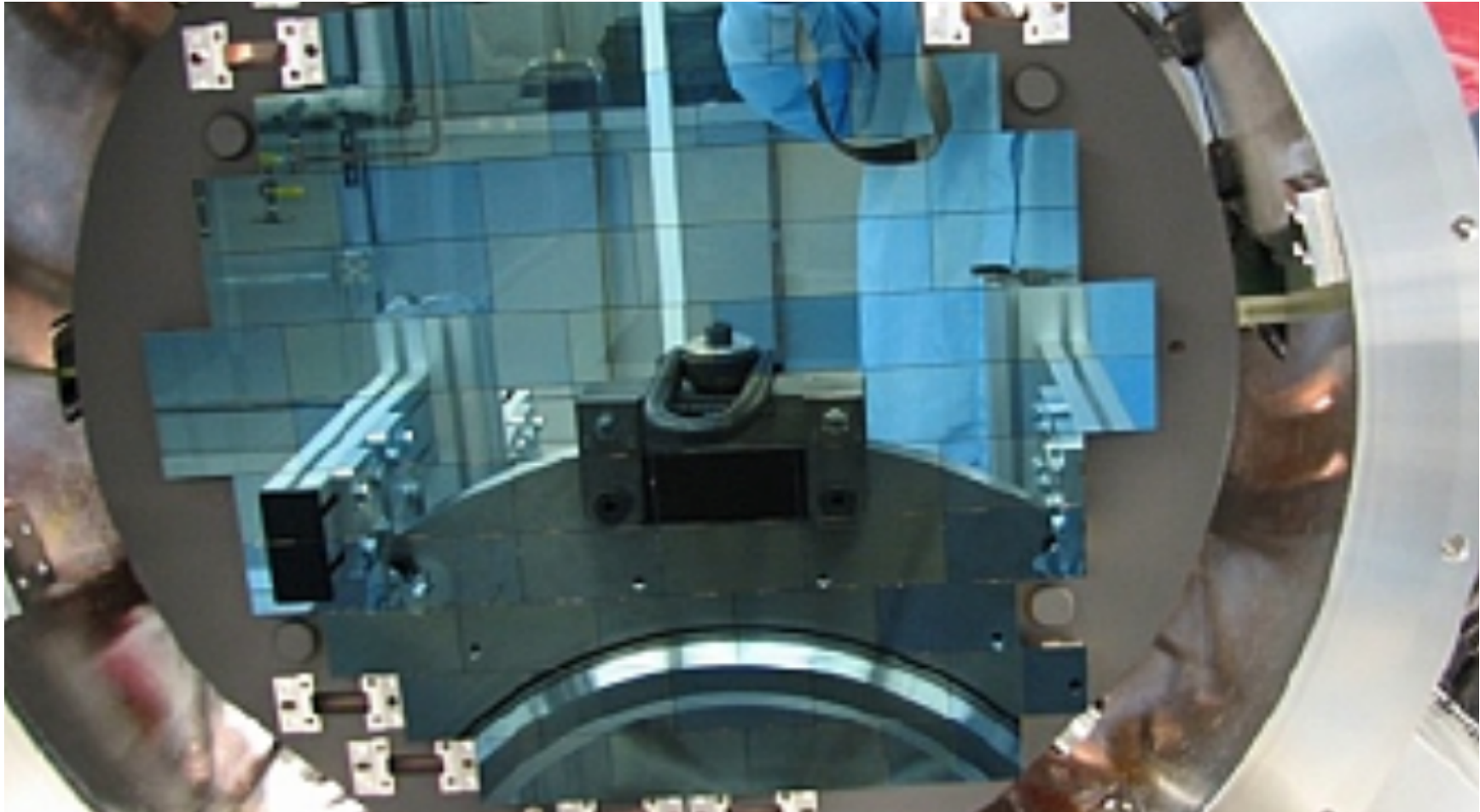
The Dark Energy Survey

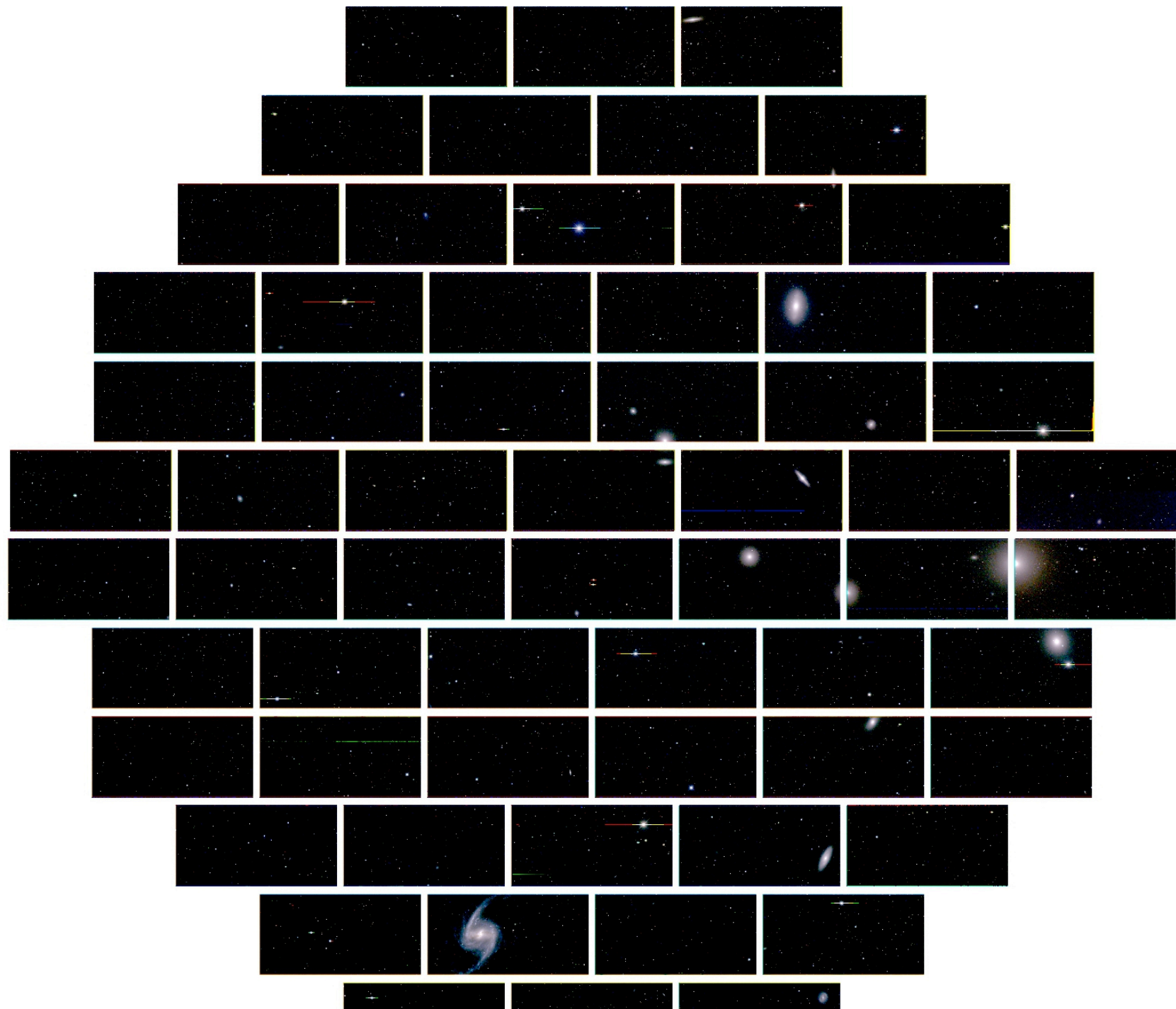


The Dark Energy Survey

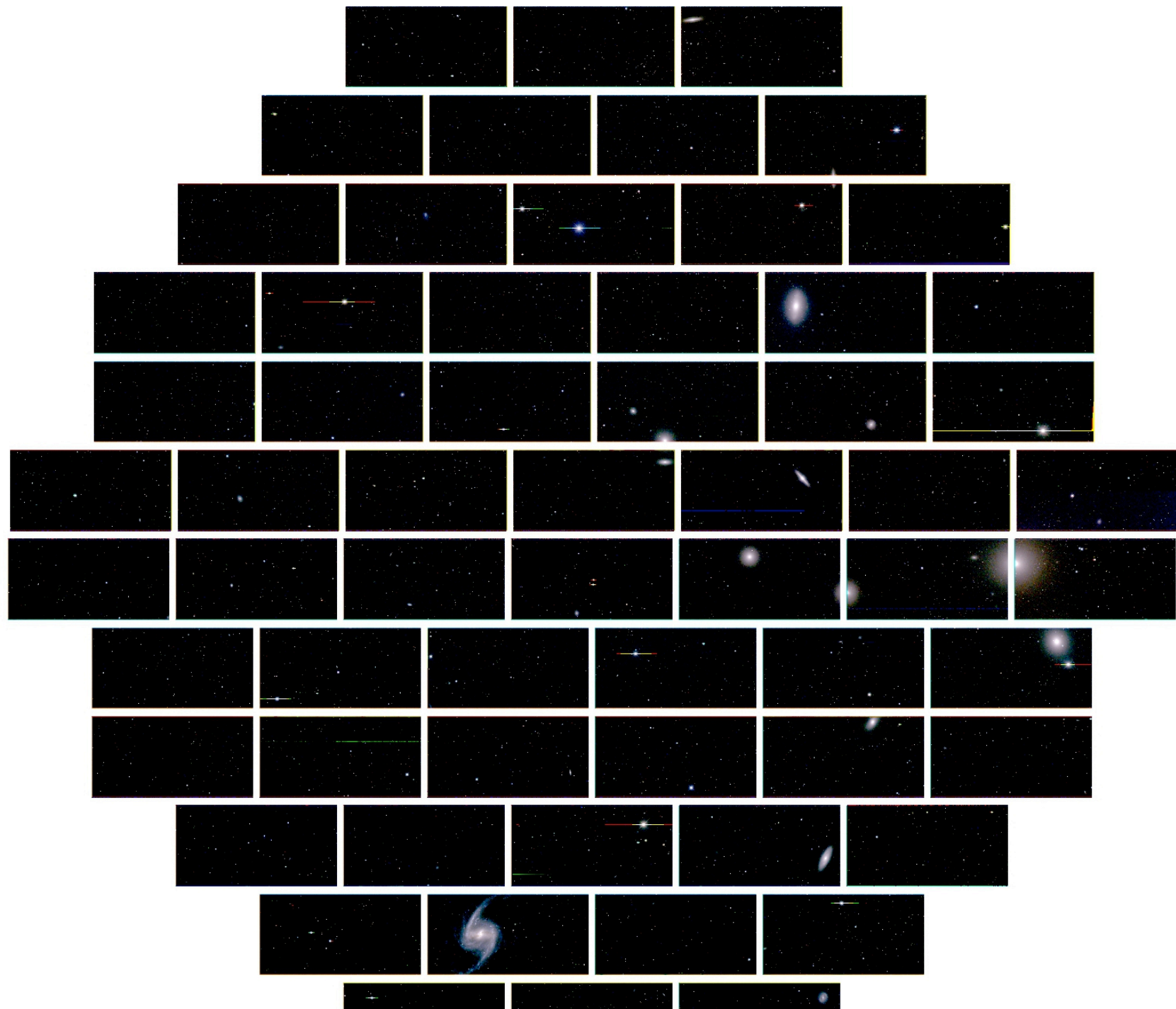


The Dark Energy Survey





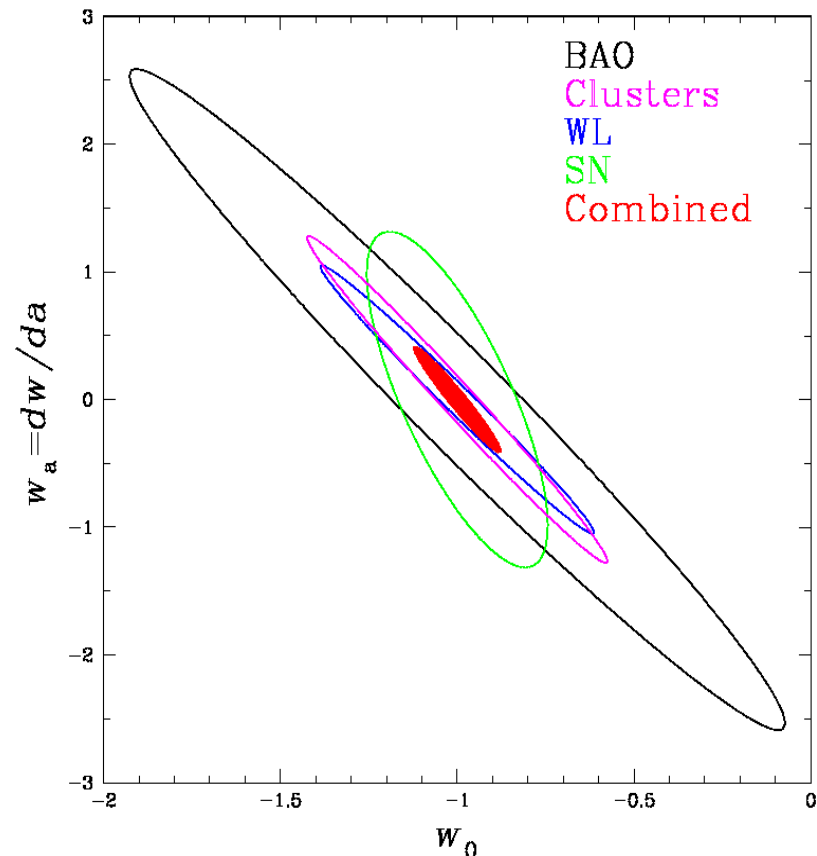








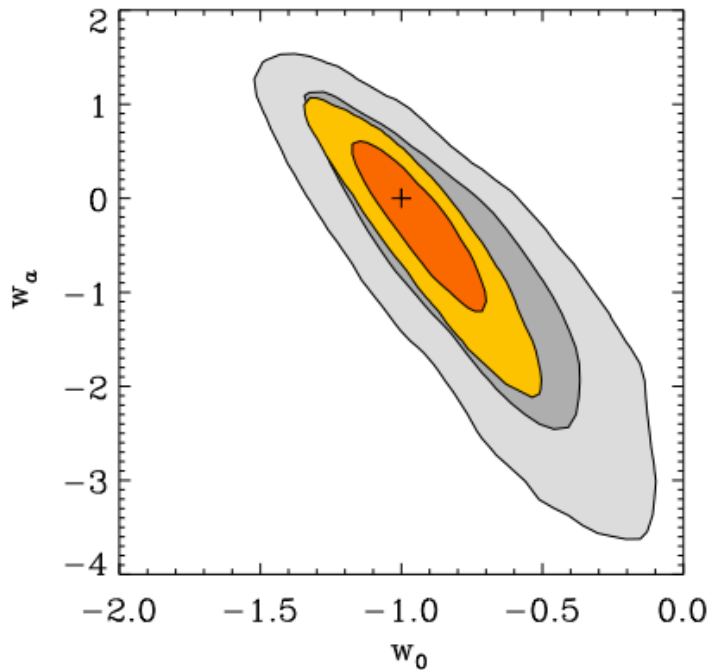
We just need to add another 499,998 clusters (with masses and redshifts) and we'll have solved dark energy...



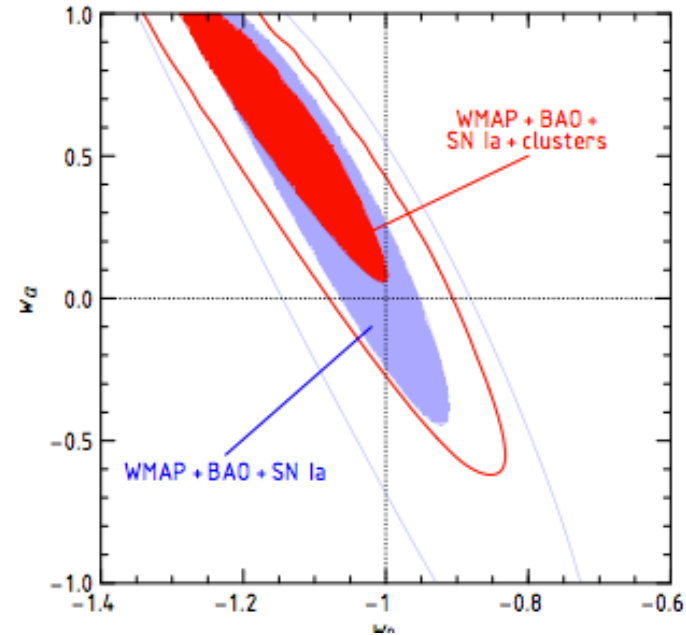
Plot taken from the DES proposal to NSF

This builds on a strong tradition of cluster cosmology, e.g....

Mantz et al. 2010MNRAS.406.1759M



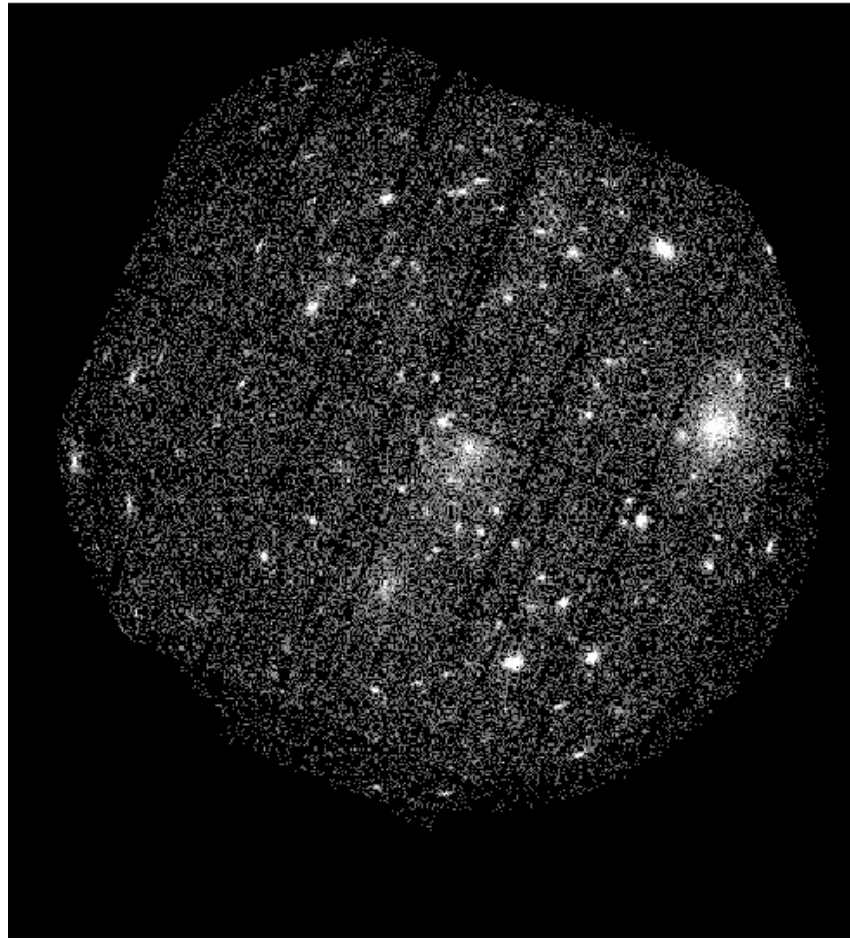
Vikhlinin et al. 2009ApJ.692.1060V



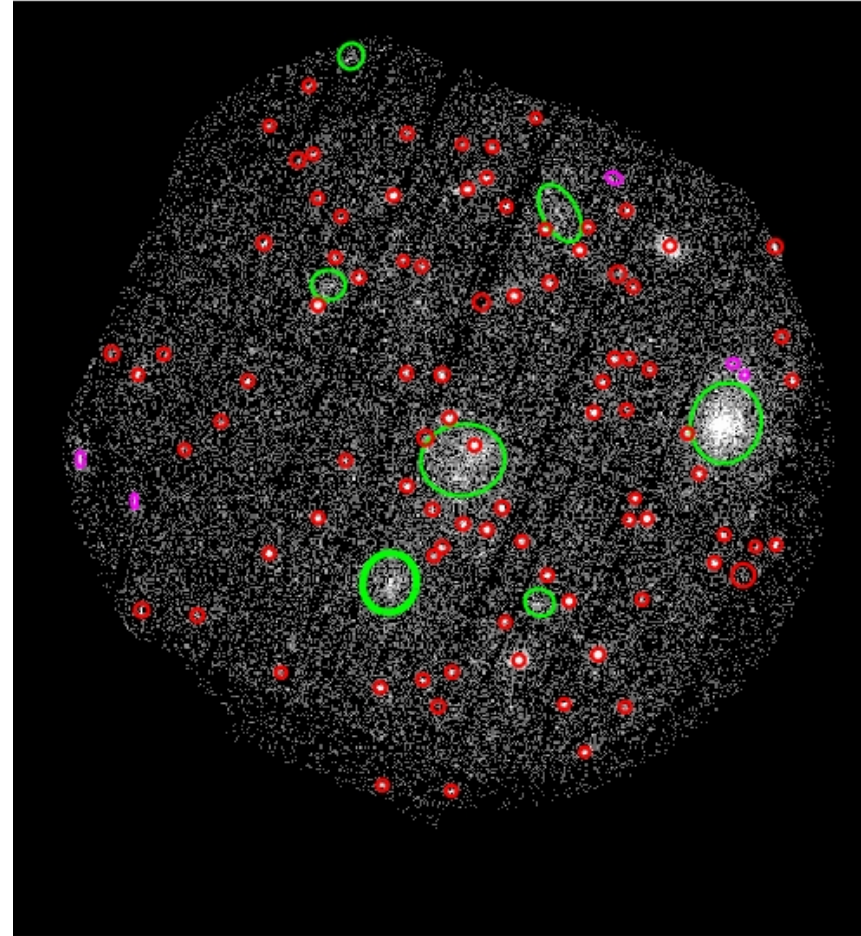
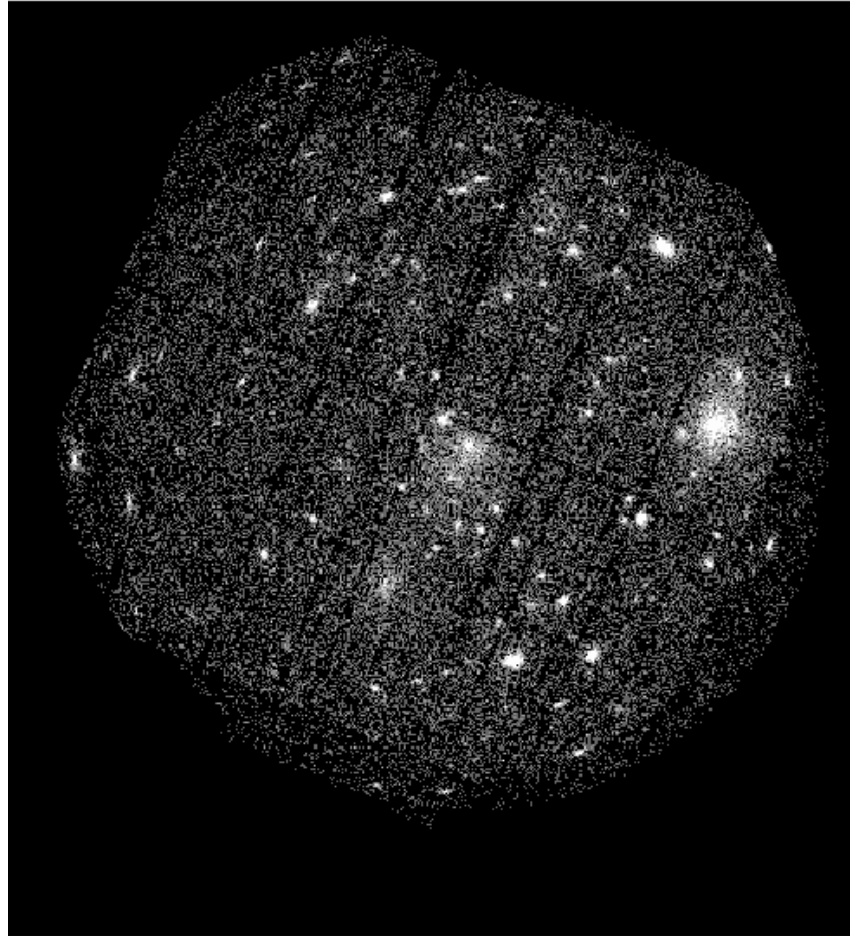
Overview

- The Dark Energy Survey
- **The XMM Cluster Survey**
- Bringing XCS and DES together

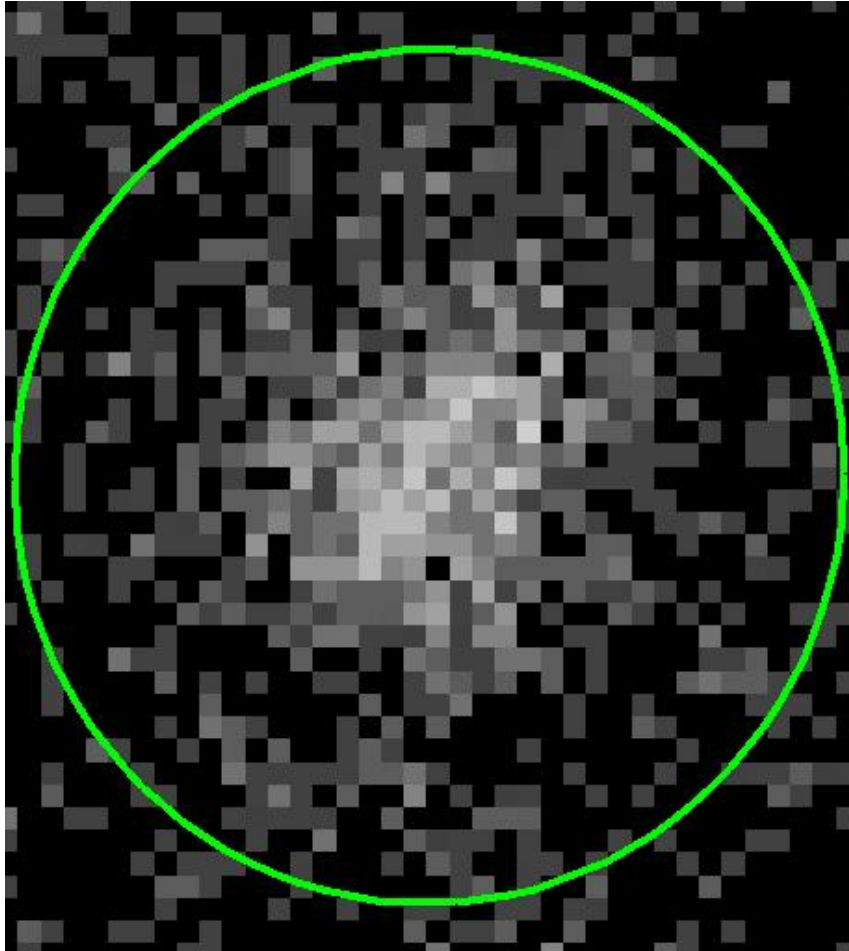
We reduce every observation in the XMM archive to produce images like this



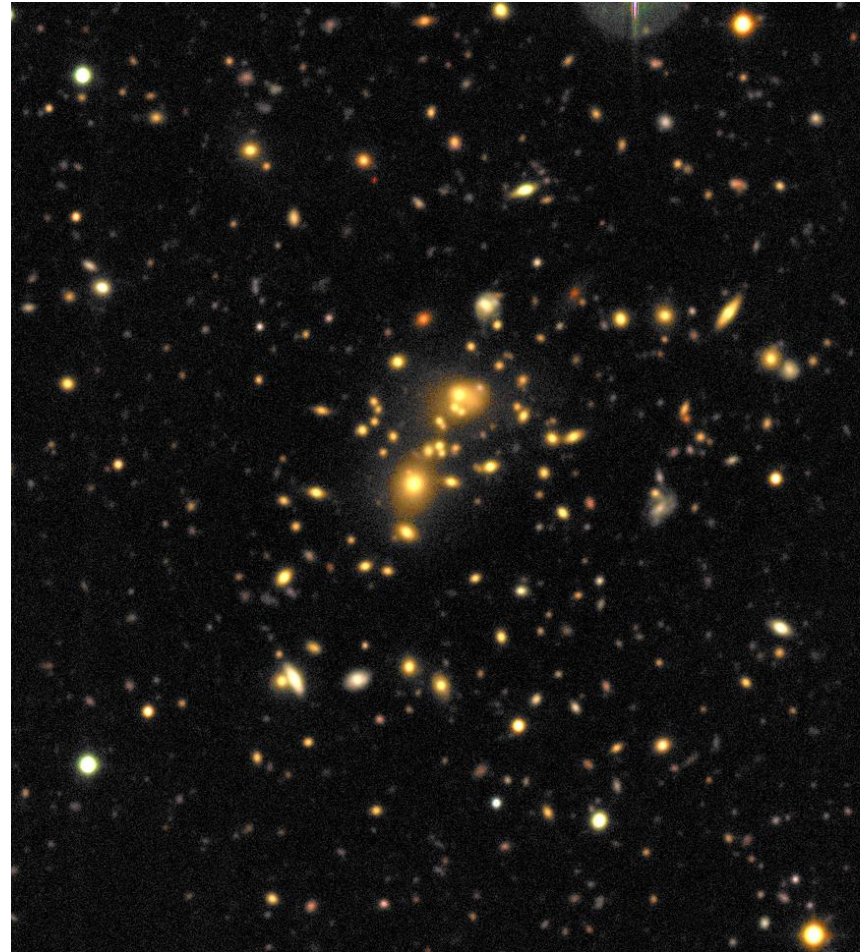
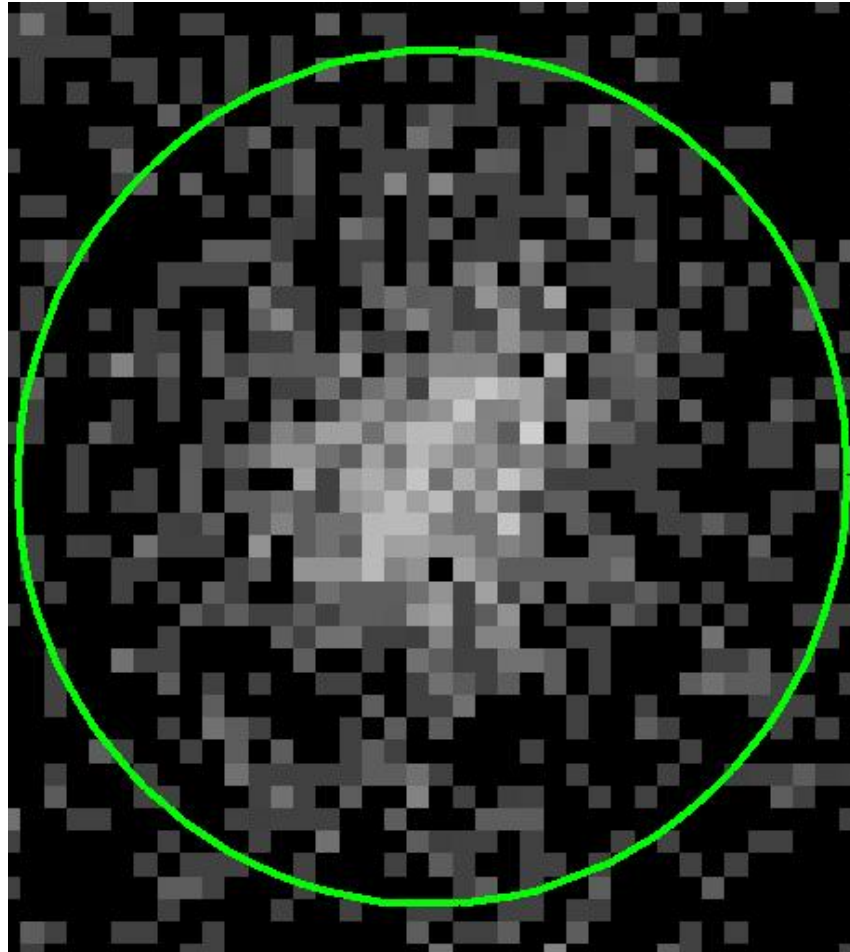
We then find all the **point** like and **extended** sources



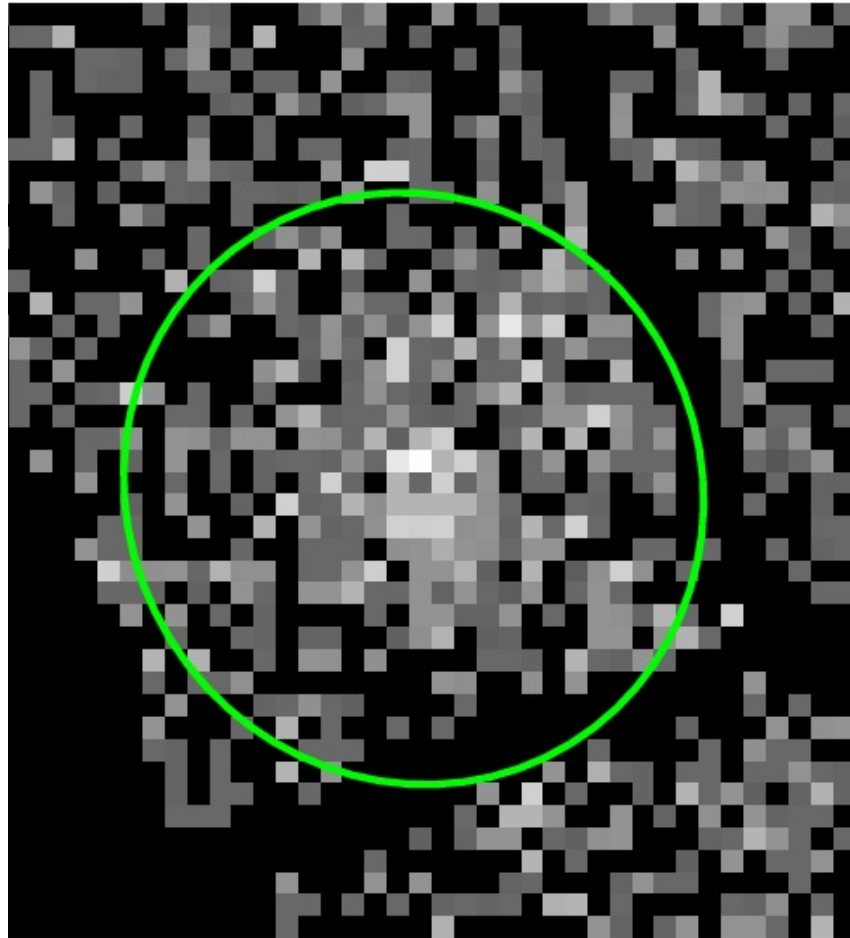
Most extended sources are clusters



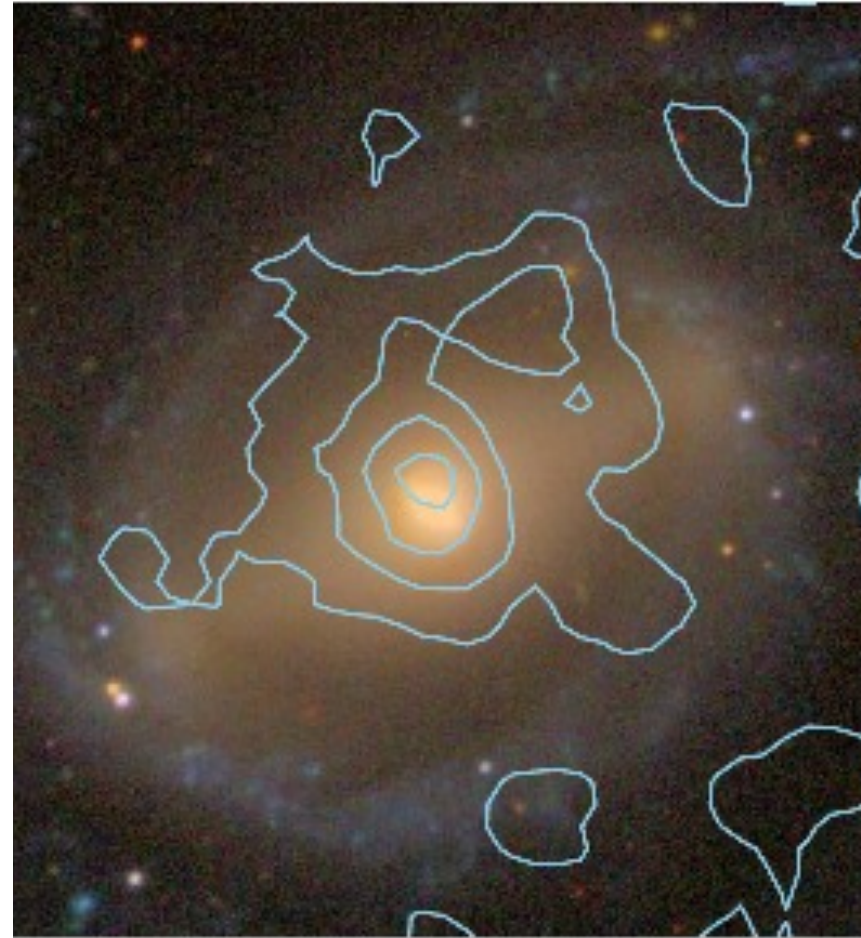
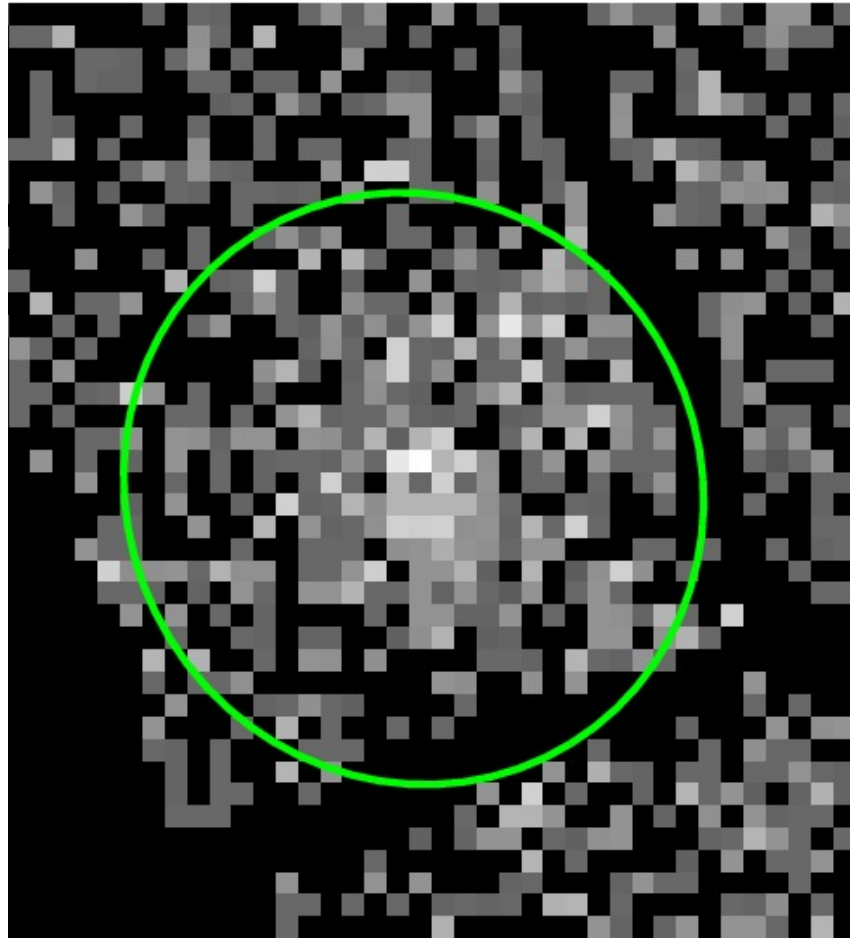
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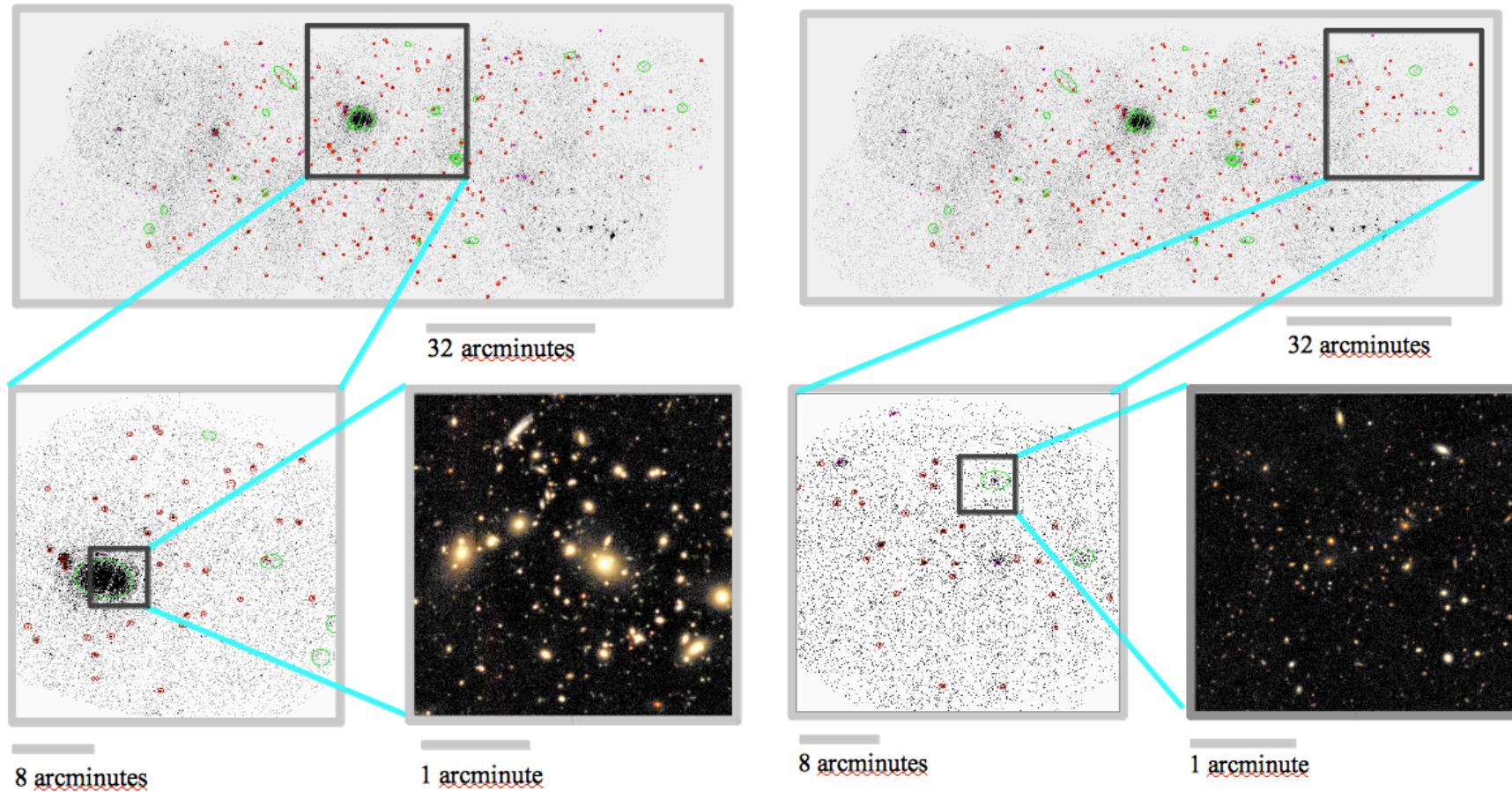
But not all....



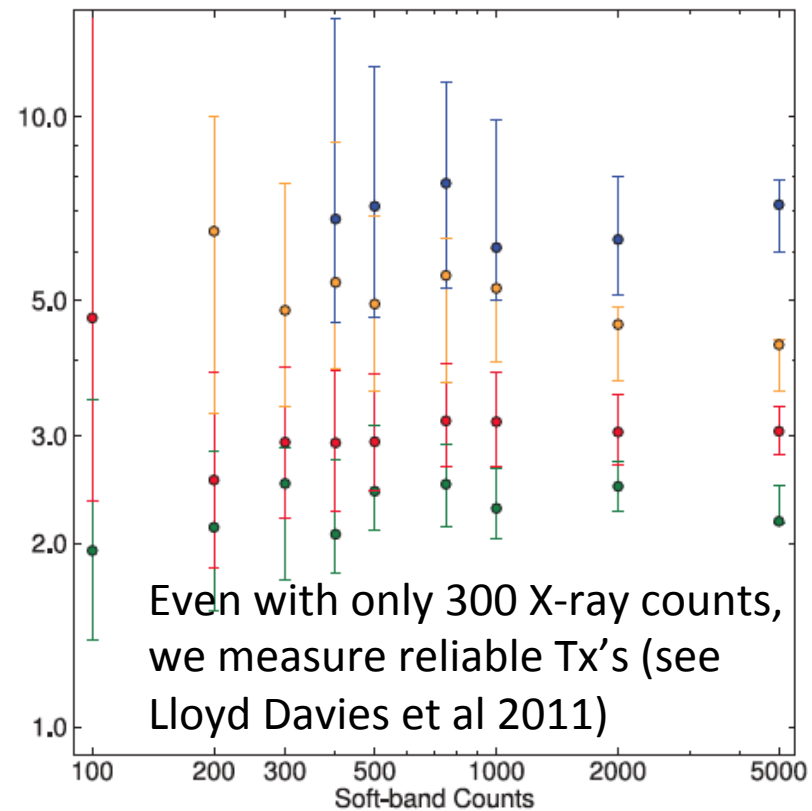
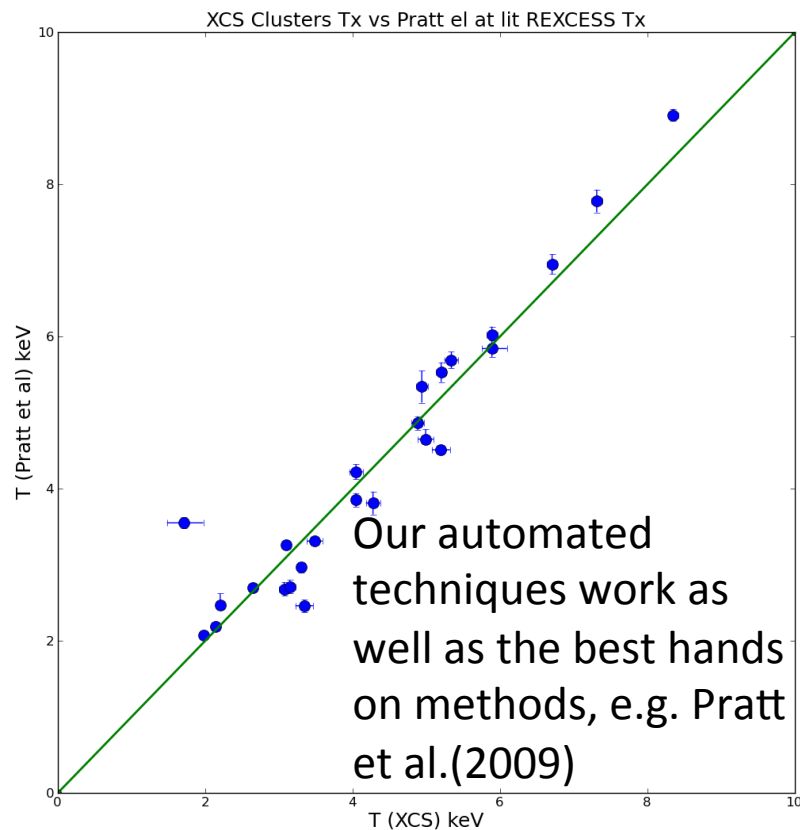
So we eyeball all of them before adding them to a cluster candidate list



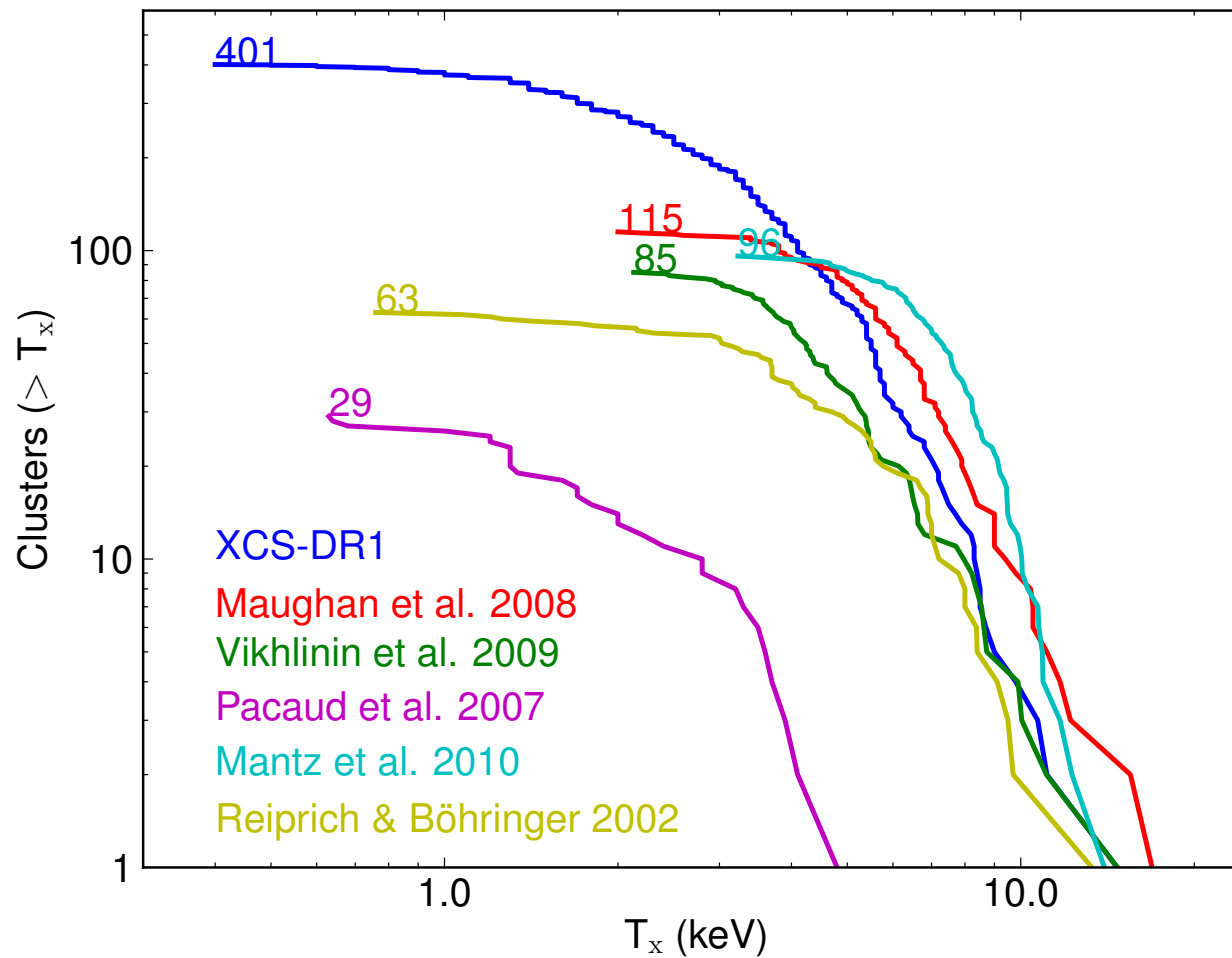
We process both normal and mosaic mode observations



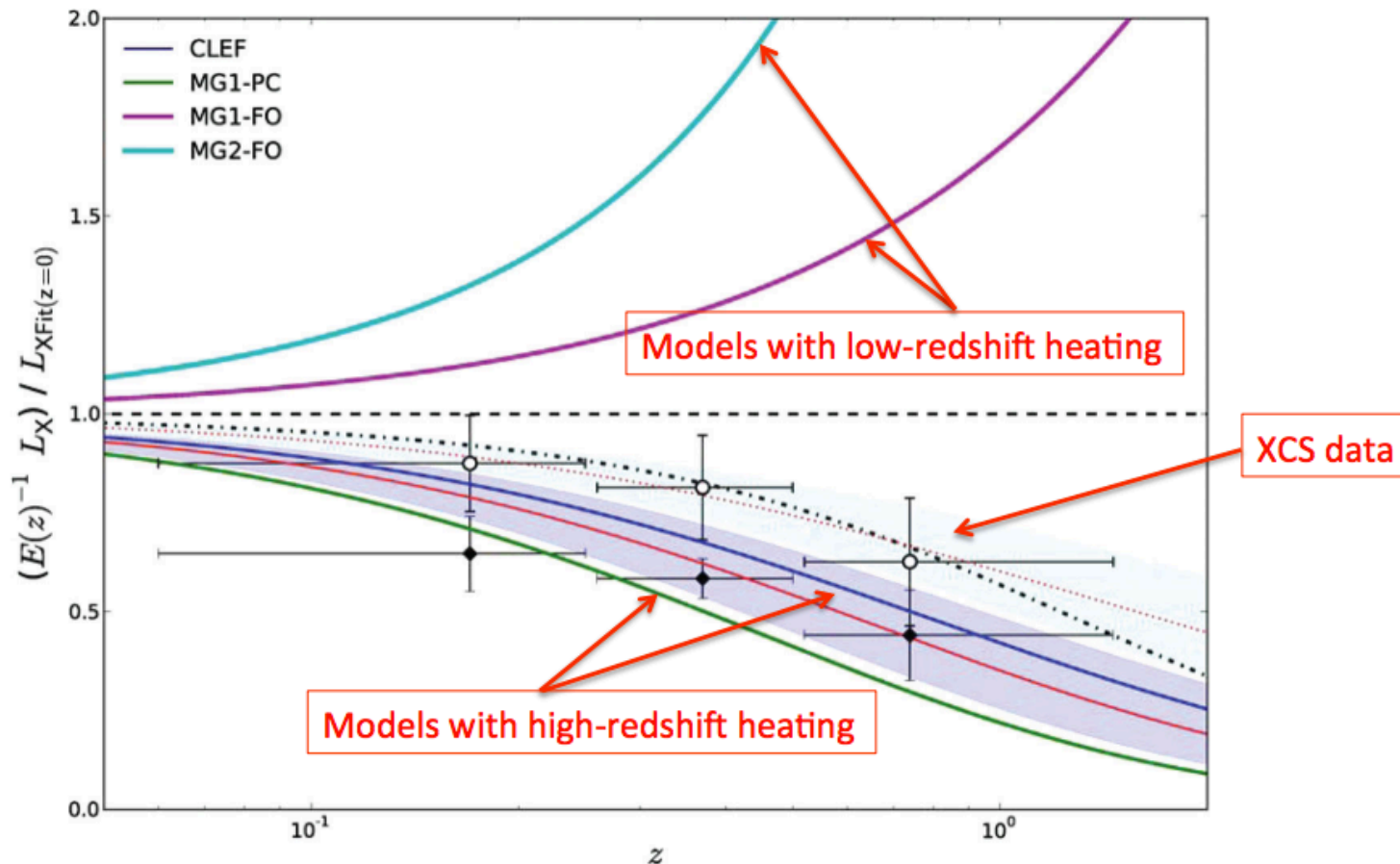
Once the clusters are confirmed and redshifts measured, we have automated pipelines to measure cluster properties.



401 XCS cluster T_x 's have been published so far (Mehrrens et al. 2012)



Using this sample, we have shown that energy must have been injected into cluster gas at high redshift (Hilton et al. 2012)

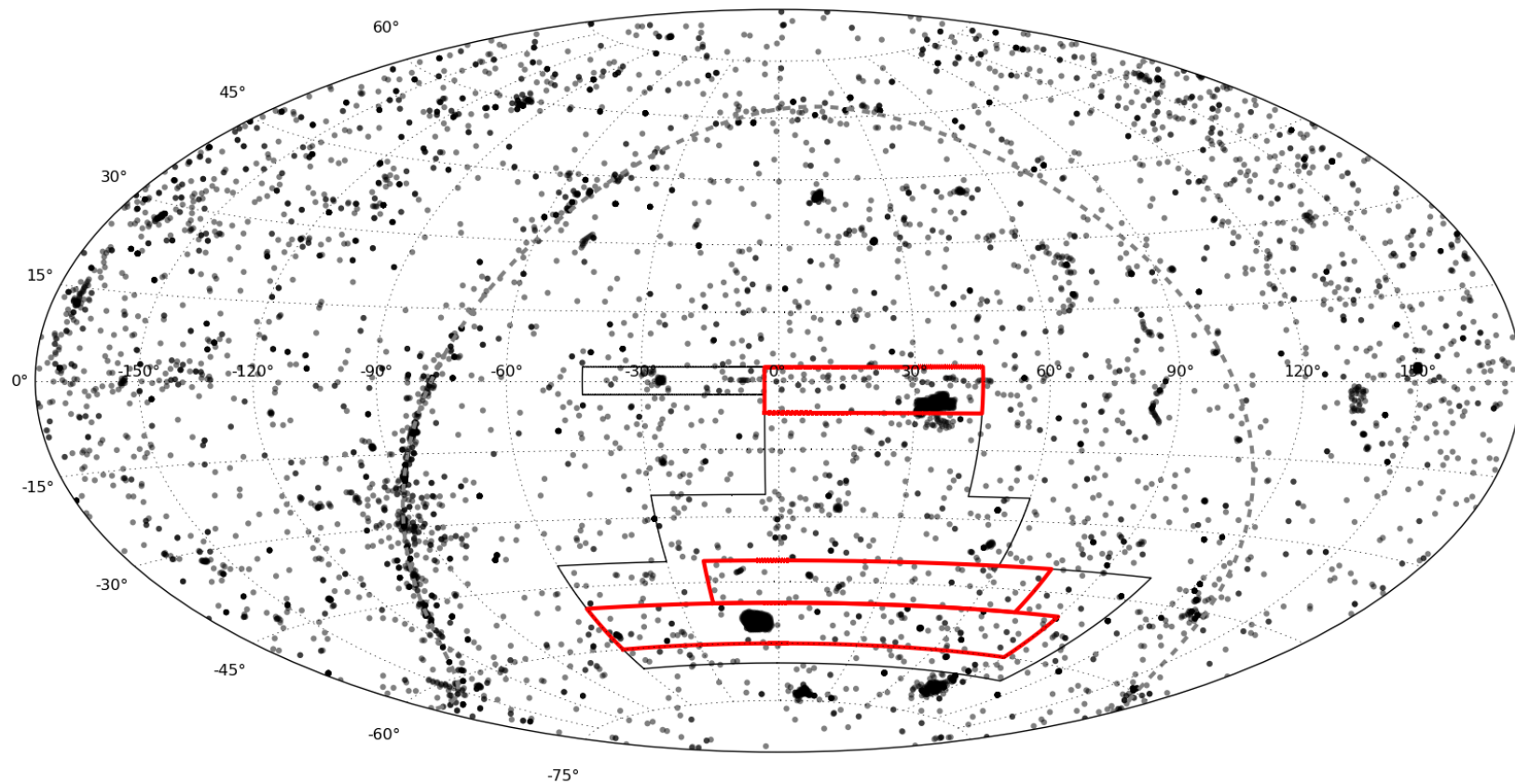


XCS science results can also be found in Viana et al. 2012;
Harrison et al. 2012; Stott et al. 2012; Shimwell et al. 2013.

Overview

- The Dark Energy Survey
- The XMM Cluster Survey
- **Bringing XCS and DES together**

So far there are 174 sq.degrees of overlap
between DES and the XMM archive
(outside MCs and Galactic plane)



DES footprint

XMM archive

The grey outline shows the full DES footprint, the red shows what we'll cover in year 1 (with 4 tilings, cf 10 for final survey)

By combining with DES and XCS we will:

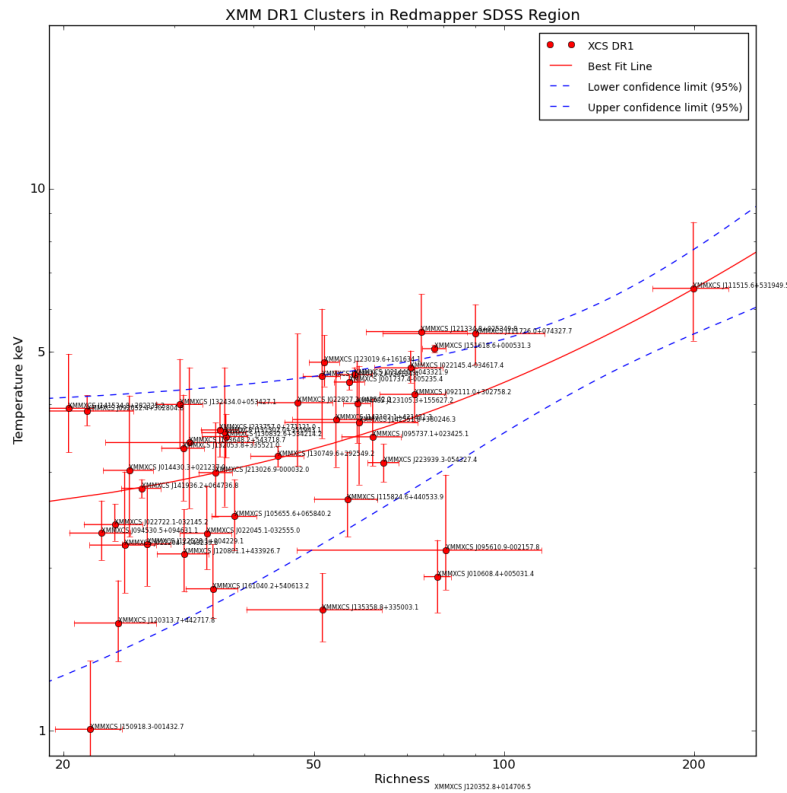
- Confirm hundreds of extended XMM sources as clusters (and measure X-ray temperatures for about a third of them)
- Improve our understanding of cluster physics
- Enhance optical cluster finding algorithms (by testing centering and mass calibration)

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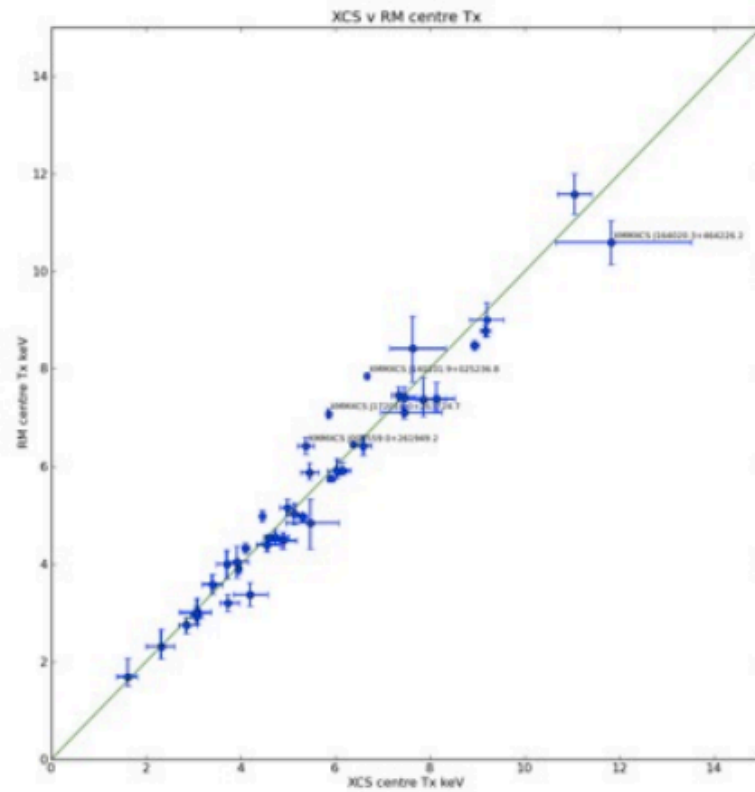
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We are doing similar work with the SDSS RedMaPPer cluster sample (Rykoff et al. 2013)

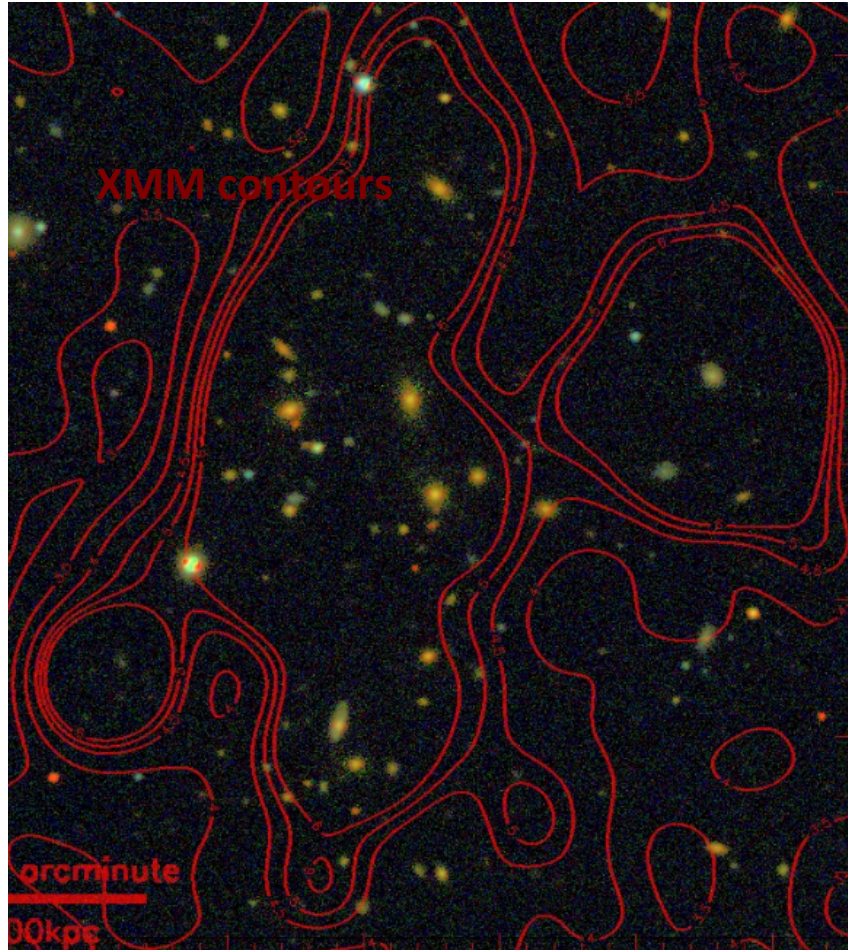
There are strong correlations between X-ray temperature and galaxy richness



Centering offsets do not impact the measured X-ray temperature

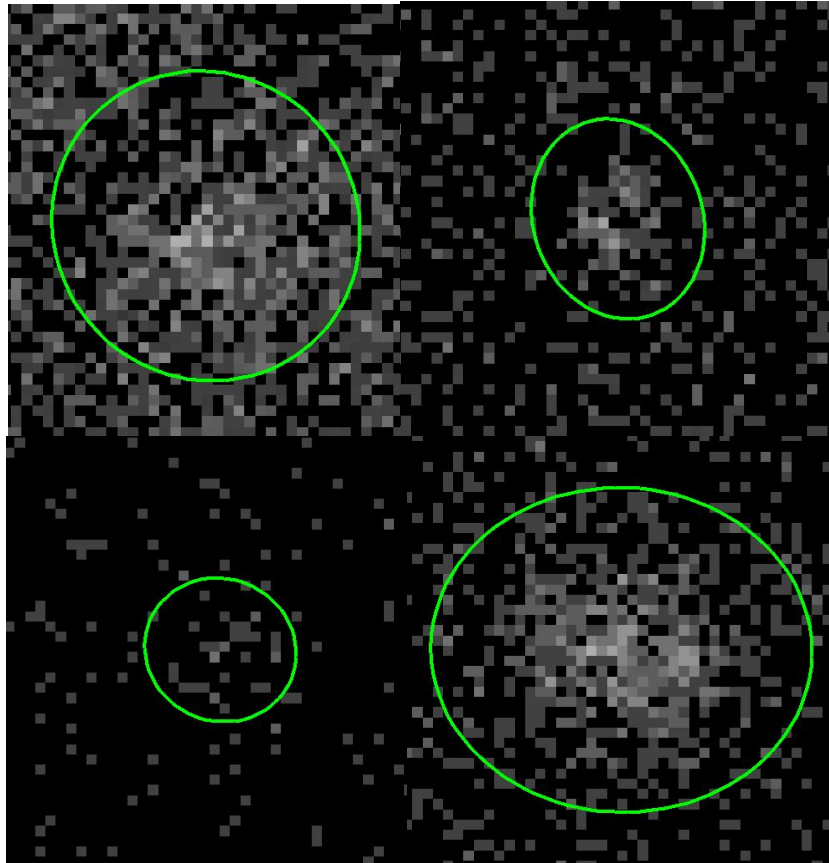


The XCS-DES-SV cluster sample



- The 2012/13 observing season with DECam was used for Science Verification, both for DES and for Community Time projects
- We have identified 606 cluster candidates in the overlap regions between XMM and DECam-SV data

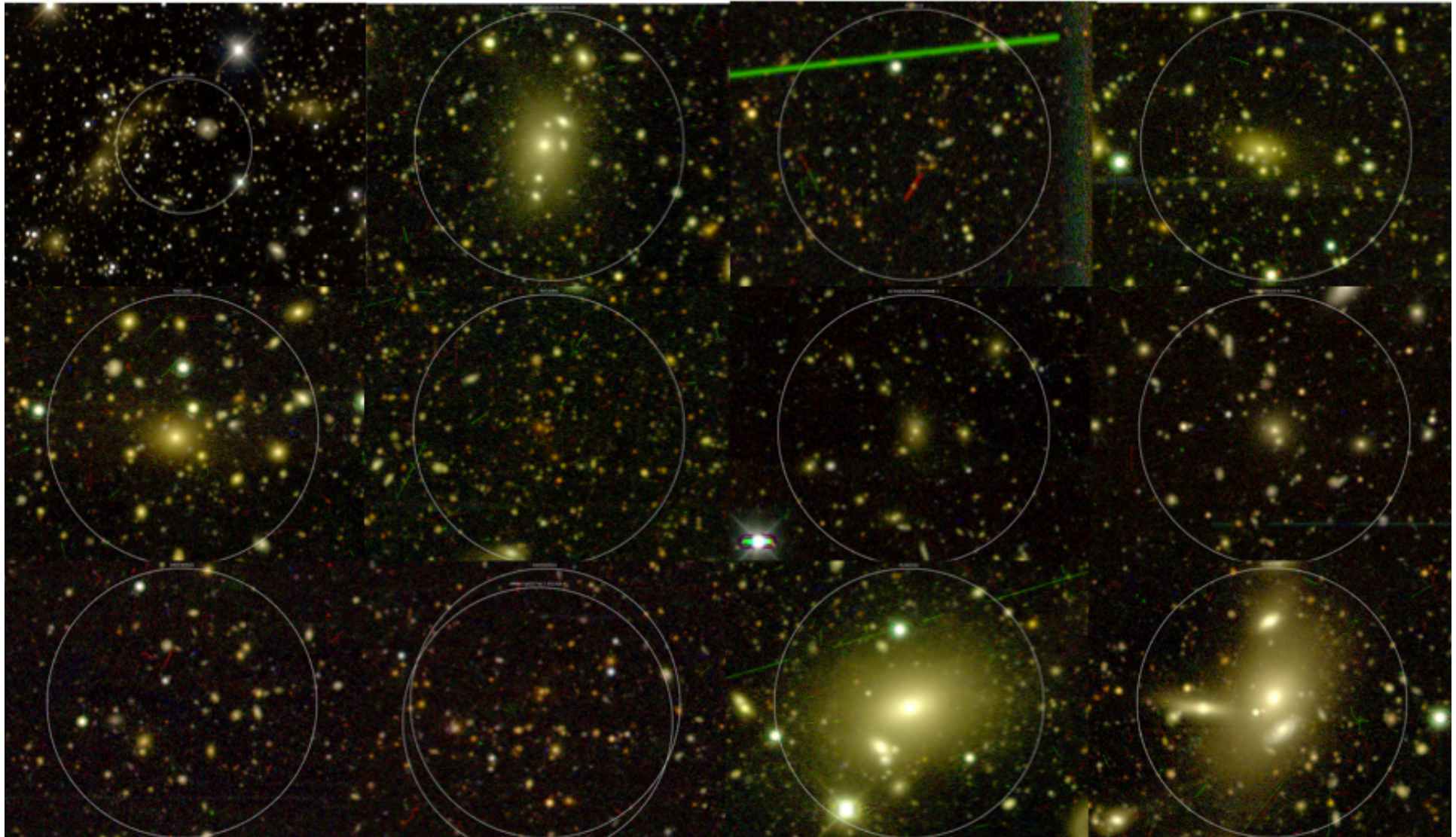
The XCS-DES-SV cluster sample



4 examples of the 606 candidate clusters

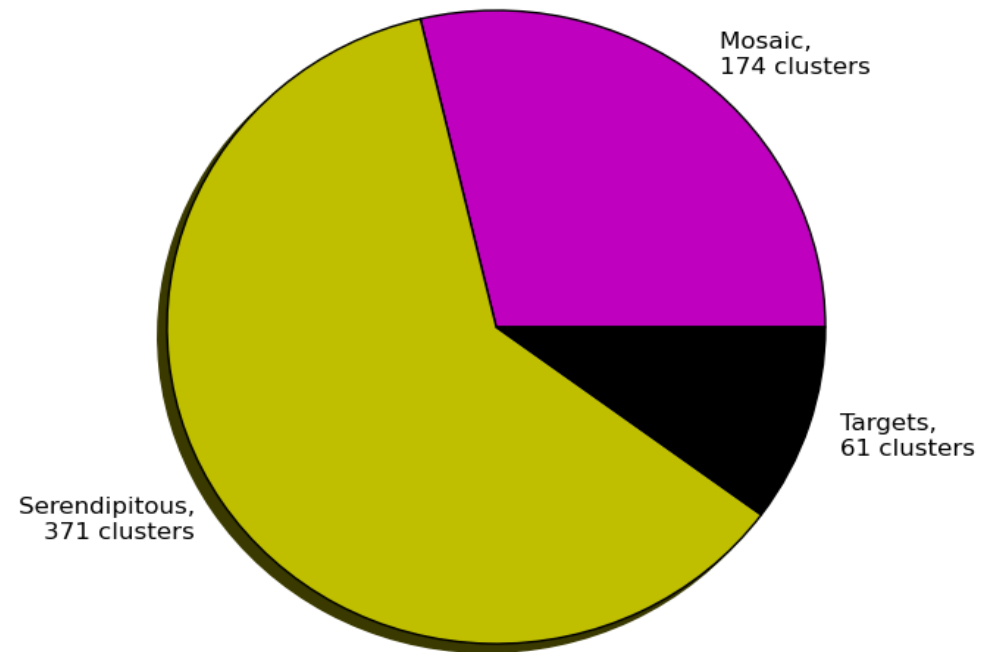
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DECam images of XMM clusters



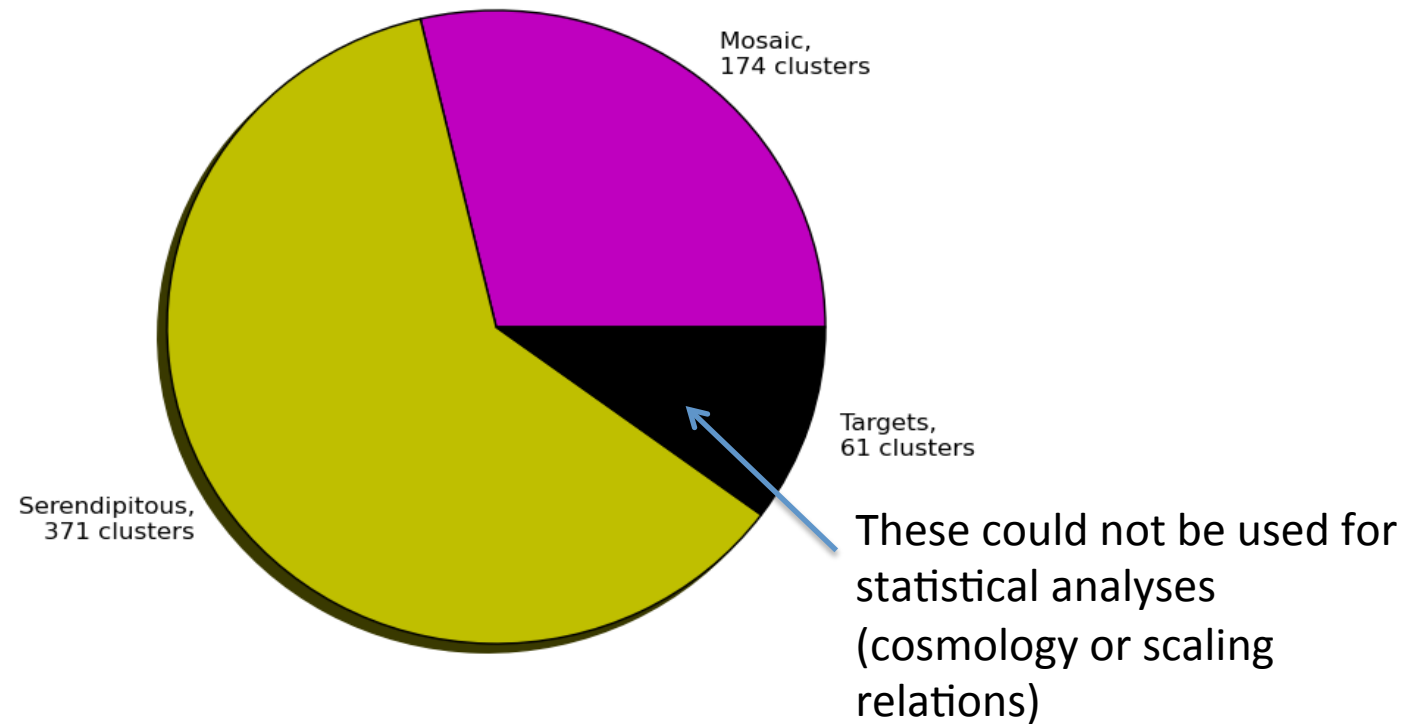
Types of XMM source

XMM Source Types



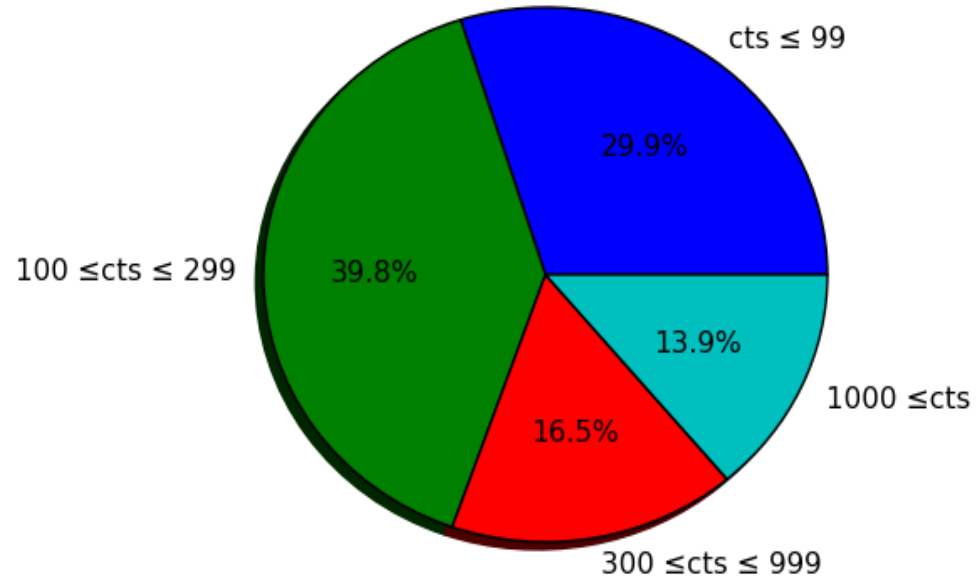
Types of XMM source

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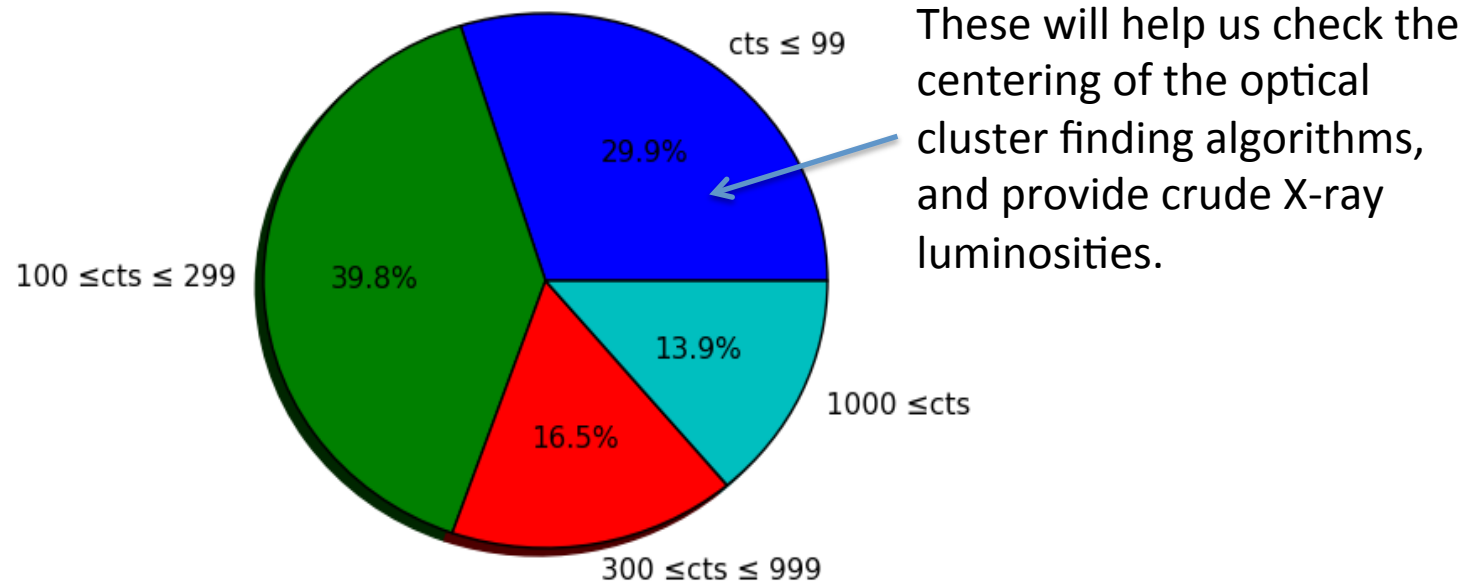
Distribution of counts

XMM Clusters Background Subtracted Source Counts



Distribution of counts

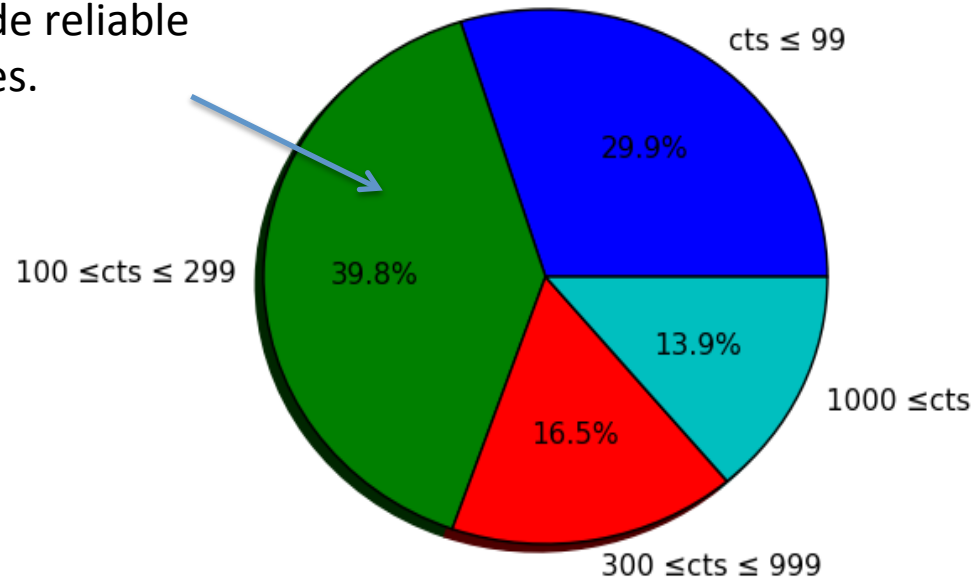
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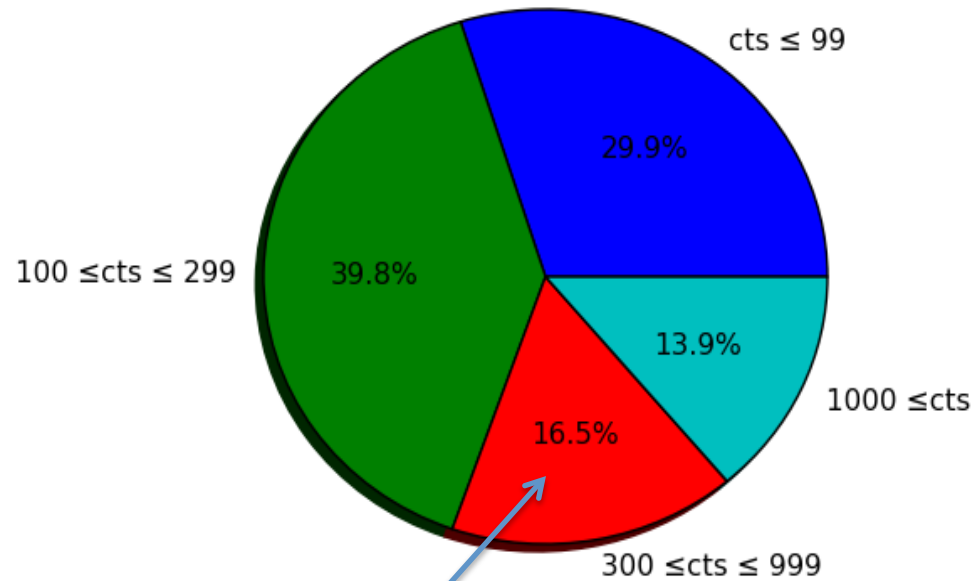
XMM Clusters Background Subtracted Source Counts

These will provide reliable X-ray luminosities.



Distribution of counts

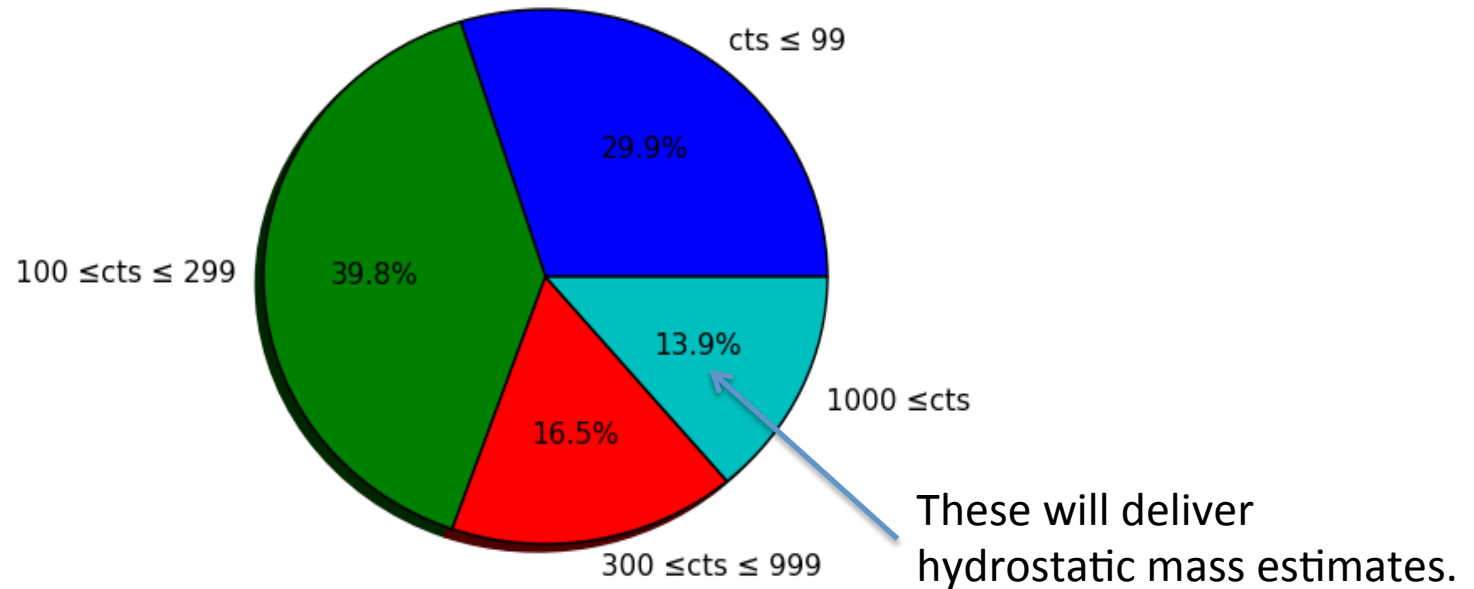
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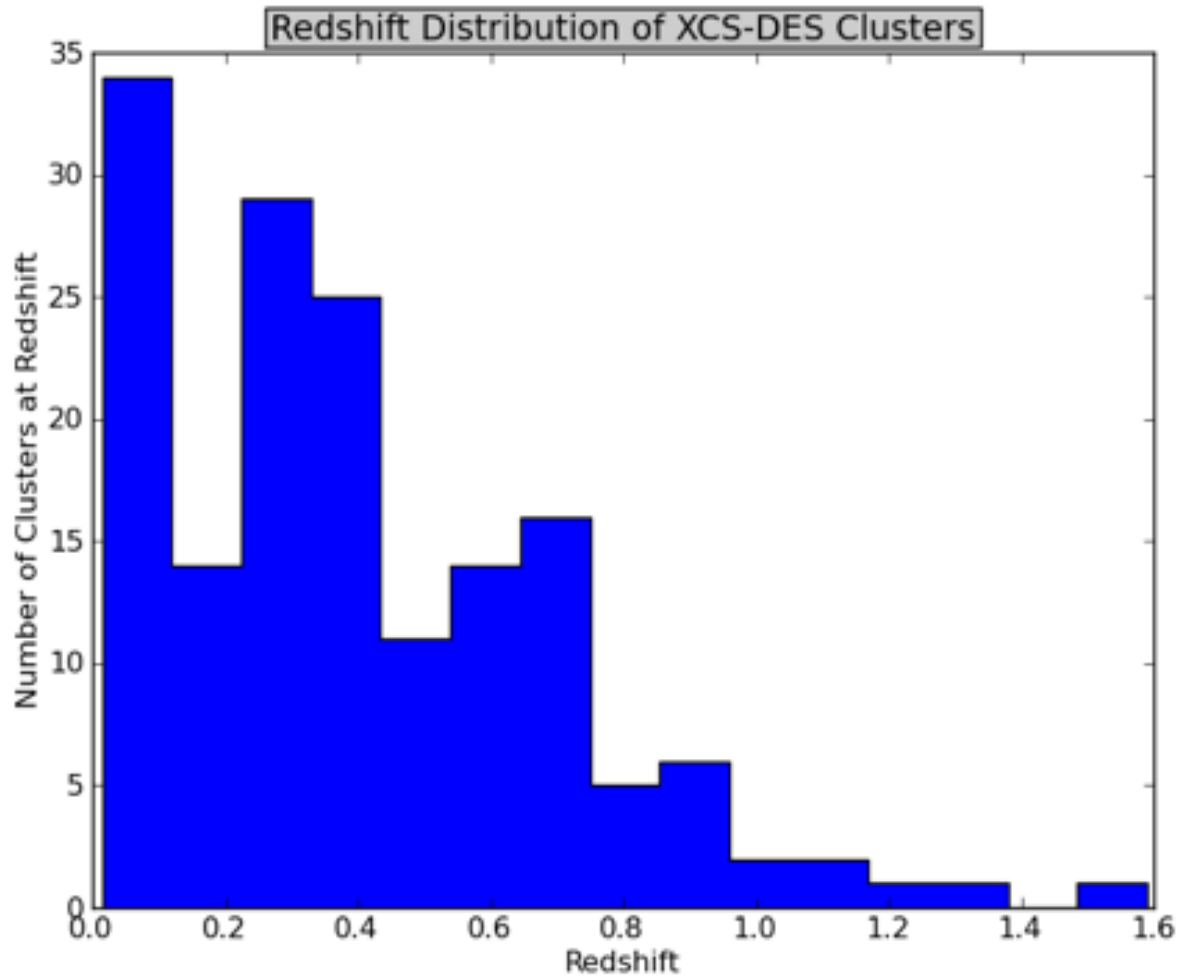
These will provide reliable X-ray temperatures.

Distribution of counts

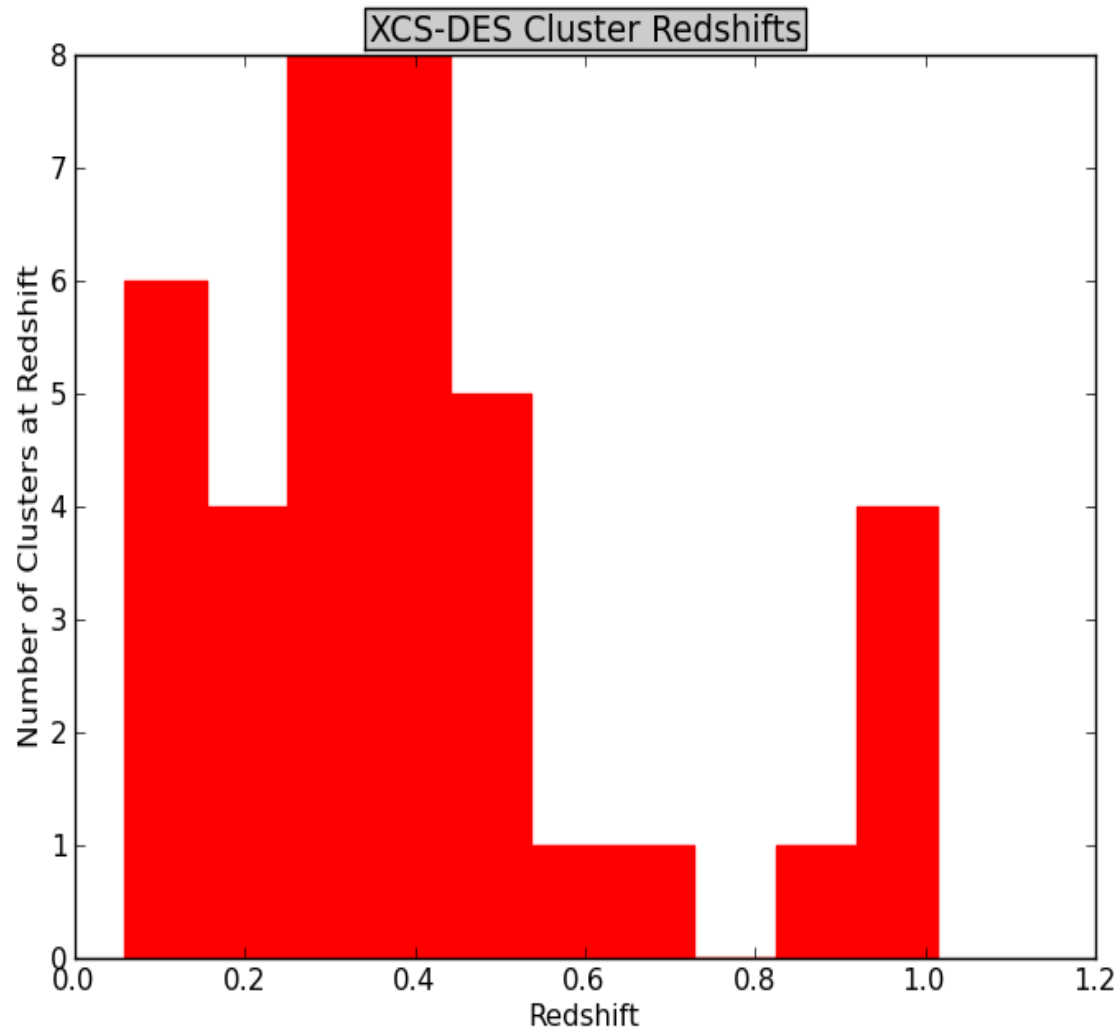
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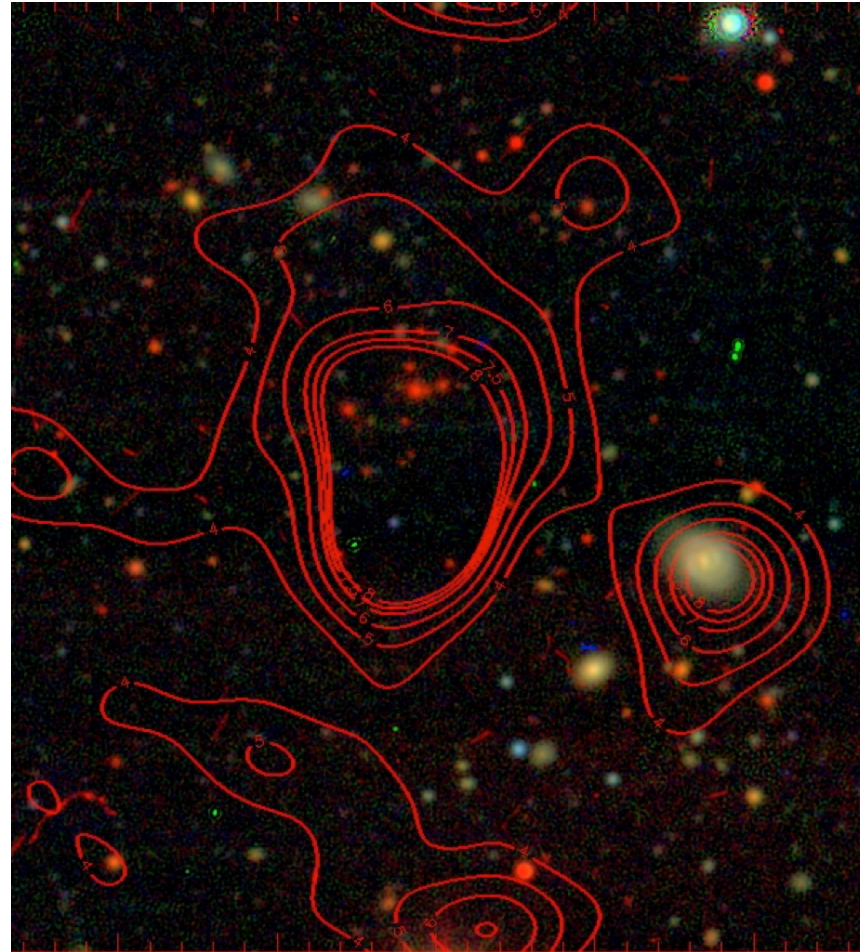
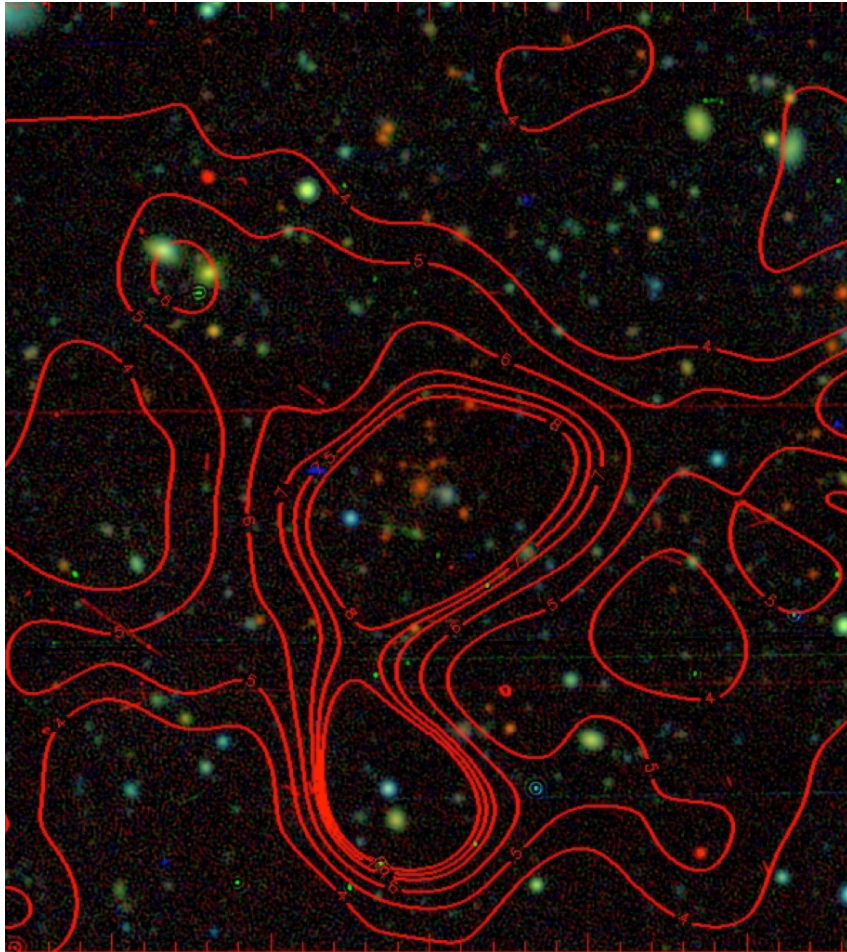
Distribution of known redshifts



Distribution of redshifts measured using DECam data (with a red sequence technique)



$z=0.9$ clusters



Overview

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- Visualizing cosmology from clusters

How does cosmology from clusters work?

- Imagine the cluster mass function at $z=0$ represented by UK coins (after a realistic DES-like selection function has been applied)

Open geometry; dominated by dark matter; no dark energy.....



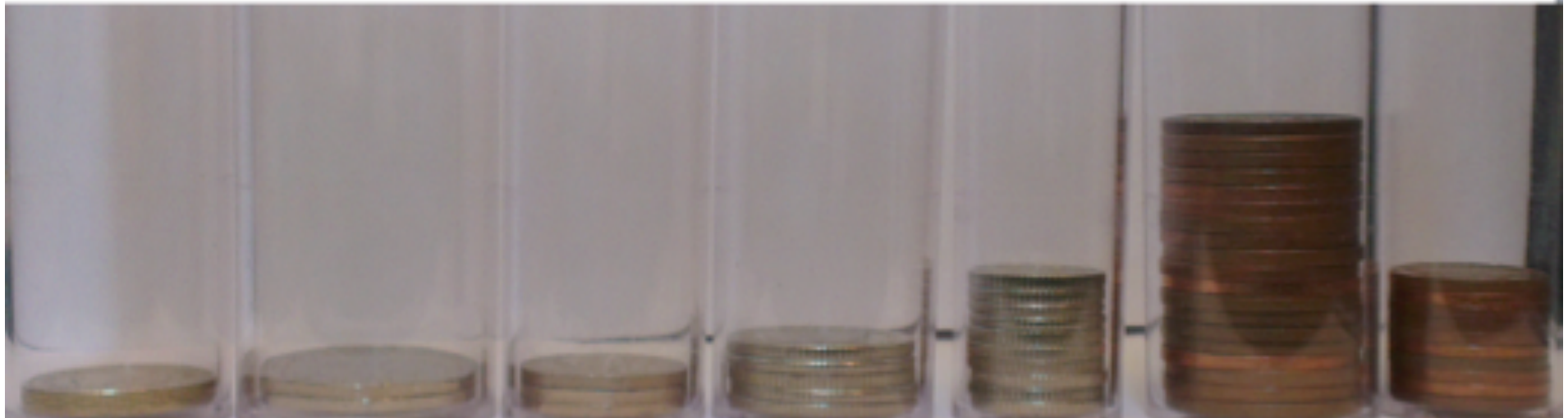
Flat geometry; dominated by dark energy with some added dark matter.....



And for Tom's benefit....

Flat geometry; dominated by baryons; no dark energy.....





Conclusions

- Using XCS pipelines, we have found hundreds of XMM clusters in the DES-SV footprint
- The combination of XCS and DES will improve, and calibrate, the optical cluster finding algorithms used by DES to constrain dark energy.
- This will also allow us to carry out studies of galaxy evolution and cluster physics
- Please use DECam and the (public) DES-SV for your own projects