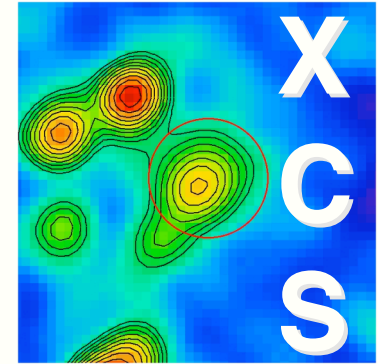


# X-ray Spectroscopy from the XMM-Newton Cluster Survey

Dr A. Kathy Romer  
University of Sussex  
(for the XCS collaboration)

With thanks to.....



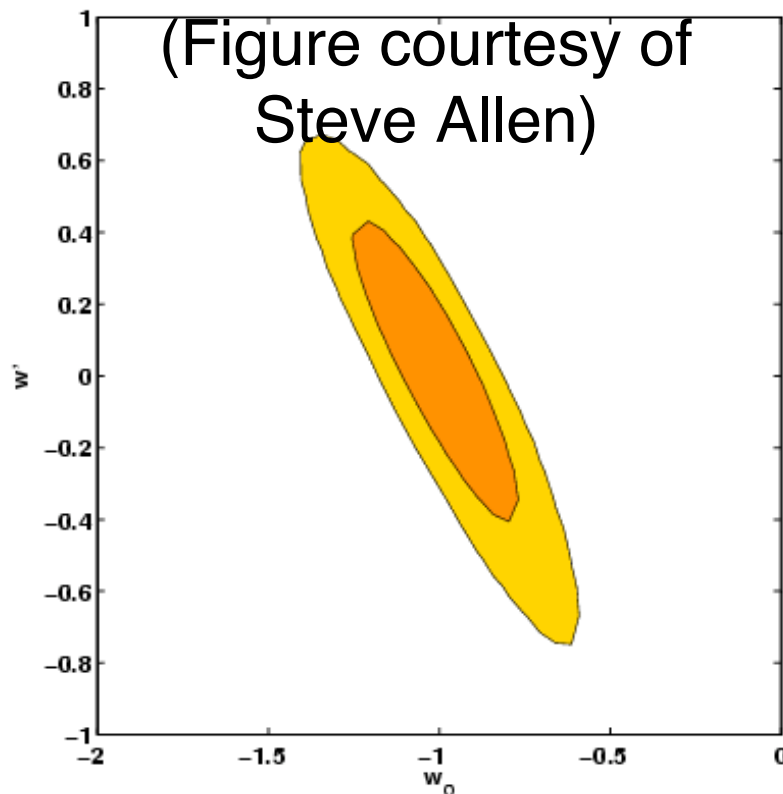
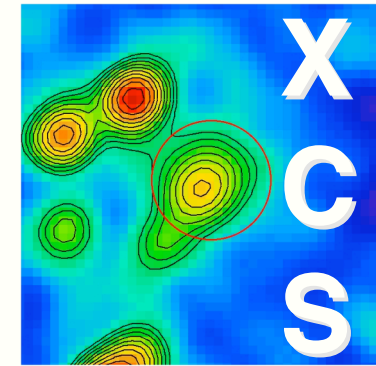
**Kivanc Sabirli, Michael Davidson, Pedro Viana, Adam Stanford**




**Chris Collins, Matt Hilton, Mark Hosmer, Scott Kay, Andrew Liddle, Bob Mann, Nicola Merhtens, Chris Miller, Bob Nichol, Mike West**

**NASA, PPARC, Hosie Bequest, the Universities**

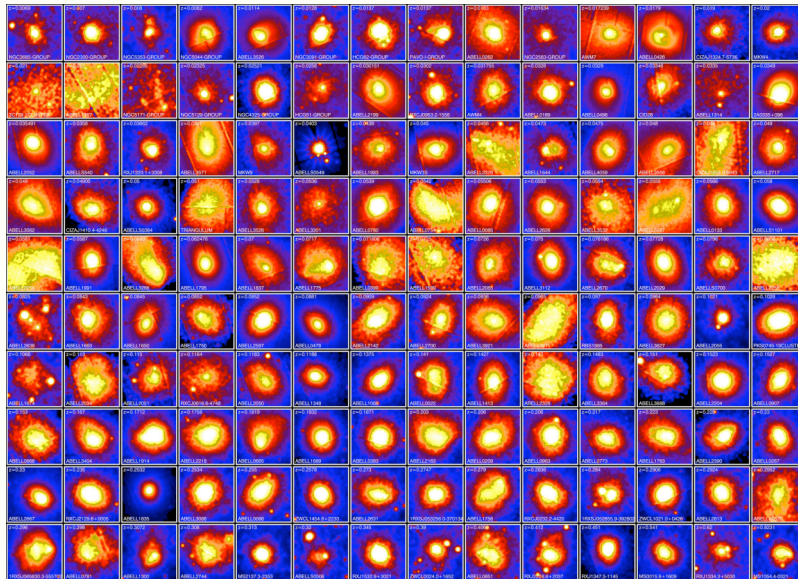
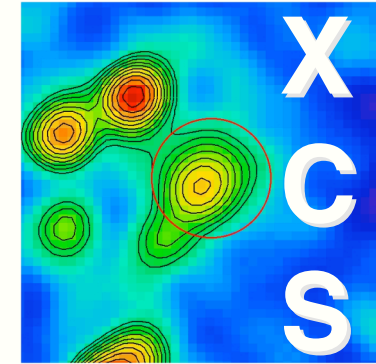
**Sussex, Edinburgh, Liverpool John Moores, Oxford, Portsmouth, Porto, Gemini, UC Davis, NOAO/CTIO, CMU**

# Bottom Line.....



-  1,000 clusters plus Con-X/XEUS, will constrain Dark Energy evolution
-  The XMM archive will have to supply those clusters
-  The XCS exploits the entire XMM archive

we like to stay busy, so  
before 2020...

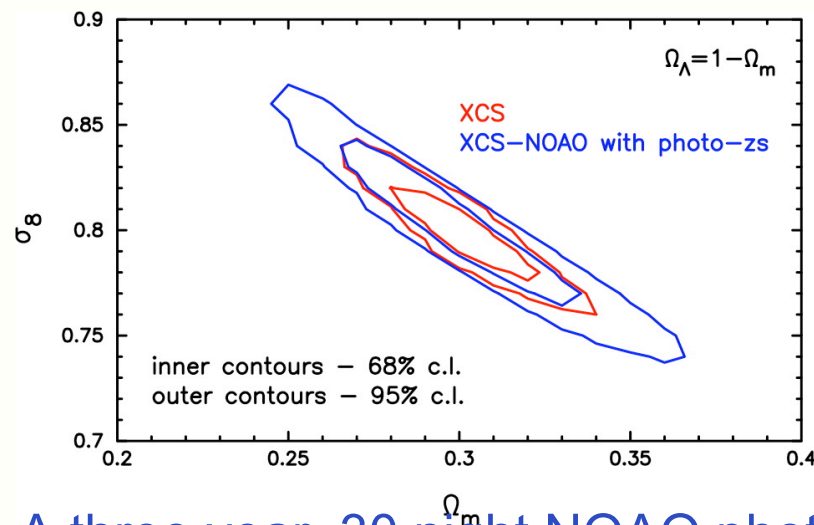
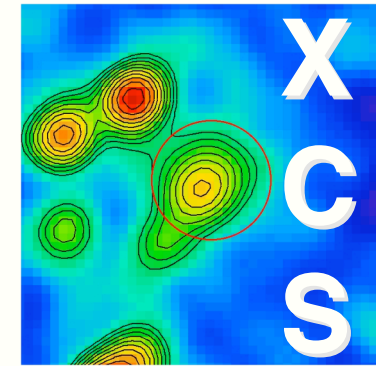


There is a wealth of data  
in the archive waiting to  
be exploited




- XCS will constrain other cosmological parameters
- XCS will discover very high redshift clusters
- XCS will constrain models of cluster formation



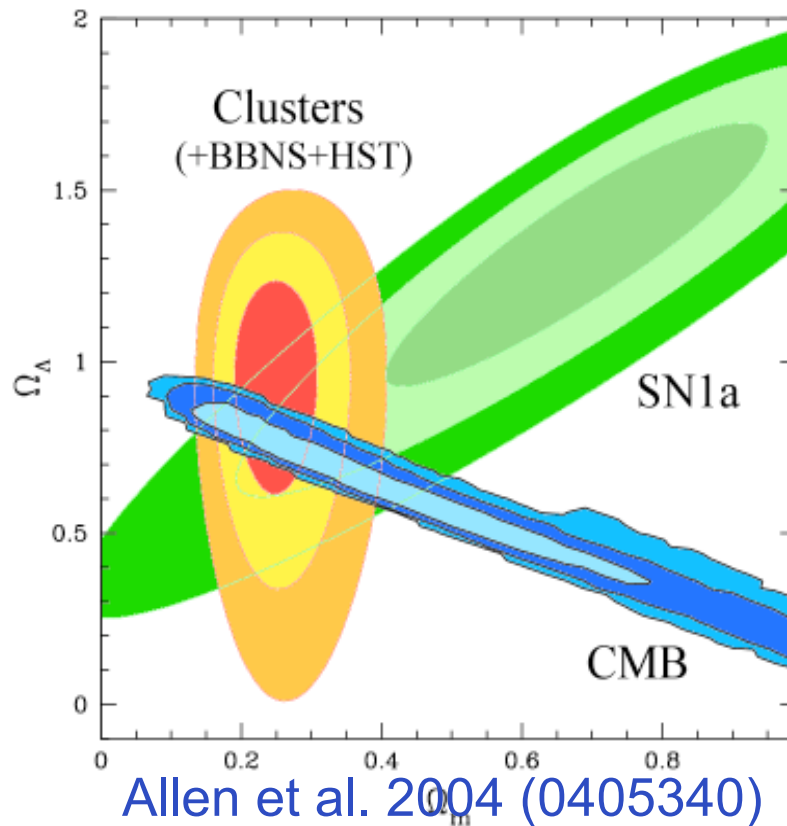
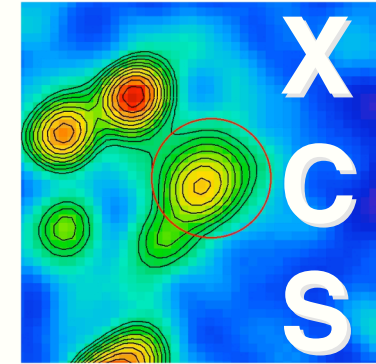
we like to stay busy, so  
before 2010...



A three year, 30 night NOAO photo-z survey (NXS) will provide allow us to do the bulk of the XCS cosmology tests before 2010 (NOTE: XCS parameter predictions are based only on those clusters with measured  $T_x$ ).

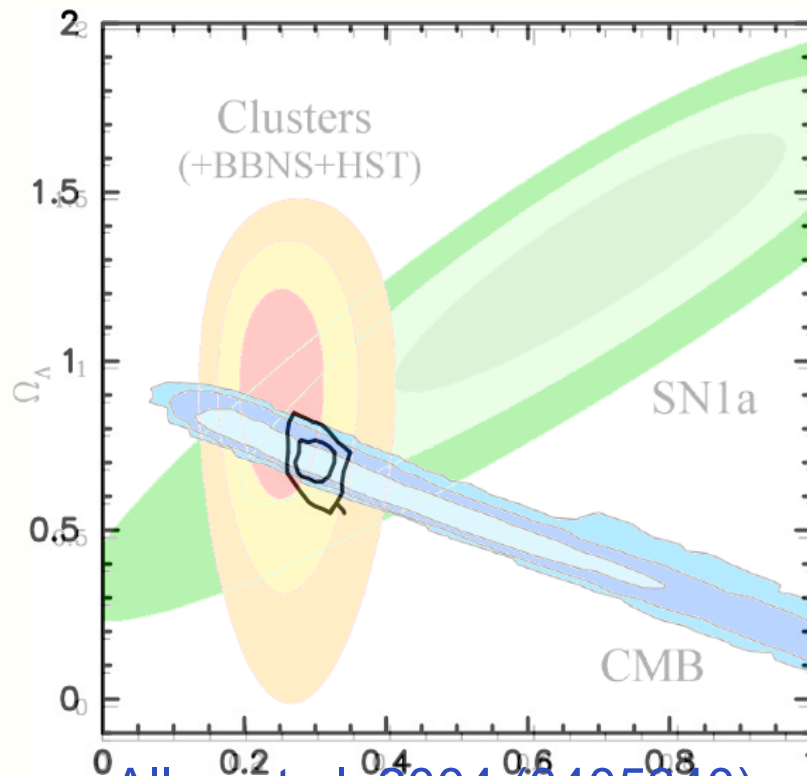
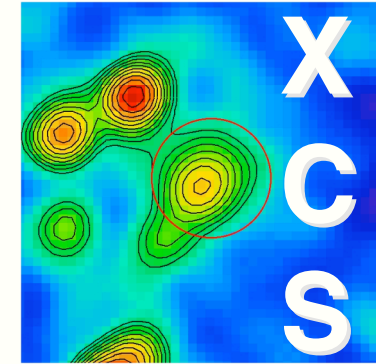
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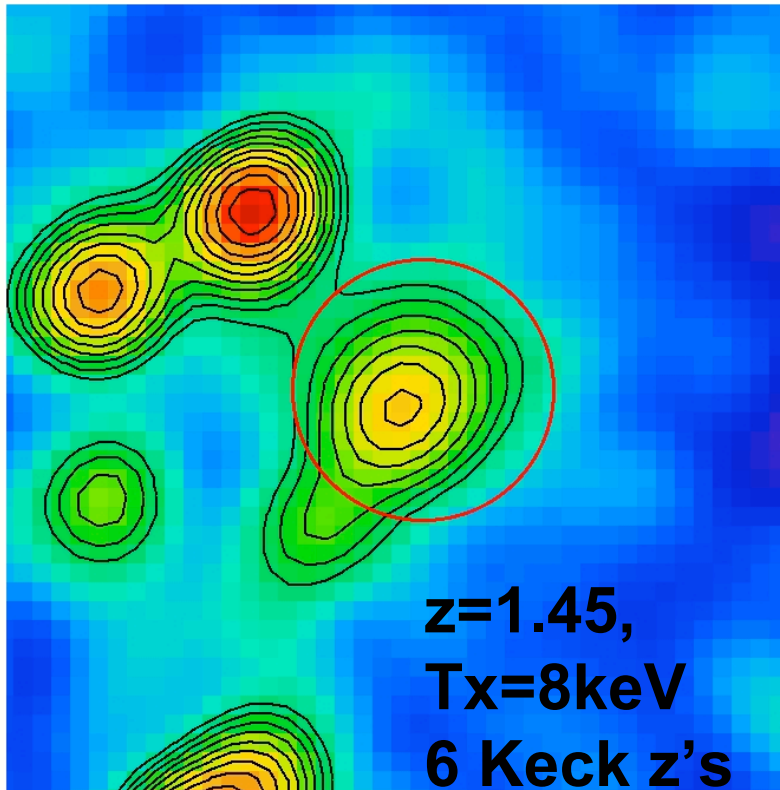
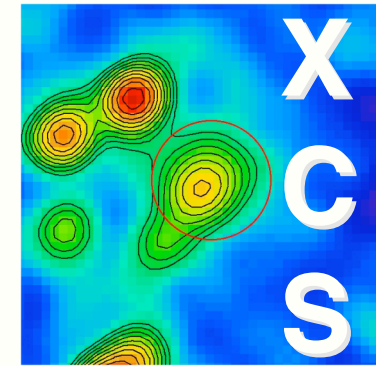


Allen et al. 2004 (0405340)

**XCS (Viana et al. 2006)**




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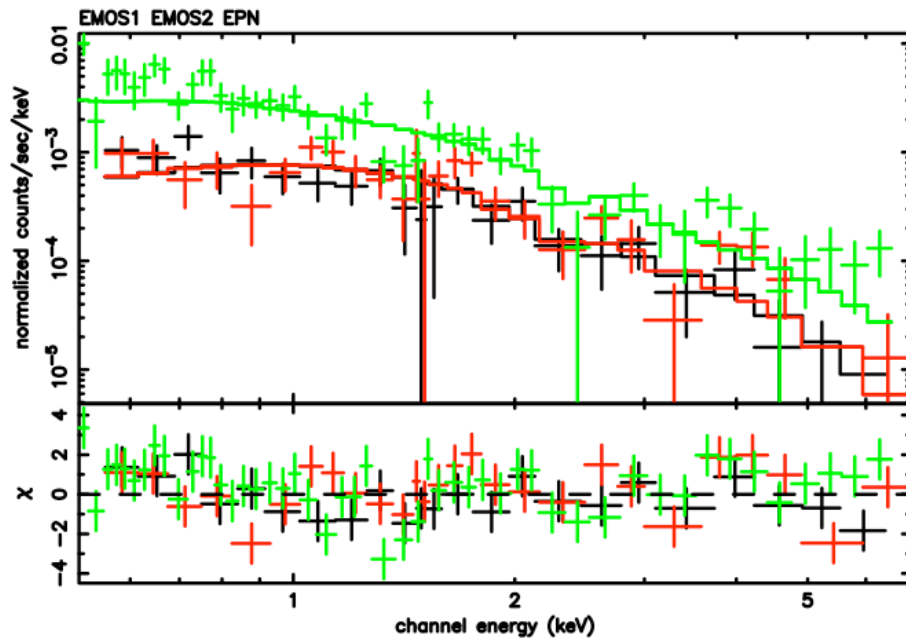
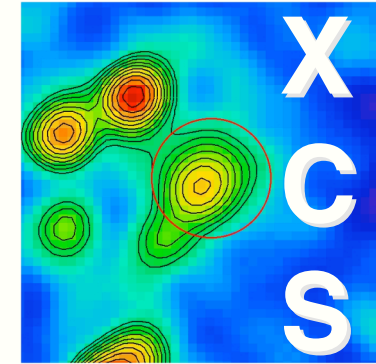


Stanford et al. 2006

(submitted - $\epsilon$ )

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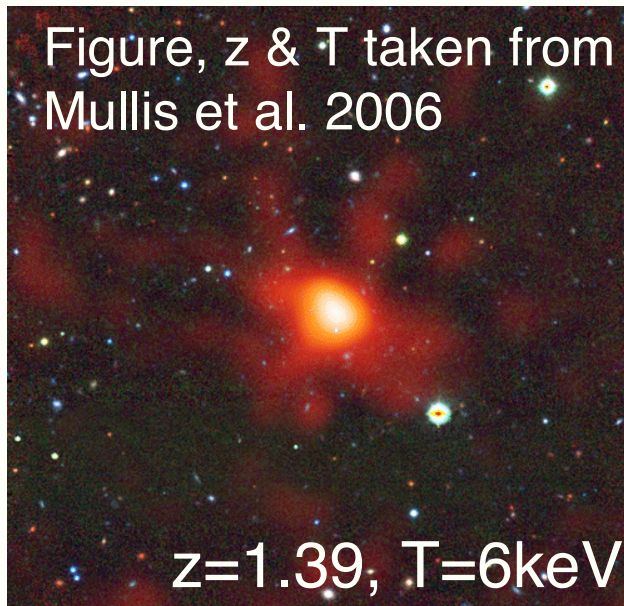
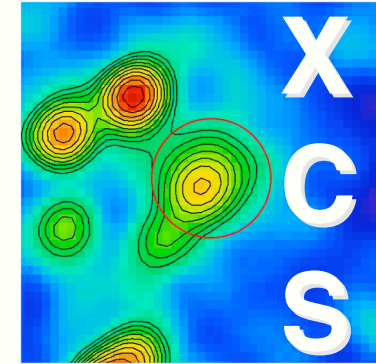
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Spectrum obtained from a 240 ks  
observation; 1200 counts (bkgd  
corrected)

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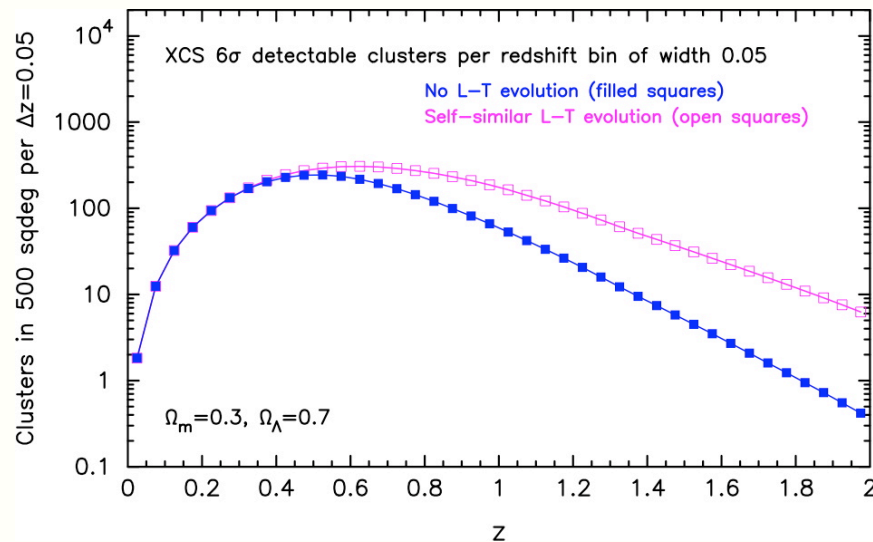
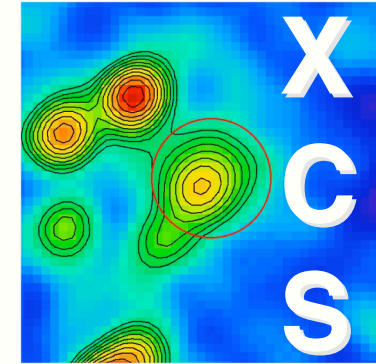


High  $z$  clusters are valuable to galaxy & lensing studies, to SN searches and to cosmology. To date; **nine** confirmed XCS clusters at  $z>1$  ( $z$ 's coming from Keck, Gemini, [VLT], the literature, XMM)




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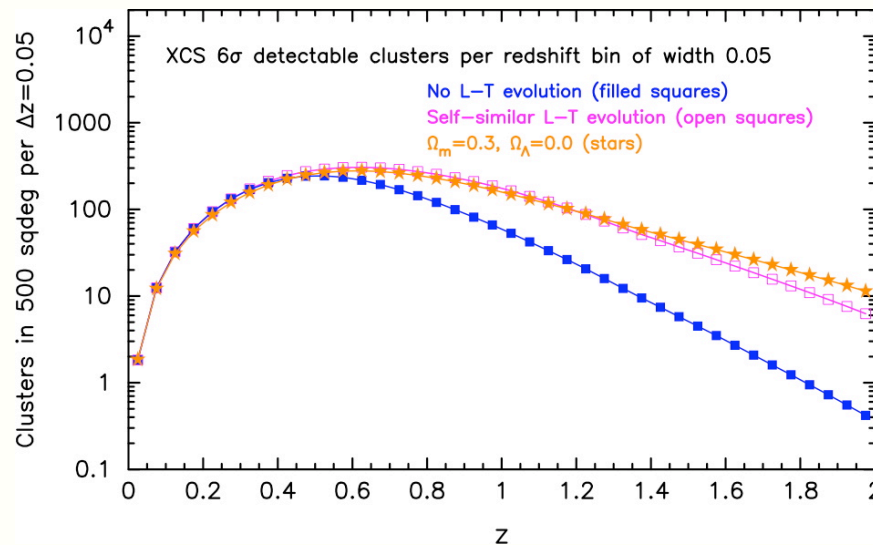
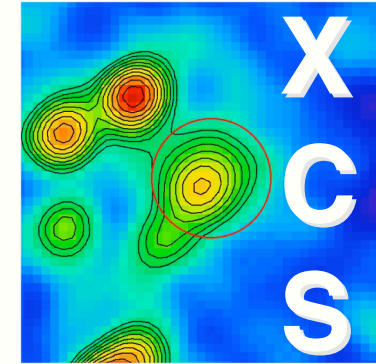


It is vital to understand  
cluster evolution before  
attempting to do Cosmology

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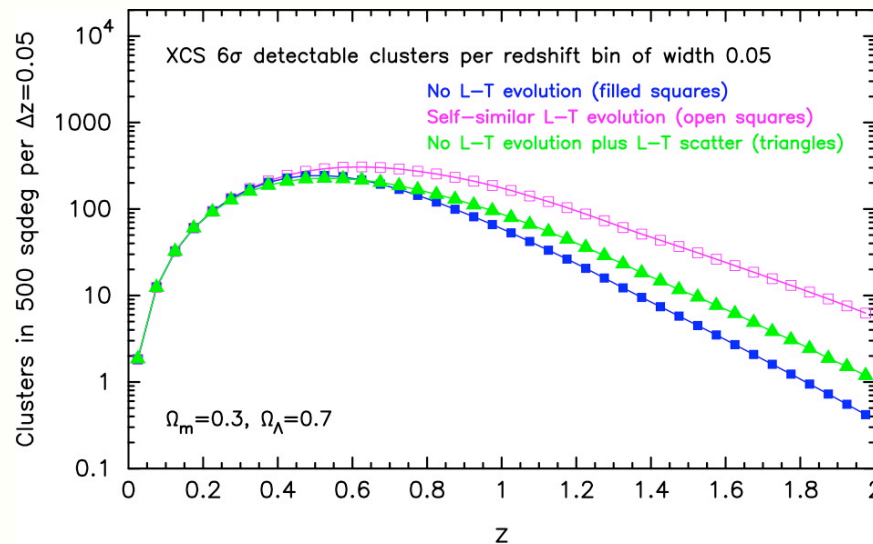
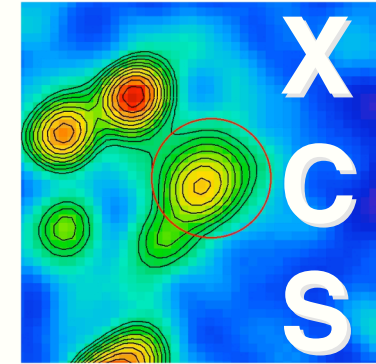
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


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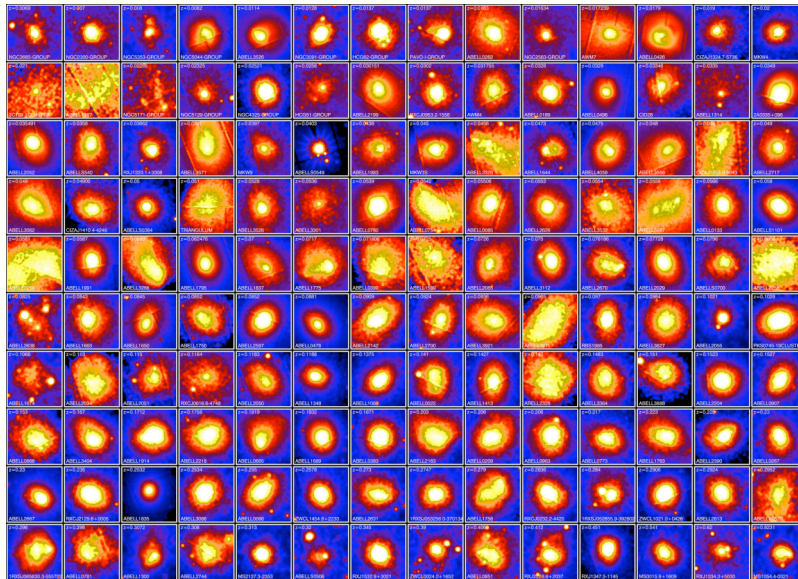
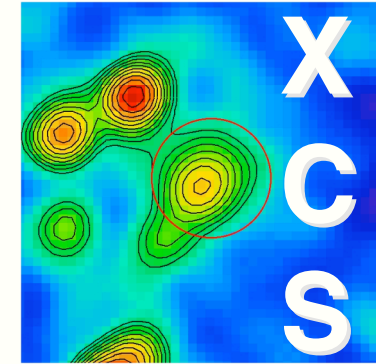
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


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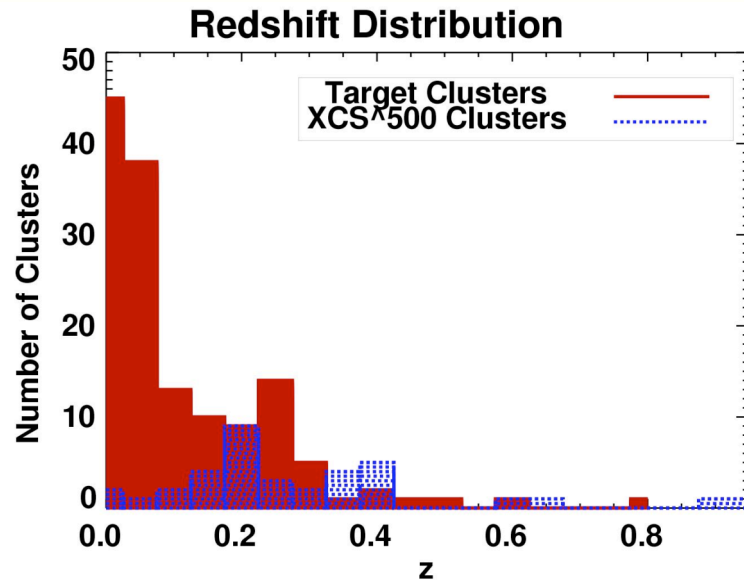
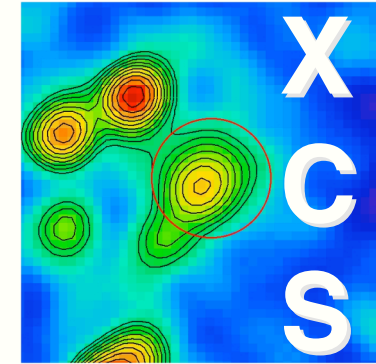
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XCS will take a two-pronged approach and use both target and serendipitous clusters.

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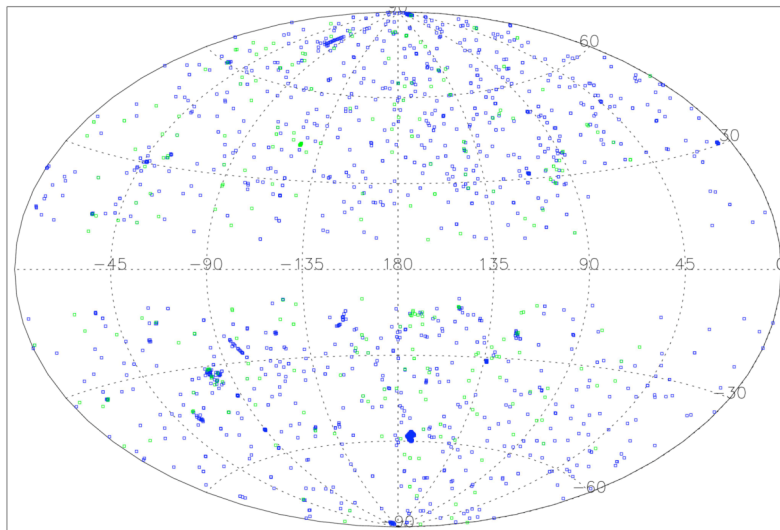
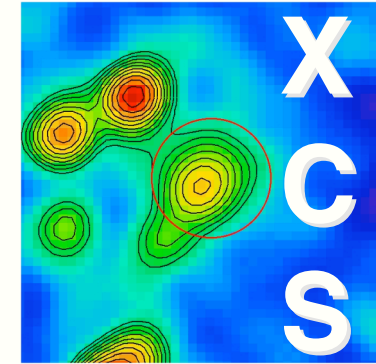
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# other cool stuff coming out of XCS...



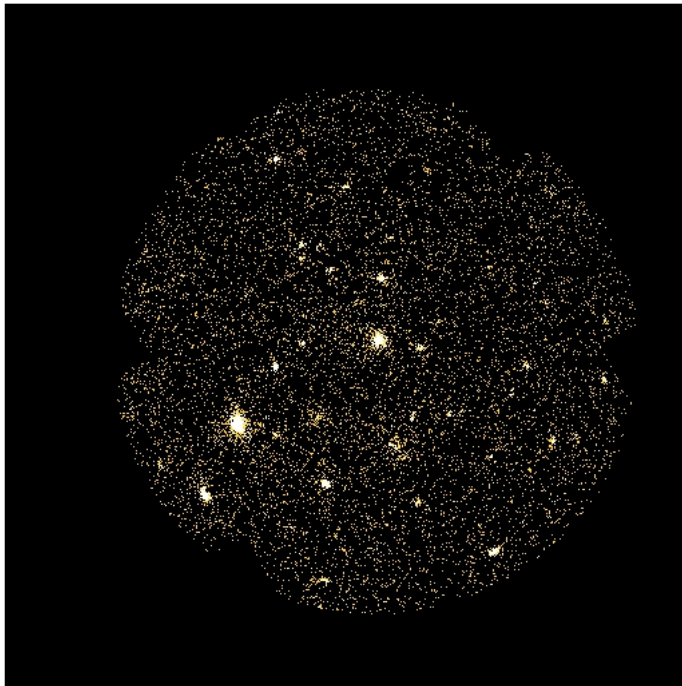
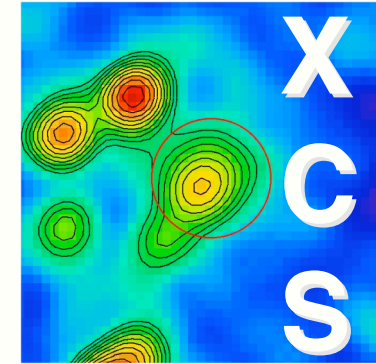
**Location of 2,500 public XMM observations (blue) and 300 private (green) [ $|\mathit{b}| > 10$  degrees]**

**240 sq. degrees now, 500+ by 2010**

- 70,000 point sources
  - 6MS background templates
  - The XMM point spread function
- Customised hydro simulations
- WDM constraints
- X-ray follow-up of SDSS clusters
- X-ray redshifts



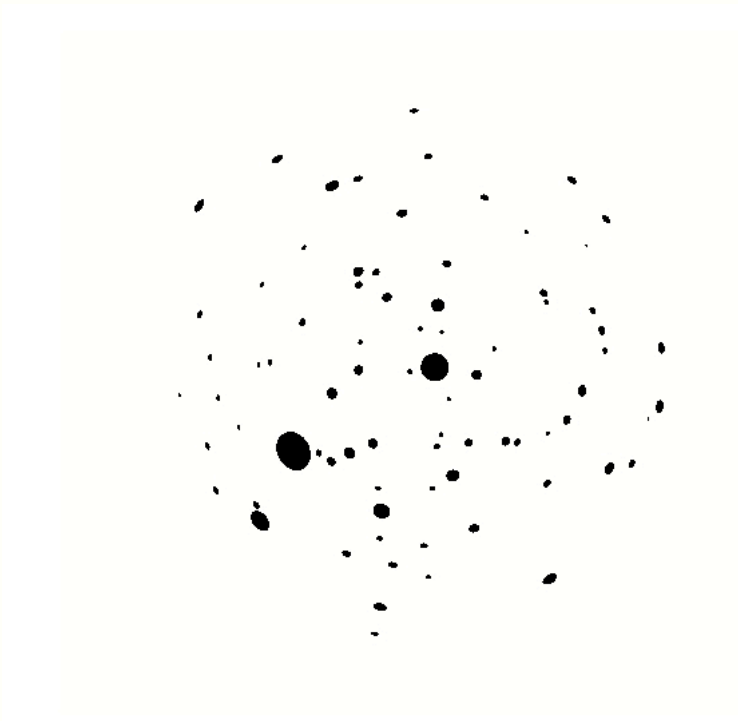
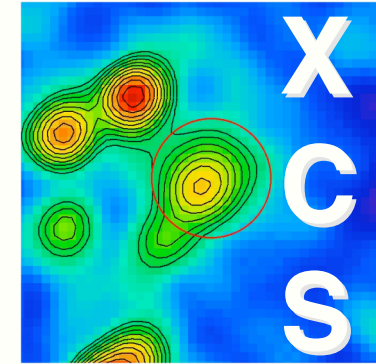
# other cool stuff coming out of XCS...



**XCS processed XMM image**

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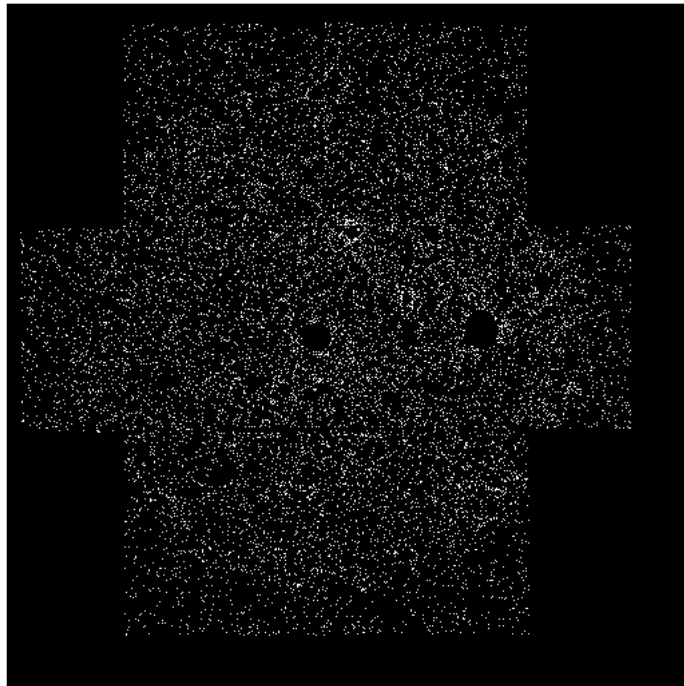
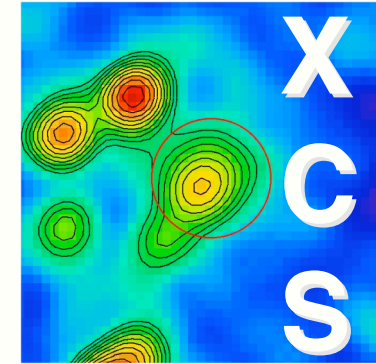


**XCS detected source ellipses**

- 70,000 point sources
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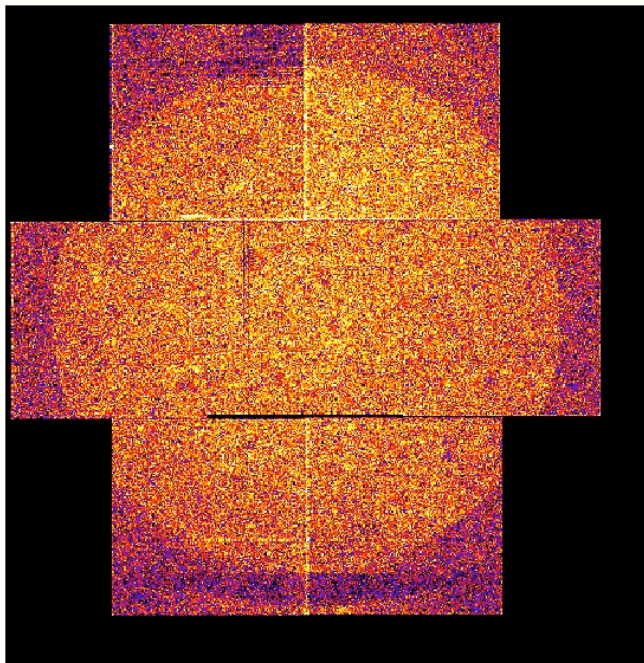
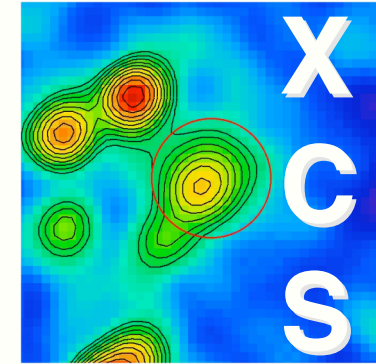
# other cool stuff coming out of XCS...



**After removing the sources**

- 70,000 point sources
  - 6MS background templates
  - The XMM point spread function
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- WDM constraints
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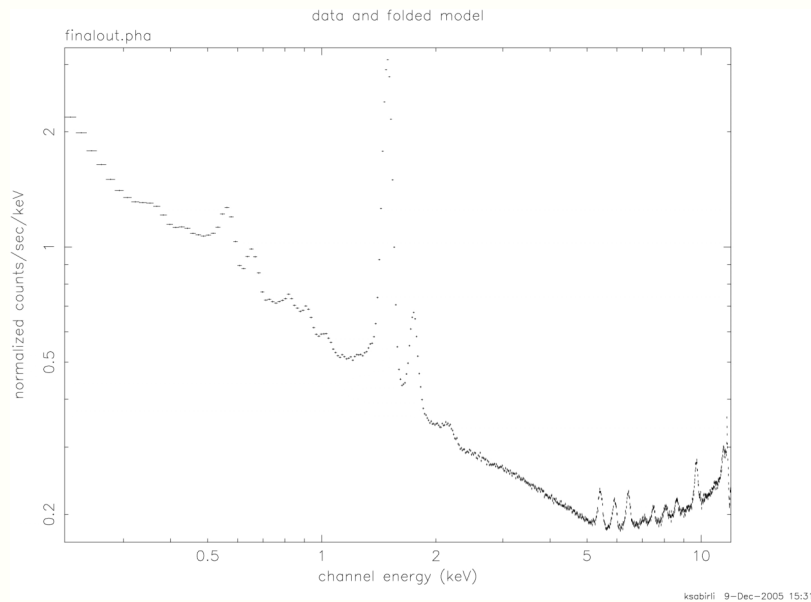
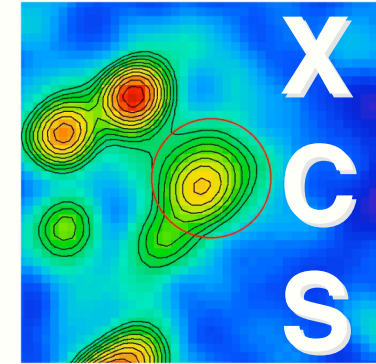
# other cool stuff coming out of XCS...



**merge several cleaned images**

- 70,000 point sources
  - 6MS background templates
  - The XMM point spread function
- Customised hydro simulations
- WDM constraints
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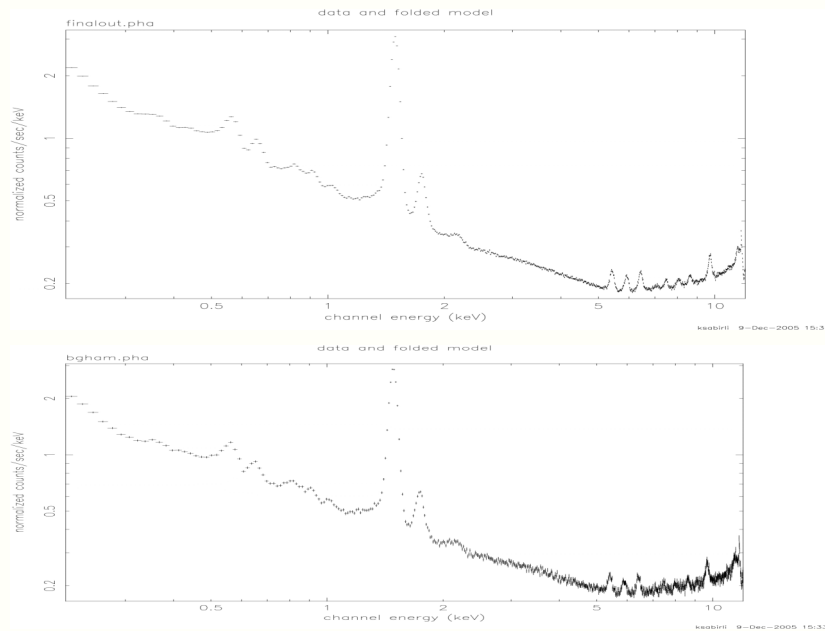
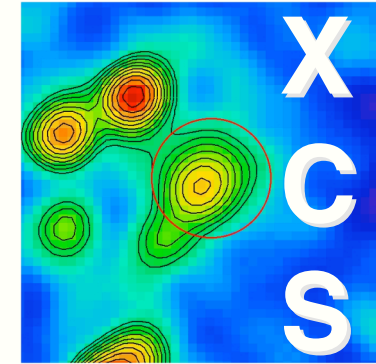
# other cool stuff coming out of XCS...



- 70,000 point sources
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**extract spectra.**

# other cool stuff coming out of XCS...

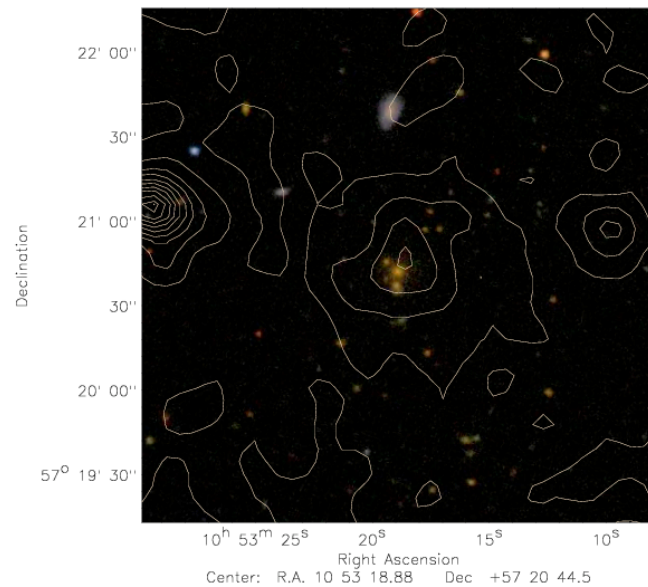
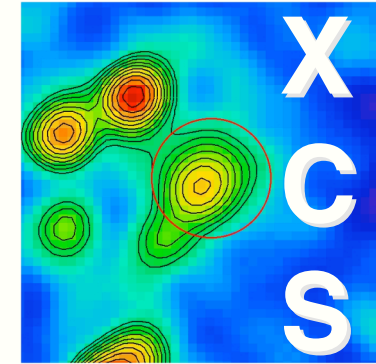


**Top: XCS (6 MS)**

**Bottom: best published (1MS)**

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  - The XMM point spread function
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- WDM constraints
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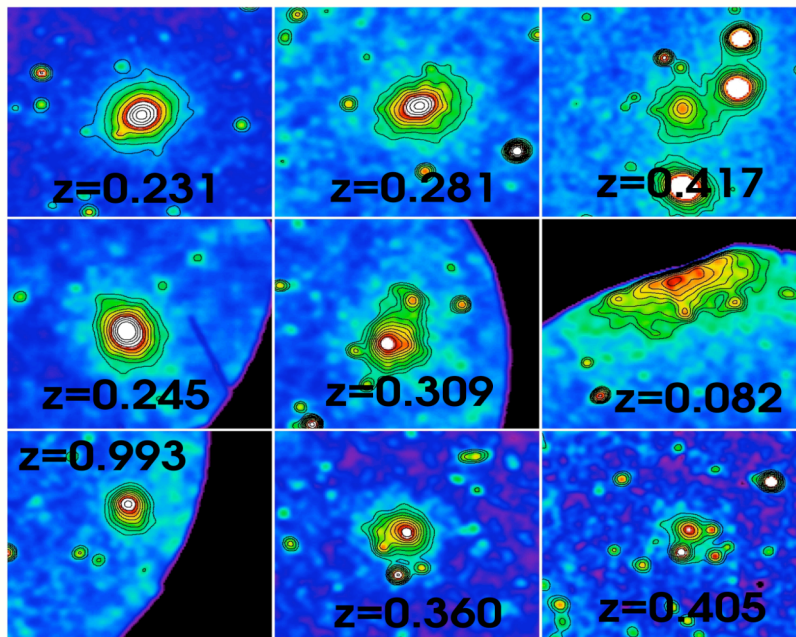
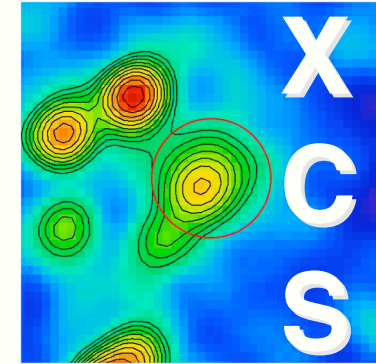
# other cool stuff coming out of XCS...



**z=0.34 SDSS cluster**

- 70,000 point sources
  - 6MS background templates
  - The XMM point spread function
- Customised hydro simulations (Kay et al.)
- WDM constraints (Abazajian)
- X-ray follow-up of SDSS clusters (McKay et al.)
- X-ray redshifts

# other cool stuff coming out of XCS...

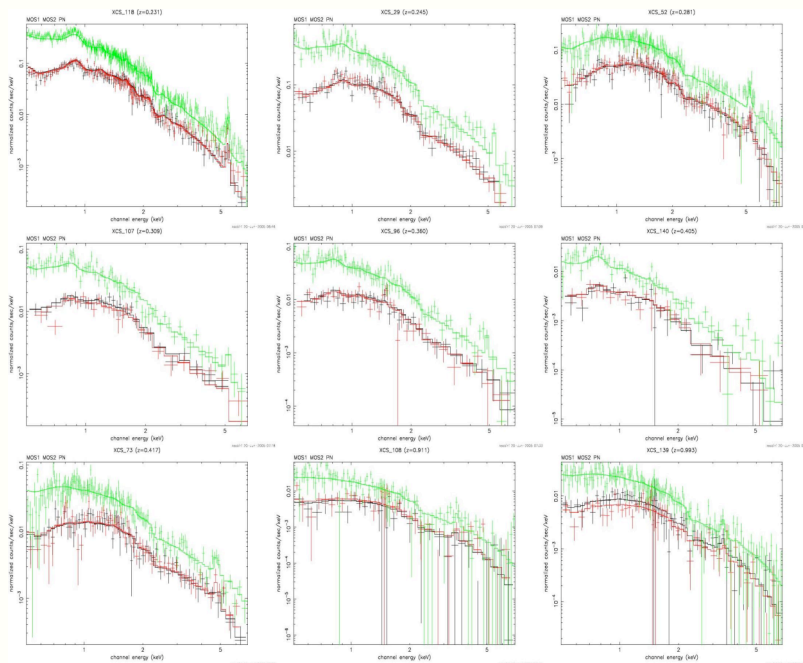
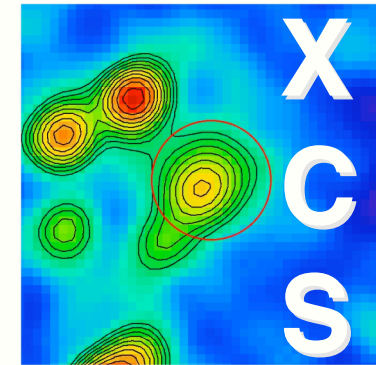


- 70,000 point sources
- 6MS background templates
- The XMM point spread function
- Customised hydro simulations
- WDM constraints
- X-ray follow-up of SDSS clusters
- X-ray redshifts

**X-ray redshifts possible for highest s:n clusters. These nine have no other redshift data;  $0.082 < z_x < 0.993$**



# other cool stuff coming out of XCS...

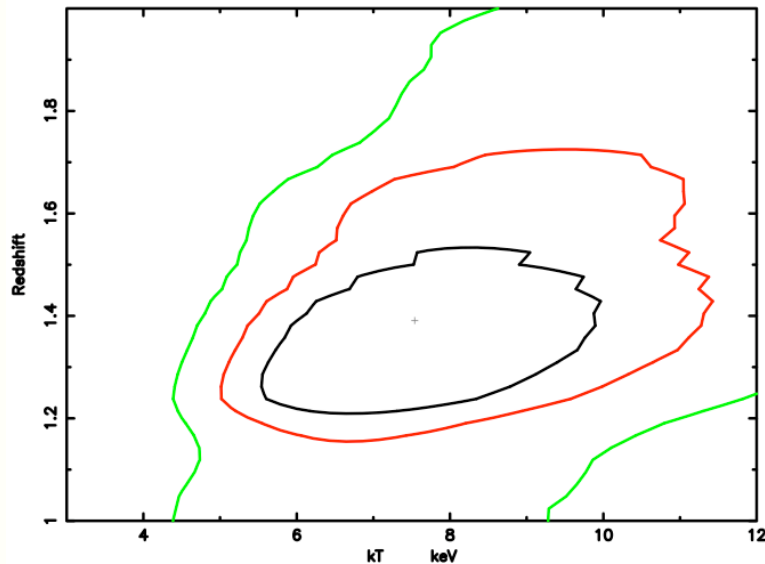
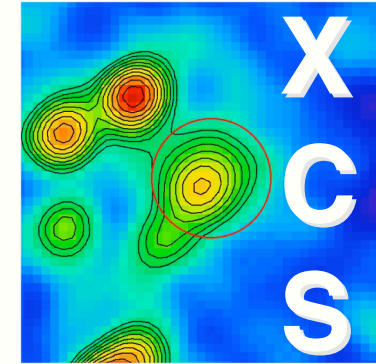


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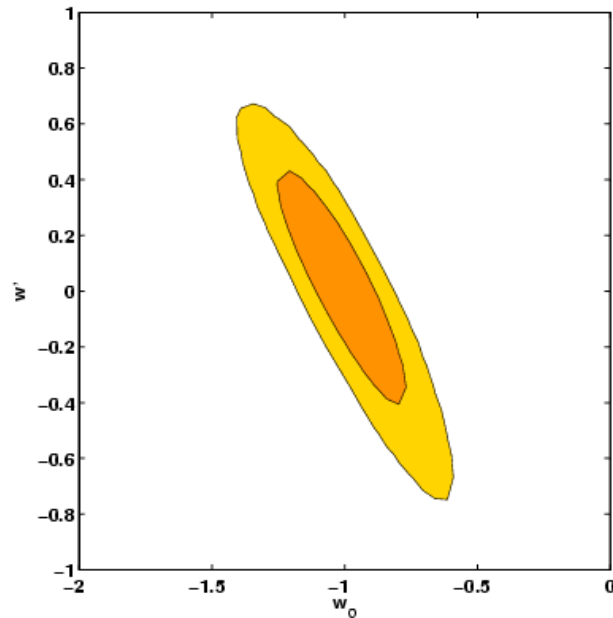
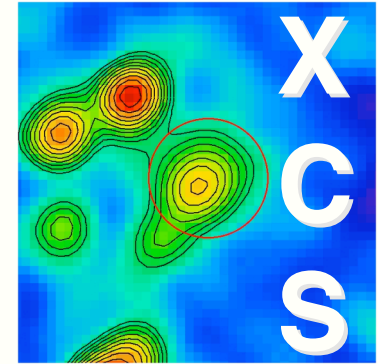


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**Method even works at  $z=1.5$ !**

**Imagine what we could do with CON-X/XEUS!**

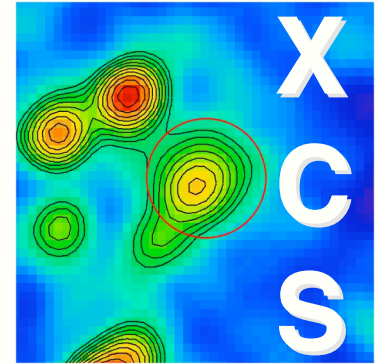
# Just imagine what we could do with CON-X/XEUS!

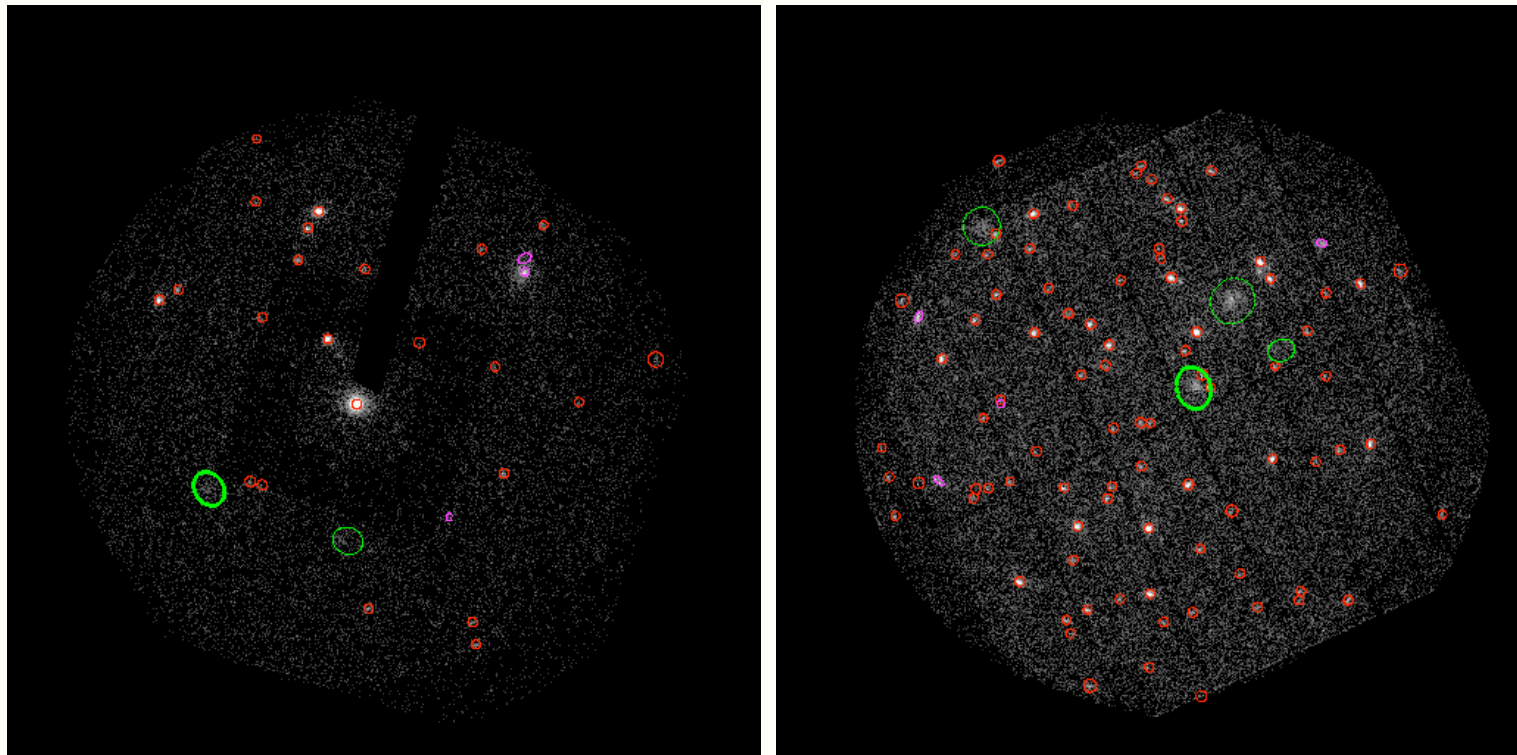
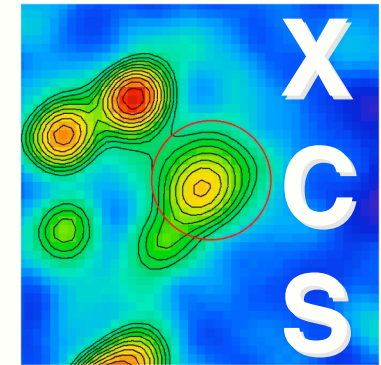


**independent  
precision  
cosmology!**

- Complete redshift and temperature follow-up for XCS and other large surveys (e.g. South Pole 8m, new X-ray survey satellite?????)
- Much better mass estimates
- Detailed studies of evolution of scaling relations - we can't claim to understand cosmology until we understand these
- Answers to sticky questions like, "where did all those metals come from?", "why aren't there any spirals in clusters?"
- Real constraints on WDM

# Thank you





MSSL Workshop on High Resolution X-ray Spectroscopy  
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