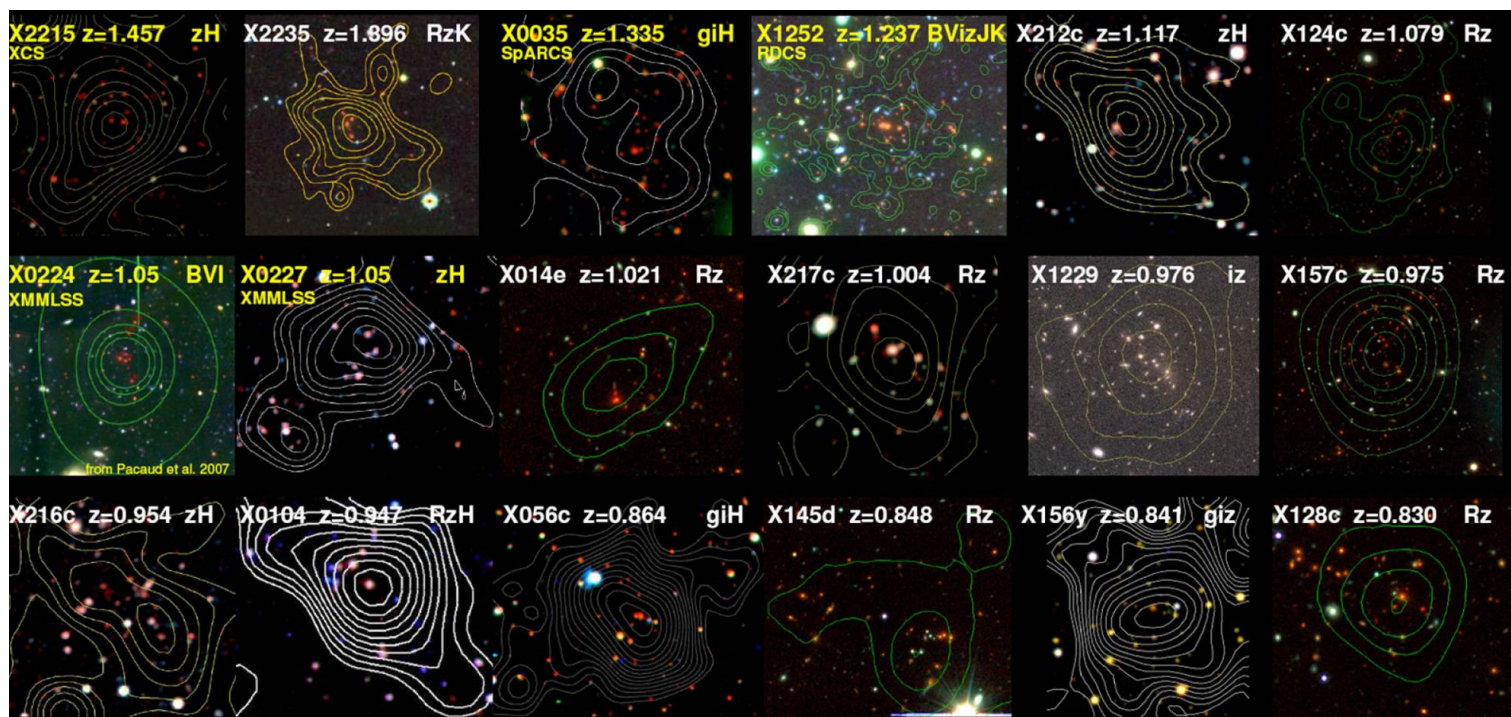


New High-z X-ray Clusters

from the

XMM-Newton Distant Cluster Project



Rene Fassbender

rfassben@mpe.mpg.de

GCEU Pucon, 11 November 2009

Agenda

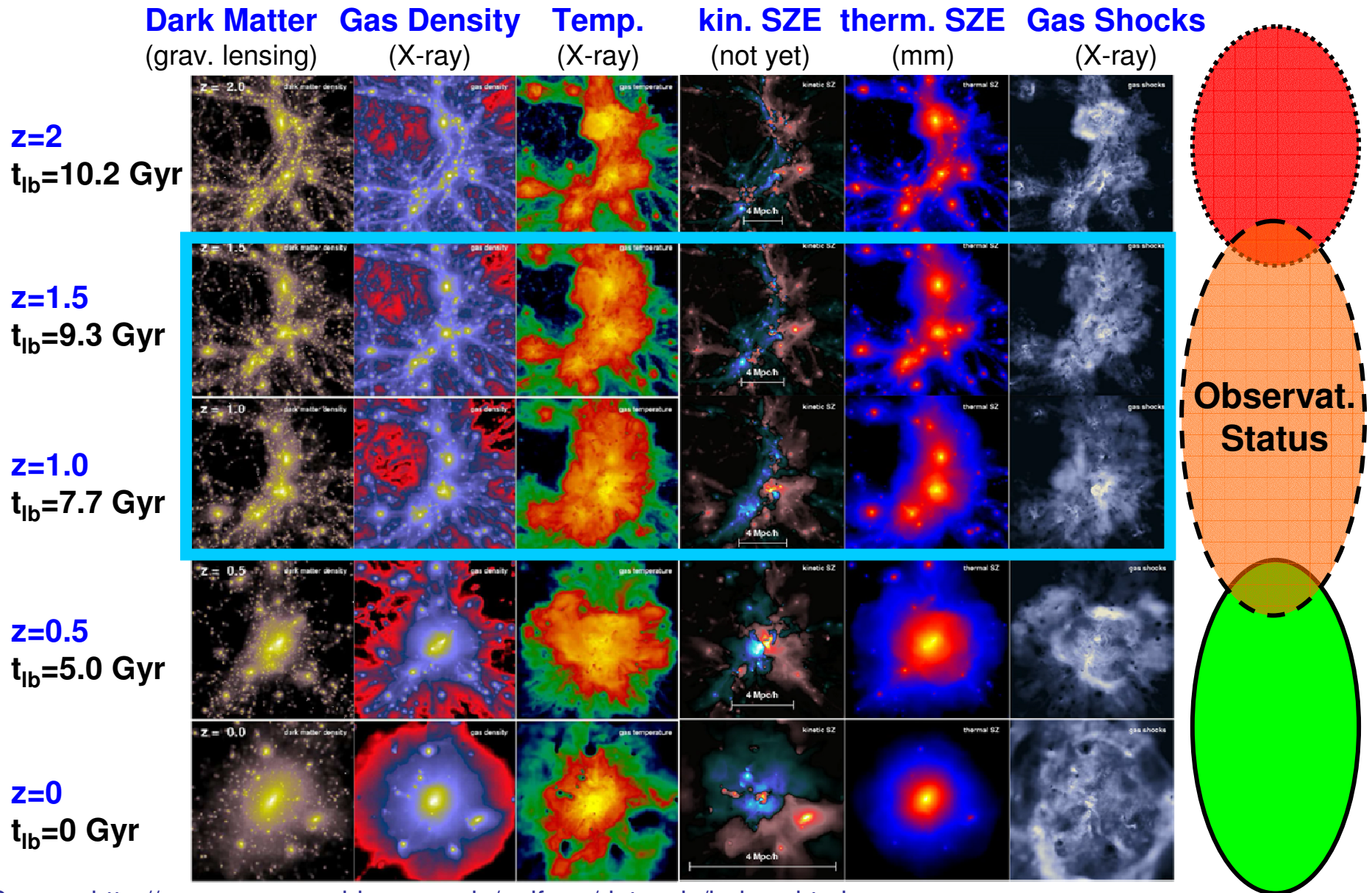
- I. The XMM-Newton Distant Cluster Project
- II. Recent X-ray Cluster Results
- III. Status & Outlook

I. The XMM-Newton Distant Cluster Project

II. Recent X-ray Cluster Results

III. Status & Outlook

Simulated Formation of a Massive Galaxy Cluster



Source: http://www.mpa-garching.mpg.de/galform/data_vis/index.shtml

Rene Fassbender (MPE)

An XDCP Primer

Aim: find & study distant X-ray clusters at $z > 0.8$

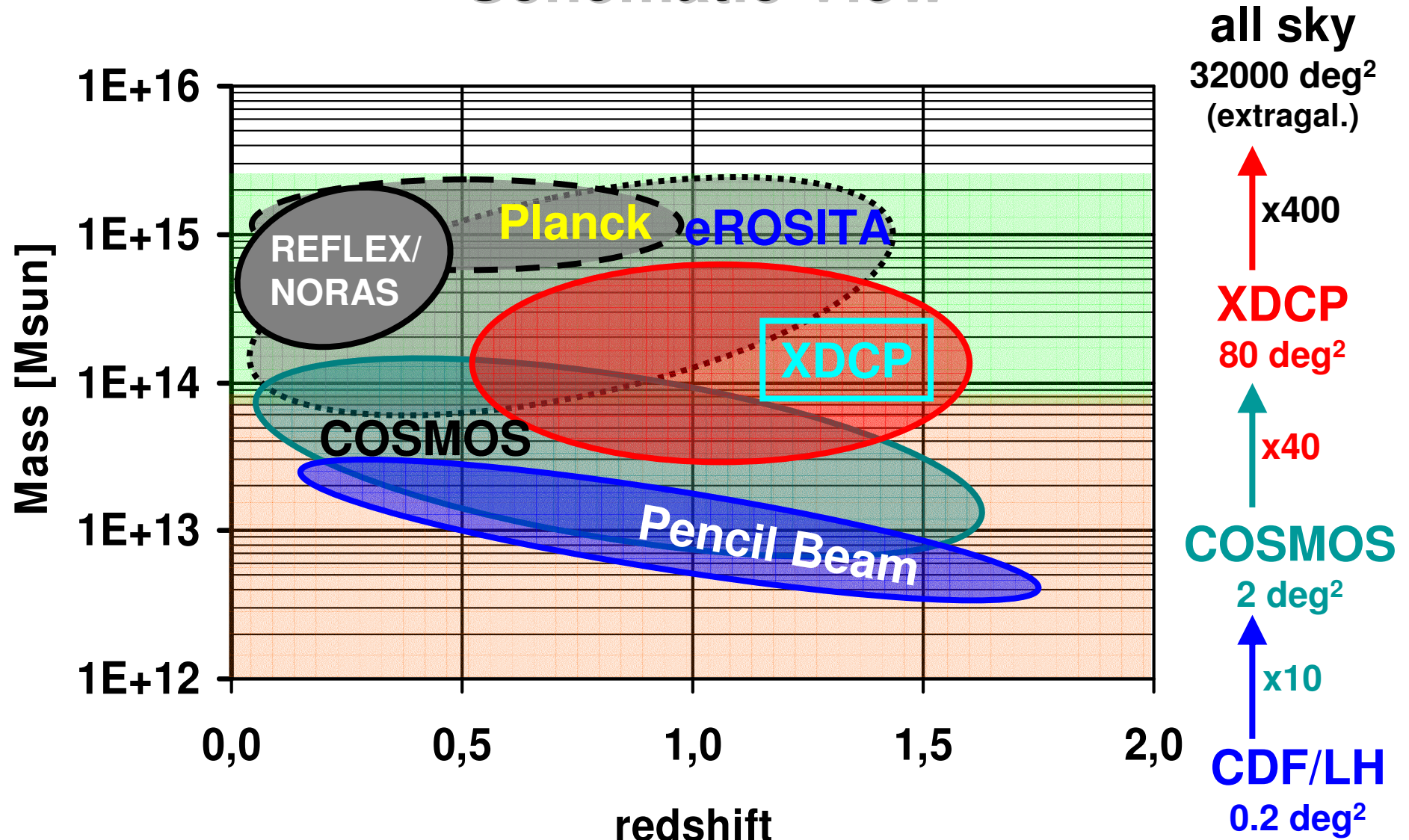
Science Goals:

- multi-wavelength studies of distant clusters
- high- z scaling relations
- cluster abundance evolution

XDCP Survey Assets:

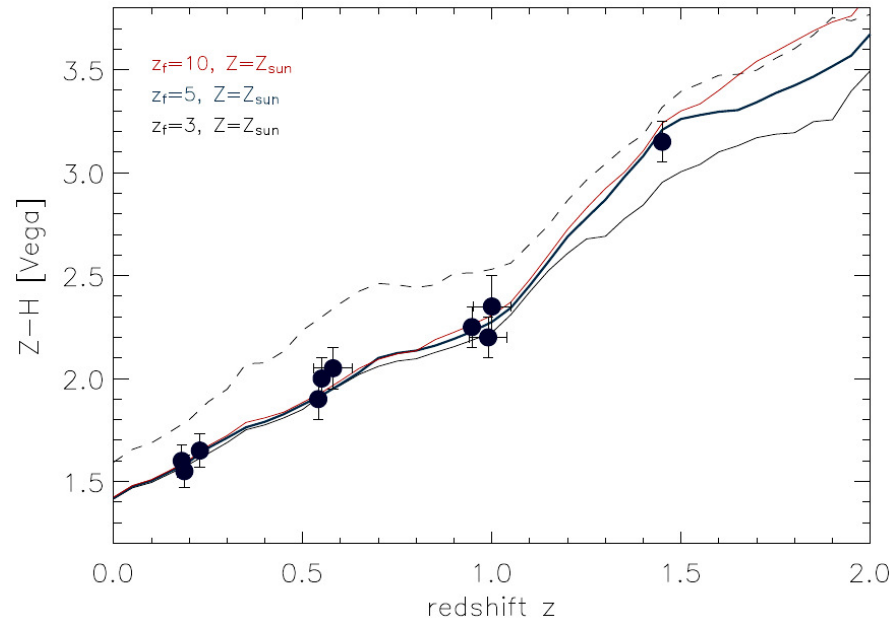
- ~1000 X-ray selected cluster candidates from 15Msec of XMM-Newton archive data at $\text{DEC} < +20$ (~250 candidates at $z > 0.5$)
- 2-5 band imaging for 80% of distant candidates + 200 lower- z clusters
- increasing amount of VLT spectroscopy data of $z > 0.8$ clusters
- deep X-ray / optical imaging / spectroscopy follow-up data for prominent clusters

Galaxy Cluster Surveys based on ICM Signature Schematic View

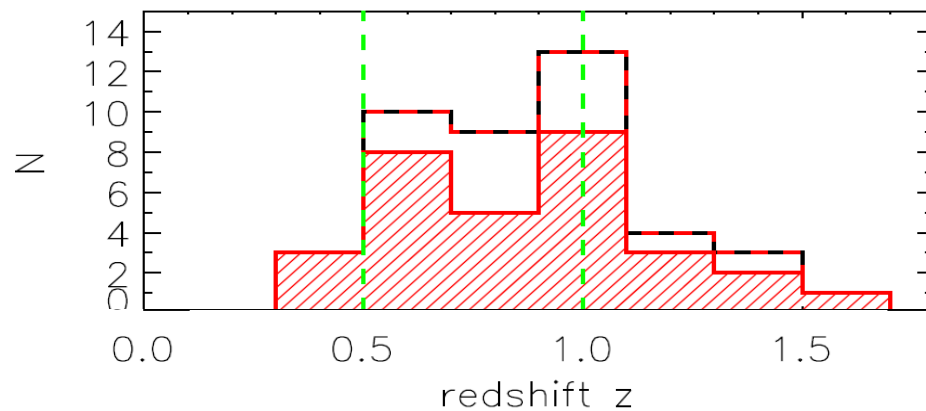


Follow-up focuses on NIR imaging techniques

z-H imaging at Calar Alto 3.5m Telescope



photometric cluster
identifications
out to $z \sim 2$ possible
(if nature permits)

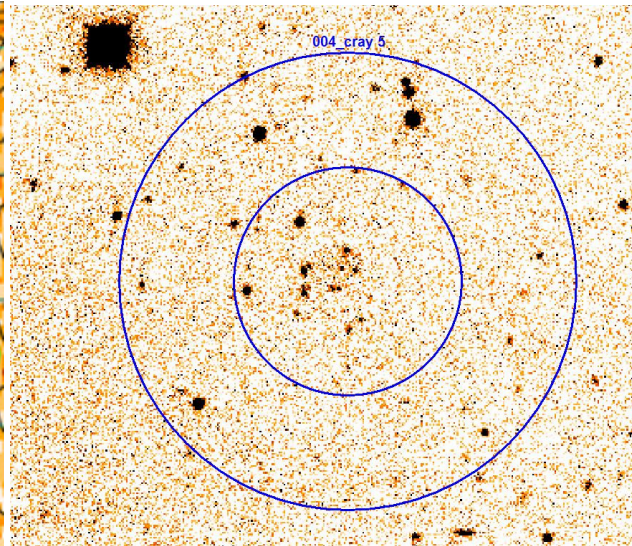
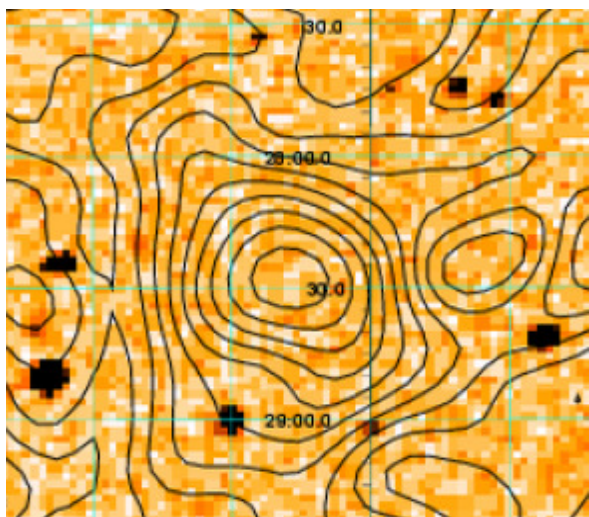
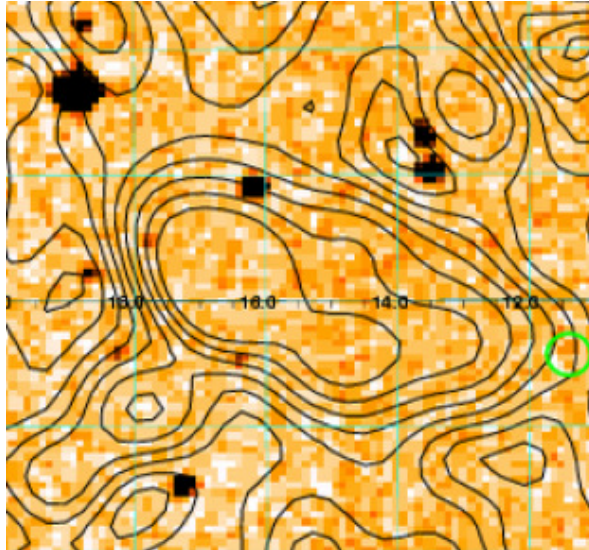


identification rate:
 ~ 3 $z > 0.9$ X-ray clusters
per night of 3.5m time

The latest XDCP identifications of high-z candidates

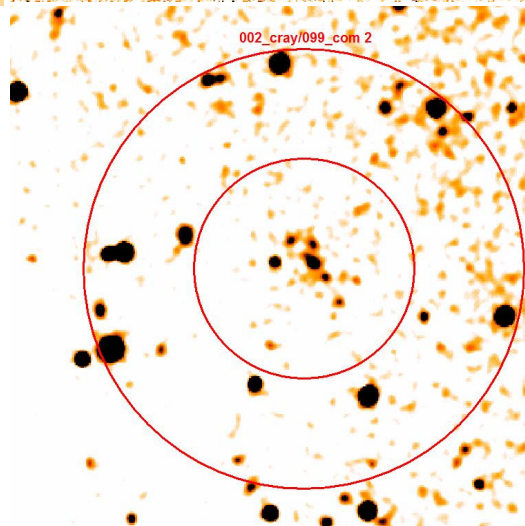
First 15min of online reduced H-band data from last Saturday

DSS +
X-ray
contours



**z~0.8 cluster
candidate**

**15 min H
same FoV**



**z≥1 cluster
candidate**

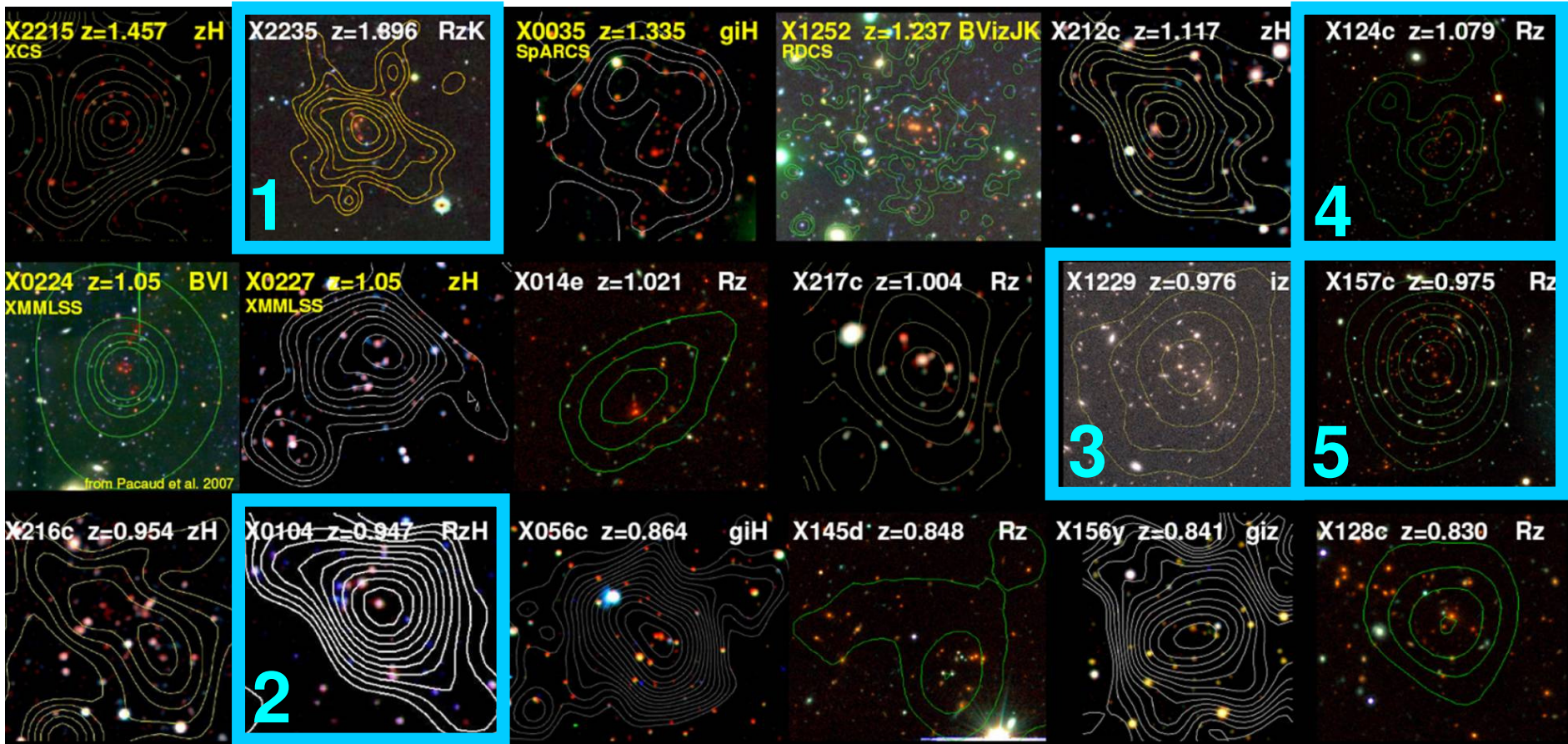
smoothed image

I. The XMM-Newton Distant Cluster Project

II. Recent X-ray Cluster Results

III. Status & Outlook

The XDCP Survey currently includes 18 spectroscopically confirmed $z > 0.8$ X-ray clusters

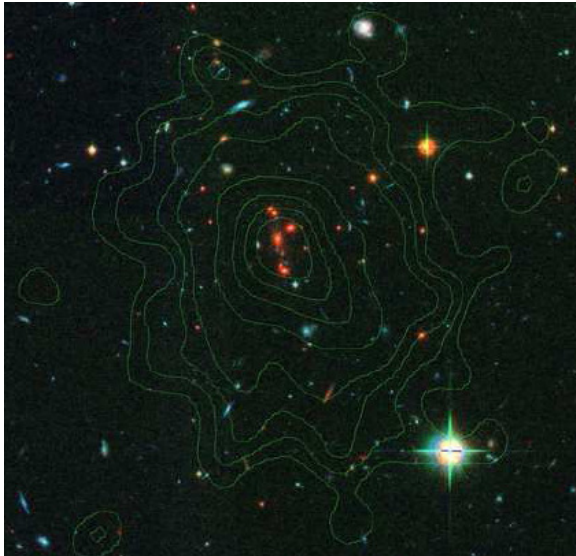


5 clusters with spectroscopy from other surveys (yellow)
 10 clusters to be published

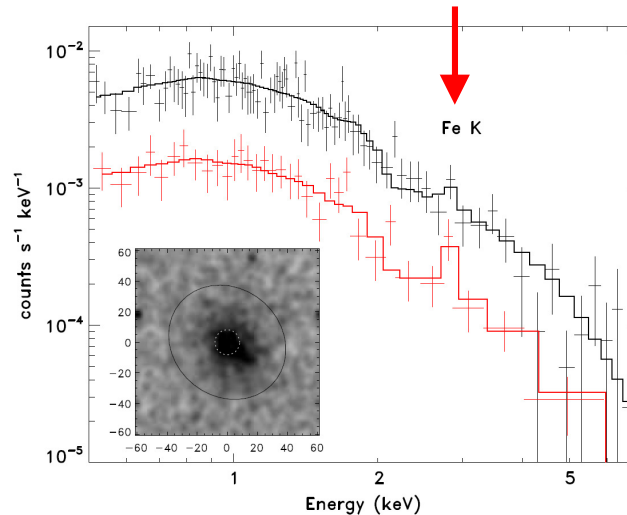
Source: http://www.xray.mpe.mpg.de/theorie/cluster/XDCP/xdcp_index.html

(1) Progress at $z=1.4$: XMMU J2235.3-2557

New results from the multi- λ follow-up campaigns



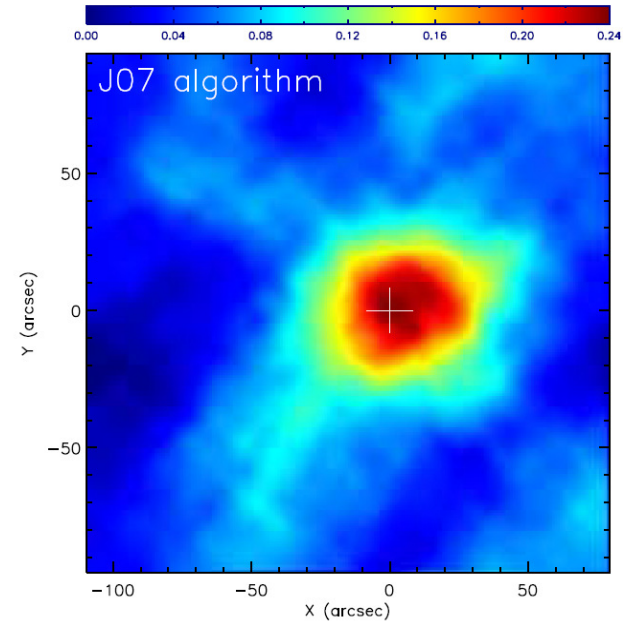
HST/ACS i+z & VLT/ISAAC K_s
with Chandra X-ray contours



200 ksec Chandra Spectrum

$T_x = 8.6 \text{ keV } (+1.3)$

$M_{200} = 6 (+1.3) 10^{14} M_{\text{sun}}$



HST Weak Lensing Map (8σ)

$M_{200} = 7.3 (+1.3) 10^{14} M_{\text{sun}}$

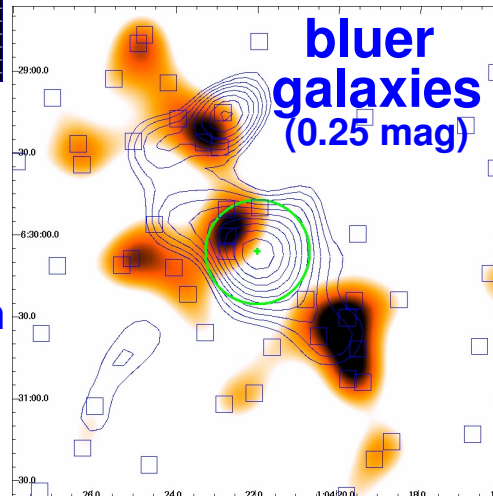
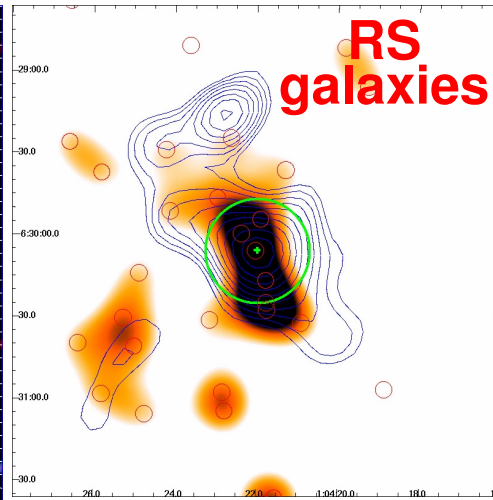
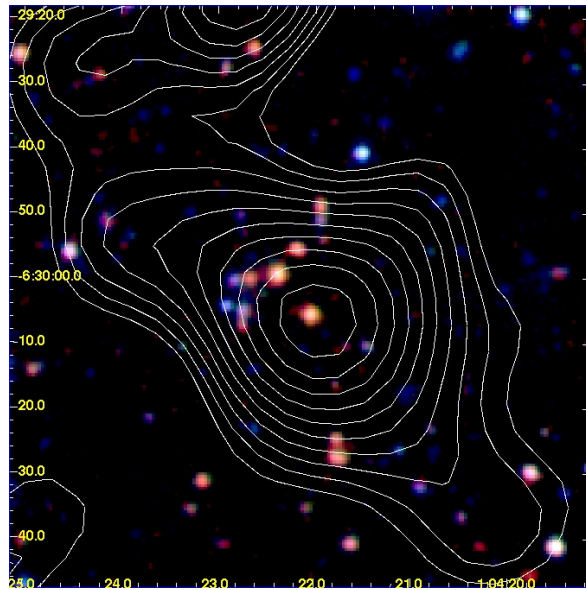
**XMMU J2235.3-2557 is the
hottest and most massive cluster known at $z > 1$
expected surface density: 1 in $>1000 \text{ deg}^2$**

P. Rosati et al., in print, A&A, arXiv:0910.1716

M.J. Jee et al., 2009, ApJ, 704

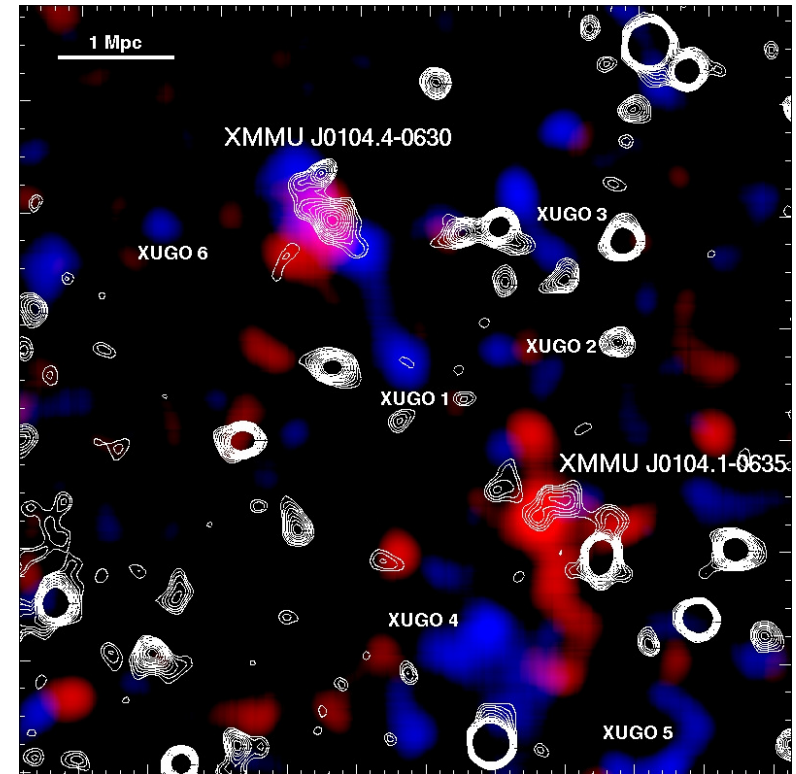
(2) More common systems at $z \sim 1$

XMMU J0104.4-0630 at $z=0.95$ and associated LSS



$T_x \sim 3 \text{ keV}$

$M_{200} \sim 1.5 \cdot 10^{14} M_{\text{sun}}$



color selected galaxy densities
with X-ray contours

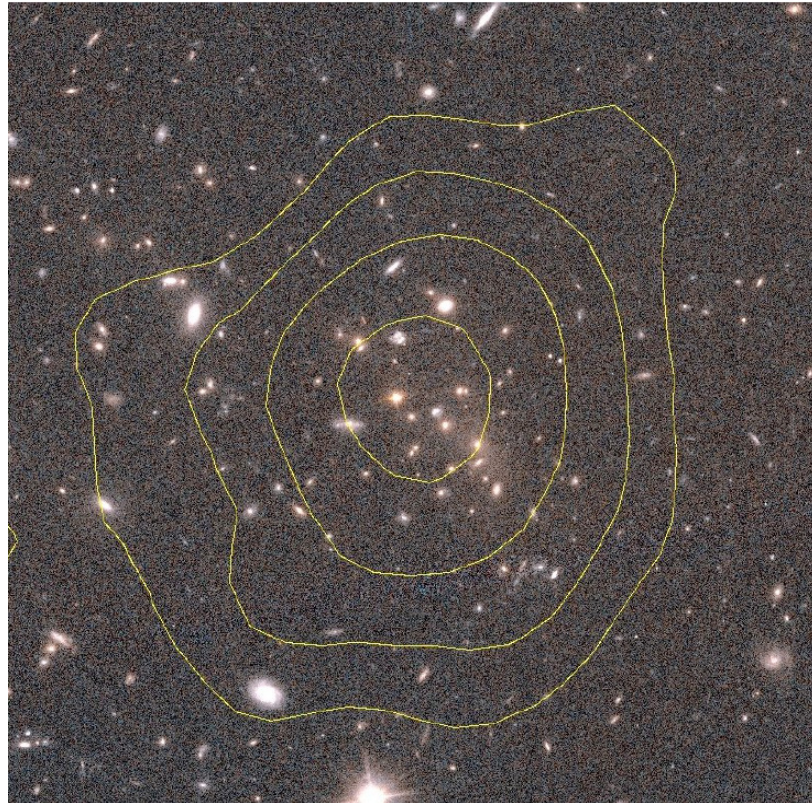
spectroscopic follow-up
scheduled at VLT/VIMOS

R. Fassbender et al. 2008, A&A, 482

Rene Fassbender (MPE)

(3) Massive $z \sim 1$ clusters as upcoming cosmological probes

HST Study of XMMU J1229.5+0151 at $z=0.975$

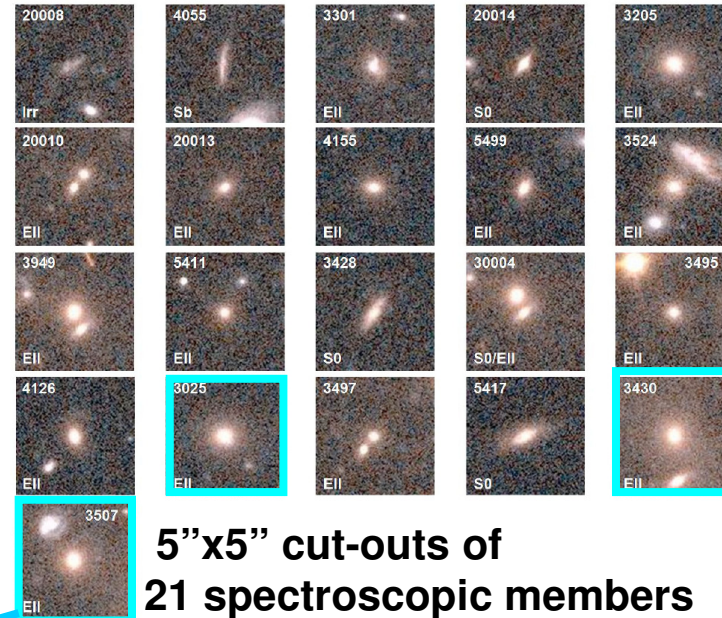


1.5'x1.5' HST/ACS i+z image + XMM contours

$$T_x = 6.4 \pm 0.7 \text{ keV}$$

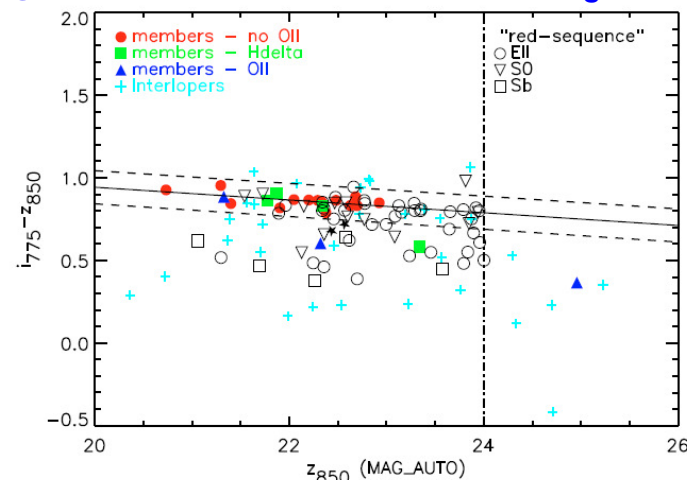
$$M_{200} \sim 5 \cdot 10^{14} M_{\text{sun}}$$

J. Santos et al. 2009, A&A, 501



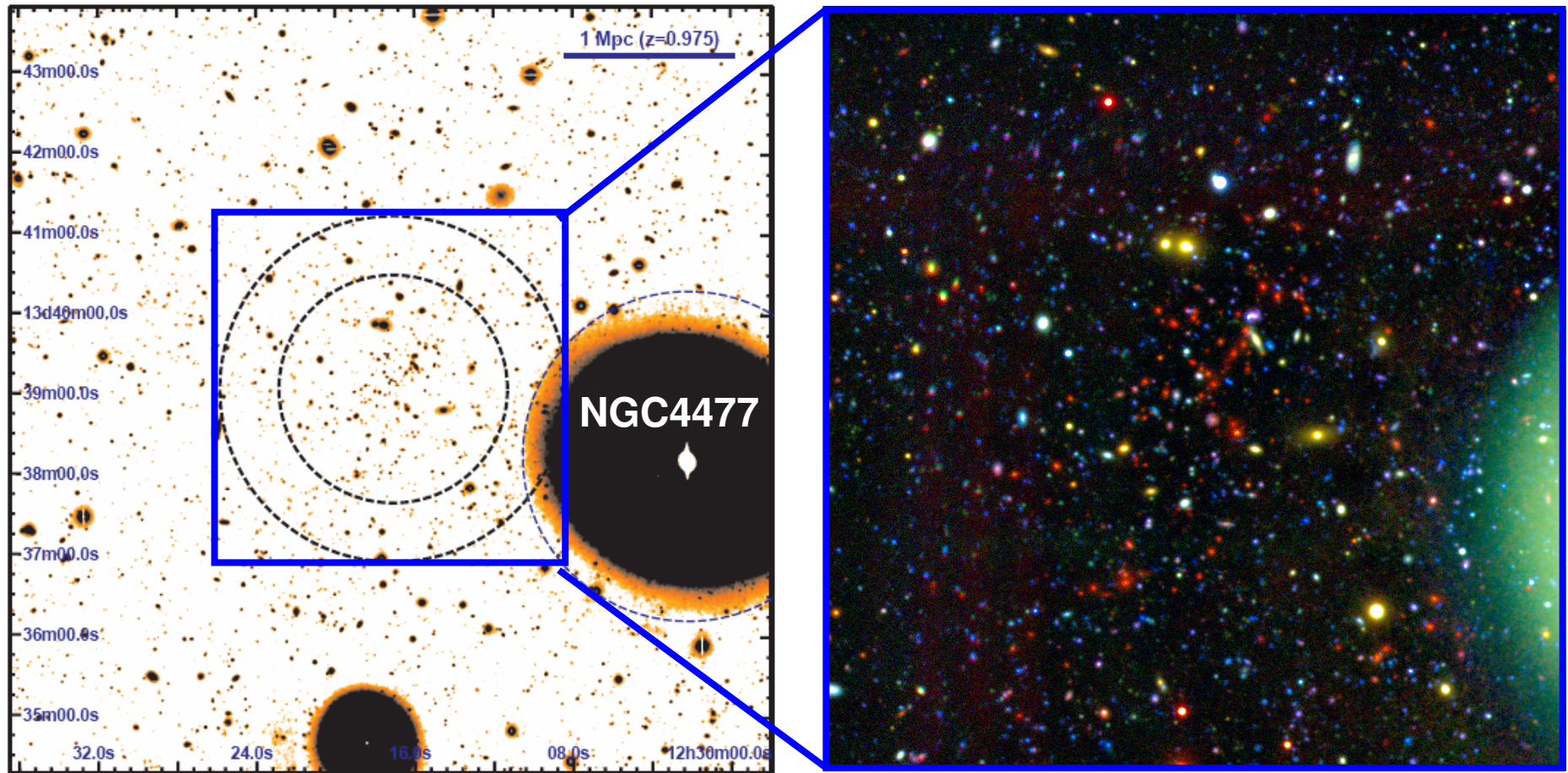
5''x5'' cut-outs of
21 spectroscopic members

3 galaxies with stellar mass $M_s > 2 \cdot 10^{11} M_{\text{sun}}$



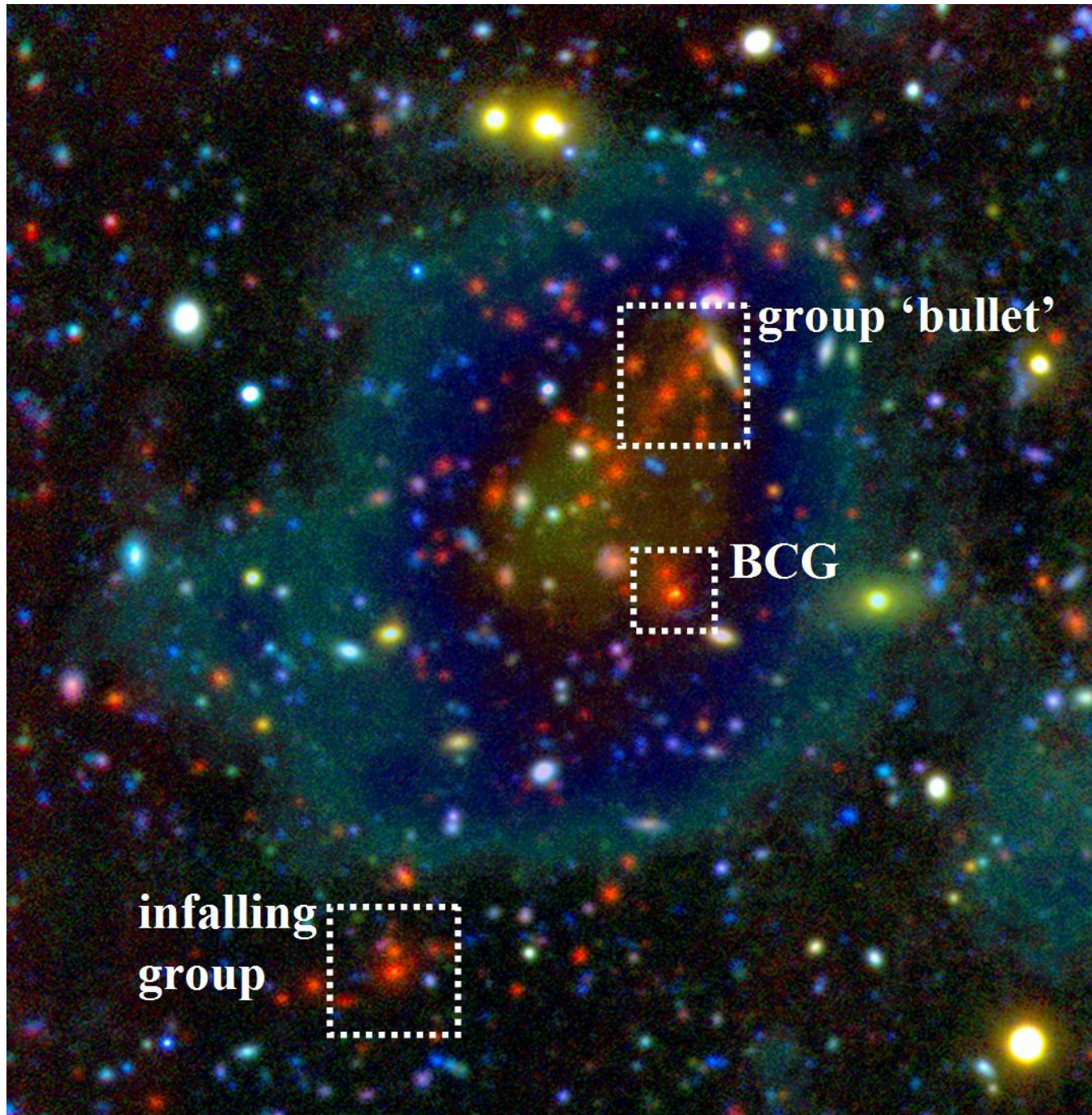
tight 'red-sequence'

(5a) Observing the assembly of a Coma-like cluster XMMU J1230.3+1339 at $z=0.975$ behind Virgo



9'x9' iz

4'x4' UB+Vr+iz



X1230.3+1339

$M_{200} = 5 \cdot 10^{14} M_{\text{sun}}$

$z = 0.975$

$T_x = 6 \text{ keV}$

$L_{X,\text{bol}} = 8 \cdot 10^{44} \text{ erg/s}$

$N_{200} = 60$

**3'x3' UB+Vr+iz
~ R_{500} region**

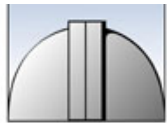
I. The XMM-Newton Distant Cluster Project

II. Recent X-ray Cluster Results

III. Status & Outlook

Status & Outlook

1. The XMM-Newton Distant Cluster Project is now at a mature state with lots of distant X-ray clusters and science applications appearing
2. The survey spans the range from common moderate mass systems at $z \sim 1$ (XMMU J0104-0640) to very rare massive objects at $z=1.4$ (XMMU J2235-2557) for various high- z studies
3. XMMU J1007+1258 is a new strong lensing cluster at $z=1.08$
4. XMMU J1230+1339 one of the best suited model systems to study in-situ cluster evolution on all scales at a lookback time of 7.6 Gyr
5. The XDCP sample of spectroscopically confirmed X-ray clusters at $z > 0.8$ will increase from currently 18 objects to more than 50 systems in the next few years



AIP



The XMM-Newton Distant Cluster Project Team

- Hans Böhringer (MPE)**
- Rene Fassbender (MPE)**
- Robert Suhada (MPE)**
- Martin Mühlegger (MPE)**
- Daniele Pierini (MPE)**
- Alessandro Nastasi (MPE)**
- Joana Santos (INAF Trieste)**
- Piero Rosati (ESO)**
- Axel Schwobe (AIP)**
- Georg Lamer (AIP)**
- Jan Kohnert (AIP)**
- Arjen de Hoon (AIP)**
- Gabriel Pratt (Saclay)**
- Hernan Quintana (PUC)**
- Joe Mohr (USM Munich)**

