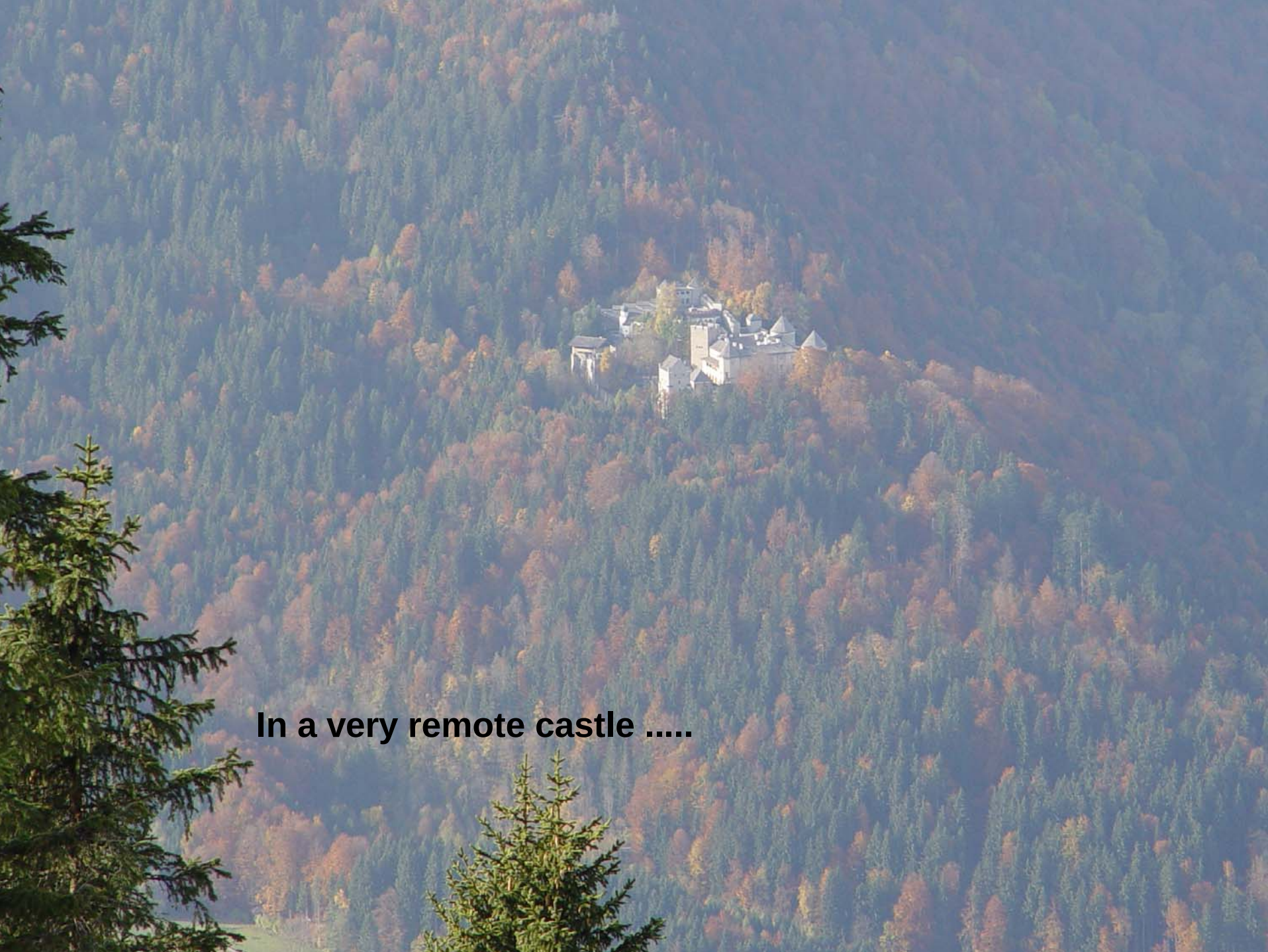
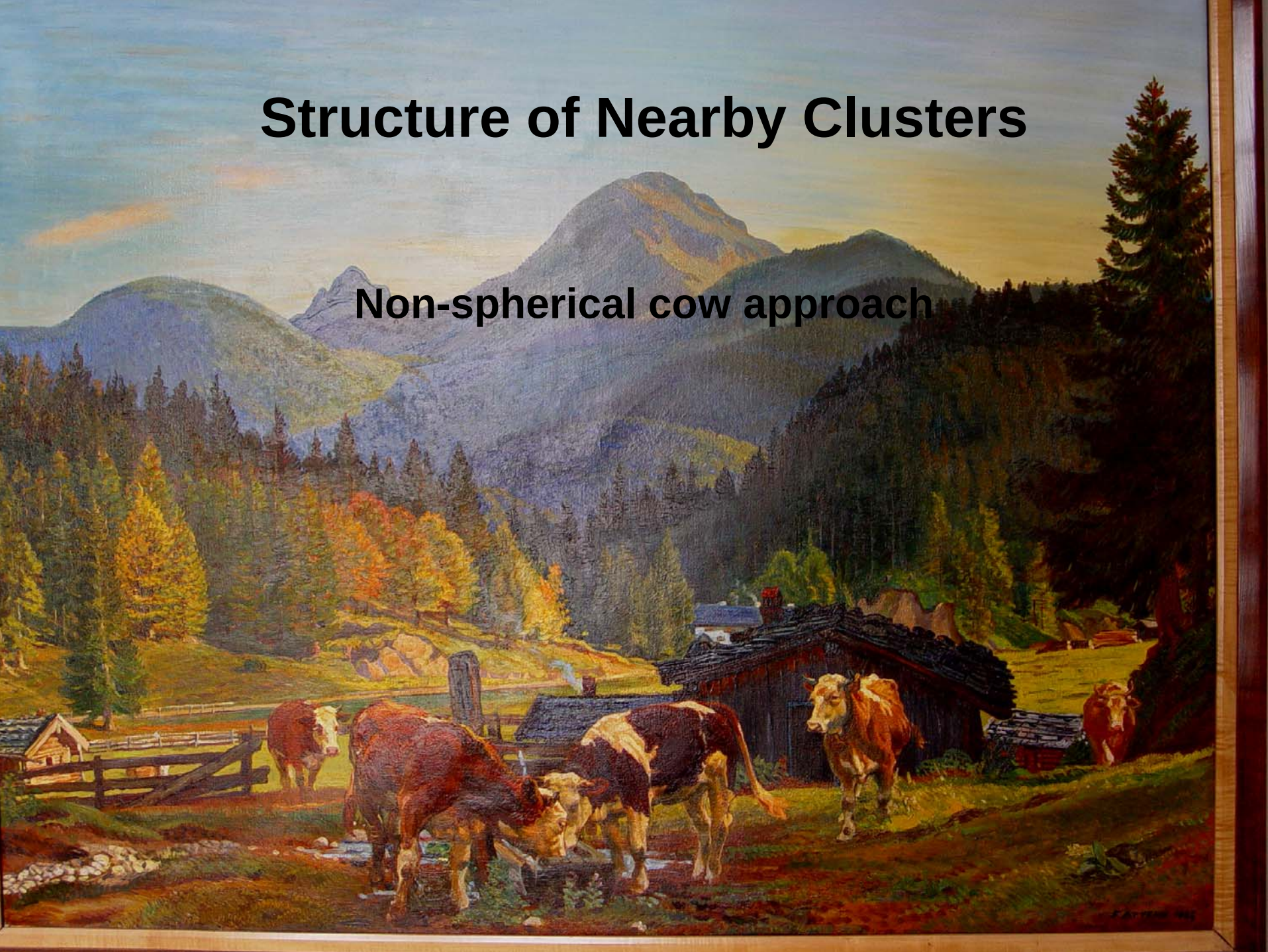

In a very remote castle .....


... reached after having made hidden
BOB train connection .....

... we finally met for our

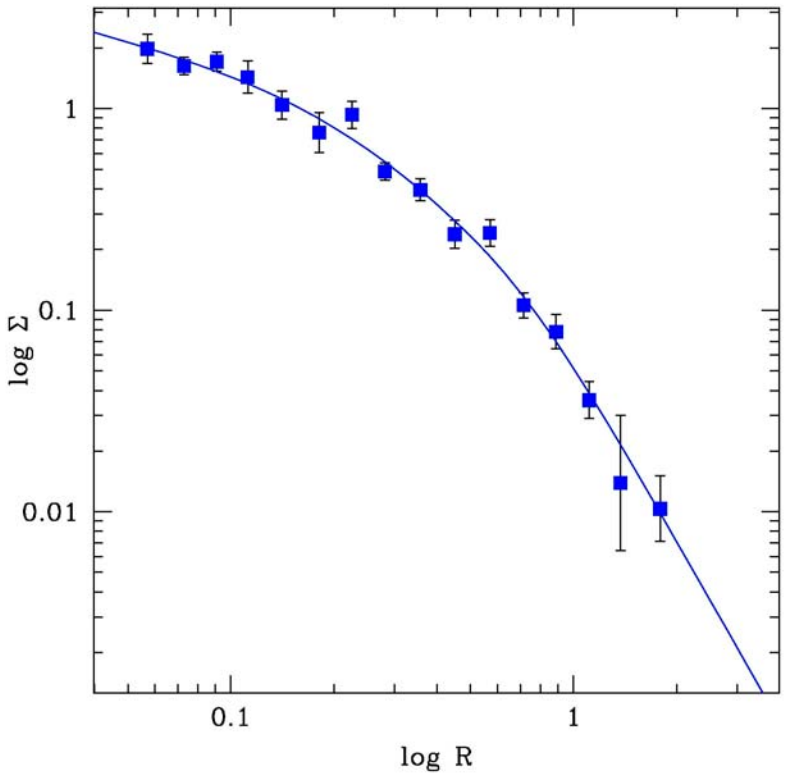
Distant Cluster Workshop

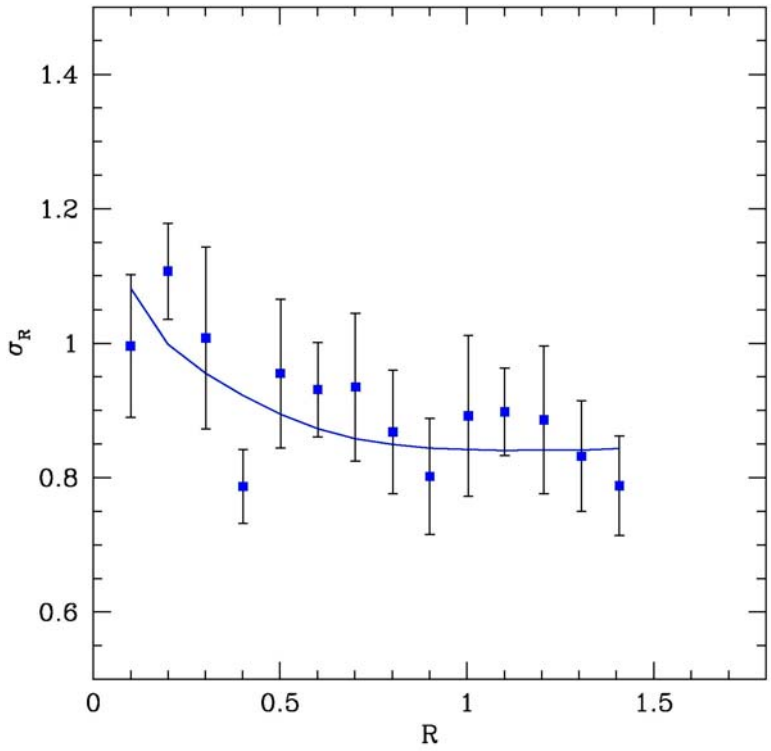
Structure of Nearby Clusters



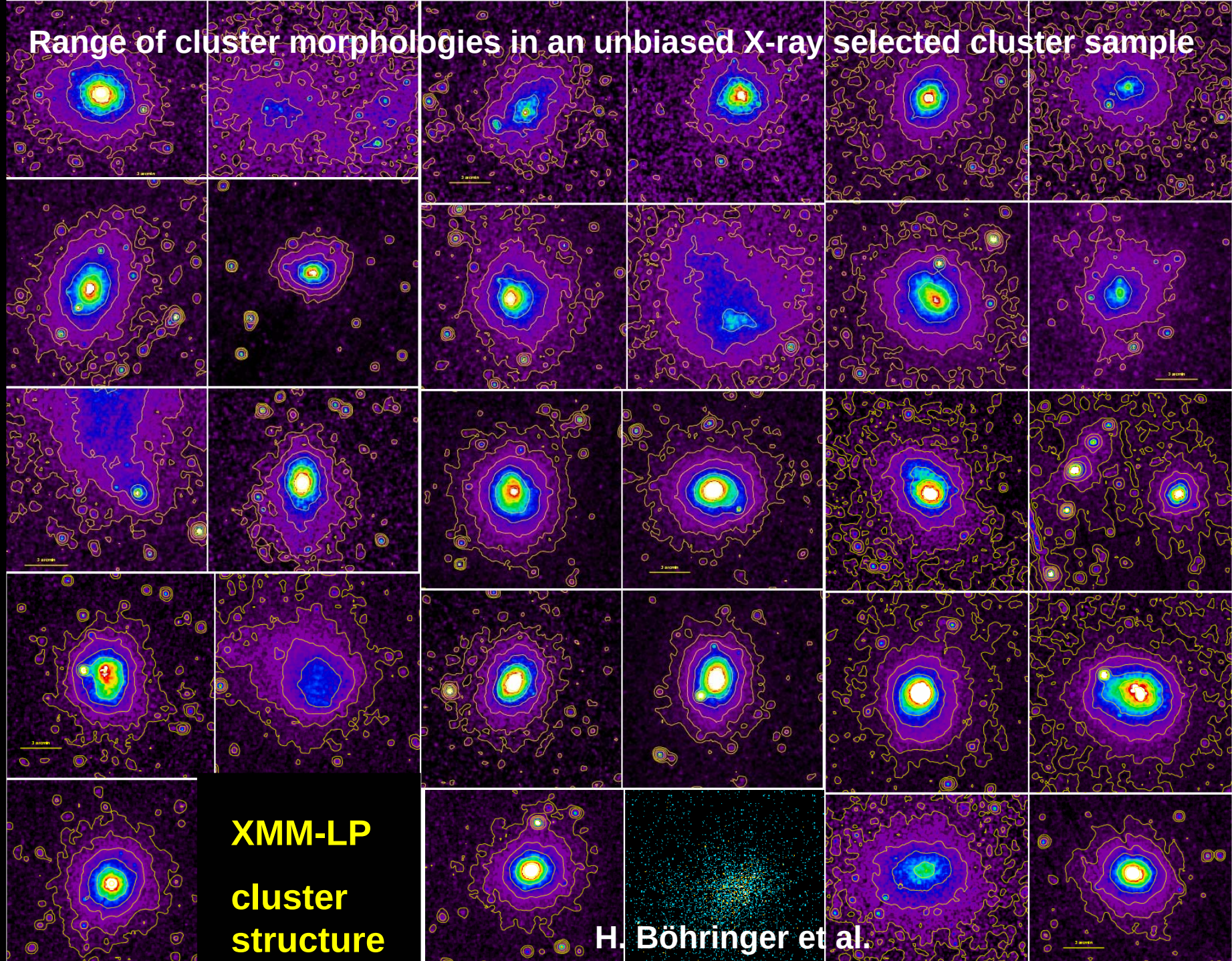
Non-spherical cow approach

Average Global Cluster Properties (Optical)





Combined galaxy density profile and velocity disperson profile of 36 RCS clusters z = 0.15 – 0.6 **Chris Blindert**

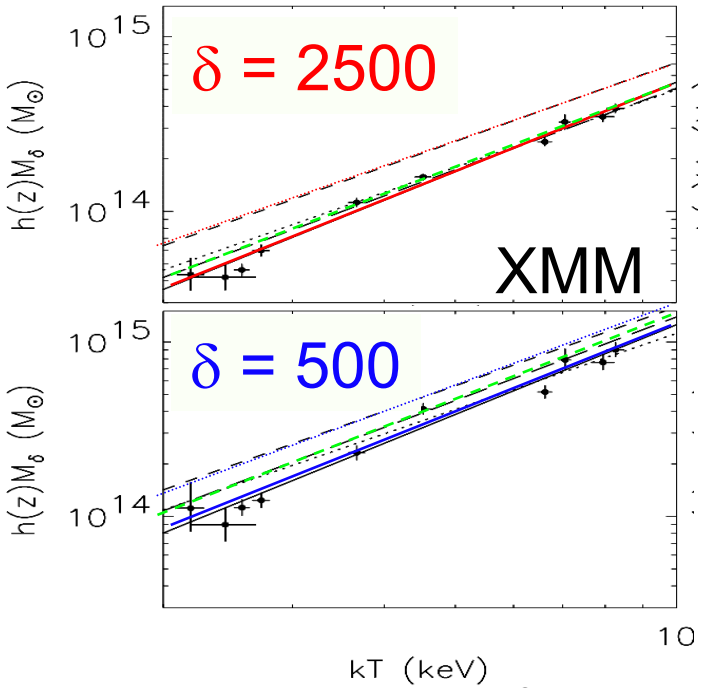

Range of cluster morphologies in an unbiased X-ray selected cluster sample
XMM-LP
cluster
structure
H. Böhringer et al.

Assessing Cluster Morphology

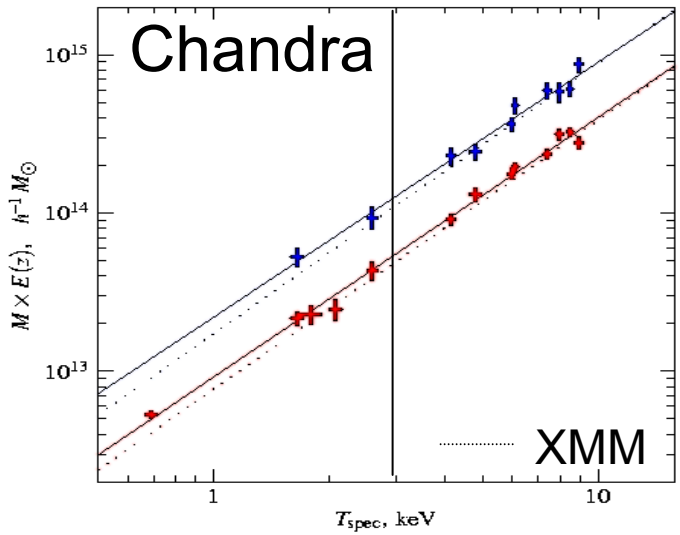
→ **See also talk by Irini Sakelliou**

On X-ray cluster morphology analysis

Evolution of the M-T relation



Arnaud,Pointecouteau & Pratt,05



Vikhlinin et al, 05, astro-ph/0507092

relaxed clusters

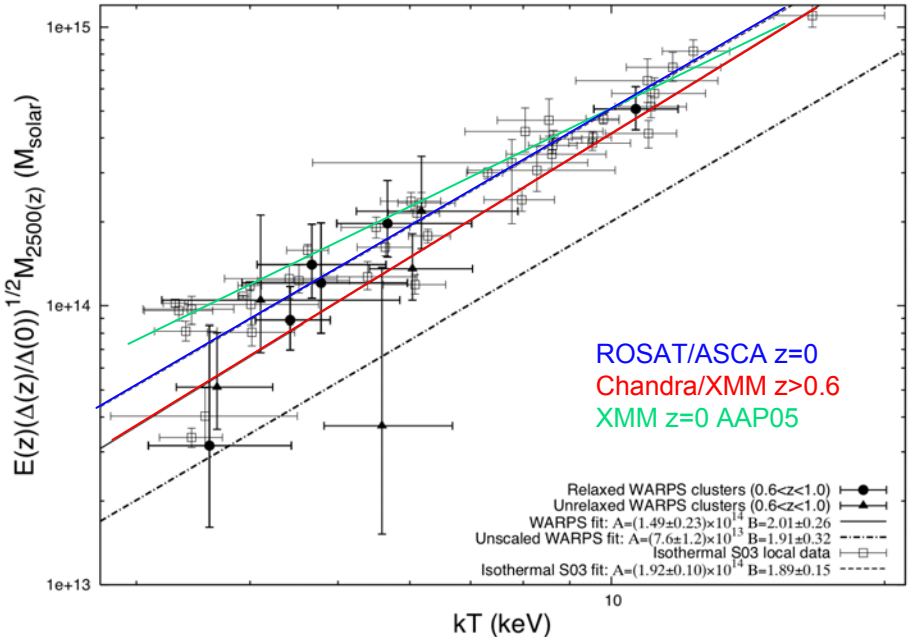
Precise converging calibration of the *local* M-T relation

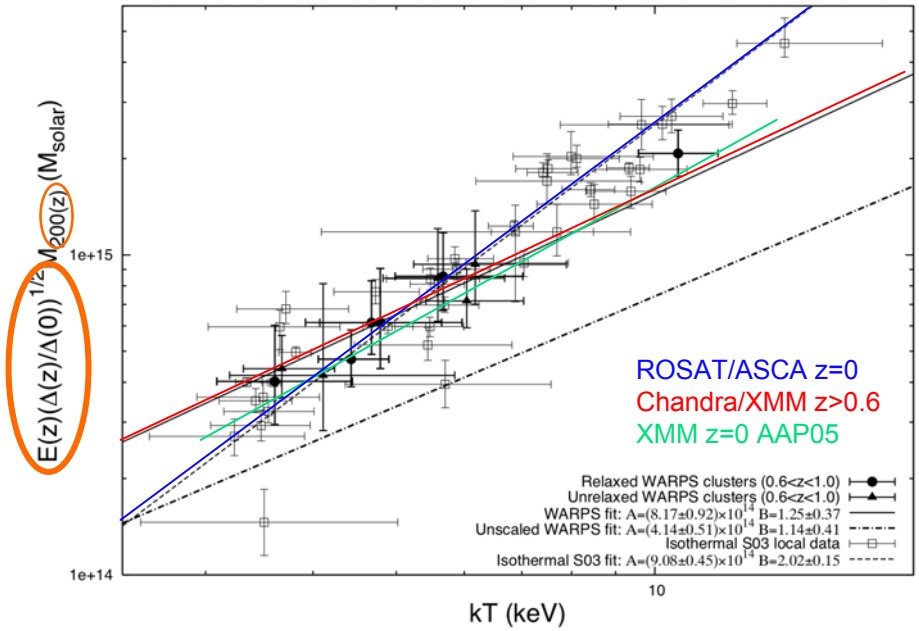
- M(r) from the HE equation with kT profile => consistent estimate of R_δ and M_δ
- effect on non-grav. physics: normalisation offset ; α = 1.5±0.1 (T>3.5 keV) α ~ 1.7 (T>2 keV)

😐 Some discrepancies with previous ROSAT/ASCA studies (*see Arnaud et al, 05*)

Monique Arnaud

Evolution of the M-T relation (3)





Maughan et al, 05, astro-ph/0503455

- There is evolution
- Consistent with expected

☺ Larger, ~ unbiased (0.6<z< 1; local) sample

☹ M_Δ assuming isothermality; HE valid?

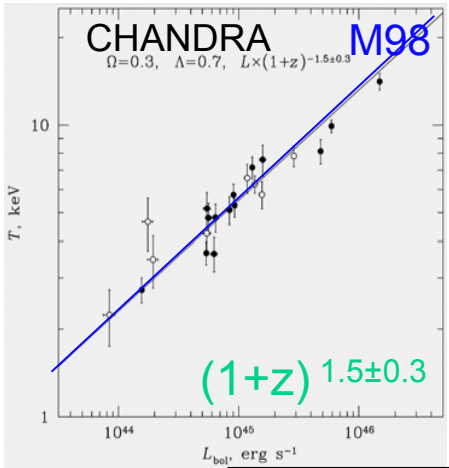
😐 Different definition for M_Δ

Monique Arnaud

See also Ettori et al, 04

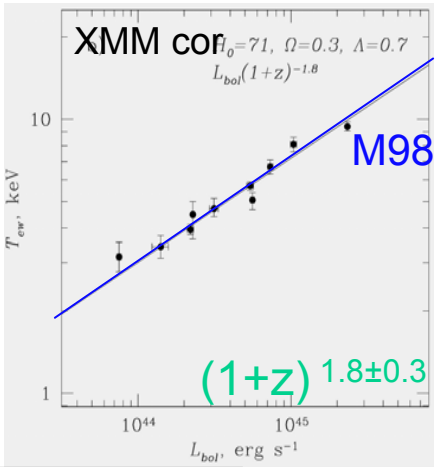
The evolution of the L_x -T relation

Vikhlinin et al 02

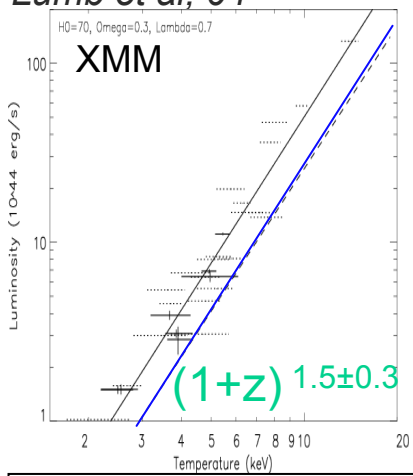


R fixed; CF corrected

Kotov & Vikhlinin 05

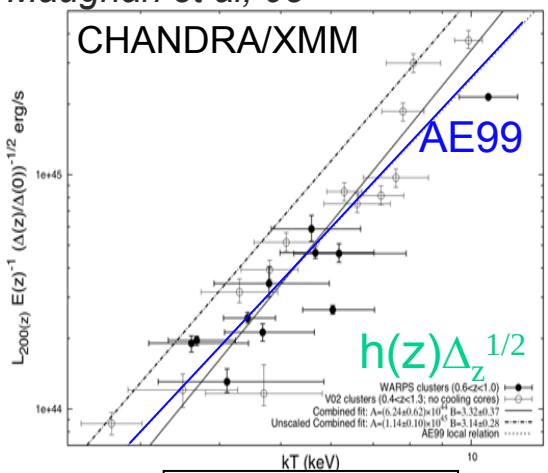


Lumb et al, 04



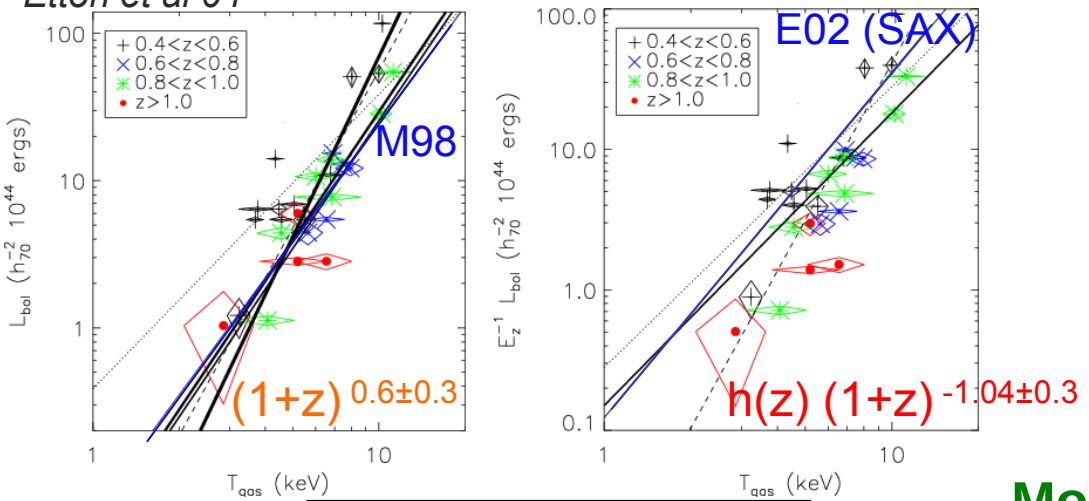
R_{200}; CF corrected

Maughan et al, 05



$R_{200(z)}$; no CF

Ettori et al 04



R'$_{500(z)}$; no CF correction

More than h(z)
or
as h(z)
or
less than h(z)

Monique Arnaud

Scaling Relations

- We need to agree on a common, acceptable recipe !
- Scaling with E(z) or E(z)Δz

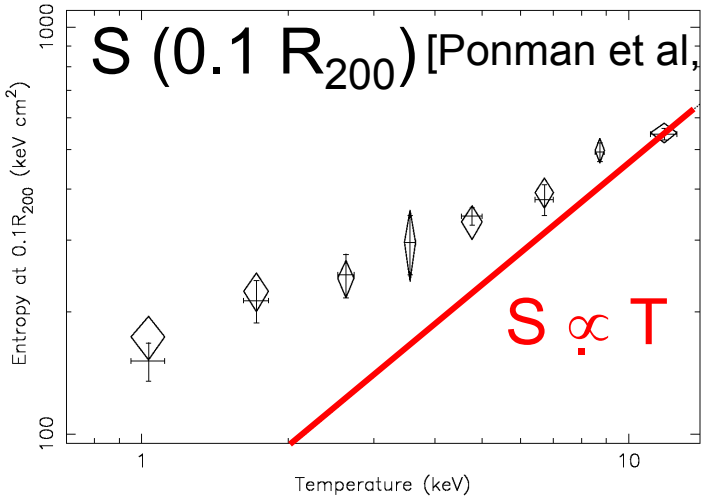
(E(z) == h(z))

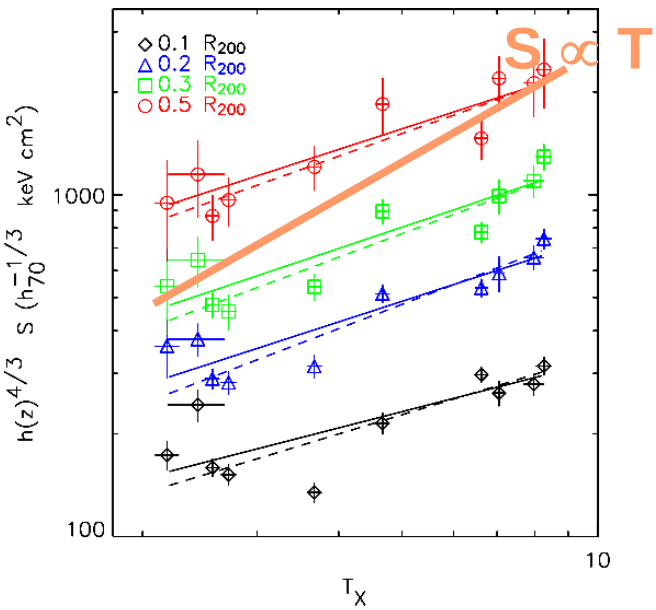
Monique Arnaud

Entropy scaling

If clusters are self similar,
$\rho_{gas} \propto \rho_{DM} \propto \delta_c(0) = cst$
$\Rightarrow S \propto T$

- Find $S \propto T^{0.65}$ with slope stable to 0.5 R_{200} [see also Ponman et al. 2003]
- $S \propto T^{0.65} \Rightarrow L_X \propto T^{2.7}$
- Increased dispersion towards central regions



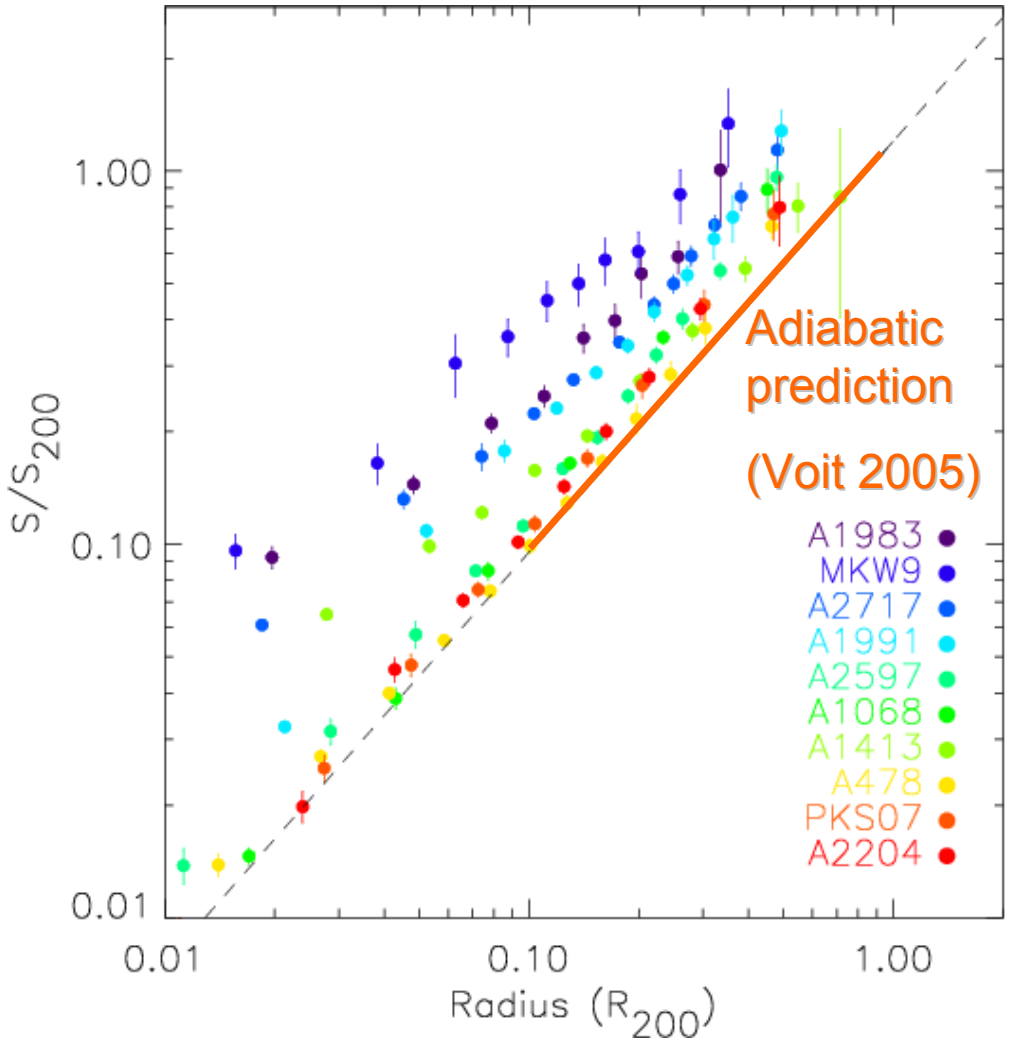


[Pratt et al., astro-ph/0508234]

Gabriel Pratt

Entropy scaling: comparison with adiabatic simulations

- Hotter systems in relatively good agreement (slope & normalisation)
- Clear excess normalisation at all measured radii in poorer systems (x2.5 at 2 keV)
- Increased dispersion in central regions
- Need mechanism which increases normalisation ar large R and dispersion at small R



[Pratt et al., astro-ph/0508234; also Pratt & Arnaud 2005]

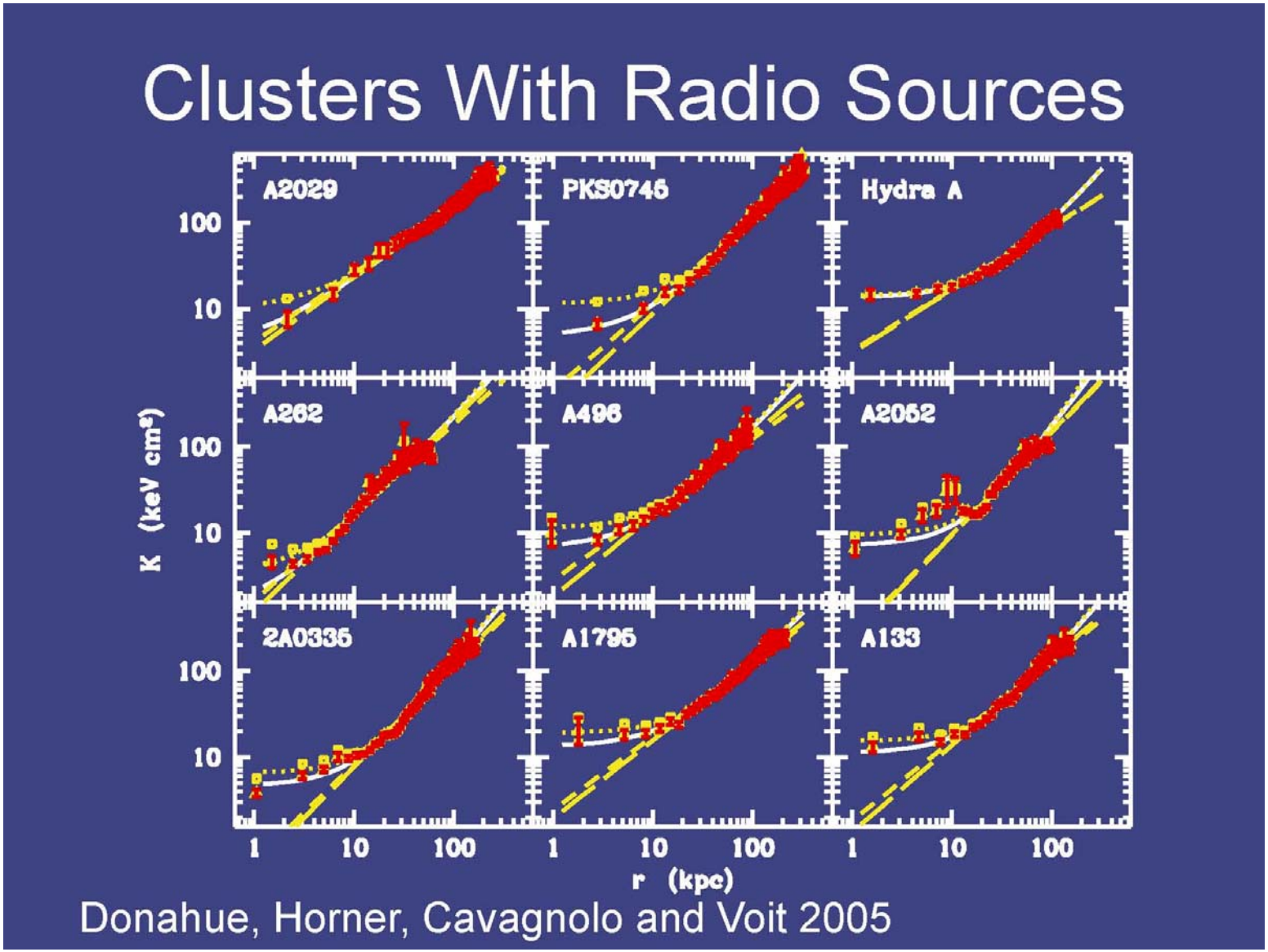
Gabriel Pratt / Stefano Borgani

Caveat: Multi-Temperature Structure

Elena Rasia:

Temperature can be biased low, if multi-temperature ICM is fitted with single temperature models

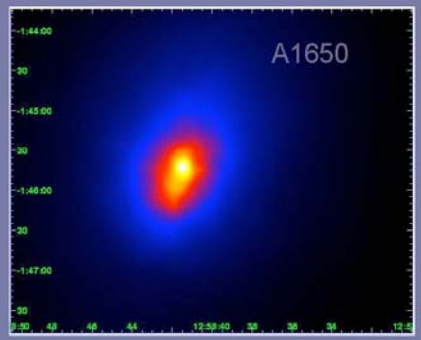
Cooling Core Clusters Megan Donahue



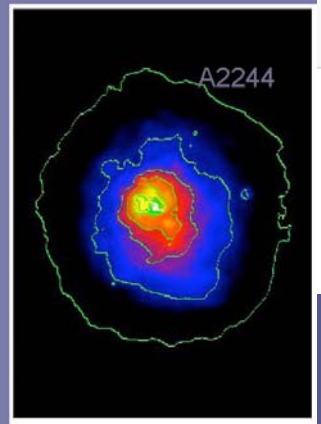
Very low entropy cores ~< 10 keV cm^2

Megan Donahue

- No fossil bubbles out to ~100 kpc
- Little or no temperature gradients

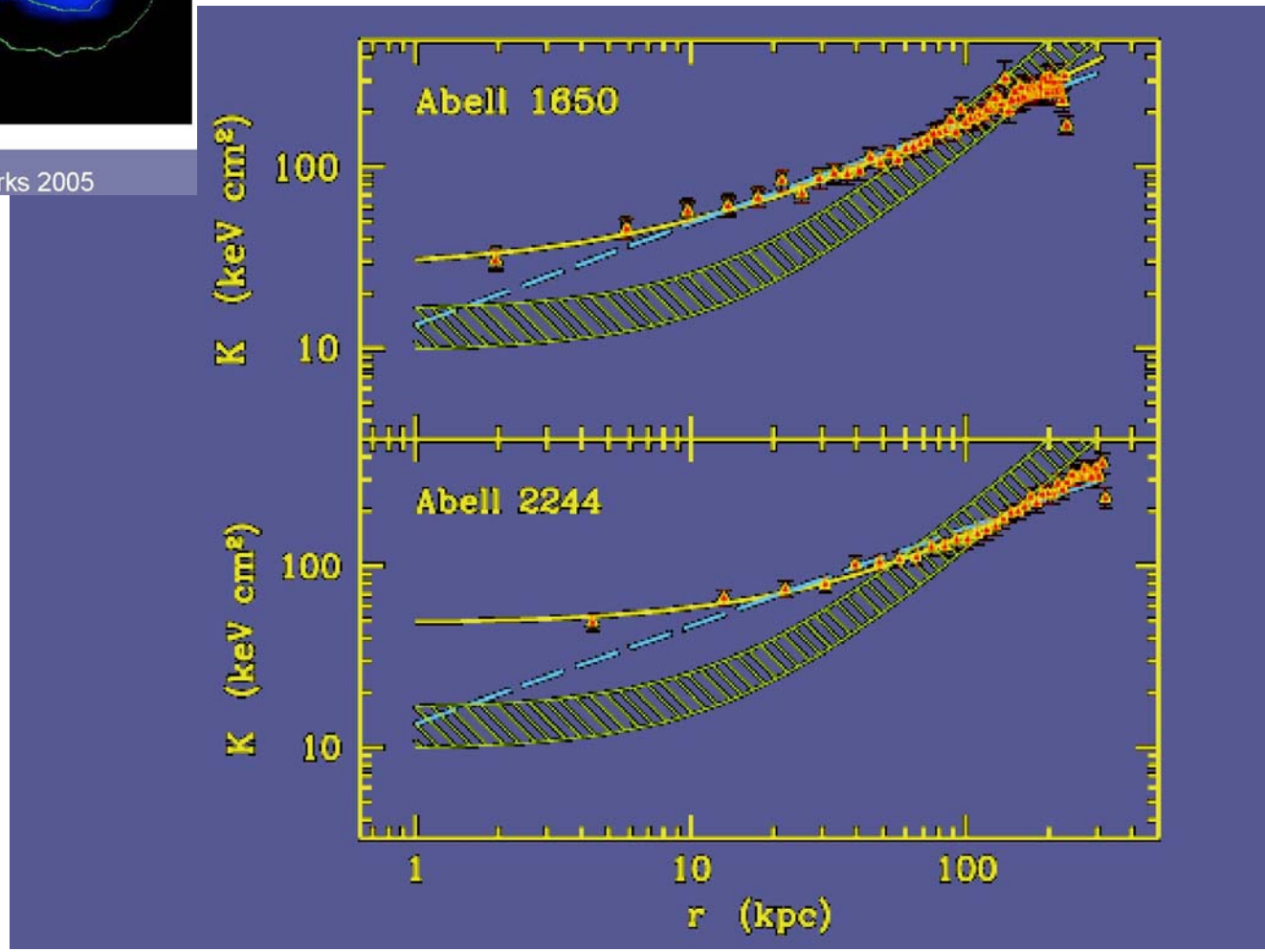


What is



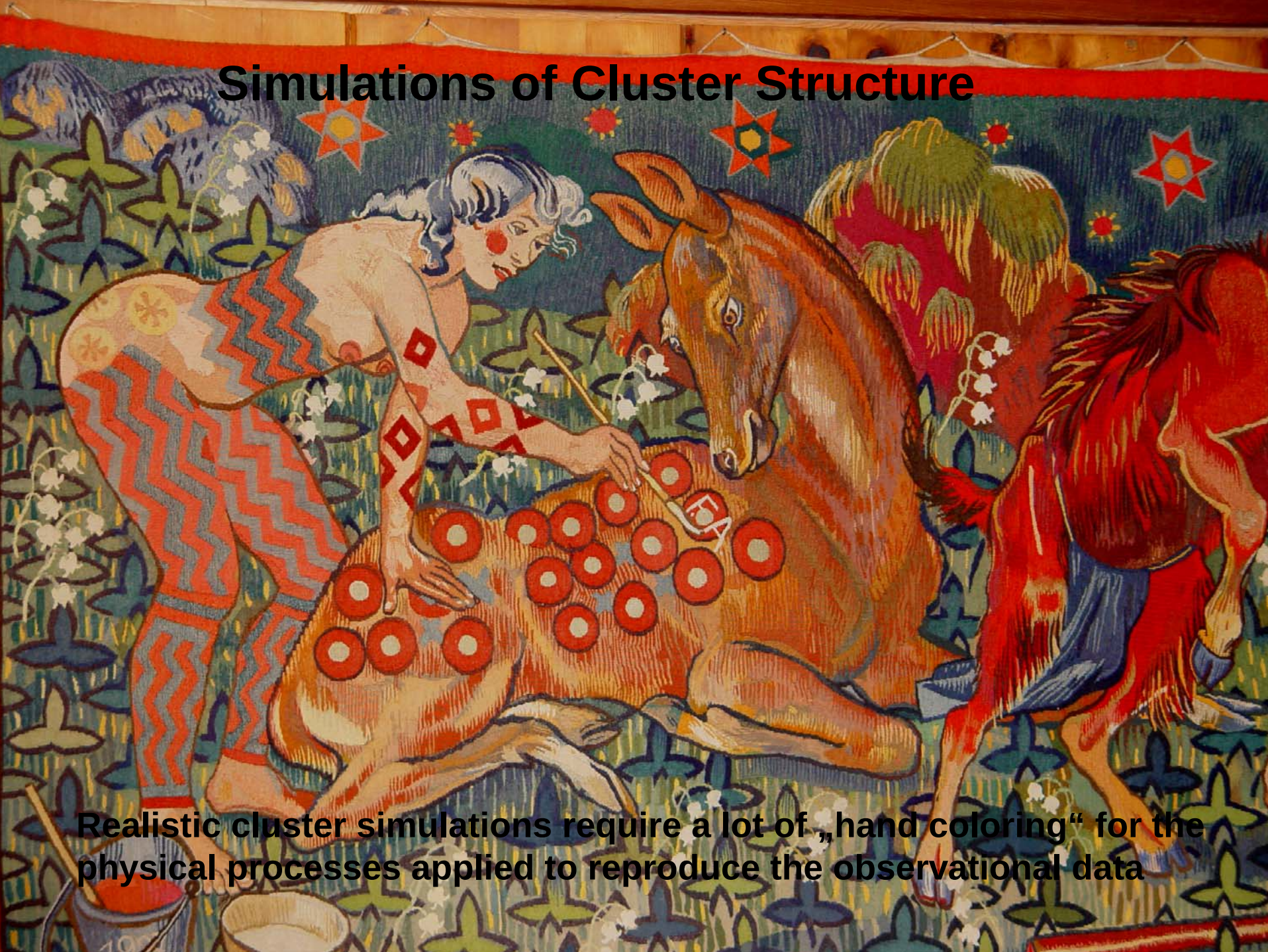
Donahue, Voit, O'Dea, Baum & Sparks 2005

Cooling Core Clusters without central radio source



These clusters show less entropy decrease in the center and consequently feature a longer cooling time

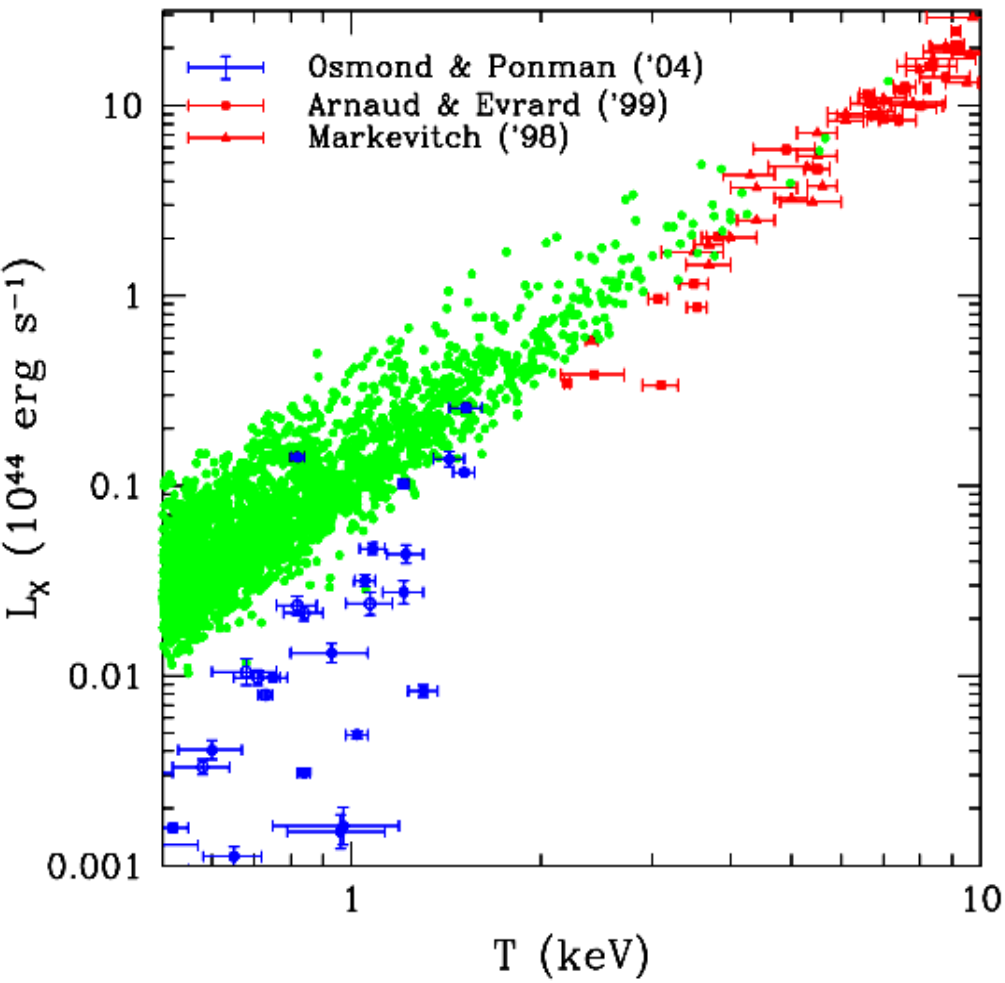
Simulations of Cluster Structure



Realistic cluster simulations require a lot of „hand coloring“ for the physical processes applied to reproduce the observational data

The L_X-T relation

Stefano Borgani



□□□□□□□□ '02: cooling only

L_X-T relation reasonable, but up to 80% of baryons in stars for groups!

Muanwong et al'03: cooling + pre-heating

No much bending at the scale of groups.

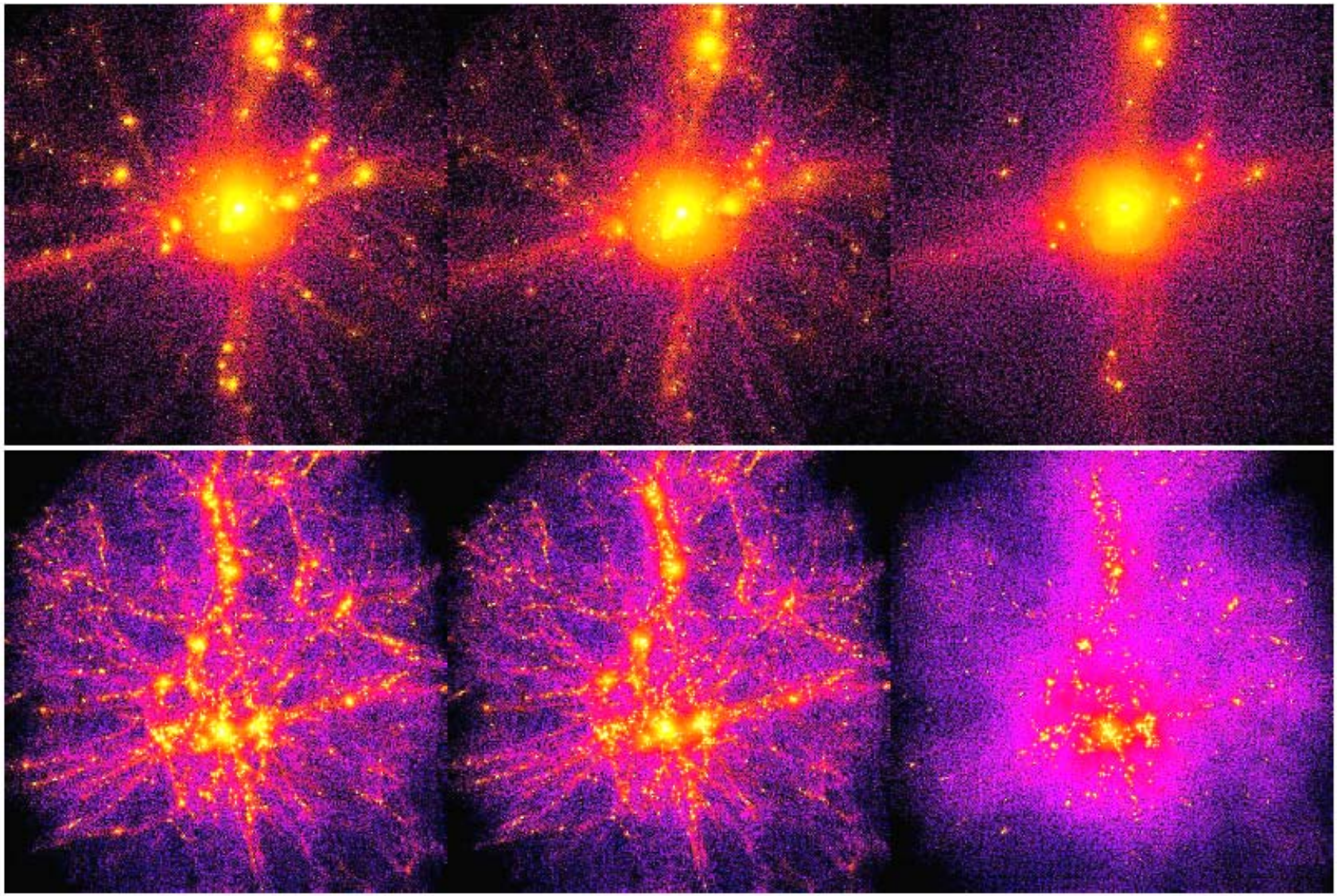
SB et al'04: cooling + SF + galactic winds

Again, wrong shape and small scatter for groups.

Entropy amplification from feedback

Stefano Borgani

340 km s^{-1} | 830 km s^{-1} | 340 km s^{-1} + $S_{fl}100$

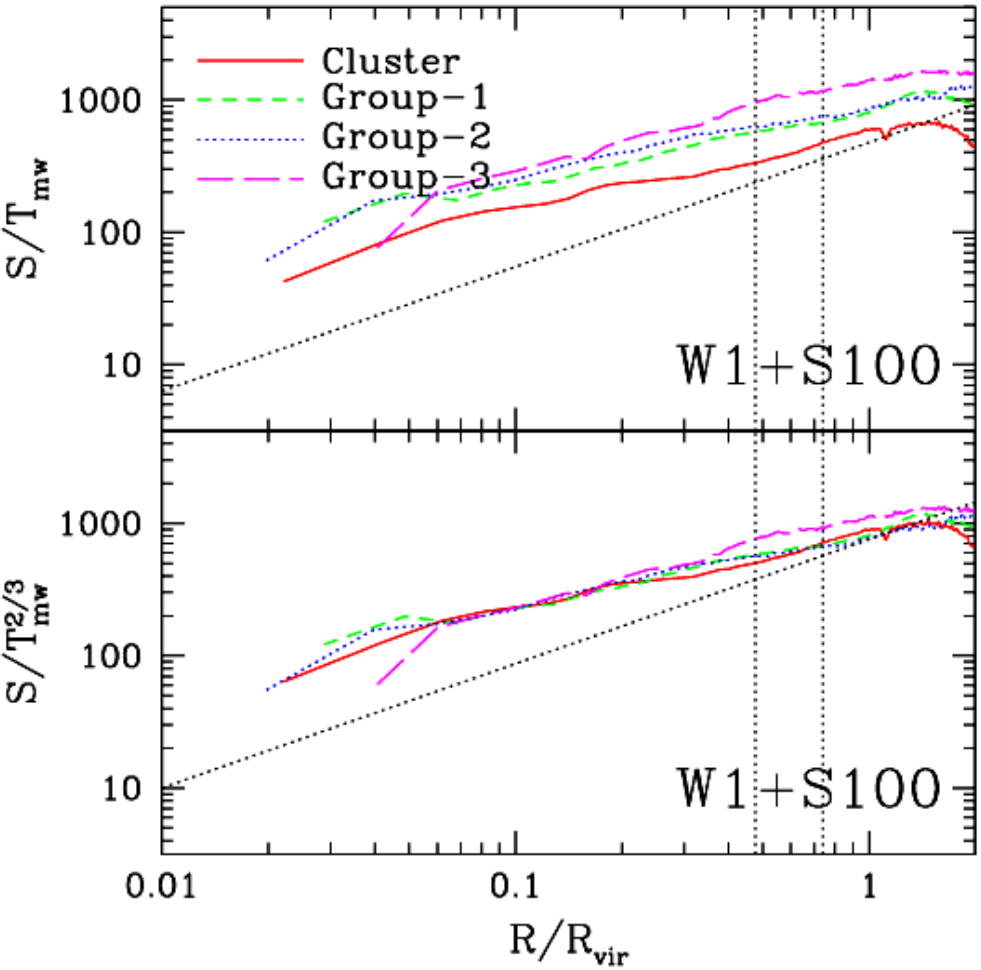


z=0

z=2

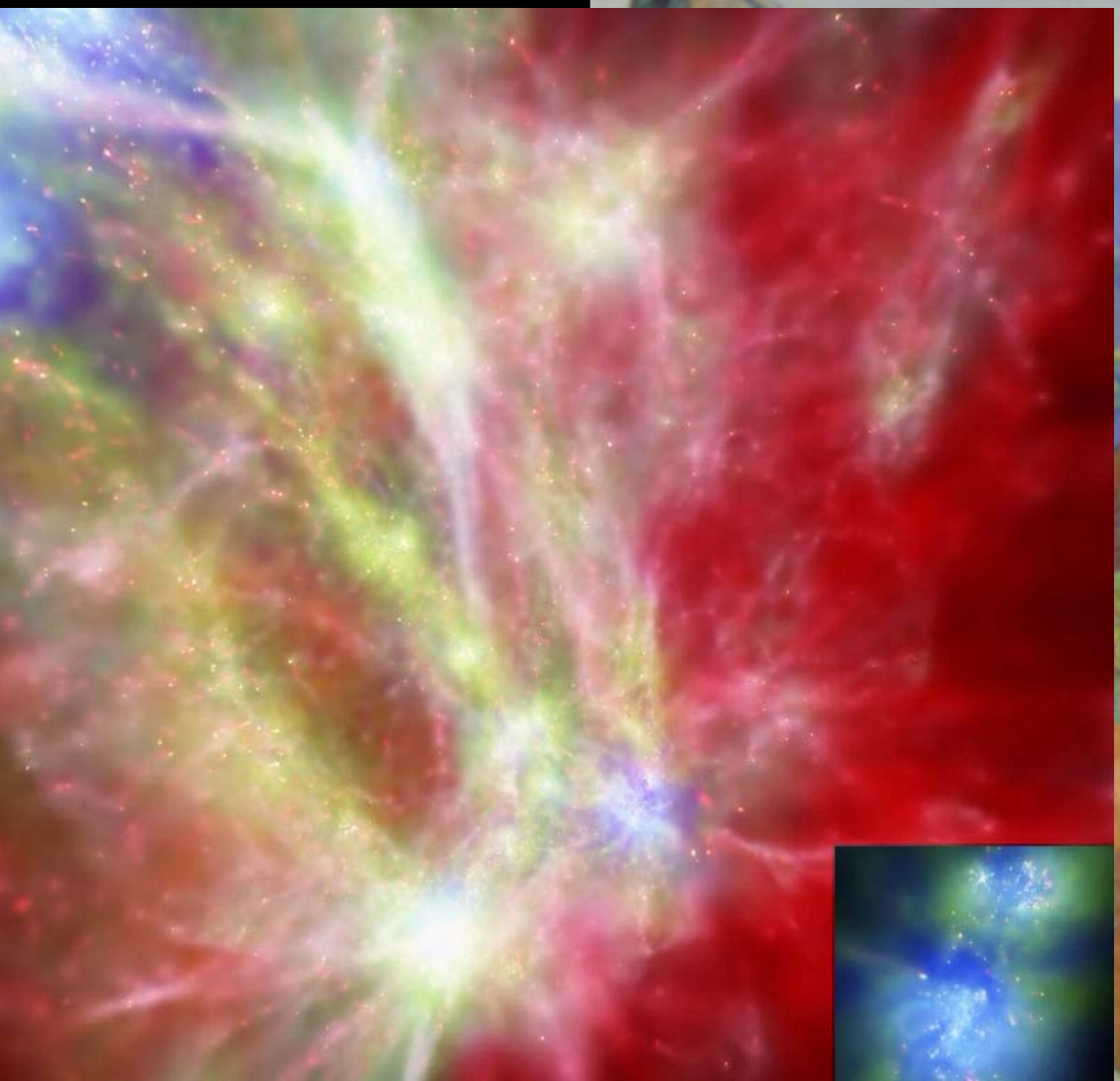
Entropy amplification from feedback

Stefano Borgani



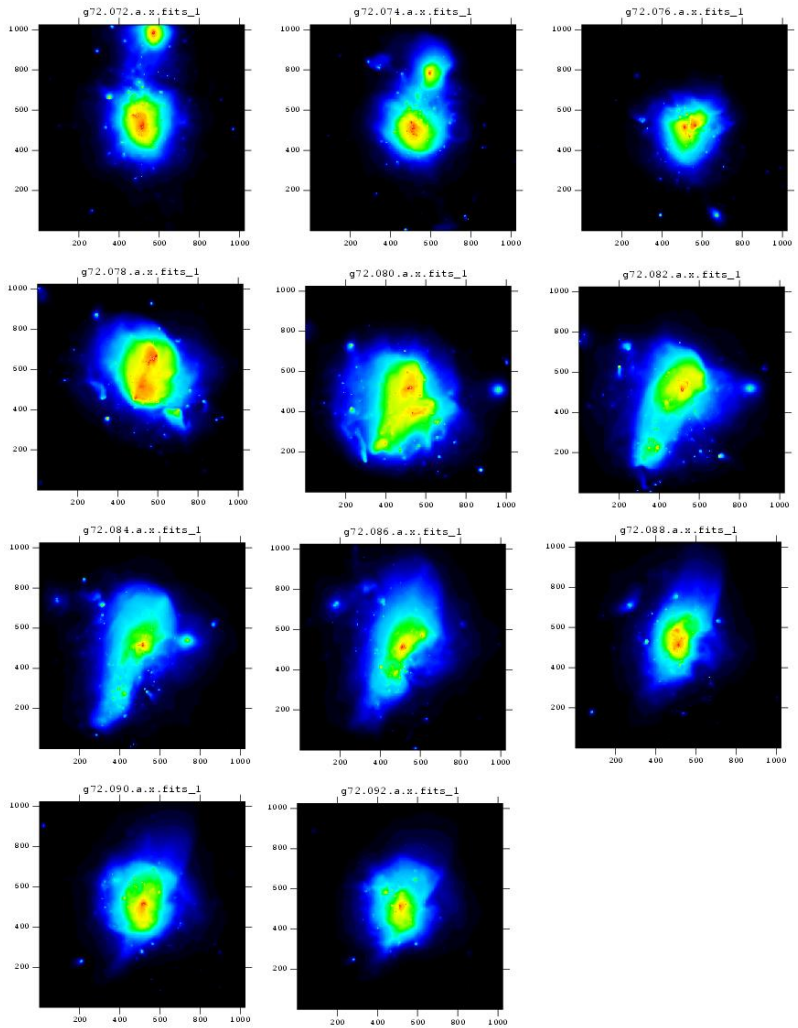
⇒ Even strong winds don't break self-similarity in the halo outskirts (although effective in regulating star formation)

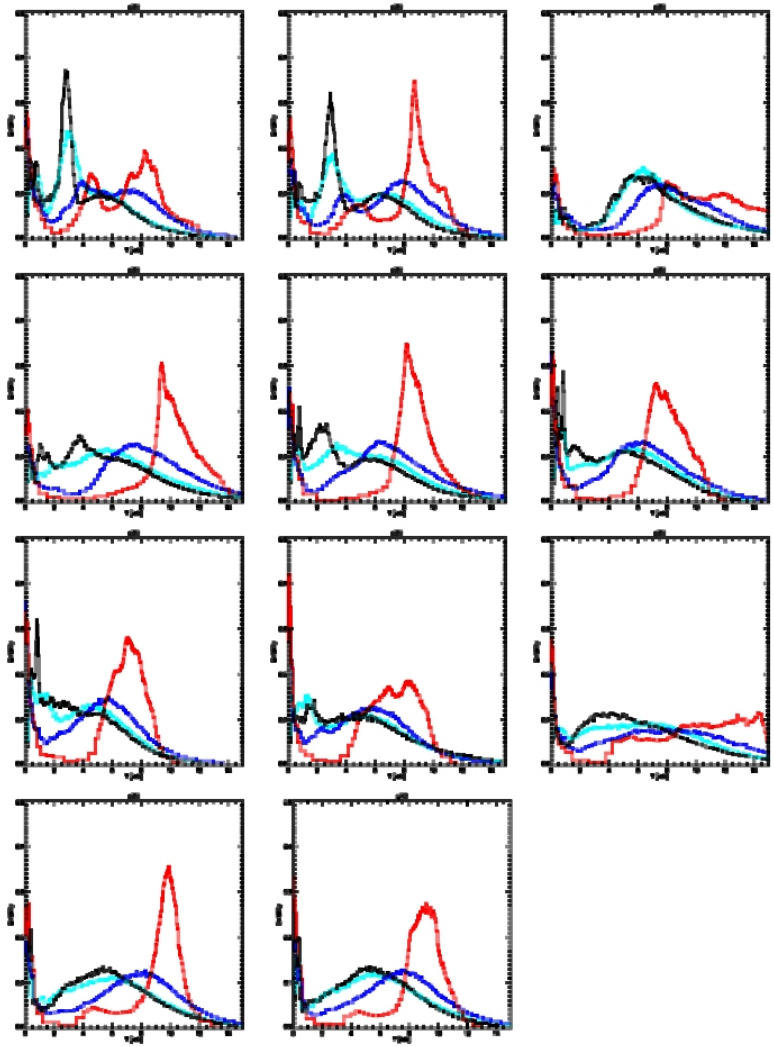
⇒ Entropy amplification requires a quite diffuse feedback heating (i.e. not localized around SF regions).



Beautiful cluster
simulation by Klaus Dolag

Following Details of Processes in Simulations

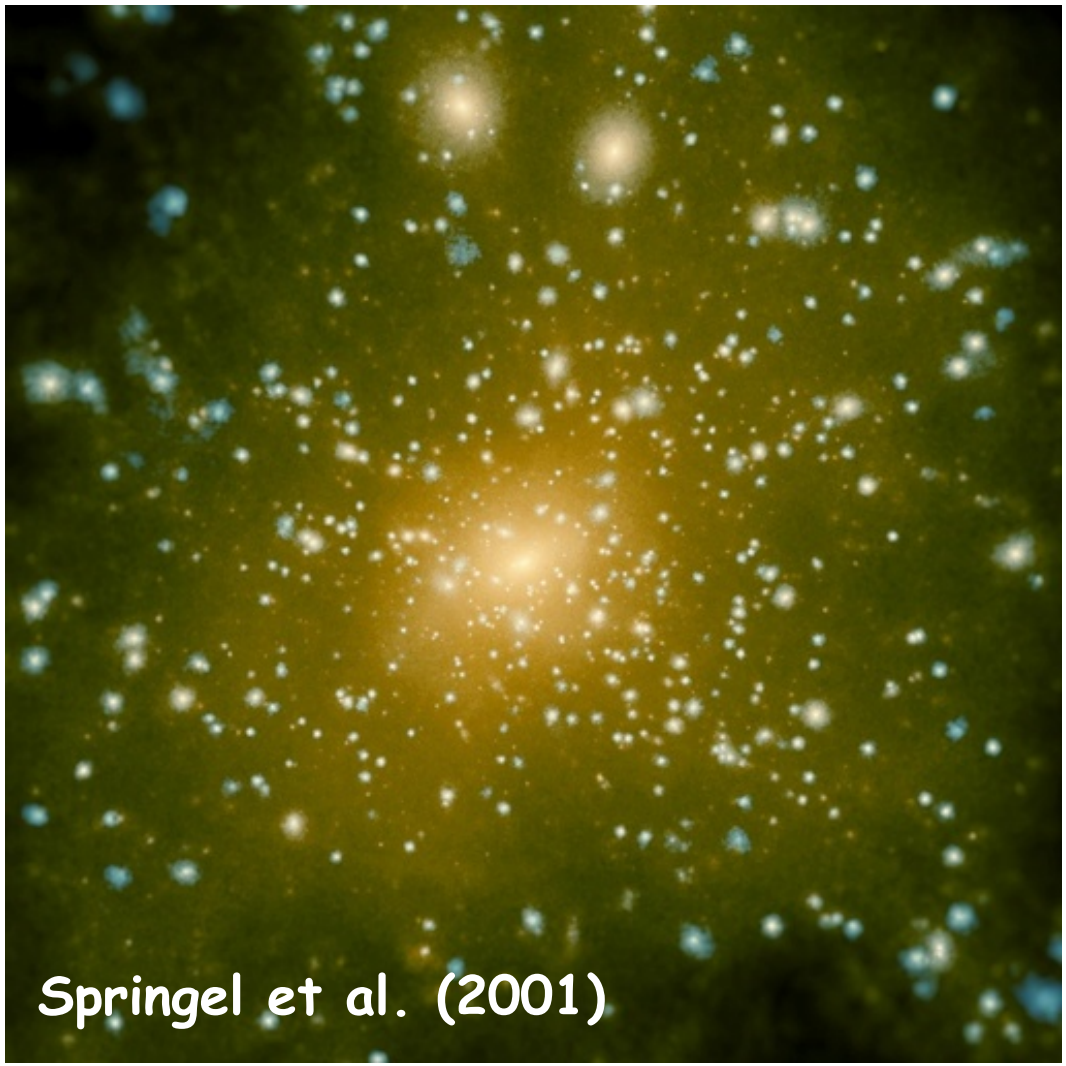


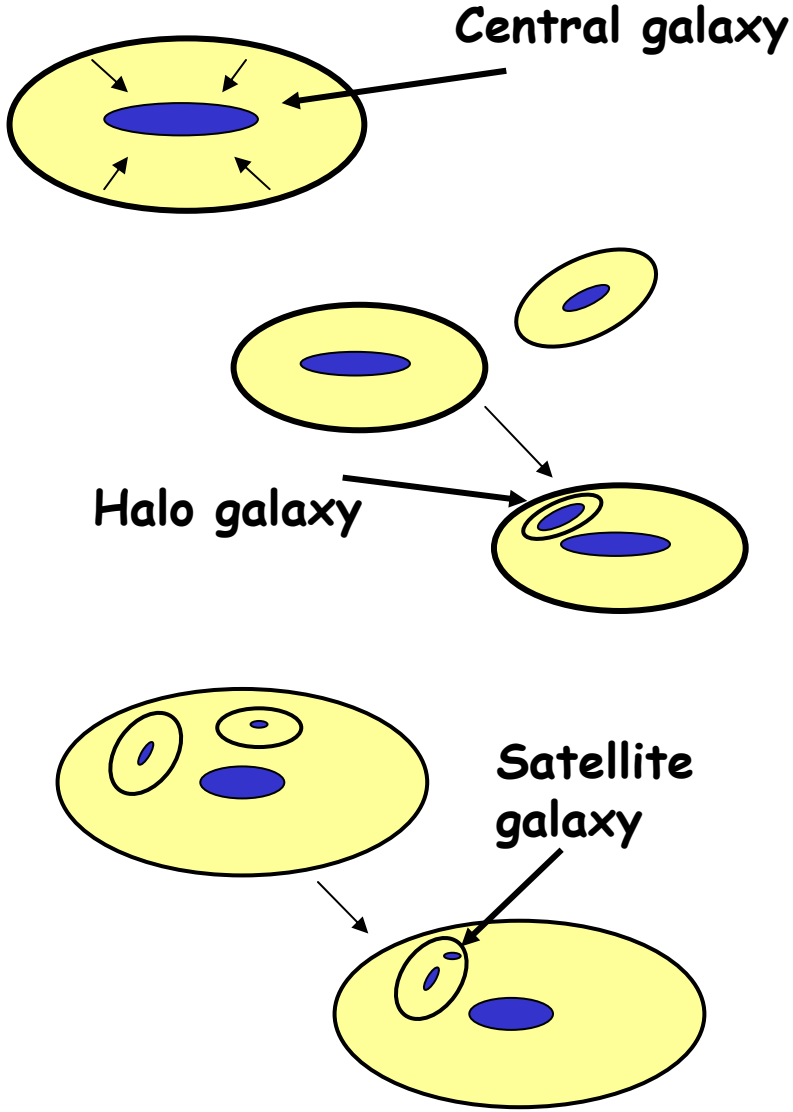


Talk by Klaus Dolag


Conclusion:
Theory is close to grasp
the properties of real
clusters !

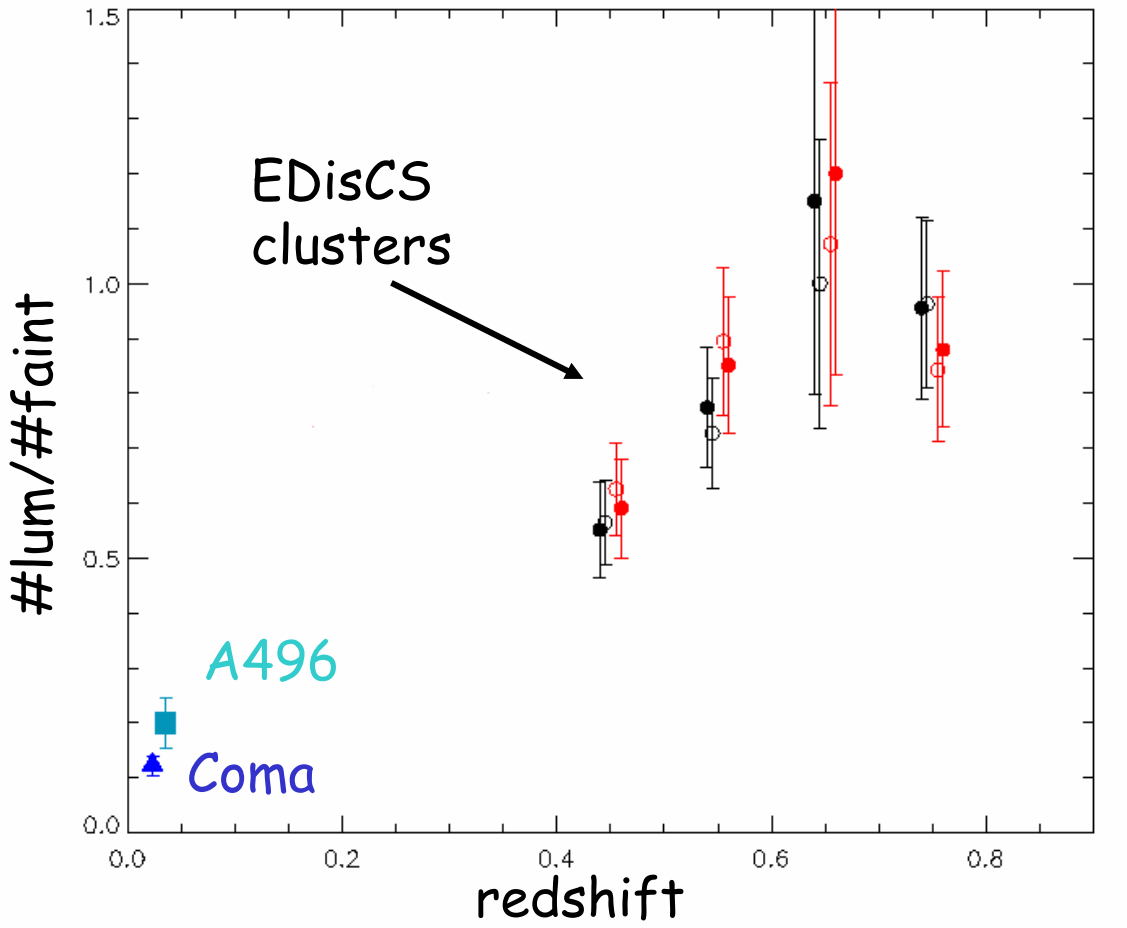
The SAM – the hybrid models:





De Lucia et al., MNRAS, 2004

The build-up of the CM relation



There is a clear increase in the luminous-to-faint ratio with increasing redshift

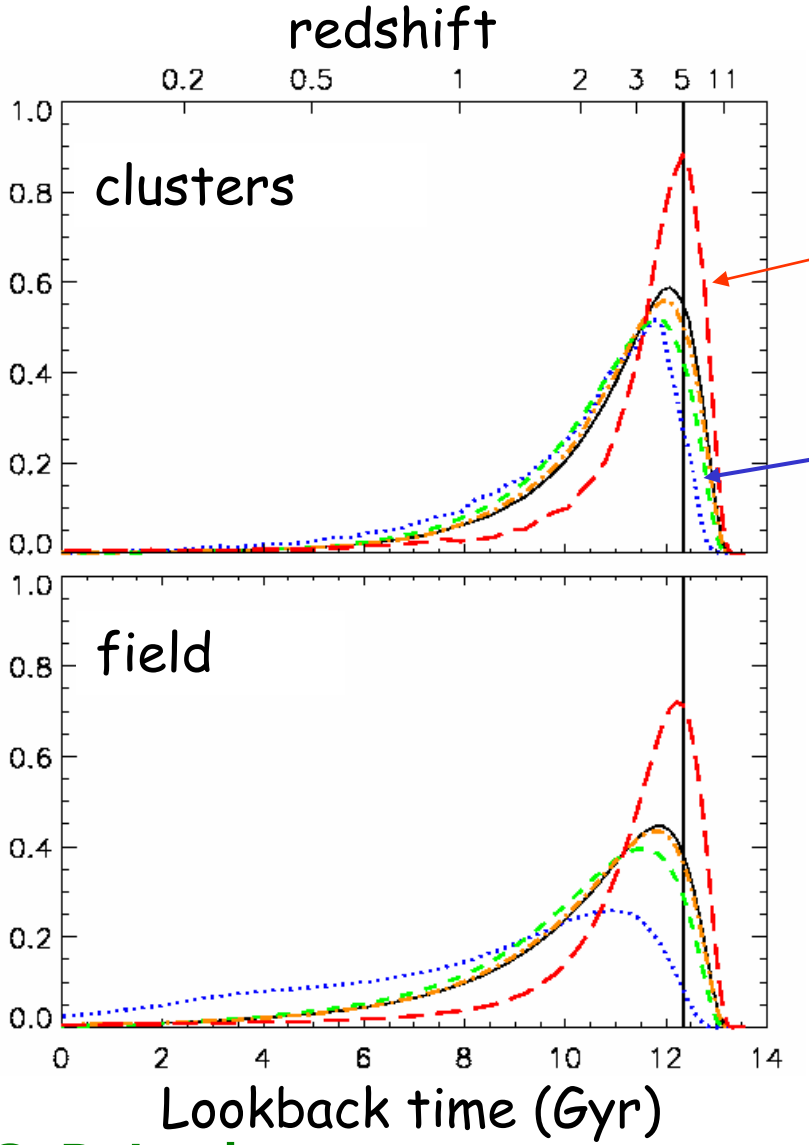
De Lucia et al., in prep.

G. DeLucia

A "cosmic down-sizing" (Cowie, 1996).

A problem for the hierarchical paradigm?

The star formation histories: mass



$M_{star} = 10^{12}\ M_{sun}$

$M_{star} = 10^{9}\ M_{sun}$

Elliptical galaxies also have a shorter formation timescale!

This is "anti-hierarchical"!!!

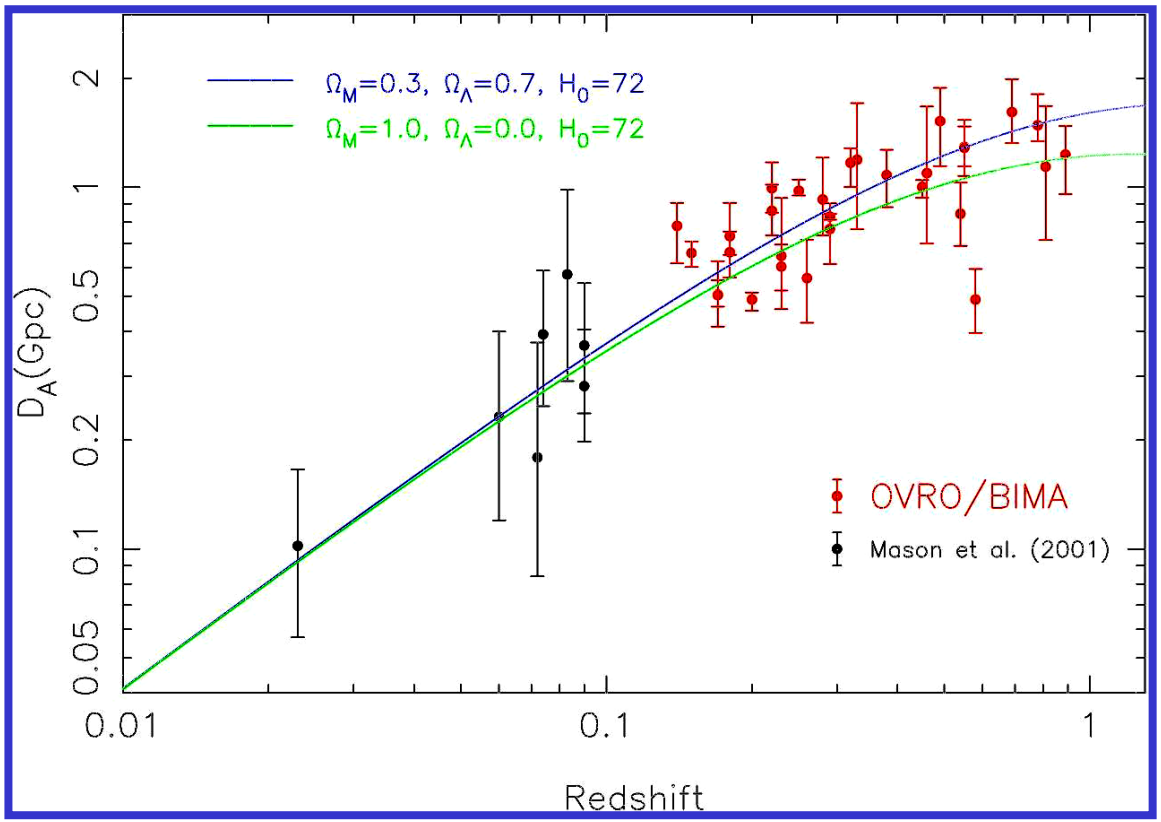
De Lucia et al., astro-ph/0509725

G. DeLucia

Joe Mohr

The SNe Ia Experiment with Clusters?

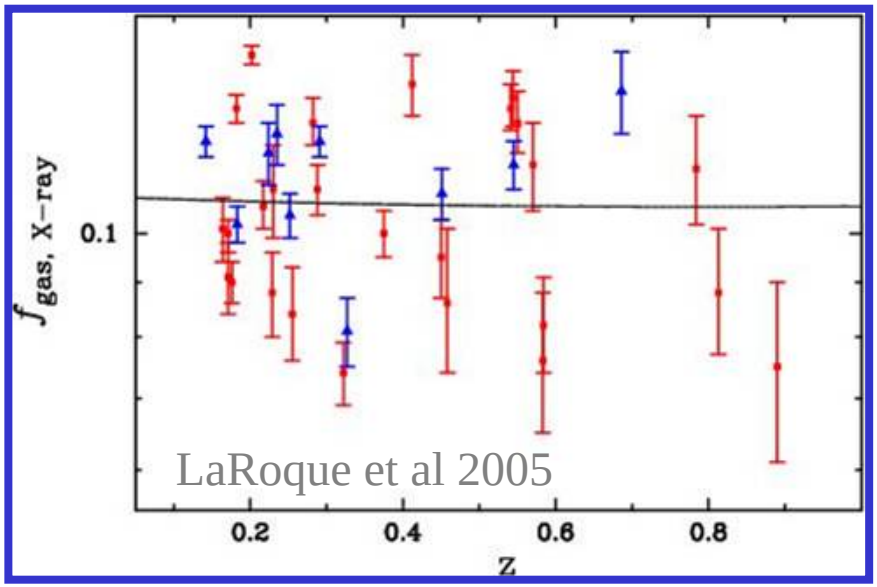
They have recently expanded their sample to 28 and are using Chandra X-ray data to measure distances. In combination with local distance measurements of Mason et al (2001), they can begin to probe the dark energy.

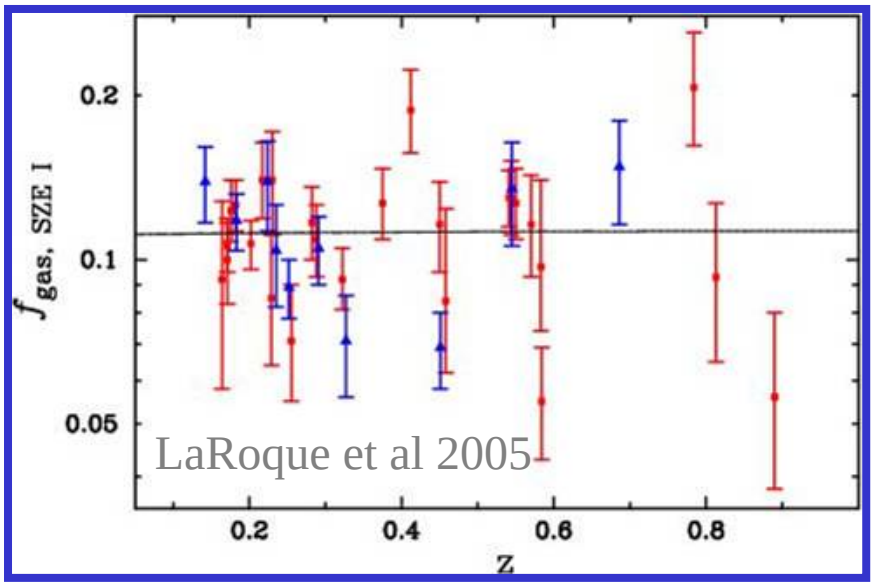


BIMA/OVRO SZE team, 2005

Joe Mohr

Recent Gas Mass Fractions





Gas mass fractions can be used to constrain Ω_m (SZE: Mason et al 2001, Grego et al 2001, Lancaster et al 2005)

Comparison between X-ray and SZE derived gas mass fractions allows one to constrain clumping in the gas.

This sample of 28 shows good agreement- no evidence for clumping

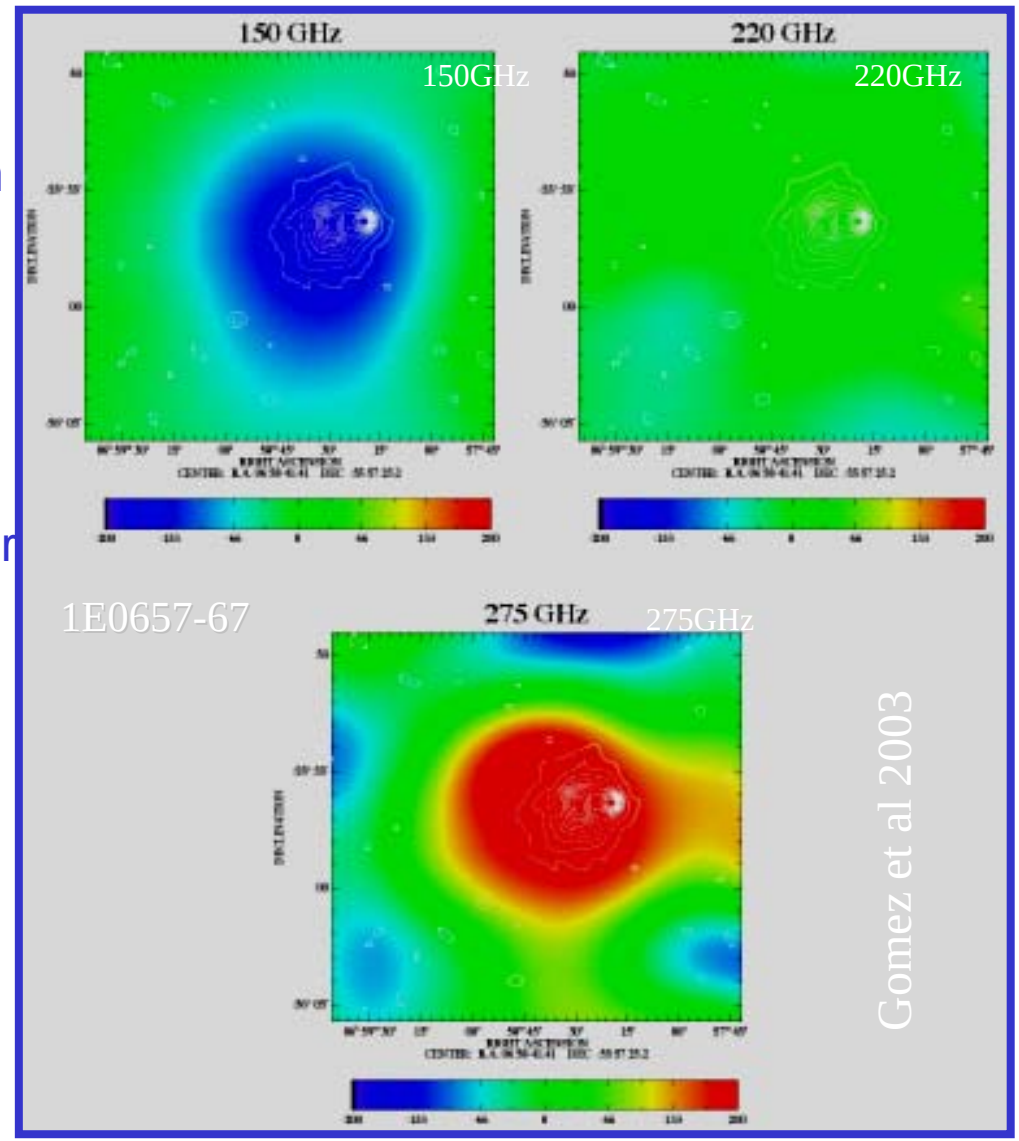
f_g(X-ray) = 0.109±0.003

f_g(SZE) = 0.115±0.005

Joe Mohr

ACBAR Survey

- ACBAR (led by Bill Holzapfel) is a multifrequency, 4 arcminute beam bolometer deployed on the 2.5m Viper telescope at the South Pole
  - Beam scale (similar to Planck high frequency) has made it challenging to separate cluster signal from the primary CMB anisotropy
  - Have targeted known clusters
  - Observations of a new ACBAR deep field are just now ending



Joe Mohr

Gravitational Lensing

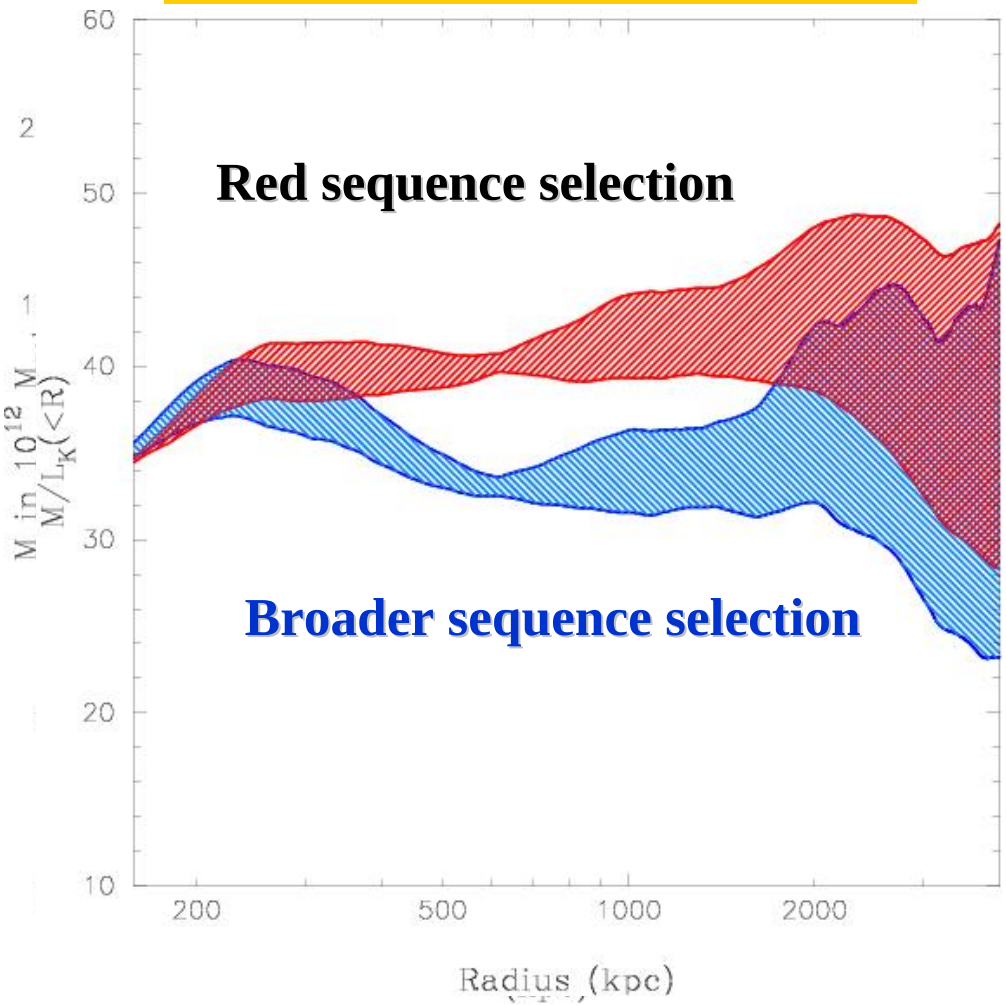
Cl0024: Mass vs. Light

Mass traces Light !!!

- **NFW and Power-Law model fit the strong+weak lensing**
  But high concentration compared to expectations **(similar results on other clusters: A1689 …)**

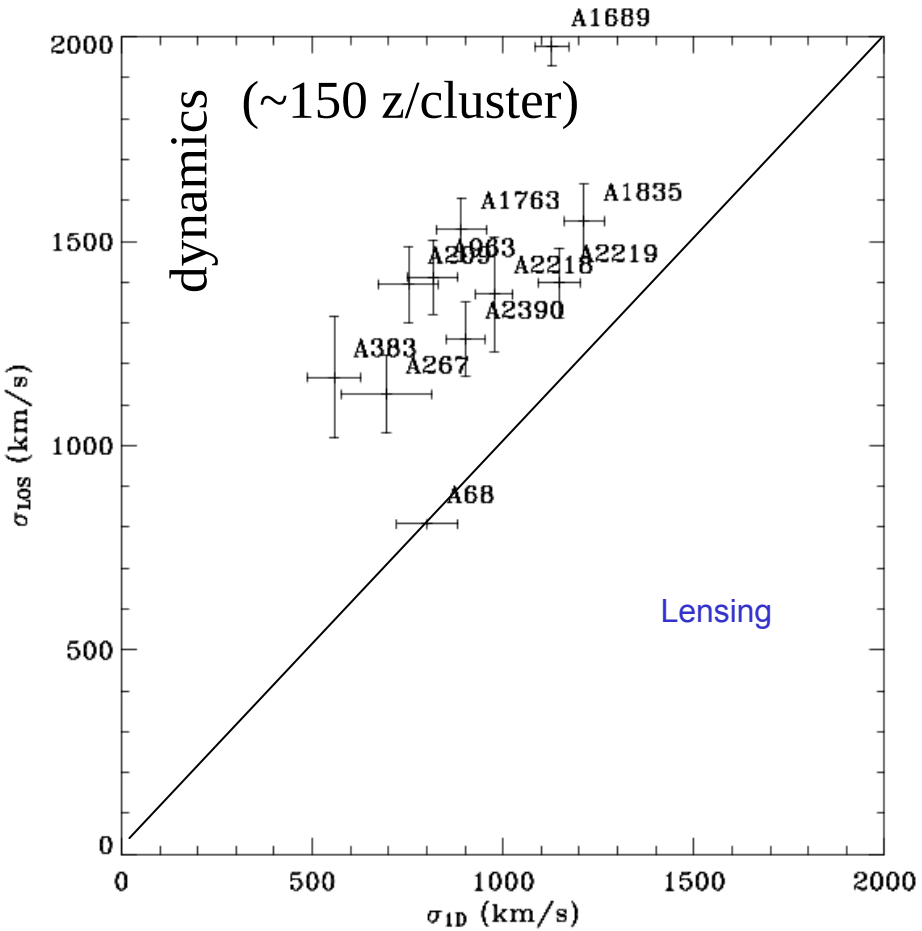
- **SIS does not fit the strong+weak lensing**

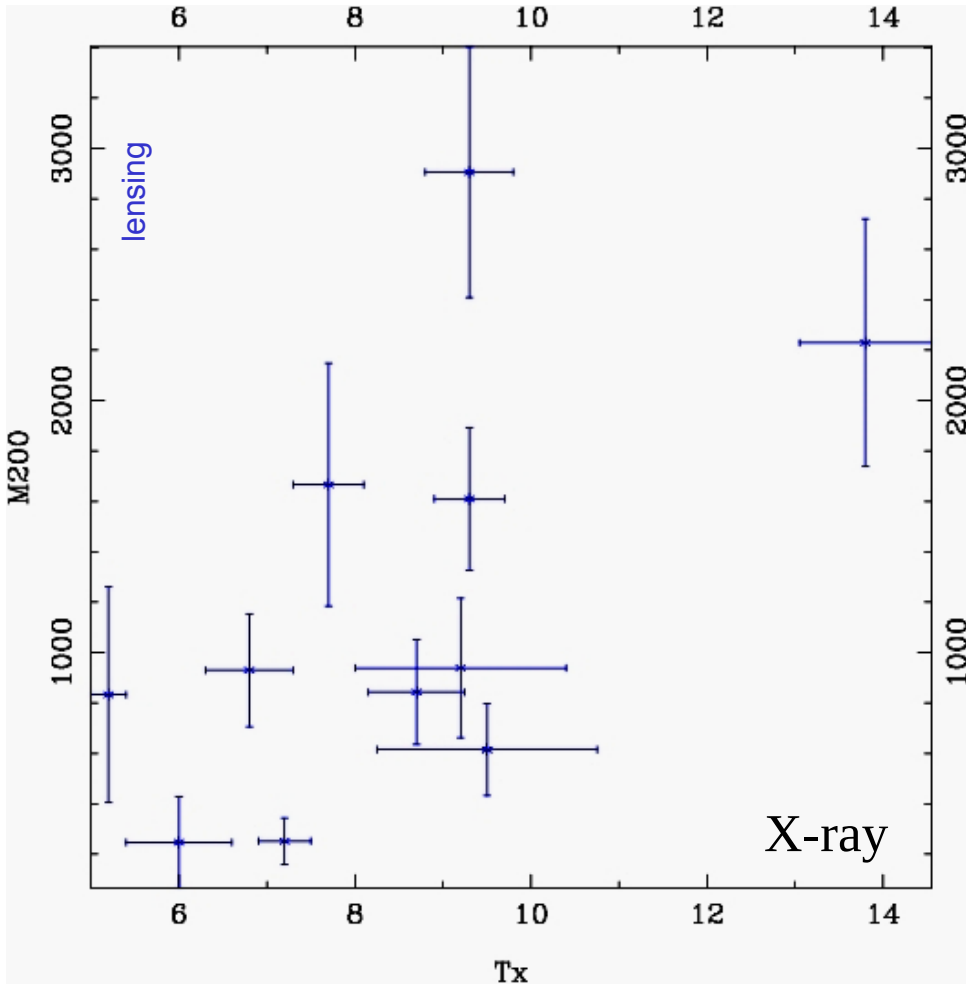
- **M/L is constant with radius with M/L_K~40**



Kneib et al 2003

weak lensing scatter plots – correlation with velocity dispersion and X-ray temperature

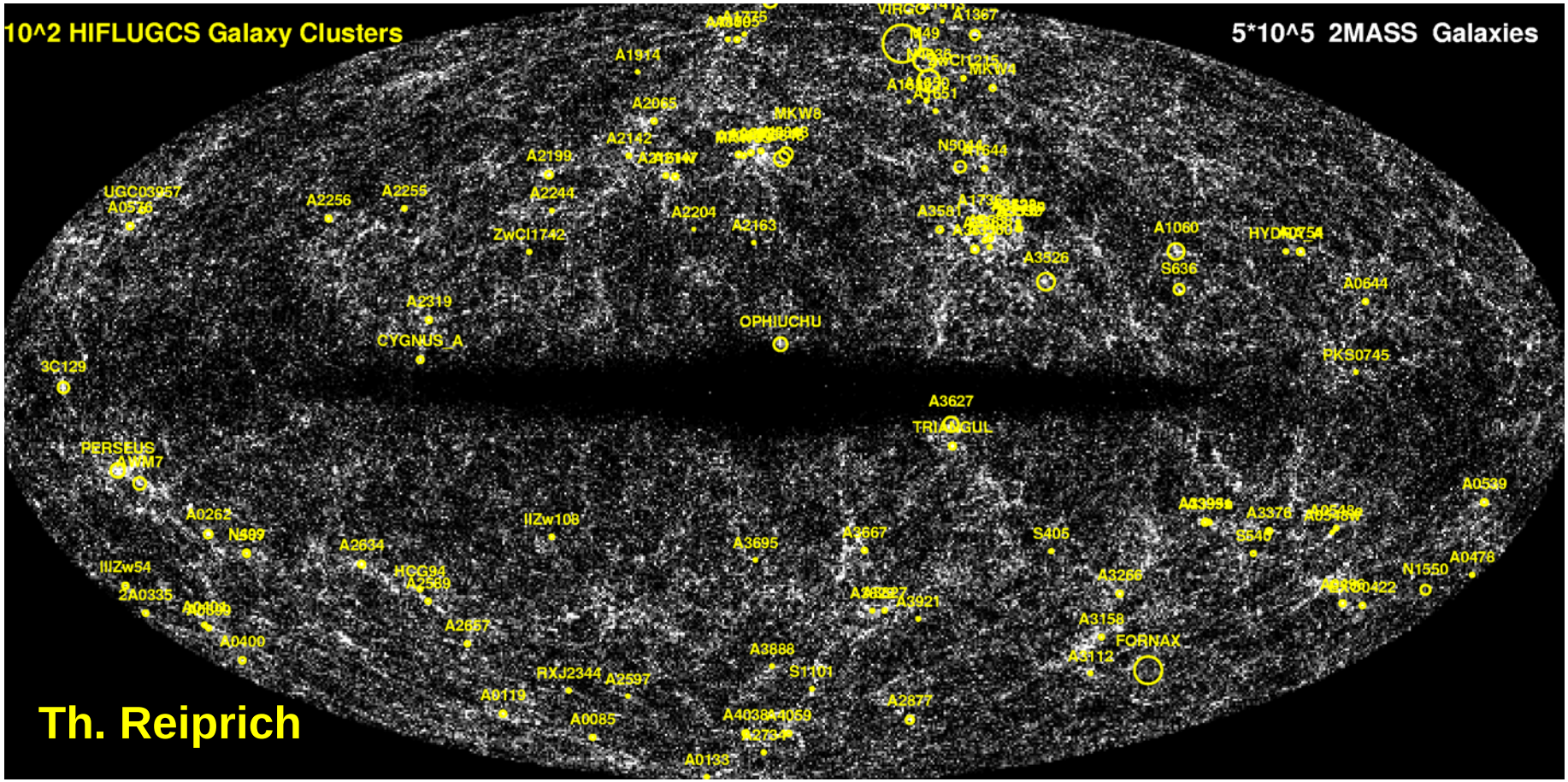




Jean-Paul Kneib

Local Sample: *HIFLUGCS*

- ~60 X-ray brightest clusters in sky (Reiprich & Böhringer 2002),
- ~completely covered with *both* Chandra (Hudson et al., in prep) and XMM-Newton (Nenestyan et al., in prep.).



Th. Reiprich

Red Sequence Cluster Survey

Talks by: Howard Yee, David Gilbank, Erica Ellingson, Shuba Majumdar, Chris Blindert

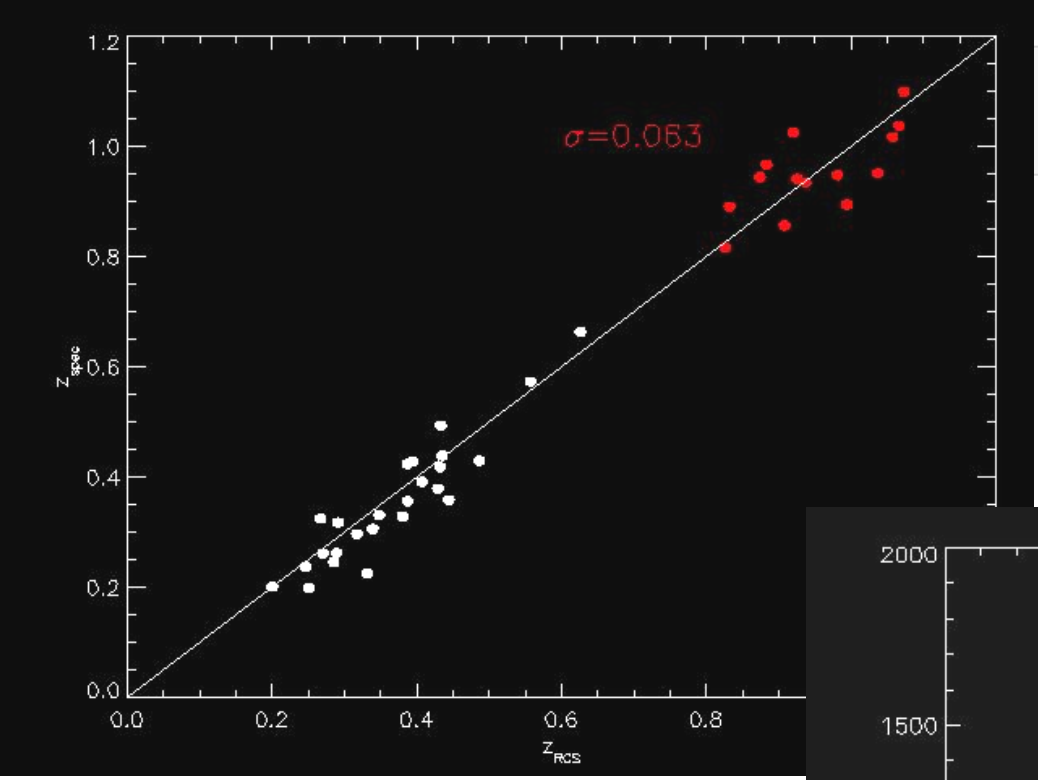
RCS 1: 90 deg2 30 telescope nights

Future: RCS 2 1000 deg2 CFHT MegaCam finished 2007

Other upcoming surveys:

DES, UKIDSS (+KIDS), PanStar, +

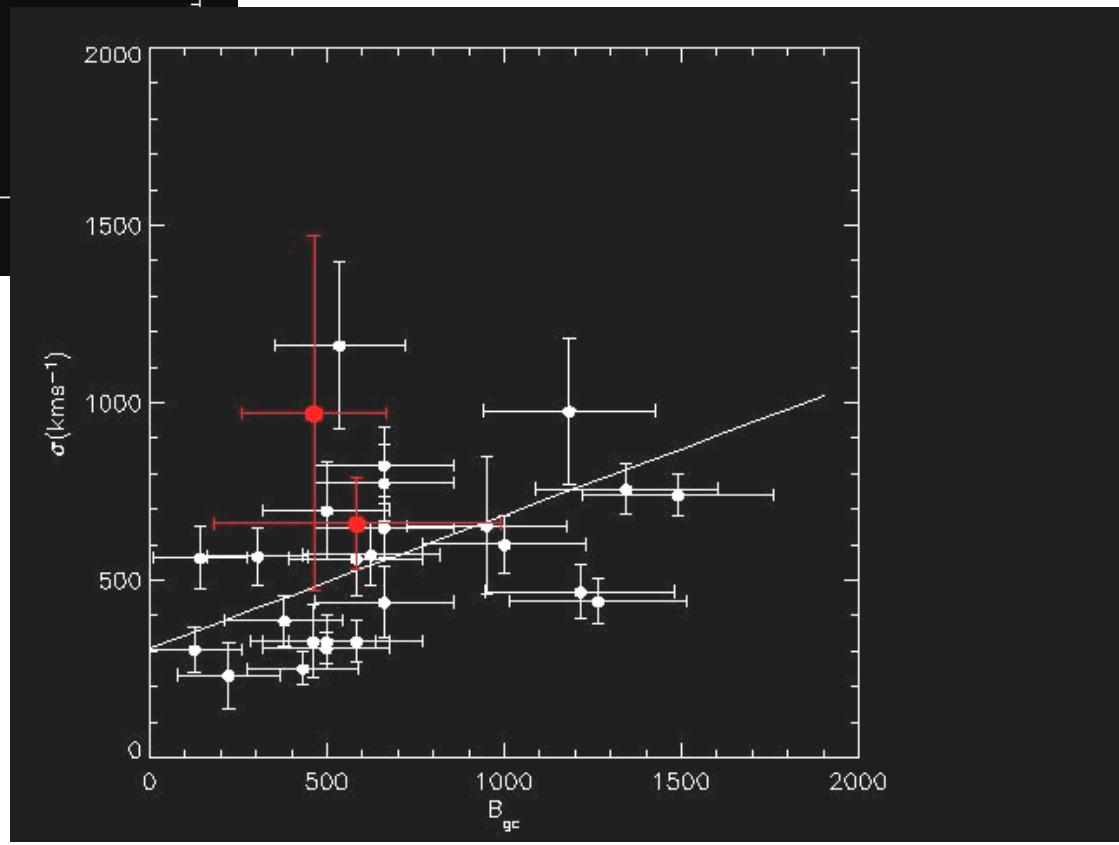
RCS



Good redshift prediction

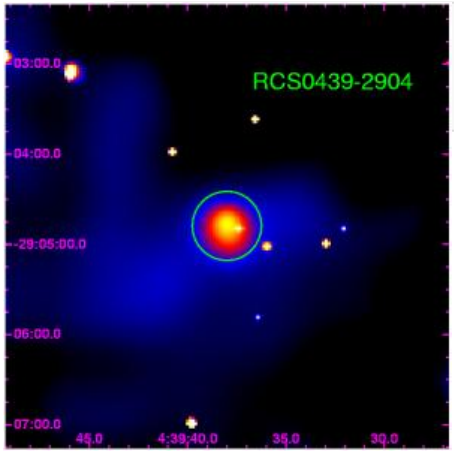
σ_z = 0.063 !!!

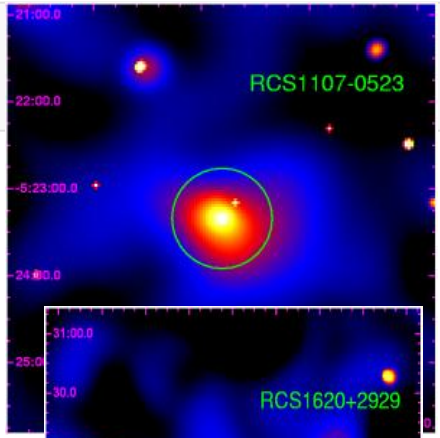
Correlation of velocity dispersion with optical richness

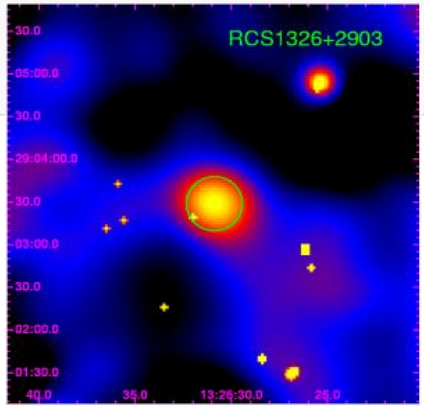


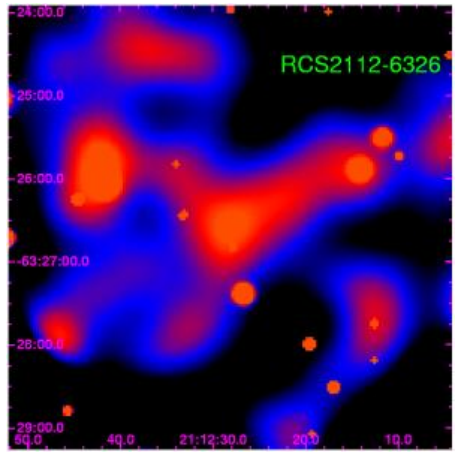
David Gilbank

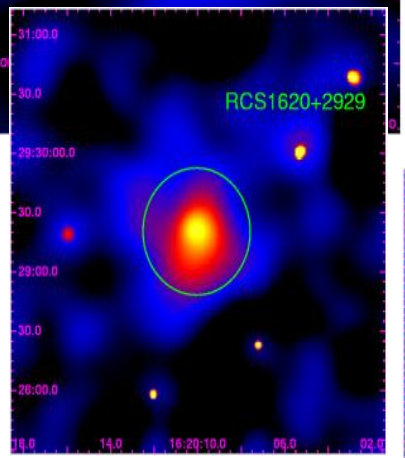
RCS in X-rays

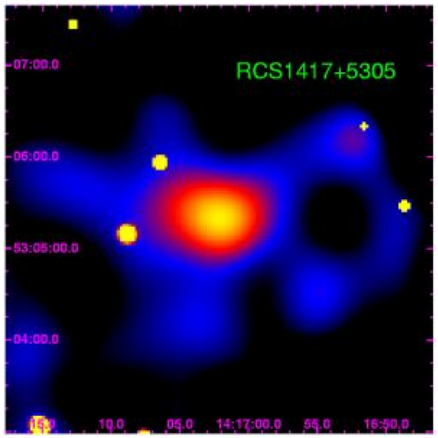


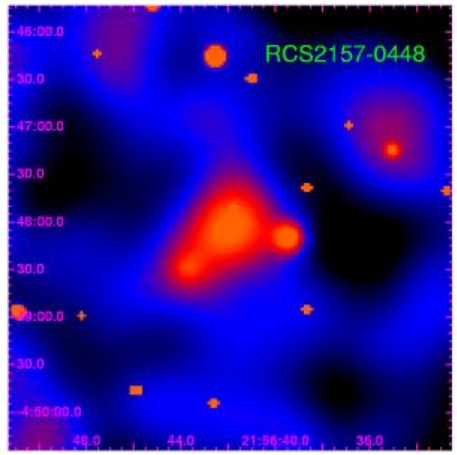












z=1.0

Erica Ellingson

8 out of 9 detected with > 5σ
(2112-6326 at zph=1.1 is 2-3σ)
3 additional cluster detections on the way
(final data arrived this week)

RCS: Lx-Bgc

correlation of X-ray luminosity and optical richness

RCS clusters are under-luminous for their optical richness

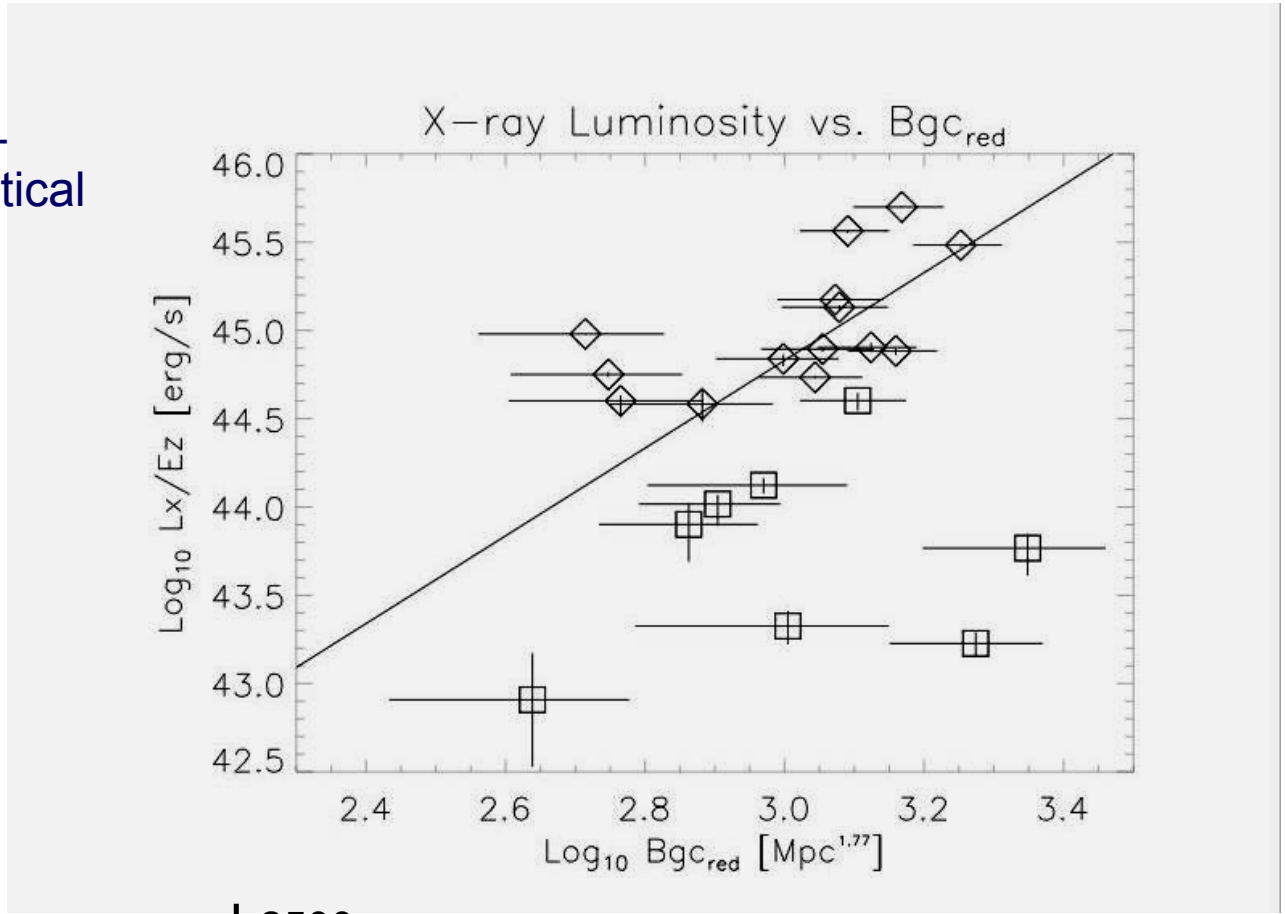
See also:

Donahue et al. 99,

Gilbank, 2004

Lubin et al., 2004

…



L_{2500}

CNOC, CF corrected : diamonds

RCS: squares

Erica Ellingson

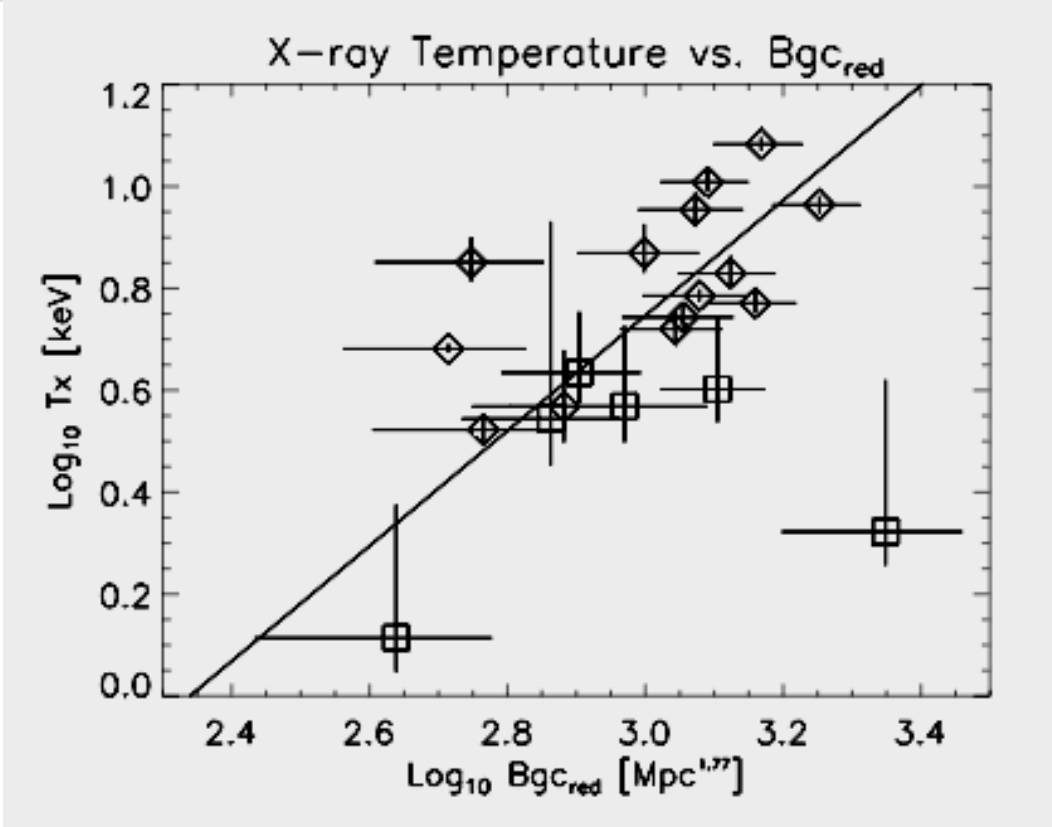
RCS: Tx-Bgc

Correlation of X-ray temperature with optical richness

Temperatures show general agreement with lower-z X-ray samples

Slightly systematically lower temperature for their optical richnesses

Outlier: superposition of groups in small z range (e.g., Gilbank's talk, also Gonzales' supergroup?): predicted to be ~5% of RCS?



Diamonds= CNOC
Squares = 6 RCS clusters with enough signal to measure Tx

Erica Ellingson

Lx-Tx

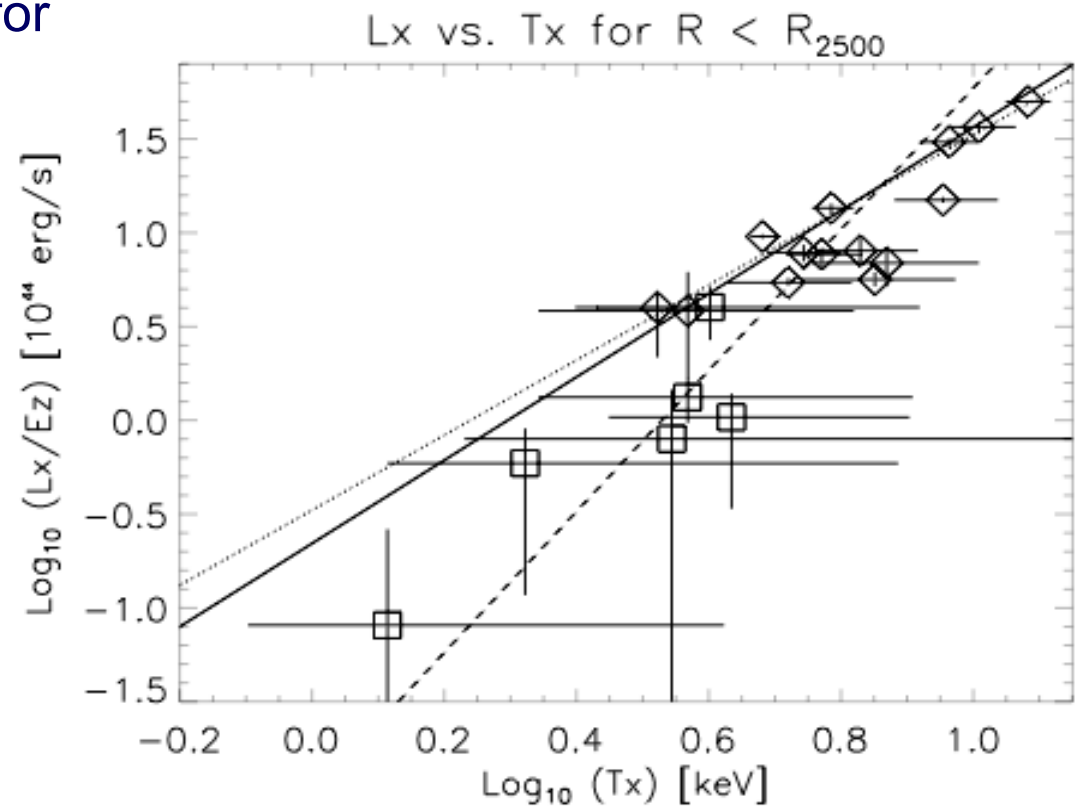
RCS: clusters underluminous for expected Tx? Large uncertainties…

Solid: slope=2.2

Dotted = 2.0

Dashed= best fit slope 4+/- 2

See also Lubin, et al., 2004

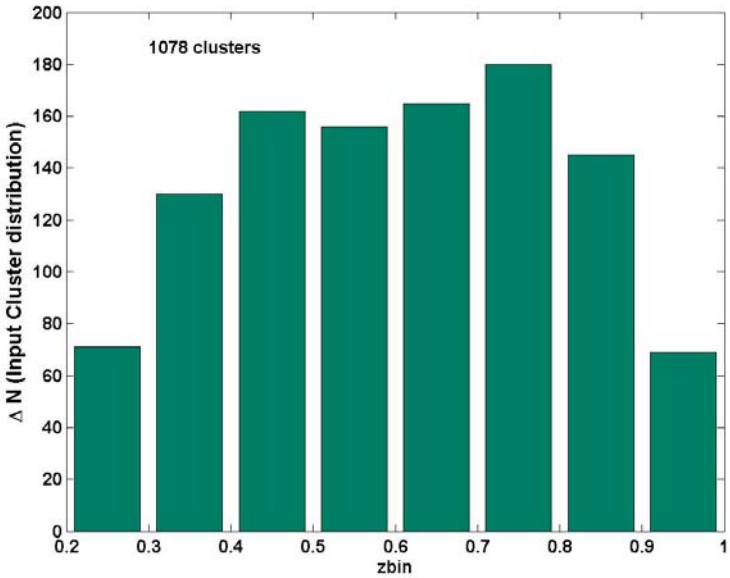


CNOC: diamonds

RCS: squares

Erica Ellingson

Doing cosmology AND cluster physics with actual data: RCS1



RCS1: the survey

76 deg^2, B_{gc} > 300, σ-detection > 3.3

ΔB_{gc} < 0.5, z= 0.2 – 1, ~1100 clusters

Completeness fraction corrected from simulated catalogs + Yeong Loh's estimate of evolution of blue fraction with redshift.

RCS: the results

Ω_M = 0.34 +/- 0.064
(0.29 +/- 0.07)

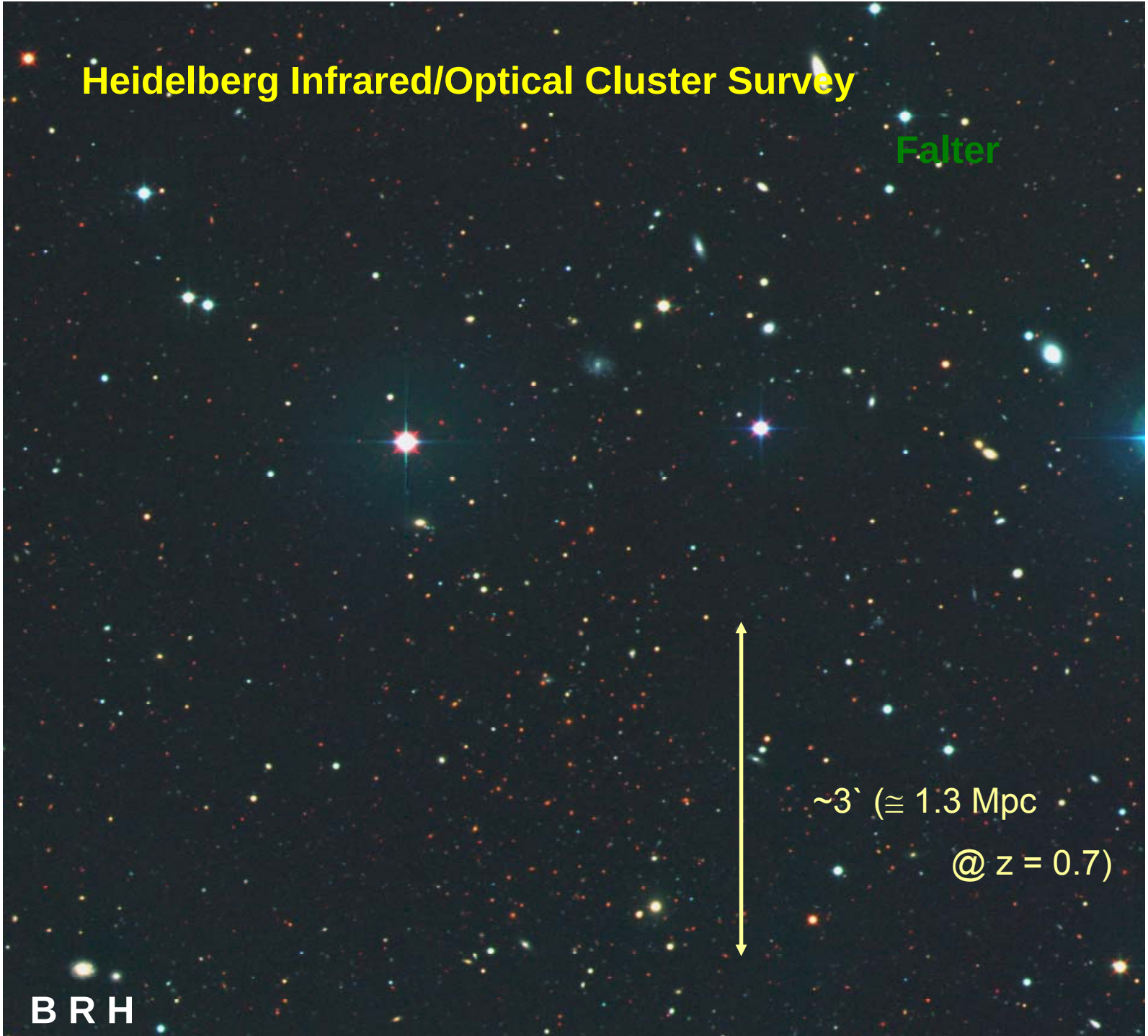
σ_8 = 1.05 +/- 0.14
(0.9 +/- 0.1)

log(A_{Bgc}) = 10.95 +/- 0.78
(z=0.3) (10.05 +/- 0.89)

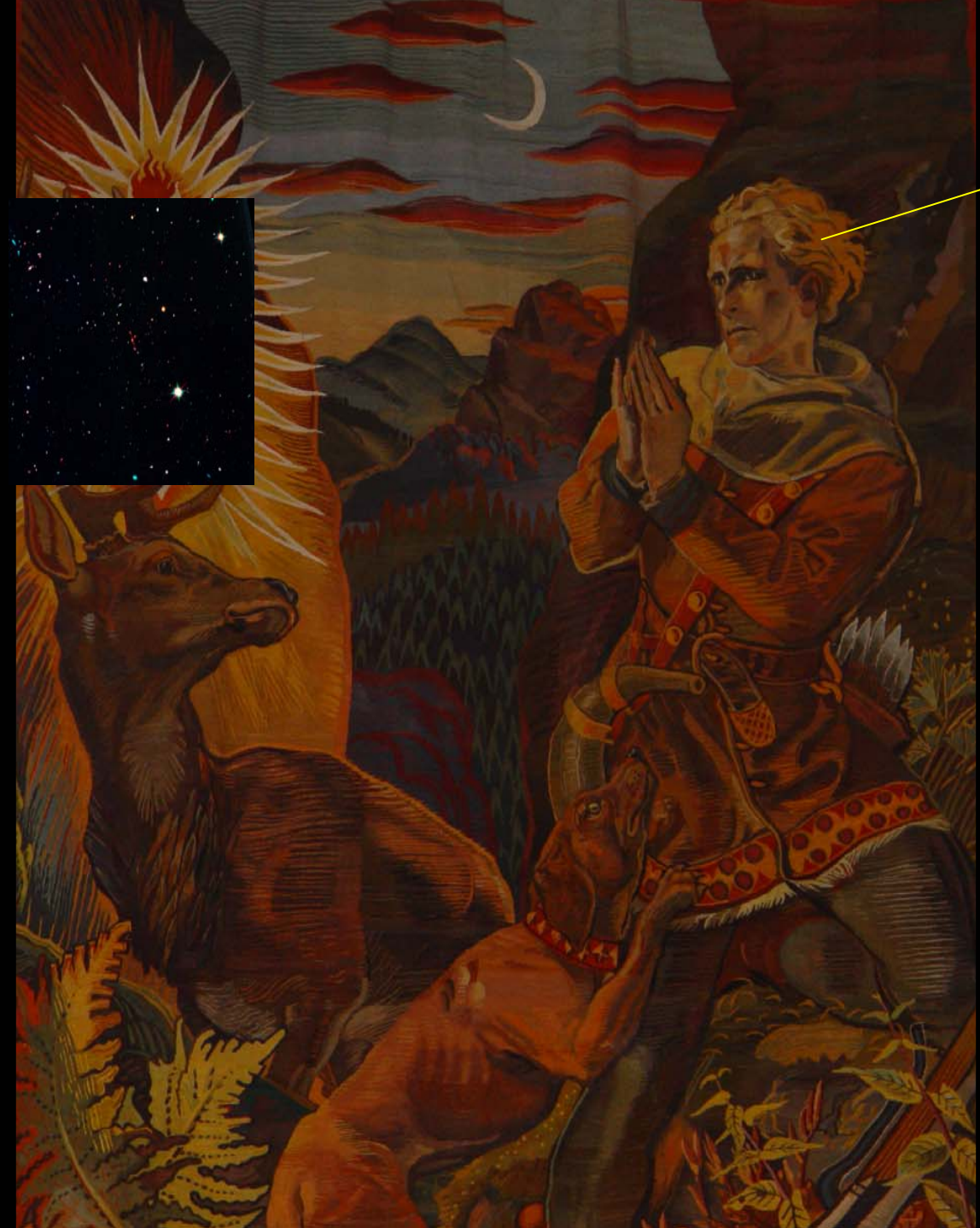
α = 1.64 +/- 0.28
(1.58 +/- 0.27)

γ = 0.28 +/- 0.35
(-0.5 +/- 0.5)

Changing redshift dependent completeness does not change cosmology much which is a big endorsement of the self-calibration technique!


Heidelberg Infrared/Optical Cluster Survey
Falter
~3` (≅ 1.3 Mpc
@ z = 0.7)
B R H

Distant Cluster Hunting



Redshift
1.39 !!!!

VLT 8m

R 1140s

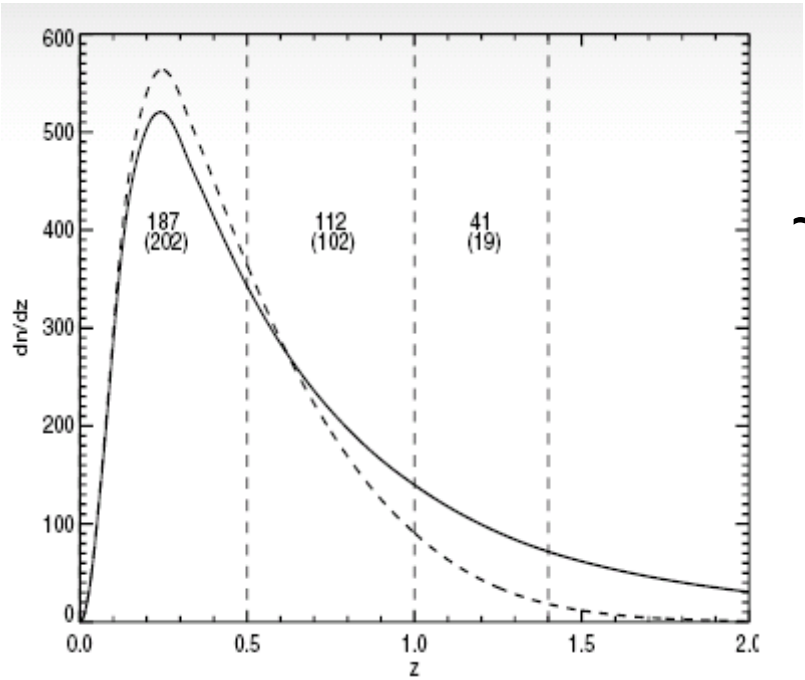
Z 480s

Ks 3600s

2.5’ x 2.5’

1.3 x 1.3 Mpc^2

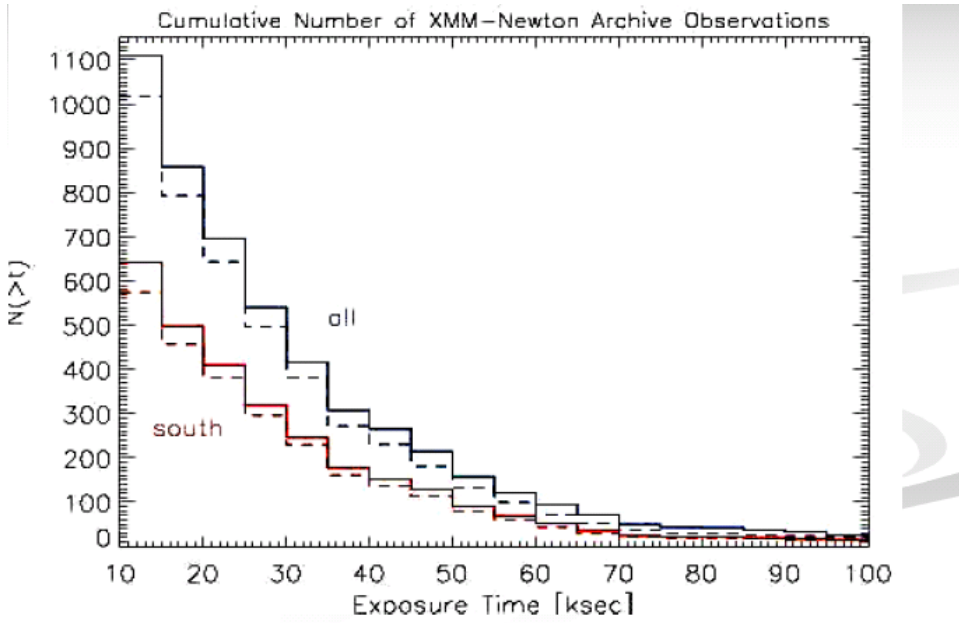
Prospects for the XDCP



X-ray Distant Cluster Project

~ 1 cluster /deg² @ z >1

Over 100 deg² in about two years

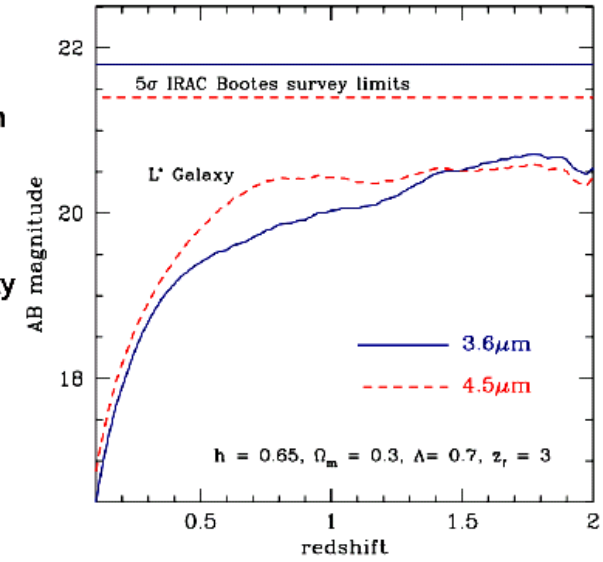


Rene Fassbender

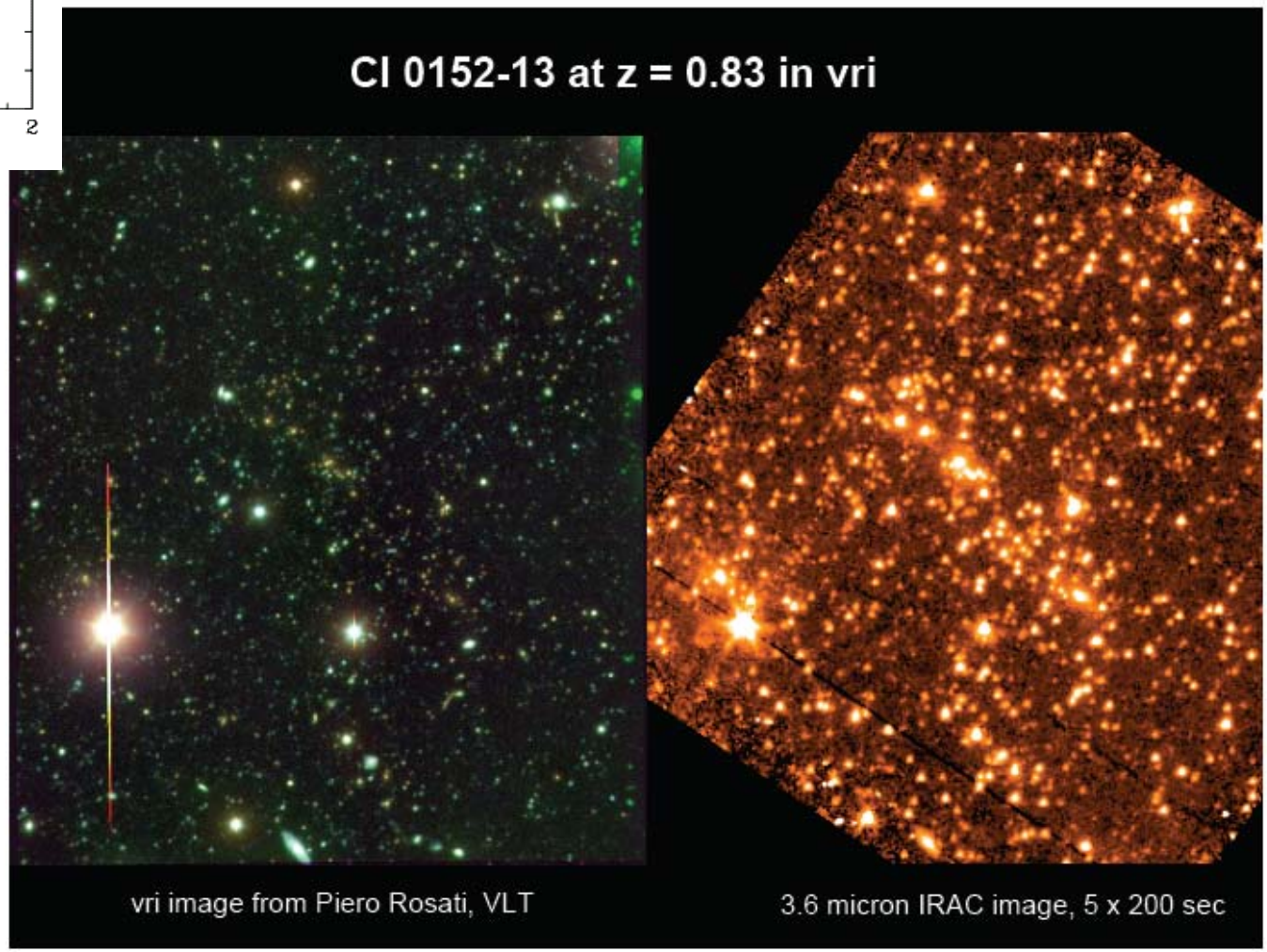
Georg Lamer


More distant cluster are found .....
z = 1.11
z = 1.24
z = 1.37
z = 1.45
z = 1.41

Spitzer/IRAC Shallow Survey



Distant clusters feature very prominently in the IRAC MID-IR-Bands

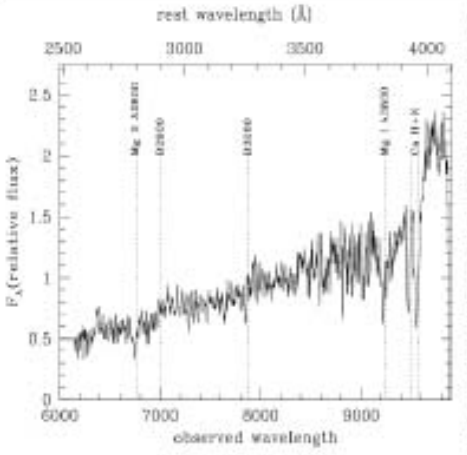


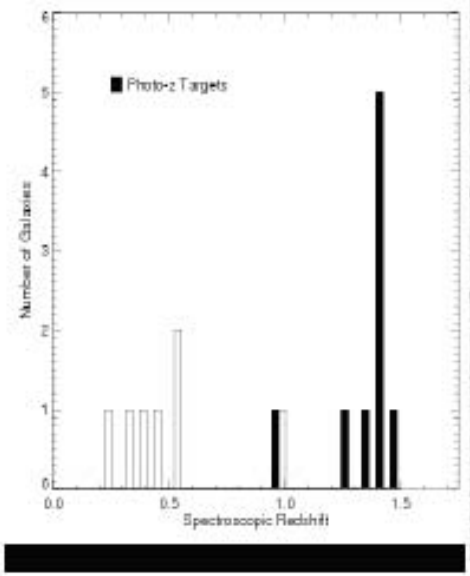
P. Eisenhardt

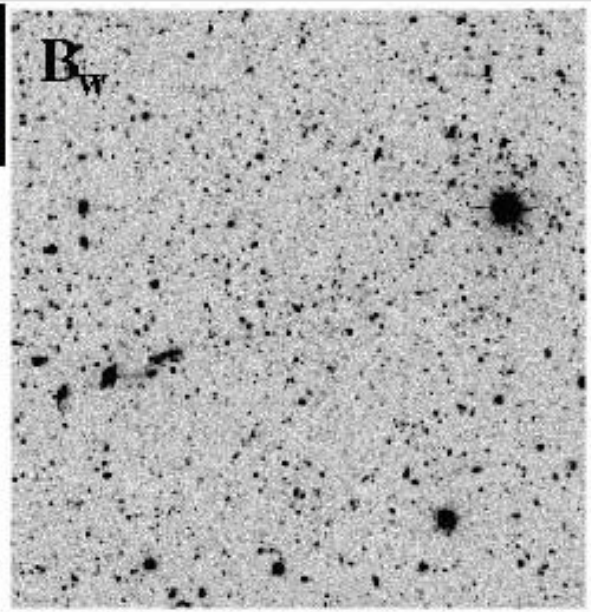
Z = 1.41 Cluster P. Eisenhardt

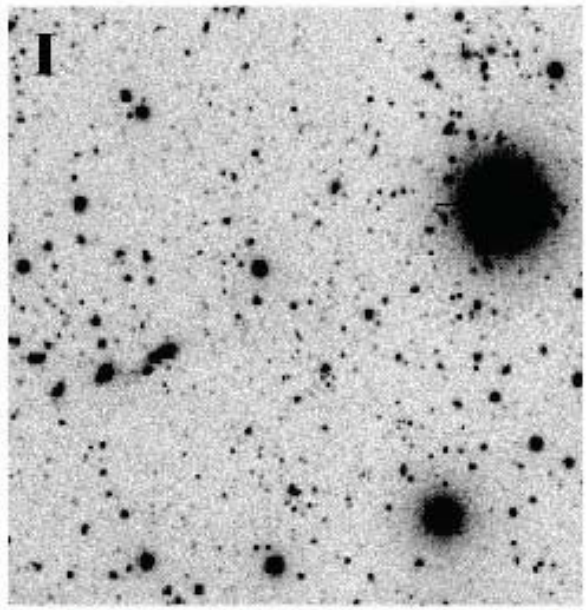
most distant conformed SPITZER detected cluster

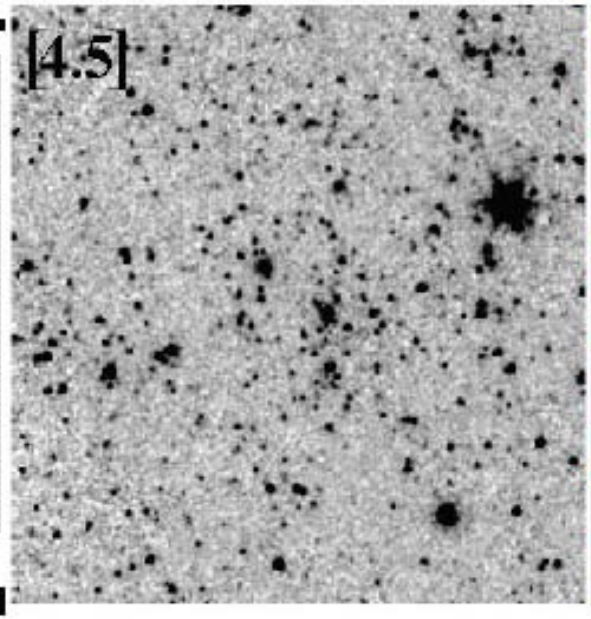
<z> = 1.41
Stanford et al. 2006,
ApJ Lett, astro-ph 0510655

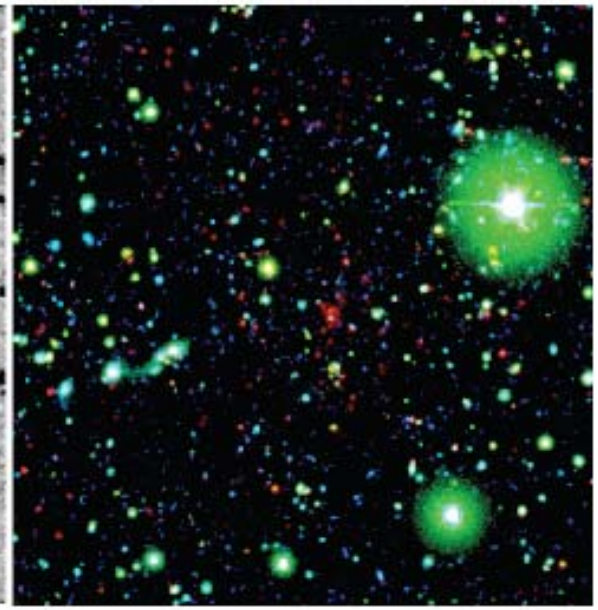




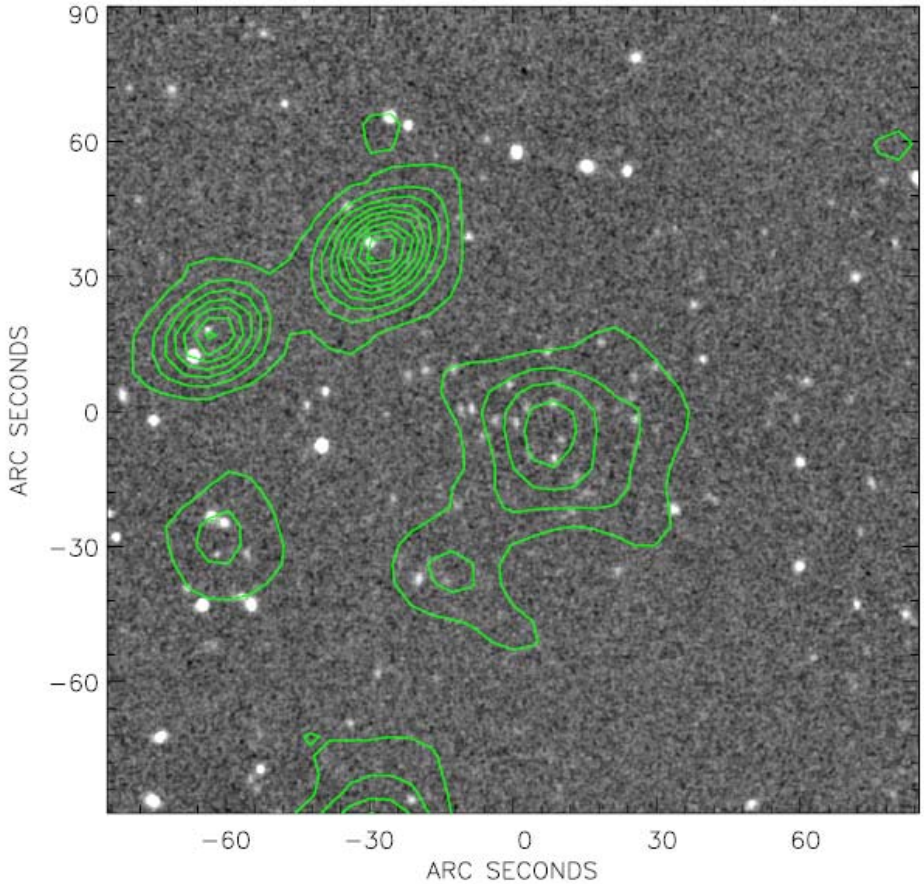




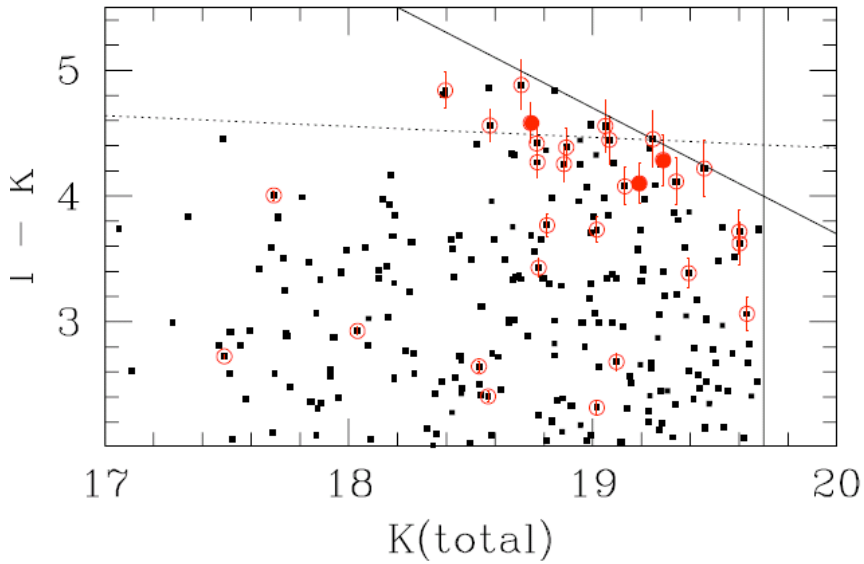




New XCS Cluster at z=1.45



Color-mag diagram is reasonable



X-ray information:

- 287 counts in 0.5-2.0 keV band in r=30" aperture (255 kpc)
- kT = 4.1 +/- 1.1 keV
- L(0.5-2.0) = 1.7 x 10^{44} ergs/s

Adam Stanford

Spitzer SWIRE Survey

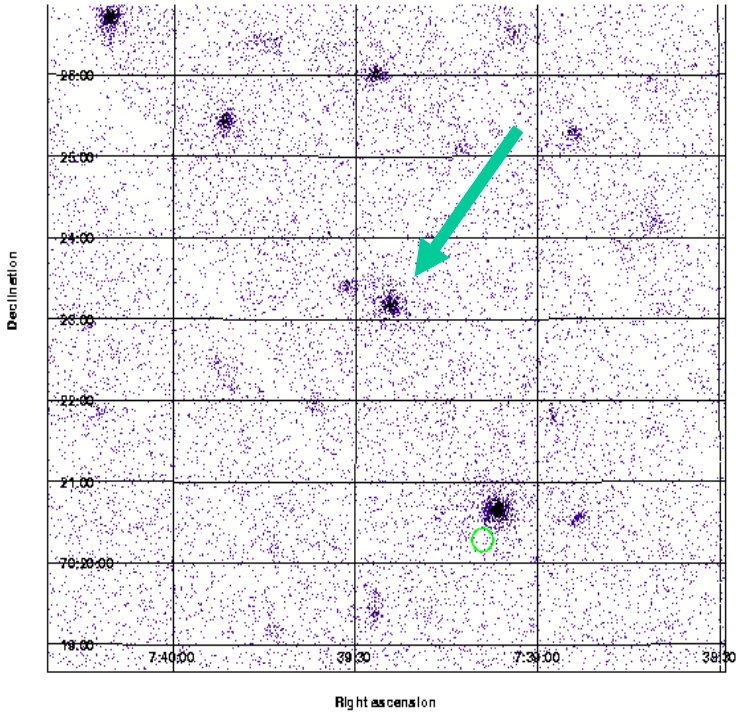
Talk by Muzzin:

Clusters with red-sequence redshifts up to $z \sim 1.75$!!!

Red-sequence also exists in LB protoclusters @ z~2.3 (Steidel)

Distant galaxy clusters detected around radio galaxies

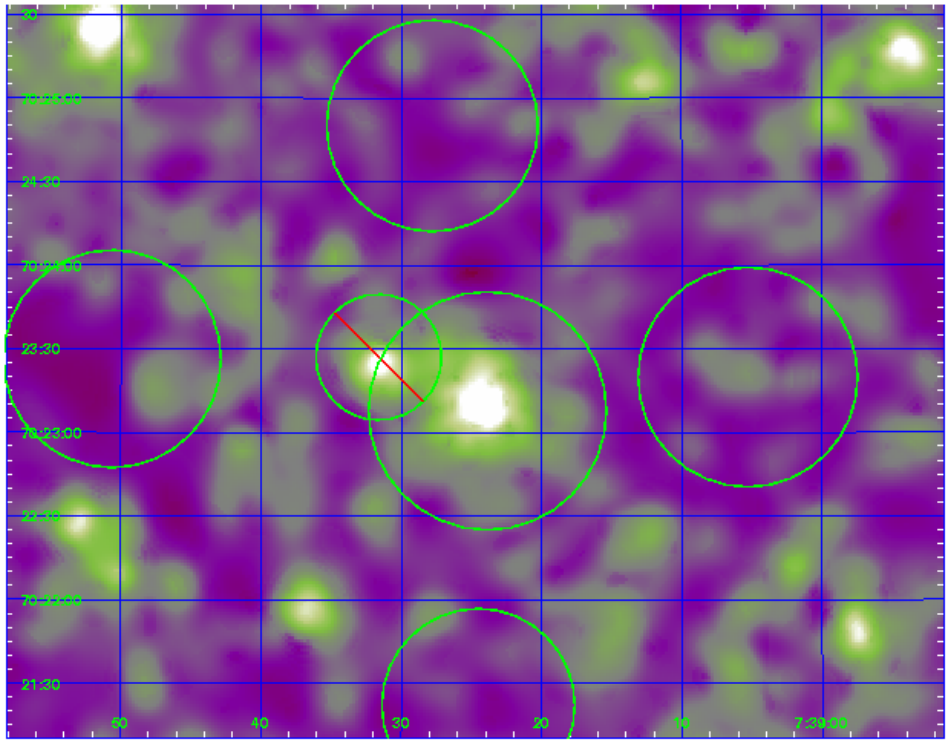
3C184 z:0.994



XMM/EPIC image

54 ks (MOS)

16 ks (pn)

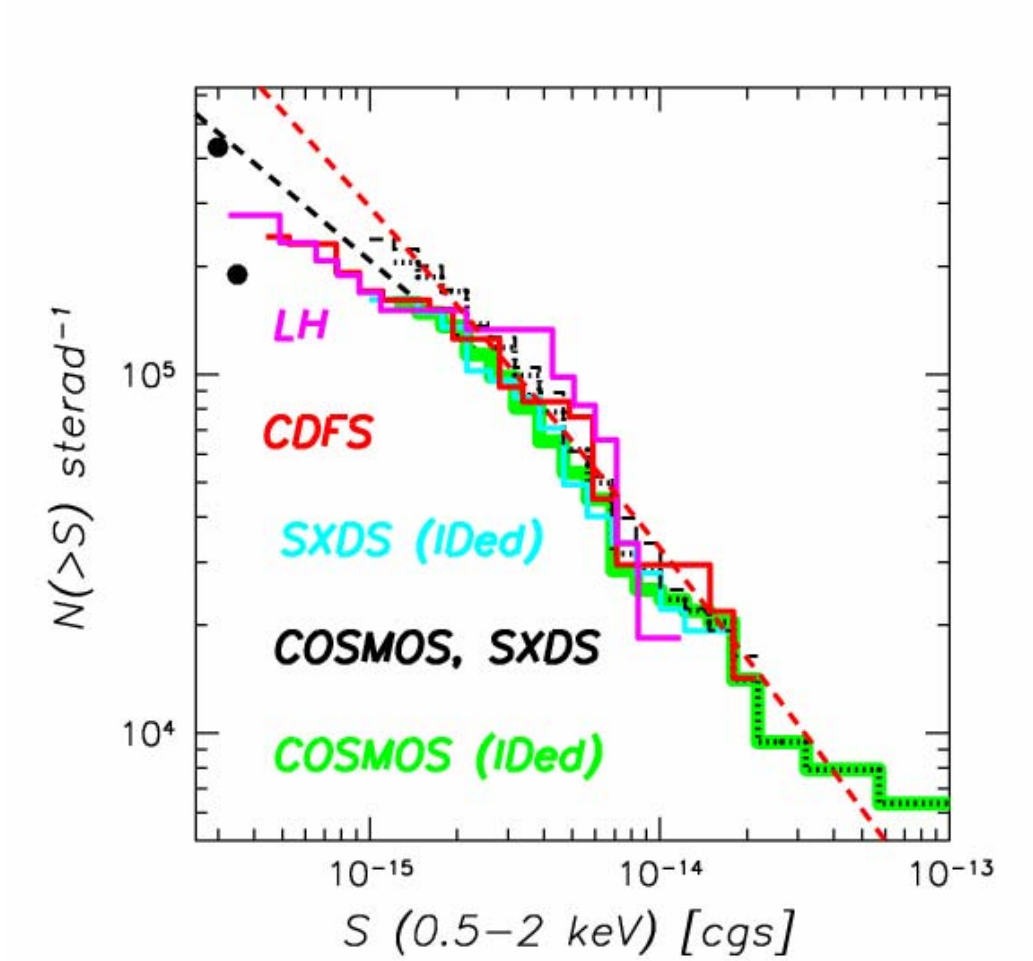


Belsole et al. 2004

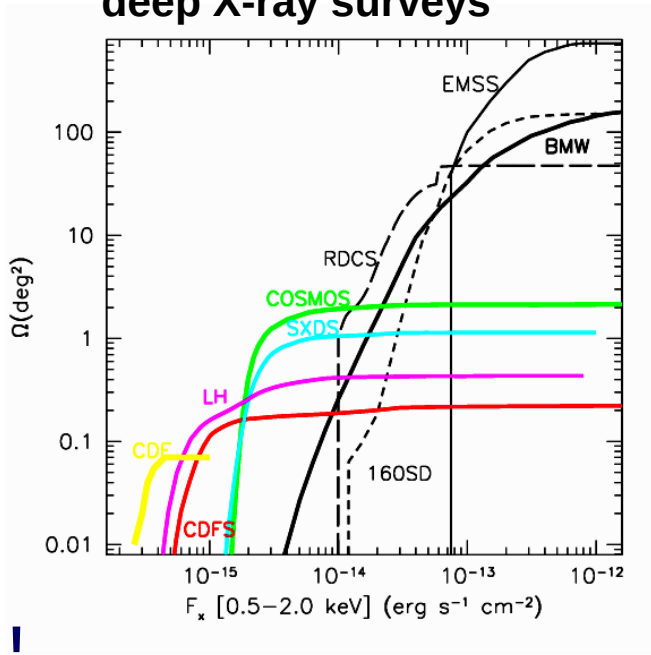
Talk by Elena Belsole

The X-ray Cluster LogNLogS from the Deepest Surveys

Alexis Finoguenov



Sky coverage of different deep X-ray surveys

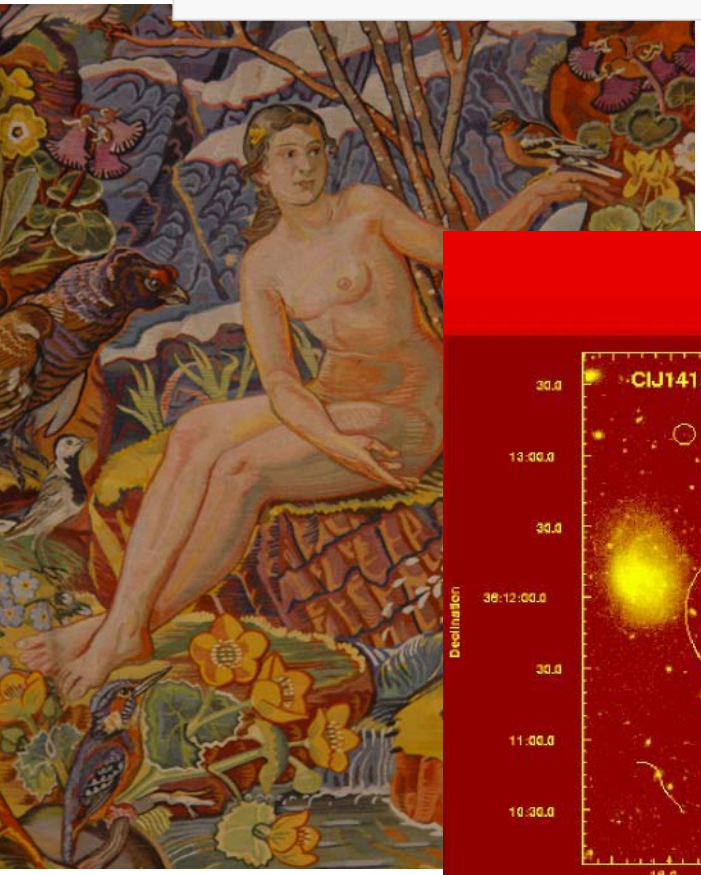


The results of different deep surveys on the galaxy cluster X-ray source counts converge !

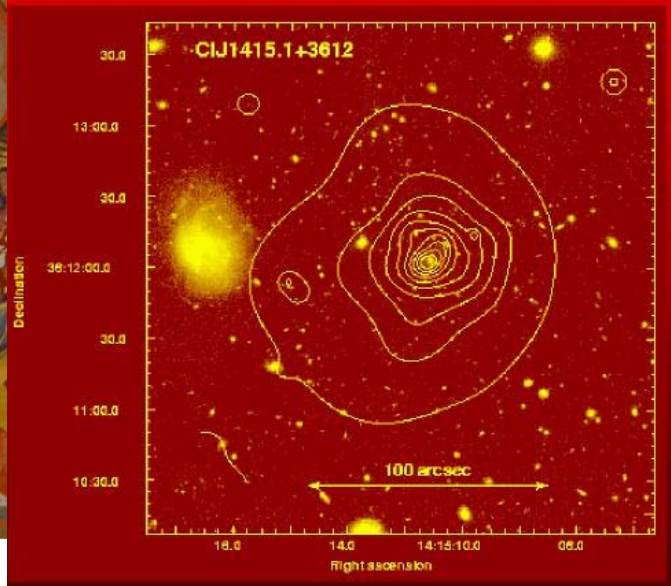
SZA Results Pryke

SZA Results

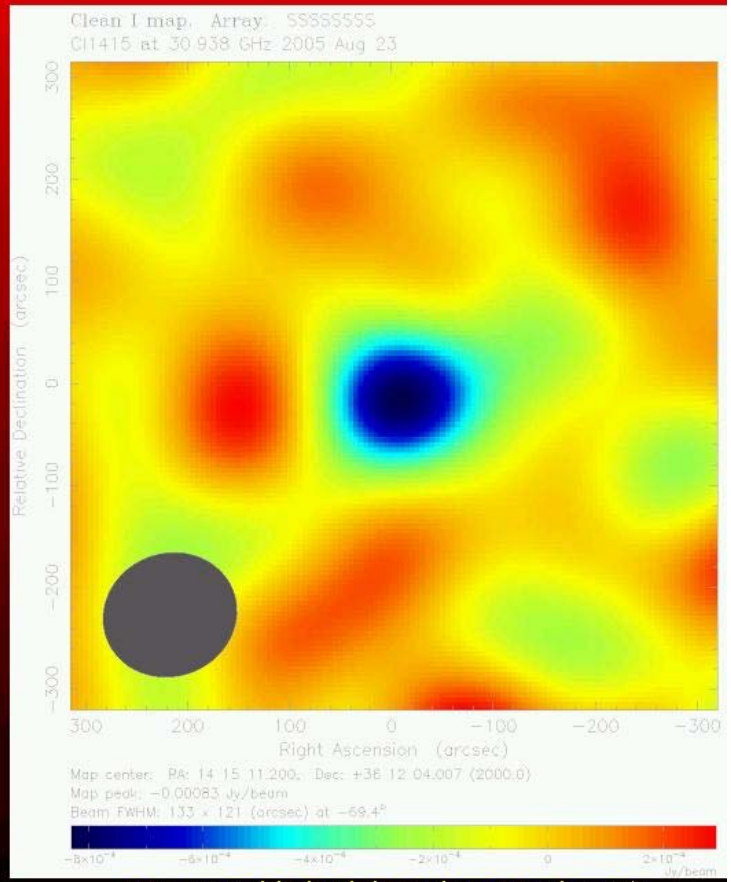
Pryke



Cl1415 new in SZ at z=1

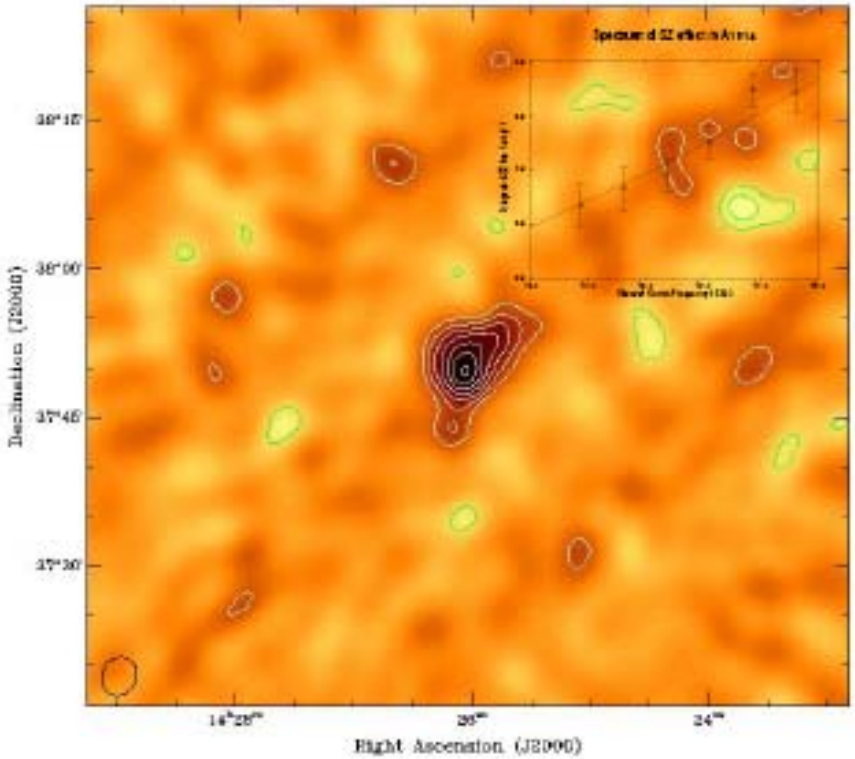


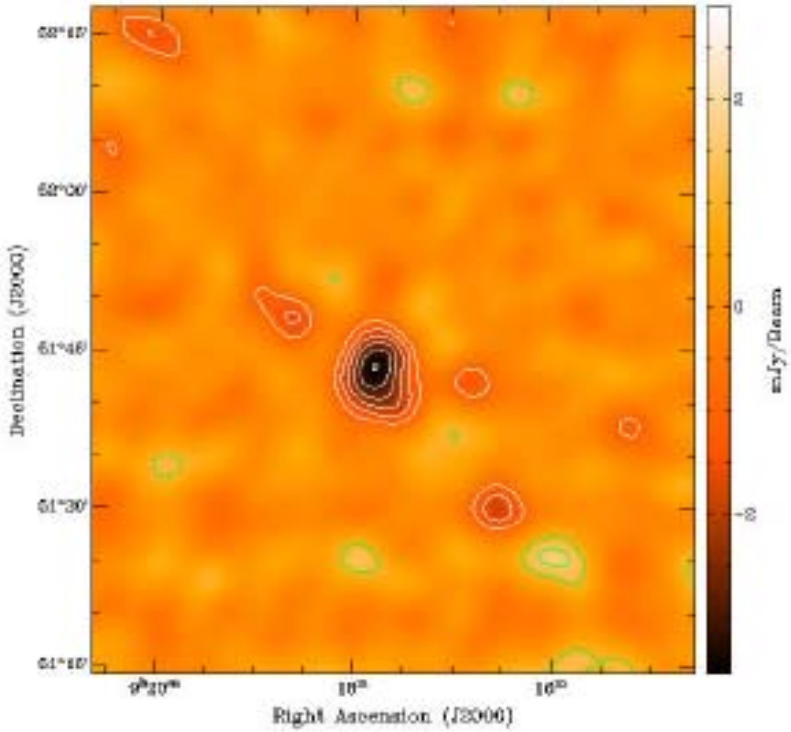
Cl1415+36, M = 4x10 ^14 solar
X-ray WARPS sample, B. Maughan et al,
astro-ph/0503455



SZA unpublished (Stephen Muchovej)

First AMI Cluster Detections



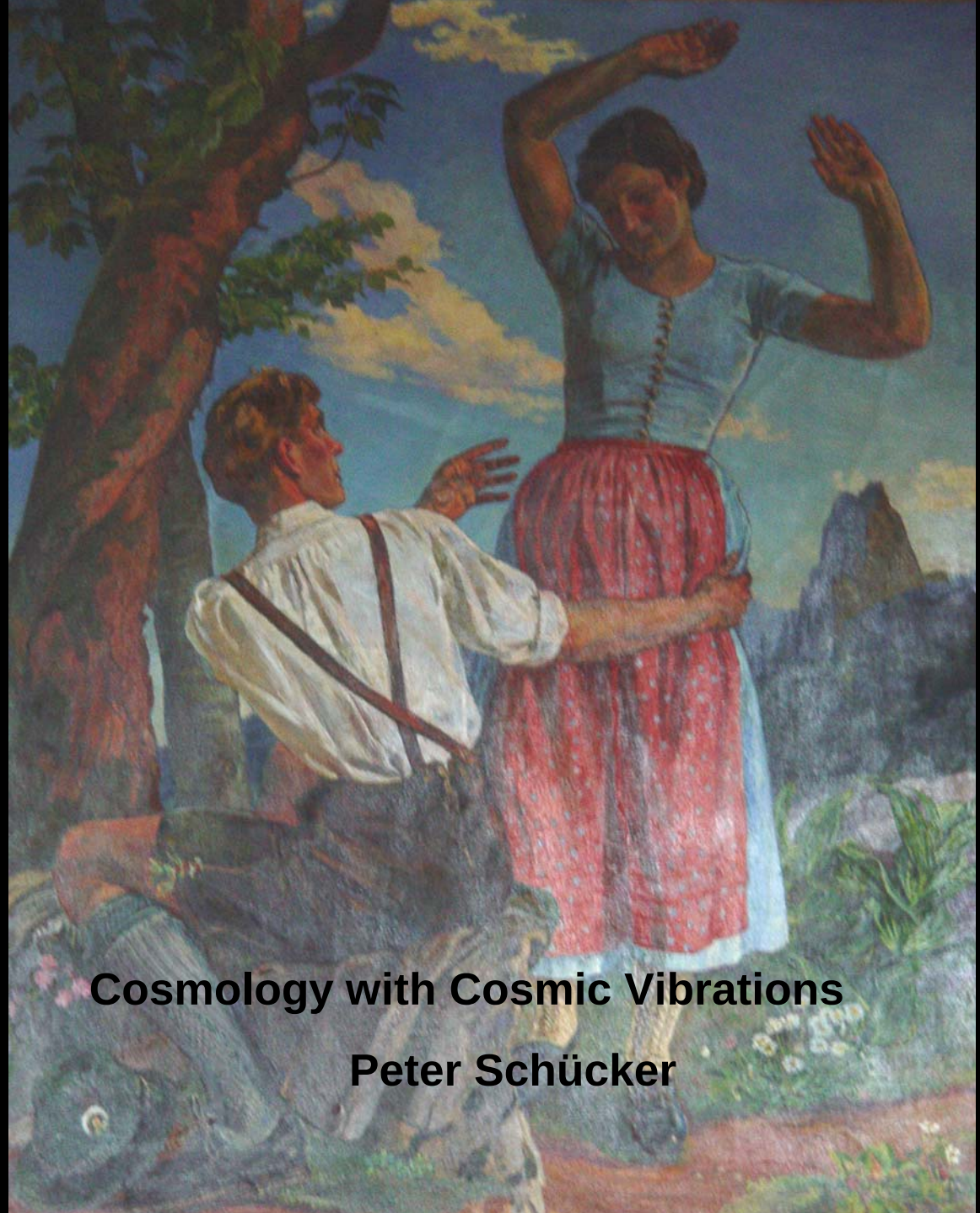


A1914 (astro-ph/0509215; Accepted for publication in MNRAS Letters)

S = -8.6 mJy, noise = 0.2 mJy/beam

A773 (6h observation)

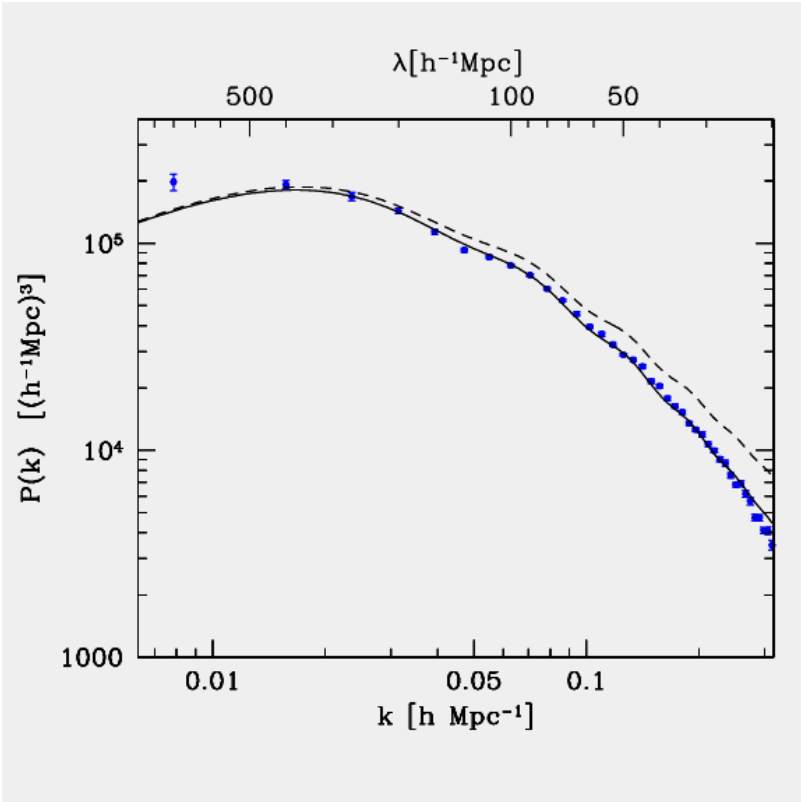
Rüdiger Kneissel

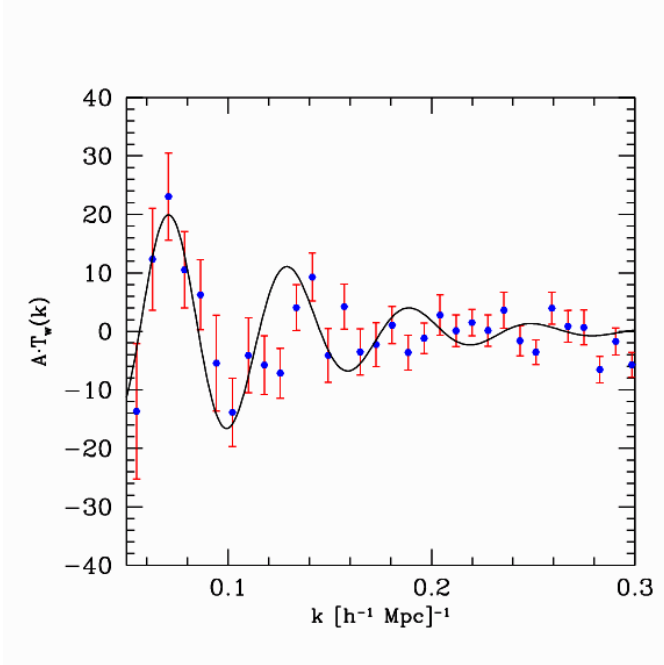


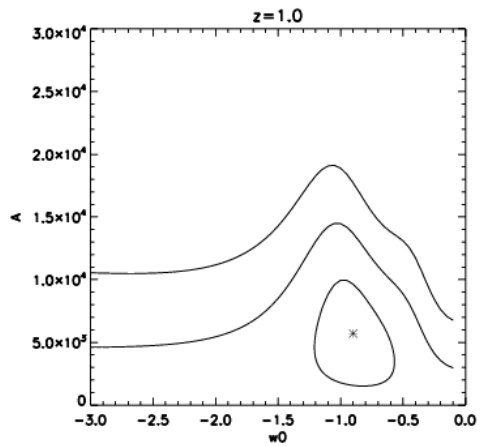
Cosmology with Cosmic Vibrations

Peter Schücker

Cosmological Constraints with Baryon Oscillations measured in the cluster power spectrum



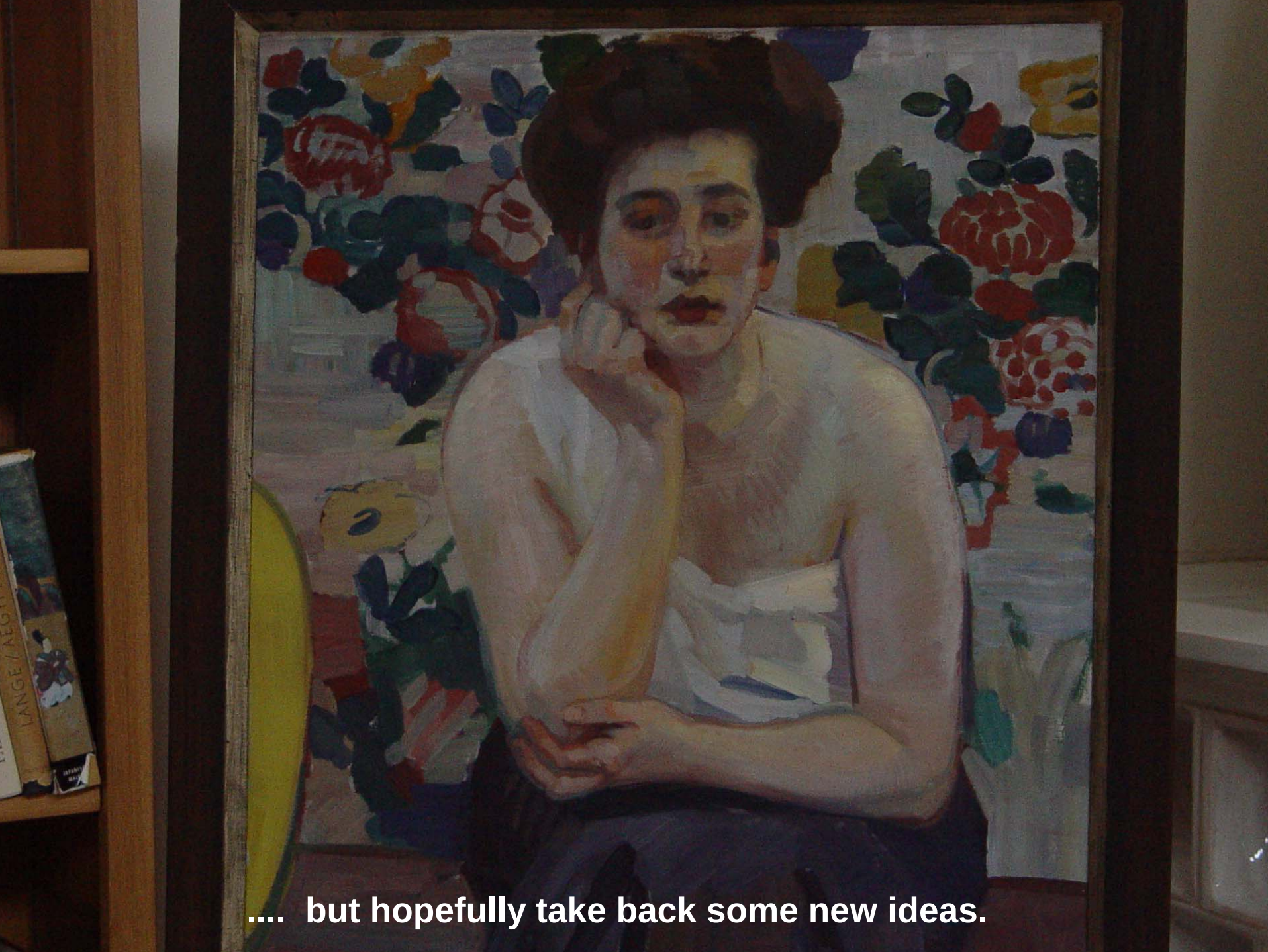




>= 100 000 clusters in survey required !

Peter Schuecker Talk


At the end of the meeting
we feel a bit exhausted ...



.... but hopefully take back some new ideas.

Bye bye Ringberg

A Big Thanks to Hermann !