ESO Large Programme Workshop
Garching, May, 2003

The ESO Distant Cluster Survey
EDisCS

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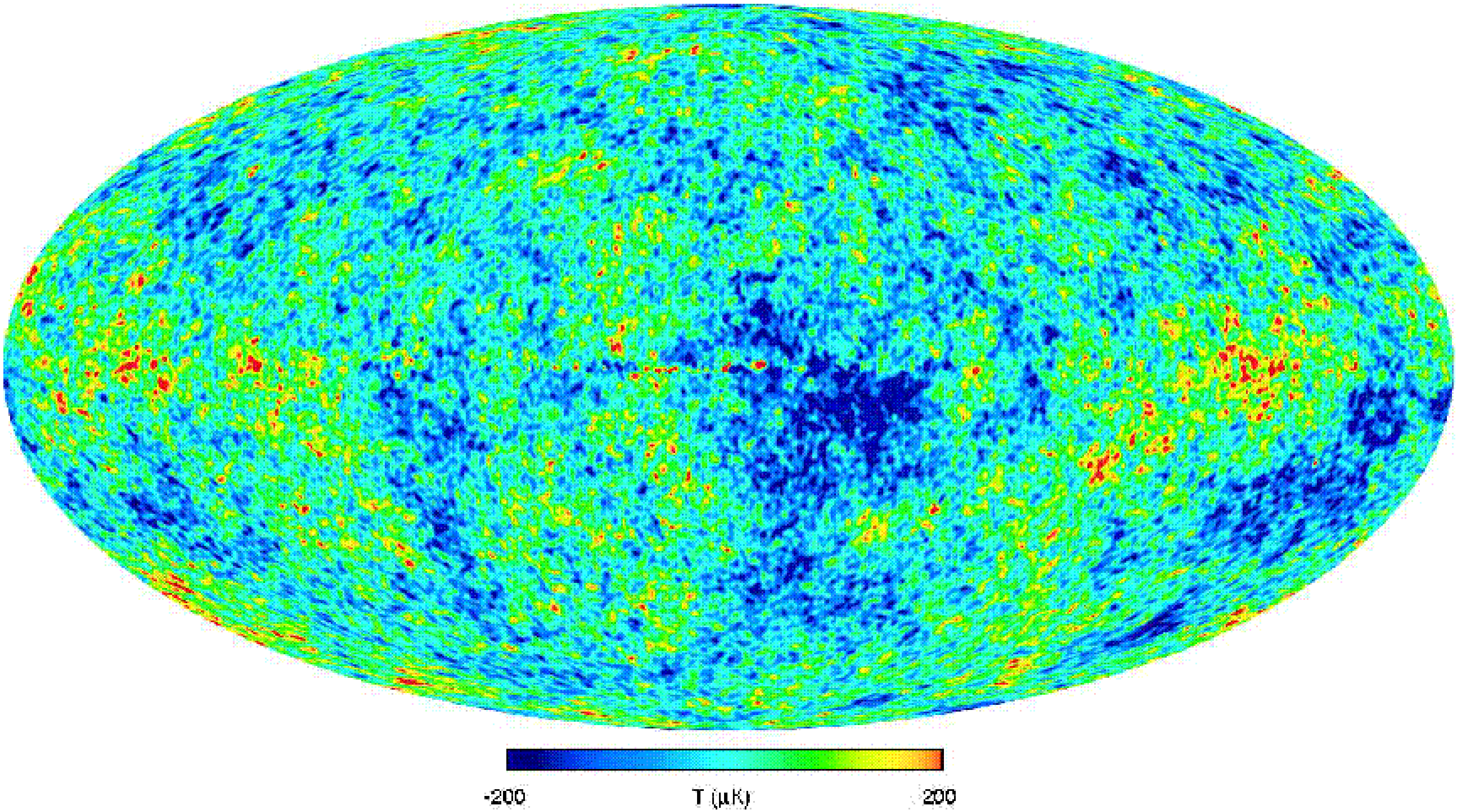
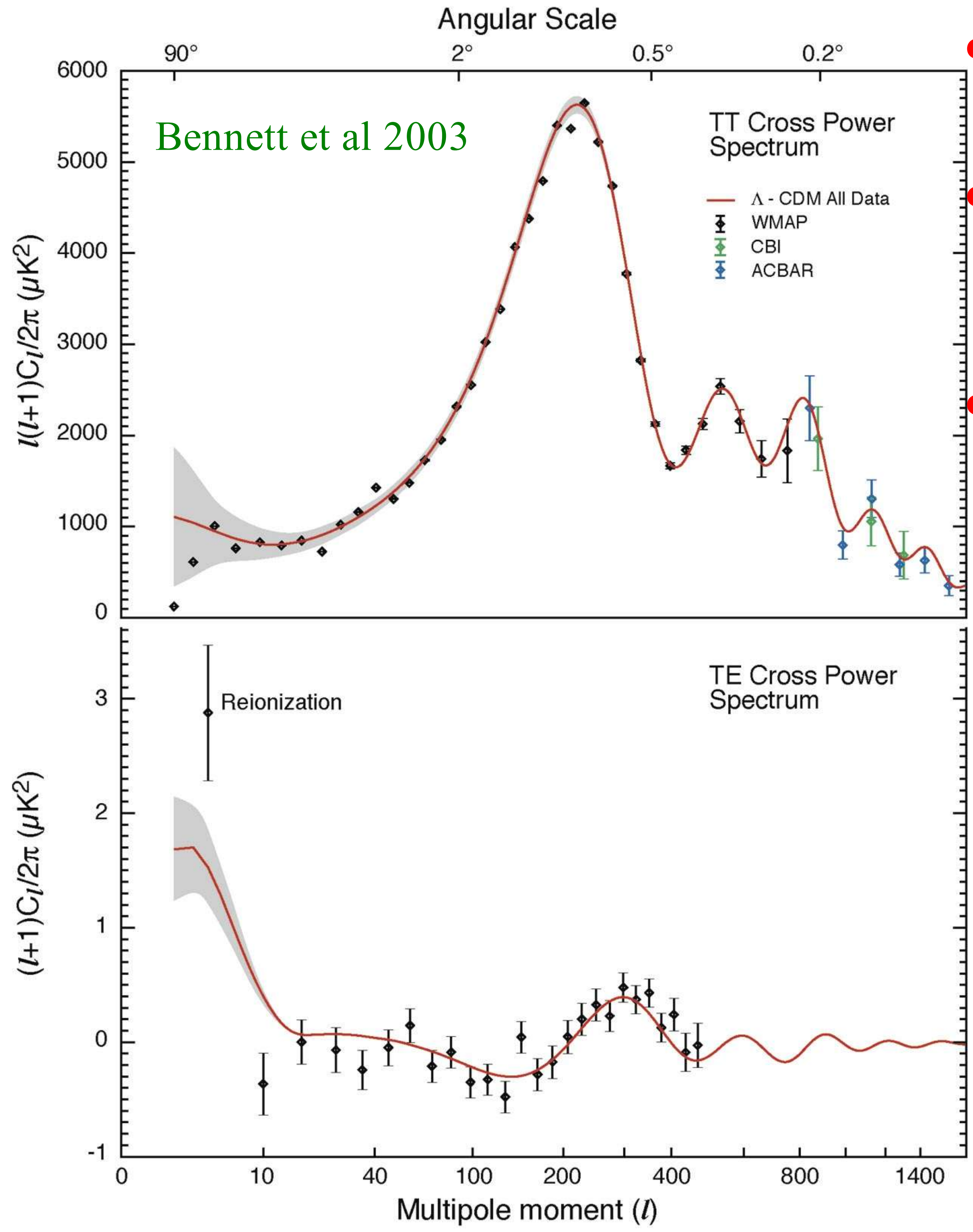
WMAP Map of the Cosmic Microwave Background

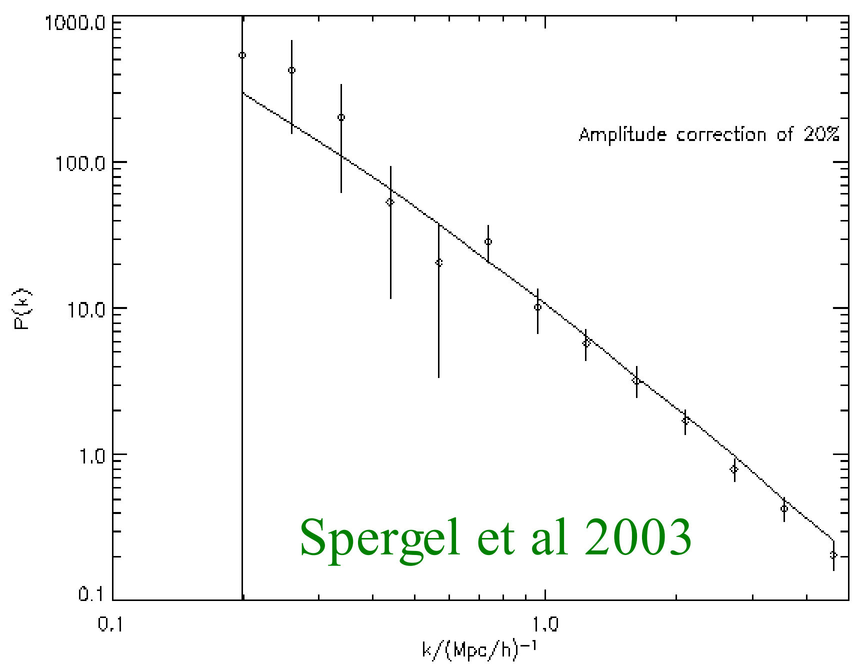


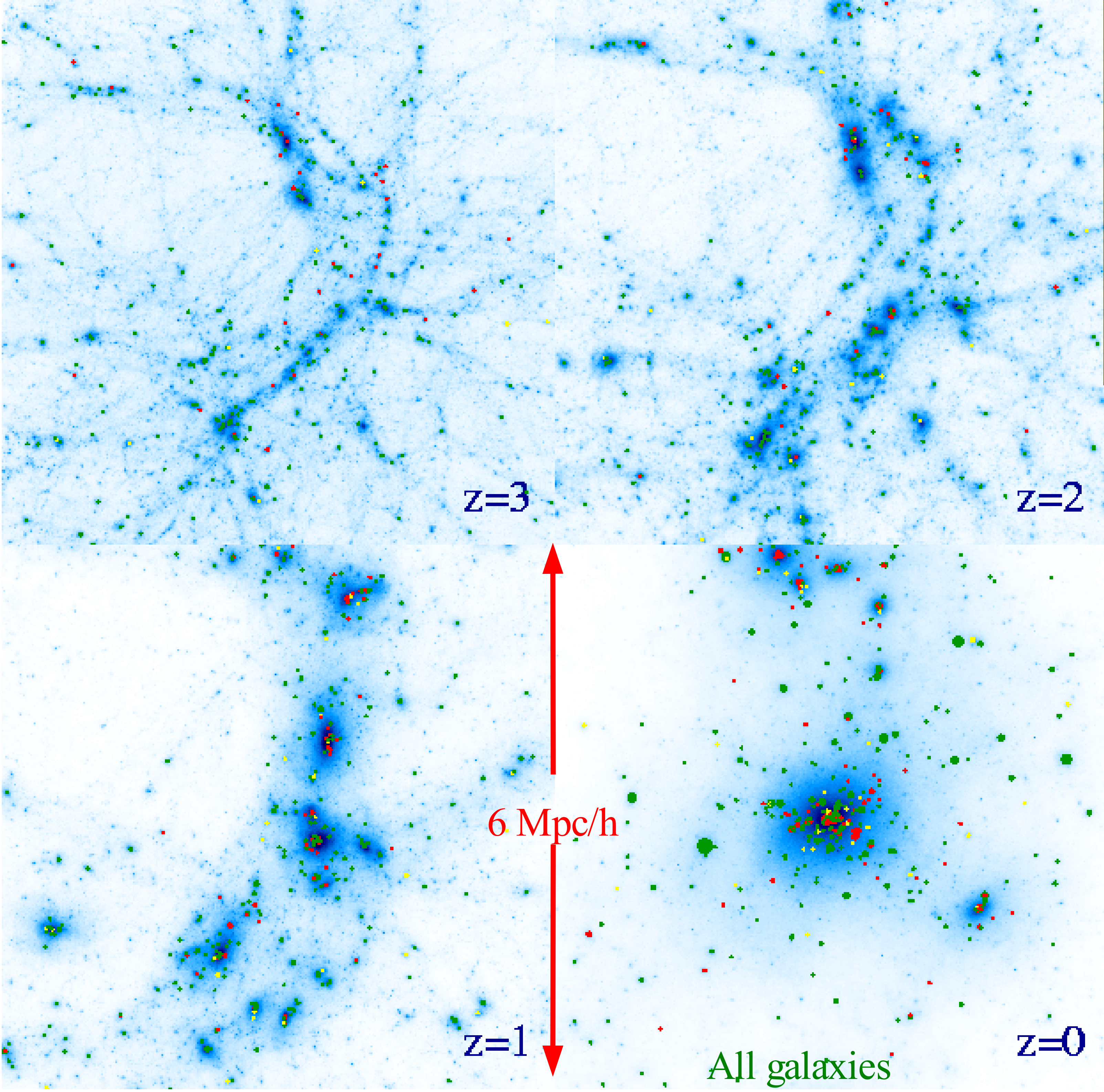
Bennett et al 2003



- $> 10^5$ near-independent 5σ temperature measurements
- Gaussian map: PS fit by a CDM model with parameters consistent with other data
- Extrapolation fits the Ly-α forest power spectrum

Confirms standard model to scales well below those of clusters and bright galaxies

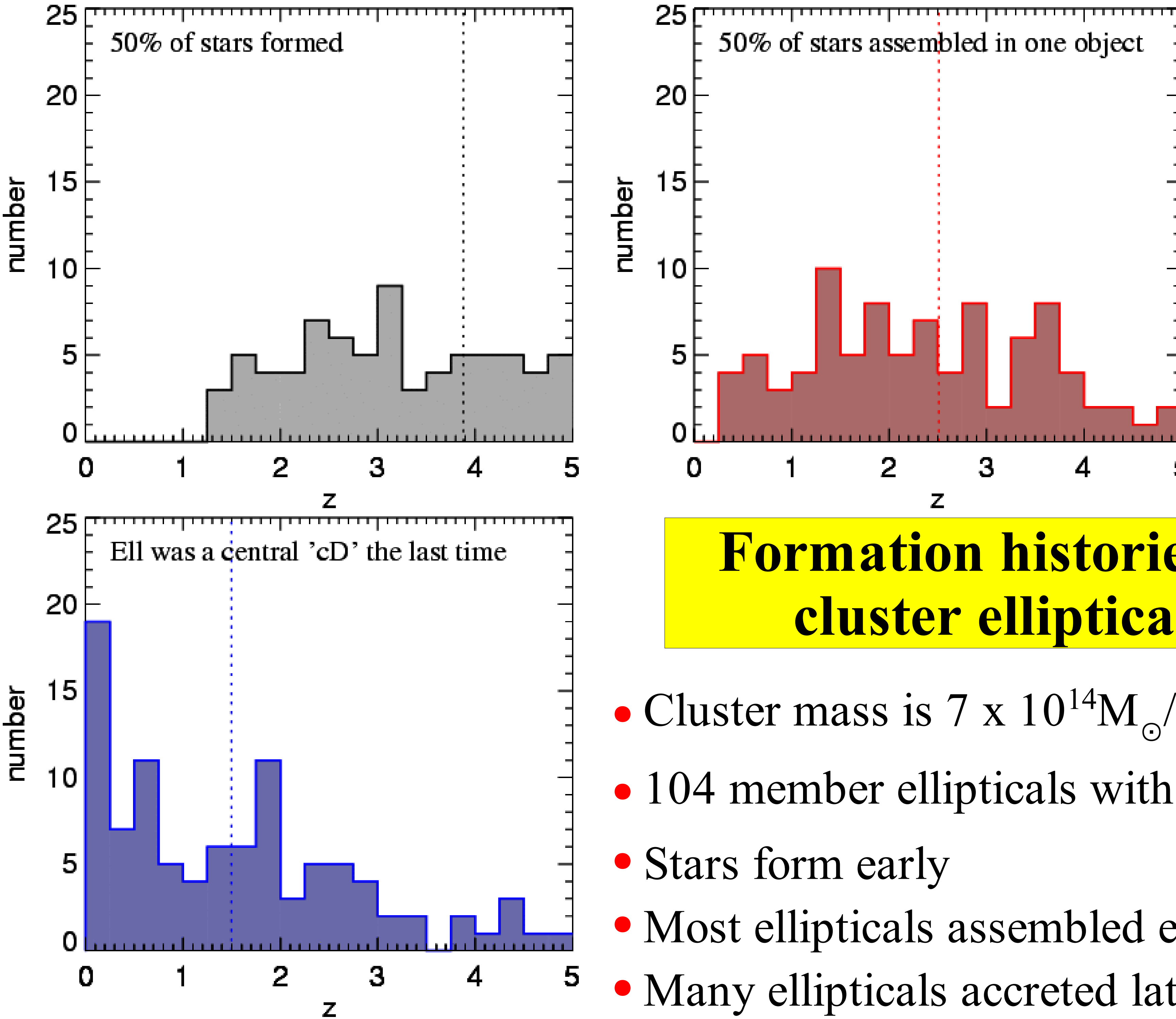




Evolution of the galaxy population in a Coma-like cluster

Springel et al 2001

- Formation of the galaxies tracked within evolving (sub)halos
- Luminosity and stellar mass are uncertain
- Position and velocity are followed well



Springel et al 2003

Formation histories of cluster ellipticals

- Cluster mass is 7 x $10^{14}M_{\odot}/h$
- 104 member ellipticals with $M_B < -18$
- Stars form early
- Most ellipticals assembled early
- Many ellipticals accreted late

Science Goals for EDisCS

- Obtain a uniform photometric and spectroscopic database for a large and representative sample of galaxy clusters covering the last half of the Hubble time
- Characterise the sizes, luminosities, morphologies, internal kinematics, star formation and stellar populations of cluster galaxies
- Compare cluster samples at z=0.8, 0.5 and 0.1 (SDSS) to establish trends as a function of redshift and cluster properties
- Compare with high-resolution simulations of galaxy and galaxy cluster formation in a ΛCDM universe to determine the role of various physical processes (e.g. harassment, stripping, strangulation, cannibalism, merging, induced star-formation, SN/AGN feedback) in establishing the properties of galaxies

EDisCS Participants

Co-I Team on Proposal 166.A-0162

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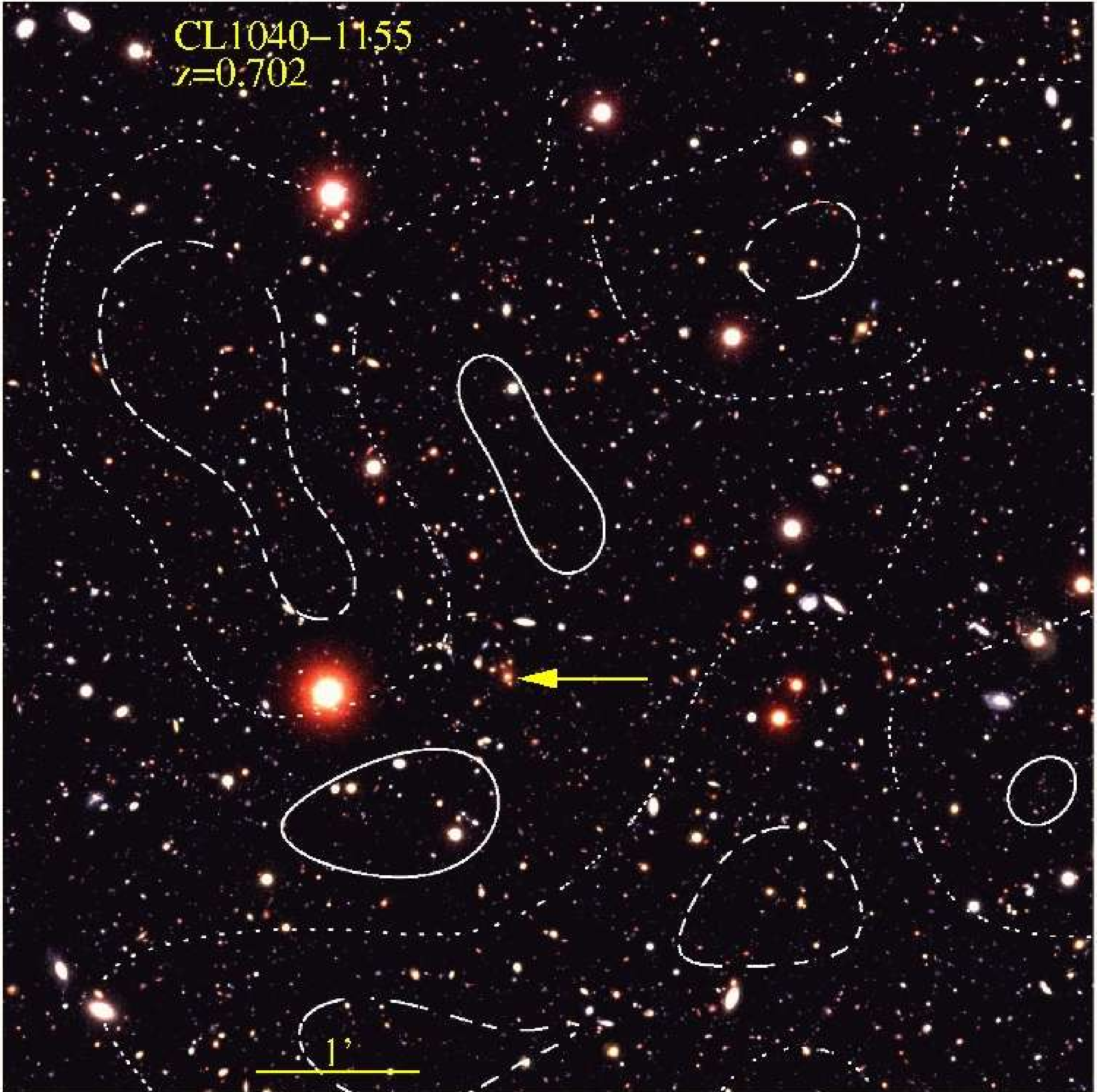
The EDisCS Strategy

- Select 15 bright candidates with $z_{est} \sim 0.5$ and 15 with $z_{est} \sim 0.8$ from the Las Campanas Distant Cluster Survey (130 deg^2)
- Image each field in 2 bands for 20min with FORS2 (3 FORS nights)
- Select 10+10 best cluster fields for deep imaging:
  VRIJK at $z \sim 0.8$, BVIK at $z \sim 0.5$ (11 FORS + 20 SOFI nights)
- 30min exposure of one FORS2 mask of each field to confirm reality of cluster (1.5 FORS nights)
- 3 or 4 FORS2 masks of each confirmed field at longer exposure to get spectra of representative systems to I=23 (20.5 FORS nights)
- Get HST/ACS imaging of 10 most distant fields (80 orbits)
- Get WFI 3-colour imaging of all 20 fields to study large-scale environment of clusters (84 hours of WFI imaging)

LP Allocation: 36 nights on FORS2 + 20 nights on NTT/SOFI

EDisCS Status

- Deep optical imaging is complete for all 20 cluster fields
  - -- data are fully reduced, calibrated and combined
  - -- photometry and image quality excellent (seeing 0.5 to 0.8 arcsec)
  - -- preliminary weak lensing and morphology analysis complete
- Deep NIR imaging almost complete (one final night required)
  - -- data through summer 2002 fully reduced, calibrated and combined with the optical (about 60% of total)
- Nineteen nights of FORS2 spectroscopy successfully completed
  - -- data through summer 2002 fully reduced (about 38% of total)
  - -- data quality good -- fully consistent with expected performance
  - -- three nights still required to complete programme (14% of total)
- HST/ACS data currently being taken, first frames now reduced
- About 60% of WFI data taken and already reduced
- Large suite of high resolution simulations completed



Clowe,
Halliday

High redshift but no detected lensing

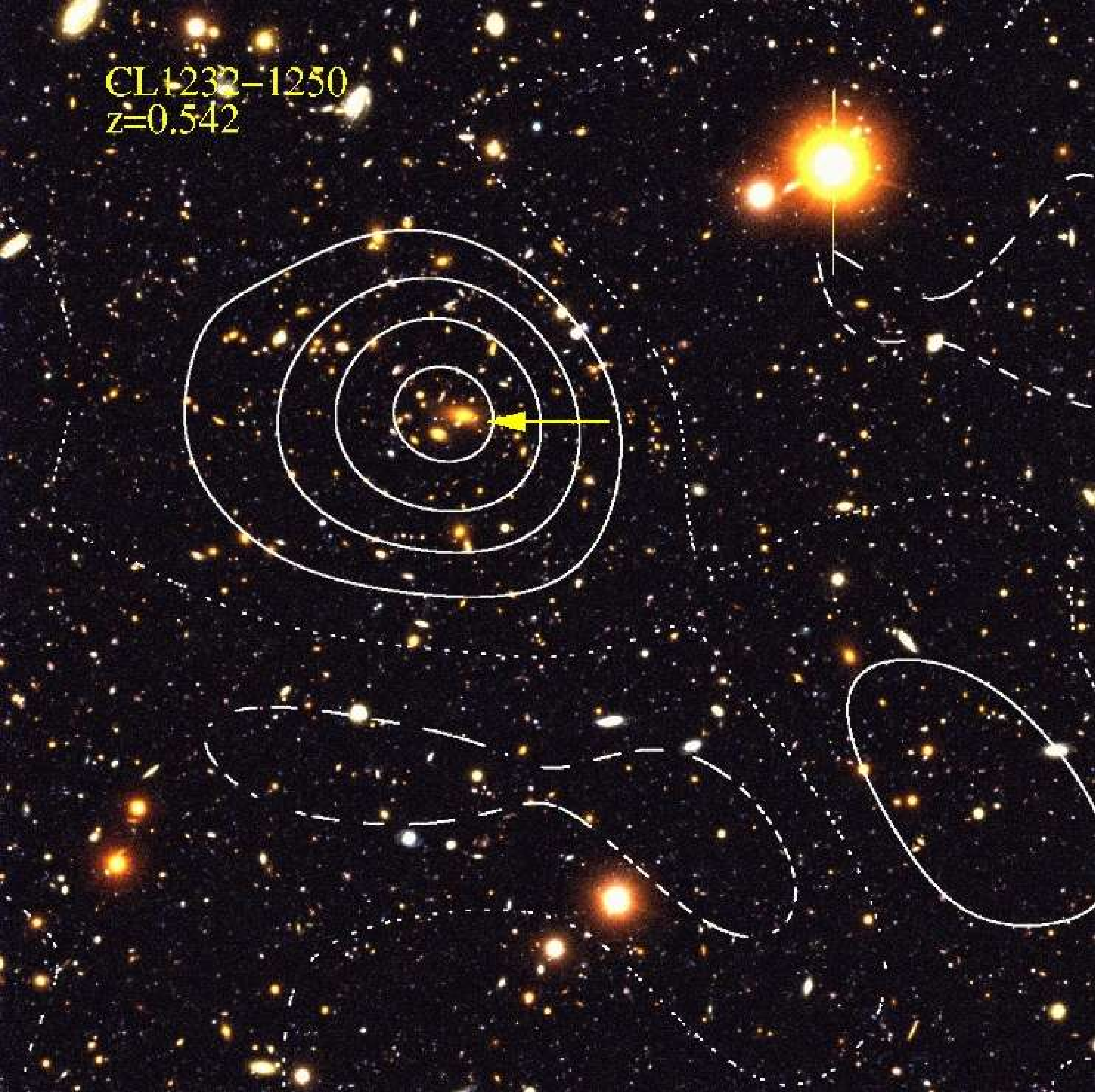
σ_{clus}=453±41km/s

from measured redshifts

High redshift with strong lensing

σ_{clus}=1034±46

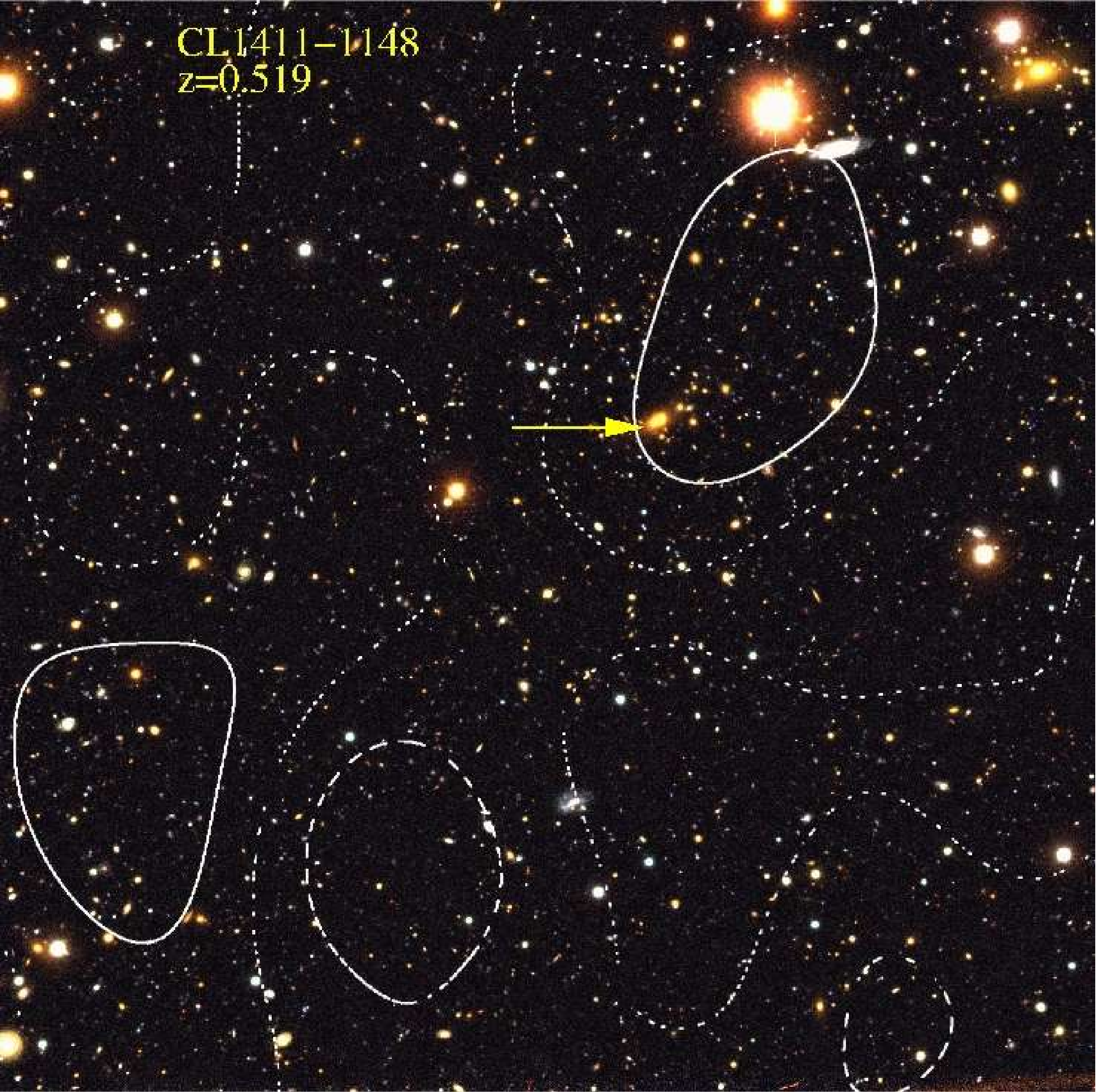
from measured redshifts



Interm. redshift with strong lensing

$\sigma_{clus} = 1160 \pm 139$

from measured redshifts

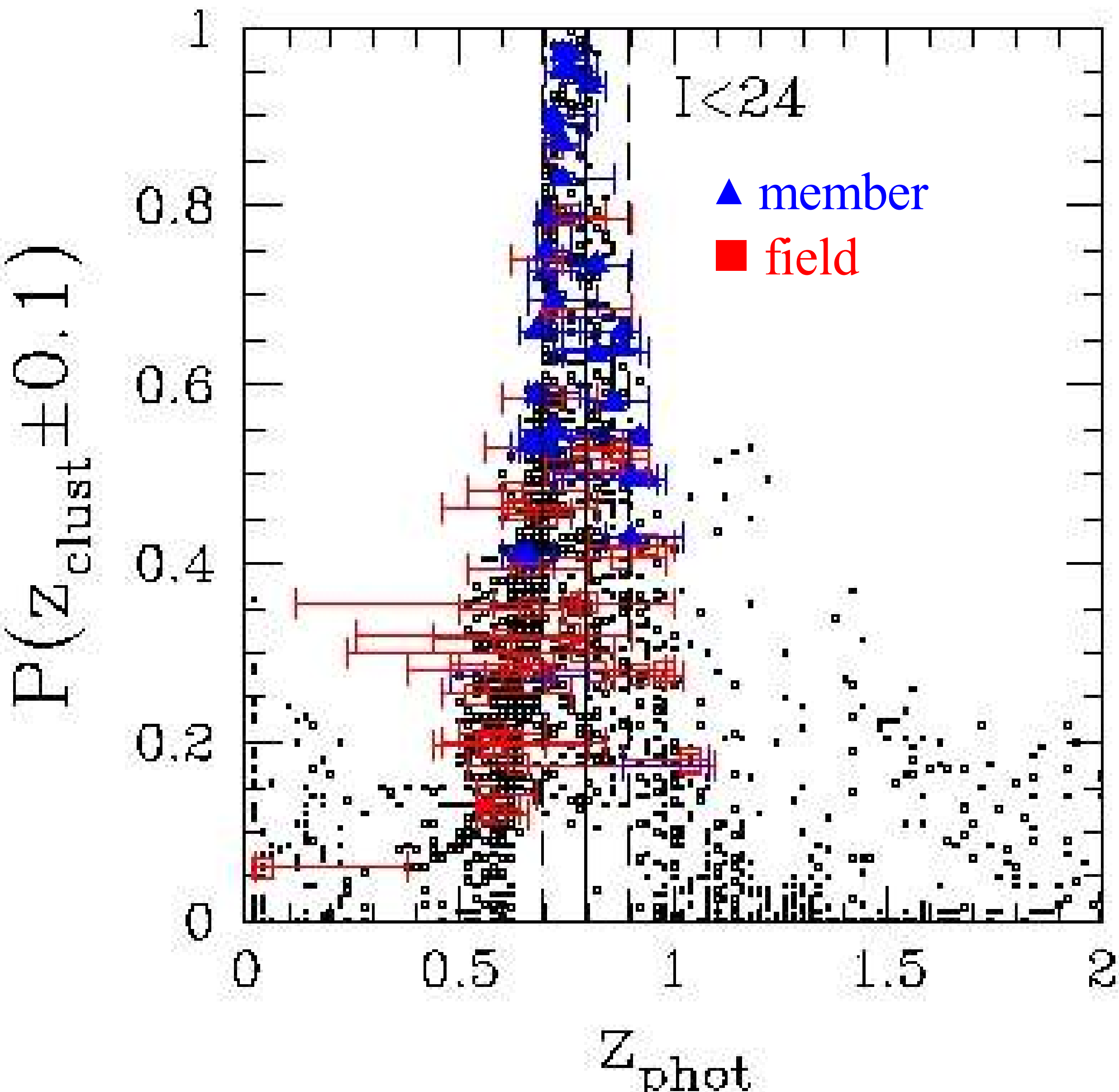


Interm. redshift
with weak lensing

Insufficent spectra
for a robust $\sigma_{\rm clus}$

Using Photo-z's to reject foreground

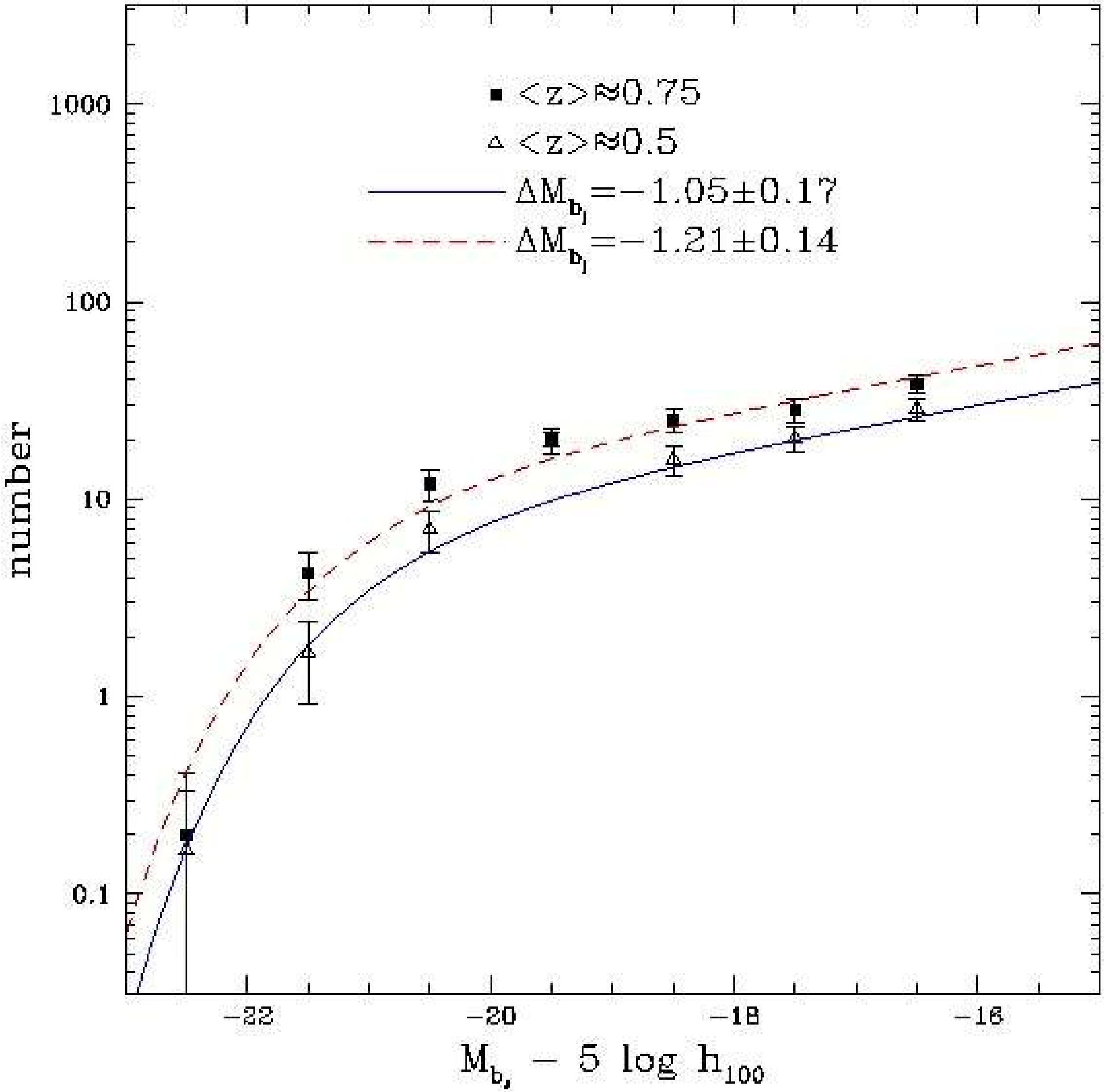
Pello, Rudnick, De Lucia



- We use two independent photo-z codes, Hyper-z and Rudnick's thesis code
- Each code is optimised using our 2002 spectra
- For each code and each galaxy we calculate the probability its redshift is in $z_{clus} \pm 0.1$
- If *either* code gives P<0.25 then we reject
- This rejects half of the confirmed field while it keeps 90% of members

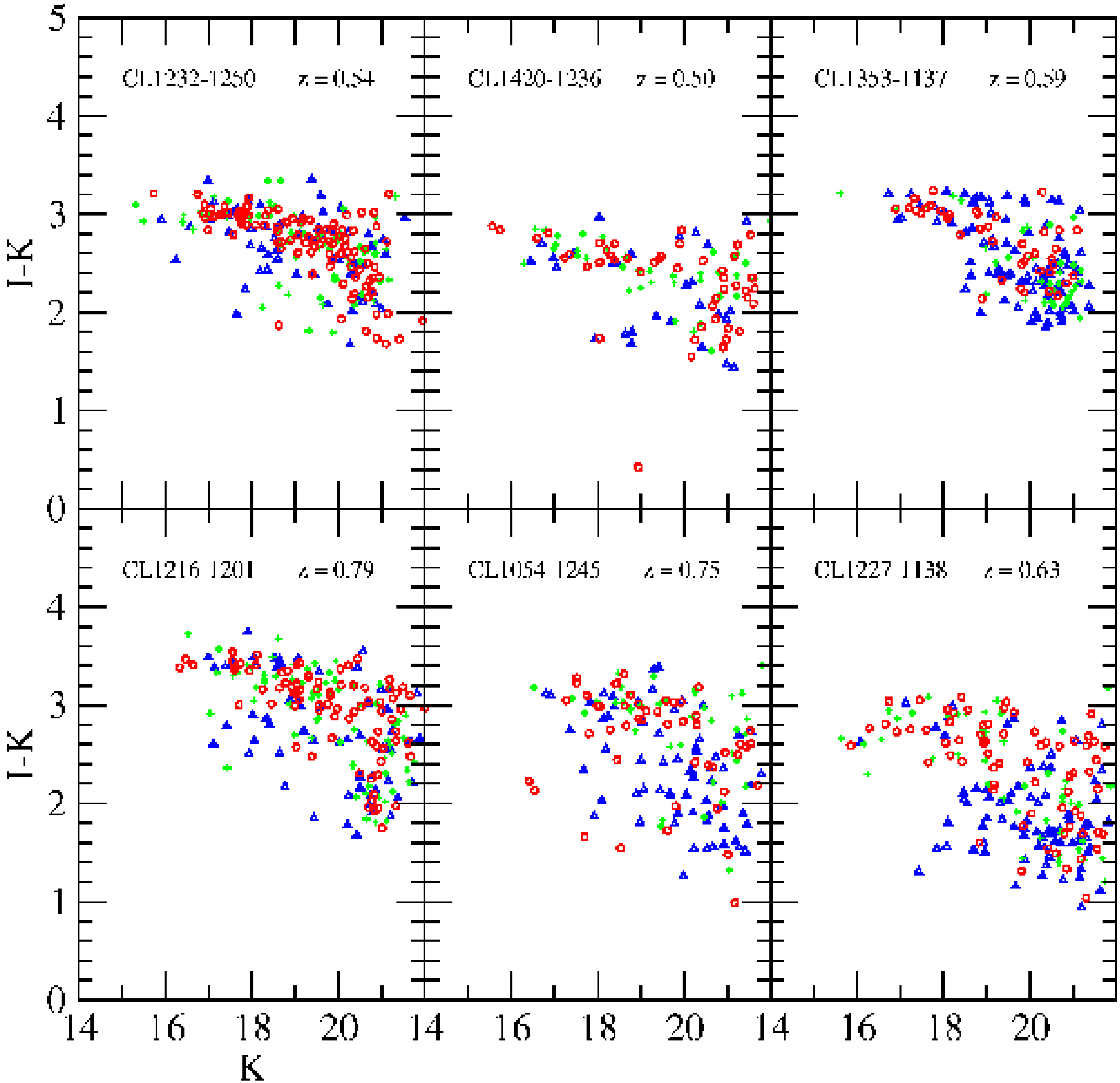
Evolution of the cluster luminosity function

Rudnick



- Field-corrected cluster luminosity functions are well fit by the *shape* of the 2dF cluster LF both at z = 0.5 and z = 0.75
- Their characteristic L_* are brighter at rest B by more than a magnitude
- This brightening is *larger* than expected from the aging of stars as inferred from fundamental plane studies (–0.57 at z = 0.5 and –0.86 at z = 0.75)

Colour-Magnitude-Morphology Diagrams

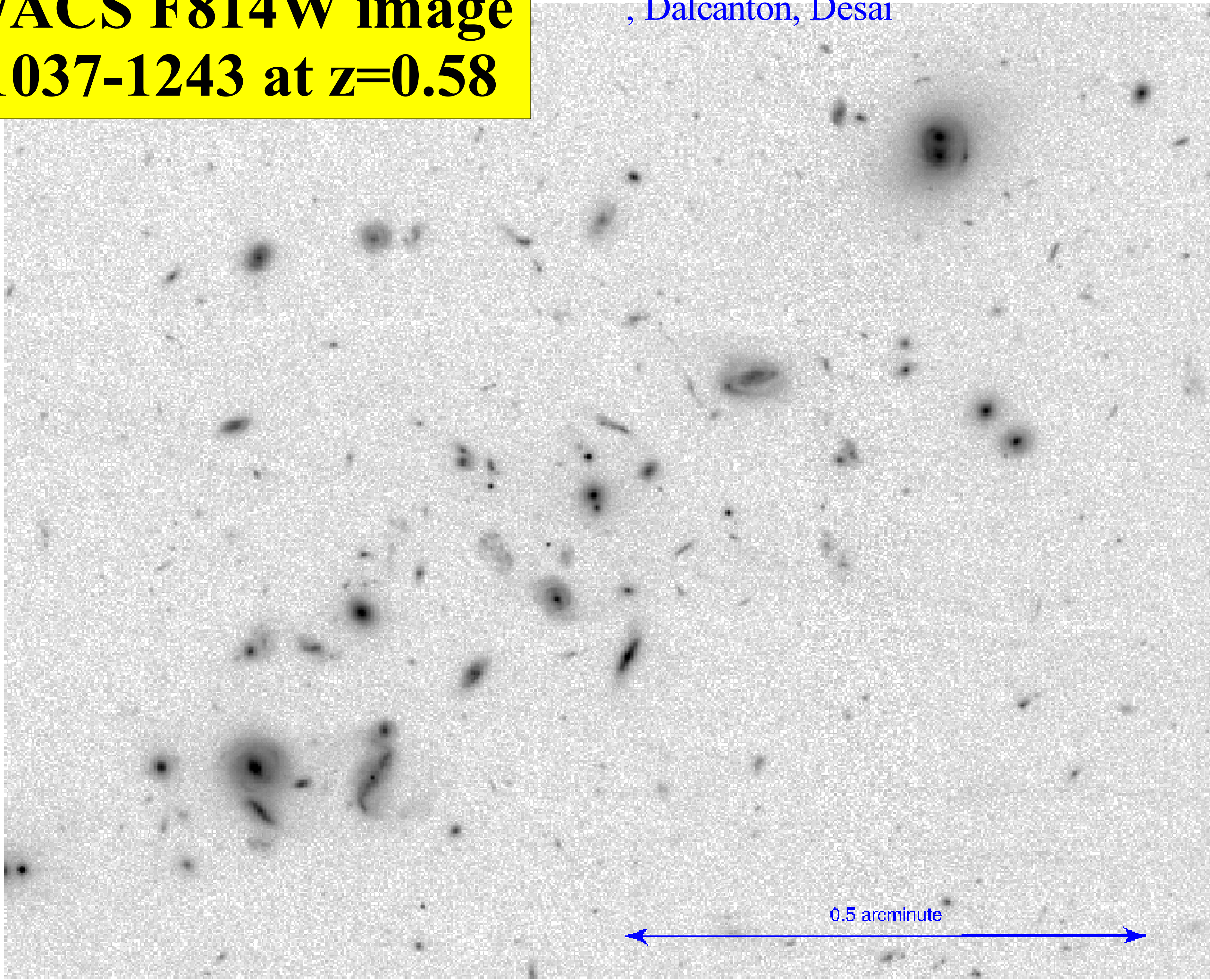


Simard

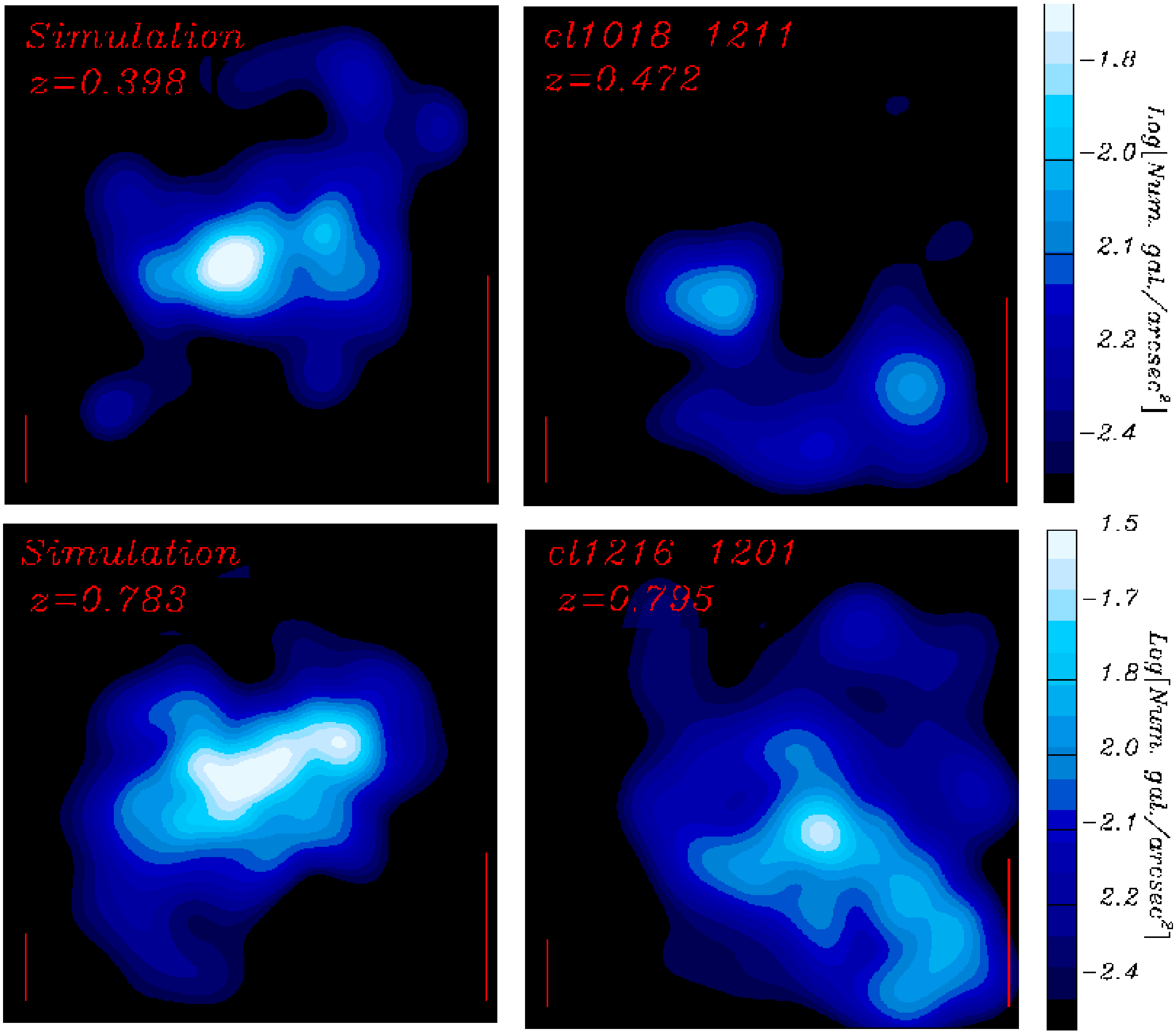
- Field corrected C-M diagrams for typical clusters
- 'Morphologies' are B/T values derived from the 2D image fitting code GIM2D
- Clusters show a wide range of richness
- Strength of red sequence and of blue 'B-O' population is variable
- Many disky galaxies on the red sequence

HST/ACS F814W image of cl1037-1243 at z=0.58

, Dalcanton, Desai



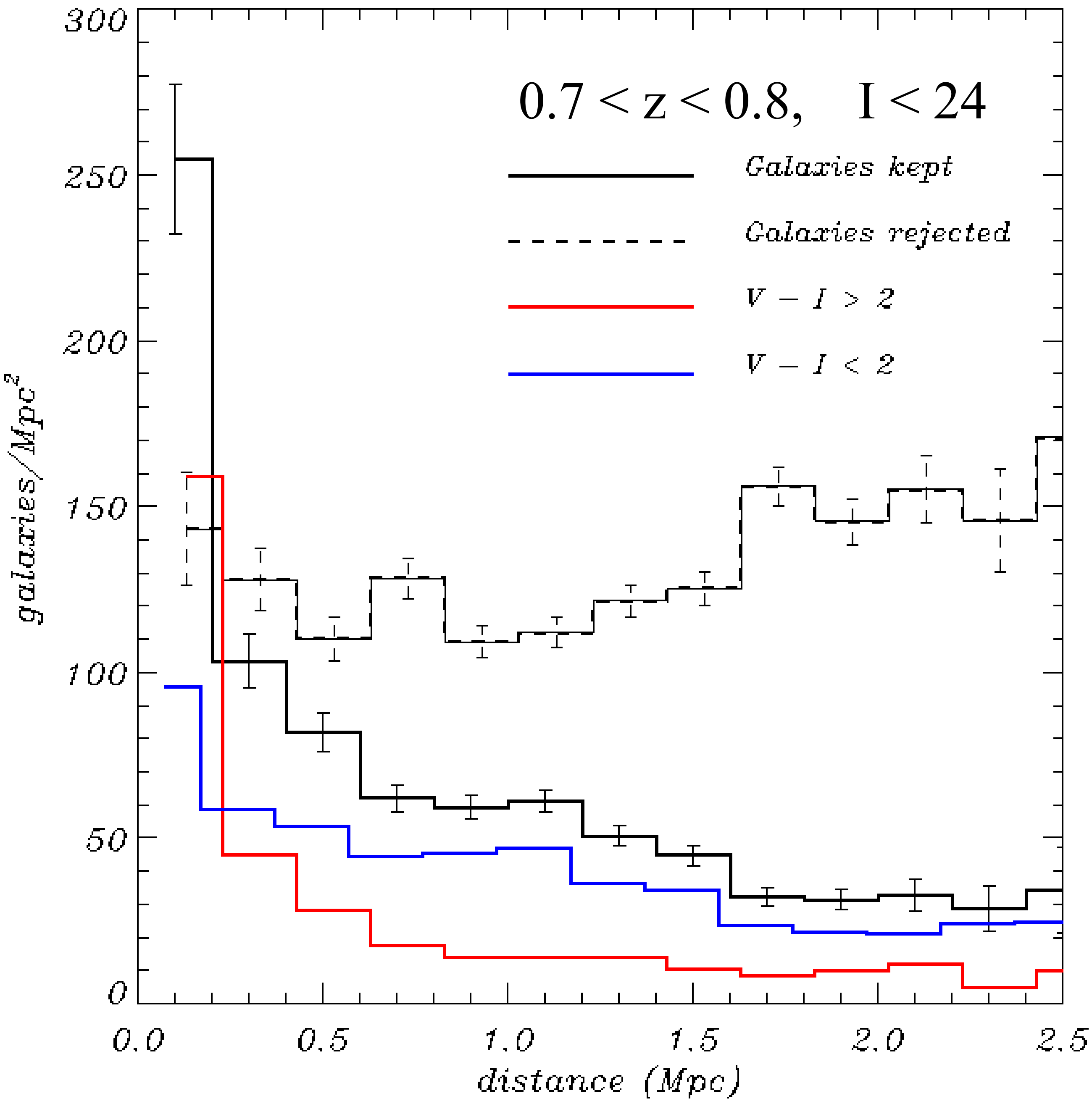
Cluster images: observation vs simulation



De Lucia

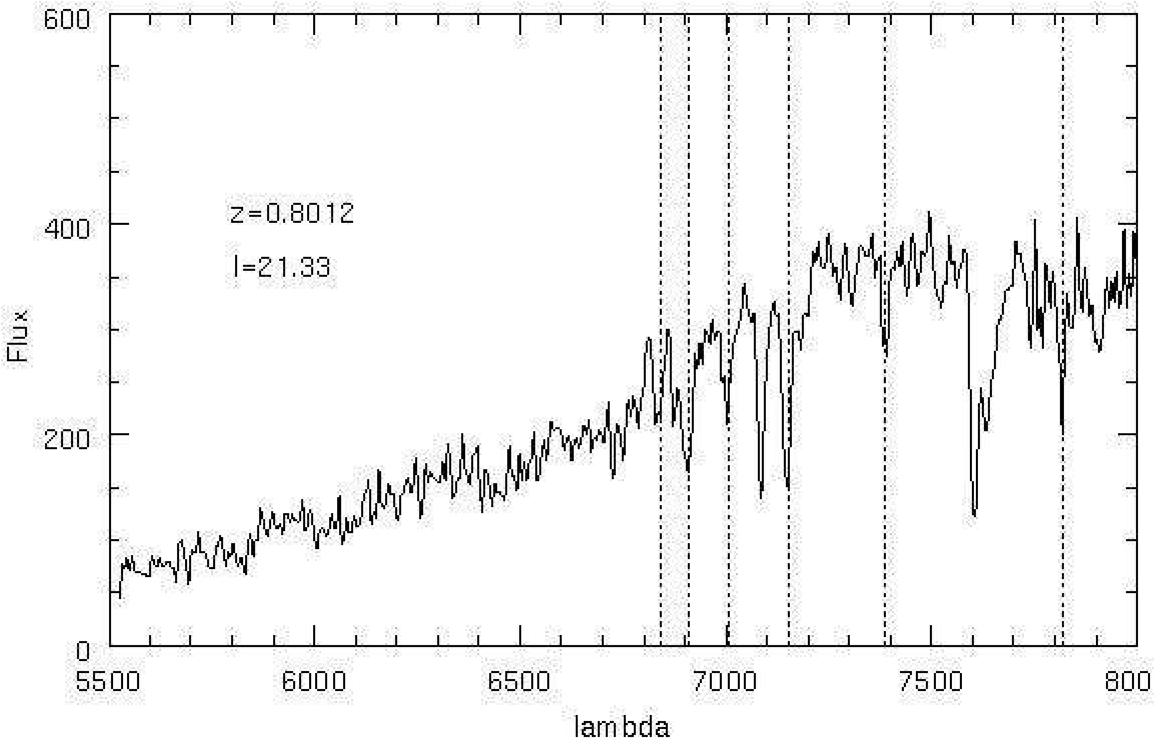
- Photo-z rejection used on real data
- Only galaxies with I < 25 used either in real or in simulated clusters
- Galaxy formation assumptions in simulations are as in Springel et al (2001)

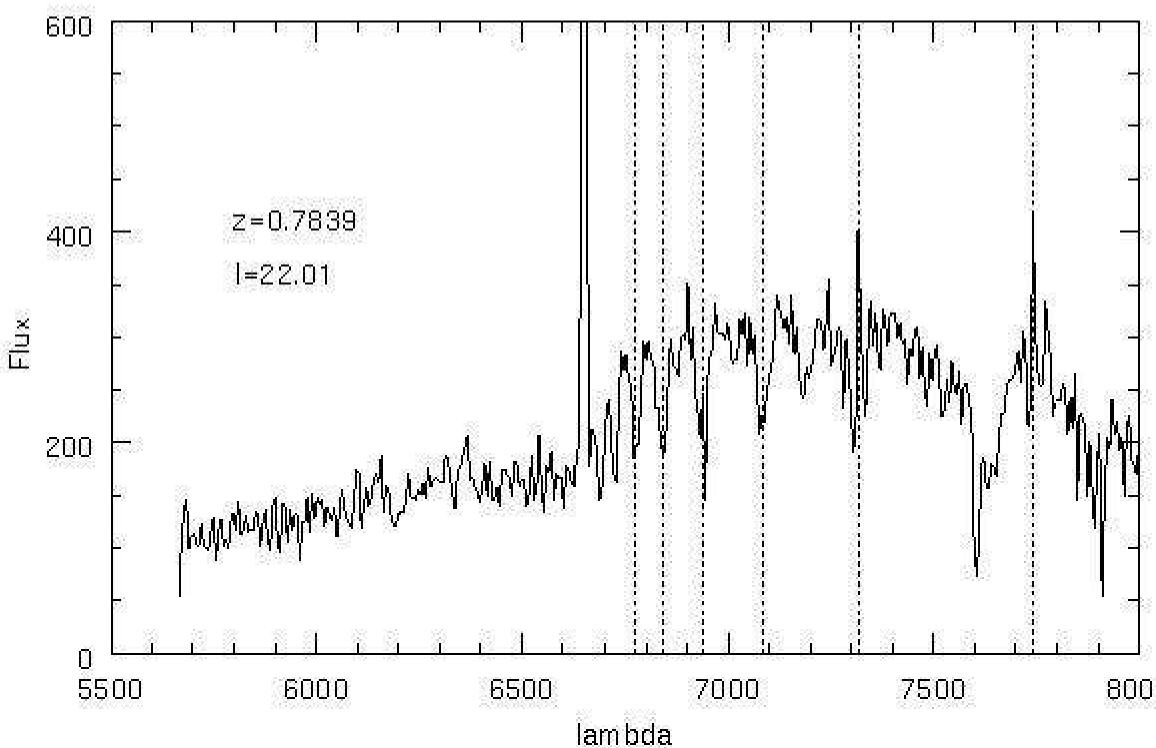
Cluster Density Profiles



De Lucia

- Galaxies rejected by the photo-z's are not concentrated to cluster centre
- Photo-z rejection gives enhances contrast by a factor of about 5
- Mean cluster profile is detected out to 1.5 Mpc
- Blue galaxies are much less concentrated to the cluster centre than red ones



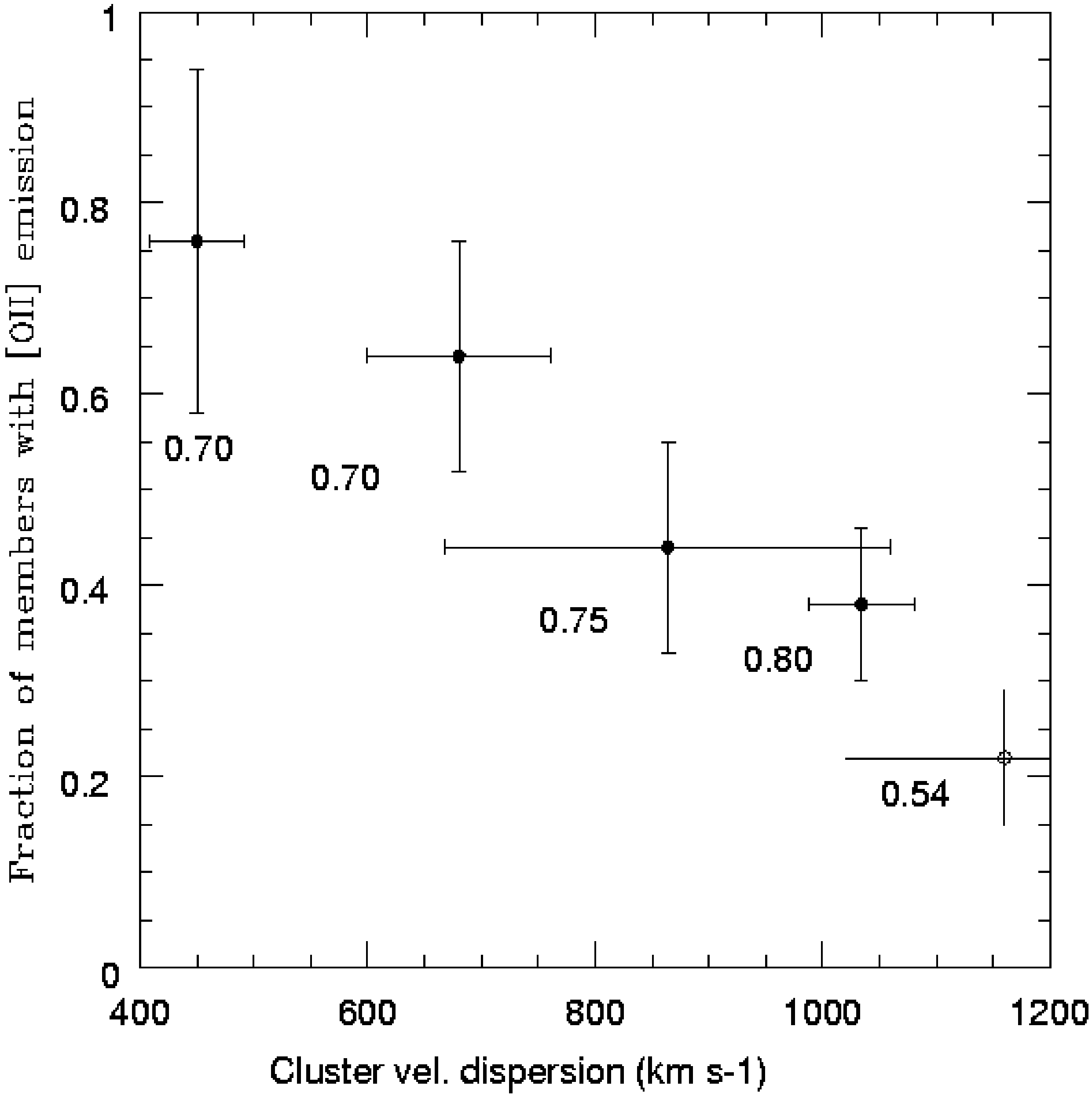


EDisCS Spectra

Halliday, Poggianti

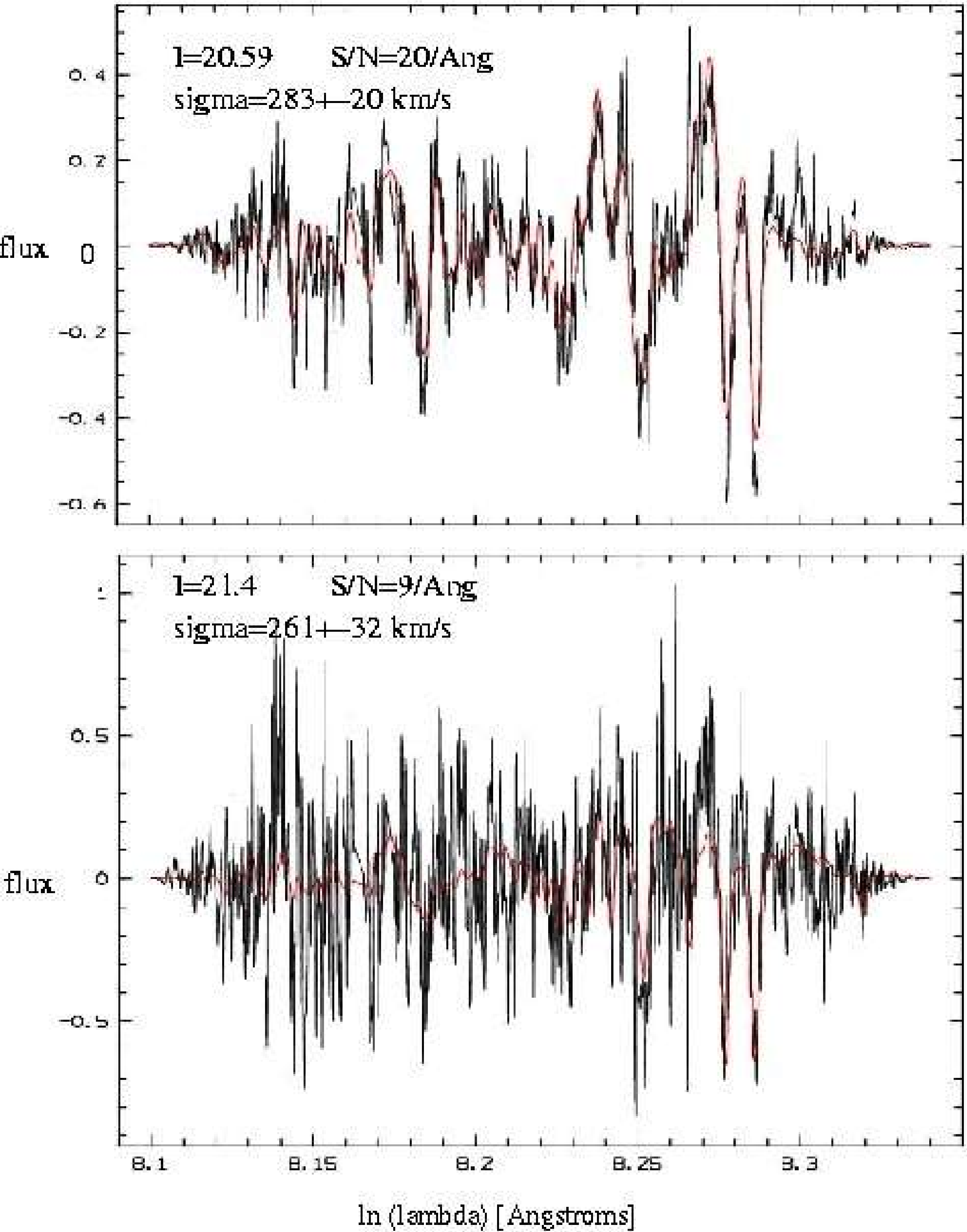
- FORS2 spectra are of very high quality
- Redshifts can measured to I ~ 23
- Line indices can be measured to I ~ 22.5
- Velocity dispersions can be measured accurately to I ~ 21.5

Emission fraction vs cluster velocity dispersion



Poggianti, Halliday

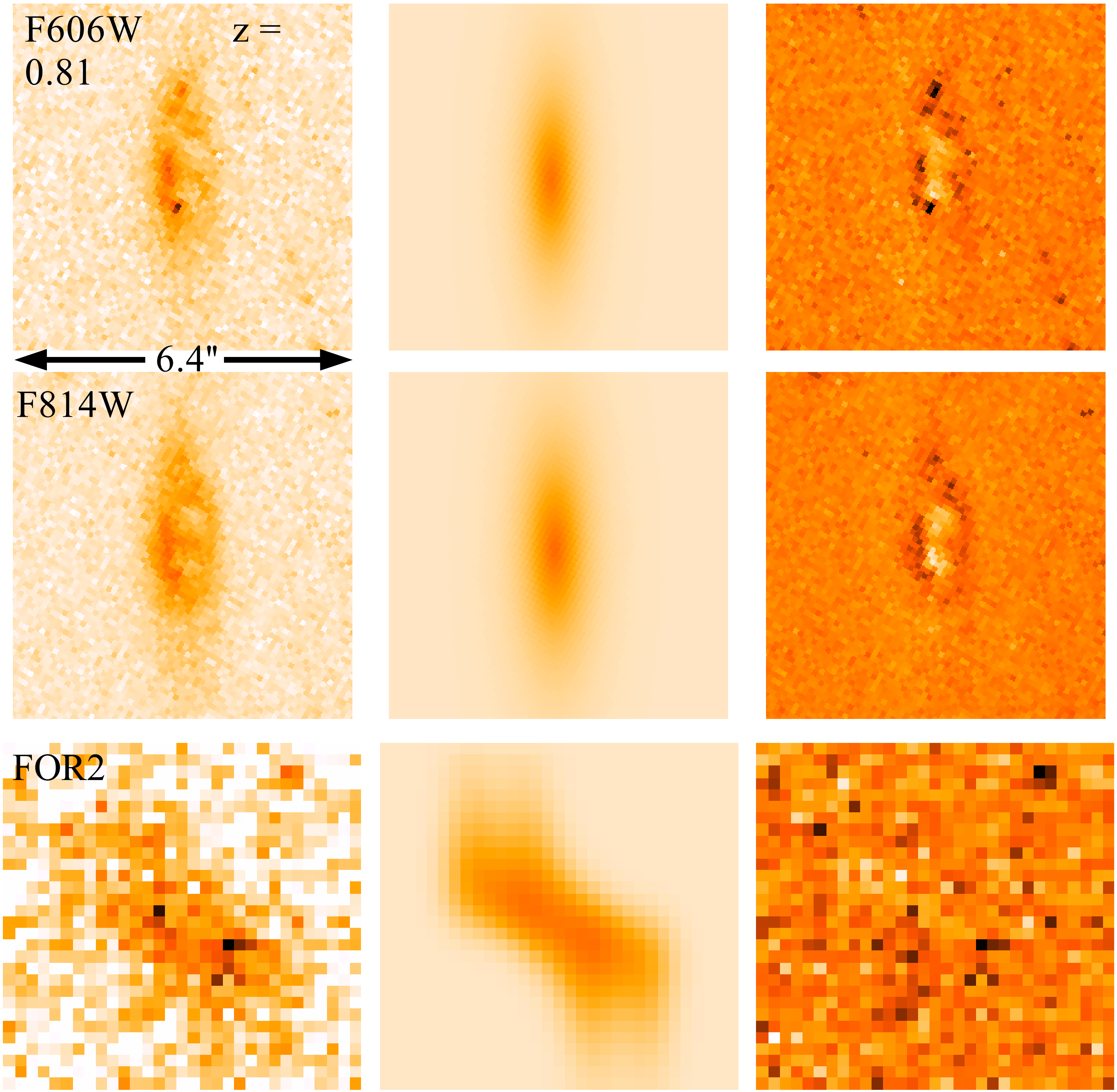
Fraction of emission line galaxies in FORS2 field correlates strongly with cluster velocity dispersion



Velocity dispersion measurements

Saglia

Velocity dispersions with 15% uncertainty at I ~ 21.5



Emission line kinematics

Milvang-Jensen

Characteristic sizes and rotation speeds for disk systems from combined HST/VLT data

Possible to I ~ 22

line: 3727

image sizes: 33 Å × 6.4″

image1+2 cuts: $(-1, 12)$

image3 cuts: $(-7, 7)$

$V_{\mathrm{rot}} \sin i = 270.8^{+8.0}_{-12.7}\ \mathrm{km\,s^{-1}}$

$r_{\mathrm{d}} = 0.84^{+0.08}_{-0.06}{}''$

Expected statistics for final spectroscopy

If our final 3 spectroscopic nights are as successful as the previous 19, we expect our final EDisCS spectroscopic sample to contain:

	Intermediate z fields 10 clusters	High z fields 9 clusters	Total
Spectra	1000	1300	2300
Redshifts	900	1200	2100
Cluster members	400	420	820
Accurate line indices	100 (+ 150 field)	150 (+ 250 field)	650
velocity dispersions	75 (+ 70 field)	110 (+ 70 field)	325
rotation curves	60 (+ 100 field)	80 (+ 130 field)	370

Accurate line indices for fainter galaxies will be obtained by stacking spectra for similar systems

Comments on Large Programmes

- EDisCS is only possible as a Large Programme and at ESO
  - -- availability of full instrument suite (FORS2, SOFI, WFI)
  - -- commitment to full time needed (incl. weather replacement)
  - -- availability of service mode
  - -- flexibility of scheduling
  - -- high quality and reliability of typical nights at Paranal

- ESOs commitment to complete Large Programmes in a timely fashion helps to get time from other facilities
  - -- EDisCS was the only large cluster programme to get time in the first round of HST/ACS allocations

- Large Programmes provide an opportunity to federate and develop European expertise in specific areas. This requires the internal atmosphere to be open and inclusive, rather than competitive