Subaru Hα Survey for the Coma Cluster

Survey Highlights and Hα Luminosity Function

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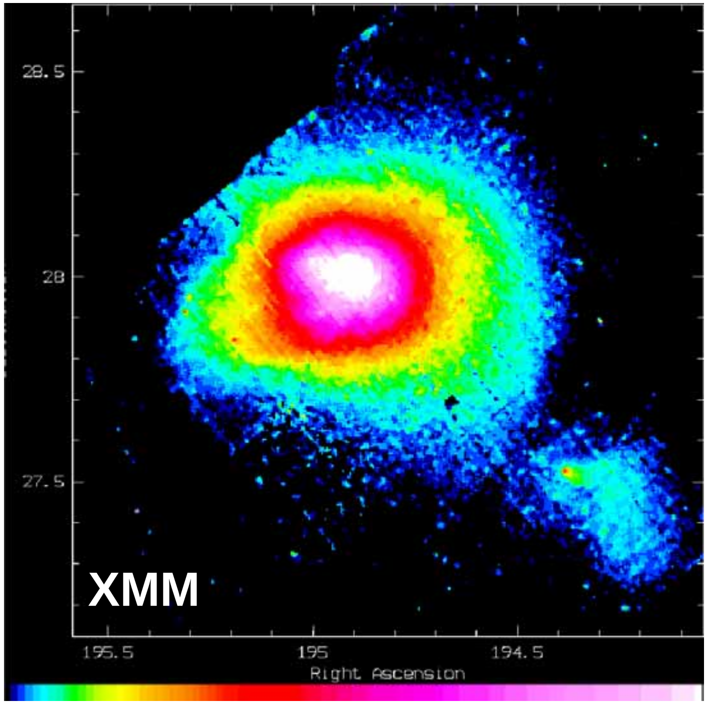
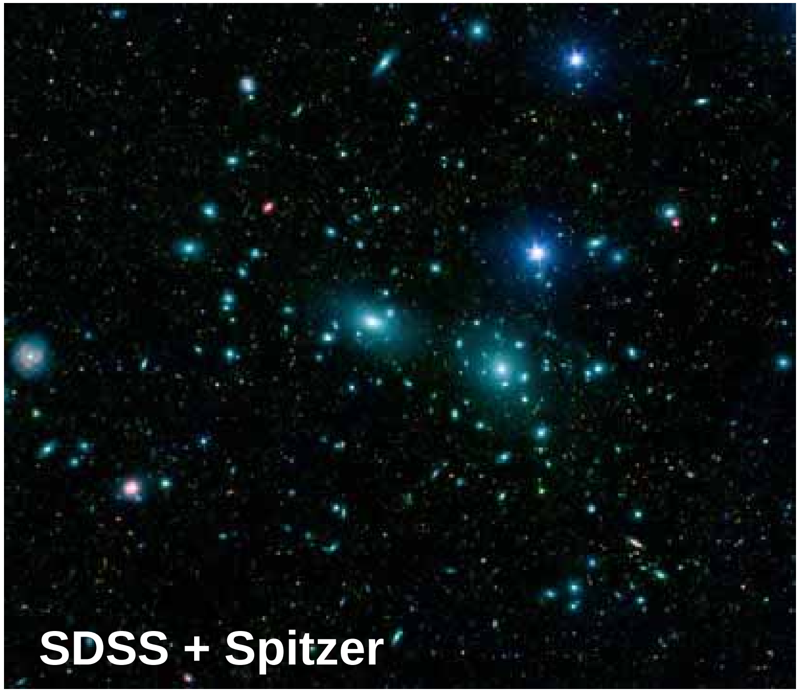
Coma Cluster

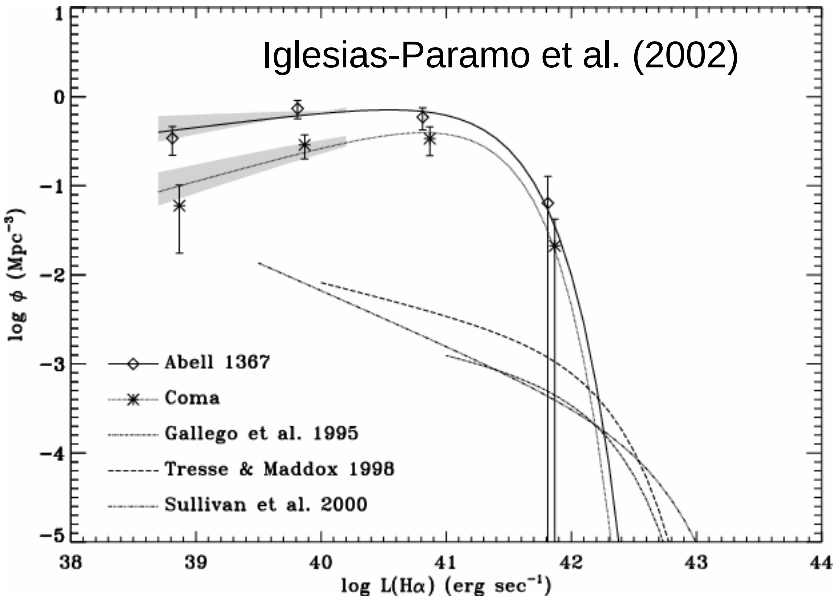
- One of well studied galaxy clusters located at z=0.023
  – Panchromatic coverage from X-ray to Radio (e.g. XMM, GALEX, WFCAM, Spitzer, VLA)
  – Follow-up Spectroscopy (for over 1000 galaxies)
  – ASC Treasury Program (Carter et al.)
- Important target as a local benchmark
  – Comparison with field, other clusters and high-z clusters

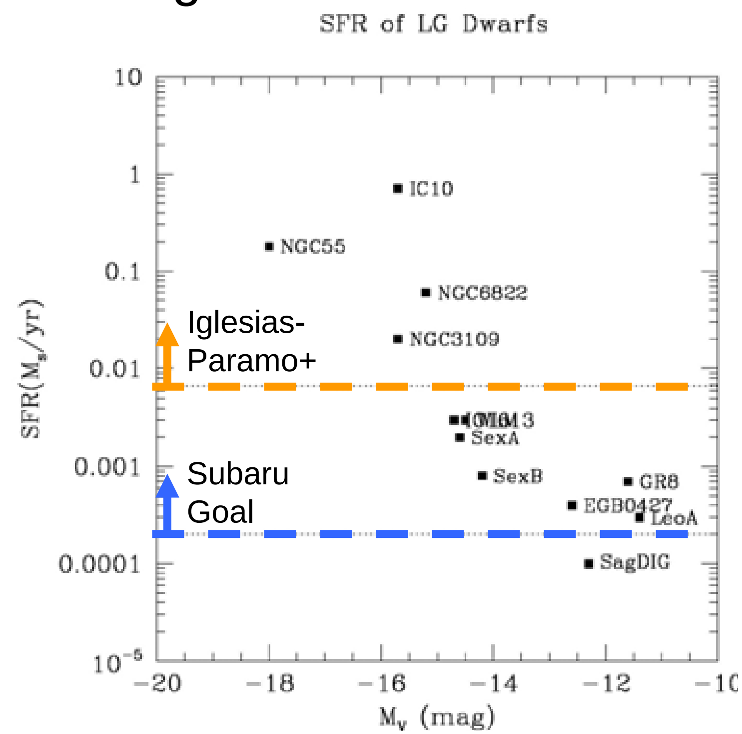




Hα Imaging of Galaxy Clusters

- Star formation activity of the cluster of galaxy
  - how significant faint dwarf population contribute to Hα LF
  - SFR of galaxies in different environment
- Hα observation was carried out for Coma and A1367 down to SFR of ~0.01 Ms/yr by Iglesias-Paramo et al. (2002)
  - Samples only active star-forming dwarf galaxies (e.g. NGC6822, NGC3109) and misses many less active galaxies



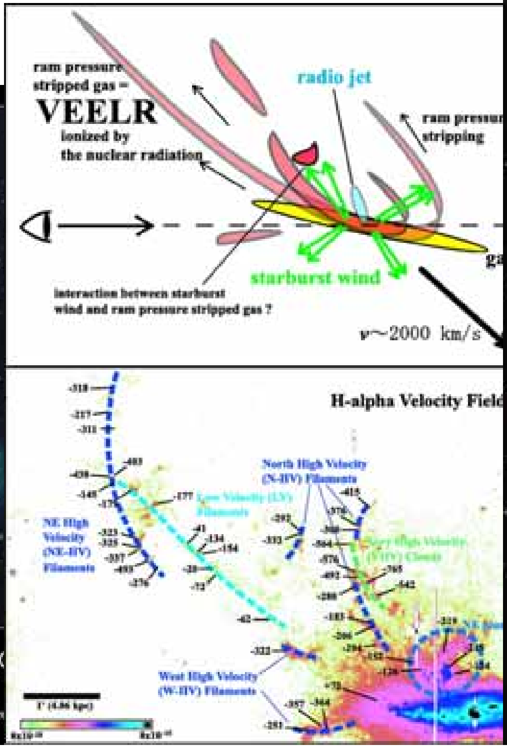


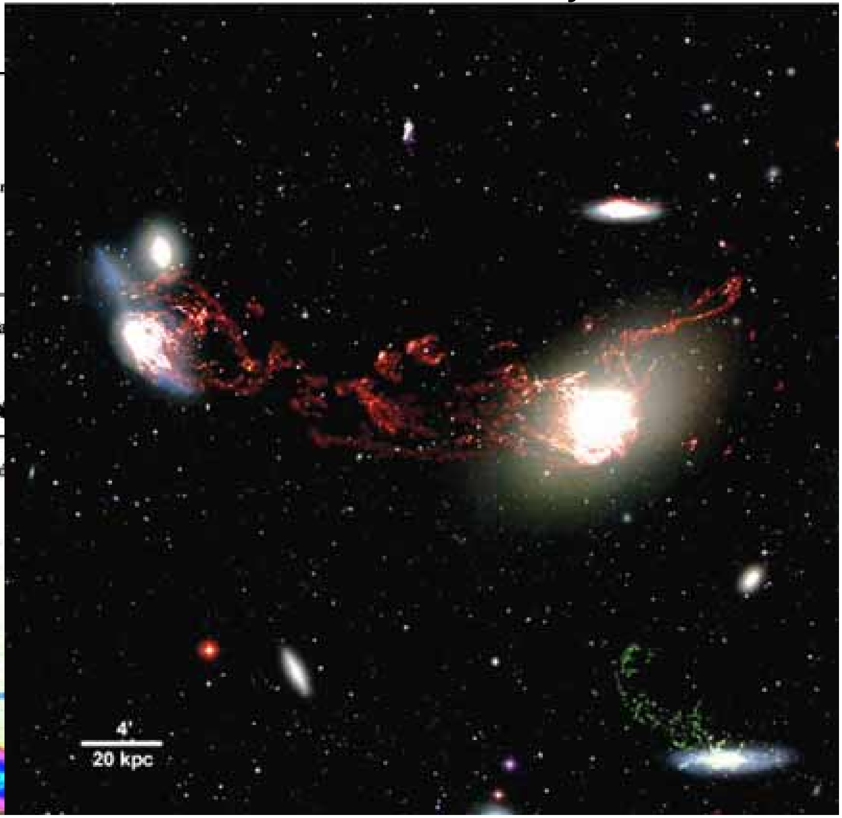
Hα Imaging of Galaxy Clusters

- Environmental processes
  - extended emission line regions found for NGC 4388 (Yoshida et al. 2002, 2004) and M86 (Kenney et al 2008) in the Virgo cluster
  - How rare? Dependence on environment ? Properties of host galaxy ?

Kenney et al. 2008

Yoshida et al. 2002, 2004

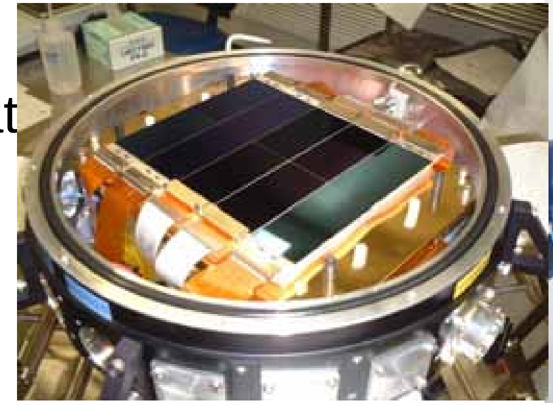




Suprime-Cam Hα Imaging Survey

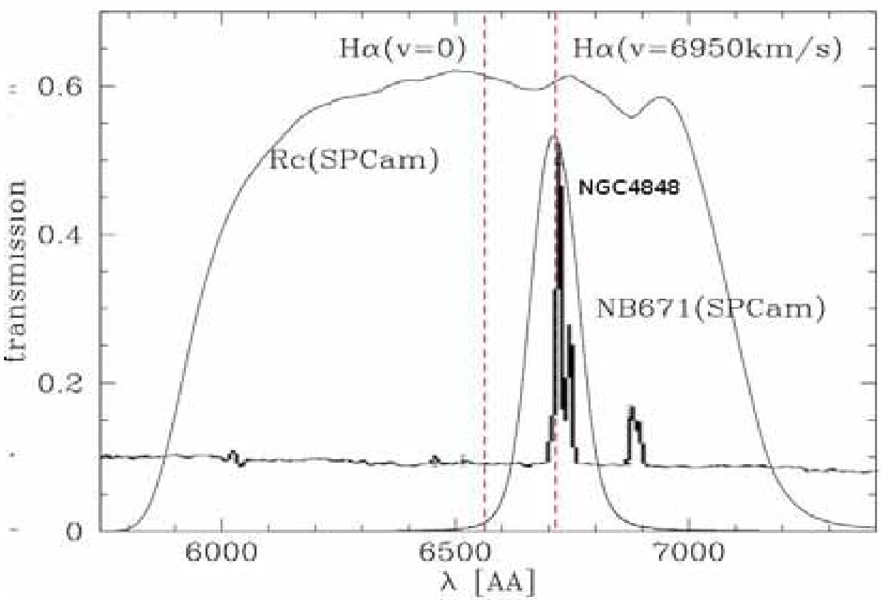
- Subaru Telescope provides us
  - sufficient survey depth by its 8.2m primary mirror
  - good image quality
    - Median seeing ~0".6 in R-band
    - Excellent tracking accuracy
- Suprimr-Cam provides us
  - wide-field survey capability:

    FoV 34x27 arcmin^2 covered by ten 2kx4k CCDs with 0".2/pixel sampling
  - dedicated narrow-band filter which samples Hα emission at the redshift of Coma



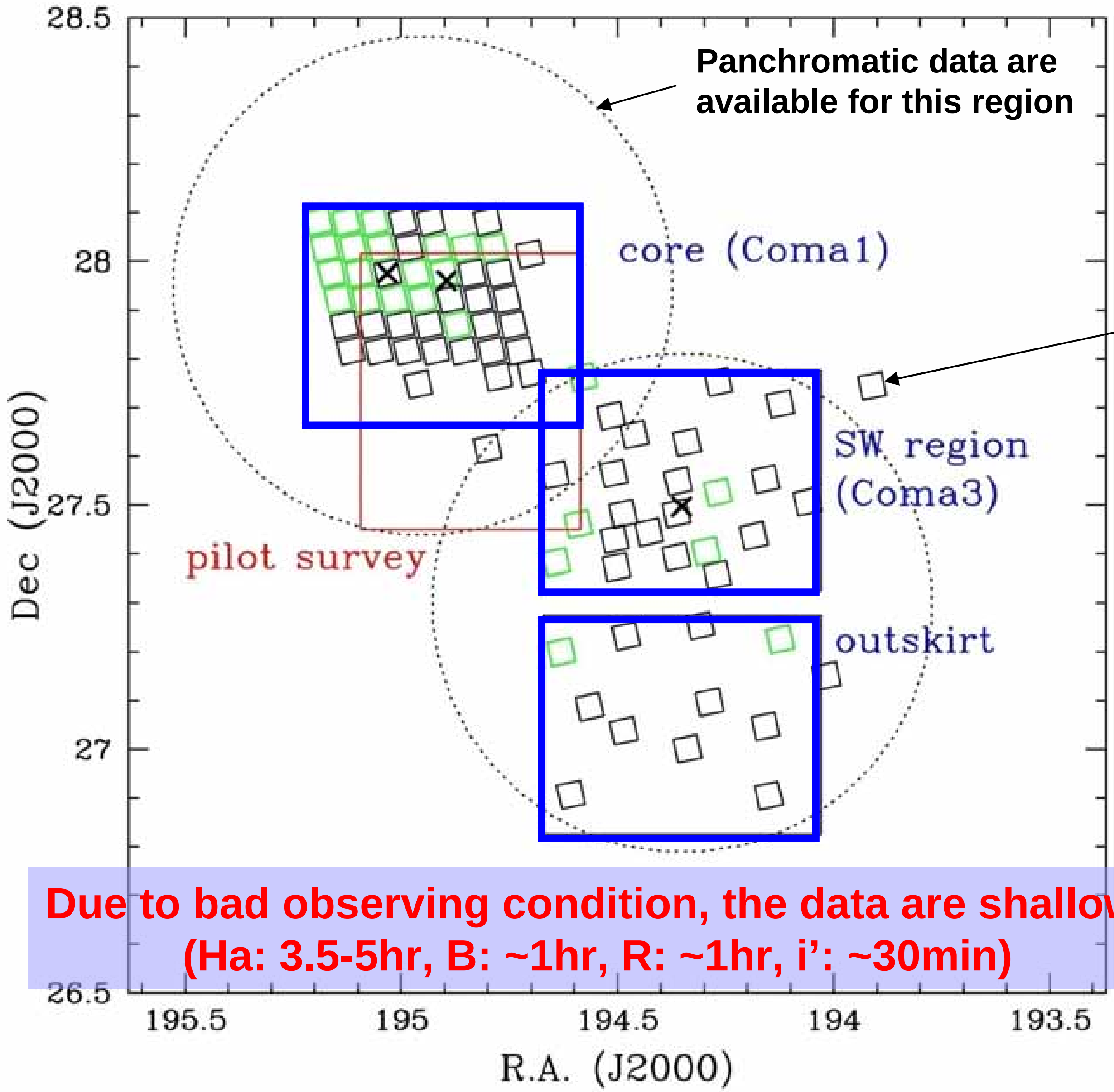
Suprime-Cam Hα Imaging Survey

- Narrow-band filter (NB671)
  - λc=6714A, FWHM=130A
  - sample H **α** line @ Coma redshift
  - goes as deep as 26.2 ABmag (6.0×10^{-18} erg/s/cm^2), corresponding to SFR of 2×10^{-4} Ms/yr
  - 2 order of magnitude deeper than Igresias-Paramo et al. (2002)
- 3 broad band filters: B, R, i’
  - continuum flux is estimated from weighted combination of B, R, i’-band fluxes
  - broad band colors are useful to discriminate distant [OIII] and [OII] emitting galaxies
- 3 different fields
  - cluster core, infalling region, outskirts



	Limiting Magnitude	Exposure Time (hr)
NB671(Hα)	26.2	6.0
B	28.0	1.9
R	27.4	1.0
i’	26.9	1.0

Suprime-Cam Hα Imaging



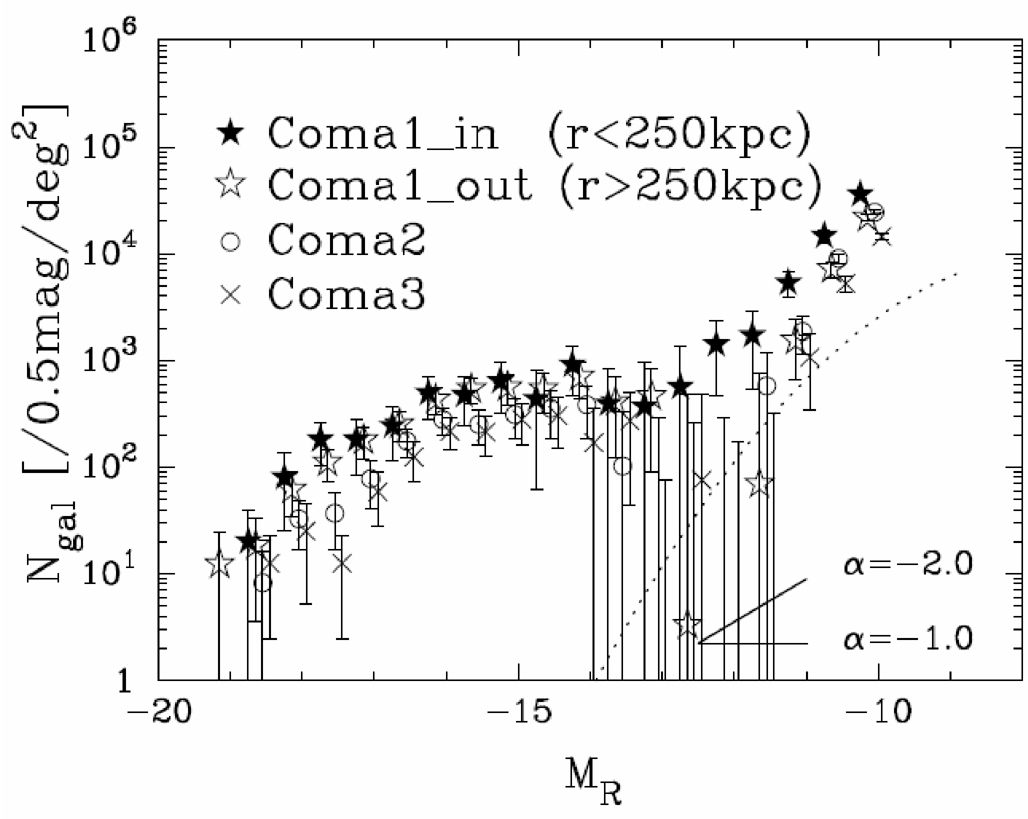
Observations:

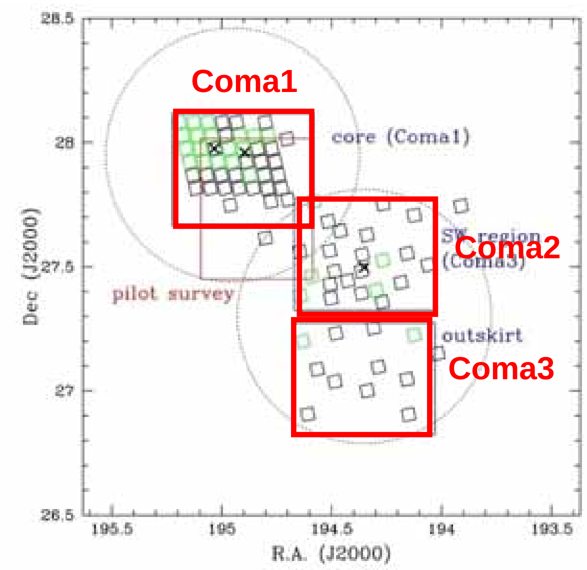
- Shallow Pilot Survey (2006)
- Main Survey for 3 fields (2007~2009)

Due to bad observing condition, the data are shallow (Ha: 3.5-5hr, B: ~1hr, R: ~1hr, i': ~30min)

Broad-band Luminosity Function

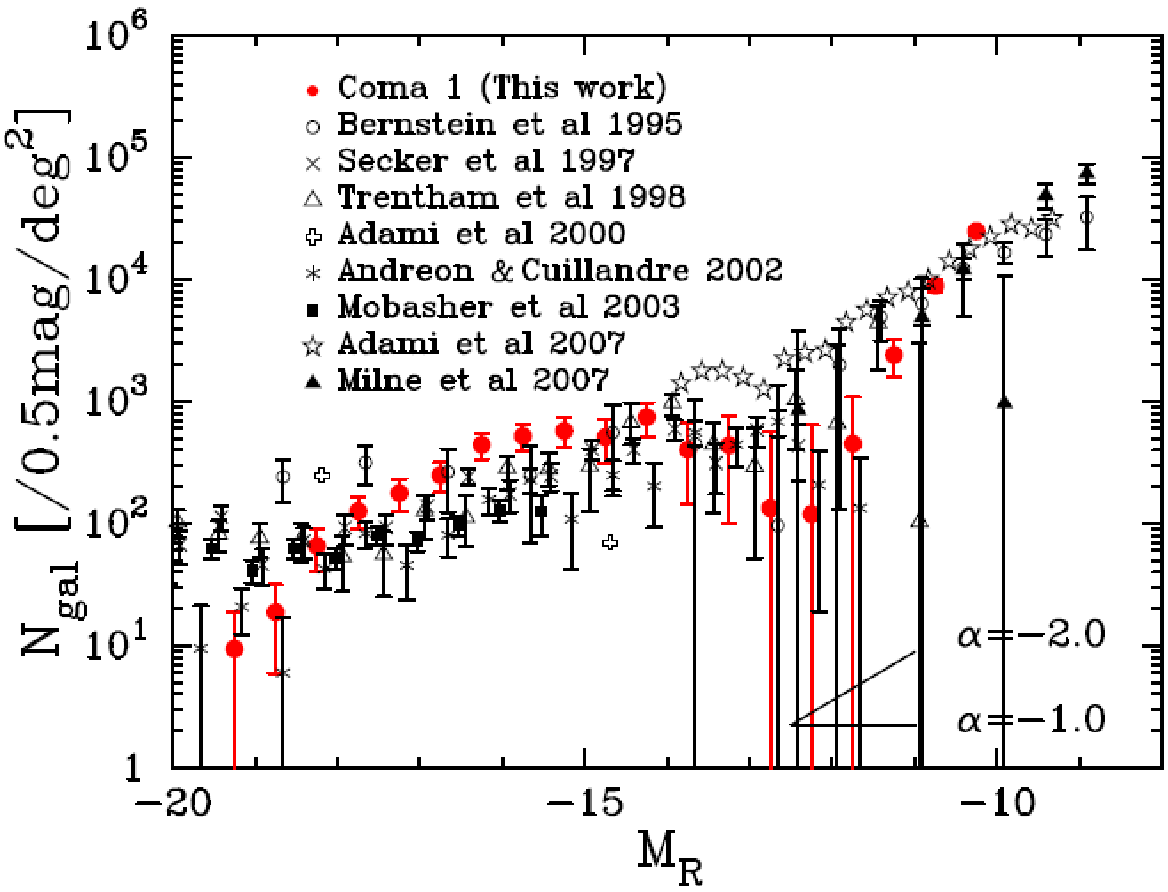
- Yamanoi et al. (in prep.)
  - B and R band LFs for three fields in different environment based on the statistical background subtraction
  - steep rise of faint-end slope of Schechter α ~ -2
  - no significant difference in faint-end slope between three fields.

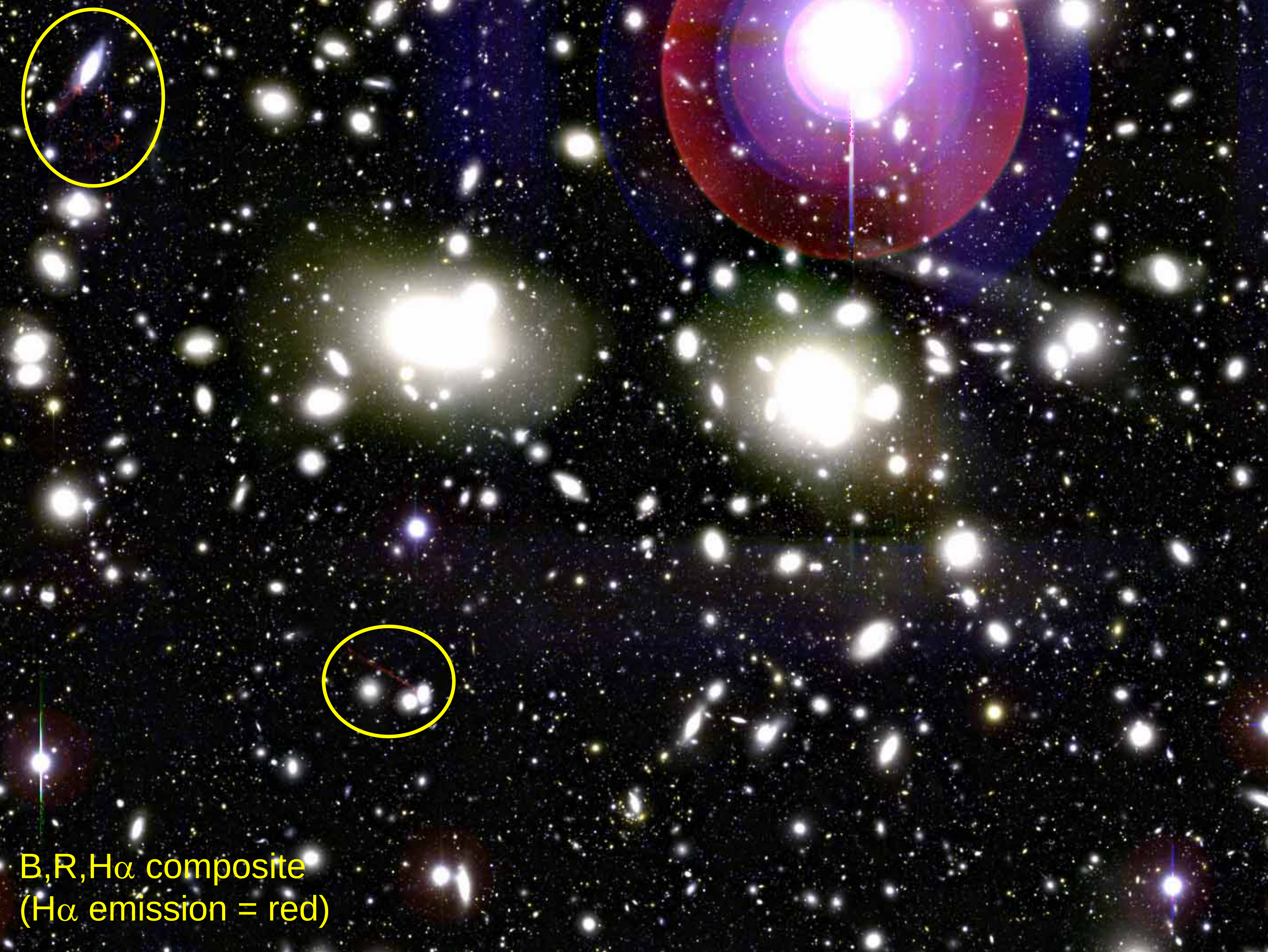




Broad-band Luminosity Function

- Comparison with Other Surveys
  - Confirms the steep faint-end slope reported by various authors (e.g. Milne et al. 2007, Adami et al. 2007)
  - Suggests that the faint-end slope is actually steep from the core to the outskirts of the cluster

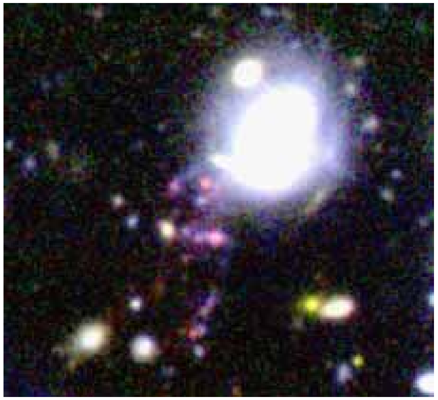


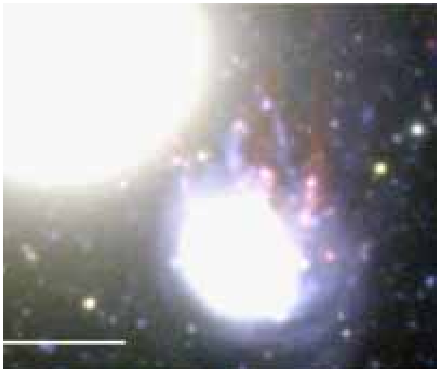

B,R,Hα composite
(Hα emission = red)

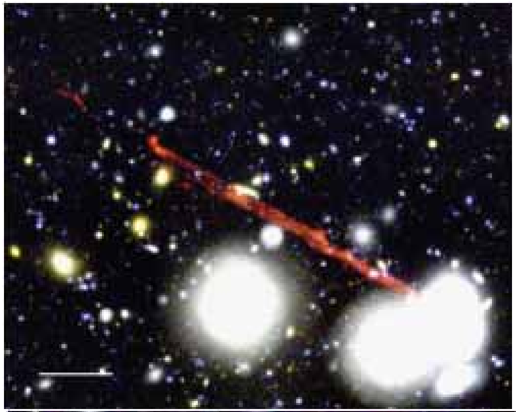
Extended Hα Emission Line Regions

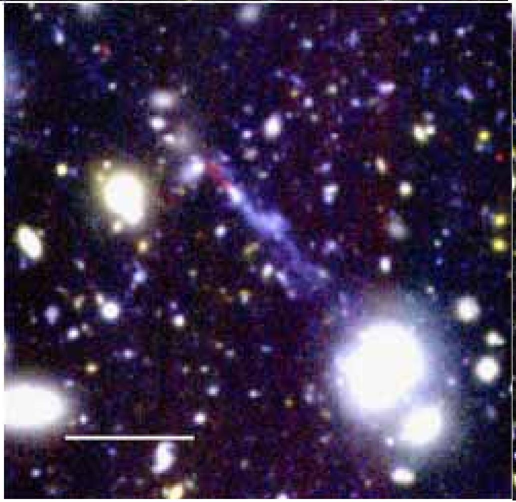
- 14 extended emission line regions are found for the cluster core field
  (Yagi et al. 2007, 2010; Yoshida et al. 2008)

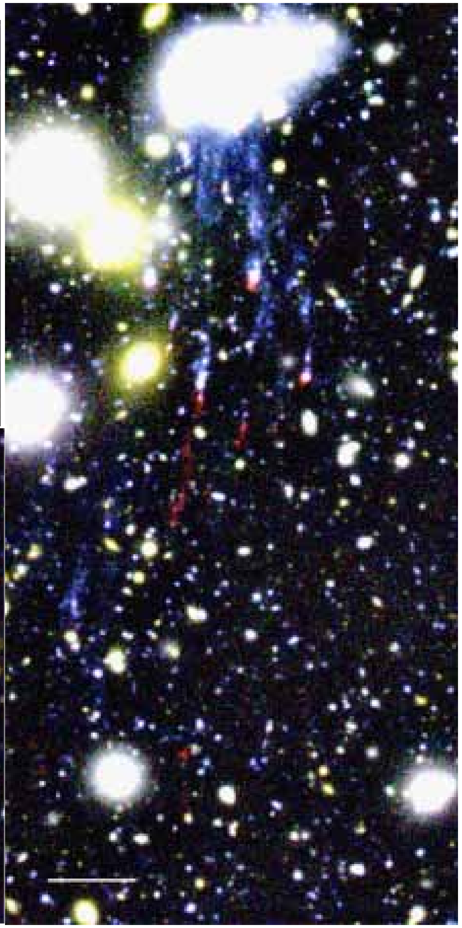
B,R,Hα composite
(Hα emission = red)





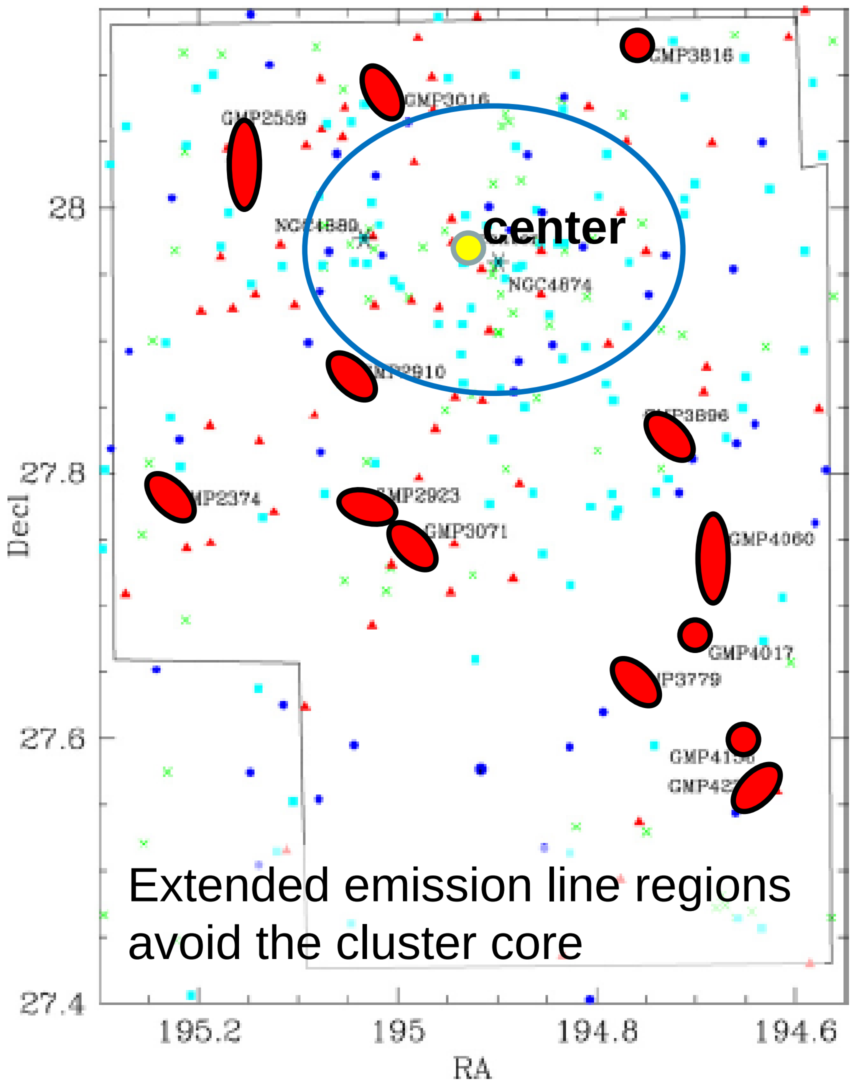




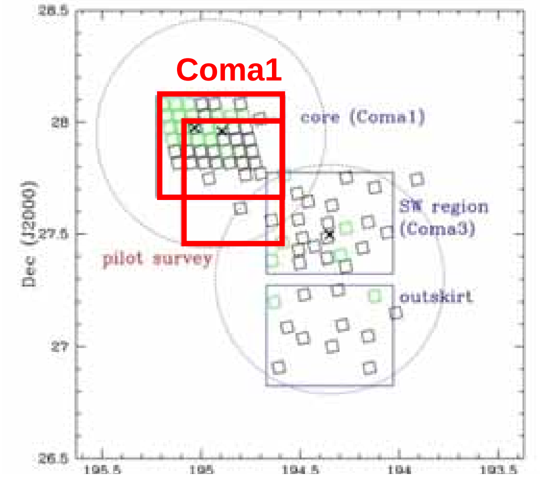


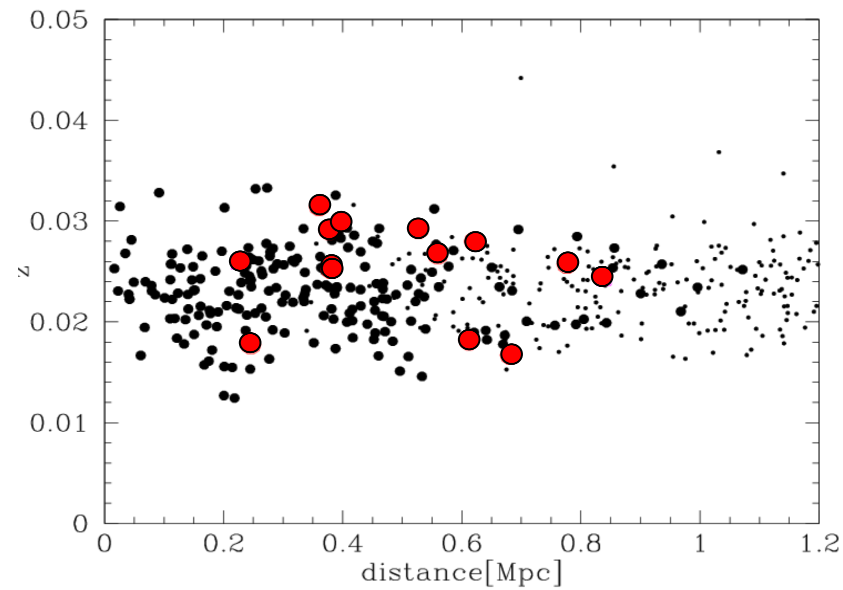
Extended Hα Emission Line Regions

- Spatial/Velocity Distribution



Extended emission line regions avoid the cluster core





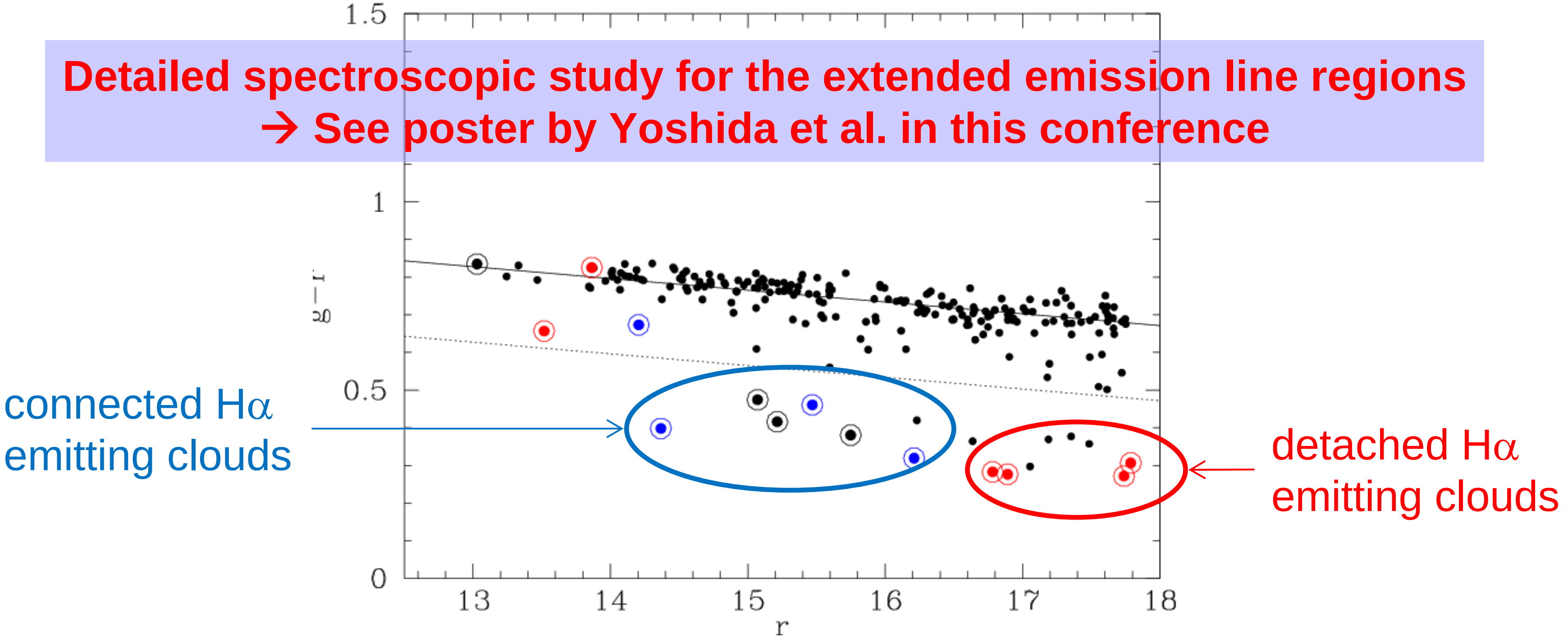
Parent galaxies reside near the red/blue edges of the distribution
(i.e. large velocities relative to the cluster)

Extended Hα Emission Line Regions

- Color Distribution
  - Most parent galaxies are blue (account for 57% of g-r<0.5, r<17.8 galaxies)
  - Less massive ones tend to have detached Hα emitting clouds and are in poststarburst phase
  - More massive ones tend to have connected Hα emitting clouds to the parents with starburst

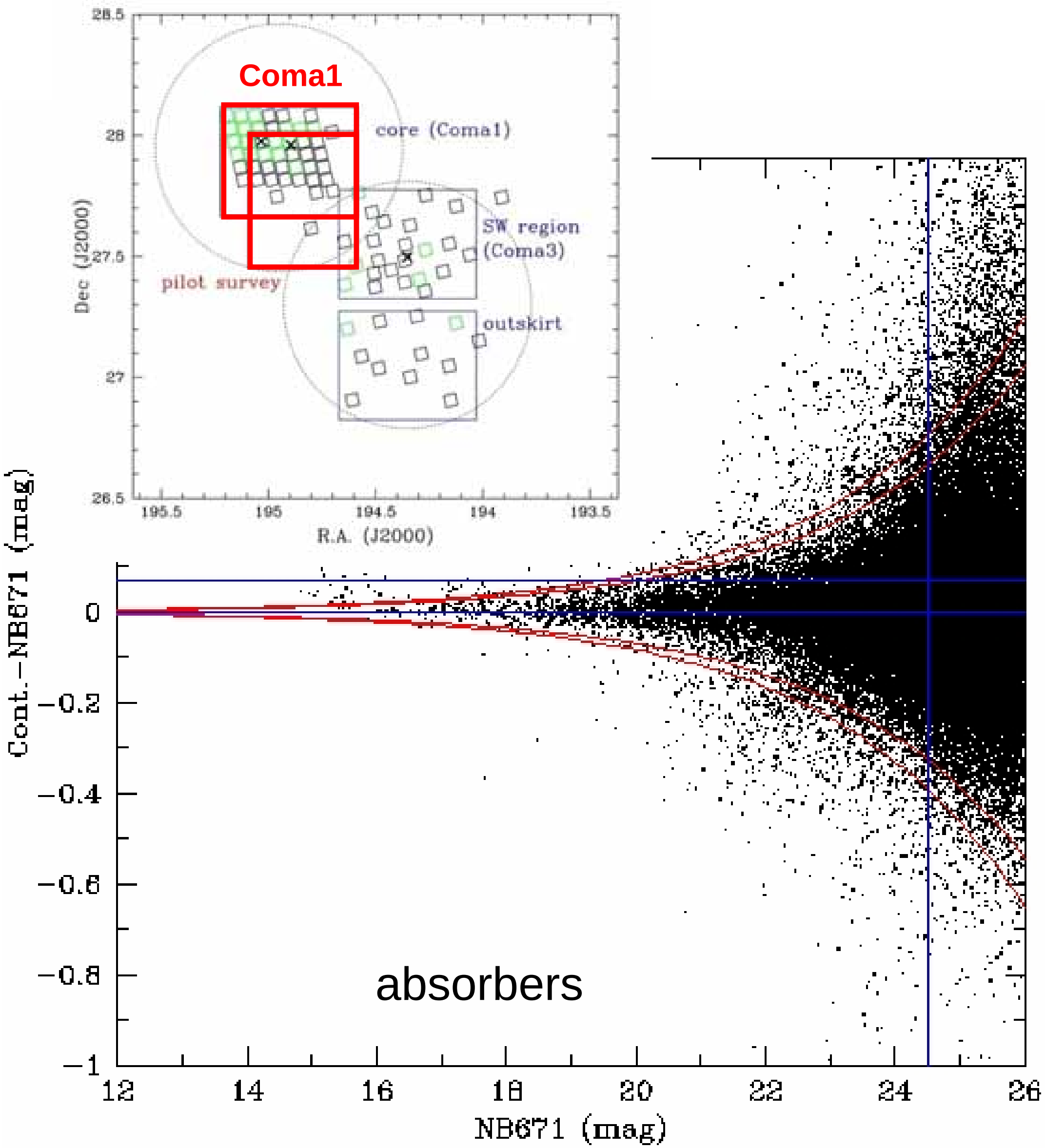
→We suggest that the parent galaxies are infalling into the cluster center with their gas being stripped off and forming the Hα emission line regions

Detailed spectroscopic study for the extended emission line regions
→ See poster by Yoshida et al. in this conference



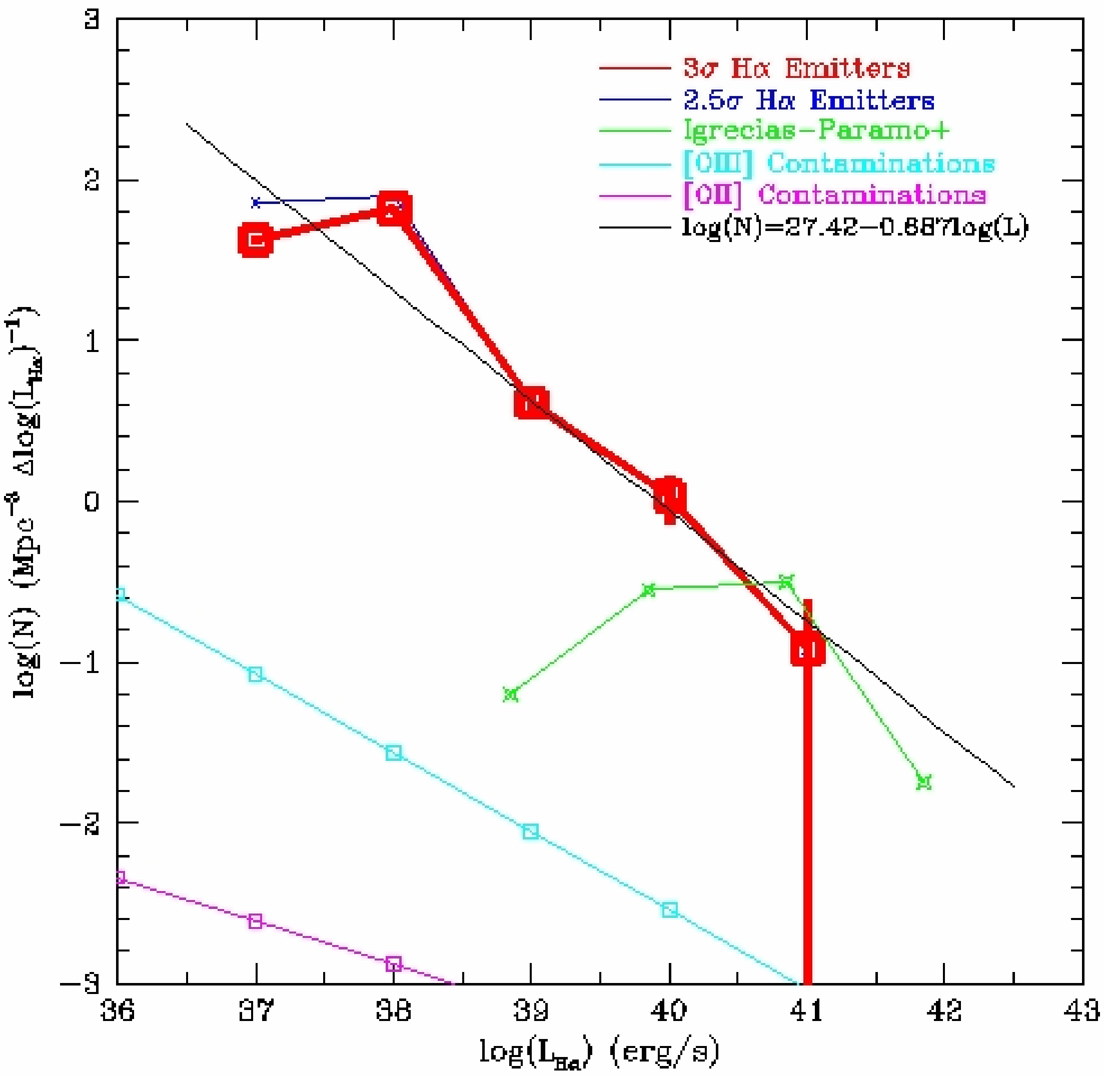
Hα Luminosity Function

- We analyzed cluster core field following the standard technique to derive the Hα luminosity function (e.g. Ly et al. 2007, Shioya et al. 2008)
- Sample Selection
  - Continuum flux is estimated from B,R,I fluxes
  - Cont.-NB671 > 0.07 (EW>10A)
  - Cont.-NB671 > 3σ
  - NB671<24.5
- No [NII] contamination correction nor internal absorption correction is applied at this moment



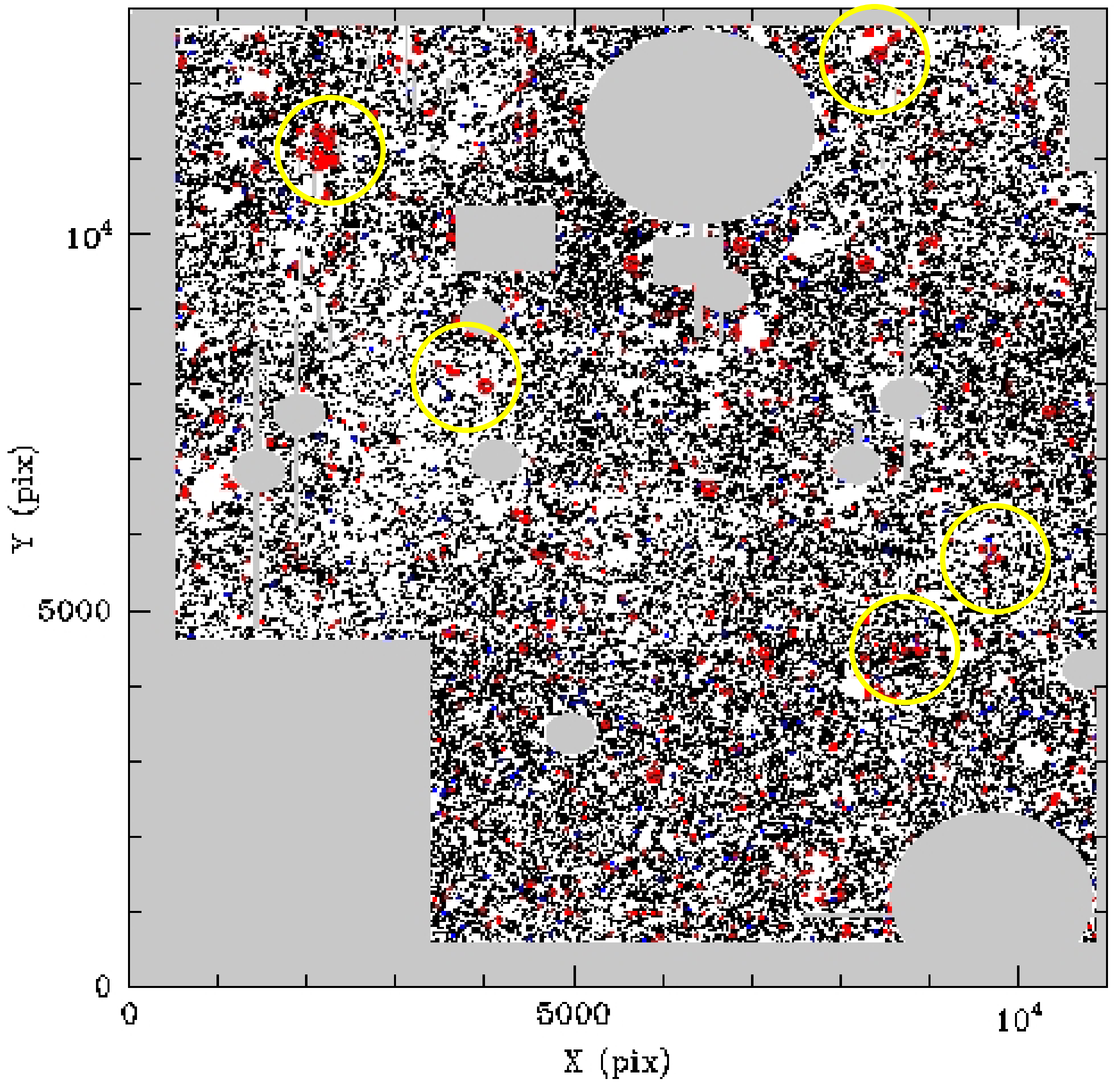
Hα Luminosity Function

- Hα LF shows monotonic rise for less luminous range
  - d(logN)/d(logL) ~ -0.7 corresponding to α ~ -1.7
- Contamination from background [OIII], [OII] emitters
  - Estimated from [OIII] and [OII] emitter luminosity function for NB704 (Ly et al. 2007)
  - Can be negligible
- Contamination from intra-cluster PNe
  - Estimated from PNe in Sextans A, B (Magrini+ 2005)
  - Hα+[NII]~10^(34~35) erg/s: can be negligible(?)



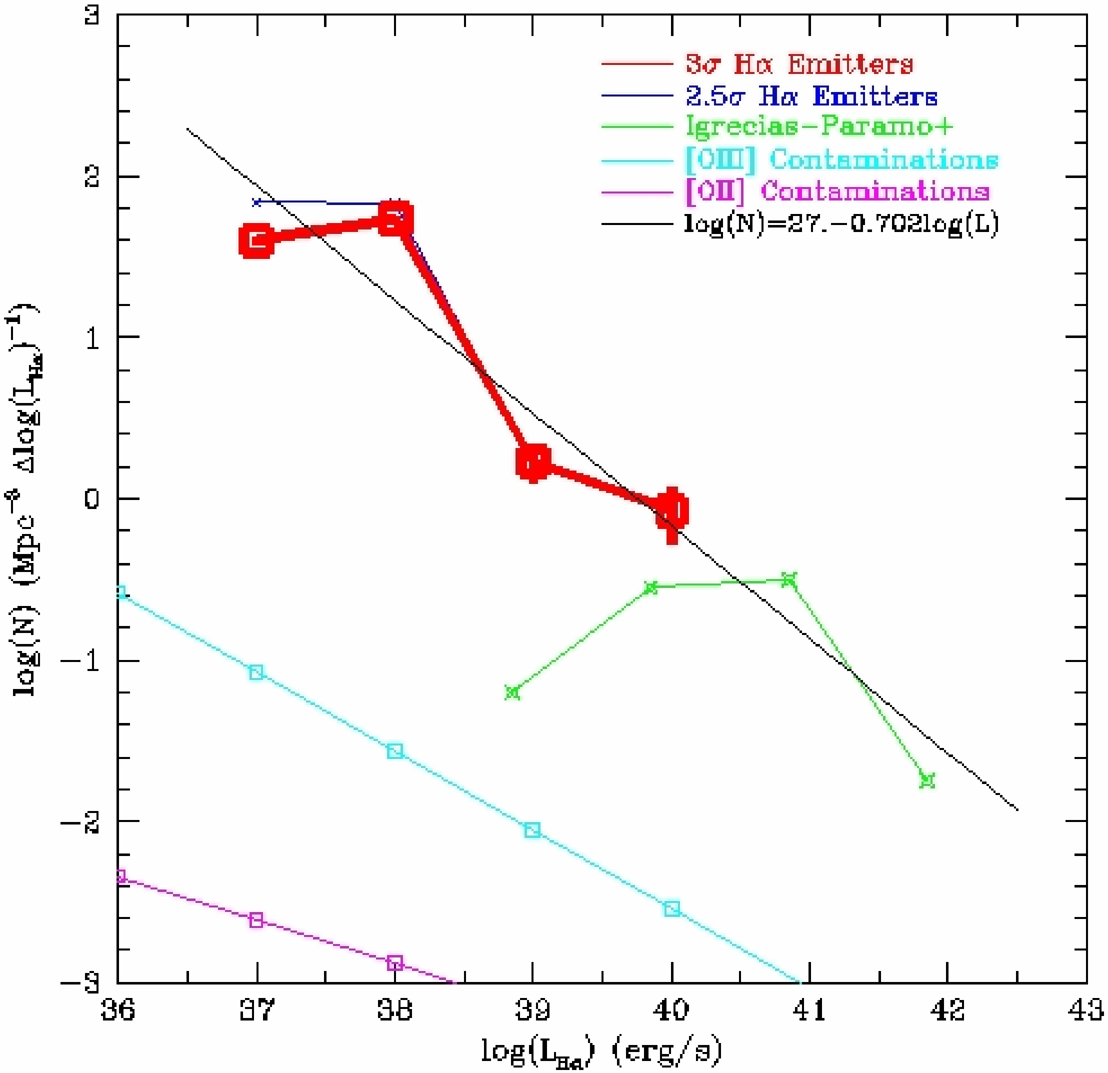
Hα Luminosity Function

- Spatial Distribution
  - There are some regions where Hα emitters are concentrated
  - Some of them are associated with extended emission line regions listed by Yagi et al. (2010)



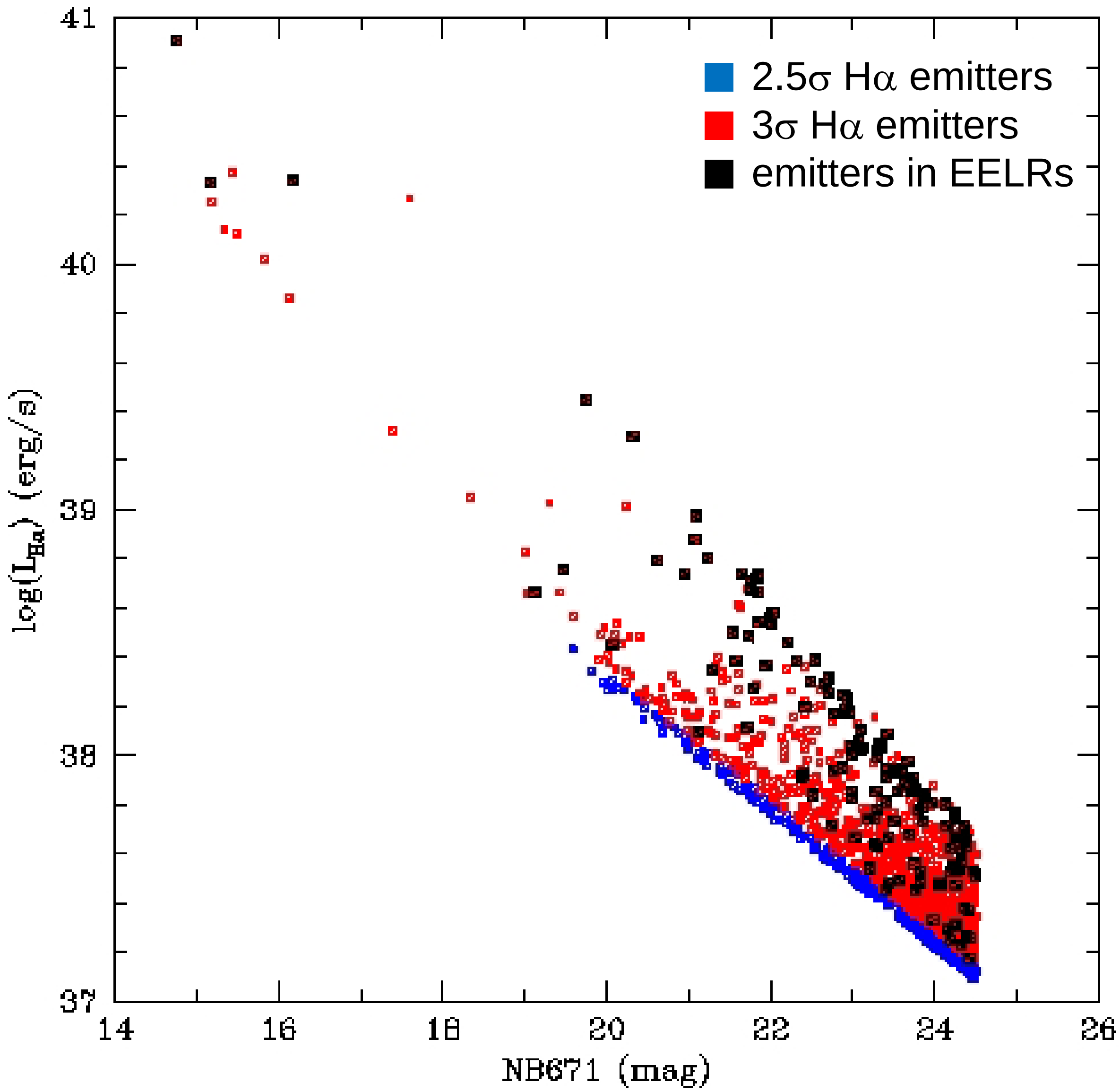
Hα Luminosity Function

- Hα emitting objects found around extended emission line regions (EELR, Yagi et al. 2010) account for bright part of Hα LF
- Even if those objects are excluded, the faint-end slope remains unchanged.
  - d(logN)/d(logL) ~ -0.7



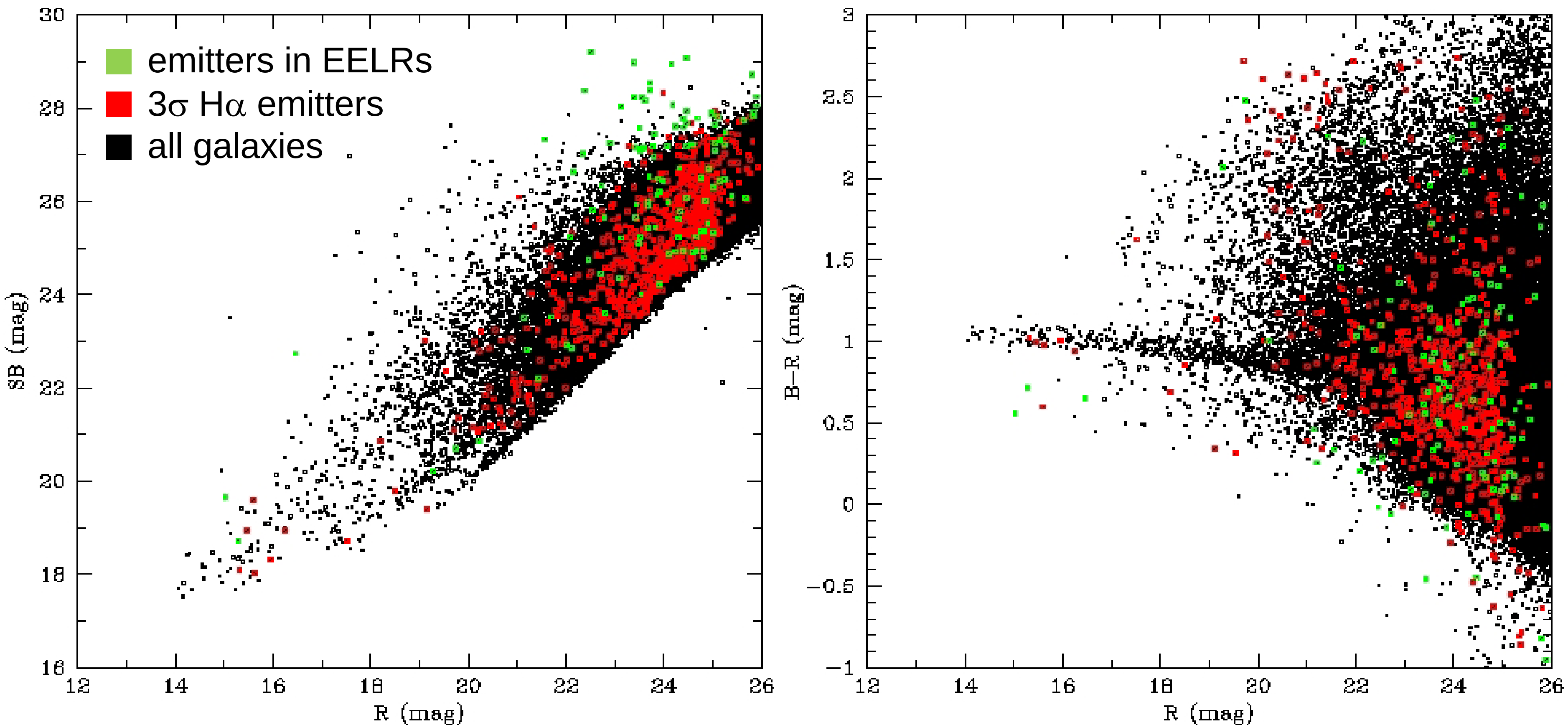
Nature of Faint Hα Emitting Objects

- Hα luminosity decreases as NB magnitude goes faint
- dlogL(Hα) ~ 1 at a given magnitude
- Hα emitters in extended emission line regions (EELR) always have higher Hα luminosity at a given magnitude



Nature of Faint Hα Emitting Objects

- Surface Brightness
  - Hα emitters in EELRs are on average lower surface brightness (i.e., more extended) at a given magnitude
- Broad-band Color
  - Although the fraction of blue objects is high, Hα emitters are not always blue



Summary

- Broad-band Luminosity Function
  - shows steep rise of faint-end slope of Schechter α ~ -2
  - no significant difference in faint-end slope between three fields.
  - confirms the steep faint-end slope reported by various authors (e.g. Milne et al. 2007, Adami et al. 2007)
  - suggests that the faint-end slope is actually steep from the core to the outskirts of the cluster
- Extended Hα Emission Line Regions
  - parent galaxies with emission line regions avoid the cluster core and reside near the red/blue edges of the distribution
  - suggests that the parent galaxies are infalling into the cluster center with their gas being stripped off and forming the Hα emission line regions
- Hα Luminosity Function
  - shows monotonic rise for less luminous range
  - d(logN)/d(logL) ~ -0.7, corresponding to α ~ -1.7
  - Hα emitters in EELRs always have higher Hα luminosity at a given magnitude and are lower surface brightness objects