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INAF - Istituto Nazionale di Astrofisica

Osservatorio Astronomico di Padova



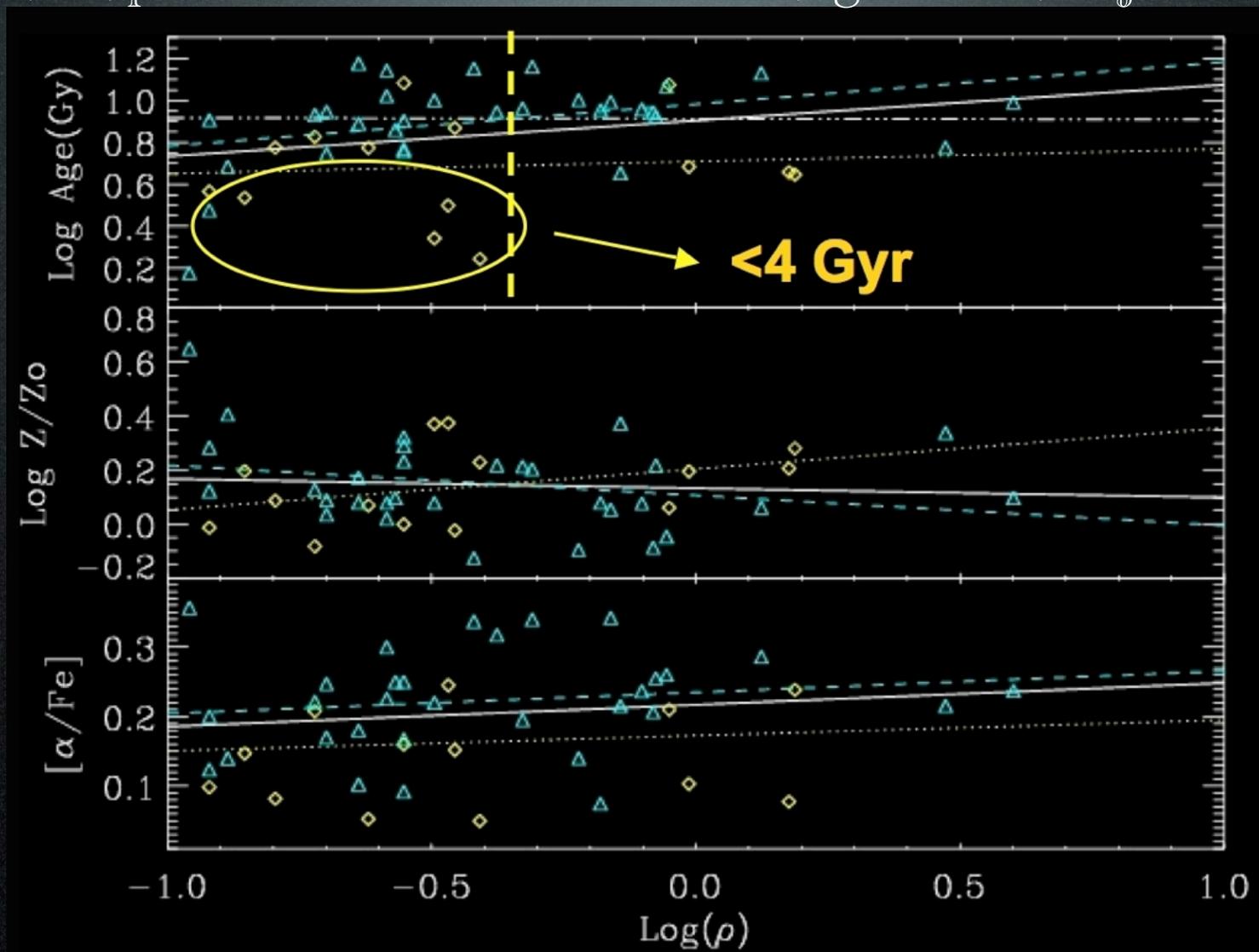
Study of early-type galaxies in low density environments An archeological approach

Roberto Rampazzo

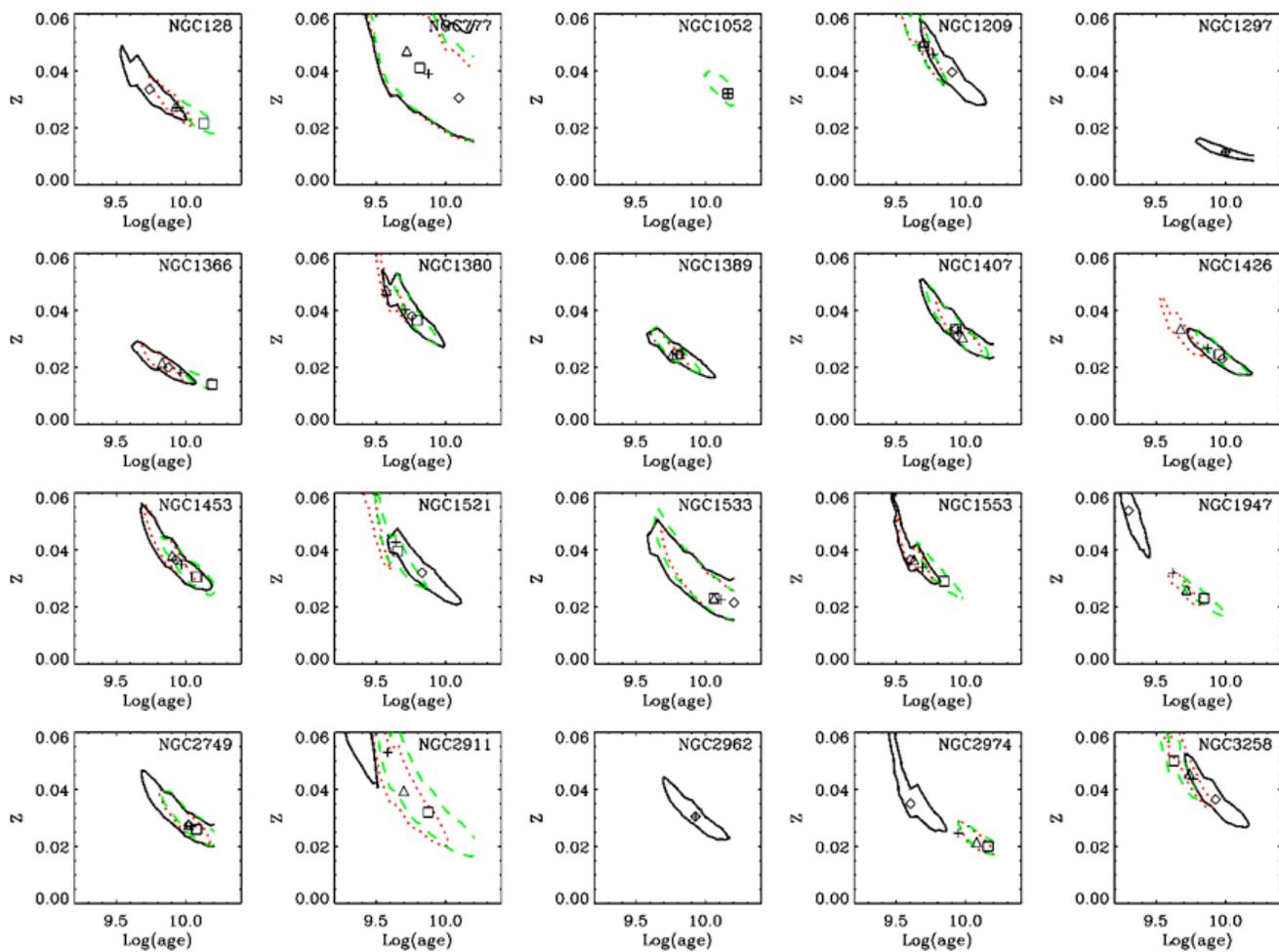
D. Bettoni, L.M. Buson, A. Bressan, M. Clemens, G.L. Granato, E.V. Held, A. Marino (INAF-OAPD)
C. Chiosi, G. Galletta, R. Tantalo (Univ. Padova)
L. Longhetti, G. Trinchieri (INAF - Brera-Milano)
P. Alexander (Cavendish Lab., Cambridge, UK)
F. Annibali (StScl, Baltimore USA)
P. Amram, J. Boulesteix, J-L. Gach, M. Marcelin (Obs. Astron. LAM, Marseille, France)
L. Bianchi (JHU, Baltimore, USA)
C. Carignan, O. Hernandez (Univ. de Montreal, Canada)
R. Grutzbauch, W.W. Zeilinger (IfA, Univ. Wien, Austria)
B. Nikolic (NRAO, Charlottesville, USA)
P. Panuzzo (CEA, Saclay, France)
H. Plana (Univ. Estadual de S. Cruz, BA, Brazil)
R.M. Rich (UCLA, Los Angeles, USA)
L. Rizzi (Univ. Hawaii, USA)
M. Rosado (UNAM, Mexico DF, Mexico)
K. Sheth (Caltech, Pasadena, USA)
J.W. Sulentic (Univ. Alabama, Tuscaloosa)
J.R. Valdes (INAOE, Puebla, Mexico)
O. Vega (INAOE, Puebla, Mexico)

1. Early-Type Galaxies in LDE: are they genuinely rejuvenated ?
2. A case study: the evolution of the E+S pairs environment
3. The warm (10^4 K) IGM with 3D-NTT (& company)

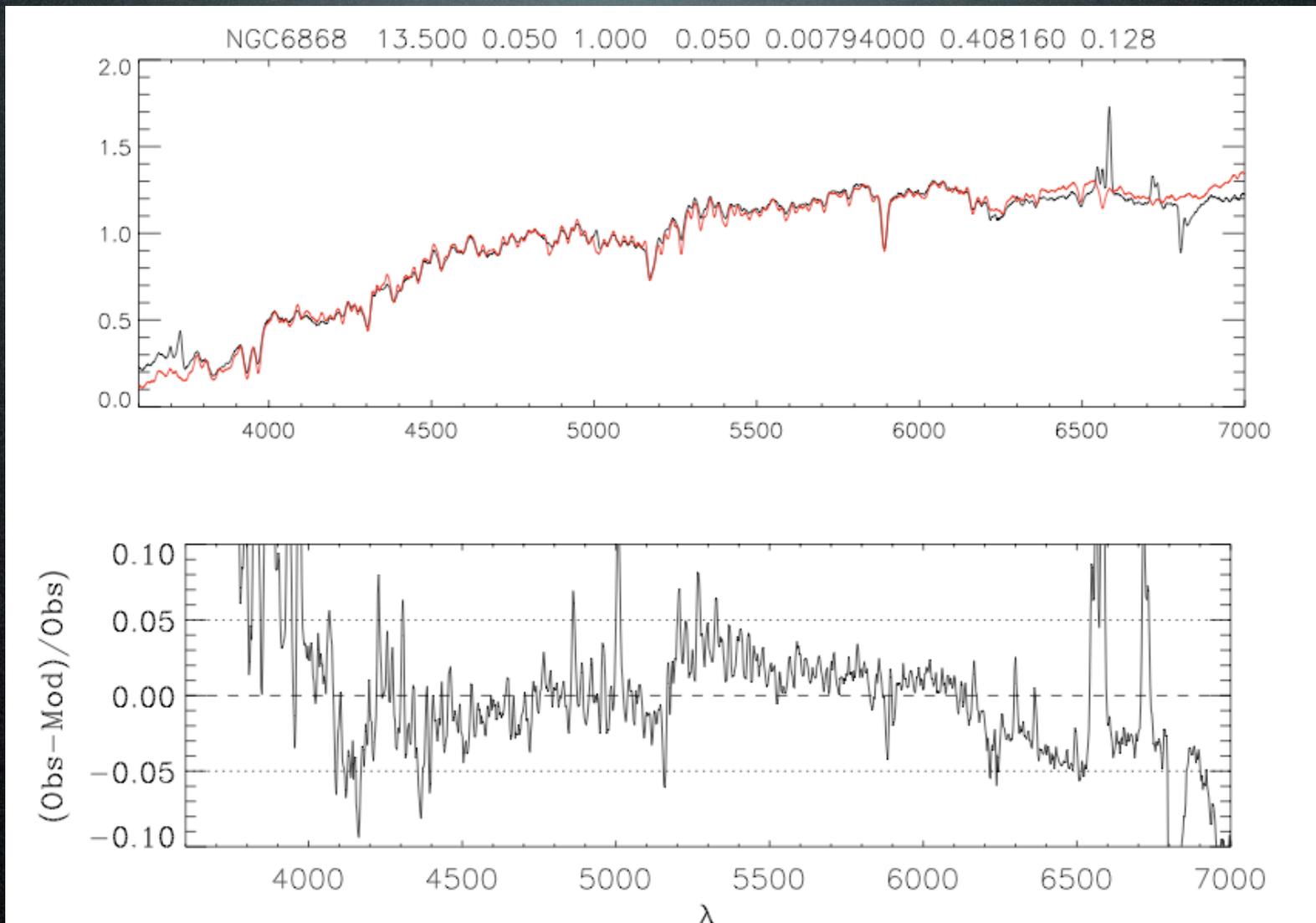
1. Early-Type Galaxies in LDE: are they genuinely rejuvenated ?



Ages, metallicities and $[\alpha/\text{Fe}]$ ratios measured at $r_e/8$ vs. the density of the environment, $\log \rho$ [gal Mpc^{-3} brighter than $M_B = -16$, considered 2189 galaxies within 40 Mpc] (Tully 1988). Triangles and diamonds indicate E and SO galaxies respectively. The solid line is the linear fit performed to all the galaxies. Dashed and dotted lines are the best fit to E and SO sub-samples. (Annibali, Bressan, Rampazzo, Zeilinger & Danese 2007, *A&A*, 463, 455).



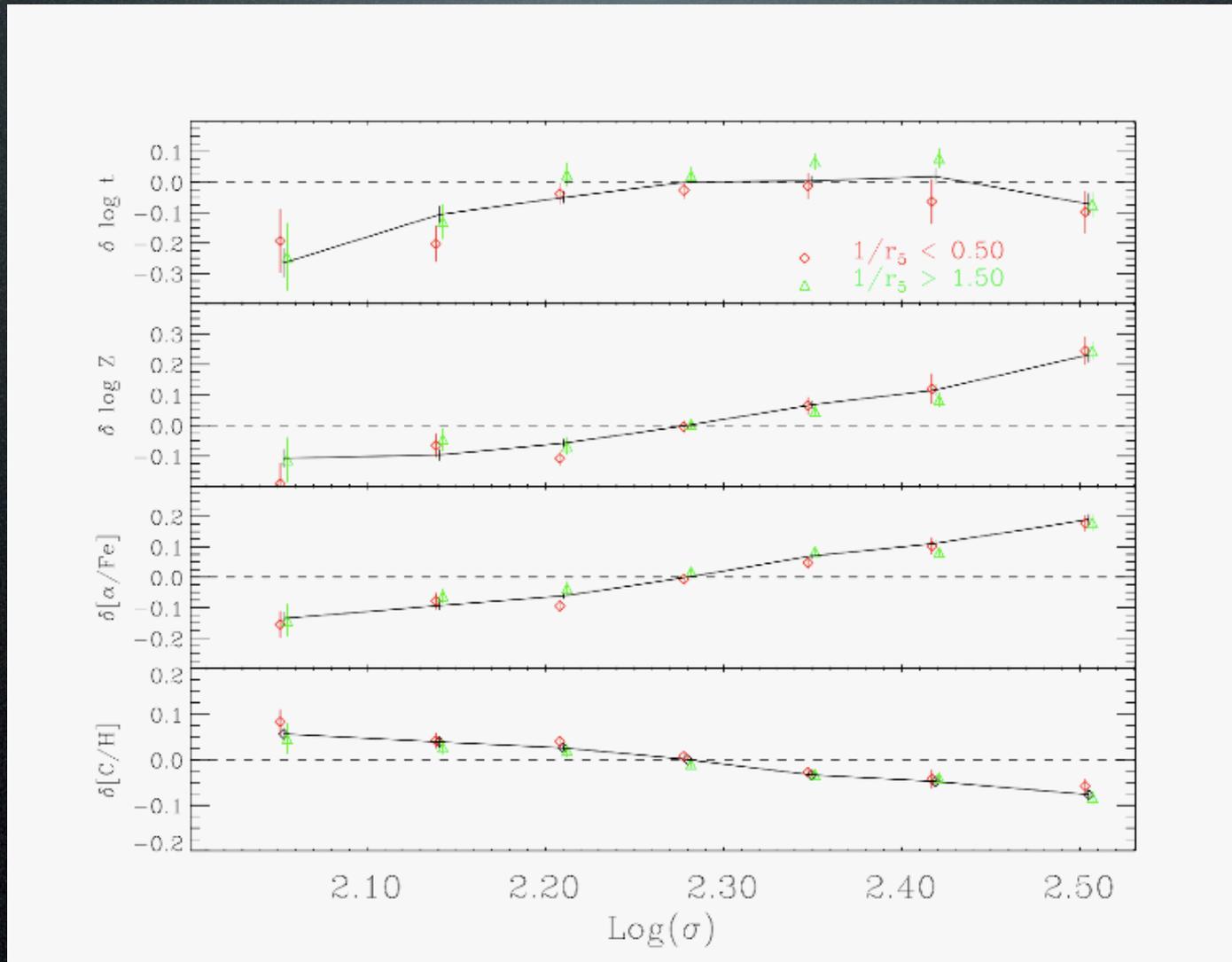
Example of contour levels enclosing solutions that are within one σ from the observed value. Black solid lines are for $(H\beta, \langle Fe \rangle, Mg_b)$ triplets, red dotted lines for the $(H\gamma_f, \langle Fe \rangle, Mg_b)$ triplets and green dashed lines for the $(H\delta_f, \langle Fe \rangle, Mg_b)$ triplets. Diamonds, triangles and squares refer to the most probable solution for each triplet, while cross indicates the average of the logarithmic values of the solutions.



(top panel) Observed (black) and synthetic spectrum obtained as a mix of and old (13.5 Gyr) and a young (1 Gyr) SSP .

(bottom panel) Difference between the observed and the synthetic spectrum.

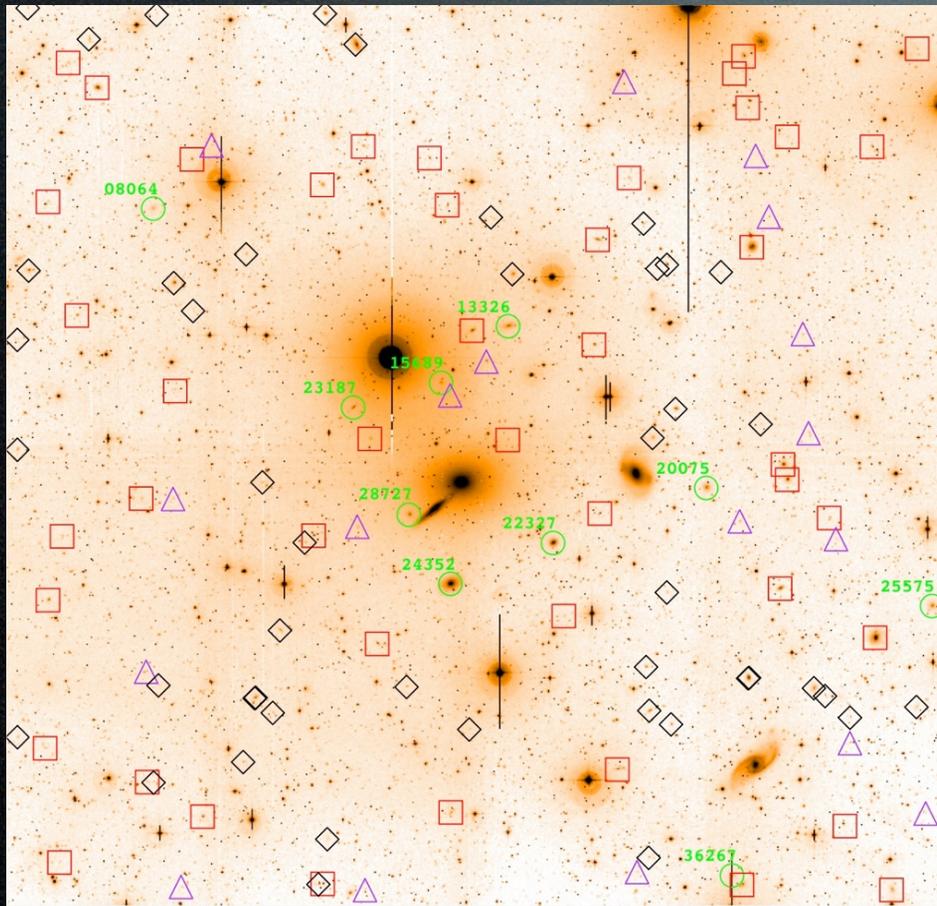
from SLOAN DSS



Age, metallicity, α -enhancement and carbon enhancement variations as a function of velocity dispersion. A linear regression analysis has been carried out simultaneously on the $\text{H}\beta$, $\text{H}\delta$, $\text{Mg}1$, $\text{Mg}2$, $\text{Mg}b$, $\text{Fe}4383$, $\text{Fe}4531$, $\text{Fe}5270$, $\text{Fe}5335$, $\text{G}4300$ and $\text{C}4668$ indices. The solid line represents the entire sample, diamonds only those objects in low density environments ($1/r_5 < 0.5$) and triangles only those in high density environments ($1/r_5 > 1.5$). Values are differences with respect to those of the entire sample at a velocity dispersion of 200 km s^{-1} (Clemens, Bressan, Nikolic, Alexander, Annibali & Rampazzo 2006, MNRAS, 370, 702).

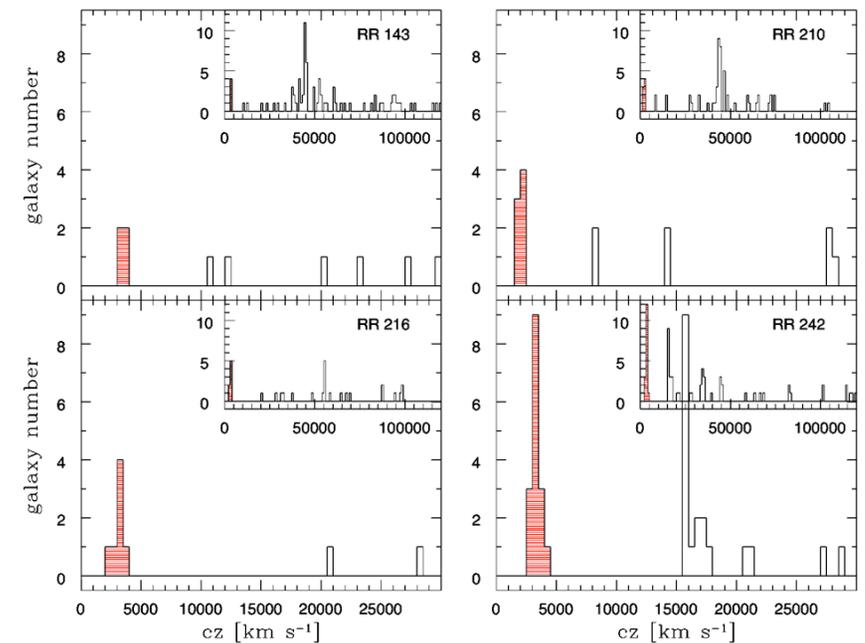
2. A case study: evolution of the E+S pairs environment

Great laboratories to explore the relations $\log s$ - Age, $\log s$ - Z and $\log s$ - $[a/Fe]$ in the E+S Environment from giant ETGs to faint companions.

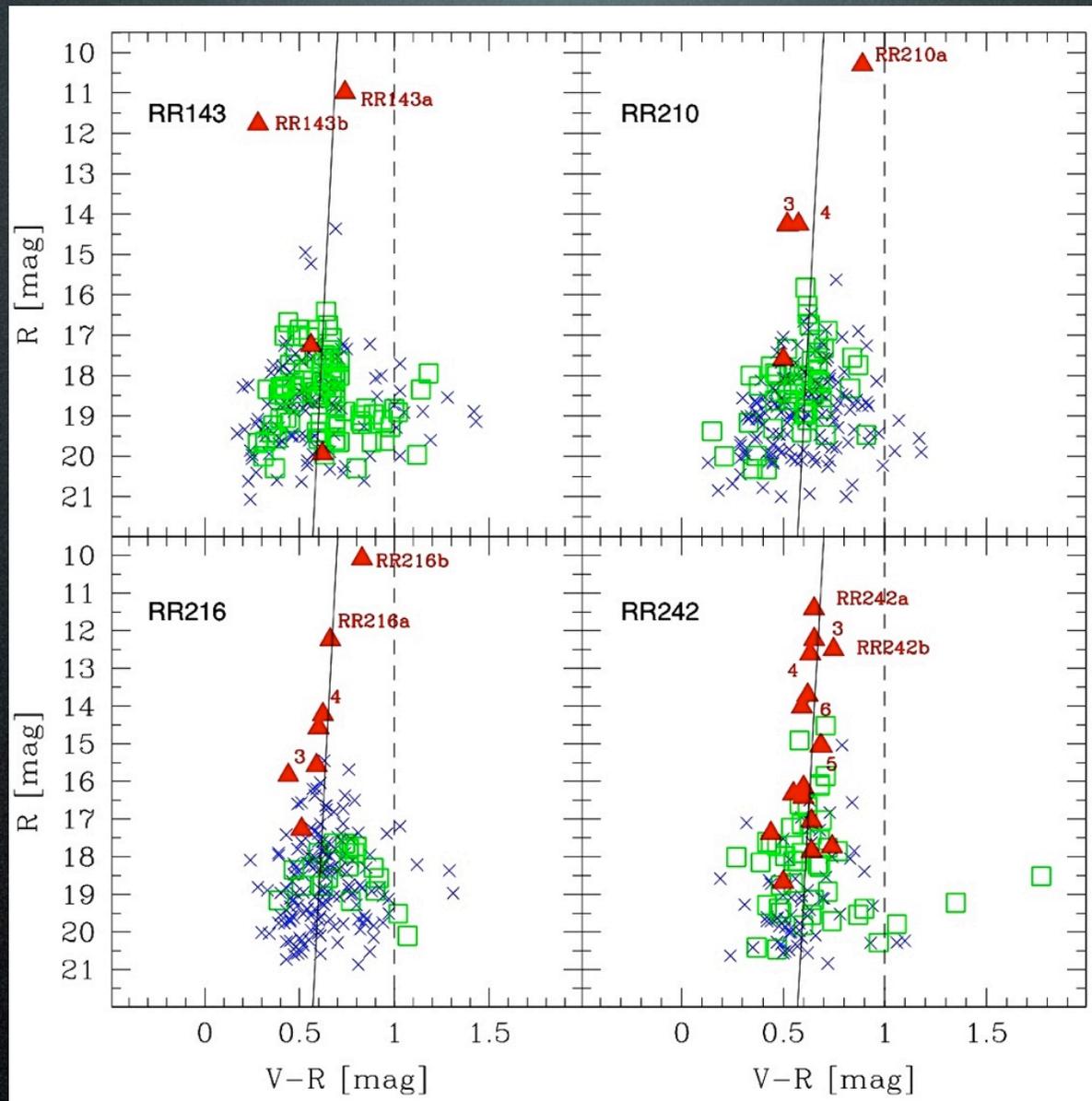


Results of VLT-VIMOS observations. Members of the E+S group RR 242 (in green) superposed to the WFI frame. Marked with different symbols are: background galaxies (red squares), objects too faint to measure a redshift (blue triangles) and un-observed objects (black diamonds) ((Grutzbauch et al. 2007, *AJ*, 133, 220; Grutzbauch et al. 2008 in preparation).

We identify faint galaxies with 2.2 ESO + WFI and measured their redshifts with VLT-VIMOS. We cover on the average an area of about $0.2 h^{-1}_{100}$ Mpc.

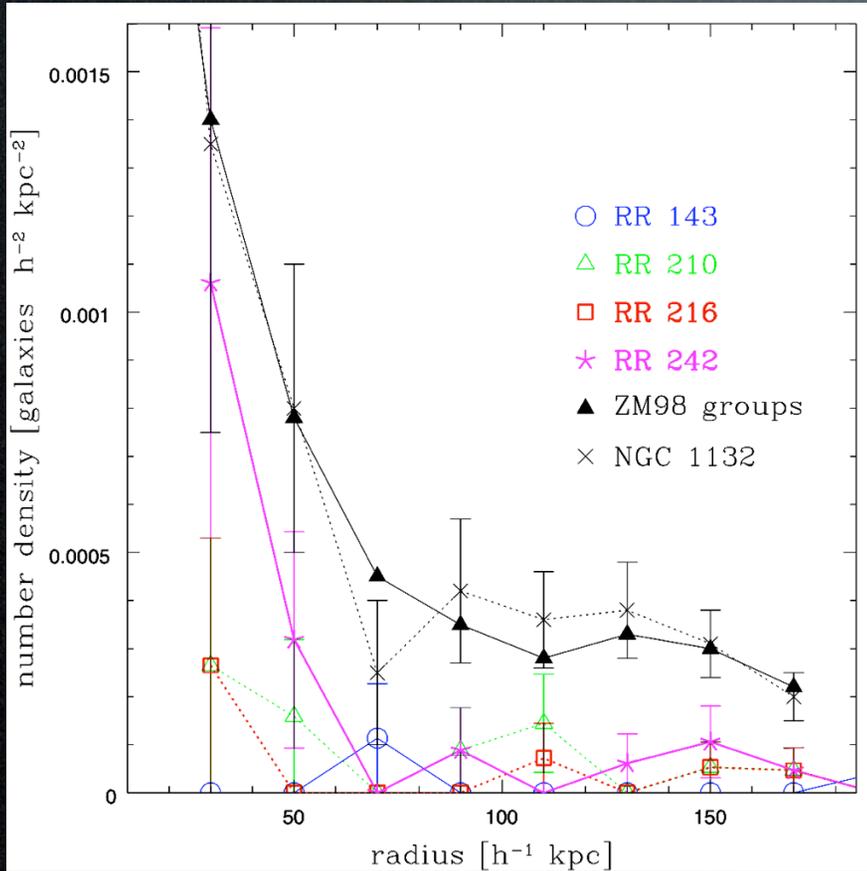


Results of VLT-VIMOS observations. The redshift distribution within the WFI FOV.

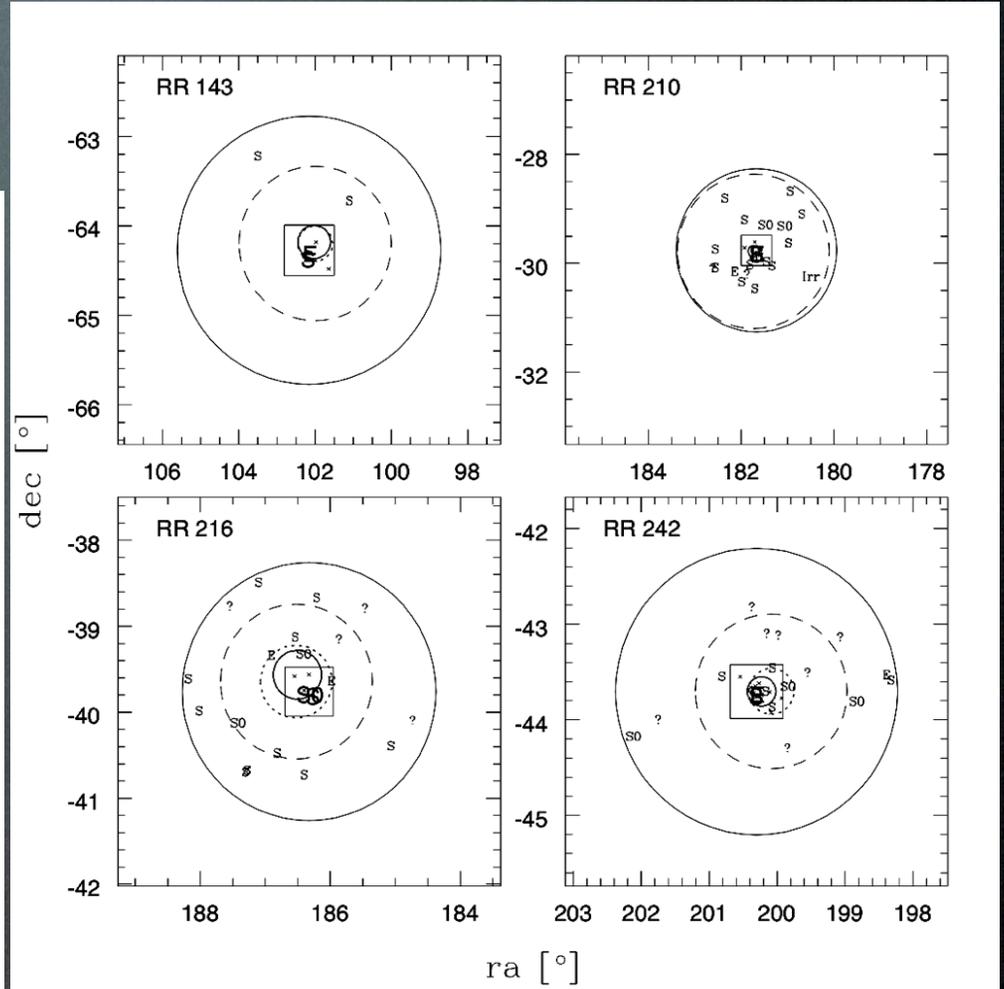


($V-R$) color-magnitude relation for four E+S pairs/groups. The solid line is the color-magnitude relation for the Virgo Cluster (shifted to the pair redshift), while the dashed line represents the color restriction at $(V-R)=1$ applied to exclude background objects. The spectroscopically confirmed members are indicated with red triangles. Objects indicated with crosses are candidate galaxies in the WFI field, squares are candidates, inspected using VLT-VIMOS, not related to the groups.

The E member dominates the group: in RR 143 and RR 210 it represents 1/2 of the total light and about 1/3 in RR 216 and RR 242.

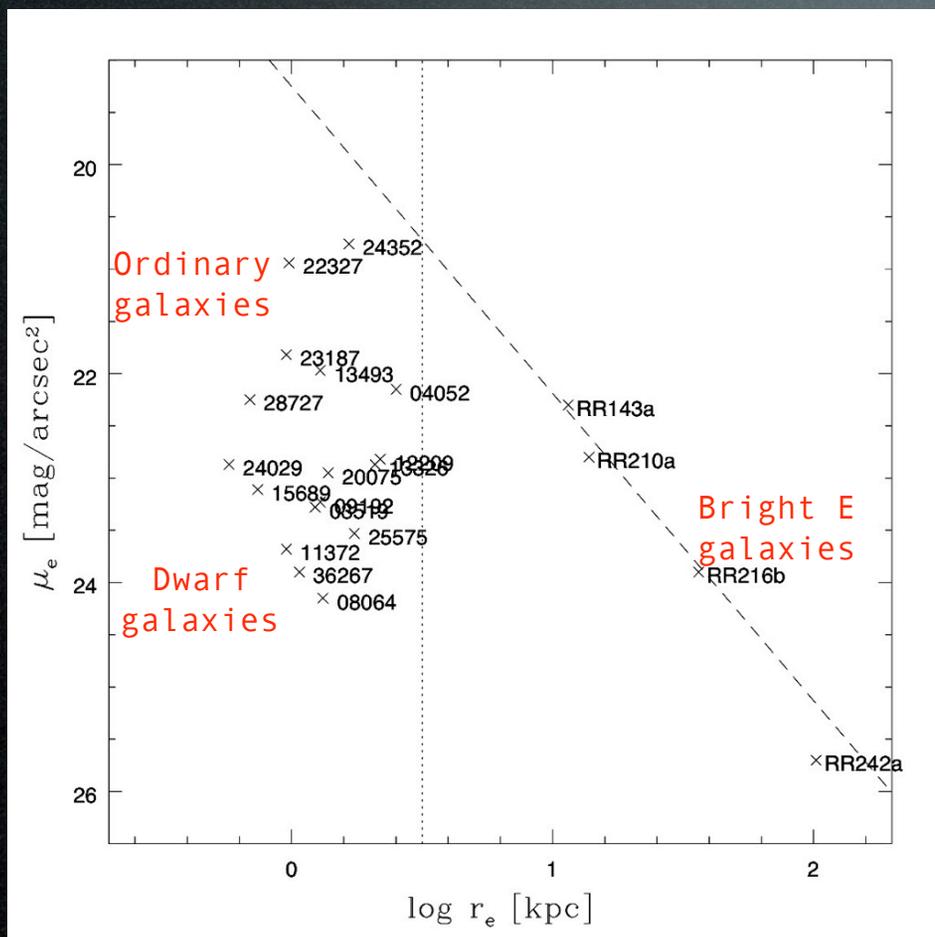


Radial density profile of E+S systems. The average density profile of the X-ray luminous groups (Zabludoff & Mulchaey 1998: ZM98) and of the “fossil group” NGC 1132 (Mulchaey & Zabludoff 1999) are plotted for comparison.

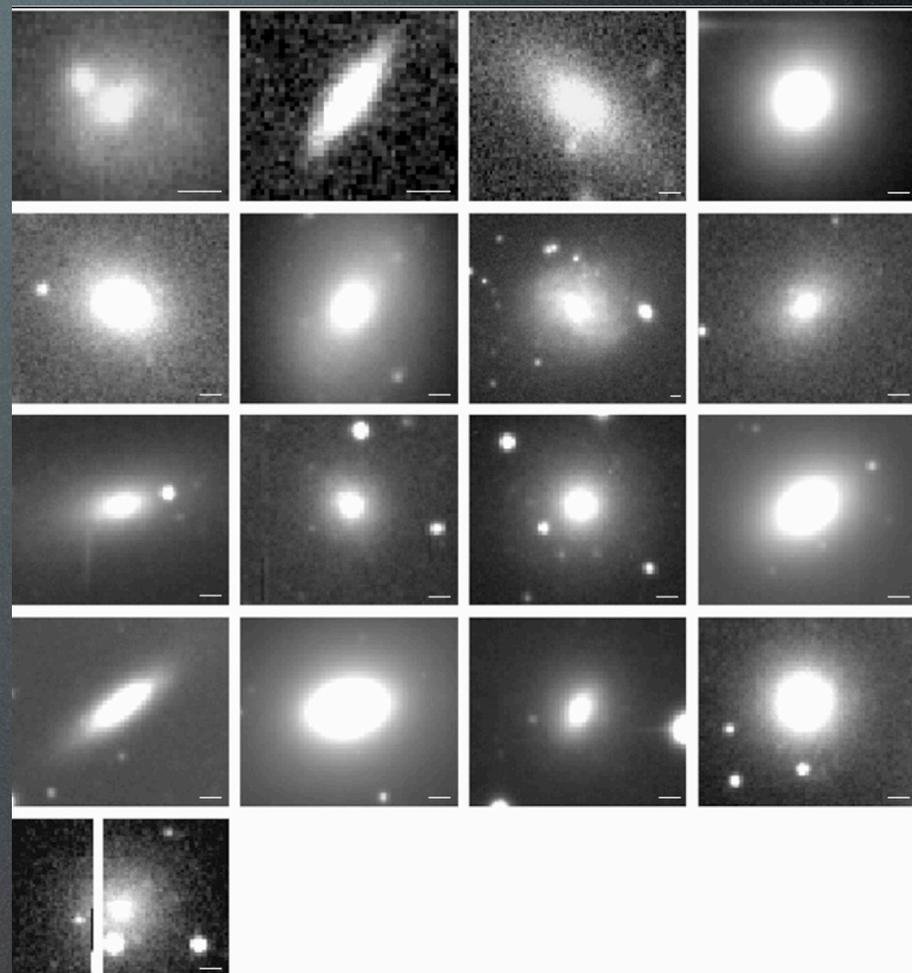


Position of member galaxies of four E+S groups moved to a common distance. Each side of the plot is about $2.5 h^{-1}$ Mpc. The position of all galaxies with concordant redshift within 90° (large circle) are plotted. The central square is the WFI FoV. The central circle is the luminosity weighted mean harmonic radius R_H centred on the group center of mass calculated with group members inside $0.5 h^{-1}$ Mpc radius (dashed circle).

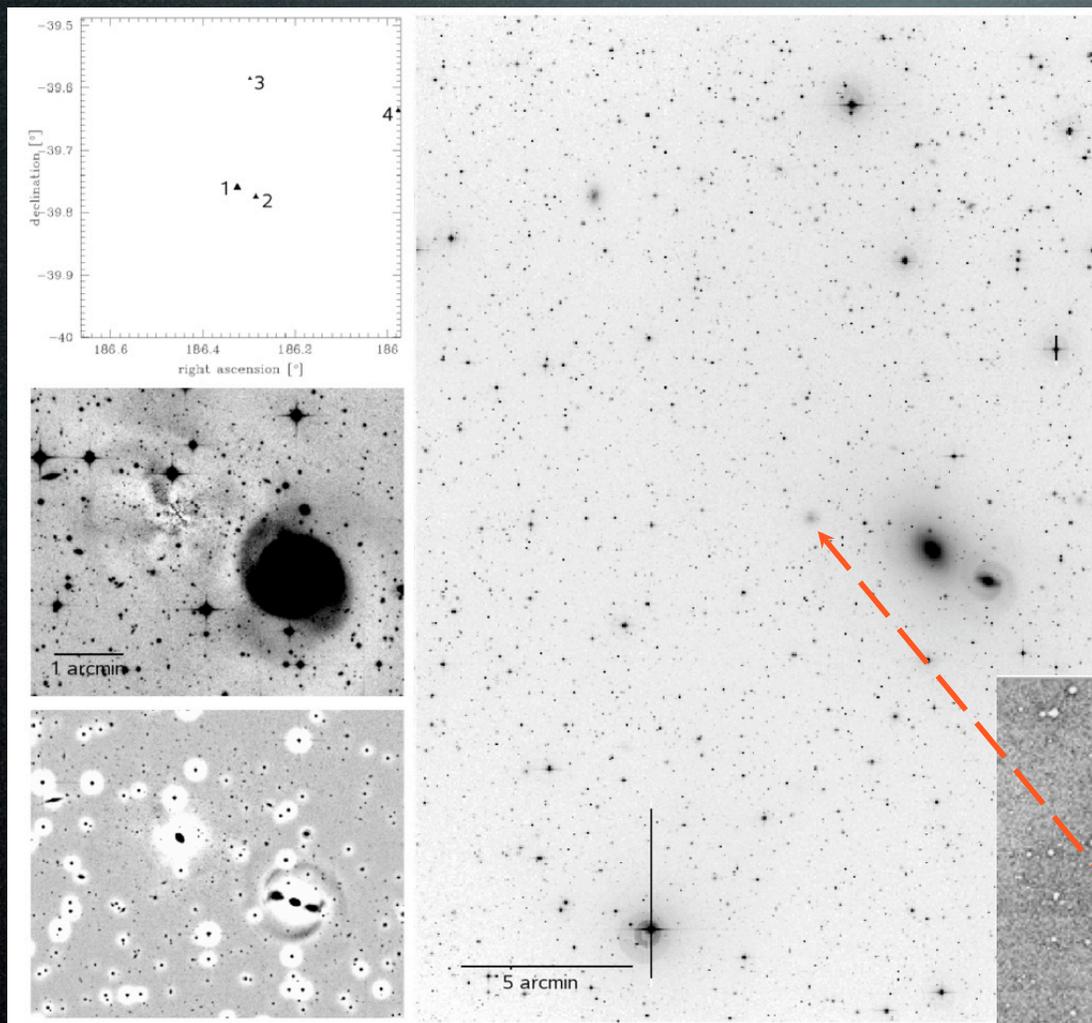
The faint galaxy population is dominated by disk galaxies. 35% are SOs with a low bulge to total light ratio.



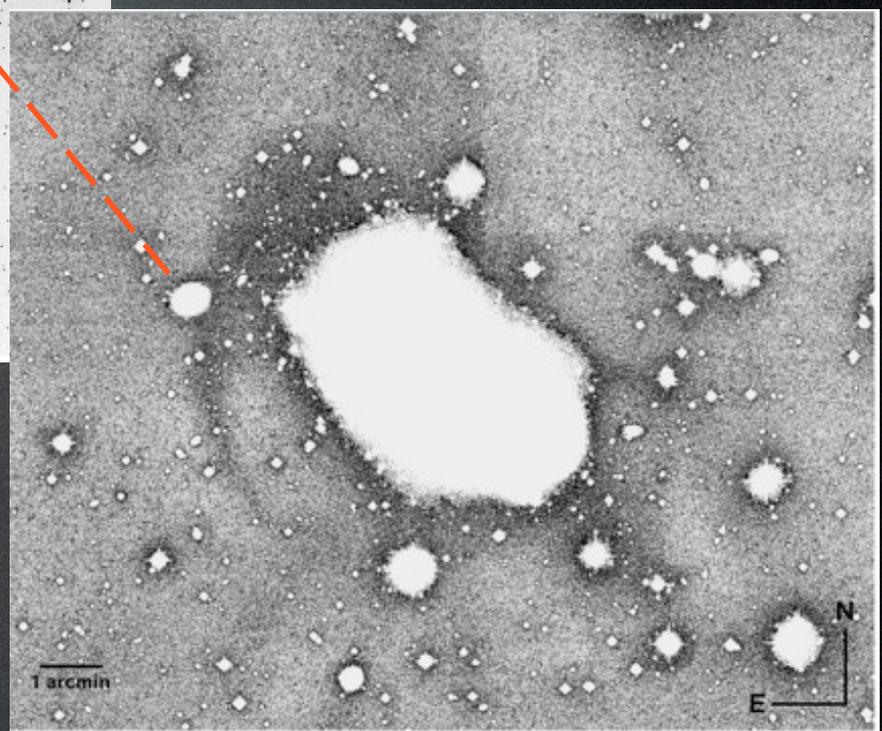
HK relation is not reproducible by merger of dwarf early-type systems...unless a considerable amount of dissipation (Evstigneeva et al. 2004)



(left panel) The Hamabe-Kormendy relation (Hamabe & Kormendy 1987) for the early-type galaxies members of the E+S systems. The area at the left of the vertical dotted line represents the region inhabited by so called “ordinary” galaxies (Capaccioli et al. 1992). All galaxies are labelled with their ID. (right panels) R-band thumbnails of faint members of the four E+S systems.



Plume of diffuse light detected in RR 210.
 (Grutzbauch R., Trinchieri G. Rampazzo R., Held E.V., Rizzi L., Sulentic J.W., Zeilinger W.W. 2007, ApJ, 133, 220)



(large right panel) WFI R-band image of RR 210 and its environment. (top left panel) Finding chart of spectroscopically confirmed members of the RR 210 system within the FoV. Galaxies are marked with symbols sized according to their absolute magnitude.

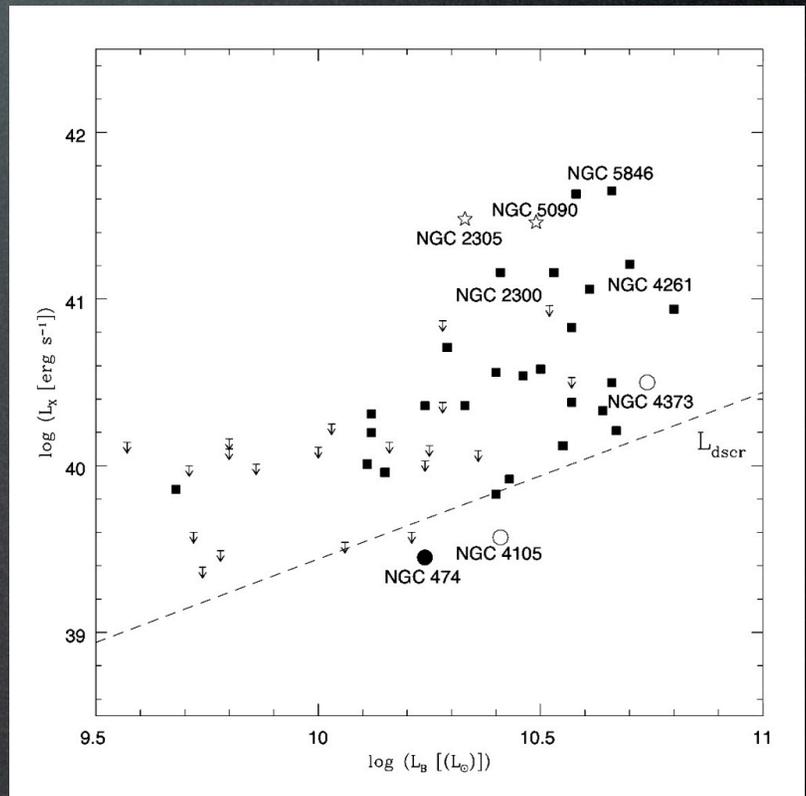
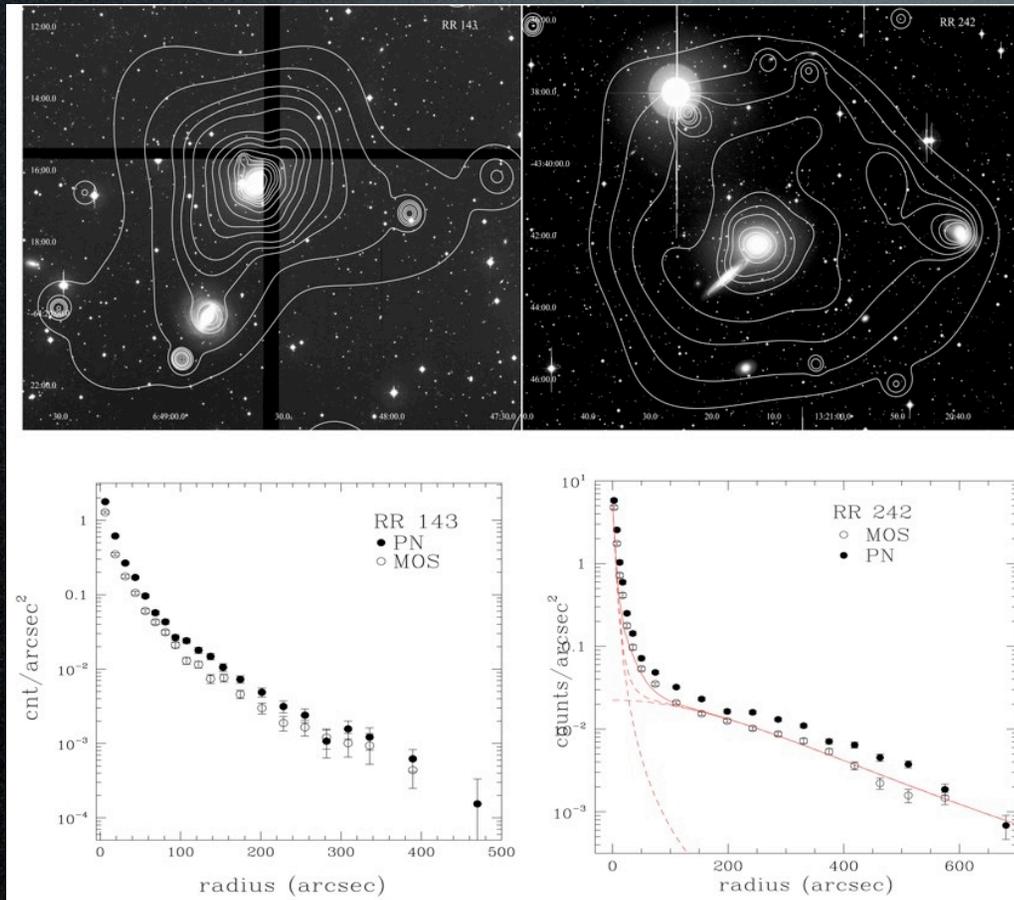
other variables in the study: the gas

there is a lot of gas around in different phases... and different proportions...

the hot gas (10^7 K)

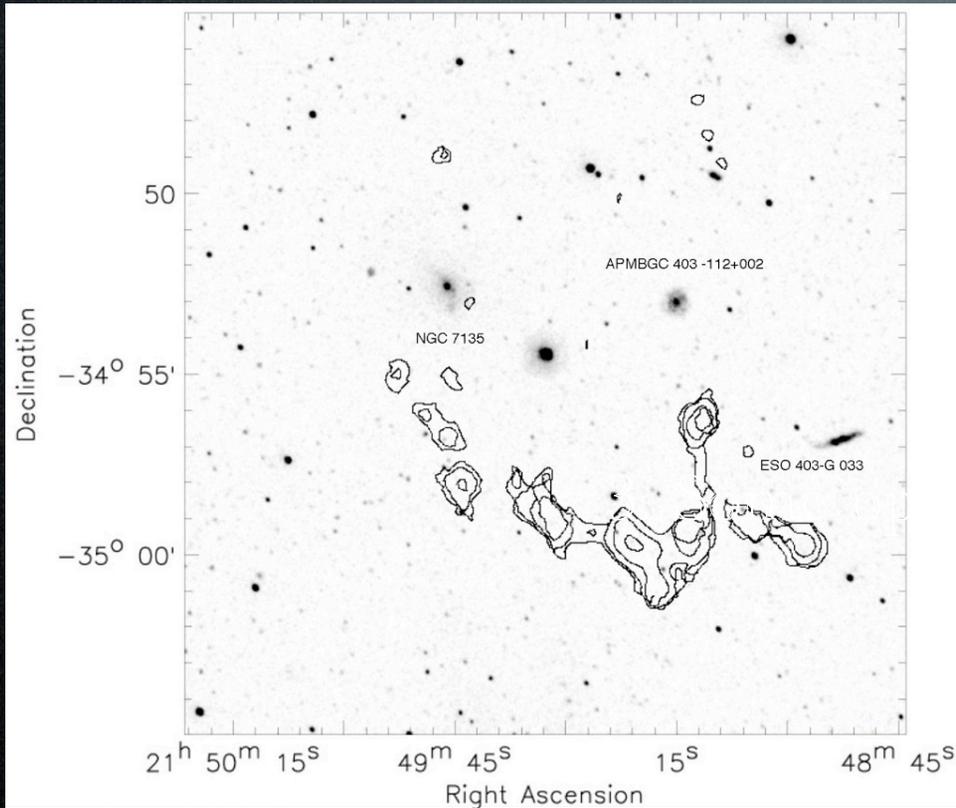
Both the morphology and the X-ray luminosity are very different suggesting different sources of emission.

$\log L_B - \log L_X$ plane. RR systems are indicated with red circles.



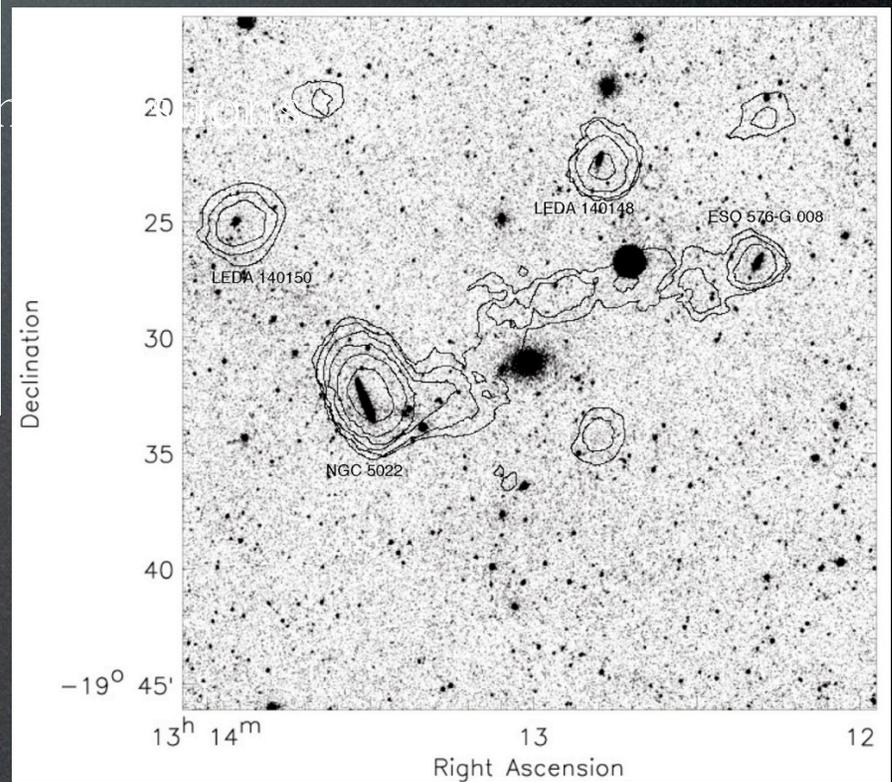
(top panels) Iso-intensity contours of the adaptively smoothed X-ray emission from RR 143 (NGC 2305/NGC 2307; left) and RR 242 (NGC 5090/NGC 5091; right) detected with XMM-Newton. Contours are superposed on R-band images obtained with the 2.2m MPI/ESO. The galaxy west of NGC 5090 is NGC 5082. (bottom panels) Surface brightness profile of the raw XMM-Newton data (Grutzbauch et al. 2007, AJ, 133, 220).

the cold atomic gas (10 K)

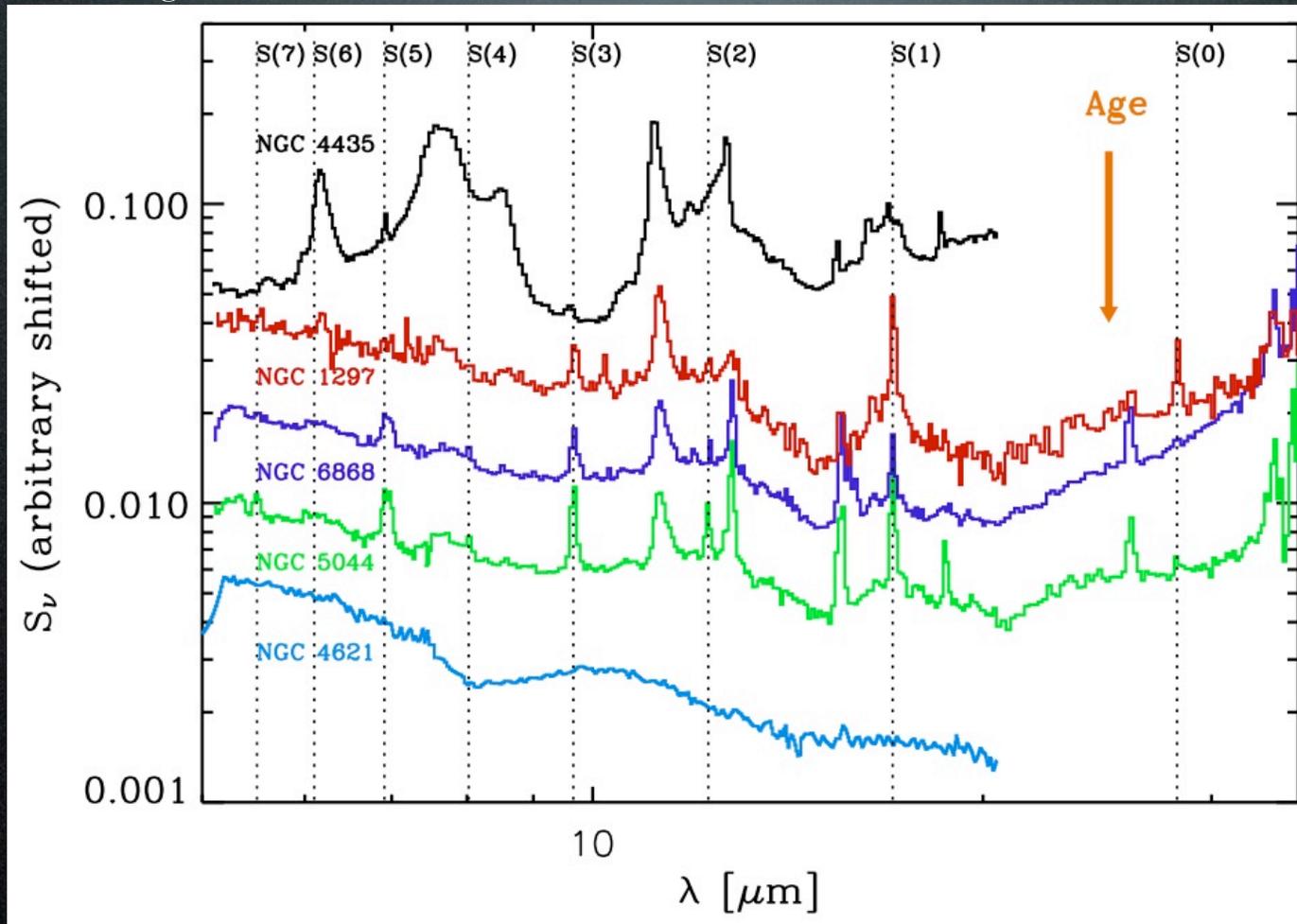


(left panel) NGC 7135. HI observations overlaid on the GALEX NUV adaptively smoothed image. The FOV is $20' \times 20'$. The HI image obtained with VLA C+D-array, has a resolution of $60.4'' \times 43.2''$ (Schiminovich et al. 2000). (Rampazzo R., Marino A., Tantalò R., Bettoni D., Buson L.M., Chiosi C., Galletta G., Grutzbauch R., Rich R.M. 2007, MNRAS, 381, 245)

(right panel) NGC 5018. HI observations overlaid on the GALEX NUV original adaptively smoothed image. The FOV is $30' \times 30'$. The HI image obtained with VLA C+D-array, has a resolution of $60''$ (Kim et al 1988).



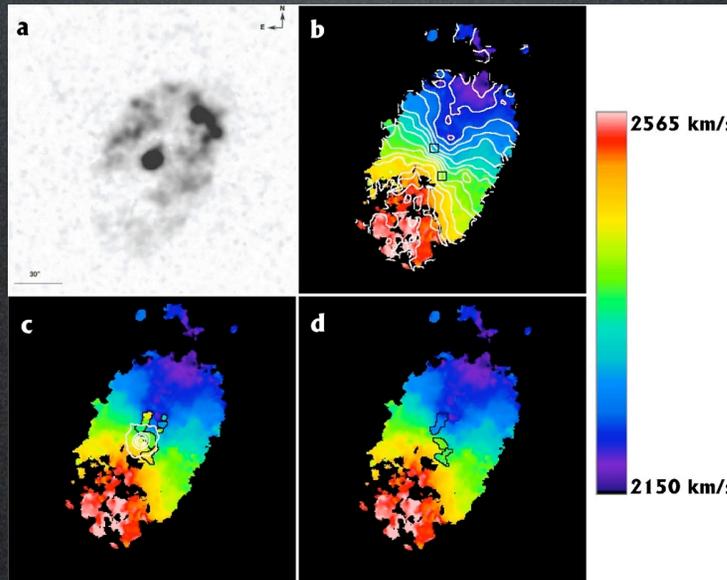
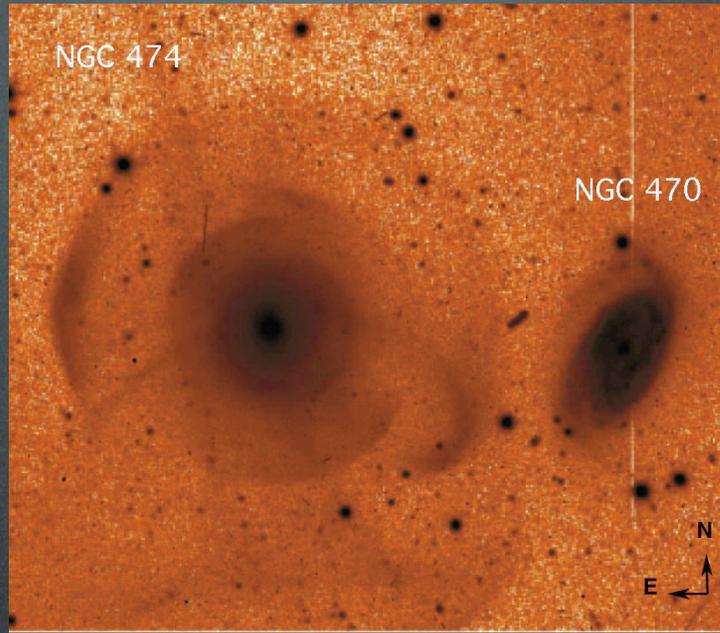
the molecular gas ($10^2 - 10^3$ K)



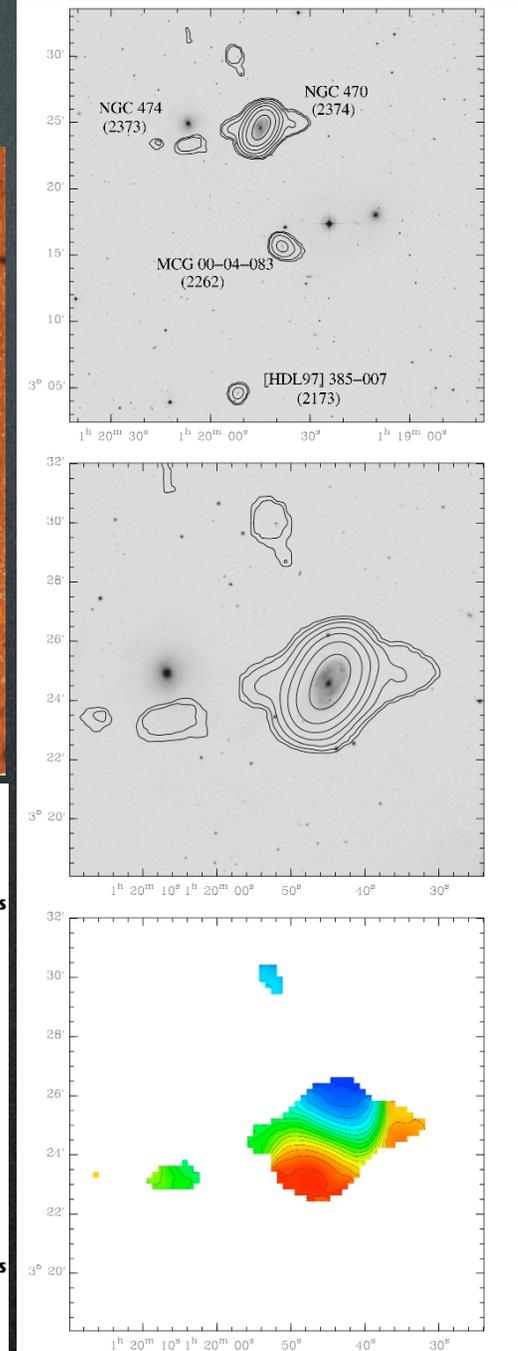
IRS spectra of ETGs from our Cycle 1 (P.I. A. Bressan) and Cycle 3 (P.I. R. Rampazzo) Spitzer proposals. NGC 4435, an ETG with a nuclear starburst and faint H_2 emission lines; NGC 1297, NGC 6868, NGC 5044, three field ETGs with exceptionally strong H_2 emission lines; NGC 4621, representative of passive evolving ETGs. Note, 1) the absence of significant PAH features at 7.7 and $8.3 \mu m$ (indicating a lack of ongoing SF), 2) the lack of both a dip at $8 \mu m$ and an excess at $10 \mu m$ (both present in NGC 4621), 3) a broad bump centered at $11 \mu m$ and the presence of PAHs at $11.3 \mu m$ and 4) significant dust emission at longer wavelengths, evidently not due to current SF. For NGC 1297, NGC 5044 and NGC 6868, we argue that the almost featureless NIR-MIR continua ($< 10 \mu m$), the absence of the silicate feature at $10 \mu m$ and the presence of the feature at $\sim 11.2 \mu m$ (coincident with that of silicon carbide, SiC) could be due to carbonaceous dust in the circumstellar envelopes of Carbon stars and their progeny. This would be a strong indication of the presence of intermediate age ($0.2-2$ Gyr) stellar populations. The spectra were arbitrarily shifted to illustrate an eventual trend of the features with the epoch of the rejuvenation episode.

3. The warm (10^4 K) IGM with 3D-NTT (& company)

What are the drivers of the evolution?

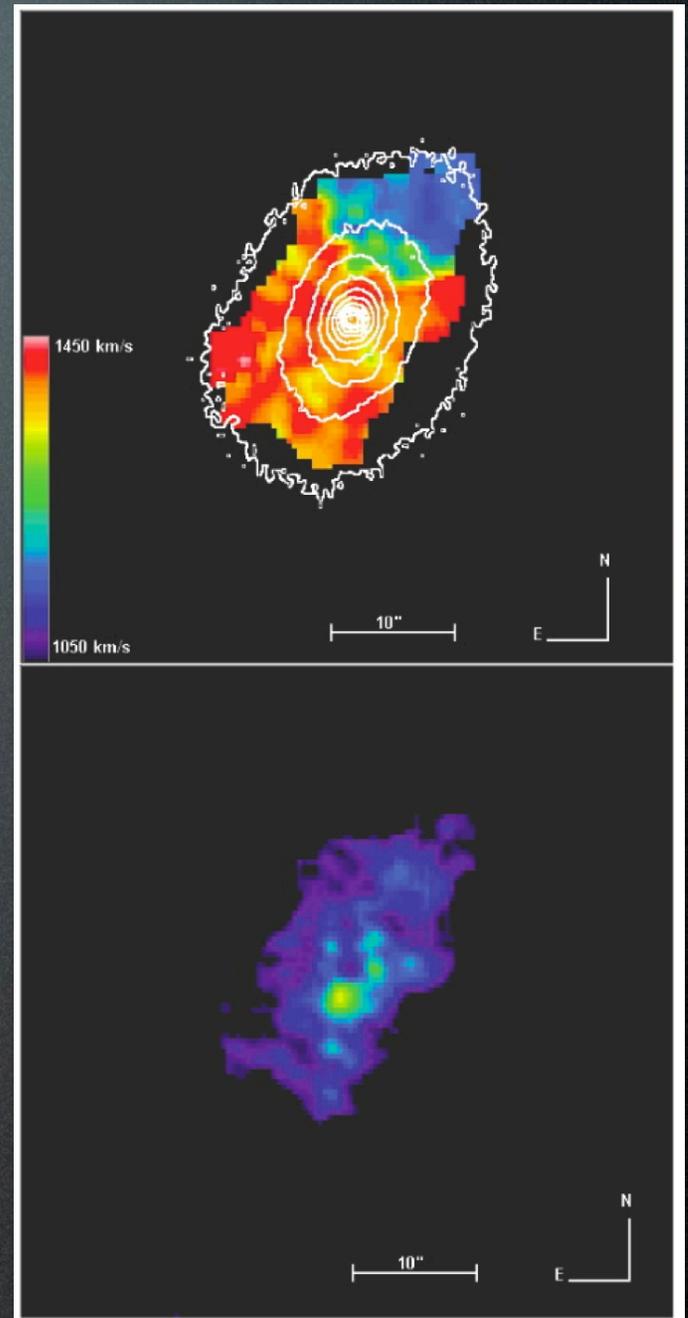
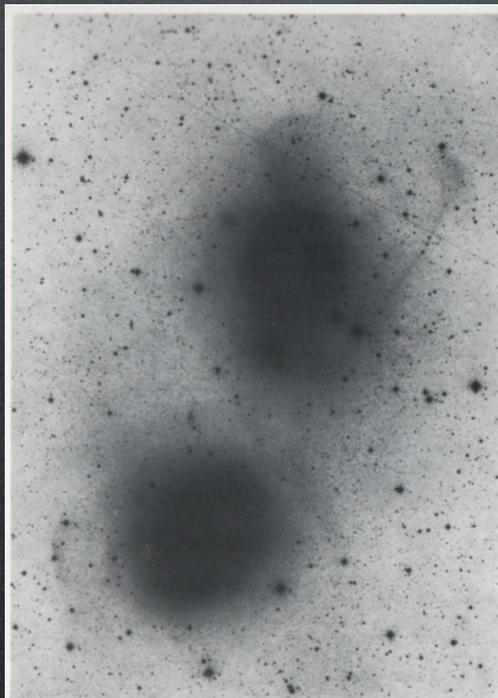
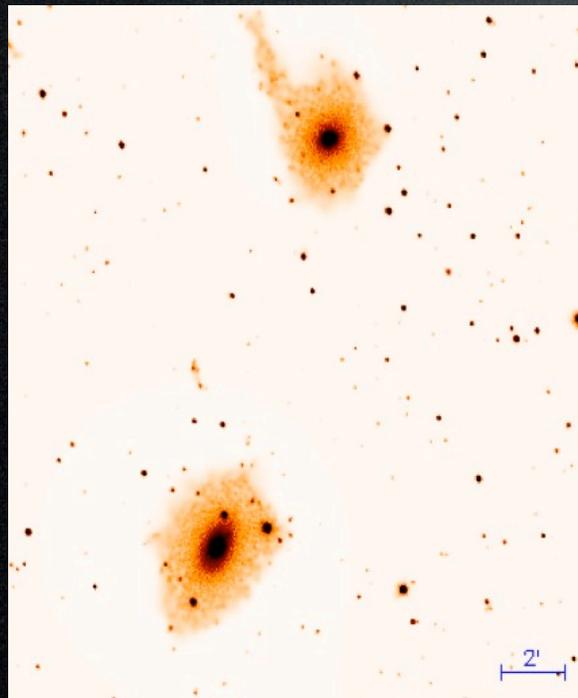


(top left panel) B-band image of Arp 227 (right panels) HI emission in Arp 227 system. The main galaxies in the area and their systemic velocities are indicated. In the bottom panel the intensity-weighted mean velocity field is shown. Contour levels run from 2240 to 2540 with a separation of 20 km/s. (bottom left panel) Velocity field of NGC 470 (Rampazzo, Alexander, Carignan, Clemens, Cullen et al. 2006, MNRAS, 368, 863)

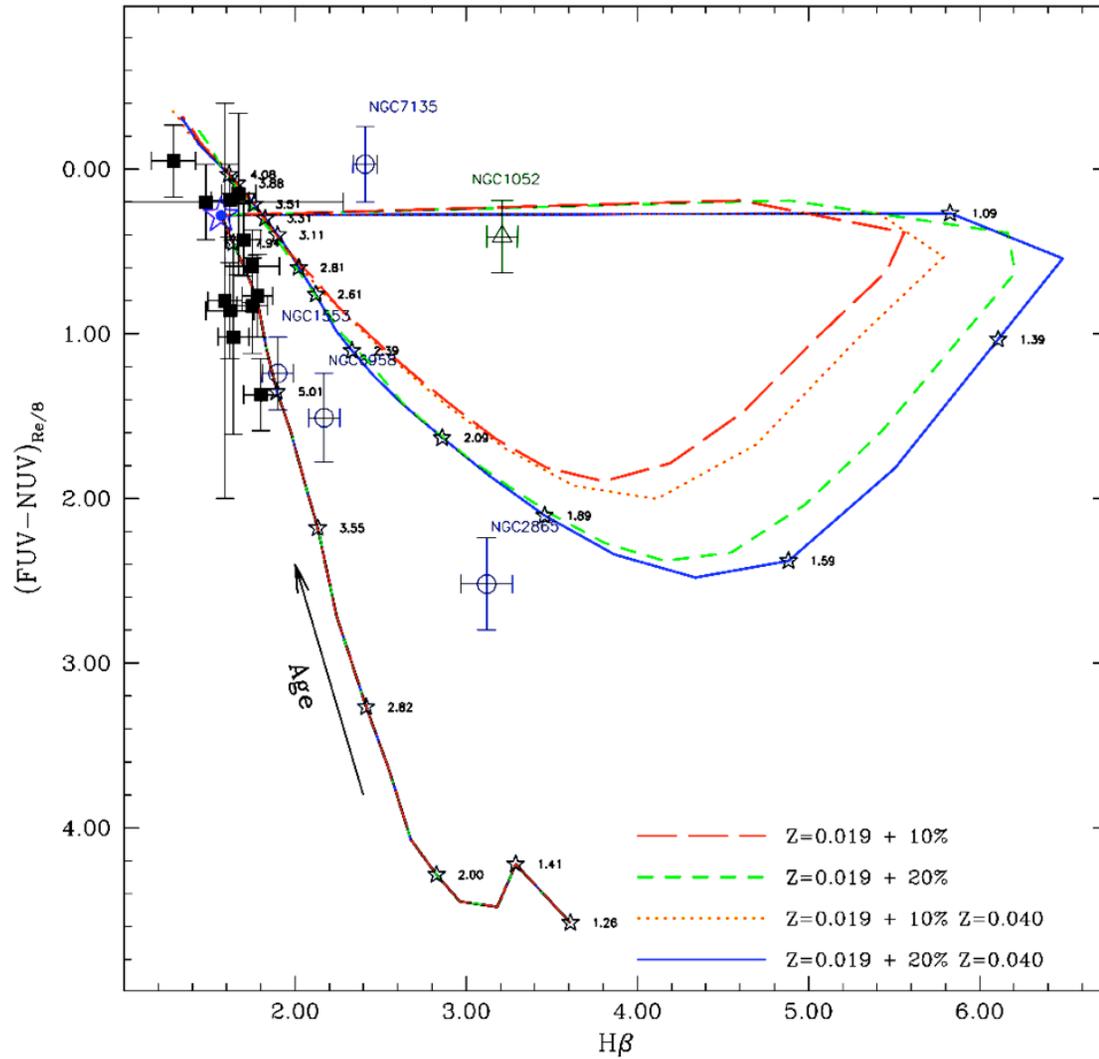
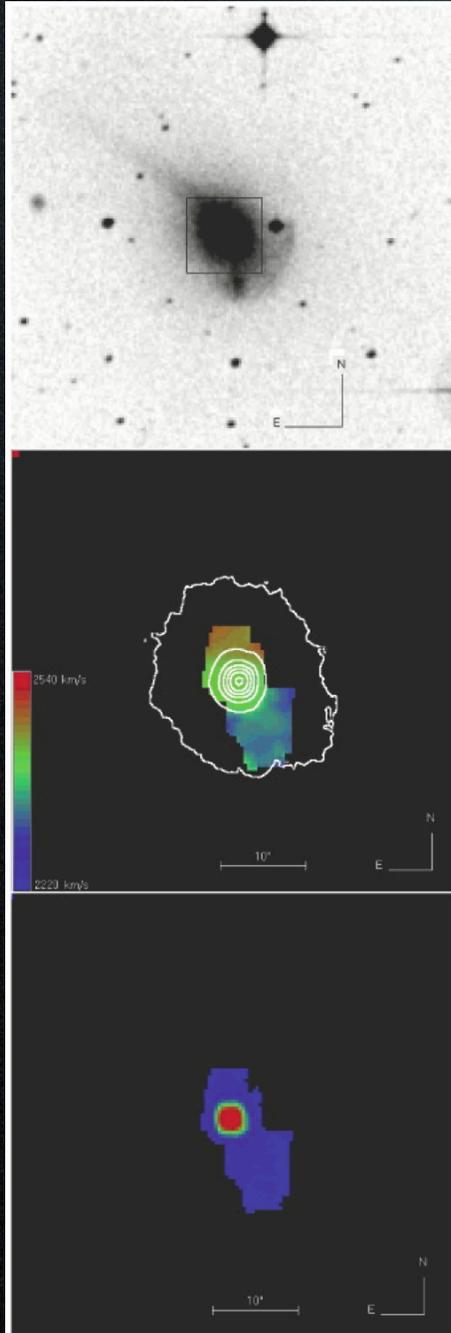


How many accretion events ?

(left panel) Malin & Carter image of the shell galaxies NGC 1549 (North) and NGC 1553 (south). (mid panel) GALEX NUV image of the pairs. **Multiple accretion events ?** (top right panel) Velocity field and (bottom right panel) ionized gas distribution in NGC 1553 (Rampazzo et al. 2003, *MNRAS*, 348, 819)

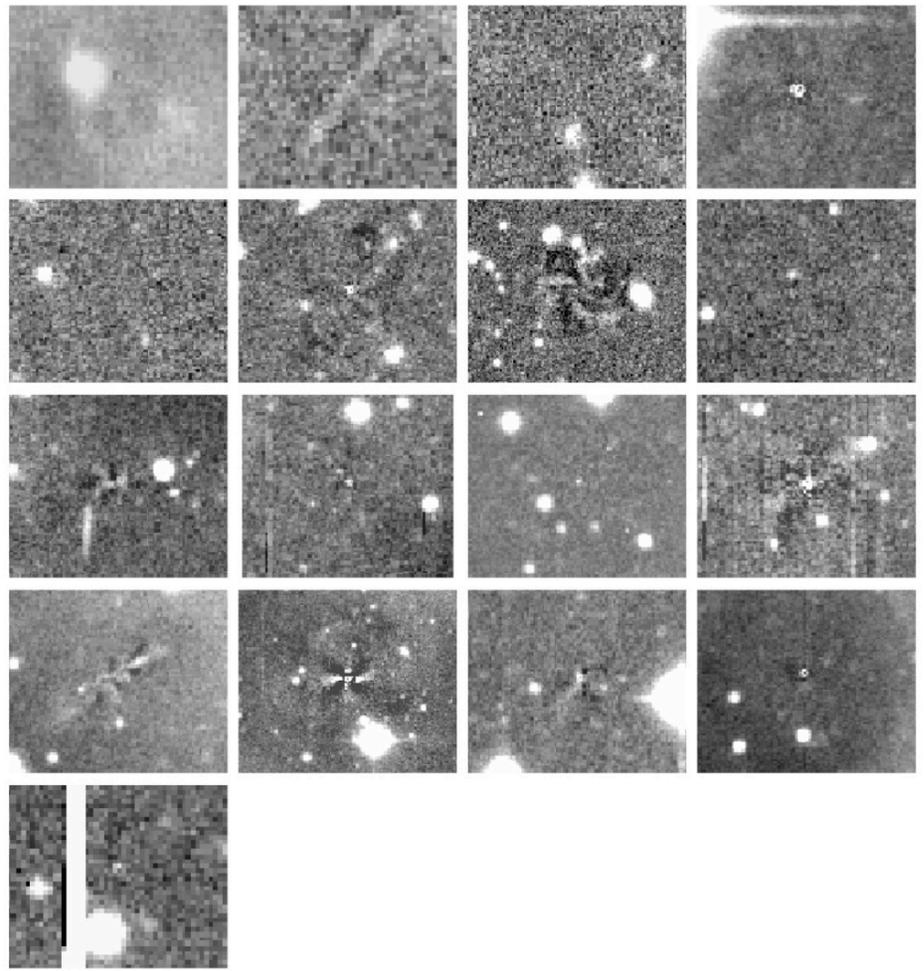


Wet or dry accretions/mergers ?

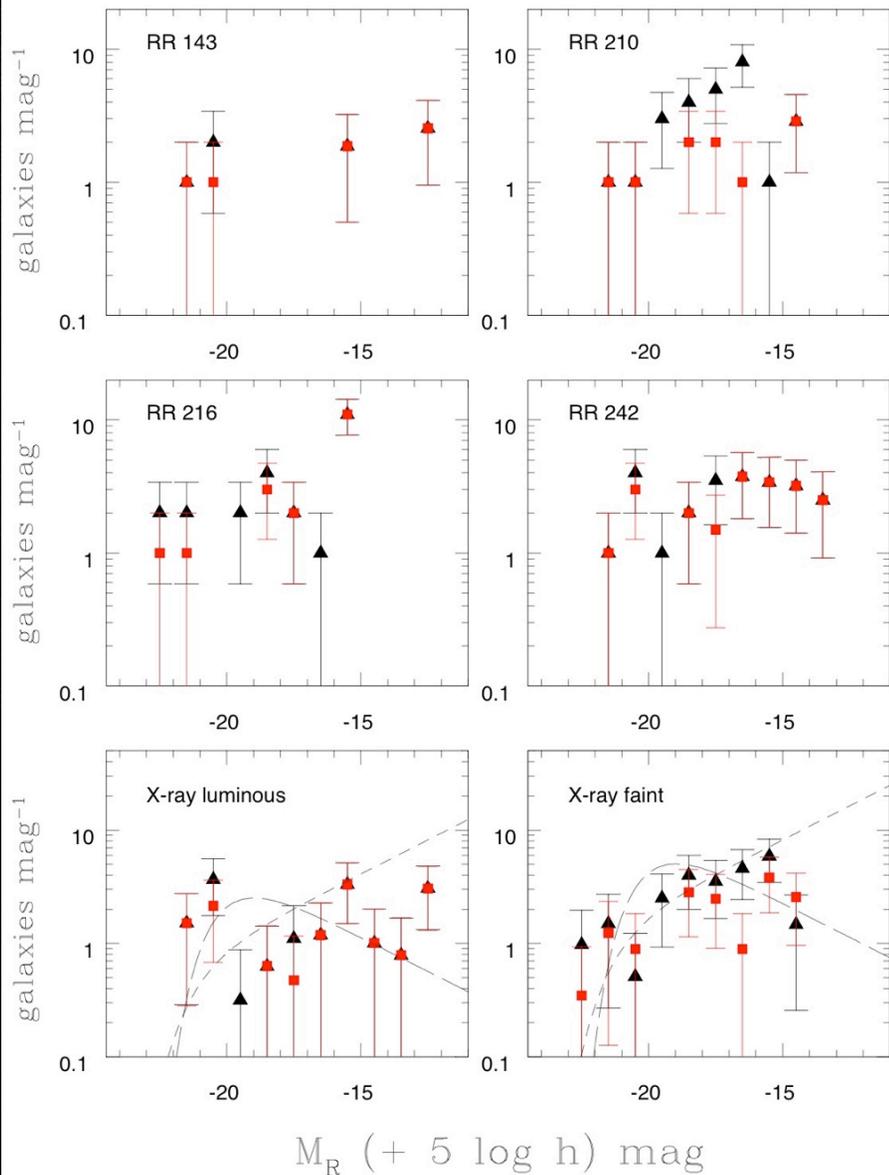


GALEX (FUV - NUV) colour vs. $H\beta$ within an aperture of $re/8$ radius. In above plane, the aging path of a galaxy stellar population is indicated by the arrow.

Optical Luminosity Function

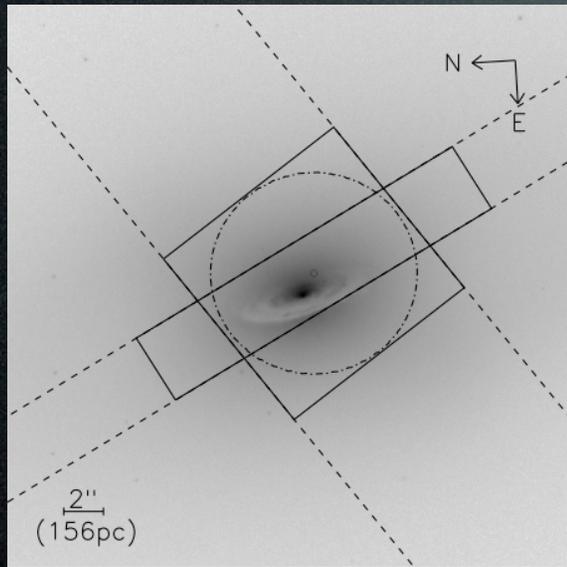


What is the degree of “activity” in the dwarf galaxy population ?

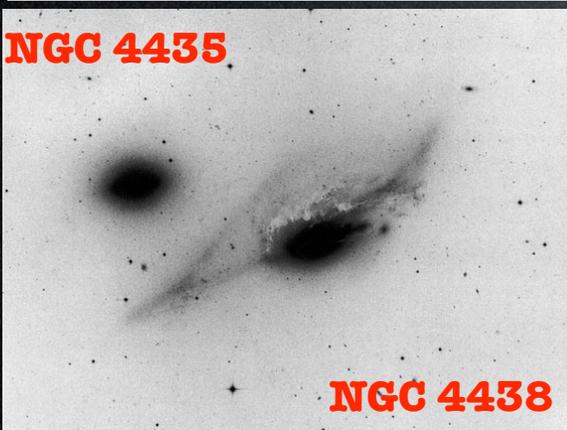


(left panels) Individual and combined luminosity functions of the four E+S groups. The LFs of the X-ray luminous and of the 2 X-ray faint groups are combined respectively in the bottom panels. For this combined LFs the counts of the groups are normalized so that each group contains the same number of galaxies with $M_R < -15 + 5 \log h_{100}$. This avoids the shape of the combined LF to be dominated by the richer group. The LFs are computed for the large scale sample (black triangles) and the WFI field sub sample (red squares). The dashed and long-dashed lines represent the LF of X-ray luminous groups and field galaxies, respectively. (right panels) Residual images after subtraction of a galaxy model (IRAF-ELLIPSE).

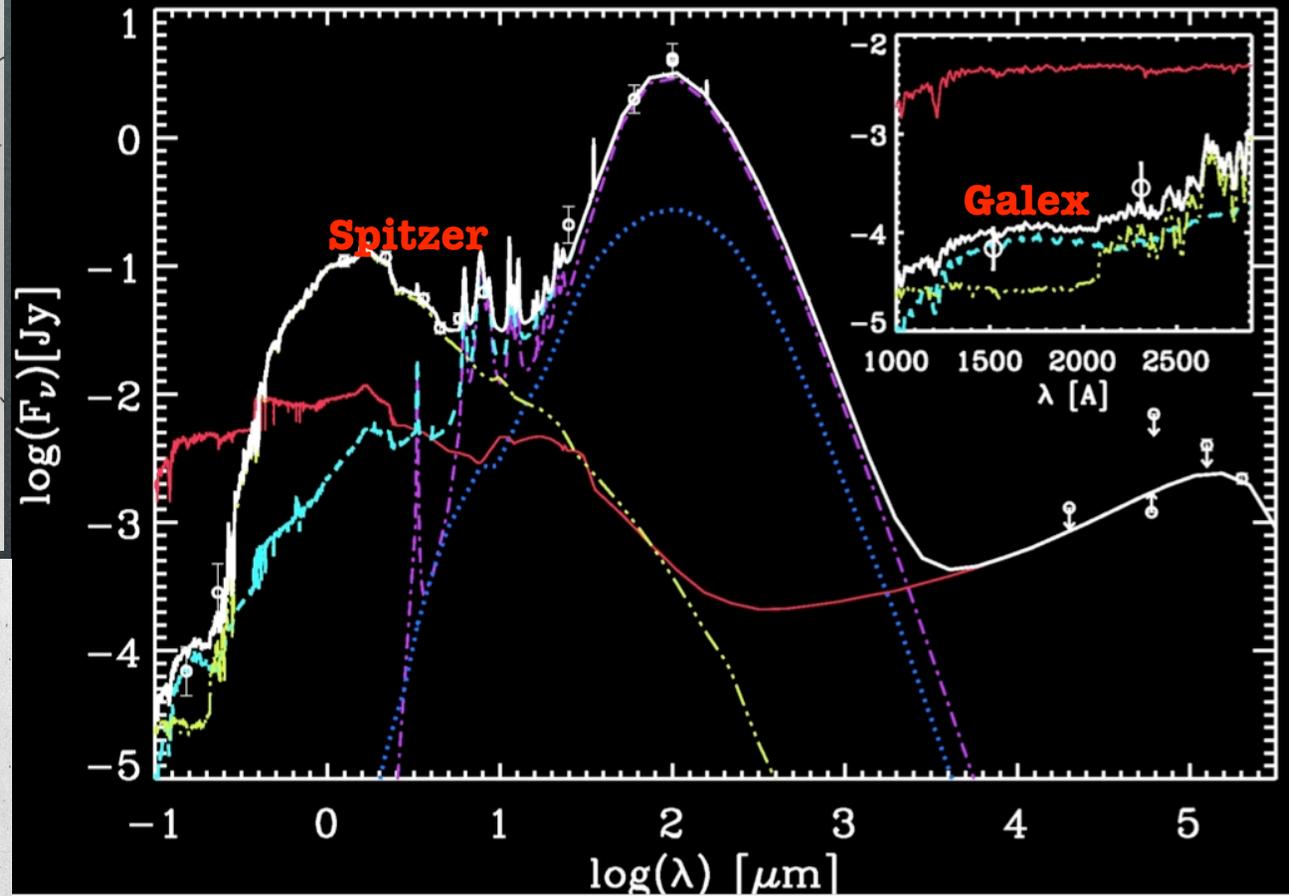
Are the time-scales provided by kinematic and stellar evolution consistent ?



NGC 4435



NGC 4438



NGC 4435 is an Elliptical located in the Virgo cluster interacting with the spiral NGC 4438. Here we show the comparison in the range 0.1 mm to 30 cm between the observed SED of NGC 4435 central region and our model. The thick white line represents the model for the total SED, i.e. a starburst component plus an old stellar component. The best fit of the NGC 4435 SED can be obtained with a old stellar population of 8 Gyr (98.5%) and 200 Mys (1.5%). We did not measured an appreciable AGN activity in the galaxy ($< 2\%$, if any). (Panuzzo et al. 2007, *ApJ*, 656, 206). See Vollmer et al. (2005, *A&A*, 441, 473) for simulation and CO observations.

Feasibility

kinematics of faint nearby galaxies
kinematics of bright nearby galaxies
cross fueling, accretion, merging, activity

2D ionization structure
physics of the gas
detection of faint galaxy population
detection of Irr galaxies ?

High spatial
resolution

Intermediate
FoV

Large FoV

High Sp Res

3D-NTT/FP

GH α FaS

3D-NTT/TF

Low Sp Res

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