The Growth of Red and Early Type Galaxies in Distant Clusters.

The View From EDisCS and STAGES.

A progress report.

EDisCS
Eso Distant Clusters Survey

STAGES

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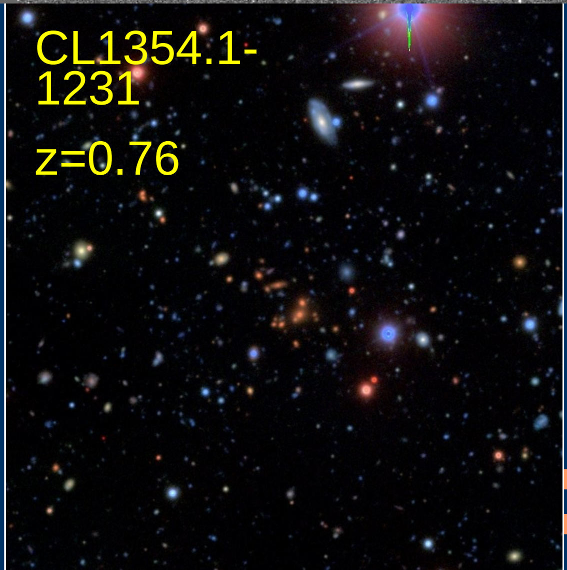
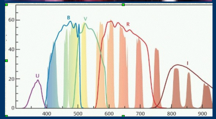
EDISCS. Data and Science Goals

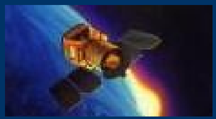


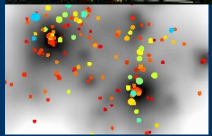
PLUS:
- FORS2 MXU spectra (50 galaxies/cluster). zs, line indices, σ.
- XMM-Newton (3 clusters). Intracluster Ts, Masses.

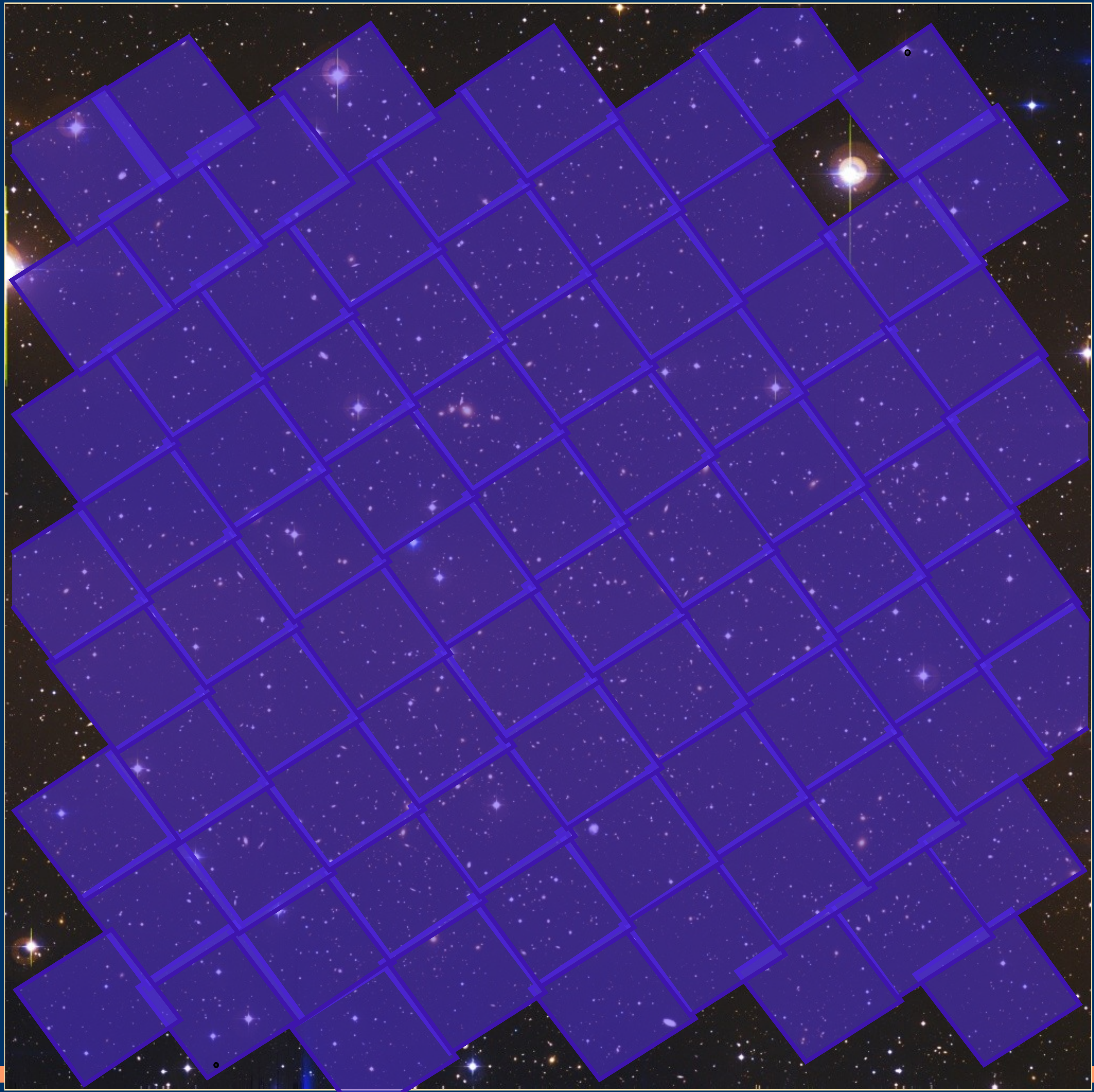
- Obtain a uniform imaging and spectroscopic database for a large and representative sample of galaxy clusters covering at least half of the Hubble time.
- Characterise the sizes, luminosities, morphologies, internal kinematics, star formation and stellar populations of cluster galaxies.
- Compare cluster samples at z=0.8, 0.5 and 0.1 (SDSS) to establish trends as a function of redshift exploring a large cluster mass range, and asses cluster-field evolutionary differences.
- Compare with simulations of galaxy and galaxy cluster formation to determine the role of the relevant physical processes.

STAGES. Data and Science Goals









Introduction. Growth of Galaxy Sizes of ETGs and Red Galaxies in Clusters. Plans.

- The characteristic size of ETGs of a given stellar mass is observed to increase significantly with cosmic time from z~2.0 till the present time. A popular explanation is that these galaxies grow via “dry” mergers, thus becoming less compact. This is bound not to be the whole story, though. Simulations show that the resulting growth might not be enough, and the final scatter in scaling laws would be too big. Some star formation is then needed, or even non-standard dark matter, as some people have suggested.

- We **will** study the impact of both multiple minor and unequal mass mergers in the size evolution of the Rseq in different environments. We use HST/ACS images of different clusters from z=0.1 to z=1.0 from the (STAGES)/EDISCS surveys.

- We **have** fit Single-Sersic models to red and ETs cluster galaxies. We **have** calculated the structural properties of galaxies and residuals. We use CAS, Gini, M20, RFF, EVI, and SAi.

- We plan to carry out the same analysis on simulated mergers models. This will allow us to interpret the above results in terms of merger properties.

HST/ACS images of the EDISCS clusters.

- 10/20 EDISCs clusters have been observed with the **ACS** camera on board HST. By eye morphological classifications are available (Desai, V. et al 2007).
- Individual _flt frames were multidrizzled together, resulting in a coverage of around 40arcmin^2 per cluster. **Image depth is variable. Min depth=2.0ks, Ilim=27(AB). Max depth=10.2ks, Ilim=28.2(AB).**
- Roughly **rest frame V-band.**

The GalPhyt code. Python+Galfit.

- We use Galfit in order to fit a Single Sersic profile to photo-z confirmed cluster members.

- The fits are set as follows:

1) The target galaxy is fit by Sersic profile. Can be disky, boxy or elliptical.

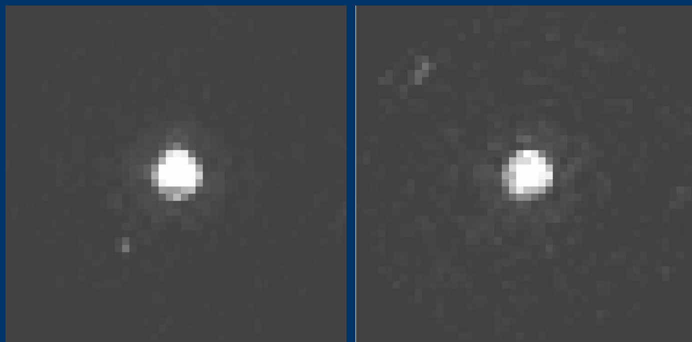
2) Things up to **2 mags fainter** than target within its Kron aperture fit by elliptical Sersic models.

3)Close galaxies up to **3 mags fainter** than target **are masked AND fit** by pure exponential profiles of fixed PA, E. All other galaxies are simply masked.

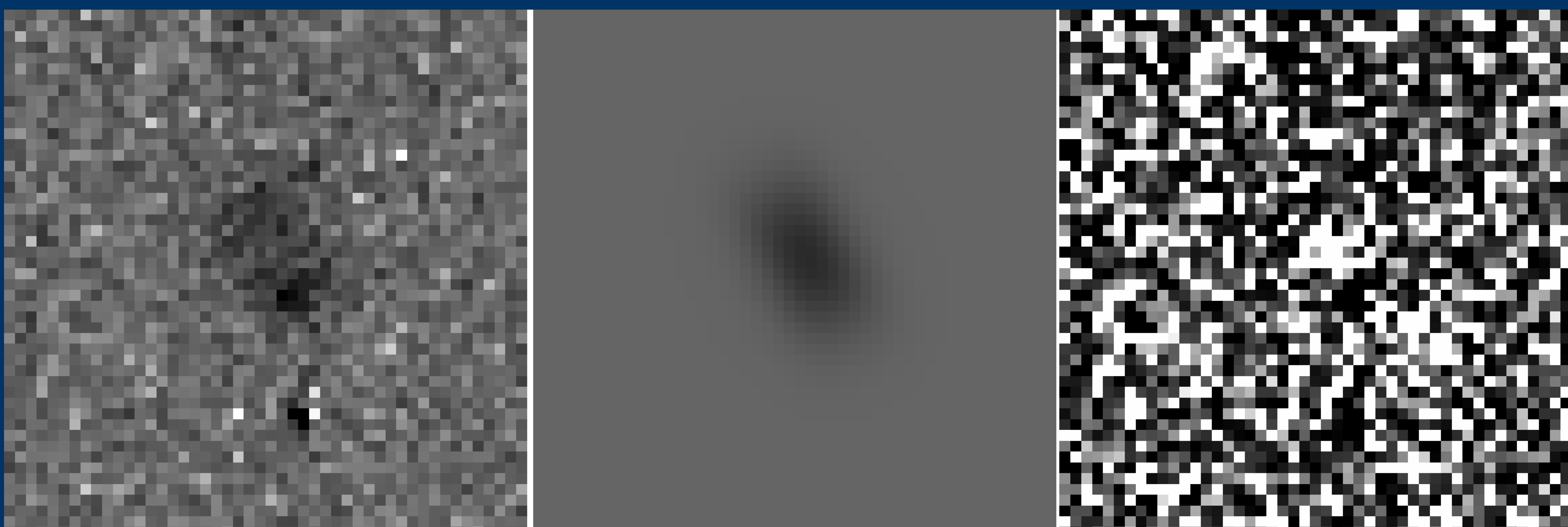
4)The **sky is free.** PSFs are **dynamically created for each object** from a PSF database created from actual stars. Sensible constraints and initial conditions are applied to output parameters.

5)GalPhyt © by Carlos Hoyos, **is implemented for use in a 3000+CPU HPC computer** in the University of Nottingham. Not quite ready for distribution if you are interested, but indeed capable or producing fits.

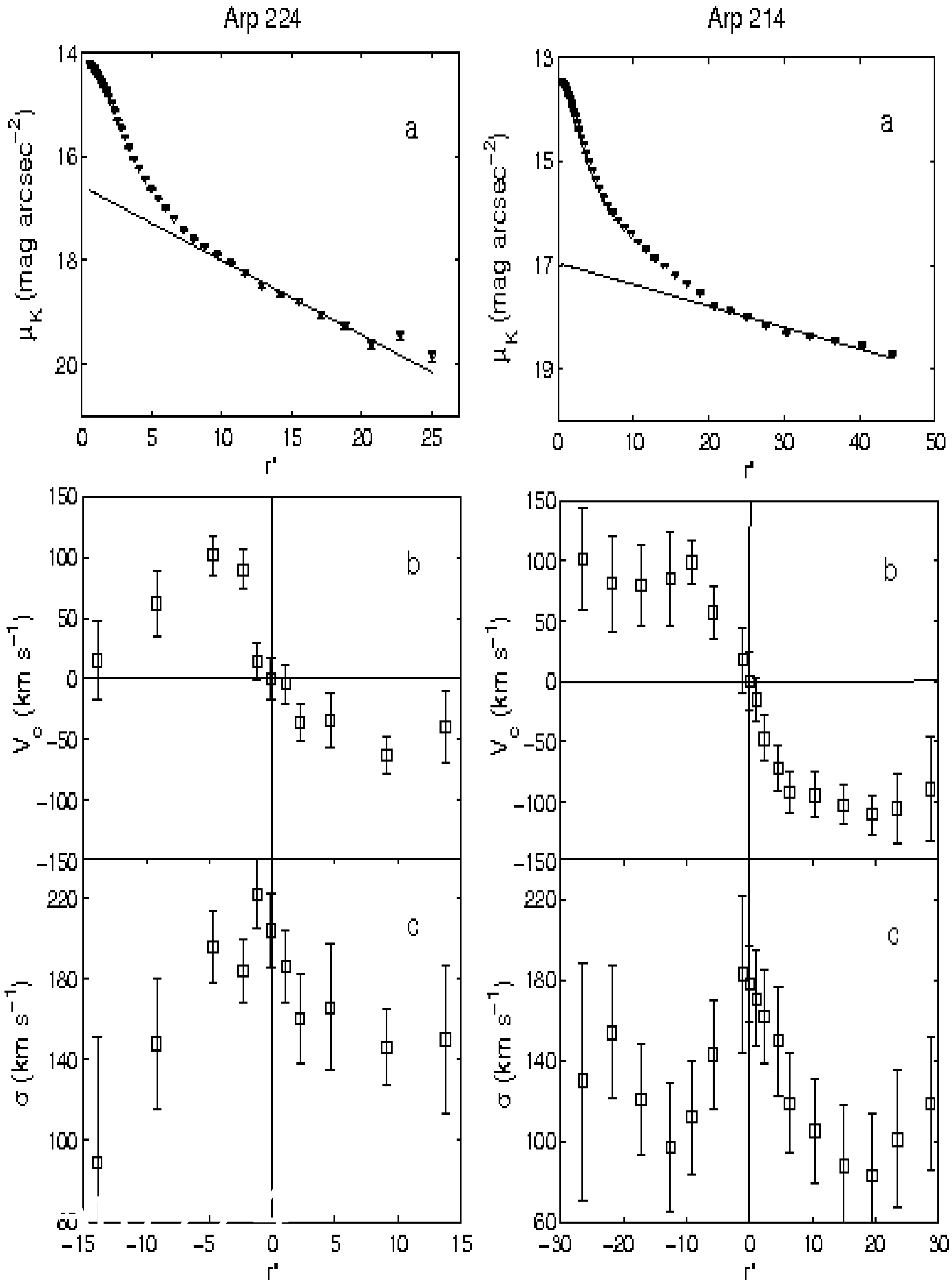
The GalPhyt code. Examples.



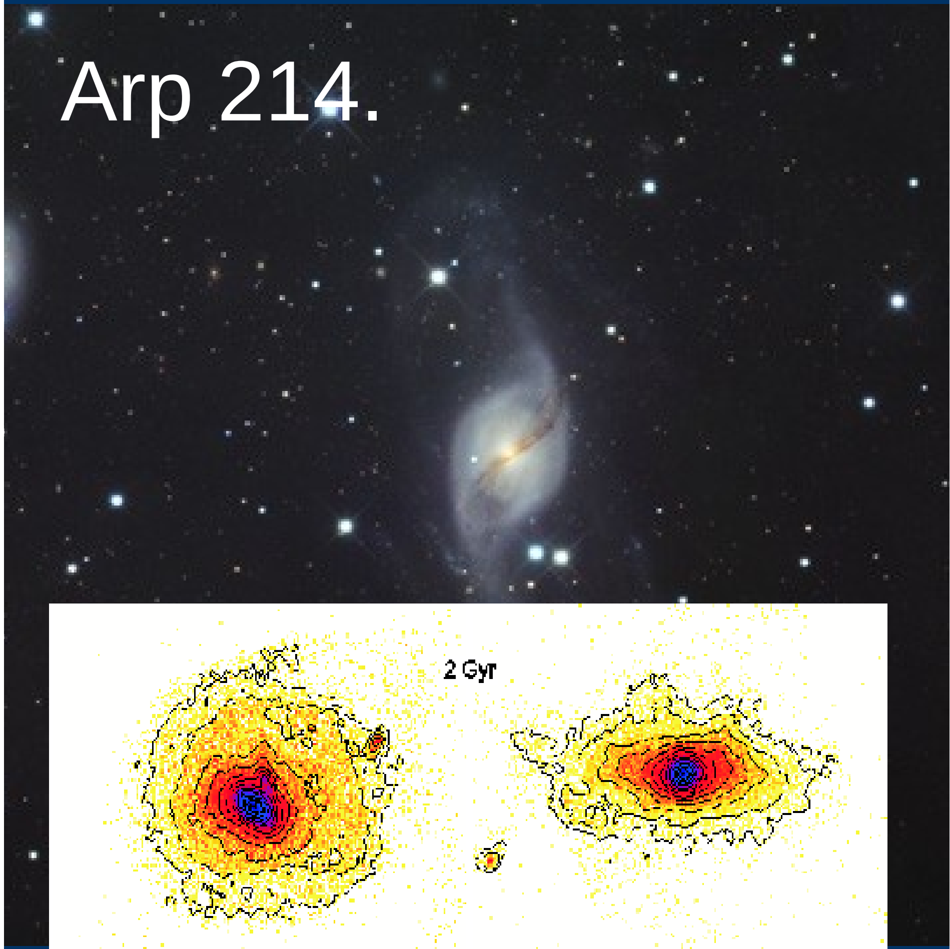
Two samples of input PSFs used by GalPhyt. PSFs for problem objects are created by combining input PSFs using appropriate weights.

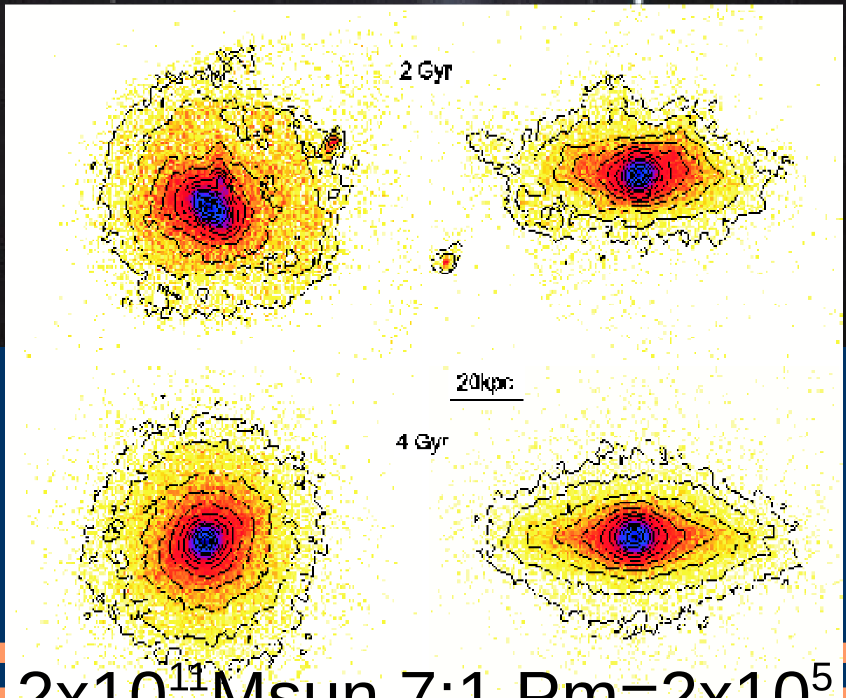


Unequal Mass Mergers (3-7:1).

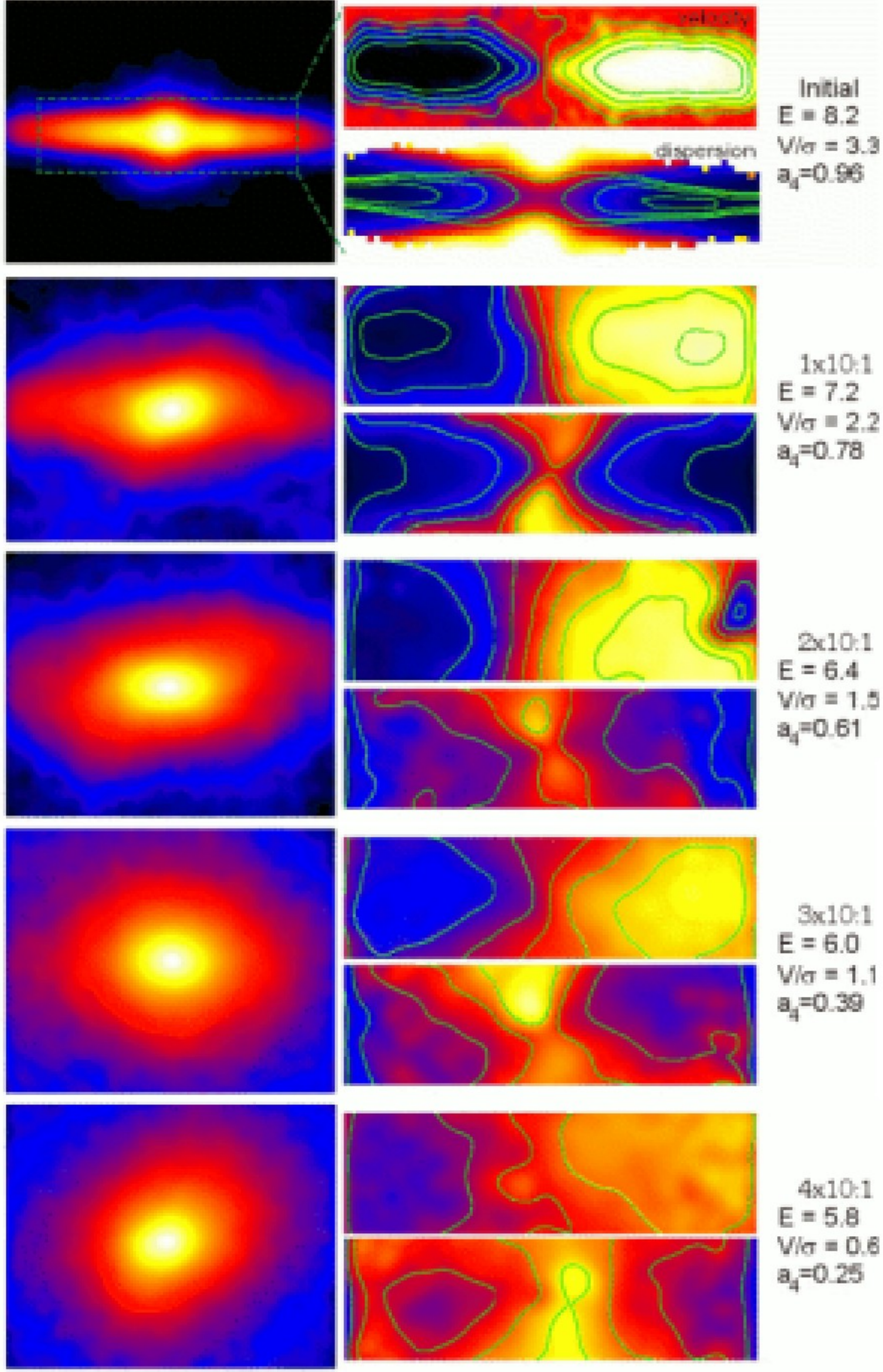


Arp 214.



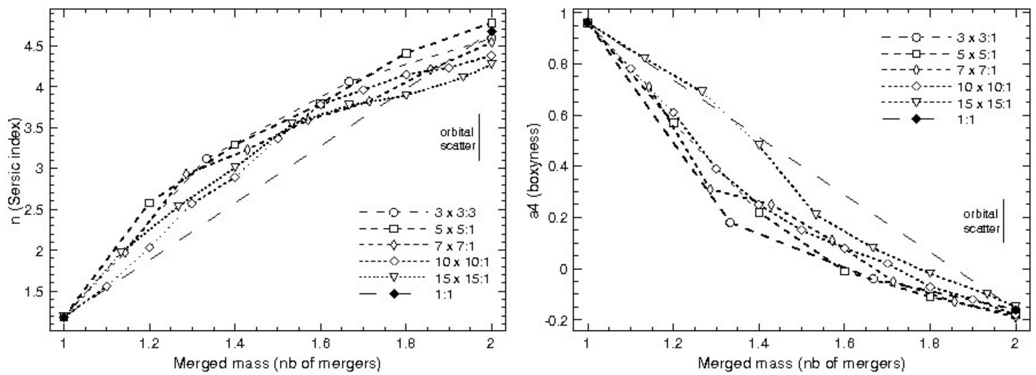


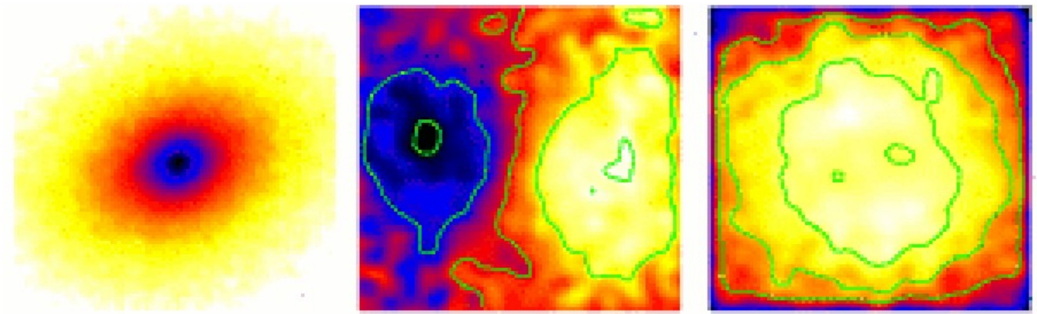
$2x10^{11}$Msun.7:1.Pm=$2x10^{5}$.



Multiple Minor Mergers (NxN:1).

$2x10^{11}$Msun.Pm=$5x10^{4}$. Schmidt SF law. R=400pc



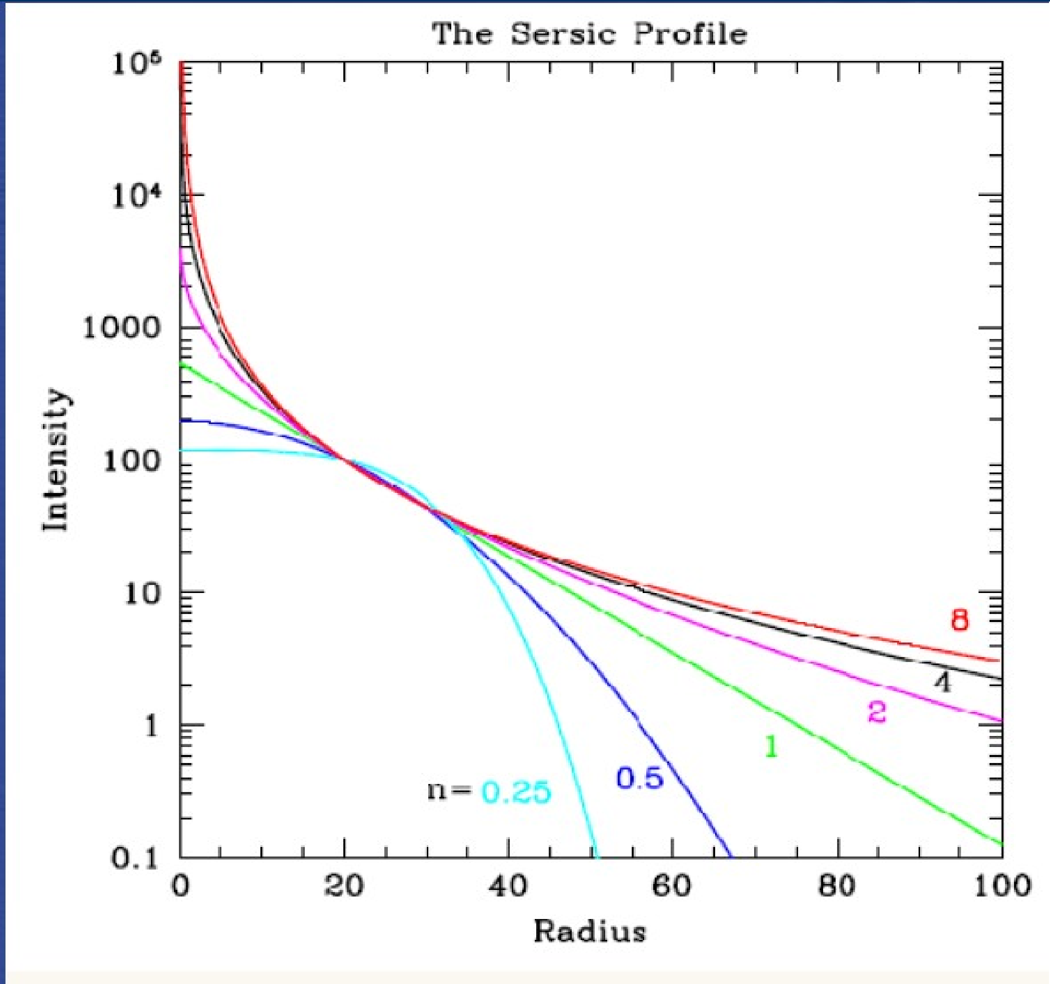


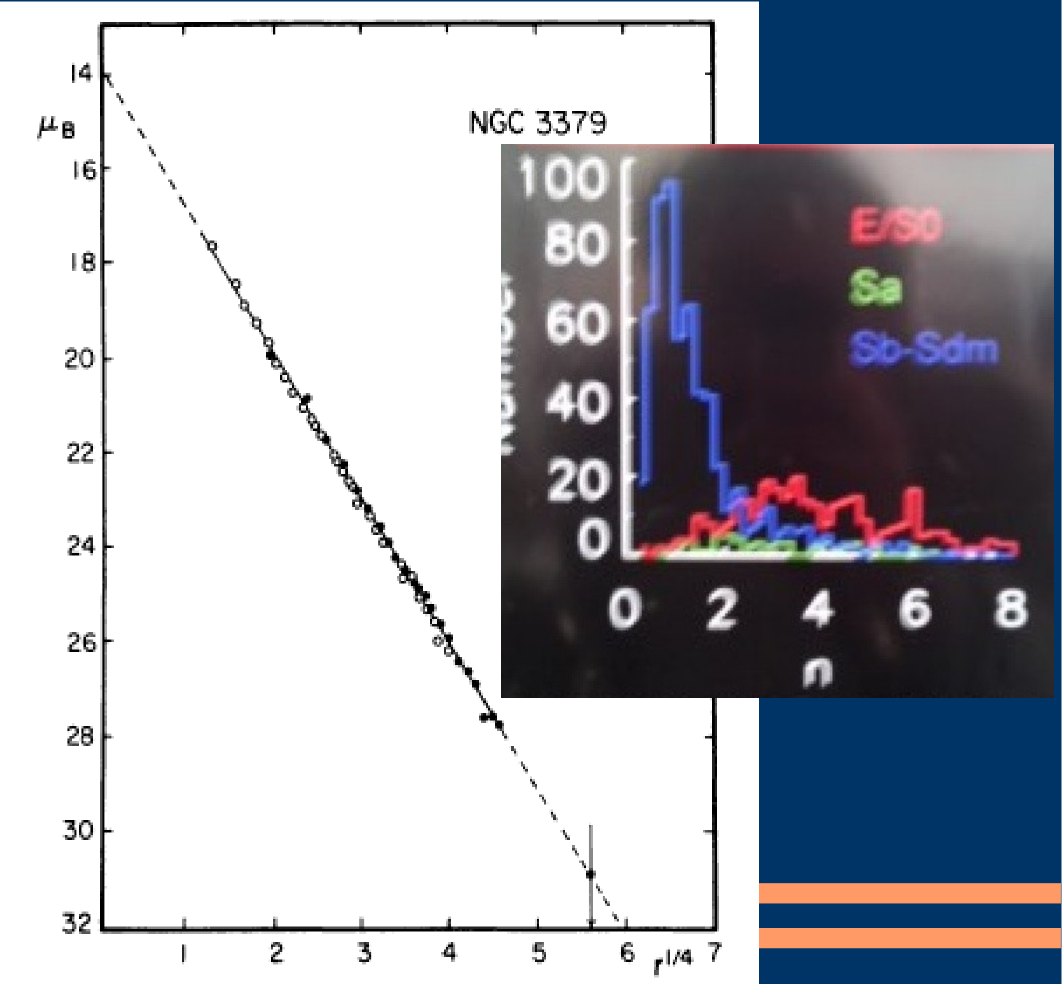
Information available 1. Sersic fitting.

$I(r)=(Ie/\alpha)*\exp\{-b(n)*(((X^2+(Y/\alpha)^2)^{1/2}/Re)^{(1/n)}-1)\}$

N:Model Index. Re:Half-light radius. α:Axial Ratio (b/a). b(n)=2*n-1/3.

- Correlated with morphological type.
- It fits very well E galaxies.





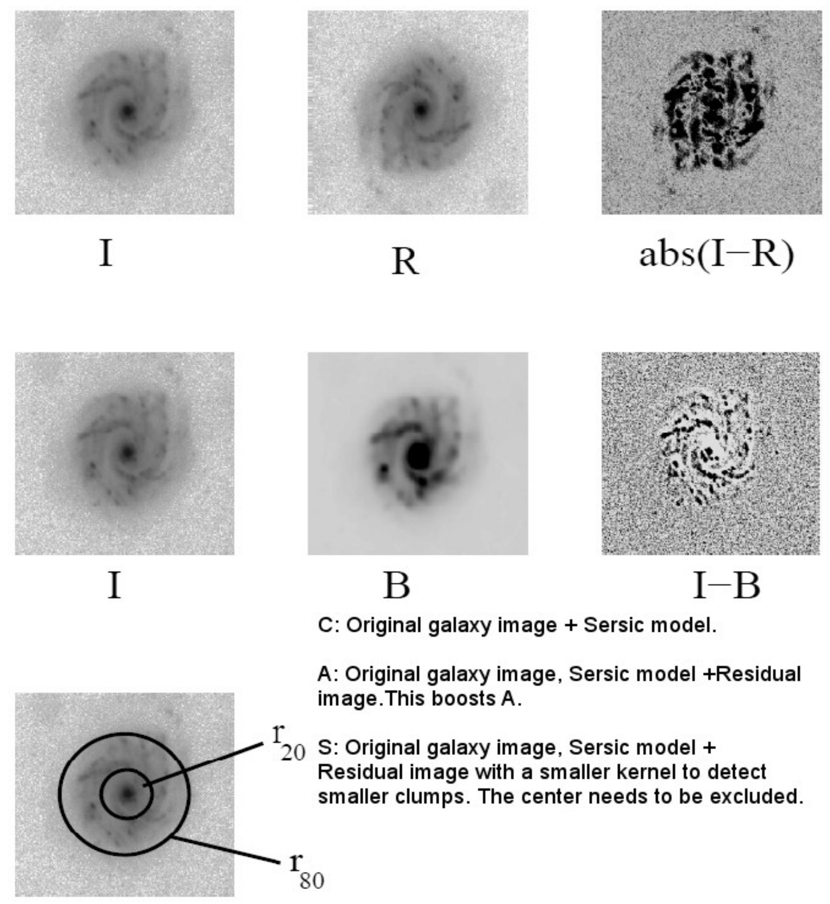
Information available 2. CAS parameters.

- CAS stands for **C**oncentration, **A**symetry, Clumpine**S**s. Three dimensional parameter space. The classical, rest-frame optical CAS definition for determining whether a system is a merger is A>0.35, A>S (Conselice 2003).
- Affected by **aperture and resolution issues** and **morphological k-corrections.**

$$C = 5 \times \log\left(\frac{R_{80}}{R_{20}}\right)$$

$$A = min\left(\frac{\sum |I_0 - I_{180}|}{\sum |I_0|}\right) - min\left(\frac{\sum |B_0 - B_{180}|}{\sum |I_0|}\right)$$

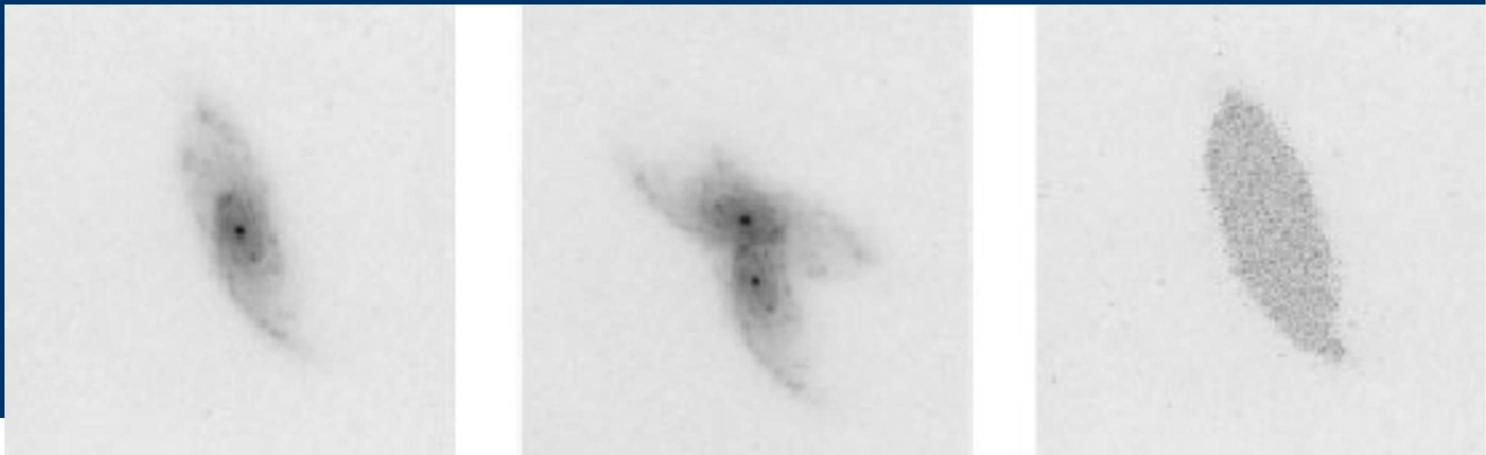
$$S = 10 \times \left\{\left[\frac{\sum (I_{x,y} - I^{\sigma}_{x,y})}{\sum I_{x,y}} - \frac{\sum (B_{x,y} - B^{\sigma}_{x,y})}{\sum I_{x,y}}\right]\right\}$$



Information available 3. Gini, C3 and M20.

- G measures to what extent some property is evenly distributed among a population. G=0=>Homogeneous, G=1=>Inhomogeneous.
- C3 measures **concentration**. Ratio of **fluxes** instead of ratio of radii. **Aperture up to a fixed** μ.
- M20 is the second order radial moment of the pixels containing 20% of the object's light.

Three Jackknife realizations with the same G.



$$G=\left(\frac{1}{|\bar{f}|\times n\times(n-1)}\sum_{i=1}^{n}(2\times i-n-1)\right)$$

$$M_{20}=\log\left(\frac{\sum M_i}{M_{Tot}}\right)\quad While\quad\left(\sum f_i\right)<0.2\times L_{Tot}$$

These diagnostics are calculated on the **original galaxy image** and on the **residuals**.

Example of Use of Gini, C and M20.

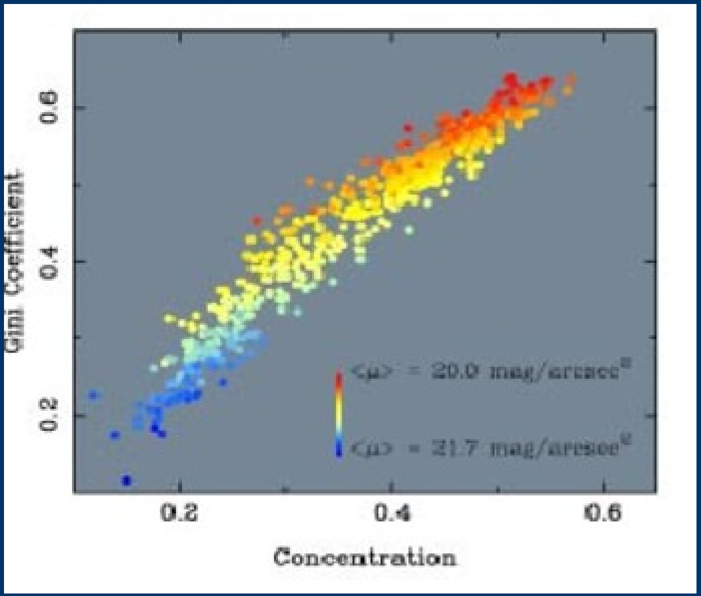
- G, M20, A(Cas) and C(Cas) have been used to identify mergers among local ULIRGs. The criteria are:

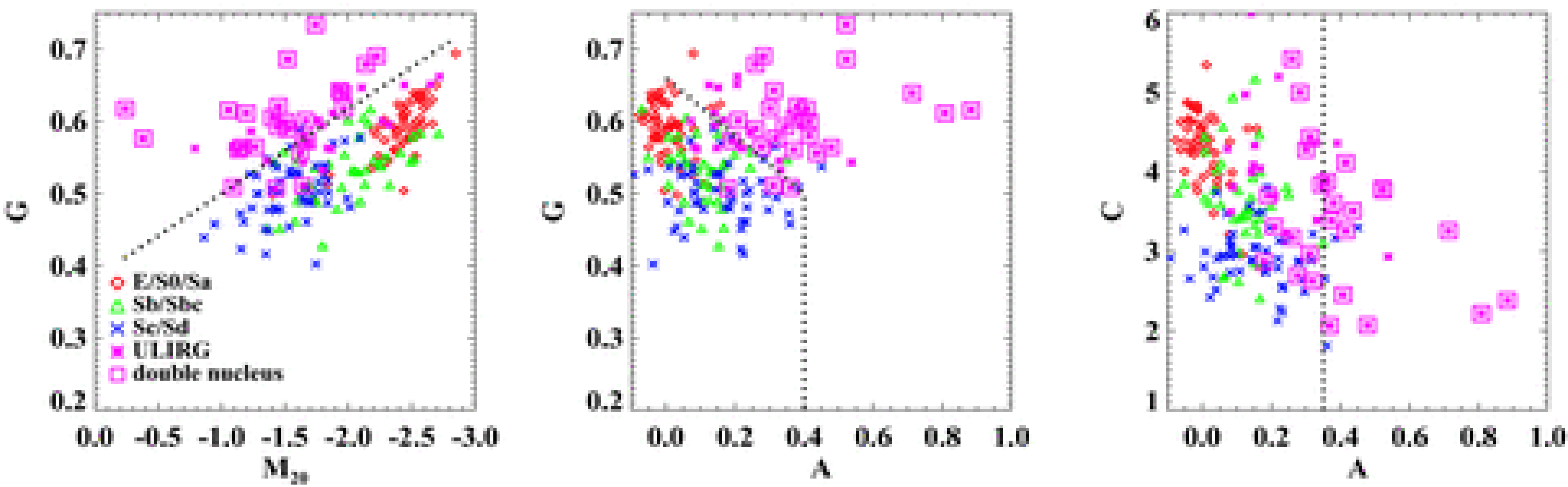
1) $G > 0.384 - 0.115\ M_{20}$.

2) $G > 0.66 - 0.4\ A$.

3) $A(Cas) > 0.35$

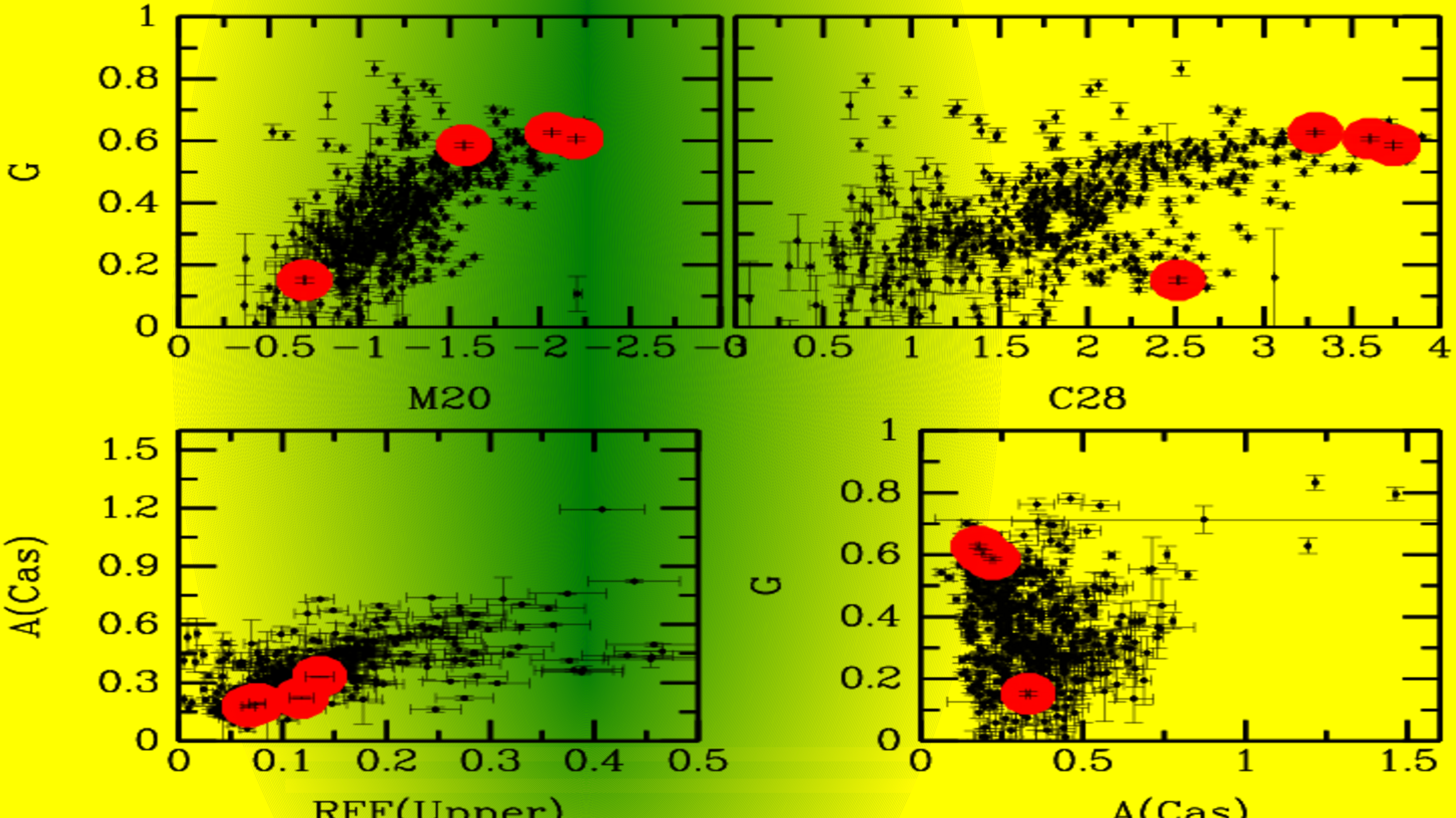
- Gini and C define a plane. μ **is the hidden** parameter.





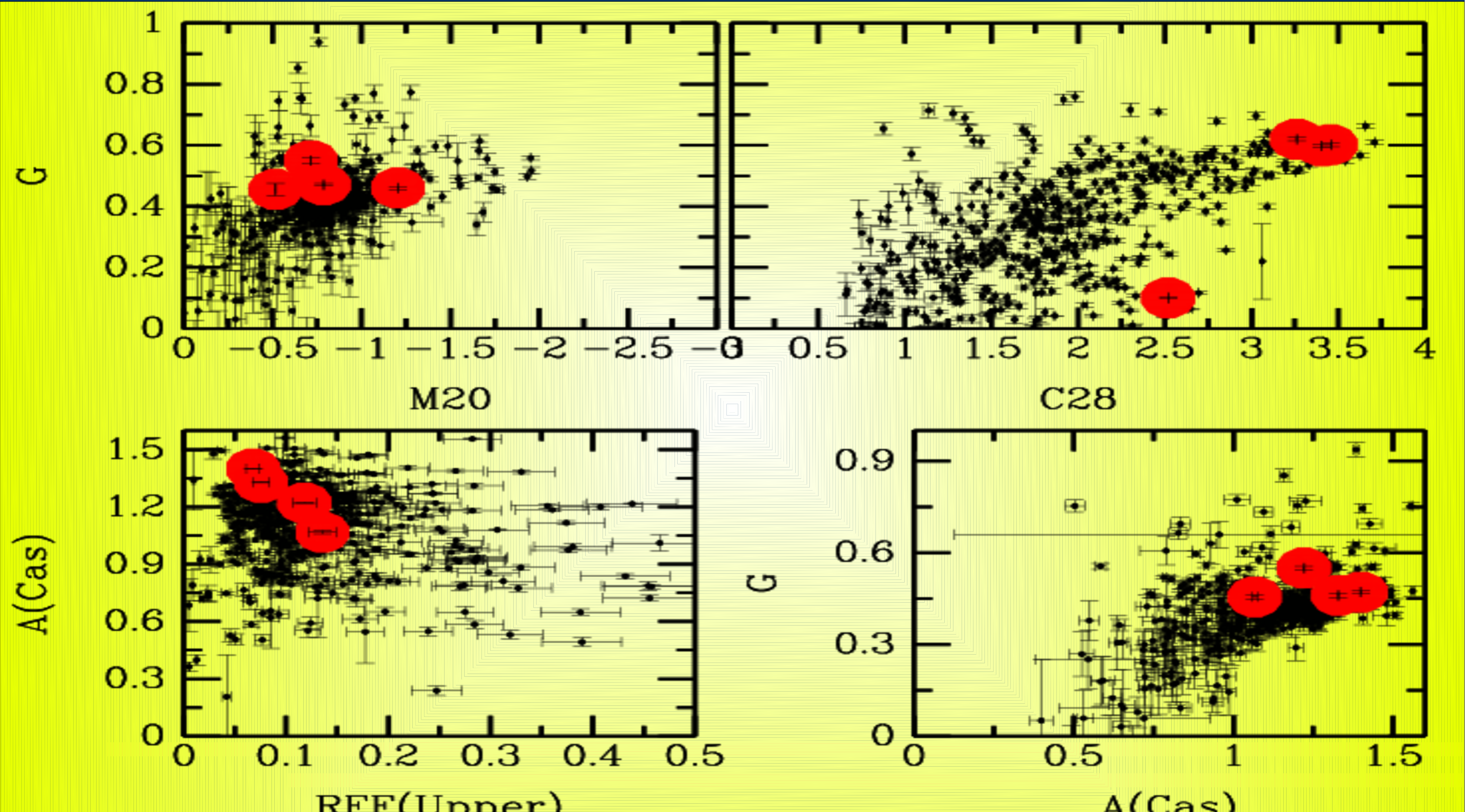
Preliminary Results. Image Structural parameters.

Parameters calculated over **ISOAREA**. CL1037 cluster.

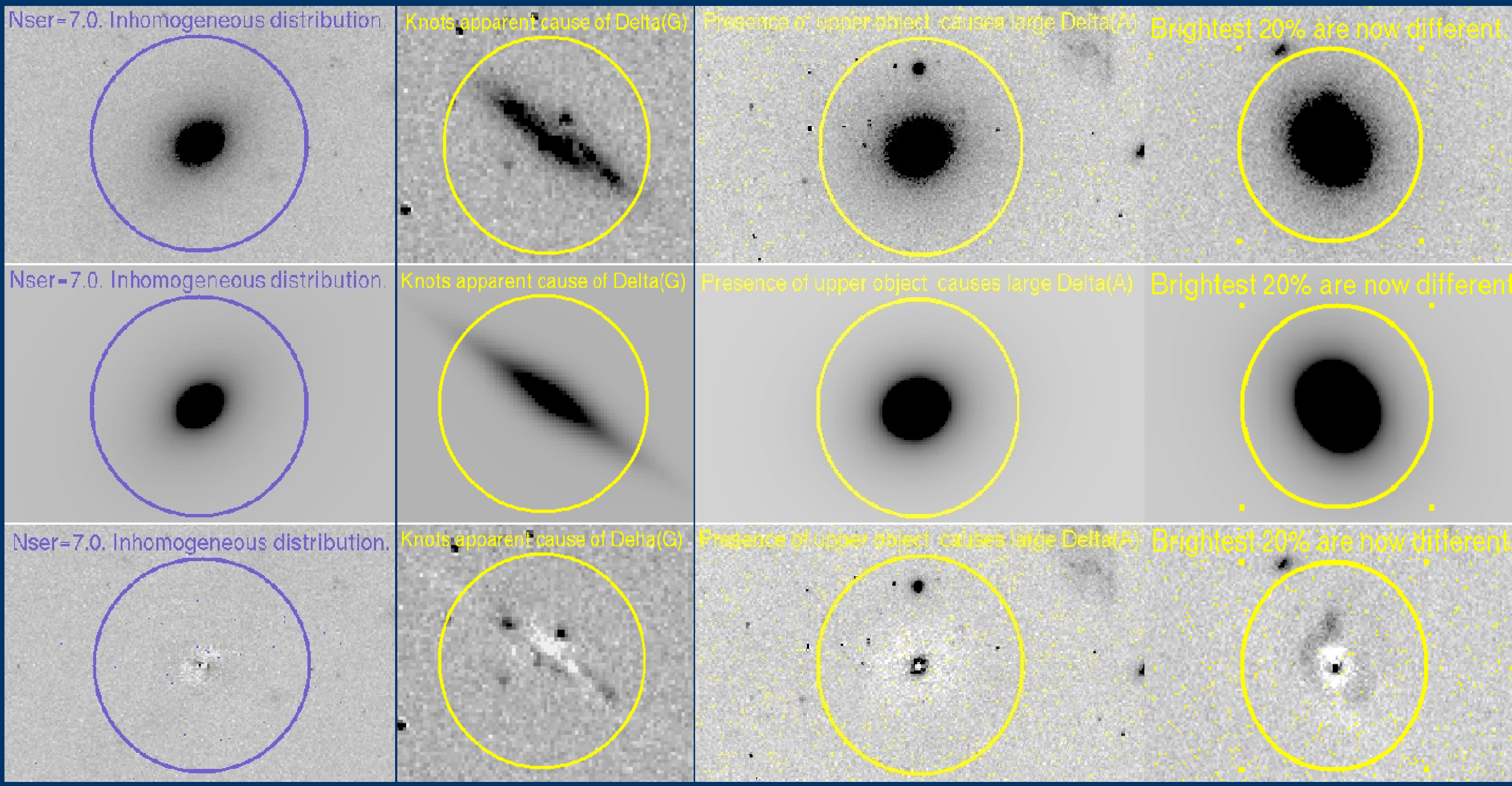


Preliminary Results. Residuals Structural parameters.

Parameters calculated over **ISOAREA**. CL1037 cluster.



Preliminary insights to what could be going on.



$G>0.6$ $\Delta G>0.3$ $\Delta A=1.0$ $\Delta M20>1.0$

Conclusions. Work to come.

- Galphyt code **capable of processing large number of galaxies** and **produce structural parameters** in very short time.

- Structural analysis of the **residuals can provide** with additional information, not exploited in previous studies. Among other things, we think that the **redistribution of sources** in G-M_{20},G-A, CAS, other planes, or the **use of a smaller kernel to compute the Clumpiness of the residuals** will help in the detection of high-redshift mergers.

- The analysis of **tailored simulobservations** (F. Bournaud) will produce a grid of models thanks to which it will be possible to study merger histories of galaxies in clusters **independently of morphological k-corrections and other assumptions.** These simulobservations will be available to us soon (maybe as I speak).