Environmental Effects on Galaxy Evolution: Multifrequency study of the nearby clusters A85/A496/A2670

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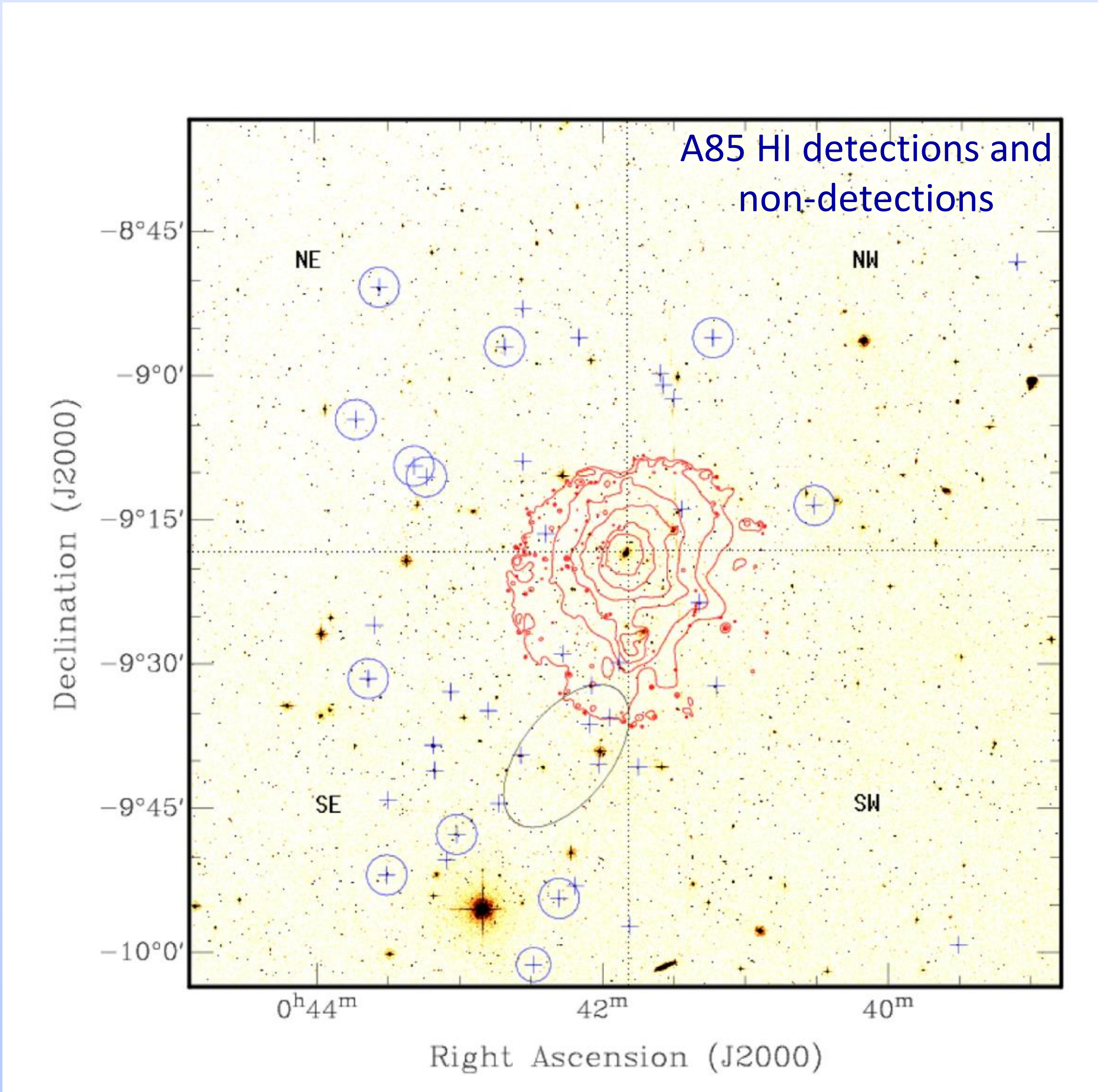
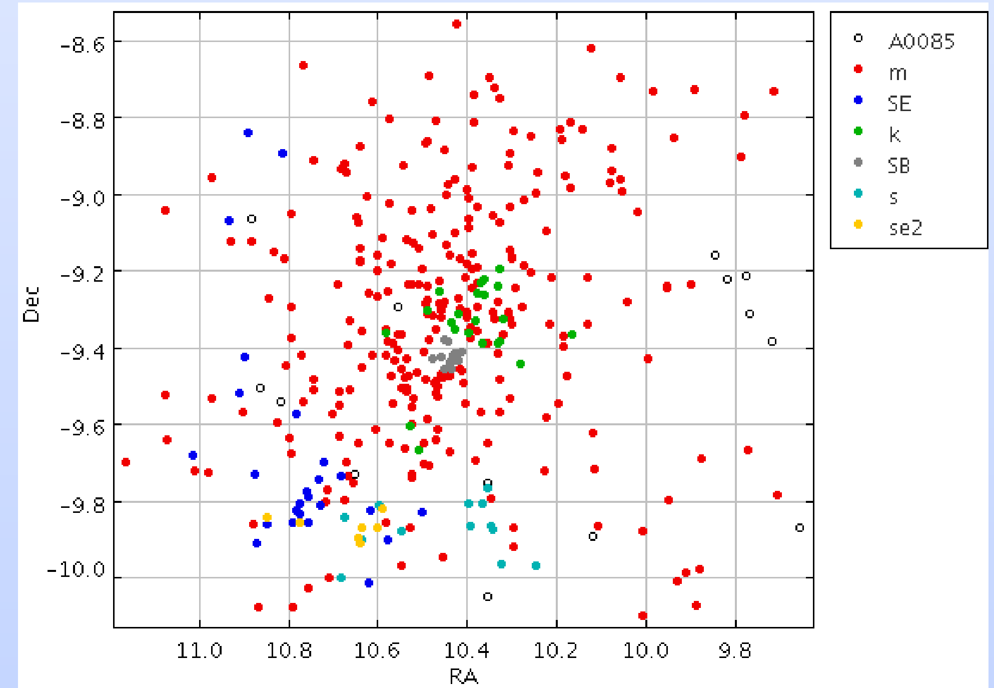
Abstract

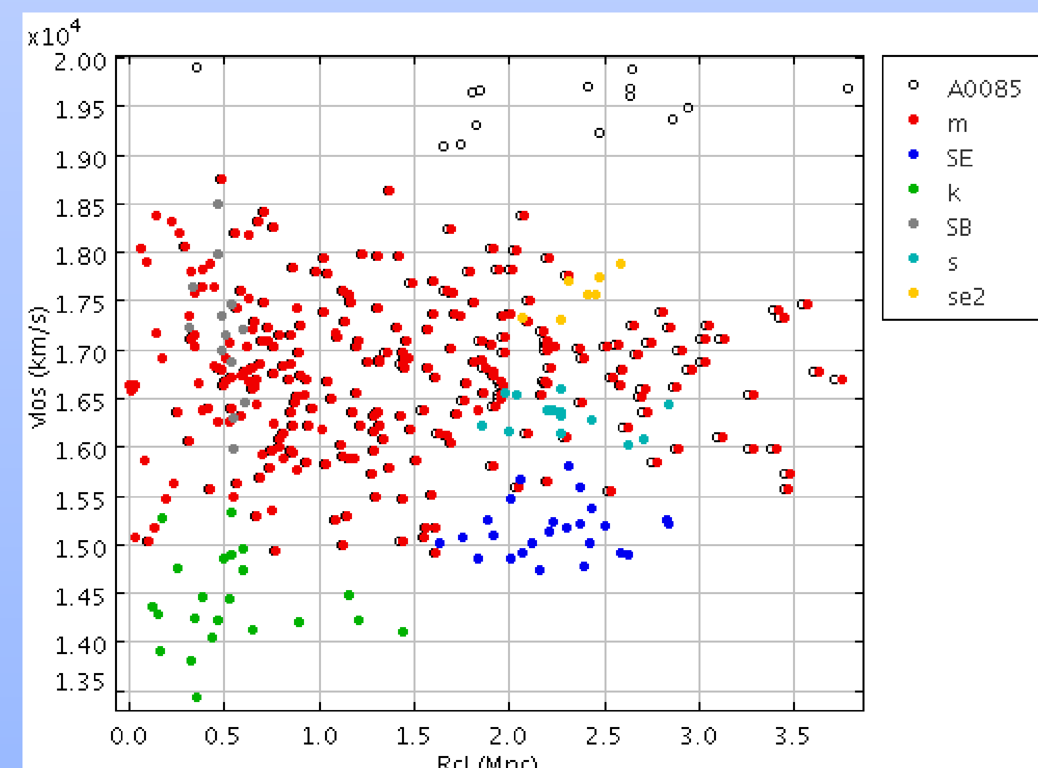
These are preliminary results of a study on the mechanisms driving the transformation from late to early-types of infalling galaxies into clusters. We compare the environment effects on the 21cm-HI gaseous component (observed with the VLA) with those affecting the old stellar disks as seen in deep optical and NIR imaging of cluster galaxies (2m-SPM and 3.6m CFHT). The VLA-HI survey enables us to study the ram-pressure stripping effects, while the NIR looks for systematic tidal (gravitational) features in cluster members. Our targets are the Abell clusters A85, A496, A2670 (z-range 0.033 - 0.066), spaning different relaxation degrees, masses and X-ray luminosities. These objects were surveyed in HI throughout large volume regions, covering several times their Abell radius in order to study both the core and the outskirts of the clusters.

Abell 85





Top panel: The galaxy projected distribution of A 85, showing some of the substructures. Bottom panel: A caustic plot of the radial velocities vs projected clustercentric distance (Bravo-Alfaro et al. 2015, in prep.)

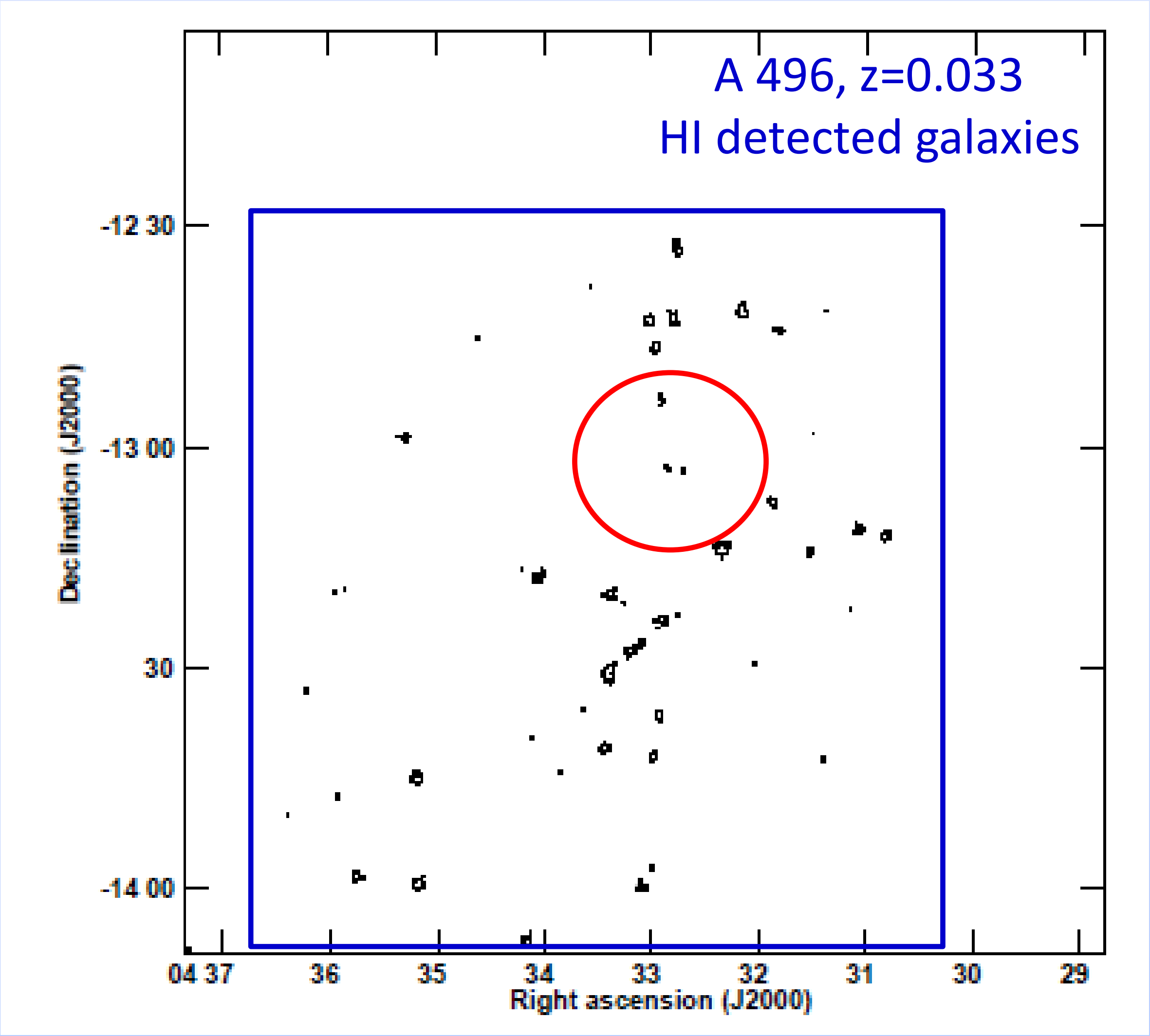


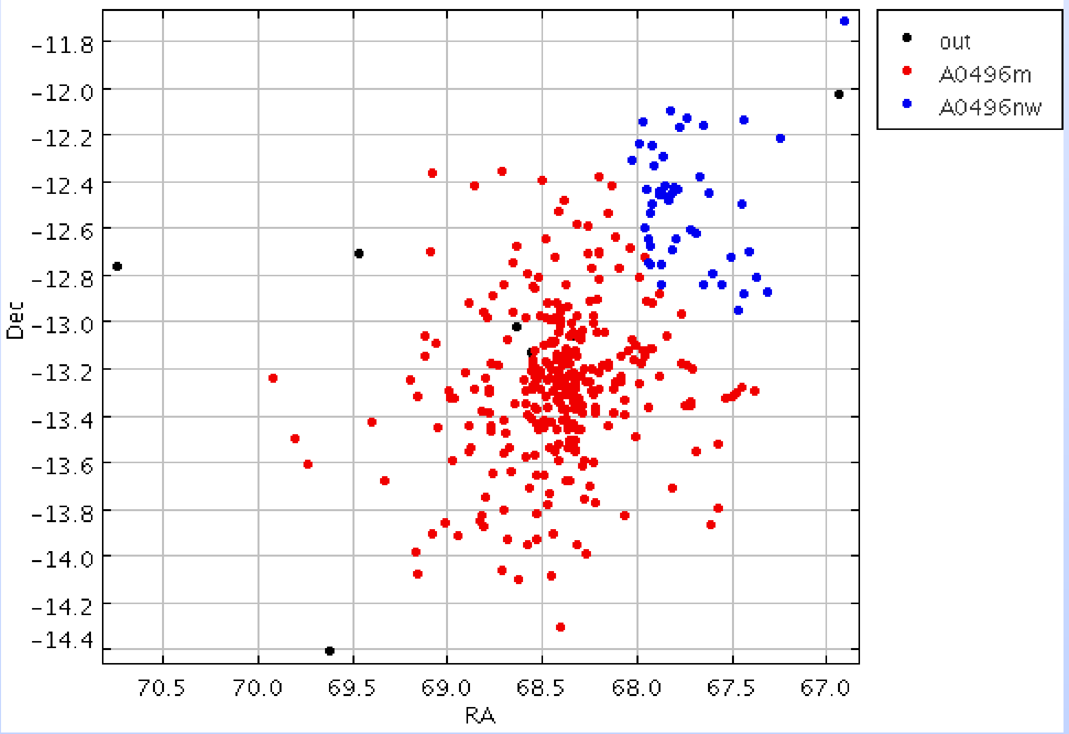
Topl: *Abell 85 is a rich cluster, being part of a supercluster having other 10 members. This figure shows the blue galaxies in Abell 85 (crosses), with those detected in HI (VLA, C-config.) indicated with circles; the non-encircled ones correspond to the HI-deficient galaxies (taken from Bravo-Alfaro et al. 2009). The red contours draw the X-ray emission.*

*Some **DATA***

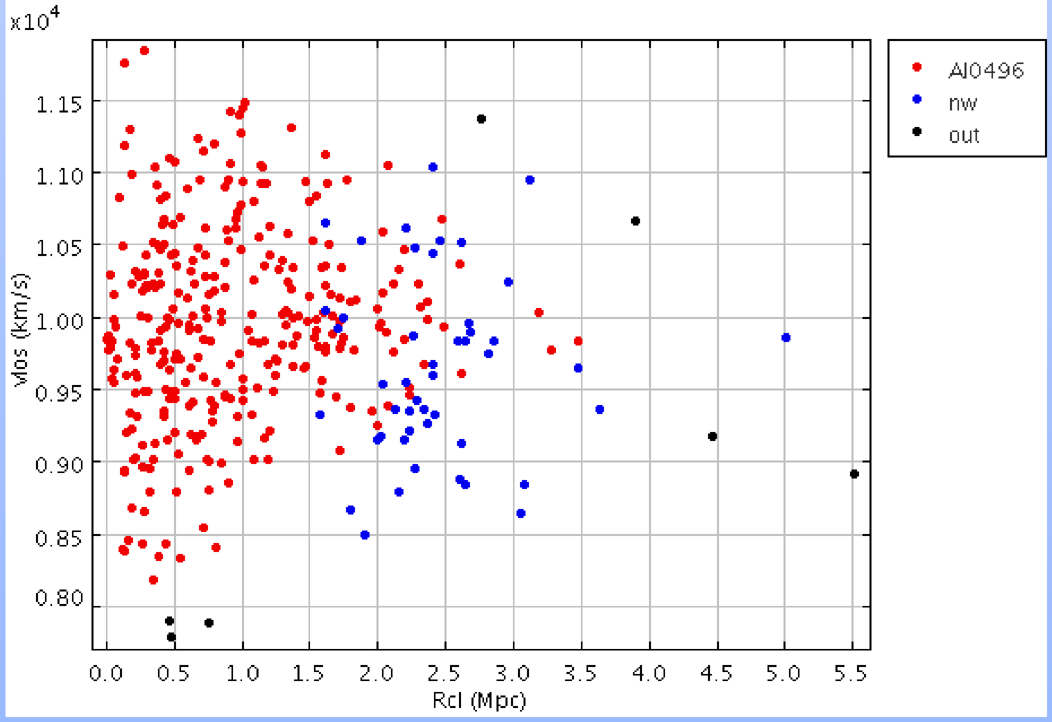
Redshift:	*0.055*	*HI-detections:*	*10-12*
B-M type:	*I*	*Vel-disp (km/s):*	*1097*
L(x) :	*$9.4x10^{44}$ erg/s/cm^2*		

Abell 496





Top panel: The galaxy projected distribution of Abell 496, showing the main subcluster in the NW. Bottom: A caustic plot of the radial velocities vs projected clustercentric distance (Bravo-Alfaro et al. 2015, in prep.)



TopI: *Abell 496 is a rather isolated cluster. This figure shows the HI detections, showing that this system is rather HI-rich. The blue square shows the area surveyed with the VLA. The red circle indicates the central X-ray emission.*

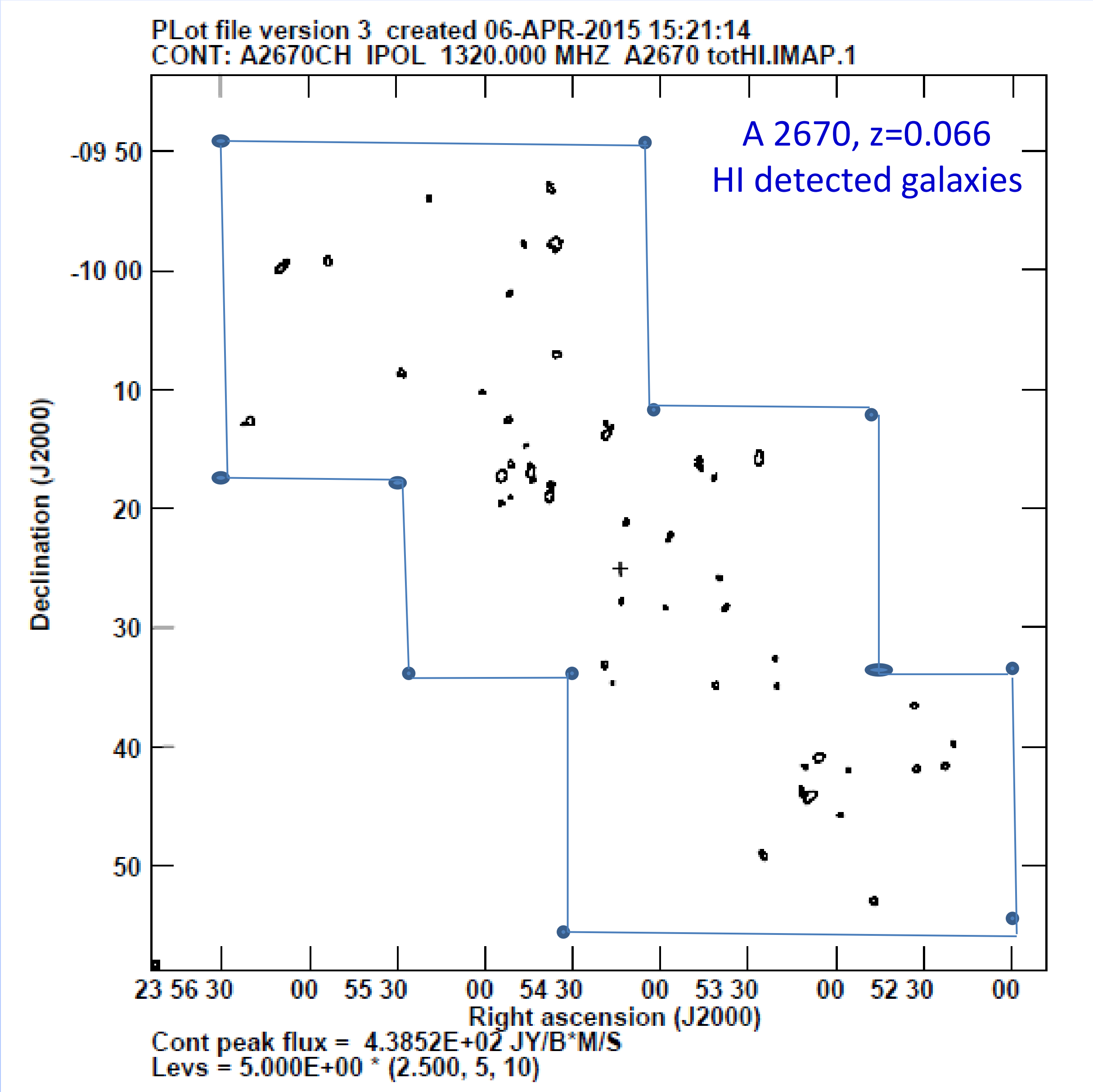
*Some **DATA***

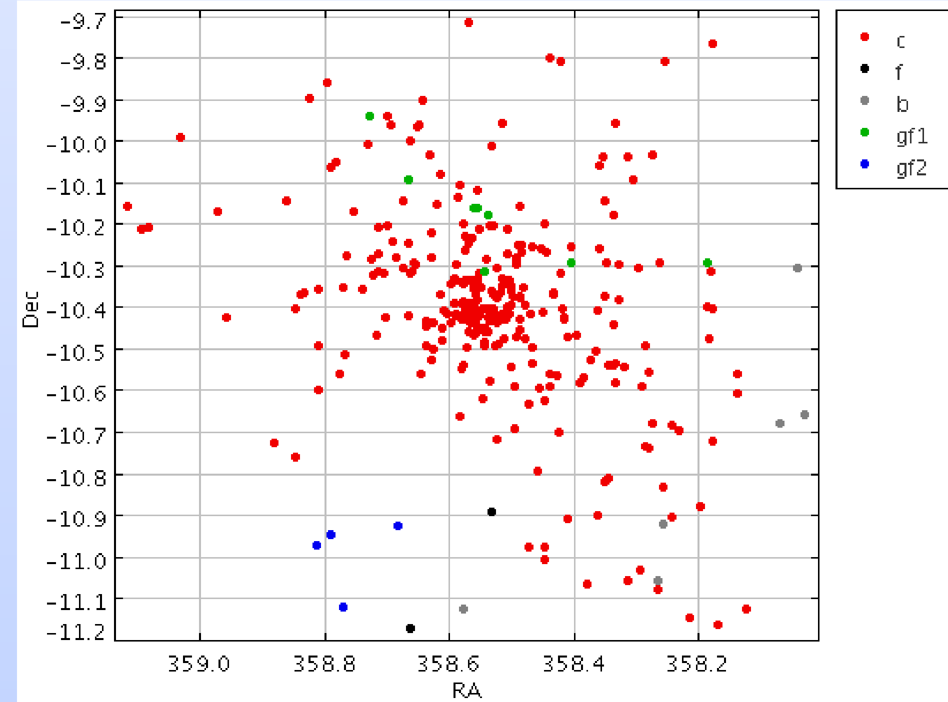
Redshift: 0.033 *HI-detections: 45-60*

B-M type: I *Vel-disp (km/s): 682*

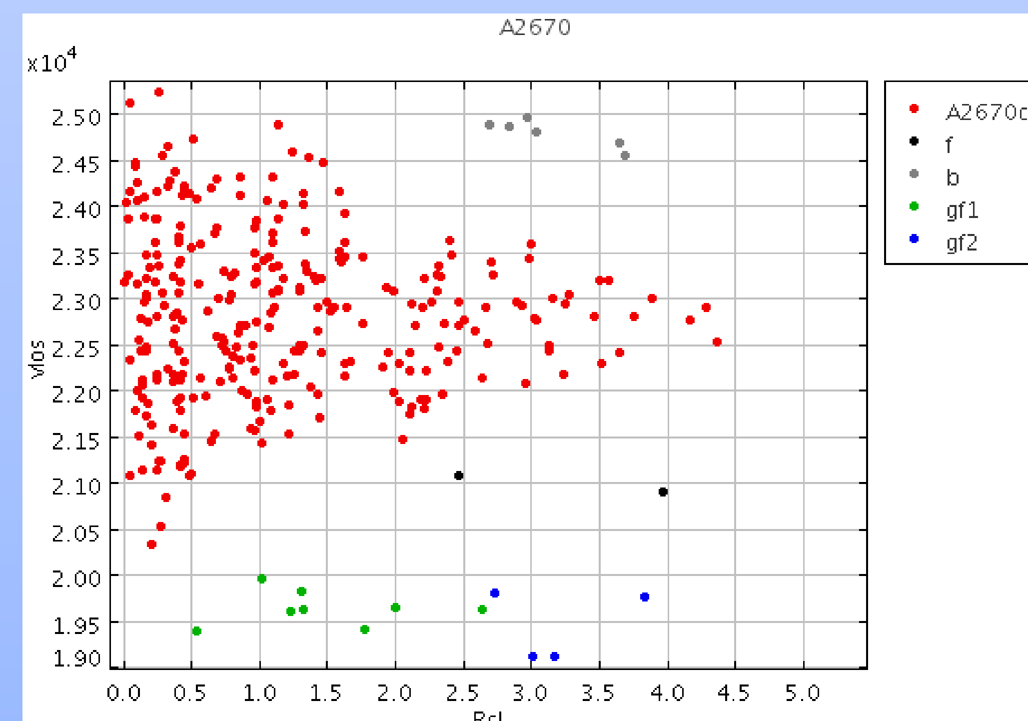
L(x) : 3.8×10^{44} erg/s/cm^2

Abell 2670





Top panel: The galaxy projected distribution of A2670, showing some of the substructures. Bottom: A caustic plot of the radial velocities vs projected clustercentric distance (Bravo-Alfaro et al. 2015, in prep.)

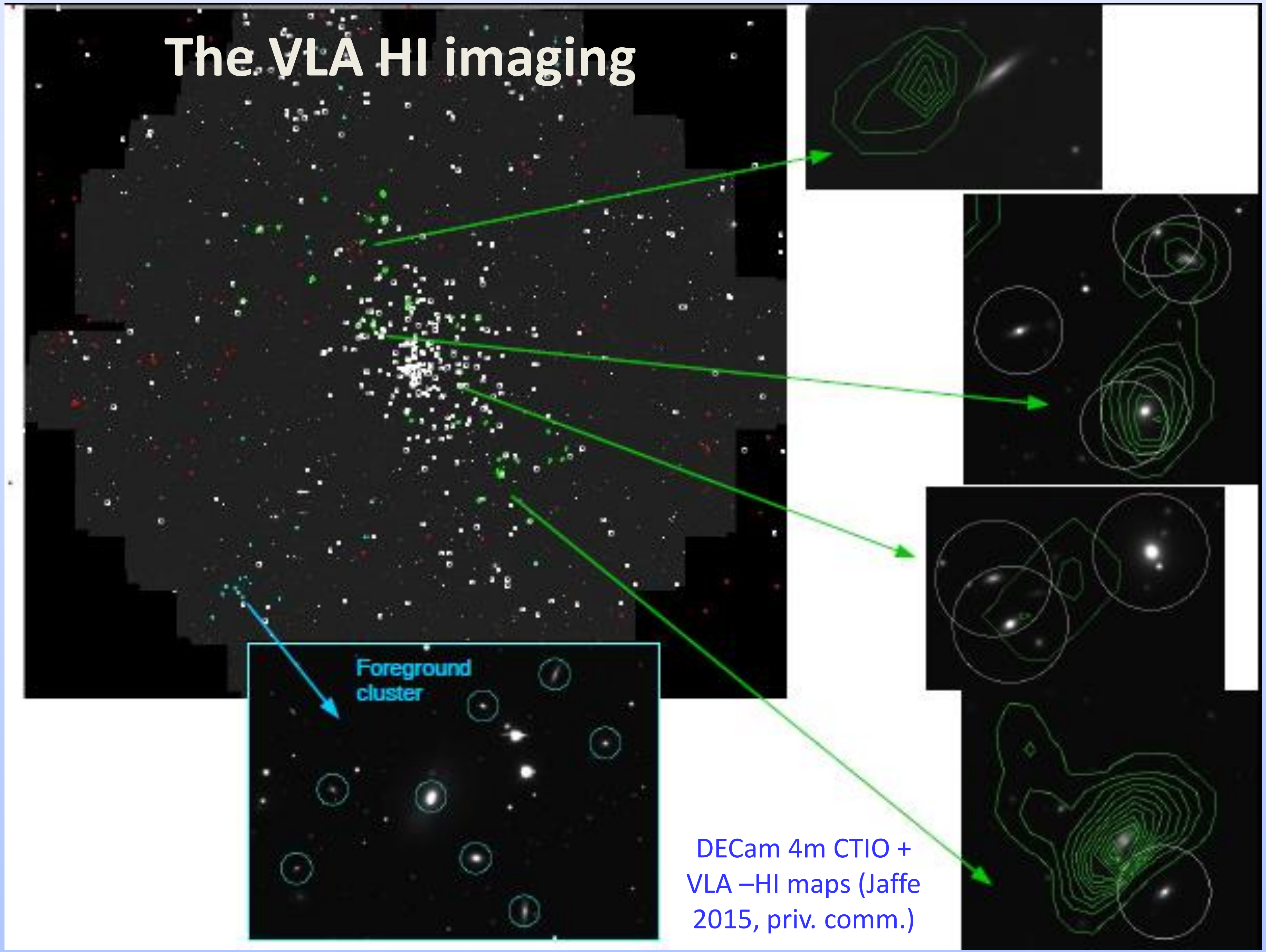


***Topl:** Abell 2670 is an isolated cluster. The high number of HI detections agrees with a rather dynamically young system with the HI-rich galaxies projected along a NE-SW axis. The blue polygon shows the zone surveyed by the VLA.*

*Some **DATA***

Redshift:	*0.076*	*HI-detections:*	*50-70*
B-M type:	*I-II*	*Vel-disp (km/s):*	*908*
L(x) :	*2.3×10^{44} erg/s/cm^2*		

Abell 2670 : Some examples of HI detected galaxies



We are studying individual galaxies and groups detected in HI. We observed HI-deficient objects, shrunken gas disks and offsets between the stellar and the HI-gas components.

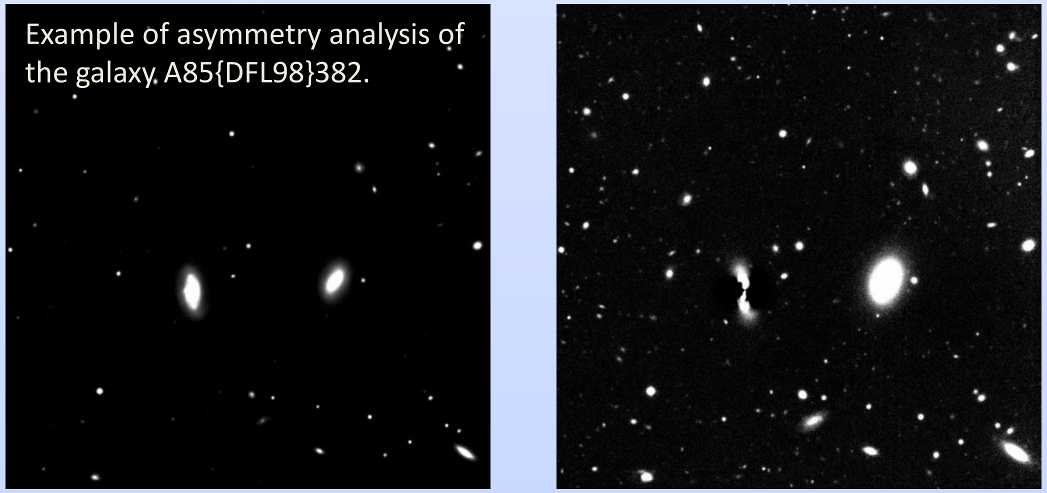
We compare the HI maps with deep optical/NIR images in order to dissentangle the physical mechanisms playing a major role in the spirals to S0 transformation :

hydrodinamic vs gravitational

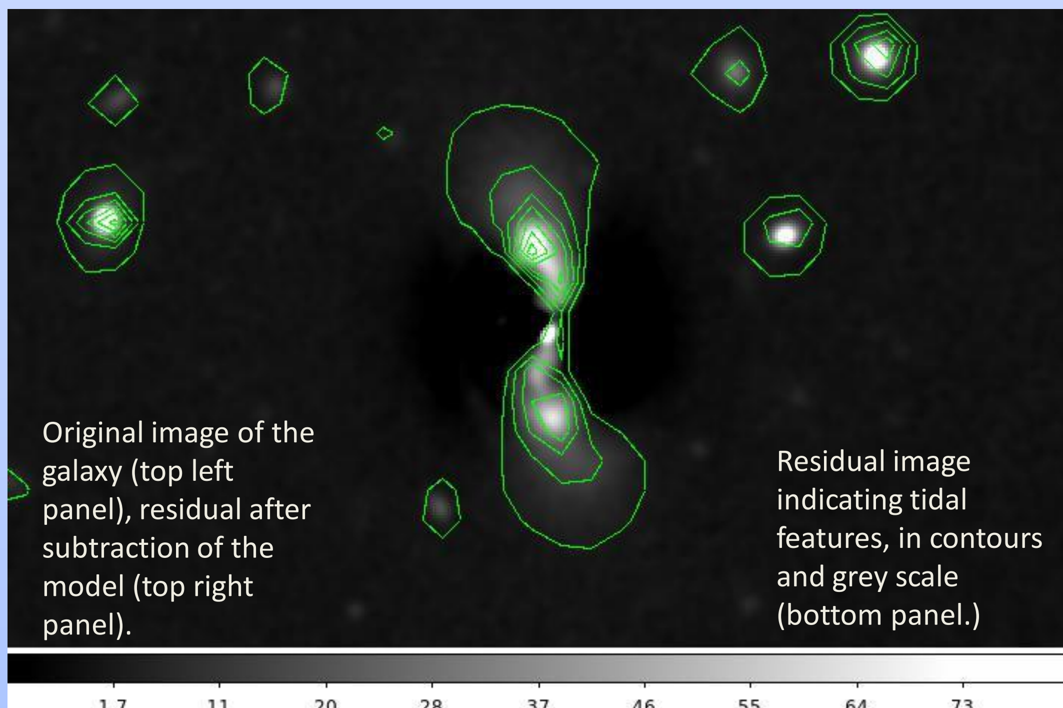
Several hundred hours were devoted to observe these clusters with the NRAO-VLA. Exploring their cores and outskirts enables us to study:

- The global cluster HI richness/deficiency.
- The effects of the ram-pressure stripping on individual galaxies.
- The effects occurring on the regions joining filaments with clusters.
- The dynamical stage of individual clusters.

Optical and NIR imaging



Example of asymmetry analysis of the galaxy A85{DFL98}382.



Original image of the galaxy (top left panel), residual after subtraction of the model (top right panel).

Residual image indicating tidal features, in contours and grey scale (bottom panel.)

Observations

- We dispose of optical images for these clusters, coming from MEGACam-3.6m CFHT.
- Deep NIR images of selected fields of A85, obtained with the 2m SPM Baja California, Mx.
- Deep NIR images of one squared degree in A 496, obtained with WIRCam-3.6m CFHT.

Goals

- Search for disrupted old stellar disks of individual galaxies.
- Quantifying the degree of disruption by applying an asymmetry index.
- Carry out a statistical analysis of assymetric objects through each cluster, and correlate with phisical properties of the clusters.
- Compare the ram-pressure stripping effects (seen in HI) with gravitational effects seen in NIR.

Results

- Our asymmetry analysis is based on the residual after subtraction of an axi-symmetric model of the galaxy from the original image. Our index A_μ considers the surface (in pixels) of the tidal features Σ(N_tidal) relative to the total size of the galaxy, Σ(N_gal) : **$A_\mu = \Sigma(N\_tidal) / \Sigma(N\_gal)$**
- This tool enables us to quantifying the degree of disruption on individual galaxies.
- We carry out a statistical analysis of asymmetry through each cluster, and correlate with the physical properties of the global clusters.
- We compare the ram-pressure stripping effects (seen in HI) with gravitational effects seen in NIR.