WINGS: WIde-field Nearby Galaxy-cluster Survey

Jesús Varela[1] and the WINGS collaboration[2]

[1]INAF-Osservatorio di Padova, Italy
email: jesus.varela@oapd.inaf.it
[2]WINGS website: http://web.oapd.inaf.it/wings/

Abstract. The **WI**de-field **N**earby **G**alaxy-cluster **S**urvey (WINGS) is a long term project whose main goal is to establish the zero point and variance of properties of nearby clusters, and galaxies in them, to be used as a local reference in evolutionary studies.

To achieve such objective, wide-field multiwavelenght photometry and optical spectroscopy has been gathered and analysed for a sample of 77 X-ray emitting nearby galaxy clusters.

This contribution shows the current status of the project.

Complete poster contents is reproduced in "On-line Section" and PDF copy is available in `http://web.oapd.inaf.it/wings/Docs/IAU2006_Varela.pdf`.

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Current Status of the WINGS project

WINGS is a multiwavelength survey of 77 nearby ($0.04 < z < 0.07$) X-ray selected ($L_X > 10^{43.5}$ erg/s) Galaxy Clusters (Fasano *et al.*, 2006,A&A, 445, 805). The main goal of this survey is to establish the zero point and local variance of the properties of clusters and cluster galaxies to be used in evolutionary studies.

The current status of the WINGS project is summarized:

Photometry

B & V For characterization of galaxies (positions, magnitudes, sizes) and clusters (luminosity function, color-magnitude diagram, spatial distribution of galaxies, subclustering,...).

- Catalogs with positions, star/galaxy classification and basic photometry (SExtractor's output). 90% of completeness at $V \sim 21.7$ (Varela *et al.*, in prep)
- Surface photometry performed with GASPHOT for the ~ 45000 largest galaxies.
- Objective morphology performed with MORPHOT (Fasano et al., in prep) for galaxies with more than 500 pixels of area.

U & Hα To determine the current star formation rate of galaxies.

- 11 clusters observed in U band with WFC@INT reduced with catalogs constructed.
- 5 clusters observed in U band with 90Prime@BoK.
- 4 cluster observed in Hα band with WFC@INT.

J & K To analyse the stellar mass of galaxies.

- 25 clusters observed in K band with WFCAM@AAT.
- 15 clusters observed in J band with WFCAM@AAT.
- 90% completeness at K$\sim$ 19 and J$\sim$ 20.

Spectroscopy To determine the redshifts of the galaxies for studies of kinematics and dynamics, and to analyse the star formation histories.

- 22 clusters observed with 2dF@AAT, reduced and with high quality redshifts measured for > 6100 galaxies.

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- 26 clusters observed with WYFFOS/Autofib2@WHT in process of analysis.
- Spectral analysis (star formation histories, extinctions and stellar masses) with SSPs, performed automatically with SIMSPEC (Fritz *et al.*, in prep.).

Appendix A. On-line Section

A.1. *Poster Contents*

In this Appendix the contents of the poster are reproduced. A copy of the poster can be obtained in `http://web.oapd.inaf.it/wings/`

A.2. *Abstract*

WINGS is a multiwavelength survey of 77 nearby ($0.04 < z < 0.07$) X-ray selected ($L_X > 10^{43.5}$ erg/s) galaxy clusters (Fasano *et al.* 2006, A&A, 445. 805). The main goal of this survey is to establish the zero point and local variance of the properties of clusters and cluster galaxies to be used for evolutionary studies.

The WINGS project includes:

- Photometry
  - ○ Optical (B,V) wide-field ($\sim 34' \times 34'$) deep photometry of 77 fields (Varela *et al.* 2006, in prep.). Catalogs contain $\sim 6 \times 10^5$ objects classified as stars and galaxies. Position, basic photometry (total magnitude and aperture photometry) and geometrical parameters (isophotal area, ellipticity, position angle,...) have been measured for each object. For the 10% largest galaxies surface photometry and objective morphological classification is also being performed with special designed tools. Images and catalogs will be publicly available.
  - ○ On-going photometric follow-up programs:
    - —— NIR (J,K) wide field imaging focused on stellar mass analysis.
    - —— U and $H\alpha$ wide field imaging for analysis of the star formation in cluster galaxies.
    - —— Ultra-wide-field (90Prime@BoK) imaging in UBV to study the outer parts of the clusters of galaxies and their infalling regions.
- Spectroscopy
  - ○ Spectra have been already taken for a subsample of 51 fields ($\sim 100 - 200$ galaxies per field) covering the wavelength range $\sim 3600 - 8000\mathring{A}$. This allows to obtain redshifts, for cluster membership and dynamical studies, as well as to analyze the star formation history, extinction and stellar masses of the different stellar populations that compound galaxies.

A.3. *Goals*

- Global properties of nearby cluster of galaxies: luminosity profile, internal dynamics and subclustering.
- Zero point and variance of properties of nearby clusters and galaxies in clusters to be used as a local reference in evolutionary studies.
- Properties of galaxies as a function of the local density, clustercentric distance and cluster properties.

A.4. *Sample*

- Nearby Clusters of Galaxies ($0.04 < z < 0.07$)
- X ray emitting clusters ($\log(L_X) > 43.5$)
- Out of the galactic plane ($|b| > 20^o$)

This results in **77 Clusters of Galaxies**.

A.5. *Strategy*

- Wide Field Observations ($FOV \geqslant 30' \times 30'$)
- Multiwavelenght photometry (U,B,V,J,K)
- Multiobject Optical Spectroscopy ($\sim 3600\mathring{A} - 8000\mathring{A}$))
- Development of programs for automatic analysis:
  - GASPHOT (Surface Photometry) (Pignatelli *et al.*, 2006)
  - MORPHOT (Morphology) (Fasano *et al.*, in prep.)
  - SIMSPEC (SSPs Fitting) (Fritz *et al.*, in prep)

A.6. *Photometry*

A.6.1. *B & V*

Basic Photometry

- Goals
  - Construction of the reference catalogs of the survey with optical magnitudes, positions, star/galaxy classification and geometrical parameters of all the detected objects.
  - Luminosity Function and Color-Magnitude Diagram.
  - Spatial distribution of galaxies in clusters: Luminosity Profile and Subclustering.
- Observations
  - B & V band
  - 77 clusters
  - WFC@INT + WFI@MPG/ESO-2.2m ($\sim 34' \times 34'$)
  - 90% completeness at $V \sim 21.7$
- Data and preliminary results
  - Catalogs constructed using SExtractor
  - Particular procedure to treat objects with large halos which improves their photometry and that of close objects.
  - Detected $\sim 6 \times 10^5$ objects: 53 % Galaxies; 30% Stars and 16% Not Classified
  - Catalogs will be released in Varela *et al.* 2006. (in prep.)
  - An example of the results is shown in Fig. 1 which presents the color-magnitude diagram constructed with all the galaxies detected in the 77 clusters.

Surface Photometry & Morphology

- Goals
  - Study of the scaling relations of galaxies.
  - Study of the galactic populations in clusters.
  - Analysis of the dependence of galaxy spatial distribution and galaxy relations on morphology .
- Procedure
  - Selection of largest galaxies (Area>17 arcsec^2)
  - ~ 45700 galaxies in 77 fields
  - Surface Photometry:
    - — Automatic procedure: GASPHOT
    - — Space varying PSF
    - — Growth curves
    - — Fitting to Sérsic profile
    - — n Sérsic index
    - — Effective radius
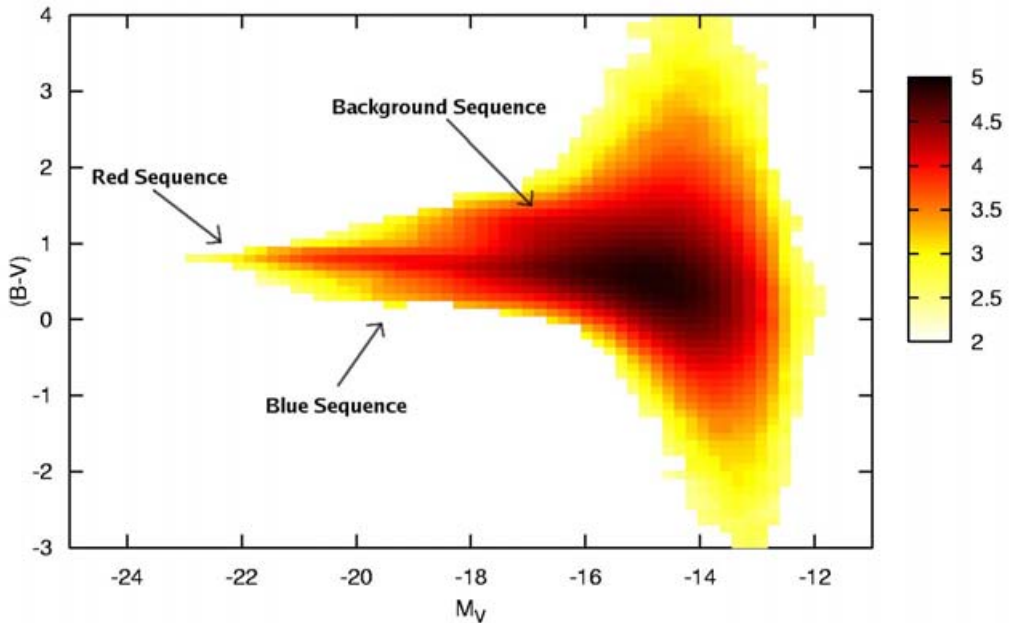   - — Total Magnitudes

Figure 1. Fig.1. Color-Magnitude Diagram constructed with all the galaxies detected in WINGS. (B-V) is measured within an aperture of 5Kpc of radius. The colors represent the density of points in the diagram in logarithm scale. The Red Sequence is clearly visible. The Blue Sequence one is due to blue cluster members. The reddest sequence one is related with background galaxies.

— Fig. 2 shows the Kormendy plane resulting when taking all the galaxies with surface photometry.
∘ Objective Morphology:
— Automatic procedure: MORPHOT (Fasano, in prep.)
— Multiparametric + Neural Network
— Calibrated with large sample of visually classified galaxies

A.6.2. *U & Hα*

• Goals
∘ Analysis of the Star Formation Rate of galaxies in clusters and its relation with position in the cluster and local environment.
• On going Observations
∘ U band
— 11 clusters observed with WFC@INT
— 90% Completeness $U \sim 22$
— 5 clusters observed with 90Prime@BoK
∘ Hα (at cluster redshift):
— 4 clusters observed with WFC@INT
∘ Data and preliminary results
— 11 UV WFC@INT clusters fully reduced
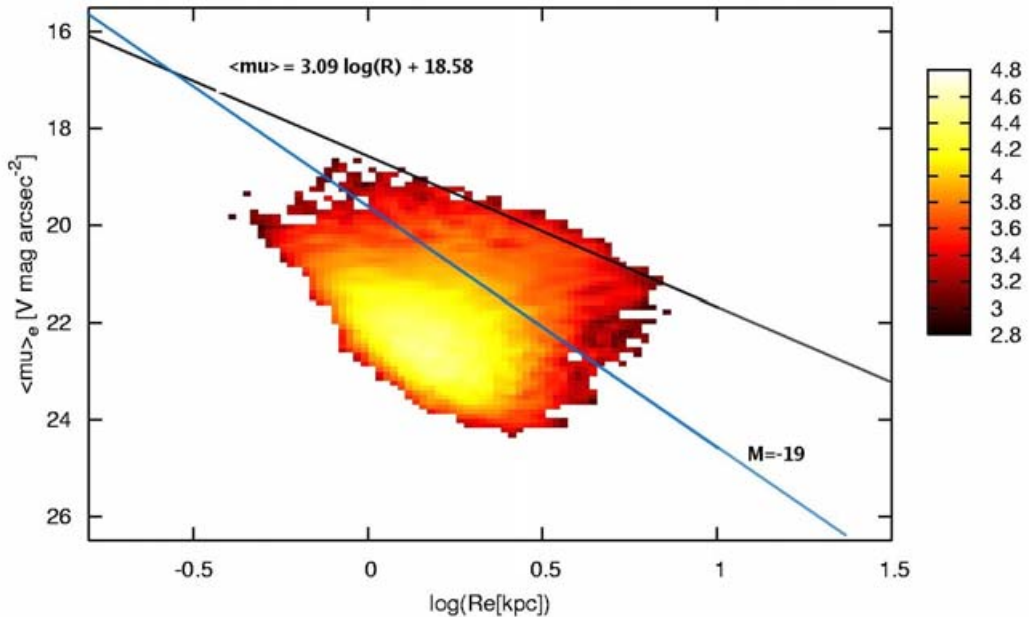— Catalogs constructed using SExtractor

Figure 2. Kormendy plane created with the data from the 77 fields of WINGS. Color scale is related with the density of points in the diagram. No subtraction of background population have been done. Black line: Kormendy Relation (D'Onofrio, private comm.). Blue line: Line of constant.

—— Fig. 3 shows the U-(U-B) plane for the cluster A1291. The confirmed members of the cluster are identified with red circles. Two well defined sequence are evident.

A.6.3. *J & K*

- Goals
  - Analysis of the stellar mass of galaxies in Clusters
  - Stellar Mass Function of Clusters.
- On going Observations
  - J & K band
  - WFCAM@UKIRT (FOV $\sim 30' \times 30'$)
  - 15 clusters observed in J
  - 25 clusters observed in K
  - 90% Completeness $K \sim 19$ and $J \sim 20$
- Data and preliminary results
  - Photometric catalogs from UKIRT pipeline
  - Fig. 4 shows the color-color diagram from WFCAM(NIR)+WINGS(optical) photometry of galaxies in Abell 1631A with evolutionary models overplotted.

A.7. *Spectroscopy*

- Goals
  - Determination of membership
  - Analysis of internal dynamics of Clusters
  - 3D distribution of galaxies in Clusters
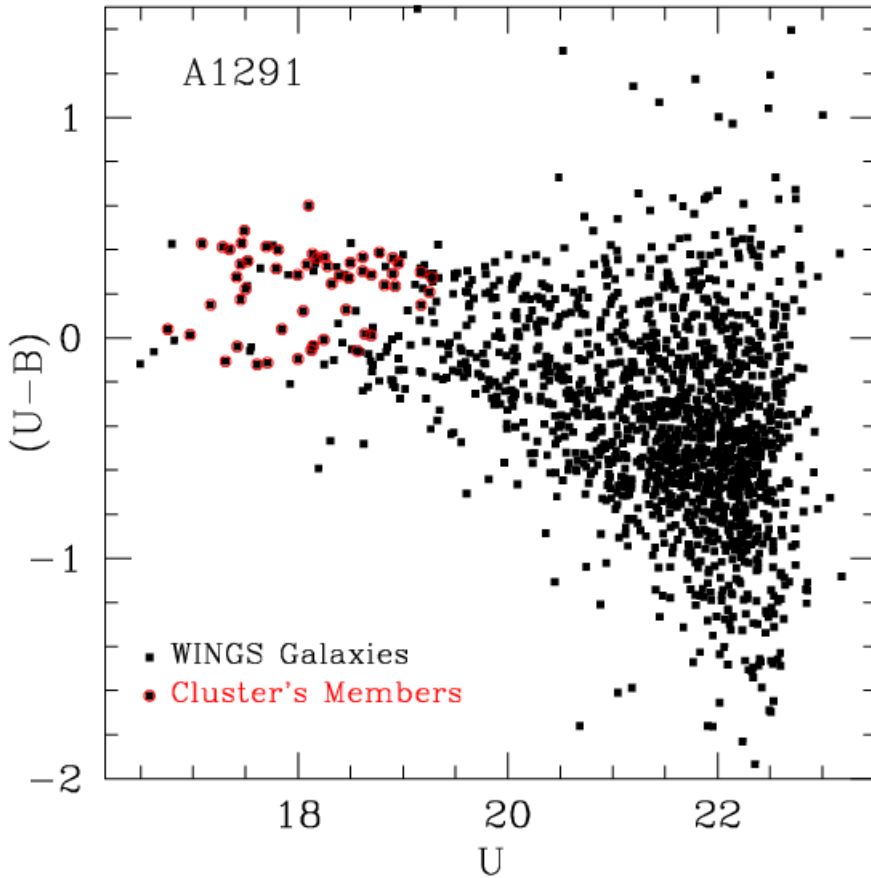 - Analysis of the Star Formation History of galaxies in Clusters

Figure 3. U - (U-B) Color-Magnitude Diagram for the galaxies in the field of A1291. Red circles represent galaxies with known redshift closer than 0.005 to that of A1291. The Red and Blue Sequences are evident and quite well separated.

- Observations
  - WYFFOS/Autofib2@WHT $(3800\mathring{A} - 7000\mathring{A}, \Delta\lambda \sim 3\mathring{A})$
  - 2dF@AAT $(3600\mathring{A} - 8000\mathring{A}, \Delta\lambda \sim 9\mathring{A})$
  - $V < 20$
  - 26 Clusters observed with WYFFOS@WHT
  - 22 Clusters observed with 2dF@AAT
- Data and preliminary results
  - 22 2dF@AAT clusters fully reduced and analyzed
  - Redshift measured with cross-correlation + individual check.
  - High quality redshifts for > 6100 galaxies.
  - High quality redshift and velocity dispersion for 22 clusters.
  - Fig.5 shows the redshift distribution of galaxies in the first 22 WINGS clusters already analysed with the values of mean cluster redshift and velocity dispersion computed.
- Spectral Analysis
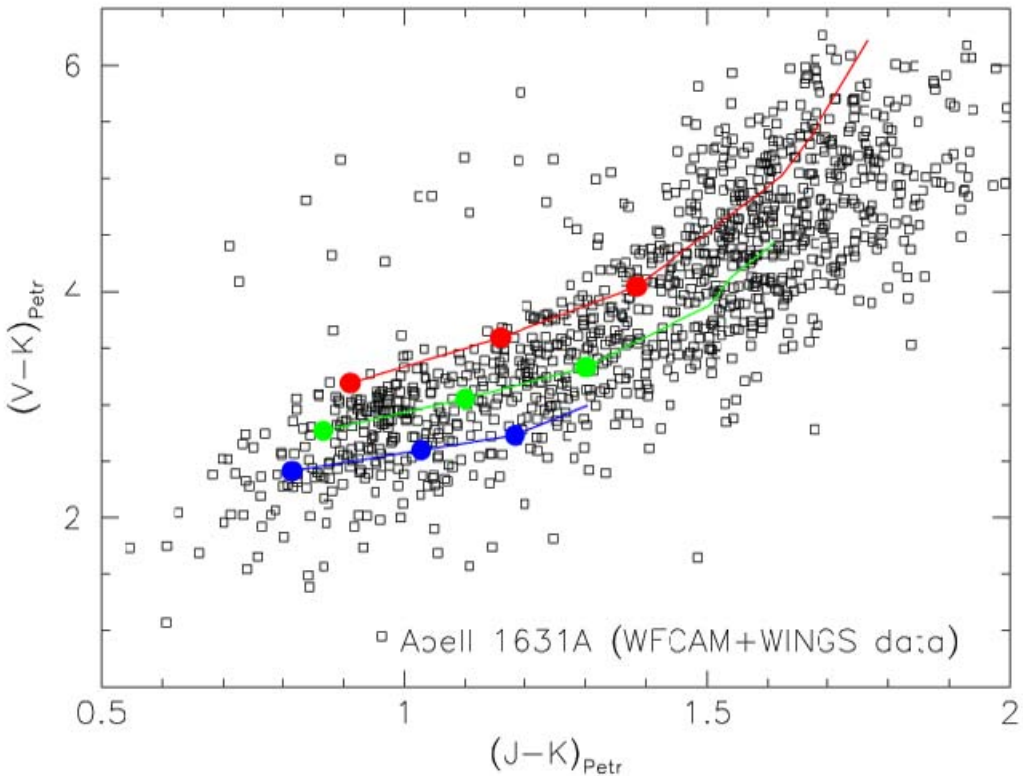 - SIMSPEC (Fritz *et al.*, in prep.)
  - Spectral fitting by means of SSPs

Figure 4. (V-K)-(J-K) Color-Color diagram from WFCAM+WINGS (optical) photometry of galaxies in Abell 1631A. The lines correspond to galaxy evolutionary models by Bressan (priv. communication), from z=0 (lower left) to z=0.9 (upper right), for bulge fractions of 1,0.5 and 0 (top, middle and bottom lines, respectively). The big points on the tracks refer to z=0, z=0.1 and z=0.2.

- ○ Determination of:
    - —— Star Formation Histories
    - —— Stellar masses
    - —— Extinction
    - —— Measurement of Equivalent Widths

References

Fasano, G., Marmo, C., Varela, J., D'Onofrio, M., Poggianti, B. M., Moles, M., Pignatelli, E., Bettoni, D., Kjergaard, P., Rizzi, L., Couch, W. J., & Dressler, A. 2006, *A&A*, 445, 805.
Pignatelli, E., Fasano, G., & Cassata, P. 2006, *A&A*,, 446, 373.
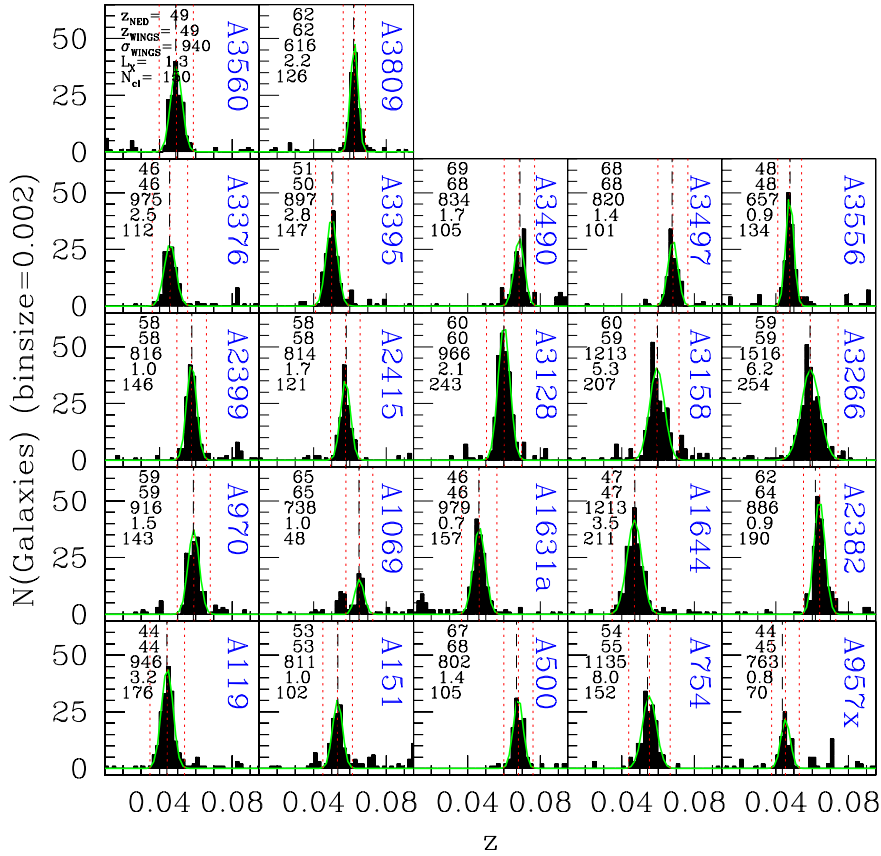
Acknowledgements

Redshift Histogram (with sigma clipping at 2 σ) for WINGS data

Figure 5. Redshift distribution of galaxies in 22 WINGS' clusters' fields. Upper left numbers in each small box are: NED redshift (x1000); WINGS redshift (x1000); cluster velocity dispersion σ; $\log(L_X)$ in units of 10^{44} erg/s; cluster members within 3σ. Black dashed line: WINGS redshift. Red dotted lines: $\pm 3\sigma$ lines. Green line: Gaussian fit.