# The J-PLUS Survey: Understanding the Formation and Evolution of M33

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## Abstract

It is widely accepted that large disk galaxies derive from the merger and accretion of many smaller subsystems. However, it is less clear how low-mass spiral galaxies fit into this picture. The best way to answer this question is to study the nearest example of a dwarf spiral galaxy, M33. We propose to perform a detailed photometric analysis of the resolved and unresolved stellar population of M33 using data from the Javalambre Photometric Local Universe Survey (J-PLUS). This study will provide key insights into the star formation history and composition of M33 and place it within the context of galaxy formation process.

## Scientific Goals: J-PLUS & M33

The J-PLUS is a large photometric survey that will be carried out at the Observatorio Astrofisico de Javalambre (OAJ) in Teruel, Spain. This research project has been scheduled as part of the commissioning and scientific verification of the survey that will start scientific operation during Fall 2014. Using a set of 12 broad-, intermediate- and narrow-band filters, J-PLUS will cover a wavelength range between 330-1000 nm, reaching magnitudes of r~22. We will take advantage of the IFU-like capabilities of the survey to determine the properties of the spatially resolved and unresolved components of the galaxy. In particular, we will perform a 2-D analysis of the underlying population as well as a detailed study of M33 star cluster system.

## M33 Star Cluster System

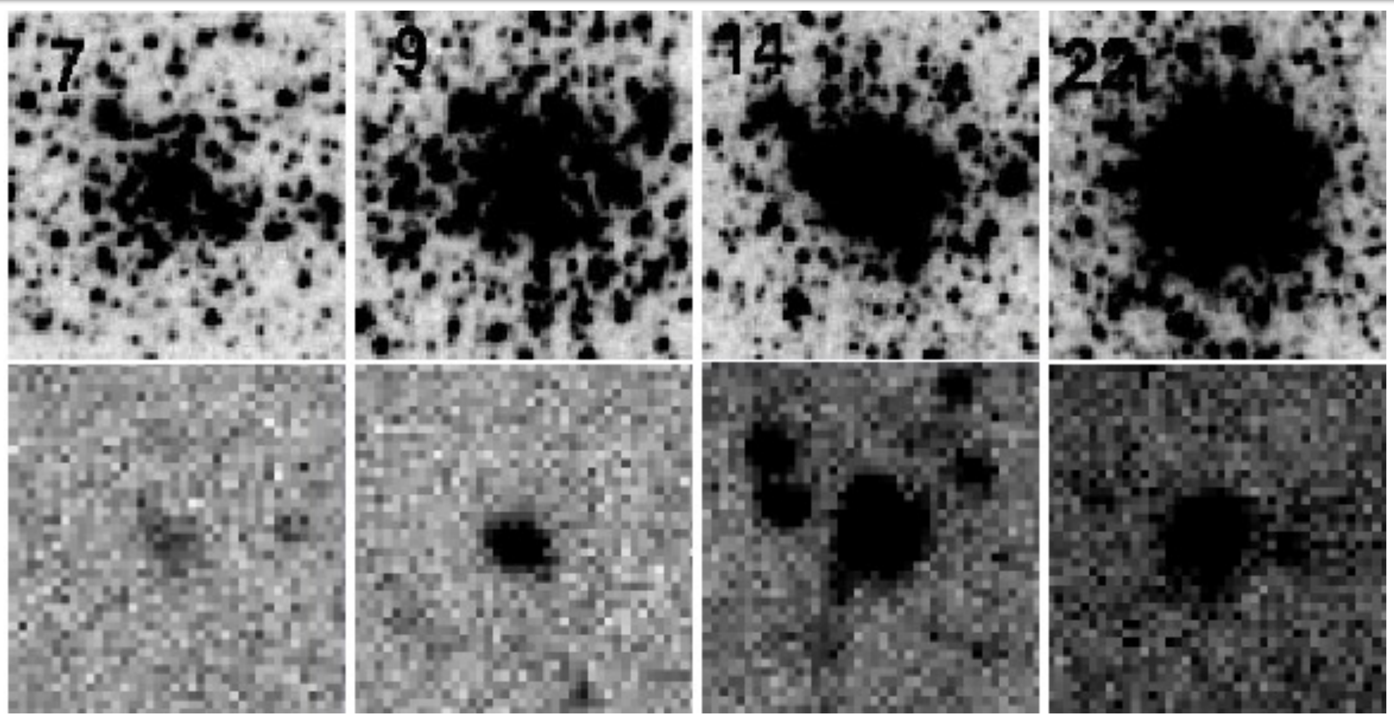


*Fig. 1: Representative sample of M33 star clusters: (Top row) Star clusters as seem by the HST/ACS in the F606W filter. (Bottom row) Star clusters as seem by simulated observations of J-PLUS in g' filter. Each image is shown with the same gray-scale intensity and 5" on a side for the HST/AST observations and 20" for the J-PLUS observations.*

At the distance of M33, J-PLUS will be able to cover the entire luminosity function of the cluster system, studying not only the bright objects but also reaching the faint tail of the function (Fig.1). With a field of view of 1.4º x 1.4º (Fig. 2), we will extend the most updated catalog of M33 star clusters (San Roman et al. 2010). In addition, the multi-filter approach will provide spectral energy distributions (SEDs) over a wide range of wavelengths. We will determine ages and metallicities of the clusters using spectral fitting techniques as well as a combination of properly selected spectral indices The sample size of clusters with measured metallicity and ages that this project will release will rival those presently in existence in the Milky Way and M31. We will, for the first time, have enough clusters with adequate metallicity values to search for the existence of radial gradients or substructures. Both of these factors promise to reveal essential information about the process of galaxy formation and evolution.

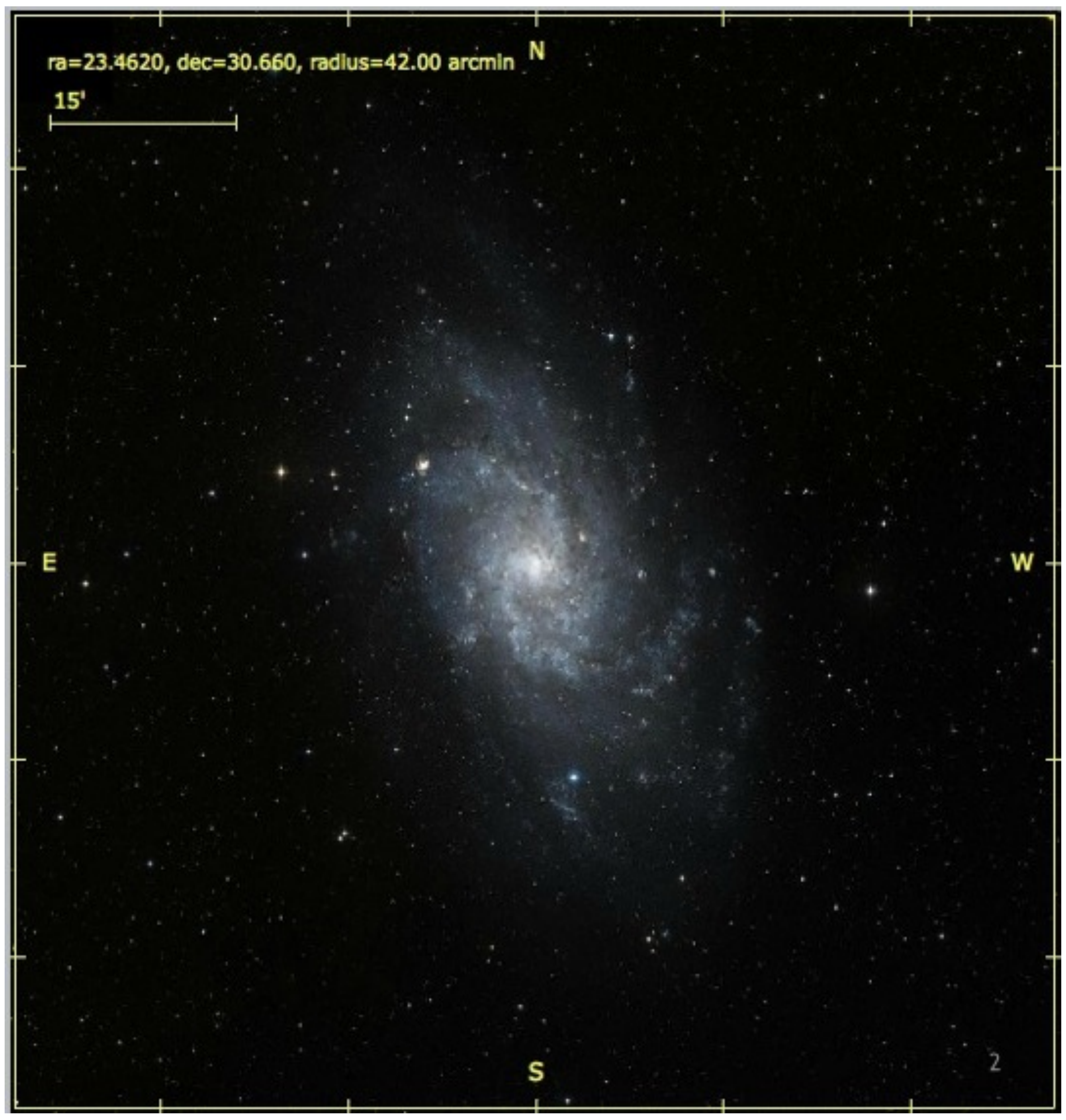


*Fig. 2 (Left Figure): A 1.4º x 1.4º digitized sky survey image of M33 representing the field of view of J-PLUS. North is up and east is to the left. This will be the first time that M33 (disk and outskirts) will be mapped in a single pointing/chip using a set of 12 filters.*

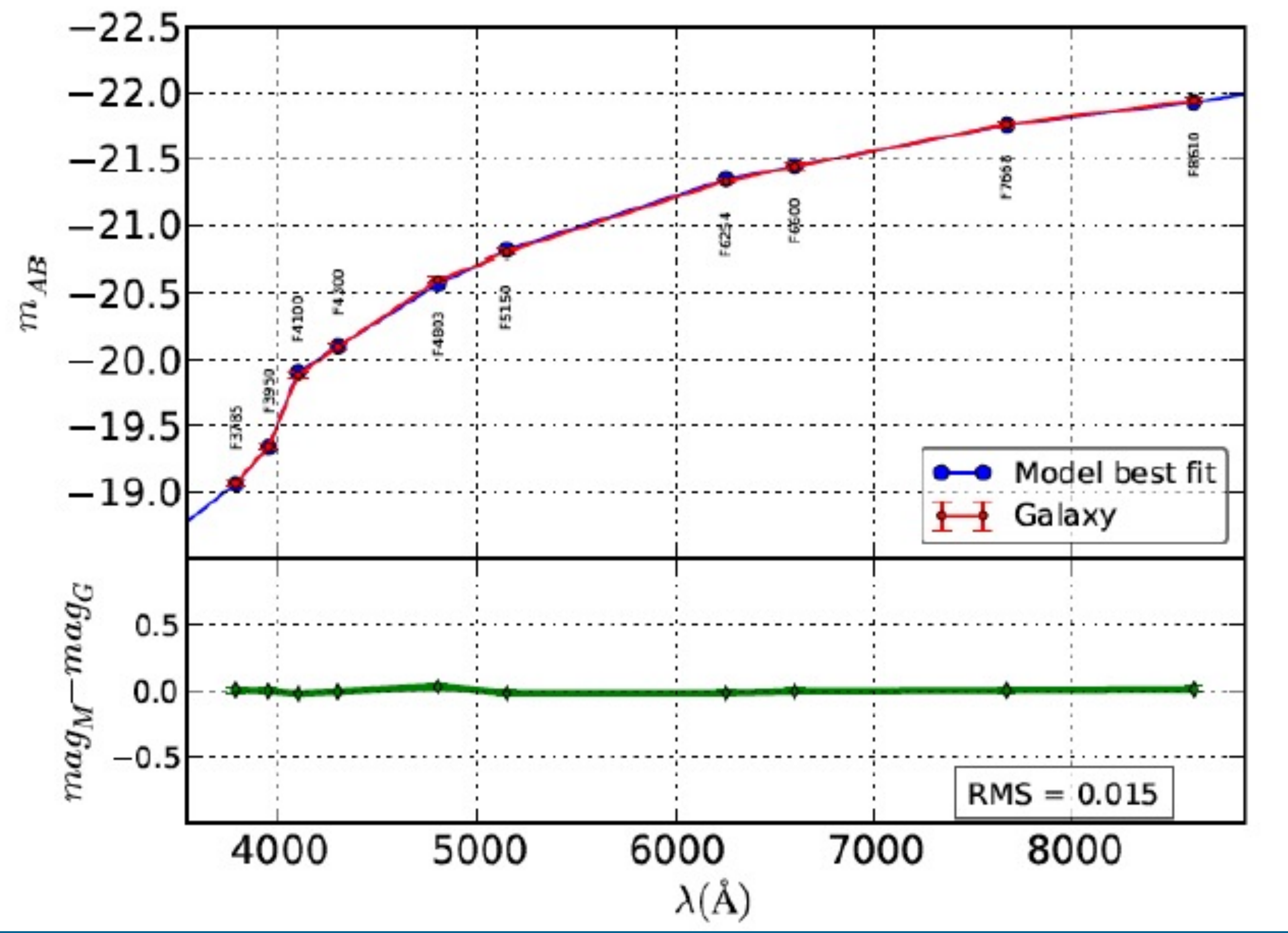


*Fig. 3 (Above Figure): Spectral fitting of a galaxy as seen by J-PLUS. The red line represents the SED of the object at the J-PLUS spectral resolution while the best model fit corresponds with the blue line.*

## Unresolved Stellar Population

M33 will appear as an extended object although no completely resolved into individual stars. A two-dimensional (2-D) analysis of the underlying stellar populations in combination with spectral fitting diagnostics has opened a new way to disentangle the stellar population of unresolved extended galaxies. The multi-color photometry will provide SEDs for the whole galaxy. To determine the stellar parameters of the stellar populations, specially the old populations, the research group at CEFCA has developed generic code focused on large scale multi-filter surveys (Diaz-Garcia et al. 2014). We will apply the spectral fitting technique over different areas of the galaxy performing a 2-D analysis (Fig. 3).

## M33-M31 Interaction

We will analyze two regions covering a total area of 3.92 squared degrees. One field will be centered on M33 covering the disk and the outskirts of the galaxy. A second field will cover the line connecting M33 with M31 to map the stellar substructure surrounding M33 (McConnachie et al. 2009). In addition to map the stellar substructure we will investigate any cluster associated with it.

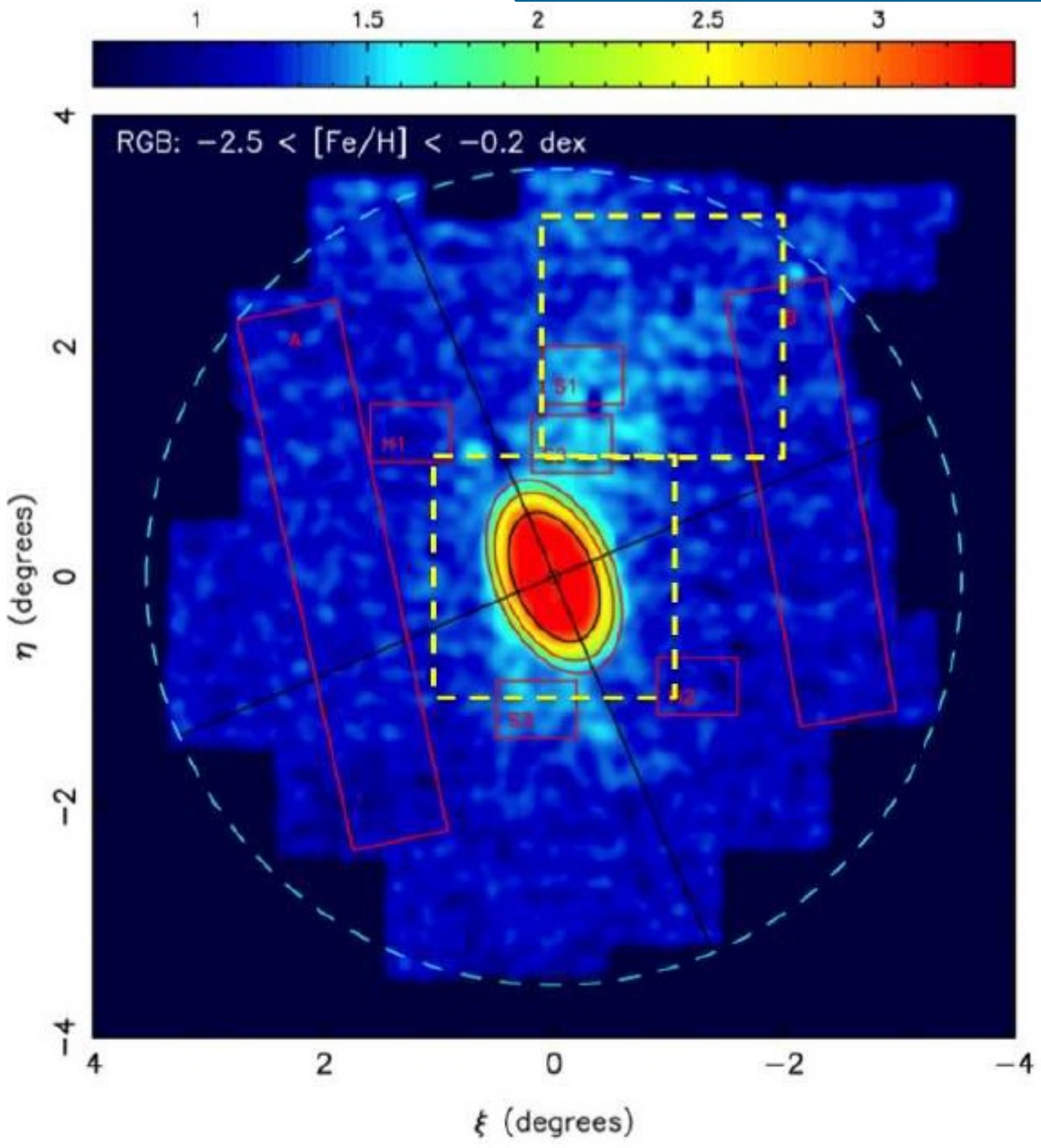


*Fig.4: Spatial distribution of candidate RGB stars at the distance of M33 with i < 23.5 in a tangent-plane projection displayed with logarithmic scaling (McConnachie et al. 2010). The yellow dashed-line squares correspond with the two observing fields of 1.4º x 1.4º included in our survey.*

## Conclusion

Spectral fitting diagnostics of the resolved and unresolved populations will allow us to determine ages, metallicities, and masses of the galactic disk, spheroidal components, and cluster system to answer questions as: Are there any indications of substructure in the disk and halo of M33? Where is the disk/halo transition and how far out from the center can we trace the halo? Does the disk metallicity gradient change slope at large galactocentric radii? At what radius does it merge with the halo metallicity? Do the identified tidal streams have clusters associated to them? The combination of the number of filters, the sky coverage and the depth of this survey will make this project an unprecedented experiment for stellar population studies.

*References:*

*Diaz-Garcia, L. A., Cenarro, A. J. , et al. 2014, in prep.*

*McConnachie, A., Irwin, J., Ibata, R., Dubinski, J., Widrow, L., et al. 2009, Nature 461, 66*

*San Roman, I., Sarajedini, A., and Aparicio, A., 2010, ApJ 720, 1674.*

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