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THE NEXT GENERATION VIRGO CLUSTER SURVEY: STATUS AND FIRST RESULTS

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Abstract. We present recent results from the Next Generation Virgo Cluster Survey (NGVS). NGVS is a CFHT MegaCam large program to observe the Virgo Cluster from its core to virial radius, for a total coverage of 104 square degrees. The survey is performing deep imaging (10 sigma detection for point sources of 25.9 mag in the g-band) in five band-passes (u*,g',r',i',z') and will reach a depth never attained before

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in optical studies of the Virgo cluster. The program's main scientific objectives are: the characterization of the faint-end of the galaxy luminosity function, the characterization of galaxy scaling relations from low to high masses, the cluster/intracluster medium/galaxy connection, the role of environmental effects in galaxy evolution,and the fossil record of star formation and chemical enrichment in dense environments. Numerous ancillary projects — from a survey of the Galactic halo to a cosmic shear measurement of the matter power spectrum on large scales — are also under way. We present the status of the survey and multi–wavelength projects, and results on recently detected high–redshift galaxy clusters.

Keywords: Galaxy clusters, galaxies, evolution

1 Introduction

The Next Generation Virgo Cluster Survey (NGVS; Ferrarese et al. 2011) is a large program at the Canada France Hawaii Telescope (PI: Laura Ferrarese), and aims to observe 104 square degrees of sky within the virial radius of the Virgo cluster in five spectral bandpasses (u',g',r',i',z') with the instrument Megaprime. The program involves around 50 scientists from more than 20 institutions. Observations have started in December 2008 and are scheduled to be completed by June 2012. The current status of the survey is shown in Fig. 1.

The main goals of the survey are the characterization of (1) the faint-end of the galaxy luminosity function, (2) galaxy scaling relations from low to high masses, (3) the cluster/intracluster medium/galaxy connection, (4) the role of environment in galaxy evolution, and (5) the fossil record of star formation and chemical enrichment in dense environments. Numerous ancillary projects — from a survey of the Galactic halo to a cosmic shear measurement of the matter power spectrum on large scales — are also under way.

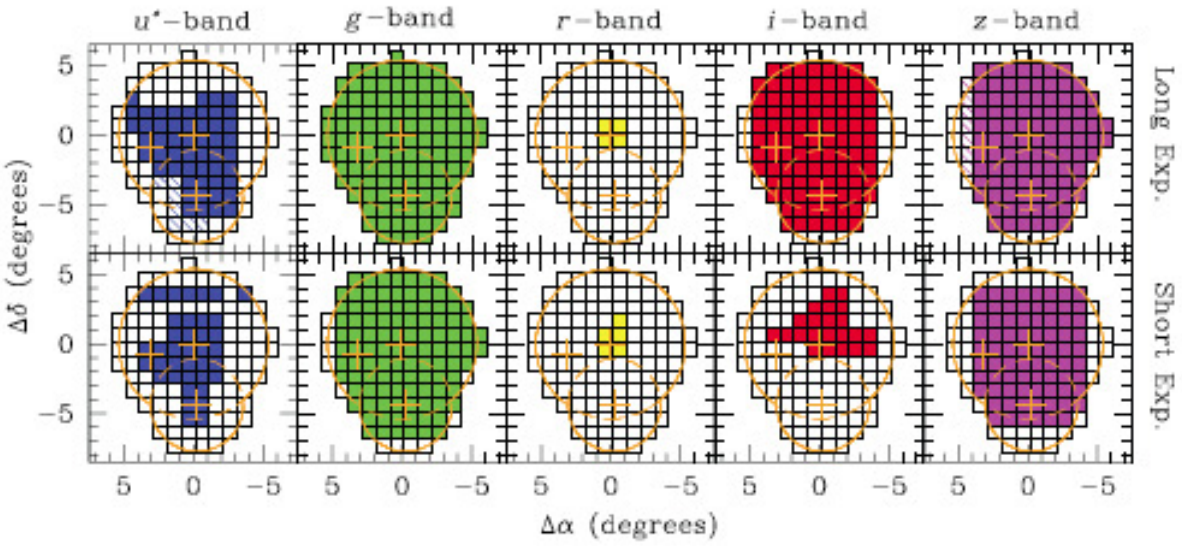

Fig. 1. NGVS observing status as of September 2011 (Ferrarese et al. 2011). Empty squares show Megacam pointings. Long and short exposures (see Ferrarese et al. 2011 for details) are shown in the top and bottom rows, for the five bandpasses covered by the survey. Fields for which observations have been completed are indicated by colored filled squares, while only partial data have been obtained for dashed fields. The orange outline indicates the virial radii of Virgo A and B subclusters, while the crosses mark the location of M87 to the North, M49 to the South and M60 to the East.

2 New adapted observational strategies

The NGVS observational strategy has been optimized to reach very faint surface brightness levels, thus allowing us to characterize the outer haloes of galaxies and detect low surface brightness, diffuse features, such as tidal tails and intracluster light. The main challenge is to characterize and correct for scattered light contamination

in the raw frames. This is achieved thanks to a dedicated data acquisition strategy that allows a real time sampling of the scattered light component, which is then removed during data processing. The final images attain a surface brightness of $\mu_g = 29$ mag arcsec^{-2}. The individual frames are processed at CFHT using a newly developed pipeline (Elixir-LSB, Cuillandre et al., in prep.; Fig. 2).

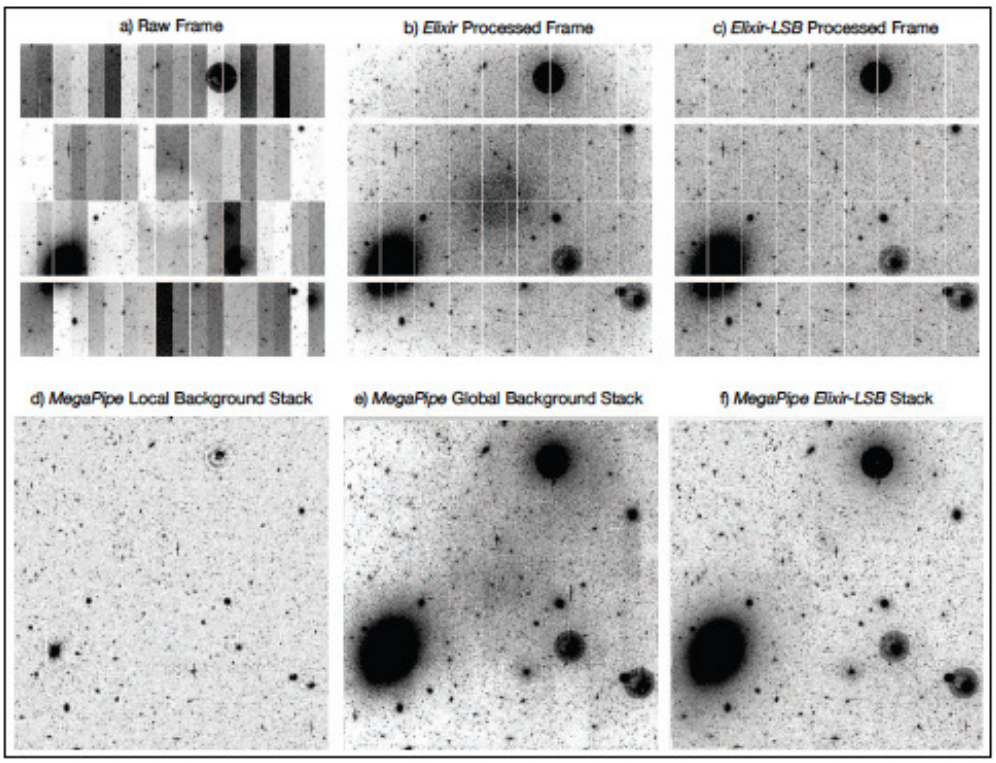

Fig. 2. The *Elixir-LSB* pipeline results are shown (top), compared to the standard Megapipe reduction (bottom). The top row shows, from left to right, a raw, Elixir and Elixir-LSB processed single frame. The bottom row shows, from left to right, MegaPipe *local background*, *global background* and *Elixir-LSB* stacks obtained by combining all five long g–band dithered frames obtained for a NGVS field (Cuillandre et al, in preparation; see Ferrarese et al. 2011 for details).

3 Multi–wavelength follow-up of the Virgo Cluster

Two imaging programs designed to complement the NGVS data have been undertaken in the past year: the NGVS-IR (NGVS-Infrared) and GUViCS (GALEX Ultraviolet Virgo Cluster Survey).

The NGVS-IR survey (coPI: Ariane Lançon and Thomas Puzia) covers the Virgo central 4 deg^2 in the K-band with 34 pointings (4x2048x2048 pixels) of CFHT/WIRCAM, each observed 108 times with non-redundant offsets. Acquisition started in December 2009, and was completed in June 2010. The observational strategy includes nodding, within the target area, between relatively empty fields and crowded ones, in order to sample the sky in every pixel at a frequency comparable to that of the large near-IR sky brightness variations.

GUViCS (PI: Alessandro Boselli; Boselli et al. 2011) observations were completed in 2010 and processed by the standard GALEX pipelines. Photometry and cut-offs were extracted for extended objects following standard procedures. This includes flux extraction of pointlike and extended sources, low surface brightness features, not homogeneously provided by the standard GALEX pipelines. For extended sources we reconstruct the NUV and FUV radial profiles, necessary for the determination of the structural parameters used in the construction of several scaling relations (e.g the effective radius and surface brightness) and in the comparison with model predictions. We determined the FUV and NUV luminosity functions of the Virgo cluster core for all cluster members and separately for early- and late-type galaxies for the central 12 sq. deg. (Boselli et al. 2011).

4 Background galaxy clusters

Among the ancillary projects, we briefly describe detections of background high–redshift galaxy clusters. With the depth and spectral energy distribution coverage of the NGVS, we expect to detect 5-10 background galaxy clusters per square degree, with masses above $M \approx 5 \times 10^{13} M_{\odot}$ over the redshift range $0.1 < z < 1$. This will give a total of 500 to 1000 background galaxy clusters. Fig. 3 shows examples of clusters in the range $0.4 < z < 0.8$ identified in the NGVS using the 3D-Matched-Filter cluster finding algorithm of Milkeraitis et al. (2010) and an independent red sequence based algorithm (Mei et al. 2011). Based on a preliminary analysis, and on results from surveys with similar depth and spectral coverage (e.g., Ilbert et al. 2006; Coupon et al. 2009), we expect to measure reliable photometric redshifts and select cluster populations to a depth of $i \approx 22.5$ mag.

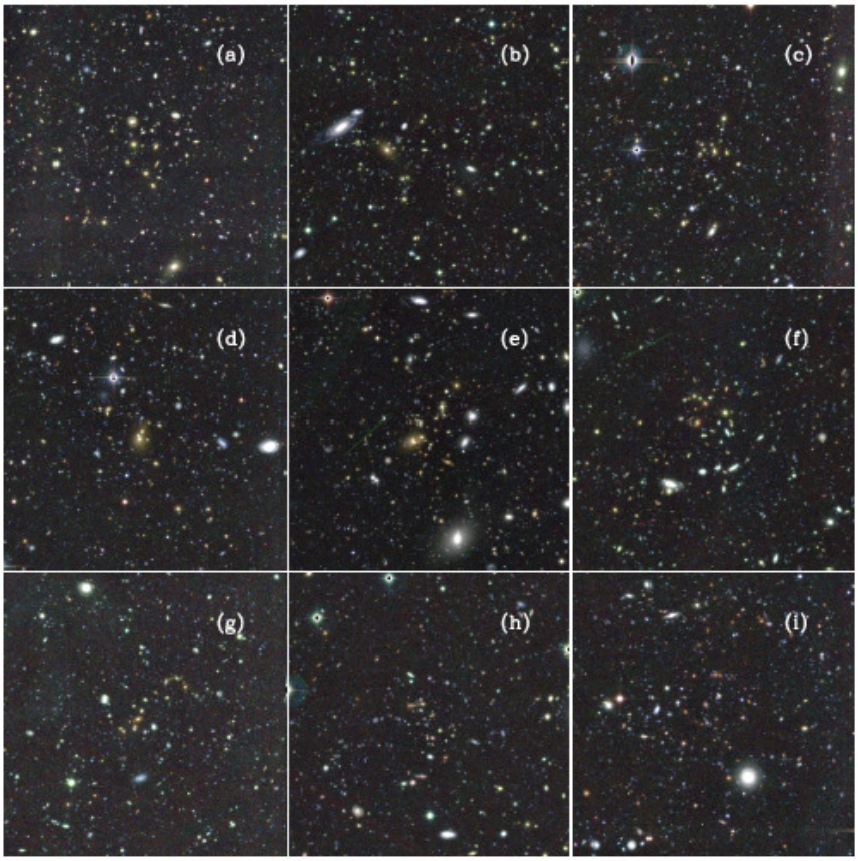

Fig. 3. Examples of background galaxy clusters identified in the NGVS using the 3D-Matched-Filter cluster finding algorithm of Milkeraitis et al. (2010) and the red sequence based algorithm of Mei et al. (2011). Each image measures 1.5 X 1.5 Mpc in size and the detections are in the redshift range $0.4 < z < 0.8$.

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