improvement of image quality from the 1993 EMMI images (Figs. 1a, b) to the 1994 USI ones (Figs. 1c, d), where many more stars are resolved and much fainter limiting magnitudes are reached in considerably shorter exposure times.

The seeing effect can be even better seen in Figs. 2a,b in colours, showing I images corresponding to Figs. 1a and 1d respectively.

In Fig. 3 is shown an EMMI whole field image (seeing 1.3") where it is shown that, on the other hand, EMMI provides a large field (9.9'x8.1') relative to SUSI (2.2'x2.2').

The image quality improvement is the result not only of the better sampling of SUSI but also due to the effort in keeping the best optical quality during the observations, through continuous image analysis and a very careful focussing. This was possible thanks to the active collaboration of the ESO technical staff.

Colour-magnitude diagrams

The effect of seeing on the CMD quality is illustrated in Fig. 4 (SUSI) and Fig. 5 (EMMI): note in particular that the SUSI diagram reaches about 1.5 magnitudes deeper besides a much sharper definition of the main features which are: the blue disk main sequence on the left side, the cluster horizontal branch (tilted and elongated by differential reddening) and the red giant branch showing a faint red tip.

Finally, this study permitted us to derive parameters for Terzan 5: a reddening of E(B-V) = 2.49 and a distance to the Sun of $d_\odot$ = 5.6 kpc (closer than previous estimates). Also, based on the red giant branch curvature, we derive a metallicity somewhat higher than that of NGC 6553, probably solar. More details on Terzan 5 are given in Ortolani et al. (1995b) It is a peculiar cluster, resembling other bulge clusters such as NGC 6553, NGC 6528, Liller 1 and Pal 6 among others (Ortolani et al. 1990, 1992, 1995c,d and references therein).

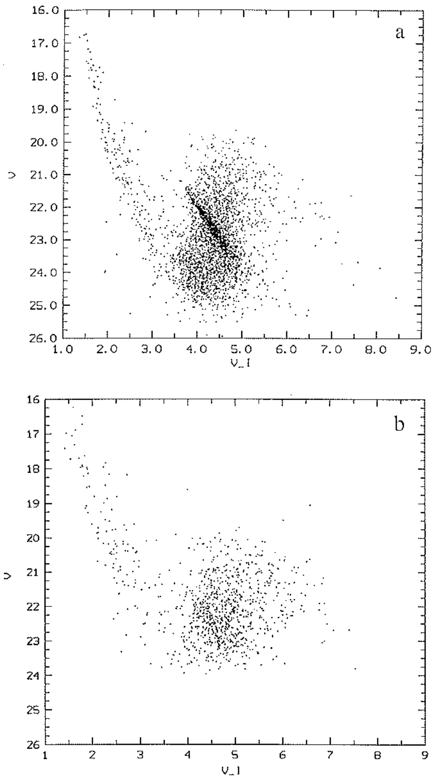

Figure 4: – *V vs. (V-I) colour-magnitude diagrams of Terzan 5 obtained with (a) SUSI (seeing 0.34") and (b) EMMI (seeing 1.3") with an extraction corresponding to the same frame area of SUSI.*

Conclusions

The exceptional high quality images allowed us to approach the HST (Wide-Field PC2) resolution (where about 0.1" is reached) with the advantages of a constant point spread function along the frame and easy calibration to the standard Johnson-Cousins systems, besides a larger field of view. This was possible thanks to a combination of good seeing and the intrinsic optical quality of NTT.

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New Globular clusters identified in the inner regions of NGC 5128 using ESO and HST Data

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Introduction

The study of globular cluster systems leads the way in our understanding of galaxy formation. In distant galaxies, the observational evidence in favor of globular cluster formation during merger episodes is rapidly growing. This mechanism naturally accounts for the high specific frequency of globulars observed in elliptical galaxies (e.g., Ashman Zepf 1992).

A very special case for the study of globular cluster formation in such violent events is NGC 5128 (Cen A), the nearest giant merger galaxy (Sérsic 1982). This galaxy has a very rich system of globular clusters, with membership of part of them confirmed spectroscopically (Sharples 1988). However, there are only very few known clusters in the inner regions of this galaxy (Sharples 1995). Consequently, the basic question about the existence of super-metal-rich clusters in NGC 5128 remains unanswered (see Jablonka et al. 1995). These putative super-metal-rich clusters are expected to be found preferentially in the inner regions, since in our Galaxy about 90% of these globulars are confined to the inner 3 kpc (Minniti 1995).

The usual problems inherent in the identification and study of globular clusters in the inner regions of distant galaxies are faintness, crowding, high background galaxy light, nonuniform extinction, foreground contamination by stars in our own galaxy, and background contamination by distant galaxies. In this work we take advantage of the combination of archive HST data with our ground-based IR observations in order to overcome these difficulties. We study the globular clusters in the inner 3 kpc of the peculiar E2 galaxy NGC 5128 (Figure 1).

Identification of Globular Clusters

We use archive F675W images obtained with the WFPC and the (pre-

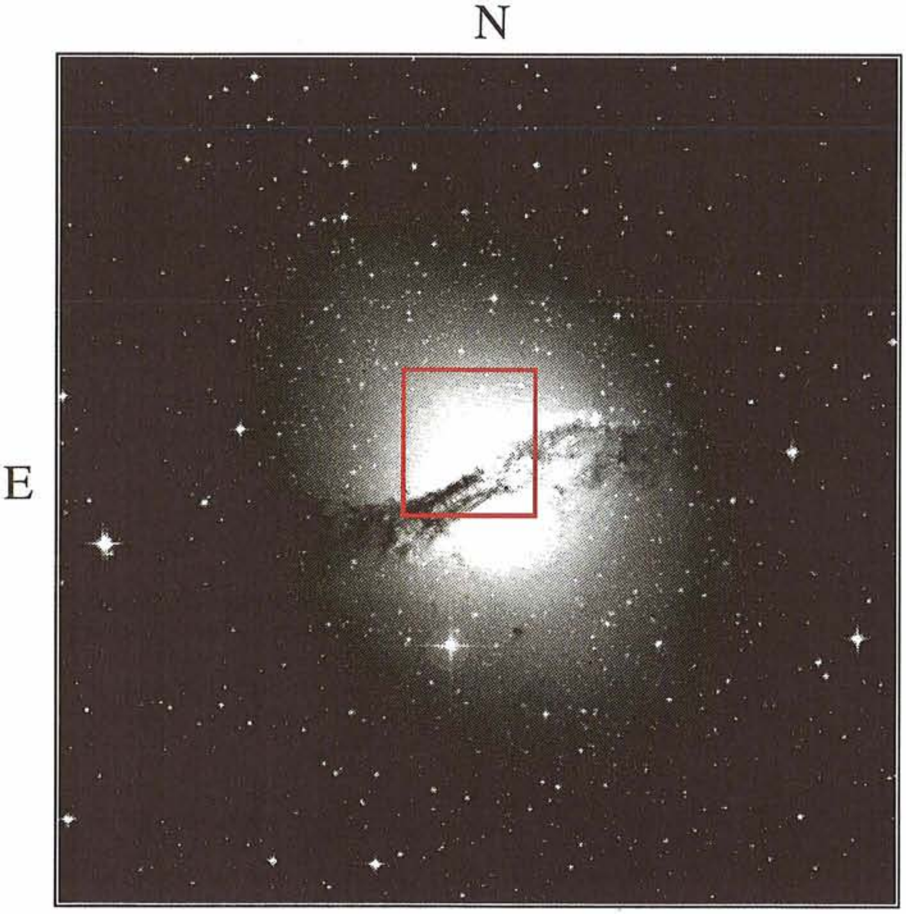

Figure 1: *NGC 5128 (Cen A) as seen from the Digital Sky Survey (30 x 30 arcmin²). The location of the JHK mosaics is indicated. North is up and East to the left.*

COSTAR) HST in order to identify globular clusters in the inner regions of NGC 5128. The F675W filter is essentially equivalent to the Cousins R filter (Harris et al. 1993), and to the Washington T1 filter (Geisler 1996). We have then calibrated the HST frames with existing ground based photometry in the T_1 filter for a few known globulars in this region from Harris et al. (1992).

The typical core diameters of Galactic globular clusters are $D_C = 6$ pc, with a total range from about 1 to 20 pc, as listed in the most recent compilation by Harris (1995). At a distance of 3 Mpc this diameter translates to ~0.32 arcsec. These sizes can be resolved thanks to the superb spatial resolution of the WFPC (0.1 *arcsec/pix*), giving $D_C \approx 3$ WFPC pixels. Thus, foreground stars can be distinguished from typical globular clusters in NGC 5128. At the same time, Galactic globular clusters are almost round, which gives an extra criterion for the discrimination against background galaxies.

Then, the basic procedure for identifying globular clusters is by looking at their sizes and ellipticities. Figure 2 shows a plot of ellipticity FWHM of sources in the PC4 frame, where three known globular clusters (members of NGC 5128 from their radial velocities) are identified. Note that this procedure clearly produces an incomplete list of globulars, where extremely compact or very loose ones are missed. However, based on their morphology, the candidates on our list can be considered bonafide globular clusters.

The IR Photometry

The HST images are complemented here with our deep near-IR images,

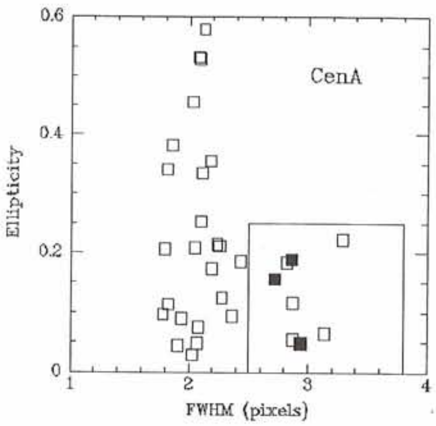

Figure 2: *Ellipticity vs. FWHM of all the sources identified in the PC4 chip down to R = 21 mag. The loci of the globular clusters G206, G268 and G359 (Harris et al. 1992) are indicated (filled squares). The region used to select potential globular clusters in all the chips of WFPC is enclosed with the solid line.*

which have the advantage of high contrast and reduced reddening sensitivity. The inner structure of NGC 5128 is complicated by the presence of large and non-uniform extinction. The surface magnitude of the underlying galaxy ranges from $\mu_K = 12$ to 16 *mag arcsec⁻²* in the region observed here. It would have been challenging to try to identify the clusters on top of the galaxy light without the aid of the HST images.

The observations were obtained with IRAC2B at the ESO 2.2-m telescope during March 4, 1995. We mapped a region of 3x3 *arcmin²* with the *JHK* filters, centered at about 1 arcmin NE of the nucleus of the galaxy (see Figure 1). We also mapped a comparison field located at about 30 arcmin NE of the nucleus, in order to estimate back- and foreground contaminations.

The photometric reductions were done using the aperture photometry packages in IRAF. The achieved limiting magnitudes are $K = 18$ *mag* and $J = 19.5$ *mag*, which are complementary to those of the WFPC images, $R = 21$ *mag*. These limiting magnitudes reach clusters beyond the peak of the globular cluster luminosity function in NGC 5128.

The positions of the globular cluster candidates are displayed in Figure 3, along with the location of the HST frame. The cluster IDs, coordinates, magnitudes, and radial distances from the nucleus are listed in Table 1. The x and y

TABLE 1.

ID	x	y	T_1	r	Comments
1	326.3	20.6	19.43	2.1	
2	150.0	35.7	18.53	2.6	G268
3	242.0	42.0	20.90	2.1	
4	268.0	55.0	20.46	2.0	
5	174.2	59.6	20.12	2.3	
6	228.1	77.3	18.00	2.0	G242
7	301.0	87.0	20.05	1.6	
8	180.6	102.9	18.91	2.1	
9	218.5	122.0	20.51	1.7	
10	112.1	133.2	18.55	2.4	G206
11	188.8	137.1	18.50	1.8	
12	117.0	153.0	19.75	2.3	
13	91.2	169.8	18.24	2.4	G359
14	225.1	184.9	19.75	1.4	
15	235.1	188.2	17.09	1.3	
16	8.3	189.9	19.34	3.0	G292
17	179.3	216.8	18.53	1.6	
18	239.1	225.0	17.39	1.1	
19	11.1	234.7	18.97	2.9	G169
20	257.9	238.0	20.05	0.9	
21	245.5	252.0	19.38	1.0	
22	144.2	268.2	20.05	1.8	
23	154.0	269.0	20.51	1.7	
24	162.0	280.0	19.62	1.7	
25	186.8	284.1	19.17	1.5	
26	231.0	285.0	20.08	1.1	
27	161.0	294.0	20.81	1.7	
28	153.6	319.7	19.34	1.8	
29	291.0	97.0	21.91	1.6	
20	368.0	101.0	20.74	1.4	
31	368.0	107.5	21.83	1.4	
32	212.0	322.0	20.71	1.3	

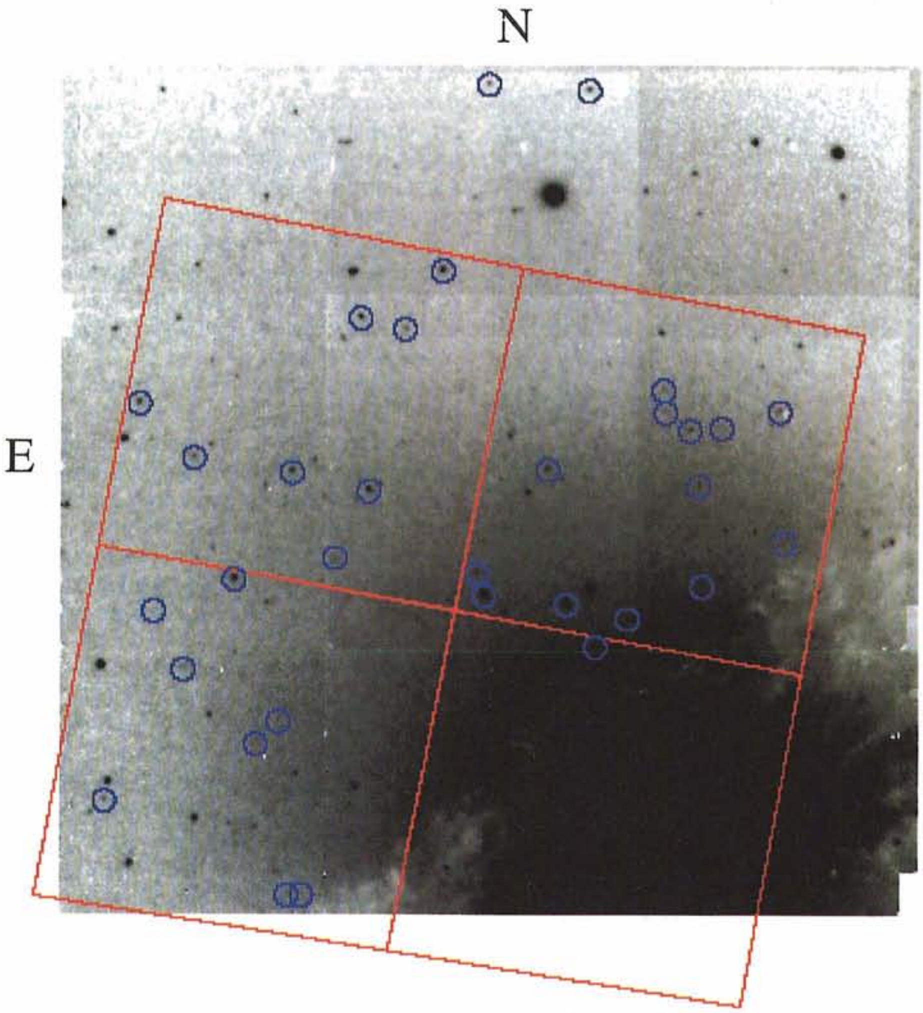

Figure 3: *H mosaic of the central region of NGC 5128 observed with IRAC2B at the La Silla 2.2-m telescope. The location of the WFPC frames is shown in red. The globular cluster candidates are indicated with blue circles.*

coordinates are measured in pixels (scale=0.49 arcsec/pix) with origin in the lower left corner of the mosaic, and the radial distances are measured in arcmin.

Reddening maps are constructed by dividing the different color frames. Based on these maps, it was decided to study the candidates away from the inner region enclosed by the prominent dust lane, shown in Figure 3. Even though the majority of the sources were detected in this region, it is not trivial to evaluate the amount of reddening affecting these different sources.

JHK photometry in the comparison field allows us to estimate the completeness of the present sample. We have identified 30 globulars based on their morphology. Matching the number counts in the field with those of the comparison field gives a total of 50 expected globulars in the region studied down to $K = 18\,mag$. We also estimate that there should be only about 5 galaxies present in our field, most of which would have been eliminated from our list based on their morphology.

Figure 4 shows the optical-IR color-magnitude diagram for the cluster candidates. Their location in this diagram and in the color-color diagrams matches the locus expected for globular clusters found in Local Group galaxies. Therefore, from their sizes and shapes as well as from their colors, the candidates in our list seem to be globular clusters.

Summary and Final Remarks

We have identified globular clusters in the inner regions of NGC 5128, the nearest known large galaxy product of a merger. The clusters are selected on the basis of their structural parameters (observed core diameters and ellipticities), as measured from deep WFPC HST images. These identifications are confirmed by IR photometry obtained with IRAC2B at the ESO 2.2-m telescope.

This new sample of clusters, deep into the core of NGC 5128, represents a basis for the measurement of the distance to NGC 5128, for the determination of the metallicity gradient in the globular cluster system, and for the study of the history of cluster formation in such a recent merger event.

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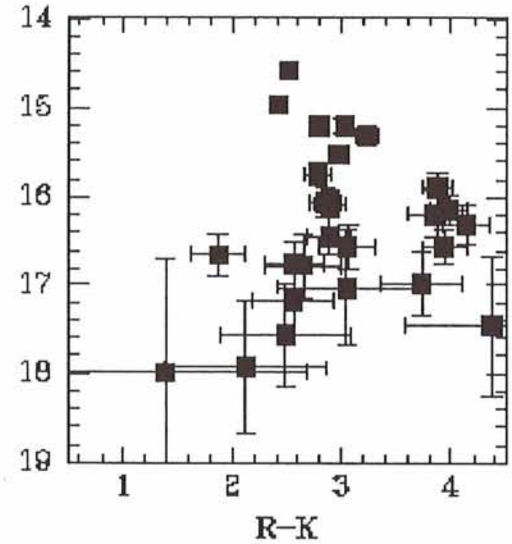

Figure 4: *Color-magnitude diagram for the globular cluster candidates.*