# NTT-SUSI images of superb seeing (0.34"-0.40"): Terzan 5

*S. ORTOLANI, Universita di Padova; B. BARBUY, Universidade de Sao Paulo; E. BICA, Universidade Federal do Rio Grande do Sul*

The study of globular clusters in the Galactic bulge can provide information on the behaviour of metal-rich populations, through their colour-magnitude diagrams (CMDs) and element abundances, and can be a major piece of evidence regarding the timescales for formation of our Galaxy through their ages derived from CMDs (Ortolani et al. 1995a). Besides, the derivation of their distances and metallicities should make it possible to better establish the structure of globular cluster distribution in the bulge.

High quality images are necessary to derive clear CMDs in such crowded regions with high obscuration and differential reddening.

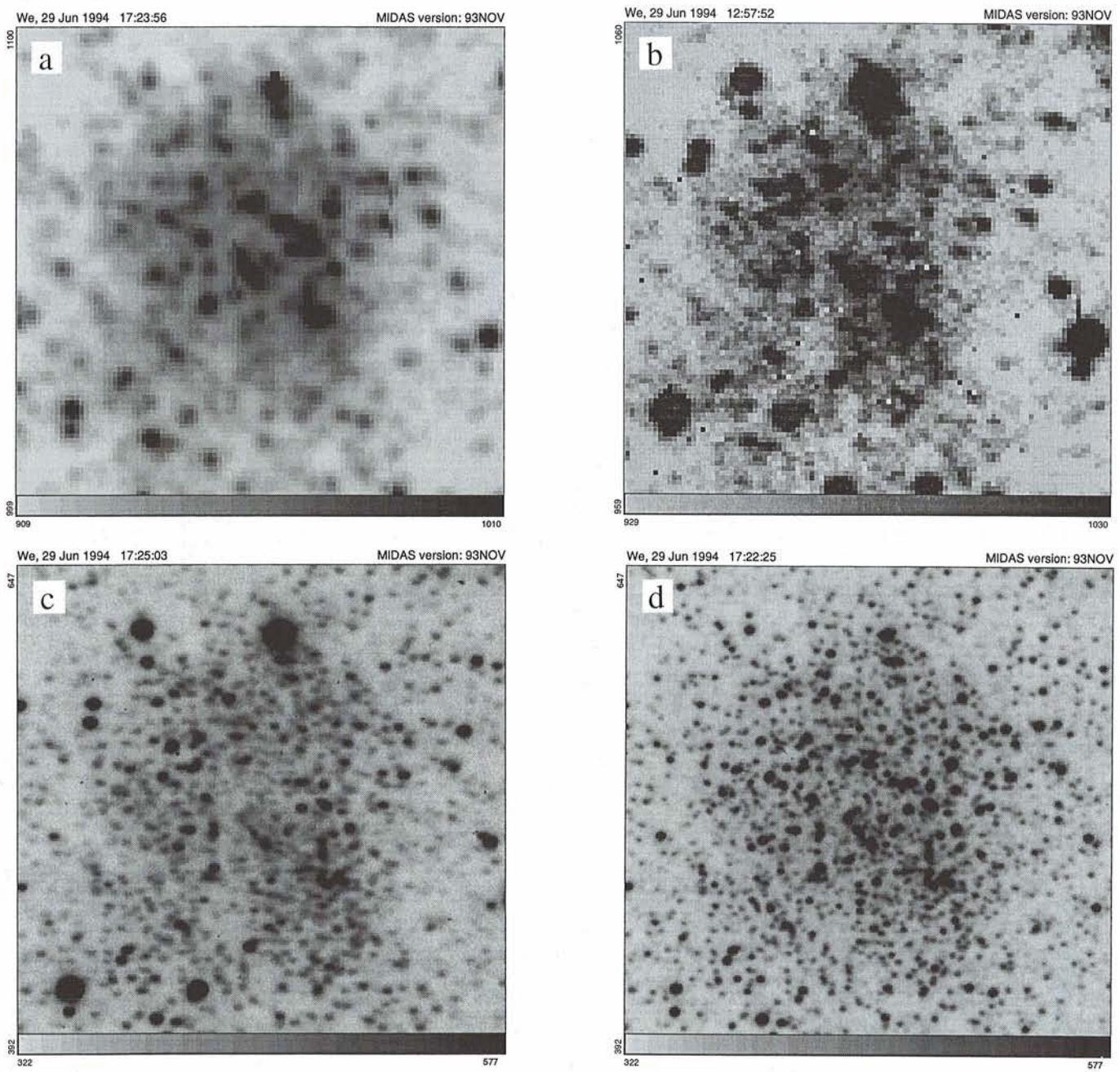


Figure 1: – *Terzan 5 images obtained with: (a) EMMI I image with seeing 1.2"; (b) EMMI V image with seeing 0.8"; (c) SUSI V image with seeing 0.65"; (d) SUSI I image with seeing 0.34".*

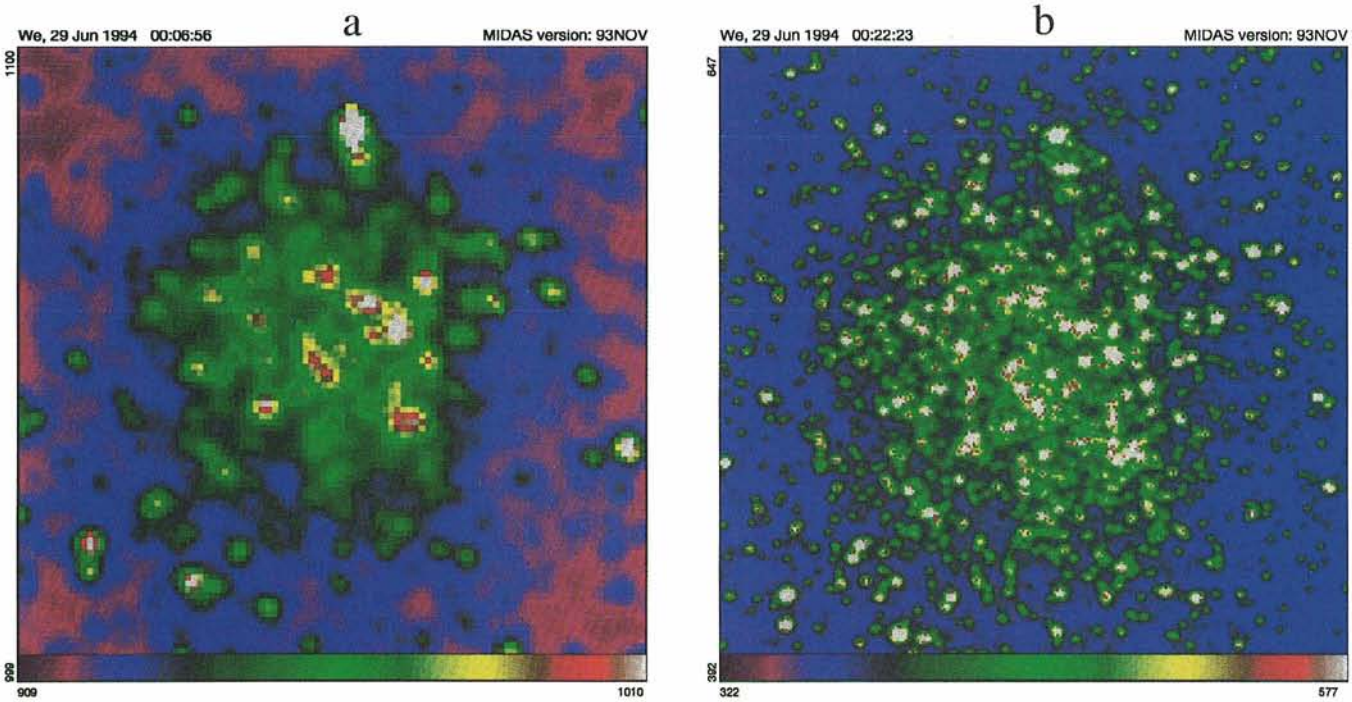


Figure 2: – *Terzan 5 images shown in colours: (a) EMMI I image with seeing 1.2" – same as Fig. 1a (b) SUSI I image with seeing 0.34" – same as Fig. 1d.*

An unprecedented high quality image for Terzan 5 with a seeing of 0.34" was obtained with the NTT equipped with SUSI in May 1994. A comparison with previous images obtained with EMMI under less good quality seeing illustrates the need for the high quality images. Our main goal in the last few years has been to obtain such high quality photometry, but only now has NTT equipped with SUSI permitted such results.

## Observations

Terzan 5 was observed at the ESO New Technology Telescope (NTT) equipped with EMMI in June 1993 and with SUSI in May 1994. An unprecedented image quality was obtained for Terzan 5 in the May 1994 run, in particular for a 60s I image with a seeing of 0.34".

In the 1993 observations, the NTT was equipped with EMMI operating in the focal reducer mode, at the red arm. The detector was a LORAL front illuminated CCD (ESO # 34), with a pixel size of 15$\mu$m (0.35" on the sky). The whole size of the CCD is 2048 x 2048 pixels, but it was read out in the format 1700x1400 pixels (9.9'x8.1' on the sky) excluding peripherical vignetted regions.

In June 1994 the observations were carried out at the Nasmyth focus B, with a 1024x1024 thinned Tektronix CCD (SUSI camera). The pixel size is 24 $\mu$m (0.13" on the sky) with a total 2.2'x2.2' frame size.

The images were processed using the MIDAS package at ESO-Garching computer center. After the standard flat-field corrections, instrumental magnitudes have been obtained using DAOPHOT II.

The effect of improvement of seeing is illustrated in Figs. 1a,b,c,d where a sequence of improved seeing is shown for Terzan 5 images obtained with: (a) EMMI I image with seeing 1.2"; (b) EMMI V image with seeing 0.8"; (c) SUSI V image with seeing 0.65"; (d) SUSI I image with seeing 0.34". One clearly sees the

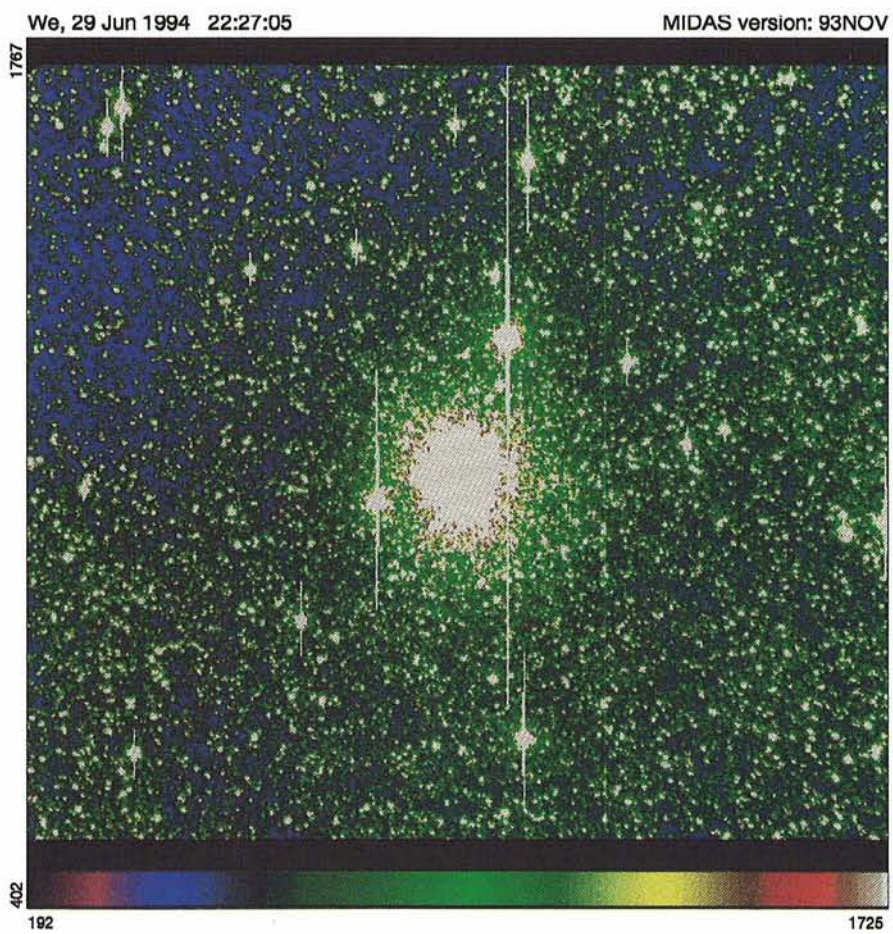


Figure 3: – *EMMI whole field image.*

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).

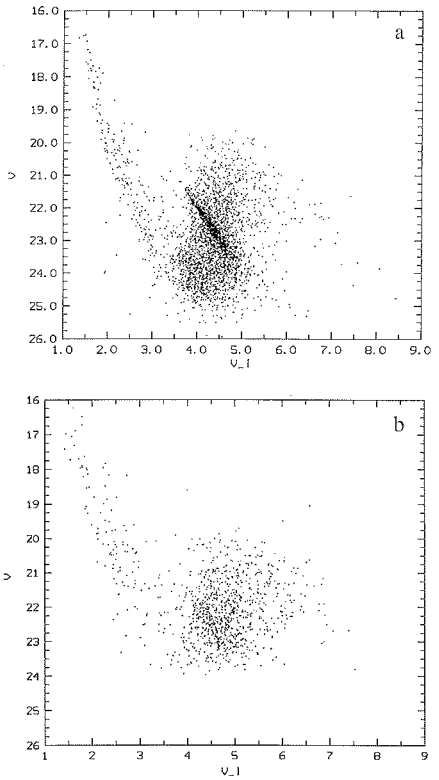


Figure 4: – *V vs. (V-I) colour-magnitude diagrams of Terzan 5 obtained with (a) SUSI (seeing 0.34") and (b) EMMI (seeing 1.3") with an extraction corresponding to the same frame area of SUSI.*

## 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


*DANTE MINNITI (ESO), M. VICTORIA ALONSO (Observatorio Cordoba), PAUL GOUDFROOIJ (ESO), GEORGES MEYLAN (ESO), PASCALE JABLONKA (Meudon)*


## 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-