

NGC 6603: a young rich open cluster towards the bulge [★]

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Abstract. We present B , V colour magnitude diagrams of the rich open cluster NGC 6603. A foreground reddening of $E(B-V)_f = 0.50$ and an internal one of $E(B-V)_i = 0.29$ were derived with the additional help of integrated spectra.

The resulting age is 200 ± 100 Myr, and the distance is about 3.6 kpc.

The surrounding field is also studied, appearing to be part of a star cloud which contains age components in the range 200 to 600 Myr or more. The cluster appears to be spatially associated with the star cloud, being part of its youngest component.

The cluster and the star cloud location in the inner disk are in agreement with other studies showing an enhancement of star formation in this region.

Key words: open clusters – colour-magnitude diagram

1. Introduction

NGC 6603 ($\alpha_{1950} = 18^h 15^m 31^s$, $\delta_{1950} = -18^\circ 25' 30''$; $l = 12^\circ 81$, $b = -1^\circ 31$) is an open cluster very rich in stars, embedded in a star cloud (or window) near the direction of the Galactic Center in Sagittarius. Some catalogues refer to it as Messier 24, but Messier's description fits better to the star cloud. Early studies of NGC 6603, also designated as OCL-36, MEL 197, RB 129, CR 374, ESO 590-SC 17, are listed in Alter et al. (1970), which basically indicate the cluster angular size, approximately $5'$ and crude distance estimates varying by a factor 10. The only recent study of which we are aware of is an unpublished colour magnitude diagram (CMD) by Grubisich, whose cluster parameters are given as private communication in a compilation of

star clusters by Becker & Fenkart (1971). The cluster parameters provided by these authors are reddening $E(B-V) = 0.61$, turn-off (TO) around B9 and distance 2840 pc, which places the cluster in one of the innermost regions of the disk which can be studied optically.

Recently we have started a systematic study of globular clusters in the central parts of the Galaxy, attracted by the fact that some of them present very high metallicity, e.g. NGC 6553 (Ortolani et al 1990; Barbuy et al. 1992), and have examined on sky survey plates all clusters in the region. NGC 6603 called our attention by its richness in stars, which gives the cluster a globular appearance. Indeed NGC 6603 might be one of the rare galactic counterparts of young clusters in the Magellanic Clouds with globular cluster characteristics. Other examples of this kind in the Galaxy are M 11 = NGC 6705 with age 200 Myr (Solomon & McNamara, 1980; Santos Jr. et al. 1990) and NGC 3603 with only 2–3 Myr (Melnick et al. 1989).

In the present study we provide BV CCD CMDs of NGC 6603 in order to derive precise reddening, distance and age estimates. We also study the surrounding field in order to verify the possible physical relation of the cluster to the star cloud on which it is projected. Owing to its structural properties, NGC 6603 is one of the few open clusters for which an integrated spectrum can be obtained.

In Sect. 2 we present the observations. In Sect. 3 the colour-magnitude diagrams are discussed, and the concluding remarks are given in Sect. 4.

2. Observations

BV images were obtained with the 1.54 m Danish and 3.5 m NTT telescopes at the European Southern Observatory (ESO), at La Silla, Chile, in May–June/1990. The ESO RCA CCD no. 5 with 512×320 $30 \mu\text{m}$ pixels and the coated Thomson CCD ESO no. 17 with 1024×1024 $19 \mu\text{m}$ pixels, were employed respectively at the Danish and NTT.

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[★] Observations collected at the European Southern Observatory, La Silla, Chile

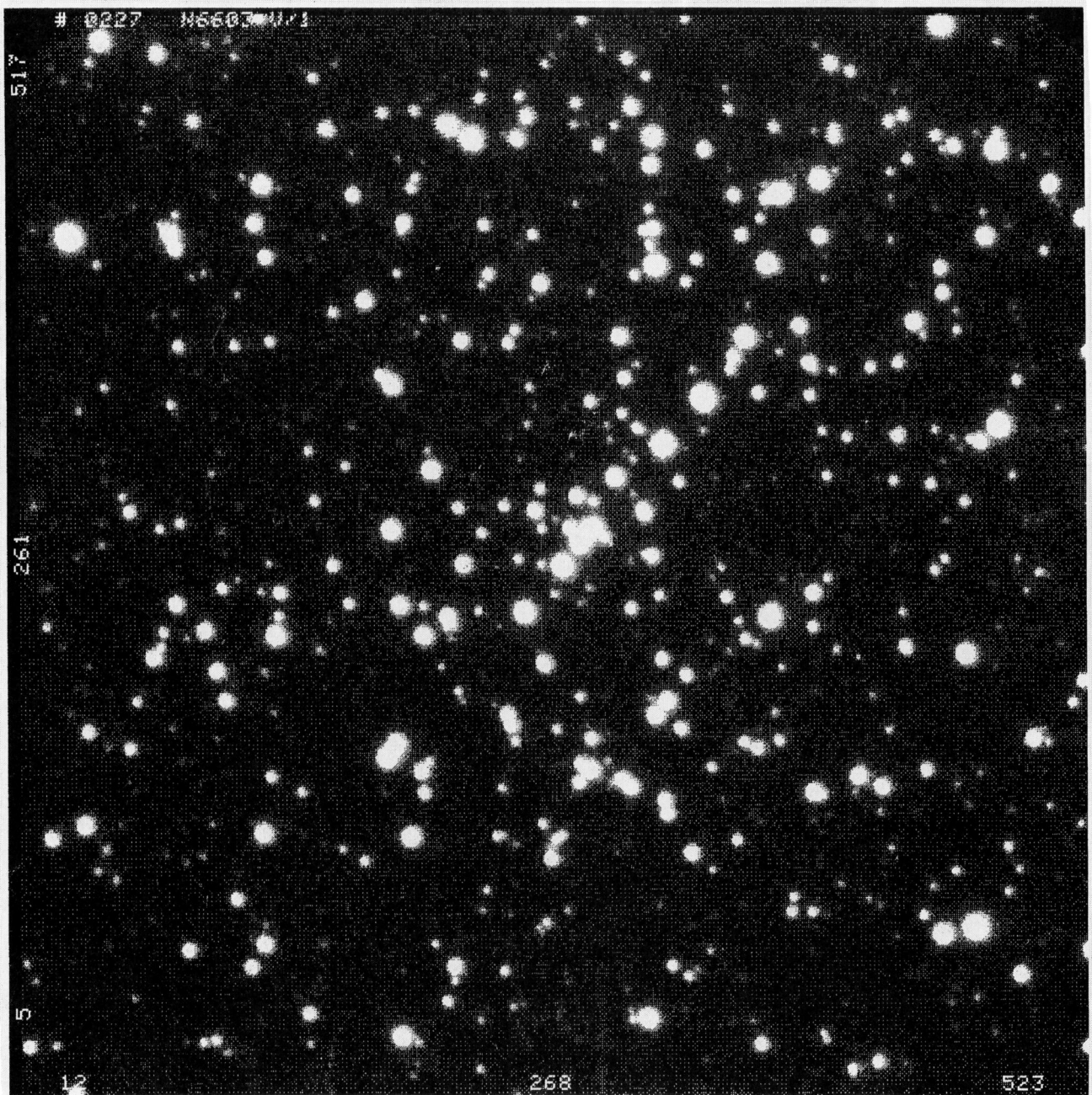


Fig. 1. V NTT image of NGC 6603. The field is $2\frac{1}{5} \times 2\frac{1}{5}$

An NTT V image of the cluster is shown in Fig. 1. Owing to the large cluster size it fills the whole CCD frame which corresponds on the sky to about $2\frac{1}{5} \times 2\frac{1}{5}$. At the Danish, the field is $4' \times 2\frac{1}{5}$.

The field exposure was taken $15'$ north of the cluster center, well within the star cloud. The integration times were 1 min in V and 4 min in B for the cluster, whereas for the field they were of 1 min and 15 min respectively, with a seeing of $1\frac{1}{4}$.

The reductions were carried out at ESO-Garching with Midas and IHAP image packages. The DAOPHOT code

was used in Midas environment for the stellar photometry. Calibrations were applied in the usual way using Landolt's (1983) standard stars. A discussion of the equations were given in the study of the globular cluster Terzan 1 (Ortolani et al. 1992) taken in the same run under the same set ups at the Danish. The results of the stellar photometry for the cluster and offset fields are available under request to one of us (S.O.).

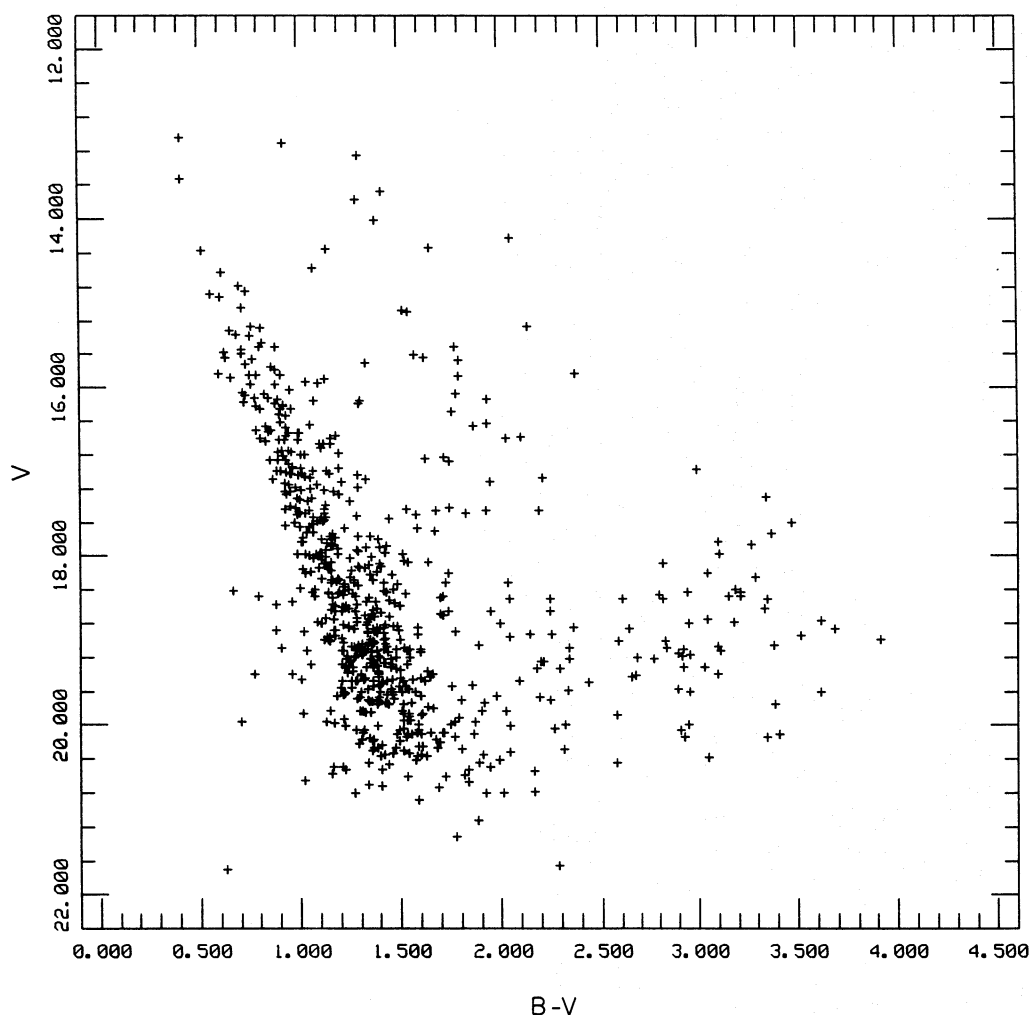


Fig. 2. Observed V vs. $(B-V)$ CMD for NGC 6603. The cluster total dereddening vector is indicated

3. Colour-magnitude diagrams

We show in Fig. 2 the V vs. $(B-V)$ diagram of NGC 6603. In Fig. 3 the field background CMD diagram taken 15' north of the cluster is presented. The cluster diagram is contaminated but it clearly extends to brighter magnitudes. This is illustrated in Fig. 4 where the histogram distributions along the MS are plotted. The field MS histogram is steeper which suggests a superposition of TOs of different ages.

The cluster parameters are determined below by means of usual methods of CMD comparisons, i.e., well studied clusters with properties like age, metallicity and reddening, which are fiducially determined, are taken as reference. We then identify CMD features in our clusters and field, which are in common with the reference fiducial clusters and derive the parameters.

3.1. The cluster CMD

The blue main-sequence (MS) indicates that the cluster is young. The TO is located at $V = 14.3 \pm 0.2$ and

$(B-V) = 0.72 \pm 0.05$. A clump of 10 red giants is present at $V \approx 13.6$ and $(B-V) \approx 1.90$ and a redder possible giant member at $(B-V) \approx 2.38$ is also observed.

A comparison with the composite HR diagrams of galactic open clusters (Mermilliod 1981a) shows that the separation between the clump of giants and the upper main sequence $\Delta(B-V) \approx 1.05$ is too small to be interpreted as red supergiants in clusters younger than 20 Myr. Rather, the separation indicates that we are dealing with a red giant clump like those in Mermilliod's NGC 6475 group, i.e., of age ≈ 200 Myr, according to a classical (no overshooting) stellar evolution model calibration (Mermilliod 1981b). If overshooting is taken into account, the age is reduced by about 30% (Alongi et al. 1991). The TO morphology resembles more his slightly older group NGC 2281 (age ≈ 300 Myr). The very red giant star mentioned above could be interpreted as one of those present in the extended red giant branch of his group NGC 2516 of 100 Myr. Magellanic Cloud clusters of similar age like NGC 1866 also show this effect (Bica et al., 1990). These comparisons lead to an age of 200 ± 100 Myr for NGC 6603.

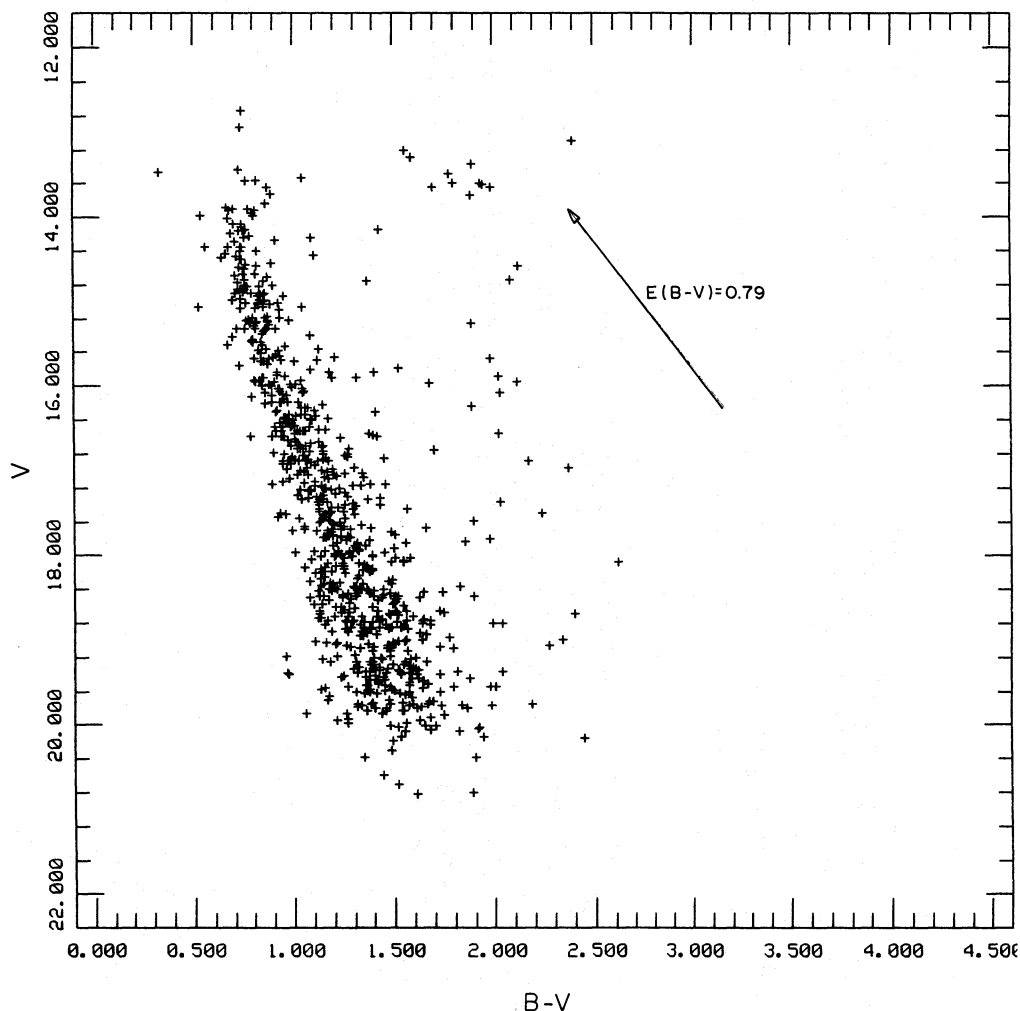


Fig. 3. Observed V vs. $(B-V)$ CMD of the background field at 15' north of cluster. The field is deeper than the cluster because of the longer exposure in B (Sect. 2)

The TO comparison with the NGC 6475 group provided $E(B-V) = 0.79$, which is somewhat higher than the value given by Becker & Fenkart (1971). We derived a reddening corrected TO $V_0 = 11.93$. The same position in the absolute diagram of the NGC 6475 group is $M_V = -1.0$, which implies for NGC 6603 a distance modulus of $(V-M_V)_0 = 12.93 \pm 0.2$, and a distance of 3.6 ± 0.4 kpc. Consequently the cluster is located in a relatively distant position in the inner disk of the Galaxy.

Recently Santos Jr. & Bica (1992) have analyzed integrated spectra of Galactic disk clusters including NGC 6603 obtained at the 1.52 m telescope at ESO, in May/1990. They compared line equivalent widths and continuum distribution with star cluster templates (Bica 1988). NGC 6603, after a foreground reddening correction of $E(B-V) \approx 0.50$, fits well the cluster template Y3, of age ≈ 100 Myr. A poorer fit is obtained for Y4 (age ≈ 500 Myr). The difference $\Delta E(B-V) = 0.29$ between the estimate from the integrated spectrum and that from the CMD might be caused by an internal reddening which is expected to be significant for such ages. This is consistent with the colour spread observed in the cluster MS (Fig. 2).

3.2. The field CMD

The field V vs. $(B-V)$ CMD (Fig. 3) presents a young MS with a TO slightly lower than that of the cluster. The field contains in addition a sequence of red giants parallel to the MS which is much less populated than the latter. This sequence is further evidence for an age range in the star cloud, which can be inferred from Mermilliod's (1981a) CMDs of galactic open clusters of ages in the range $300 < t(\text{Myr}) < 600$ (or $200 < t(\text{Myr}) < 400$ with overshooting). The fainter red stars correspond to an old bulge/halo population component.

The field TO is located at $V \approx 14.9$ and $(B-V) \approx 0.60$ (neglecting the two brightest stars in the MS). We associate this TO with that of Mermilliod's group NGC 2281 ($M_V = 0.0$; $(B-V)_0 = 0.0$ for the TO) of age $t \approx 300$ Myr. We derive $E(B-V) = 0.60$, $(V-M_V)_0 = 13.10$ which corresponds to a distance of $d \approx 4.2$ kpc.

This suggests that the cluster and the star cloud are spatially in the same region. We notice that the star cloud may contain a component as young as that of the cluster because we are only observing a small fraction of it. This is suggested by the two bright MS stars detected.

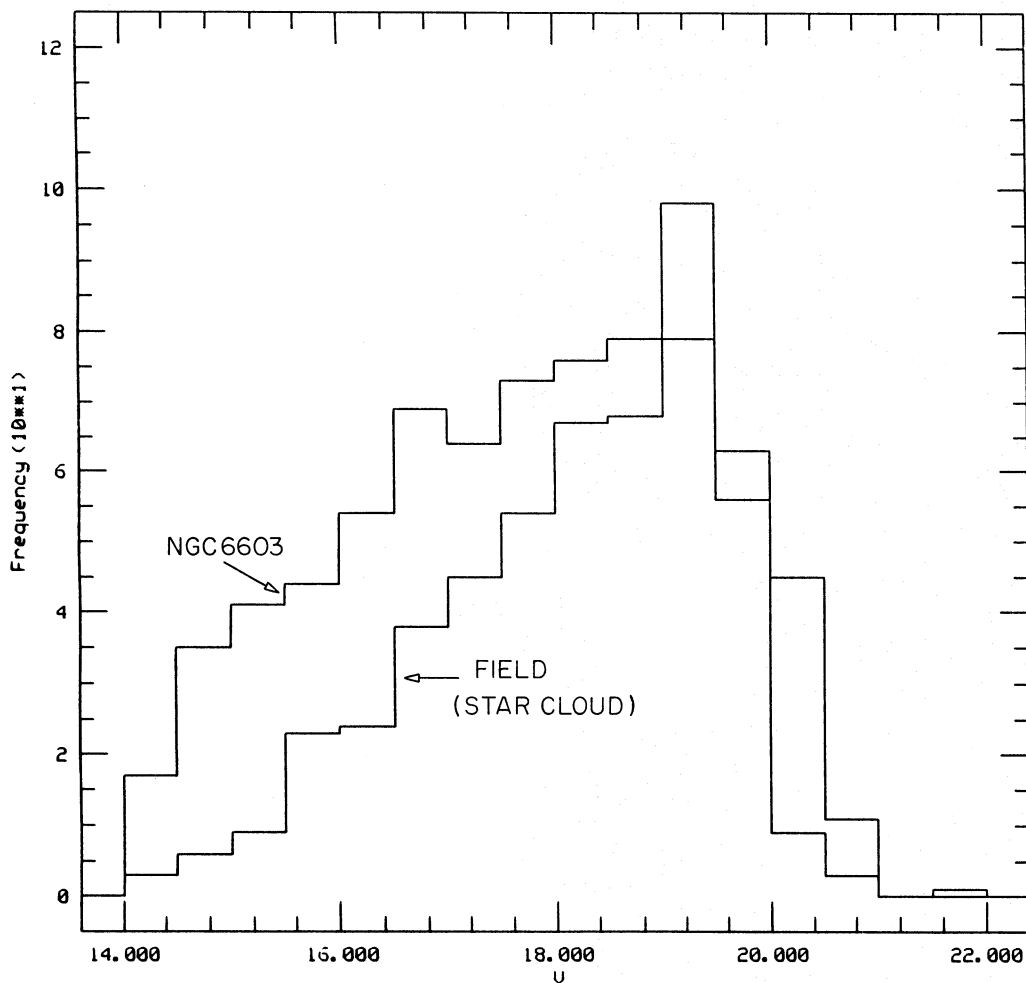


Fig. 4. Histogram of cluster and field (star cloud) along the main sequence

The possible uncertainties caused by differential reddening would not change much these conclusions.

4. Concluding remarks

The cluster and the apparently related star cloud are in a line of sight close to the Galactic Center direction. The estimated distance (3.5 to 4.0 kpc) coincides with the observed star formation peak in the Galaxy (Güsten 1986). The age we have derived for the cluster (≈ 200 Myr) and the star cloud ($200 < t(\text{Myr}) < 600$) might date this peak of star formation.

The cluster red giants are interesting candidates for detailed abundance analysis, because of the cluster inner disk location.

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