Age and Metallicity of two dwarf spheroidal galaxies in the Centaurus A Group

Makarova L., Makarov D.

Special Astrophysical Observatory,
September 14, 2009

Специальная астрофизическая обсерватория

Российская академия наук

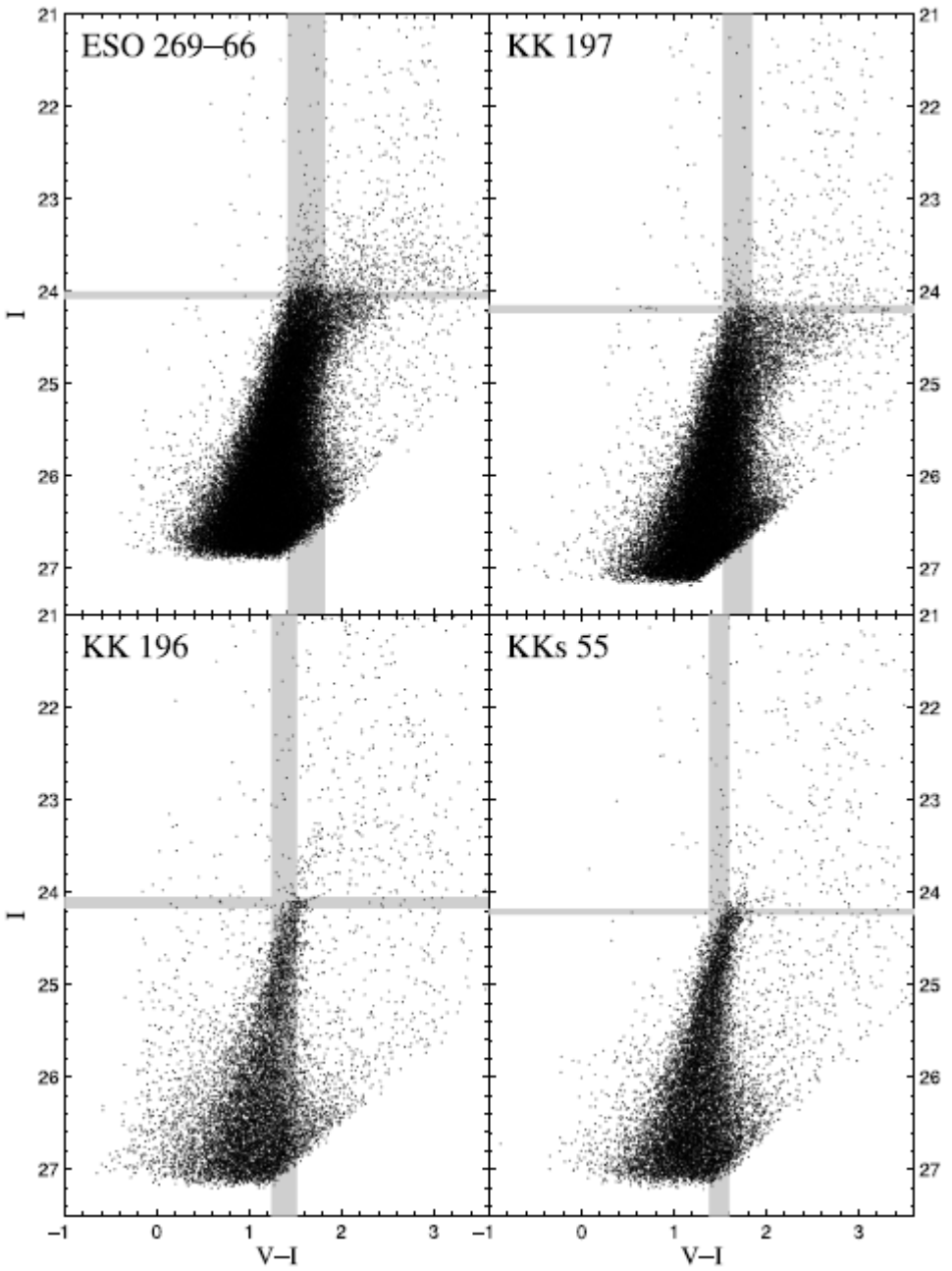
Our team

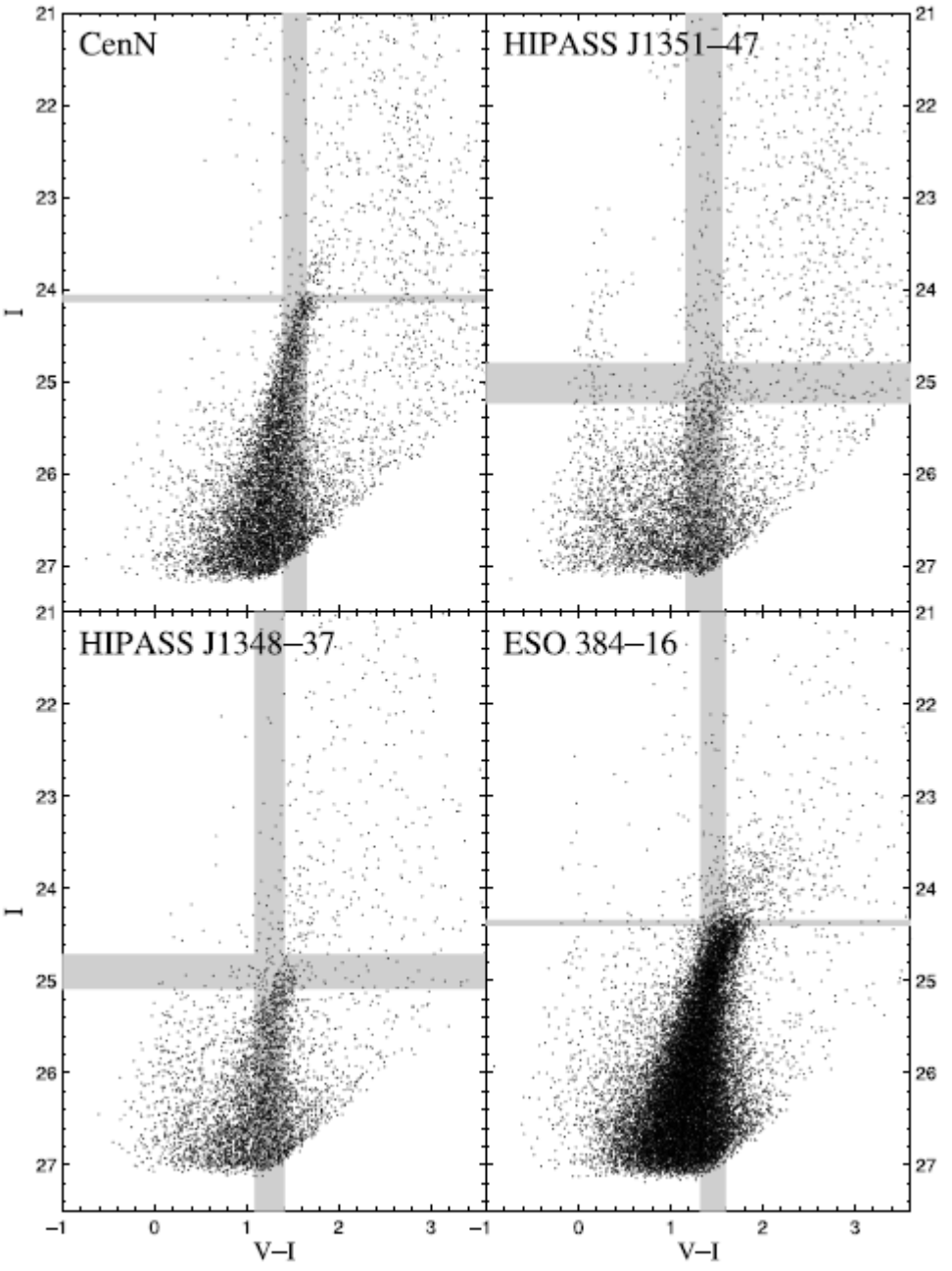
I.Karachentsev (SAO), B. Tully (IfA), Dolphin A. (Raytheon C.), Makarov D. (SAO), Makarova L. (SAO), Shaya E. (UMD), Sharina M. (SAO), Sakai Sh. (UCLA), Rizzi L. (JAC), Karachentseva V. (KU), Jacobs B. (IfA)

Outline

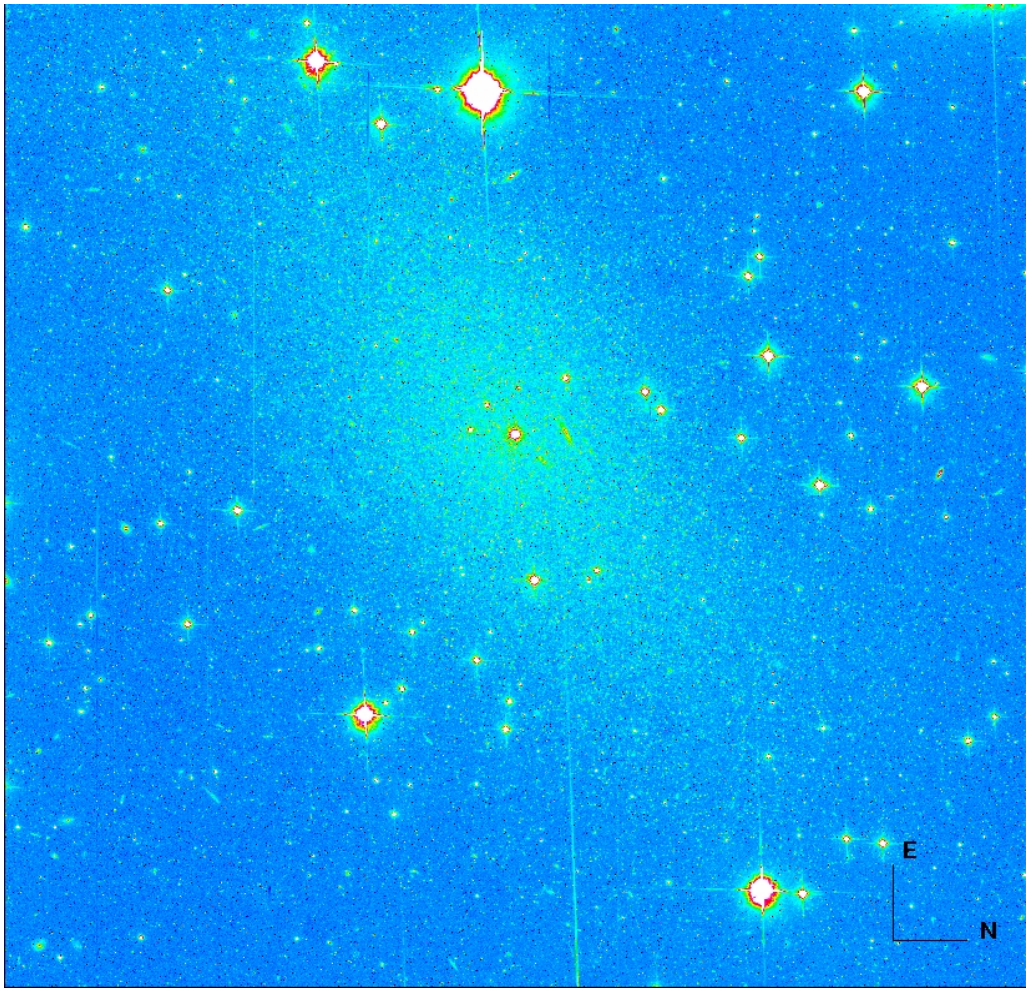
- In our recent work «The Hubble Flow around the CentaurusA/M83 galaxy complex» by Karachentsev et al. (2007) we have determined the photometric distances for 24 galaxies within the complex
- Centaurus A is one of the nearest group of galaxies (mean distance is 3.8 Mpc). It contains about 30 members, most of which were observed with HST/ACS (our proj. 9771 and 10235) or HST/WFPC2
- We continue to study star formation processes in nearby dwarf galaxies (< 10 Mpc) using the observational data obtained by our team at the HST/WFPC2 and HST/ACS
- We have determined star formation histories of 20 dwarf galaxies within the group from the resolved stars in the galaxies
- Two dwarf spheroidal galaxies KK 197 and ESO 269-066 show the most pronounsed 'red tail' features. We are giving the detailed consideration of these objects

Examples of the color-magnitude diagrams from the article of Karachentsev et al. (2007)

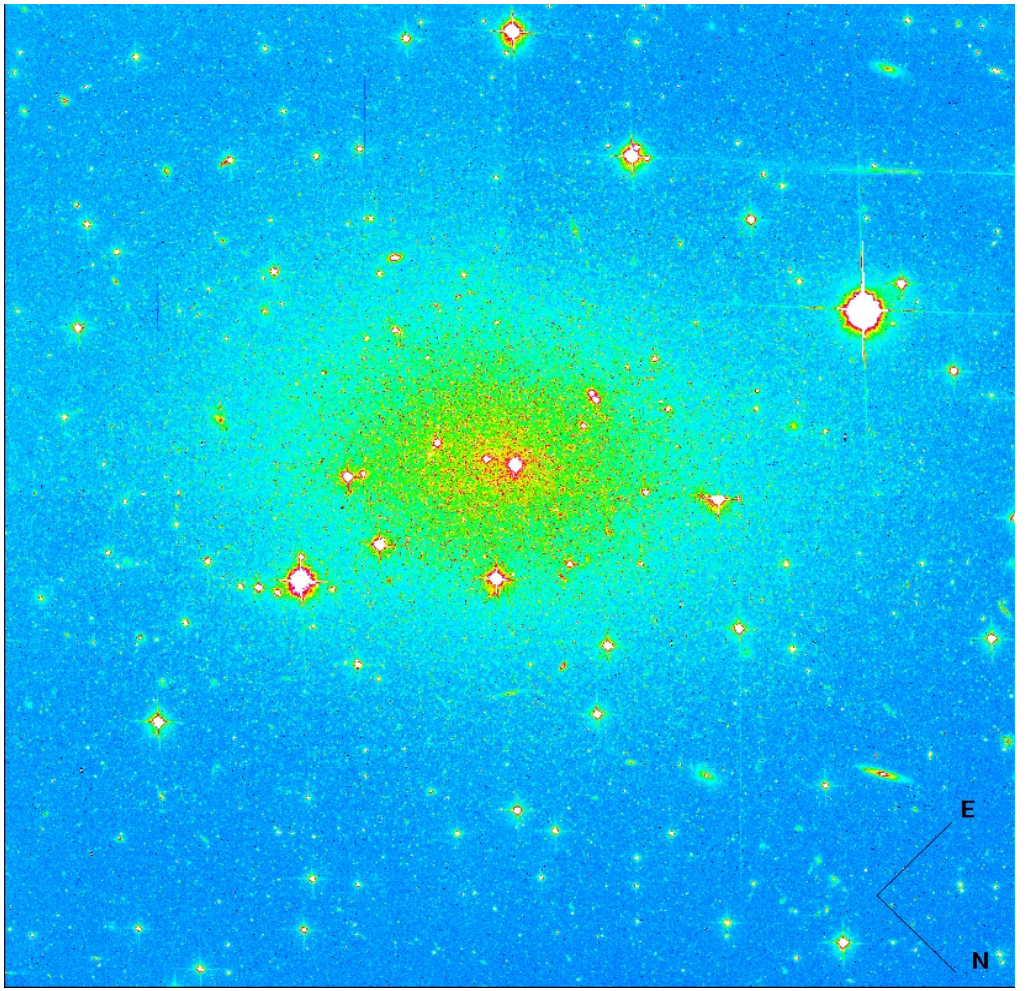




KK 197 (F814W)



ESO 269-066 (F814W)



Photometry of resolved stars in the galaxies was made with the DOLPHOT package (Dolphin 2002) for crowded field photometry. Photometric distances were determined using our implementation of ML algorithm for theTRGB distance indicator (Makarov et al. 2006).

General parameters

KK 197

- Distance modulus : 27.88 mag
- Distance : 3.76 Mpc
- Diameter : 1 kpc
- B_T : 15.68 mag
- V_T : 14.80 mag
- $(B-V)_T$: 0.88 mag
- M_V : -13.08 mag
- M_{HI}/L_B : < 0.01
- $M_{HI} < 2.9 \cdot 10^5 M_{sun}$

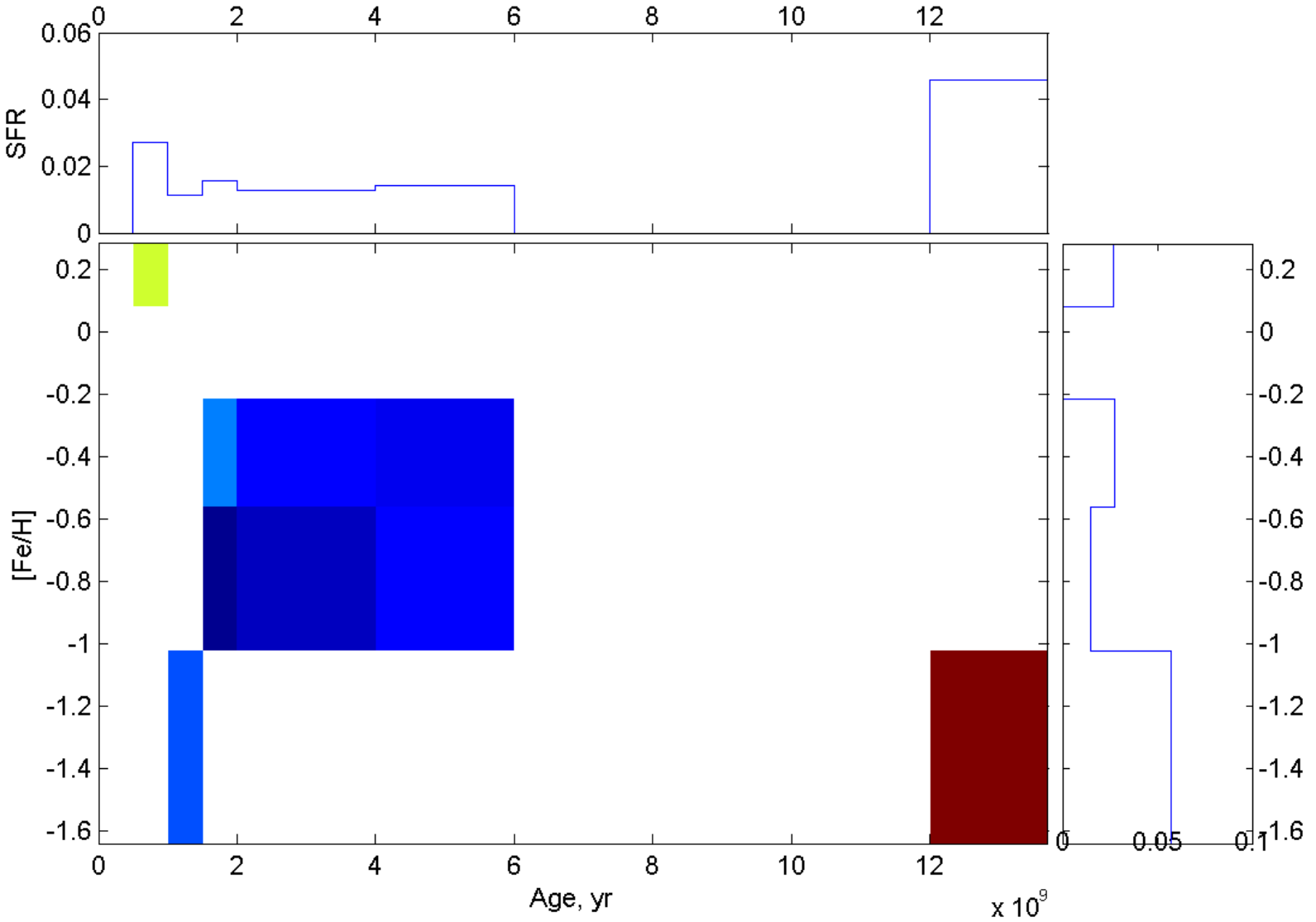
ESO 269-066

- Distance modulus : 27.82 mag
- Distance : 3.66 Mpc
- Diameter : 1.5 kpc
- B_T : 14.59 mag
- V_T : 13.43 mag
- $(B-V)_T$: 1.16 mag
- M_V : -14.39 mag
- M_{HI}/L_B : < 0.002
- $M_{HI} < 1.0 \cdot 10^5 M_{sun}$

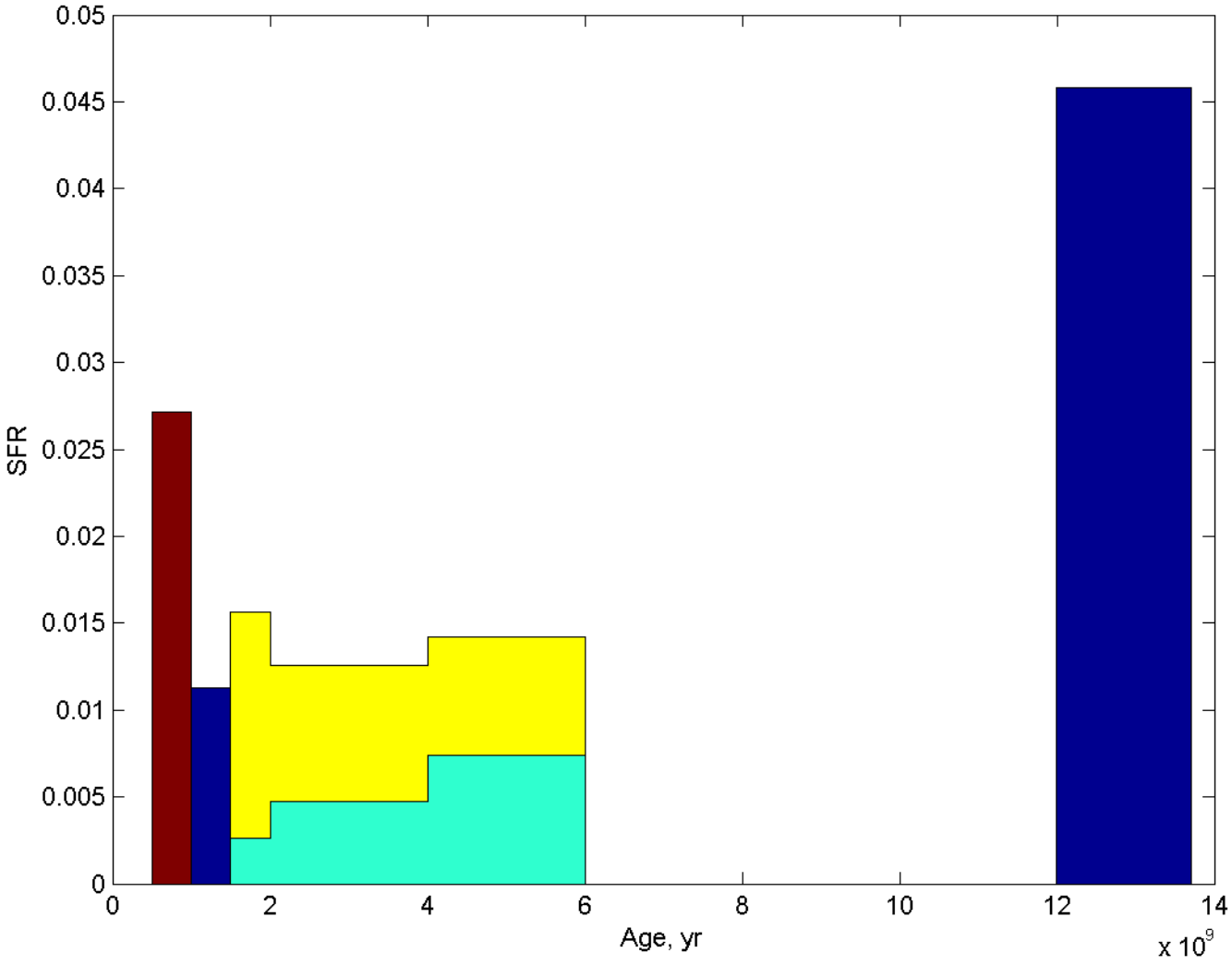
The method

- Quantitative approach to SFH determination: Tosi et al. 1989, Aparicio et al. 1997, Dolphin 2000
- We have created a program StarProbe to analyze our large and homogeneous sample of nearby galaxies (Makarov and Makarova 2004). The objects are situated outside the Local Group. Only brightest part of their stellar populations appears at the CMDs.
- We construct synthetic color-magnitude diagrams from theoretical stellar isochrones taking into account the initial mass function, galaxy distance, external extinction and photometric errors. We use the Padova stellar isochrones set.
- Photometric uncertainties and completeness values were added using results of artificial star tests, that are the accurate way to solve the problems of photometric errors, blending and incompleteness
- A linear combination of synthetic CMDs of different ages and metallicities forms a model CMD
- For SFH determination we have to find a best linear combination of partial model CMDs to match the observed data. We construct a maximum-likelihood function for this task.

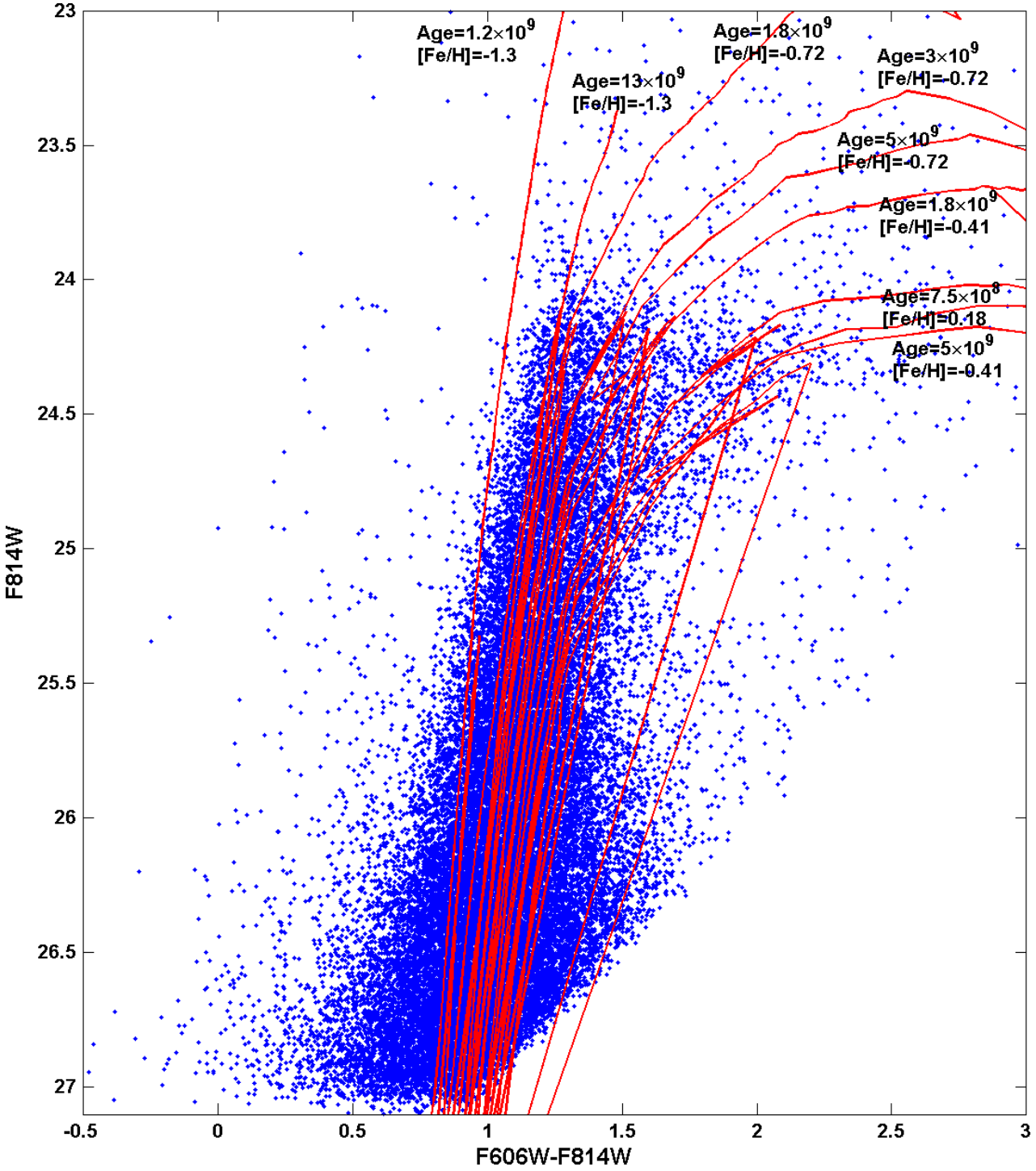
KK 197 : Star Formation History



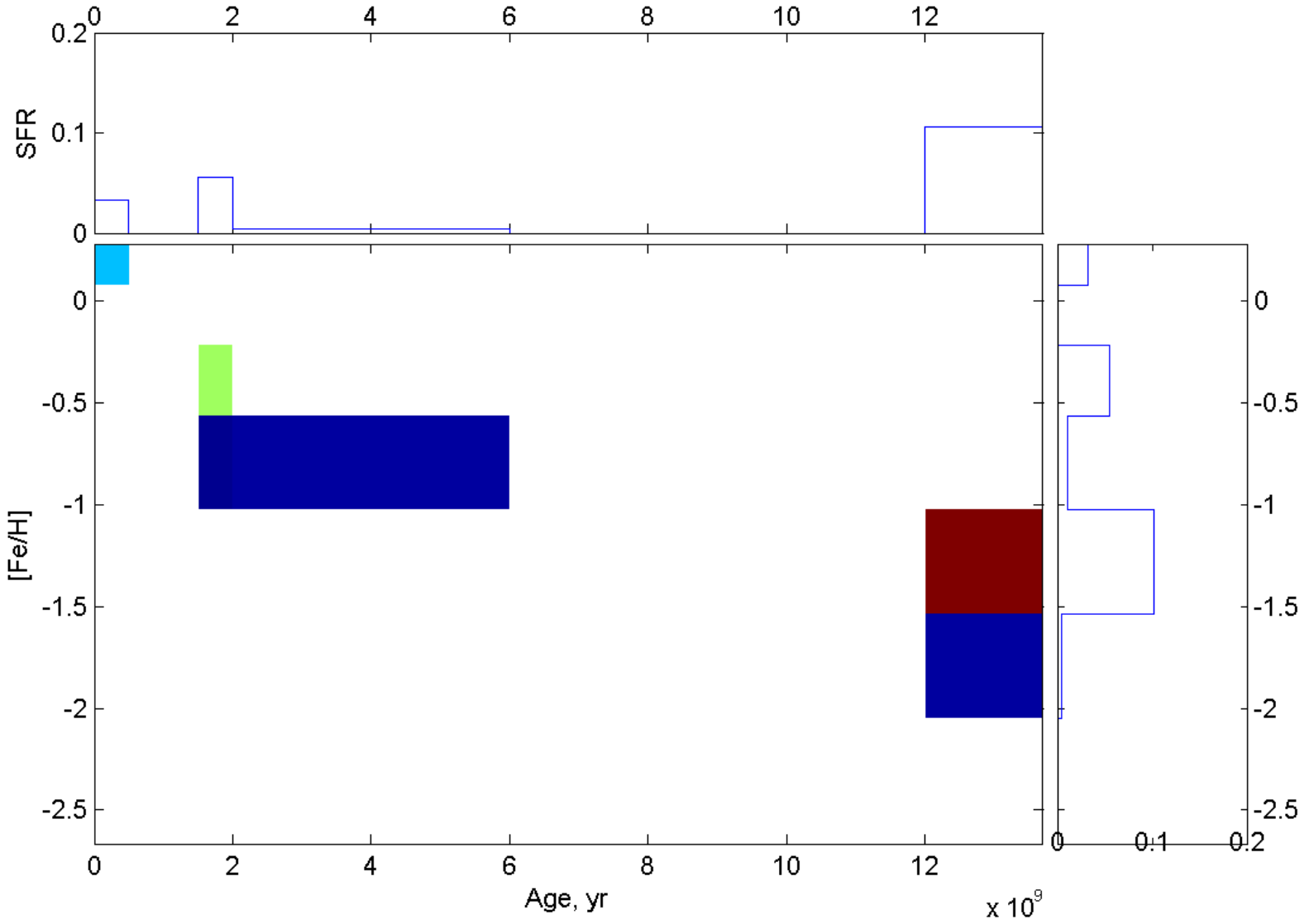
KK 197 : SFH


0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
SFR
0
2
4
6
8
10
12
14
Age, yr
x 10^9

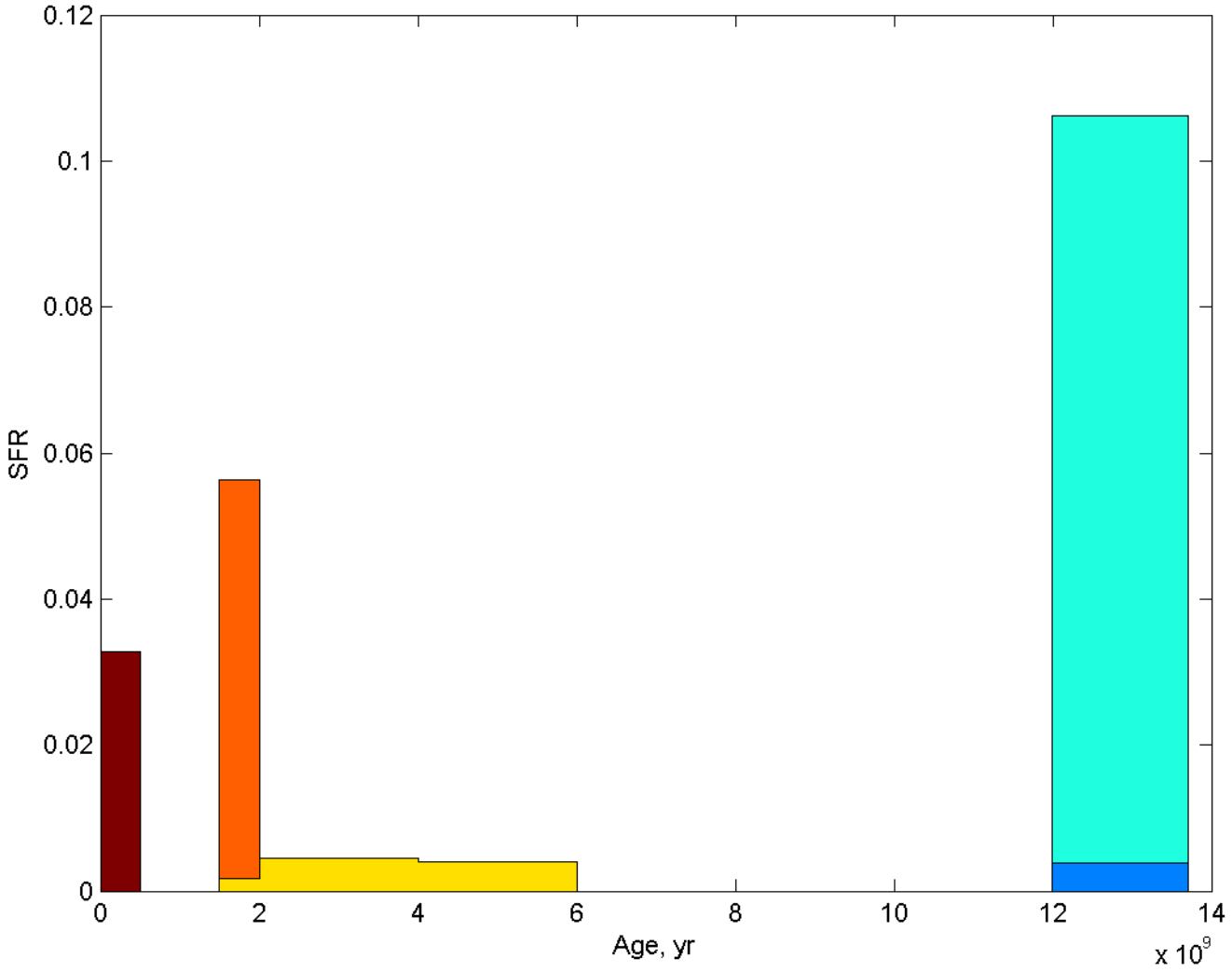
KK 197


Age=1.2×10^9
[Fe/H]=-1.3
Age=13×10^9
[Fe/H]=-1.3
Age=1.8×10^9
[Fe/H]=-0.72
Age=3×10^9
[Fe/H]=-0.72
Age=5×10^9
[Fe/H]=-0.72
Age=1.8×10^9
[Fe/H]=-0.41
Age=7.5×10^8
[Fe/H]=0.18
Age=5×10^9
[Fe/H]=-0.41
F814W
F606W-F814W
23
23.5
24
24.5
25
25.5
26
26.5
27
-0.5
0
0.5
1
1.5
2
2.5
3

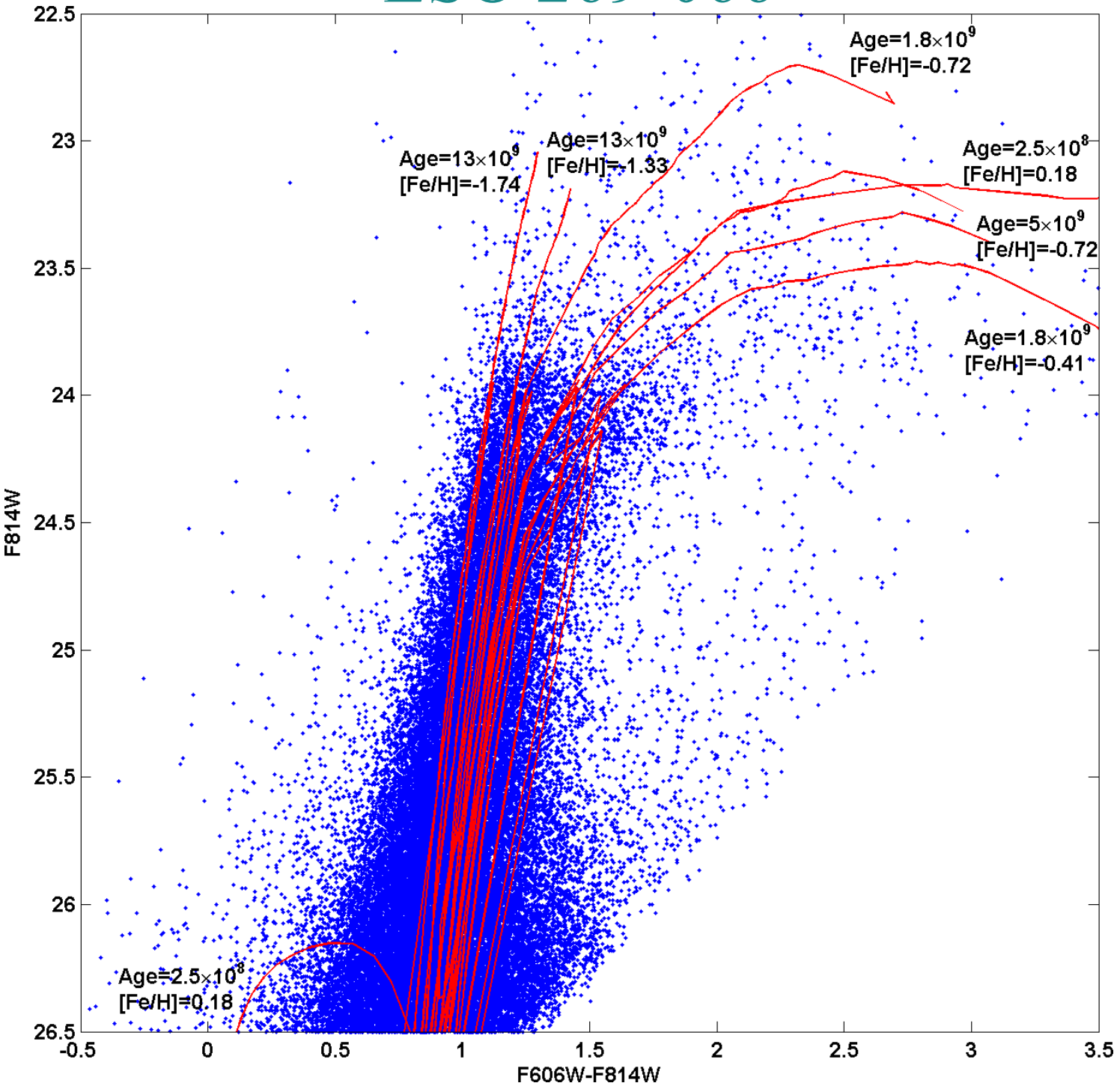
ESO 269-066 :Star Formation History



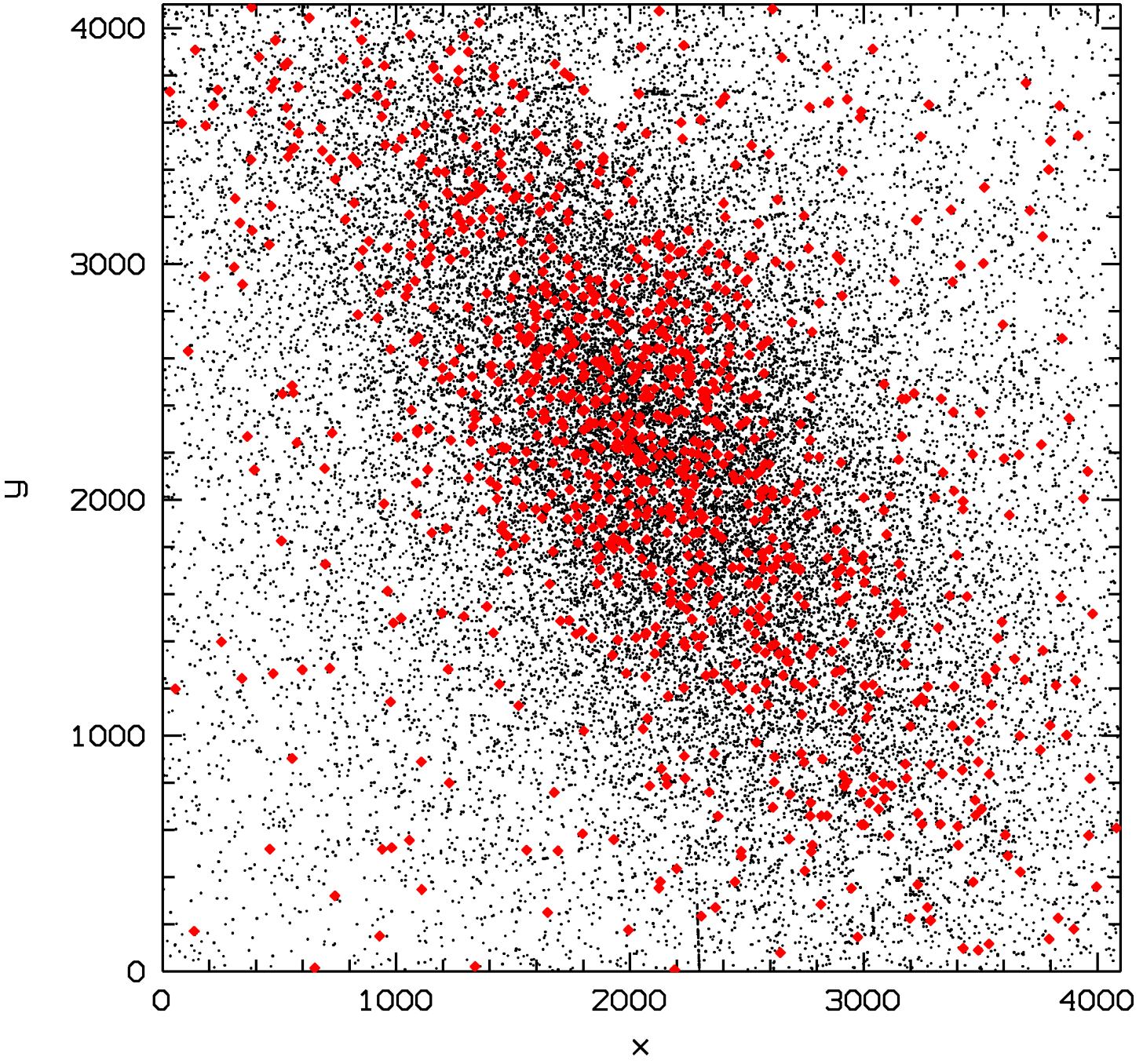
ESO 269-066: SFH



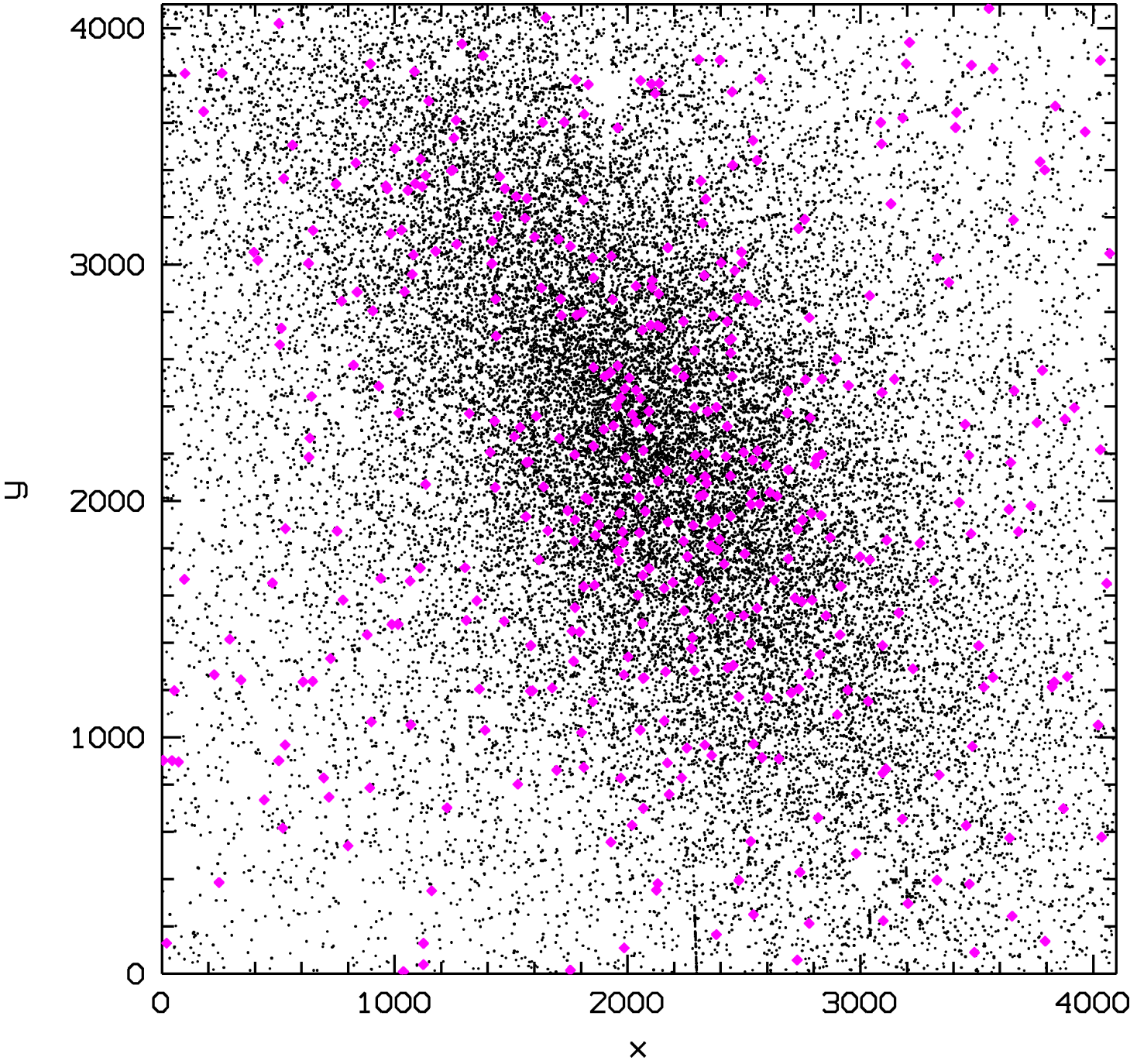
ESO 269-066


Age=1.8×10^9
[Fe/H]=-0.72
Age=13×10^9
[Fe/H]=-1.74
Age=13×10^9
[Fe/H]=-1.33
Age=2.5×10^8
[Fe/H]=0.18
Age=5×10^9
[Fe/H]=-0.72
Age=1.8×10^9
[Fe/H]=-0.41
Age=2.5×10^8
[Fe/H]=0.18
F814W
F606W-F814W
22.5
23
23.5
24
24.5
25
25.5
26
26.5
-0.5
0
0.5
1
1.5
2
2.5
3
3.5

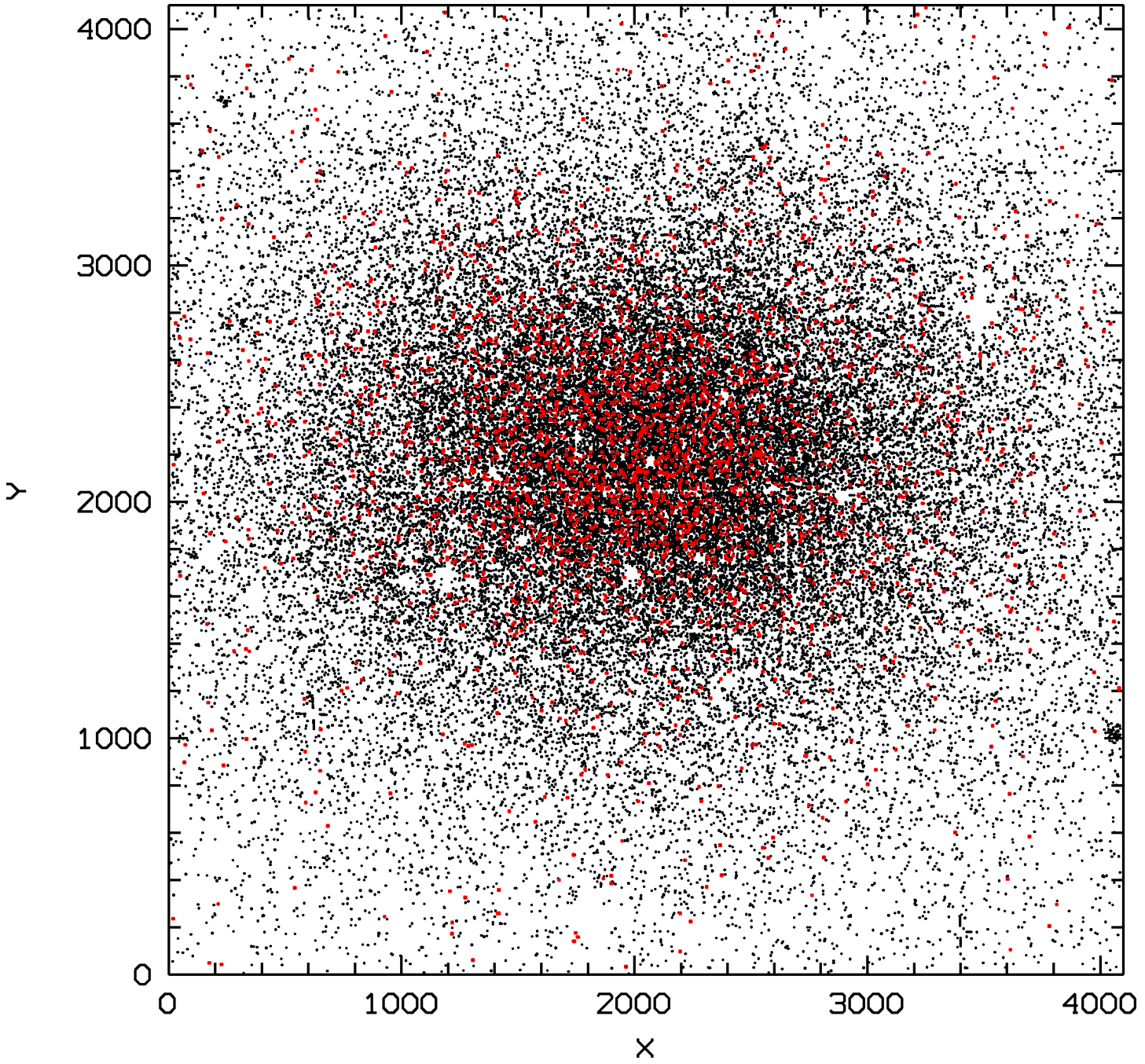
KK 197 : the spatial distribution of redder stars



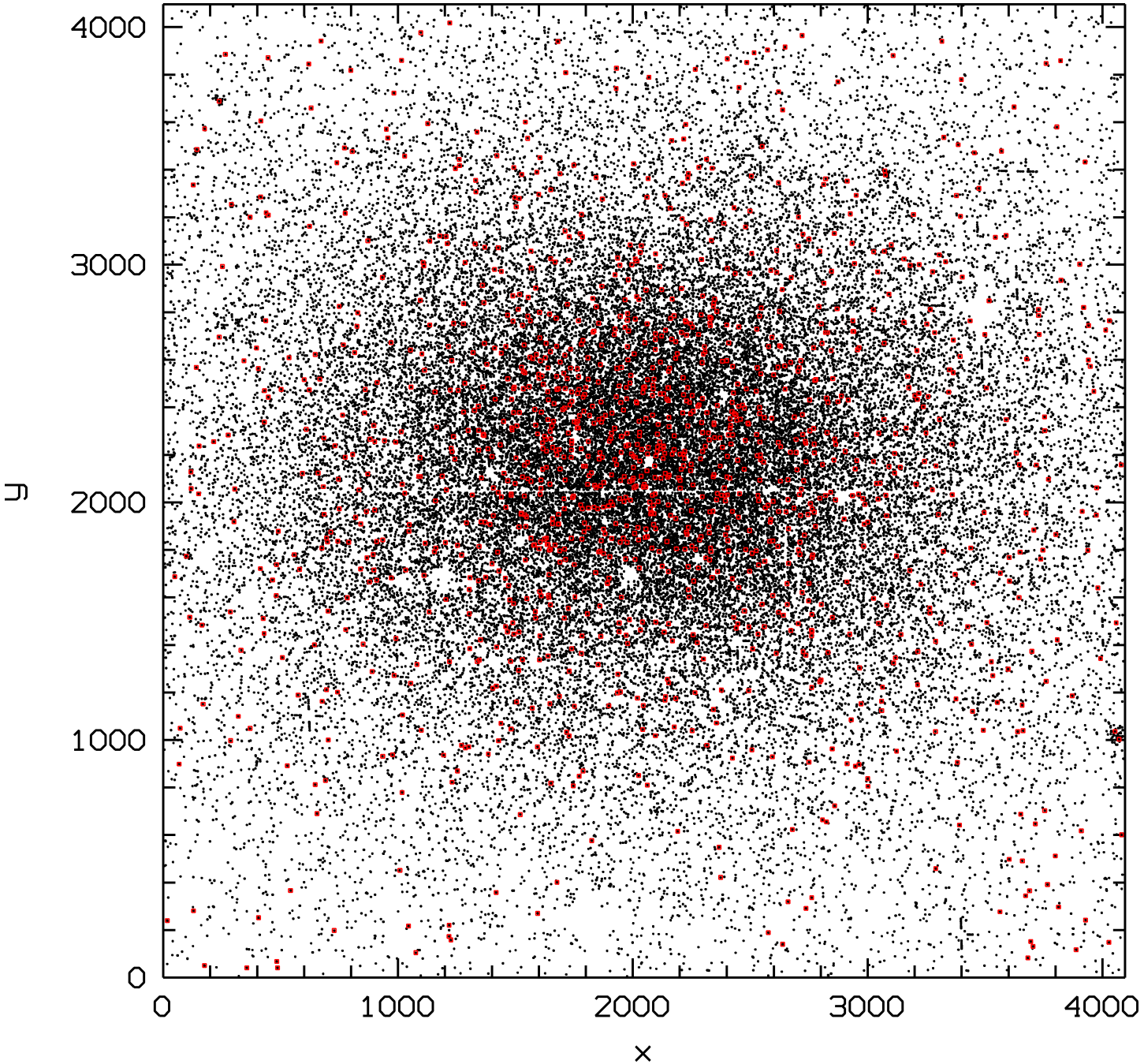
KK 197 : the spatial distribution of probable AGB stars



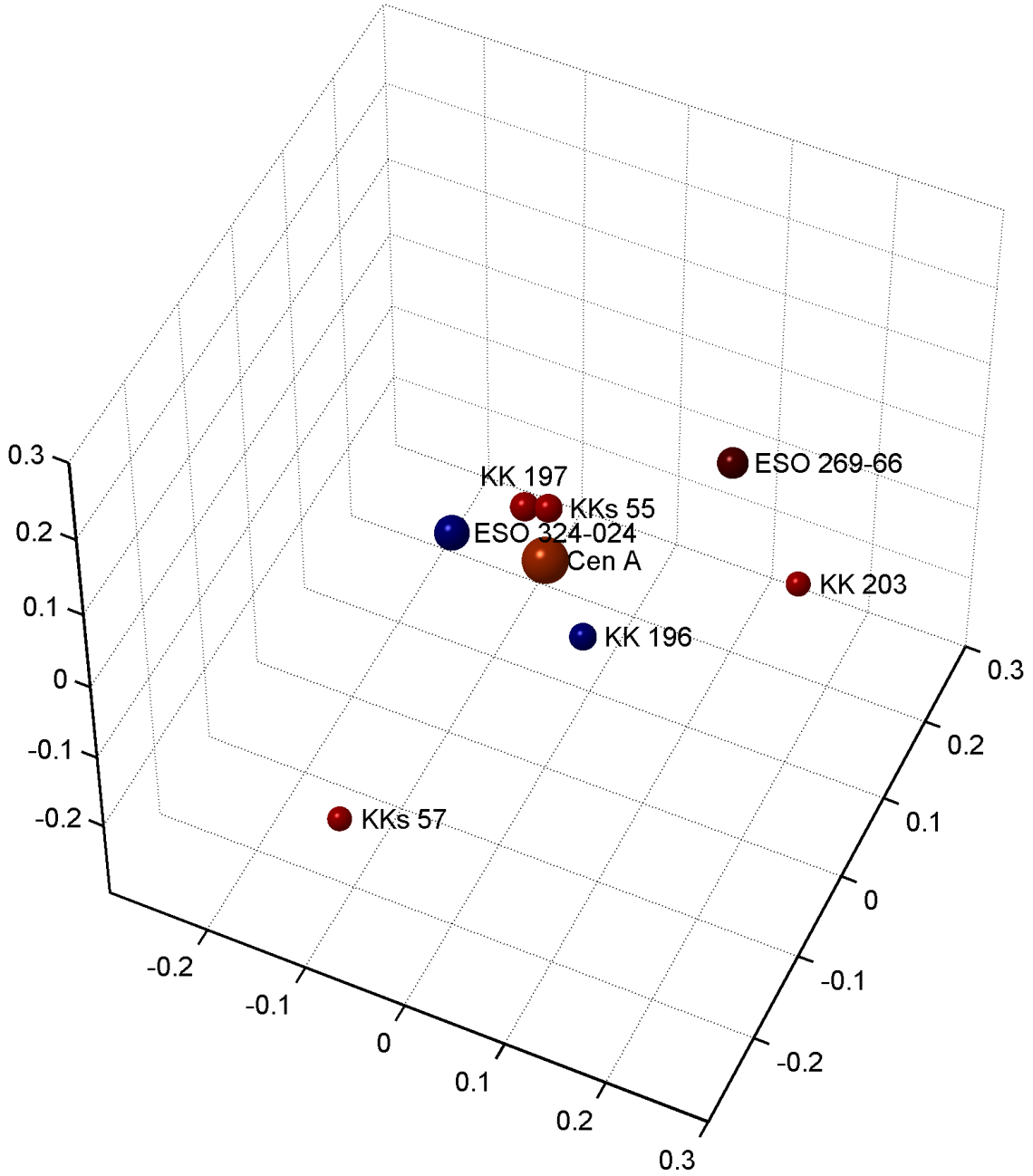
ESO 269-066 : redder stars

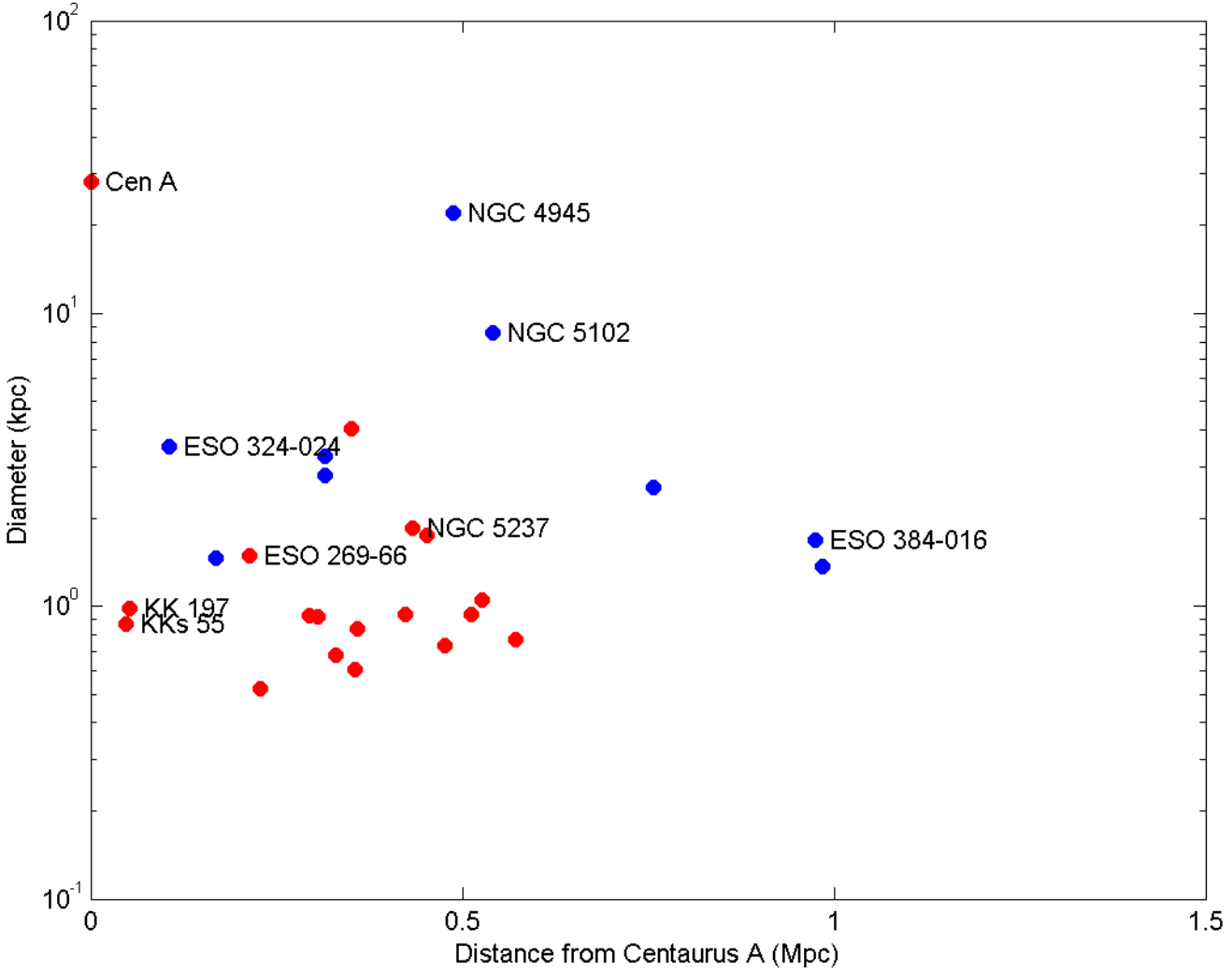


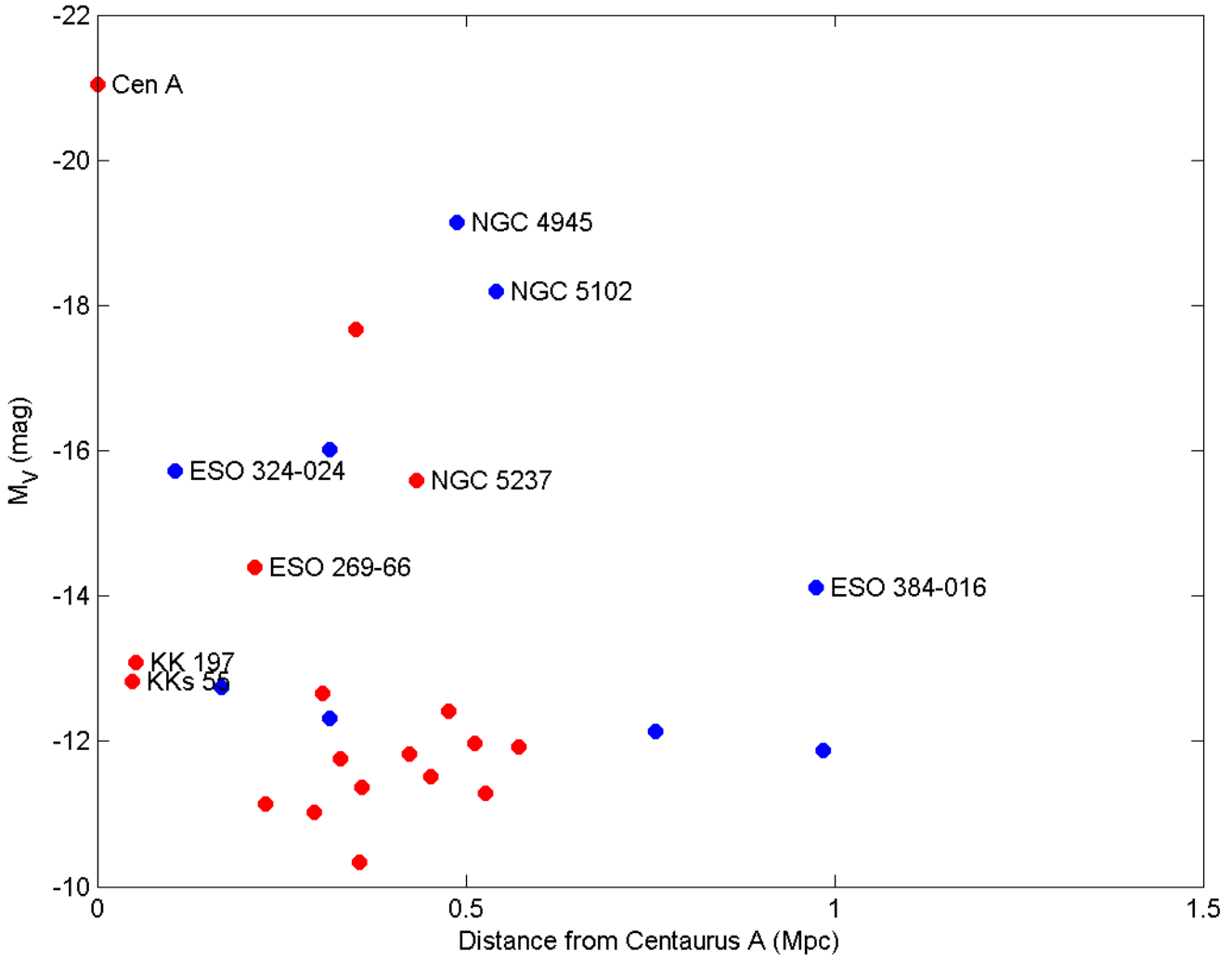
ESO 269-066 : probable AGB stars



The Centaurus A group structure : 300 kpc from the center




Cen A
NGC 4945
NGC 5102
ESO 324-024
NGC 5237
ESO 269-66
ESO 384-016
KK 197
KKs 55
Diameter (kpc)
Distance from Centaurus A (Mpc)
10^2
10^1
10^0
10^{-1}
0
0.5
1
1.5


-22
-20
-18
-16
-14
-12
-10
0
0.5
1
1.5
M_V (mag)
Distance from Centaurus A (Mpc)
Cen A
NGC 4945
NGC 5102
ESO 324-024
NGC 5237
ESO 269-66
ESO 384-016
KK 197
KKs 55

Summary

- We have considered the detailed star formation history of the two dwarf galaxies in the nearby Cen A group. The SFH were measured using the resolved stellar populations.
- The dSph galaxies under study show the unusually rich RGB population of redder colors
- Our measurements show one old and most intensive star formation episode 12-14 Gyr ago in the both galaxies and less intensive star formation between 6 Gyr and 1 Gyr ago with the period of quiescence
- We have detected rather homogeneous spatial distribution of the resolved stellar populations along the galaxy diameter
- The absolute luminosities, apparent sizes and distances of the both galaxies under study cannot explain the red feature
- The galaxies probably need additional hidden resource for the considerable star formation episode at the younger ages plus probable interaction in the past, which can trigger the star formation about 6 Gyr ago

Acknowledgements

We acknowledge the support of our work by RFBR grants 08-02-00627 and 07-02-00792