Globular Clusters in M87

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First NEON Archive Observing School
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  - Data Retrieving
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  - HST WFPC2
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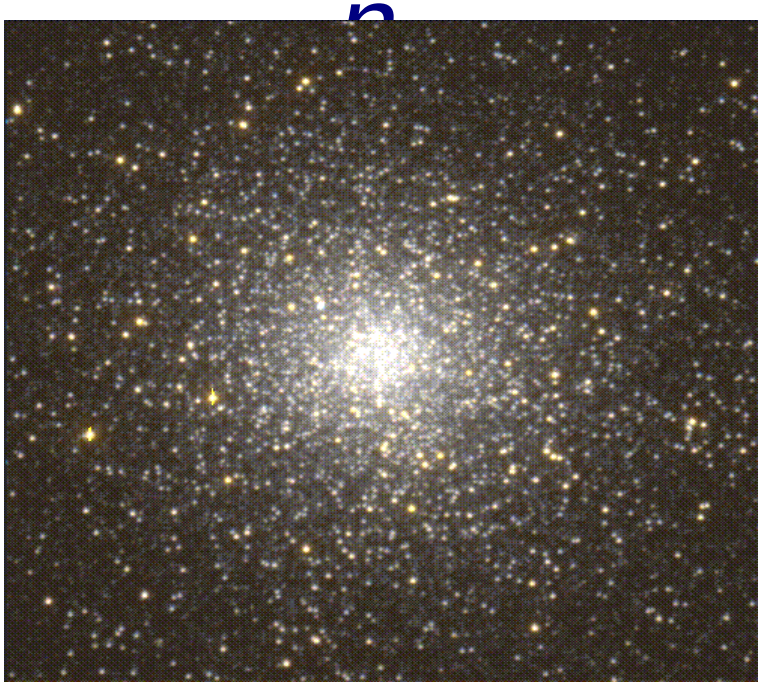
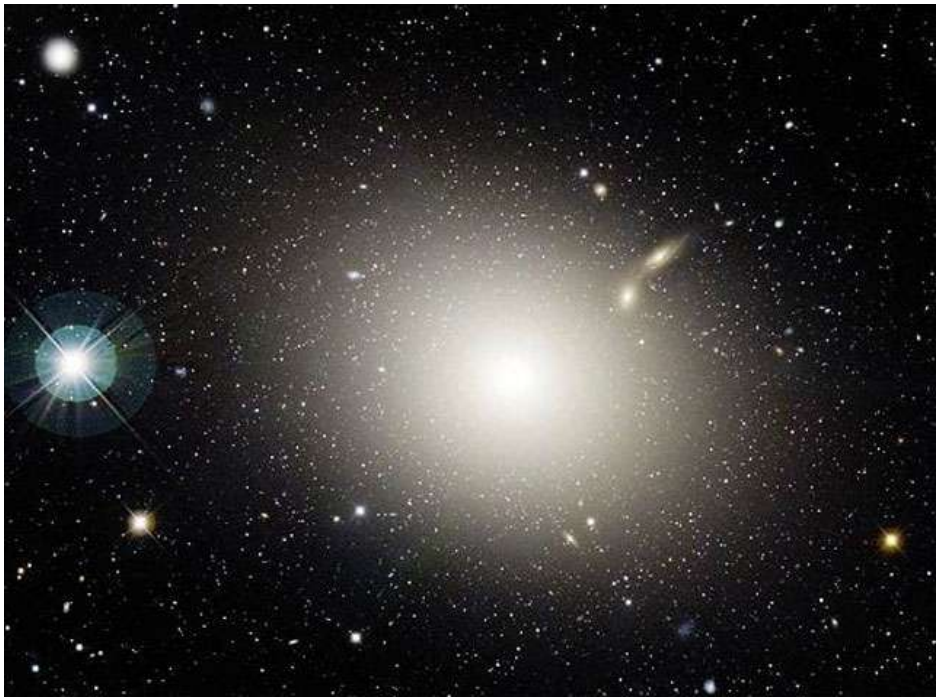
Introductio
n

Globular Clusters (GCs)

- Milky Way ~ 150
- Very old stars ~ 10–12*10^9 years
- Typical size ~ few pc





M87

- Elliptical galaxy in Virgo Cluster
- 15 Mpc

Task

Similar properties ?

Milky Way Gcs

Bimodal metallicity distribution

M87 Gcs

?

Science Archive Facility

ST-ECF

The ESO/ST-ECF Science Archive is a joint collaboration of the European Southern Observatory (ESO) and the Space Telescope - European Coordinating Facility (ST-ECF).
ESO observational data can be requested after the proprietary period by the astronomical community of the ESO member states and Chile. Please read the official 'ESO Data Access Policy' statement for more information. The entire HST archive is available world-wide. To request data you have to register as an ESO/ST-ECF Archive user. Please acknowledge the use of archive data in your publications.

On-Line Services

Archive User Profile
On-line User Registration go

ESO Databases
VLT Science Archive go

Hubble Space Telescope Data
HST Science Archive go

Catalogs & DSS
Digitized Sky Survey go

Tools & Documentation
ESO's Data Interface go

Related External Services
The Vizier catalogs, CDS go

ESO & HST Image Galleries
ESO Photo Gallery go

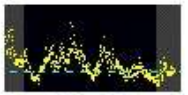
News and updates

- **New ESO data-based publication query form (July 2, 2004)**
- **New MIDI public data packages Eta Car and OH26.5+0.6 available for download (Jun 25, 2004).**
- **New VISIR commissioning data package with the Galactic Centre observations available for download (May 12, 2004).**
- **Starting April 1st, 2004 (ESO Period 73), tapes will no longer be supported as archive data distribution media. *USB disks* will be used for large requests. Read more about this topic.**
- **Search the ESO and HST archives *simultaneously* with Querator. V0.5 now released (Oct 10, 2003).**
- **GOODS ACS V1.0 data release available for download at the ST-ECF mirror archive (Oct 2, 2003).**
- **New release (2.56) of the DSS stand-alone client software for MacOS X, Linux, Solaris and HP-UX. Simply download under ftp://ftp.eso.org/pub/archive/dss.**
- **New WFPC2 "type B" Associations common release (CADC, STScI, ST-ECF). Please read the description or search the archive directly.**
- **Having trouble using the Science Archive Facility? Pay a visit to our FAQ section (frequently asked questions).**

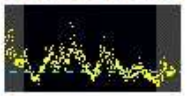
Public Datasets

Digitized Sky

Paranal Meteo



La Silla Meteo

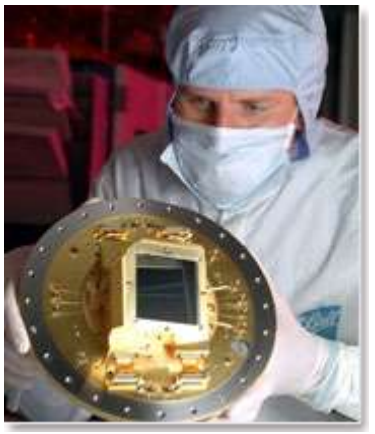


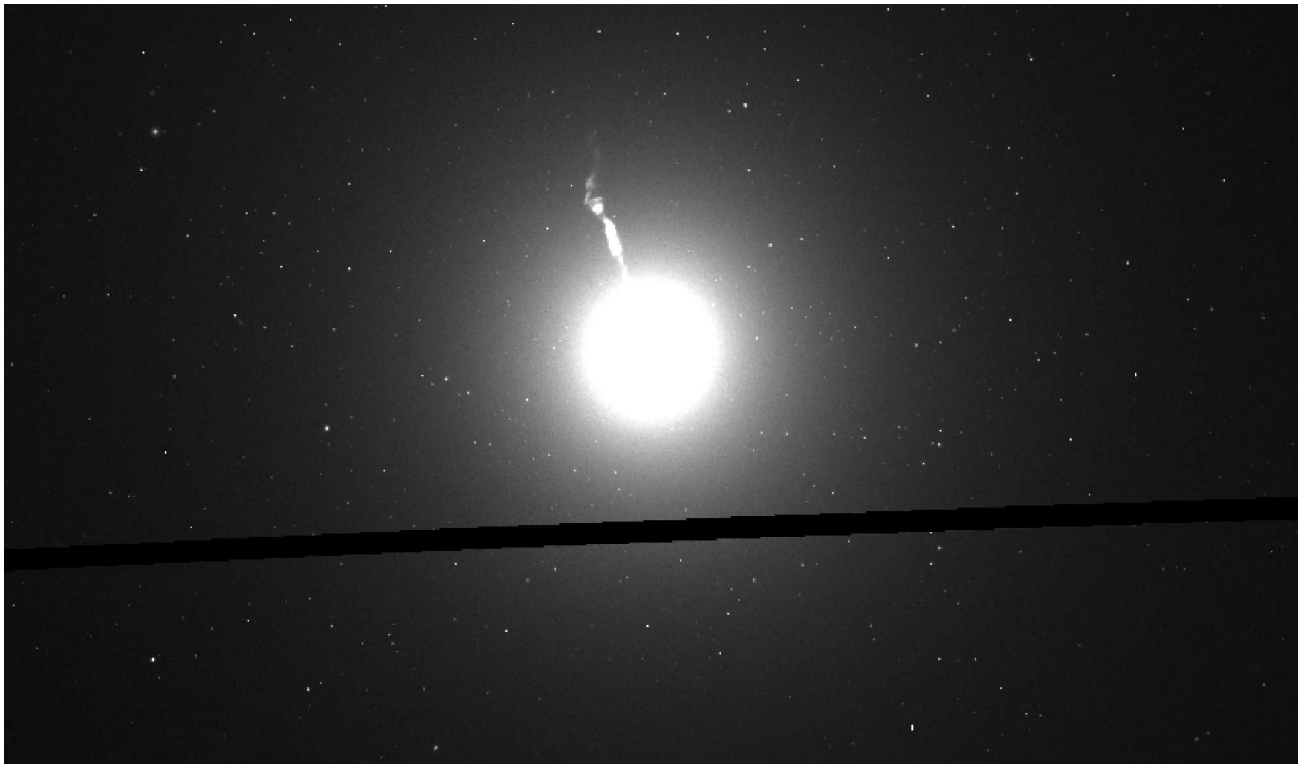
Hubble European Space Agency Information Centre

ASTROVIRTEL

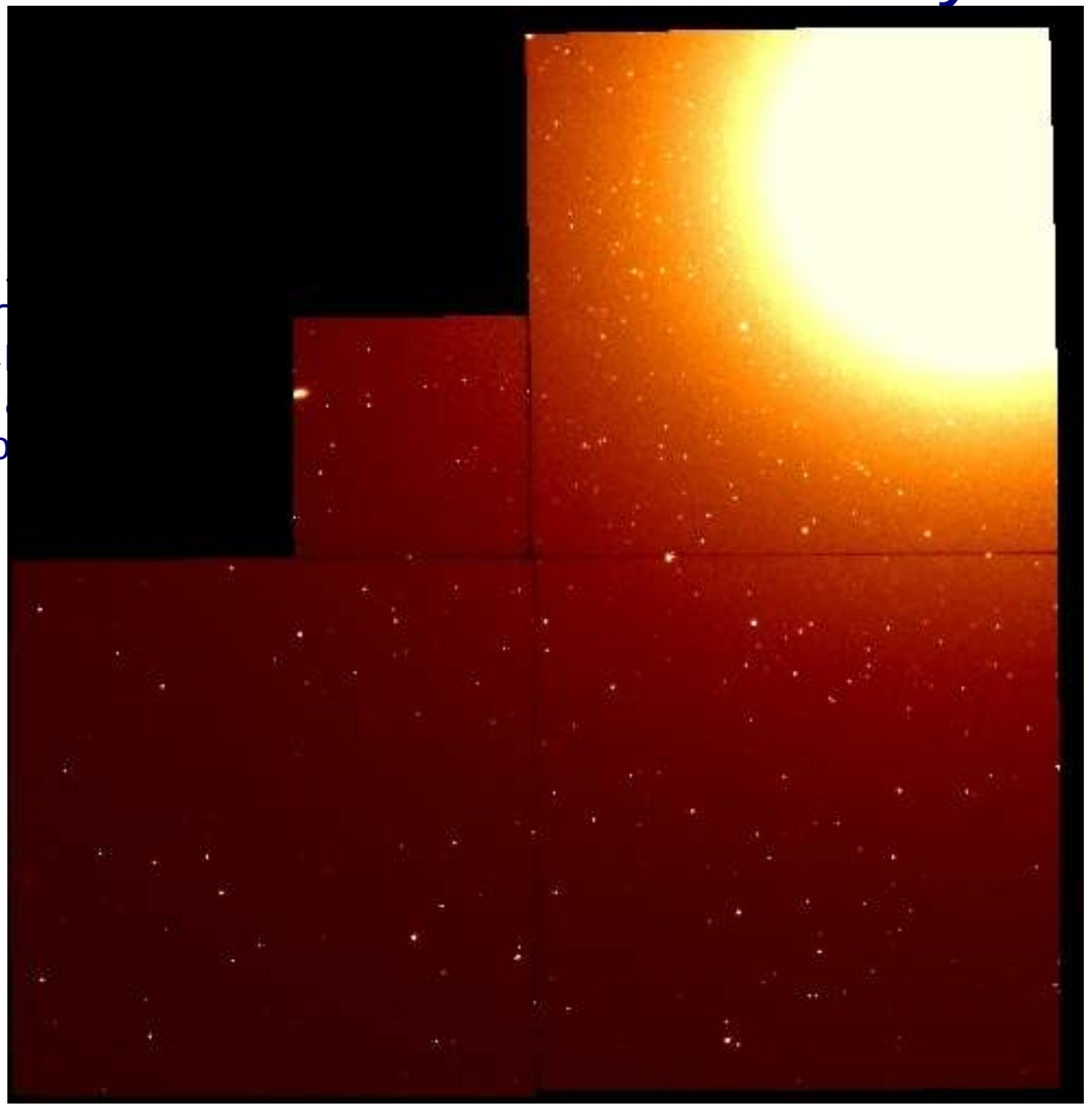
•Advanced Camera for Surveys (ACS)

- 3 cameras: wide-field camera
  high-resolution camera
  solar-blind camera
- Wavelength range from ultraviolet to near-infrared light
- Installed by astronauts aboard the telescope in Servicing Mission 3B February 2002





Wide Field Planetary Camera 2



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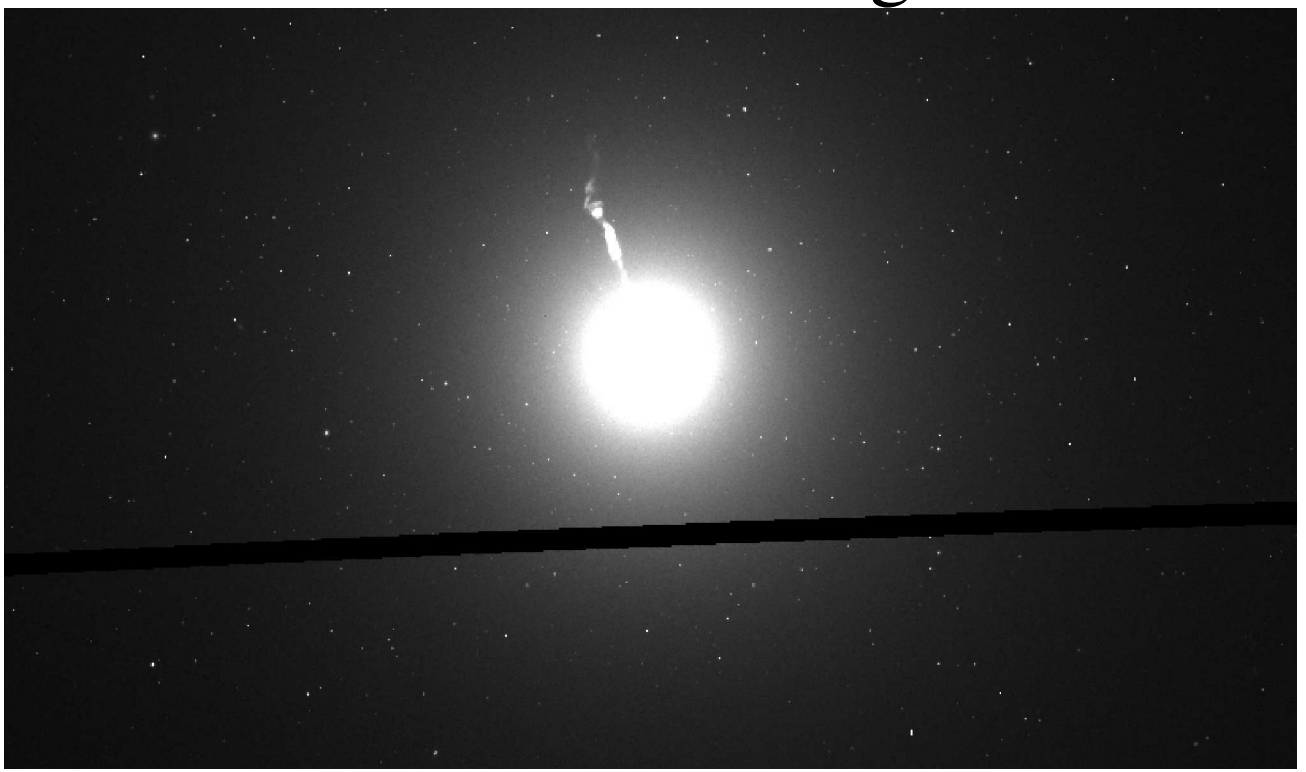
ACS Data Reduction

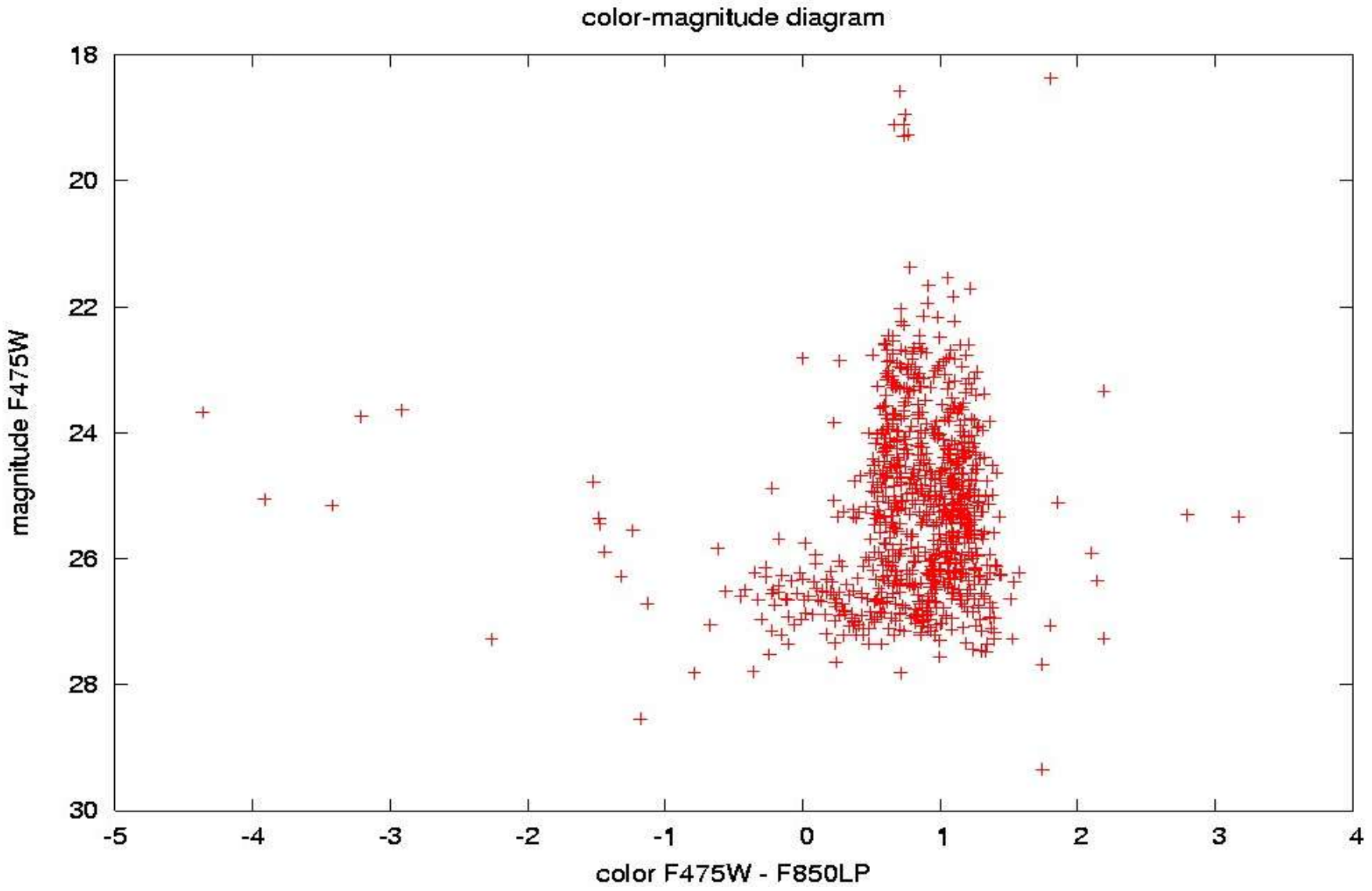
Multidrizzled F475 Image



Applied Reduction Steps:

- Multidrizzle files with Pyraf script multidrizzle (registering, cleaning, combining images);
- Extract all sources with Sextractor (minarea=9 pix, thresh=3 sigmas, photometric aperture diametre= 3 pix, gain=exposure time);
- Plots and cuts.

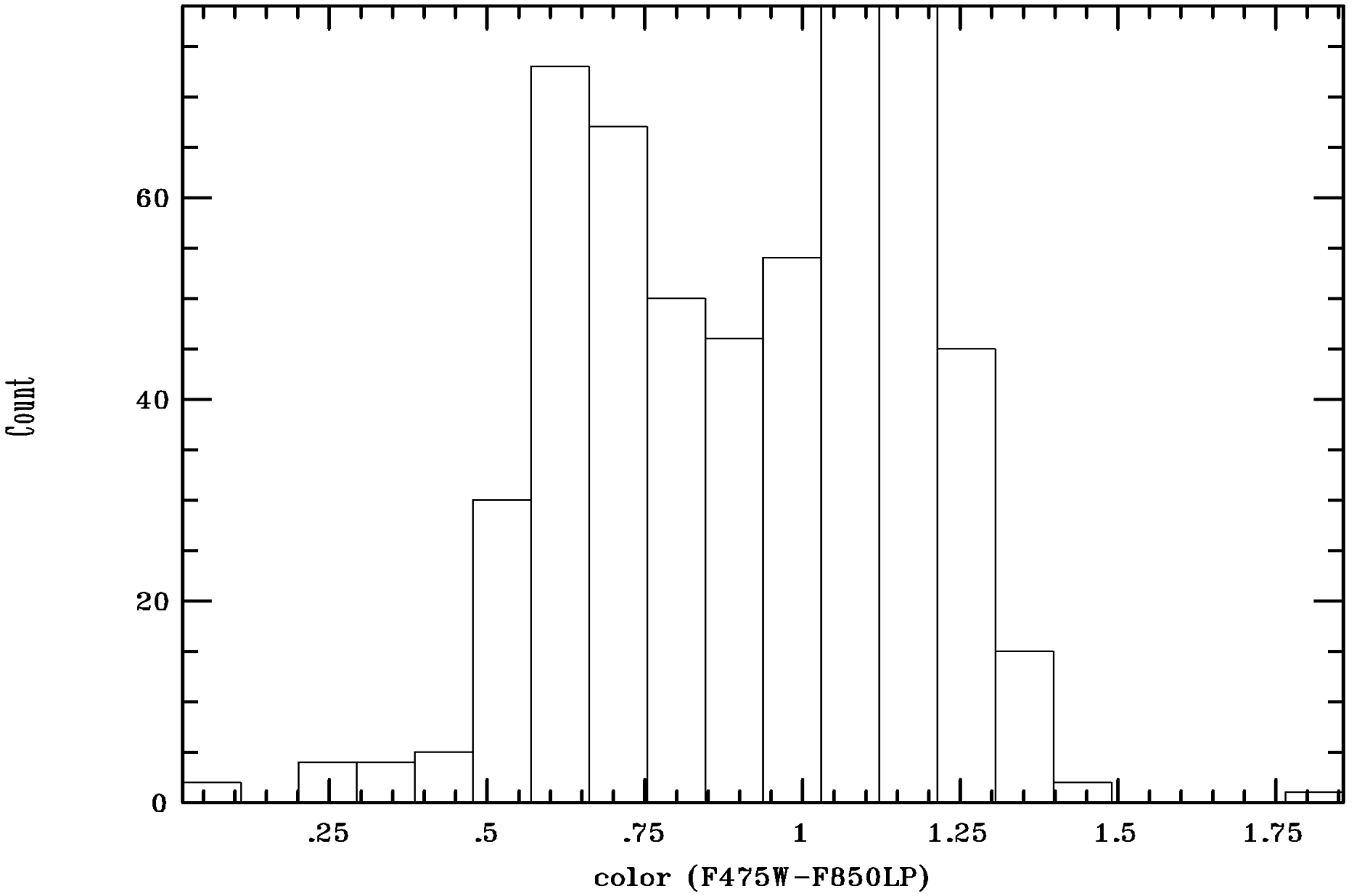
ACS Data Reduction



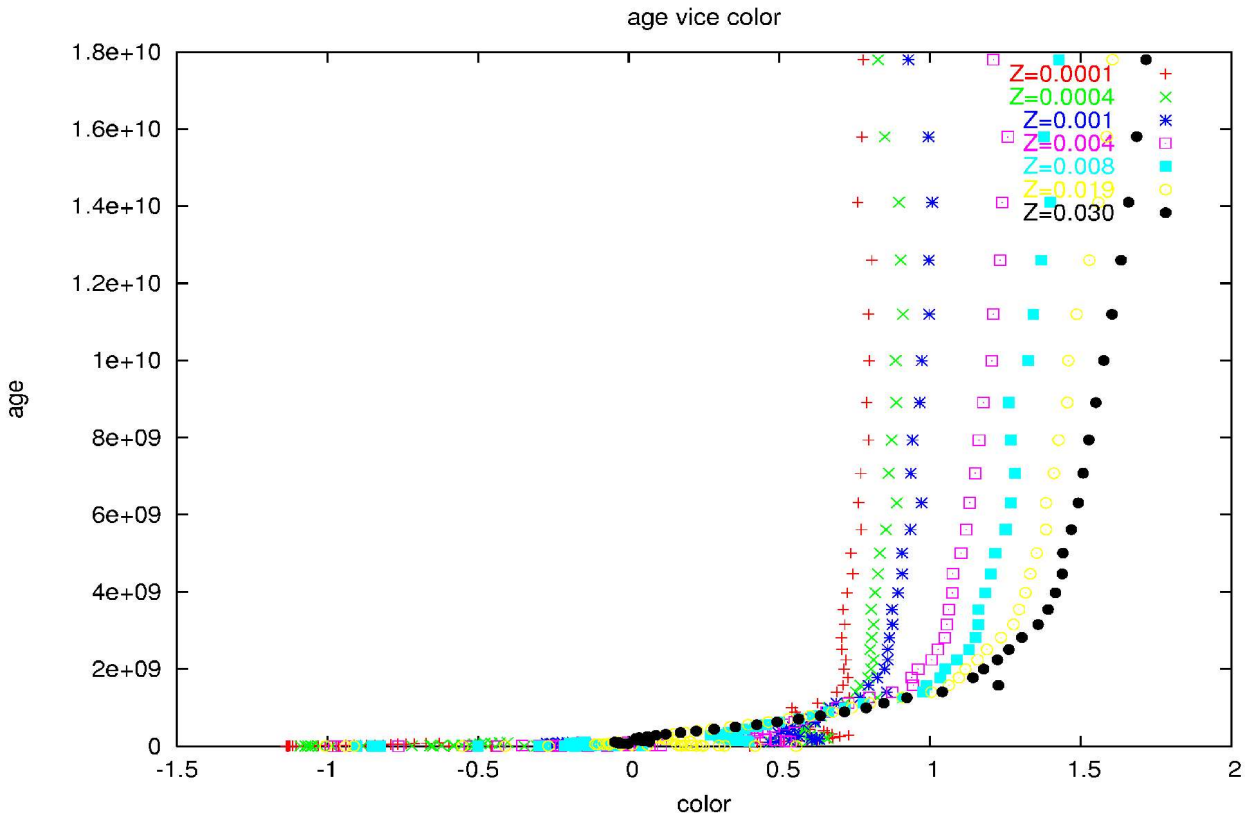
Correction for reddening law is applied.

ACS Data Reduction

Color histogram



ACS Data Reduction



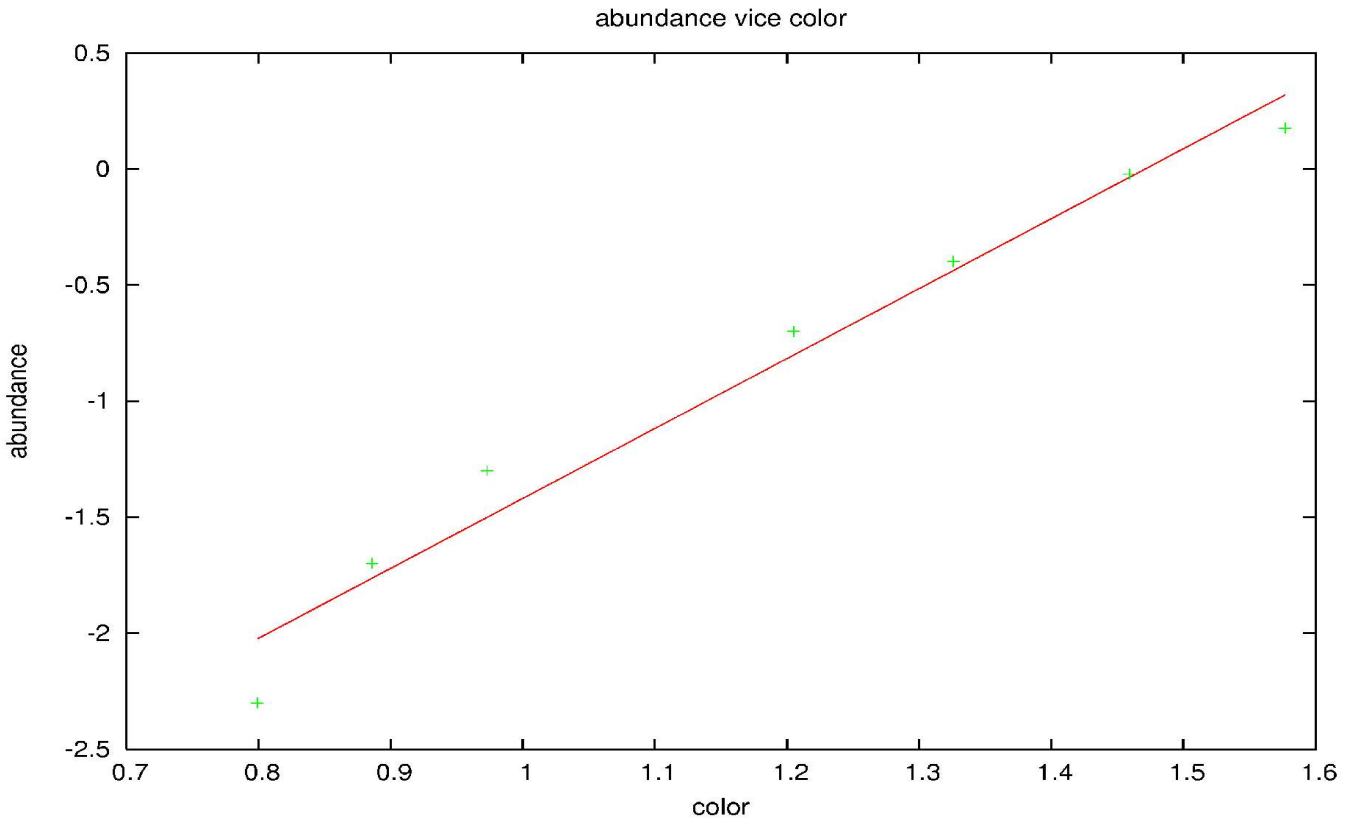
The color histogram lays mainly in interval of colors between 0.5 and 1.3. We have adopted age of 1e10 years.

Theoretical isochrones in the HST/WFPC2 Abmag system were taken from *http://pleiadi.pd.astro.it/*

ACS Data Reduction

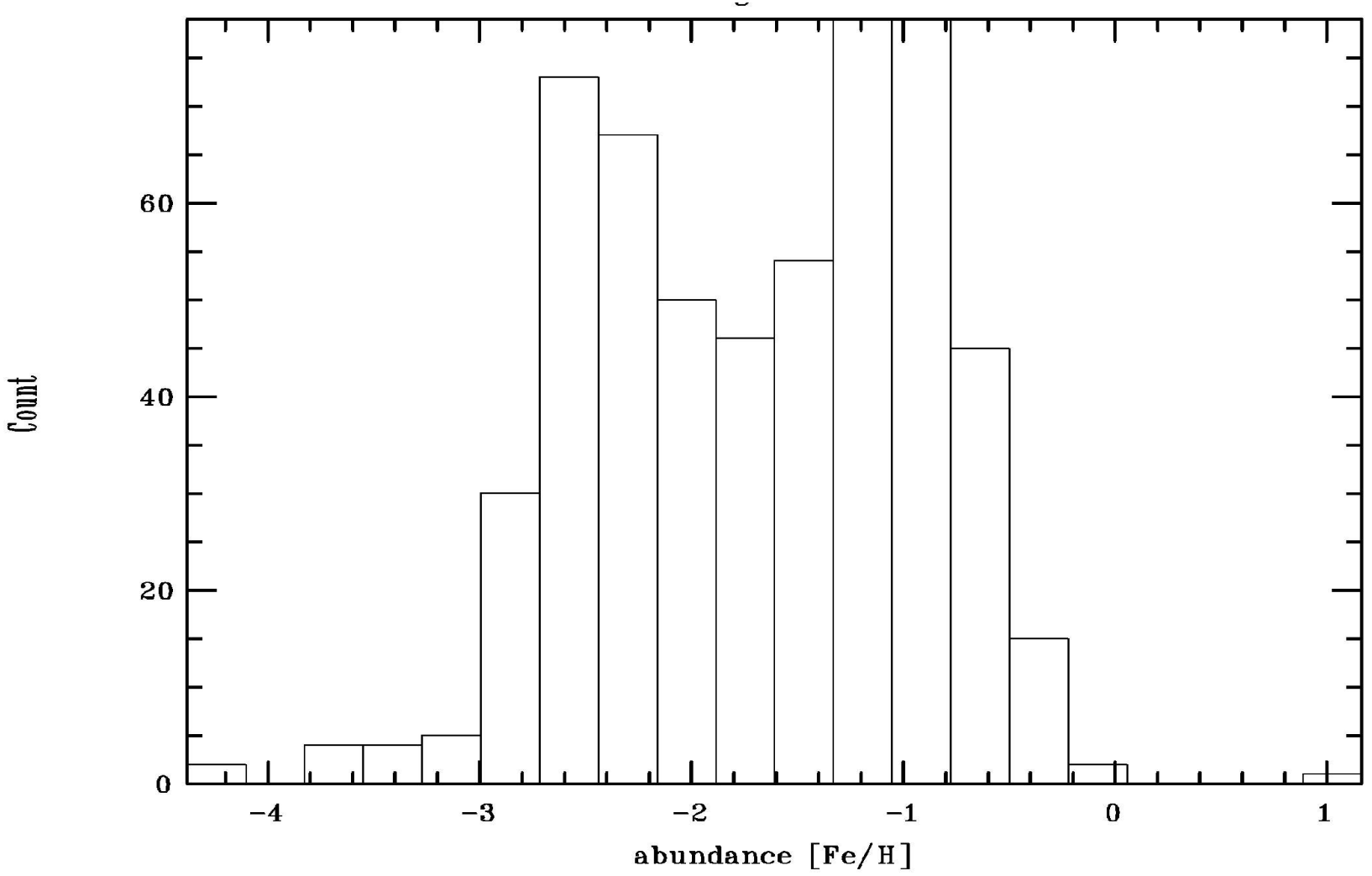
Abundance=[Fe/H]=$\log_{10}$ (Z/Z_{sun})

The plot is for age of 1e10 years.



ACS Data Reduction

Abundance histogram



Bimodal distribution of abundances!

Wide Field Planetary Camera 2 - WFPC2

[wif-pik]

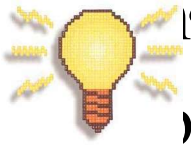
study of radial trends in the properties of the M87

data from the ESO/ST-ECF archive

need to cover a range of distances from the M87

<=> 30 arcmin search box

=> lot of data returned from search...



"mmm 6844 is particularly interesting for our purpose..."

-- Søren

we got observations at 1.7, 2.3, 8.0, 12.0, 15.0 arcmin...

and a gap at a radius ~ 4 arcmin... would be nice to have also that

"also of interest may be data from prog.7274..."

-- Søren

WFPC2 – Detector, Filters

F555W – 5252A, 1222.5A ~ Johnson V
F814W – 8269A, 1758.0A ~ Cousins I

4 CCD chips, each 800 x 800 pixels
Planetary Camera (PC) chip and 3 Wide Field (WF) chips
PC chip scale: 0.04555 arcsec per pixel
WF chip scale: 0.1 arcsec per pixel

Data format

GEIS images provided by the archive pipeline
wfpc2 associations - “un-biased”, “flat-fielded”, combined
(!!!)
not directly readable by iraf => conversion to the iraf format
each file contains 4 extensions (4 chips) => 1PC .fits & 3WF .fits
observations at 7 different radii, 2 filters per radius,
3 .fits files per filter...

= 42 .fits files in total

Scripts!

Reductions and Photometry

all images have been registered, shifted and cut

photometric zero points VEGAMAG system

Photometry with Sextractor:
not that complicated, fast, flexible, dual image mode

Aperture size of 5pix for photometry

Detection threshold of 4

Contamination

Need to take care of contamination by background galaxies and stars. We used the Hubble Deep Field to estimate contamination by galaxies and stars.

We had slightly different filters: F606w instead of F555w.

Color histograms

a histogram per radius from the M87 center
(histograms at 1.7, 2.3, 4.3, 8.0, 10.0, 12.0, 15.0 arcmins)

Conclusions

ACS compared with WFPC2

ACS --> 50 milli arcsec/pixel
WFPC --> 100 milli arcsec/pixel

Comparing data M87 with data Milkyway

('The Globular Cluster System of the Galaxy. IV. The halo and disk subsystem ' by Robert Zinn)

- Luminosity function
- Abundance
- Number of Globular Clusters

Luminosity Function

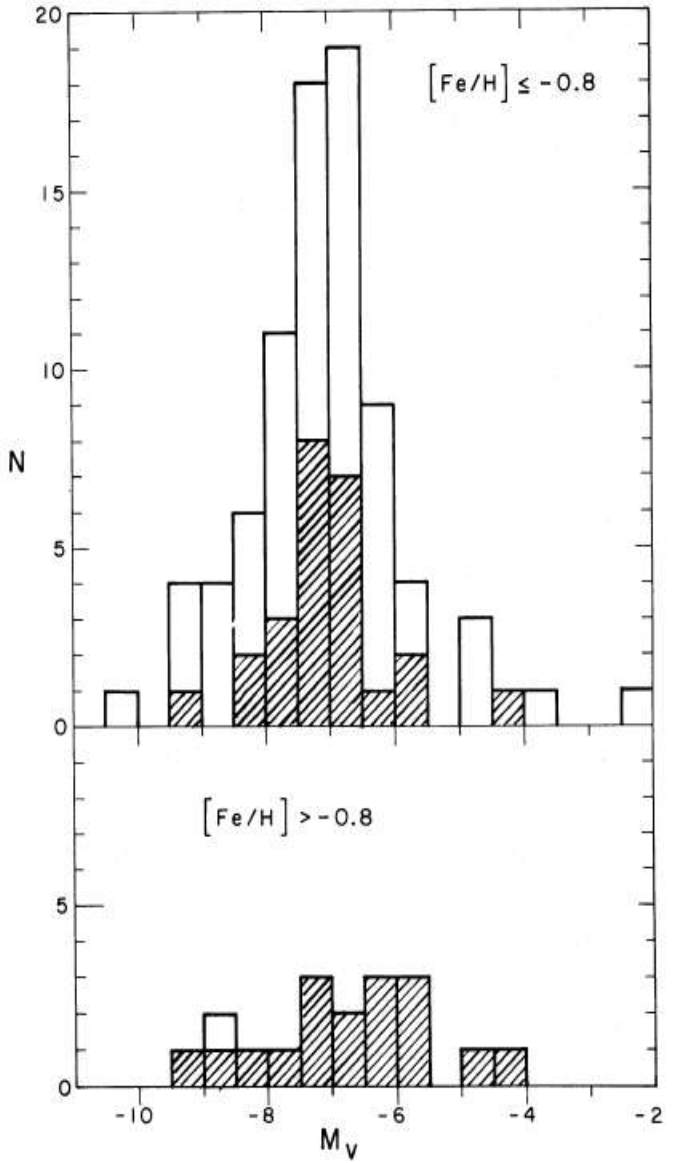
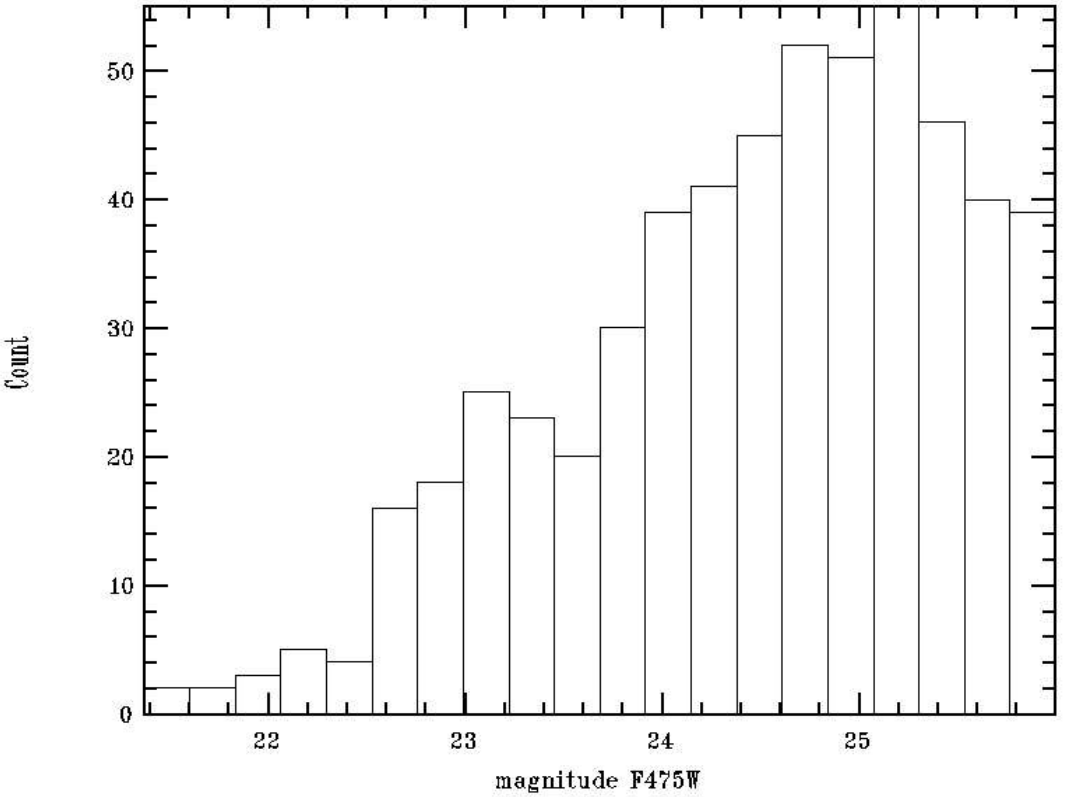


FIG. 10.—The luminosity functions of the halo (*top*) and disk (*bottom*) clusters. The shaded histograms are the luminosity functions of the clusters that have $|b| < 11°$.



$M_{V(M87)} = M_V + 5\log(d/10pc) \sim 24$ mag

d = 15 Mpc

F475W bluer than Mv --> fainter

No aperture correction performed!

Abundances

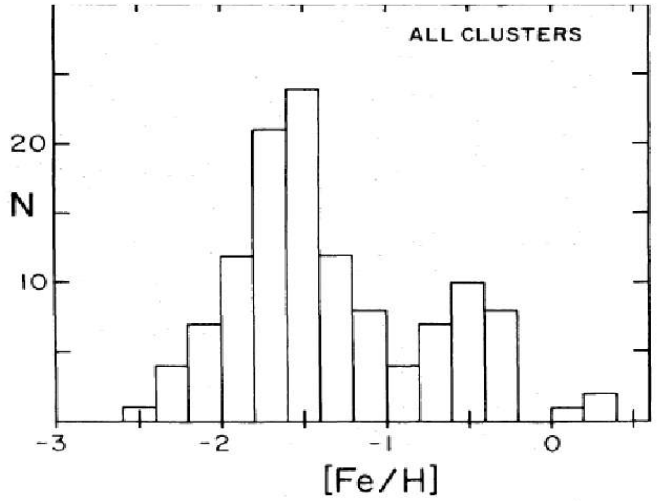
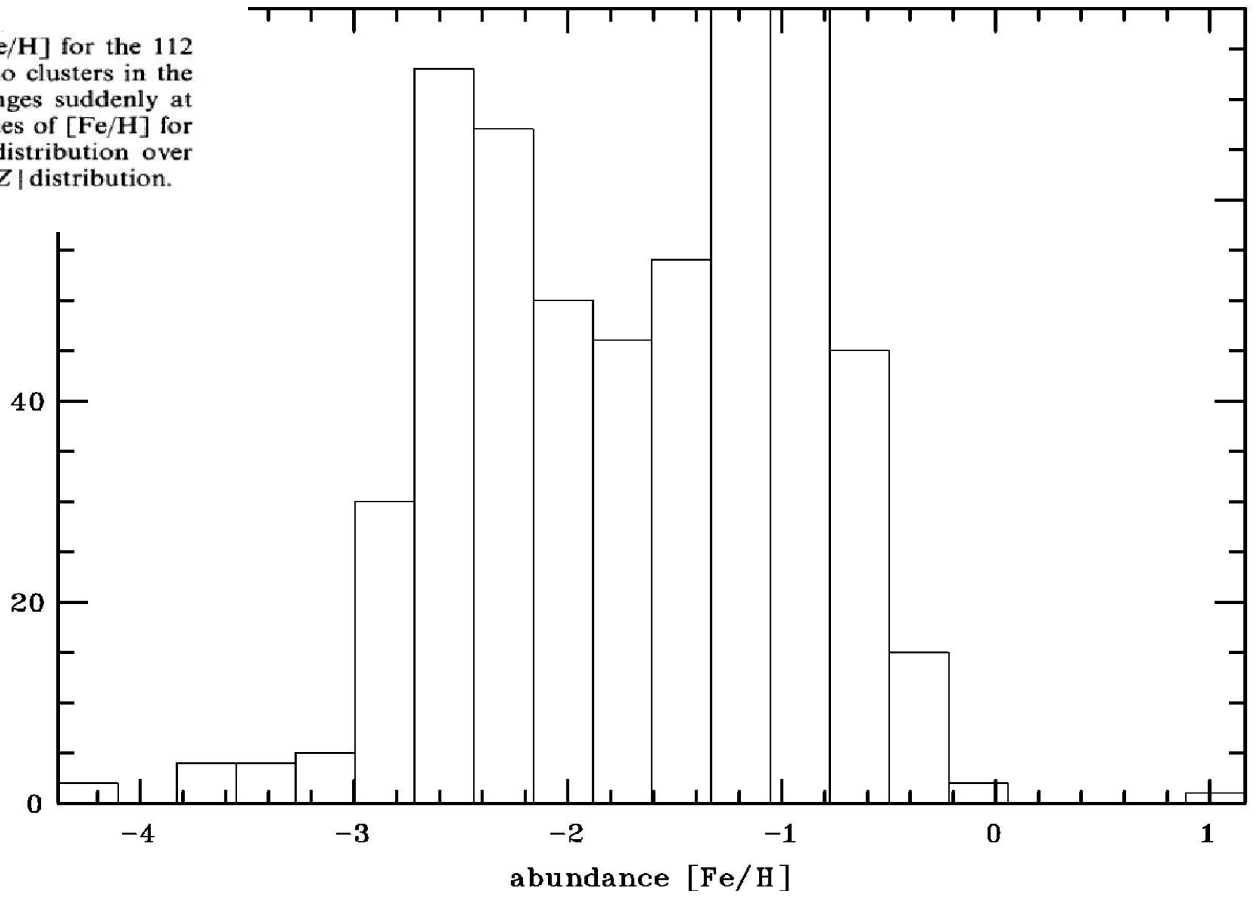


FIG. 1.—In the upper diagram, $|Z|$ is plotted against [Fe/H] for the 112 globular clusters of known distance. Notice that there are no clusters in the zone $20 \lesssim |Z| \lesssim 37$ kpc and that the $|Z|$ distribution changes suddenly at [Fe/H] ≈ -1. The lower diagram is a histogram of the values of [Fe/H] for all 121 clusters in Table 1. Notice that the valley in the distribution over [Fe/H] occurs at the same value as the sudden change in the $|Z|$ distribution.

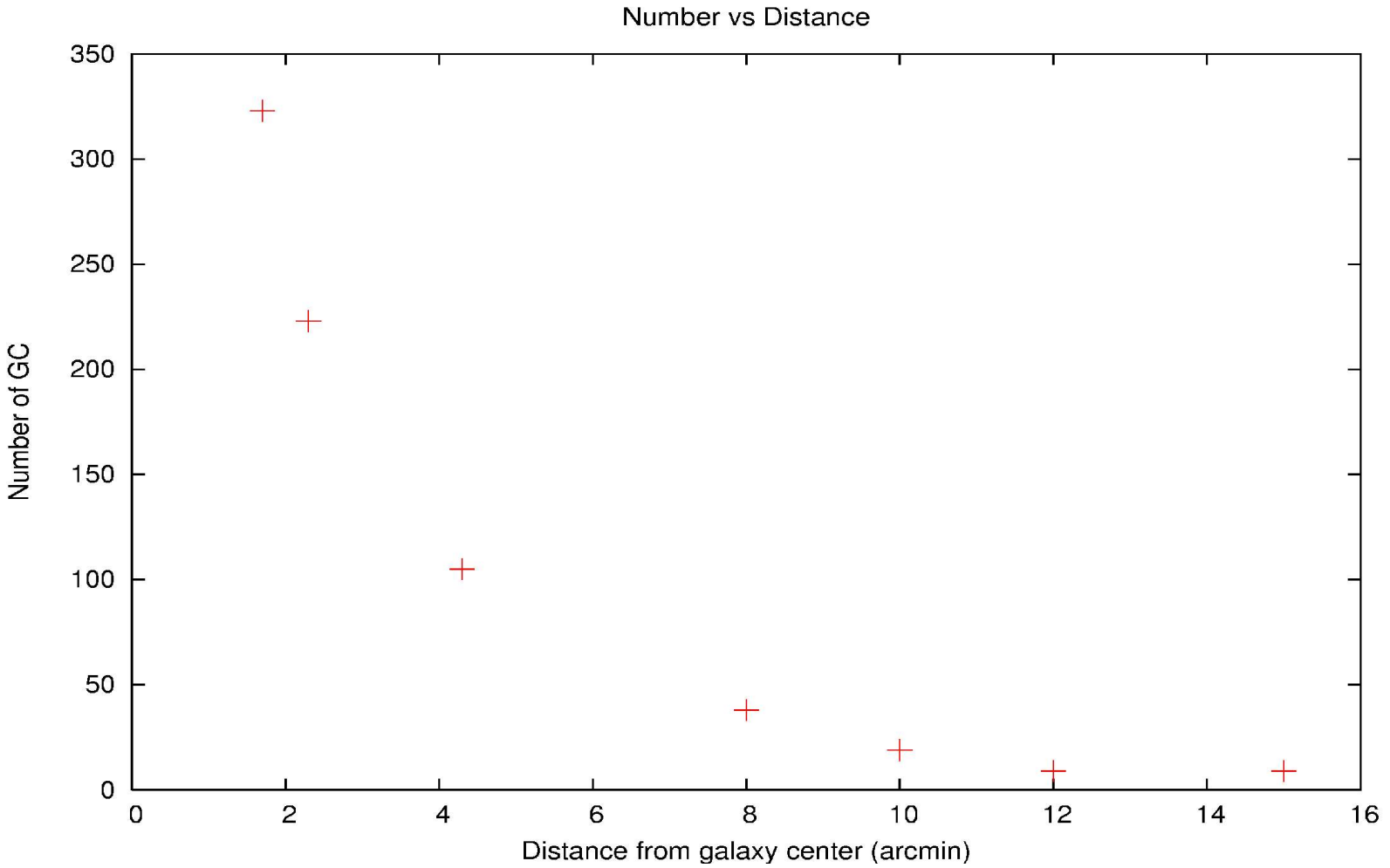
<-- more metal poor GCs
in Milky Way

more metal rich GCs
in M87
-->



Number of Globular Clusters in M87

Milky Way --> ~150 Globular Clusters
M87 --> ~ 1282 Globular Clusters (~556 ACS, ~726 WFPC2)
in the small FOVs considered



Further Research

- Total Number of Globular Clusters in M87 (per cubic kpc)
- Divide between “blue” and “red” Globular Clusters
- Abundances at outer radii of M87
- More accurate isochrones (not accurate in the blue region)
- ACS data for the outer radii of M87