STAR FORMATION HISTORY FROM RESOLVED STARS IN GALAXIES UP TO VIRGO

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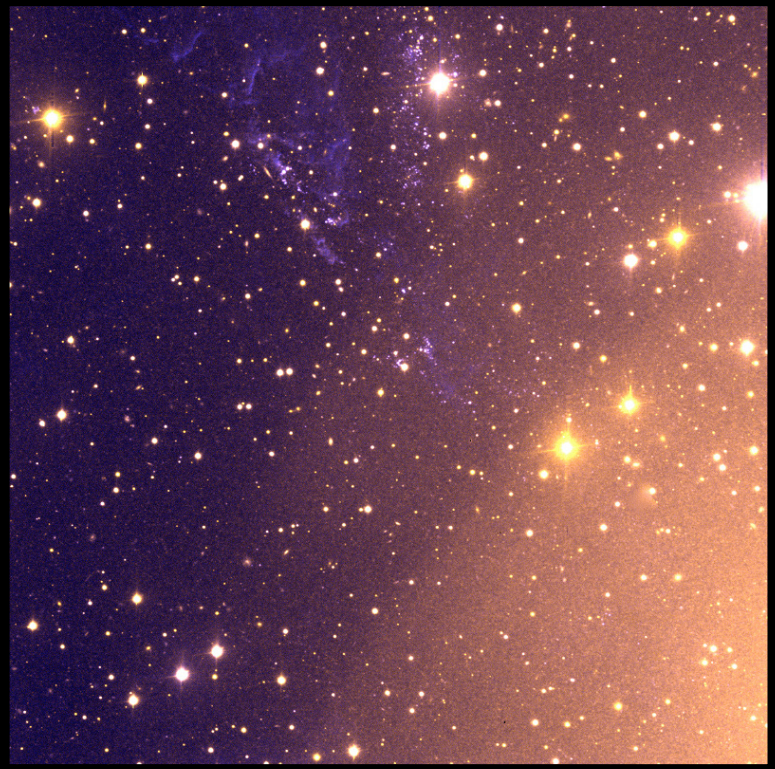
(INAF, OAPd & IASF-Mi)

Elliptical Galaxy Centaurus A

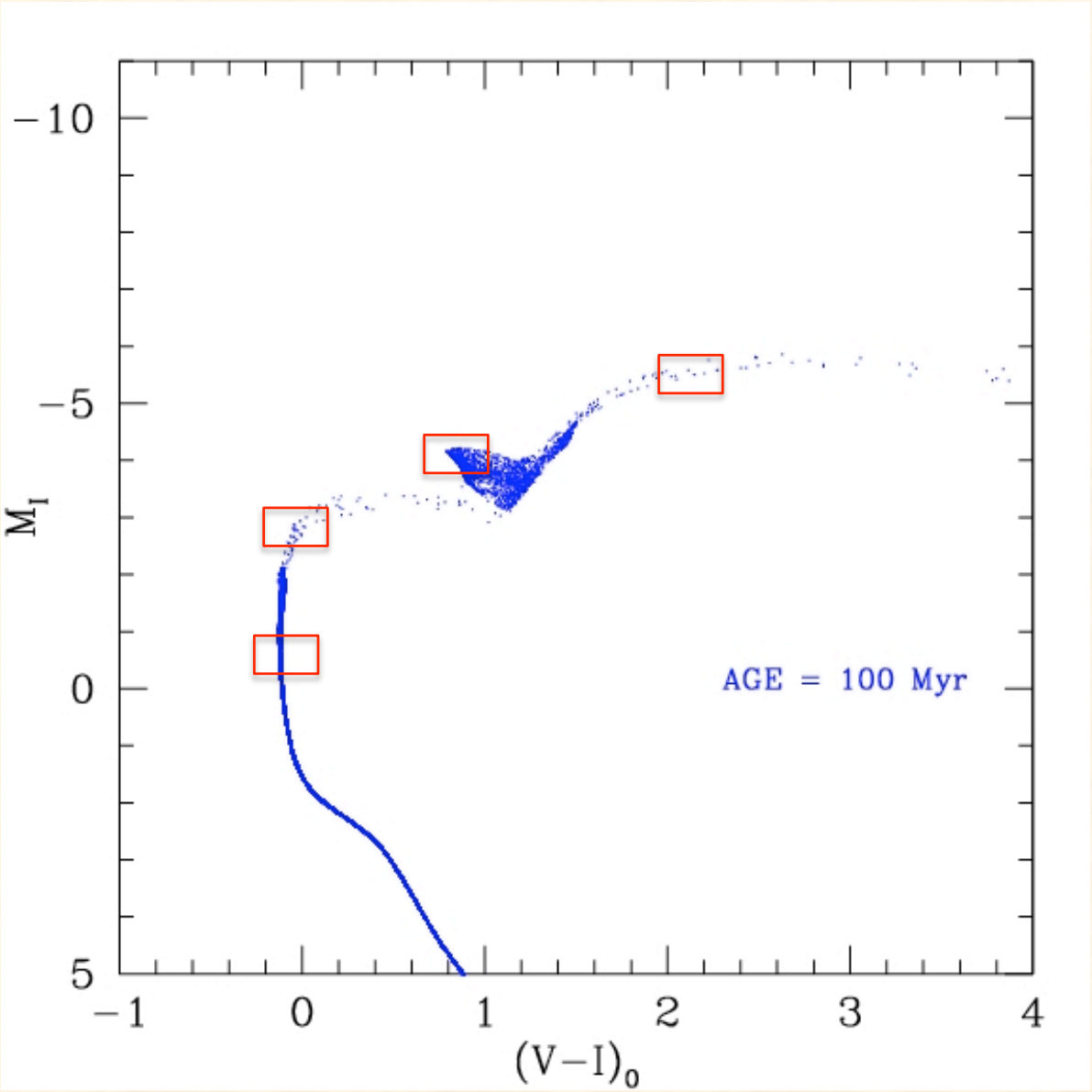


ESO for the Public

Dwarf Irregular Galaxy NGC 1705

Hubble Heritage

THE SPECIFIC PRODUCTION

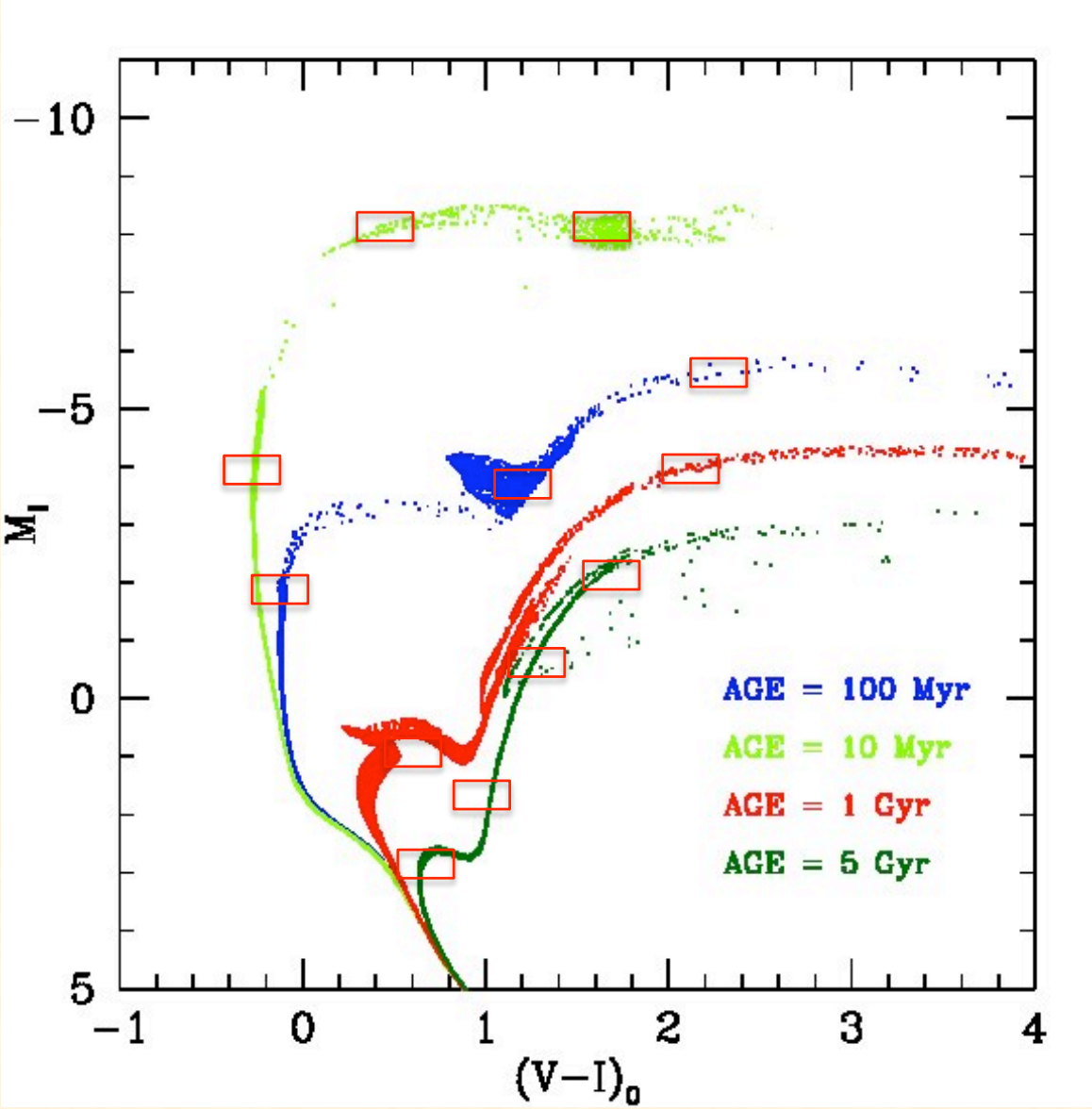


Based on proportionality between star counts in boxes on the CMD and the total mass of the parent Stellar Population

$$\Delta n_j = \delta n_j \times M_{SP}$$

SPECIFIC PRODUCTION
of stars in box *j*
(from this isochrone)
known from stellar evolution
+ IMF choice
it varies along the isochrone
According to evolutionary lifetimes

THE SPECIFIC PRODUCTIONS



Stellar evolution theory provides the specific productions for any isochrone

$$\delta n_j = f(age, comp.)$$

star counts along an isoch.

↓

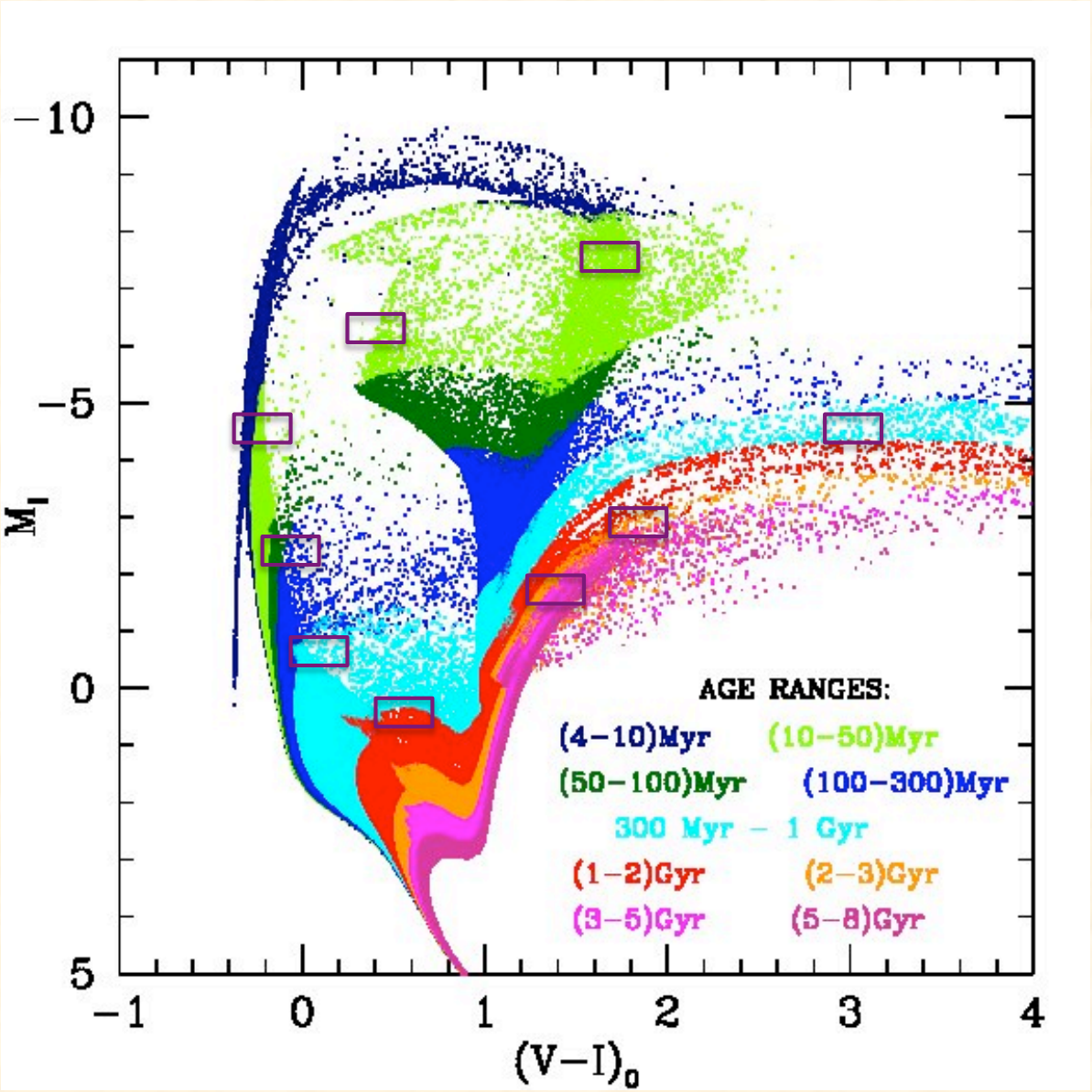
M_{SP} @ (age,comp.)

perfom the exercise along different isochrones

↓

STAR FORMATION HISTORY

THE SYNTHETIC CMD METHOD



Minimize distance between the stellar density across the observed CMD and a model CMD

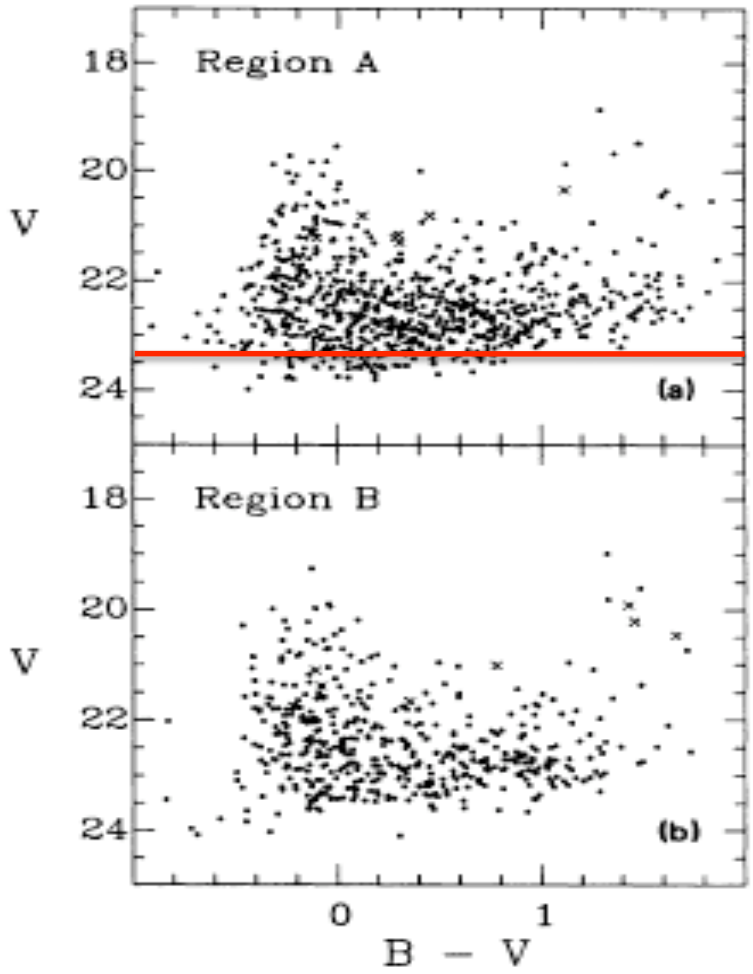
Different regions on the CMD have different diagnostic power

Best sensitivity to (old) ages is for MS Turn Off

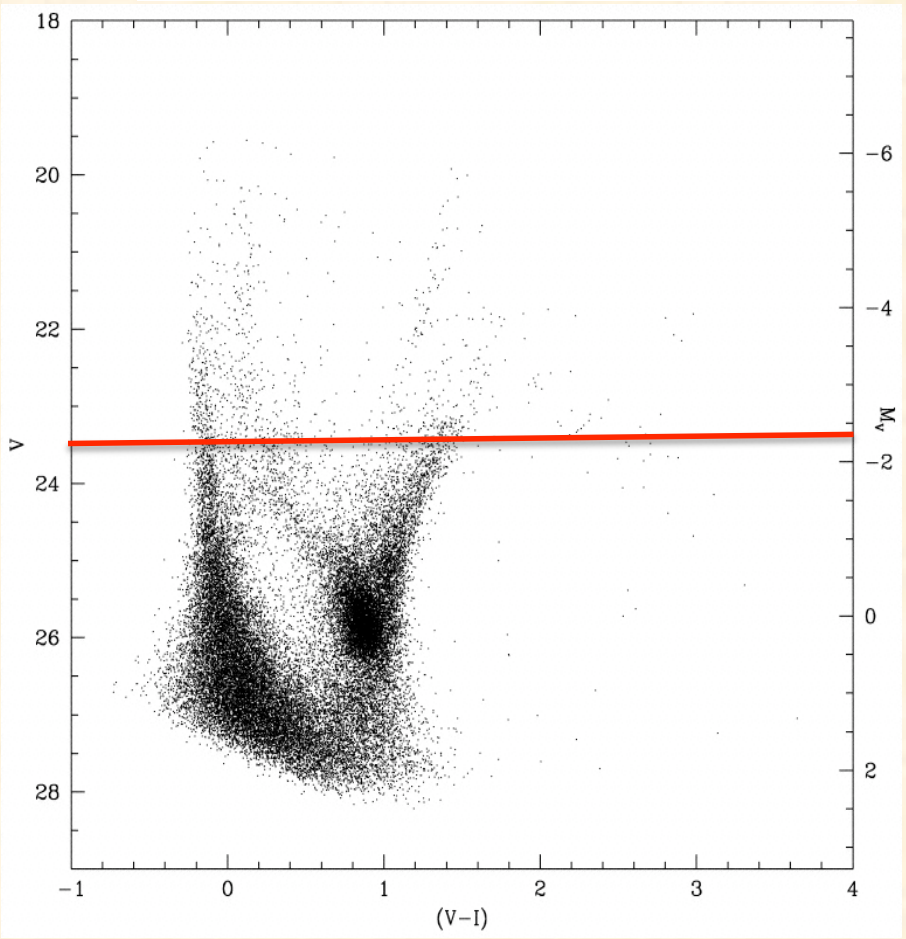
Boxes along the RGBs include a wide range of ages

A BIT OF HISTORY

Sextans B MOD=25.6
from Tosi et al. 1991
data from 2.2m ESO-MPI
t_{exp}= 2^h (B) 1^h (V)



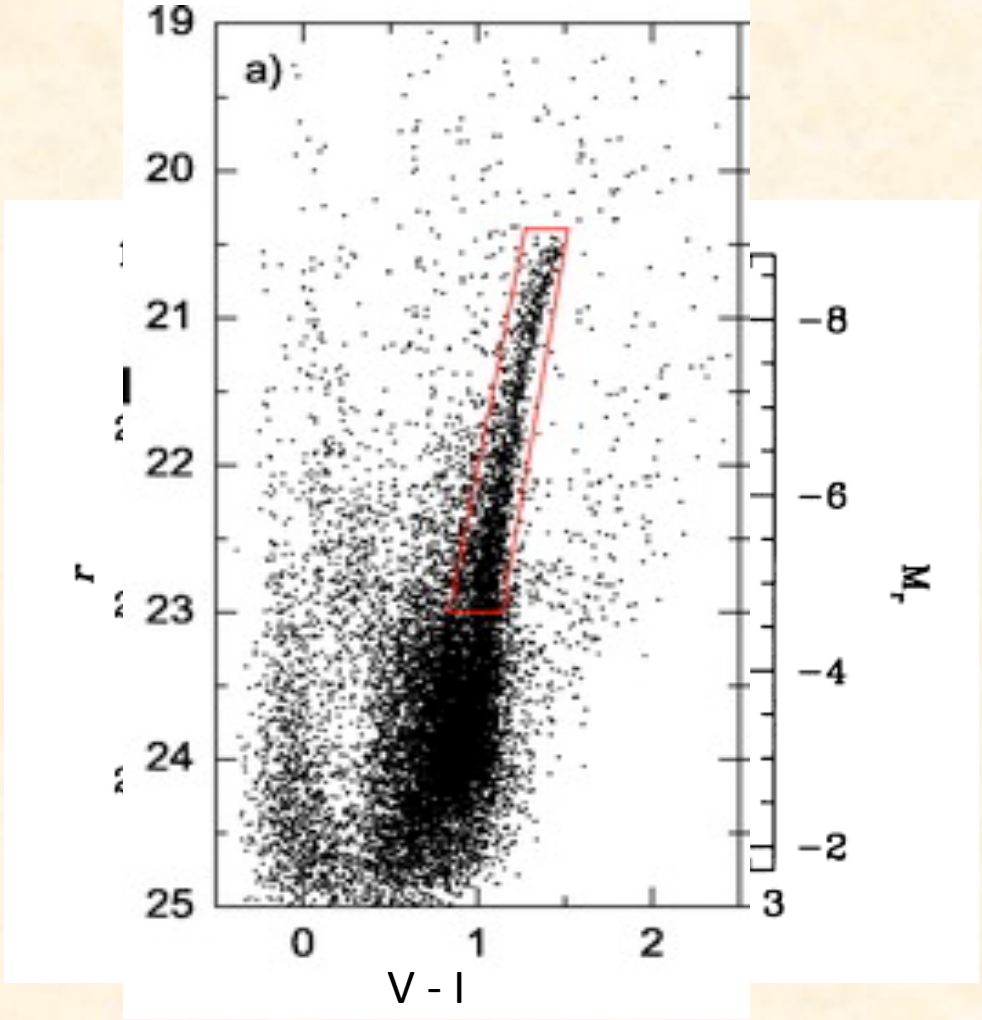
Sextans A MOD~25.6
from Dolphin et al. 2003
data from WFPC2@HST
t_{exp}~ 5^h (F555W) 11^h (F814W)



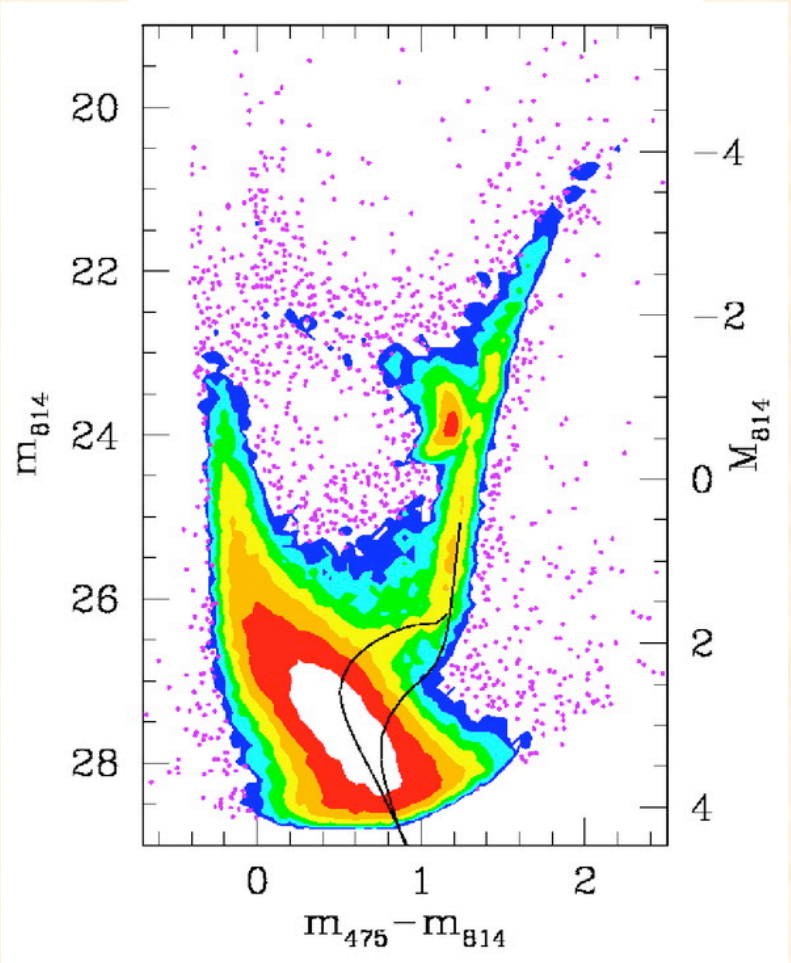
SAME GALAXY - DIFFERENT SET UPs

Leo A: a DIG @ Mod ~ 24.5

Vansevicius et al. 2004
Suprime-Cam @ SUBARU
t_{exp}= 50^m(B) 30^m(V)2^h(I)



Cole et al. 2007
ACS@HST
t_{exp}~ 5.3^h(F475) 5.4^h(F814)



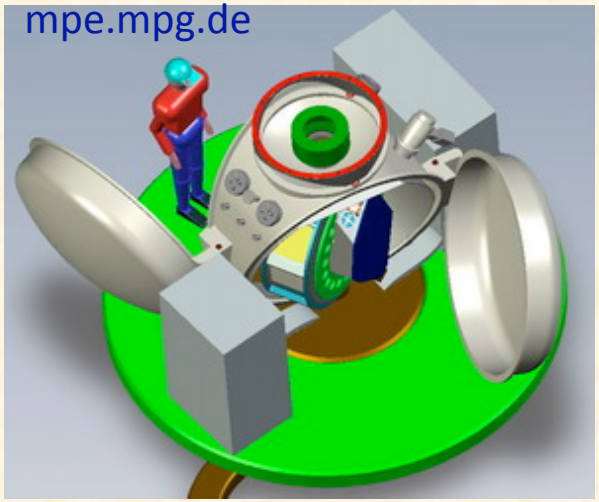
TO DERIVE THE SFH FROM THE CMD OF
RESOLVED STELLAR POPULATIONS
WE NEED

DEPTH & PHOTOMETRIC ACCURACY

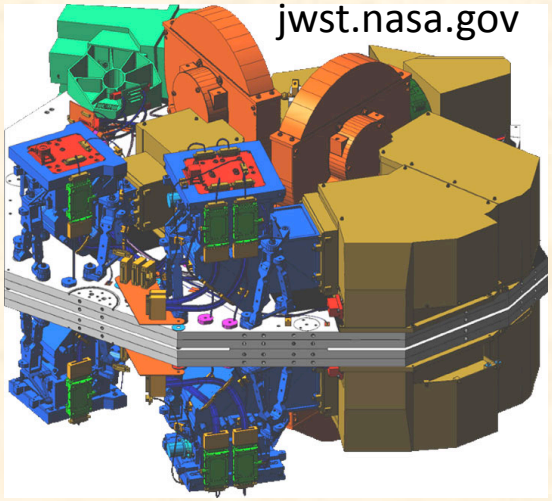
BOTH ARE CRUCIAL

PERSPECTIVES FOR ELT & JWST ARE EXTREMELY
INTERESTING BECAUSE OF THEIR LARGE
COLLECTING AREAS AND HIGH RESOLUTION

MICADO @ E-ELT



NIRcam @ JWST



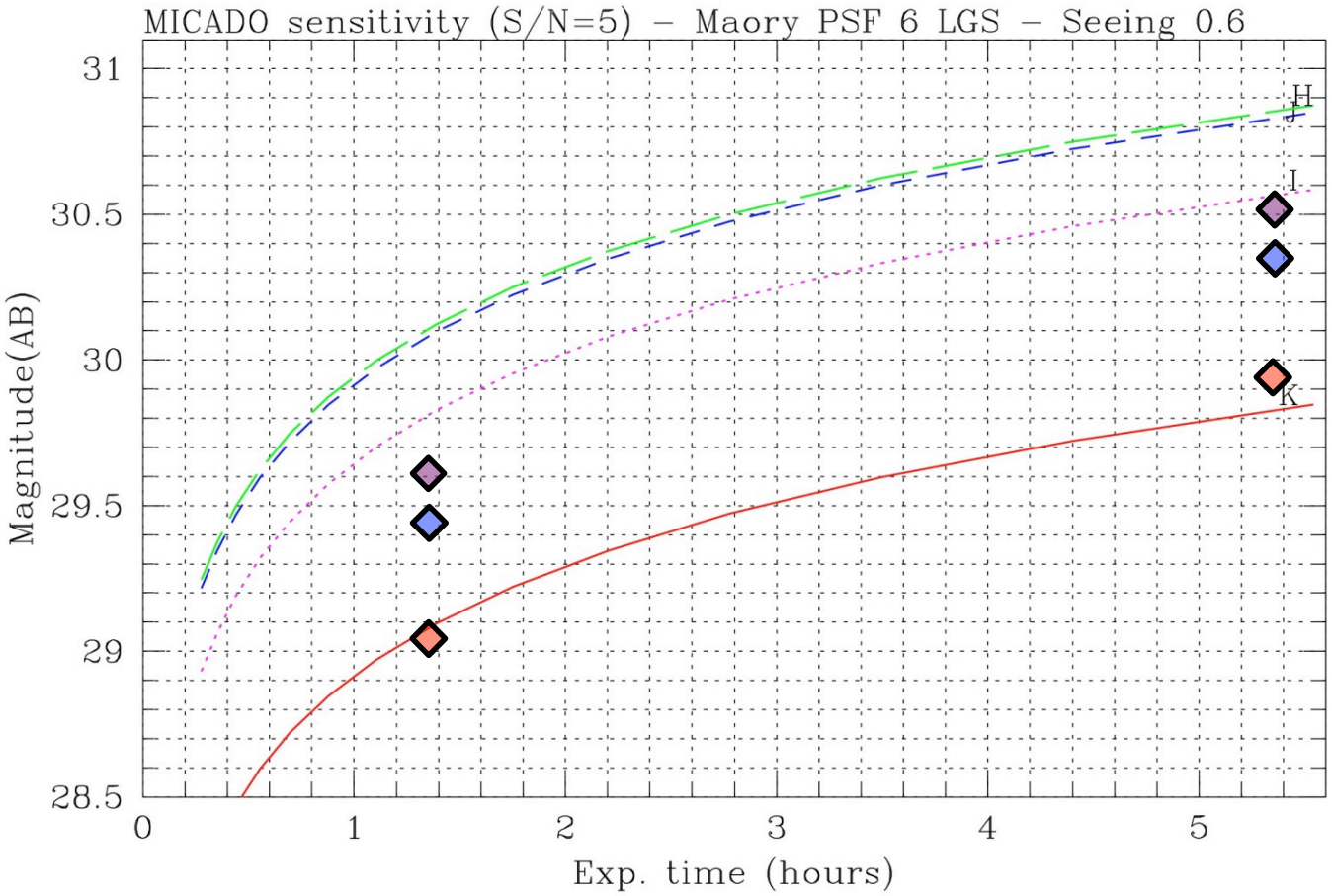
+ MAORY

BACKGROUND AB MAGS @ 2.1 μm	~ 15	~ 23
PIXEL SCALE	~ 3 mas	~ 32 mas
SPATIAL RESOLUTION (FWHM, mas) @ 2.1 μm	~ 10 mas	~ 90 mas
FIELD OF VIEW	53” x 53”	2’.2 x 2’.2

DEPTH

Sensitivity: imaging

Isolated Point Sources to 5σ

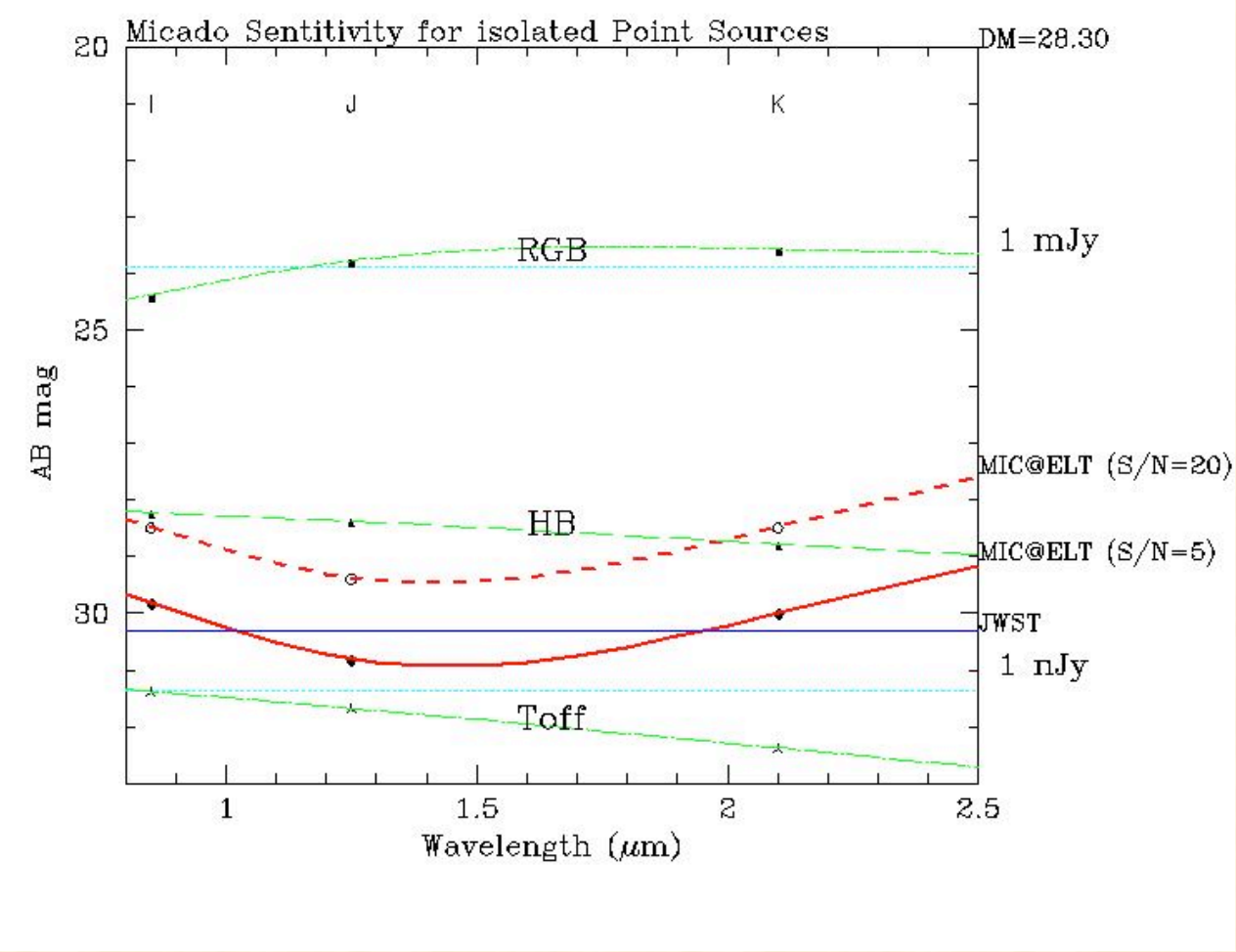


- JWST in J-band
- JWST in I-band
- JWST in K-band

5hrs, 5σ	J_{AB}	H_{AB}	K_{AB}
Imaging	30.8	30.8	29.8
Imaging with advanced filters	31.3	31.3	30.1

SFH TRACERS

Reasonable exposure: 5 hours integration Reasonable S/N : 5 - 10



We can measure:

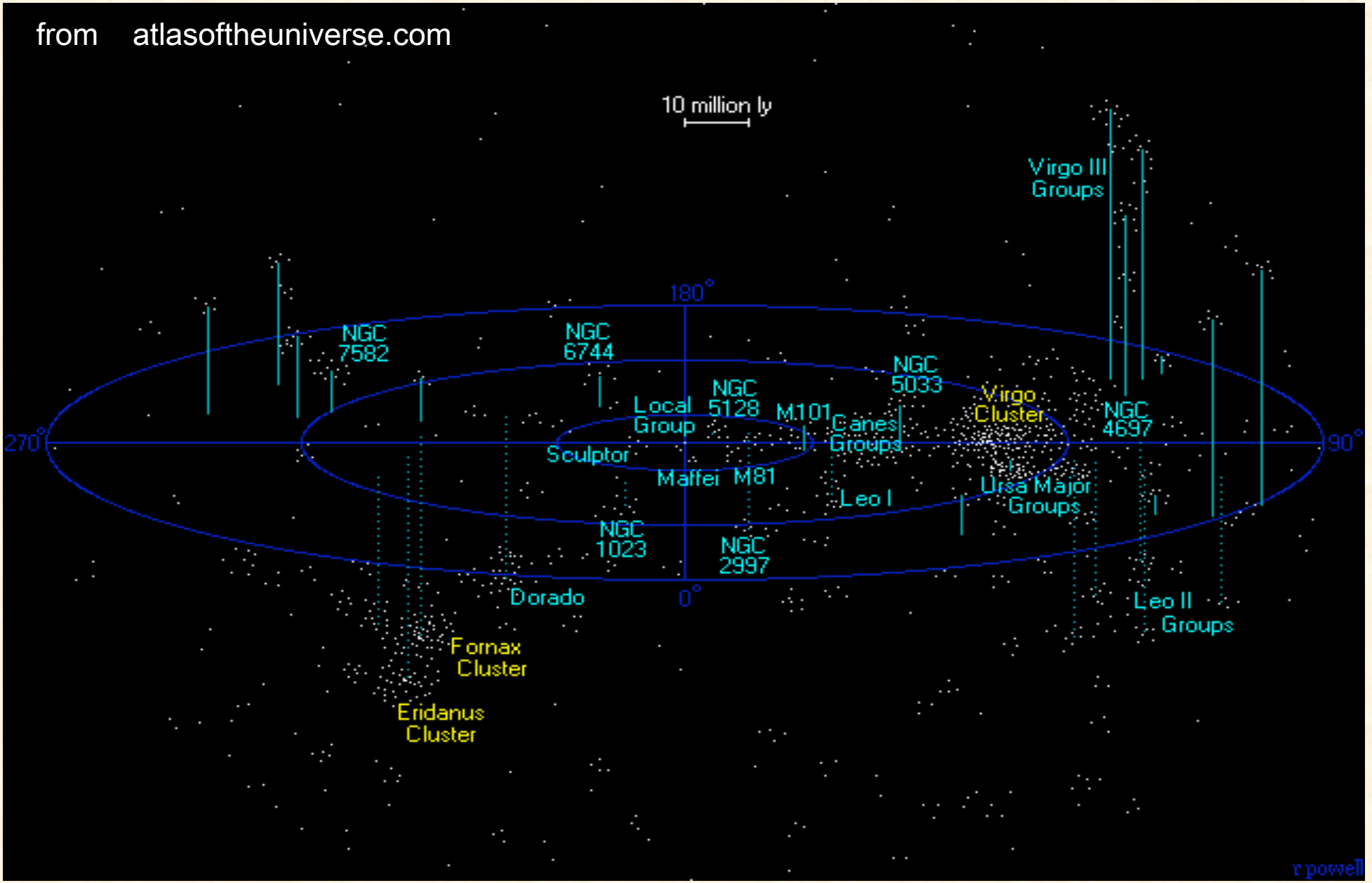
OLD (~ 10 G) MS Tos
up to MOD=26.5

RED HBs
up to MOD = 30

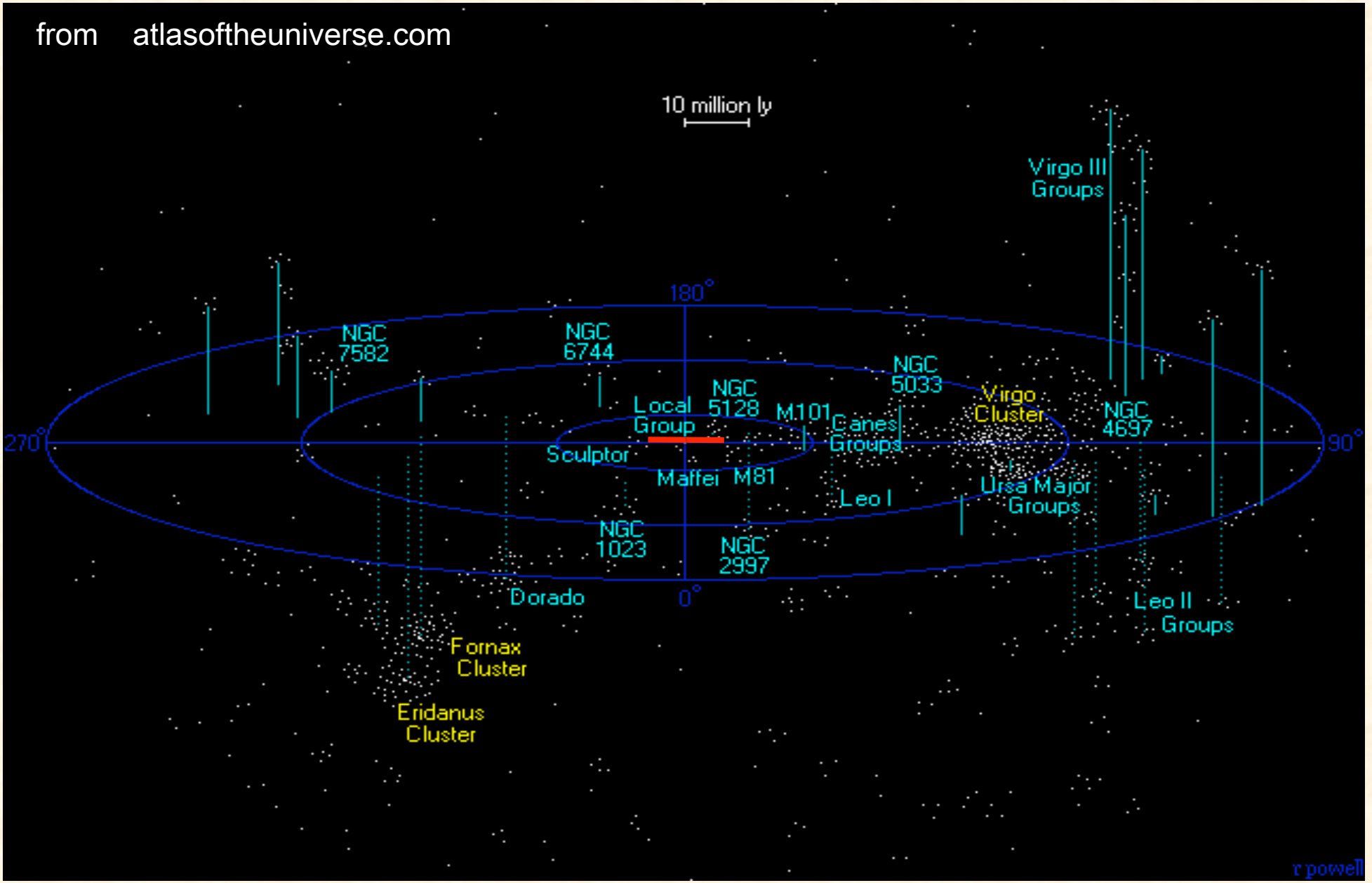
RR Lyraes
up to MOD = 27.5

Upper RGB stars
up to MOD = 32.5

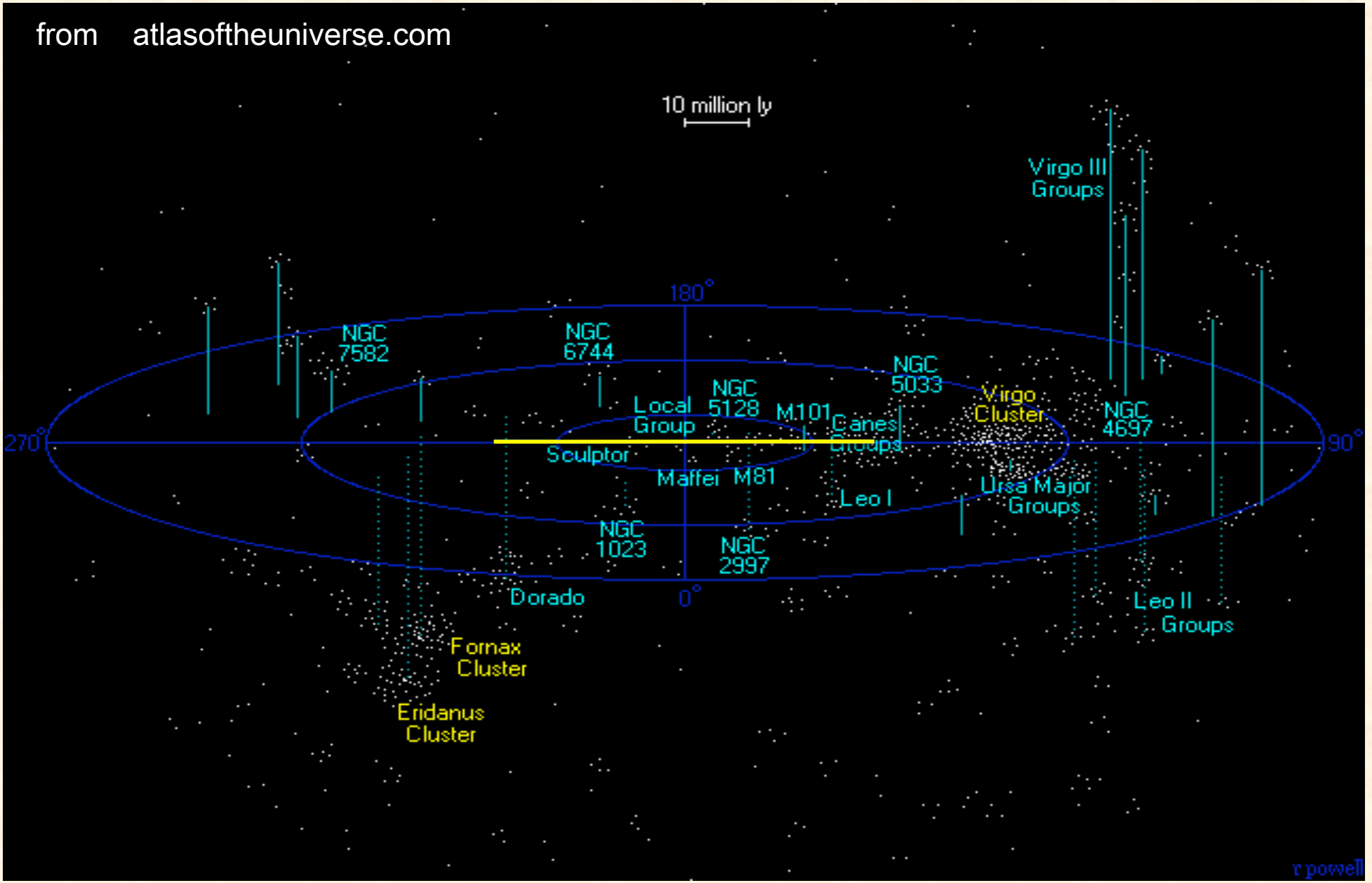
THE GALAXIES AROUND US



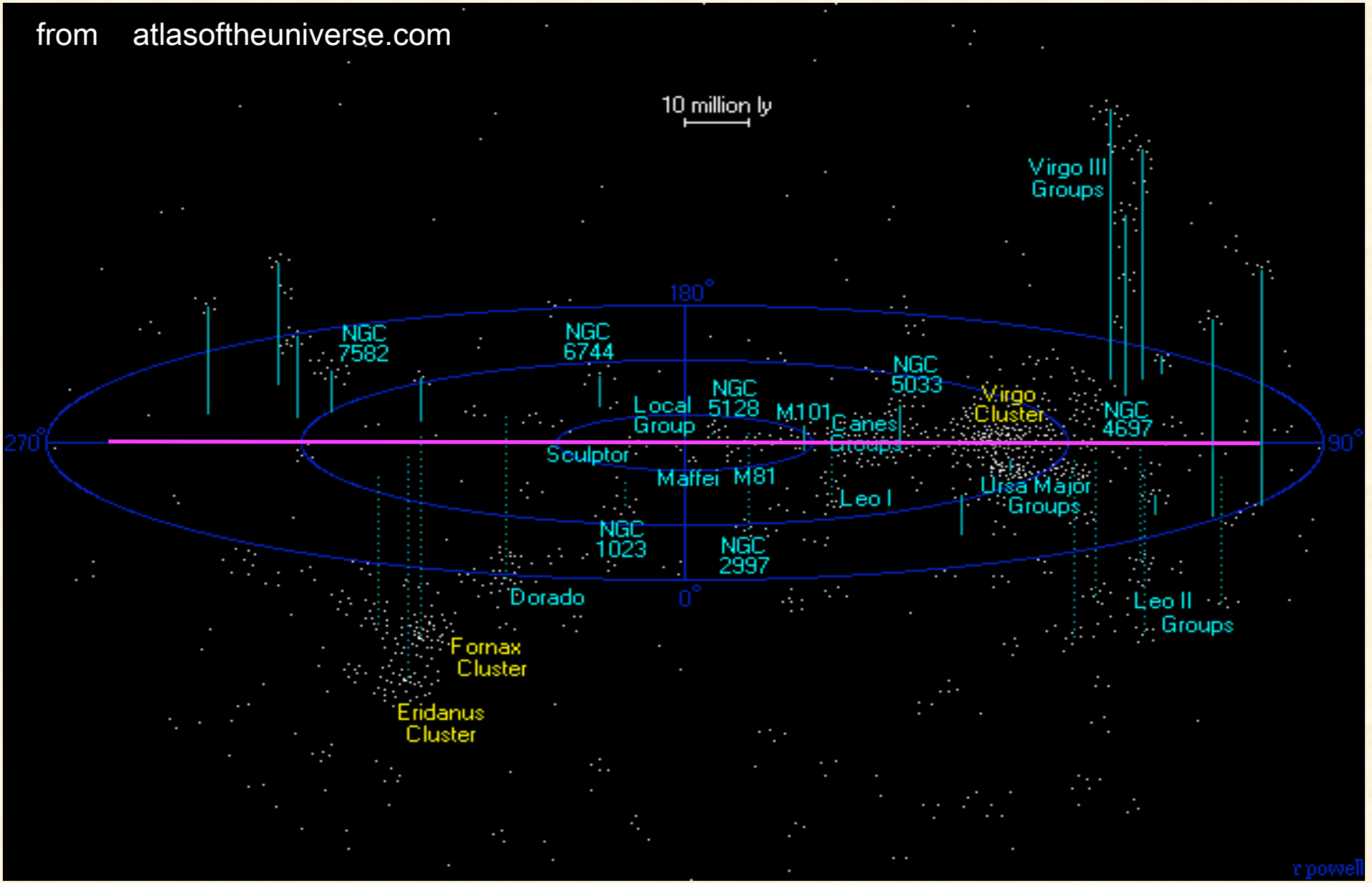
THE GALAXIES AROUND US



THE GALAXIES AROUND US



THE GALAXIES AROUND US

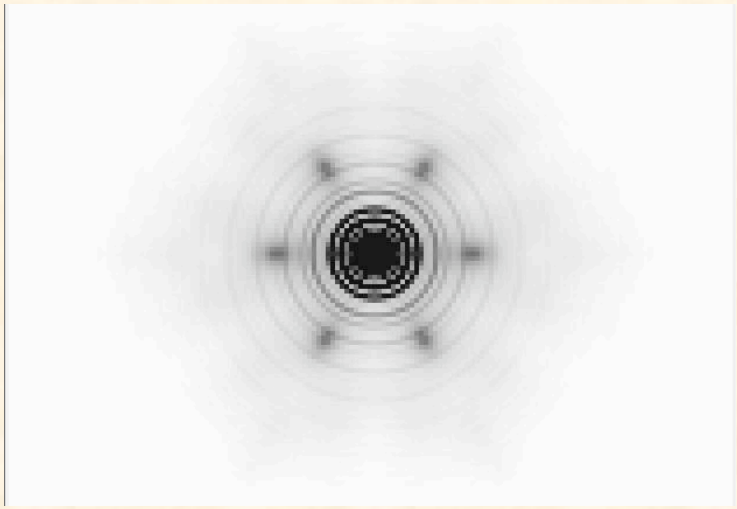


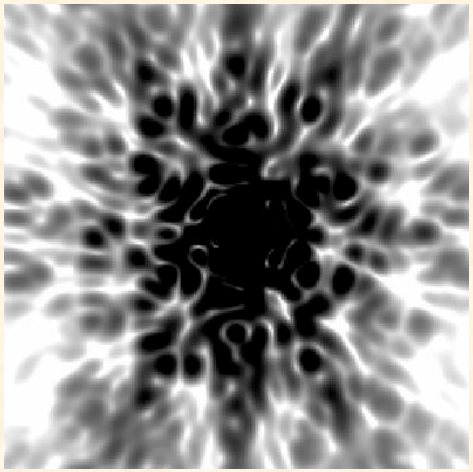
Photometric Accuracy

In crowded fields photometry is affected by blending and incompleteness

limiting magnitudes will be brighter
S/N at given magnitude will be lower

Photometry performed via PSF fitting: the narrower the PSF the easier for the package to recognize stars, and measure them





TWO SPECIFIC SCIENCE CASES

- A DISK GALAXY IN THE CENTAURUS GROUP

  MOD = 28.3 5 hr EXPOSURE IN I J K

  DERIVE THE STAR FORMATION HISTORY

W. Keel, KPNO,4m Mayall Telescope

- AN ELLIPTICAL GALAXY IN THE VIRGO CLUSTER

  MOD = 31.3 5 hr EXPOSURE IN I J K

  DETERMINE THE METALLICITY DISTRIBUTION OF THE STARS

J.C. Cuillandre, Hawaiian Starlight, CFHT

Advanced Exposure Time Calculator

M_{GAL} MOD
R_e r/R_e FoV

INPUT
STELL. POP.

MODEL
STELL. POP.
SAMPLED by the FoV

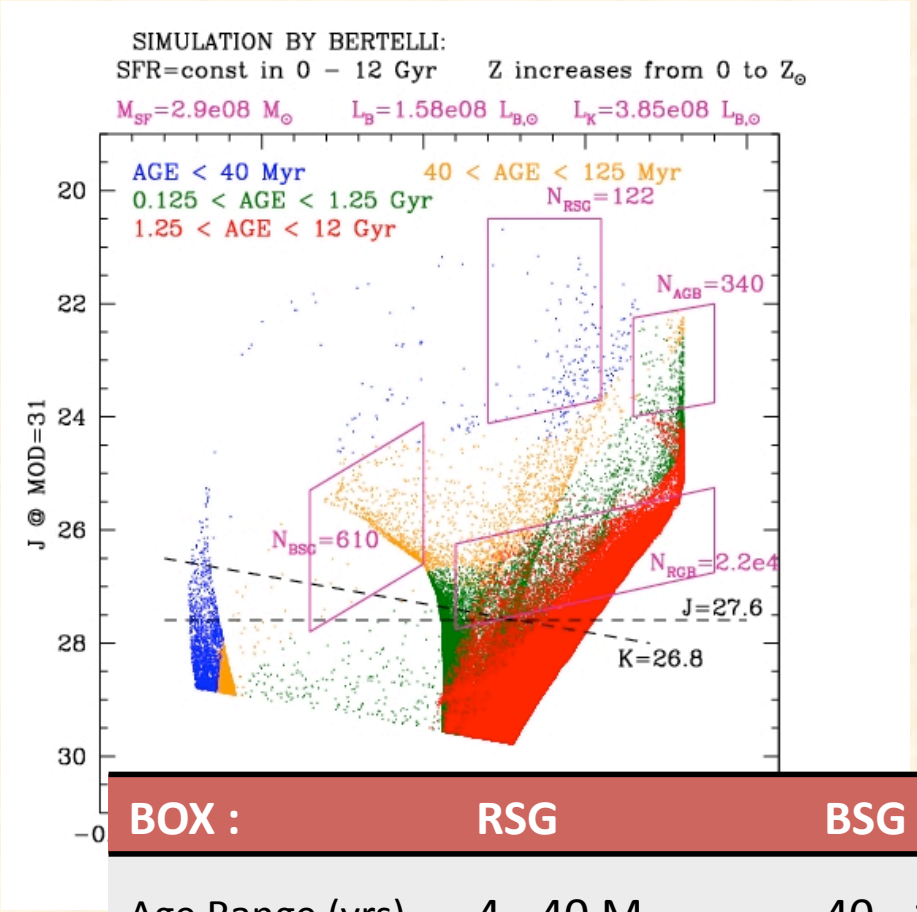
OBSERVAT.
SET UP

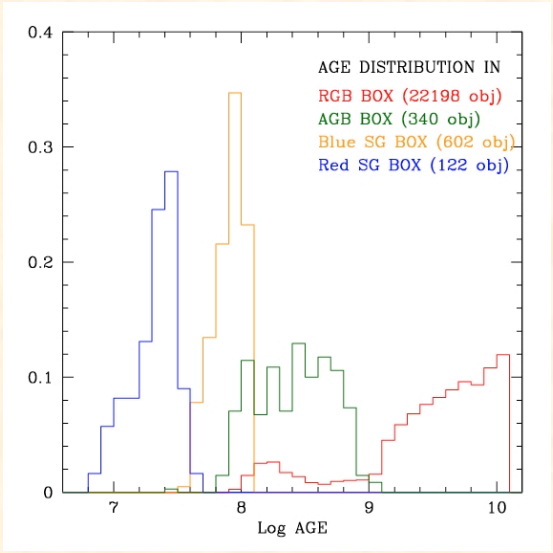
SYNTHETIC FRAMES
(I J H K)

DATA REDUCTION
(DAOPHOT)

COMPARISON
INPUT – OUTPUT
MAGS

STAR FORMATION HISTORY IN DISK GALAXIES



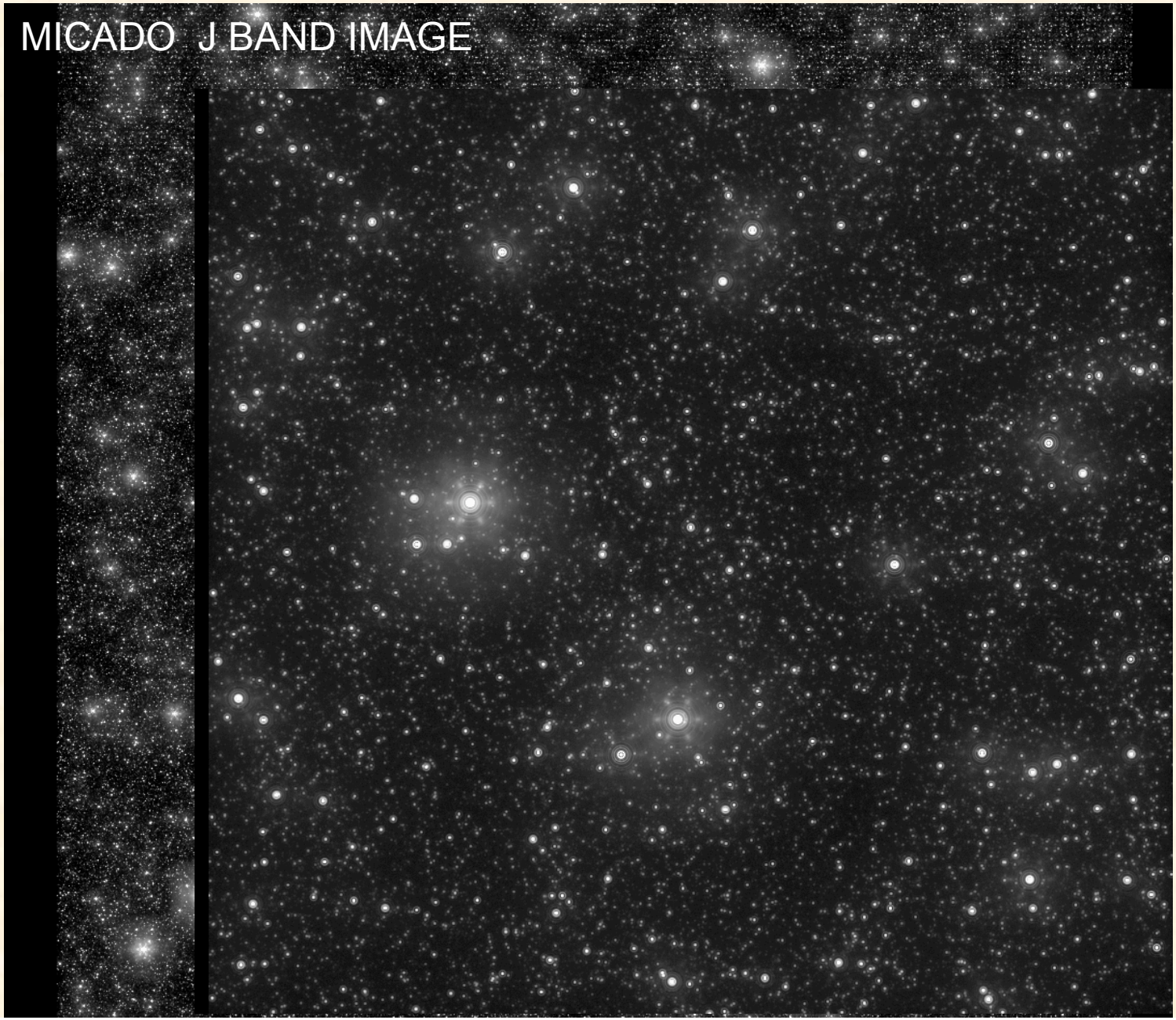


$$N_{BOX} = \delta n_{BOX} \left\langle M_{SF} \right\rangle_{\Delta\tau_{BOX}}$$

THE SIMULATION HAS: SFR=2.4 X 10^{-2} Mo/yr

BOX :	RSG	BSG	AGB	RGB
Age Range (yrs)	4 - 40 M	40 - 125 M	125 M –1G	1 – 12 G
ΔM_{SF} (M_o)	0.96 M	2.04 M	21 M	264 M
$\langle\delta n\rangle_{BOX}$(#/Mo)	1.3 x 10^{-4}	3 x 10^{-4}	1.6 x 10^{-5}	8.4 x 10^{-5}

DISK GALAXY IN THE CENTAURUS GROUP

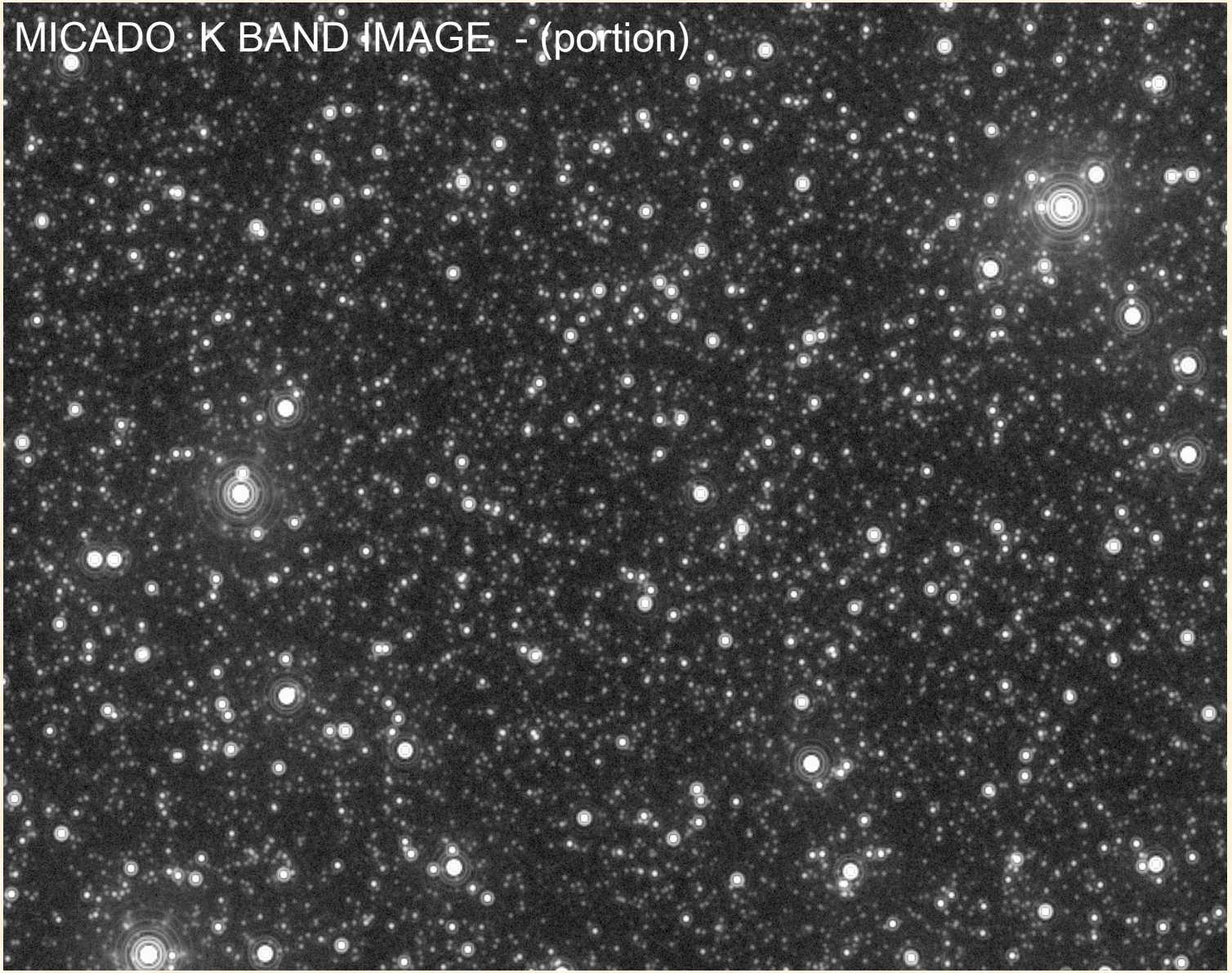


$M_{B,GAL}$ = -20
R_e = 3 Kpc
r/R_e = 0

MOD = 28.3
μ_B = 21.07
μ_I = 19.8
μ_J = 18.9
μ_K = 18.1

FoV = 12” x 12”
$L_B = 17.5\ 10^6\ L_{B,o}$
$L_I = 15.7\ 10^6\ L_{I,o}$
$L_J = 23.6\ 10^6\ L_{J,o}$
$L_K = 35.2\ 10^6\ L_{K,o}$
$M_{SF} = 26.6\ 10^6\ M_o$

DISK GALAXY IN THE CENTAURUS GROUP



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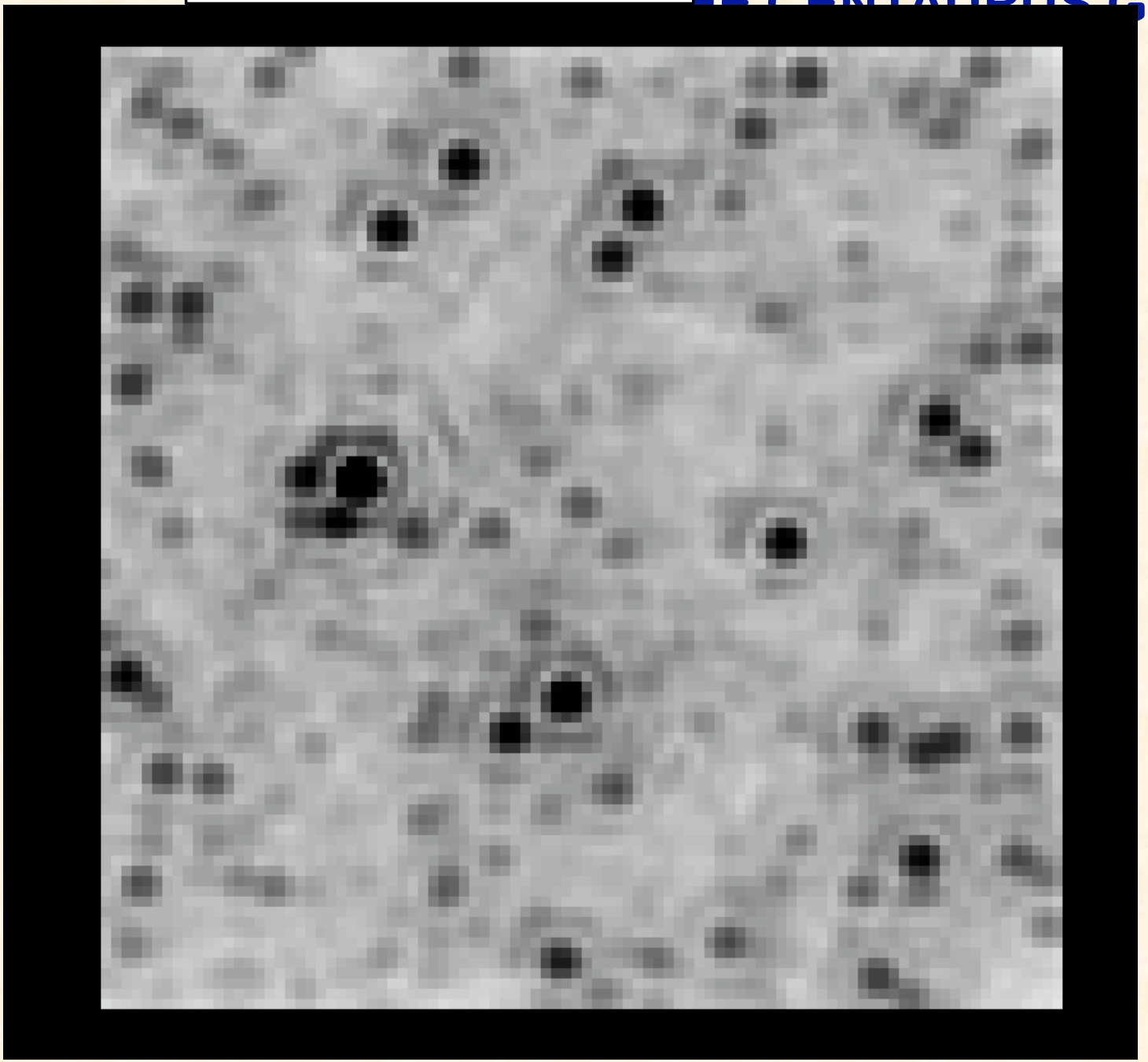
$L_K = 35.2\ 10^6\ L_{K,o}$
$M_{SF} = 26.6\ 10^6\ M_o$

NIRCAM - K BAND IMAGE



HE CENTAURUS GROUP

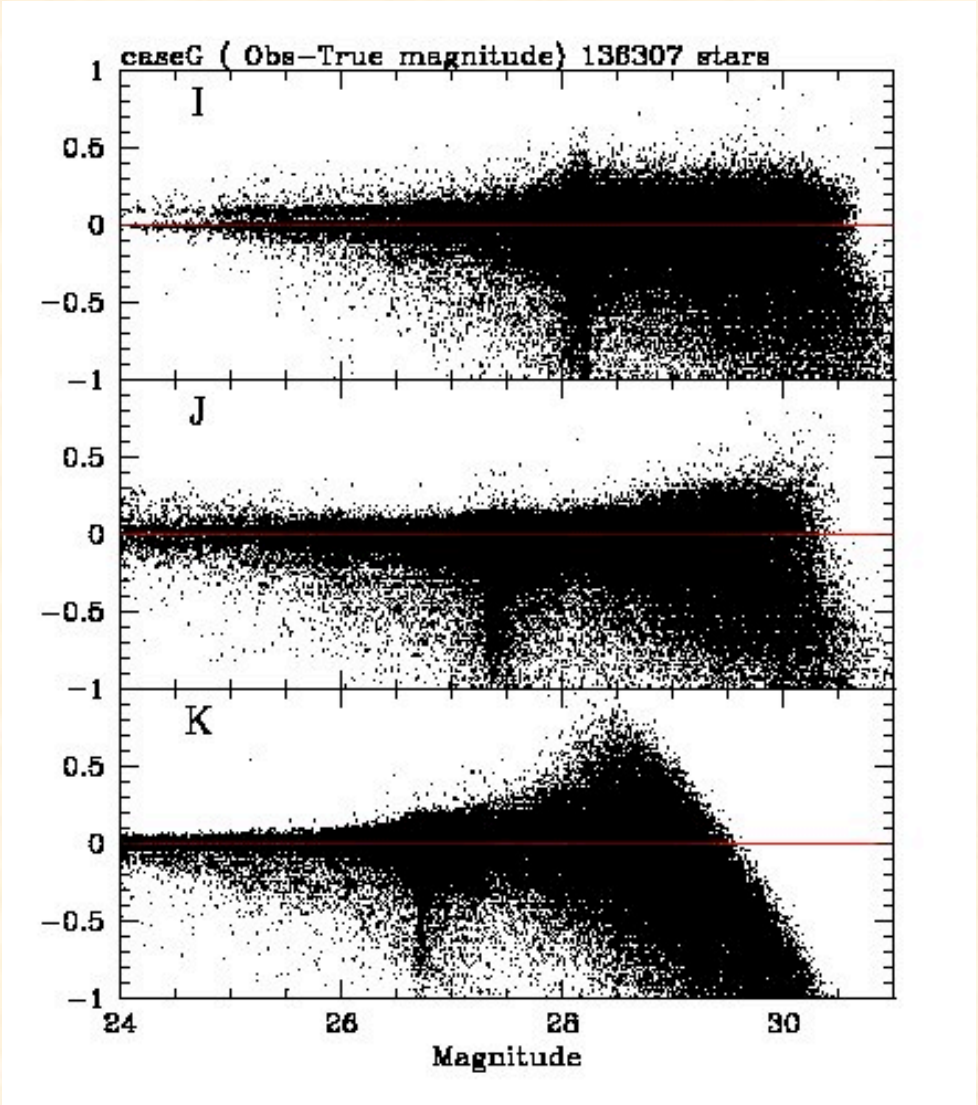
$M_{B,GAL}$ = -20
R_e = 3 Kpc
r/R_e = 0

MOD = 28.3
μ_B = 21.07
μ_I = 19.8
μ_J = 18.9
μ_K = 18.1

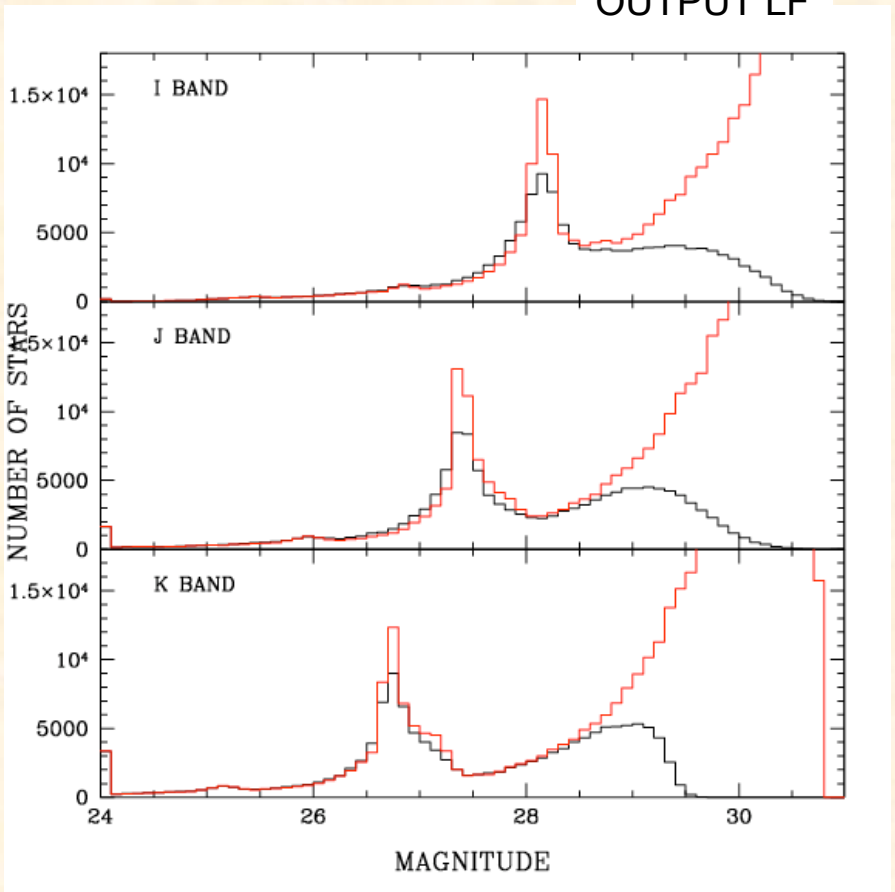
FoV = 3” x 3”
$L_B = 1.1\ 10^6\ L_{B,o}$
$L_I = 0.98\ 10^6\ L_{I,o}$
$L_J = 1.5\ 10^6\ L_{J,o}$
$L_K = 2.2\ 10^6\ L_{K,o}$
$M_{SF} = 1.7\ 10^6\ M_o$

QUALITY OF THE PHOTOMETRY

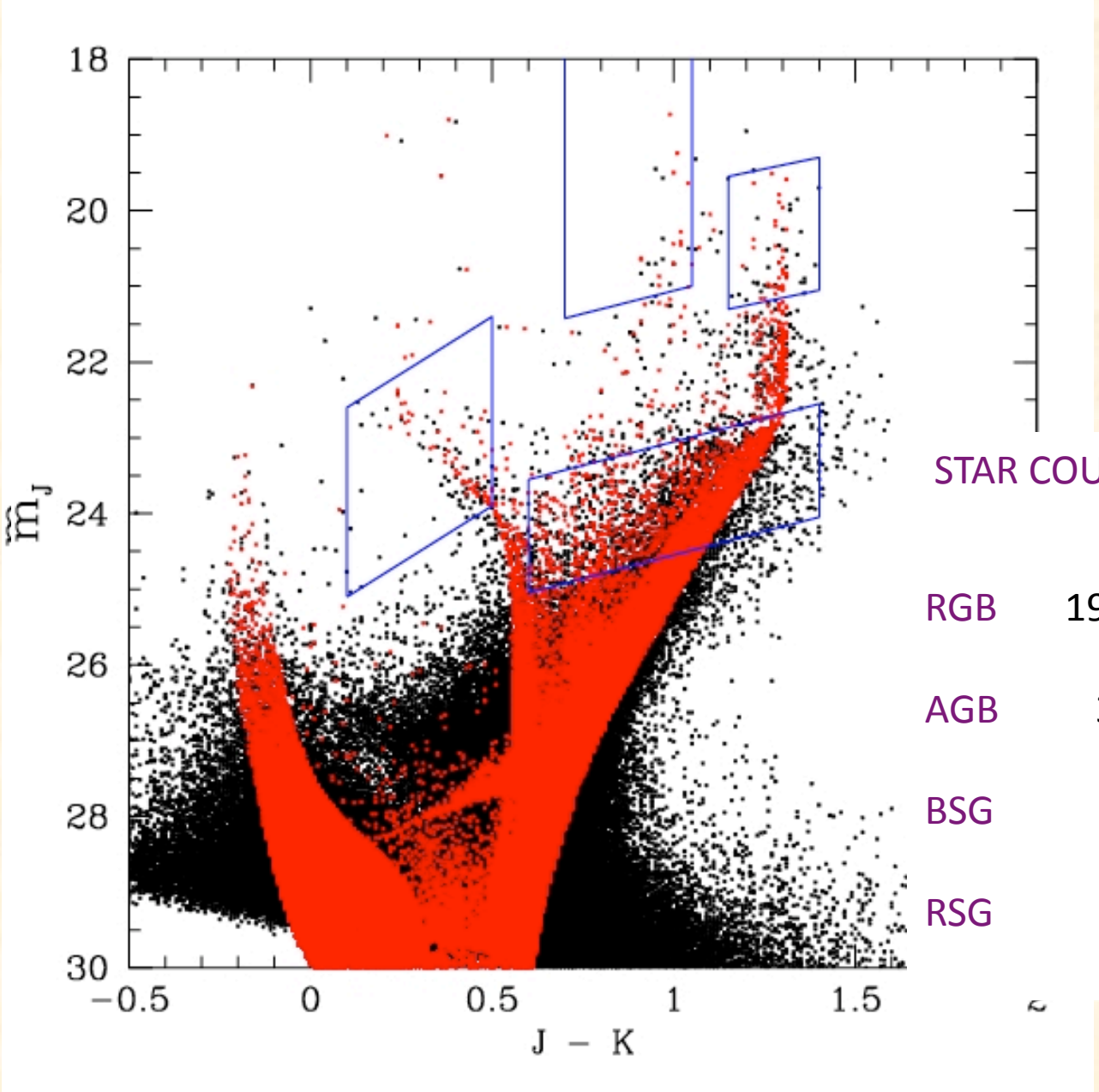
Checked on 136307 objects detected in I, J and K



INPUT LF
OUTPUT LF



INPUT AND OUTPUT CMDs

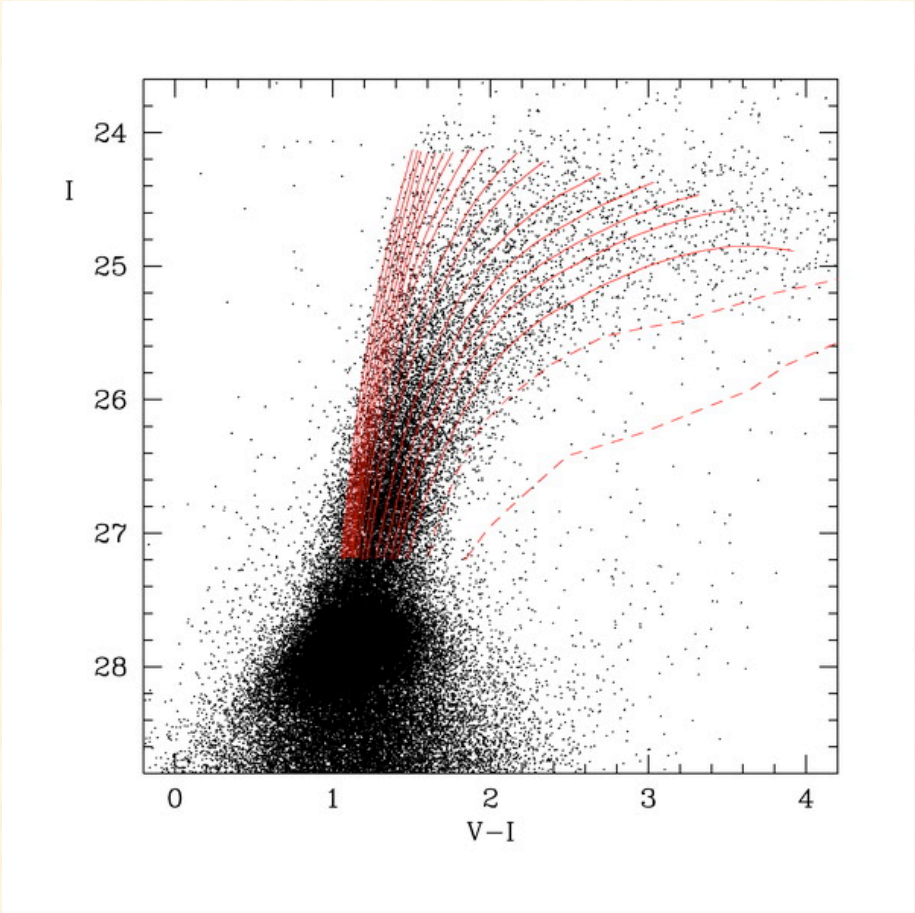


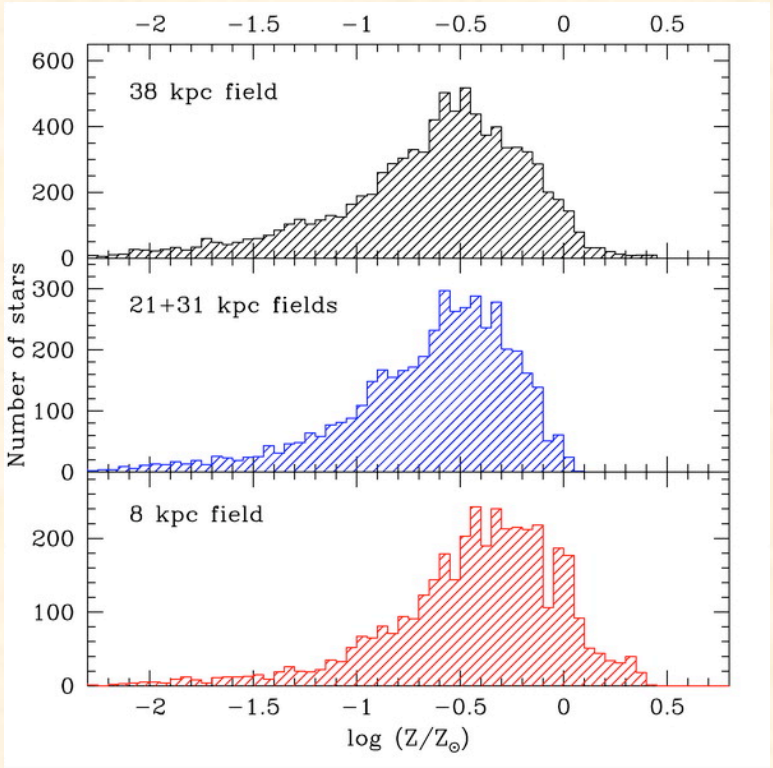
STAR COUNTS IN BOXES

RGB	1916	vs	1933
AGB	33	vs	35
BSG	65	vs	61
RSG	11	vs	14

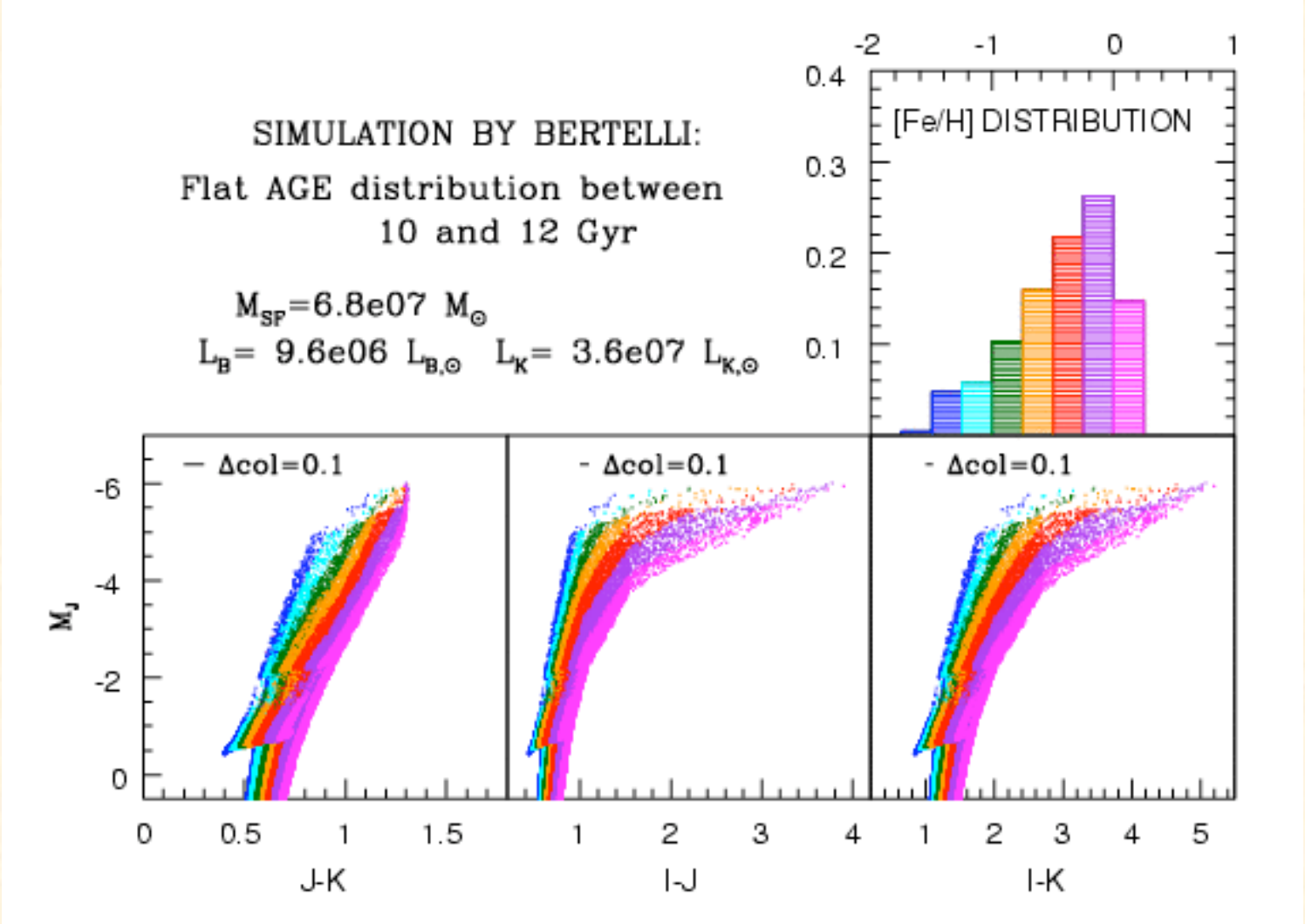
METALLICITY DISTRIBUTION IN ELLIPTICAL GALAXIES

e.g.: Rejkuba et al 2005.
A stellar field in the halo of Centaurus A

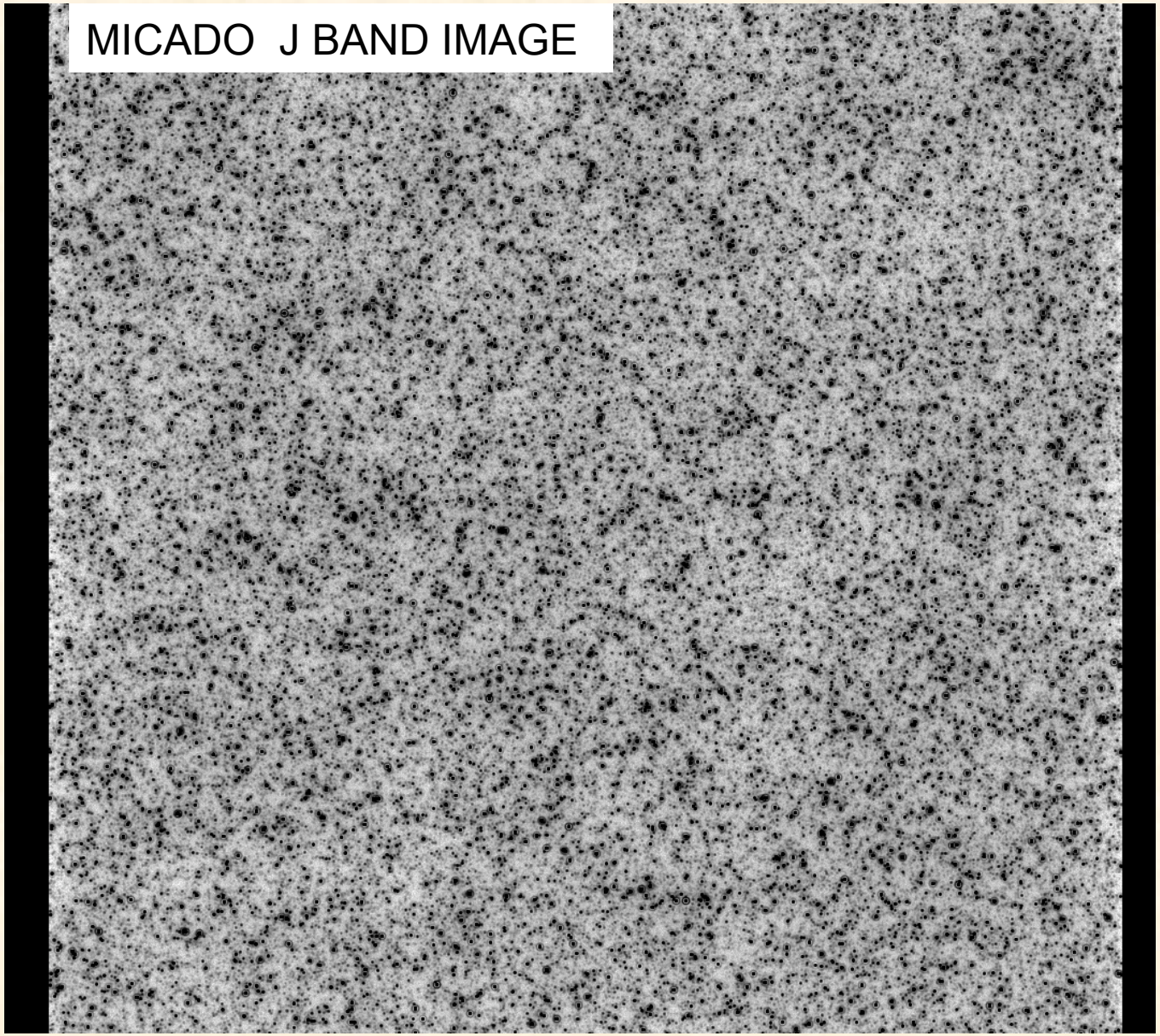




METALLICITY DISTRIBUTION IN ELLIPTICAL GALAXIES



ELLIPTICAL GALAXY IN THE VIRGO CLUSTER



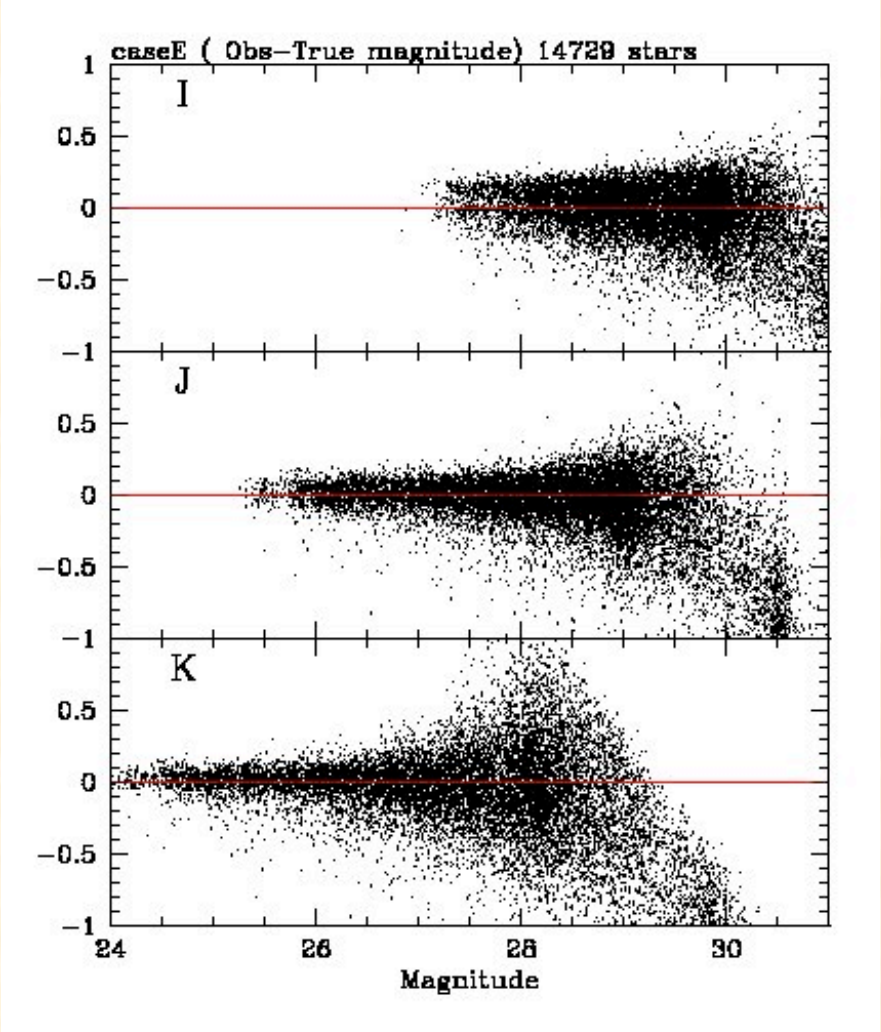
$M_{B,GAL}$ = -22
R_e = 10 Kpc
r/R_e = 0.5

MOD = 31.3
μ_B = 21.6
μ_I = 19.6
μ_J = 18.8
μ_K = 17.9

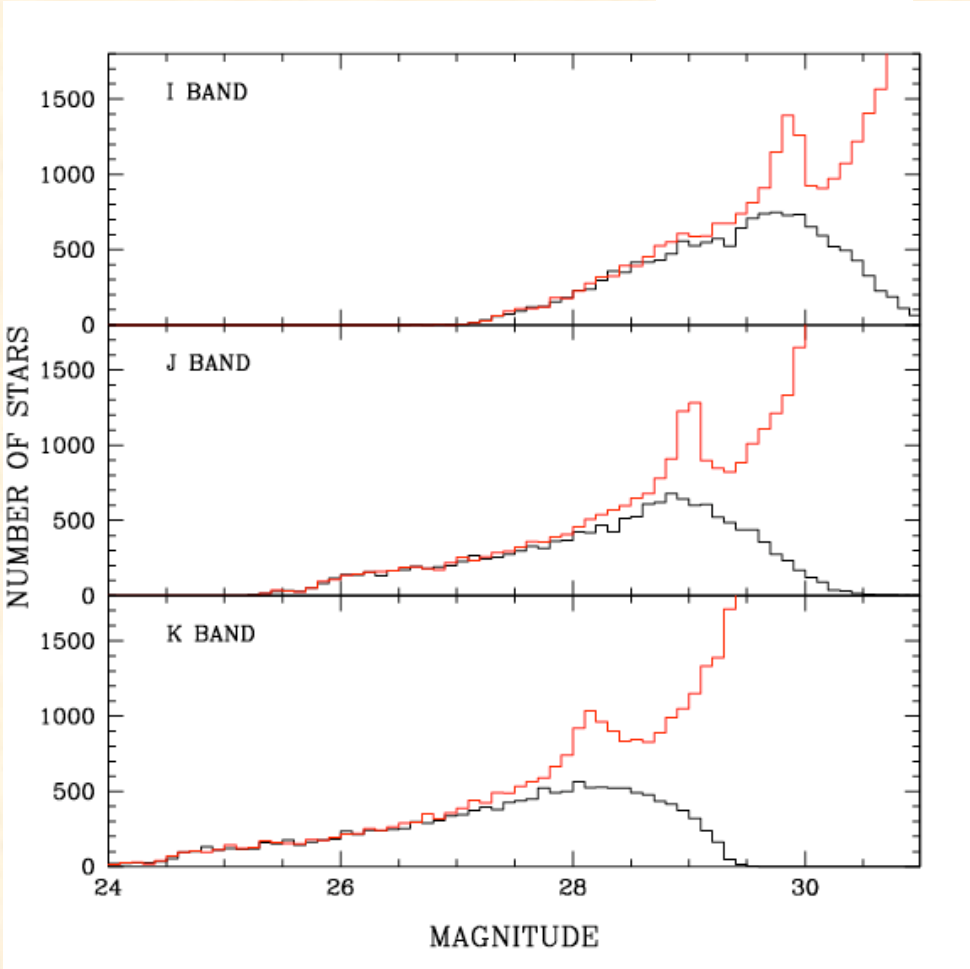
FoV = 3" x 3"
$L_B = 10.6\ 10^6\ L_{B,o}$
$L_I = 17.8\ 10^6\ L_{I,o}$
$L_J = 26.8\ 10^6\ L_{J,o}$
$L_K = 39.7\ 10^6\ L_{K,o}$
$M_{SF} = 75.3\ 10^6\ M_o$

QUALITY OF THE PHOTOMETRY

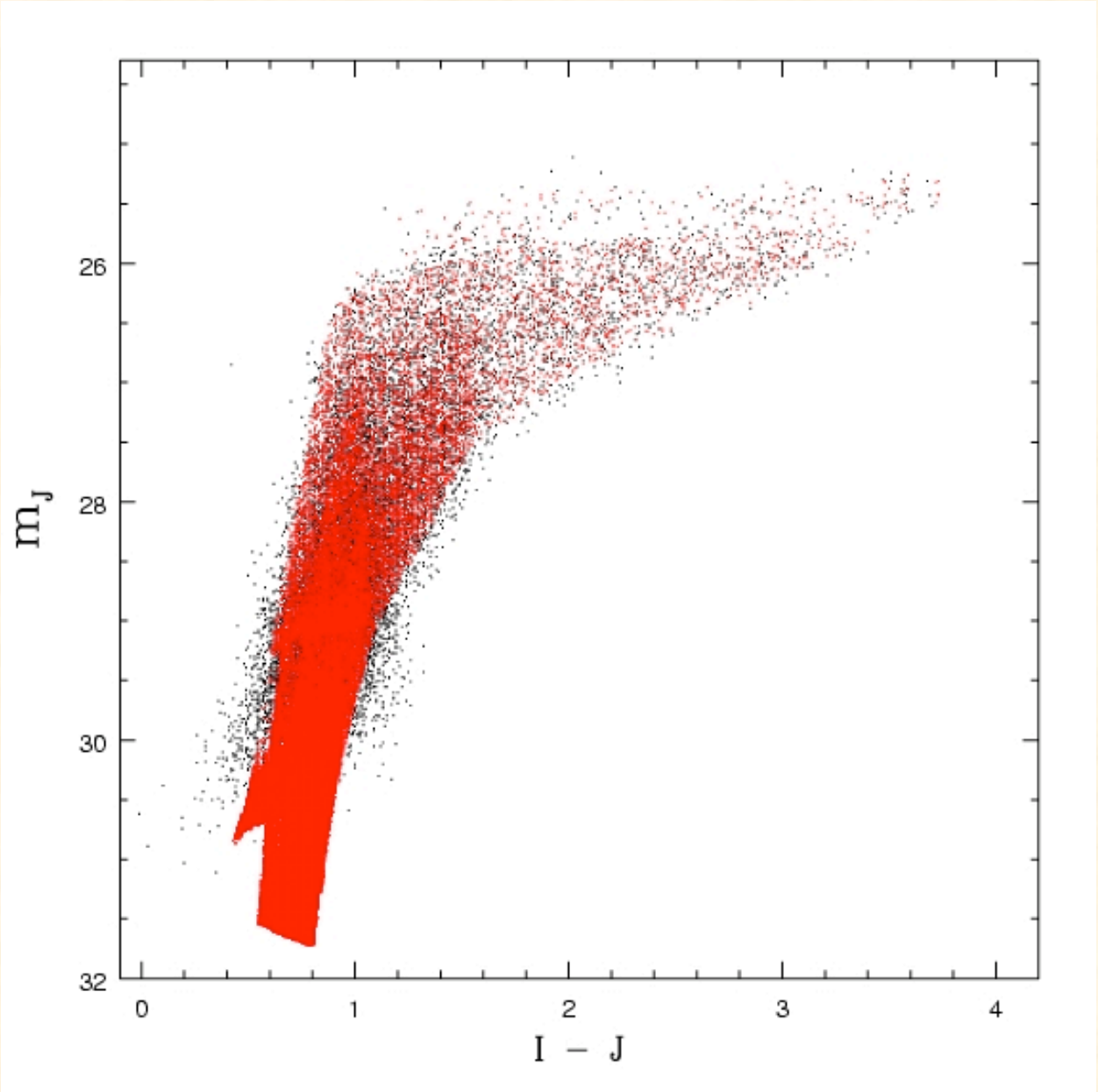
Checked on 14729 objects detected in I, J and K



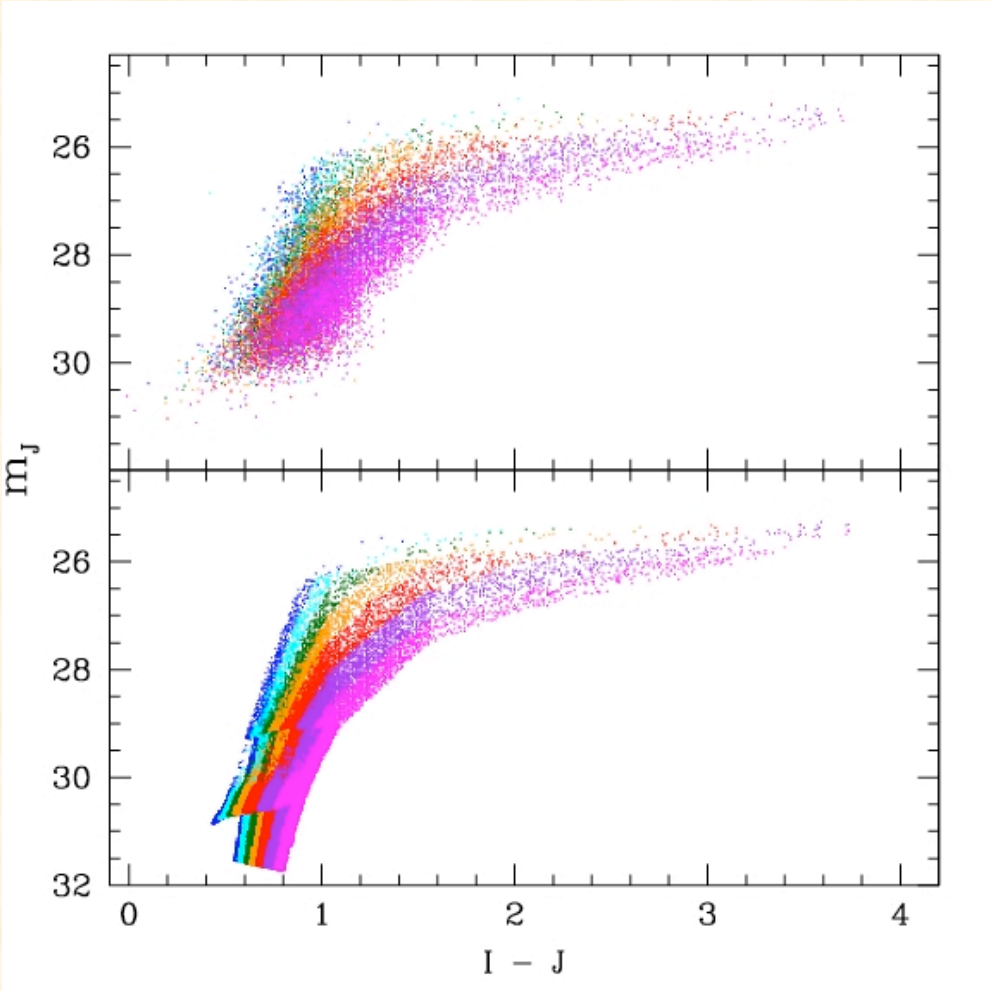
INPUT LF
OUTPUT LF



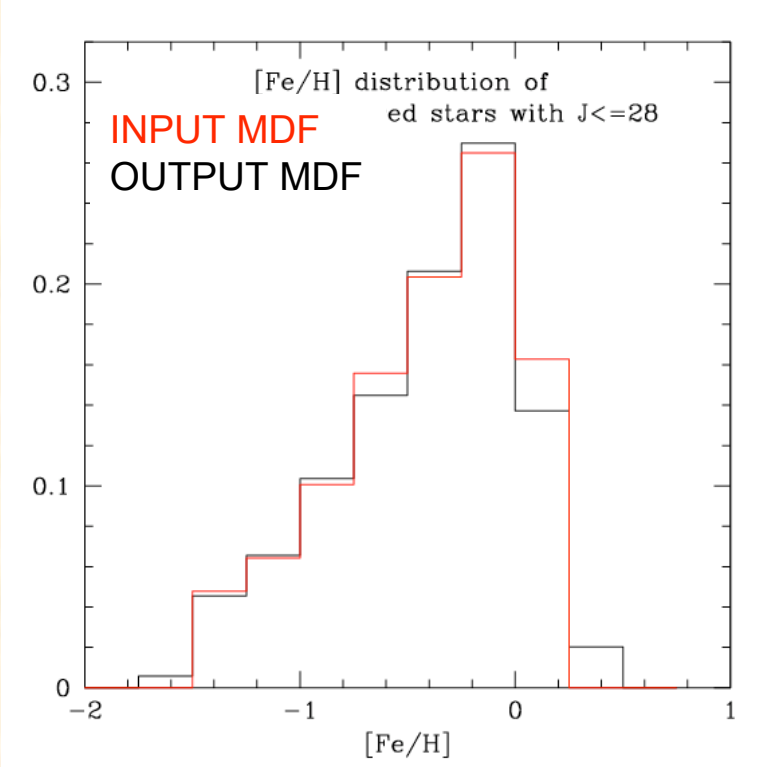
INPUT AND OUTPUT CMDs



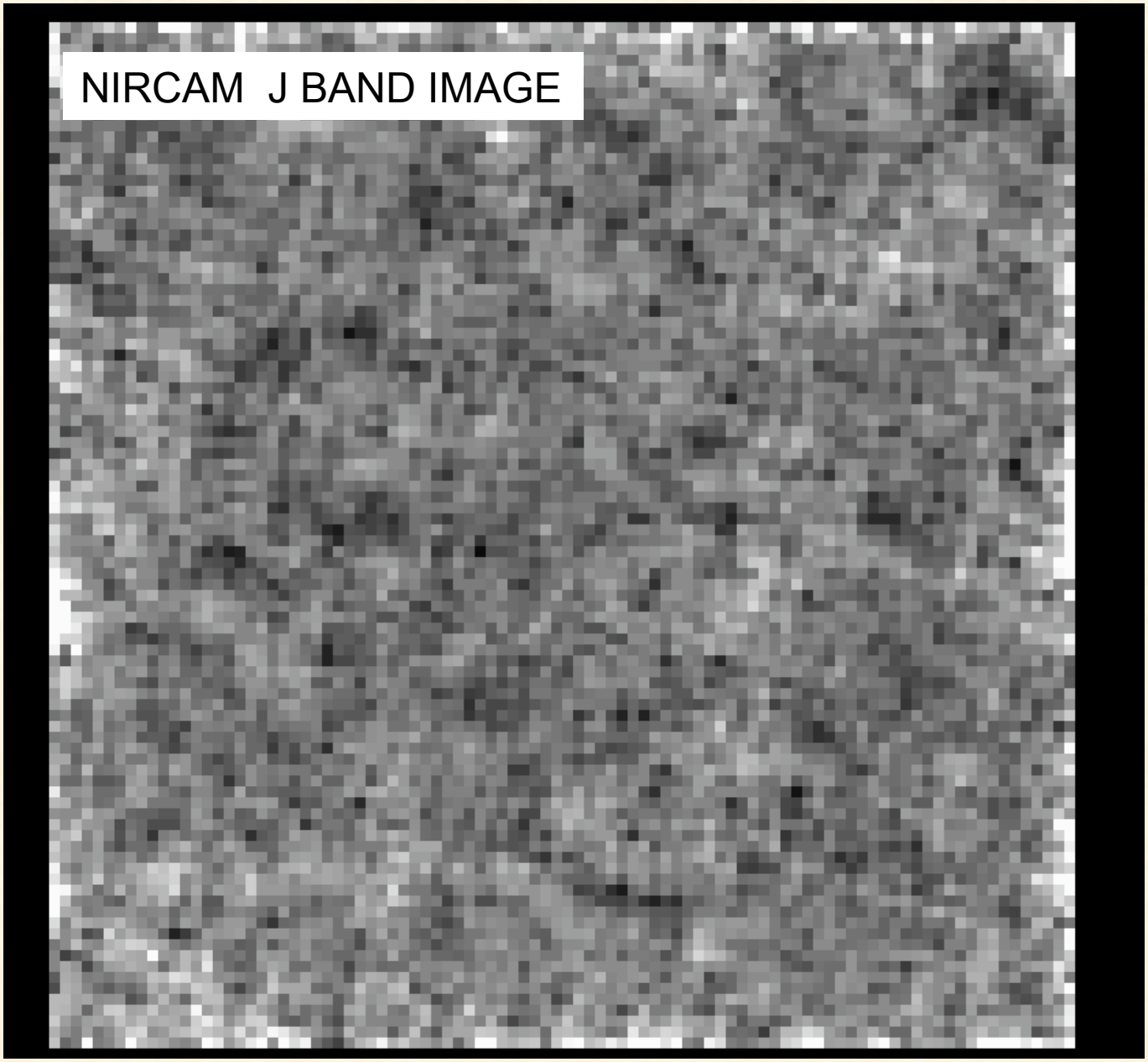
METALLICITY DISTRIBUTION FROM THE CMD



THE METALLICITY BINS ARE SEPARATED IN COLOR IN SPITE OF THE PHOTOMETRIC ERROR



ELLIPTICAL GALAXY IN THE VIRGO CLUSTER

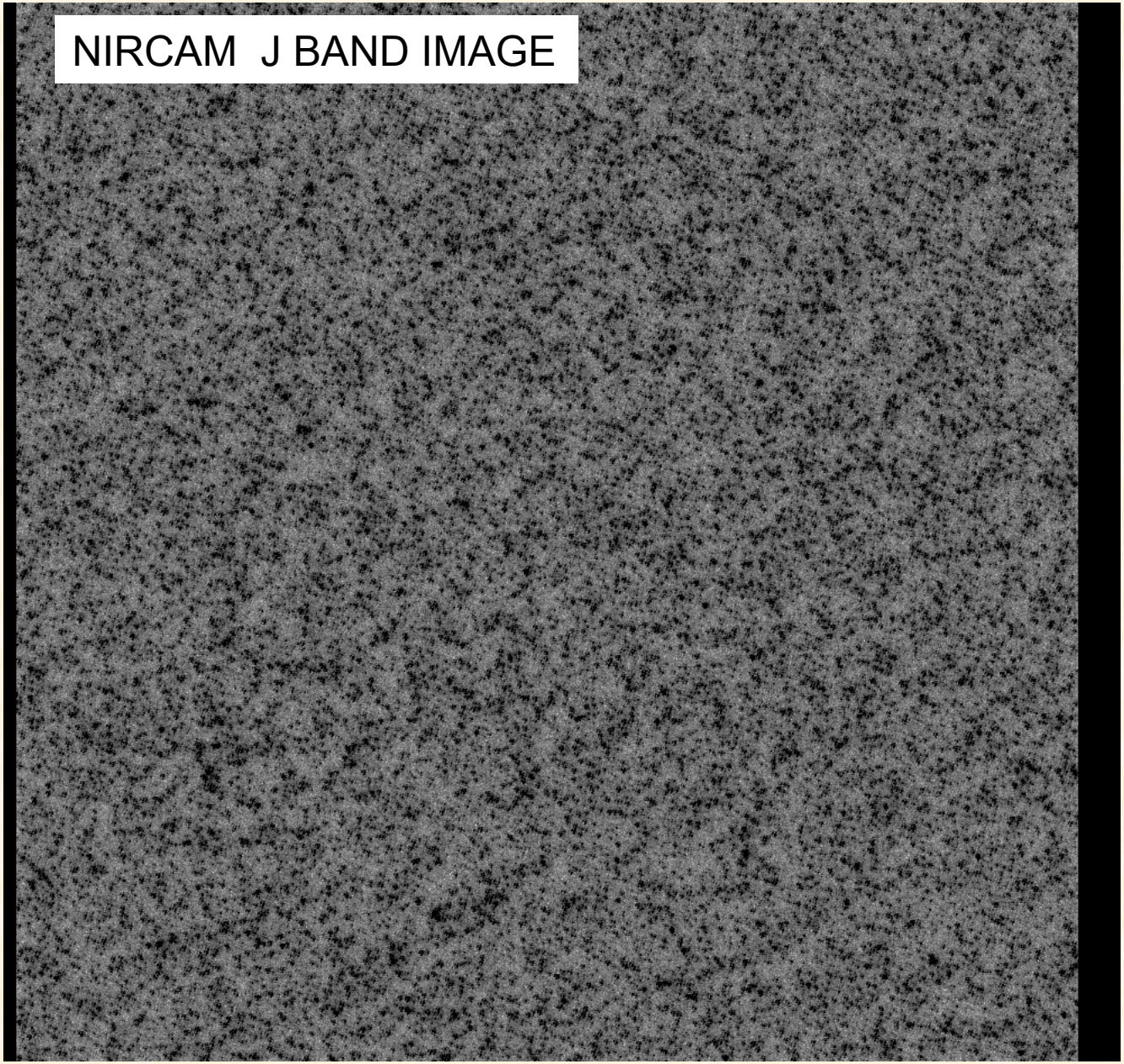


$M_{B,GAL} = -22$
$R_e = 10$ Kpc
$r/R_e = 0.5$

MOD = 31.3
$\mu_B = 21.6$
$\mu_I = 19.6$
$\mu_J = 18.8$
$\mu_K = 17.9$

FoV = 3" x 3"
$L_B = 10.6\ 10^6\ L_{B,o}$
$L_I = 17.8\ 10^6\ L_{I,o}$
$L_J = 26.8\ 10^6\ L_{J,o}$
$L_K = 39.7\ 10^6\ L_{K,o}$
$M_{SF} = 75.3\ 10^6\ M_o$

ELLIPTICAL GALAXY IN THE VIRGO CLUSTER



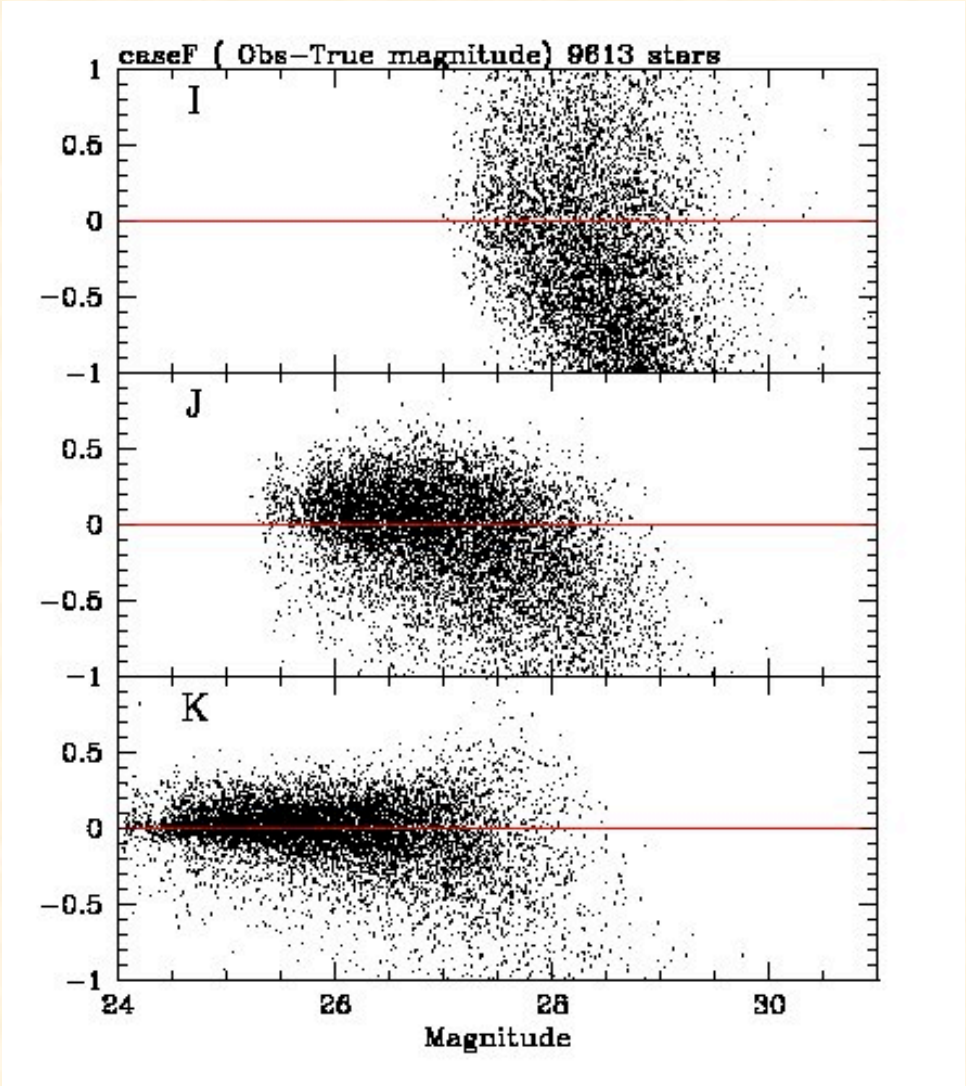
A LOWER SURFACE BRIGHTNESS REGION

$M_{B,GAL} = -22$
$R_e = 10$ Kpc
$r/R_e = 3$

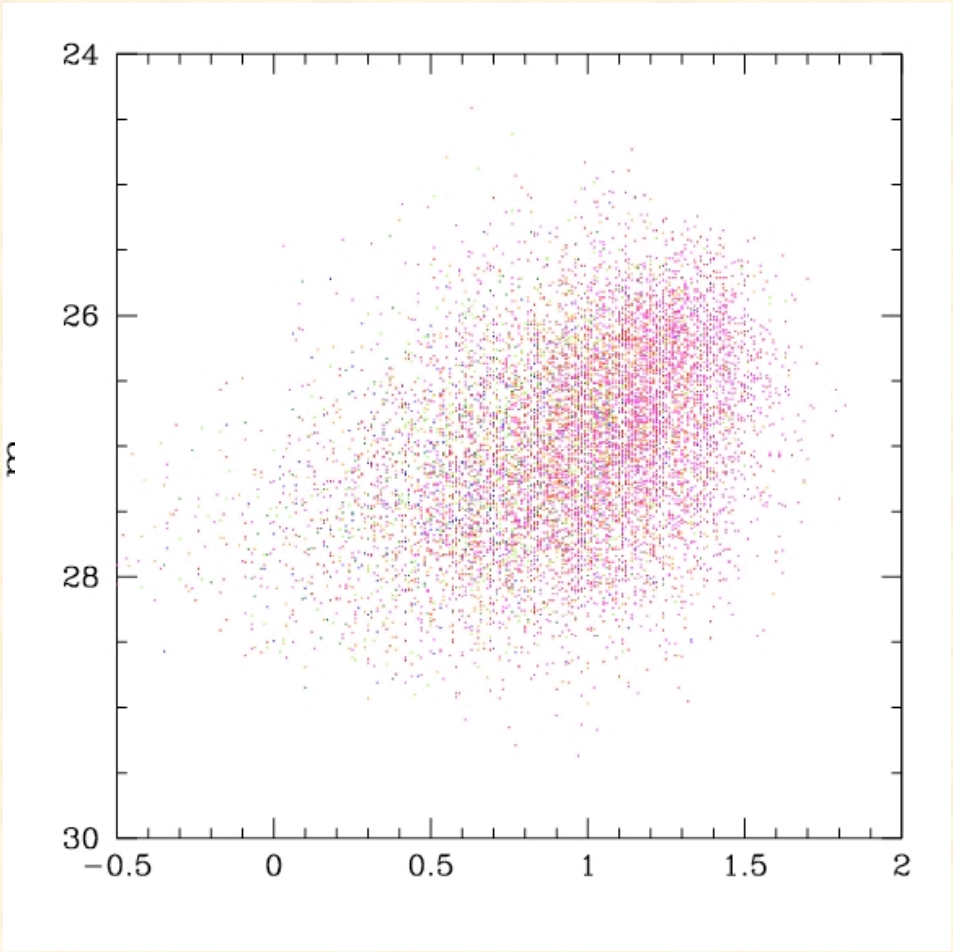
MOD = 31.3
$\mu_B = 25.6$
$\mu_I = 23.6$
$\mu_J = 22.8$
$\mu_K = 21.9$

FoV = 30" x 30"
$L_B = 26.7\ 10^6\ L_{B,o}$
$L_I = 44.8\ 10^6\ L_{I,o}$
$L_J = 67.4\ 10^6\ L_{J,o}$
$L_K = 99.8\ 10^6\ L_{K,o}$
$M_{SF} = 189\ 10^6\ M_o$

RESULTS



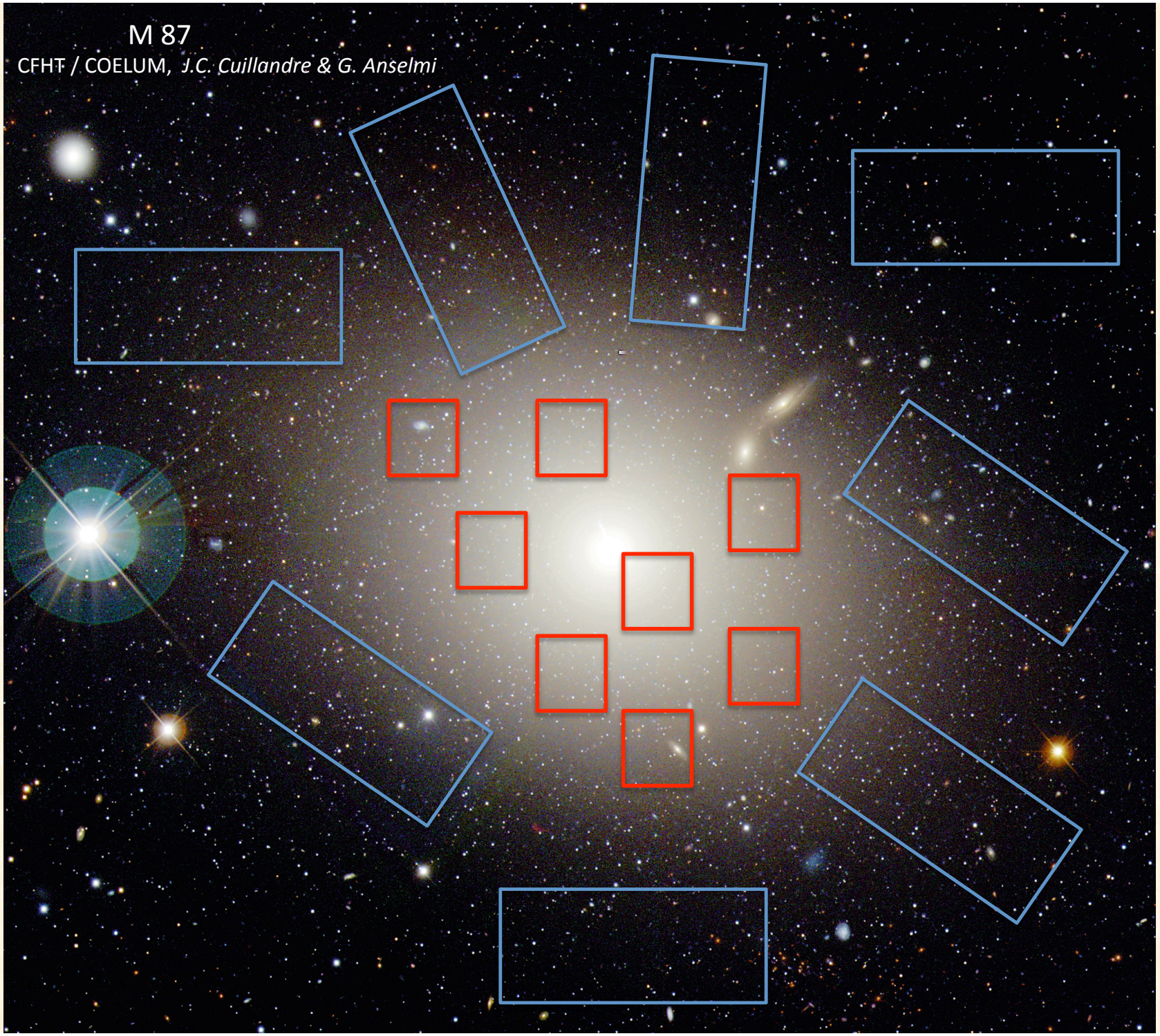
THE I BAND IMAGE IS EXTREMELY CROWDED (RESOLUTION TOO LOW)



CONCLUSION

THE COMBINATION MICADO@E-ELT & NIRCAM@JWST WILL ENABLE US TO EFFICIENTLY MAP THE RESOLVED STELLAR POPULATIONS OF ENTIRE GIANT GALAXIES UP TO THE VIRGO CLUSTER

WE WILL DERIVE GLOBAL STAR FORMATION HISTORIES AND STUDY STELLAR POPULATION GRADIENTS ALL OVER THE GALAXY AREA WITH A FEW SHOTS


M 87
CFHT / COELUM, J.C. Cuillandre & G. Anselmi

Advanced Exposure Time Calculator
(parameters)

- Total integration time : 18000 sec (5h)
- Number of individual exposure : 180
- Background (sky + thermal + residual/unresolved star light)
- Noise model (statistical + RON)
- PSF (fixed in the FoV)
- Throughput (nominal: aperture, obstruction, efficiency)