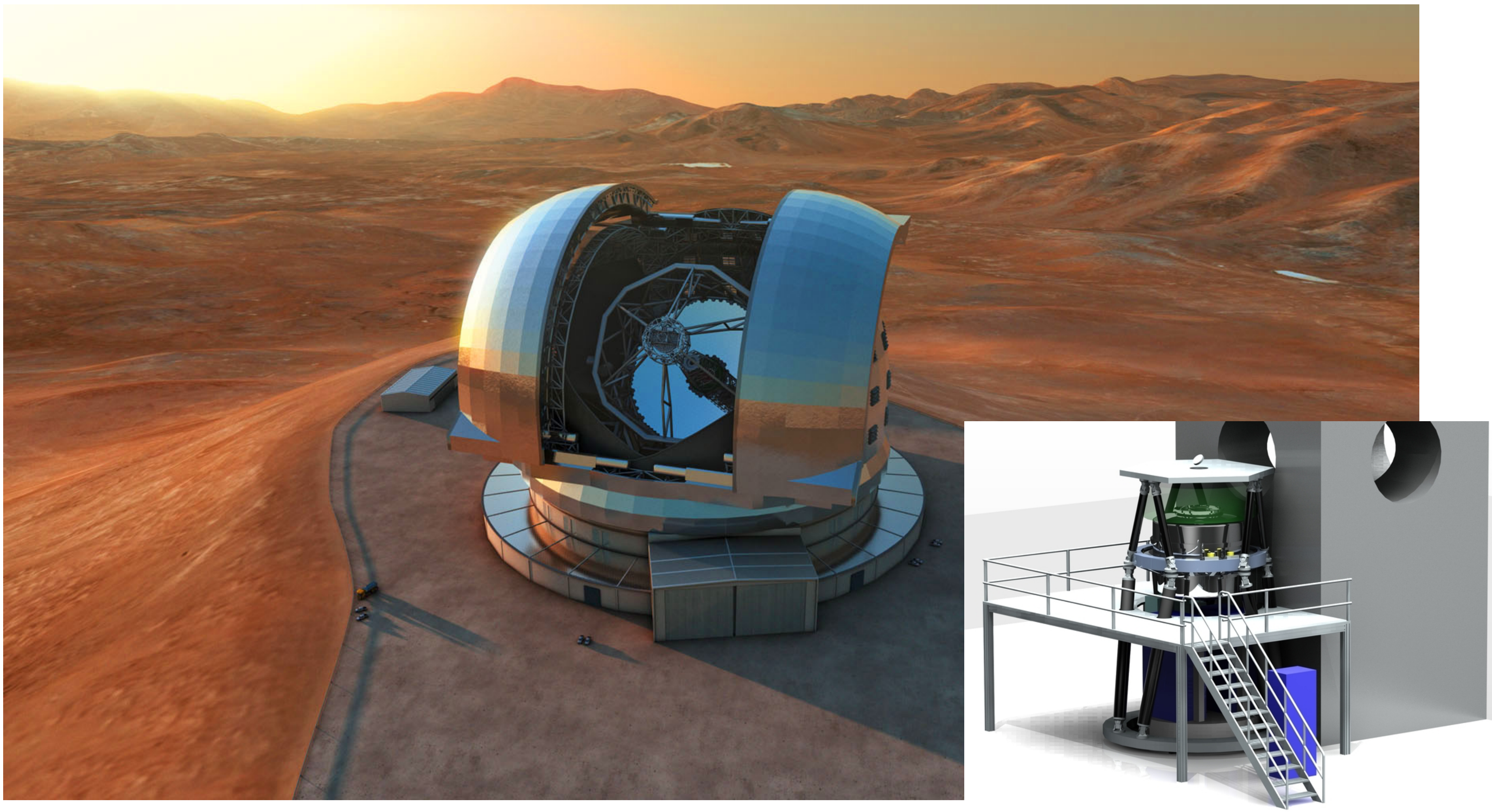
Science Cases for High Resolution Imaging with MICADO@ELT

Laura Greggio, INAF-OAPd



MICADO
Multi-AO Imaging Camera for Deep Observations

a high resolution camera optimized for imaging at the diffraction limit of a 40m class telescope
designed to work with the AO module MAORY

- will be first light instrument at E-ELT
- kick off meeting on 5-6 October 2015
- built by a European consortium lead by MPE - Garching (Germany, France, The Netherlands, Austria, Italy)

courtesy of R. Davies, MICADO's PI

Key Capabilities

- ❑ Imaging
  - 0.8-2.4µm with >30 broad/narrow filters
  - 1.5 & 4mas pixels for 19 & 51" FoV at 6-12mas
  - Similar sensitivity to JWST, and 6× better resolution
- ❑ Astrometric imaging
  - 50µas precision across full field
  - 10µas/yr = 5km/s at 100kpc after 3-4 years
  - bring precision astrometry into mainstream
- ❑ Spectroscopy
  - ideal for compact sources
  - fixed configuration for 0.8-1.45µm & 1.45-2.4µm
  - R ~ 8000 across slit, higher for point sources
- ❑ High Contrast imaging
  - focal plane coronagraph & lyot stop
  - angular differential imaging
  - small inner working angle
- ❑ Time Resolved Astronomy
  - windowing for frame rates up to ~100Hz

courtesy of R. Davies, MICADO's PI

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❑ Astro tric

- 50µas precision across full field

Since a few years we have been developing science cases on high resolution imaging

R. Falomo, M. Uslenghi, D. Fantinel, S. Zaggia, L. Schreiber, M. Gullieuszik

- R ~ 8000 across slit, higher for point sources

❑ High Contrast imaging

- focal plane coronagraph & lyot stop
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❑ Time Resolved Astronomy

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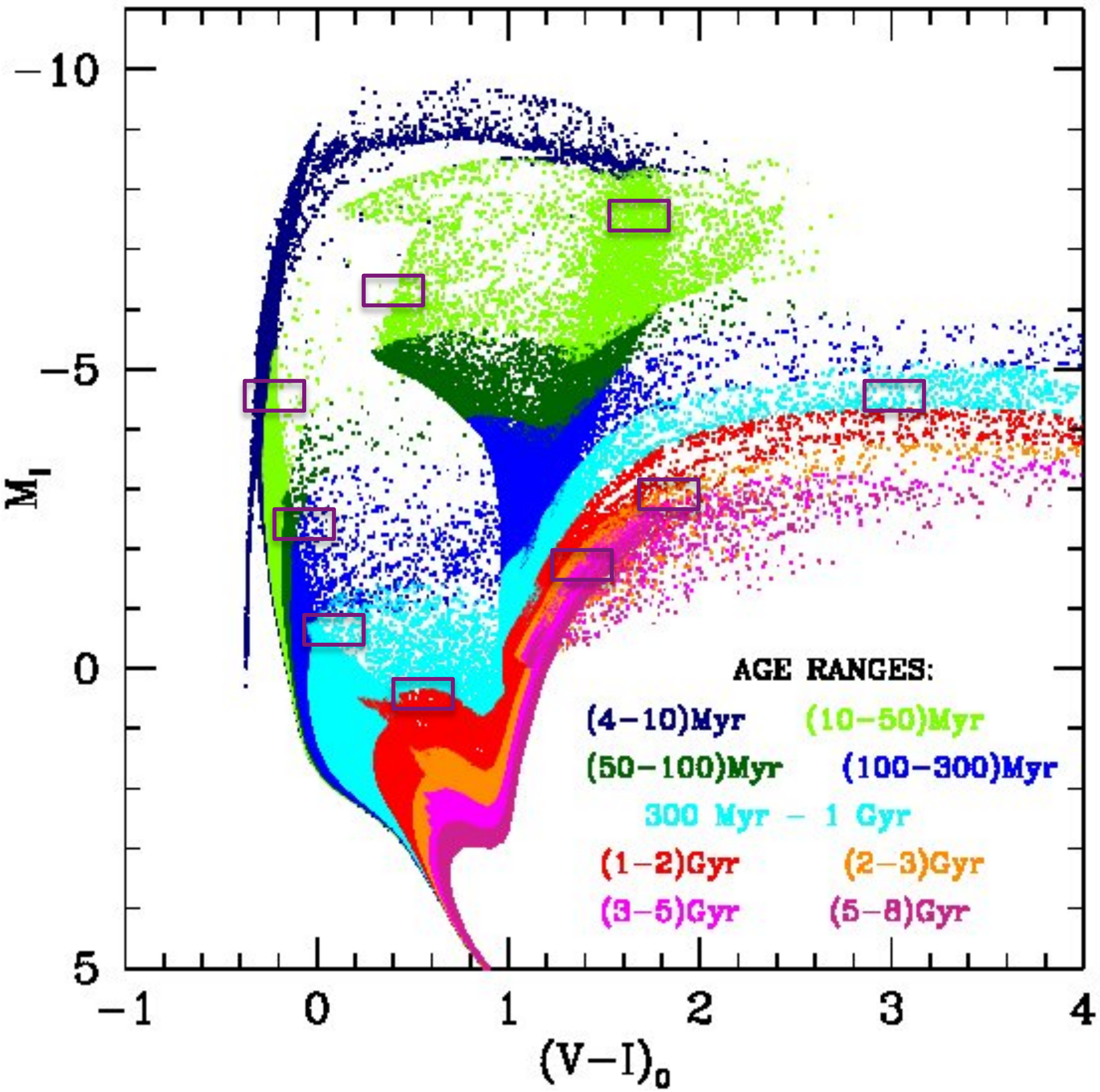
Ricovering the Star Formation History in galaxies: THE SYNTHETIC CMD METHOD



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

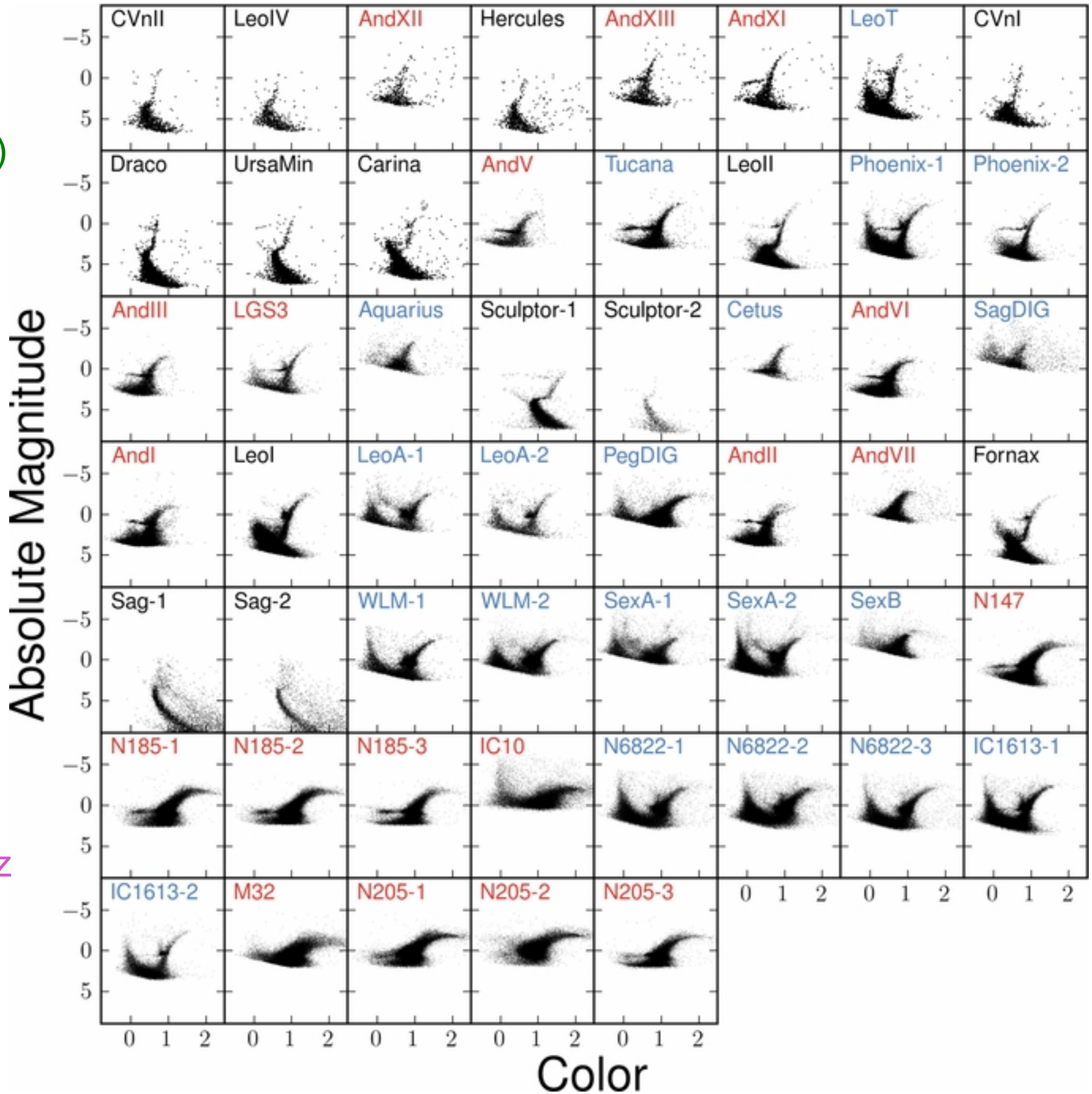
Different regions on the CMD have different diagnostic power

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

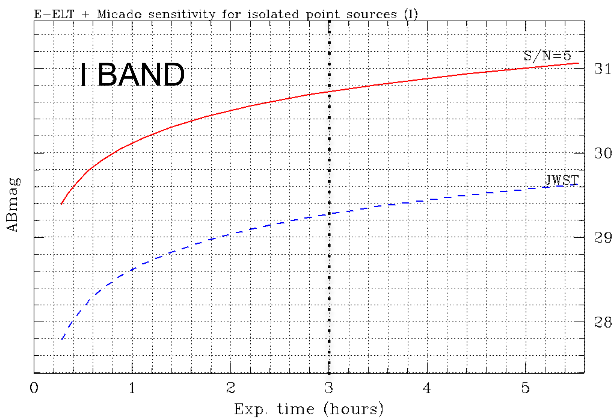
Boxes along the RGBs include a wide range of ages

Weisz +, 2014:
SFH in 40 LG dwarfs
(within 1 Mpc distance)

MW Satellites
M31 Satellites
Field Dwarfs

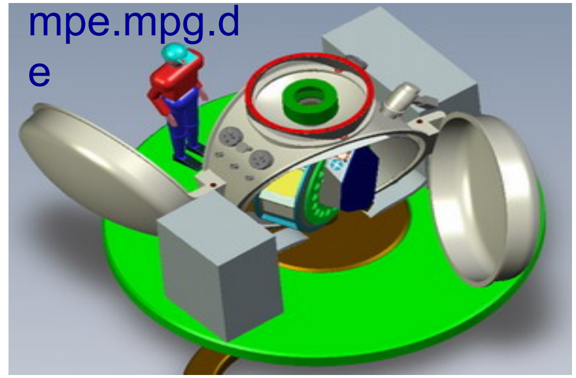


Investigate:
SFH vs environment
SFH vs Dwarf Type
Fraction of SF at high z
….



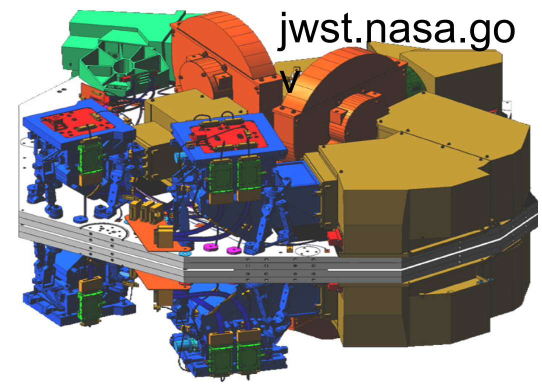
MICADO parameters as from phase A study

MICADO @ E-ELT



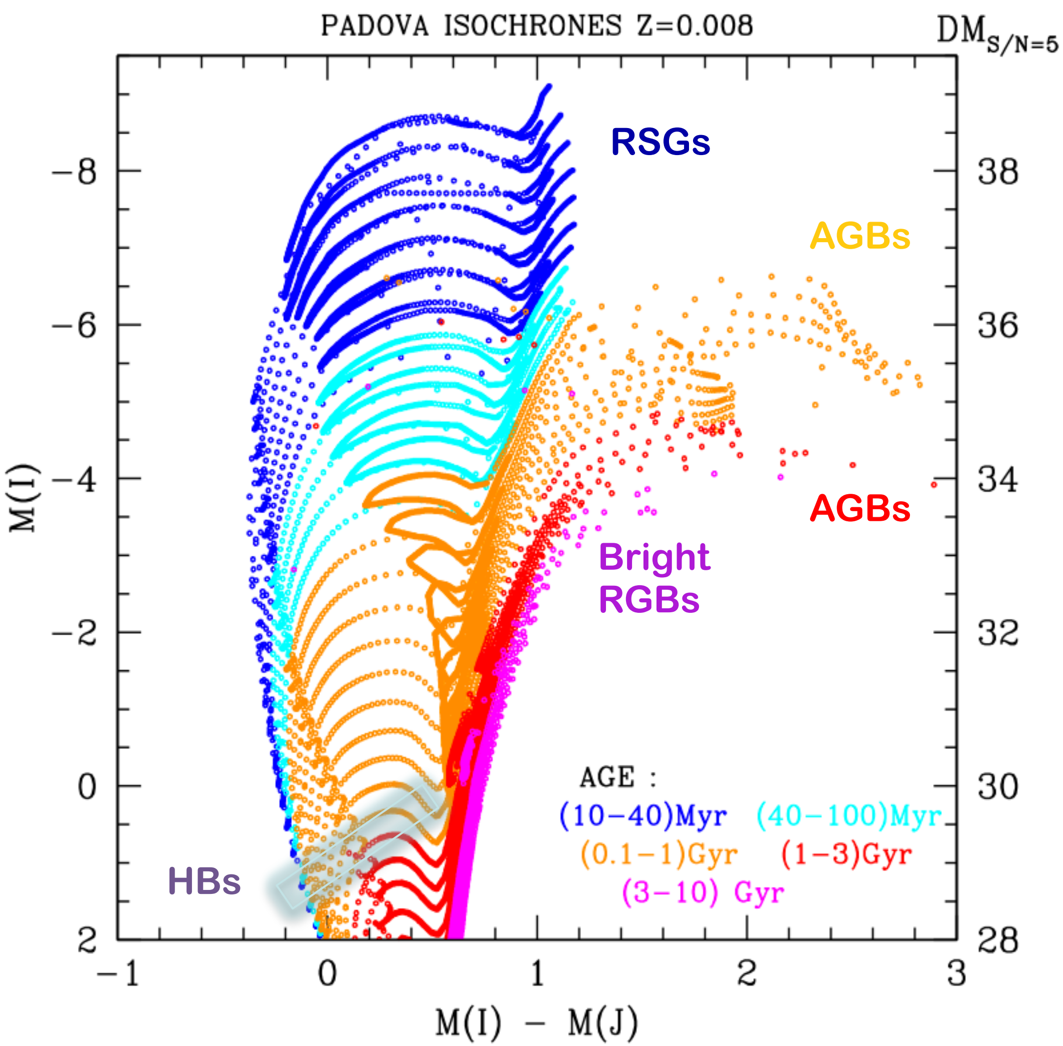
+ MAORY

NIRcam @ JWST



FIELD OF VIEW	~ 53” x 53”	2 x (2.16’ x 2.16’)
PIXEL SCALE	~ 3 mas	~ 32 mas
MAGNITUDE LIMITS: (isolated, t_{exp}=3hrs, S/N=5) I – BAND (vegamag) J – BAND (vegamag)	 30.3 29.5	 28.8 28.3

Stellar probes

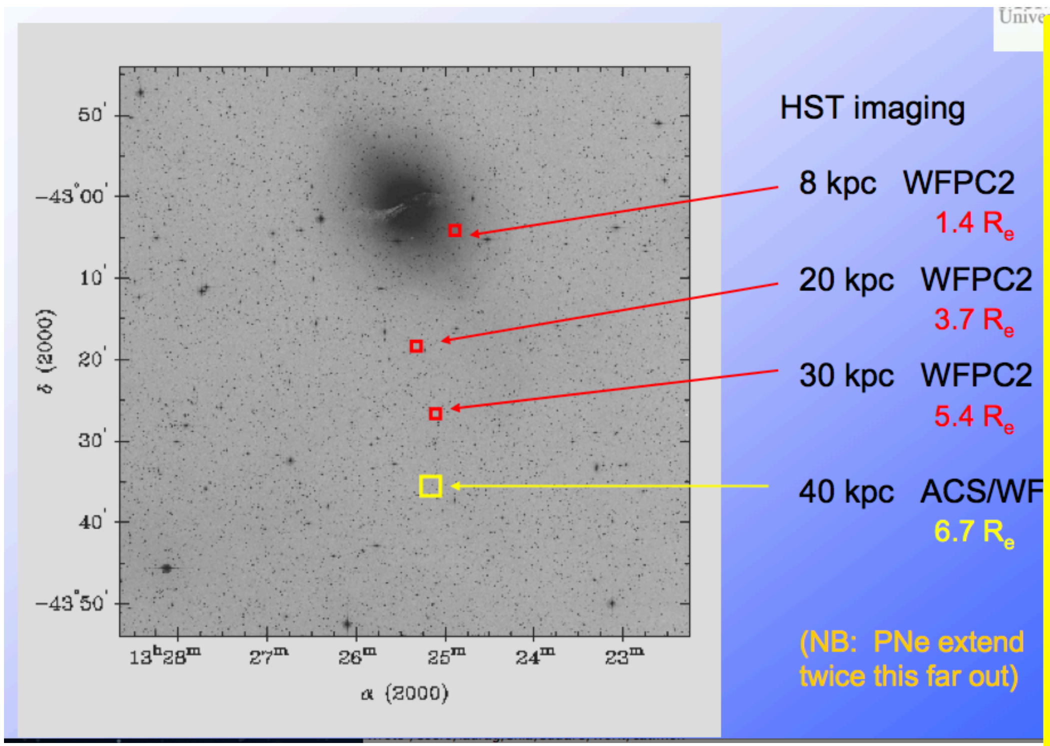


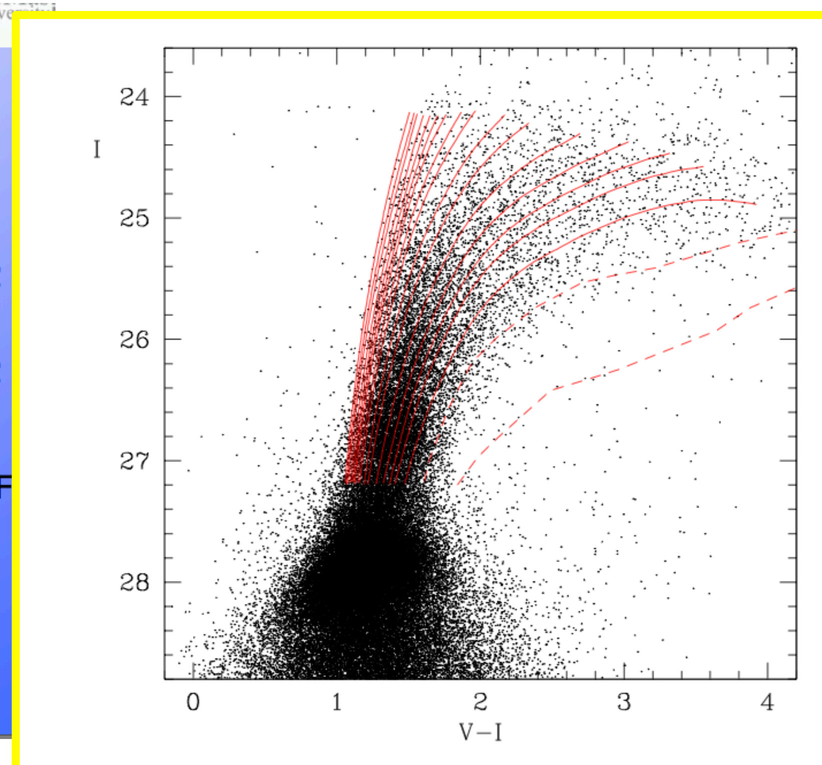
probe	up to D
RSGs (few 10Myrs)	450 Mpc
AGBs (up to 1Gyr)	80 Mpc
RGBs (up to t(H))	25 Mpc
Red HBs	10 Mpc
Blue HBs	5 Mpc
Old MS TOs	2 Mpc

Science Case: Metallicity distribution from the photometry of RGB stars

Harris + 1999,2000,2002
Rejkuba +, 2005,2010

HST photometry of a few fields in Centaurus A
a giant Elliptical galaxy at a distance of 3.8 Mpc





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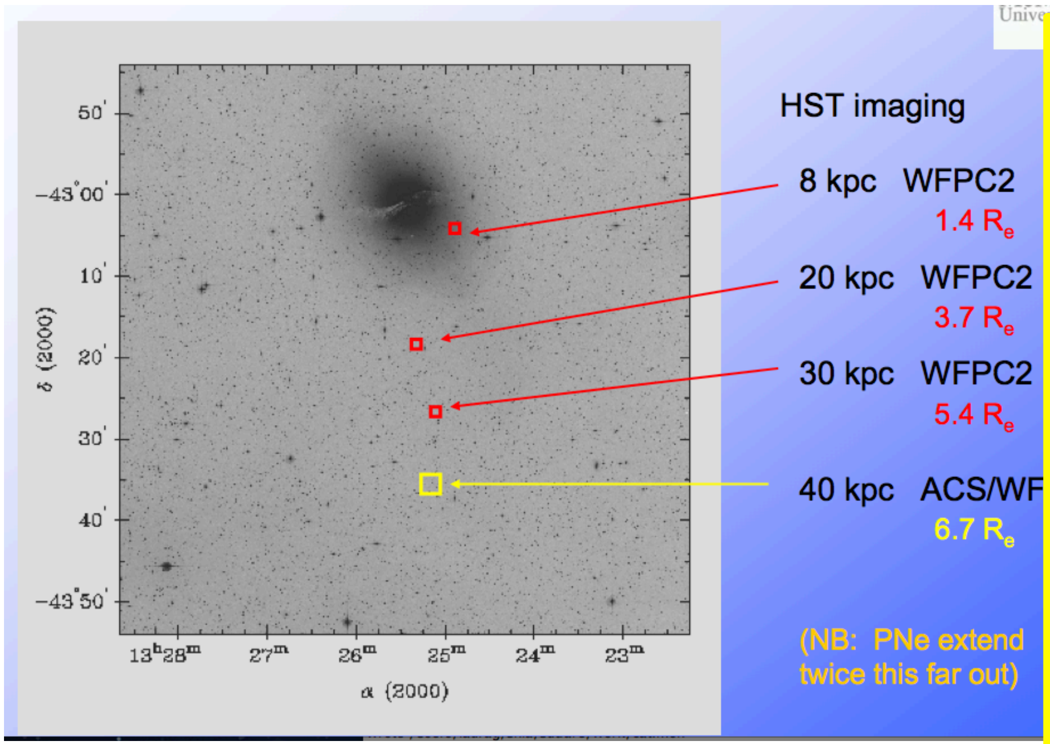
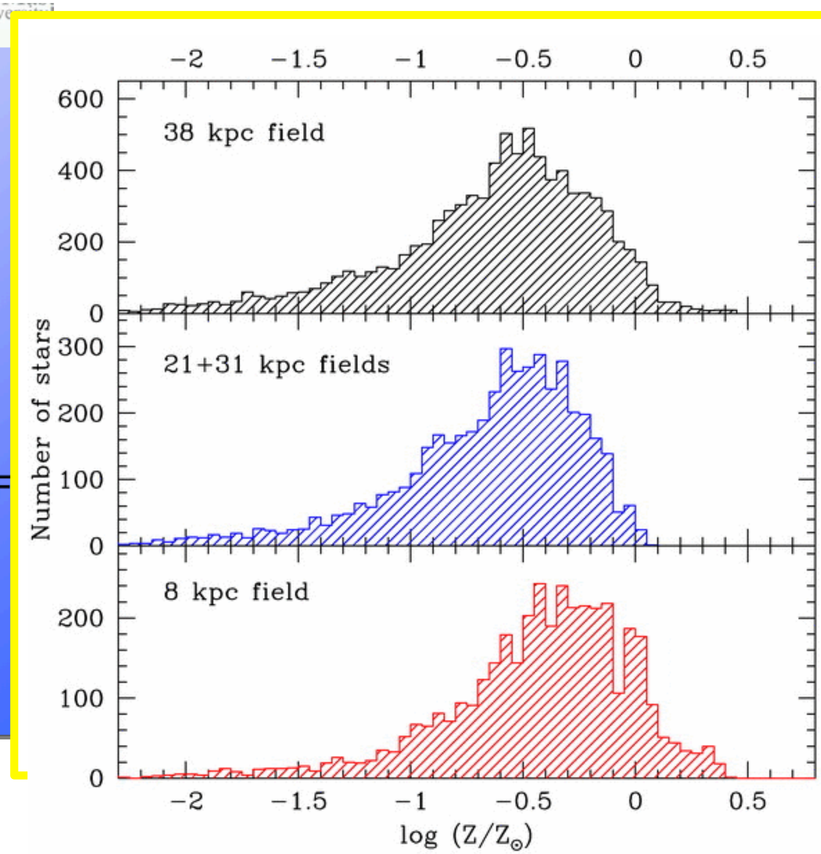




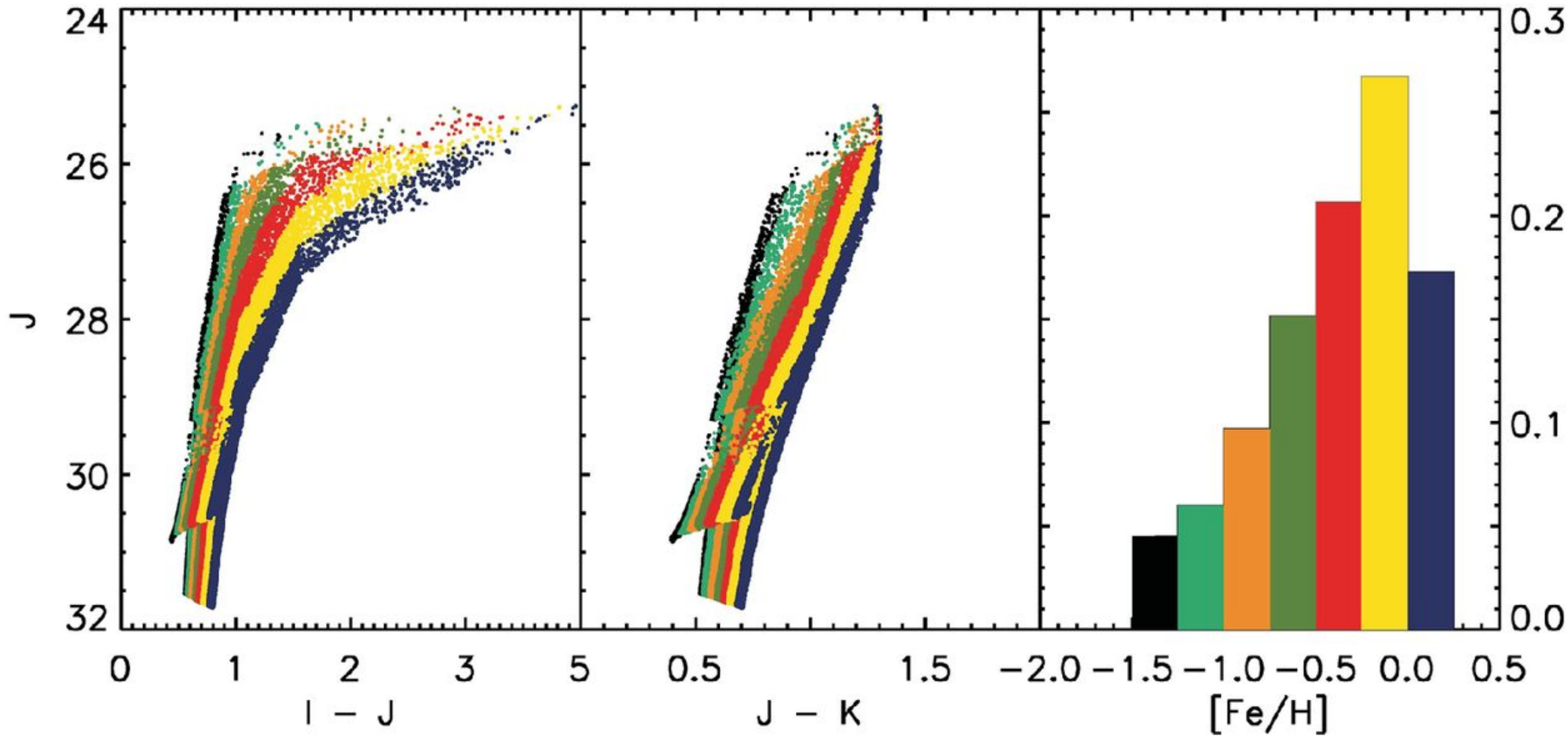
With MICADO@ELT we access the inner regions of Es in Virgo

From Schreiber et al. 2013

Model SP:
a flat age distribution between 10 and 12 Gyr, a wide metallicity distribution, M_{TOT}= 7 10^7 Mo at a distance of 18 Mpc

scaled at different radii $\mu_B = -2.5 \log \sigma(K < 31) + 31.97$

Case	μ_B	FoV	$R/R_{\rm eff}$	No. of stars
1	19.3	1.03	0.1	124 533
2	20.54	1.8	0.25	125 581
3	21.06	2.29	0.35	126 108
4	21.64	3.01	0.5	125 552
5	22.26	4	0.7	126 128
6	22.97	5.54	1	126 002
7	23.85	8.34	1.5	125 997
8	24.54	11.45	2	126 083



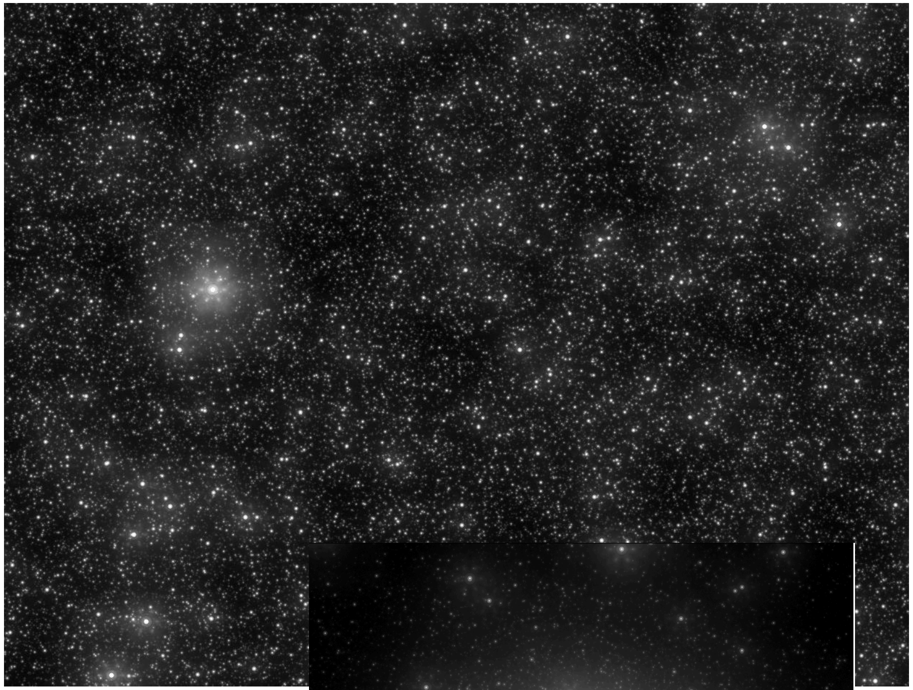
(Advanced Exposure Time Calculator)

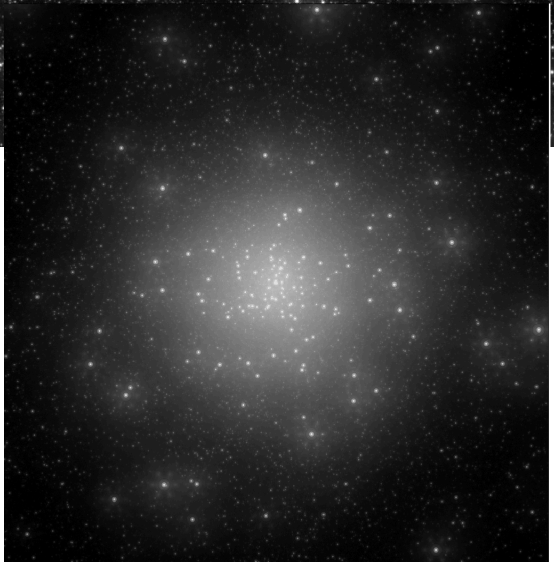
http:aetc.oapd.inaf.it

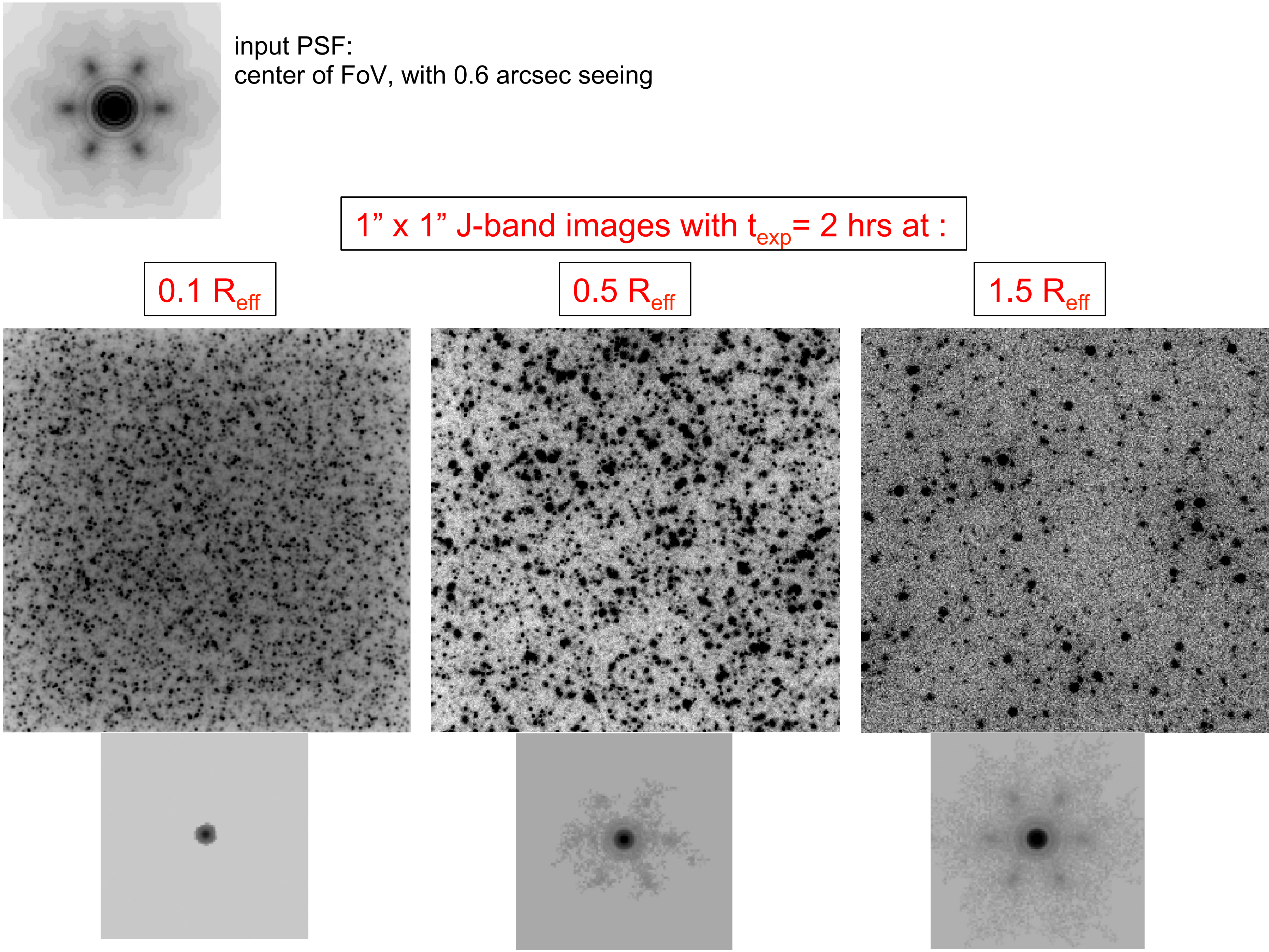
Falomo, Fantinel, Uslenghi

Simulates images of astronomical objects with any combination of telescope, instrument and passband, using a suitable set of parameters which specify the observational set up.

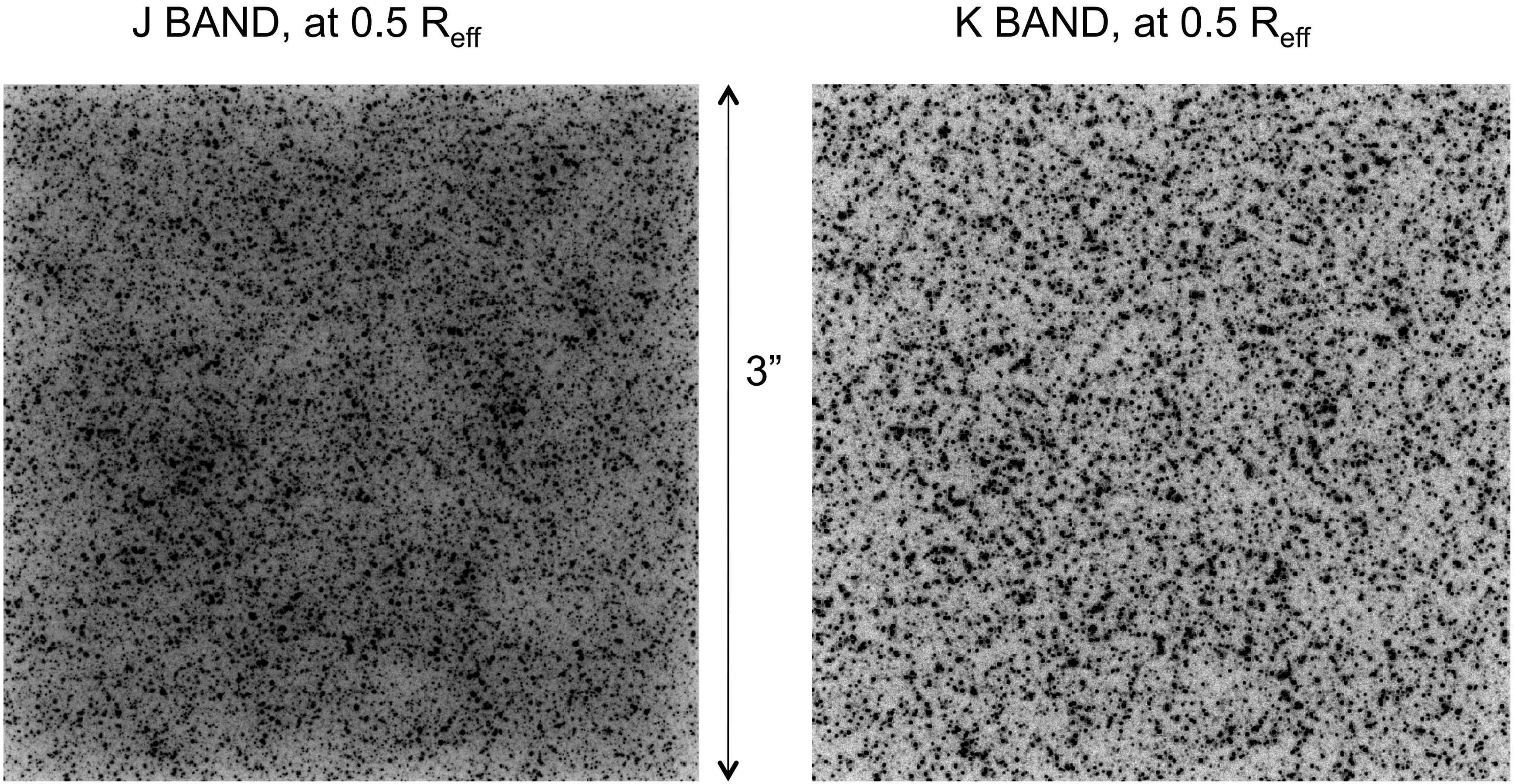
One can simulate stellar fields (stellar list in input), or extended objects (μ distribution in input, or template)







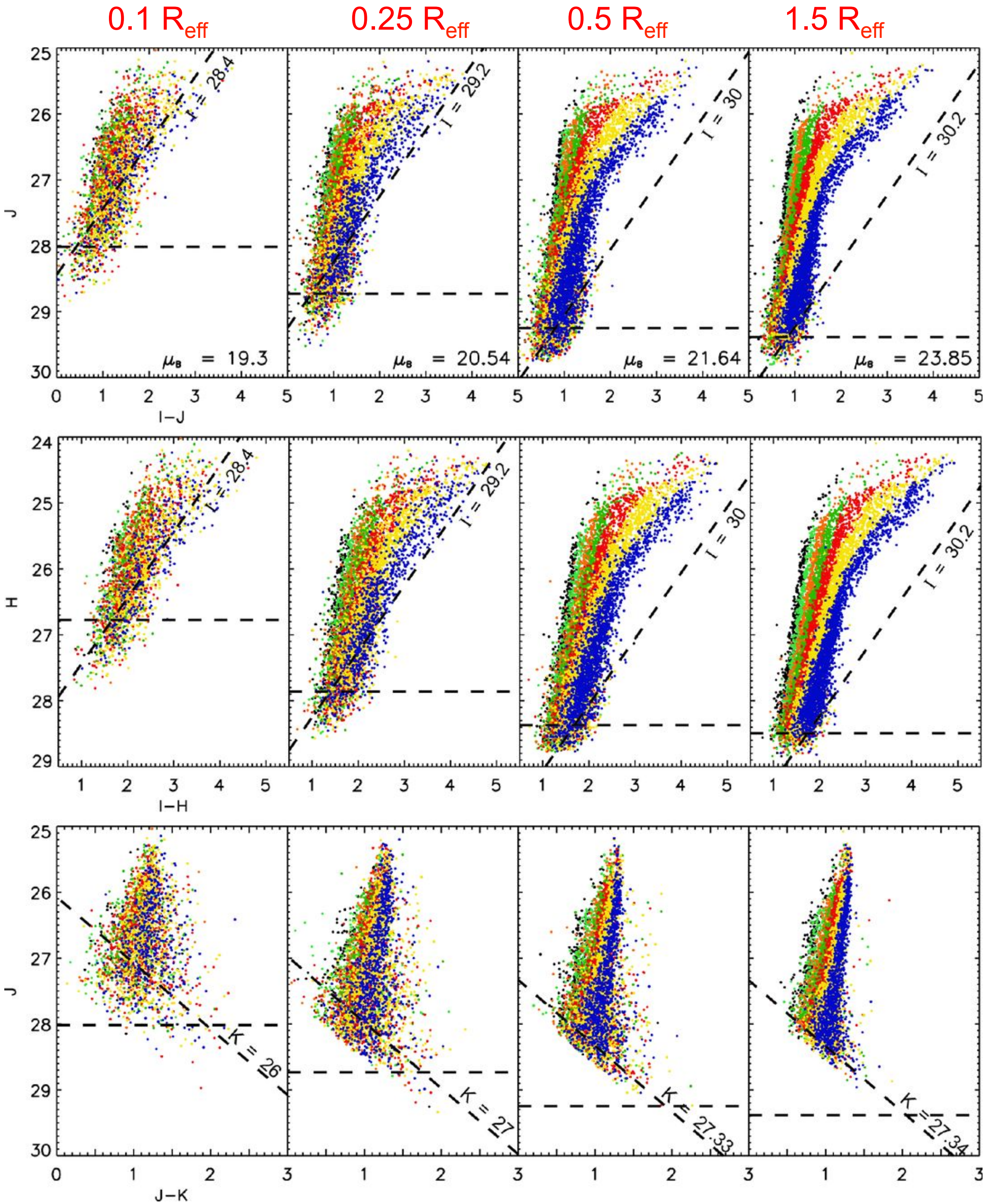
input PSF:
center of FoV, with 0.6 arcsec seeing
1” x 1” J-band images with t_exp= 2 hrs at :
0.1 R_eff
0.5 R_eff
1.5 R_eff

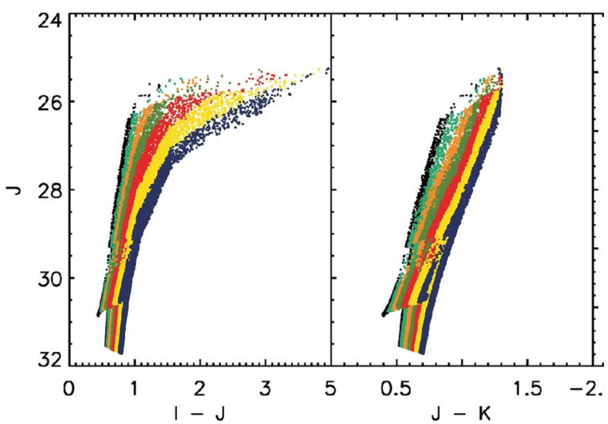

J BAND, at 0.5 R_eff
K BAND, at 0.5 R_eff
3”

Images produced in I, J, H, and K bands

PSF photometry with Starfinder

Identification of output stars via positional comparison with input star list, so that metallicity is assigned to each output star

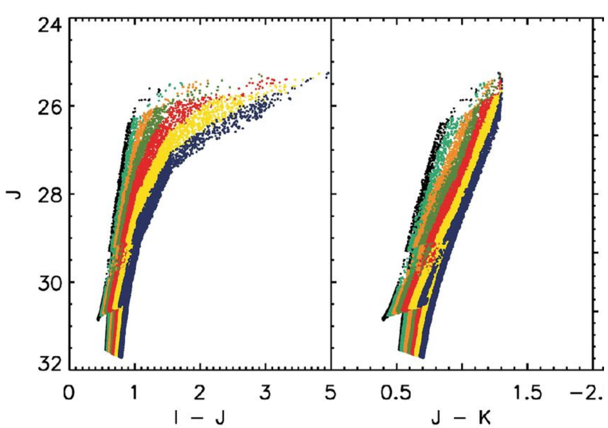


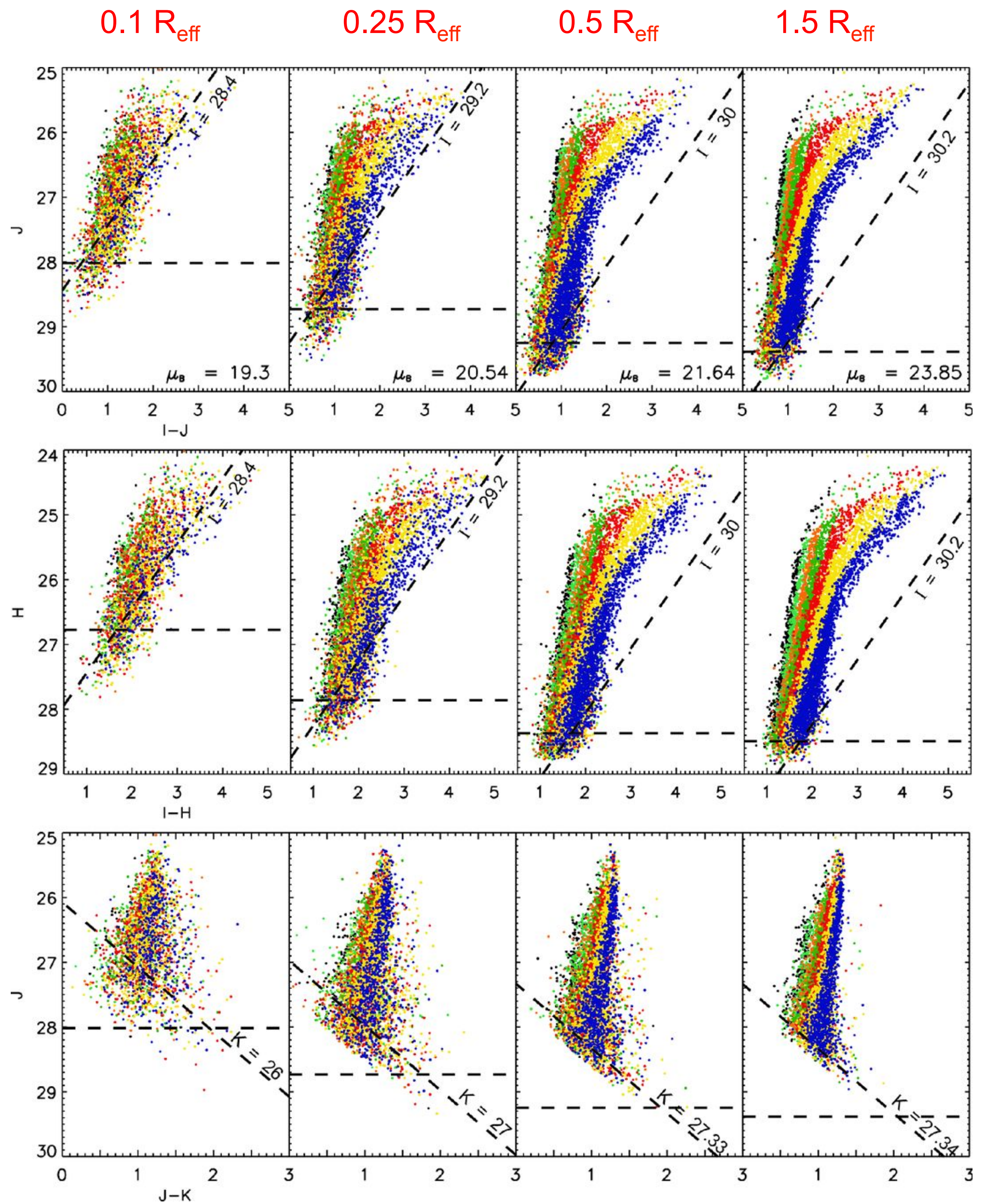


The lower the surface brightness the deeper and more accurate the photometry.

Metallicity bins are clearly separated at R > 0.5 R_{eff}, very confused in the center.

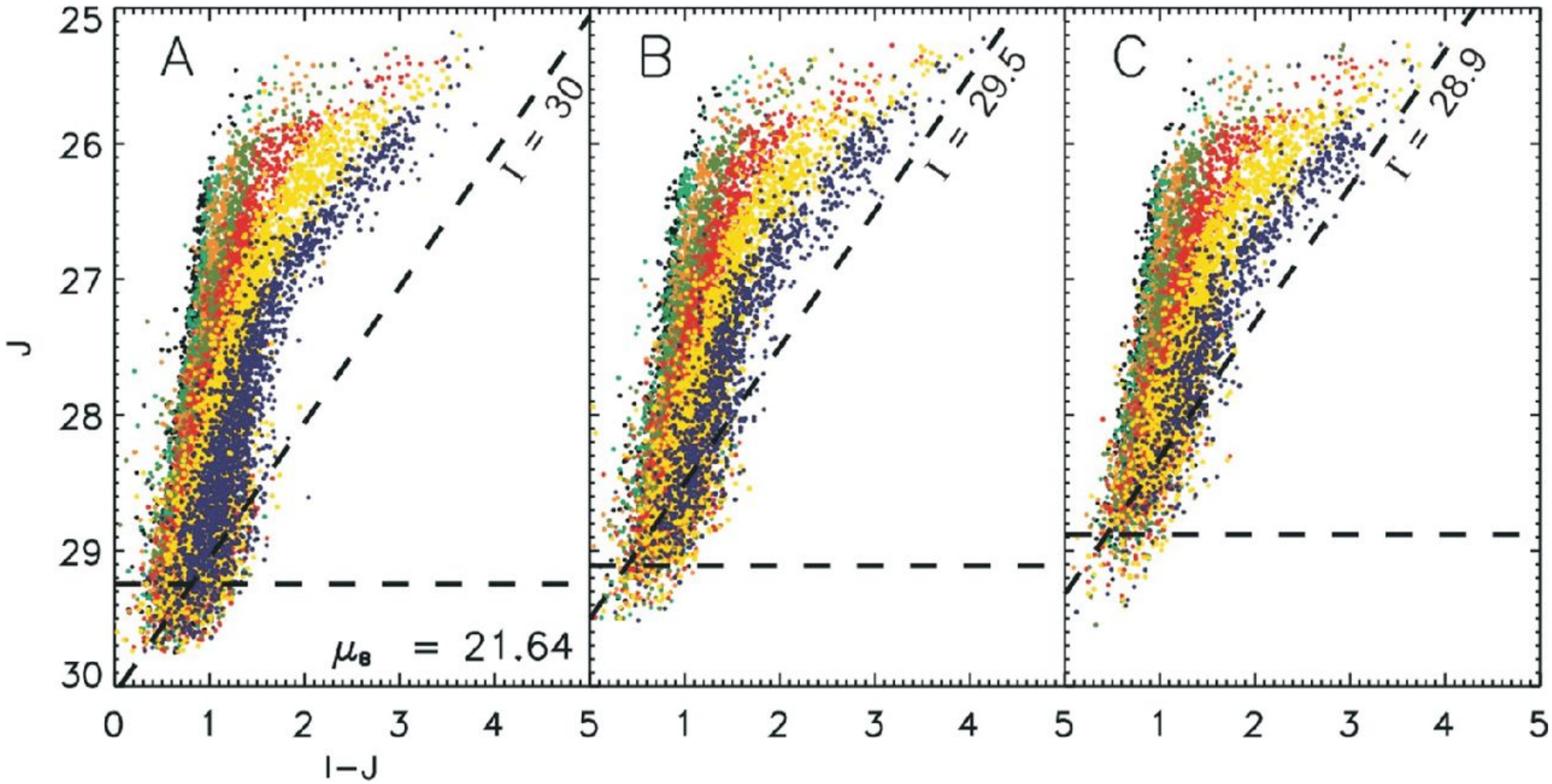
To recover the metallicity distribution, the I-J (I-H) diagrams are much better suited than the J-K diagram.





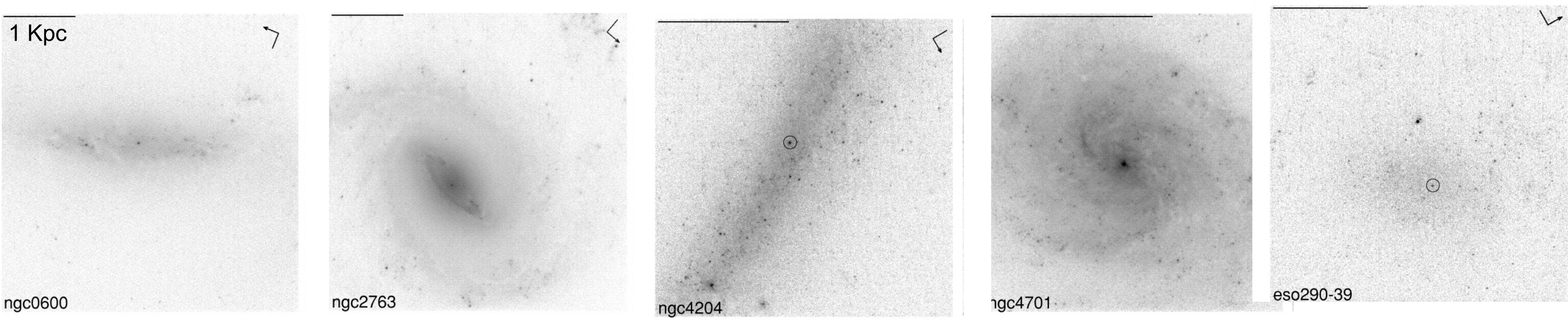
Case	PSF position in the FoV $(X;Y)''$	seeing	SR I band	SR J band
A	$(0;0)''$	$0.6''$	0.06	0.22
B	$(23;19.3)''$	$0.6''$	0.042	0.17
C	$(0;0)''$	$0.8''$	0.03	0.16

case at mu_B=21.64 (EE2); lines show 50% compl. levels



Science Case: Resolved Stellar Populations in Nuclear Star Clusters

Boker+, 2002 : WFPC2 images in F814W of 77 late type galaxies, the great majority shows a NSC



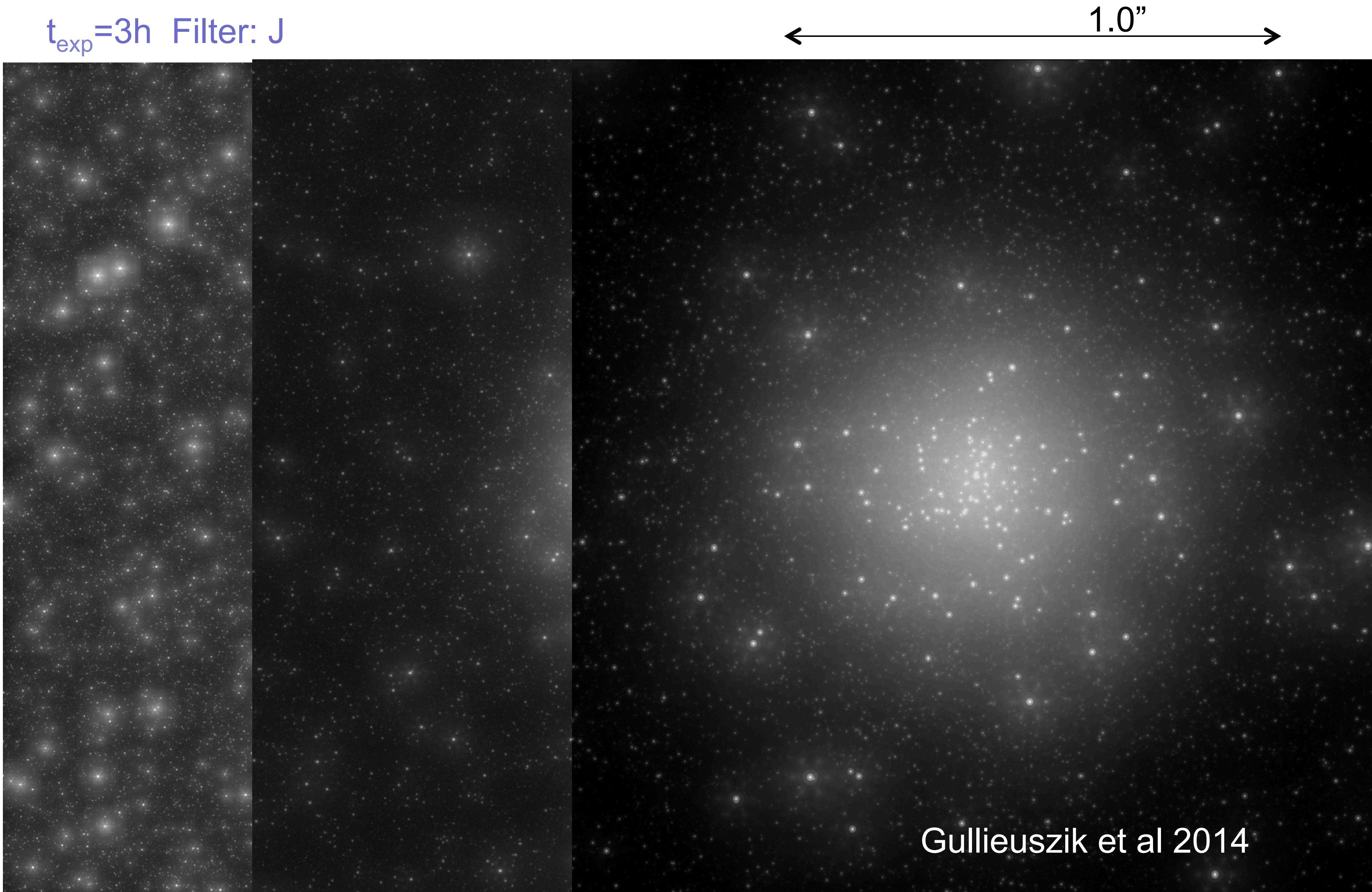
NSCs are compact objects (R ~ 2 - 4 parsec)
Massive and Bright (~3 mags brighter than galactic globular clusters)
Found in ~ 70% of galaxies of any type
They follow the same scaling relations of SMBHs
Is there a relation between the NSC formation and the evolution of the SMBH?
Did the NSC form from pre-existing GCs, or from gas which underwent SF?
We need to analyze their stellar population and recover their SFH

NGC 300: a spiral at a distance of ~ 2 Mpc hosting a NSC

E-ELT simulation of NGC 300 core:

a Zo, 1 Gyr old SSP at a distance of 2 Mpc, follows a King profile with r_c=0.095”, r_t=2.87”
superimposed on a disk SP with μ_B=20.4 mag/arcsec^2

t_{exp}=3h Filter: J

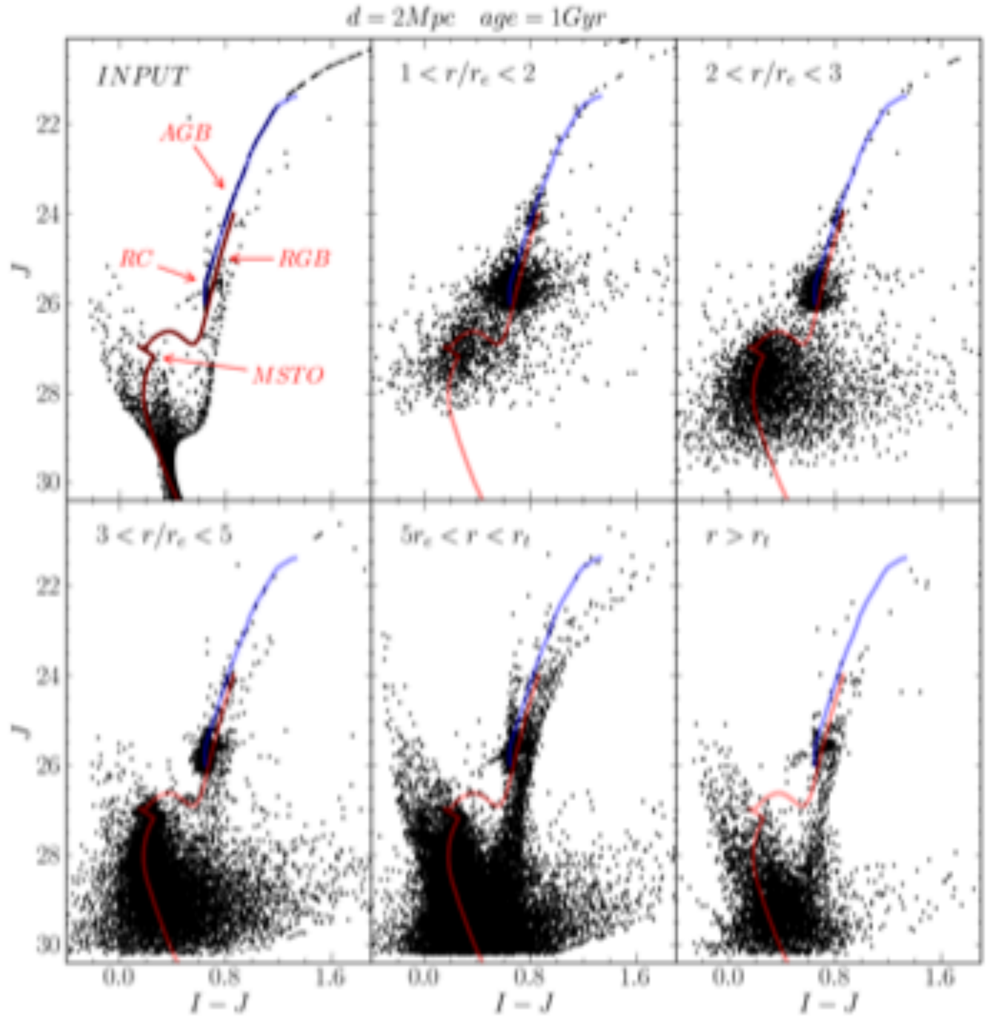


Photometry with Starfinder

CMDs of objects detected
at different locations

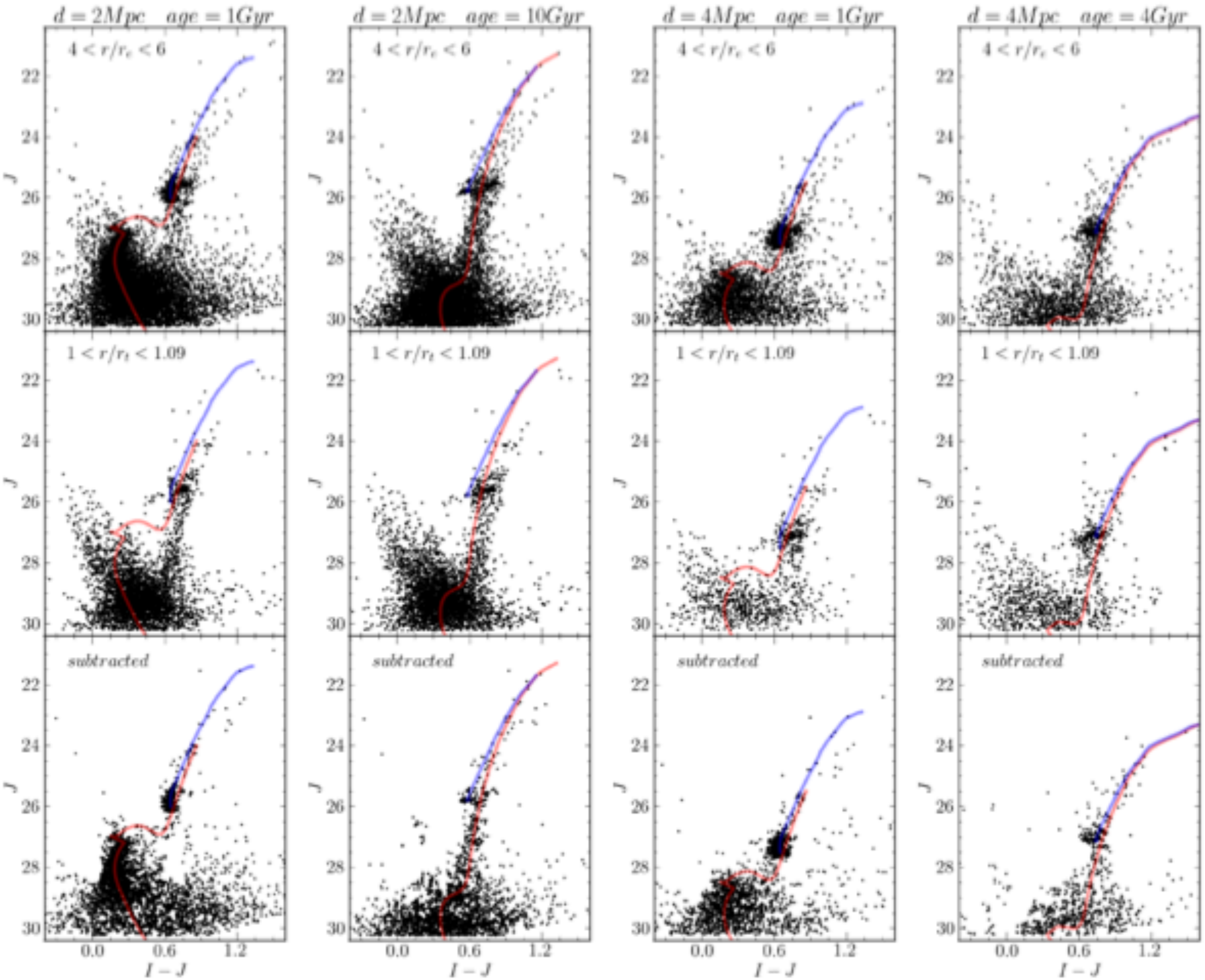
The central parts are dominated
by the cluster population,
but the CMD is highly incomplete
The outer parts are dominated
by the field population

The intermediate regions are
characterized by a good
photometry and most of the stars
are cluster members.



τ [Gyr]	Z	N	M_I	M [$10^6\ M_\odot$]
1	0.019	4×10^5	−11.3	1.1
4	0.019	4×10^5	−10.3	1.2
10	0.004	5×10^5	−10.4	2.0

at D=2 and 4 Mpc



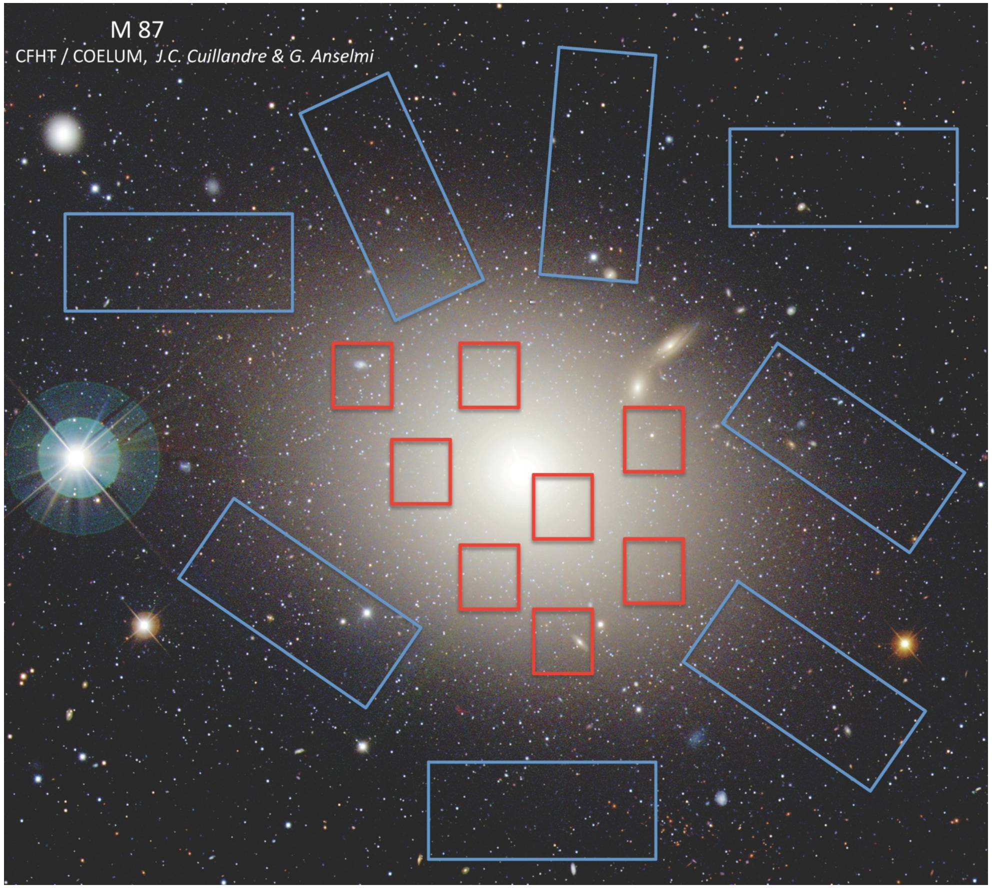
Applying statistical subtraction of the host galaxy stellar population:

old MS TOs can be detected out to ~ 2 Mpc

young MS TOs out to ~ 5 Mpc

To conclude:

the exceptional resolution will open to the exploration of the very crowded inaccessible portions of galaxies, enabling detailed studies of the SFH in those regions where most of the action takes place



these studies require accurate photometry over a long wavelength baseline

we need at least one optical filter and we need a sharp, well sampled, and stable PSF