Imaging with Micado at the E-ELT

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WORKSHOP: Imaging at the E-ELT

29 May 2009, Garching

Resolved stellar population in Virgo (high SB)

Detailed View of high redshift galaxies

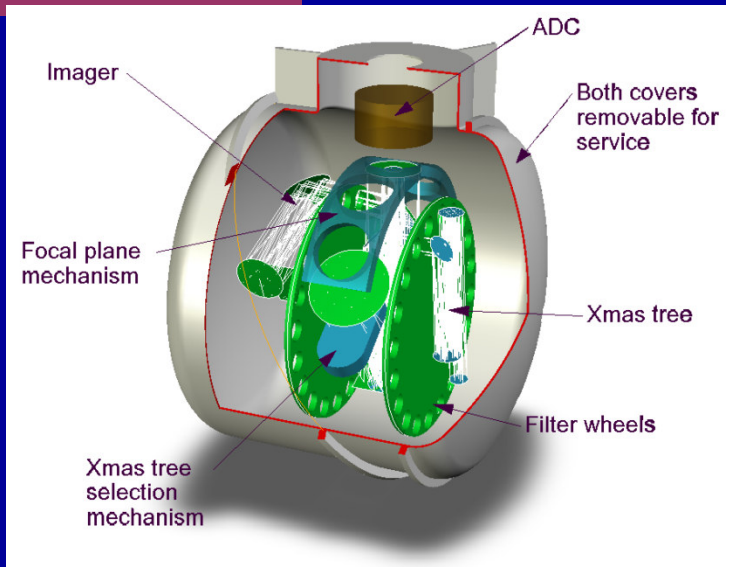
MICADO - Main characteristics

Wavelength range :	(0.6)-0.8 to 2.5 mic	I, Y, J, H, Ks
Field of View	: 53 x 53 arcsec	
Pixel scale	: 3 mas	
PSF	: FWHM 6(J) , 10(Ks)	mas
	: Strehl 0.015(I) 0.13(J)	0.47(Ks)
	: EE(10mas) 0.10(J)	0.22(Ks)

Overall Throughput

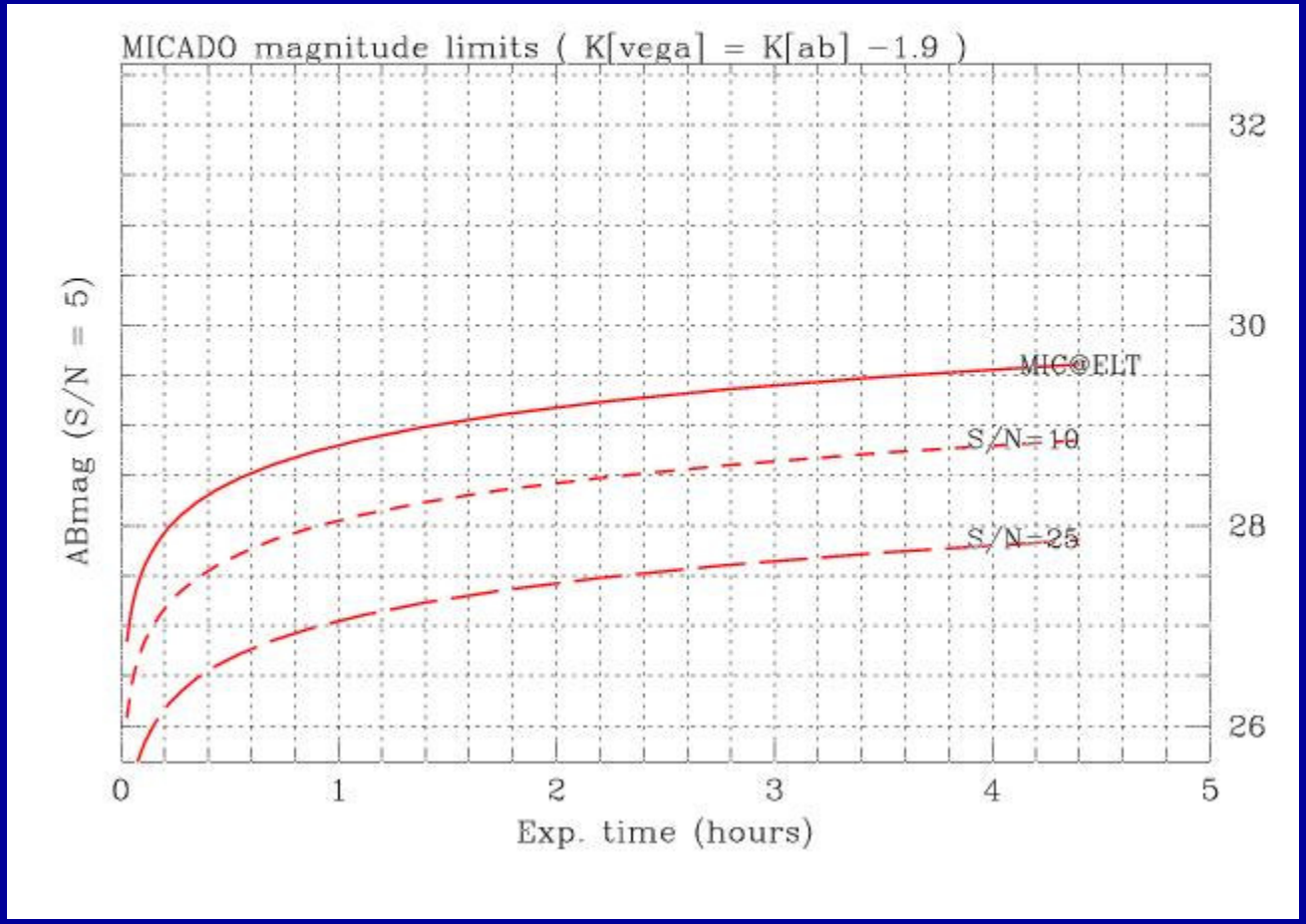
40 %

Telescope + instrument + detector



MICADO - Expected performance

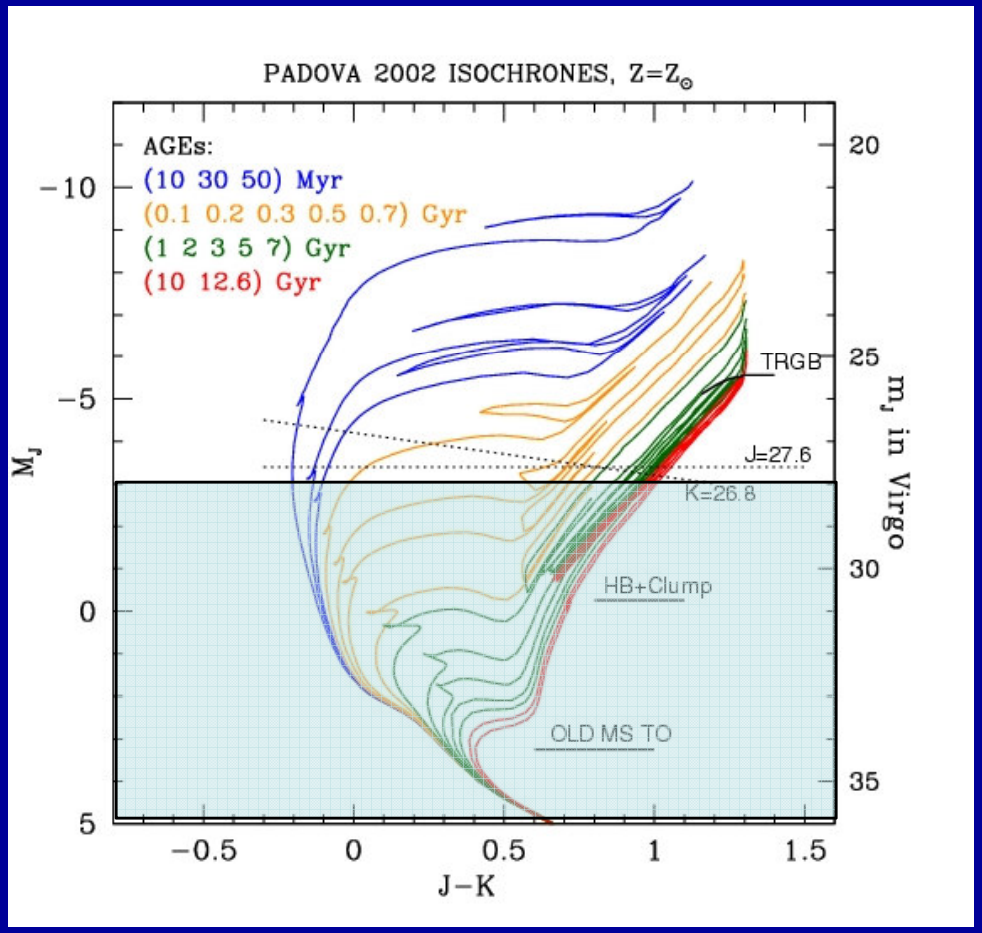
AB mag limits for isolated point sources



J(AB) = 30 in 5h (S/N=5)

K(AB) = 29.5 in 5h (S/N=5)

Resolved Stellar Populations in Distant Galaxies



SFH from analysis of stellar distribution on the CMD using stellar evolution theory

Best diagnostic from MS TOs where different luminosities sample different stellar ages, but old TOs are very faint

Old SPs can be sampled on the bright RGB, at ~ 7 mags brighter, a gain in volume of a factor of ~ 15 10^6

SCIENCE CASE FOCUSSES ON DERIVING SFH FROM THE INTRINS. BRIGHTEST PORTION OF THE CMD

Probe as much as possible distant SP

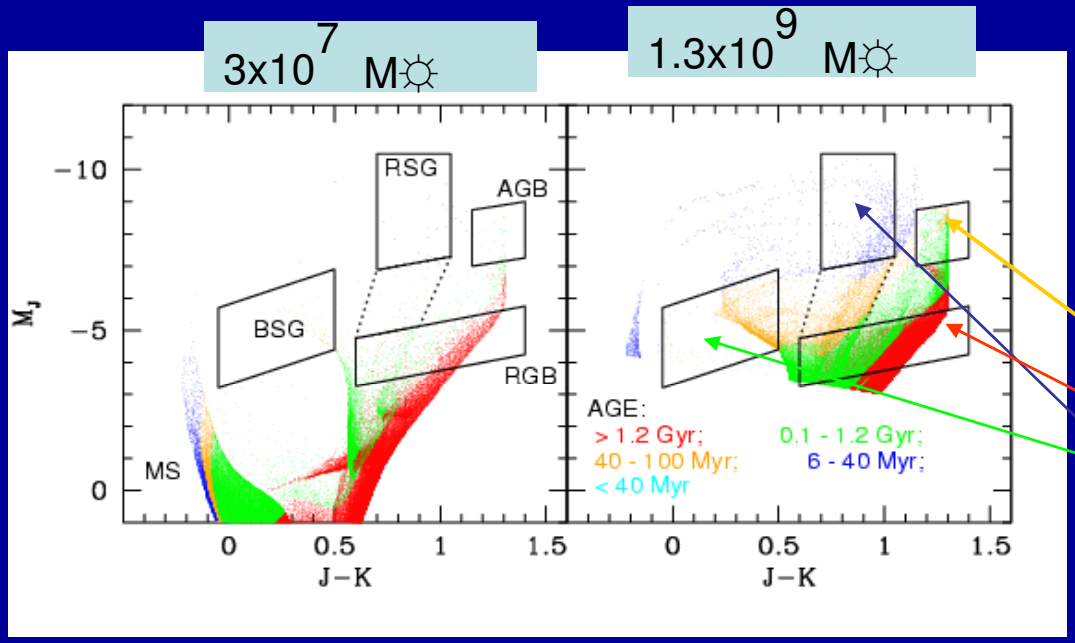
The Goal of Resolved Stellar Populations

VIRGO cluster (DM = 31)

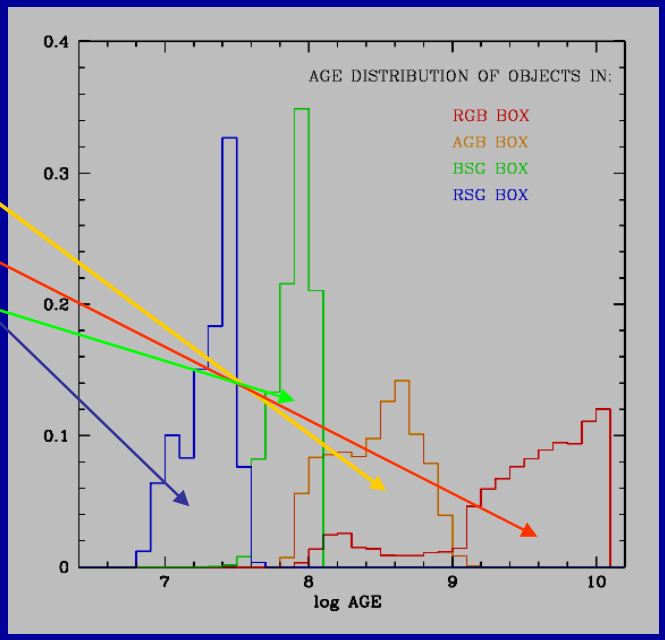
The closest rich cluster of galaxies

THE METHOD

Simulation of a Stellar Population with ages between 0 and 12 Gyr
and metallicity between 0.02 and 1 times solar (IMF by Kroupa)
Code ZVAR (Bertelli et al. 92 + updates)



Selected Areas in the CMD in order to:
- Sample specific AGE ranges
- Minimize effects of photometric errors
- Include enough objects for statistics



In each area: $N_{box} = \delta_{box} \times M(\Delta\tau_{box})$

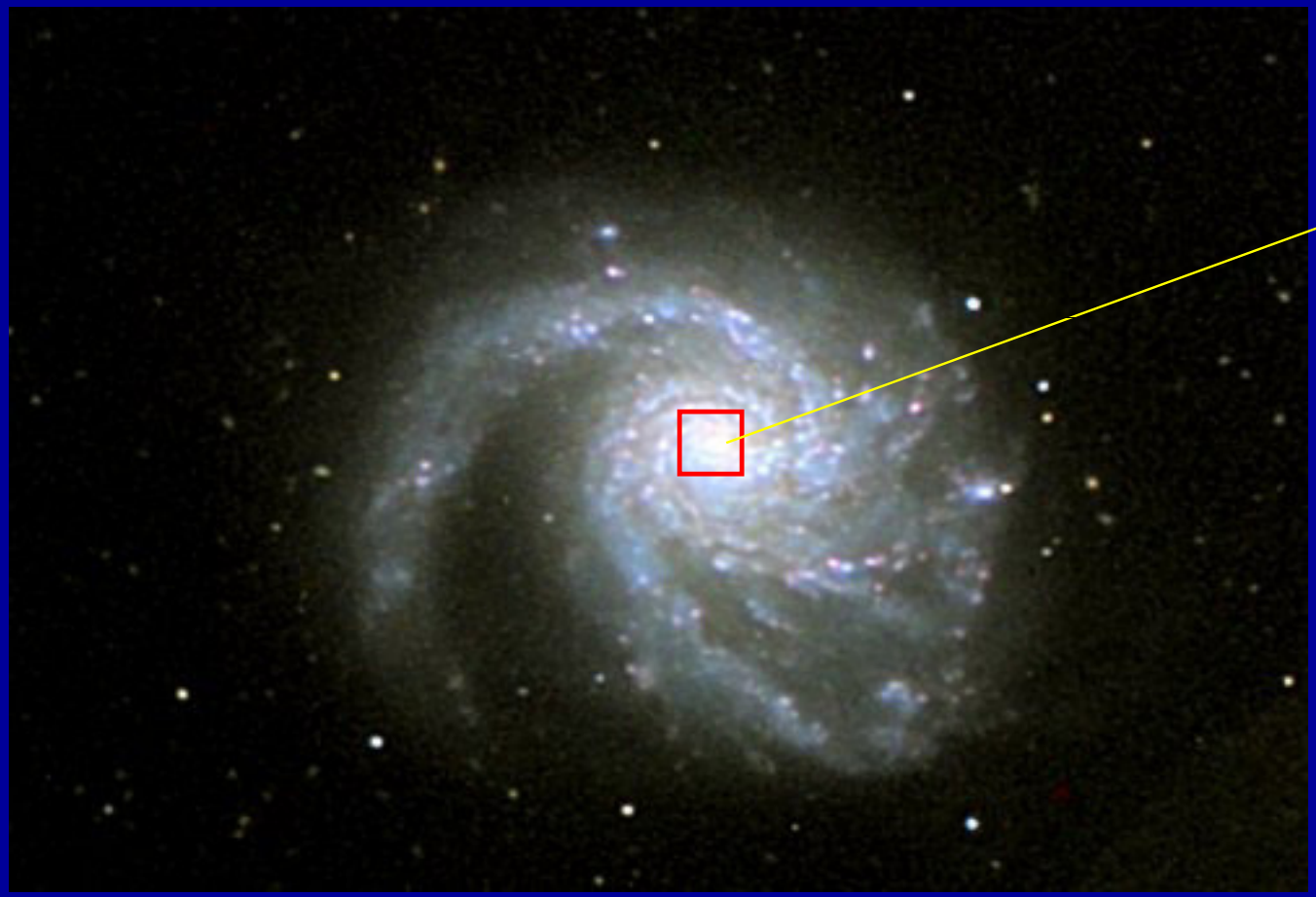
from Stellar Evolution
Greggio 2002, ASPC 274 444

Counting stars in selected boxes
GIVES STELLAR MASS IN THE SPECIFIC AGE RANGE

MICADO - The science case

AETC

Simulation and testing: possible observation



M99 spiral galaxy in Virgo cluster

MICADO - The science

Resolved stellar population in distant galaxies

Simulation and testing

Stellar population : constant SFR (Age 0 to 12 Gyr)

FoV = 3x3 arcsec (0.003 x FoV)

Distance module = 31 (Virgo cluster)

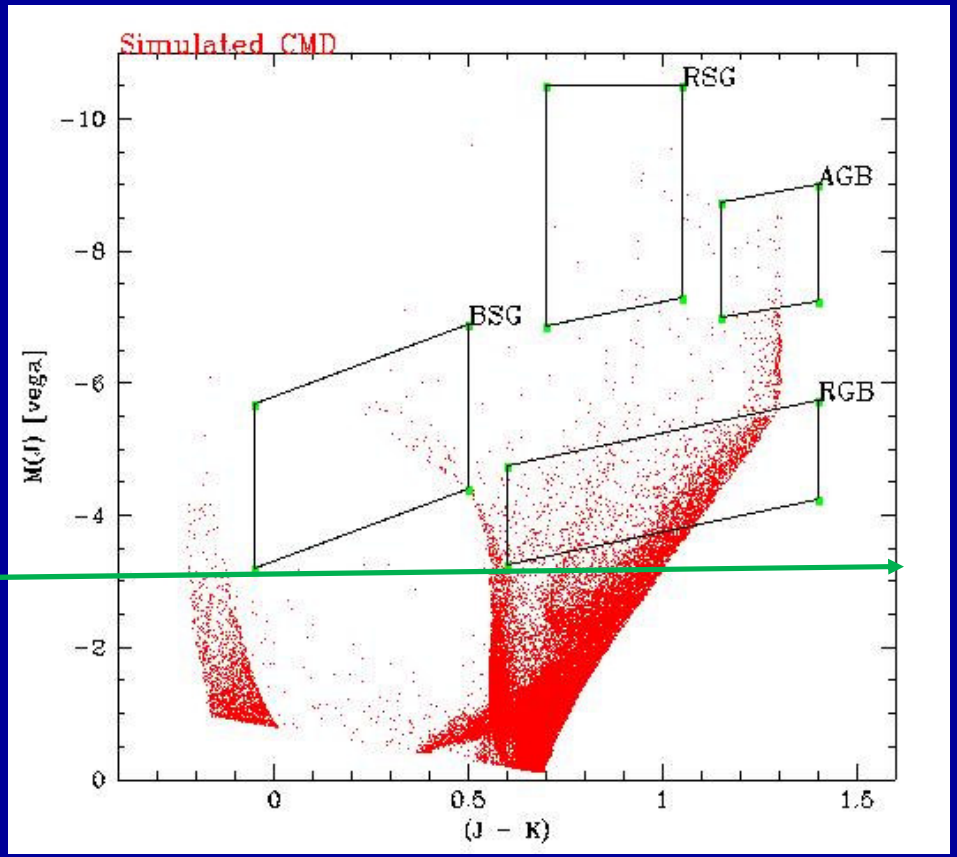
All stars with M(J) < -3.5 (Vega mag)

Case A

70000 stars

Average SB : μ(K) ~ 18

J(AB) <28.5



MICADO - Expected performance

Instrument parameters

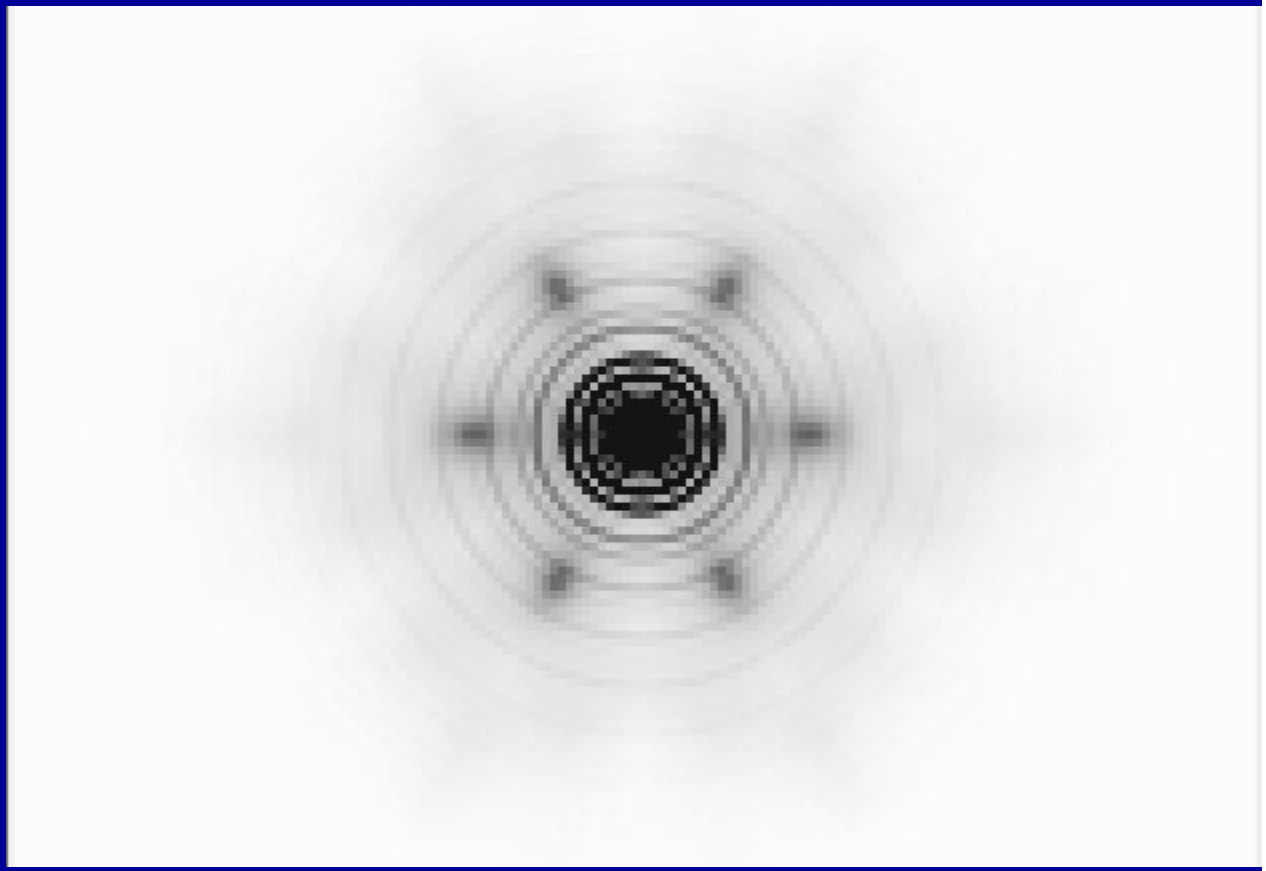
Collecting area	m^2	1360
Telescope throughput		0.7
AO throughput		0.80
Instrument throughput		0.60
Total throughput		0.35
read out noise	e-	5
instrumental background	e-/s	0.1
pixel size	mas	3

MICADO @E-ELT - Simulation

AETC

Simulation and testing: NEW Maory PSF

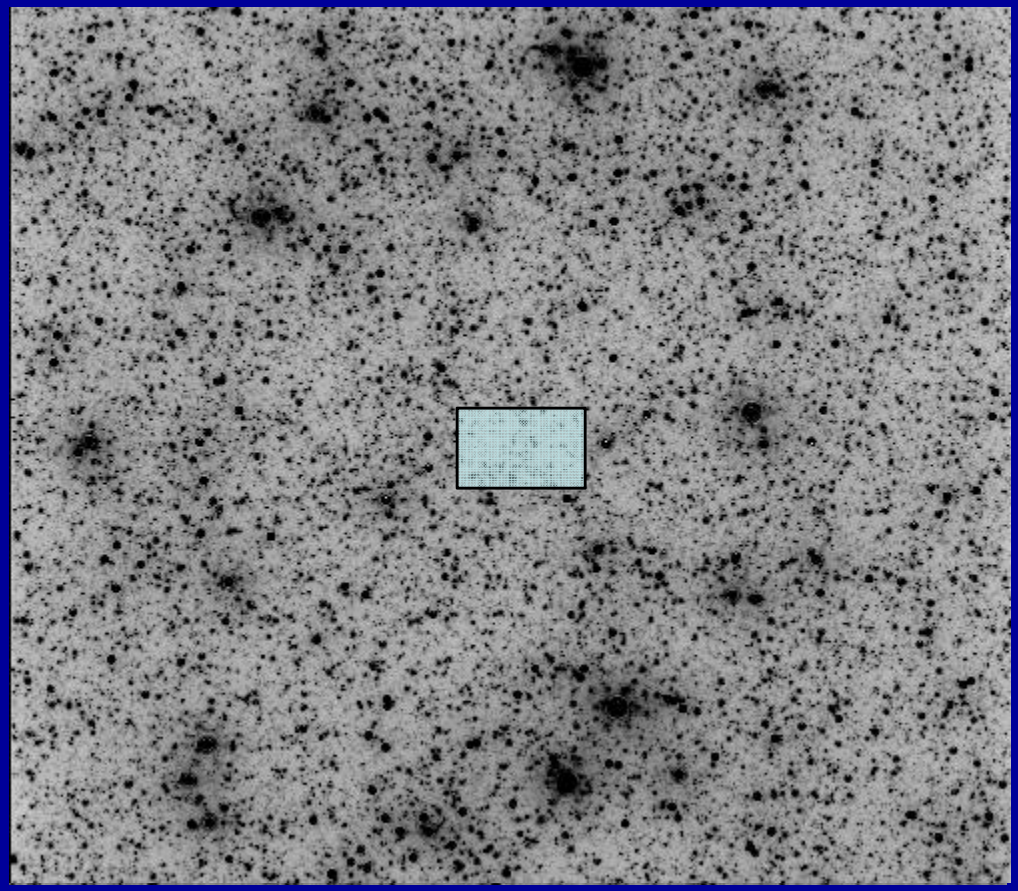
- Six LGS
- Seeing 0.6 arcsec
- J 2.98 mas
- K 5.3 mas
- SR = 0.6 (K)
- Central 3 arcsec (constant PSF)



MICADO @E-ELT - Simulation

Resolved stellar population in distant galaxies

Simulation and testing: Maory PSF



70000 stars

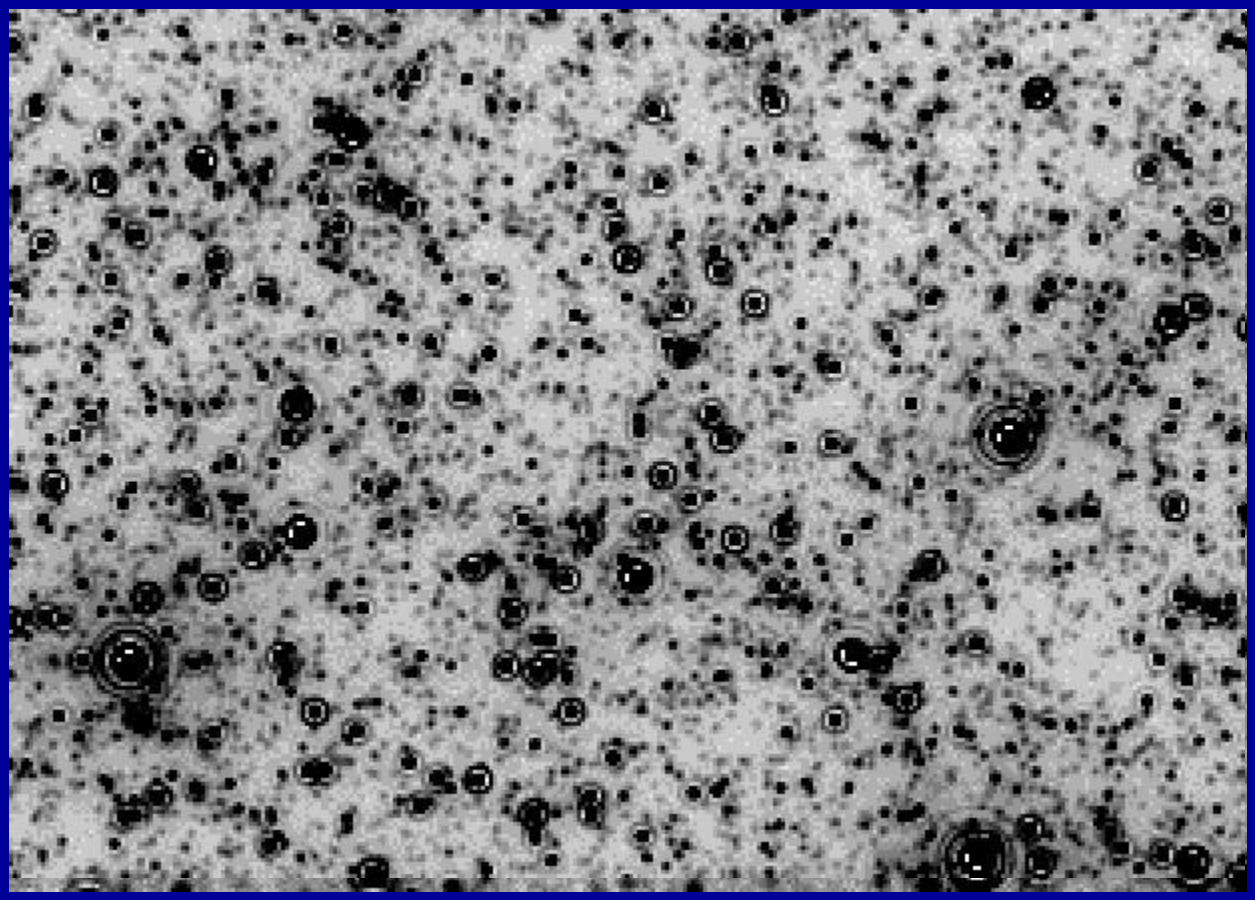
FoV = 3x3 arcsec

MICADO : J filter – 5 h

MICADO - The science

Resolved stellar population in Virgo galaxies

Simulation and testing: Maory PSF



Central FoV 0.9x0.6 arcsec

MICADO : J filter – 5 h

MICADO@E-ELT - Simulation

Simulation and testing : Photometric analysis

Comparison of simulated vs *observed* data

Photometry performed by L. Bedin @ STScI without any knowledge of the simulated data

RESULTS:

- Catalogue of detected objects
- X, Y positions
- magnitude in J and K bands
- photometric additional parameters
- analysis NOT yet optimized

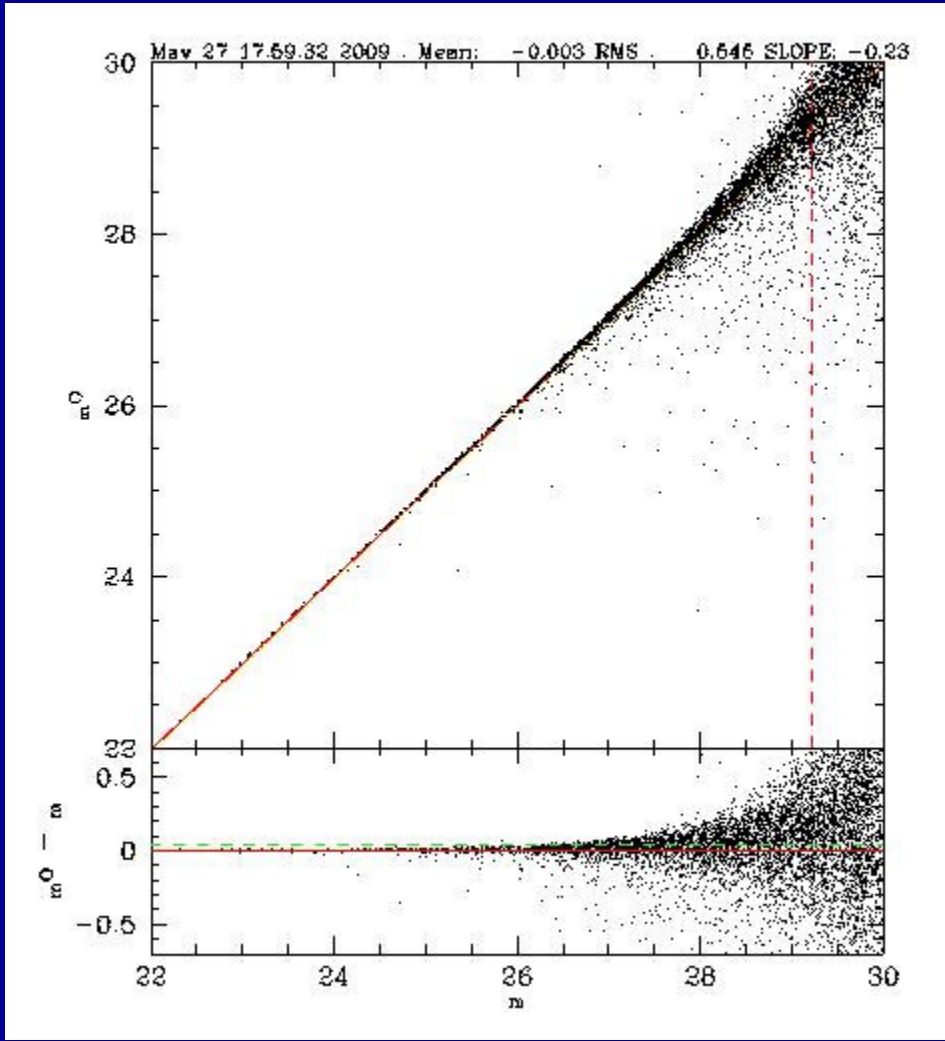
MICADO@E-ELT - Simulation

Simulation and testing : Photometric analysis

by L. Bedin @ STScI

Comparison of simulated vs observed magnitude

K band



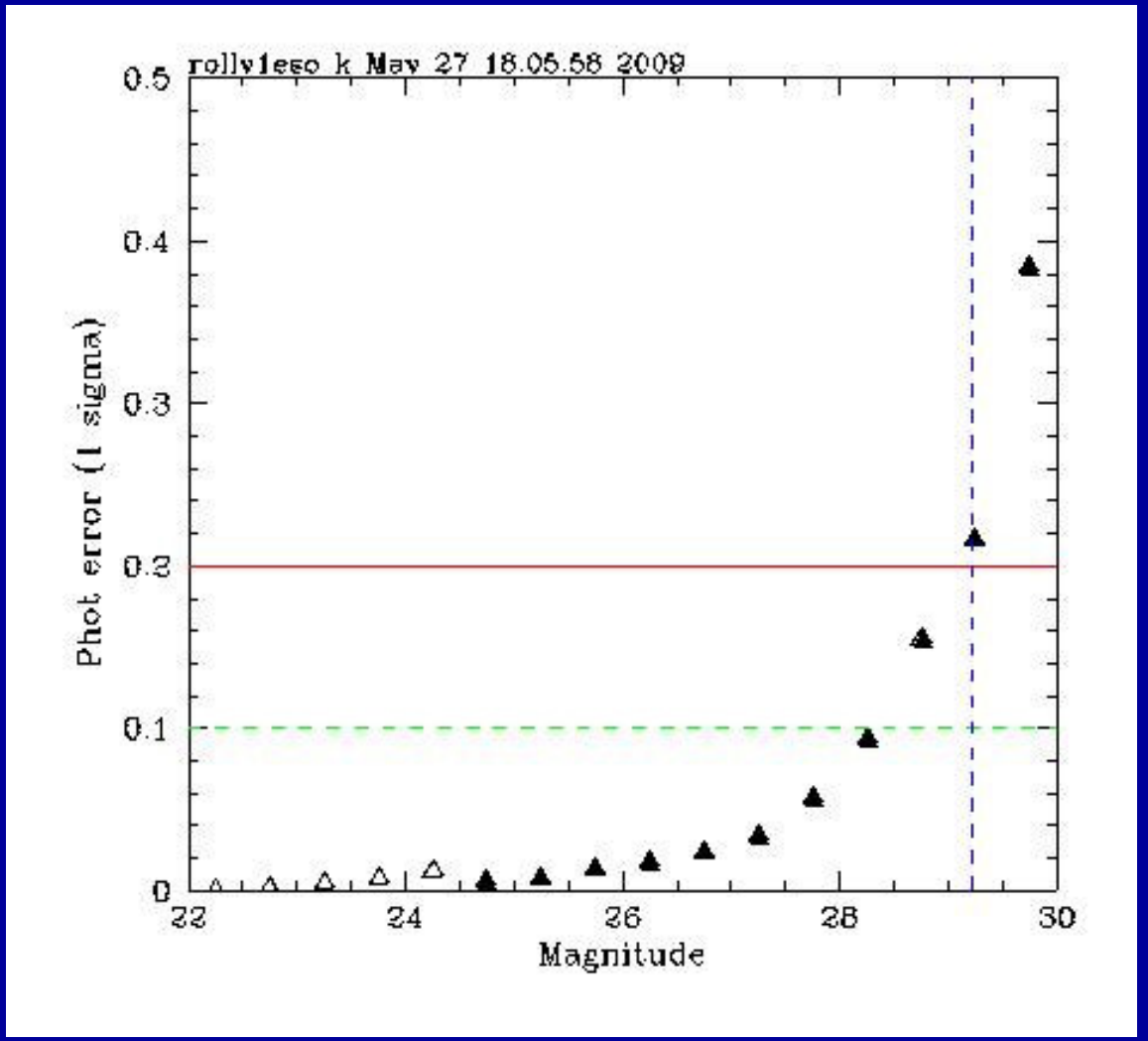
MICADO@E-ELT - Simulation

Simulation and testing : Photometric analysis

Photometric accuracy

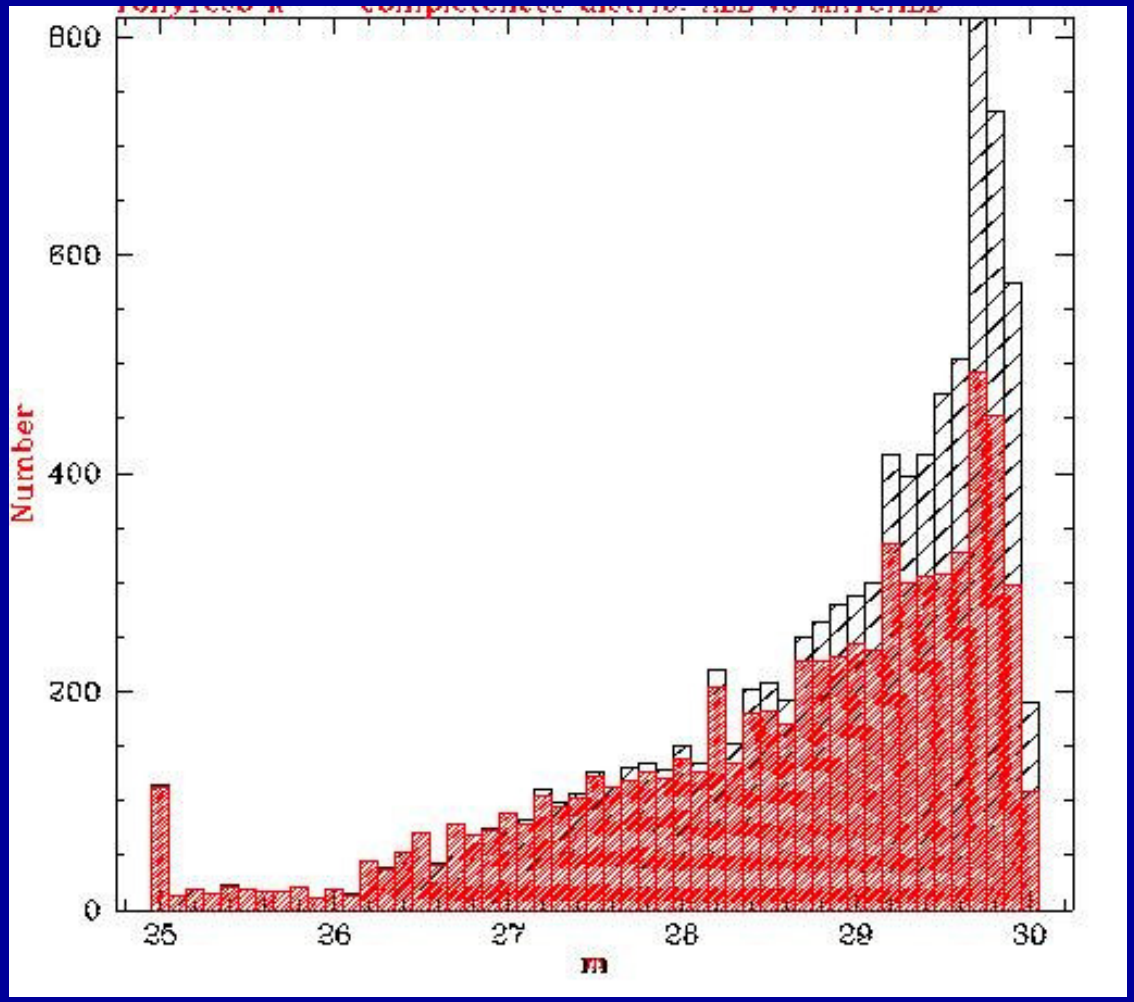
< 0.1 mag

for J<28.5



MICADO@E-ELT - Simulation

Simulation and testing : Photometric analysis



Completeness

Completeness

> 90% up to

J(AB) ~ 28.5

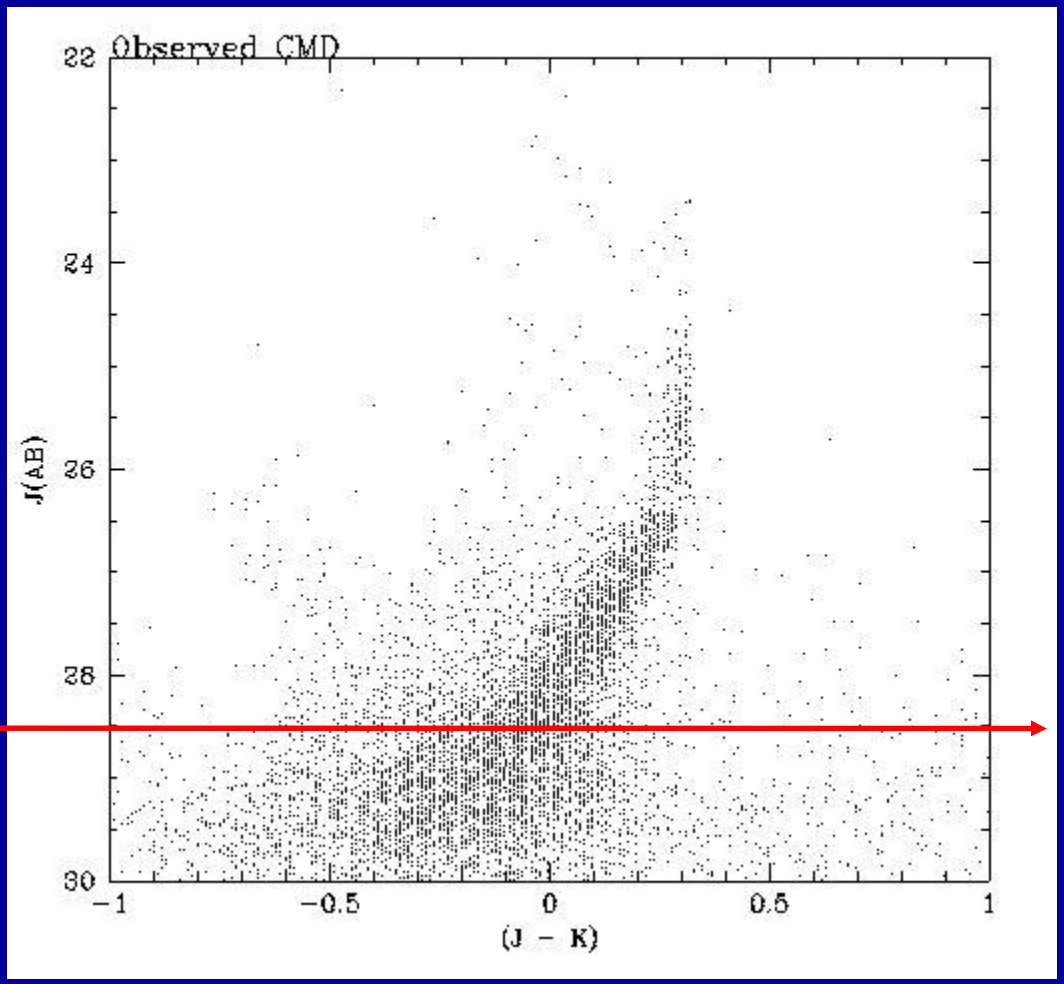
> 70% up to

J(AB) ~ 29.5

MICADO@E-ELT - Simulation

Simulation and testing : Photometric analysis

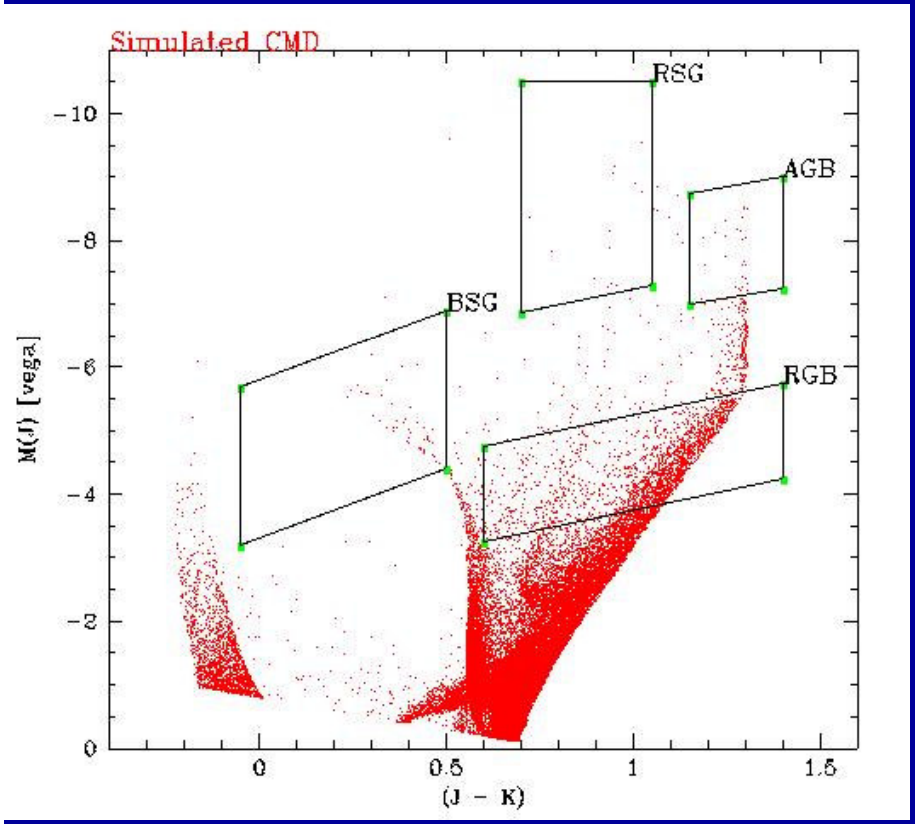
Calibrated observed CMD from macthed stars

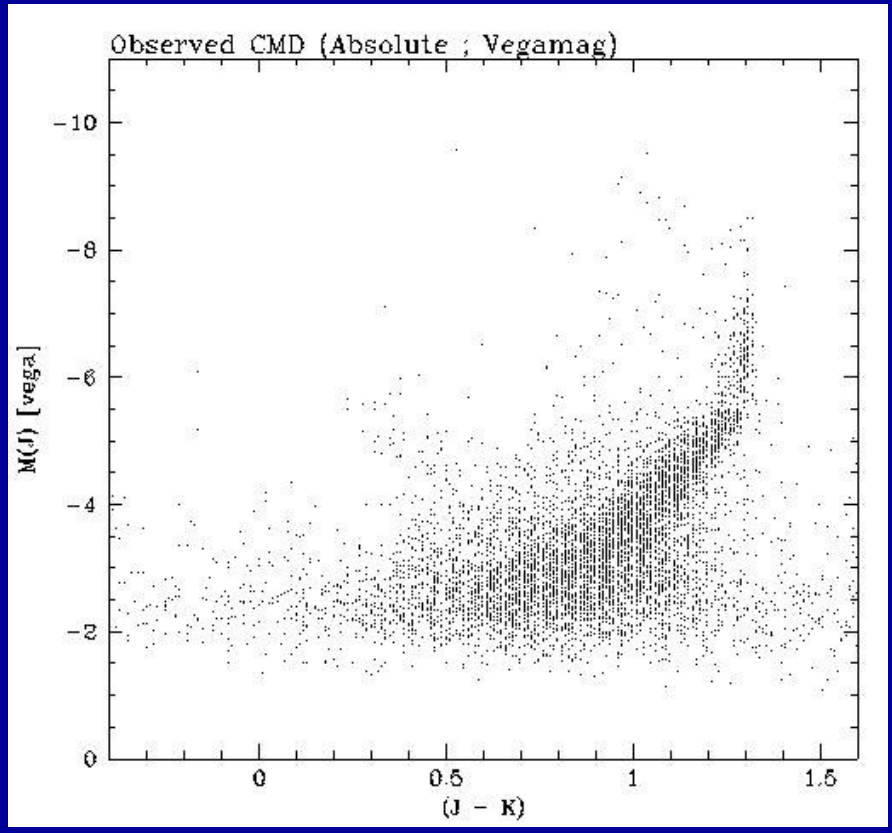


J(AB) <28.5

MICADO@E-ELT - Simulation

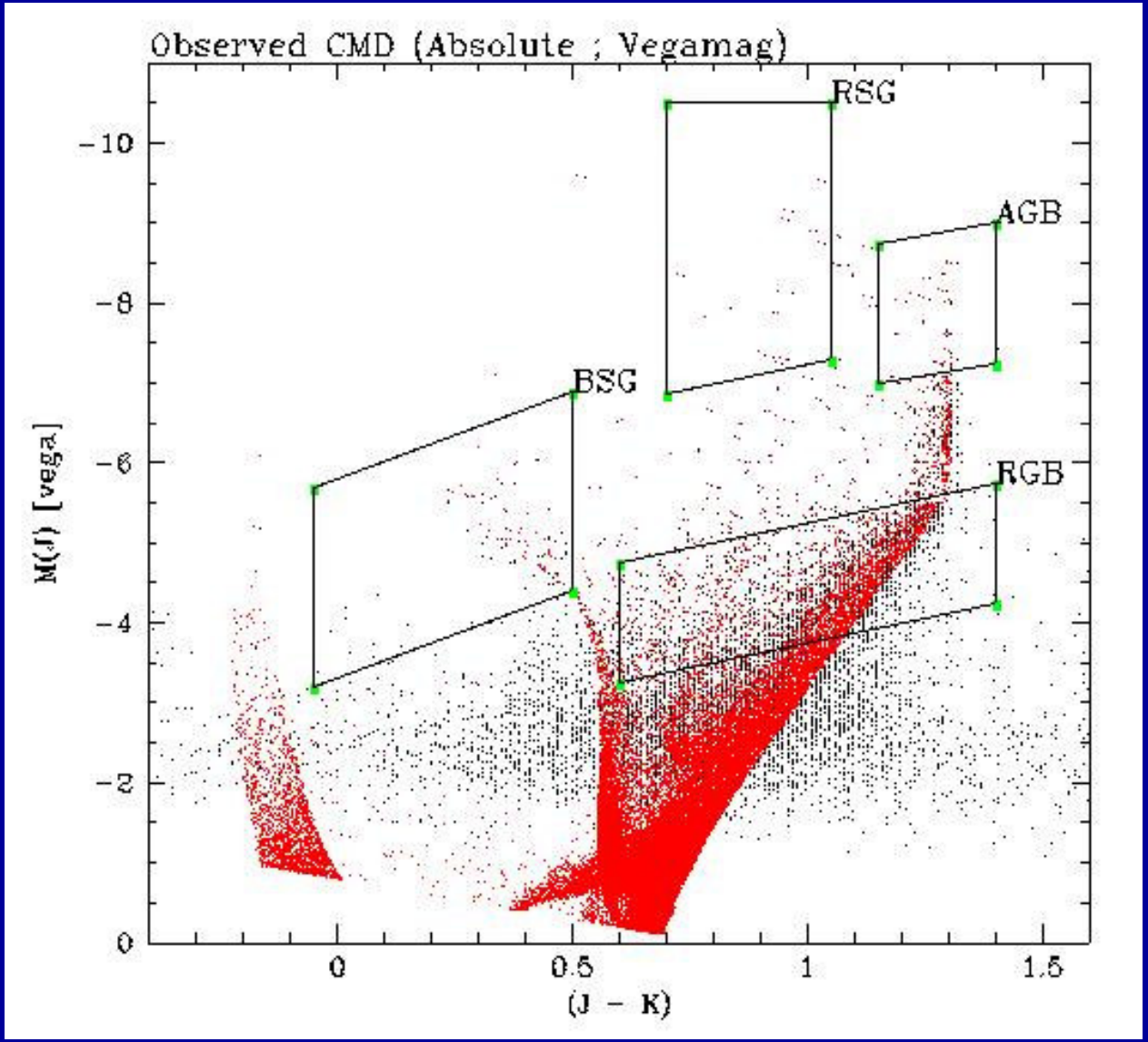
Simulation and testing : Photometric analysis





MICADO@E-ELT - Simulation

Simulation and testing : Photometric analysis



MICADO@E-ELT - Simulation

Simulation and testing : Photometric analysis

Recovering the stellar mass in selected boxes

	Simulated	Observed	Difference%
RSG	13	13	0
BSG	49	61	+25 %
AGB	26	26	0
RGB	1901	1828	-4 %

Full numbers are x 300
since this is a small fraction of Micado FOV

Near-IR images by MICADO @ E-ELT are able to determine the STELLAR MASS of different populations in galaxies of the Virgo cluster

NIR Imaging Camera in the next decade

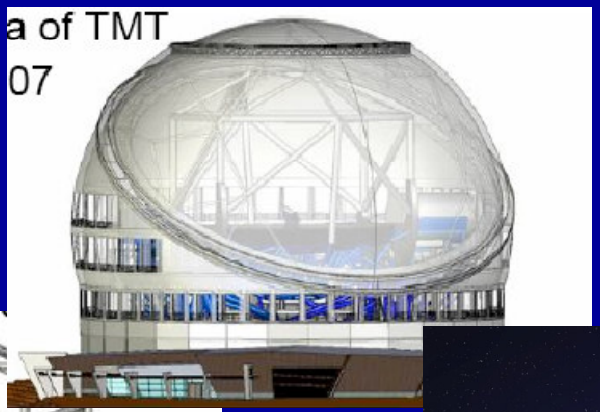
MICADO @ E-ELT (42m)

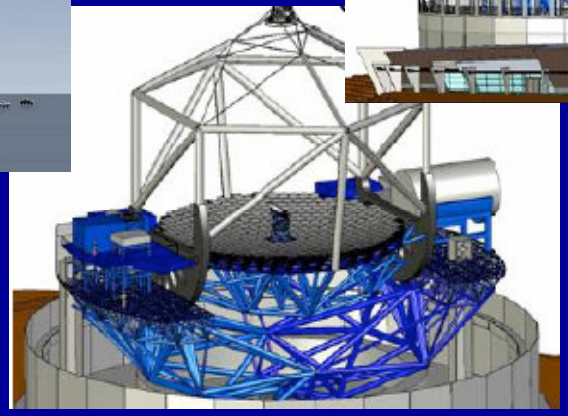
WIRC @ TMT (30m)

NIRCam @ JWST (6m)

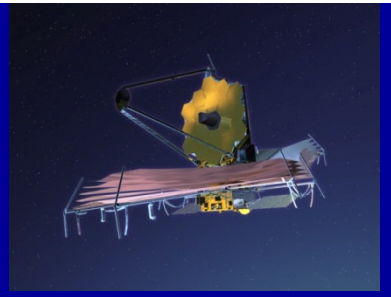
Imaging @ GMT

E-ELT (OWL)





NIRCam - JWST



Main properties

Main mirror (JWST): 6.5m

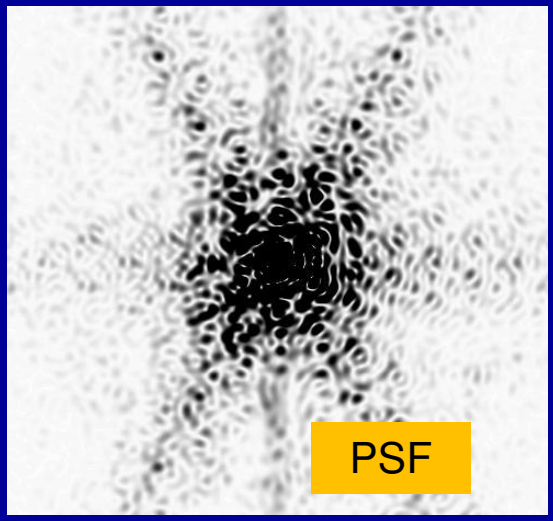
Resolution : 90 mas (K)

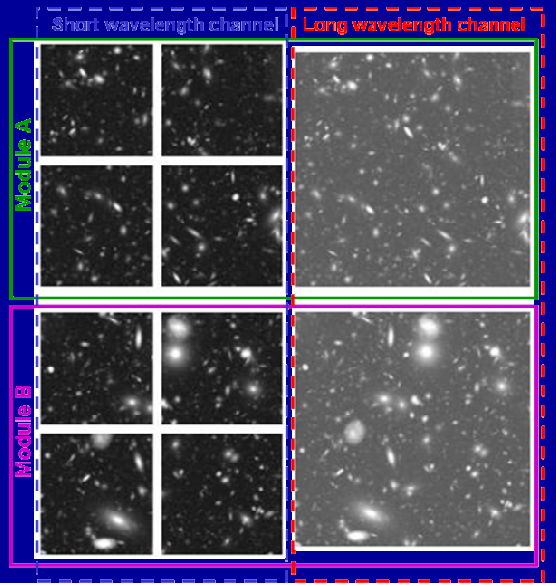
Platescale : **0.0317 "/pixel**

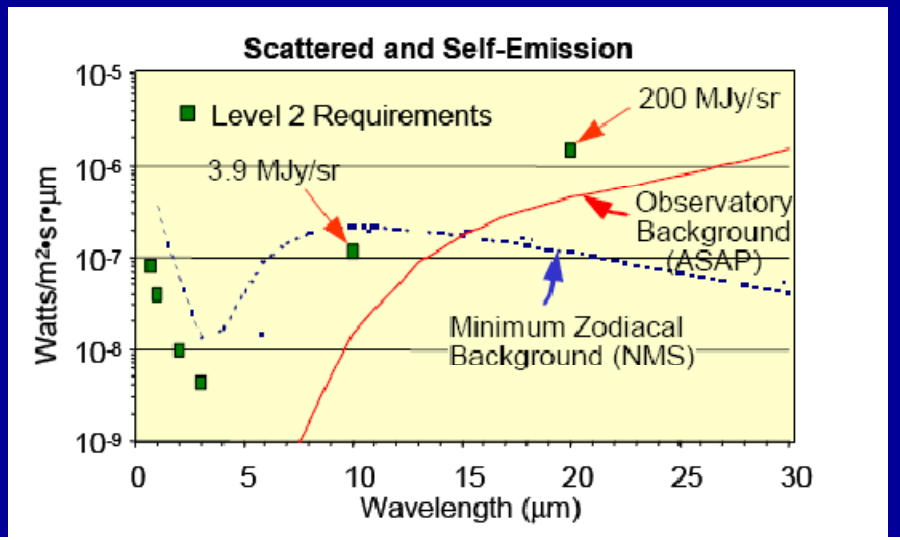
FoV : 2.3‘ x 4.6’

Wavelength range: 0.6 – 5 micron

Background : ~ Zodiacal light







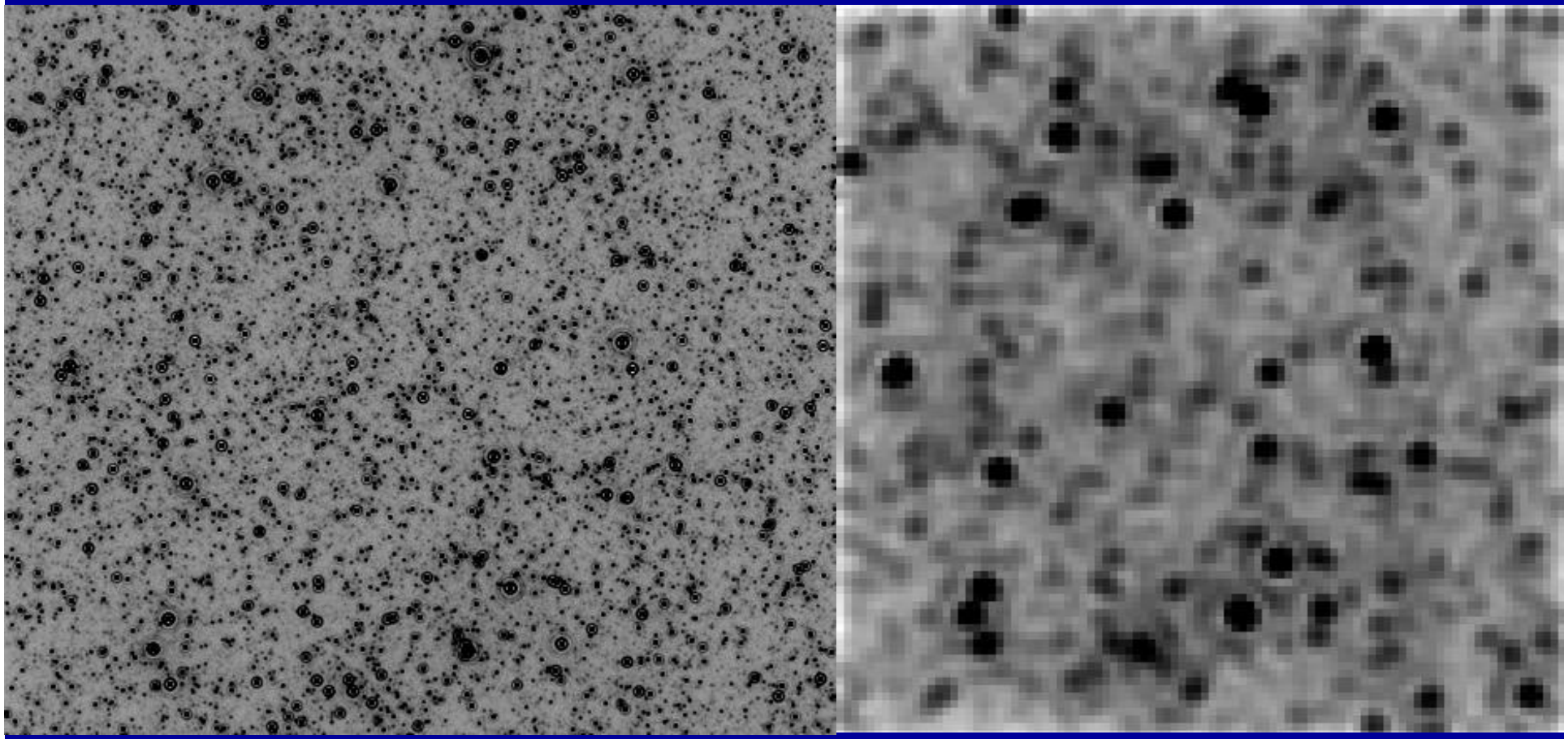
Micado@ELT vs NIRCam@JWST

K filter (2.1 micron)	**MICADO E-ELT**	**NIRCam JWST**
Background (ABmag)	15-15.5	~23
PS Sensitivity (5h; S/N=5) ABmag	29.5 - 30	30 – 30.5
Spatial Resolution (FWHM) mas	~10	90
Field of View arcmin^2	~0.3	~10

The study of stellar populations: Crowding limits

MICADO@E-ELT vs NIRCam@JWST

(K filter, FoV 3x3 arcsec)



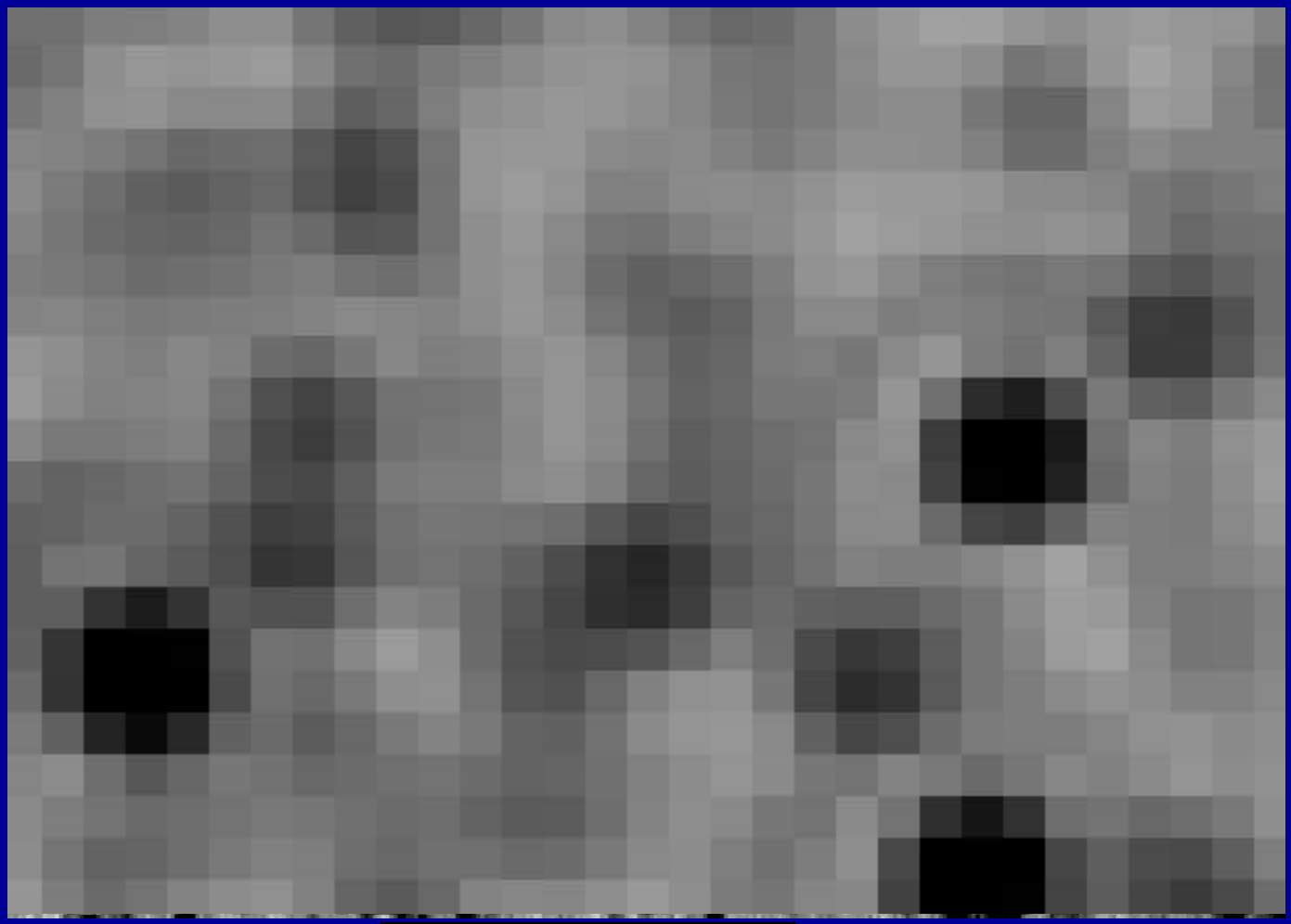
MICADO E-ELT

NIRCam JWST

The study of stellar populations: Crowding limits

MICADO@E-ELT vs NIRCam@JWST

(K filter, FoV 0.9x0.6 arcsec)



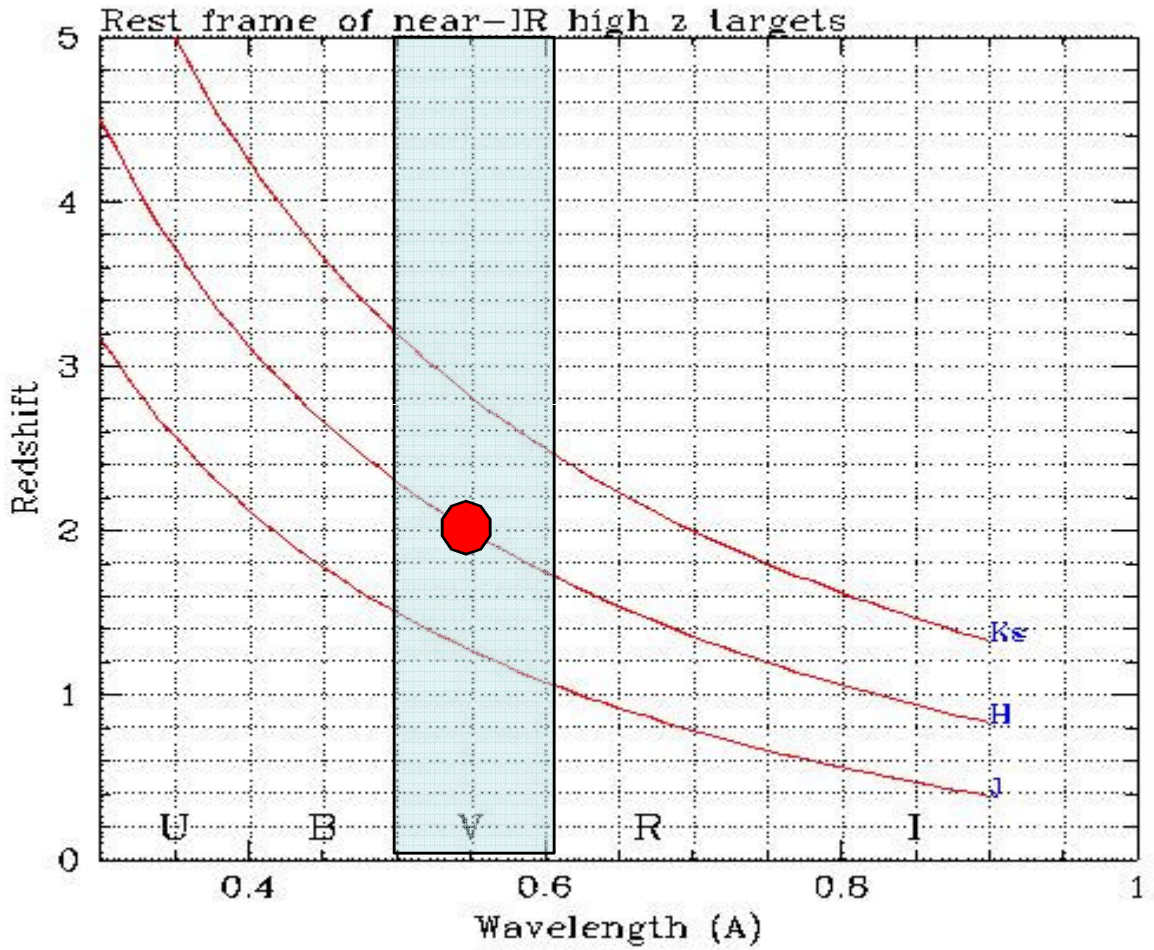
NIRCam JWST

Resolved stellar populations in Virgo galaxies

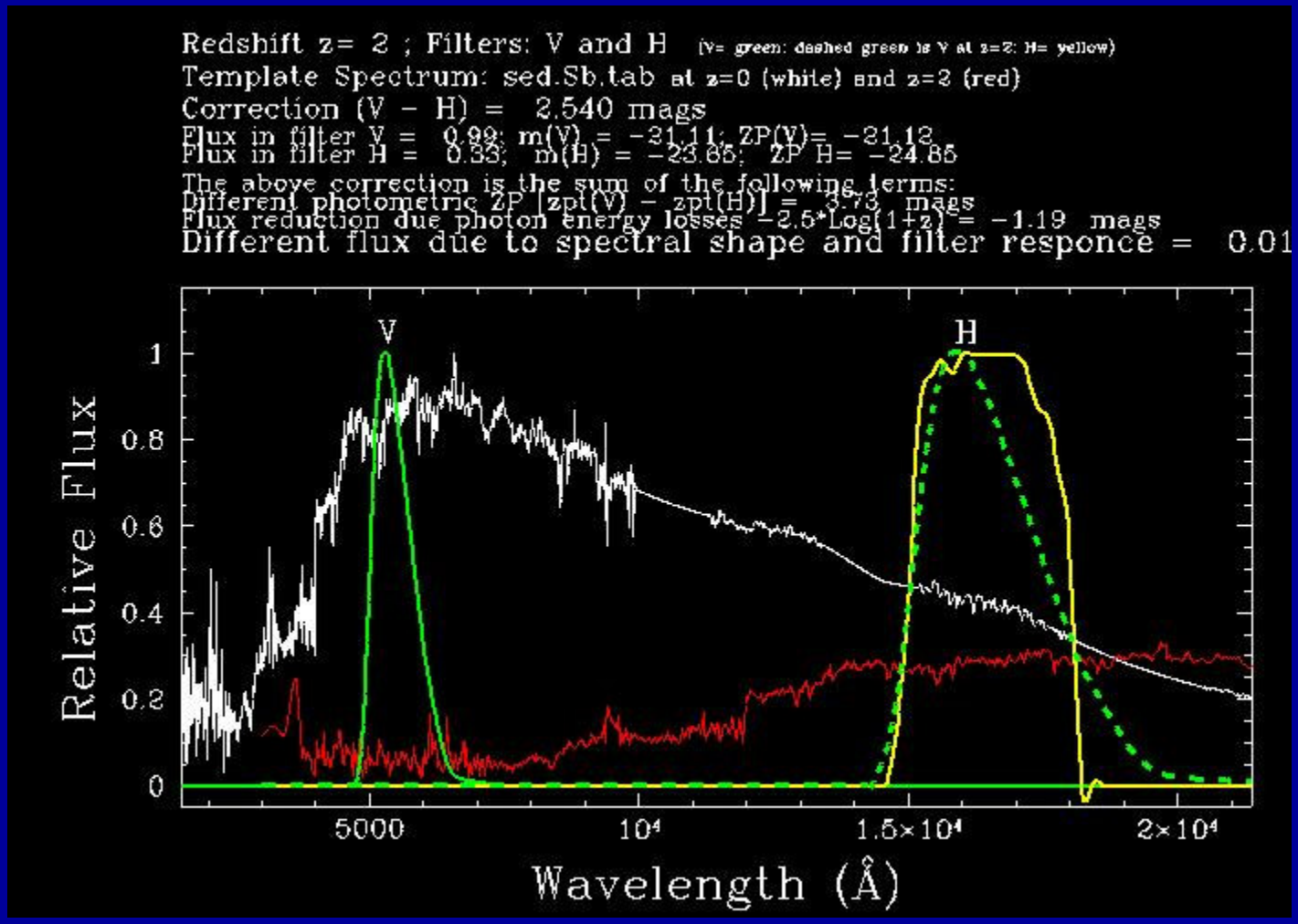
Micado@E-ELT

offers a unique capability to investigate the stellar population in the *in crowded fields of distant galaxies (up to Virgo cluster)*

MICADO view of high z galaxies

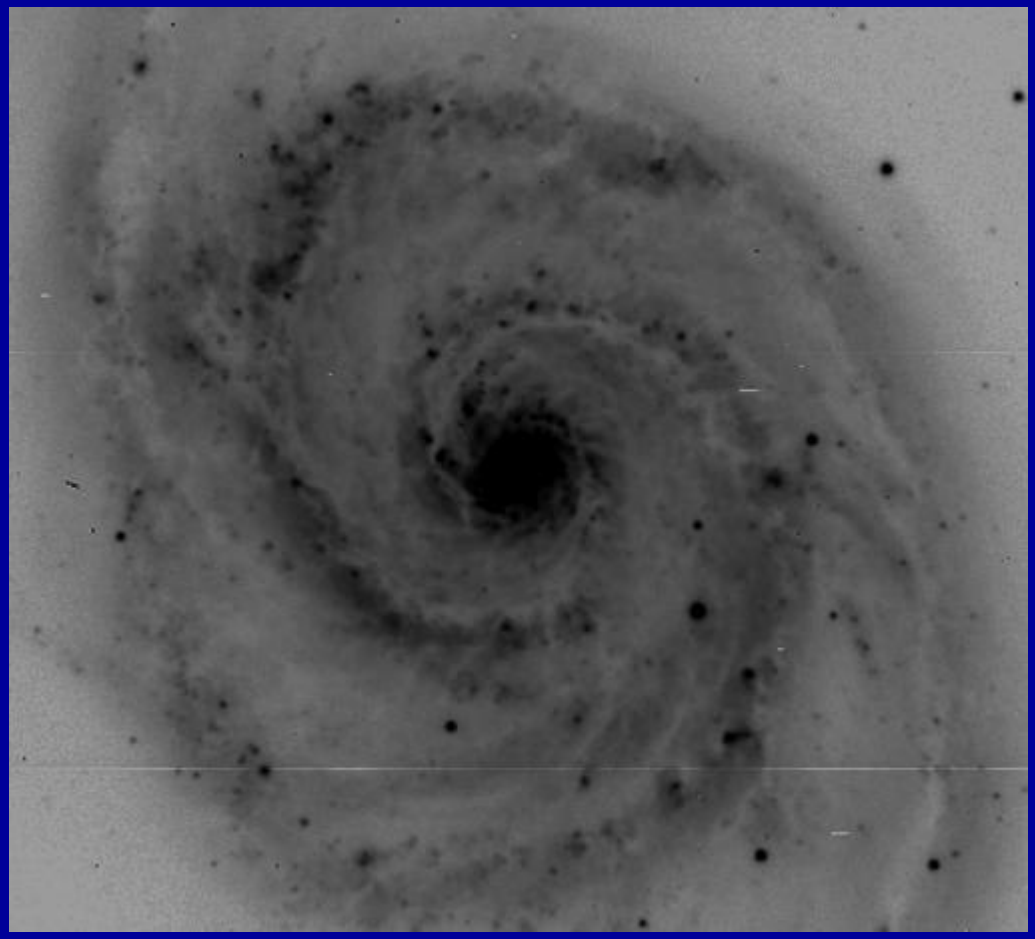


MICADO view of high z galaxies



MICADO view of high z galaxies

Example 1



M(V) = -21
Re = 5 kpc

Redshift : 1-5

SB dimming $(1+z)^4$

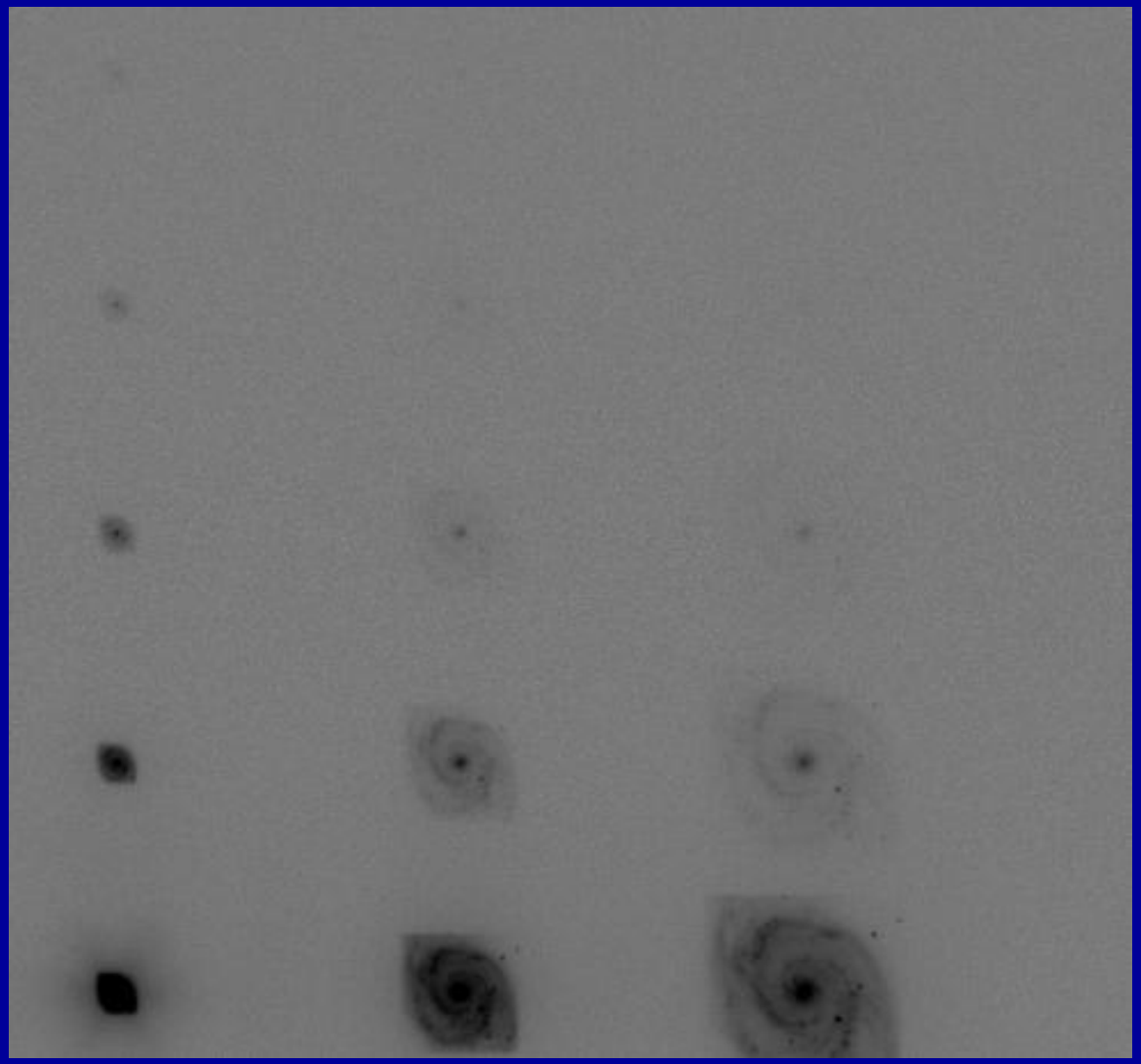
Size evolution helps a lot to detect high z galaxies

Include k-correction & filter tranfsormation

Galaxy template -→ simulated images

MICADO view of high z galaxies

SIMULATION



Mv = -21

Re = 5 kpc

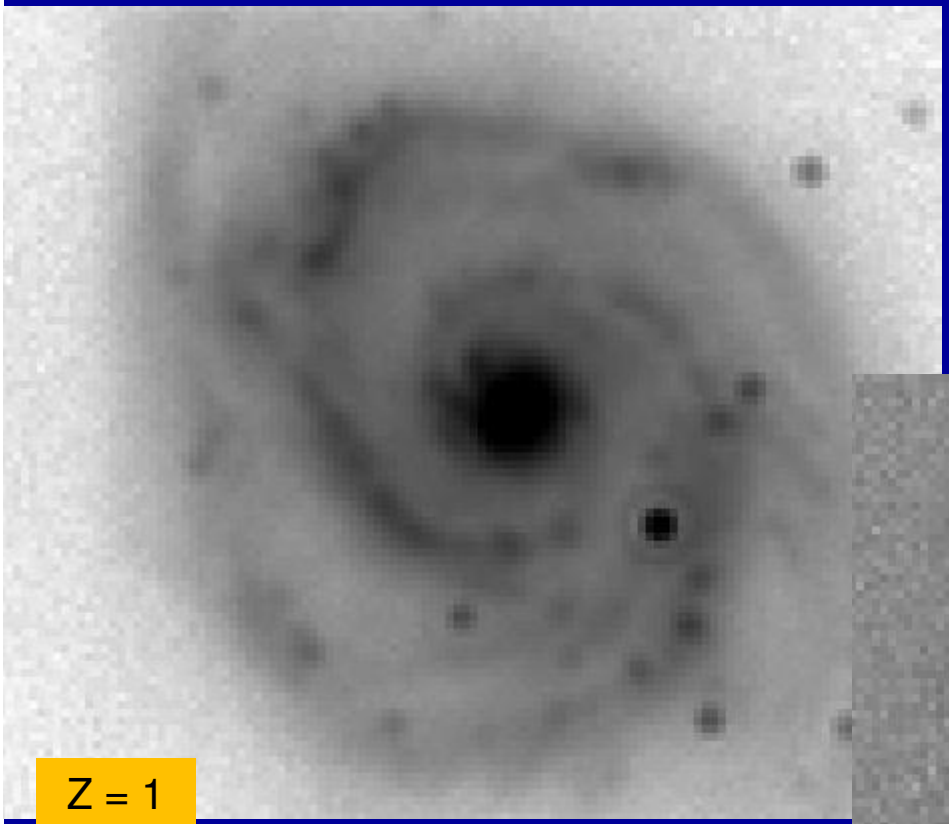
H band

5 hours

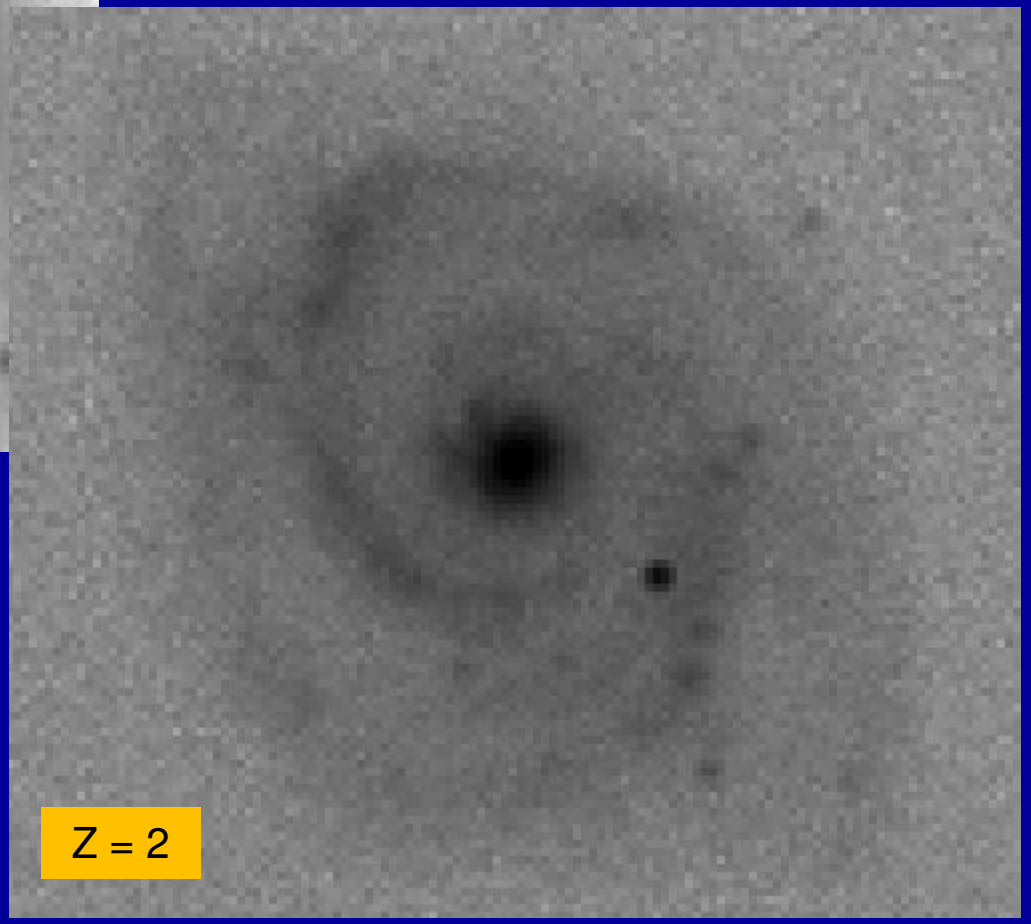
MICADO view of high z galaxies

SIMULATION

Size 0.3 “



Z = 1

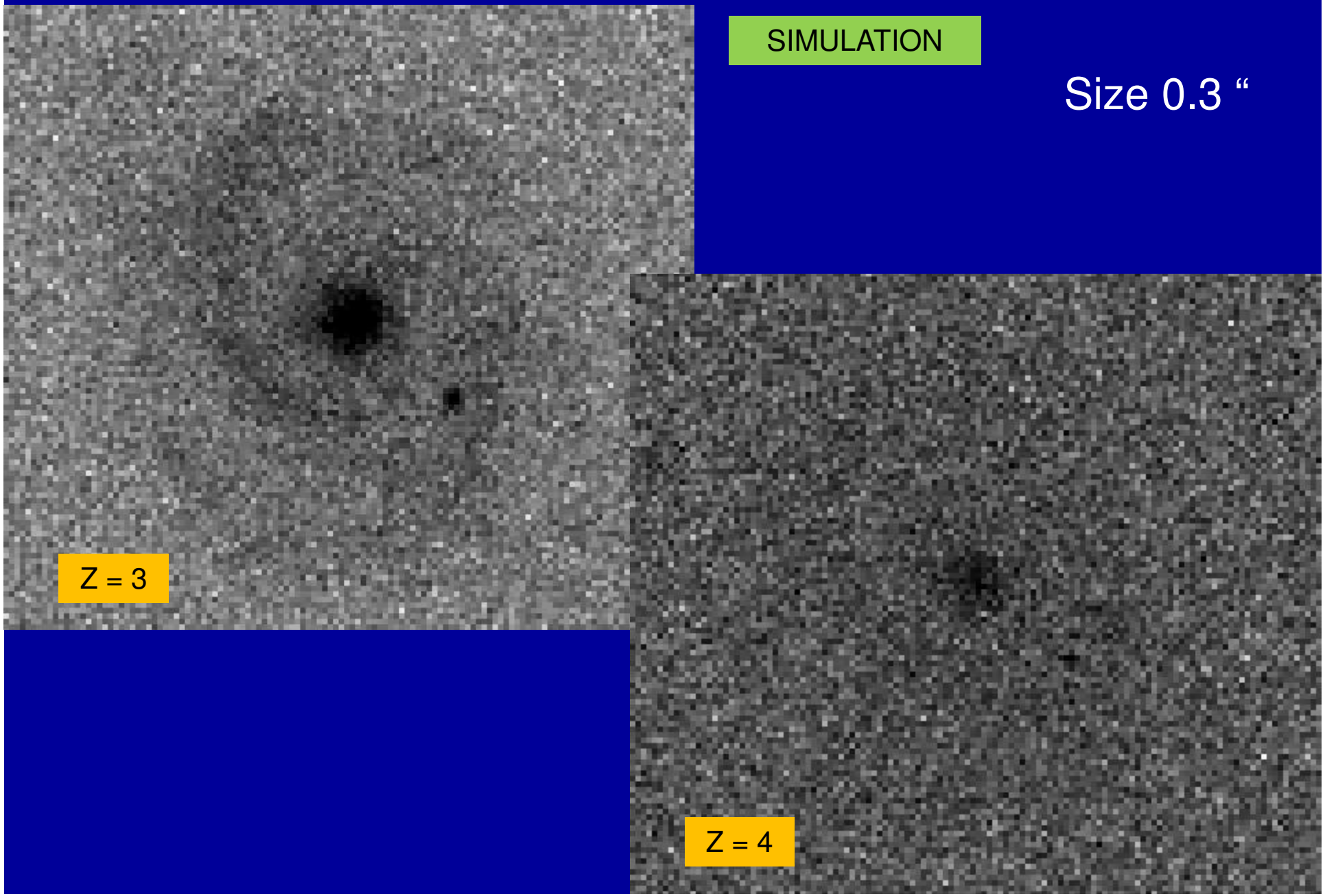


Z = 2

MICADO view of high z galaxies

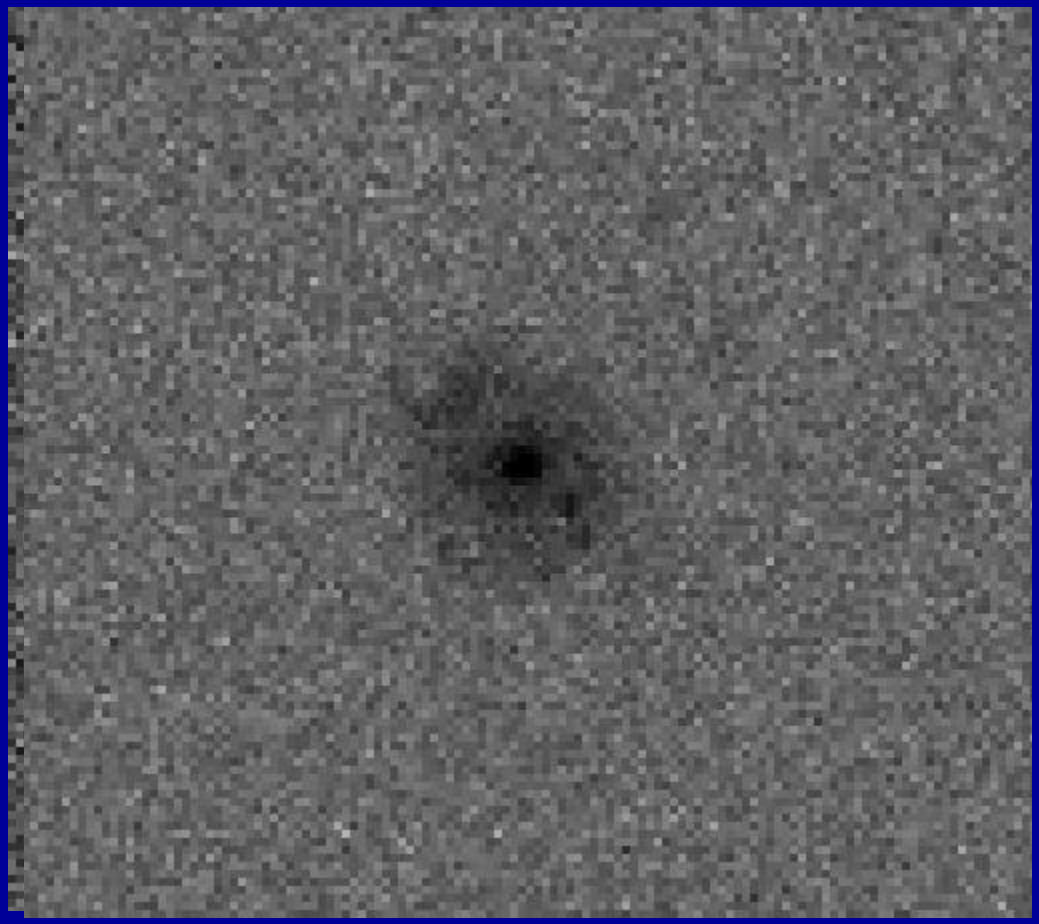
SIMULATION

Size 0.3 “



MICADO view of high z galaxies

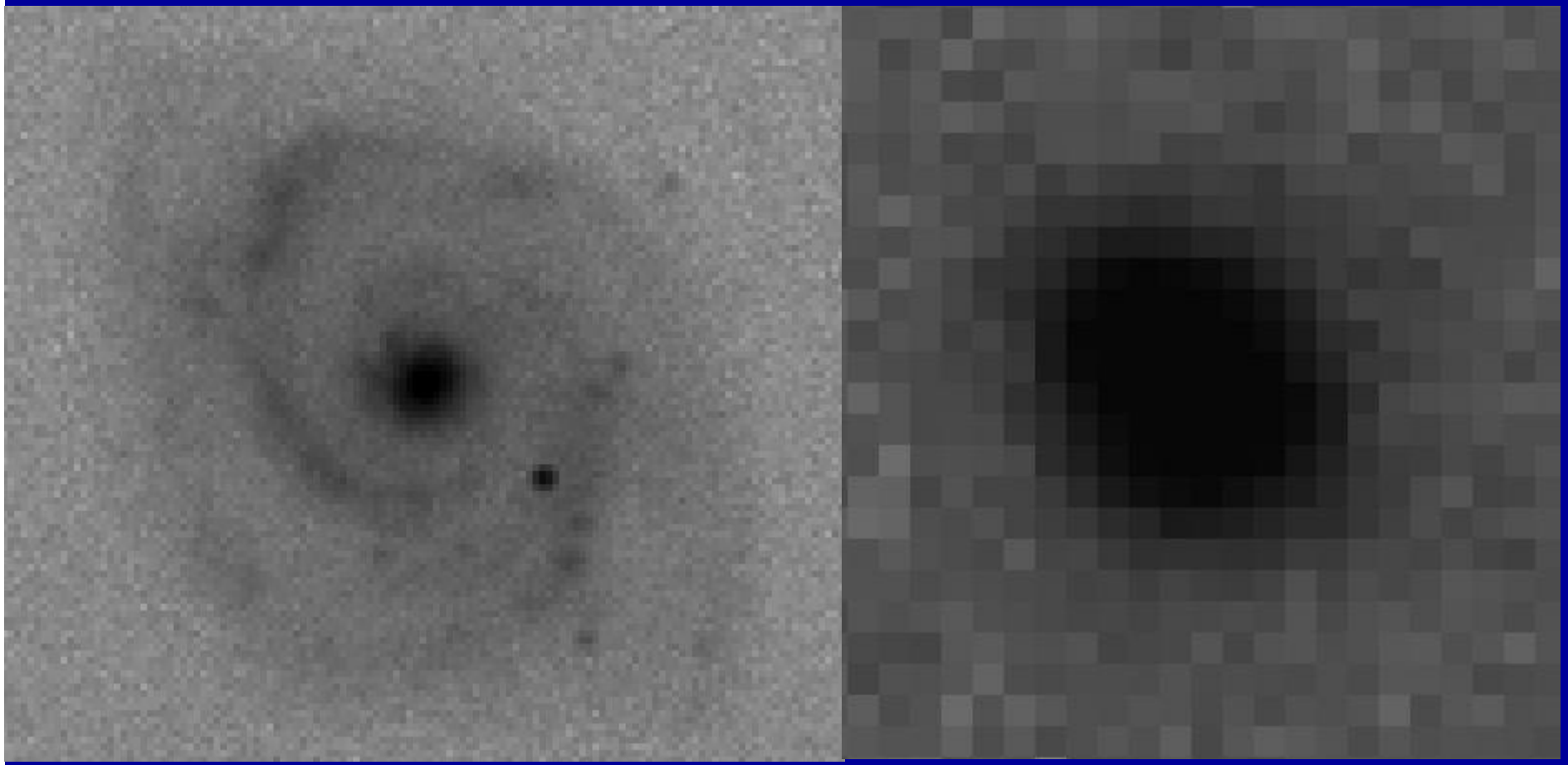
SIMULATION



Z = 4 size = 0.1“

Spiral galaxy at z = 2 Re 5kpc (0.3”)
H band -- 5h

SIMULATION



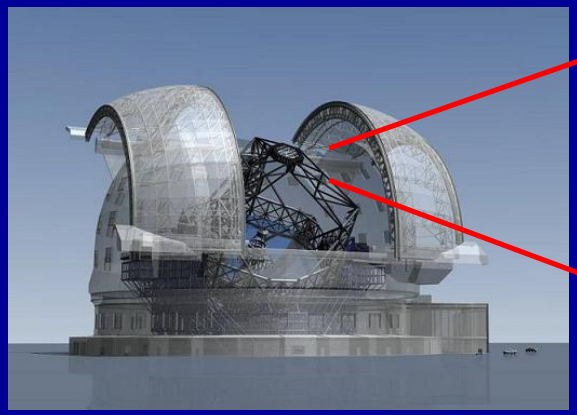
MICADO@ELT

NIRcam@JWST

ELT view of high redshift galaxies

MICADO @ E-ELT will be able to characterize the properties (incl. morphology) of high redshift galaxies and study their environments.

Near-IR (rest-optical) observations yield direct comparison with the local Universe (in the optical)



The E-ELT high (10mas) angular resolution (*combined with high sensitivity*) is the Key capability for unique imaging studies in stellar and extragalactic astrophysics.