Exploring the stellar population of nearby and high redshift galaxies with ELTs

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Outline

Resolved And unresolved Stellar PopUlaTIoNs
Nearby Galaxies:

+ Stellar populations
  - Age and metallicity from the CMD
  - Present-day limits
  - Why do we need ELTs?

+ ELTs science cases
  - Disc galaxies in Sculptor group *Greggio et al. (2012)*
  - Ellipticals in Virgo Cluster *Schreiber et al. (2014)*
  - Nuclear Star Clusters *Gullieuszik et al. (2014)*

Resolved And unresolved Stellar PopUlaTIoNs
High-z Galaxies

- Structural parameters
- Gradients *work in progress*
- Sub-structures

Introduction

To constrain models of formation and evolution of stellar systems we need to understand the history of their stellar population

→ reconstruct:
SFR(t) Star formation history
Z(t) Chemical evolution history

measure age and metallicity for all stellar populations in a galaxy

How stellar and galaxy formation and evolution depend on environment?
→ metal-poor vs. metal-rich systems
→ Isolated galaxies vs. groups vs. clusters

We need to look outside the Local Group

CMDs in the Local Universe

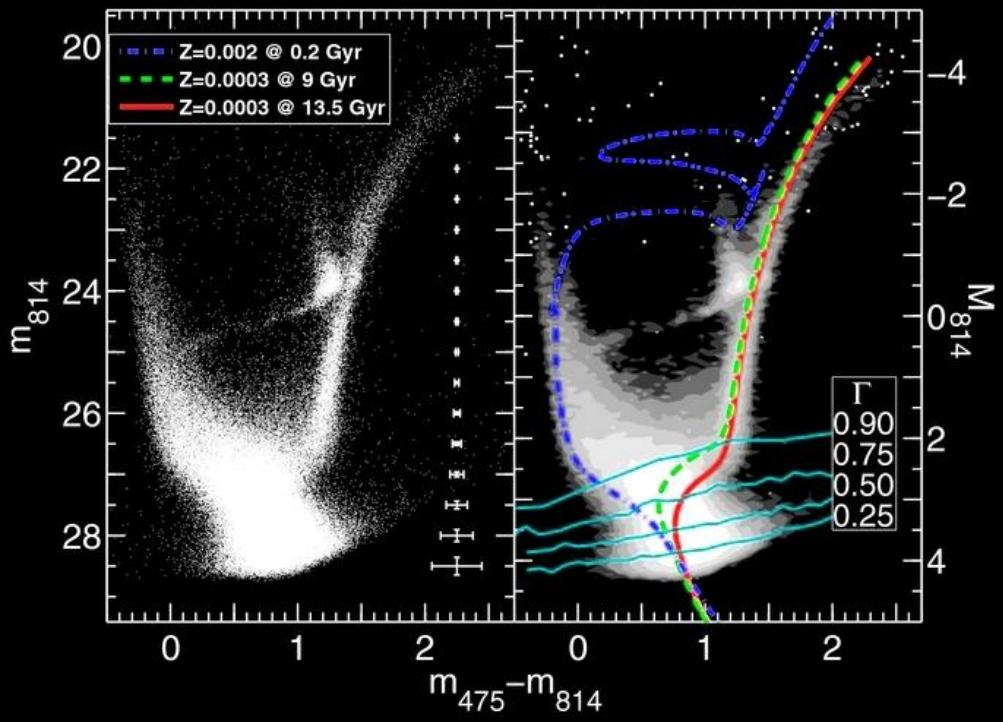
Resolved stellar photometry of MSTO stars is NOW possible only in the Local Group (d<1Mpc)

For more distant galaxies only evolved stellar populations can be detected

Beyond ~5Mpc : ages and metallicities from unresolved stellar populations

ACS@HST, ~8h each band

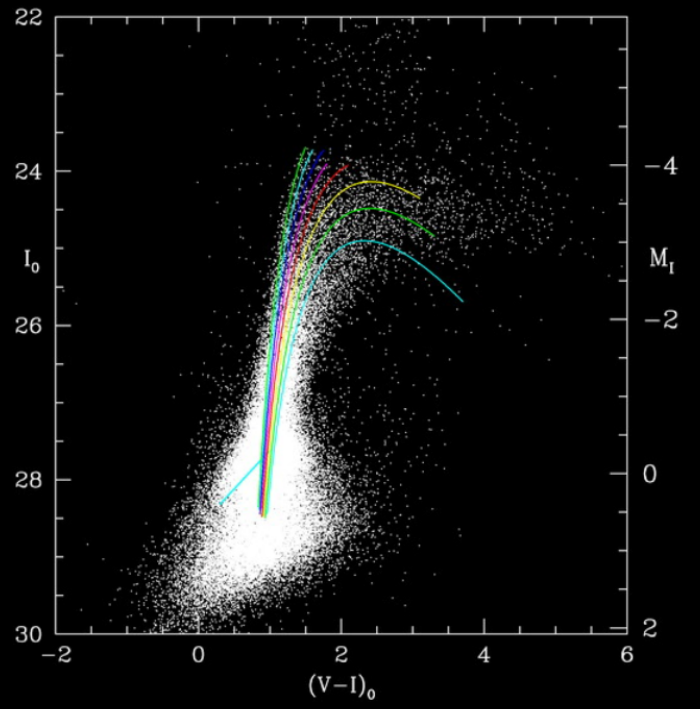
Skillman+2013



IC 1613: $(m-M)_0$=24.4 mag; d=0.7 Mpc

ACS@HST, ~8.5h each band

Rejkuba+2005



NGC 5128: $(m-M)_0$=27.9 mag; d=3.8 Mpc

Beyond the limit

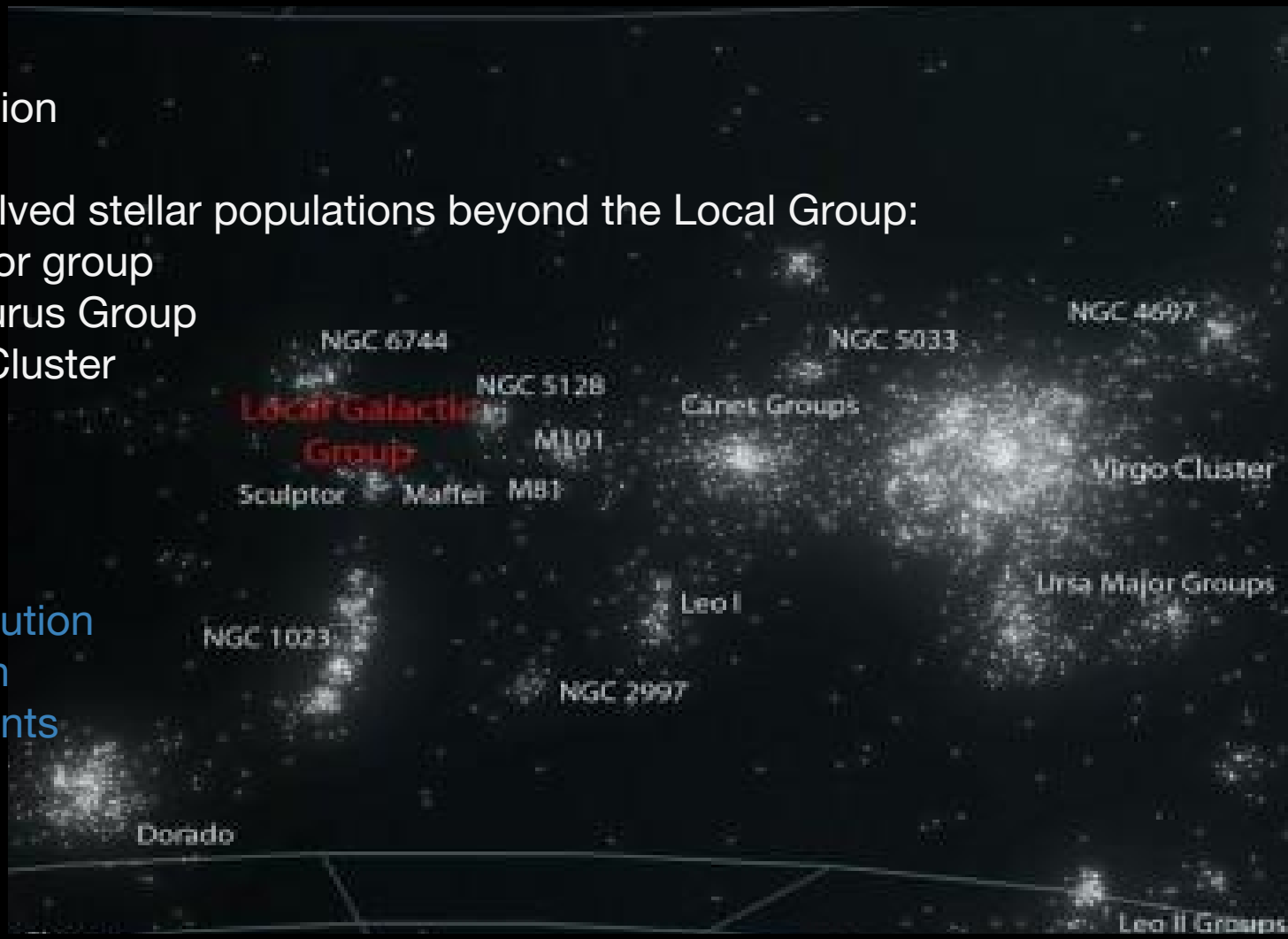
ELTs

→ sensitivity
→ spatial resolution

Photometry of resolved stellar populations beyond the Local Group:

→ Sculptor group
→ Centaurus Group
→ Virgo Cluster

Formation and evolution of stellar systems in different environments



Our project: science cases for E-ELT

Method

We simulated E-ELT observations adopting the specs of MICADO@E-ELT
Images are simulated using the Advanced Exposure Time Calculator http://aetc.oapd.inaf.it
Photometric measurements and analysis to asses the feasibility of the science cases
→ DAOphot and StarFinder

Cases

Greggio et al. 2012:
→ SFH in the center of the disk of a giant spiral in the Centaurus Group (4.6 Mpc)
→ SFH in the halo of giant ellipticals in the Virgo Cluster (18 Mpc)

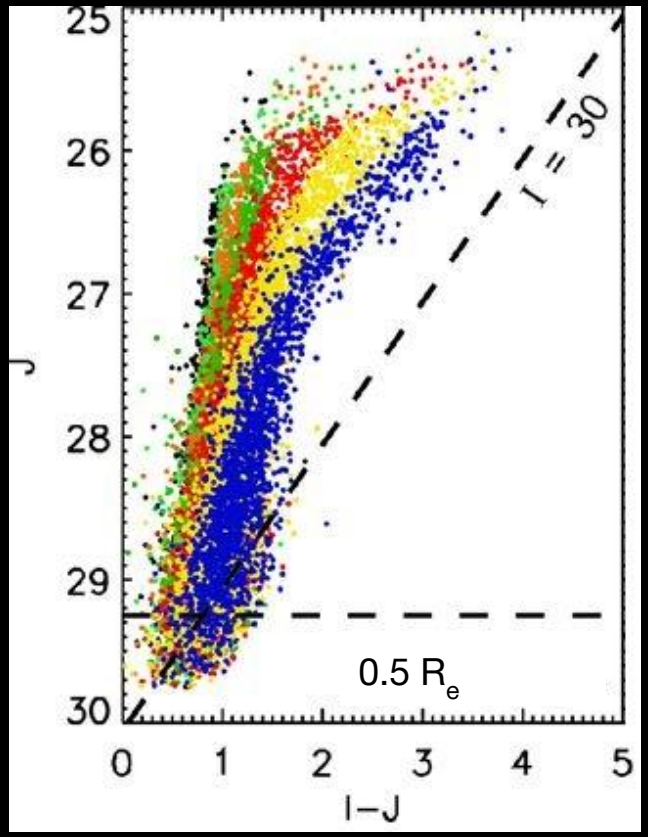
Schreiber et al. 2014:
→ Metallicity gradients in Virgo ellipticals

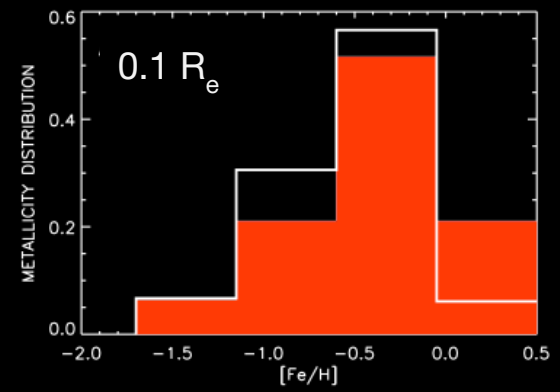
Gullieuszik et al. 2014:
→ Nuclear Stars Clusters

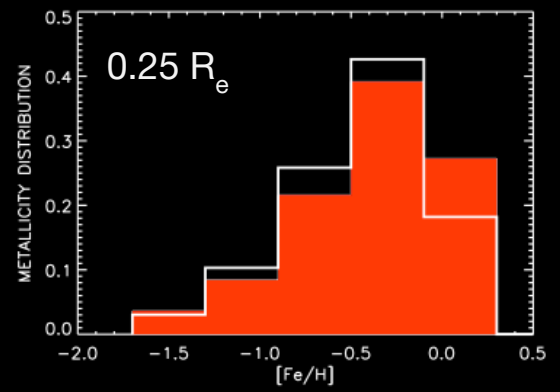
Metallicity gradients in Virgo cluster [Schreiber et al. 2014]

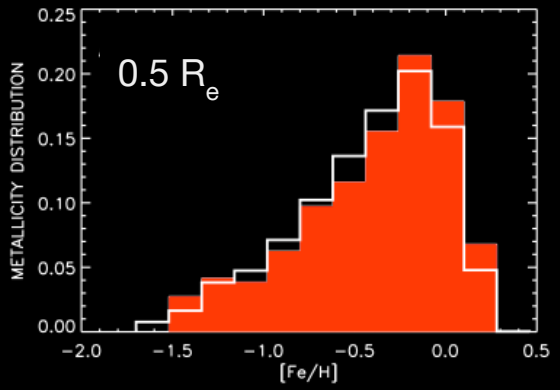
Elliptical galaxy at the distance of the Virgo Cluster

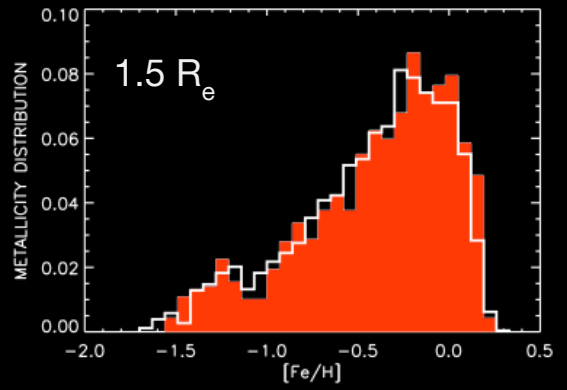
4 surface brightness values to simulate 4 different fields at increasing radial distances







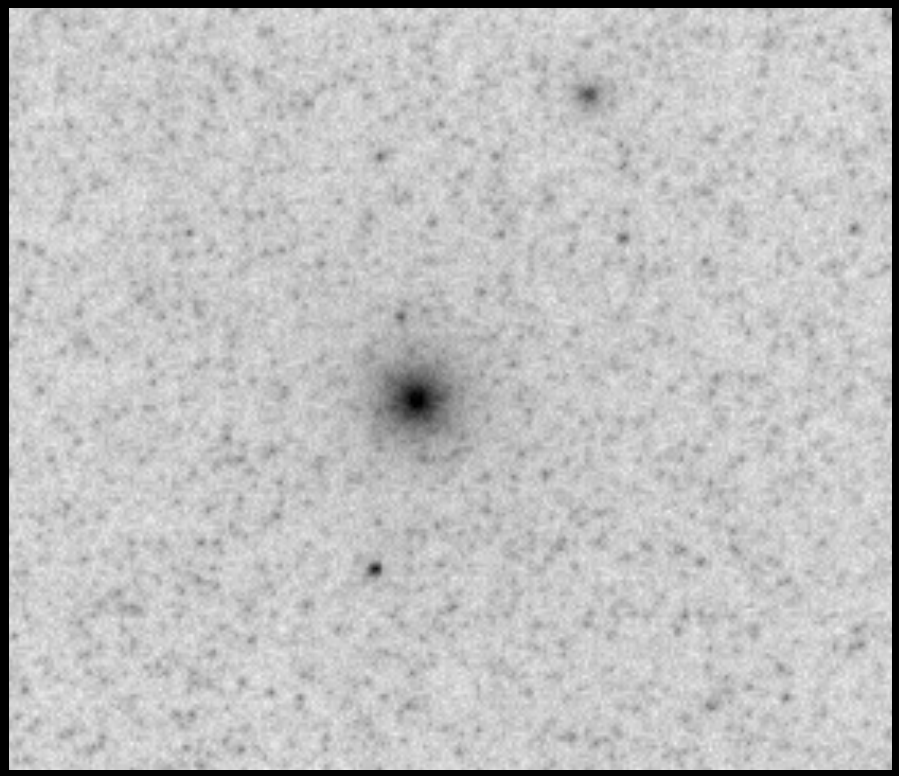




Metallicity gradients can be detected and measured in elliptical galaxies in Virgo cluster

Nuclear Star Clusters [Gullieuszik et al. 2014]

Compact objects (R ~ 2 - 4 parsec)
Massive and Bright (~3 mags brighter than galactic globular clusters)
Not resolved by HST
High spatial resolution is required
Perfect test-bed for ELTs performances



NGC300; d= 2.2 Mpc ; ACS@HST

Böker+2002

Found in ~70% of galaxies of all types

They follow the same scaling relations found for SMBH

Is there any relation between NSC and formation and evolution of SMBHs and galaxies?

We need to recover their SFHs

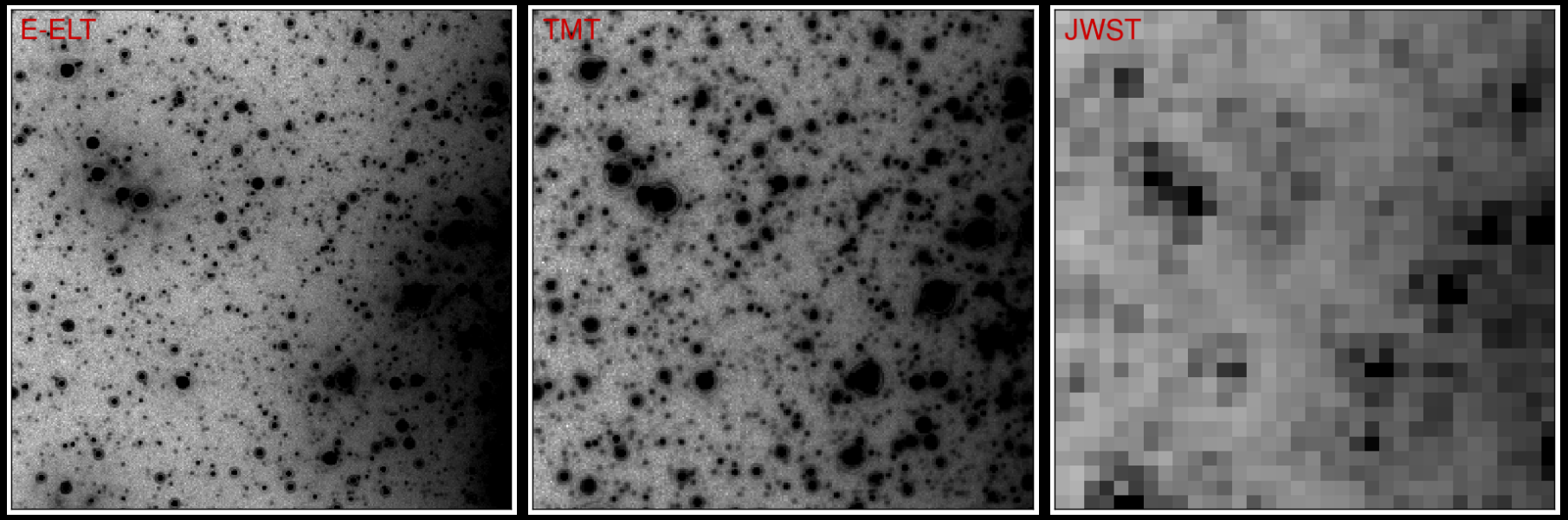
> resolved stellar photometry

Nuclear Star Clusters [Gullieuszik et al. 2014]

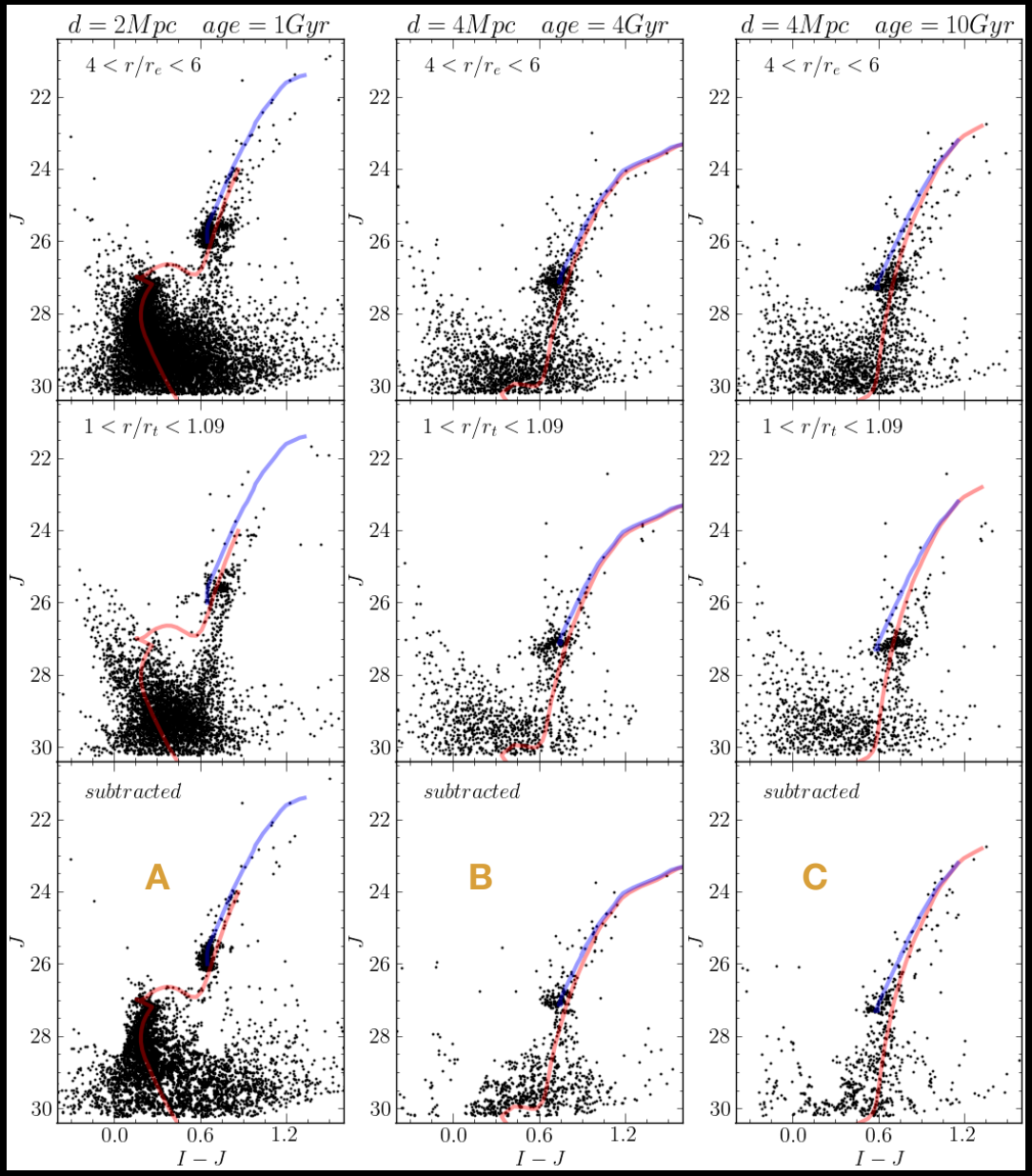
What stellar populations can be studied with ELTs?
> which MSTOs are detectable with an ELT?

We simulated NSC using SSPs:
→ Ages: 1,4, 10 Gyr
→ Distance: 2, 4 Mpc
\+ host galaxy stellar populations

- Photometry with Starfinder
- Analysis of photometric errors and completeness
- Statistical subtraction of foreground host galaxy
- detection of Main Sequence Turn off to asses the feasibility of SFH recovery
- feasibility with E-ELT, TMT (and JWST)



Nuclear Star Clusters [Gullieuszik et al. 2014]



In the central regions the crowding worsen the photometric accuracy

The outer region is dominated by the host galaxy

In the intermediate region the NSC populations are clearly visible.

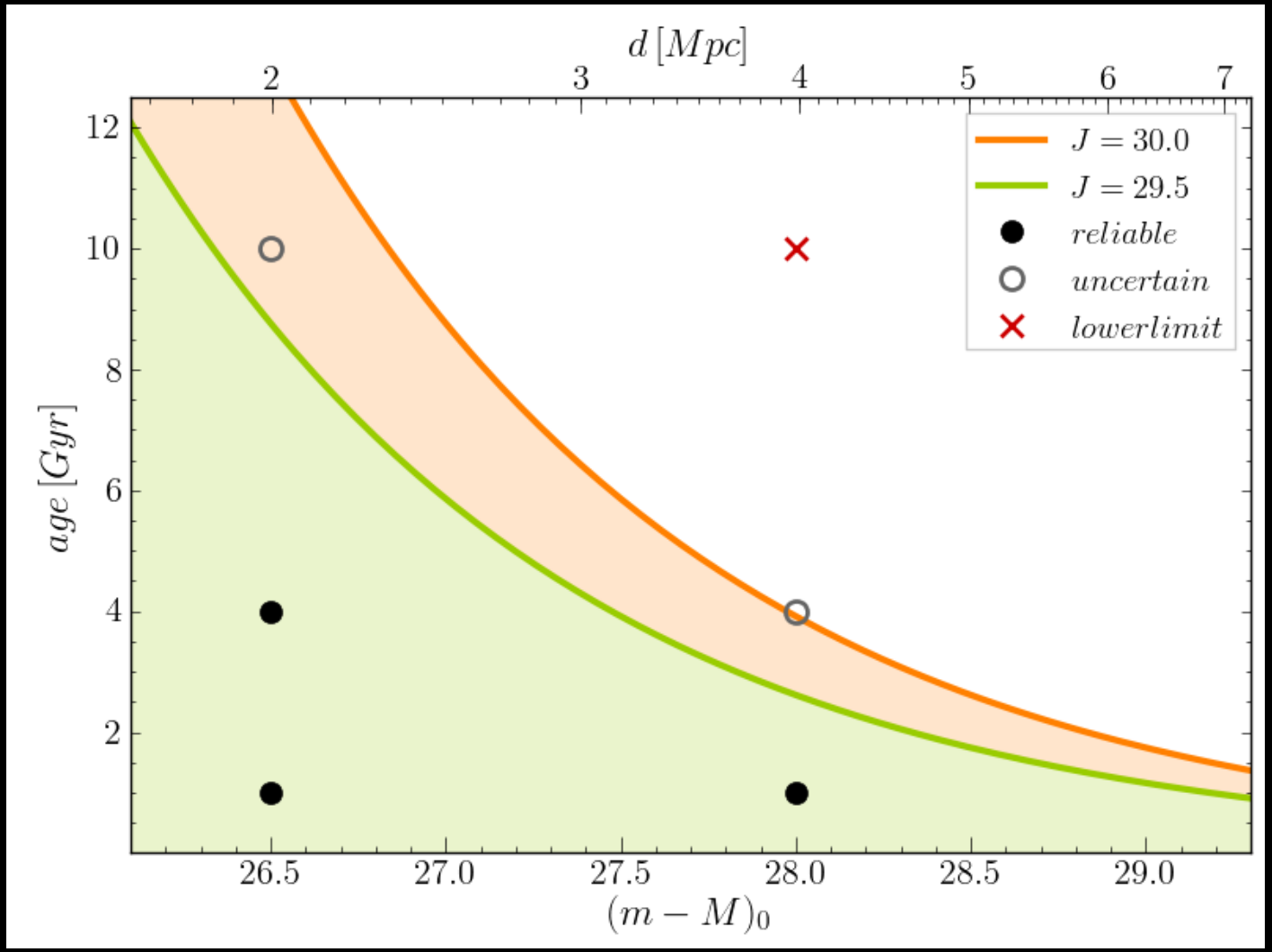
Statistical subtraction of the host galaxy stellar population

A: Detected:
Reliable age estimate

B: At detection limit:
Uncertain

C: Undetected
No age. Lower limit?

Nuclear Star Clusters [Gullieuszik et al. 2014]



MSTO magnitude calculated from Marigo+2008 stellar evolution models

Stellar population with MSTO magnitude:

Green: brighter than 80% completeness limit (J=29.5 mag)

Orange: brighter than 50% completeness limit (J=30.0 mag)

High-z galaxies. Intro

Galaxies @z~2 have Re smaller than a few Kpc

[~4 Kpc -> ~0.5 arcsec]

they have Re ~ FWHM of HST

determination of structural parameters are strongly dependent on PSF deconvolutions

Populations gradients are more prominent in the inner regions.

>> higher spatial resolution

High-z galaxies

- 9 template early-type galaxy
  $10^9 < M/M_\odot < 10^{11}$
- Magnitude, colour, Re from scaling rel
  high-z galaxies

van der Wel+2014

High-z galaxies

- 9 template early-type galaxy
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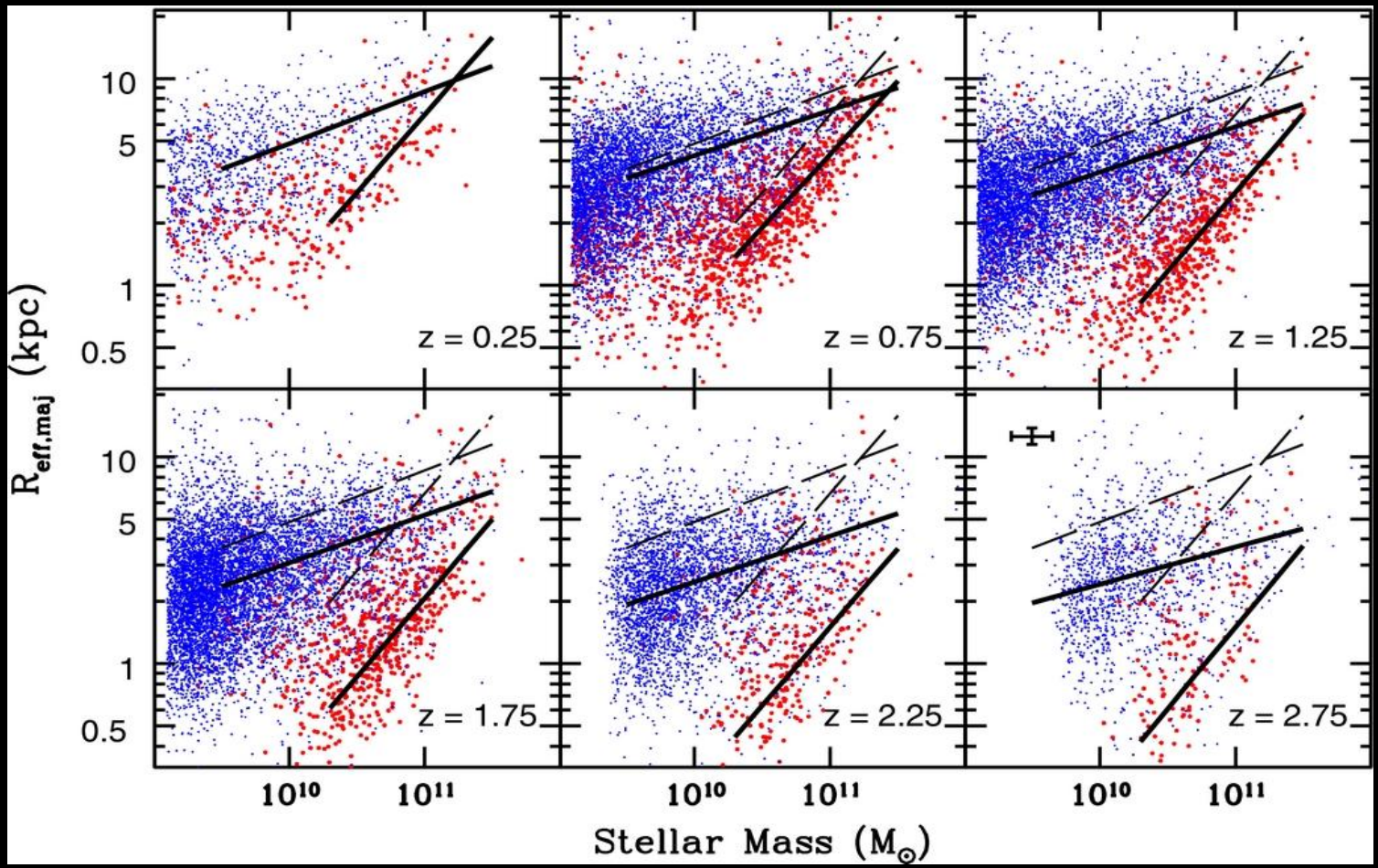
- Magnitude, colour, Re from scaling relations for high-z galaxies

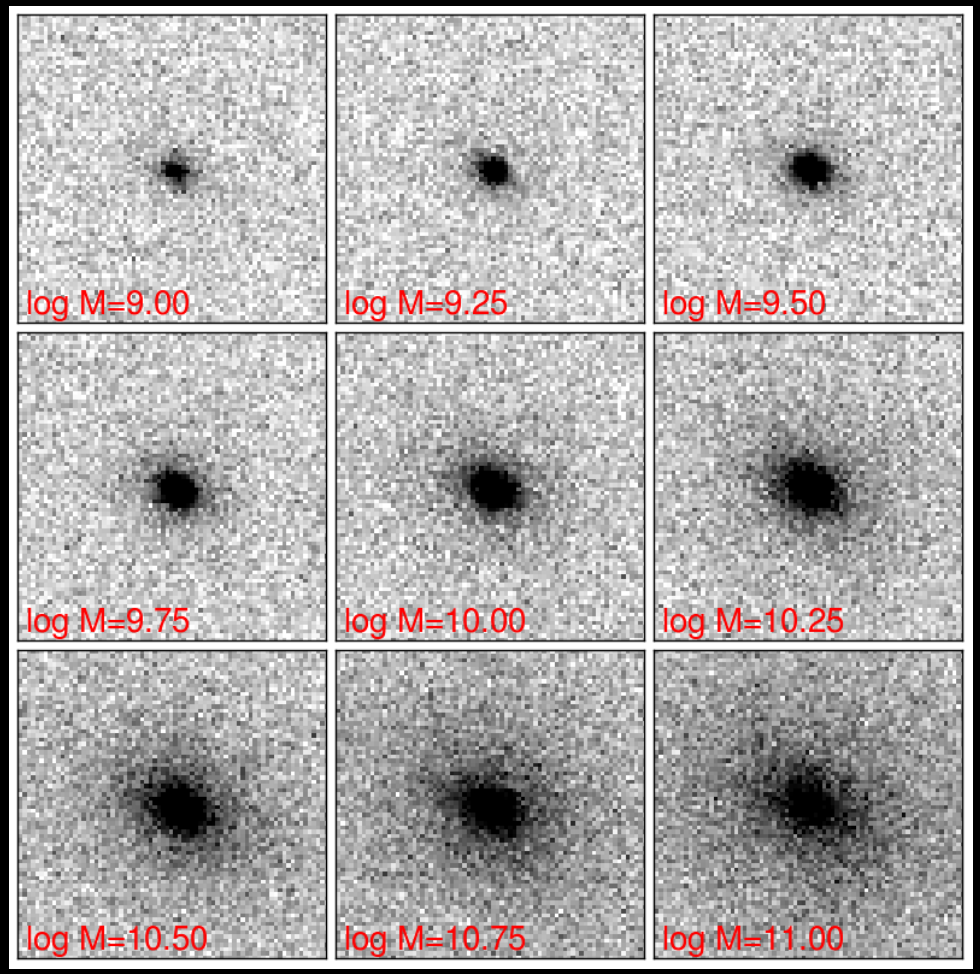
van der Wel+2014



High-z galaxies

- 9 template early-type galaxy
  $10^9 < M/M_\odot < 10^{11}$
- Magnitude, colour, Re from scaling relations for high-z galaxies
- 60 AETC simulations for each template galaxy [Sersic profile with n=2.5]
- Sersic-fit with GALFIT
- compare measured vs. input parameters and radial profile

(U,V) -> J, H @ **z=2.2**

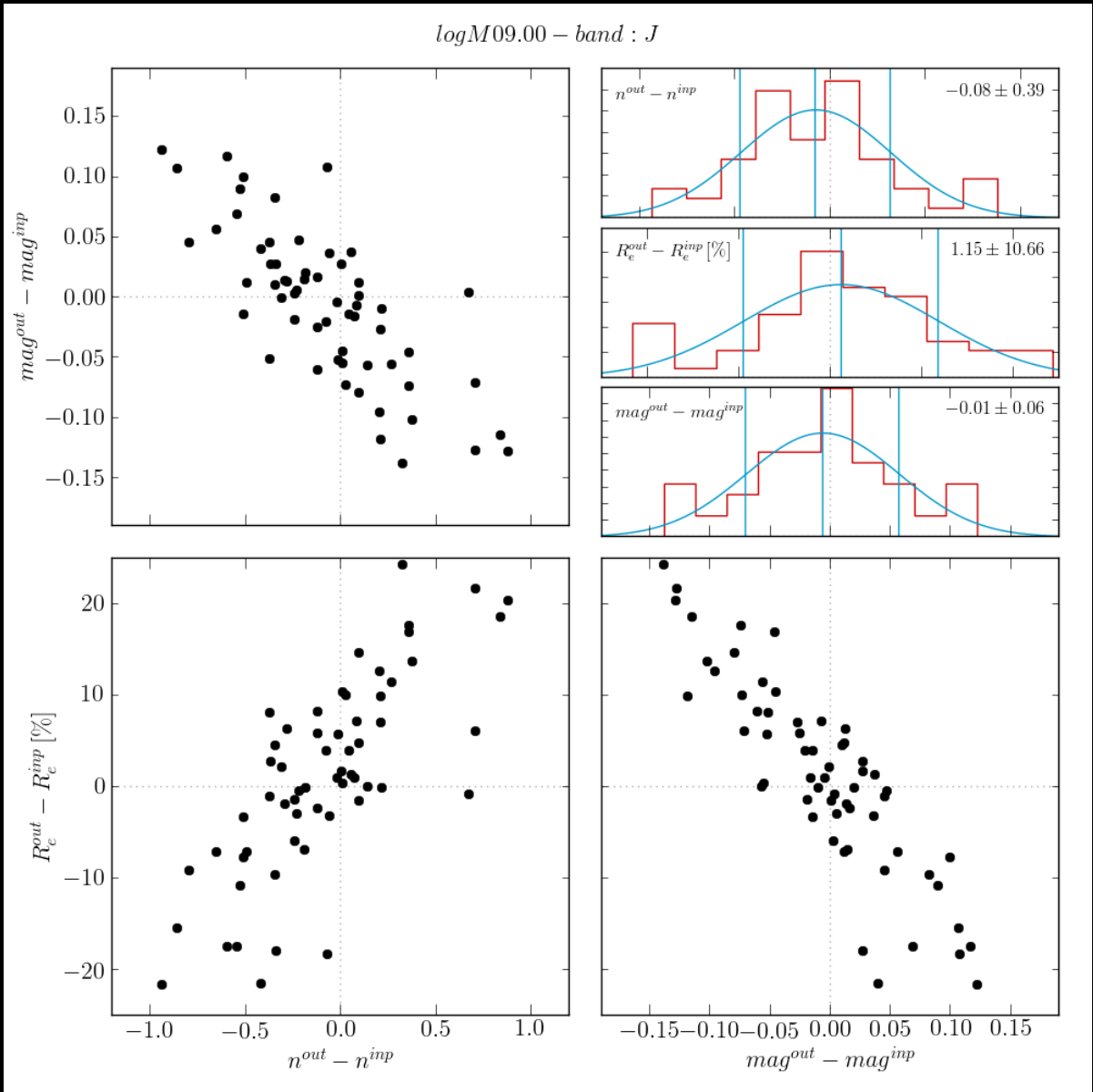


> Accuracy of GALFIT structural parameters

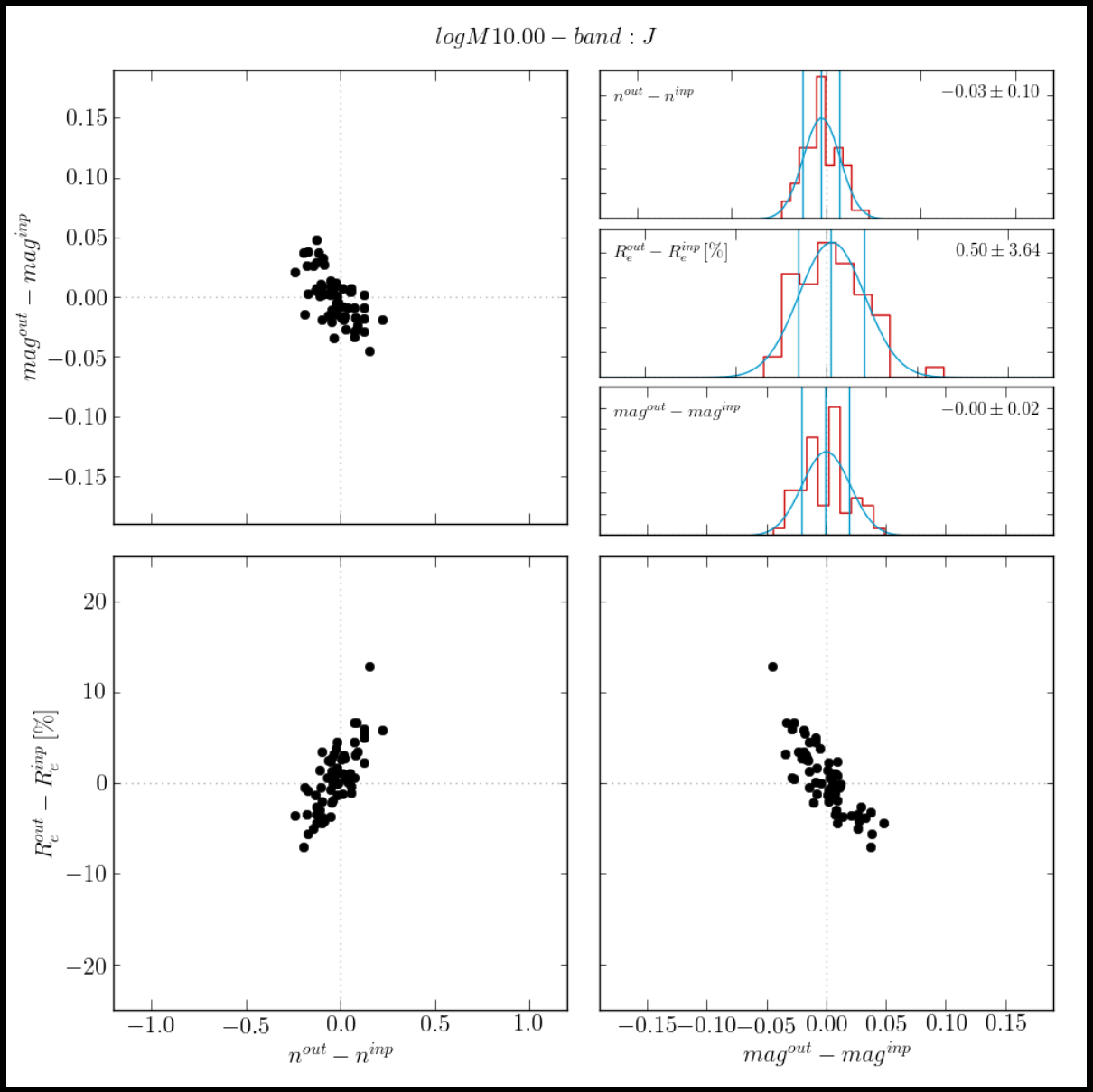
> Could we detect colour gradients?

>> what is the uncertainty in the recovered radial profile?

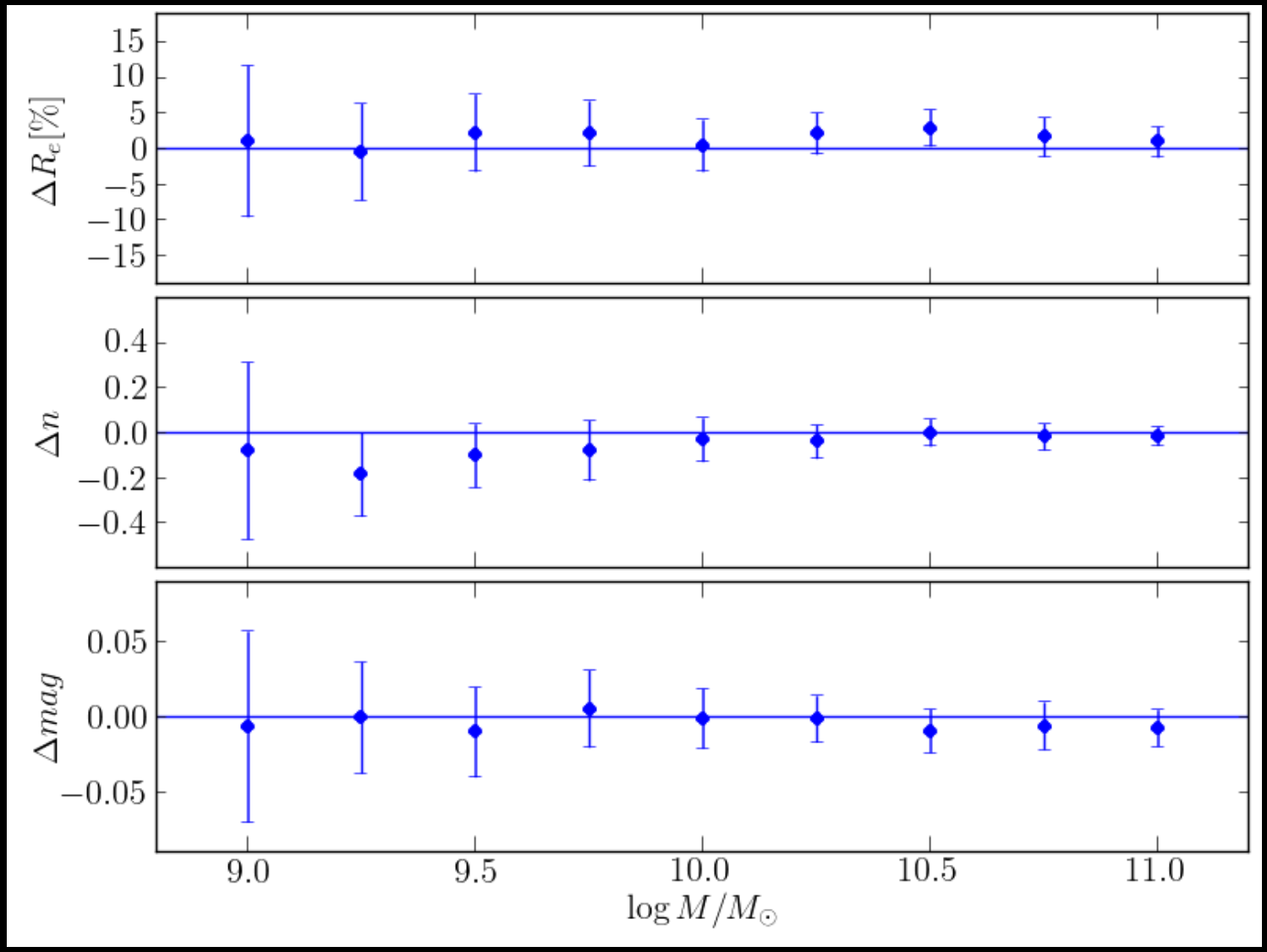
High-z galaxies



High-z galaxies

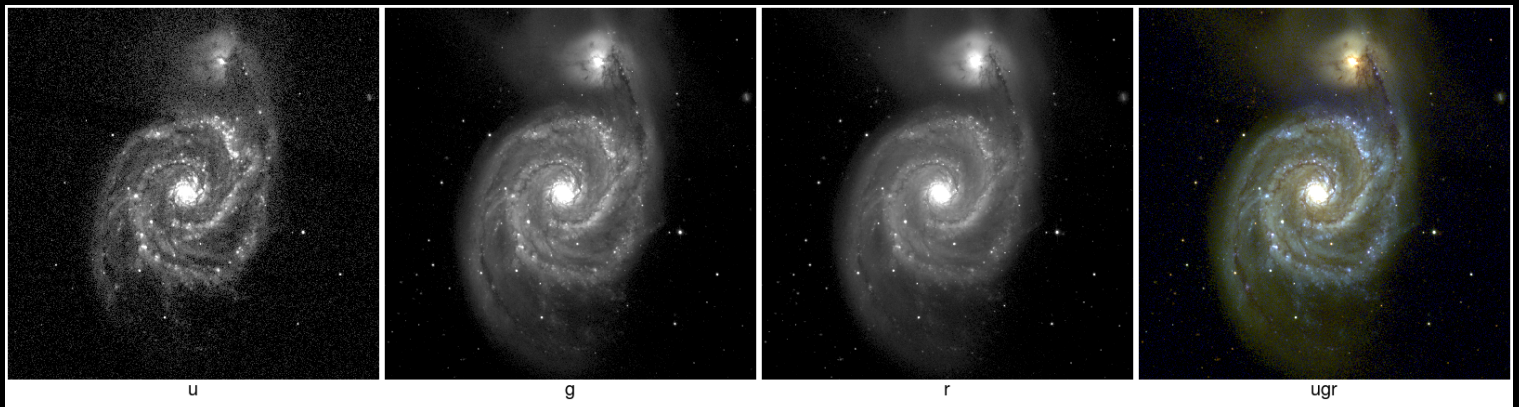


High-z galaxies



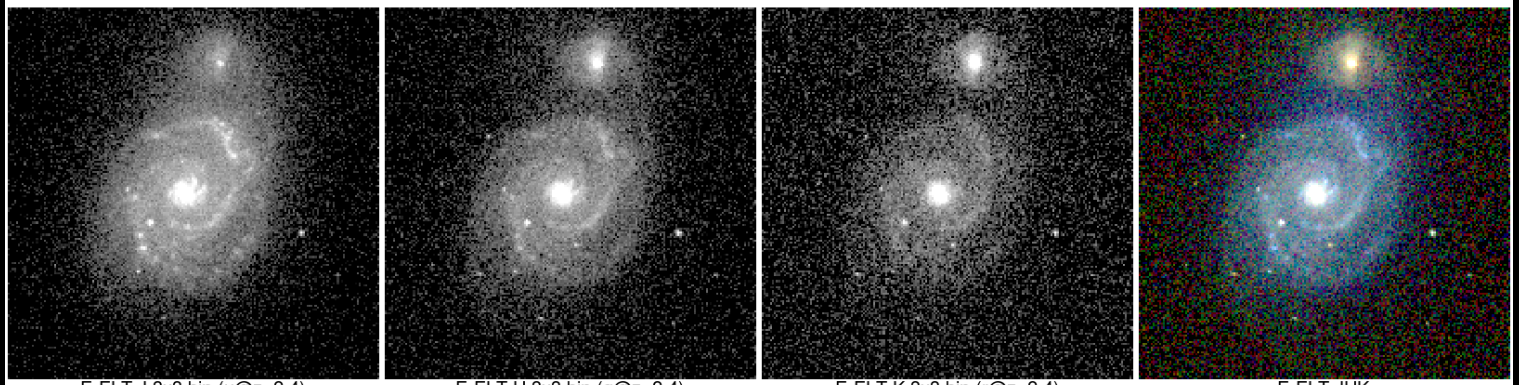
High-z galaxies

M51
SDSS



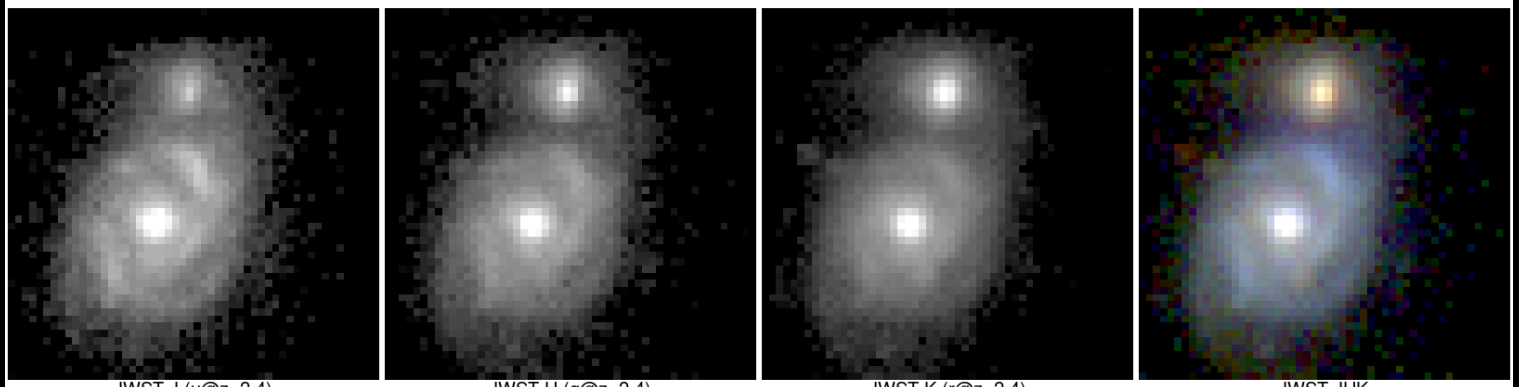
u | g | r | ugr

z=2.4
MICADO@E-ELT



E-ELT J 3x3 bin (u@z=2.4) | E-ELT H 3x3 bin (g@z=2.4) | E-ELT K 3x3 bin (r@z=2.4) | E-ELT JHK

z=2.4
NIRCam@JWST



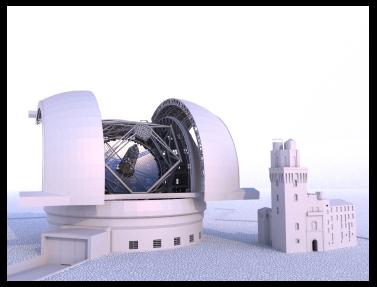
JWST J (u@z=2.4) | JWST H (g@z=2.4) | JWST K (r@z=2.4) | JWST JHK

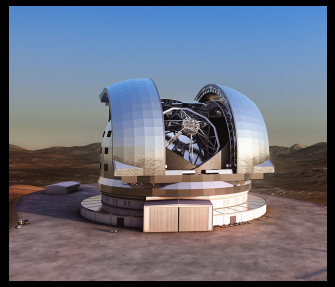
Summary

With (E-)ELT it will be possible to:

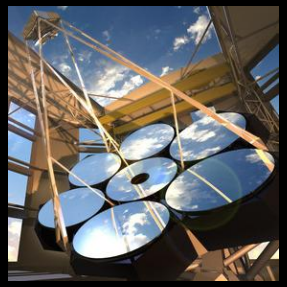
- ★ Recover SFH in galaxies at ~5 Mpc
- ★ Measure metallicity in the central regions of Virgo cluster ellipticals
- ★ Study stellar populations in NSCs
  - Old: up to 2Mpc
  - Intermediate-age: up to 3 Mpc
  - Young: up to 4 – (5?) MpcWith (E-)ELT it will be possible to:

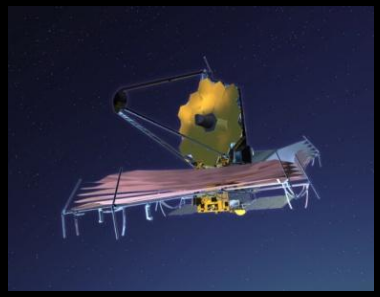
- ★ Measure the structural parameters (nSersic, Re, mag) of low-mass (~10^9 $M_\odot$) galaxies @z~2
- ★ Measure colour gradients (~<0.1 dex) @z~2 for galaxies with M~$10^{10}M_\odot$
- ★ detect substructures (i.e. spiral arms/star forming regions) @z~2.5


E-ELT @ Padova credit: M. Dima


E-ELT @ Amazones


TMT @ Mauna Kea


E-ELT @ Las Campanas


JWST @ L2