Calibrating Legacy Science in Euclid

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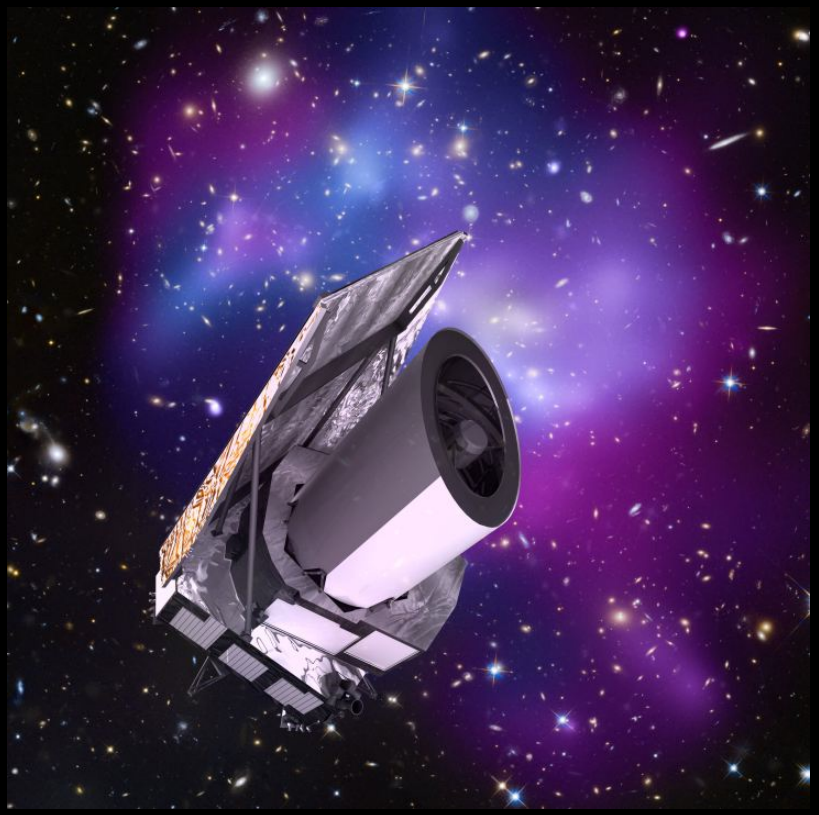
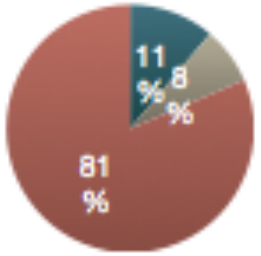
SWG Nearby Universe and Legacy Requirements co-lead



History of surveys for discovery & legacy science

- Started with the Palomar Observatory Sky Survey (1958), later digitized into the digital sky survey (DSS) (1994)
- Truly came of age with the Sloan Digital Sky Survey (SDSS)

Area	# papers	Percentage
Cosmology	93	11.2%
Supernovae	62	7.4%
Legacy	679	81.4%



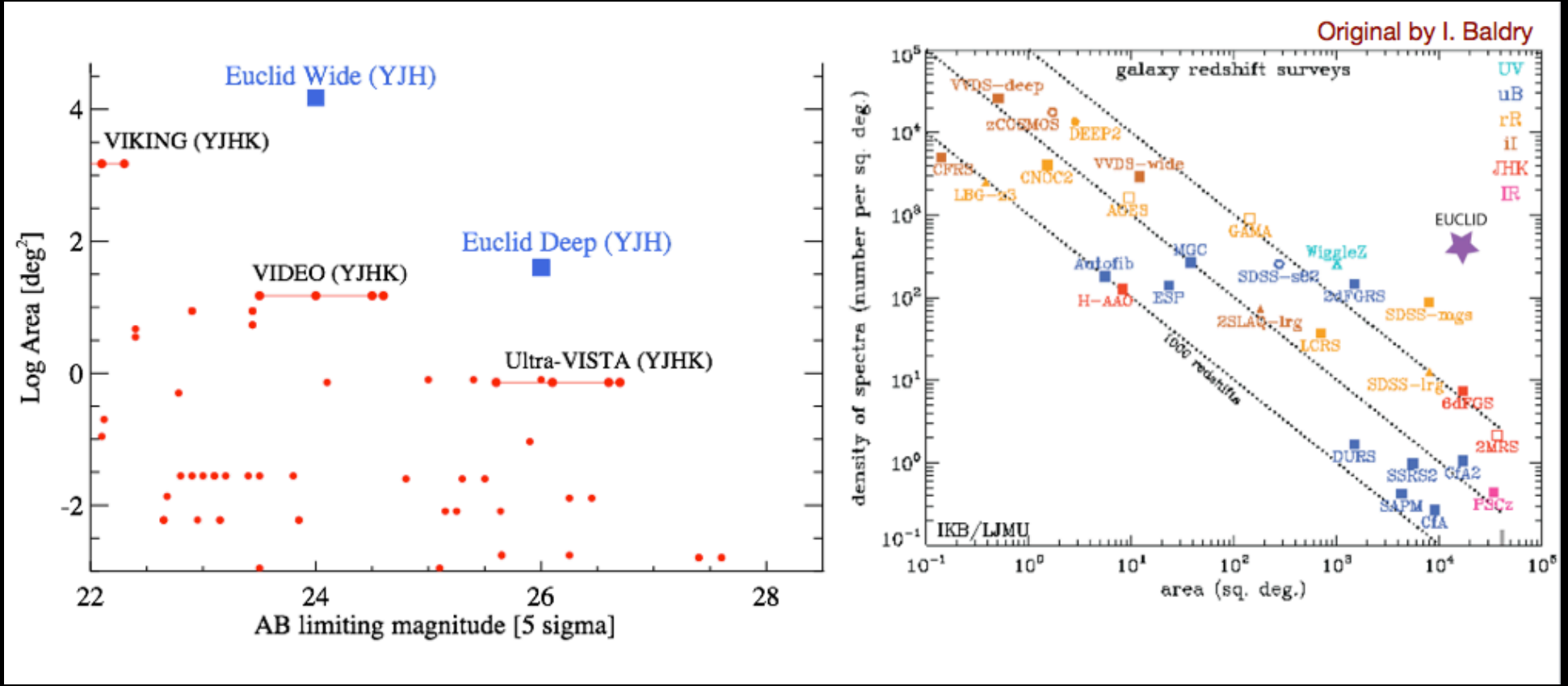
- SDSS has set the standard – most science from large astronomy surveys will be legacy
- Best prepare as well as we can for this, although always unknowns

What kind of data will Euclid will provide us with?

- Cosmology – lensing, clustering, etc.

- Extragalactic science we can do with Euclid
  - +Very large samples → distribution functions, environment
  - +Exquisite imaging → morphological studies, mergers, strong galaxy-scale lenses, etc
  - +Lensing → Galaxy evolution as a function of halo properties, galaxy alignment
  - +Very large volume → Rare sources, probing the extremes
  - +Spectroscopy → Metals, star formation at z>1

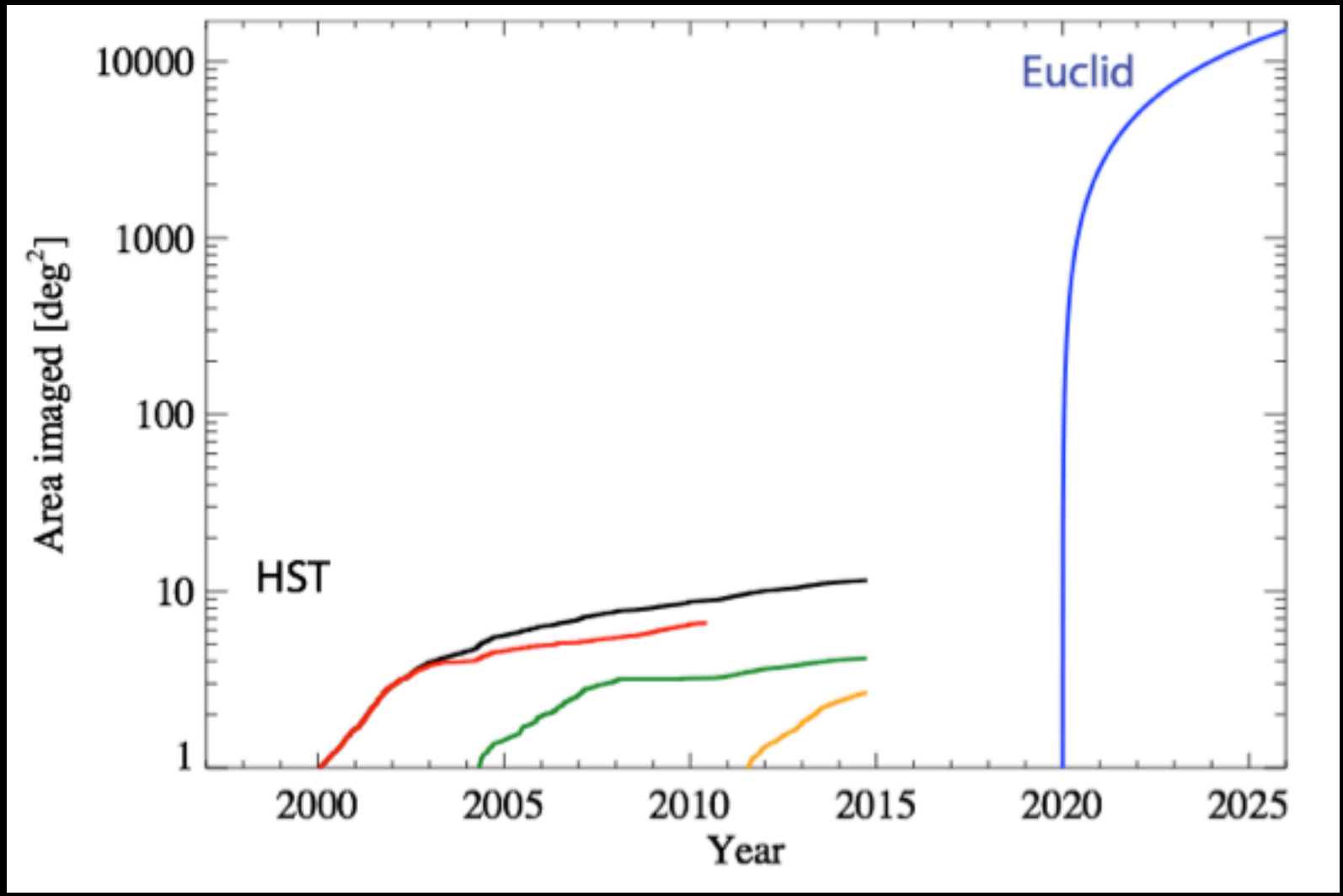
Euclid Wide and Deep Surveys probe unique parameter space



The equivalent 5 year Wide and Deep surveys would take ~700 and 72 years, respectively, to carry out with VISTA

Automation is important – however, must be tested in detail

An unprecedented area for studying distant resolve galaxies



Has all the problems of deep HST and wide-field SDSS imaging

Current best estimates of sources detected with Euclid

What	Euclid	Before Euclid
Galaxies at 1<z<3 with good mass estimates	~2×10^8	~5×10^6
Massive galaxies (1<z<3) w/ spectra	~few x 10^3	~few tens
Hα emitters/metal abundance in z~2-3	~$4\times10^7/10^4$	~10^4/~10^2?
Galaxies in massive clusters at z>1	~2×10^4	~10^3?
Type 2 AGN (0.7<z<2)	~10^4	<10^3
Dwarf galaxies	~10^5	
T_{eff} ~400K Y dwarfs	~few 10^2	<10
Strongly lensed galaxy-scale lenses	~300,000	~10-100
z > 8 QSOs	~30	None

Calibration for legacy science

- Accurate photometric redshifts for most/all galaxies at level of $\Delta z/(1+z) < 0.04$ (discussed earlier)

- Differing levels of absolute and relative photometry, depending on the science

- Relative photometry accuracy of a few % across large fields of view for low-surface brightness science and large galaxies

ec	**Legacy Requirements Document**	Ref. EUCL-LEI-SGS-REQ-00269 Version: 1.0 Date: 1/5/2012 Page:

R-LRD-009	Measured parameters on detected objects shall include (TBD): RA, Dec, and positional error ellipse Ellipticity, orientation Quality control flags
R-LRD-011	Photometric measurements on each detected object shall include (TBD): Psf magnitude Magnitudes in a series of elliptical apertures Deconvolved 2D bulge/disk decomposition Petrosian magnitudes Kron magnitudes 'total' magnitude Concentration Gini coefficient Asymmetry parameter M20 parameter Clumpiness parameter

Contact Legacy Science Document coordinators: C. Conselice, J. Brinchmann

Legacy Science Preparation for Calibration

+ Think about why/what to measure and to what accuracy?

+ Use simulations to optimize observing strategy and to understand the data once it appears

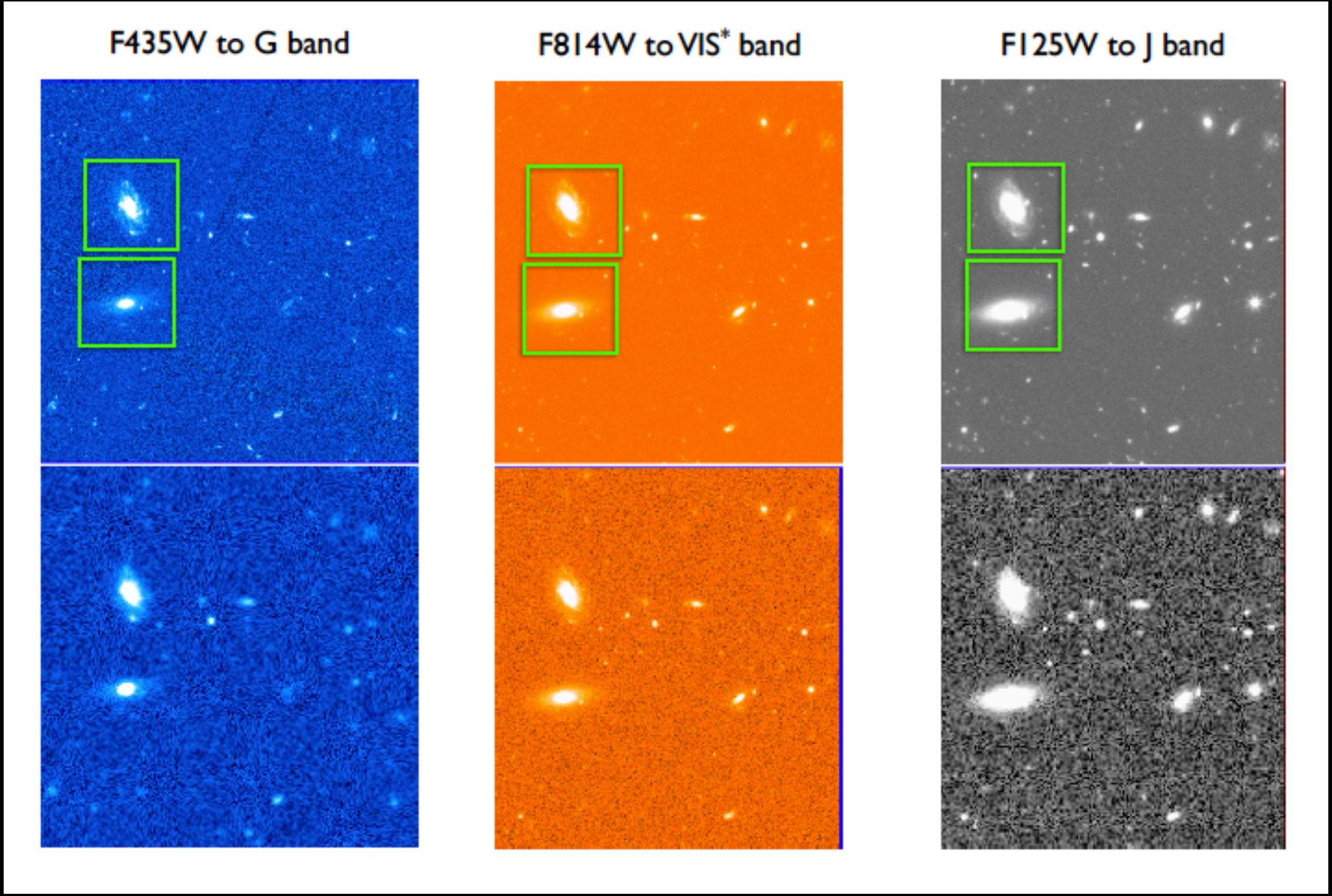
+ Degrading existing HST images – few ground based have as good resolution as Euclid – but HST is limited

+ 'Redshift' nearby galaxy images and spectra at high redshifts

+ Determine how parameters change as f(z)

+ What samples should be used?

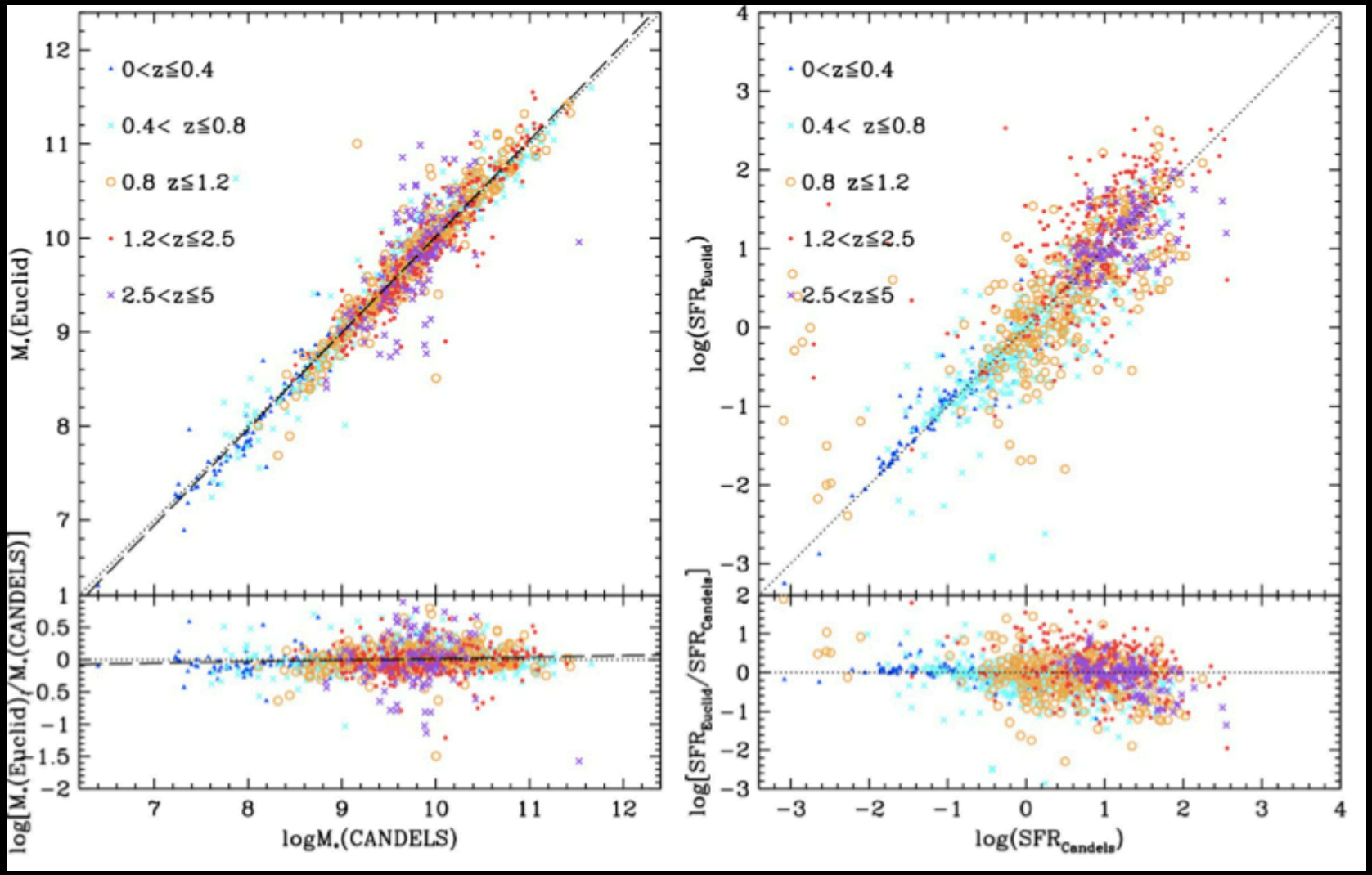
Some early simulations of the VIS imaging



HST images ‘Euclidized’

OU-MER: Adriano Fontana

Investigating: parameters of galaxies



From L. Pozzetti

Simulated Euclid SEDs from CANDELS

Study on Euclid-like spectra

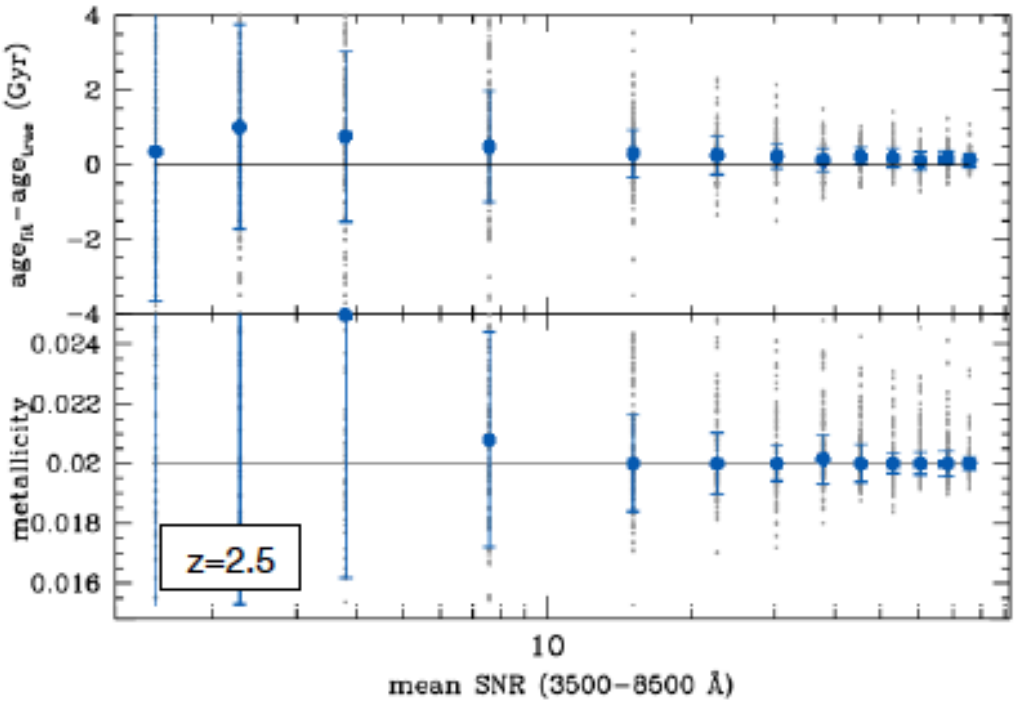
work done by A.Citro, S. Quai, A. Cimatti, L. Pozzetti, M. Moresco

Preliminary analysis on **full spectral fitting** have been extended to Euclid-like simulated spectra: SFH, age, stellar metallicity and A_V can be recovered with good accuracy at high-z for SNR≈20-30 (stacked spectra).

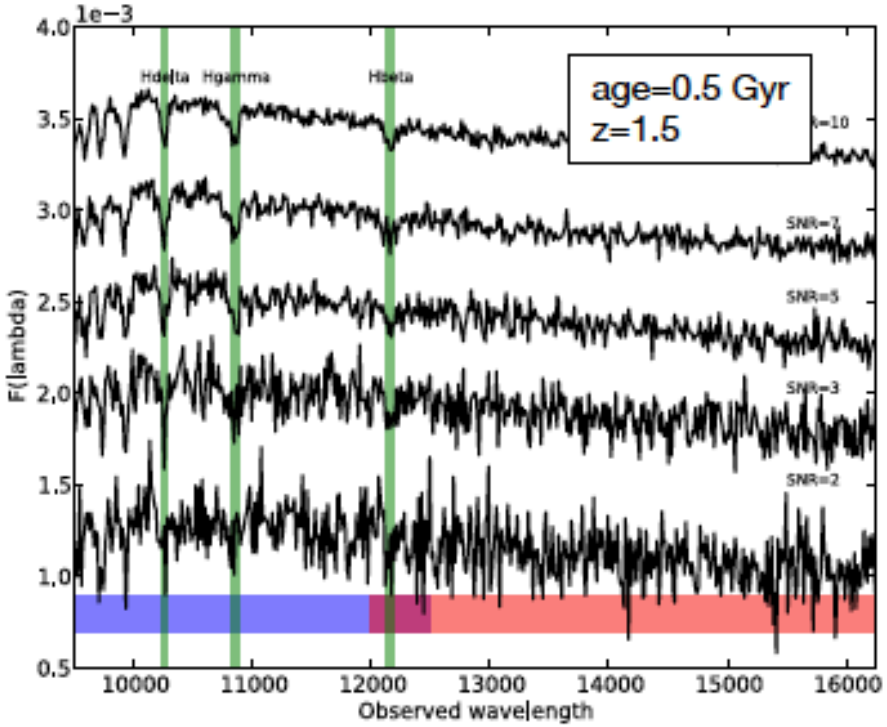
It has been also estimated the probability of measuring **Lick and continuum indices** as a function of SNR, age and redshift, together with signal-to-noise ratio and accuracy.

RECOVERED PARAMETERS

from spectral fitting



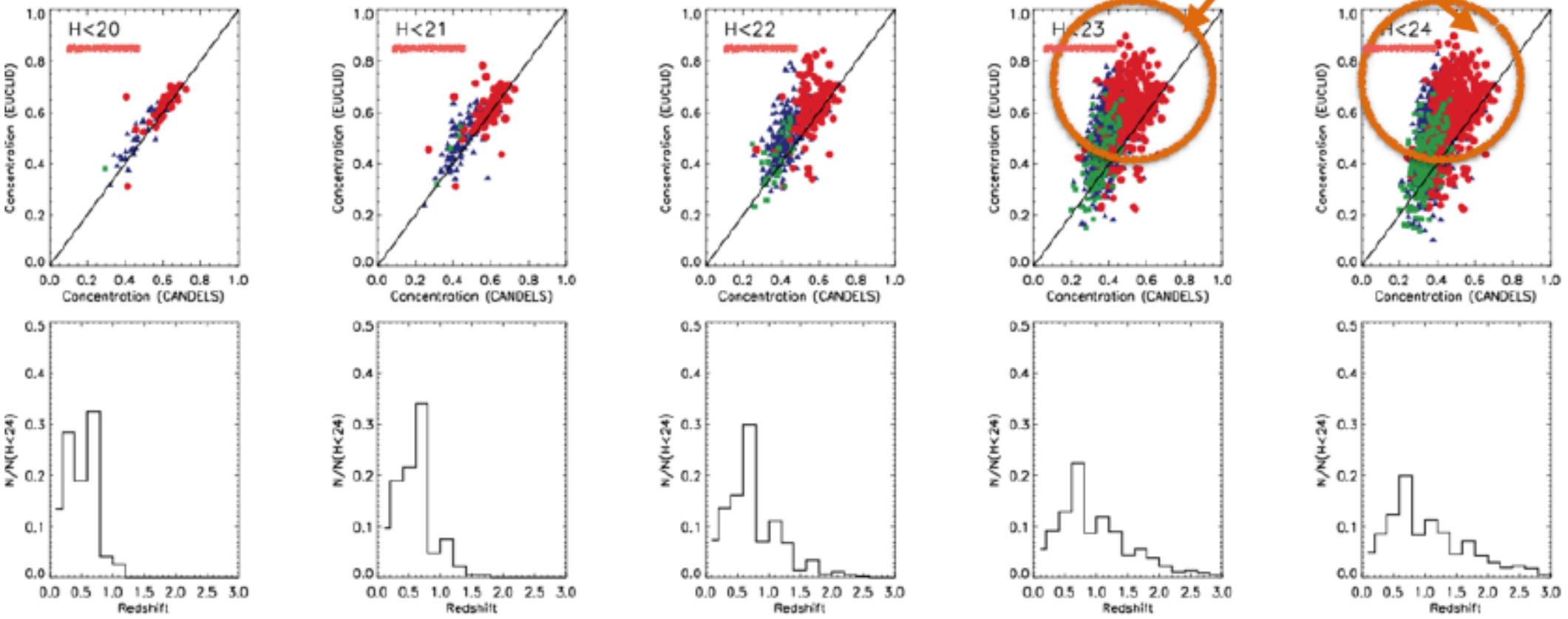
SIMULATED SPECTRA

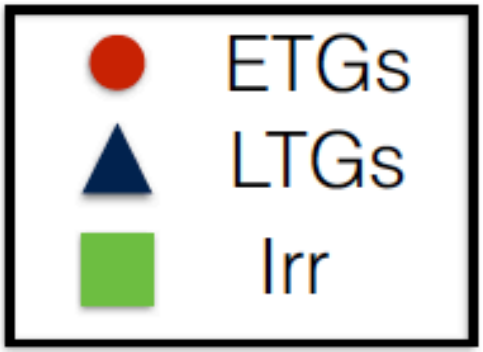


Concentration

Unresolved/faint — very high concentration

Simulations of Euclid imaging

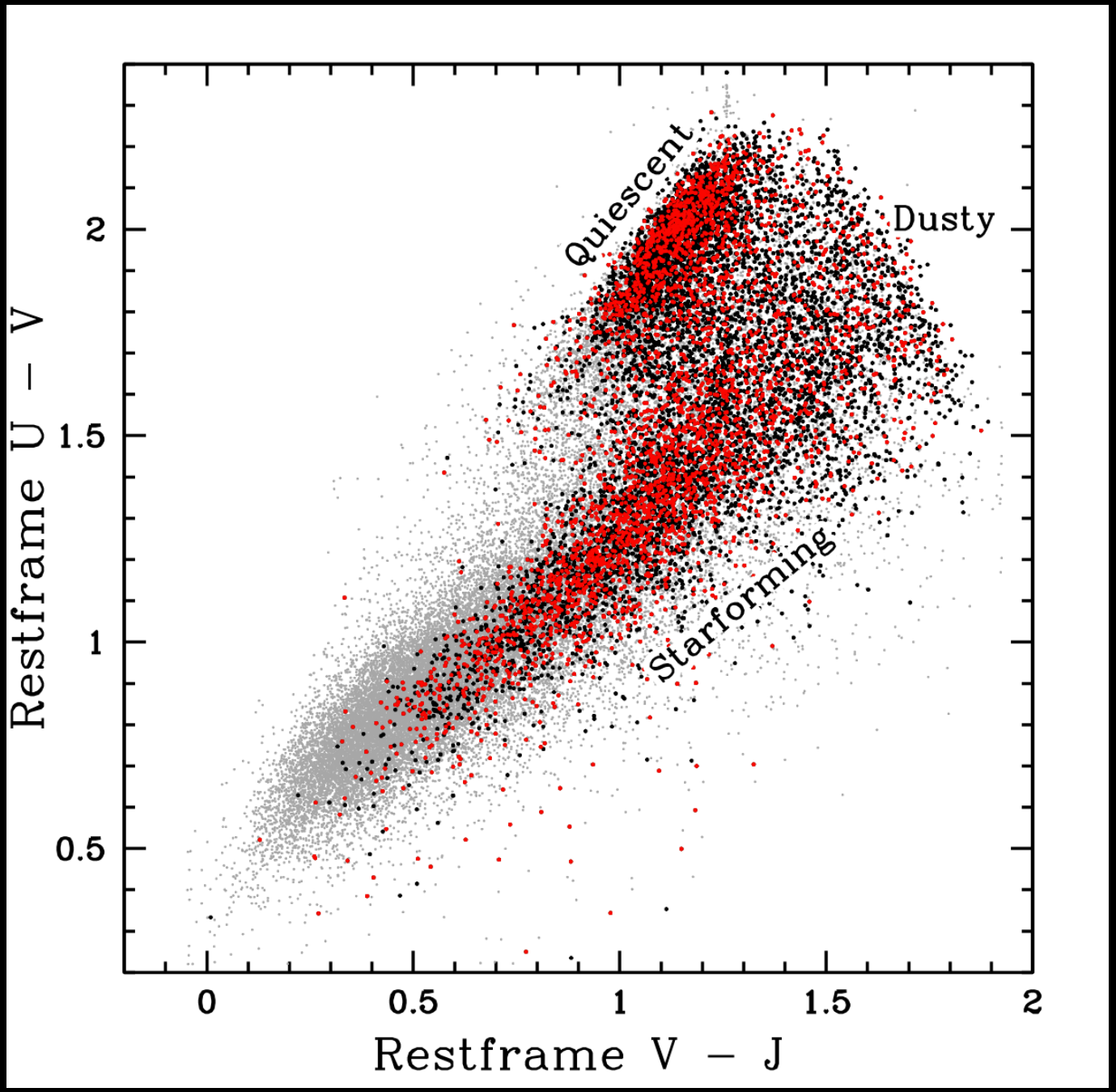




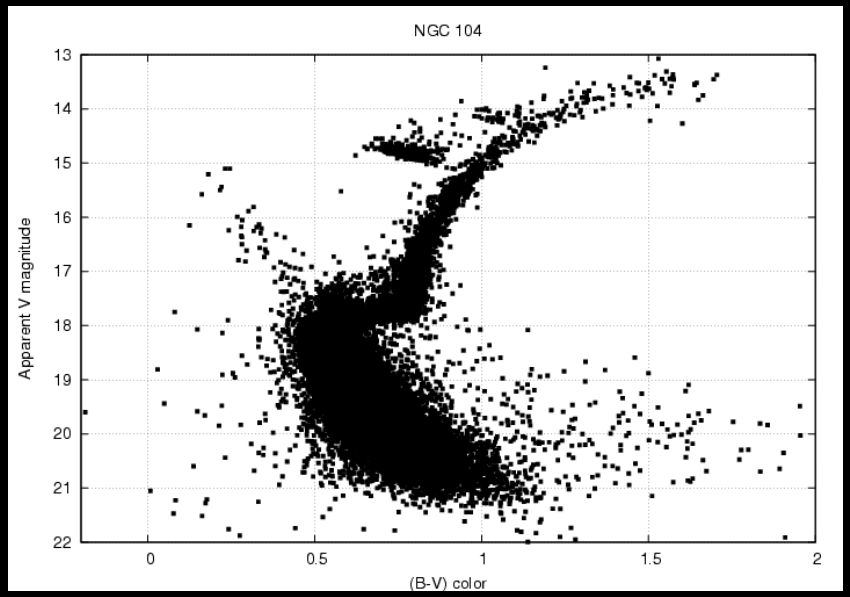
Important for also determining fidelity of shapes and morphologies

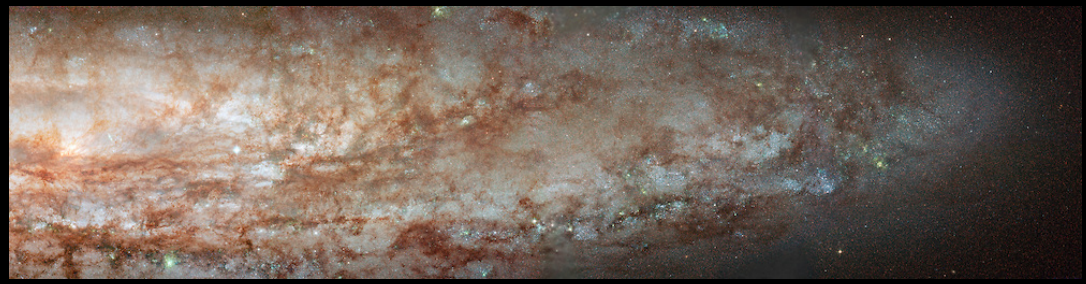
M. Huertas-Company

UVJ Colour-Colour plot for z > 1 galaxies



Resolved Stellar Populations



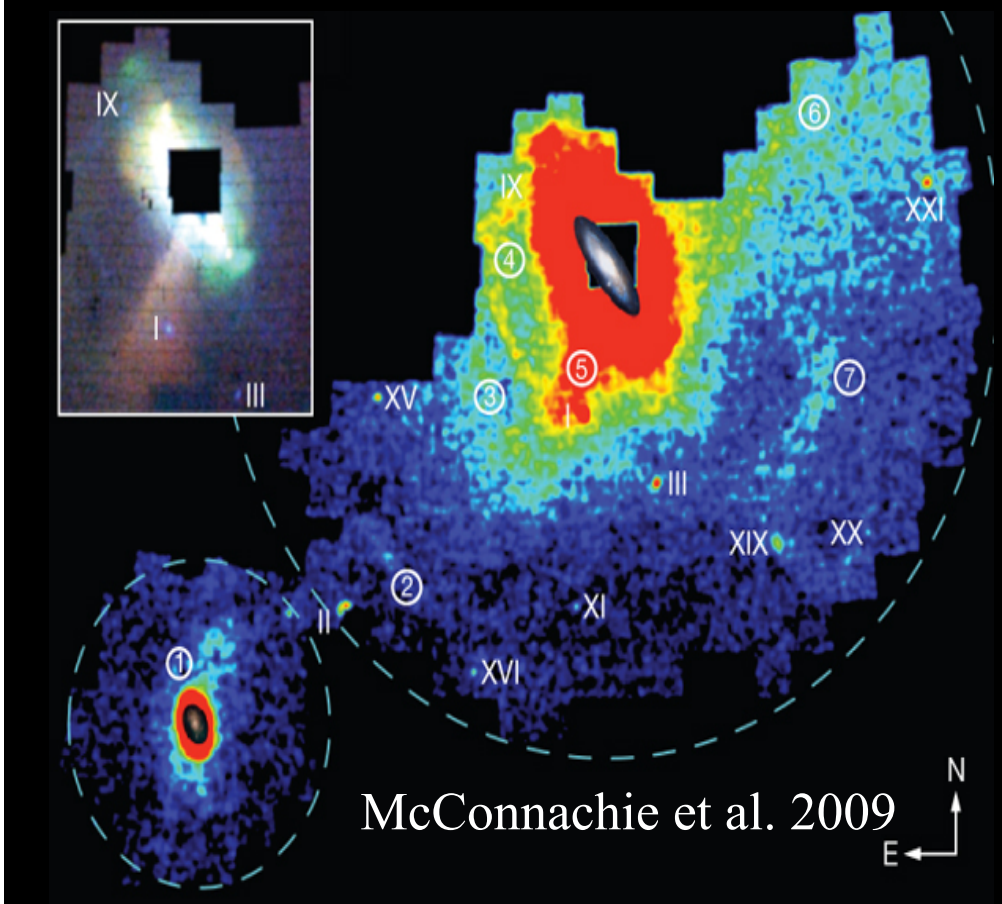


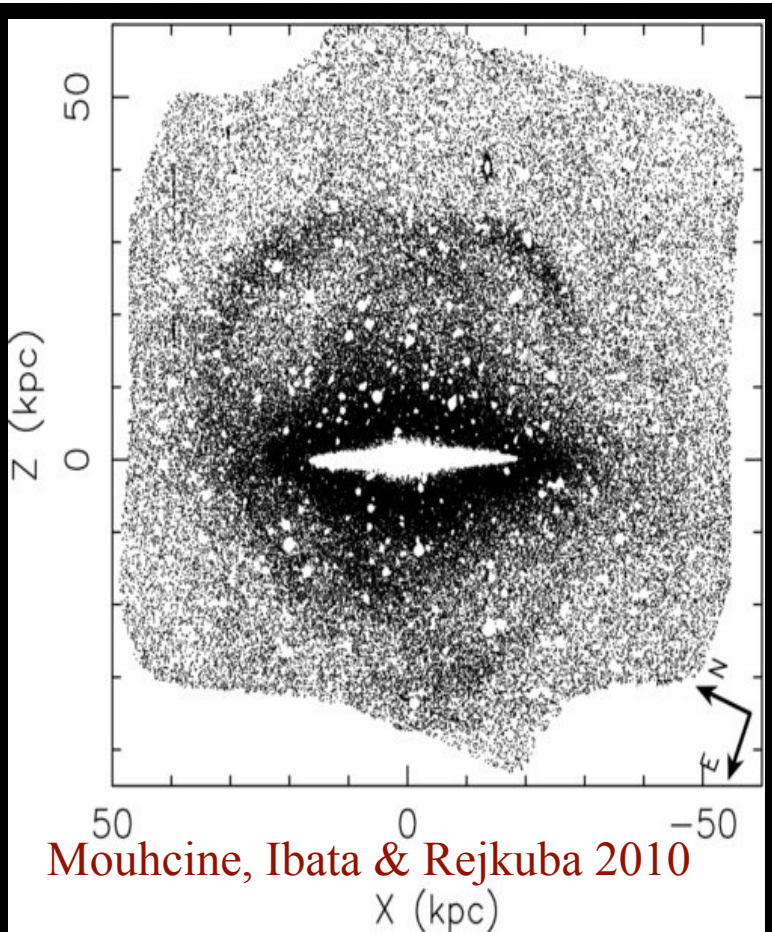
Can resolve stellar populations out to 5 Mpc with Euclid

Near-IR + optical a powerful approach for studying these stellar populations and thus the history of galaxy formation

Accurate absolute photometry essential for this

Extensive LSB structures around nearby galaxies





For legacy science we need

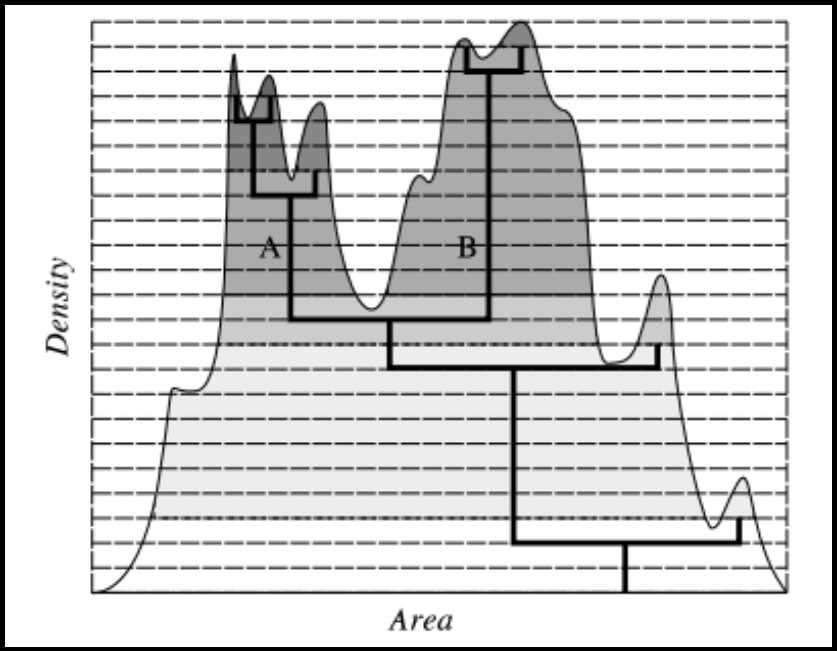
- Absolute photometry for nearby resolved stellar populations with accuracy ~0.01 mags

- Need absolute photometry to level of <0.03 mags for measurements of galaxy photometry (absolute mags, colours, stellar masses, etc)

- Relative photometry across field of view for lower surface brightness measurements for galaxies, as well as in morphological studies.

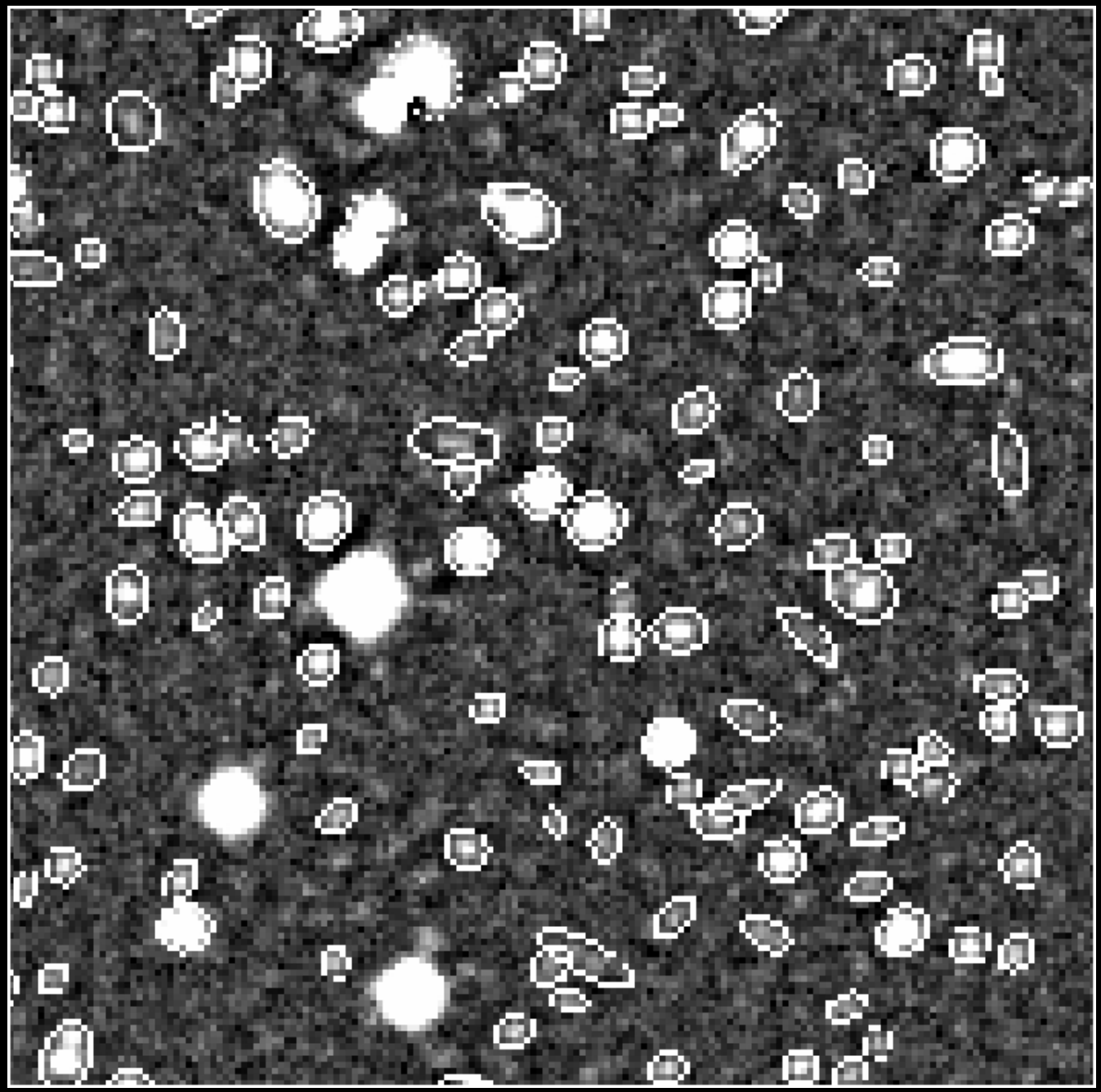
- Need to have at most a few % gradient in relative calibration across 10s arcmin – the sizes of the largest nearby galaxies

Example of preparation work needed: galaxy detection and segmentation mapping



Important for:

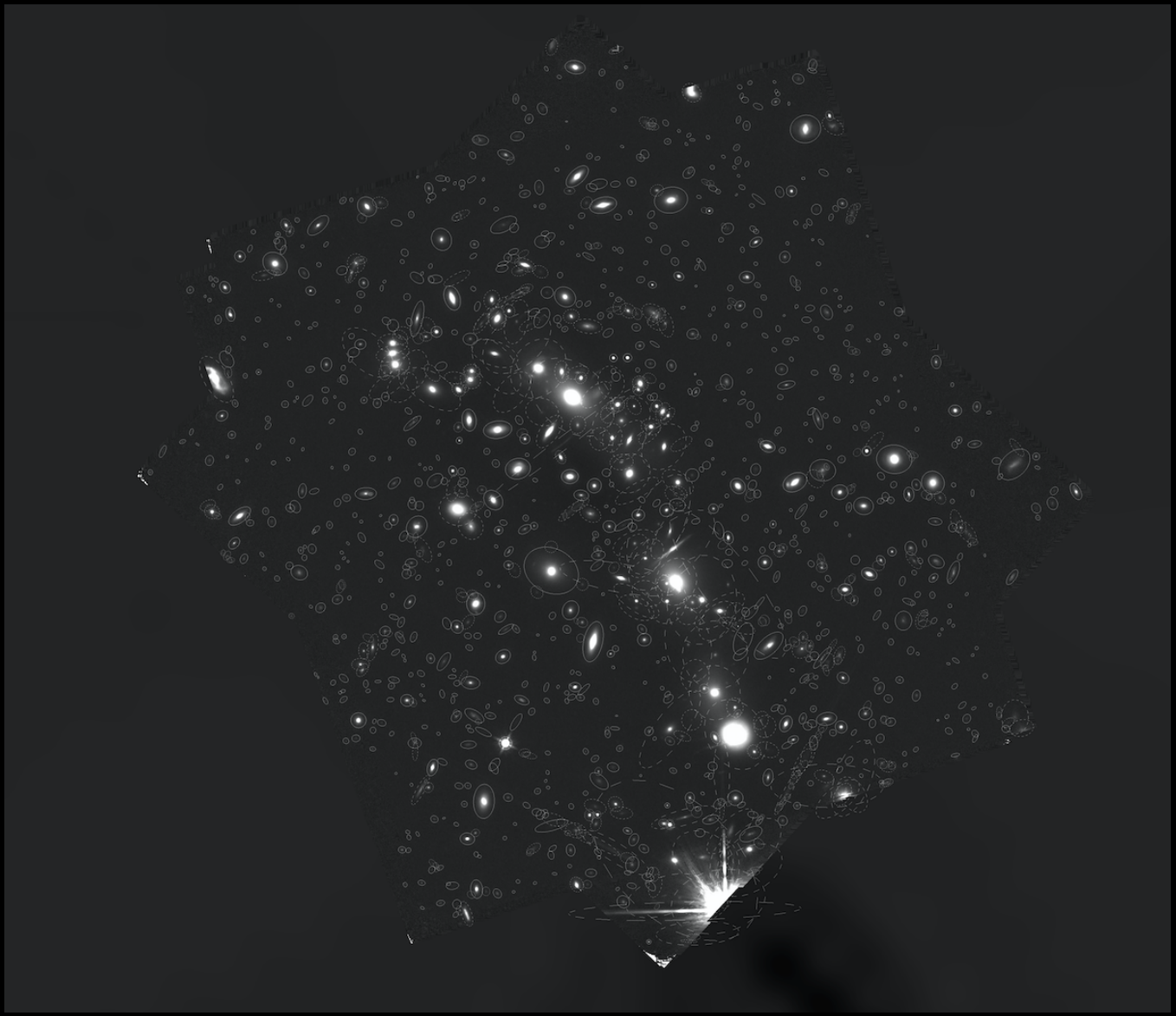
- Photometry
- Galaxy positions/catalogs
- Clustering measures
- Measures of overdensities
- Influence most areas in Euclid
- Measuring clusters



Typical
deep field
segmentation map

All galaxies
a few arcsec in
size in these
deep fields
(e.g., GOODS,
CANDELS)

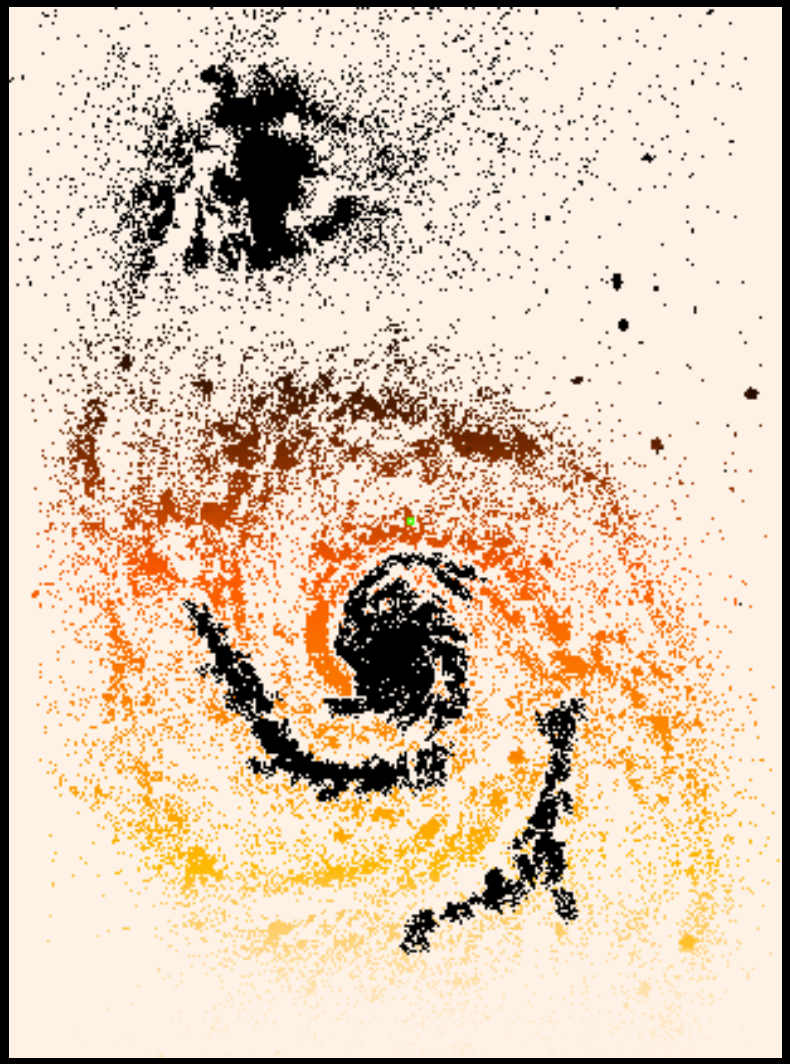
Problems with overdense regions



Extract multiple objects in same segmentation area

Problem of ‘large galaxies’

Shredding of galaxies – well known problem for larger galaxies



Example using typical CANDELS and Frontier Fields HST Sextractor detection parameters on HST image of M51 – each colour a separate ‘galaxy’ in catalog

Well known problem in SDSS

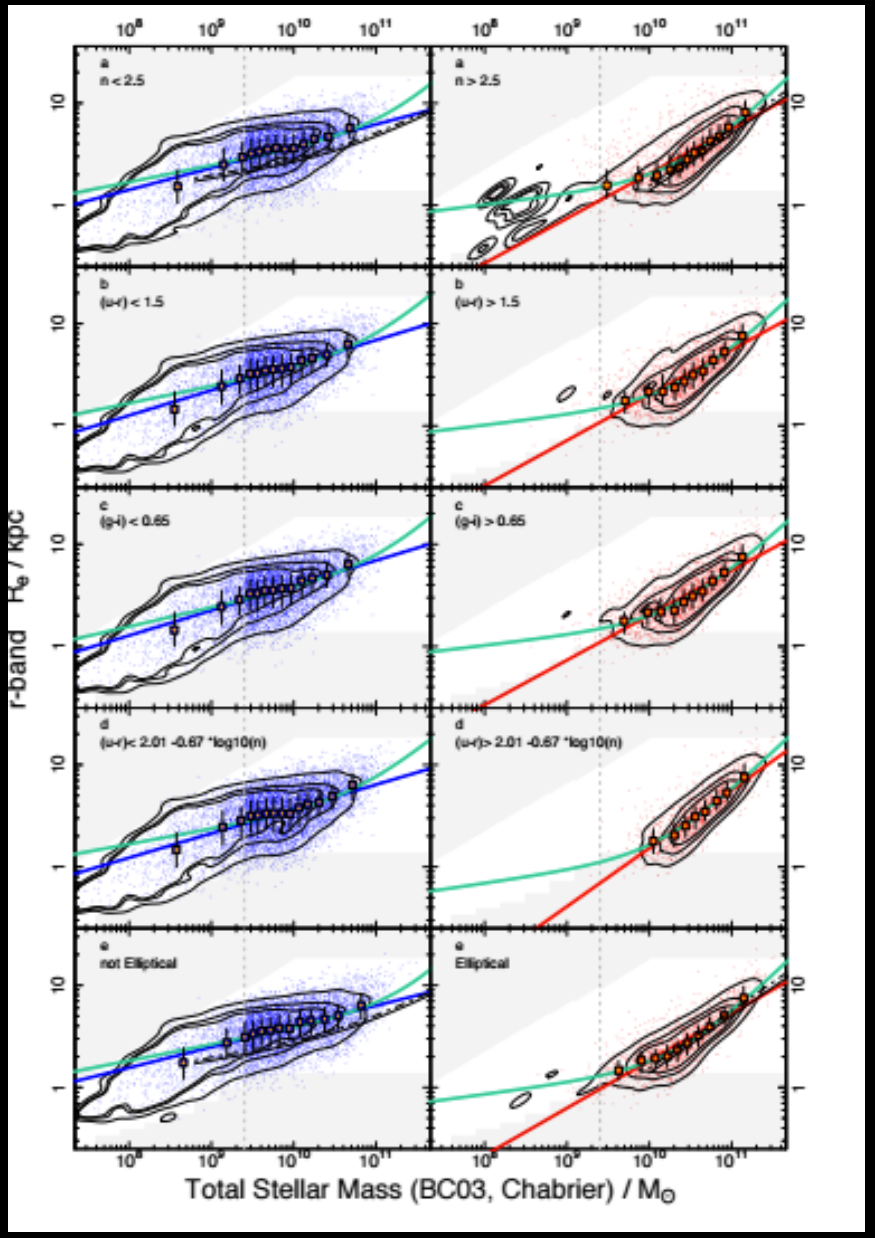
<u>Must do simulations beyond just using HST deep field imaging</u>

Is this really a problem? What fraction of Euclid imaging will contain these large galaxies?

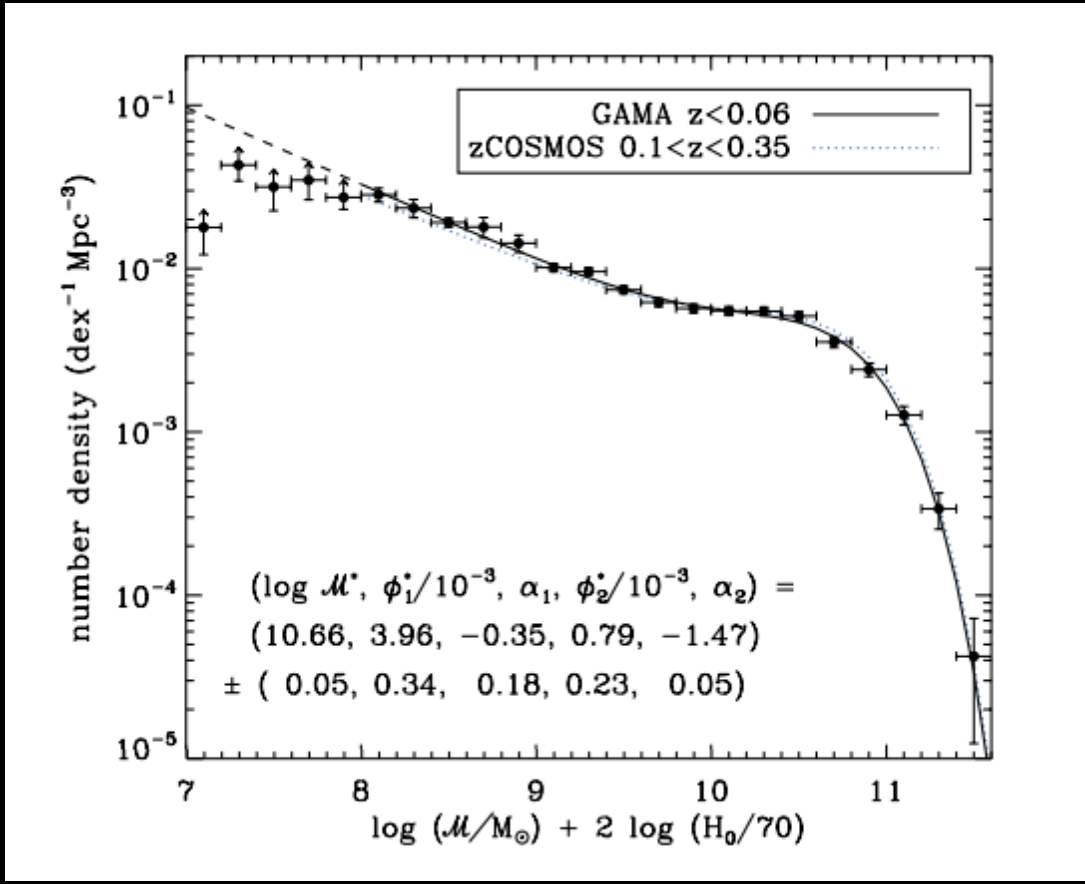
$$R_e = \gamma \left(\frac{\mathcal{M}_*}{\mathcal{M}_\odot} \right)^{\alpha} \left(1 + \frac{\mathcal{M}_*}{\mathcal{M}_0} \right)^{\beta - \alpha}$$

$$R_e = a \left(\frac{\mathcal{M}_*}{\mathcal{M}_\odot} \right)^{b}$$

Size-mass relations
(Lange et al. 2015)



Integrate sizes with number densities



Baldry et al. 2012

Shows that up to >2% of sky occupied by large galaxies not including clusters

An unnecessary source of systematic errors

Calibration must take into account the non-uniform nature of the universe

Future for Legacy Preparation in Euclid

+ Carefully consider which parameters to measure, and how to quantify properties, to derive galaxy evolution
  (a) criteria for certain parameters – size, S/N, colour limit
  (b) interact with science working groups
+ Simulation work needs to be done. Optimize dithering strategy, etc. as well as for understanding output
+ Consider how parameters can be used –
  (a) define galaxy types, find mergers, other galaxy sci.
  (b) use in other areas – clustering, lensing and photo-zs
+ Need to understand how the limits is photometric accuracy can affect the legacy science requirements. Once these are known we can determine what we can do