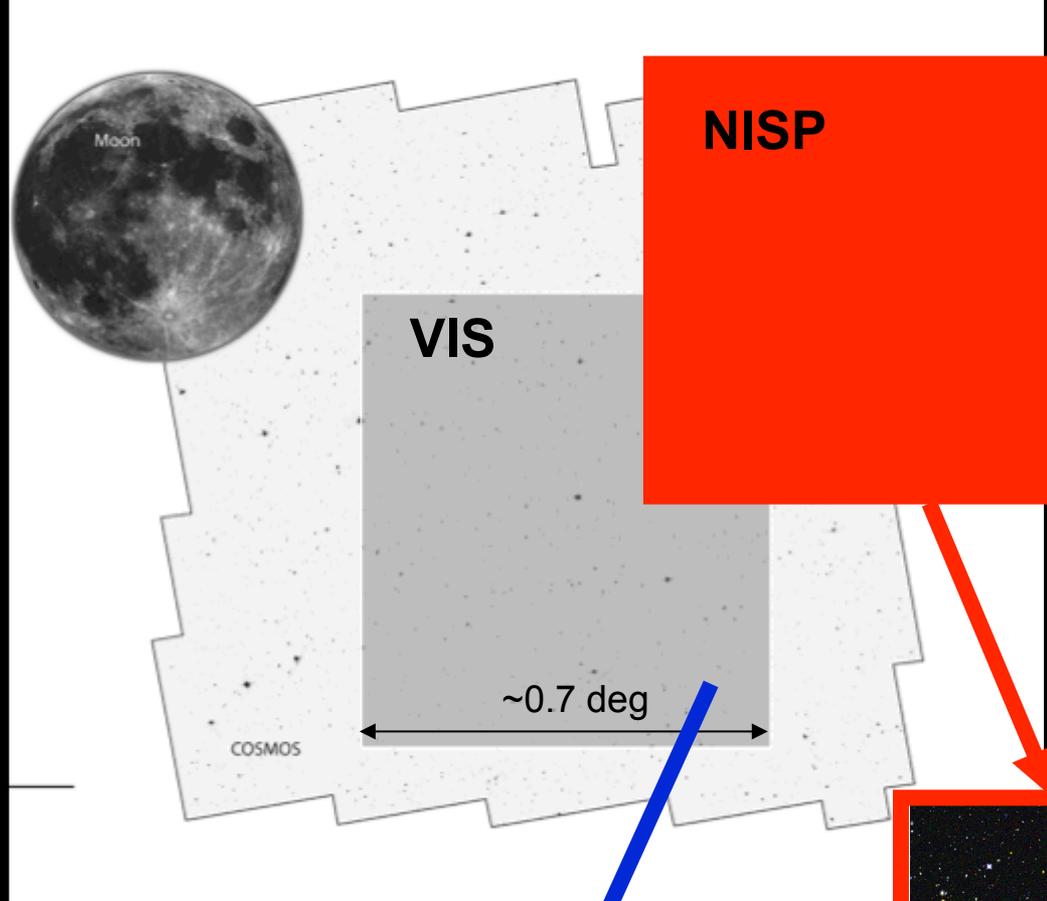


Euclid

Legacy Science on Galaxy & AGN evolution

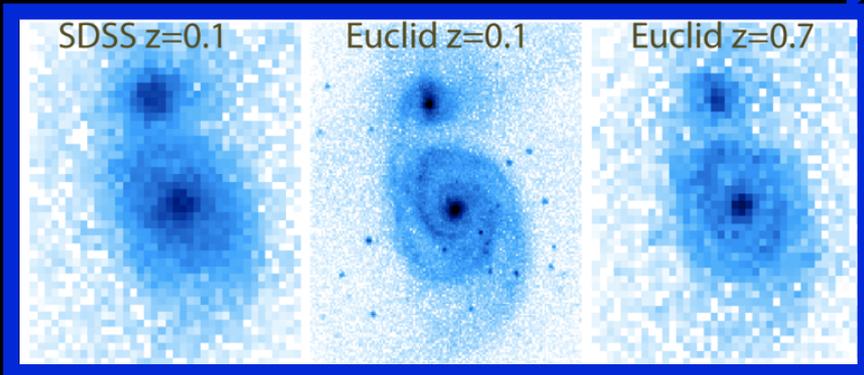
WP	Lead	Country
1 Phys.param. from SEDs	Lucia Pozzetti	I
2 Phys.param. from spectra	Giovanni Cresci	I
3 Environment	Manuela Magliocchetti	I
4 Morphology	Pierre-Alain Duc / Chris Conselice	F UK
5 Passive galaxies	Andrea Cimatti	I
6 Theoretical models	Gabriela de Lucia	I
7 Lensing	Steve Serjeant	UK
8 Multi-band synergies	Hervé Aussel	F
9 AGNs	Stéphanie Juneau	F
10 High-z ($2 < z < 7$)	Emanuele Daddi	F
11 Distrib. funct.	Elena Zucca	I

Coordinators:
Jarle Brinchman,
Andrea Cimatti,
David Elbaz



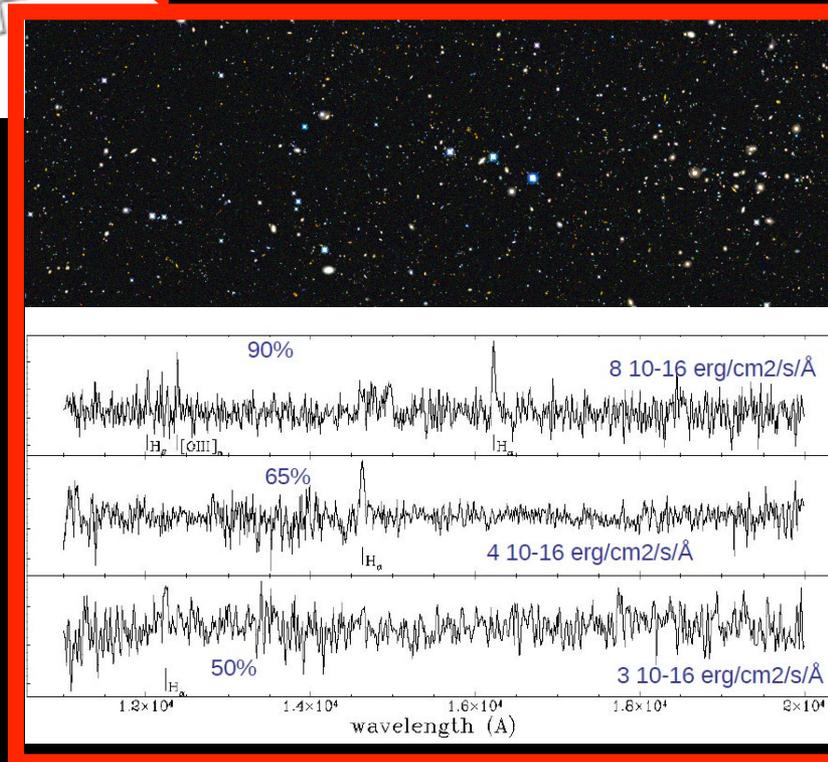
Y, J, H **imaging**, 0.3" pix, AB=24
 Slitless **spectroscopy**
 1.1 – 2 μm, R~300
 $F > 3 \times 10^{-16} \text{ ergs cm}^{-2} \text{ s}^{-1}$, $H_{AB} < 19.5$

High-resolution imaging (0.1" pixel)
 RIZ filter (0.55-0.92 μm), AB=24.5



SDSS
 -1.5 Gyr

Euclid
 -6.5 Gyr

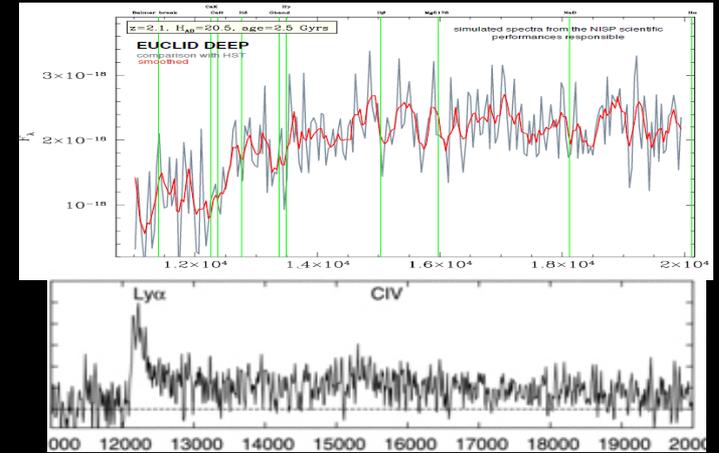


Galaxies & AGNs ($0 < z < 8+$)

Statistics: ~2 billion (imaging) + ~50 million (spectra)
→ $G(z, L, M^*, Z, \text{SFR}, \text{age}, \text{AGN}, \text{structure}, \text{environment})$
Multidimensional distribution functions

Galaxies & AGNs ($0 < z < 8+$)

Rarest ($L, M^*, Z, \text{SFR}, \dots$) (10^{3-4+})
Highest- z (e.g. 1000+ LBGs @ $z > 7$, AGNs)
Comparison with galaxy formation models



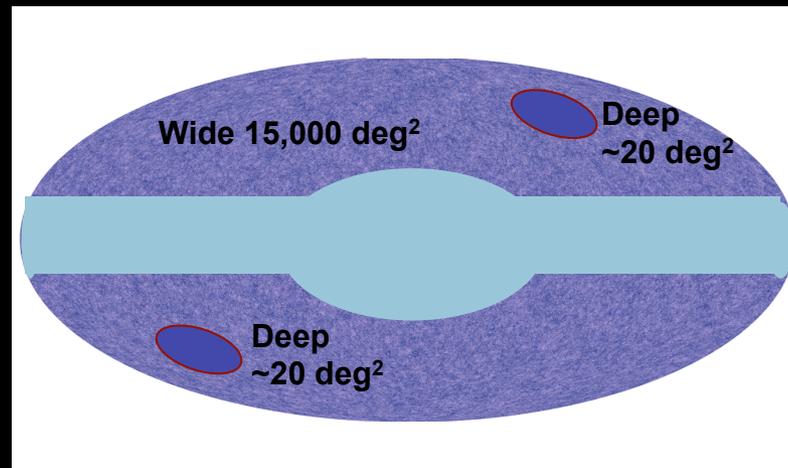
Clusters of galaxies

Statistics
Highest redshifts ($z > 2$)
Cosmological applications



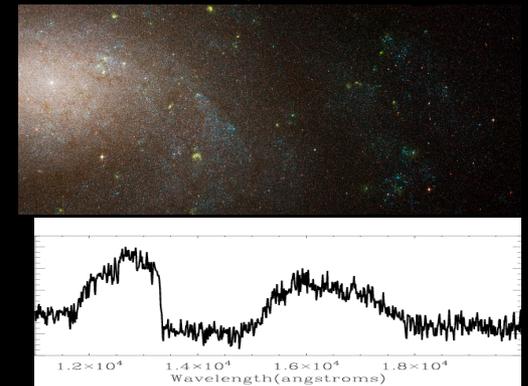
Strong Lensing

300,000+
Mass profiles



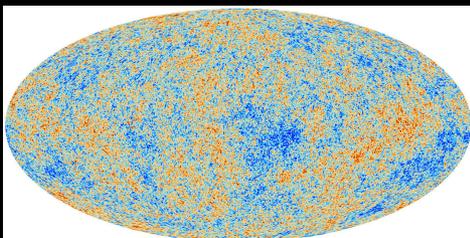
MW & Local Universe

Resolved stellar populations
Low-mass objects



CMB cross-correlations

ISW tests



Additional Surveys (TBD)

Supernovae
Exoplanets

Euclid in context

NIR Spectroscopy

- * 3D-HST: 248 orbits of HST grism over 600 sq.arcmin, PSF FWHM **0.13"** on well studied "CANDELS" fields (GOODS-S, UDS, EGS, COSMOS)
- **10 000 redshifts at $z > 1$** , $SFR > 1.5 M_{\odot} \text{yr}^{-1}$ at $z=1$ and $15 M_{\odot} \text{yr}^{-1}$ at $z=2$
- **JWST/NIRSPEC** will increase the depth but on **known targets** !

Euclid: DEEP 300 000 galaxies $1.06 < z < 2.05$ ($SFR > 20 M_{\odot} \text{yr}^{-1}$)
WIDE 1 million

- $H\alpha$ LF with 0.4% precision down to $0.1 L^*$ at $z=1.5$
- multi-parameter physics : SFR vs mass and redshift
- ⇒ **AGN** BPT AGN selection $[OIII]/H\beta$ vs $[NII]/H\alpha$ for bright enough galaxies where the separation of $[NII]$ vs $H\alpha$ is feasible ($F(H\alpha) > 10^{-15} \text{ erg.s}^{-1} \text{cm}^{-2}$)

VIS Morphology

- * **HST:** **100s galaxies at $z > 1$**
- Euclid** **x10 000** for galaxies with z_{spec} !
x 500 000 for galaxies with z_{phot} !
- ⇒ **merger rate** up to $z \sim 6$ instead of $z \sim 1$
- ⇒ **merger / AGN connection**

61 % in E/S0

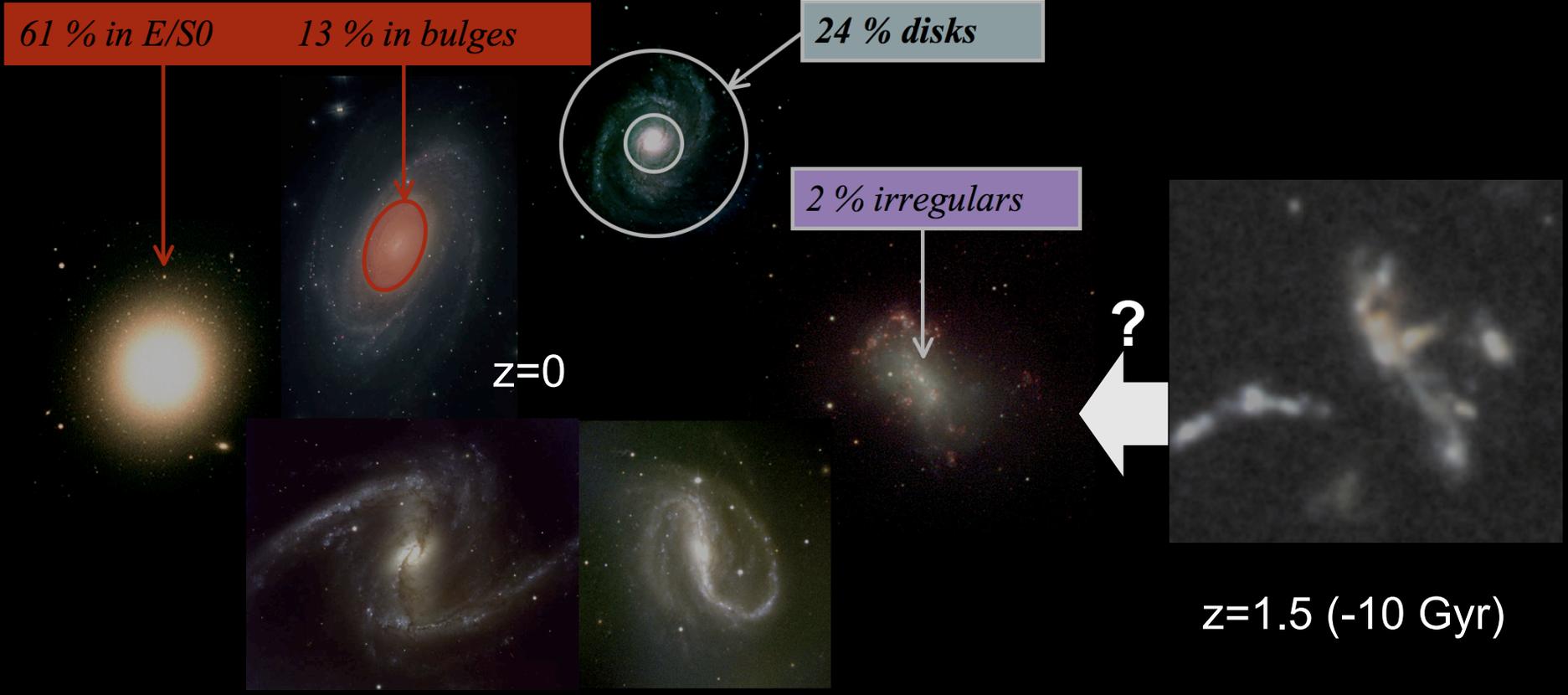
13 % in bulges

24 % disks

2 % irregulars

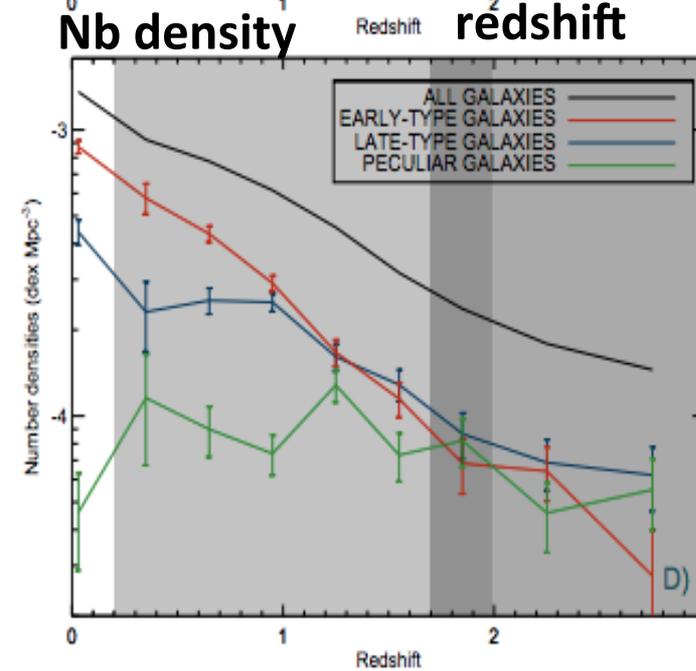
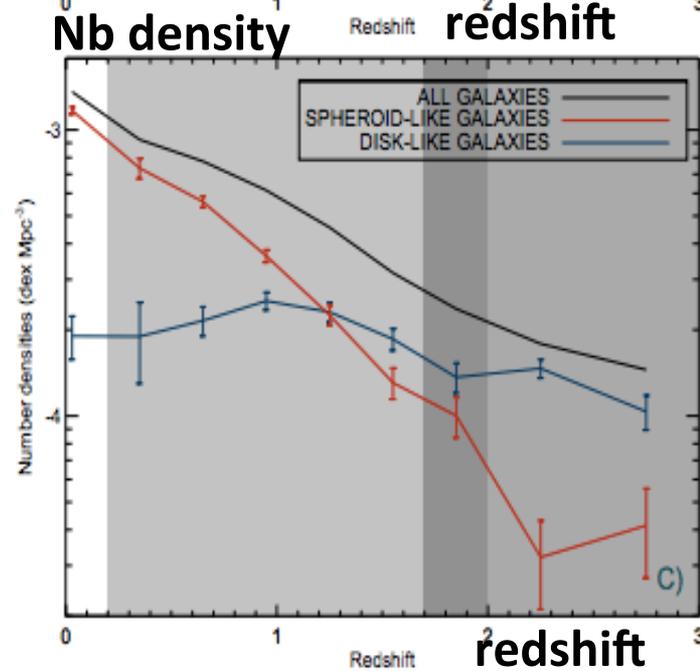
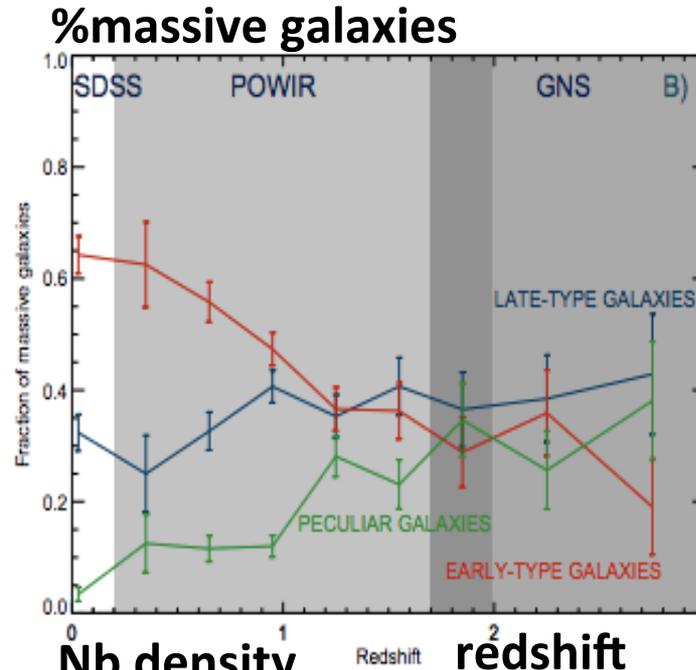
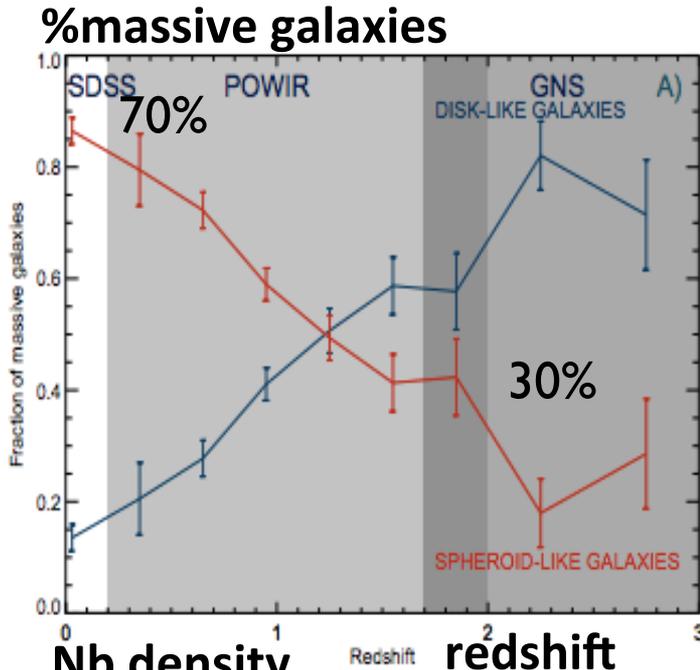
$z=0$

$z=1.5$ (-10 Gyr)



Morphological evolution of galaxies (WP4 P.A.Duc)

Today 70% of massive galaxies are ellipticals
but at $z > 1$ they were a minority !!!



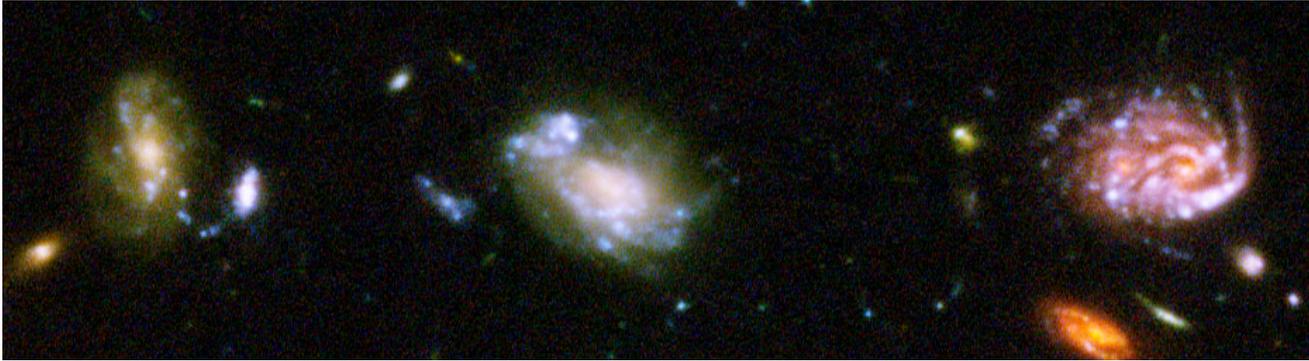
1082 galaxies
with $M_* > 10^{11} M_{\text{sun}}$

- Based on 1082 objects (SDSS + Palomar Observatory Wide-Field Infrared/Deep2+ Goods Nicmos Survey)

- Euclid:**
morphology for 2 billion galaxies

Morphological evolution of galaxies

- Merger rate redshift evolution highly debated: based on pairs (with assumed merging scale), fraction of perturbed galaxies, etc...



- High distant disks are more gas rich and clumpy



Morphological evolution of galaxies

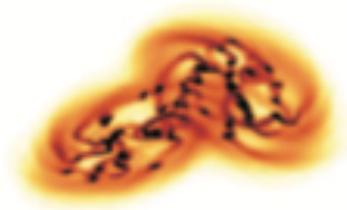
- Mergers at $z=0$



Duc et al., 2012

- A merger at $z=2$

Gas - C1



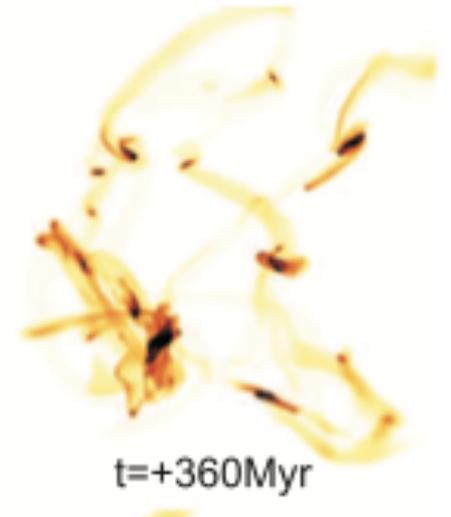
T=-155 Myr



t=+55 Myr



t=+215 Myr



t=+360 Myr

Bournaud et al., 2011

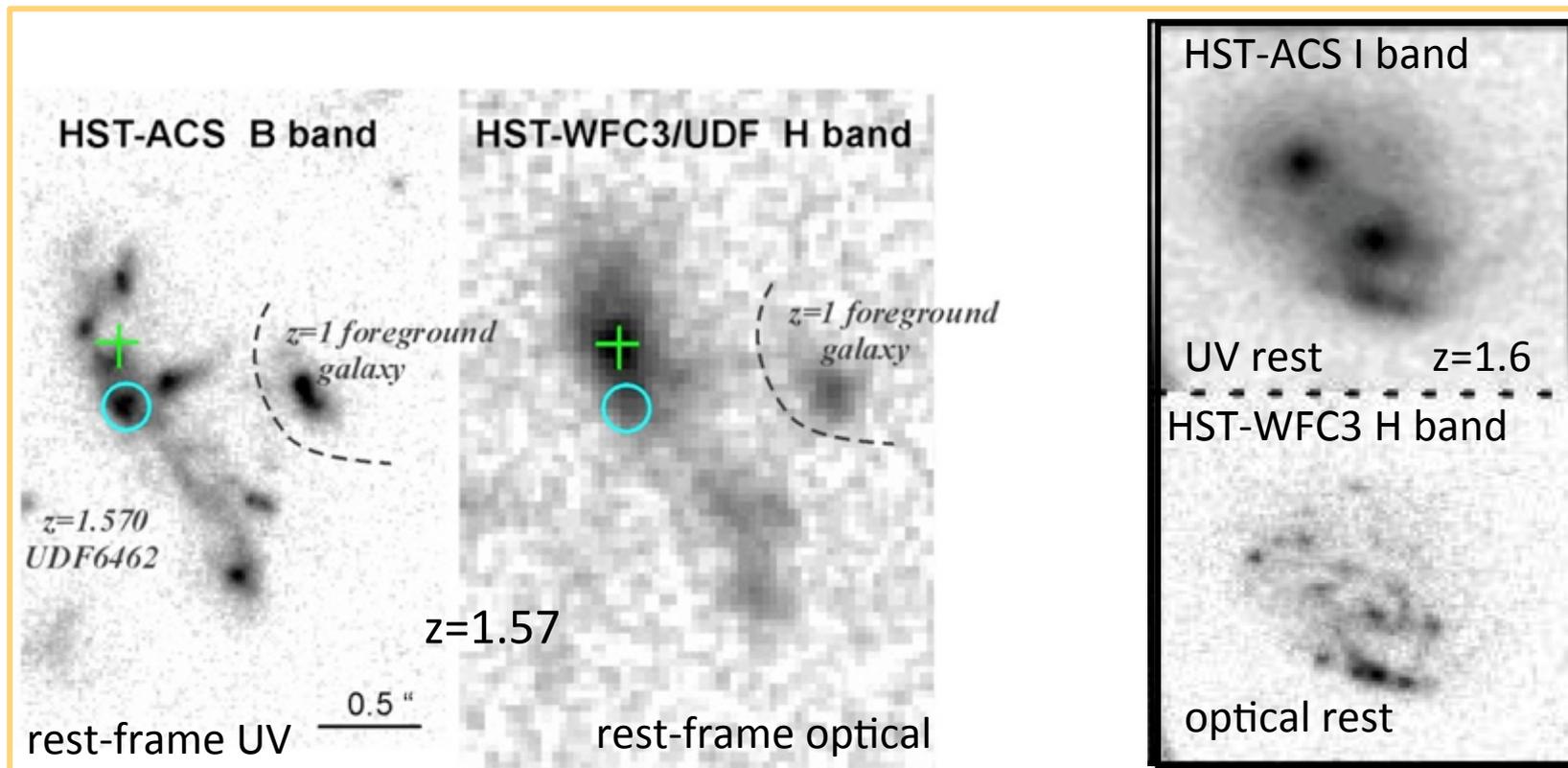
➔ Prominent tidal tails no longer visible

- VIS: one single visual very broad band

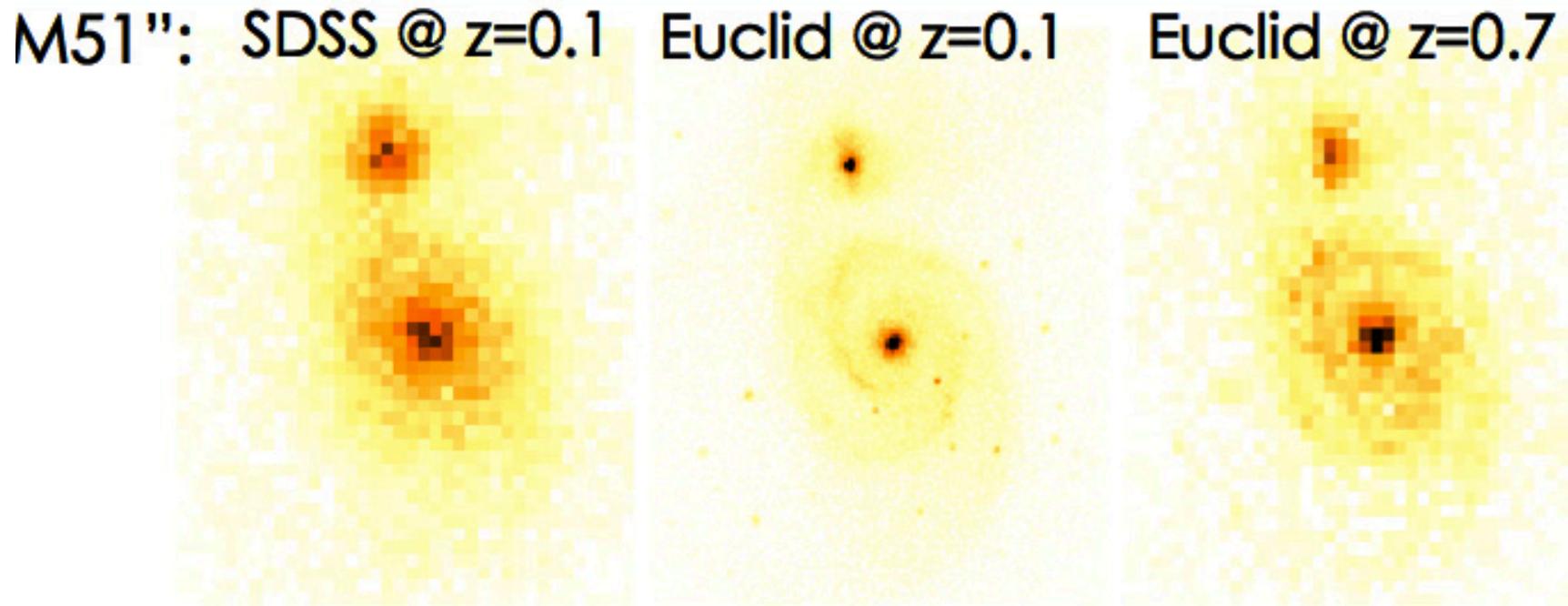
What is the impact on morphological classification?

- NIR: several filters, but worse spatial resolution

Will they be useful for distant ($z > 2$) galaxies?

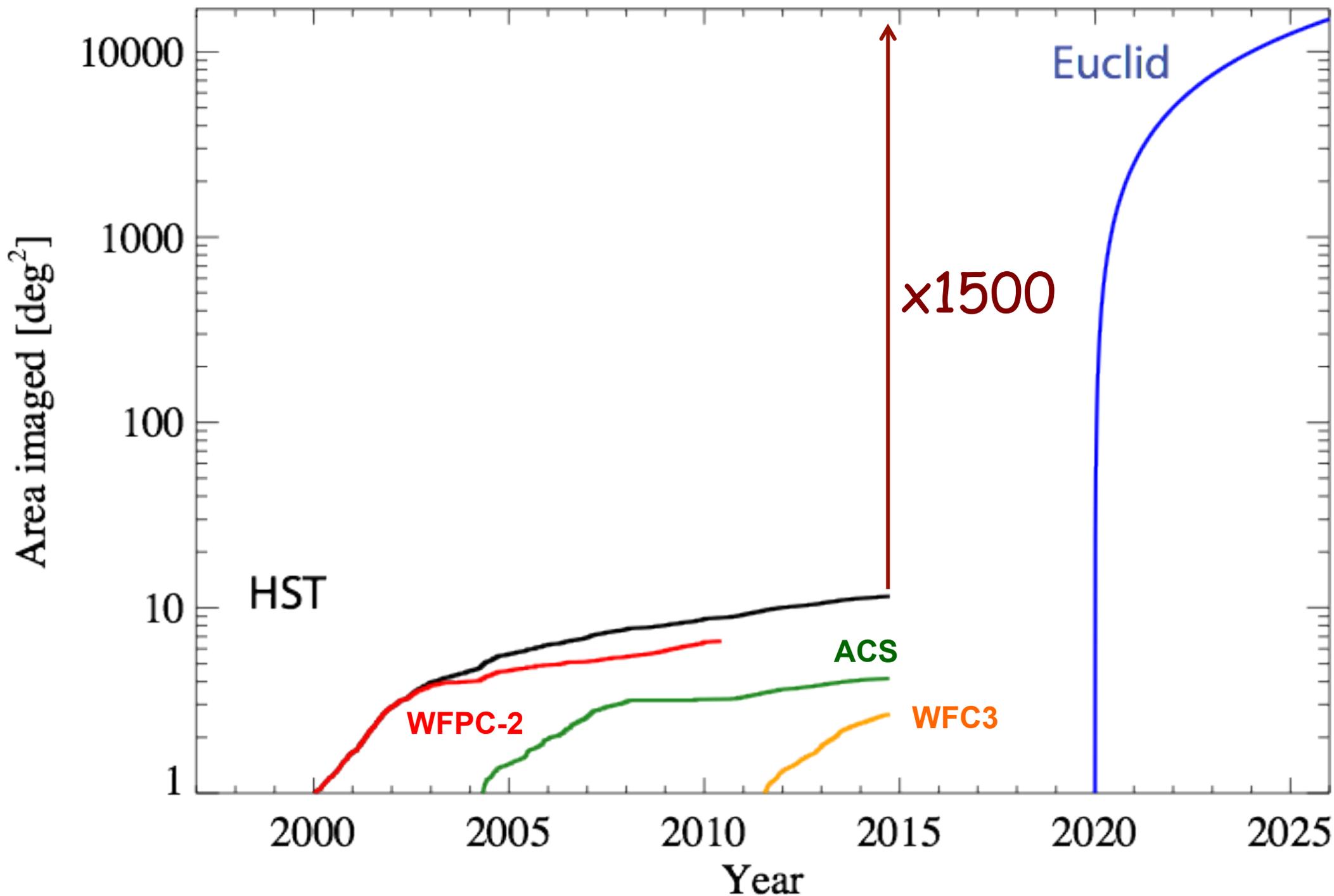


Euclid imaging performance



- VIS: $0.17''$ FWHM; $0.1''$ /px
- NIR: $0.3''$ /px
- ➔ resolution of 1.3 kpc for distant galaxies
- ➔ same resolution as SDSS images at $z=0.05$ at $z=1$

Euclid High-resolution Imaging (VIS Instrument)



Galaxy morphological classification and surface brightness limit



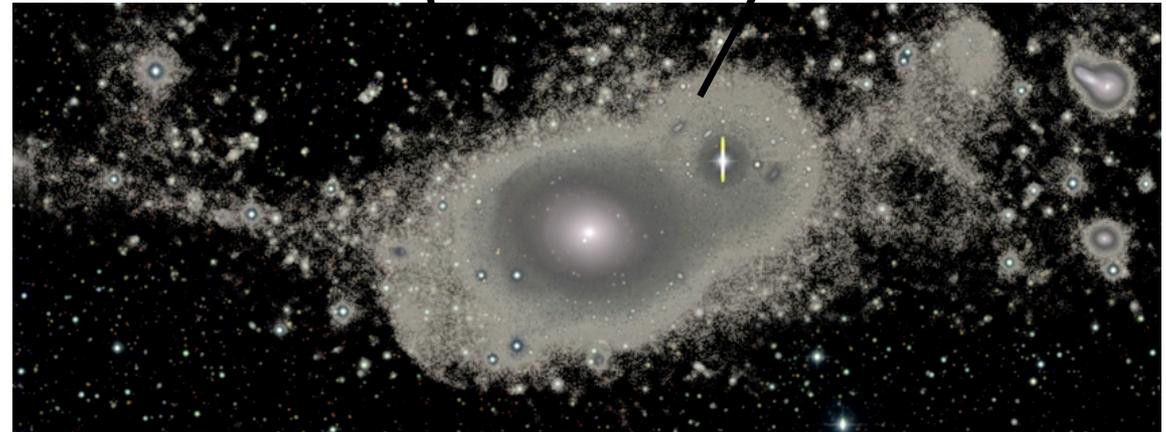
SDSS: an E

MegaCam: a spiral!



SDSS: a fully relaxed ETG

MegaCam: a major merger remnant!



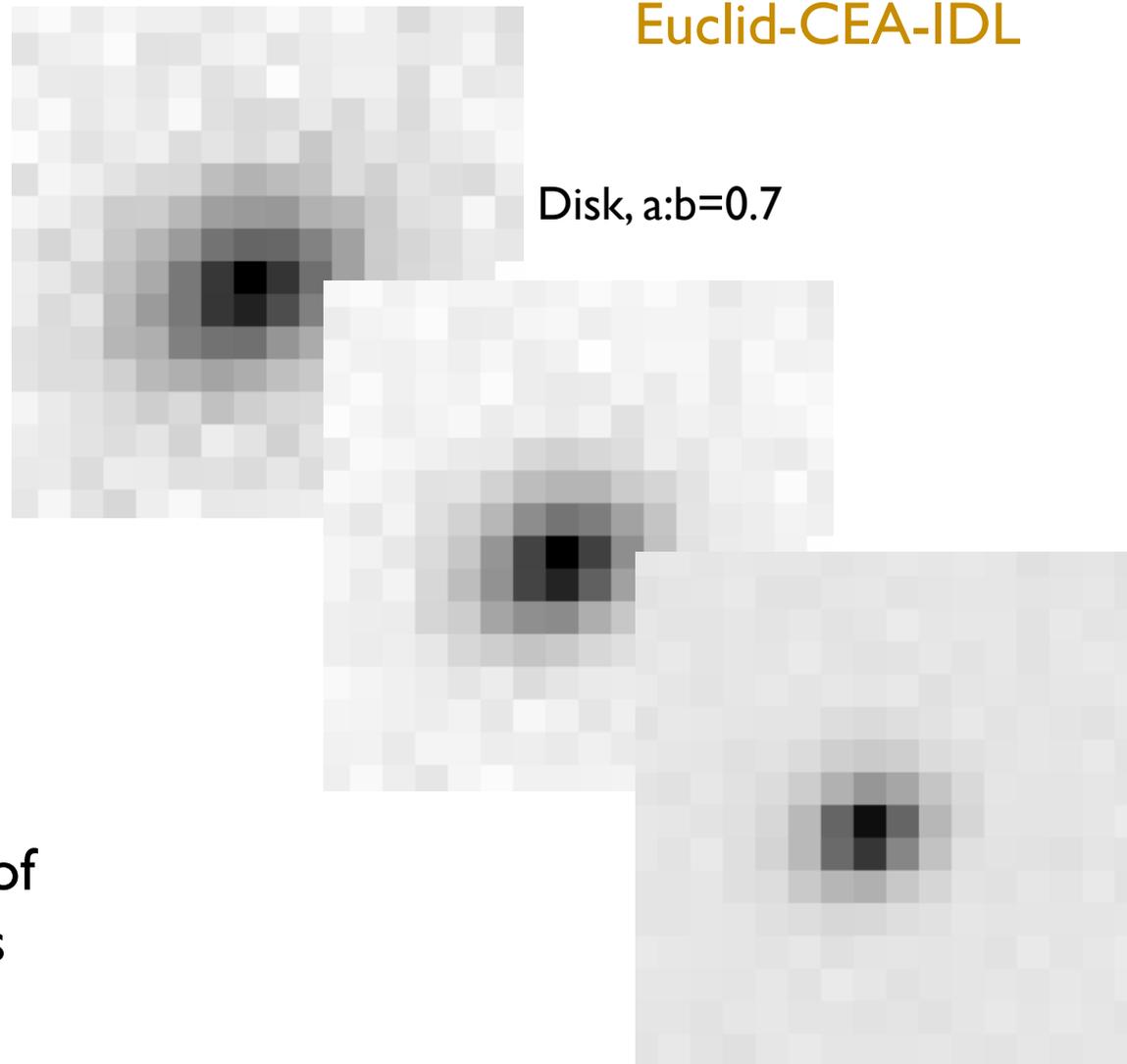
MATLAS/Atlas3D survey: Duc et al., 2013

- Classification depends on limiting surface brightness even in the nearby Universe !

What will be the limiting surface brightness of Euclid?

Galaxy morphological classification and surface brightness limit

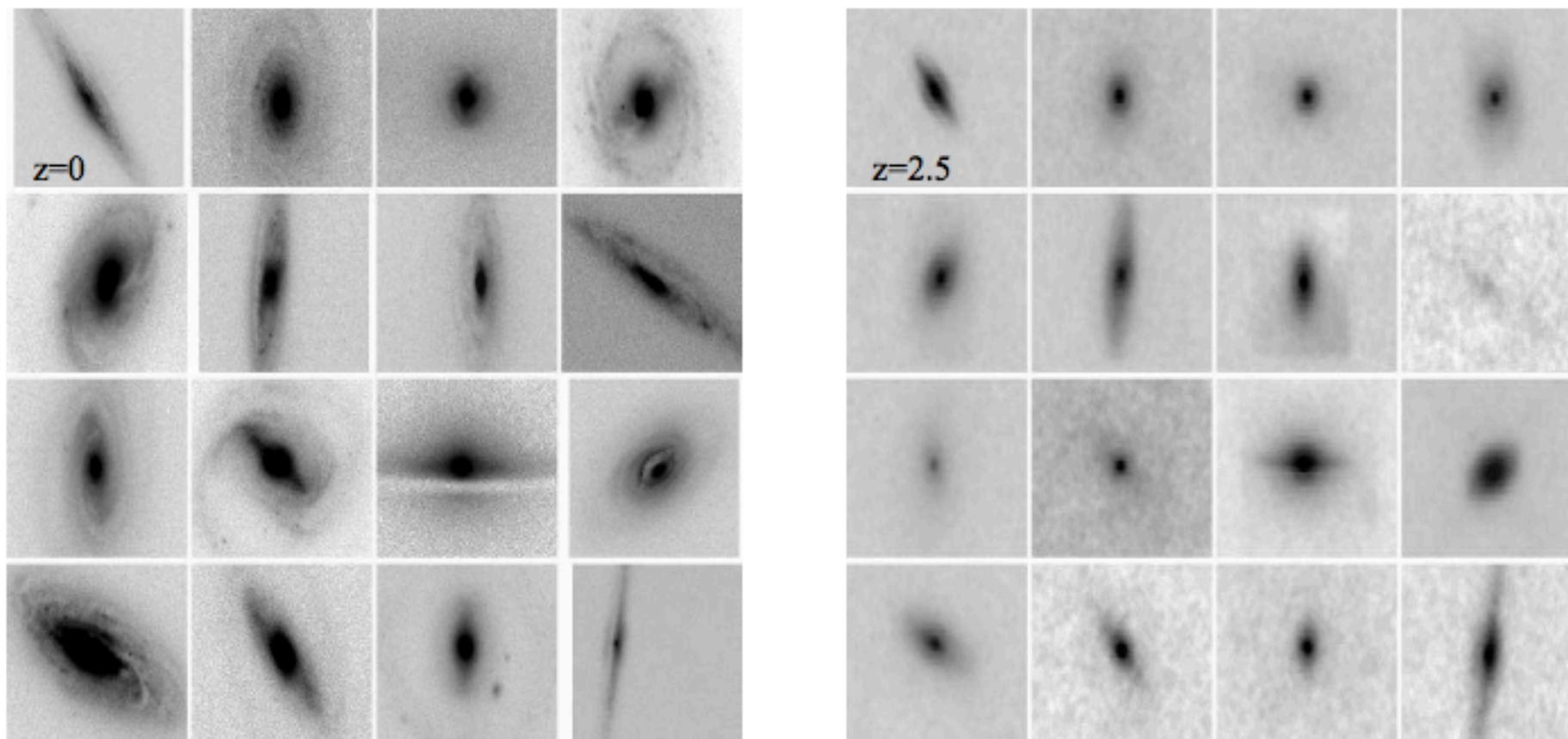
Courtesy: Stéphane Paulin-Henriksson
Euclid-CEA-IDL



- Simulations of model galaxies

➡ Euclid will resolve 1/3 of the R_{eff} of a $5 \times 10^{10} M_{\odot}$ galaxy at $z=2$

Galaxy morphological classification and surface brightness limit



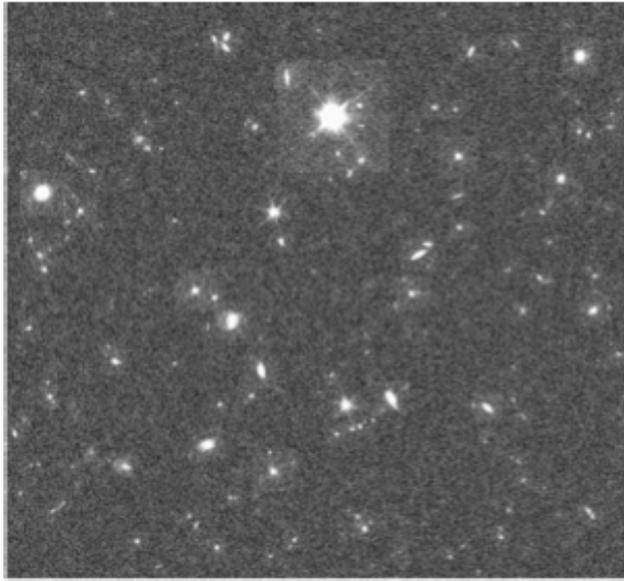
Courtesy: C Conselice

Nearby $z=0$ early-type spirals simulated into the Hubble UDF

- Projecting nearby galaxies at higher redshift, and simulated them at Euclid resolution

Galaxy morphological classification and surface brightness limit

VIS - 565 seconds
Nominal Pixel Scale



ACS - F814W 6900s
AstroDrizzled to 0".03



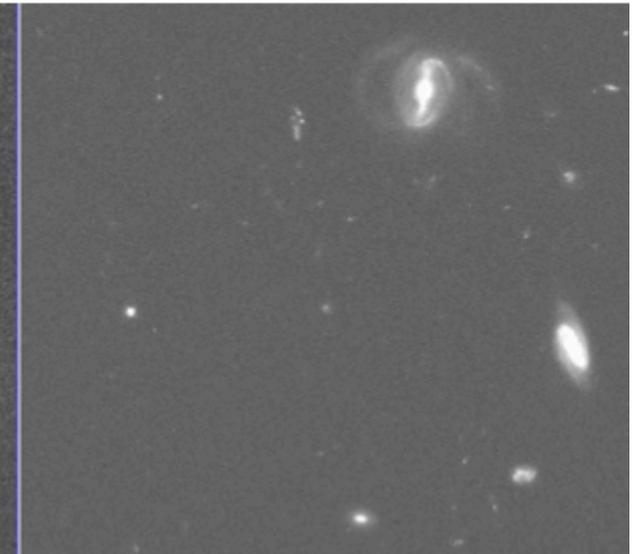
Courtesy: Sami Niemi
WL-SWG

- Simulations of distant HST galaxies at Euclid resolution

VIS - 565 seconds
Nominal Pixel Scale



ACS - F814W 6900s
AstroDrizzled to 0".03



➡ The need for «realistic»
Euclid images....

Identifying relevant parameters for morphological classification

- Eye classification à la Galaxy zoo?

150 000 persons have classified 50 million galaxies



Karen Masters @KarenLMasters

10 Mai

@PenguinGalaxy @thebamf I have calculated #euclidmission well resolved galaxy images would take ~70 yrs of @galaxyzoo #needtocheckfigures

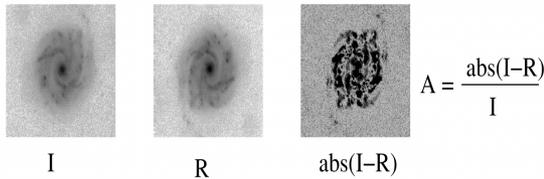
Identifying relevant parameters for morphological classification

- Single parameters: Sersic profile fitting

$$I(R) = I_e \exp(-b [(R/R_e)^{1/n} - 1])$$

- CAS system

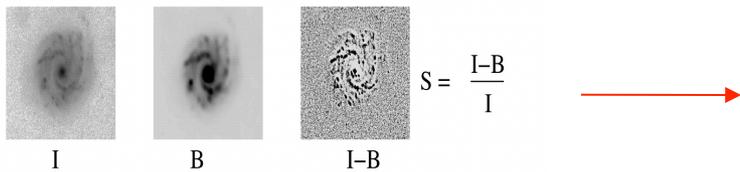
Concentration (C) \longrightarrow the scale or mass
Asymmetry (A) \longrightarrow major mergers
Clumpiness (S) \longrightarrow star formation



Asymmetry (A)

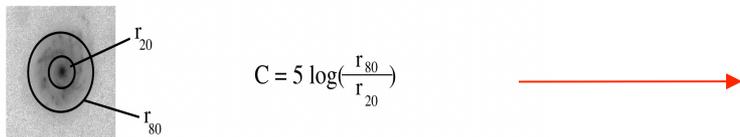
- Gini system

Uniform or patchy brightness



Clumpiness (S)

- Color of galaxies?



Concentration (C)

Conselice (2003)

Galaxy morphologies: the gain of having large statistics

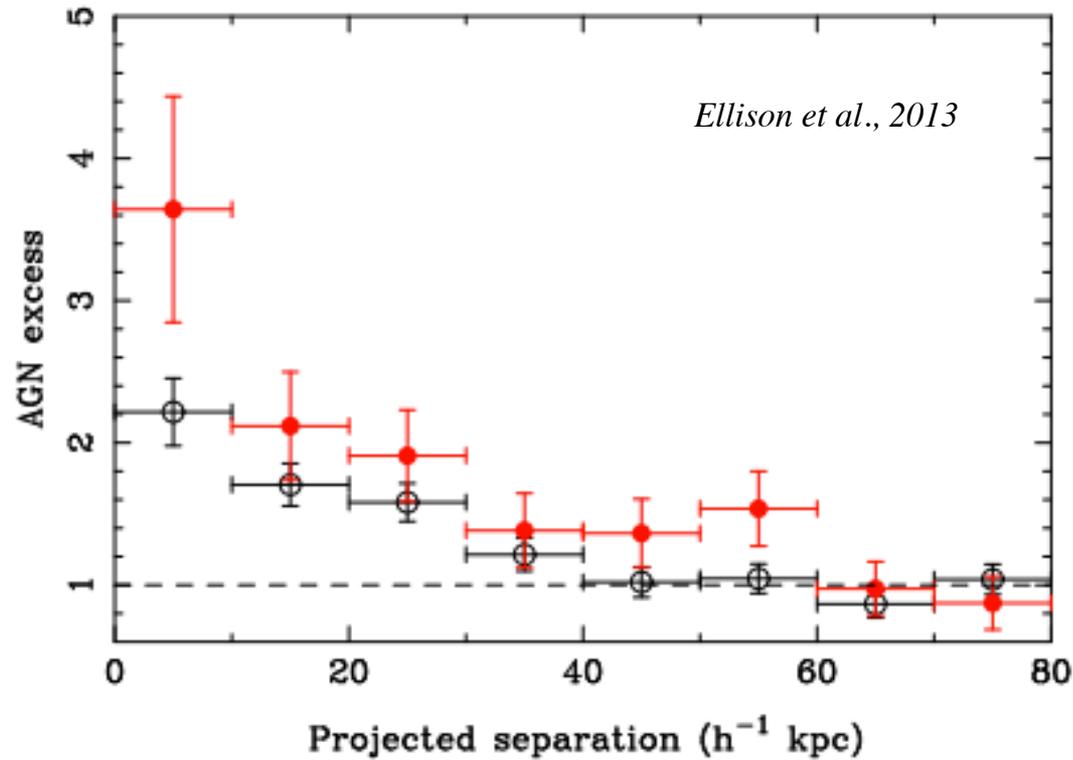


Figure 3. The AGN excess (fraction of AGN in the pairs relative to the fraction of AGN in the control sample) is plotted as a function of projected separation. Black open symbols show galaxies at $z < 0.1$ and red filled points show galaxies at $z \geq 0.1$.

- As shown by the SDSS:
AGN fraction vs galaxy pairs

WP9: Active Galactic Nuclei

Coordinator: Stéphanie Juneau (CEA)

AGN identification

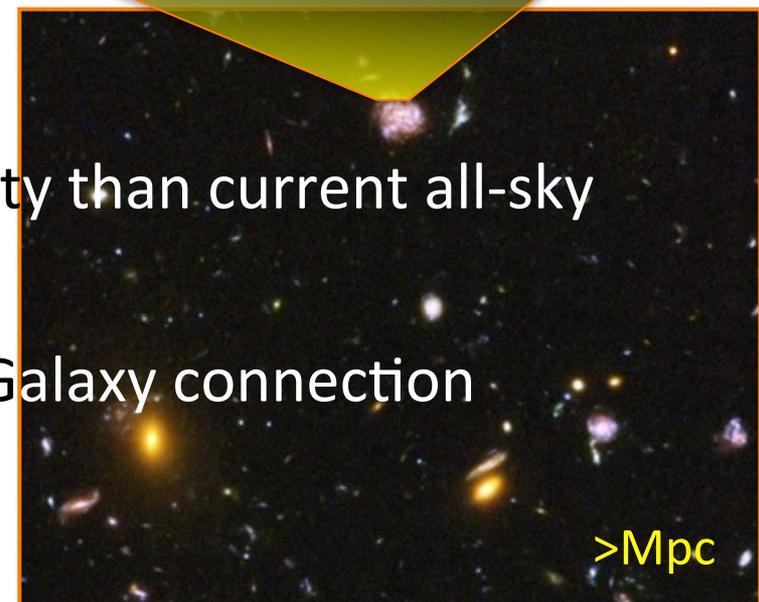
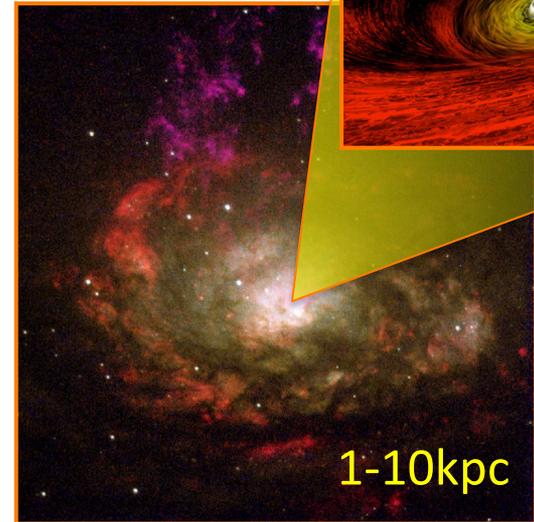
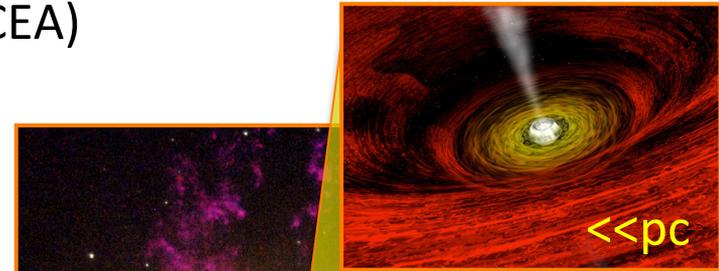
→ AGN Database useable by all other WPs

AGN studies:

- AGN triggering/feedback
- AGN obscuration
- BH masses, BH growth budget
- Connection with host galaxies
- Connection with environment

Probe of luminous objects with more sensitivity than current all-sky AGN surveys (+ get host galaxy properties!)

Improved understanding of the Black-Hole – Galaxy connection
the peak epoch of activity ($z \sim 2$)



WP9 (AGN): Methods

- Euclid “internal” identification of AGNs:
 - NIR spectroscopy
 - Broad lines (type 1): 10^6 at $0.7 < z < 9$
 - Narrow lines (type 2): $0.6-2 \times 10^4$ from $[\text{NII}]/\text{H}\alpha$; 7×10^4 from $[\text{OIII}]/\text{H}\beta$
 - Imaging
 - Point-sources (w/ OU-PHZ)
 - SED fitting (w/ WP1; OU-PHZ)
 - Variability
- Euclid “external” identification of AGNs:
 - Ancillary data (OU-MER?)
 - X-ray (e.g., eROSITA)
 - MIR/FIR? (e.g., WISE)
 - Radio
 - Follow-up surveys

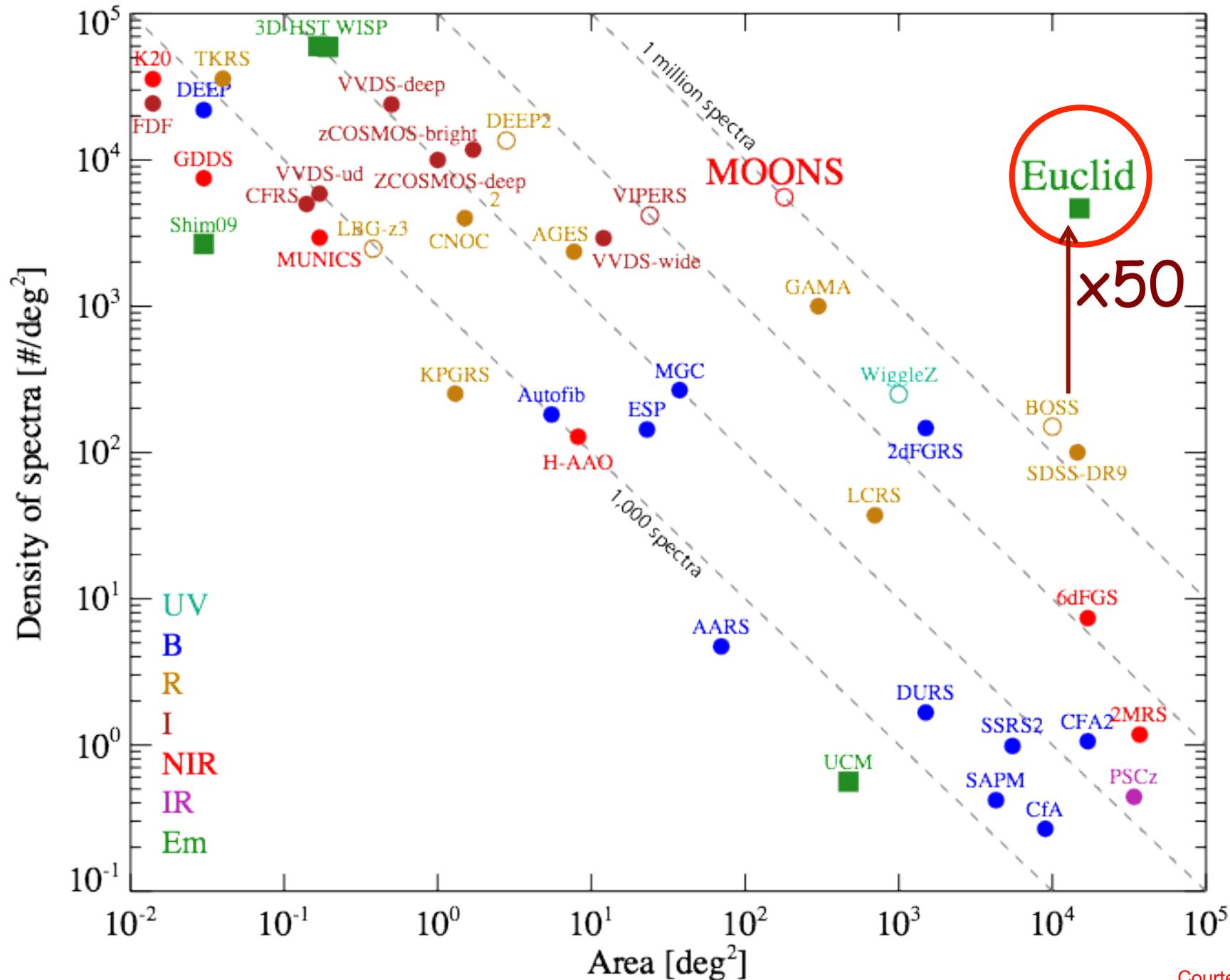
WP9 (AGN): Challenges

- Limited spectral resolution $R \sim 250$
 - Blending of key emission lines ($H\alpha + [NII]$) (w/ WP2)
- Limited availability of given sets of diagnostic emission lines (for Type 2 AGN)
 - “BPT” lines only at $1 < z < 2$
 - $[NII]/H\alpha$ at $0.7 < z < 2$
 - $[OIII]/H\beta$ at $1 < z < 3$
 - Behavior of emission line diagnostics at high redshift? (e.g., Kewley +2013a,b; Juneau+ submitted to ApJ)
 - BPT AGN selection $[OIII]/H\beta$ vs $[NII]/H\alpha$ for bright enough galaxies where the separation of $[NII]$ vs $H\alpha$ is feasible ($F(H\alpha) > 10^{-15}$ erg.s $^{-1}$ cm $^{-2}$) else MEx (Juneau +11) : $[OIII]/H\beta$ vs M^*
- Heterogeneous selection/detection limits from multi-wavelength AGN studies (X-ray, etc.)

WP9 (AGN): First tasks

- **Measurements wish list:**
 - Emission lines (complement the list w/ WP2)
 - Host galaxy properties (link w/ most other WPs in GA-WG)
 - Simulations (add lines ourselves)
- **Feasibility studies:**
 - Deblending of emission lines in degraded observed spectra to Euclid specs (+ simulated spectra)
 - AGN parameter space: accretion rate, obscuration
 - Reverberation mapping (in calibration fields)
- **Methodology for SED fitting w/ AGN**
 - AGN identification before vs. during SED fitting (OU-PHZ; WP1; WP8)
- **Definition of “boundaries” / links**
 - E.g., Highest redshifts (WP10; PU-SWG)
 - Connections w/ all GA-WG WPs desirable
- **Implementing AGN in mocks/simulations (through WP6)**
 - Empirically motivated implementation *a posteriori* (~ HOD)
 - Physical model (longer term?)

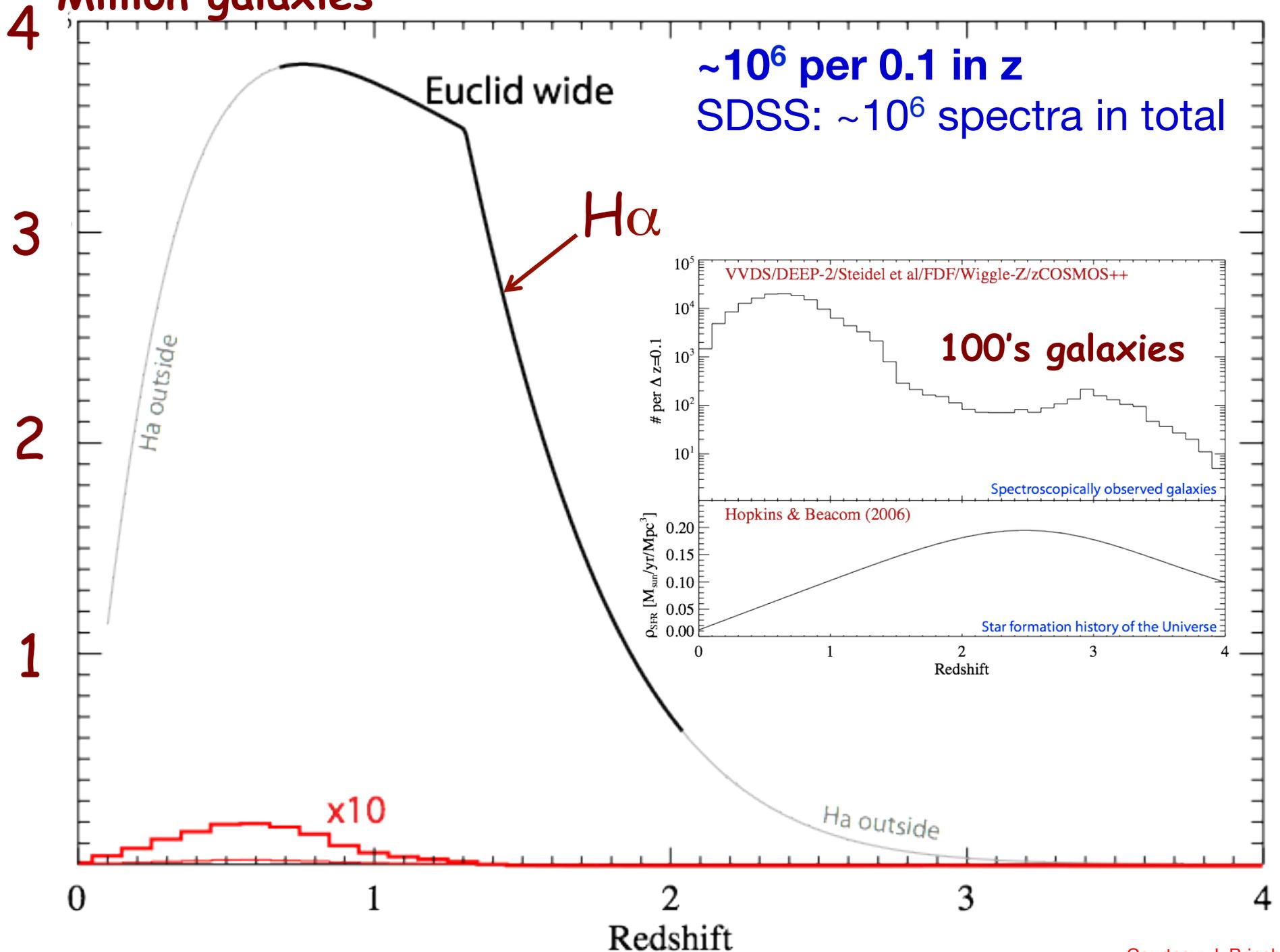
Euclid Spectroscopic Wide Survey (NISP)



The Role of Euclid Spectroscopy

Million galaxies

per $\Delta z=0.1$!!!



$\sim 10^6$ per 0.1 in z
SDSS: $\sim 10^6$ spectra in total

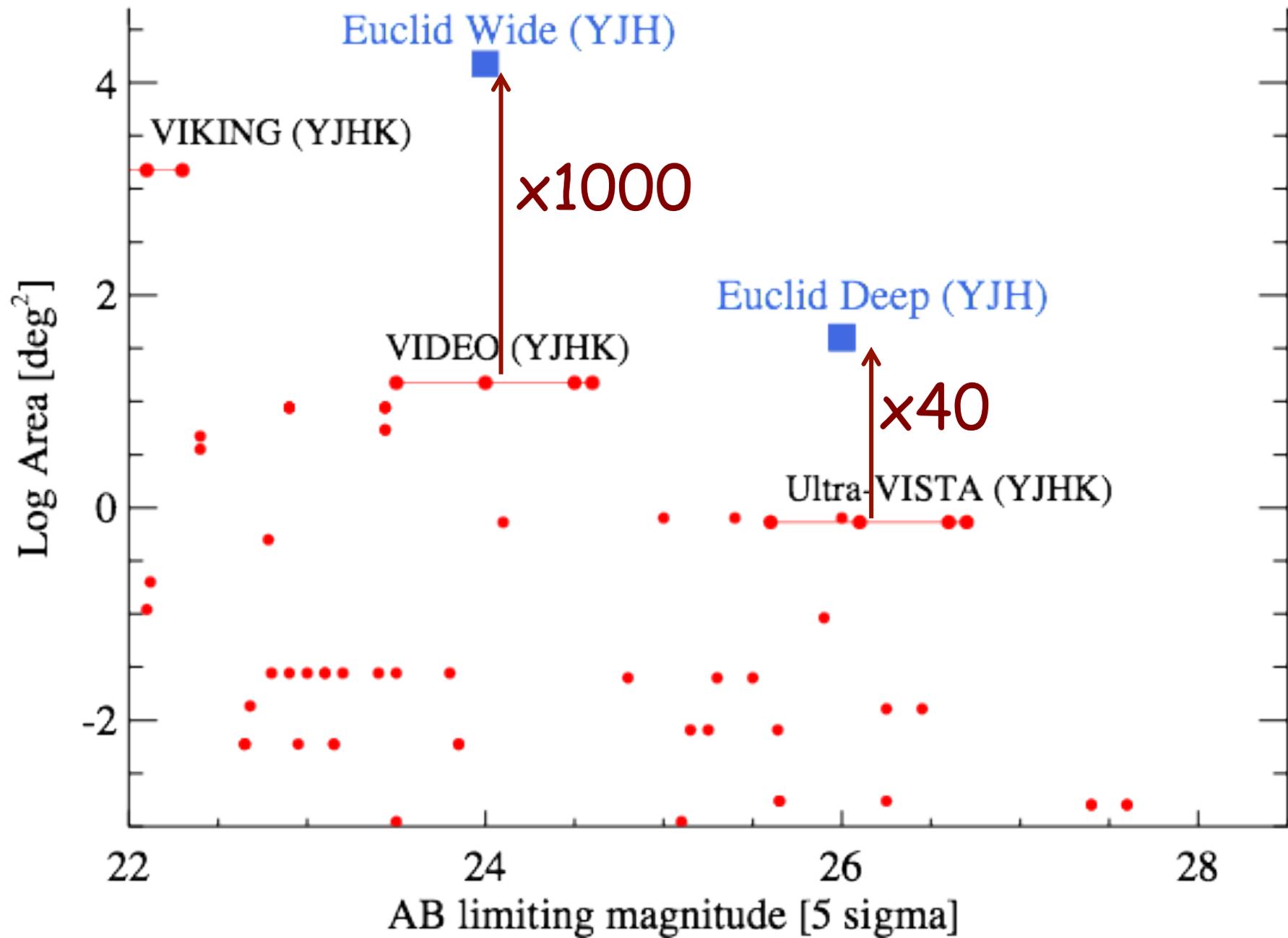
Changes in NISP

- baseline of 2 different grisms (blue and red) and 2 position angles
- 4 identical grisms at 4 position angles
 - to improve the performances of the spectroscopic survey and the cosmology clustering science (e.g. BAO)

Implications

- $0.68 < z(\text{H}\alpha) < 2.05 \rightarrow 1.0 < z(\text{H}\alpha) < 1.8$
- $\text{H}\alpha$ & $\text{H}\beta/[\text{O III}]_{4959,5007}$ to determine metallicity & dust attenuation no more possible...
- Euclid $\text{H}\alpha/[\text{N II}]$ measurements with $\text{H}\beta/[\text{O III}]/[\text{O II}]$ from ground-based spectroscopy but will they target the same galaxies ?
(e.g. BOSS predominantly target massive early-type galaxies).

Euclid Near-IR Imaging Surveys (NISIP)



The Euclid Revolution

Euclid

SDSS

$0 < z < 2+$

$0 < z < 0.2$

$\sim 20 \text{ Gpc}^3$

$\sim 0.3 \text{ Gpc}^3$

$\sim 2 \text{ billion}$

$\sim 200 \text{ million}$

$\sim 30 - 50 \text{ million}$

$\sim 1 \text{ million}$