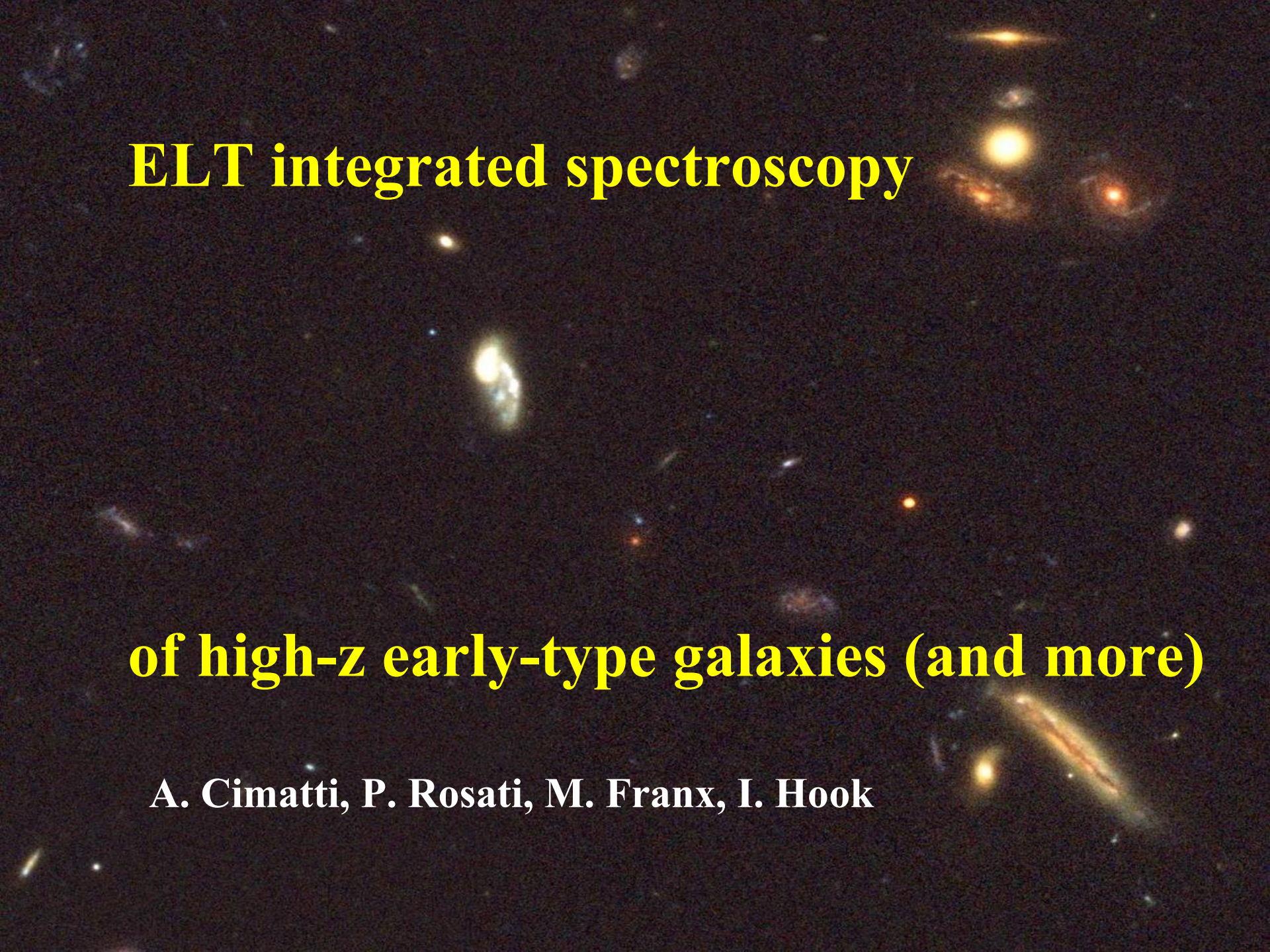
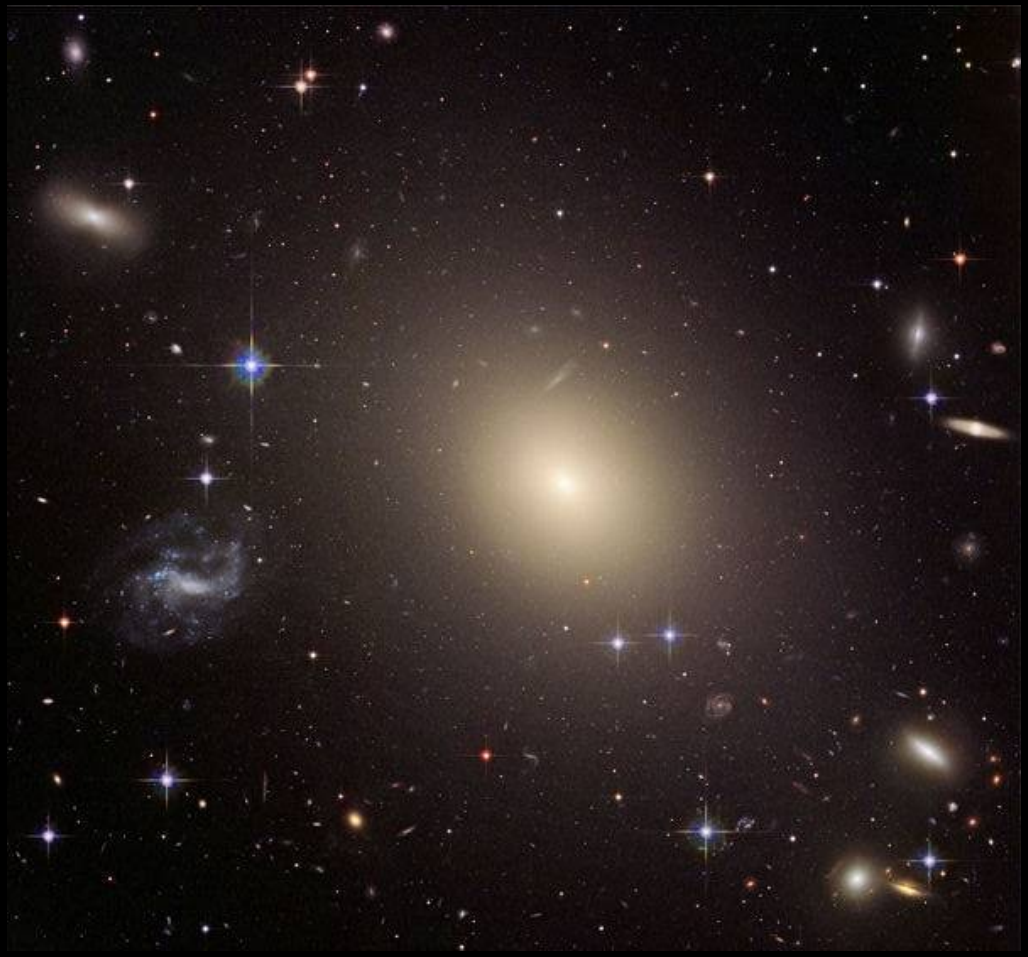


ELT integrated spectroscopy

of high-z early-type galaxies (and more)

A. Cimatti, P. Rosati, M. Franx, I. Hook

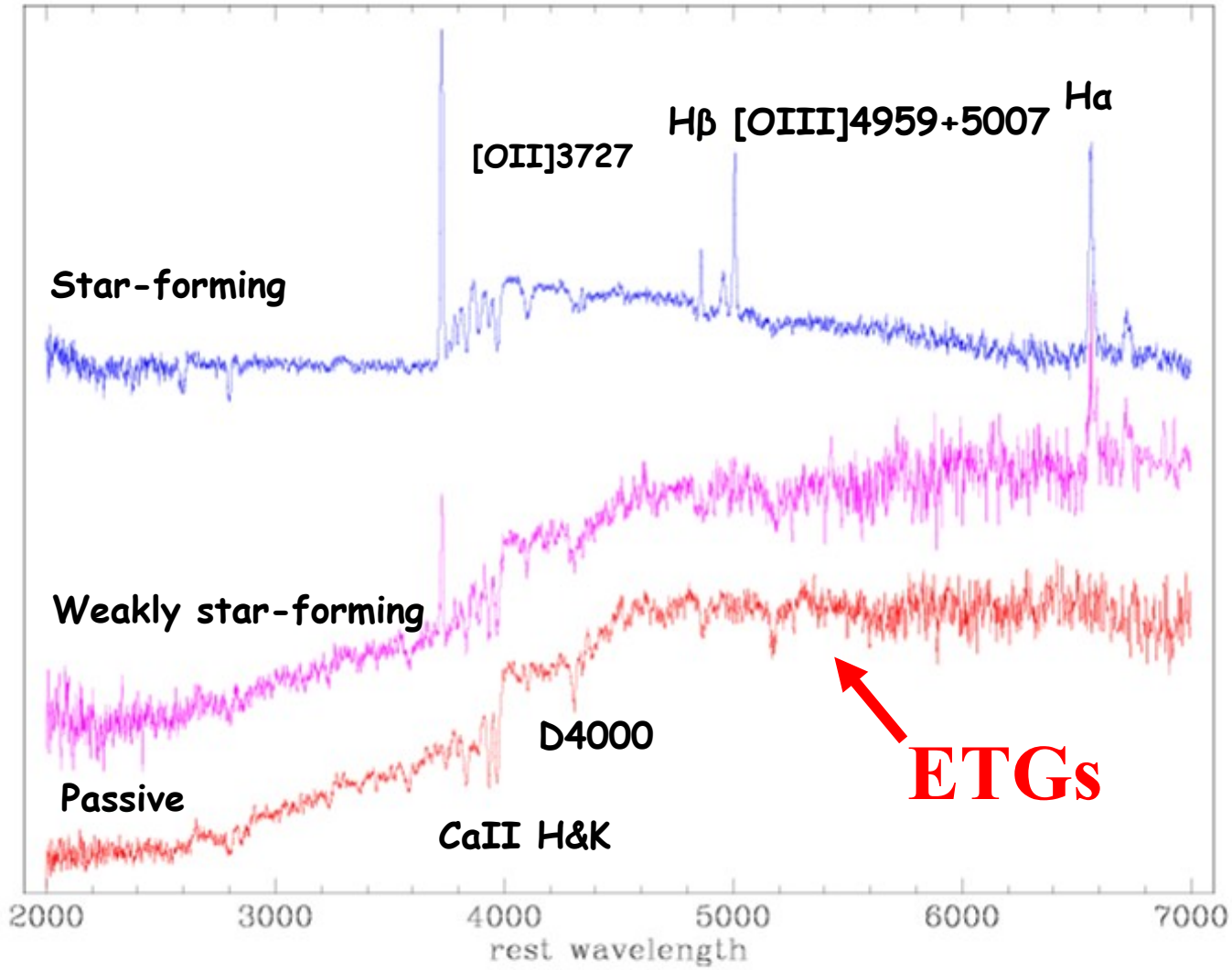
Early-type galaxies (ETGs) as cosmological probes



- Simple systems (E/S0 morphology)
- Contain most of the stellar mass at z=0
- Tracers of galaxy mass assembly evolution and "downsizing"
- Tracers of large scale structure and clusters
- Tracers of supermassive black hole – galaxy co-evolution

REDSHIFT COVERAGE NEEDED

Unfortunately …



Status

Only a few spectroscopic IDs of ETGs at $1.5 < z < 2.5$

Substantial number of photometric candidates up to $z \approx 5$ (?)

Key questions still open ($z > 1$)

Photometric redshifts and SEDs are not enough

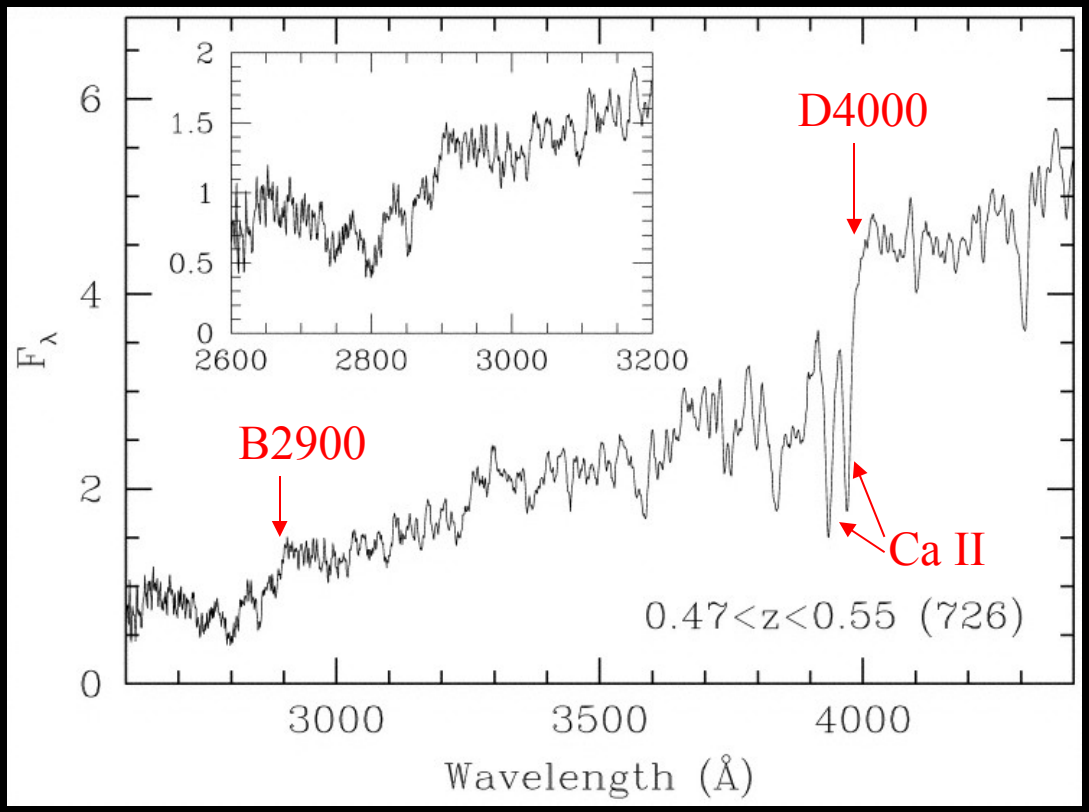
Opt – NIR spectroscopy often impossible with 8-10m telescopes
(simply too faint, no emission lines, strong spectral features @λ>0.8μm for $z > 1$)

Bottom line : we are stuck to $z < 1$

Redshift and nature

Stellar age and metallicity

Dynamical mass



Star formation history

Stellar mass

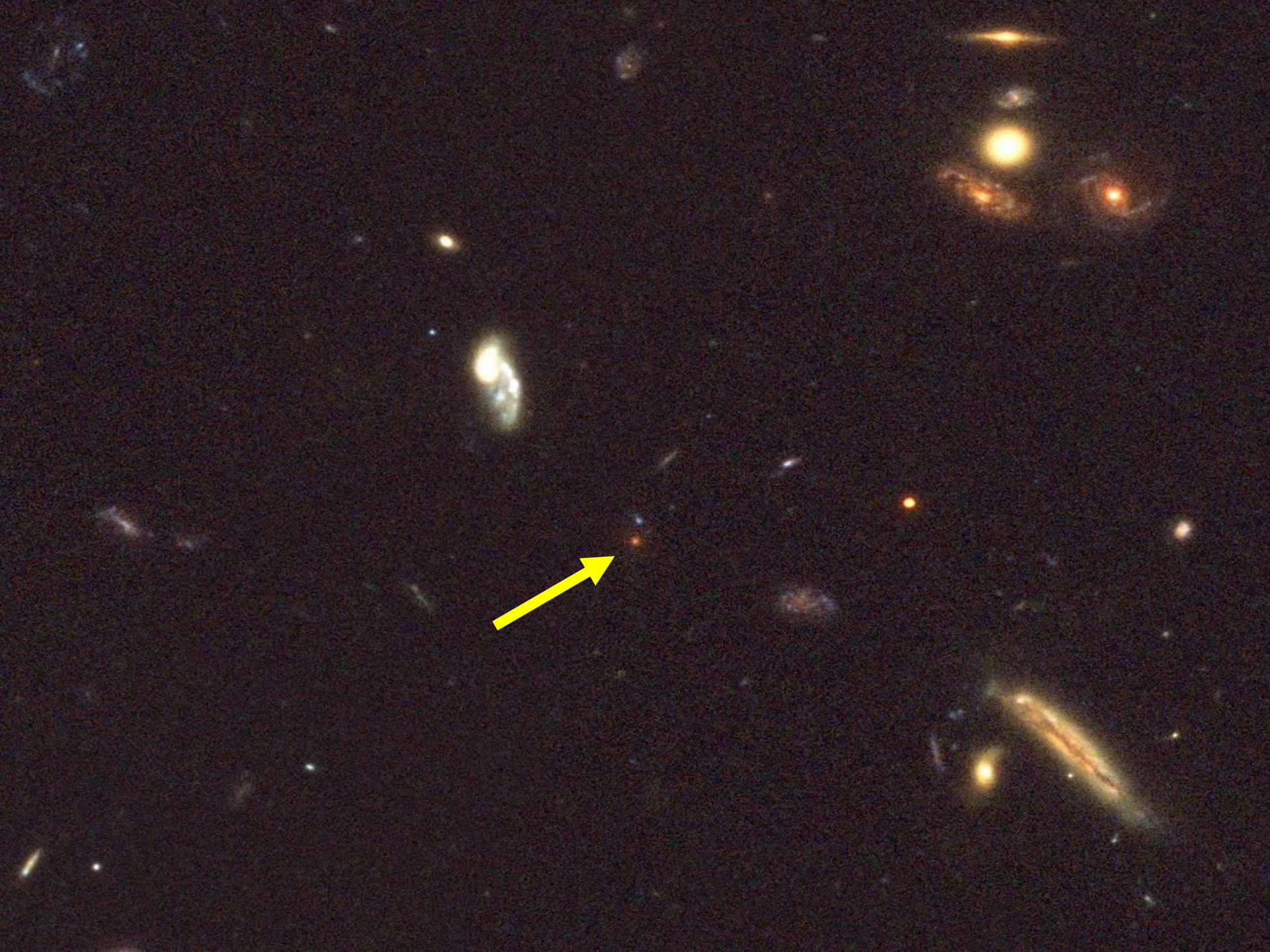
Key properties as ELT instrument drivers

M* ➔ K ≈ 21 (Vega) at z ≈ 2 – 3

Very red colors : J-K ≈ 2 – 3, I-K ≥ 4 (I > 25)

Surface density ≈ 0.1 – 1 arcmin^{-2}, depending on clustering and N(z)

Spheroidal morphology with very compact size : r_e ≈ 0.1 – 0.3 arcsec



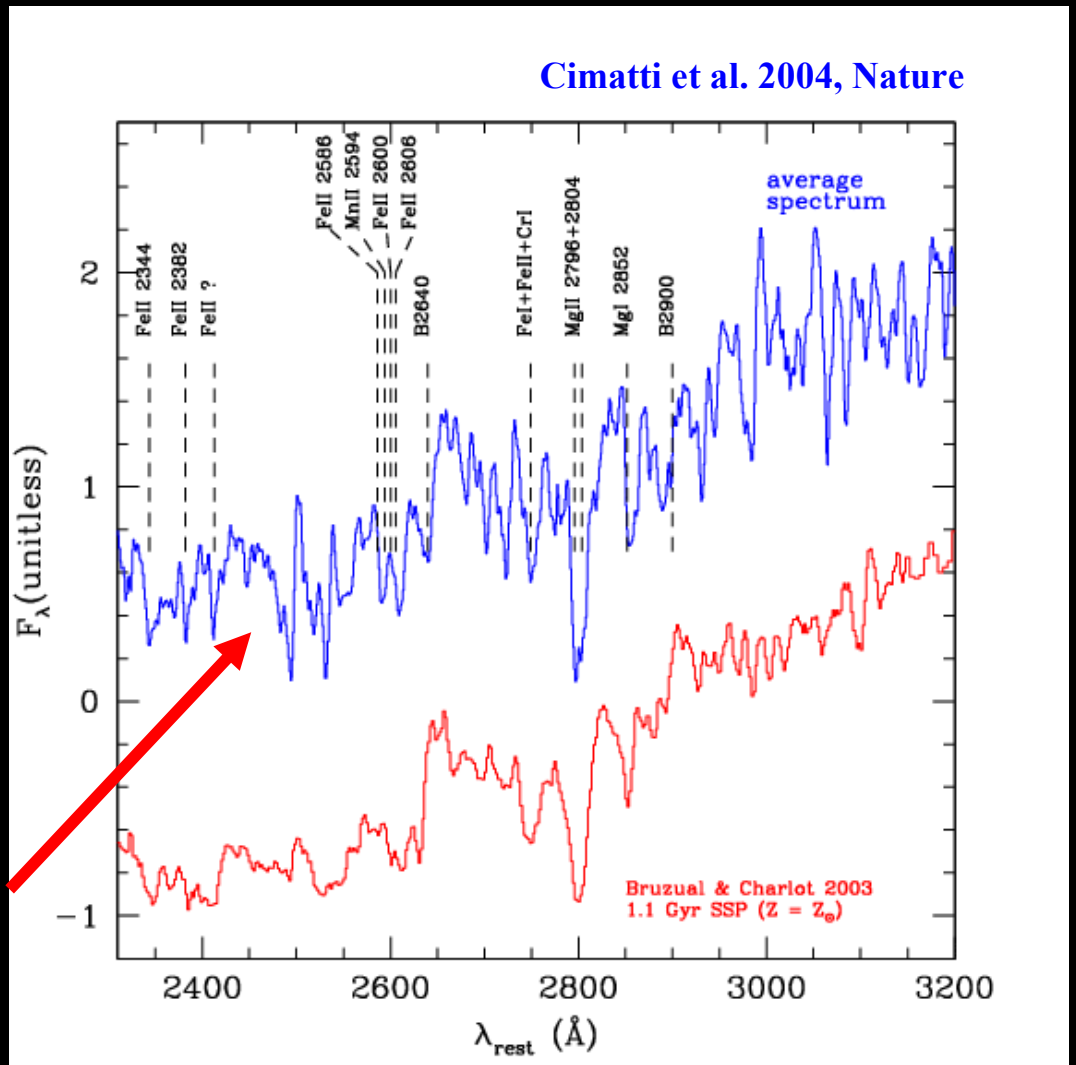
ETGs at z ~ 2

0.5 - 3 Gyr old stars

M(stars) > 10^{11} Msun

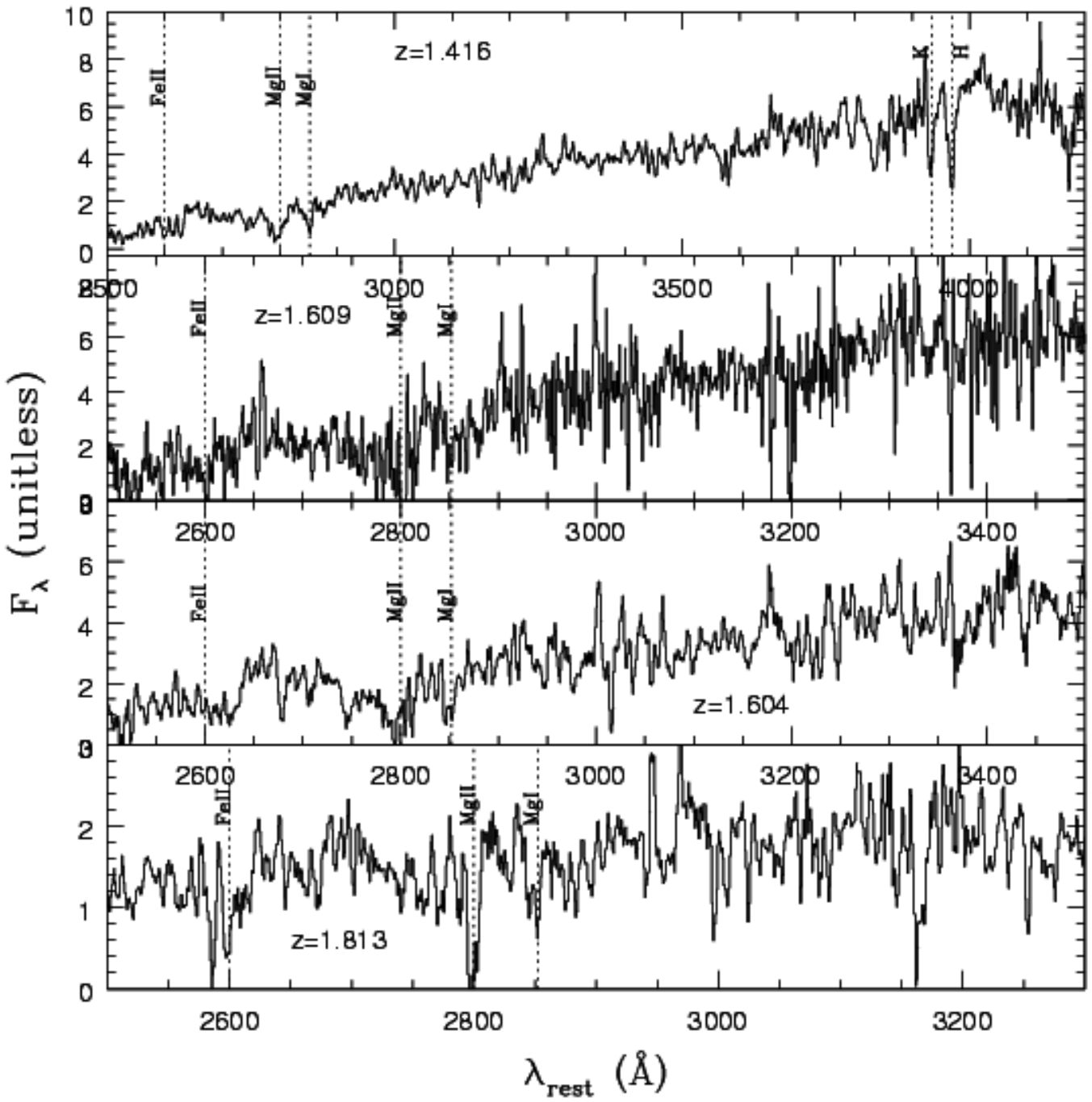
➔ **SFH : z(SF onset) > 2 + starburst**

Cimatti et al. 2004, Nature



Cimatti et al. 2004, Glazebrook et al. 2004, McCarthy et al. 2004, Daddi et al. 2005, Saracco et al. 2005, Longhetti et al. 2005, Kong et al. 2006, Kriek et al. 2006

VLT 40h-equivalent integration (I ≈ 24)

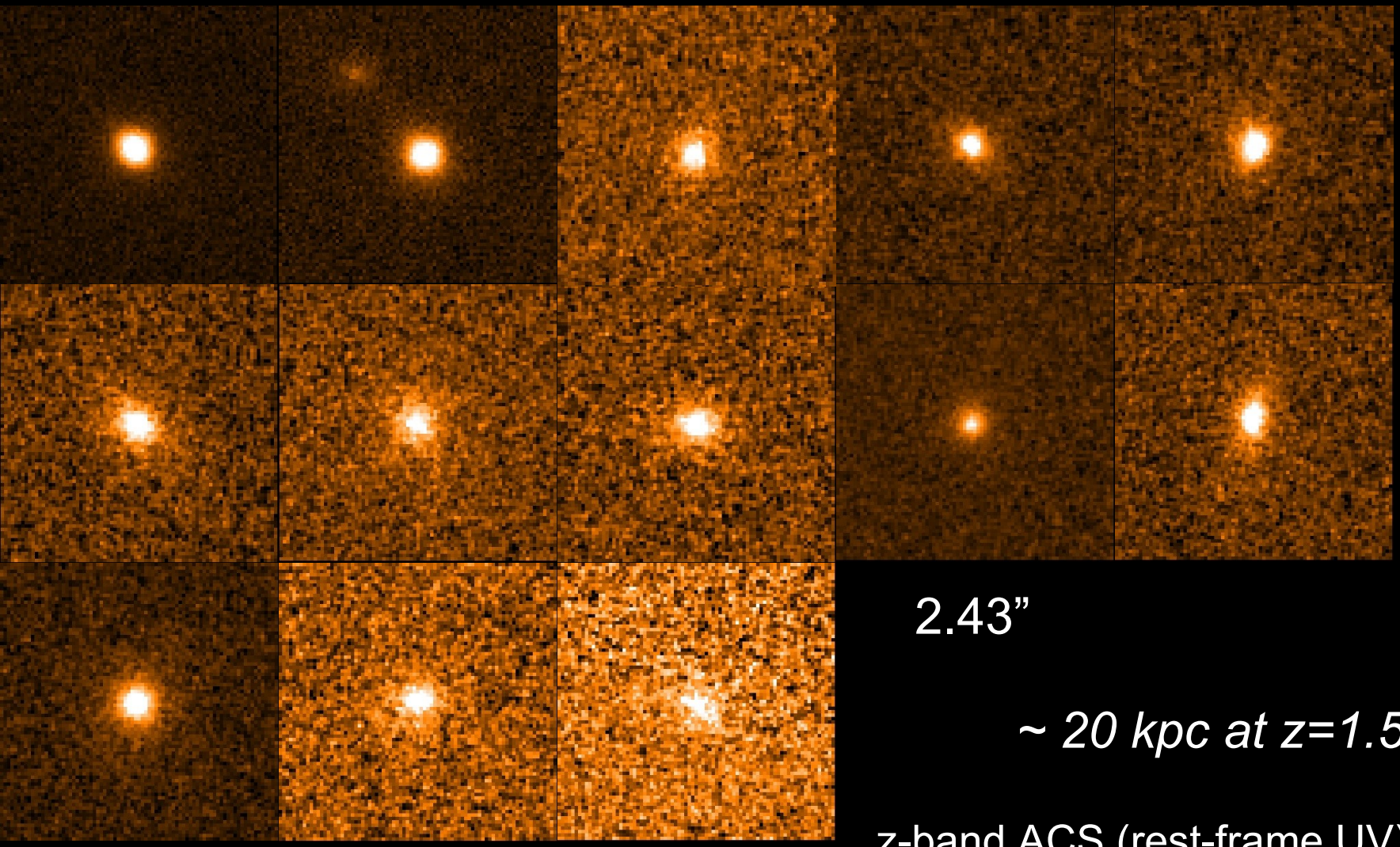


VLT+FORS2
grism 300I
R ≈ 600
GMASS project

t = 32 hours !!

I ≈ 25 (Vega)

Early-type galaxies in GMASS sample

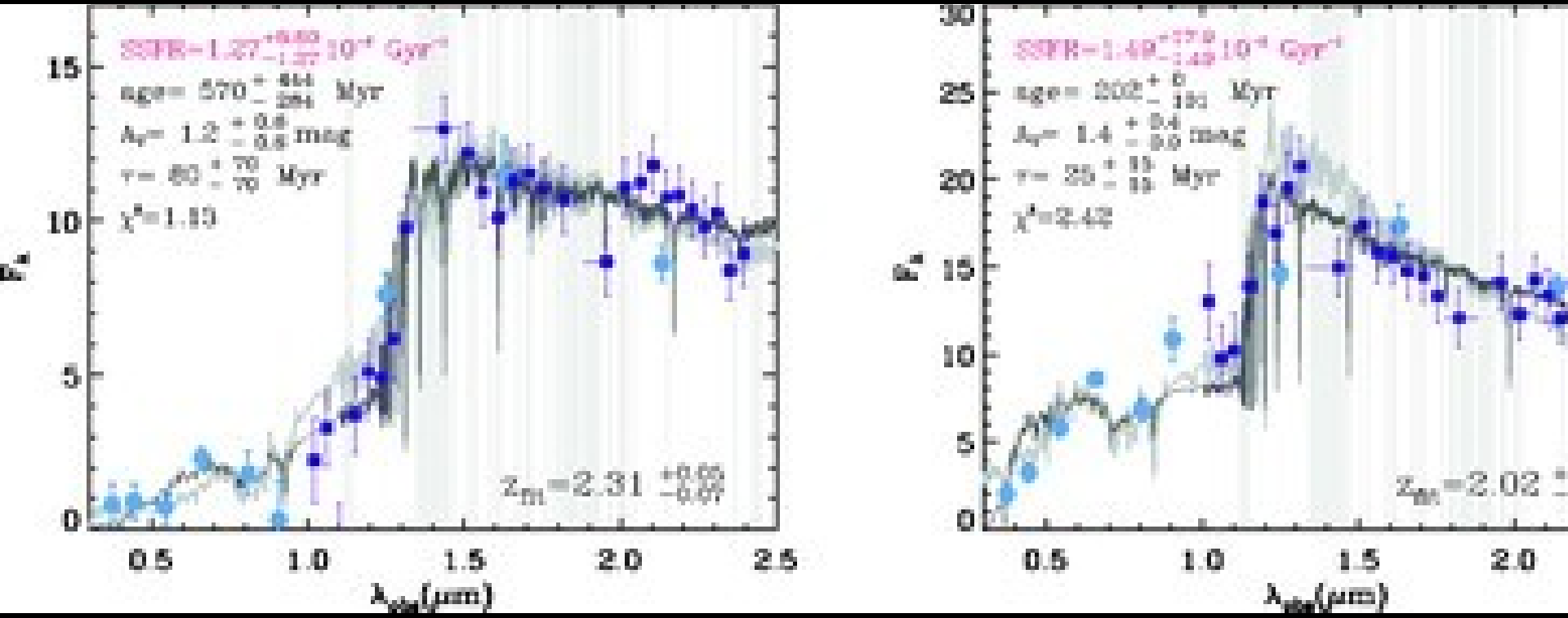


2.43”

~ 20 kpc at z=1.5

z-band ACS (rest-frame UV)

1.4 < z(spec) < 2.0



Near-IR **“spectro-photometric”** identification of
ETGs at 2.0 < z < 2.7 with **K < 19.7(!)** (Gemini, R ≈ 1000)

Kriek et al. 2006

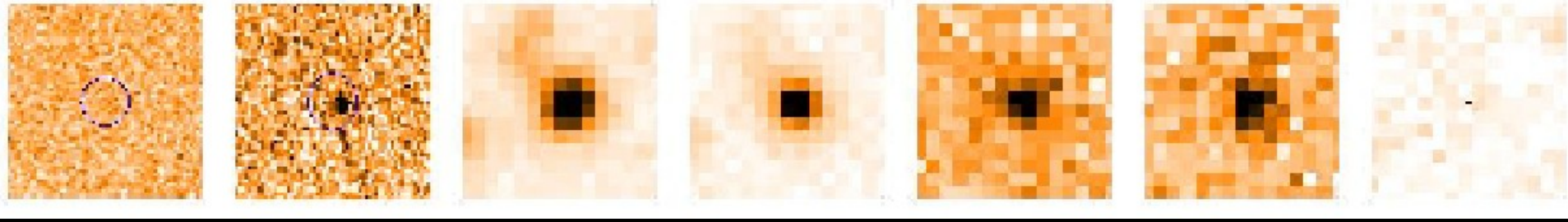
ETG massive candidates at z ≈ 4 – 6 ?

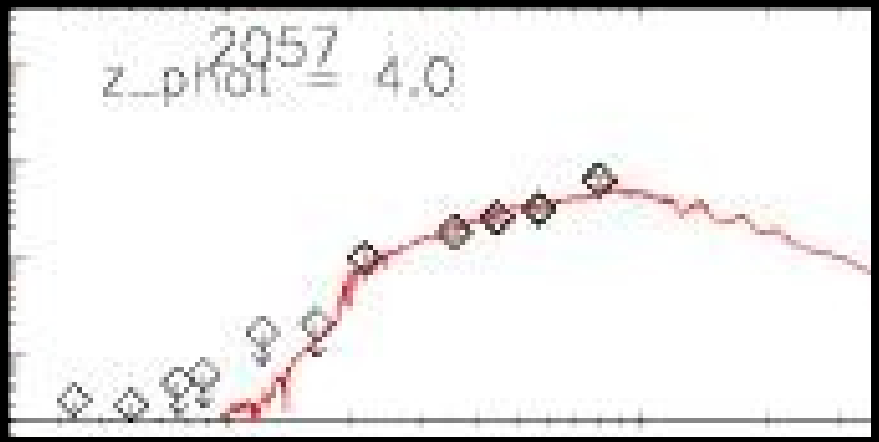
Formally : stellar mass up to ≈ 10^{11} Msun, ages up to 0.8 Gyr

True ?

ACS (z) ISAAC (K) 3.6 μm 4.5 μm 5.8 μm 8.0 μm 24 μm

K≈23





Mobasher et al. 2005
Dunlop et al. 2006
Wiklind et al. 2006
Brammer & van Dokkum 2006
Rodighiero et al. 2007
Mancini et al. 2007

Scientific Aims

Spectra of N ≈ 300 ETGs at z>1 (K < 22) (from VISTA surveys) (≈ 300 hours)

Detailed spectral analysis

Dynamical masses

Evolution of scaling relations (synergy with AO imaging ➔ μ_e and r_e)

Mass assembly evolution and link with other galaxy types

Unveil the nature of z > 3 ETG candidates

Identify and study high-z clusters (synergy with e-ROSITA and SPT surveys)

Complementary with JWST : FOV, multiplex, R, Δλ, slit width (0.2")
(see Marijn's talk)
JWST useful for high-resolution imaging (to derive μ_e and r_e)

ELT instrument requirements

FOV $\geq$ 25 arcmin^2 (multiplex $\geq$ 10)

$1000 < R \leq 5000$

Wavelength range: widest possible (e.g. 0.6 – 2.4 μm)

Simultaneous coverage of $\geq$ 2 spectral bands (e.g. J+H)

AO : GLAO(?), FWHM $\approx$ 0.1 – 0.3 arcsec

But : seeing-limited observations feasible too (0.4" - 0.8")

Pixel scale $\approx$ 100 $\pm$ 50 mas

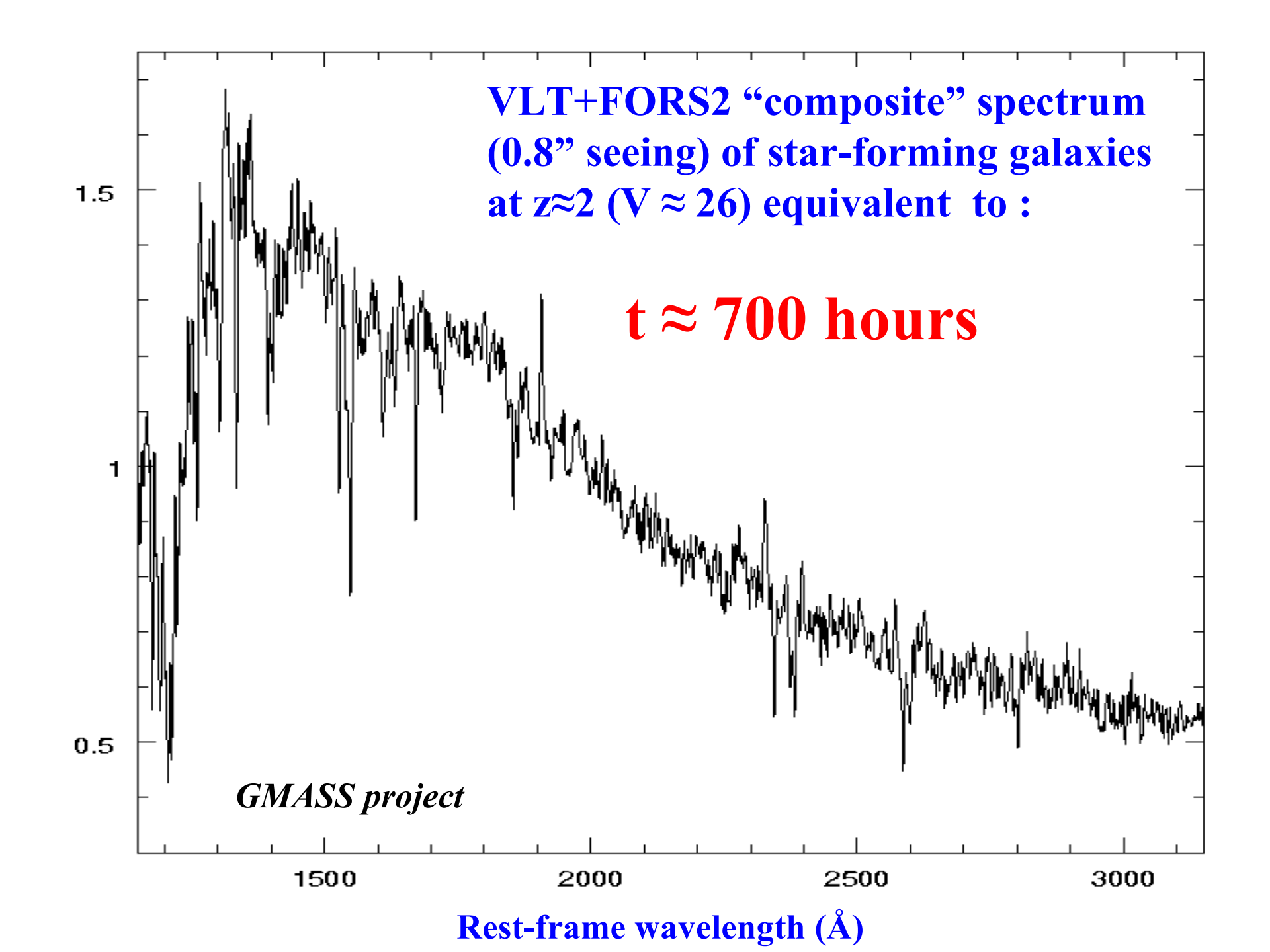
Typical integrations : 10 – 30 hours for faintest targets (S/N$\geq$10)

Other examples (opt+NIR low-order AO or seeing-limited multi-object spectroscopy)

* **"Classical" diagnostics** for faint galaxies at z > 1 not observable with high-performance AO (e.g. faint-end of luminosity function):

redshift (!)
nature
luminosity
emission and absorption lines
stellar content
integrated SFR
stellar metallicity from absorptions
gas metallicity from emission lines
line ratio diagnostics (e.g. ionization)
line velocity dispersion
AGN

* Spectroscopic ID and study of the FIR – to – radio sources (Herschel, SCUBA2, APEX, ALMA, LOFAR, …), GRBs, …


VLT+FORS2 “composite” spectrum
(0.8” seeing) of star-forming galaxies
at z≈2 (V ≈ 26) equivalent to :
t ≈ 700 hours
GMASS project
1.5
1
0.5
1500
2000
2500
3000
Rest-frame wavelength (Å)