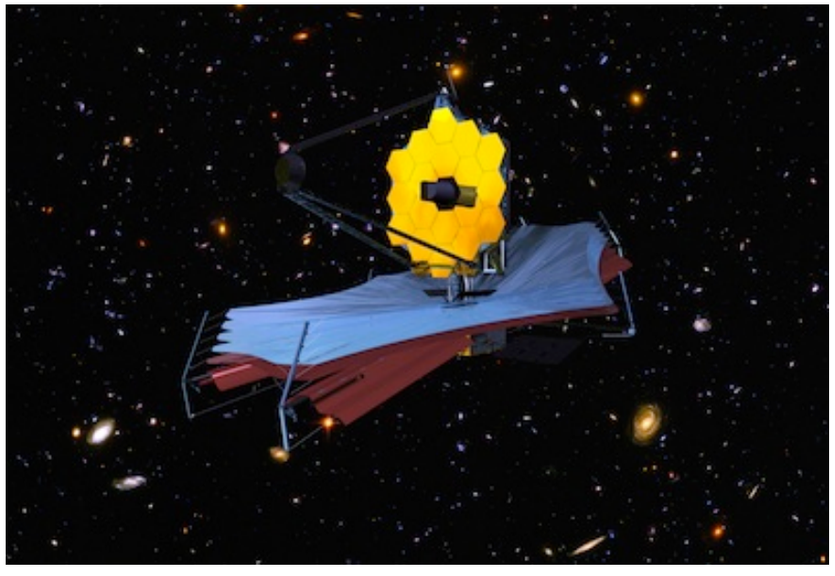
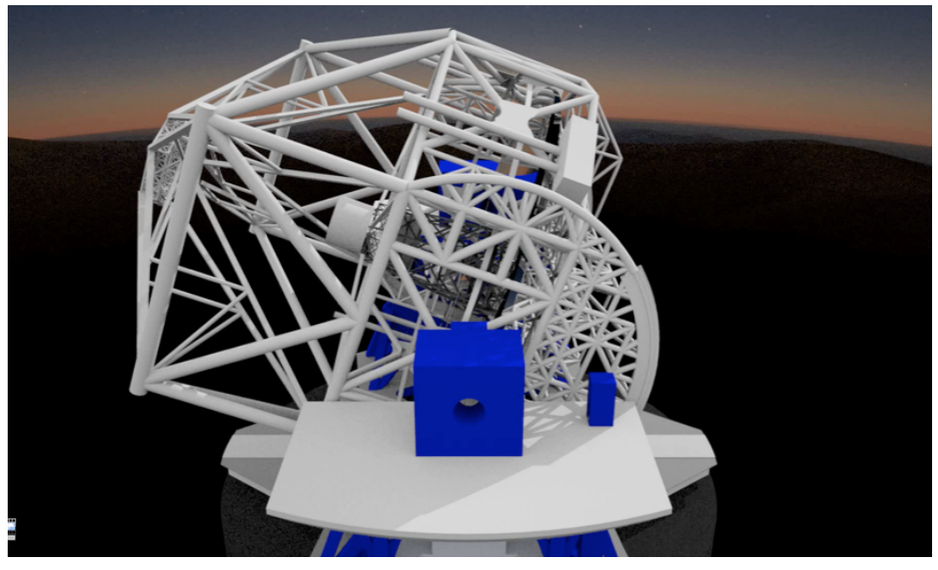
Synergy JWST and MOS-ELT(MOSAIC)

Morpho-kinematic of distant galaxies up to z=4.0





Myriam Rodrigues
GEPI - Observatoire de Paris
(Deputy Insrument Scientist)

Nature of distant galaxies

How did galaxies assemble their mass as a function of time ?

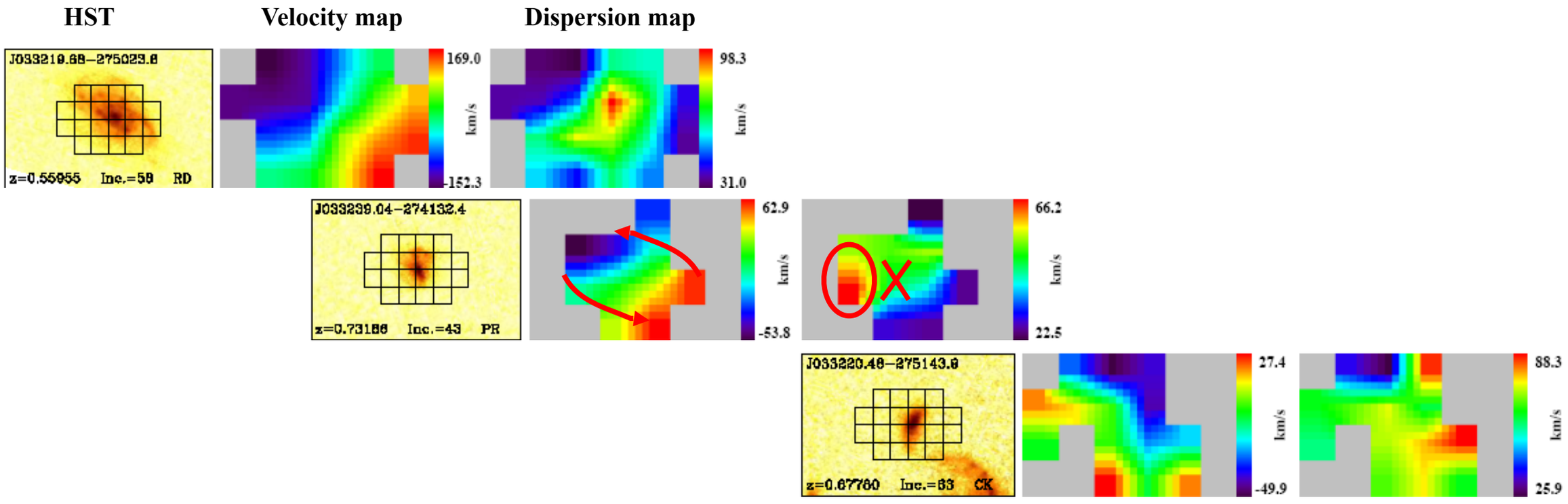
Galaxy merger VS Gas accreation

Kinematics properties of galaxies with 3D spectroscopy

Detection of large scale perturbation

Relaxed systems
(rotating disk)

Unrelaxed systems
(strong gravitational perturbation)



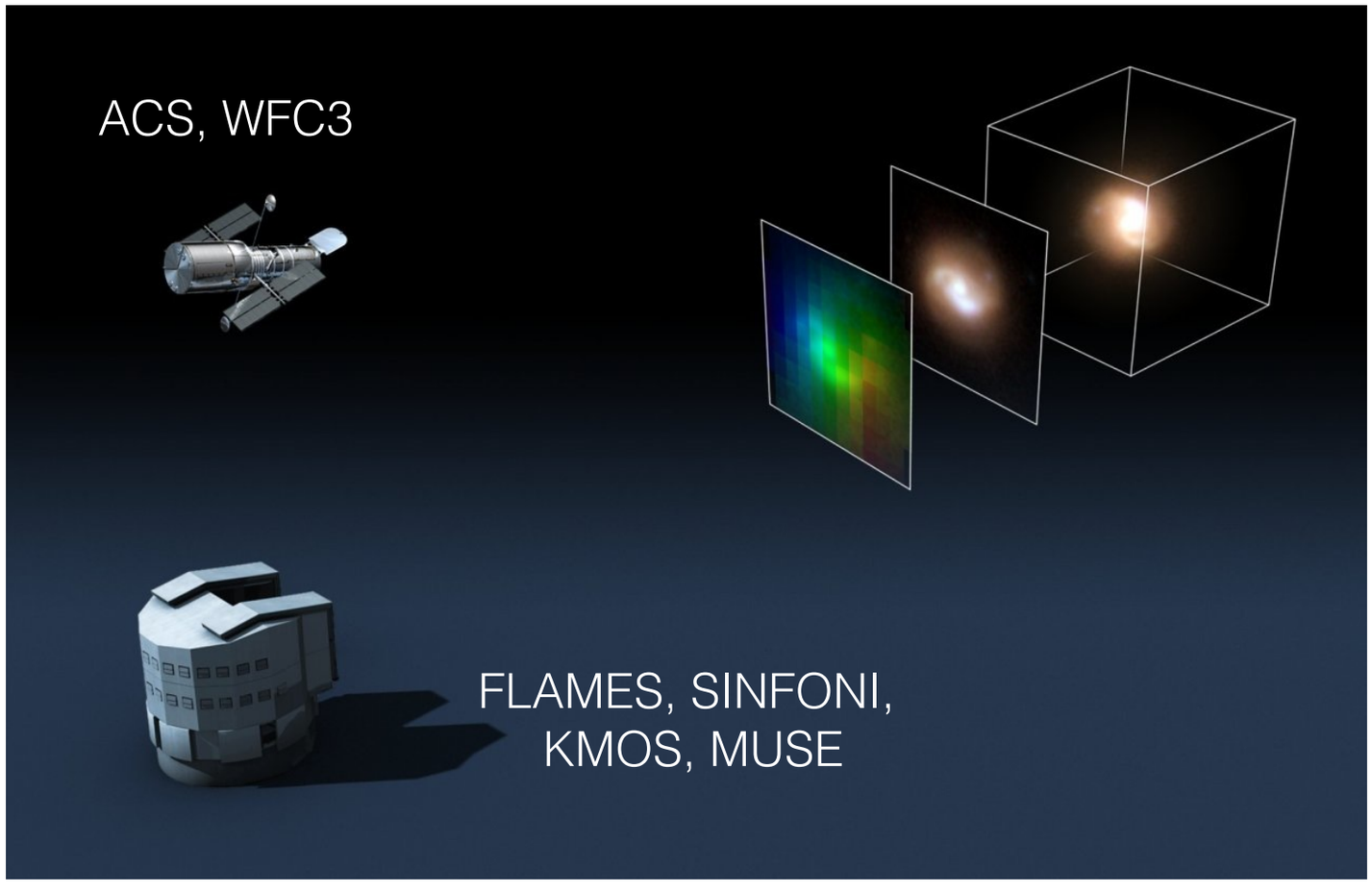
The need for deep and high-resolution imagery

Kinematics studies cannot alone retrieve the nature of galaxies:

- IFUs only probe the ionised gas
- Strong limitation on S/N and number of spatial resolution elements

Tend to give an upper limit for the number of rotating disk in a sample (*Hung et al. 2015*)

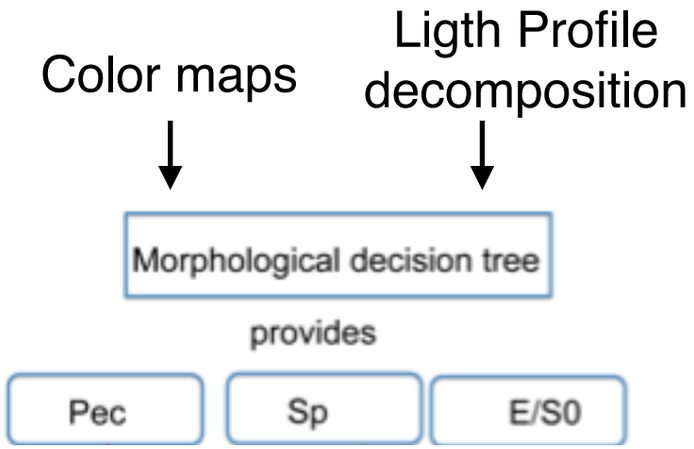
Synergy HST imagery and VLT/3D spectroscopy



Press release
http://www.spacetelescope.org/updates/html/update0903.html

Morpho-kinematics classification

Morphology classification

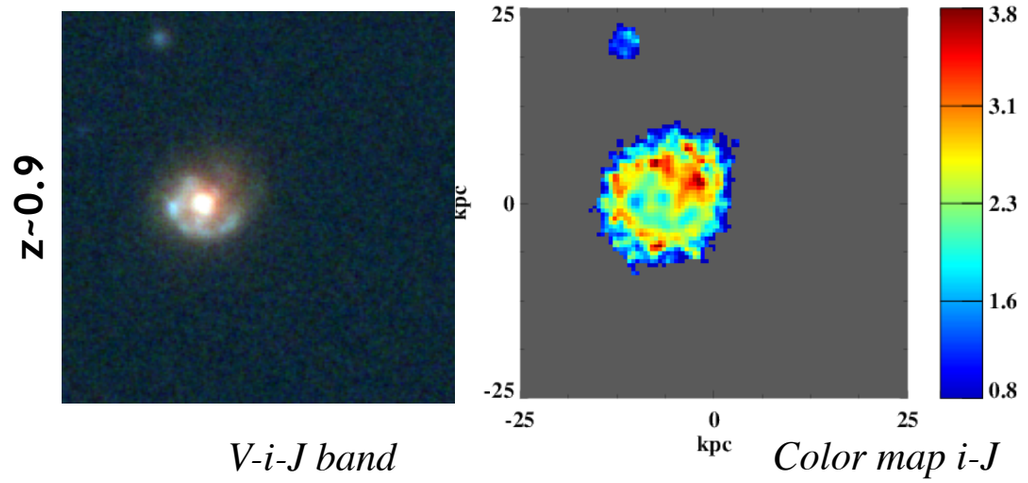


C_{opt}, PA_{opt}, i_{opt}

- Center of mass of the system
- Position angle and inclination of the disk

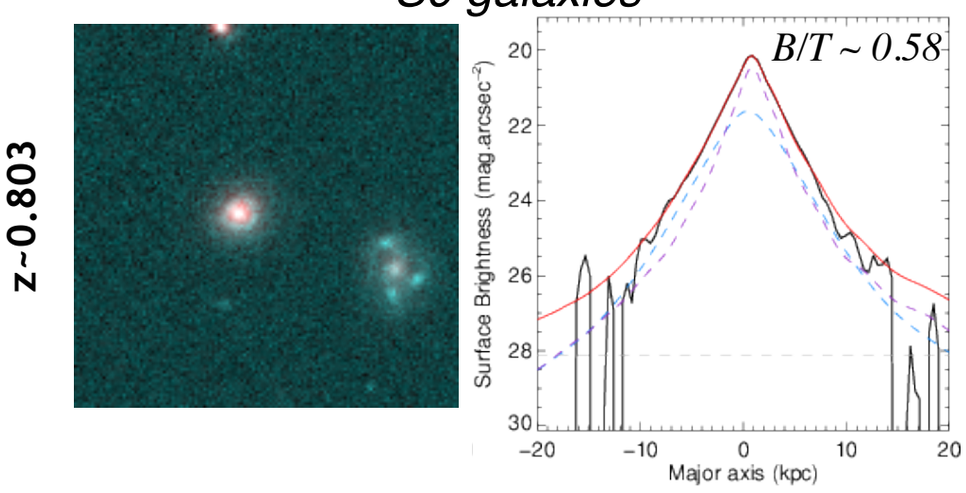
- **Delgado-Serrano et al, 2010, A&A, 509, 78**
- Neichel et al. 2008, A&A, 484, 159
- also Zheng et al. 2005, 2006

blue core galaxy



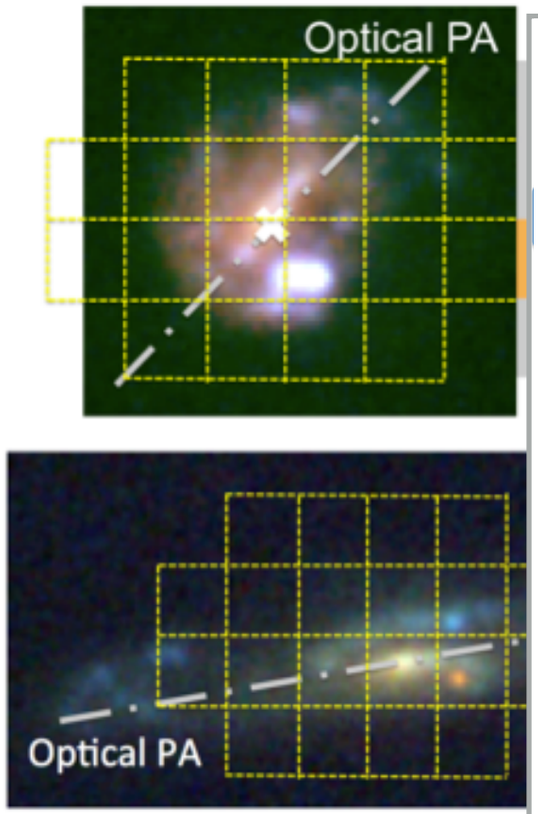
V-i-J band *Color map i-J*

S0 galaxies

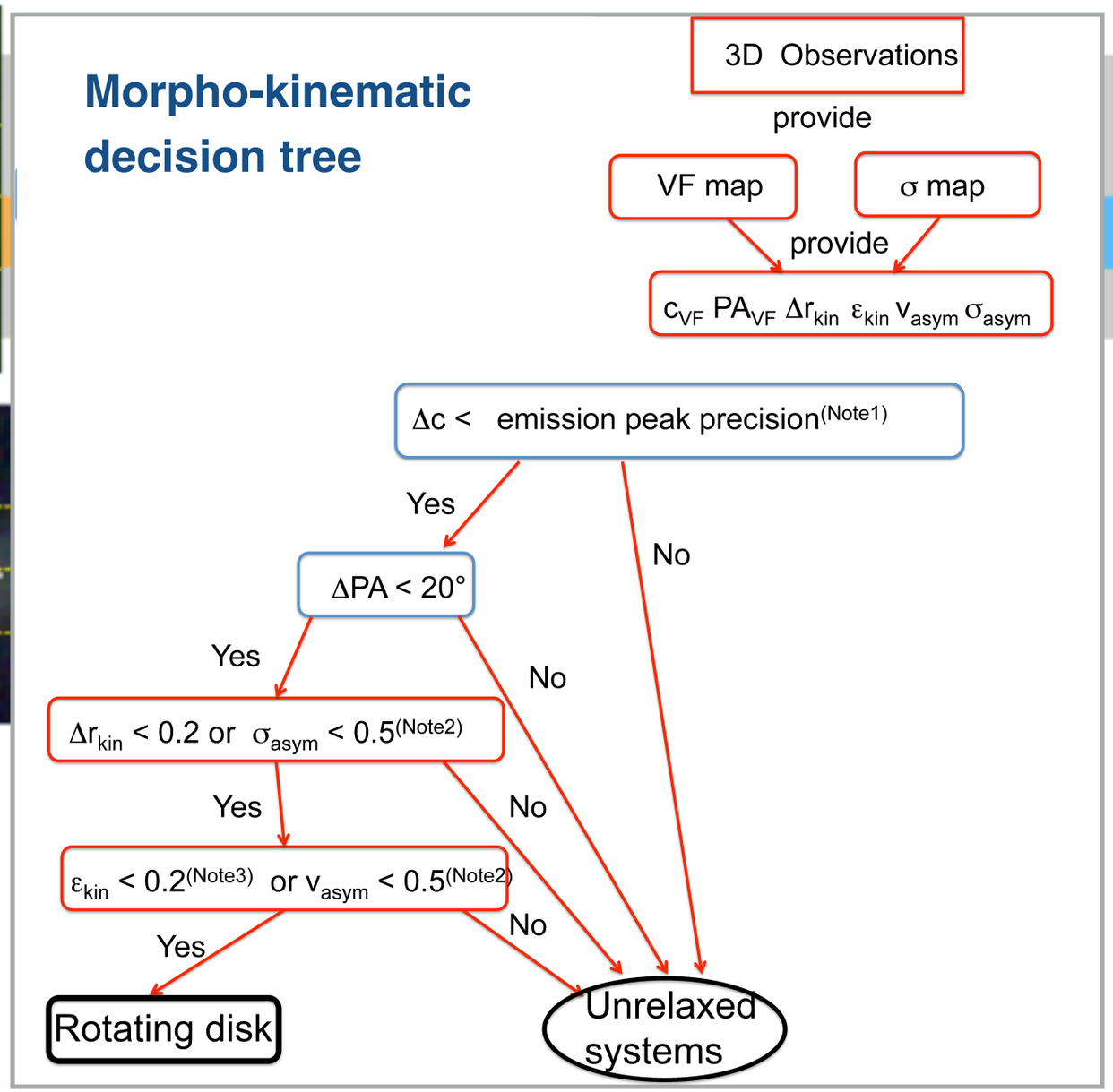


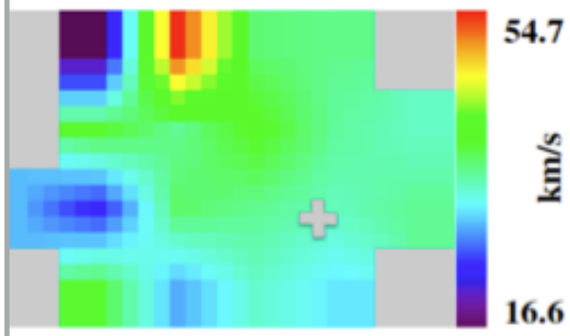
Morpho-kinematics classification

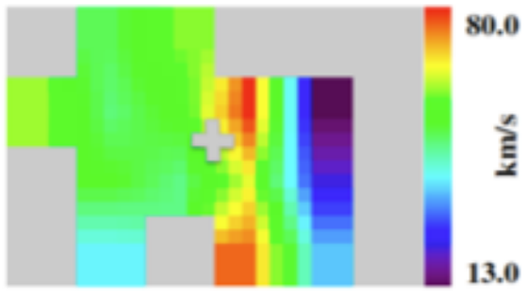
Unrelaxed systems can be easely distinguish by strong misalignement between the gas (IFU) and stars (imagery)



Morpho-kinematic decision tree







Studying Distant Galaxies:
a Handbook of Methods and Analysis
by F. Hammer, M. Puech, H. Flores & M. Rodrigues

IMAGES z~0.6

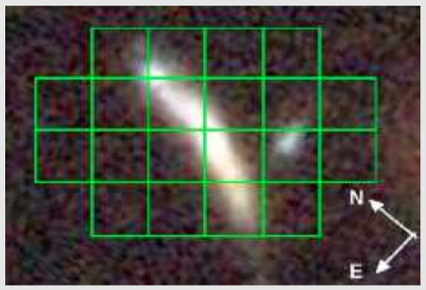
PI: Hammer F.

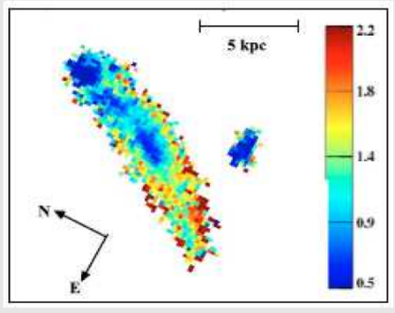
A multi-instrumental study of local disc progenitors at z~0.6

Sample selection

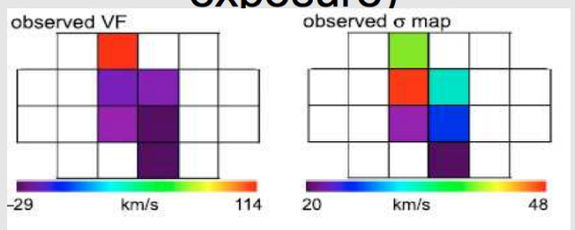
$M_J < -20.3$ & $0.4 < z < 0.9$, 4 fields, Intermediate-mass galaxies $M_{stellar} > 1.5\ 10^{10} M$

Imaging
ACS images (≥ 3 orbits)

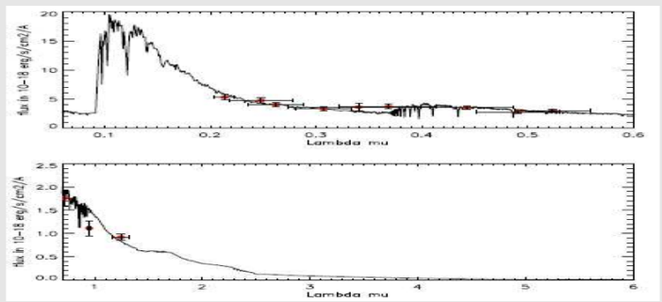




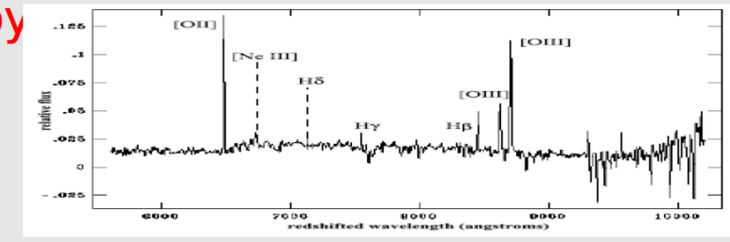
3D Spectroscopy
VLT/FLAMES-GIRAFFE
(R~10000, 8-24hrs exposure)



Multi-λ photometry
Spitzer, GALEX, ACS, EIS,etc.



Integrated spectroscopy
VLT/FORS2 (600RI+600z)
(≥ 3 hrs each)



- 50% of intermediate-mass galaxies at z~0.6 are not relaxed morphologically OR kinematically
- Rapid evolution of kinematics most probably induced by merging
- Mecanism of disk rebuilding as scenario of spiral formation

(Neichel et al. 2008, Yang et al. 2008, Delgado-Serrano et al. 2009, Hammer 2009, Puech et al. 2008, 2012, Rodrigues et al. 2010,2012)

Discordant results at z~1

z ~ 1.3 (MASSIV):~ 35 % of stable disks similar to low-z disks (Epinat et al. 2008)

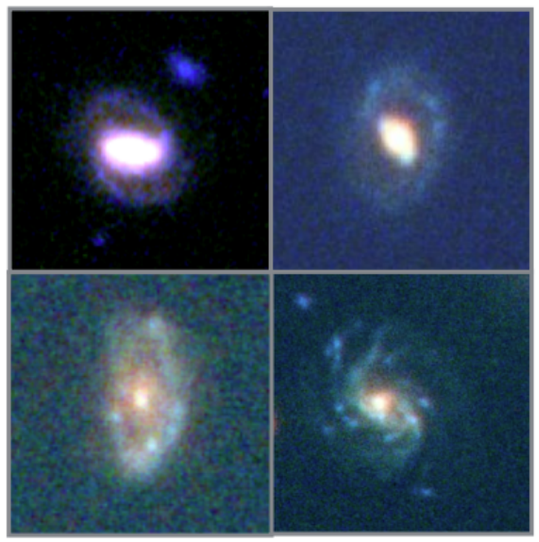
z ~ 1 (KMOS-3D-HST): from 70% to 93% of rotating disk ! (Winioski et al. 2014)

Morpho-kinelatic classification of 3D-HST galaxies at z~1

Table 1
% of galaxies satisfying disk criteria (Winioski et al. 2014)

Criteria:	1,2	1,2,3	1,2,3,4	1,2,3,4,5	Morpho-kinematics
Full Sample	83%	73%	71%	58%	
$z \sim 1$	93%	78%	78%	70%	
$z \sim 2$	74%	68%	64%	47%	
Rodrigues et al. *in prep*					**32 %**

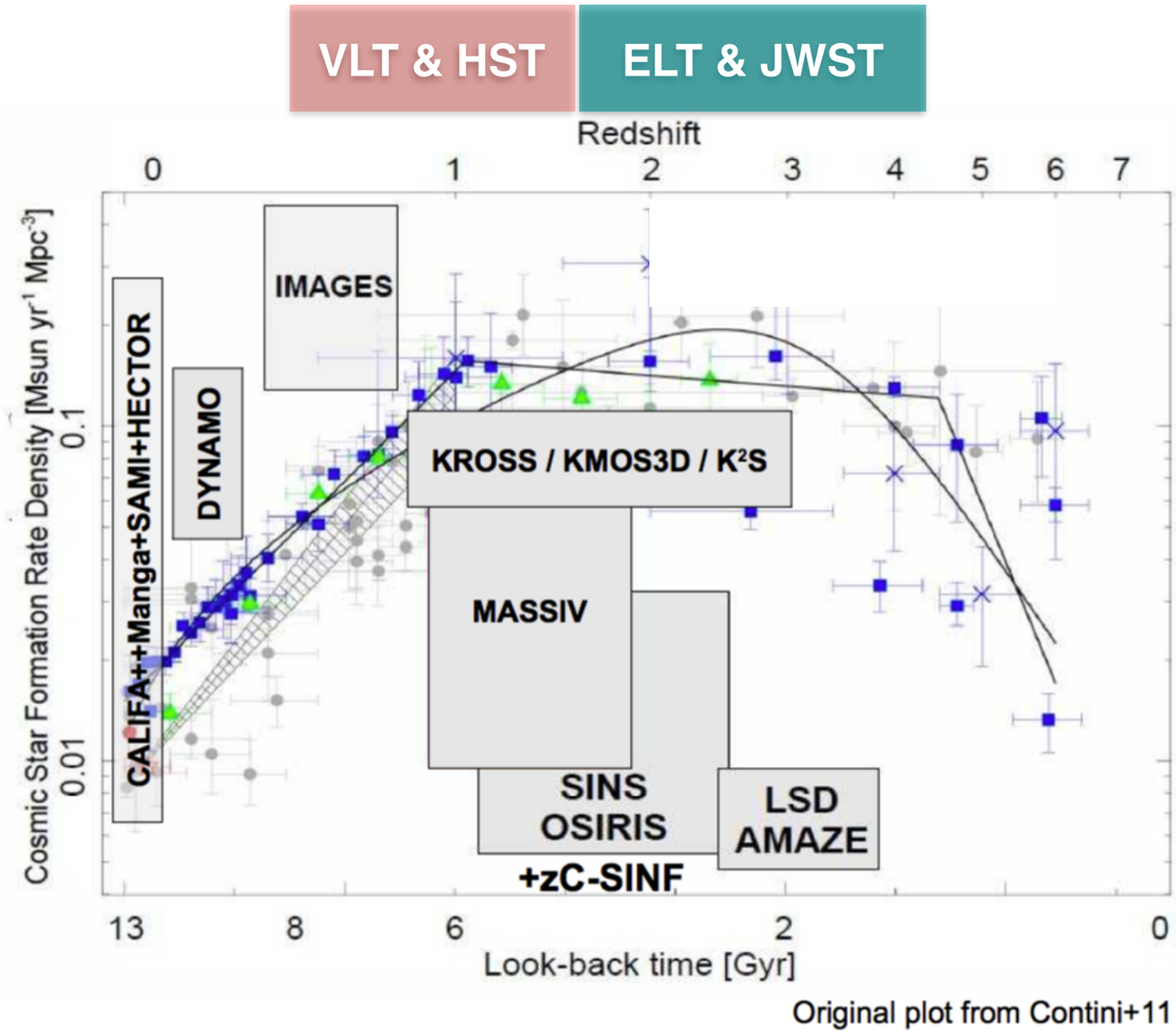
Peculiar (60%)



Spirals (40%)

3D spectroscopy surveys of distant galaxies

Above z~1.5-2 only the most massive, high-surface-brightness systems are within the graps of current facilities



Original plot from Contini+11

- Mass selected sample up to z~4
- Deepest, high resolution near-IR imaging avaible from JWST
- Spatially resolved kinematics from ELT-MOS

Scientific requieremements for a MOS E-ELT

Resolving the kinematics of distant galaxies

Expected galaxy R_{half} as a function of z and stellar mass

Puech et al. 2008

Z	0.1M*(z)	0.5M*(z)	M*(z)	5M*(z)	10M*(z)
2	170	300	380	670	850
4	80	150	190	330	430
5.6	70	130	160	280	350

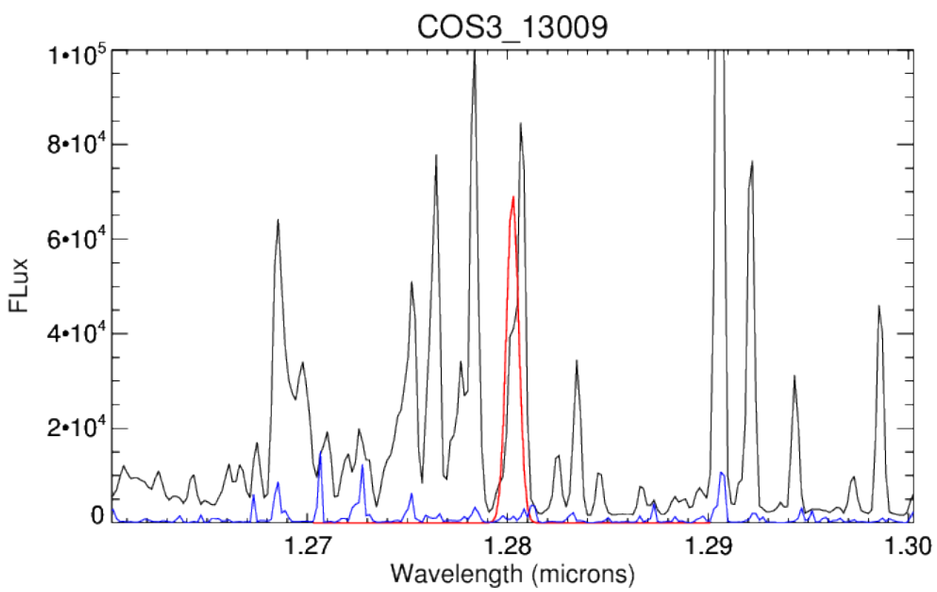
- MOAO mandatory for recovering the 2D kinematics
- Optimal spatial sampling: 50-75 mas/pixel

Resolved (2 spatial elements)

Un-resesolved

Sky subtraction

- Near-IR sky dominated by intense and rapidely varying sky lines
- R > 5000 is requiered to observe spectral features between sky lines
- IFU observation allow an optimuun sky continuun subtraction



KMOS : R~3000 is not enough to decouple target and sky lines

MOSAIC

Phase A : fin 2015
FDR : 2019/20

Multi-Object Spectrograph for Astrophysics, Intergalactic medium and Cosmology

Field of view: 7 x 7 arcmin at the 40m E-ELT

High Multiplex Mode

On-sky aperture : 0.6 arc sec
Multiplex : 200 (400)
R : 5000 & 15000 (5000 & 20000)
Coverage : 0.4 - 1.8 mm
(Extension to K-band)

+

High Definition Mode

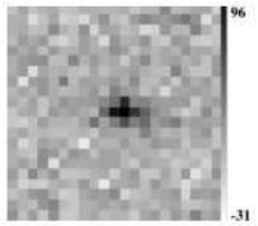
- **FOV IFU**: 2.0x2.0arcsec
- **Multiplex** : 20 IFUs (20)
- Spatial pixel scale: 40-50 mas in H-band
- **EE**: 25% (30) EE in 2spatial spatial pixels
- **R:**4000-5000
- **Coverage**: 0.8 - 2.45 microns

ArXiv:1501.04726

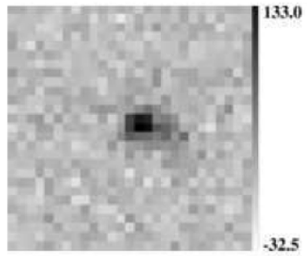
Includes also: AIP Potsdam, Nice, Toulouse, Vienna, Stockholm, Roma, Arcetri, Madrid & Geneva

Morpho-kinematics of galaxy up to z~4

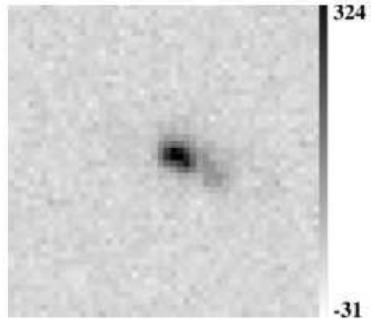
z=4.0
JWST/NIRCAM
H-band



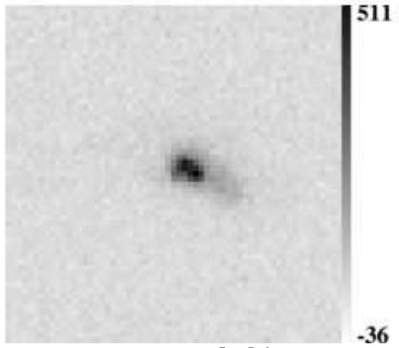
*0.1M**



*0.5M**



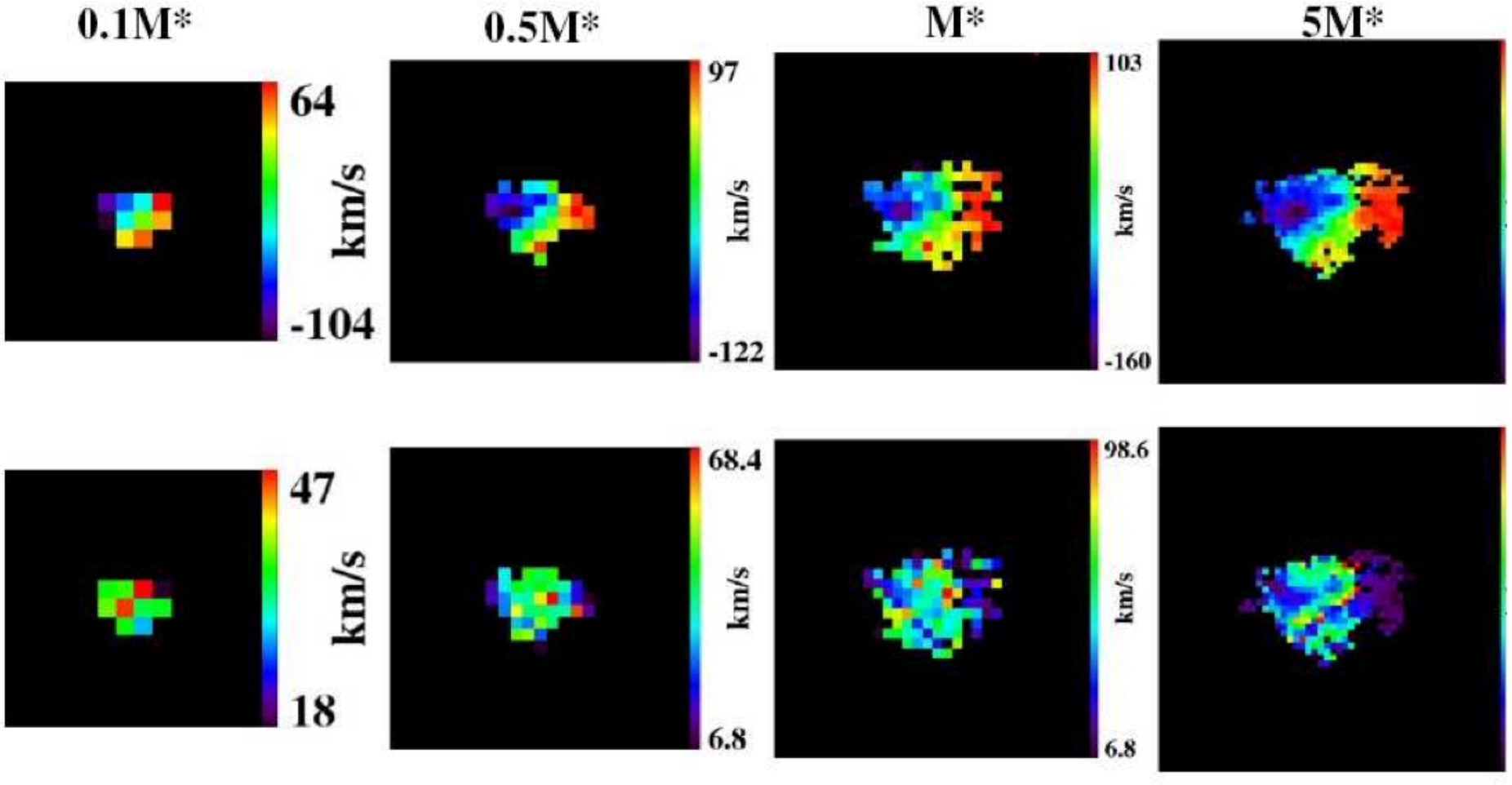
*1M**



*5M**

From the E-ELT DESIGN REFERENCE MISSION

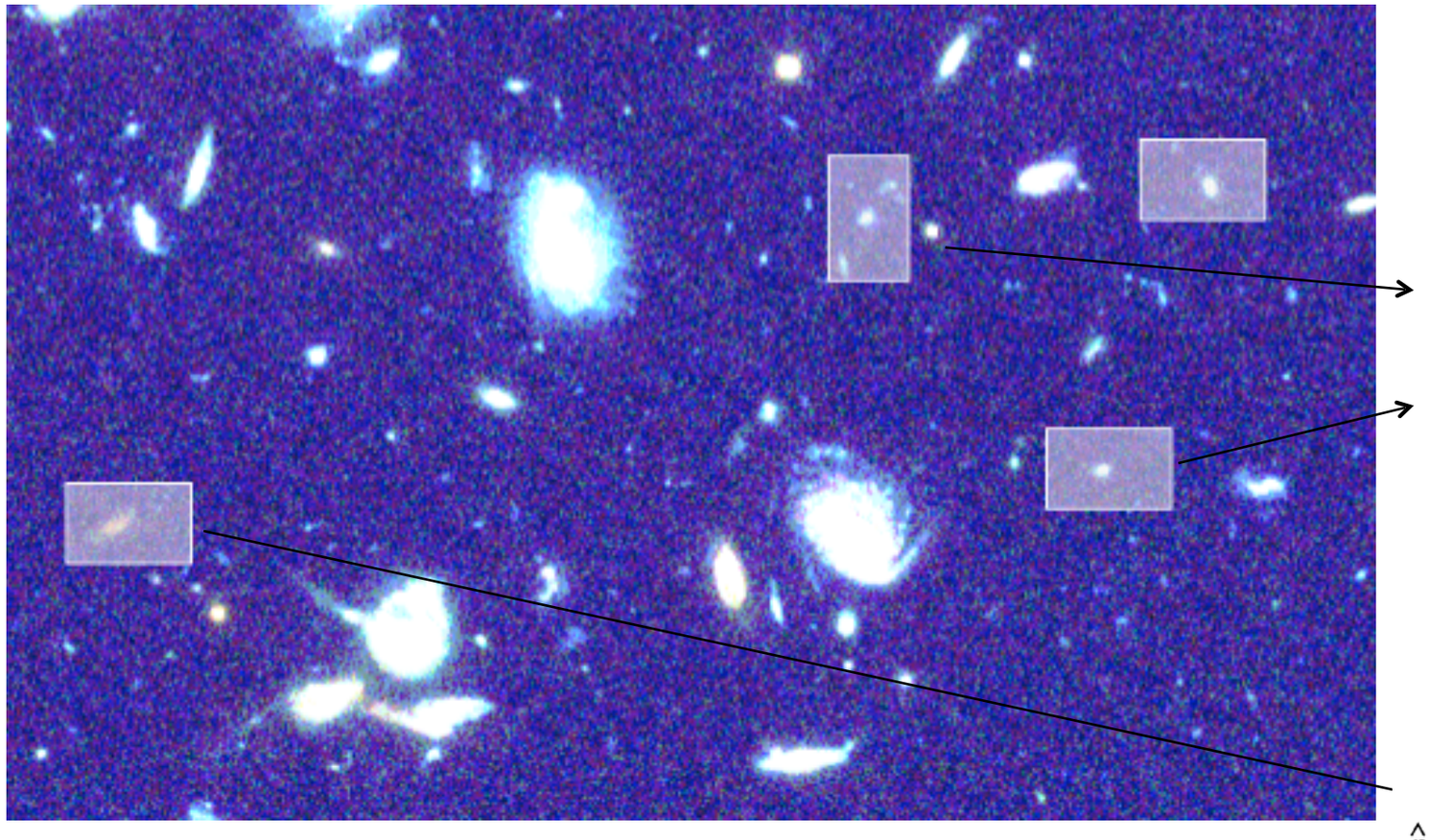
z=4.0
E-ELT/MOSAIC
(MOAO)



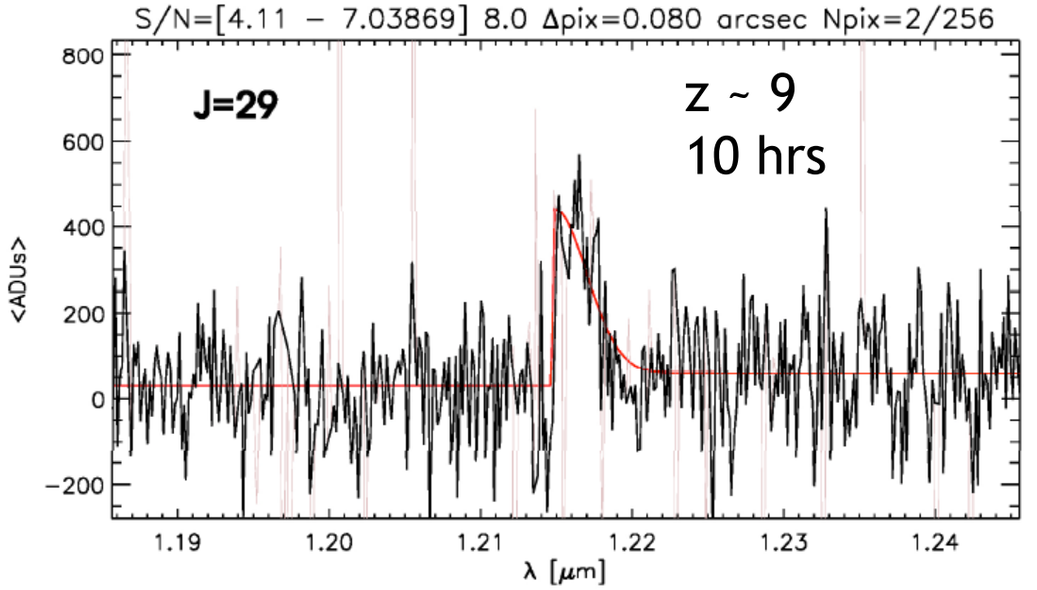
From Puech et al. 2008

First galaxies with MOSAIC

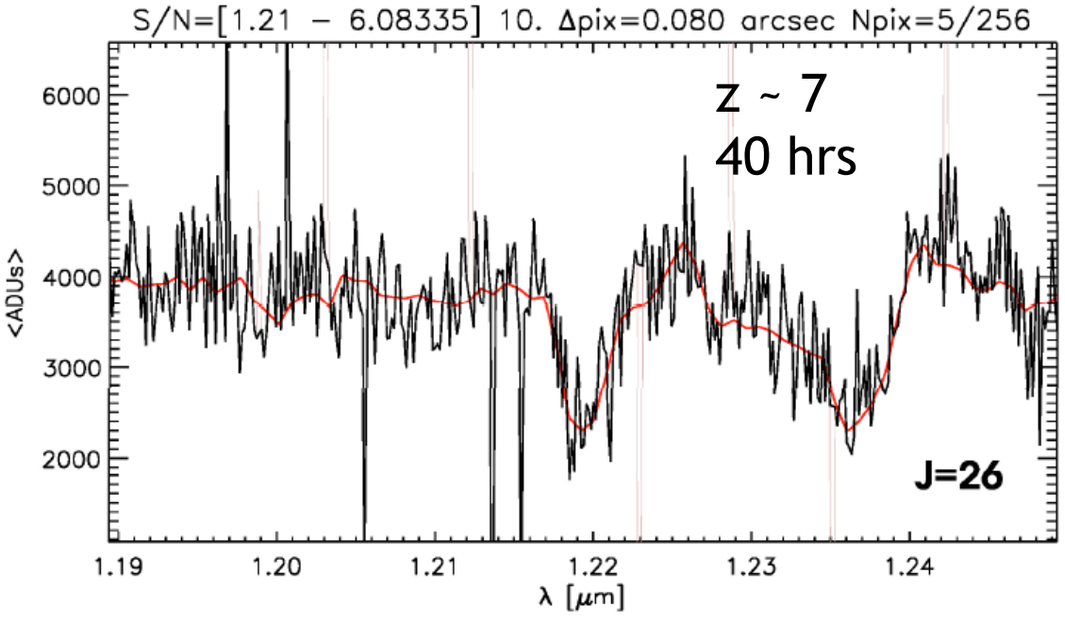
Spectroscopic follow-up of JWST sources



End-to-end simulations, see Disseau et al. (2014, SPIE)

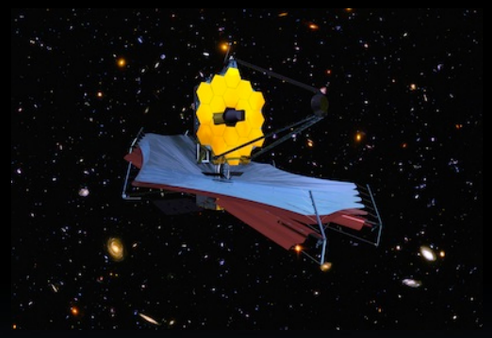


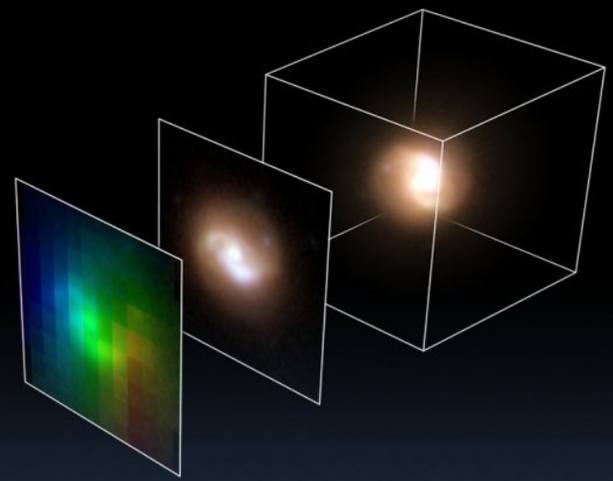
Lyman alpha emitter

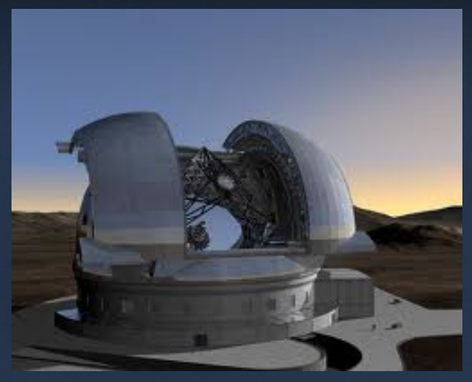


UV ISM lines
Si II / C IV

R=5000 will allow to resolve the Ly alpha profiles bellow
FWHM ~ 100 km/s







MOSAIC E-ELT