Galaxy mass assembly with the ELT-MOS: lessons from the VLT & HST IMAGES survey

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Galaxies Étoiles Physique et Instrumentation

Most -72%- large galaxies have spiral structures

M83

NGC 1365

M100 SABbc

An evidence for dark matter: gas & stars are rotating too fast!
(e.g., Zwicky, 1933)

M 31

NGC 2997

NGC 1313

What is the past history of giant spiral galaxies?

Their progenitors are within distant galaxies

The IMAGES Survey: provides us with the most complete description of galaxy properties, 6 Gyr ago

Sample selection
$M_{J(AB)} < -20.3$ & $0.4 < z < 0.9$
4 fields including CDFS

→ **Intermediate-mass galaxies**
$M_{stellar} > 1.5\ 10^{10} M_{\odot}$
(average ~M*, e.g. MW)

Imaging
ACS imagery (≥ 3 orbits)

→ Color-morphology
comparable to SDSS (depth, resolution)

3D Spectroscopy
VLT/FLAMES-GIRAFFE
(R=9000, 8-24hrs exposure)

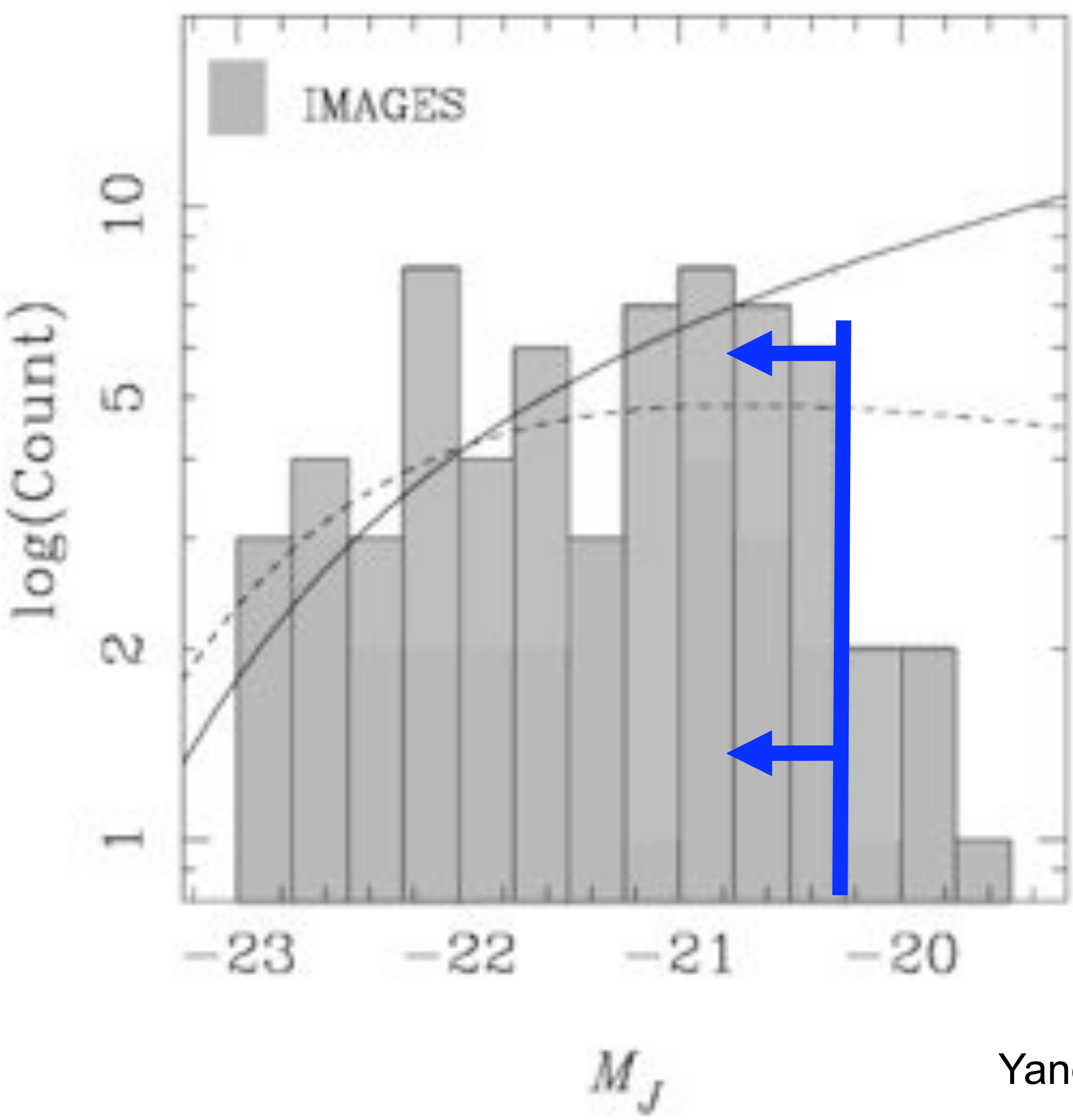
→ Spatially resolved kinematics
Large scale dynamics

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

→ SFR
Metallicity of the gas (O/H)

IMAGES : a representative sample of M* galaxies, 6 billion years ago

$M_{J(AB)} < -20.3$
$M_{stellar} > 1.5\ 10^{10} M_{\odot}$
(average ~M*,
e.g. the Milky Way)



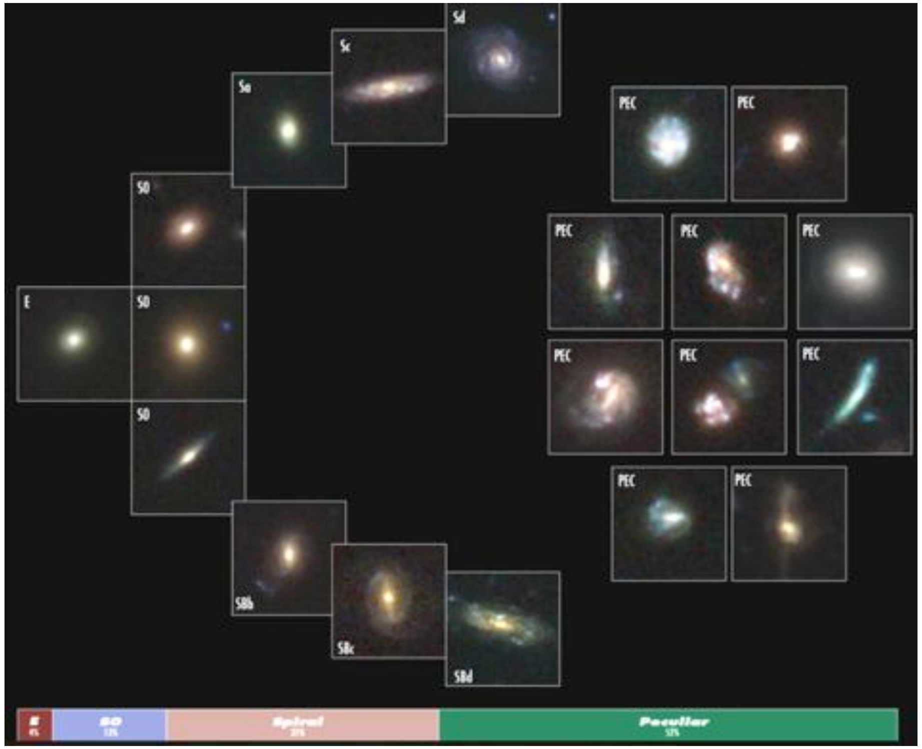
LF, z=0.5,1
Pozzetti et al 2003

Yang et al (2008)

Formation of giant spiral galaxies

Today

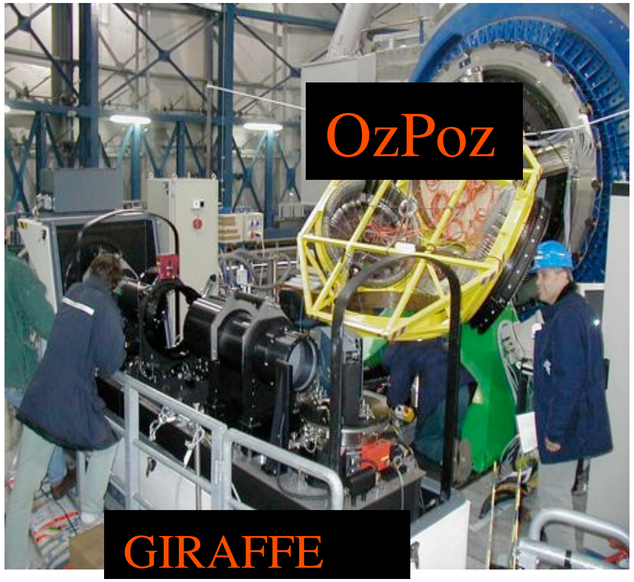
6 billion years, ago

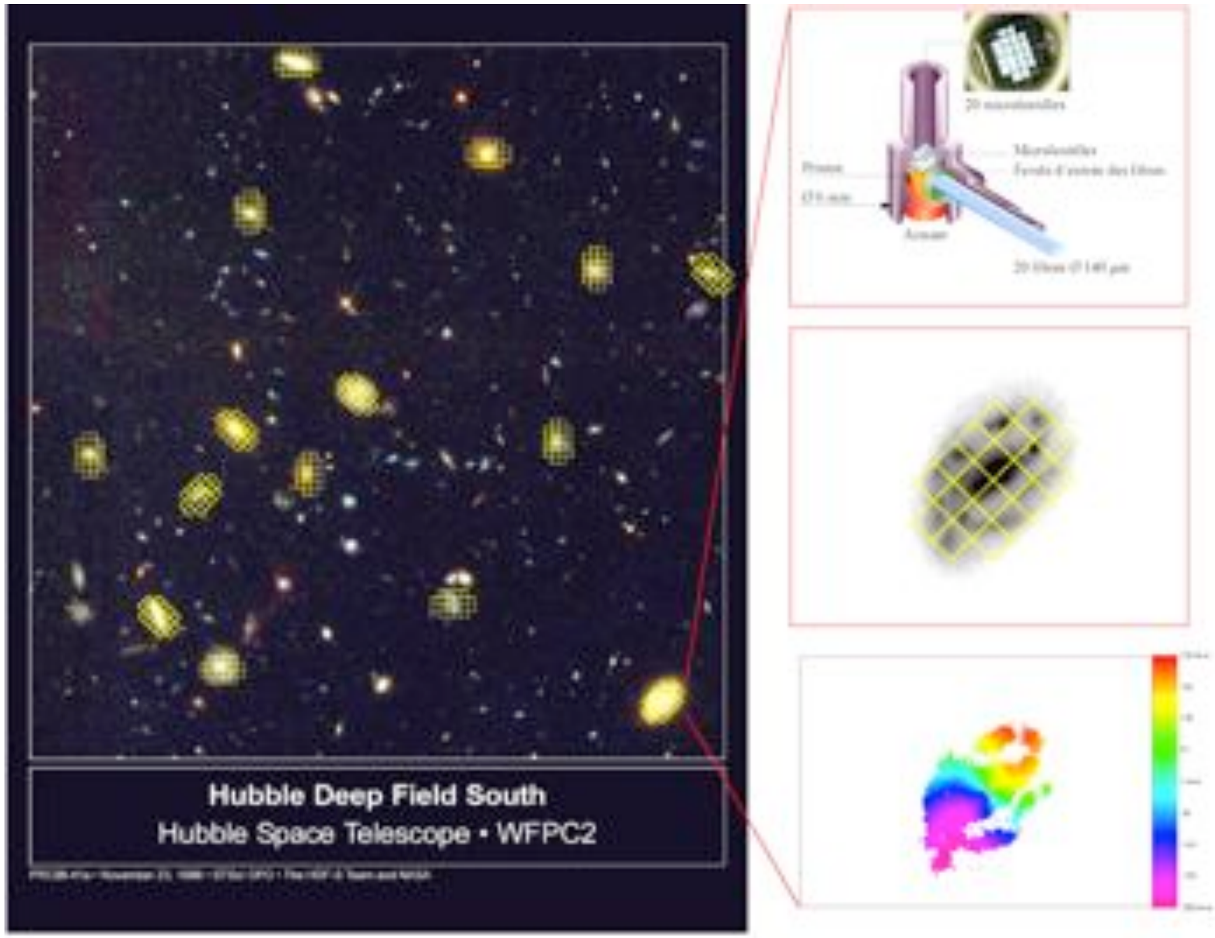


@ NASA, ESA, Sloan Digital Sky Survey, R. Delgado-Serrano, F. Hammer, Y.B. Yang, M. Puech & H. Flores (Observatoire de Paris)

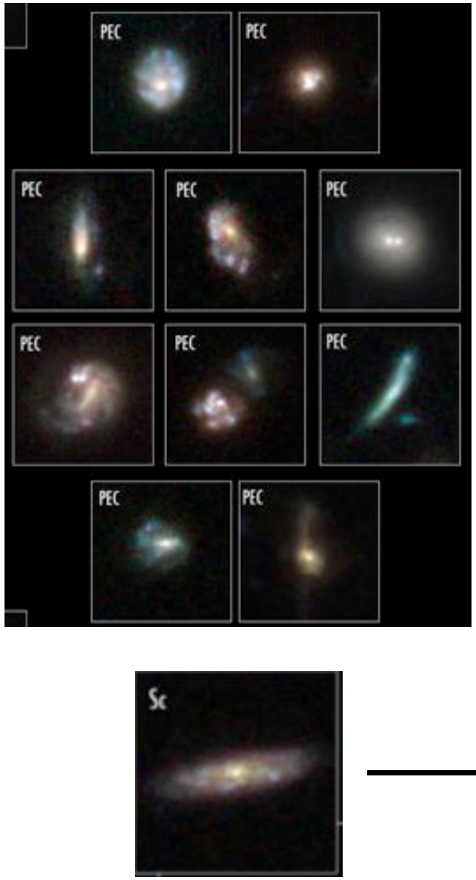
The Very Large Telescope (VLT)

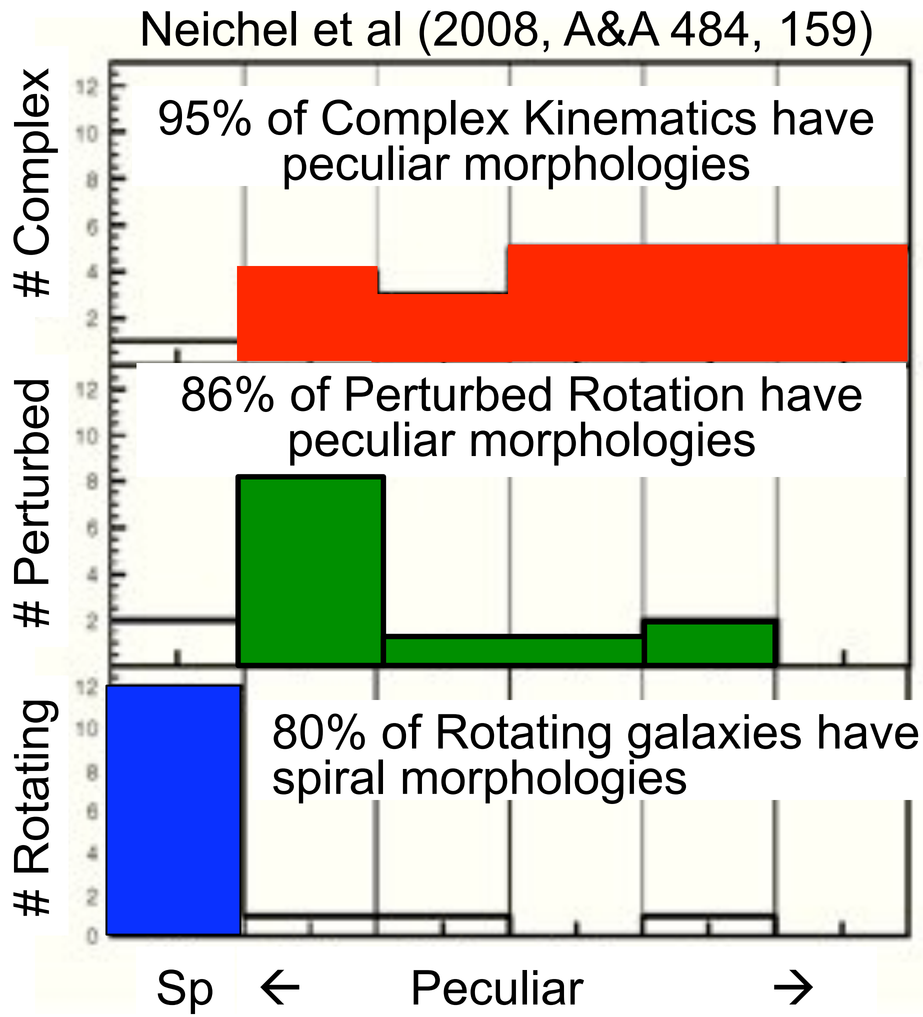
VLT/GIRAFFE





Agreement between spatially-resolved kinematics and morphological classifications

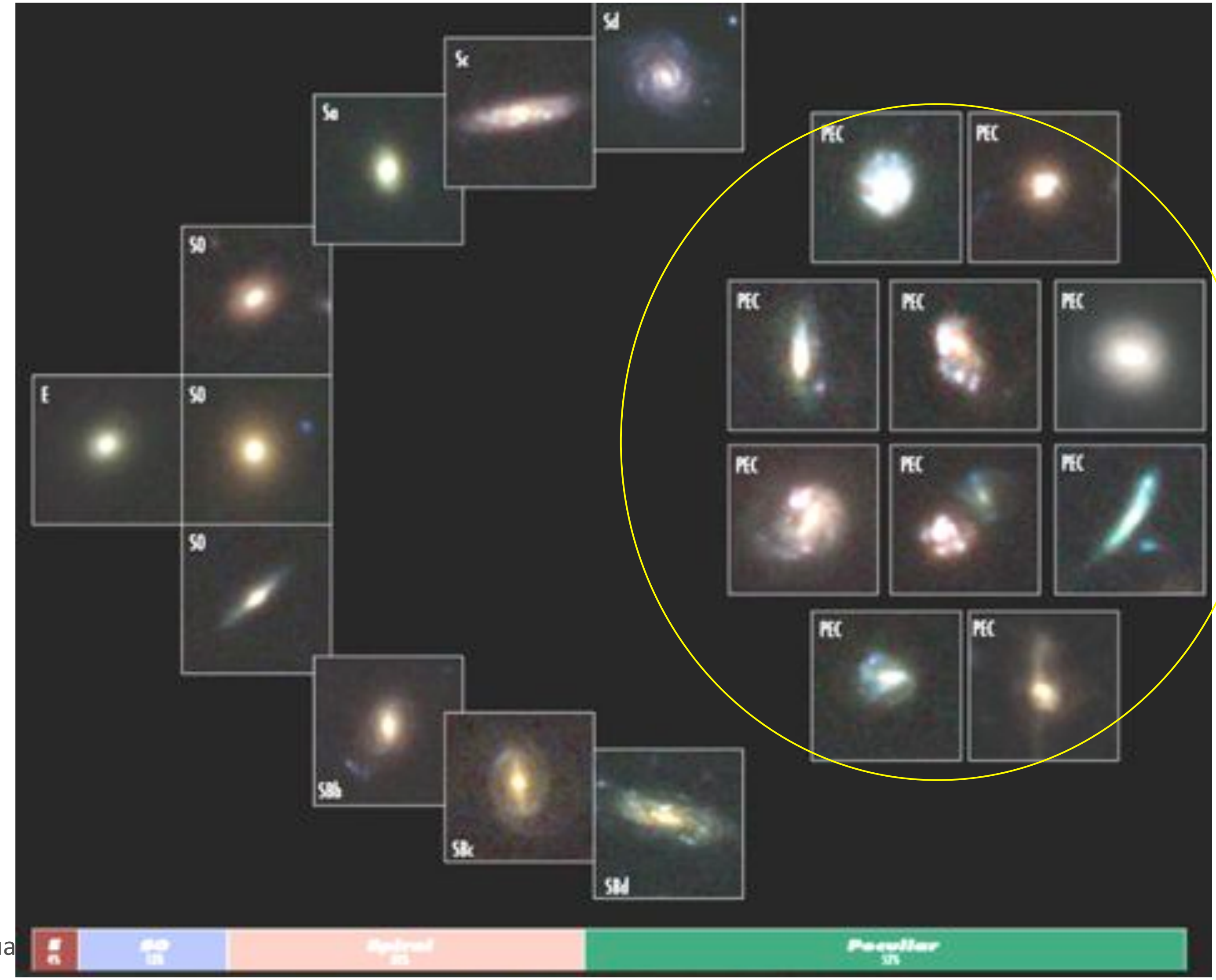




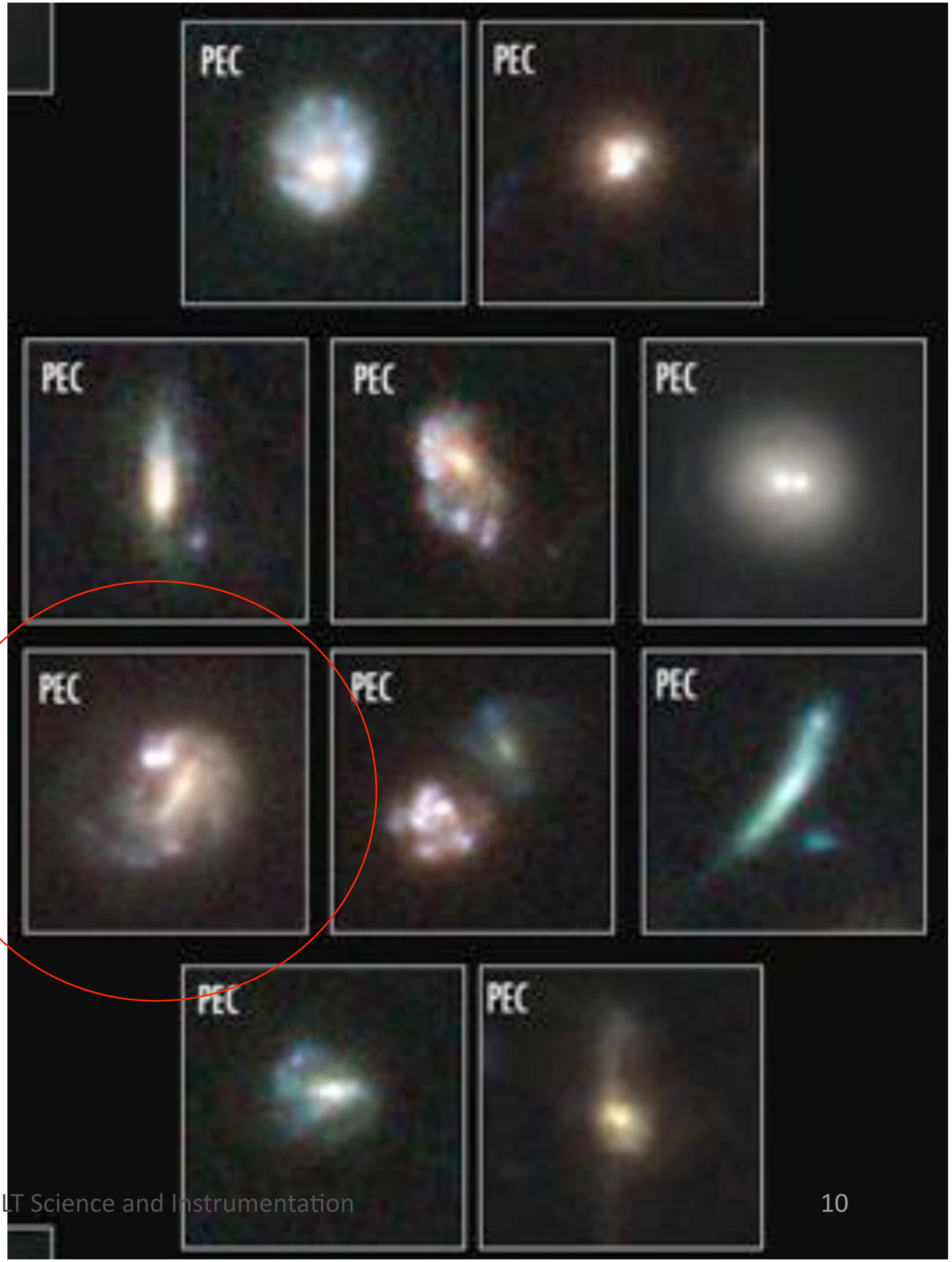
Anomalous kinematics of the ionised gas is linked to anomalous morphological distribution of the stars

The ancestors of giant spiral galaxies

6 billion years ago



The ancestors of giant spiral galaxies, 6 billion years ago

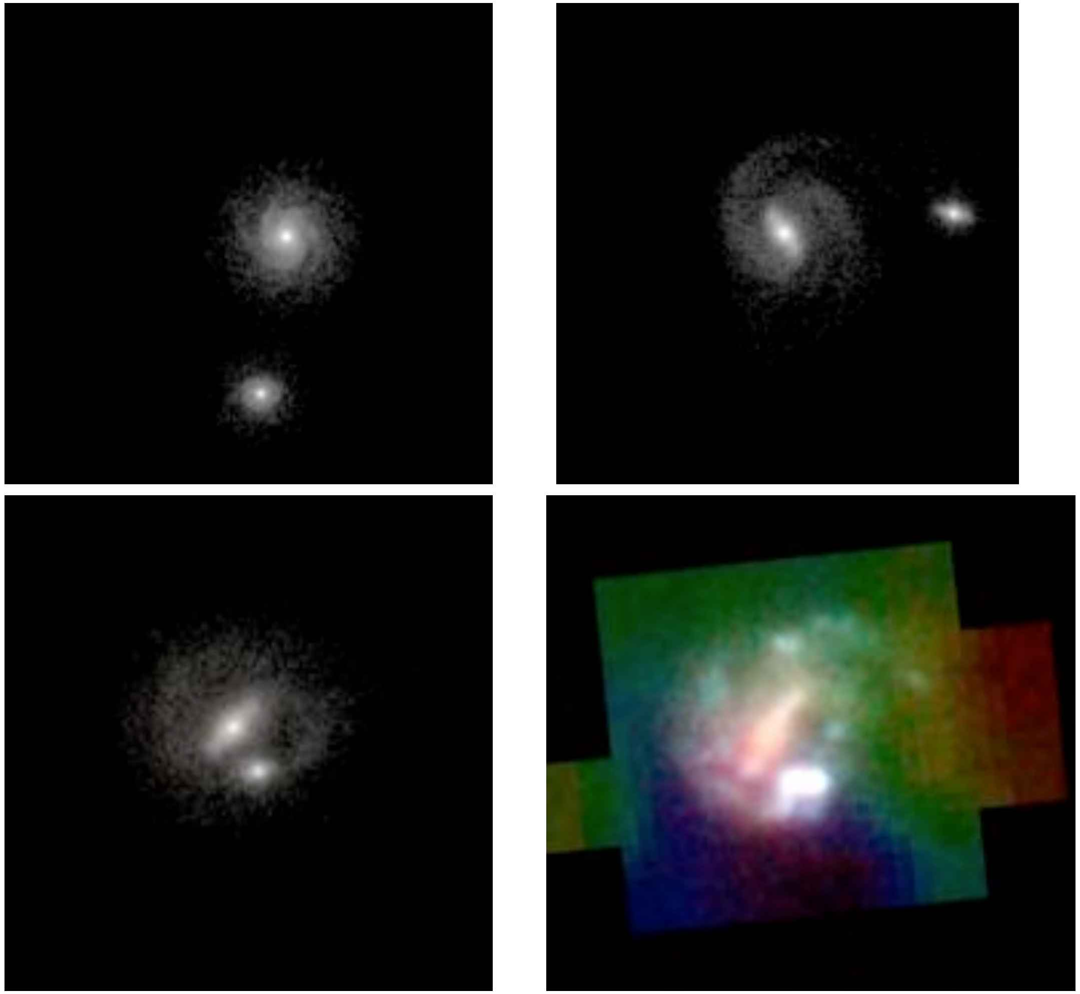


Half of them have peculiar morphologies and anomalous kinematics

Can be reproduced by hydrodynamical models of major mergers

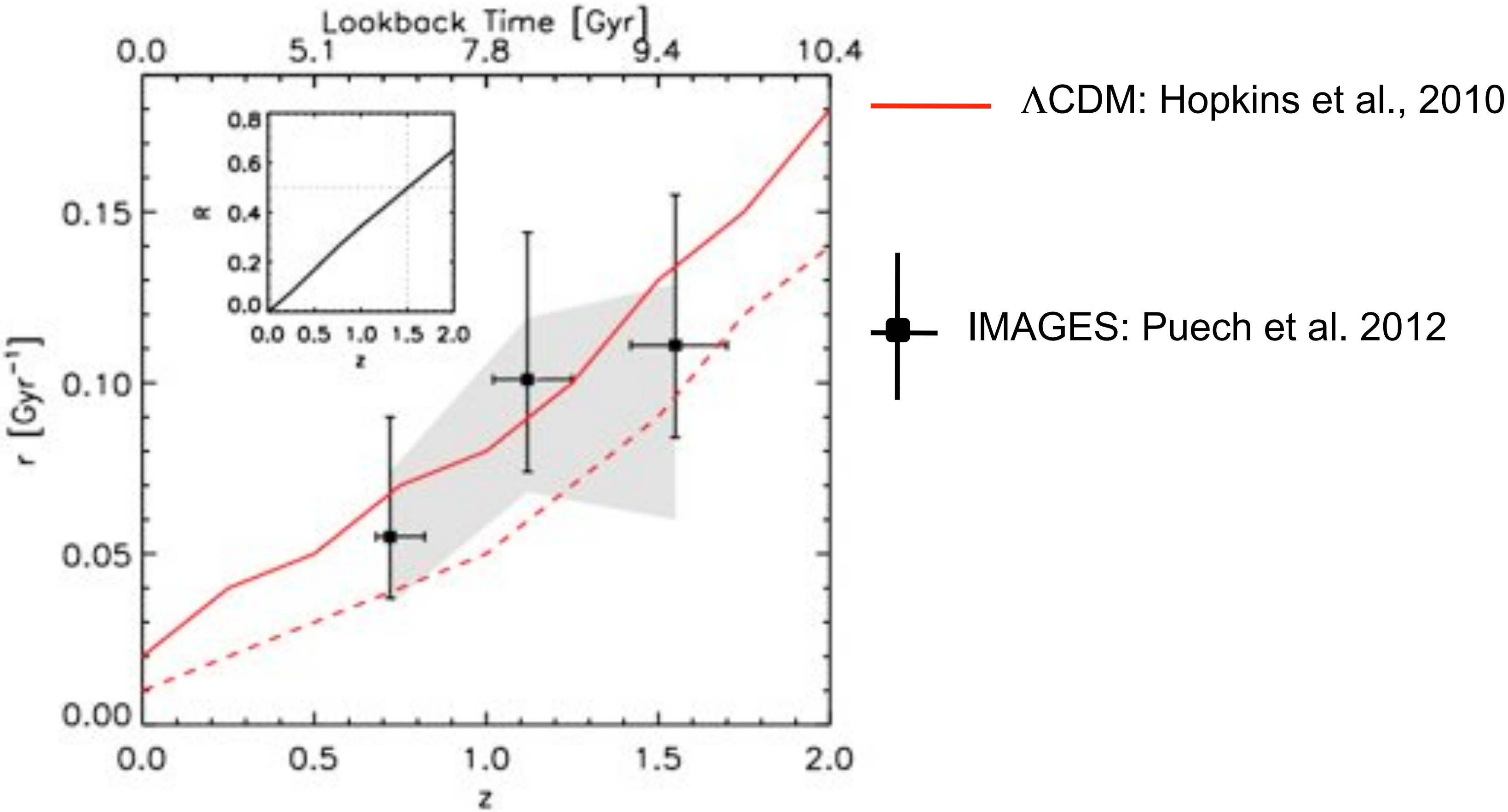
50% of giant spiral ancestors are experiencing major mergers

VLT/GIRAFFE & HST/ACS



@ ESO, S. Peirani, F. Hammer & H. Flores (Observatoire de Paris)

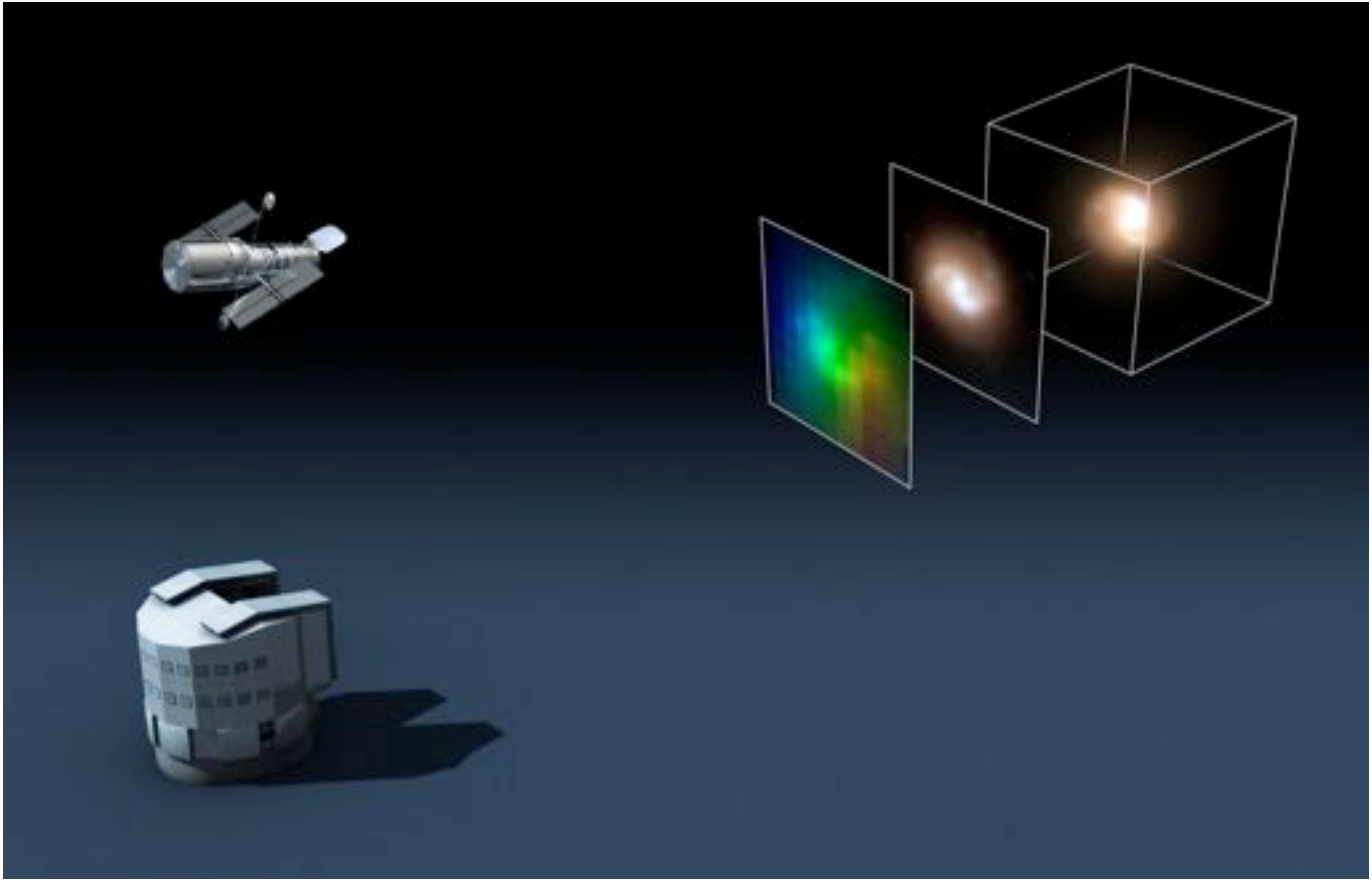
Mergers: observations vs. theory



Both ΛCDM theory and observations predict that spirals have rebuilt their disks after a major merger

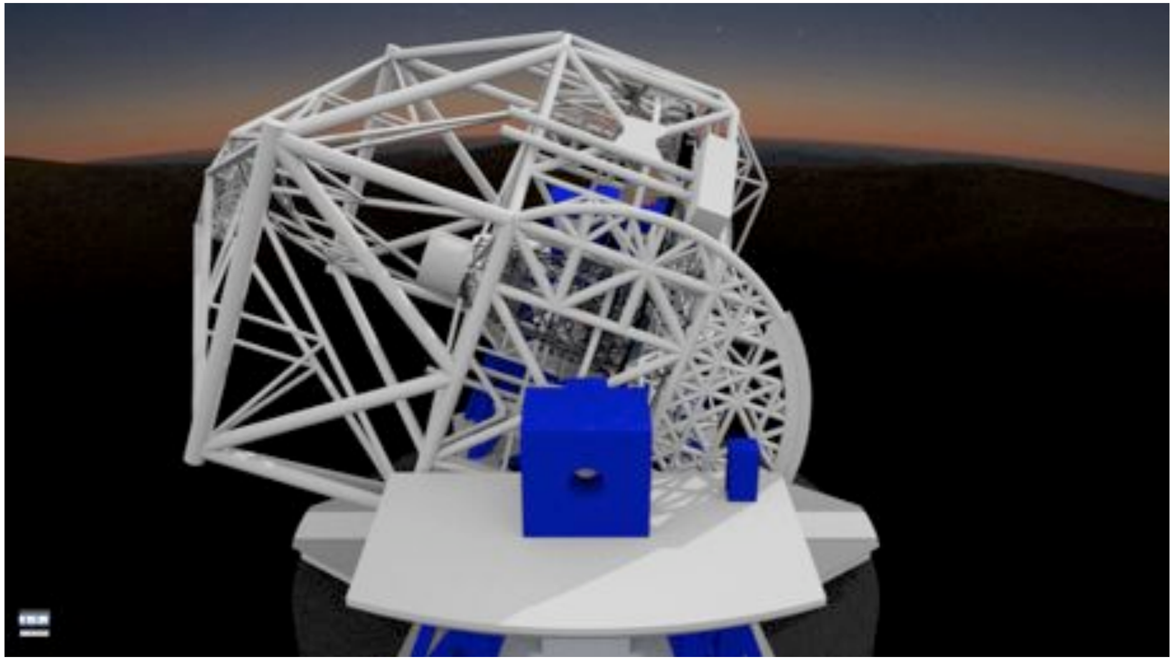
(see also Keres+2011; Guedes+11, Font+11, Brook+11)

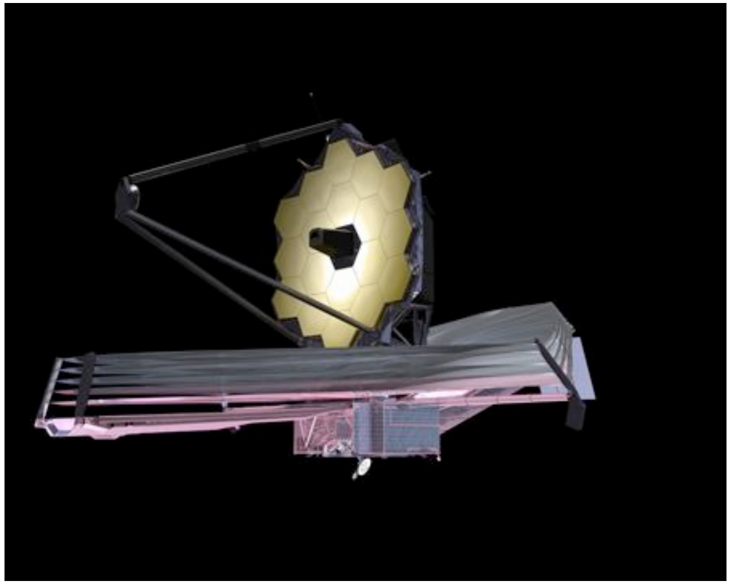
TODAY: z < 1 galaxies



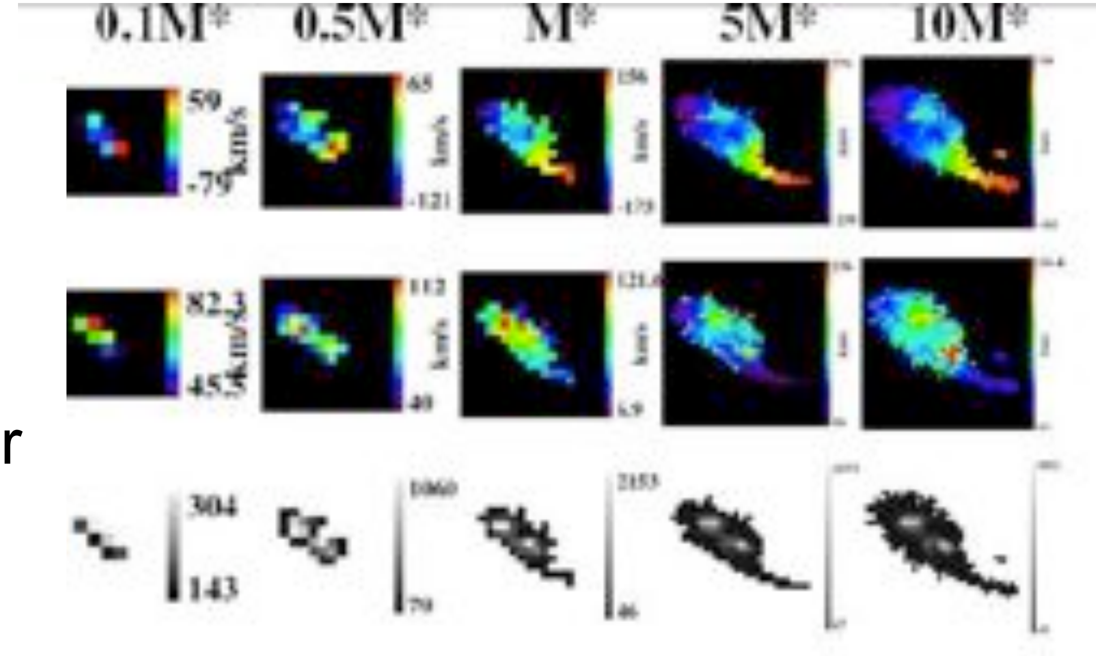
TOMORROW: z >> 1 galaxies with E-ELT + JWST

Multiplex is a key issue for studies of galaxy evolution & formation
See ELT-MOS white paper by Evans, Puech et al.



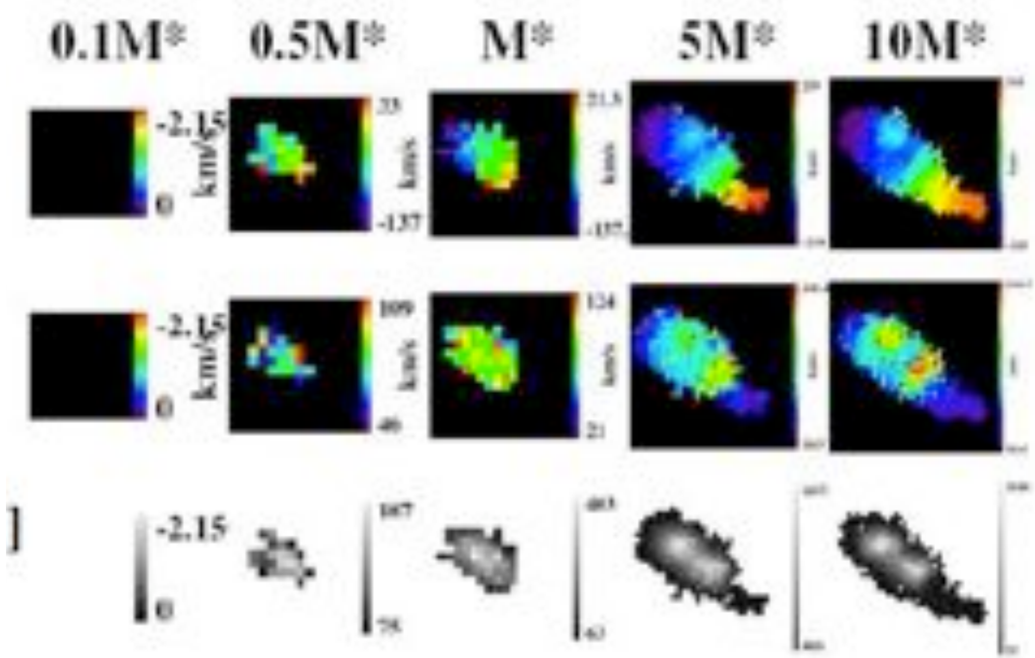


Spatially resolved spectroscopy of z ~4-6 galaxies is required for e.g. distinguishing merger from rotation (Puech et al. 2010)



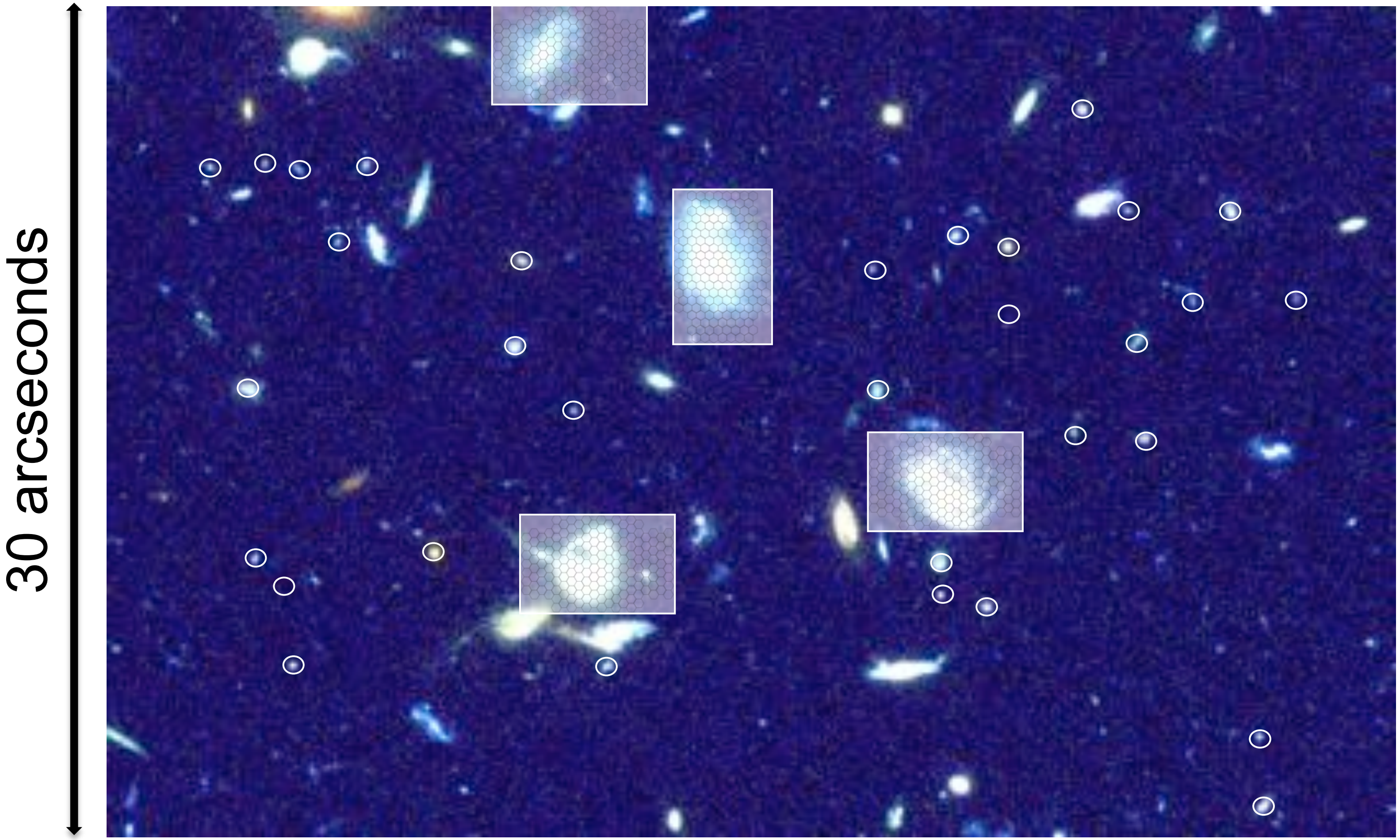
MOAO

GLAO does not suffice: it requires MOAO Integral Field Units



GLAO

A CENSUS for z >> 1 galaxies

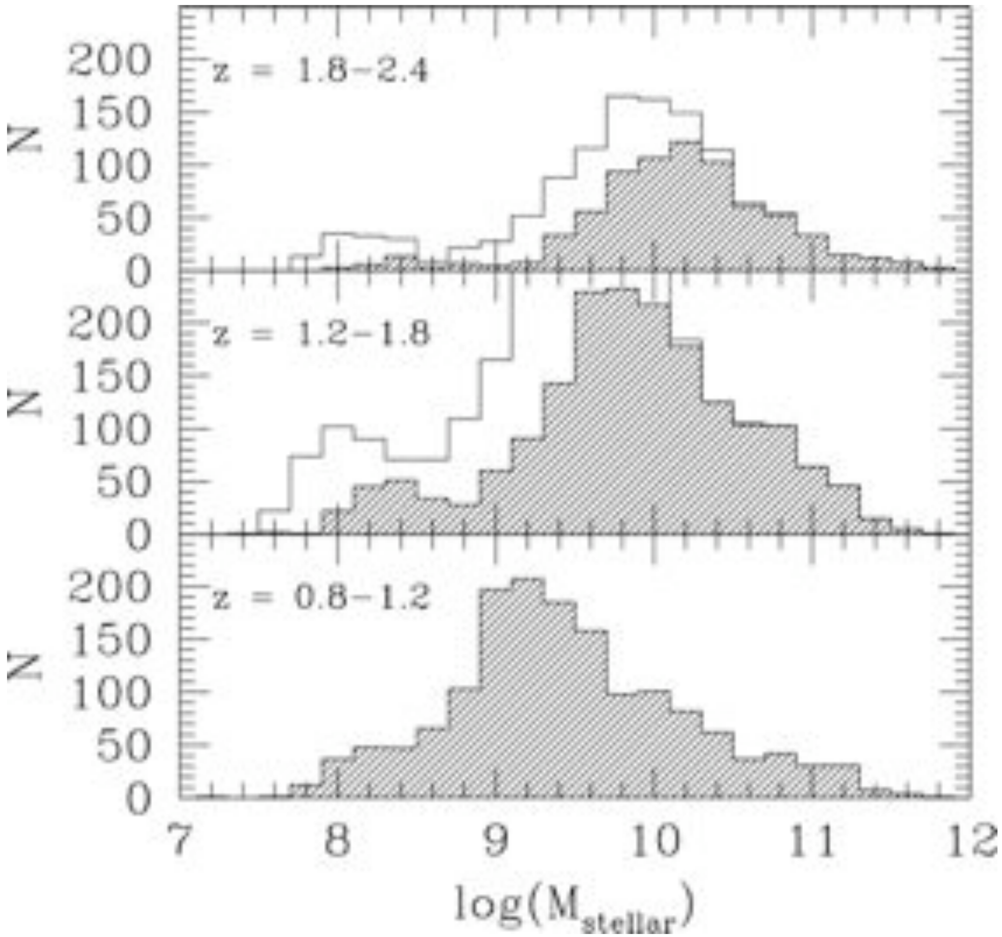


- spatially resolved kinematics of z>>1 massive galaxies
- spectroscopy of dwarfs and their link to massive galaxies

Study the numerous distant galaxy population

1600 galaxies at z> 1.5 in an E-ELT FoV (mostly dwarfs)

- Origin of dwarves: primordial galaxies or tidal dwarfs?
- Low surface brightness galaxies in the gaseous-rich Universe
- Test of curvature (Λ using HII galaxies)



m_J(AB)<26

Based on CANDEL counts & Dahlen photo'z

MOSAIC

2 main different observing modes

- High definition (HDM, 40-80 mas/pix) with ≥10 MOAO IFUs

e.g., EAGLE science case

detailed kinematics of galaxies up to z=5, R=5000

- High multiplex (HMM, 100-250), GLAO/seeing resolution

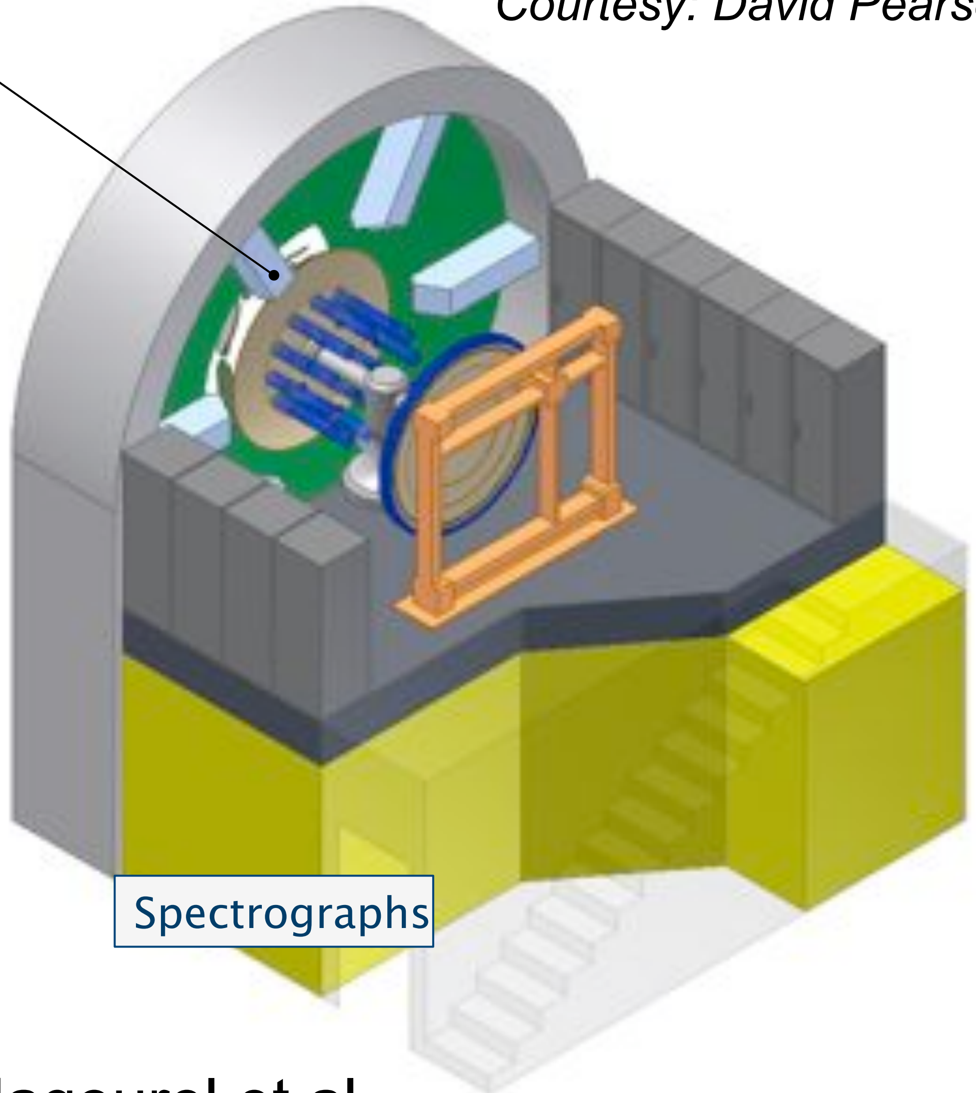
e.g., OPTIMOS-EVE science case

1600 z > 1.5 galaxies in an E-ELT FoV, R=5000-20000

See Chris Evans's talk for further science requirements

Fibre Only Option: High Definition Mode (HDM)

Courtesy: David Pearson



Assumptions
12 science channels
Light transfer optics:
- Pick off mirror
- Intermediate fold mirror
- Receiving mirror

In-plane rotation >180deg

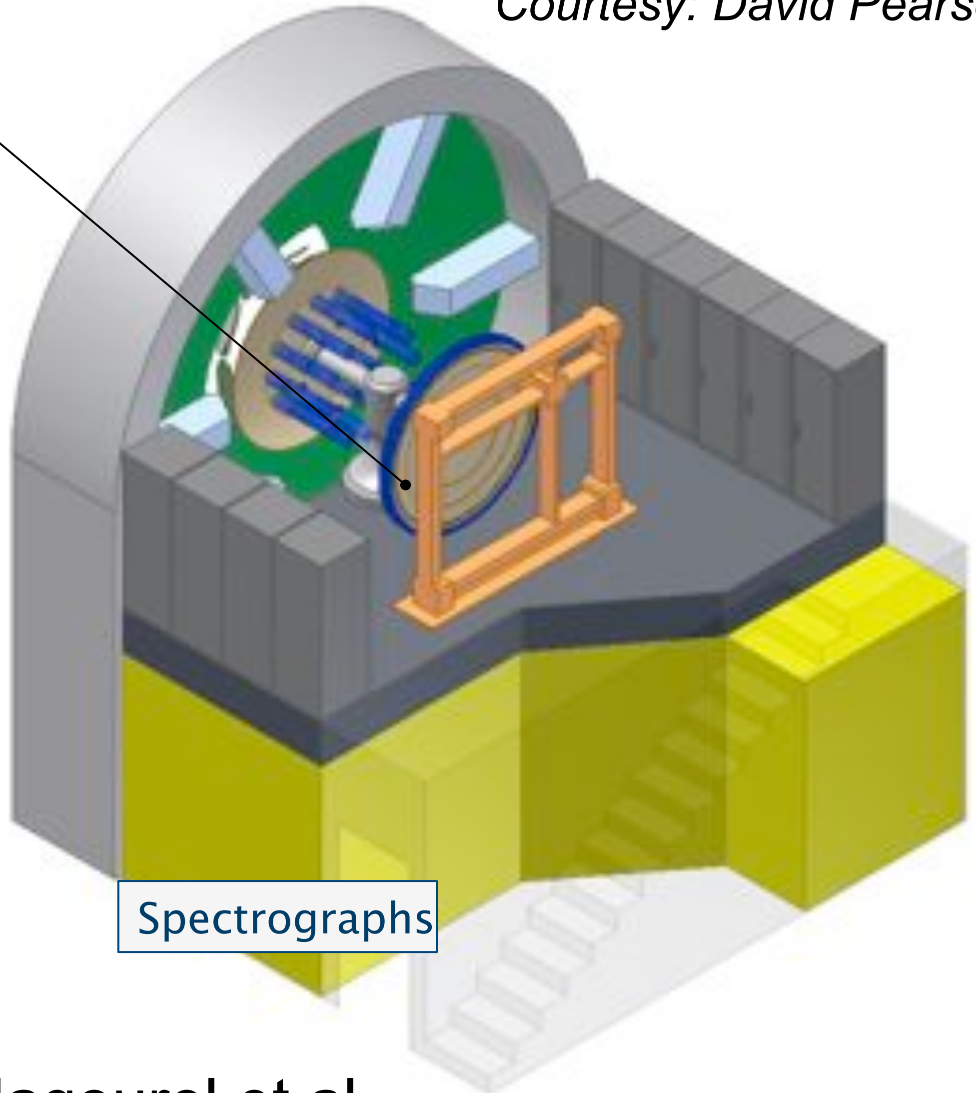
Known issues
Further degrees of freedom required in each optical item.
Pick-and-place system required to cope with optical items of different shapes and sizes.
Synchronisation of plate rotation with LGS system.

MOSAIC

See Poster by Jagourel et al.

Fibre Only Option: High Multiplex Mode

Courtesy: David Pearson



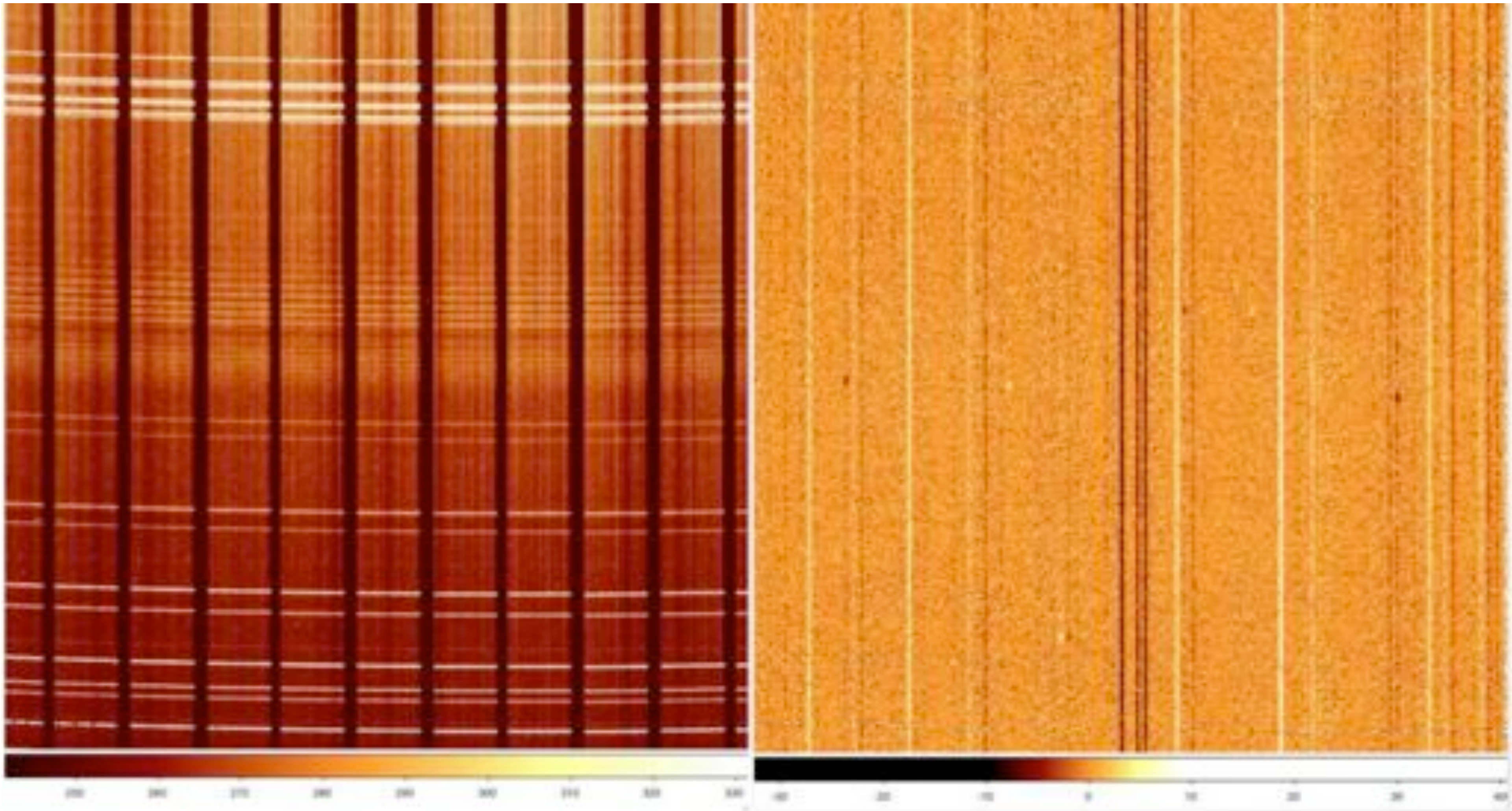
Assumptions
120 science channels
Buttons with fibre retraction scheme
Stepped focal plate
In-plane rotation >180deg

Known issues
Change in field curvature causes difficulty in fibre alignment and focus.
Synchronisation of plate rotation with LGS system.

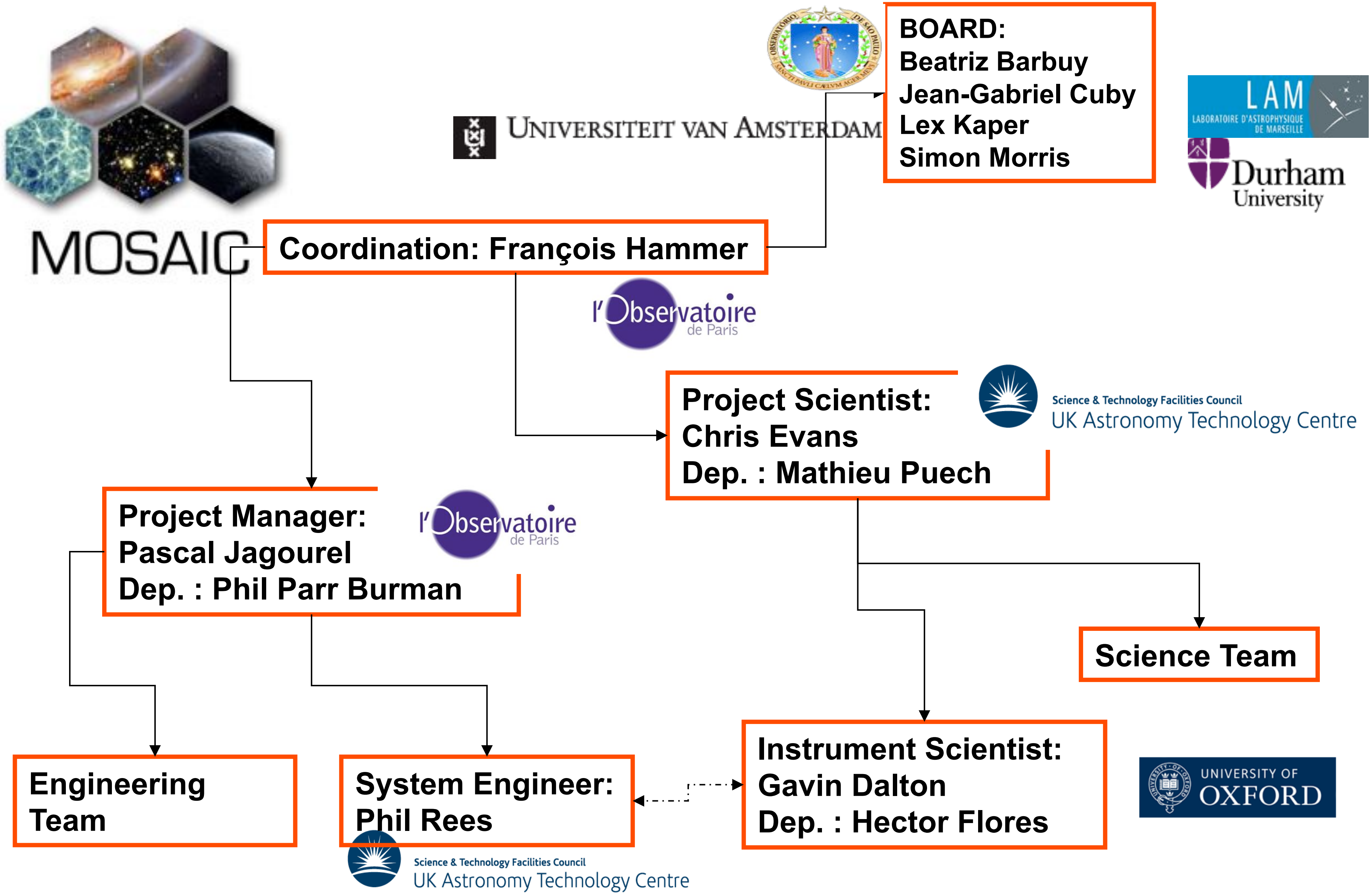
MOSAIC

See Poster by Jagourel et al.

Sky subtraction with fibers demonstrated with FLAMES (I-band) on sky



Expected in J-band: 0.6% of the sky-continuum & much better with IFUs
(Yang et al., Messenger, in press; see also Yang et al' Poster)



Other contacts: LNA & AIP (fibers), Univ. Nice, Vienna, Stockholm

Conclusions

- Good knowledge of galaxy evolution z < 1 (IMAGES)
- Still questions at z>1-2: mergers versus cold accretion (e.g. representative samples & depth)
- An E-ELT FoV contains 1600 z > 1.5 galaxies
- High multiplex & high definition modes needed: this is MOSAIC
- Only a MOS@E-ELT can detect the first light, solve the reionisation problem & probe the galaxy mass assembly

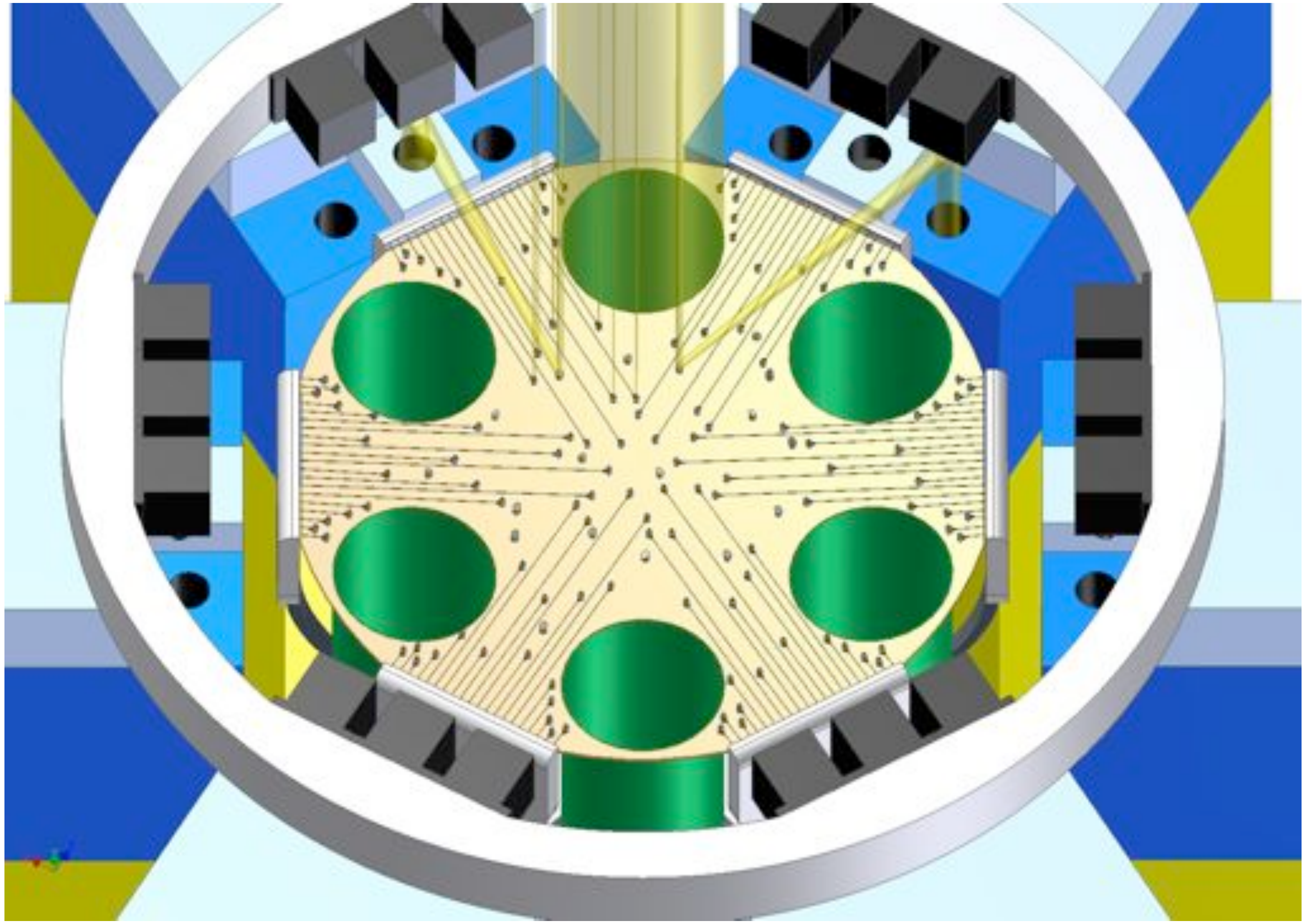
  (see J. Dunlop, JG Cuby & H. Flores talks)

100 billions stars per galaxy & 100 billions galaxies: they require a MOS

Mixed Architecture Design: implementation

Focal plate close up

1x LGS light path
1x NGS light path
1xHDM light path
6x HMM or IGM light paths



MOSAIC

See Poster by Jagourel et al.

PRESENT STATUS OF MOSAIC

Science:

• a white paper written for all science cases (to be sent to the Project Science Group): too much Science Cases for a MOS at E-ELT!

• all science cases require both high multiplex and high definition modes

• trade-off between pixel size and need for K-band (high definition mode, MOAO-IFUs) and the high multiplex mode (100 to 300)

• final trade-off expected mid-2013