

Evolutionary properties of galaxies with the VLT and HST & lessons for the E-ELT

by François Hammer



Most -72%- large galaxies have spiral structures

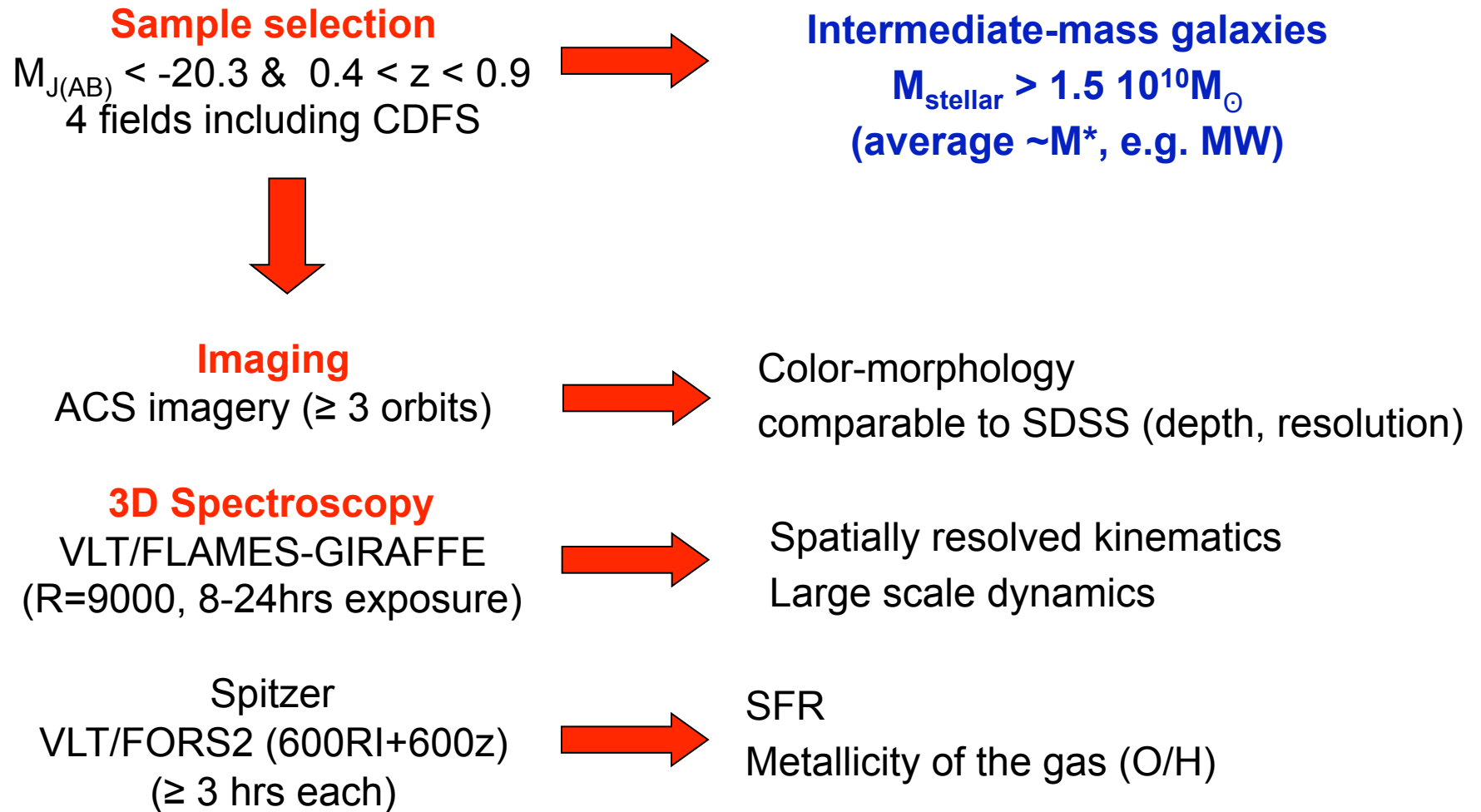


An evidence for dark matter: gas & stars are rotating too fast!
(e.g., Zwicky, 1933)

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



Studying Distant Galaxies: Methods and Analysis

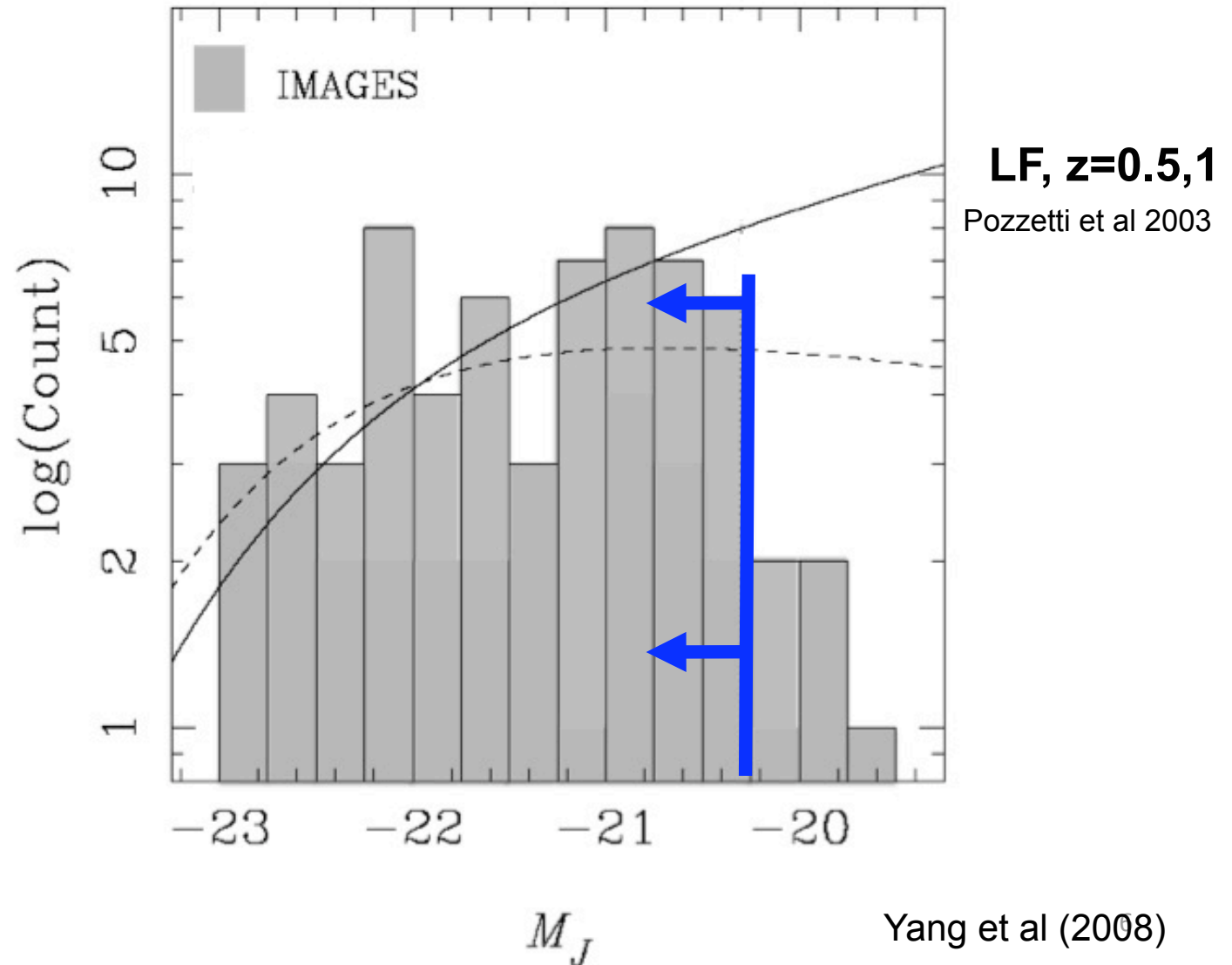
by F. Hammer, M. Puech, H. Flores & M. Rodrigues



(to be printed, 2013)

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

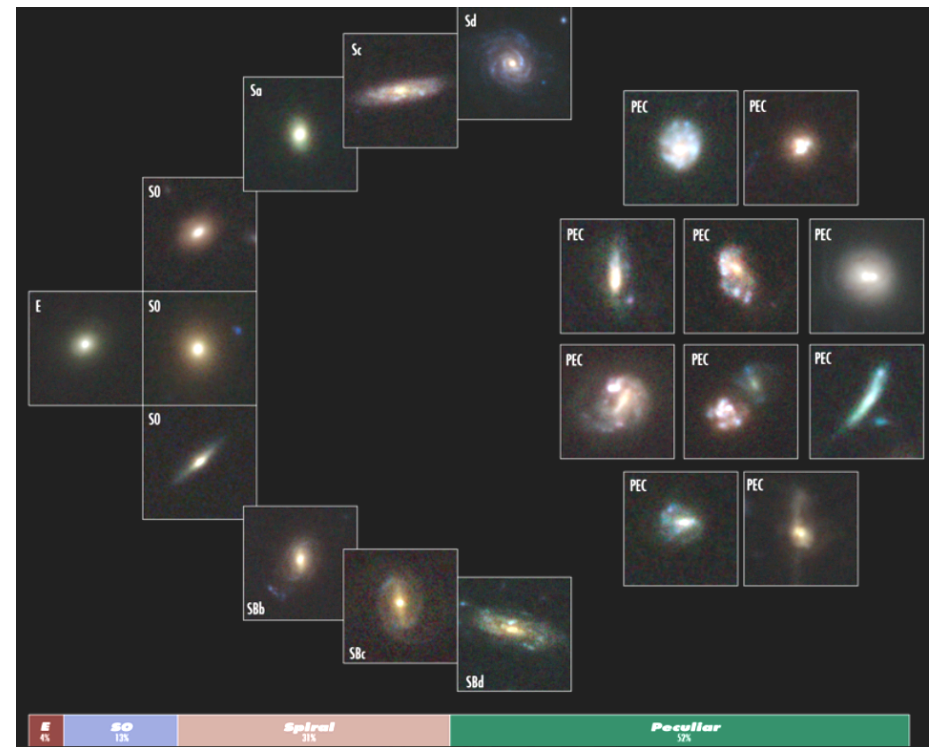
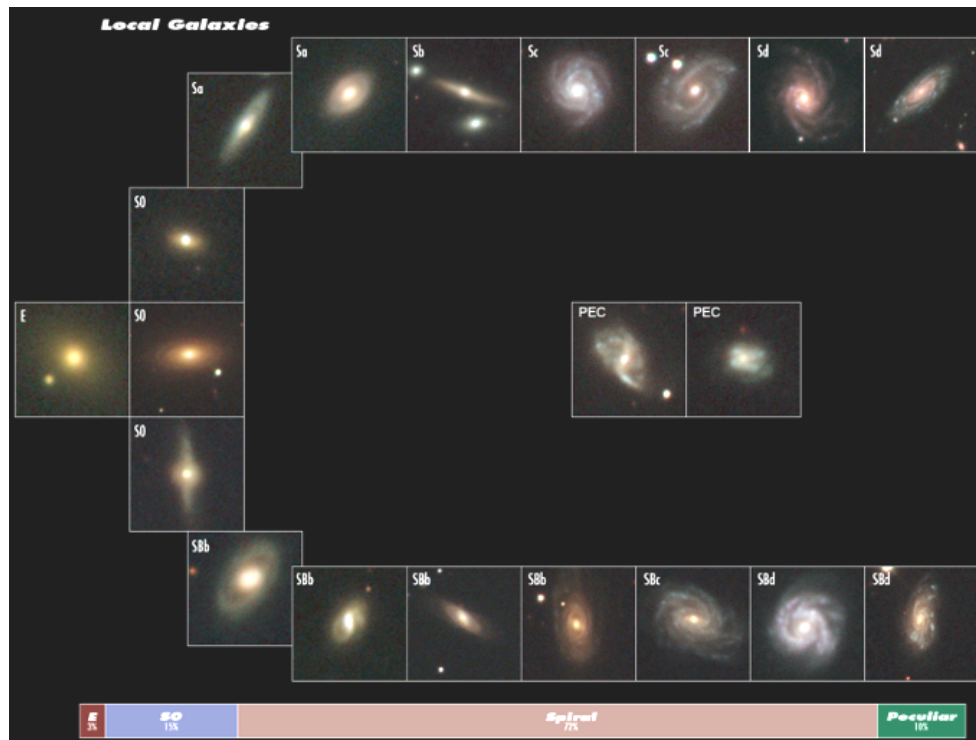
$M_{J(AB)} < -20.3$
 $M_{\text{stellar}} > 1.5 \cdot 10^{10} M_{\odot}$
(average $\sim M^*$,
e.g. the Milky Way)



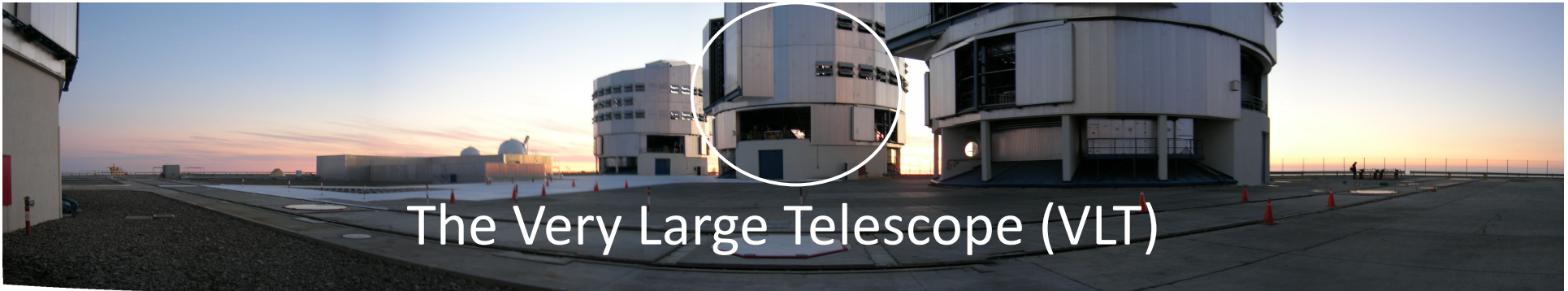
Formation of giant spiral galaxies

Today

6 billion years, ago

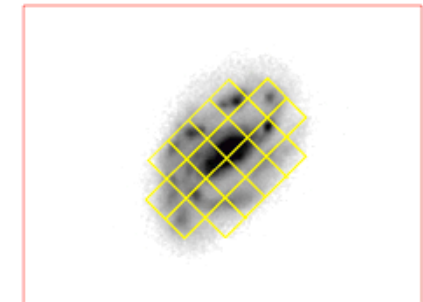
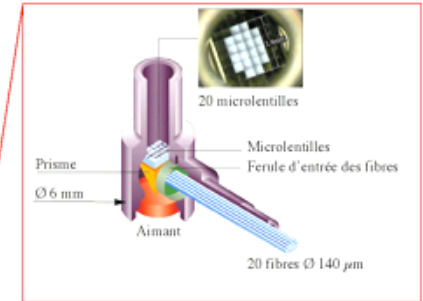
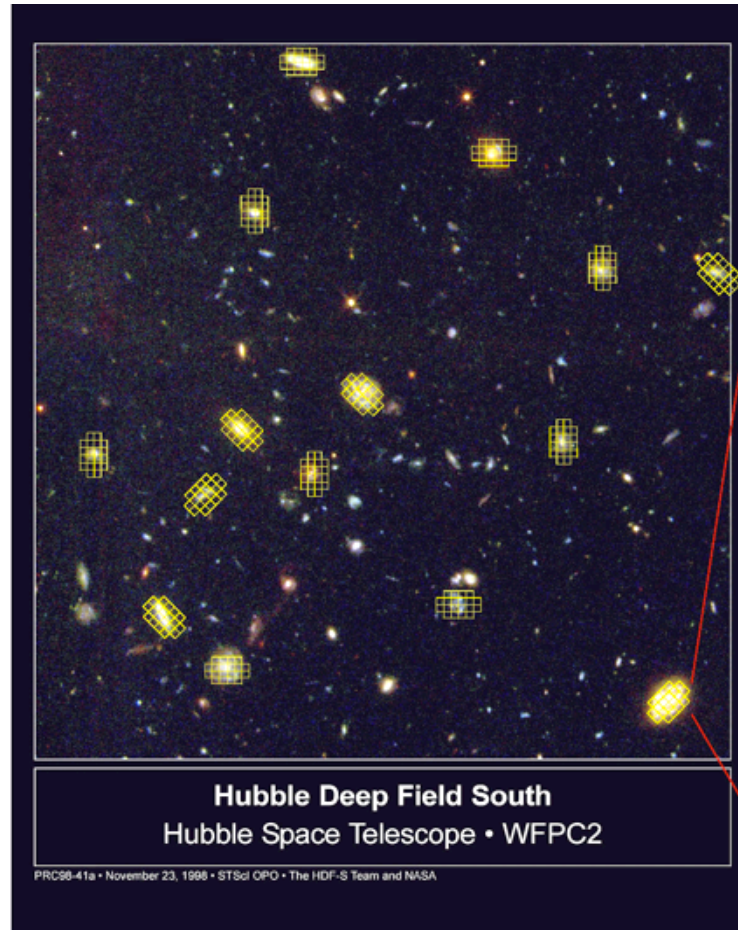
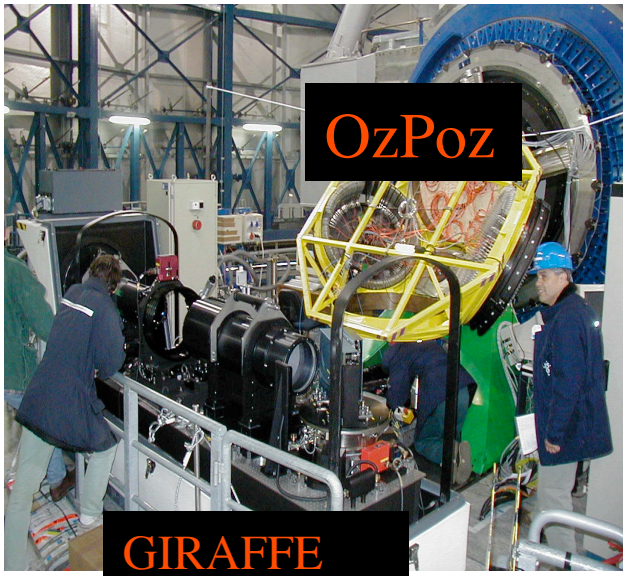


@ NASA, ESA, Sloan Digital Sky Survey, R. Delgado-Serrano, F. Hammer, Y.B. Yang, M. Puech & H. Flores (Observatoire de Paris)

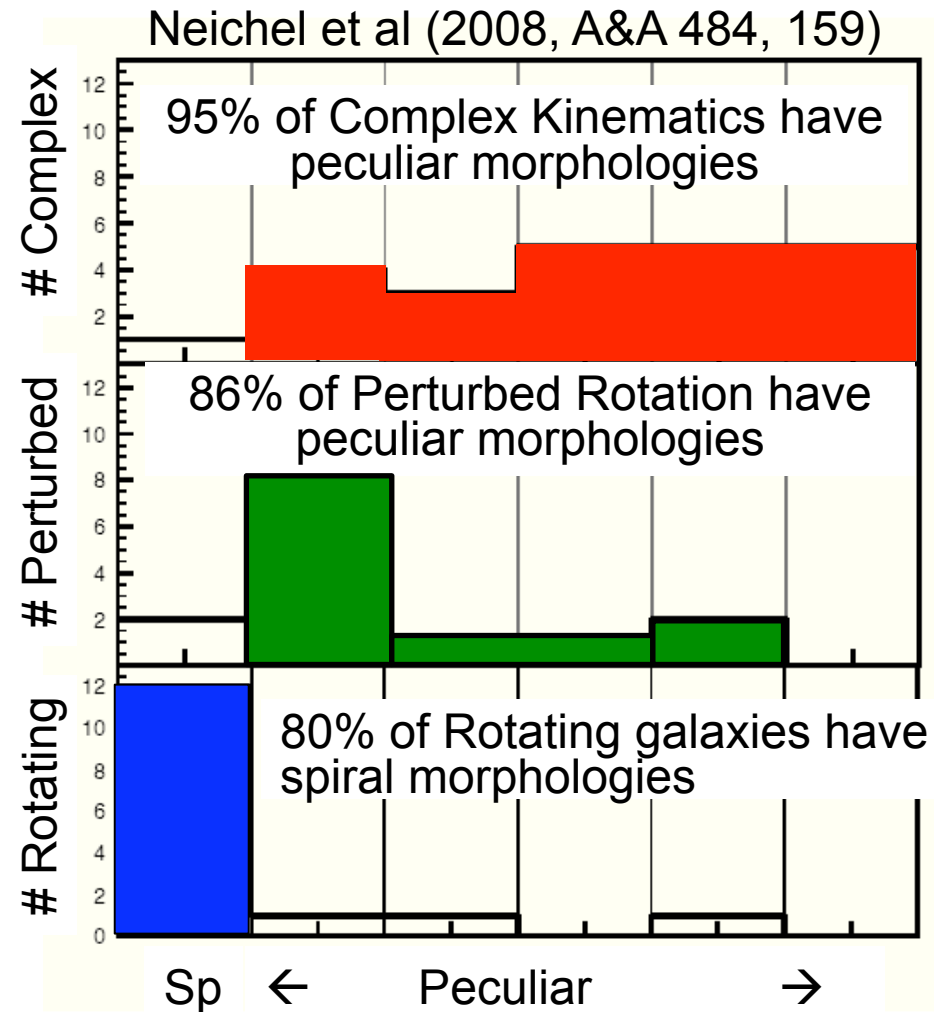
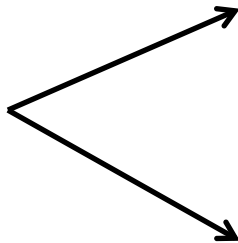
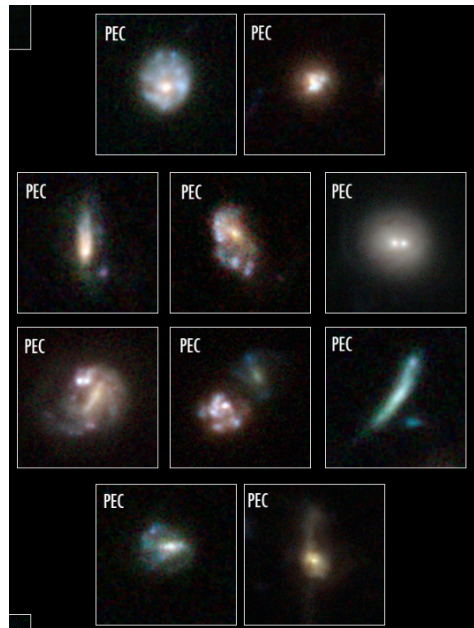


The Very Large Telescope (VLT)

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

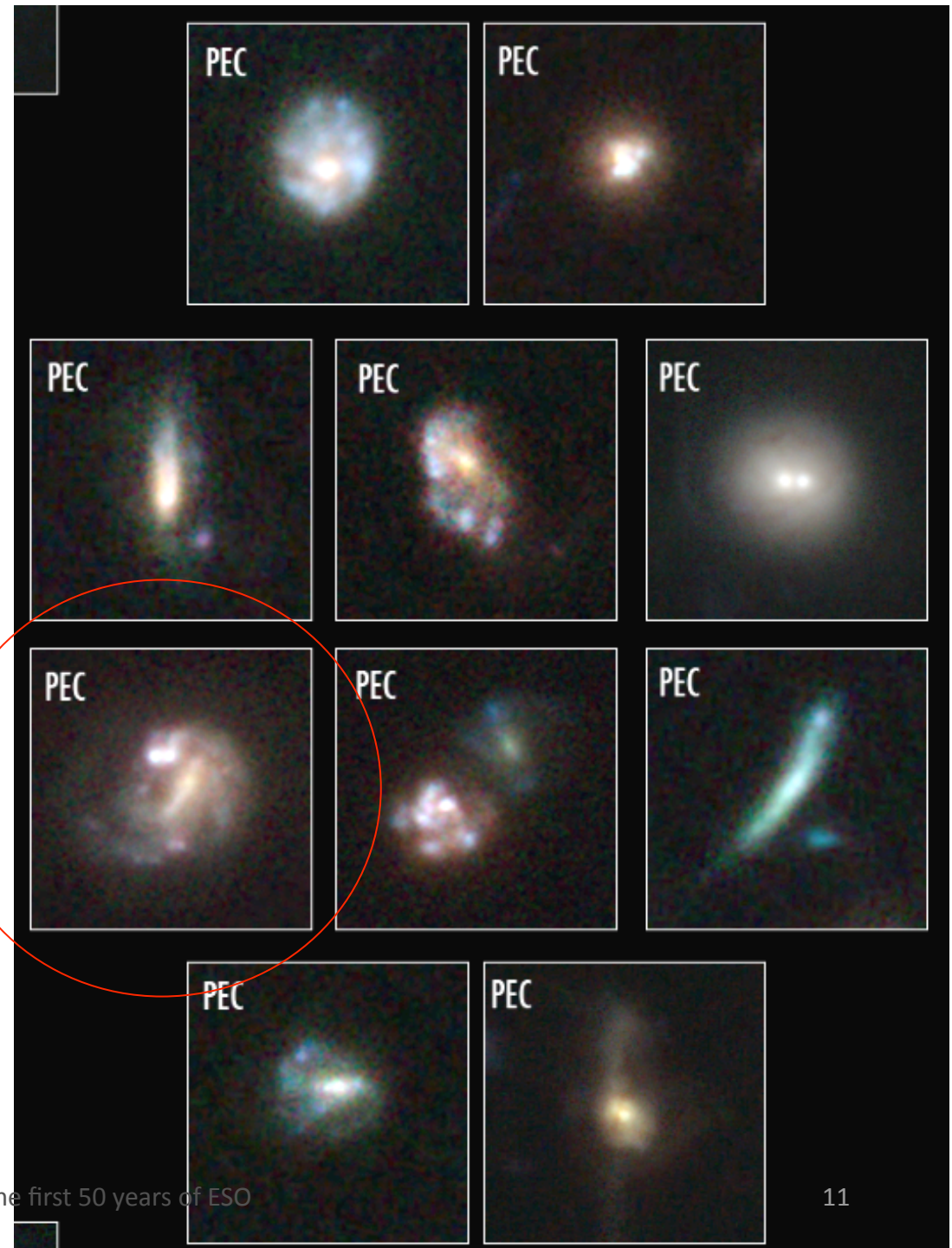
6 billion years ago



The ancestors of giant spiral galaxies, 6 billion years ago

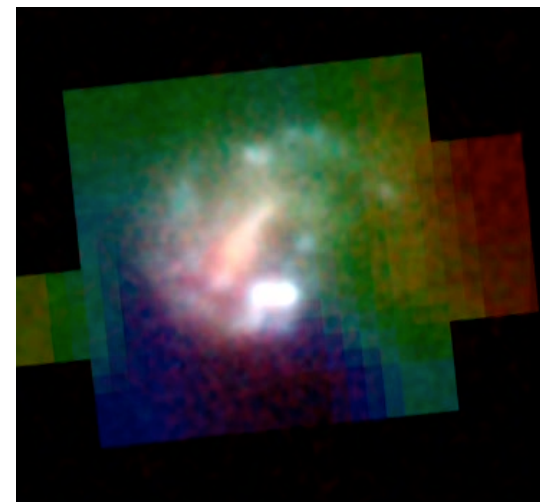
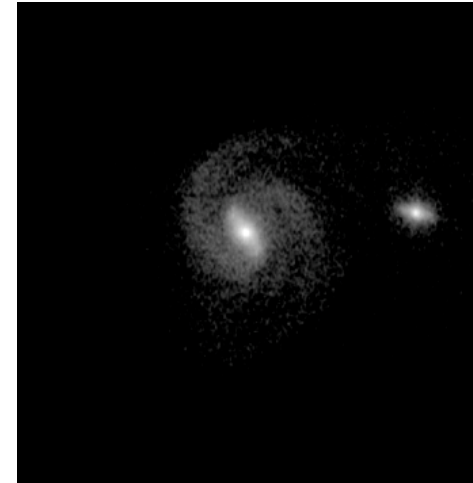
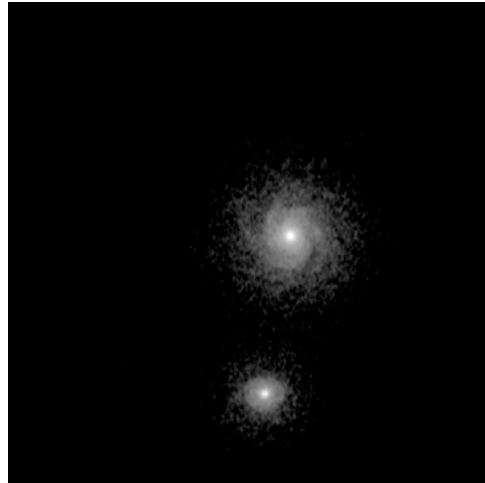
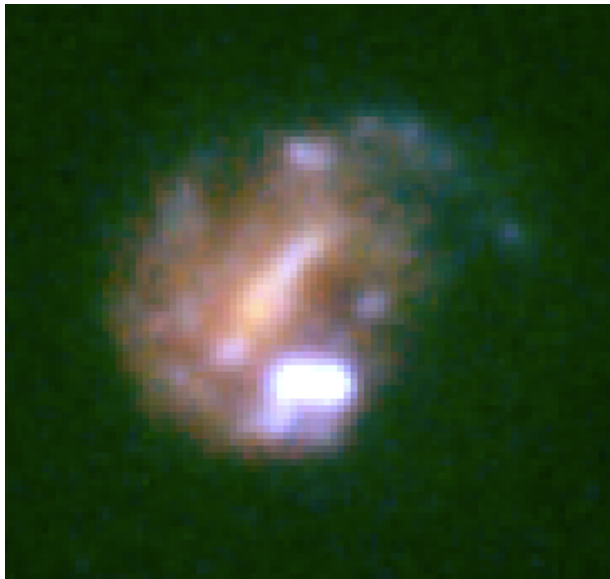
Half of them have peculiar morphologies and anomalous kinematics

Can be reproduced by hydrodynamical models of major mergers



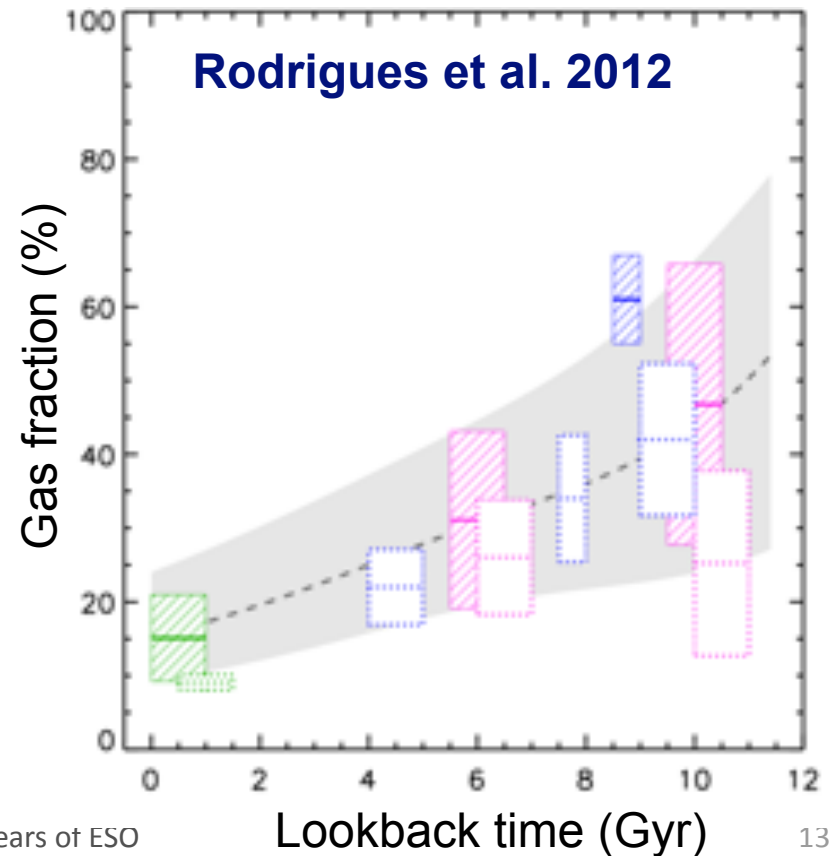
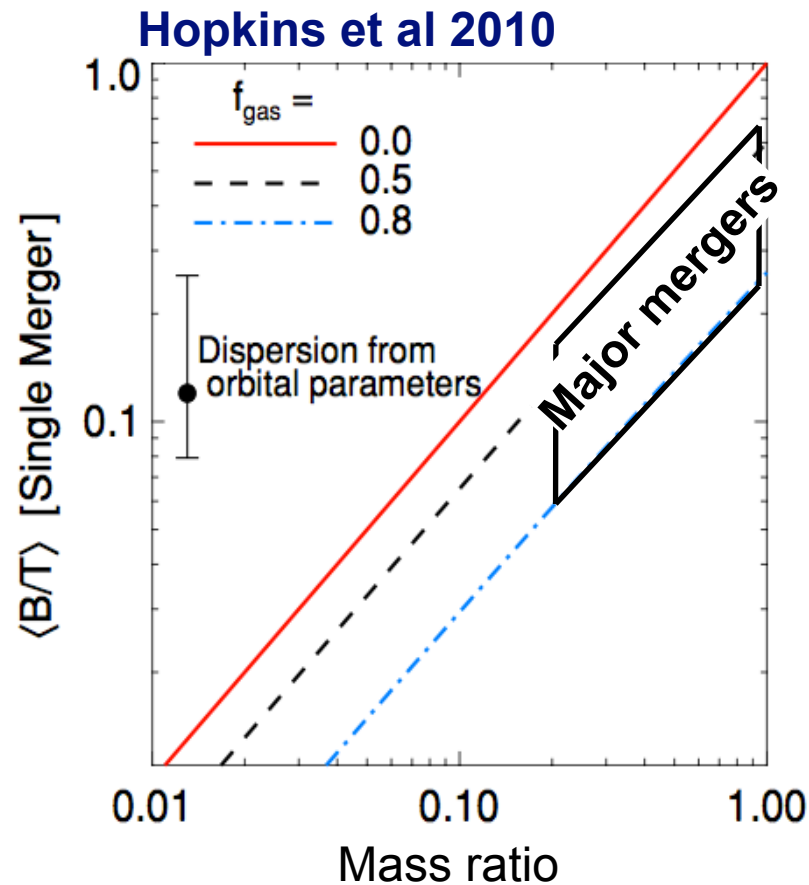
50% of giant spiral ancestors are experiencing major mergers

VLT/GIRAFFE & HST/ACS

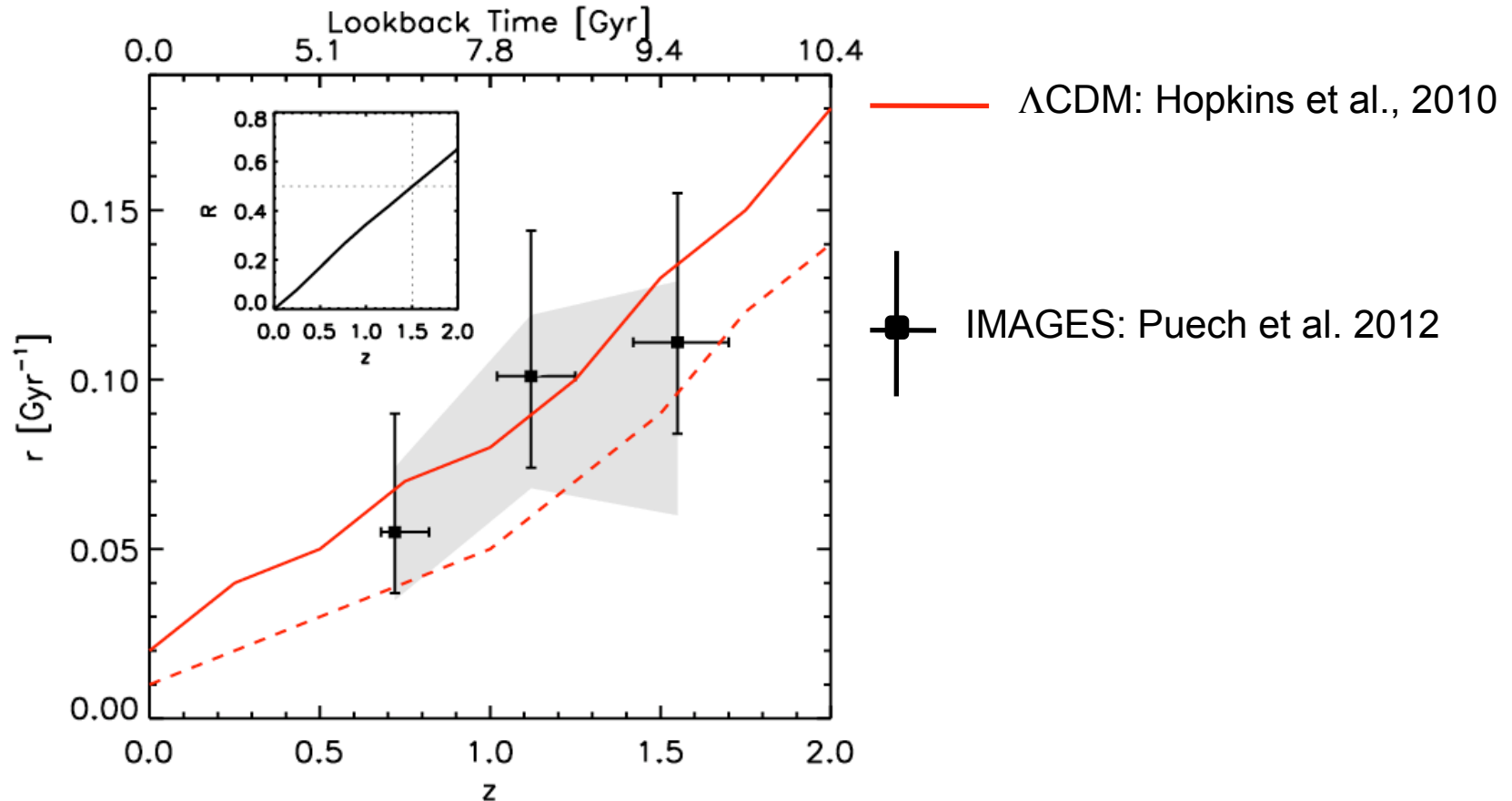


A novel channel to form large disks: rebuilding disks after gas-rich mergers

The orbital angular momentum from major mergers may solve the spin
“catastrophe”
(Maller, Dekel & Somerville, 2002)

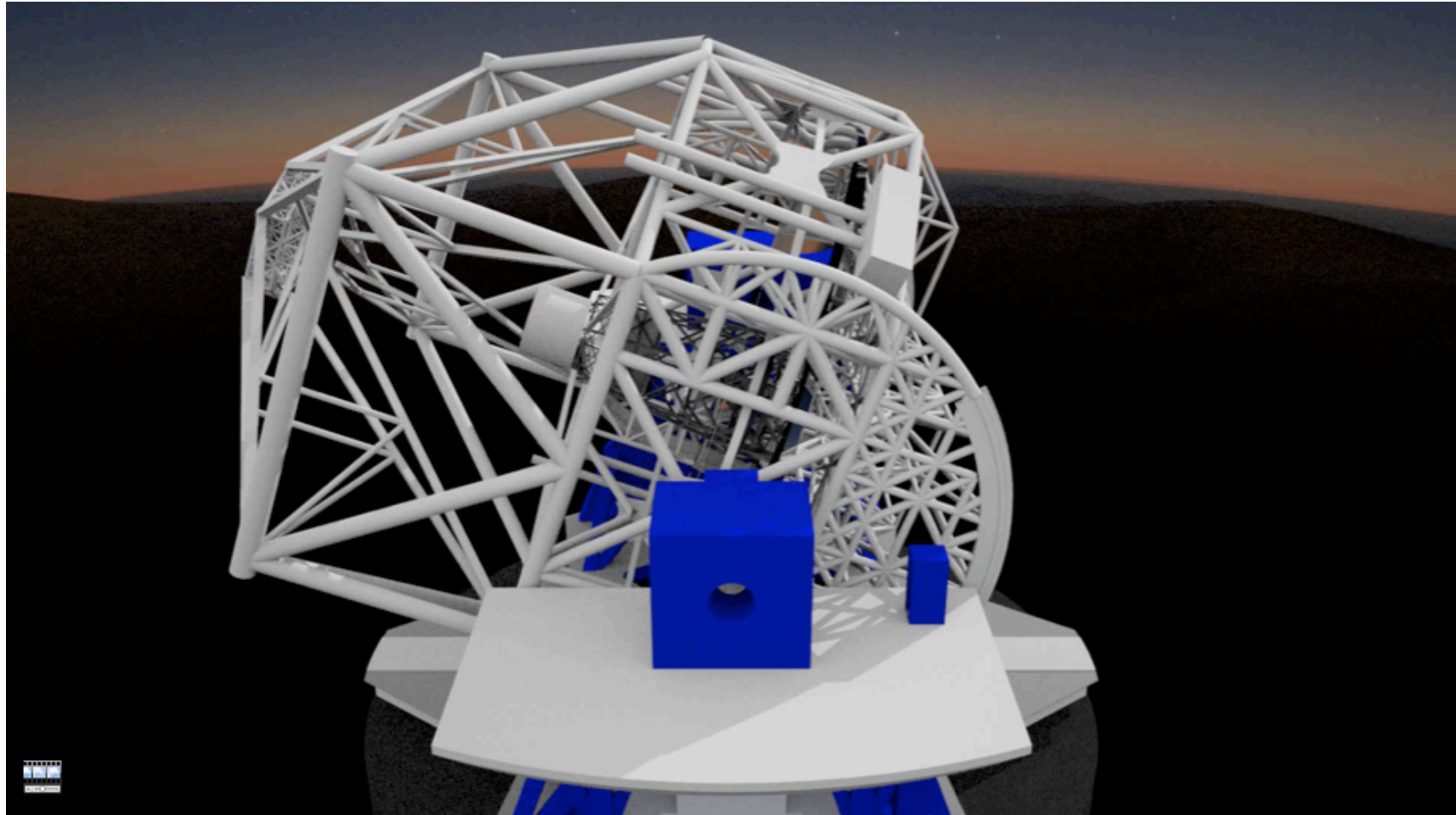


Mergers: observations vs. theory



Both Λ CDM theory and observations predict that spirals have rebuilt their disks after a major merger
(see also Keres+2011; Guedes+11, Font+11, Brook+11)

Multi Object Spectrograph @ E-ELT



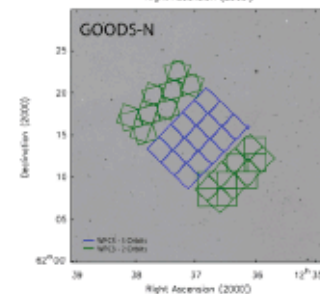
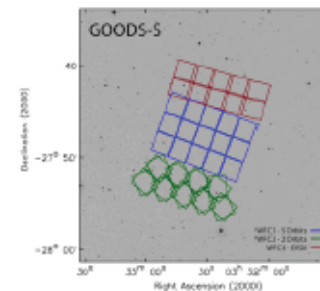
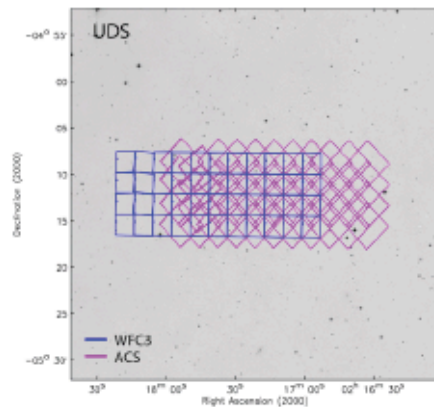
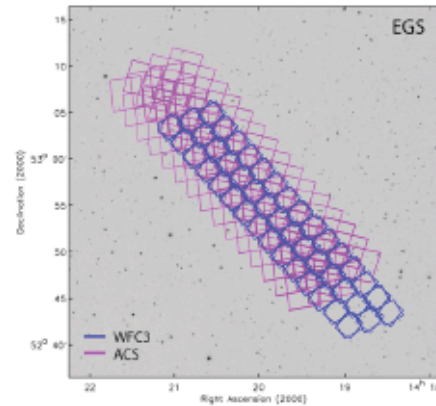
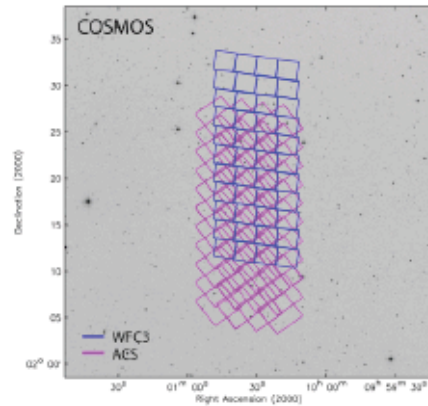
Deepest galaxy surveys

CANDLES

Area: 0.25 deg²

Groging+11

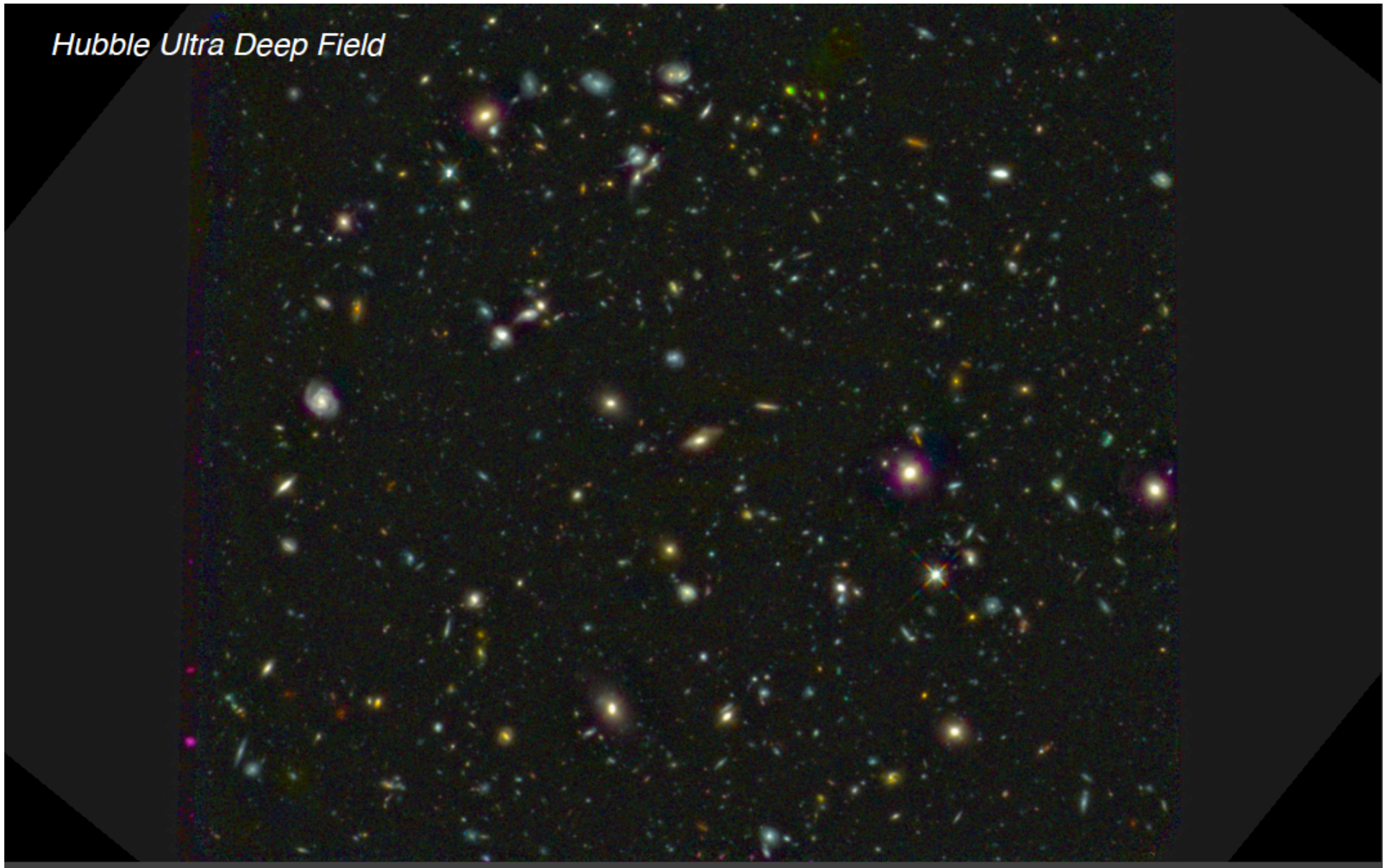
Keokemoer+11



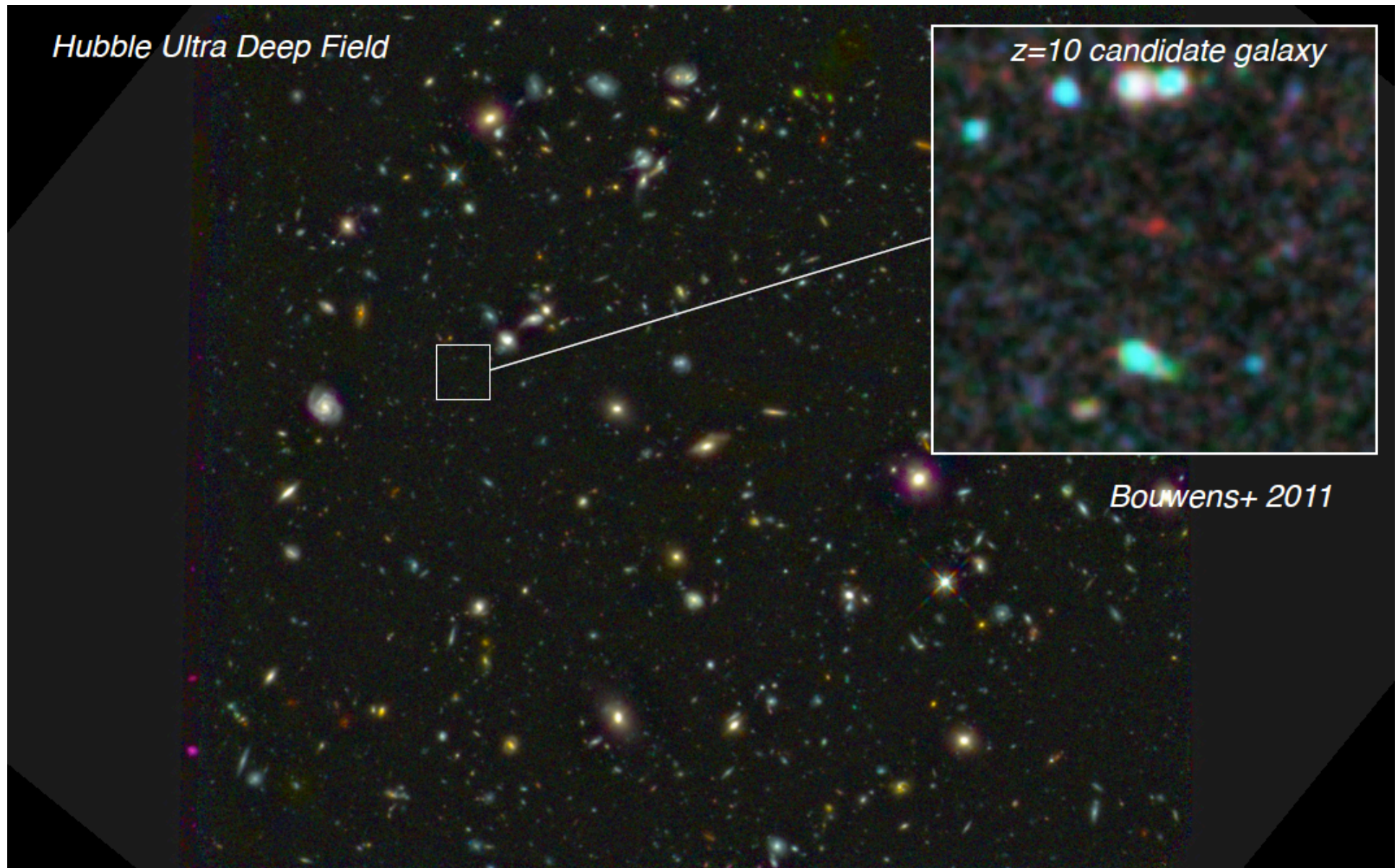
$$H_{AB} = 27:$$

- 8000 galaxies in an E-ELT FoV (~40 arcmin²)
- 1600 $z > 1.5$ galaxies

Hubble Ultra Deep Field



A needle in a haystack!

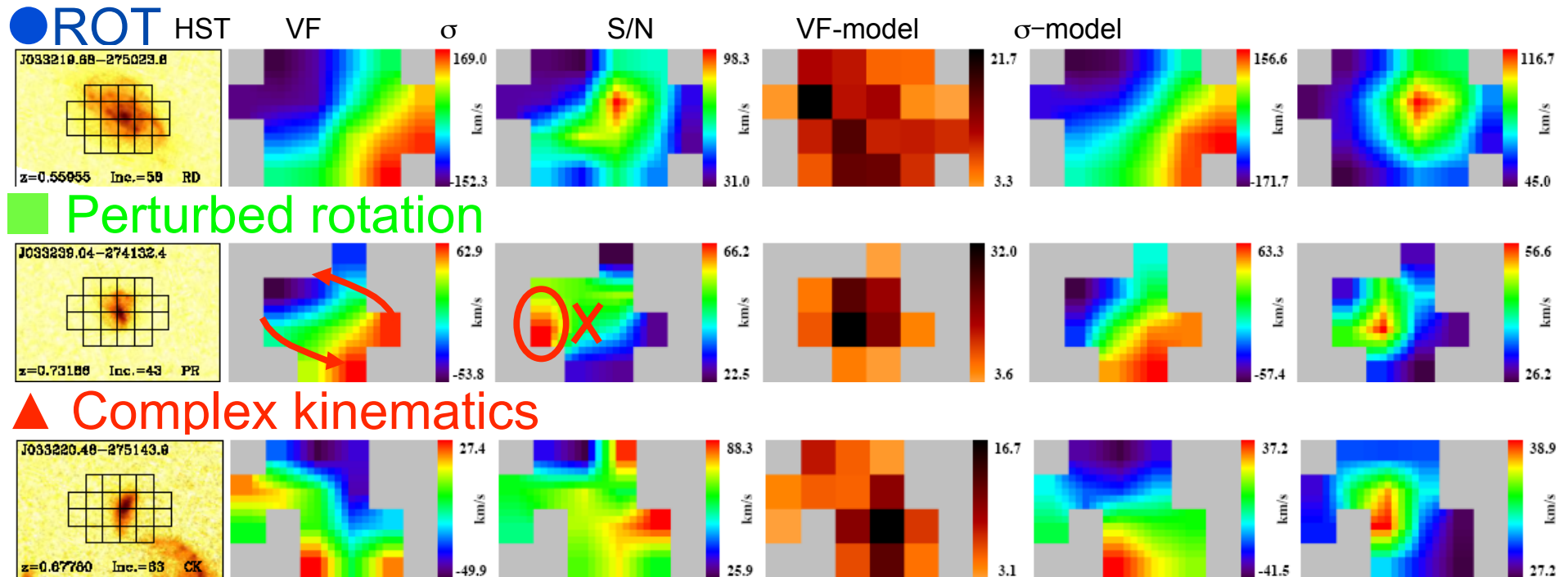


Conclusions

- Good knowledge of galaxy evolution $z < 1$ (IMAGES)
- Still questions at $z > 1$: mergers versus cold accretion (e.g. representative samples & depth)
- An E-ELT FoV contains thousand of $z > 1.5$ galaxies
- Only a MOS@E-ELT could study representative samples (≥ 100 objects) for studying chemistry & kinematics
- Only a MOS@E-ELT can detect the first light and solve the reionisation problem

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

Spatially resolved kinematics of distant galaxies



Flores et al (2006)
Yang et al (2008)

Statistics, 6 billion years ago:

Rotating galaxies : 19%
anomalous kinematics: 41% (incl. PR: 15%, CK: 26%)
without emission (E/S0/Sa..): 40%