Galaxy evolution studies at 0<z<2 with PFS

1 – statistical nature of galaxy properties

2 – science cases from the white paper

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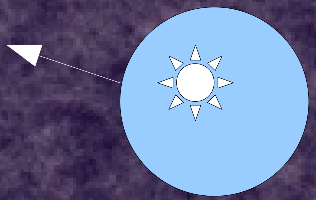
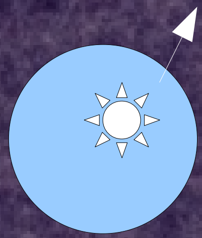
Statistical nature of galaxy properties

I know this is just like preaching the Buddha...

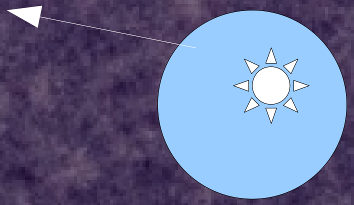
Galaxies form from density fluctuations





Galaxy formation takes place at peaks of density fluctuations – galaxy formation is a statistical event!

Not surprisingly, each galaxy form and evolve in different ways and the only way to characterize the galaxy evolution is to study galaxies in a statistical way.



How do we characterize the galaxy evolution?

SFR = f (time, environment, mass, merger, AGN, etc)

Stellar mass = g (time, environment, mass, SFR, merger, etc)

Metallicity = h (time, environment, mass, SFR, etc)

AGN rate = i (time, environment, mass, SFR, merger, etc)

Merger rate = j (time, environment, mass, etc)

Morphology = k (time, environment, mass, SFR, merger, etc)

We need a statistical sample of galaxies with least possible selection biases to solve these galaxy equations.

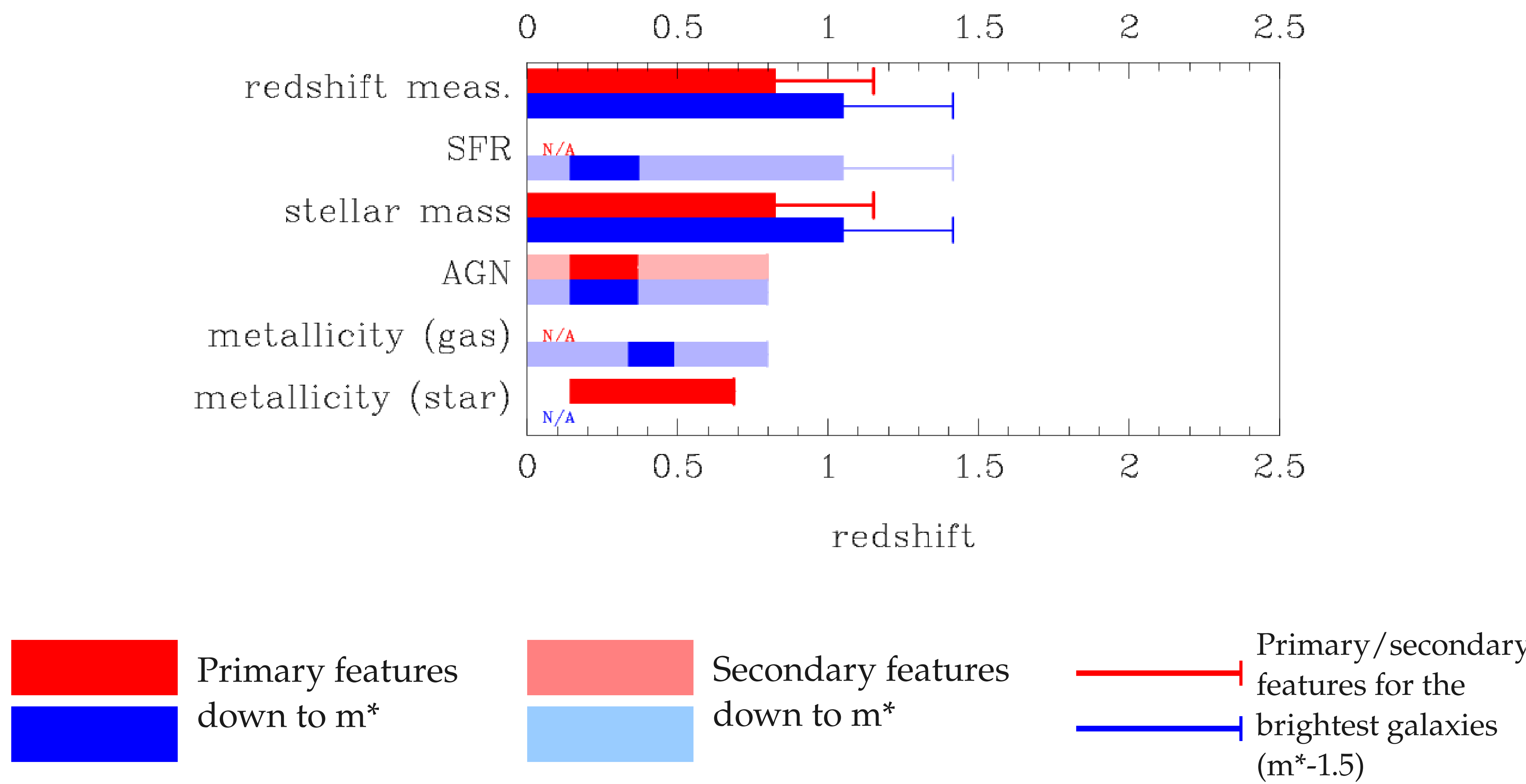
How does PFS compare to the on-going surveys?

Size = l (time, environment, mass, merger, etc)

etc..

The galaxy evolution is not a single equation. We have a set of parameters and we have to solve all the equations simultaneously. Only when we find a parameter set that satisfies all the equations, we can say 'we understand the galaxy evolution'.

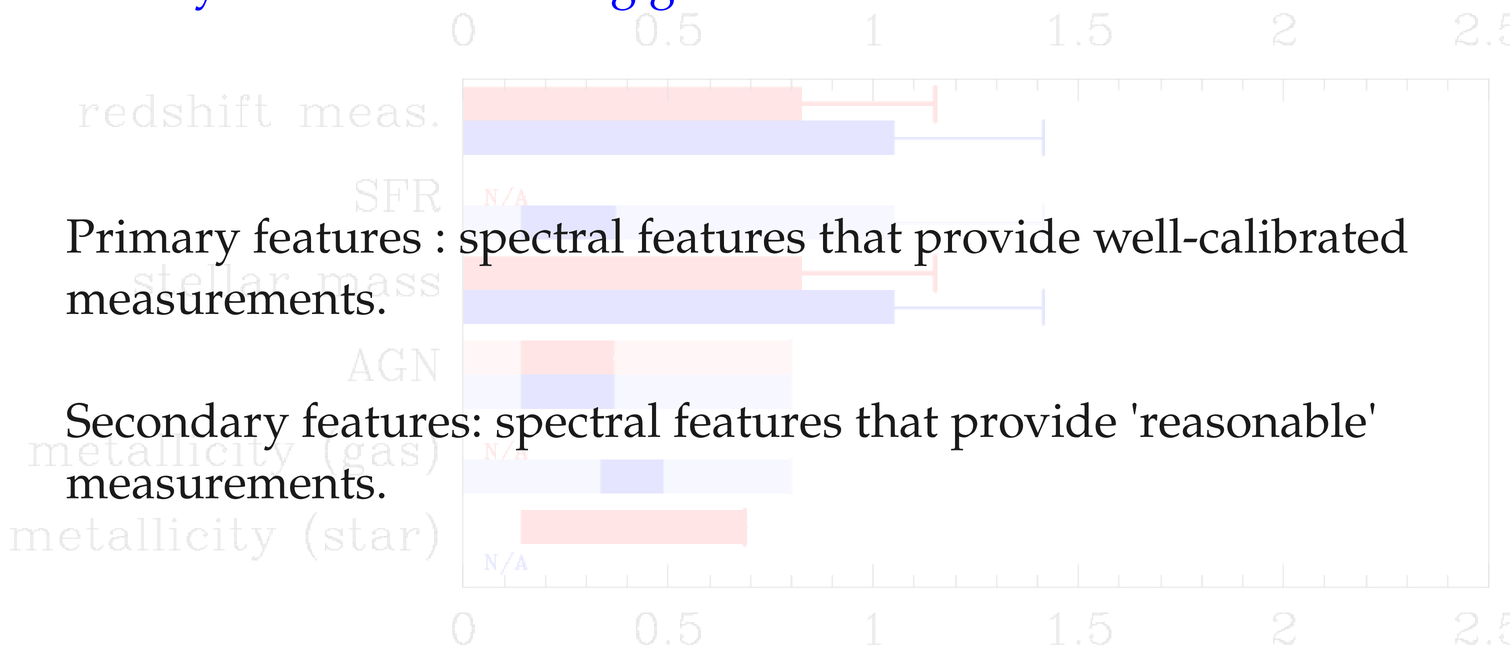
zCOSMOS – a flux-limited survey to i=22.5



zCOSMOS – a flux-limited survey to i=22.5

Red symbols : quiescent galaxies

Blue symbols: star forming galaxies

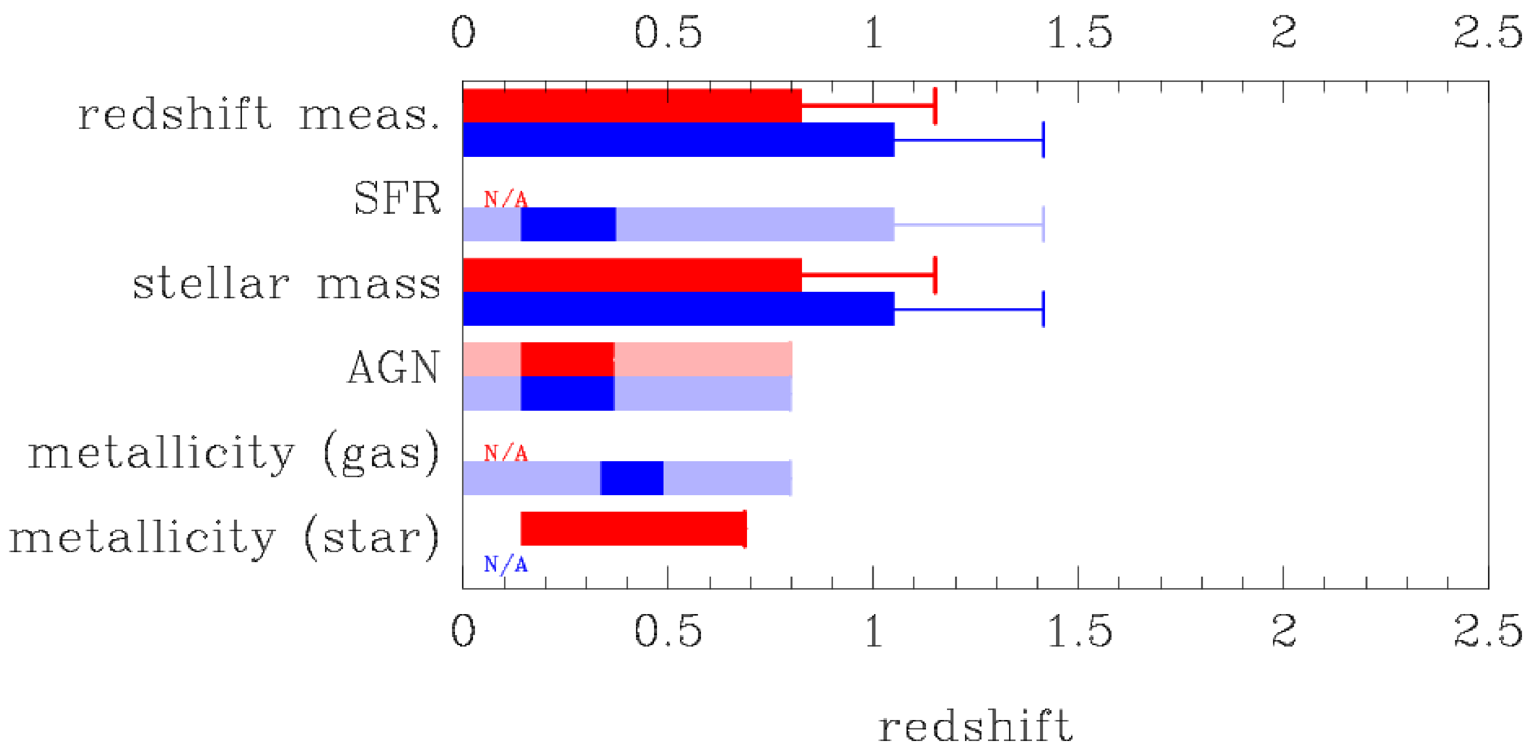


Primary features : spectral features that provide well-calibrated measurements.

Secondary features: spectral features that provide 'reasonable' measurements.

We model the evolution of m* (characteristic magnitude of the Schechter function) to quantify up to what redshfit we can study typical galaxies.

zCOSMOS – a flux-limited survey to i=22.5

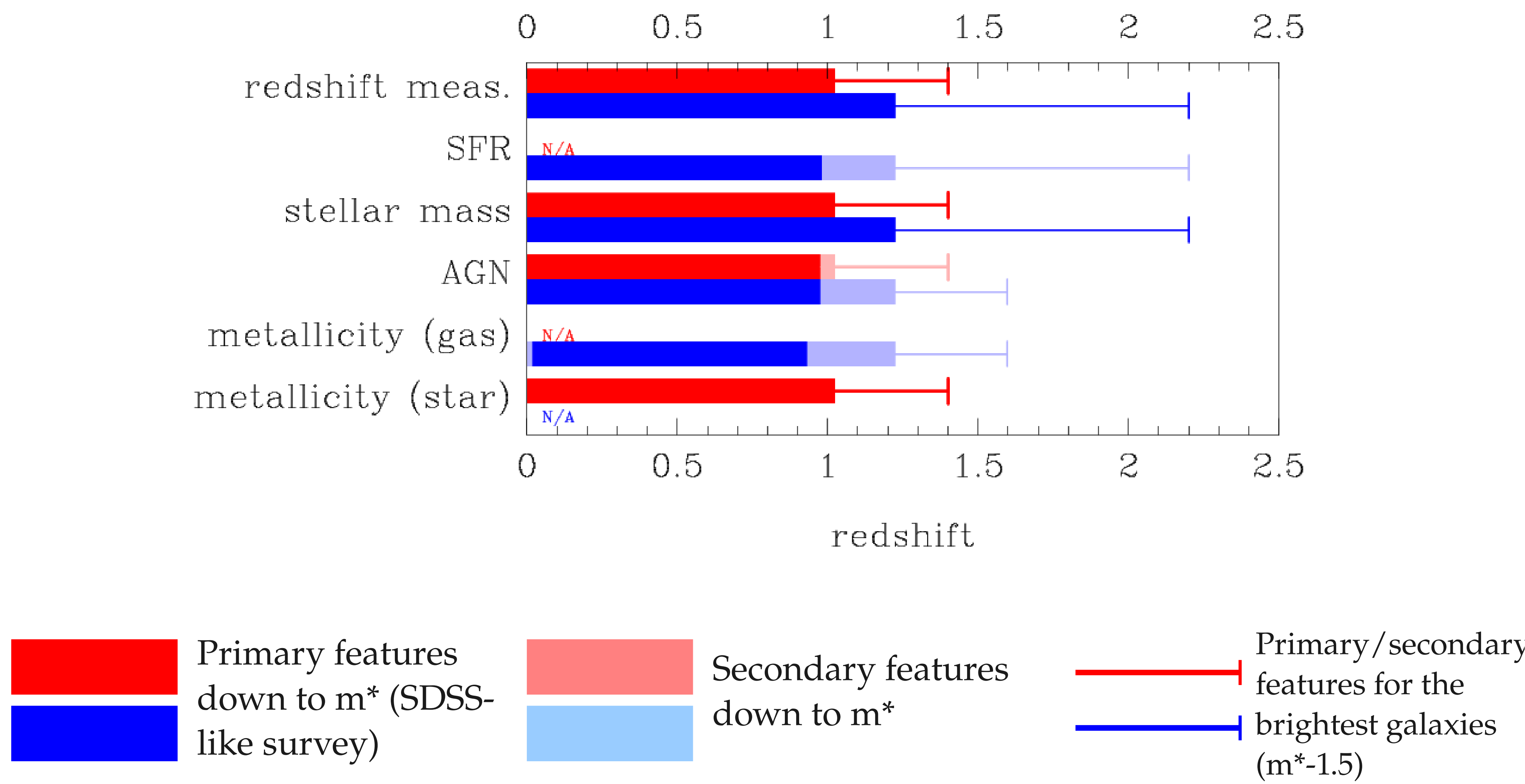


Primary features down to m* (SDSS-like survey)

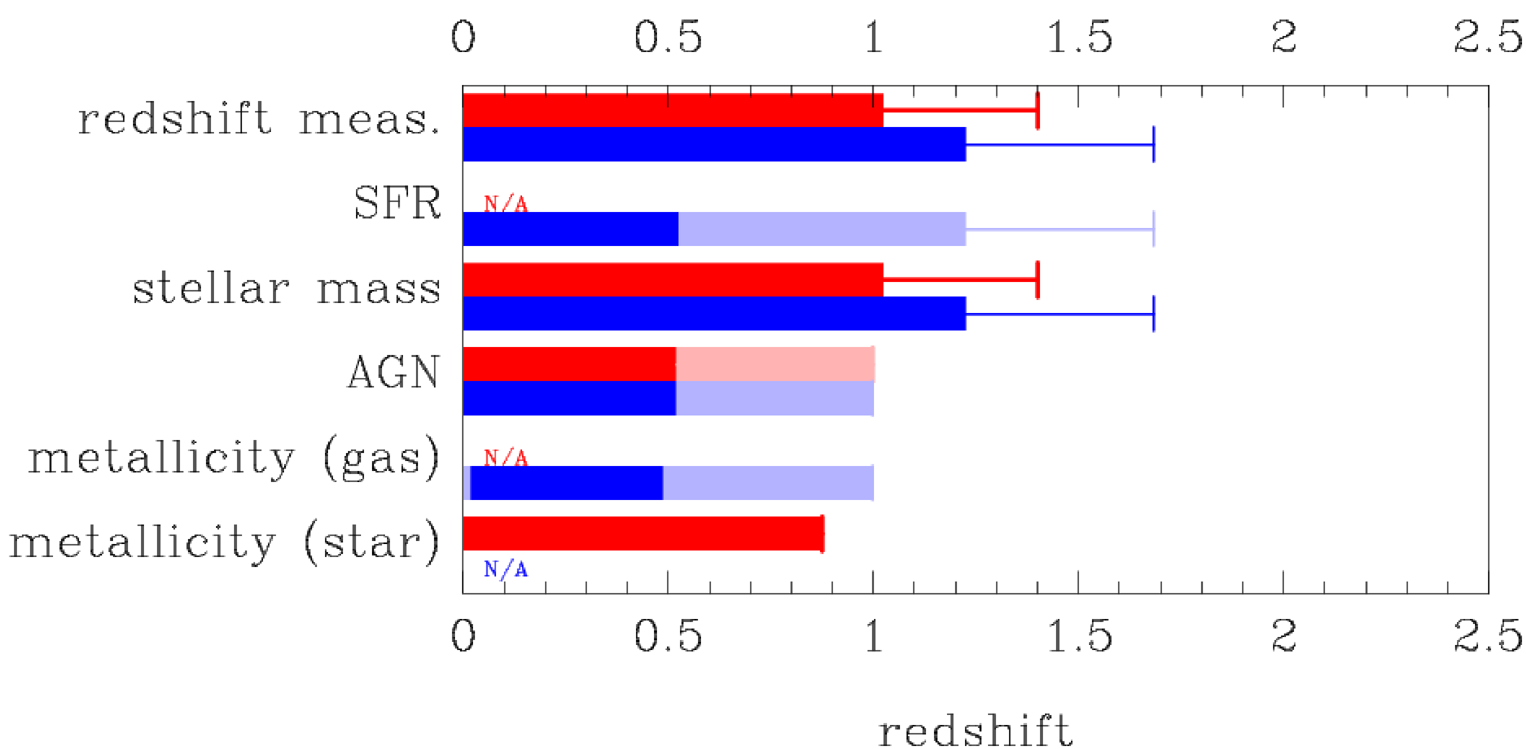
Secondary features down to m*

Primary/secondary features for the brightest galaxies (m*-1.5)

PFS (with NIR) – a flux-limited survey to z=22.5



PFS (no NIR) – a flux-limited survey to z=22.5



Primary features down to m* (SDSS-like survey)

Secondary features down to m*

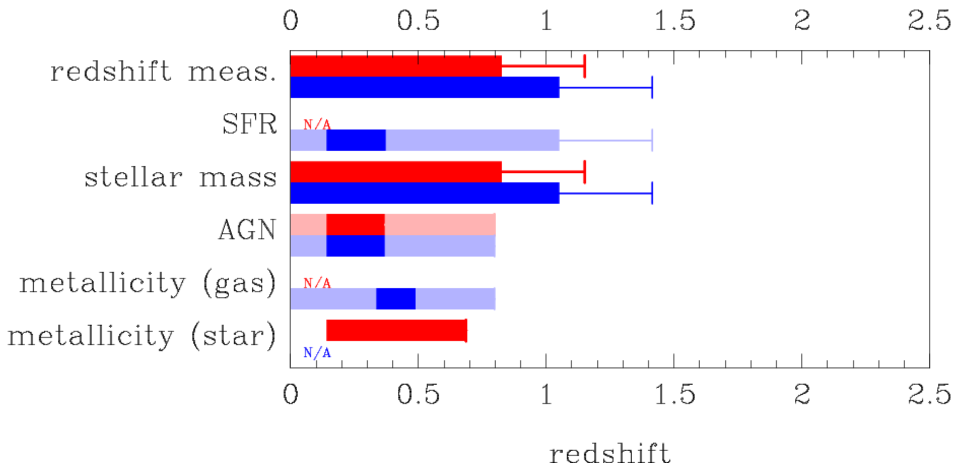
Primary/secondary features for the brightest galaxies (m*-1.5)

Comparison of the surveys

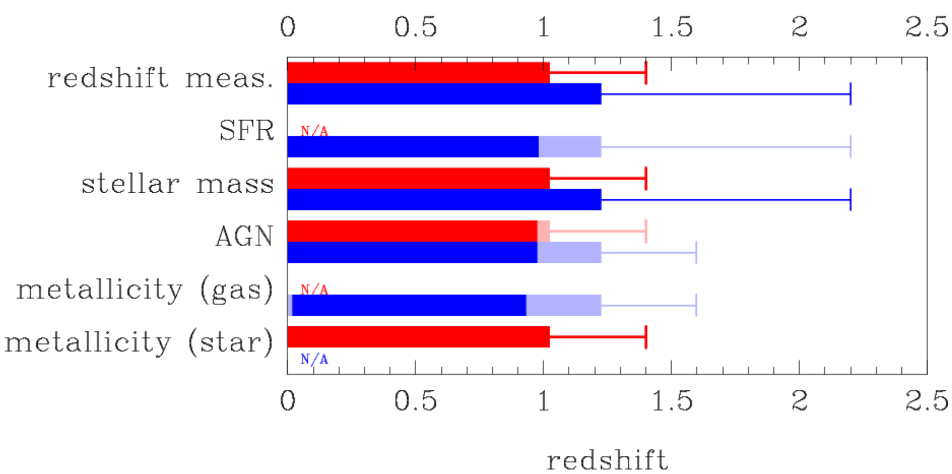
To solve the galaxy equations, we need good measurements of galaxy properties over a wide redshift range.

Which one gives us good measurements of all the properties over the widest redshift range?

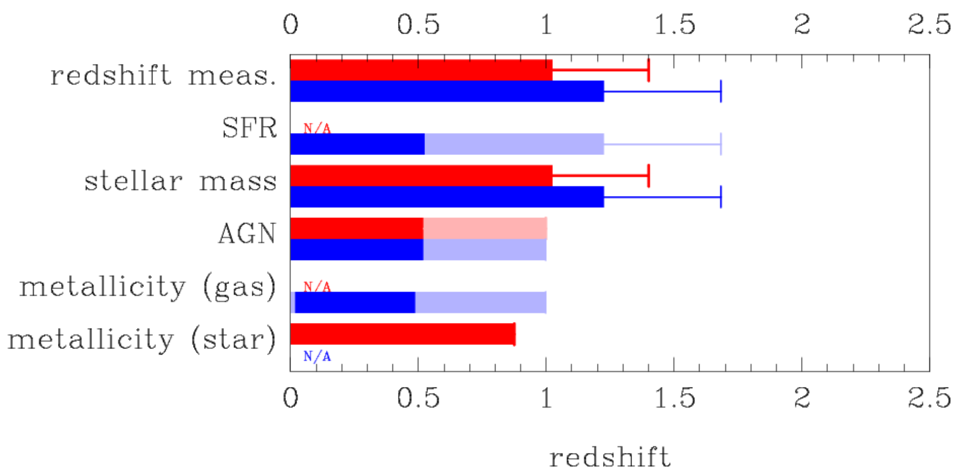
zCOSMOS down to i=22.5



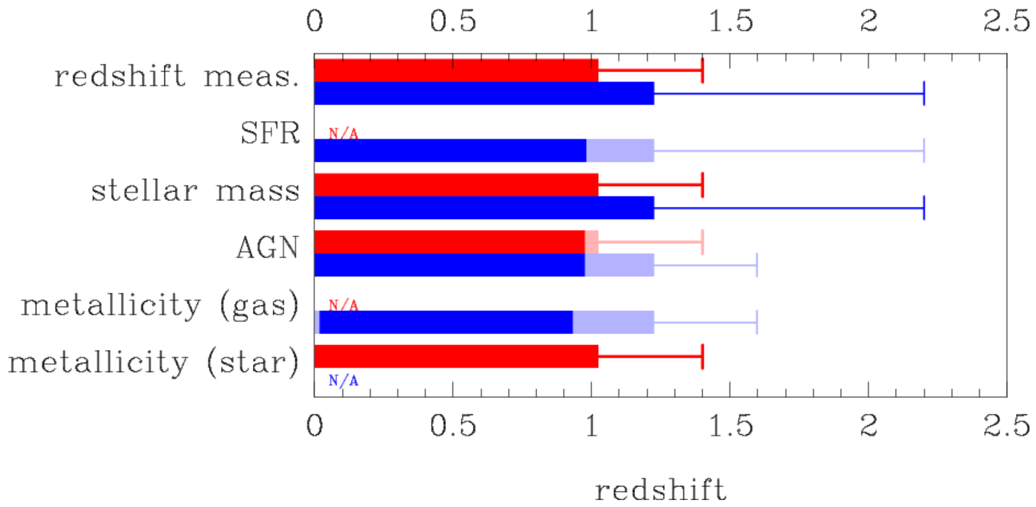
PFS with nearIR down to z=22.5



PFS with no nearIR down to z=22.5



So, the best one is PFS with NIR



The existing surveys do not allow us to solve all the galaxy equations simultaneously. A large survey with PFS with nearIR arm will be the first one to deliver a data set to do this job at z>0.

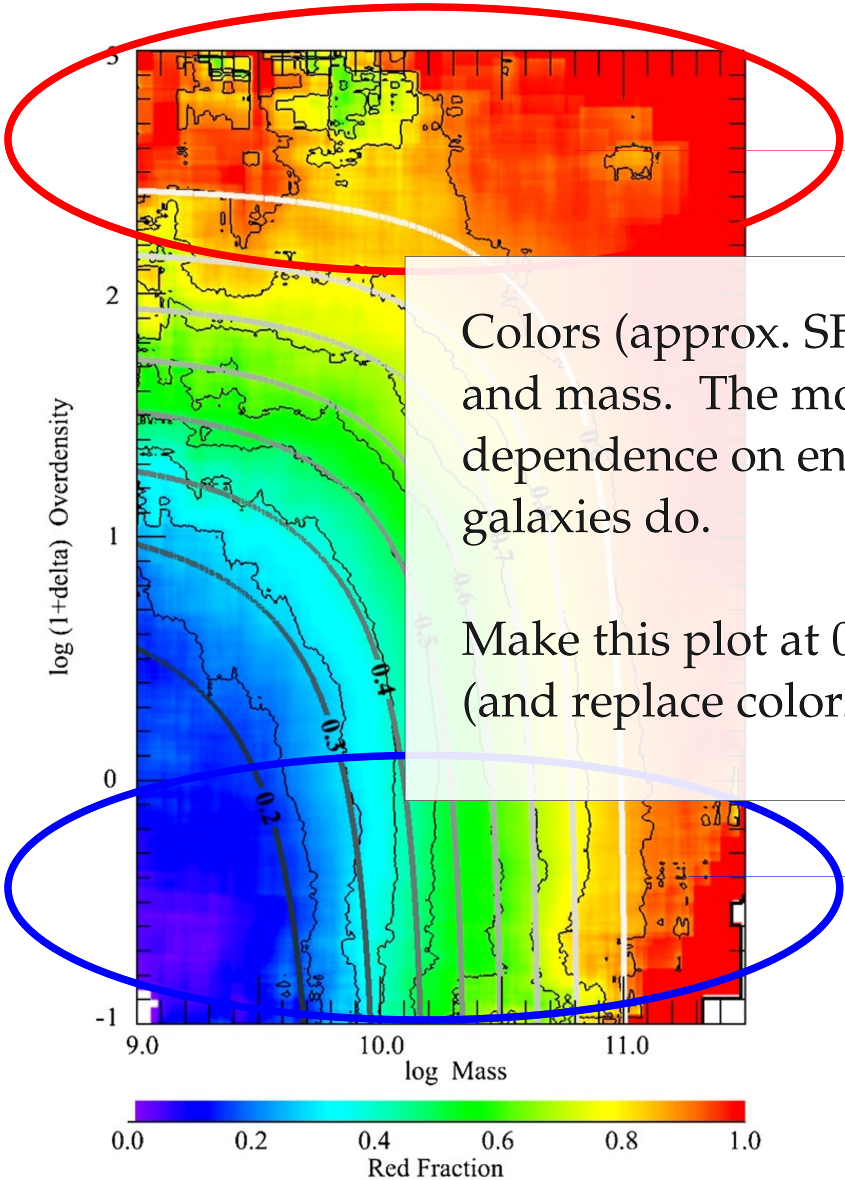
PFS delivers:

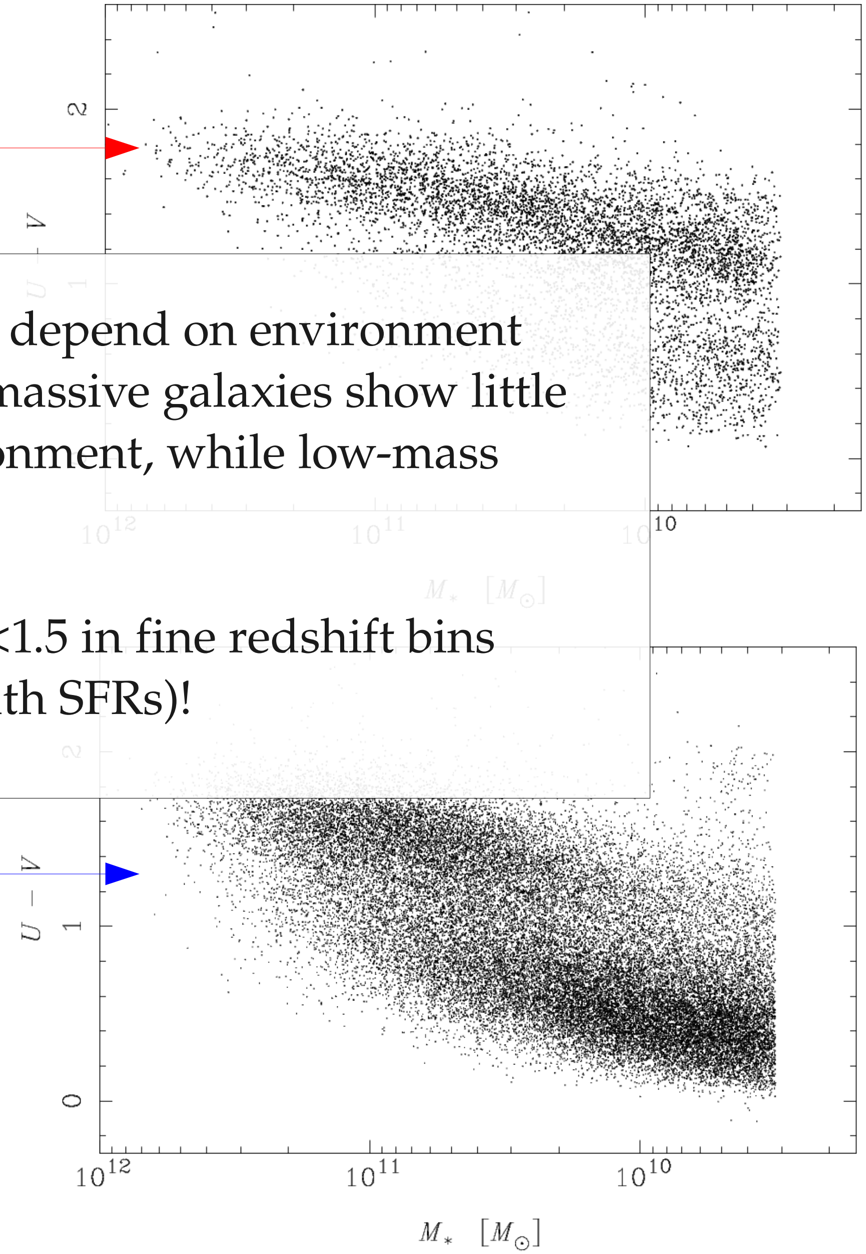
0<z<1 : a perfect data set to study the galaxy evolution
1<z<1.5: the first statistical sample of bright galaxies
1.5<z<2: the first statistical sample of bright, star-forming galaxies

Science cases from the white paper

I'm going to discuss galaxy properties as functions of environment, mass and time. This is very complicated. But, don't panic! The message here is that the current galaxy studies are sort of 'patch work' and we do not have a big picture of galaxy evolution yet.

Star formation histories



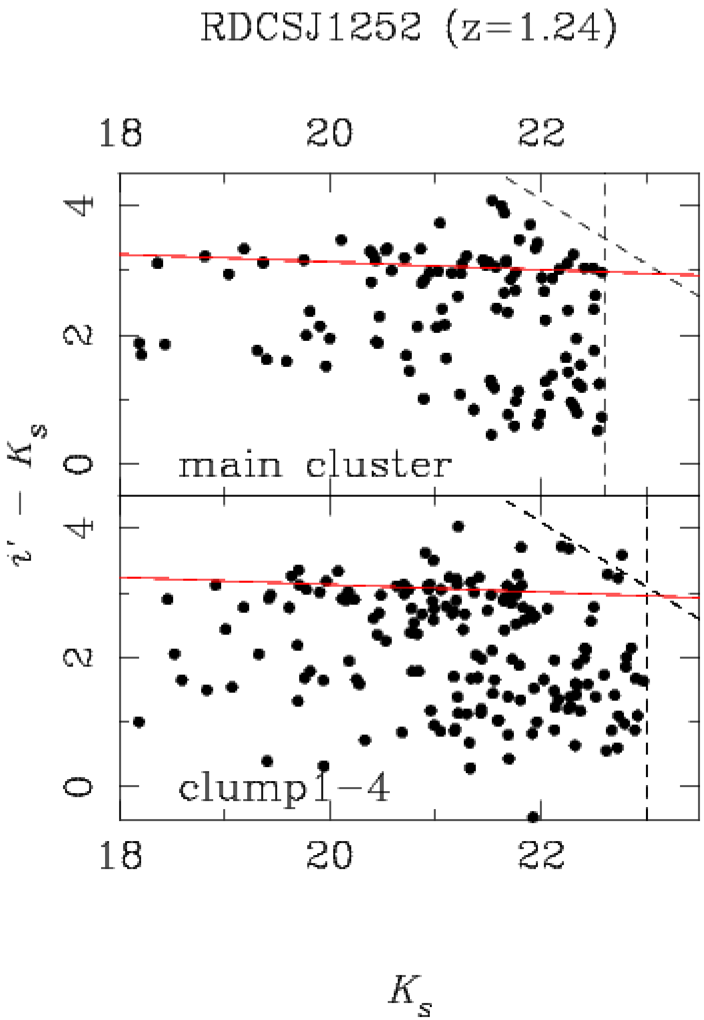


Colors (approx. SFRs) depend on environment and mass. The most massive galaxies show little dependence on environment, while low-mass galaxies do.

Make this plot at 0<z<1.5 in fine redshift bins (and replace colors with SFRs)!

Peng et al. 2010

Star formation histories



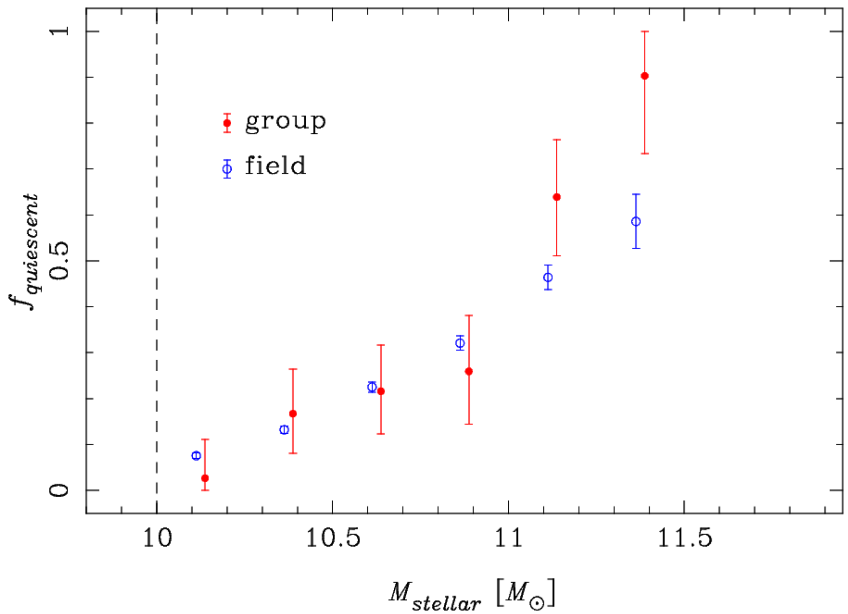
Tanaka et al. 2007

At z=1.2, we still observe the clear red sequence in clusters, while the sequence is sharply truncated at Ks=22 in groups.

The fraction of quiescent galaxies is higher at >10^11 M_sun. The fraction is similar at lower mass.

In the last slide, we saw that the most massive galaxies do not depend on environment. But, massive galaxies at z>1 depend more strongly on environment than lower mass galaxies.

Star formation histories



Tanaka et al. in prep.

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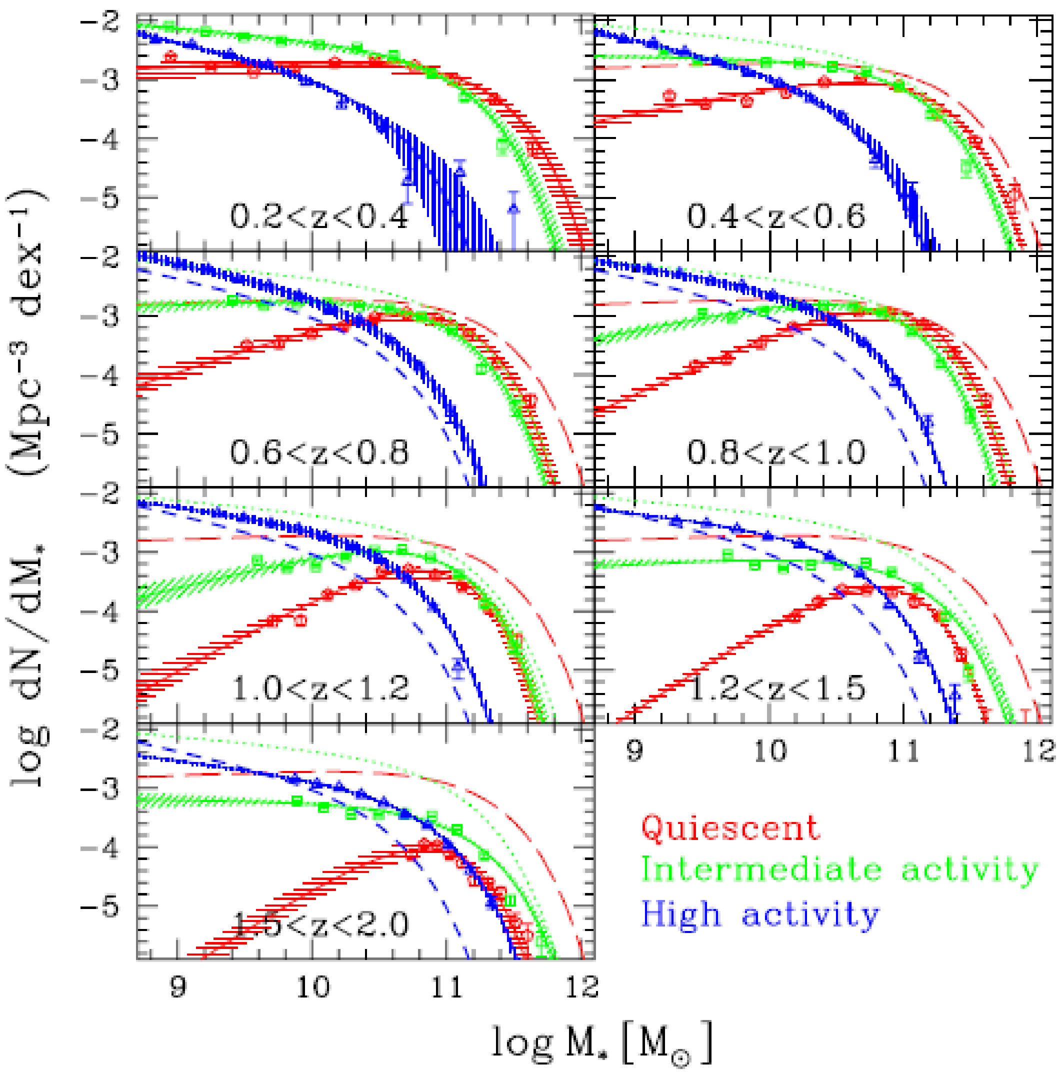
Stellar mass assembly histories



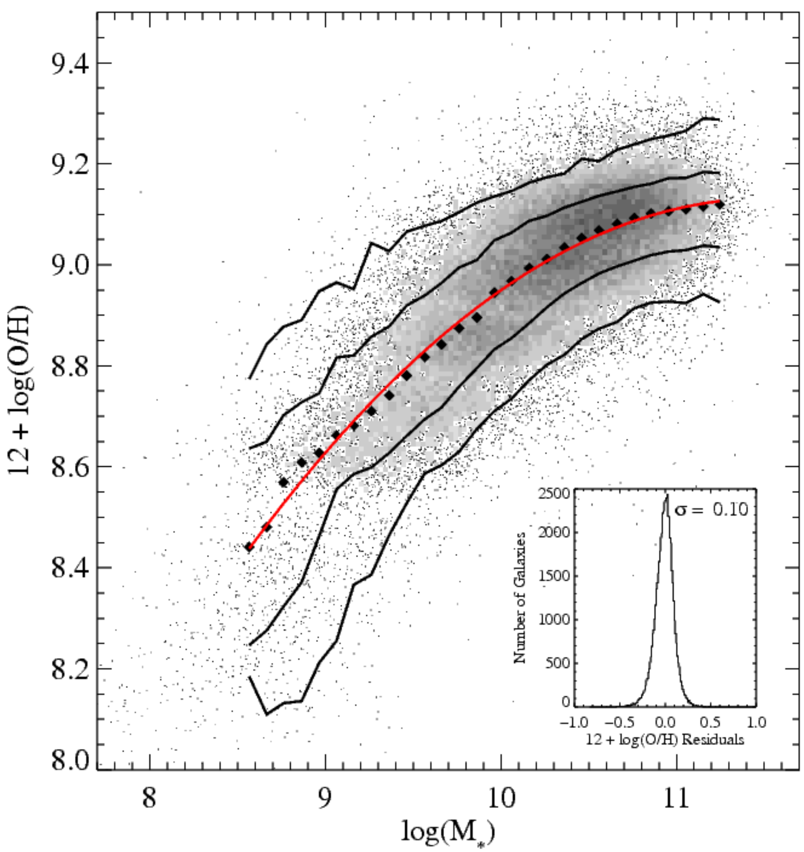
Ilbert et al. 2009

Stellar mass functions in the field at 0<z<1.5 are fairly well constrained except for the most massive end.

But, how does the stellar mass assembly depend on environment?

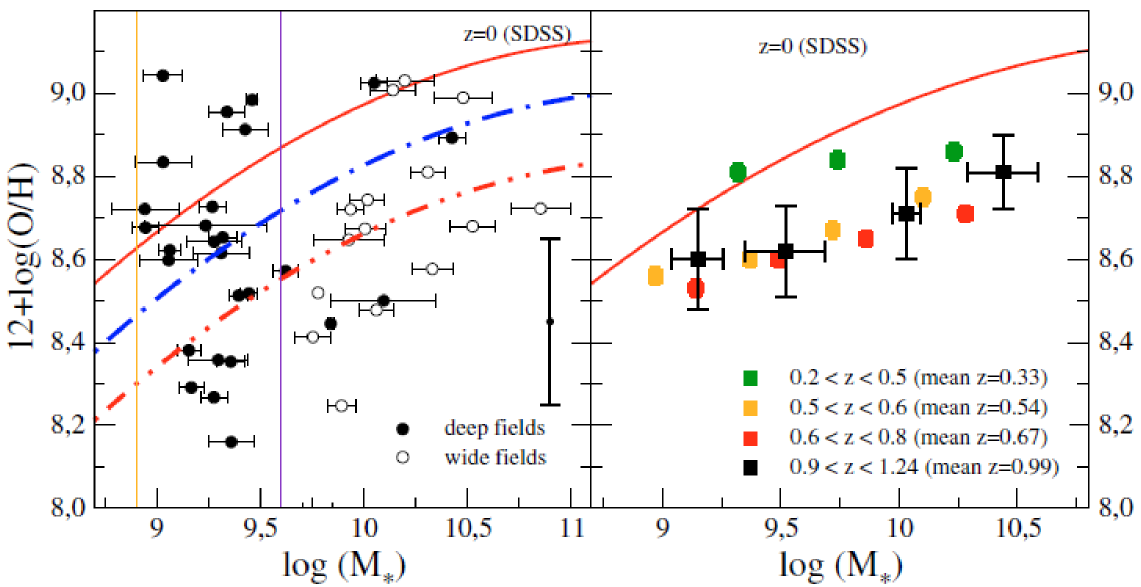
Metal enrichment histories

$z = 0$



Tremonti et al 2004

$0.2 < z < 1.2$

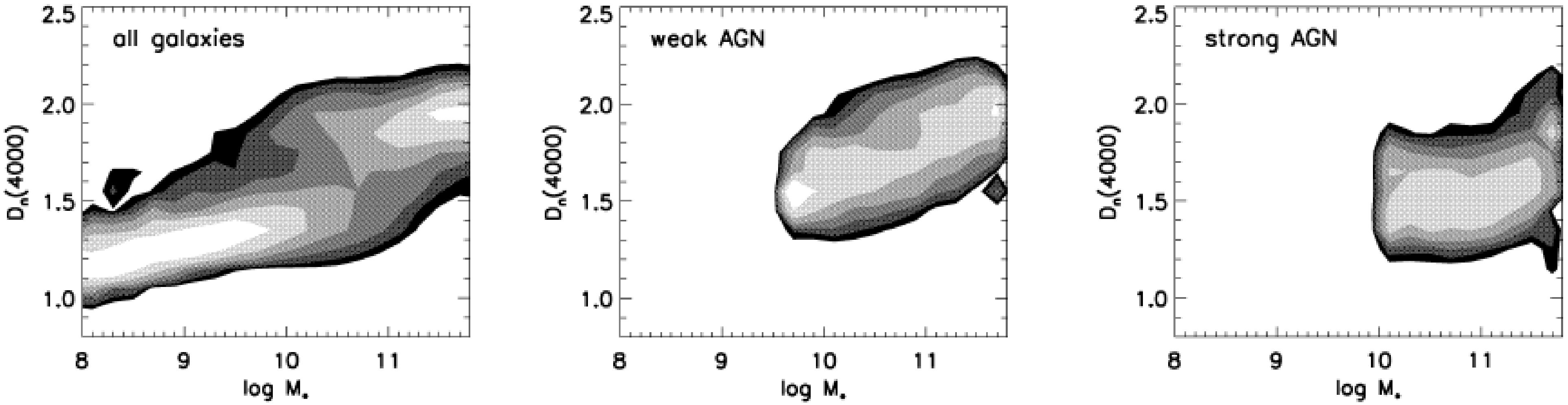


Peres-Montero et al. 2009

Very poor statistics. I'm sure that PFS will dramatically improves the situation.

AGN evolution (see Imanishi-san's talk)

Kauffmann et al. 2003



We don't know how the AGN fraction depends on mass and environment at high redshift. Some work on X-ray AGNs has been made, but X-rays find a small fraction of the overall AGN populations. PFS allows us to study emission line AGNs in all the environments up to z=1.

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Morphology	=	k (time, mass, environment, SFR, merger, etc)
Size	=	l (time, mass, environment, merger, etc)
etc...		

So far, galaxy evolution studies at $z>0$ are sort of 'patch work' and we are still far from understanding the whole set of equations. SDSS provided an excellent data set to study many of the equations at $z=0$. PFS will deliver a data set that allows us to extend the SDSS up to $z=1.5$ for the first time.

Summary

– Galaxies are statistical objects. Their properties can be studied only statistically.

– The galaxy evolution is multi-parameter equations.

Need to solve them simultaneously with least biased statistical galaxy sample.

– The on-going surveys do not deliver good enough data sets for us.

– PFS survey will be the one to solve the equations up to z=1.5.

Table 6: Optical papers and citations by telescope/observatory.

Telescope	Papers[1]	Citat.[1]	C/P[1]	Papers[2]
HST	206.6	765	3.70	391.5
VLT	139.1	452	3.25	290.6
Keck	59.6	333	5.59	121.5
CFHT	38.0	152	4.00	69.6
Gemini	34.3	108	3.15	63.7
Subaru	33.0	138	4.18	70.0
AAT	23.0	83	3.61	42.4
WHT	19.5	55	2.82	34.7
IRTF	16.9	46	2.72	31.2
UKIRT	15.8	54	3.42	34.3

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