The long and spectroscopic way to Euclid

Olga Cucciati
(INAF – Bologna Astronomical Observatory)

Meeting di Macroarea 1 – Padova – 13/9/2017

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(with focus on galaxy evolution)

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The long and spectroscopic way to Euclid
(with focus on galaxy evolution
and how environment affects it)

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The long and spectroscopic way to Euclid
(with focus on galaxy evolution and how environment affects it) told in a very biased way

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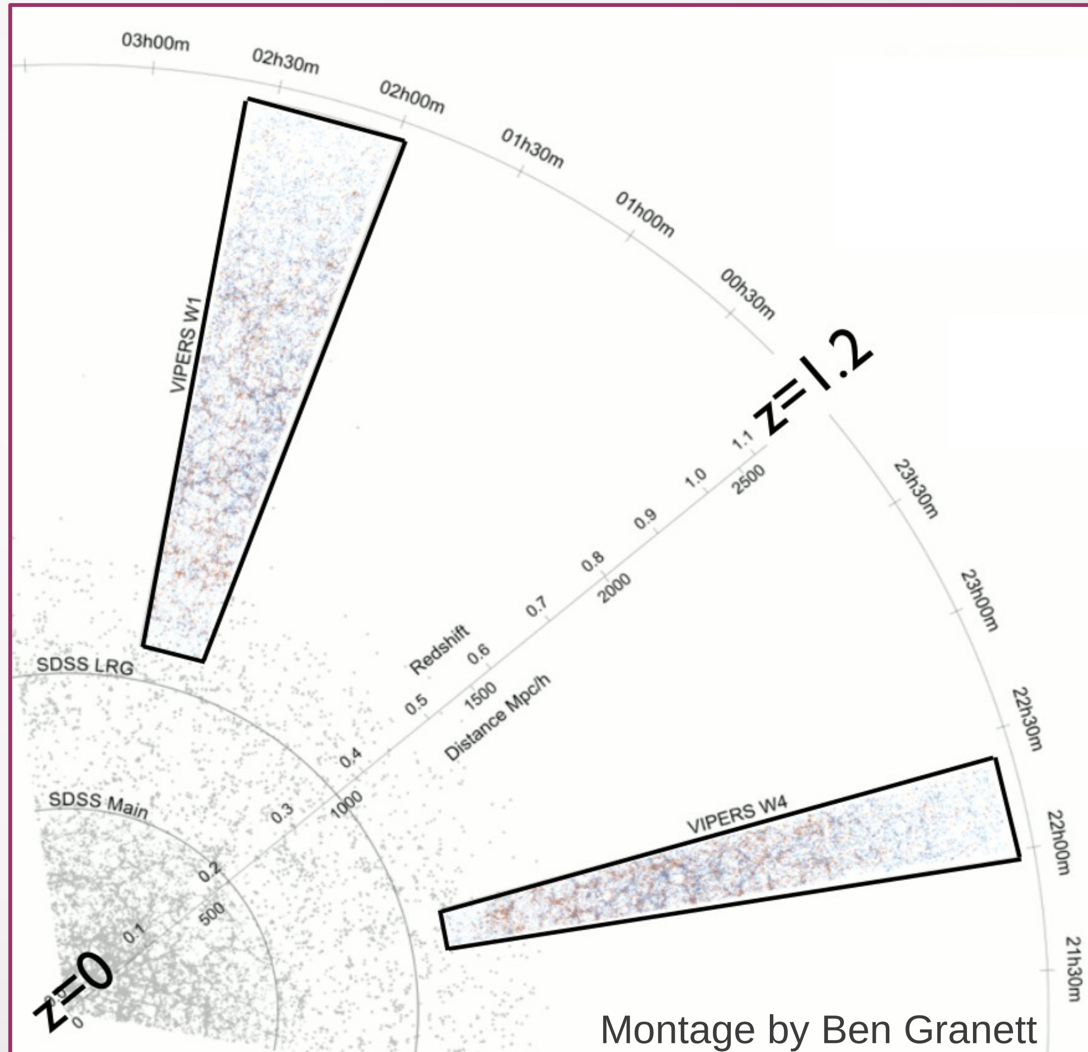
Galaxies as tracers of environment

We can trace environment by using the galaxy distribution:

1) Galaxies trace matter in a biased way … in a more precise way if using spec-z



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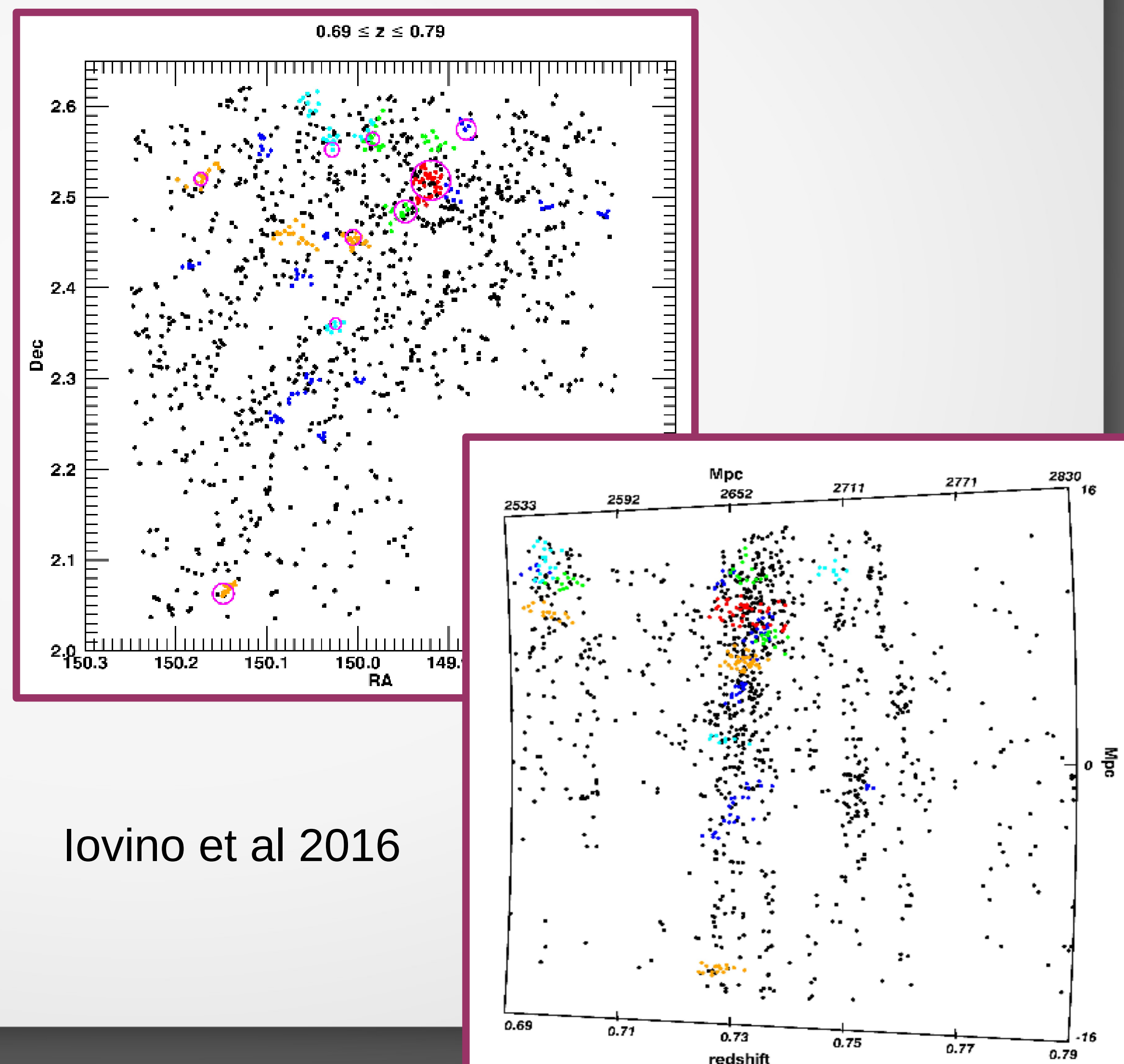
2) We can identify density peaks without assumptions on “other physics” (“presence of deep potential well, relaxation...)



Iovino et al 2016

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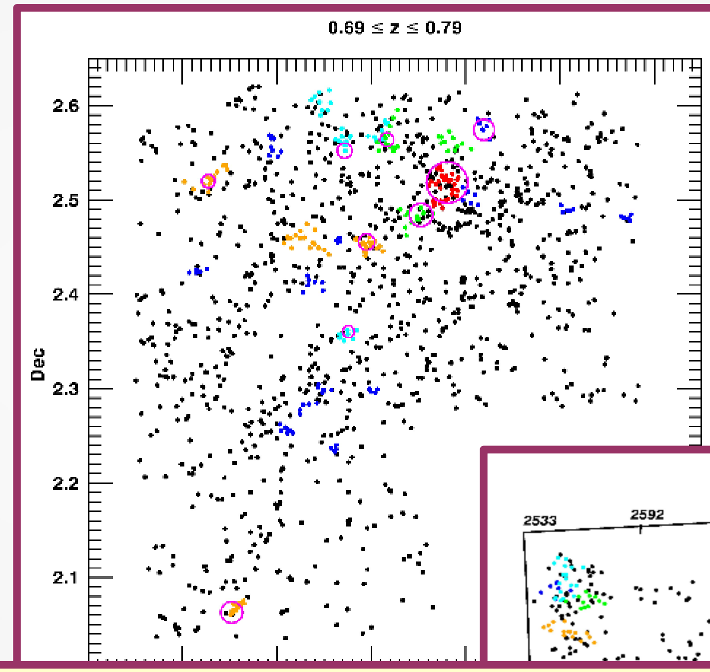
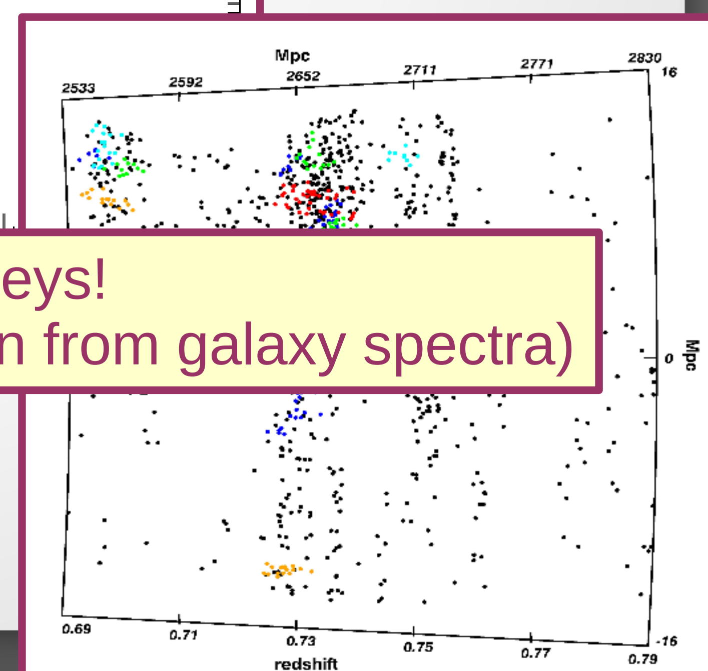


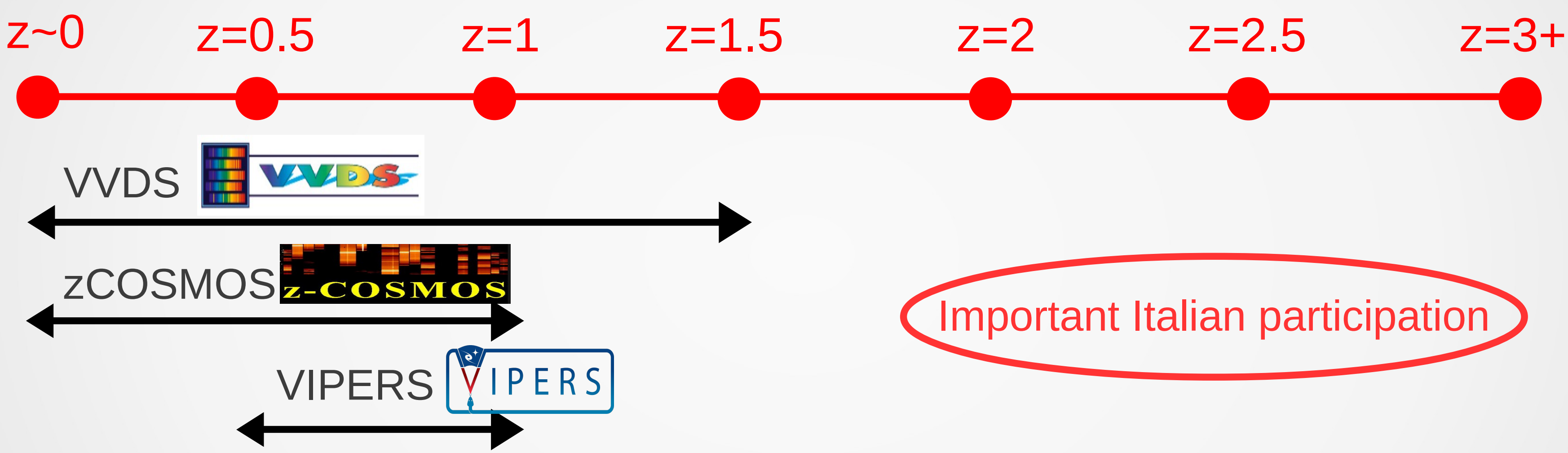


We need spectroscopic surveys!
(not to mention the gain in physical information from galaxy spectra)

Iovino et al 2016

Environment and galaxy redshift surveys

Many spec-z surveys have been used to study environment up to z=1.5



- statistical approach
- each survey had at least one reason of “excellence”, but also at least one “drawback” for environmental studies
- synergy between spec-z and photo-z proven to be effective
  → it is not always necessary to have 100% sampling rate

Environment and galaxy redshift surveys

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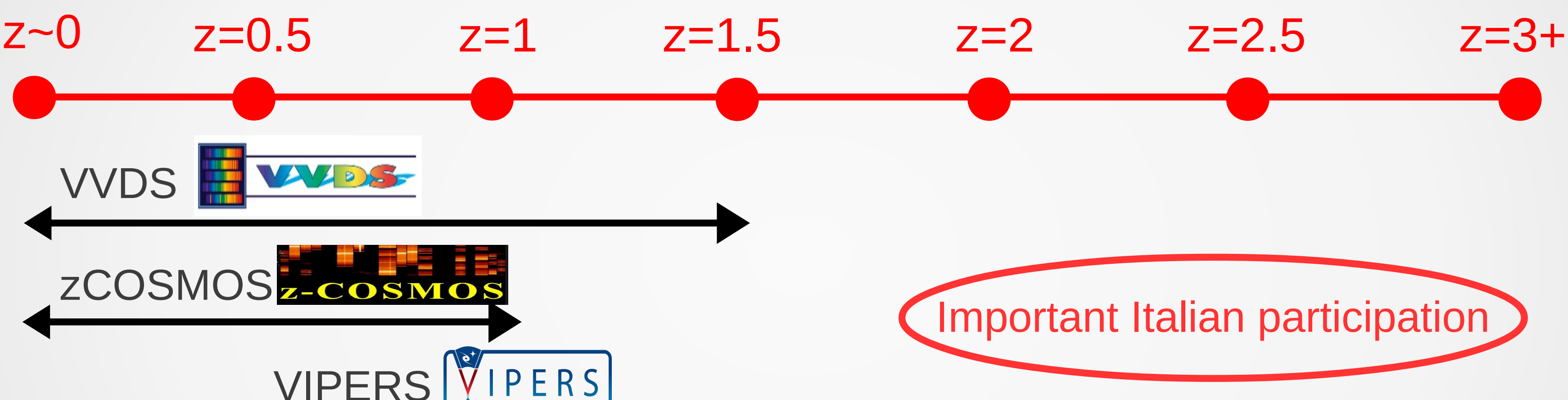


We have come to a point where we need more feedbacks from

- detailed studies of environmental processes (time scales, typical environment, frequency etc) → see other talks also during SAIt session
- simulations of galaxy evolution: they have to reproduce statistical trends found by observations, and they can provide observers with the environmental history of galaxies

The environmental history of galaxies

Galaxy merger tree:

→ at the very least, a z=0 massive galaxy goes through several mergers

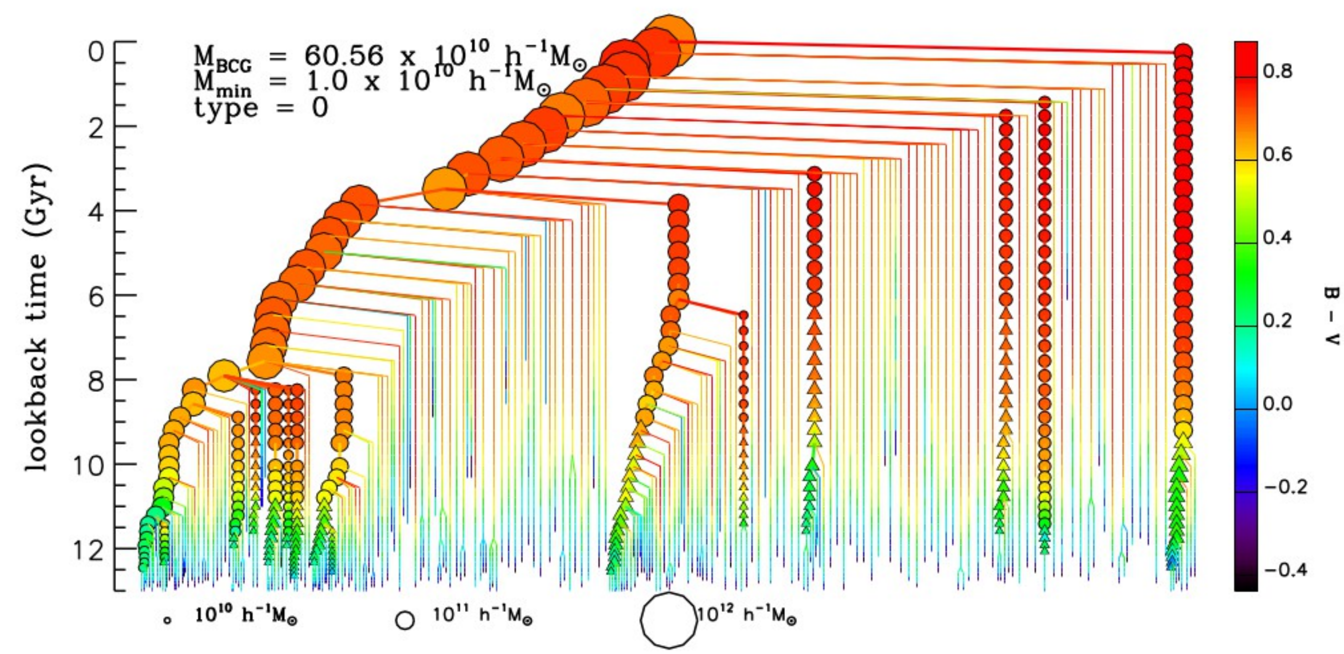


Figure 1. BCG merger tree. Symbols are colour–coded as a function of B - V colour and their area scales with the stellar mass. Only progenitors more massive than 10^{10} $M_{\odot}$ h^{-1} are shown with symbols. Circles are used for galaxies that reside in the FOF group inhabited by the main branch. Triangles show galaxies that have not yet joined this FOF group.

De Lucia & Blaizot 2007

The environmental history of galaxies

Merger tree of its hosting halo

→ strong connection between “environment” and hosting halo

→ many environments experienced for different timescales

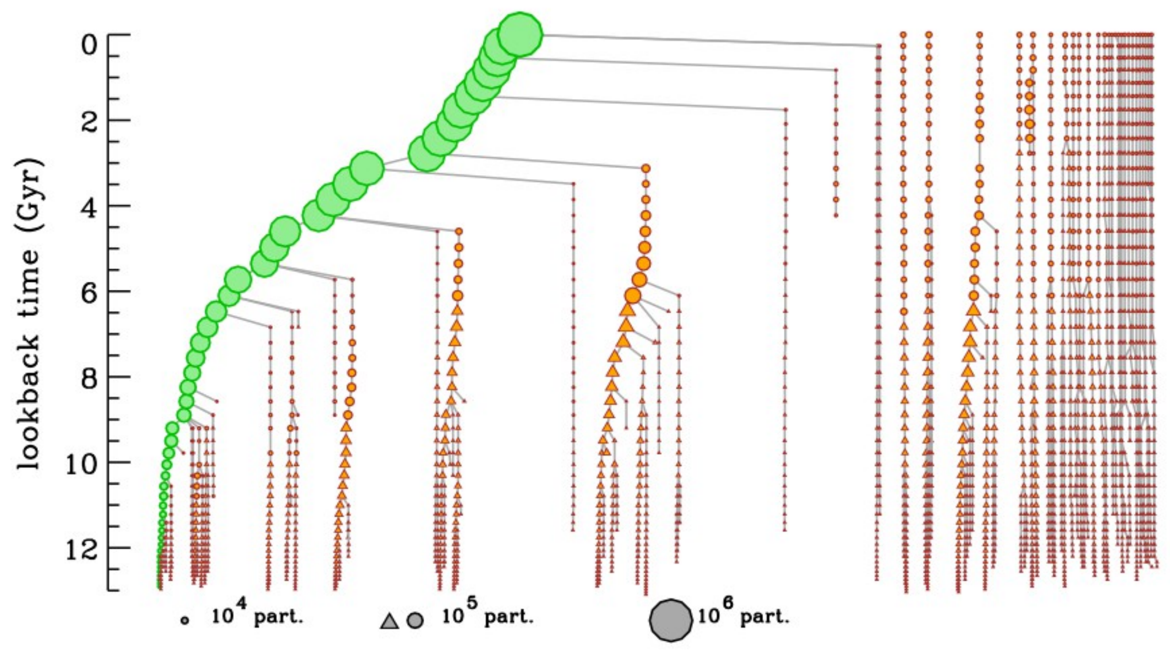


Figure 2. Merger tree of the FOF group in which the BCG sits at redshift zero. Only the trees of subhalos with more than 500 particles at $z = 0$ are shown. Their progenitors are shown down to a 100 particle limit. Symbol coding is the same as in Fig. 1. The left-most tree is that of the main subhalo of the FOF, while the trees on the right correspond to other substructures identified in the FOF group at $z = 0$. In green, we mark the subhalo that contains the main branch of the BCG.

De Lucia & Blaizot 2007

The environmental history of galaxies

Looking on the other way round, observers can help simulations by giving more stringent constraints:

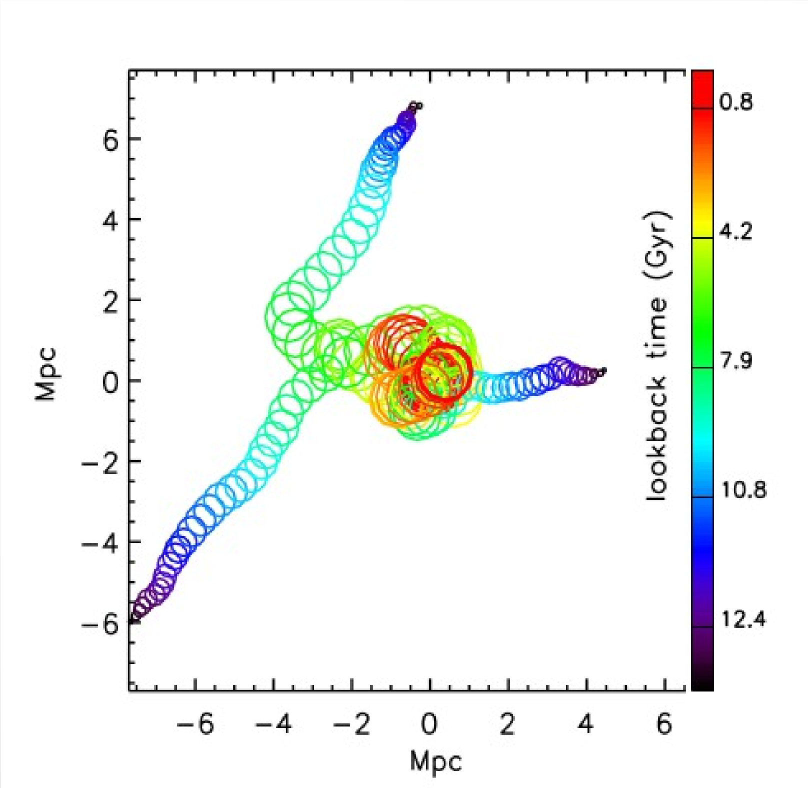
- systematically identify different environments at high z
- at higher z we should search for lower mass halos

The environmental history of galaxies

Looking on the other way round, observers can help simulations by giving more stringent constraints:

- systematically identify different environments at high z
- at higher z we should search for lower mass halos …

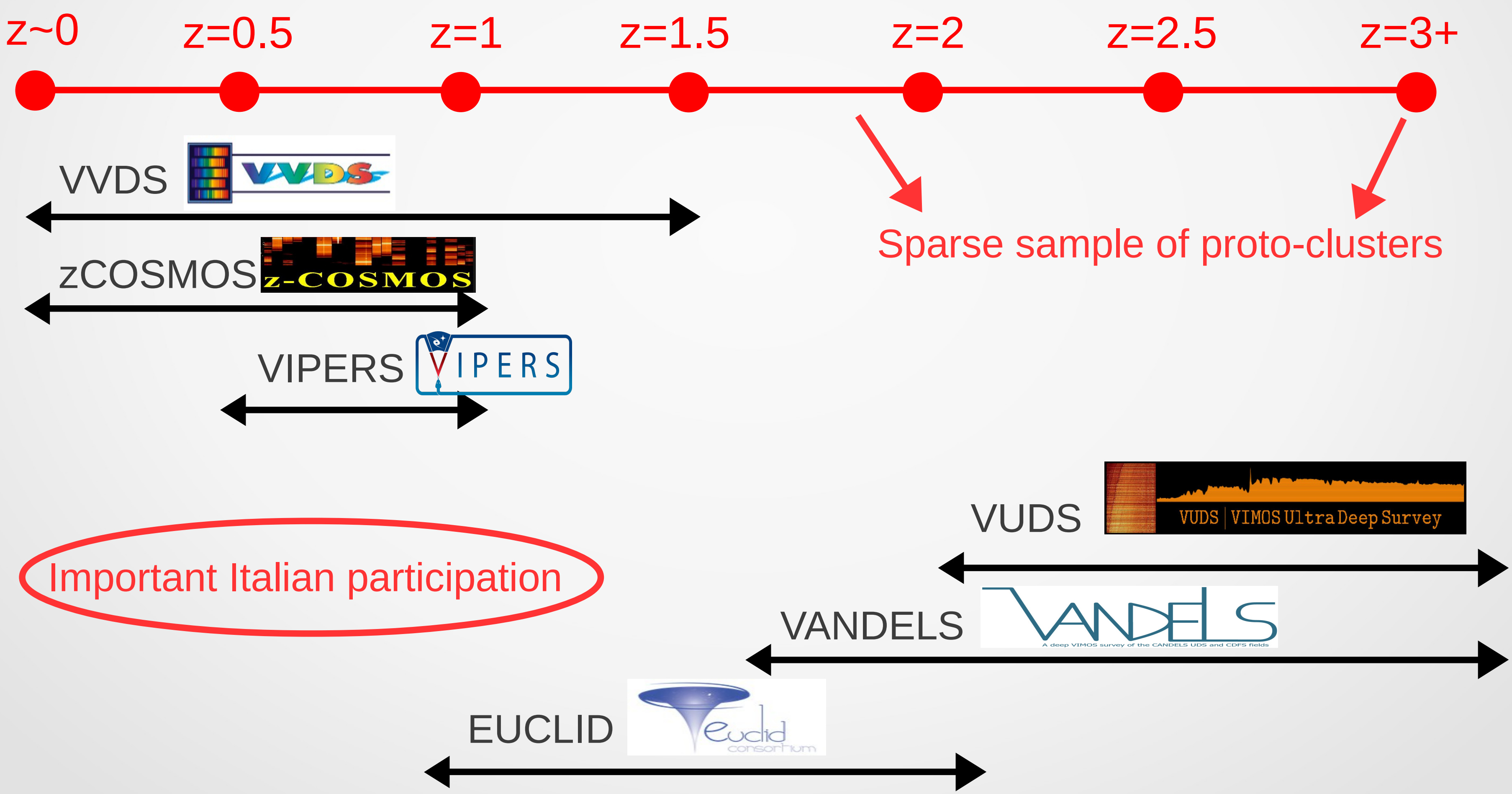
… and in much larger volumes



De Lucia et al 2012

Proto-structures at z>2

Address this issue with recent/on going/future surveys



Proto-structures at $z>2$

VIMOS Ultra-Deep Survey (VUDS):

- systematic and homogeneous search with specz+photoz
  → 2D density maps in narrow redshift slices
  → proto-structures identified “blindly” as extended regions with a density value above a given threshold

- **found ~50 density peaks at $2<z<4.5$**
- 10-12 spectroscopic members each, extension of few comoving Mpc

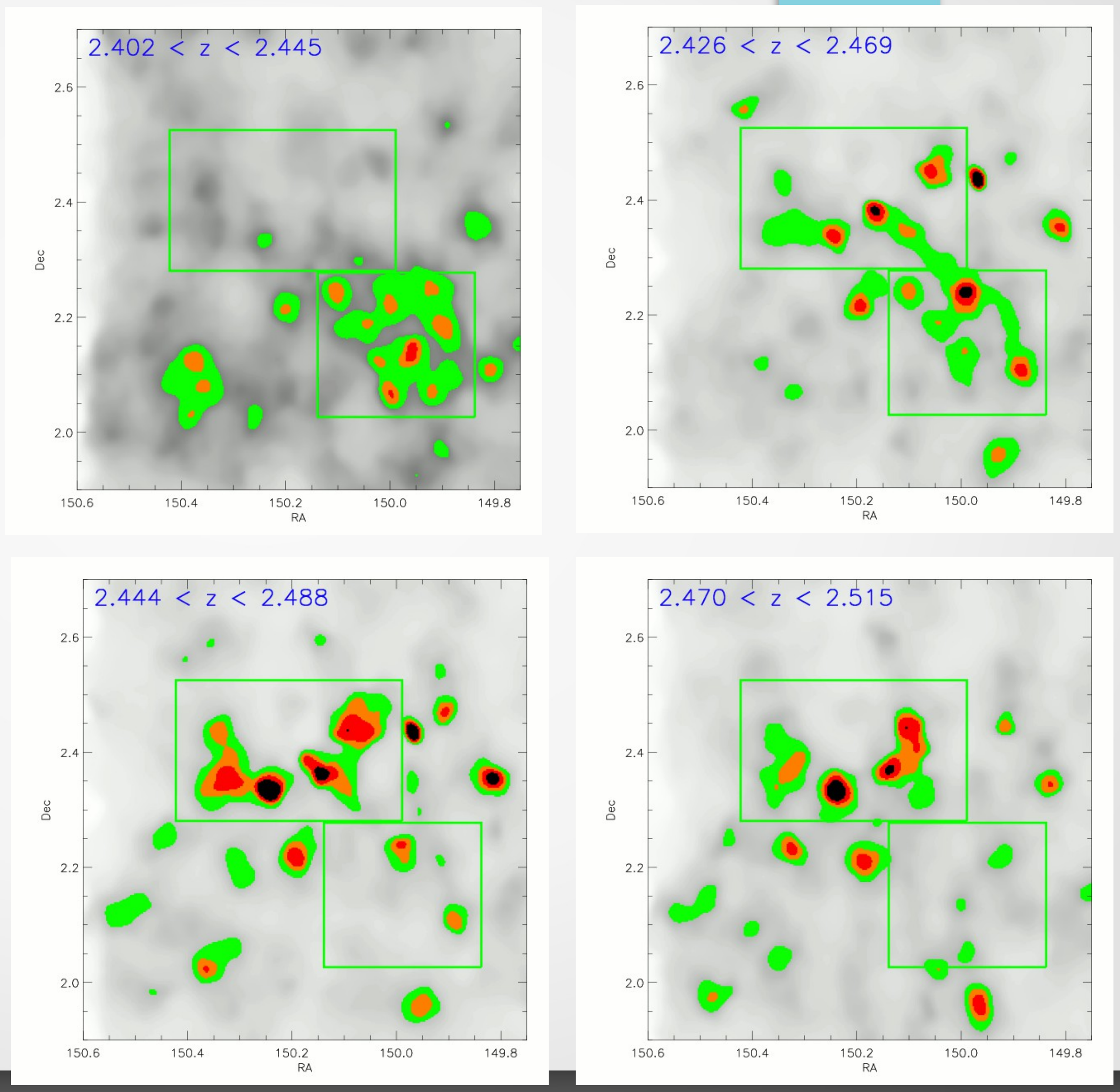
  → analysis on going (Lemaux et al in prep.)

  → ideal homogenous sample of proto-structures to be compared with simulations (properties of both halos and member galaxies)

Proto-supercluster at z=2.45

VUDS | VIMOS Ultra Deep Survey

VUDS: specz+photoz
→ 2.40 < z < 2.53



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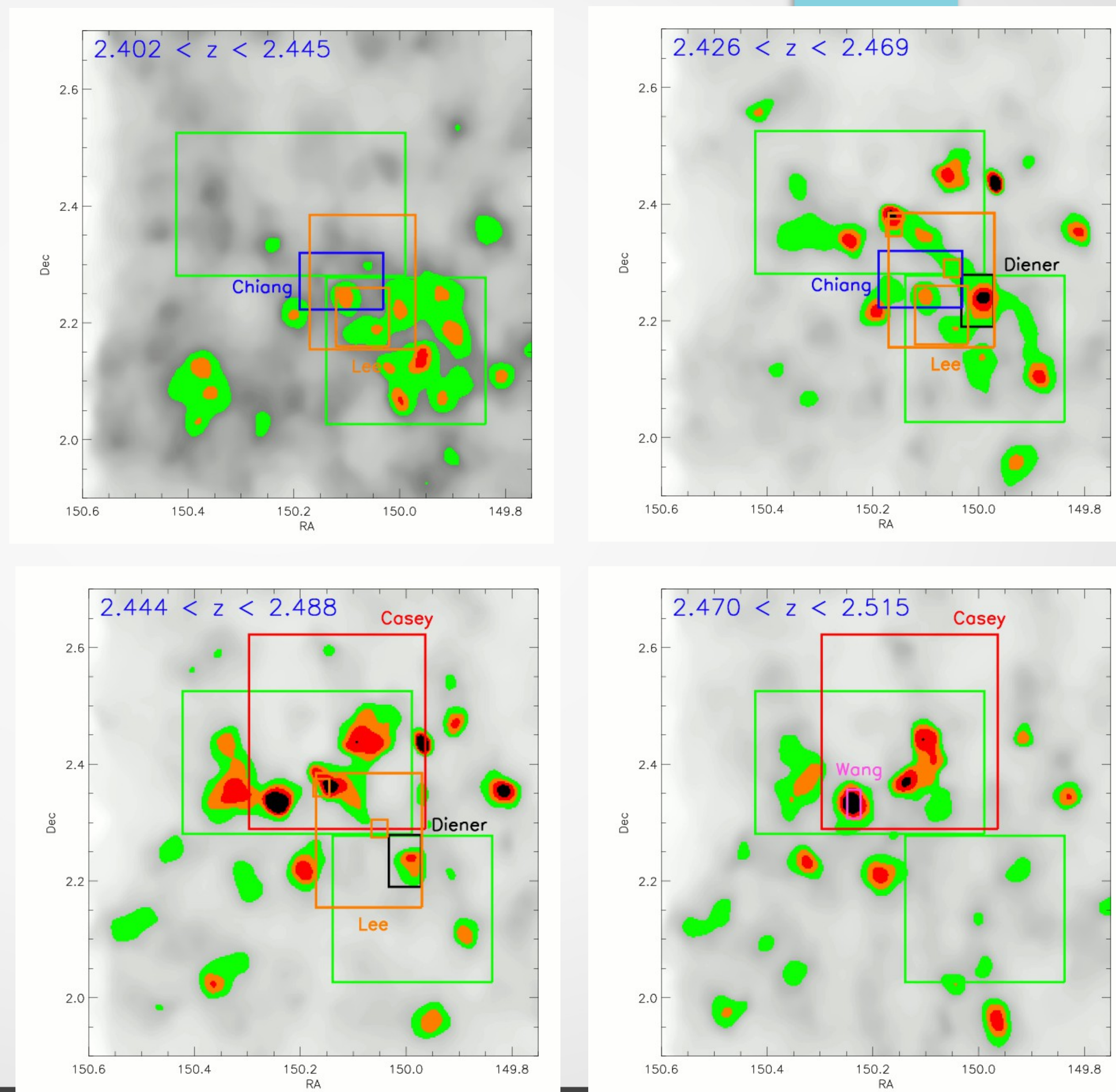
Diener et al 2015: optical follow-up from zCOSMOS-Deep
→ 2.439 < z < 2.453

Casey et al 2015: submm starbursting galaxies + AGNs
→ 2.463 < z < 2.487

Chiang et al 2015: LAEs
→ 2.4284 < z < 2.4558

Lee et al 2016: 3D Lya forest tomographic mapping:
→ 2.43 < z < 2.48:
  → 2.43 < z < 2.44
  → 2.445 < z < 2.455
  → 2.46 < z < 2.478

Wang et al 2016: CO
→ 2.494 < z < 2.515



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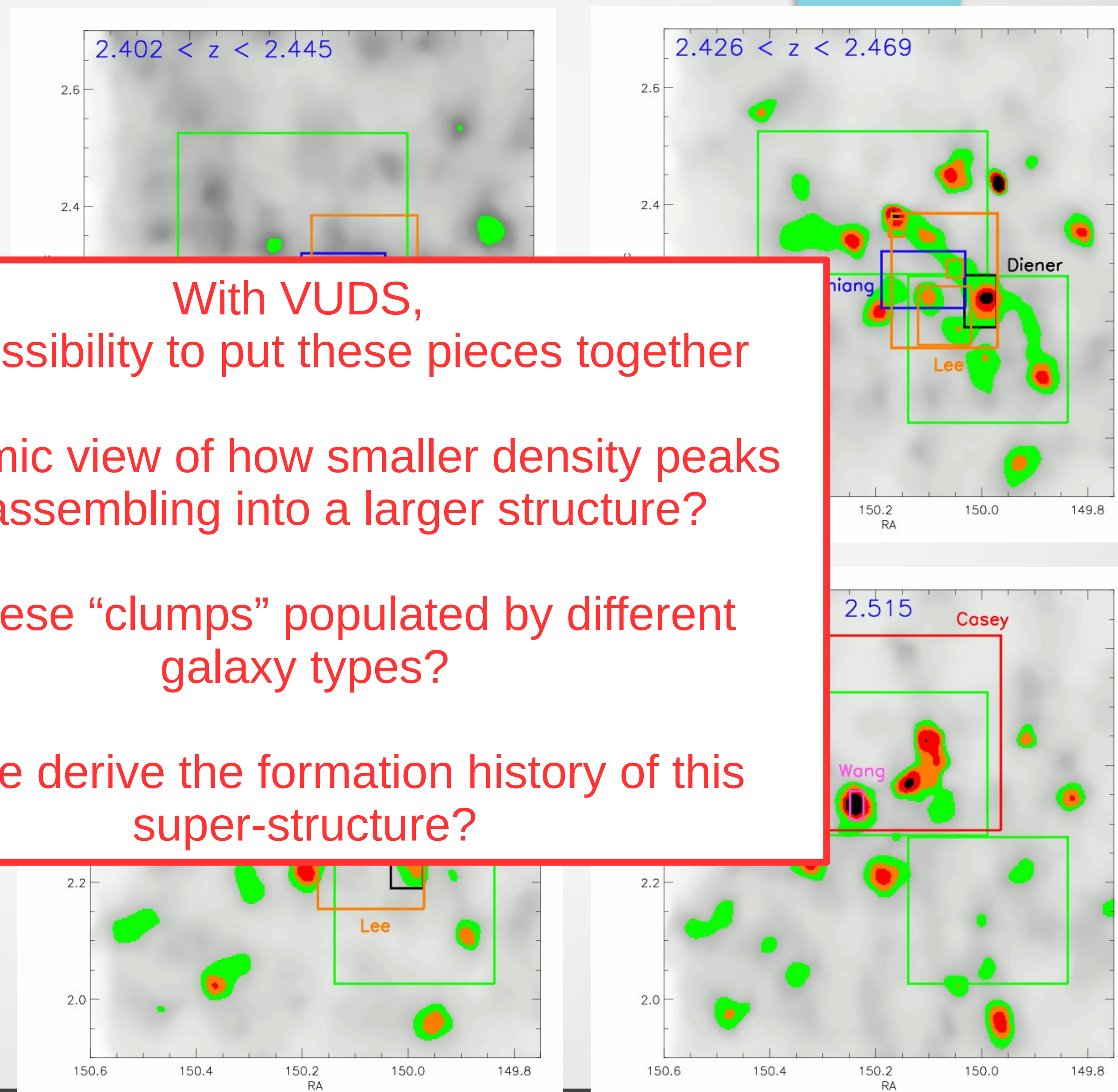


With VUDS,
first possibility to put these pieces together

Panoramic view of how smaller density peaks are assembling into a larger structure?

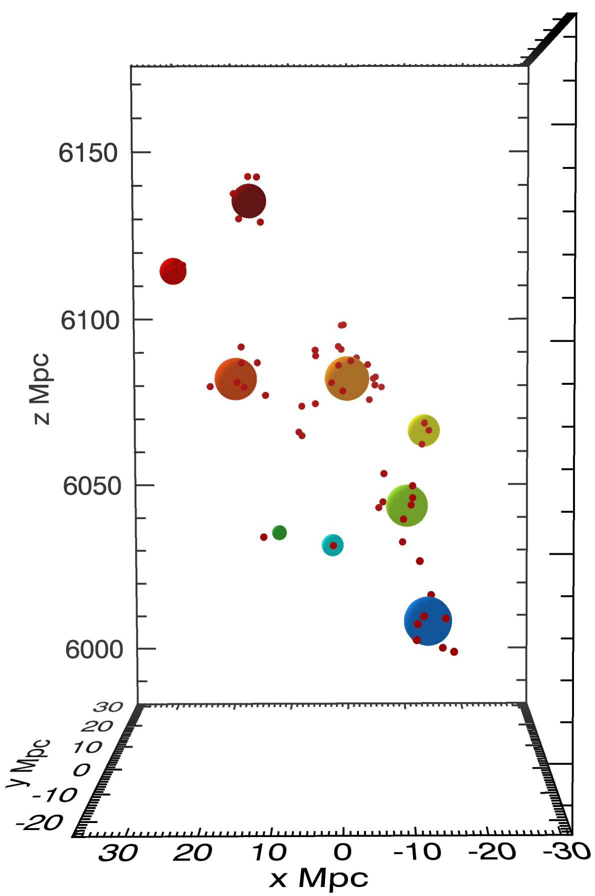
Are these “clumps” populated by different galaxy types?

Can we derive the formation history of this super-structure?

Proto-supercluster at z=2.45

VUDS | VIMOS Ultra Deep Survey

Preliminary analysis of the highest density peaks in the structure



$$M = \rho_m V (1+\delta_m)$$

Volume ($cMpc^3$)	Mass ($10^{14} M_{sun}$)
2808	2.25
2013	1.47
1390	1.19
1173	0.89
422	0.31
327	0.30
113	0.08
56	0.04
18	0.01

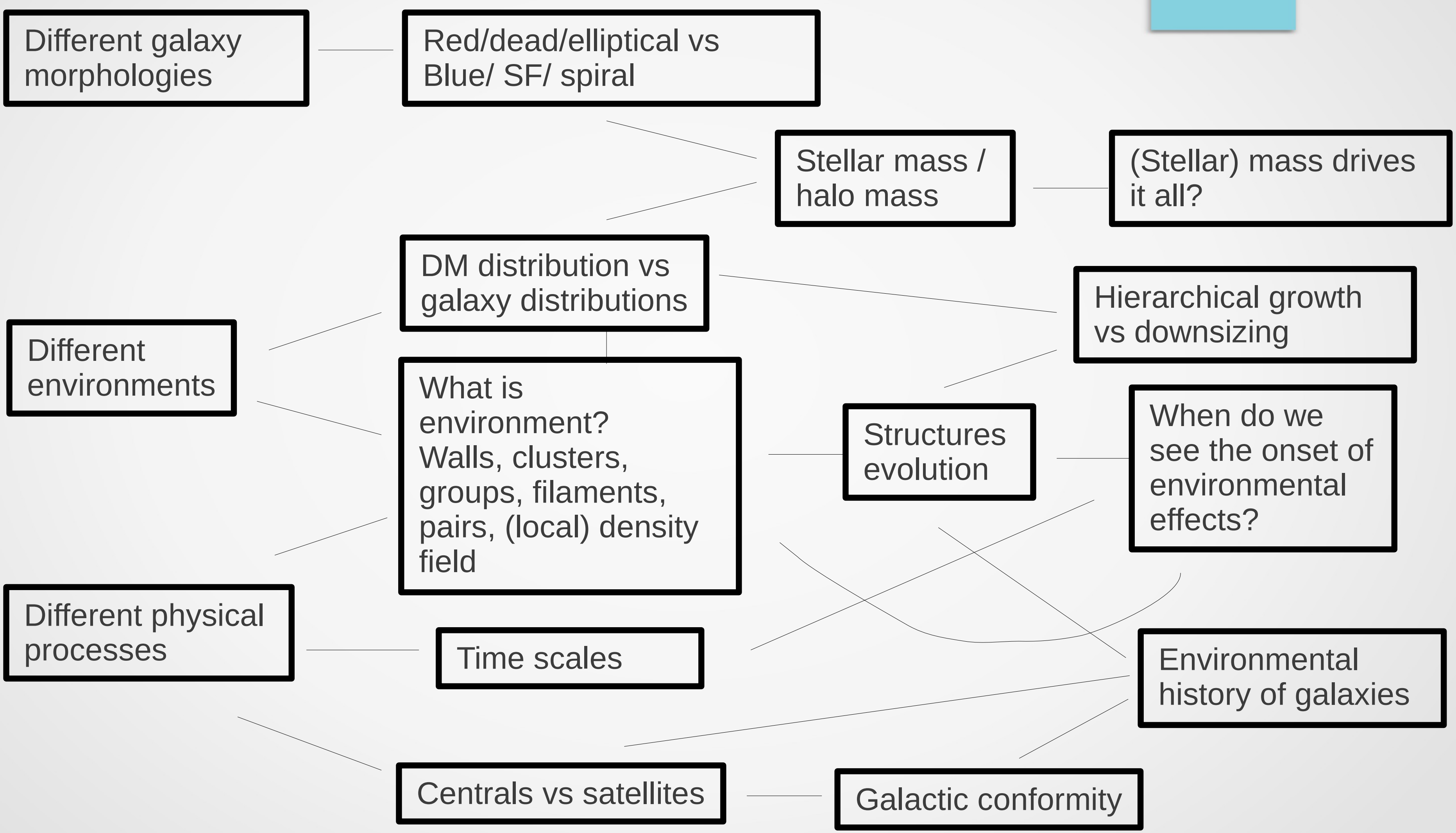
Next steps in the “surveys” (statistical) approach for environmental studies

- **Lessons learned**
  - need to use galaxy surveys to trace environment in a systematic way
  - spec-z are necessary, but we can use spec-z and photo-z together

    → it is not (always) necessary to have 100% of spectroscopic sampling rate
- **Planned surveys/missions**
  - [High z] EUCLID: provides constraints to simulations at z~1.5-2.0 via systematic identification of density peaks/halos
  - [low-intermediate z] current/planned surveys focused on specific physical processes (see other talks): provide constraints to simulations at z<1 via detailed analysis of time scales etc
- **Next-generation spec-z surveys:** several planned at low/intermediate redshift

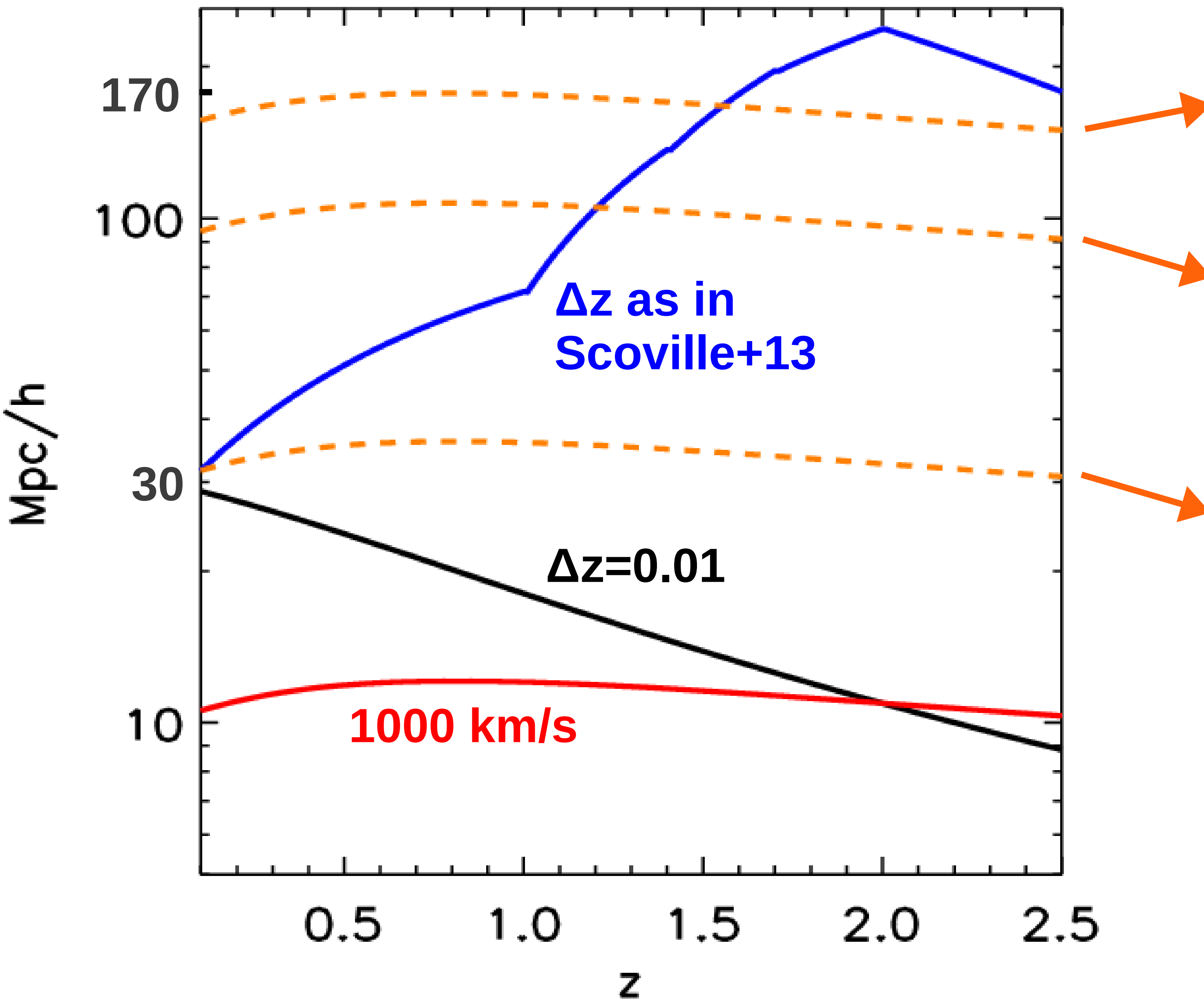
  → don't forget high z!
- **Synergy between galaxy evolution and cosmology**

The many pieces of the big picture



(not to mention the role of AGN, ICM etc)

Spectroscopic vs photometric redshift



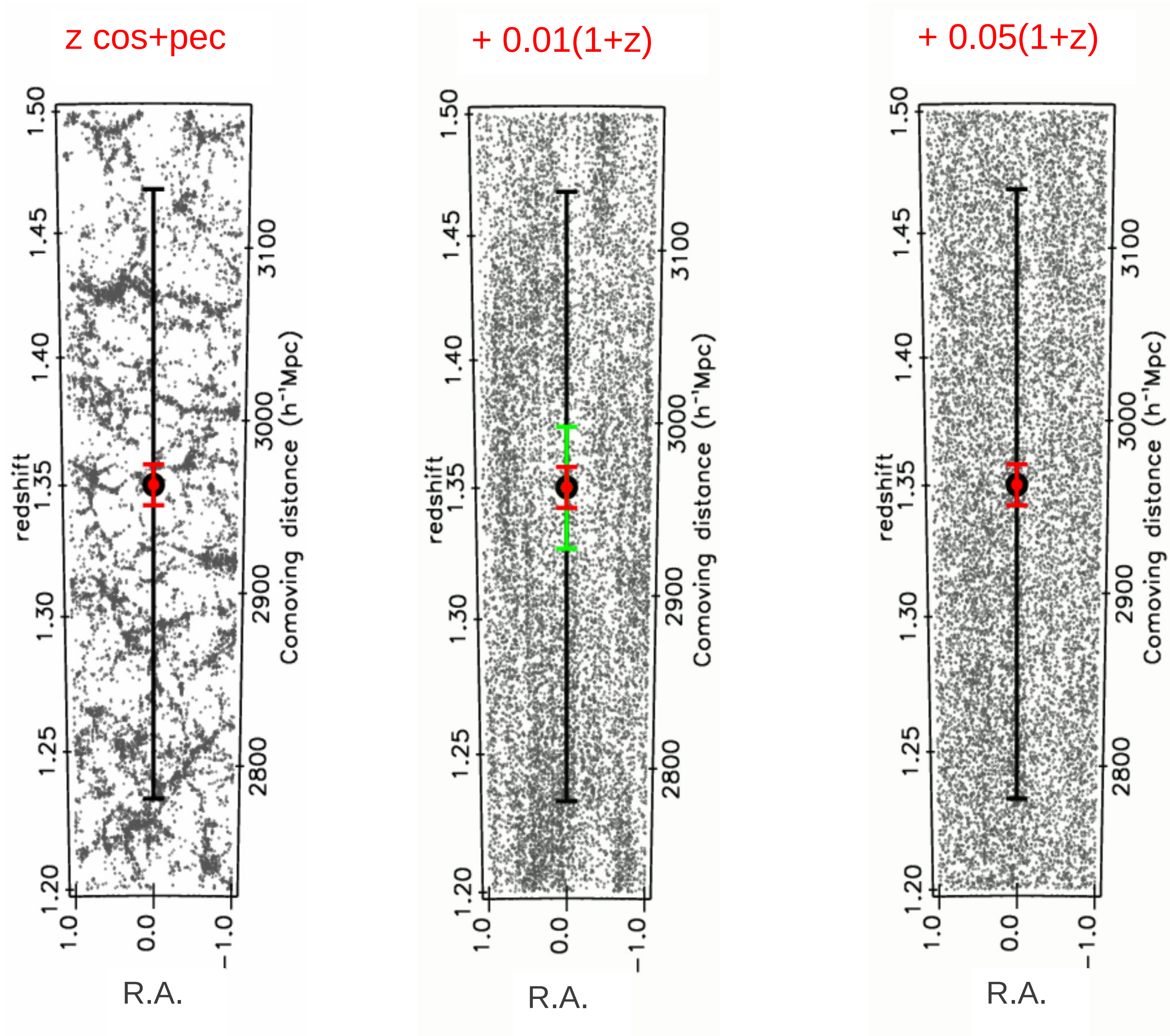
σ = 0.05 (1+z)
(~Euclid requirement)

σ = 0.03 (1+z)
(~ VIPERS
~ Euclid goal)

σ = 0.01 (1+z)
(~ COSMOS,
~ Alhambra)

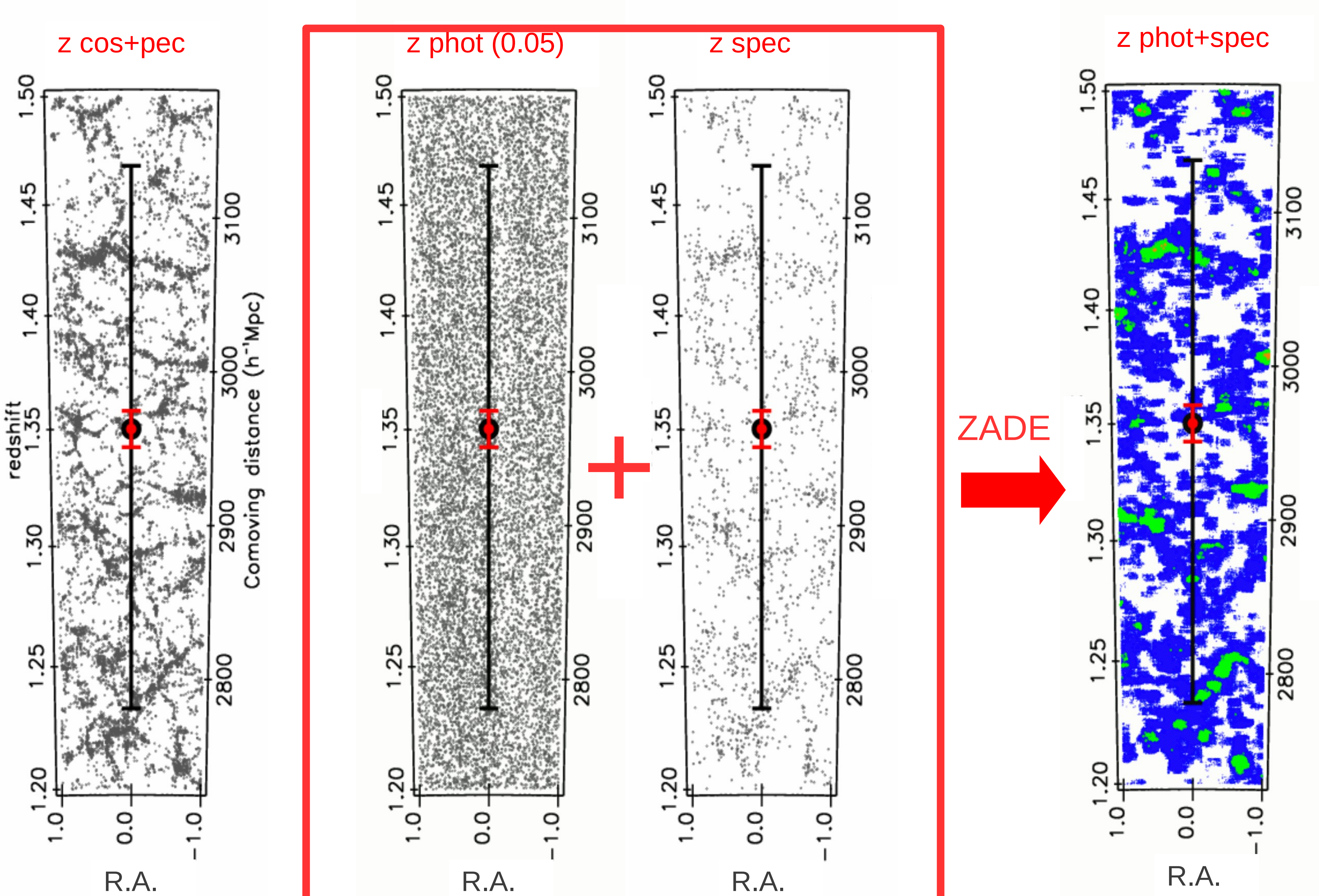
Typical spec-z error in recent surveys:

~70-150 km/s



Mock catalogues

The Euclid Deep Survey: photometric and spectroscopic redshifts



Cucciati et al 2016