



# **The E-ELT Science Case**

**Science Pep Talk #4**



# 9 Prominent Science Cases

“Prominent” science cases are considered to be among the most important scientifically and are useful for defining capabilities of the telescope.

- Planets and Stars
  - **From giant to terrestrial exoplanets: detection, characterization and evolution**
  - **Circumstellar disks**
  - **Young stellar clusters**
- Stars and Galaxies
  - **Imaging and spectroscopy of resolved stellar populations in galaxies**
  - **Black holes and AGN demographics**
- Galaxies and Cosmology
  - **Physics of high redshift galaxies**
  - **First light – The highest redshift galaxies ( $z > 10$ )**
  - **Is the low-density IGM metal-enriched?**
  - **A dynamical measurement of the expansion history of the Universe**

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  - Physics of dark matter and dark energy
  - First galaxies and the first stars
  - First galaxies: most redshift galaxies ( $z > 10$ )
  - Intergalactic medium: density IGM metal-enriched?
  - A dynamical measurement of the expansion history of the Universe

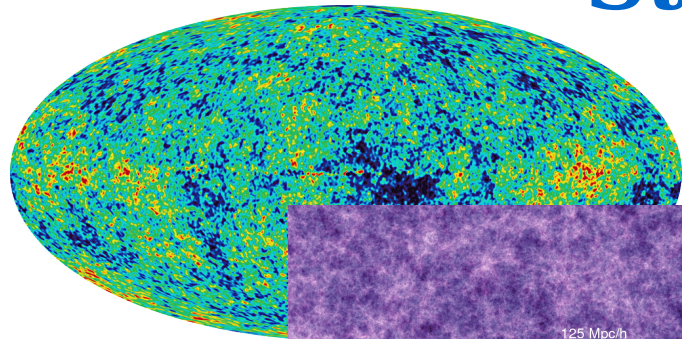
**Extra-galactic**

# The real topic is galaxy formation

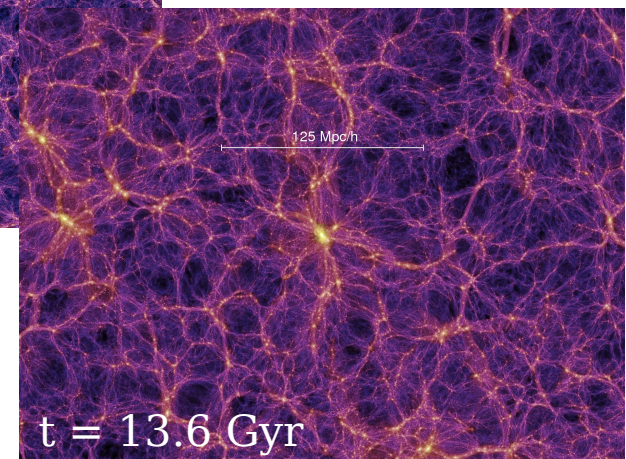
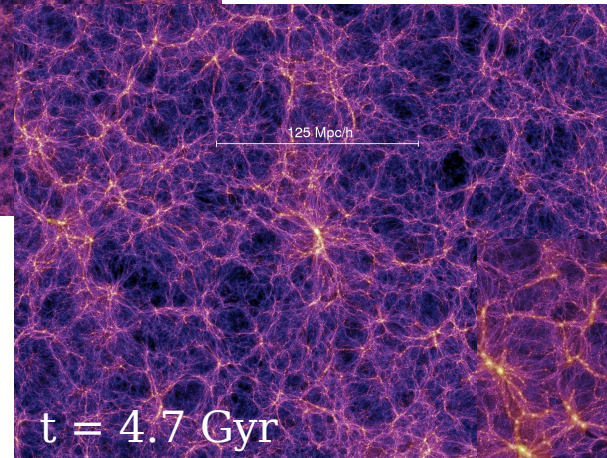
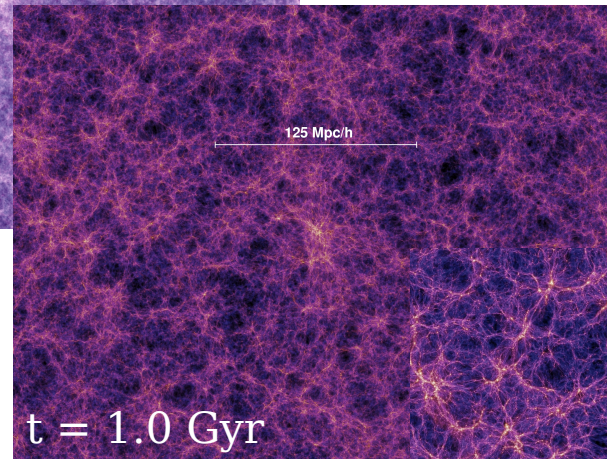
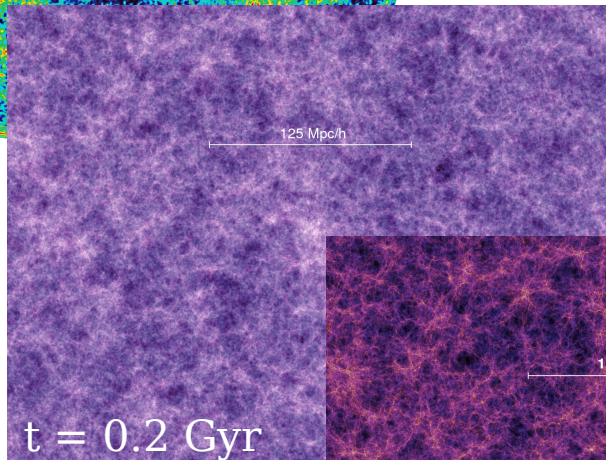
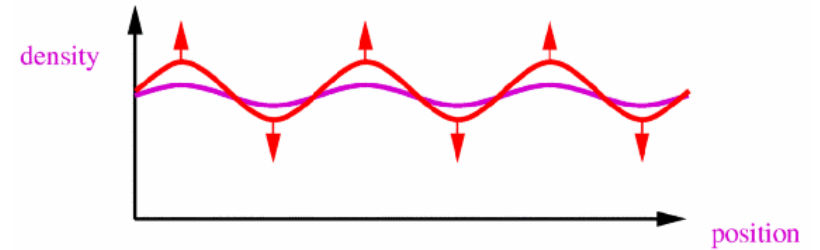
A quick overview:

- Galaxy formation and evolution is part of the larger structure formation process.
- Galaxies form inside Dark Matter halos.
- Structure formation (and hence the build-up of galaxies) proceeds hierarchically, i.e. bottom-up.
- In particular, elliptical galaxies are thought to be the result of one or more major mergers.
- If the merging galaxies contain gas, then the merger triggers wide-spread star-formation.

# Structure formation



by gravitational instability:

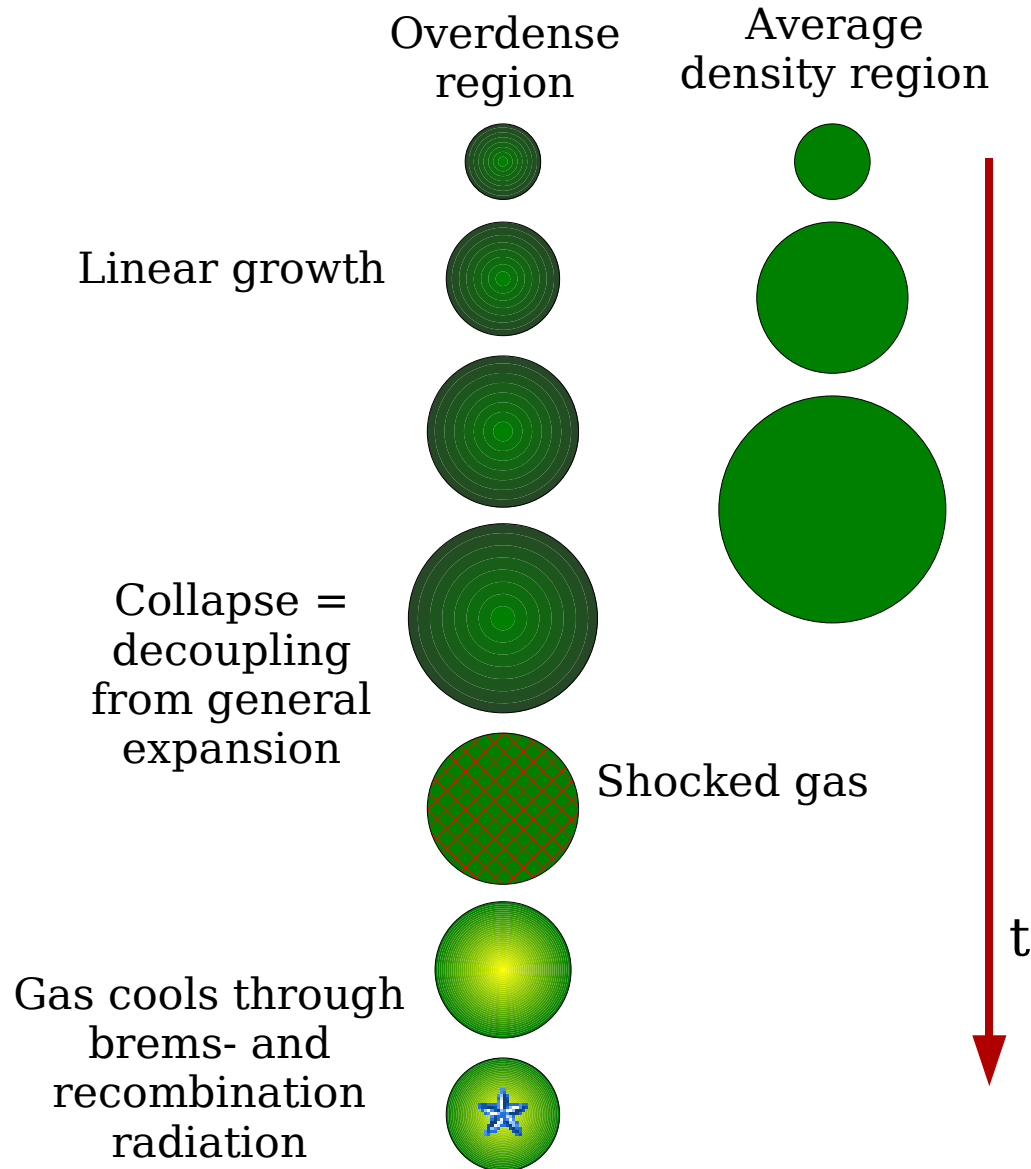


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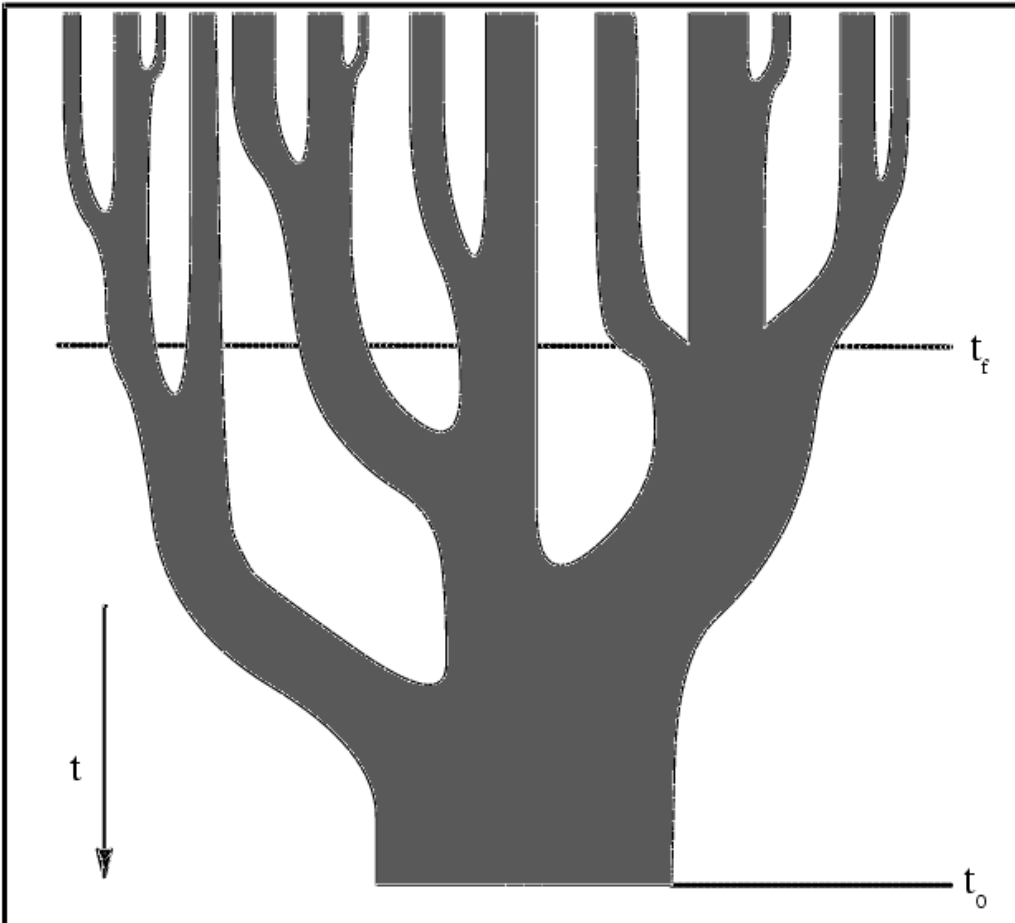


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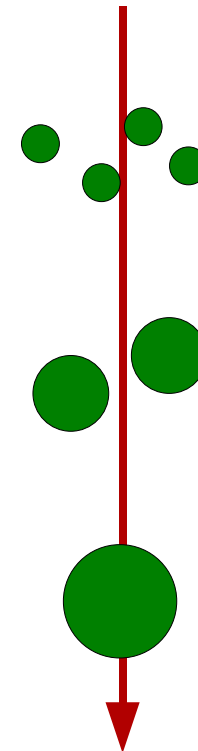
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# Hierarchical build-up



Merger tree





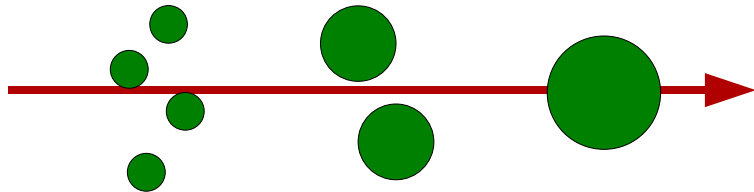
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# Hierarchical build-up



Note: ellipticals should form late in the evolution of the Universe. But: they are found to be old! A major conundrum of galaxy formation and evolution theory.

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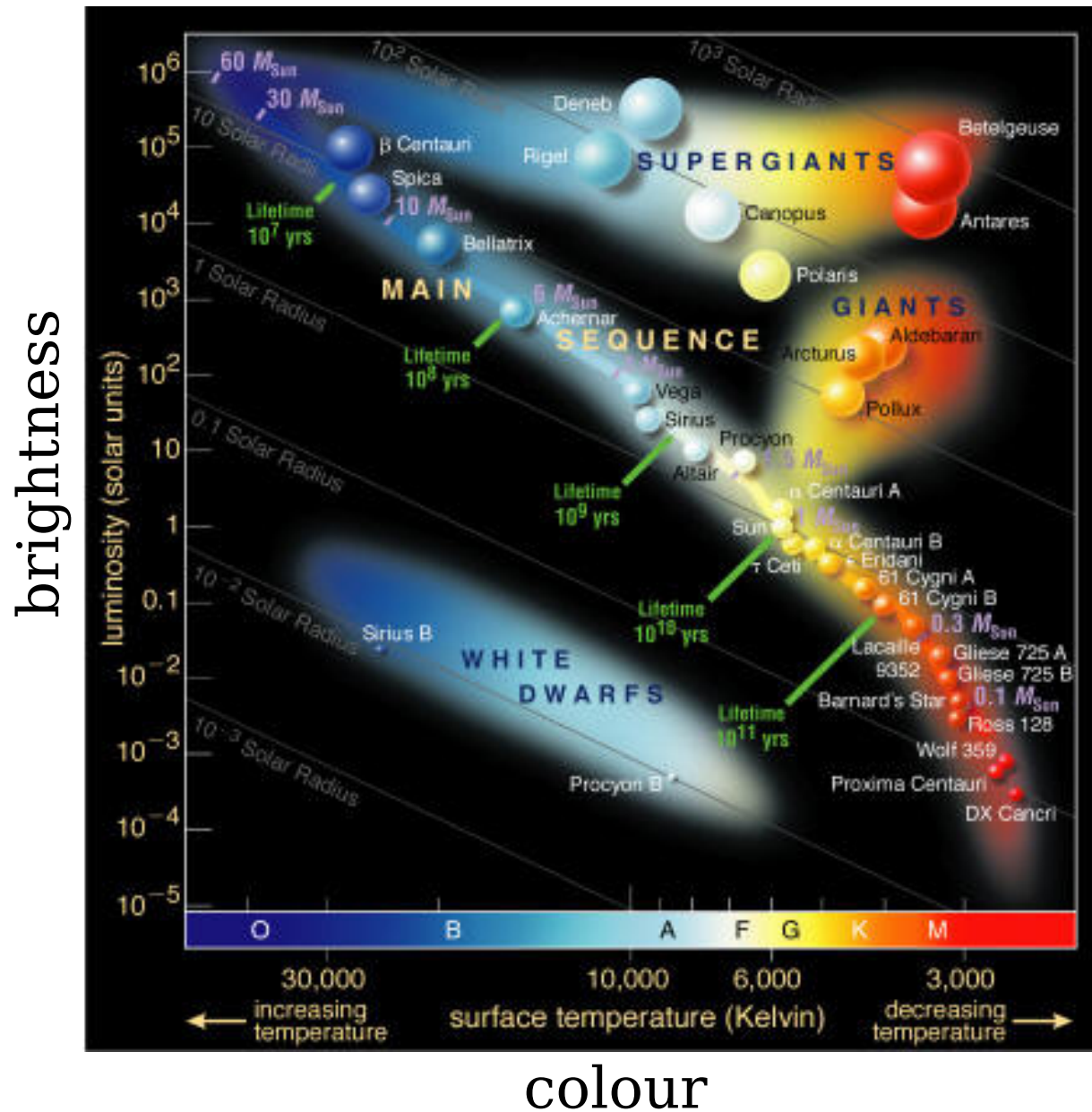
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  - In particular, elliptical galaxies are thought to be the result of one or more major mergers.
  - If the merging galaxies contain gas, then the merger triggers wide-spread star-formation.
- Stars may form throughout a galaxy's history, either quiescently from cool gas or during mergers.

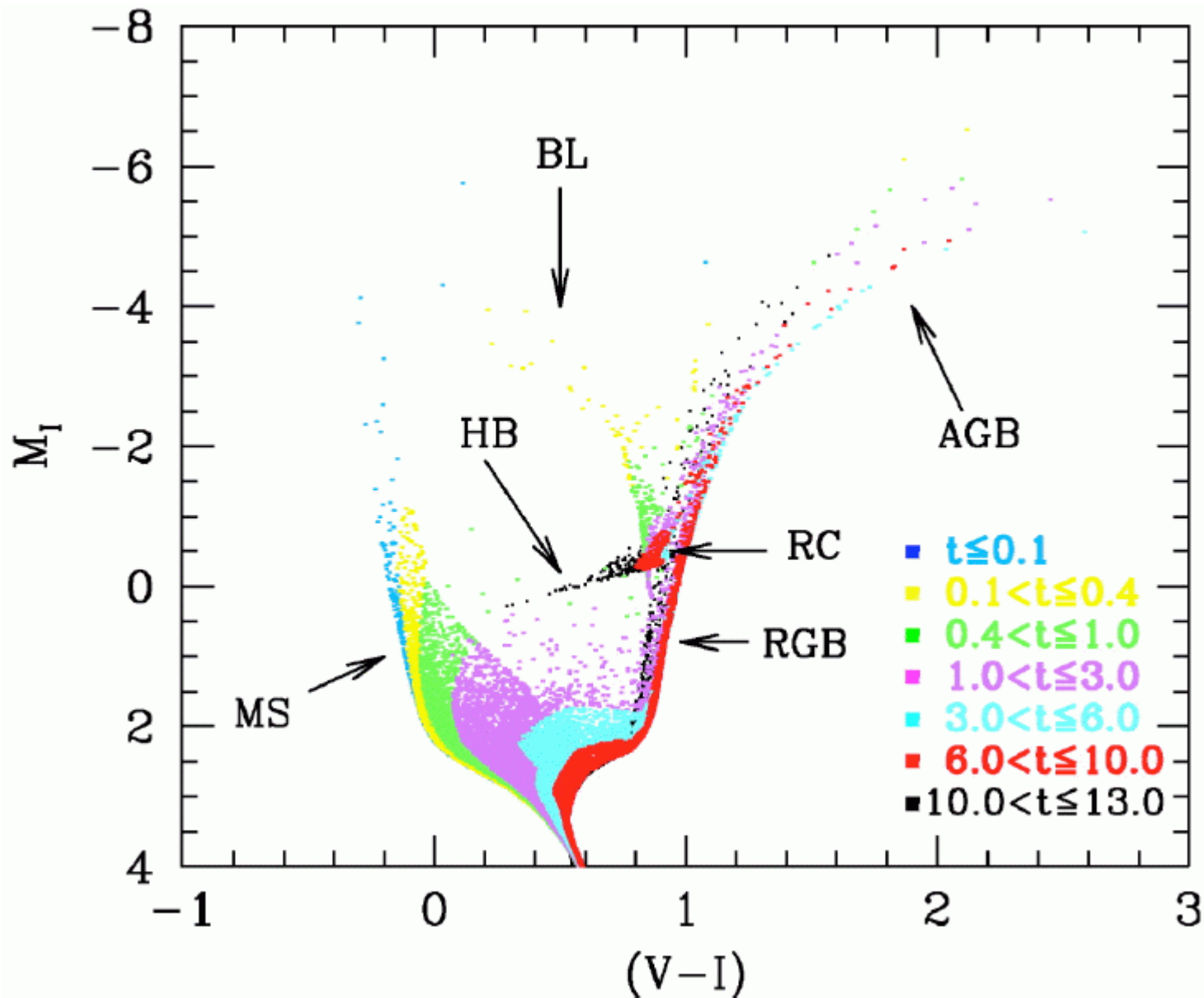
# Stars are direct tracers of the early Universe

- The present-day population of stars in a galaxy is the result of all of the star-formation it experienced + stellar evolution.
- We understand stellar evolution.
- ➔ A galaxy's present-day stellar population can be used to deduce the galaxy's major episodes of star-formation (initial formation, major mergers) and hence to reconstruct its assembly history.
- Stars retain a memory of the interstellar medium out of which they were formed. Since some stars are very long-lived this is a very handy tracer of conditions under which stars formed from the earliest times to the present.

# Understanding a population of stars: the Hertzsprung-Russel diagram



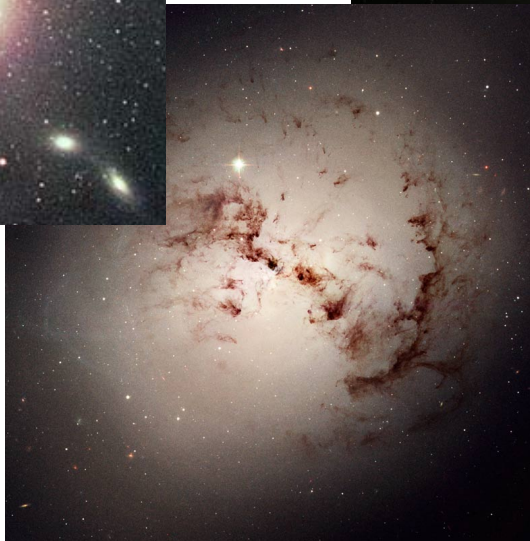
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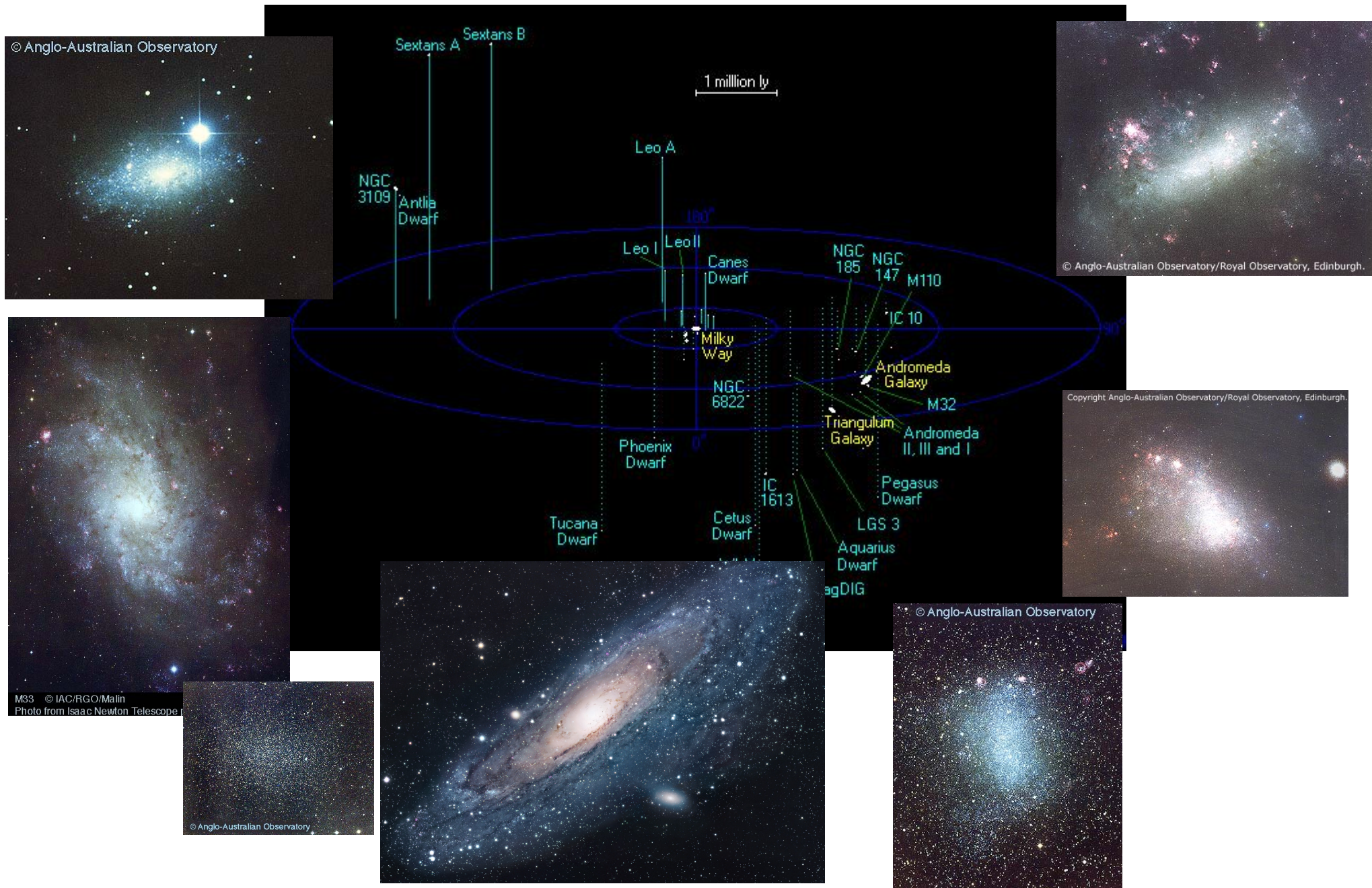
# Resolved stellar populations → galaxy evolution

- Want to do photometry and spectroscopy of individual stars (i.e. resolved from one another) for as many different types of galaxy as possible. Need to measure faint stars in crowded fields!



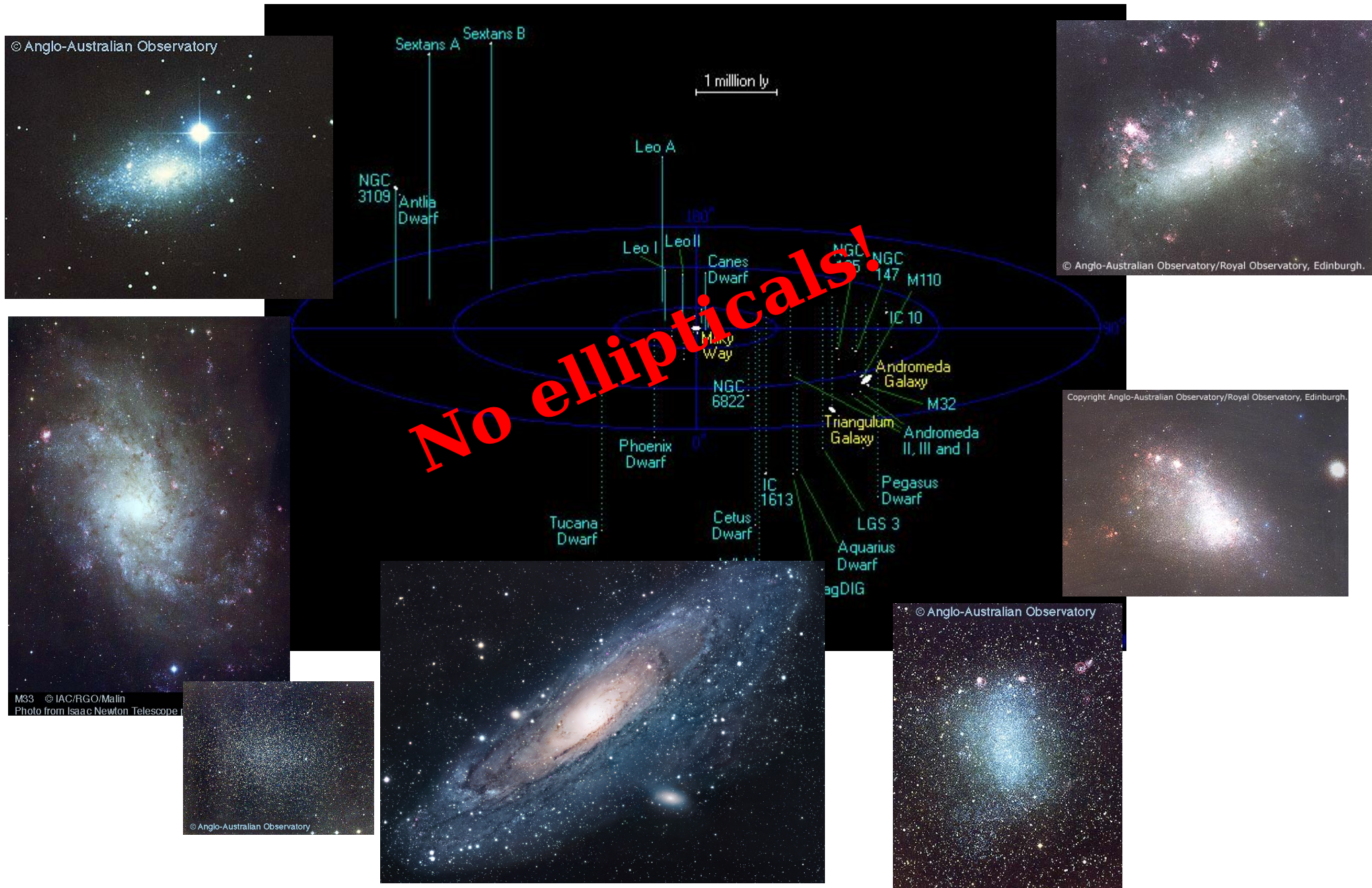


# The Local Group of Galaxies





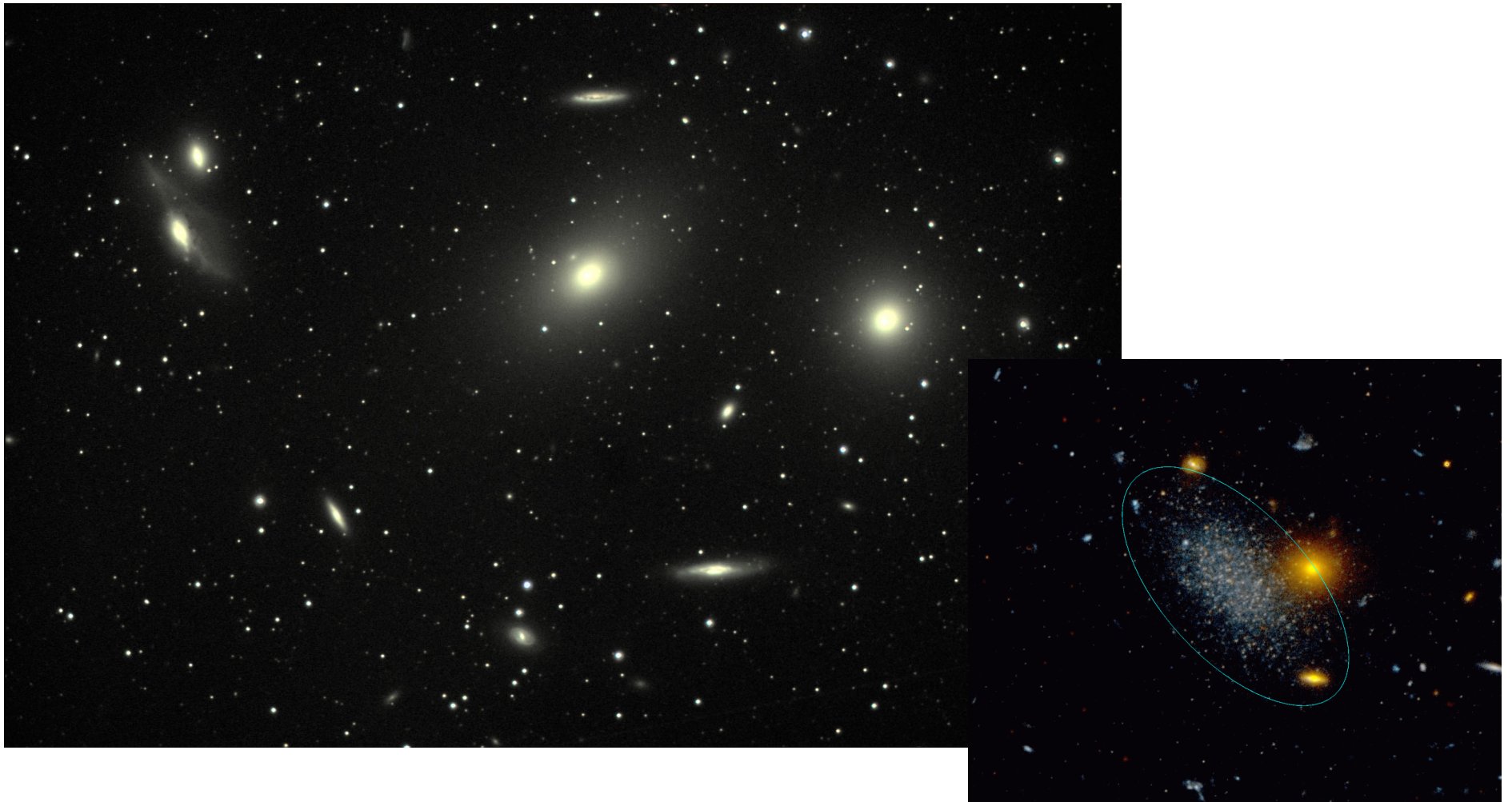
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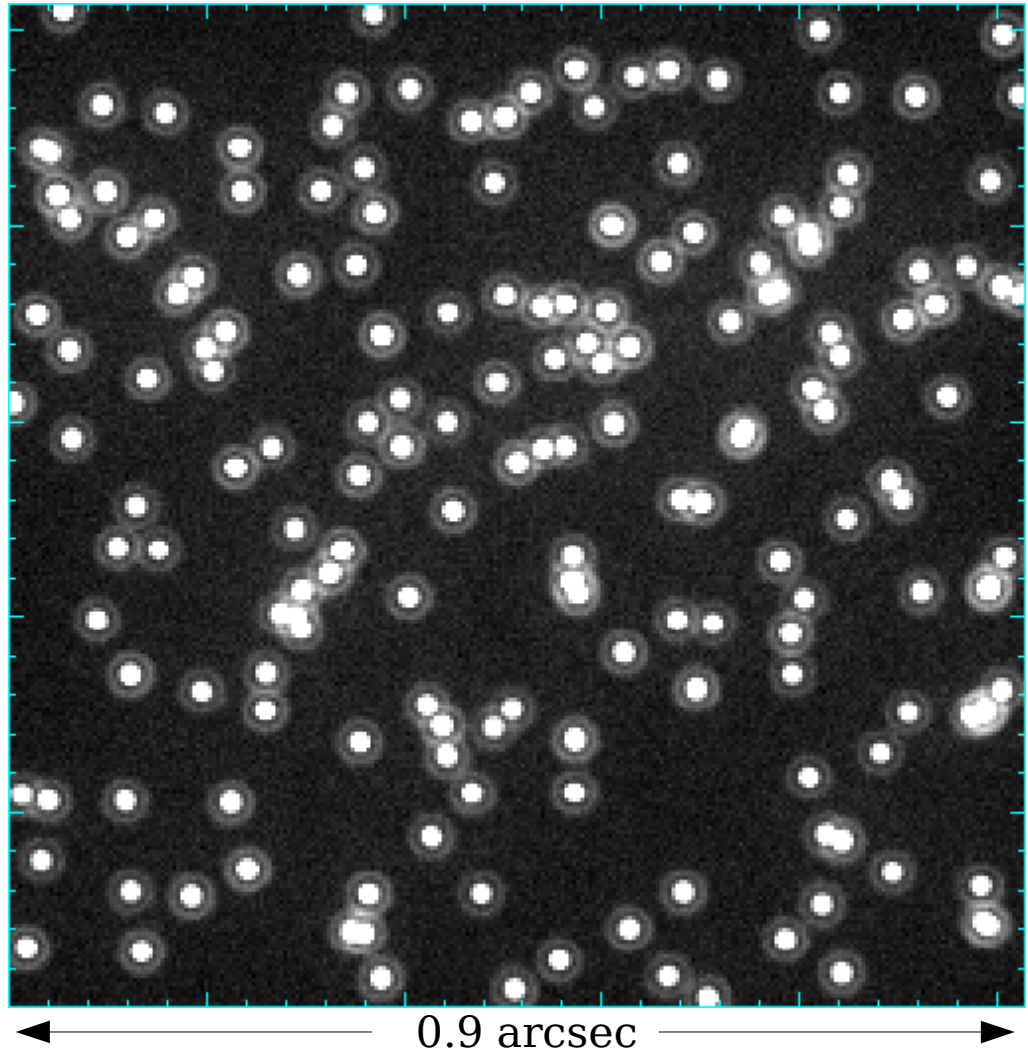
# What the E-ELT will bring

- To get ellipticals we need to go out to the Virgo cluster.
- $D(\text{Virgo}) = 18 \text{ Mpc!}$
- So far it has not been possible to resolve stars at that distance (except with HST for a few dwarfs and a total of a few hundred stars).



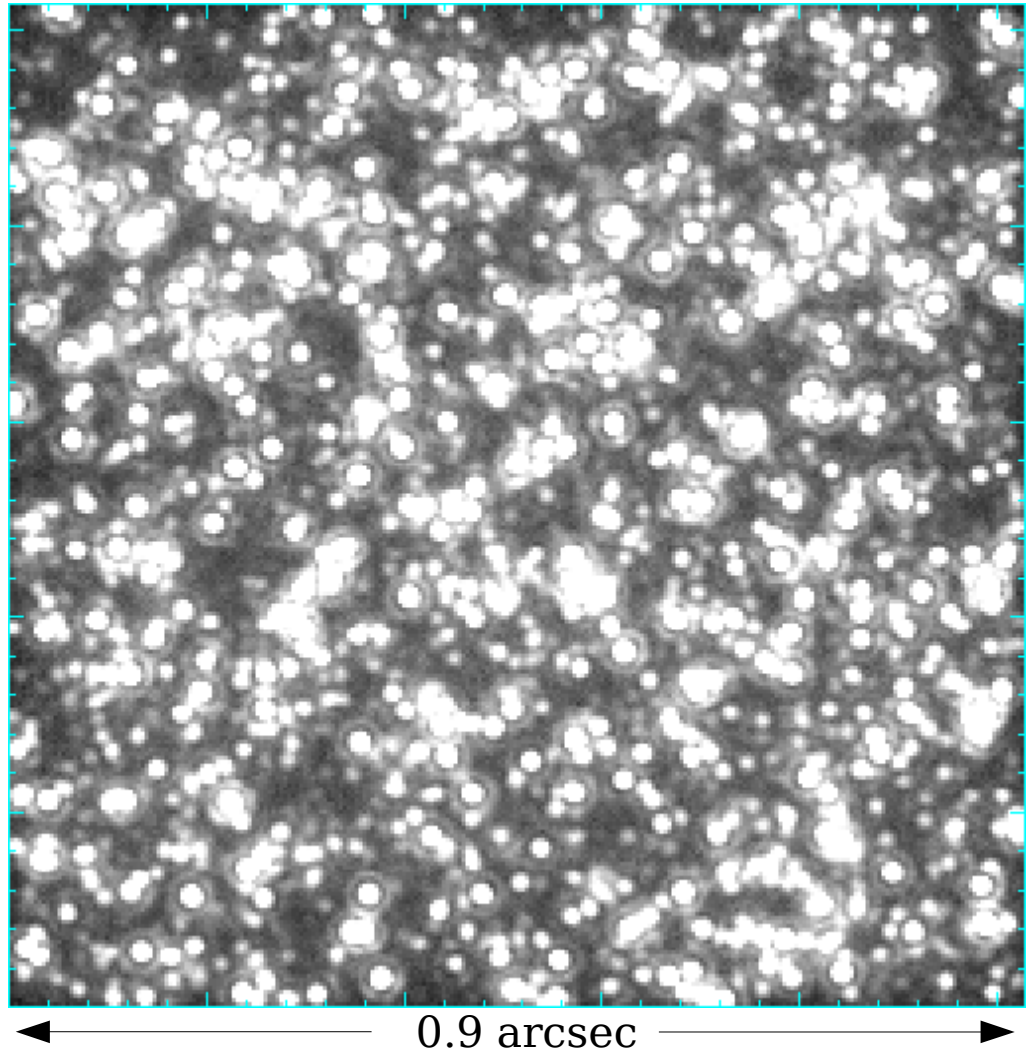
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- This requires resolution *and* photon collecting power!
- E-ELT will allow us, for the first time, to probe the stellar populations of the full variety of galaxies through optical-NIR imaging and low-resolution spectroscopy.
- E-ELT will provide us with the detailed assembly histories of elliptical galaxies which will constitute an extremely important test for the paradigm of hierarchical galaxy formation.



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