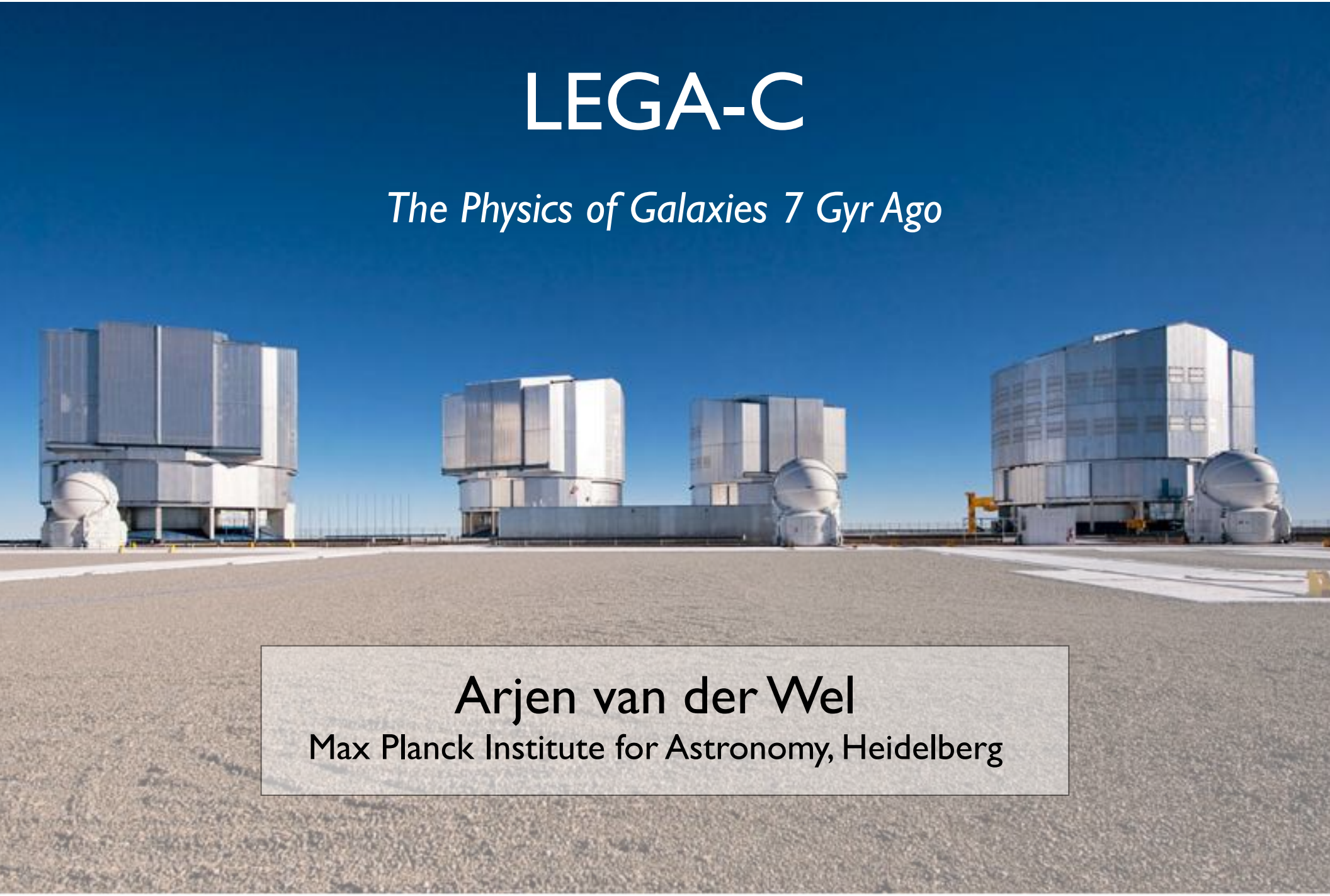
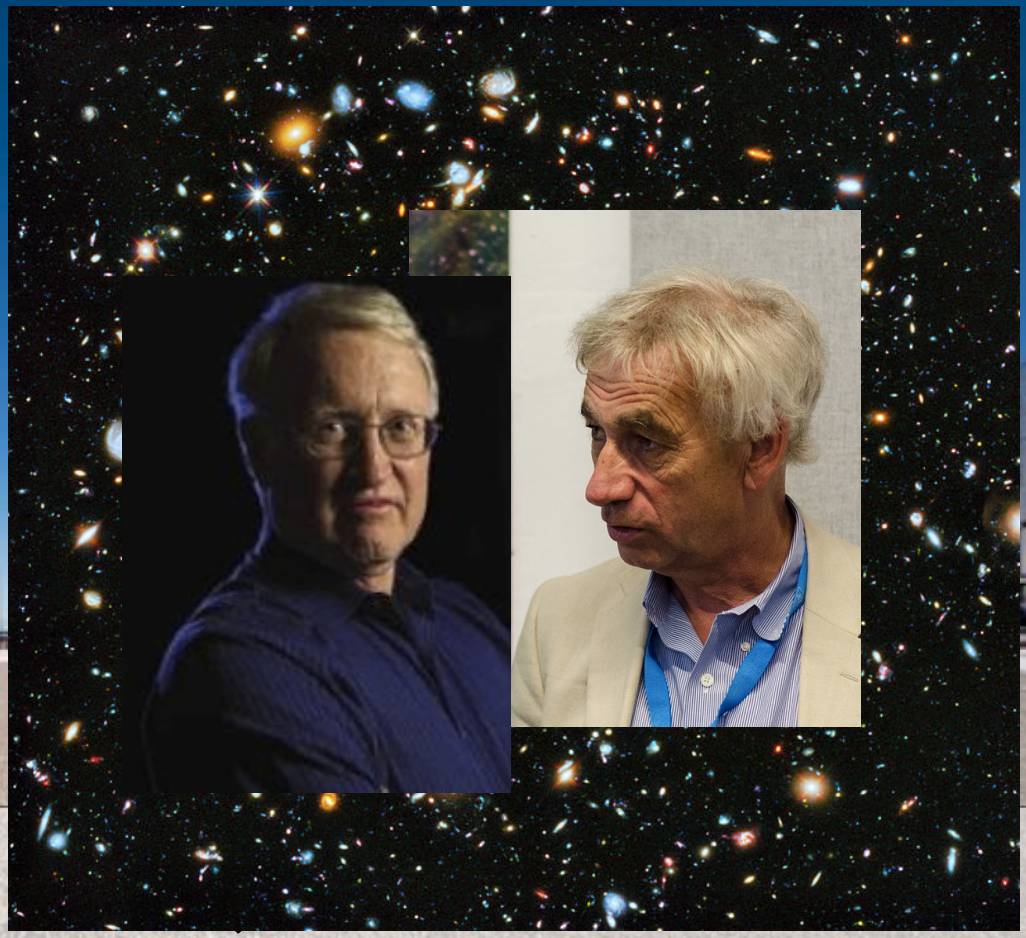
LEGA-C

The Physics of Galaxies 7 Gyr Ago



Arjen van der Wel
Max Planck Institute for Astronomy, Heidelberg

LEGA-C



Max Planck Institute for Astronomy, Heidelberg

LEGA-C

A spectroscopic galaxy survey with VLT/VIMOS

Large Early Galaxy Astrophysics Census

- 128-night Public Spectroscopic Survey with VLT / VIMOS
- Observations: December 2014 - Spring 2018

- R = 3000, λ = 6000 - 9000 Å (HR Red)
- Primary sample: 2500 galaxies (K-selected) at $0.6 < z < 1.0$
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- Stellar ages and metallicities
- Dynamical masses
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LEGA-C

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Large Early Galaxy Astrophysics Census

PI: Arjen van der Wel (MPIA)

Survey Manager:

- Kai Noeske (MPIA)

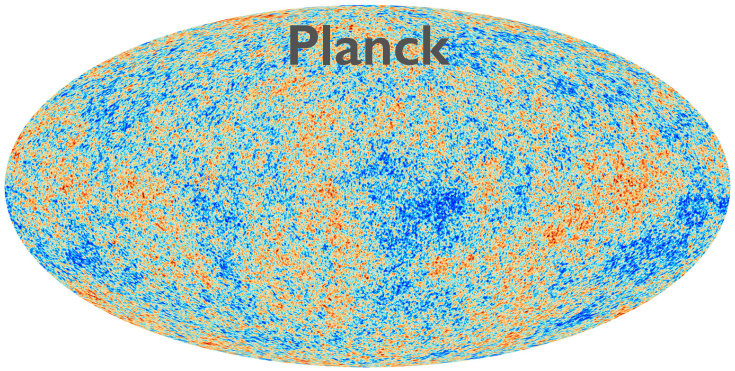
Survey Scientists:

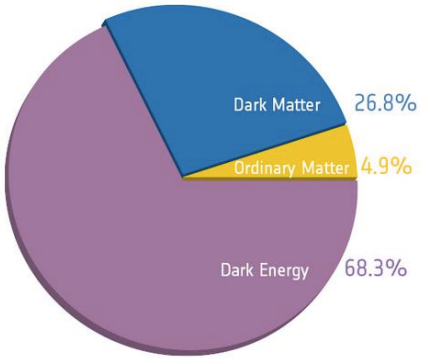
- Anna Gallazzi (Arcetri) — *Chemistry/Abundances*
- Camilla Pacifici (STScI) — *Star formation histories*
- Rachel Bezanson (Arizona) — *Dynamics*

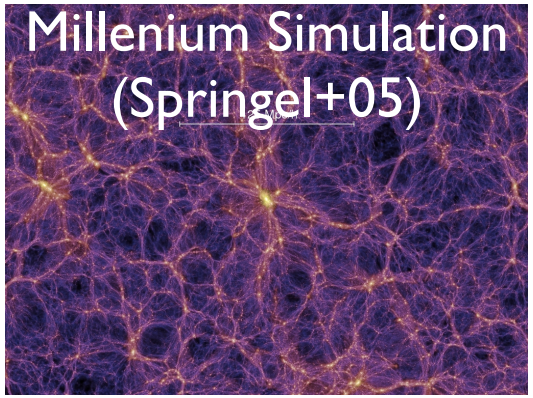
co-I's:

Eric Bell (Michigan)
Gabriel Brammer (STScI)
Stephane Charlot (IA Paris)
Priscilla Chauke (MPIA)
Marijn Franx (Leiden)
Ivo Labbe (Leiden)
Michael Maseda (MPIA)
Juan Carlos Munoz (ESO)
Adam Muzzin (Leiden)
Hans-Walter Rix (MPIA)
David Sobral (Lisbon)
Jesse van de Sande (Leiden)
Ros Skelton (Capetown)
Pieter van Dokkum (Yale)
Vivienne Wild (St. Andrews)
Christian Wolf (ASU)

Λ Cold Dark Matter and Galaxy Formation

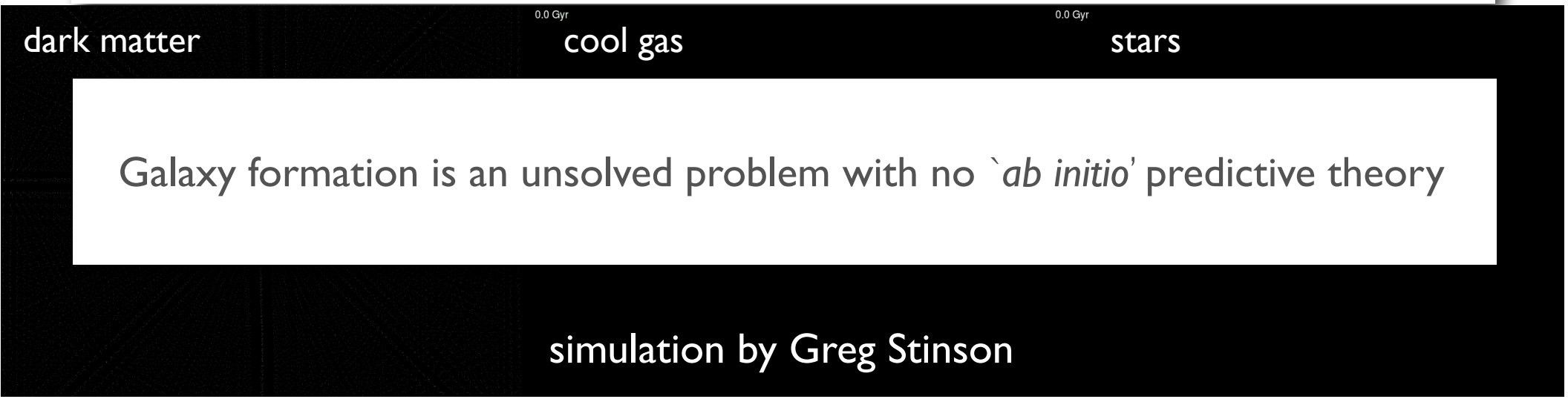






Central question in galaxy formation

How does gas assemble and convert to stars in the centers of DM halos?



Galaxy formation is an unsolved problem with no `*ab initio*' predictive theory

simulation by Greg Stinson

How do galaxies assemble their stellar bodies?

Collection of large samples at large lookback times

- Redshift surveys
- Multi-wavelength photometric surveys
- Hubble Space Telescope imaging surveys
- Deep spectroscopic surveys?

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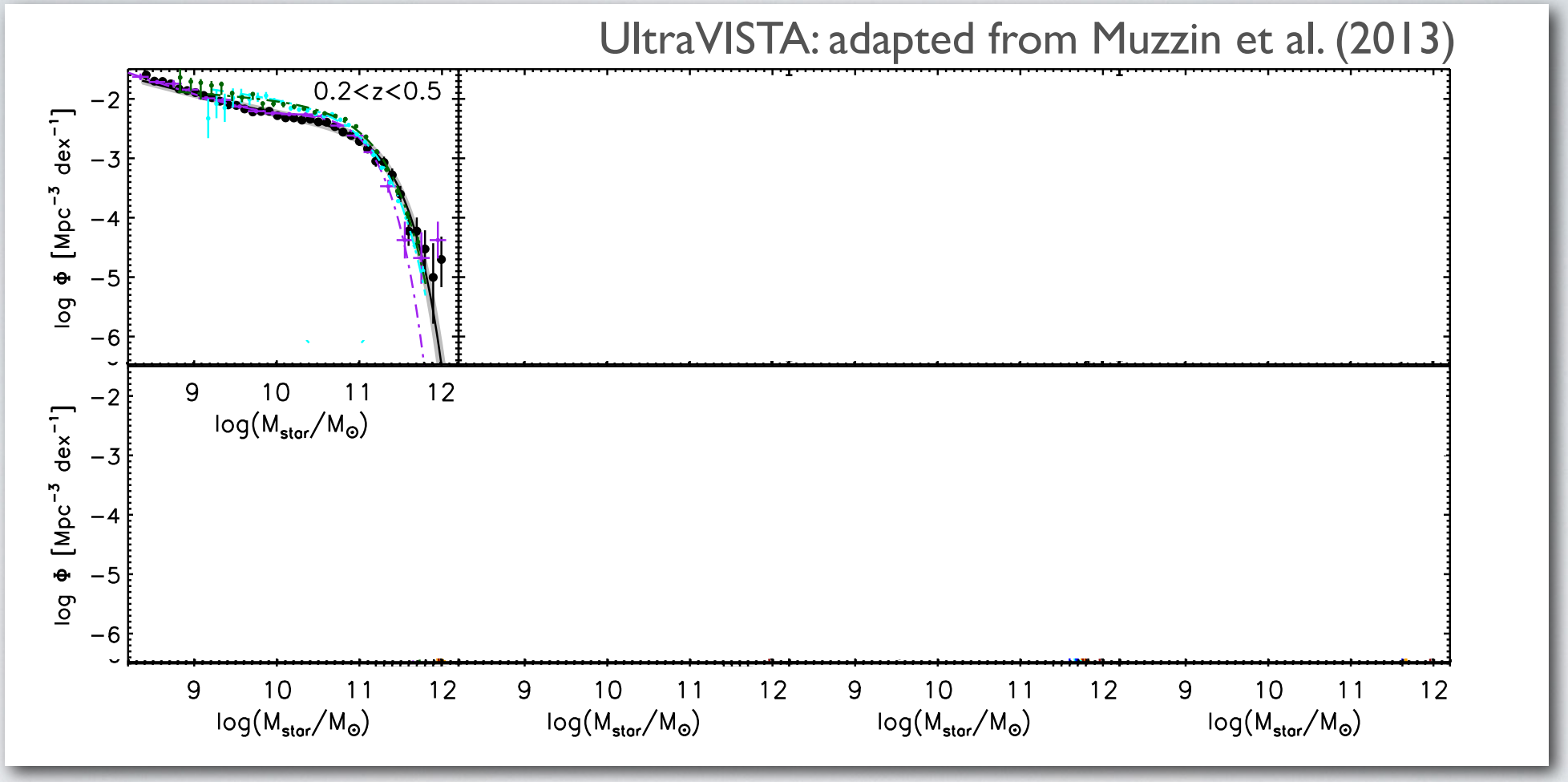
EVOLUTION OF THE MASS FUNCTION



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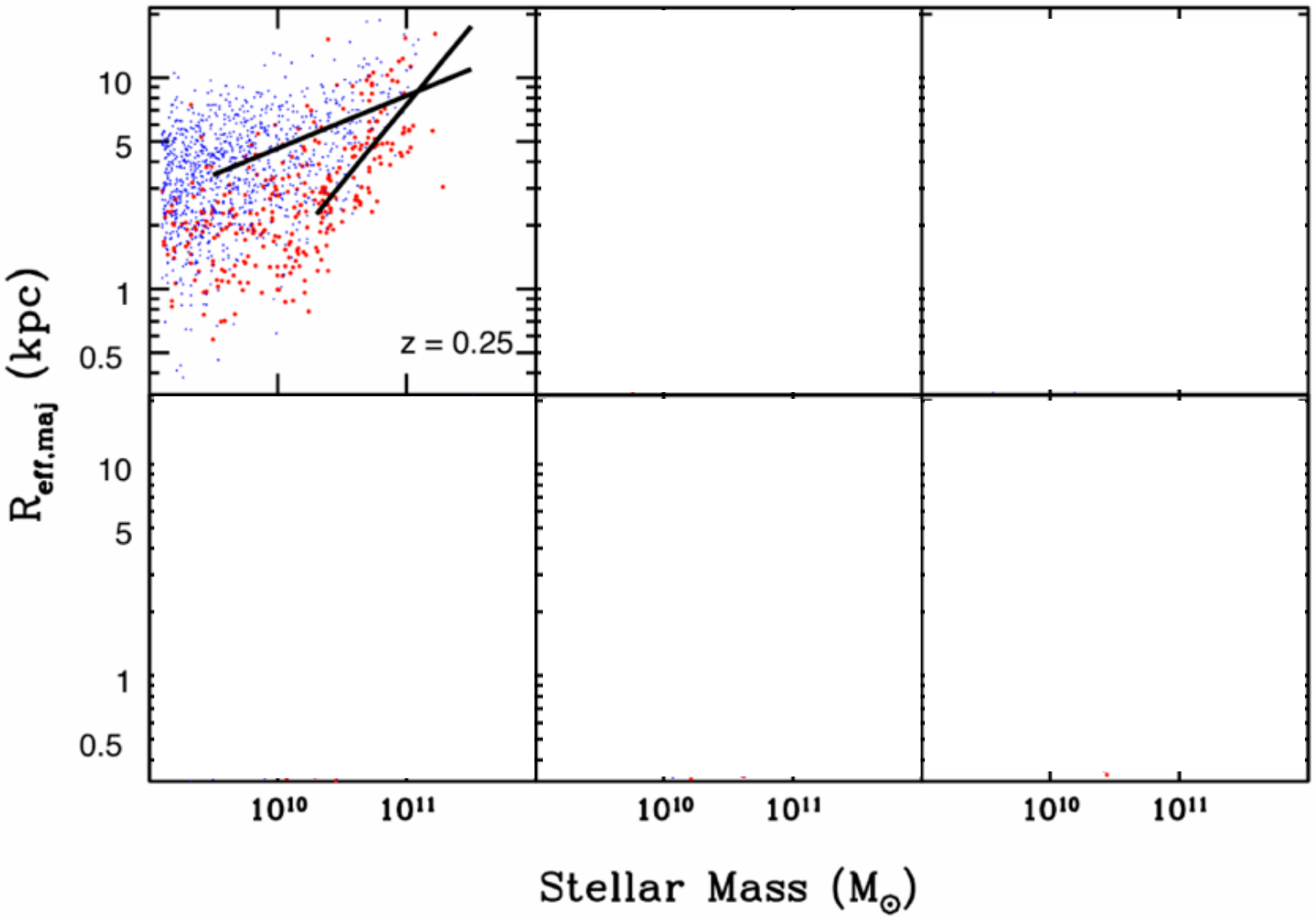
Evolution of the Size Distribution

CANDELS + 3D-HST: van der Wel et al. (2014a)



Where we are now…

We have a detailed census and phenomenological description …

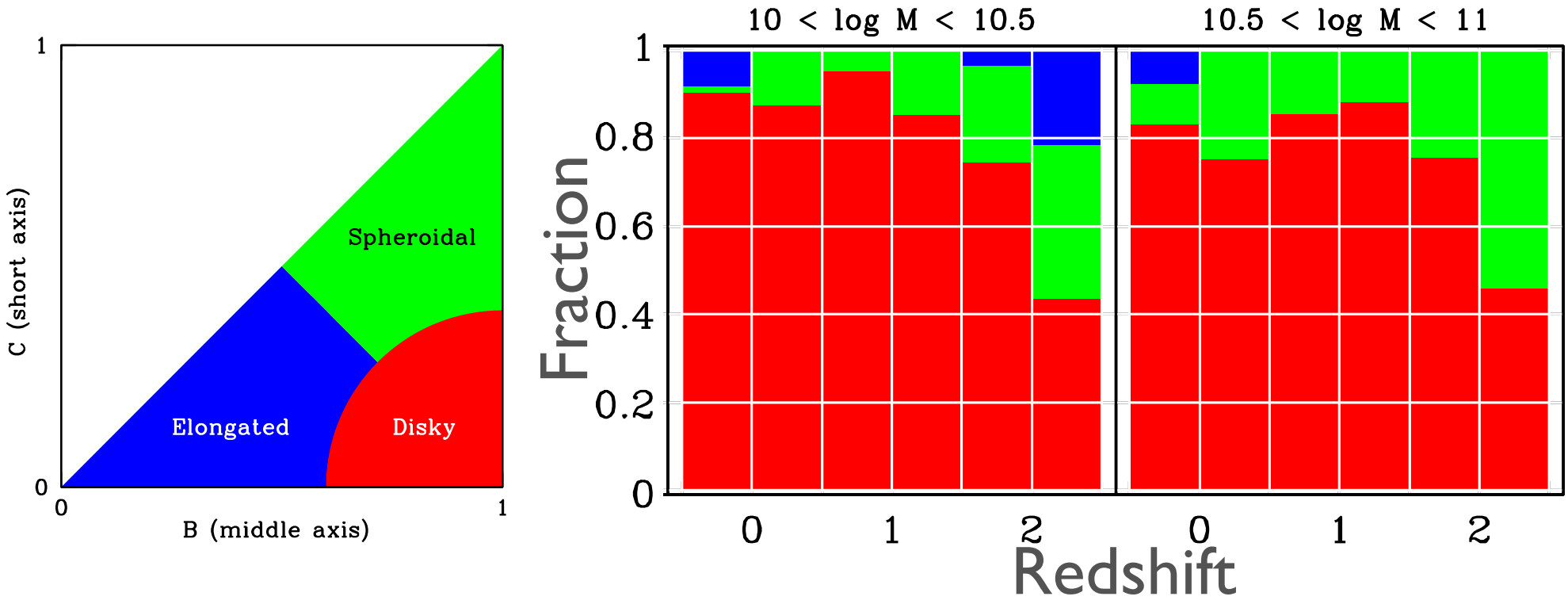
- No change in M* (in Schechter) over 10 Gyr
- Evolution in number density
- Quenching
- Star formation inside-out
- Assembly through merging

… allowing us to make sweeping statements, e.g.,

The majority of all stars formed in disk galaxies with similar mass as the present-day Milky Way (*van der Wel et al. 2014b*)

Where we are now…

Profound insights into galaxy formation



The majority of all stars formed in disk galaxies with similar mass as the present-day Milky Way (*van der Wel et al. 2014b*)

The Challenge

Understanding the 3 Phases of Galaxy Formation

- What is the evolutionary history of star-forming disks?
- Why do those disks stop growing, and galaxies become quiescent?
- To what extent do quiescent galaxies keep growing by merging?

We need ages, chemical composition and dynamical masses of a large sample of galaxies at large loopback time.

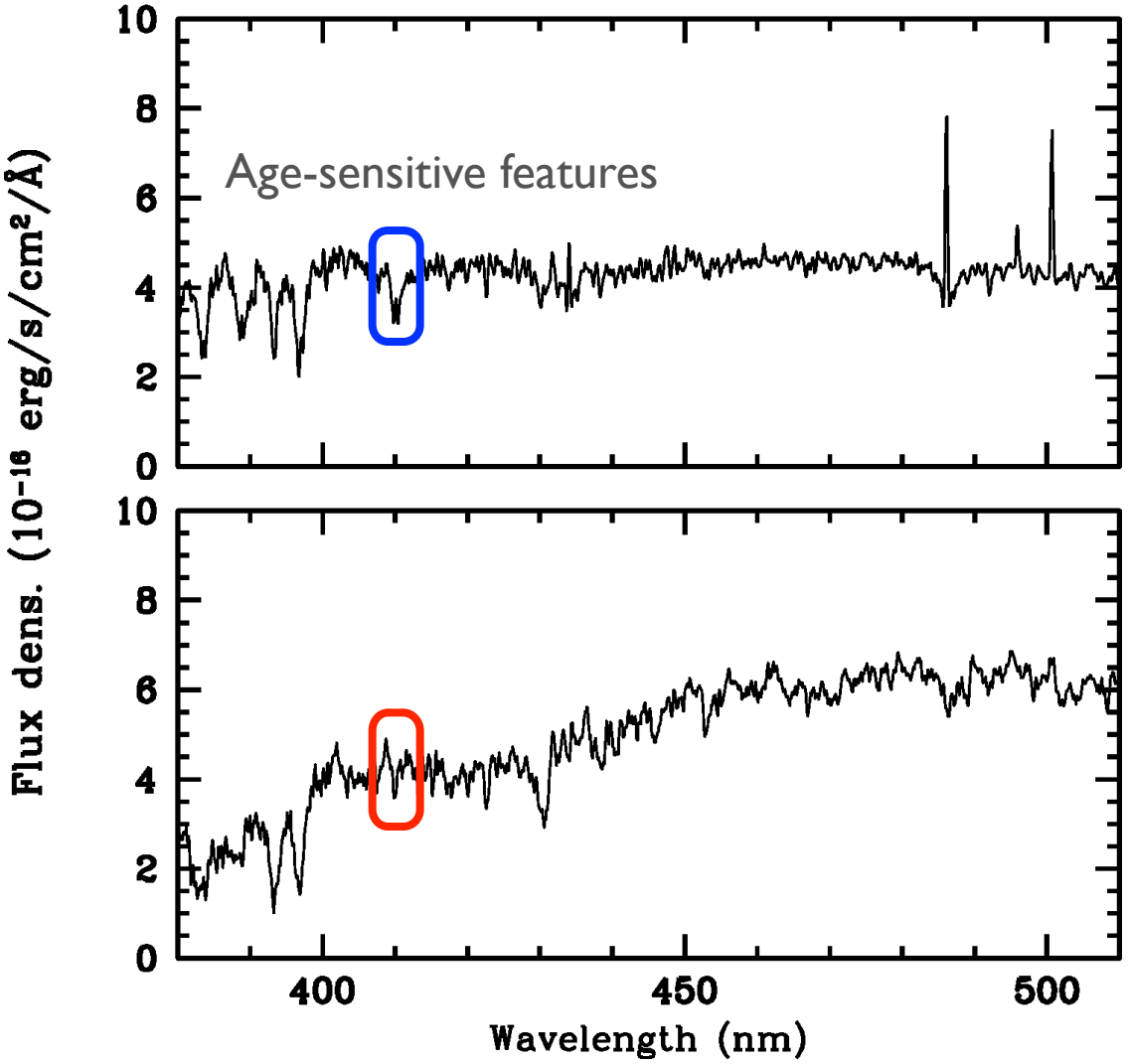
Addressing the central question

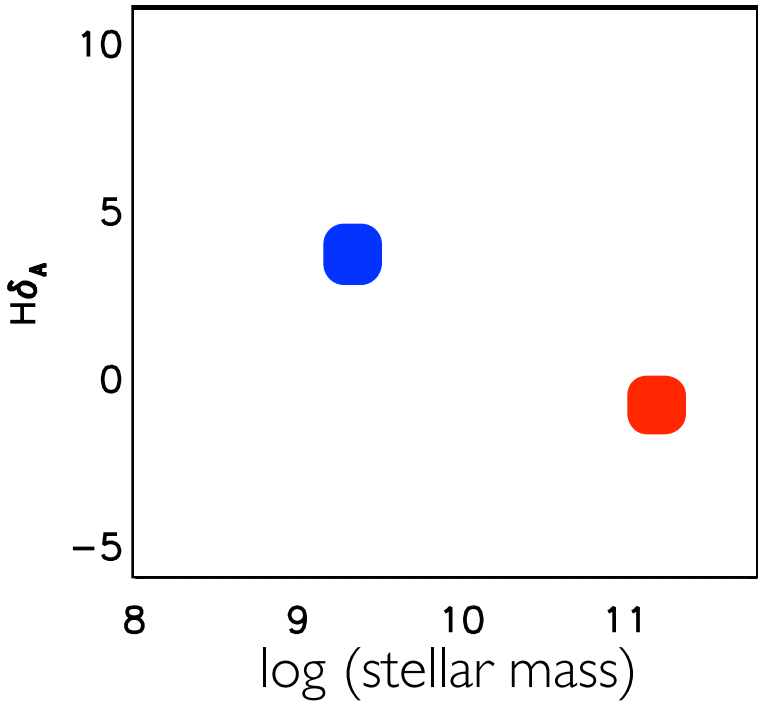
How do galaxies assemble their stellar bodies?

Collection of large samples at large lookback times

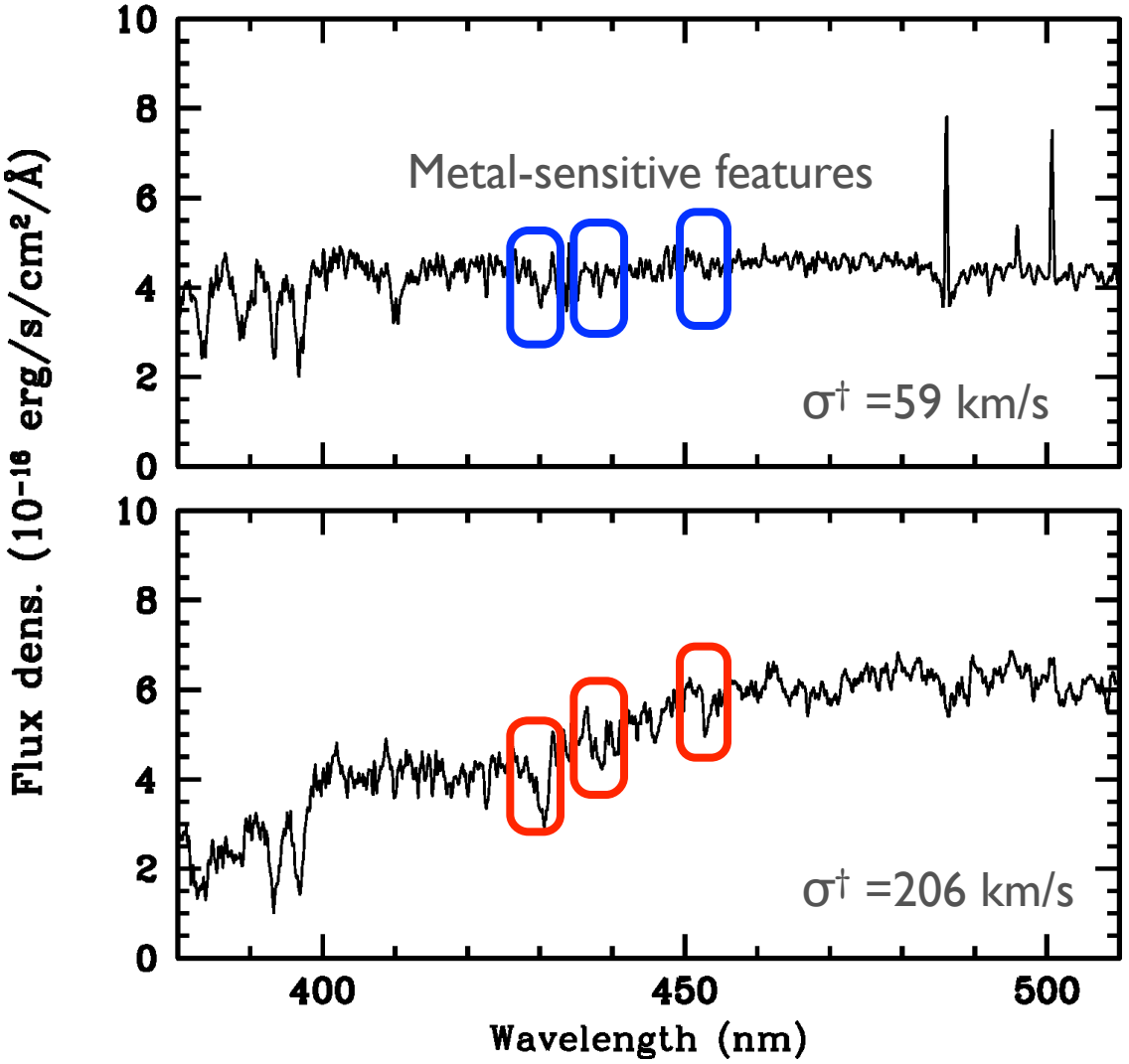
- Redshift surveys
- Multi-wavelength photometric surveys
- Hubble Space Telescope imaging surveys
- Deep spectroscopic surveys?

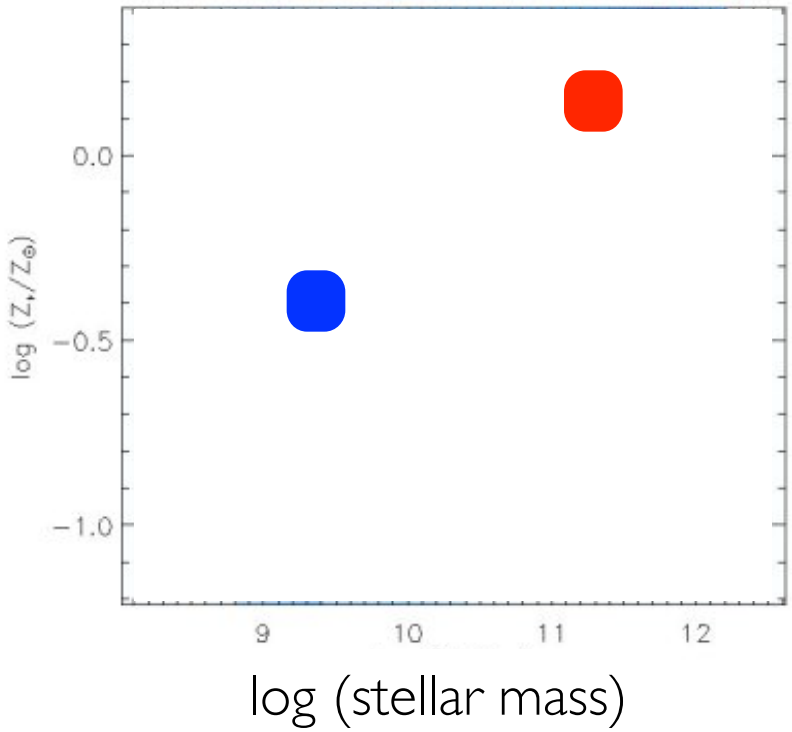
The legacy of SDSS spectra





The legacy of SDSS spectra





† σ: stellar velocity dispersion, measured from Doppler broadening of absorption lines

LEGA-C

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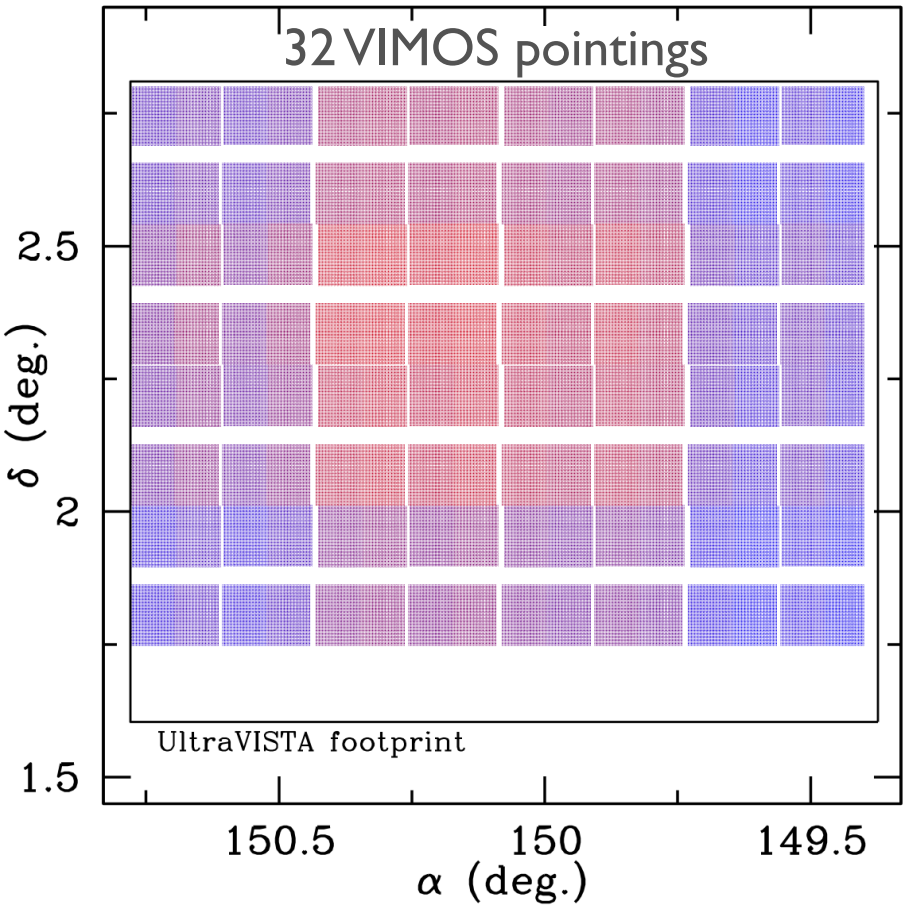
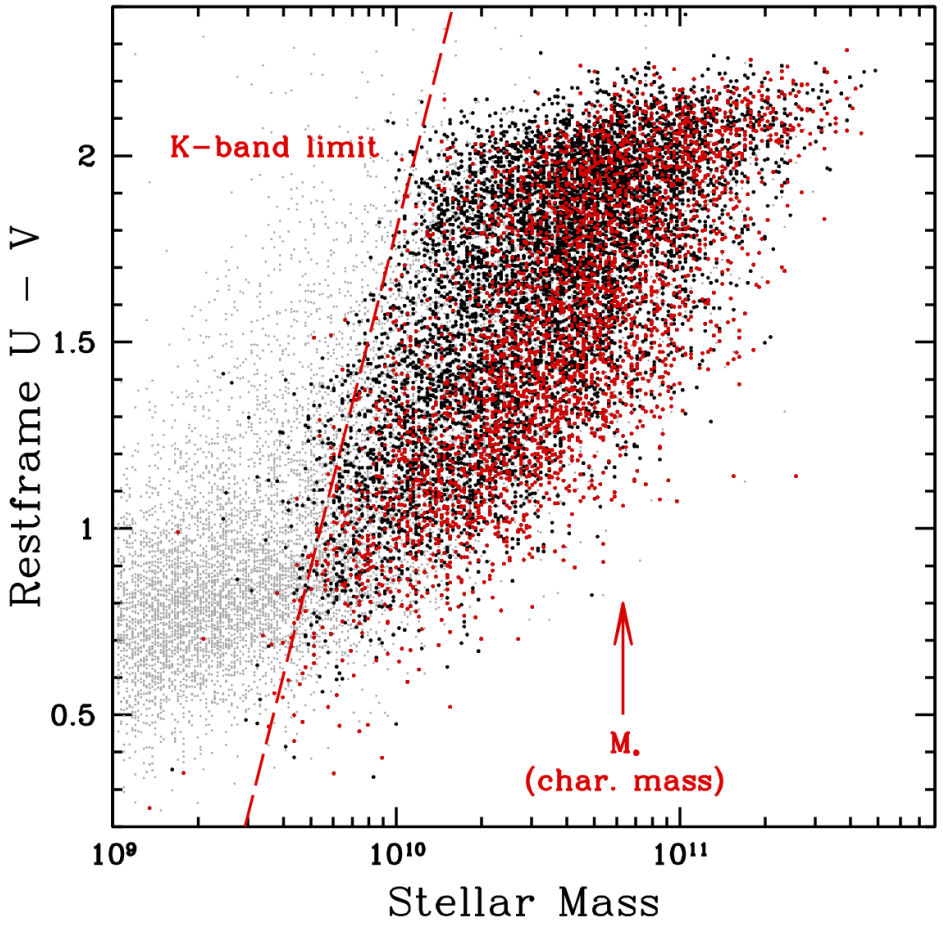
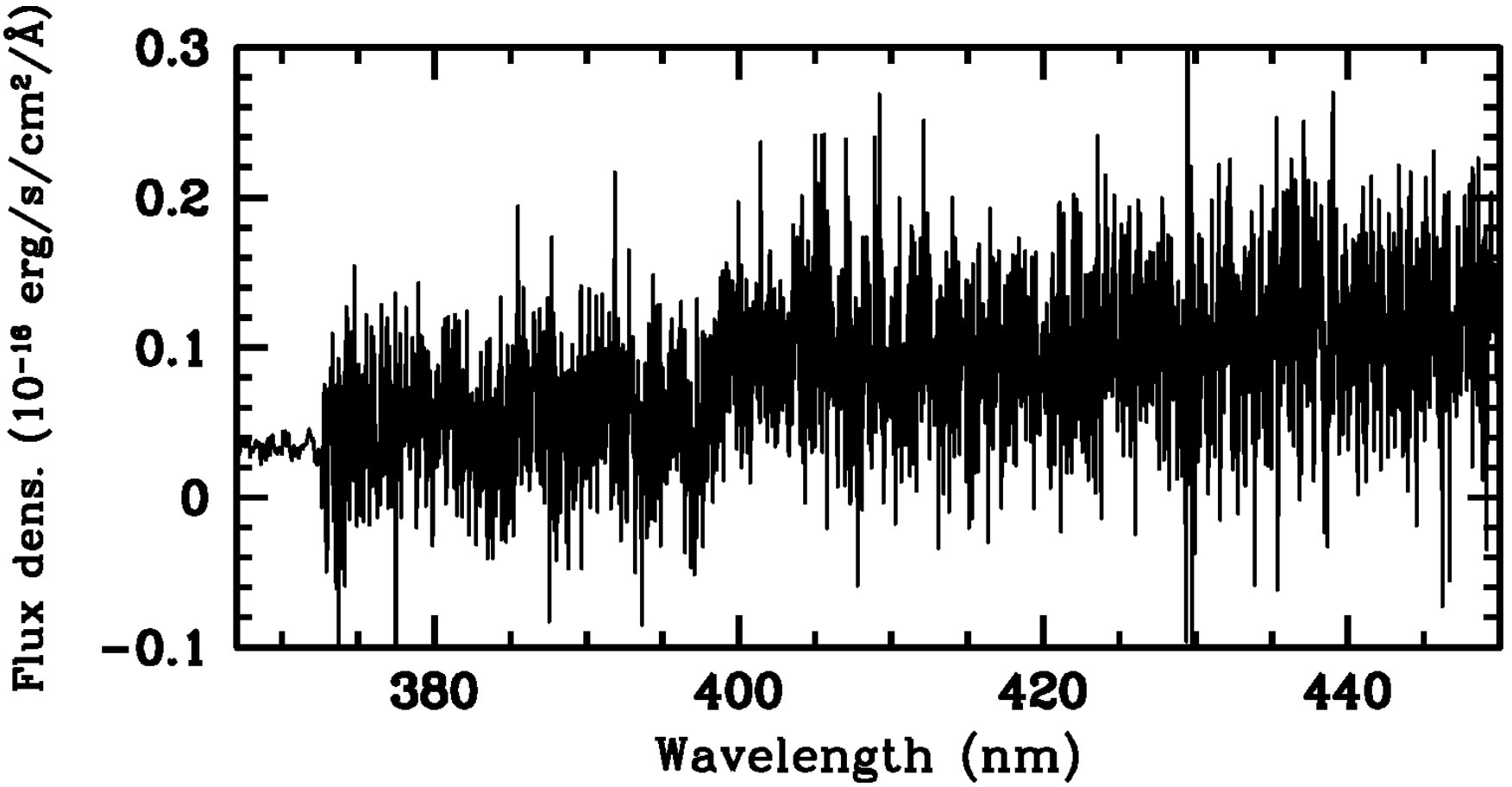


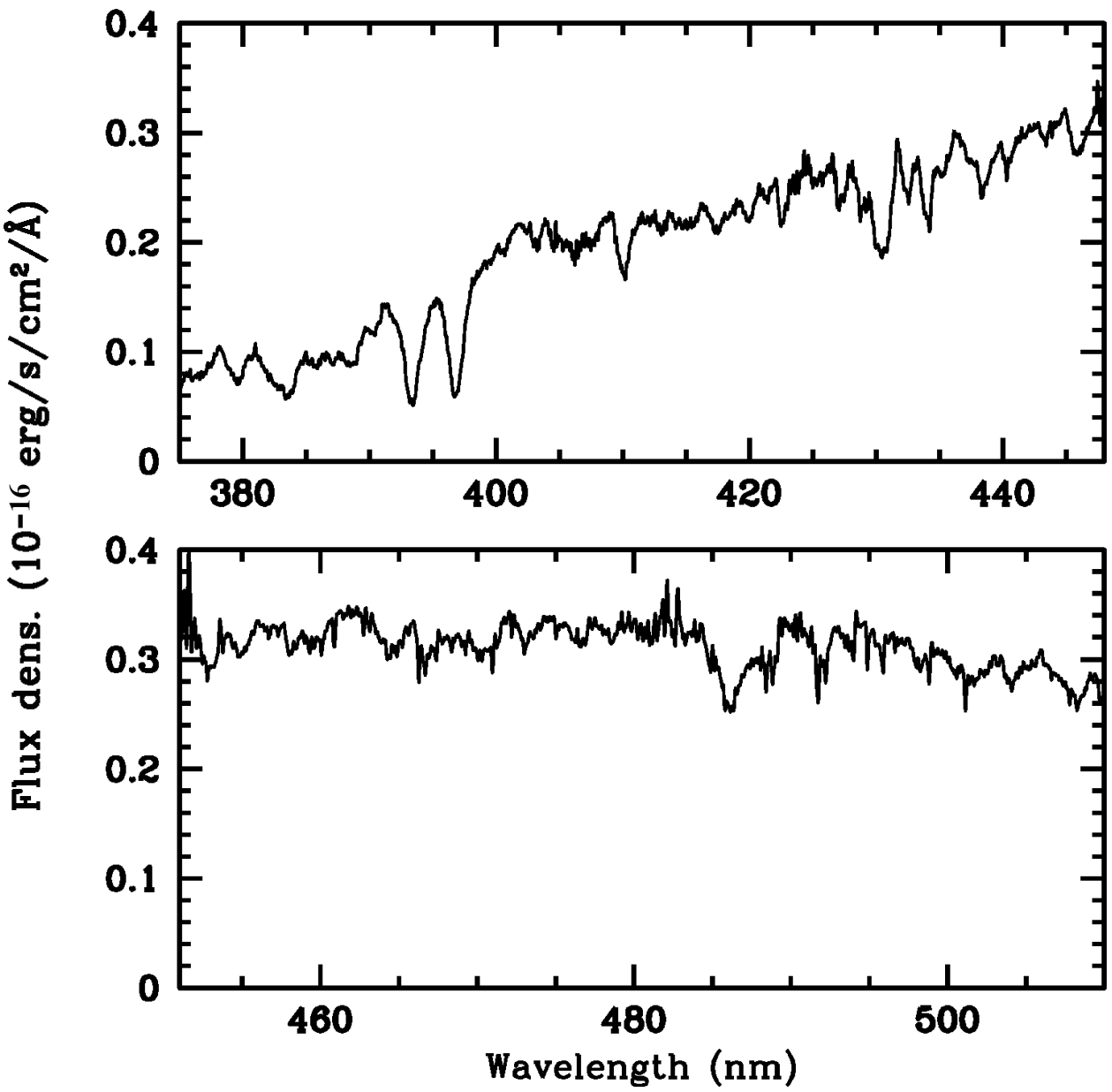


K-band selected from UltraVISTA (Muzzin et al. catalog) in the COSMOS field

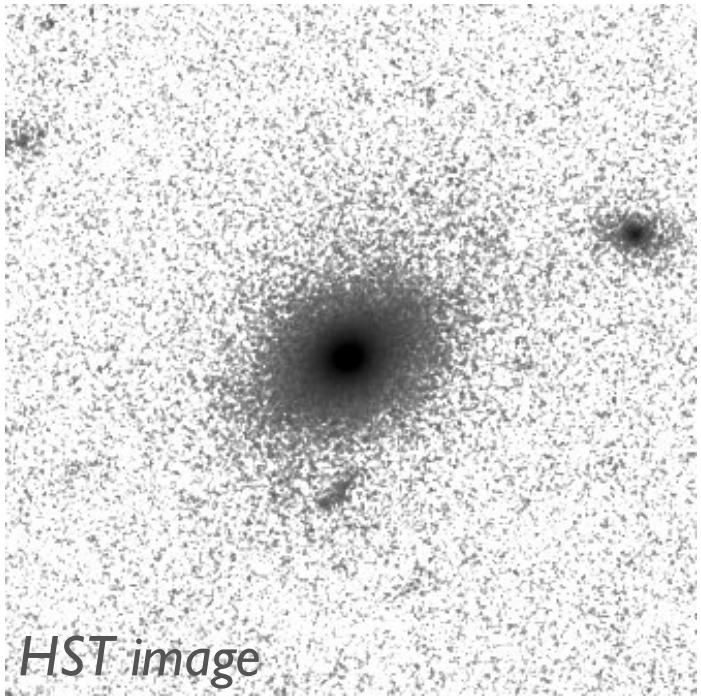
Typical spectrum from redshift surveys



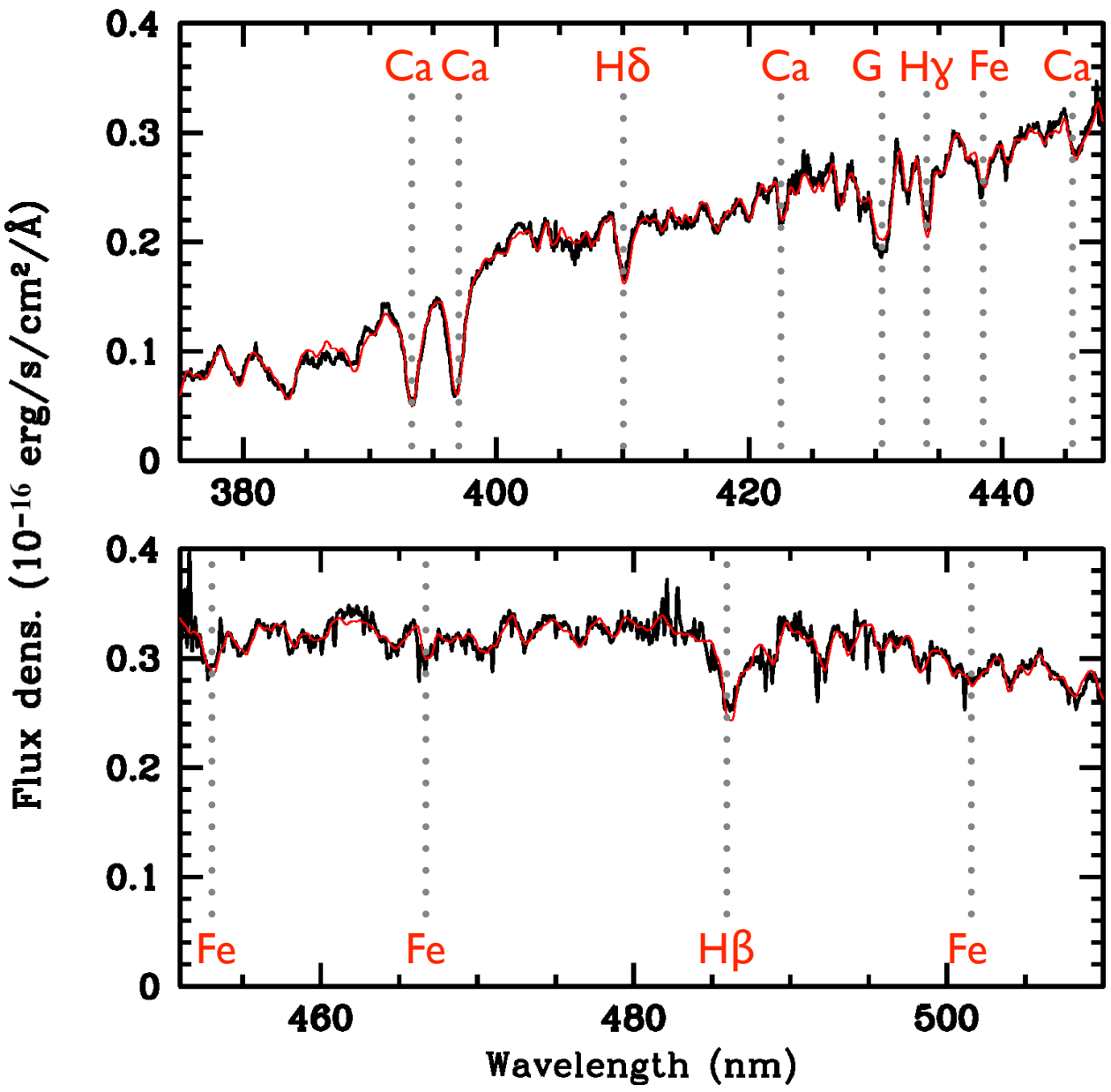
What LEGA-C Spectra Reveal



- Redshift: 0.70 (6.3 Gyr ago)
- Stellar mass:
  $M_* = 1.4 +/- 0.5 \times 10^{11}$ Msol
  (~2.5-3 x Milky Way)

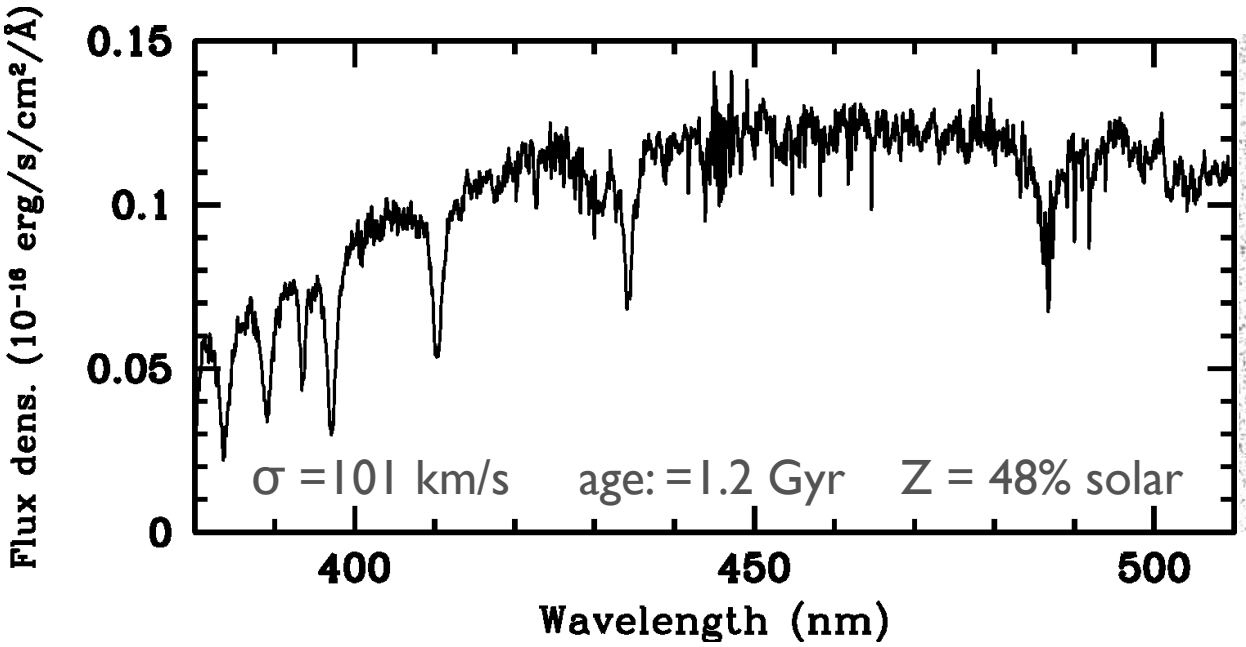


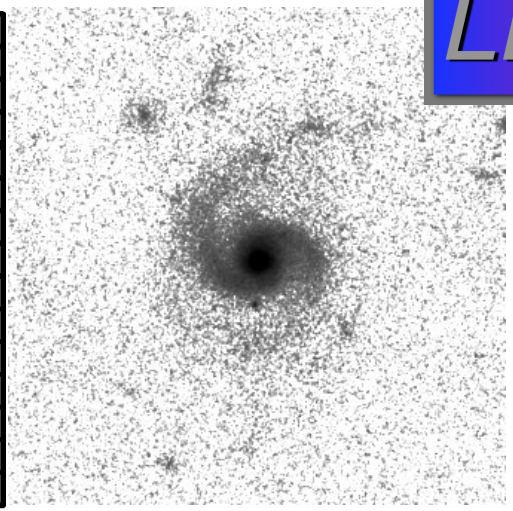
What LEGA-C Spectra Reveal



- Redshift: 0.70 (6.3 Gyr ago)
- Stellar mass:
  $M_* = 1.4 +/- 0.5 \times 10^{11}$ Msol
  (~2.5-3 x Milky Way)
- Stellar velocity dispersion:
  154 +/- 6 km/s
- Dynamical mass:
  $1.5 +/- 0.3 \times 10^{11}$ Msol
- Mean stellar age:
  2.9 +/- 0.3 Gyr
- Metal content:
  65% +/- 7% solar

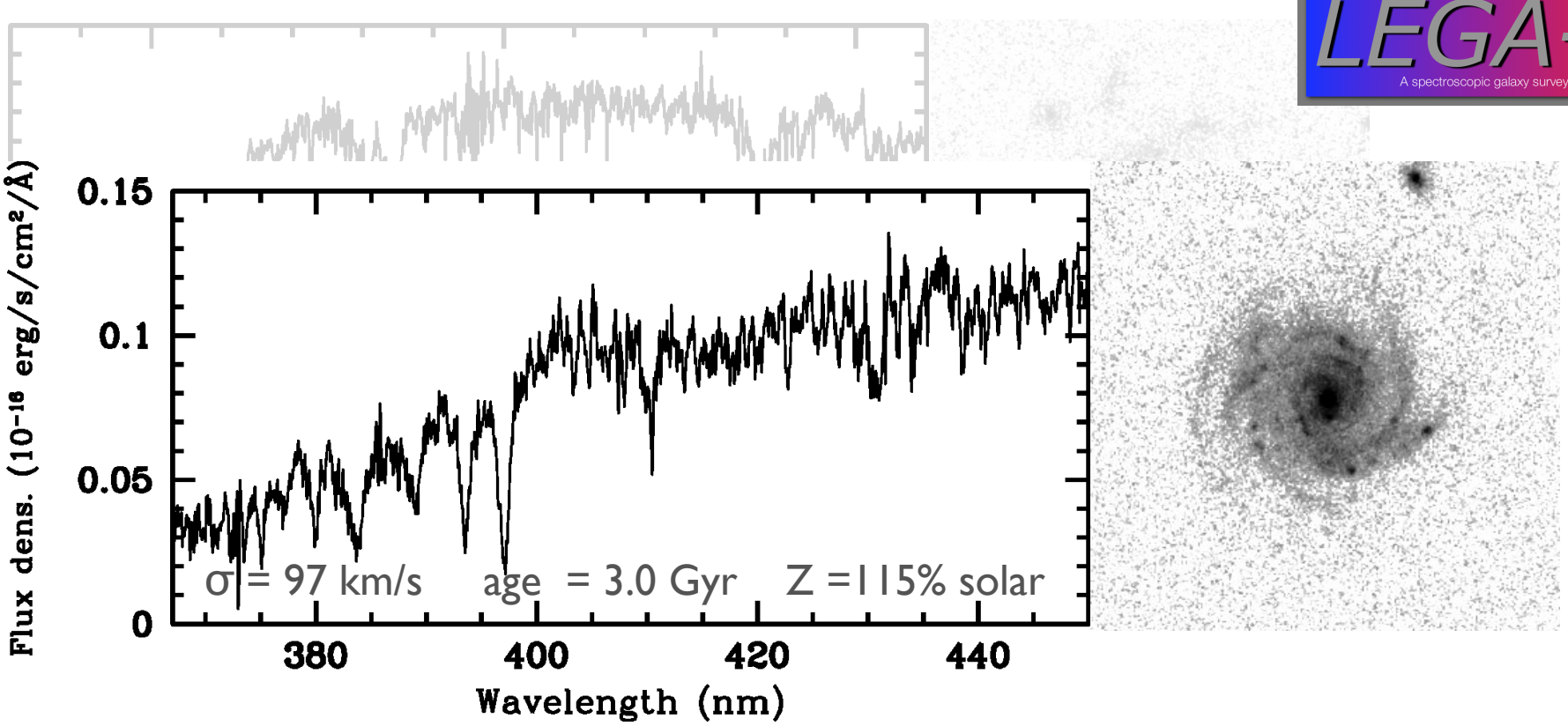
What LEGA-C Spectra Reveal





Post-starburst galaxies (mergers?):
Young stellar population / no ongoing star formation

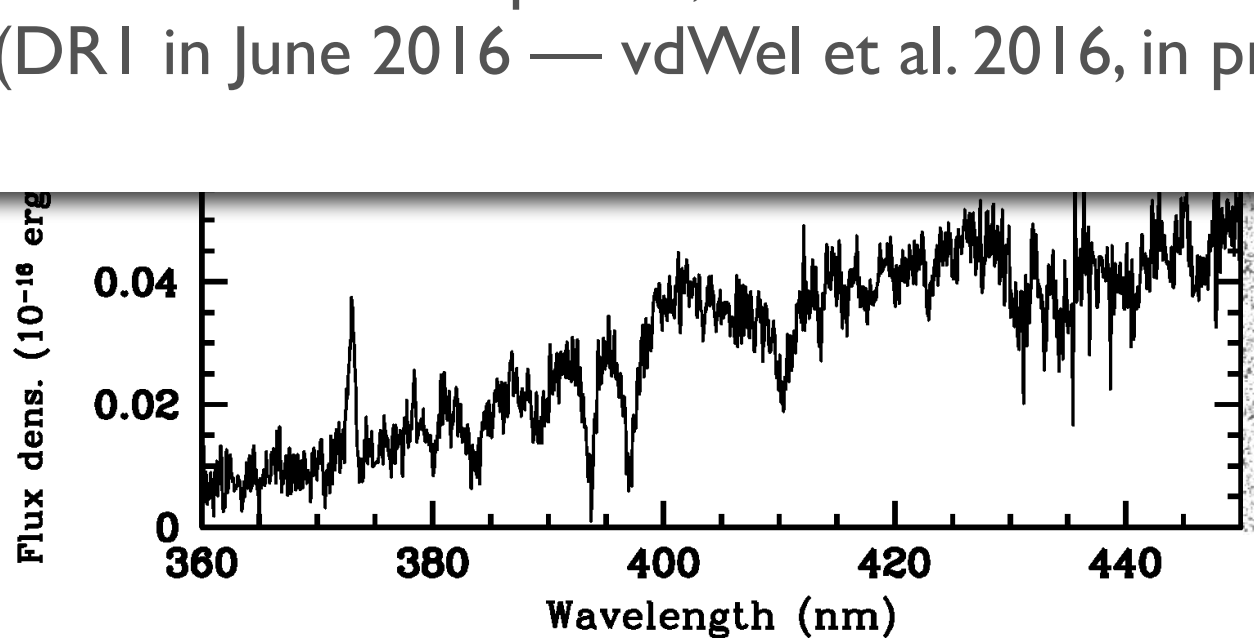
What LEGA-C Spectra Reveal

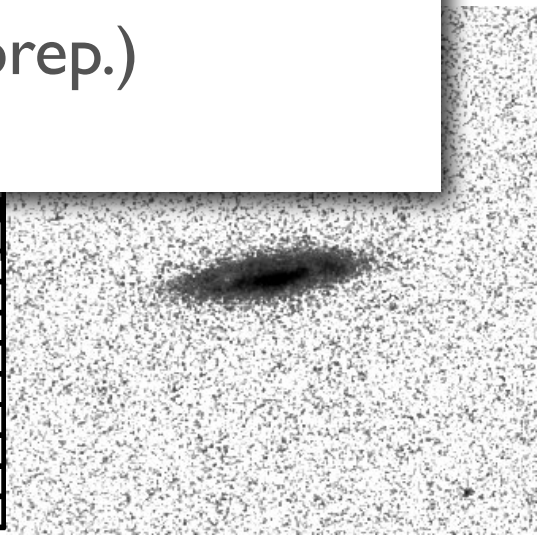


Star-forming galaxies (disks with spirals):
Old stellar population / ongoing star formation

What LEGA-C Spectra Reveal

~2500 such spectra; ~600 in hand now
(DR1 in June 2016 — vdWel et al. 2016, in prep.)

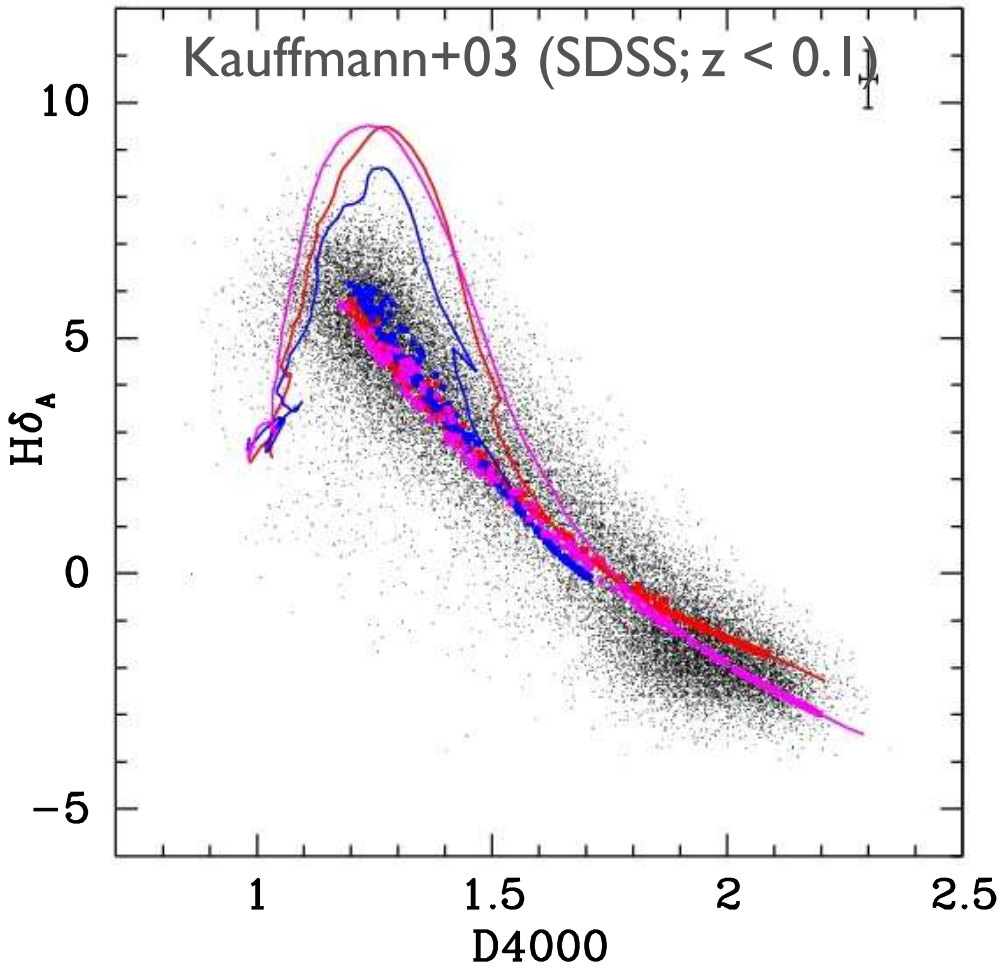




Dusty star-forming galaxies / edge-on disks:
Old stellar population / ongoing star formation

What LEGA-C Spectra Reveal

Distribution of age indicators: D4000 and Hδ



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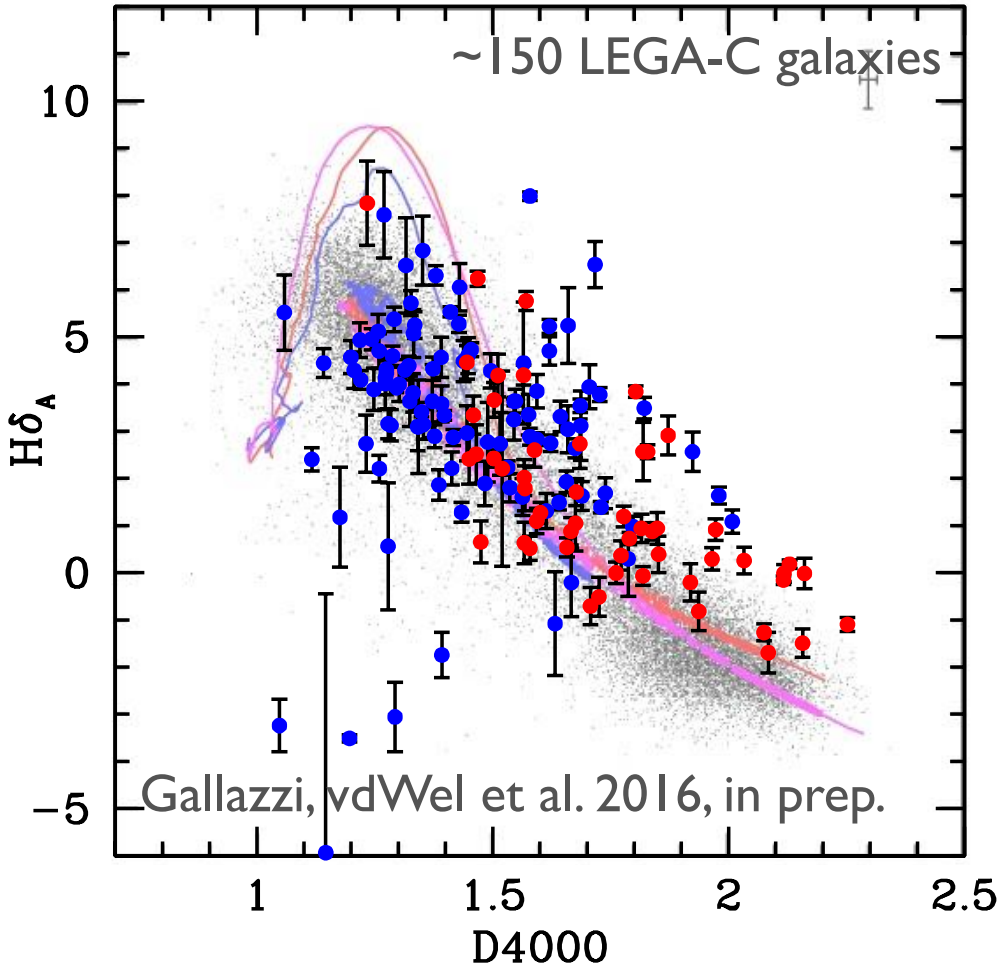

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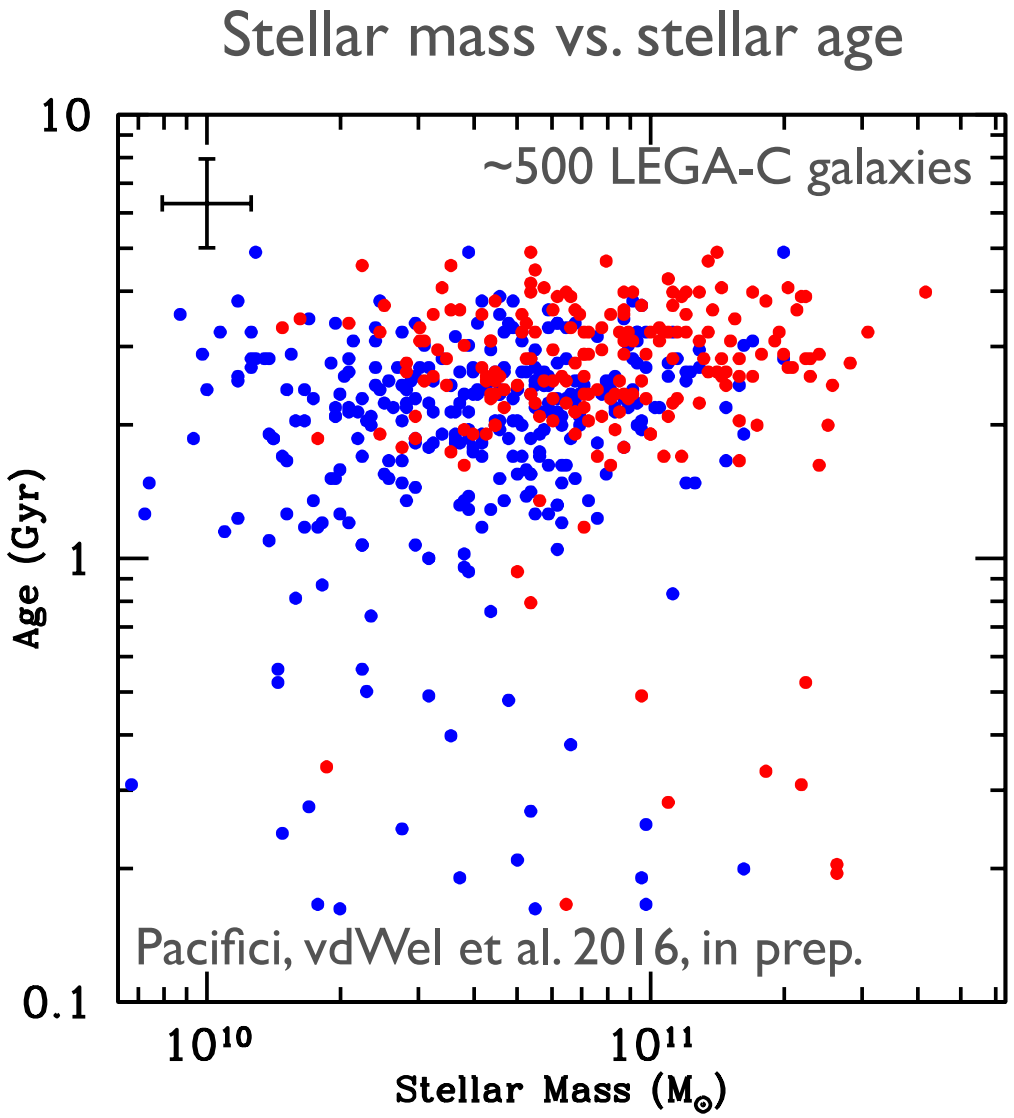

Goals of LEGA-C

Understanding the physics of the 3 phases of galaxy evolution

- The Star Formation phase
  Reconstruct the star formation history across the galaxy population
- The Quenching Phase
  Identify what conditions trigger star formation quenching, and how it proceeds
- The Stellar Accretion phase
  Show to what extent galaxies galaxies continue to grow after quenching

Summary

- LEGA-C is a 128-night survey with VLT/VIMOS: deep continuum spectroscopy of ~2500 galaxies at z = 0.6 — 1
- LEGA-C will reveal the physics of galaxy formation by measuring the evolution of stellar populations over the past 7 Gyr
- Observations started in 10 months ago; we have collected 22% of data
- First Data Release (spectra) by June 1st, 2016
- Second Data Release (spectra + phys. parameters) by Dec 1st, 2016

Thank you

Resolved stellar kinematics at z = 1

van der Wel & van der Marel 2008