Can stellar sources form enough dust in galaxies?

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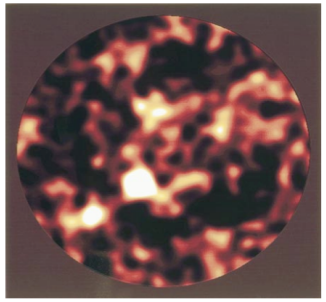
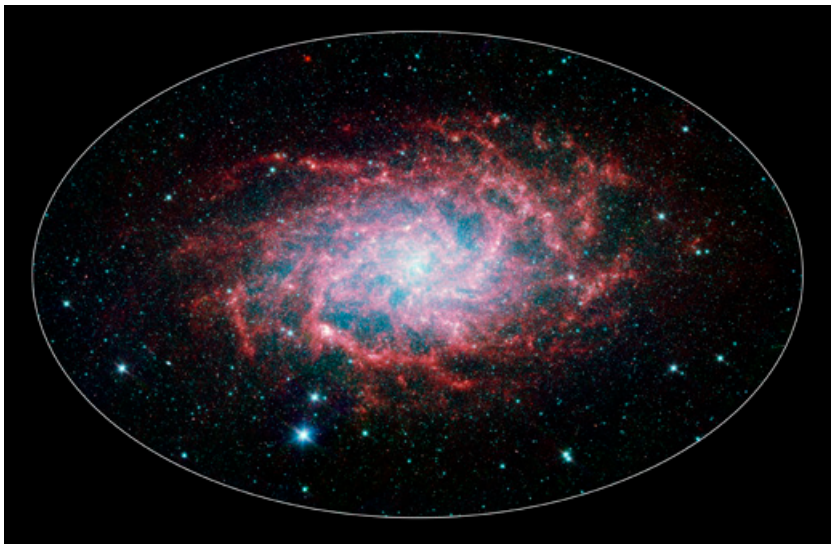
Importance of dust

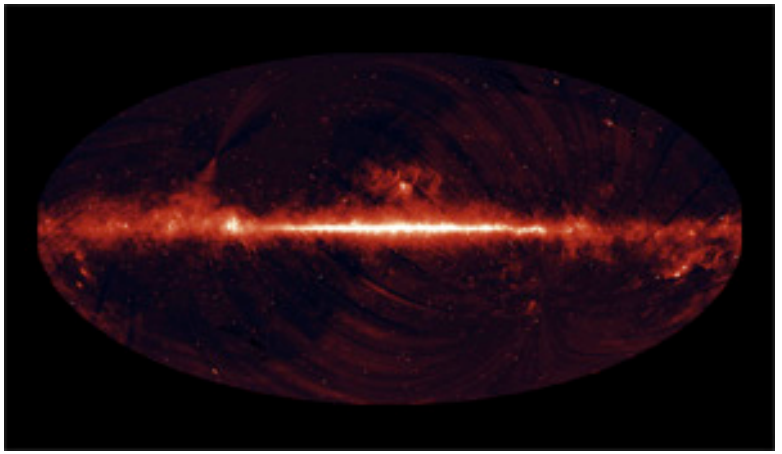
- Dust is found in the interstellar media (ISM) of many galaxies



Submm-galaxies
(z~6.4)

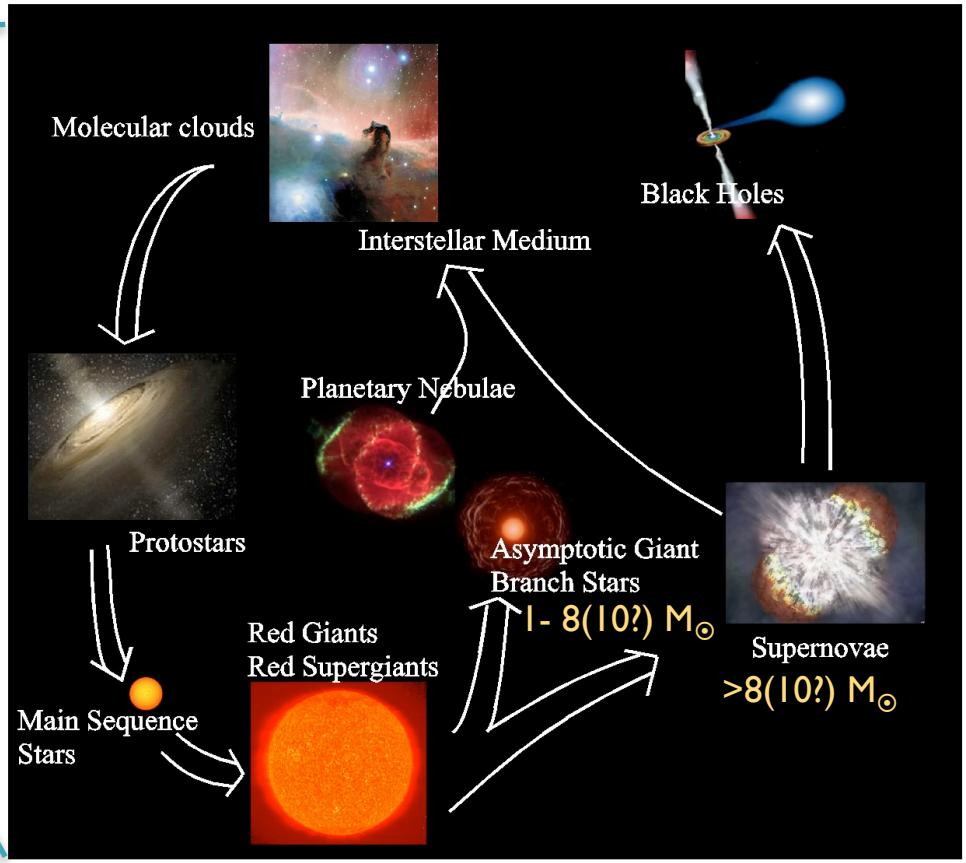


M33
Spitzer 3.6, 4.5 and 8.0 micron



Infrared image of the Milky Way (90 micron)

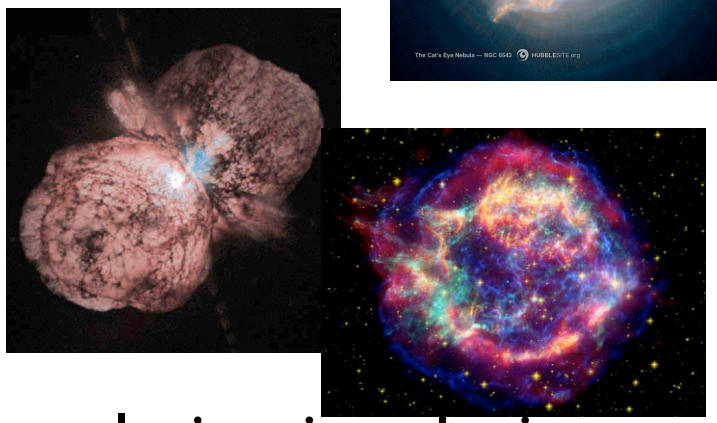
Lifecycle of dust in galaxies



Concept of cycle of matter
Past: Theory/models
(population synthesis/chemical evolution models of galaxies)

The origins of dust

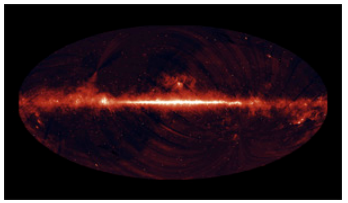
- The origins of dust : evolved stars
  - Low-and intermediate-mass (1-8 $M_\odot$) stars
    - Asymptotic Giant Branch (AGB) stars
  - High mass (>8 $M_\odot$) stars
    - Luminous blue variables (LBVs)
    - Wolf Rayet (WR) stars
    - Red supergiants
    - Supernovae?
  - Novae?

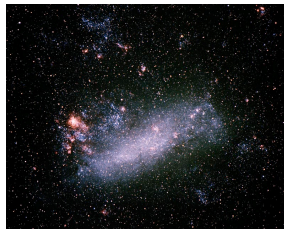


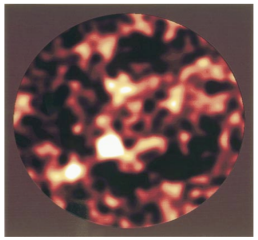
- To understand the origin of dust and its evolution in galaxies
  - Stellar population/stellar evolution + dust formation in stars

Questions related with evolution of dust in galaxies

- Can stellar sources form enough dust to account the mass present in galaxies?
  - Dispute
    - Observations
      - Milky Way: yes (Gehrz 1989); no (Tielens 2001)
      - Large Magellanic Cloud: no (Matsuura et al. 2009)
    - Models
      - Yes…. (default answer?)
      - Milky Way: yes (Dwek 1998); no (Zhukovska et al. 2008)
      - SDSS J1148+5251 (quasar at z = 6.4):yes (Valiante et al. 2009)
  - ELT will be able to make a significant step to resolve this situation
    - Observational constrains on metallicity age dependence of dust production

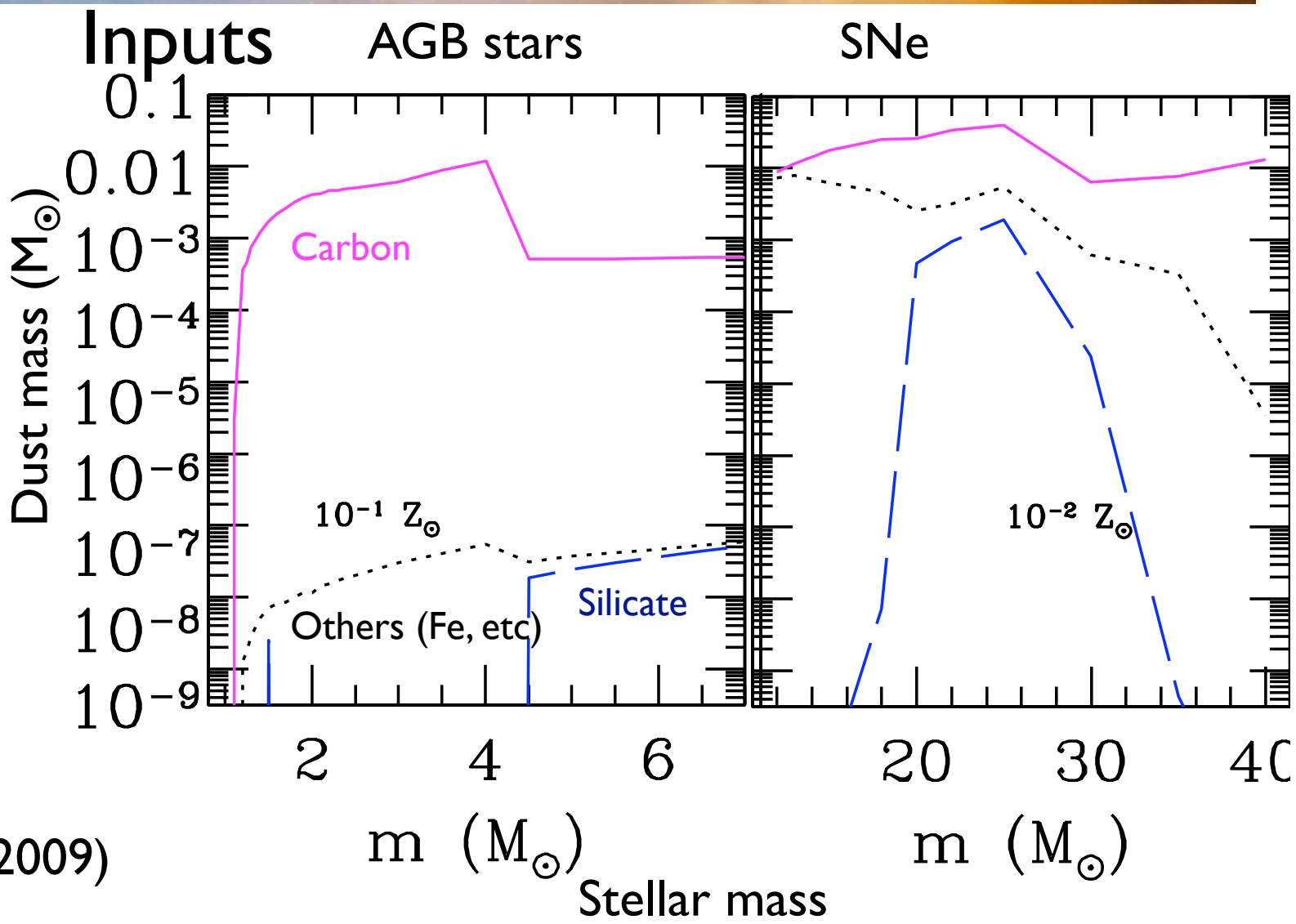






Case study (1): theoretical works

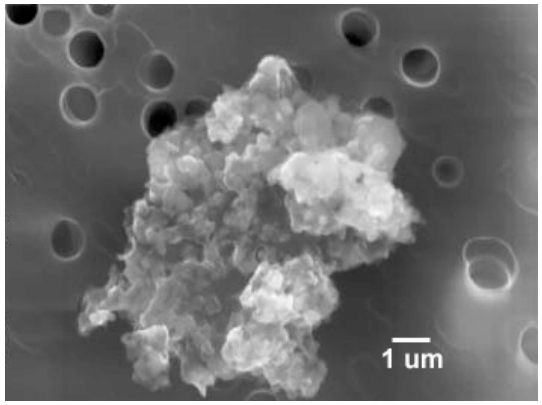
- Following chemical evolution of galaxies



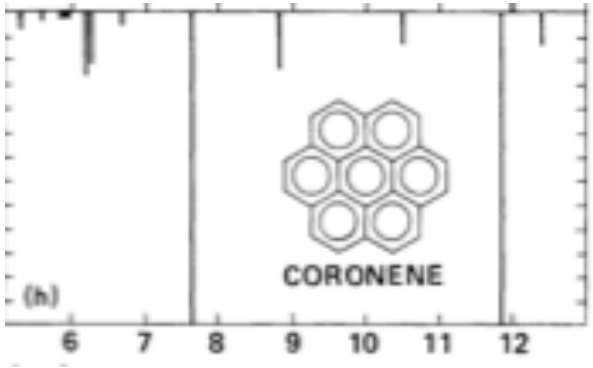
Valiante et al. (2009)

Can dust be formed at low metallicities? Dust needs (astronomical) metals!

- Oxides
  - Olivines : $Mg_{2x}Fe_{(2-2x)}SiO_4$
  - Pyroxenes : $Mg_xFe_{1-x}SiO_3$



- Carbonaceous dust
  - Graphite : C
  - Amorphous : C
  - Polycyclic aromatic hydrocarbons (PAHs)

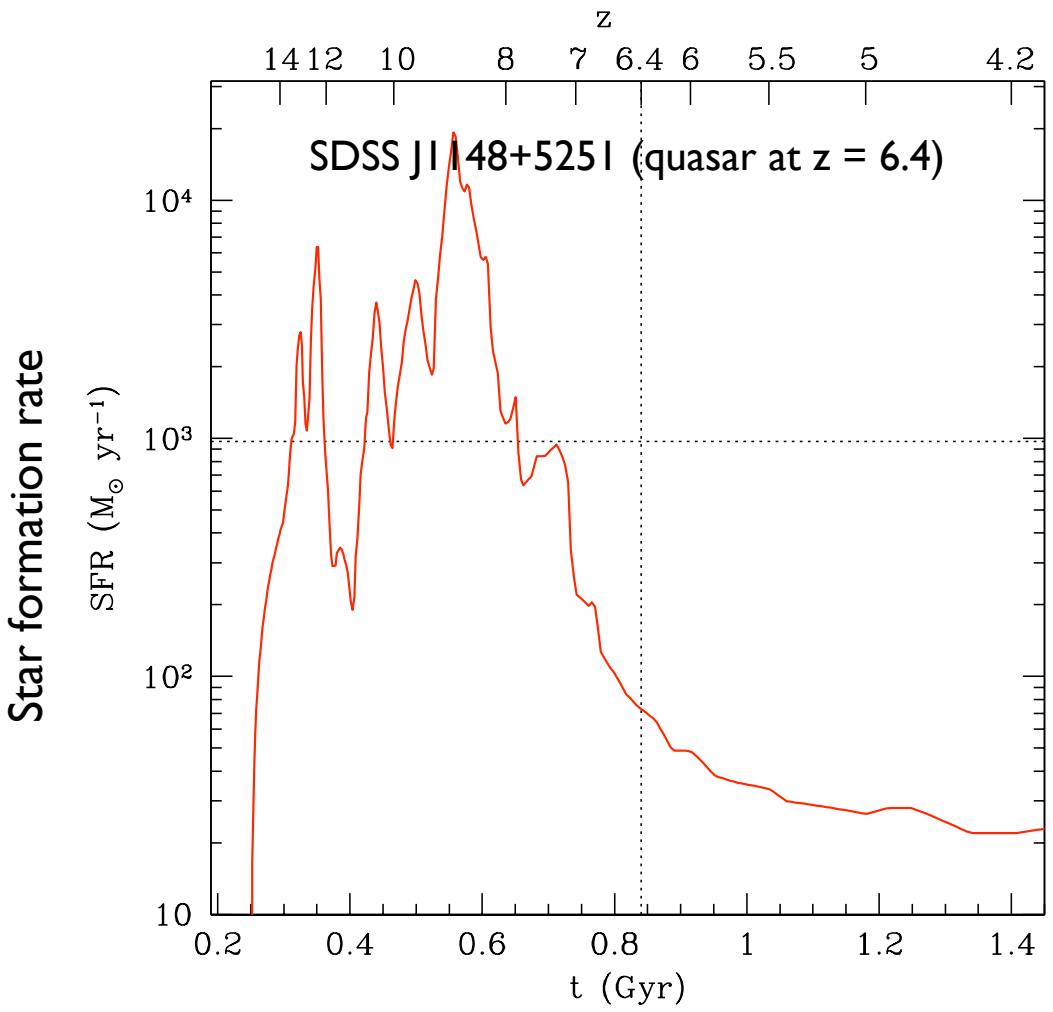


Dust mass : as a function of metallicity of the interstellar medium of galaxies. … but … elements synthesized in stars themselves affect the dust mass/ compositions (at least for carbon-rich AGB; Sloan, Matsuura et al. 2009, Science 323, 353)

Case study (1): theoretical works

Inputs

- Following chemical evolution of galaxies



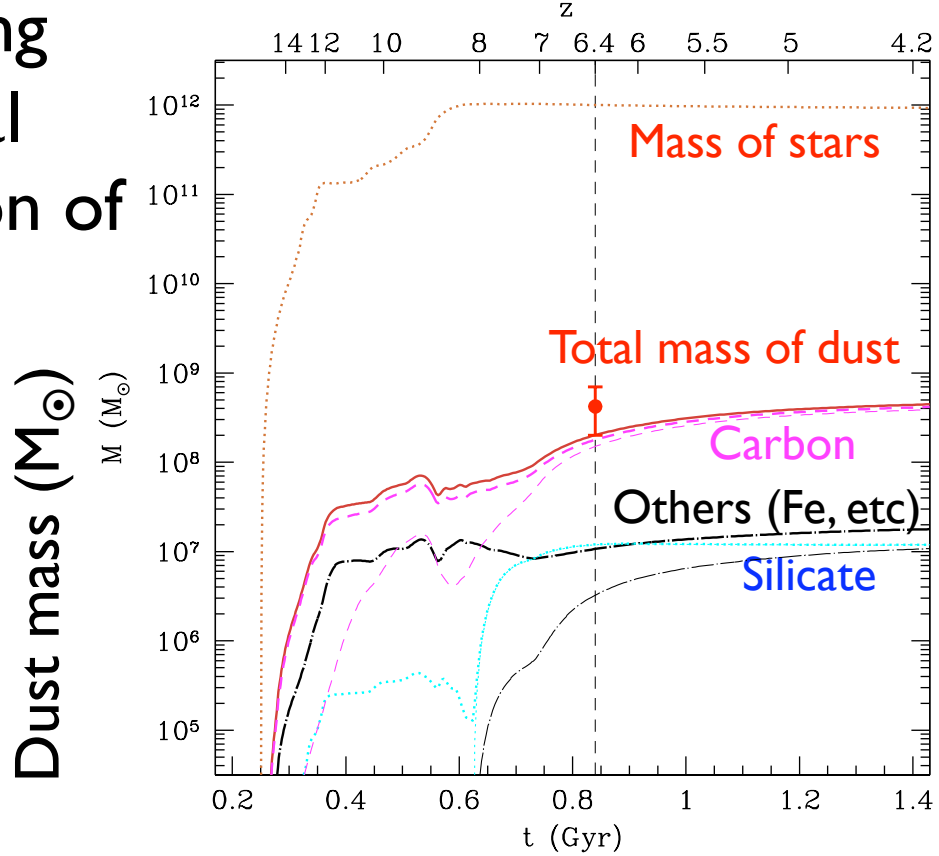
Time since the formation of galaxies

Valiante et al. (2009)

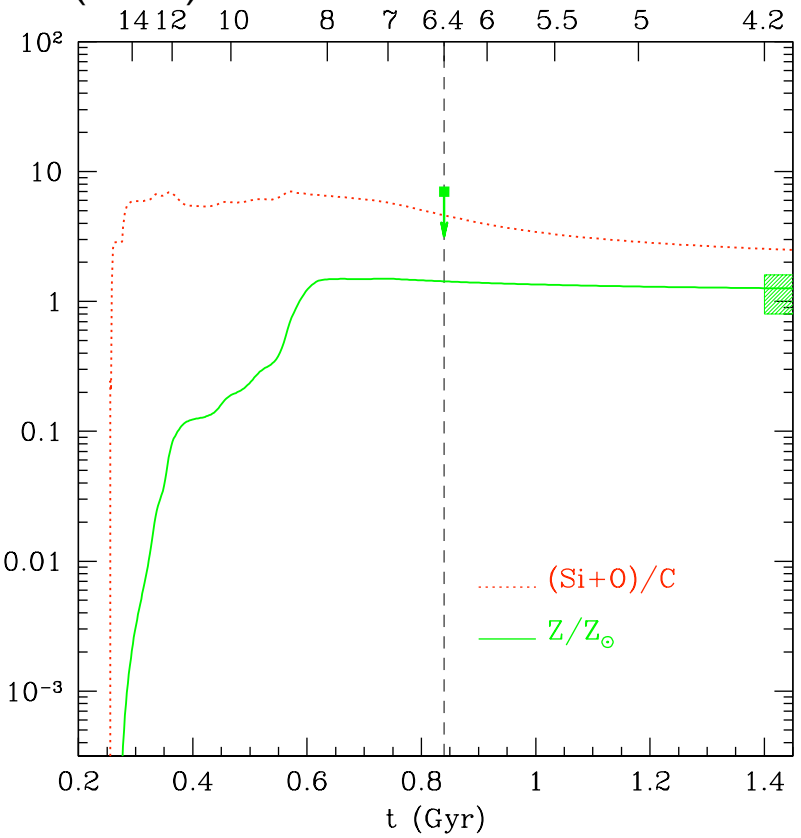
Case study (1): theoretical works

- Following chemical evolution of galaxies

Evolution of dust mass



Evolution of the metallicity and the (Si+O)/C elemental ratio



SDSS J1148+5251 (quasar at z = 6.4)

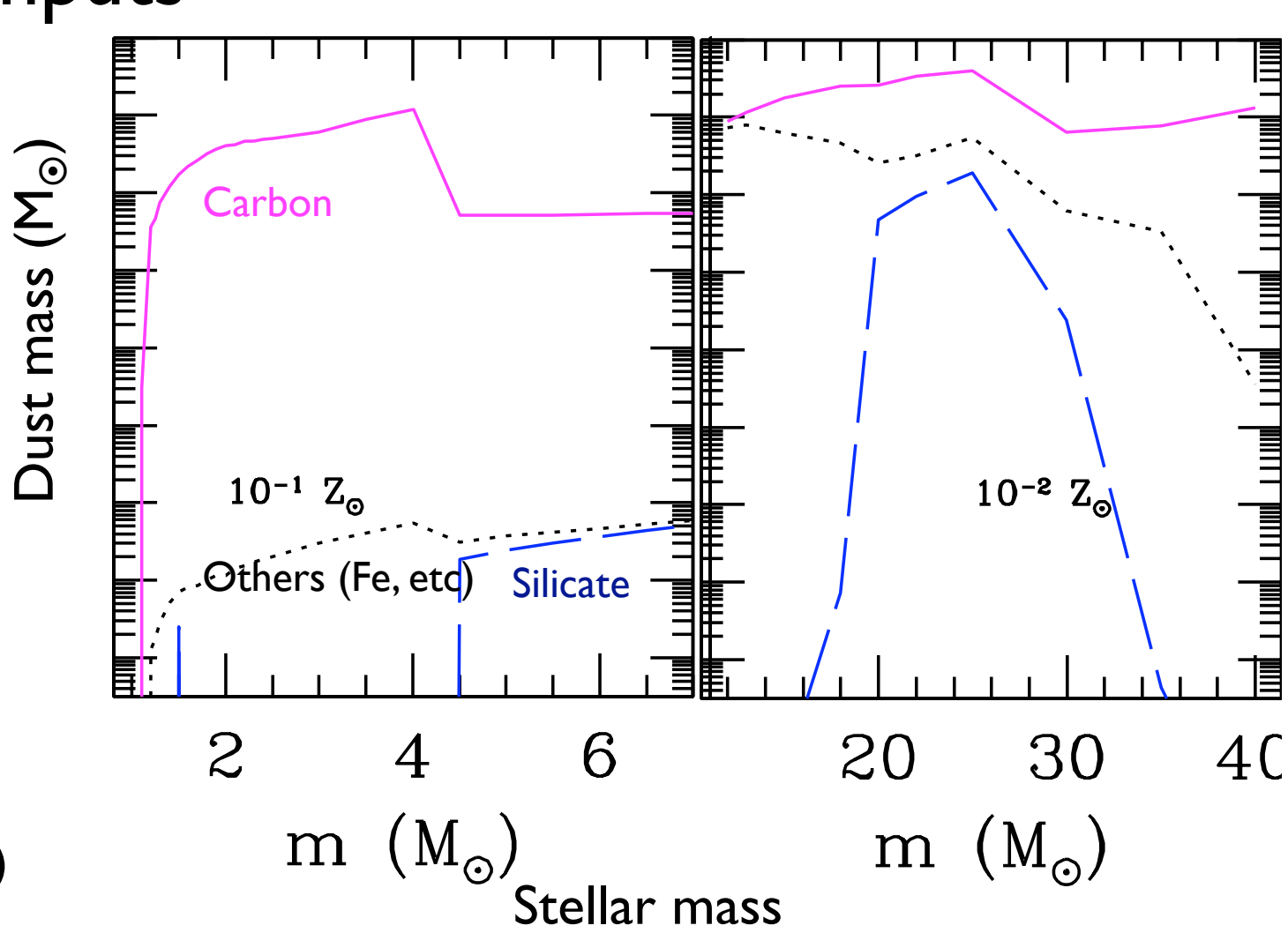
Valiante et al. (2009)

Time since the formation of galaxies

Case study (1): theoretical works

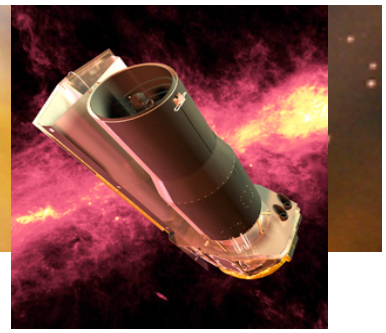
- Following chemical evolution of galaxies
- No observational constrains given

Inputs



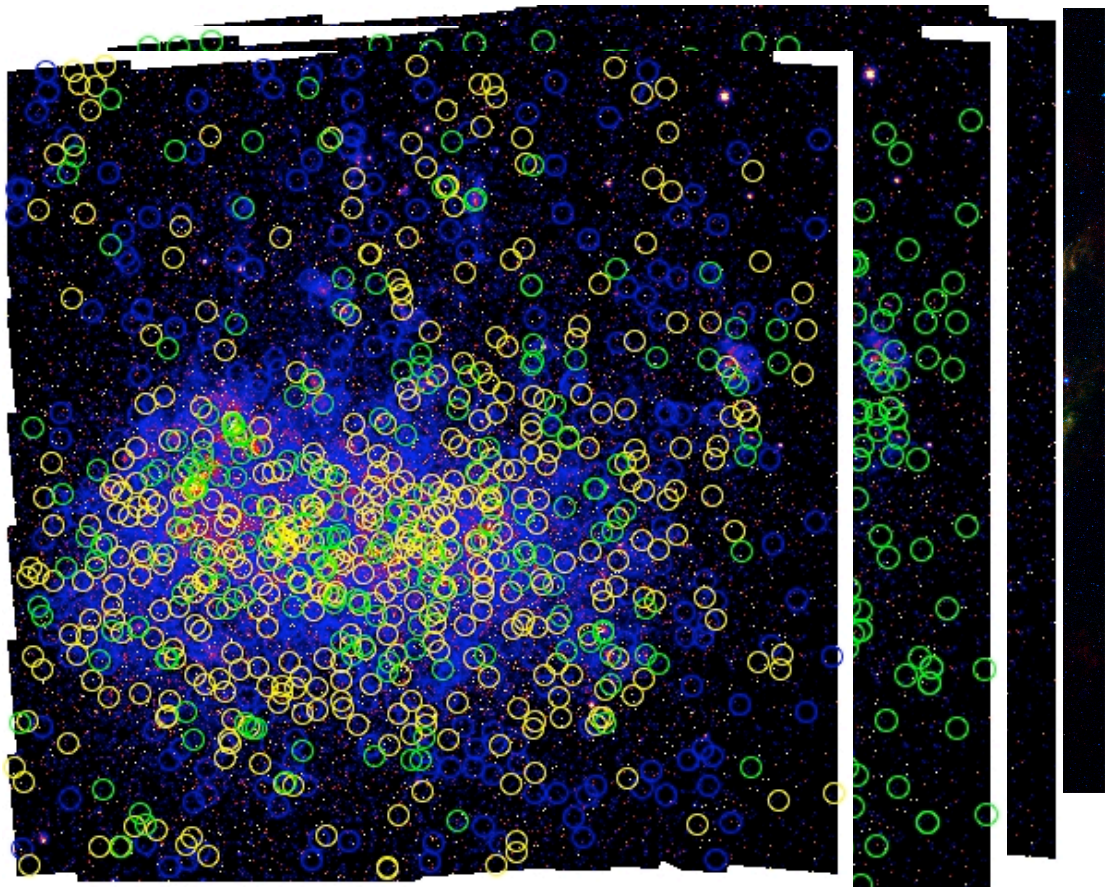
Valiante et al. (2009)

Case study (2) : Observations



- Field stars in the Large Magellanic Cloud (LMC)
- Total dust input from evolved stars into the interstellar medium
  - AGB: (4-9)x10^{-5} $M_\odot$ yr^{-1}
  - SNe: (0.1-10)x10^{-5} $M_\odot$ yr^{-1}
    - (up to 100x$10^{-5}$$M_\odot$ yr^{-1} ?)
  - Total dust input: 10^4 -10^5 $M_\odot$
    - Over 1 Gyrs (=life time of dust), if SFR is constant
  - ISM dust: 10^6 $M_\odot$
- No info about age, metallicity (elemental abundances) and main sequence mass of individual stars

(from stars into the interstellar medium)

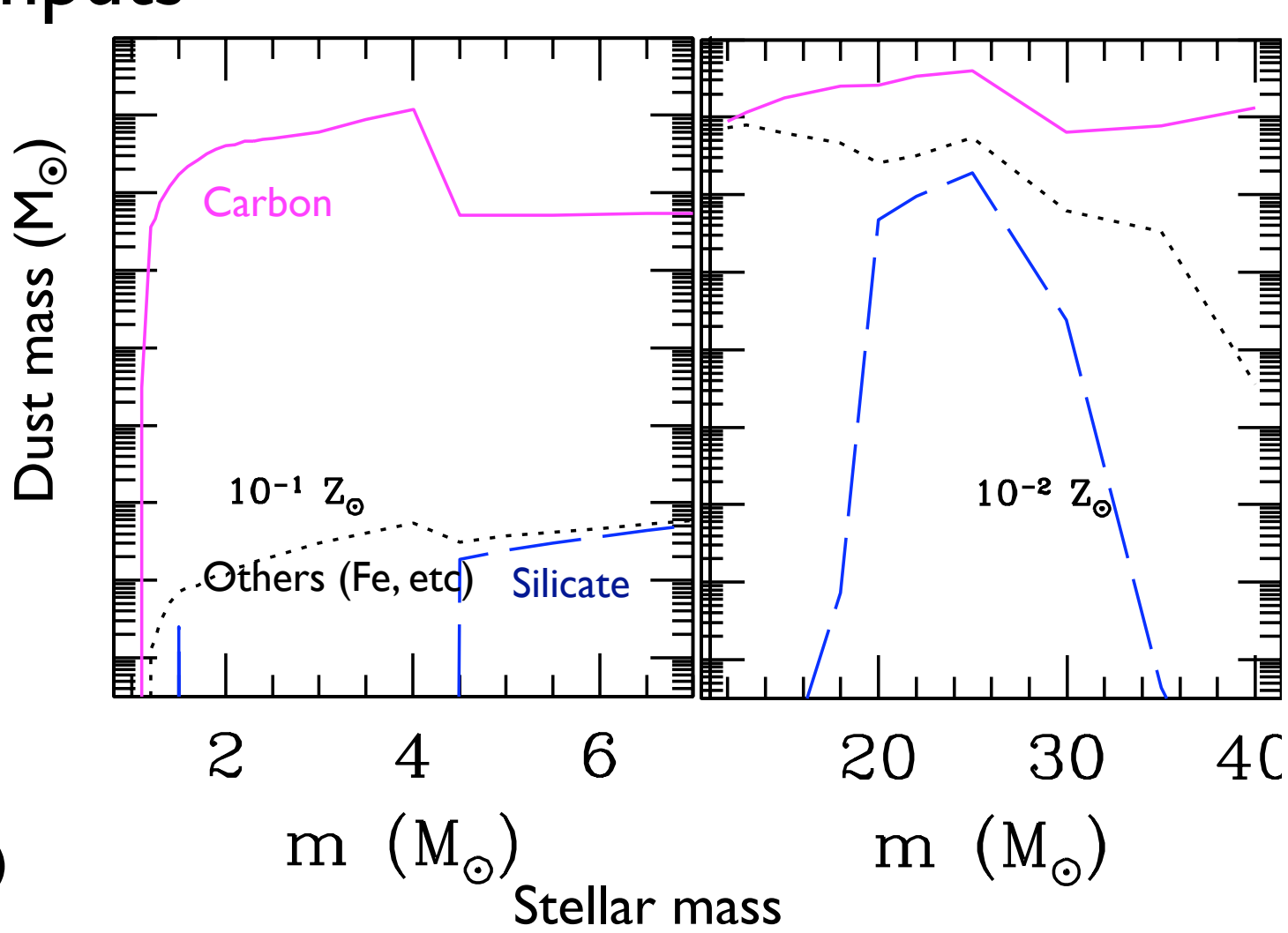


Matsuura et al. (2009, MNRAS 396, 918)

Case study (1): theoretical works

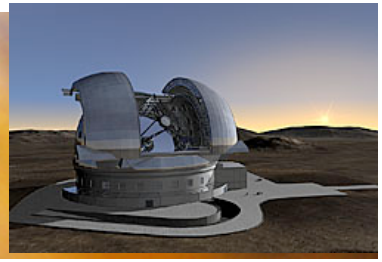
- Following chemical evolution of galaxies
- No observational constrains given

Inputs

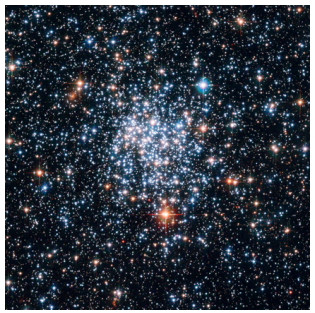


Valiante et al. (2009)

What can we do with the ELT?



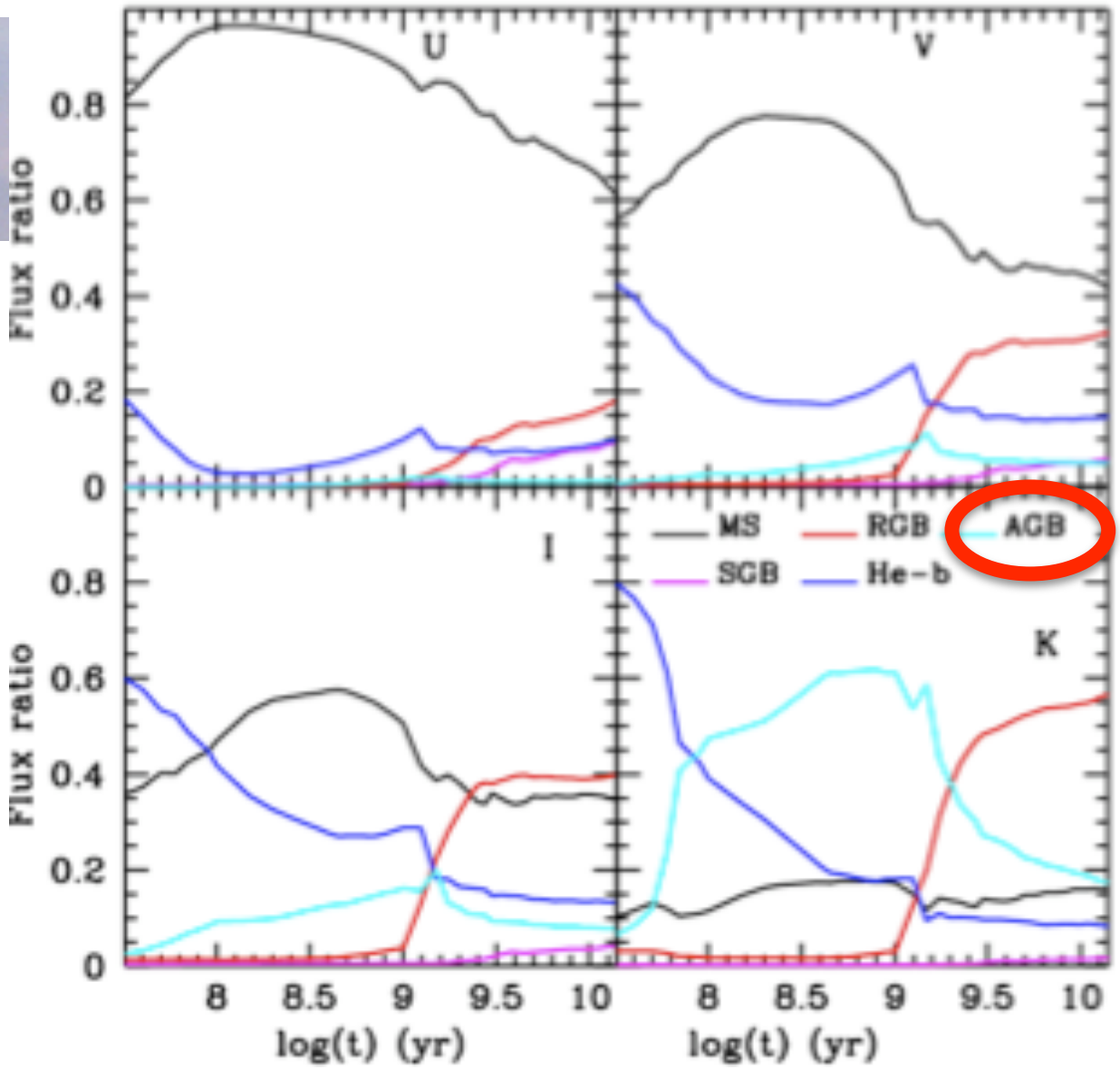
- Dust formation in AGB stars in clusters
  - Field stars in galaxies -> Clusters (LMC and beyond)
    - Age, mass, and metallicity
    - Elemental abundances (of planetary nebulae)
      - Carbon abundance in AGB stars
        - UV (HST) or deep optical spectra with ELT



- Dust measured from near/ mid-infrared emissions (ELT+JWST)
- Dust formation in SNe?

Side products

- Stellar evolution along the AGB stars



Maraston (2005)


THANK YOU

What is needed?

- ELT: bridging observational and theoretical works
- Parameters poorly constrained by observations
- Population synthesis + dust evolution
  - Evolution of elemental abundances in the gas and dust phases
- Dust production along with stellar evolution
  - Dust condensation rate / Dust ejection rate in a star
    - Dust production over stellar evolution
  - Stellar population
    - Metallicity / elemental abundance/ Stellar yields
    - Star formation history
    - Initial mass function