Stellar sources of dust at high redshift: SN vs AGB stars

Rosa Valiante

Raffaella Schneider, Simone Bianchi

& Anja Andersen

Dipartimento di Astronomia, Università di Firenze

INAF/Osservatorio Astrofisico di Arcetri

Dark Cosmology Center

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DAVID

The Dark Ages VIrtual Department

http://www.arcetri.astro.it/david

S. Bianchi
INAF/Arcetri

B. Ciardi
MPA

P. Dayal
SISSA

C. Evoli
SISSA

A. Ferrara
SNS Pisa

S. Gallerani
OARoma

F. Iocco
IAP

F. Kitaura
SISSA

M. Mapelli
ETH

A. Maselli
MPA

R. Salvaterra
INAF/Milano

S. Salvadori
SISSA

R. Schneider
INAF/Arcetri

L. Tornatore
INAF/Trieste

M. Valdes
IPMU

R. Valiante
Univ. Firenze

Why high redshift dust?

- FIR and sub-mm observations of QSOs and galaxies at z>5-6 suggest huge dust masses (>10^8 M_{sun})
- Dust evolution in high redshift galaxies affects the cosmic IR emission which in turns provides important constraints on the global SFH

Where is high-z dust produced?

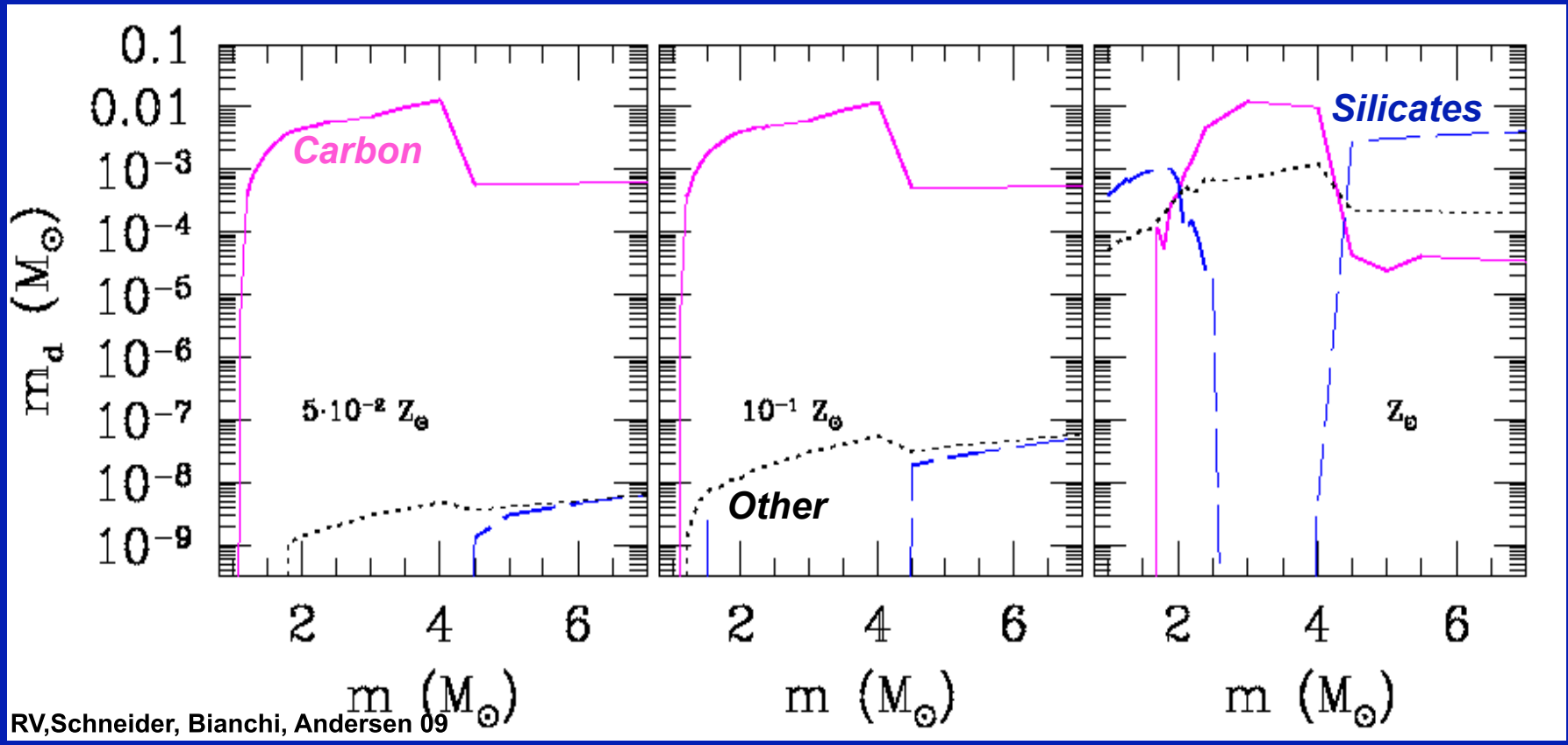
- It is commonly believed that AGB stars cannot be responsible for high-z dust since their lifetimes are longer/comparable to the age of Universe at that redshifts
- Among all stellar dust sources, SN appear to be the only viable sites of grain condensation fast enough to explain these large dust masses
- Many chemical evolution models of high-z objects (e.g. QSOs) do not include dust produced by AGB stars….

Our Aims

- Investigate whether stellar sources can account for the huge amount of dust inferred from mm/sub-mm observations of high redshift quasars (5<z<6.4) by considering both SN and AGB stars in our model

- Investigate the relative role of AGB stars and SN in producing this dust

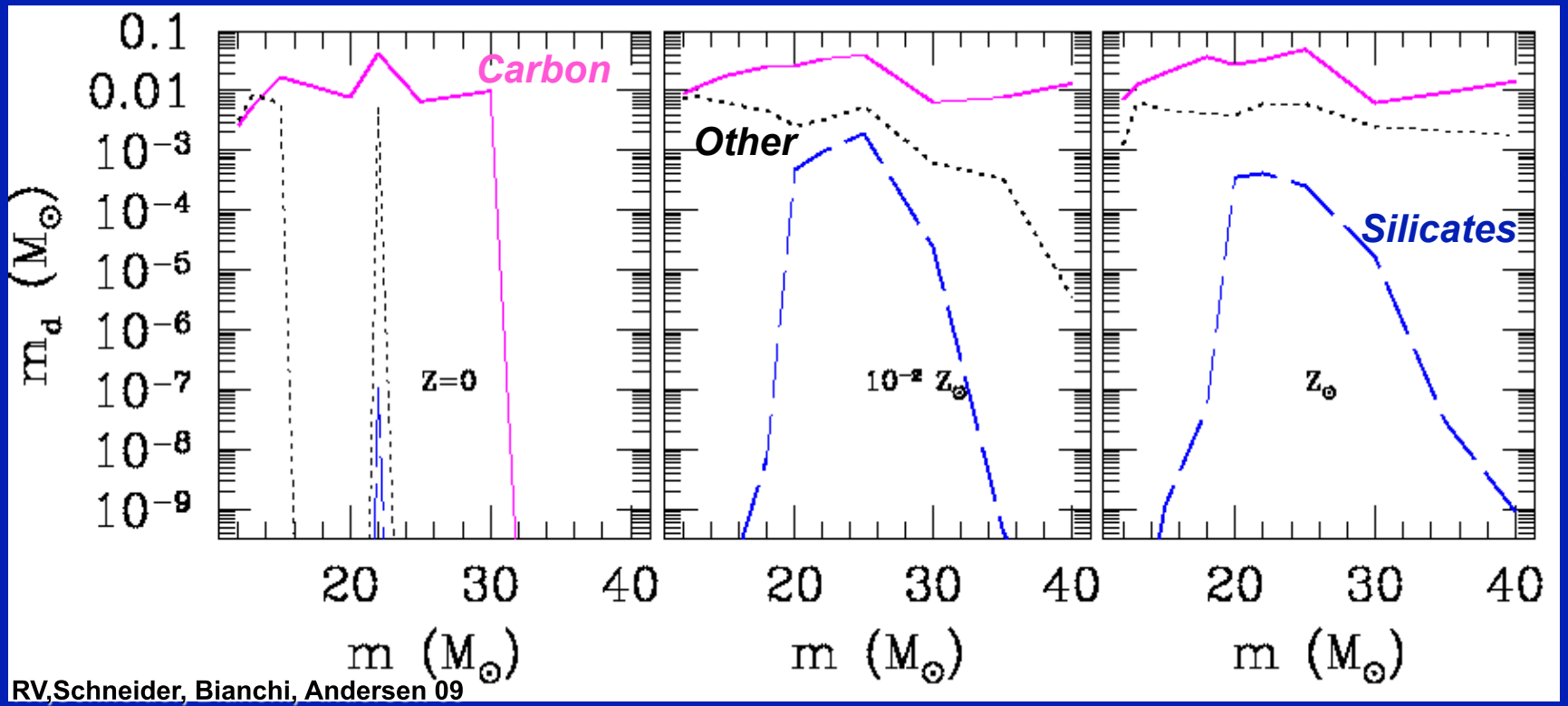
Dust by AGB stars



RV,Schneider, Bianchi, Andersen 09

AGB stars produce 10^{-3} – 10^{-2} M_{sun} of dust
mainly carbon dust
silicates are only produced by stars with < $2M_{sun}$ and > 4 M_{sun} then $Z = Z_{sun}$

Dust by SN



RV,Schneider, Bianchi, Andersen 09

SN produce 10^{-2} – 10^{-1} M_{sun} of dust
mainly carbon dust!

Cosmic Dust yields: SN vs AGB stars

- The relative importance of the two dust production channels and the characteristic time-scales at which one dominates over the other depend on the star formation history (SFH) and the stellar initial mass function (IMF)…

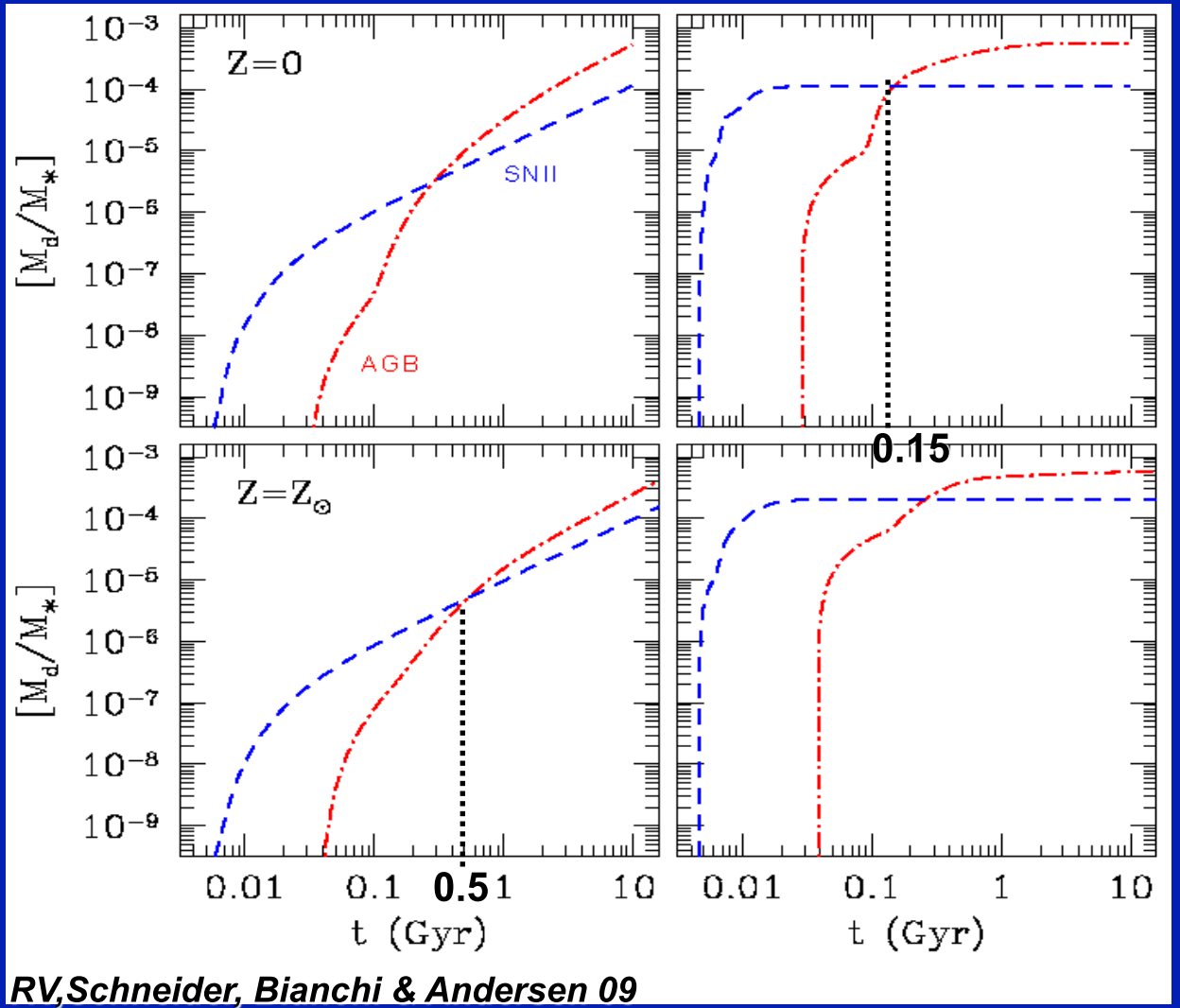
$$M_d(t) = \int_0^t dt' \int_{m_*(t)}^{100 M_\Theta} m_d(m)\phi(m)SFR(t' - \tau_m)dm$$

Larson IMF with $m_{ch}=0.35M_{sun}$

Burst/Continuous SF

No Istantaneous Recycling Approximation

Continuous & Constant SFH **Burst-like SFH**



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AGB dominate dust production after 150 - 500 Myr

These stellar dust sources must be taken into account even at early cosmic epochs!

Dependence on the stellar IMF

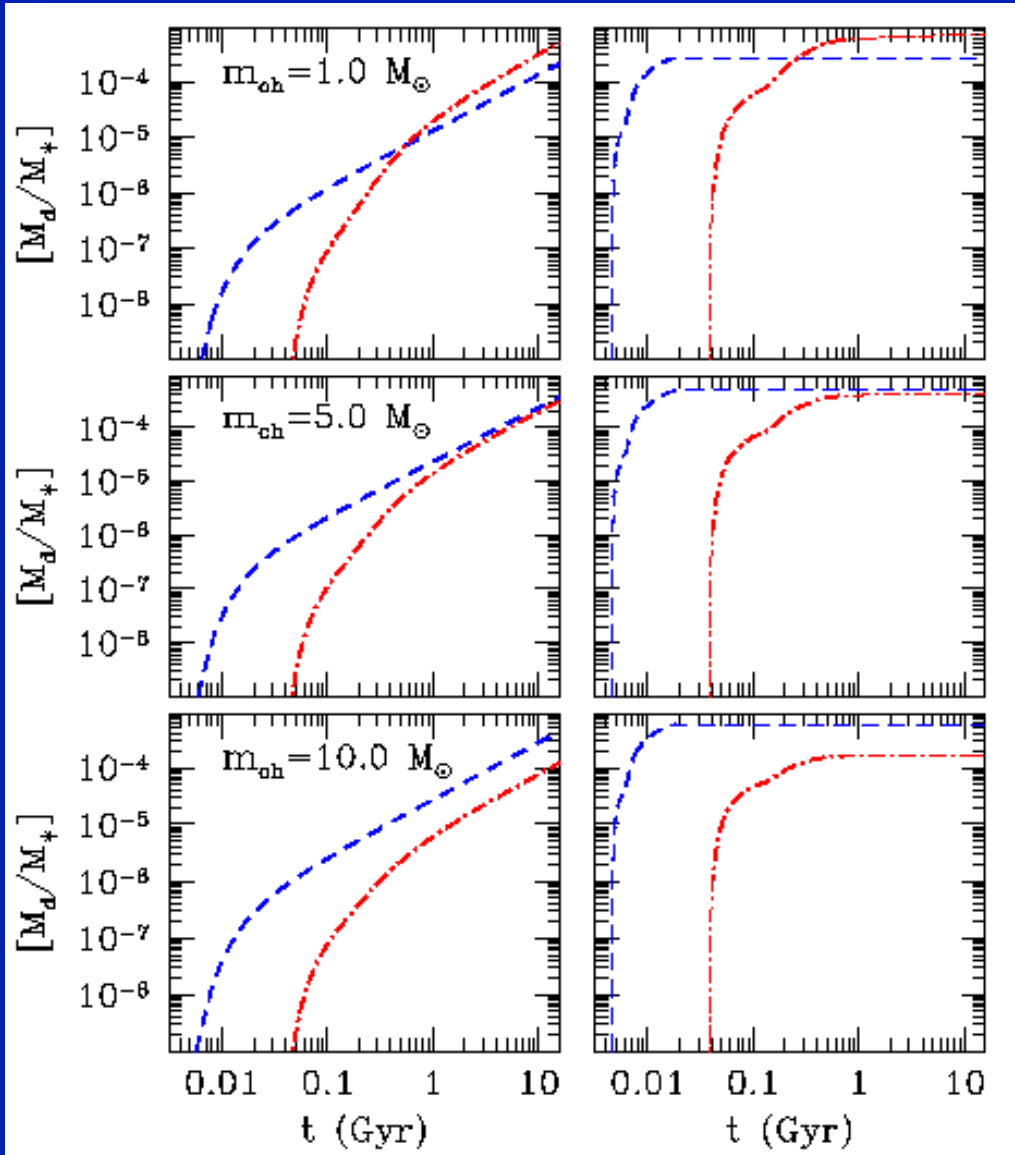
$$\phi(m) \propto m^{-1-x} \exp(-m_{ch}/m)$$

$$x = 1.35$$

$$m \in [0.1 - 100] M_{sun}$$

For m_{ch} = 5 M_{sun} AGB dust is comparable to the SN dust after 1Gyr

For $m_{ch} \geq$ 10 M_{sun} SN dominate dust evolution



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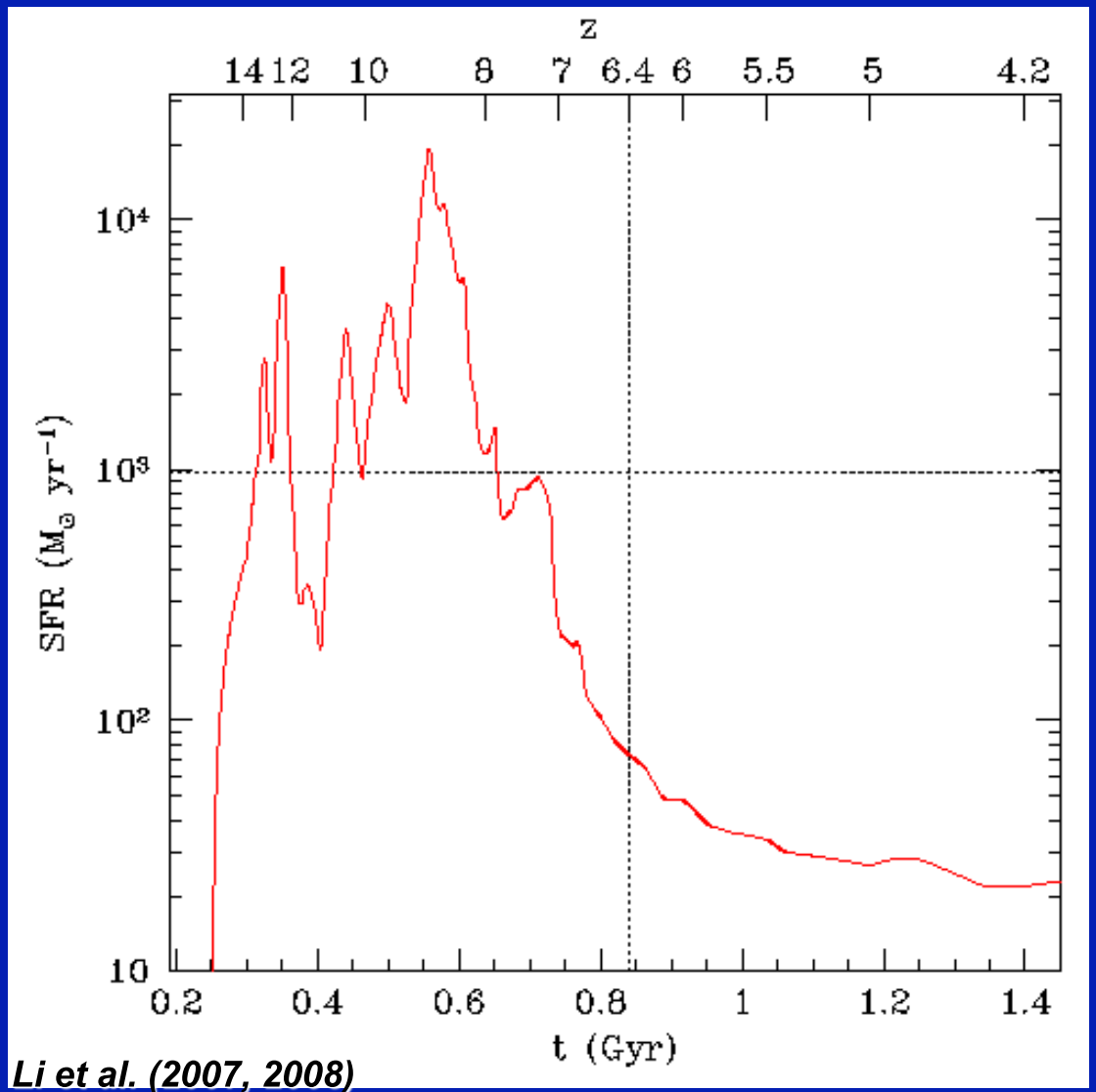
SN vs AGB dust in the most extreme QSO @ z=6.4

SDSS J1148+5251 *(Fan et al. 2003)*

- Larson IMF with m_{ch}=0.35 M_{sun}
- No Instantaneous Recycling Approximation
- Numerically simulated Star Formation History *(Li et al. 2007)* and/or a continuous SFH constant in time ($10^3 M_{sun}$/yr)
- Dust destruction by interstellar SN shocks

  (e.g. Dwek, Galliano & Jones 2007)

Simulated SFH of SDSS J1148+5251



Li et al. (2007, 2008)

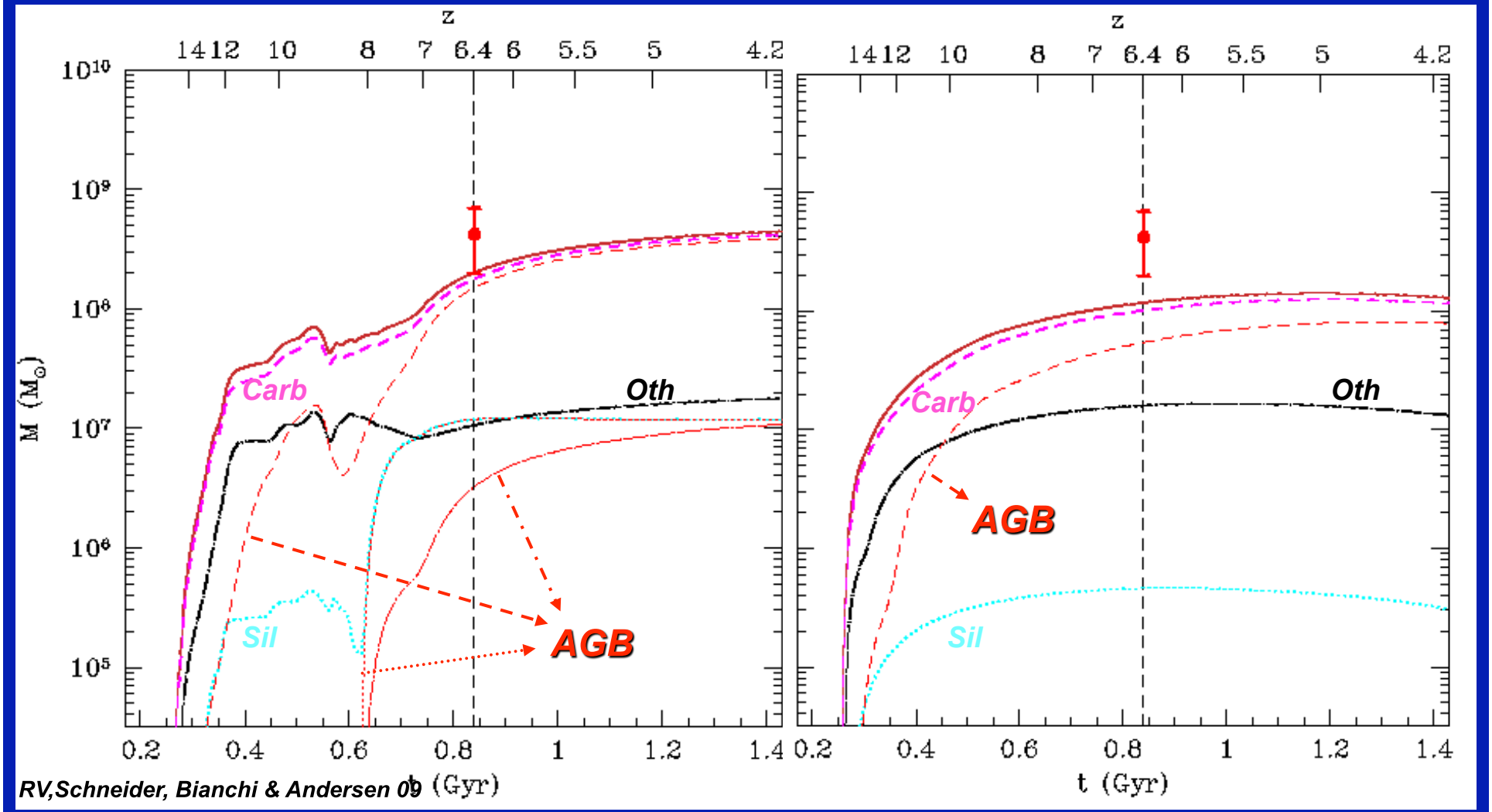
$M_{halo} = 10^{13}\ M_{sun}$

SFR (z=6.4) ~ 100 M_{sun}/yr

$M_{star} \sim 10^{12}\ M_{sun}$

Simulated SFR (Li et al. 2007)

Continuous SFR



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AGB stars give a significant contribution about the 80% of the total dust mass @ z= 6.4

AGB stars produce about the 50% of carbon dust @ z=6.4

Summary

- AGB stars produce 10^{-3} – 10^{-2} M_{sun} of dust (mainly carbon)
- SN produce 10^{-2} – 10^{-1} M_{sun} of dust (mainly carbon)
- The dominant dust component is always Carbon dust, silicates are mainly produced by stars with <2 M_{sun} and >4 M_{sun} when $Z = Z_{sun}$
- For a stellar population forming according to a present-day Larson IMF with $m_{ch}=0.35M_{sun}$ the characteristic time-scale at which AGB stars dominate dust production ranges between 150 and 500 Myr, depending both on the assumed SFH and initial stellar metallicity.
- **AGB stars can significantly contribute to the total dust mass observed at high redshift**
- **The nature of dust at high-z depends more on the star formation history of the host galaxy rather than on the cosmic time**