GRB hosts identification through chemical abundances

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Outline

Goal of the work

We want to infer the main features of high redshift GRB host galaxies: galaxy morphology, age of the galaxy at GRB's time

In order to do that, we adopt

chemical abundance data from GRB afterglow spectra

detailed chemical evolution models

We select a sample of 7 long GRB hosts taken from the literature
(050730, 050820, 081008, 090926A, 120327A, 120815A, 161023A)
with

- $z \gtrsim 2$
- sufficient number of metal column abundances available

Chemical evolution models with dust

Compute the evolution of chemical elements in the ISM
in gas and dust phase, for galaxies of different morphological type

To do that

Chemical evolution equation

$$\dot{G}_i(t) = -\psi(t)X_i(t) + R_i(t) + \dot{G}_{i,inf}(t) - \dot{G}_{i,w}(t)$$

Dust evolution equation

$$\dot{G}_{i,d}(t) = -\psi(t)X_{i,d}(t) + R_{i,d}(t) + \dot{G}_{i,d,accr}(t) - \dot{G}_{i,d,destr}(t) - \dot{G}_{i,d,w}(t)$$

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Fundamental ingredients

- Star formation rate (SFR) $\psi(t)$ *(Schmidt 1959, Kennicutt 1989)*
- Initial mass function (IMF) $\phi(m)$ (e.g. *Salpeter 1955, Scalo 1986)*
- Stellar yields $Q_{m,ij}$ *(Karakas 2010, Nomoto et al. 2013, Iwamoto et al. 1999)*

N.B. $G_i = M_{ISM}\, X_i / M_{inf} = M_{ISM,i} / M_{inf}$ **N.B.**

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Fundamental ingredients

- condensation efficiencies δ_i *(Piovan et al. 2011, Gioannini et al. 2017)*
- accretion timescale τ_{accr} *(Asano et al. 2013)*
- destruction timescale τ_{destr} *(Asano et al. 2013)*

N.B. $G_{i,d} = M_{ISM}\, X_{i,d} / M_{inf} = M_{dust,i} / M_{inf}$ **N.B.**

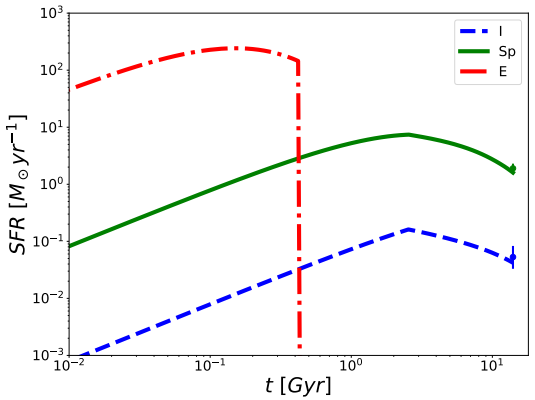
Chemical evolution models - specifications

Reference models

morphology	M_{inf} $[M_\odot]$	τ_{inf} $[Gyr]$	ν $[Gyr^{-1}]$	k_i	IMF	δ^{CC}
Irregular	$5 \cdot 10^9$	10	0.1	0.5	*Salpeter*	δ_{HP}
Spiral	$5 \cdot 10^{10}$	7	1	0.2	*Salpeter*	δ_{MP}
Elliptical	10^{11}	0.3	15	10	*Salpeter*	δ_{MP}

Tuned to reproduce

- SFR observed behaviour
- dust-to-gas ratio in local universe (spirals and irregulars)
- dust mass in very high redshift galaxies (ellipticals)



Performed variations in parameters
in order to consider differences between galaxies of a certain type

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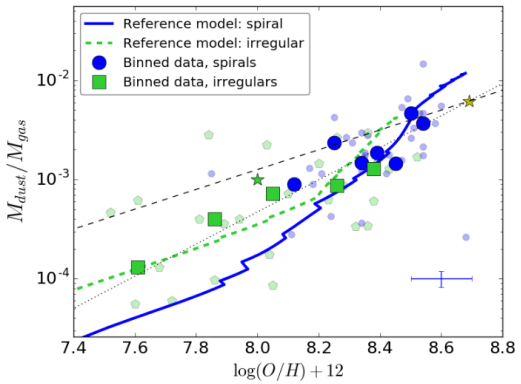

Gioannini et al. (2017)

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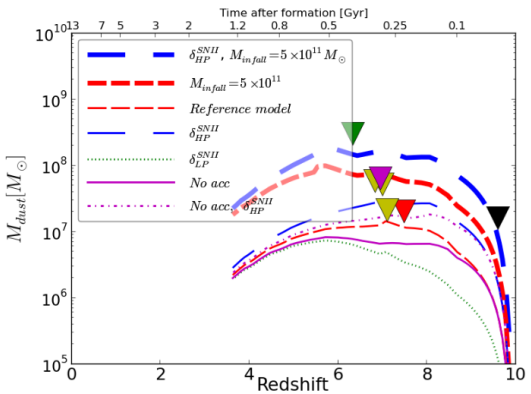

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How to identify galaxies through chemical abundances: "time-delay model"

Different type of galaxies

↓

different star formation histories

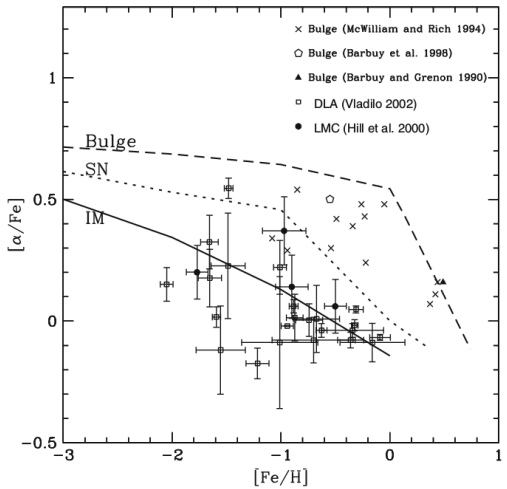
↓

different behaviour of abundance ratios [X/Fe] vs. [Fe/H]

↓

!!! galaxies can be identified by abundance ratios !!!

(Matteucci 2003, 2012)



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At the same time

necessity to take into account dust

- abundances are in gas phase
- dusty environments indications from observations

(e.g. *Hatsukade et al. 2012, Perley et al. 2017*)

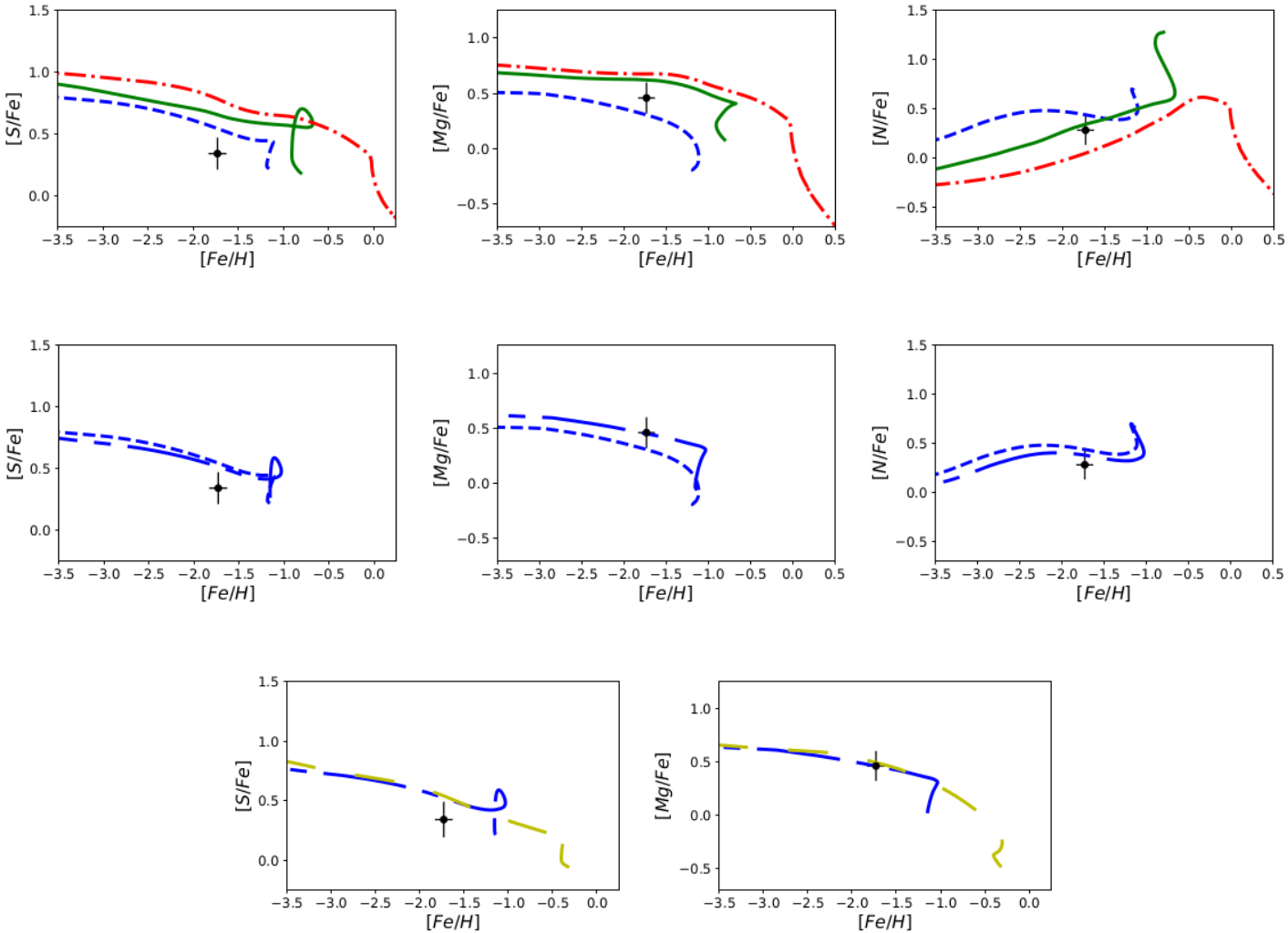
Results

One case: GRB 120327A (z=2.815)

I Reference models

II Decreasing dust content in the galaxy

III Changing the IMF (*Scalo* IMF)



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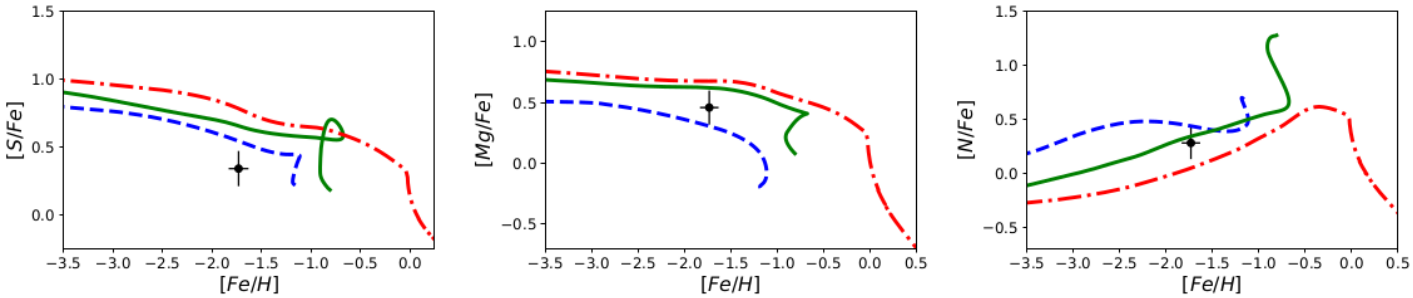
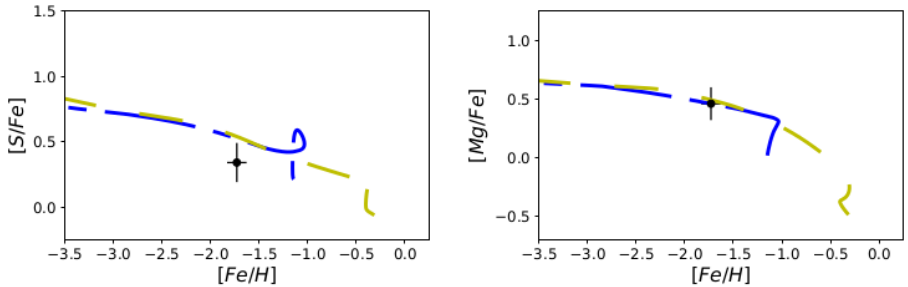


Best models

Moderate dusty irregular galaxy Age: $\sim 0.8 Gyr$

Spiral disk (*Scalo* IMF) Age: $\sim 0.25 Gyr$

III Changing the IMF (*Scalo* IMF)



Conclusions

By comparing observed and predicted abundance ratios for GRB host galaxies we conclude that

- All morphological types are present in the sample of galaxies analysed
- Ages of the host galaxies lie in the range 10 Myr–1.15 Gyr
- Changing IMF (*Salpeter* default) in the models can explain better the observed abundance ratios in some host galaxies
- Not always agreement with previous identifications by *Calura et al. (2009)* and *Grieco et al. (2014)*

The complete work is available at: https://arxiv.org/abs/1903.01353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