

Veduta del Real Osservatorio Astronomico in Napoli
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GRBs as tracers of SFR and metallicity evolution

S.D. Vergani - CNRS - Observatoire de Paris

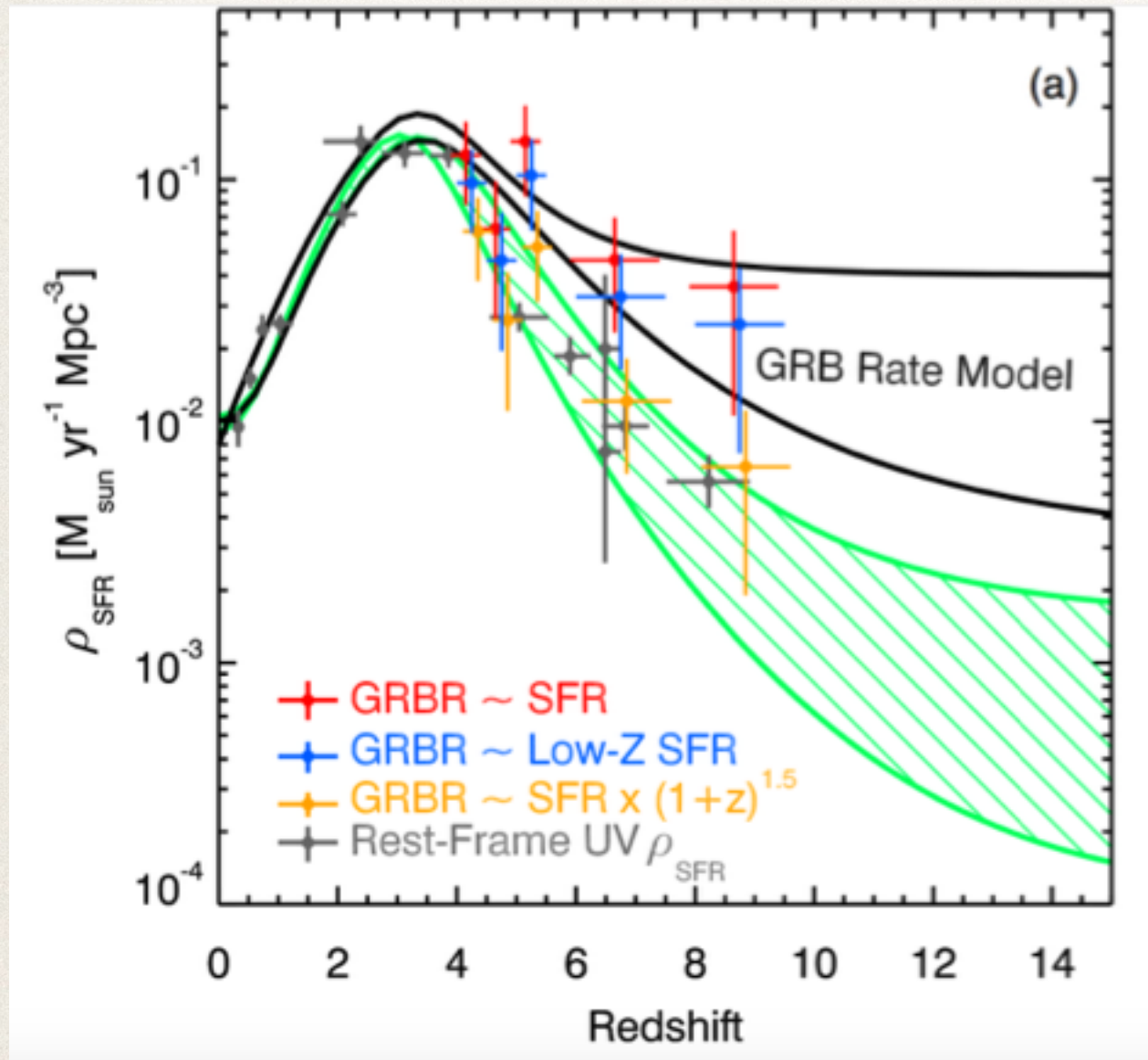
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LGRBs as SFR tracers

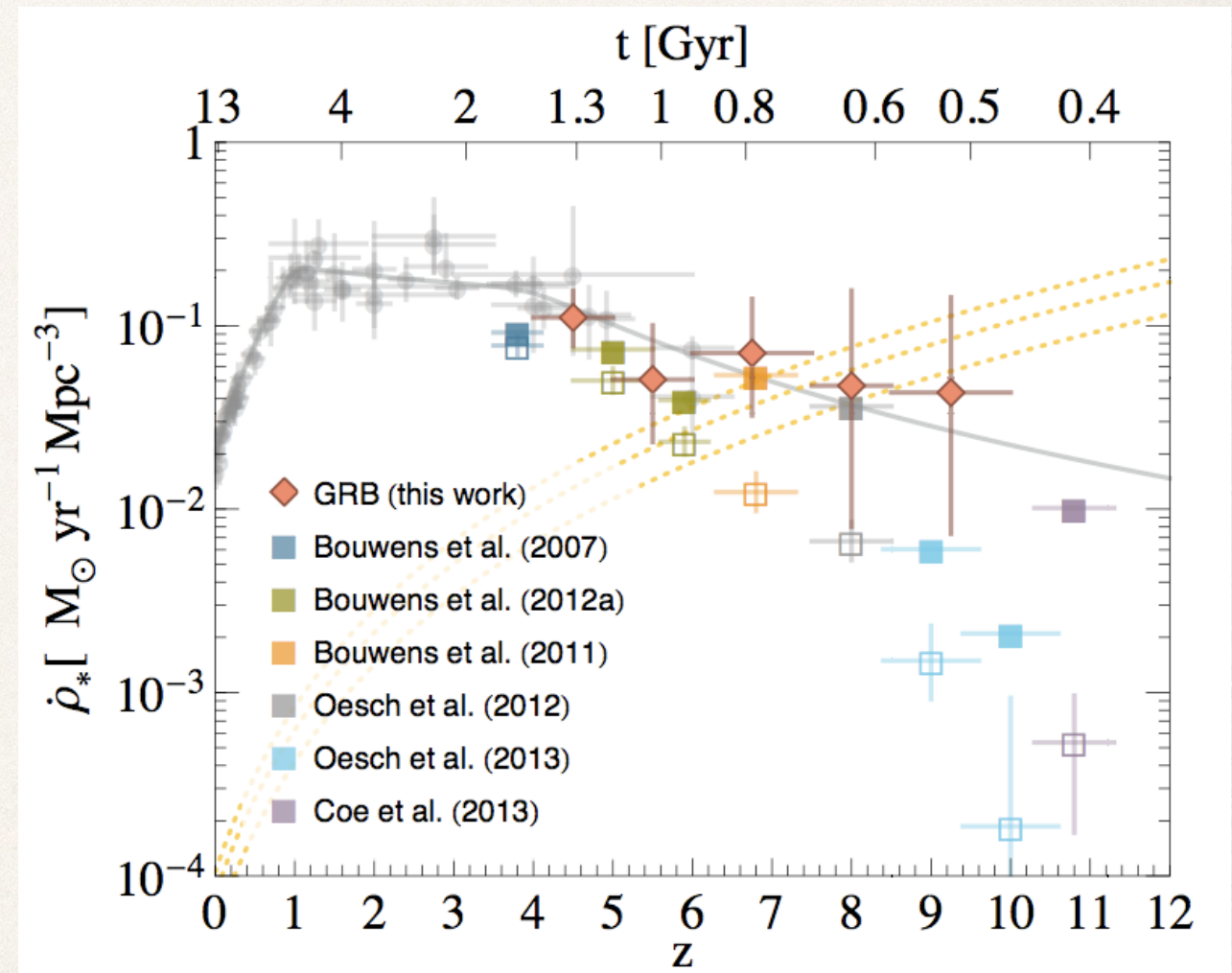
- LGRBs connected with massive stars
- LGRBs connected with star formation

LGRBs as SFR tracers

Robertson & Ellis 2012



Kistler+13

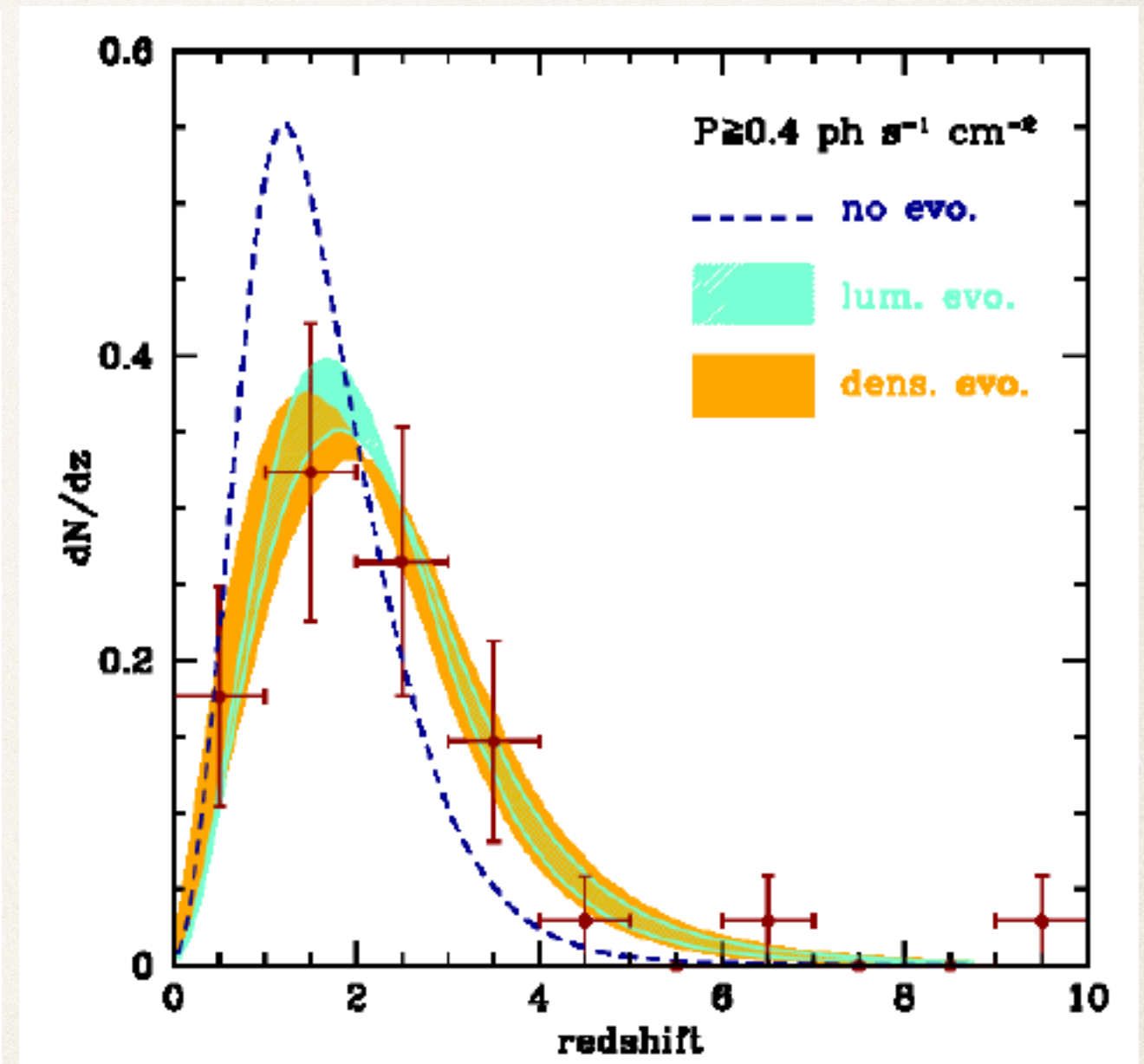
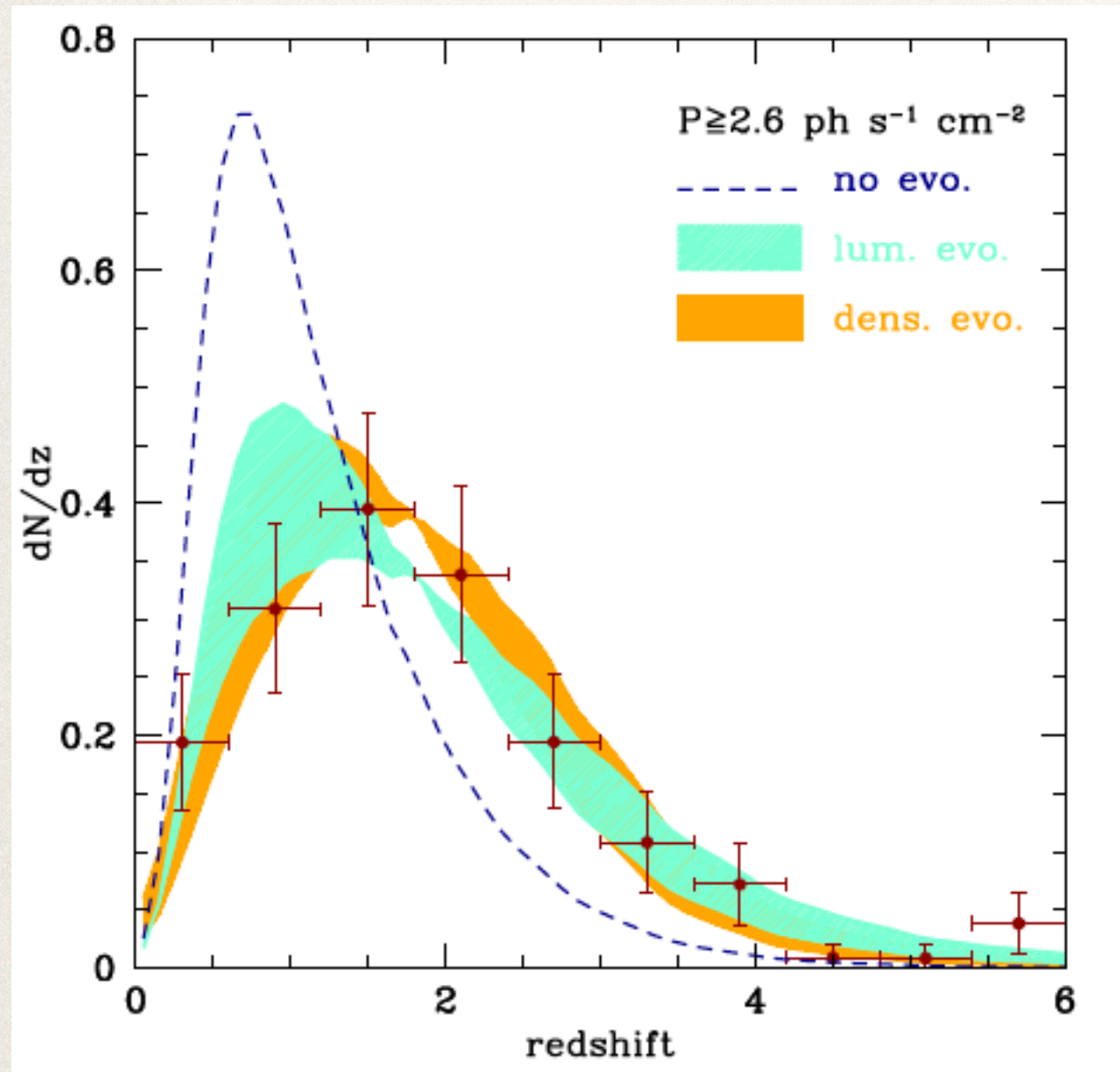


GRBRate = eff. \times SFR ?

eff. = eff.(z) ?

LGRBs as SFR tracers

Salvaterra+12



LGRBs as SFR tracers

- LGRBs connected with massive stars
- LGRBs connected with star formation
- which are the conditions to have a LGRB?

$$\text{GRBrate} = \text{eff.} \times \text{SFR} ?$$

$$\text{eff.} = \text{eff.}(z) ?$$

LGRBs as SFR tracers

- which are the progenitor star conditions to have a LGRB?

Single stars \longrightarrow Very low metallicity

Binary stars \longrightarrow Any metallicity???

More than one channel? \longrightarrow ???

$$\text{GRBrate} = \text{eff.} \times \text{SFR} ?$$

$$\text{eff.} = \text{eff.}(z) ?$$

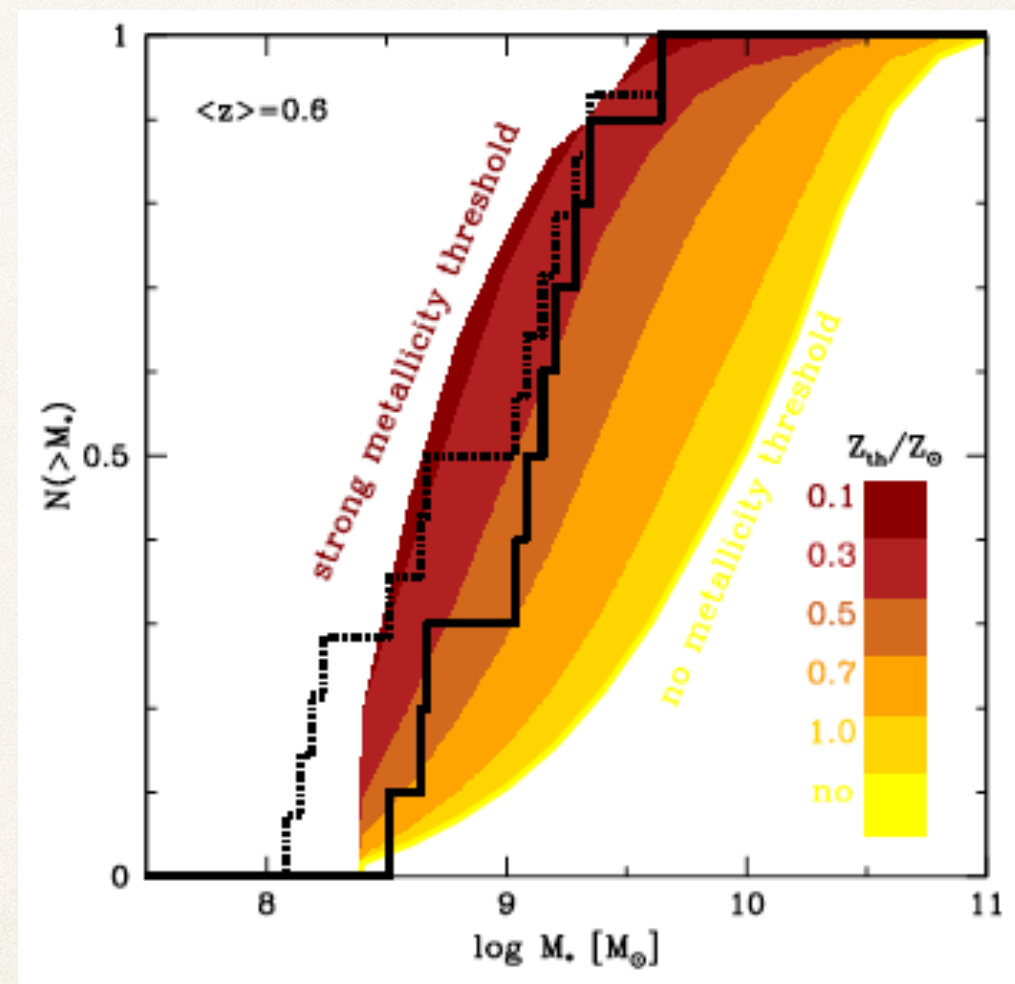
Sample of LGRB host galaxies

- TOUGH
- *Swift*/BAT6
- SHOALS

COMPLETE

Stellar Mass distribution

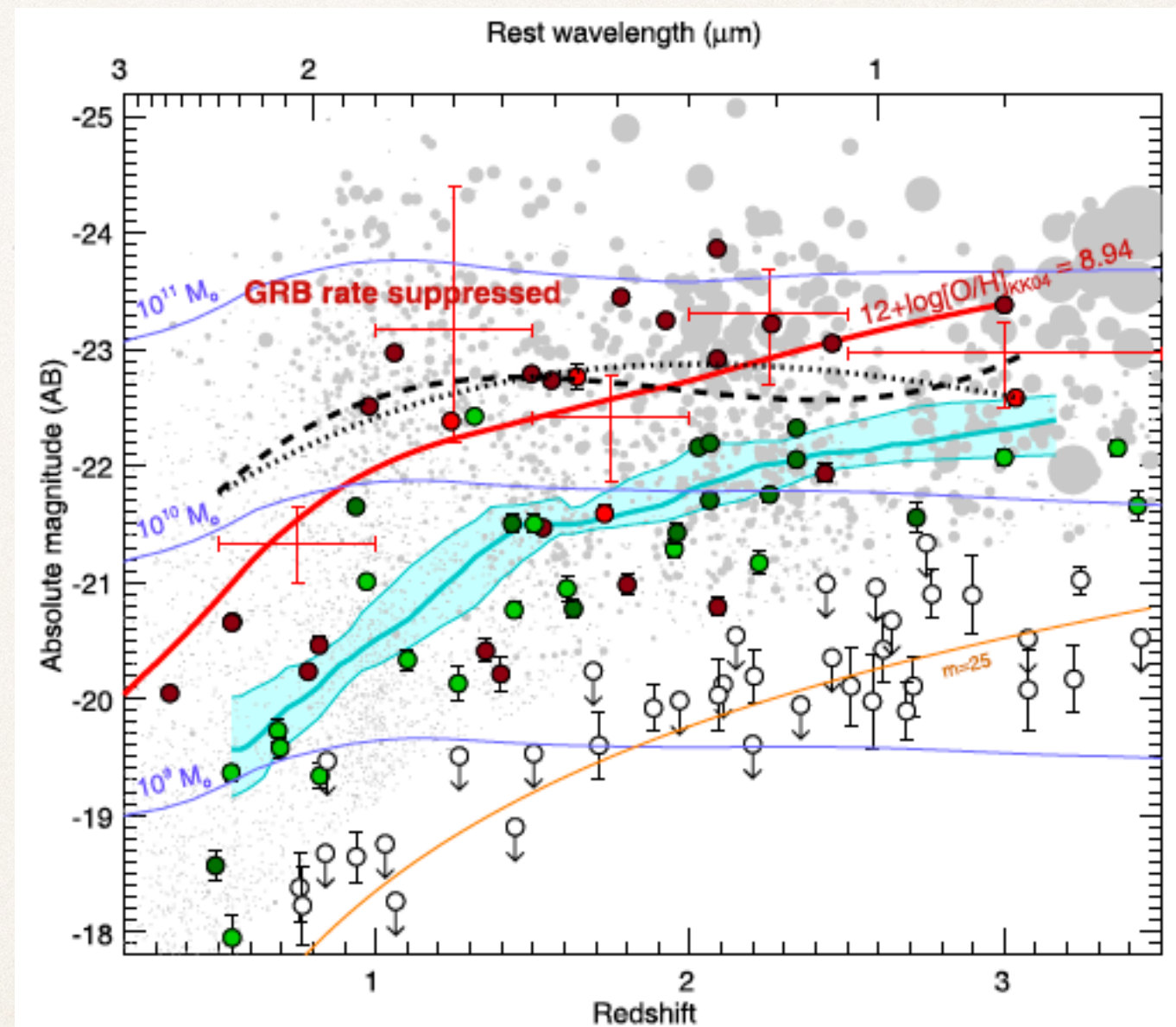
Swift / BAT6 $z < 1$ (Vergani+15)



At $z < 1$ LGRBs do not trace SFR

Metallicity plays a role but not as low metallicity as expected

Stellar Mass distribution



SHOALS
(Perley+16)

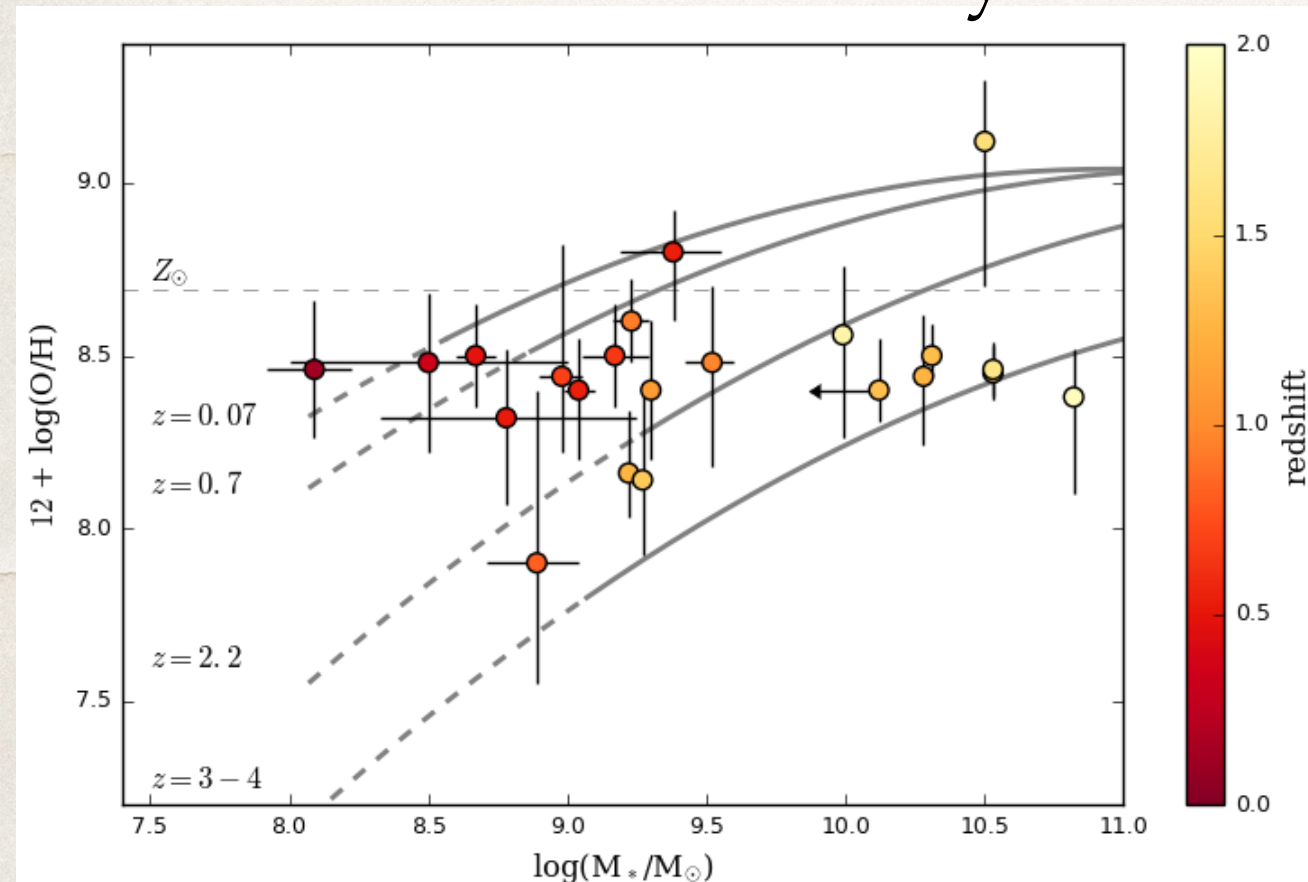
Things get better at higher z

Metallicity plays a role but not as low metallicity as expected

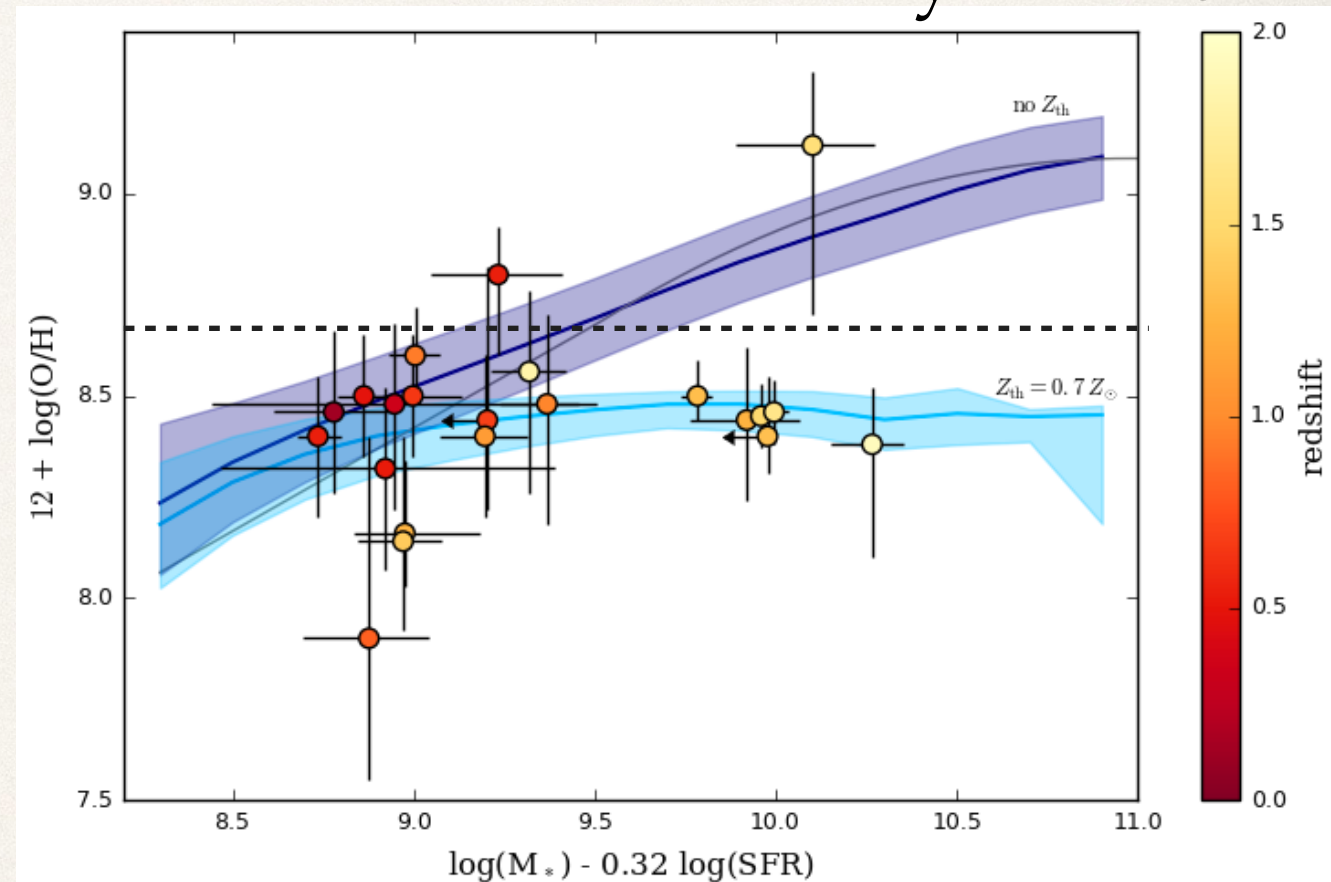
Mass vs Metallicity & FMR

Swift / BAT6 $z < 2$ (Vergani+17)

Mass vs Metallicity



Fundamental Metallicity Relation

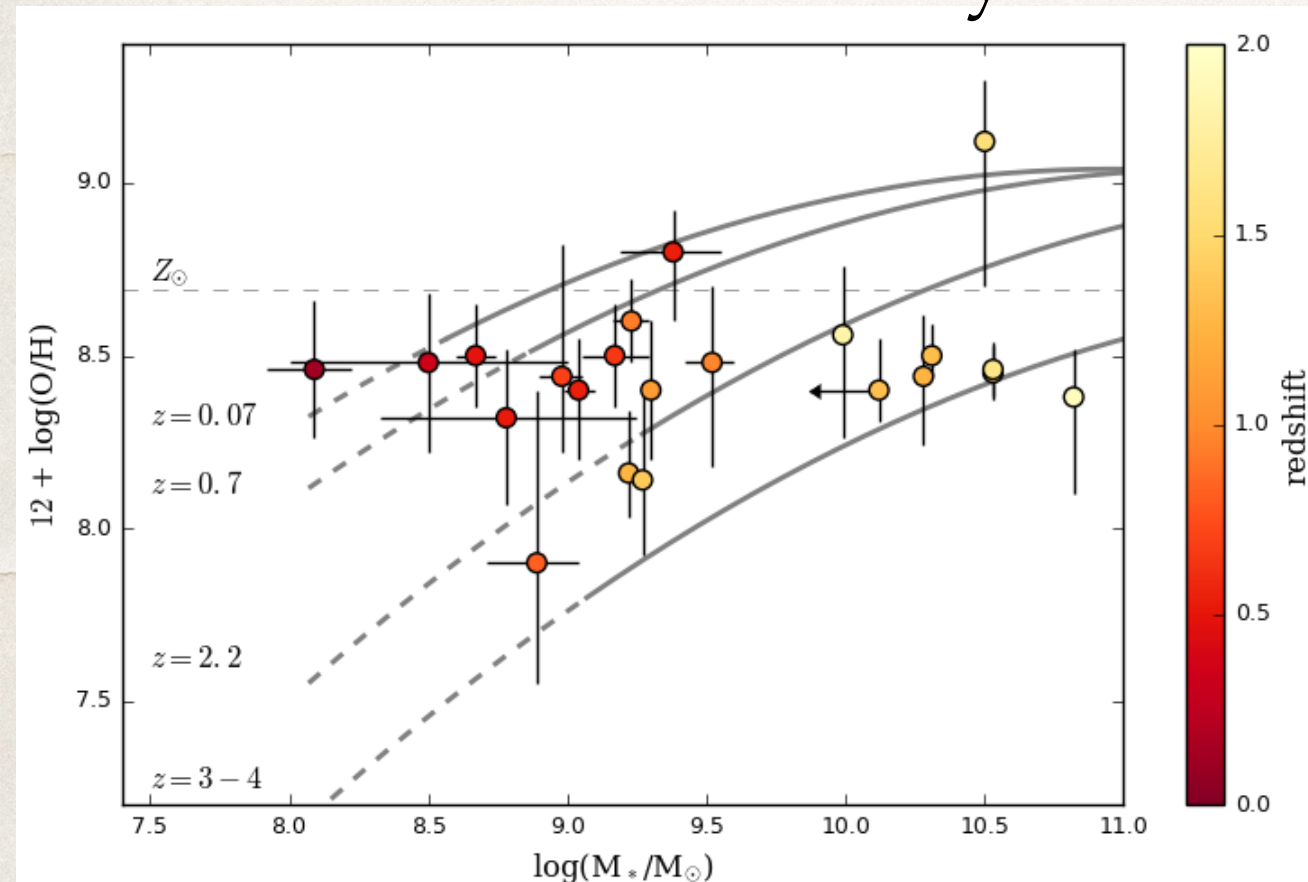


LGRB host galaxies do not follow the FMR
 Sub-solar metallicity threshold, but not so low ($Z < 0.7 Z_{\text{sun}}$)

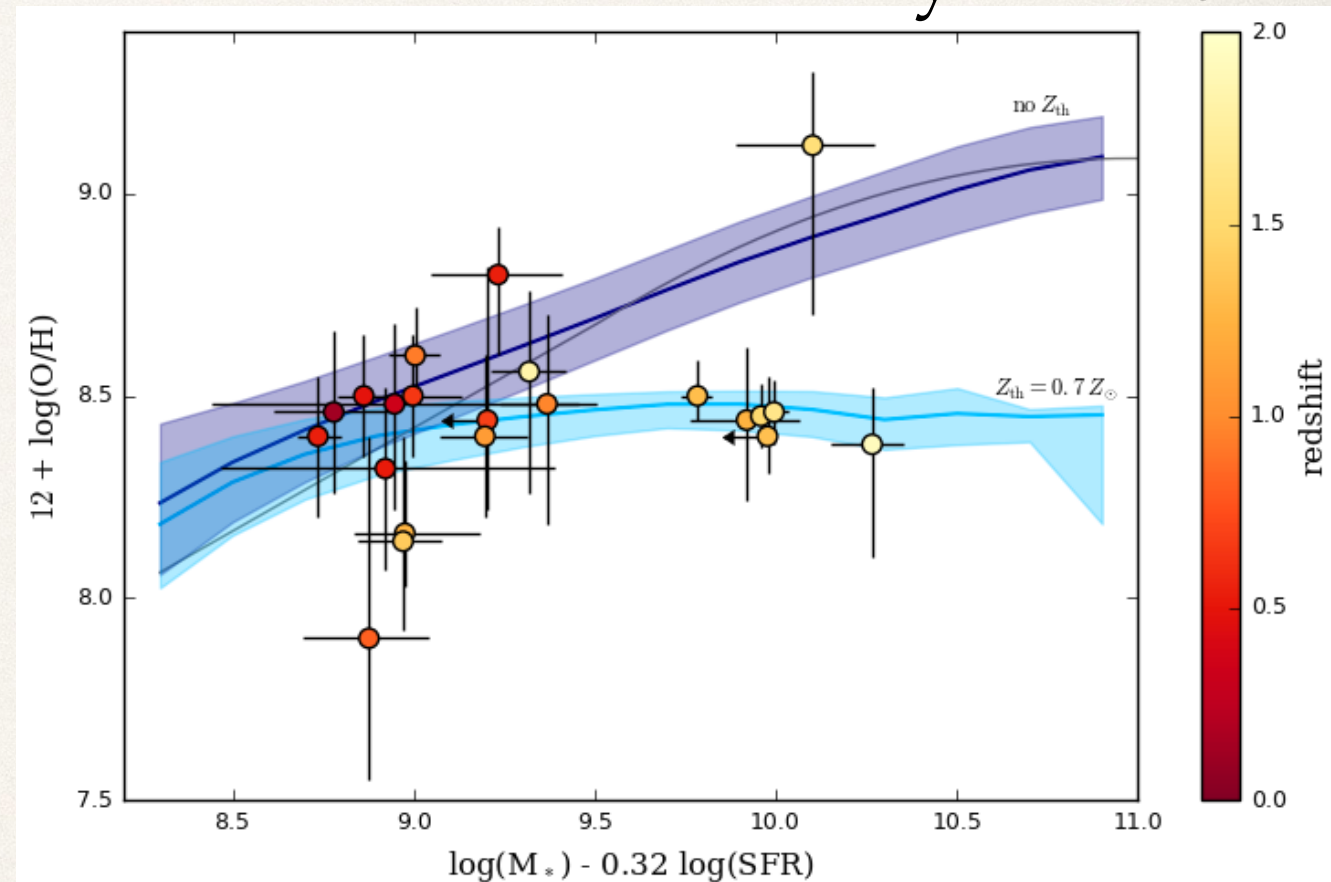
Mass vs Metallicity & FMR

Swift / BAT6 $z < 2$ (Vergani+17)

Mass vs Metallicity



Fundamental Metallicity Relation



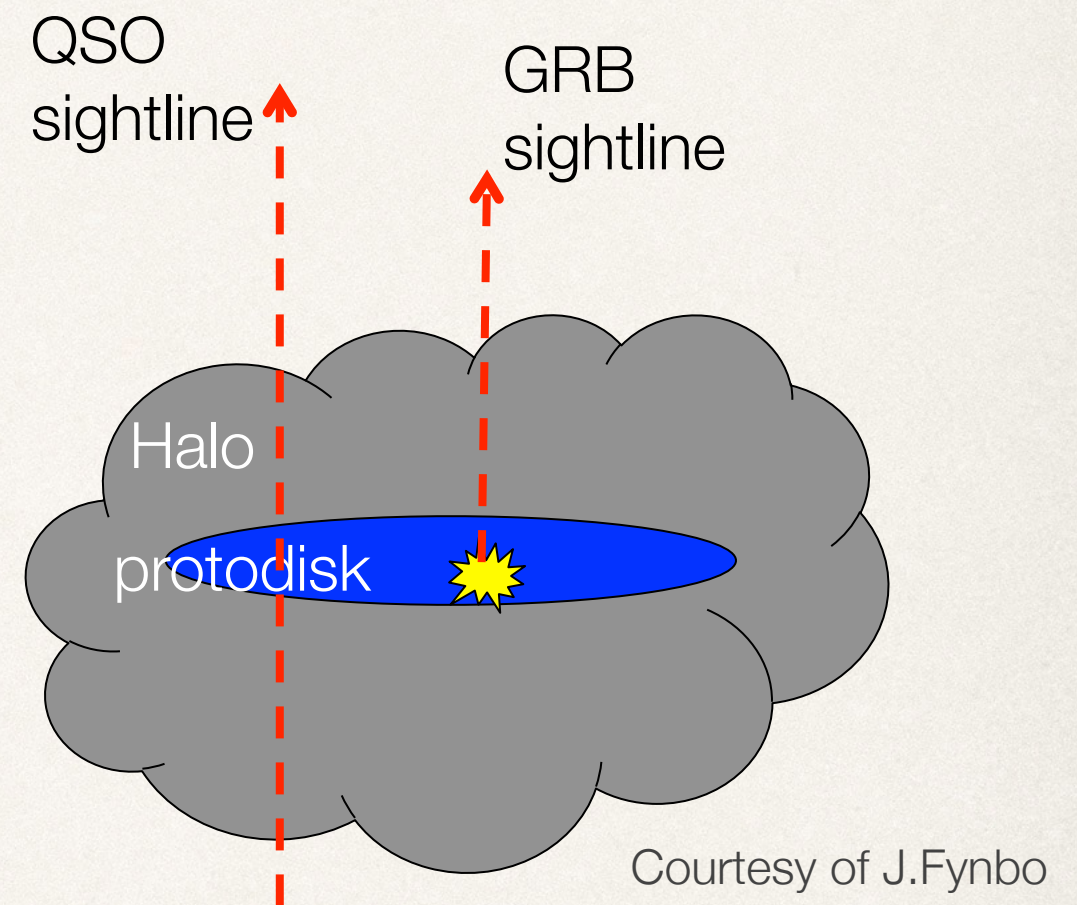
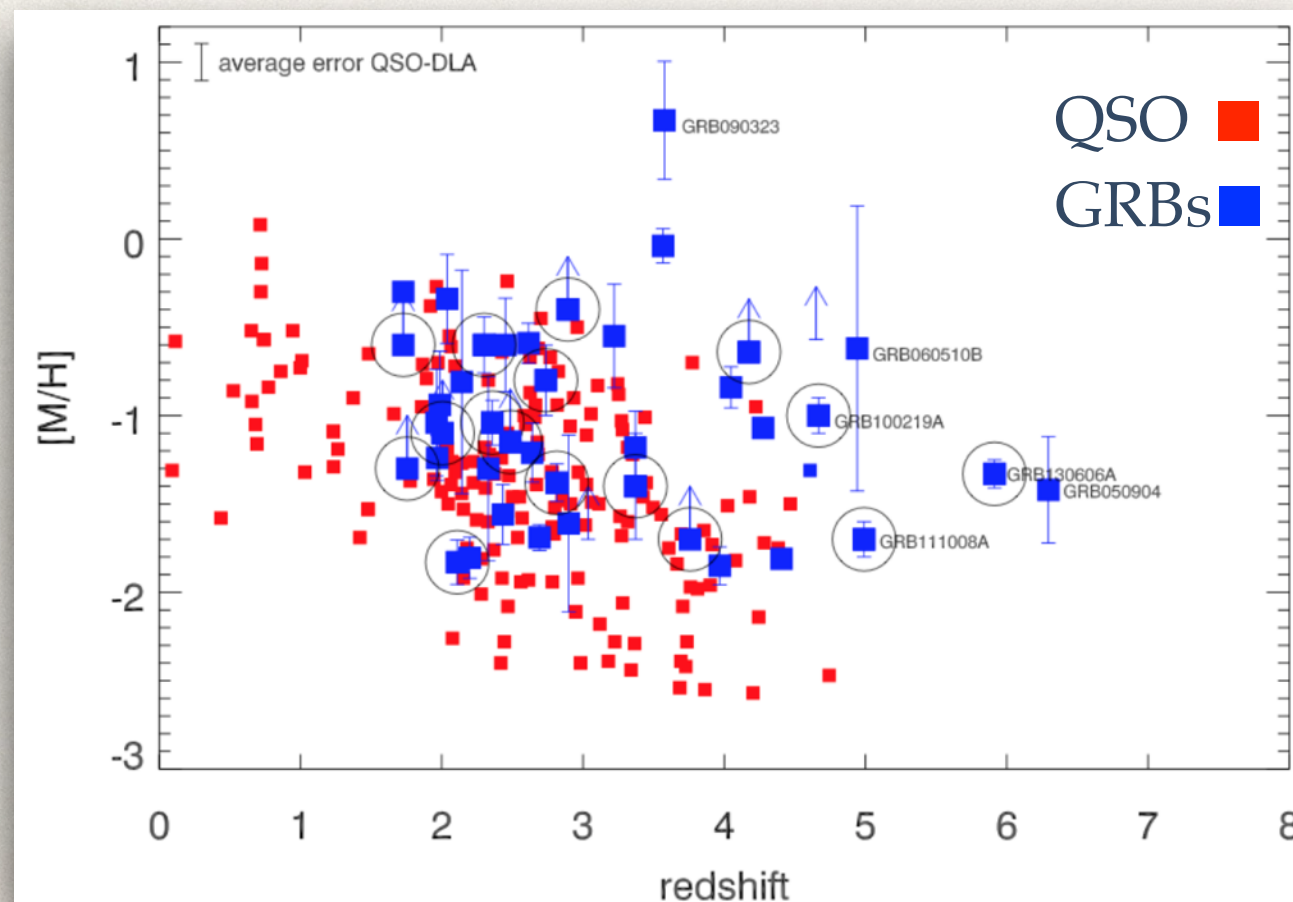
Problem for single star progenitor models?
Binaries? But threshold

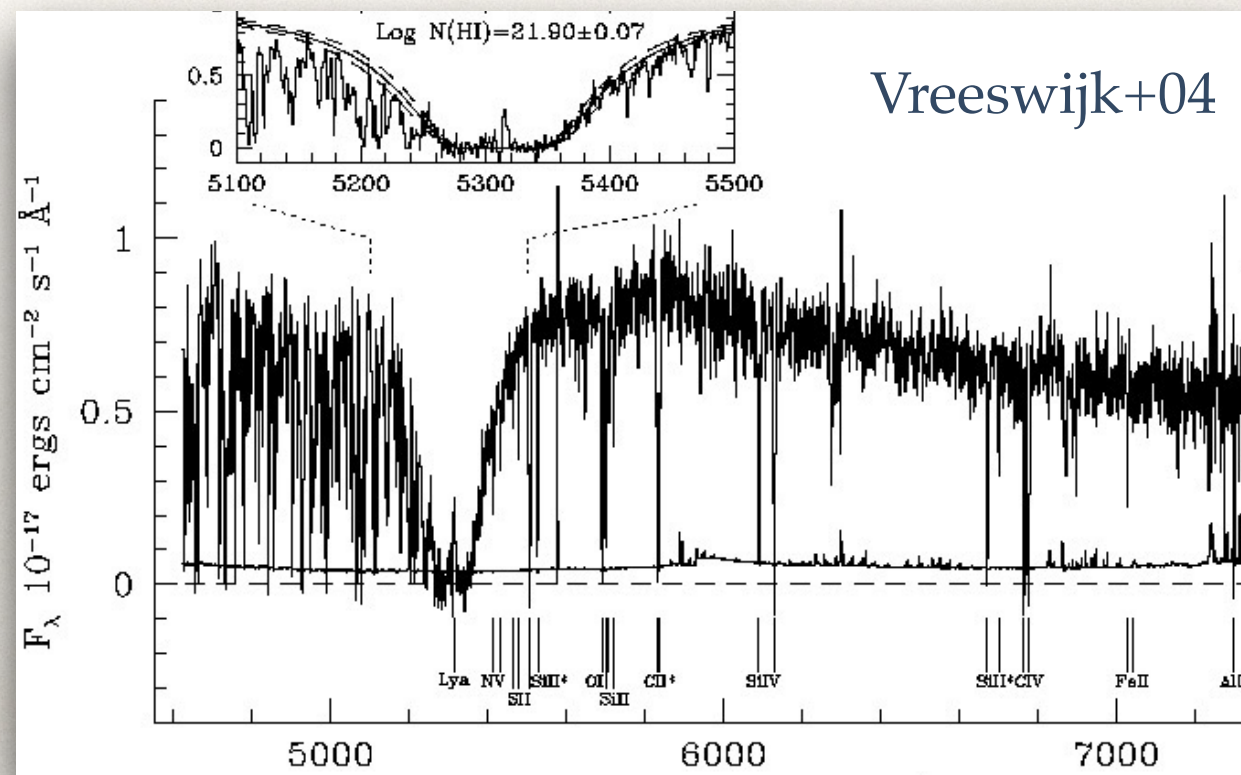
LGRBs as SFR tracers

If metallicity is the only factor that rules the GRB efficiency
a $Z_{\text{th}} \sim 0.7 Z_{\text{sun}}$ would imply that
LGRBs are direct tracers of SFR at $z \sim 3-4$

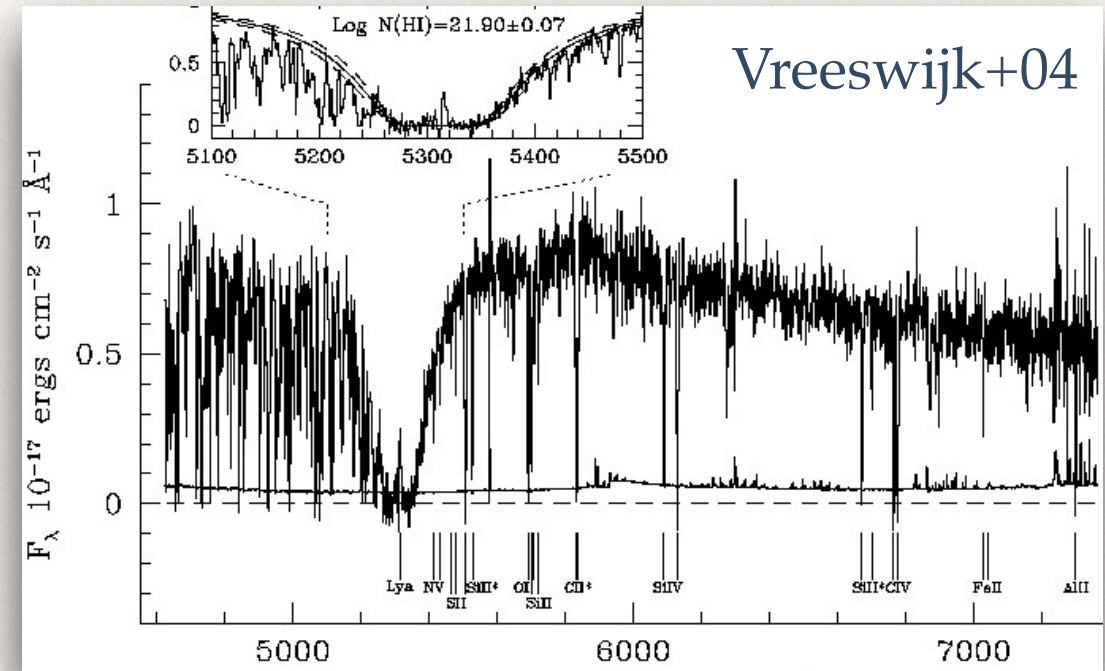
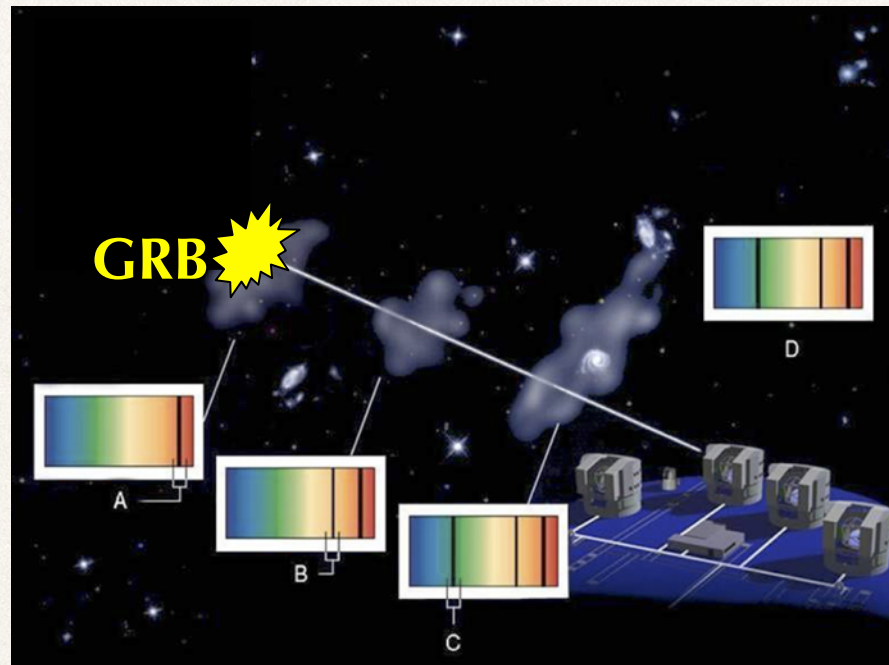
THESEUS the perfect satellite to detect high- z GRBs
and trace the SFR up to the very first objects

LGRBs as tracers of chemical enrichment





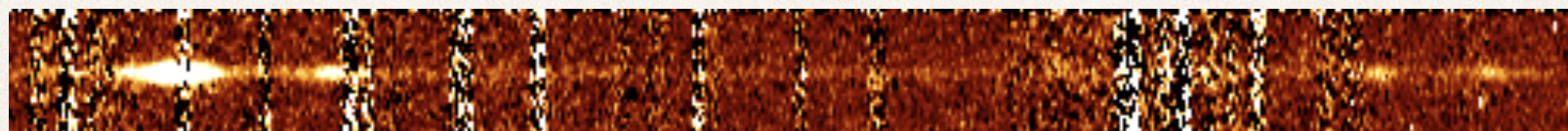
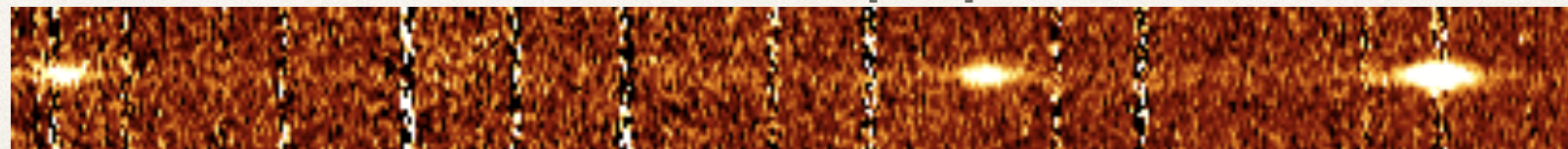
The uniqueness of LGRBs



H-beta

[OIII]4959

[OIII]5007



H-alpha [NII]

[SII]

GRB070306 $z=1.49$

The uniqueness of LGRBs

- ❖ Star-forming galaxies
- ❖ not luminosity selected
- ❖ extend to faint galaxies & high z
- ❖ cold / warm gas + continuum + excited gas

The uniqueness of LGRBs

Host Galaxy

- Metallicity: indirect calibrators (R23, [NII], $H\alpha$, ...)
- Dust: Balmer decrement, continuum shape, SED
- SFR: $H\alpha$, SED(UV)
- n_e : [OII], [SII]
- M_{star} : SED
- Reionization

Afterglow

- HI
- H₂, CO
- Metallicities
- Extinction curves, dust
- UV-photon escape fraction
- reionization
- PopIII stars?

The uniqueness of LGRBs

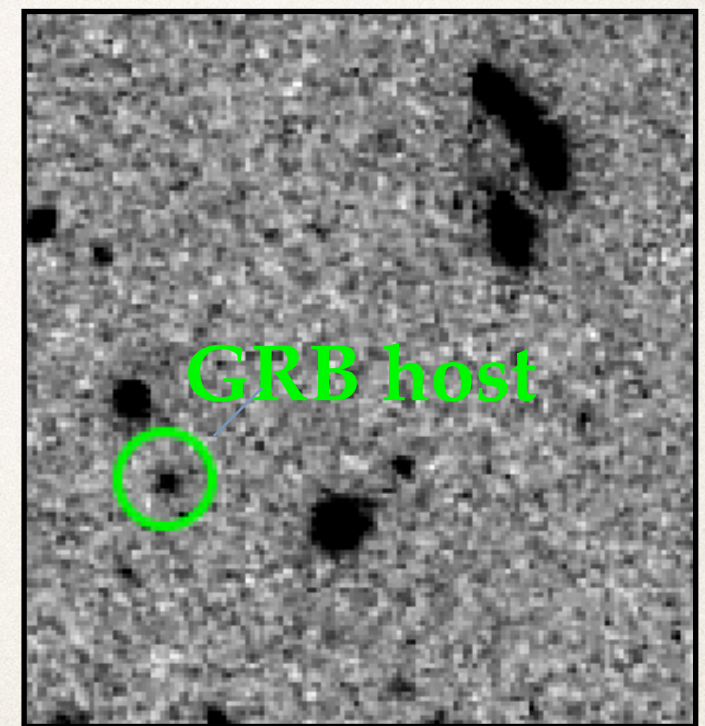
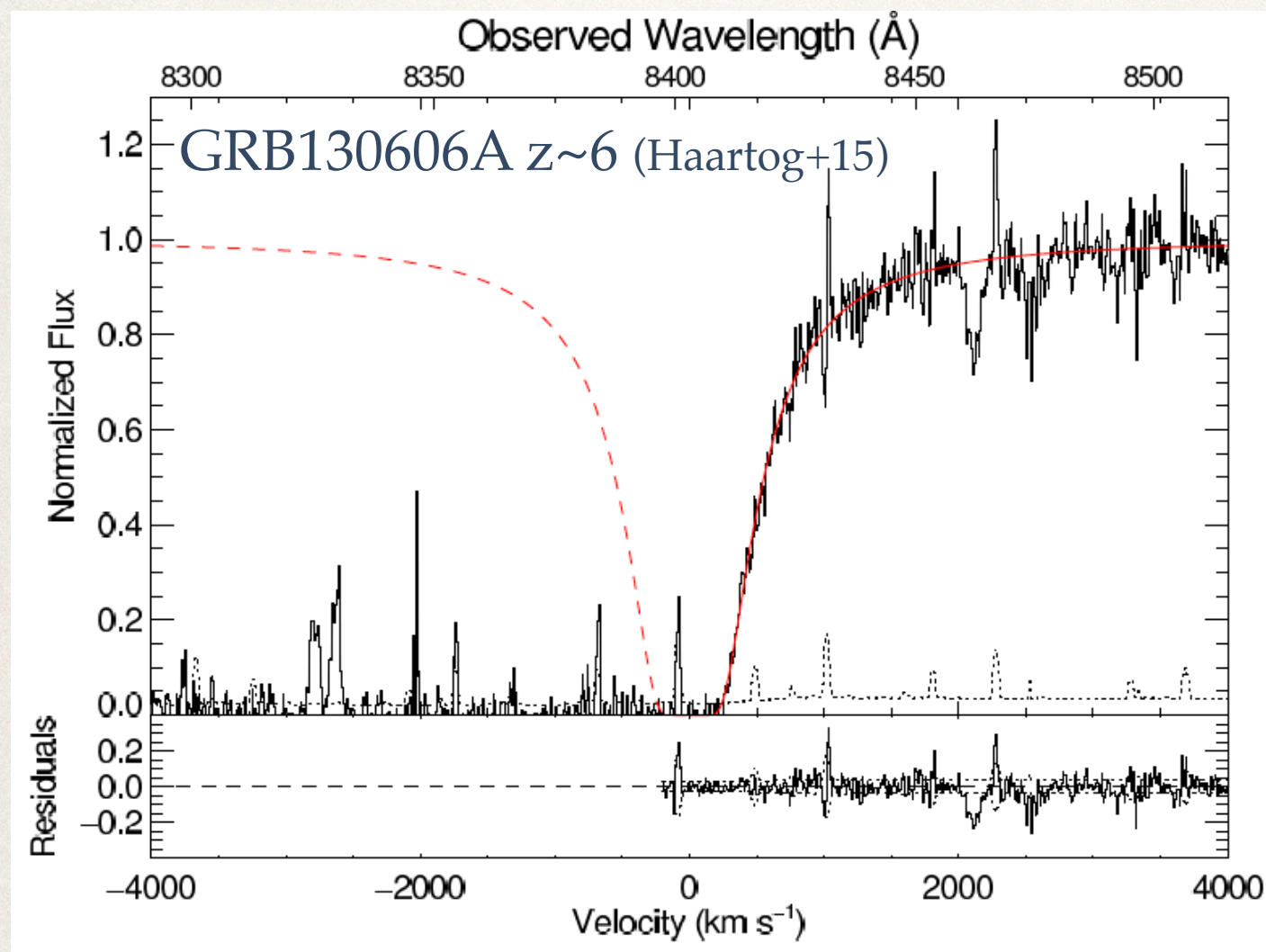
- ❖ combine cold / warm ISM with ionised gas properties
- ❖ metallicity, dust
- ❖ kinematics
- ❖ inflow / outflow
- ❖ systematically & at any z !

Not possible with “usual” galaxy studies,
not even with JWST for faint galaxies

The uniqueness of LGRBs

More to come....

HI + Abundances



HST (McGuire+16)

The uniqueness of LGRBs

- ❖ combine cold / warm ISM with ionised gas properties
- ❖ metallicity, dust
- ❖ kinematics
- ❖ inflow / outflow
- ❖ systematically & at any z !

THESEUS is crucial to extend it to the highest redshift!

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Grazie!

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