

GRBs as probes of the high-redshift Universe

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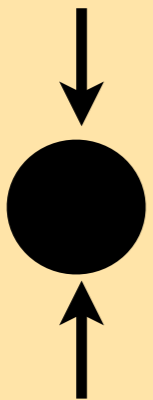


PROGRAMME NATIONAL DE COSMOLOGIE ET GALAXIES

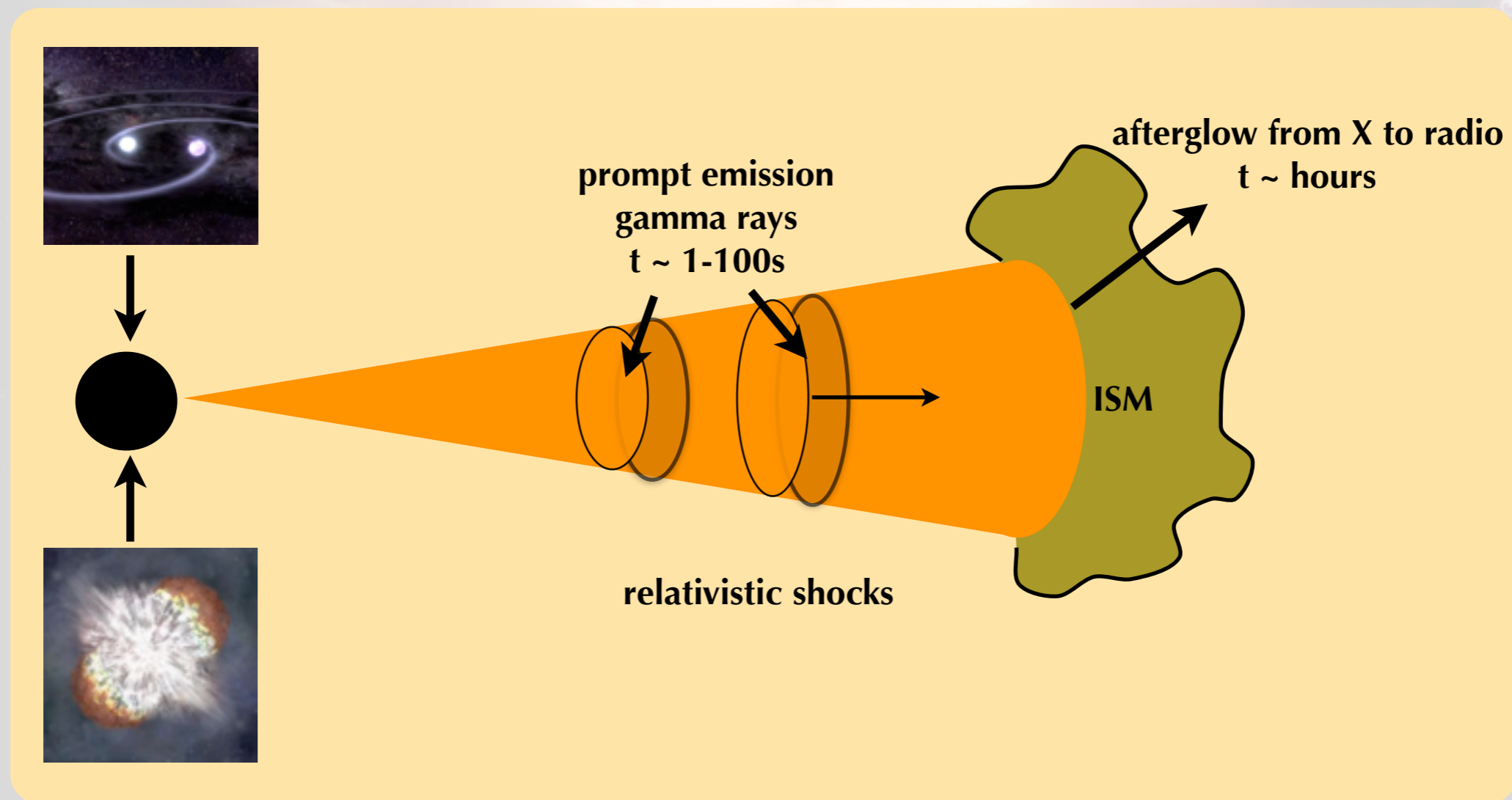
Gamma-ray bursts (GRBs)

Ultra-relativistic jets associated with black holes formation
merging of compact objects massive star explosion

Short

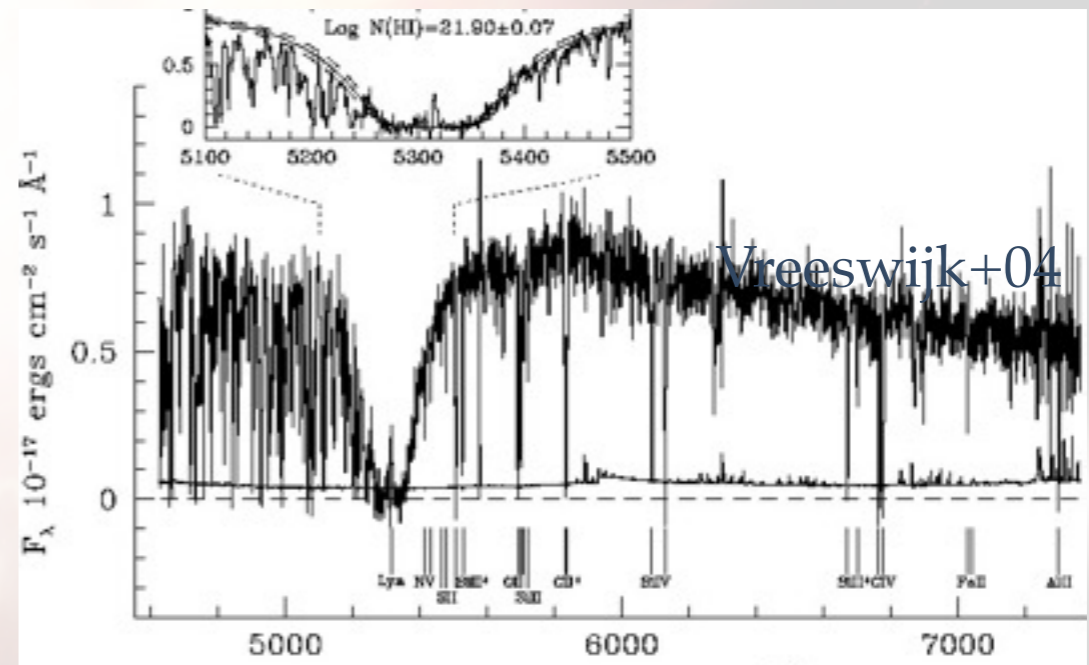
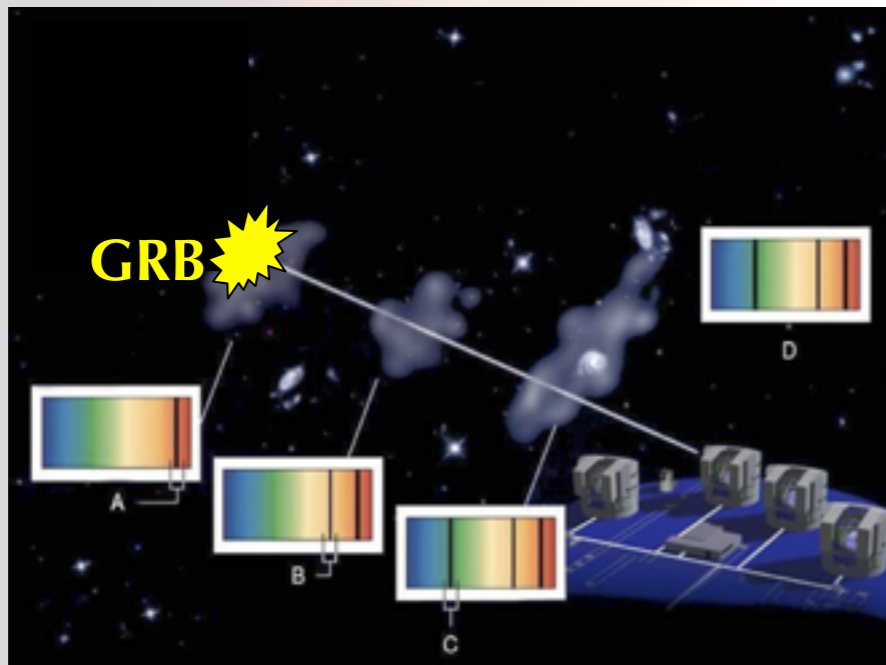


Long



LGRBs & PNCG

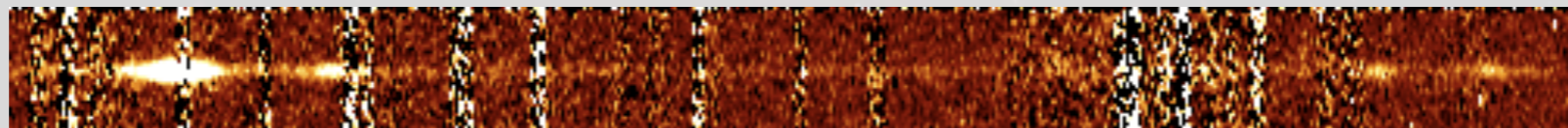
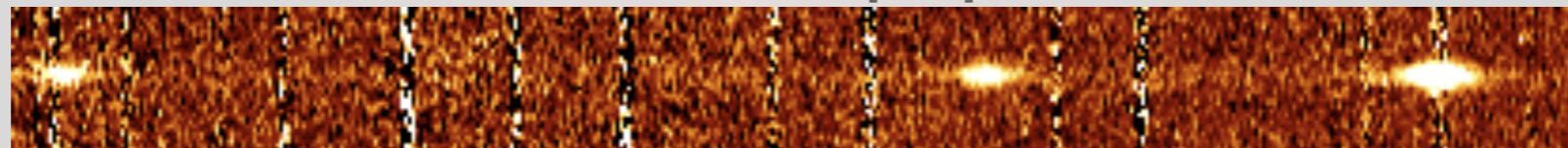
- LGRBs connected with massive stars
- LGRBs connected with star formation
- LGRBs detected up to the highest z



H-beta

[OIII]4959

[OIII]5007



H-alpha [NII]

GRB070306 $z=1.49$

[SII]

LGRBs & PNCG

- **LGRBs connected with massive stars**
- **LGRBs connected with star formation**
- **LGRBs detected up to the highest z**

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

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



Sino-French mission to detect and follow-up GRBs and transients
Launch: end 2021

LGRBs & PNCG

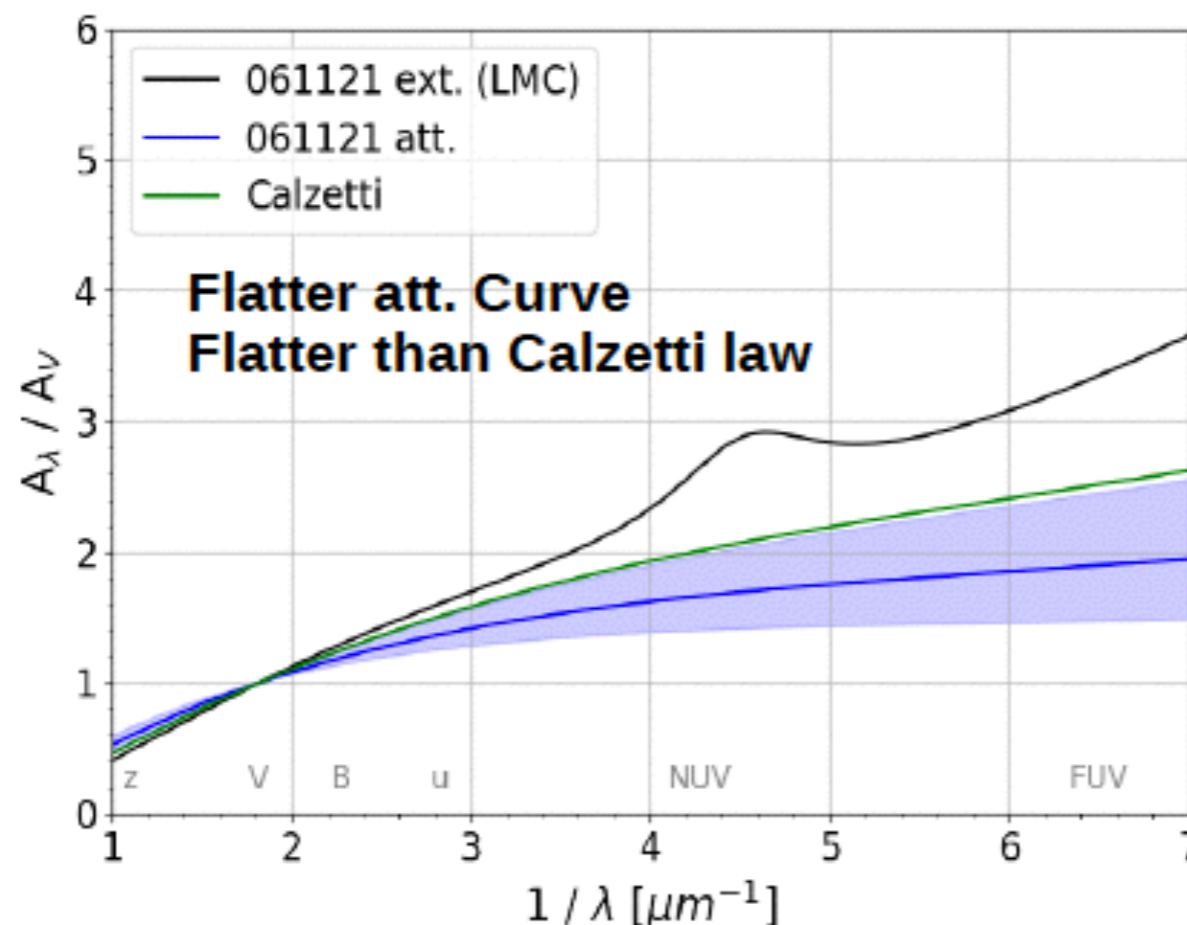
Joining expertise of French
“GRB hosts” & “high-redshift galaxies” researchers

Atelier GRBs meet Galaxies
(Marseille, Septembre 2017)

SED fitting + Attenuation curve on a GRBHs sample

Corre, Buat et al., in preparation. In collaboration with S. Vergani & J. Palmerio

- Attenuation curve derived from the SED fitting
- Comparison of extinction curve along GRB sight-line with the host attenuation curve
→ insight of the dust-star geometry at high-z



Calzetti and Calzetti modified laws

$$k(\lambda) = \left(\frac{A(\lambda)}{E(B-V)} + \frac{E_b \lambda^2 \gamma^2}{(\lambda^2 - \lambda_0^2) + \lambda^2 \gamma^2} \right) \left(\frac{\lambda}{\lambda_V} \right)^\delta$$

(Calzetti+00 + UV bump) X power law

$E(B-V)$ for stellar continuum

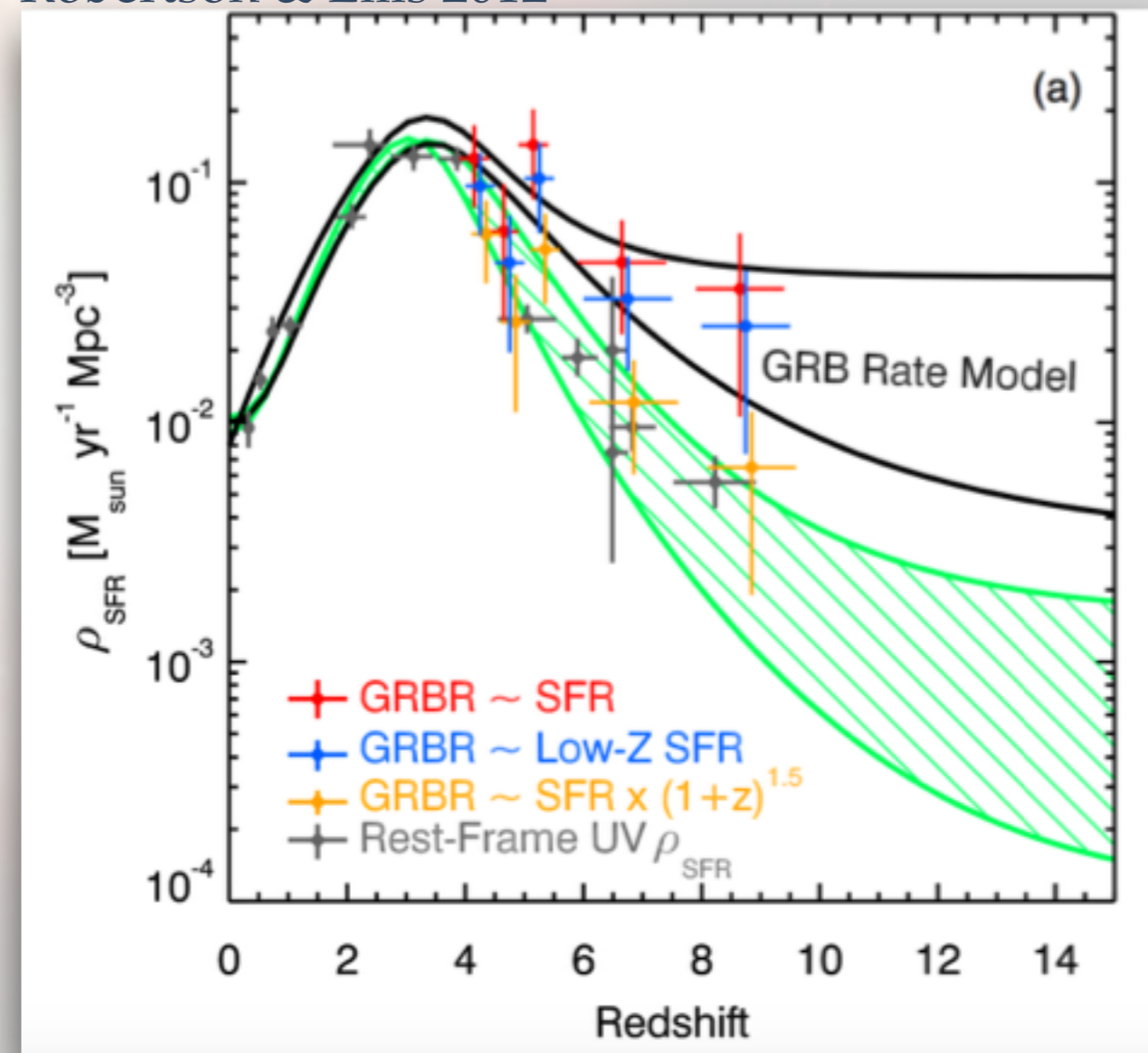
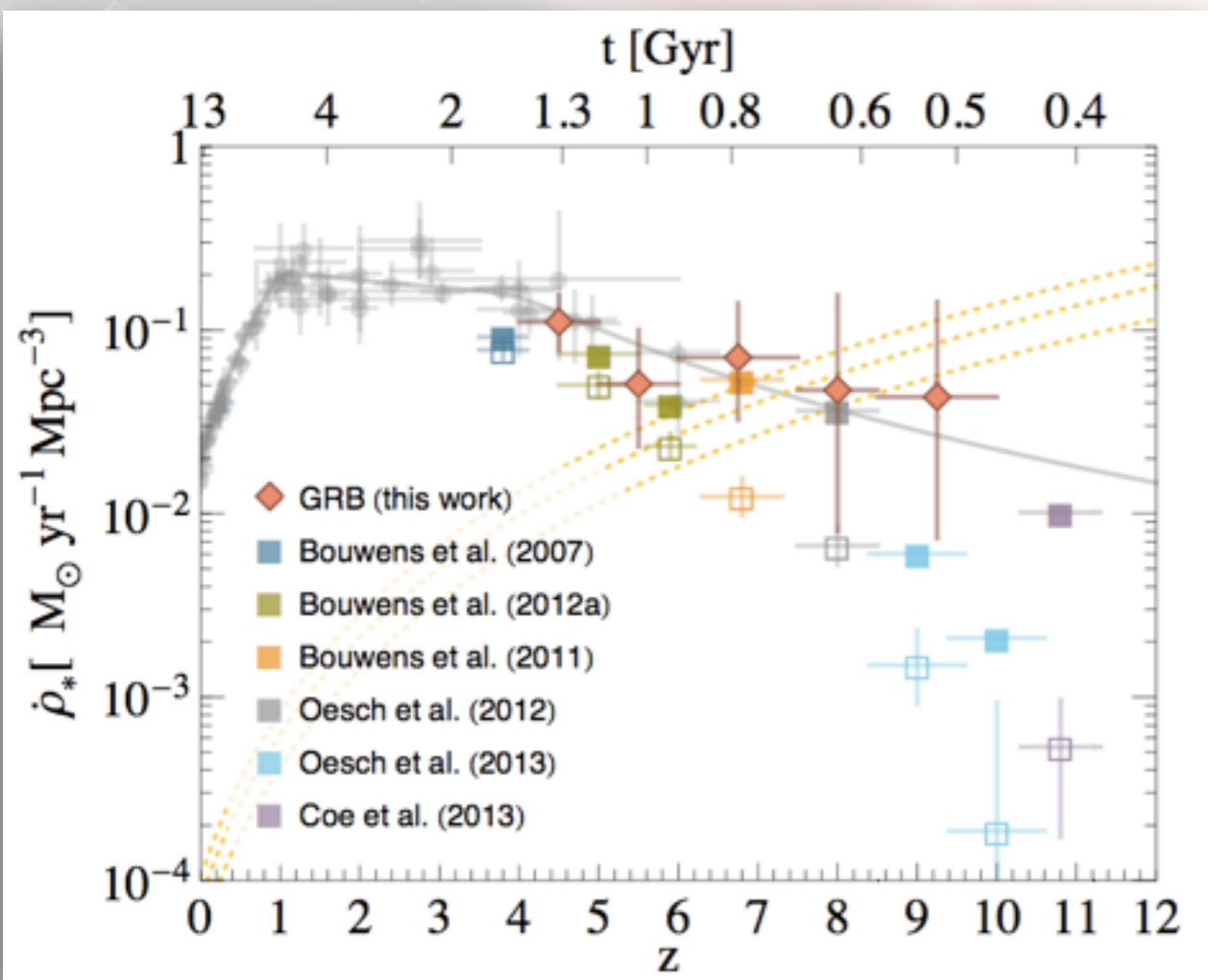
Amplification factor (1/0.44 for Calzetti law) for gas recombination lines and a MW extinction curve+screen

Baseline for the Cigale code,
Kriek&Conroy13, Salmon+15...

LGRBs as SFR tracers

Robertson & Ellis 2012

Kistler+13



GRBRate = eff. x SFR ?

eff. = eff.(z) ?

LGRBs as SFR tracers

GRBrate = eff. x SFR ?

eff. = eff.(z) ?

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

Single stars \longrightarrow Very low metallicity

Binary stars \longrightarrow Any metallicity???

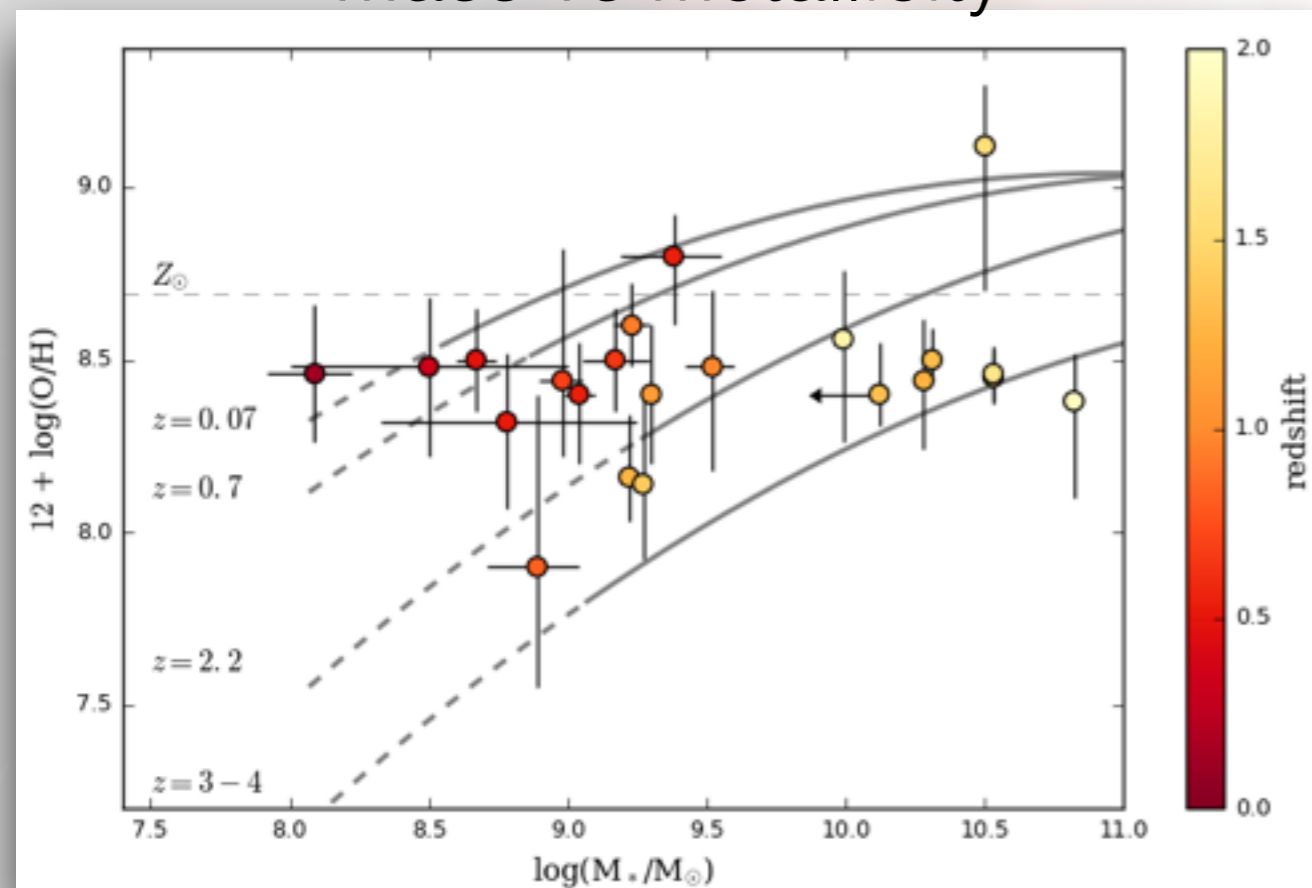
More than one channel? \longrightarrow ???

Study of the host galaxies of a complete sample of LGRBs with extremely high completeness (98%) in redshift

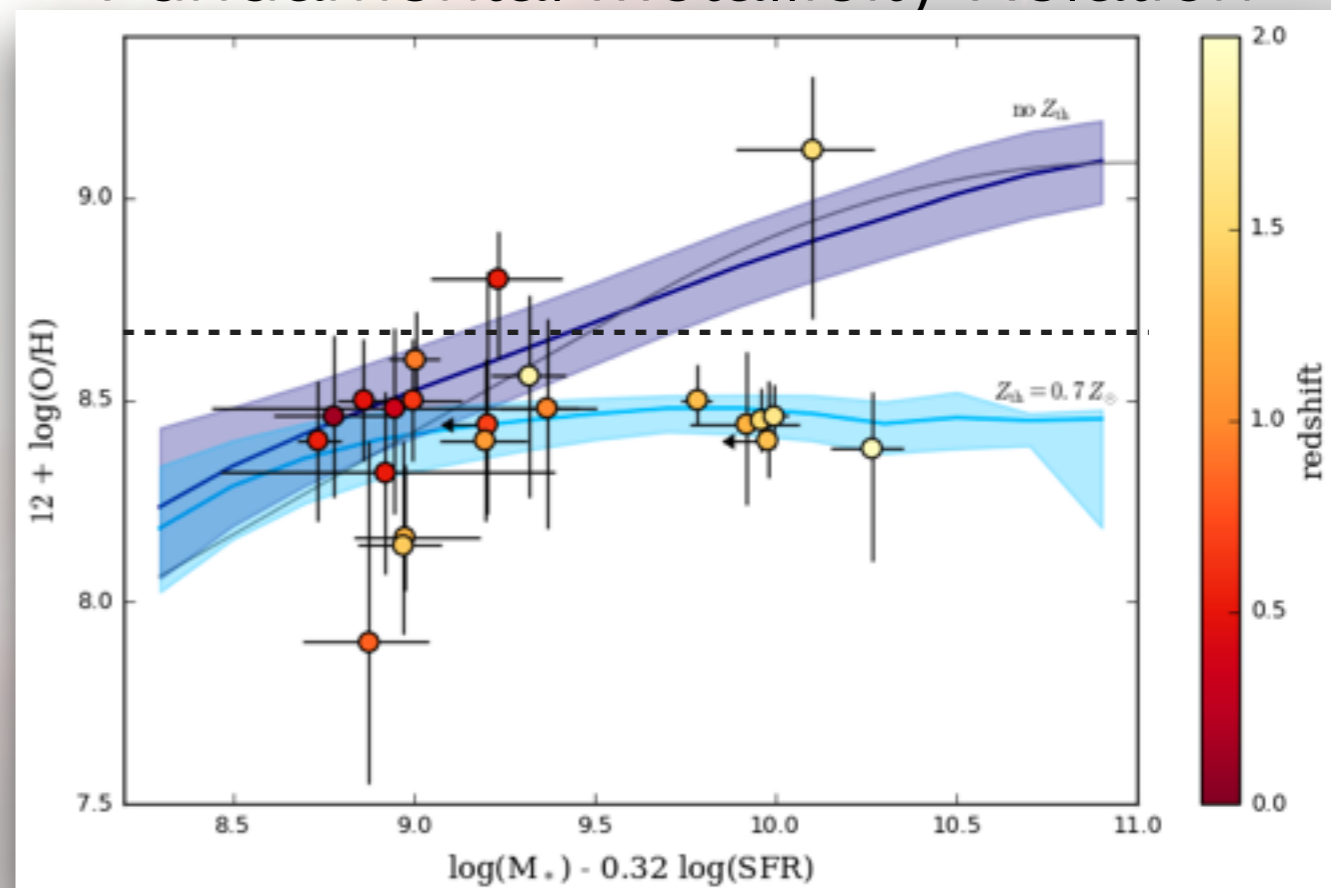
LGRBs as SFR tracers

Vergani+15; Boissier+15; Japelj, Vergani+16; Vergani+17

Mass vs Metallicity



Fundamental Metallicity Relation



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

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 $z \sim 3-4$

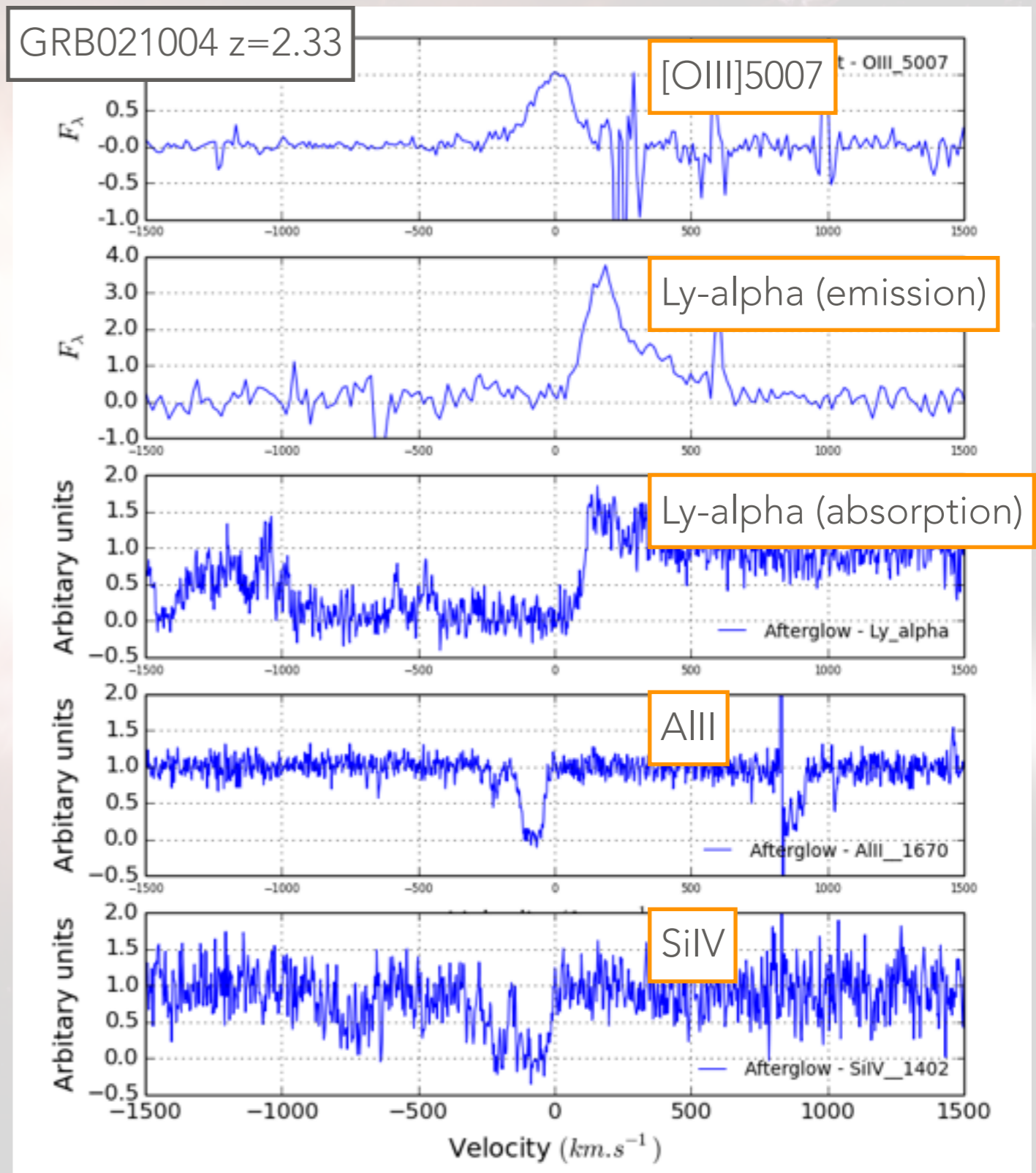
Extending the studies to higher redshift
collaboration also with IAP (Atek, McCracken...)

Combining the information on LGRB host galaxies

- warm gas absorption lines from afterglow spectra (X-shooter / UVES)
- Imaging (HST)
- Host galaxy emission lines (X-shooter)

e.g: Lyman-alpha modeling

Vergani, Atek, Richard, Verhamme,...
+ post-docs & students



Combining the information on LGRB host galaxies

- warm gas absorption lines from afterglow spectra (X-shooter / UVES)
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More to come,
Stay tuned!

e.g: Lyman-alpha modeling

Vergani, Atek, Richard, Verhamme,...

+ post-docs & students

A vibrant, fiery explosion or nebula in space, with a bright yellow and orange core surrounded by a glowing red and orange ring. The background is dark with scattered stars and faint nebulae. The word "Merci!" is written in a bold, red, sans-serif font in the center of the image.

Merci!