

“Dark” GRB 080325 in a Dusty Massive Galaxy at $z \sim 2$

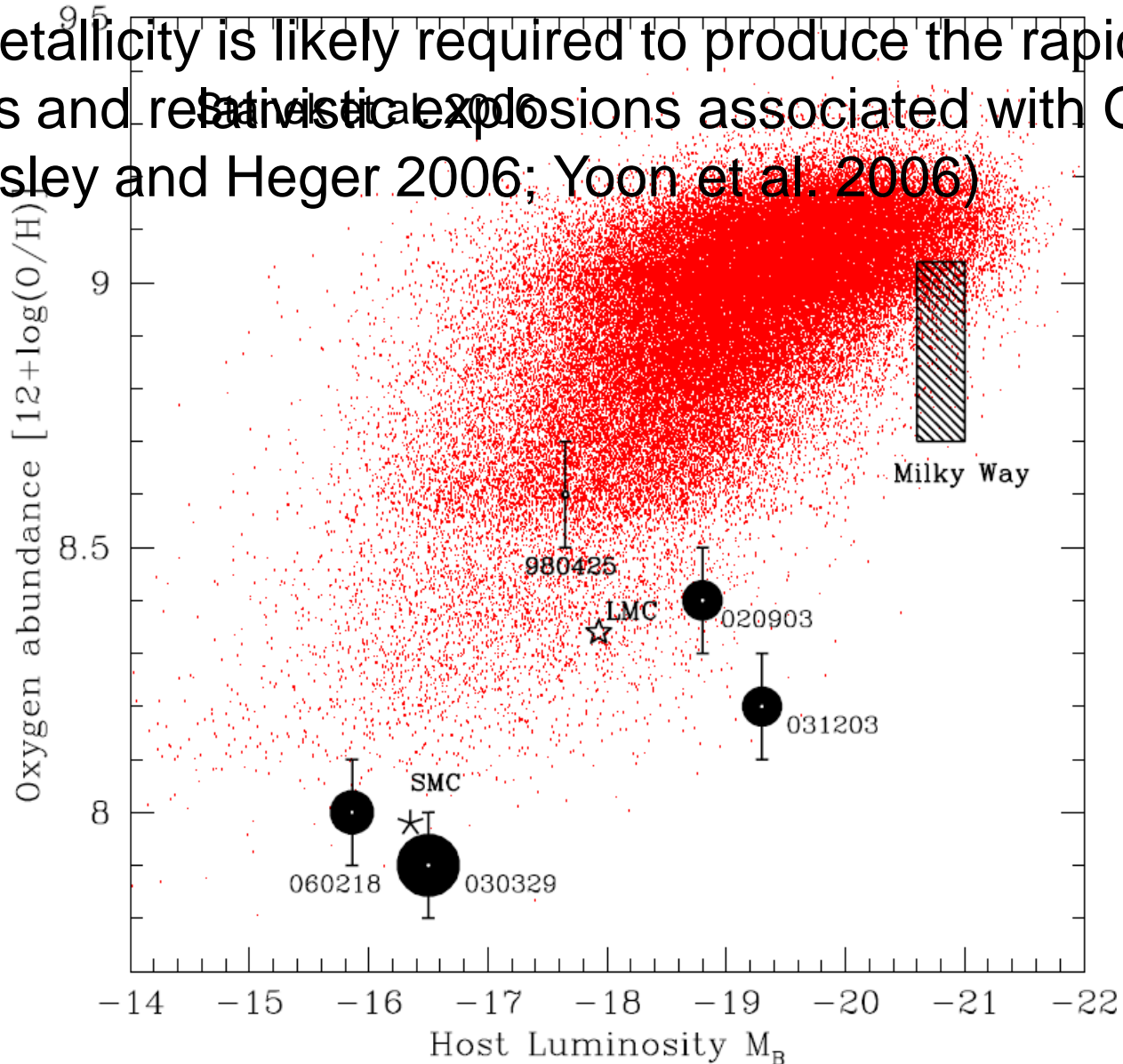
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Low metallicity environment of GRBs

The low metallicity is likely required to produce the rapid rotating progenitors and relativistic explosions associated with GRBs (e.g., Woosley and Heger 2006; Yoon et al. 2006)



“Dark” GRBs

GRBs and afterglow (AG) statistics (yearly sums of the table above)

No of GRBs	No of X-ray AGs	No of optical AGs	No of radio AGs	No of redshifts
811	515	345	71	216

<http://www.mpe.mpg.de/~jcg/grbgen.html>

Jochen Greiner, last update: 16-Mar-2010

Significant numbers of dark GRBs

→ Properties of Dark GRB hosts remains a mystery

Why they are “Dark”?

▪ Low density environment around GRB

(e.g., Kumar & Panaitescu 2000).

▪ Large extinction along the line of sight to GRB

(e.g., Perley et al. 2009)

▪ Intrinsically low luminosity GRB

(e.g., Gehrels et al. 2008)

▪ High redshift

(e.g., Tanvir et al. 2009)

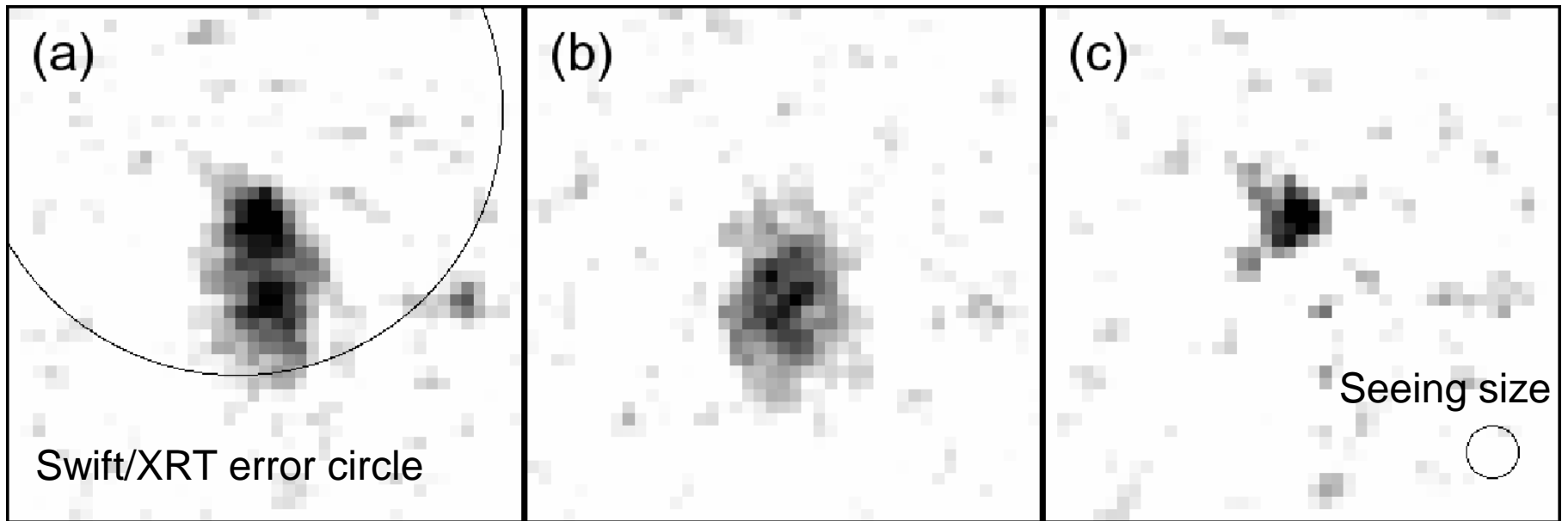
Subaru/MOIRCS ToO observation of GRB 080325

No optical detection of the afterglow within Swift/XRT error circle

Subaru/MOIRCS J, Ks band ToO obs.

→ Detection in Ks band (Ks=22.8)

MOIRCS Ks band (5".0 x 5".0)



8.7 hours after the burst

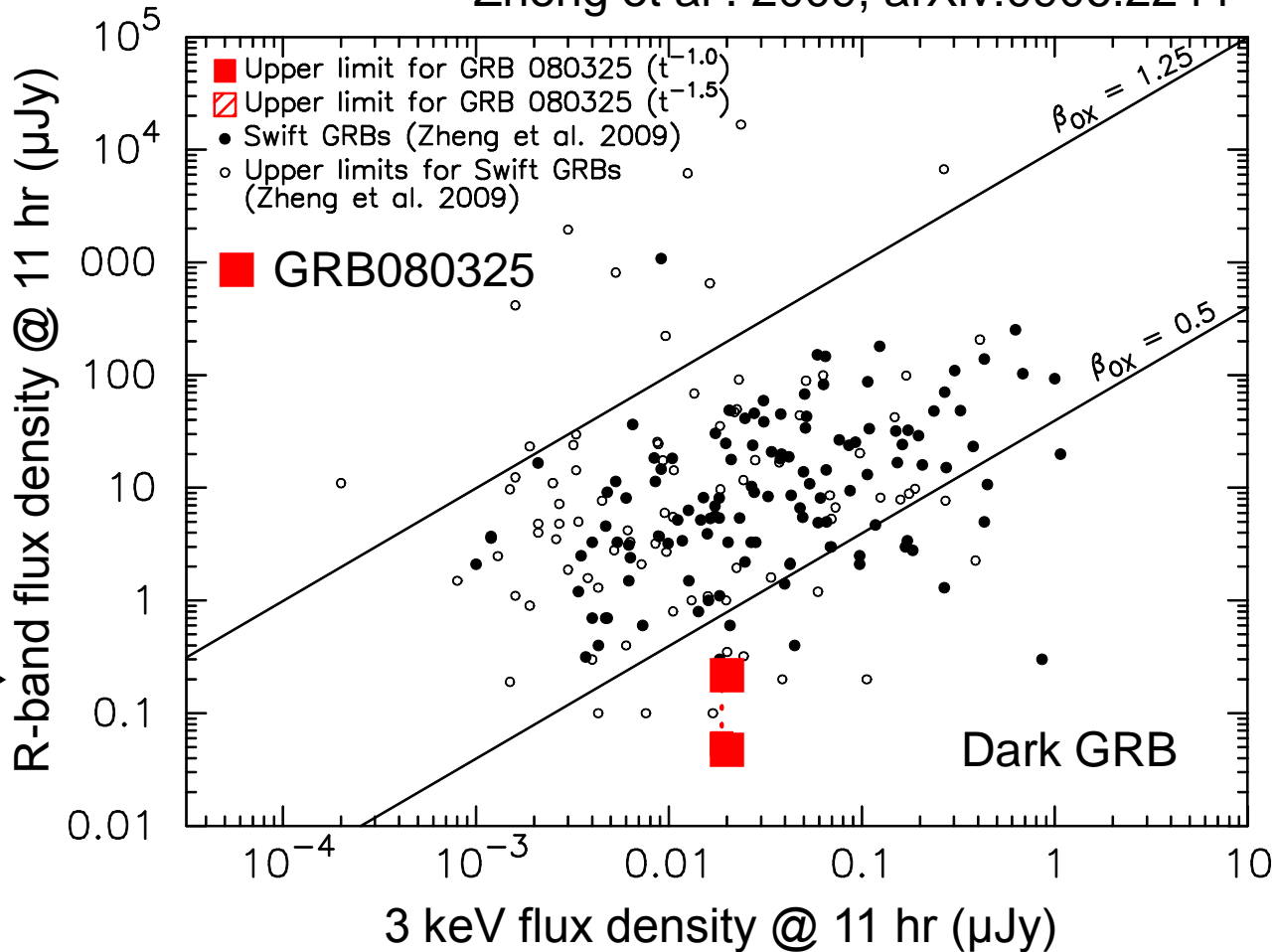
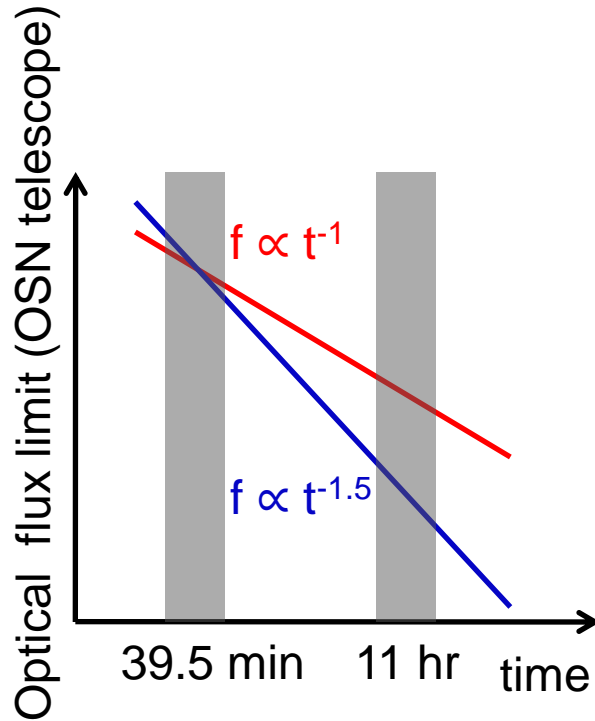
33.5 hours after the burst

Afterglow (a)-(b)

Dark GRBs Defined by β_{OX} (Jakobsson et al. 2004)

$$\beta_{OX} = \log\{f_{\nu}(3\text{keV})/f_{\nu}(R)\}/\log(\lambda_{3\text{keV}}/\lambda_R)$$

Zheng et al. 2009, arXiv:0906.2244

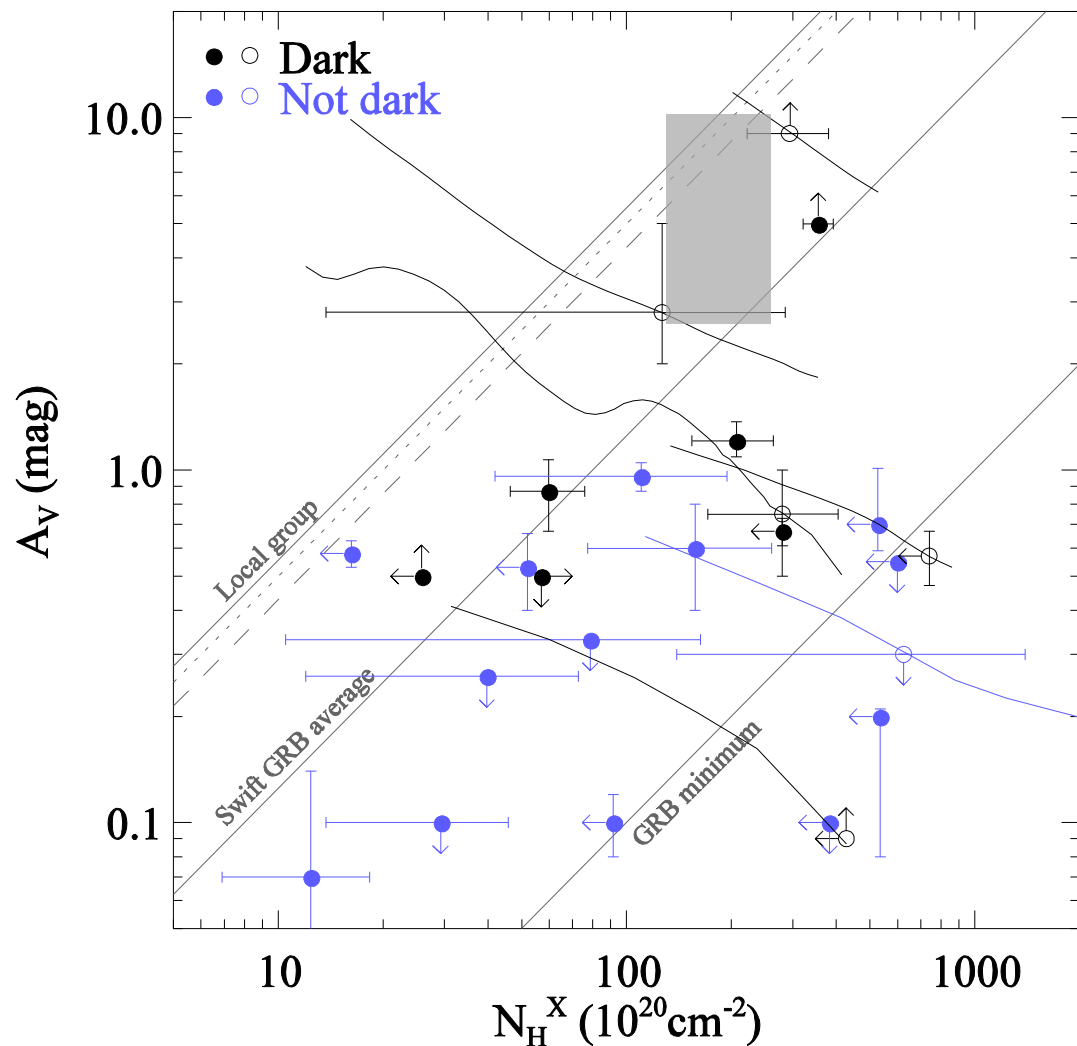


Extinction along the line of sight to the GRB

$$0.5 < \beta_{OX} < 1.25 \rightarrow 2.7 \text{ mag} < A_{V,AG} < 10.0 \text{ mag}$$

Dust Extinction along the Line of Sight to GRBs

Perley et al. 2009



■ GRB080325

$A_{V,AG}$: from $0.5 < \beta_{OX} < 1.25$

N_H^X : Spectral fitting of X-ray afterglow

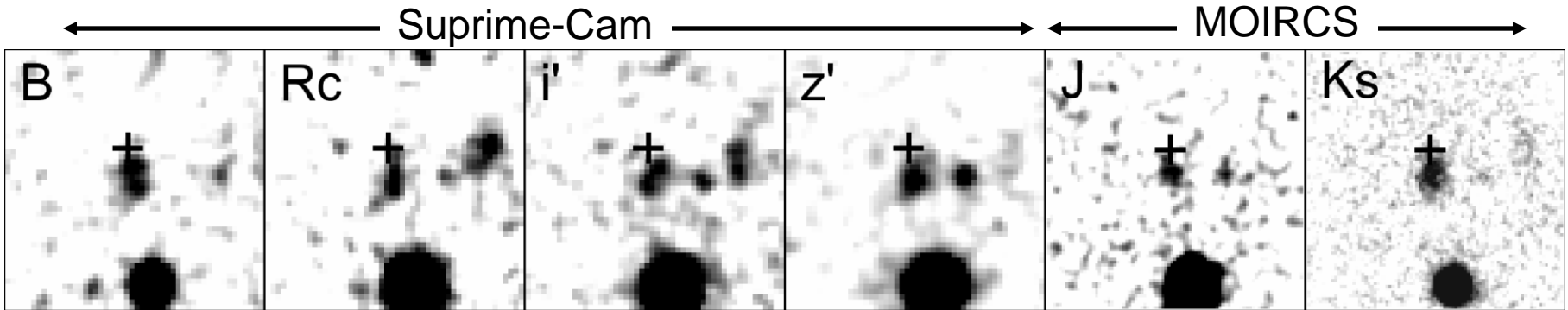
$A_{V,AG}$

is larger than $A_{V,AG}$ of
not dark GRBs
and

is comparable to $A_{V,AG}$ of
other dark GRBs

How about the host galaxy?

Subaru/Sprime-Cam (1 year after the burst)



10" x 10"

SFH = constant SFR

$\tau = 10\text{Myr}, 100\text{Myr}, 1\text{Gyr}, 10\text{Gyr}$
instantaneous burst

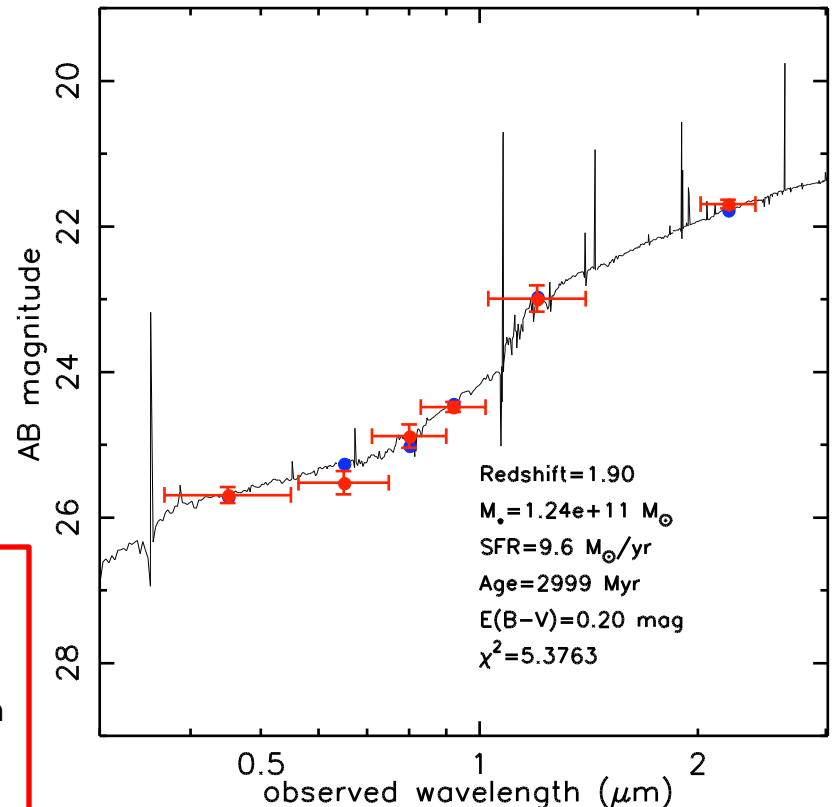
IMF = Salpeter

Stellar population synthesis model
= PEGASE.2

$$\text{Redshift} = 1.9^{+0.3}_{-0.15} \quad \text{SFR} = 9.6^{+4.1}_{-5} M_{\text{sun}}/\text{yr}$$

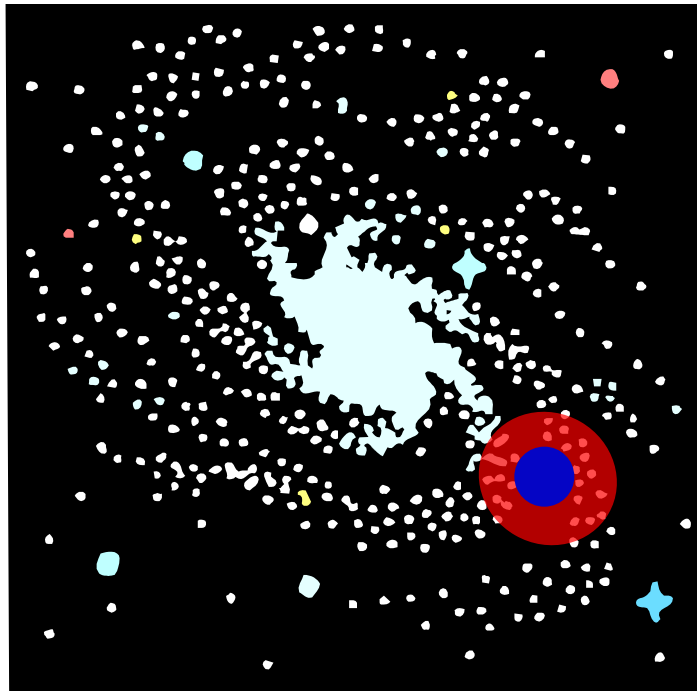
$$A_{V,\text{host}} = 0.8^{+0.6}_{-0.2} \text{ mag} \quad M_* = 1.2^{+0.6}_{-0.3} \times 10^{11} M_{\text{sun}}$$

$$M_B = -21.8 \sim L^* \text{ at } z \sim 2$$

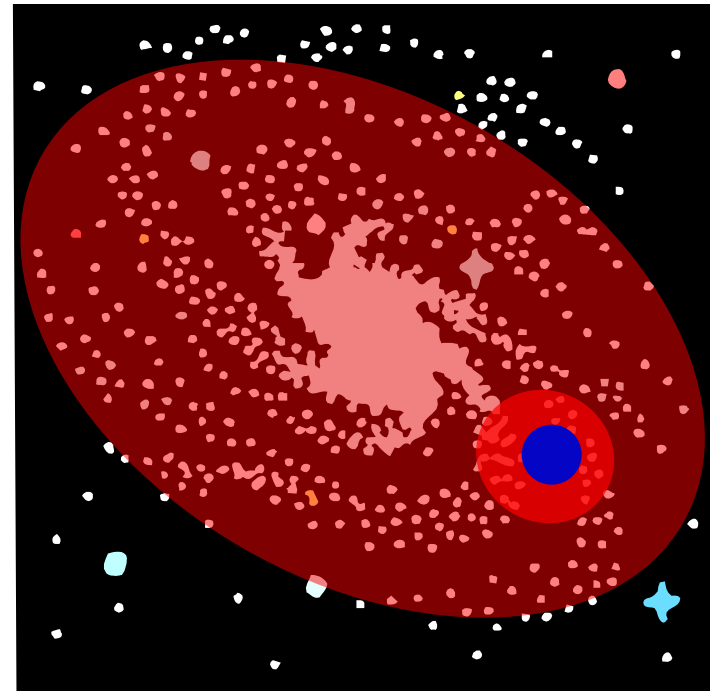


Local dusty environment around GRB 080325?

Blue Dark GRB hosts with small $A_{V,host}$
(Perley et al. 2009)



Red Dark GRB hosts with large $A_{V,host}$
GRB 080325
GRB 051022



● GRB position

■ Dust distribution

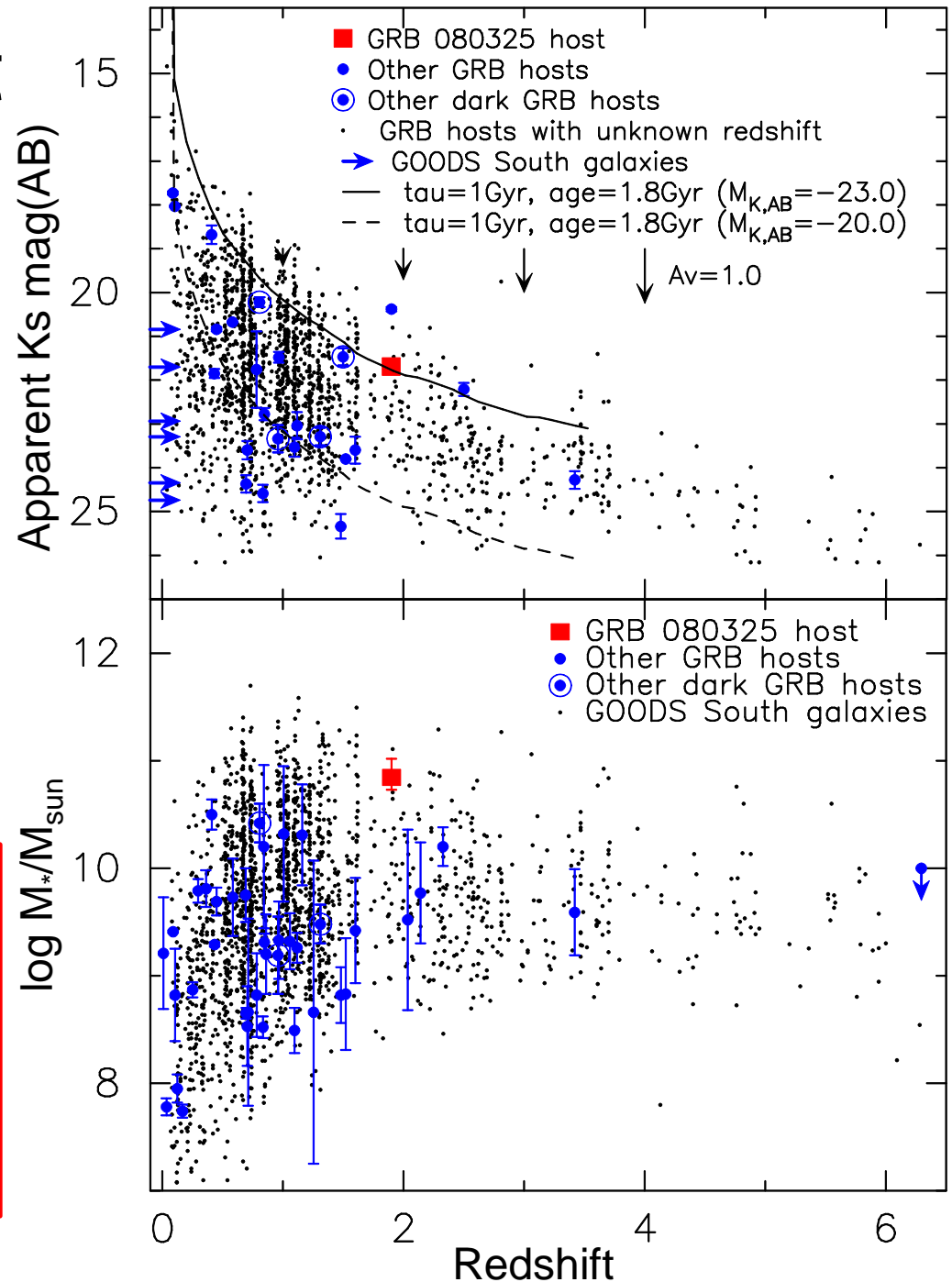
→ Local high metallicity environment?

Massive GRB host

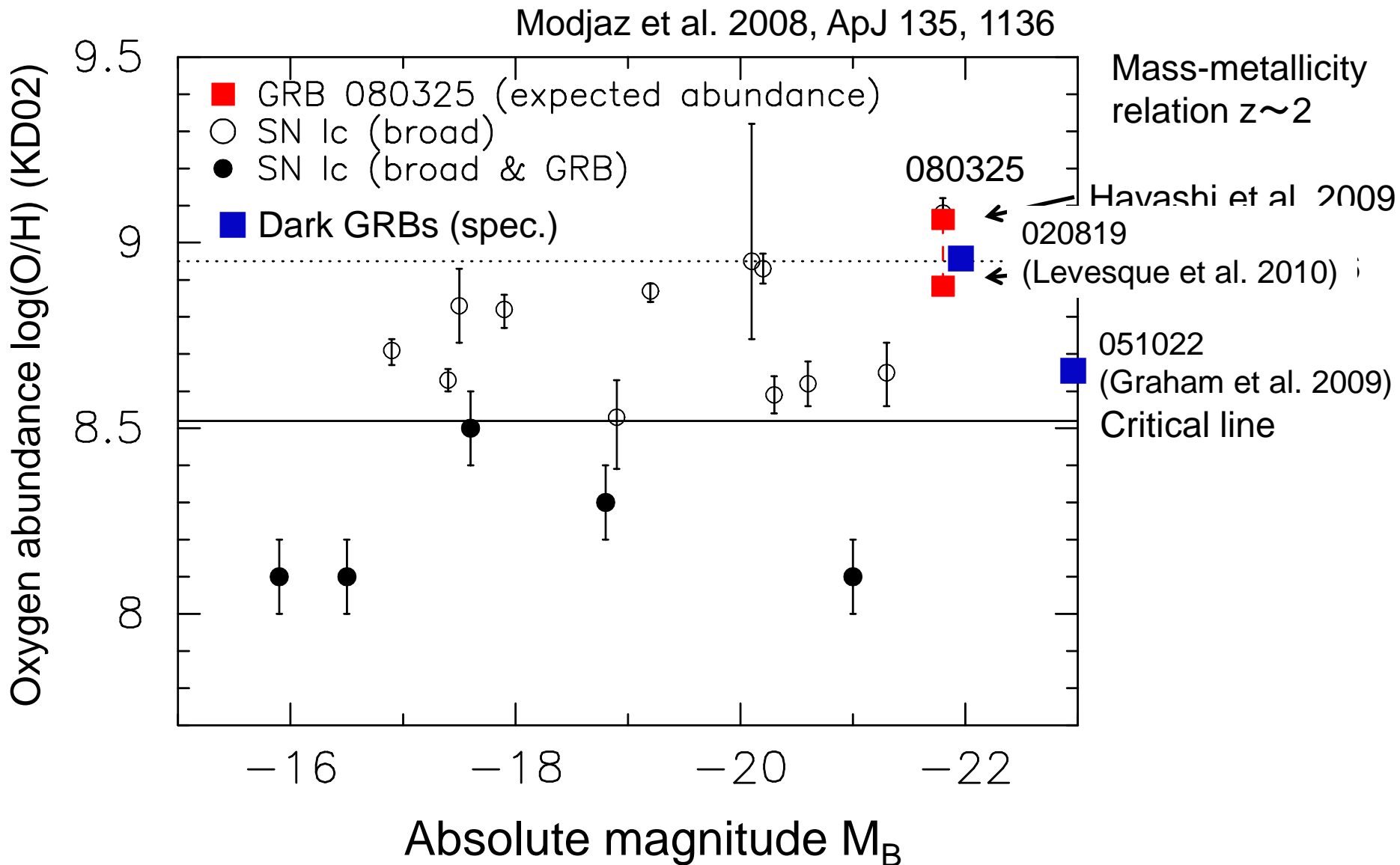
- GRB080325
- Long GRB host (Savaglio et al. 2009)
- ➔ Long GRB host (unknown z)
- GOODS South galaxies (spec-z; Grazian et al. 2006)

GRB080325

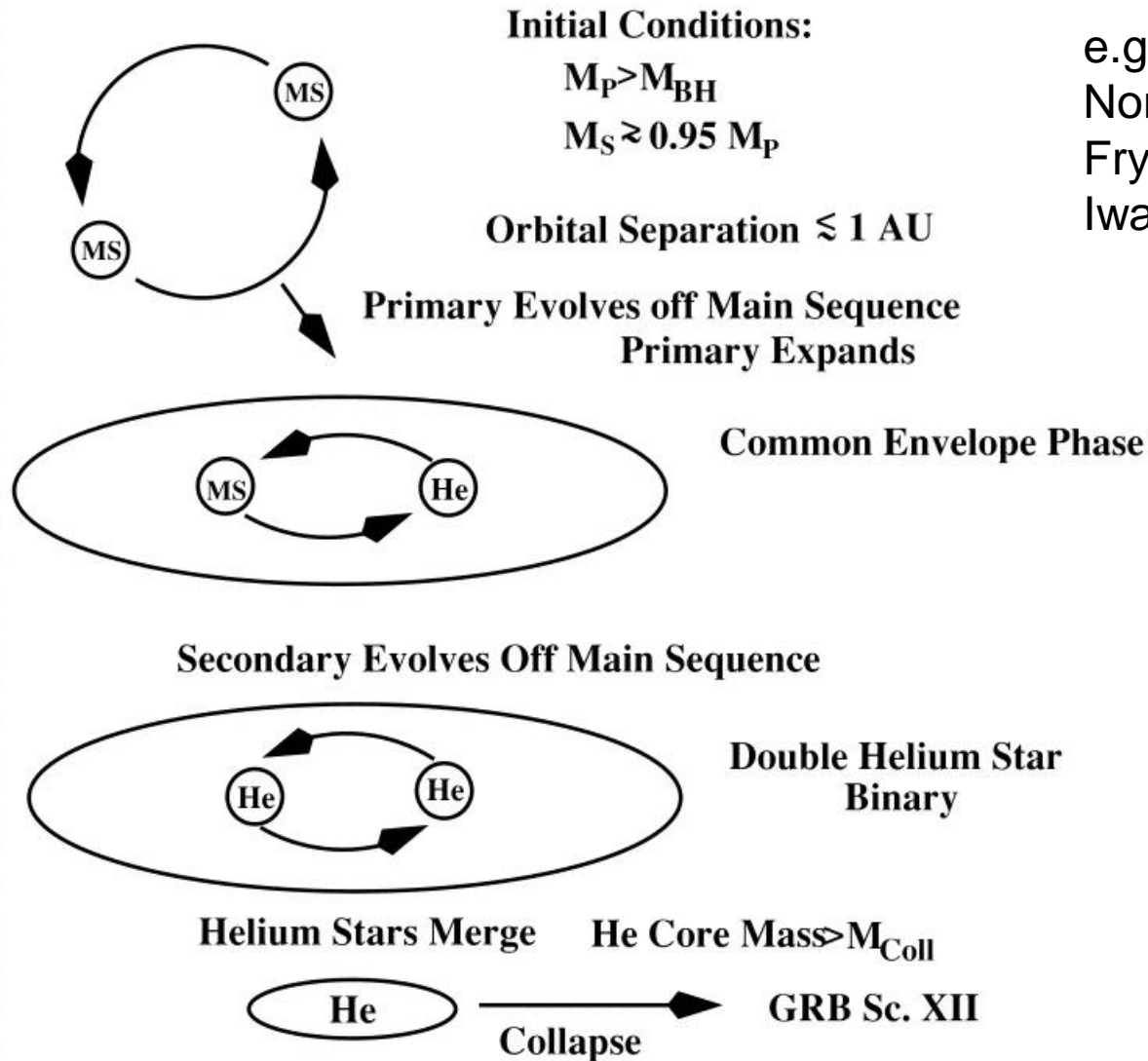
GRB 080325 host is
brighter ($L \geq L^*$ at $z=2$)
 and
massive
 compared with typical GRB hosts



High metallicity environment around GRB?



Binary-star merger Scenario?



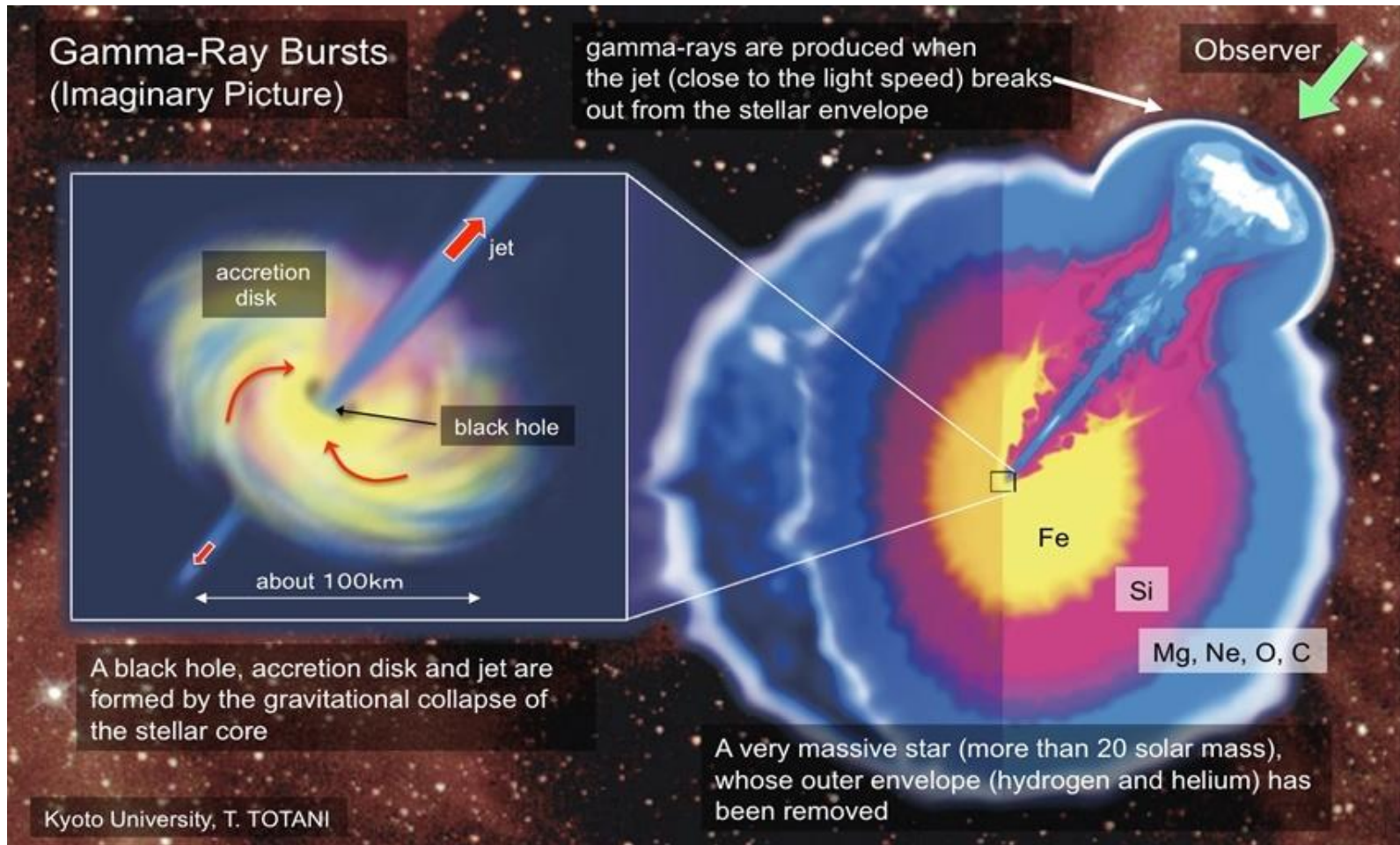
e.g.,
Nomoto et al. 1995
Fryer et al. 1999
Iwamoto et al. 2000

The orbital angular momentum contributes to produce a GRB explosion during the merging process

Summary

- Near-infrared observations with **Subaru/MOIRCS** provided a clear detection of "Dark" GRB 080325 **afterglow** in Ks band, although no optical counterpart was reported.
- The "dark" nature of GRB 080325 is likely attributed to the local dusty environment around the GRB.
- GRB 080325 host is a **luminous (massive) dusty star-forming galaxy** in contrast to the less dusty and sub-L* property of typical GRB hosts at lower redshift.
- The large stellar mass of GRB 080325 host suggests high metallicity environment around GRB. But **spectroscopic observation is essential** especially at the GRB position.

(Long) Gamma-Ray Burst (GRB)



	GRB	X-ray, optical, near infrared, and radio afterglow
Time scale	Several tens of seconds	Several minutes ~ several tens of hours

Dust Extinction

$A_{V,host}$



Total brightness of a host



SED fitting



(Flux weighted) Extinction for a whole host galaxy

$A_{V,AG}$

Obscuration-free flux density of a X-ray afterglow

+

Afterglow model
($0.5 < \beta_{OX} < 1.25$)



Upper and lower limits on obscuration-free flux density of an optical afterglow



Comparison with observed (rest-wavelength) optical afterglow

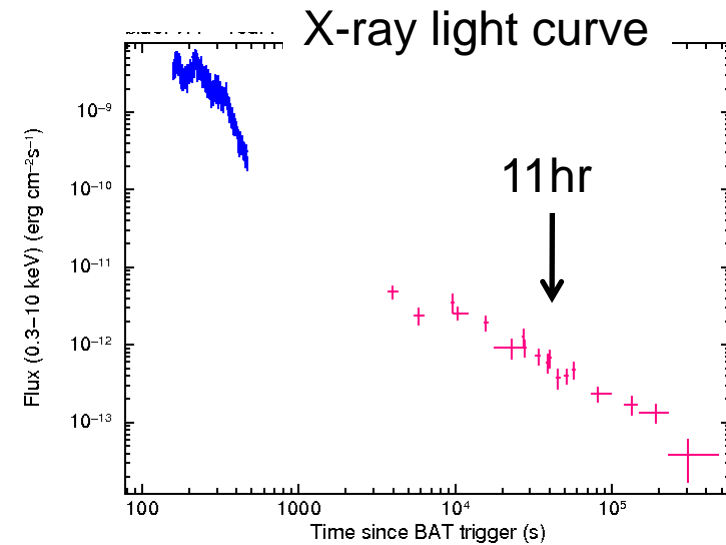
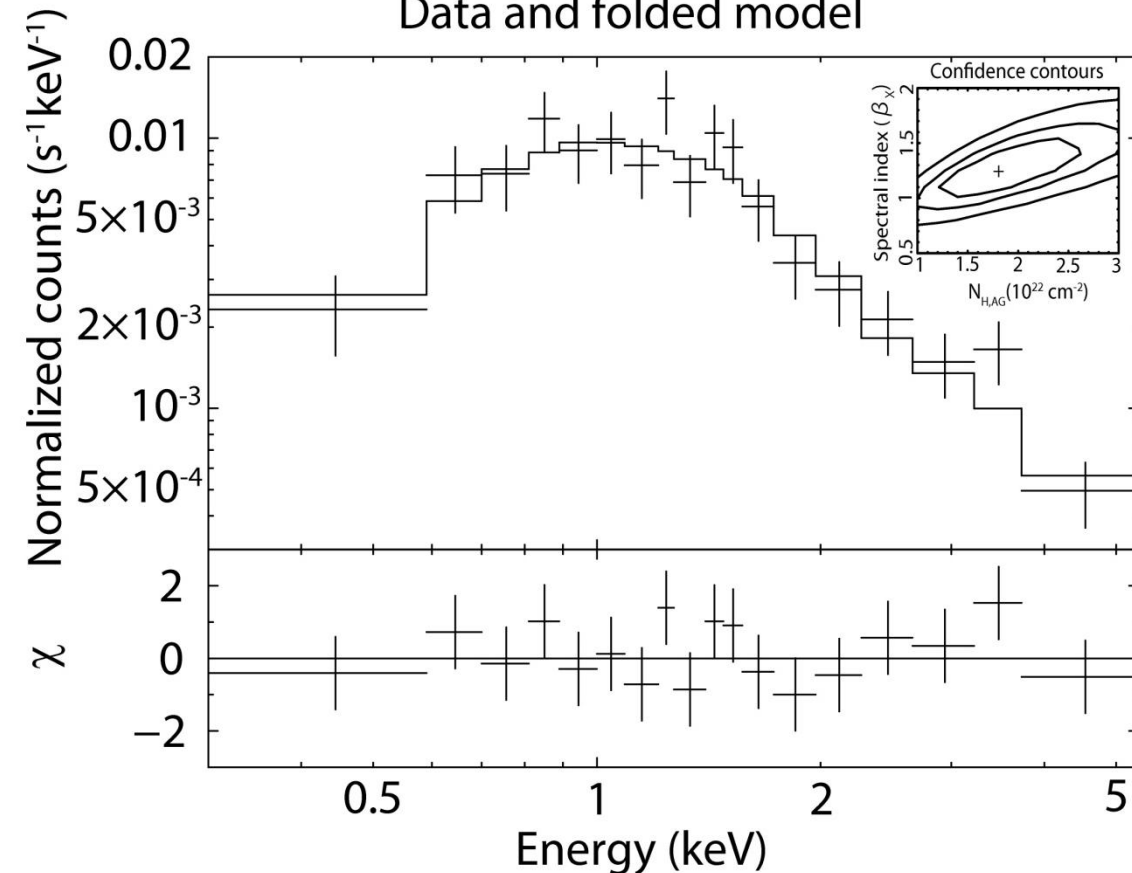


Extinction along the line of sight to a GRB

X-ray Light Curve and Spectrum (Swift/XRT)

X-ray spectrum
(1-16 hours after the burst)

Data and folded model



- Galactic extinction ($N_H = 3.8 \times 10^{20} m^{-2}$)
- Extinction by GRB host at $z=2$
- power law spectral index $\beta_X = (f_\nu = \nu^{-\beta_X})$



- Extinction by GRB host $N_H = 2.4 \times 10^{22} cm^{-2}$
- power law spectral index $\beta_X = (f_\nu = \nu^{-\beta_X}) = 1.5$

J-Ks Color of the Host

$J-Ks, \text{host} = 1.3$ mag (AB magnitude)

- Long GRB host (Levan et al. 2006; Berger et al. 2007; Jaunsen et al. 2008; Savaglio et al. 2009)
- Long GRB host (unknown z)
- GOODS South galaxies (spec-z; Grazian et al. 2006)

Typical GRB hosts (including “dark”)
(Le Floc’h et al. 2003, A&A 400, 499;
Perley et al. 2009)

Blue color
Faint (Sub L^*)



GRB080325 host

Red color, strong extinction (low z)
or
Luminous ($z > 3$)

