“Dark” GRB 080325 in a Dusty Massive Galaxy at z ∼ 2

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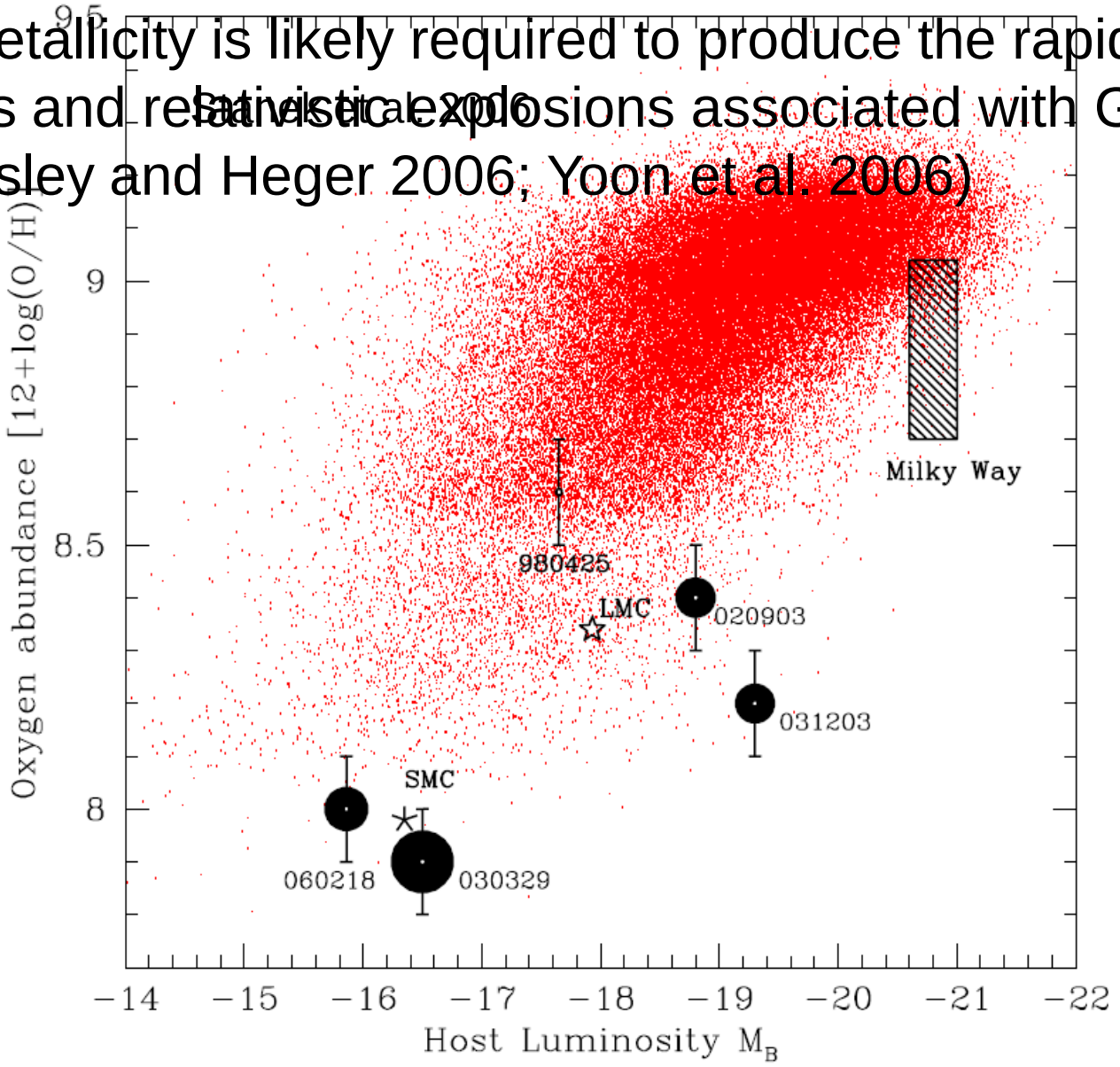
Low metallicity environment of GRBs

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)

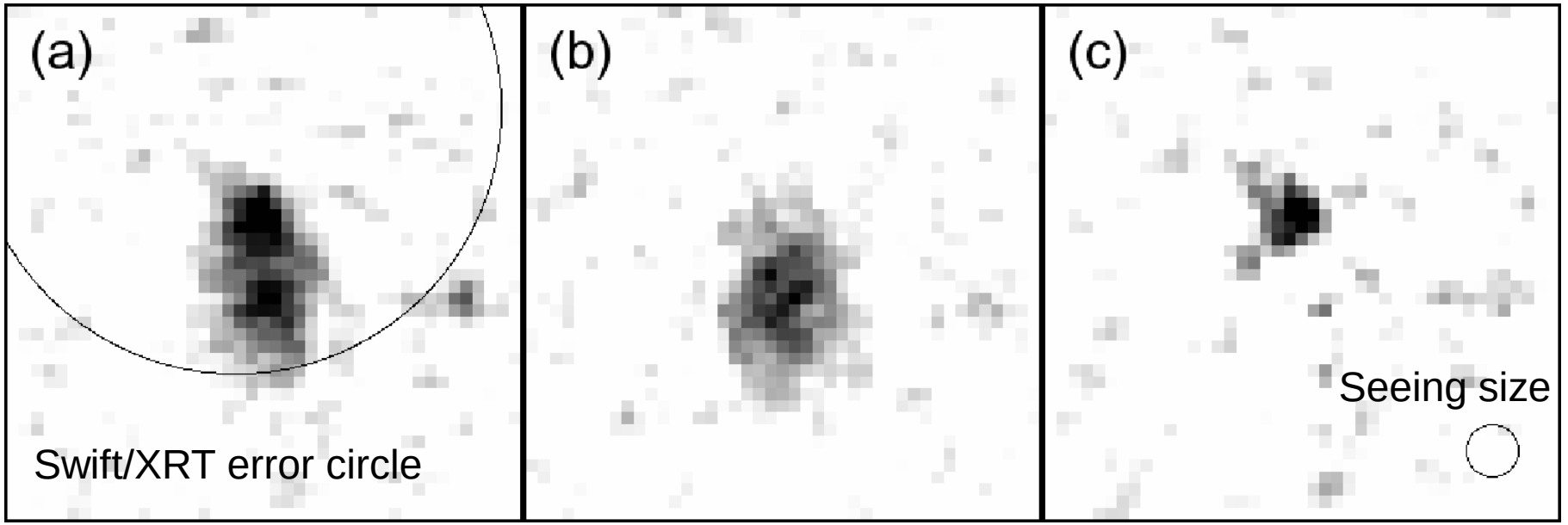
Subaru/MOIRCS ToO observation of GRB 080325

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)

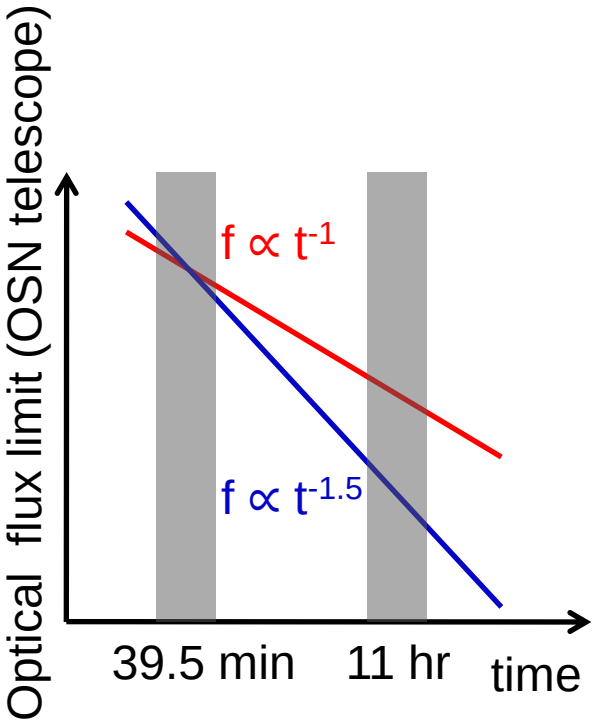


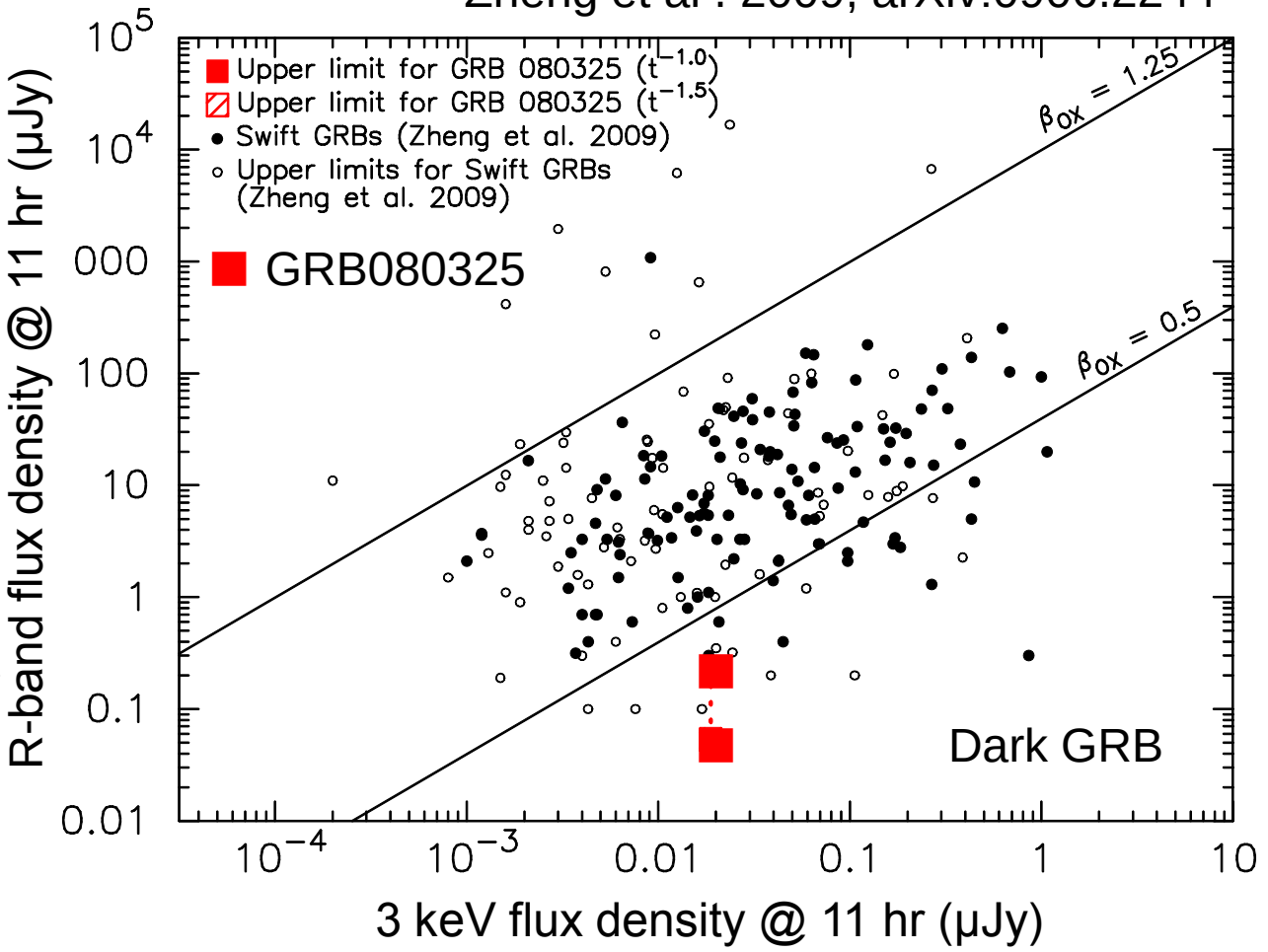
8.7 hours after the burst | 33.5 hours after the burst | Afterglow (a)-(b)

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



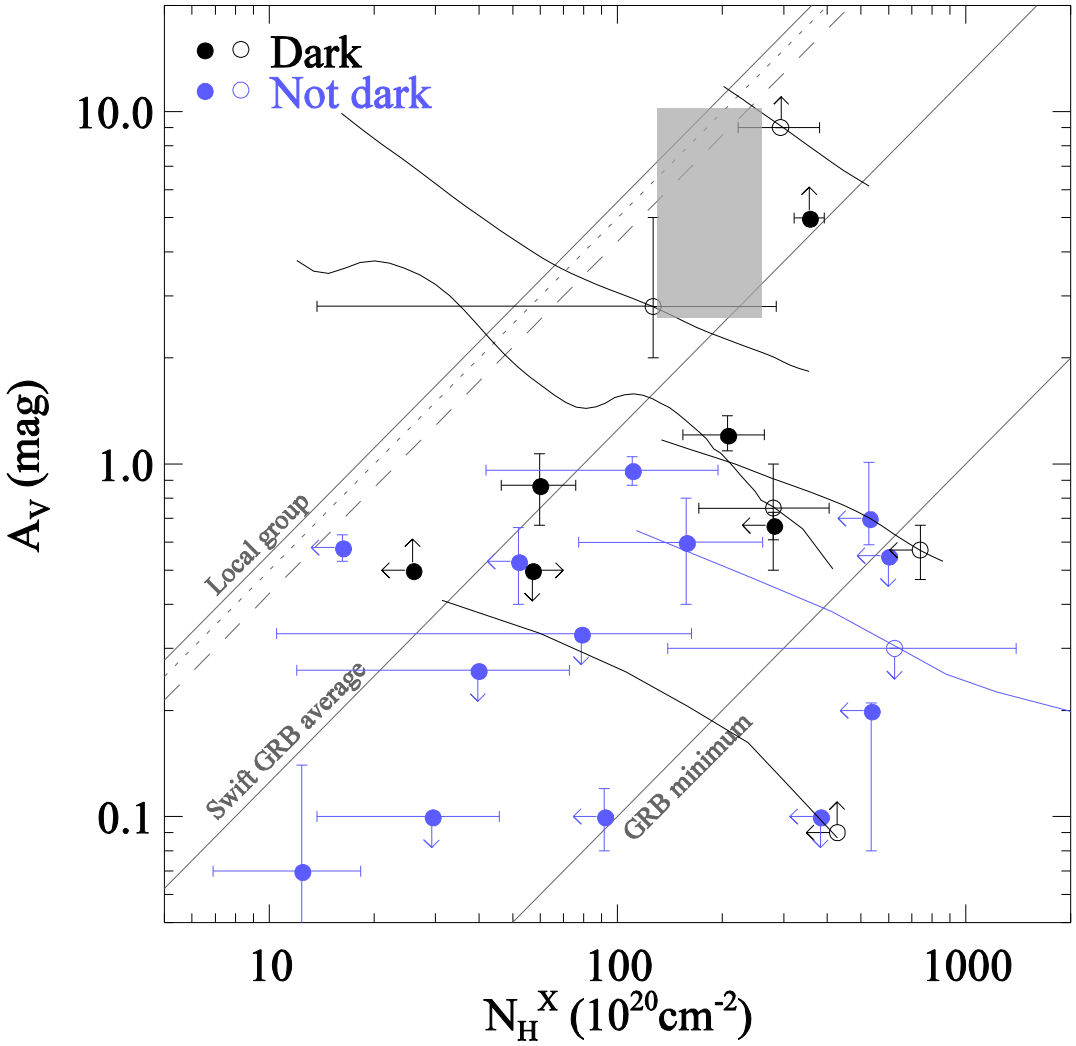


Extinction along the line of sight to the GRB

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

Dust Extinction along the Line of Sight to GRBs

Perley et al. 2009



GRB080325

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

N_H^X :Spectral fitting of X-ray afterglow

Av,AG

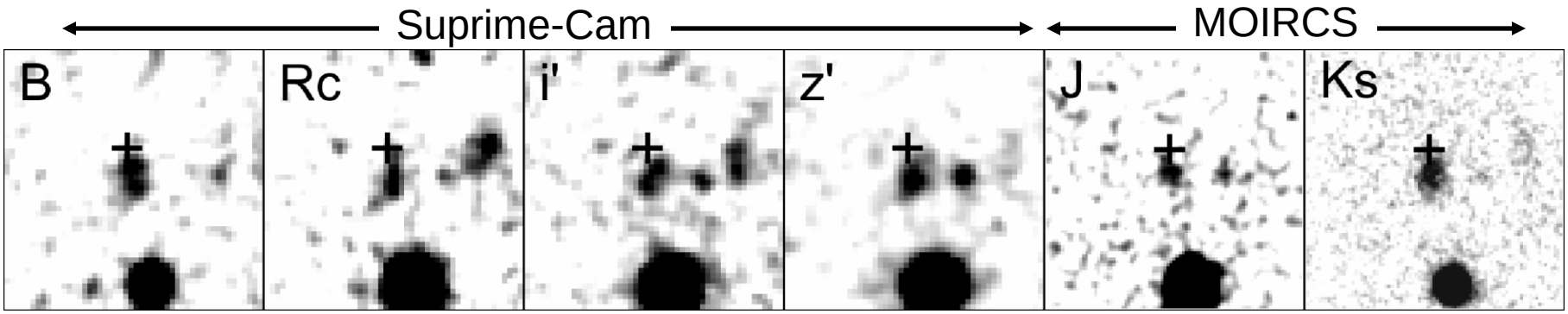
is larger than Av,AG of not dark GRBs

and

is comparable to Av,AG of other dark GRBs

How about the host galaxy?

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

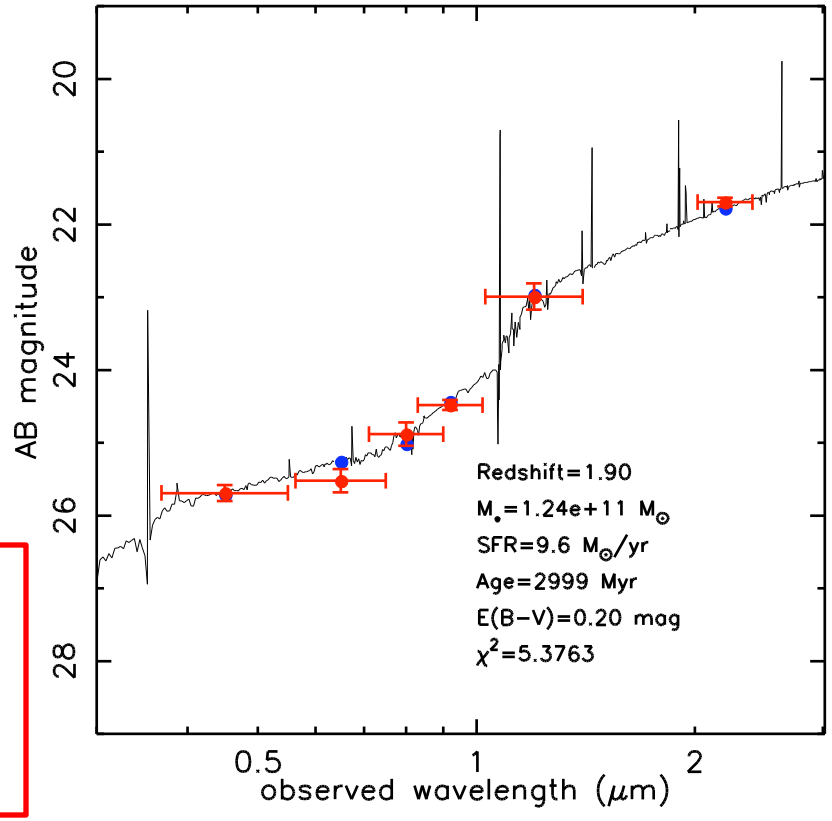


10” x 10”

SFH = constant SFR
tau =10Myr, 100Myr, 1Gyr, 10Gyr
instantaneous burst

IMF = Salpeter

Stellar population synthesis model
= PEGASE.2



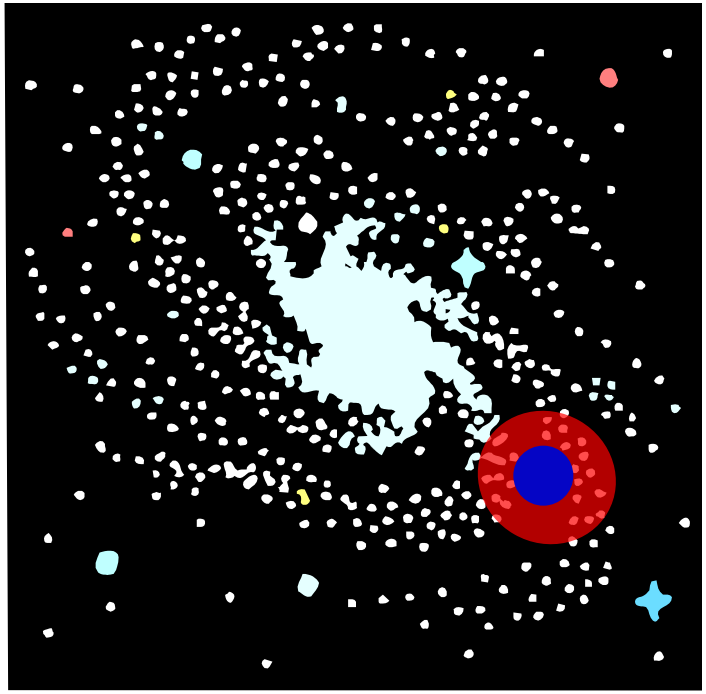
Redshift $= 1.9^{+0.3}_{-0.15}$ SFR $= 9.6^{+41}_{-5}$ M_{sun}/yr

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

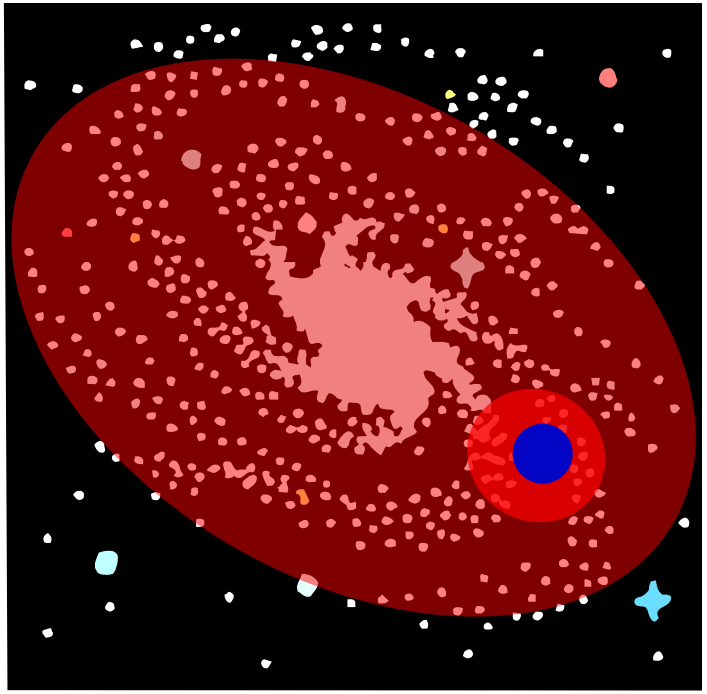
M_B = -21.8 ~ L* at z ~ 2

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

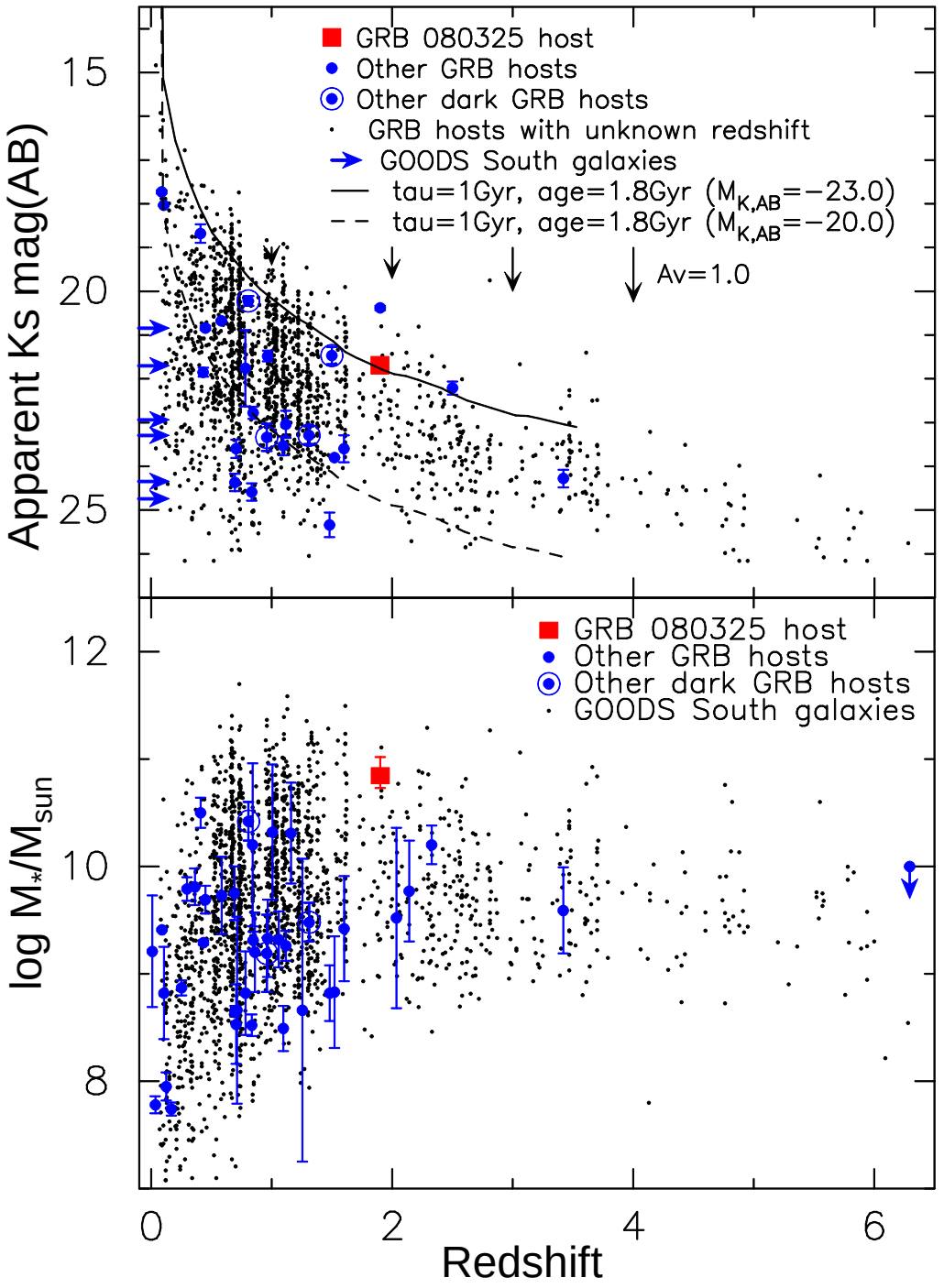
→ Local high metallicity environment?

Massive GRB host

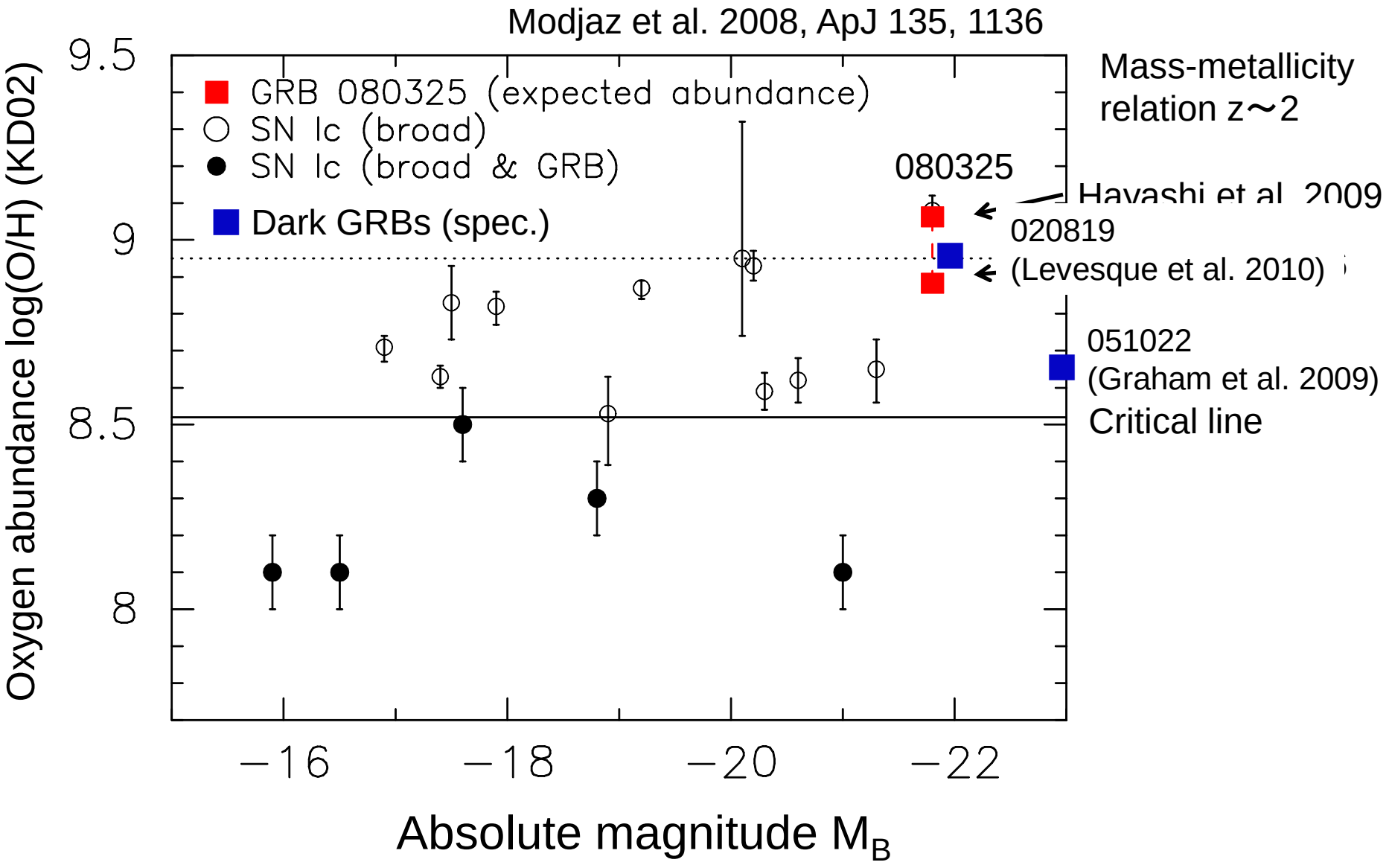
- GRB080325
- Long GRB host (Savaglio et al. 2009)
- → Long GRB host (unknown z)
- GOODS South galaxies (spec-z; Grazian et al. 2006)

GRB080325

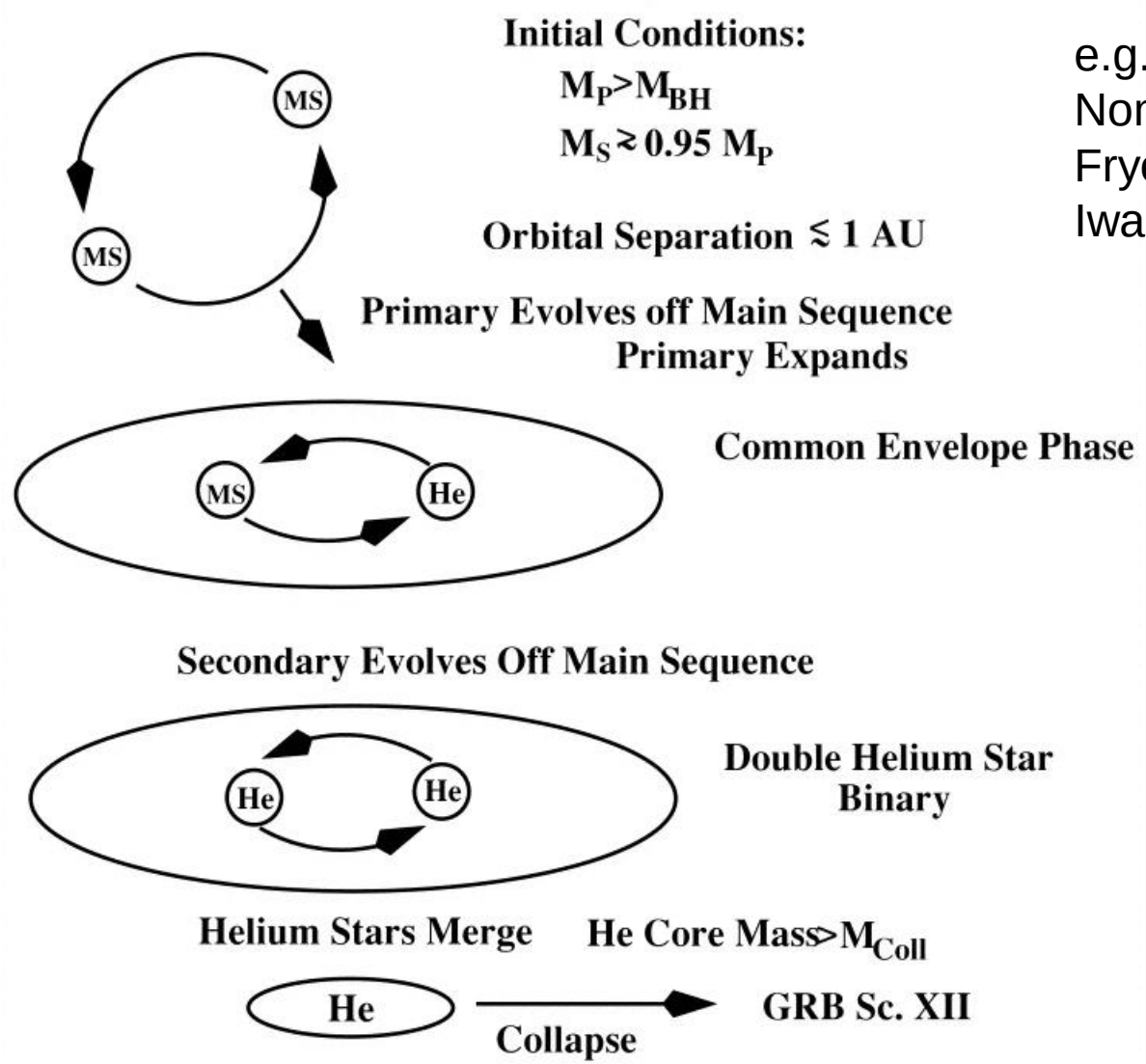
GRB 080325 host is
brighter ($L \geq L^*$ at z=2)
and
massive
compared with typical GRB hosts



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

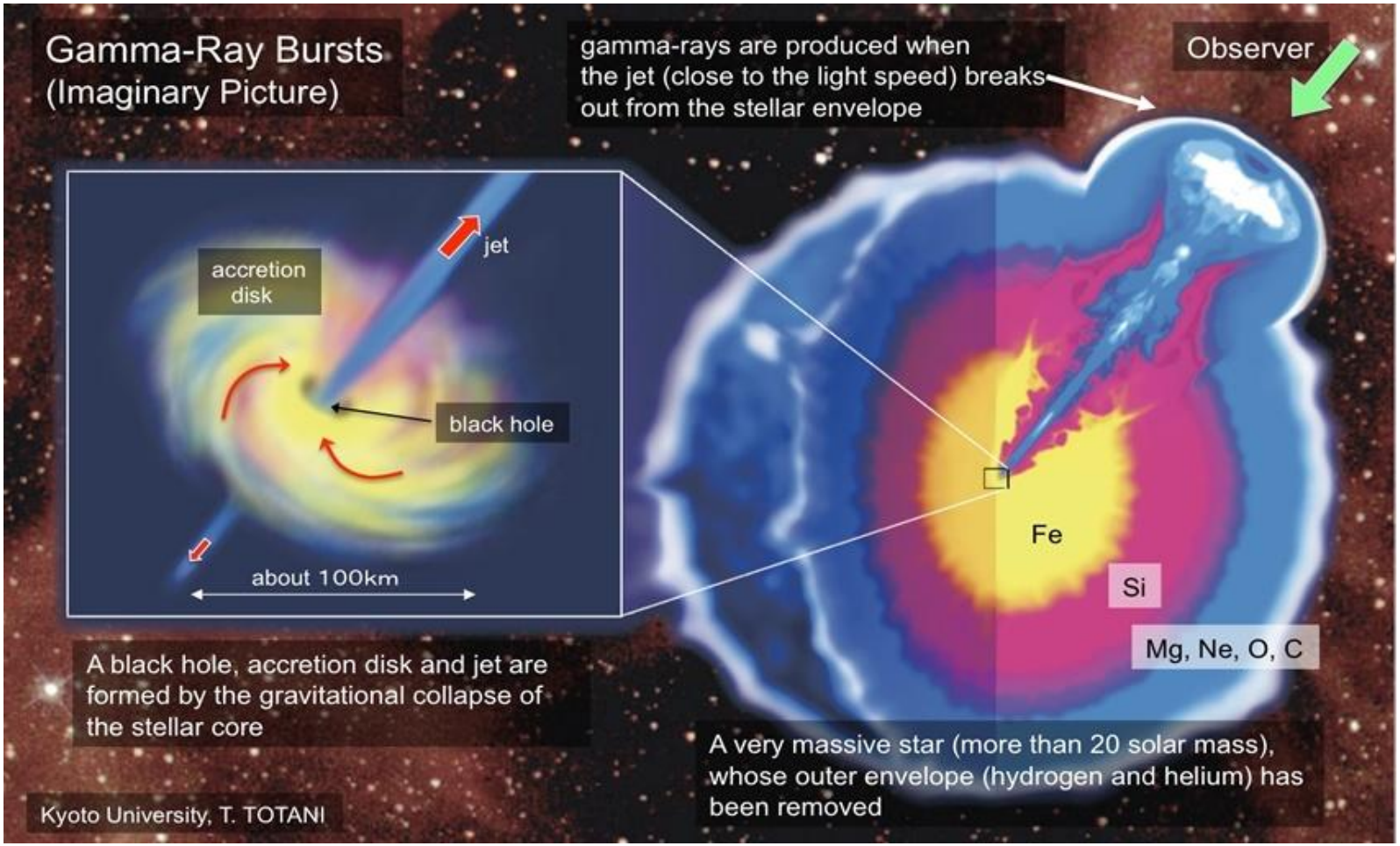
- Near-infrared observations with Subaru/MOIRCS provided a clear detection of ”Dark” GRB 080325 afterglow in Ks band, although no optical counterpart was reported.

- 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

↓

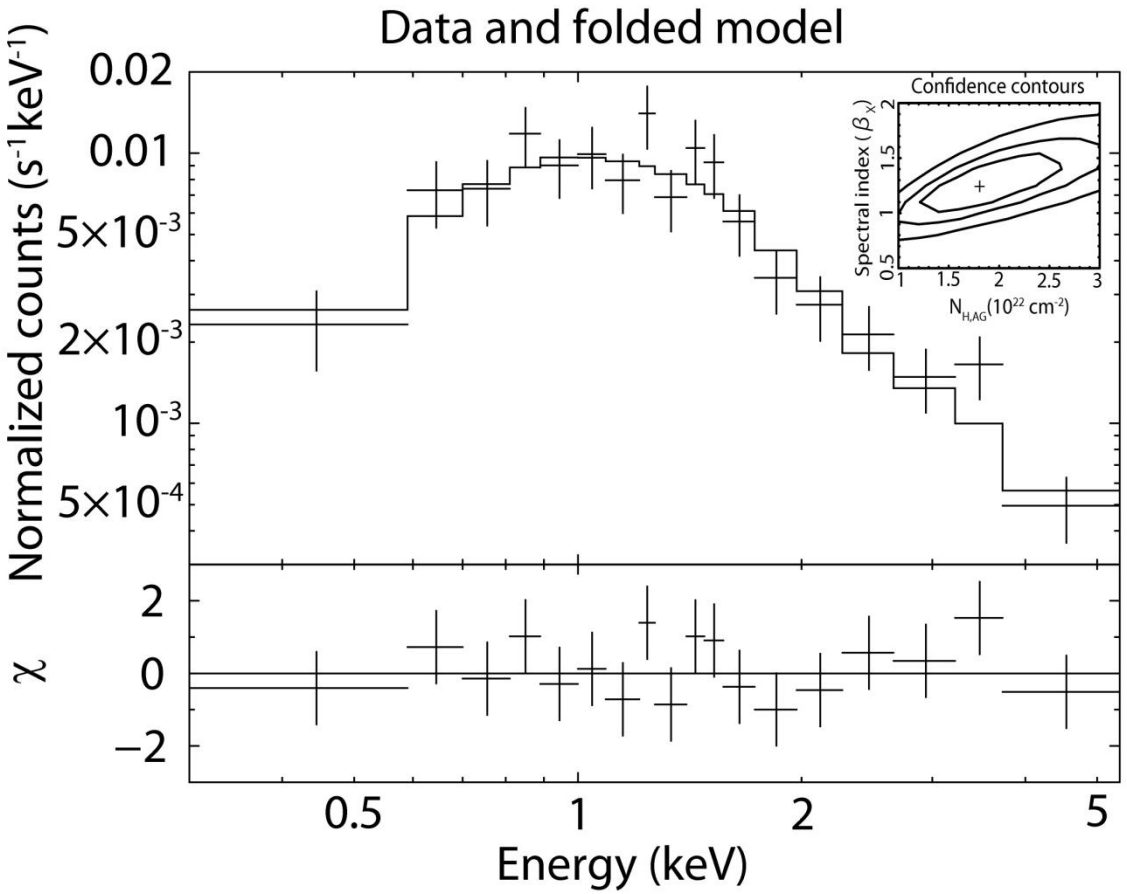
Comparison with observed (rest-wavelength) optical afterglow

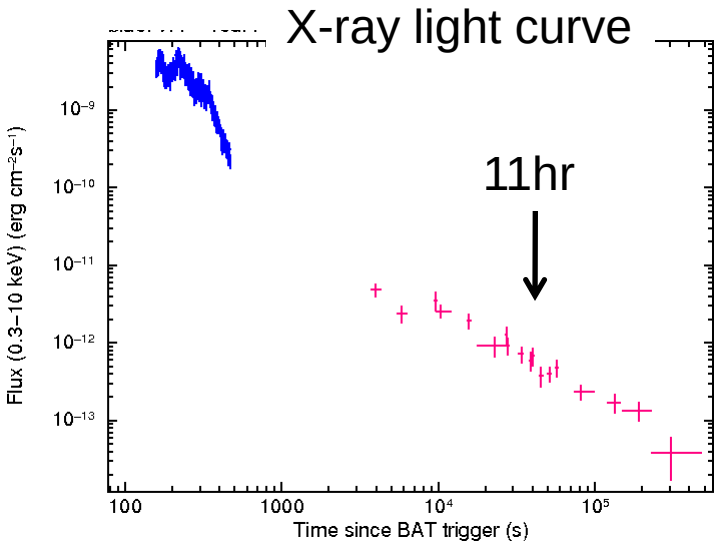
↓

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)





- Galactic extinction (N_H=3.8x10^{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=2.4x10^{22} cm^{-2}
- power law spectral index
  $\beta_X = (f_\nu = \nu^{-\beta_X}) = 1.5$

J-Ks Color of the Host

$J\text{-}Ks_{,host} = 1.3$ 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)

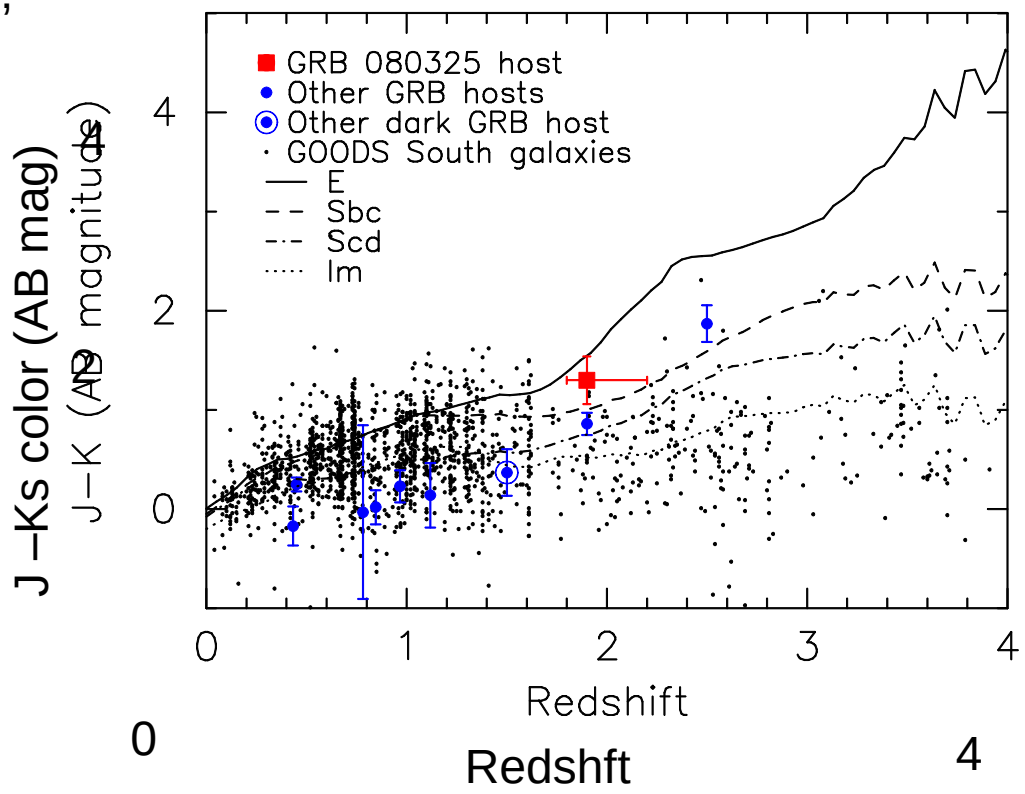
Typical GRB hosts (including "dark") (Le Floc'h et al. 2003, A&A 400, 499; Perley et al. 2009)

Blue color
Faint (Sub L*)

⇕

GRB080325 host

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



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