Possible high metallicity environment of GRB 080325 and 100418A

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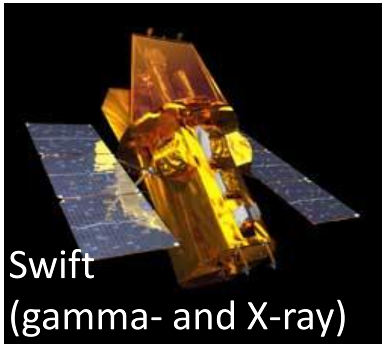
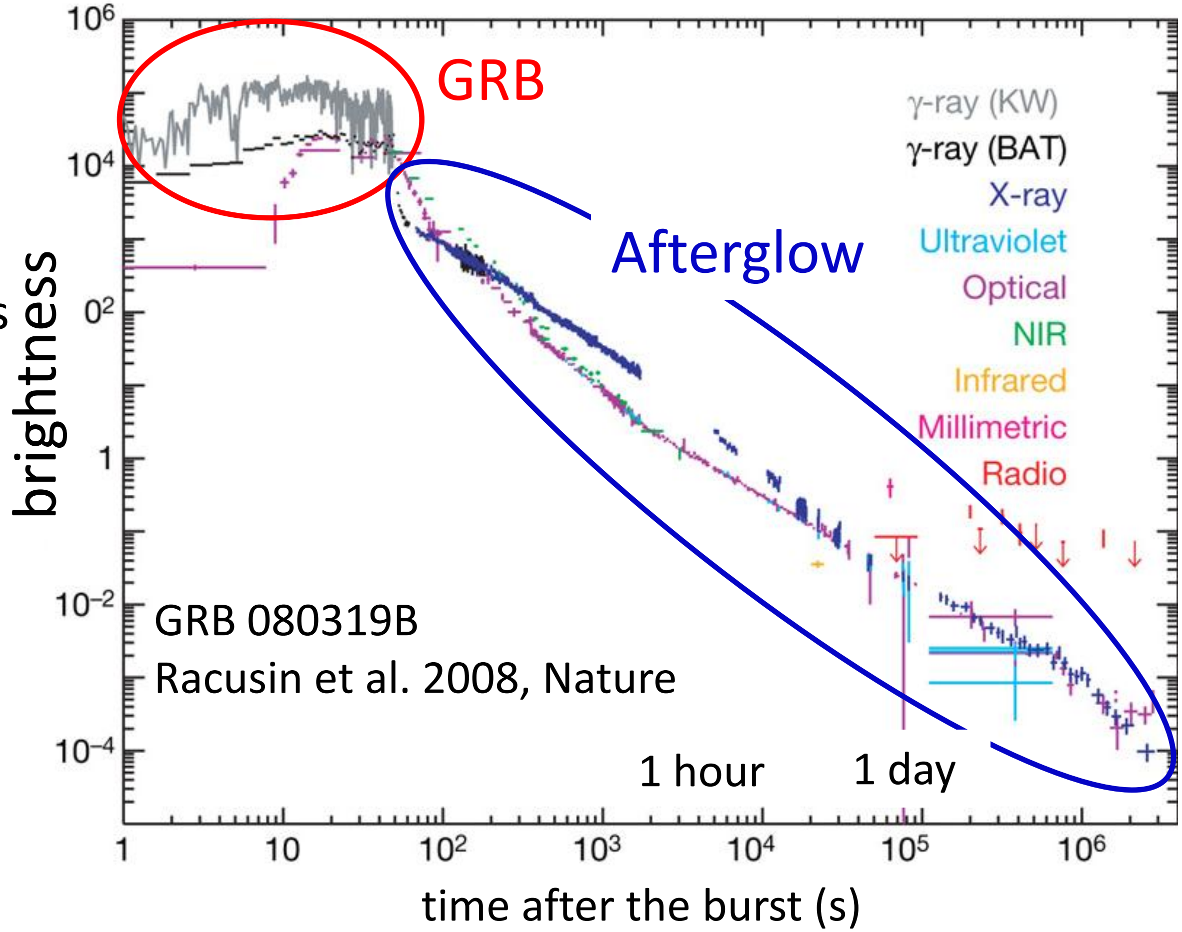
1st March 2012 Subaru User's Meeting

Gamma-Ray Burst (GRB)

Among the most energetic explosions in the universe, GRBs are bright flashes of enormous gamma rays that appear suddenly in the sky and usually last only several to a few tens of seconds



Light curve



``Afterglow''

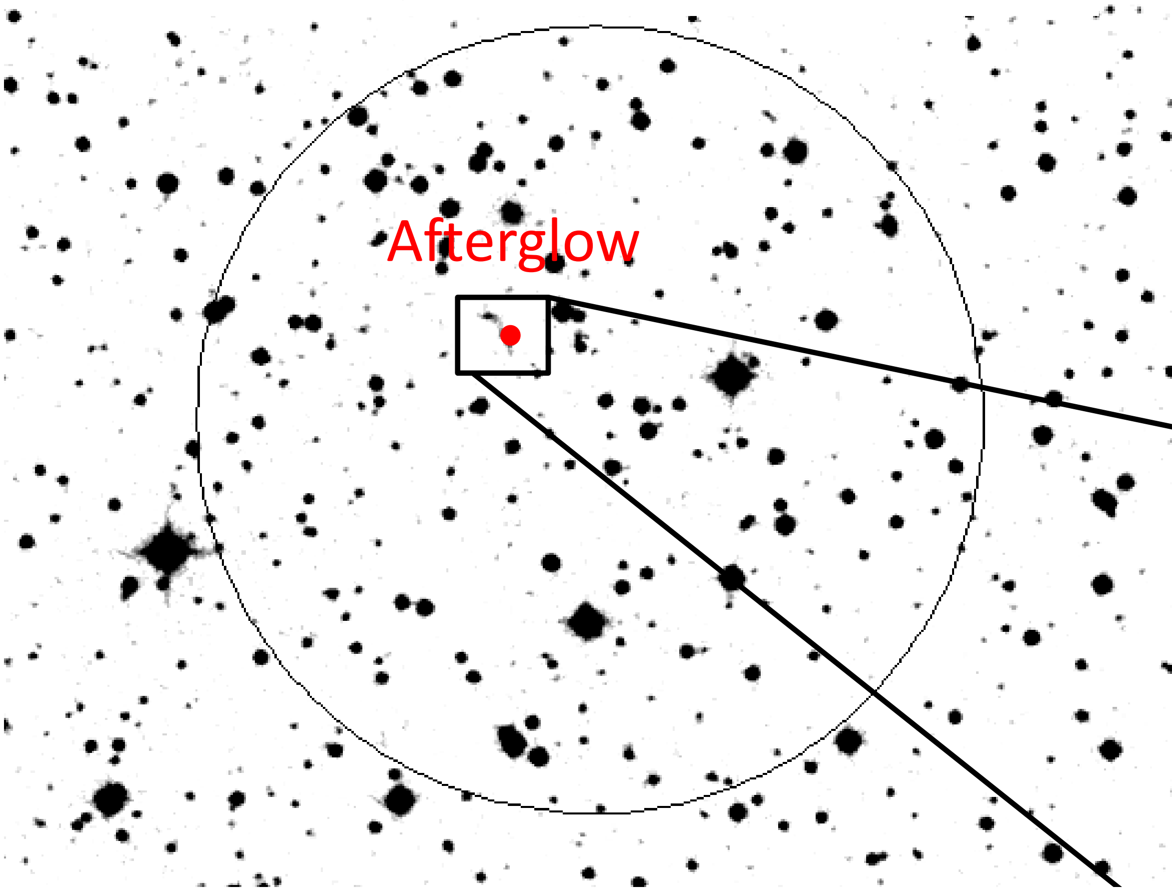
The afterglow of a GRB can be observed in the X-ray, optical, and near-infrared wavelengths for several hours to several days

Afterglows quickly fade after the burst

Poor eyesight of gamma-ray detector

Accuracy of GRB position

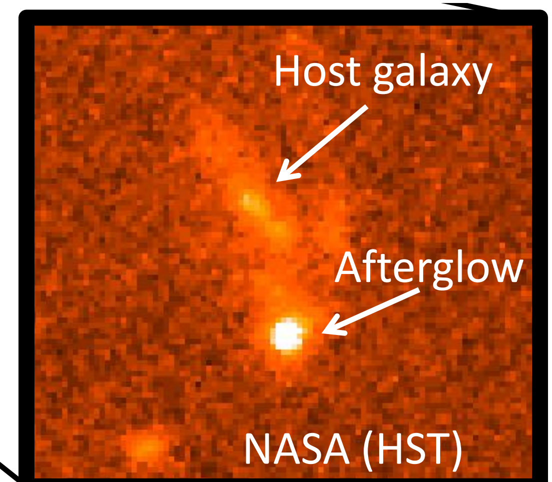
derived from gamma-ray detector



Only gamma-ray observations do not provide accurate GRB positions

Quick follow up observations of the afterglow with ``good-eye'' optical and/or near-infrared telescopes is required

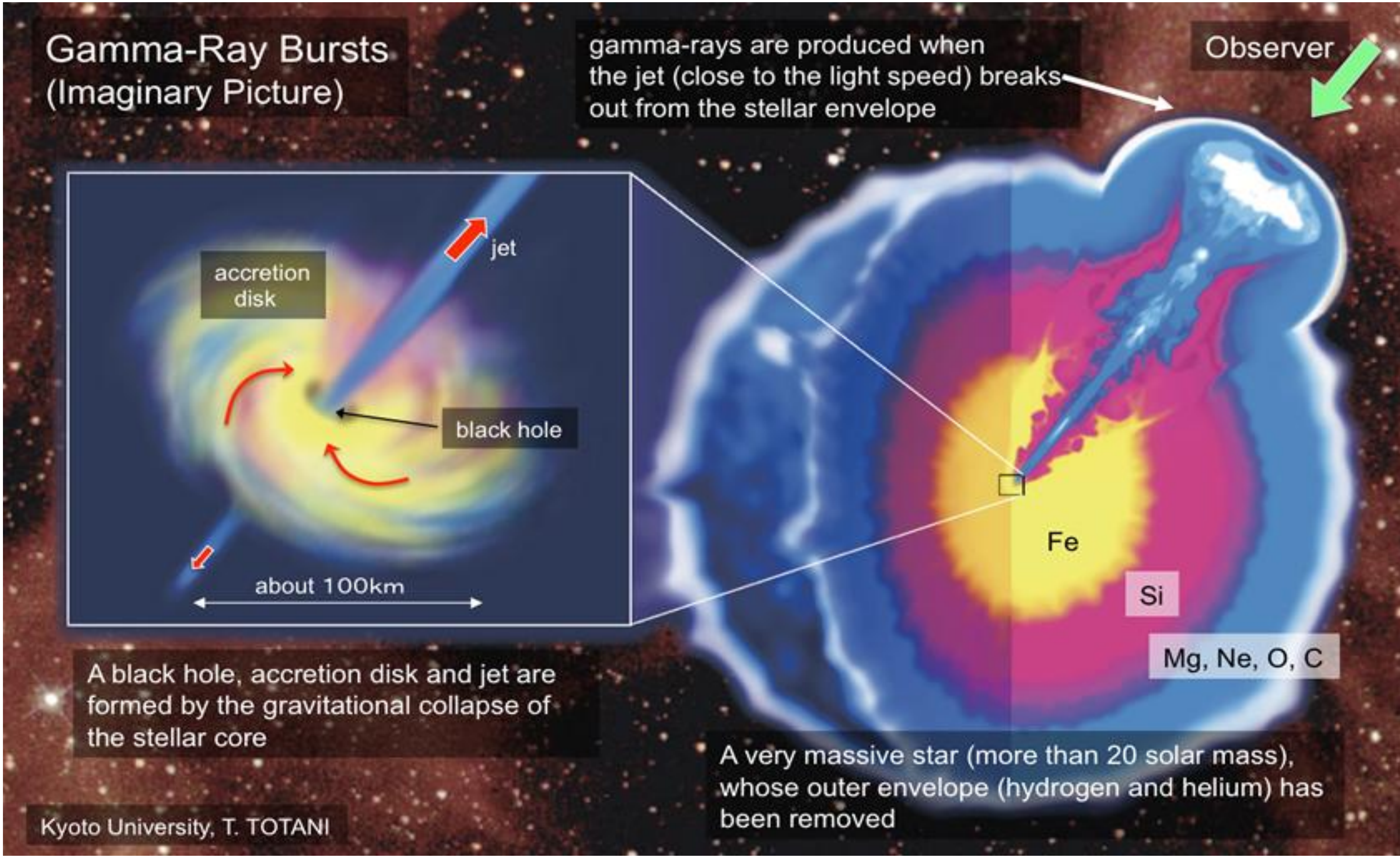
``Afterglow'' and ``host galaxy'' of GRB



GRBs occur in distant galaxies

Imaginary picture of GRB –death of massive star

that is, supernova explosion

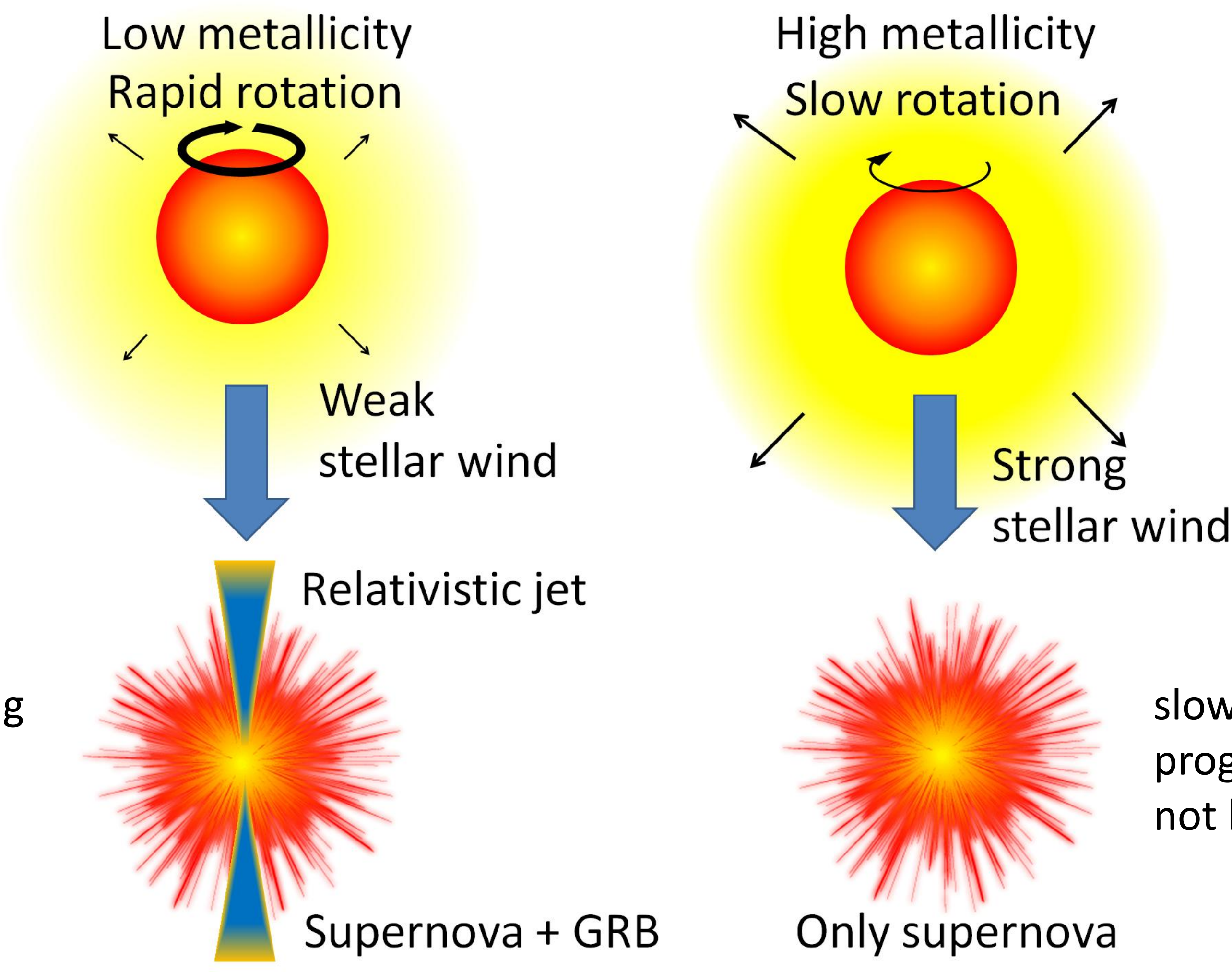


GRB and metallicity (Theory)
(single-star explosion scenario)

e.g., Woosley & Bloom 2006, Yoon et al. 2006

Before massive star explodes, stellar wind carries the rotating momentum (spin angular momentum) of the progenitor away

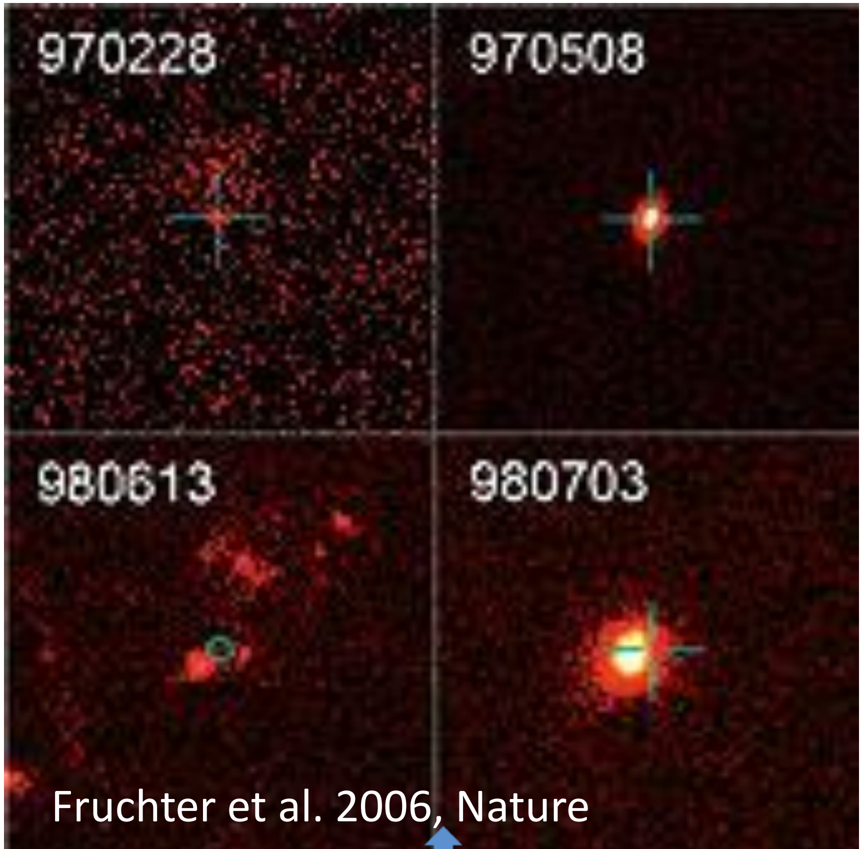
rapidly rotating progenitor becomes GRB



slowly rotating progenitor does not become GRB

GRB and metallicity (Observation)

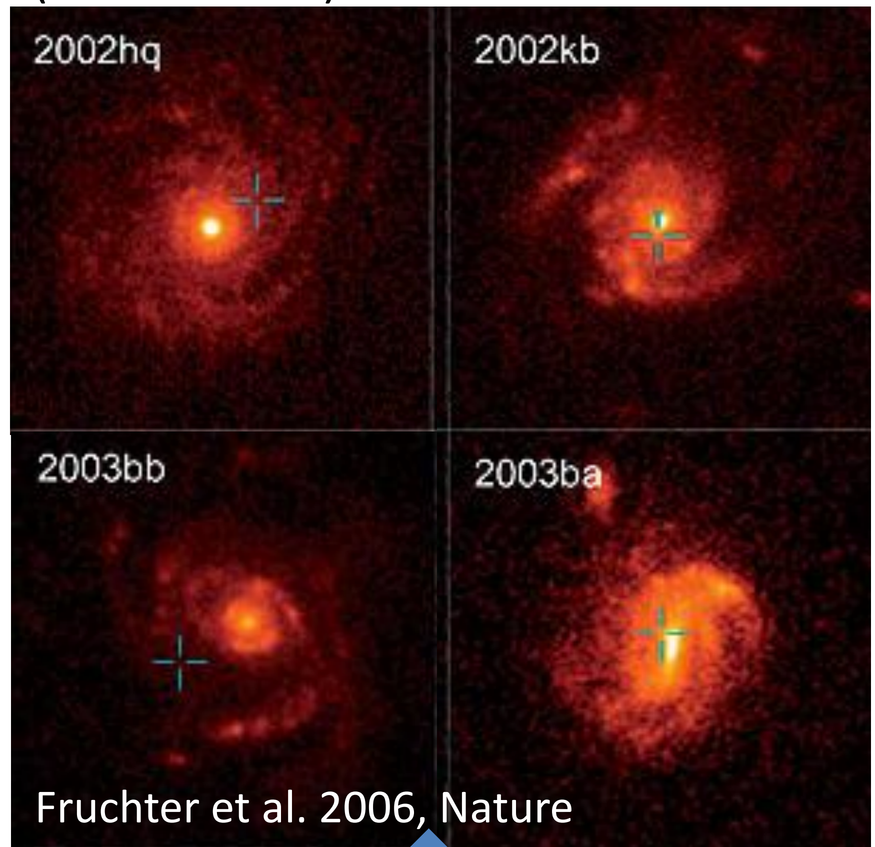
GRB host galaxies



Fruchter et al. 2006, Nature

Supernova host galaxies

(without GRB)



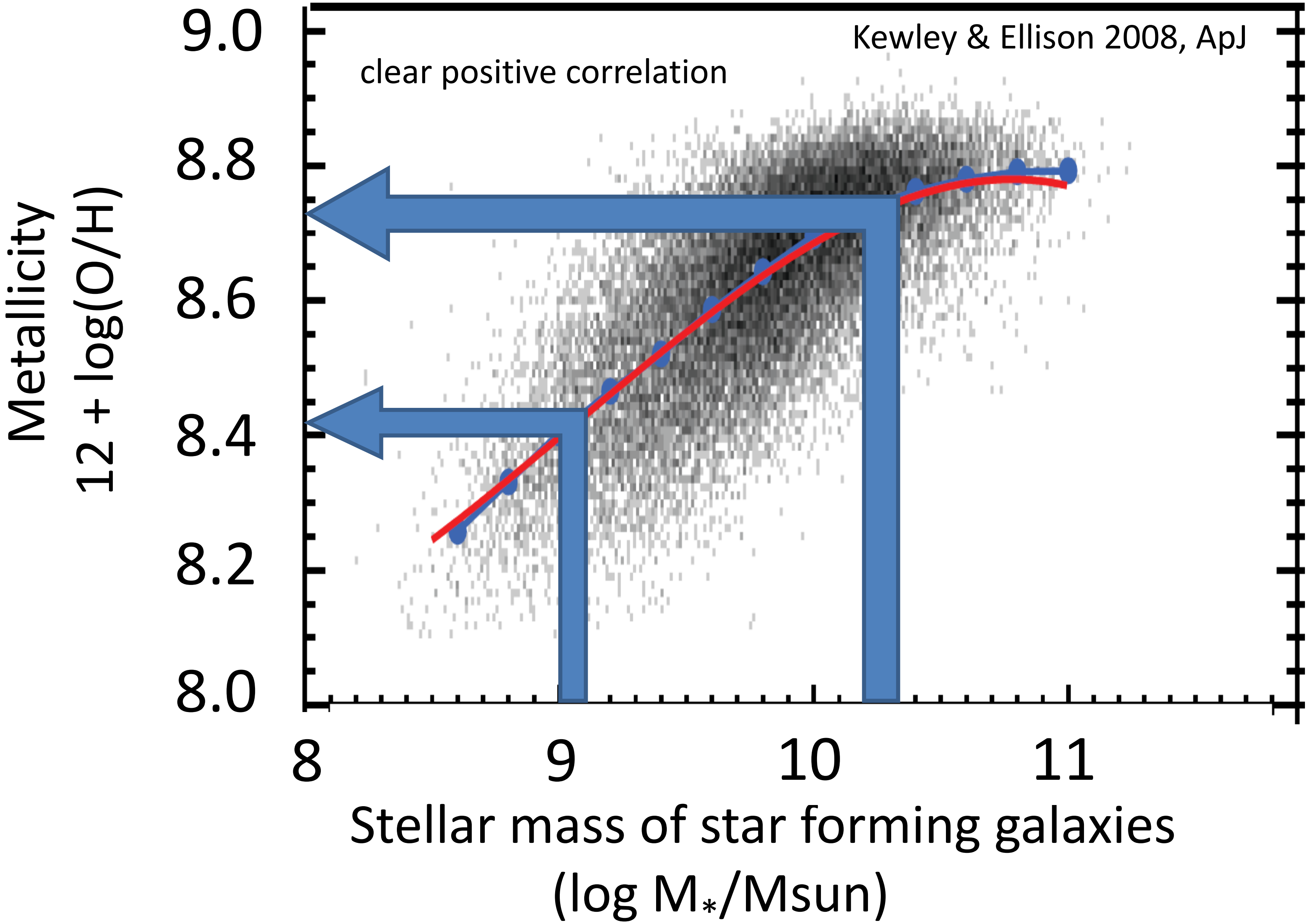
Fruchter et al. 2006, Nature

similar redshifts

Small and faint, i.e., less massive host galaxies

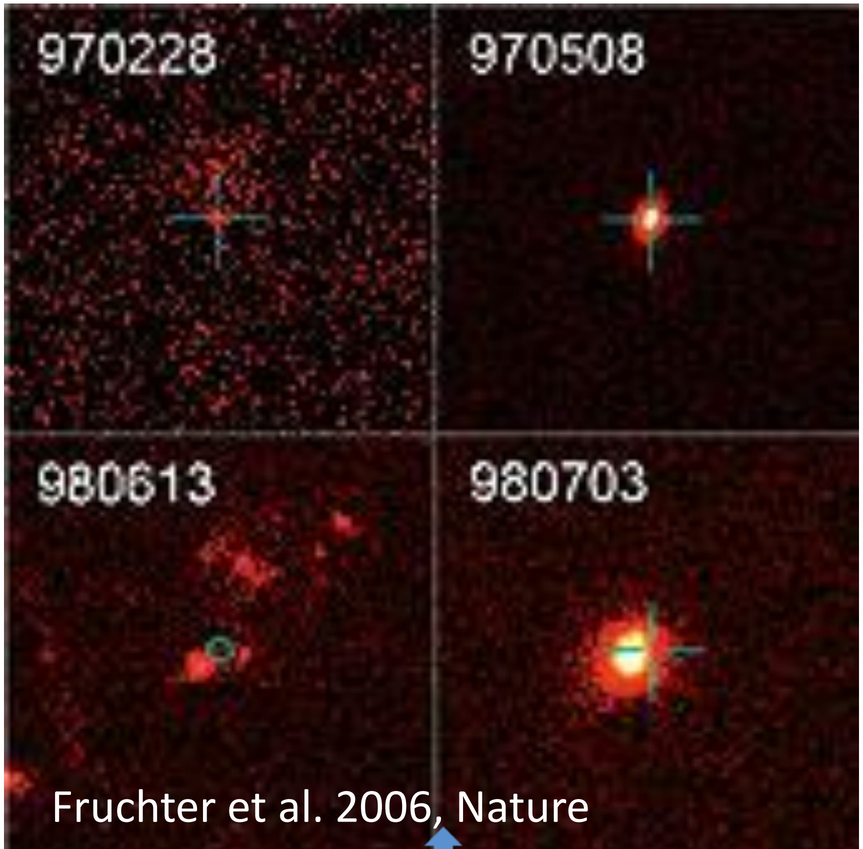
Large and bright, i.e., massive host galaxies

The more massive galaxies show the more metal-rich environment



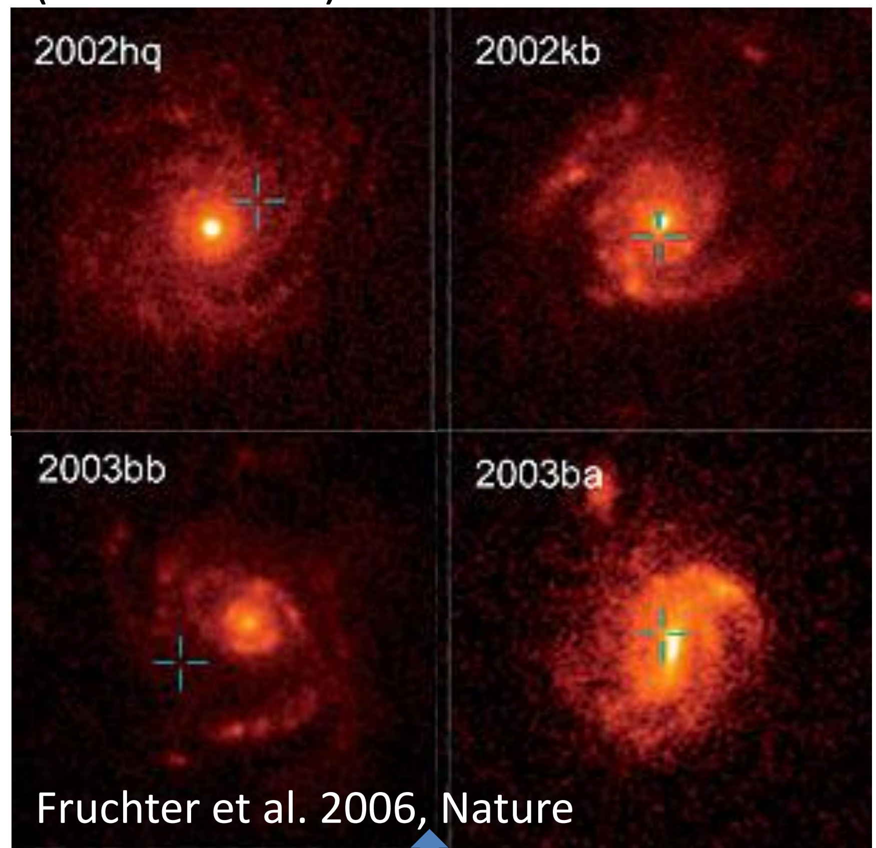
GRB and metallicity (Observation)

GRB host galaxies



Supernova host galaxies

(without GRB)

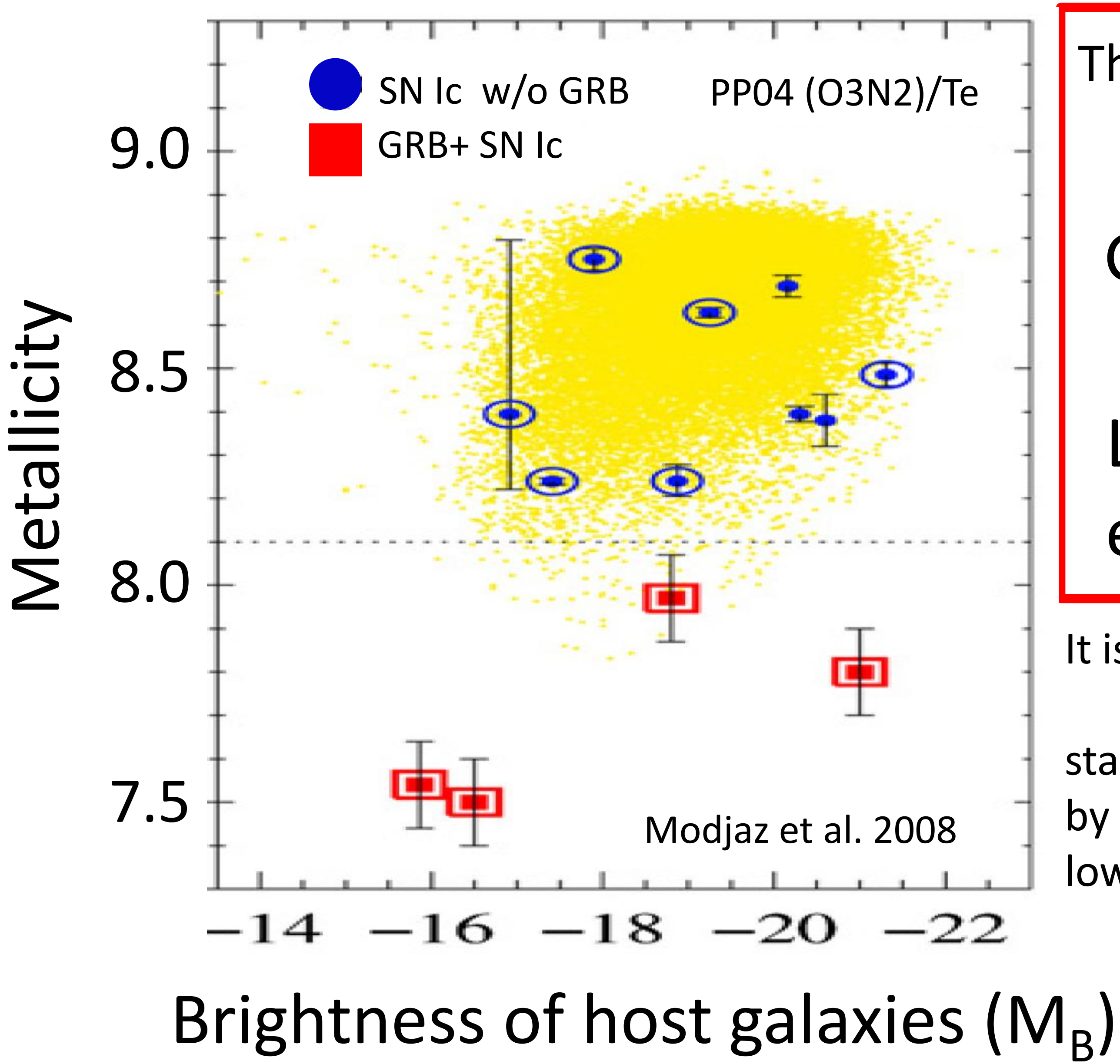


similar redshifts

Metal-poor galaxies

Metal-rich galaxies

Direct metallicity measurements of GRB host galaxies by spectroscopic observations



Theory + Observation

GRBs occur in

Low-metallicity environment

It is widely accepted that

star forming activity traced by GRBs is biased toward low-metallicity

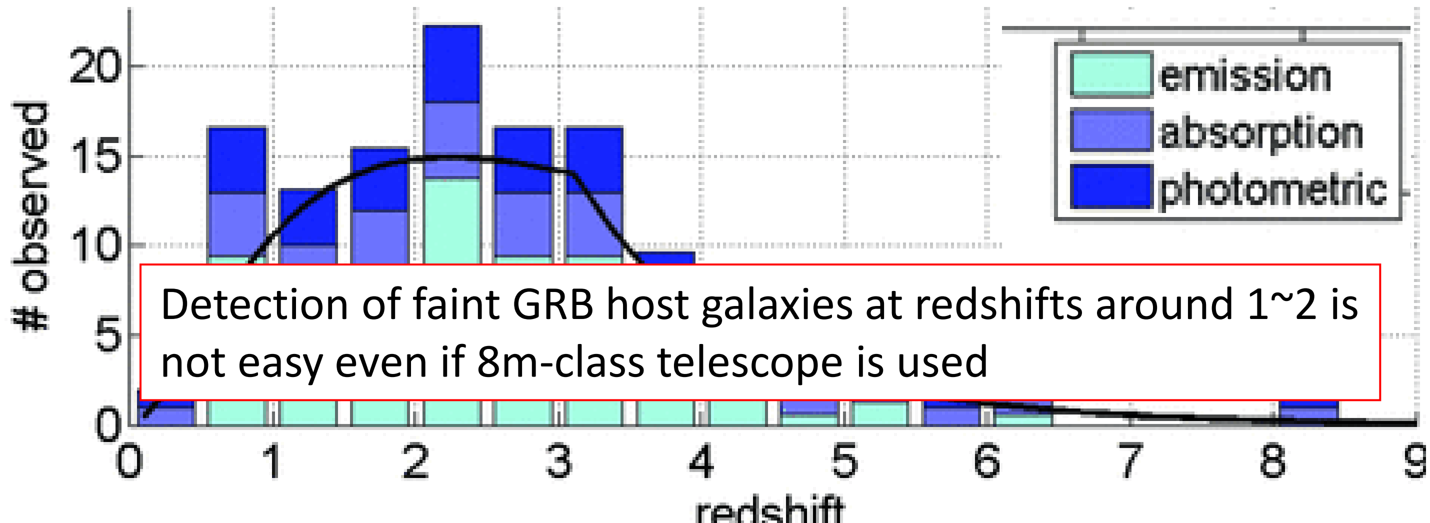
However....

The current sample of GRB hosts is very small

GRB event rate ~ 1 event / 3 day → totally ~800 event at the present time

But... ``well explored'' GRB hosts ~ 50 (Savaglio et al. 2009)

This is because majority of GRBs is at redshift = 1~2



Detection of faint GRB host galaxies at redshifts around 1~2 is not easy even if 8m-class telescope is used

"Dark" GRB (shows unusually optical faint afterglow)

prevent us from discovering and identifying GRB hosts

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

Jochen Greiner, 16-Mar-2010

Significant numbers of dark GRBs

Properties of Dark GRB hosts remains a mystery

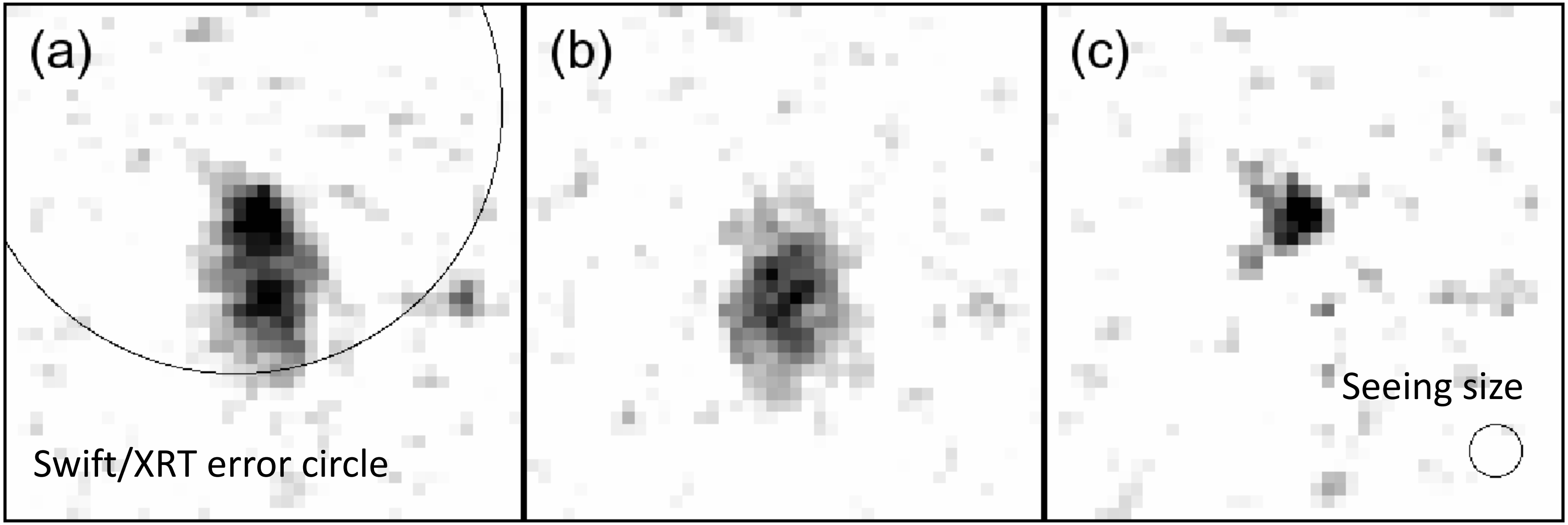
Subaru observations of dark GRB 080325(T_{90}=128s)

No optical detection of the afterglow within the error circle derived from X-ray afterglow observations with Swift/XRT

Subaru/MOIRCS J (1.2μm), Ks (2.2μm) band observations.

→ Detection in Ks (2.2μm) band

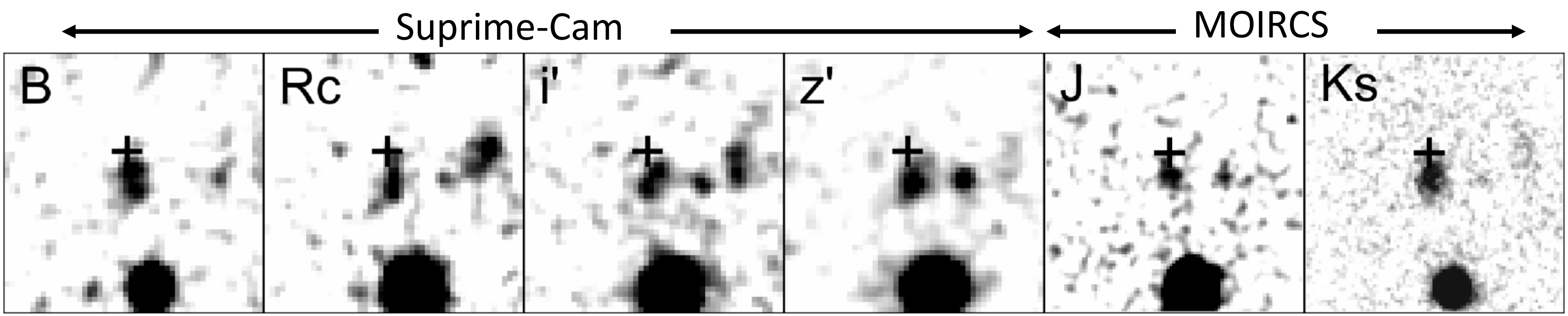
MOIRCS Ks band (5".0 x 5".0)



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

Hashimoto et al. 2010

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



Subaru/Sprime-Cam 10” x 10”

SFH = constant SFR

tau =10Myr, 100Myr, 1Gyr, 10Gyr

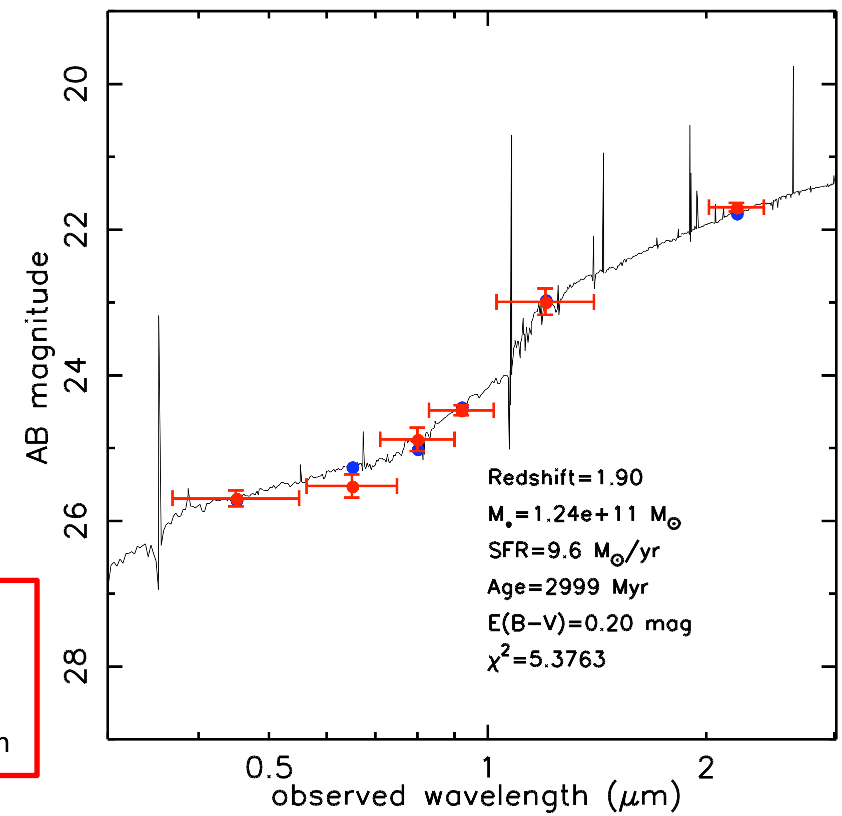
instantaneous burst

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_{*} = $1.2^{+0.6}_{-0.3}\times10^{11}$ M_{sun}



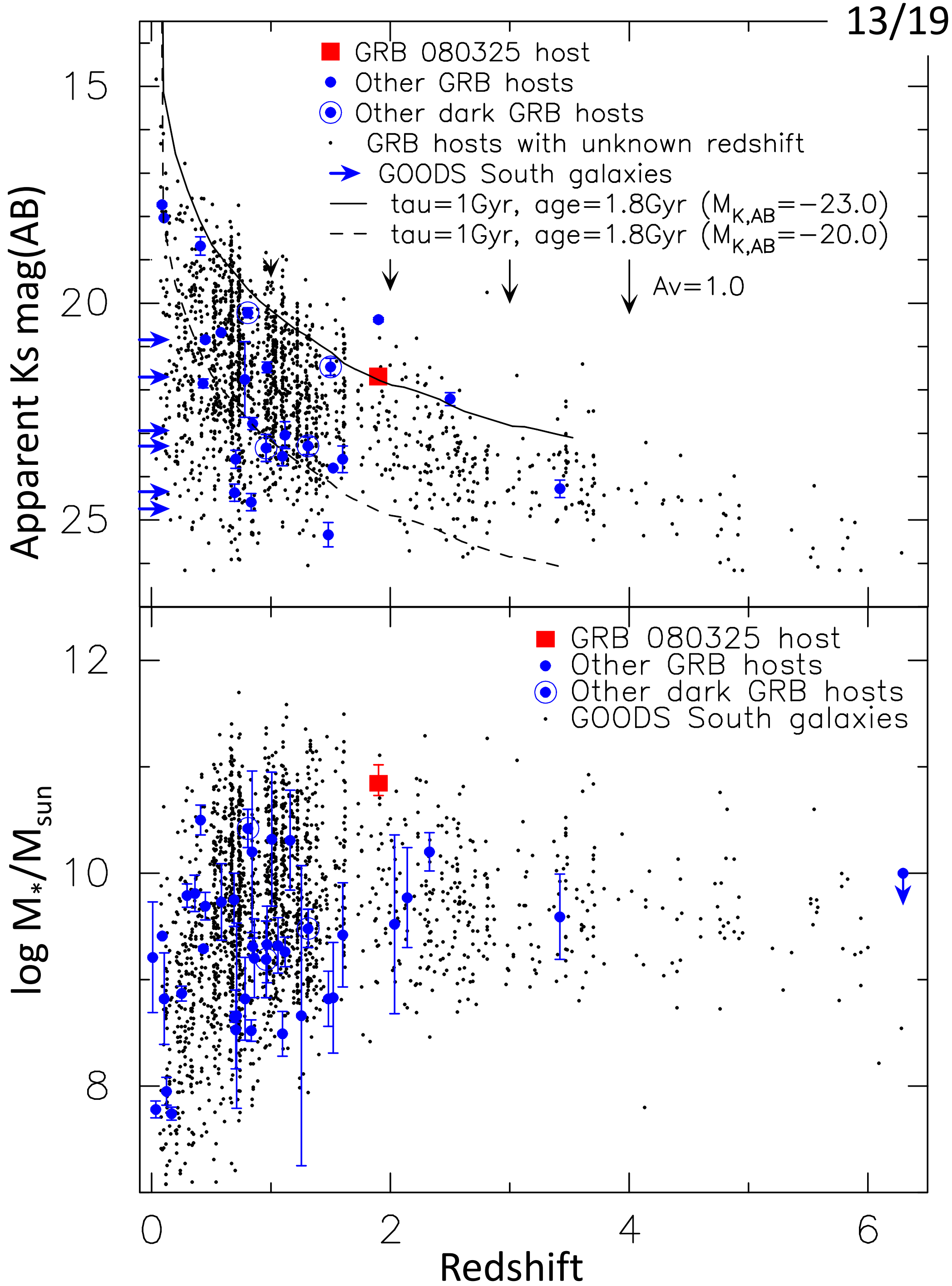
Massive GRB host

■ GRB080325

● Long GRB host (Savaglio et al. 2009)

→ Long GRB host (unknown z)

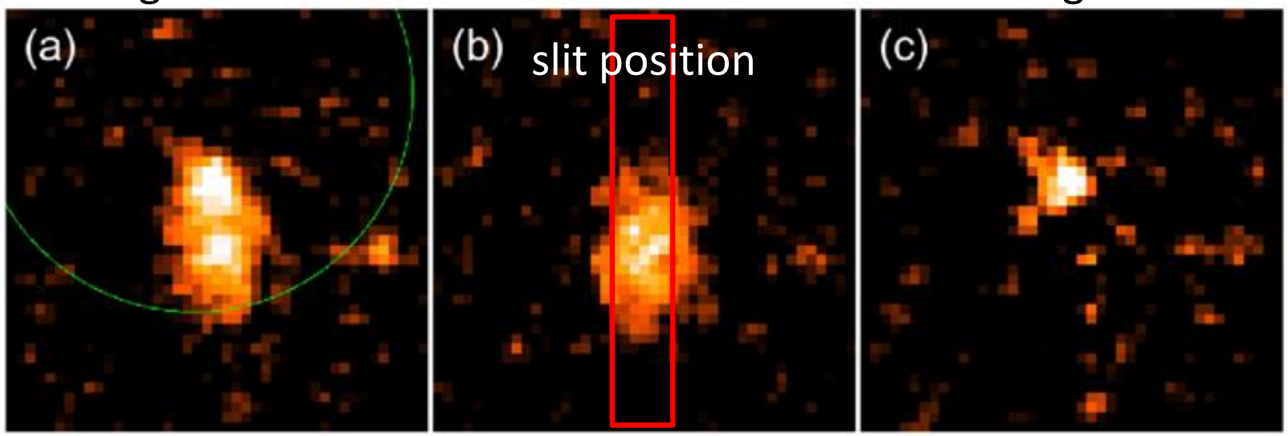
● GOODS South galaxies (spec-z; Grazian et al. 2006)



GRB080325

GRB 080325 host is
brighter (L ≥ L* at z=2)
and
massive
compared with typical GRB hosts

Spectroscopic follow up with Subaru/MOIRCS (2011/06)



grism : HK500

exposure time = 7 hours

Resolving power

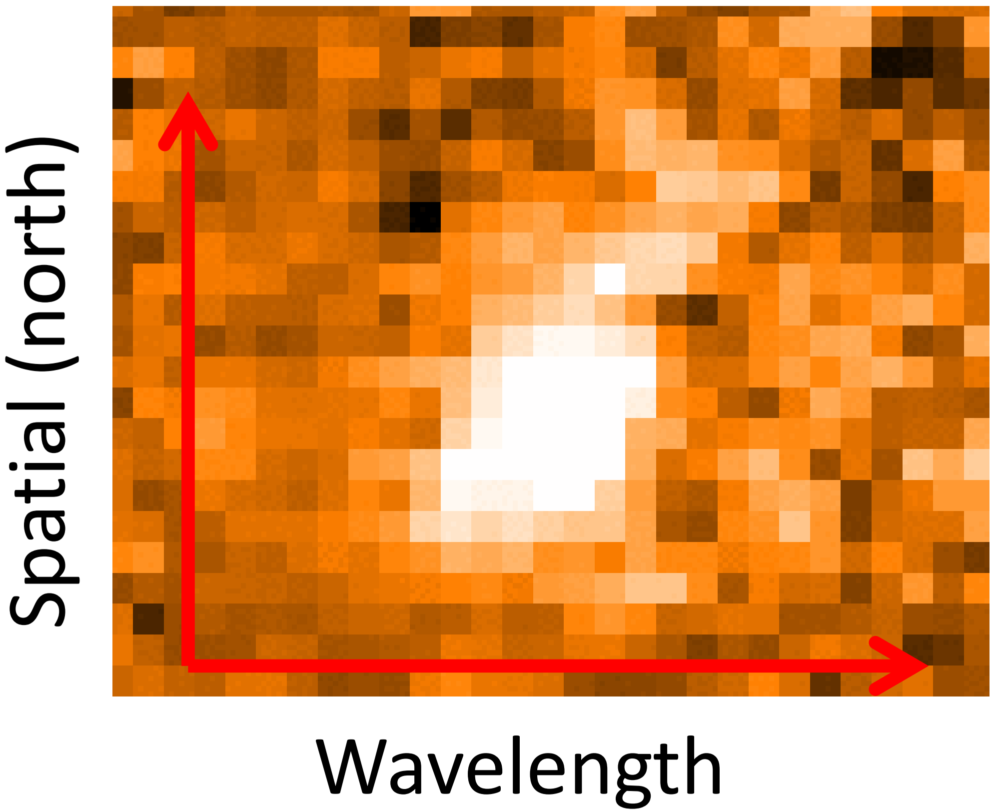
δλ/λ = 630 @1.8um

Detection of Hα!

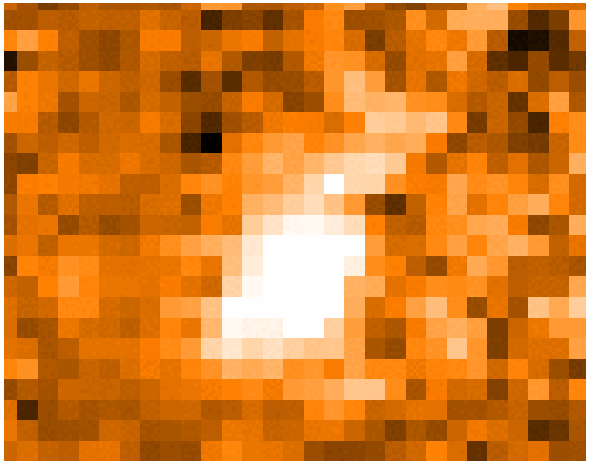
z_phot=1.9

↓

z_spec=1.78



Spectroscopic follow up with Subaru/MOIRCS (2011/06)

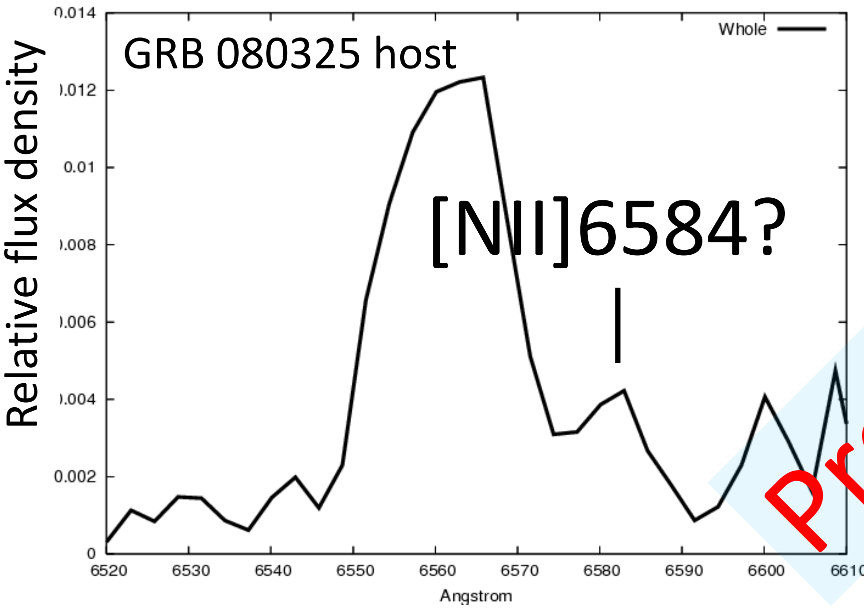


GRB site

South part

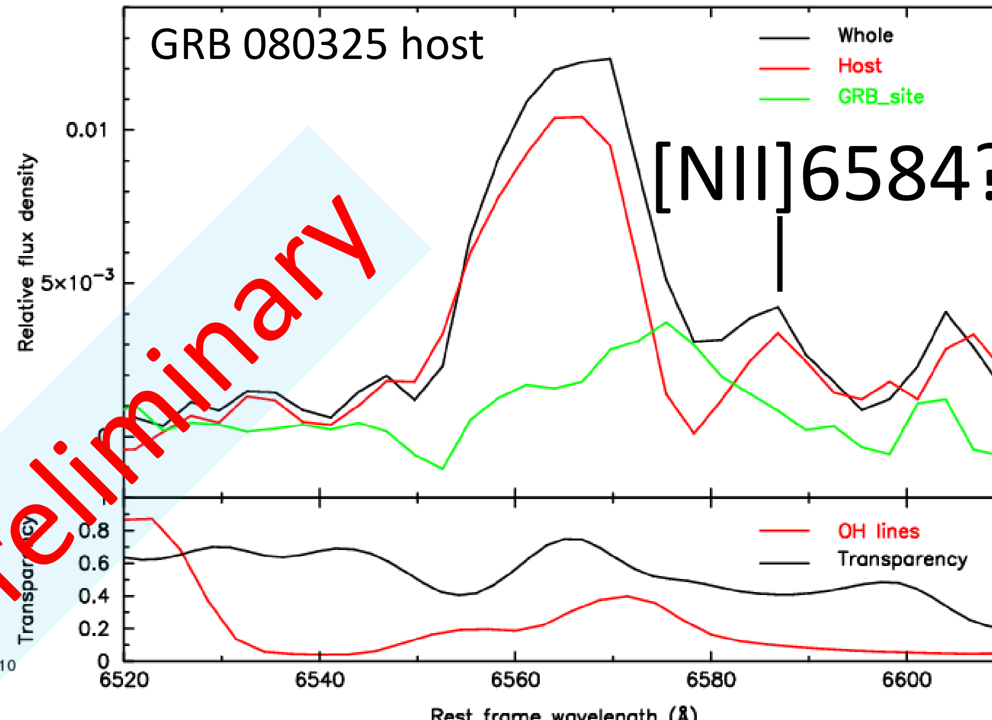
Whole

Hα



6520 Angstrom 6600

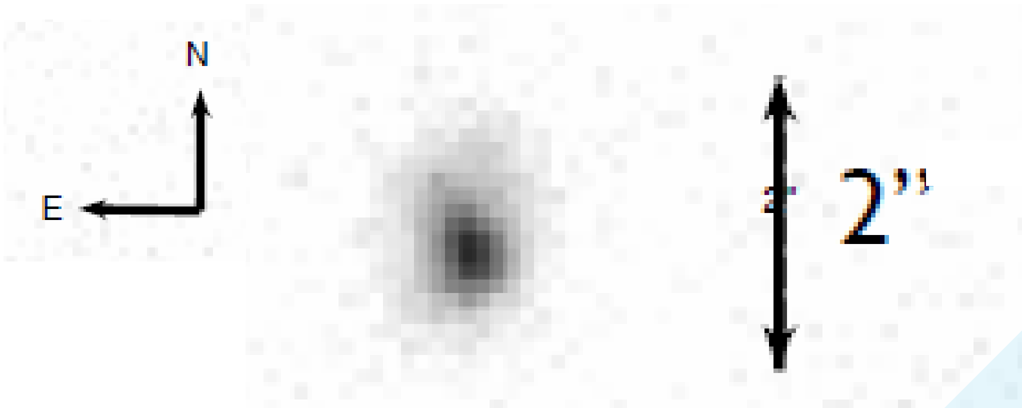
Hα



6520 Angstrom 6600

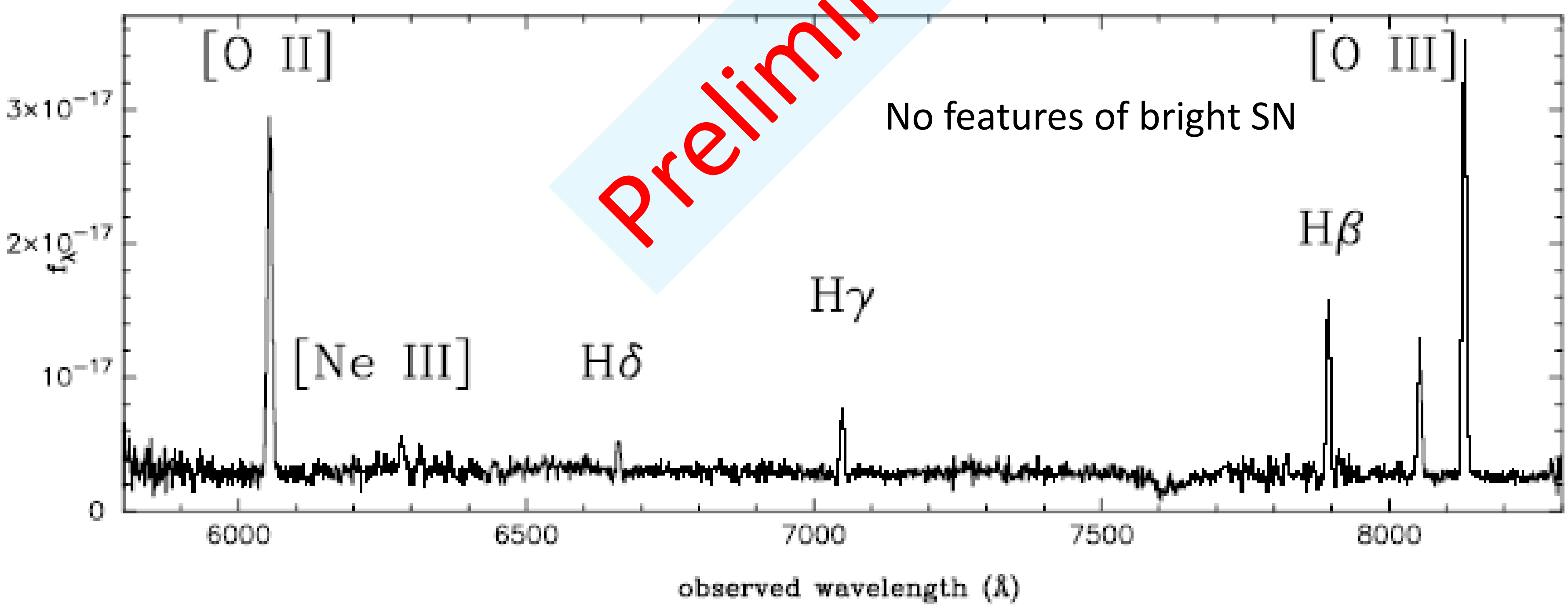
GRB 100418A (z=0.624) observed with Subaru/FOCAS

T_{90} = 7s



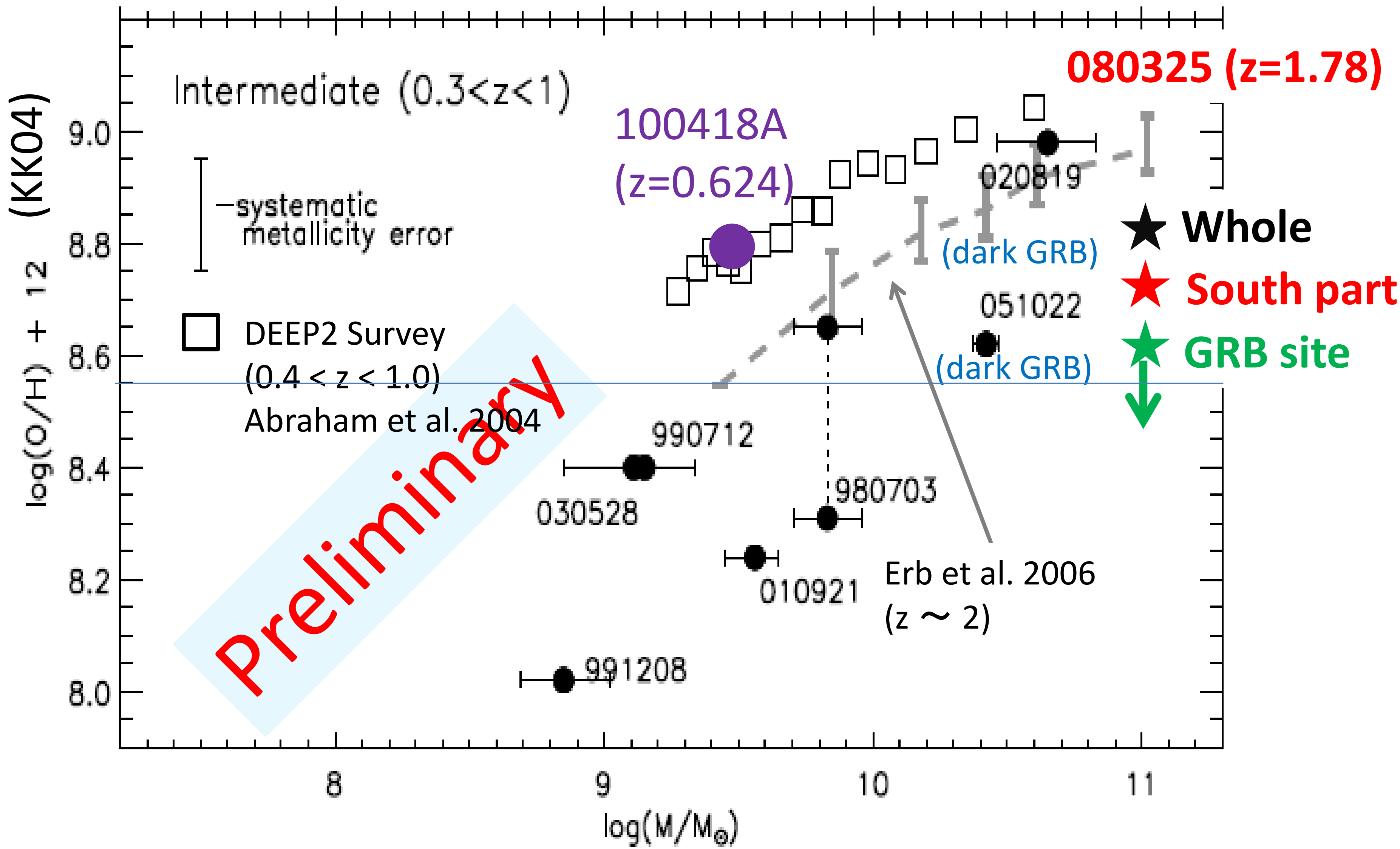
Detected emission lines

- [O II]3727
- [Ne III]3869
- Hδ
- Hγ
- Hβ
- [O III]4959+5007



High-metal host!?

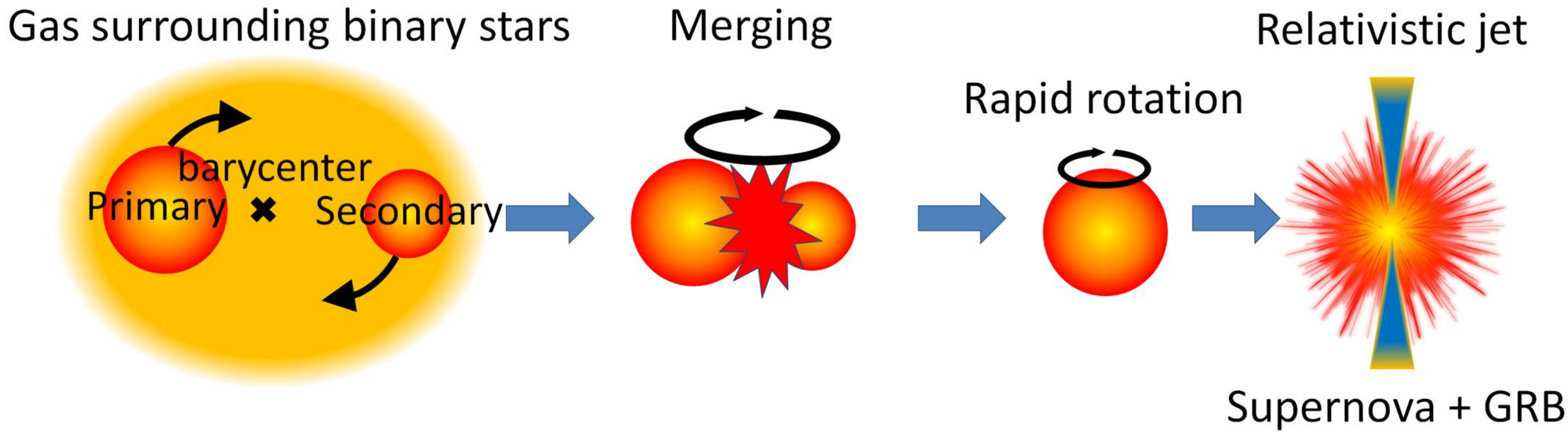
levesque et al. 2010



A hint of another mechanism of GRBs?

(for example, binary-star merger scenario)

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



The angular momentum associated with the orbital motion of the two stars remains after the merging of them. The merged star rotates rapidly and may become the progenitor of a GRB

⇨ This scenario suggests that a GRB can occur even in a high-metallicity environment

Summary

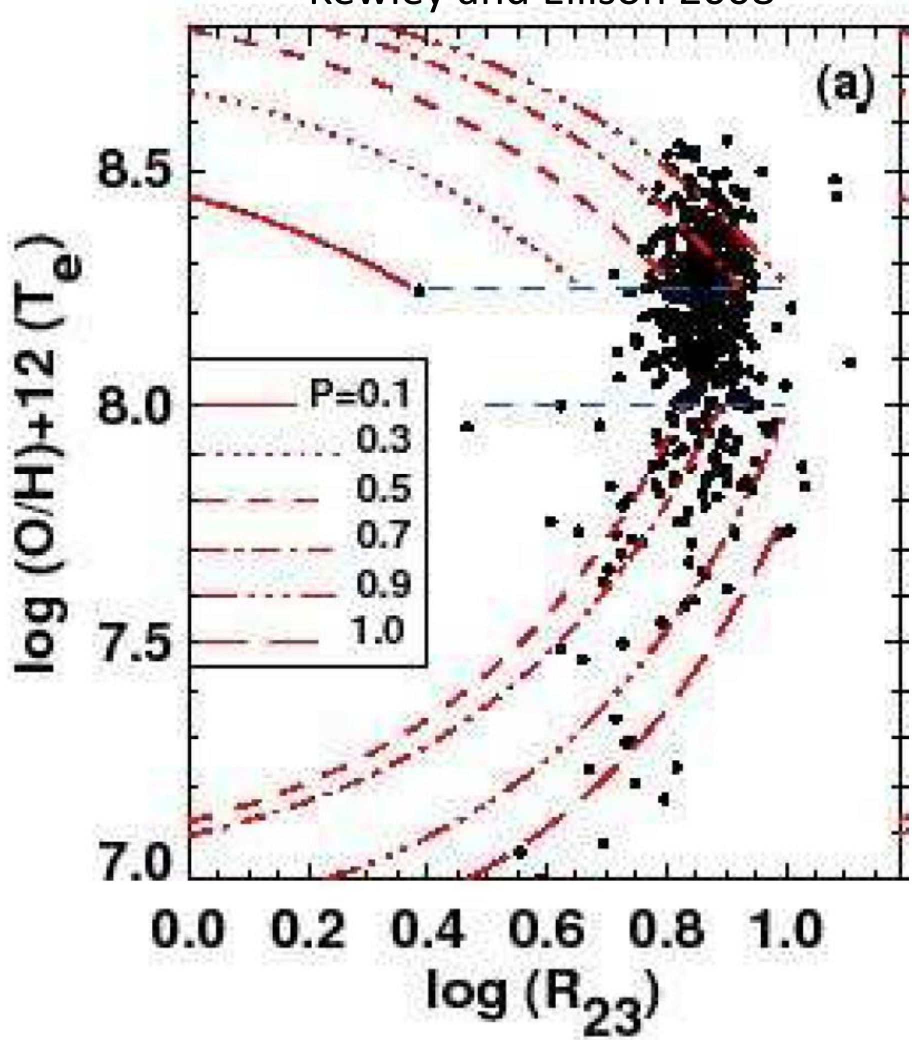
・It is widely accepted that GRBs occur in low-metallicity environment from both aspects of observation and theory. Especially properties of hosts of ``dark GRB'' remain a mystery.

・We found the high-metallicity host of GRB 080325 and 100418A. But....
The local metal-poor environment of GRB 080325 can not be excluded although S/N is poor (e.g., Niino 2011).

・Recently reported possible high metallicity environment of GRBs is a hint of another mechanism of GRBs, e.g., binary-star merger.

$$R_{23} = \frac{\text{[OII] } \lambda\lambda 3727{,}29 + \text{[OIII] } \lambda\lambda 4959{,}5007}{\text{H}\beta}$$

Kewley and Ellison 2008



$$P = \frac{\text{[OIII] } \lambda\lambda 4959{,}5007/\text{H}\beta}{R_{23}}$$

Nagao et al. 2006