Properties of Gamma-ray Bursts Localized by the HETE-2 satellite

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On behalf of
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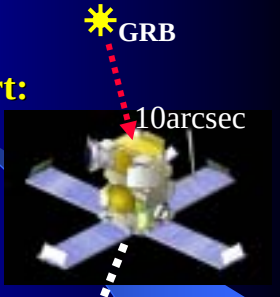
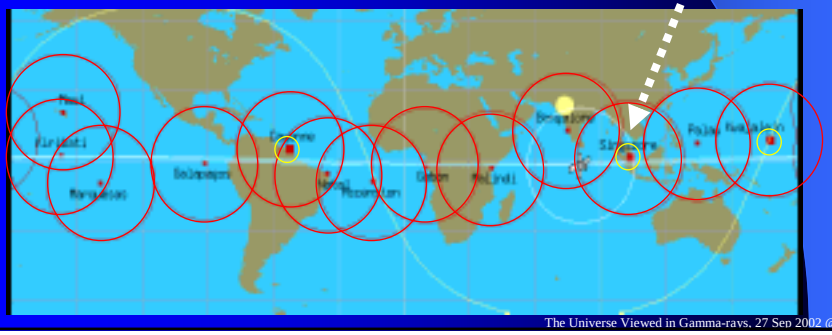
The High Energy Transient Explorer 2

- **Wide field of view:** 1/12 of all sky
- **Prompt and accurate position alert:**
  - 20sec~10min (cf. 3-12hr BeppoSAX)
  - OT decay $\Rightarrow T^{-0.5 \sim -2}$
- **Wide energy band:** 0.5-400keV

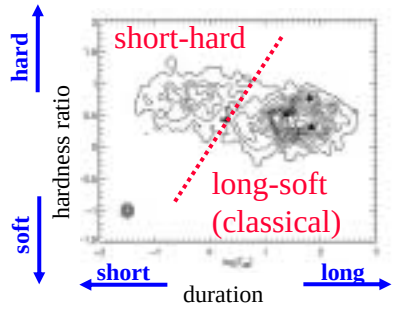




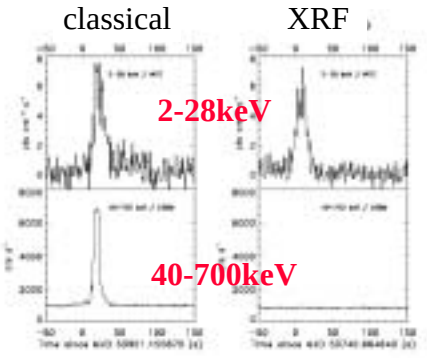
Three Classes of Gamma-ray Bursts

~20 GRBs/year

1. **Classical GRB :** long duration (>1sec), X-ray / optical / radio afterglow, host galaxy, red-shift (z)~1
2. **Short-hard GRB :** short duration(<1sec), hard spectrum, no afterglow found
3. **X-ray Flash (XRF) or X-ray rich:** very soft spectrum, no afterglow found **~40% of GRBs localized by HETE-2**



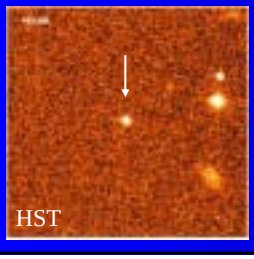
Gorosabel et al. 2001

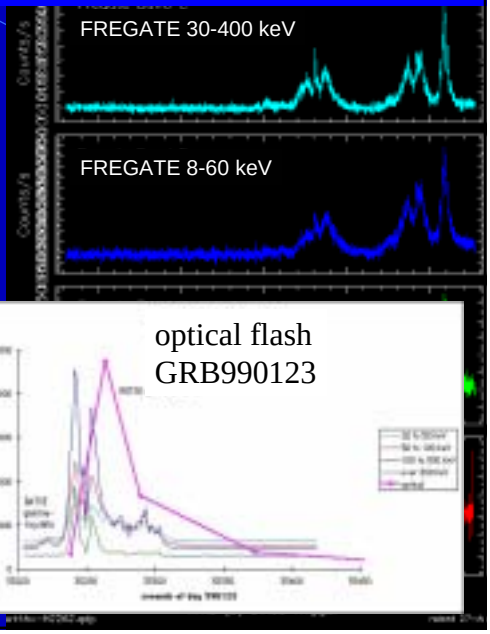


BeppoSAX/BATSE, Heise et al. 2001

Classical GRB / GRB020813

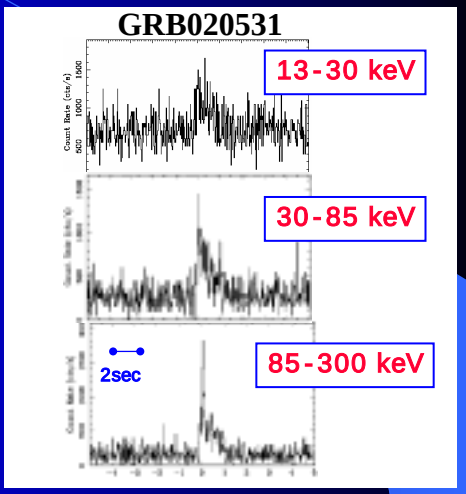
- Long bright GRB
- Pos. alert 4min after the burst
- Optical transient
- X-ray afterglow
- Radio afterglow
- z > 1.25
- ROTSE-2 robotic telescope
  - 4min after the burst
  - upper limit



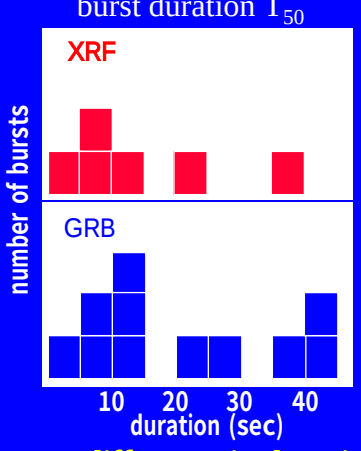


Short-hard GRB020531

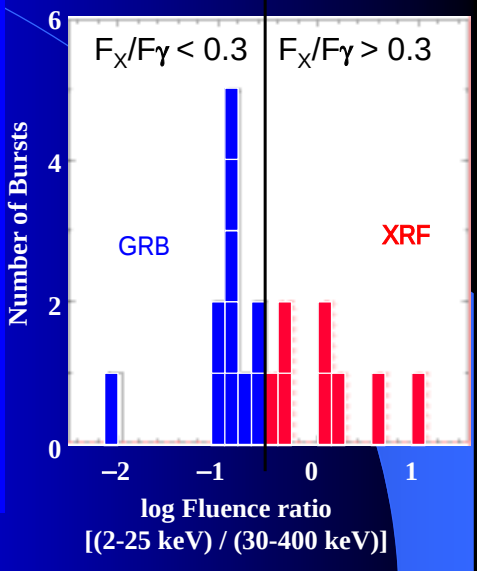
- **The only one localized short-hard GRB**
- **Follow-up observations:**
  - **X-ray, optical, …**
  - **No afterglow was found**
- **Unknown: Extra galactic source or galactic ?**
- **HETE-2 !**



X-ray Flash (X-ray rich GRB)

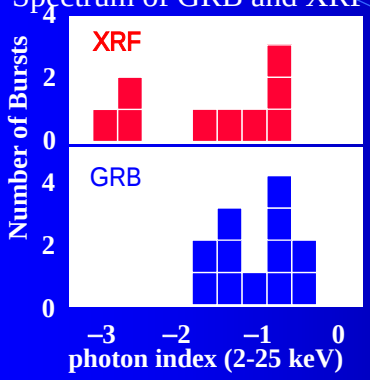


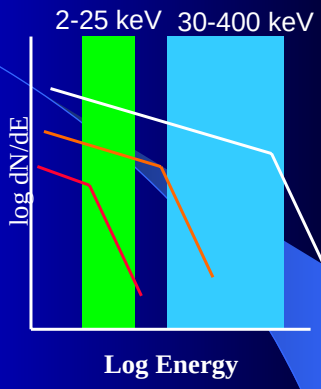
No difference in duration



What is XRF?

Spectrum of GRB and XRF

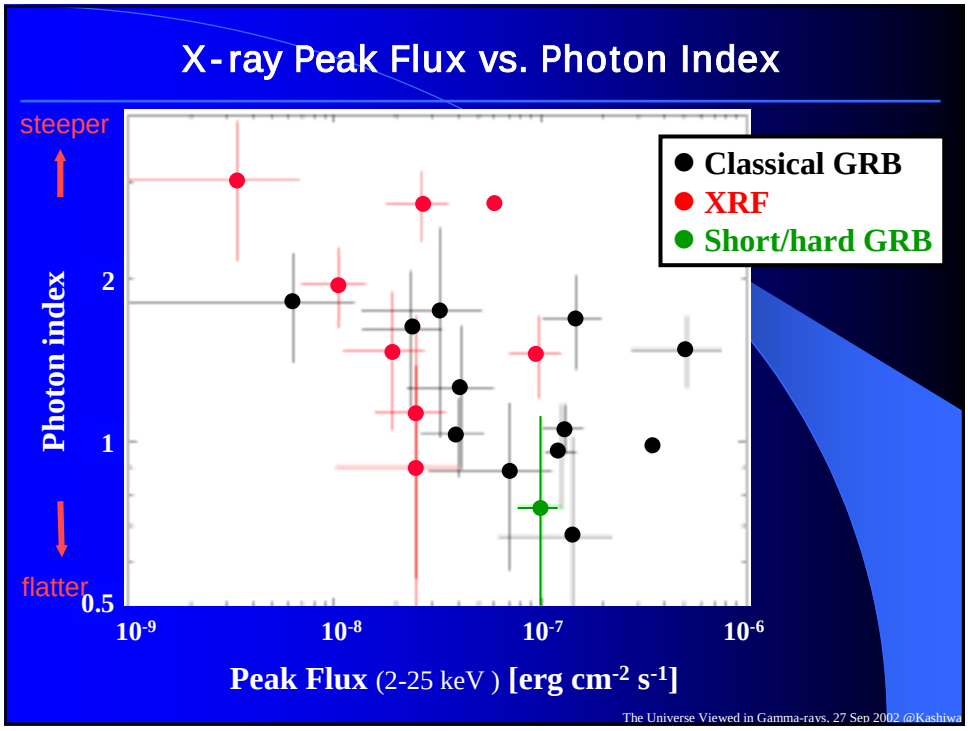


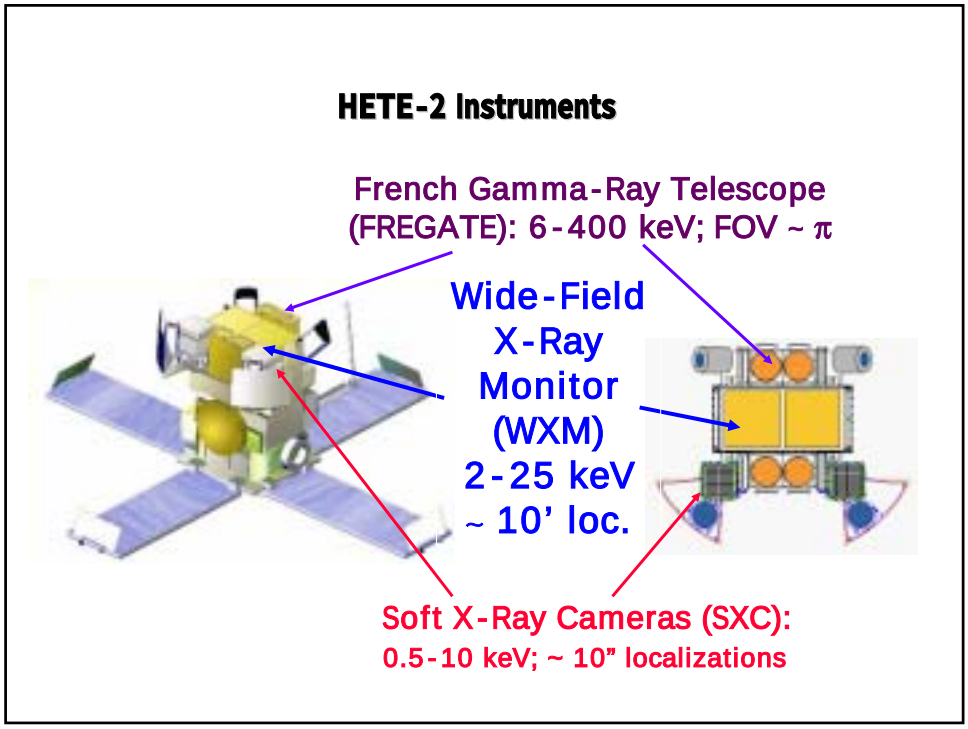


- **XRF = red-shifted classical GRB**
  - Cosmological?
  - Lower Lorenz factor of jet ejecta (Heise, 2002)
- **No optical transient has been found yet.**

Summary

- HETE-2 has the prompt GRB alert system.
  - ~10 sec alert with ~10arcmin position
  - ~20 GRBs/year
- HETE-2 localized short/hard-GRB
  - No optical/X-ray transient was found.
- 40% of GRBs localized by HETE-2 are X-ray Flashes.
- Our results indicate XRFs are almost same as GRBs.
  - red-shifted GRB?
- So far no optical transient is found for XRFs.
  - Need to detect optical transient to determine the distance.
  - Need prompt observation by HETE alert.
- Prompt/delayed observation in TeV gamma-ray??


X-ray Peak Flux vs. Photon Index
steeper
flatter
Photon index
2
1
0.5
Classical GRB
XRF
Short/hard GRB
10-9
10-8
10-7
10-6
Peak Flux (2-25 keV) [erg cm-2 s-1]
The Universe Viewed in Gamma-rays, 27 Sep 2002 @Kashiwa


HETE-2 Instruments
French Gamma-Ray Telescope
(FREGATE): 6-400 keV; FOV ~ π
Wide-Field
X-Ray
Monitor
(WXM)
2-25 keV
~ 10' loc.
Soft X-Ray Cameras (SXC):
0.5-10 keV; ~ 10" localizations

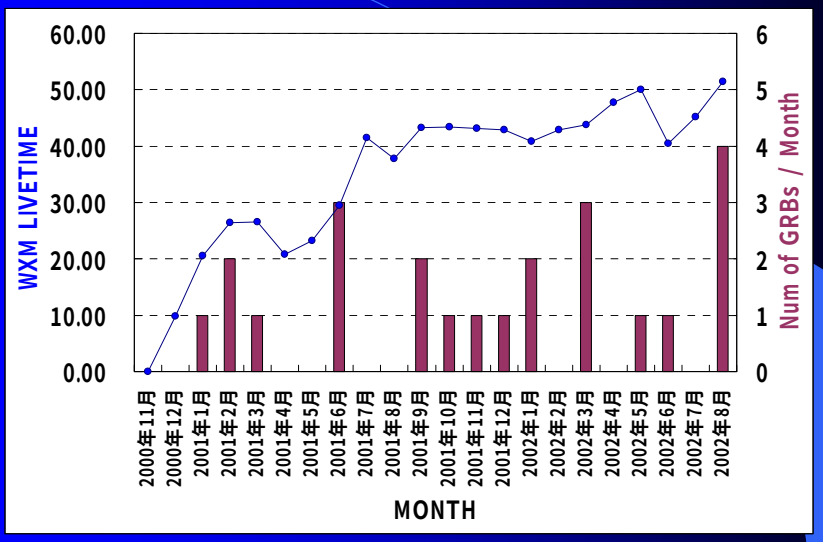
WXM GRB Localization 2001

	dura-tion	GCN Delay	followup obs	couter-part	type	remarks
1. 010110	60s	--------	--------	--------		no aspect
2. 010213	24s	36h14′	38h~	none	*X rich*	
3. 010225	10s	--------	--------	--------	*X rich*	
4. 010326B	1.5s	4h45′	6h~	none		
5. 010612	4s	69h19′	--------	--------		IPN
6. 010613	120s	56h55′	--------	--------		IPN
7. 010629	16s	8h57′	11.7h~	none	*X rich*	IPN
8. **010921**	22s	5h10′	22h~	**OT**		1dim + IPN
9. 010928	40s	6h10′	--------	--------		1dim
10. 011019	30s	12h07′	13.3h~	none	*X rich*	
11. 011130	5s	5h42′	23.4h~	**?**	*X rich*	
12. 011212	80s	10h15′	23.5h~	**?**	*X rich*	

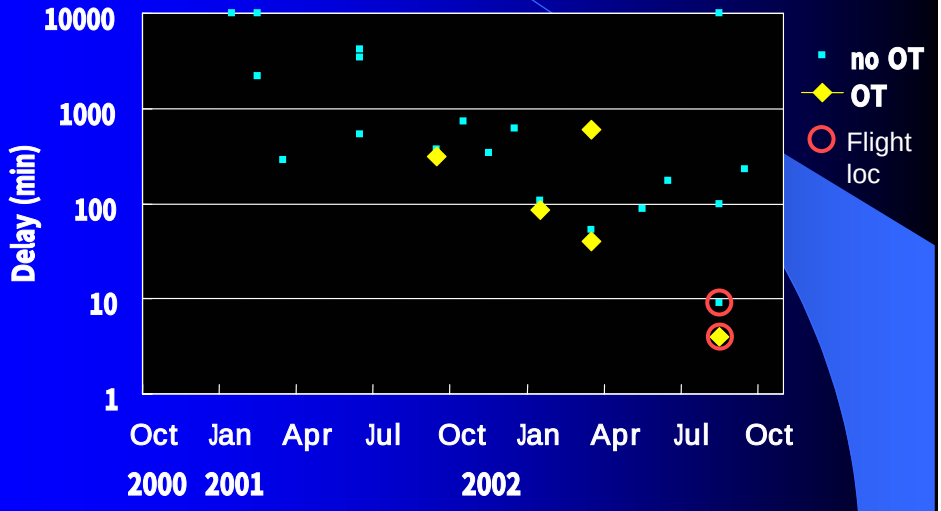
WXM GRB Localization 2002

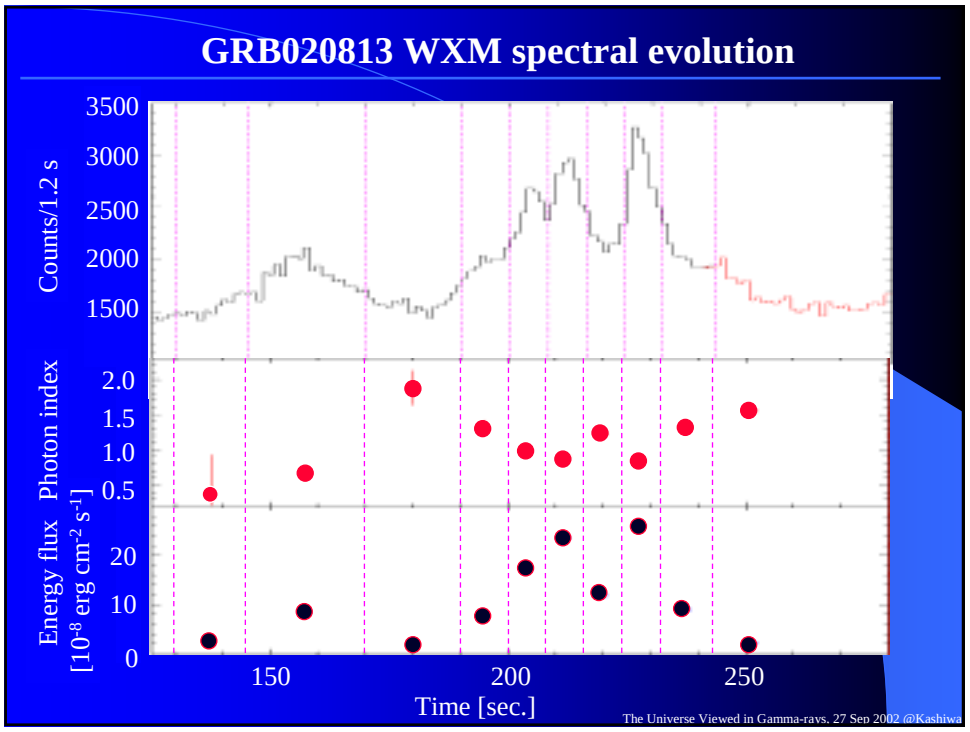
	dura-tion	GCN Delay	followup obs	couter-part	type	remarks
13. 020124	**70s**	**1h26′**	**2h~**	**OT**	*X rich*	
14. 020127	2s	1h46′	4.4h~	?		Multiple candidates
15. 020305	**252s**	**9h56′**	**20h~**	**OT**	**precursor**	
16. 020317	2s	53′	18.5h~	**?**		
17. 020331	**50s**	**40′**	**2.5h~**	**OT**		
18. 020531	0.2s	1h28′	4.5h~	none	*short*	IPN XT? z=1.0?
19. 020625	20s	2h54′	10.5h~	none	*X rich*	
20. 020801	?s	-----	-----	none		IPN
21. 020812	20s	9′	28′~	none		
22. 020813	**125s**	**4′**	**4.48′~**	**OT**	**precursor**	**z=1.24, Polariz.**
23. 020819	20s	1h38′	2.96h~	none		
24. 020903	20s	3h50′	4.5 h~	none	*X rich*	

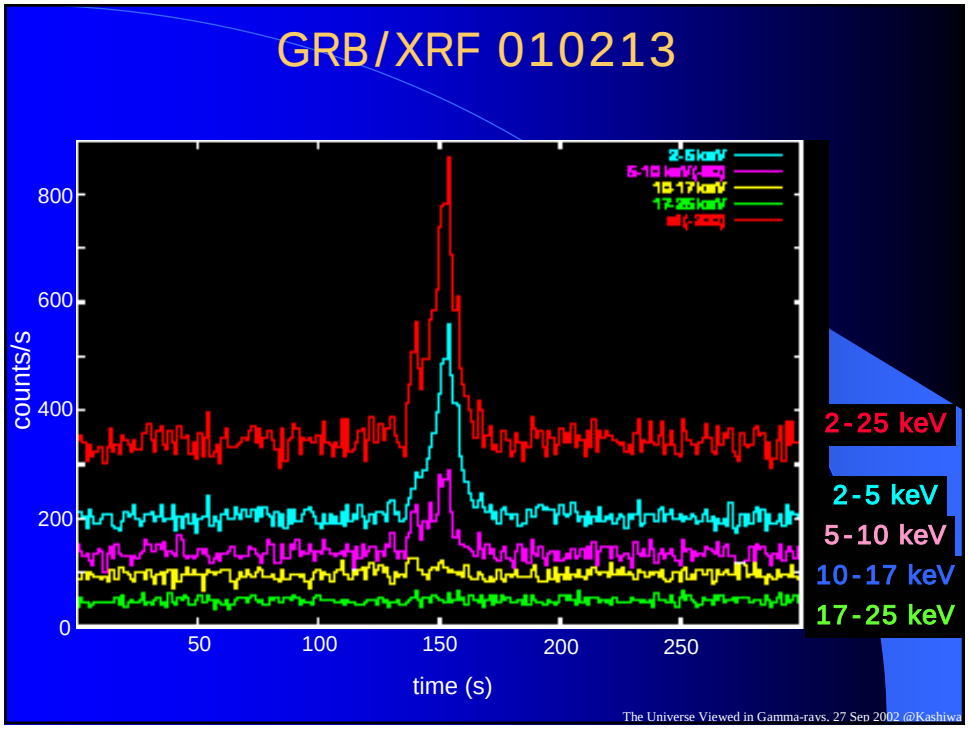
Livetime and number of localized GRBs



HETE-2 Localization delay




GRB020813 WXM spectral evolution
Counts/1.2 s
3500
3000
2500
2000
1500
Photon index
2.0
1.5
1.0
0.5
Energy flux
[10^-8 erg cm^-2 s^-1]
20
10
0
150
200
250
Time [sec.]
The Universe Viewed in Gamma-rays, 27 Sep 2002 @Kashiwa


GRB/XRF 010213
counts/s
800
600
400
200
0
50
100
150
200
250
time (s)
2-25 keV
2-5 keV
5-10 keV
10-17 keV
17-25 keV
The Universe Viewed in Gamma-rays, 27 Sep 2002 @Kashiwa

HETE X-ray rich events

GRB	Photon index	2-25 keV energy flux [10^{-8} erg cm^{-2} s^{-1}]	Fluence ratio [2-25 keV / 30-400 keV]
010213	2.75	1.39	1.21
010225	1.47±0.42	1.27±0.36	1.30
010629B	1.45±0.25	9.16±1.48	0.53
011019	1.13±0.57	1.23±0.48	1.83
011130	2.74±0.40	1.05±0.19	12.47
011212	1.95±0.33	0.93±0.19	4.61
020124	0.88±0.30	4.70±0.90	0.54
020317	0.90±0.48	1.71±0.53	0.33
020903	3.02±0.87	0.33±0.12	no signal in FREGATE

Energy range : 2-25 keV
Spectral model: Power-law
30-400 keV fluence is from FREGATE spectral analysis (astro-ph/0206380)

Fluence Ratio: F_X/F_γ