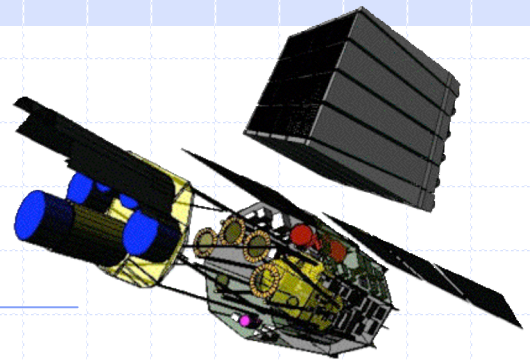


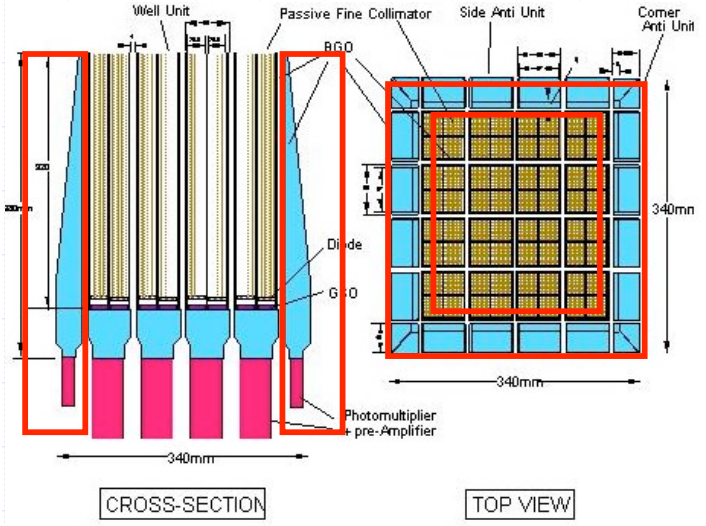
Suzaku wide-band all-sky monitor observations of GRB prompt emissions

Kazutaka Yamaoka (Aoyama Gakuin Univ.)

M.Tashiro, Y. Terada, Y.Urata, K.Onda, A.Endo, M.Suzuki, N.Kodaka, K.Morigami (Saitama-U), T.Tamagawa (RIKEN), Y.Fukazawa, M.Ohno, T.Takahashi, T.Uehara, C.Kira, Y.Hanabata (Hiroshima-U), K.Makishima, K.Nakazawa, T.Enoto (Univ.of Tokyo), M.Suzuki, M.Kokubun, T.Takahashi (JAXA/ISAS), S.Sugita, Y.E.Nakagawa (Aoyama Gakuin Univ.), M.Yamauchi, E.Sonoda, S.Maeno, R.Hara,H.Tanaka (Univ. of Miyazaki), S.Hong (Nihon Univ.), H.Tajima (SLAC) and the Suzaku WAM team

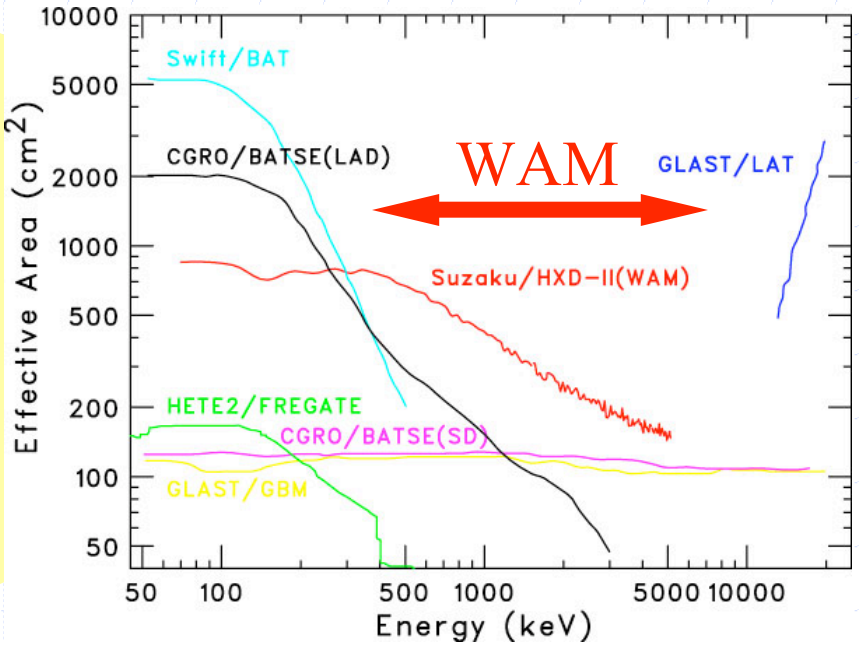
Wide-band all-sky monitor (WAM)

- Lateral large BGO shield of the HXD
- 4th instruments onboard Suzaku
- Scientific objectives: GRB, SGR, solar flare, black hole candidate



The WAM key parameters

Energy range : 50-5000 keV
Field of view : ~2 π
Geometrical area : 800 cm^2
Effective Area : 400 cm^2@1 MeV
Energy resolution: ~30%@662 keV
Time resolution : 1 s (TRN)
15.625 msec (BST)



GRB statistics (2005 Aug.~2007 Aug.)

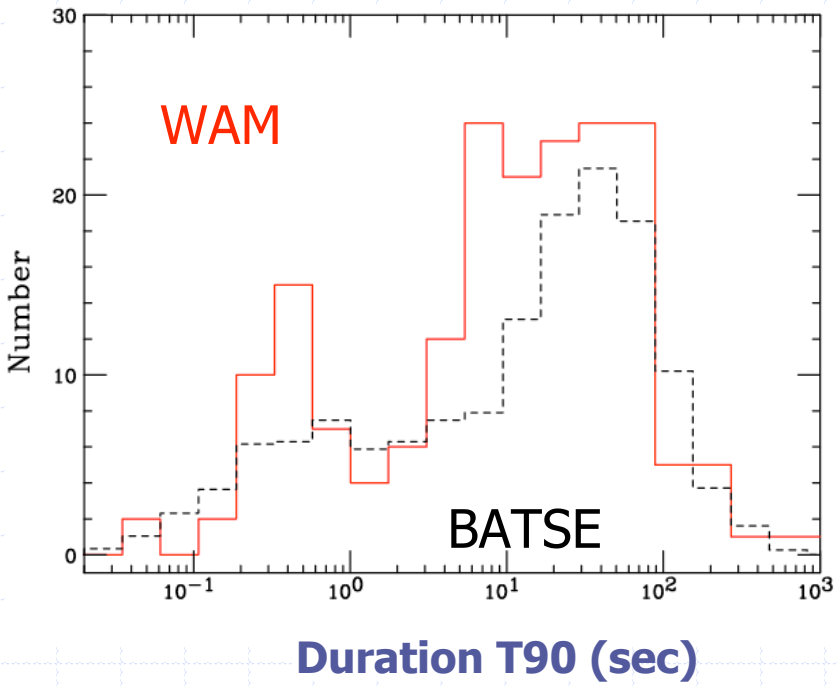
- Confirmed GRBs 288 (trigger 185)

Localized	102
Swift/BAT	58
IPN	36
INTEGRAL	5
HETE2	2
superAGILE	1

The WAM is detecting more than 140 GRBs per year.

→ one of the largest rate in current GRB detectors

T90 duration distribution



- GCNs 47

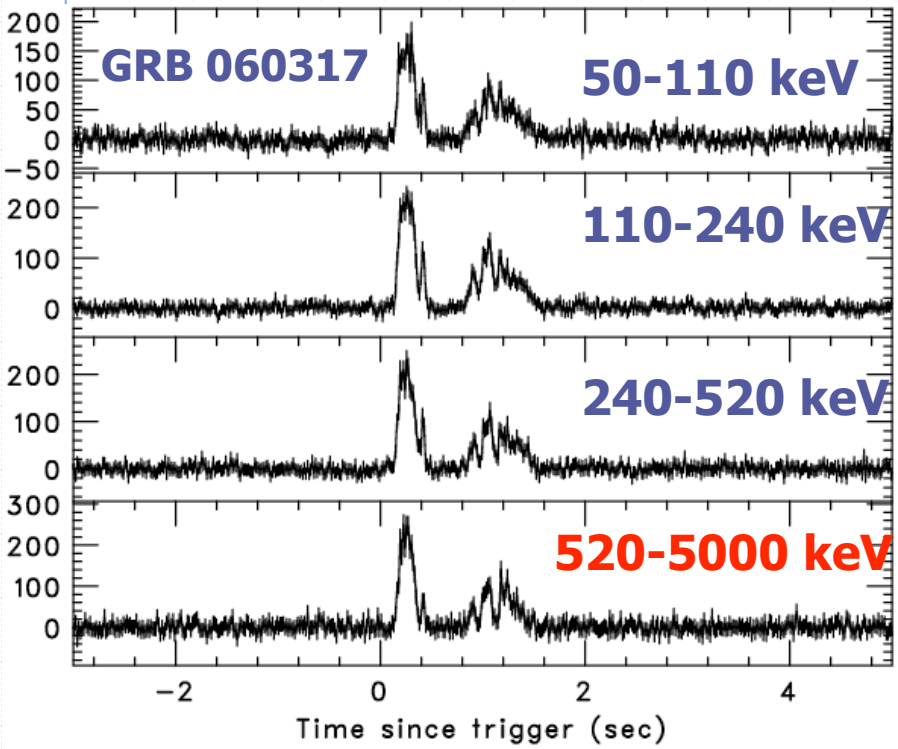
rapid localization by IPN 11 → X-ray counterpart 2

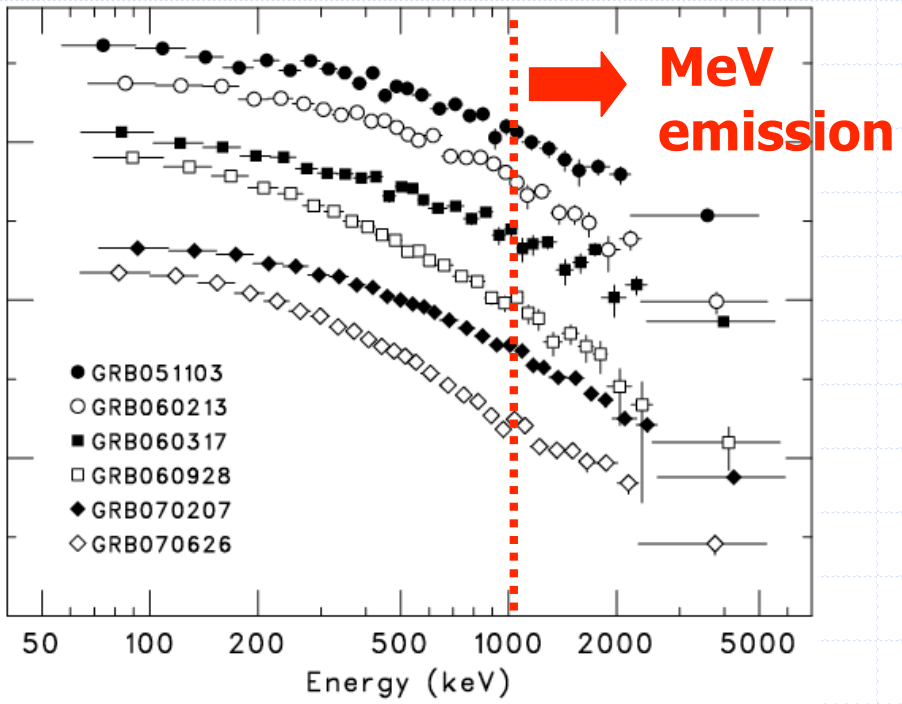
WAM spectral parameters 24

GRB light curves and energy spectra

- Thanks to the WAM large effective area, high quality light curves and spectra can be obtained.

1/64 sec, 4 energy bands (BST data)

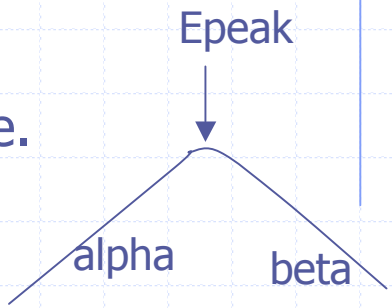




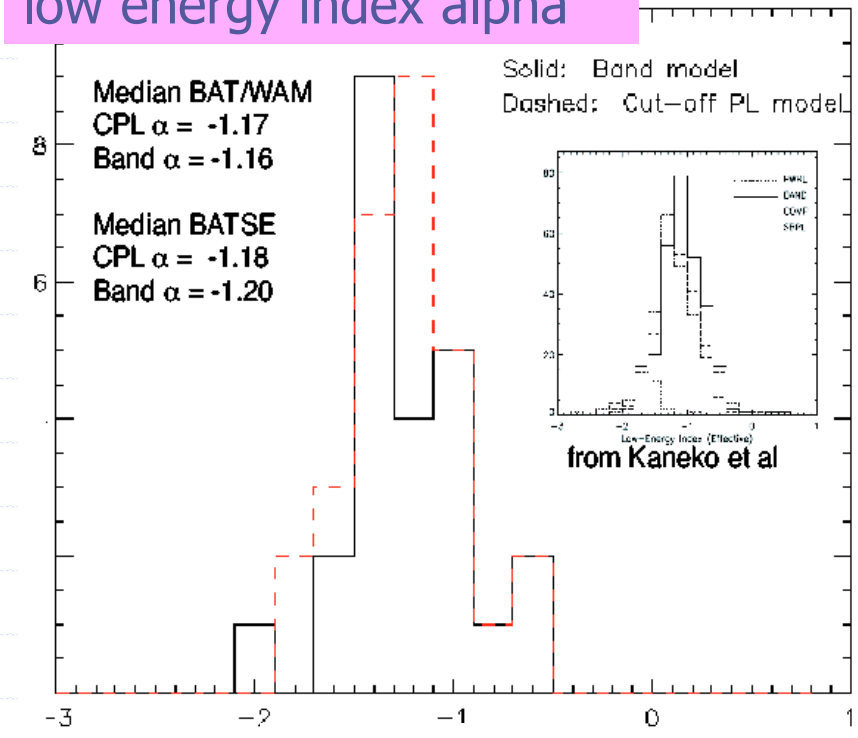
http://www.astro.isas.jaxa.jp/suzaku/HXD-WAM/WAM-GRB

WAM-BAT joint analysis (I)

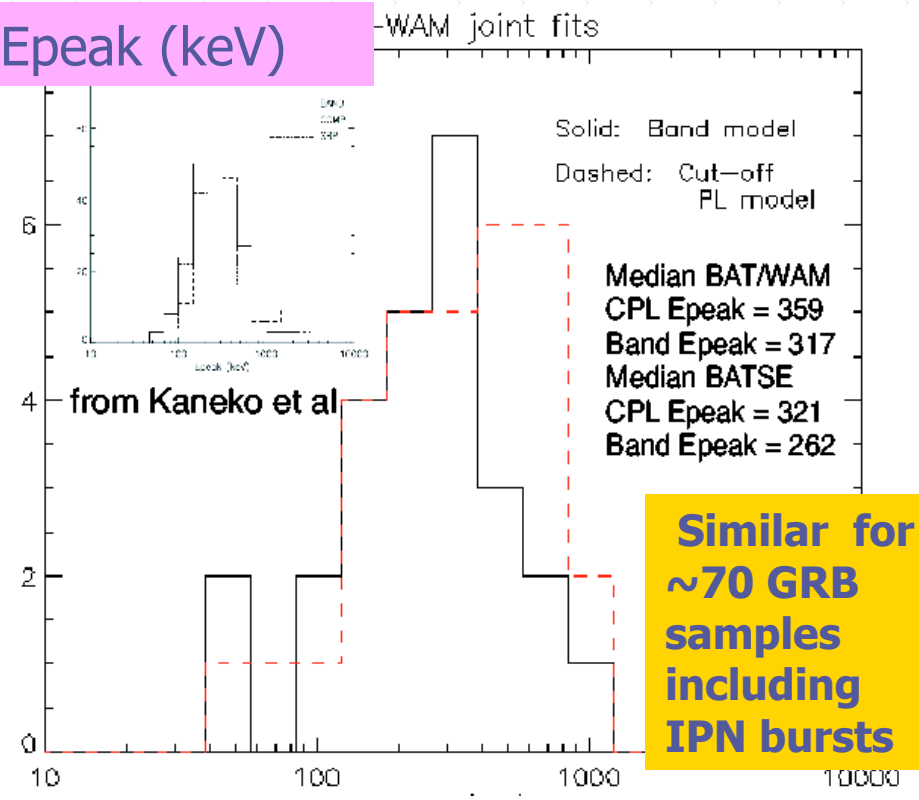
- Only 33 triggered bursts of 61 samples were analyzed
- Could determine the Epeak for 32 GRBs except for one.
- The WAM-BAT parameter distribution corresponds quite well to the BATSE results.



low energy index alpha



Epeak (keV)



Similar for ~70 GRB samples including IPN bursts

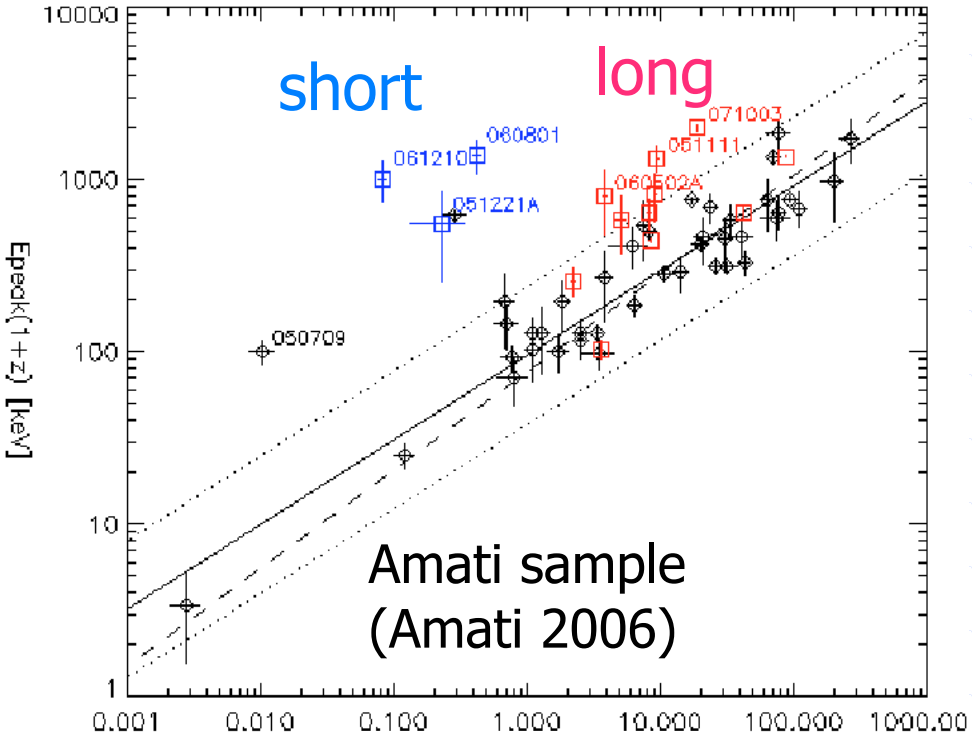
WAM-BAT joint analysis (II)

- 11 long GRB samples
  Almost satisfy the Amati relation
- 3 short GRB samples
  - GRB 051221A (z=0.5465)

  New additional GRBs
  - GRB 060801 (z=1.131)
  - GRB 061210 (z=0.41

→These all are outliers in the Amati relation.

Amati relation



Different origin. another correlation ?

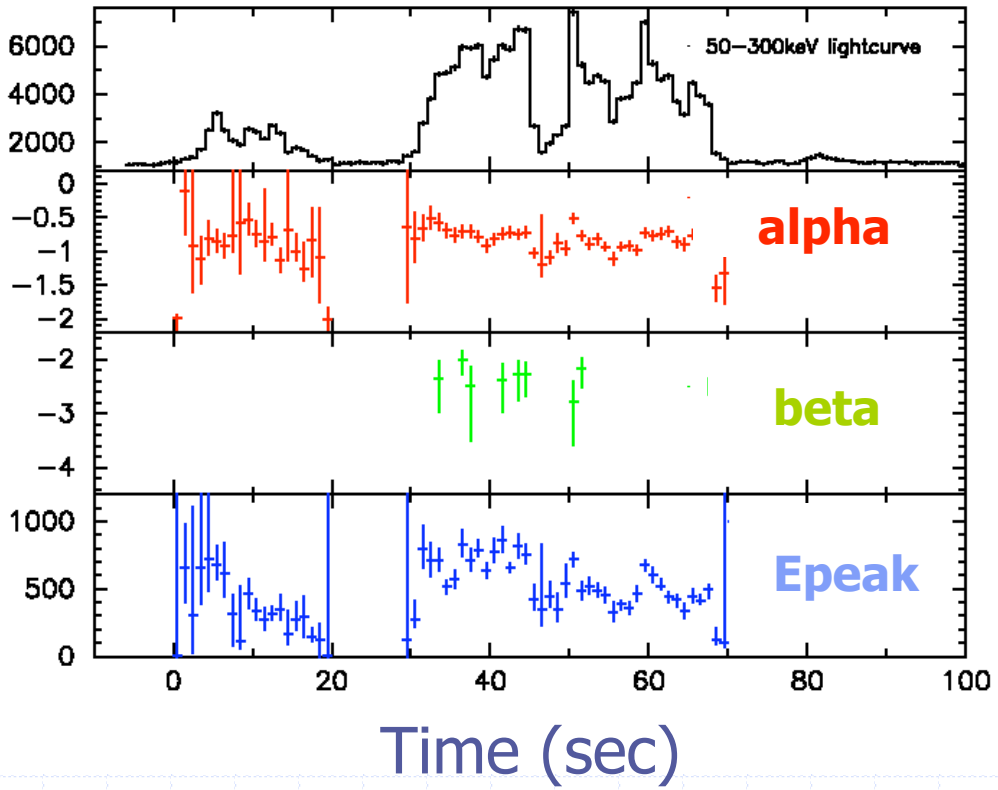
Time resolved spectroscopy (I)

- Swift bright GRB 061007
  - **z=1.261**
  - **T90 ~ 60 sec**
- We successfully performed a time-resolved spectroscopy every 1 sec thanks to the large effective area.

Unique in current GRB detectors

- The Epeak is variable with the source intensity in this short time scale.

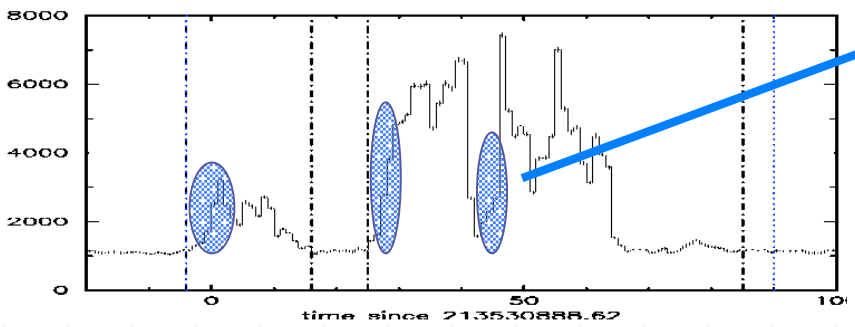
1-sec time-resolved analysis



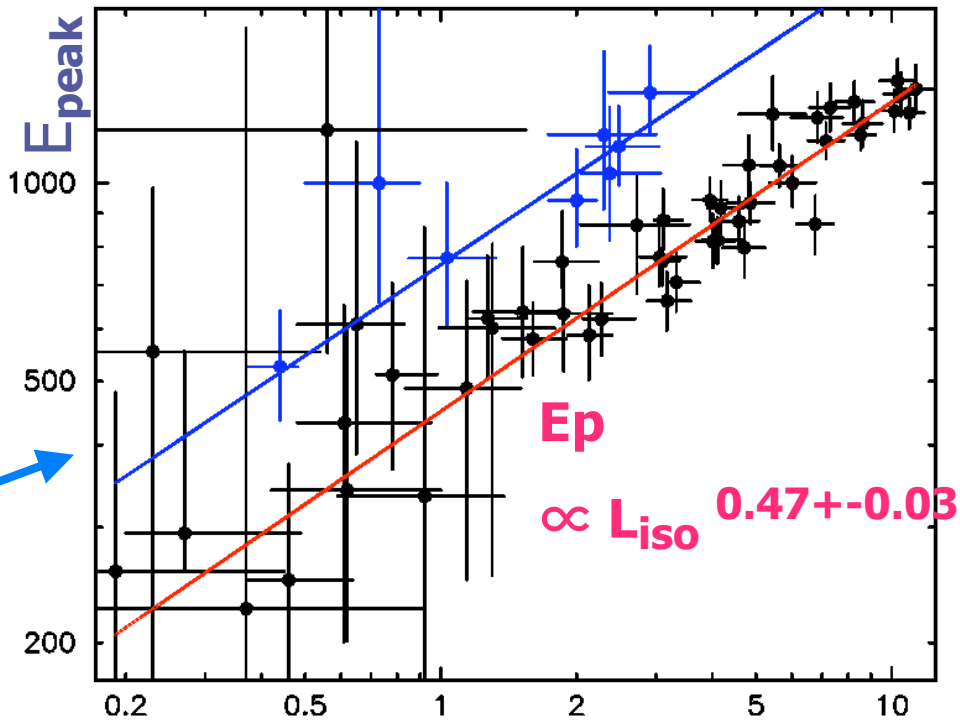
Time resolved spectroscopy (II)

- A clear correlation is found in a short time scale of 1 sec
  similar to Yonetoku et al. and Liang et al.
- In the rising phase,
  some deviations can be seen.

→ subject to different process in rise and decay phase.



L_{iso} – E_{peak} relation

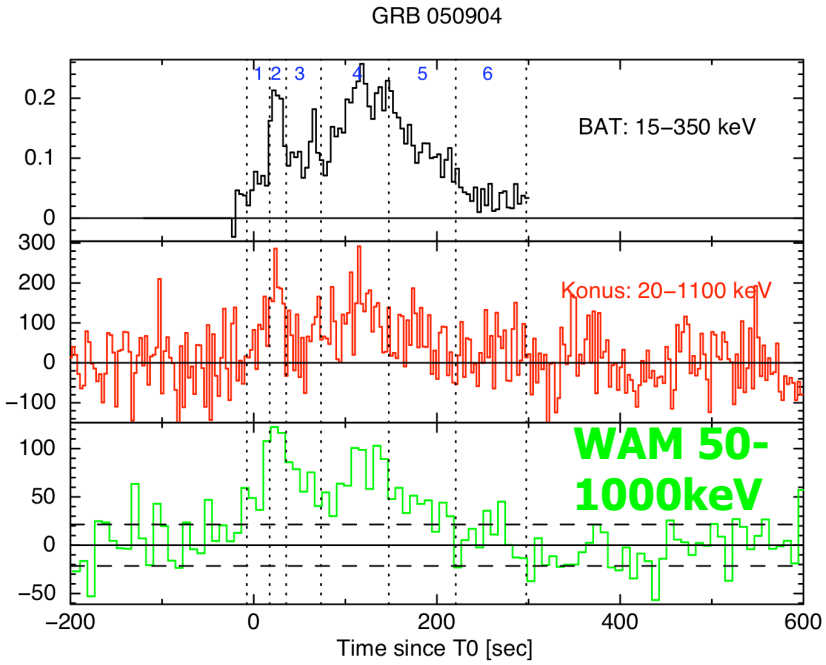


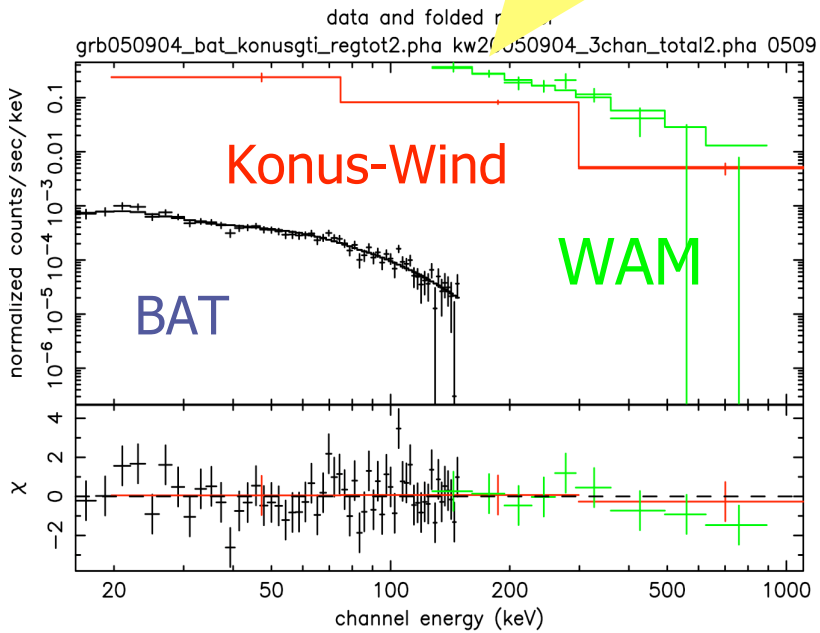
The highest redshift GRB 050904 (I)

- Discovered by Swift/BAT on 2005 Sep. 4, 01:51:44
- Redshift of 6.295+-0.003 (Kawai et al. 2005)
- Photon index of 1.34+-0.06 in 15-150 keV.
- WAM detected signals above BAT energy range!

→ Detailed information of prompt emissions

Alpha = 1.13+-0.13
Epeak =
338 (-93, +168) keV
chi2/d.o.f = 71/65

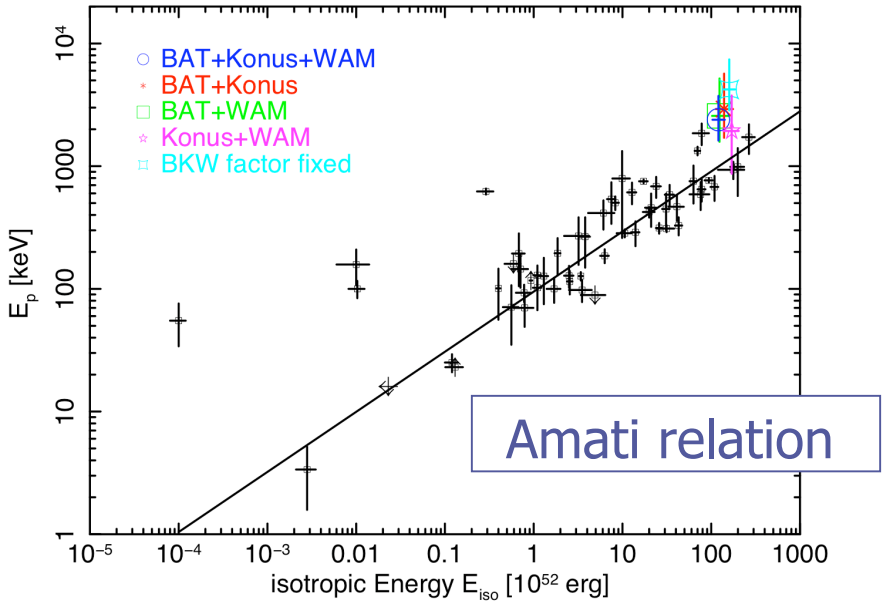


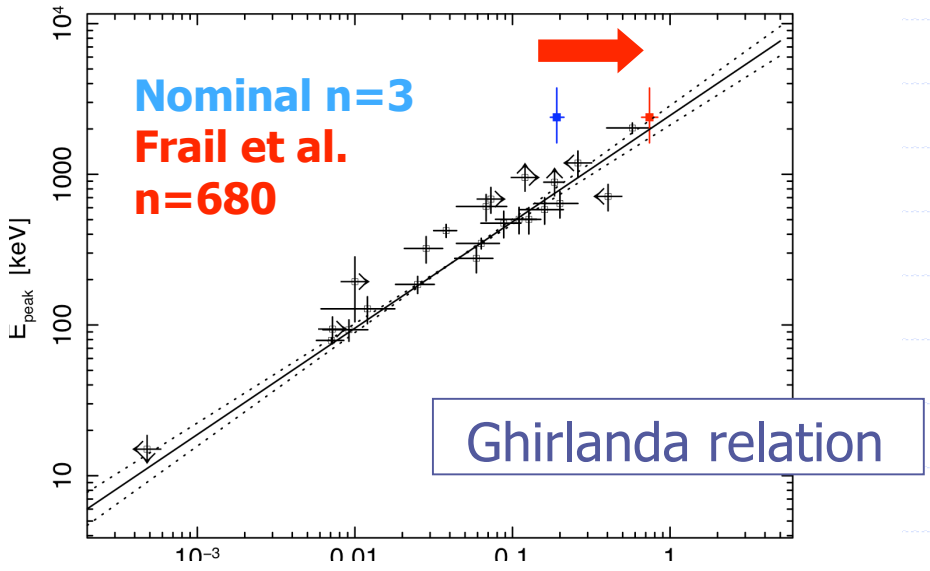


The highest redshift GRB 050904 (II)

- Spectral parameters:
  Epeak(1+z)=2390(-771,+1346) keV,
  Eiso = (1.20+-0.21)X10^{54} erg, Egamma = (1.9+-0.3)X10^{51} erg
- Consistent with Amati relation even at the high redshift,
  but not with Ghirlanda relation (nominal circumburst density 3 cm^{-3}).

→ imply that the circumburst density might be larger than nominal one.

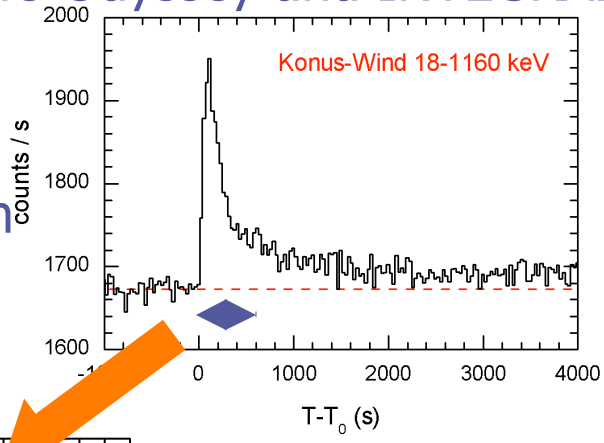


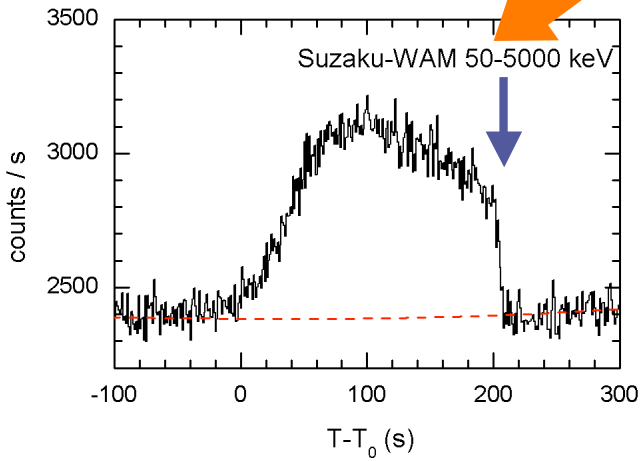


Jet-angle corrected luminosity Egamma

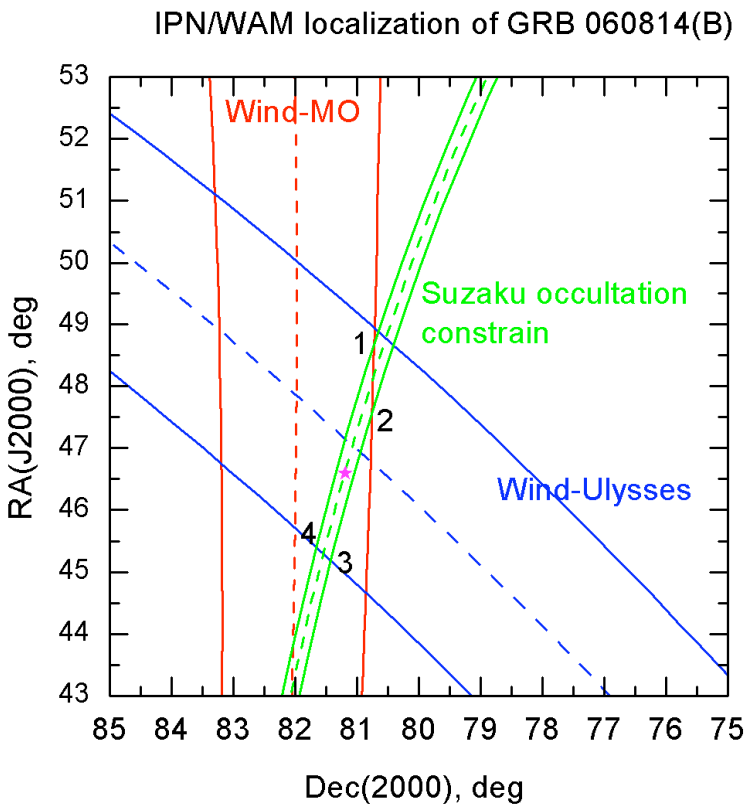
Discovery of very long GRB 060814B (I)

- Very long duration of ~2600 seconds (maybe record)
- Detected by Suzaku-WAM, Konus-Wind, Ulysses, Mars-Odyssey and INTEGRAL SPI-ACS. ⇒ IPN localization
- FRED, very smooth





Earth occultation information further constrain the position

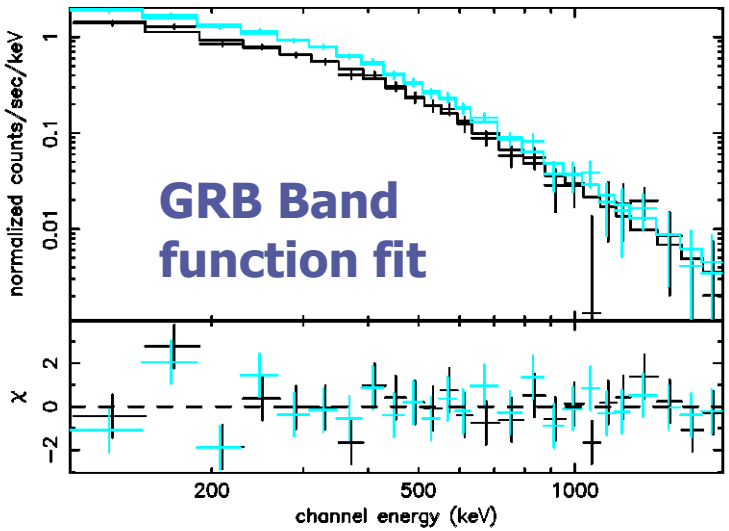


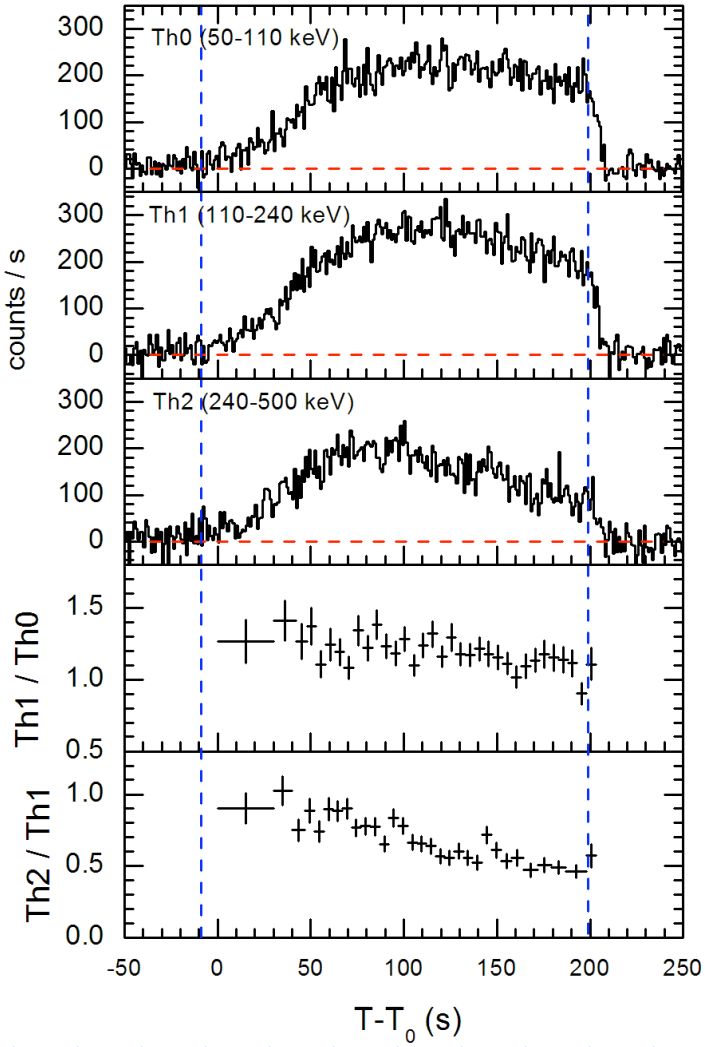
GRB 060814B (II)

- The WAM spectral parameters
  - **Alpha = -0.33 (-0.18, +0.22)**
  - **Beta = -2.49 (-0.53, +0.27)**
  - **Epeak = 483 +- 48 keV**
  - **Fluence in 100-2000 keV**
    >1.04x10^{-4} erg/cm^2

Konus Fluence in 15-1000 keV

(2.35 ± 0.22)_10^{-4} erg/cm^2





Hard to soft evolution

Spectral parameters and evolutions are typical in GRBs, but more energetic

Summary

- Suzaku WAM has been detecting more than 140 GRBs per year which shows one of the largest rate in current GRB missions.
- BAT-WAM joint analysis has derived Epeak from many GRBs. The spectral parameters are consistent with BATSE results.
- Time resolved spectroscopy using the WAM is very unique in studying the prompt emissions.
- The WAM detected three interesting GRBs:
  - GRB 060814B with the longest duration
  - GRB 050904 with the highest redshift
  - GRB 051103 can be a candidate of magnetar in M81 or M82

WAM poster presentations at this conference

- [A36] short GRB summary (M.Ohno et al.)
- [A34] IPN localization (K.Hurley et al.)
- [A37] GRB 060814 and GRB 070125 (K.Onda et al.)
- [A6] Earth occultation technique (Y.Fukazawa et al.)

Outline of my talk

- Introduction of the WAM
- GRB observation status
- WAM-BAT joint analysis
  - Epeak distribution
  - updated Amati relation
- Time-resolved spectroscopy for bright GRBs
- Two interesting GRBs
  - GRB 050904 (with the highest redshift)
  - GRB 060814B (with the longest duration)

WAM-BAT joint analysis (I)

- Started a cross-calibration work on Aug. 2006
  with Konus-Wind and Swift-BAT team.
  → Now calibration uncertainties are estimated to ~20%
  → Next step is to derive scientific results.

- Almost of all the Swift bursts can not determine the Epeak.
  A combination of BAT (15-150 keV) and WAM (50- 5000 keV) allows us to determine the spectral parameters including Epeak.

- 61 Swift GRBs detected by the WAM up to present
  - 35 triggered GRBs (33 analyzed)
  - 26 un-triggered GRBs (only GRB 050904)
  - 25 with redshifts

Detector Calibration

- Absolute Timing

  verified within 2 msec by the IPN

- Absolute Effective area

  20-30 % for various angles