WAM Archive Ver. 2 Document

Terada, Y., Tashiro, M., Odaka, K., Murakami, S., Takahashi, K. (Saitama Univ.),
Yamaoka, K. (Nagoya Univ.; corresponding author*)

ver1.0 2018-02-28 The first version
ver2.0 2018-03-13 Event information is refined.
ver3.0 2018-09-22 Categories are updated according to the archive.
ver3.1 2018-09-27 Trigger ID descripton is updated.
ver4.0 2018-10-10 OBSID is added.

Abstract

This document describes the Suzaku Wide-band All-sky Monitor (WAM) Data Archive (Version 2)[1]. WAM was the sub-system of the Hard X-ray Detector (HXD), and capable to detect transient events such as gamma-ray bursts (GRBs) and Solar flares. WAM detected more than 3,000 transient events for over 10 years from August 2005 to March 2006. We release light-curves of these events in the Version 2 archive. Energy spectra and responses will be released in future.

1 WAM Event Classification

WAM continuously obtained light-curve data with one-second time-resolution. Besides, WAM had an automated GRB detection system to trigger Burst observations with finer time-resolutions. The one-second light-curve data are named "transient data" (TRN) or "untriggered data", and the triggered data is called "burst data" (BST). The WAM event classification is shown in Table 1.

Table 1: Classification of the WAM events

Classification	Explanation
Confirmed GRB	Confirmed GRBs which are also detected by other satellites
Possible GRB	Possible GRBs not detected by other satellites
Solarflare	Solar flares, which often synchronize with GOES satellite
Confirmed AXP/SGR	Confirmed AXPs and SGRs which are also detected by other satellites
Possible AXP/SGR	Possible AXPs and SGRs not detected by other satellites
Particle/SAA	Particle background events including SAA passage
Noise/Spike	Noise or spike which originate in background fluctuation
Operation	False events due to mis-operation, HV-on, unit-scan etc.

*Original document was in Japanese, translated by Ken Ebisawa.

[1]Version 2 is available at `https://darts.isas.jaxa.jp/pub/suzaku/wam-2.0`. Preliminary version of the WAM archive, which we call Version 1, has been public at `http://www.astro.isas.jaxa.jp/suzaku/HXD-WAM/WAM-GRB/`; this is permanently archived at DARTS, `http://darts.isas.jaxa.jp/astro/suzaku/wam-1.0`. In addition, Version 3 is made at HEASARC by restructuring Version 2, and mirrored to DARTS (`http://darts.isas.jaxa.jp/astro/suzaku/wam-3.0`).

2 Event attribute

Event attribute is shown in Table 2. In Ver. 1 archive, trigger events and untriggered events were handled independently, while in Ver. 2, they are handled in the same scheme only having different flags.

Table 2: Event attribute

Item	Ver.†	Explanation
Event No.	1,2	YYMMDDHHMMSS of the detection time.
Obs. ID	2	Suzaku observation ID. For those without observation ID (such as maneuver), 999999999.
Trig. ID	1,2	Trigger ID starting with 1. For those without trigger, start with 4001.
DateTime (UTC)	1,2	Event detection time (UT).
Event type	2	Triggered or Untriggered
Trigger WAM0	1,2	Triggered by WAM0, yes/no. If untriggered, N/A‡.
Trigger WAM1	1,2	Triggered by WAM1, yes/no. If untriggered, N/A‡.
Trigger WAM2	1,2	Triggered by WAM2, yes/no. If untriggered, N/A‡.
Trigger WAM3	1,2	Triggered by WAM3, yes/no. If untriggered, N/A‡.
Classification	2	Classification by Table 1.
Name	2	Source/Event name, such as GRBYYMMDD, 1E 1547.0-5408, SGR 1900+14.
RAC	2	Right Ascension (J2000) , if known.
DEC	2	Declination (J2000), if known.
Input angle θ	1,2	Incident polar-angle to WAM (θ)
Input angle ϕ	1,2	Incident azimuth-angle to WAM (ϕ)
Duration T_{90}	1,2	Duration from 5% to 95% of the total flux (seconds)
Fluence	1,2	Total energy (erg cm^{-2})
Other Detection	1,2	Detectors which detected this event
Redshift	2	GRB redshift
Position Reference	2	Reference of the GRB position
WAM Reference	1,2	Relevant GCN or catalog
GOES class	1,2	Soft X-ray solar flare flux (A,B,C,M,X) by GOES
Comments	1,2	Comments (maneuver, SAA, etc.)

†: "1,2" means both in Ver. 1 and Ver. 2. and "2" means only in Ver. 2.
‡: There are triggered events where all the WAM give trigger "no". In this case, "N/A".

3 Data Product Explanation

A. TRN data for all the events (both triggered and untriggered).

A1. TRN event data (FITS)
ae[ObsID]_YYYYMMDDHHMMSS_wam_[short,long].evt
Long and short events are extracted for two different time-intervals as follows, where T_0 is the event detection time.

- long: T_0–500 s ∼ T_0+T_{90}+400 s (for T_{90} ≥100 s)
  T_0–5×T_{90} s ∼ T_0+5×T_{90} s (for T_{90} <100 s)
- short: T_0–0.5×T_{90} s ∼ T_0+2×T_{90} s (T_{90} ≥10 s)
  T_0–5 s ∼ T_0+15 s (T_{90} <10 s)

A2. TRN light-curve FITS without deadtime correction, four energy bands, time bin-width=1s. The four energy bands correspond to the BST data TH=0, 1, 2, 3.
ae[ObsID]_YYYYMMDDHHMMSS_wam[0-3]_th[0-3]_[short,long]_ndtc.lc

A3. TRN light-curve FITS (with deadtime correction), four energy bands, time bin-width=1s
ae[ObsID]_YYYYMMDDHHMMSS_wam[0-3]_th[0-3]_[short,long].lc

A4. QDP files, PNG files, where the time bin-width is 1sec

- **ae[ObsID]_YYYYMMDDHHMMSS_wam[0-3]_trn_4band_[short,long].{qdp,png}**
  With deadtime correction.
- **ae[ObsID]_YYYYMMDDHHMMSS_wam[0-3]_trn_4band_[short,long]_ndtc.{qdp,png}**
  Without deadtime correction.

B. BST data (only for triggered events)

B1. BST event FITS **hxd_[0-9]_bst0[1-9]_uf.evt**

B2. BST light-curve FITS without deadtime correction, for each WAN (0,1,2,3) for four energy bands (TH0,1,2,3)
ae[ObsID]_YYYYMMDDHHMMSS_wam[0-3]_bst_th[0-3]_ndtc.lc

B3. BST light-curve FITS with deadtime correction, for four energy bands (TH0,1,2,3), for different time bins (1/32s, 1/2s or 1/64s,1/4s)
ae[ObsID]_YYYYMMDDHHMMSS_wam[0-3]_bst_th[0-3].lc

B4. QDP and PNG files for time bine-width (1/32, 1/2 sec or 1/64,1/4 sec)

- **ae[ObsID]_YYYYMMDDHHMMSS_wam[0-3]_bst_4band_nobin.{qdp,png}**
  1 bin (1/32 or 1/64 s), with deadtime correction
- **ae[ObsID]_YYYYMMDDHHMMSS_wam[0-3]_bst_4band_nobin_ndtc.{qdp,png}**
  1 bin (1/2 or 1/4 s), without deadtime correction
- **ae[ObsID]_YYYYMMDDHHMMSS_wam[0-3]_bst_4band_16bin.{qdp,png}**
  16 binned (1/32 or 1/64 s), with deadtime correction
- **ae[ObsID]_YYYYMMDDHHMMSS_wam[0-3]_bst_4band_16bin_ndtc.{qdp,png}**
  16 binned (1/2 or 1/4 s) without deadtime correction

C. GTI (Good Time Interval) FITS: **ae[ObsID]_YYYYMMDDHHMMSS.gti**

Good time intervals when the instrument is carrying out observation with normal condition. The following intervals are excluded:

(a) HV is off.

(b) Health check of the instrument ("WAM scan").

(c) Earth occultation periods for the sources with known location. Effect of earth atmosphere is not taken into account.

4 Difference between Ver. 1 and Ver. 2

- Ver. 1 was s produced from the proprietary QL (Quick Look) data taken at USC (ground station). Ver. 2 was produced from the officially processed public data besides exception (see below).

  In addition, Ver. 2 has the following features:

  - Attitude and time-correction are updated.
  - When maneuver data and non-standard observation data are not publicly released, QL data are used to supplement these. When QL data are used, Obs. ID is 999999999 for TRN data, and 99999[TrigID] for BST data.

- Following new products are added in Ver. 2.

  - Standard event FITS (TRN and BST). Users can analyze these data using standard FTOOLS.
  - 16 binned (1/2 or 1/4 s) light-curves for BST data.

- Deadtime correct light curves.
  Deadtime was not corrected in Ver. 1, thus light-curve drops in bright solar-flares etc.; this is fixed by deadtime correction. BST data are also deadtime corrected, but this is currently approximation. Current deadtime correction method, which is adopted in the light-curve generation tool `hxdmkbstlc`, is explained in Appendix A.
- GTI FITS is added.

5 Other comments

- When you used the current archive, please indicate the following acknowledgment:

  " This research has been made using the WAM archive data products Ver. 2 provided by JAXA C-SODA and Suzaku WAM team."

- Here is the future plan of WAM archive:
  - Develop a Web tool to extract a light-curve for given time-interval.
  - Produce GRB catalogs, Solar flare catalog
  - Produce energy spectra, background spectra and responses.

A Method of deadtime Correction

A.1 Using deadtime Counter

For PH data (output every 1 sec), deadtime counter is used for deadtime correction. WAM deadtime DT is calculated using the deadtime clock whose period is $T_{\rm CLK}$(=12.8 μs), as

$$DT = N_{\rm DT} \times T_{\rm CLK}, \tag{1}$$

where $N_{\rm DT}$ is the deadtime counts which is output every 1 sec for TRN data and 0.5 or 1 sec for BST data.

A.2 Using Event Rates

For the TH data shorter than 1 sec, the deadtime counter cannot be used. In this case, deadtime is estimated from the number of PH events. Typical deadtime for the PH event in 0-55 channel ($<$ 5 MeV) including overflow is $D_{\rm PH}$=13.0 μs, and that for the UD event (>5 MeV) is $D_{\rm UD}$=25.6 μs. Thus, deadtime is estimated as

$$DT = DT_{\rm PH} \times N_{\rm PH0-55} + DT_{\rm UD} \times N_{\rm UD}. \tag{2}$$

However, this relation may not hold for extremely high counting rates, since deadtime is not precisely constant.

In the case of BST data in 1/32 or 1/64 sec, output counts are combined for TH0+1+2+3 and 2-55 channel, while UD and PH 0-1 counts are output only every 0.5 sec or 1 sec. Thus, the total counts in PH0-55 channel in 1/32 or 1/64 sec are estimated from the counts in PH2-55 in the short periods and the ratio between PH2-55 and PH0-55 counts in 0.5 or 1 sec. Also, UD, which is mainly due to particle events, is assumed to be constant within 0.5 sec or 1 sec.

Consequently, deadtime is estimated as

$$\begin{aligned} DT = {} & DT_{\rm PH} \times N_{\rm PH2-55} \times N(0.5/1s)_{\rm PH0-55}/N(0.5/1s)_{\rm PH2-55} \\ & + 1/32 \times (N(0.5/1s)_{\rm DT} \times T_{\rm CLK} - DT_{\rm PH} \times N(0.5/1s)_{\rm PH0-55}). \end{aligned} \tag{3}$$

The first term is contribution from PH deadtime, and the second term is contribution from UD deadtime.

Currently, it is assumed that the spectral shape does not change during the burst. If spectral variation is significant, the above relation may not hold; deadtime correction for such cases remain as a future task.