Laboratory for High Energy Astrophysics

Office of Guest Investigator Programs

SAS-2
Calibration Guide

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LOG OF SIGNIFICANT CHANGES

Release Date	Sections Changed	Brief Notes
1993 Dec 01	All	First Release
1995 Feb 23	All	Made compatible with `LaTeX2HTML` software

Contents

***SAS2* Acronyms & Abbreviations**

BCF	Basic Calibration File
caldb	calibration database
CPF	Calibration Product File
DESY	Deutsches Elektronen-Synchrotron
GSFC	Goddard Space Flight Center
LHEA	Laboratory for High Energy Astrophysics
OGIP	Office of Guest Investigator Programs
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards
SAS-2	2nd NASA Small Astronomy Satellite

Chapter 1

INTRODUCTION

1.1 *SAS-2* mission overview

(*Source:* Fichtel *et al.* 1975, Thompson 1993)

The second NASA Small Astronomy Satellite (*SAS-2*) was dedicated to γ-ray astronomy in the energy range above 35 MeV. The satellite carried a single telescope using a 32-level wire spark-chamber. The satellite was spin stabilized with the telescope axis along the spin axis. *SAS-2* was launched on 1972 November 15 and became operational on 1972 November 19. On 1973 June 8, a failure of the low-voltage power supply ended the collection of data. During the approximately six months of the mission, 27 pointed observations, typically of a week duration, were made resulting in about 55 percent of the sky being observed, including most of the galactic plane. The field-of-view of the telescope is about 35 degrees (full width at half maximum) with an angular resolution of a few degrees. In addition to the general galactic emission, high-energy γ-rays were also seen from the Crab and Vela pulsars.

The low fluxes involved in the study of γ-ray sources make it desirable to minimize the background flux from cosmic-rays. Therefore a low Earth equatorial orbit was chosen having a 2 degree inclination; an apogee and perigee of 610 km and 440 km, respectively; and an orbital period of about 95 minutes. During the short lifetime of the mission, there was some noticable decrease in sensitivity due to deterioration of the spark-chamber gas. The calibration of the SAS-2 experiment was done using both the flight unit and an identical flight spare unit. The range of energy studied at the National Bureau of Standards (NBS) Synchrotron, Gaithersburg, Maryland, was approximately 20 to 114 MeV. The energy range between 200 to 1000 MeV was studied at the Deutsches Elektronen-Synchrotron (DESY), Hamburg, West Germany.

References

Fichtel, C.E., Hartman, R.C., Kniffen, D.A., Thompson, D.J., Bignami, G.F., Ögelman, H., Özel, M.E., & Tümer, T. 1975. *Astrophys. J.*, **198**, 163.

Thompson, D.J. 1993. private communication.

Chapter 2

SPARKCHAMBER DETECTOR CHARACTERISTICS

2.1 In-Orbit Performance

(*Source:* Fichtel *et al.* 1975)

2.1.1 Malfunctions and configuration changes

Only one significant malfunction is reported for *SAS-2* , that being the unfortunate failure of the low-voltage power supply on 1973 June 8 ending the collection of data and, hence, the mission. The spark chamber gas showed degradation during the six months lifetime of the mission and had degraded to the point that it would have lasted for only a few more months, if the low-voltage power supply had not failed. This would have ended the mission, since no gas was available to replenish that in the spark chamber.

2.2 Standard Data Processing

2.2.1 Automated Selection

(*Source:* Derdeyn *et al.* 1971, Fichtel *et al.* 1975)

Automated selection of events was done in-flight and on the ground. The in-flight selection had the following criterium: the spacecraft triggered an event when a charged particle was detected in the 1/4" plastic scintillator and one of four Cherenkov counters, but *not* in the anti-coincidence dome. The trigger then initiated recording of spark-chamber data. Further processing was done on the ground.

The post-flight selection of events was based on the following criteria. The detection of an inverted Y or V shape in one orthogonal view of the spark-chamber, and the elimination of single-track events or those intersecting the wall. After the event being accepted, its direction and energy were determined. The determination of event direction was based on a weighted bisector method: the direction was weighted toward the higher energy electron or positron. Details of this method can be found in Fichtel *et al.* (1972). The arrival direction is first determined in space-craft coordinates (altitude-azimuth), and then using the space-craft's attitude data, the celestial coordinates are determined.

The energy calculation is based on multiple Coulomb scattering of pair electrons in the tungsten plates. A description of this formalism is given by Pinkau (1966, 1968) and Kniffen (1969). The accuracy of measuring the scattering angle limits the maximum measurable energy, since higher energy γ-rays have smaller scattering angles. For SAS-2 this energy is about 200 MeV.

2.2.2 Human Selection

About 10% of events are considered marginal, based on the automated-selection criteria. Humans are then used to select those events which are γ-rays, by viewing the two orthogonal views of the spark-chamber on a graphics terminal. If the event is accepted then the direction and energy are determined using the automated selection software.

References

Derdeyn, S.M., Ehrmann, C.H., Fichtel, C.E., Kniffen, D.A. & Ross, R.W. 1972, *Nucl. Instr. & Methods.*, **98**, 557.

Fichtel, C.E., Hartman, R.C., Kniffen, D.A. & Sommer, M. 1972, *Astrophys. J.*, **171**, 31.

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Kniffen, D.A., 1969, *NASA Tech. Report TR R-308.*

Pinkau, K. 1966, *Zs. f. Phys.*, **96**, 163.

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Chapter 3

POTENTIAL PROBLEMS

3.1 Earth Albedo

(*Source:* Marvin 1978)

One of the major problems with γ-ray astronomy is the interaction of cosmic-rays with the Earth's atmosphere producing high energy γ-rays. Most of these events were rejected and not included in the database, because the zenith angle (the angle between the estimated γ-ray direction and the zenith (the spacecraft pointing direction)) was $> 90^o$, implying their direction is near the Earth's horizon.

During the creation of the *SAS-2* database, the STDGTI (standard good-time-interval) and ALLGTI (all good-time-interval) were determined from the spacecraft orbital data using the following criteria: for the STDGTI, the zenith angle $\leq 90^o$ and, for the ALLGTI, the zenith angle $\leq 115^o$.

References

Marvin, J.W. 1978, *SAS-B Spark Chamber Sensitivity Program Description*, NASA/GSFC document.