ABSTRACT

The Position Sensitive Proportional Counter (PSPC) was the prime focal plane instrument on board ROSAT. It was a conventional multi-wire counter, operating in an energy range from 0.1 to 2.4 keV. The counter gas was a mixture of 65%Ar, 15%Xe and 20%Kr, at a pressure of about 1.5 bar, replenished at a flow rate of 2.5 std cm$^{-2}$ per day. At 1.5 keV the detector had an energy resolution of $\Delta E/E = 0.41$ FWHM, a position resolution of 300 μm FWHM and a quantum efficiency of 50%. The background rejection capability of the detector in space environment was 90.6%. Within the first four years of the mission the PSPC has been used for 80% of the observing time. Thereafter the gas supply was nearly exhausted and the PSPC was used only for special observations. The drop of the gas gain of the detector during the whole mission was 10%. After eight years of observation the PSPC has been turned off due to an extremely reduced gas flow and at the border of the radiation regions. During this observation the detector probably suffered a discharge and within several days an increasing area with 50% gain loss and extremely reduced gas flow and at the border of the radiation belts with a very high particle background. This area increased rapidly.

INTRODUCTION

ROSAT (RÖNGEN SATELLIT) [1] is a German X-ray satellite with major contributions from UK (UV-telescope) and USA (HRI-detector and satellite launch). The satellite was launched in 1990 and operated for more than eight years in orbit. The main scientific objectives of the ROSAT mission was the performance of the first X-ray all sky survey in the energy band from 0.2 to 2.4 keV with an imaging telescope. After completion of the survey ROSAT was used in pointed mode for detailed observations of selected objects. The main scientific payload of ROSAT was an imaging X-ray telescope with a fourfold nested Wolter type I mirror system with a maximum aperture of 83 cm and a focal length of 2.4 m. The focal plane instrumentation [2] carried two different types of X-ray image detectors, which complement one another: two redundant Position Sensitive Proportional Counters (PSPC) with a sensitive area of 8.1 cm diameter, and one High Resolution Imager (HRI) based on micro channel plates, with a sensitive area of 2.5 cm diameter. The detectors are mounted on a carousel, which allows the positioning of the desired detector in the focus of the mirror system. Except for the HRI, the whole focal plane instrumentation was developed and built in our institute.

RESULTS OF THE ROSAT MISSION

ROSAT ALL-SKY SURVEY Bright Sources

With more than eight years of active observing time (Jun. 1990-Feb. 1999) ROSAT has been so far the most fruitful X-ray astronomy observatory. The ROSAT mission increased the number of known celestial X-ray sources from several 10$^3$ over more than 10$^5$. But ROSAT not only contributed to the number of known X-ray sources. Due to the high background rejection efficiency and the good energy resolution of the PSPC four-colour X-ray images of all types of objects like the near sun, coronal, normal stars, binary systems, supernova remnants, galaxies, cluster of galaxies and the most distant quasars could be measured with high contrast. After the sky survey about 10$^6$ pointed observations has been carried out, which led to more than 4500 scientific publications.

DESIGN AND PERFORMANCE OF THE DETECTOR

Fig. 1: Schematic cross section of the X-ray telescope of ROSAT

Fig. 2: Wire grid system of the PSPC. The ceramic frames have a size of 20 cm x 20 cm. The detector housing is removed.

Fig. 3: Schematic diagram of the grid system.

WIRE GRID PARAMETERS

Anode grid: 10μm tungsten wires with 1.5mm pitch for anode 1 and 2mm for anode 2. Side wires have increasing diameters. The signal of anode 1 is used as trigger for readout and for the energy measurement of an event.

Cathode grids: 50μm platinum iridium wires with 0.5mm pitch. Cathode 1 and cathode 2 are electrically subdivided in strips of 3.5mm width for the position readout of the events by the center of gravity method. Cathode 1 and cathode 2 are mounted orthogonal to each other for the readout of both coordinates of the events.

DETECTOR GAS

Composition: 65%Ar, 15%Xe, 15%CH$_4$; Pressure: 1 bar; Ox = 0.5 rpm; HO = 1 rpm, Ke = 0.5 rpm, N$_i$ = 0.5 rpm; Gas pressure: 1000 bar at 22°C; Flow rate: selectable by telecommand 2.5–5 std cm$^{-2}$ per day, normal 2.5 std cm$^{-2}$ per day; Regulation: Gas density regulation. Regulation is a sealed volume in the detector housing. Regulation accuracy ± 1bar.

ANTICOINCIDENCE SYSTEM FOR BACKGROUND REJECTION

By using the signals of anode 2 and the outer strips of cathode 1 and cathode 2 an anticoincidence, a fivefold anticoincidence is realized. In addition the experiment electronics checks the signal patterns of cathode 1 and cathode 2.

AGING EFFECTS DURING 8 YEARS IN ORBIT

Fig. 4: Flat field illumination with 0.95 keV X-rays; shadow of the metal support structure and the 100 μm support wires.

Fig. 5: Detector widow/in polycarbonate foil with carbon and lexan coating.

Fig. 6: Detector gain during eight years operation. The diagram shows the peak position in adu channels of the 1.5 keV Al Kα line of the calibration source (Al fluorescence excited by an Fe$^{55}$ source).

Period 1: PSPC A showed a stronger gain decrease compared to PSPC B.

Period 2: Redundant PSPC B with nominal high voltage setting.

Period 3: Reduced high voltage due to a warm spot with 0.5 cm.

Period 4: Same HV setting with reduced gas flow to save gas.

Period 5: Alternating observations between HRI and PSPC with switching of the PSPC during HRI observations.

Period 6: Only HRI observations. Gas for PSPC nearly exhausted.

Period 7: PSPC with a factor 20 reduced gas flow.

REFERENCES


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