Design and In–Orbit–Performance of the Position–Sensitive Proportional Counter on Board the X-Ray Astronomy Satellite ROSAT

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The Position Sensitive Proportional Counter (PSPC) was the prime focal plane instrument on board ROSAT. It was a conventional multiwire counter, operating in an energy range from 0.1 to 2.4 keV. The counter gas was a mixture of Ar/Xe/CH_4 65:20:15 at a pressure of about 1.5 bar, replenished at a flow rate of 2.5 $stcm^3min^{-1}$. At 1 keV the detector had an energy resolution of δE/E = 0.41 FWHM, a position resolution of 230 μm FWHM and a quantum efficiency of 50%. The background rejection capability of the detector in a space environment was 99.85%. 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 a final observation with the PSPC has been carried out with an extremely reduced gas flow and at the border of the radiation belts with a very high particle background. During this observation the detector probably suffered a discharge and within several days an increasing area with 50% gain loss developed. We will report on the detector design, the in–orbit–performance of the PSPC and some results of the ROSAT mission.

Summary of Poster: ROSAT is a German X-ray satellite with major contributions from the UK (UV-telescope) and the USA (HRI-detector and satellite launch). The satellite was launched in 1990 and operated for more than eight years in orbit. The main scientific objective of the ROSAT mission was to perform the first all–sky–survey in the energy band from 0.1 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 1 mirror system with a maximum aperture of 83 cm and a focal length of 2.4 m. The focal plane instrumentation carried two different types of X-ray image detectors, which complemented one another: two redundant Position Sensitive Proportional Counters (PSPC) with a sensitive area of 8 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. The PSPC includes two multiwire proportional counters. The upper one, below the entrance window and a drift region of 8 mm, is the position and energy sensing X-ray detector. The lower one is an anti-coincidence counter, to distinguish between X-ray events and background events. We used 10 μm tungsten wires for the anode grids with a wire spacing of 1.5 mm for the X-ray detector and 2 mm for the anti-coincidence counter. For the cathode grids 50 μm Pt–Ir wires had been used with a wire spacing of 0.5 mm. The two cathode grids of the X-ray detector are electrically subdivided in strips of 3.5 mm width for the position readout of the x-ray events by the center–of–gravity method. The grids were manufactured on a winding machine and glued on glascermic frames. Due to a very precise spacing of the wires ($\pm 2\mu m$) and the grid gaps ($\pm 5\mu m$), we obtained a very homogeneous gas gain over the sensitive area (variation 3%). All grids of the flight units were checked for wire spacing and wire tension. The resonance frequencies of the wires had to be above 400 Hz to survive the rocket launch. The PSPC is operated with a gas mixture of Ar/Xe/CH_4 65:20:15 at a pressure of 1466 mbar at 22^{o}C. The detector window is a 1 μm thick polypropylene foil coated with carbon and Lexan. The foil is supported by wire grids and aluminum struts. The differential diffusion and the leakage of the window foil as well as the cleaning of the detector gas from crack products of the quench gas required a gas flow system. The detector gas was density controlled with a selectable flow rate between 2 to 5 $stcm^3min^{-1}$. A filter wheel in front of the detector window included a vacuum door with three calibration sources for ground checkout and in orbit calibration. Several watch dog functions were implemented in the on-board software of the experiment computers to ensure the nominal function of the PSPC: Limit checks of housekeeping values like gas pressure, high voltage and count rates were carried out continuously and in case of an overshoot the detector was switched off. The ROSAT orbit (circular, 580 km, inclination 58 deg) touches at its northern and the southern part the inner radiation belt and crosses the South Atlantic Anomaly, regions with extremely high particle fluxes. Within these parts of the orbit the detector was switched off. During the mission we found two degradation features. We had a gas gain loss of about 3% $year^{-1}$. In addition, we found a slight increase of background in the energy channels below 180 eV. These low energy events were after-pulses of high energy events with a time delay of about 1 ms. At the end of the mission, with nearly no gas flow, high particle rates, and watch dogs switched off the detector had a corona discharge. After that, an area increasing from 1 mm^2 to several

cm^2 developed with a factor of two lower gas gain. The ROSAT mission increased the number of known celestial X-ray sources from several 10^3 to 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-color X-ray images of all types of objects like the near moon, comets, normal stars, neutron stars, binary systems, supernova remnants, galaxies, clusters of galaxies and the most distant quasars could be measured with high contrast.