Chapter 4

PCA Instrument Description

The PCA and EDS should be considered as a single experiment by proposers but since they are built by different institutions their technical descriptions are presented here in separate chapters. The interface between the two subsystems is also covered within this chapter. It is important to note that NO event selection occurs within the PCA electronics. Every detected event is passed to the EDS where a vast range of options exist for event rejection, selection and processing. The EDS also provides the μs time stamp for every photon detected by the PCA.

The PCA is co-aligned with the High Energy X-ray Timing Experiment (HEXTE) on XTE and both experiments have the same field of view. Together the two experiments provide simultaneous spectroscopic coverage from 2 - 200 keV with an overlap from about 20 keV to 60 keV.

4.1 General Principles

The PCA experiment on XTE consists of 5 identical sealed and collimated (1^0 FWHM), xenon/methane multi-anode proportional counters sensitive to x-rays in the energy range 2 - 60 keV. The total effective area at the peak of the efficiency curve is approximately 7,000 cm^2. The data system can tag the relative time of arrival of each event with an accuracy of 1 μs. The overall absolute time accuracy is maintained by the spacecraft to better than 1 ms. Following the design principles of the HEAO-1 A2 HED detectors, the PCA adopts the interleaved anode connection scheme with an active propane anti-coincidence layer in the front and an anti-coincidence xenon/methane layer on the three other sides of the detector. The interleaved anode connection scheme and the anti-coincidence layers allows rejection of background events caused by charged particles with high efficiency which significantly reduces the residual background event rate at lower energies.

In general terms the EDS provides many commandable observing modes for the proposer to select from whereas the PCA provides almost none (only the HRM level). The PCA commandable parameters will normally be entirely under the control of the PCA PI team who will maintain the detectors in the optimum state for all observers. A good understanding of the design and operation of the PCA experiment is essential when selecting appropriate EDS modes for any particular observation and these combined characteristics are covered in the feasibility chapter.

4.2 The PCU Detectors

Since the 5 Proportional Counter Units (PCU's) are essentially identical and operate independently much of this chapter will refer to only a single detector module. Each PCU has an effective area of approximately 1,400 cm^2 and its internal construction and general design are based very closely on the HEAO-1 A2 detectors. In the following numerical values should be taken as approximate.

4.2.1 Physical Description

Figure 4.1 shows a cross section view of a single PCU and the following describes the components from the top down, adhering to the non-metric engineering terminology of 0.001 in = 1 mil = 25.4 microns.

- Each PCU is covered by a thermal shield consisting of aluminized 1/3 mil Kapton. The thermal shield is part of the passive thermal design of the PCA and each detector is thermally connected to the XTE spacecraft. The thermal shield will not be illuminated by direct sunlight except for observations which are < 45 degrees away from the sun. (The baffles which accomplish this are part of the spacecraft.)
- Each PCU contains 5 collimator modules. Each module is formed from 3 mil beryllium-copper sheets which are tin-coated, stamped into half-hexagonal form, stacked, and then heated which causes the tin coating to solder the sheets together. Each module is a cube about 8 inches on a side and each hexagonal cell is about 1/8 inch across the flats. The bottom surface is polished and coated with a small amount of uralane to protect the mylar window. Each of the 5 modules also has a 1 square cm mirror bonded to the front surface. These were used to align the modules within their surrounding frame before they were fixed in position with epoxy.
- Immediately behind the collimator is a 20 mil beryllium-copper shoe which duplicates the footprint of the first interior grid. A one mil mylar window with 700 angstroms of sputter-deposited aluminum on each side is held in place between the shoe and the first grid. A second window is held between the first and second grids. The two windows and the first grid form the boundaries of a 1.3 cm deep volume which is filled with propane.

- The propane volume serves primarily as an electron veto region and front charged particle anti-coincidence shield. The propane detector has twenty anodes across its width on 1.3 cm centers, each being separated by thin solid aluminum walls that support the second window. The propane nominal pressure is 1.05 atmospheres. The double gas volume design requires that this pressure be less than or equal to the pressure behind the second window at all times during the filling and operation of the detector.
- Below the second window is the xenon volume. This consists of four more wire grids, each with twenty anodes at approximately the same spacing as for the propane volume. These anodes are separated by wire wall cathodes (5 across a cell side) and this volume is normally filled with xenon plus 10% methane mixture at a total pressure of 1.10 atmospheres. All anode and cathode wires are made from gold coated, 2 mil diameter, stainless steel wire. The wires are installed under tension (~110 gram) sufficient to stay taut at the lower survival temperature of -25^{0}C but low enough not to yield at the highest temperatures considered for baking out the detectors (60^{0}C). Wire tension is checked after installation by measuring the fundamental acoustic frequency of each wire. The upper 3 of the 4 xenon grid layers are used for x-ray detection.
- The bottom of the 4 xenon anode layers plus the xenon layer anodes nearest the sides form a veto detector for charged particles. The lower surface ground plane of the bottom layer is defined by a beryllium-copper back plate. This also provides some shielding from events which are created in the dead (i.e. non-instrumented) xenon volume at the rear of the counter. Mounted on this plate is an Americium-241 source which provides a continuous, low-level energy calibration signal of tagged events.
- A detector housing (the outer box) and a rear cover complete the detector structure. Mounted on the rear cover is a pressure transducer (for the xenon volume) and a getter pump which is filled with a zirconium/vanadium/iron alloy that is activated by external heating just before the detector is filled. There is also a second pressure transducer for the propane volume mounted on the side of the detector.
- Each PCU is covered by a graded shield of tantalum (60 mil) over tin (20 mil) to reduce the cosmic X-ray background flux and absorb the hard X-ray and gamma ray events generated in the spacecraft by cosmic ray impacts. The tin thickness is chosen to absorb escape photons generated from interactions in the outer tantalum layer.

4.2.2 PCU Anode Signals

Each PCU contains a stack of electronics boxes that ultimately produce signals from 9 independent anode chains. The internal anode connections that produce these 9 signals are shown in Figure 4.2.