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A.B. GILES, K. JAHODA, J.H. SWANK and W. ZHANG

LABORATORY FOR HIGH ENERGY ASTROPHYSICS

National Aeronautics And Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

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A.B. GILES[1], K. JAHODA, J.H. SWANK, AND W. ZHANG[1]

Code 666
X-ray Astrophysics Branch
Laboratory for High Energy Astrophysics
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771

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[1]Also Universities Space Research Association

ABSTRACT

The X-ray Timing Explorer (XTE) is a NASA satellite designed to perform high time resolution studies of known X-ray sources. The two main experiments are a large area Proportional Counter Array (PCA) from the Goddard Space Flight Center (GSFC) and a High Energy X-ray Timing Experiment (HEXTE) from the University of California at San Diego (UCSD). The PCA data is processed by an Electronic Data System (EDS) built by the Massachusetts Institute of Technology (MIT) that performs many parallel processing analysis functions for on-board evaluation and data compression. MIT also provide an All Sky Monitor (ASM) experiment so that XTE can be slewed rapidly to new transient sources. The spacecraft provides a mean science telemetry rate for the PCA of ~20 thousand bits per second (kbps) with bursts to 256 kbps for durations of 30 minutes. Photons are tagged to 1 microsecond and absolute timing should be better than 100 microseconds.

XTE is due for launch in late August 1995 and the first NASA Research Announcement (NRA) is due out in January 1995. This paper summarises the XTE performance and then discusses the interactive and flexible operations of the satellite and some of the science it can do. These features should make XTE a productive spacecraft for coordinated observation programs.

Subject headings: X-Rays:General Instrumentation:Detectors(XTE)

1. The XTE Mission

Early concepts for an XTE type spacecraft date back to the late seventies when follow on missions to HEAO 1 were being considered. By 1988 designs from the early eighties had been scaled back in sensitive area to reduce cost and weight but the experiments were much the same as those now being integrated with the spacecraft at GSFC. At that stage however XTE was envisaged as having a shuttle launch for a fixed period in orbit on a multi-mission reusable platform. Such schemes were dropped due to the general complications of shuttle involvement and XTE is now a free flyer to be launched on an expendable Delta II from the Kennedy Space Center. The planned orbit height is 600 Km with an inclination of 23 degrees. The fixed price nature of the mission includes contingency funds that define a launch window running from August 31st 1995 to April 30th 1996.

XTE will be the second and last in the present full size NASA Explorer series. It follows the EUVE mission and precedes FUSE which is now substantially downsizing to fit within the new Mid Explorer (MIDEX) program. It is being developed for a fixed budget of US$230M excluding the Mission Operations & Data Analysis (MODA) costs. XTE is a trail blazer for NASA management in a number of ways and principal among these is the fact that this budget limit is treated as a "real one". XTE is also somewhat unusual in the modern era in that it has no overseas involvement being an entirely US affair with the three experiments being provided by GSFC, UCSD and MIT. These groups are referred to as the Instrument Teams.

XTE will not perform survey type work but is intended to point at the known brighter sources giving a potential target list of perhaps 1000 sources. There is guaranteed operation funding for a two year mission though the actual level of this funding commitment has been steadily falling over the last few years and is now impacting on the operational flexibility that will be supported. An extension of the mission up to the expected 5 year orbit lifetime has recently been approved but there is still considerable uncertainty about future NASA funding in general.

The entire Explorer program is managed at Goddard where XTE has been designed, built, integrated and will be operated from. Goddard will be home to the Mission Operation Center (MOC), the Science Operation Facility (SOF), the Guest Observer facility (GOF) and various other NASA spacecraft support services. Eventually the complete flight data will also reside at Goddard as part of the High Energy Astrophysics Science Archive Research Center (HEASARC).

2. The XTE Spacecraft

The XTE spacecraft is shown in schematic form in Figure 1. It is basically a rectangular box of size 3.6(L) x 1.8(W) x 1.8(H) in meters and has a total weight of $\sim$3250 Kg. The PCA and HEXTE experiments and the two star trackers are on the upper half of the box and all the spacecraft systems below. The 3 ASM units are on a special bracket at the PCA end of the spacecraft. Also visible in Figure 1 are the solar panels and the two high gain antennae for telemetry via NASA's Tracking Data Relay Satellite System (TDRSS). Having two antennae simplifies the TDRSS scheduling. The TDRSS system allows very high data rates to be returned from XTE mostly in real time or near real time but involves considerable sophistication in the antenna mounts. These multiple jointed arms are controlled at all times so that the flat panels track a visible TDRSS in Geostationary Orbit (GEO) while XTE "scoots round" in a Low Earth Orbit (LEO). It is hoped that these complicated mechanical systems do not become an "Achilles Heel" for XTE due to reliability problems or to possible TDRSS operational or funding problems in the latter part of the 1990's.

The spacecraft can slew at the very high rate of 12 degrees per minute with no use of consumables since it has a full 3 axis momentum wheel system. This will allow short duration pointings without greatly reducing observing efficiency. However, it is not intended to "ping-pong" between target sources during Earth occultation periods. The pointing direction will be known to ~2 arc minutes and total jitter should be <30 arc seconds.

XTE has a large 920 Mbit solid state memory which is sized to store 4 orbits of data at the mean total spacecraft rate of ~40 kbps should TDRSS contact not be possible for any reason. This memory can however be filled rapidly, at up to 512 kbps, for a short period and then dumped through TDRSS. In this way a 256 kbps data rate (essentially all from the PCA) can be acquired for about 30 minutes. A modest share of the data management system is reserved for spacecraft systems telemetry and some fixed rate experiment components such as housekeeping data that are always present.

Since XTE is primarily concerned with accurate timing studies the accuracy and stability of the on-board spacecraft clock is vital as the individual experiments rely on this for timing. The stability will be 10^{-9} per day and the cross calibration to UTC will be achieved to better then 1 millisecond with a target of 100 microseconds. More details on the XTE spacecraft and its experiments can be found in Bradt et al. 1990, Bradt et al. 1993 and Swank et al. 1994.

3. The XTE Experiments

The XTE spacecraft contains three experiments. Two of these, the PCA and HEXTE are co-aligned and have the same field of view of 1 degree FWHM. The 5 PCA detectors are rigidly bolted to the spacecraft structure but the 8 HEXTE detectors are mounted in two clusters of 4 units with each cluster being able to rock backwards and forwards in orthogonal axes. These rocking motions are a typical method of doing source-background measurements in high energy X-ray astronomy. The 3 ASM units are mounted on the end of the spacecraft to give them a relatively unobstructed view of the sky.

3.1. The PCA Experiment

The 5 PCA detectors are based on the design of the HED detectors on the earlier HEAO 1 A2 experiment (Rothschild et al. 1979). The XTE units are however much larger being 1.2 m long and having a weight of about 110 Kg. The PCA detectors do not image the sky but rely on the mechanical collimation provided by many hexagonal parallel metal tubes. The PCA experiment itself contains very few commandable parameters for Guest Observer (GO) selection as all calibration adjustments will be performed by the PCA Instrument Team. In contrast the data processing side of the PCA, the EDS, contains many GO selectable options.

The PCA detectors are fairly conventional proportional counters filled to about 1 atmosphere with a gas mixture of 90% Xenon and 10% Methane. A front Propane layer extends the response to lower energies but is intended principally as a part of the background veto system. An unusual feature of the individual PCA electronics is that no events are rejected within the actual PCA units themselves. Instead a "serial package" of data bits is transferred to the EDS for all types of events detected within each PCA:

- X-ray source photons
- Internal calibration source tagged photons
- Background particle events
- Various anode veto signal events

The actual selection and rejection criteria are applied within the EDS. These criteria thus form part of the EDS mode options and are often embedded within them in suitable fixed preselected combinations. In principle however any type of event combination could be selected by devising and testing a new program on the ground and then up-loading it to the EDS.

The PCA will normally have an average of 20 kbps of telemetry capacity available though after allowing for South Atlantic Anomaly (SAA) passages and Earth Occultations the effective rate while on source can approach twice this figure. As has already been mentioned short periods at much higher telemetry rates are possible. Further details on the PCA experiment can be found in Zhang et al. 1993. Table 1 provides the key parameters of the PCA experiment alongside those of the HEXTE so that their complementary nature is more clear.

3.2. The EDS System

The Electronic Data System built at MIT is a compact and extremely powerful data processing device that performs multiple analysis options and also provides data compression facilities. It consists of A and B side system manager boards for redundancy each with 4 Event Analysers (EA's). One EA on each side is dedicated to supporting the ASM experiment but the others, a total of 6, are available for use with the PCA experiment. Each of these EA's can run many hundreds of stored analysis programs and many more could be sent up from the ground at a later date if new modes seem appropriate due to unexpected scientific discoveries and insights. Each EA contains a Digital Signal Processor (DSP) chip and a 286 equivalent control processor.

The many operating modes are too extensive to fully describe here but they do fall into a number of simple families.

- Two standard modes which are always presen
- Various types of data on "raw" individual photon events

- A wide selection of various combinations of different spectral and temporal resolution
- Various types of processed EDS data such as FFT's and pulse period folded data

Note that 2 of the 6 PCA EA's are reserved for Standard Modes 1 & 2. The purpose of these modes is twofold. Firstly, they provide a common data sampling in terms of energy and temporal resolution for all sources observed during the entire mission. This is expected to be particularly significant for later comparative studies using the archive data base. Secondly, the standard modes provide some calibration information so that this is always available to monitor and optimise the performance of the PCA detectors.

Another significant feature of the PCA/EDS combined system is that all events from all detectors are seen by all of the 6 EA's. This means that in principle all 5 PCU's can detect photons at the same instant and all can be logged in the EA's with the same time stamp to 1 microsecond accuracy. This ability to see coincident event bursts has not been possible before. Recent work by Orlandini and Boldt (1993) has suggested that such bursts may be detectable from infalling blob impacts on the surface of neutron stars. Further details of the EDS can be found in Bradt et al. 1991 & 1993.

3.3. The HEXTE Experiment

The HEXTE is also derived from the earlier A4 experiment on HEAO 1 (Matteson 1978). The eight HEXTE detectors are mounted in two clusters of four units with each cluster being able to rock backwards and forwards in orthogonal directions through angles of 1.5 or 3 degrees. The rock dwell periods are specified in multiples of a base period of 16 seconds. The two HEXTE clusters are shown in Figure 1 and the main detector parameters are also summarised in Table 1. The NaI/CsI phoswich scintillators extend the energy sensitivity of XTE all the way to ~250 keV but there is a region of overlap with the PCA at the lower end from 20 to 60 keV. This common energy range should allow adequate cross calibration between the two experiments.

The HEXTE experiment contains its own data processing system and does not share any part of the EDS. HEXTE also has a variety of operating modes though these are far fewer in number and more limited than those provided by the EDS. In general X-ray sources provide far fewer high energy photons than at the lower energies covered by the PCA so the telemetry requirements of HEXTE are quite modest by comparison. The maximum HEXTE telemetry rate is ~7 kbps. The various data modes and some telemetry options are selectable by the proposing GO. Further details on HEXTE can be found in Pelling et al. 1991.

3.4. The ASM Experiment

The All Sky Monitor experiment consists of 3 separate coded mask imaging detectors offset from each other so as to span a large arc across the sky. These 3 units rotate backwards and forwards about the longitudinal axis of the spacecraft driven by a stepper motor which can turn through a total angle of ~500 degrees. Motion range and scan speed are continually optimised for the ASM so that time is not wasted scanning across the Earth. The main parameters of the ASM are shown in Table 2.

All the data from the ASM will be in the public domain once it is processed by the self contained software system supplied with their experiment by MIT. Any external user will be able to examine the ASM data base to construct light curves for any known source or general sky position. The MIT software also runs in the SOF and compares the incoming scans with a catalogue of known source positions and expected intensities so that new transients can be flagged and become Targets Of Opportunity (TOO's) for the two main experiments. XTE can slew to the derived position quite rapidly but if this is not known accurately enough the ASM can be commanded to scan only a small region of sky surrounding the new position in order to get a much more accurate fix. There are no GO commandable features in the ASM experiment. Further details on the ASM can be found in Bradt et al. 1990 & 1993.

4. NASA Research Announcement (NRA) Plans

XTE has just undergone a Launch - 1 year review and is now committed to a launch in the 80 days following the opening of its launch window on 31st August 1995. This now dictates the following time scale for the 1st and 2nd NRA releases.

NRA1 Release	January 1995
Deadline	April 1995
Selection	July 1995
NRA2 Release	~ October 1995

The period covered by NRA1 will be 9 months and for NRA2 it will be 12 months. On XTE GO's will propose for both observing time and telemetry capacity. Since telemetry is a valuable resource observers will be encouraged to exercise some altruism in terms of not taking their maximum entitlement unless they really demonstrate a need for it in their observing proposals. In the worst case everyone awarded time might have chosen "wasteful" modes to top up to the mean rate thus potentially depriving those who genuinely need more capacity, for observations of bright sources, from having extra available.

Guest Observers will have 12 months proprietary rights on the data following their receipt of it from the GOF. The elapsed time from observation to data delivery of the final products to the GO should be less than 14 days. Some standard products will be available as well as the basic FITS observation files and associated calibration materials.

GO's will be able to work on their data at Goddard, by prior arrangement, as guests of the GOF and "hand holding" assistance will be available. Most GO's will prefer to export and install a copy of the GOF analysis system of FITS files, FTOOLS, XSPEC & XRONOS etc. at their home institution. The GOF system should be able to run under UNIX, ULTRIX, ALPHA or VMS but serious users will require quite a powerful workstation with large disc capacity.

5. Other Access Information

A review committee will select GO proposals to be observed within each NRA period purely on scientific merit. There are no restrictions on the nationality of proposers and no quota systems. In addition to this, and somewhat unusually, there is no guaranteed time for the experiment groups who have provided the equipment. Once a pool of successful proposals is created it will be passed to a scheduling program called SPIKE which has been provided by MIT. This is a derivative of the program used for the scheduling performed for the Hubble Space Telescope and for the Japanese satellite ASCA.

To produce the Long Term Schedule for the whole of an NRA period it is necessary to have an oversupply of approved proposals so that some optimisation can occur. The standard NRA proposal form that will be used by the GO's provides a wide variety of source constraint conditions and requirements which can all be used by SPIKE. In addition, a Short Term Plan (1-2 weeks) will be produced at intervals to take into account any change in circumstances that needs to be propagated into the future. Finally, a Daily Activity Plan (DAP) is constructed in advance for each day's activities on the spacecraft. It is envisaged that the above three plans will always be available to anyone via anonymous FTP (heasarc.gsfc.nasa.gov) or on the World Wide Web (home page http://heasarc.gsfc.nasa.gov). This will allow any interested person to find out the upcoming target sequence and also to know where the experiments are looking at any particular moment.

Although many official ground based consortia will exist in connection with successful X-ray proposals there is always the chance of bad weather or poor global phase coverage of any particular planned source. It is therefore assumed and encouraged that any scientist with access to suitable equipment will attempt to make complementary simultaneous or near simultaneous observations. Any such efforts that produce quality data will provide an opportunity for collaboration with any official activity that occurs during the same period.

XTE is in a low Earth orbit so unlike EXOSAT it will suffer from SAA passages and Earth occultation gaps in data observations. Beyond these limitations the XTE experiments are extremely powerful so any type of high speed photometry or spectroscopy in the IR or optical should be worthwhile particularly on Galactic sources.

XTE will return $\sim$0.3 Gbyte of data each day which when converted to the standard FITS files will represent about 1 Tbyte a year. Some 1 Tbyte of this will be on line in the GOF on large optical Jukeboxes. The remainder will be available from tape after some delay period. At the time of writing it is unclear if the entire mission will eventually be on-line within the HEASARC but it is hoped that this will be the case.

6. Targets Of opportunity (TOO's)

Targets of opportunity can originate from anywhere. They may be transients seen and located by the ASM or they might be Supernova discovered by ground based observatories. Whatever their origin XTE will be able to observe any TOO within a worst case delay of

7 hours. Most of this delay results from a combination of the ASM analysis requirements and from the reprogramming of the high gain TDRSS antennae tracking subsystem. It will be the SOF Duty Scientist, with backup from the GOF and the Project Scientist, who will decide whether to drop the observation in progress to go to a TOO. It is expected that initially some 2 a month will be executed but more may be possible later in the mission if these unplanned spacecraft changes take place smoothly. It will also be possible for GO's to propose for general classes of TOO's or even specific TOO's if a known target is expected to flare at some time in the future. If awarded time they will get the data for the next example of the approved type that occurs though there may be some delay while the XTE staff decide exactly what type of TOO category has been observed.

It is important to remember that much of the operational flexibility that XTE ultimately offers is dependant on the level of Mission Operation & Data Analysis (MODA) funds. Although funding for the 2 year mission is "guaranteed", its level is not and various cuts have been made over the last few years. XTE is not a NASA Observatory Class mission and so has always been attempting to operate on a low budget considering the likely number of targeted observations, GO's supported and data volume returned. The recent Senior Review of 12 NASA Astrophysics Missions, including the Hubble Space Telescope, resulted in another small cut for the second year in what is by previous NASA standards already a lean operation. Significantly, however, a 3 year extension was approved at about half the operating costs of the primary 2 years. A 5 year mission now seems assured.

7. Key Calibration Issues

There are three calibration issues on XTE that are central to the mission objective of accurate timing studies. These concern the main clock stability, the Universal Time Correction Factor (UTCF) to absolute time and the detailed characterisation of the dead time of each experiment, particularly the PCA. The first two of these are the responsibility of the spacecraft team.

The main spacecraft clock provides centralised timing pulses to all the experiments which are dependant upon it for their ultimate accuracy and stability. The hardware clock has dual enclosure oven regulation and small trims can be made to the crystal rate to "track" the desired frequency. There is also a second completely separate hardware clock to provide a backup redundant system. The hardware clock powers a software clock which is used to time stamp all telemetry packets returned to the ground.

The software clock starts from a defined but somewhat arbitrary zero epoch over one year before launch so a correction term (UTCF), which is always positive, is required to synchronise the software clock readings with UTC. This large UTCF offset number will be fairly constant but will slowly change as continual comparisons are made between the indicated UTC time and a ground reference master clock. The way in which this process is continuously done is outside the scope of this paper but has been used successfully for several years on the Compton Gamma Ray Observatory mission. The UTCF value also comes down in the telemetry packets in real time and should be good to 1ms or better. After the event statistical studies of the timing should reduce the correction error to 100 microseconds or better in the GOF analysis system.

Attempts to find Quasi Periodic Oscillation (QPO) features in X-ray sources using EXOSAT and GINGA data have shown the vital importance of quantifying the dead time characteristics of a large detector as accurately as possible. A good example of what can be achieved on QPO is the paper on EXOSAT data for Cir X-1 by Tennant (1988). Extensive analytical modelling and analysis of ground test data for the PCA has been carried out to achieve this objective. This is an on-going study and a detailed paper has been submitted for publication (Zhang et al. 1994) on the various interesting insights that have been noted.

It is important to remember that whereas earlier observers only looked for QPO or periodic signals up to ~500 Hz the PCA experiment dead time effects have now been well measured up to 500,000 Hz.

8. How Powerful Is The PCA/EDS System ?

To demonstrate the power of the PCA/EDS system it is instructive to make some comparisons with previous large area experiments and an attempt to do this is shown in Table 3. In compressing this information to a single table it is inevitable that some complexities are glossed over though the table footnotes begin to indicate some of the subtleties hidden behind the figures. To be really effective in high time resolution studies an experiment needs substantial performance simultaneously in the areas of detector area, time resolution and telemetry capacity.

The main things to note in Table 3 are:

a) The first two columns show short duration rocket flights (Rothschild et al. 1977 & Giles 1981) but note that on a second by second basis the PCA will be the first experiment to exceed the performance of the Skylark experiment SL-1306 flown in 1976. This span of almost 20 years is almost certainly due to the fact that the emphasis in the intervening years has been largely on imaging systems

b) HEAO 1 was essentially a survey mission but did make pointed observations (Meekins et al. 1984)

c) EXOSAT turned out to have substantial problems with the characterisation of its dead time and was always greatly telemetry limited. It has however set the standard for timing studies due to its long uninterrupted orbit and its large ME area (Turner et al. 1981)

d) GINGA was never open for proposals to the external community and most of its data was not available for a considerable period of time. It also had severe telemetry constraints and some dead time calibration problems at its fastest sampling rates of 1 ms on bright sources such as Cyg X-1 (Turner et al. 1989)

9. XTE Science Potential

It is not practical to review here all the areas of science that XTE can contribute to. In Figure 2 we show a good summary of the range of phenomena that can be addressed by a large area, accurate timing experiment. Most of these topics will greatly benefit from simultaneous or co-ordinated multi wavelength observations from the ground or from other spacecraft.

XTE explores a new region of parameter space by virtue of combining:

- Large area (7000 cm^2)
- Very high time resolution (1 microsecond)
- High telemetry rate (mean of 32 kbps, peak to 512 kbps)
- Wide energy bandwidth (2-250 keV)
- Rapid pointing response (TOO's)
- Flexible scheduling (up to 15 targets a day)

10. Galactic Science

Some highlights of the galactic science that XTE can do are grouped under the following subject headings:

White Dwarfs

- Magnetic field strengths
- Cyclotron features - harmonics at high energies
- Dwarf novae outbursts
- Accretion processes

Neutron stars

- Mass - Doppler shift of X-ray pulses
- Radii - luminosity, burst temperature and assumed distance
- Period changes - from infalling accretion torques
- Pulse profiles - oscillations, internal structure, core/crust coupling
- QPO phenomena - beat frequency model (5-100 Hz)
- millisecond (ms) QPO - low magnetic field cases
- ms instabilities - gravitational radiation/beaming/scattering/lags
- microsec coincidences - "blob" impact on surface of accretion funnel
- Transients - all above aspects

Black holes

- ms bursts / aperiodic variability - still to be confirmed
- ms phase lags - scattering phenomena
- Diagnostic of innermost regions of accretion disc
- Innermost stable orbit times for 5 solar masses 0.4 - 3 ms

Transients

- High mass - accretion rate strongly correlated with spin rate change and pulse shape changes
- Low mass - limits on masses of neutron stars & black holes

Binaries

- Any of the above possibilities

11. Extra-Galactic Science

Although Active Galactic Nuclei (AGN) do not change, so far as is known, on sub-second time scales a few are known to vary on time scales of minutes. A good estimate of the number of potential targets is given by examining the HEAO A1 survey (Wood et al. 1984). This revealed:

~100 Seyfert Galaxies
34 Quasars
23 BL Lac Objects

The potential of XTE in the AGN field is two fold. Firstly, it provides simultaneous coverage to high X-ray energies and secondly, it will allow frequent repetitive monitoring of a large set of objects to be made. This allows searches for variability on a time scale of days and is easily possible for planned observations, as opposed to TOO's, since XTE can slew efficiently.

The simultaneous PCA & HEXTE data covers the range 2 - 250 keV and will be used to address the following AGN questions:

- The location of the High Energy (>30 keV) cut off
- The total flux distribution of these sources
- The spectral and flux implications for the X-ray background
- The characteristic variability time scales
- The time lags between the hard & soft components

The XTE sensitivity is such that an observation by the PCA for 100 seconds of a 1 mCrab AGN should produce a 19 sigma detection in the 2-10 keV band and a 6.5 sigma detection in the 10-30 keV band. During the same time interval HEXTE should obtain a 1.4 sigma detection above 30 keV.

The XTE project involves many hundreds of workers around the USA with the majority based at GSFC and the PCA team scientists listed above would like to thank all of them for their work to date on XTE. The authors also particularly thank all the other instrument teams for their help and support. The HEXTE team at UCSD is led by Rick Rothschild, the ASM and EDS teams at MIT are led by Hale Bradt and the PCA team at GSFC is led by Jean Swank, who is also the project scientist.

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Figure Captions

Figure 1. The XTE spacecraft showing the principal components.

Figure 2. A "clock face" of the timing and spectral studies possible with the XTE spacecraft.

Table 1: The main parameters of the PCA and HEXTE

Parameter	PCA Experiment	HEXTE Experiment
Detector system	Xe gas proportional counters	NaI / CsI phoswich scintillators
Energy range	2 - 60 keV	15 - 250 keV
Time resolution	1 micro second	10 micro seconds
Total area	7000 cm^2	1600 cm^2
No. of detectors	5 (each 1400 cm^2)	2 clusters of 4 units
Mounting	Fixed	Clusters rock in orthogonal axes up to +-3 degrees
Energy resolution	< 18% at 6 keV	< 16% at 60 keV
Field of view	1 deg. FWHM	1 deg. FWHM
Sensitivity	0.1 mCrab (confusion limited)	1 mCrab (3 sigma in 10^5 sec)

Table 2: The main parameters of the ASM

Parameter	ASM Experiment
Detector system	Multi-wire proportional counters resistive wire & coded masks
Energy range	2 - 10 keV
Scan time	90 min. 70% of sky per orbit
Total area	90 cm^2
No. of detectors	3
Mounting	Rotating back and forth
Position resolution	~ 3' x 15'
Sensitivity	~ 20 mCrab in 1 orbit < 10 mCrab in 1 day

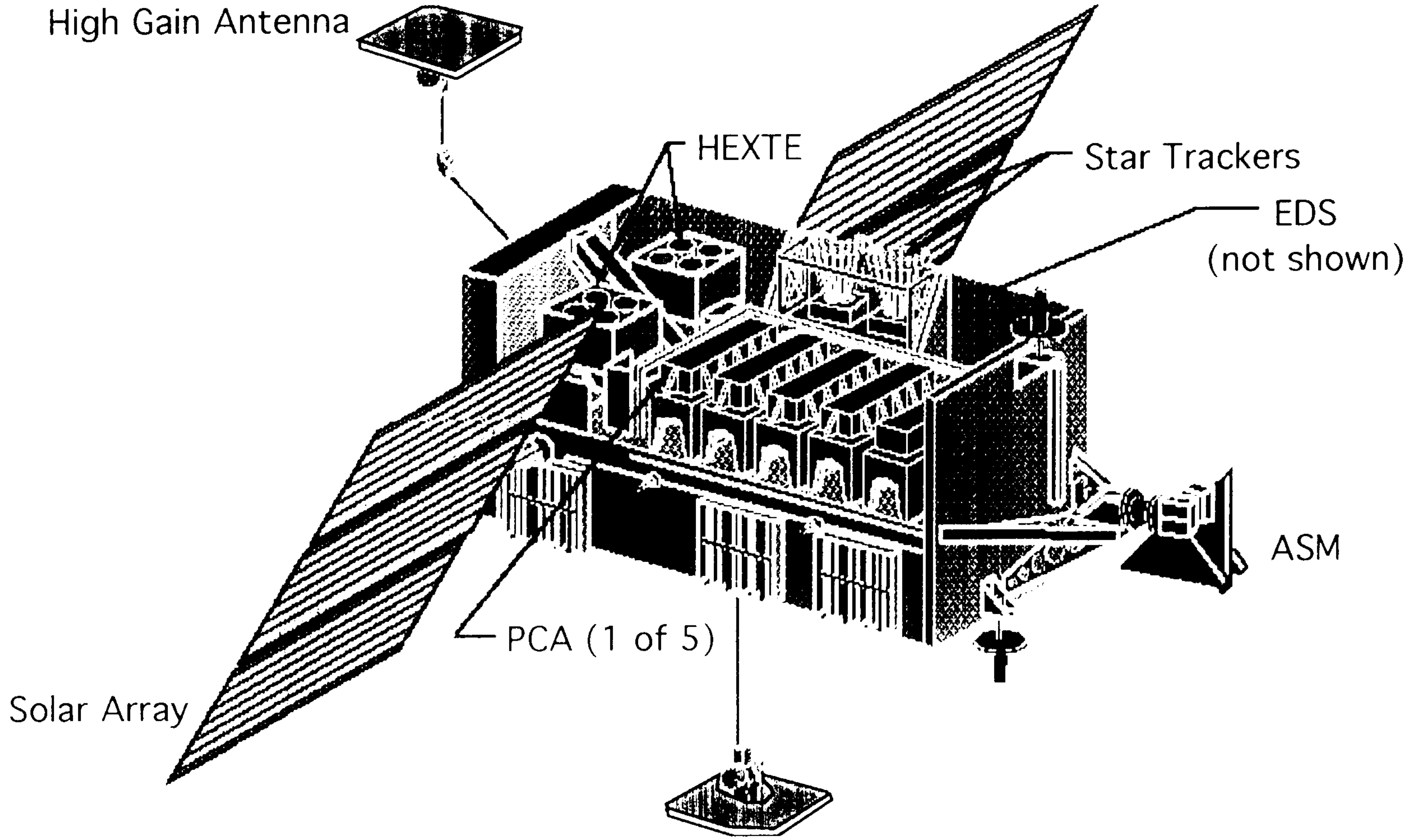
Table 3: Large Detectors - how powerful is the PCA / EDS system ?

	Experiment					
Parameter	GSFC	SL-1306	HEAO 1 NRL	EXOSAT ME	GINGA LAC	XTE PCA
Date	Oct 73 Oct 74	Nov 76	Aug 77 to Jan 79	May 83 to May 86	Feb 87 to Nov 91	Sep 95 to ?
Area cm^2	1360	4000	1650	1800[a]	4500	7000
Energy range keV	1.5 - 35	1.5 - 12	1 - 20	1 - 50	1.5 - 30	2 - 60
No. of E channels	128[b]	8	1 (128)	128	2 (48)	256
Time resolution micro sec	320 / 160	2	10[c]	7.6[d,e]	980	1
Telemetry kbps	50	128	128	< 7.2[f]	16 (2)	32 - 512
"Orbit"	Rocket	Rocket	LEO	97 hr	LEO	LEO
Reference	(1)	(2)	(3)	(4)	(5)	(6)

[a] often only 1/2 on source
[b] first event in 320 mico sec bin in 73 (160 in 74)
[c] single bit mode
[d] virtually never used
[e] major dead time calibration problems
[f] all other experiments off

(1) Rothschild et al 1977
(2) Giles 1981
(3) Meekins et al 1984
(4) Turner et al 1981
(5) Turner et al 1989
(6) Swank et al 1994

XTE Spacecraft



XTE Science Capabilities