

Current status of the X-ray Polarimeter

Rishin P. V., Gopala Krishna M. R., Biswajit Paul, Duraichelvan R., Atequlla C.M., Chandreyee Maitra, Rajagopala G., Nagaraja H.N., Ezhilarasi M.S., Sandhya P., Mamatha T.S.
Raman Research Institute, Bangalore, India

Abstract

We describe the current status of a Thomson X-ray polarimeter developed for a small satellite mission. Currently, a laboratory model has been made and tested successfully and the design and fabrication of an engineering model is in progress. This involves, re-design of the currently developed lab model, taking into consideration the different standards required for space qualification. We describe the design aspects of the detector, front-end electronics and the processing electronics.

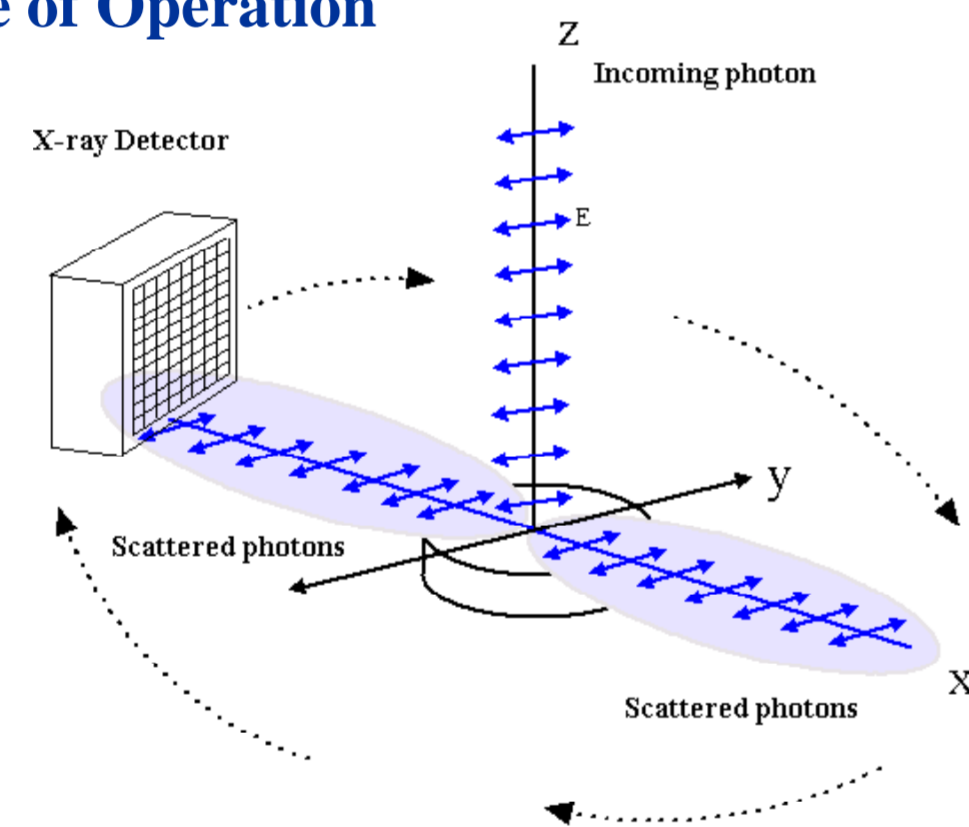
Scientific Objectives

X-ray polarimetry is an unexplored area in high energy astrophysics. In the whole history of X-ray astronomy, there was only one experiment for X-ray polarisation measurement and Crab nebula is the only X-ray source for which a definite polarisation measurement exists. Polarisation measurement gives insight about the strength and the distribution of magnetic field in the source, geometric anisotropies in the source and their alignment with respect to the line of sight, as well as the nature of the accelerator responsible for energizing the electrons taking part in radiation and scattering.

A laboratory model [1,2] and variations [3] have been made and tested successfully and the design and fabrication of an engineering model is in progress. This experiment will be suitable for X-ray polarisation measurement of hard X-ray sources like accretion powered pulsars, black hole binaries in low-hard states, and even for black hole binaries in thermal state [4]. For about 50 brightest X-ray sources, a Minimum Detectable Polarisation (MDP) of 2-3% will be achieved.

Principle of Operation

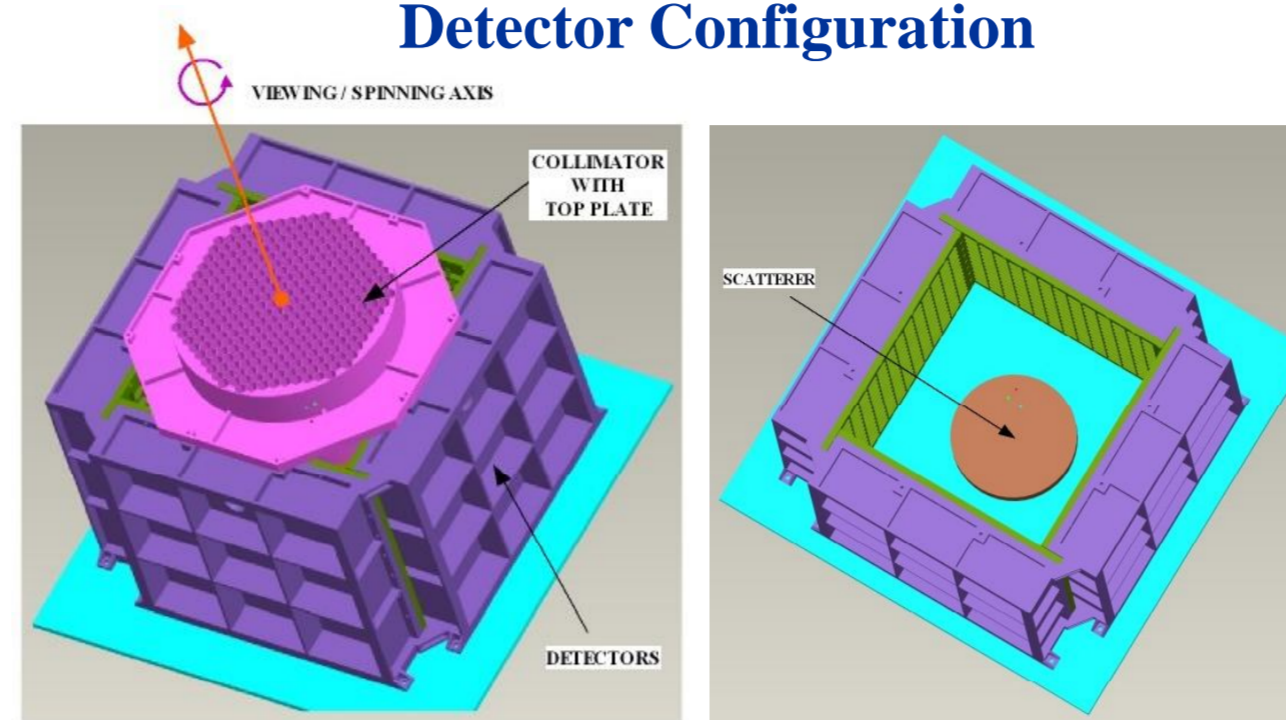
The instrument is based on **anisotropic Thomson scattering** of X-ray photons. X-rays from the source are made to undergo Thomson scattering and the intensity distribution of the scattered photons is measured as a function of azimuthal angle. Polarised X-ray will produce an azimuthal modulation in the count rate. The total configuration will be rotated about the viewing axis.



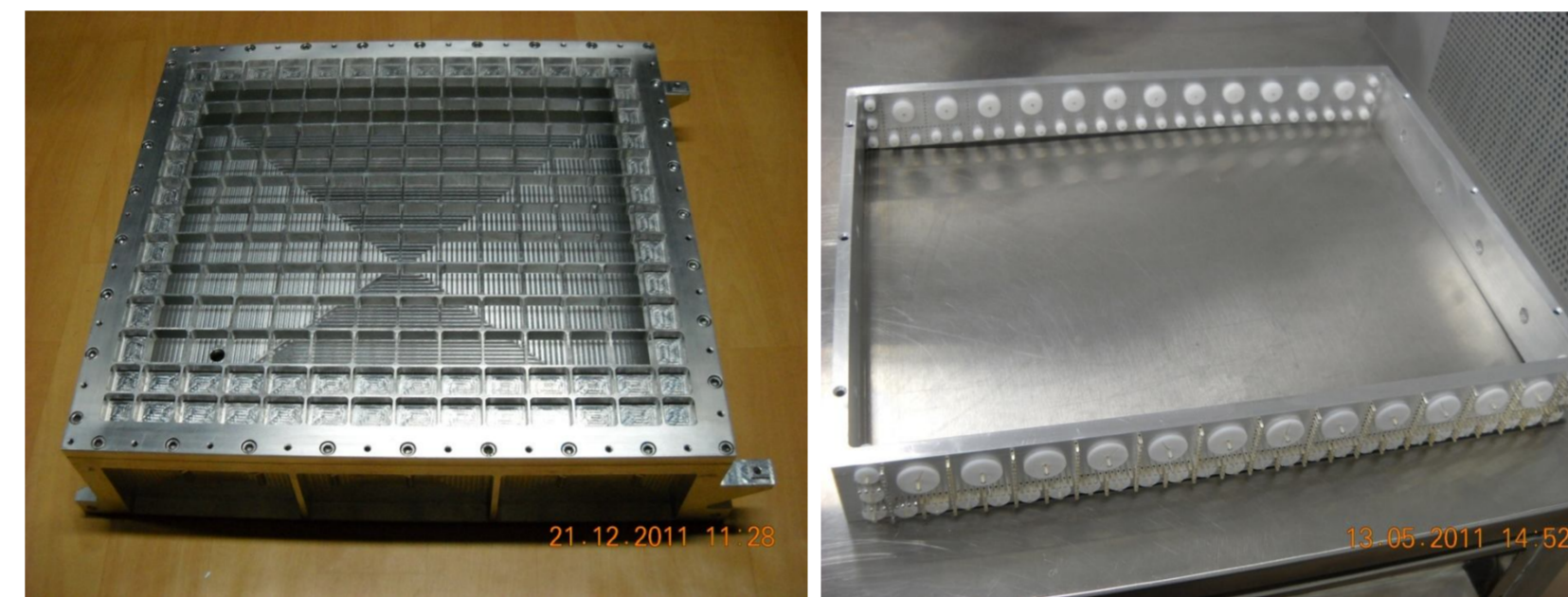
Instrument Specifications

Photon collection area	1018 cm ²
Energy range	5-30 keV
Field of view	3×3 degree with 0.2 degree flat topped response
Detectors	Proportional counters
Total weight	~100 kgs.
Overall dimension	~ 650 x 650 x 550 mm ³
Power	50 Watt
Data generation rate	4.2 Gbits per day
Scattering element	Beryllium/Lithium
Life time	3-5 years
Modulation factor	~40%
Sensitivity	2-3% Minimum Detectable Polarisation (MDP) for 50 mCrab sources with 1 mega sec exposure
Satellite requirements	Equatorial orbit (preferred) of altitude 500-600km, with pointing accuracy of 0.1 deg, and with spin along roll axis of about 0.5 rpm

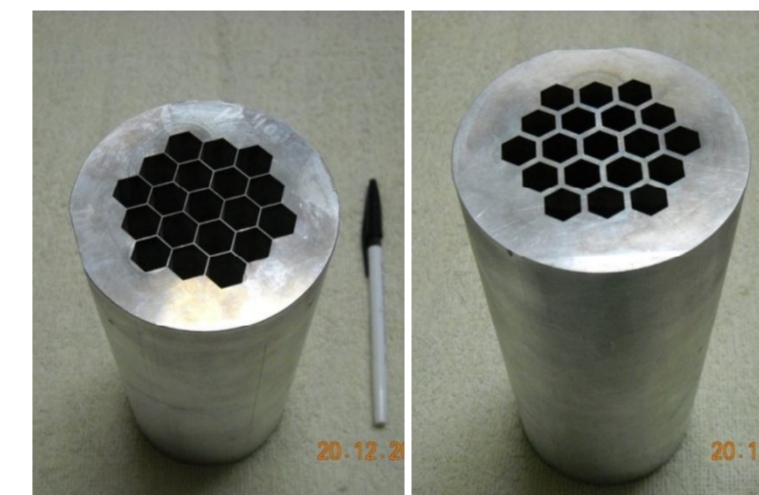
Detector Configuration



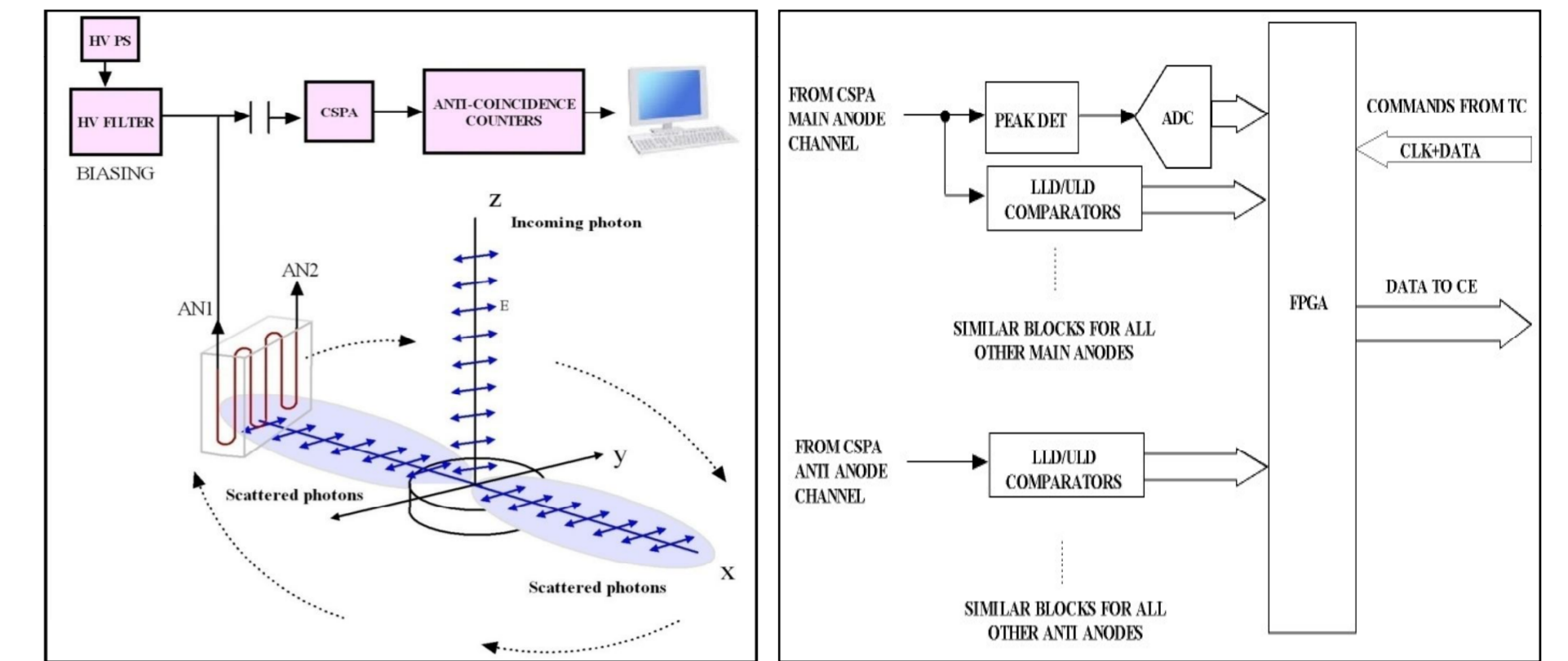
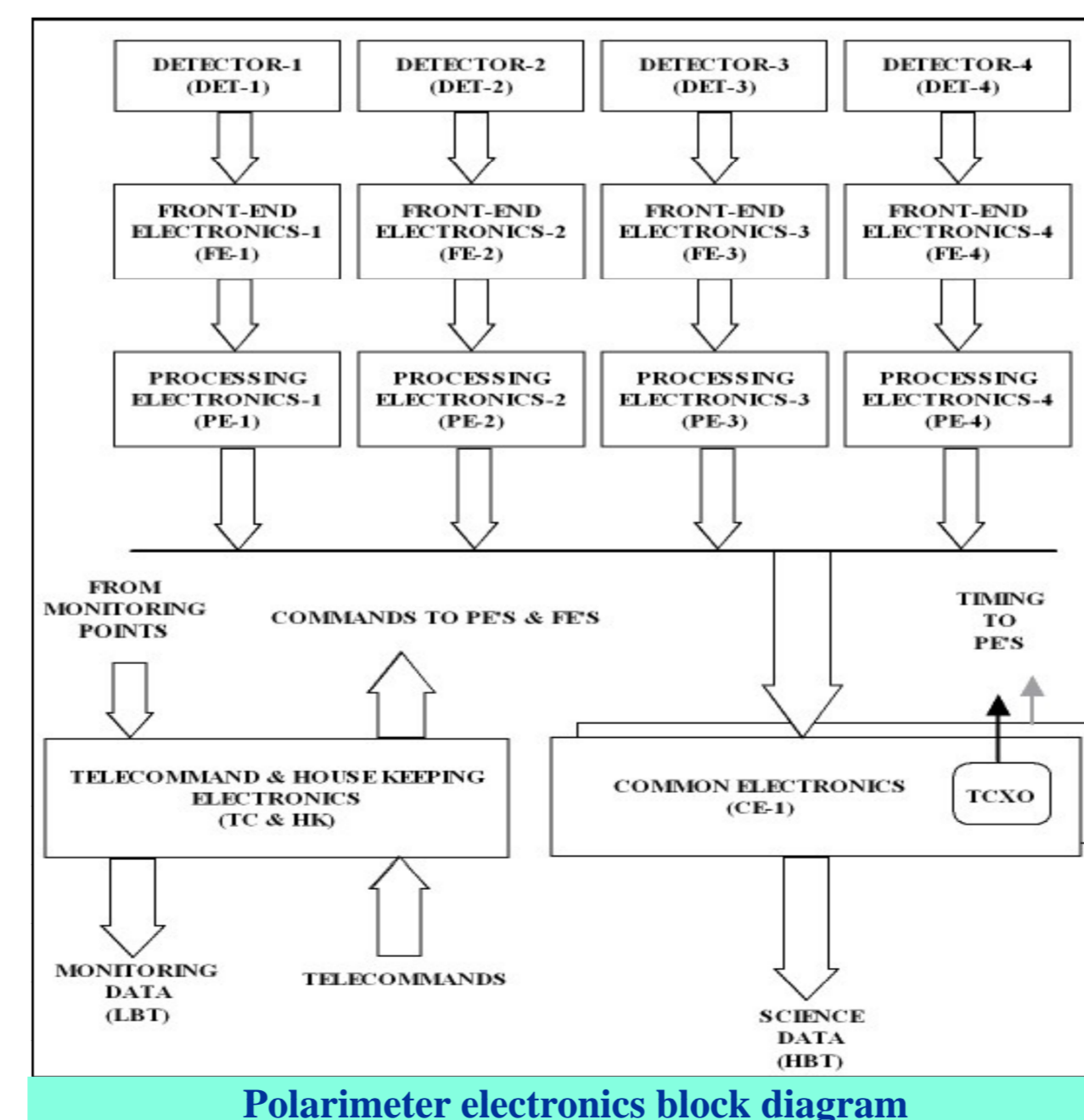
Fabricated Engineering Model Detector



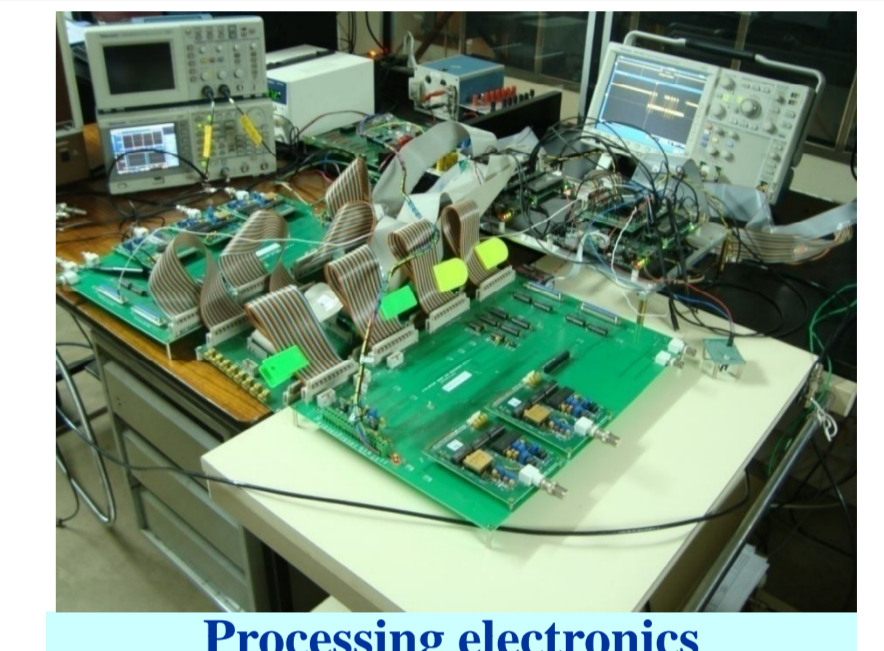
Fabricated Prototype Collimator



Electronics for Engineering Model



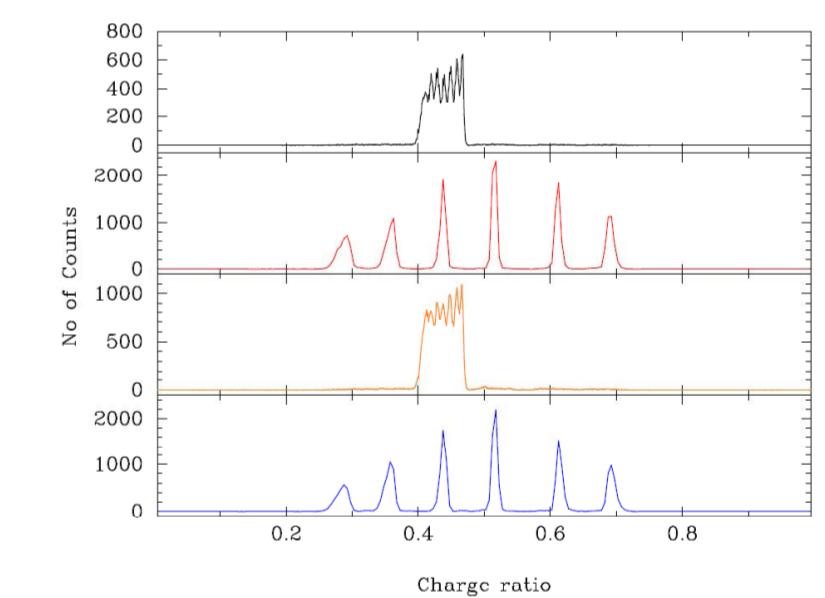
Front-end electronics



Processing electronics

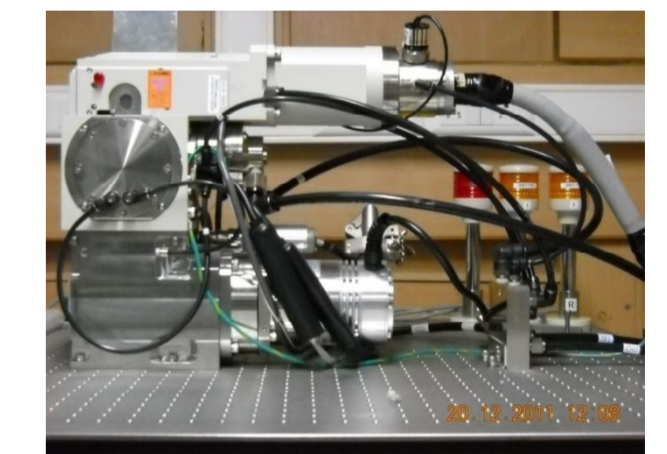
Results

The position sensitivity is achieved by charge division method. The processing electronics logic is implemented in Field Programmable Gate Array (FPGA). The test results obtained with lab unit of the detector and electronics designed for the Engineering model are shown.



Infrastructure Development

For the purpose of test and calibration of the X-ray polarimeter detectors, an 18kW X-ray generator has been procured and the installation is in progress. The installation of the chiller required for the x-ray generator is complete.



References

- [1] Development of a Thomson X-ray Polarimeter, Rishin, P.V. et al. 2009, arXiv:1009.0846v1 [astro-ph.IM]
- [2] Comparative study of different scattering geometries for the proposed Indian X-ray polarisation measurement experiment using Geant4, Vadawale, S.V. et al. 2010, arXiv:1003.0519v1 [astro-ph.IM]
- [3] Hard X-ray polarimeter for small-satellite missions, Cowsik, R. et al. 2009, Proceedings of "The Coming of Age of X-ray Polarimetry", Rome, 2009
- [4] Prospect of polarisation measurements from black hole binaries in their thermal state with a scattering polarimeter, Chandreyee Maitra et al. 2011, arXiv:1103.2639 [astro-ph.HE]

Acknowledgement

We would like to thank Dhiraj Dedhia (TIFR), Parag Shaw (TIFR), for all the timely help and support. Special thanks to the members of RRI Mechanical Engineering Services.

For details contact : rishinp/gkrishna/bpaul/durai@rri.res.in