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Multinode data acquisition and control system for the 4-element TACTIC telescope array.

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Abstract. An interrupt driven multinode data acquisition and control system has been developed for the 4-element gamma-ray telescope array, TACTIC. Computer networking technology and the CAMAC bus have been integrated to develop this icon-based, userfriendly failsafe system. The paper describes the salient features of the system.

Key words: Multinode data acquisition, RTOS, Computer network

1. Introduction

The TACTIC (TeV Atmospheric Cerenkov Telescope with Imaging Camera) gamma-ray telescope is a compact array of 4 atmospheric Cerenkov telescopes recently set up at Mt. Abu, a hill resort in western Rajasthan (24.6° N, 72.7° E, 1300m asl). The 4 telescope elements, each with a $9.5 m^2$ tesselated light collector are positioned at the centroid and the verticies of an equilateral triangle of 20m side. While the central Imaging Element (IE) deploys a 349-pixel camera with a uniform resolution of 0.31° , each of the three Vertex Elements (VE) has a novel 58 -pixel duplex camera at its focal plane. The IE which has been in operation for the last 3 years records the photon distribution details of the proton and photon initiated atmospheric Cerenkov events (ACE), and has successfully detected gamma-ray signals from the Crab Nebula and the BL-Lac object, Mkn-421 (Bhatt et. al 2002).The duplex cameras of the VE which are presently being optimised with respect to their event rates, will record the spectral, polarisation and temporal characteristics of the ACE.

The large number of input data channels coupled with a high anticipated event rate has necessitated the use of multi-node PC network based data acquisition and control system for the TACTIC array. P-II based PCs with Ethernet connectivity have been used as individual nodes of the system. In order to ensure low interrupt latency and to implement concurrent multi-process operation, the Real Time Operating System (RTOS) QNX has been used. The high level of interprocess communication facilities available with this RTOS have been used to advantage in the design of the system.

2. System Description

The data acquisition and control system for the TACTIC array has been designed with a modular structure. As depicted in Fig.1 one network of 4 PCs controls the 349-pixel imaging camera, while another largely similar network controls the 174 pixels distributed over the 3 Vertex Elements. In each of these networks two PCs are coupled to the front-end CAMAC hardware comprising scalers, charge to digital converters and high voltage modules. These two PCs form a network with their designated 'Master node' and the node used for data processing and archiving. Both the networks are in turn connected to the Mailserver of the Observatory to allow for quick world-wide access to pre-processed data on a day to day basis. It is also planned to use this connectivity for the remote control of the telescope array.

The multi-pixel Cerenkov cameras of the 4 telescope elements use fast photomultiplier tubes for detecting the short duration Cerenkov flashes produced by the ACE. The signals picked up by the photomultipliers are brought to the control room using long coaxial cables (55m length for IE and 90m length for VE) of RG58 type. These signals are processed by the NIM and CAMAC based instrumentation for trigger generation and quantification of the event charge content. In order to obtain a stable and low trigger threshold, the individual pixels of the IE are operated at a single channel rate of about 3kHz. The individual pixel rates which can vary substantially as a result of changes in the sky transparency and starfield rotation (Bhatt et. al 2001) are stabilized to the required range by changing their individual gains. After each such gain change which is implemented by varying the High Voltage (HV) applied to the photomultiplier, a relative calibration run of all the pixels is taken by exposing the camera to short duration (20ns) optical flashes from a high intensity blue light emitting diode placed about 1.5m from the imaging camera. Four pixels of the IE located at the periphery of the camera are operated at a fixed HV and are also provided with radioisotope based optical pulsars which continuously emit optical flashes of a fixed mean amplitude at a rate of $\sim$ 20 Hz. This data is used for monitoring the variations in the absolute gain of the various pixels of the camera (Tickoo et. al 2002) during the course of an observation run.

The 3 Vertex Elements are also operated in a low threshold mode with the individual pixel rates around 100kHz. 2-fold triggers generated from each duplex camera are consolidated into a final array trigger by seeking a 3-fold coincidence from the 3 Vertex Elements after the incorporation of appropriate differential delays based on the position and zenith angle of each element. The variable delay is provided by a CAMAC based digital delay generator module.

Both the IE and the VE detect the ACE using the programmable TACTIC trigger generator hardware (Kaul et. al 2001), however the coincidence logic used is different in the two cases. The two systems acquire data on the basis of their individual triggers, however there is also a provision of triggering the VE data acquisition with the IE trigger.

The QNX windows based data acquisition and control software of the telescope array comprises about 6000 lines of C-code distributed over 15 routines and device drivers. 12 concurrent processes running across the network handle the various aspects of the telescope operation. All the executable modules are available on the master nodes of the two networks. The master process START_TACTIC running on the master node spawns the executables on their respective nodes and receives the acquired data from the CAMAC front-ends for display and storage. The HV control node continuosly monitors the shot noise rate of all the pixels of the camera and informs the data acquisition node about the same. Based on this status information the data acquisition node acquires the

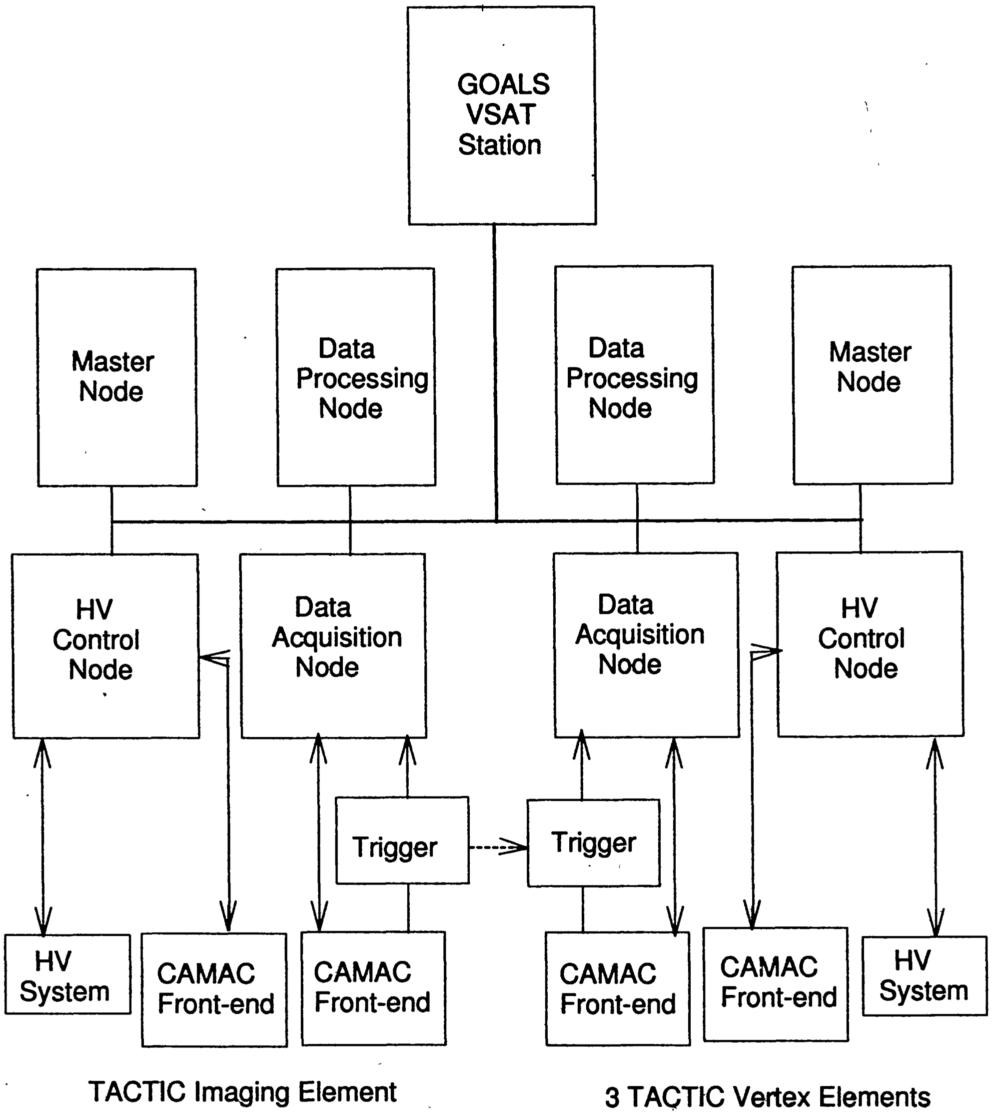

Figure 1. Block diagram of the multinode data acquisition and control syatem of the 4-element TACTIC telescope array.

event data, relative calibration data and the sky noise data, using PC interrupt levels 3 and 4. A separate process continuously acquires the data from the 4 absolute calibration pixels. The software includes Semaphore routines which have been developed to allow the controlled access of various processes to the same hardware during the course of a data acquisition cycle. In order to limit the size of the datafiles to less than 20MB a strategy for storing the data on an hourly basis has been evolved, the software generates a elaborate file system for this purpose.

A comprehensive icon based graphics user interface has also been implemented which prompts the user to follow the required sequence of operations. The system control processes have built in safety mechanisms which ensure fail safe operation of the camera in the event of excessive background light. The software also generates a number of status information files which store details about individual pixels and the overall system configuration used in a particular observation run. This information is useful during data analysis. A posse of test programs for various subsystems of the telescope have also been devised to ensure their optimal operation.

3. System Performance

The data acquisition and control system of the 349- pixel IE has been operating reliably for about 2 years. The Interrupt driven system can acquire data at event rates of upto 200 Hz, however during regular source observation runs data is acquired at an average rate of about 5Hz leading to a total binary data volume of about 20MB/hour. While the data acquisition system of the three Vertex Elements has also been tested extensively at event rates of upto about 200 Hz, regular observation campaigns with the 3 Vertex Elements will commence in the next few months after their duplex cameras have been optimised.

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