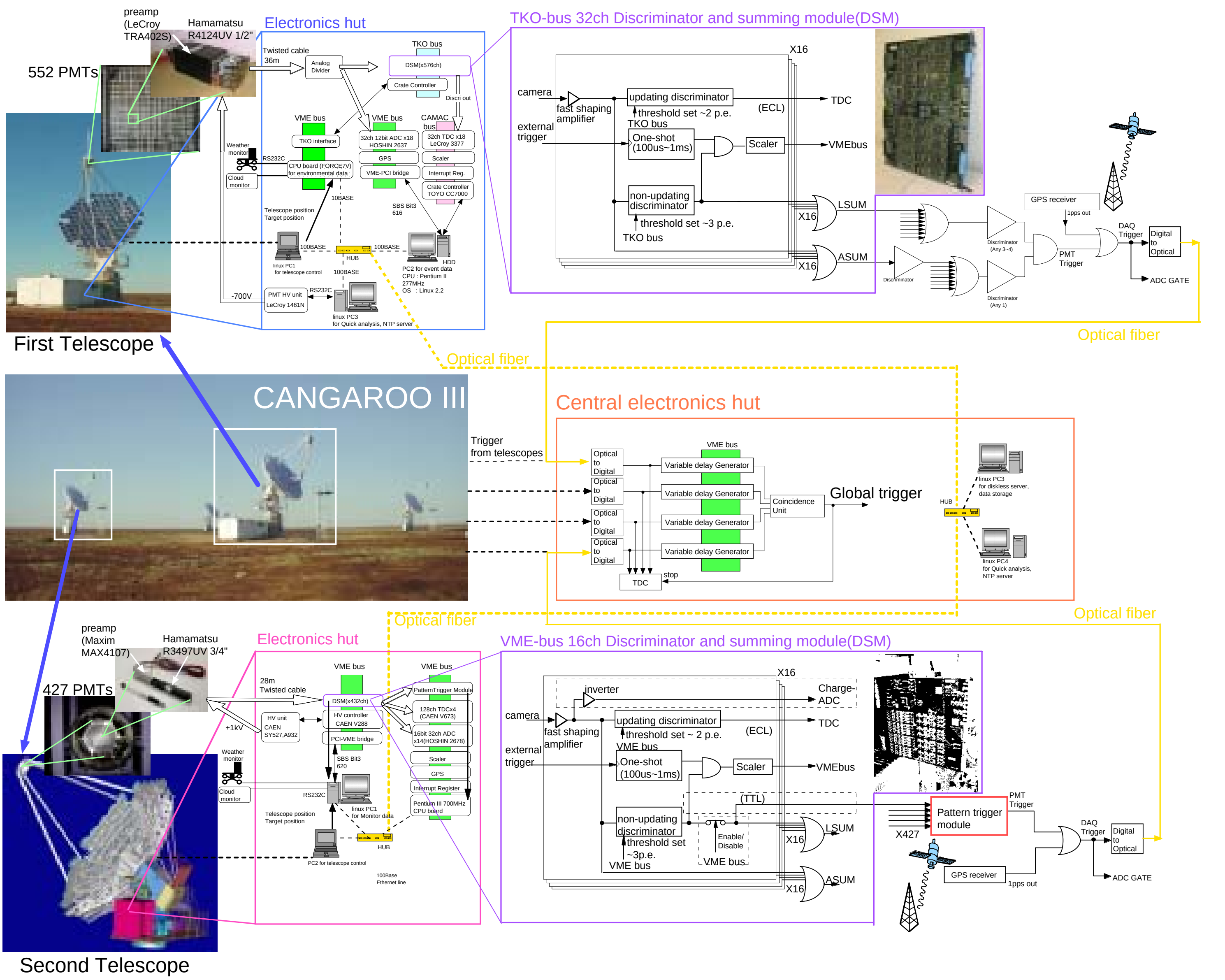
Data Acquisition System of the CANGAROO-III Telescope

H.Kubo[1]*, A.Asahara[1], G.V.Bicknell[2], R.W.Clay[3], P.G.Edwards[4], R.Enomoto[5], S.Gunji[6], S.Hara[7], T.Hara[8], S.Hayashi[9], C.Itoh[10], S.Kabuki[5], F.Kajino[9], H.Katagiri[5], A.Kawachi[5], T.Kifune[11], J.Kushida[7], S.Maeda[9], A.Maeshiro[9], Y.Matsubara[12], Y.Mizumoto[13], M.Mori[5], H.Muraishi[14], Y.Muraki[12], T.Naito[8], T.Nakase[15], K.Nishijima[15], M.Ohishi[5], K.Okumura[5], J.R.Patterson[3], R.J.Protheroe[3], K.Sakurazawa[7], R.Suzuki[5], D.L.Swaby[3], T.Tanimori[1], F.Tokanai[6], K.Tsuchiya[5], H.Tsunoo[5], K.Uruma[15], A.Watanabe[6], S.Yanagita[10], T.Yoshida[10], T.Yoshikoshi[16]

[1]Department of Physics, Faculty of Science, Kyoto University, Sakyo-ku, Kyoto, Kyoto 606-8502, Japan
[2]MSSSO, Australian National University, ACT 2611, Australia
[3]Department of Physics and Math. Physics, University of Adelaide, SA 5005, Australia
[4]Institute of Space and Astronautical Science, Sagamihara, Kanagawa 229-8510, Japan
[5]Institute for Cosmic Ray Research, University of Tokyo, Kashiwa, Chiba 277-8582, Japan
[6]Department of Physics, Yamagata University, Yamagata, Yamagata 990-8560, Japan
[7]Department of Physics, Tokyo Institute of Technology, Meguro-ku, Tokyo 152-8551, Japan
[8]Faculty of Management Information, Yamanashi Gakuin University, Kofu, Yamanashi 400-8575, Japan
[9]Department of Physics, Konan University, Kobe, Hyogo 658-8501, Japan
[10]Faculty of Science, Ibaraki University, Mito, Ibaraki 310-8512, Japan
[11]Faculty of Engineering, Shinshu University, Nagano, Nagano 380-8553, Japan
[12]STE Laboratory, Nagoya University, Nagoya, Aichi 464-8602, Japan
[13]National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588, Japan
[14]Ibaraki Prefectual University of Health Sciences, Ami, Ibaraki 300-0394, Japan
[15]Department of Physics, Tokai University, Hiratsuka, Kanagawa 259-1292, Japan
[16]Department of Physics, Osaka-city University, Osaka, Osaka 558-8585, Japan
*email:kubo@cr.scphys.kyoto-u.ac.jp

abstract

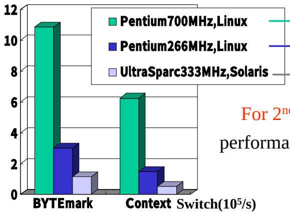
We report the development of the data acquisition system of the CANGAROO-III imaging Cherenkov telescope. Multi-pixel cameras consisting of 552 and 427 PMTs are placed at the prime focus of the first and second telescopes respectively. The charge and hit timings of each PMT are measured with ADCs and TDCs respectively via a fast VME-bus which is selected to reduce the data acquisition time. The VME-bus data are read by computers running a linux OS. Furthermore a module to select hit pattern in hardware whether triggered PMTs are adjacent or not will be installed to the second telescope. In CANGAROO-III observations, a global trigger is generated by the coincidence of the local triggers of the four telescopes, and the event data is collected via fast-ethernet, and analyzed with the central event-builder. The data acquisition system of each telescope is designed to accept triggers up to 400Hz with dead-time 20%.



Introduction

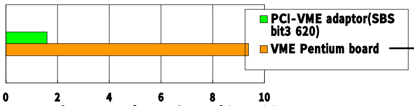
The CANGAROO-III project to construct an array of four 10m imaging atmospheric Cherenkov telescopes is underway in Woomera, South Australia. Observations with the first telescope started in March 2000, and results are presented in this conference[1]. The second telescope will be constructed at the end of 2001, and the overall status of CANGAROO-III is presented in this conference by Mori et al[2]. In this poster we report the data acquisition system (DAQ) of CANGAROO-III in detail.

CPU&OS



For event data of 2nd telescope
For event data of 1st telescope
For environmental data of 1st telescope

For 2nd telescope only Pentium&Linux is adopted, and performance test of various kinds of realtime Linux is in progress



For event data of 2nd telescope

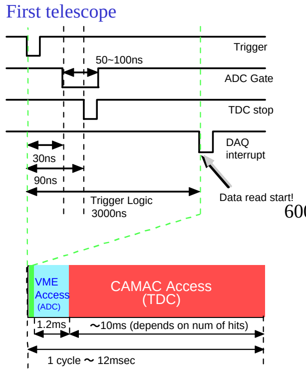
VME bus transfer PIO read(MB/s)

Data size

- PMT event data ～ 1.5kB/event
- Environmental data = 1.2kB/s

DAQ Timing

First telescope

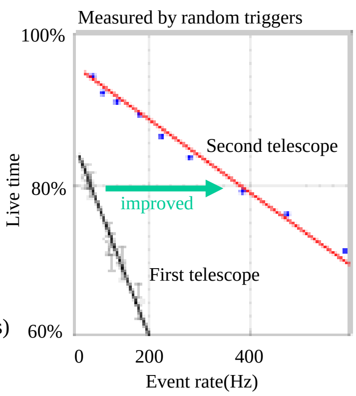


Bus transfer speed
CAMAC-bus(1MB/s) <VME-bus(>8MB/s)
For 2nd telescope CAMAC-bus is not adopted; VME-bus TDCs are used.

Software

Portable DAQ system "UNIDAQ" [3] is installed
Multi processes are running on a CPU:
- Collecting the data via VME or CAMAC-bus
- Buffering the data
- Storing the data on the disk,
- Transmitting the data to other computers via network
- Analyzing the data

Live time of DAQ



Summary

The DAQ system for an array of CANGAROO-III telescope has been developed in order to explore the southern sky in the gamma-ray band above 100 GeV. The first telescope of CANGAROO-III has been in operation from 2000, and the DAQ system of the second telescope is now being bulit to improve performance, based on that of the first one. The system of the first telescope consists of three data-buses, e.g. TKO, CAMAC, and VME, and two operating systems, linux and solaris, while that of the second telescope consists of only VME-bus and linux-OS to speed up the readout time. A module to select hit pattern in hardware whether triggered PMTs are adjacent or not will be installed to the second telescope instead of the present selection of *N* hits of any PMTs in order to reduce the night-sky background. In stereoscopic observations, a global trigger is generated from coincidence of four telescope with variable delay generators using telescope positions. All observation data of four telescopes are transmitted to the workstation in the central electronics hut and stored, and the events are reconstructed.

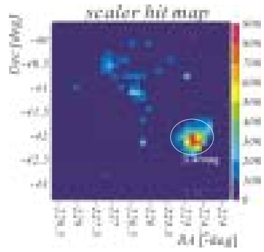
Discriminator and Summing Module(DSM)

- Signal from preamp in the camera is fed to a fast shaping amplifier, and splitted to ADC and TDC

- TDC has a 0.5ns(1st telescope), 1ns(2nd telescope) resolution in the window of 256nsec
  → Reject PMTs hit by night-sky background
  CANGAROO telescope is parabolic and the time propagation of a shower can be reproduced

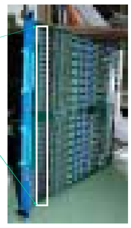
- For each PMT a signal is counted by a scaler when the pulse height is over the threshold(～3 p.e.)
  ↓
  Reject PMTs hit by starlight in the offline analysis

- TKO(1st telescope), VME 9U[J1,J2,Jaux](2nd telescope)



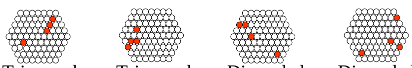
Charge ADC

- VME 9U size, A24D16/D32 access
- 16ch*2/board * 14 boards
- Internal 150ns delay-line chip for each channel
- One 16bit ADC chip for each channel
  BB ADS7815 conversion time 4 μs 250mW or
  BB ADS7805 conversion time 10 μs 100mW
- Readout 1ch or 2ch(readout time <20 μs/board)
- 0.1pC/ADC ch
- VME J1,J2,Jaux(CERN V430) required
- 24W/board



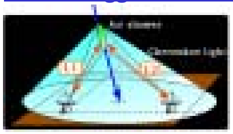
Pattern Trigger Module

- Installed to the 2nd telescope in order to reduce triggers by the night-sky background
- Accepts hit signals of all 427 PMTs and recognizes the 2-dimensional pixel pattern
- Generates a trigger if there is pattern of N(>3) adjacent pixels
- PLDs (Altera EPF10k130) are used for the pattern selection
- 60ns from input to output
- Delay dispersion between pins of PLDs ～17ns
- VME 9U size



Triggered Triggered Discarded Discarded

Global trigger of stereo observations



Sequence
1. Trigger of each telescope is transmitted to the central electronics hut
2. Delayed with a VME-bus controlled delay generator,whose delay is set by realtime calculation of the difference of path lengths of Cherenkov light(L1-L2)
3. Global trigger stops a TDC to measure the time difference of the local triggers of the four telescopes
4. Global trigger is distributed to the four telescopes
5. It interrupts the VME-CPUs, then starts to collect data from the ADCs, TDCs, scalers, and GPS

If a global trigger is not generated in 2 μs after a local trigger is generated, these readout module are to be reset in each telescope

References

[1] R.Enomoto et al.(OG2.02); S.Hara et al.(OG2.02); J.Kushida et al.(OG2.02); K.Nishijima et al.(OG2.03); K.Okumura et al.(OG2.03) in this conference.
[2] M.Mori et al.(OG2.31) in this conference
[3] M.Nomachi, et al., in Proc. *Int. Conf. On Computing in High Energy Physics* '94, LBL-35822,p.114,1994