Panoramic SETI: Overall focal plane electronics and timing and network protocols

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INTRODUCTION

The PANOSETI experiment is an all-sky, all-the-time visible search for nanosecond to millisecond time-scale transients. The experiment will deploy observatory domes at several sites, each dome containing ~45 telescopes and covering ~4,440 square degrees. Here we describe the focal-plane electronics for the visible wavelength elescopes, each of which contains a Mother Board and four Quadrant Boards. On each quadrant board, 1024 silicon photomultiplier (SiPM) photon detectors are arranged to measure pulse heights to search for nanosecond time-scale pulses. The instrument implements both a Continuous Imaging Mode (CI-Mode) and a Pulse Height Mode (PH-Mode). Precise timing is implemented in the gateware with the White Rabbit protocol.

PANOSETI HARDWARE

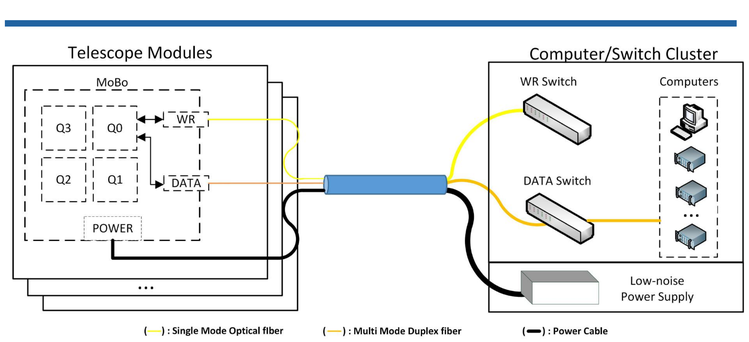

Fig.1 Block Diagram of the Panoseti Electronic System

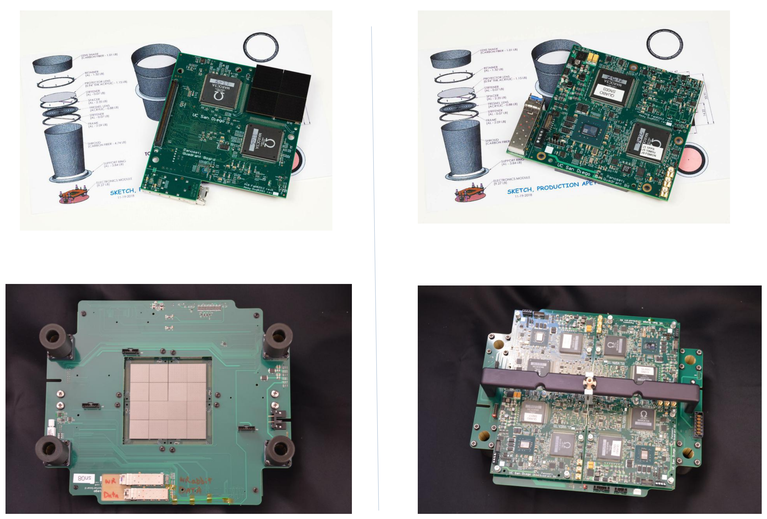

Fig.2-5 Photos of quadrant board and mother board. The quadrant board is the most important part of the electronics. Each “quabo” has four 8-by-8 SiPM arrays and four Maroc3A chips (plus ADCs) for converting 256-pixel analog signals to digital quantities

PANOSETI GATEWARE

In the FPGA gateware, we have currently implemented two observation modes: Continuous Imaging (CIM) mode and Pulse Height (PH) mode. Pulse height mode is optimized for detecting optical pulse widths <30 ns. Continuous imaging mode employs counters on every pixel that count over-threshold events to produce images at a programmable frame rate. White rabbit is also implemented in the gateware for precise timing

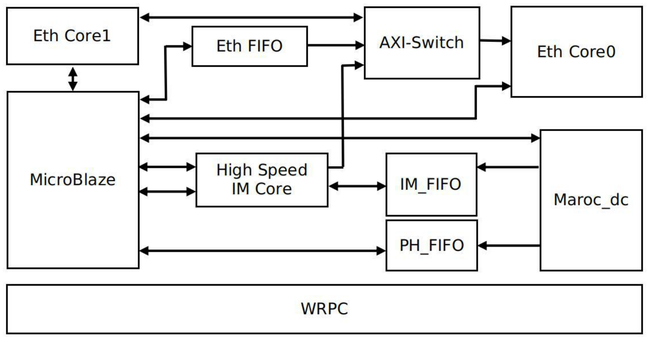

Fig.6 PANOSETI Gateware Design

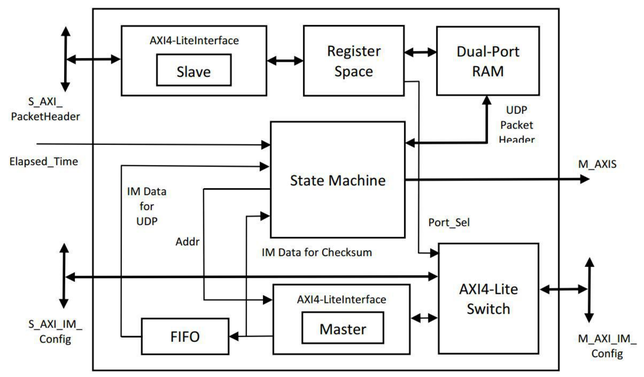

Fig.7 FPGA high speed imaging block diagram: Here are three AXI4 interfaces on the HS-IM Core. S_AXI_PacketHeader is used for writing packet header information to the Dual-Port RAM. S_AXI_IM config is used for configuring IM_FIFO from Microblaze core. M_AXI_IM Config is used for getting data from IM_FIFO. The State machine in HS-IM core is the key part, which is used for generating image packets at a high frame rate.

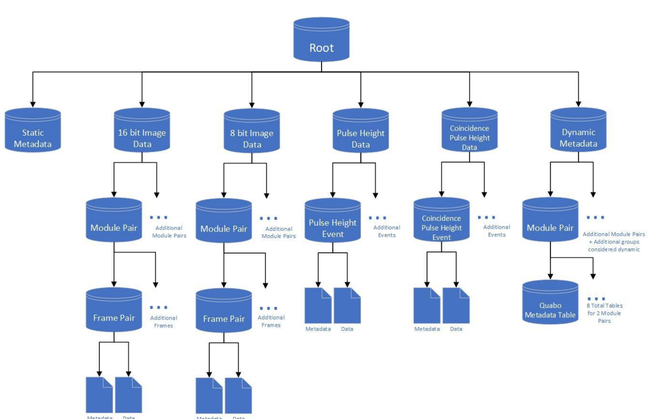

Fig.8 File Structure Diagram for continuous Image mode and pulse height mode

Networking

In PANOSETI project, ~90 telescopes will be deployed between two domes for covering ~4,441 square degrees. A large quantity of scientific packets will be generated over the nightly observations, sent via a data network to storage and computing units. We also need a computer cluster for controlling and monitoring the domes and all the telescopes, and processing and storing the scientific data.

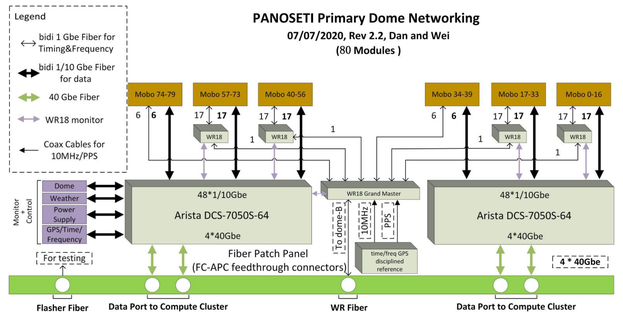

Fig.9 PANOSETI Primary Dome Networking

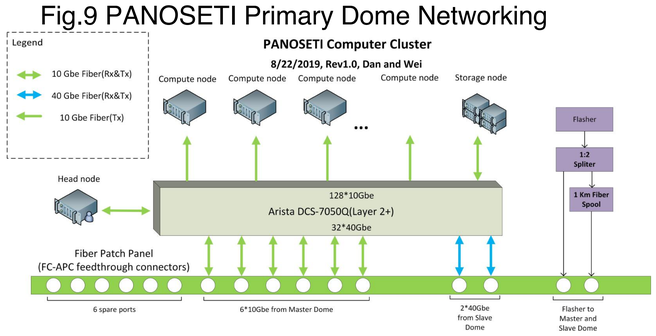

Fig.10 PANOSETI Computer Cluster

CONCLUSIONS

The PANOSETI focal plane electronics for each of the visible wavelength telescopes contains 1024 SiPM detectors, sensitive to 300–850 nm wavelengths, feeding 1024 channels of analog and digital electronics in Maroc3 ASICs. We implemented continuous imaging mode and pulse height mode for capturing transients with pulse widths from nanoseconds to milliseconds, and with ns-accurate time stamping via the White Rabbit protocol. The PANOSETI data network is designed to accommodate the challenging rates of data transmission, real time data processing, and data storage.

REFERENCES

[1] Korpela, E., Werthimer, D., Anderson, D., Cobb, J., and Lebofsky, M., “Seti@ home—massively distributed computing for seti,” Computing in science & engineering 3(1), 78–83 (2001).

[2] Townes, C. H., “At what wavelengths should we search for signals from extraterrestrial intelligence?,” Proceedings of the National Academy of Sciences 80(4), 1147–1151 (1983).