PHENIX ELECTROMAGNETIC CALORIMETER FRONT-END ELECTRONICS

W. Allen,[1] T. Awes, S. Belikov, J. Branning,[1] S. Daniels,[1]
N. Ericson,[1] S. Frank,[1] G. Jackson,[1] J. P. Jones,[1]
M. Musrock,[1] M. Simpson,[1] D. Smith,[1] P. Stankus,
J. Walker,[1] A. Wintenberg,[1] G. R. Young

The PHENIX Electromagnetic Calorimeter (EMCal) is a laterally segmented array of approximately 25,000 individual towers each with photomultiplier tube (PMT) readout. The calorimeter is made up of two subsystems: one with modules of lead-glass (PbGl) blocks, totalling approximately 10,000 channels; the other with modules of stacked lead/scintillator layers (PbScint) with fiber lightpipes, totalling approximately 15,000 channels. The EMCal system is central to PHENIX' capability to identify high-momentum electrons, and for measurement of photons, π^0's, and other neutral mesons.

Conventional commodity electronics cannot accomplish sufficiently high-precision measurements of energy deposition and arrival times in each module ($<$0.1% energy resolution, $<$150-ps timing resolution) and derivation of needed trigger information within an allowable budget for space, power, and money. For that reason, as well as to conform with the overall PHENIX electronics pipeline architecture, a custom readout system for the EMCal is being designed and built by the ORNL I&C Division with the participation of High-Energy Reactions Group physicists.

The EMCal readout follows the PHENIX pipeline-sample scheme. Each PMT signals is passively integrated; the output of the integrator is sampled at a high frequency (10 MHz); and the samples are stored in an array of analog memory units (AMUs). After a trigger decision is made, samples from before and after the physics event are digitized, and the difference measures the integrated charge from the PMT. Here this scheme is realized using two custom-designed analog integrated circuits (ASICs): the amplifier/TAC/triggersum chip (Int-E) and the analog-memory/digitizer chip (AMU/ADC, also used in PHENIX MVD, RICH, and muon-tracker). The Int-E chip provides several functions: it amplifies the integrator output in two different gain ranges, allowing an effective 16-bit dynamic range in the energy measurement with only a 12-bit ADC; it includes a programmable variable gain amplifier to compensate for intrinsic gain variations between PMTs; in addition to the energy channel, the PMT signal is also sent to a discriminator which starts a TAC module, and so digitizing the TAC output measures the PMT pulse's arrival time. Each Int-E chip serves 4 channels, while each AMU/ADC chip serves 32 channels.

In addition to the per-channel measurements, the Int-E chip also constructs an analog sum of its four channels and combines this with the sum from "neighboring" Int-E chips to form overlapping 4x4 tower sums; these 4x4 sums are then discriminated against programmable thresholds. This allows the experiment to be triggered on the presence of a single photon or electron of high energy in the calorimeter. This triggering capability is crucial for the measurement of high-energy electrons and photons during high-luminosity operation of the accelerator.

The ASICs to read out 24 PMT channels are collected onto one “analog daughter card;” six of these, plus four daughter cards for digital communication and control, are knitted together with a custom backplane to form one standard front-end-module (FEM) that services 144 PMTs. The system is currently very far along in its development: the AMU/ADC chip is manufactured; the Int-E chip design is complete; and it is currently in fab. All the circuit boards are either at the final design or at the final prototype stage. We anticipate a pilot system of 10 FEMs to be in place in June 1999 for the PHENIX Engineering Run, with the full complement to follow by October 1999 for the PHENIX Year-1 Physics Run.

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1. ORNL Instrumentation and Controls Division.