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The Readout Electronics of the NA62 Large Angle Photon Veto System

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The branching ratio for the decay K+ -> pi+ nu anti-nu is sensitive to new physics; the NA62 experiment will measure it to within about 10%. To reject the dominant background from channels with final state photons, the large-angle vetoes (LAVs) must detect particles with 1-ns time resolution and 10% energy resolution over a very large energy range.
Our custom readout board uses a time-over-threshold discriminator as a straightforward solution to satisfy these criteria. A prototype of the readout system was extensively tested together with a LAV module at CERN in summer 2010.

Summary 500 words

The branching ratio (BR) for the decay K+ -> pi+ nu anti-nu is a sensitive probe for new physics. The goal of the NA62 experiment is to measure this BR to within about 10%. To reject the dominant background from channels with final state photons, the large-angle vetoes (LAV) make creative reuse of lead-glass blocks recycled from the OPAL electromagnetic calorimeter
barrel.

There are 12 LAV stations positioned at roughly 10-m intervals along the decay volume. Each LAV station is made up of four or five rings of lead-glass blocks, which are staggered in azimuth providing complete hermeticity.
The light from each block is read out with a Hamamatsu R2238 76-mm phototube.

For each incoming particle, the veto detectors are expected to provide a time measurement with a resolution of < 1 ns, as well as an energy measurement with a resolution of ~10% at 1 GeV. The system must also be sensitive to minimum-ionizing particles (MIPs). The dynamic range must therefore cover three orders of magnitude, from a few tens of MeV up to 25 GeV.
In order to reduce cost and complexity, we have developed a readout board that makes use of the time-over-threshold technique. To cope with the large dynamic range, a clamping stage is used in front of an amplifier with 5x gain; then the same signal is compared to two independent thresholds to measure the signal amplitude using the time-over-threshold and to
simultaneously correct the time measurement for slewing. In the final configuration, the LVDS signals from the readout electronics will be measured by TDC daughter-boards mounted on the standard NA62 acquisition board (TEL62). Using a time-to-charge calibration parametrization, the FPGA inside the TEL62 will calculate the time corrected for the slewing introduced by the discriminator, as well the charge for each hit as reconstructed from the pulse width above threshold. This information will be sent to the subsequent DAQ stages; level-0 trigger primitives will also be calculated on board TEL62 and sent to the level-0 trigger processor.

The definitive prototype of the readout board was tested together with the second LAV station to be constructed. The test was performed using electron, pion, and muon beams at the T9 beamline of the CERN PS in summer 2010.
For much of the test, our readout electronics were used together with commercial QDCs and TDCs, but in dedicated runs, the times were also measured with a prototype setup using the TEL62 and TDC mezzanine boards.
The performance in terms of pulse height and time resolution was fully satisfactory: from a preliminary analysis, an intrinsic time-resolution of better than 0.5 ns and 9% energy resolution at 1 GeV appear to have been achieved.

The construction of the full set of veto stations is proceeding at full steam. Five of the twelve detectors have been assembled and quality tested. These detectors will be installed during summer 2011. The remaining detectors are under construction and will be installed by the end of 2012 for physics running in 2013.

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