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Response and resolution measurements of CALIFA CsI(Tl) detectors

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A test bench has been constructed for acceptance test of CsI(Tl) detector elements for the CALIFA calorimeter [1] for R^{3}B. A detector module consists of an APD and a long tapered CsI(Tl) crystal wrapped in ESR foil. The geometry is a consequence of the requirement to have high granularity, to achieve the necessary angular resolution for Doppler correction, and the need to be able to register high-energy charged particles that emerge from the reactions.

Figure 1: The test bench for CALIFA Barrel crystals in the Lund university detector laboratory. Batches of up to 32 crystals can be scanned per test with a rate of 5.2 detectors per hour.

An inherent challenge with such a geometry is that the combined effects of absorption and focusing of optical photons influence the scintillation light output, and thus the signal amplitude for events occurring at different depths in the crystal. In order to ensure that these effects do not influence the overall resolution of the detector module, it is necessary to measure the response to ionizing radiation along the crystal axis.

To accomplish this, a test stand consisting of an insulated dark box, in which up to 32 crystals can be mounted for performance tests, has been constructed. The temperature in the enclosed volume of the setup can be regulated with the help of a Peltier element and a temperature sensor feedback loop. The crystals are scanned using two separate scanning heads mounted on a commercial XY-table using a collimated ^{137}Cs source for light output nonlinearity tests, or alternatively an uncollimated ^{22}Na source for energy resolution measurements. Dedicated software has been developed to operate the XY-table, the temperature regulation, the bias supply and to automatically analyse the registered spectra to extract the resolution and light output nonlinearity (LON) along the crystal axis.

Readout of the signals from the modules is done using the standard readout chain planned for CALIFA. The chain comprises a Mesytec MPRB-32 preamplifier, with integrated detector bias supply, and a FEBEX3B sampling digitizer [2]. The data from from the digitizer is fed to an acquisition system based on the Multi Branch System (MBS).

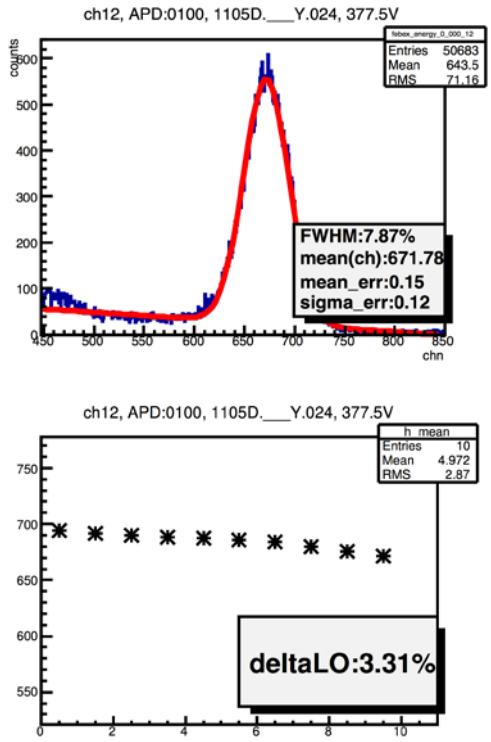

Figure 2: Typical response of a test scan showing, in the top panel, an automatically fitted response of the 662 keV gamma ray from ^{137}Cs source and the change in position of the centroid of this peak as a function of the source position.

The typical crystal scanning rate is 5.2 detectors per hour for a non-linearity test, using 10 points along the crystal axis and 2 minutes per measurement point; and 13.8 detectors per hour for resolution measurements. To date ca 600 crystals have been tested using the test bench, corresponding to nine CALIFA petals of 64 crystals, that can be used in Phase-0 experiments in the fall of 2018.

References

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