DESY beam test

February 2025

Abstract

High-level run plan for the upcoming DESY beam test (Feb 17 – Mar 3, 2025)

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1 Pre-beam setup and checkout

During the weekend and without beam or prototype assembled:

- Setup DAQ with 4 protoboards and KCUs
- Calibrate pedestals and TOT
- Check event sync across boards
- Develop/finalize software for data taking (event display, control plots and histograms…)

If possible:

- Align prototype
- Calibrate X-Y table to center the beam roughly at the central crystal

2 Setup and calibration (commissioning)

We'll start with all 25 crystals instrumented with the fully independent readout ("16-ind" daughter boards): each SiPM is readout individually for a total of 400 channels.

2.1 Trigger setup

- With the 2×2 mm^2 collimator, adjust trigger rates to be around **100 Hz**. If rates are too high, we can adjust thresholds in the scintillating paddles and prescale if needed. If rates are too low (unlikely), we can use a larger collimator.

2.2 ADC, TOA and TOT calibration

- With beam (roughly[1]) centered in the central crystal, take $\sim$10k events at different energies from min to max (eg. 1, 2, 3, 4, 5 and 6 GeV).
- Examine ADC and TOT histograms as a function of energy
- Adjust TOT threshold so that TOT kicks-in before the ADC saturates
- Adjust TOA threshold above noise levels

2.3 Phase scan

- Take 16 runs by shifting the phase (16 phases in 25 ns) to reconstruct the full waveform in detail.

This will provide a good template for the waveform fit and determine the best time delay to sample the peak of the signal.

It can be initially done with LEDs, but must be repeated once beam is available.

3 Position scan

We'll use the smallest collimator (2×2 mm^2) for the rest of the test (if not setup from the beginning of it).

3.1 Center determination

- Scan the calorimeter horizontally by steps of 2 mm (along the central row of crystals) and $\pm$ 1 cm around the center: 10 runs
- Scan the calorimeter vertically by steps of 2 mm (along the central column of crystals) and $\pm$ 1 cm around the center: 10 runs

[1] By roughly we mean that the crystal centers have been determined based on the laser

- Take ∼10k events at each step/run

Check the amplitude of the central crystal to determine the rough center to a ∼2 mm precision. Then do a finer scan at 0.5 mm precision:

- Scan the calorimeter horizontally by steps of 0.5 mm (along the central row of crystals) and ± 0.2 cm around the center: 4 runs
- Scan the calorimeter vertically by steps of 0.5 mm (along the central column of crystals) and ± 0.2 cm around the center: 4 runs
- Take ∼10k events at each step/run

Determine the X-Y center to 0.5 mm precision by looking at the amplitude of the central crystal.

The center determination study is estimated to take 2–3 h.

3.2 Gain matching

Using the detector center and the crystal pitch (**21.26 mm**) to compute the X-Y coordinates of each of the 25 crystal centers.

- Take ∼10k events centered at each of the crystals with a beam energy that does not saturate ADCs.
- Take ∼10k events centered at each of the crystals at a beam energy above the TOT threshold.
- Gains will be adjusted later by software (see section 7.2 if time is available at the end of the test).

Estimate time needed: 2 h.

3.3 Position resolution study

- Scan the calorimeter horizontally by steps of 4 mm (along the central row of crystals) and ± 3 cm around the center: 15 runs
- Scan the calorimeter vertically by steps of 4 mm (along the central column of crystals) and ± 3 cm around the center: 15 runs
- Take ∼10k events at each step/run

With 2-min runs, this step should take ∼ 2h.

4 Energy scan

With the beam centered in the central crystal:

- Take **10k–100k** events at each beam energy: 1, 2, 3, 4, 5, 6 GeV (nominal values: simply go as low and as high as possible and take 5–6 runs at different beam energies in between).

We expect 30-min runs, for a total length of 3 h for this step. This is TBC depending on the trigger rate.

5 Different readout options

Repeat steps 3.3 and 4 for each of the readout options:

- 16-ind: all SiPMs readout independently (done already, in principle)
- 16//: all SiPMs of crystal readout in parallel, for a total of 25 channels only for the whole detector
- 4×4: SiPMs grouped by 4, for a total of 4 channels per crystal and 100 channels overall
- Serial: experimental configuration with 8 series of 2 SiPMs readout in parallel. There are 8 channels per crystal in this configuration. We only have 9 boards of this type. We will instrument the central 3×3 crystals with these. Other crystals can remain with the previous daughter boards (4×4).

NB: Before each of these steps, the daughter boards in the prototype need to be swapped with a new set. Plan for a $\sim$2 hours "downtime" while this is done by one of the experts (Clément, Shihai, Stepan, Tristan).

Data taking for each configuration is expected to be $\sim$5 h. Including the hardware changes needed to switch configuration, we hope to run through one option per day: a total of 4 days. Assuming everything goes well (which never happens…), we should be ready to move to the next step (6) by the end of the first week.

6 Discrete readout (Justin will drive this part of the test)

Repeat steps 3.3 and 4 with the discrete readout electronics. This step requires more hardware changes:

- Swap all daughter boards with the discrete readout ones
- Provide LV to the daughter boards (dedicated power supply brought by Justin)
- Provide bias voltage to the daughter boards with Orsay's power supply
- Route signal cables from daughter boards to MIT's ADCs
- Run MITs DAQ for data acquisition

7 Additional studies if time allows

Setup the prototype with the "16-ind" daughter boards.

7.1 TOA threshold study

- At a beam energy that does not saturate the ADC, take 10k-event runs at decreasing values of the TOA threshold.
- Repeat at a beam energy where TOT kicks in.

7.2 Gain matching with HGCROC

- Take $\sim$10k events centered at each of the crystals with a beam energy that does not saturate ADCs.
- Play with the HGCROC input DAC to adjust the individual 16 SiPM bias (`Inputdacb<5:0>`) of each of the crystals.