

Testing the Integrated DOM

Single OM Testing Software Requirements

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Testing Objectives

- Does integrated OM system meet analog signal requirements (noise, signal quality)?
- DOM MB testing beforehand.
- First test of the IceCube DAQ software
 - Single – OM only capabilities
 - On board devices
 - Waveforms
 - RAPCal
 - *No testing of triggering or event building yet.*
- Collect millions of waveforms for Feature Ext.

PMT Testing

- Hamamatsu PMTs underwent extensive testing this summer to determine 'best fit' to IceCube application.
- R7081-02 chosen (10-stage – 1E+08 nominal gain).
- During process we measured tube properties.
- Order for 24 OMs this week – should arrive by early January.
- Each PMT will be tested with standard DAQ before integration into DOM – entered into database.

P/V Ratio	> 2.2
Pulse Risetime:	3.8 ns
Pulse Width	6.2 ns
Dark Counts at -40 C	< 300 Hz
Dynamic Range	> 500 pe / 10 ns > 30000 pe / 1 us

Integrated DOM Testing

- Monitor short term stability of DOM
- Only complete system will give total dark counting rate (from sphere, mostly, but also other mass inside).
- The DOM analog front-end is likely very different from NIM front-end.
- DAQ is through ATWD/FADC – also quite different from Camac ADCs – but like a nice digital scope.

DOM Testing Schedule

- Assembly of 20 DOMs - March 2003
 - Modules will be available as early as end of February – no reason to wait.
 - Cold darkroom at PSL ready in February.
- Allotted 11 weeks for testing from completion of DOM assembly.
- Darkroom can accommodate all PMTs simultaneously – with proper planning initial tests should proceed quickly.

Equipment (HW/SW) Needed?

- What equipment do we need at PSL to run tests?
 - How many PCs – particular requirements on PC hardware (PCI slots, ...)?
 - What software will be necessary to run?
 - What software will be needed to develop interfaces with the DAQ software?
 - What software will be needed to keep in sync with latest DAQ source?

Why am I Giving This Talk?

- Point of 3rd bullet a few slides ago – **DAQ is the DOM**. There are no other communication paths to the hardware.
- Need to communicate the core functional requirements on the DOM hardware and software.
 - Internal hardware, software, & firmware for acquiring the data,
 - External hardware and software for reading out the DOM, synchronizing to world.

Drawing Lines

- Who takes responsibility for what?
 - LBNL
 - DOM data acquisition firmware/software, including:
 - HV control
 - Triggering control
 - On-board LED control.
 - DOM Hub software
 - UW / PSL
 - **Readout software + API**
 - All analysis software
 - Databasing of testing results

Overview of Measurements

- Synchronous LED trigger
 - Gain
 - Peak to valley
 - Jitter
- Asynchronous, DOM-triggered.
 - Dark counts
 - **Dynamic range**
 - **Time synchronization**

PMT Occupancy

- *Occupancy*: Relative fraction of events producing a PMT pulse above threshold.

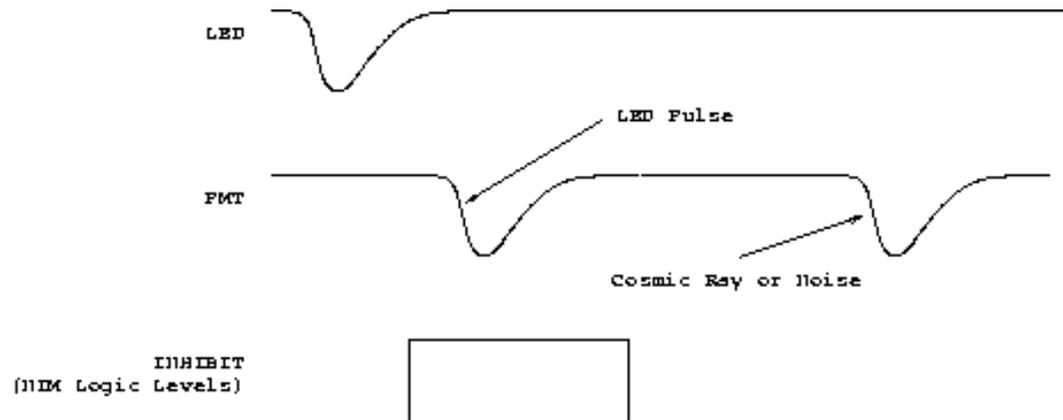
Example: If an LED is pulsed 1000 times producing PMT signals above threshold in 25 events, then that PMT is said to have an occupancy of $2.5\% \pm 0.5\%$.

- Occupancy measurement useful to monitor mean pe levels for very weak signals.

Measuring Occupancy Correctly

May be measuring occupancy with slow device (i.e. laser – 20 Hz max. rep rate). Therefore, important to inhibit noise and other uncorrelated pulses.

In NIM system – used logic units to generate inhibits.



In digital system controlling LED flasher – could tag triggers that were synchronous with LED. Perhaps this is done already.

UC#1: Synchronous Trigger

- Scenario
 - Operator selects desired values of HV and trigger threshold (for occupancy measurement).
 - Operator sets up desired occupancy:
 - OPTION A: Operator interactively controls intensity of LED flasher by monitoring PMT occupancy,
 - OPTION B: Operator specifies occupancy and DOM software sets LED intensity
 - Operator informs DAQ to trigger synchronously on LED pulser.
 - Operator requests N LED flashes.
 - Operator requests LED rate be R flashes per second.
 - Operator starts run, logs data to disk file.

- **Data Elements Needed**
 - Pulse height (mV units)
 - Total pulse charge (pC units)
 - Occupancy
 - Relative time between LED flash and pulse leading edge.
- **DAQ Software Requirements**
 - HV and discriminator threshold programming in voltage units.
 - LED control: intensity and period.
 - Tagging or veto for LED trigger association.
 - Occupancy setting:
 - **OPTION A: Interactive occupancy monitoring facility**
 - **OPTION B: Feedback system for automatically setting LED intensity based on input occupancy.**

UC#2: Dark Counts

- Scenario:
 - Operator sets trigger threshold
 - Operator requests N triggers from DOM.
 - Operator begins run, logs data to disk.
- Data Elements
 - Pulse height
 - Pulse integrated charge
 - Relative pulse times (i.e. not necessarily referenced to external timebase).

Follow-On Tests

- **Single DOM**
 - Stability tests / long term testing
 - Gain vs time
 - Noise vs time
- **Multiple DOM**
 - Inter-DOM time synchronization
 - Dynamic range /w/ external pulser.
- **String Tests (/w/ 20 OMs, at least)**
 - Triggering tests
 - Event building tests
- **Local coincidence trigger (inside DOM)**
- **Cosmic ray testing**

UC#3: Dynamic Range

- Scenario
 - Operator selects desired values of HV and trigger threshold
 - Operator sets intensity on external high-output LED to 10's of pe in OM.
 - External DAQ is started to capture reference PMT pulses.
 - Operator requests N triggers from OM.
 - Run is started.
- Data Elements
 - Pulse height/charge
 - Full waveform spanning several microseconds
 - *Absolute GPS* time for matching pulses in reference PMT.
- DAQ Requirements
 - GPS-referenced times.
 - Utility for realtime monitoring of PMT pulse amplitudes (for setting level of the ext. flasher).
 - Long timescale readout of waveforms from FADC.

UC#4: Time Synchronization

- Scenario
 - Operator selects default values of HV and trigger threshold.
 - External flasher is setup to provide high occupancy in all OMs under test.
 - Operator starts runs to acquire data, N triggers, from up to 20 OMs simultaneously.
- Data Elements
 - *Absolute GPS* time for matching pulses among the different OMs in the test.
- DAQ Requirements
 - GPS-referenced times.
 - Utility for realtime monitoring of PMT occupancy.

Remarks

- While it's not an absolute necessity for any test but the time synchronization, the ability to run **simultaneous**, independent data logging applications would speed up testing.
- A scriptable logger interface desirable – can insert into shell script and spawn many copies from there. *No GUIs.*

Conclusions

- Time synch is integral part of DOM operation and should get integrated into function set ASAP.
- Single DOM testing should commence in April 03 and end by end of June at which time we will be ready to test multiple DOMs and early string configurations.
- Meanwhile, PMT/base configuration testing continues ...