**How To Run PMT Testing at Boulby in 10 Steps**

A Step by Step Guide for Testing Loaded PMT’s at Boulby, including Terminal Instructions

Initially when loading PMTs - make a quick visual inspection to check for imperfections on the surface of the PMT. Any deformities **greater than 2 cm,** and deformities you believe are worth including, must be noted on the Google Spreadsheet.

**Step 1:** Find the Hamamatsu Nominal Voltages for your loaded PMT’s on the HVScan.txt file - 7th column, ie. 6th voltage step. Set this Nominal Voltage on GECO.

*$ ssh -Y root@194.74.2.25*

*$ [root password]*

*$ cd /home/user1/Wrapper*

*$ open HVScan.txt*

*$ cd /home/user1/Data/*

*$ CAENGECO2020 &*

**Step 2:** Open a second Terminal for data taking.

*$ ssh -Y user1@194.74.2.25*

*$ [user1 password]*

Make the directories where the data you’re taking will be stored.

*$ cd /home/user1/Data/*

***4 x the below for the 4 loaded PMT’s, where ---- is the 4 digit PMT number:***

*$ mkdir /home/user1/BinaryData/PMT----/*

*$ mkdir /home/user1/BinaryData/PMT----/APTest;*

*$ mkdir /home/user1/BinaryData/PMT----/DarkRateTest;*

*$ mkdir /home/user1/BinaryData/PMT----/GainTest ;*

*$ mkdir /home/user1/BinaryData/PMT----/SPEtest;*

*$ mkdir /home/user1/BinaryData/PMT----/Nominal;*

**Note the current value** for each PMT (which can be found on GECO) at Nominal Voltages on the monthly ELog.

**Step 3:** Take SPE Test at Hamamatsu Nominal Voltage - run for 5 minutes. This will run wavedump

with the correct configuration file for the gain, SPE and dark rate tests.

*$ cd /home/user1/Data*

*$ wavedump\_G\_SPE\_DR*

s to start, W to enable continuous writing (“W” must be capital), s again to stop and q to quit

**Step 4:** Run SPE\_Gen to generate the charge distribution histograms.

*$ cd /home/user1/Wrapper/SPE\_Analysis*

*$ ./SPE\_Gen*

Check that there is nothing unusual - all 4 single photoelectron peaks are at approx. 400 mV/ns - before proceeding with the 5 gain tests.  
If not at 400 mV/ns adjust HV Steps for Gain Test.

**Step 5:** Move all 4 Binary Files to Nominal Folder, *n* is Position in Testing Rig and *----* is the 4 digit PMT number.

*$ mv $DATA\_DIR/wave\_n.dat /home/user1/BinaryData/PMT----/Nominal/*

**Step 6: Gain Tests:** Having established there are no problems at the nominal voltage, run through the 5 Gain Tests detailed below.

**TEST 1**

107 gain test: On GECO set PMTs to the voltage value in the second column, ie. first voltage step. Run wavedump from the Data Folder - 5 minutes.

*$ wavedump\_G\_SPE\_DR*

*$ cd /home/user1/Wrapper/Gain\_Test*

*$ ./SPE\_Gen*

Move Data Files

*$ mv $DATA\_DIR/wave\_n.dat /home/user1/BinaryData/PMT----/GainTest/wave\_n\_hv1.dat*

**TEST 2**

107 gain test: On GECO set PMTs to the voltage value in the third column, ie. second voltage step. Run wavedump from the Data Folder - 5 minutes.

*$ wavedump\_G\_SPE\_DR*

*$ cd /home/user1/Wrapper/Gain\_Test*

*$ ./SPE\_Gen*

Move Data Files

*$ mv $DATA\_DIR/wave\_n.dat /home/user1/BinaryData/PMT----/GainTest/wave\_n\_hv2.dat*

**TEST 3**

107 gain test: On GECO set PMTs to the voltage value in the fourth column, ie. third voltage step. Run wavedump from the Data Folder - 5 minutes.

*$ wavedump\_G\_SPE\_DR*

*$ cd /home/user1/Wrapper/Gain\_Test*

*$ ./SPE\_Gen*

Move Data Files

*$ mv $DATA\_DIR/wave\_n.dat /home/user1/BinaryData/PMT----/GainTest/wave\_n\_hv3.dat*

**TEST 4**

107 gain test: On GECO set PMTs to the voltage value in the fifth column, ie. fourth voltage step. Run wavedump from the Data Folder - 5 minutes.

*$ wavedump\_G\_SPE\_DR*

*$ cd /home/user1/Wrapper/Gain\_Test*

*$ ./SPE\_Gen*

Move Data Files

*$ mv $DATA\_DIR/wave\_n.dat /home/user1/BinaryData/PMT----/GainTest/wave\_n\_hv4.dat*

**TEST 5**

107 gain test: On GECO set PMTs to the voltage value in the sixth column, ie. fifth voltage step. Run wavedump from the Data Folder - 5 minutes.

*$ wavedump\_G\_SPE\_DR*

*$ cd /home/user1/Wrapper/Gain\_Test*

*$ ./SPE\_Gen*

Move Data Files

*$ mv $DATA\_DIR/wave\_n.dat /home/user1/BinaryData/PMT----/GainTest/wave\_n\_hv5.dat*

**Step 7: Determine Operating Voltage:** Run SPE\_Fit to determine the optimal Operating Voltages and record these. Copy all root files from Gain Test to /RootData

*$ cd /home/user1/Wrapper/Gain\_Test (or cd $GAIN\_TEST\_DIR)*

*$ ./SPE\_Fit*

*$ cd HV\_SPE*

*$ mv PMT\_NB----\_HV----.root /home/user1/RootData/Gain*

**Step 8: SPE test at Operating Voltage:** On GECO, set PMT’s to Operating Voltage calculated in Gain Test. Run wavedump from the Data Folder - 5 minutes.

*$ cd /home/user1/Data*

*$ wavedump\_G\_SPE\_DR*

*$ cd Wrapper/SPE\_Analysis*

*$ ./SPE\_Gen*

Check that the Histograms look sensible - all 4 single photoelectron peaks are at approx. 400 mV/ns

Move data to relevant directories and move root files in SPE\_Root to ~/RootData/Nominal

*$ cd /home/user1/Data*

*$ mv $DATA\_DIR/wave\_n.dat /home/user1/BinaryData/PMT----/SPEtest/*

*$ cd /home/user1/Wrapper/SPE\_Analysis/SPE\_Root*

*$ mv \*PMT\_NB----\*.root /home/user1/RootData/Nominal*

**Step 9: After Pulsing Test:** On GECO, set HV to Operating Voltage and run After-Pulsing Test - 15 minutes. This will take data with an acquisition window on 10us - as opposed to 200ns used for other tests. Move Data Files.

*$ cd /home/user1/Data*

*$ wavedump\_AP*

*$ mv $DATA\_DIR/wave\_n.dat /home/user1/BinaryData/PMT----/APTest/*

**Step 10: Dark Rate Test:** Switch off LED. With PMT’s at Operating Voltage run for 15 minutes.

*$ cd /home/user1/Data*

*$ wavedump\_G\_SPE\_DR*

*$ mv $DATA\_DIR/wave\_n.dat /home/user1/BinaryData/PMT----/DarkRateTest/*

**Back up** the relevant directories to the external hard drive. It may be necessary to delete > 2 weeks old data to clear space on the computer for new data.

**Update** Tested PMT’s on the Google Sheet and on the monthly ELog.