Tests of the NPS and COMPCAL Readout

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The NPS (Hall C) and COMCAL (Hall D) will use the same readout setup consisting of Lead Tungstate crystals, R4125 PMTs and PMT dividers. The PMT dividers were designed by Vladimir Popov and optimized for similar scintillator pulse shapes. This note describes the tests performed on the presently configured setup.

1. Experimental Setup

The NPS/COMCAL readout is shown in fig. 1. The readout includes an optical fiber coupled to the face of the crystal to allow for calibration via an external optical source.

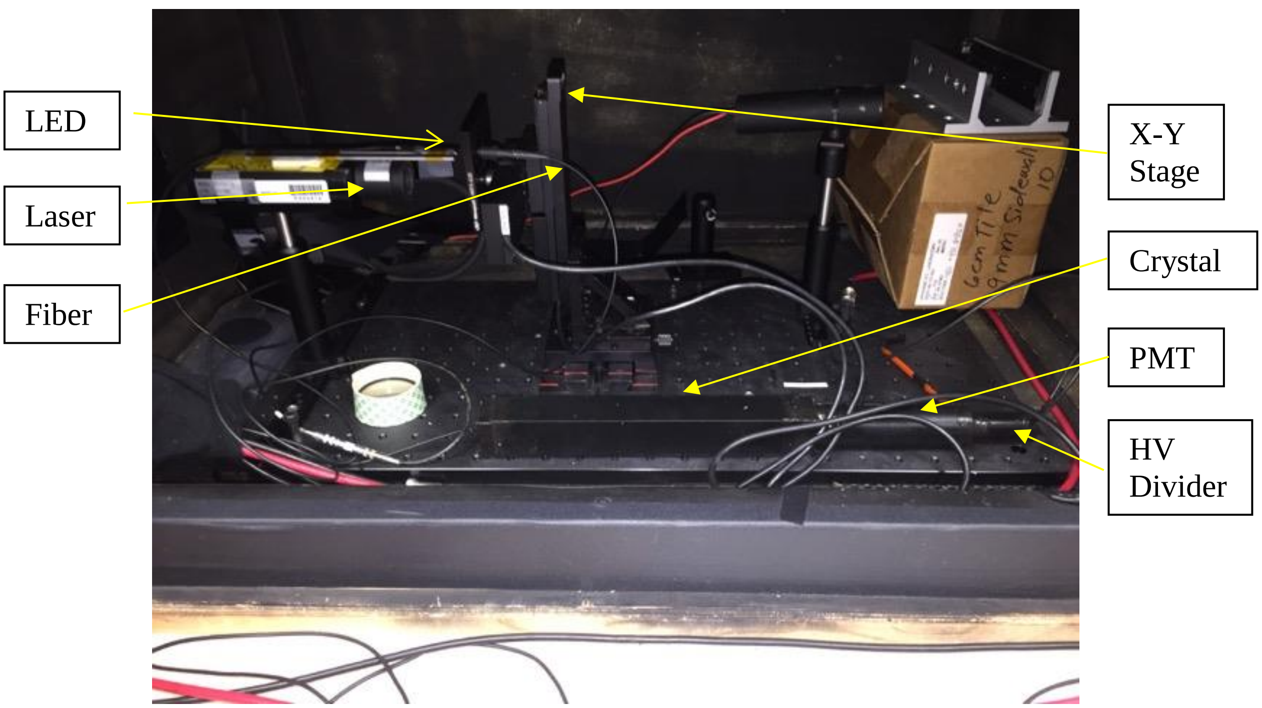

Fig. 1 – The NPS/COMCAL readout test setup

Laser head characteristics:

Wavelength	405 nm
Pulse width (FWHM)	70 ps
Repetition rate	Up to 100 MHz, externally adjustable

Intensity Externally adjustable
Class 3B

LED characteristics:

Wavelength 420 nm
Pulse width (FWHM) 20 ns, externally adjustable from pulse generator
Repetition rate Up to 240 MHz, adjustable from pulse generator

The optical sources were each coupled to the optical fiber by alignment via air gap and with the X-Y stage controls, which are external to the optical dark box. Adjustment of the optical pulse intensity coupled to the fiber was performed via the X-Y stage.

Tests were also performed with various PMT HV settings of 1.0 kV, 1.1 kV and 1.2 kV; with various repetition frequencies of 1 kHz, 10 kHz, 100 kHz, 1 MHz, 2 MHz, 5 MHz and 10 MHz; and with various optical intensities resulting in 200 mV, 300 mV and 500 mV pulse amplitudes observed on a scope. Nominal operation for these tests were set for HV = -1.1 kV and 300 mV pulse amplitudes.

2. LED Tests

Fig. 2 shows a representative pulse with the HV set at -1.1 kV, the pulse repetition rate set at 1 kHz and the resulting pulse amplitude of about 300 mV, obtained in sample mode; Fig. 3 is similar but obtained for an average of 32 pulses. Pulse amplitudes were measured with the scope set for average mode.

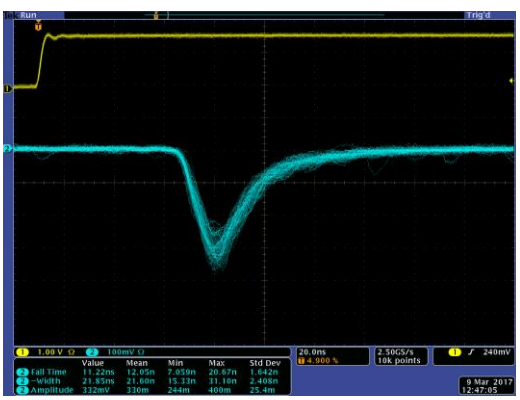

Fig. 2 – Sample Mode, -1.1 kV, 1 kHz

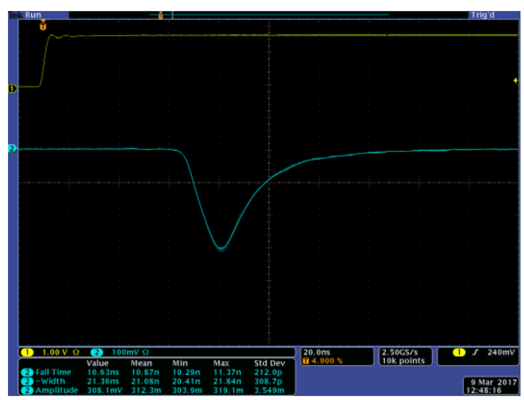

Fig. 3 – Average mode

The amplitude responses shown in fig. 4 were measured at -1.1 kV for three distinct optical intensities, which resulted in pulse amplitudes of approximately 200 mV, 300 mV and 500 mV. For intensities resulting in 200 mV and 300 mV pulses, the responses are within 2% to 3% up to 2 MHz repetition rate; for 500 mV pulses, the deviation is up to 12%. At 5 MHz, the deviation exceeds 15% for all pulse intensities. This is, this readout is not optimized for rates higher than about 2 MHz or where pulse amplitudes larger than 300 mV are anticipated under these operational conditions.

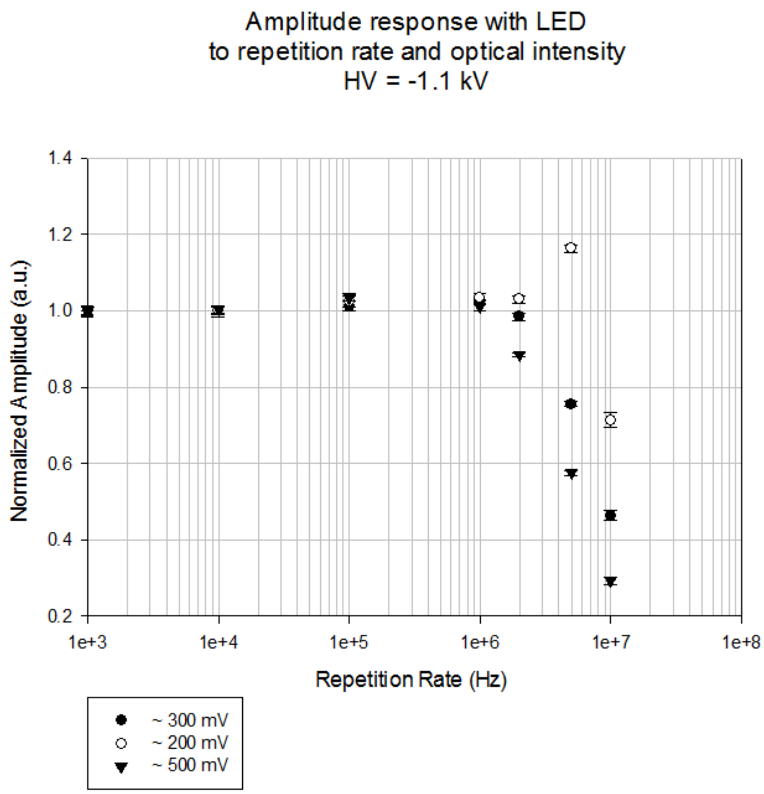

Fig. 4 – Normalized amplitude responses to various optical intensities

Next, the readout response was measured for different PMT HV settings around the nominal value of -1.1 kV and at nominal output pulse amplitudes of about 300 mV. Fig. 5 shows the normalized response of the readout. For the nominal PMT HV setting of -1.1 kV, the response is within 2% up to 2 MHz repetition rate; for the PMT HV settings of -1.0 kV and -1.2 kV, the responses are within 4% up to 2 MHz repetition rate. At 5 MHz, the deviation exceeds 20% for all pulse intensities. Therefore, it seems plausible to optimize the response of this readout by adjusting the PMT HV in accordance with the anticipated optical intensities at the face of the phot-cathode, i.e. lower intensities and higher HV settings will likely extend the range of operation to higher repetition rates while maintaining good linearity.

3. Laser Tests

This readout was first tested with a fast laser to determine the impulse response, given the fast optical pulses of 70 ps FWHM width. Under this condition, the full bandwidth of the readout is exercised and this may be of interest to other applications where much faster scintillator materials could be under consideration. Fig. 6 compares the responses of this readout at the nominal settings of -1.1 kV and 300 mV pulses, for the LED and the Laser. It should be noted that the pulse width of the laser is far shorter than the transmission time specification of the PMT, far shorter than the scintillation characteristics of the crystal and also taxes the bandwidth of the electronics.

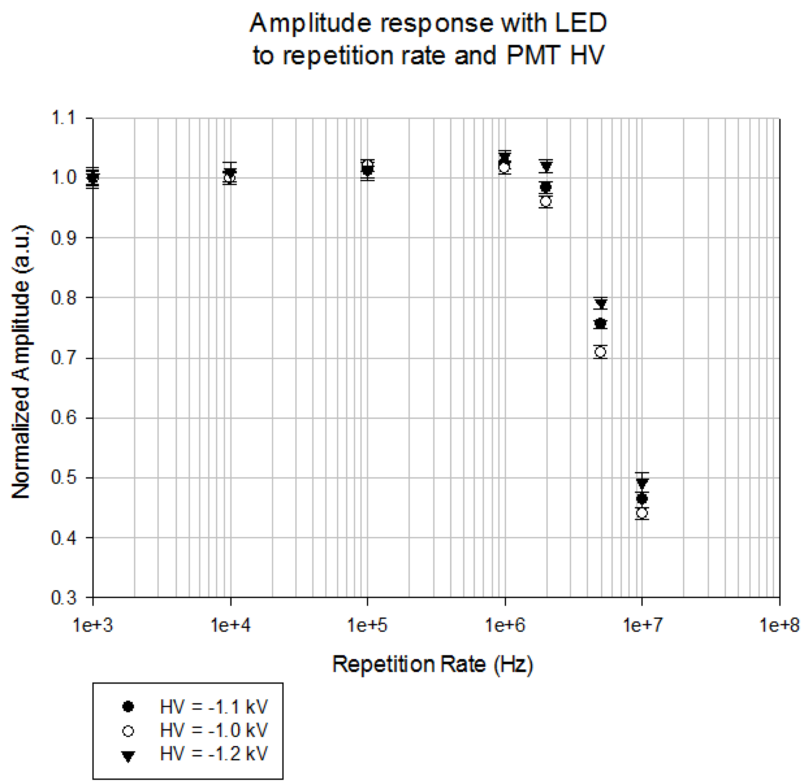

Fig. 5 – Normalized amplitude responses to various PMT HV settings

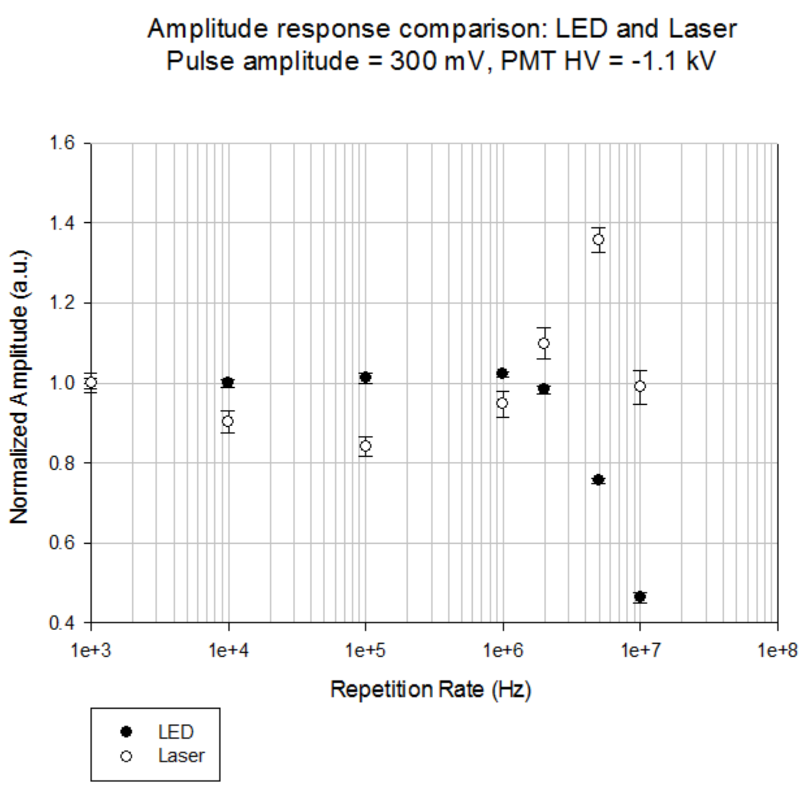

Fig. 6 – Comparison of LED and Laser responses

4. Baseline Shifts and HV Supply Currents

This readout is AC-coupled and baseline shifts will occur, dependent on pulse characteristics. For the nominal LED operation with 300 mV pulses and PMT HV = -1.1 kV, baseline shifts were as follows:

Repetition Rate (Hz)	Offset (mV)
1 k	0
10 k	0
100 k	0
1 M	+9
2 M	+14
5 M	+16
10 M	+14

The HV supply currents were as follows:

PMT HV (kV)	HV Supply I (µA)
-1.0	392
-1.1	431
-1.2	471

5. Summary

It is reasonable to expect good operation from this readout to within 2% of linearity for up to 2 MHz rates. It is also possible to optimize its operations by considering moderate output amplitudes and adjusting the PMT HV accordingly. Further optimization, if necessary, may also be possible by considering modifications to the divider and preamp.