Summary of NPS high voltage divider additional tests

(March 2017)

1. Experimental Setup

New tests of R4125 high voltage active divider have been performed by Fernando Barbosa. (Note, we are planning use similar PMTs, divider and crystals for NPS and COMCAL). For these tests we have used one-crystal based prototype (assembled by Arthur) and Hall D test setup shown in Fig.1. Light from Laser or LED are transported to crystal via fiber.

Fig.1 The NPS/COMCAL readout test setup

Test setup is mounted inside of dark-box and consisted of following elements:

- Solid state Laser: λ=405 nm, Pulse width (FWHM) 70 ps, rate up to 100 MHz
- LED
- Fiber X-Y Positioning system (remount control)
- Crystal with divider
- HV power supply and
- Scope to measure PMT output signal amplitude in "single" and "average of 32" modes.

2. Laser Tests

The divider was first tested with a fast laser (70 ps). Note, that the pulse width of the laser is far shorter than the transmission time of the PMT(~15 ns), and far shorter than the scintillation characteristics of the crystal (10-30 ns), as well as the electronics.

- At the nominal settings of -1.1 kV and 300 mV pulses with the laser we observed strange behavior of average amplitude with rate: first it drops down by ~17% at 100 kHz, then go up by ~10% at ~5 MHz, and at 10 MHz back to nominal value (as show open circles in Fig.2).

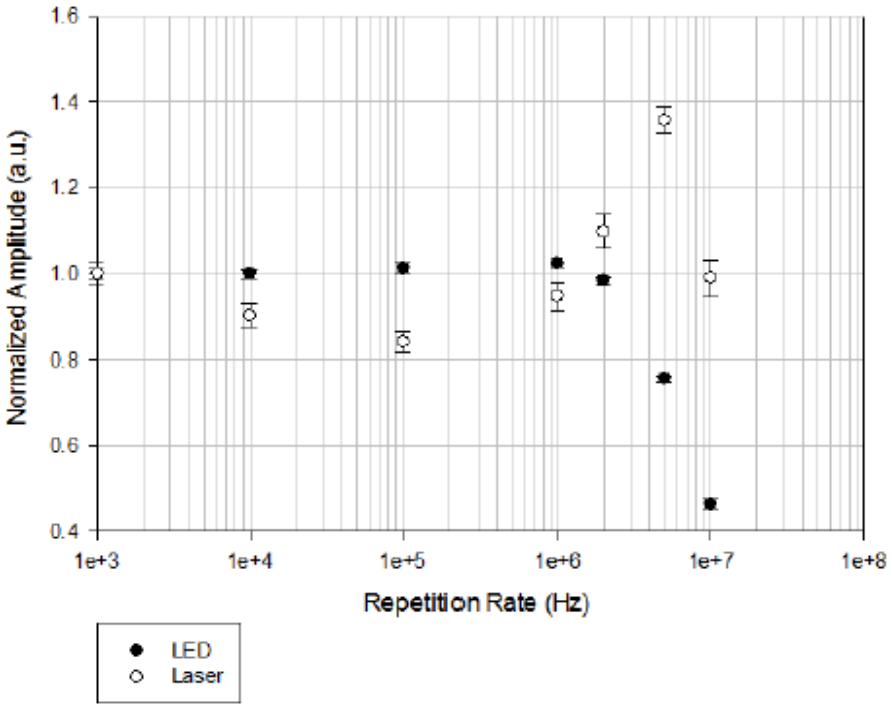

Fig.2 Comparison of Laser and LED responses

We realize that this strange rate-dependence due to very short pulse of the Laser (70 ps). Note, that the pulse width of the laser is shorter than the transmission time of the PMT (~15 ns), and far shorter than the scintillation characteristics of the crystal (10-30 ns), as well as the electronics. So, future test was done with LED.

3. LED Tests

Fig. 3 show typical single and average pulse amplitudes at PMT high voltage -1100 V, and at starting pulse repetition rate 1 kHz. The LED intensity was set for the PMT ~300 mV output signal amplitude.

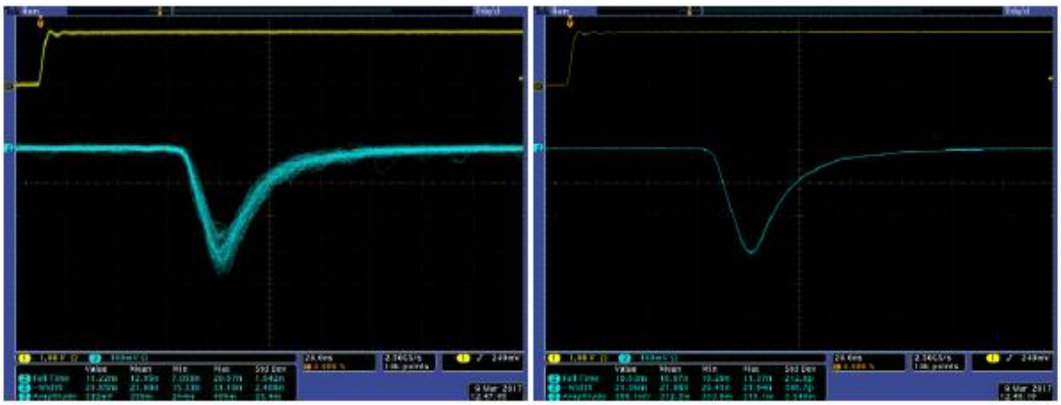

Fig.3 PMT output signal at 1.1 kV and 1 kHz measured in Sample (left) and Average modes.

In Fig.4 shown the amplitude responses at 1.1 kV for three intensities of LED which resulted in PMT output pulse amplitudes 200 mV, 300 mV and 500 mV.

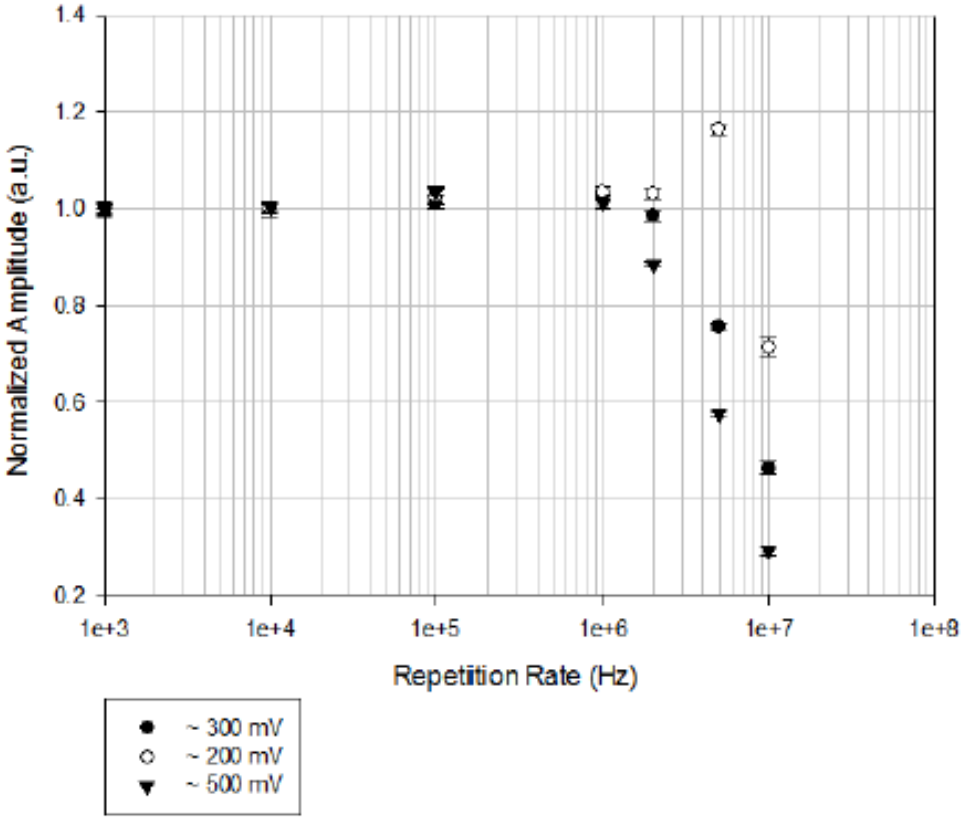

Fig.4 Normalized amplitude responses to various intensities of LED

- For 200 and 300 mV pulses the responses are within 2-3% up to 2 MHz repetition rate
- For 500 mV pulses the deviation is up to12%
- At 5 MHz the deviation exceeds 15% for all pulse intensities

The readout response was measured at PMT HV settings -1.0, -1.1 and -1.2 kV (± 100 V relative to nominal) and output pulse amplitudes ~300 mV. Results are shown in Fig.5.

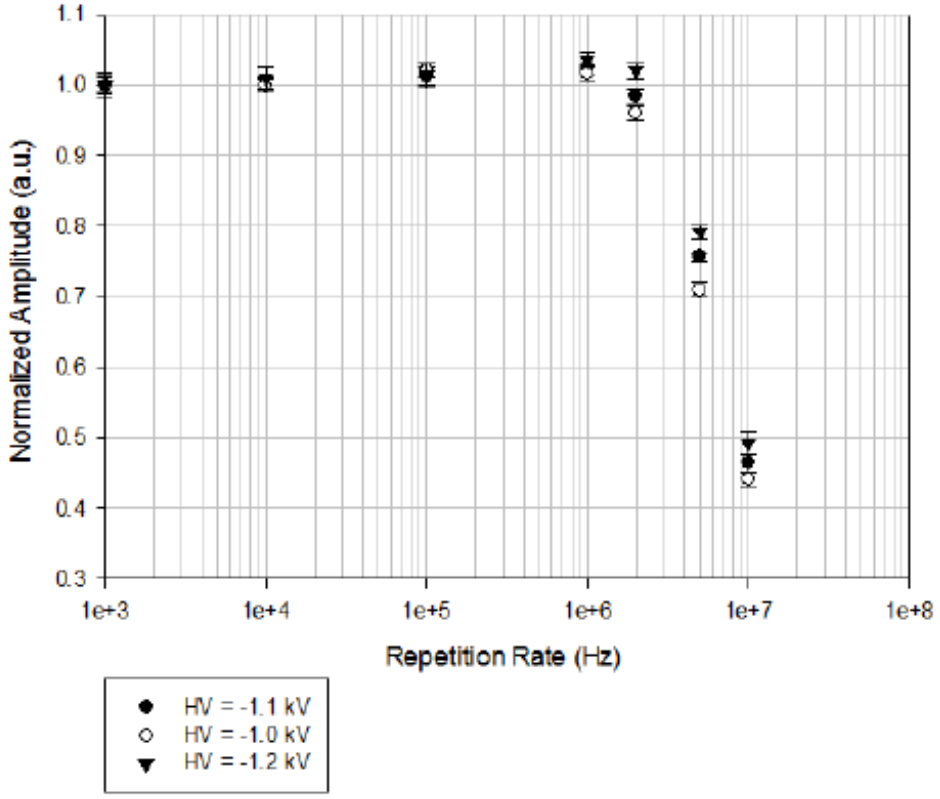

Fig.5 Normalized amplitude responses to various PMT HV settings

- For the nominal HV setting of -1.1 kV the response is within 2% up to rates 2 MHz
- For the HV -1.0 kV and -1.2 kV response is within 4% up to rates 2 MHz

4. Summary

- Test show that divider have linearity within 1% for rates up 1 MHz for the pulses 200-500 mV (which conform earlier studies Vladimir Popov and Hamlet Mkrtchyan).
- At 2 MHz rates divider linearity within 2-3% for pulses 200-300 mV, and within 12% for pulses 500 mV
- At 5 MHz the deviation from linearity exceeds 15% for all pulses in range 200-300 mV
- This divider is not optimized for rates higher than 2 MHz at nominal HV 1.1 kV, but linearity can be improved by adjusting the PMT gain (HV).
- Further optimization of the divider and preamplifier (if needed) is possible, but it will require time and man-power.