

Main Detector Front-end Electronics Update

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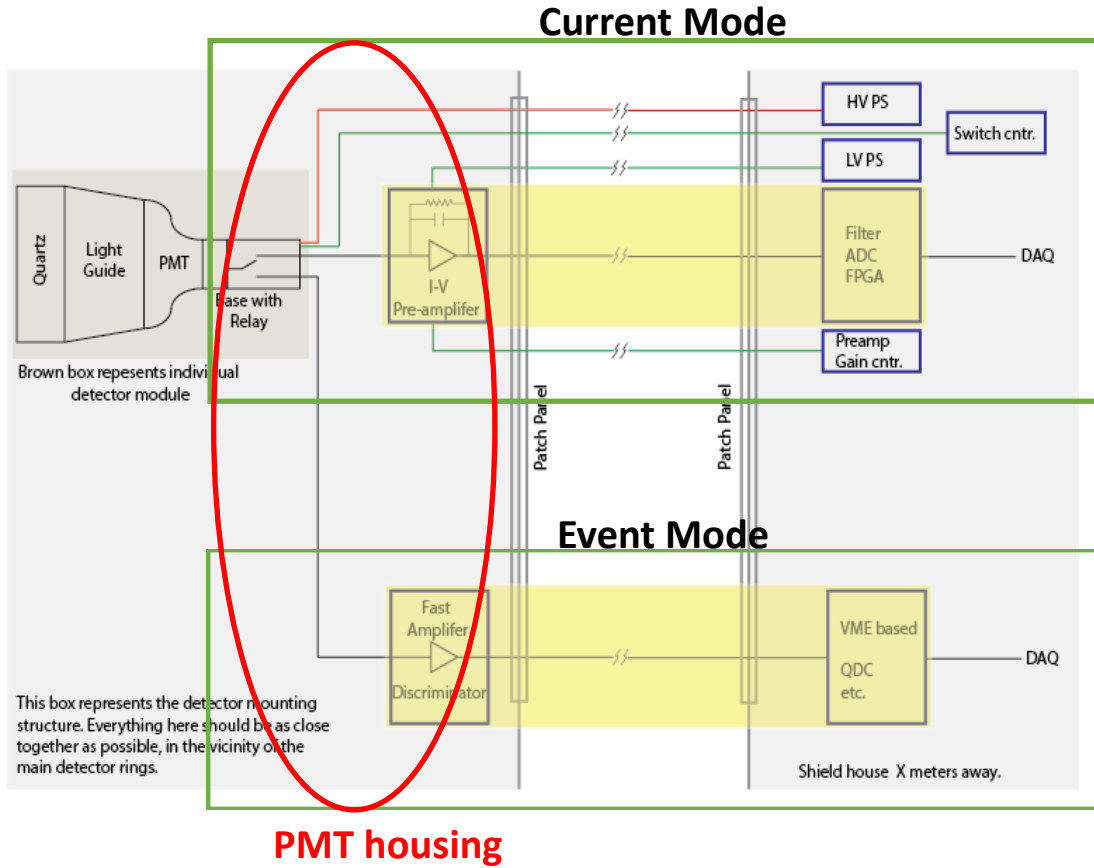
University of Manitoba

MOLLER Collaboration Meeting
May 5-6, 2023

Updates Since Last Collaboration Meeting

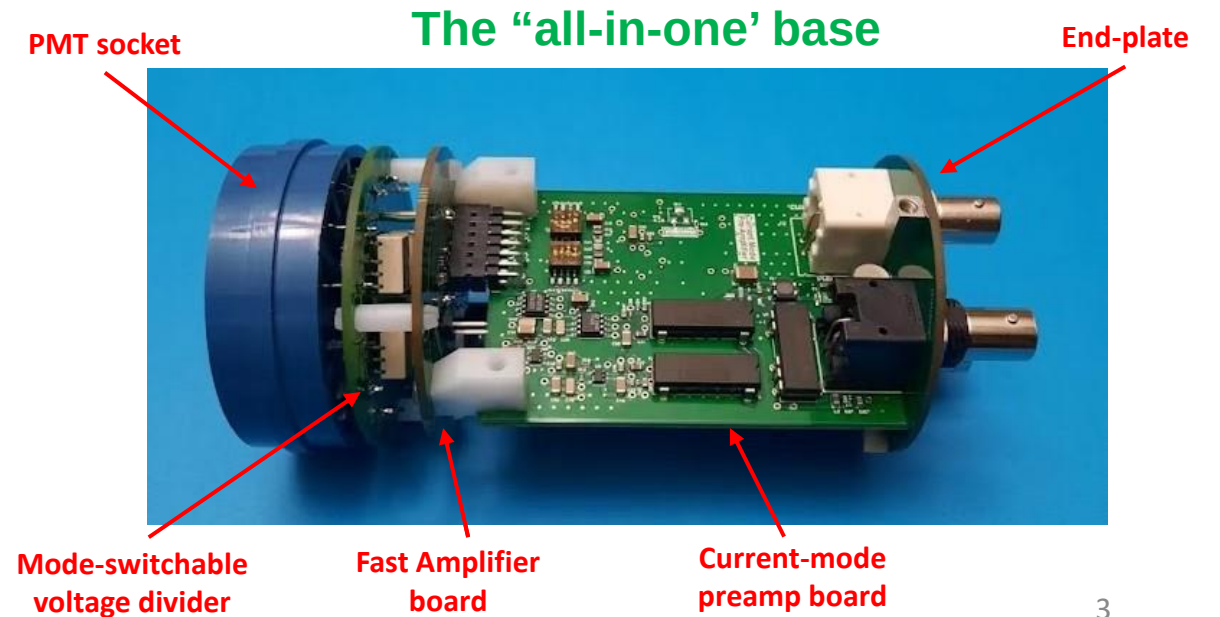
- Production of 20 PMT Bases
- Beam tests at Mainz
- Radiation hardness test at ISU
- 2 prototypes with new single DC/DC convertor for further rad test
- Power supply design & selection

Integrated PMT Base



The latest version:

- Current-mode and Event-mode chains share the same PMT voltage divider (switching base)
- Dual-mode amplifiers (I-to-V amplifier & fast amplifier) are incorporated into one PMT base

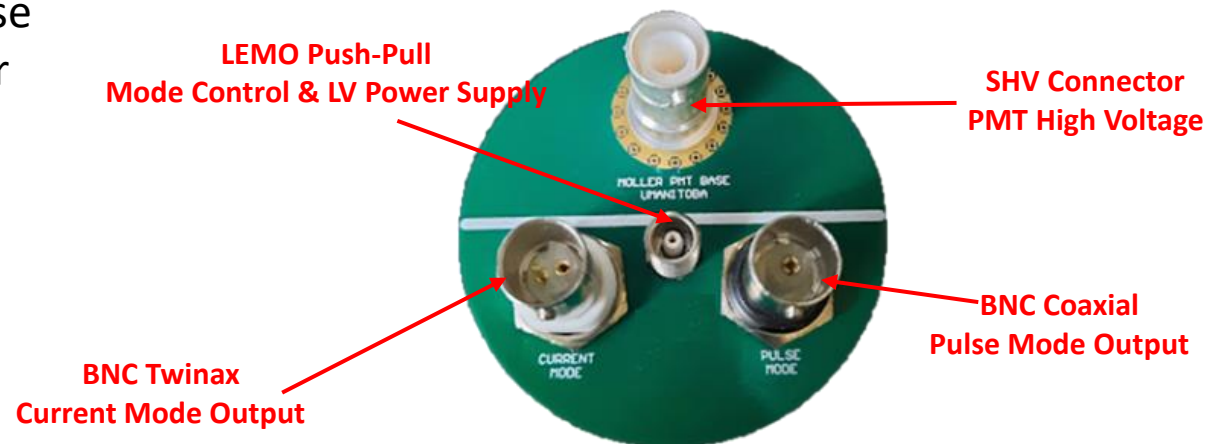
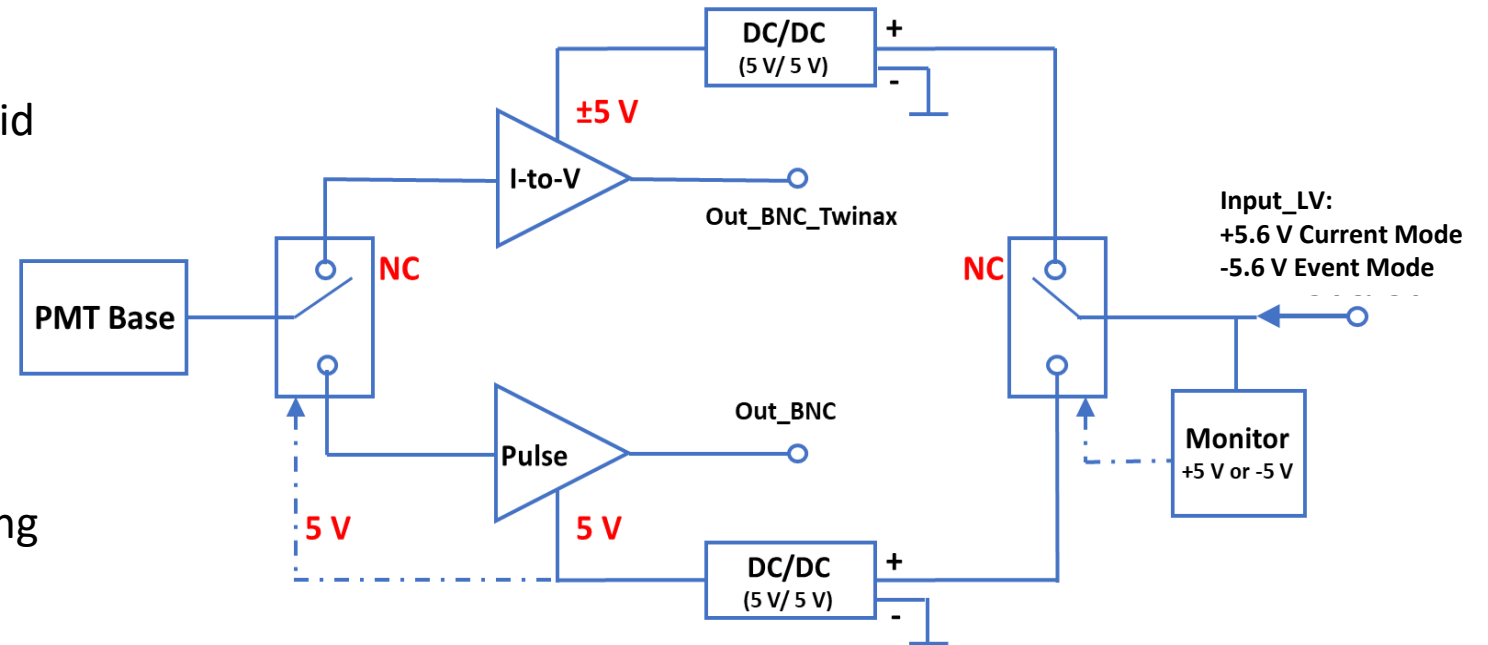


PMT Base: Mode Control & Low Voltage Power Supplies

- PMT base needs inter-isolating and ground-isolating low voltage power supplies (to avoid possible ground-loop):

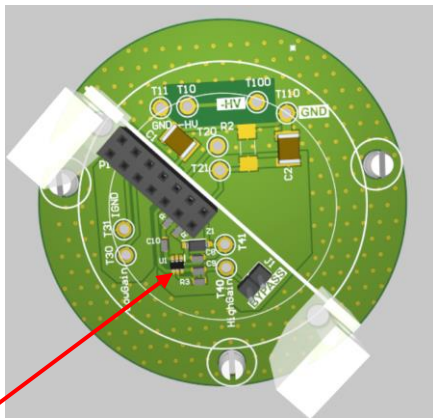
Current mode preamp: $\pm 5V$
Pulse mode fast amp: $+5V$
Mode switching control: $+5V$

- Use one LV connection to do mode-switching control and power the preamps
- Mode-switching between current mode and pulse mode is done by change the polarity of LV power supply



Radiation Tests at ISU

- The radiation test in last Dec. – Major sensitive components on current-mode preamp board were tested (DC-DC convertors & OP-Amps)
- The next radiation test has been planned – will test DC-DC convertors (& replacement) in fine steps; will test the event-mode amplifier IC

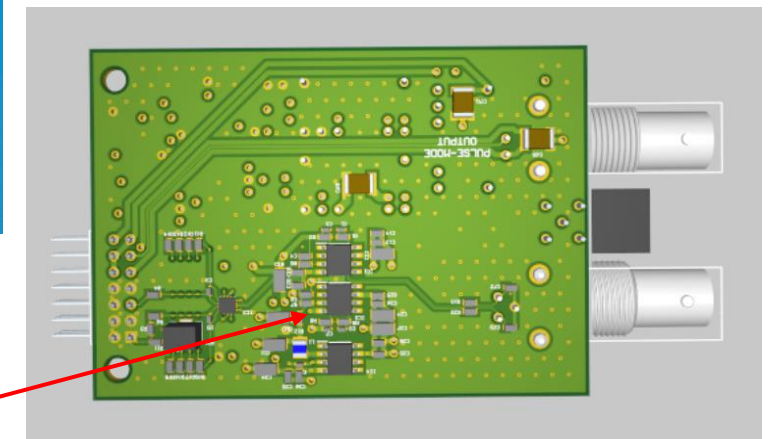
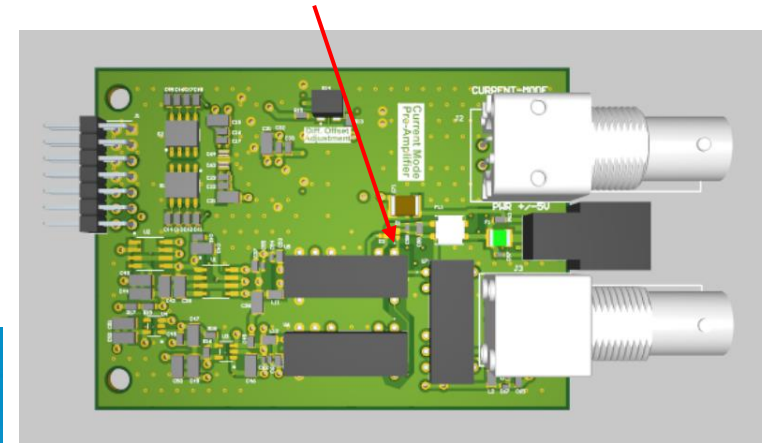


Pulse mode amplifier IC
– need to be tested

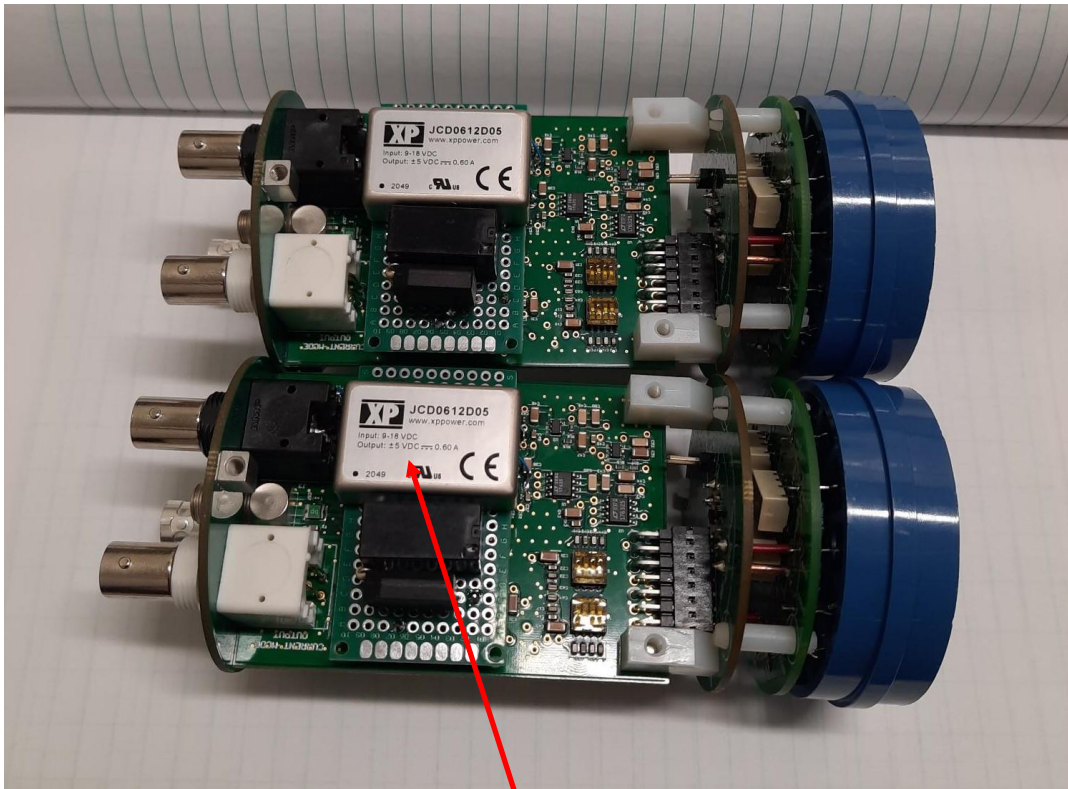


Current mode op-amps
– rad-hard tested

Isolated DC/DC Convertors
– rad-hard tested, failed
between 50 - 100 kRad



PMT Base Modification for Radiation Hardness Tests



DC/DC Converter: JCD0612D05

- DC/DC Converters in current design fail around 50 – 100 kRad (from Dustin's Study)
- Two PMT bases were modified to test a new DC/DC converter: Model# JCD0612D05, Input 9-18V, Output +/-5V/0.6A regulated

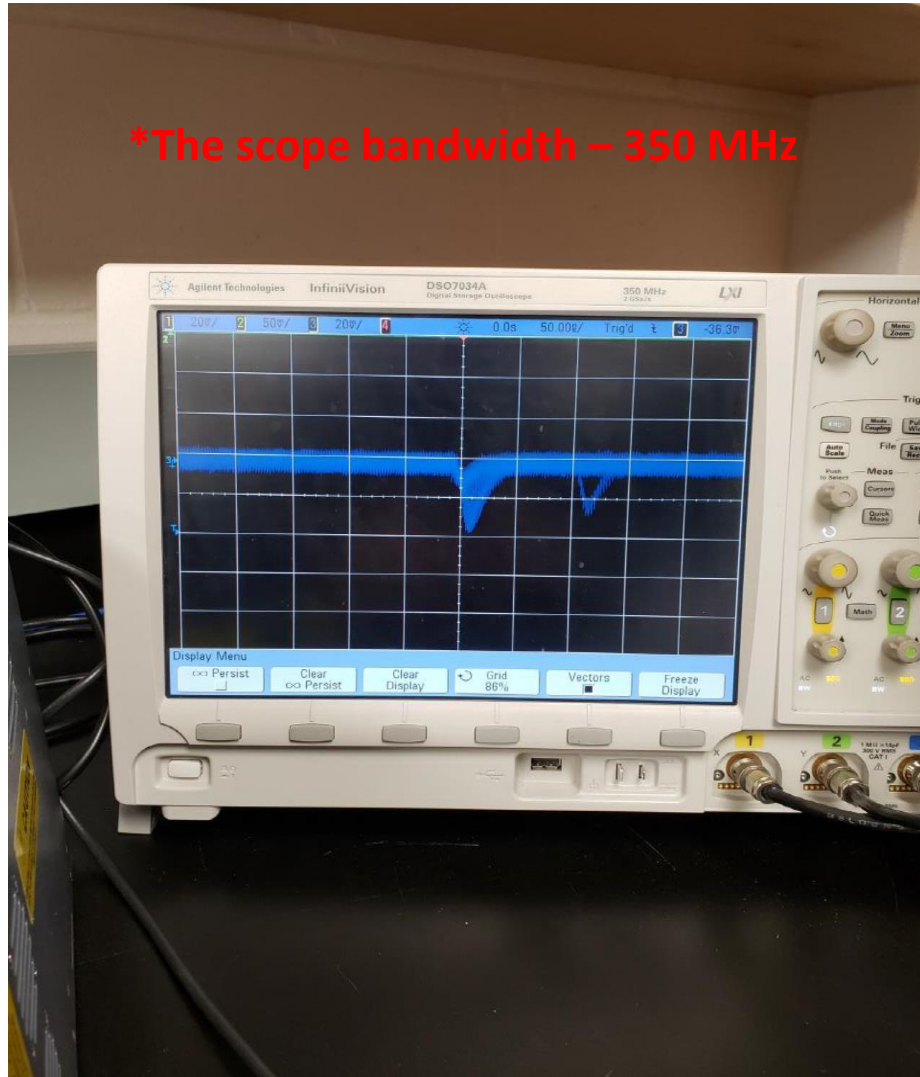
Another (rad-hard) DC/DC Converter is identified as a back up option:

- Crane Interpoint Aerospace & Electronics
- Model# SMSA2805D/KR
- RHA dose up to 100 krad
- <https://www.craneae.com/electrical-power-solutions-interpoint-stock-smsa-series>

PMT Base Event-Mode Tests

- Pulse mode amplifier output signals have low amplitude, very higher frequency oscillations (~ 1 GHz, observable only in wide band width oscilloscope)
- The oscillation is most likely caused by stray capacitance (coupled from surroundings and current mode amplifier which is ground-floated in pulse mode operation)
- Small modification was made to reduce the oscillation amplitude – added in a low-pass filter on the pulse mode output

PMT Base Event-Mode Tests

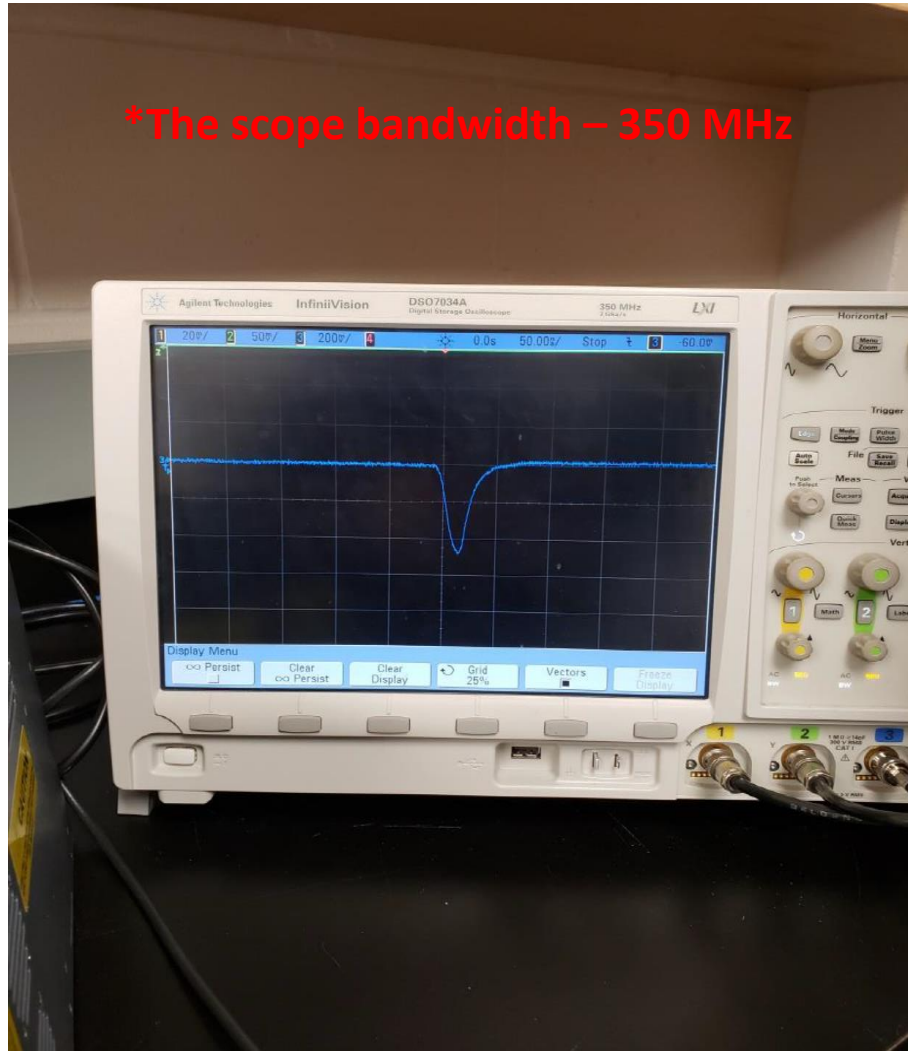


*The scope bandwidth – 350 MHz

- Observe Single PE on a 350 MHz bandwidth oscilloscope:
PMT HV: -1 kV
SPE Amplitude: ~20 mV
Oscillation on baseline: ~5 mVpp, ~1 GHz
- Oscillation amplitude is much less than single PE amplitude, and its frequency is beyond the flash ADC's bandwidth (250 MHz), hence it won't affect pulse mode measurements.

PMT Base Event-Mode Tests

*The scope bandwidth – 350 MHz



Example: random cosmic pulses

PMT HV = -1 kV

Typical pulse amplitude: 100 –600 mV

Baseline oscillation is negligible
comparing to the pulse amplitude

PMT Base/Preamplifier for Shower Max Detector

Requirements:

- Separating amplifier and voltage divider to meet the space limitation
- ~2m distance from each other
- Switchable between current mode and pulse mode
- Reduced amplifier gains

One prototype PMT Base was modified for test (using head connector and ~2.5 m long Ribbon cable). Design will be initialized when the test is done.



Ribbon cable can be replaced by shielded twisted pairs.
Head connectors can be replaced by LEMO multi-conductor push-pull.
Low profile HV connector would be considered.

Low Voltage Power Supply Requirements and Selection

- Need to provide power for 224 PMT Bases, individually controllable for flexibility, debug and monitoring purpose
- Power consumption: 2.8 W each (20% safety factor included)
- Power supply for each module: 5V/0.5A (using current DC/DC convertor) or 12V/0.2A (using the new DC/DC convertor that will be radiation-tested soon, which has a wider voltage range 9 – 12V, higher voltage and lower voltage drop and power consumption on cables)
- Have quotes for several power supply modules: [CAEN A255x](#) and [Wiener MPV8016I](#), [MPV 32SWP](#)
- Wiener MPV 32SWP module is preferable for its high density of channels and programmable polarity switch.



Wiener MPV 32SWP (32 Individual floating channels, 5A/ch, only 7 modules are needed)

To do list:

- Radiation hardness tests for DC/DC convertor module, pulse mode amplifier, etc.
- Redesign PMT base using rad-hard Op-Amp & DC/DC convertor, and test
- Ordering PSU for PMT base/preamp