Subject:	**Comments and Questions on the PMT HV Base Prototypes (Model 7081B-10)**
Date:	August 14, 2003
To:	Dr. F. Gleisberg—Iseg
CC:	A. Karle – UW-Madison / Physics K.-H. Becker—University of Wuppertal
From:	N. Kitamura – SSEC / UW-Madison

This communication outlines the findings made by myself and my colleagues at UW-Madison. The comments and questions are formulated in such a way as to address my concerns as the engineer in charge of defining the engineering requirements for the PMT HV Base board. Establishing a solid understanding of the behaviors of the prototypes is important for our moving towards the next iteration of the design, and having your response on record is likewise important.

IceCube has received a total of thirty (30) prototype boards from your company this year in two shipments, and the phrases “the first shipment” and “the second shipment” will be used in the subsequent writing.

First shipment (5/29/03):	UW received seven (7) boards and Wuppertal received one (1) board.
Second shipment (6/24/03):	UW received twenty-two(22) boards.

VISUAL OBSERVATIONS

Copper shield

The Burr-Brown DC-DC converter on the units from the first shipment has been wrapped in copper foil, presumably to reduce radiating noise, but the component mounted at the same location on the boards from the second shipment does not have a shield. Not knowing how different the two are, we have so far treated them as distinct components for test purposes. Please tell us how Iseg engineers managed to eliminate the need for the foil.

Stacked surface-mount components

There are stacked surface-mount components at two locations. K.-H. Becker mentioned that they are not due to shortage of components of certain values but rather due to Iseg’s **effort to stabilize the regulator feedback**. I would like to confirm if this is indeed the case.

Component rating

The two large ceramic disk capacitors on the prototype boards we received in August, 2002, are rated at 3kV, whereas those on the prototype boards from the first shipment this year are rated at 2kV. Those from the second shipment this year do not have a marking on the component, but they appear to be identical parts to those on the boards from the first shipment. I wish to know the reason behind this change.

Component placement

When attaching the PMT to the board by soldering the leads to the plated-through pads, I noted that some of the surface mount components are heated substantially. When cutting off the excessive length of lead after soldering, I also noted that some of the nearby components are in danger of damage due to a mechanical stress. From these observations, I estimate that approximately 1mm-wide band of “no component zone” is necessary around each of the PMT pads.

On related note, when attaching the PMT, we make sure that the solder pads are covered with solder in a hemispherical shape to minimize corona discharge. Literatures suggest that surface mount components in a high voltage circuit should all have a smooth solder fillet, for the same reason, and I would like your comment on such a technique.

Copper trace spacing

Although K.-H. Becker has told me that your CAD system takes care of the trace spacing rules, I would still like to reiterate that the copper trace spacing rules must be consistent with the 0.5 atm environment without a dielectric overlayer. Please give us your comment on the removal of the requirement for the conformal coating, which we requested for the current prototypes. I would also like to point out that the trace spacing rules are also subject to handling (assembly) needs. For example, the soldering pads for the coaxial cable shield (output cable, toroidal transformer) are exceedingly close to the surrounding ground. Although the narrow gap does not support a high potential, there is a danger that it may be bridged during a soldering operation.

Output cable attachment

In the prototype design, the coaxial cable enters the board from the bottom side and the shield of the cable is soldered to the periphery of the hole, while the bare center conductor makes an approximately 5mm-radius arc to a nearby pad where it connects. There are several concerns here. First, the attachment of the shield in this manner would involve a fair amount of heating of the dielectric insulation. Second, the bare center conductor is fragile and can be bent easily by a mechanical contact. Third, the PMT pulse signal may be affected by this arrangement. **The method of attaching the output cable must be reconsidered. We would like to discuss this matter with Iseg engineers and come up with a suitable solution.**

ELECTRICAL MEASUREMENTS

First dynode voltage

We plan to operate the PMT with the first dynode voltage set to a fixed 600VDC (± 20%), which is the lower end of the adjustable rage stated in the datasheets accompanied the first shipment. (We have made a change in the requirement from 600VDC from 700VDC.) Our test on one sample (S/N 372049) shows that the first dynode monitor voltage at $V_{D1/C\text{-}MON}$ with R1=36.0kΩ and R2=0Ω is 0.618V, corresponding to the first dynode voltage of 618V. In the future, we would like to have the target value of 600VDC to be in the mid-range of the adjustable window.

Voltage accuracy

The first dynode voltage has a factory-set value of 700V± 5%, according to the datasheet. The actual voltage monitored at $V_{D1/C\text{-}MON}$ for S/N 372049 is 0.720V, which is within the specified range. For the same board, however, the cathode-to-anode voltage monitored at Vmon is consistently 10mV higher than the command value appearing at Vset, over the DAC value of 2000 and 4000 (decimal). An offset of 10mV in monitor corresponds to a 10V error in the HV output. Please confirm and address this issue.

Voltage stability

We observe that **the output voltage is unstable when no jumper is installed between the split grounds** (Fig. 1). The instability is observed as apparent random fluctuations in the range of +/- 200V or so, which do not settle even after ten minutes of waiting. We find that installing a 1MΩ resistor across the jumper pads near the ribbon connector stabilizes the output voltage.

Split grounds

Installing a zero-ohm jumper to the pads near the ribbon connector introduces sharp noise spikes at ~600kHz (2 mVpp) on the secondary side of the toroidal transformer (Fig. 2). Since removing the jumper results in output instability (see above), **we find it necessary to connect the split grounds with a resistor**.

Please note that I replaced the 100 Ohm output cable with a 50 Ohm coaxial cable in order to use a 50-Ohm-input oscilloscope. In order to make the toroidal transformer output to see a 100-Ohm load, I inserted a 50 Ohm resistor in the signal path.

Noise on the output

With a 1MΩ resister installed across the jumper pads near the ribbon connector, the noise level measured at the end of the coaxial output is featureless and below 1mVpp (as observed on the oscilloscope), which is similar to what we observe with one of the prototypes from August, 2002. (Fig. 3)

<u>Noise induced by ADC reads</u>

Reading the ADC through the ribbon cable connected to the DOM Main Board induces noise spikes regardless of the split ground jumper. When the two grounds are tied with a 1MΩ resister, the noise amplitude is approximately 4mVpp. Adjusting the slew rate of the digital signals may moderate the situation, but I have not had a chance to work on this problem. I would like your comment on this problem. (Fig. 4)

MISCELLANEOUS

<u>Electronic board serial number</u>

We now have a working interface circuit and software for reading the electronic board serial number, which we would like to be implemented in the next design. I acknowledge that the board ID function of the current prototype does not work due to the fault on our side.

<u>Storage temperature</u>

The storage temperature range stated in the datasheet is –40C to +60C. As you know, we require –55C to +45C, instead. You previously mentioned over the phone that this is due to a typographical error. Please confirm this point.

<u>Target PMT</u>

The PMT used by the IceCube project is a Hamamatsu R7081-02, and not 7081-10, as stated in the data sheet.

<u>Control and monitor resolution</u>

The data sheet states a resolution of 10-bit, which, I believe, is in error--- the on-board DAC and ADC have a 12-bit resolution.

NK

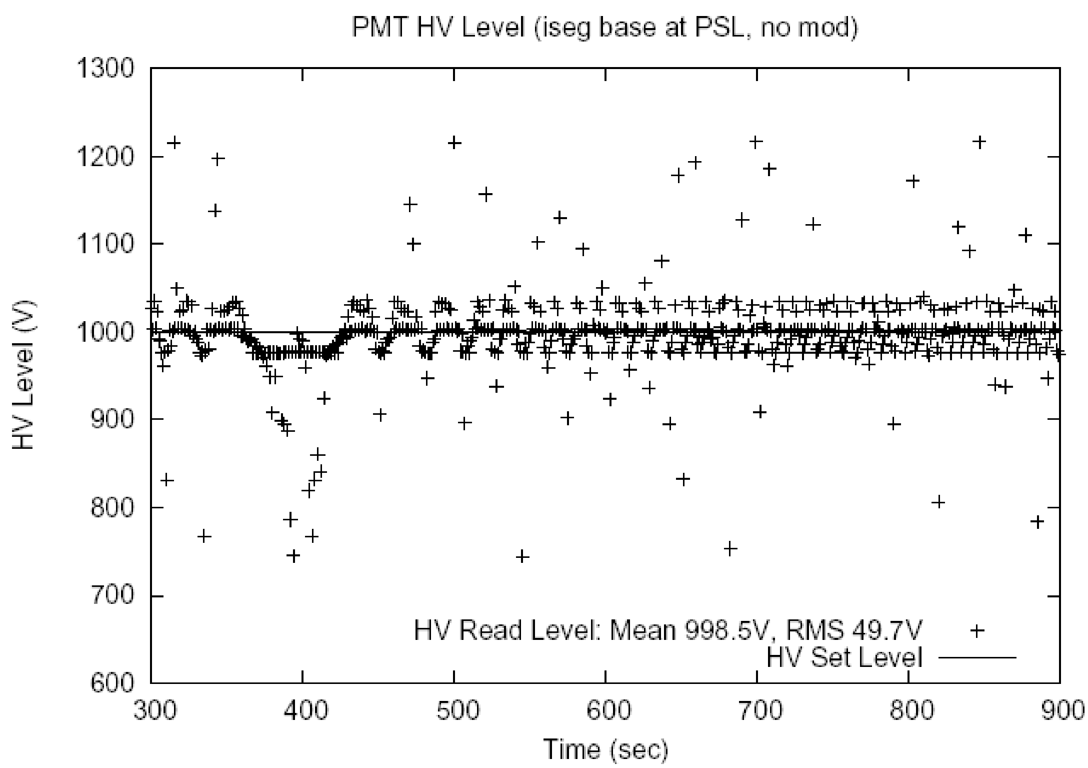

Fig. 1 HV output monitored by ADC readings with no jumpers installed to bridge the ground areas.

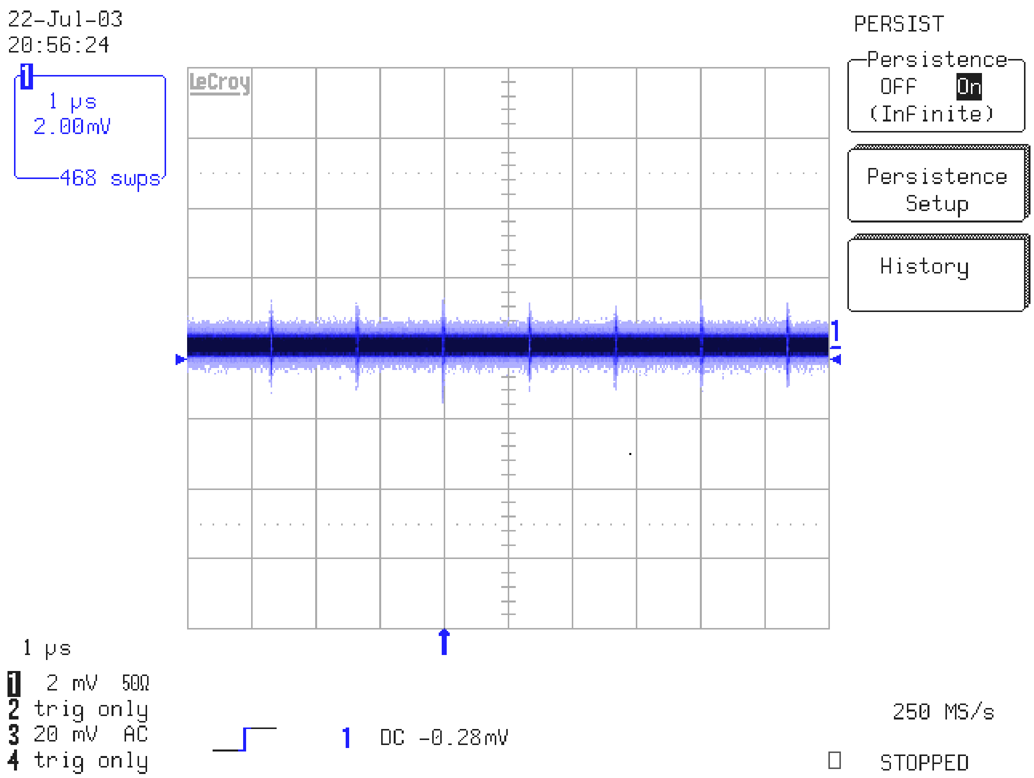

Fig. 2 Output with a zero-ohm jumper installed.

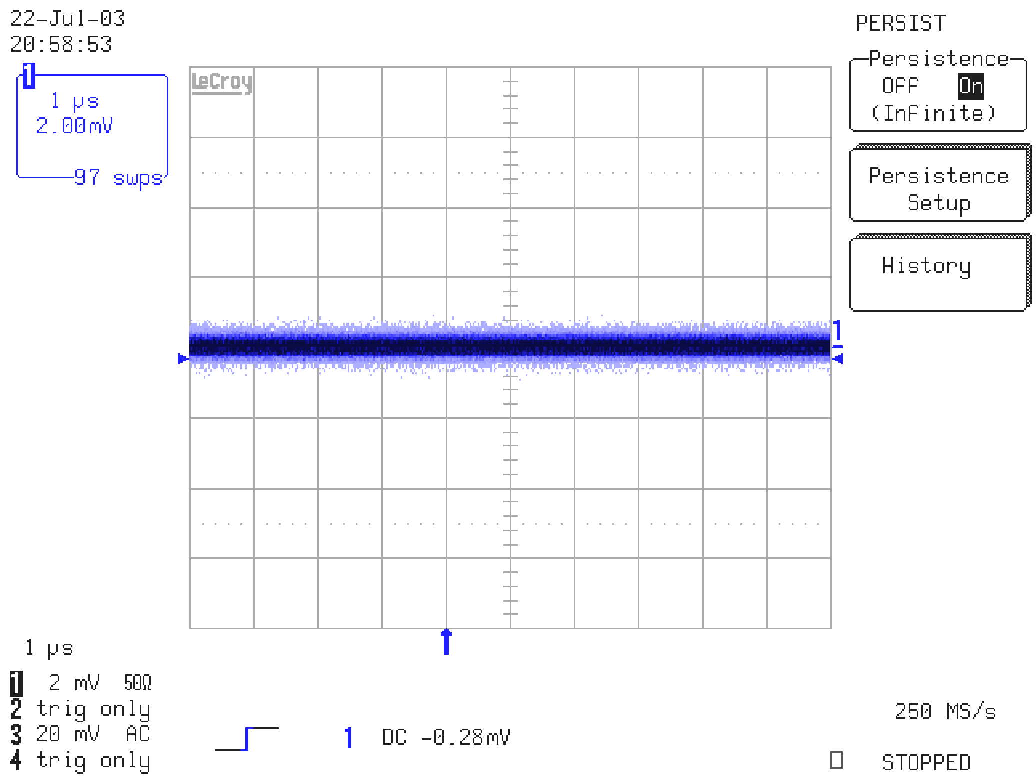

Fig. 3 Output with a 1Mohm jumper installed.

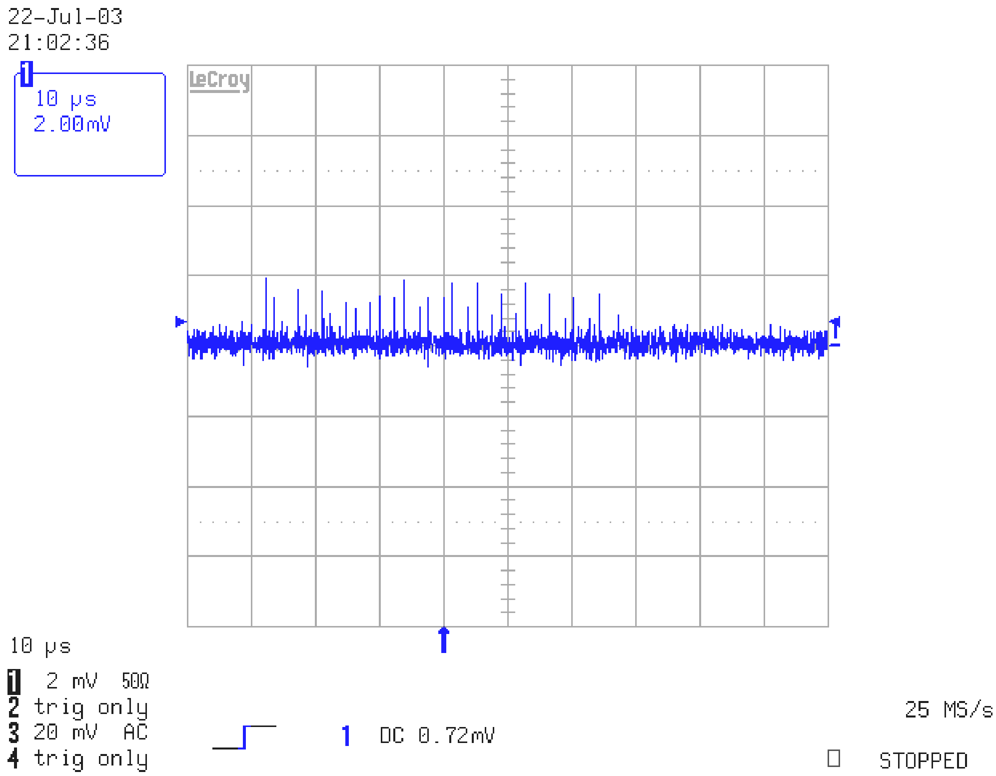

Fig. 4 Noise induced by ADC read operation with a 1Mohm jumper installed. (Note: at 25 MS/s, not all noise spikes are captured.)