

Hemispherical Photomultiplier Tube (PMT) Safety Handling Guidelines for the Pierre Auger Observatory

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Below is my draft of what I propose to be the Pierre Auger Observatory safety guidelines for handling the hemispherical PMTs for the surface array. Let me offer the following executive summary:

1. People hired to handle the tubes regularly need eye and ear protection
2. Occasional handling by physicists should not require safety gear
3. Cleanup of a broken tube is mentioned
4. Some comments on tube handling/shipping are appended

Warning—Personal Safety Hazards

Primary Safety Concerns

Implosion—Breaking this high vacuum device, whether or not in operation, can cause injury due to flying glass or toxic fragments.^{1,2}

The following safety gear must be worn when ROUTINELY handling PMTs:

Eyewear: Satisfies ANSI Z87.1-1989 and CSA Z94.3-1992 or local equivalent. If outdoor handling of PMTs is planned and sunglasses are desired, they should also meet ANSI Z80.3-1986 or local equivalent.³ Full-face shields may also be used as primary eyewear provided the shield is sold as primary and not secondary eye safety equipment.

Ear protection: Should satisfy ANSI S3.19-1974 or local equivalent.⁴

Implosion Cleanup—Cleanup of broken phototubes requires the following equipment/procedures:⁵

1. Fragment pickup with kevlar gloves
2. Disposal of the fragments as hazardous material (heavy metals most notably)

¹ The stored energy in an 8" PMT is greater than 400 Joules. The imploding PMT rebounds with virtually all of this energy that is distributed into a number of low-mass (from the thin glass) fragments. These high-velocity fragments are mostly harmful to the eyes and the concussion to the ears.

² Shock for a PMT is quoted at 10g maximum typical (high shock tubes meet MIL-E-5272C or MIL-STD-810B with both sinusoidal and random vibration tests as applicable)

³ These would be polycarbonate glasses with side-shields. Sunglasses would be UVA/UVB blocking, but more importantly the plastics would be UV stable for outdoor use. Basic safety glasses available in the States (from Lab Safety for example) typically meet these specs. Some face shields meet these standards.

⁴ Once again, this is a basic safety specification.

⁵ Best estimates are .1-.5% breakage in a non-controlled environment. A 5-atmosphere impact is assumed to be typically catastrophic for an 8" PMT. Anecdotally, four 1-2m falls by 8" tubes broke zero tubes.

Secondary Safety Concerns

Electrical Shock—Operating voltages applied to these devices present a shock hazard. Appropriate precautions should be taken.⁶

Hazardous Material Content—Exposure to hazardous material would normally not occur in the ordinary use of this product. However, certain parts and components in this product may contain small amounts of materials that are considered by certain governmental bodies as having potential harmful effects. Therefore, please follow manufacturer's instructions in handling and using this product; refer servicing to an authorized service representative; and dispose of this product in accordance with all applicable environmental laws and regulations.⁷

High Voltage—Although the user of this product is normally protected from the high voltage hazard by the equipment design, the voltages applied to this unit in normal operation are hazardous. High voltage safety precautions must be followed. Equipment caution labels and safety features must not be disregarded.^{8,9}

Damaging the tube—People handling the PMTs should not be wearing jewelry (rings, watches, etc.) on their hands or wrists while handling the tubes. Jewelry increases the risk of scratching the PMT. All wiping or cleaning of the phototubes should be done with Kimwipes, also to prevent scratching.

Shipping Concerns

Using the 10g figure as a guideline, the original tube boxes for Hamamatsu 8 inch tubes were tested for felt acceleration at the surface of a (modeled) tube for varying drops.¹⁰ Reasonable drops consistently failed to exceed 10g at the tube—even falls of greater than 5 meters. Dropping tubes in the box shouldn't hurt them.¹¹ A shipping suggestion would be to install 5 and 10g non-resettable shipping acceleration indicators on the tubes in the first few shipments and seeing if any are being tripped.¹² Physical intrusion into the box or crushing would seem to be much more worrisome failure modes.

Tubes should be kept in their boxes as much as possible. Then removed from the boxes only for immediate installation.

⁶ Though this might be directed to a different person, depending on whether or not the tubes are fired up in the assembly building.

⁷ Cadmium, antimony, etc. Quantities are small, so any disposal shouldn't be a major issue, but we should be polite.

⁸ Same comments as number 6, but the high voltage nature of the working PMT should be part of the safety warning.

⁹ The wording of the secondary safety concerns is standard OSHA boilerplate for these situations—dangerous low voltage, hard-to-access toxics, and high-voltage.

¹⁰ Photonis claims protection for drops of a meter with their boxes. We believe this to be very conservative.

¹¹ We also know this from having a tube survive falling out of the back of a truck on Rte. 40 (at 120 kph?) and surviving unharmed.

¹² Available from a number of suppliers, including Uline, Inc. in the States (www.uline.com).