

## Adding a Second ACD HVBS to Each FREE Board

### Motivation

The decision to de-scope the ACD electronics design by removing the planned (stand-by) redundant HVBS's was originally made as a cost-saving measure. At the time of the ACD Peer Review in July 2001, it was believed by many people that the efficiency of an ACD scintillator tile would meet the LAT requirement with only one of its two photomultiplier tubes (PMT's) functioning. However, the information available at that time did not take into account the expected 15% light loss in the fiber-to-fiber connectors. Since that time, careful measurements have shown that the tile efficiency is quite unlikely to be adequate with a single PMT.

Figure 1 shows the measured efficiency for two different flight-like tiles, as a function of threshold, with only one PMT per tile operating (colored curves), and with both PMT's on a tile operating (black curves).

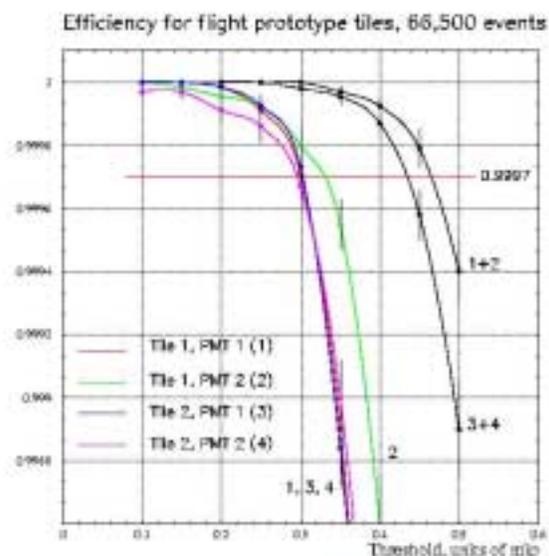


Figure 1 seems to indicate that the required efficiency (0.9997, the horizontal brown line) is met, at the nominal detection threshold of 0.3 MIP, with only one PMT per tile. Note, however, that there is no margin at all for three of the four PMT's used. Additionally, for these measurements no clear-fiber extenders were used. Although no tests have yet been done with the clear-fiber extenders, it is anticipated that the wave-shifting-fiber-to-clear-fiber connectors could cause a light loss of as much as 15%. (The clear fibers themselves should have essentially no loss.) Calculation of the effect of a 15% reduction in signal (light loss) shows that it will lead to a significant decrease in the tile efficiency. For single-PMT operation, the tile efficiency is expected to be about 0.9990, well below the

required 0.9997.

Since each HVBS powers the PMT's for 14-16 tiles, failure of a HVBS therefore reduces the efficiency for 14-16 tiles to  $\sim 0.9990$ . This is considered to be unacceptable, and thus the HVBS is considered to be a potential for single-point failure.

### **Reliability Rationale**

Based on potential failure criteria changes and their corresponding impact on the mission success, it is recommended that (stand-by) redundant High Voltage Bias Supplies (HVBS's) be added to each of the 12 ACD Front-End Electronics (FREE) circuit cards.

At the time of the decision to de-scope the ACD electronics design by removing planned (stand-by) redundant HVBS's, assumptions were made including the number of working tiles and Photo Multiplier Tubes (PMTs) needed to fulfill ACD mission success requirements. However, as the design process continued, potential changes to our baseline assumptions were identified that can significantly impact the likelihood for mission success. The changes are described in the table below:

<b>Requirements</b>	<b>Mission Success Assumptions</b>	<b>Potential Changes and Impact</b>
<ul style="list-style-type: none"><li>• <math>\geq 0.9997</math> average detection efficiency over entire area of ACD (excluding bottom row of tiles)</li><li>• No single failure in the ACD electronics shall result in the loss of signal from both PMTs on any single tile.</li></ul>	A total of 88 out of 89 ACD Tile Detector Assemblies and 1-out-of-2 PMTs assigned to each tile must be working to meet the detection efficiency requirement	<p><b>Change</b> - Given preliminary light yield analysis, 2-out-of-2 PMTs assigned to each tile will likely be required to work in order to meet the detection efficiency requirements. This is especially true when a reasonable level of PMT performance degradation is considered.</p> <p><b>Impact</b> – Loss of a single HVBS would constitute a single failure resulting in the loss of up to 18 PMTs supporting 18 different tiles.</p>

The addition of (stand-by) redundant HVBS's eliminates the potential *single-point* failure mode.

### **Cost Impact**

+~\$60K (includes fab, parts, populating, functional testing, thermal vac testing, and a 2nd functional)

### **Schedule Impact**

None expected (fabrication and assembly to be done in parallel with first 14 units)

### **Volume Impact**

Minimal impact expected (Two units to be stacked, slightly increases HVBS box actual volume but leaving available area for FREE board unchanged)

### **Mass Impact**

+12 x 120 grams = +1.44 kg

### **Power Impact (none)**

Each HVBS requires ~42 mw in standby mode. The addition of twelve (12) units in standby mode will therefore increase the ACD power requirement by ~500 mw.