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	Responsible Engineer(s) Alex Moiseev	Supersedes None
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Document Title **LAT ACD Supplemental Detector Performance Tests**		

Gamma-ray Large Area Space Telescope

(GLAST)

Large Area Telescope (LAT)

Anticoincidence Detector (ACD)

LAT ACD Supplemental Detector Performance Tests

CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes	DCN #
1		Initial Release	

1. PURPOSE

This document describes supplemental light collection and efficiency testing of the GLAST LAT ACD detectors, including the scintillating fibers and the large bottom row scintillator.

2. Light Yield Test for Fiber Ribbon

Recently we decided to use 3-layer fiber ribbon to improve its efficiency. The ribbon made of 3 layers of 1.5 mm square fibers, made from WU scintillator, was subject of this test.

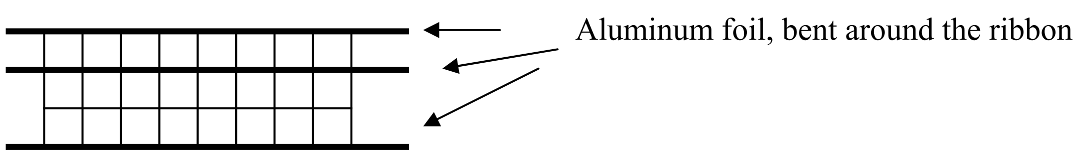

Fig.1 Ribbon: 3-layer ribbon, with 8 fibers in each layer

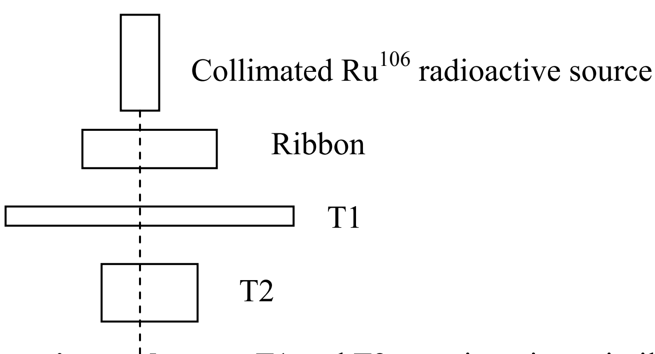

Fig.2 Experimental setup. T1 and T2 are triggering scintillators
T1 is 5 mm thick, 10 cm by 10 cm tile viewed by WSF
T2 is 1 cm thick, 1 cm by 1 cm scintillator, directly viewed by R647

The idea of the test is to use 3.5 MeV β–source Ru^{106}, and triggering by the coincidence from 2 consequent scintillators, T1 and T2. The problem is that the number of electrons which pass all 3 detectors (ribbon, T1 and T2) is very small in respect to the high rate of accompanying photons. This makes the measurement to be finely tuned. The ribbon length between the point illuminated by the source and the PMT window was 40 cm.

The obtained spectrum is shown in fig.3, and fitted spectrum is shown in fig.4 (photon background is removed to fit the *mip* peak).

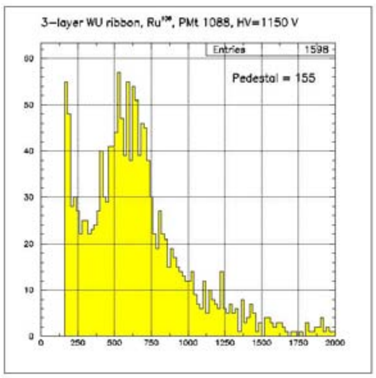

Fig.3 Obtained spectrum

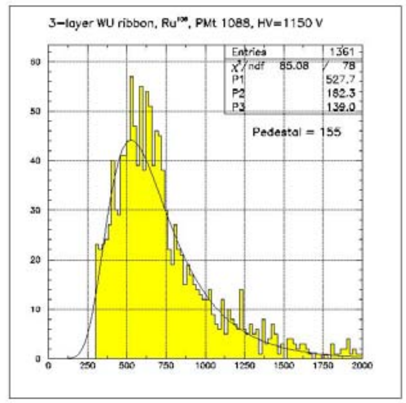

Fig.4 Fitted spectrum with *mip* peaked at 372.7 (after pedestal subtracted)

Re-calibration of used PMT (qualification PMT #1088) showed that it peaks at 381 for cosmic muons (*mip*) at the same HV=1150 V. So, the light yield of this 40-cm long ribbon is 0.986 of that for the MIP for PMT #1088. Our earlier tests showed that the light yield for this PMT, corresponding to single mip, is **21 p.e.** Simple calculation gives the light yield for the ribbon of **20.7 p.e.**

Using measured earlier attenuation curve for WU ribbon (fig.5), we can scale this light yield to the worst place which is 150 cm away from PMT (comparing with 40 cm for the tested ribbon). Applying scaling factor of 0.4, we find **8.2 p.e.** at a farest distance from PMT.

In my recent gap simulations, I used the ribbon light yield of 9 p.e. along the whole ribbon. I believe that the obtained results are satisfactory. We hope to get slightly more light using ribbon made of Bicron scintillator (Bob Binns's expectation).

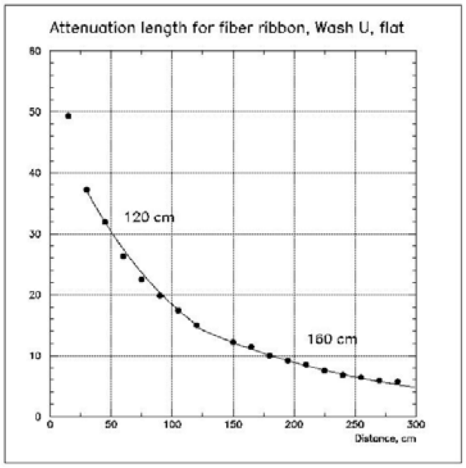

Fig.5 Attenuation length for fiber ribbon

3. Performance test results for the bottom row (long) tile

The tile for the bottom ACD row is single-piece, 170cm long and 15cm wide scintillator tile with embedded WLS fibers along the whole tile. The readout is provided from both tile ends with fibers bent inside the tile in the grooves.

Test task. Since the light output from this tile is strongly non-uniform, we have to measure what will be efficiency of MIP detection by this tile, depending of the detected particle hit position. Also, since this tile is long, we need to prove that with significant light attenuation in the WLS fibers (along the tile) it still meets the efficiency requirement.

Experimental setup.

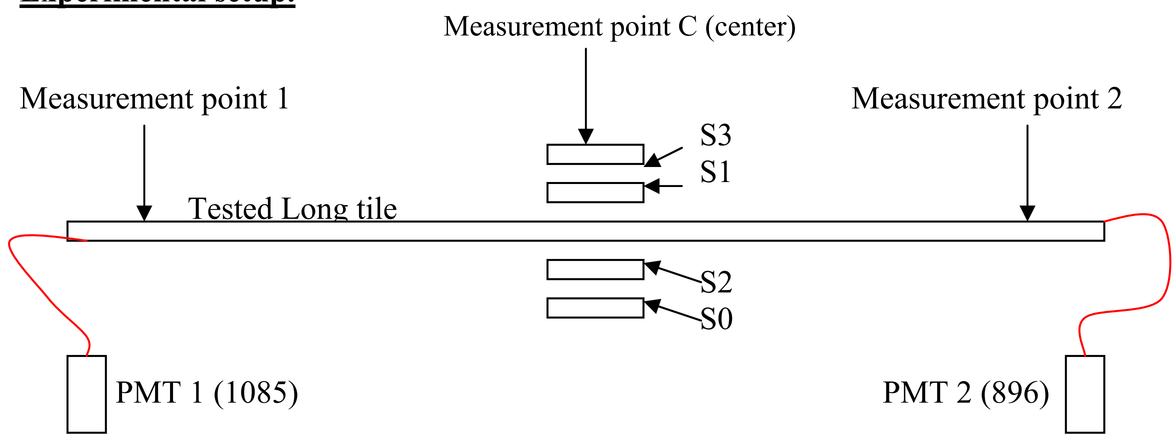

Fig.1 Experimental setup. The length of the tile is 170cm; measurement point 1 and 2 are positioned at 28cm from the tile ends, measurement point C is in the tile middle. The length of the fibers connecting the PMT and the tile is 46cm (shown by red lines). Cosmic muons are used for this test. S1 and S2 are 5cm by 5cm triggering scintillators, and S0 and S3 are the scintillators used to select good and clean muon events by PHA.

Results.
The efficiency of muon detection was measured assuming both PMT running (adding them in “OR”) and for the case of one PMT failure. The question is what threshold to use, because the light output from the particle detected depends on the distance between particle hit in the tile and the PMT window (effectively the corresponding end of the tile). I use the thresholds corresponding to the particle passage in the tile middle if both PMT are in a good shape, and the thresholds corresponding to the particle passage at the far from PMT tile end if another PMT is dead. The results are shown in four panels of fig.2 where PMT1 (#1085) is used as single PMT. This PMT has Q.E.=0.152 (just slightly above the required). Fig. 3 shows the results for single PMT 2 (#896) which has higher Q.E.=0.176. Improved performance is seen.

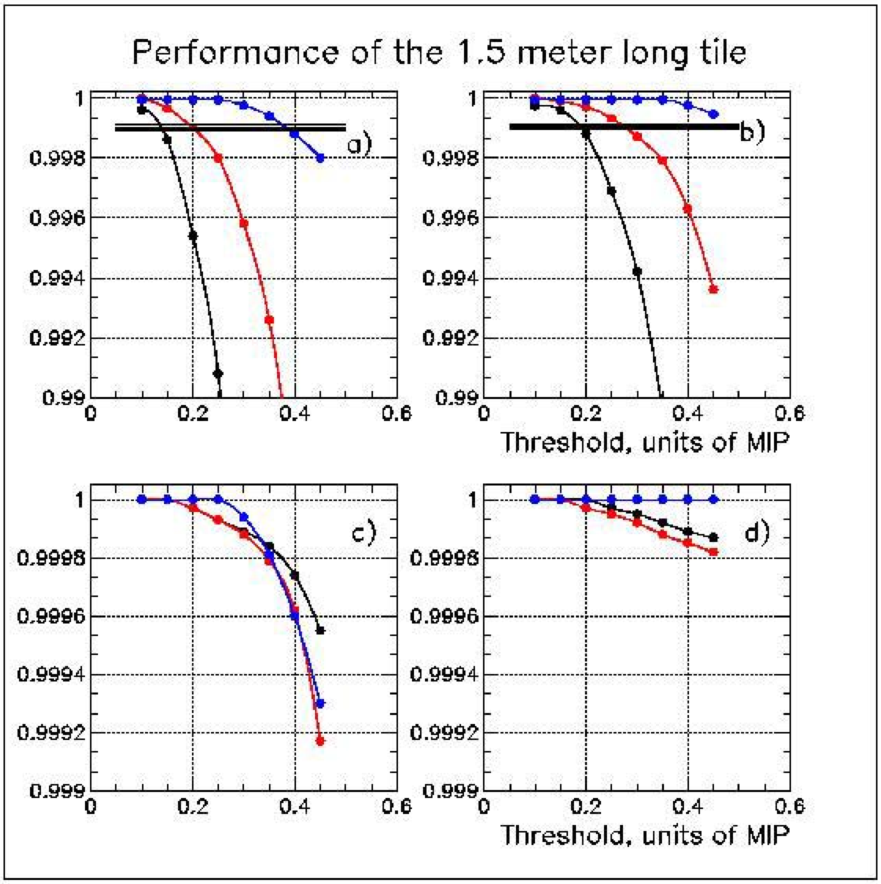

Fig.2. Efficiency for the long tile. Black lines correspond to the case when the muon passed the tile near the opposite tile end, red – in the tile center, and blue – at the same tile end where the PMT is. Panels a) and b) correspond to single PMT running, and panels c) and d) – both PMT running in "OR". Panels a) and c) are plotted for the threshold corresponding to the muon passage in the tile center, and panels b) and d) – in the opposite tile end. In the case of both PMT running the panel c) is applicable, and for one PMT running – panel b). PMT1 is PMT #1085 with Q.E.=0.152

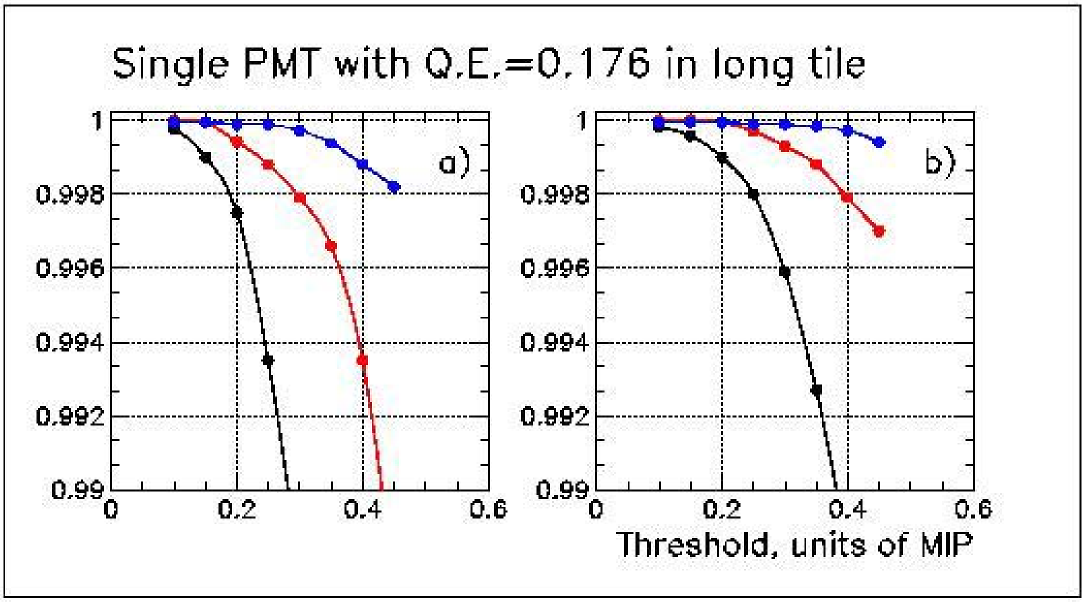

Fig.3. Efficiency for single PMT running. Same as at Fig.2 panels a) and b), but for PMT # 0896 with Q.E.=0.176

Variable threshold effect. The fact that the MIP produces different signals depending on its passage position, the effective threshold for each event is different. The effective threshold (in units of *mip*) can be approximately calculated from the following relations:

$T_{far} = 0.56 \times T_{close}$

$T_{middle} = 0.78 \times T_{close}$

Let's consider panel b) of fig.2 as an example. Blue line is made for the threshold set according to the far end, with the thresholds T_{far}, but for the particles passed near the PMT. So, for this curve the effective threshold will be T_{close}, and it can be obtained scaling the values at the X-axis by factor of 0.56.

Attenuation in the green fibers. Comparing the muon mean pulse heights, measured along the tile, the light attenuation in the fibers can be estimated and compared with that measured earlier (see my earlier notes).

Fiber length from PMT to the measurement point	74cm	130cm	187 cm
Signal attenuation measured in current test	1	0.7 – 0.8	0.55 – 0.60
Signal attenuation from previous measurements	1	0.78 – 0.82	0.60 – 0.68

We can see not too bad agreement.

Conclusion. Having 0.999 efficiency requirement for the bottom row tile at not-specified threshold, current test proves the tile design. With both PMT running, setting the threshold to 0.3 of the mip (based on their passage at the tile center), **the efficiency is >0.9998** at any position of the particle hit. In a case of one PMT failing, the threshold should be lowered to correspond to the farest position of the hit in respect to the healthy PMT, and threshold of 0.2 provides required efficiency of 0.999. I assume that backsplash is not an issue for the bottom tile.