Draft PMT Deployment Plan
29 January, 2018

This document describes the basic plan for obtaining Photomultiplier Tubes (PMTs) from a Vendor located outside of the U.K., testing them, cleaning them, and transporting them to the Advanced Instrumentation Testbed (AIT), cleaning them, and installing in WATCHMAN.

Work Flow:

1. When in full production, delivery rate will be 200 per month (this is conservative, as the actual delivery rate may be lower). If we need 3600 PMTs this will take 18 months. This drives many requirements. Faster installation means larger capacity facilities.
2. It will be necessary to place PMTs under power for 48 hours prior to testing in order to allow them time to stabilize gain and dark noise, and to have an initial "burn in" to tag defective units.
3. Initial testing will include setting individual operating HV to achieve a standard gain, then measuring the dark noise rate, after-pulsing rate, pre-pulsing rate, and relative full-face illumination efficiency at operating HV. Initial PMT testing will be done at the Boulby Surface Facility (BSF)
4. PMTs will be cleaned at the BSF before transport underground. Transport will be done using the original shipping boxes as shock protection.
5. PMT holders and associated fasteners will cleaned at the BSF and transported underground separately from the PMTs
6. PMTs will be integrated with their holder at an underground clean room at the AIT site. A final QA check consisting of a visual inspection, final cleaning, base resistance, and test of power-on visible pulses before installation.
7. PMTs will be installed in a clean environment established in the tank
8. PMTs will be checked after tank installation via power up to operating HV and observation of pulses. Plans will be made for replacement/repair of identified defective units *in situ* as needed.

Assumptions:

1. Surface clean room will need to hold at least 400 PMTs at a time (two months delivery, assuming installation could sometimes be delayed). Conservatively estimating we have 12-inch PMTs with boxes 50cm x 50cm x 75 cm, this would require a floor space of (0.5 x 0.5 x 400)/2 = 50 $m^2$ if they are stacked two high. CONSIDER RACKS WITH 3-4 HIGH
2. ADD IN CLEAN LAY DOWN AREA AT BUL
3. The BSF test stand would operate 5 days/week and thus need have a nominal test rate of 10 PMTs/day. Allowing for a factor of two for unplanned delays and equipment problems, the BSF should be capable of testing 20 PMTs at a time. Estimated floor space needed would be about 25 $m^2$
4. Electronic testing need not be done in a clean environment. PMTs can be tested and then moved through a cleaning area located next to the test stand.
5. The underground clean room should be capable of holding at least three days of PMT backlog, or about 30 PMTs. THINK ABOUT TWO DAYS/WEEK INSTALLATION

General Facility Requirements:

1. The BSF test stand + storage will require a nominal area of 50 $m^2$ plus 25 $m^2$ = 75 $m^2$. Assuming a 100% access space allowance, this corresponds to about 150 $m^2$ (1080 $ft^2$).

2. The BSF clean room estimate is 10 meters x 4 meters = 40 $m^2$. Assuming a 50% access space allowance, this corresponds to 60 $m^2$ (650 $ft^2$).
3. BSF needs to be climate controlled
4. The AIT site clean room should have a storage area of at least 30 x 0.5 x 0.5 = 8 m^2 and a clean room of about 6m x 4m = 24 $m^2$. Assuming an access allowance of 100% means 64 $m^2$ (690 $ft^2$).
5. The transport cart should only need to make 1-2 trips/day if possible. So, the cart should be able to transport 10 -20 PMTs at a time through the cage and drifts.