LST QC/QA Procedures and Test Part II:
Module Assembly at Ohio State and Princeton

This document outlines the quality control procedures and tests we will perform at Ohio State and at Princeton before and after the tubes are assembled to modules.

1. **Inspection of Shipping Boxes**
   - Every shipping box shall be visually inspected for any transport damages.
   - The bar code tag on the shipping box will be scanned and the appropriate information in the QC database will be updated (arrival time, location, possible damage etc.)

2. **Tube resistance and capacitance**
   With the tubes still in the shipping box but with the box endplates removed we perform the following tests on each tube.
   - Measure the resistance between anode and cathode. A small value indicates a broken wire or a similar problem.
   - Measure the capacitance between anode and cathode. While a study showed that this will not be sensitive enough to control wire tension this test will help to find tubes where one or more wires are not properly connected to the HV pc board. For a 3.7 m long tube with two layers of eight 9x8 cells the capacitance between anode and cathode will be around 340 pF. For each wire that is not connected to the HV board this will be reduced by ~40 pF.

3. **Leak check (still under consideration)**
   We are considering performing a second leak test (the first being done at Pol.Hi. Tech). Options include to submerge the tubes in water (that causes all kinds of problems and forces us to remove the tubes from the shipping box), to flush the tubes with argon and to use a leak detector around the endcaps (this is rather time/labor intensive and not suited for production quantities), or to monitor the pressure inside a tube with the gas outlet blocked (is that sensitive enough?).

4. **Long term test, burn in**
   With the tubes in the shipping box connect gas lines and HV. All tests will be performed with our standard Ar:Isobutane:CO_2 (2.5:9.5:88) gas mixture.
   - Flush for one day and about 10 volume exchanges
   - Turn on HV and monitor tube current. Since we don't know how well the tubes survived being shipped across the Atlantic we assume here that a few days of HV conditioning/burn in will be required. This will follow the same procedure developed for LST conditioning at Pol.Hi. Tech.
   - Tubes that don't reach 4900 V after 48 hours or that draw a current larger than 5 μA will be rejected.
   - Tubes are kept at 4900 V for four days (96 hours). The current drawn must not exceed 2 mA for the first day and 100 nA for the remaining 3 days. Tubes

failing these tests will be rejected.

5. **Signal Shape Test**
   - The (anode) pulse shape of each tube will be studied with an oscilloscope.
   - Pulses should be ~40 ns wide and 30 – 50 mV high.
   - Rejection criteria: anomalously shaped pulses or no pulses at all.
   - We are still investigating if pulse shapes (or the average over several pulses should be recorded in the QC database. Maybe it will be sufficient to just record the average pulse height.)
   - This test will be performed with the tubes in the shipping box.
   - Shielding either integrated in the box or around it will be required.

6. **Plateau Curves**
   - For each tube the plateau curve will be measured.
   - The plateau length should be at least 300 V with the ternary gas mixture (Ar: Isobutane:CO_2) (2.5:9.5:88).
   - The counting rate at the plateau region should be fairly stable (need to confirm this). Once the average counting rate for a test site has been determined we can use deviations from this value to identify tubes with bad cells.
   - The plateau curves will be measured without a pre-amplifier and with a discriminator threshold of 25 mV (needs to be defined/confirmed)
   - This test will be performed with the tubes in the shipping box.
   - For each tube the plateau and the counting rate will be recorded in the QC database.

7. **Tube Efficiency**
   - For QC tests 7 and 8 and of course for the following module assembly the tubes have to be out of the shipping box. Careful handling guidelines will be established once we gain experience with the prototypes.
   - For a sample of tubes we will determine the efficiency using a cosmic ray telescope.
   - The results will be recorded in the QC database.
   - Comment from Lu: Before we install the LSTs in BaBar we will have to measure the efficiency of every tube. The question is when this should be done.

8. **Scan Test with radioactive source**
   - This test consists of producing an exceptionally high rate using a radioactive source. This results in a high rate of charge exchange on the cathode which will allow us to identify non-uniformities in the graphite coating, in particular so called bald spots or graphite islands.
   - A radioactive source (OPAL used 10 μCi (or 370 KBq) ^{60}Co, we are planning to use several 5 μCi ^{137}Cs sources. A 1 mCi ^{90}Sr source is also available.
   - The source will be moved above each cell in every tube at a rate of approximately 10 cm/second to achieve a tube current of ~300 nA.

- While the source moves over the cells the tube current is monitored and the values are recorded on a computer (and eventually the QC database). This requires a HV power supply with fast current readback.
- Following the OPAL procedures we will classify the test results in 6 categories:
    a. Perfect behavior
    b. No peaks exceeding 1 μA.
    c. No more than 2 peaks exceeding 1 μA; no peaks above 2 μA.
    d. More than 2 peaks exceeding 1 μA or duty factor > 50%; no peaks above 2 μA.
    e. Worse than (d) but current returns to normal level spontaneously when the source is removed.
    f. Non-self extinguishing discharges.

- Only tubes with a grade of (c) or better was accepted by OPAL. We will adjust these criteria once we gain experience with our prototypes.

9. Inspection of ϕ strips

- Visual inspection. Look for bents, cracks, and transport damage.
- Measure resistivity (to find shorts) and capacitance between ground and signal traces.

10. Long term test II (one week)

- After assembly the modules are returned to the shipping box
- Attach gas lines and HV supply.
- Flush for one day and about 10 volume exchanges
- Turn on HV and monitor current in each tube.
- Modules don't reach 4900 V after 48 hours or that draw a current larger than 5 μA will be rejected.
- Modules are kept at 4900 V for five days (120 hours). The current drawn by each tube must not exceed 2 μA for the first day and 100 nA for the remaining 4 days. Tubes failing these tests will be rejected.