PMT REPORT, February 19, 1991. H.B. MAK

SNO-STR-91-12

1. Hamamatsu made 1 R1408 PMT out of the pot melt ordered in December. There were problems with the dimension of the glass bulbs; the wall was too thick. Hamamatsu had a hard time to make 1 PMT out of 30 or so 8246 bulbs. They are now testing this PMT. The contract required Hamamatsu to produce 1 R1408 PMT from Schott 8246 glass and show that this PMT can meet all the minimum requirements before production can begin (9-LF -M7719-1 page 7 of 7 item 14).

2. Contract calls for delivery of Schott glass bulb at the beginning of January 1991. This is delayed by approximately 2 months.

3. Hamamatsu will ship some evacuated PMT bulbs with dynode structure to Queen's University as soon as possible for pressure test (delayed by at least 2 months).

4. Hamamatsu shipped all the necessary samples of internal components to SNO for Th and U measurement. SNO received two of three such shipments. Mesurements of samples in first shipment is completed at Guelph, and the samples have been forwarded to LBL.

   Reults from Guelph:

Sample	Wt per PMT	Th (ng/g)	U (ng/g)	K (%)
PM50BD	14g	446+-23	133+-10	0.015+-0.001
PM76MB	5.7g	3436+-60	4110+-46	0.005+-0.002
SUS304	37g	14+-6	5+-3	0.001+-0.0005
NM-BA	47.9g	<3	4+-2	<0.0005
BSK18L64	30.2g	579+-38	1394+-26	1.963+-0.012

   It should be noted that BSK18L64 is the glass stem with 8cm long metal pins. These pins will be snipped after soldering to app. 1.7cm long.

5. It was decided that SNO will not ask Hamamatsu to use low Th and U ceramics (too expensive and Hamamatsu does not wish to use such important components from a company they do not know). Negotiation for using Schott 8246 glass in pin feedthrough stem is on going.

6. Report from Oxford University shows that PMT with higher photon detection near the outer edge of the photocathode would give higher overall detection efficency when used with a reflector. As the present PMT has higher efficiency near the edge already, it is not necessary to ask Hamamatsu to change the photocathode chemical distribution (the control of the evaporation process is not precise enough to justify a separate research contract).

7. Hamamatsu is not willing to develope a waterproof base for SNO, citing problems at Kamiokande as their concern. They can assemble the base and intall waterproof base onto PMT for SNO if the components are provided. It is not possible to do so within the time period specified by Hamamatsu. So SNO will have to assemble the PMT base.

8. Rob. Stevenson and Mitch Newcomer worked on the PMT resistor chain design and have reduced the ringing substantially. The single photoelecton pulse is around 20mV and the ringing is about 1mV at 30ns later. When the base is filled with SYLGARD, a silicon base dielectric gel, there is no observable change in the PMT pulse shapes.

9. Dr. H.C. Evans produced a prelimary design of the waterproof base enclosure. For cost consideration, the plastic casing will be made by injection moulding. Heat shrink tubing (manufacturer Raychem, estimated cost C$3.00 each). will be used to hold the plastic casing onto the PMT. The space inside the plastic casing will be filled with silicon gel (SYLGARD, pours like water when mixed, then sets with the consistency of jello in 24 hr. Even though there were some air bubbles after mixing, there are no visible bubble after it sets). Unfortunately, the tolerance of the glass bulb is such that the plastic casing will have to fit VERY loosely on the PMT stem (or neck) and cannot be used to align the PMT in the support structure, which LBL would like to do. One possibility is to use harder potting material. Further discussion with LBL is required. If the plastic casing is to be used for aligning the PMT in the support structure, extreme care is needed in assembling the plastic casing onto the PMT; heat shrink which may relax non-uniformly will probably be unacceptable as this may put too much stress on the PMT pins and plastic casing may move in time. BNC or similar connectors are mounted on a bulkhead extended from the plastic casing and waterproofing is done by means of rubber boots (Ocean Design) or heat shrink boots (Raychem) over the cable and bulkhead. Rubber boot samples from Ocean Design has been tested using small wire at Queen's University. Under water at 80 p.s.i. for 10 days, there is no indication that there is water leak. For budgetary purposes, the estimated price of the rubber boot is U$5.00 each, BNC connector is C$4.00 each, the heat shrink boot is C$1.00 each and the large heat shrink is C$0.15/cm. There are 3 other waterproof connector proposals, but they are more expensive.

10 The plastic used in the waterproof case must;

a. has low water vapour transmission,
b. can be used in injection moulding,
c. can withstand 100 degree C for approximately 10 minutes,

d. has sufficient mechanical strength,
e. can be glued on heat shrink tubings/boots,
f. resistance to potting compound
g. does not deform when placed in water for long time, and
h. preferrably clear.

Talked with expert at Dupont Research Lab. The conclusion is that for water barrier, high density polyethylene and polypropylene are the best. Coating the outer surface of plastic with Saran latex will also improve the water barrier properties. Unfortunately, the temperature range for such latex is 0 to 38 degree C, not very useful.

Possiblities suggested by injection moulders are

A. K resin; satisfies b to f and h, Moisture vapour transmission is 5gm-mil/100in*in/24hr. Likely to be ok for g.
B. SAN; fails condition c.
C. Zytel; water absorption is 0.45% in 24hr and 5.8% at saturation. This seems high (for acrylic, water absorption is 0.3% in 24hr)

So the search for plastic is not so successful. Will talk to injection moulders further for other possibilities. High density polyethylene {moisture vapour transmission is 0.4 (same unit as before) and water absorption is less than 0.03% in 24 hr} cannot be used in injection moulding. Low density polyethylene is possible {moisture vapour transmission is 1.5 (same unit as before) and water absorption is less than 0.04% in 24 hr}. However, polyethylene becomes brittle after long exposure in air and this process is accelerated by U.V.. So some thought on storage is needed (app. 3 years in air). Low density polyethylene is not transparent and the moisture transmission is only a facotr of 3 better than K resin. Samples of K resin has been shipped to LBL and Guelph for measurement of Th and U concentrations; prelimary results from Guelph show that this resin contains very little Th and U (at background level).

11. Plastic capacitors and surface mount resistors will be used in the final design of the resistor chain. Maximum resistance for each resistor is limited to 1 megohm, series resistors are used where higher resistance is needed. The total resistance of the chain is 17 megohm. Hamamatsu has approved a simple resistor chain of 17 megohm total resistance. Since this design is modified to reduce the ringing, new approval from Hamamatsu is required. New circuit board design will start in February 1991 and prototypee board will be available in 1 month for testing. Prototype board will be sent to Hamamatsu for approval. Will investigate if excess solder can be

applied to hole for PMT pin in the production of circuit board so that when the board is to be soldered to PMT only a heat gun is needed.

12. Rough time schedule for waterproof base.

a. Production of plastic mould = 4 months
b. Production of plastic casing = 1 week.
c. Production of heat shrink boots = 3 months
d. Production of mould for rubber boots = 4 months.
e. Production of rubber boot = 2000/month.
f. Production of connectors = app. 1000/month.
g. Production of potential divider circuit board = 3 months.
h. Approval from Hamamatsu 1 month (estimate)

It is expected that PMTs will start arriving at Kingston in October 1991, so all parts must be ready by the middle of September 1991. The final designs of all components should be completed by early April 1991 to give some leeway. Connector delivery can be spread out and rubber or heat shrink boots for connectors will not be needed until time for cable preparation (estimated time August 1992).

13. Tentative base assembly schedule.

a. Check PMT and install bar code.
b. Create data file and apply stickers to PMT box for Q.A.
c. Solder base onto PMT and secure BNC connectors to plastic casing (15 min.).
d. Measure after pulse probability, Q.C. on resistor chain to PMT pin connections. enter data into file and check Q.A. sheet (measurement time less than 20 min at 5khz pulse rate, technician time 2min.)
e. Heat up shrinkable tubing to support plastic casing (5 min).
f. Fill plastic casing with potting compound and let cure for 24 hours (5 min).
g. Sign and check off Q.A. sheet and data file.

14. Mr. Phil. Harvey is writing the data acquisition and display programs for the the measurments of single and multiple photoelectron (s.p.e. and m.p.e.) responses of the PMTs on a 386 PC. The C.A.E.N 111 CAMAC controller can read 48 QDCs in app. 0.5ms; so reading 48 QDC and 48 TDC will require about 1ms. This is acceptable because the pulse rate of the nitrogen laser SNO has is less than 20Hz. Data will be accumulated in related address mode with the threshold set at 1/6 s.p.e. level to allow maximum flexibility in data analysis in the future. Dyes to shift the laser photon wavelength to app. 400nm have been ordered. A quartz light

diffuser is now being assembled and the angular distribution of the scattered laser photon intensity will be measured within the next week or two. A second copper box to shield the laser radiowave radiation is under construction. The time dispersion of photon pulse in fibre optics has been investigated by Dr. J.R. Leslie and summer student N. Higgs, and they concluded that graded index fibre optics cable is the best; with a time spread of less than 3ns over a path length of 30m. Other fibre optics cable will be investigated. The TDC are not functioning and will be returned for repair (still under warrantee).

15. Items in darkroom to be completed by August 1991.

a. Installation of 4" laser light scatterers for each room.
b. Installation of black partitions to separate PMT into 4 groups.
c. Measurements of magnetic field.
d. Installation of current coils to compensate the vertical component of magnetic field.
e. Mark PMT locations on floor and install mechanical jig.
f. Install cables.
g. measure relative photon intensities at all PMT locations.
h. PMT collimators to cover photocathode.

(CONTINUE ON NES\XT MAIL)

16. Prototype computer controlled H.V. distribution board is being assembled. It will be completed by March 1991. Each board has 8 channels. The H.V. adjustable range is from H.V. supply voltage to 250V lower. Completed system will be installed and tested by July 1991.

17. Item in electronics to be completed by August 1991.

    a. H.V. distribution panel and computer control system.
    b. Check and set QDCs and TDCs
    c. Set gains and D.C. of all amplifiers.
    d. Complete all cable connections according to circuit diagram.
    e. Complete and test all computer programs.

18. Tentative automatic PMT test schedule,

    a. Change inputs to amplifiers (10 min).
    b. Set H.V. for 1.0E+07 gain on noise pulses (30 min).
    c. Set H.V. for 1.0E+07 gain on s.p.e. pulses (30 min).
    d. Measure s.p.e. response of PMTs (7 hrs. 50000 pulses at 2Hz)
    e. Measure m.p.e. response od PMTs (12 hrs. rate 20Hz).

19. One low pressure water tank for water leak test in now under construction. This will hold 12 PMTs. It is schedule to be tested in March 1991. 3 more water tanks to be completed by July 1991. Design for PMT holders in this water tank is completed. The room for water test has to be cleared by July 1991.

20. Tentative schedule for water leak test.
    a. Mount 48 PMTs on jig and place in water tanks (2 hrs).
    b. Test PMT in water under pressure for app. 22 hrs.
    c. Remove PMT from tank, dry PMT and connect short extension cables on PMT (4 hrs)

21. Mr. Bob Stevenson sent out specifications for pc based unit to measure after pulsing probability from 100ns to 0.1ms to a consulting firm in February 1991. This unit can measure 8 PMTs simultaneously, and will be used to check PMT base connections before application of heat shrink and potting material. The time bin is 100ns per channel. Proposal is expected within the next week or 2. Production is to be completed by August 1991.