Draft: Observations and Recommendation on the Rebuilding of Hodoscope Bars for the Big Bite Spectrometer

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Figure 1: Photo of a two scintillator assembly showing the straight versus curved light guides. The extra length to the light guides is necessary for the PMT assemblies to both clear each other and to clear the Big Bite frame.

Introduction: This report provides observations and recommendations for the rebuilding of the PMT assemblies for the Big Bite hodoscope scintillator bars. This report is based in part on the document presented by Marco Carmignotto on September 27, 2017, which is addendum to the end of this report.

The Big Bite Hodoscopes are comprised of a long scintillator bar that has a 25-mm by 25-mm cross section (Figure 1). To accommodate the PMT housing which is larger than 25-mm, every other scintillator has a curved light guide. This design necessitates long light guides supporting heavy PMT assemblies. A single glue joint holds the light guide to the end of the scintillator.

During 2019, several of the hodoscopes were observed to have broken scintillator light guide joints. The hodoscopes were removed from the Big Bite stand and several more were found to be broken. Upon further inspection and disassembly of the PMT assemblies, several issues were identified. The next section will detail the issues found.

Observations

Observation 1: The glue joint is insufficient to support the weight of the PMT assembly at the end of such a long light guide (Figure 1). Additionally, the surface of the light guide and scintillator was fully polished which degrades the strength of the epoxy joint.

Observation 2: The use of black RTV to seal the PMT housing and the magnetic shield was unnecessary and made removal of the PMTs difficult. Performing this duty while installed in the BB frame would have been impossible (Figure 2). The PMT base-collar and PMT have been partially removed from the assembly in the right hand picture of Figure 2. RTV sealant can be seen around the lip (right side) of the PMT base. This makes it difficult to remove the PMT base from the assembly during PMT replacement.

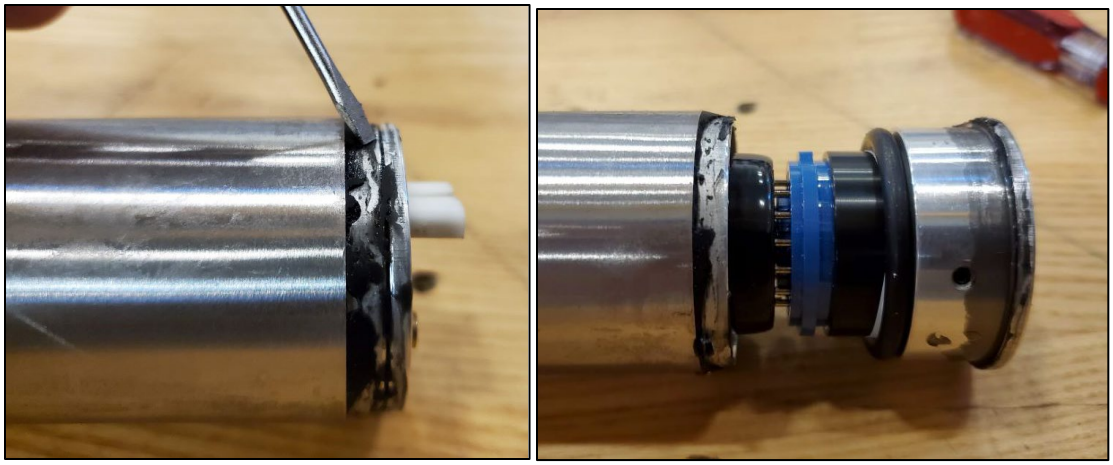


Figure 2: Two pictures of the PMT assembly and the RTV sealant around the PMT base collar and the mu-metal and inner aluminum pipe. This RTV sealant makes removal of the mu-metal and the PMT base and base collar very difficult.

Figure 3: A picture of the nylon washer in the aluminum pipe.

Observation 3: A nylon washer is placed inside the aluminum pipe to keep the PMT stable (Figure 3). During disassembly, many of the PMTs were found stuck in the nylon washer. Removing the PMT uses only the friction between the pins on the PMT and the PMT base (Figure 2). The nylon washer was very tight against the inside of the aluminum pipe and PMT, which often resulted in the PMT decoupling from the PMT base. In this case, it was necessary to use alternative methods to remove the PMT from the assembly. During experimental operations, these alternatives would not be possible.

Figure 4: Scintillator covering.

Observation 4: The use of blackout wrapping paper leaves the scintillators vulnerable to small light leaks and slippage of the covering. The coupling point between the scintillator and light guide was sealed with black vinyl electrical tape (Figure 4).

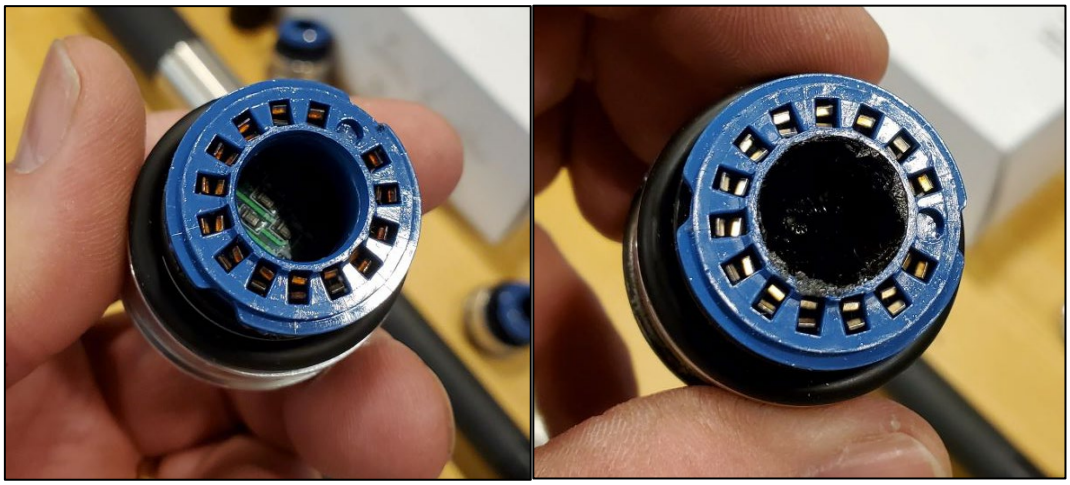


Figure 5: PMT base as it comes from the factory. (Left) PMT base with RTV sealant in the opening. (Right)

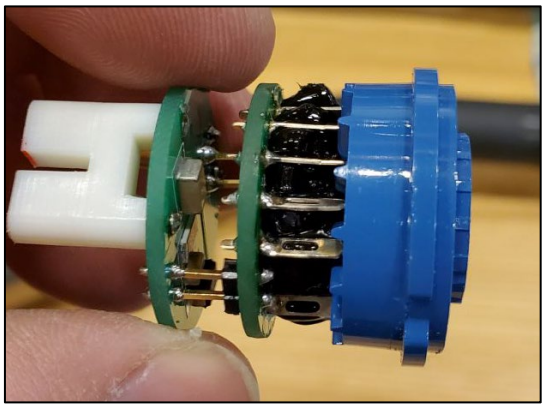


Figure 6: RTV sealant penetration into the wiring area of the PMT base.

Observation 5: The integrated PMT base has a large opening in the center (Figure 5). This is to accommodate the glass end of the PMT from the factory. This opening will allow light penetration through the board and into the PMT. RTV sealant was used to plug this opening (Figure 5) and does an excellent job while leaving room for the glass end when the base is installed. A closer inspection of the PMT base showed that the RTV had passed into the electrical area as shown in Figure 6. This raised the question of heat dissipation.

Figure 7: Connection point between the aluminum pipe and the light guide clamp collar. The small tube is the gas inlet port.

Observation 6: The light guide clamp collar (Figure 7) and aluminum pipe needs to be glued together securely. In some cases, a thin black glue or sealant was used in careful amounts and then covered with a thin clear tape. These units came apart easily with the mu-metal shield sliding off with relatively little trouble. In other cases, black RTV was used and not covered. This RTV smeared over the surfaces between the mu-metal and the aluminum pipe resulting in a need to apply unreasonable amounts of force to remove the mu-metal shield.

Observation 7: The mu-metal shield may be considerably longer than necessary. From Figure 8, the mu-metal shield can be seen to extend from the light guide clamp to almost the end of the aluminum pipe. However, the PMT is only present in the full assembly in the right half of the assembly. The pin end of the PMT starts about 15-mm in from the right side of this picture (picture not to scale) and the face of the PMT ends about 118-mm inside the assembly. The entire assembly from the top of the base collar on the right to the bottom of the light guide clamp on the left is about 180-mm This places the face of the PMT just to the left of center in the shielded area.

Figure 8: PMT assembly with mu-metal shield.

Recommendations

The following are recommendations for improving the mechanical stability of the hodoscope detectors. These recommendations will improve access to the PMTs in the event that they would need to be replaced in situ.

Recommendation 1: It is recommended that Glasgow collaborators test new types of scintillator glue and gluing techniques. This includes a slight roughening of the mating surface between the light guide and the PMT. At the time of this report, Glasgow was in the process of testing different glues and techniques.

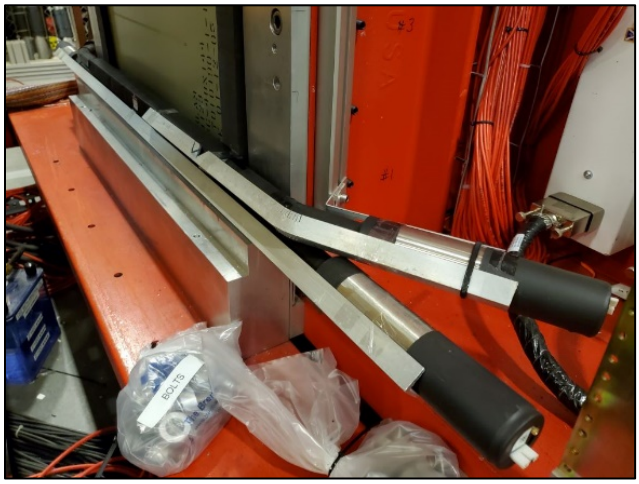


Figure 9: A photo of the mechanical support structure being fabricate and installed to support the hodoscope weight

Recommendation 2: It is recommended that a support system be designed and implemented to support the weight of the hodoscopes and remove some of the stress from the glue joint. At the time of the writing of this report, design work had been completed and fabrication and installation had begun (See Figure 9). It will be necessary to test several of the completed assemblies in such a way to assure that PMT R&R is possible. This means not placing too much force on the PMT assembly while removing the PMT and being able to access any holding screws

Recommendation 3: The use of RTV sealant on surfaces and connection points were removal is necessary should be avoided. Instead, the use of black electrical tape and black shrink tubing should be used to provide light tightness. If light tightness is in question, it is recommended that a full assembly be tested in a light leak test box.

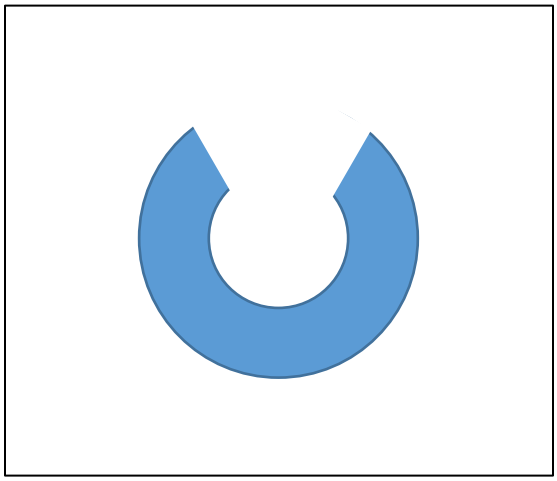


Figure 10: Drawing of the "horseshoe" shape recommended for dealing with the stuck nylon washer issue.

Recommendation 4: The PMT must move in and out of the aluminum pipe easily. This could be accomplished in a few ways. (1) The nylon ring could be cut on one side to form a horseshoe shape (see Figure 10). This would allow it to slip along the surface of the aluminum pipe but stay in contact with the PMT. (2) The inside of the nylon could be slightly enlarged to allow the PMT more clearance. Then the nylon washer could be inserted and stay permanently inside the pipe. (3) The nylon washer could be replaced with Teflon tape formed into the shape of a horseshoe (Fig. 10). It is recommended that this be investigated for several aluminum tubes to assure proper fit over many of the assemblies.

Recommendation 5: It is recommended that a PMT removal tool be designed and fabricated. This would be available for removing PMTs that have become decoupled from the PMT base during experimental operations.

Recommendation 6: The hole in the PMT base, Figure 5, will have to be plugged in one manner or another. The RTV appears to do the job well enough. The cutting of a rubber or Teflon plug is another option put may prove to be time consuming. The power consumption of the PMT base is estimated to be less than 1 watt. This should not lead to a heat problem. Since the RTV is an insulator, there is no chance of electrical short. It is not recommended to attempt to remove the RTV. It would be time consuming and most likely unnecessary.

Recommendation 7: An appropriate epoxy should be used to attach the clamp collar to the aluminum pipe (Figure 7). Care should be taken to assure that no material is outside the joint as to interfere with the installation and removal of the mu-metal shield. The epoxy should be fully cured before installation of the mu-metal shield.

Recommendation 8: The measured distance from the face of one PMT in its assembly to the outside edge of the light guide clamp was 62.5-mm. This was measured for only one setup. This gives a ballpark value for the distance the light guide is to be inserted into the assembly before the light guide collar is tightened. Since the PMT/base are not spring assisted, this will have to be tested for each assembly to minimize the distance between the PMT face and the light guide.

Recommendation 9: It is recommended to wrap the scintillators in acid free white paper and then covered with a layer of black vinyl tape. Overlapping the tape by half the width of the tape will yield a double thickness of the vinyl tape with minimum increase in space between detectors. Other solutions are possible and should be tested. It is also recommended to use

shrink tubing at the scintillator light guide coupling point. It can prove to be tricky and time consuming to wrap the vinyl tape around a square to round joint area.

Recommendation 10: The gas inlet tube should be aligned in such a way that access to the tube for installation of the gas lines is optimized. See Figure 9 for guidance given the necessary support structure to be added to the hodoscopes.

Recommendation 13: It is recommended to cut down the mu-metal shield. This is not necessary if time to do so is unavailable. The recommendation is to remove approximately 25-mm of mu-metal from the shield.

Recommendation 14: With the removal of some of the mu-metal (Figure 11), there will be sufficient space for a small hole to house a setscrew. This setscrew will hold the PMT base collar in place after assembly.

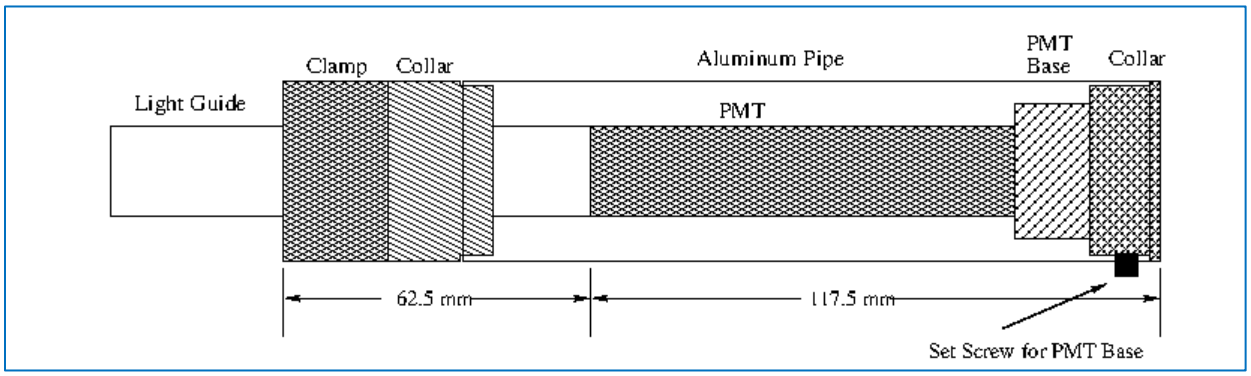


Figure 11: Schematic of the PMT assembly without mu-shield.

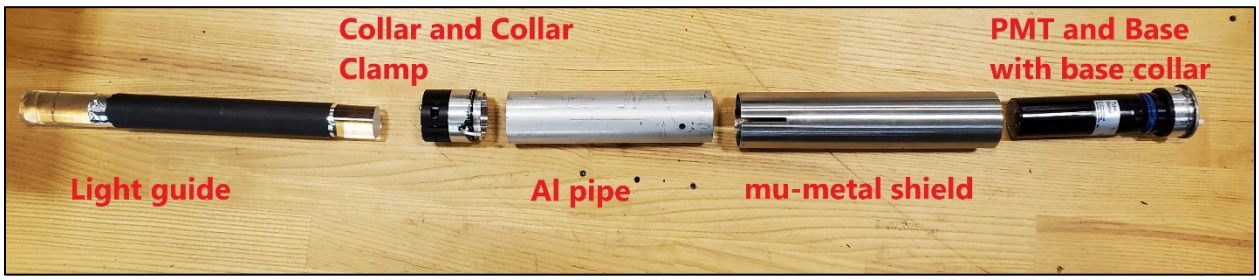


Figure 12: Partially disassembled assembly from the light guide to the PMT base.

Sources

[1] *"Suggestion to assemble the PMTs on the hodoscope bars"*, report by Marco Carmignotto, 27-September-2017.

[2] SBS Presentation, Rachel Montgomery, David Hamilton, and John Annand, University of Glasgow (2020)

Suggestion to assemble the PMTs on the hodoscope bars

Marco Carmignotto

September 27, 2017

This is a draft of procedures I put together as a suggestion to assemble the PMT components to the hodoscope bars. This is based on the design presented at the "BigBite Timing Hodoscope Installation" (by R. Montgomery, A. Clarkson, and C. Neilan - July 23rd, 2017), and also discussions with D. Higinbotham and B. Wojtsekhowski.

The following picture shows most of the components used for the assembly (picture from "BigBite Timing Hodoscope Installation"). In addition to those, a plastic set screw, an oring, and a stainless steel tube for gas inlet is used as discussed in the text.

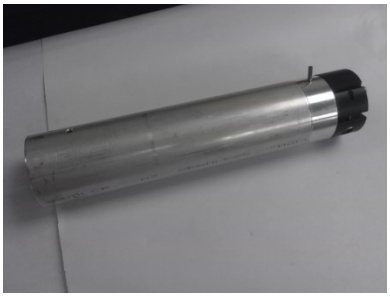
Procedures:

1) Polish the end of the light guide to have a good optical contact with PMT window (we'll need to prepare some support to hold the light guide while polishing).

2) Remove shrinking tube from the end of the light guide, exposing the Aluminized mylar.

3) Prepare one gas inlet, made of stainless steel tube 3/32” of external diameter and 0.5” long (not longer than this, so the heat shrink can still be inserted).

4) Glue the gas inlet to the existing hole on the side of the clamp collar, and glue the clamp collar to the “Al pipe”. We could use Epoxy for that.



5) Prepare the nylon washer with few grooves, to allow gas to flow from the front part (region of the PMT window) to the back (region of the HV base).

6) Attach the “base collar” to the PMT base using a plastic set screw. An o-ring placed on the PMT base seals any possible light leak from the gap between the “base collar” and the PMT base. The nylon washer goes around the PMT.

7) Attach the part from item 4 to the light guide using the “clamps”. The PMT setup is then placed in the “Al pipe”, making sure the PMT is touching the light guide. We could think about a spring based device to make sure the PMT is pressing against the light guide, so the PMT is always in contact with the light guide. What is the best alignment for the gas inlet relative to the bar?

8) Insert the mu-metal, with the gas inlet going through the slot.

9) Use heat shrink tube for sealing the region of the “clamp collar”/light guide, and also the region of the PMT base.