Budget Justifications for The GlueX Central Drift Chamber

GlueX-doc-764 (version 3)

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1 Materials

1.1 The Kapton Straws

The straw material for the CDC has an inside diameter of 1.6 cm and a nominal length of 175 cm. They are made out of 10 inch wide strips of 3.0 mil thick kapton. While the prototype had 1000 Angstroms of vapor deposited aluminum, we would like about 2500 Angstroms for the final chamber.

The kapton material was purchased from Sheldahl at a cost of \$ 8280 for 2000 linear feet of material. This was sufficient for about 1000 straws. To make about 3850 straws to allow for about 15% rejection, we will need about 7700 linear feet of kapton, which if costs scale from the original purchase, we arrive at a cost of \$ 31878.

To make the straws, the kapton is wound (non-overlapping) on a mandrel and then couter wrapped in a 1 mil think tape. The straws were manufactured by Precision Products Group/Stone Industrial at a cost of \$ 7565 for 940 straws. Extrapolating to 3850 straws yields a cost of \$ 30984.

Based on these estimates, we anticipate a cost \$ 62862 for for the total cost of all the straws.

1.2 The End Plates

The two end plates are each single item purchases. The upstream end plate is $9\,mm$ thick aluminum while the down stream end plate is likely to be a $\approx 4\,mm$ thick composite material. The plates are machined out of $60\,cm$ radius circular stock. Each plate has roughly 3300 wire holes drilled in them in precision locations. Of these, about $\frac{1}{3}$ are drilled at compound angles and counter bored to provide a flat surface for the pin holding the straw tube. The overall precision on the holes is at the $100\,\mu m$ level, which will be corrected to the $40\,\mu m$ level by measuring the location of each wire after the chamber is strung.

In addition to the holes for wires, there are on the order of 100 additional precision holes drilled for assembly and alignment as well as around 25 fiducial marks precision located on the plates.

A cost estimate made [1] for the end plates is \$ 20,000 per end plate. We are also exploring the possibility of a composite downstream end plate that may lead to an additional \$ 10,000 material cost. This yields a cost of \$ 50,000 for end plates.

1.3 Hole Location

After the chamber is strung, it will be necessary to measure the position of each of the wires at both ends of the chamber (relative to the fiducial points). This will require contracting with a vendor to come in and make these measurements.

1.4 Outer Shell Lips

The end plates will be attached to the outer shell of the CDC via a lip which is bolted onto outside face of the end plates at the outermost radius. These will be machines with groves to hold o-rings and holes through which the outer shell can be bolted.

1.5 The Outer Shell

The outer shell is anticipated to be a fiberglass tube which will attach to the outer lips at each end of the chamber. An estimate [1] for the cost of a carbon/epoxy outer shell is \$ 3,000.

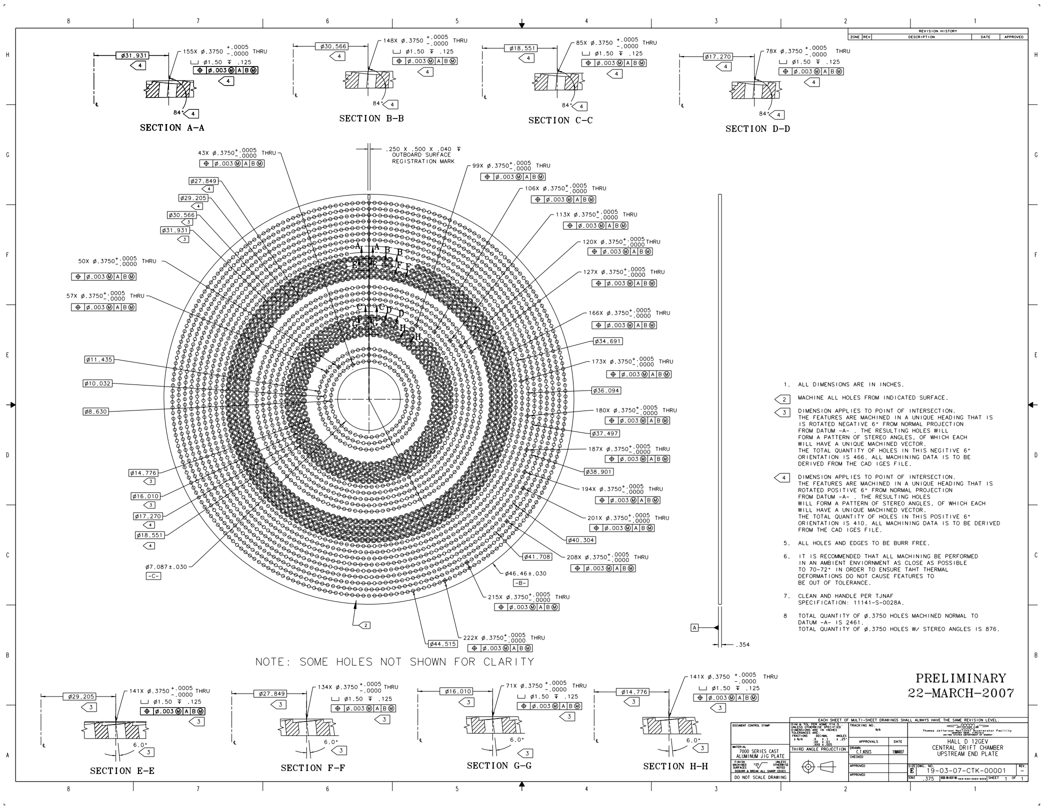

Figure 1: A mechanical drawing of one of the CDC end plates.

1.6 The Inner Shell

This shell needs to be a 176 cm long, thin shell which will be glued to the inside edges of the the two end plates. This is not load bearing, and is mainly to provide a gas seal at the inner edges of the chamber and present as little material as possible. The most likely scenario is a tube made from 10-mil thick mylar which has been formed to the correct diameter on a mandrel and then glued in place.

The estimate [1] for the cost of an inner mylar shell is $ 500.

1.7 The Crimp Pins

The crimp pins are similar to the straight pins used in region 1. However, we anticipate have a $\approx 100\,\mu m$ diameter hole in the middle. We nominally need about 7000 pins, but they all need to be checked for burs. With 50% rejection, we need about 10500 of these. Most such pins are purchased from MEDELEC in Switzerland.

The estimate [1] for the cost of crimp pins is $ 1.50 per pin. For $10,500$, we have a cost of $15,750.

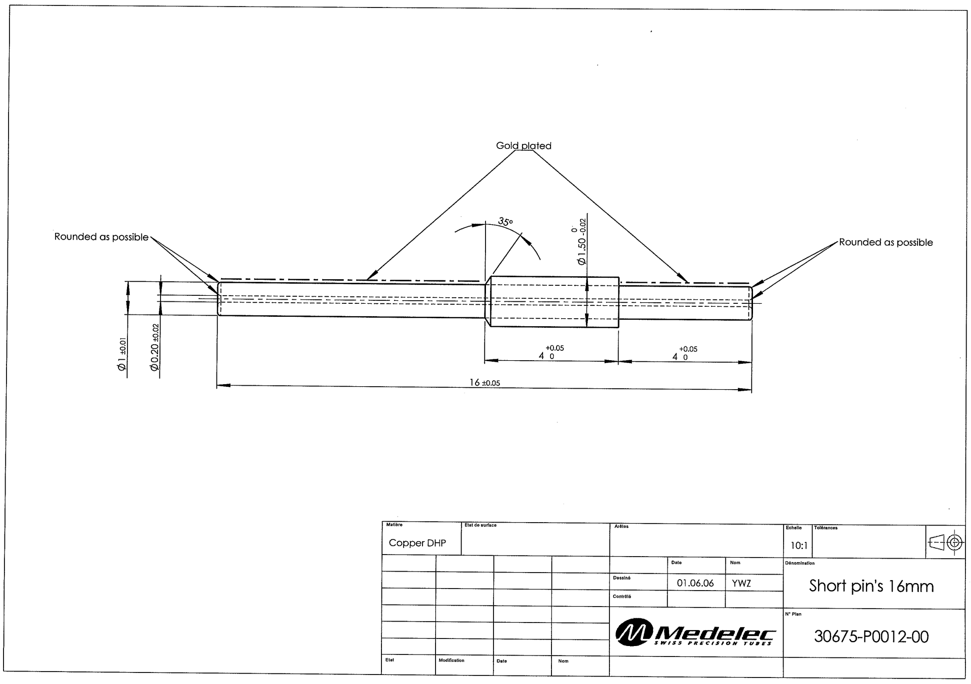

Figure 2: A mechanical drawing of one of the proposed crimp pin to be used in the CDC.

1.8 The Plastic Pin Holder

The crimp pins sit is an injection molded plastic piece that has a precision hole in the center to hold the pin, and three holes to allow gas through the ends. As with the pins, we need approximately 7000 of these, and allowing for 50% rejection, this goes to 1000 pieces.

The estimate [1] for the cost of this part is $ 6.00 per piece. For 8000 pieces, we have a cost of $ 48,000.

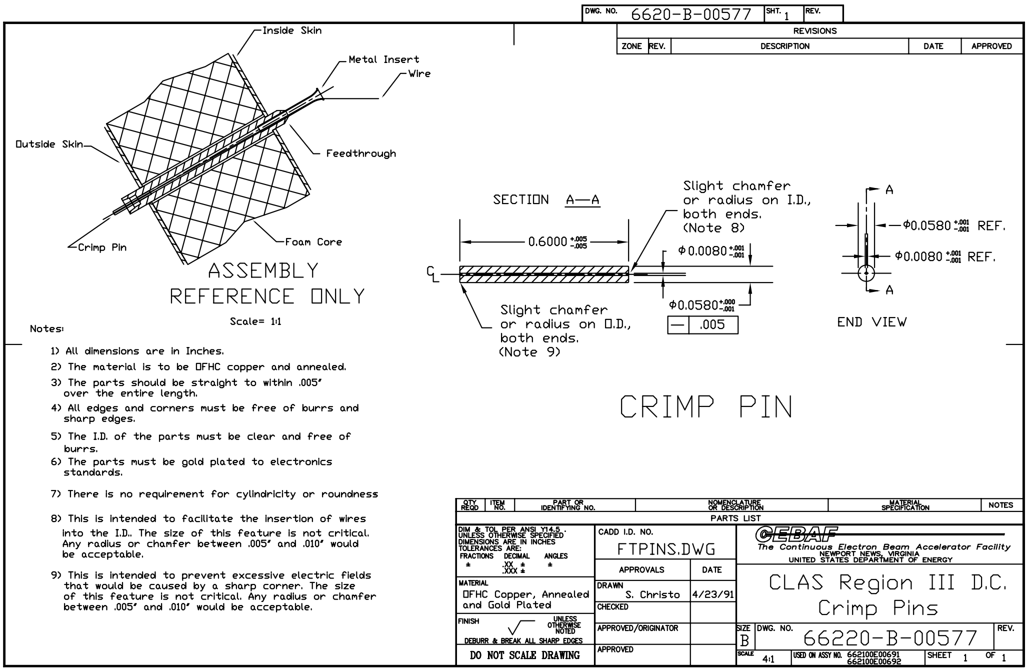

Figure 3: A mechanical drawing of one of the crimp pins used in the CLAS region three drift chamber. They are similar to those planned for the GlueX CDC.

1.9 The Donut Assembly

The upstream and down stream donut assemblies are similar, but not the same. In particular, the upstream is aluminum and the downstream is delrin. Each one consists of two pieces which can be turned out on a numerically controlled machine using round stock material. About 4000 of each piece is needed.

The estimate [1] for the cost of the donuts are \$ 3.00 each and \$ 3.75 for each sleeve. The cost for both the delrin and aluminum are the same, so 8000 of each piece yields a cost of \$ 54,000.

1.10 The High Voltage Distribution Boards

These boards will match the channel count of the preamplifier. Assuming 24 channels per board, we anticipate 140 of these plus 25 spares gives is 165 boards. Based on experience with the prototype, the boards can be made

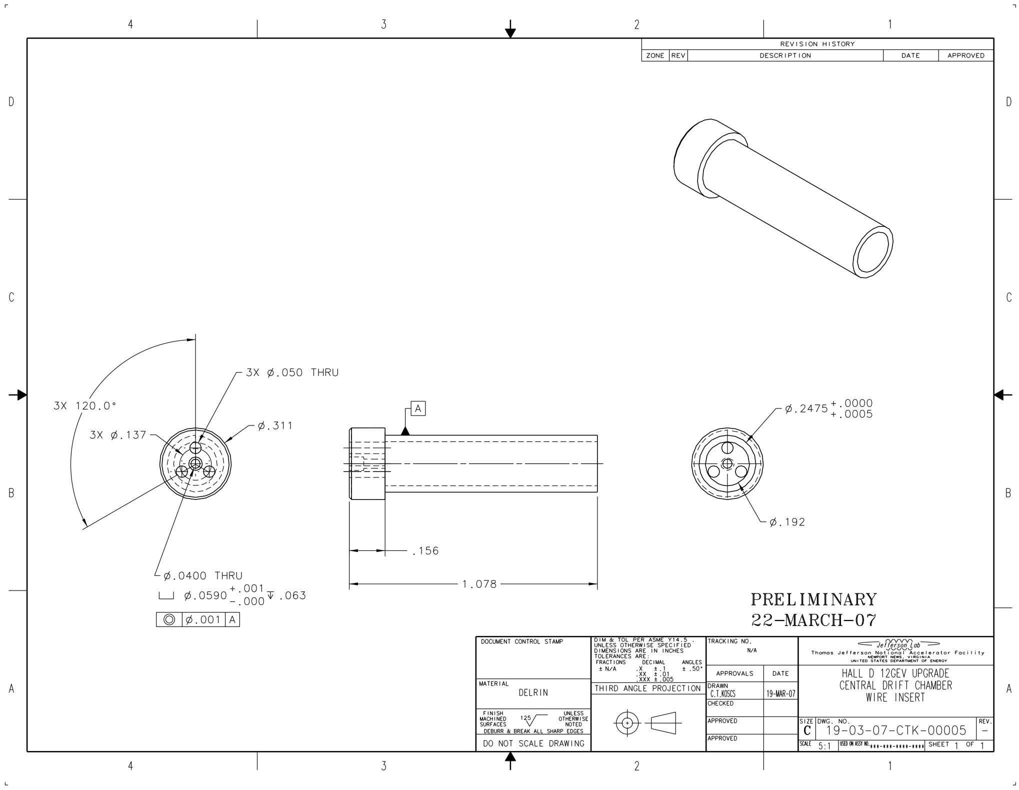

Figure 4: A mechanical drawing of one of the straw-tube wire inserts for the CDC.

for about \$ 15 each. The resistors, capacitors and High-voltage connectors exist at CMU and the connector for the preamplifier is about \$ 5 per piece. There are 26 capacitors and 50 resistors per board that need to be attached. A vendor with a machine like was purchased for IU could do the boards for \$ 15 each, leading to a per board cost of about \$ 35. The total cost for these boards for the CDC is \$ 5775 .

1.11 Preamplifiers

There will be 140 preampliers used in the CDC. With spares, we anticipate needing about 165 of these.

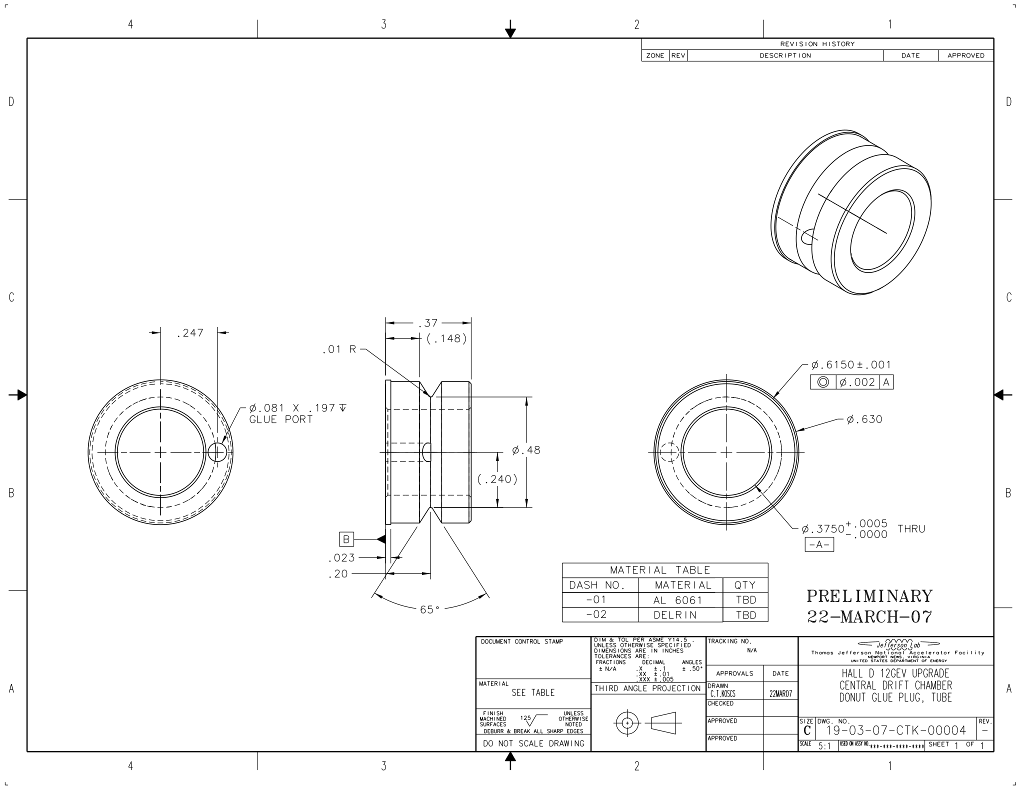

Figure 5: A mechanical drawing of one of the straw-tube donuts for the CDC.

1.12 The High Voltage Cables

There are about 140 High Voltage cables that come off the end plate of the CDC and go into a High Voltage system. We anticipate that these will be multiplexed so that all the tubes can be driven by about 20 High voltage pods.

1.13 The Signal Cables

There will be 140 signal cables

1.14 The Gas Flange

The upstream and down stream flanges are made out of Plexiglas. The most difficult part is the feedthroughs for the 3300 channels of electronics. This

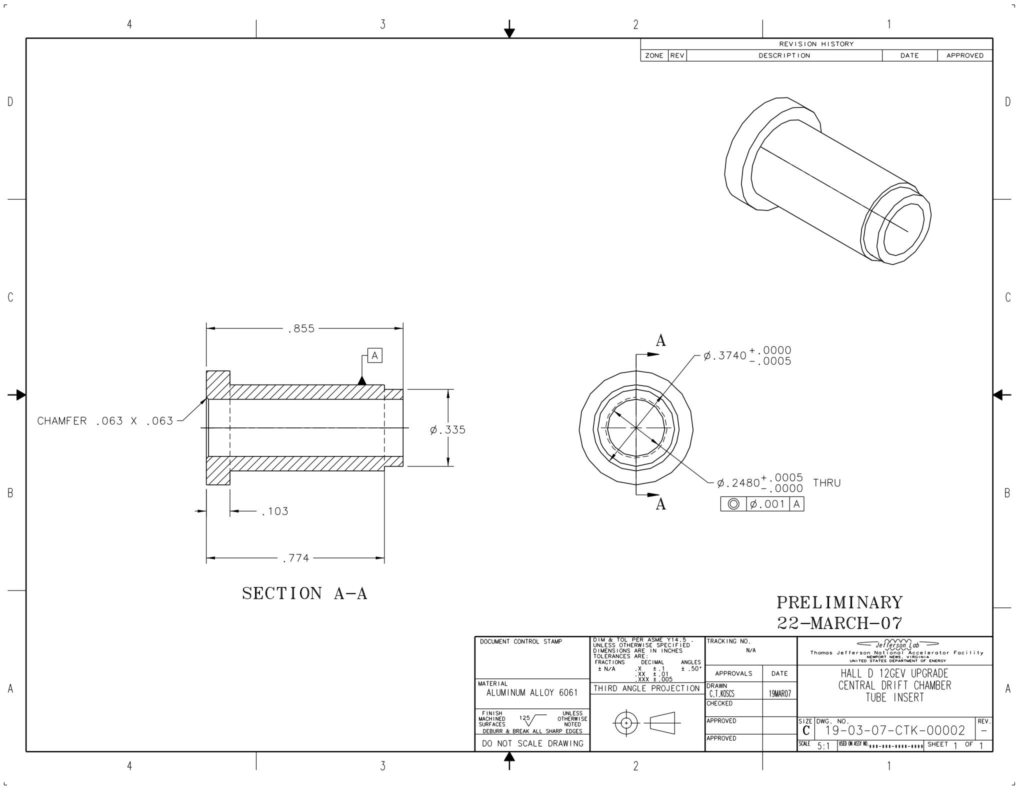

Figure 6: A mechanical drawing of one of the straw-tube donuts inserts for the CDC.

still needs to be designed. We anticipate costs of about $ 2,500 for the pair of plenums.

1.15 The Chamber Rails and Rollers

Non-magnetic rail bearings will be used to insert the CDC into the detector volume. Estimated cost [1] is $ 2,000

1.16 Insertion Cart

1.17 The Alignment System

The initial alignment of the chamber will involve pins on the downstream end plate that seat in the stops on the chamber rails. This will allow us to restore the position to an accuracy on the order of 1 millimeter. A survey of the the fiducial marks can then be used to determine where the chamber is to a higher level of accuracy. Finally, the relative alignment along the beam line can be assessed using a laser system with reflectors mounted on the down stream end plate.

1.18 Assembly Equipment

Assembly of the chamber will take place in a temporary clean room that will be erected at Carnegie Mellon. The chamber end plates will be attached to an axle (already exists) that can be suspended vertically for installation of the tubes and stringing the wires. In addition to the axle, rods will need to be installed that hold the two end plates relative to each other.

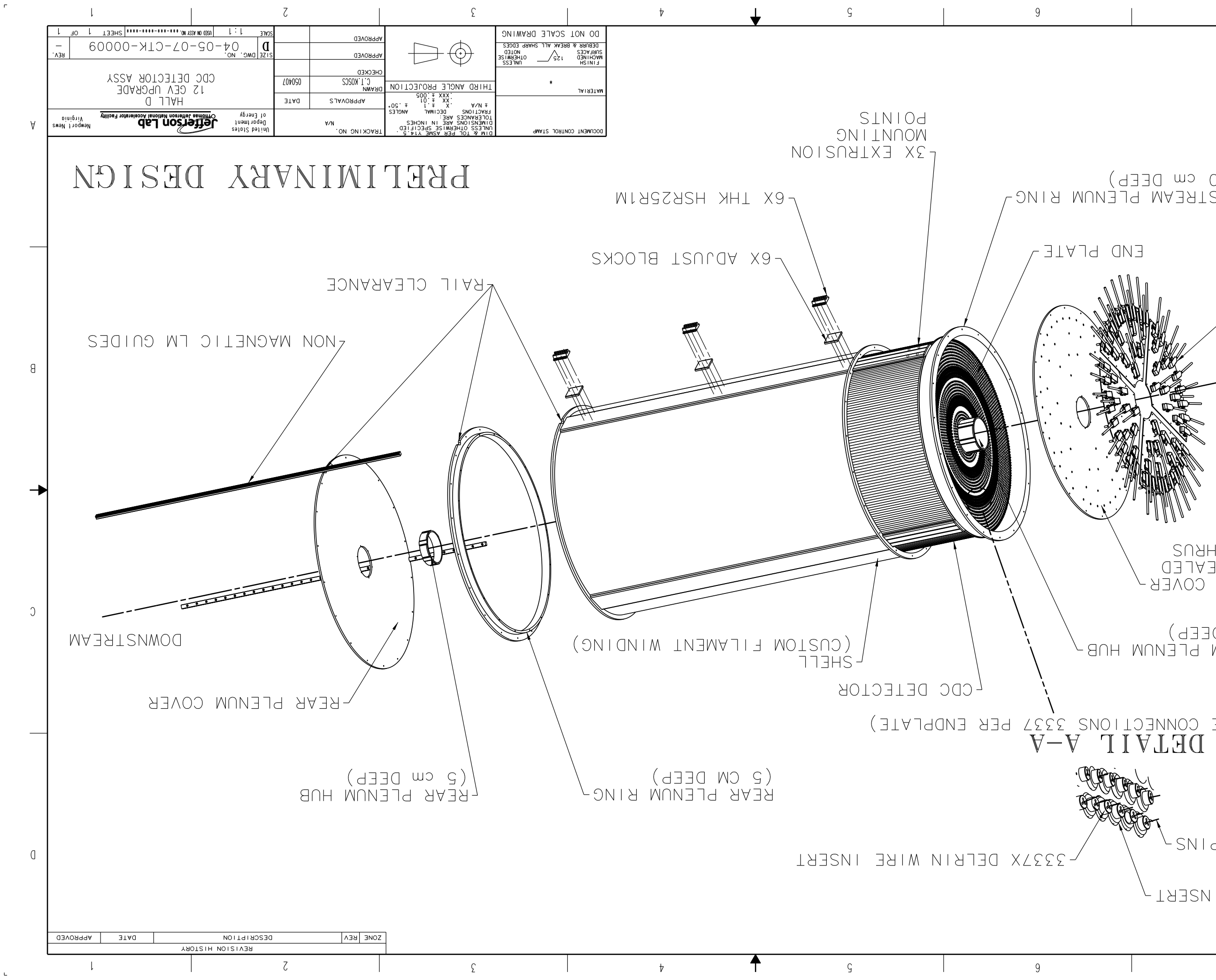

Figure 7: An exploded view of the CDC showing the parts needed in assembly of the chamber.

2 Construction of The Final Chamber

Time and manpower estimates for building the CDC are based on prototype construction carried out at Carnegie Mellon. During the period of 2002 through 2005, the Carnegie Mellon group designed and built a full-scale one-quarter prototype of the CDC. This work touched on all aspects of the chamber construction and is the basis of the time estimates for final chamber construction. The work started with the machining and drilling of two partial chamber end plates. We then sent the plates to Jefferson Lab where the hole positions were verified [2]. We then designed and built a stringing *jig* for the chamber and mounted the end plates.

With respect to the straws, we developed inspection and cleaning techniques, and then worked out how to cut the tubes to the proper length using a 10000rpm saw. After the straws had been cut, *donut assemblies* were glued into each end of the straw.

Once sufficient straws had been prepared, we inserted the straws into the chamber. This involved the remainder of the donut assembly being glued through the end plates into the straws. During the assembly, a spacer jig is used to correctly position the tube at the center of the chamber where is is glued to adjacent tubes.

After sufficient straws have been installed in the chamber, the stringing of the $20\mu m$ diameter wire can take place. The wire is inserted through the upper crimp pin, and then threaded into a magnetic needle and lowered through the straw. It comes out the lower end and is then inserted into a crimp pin. The upper crimp pin is seated and the wire is crimped. We then hang $55\,g$ of weight on the lower wire and crimp it as well. After the wires are strung, their tensions are measured.

Once the chamber is fully strung, the inner and outer shell are attached and the two gas plenums are installed. We then make electrical connections to each of the straw tubes which need to come through the plenum and go to a connector on the down stream end plate. The high-voltage distribution card with preamp are then put into the connectors.

In doing the chamber, we clocked the amount of time needed in each step as well as identifying the number of people needed to carry out the task. Except for the actual stringing, all other tasks can be carried out by a single person.

Time estimates for the final chamber construction include the time needed to inspect parts when they arrive, assemble the straws and then mount and string the actual straw tubes. It also includes the electrical hook-up of the chamber. These are based on numbers form the prototype construction.

2.1 Construction of the CDC

Upon completion of the final design for the GlueX CDC, the Carnegie Mellon University (CMU) group will take on the responsibility of building the final chamber for the experiment. This responsibility includes the detector itself as well as the electronics that mount directly on the detector (HVDB). The electronics chain from the preamplifiers into the Data Acquisition system will be the responsibility of other members of the GlueX collaboration.

The tasks necessary to build this chamber are shown along with a time line in Figure 8. The start date for this construction project is contingent on funding for the GlueX experiment. The tasks outlined represent approximately 3.25 years of work at CMU plus an addition 0.5 years installation effort at JLab. This plot is detailed in Table 1.

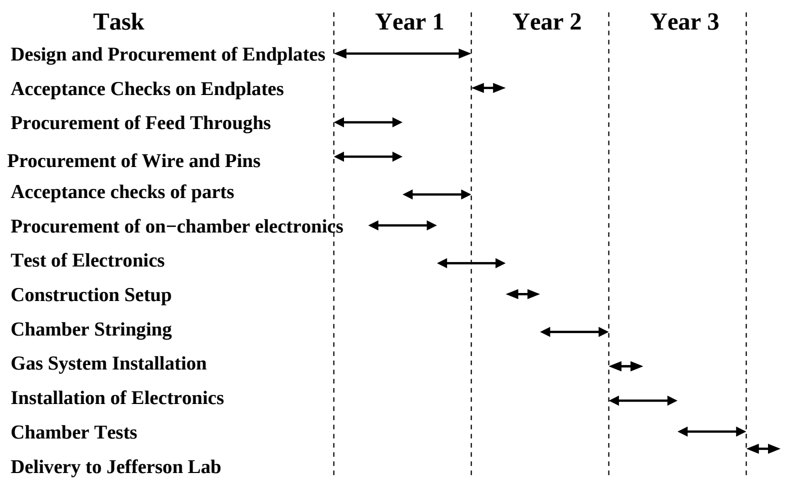

Figure 8: A time line for the construction of the CDC for the GlueX experiment. The start date and schedule are dependent on funding.

2.2 Manpower

The permanent manpower at CMU available for construction of the chamber is listed below. Included are also the estimates of amount of time available for this project.

- Curtis A. Meyer (Professor) will spend 85% of his research effort on GlueX.

Timetable for Construction	
+0 to +12 months	Design and Procurement of chamber end plates.
+0 to +6 months	Procurements of feed throughs.
+0 to +6 months	Procurement of wires and crimp pins.
+3 to +9 months	Procurement of on chamber electronics
+6 to +15 months	Acceptance checks of parts.
+9 to +15 months	Tests of electronics.
+15 to +18 months	Construction Setup.
+18 to +24 months	Chamber stringing.
+24 to +27 months	Gas System Installation.
+24 to +30 months	Installation of electronics.
+30 to +36 months	Chamber tests.
+36 to +39 months	Delivery to JLab.
+39 to +45 months	Installation of the chamber.

Table 1: The optimized time line for construction and delivery of the final straw tube chamber for GlueX. Start time is defined as start of construction funding.

- Gregg Franklin (Professor) will spend 50% of his research effort on GlueX.
- Reinhard Schumacher (Professor) will spend 50% of his research effort starting in 2010.
- Matt Bellis (Research Associate) will spend 30% of his time on GlueX.
- Yves VanHaarlan (Post Doc) will spend 75% of his time on GlueX.
- Gary Wilkins (Technician) will spend 75% of his time on GlueX.
- Unamed Student (Graduate Student) will spend 75% of his/her time on GlueX.

This manpower fully covers the *Contributed University Manpower*. In addition to this, the project will need additional *term labor* indicated as *undergraduate students* in the JLab Cost Book. As a matter of clarification, these will almost certainly not be undergraduate students, but rather short term labor which will be employed locally. CMU has had experience with this when the original CLAS region I chambers were built in Pittsburgh.

At this point in time, we also believe that the the staff/project part of the project will likely require an additional $\frac{1}{2}$ post doc during the middle year of construction. As the CMU group typically has three post docs, this can be accomplished with a one-year bump up and careful coordination in hiring of people.

References

[1] Tim Whitlatch, April 2007 based on costs estimates made by vendors able to carry out the work.

[2] Curtis A. Meyer, **Accuracy Measurements of the Straw-tube chamber End Plates**, GlueX-doc-61, (2002).