Construction of the Balloon Deployable Detector
By
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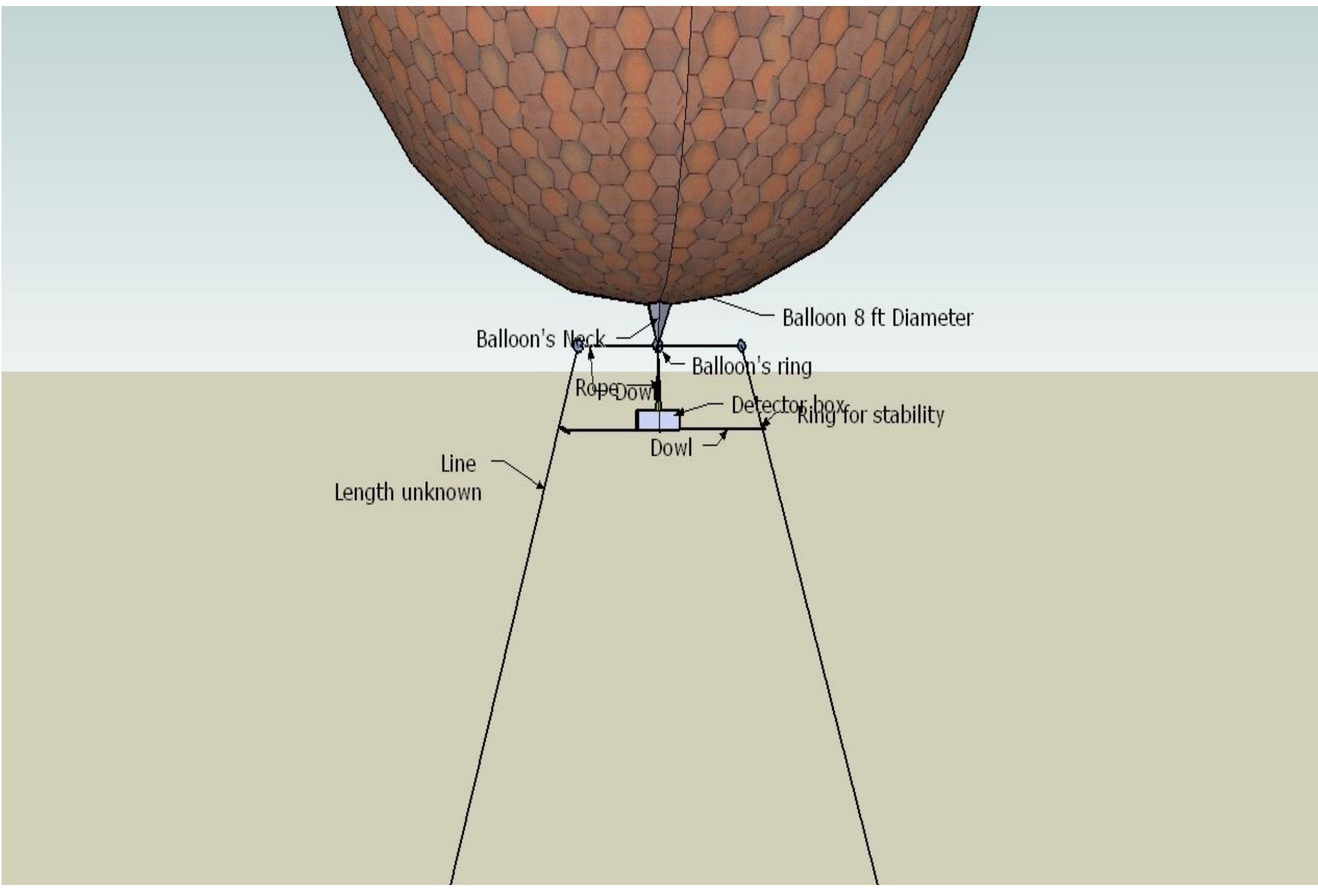

Components

The balloon detector consists of several different components:

- Box to house all the components
- Scintillator panel with two photo multiplier tubes
- Power supply board
- Xbee wireless serial transmitter
- Battery pack
- Quark net Board

Scintillator Panels:

To reduce weight, it was decided that we would use a single 1/4” scintillator panel with a rough size of 35x35cm. When we would only be using one panel instead of two, it is necessary to use two photomultiplier tubes. The two tubes gives us the ability to get coincidences from the scintillator to cut out noise. We decided to use a square panel because that allowed us to use the maximum amount of area from the panel we were given. To mount the two tubes, we cut off two of the corners of the square panel.

Quark Net Board:

The Quark net board is a board that we use to analyze signals coming from the photomultiplier tubes and output the data that we require as a digital signal. The quark net board has four signal inputs to get signals from four photomultiplier tubes. For our experiment, we only need two photomultiplier tubes so we only use two inputs on the board. The board then sends the signal through a discriminator to get accurate counts from noise. The board then counts coincidences to get rid of noise signals. The end result is a digital signal from the board with one signal being a single coincidence count and a numerical display that shows the total number of counts.

Xbee Wireless Transmitter

The original plan to send data from the quark net board to a computer on the ground using a wireless serial transmitter. After searching, we found the Xbee wireless transmitter. It was well suited for our use due to its light weight, low power requirements, long range, low cost, and its seemingly easy installation and use. Once we received the Transmitter and receiver pair, we discovered that we were lacking the necessary circuit to correctly interface with the transmitter. Due to a lack of time we switched to the back up plan of using a basic stamp as a data logger. The basic stamp turns on after 15 minutes once the balloon is at maximum Altitude then waits for an hour for the experiment to be completed then reads the data from the quark net board to be displayed on a computer when the balloon is returned to the ground.

Power Supply Board:

To supply all the power to the necessary parts (the quark net board, PMTs, and transmitter/data logger), we decided to build a specialized power supply board to suit our needs. Before we could design the board, it was crucial to find the required voltage and current needed by each component.

Component	Voltage	Current

Quark net board	5v	800ma
Each PMT	8v	20ma
Transmitter/data logger	3.3v	215ma

To supply the required voltages to each of these components we decided to use positive fixed voltage regulators that we could solder right onto a board. For the Quark net board, we chose a NTE960 to supply 5v, for each of the tubes we chose a NTE964 to supply the 8v, and for the transmitter/data logger we decided to use a TI 5cc85r9 to supply 3.3v. Because each of the voltage regulators came in a TO220 packaging, they could each handle up to an amp of current which is much more then what we would need.

Battery:

Choosing a suitable battery was one of the most important decisions in the project design. We needed to make the battery as light as possible, yet still allow for the electronics to operate long enough to perform our experiment. Julie Anne and Megan calculated that the balloon would have to be in the air for at least an hour to get a substantial count plus an extra half an hour to get the balloon up and down. We also calculated that all the components would be drawing a combined 1.075 amps total. This means that for a 2 hour flight we would need at least a 2Ah battery.

We decided to go with a Li-Ion battery due to its flat voltage discharge curve so that the voltage regulators could operate properly until the battery was almost fully discharged. For the voltage regulators to work properly we would also need an input voltage of at least 8v. Because Li-Ion batteries have cells with 3.7v instead of 1.5v we decided to go with a 3 cell battery with 11.1v. After searching we found a 11.1v 2200mAh battery at www.All-Battery.com for $25. The battery weighed a total of .15kg meeting all of out weight, power and pricing requirements.

Box:

After much debate, we decided to use a simple box that Steve Kliewer made for us. The box clamps down on the scintillator panel and encloses the PMT basses. The box is made out of balsa wood to cut down on weight and has four eye bolts to attach to the balloon. Unfortunately when the box was originally made it wasn't tooled perfectly to fit the scintillator panels and the PMT bases. Alex retooled the box with a dremel to fit the necessary components. Alex also fit some foam boxes to hold the electronics and secured them to the top of the box.

Construction

Because the box was already mostly built for us, the main components in our project that we had to build were the Scintillator panels, the power supply board, and the Xbee wireless transmitter boards.

Weight Requirements:

Weight was a critical component of this project. In order for us to legally fly a balloon without any prior FAA clearance, the balloon needed to be under 6 feet in diameter. To Fly the balloon we would need to keep the total weight under 5kg. Luckily, we were able to keep our weight down and so we would be able to fly with our 6 foot balloon.

Scintillator Panels:

The Design of the Scintillator panels was also critical part of our project. For information on building our scintillator panels, see Alex's report on Construction of a Muon Scintillator Detector.

Building The Boards:

During the construction of our project it became necessary to build several of our own PC boards. One for the power circuit and two for the Xbee transmitters. We used two different methods to create the PC boards. For the power board, we used a blank copper clad board that we drew traces onto using a dark marker. Once the lines were dry, we placed the drawn boards into a bath of $FeCl_2$ solution to etch off the copper. For the Xbee transmitters, we printed the circuit onto glossy photo paper using a laser printer. We then transfered the ink from the photo paper to the copper clad board using a hot iron. Once the ink traces were on the board, we once again etched the left over copper off the board using a $FeCl_2$ acid solution.

Putting It All Together

Putting everything together was one of the easier tasks of our project. The electronics and the battery were easily attached to the box using foam sheets and metal screws. In the end, the entire thing came in under weight and almost ready to fly.

Problems encounter

One major problem that we encountered was building the circuit for the Xbee transmitter/receiver pair. We had a couple successful communications with the Xbee and the computer but interfacing the two was a major challenge. It seemed that we needed a much larger and much more complex circuit to complete the interface. We didn't have the time or the resources to build such a circuit so we solved our problem by using a serial data logger instead.

The biggest problem that we encountered was with the quarknet board. When we went to do a test to see if the battery could supply power to the board, something went wrong and the board became unusable. We're not sure exactly what happened, but it could have been a power polarity issue or a power overload. Either way, we're pretty sure that one of the main capacitor blew out and caused a transistor down the line to also blow. Because the Quark net board was such an intricate part of our project, finding a solution was very challenging. There were several options, such as using a much underpowered board to do the discriminating and then using a FPGA programmable board to track and log data. But because of weight and time limits, our options were very limited and we were unable to fly.