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BooNE Technical Note 55

Assessment of the Risk of Tube Implosion at MiniBooNE

Len Bugel

Columbia University, FNAL, Stratton Mountain School

Abstract

In response to the accident of Nov 12, 2001, at Super-K, the MiniBooNE experiment immediately began assessing the possibility of a chain-reaction tube-implosion within our detector. There are significant differences between MiniBooNE and Super-K. The MiniBooNE detector is a substantially more stable system. Based on information available from Super K and SNO as well as calculations done by the author and others, we can say with confidence:

- There is no threat to human safety from tube implosion in the MiniBooNE tank.
- If a tube implodes within the MiniBooNE tank, calculations show that this will not set up a chain reaction destroying further tubes. Our safety factor is estimated to be $> \times 2$.

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I What is known about the Super-K Design and Accident

The detector is cylindrical, 36 m tall and 34 m in diameter. It is filled with water. Hamamatsu 20-inch phototubes line the interior of the tank on a phototube support structure. They are spaced 0.8 m center-to-center to give 40% photocathode coverage in the tank. As with all phototubes, the interior is a vacuum. The tubes are rated by Hamamatsu for 6 atm of pressure. We believe that this does not represent the failure point – it is simply the highest pressure to which the tube was tested. For this discussion, we assume that the detector is at sea-level. Therefore, when full, the pressure is 4.5 atm at the bottom of the tank.

This paragraph describes our knowledge of the accident, so far. Most of this information is available from the Super K web page [1]. The tank was being refurbished at the time. Work for the day was completed and the tank had been closed off. At the time of the accident the detector was 2/3 filled with water. The implosion began with a singe tube, probably near the bottom of the detector. The reason for the initial implosion is not yet known with certainty. One possibility which has been suggested is that something within the detector near the region of recent work fell and struck the tube. While this is a plausible suggestion, it may not be correct and the actual cause may never be known. The initial implosion set off a chain-reaction. Reports indicate that most tubes below 5 m of the waterline were destroyed and the support structure was badly damaged. All tubes within 5 m of the surface of the water survived the implosion.

II Comparison of the Super-K Design to MiniBooNE

MiniBooNE is a significantly smaller detector, which is spherical in shape and 12 m in diameter. We use 8-inch Hamamatsu phototubes which are rated to 7 atm. Again, we believe this represents the highest level tested rather than the ultimate limit of the tube. The tubes are spaced 0.55 m center-to-center within the MiniBooNE tank. MiniBooNE will be filled with oil, which is a factor of 0.9 less dense than water. MiniBooNE is at sea level. The absolute pressure at the bottom of the tank is, therefore, 2.05 atm.

III Conclusions Concerning Human Safety at MiniBooNE

All tubes are already mounted in the MiniBooNE tank and are inaccessible. The tank is now full of oil.. Since the filling process started, it has been impossible for a human to enter the MiniBooNE tank because the access is on the bottom, therefore, there is no danger to humans during or after the filling process from tube implosions.

IV Calculations Comparing Implosion Scenarios at Super K and MiniBooNE

Attached is a spread sheet which shows the calculations for a chain-reaction from tube-implosion for Super-K and MiniBooNE. We calculate the shockwave based on the stored energy in the tubes, assuming the pulse-length is the tube radius. It should be noted that the energy stored in the MiniBooNE tubes is over an order of magnitude less than the Super-K tubes. We are interested in the total pressure on a neighboring tube if an implosion occurs. This is the combined pressure due to the shock wave and the static pressure in the liquid. The tubes located at the south pole of MiniBooNE are under the greatest static pressure, therefore, we consider what will occur to neighboring tubes if one of these implodes.

We scale from the tubes which survived the Super-K accident. Recall that the tubes within 5 m of the waterline survived. Therefore, we compare the pressure in the shockwave for MiniBooNE at the bottom of the tank (12 m) for an 8-inch tube implosion to the pressure 5 m below the waterline in Super-K for a 20-inch tube implosion.

The pressure on the nearest neighbor in MiniBooNE is 0.45 of the Super-K case at the level where the tubes survived. This would indicate a safety-factor of two if the tubes in MiniBooNE were equally fragile as the Super-K tubes. However, we believe that the Super-K tubes are more fragile due to their large size. As a result, we are confident that we have a greater than $\times 2$ safety margin within our detector. Therefore an accidental implosion of one tube will not produce a chain reaction.