Lessons learned from Milagro Outrigger Detectors

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What is ... **Milagro?**

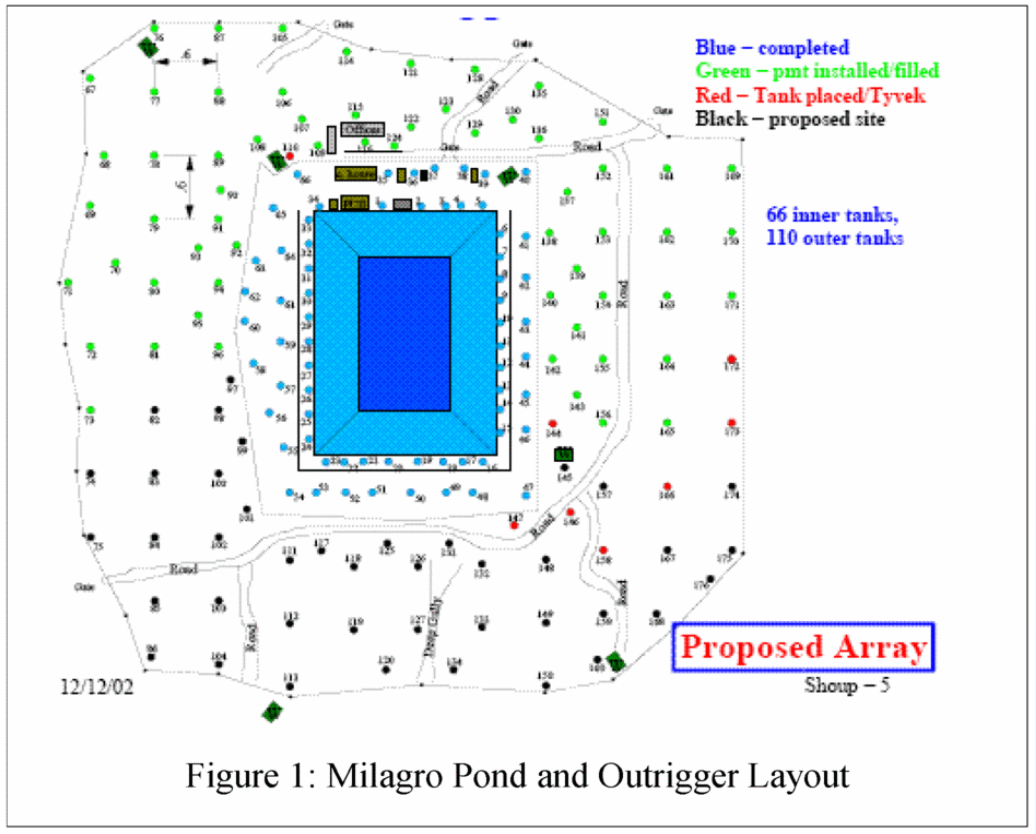

Figure 1: Milagro Pond and Outrigger Layout

- Extensive air shower array including:
  1. 723 Hamamatsu R5912SEL 8” PMTs ($800) 2-layers in 80 x 60 x 8 m^3 *pond*
  2. Array of 175 *outrigger* tanks: each 2.4m diameter (= 4.5m^2 area), 1 PMT/tank
  3. For more details go to: **www.lanl.gov/milagro/index.shtml**

What does... **Milagro look like?**

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- Details on the Milagro-*outriggers* provided by:
  1. Scott DeLay and Gaurang Yodh (U.C. (Irvine))
  2. Gus Sinnis (LANL)
  3. Tony Shoup (Ohio State (Lima))

Some Auger:Milagro-*outrigger* **similarities**

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Figure 2: Milagro Outrigger

- Water Cerenkov detectors
- TYVEK lined
- PMT readout
- Need to withstand harsh environment

Some Auger:Milagro-*outrigger* **differences**

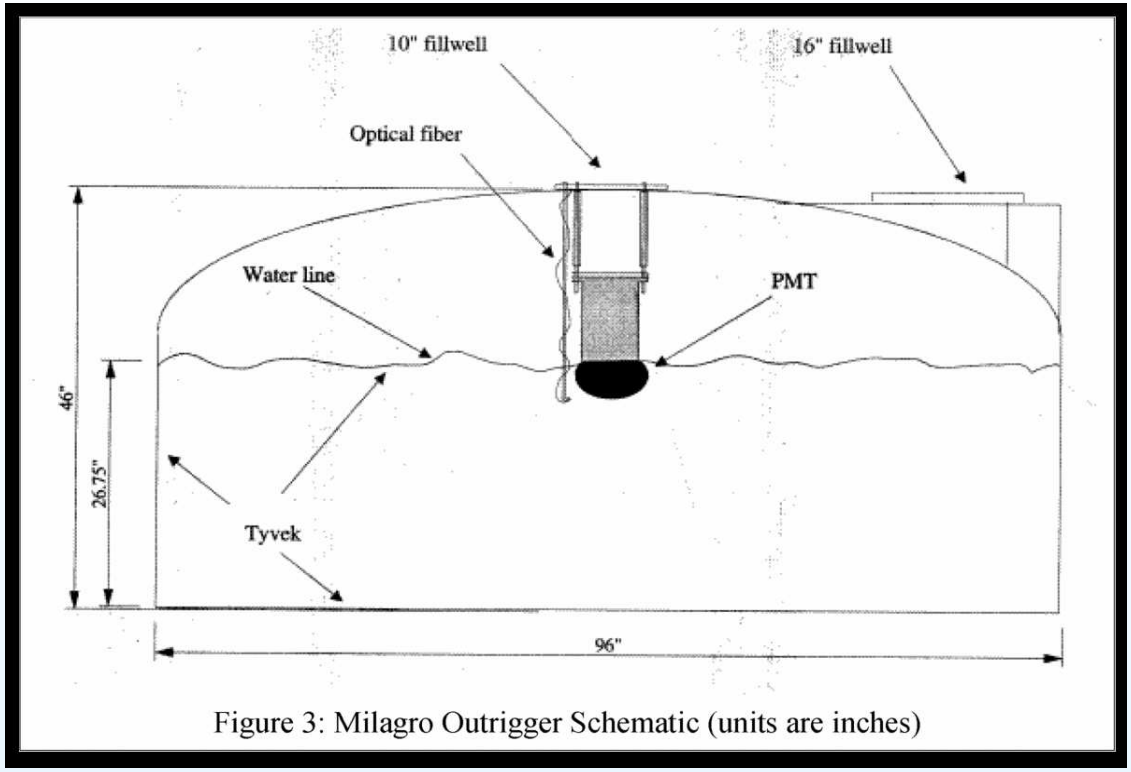


Figure 3: Milagro Outrigger Schematic (units are inches)

- **One** central PMT ... immersed in water (same housing as Milagro *pond* PMTs)
- **Only electronics is the PMT-***base* ... the calibration optical fiber has external electronics
- Filled with **clean** (not ultra-pure) water from Milagro *pond*
- Smaller water volume and colder winter temperatures (than Auger South) ... thus often “several inches of ice on water top surface/sides”

Simple TYVEK liner ... **design and installation**

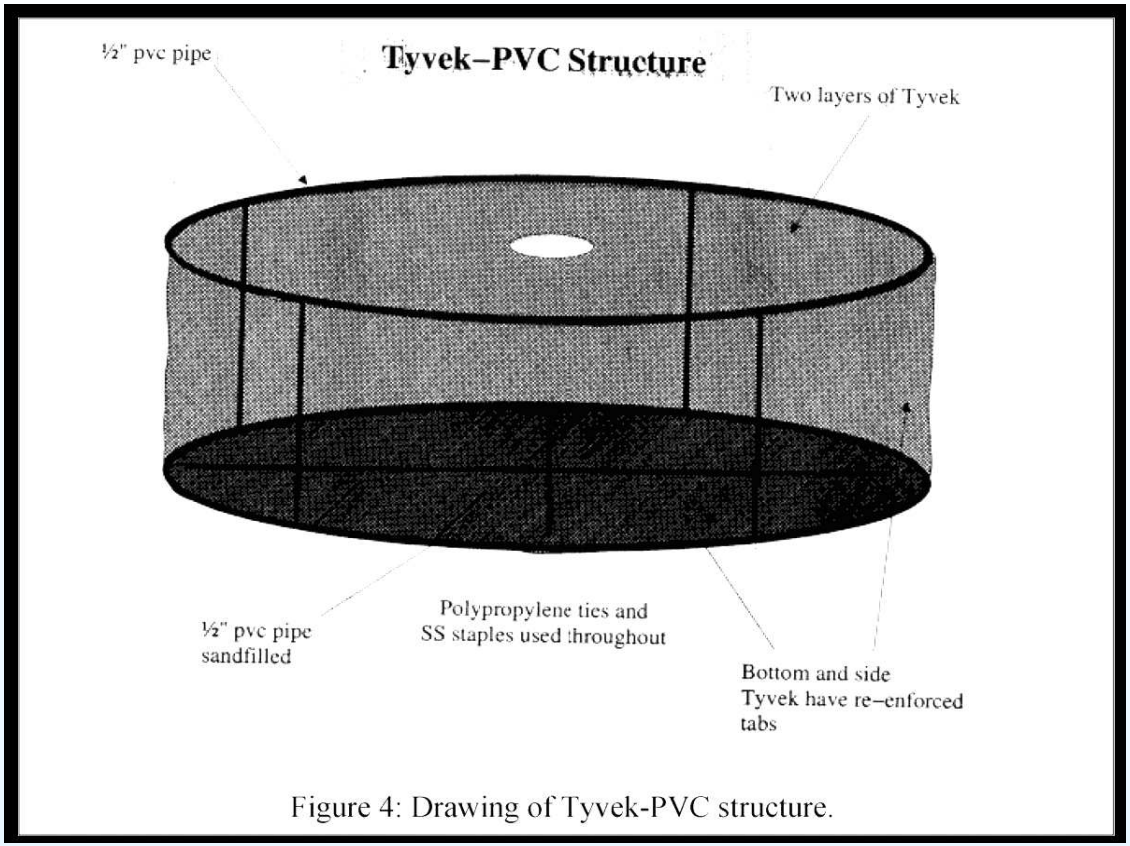


Figure 4: Drawing of Tyvek-PVC structure.

- 3-piece construction:
  1. Bottom piece (cable tied at periphery **plus** *X* of sand-filled PVC tubing)
  2. Cylindrical sides (pre-assembled in two *half* sections)
  3. Top piece that floats ...

Simple TYVEK liner ... **assembly steps**

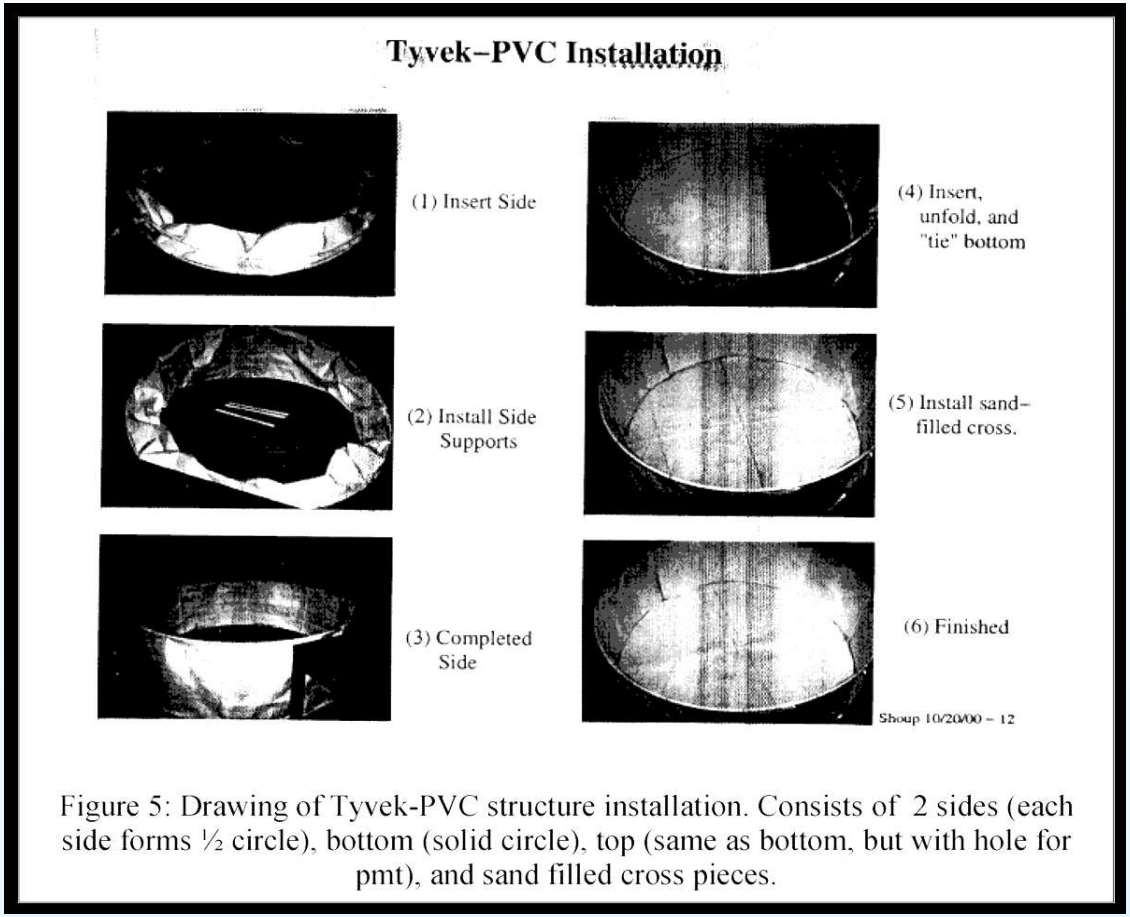


Figure 5: Drawing of Tyvek-PVC structure installation. Consists of 2 sides (each side forms ½ circle), bottom (solid circle), top (same as bottom, but with hole for pmt), and sand filled cross pieces.

- Liner components: TYVEK, PVC tubing and *T*s, cable ties, stainless steel staples
- Top, side and bottom pieces pre-assembled off-site ... using student labor
- On-site installation takes 1 technician $\sim$ 1 hour/tank

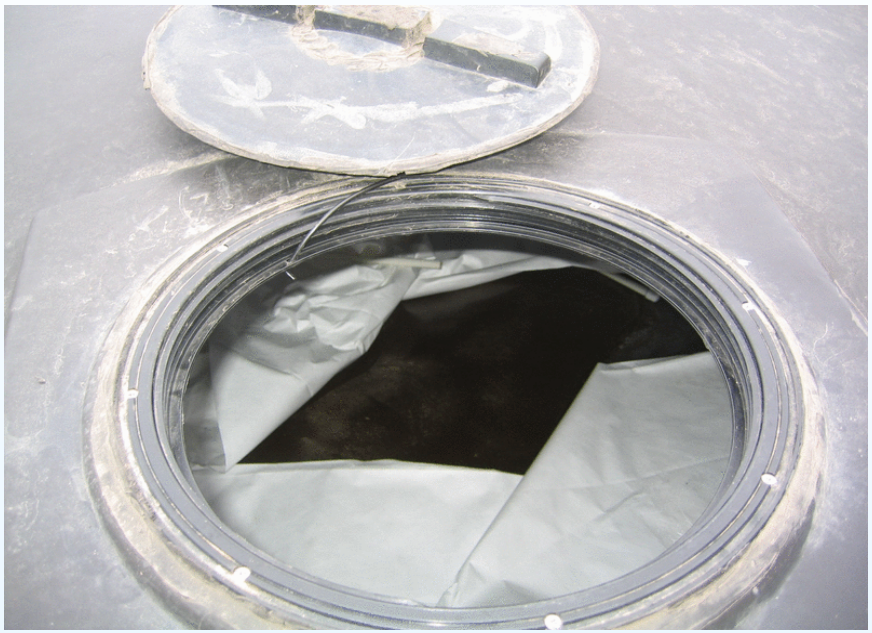
View of one tank ... **cylindrical side** *detail*

- View into tank being disassembled for shipment ...
- Tank had be running for $\sim$ 2 years
- **Every component looked as *new* as if it had just been installed!**

Another view of one tank ... **cylindrical side** *detail*

- View into tank being disassembled for shipment ...
- Wrinkling of the TYVEK on the sides ... representative or not?
- Top and bottom pieces of TYVEK and bottom *x*-pieces had been removed!

From outside ... **access into the tank**



- **LEFT** photo of the 16” access port ... simple threaded design
- **RIGHT** photo of the HV and optical fi ber penetrations (through smaller 10” access port)
  PVC tubes cover threaded rods that support/position the PMT

Tank installation ... **some preparation involved!**

- *Bobcat* used to clear/flatten the site.
- Often (but not always) road aggregate is added ... possibly for better tank-ground contact (**what about using sand?**)
- **And** most tanks have a plastic sheet under the tank.

PMT support ... **adapted Milagro** *pond* **design**

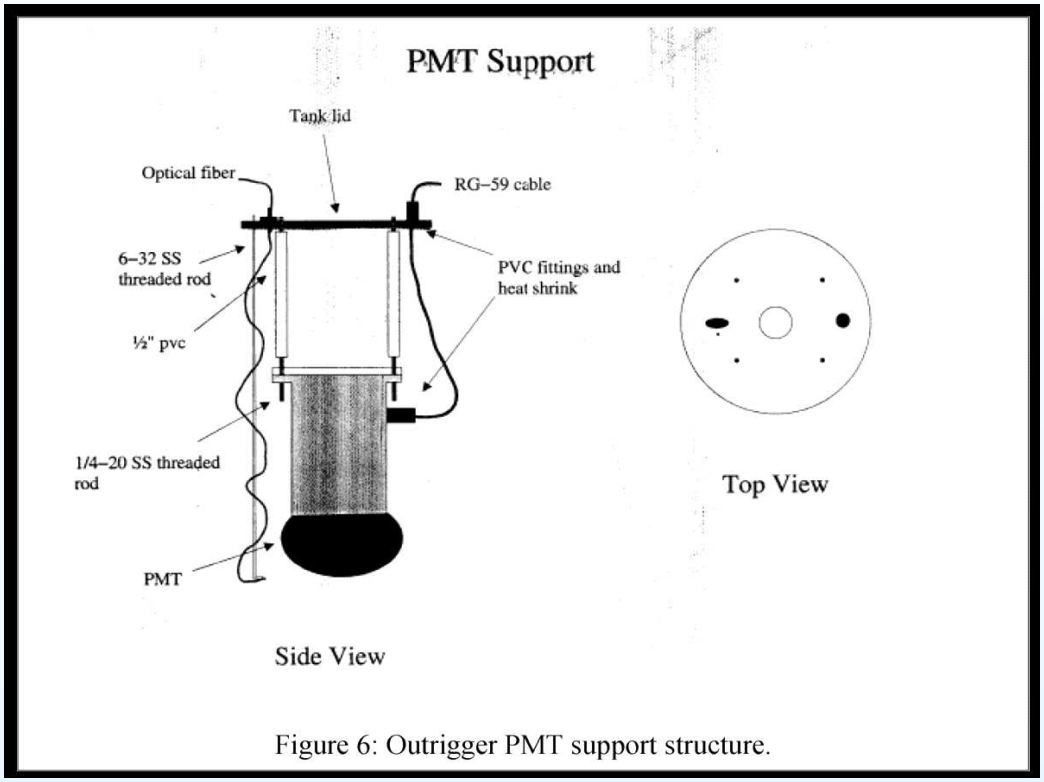


Figure 6: Outrigger PMT support structure.

- Water covers the PMT ... but not the entire PMT housing!
- Thus PMT base (electronics) subjected to extreme daily temperature fluctuations
- Some unhappiness with cable feed-through into PMT housing ...
- Ice formation has not damaged any PMTs (or effected the response significantly) but it has damaged the optical (calibration) fibers!

PMT housing ... **side view**

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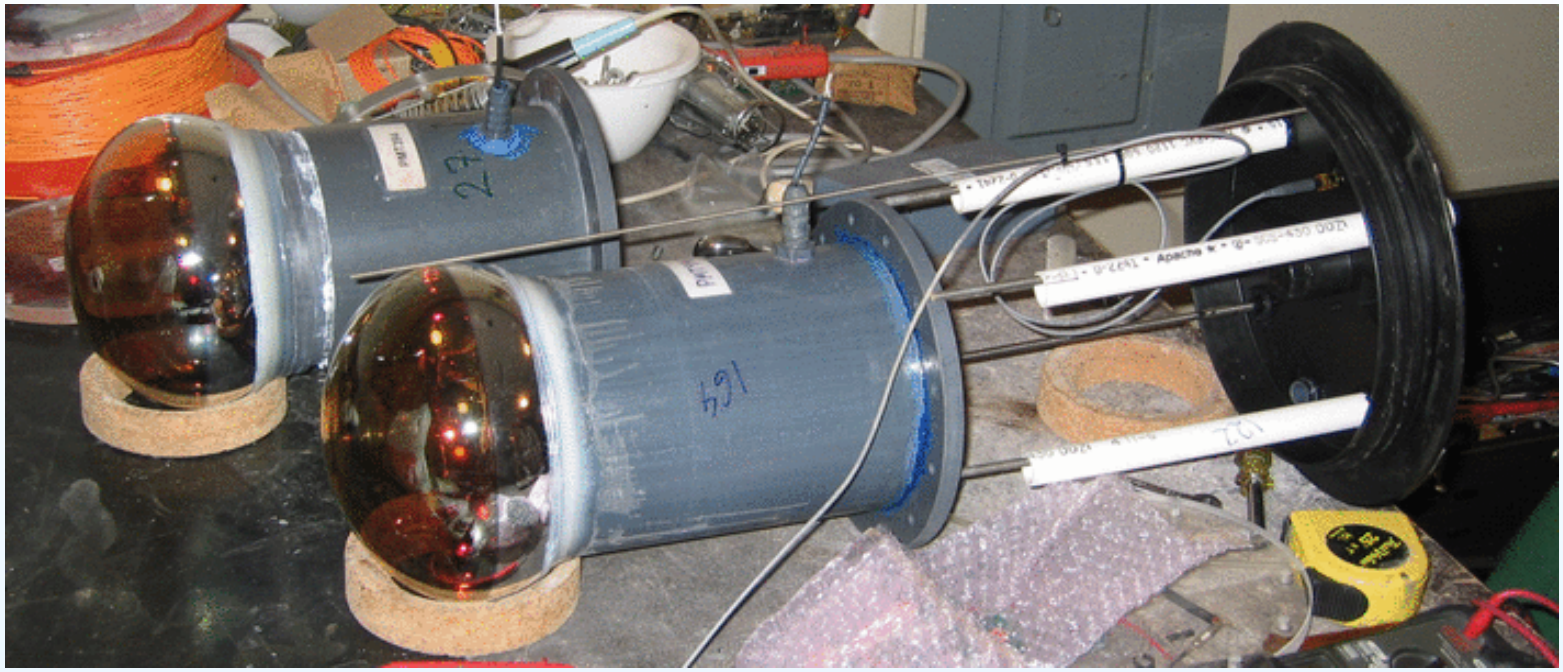

- PMT to PMT-housing sealed with RTV
- Water level visible a few inches above the RTV (by the 4 in the handwritten 164)
- Threaded rods position and support the *Milagro pond PMT housing* in the *outrigger* tanks!

PMT housing ... **another view**

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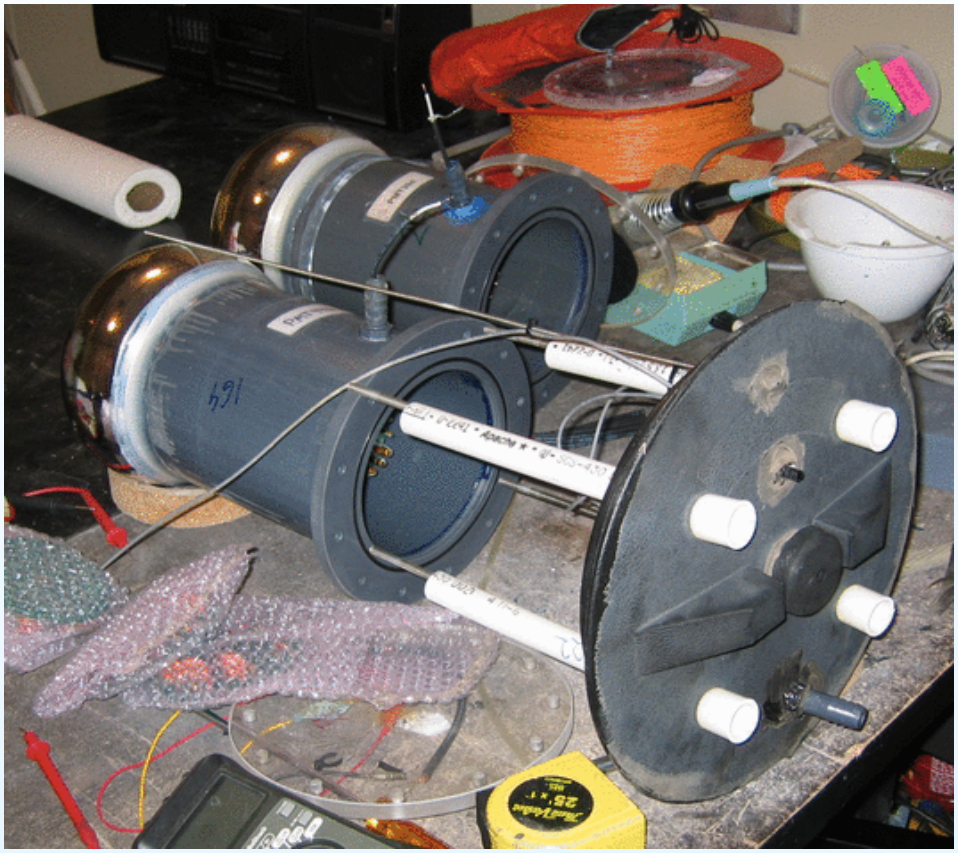

- Threaded rods connect to 10” tank access-port cover.
- Light leaks patched with black roof tar!

What other ... **lessons?**

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- Without a separate light-tight water enclosure, the (black) tanks needed to be opaque. One iteration with the vendor was needed to get suffi cient black pigment for light-tightness.
- **But even** *accepted* **tanks randomly had light leaks!** These were patched with roofi ng tar ... but the location of the light leak was diffi cult to fi nd and to repair in a permanent way. Some of the light leaks were related to the cable/fi ber feed-throughs. [No comments on the effect of temperature variations and/or weather on appearance of light leaks.]
- By comparison almost no tank water-leaks!
- Tank internal (air) temperature variations were large, especially in the summer, and resulted in PMT gain variations that were signifi cantly greater than the same (fully submerged) PMTs in the Milagro *pond*.

My own ... **impressions!**

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- Milagro *outrigger* tanks work well and are a cost effective way to extend the lateral extent of the Milagro surface detector ... **can Auger North benefit from their good ideas/experience?**
- (New) light-leaks and/or rodent *disruption* of optical fi bers (and to a lesser extent the HV/signal cables) required some level of continual maintenance ... which at the compact Milagro site was more an annoyance than a signifi cant problem ... **thus direct importing of Milagro *outrigger* ideas to Auger North needs to be done with caution.**
- Ice was less of a problem than the large daily temperature variations in the summer **... are we worrying about this?**
- Although some monitoring of gain variations with time were done using the calibration optical fi bers, I was unable to judge whether this was essential or not.