Off-Axis-NOTE-DET-5

Basic Questions Concerning Construction and Maintenance of an Off-Axis Detector

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Following the NuMI Off-Axis Experiment Detector Workshop at SLAC in January, I started thinking about some of the issues and over the last two months have been writing down these thoughts hoping a written list might help form a basis for discussion. My sense is that we are not properly confronting the crucial issues and each of the proposed technologies has a long ways to go if we expect to reach a consensus for a proposal on a time scale anything like this fall. I think the various proponents have described their basic detecting media fairly well, so I do not focus here on how Liquid Scintillator, Solid Scintillator, LSTs, and RPCs work as detectors. Others have raised the risk issues with "passive" detectors vs. "gaseous" detectors and the issues regarding readout schemes. This note focuses instead on how we would put any detector together and maintain it.

One of our primary concerns should be if a particular detector can actually be constructed and just how much it costs to construct. Proponents of each of the proposed technologies have done a lot of hand waving about how various problems might be solved, but we need to get beyond that level to real detailed plans for each. Proponents need to write down the actual scenario for construction and develop a cost estimate for all the steps. We have to get past the level where each objection to a scheme is verbally rebutted by a "well, of course then you could do ________". Instead each proponent should think through the whole detector and make sure they have a complete scheme with a complete cost. The discipline introduced by writing a full WBS structure would be to our advantage in weighing the options.

With that in mind, let me criticize each of the concepts so people might know what worries this particular collaborator.

1. Plastic filled with Liquid Scintillator

The basic concept uses 20-meter long extrusions with a N-wide by 4 deep cell structure. Call them "logs". These logs are stacked in a V-shaped trench to make X and Y readouts and a 20-meter by 20-meter structure. For stability the logs are stacked against a strong bookend with a 1-degree slope so all the logs lean against it.

My main concern is summed in a simple sentence: If it's so easy to build a plastic structure 5 to 7 stories high, why do we NEVER see such a thing in the real world? Is there any existing example of a really tall plastic structure where the plastic parts are load bearing and not just decorative like decking and railings? An example would go a long ways toward convincing me this scheme is at all possible.

<u>Then here is a long list of additional questions:</u>

How do you actually make the V-shaped trench and what does it cost?
- Is it concrete?
- Can you actually lay 20 meters of concrete at a 45-degree angle?
- Would it require a lot of forms and therefore have a high labor cost?
- No matter how the trench gets made, how smooth is it?
- How smooth does it have to be so the plastic extrusions can conform to the shape without any damage?

What are the specifications for the straightness of the 20-meter long extrusion logs?
- What are the typical vendor tolerances have been realized on real examples?
- What kind of waviness out of a straight line is typical of a log in the plane of the stack?
  - I assume the ones on the bottom will be compressed into the trench shape, but will the ones on top keep a mind of their own and leave gaps?
- What kind of waviness is typical of a log transverse to the plane of each stack?
  - Will the layers in along the beam build up some irregularity that makes "planes" impossible?
  - Will there have to be additional strong bookends periodically along the beam to compensate?

How do you transport 20-meter long plastic logs?
- 20 meters is 65 ft 7 inches while a standard truck trailer is 53 ft long.
- Does this mean a permit is required?

How exactly do you handle these 20-meter long plastic logs as you make the stack?
- What is the weight of one log?
- If a crane holds them, how do you pick a log and how do you release it?
- These plastic logs seem to be about 0.5 meters wide, therefore it takes about 40 of them per plane – how do you hold up logs 1 through 39 while adding the 40th ?

After stacking the entire array, how exactly do you reach the top of all the tubes on this 45-degree slope to insert fibers, add liquid, and add / maintain the readout?
- It doesn't seem like you can walk on it or reach ends of the logs without some custom scaffolding or other fall protection?
- It doesn't seem like you can reach it from a crane without some fixture?

Do these plastic structures creep under load?

What kind of temperature control is required to maintain this structure?
- Can it tolerate 70 degrees Fahrenheit +- 30 degrees?
- How large are expansion and contraction effects?

Does liquid scintillator wick up the fibers and make a mess outside the logs?

What are the Fire Protection requirements for such a structure?

Why does this technology need an 8-meter cosmic ray overburden for 2 GeV neutrino events when MiniBooNE only uses a 3-meter overburden for 1 GeV neutrino events?

2. Particle Board and LSTs

The basic concept uses 10-meter Limited Streamer Tubes (LSTs) in an N wide by one deep cell structure. Call them "planks". The planks are inserted into slots in a Particle Board or Oriented Strand Board (OSB) structure. The Particle Board is the supporting structure and the 10-meter long planks are inserted after the Particle Board structure is completed. Similar schemes are considered for solid scintillator and for RPCs.

My main concern is summed in a simple sentence: If it's so easy to build a Particle Board / OSB structure 5 to 7 stories high, why do we NEVER see such a thing in the real world? Typical two and three story residential houses do get sheathed with this material, but the material is well known to creep and sag and squeak and rot and … The assembly tolerance on such houses is more at the one-eighth to one-quarter inch level. Is there any existing example of a really tall Particle Board structure? Such an example would go a long way towards convincing me this scheme is at all possible.

<u>Then here is a long list of additional questions:</u>

The Particle Board is calculated to be self-supporting, but how do you actually construct the 20-meter by 20-meter detector?
- Do you build some large fraction of the bottom half first for stability and then add the top half?
- Since the planks are only 10-meters long, the bottom half of the vertical planks have to be inserted during construction?

How exactly do you handle these 10-meter long plastic planks as you insert them into the stack?
- What is the weight of one plank?
- Apparently any building housing the detector would need > 10 meters of free space on each side of the detector <u>and</u> > 10 meters of free space above the detector?

What are the specifications for the straightness of the 10-meter long planks?
- Can vendors really meet this specification?
- How much bigger than the plank will the slots in the particle board have to be to allow the planks to be inserted? How much bigger do the slots have to be in the plane and how much bigger do they have to be from plane to plane?

What kind of temperature control is required to maintain this structure?

Can it tolerate 70 degrees Fahrenheit +- 30 degrees?
Could it and the LSTs tolerate temperatures below freezing?
How large are expansion and contraction effects?
How well do you have to control humidity?

Does the Particle Board structure creep under load, particularly if wet?

What are the Fire Protection requirements for such a structure?
At least all exposed surfaces will have to be coated with fire retardant paint?
How much does that cost?

After stacking the entire array, how exactly do you reach the top of all the planks for maintenance of the readout?
Since the planks are only 10-meters long, the bottom half of the vertical ones have to be inserted during construction and then are never accessible again?

What cosmic ray overburden is needed in this technology for 2 GeV neutrino events?

3. Containers and RPCs

Now you knew I was going to advocate use of containers, so just bear with me here. My advocacy can be summed up in a simple sentence: FIVE TO SEVEN STORY HIGH STRUCTURES IN THE REAL WORLD ARE BUILT OF STEEL.

We ought to take advantage of everyday structures appropriate to the scale of detector we want to build. Containers are made of steel and are in fact designed to be stacked in structures at least 26 meters high (a stack of 10). This is done every day in ocean going container ships. Examples of tall container structures therefore exist and my SLAC talk contained pictures of real structures. A 20-meter high structure (stack of 8) for an Off-Axis Detector is well within the limits of this off-the-shelf technology.

During my talk at SLAC, someone asked if anyone had ever stacked containers for long periods. I was taken aback by such a question. This is a steel structure and as long as you pay attention to footings that can carry the full load, there just isn't a problem. If containers can't stack this high for long periods, then plastic and particle board have no chance at all.

Containers are designed to hold the load we are talking about – a maximum density of 0.7 – 0.8 gm/cc. They are tested to hold this load. They come from vendors that meet specifications from the International Standards Organization and the American Bureau of Shipping. Wood-encased modules of RPCs or other detector technologies can easily slide into standard 8.5-foot high steel shipping containers. The wood-encased modules spread out the load on the container floor in an ideal fashion. One-eighth to one-quarter inch tolerance is fine at this scale and the use of particle board to encase the RPCs (or other active detector technology) is a reasonable use of this material at the scale of a ONE-story building. My one-story house is made of wood, but has steel I-beams in it to support the floor over the basement.

OK, so I like containers – how about those RPCs inside and the plan presented at SLAC to put them in containers? There are problems with the concept as presented and <u>here is my long list of additional questions:</u>

As presented, the scheme for X and Y readout of the RPC seems complicated, maybe even unworkable.
- How exactly is a cable routed vertically out of one container and up into another?
- How many connections are there and how reliable are these connections?
- Shouldn't one just admit that each container in the stack needs its own vertical strip readout and that the baseline detector therefore requires 8 times the electronics for the vertical readout due to the 8 containers in a stack?

Even for the horizontal readout, the scheme calls for ganging the strips on multiple RPCs into one long strip.
- How exactly will that be done?
- How much does it cost to do it?

We have seen some preliminary evidence that the cracks between containers do not make a huge difference in detector performance.
- But surely there would be analysis cuts against events originating in the cracks between each of the 8 containers in a stack and between the stacks?
- Can this cut be quantified as an extra fiducial volume cut required for use of this modular solution?

Given the vertical cracks between the containers, why are the additional vertical cracks introduced by the top and bottom wood spacers around the RPCs not a worry?
- Shouldn't these spacers be an absolute minimum?
- What is the absolute minimum?

What kind of temperature control is required to maintain this structure?
- What is the evidence that these RPCs and connections can tolerate temperatures below freezing?
- How large are expansion and contraction effects on all parts of the modules?

What are the Fire Protection requirements for such a structure?
- Does all the wood inside the container have to be coated with fire retardant paint?
- Does the metal structure of the container mean the Fire Protection requirements can be relaxed?

After stacking the entire array, how exactly do you reach any of the parts (cables, connectors, RPCs) for repairs or maintenance? The basic plan using 20-foot containers in three side-by-side stacks seems to trap the modules in the interior stack forever.

Why does this technology need <u>no</u> overburden for 2 GeV neutrino events when MiniBooNE uses a 3-meter overburden for 1 GeV neutrino events?