

Single SiPM Implications

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U.S. DEPARTMENT OF
ENERGY

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Science



News

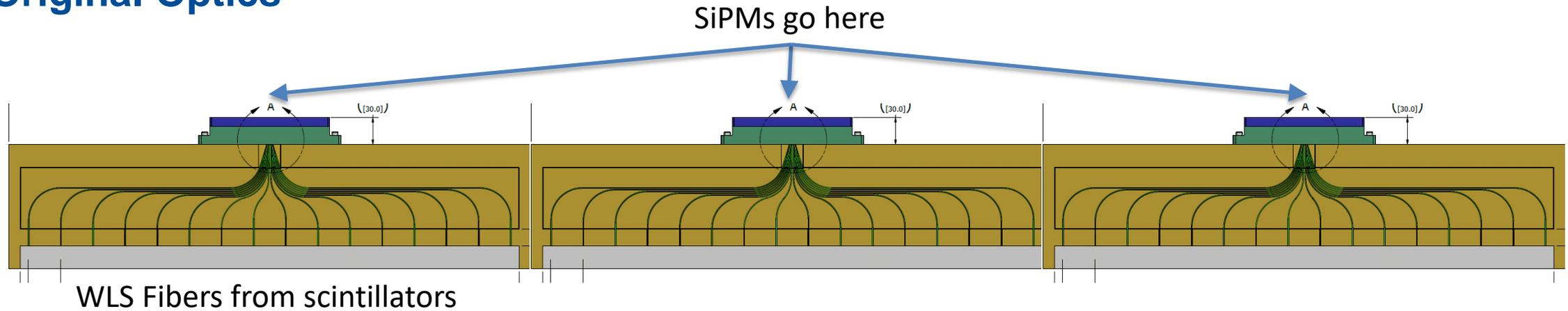
- Last week was an LBNC review
- Didn't we just have one? Why yes, we did. From the draft report:
 - *The TMS is considered to be a well-costed and “safe” backup solution, based on established technology*
 - *The collaboration's desire to defer pulling the trigger on TMS construction to allow time for an ND-GAr Lite option to be developed, is understandable. However, we caution that DUNE must be sure to be sufficiently conservative in its assumed schedule for TMS construction.*
 - *The LBNC finds that DUNE has made a convincing case that the Day 1 detectors will allow DUNE to achieve the stated sensitivity to CP violation*
- However, they declined to comment on any of the “starred” issues
- For this review, a ND-GAr (Lite) preliminary schedule was shown
 - It shows a go/no-gate a year or so ahead of ours
 - If this persists, we will adapt the TMS schedule to match, but the ND-Gar (Lite) schedule is still very new.

Background

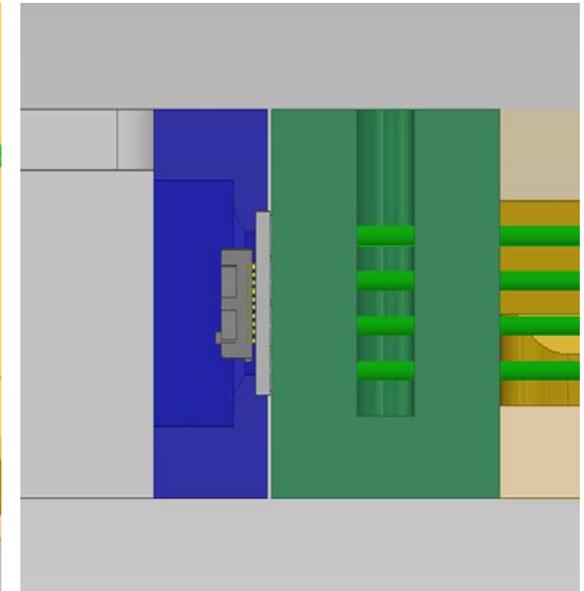
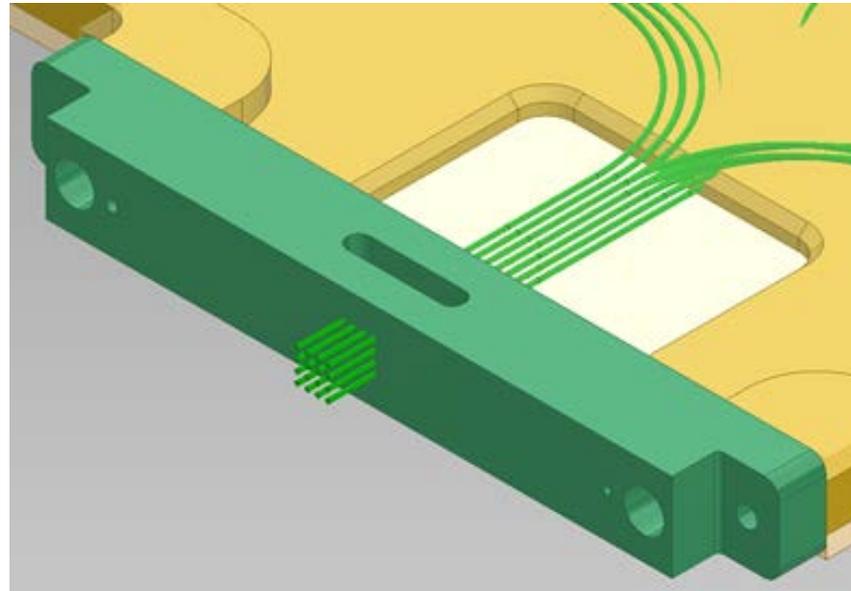
- We designed the readout around a 4x4 2mm SiPM array by Hamamatsu
 - This decision was driven by cost
- That unit is no longer available
- Last week Taritree Wongjirad reported the results of a market survey
 - 2mm 4x4 arrays are unavailable from any vendor
 - 3mm 4x4 arrays are available
 - These fit in the space we have, but not easily and not without additional labor
 - Single-channel SiPMs are ~half the cost of 3mm arrays

This talk: what are the implications of switching to single-channel SiPMs?

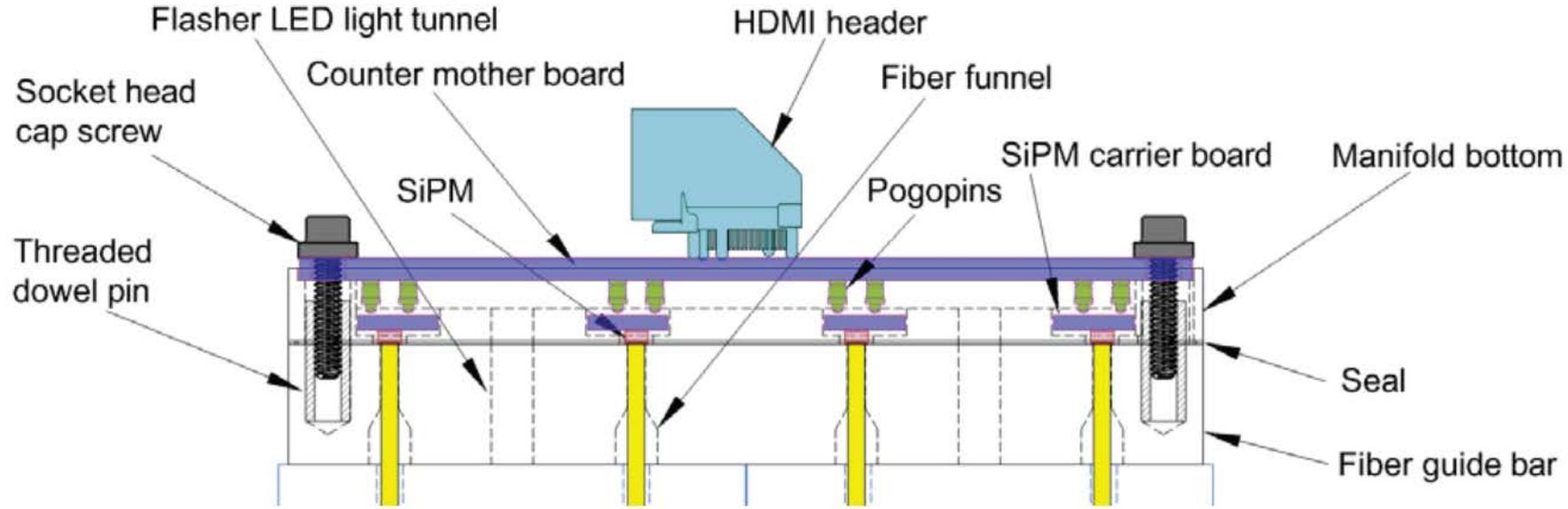
Original Optics



- None of this is necessary if we place the SiPM right on the counter.
- We could make our own arrays (probably 1x16 rather than 4x4) and keep the design, but the advantages of this are not clear.



What mu2e Does (I)

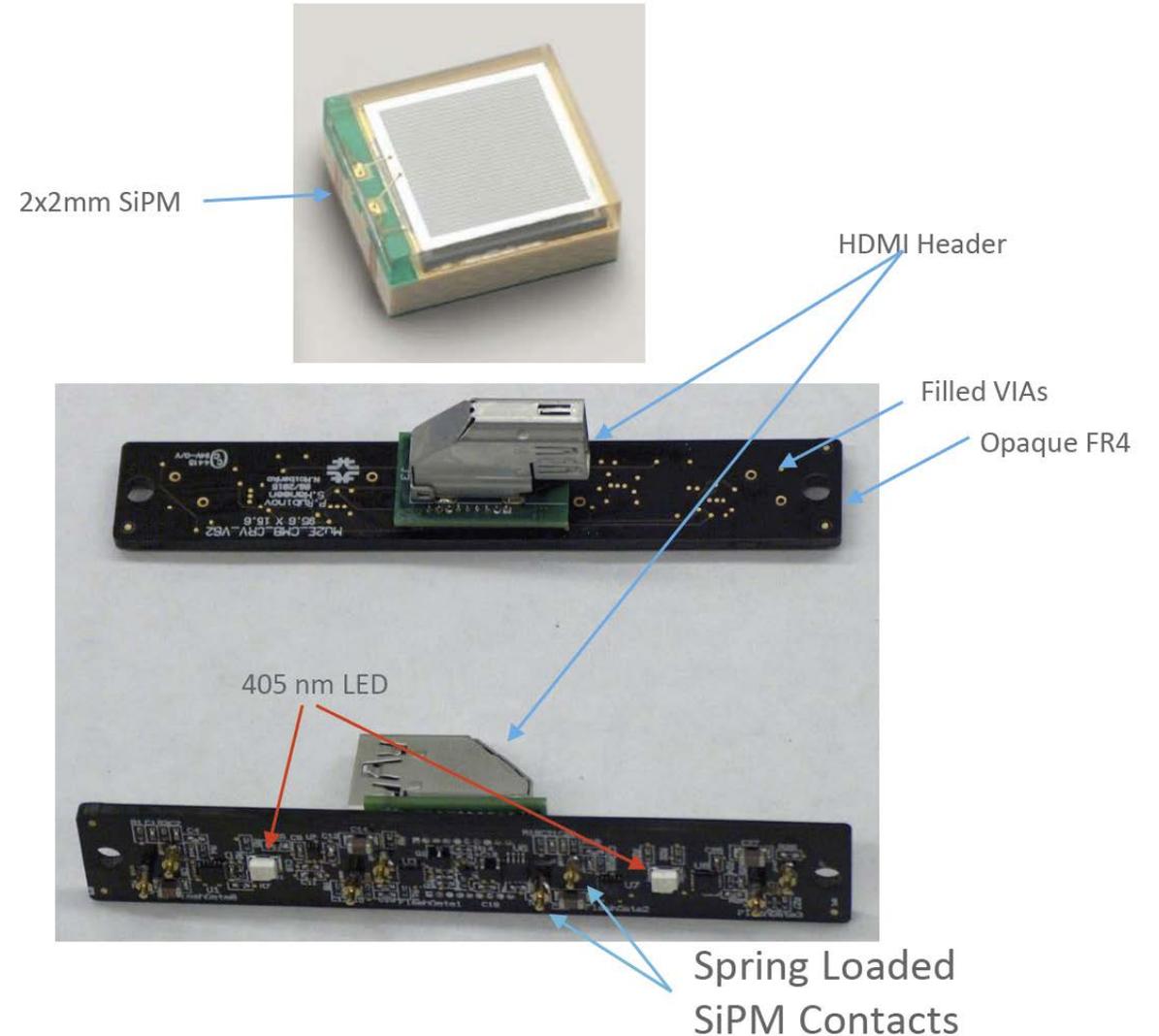


- Each Counter Mother Board (CMB) supports four fibers = two counters (for them)
- LED flashers are integrated into the CMB
 - We have not pursued LED flashers – it would be more a diagnostic for us than a calibration

What mu2e Does (II)

- 2mm x 2mm is a good size for a 1.4 mm WLS fiber
- Opaque FR-4 may not be as opaque as we would like (see later slides)
- They use a commodity header (HDMI)
 - I agree with the choice of commodity headers but prefer one that locks (locking HDMI is available) unless protected some other way (e.g. with a cover)
 - The right angle looks overly intricate, but will help with light tightness

Photo of SiPM and Counter Mother Board



The Di-Counter Concept

- mu2e uses units of two counters – we could too
 - Then 48 channel panels would be comprised of 24 di-counters in a box
- Advantages:
 - Safety: most handling will be done with 10 pound units and not 200 pound units (weight of a whole panel)
 - Testing: much easier to test 2 than 48. If we screw something up, we've only lost two channels, not all 48
 - Construction time: this is probably faster, but not fully worked out yet
- Issues:
 - The aspect ratio of the di-counter is pretty asymmetric



More DiCounter Issues

- Strength – you probably can't lift just one end
 - Perhaps we glue an aluminum strip to the bottom (yellow in the drawing below)
 - Reminder: we have 10 mm (total) in height before we reach the steel plate stay-clear
 - Perhaps we use a fixture during construction
- The space between di-counters is dead
 - All the light-tightening, glue, etc. occupies space
- There's nothing magic about 2. We could have the basic unit be tricounters, quad-counters, etc.
 - Either 2 or 4 lets us steal parts of mu2e's design
 - There are pros and cons of going to larger or smaller N. I think it's fair to say these have not been completely worked out yet.

Light Tightening and Box in A Box

- To get a reasonable darkness, we need to reduce the light by ~150 dB
 - Direct sunlight to indoors (with windows) is about 30 dB
 - Daylight to night is around 60 dB (depending on clouds, the moon etc.)
- It is likely easier to do this within our material budget by having two boxes and not one
 - But we need to make sure none of the weak spots (e.g. electronics feed-throughs) line up!
 - “Box” doesn’t necessarily imply structural. The inner “box” may simply be wrapped.
 - Investigating how best to do this, and with what. (BOPP? Mylar?)
 - A good goal is that a di/quad/N-counter can be tested outside of a dark box. (Maybe we need a blanket)
- The outer box needs to support the weight of the scintillators
 - Including transport and installation
 - This might or might not involve gluing counters into the box.



Mechanical Interferences

- The corners have zero stay-clear with the coils. We were going to address this in the optics manifold, cutting some “dead material”.
- In this design, we no longer have any dead material.



- This assumes all panels are identical. We could make four different designs with different corner combinations removed.
 - I don't think we want to do this – we are probably going to make a fiducial cut near the coils anyway. But we could.
- The “regular” counters need to be a few mm longer to compensate and still be within our KPPs.

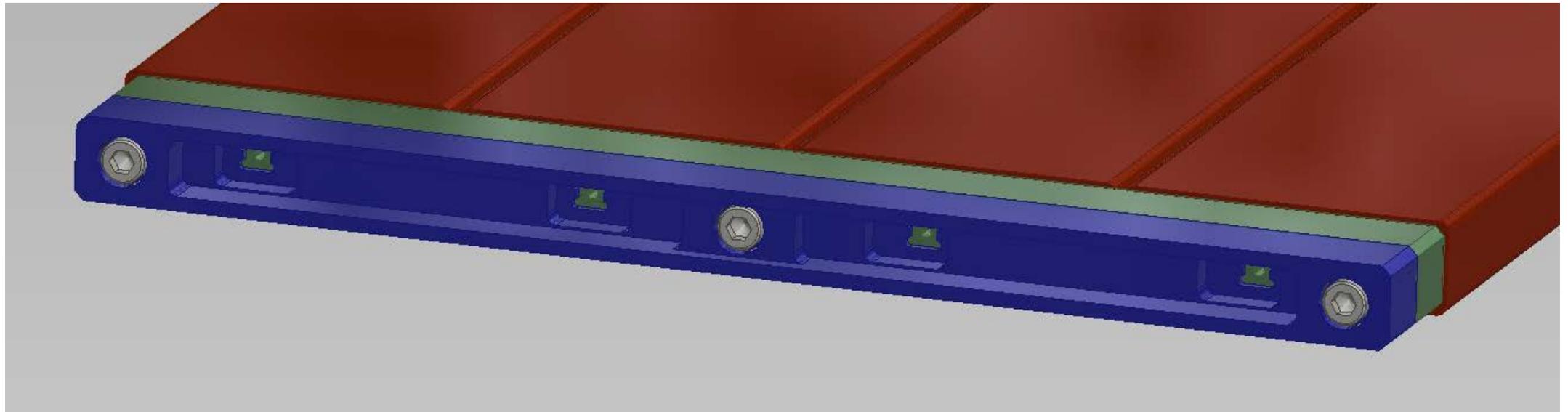
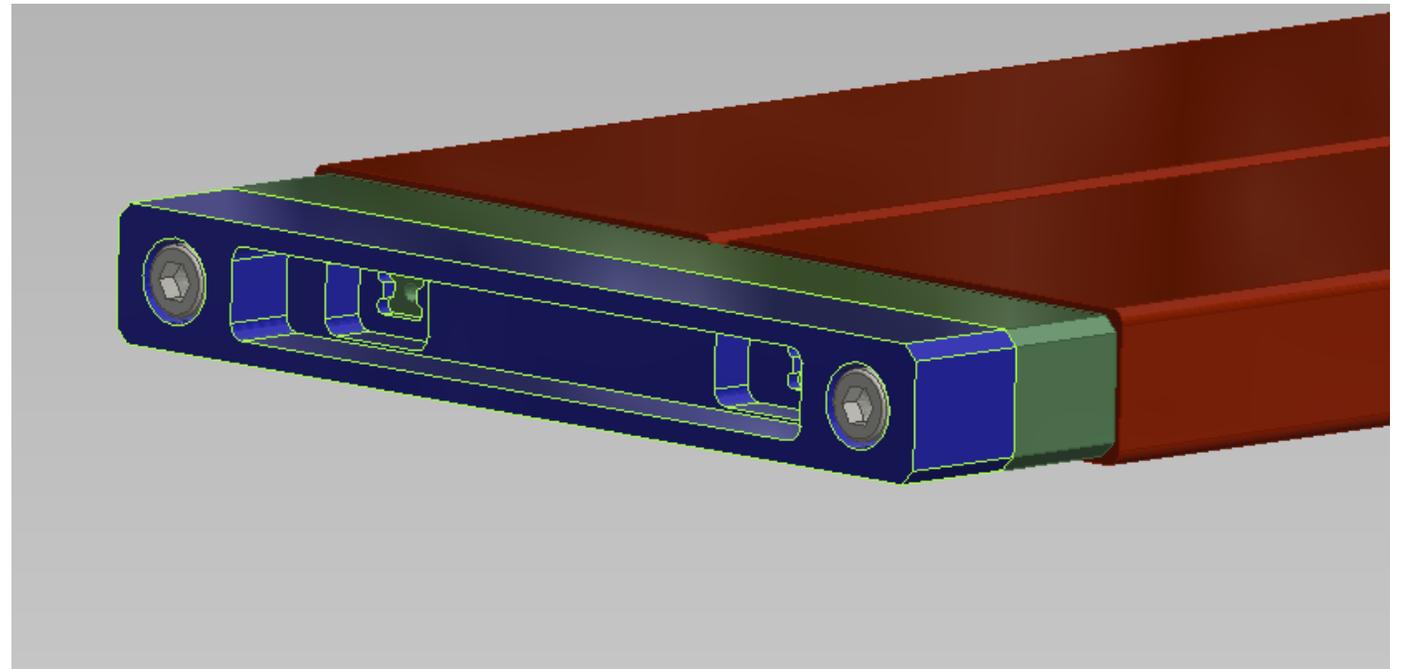
Electronics, Testing & Prototyping

- The 4x4 plan had the TI front-end chip on a board right next to the panel
 - We didn't want to run analog signals for 2 meters, especially near the magnet coils
- This doesn't change that, but we do have maybe some more flexibility on where things might go.
- We've gone from 1200 SiPMs to around 20,000. Testing 20,000 of anything is a big job.
 - We may need to bin them as well
- I've paused ANL prototyping on the optical system, as we may not need one

Prototype Drawings

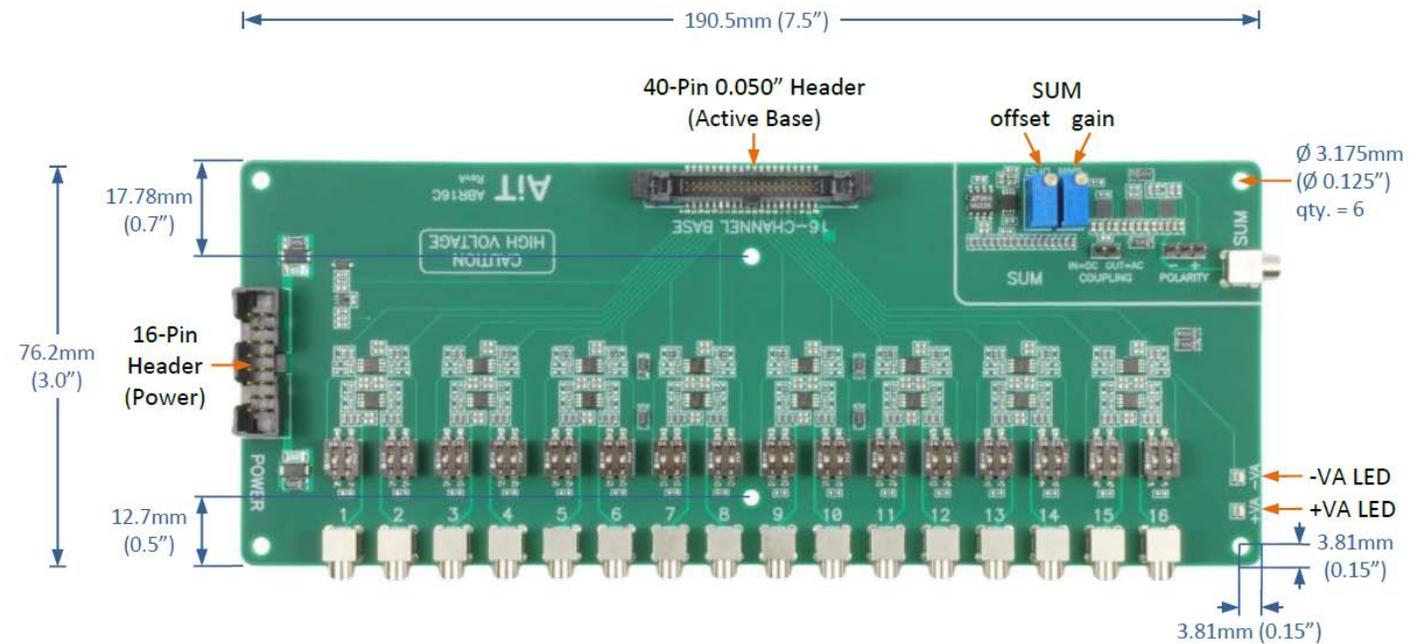
Jeff White, ANL designer, has started drawings of a first working prototype. The needs for a mechanical prototype to understand the optics went away when the optics did.

Di-counters, quad-counters and maybe tri-counters are being drawn.



Prototype Electronics

We found a commercial unit (from AiT instruments) that put the 16 channel outputs from the 4x4 array on 20 Lemo connectors.



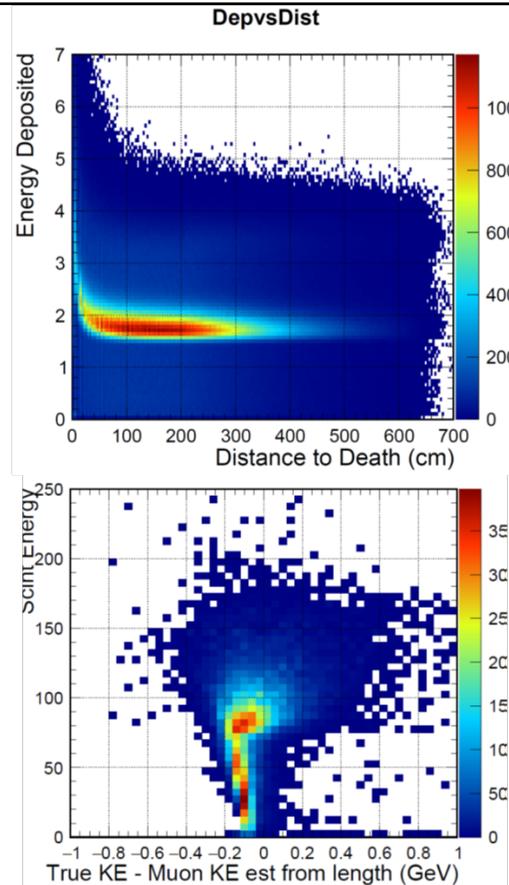
- We could use something similar now.
- While we have a lot of commonality with mu2e, we can't "just use mu2e electronics"
 - We don't own any
 - It doesn't mechanically fit
 - It's quite integrated – we're much more interested in pre-digitization output

From Two Weeks Back

Last thought

- The DOE IPR was very interested in 2.4 MW operation and pileup.
- I don't think that is our most urgent study.
- I think our most urgent study is on light requirements.
 - Will we use the energy information *at all*? Or is this purely a position measuring device?
 - If we do use energy, how good does it have to be?

Why do I think it's more urgent? Because it affects design choices. That's more important for baselining than how well the device might perform in six years time.



From Clarence Wret

This is still the case

Summary

- Based on Taritree's study, single SiPMs look to be more cost-effective than 3mm 4x4s
- There are a number of design changes this would trigger
 - We are still working out the implications and coming up with a working design
 - There appear to be no show-stoppers
- I would like to take the decision now – with a 7 day period for comments
 - Returning to a 2mm 4x4 is not an option