Prototyping

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Why *This* Meeting?

- We are in a phase where simulation and design inform each other
- Many of the people interested in simulation are also interested in eventual construction
- If I need to go to one more meeting…

For today, I will outline some of the open questions.

For most of these, there are multiple options – but we have to pick one.

What Energy Resolution Do We Need?

- Target is 4% peak, 10% RMS.
- Old studies were showing energy only was ~1.5x that
  - This is a bit better than (but in the same ballpark) ATLAS TileCal (same technology) corrected for the sampling fraction
  - If we are lucky the energy is anti-correlated with path length (energy is lost either in the iron or the scintillator)
  - If we are less lucky, the energy and path length are independent
  - If we are less lucky still, the energy and path length are correlated, or the energy resolution is so poor it makes no sense to combine it.
  - We all have our suspicions, but we need a study we can show to internal and external reviewers
    - [(True energy) – (path length determined energy)] vs. (scintillator energy) is the plot we need (scatter & profile)
- This can have substantial design and cost implications. If we don't need a good energy measurement:
  - We don't have to be so fussy about keeping every photon
  - We can go to smaller WLS fiber
  - We don't need a preamp on the electronics (effectively turns our 12-bit ADC to 7 or 8 bit)

Scintillator Design

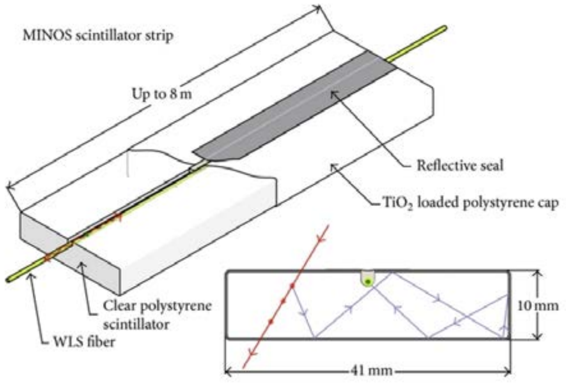
- We needed a baseline to get through the reviews. I picked MINOS. I admit this was fairly arbitrary and capricious.

- We can certainly consider alternatives
  - mu2e CRV (hole instead of grove) and MINERvA (triangular instead of rectangular)
  - A switch would need a good reason:
    - “This would shave two months off the construction time”
    - “This is necessary to meet the ND performance goals”

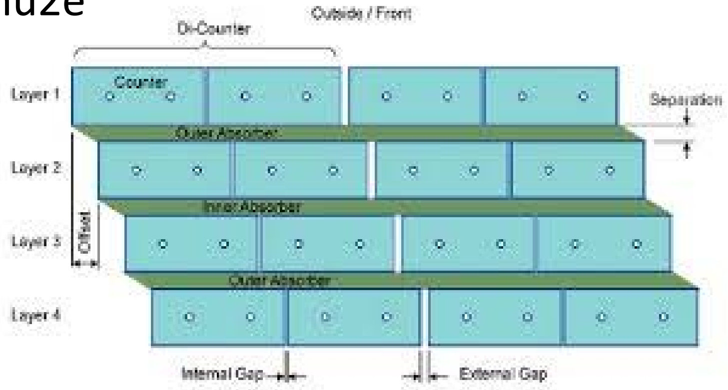
- Gluing a hole is different than gluing a groove
  - Especially handling air bubbles

- Triangle-shaped slats give better position resolution, but
  - Increase occupancy (near a level that becomes problematic)
  - Require good energy resolution (so coupled to other decisions)

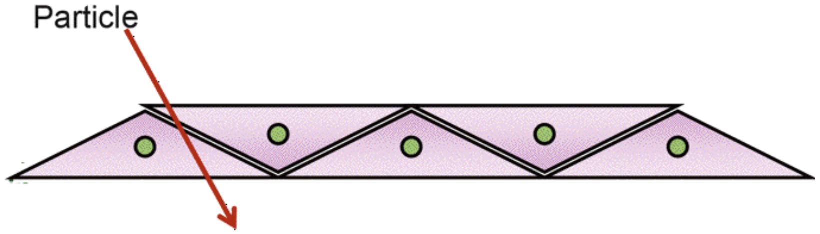
MINOS



mu2e



MINERvA

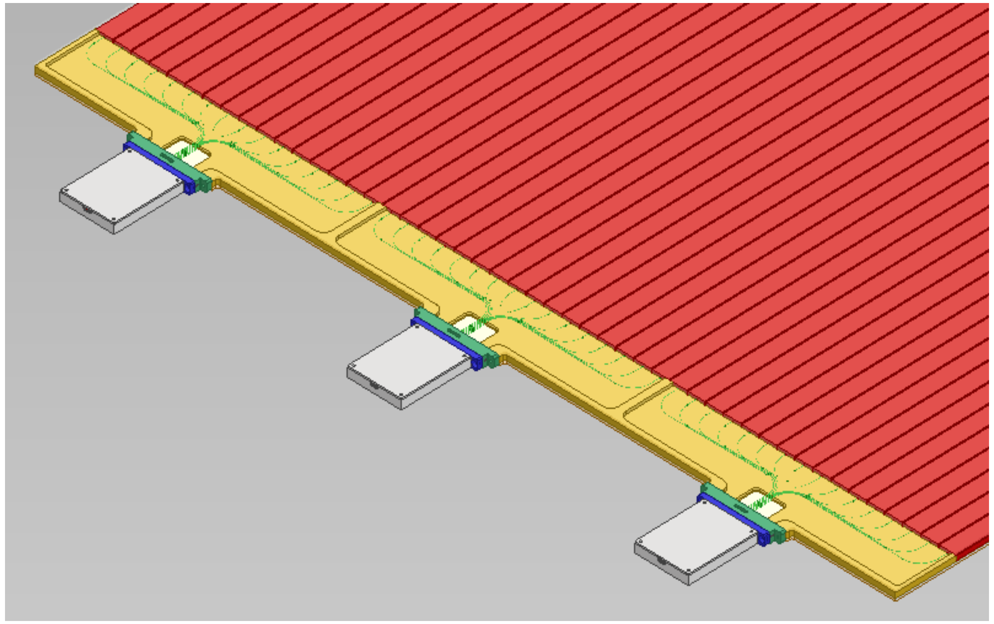


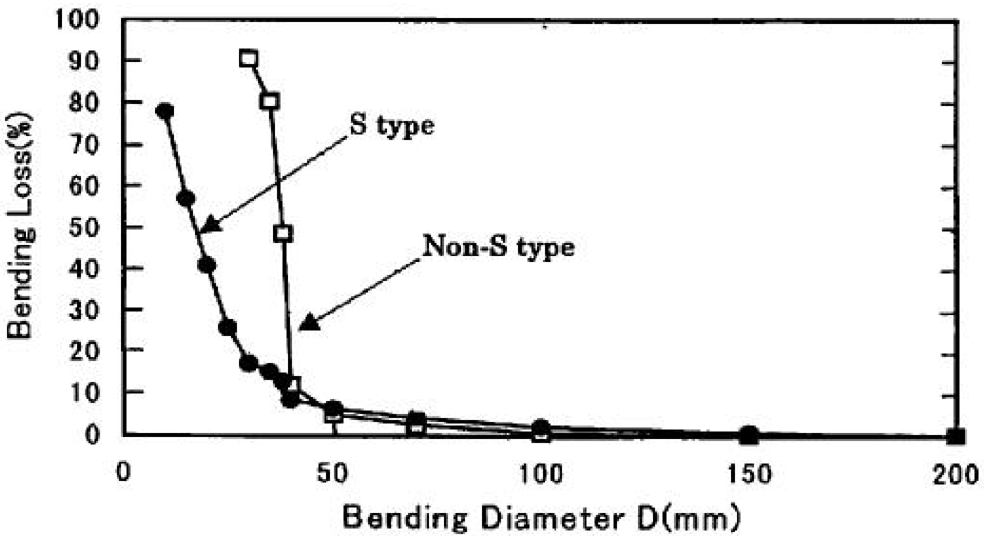
WLS Fiber to SiPM

- What does the orange piece look like in real life?
  - Not like what's shown (bend radius is rather low)

- Do we have
  - Channels cut into base material? (e.g. Styrofoam)
  - An empty box and some kind of light tightening?
  - Something else?

- Related issue – strain relief at SiPM

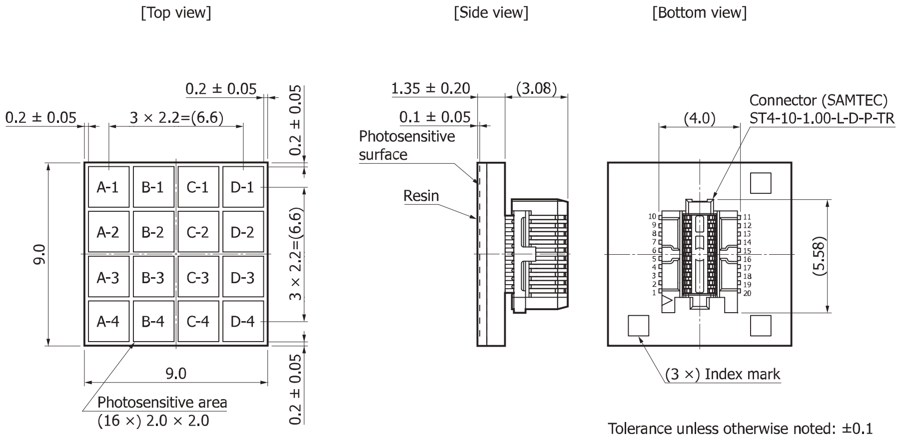




WLS Fiber Mounting

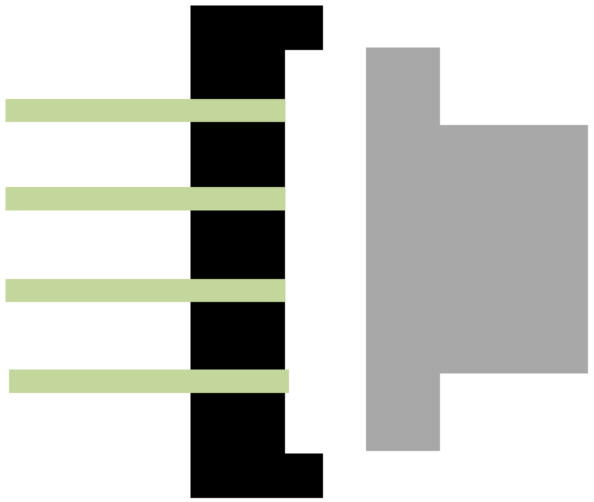
- Hamamatsu does not recommend optical grease
- They say “just let the fibers shine on the SiPM face”
- That requires a lot of precision on the black “piece” (probably multiple parts to it) and mounting the fibers to it
  - And optical efficiency
  - And low cross-talk
  - And we need to do this 1200 times (plus spares)

- Or we could disregard Hamamatsu’s advice

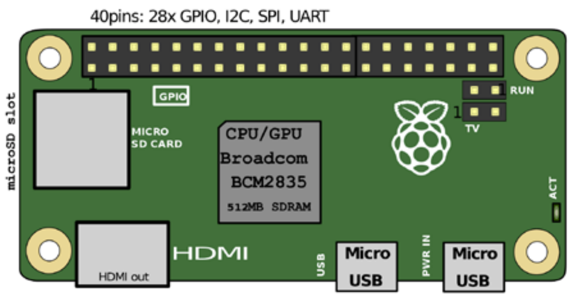


Hamamatsu S13361-2050AE-04

KAPDA0167EB



Dropping the Data Concentrators (I)



- The plan has on-panel boards sending LVDS to FPGA data concentrators via shielded 96c cable
  - The cable is expensive, hard to get, and the connectors aren't so cheap either
  - FPGA programming is a skill, and there are plenty of HEP examples where this is done badly
- There are no slow controls in the plan – LV is set "upstairs" before installation

- Single-board computers are readily available (shown is one costing $5 each)
  - Could handle slow controls
  - Could also data formatting and replace the concentrators
    - Replaces FPGA programming with C programming
  - The DAQ would see 400 independent detectors

Dropping the Data Concentrators (II)

Caveat: this is a personal interest of mine

- The panels would then have one data connection
  - Either a RJ-45 power-over-ethernet
    - Would replace both the power and data connectors (power needs are nearing the PoE limits)
  - Or a SFP connector
    - Tranceivers are $11 or $7 each and we would use either ethernet cable or optical fiber (maybe better near the coils) to the DAQ switch
- The problem? How do you keep 400 detectors meters apart timed in to within a few nanoseconds?
  - Typical computer clocks drift by100-200 ns over a second: 5-10 RF buckets
  - It may be possible to use software (e.g. Precision Time Protocol) taking advantage of 999ms of downtime
    - Possibly in conjunction with a oven-controlled crystal oscillator (10x more stable, a few dollars each)
  - Atomic clocks on chips look promising until you actually try and buy one
    - In real life the pricing hasn't caught up with the advertising hype. ("A few hundred dollars" – yeah, fifty-four of them)
    - There is also the issue of operating in magnetic fields

Summary

- There are several issues where simulation will inform prototyping and vice versa
  - There will be more
  - A Wiki would be helpful in keeping track of progress

- We need to be ready for baselining soon (November 30th is the day the documentation freezes – or at least gets slushy)
  - Post-baseline changes are doable, but it is much, much better if they are cost-neutral