# Prototyping & Some Open Questions

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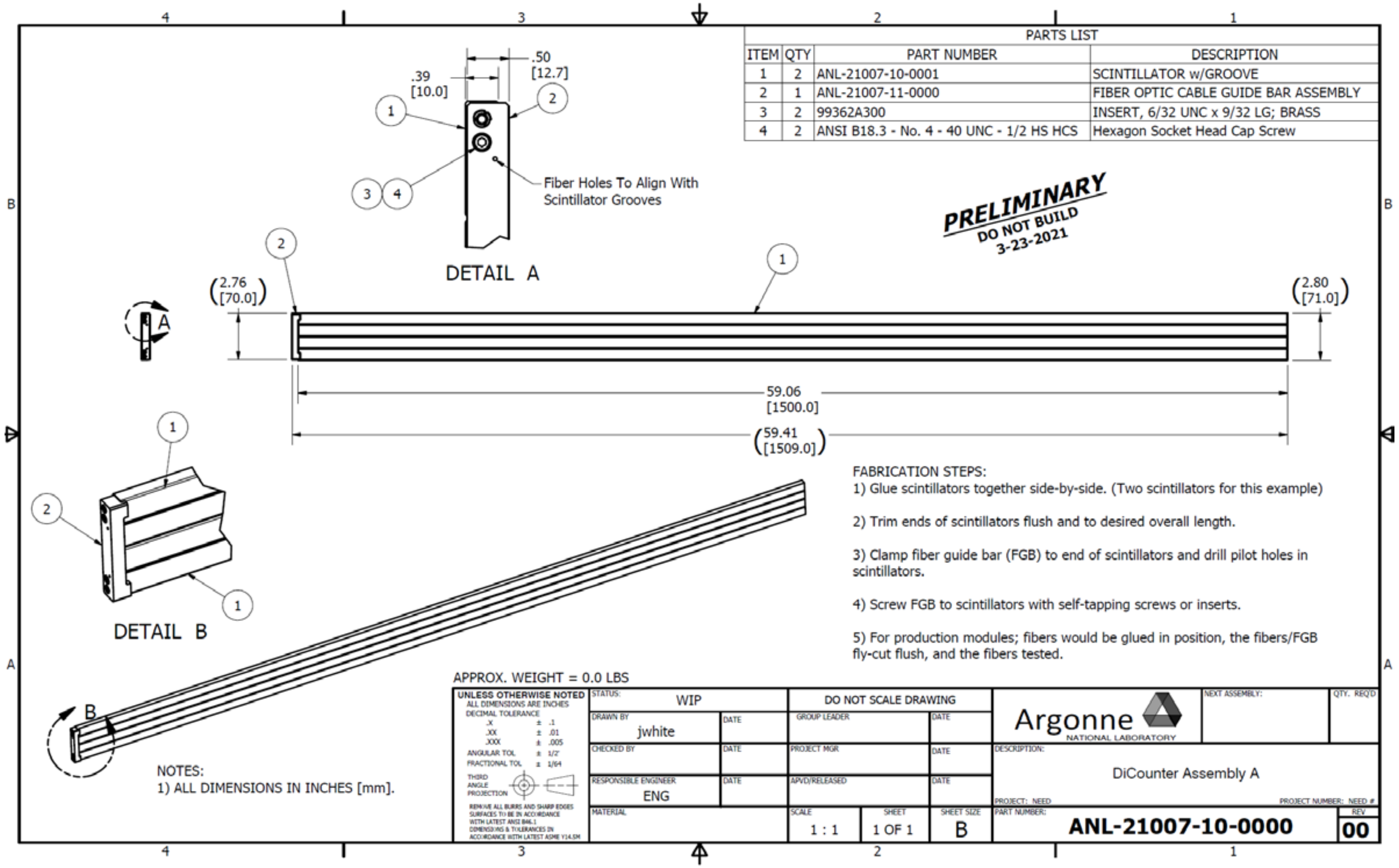
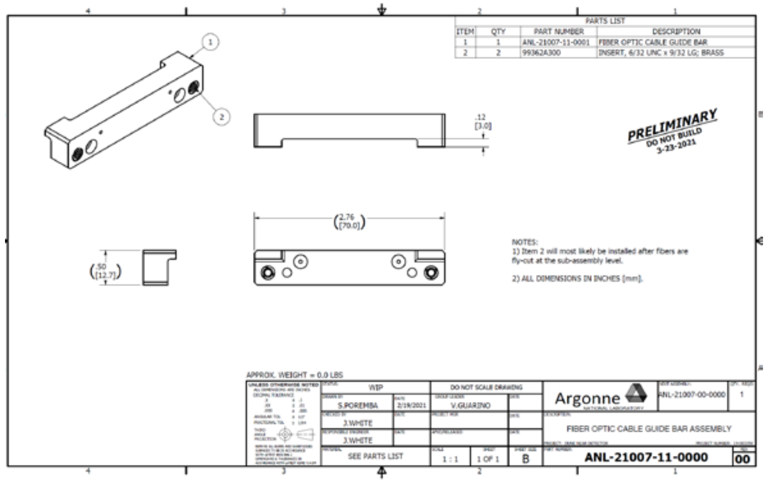
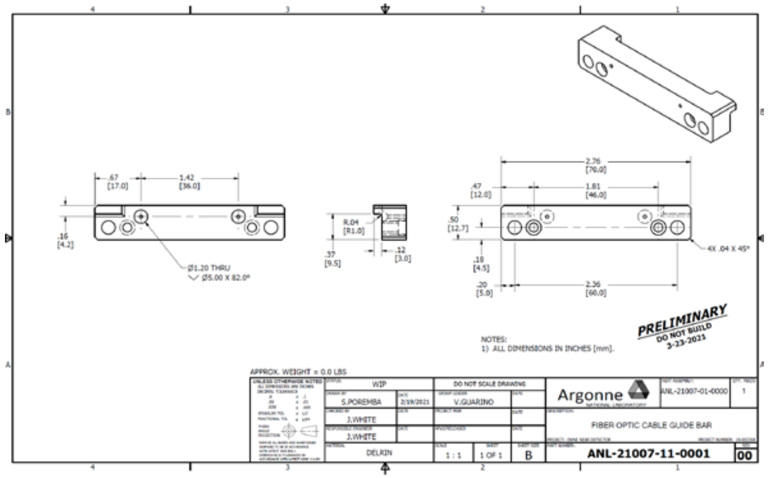
# Prototyping

- Designers have made substantial progress




Before we start chopping up scintillator, we need to decide what we want to build. (which is determined by what we want to learn.)

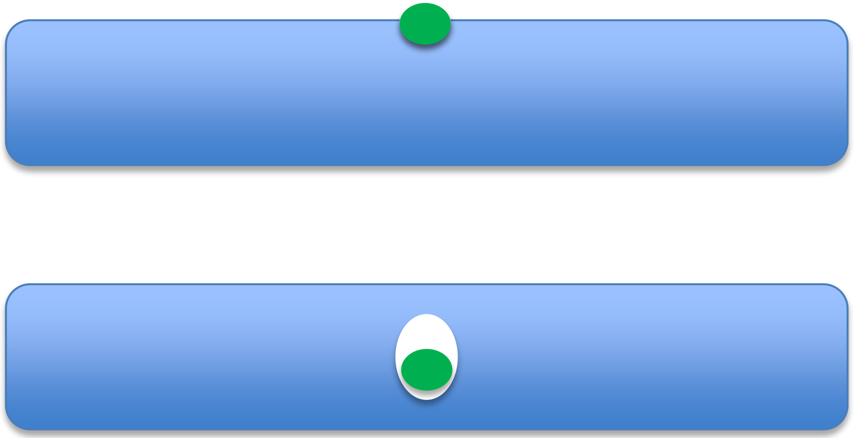
# What We Have/Can Get

- We have
  - A box of leftover scintillator
    - 103 strips 41 mm x 10 mm x ~4m with a 1.2 mm MINOS-like groove
    - 58 strips 40 mm x 10 mm z ~1.5 m with a mysterious oval hole
      - ~1.4mm x ~4mm
  - 5m of 1.2m Kuraray WLS fiber from 1999

Reminder: our nominal dimensions are 35.4 x 10 x 3000 mm

- We can get (in a few months time)
  - More Kuraray fiber (any diameter)
  - Either grooved or holed 35.4 mm scintillator
    - This costs $50,000 or so, with at least $14,000 in the cost of a new die
      - Our entire prototyping budget

# Hole vs. Groove



"In theory, there is no difference between theory and practice. In practice, there is." (L.P. Berra)

- In principle, a groove captures half the light of a hole.
  - This is simply a geometrical factor.
- Real-life complications degrade this factor of two
  - One can recover some of the light by putting reflective tape over the groove
  - One can potentially recover some of the light by placing the fiber slightly deeper in the hole.
  - The scintillator-fiber coupling is better for the groove (where you have access) than the hole (where you do not)
  - The hole has an air gap (and the mismatch in indices of refraction that come with it)

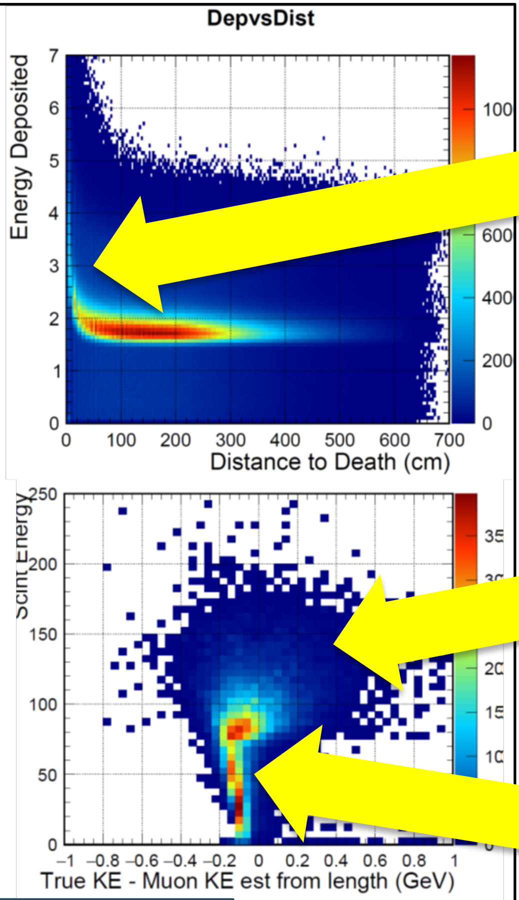
Hard to tell the exact gain with a hole, because no identical comparison seems to have been done for a real experiment, but it is likely closer to 20% than 100%. We do not have enough fiber to conduct this test ourselves.

# How Much Light Do We Need?

## 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



Can we use the Bragg peak and $1/\beta^2$ ionization to better measure the track endpoint?

Can we improve resolution/reduce tails by cutting away this cruft?

Can we improve resolution/reduce tails by straightening the response line?

Faiza is looking into this – it's fairly urgent: it informs hole vs. groove.

# Hole vs. Groove II

Hole vs. Groove affects the Quad-counter motherboard design, even for purely mechanical models.

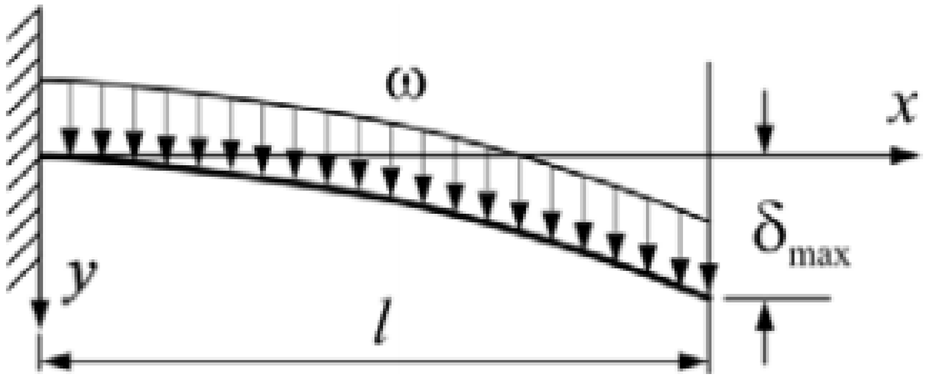
Hole SiPM Configuration

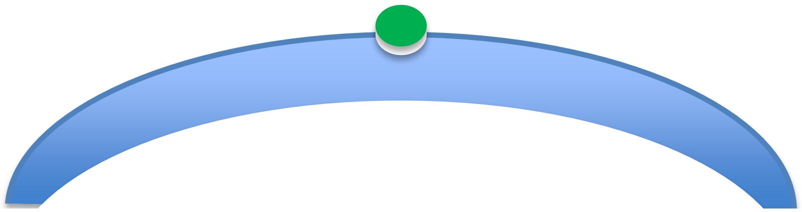
Groove SiPM Configurations

or

- We can always draw and build more prototypes…
- …but if know the advantages of a particular design don’t matter to us, we shouldn’t waste anybody’s time.

# Scintillator is Bendy

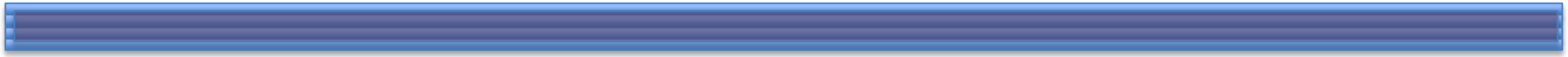


- If you pick up a piece of scintillator, the far end sags (by a little more than the equation says ordinary polystyrene should).
- This isn't good for the scintillator. More importantly, forces are transferred to the fiber-SiPM junction.
- In addition to sagging, there will be a little "hogging"
  - Bend in the "short direction"
  - A groove will make this worse
  - I didn't see any by eye last week

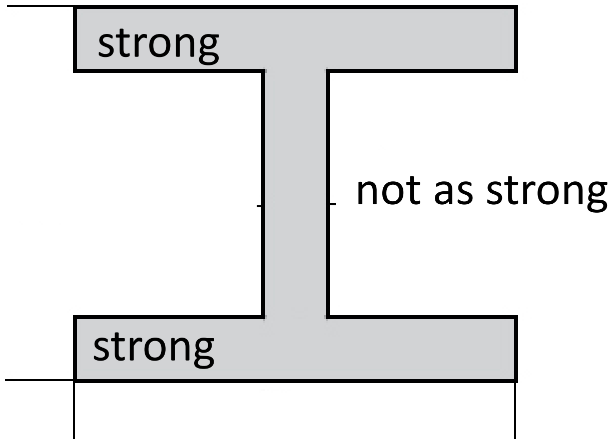
# Strengthening the Scintillator

Starting point

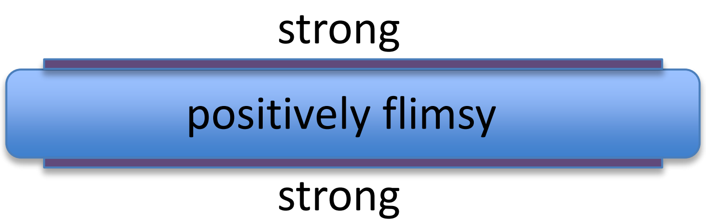


"Just" add aluminum covers (top and bottom)

This works for the same reason an I-beam works.




H-beam cross-section




counter cross-section

# Strengthening the Scintillator II

- So what's the problem?
  - Cost: each aluminum sheet costs $20-25 (13x the materials cost)
  - We need 10,000 pieces – this is a quarter of a million dollars

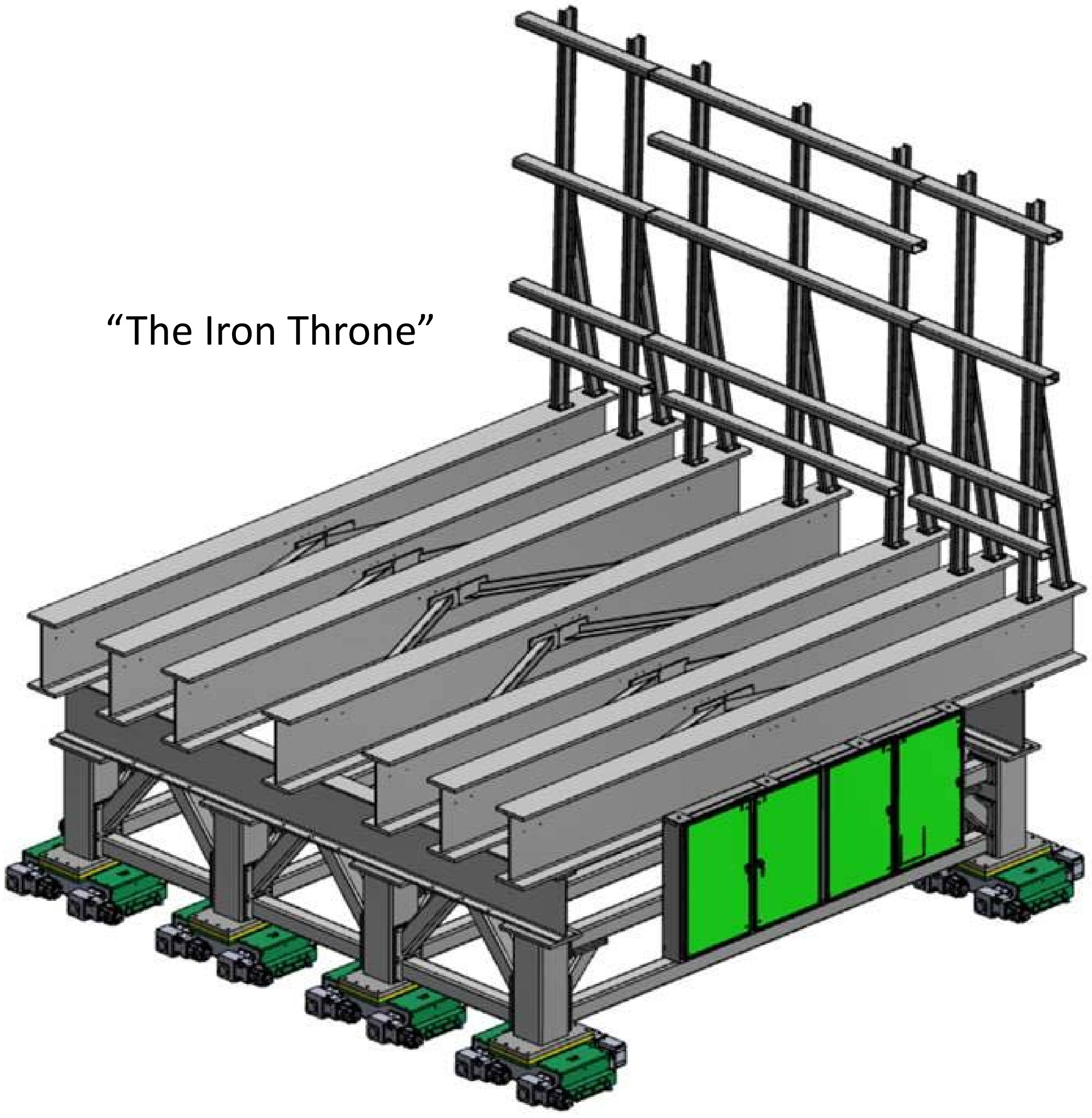
- What are our options?
  - The cost seems to be dominated by machining ($4 a cut with shears), Maybe we have options here.
  - Don't cover the whole surface (reduces light tightness) but just a small diagonal brace (the opposite direction on the reverse)
  - Use PVC instead of aluminum (probably not strong enough)
  - Use thicker scintillator (strength grows as cube of thickness) (also probably not strong enough)
  - Give up: handle the quad-counters in trays during construction
  - Really give up: don't test quad-counters; wait until all 48 are boxed to test them (**I really hate this**, but list it for completeness)

# Prototype Conclusions

- If we want to start soon, we probably need to start with a 4 cm design
  - Keeping a set of 3.54 cm design drawings in parallel
- Keeping the quad-counter stiff is a challenge
- Knowing if we need more light is becoming more urgent
- Getting more light out at the expense of uniformity may be no bargain
  - Would you rather have a unform increase of 5%
  - Or a random increase of 5-30%?
- It would be nice if there were some commercial electronics that we could simply hook up
  - We can't just "use mu2e". We don't own any; it's the wrong shape; we probably want to concentrate on the analog signal.
  - The electronics for the 4x4 array from AiT was just about perfect.

# Support Design

- We have redesigned this to have eight Hilman rollers rather than four
  - Four distributes weight 2-2: too much for the PRISM Hilmans
  - Six distributes weight 1-2-1: it doesn't help
  - Eight distributes weight 1-1-1-1: that works
- The Hilman control box has been added (green)
  - These are 60" tall, to give a sense of scale
- Next step: price this out piece by piece (rather than by the total weight)



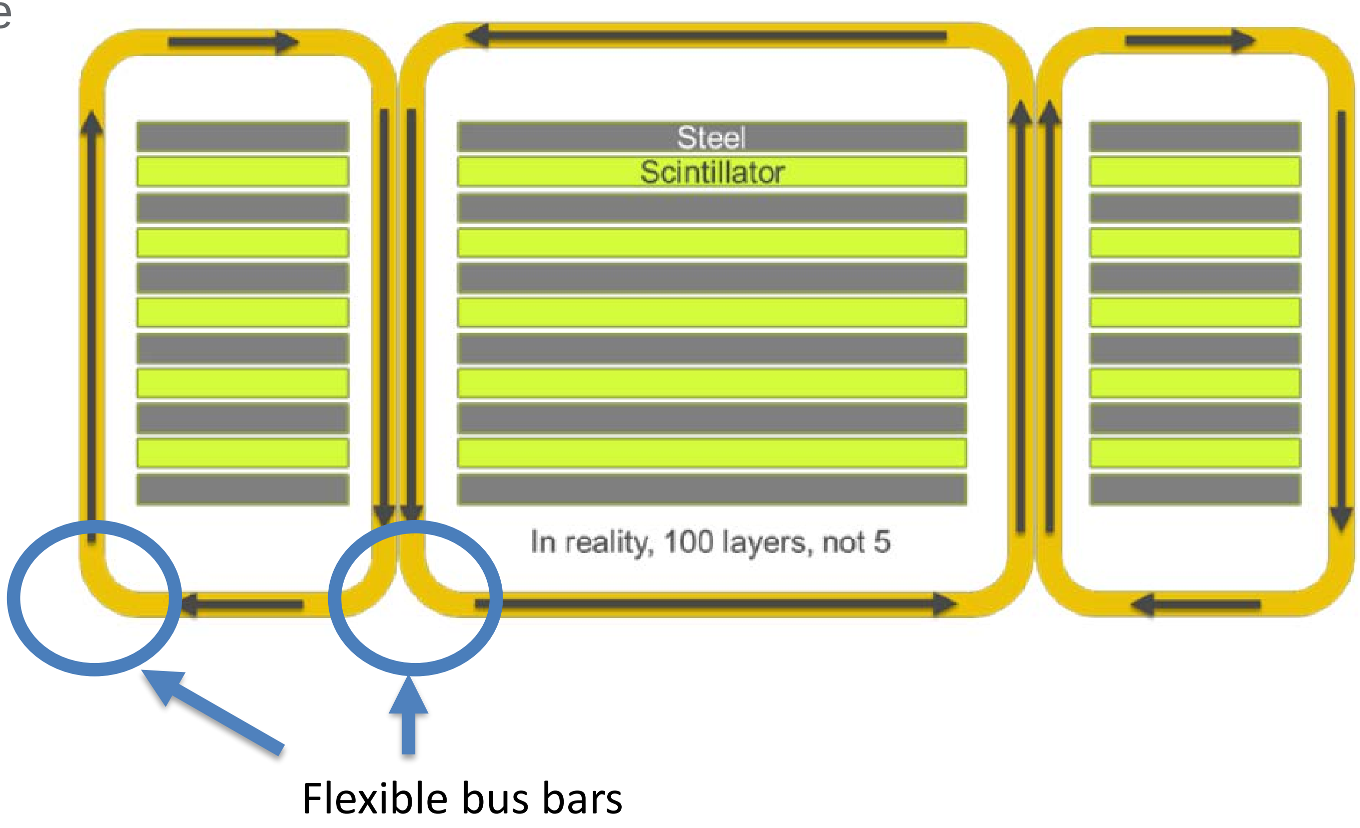
# Magnet Cooling & Mechanics

- Mettex won't tell us the resistance of the flexible bus bar, so we will buy one and measure it.

- It has probably twice the resistance per foot as the copper bus bar
  - It will generate twice as much heat
  - It's only 5-10% of the coil, but generates 10-20% of the heat.

- We believe this is fine
  - This works like a CPU cooler
  - Heat flows from the flexible bus bars into the copper rigid bus bars, and from there into the steel, where convection cools it.
  - We will do an ANSYS model once we understand the input parameters

- We will also analyze the forces on them as well.

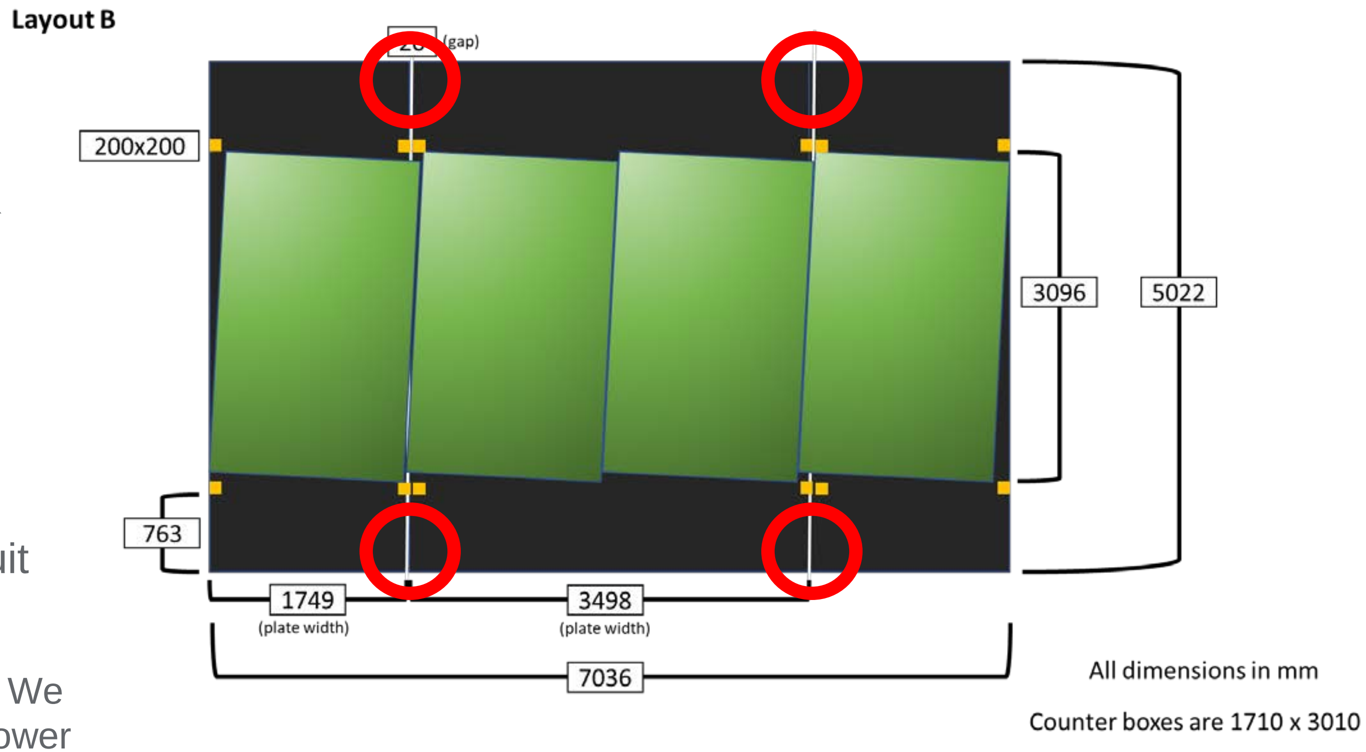


# Magnet Issues

- We had Jerry Nolan and Brahim Mustapha (ANL magnet experts) take a look at the design.

- Once they understood it (this showed we need more/better documentation here) they were OK with it.
  - ANSYS knows differential equations
  - These guys know magnets – not the same thing!

- They pointed out that the four inter-plate gaps (red circles) dominate the reluctance of the magnetic circuit
  - Up to 80% of the reluctance comes from that 1½ inches
  - Maybe we can insert a steel strip and gain some margin. We need to do some modeling, although this is at a somewhat lower priority. This may influence the number of power supplies we need.




We do not know how close we are to the 98% charge identification KPP. Therefore we don't know how much margin we need and how much we can release.