Pileup Temporary Muon Spectrometer

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General Pileup Considerations

- Many more muons are produced inside the iron than come from the argon
  - We are concerned about iron muons interfering with argon muons
  - We are less concerned about iron muons interfering with other iron muons
  - Rock muons (treated as fully penetrating) are included but a small contribution

- The detector is intrinsically fast compared to an RF bucket (few ns vs 19 ns)
  - The signal has relatively low time jitter
    - (Straight) track length contributes less than ±1 ns
    - Muon velocity contributes less than ±1 ns
    - Track curvature contributes less than ± 2 ns
    - y-position of the muon in the counter contributes about ±1 ns
- Occupancy is actually quite low

In the numbers that follow, I tried to adopt a "on the pessimisitic end of realistic" strategy.

Spectrometer Occupancy

- Assume 200 iron interactions per spill
  - This is high, but not crazy high (about 0.3 interactions per ton per MW)
  - That implies 80% of the time there is no iron muon to confuse your argon muon
    - 40% of the time there is only one muon in the instrument
    - 40% of the time the other muon is very far away, e.g. in the last meter when the muon of interest is in the first

- **Only 5% of the time do two muons end up in the same panel**
  - For this study, I assume maximum damage: these muons share this panel through their entire trajectories.

- Don't like these assumptions? I uploaded a spreadsheet so you can use your own!
  - I found it more useful to think about ranges of possibilities than a single point

The 5%

- Much of the discussion (y-view counters, larger stereo angles) revolves around making this 5% smaller.
  - If you assume we can separate muons 10 cm away in x (two unoccupied slats between them) and 60 cm in y (1.5σ) but can never untangle events with three muons in a panel, this reduces 5% to 0.3%.
  - If you assume we only do half as well (20 cm and 120 cm), this becomes 0.8%.

- Optimizing the design will help us do a little better, but to do a lot better requires increasing the channel count (strictly speaking, decreasing the occupancy per channel)
  - This costs money (money we don't have)
  - If I had that money, I probably wouldn't optimize around pile-up: I'd improve resolution and charge separation and take whatever pile-up benefits came with those other improvements

2.4 MW

- There is no cliff (exactly) between 1.2 MW and 2.4 MW

- However, 2.4 MW is roughly the point where the dominant pileup issue switches between "two muons too close to each other in the same panel" and "three or more muons in one panel".
  - The second problem is much harder to solve (especially at 48 channels per panel)

- Instead of a factor 2 worse, it's a factor 5 worse.
  - It may not be a cliff per se, but it's growing faster than linearly – and faster than quadratically.