DUNE SP DAQ Strategies for Trigger Primitives and Commands

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Concept for Collection Plane Trigger Primitives

Channel level: individual 960 collection channels:

1. Maintain rolling baseline and RMS
2. Locate threshold crossings
   - → $\mathrm{ADC}_{thres} = \mathrm{BL} + N\sigma_{rms}$, $N = 3$ or 5?
   - → $\mathrm{ROI}_{ch} = (\Sigma_i \mathrm{ADC}_i, [t_1, t_2])$, ie total charge and the times bracketing waveform above threshold.

APA-face level: all 480 collection channels on each face:

1. Form union of ROI overlapping in time: $\cup\{\mathrm{ROI}_{ch}\} \rightarrow \{\mathrm{ROI}_{face}\}$
2. Pad each side of ROI_{face}. Pick t_{pad} to assure:
   - catch induction/collection plane time offset (6.25 μs).
   - minimum waveform for field response deconvolution ($\sim$ 100μs)
3. Merge nearby ROI_{face} if separated by small gaps $< t_{gap}$
   - Avoid lots of tiny ROI. May not not useful, need study.

Emit the padded and merged $\{\mathrm{ROI}_{face}\}$ info as trigger primitves.

Variant: More processing to remove ^{39}Ar

Starting with $\{\text{ROI}_{ch}\}$ from 480 channels of each APA face:

1. Order and cluster ROI in channel vs tick space.
2. Drop "small" ROI clusters as measured in some metric.
3. Forward remaining $\{\text{ROI}_{ch}\}$ to APA-face level processing.

Comments:

- Many ideas and tests are needed to find a good clustering algorithm that can keep up with data rate.
- It need not be perfectly efficient to reject ^{39}Ar but it needs to be highly pure.
- To test, we need realistic intrinsic noise simulation and reasonable models for excess noise. ^{39}Ar collection waveform shapes also important.
- Need to think hard what "good" events this might reject!

Module Level Trigger Primitive Generation

Module Trigger Logic consumes stream of ROI from 300 collection planes and produces Trigger Primitives and sends them to **Global Trigger Logic**.

Module-level Trigger Primitives:

- Supernova Burst Primitive:
  - Reject ROI that are "too long" in time.
  - Reject ROI that are "too frequent" inside a single collection plane.
  - Form coincidence in time for remainder.
- Activity Primitive:
  - Reject ROI that are "too short" in time AND too low in charge (energy threshold)
  - Forward the remainder to GTL.

Global Trigger Commands

Global Trigger Logic consumes Module-level Trigger Primitives and emits Global Trigger Commands. Trigger Command says which APAs readout which ticks.

Which ticks:

- **Fixed readout time**: 1 or 2+ drift times around ROI.
- **Variable time slice**: merge and maybe pad and fill $\mathrm{ROI}_{face} \rightarrow \mathrm{ROI}_{APA}$, readout just inside the result.

Which APAs:

- **Whole module**: original "cosmics" trigger reading 150 APAs
- **Nearest neighbors**: all APAs with ROI_{face} and NN with no ROI.
- **Individual APA**: just APAs with ROI_{face}

Which Trigger Command Scheme?

- The **Fixed readout time** and `Whole module` scheme produces a large amount of data (6PB/year)
  - It will still (almost) let us fit into the 30 PB/year Offline limit.
  - But, clearly will consist of a lot of unneeded data.
- I suspect we can apply **Variable time slice** and **Individual APA** without introducing bias.
  - Just wild guess: "cosmics" go from 6 PB/year $\rightarrow$ 500 TB/year.
- In any case, real ROI_{ch}, ROI_{face} and ROI_{APA} algorithms need to be developed and evaluated.