TDIS DAQ and trigger requirements

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What is this based on?

- mTPC design with 10 5cm-long drift chambers arrange longitudinally; inner radius is 5 cm, outer radius is 15 cm.
  - Drift time in each chamber is ~1 us
  - Each chamber instrumented by ~2500 5mm x 5mm pads
- Rate estimates done by Marco
  - Initial rate estimates were for about 98 MHz of protons throughout each chamber → average rate per pad was ~0.8 MHz.
  - Rate estimates from Dec 2017 have ~68 MHz of charged particles crossing the inner ring of pads → average rate on inner ring ~1 MHz

Which tracks are interesting?

- The 30°-70° region of interest corresponds to tracks entering the active region ~9 cm - 2 cm forward of the e- vertex
- Tracks starting >15 cm forward of the vertex would have θ <20°; a 20° track will be confined within ~18 mm of the inner edge along the 5cm length

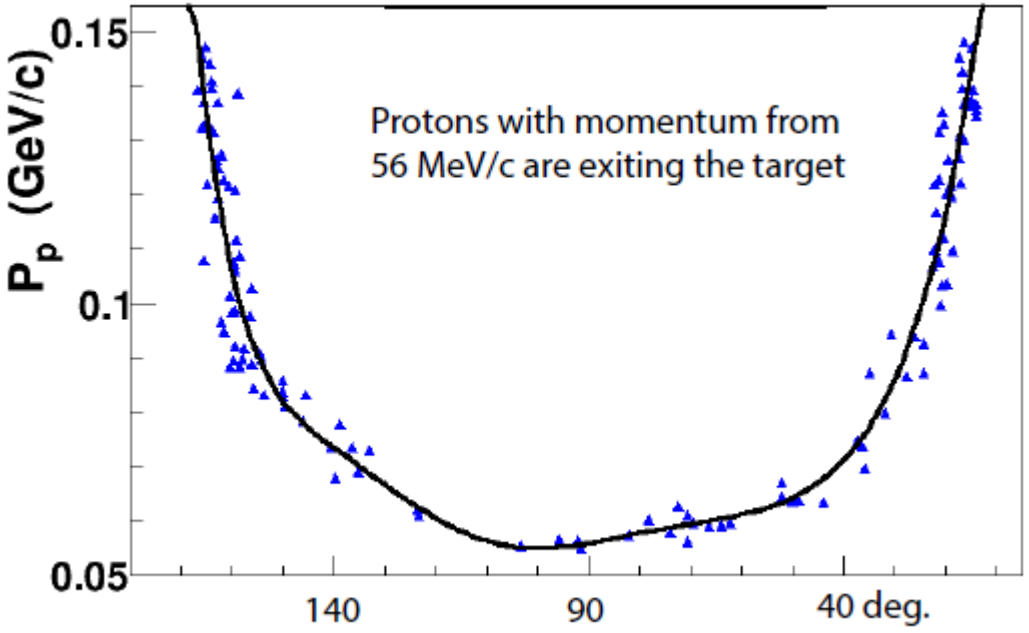


Figure 17 from proposal

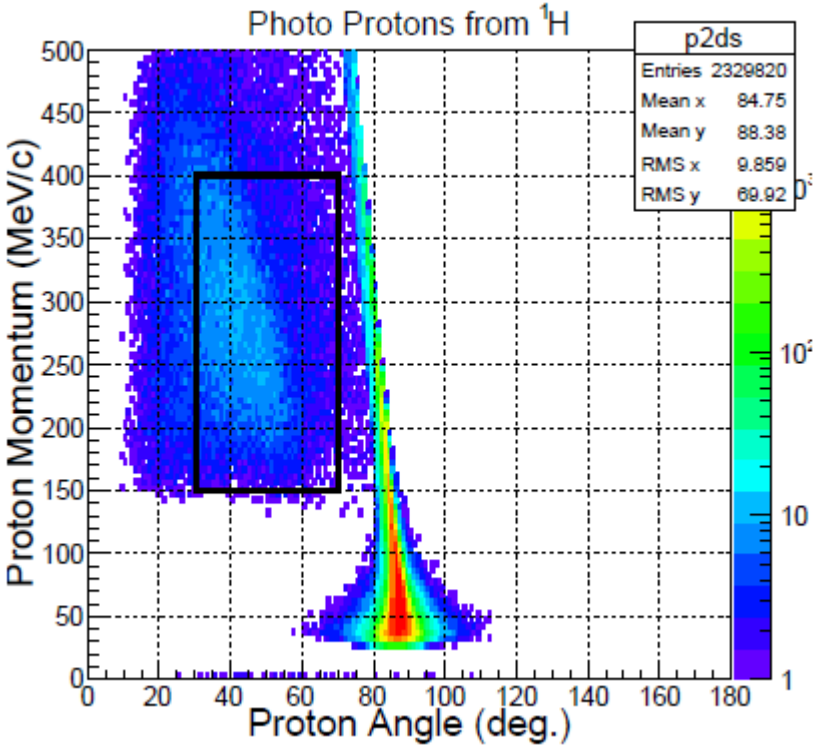


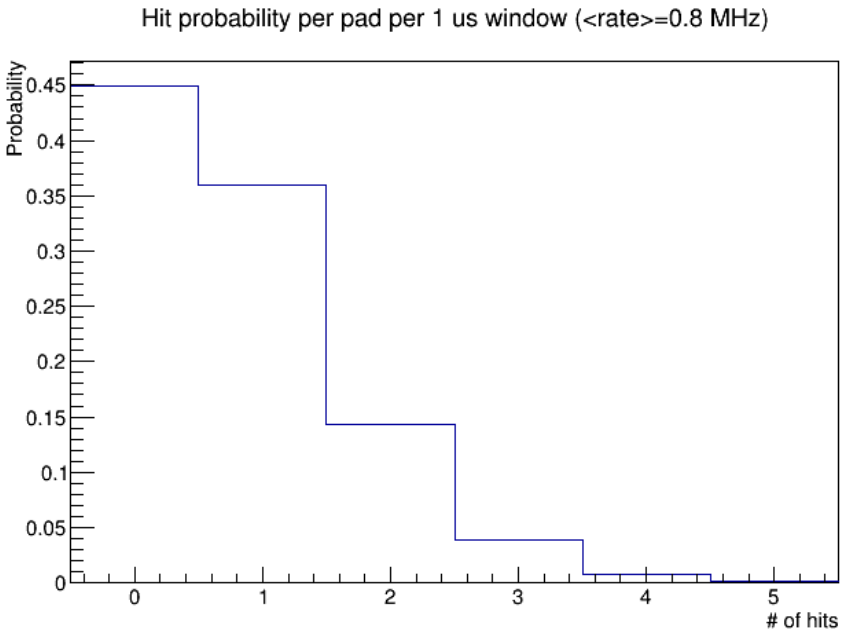
Figure 27 from proposal

Thoughts on characterization

- The maximum drift time is 1 us for 5 cm
- A track with θ=45° would have a longitudinal extent of 5mm as it traverses one 5mm pad width; the drift time would vary by 100 ns across this pad. Drift time width for 30° is ~170 ns.
- There will also be some shaping time; the SAMPA chip shaping time is 160 ns (reduction to 80 ns possible with added development effort)
- Together, this maybe gives a 200 ns double-pulse resolving time

Rates & occupancy per pad

- For a proton rate in each sub-chamber of 98 MHz and ~20 hit pads per track, there would be ~2000 MHz of pad-hits in each sub-chamber
- Each readout plane has ~2500 pads, so rate per pad is ~0.8 MHz; in each 1 us readout window, ~36% of the pads would have one hit, ~19% would have two or more.
- Occupancy is 55%, hits per struck pad is 1.45



~15% of hits will have a pulse within 200 ns.
(1 - Poisson(0, 0.8 MHz*200 ns))

Rates & occupancy on inner ring

- Using the rate per pad on the inner ring of ~1 MHz and 1 us drift time
- Occupancy is 63%, hits per struck pad is 1.58
- Abut ~18% of hits will have a pulse within 200 ns
  - About 28% of the hit pads on the inner ring have non-separable pileup

Shaping and sampling in SAMPA

- Waveform from SAMPA using 10 MHz sampling and 160 ns shaping time
  - From "Qualification of the ALICE SAMPA ASIC With a High-Speed Continuous DAQ System", G. Tambave and A. Velure, *IEEE Trans. Nucl. Sci.*, vol. 64, 1461-1466, June 2017.
- In this case, 600 ns are needed to fully contain the pulse

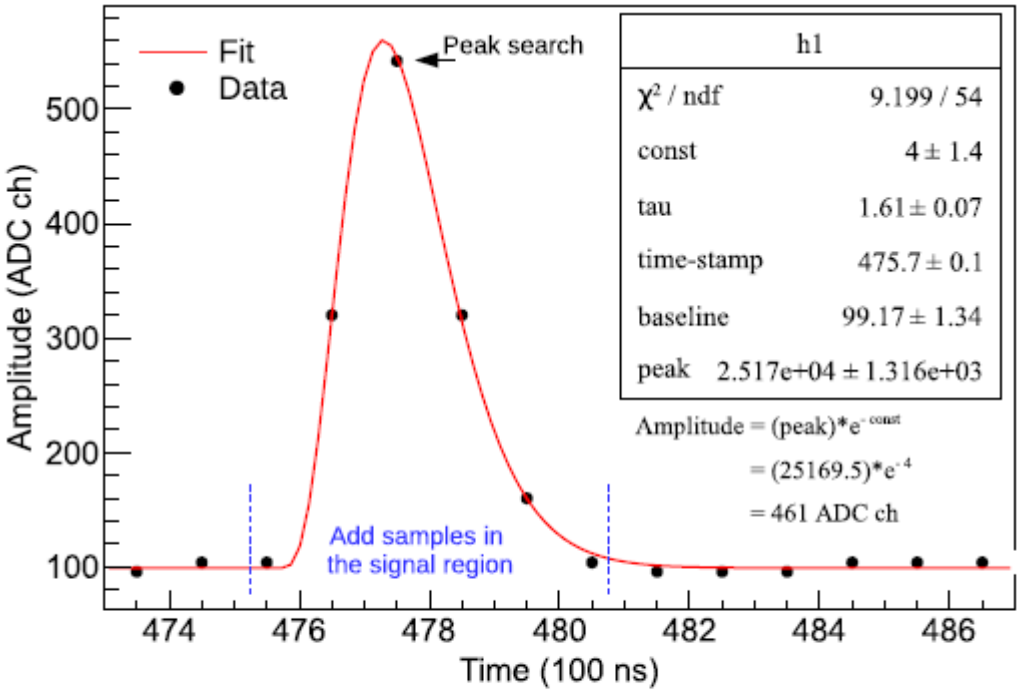


Fig. 4. Example waveform showing the different methods used for waveform feature extraction: peak search (arrow), waveform fitting shown in solid line (red curve), and area of waveform, which is calculated by adding the samples in the signal region (blue vertical dashed line).

Some data rate cases

- Assuming an average hit requires 12 50-ns time bins to be recorded (300 ns) and using the 0.8 MHz hit rate per pad, the “time-bin occupancy” will be 24%.
- Each chamber has 2500 pads sampling at 20 MHz, so there are 50e9 samples per second per chamber; 12e9 are filled.
  - Using SAMPA as a baseline, 1 chip handles 32 channels, with 10b sampling and 1.28 Gb/s output.
    - Keeping only filled bins & w/o timestamps would give 1.536 Gb/s, so to output 20 MHz sampling would require <26 pads per chip
- The trigger rate from electrons in the SBS should be ~6 kHz.
  - In each trigger, we expect an average of 0.8 hits/pad, so there would be 0.15e9 filled samples/chamber/trigger →0.6 GB/s/chamber at 4 bytes per filled sample (amplitude and timestamp)