Description and constraints of the back-end trigger of the Photon Detection System in DUNE

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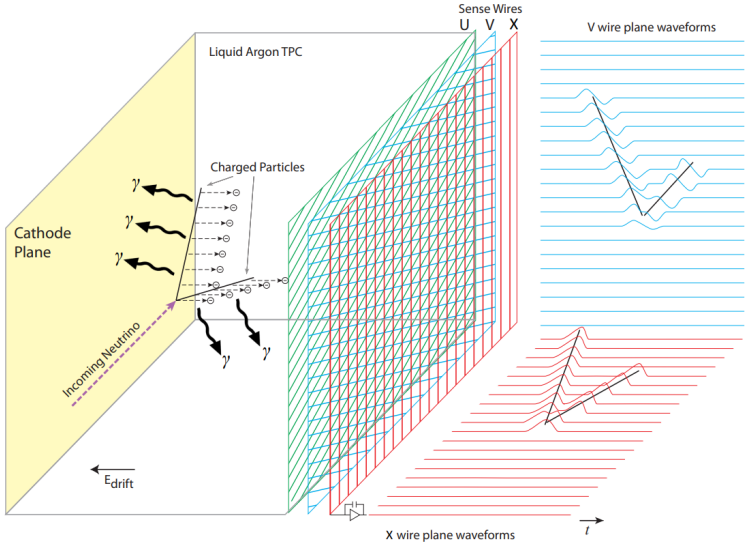
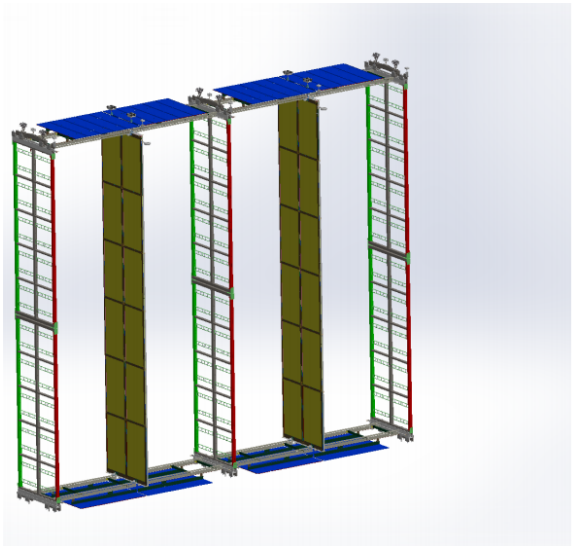
¿Why should we need PDS at DUNE?

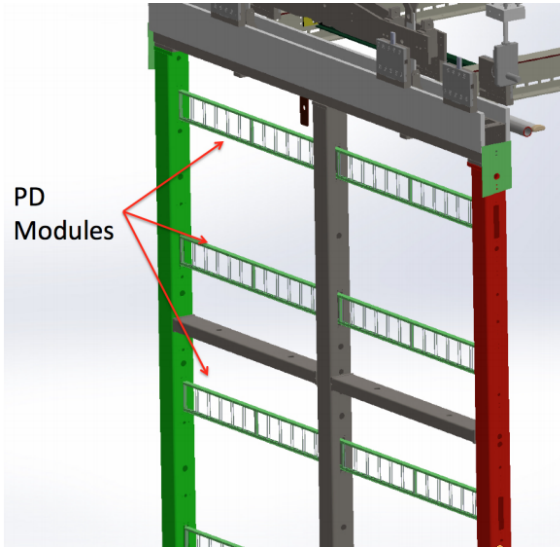
In the Time Projection Chamber, we can describe events by the traces of charged particles across the Electric field between cathode and anode.

Charge detection



PD





¿Why we need PDS at DUNE?

t_0 description.

- description of the x axis
- enhances the full 3D reconstruction
- vertex of SNB events
- enhances SNB triggering

Calorimetry

- Crosscheck to the energy measured by the TPC
- Improve the energy resolution

¿Why we need PDS at DUNE?

New areas of research

- Enhance DUNE's capability to observe few-MeV scale events, such as solar neutrinos
- Identify Michel electrons from decay produced by muons

2 Sets of events

In DUNE we will have 2 sets of events.

Those we can ”predict”
Beam Calibration

Those we can’t
Proton Decay SNB

Trigger-less DAQ

DUNE will use zero suppression at both detectors in the SP to reduce streaming data upstairs.

APAs

Comparison with a set of patterns

PDS

Threshold based on simulation
Eventually we can use FFT

Data we are working

TDR

- 24 PE/MeV
- 0.5 PE/channel

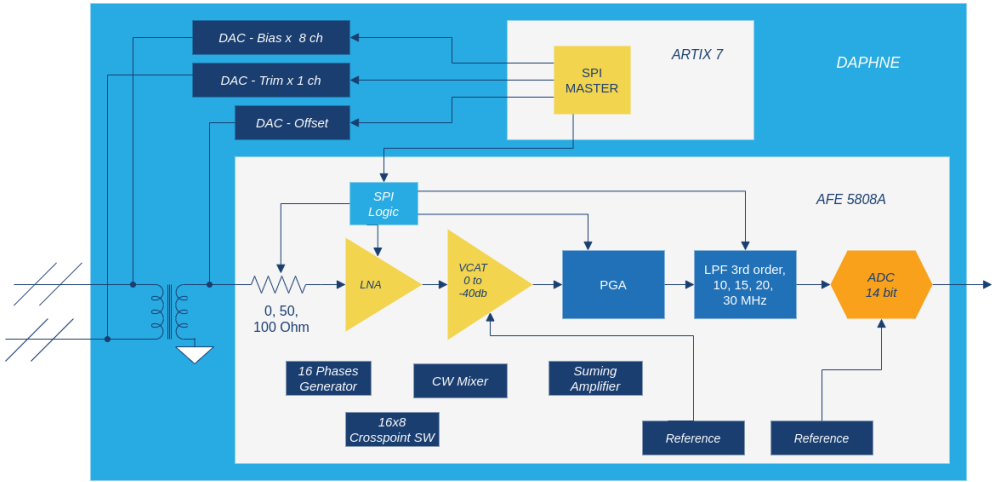
New sims

- 24 PE/MeV
- 1PE production x 10 Ar-39
- 1.5 PE/channel
- trigger rate 4.8k/s

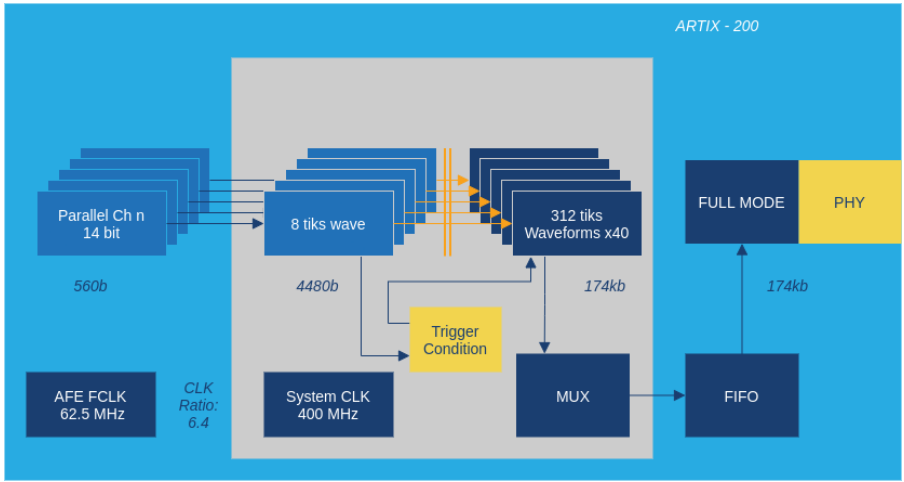
Constrains

SP-PDS-13	Data transfer rate from SP-PD to DAQ	$< 8\,\mathrm{Gbps}$
SP-PDS-14	Signal-to-noise in SP-PD	> 4
SP-PDS-15	Dark noise rate in SP-PD	$< 1\,\mathrm{kHz}$
SP-PDS-16	Dynamic Range in SP-PD	$< 20\,\%$

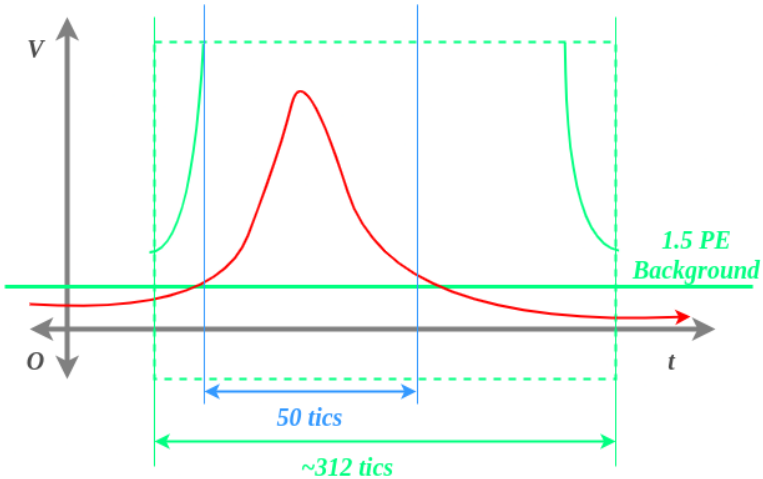
Analog Front End



Triggering


ARTIX - 200
Parallel Ch n
14 bit
560b
8 tiks wave
4480b
312 tiks
Waveforms x40
174kb
FULL MODE
PHY
174kb
Trigger
Condition
AFE FCLK
62.5 MHz
CLK
Ratio:
6.4
System CLK
400 MHz
MUX
FIFO

Waveform



Rise time of the small pieces of information

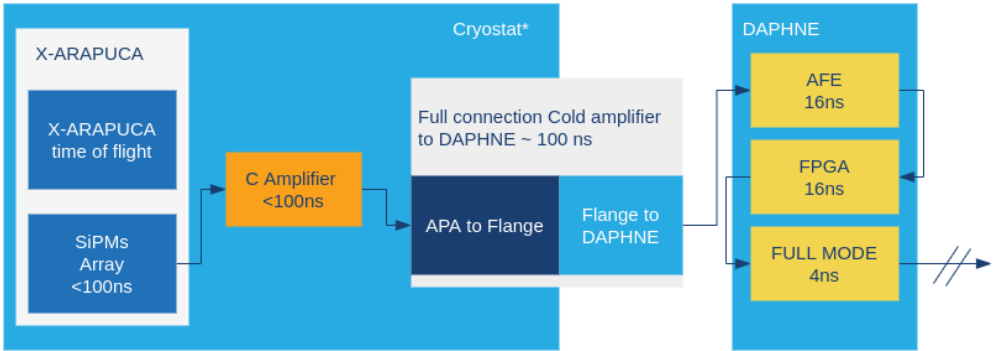


Fig 1. Rise Time Diagram

** It doesn't consider the fling time on the cryo*

It describes the time that takes the minimal piece of information to go through all the system ~340ns

Bandwidth

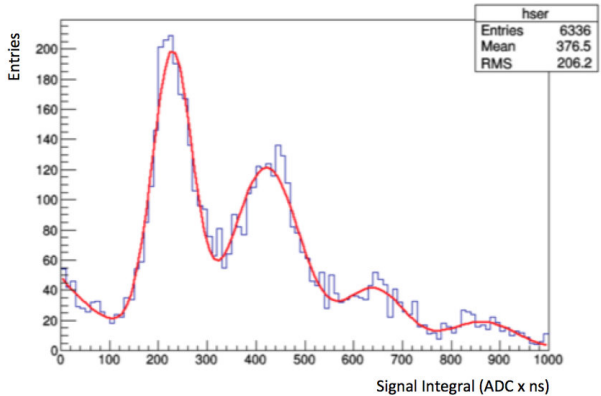
Requirements

- 1Gb/s for data streaming
- Short time resolution

Specs

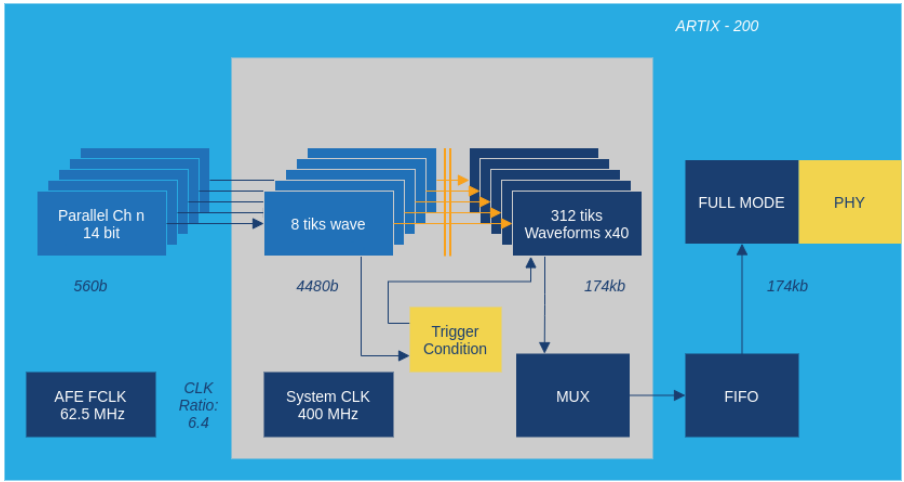
- $4.8 Gb/s$ for data streaming
- $3.7 Gb/s$ effective bandwidth
- $\approx 35 Gb/s$ rate of digitization
- $\approx 10\%$ of the full digitization capacity

histogram of the Arapuca Tests



from MOTTA et al. (2018). ARAPUCA light trap for large liquid argon time projection chambers. 153. 10.22323/1.295.0153.

Triggering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DEEP UNDERGROUND
NEUTRINO EXPERIMENT