Real-time intelligent data processing for the next generation of particle imaging detectors

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Particle Imaging Detectors

Next Generation - Deep Underground Neutrino Experiment (DUNE)

Current Generation - Short Baseline Near Detector (SBND)

Past Generation - MicroBooNE Neutrino Experiment (MicroBooNE)

Expected data rates: 5TB/s
Expected to be Operational by 2030

Expected data rates: 45GB/s
Expected to be Operational by 2023

Data rates: 33 GB/s
Data taking: 2015-2021

Liquid Argon Time Projection Chamber (LArTPC) detectors

Excellent resolution

Rare physics processes: baryon number violation

Low energy blips

On-going Development and Demonstration

- Offline development and validation using MicroBooNE data.
- Developed trigger to tag Michel electron topology.
- Used topological (change in directionality) and calorimetric (energy in Bragg peak) information.
- 2% efficiency in selecting such events

Online Processing begins with generating drift regions (2.3ms Event) from frames (1.6 ms)

Following DUNE strategy [1]

Data Processing Schemes

- For DUNE, processing > 5TB/s data is computationally challenging
  - Requires intelligent data-processing and data-reduction schemes.

TPC-based trigger - Currently being demonstrated with MicroBooNE and ProtoDUNE-Single Phase (SP), soon with SBND

Online processing

- Time over threshold
- Maximum amplitude
- ADC Integral

Summary of ionisations per wire

Zero-suppressed waveform [2]

- The TPC-based trigger can be used to trigger on any off-beam activity including rare signals.
  - Future possibility includes triggering on some of the on-beam activities.

Online data selection is currently being demonstrated with MicroBooNE and ProtoDUNE-SP.

Power efficient FPGA: Requirements

- Network downsizing
- Optimization
- Training Quantization

Demonstration

References