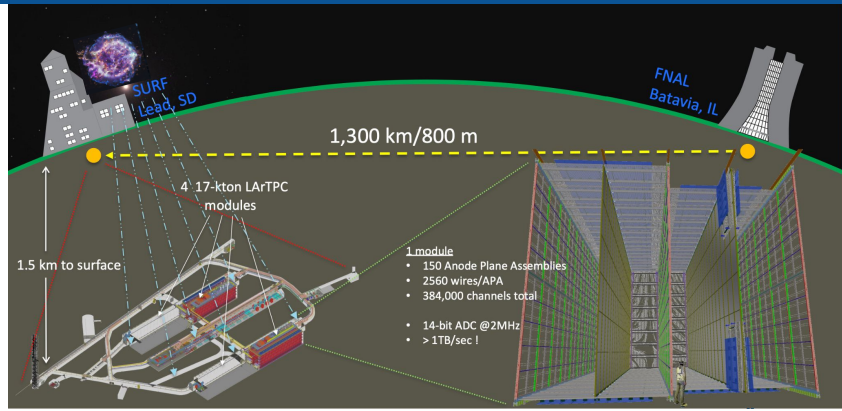
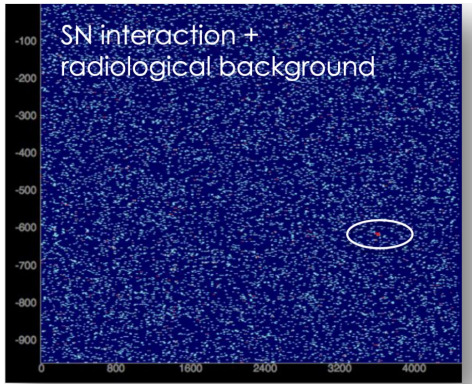
Real-Time Detection of Low-Energy Events for the DUNE Data Selection System using ML

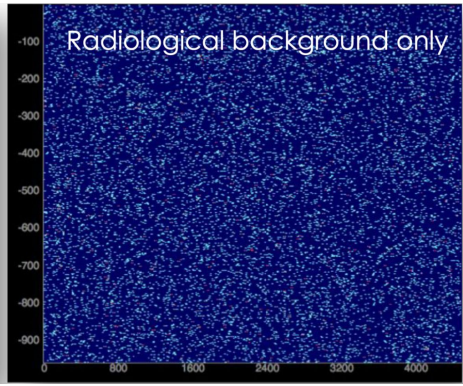
EUROPEAN AI FOR FUNDAMENTAL PHYSICS CONFERENCE EuCAIFCon 2024

The Deep Underground Neutrino Experiment (DUNE) is a next-generation experiment for neutrino science at the Fermi National Accelerator Laboratory in Batavia, Illinois.



- DUNE high-resolution “video” stream: up to 4x200 cell volumes, 11.5 MP frames per 2.25ms, 12-bit resolution, total of ~40 terabits/s.
- Designed for 95% trigger efficiency on a supernova burst.
- Early trigger & SN pointing from LE ν.
  - Hard to distinguish, Multiplicity and Clustering not efficient.
  - Differentiate between ν-LE types.
  - Delay in SN light - a few mins to days.
  - Very rare (~1/100 yr) - accuracy is important.
- Improve signal efficiency for solar ν.
  - Low sensitivity due to high Background noise and high threshold.
- Data reduction $O(10^4)$ is a necessity.
- Power consumption, heat, space an issue.
- 2DCNN on FPGA a potential solution.





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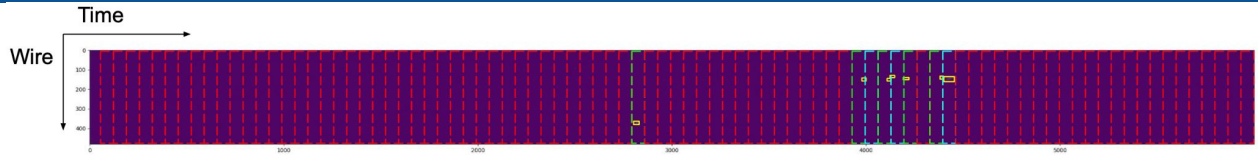

- ML algorithm for real-time data processing and trigger from a stream of LArTPCs data.
- Continuous read-out, arranged into “frames” and selected data is sent for further processing.
- Denoise + Downsize + 2DCNN
- Classify ν-LE events in real time with ≥ **90%** efficiency, reject noise background (NB) images with ≫**99.99%** efficiency.
- Each incoming 480 x 64 image must be processed within **32 µs** to avoid queuing.
- **HLS code injection** : to reach the meet latency and resource requirements.
- A detailed study of various implementations.
- A viable solution for DUNE readout.