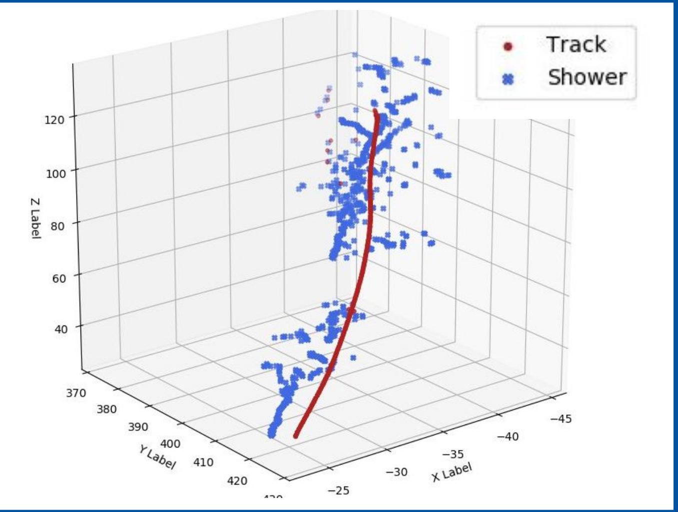
Particle identification in LAr detectors & Storage and Dataflow studies for the DAQ of HEP experiments

Adam Abed Abud

University of Liverpool: Prof. Christos Touramanis, Dr. Karol Hennessy
CERN: Dr. Giovanna Lehmann Miotto, Fabrice Le Goff

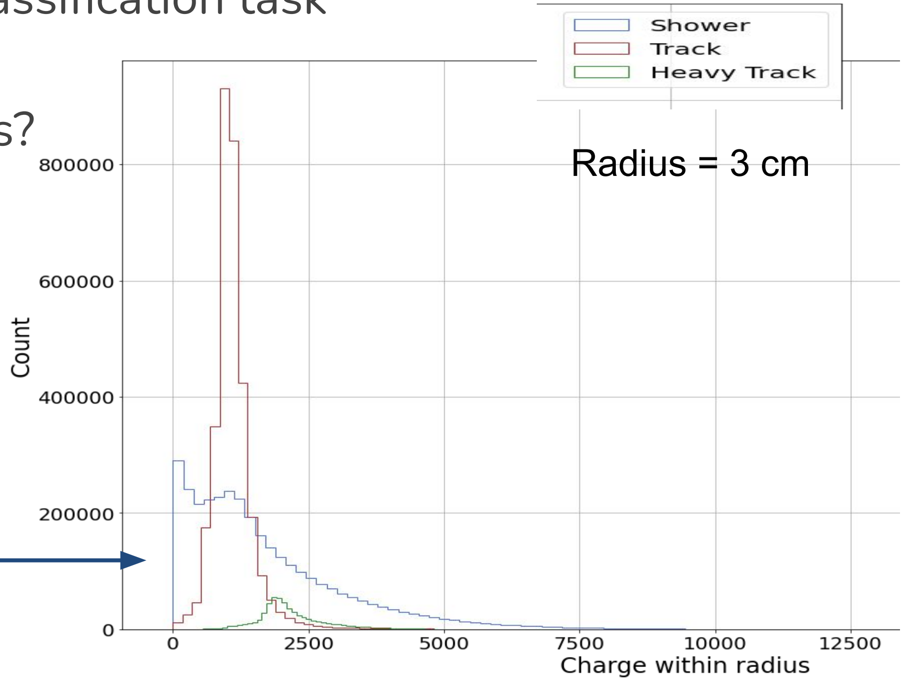
Annual HEP meeting
April 28, 2020 (Liverpool, UK)



Track vs Shower identification in LAr detectors

Track vs Showers in ProtoDUNE events

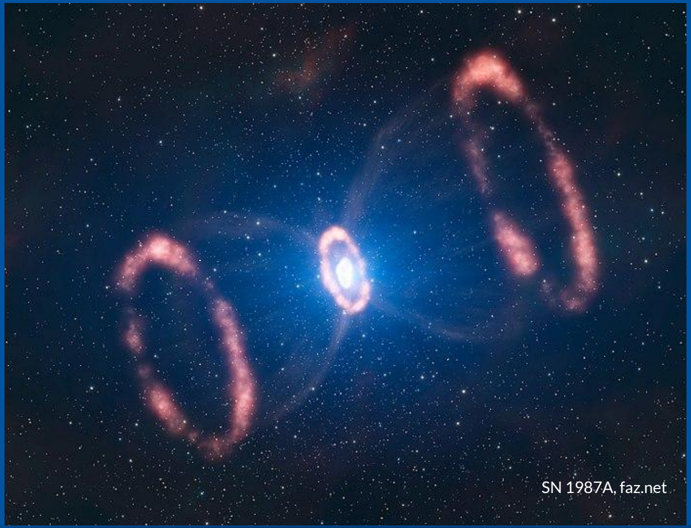
- **Goals**:
  - Discriminate between track and shower events in sparse hits from ProtoDUNE
  - Develop a Deep Learning model for the classification task
  - Apply the model to ProtoDUNE data
- How to distinguish between track and shower hits?
  - Analyzed a set of discriminating features:
    - Angle and dot product between two neighboring hits
    - Charge deposition of single hits
    - Total charge deposited over a certain distance
    - Number of neighboring hits within a certain distance



Development of the DL model

- Tested a Convolutional Neural Network designed for sparse data
  - Well suited for ProtoDUNE events
  - Trained on reconstructed MC data at 1 GeV
- Preliminary results show more than **85% efficiency** for both track and shower events

- **Next steps**:
  - Further testing is required to understand the performance of the model
  - Apply the model to ProtoDUNE data



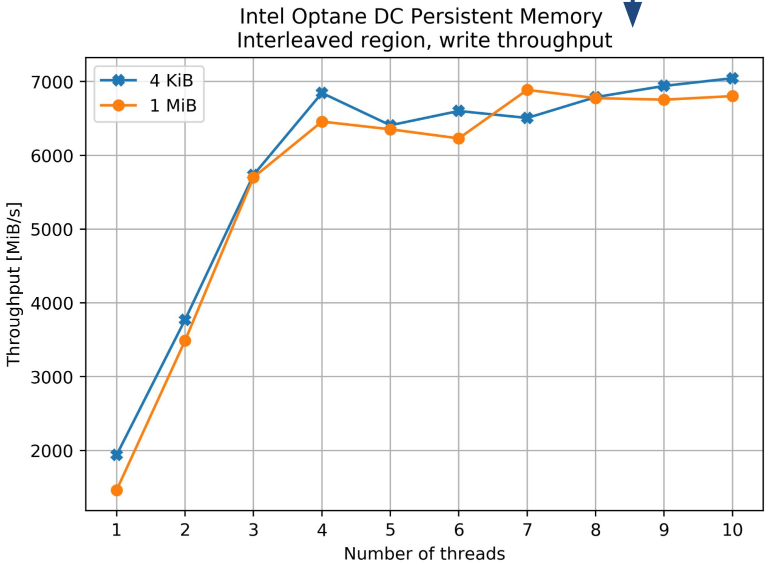
DAQ studies for the DUNE supernova storage buffer

DAQ studies for the SNB buffer (1/2)

- **Goal**: store Supernova Neutrino Burst (SNB) events
  - One of the physics goals of DUNE
  - Detection of **rare**, **low energy** and **distributed** signatures
- **Requirements:**
  - Sustain **high data rates**: 10 GB/s for each DAQ readout unit
  - **High data volumes:** minimum capacity of 150 TB
- **Solution**:
  - Use cutting edge storage devices to meet the performance demands of the DUNE experiment

DAQ studies for the SNB buffer (2/2)

- Investigated modern storage technologies for the DUNE SNB buffer:
  - Use of persistent memory devices (IEEE Real Time 2020, last October)
    - Measured the write throughput of persistent memory devices with a workload similar to the DUNE use case
    - Sustained 80 % of target throughput !
  - Use of fast 3DXPoint NVMe devices (CHEP 2021, coming up in May)
- **Next steps**:
  - Test the in ProtoDUNE-II !



ATLAS EXPERIMENT

Dataflow studies for the ATLAS data acquisition system

Dataflow studies for the ATLAS DAQ system

- **Goal**: develop a high performance distributed storage system for the Phase-II upgrade (2025)
- Contributed to the development of a first prototype
  - Developing the last component of the DAQ system before transfer to Tier0
    - **Critical system**: fault tolerance has to be taken into account
  - Performance results will be presented in May in CHEP 2021 and TIPP 2021
  - Collaborated with Intel on R&D projects for a high-throughput, distributed database solutions (DAQDB and later DAOS)
- **Next steps**:
  - Performance optimizations of the current prototype

Conclusions

- **Physics analysis of ProtoDUNE data**:
    - Very promising initial results from a DL classification model
- **DAQ studies for the DUNE system:**
    - Investigated the use of cutting-edge storage technologies and assessed their suitability for the DUNE DAQ system
- **ATLAS Dataflow:**
    - Transitioning from a prototype to a more robust and high performance system

Thank you!

Adam Abed Abud

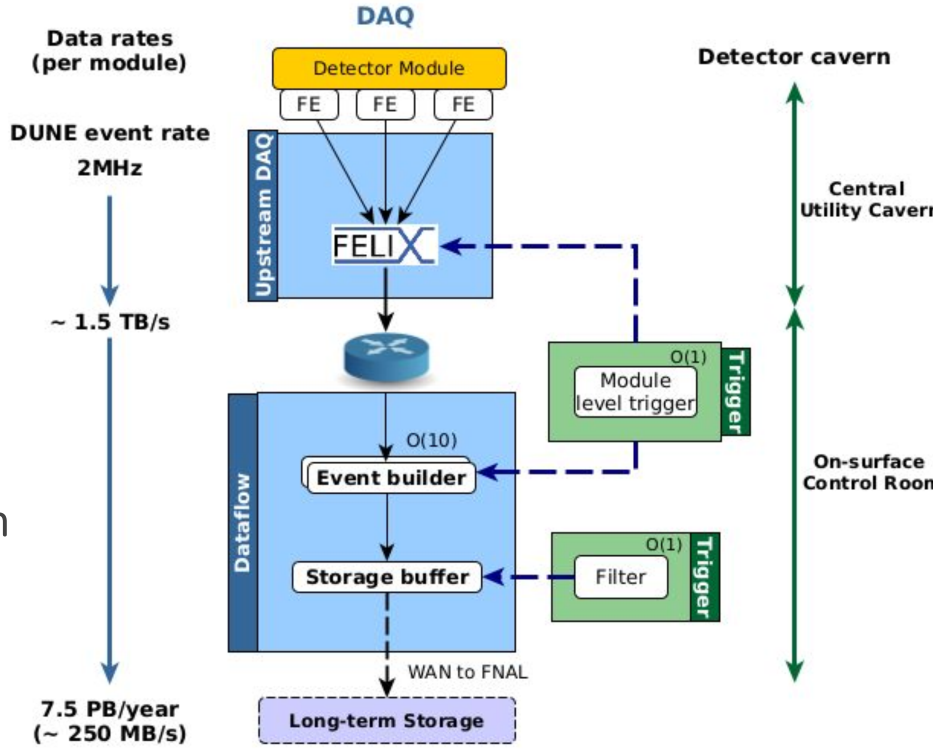
Further details

The DUNE DAQ
Data acquisition system

- Readout system handles the high data rate from the detector front-end electronics
  - 10 links
  - O(1) GB/s per link
  - 150 readout units

Bandwidth: 1.5 TB/s per cryostat

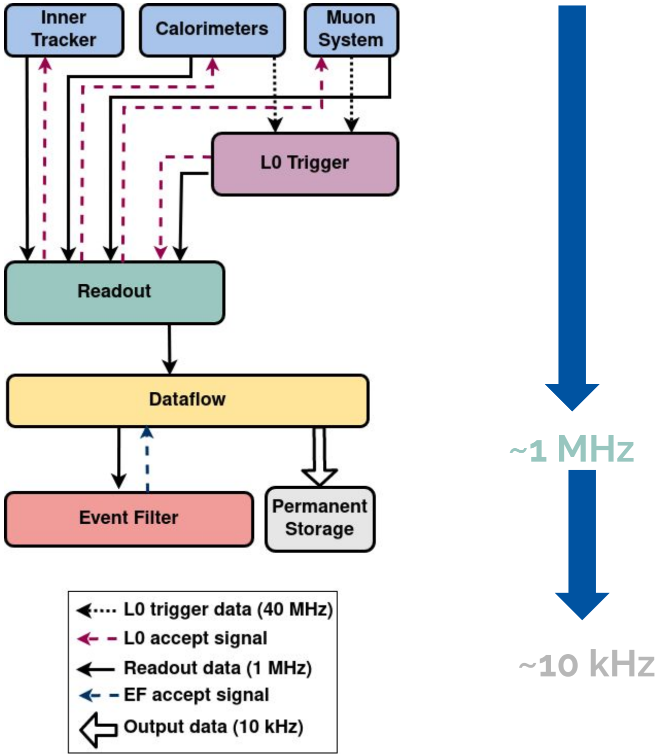
- Data selection system provides a trigger decision and reduces the data rates
- Dataflow system is responsible for the data movement from the readout nodes to the Output Storage buffer
- Output Storage System temporary stores the data O(1) PB before transfer to Fermilab



ATLAS DAQ: focus on the dataflow

- Dataflow provides persistent buffer for readout data, before and during event filter processing, and for selected events data
- **Capacity requirements:**
  - Event Builder: 5.2 TB/s x 10 minutes = ~3 PB
  - Event Aggregator: 60 GB/s x 48 hours = ~10 PB
- **System size determined by throughput requirements:**
  - Writes+Deletes: 500 MHz fragments (5.2 TB/s).
    Read: 2.6 TB/s
  - Transfer to Tier0: 10kHz accepted events (60 GB/s)
  - **Total throughput of ~7.8 TB/s**

TDAQ Phase-II (Run 4)



Latency and Bandwidth

Technology overview