Contribution ID: **341** Type: **Parallel**

Machine Learning for Real-Time Processing of ATLAS Liquid Argon Calorimeter Signals with FPGAs

Wednesday 9 July 2025 09:10 (20 minutes)

The Phase-II Upgrade of the LHC will increase its instantaneous
luminosity by a factor of 7 leading to the HL-LHC era. At the HL-LHC, the number of proton-proton collisions in one bunch crossing, pileup, increases significantly, putting stringent requirements on the LHC detectors electronics and real-time data processing capabilities.

The ATLAS LAr calorimeter measures the energy of particles produced in LHC collisions. It also feeds the ATLAS trigger to identify interesting events. To enhance the ATLAS physics discovery potential at HL-LHC, an excellent energy resolution and an accurate time detection is crucial.

The computation of the deposited energy is performed using electronic boards based on FPGAs. Currently this computation is done using optimal filtering algorithms that are adapted to situations with limited pileup. With the increased luminosity and pileup, the performance of the optimal filter algorithms decreases.

The off-detector electronic boards for the LAr Phase-II Upgrade will use the next generation of INTEL FPGAs with increased processing power and memory. This will allow the use on these boards of more complex algorithms. We developed several neural networks (NNs) with significant performance improvements with respect to the optimal filtering algorithms.

Five NN algorithms will be presented. The improvement of the energy resolution and the accuracy of the deposited time compared to the legacy filter algorithms will be discussed.
The implementation of these networks in firmware will be shown.

Secondary track

T16 - AI for HEP (special topic 2025)

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Session Classification: Joint T12+T16 (Data Handling and Computing + AI for HEP (special topic 2025))

Track Classification: T16 - AI for HEP (special topic 2025)