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Accelerating Unbinned Likelihood Computations in JUNO with GPU Parallelization

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The increasingly precise measurements needed to push the frontiers of neutrino physics require the construction of ever larger experiments, leading to ever more complex data to be interpreted. The JUNO next generation detector will reach a mass of 20 ktons and is expected to collect 2 PB/year of raw data to detect over 500.000 antineutrino events in 30 years of data.

The challenge is not just represented by the sheer volume of data. Such large detectors have inherent inhomogeneities, as spatial non uniformities and non linearity effects in the detector response. Other factors, such as detector coverage, detection efficiency or the incoming neutrino flux, can change in time due to failures, planned modifications to the detector or factors outside the control of the experiment.

Analysis frameworks must be able to cope with this evolution, allowing efficient processing of large numbers of events and providing flexible modelling of different detector responses. In this context, unbinned analyses have always been considered promising, but difficult to handle. They can incorporate spatial and temporal variations and characterize the detector response on an event by event basis. Their main limitation is the computational time, which scales linearly with the number of events processed.

Over the last few decades, architectures developed for other fields, such as GPUs, have found fertile ground in physics applications, leading to a huge leap in computing power. The use of these architectures targeted to parallel computing and the development of efficient and multi-threaded code can help to bridge the gap in this generational advance required to analyses in neutrino physics. This work describes the GPU implementation in Numba and CUDA of the unbinned likelihood calculation, capable of incorporating spatial and temporal information, to fit the JUNO reactor antineutrino spectrum.

Poster prize

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