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# $\nu^2$-Flows: Fast and improved neutrino reconstruction in multi-neutrino final states with conditional normalizing flows

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In this work we introduce $\nu^2$-Flows, an extension of the $\nu$-Flows method to final states containing multiple neutrinos. The architecture can natively scale for all combinations of object types and multiplicities in the final state for any desired neutrino multiplicities. In ttbar dilepton events, the momenta of both neutrinos and correlations between them are reconstructed more accurately than when using the most popular standard analytical techniques, and solutions are found for all events. Inference time is significantly faster than competing methods, and can be reduced further by evaluating in parallel on graphics processing units. We apply $\nu^2$-Flows to ttbar dilepton events and show that the per-bin uncertainties in unfolded distributions is much closer to the limit of performance set by perfect neutrino reconstruction than standard techniques. For the chosen double differential observables $\nu^2$-Flows results in improved statistical precision for each bin by a factor of 1.5 to 2 in comparison to the Neutrino Weighting method and up to a factor of four in comparison to the Ellipse approach.

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