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Unbinned time-dependent likelihood methods for neutrino searches with KM3NeT

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In this contribution, we present the development of an unbinned time-dependent analysis framework for KM3NeT/ARCA. This approach aims at improving the sensitivity to transient and variable neutrino sources by exploiting the event-level information, including reconstructed direction, energy, and arrival time.
The method is based on an unbinned likelihood in which the signal probability density function is factorised into spatial, energy, and temporal components allowing for the description of transient emission. We implement analytical time profiles, including box-shaped and Gaussian flares, providing a controlled and interpretable parametrisation of
transient signals through the flare time and duration. In addition, the framework supports the inclusion of external light curves, enabling the study of realistic time variability from multi-wavelength observations. The background is constructed from data, both in space-energy and time, while the signal spatial term is derived from the convolution of the
source flux with the detector response. The likelihood combines these ingredients to perform hypothesis testing via pseudo-experiments.
This framework has dedicated classes for transient sources and time-dependent components, and allows event generation and likelihood evaluation. We present the current status of the implementation, validation tests compared to time-integrated analyses, and
perspectives for applications to transient neutrino searches such as flaring blazars, high-energy neutrino core-collapse supernova sources, and untriggered neutrino bursts.
We also aim to discuss and exchange ideas with the wider community developing likelihood frameworks to share perspectives on time-dependent analyses.

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