Tau Neutrino Reconstruction with KM3NeT

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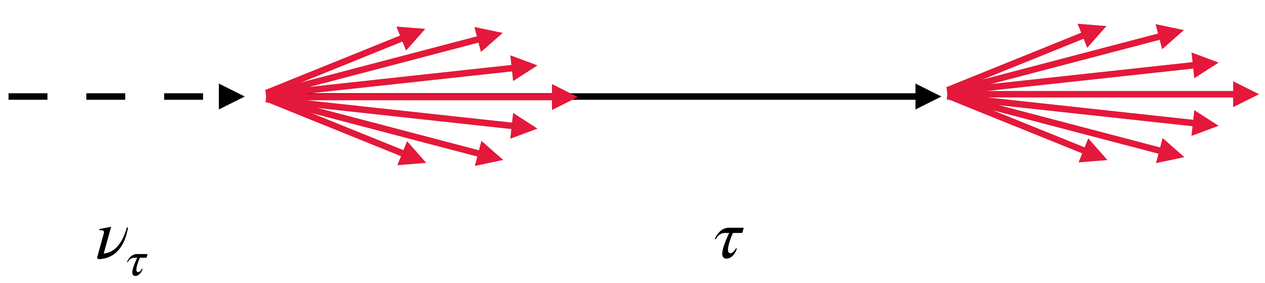
The KM3NeT detector is currently under construction in the Mediterranean sea and will be able to do astronomy with ν_τ [1]. The detection of astrophysical ν_τ is an important verification of the observed flux of high-energy neutrinos. KM3NeT/ARCA uses a 3-D grid of glass spheres housing photomultiplier tubes (top left image [2]), that detect the Cherenkov radiation emitted by neutrino interaction products.

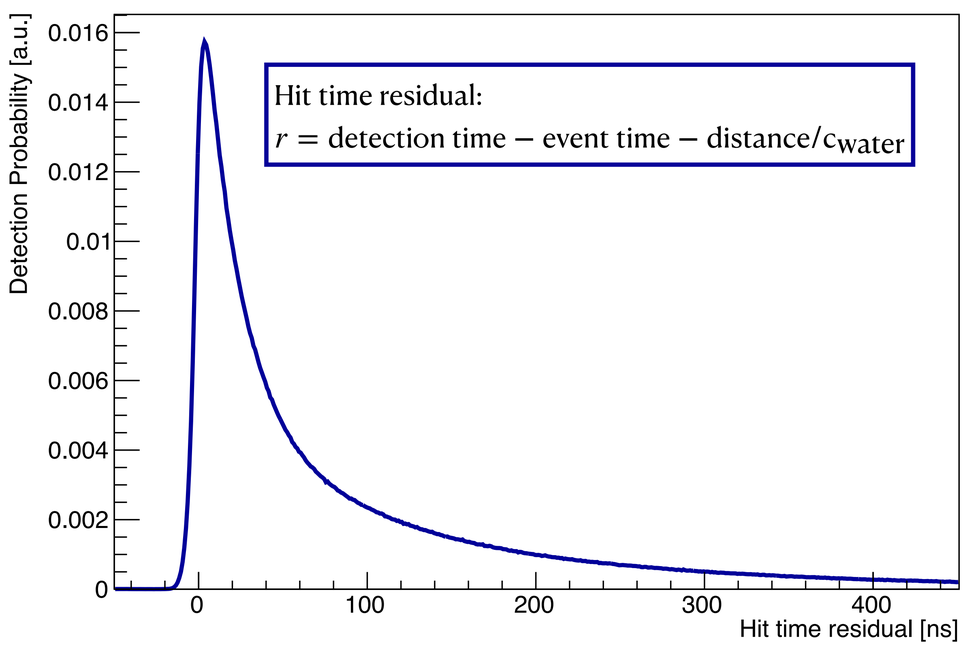


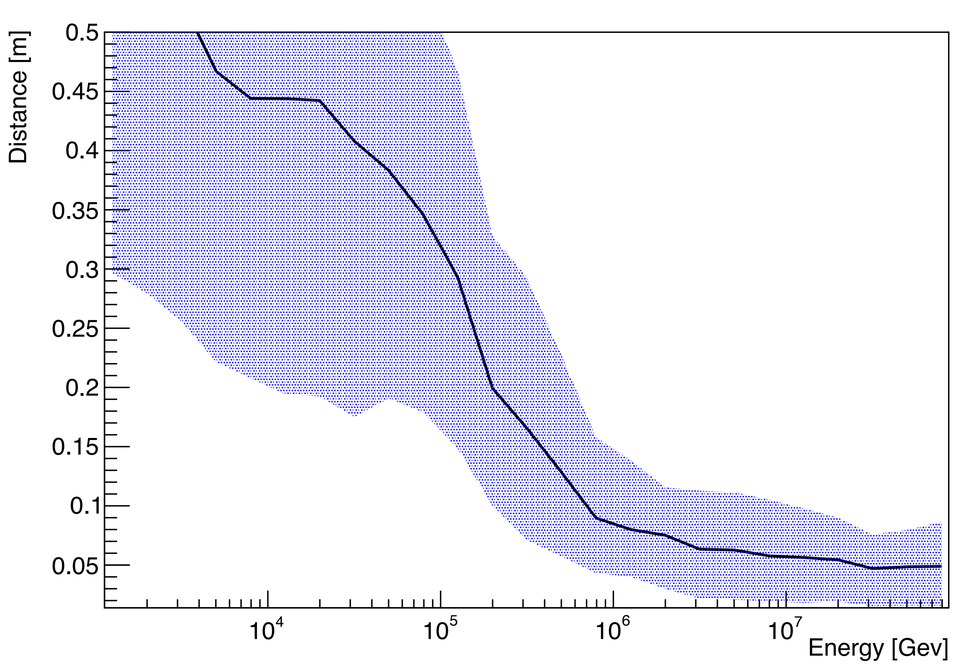
Double shower signature

When a ν_τ interacts in the deep sea, it produces a particle shower and often a τ lepton. The τ has a lifetime of 2.9×10^{-13} s and decays mainly into another shower and this results in a double shower signature. This is a unique channel due to the absence of atmospheric ν_τ.

Vertex position reconstruction

The direction of ν_τ signatures can be found using a vertex position fitter. The algorithm iteratively calculates the likelihood for different vertex positions until it finds the optimum position. The likelihood depends strongly on the time distribution of the light detected by the photomultipliers. The figure on the right shows the detection time distribution for single shower events in KM3NeT/ARCA obtained from Monte Carlo simulations.





Performance

The vertex position algorithm can be applied to both showers and this gives an estimate for the direction when drawing a straight line between both vertices. The figure on the left depicts the vertex resolution for single shower events as a function of the ν energy. The main challenge lies in identifying and separating two showers when the τ energy and travelling length are small. This superimposes the showers and worsens the vertex resolution.

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References
[1] Adrián-Martínez et al 2016 J. Phys. G: Nucl. Part. Phys. **43** 084001
[2] R. Bruijn EPJ Web Conf. vol. 207, 2019, p. 06002.