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Observation of ortho-Positronium formation in Double Chooz

The Double Chooz experiment measures the neutrino mixing angle θ13 by detecting the reactor electron anti-ν via inverse beta decay. The positron-neutron delayed coincidence yields a sizable background suppression; a further contribution might come from the development of techniques for an efficient identification of positrons. Pulse shape discrimination, a well-established technique for background rejection in liquid scintillator detectors, fails in separating them from electrons, as they give rise to identical light pulses. However, in some cases the positron decay is delayed by the formation of a positron-electron metastable bound state, called ortho-positronium (o-Ps), which introduces a delay between the light signal from the positron energy deposition in the scintillator and the one from the annihilation gammas. The consequent deformation in the positron-induced light pulse can be exploited to identify positrons with the pulse shape discrimination.
In Double Chooz, we observed the o-Ps formation using the data sets resulting from neutron capture on Gd. We performed the first o-Ps formation tagging on an event-by-event basis and we could also measure the o-Ps formation probability and its lifetime, finding (42 ± 13)% and (3.68 ± 0.23) ns respectively. These values are in good agreement with independent measurements obtained with a dedicated setup.

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