XENON1T Shows WIMP to be More Elusive than Previously Thought

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On May 28th the Xenon collaboration simultaneously broadcast multiple lectures detailing the latest result in a ~ 30 year search for the direct detection of weakly interacting massive particles (also known as WIMPs). This announcement demarcates the first time a direct detection experiment has operated a tonne scale detector for ~ 1 year – the largest milestone established by the original XENON collaboration nearly twenty years ago.

In the 1980s it was pointed out that stable electroweak-scale dark matter candidates could be probed by constructing low-background experiments, as weakly interacting massive particles (WIMPs) gravitationally bound to the galactic halo will occasionally produce observable interactions with nuclei in the detector. The following decades spawned a extensive direct detection search strategy producing an enormous number of experimental collaborations, each exploiting unique target elements and detection strategies intended to optimize sensitivity to particular dark matter candidates. Over the years various collaborations have reported tantalizing signals, most hinting to the existence of a low-mass WIMP-like particle; however, nearly all of these signals have faded or been attributed to experimental effects. The only exception today is the $\sim 13\sigma$ detection of an annual modulation of the scattering rate by the DAMA/LIBRA collaboration – although a dark matter interpretation of this observation that is consistent with the null results of other direct detection experiments is, today, seemingly unfathomable.

Among the long-time leaders in the search for dark matter-nuclei interactions is the XENON Collaboration. After constructing their first 10 kg detector in 2004, XENON quickly demonstrated the scalability of their technology while maintaining what is effectively a background-free search for dark matter. Their technological advancement has since led to the construction of a 100 kg and a multi-tonne detector (see Figure 1 for a depiction of the current tonne-scale detector), and more recently plans have been developed for the future construction of a detector potentially exceeding ~ 40 tonnes (known as DARWIN).

The recent XENON result yielded no detection of dark matter, and thus the collaboration has subsequently derived the most stringent upper limits

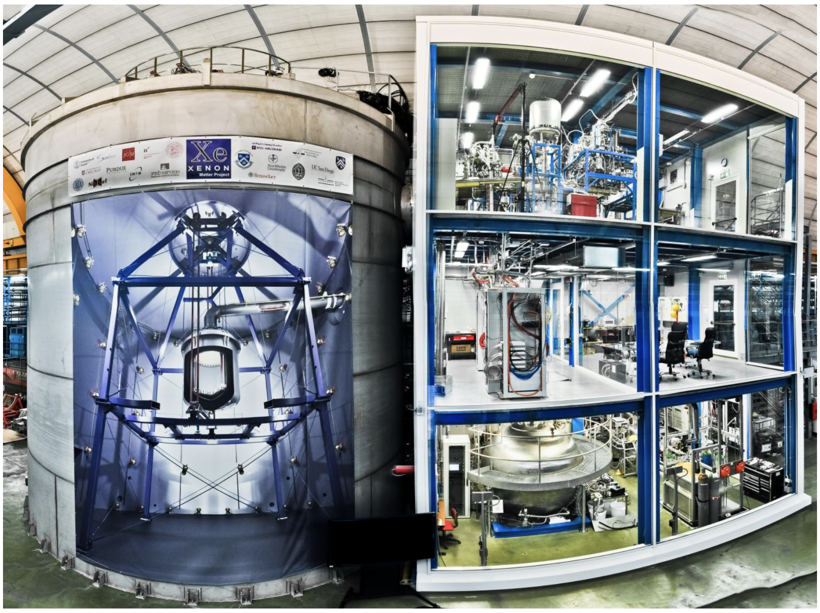

Figure 1: Depiction of the Xenon1T detector and shielding (left), compared with accompanying three story service building.

for high-mass WIMPs to date (see Fig. 2 for the derived upper limit). This new upper limit increases existing constraints on the WIMP-nuclei scattering cross section by a factor of ~ 5 in the low mass region of parameter space and a factor of ~ 2 for WIMP masses $\gtrsim 50$ GeV. Direct dark matter detection experiments will continue to probe deeper into unchartered territory and physicists worldwide hold out hope that future experiments will produce definitive evidence for the existence of the elusive dark matter.

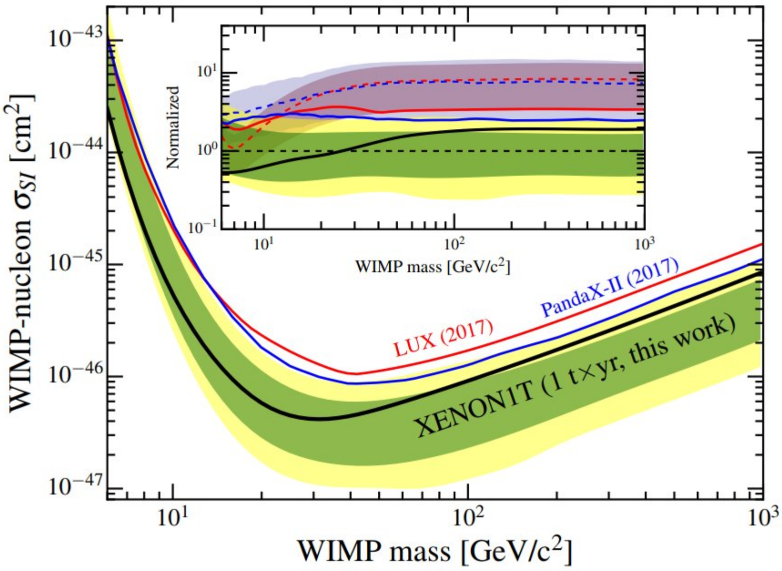

Figure 2: Upper limit derived using the recent XENON1T result on the the strength of the WIMP-nucleon interaction as a function of the WIMP mass. This result improves existing limits placed by PandaX-II by nearly a factor of two for dark matter masses below ~ 50 GeV.