Improving the Sensitivity to Low-Mass WIMPs with XENON Detectors

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Dark matter experiments based on dual-phase Xe TPCs such as XENON100 [1] and the upcoming XENON1T [2] currently place the most stringent limits on the spin-independent WIMP-nucleon cross section for WIMP masses above $\sim$6 GeV/c^2. Strategies to improve the sensitivity to lower WIMP masses rely on lowering the threshold which can, e.g., be achieved by increasing the light collection efficiency (LCE). In XENON1T several measures have been undertaken to improve the LCE in comparison to XENON100.

The XENON1T TPC is surrounded by 48 interlocking PTFE reflectors (see Figure). Reflectivity measurements in liquid xenon have been carried out to optimize the surface treatment of the PTFE.

Another important parameter is the optical transparency of the anode and cathode which was considerably increased for XENON1T. Furthermore, XENON1T uses new PMTs with a high quantum efficiency of $\sim$35% at 175 nm [3]. The absorption of scintillation light in xenon mainly depends on the concentration of impurities such as oxygen and more importantly water. The XENON1T purification system employs two heated zirconium getters aiming at an impurity concentration of $\lesssim$1 ppb oxygen equivalent. From these improvements the expected light yield for 122 keV γ's at zero field in XENON1T is about a factor of 2 higher than in XENON100 (3.8 PE/keV) [4].
Another possibility to lower the threshold is to determine the energy scale from the charge signal instead of the primary scintillation signal. This method has been used in XENON10 to achieve a threshold of $\sim$1 keV [5].

[1] XENON100 Collaboration, Astropart. Phys. **35**, 573 (2012).
[2] XENON1T Collaboration, Springer Proc. Phys. **148**, 93 (2013)
[3] XENON1T Collaboration, arXiv:1503.07698 (2015)
[4] XENON100 Collaboration, Phys. Rev. Lett. **109**, 181301 (2012)
[5] XENON10 Collaboration, Phys. Rev. Lett. **107**, 051301 (2011)