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Dark Matter Direct Detection: Signal or no signal? The best way(s) forward.

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Particle dark matter is thought to be the overwhelming majority of the matter in the Universe. Its gravitational contribution overwhelms that from the ordinary matter that we, the earth and the stars, are composed of. However, providing direct evidence for the existence of particle dark matter has proved extremely challenging and any positive results remain controversial.

We have been searching for the direct interactions of dark matter in sub-terrestrial detectors for over 35 years. A wide-range of techniques have been employed in order to establish convincing evidence for these interactions. I have worked on five of them during this period. In the early-experimental stages of our searches interaction rates in detectors of 100 per kg per day were explored. Today we are looking for dark matter events which are as rare as 1 per kg per millennium. We now carry this out with detectors that have active masses that are as large as 10 tonnes, but yet they can be sensitive to particle interactions with energies of less than 1 keV.

The detectors exploit a wide range of detection techniques including the scintillation or ionization properties of noble elements, bubbles in superheated fluids, ionization in semiconductors, and phonons in milliKelvin targets. Often these technologies are combined together. I will discuss some of the latest results in the field of direct detection, and look at the best techniques that may help us to definitively detect the illusive dark matter particles.

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