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This grant supported the enriched xenon procurement, detector construction and initial operation of the EXO-200 double beta decay experiment at the Waste Isolation Pilot Plant (WIPP). The period of performance was Aug 15, 2002 to Dec 31, 2014. The primary goal of the experiment is to search for the very rare (and to date not observed) neutrino-less double beta decay. Such decay, if observed, would shed the light of the quantum-mechanical structure of neutrinos, and the origins of elementary particle masses. Another goal of the detector is to serve as prototype of a larger neutrino-less double beta decay experiment, currently being considered by DOE-OS. EXO-200 has already been extremely successful in both areas and is, in fact, leading the way world-wide in this area of fundamental physics.

In the initial part of the grant the EXO-200 collaboration acquired 200kg of xenon enriched to 80% in the isotope 136 that is a candidate for double beta decay. At the time this was the largest isotope separation program carried out for fundamental science. The enrichment was done in Russia, providing a rare and valuable opportunity for US scientists to work alongside Russian colleagues, in some cases from the former closed cities of their military complex. By now the EXO-200 collaboration include institutions from the US, Canada, South Korea, China, Germany, Switzerland and Russia. Many collaborating scientists from these countries have taken shifts at WIPP or at the various remote monitoring sites world-wide.

EXO-200 detector construction was completed in early 2010, with the time projection chamber (TPC) installation in the cleanrooms already placed in NeXA. Detector commissioning at WIPP followed, with the last phase, the filling of the TPC with liquid Xenon, occurring in the spring 2011. EXO-200 is described in [1]. Low background data taking started on Jun 1, 2011 and within the first month of data the 2-neutrino double beta decay of 136Xe was discovered, as reported in [2]. More data provided the best half-life measurement of any 2-neutrino double-beta decay modes [3]. Until Feb 2014 the detector ran continuously producing some of the world leading results in the field and, in particular, two of the most sensitive searches for neutrinoless double beta decay [4,5]. These measurements show that the half life of this decay is longer than 10^{15} times the age of the universe. This is one of the leading results in this field world-wide and succeeded to put the DOE-funded research on the world stage in a very cost-effective way. Other results from EXO-200 include a search for exotic double-beta decay modes [6], a detailed report on the state of the art background levels achieved in the detector [7], the study of rare ion and neutral atom motion and neutralization rates in liquid Xenon [8], a study of the cosmogenic backgrounds in the detector at WIPP's depth [9], a search for Lorentz and CPT symmetries violation [10] and a search for double-beta decay to excited states [11].

In Feb 2014 the EXO-200 detector was severely disrupted by the accidents in the WIPP underground (unrelated to EXO-200). The EXO-200 operations team was able to recover the unique stockpile of enriched Xenon to high pressure cylinders and warm-up the detector to room temperature without damaging the very delicate equipment. This was a very impressive achievement as no plan had been made to complete these operations entirely from remote. This validates the robustness of well-designed liquid xenon detectors for this and other measurements in particle and nuclear astrophysics. The operations team re-gained almost regular access to the WIPP underground and the EXO-200 detector in Jan 2015 and spent calendar 2015 cleaning up the soot from the WIPP fire, assessing the damage to the EXO-200 infrastructure, correcting such damage and restarting the detector. This process was successfully carried out and culminated in the re-filling of the detector with liquid xenon, in

Jan 2016. As of late Jan 2016 EXO-200 is taking data again. The collaboration is in the process of upgrading the readout electronics and restarting a radon abatement system that had been commissioned just before the Feb 2014 events. The upgraded electronics will provide lower readout noise and, in turn, better signal to background discrimination. The radon abatement system will further reduce the radon in a small air-gap between the EXO-200 cryostat and the lead shielding. In a review in Jun 2015 DOE-OS approved EXO-200 for 2.5 more years of running at the end of which we expect to improve the sensitivity to the neutrino-less double-beta decay by a factor two or three.

For the last 5 years the EXO-200 detector, located in the WIPP underground, has been at the center of the hunt for new physics beyond the Standard Model of particle physics!

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