EXO
the Enriched Xenon Observatory for neutrino-less double-beta decay

Letter of Interest for locating EXO in the Homestake Lab.

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This letter is to express the interest by the EXO collaboration in locating a large Xe-136 detector for the detection of neutrino-less double beta decay at the Homestake Lab. The collaboration feels Xe offers the most promising opportunity to achieve the sensitivity to observe this critical process and to study the details of the process if it does occur. There are a number of R&D goals that must be met to realize this opportunity, as outlined below.

The Science

The scientific justification for the search for neutrino-less double beta decay is very well understood. Observation of this process would show that neutrinos are Majorana type particles and would identify the absolute mass scale for neutrinos.

The EXO Detector

The EXO detector will search for neutrino-less double-beta decay in isotopically enriched xenon (80% ^{136}Xe). This medium offers a number of important advantages for the search for double beta decay. It offers good (<2%) energy resolution when the combination of ionization and light are used. It can be made extremely clean so that internal radioactivity can be controlled. It is a tracking detector so that multi-site events are effectively rejected. Finally it uniquely, offers the chance to identify the double beta decay by observing the daughter barium ion. Each of these advantages is critical to the elimination of background which is the key to searching for this rare process. The objective is a detector with an ultimate sensitivity of ~10 meV for the neutrino Majorana mass.

The EXO project is proceeding along two parallel avenues of R&D: the construction of the "EXO-200" prototype detector (without barium tagging) and the development of the barium tagging technique. EXO-200 is slated for installation at WIPP at the end of calendar 2006 and the R&D on barium tagging does not require an underground location. The results of the two parallel R&D efforts will result in the design of the full EXO detector, the subject of this LOI.

Schedule

EXO-200 is under advanced construction at Stanford. We expect to install at WIPP before the end of 2006 and start data-taking in 2007. The first 6 month of data will likely be used to acquire the technical information needed to write the proposal for the full EXO detector. We expect the barium tagging R&D to proceed on a similar time scale. The EXO-200 detector will continue running for physics while full EXO is designed and built.

Therefore we expect to have an EXO design report by mid 07. If promptly funded, detector construction is expected to take about two years. Xenon enrichment can be completed in a year for one ton and in three to five years for 10 tons. Since, as discussed below, much of the detector assembly will be performed at the underground location, it is conceivable that access to the Homestake site could be required towards the end of 2007. Only access and electricity (but not uninterruptible power and cryogenics) will be needed for the first year of construction. According to this (obviously crude) timeline data taking could start in early 2009 (at which point all of the requirements below will have to be fulfilled).

Technical requirements

EXO will likely require extensive cryogenics. The temperature of liquid xenon at standard pressure is -100C. This can be achieved with close circuit refrigerators, but, at least for redundancy, a substantial LN2 storage underground (probably 10,000 liters) would be highly desirable if not essential.

Reliable power is also is very important requirement. In the case of EXO power is required to keep the xenon cold and loss of power results, in the long run, in the need to recover the xenon, a very disruptive process for the experiment. So fully redundant power, with two or more separate feeds from surface and two independent emergency generators would be very desirable.

The full size EXO detector is not designed yet; hence all space estimates here are extremely preliminary and should be taken with great caution. We imagine that the detector will be housed in cleanrooms, the cleanest region of which would be class 10 or 100. This "core" region may fit in an envelope measuring $10 \cdot 10\ m^2$ with an unobstructed overhead access of 8 to 10m at least in part of the $10 \cdot 10\ m^2$ footprint. The experiment will include a crane or hoist system inside the clean room. In addition to this we will likely need some additional $100m^2$ of clean room space with a more conventional 3m high ceiling. Probably class 1000 will be adequate for this region of the system, where electronics, cryogenics and optics are located. HVAC equipment in support for the clean rooms will also have to be build, the size of them depending on the lab infrastructure (for instance on whether chilled water is available underground). While EXO-200 is built at Stanford and transported underground in six clean room modules, we assume that the larger size of the full EXO system will require extensive construction underground. The largest component that will *have* to be transported underground will probably be the optics tables (probably 4ft by 12ft, 1ft thick). Note that, because of space limitations, EXO-200 has a chamber and cryostat with horizontal axis and access. This turned out to be quite inconvenient, so that the full EXO detector will likely have a vertical axis and access, hence the large ceiling requirement.

It is possible that extensive surface assembly facilities will not be required. However we feel like the presence in the lab of a machine shop in a clean room could be an excellent facility and, if existent, maybe advantageously used by EXO. A small "staff shop" at the lab would be also quite useful for small and unexpected conventional machining jobs.

24/7 access to the underground will be a requirement for the detector commissioning and very desirable through the experiment's lifetime.