The success of DeepCore, the 30 megaton, ~10 GeV threshold extension of the IceCube Neutrino Observatory, lies in the exceptional clarity of the ice at depths below ~2100 m, and in the use of the surrounding IceCube detector as a robust active veto against cosmic ray muons. These muons would otherwise mask the neutrino signals of interest from the atmospheric flux, dark matter annihilations and decays, and galactic point sources. The feasibility of a phased infill of the DeepCore detector, with the ultimate goal of a precision multi-megaton particle physics detector, is currently under investigation by an international group of physicists.

Phase 1 might comprise about 20 additional strings of high quantum efficiency digital optical modules at the center of the IceCube and DeepCore arrays, and would aim for a fiducial volume of ~10 MT with an energy threshold near 1 GeV. Such a detector opens a window to indirect searches for very low mass dark matter, precision measurements of atmospheric neutrino oscillations, improved sensitivity to supernova neutrinos, and first exploration of proton decay searches with a distributed volume detector. While the scientific program of such a detector is clearly rich in its own right, phase 1 would also serve a valuable function as the proving ground for constructing a much larger scale, high precision neutrino detector in the Antarctic ice. Such a detector has the unique advantage that the fiducial medium is also the support mechanism for the instrument, avoiding the need for costly and difficult cavity excavations, and permitting considerable flexibility in detector geometry and construction.

To achieve the science goals of phase 1 and establish the foundation for a longer-term future detector, phase 1 would include a refined calibration program and extensive ice modeling to a level that would permit understanding of systematics at the level of a few percent, a significant advance over current IceCube analyses. This first phase of the infill would also include rejuvenation of the hot water drill system and demonstrate the possibility of smaller (~5 m) inter-string spacing, to achieve the desired low energy threshold, as well as deployment and commissioning of prototype photodetectors that would be used for the phase 2.

Phase 2 would be a much more ambitious, longer term effort to achieve a detector with a fiducial mass of up to ~5 MT with a target energy threshold as low as a few 10's of MeV. The obvious science goals for such a detector would be searches for proton decay, supernova neutrino physics with sensitivity out to ~10 Mpc (ensuring detection of supernovae every year or two), as well as potential long baseline measurements from a northern hemisphere accelerator. This detector would require the collaboration to build on successes in phase 1 activities related to calibration, development of more advanced instrumentation, and extraction of precision physics measurements from the data.

The Antarctic ice cap offers an extremely large, high clarity, low noise Cherenkov medium. The reduced overburden relative to deep underground facilities can be largely neutralized by leveraging the existing IceCube and DeepCore arrays as active cosmic-ray muon vetos. There is significant scientific potential in the use of the ice as a relatively low cost, megaton-scale sub-GeV physics detector with the development of high photocathode area photon detection units coupled with high precision calibrations of the ice detection medium. Together these developments will allow measurements competitive with those from purpose-built underground facilities.