**IceCube Institutional Memorandum Of Understanding (MOU)**

**Scope Of Work**

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| **University of Toronto**  **Kenneth Clark**  **Ph.D Scientists** (Faculty Scientist/Post Doc Grads) : **1** (1 0 0) |

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| **Labor Cat.** | **Names** | **WBS L3** | **Tasks** | **WBS 2.1** | **WBS 2.2** | **WBS 2.3** | **WBS 2.4** | **WBS 2.5** | **Grand Total** |
| Program Management | Detector Maintenance & Operations | Computing & Data Management | Triggering & Filtering | Data Quality, Reconstruction & Simulation Tools |
| KE | CLARK, KENNETH | Reconstruction/ Analysis tools | Development of low-energy reconstruction techniques |  |  |  |  | 0.10 | 0.10 |
|  | Simulation Production | SciNet computing |  |  | 0.25 |  |  | 0.25 |
|  |  | Simulation | GENIE maintenance |  |  | 0.10 |  |  | 0.10 |
|  | **CLARK, KENNETH Total** | |  |  |  | **0.35** |  | **0.10** | **0.45** |
| **Toronto Total** | |  |  |  |  | **0.35** |  | **0.10** | 0.45 |

**Faculty:**

Kenneth Clark: Co-convener of PINGU Analysis Working Group, Technical Coordinator for Low-En/Oscillation Working Group

**Scientists and Post Docs:**

N/A

**Students:**

Graduate: 1 Undergraduate: 1 (expected 2015/16 fiscal year)

**Explanation:**

Canadian IceCube activites are supported via a Natural Science and Engineering Research Council (NSERC) Subatomic Projects Discovery Grant. The most recent request was awarded beginning April 1 2015, for 2 years, to support the established IceCube program and the formation of an IceCube institute group at the University of Toronto. The envisaged group at Toronto in the 2015/16 fiscal year includes PI Clark, 1 graduate and 1 undergraduate researcher. The expectation is that the combination of undergraduate students over the summer as well as a visiting graduate student will work on the reconstruction of low energy events with IceCube/DeepCore.

**Description of planned analysis:**

The Toronto group will focus on analyses involving data low-energy IceCube events, including DeepCore neutrino oscillations, low mass WIMP studies and the PINGU detector development. We will build on our expertise in reconstruction algorithm development (energy and angular) as well as particle ID. The continuation of the in-depth likelihood-based analysis will lead to a long term goal of the determination of the neutrino mass hierarchy with PINGU.

**Description of Service work**

The primary service work will be related to the starting of simulation on the SciNet cluster. Specifically these contributions include the coordination and administration of the production of the low energy simulations. The choice has been made to use GENIE for all low-energy simulations, the upkeep of which will be the responsibility of the University of Toronto, with major upgrades happening in 2014. Simulations in this energy range are of vital importance to the DeepCore oscillation and WIMP analyses.

In addition, Clark is co-convener of the PINGU Analysis WG and is the Technical Coordinator of the Low-En/Oscillation WG.

**Other contributions**

The University of Toronto is a major participant in the Compute Ontario (SciNet) initiative, a part of Compute Canada that funds the WestGrid clusters. Some O(35k) CPUs are a part of the SciNet systems and a new GPU cluster is in development. The Toronto group has established SciNet as an IceCube collaboration resource for simulation production and processing, just has been done for WestGrid. In the first four months of 2015, a total of roughly 250 core years have been used on the SciNet cluster for low energy event reconstruction.

**Additional Note:**

As a full IceCube institute, in conjunction with Alberta, the Toronto group has been capable of leveraging dedicated priority on these clusters in the next Compute Canada grant (Fall 2015). Further, the Canadian groups have submitted the next NSERC request (October 2014 for fiscal year 2015/16 and 2016/2017) and the CFI PINGU requests (March 2014). Recognized standing of the Toronto group within the collaboration has been essential for the success of these funding proposals.