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

**Scope of Work**

**Lawrence Berkeley National Laboratory**

**Spencer Klein**

**Ph.D Scientists** (Faculty Scientist/Post Doc Grads): **4** (2 2 1)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Labor Cat.** | **Names** | **WBS L3** | **Tasks** | **Funds Source** | WBS 2.1 | WBS 2.2 | WBS 2.3 | WBS 2.4 | WBS 2.5 | WBS 2.6 | **Grand Total** |
| Program Coordination | Detector Maintenance & Operations | Computing & Data Management  | Data Processing & Simulation  | Software | Calibration |
| KE | KLEIN, SPENCER | Administration | Supervise LBNL effort | NSF M&O Core | 0.05 |   |   |   |   |  | **0.05** |
|  |  | Computing & Data Management | Oversee raw data storage at LBNL | Institutional In-Kind |  |  | 0.08 |  |  |  | **0.08** |
|  |  | Administration | PINGU Coordination Committee | Institutional In-Kind | 0.03 |   |   |   |   |  | **0.03** |
|  |  | Administration | Gen2 HEA/Surface working group | Institutional In-Kind | 0.05 |  |  |  |  |  | **0.05** |
|   | **KLEIN, SPENCER Total** |  | **0.13** |  | **0.08** |  |  |  | **0.21** |
| PO  | ROBERTSON, SALLY | Detector Monitoring | Monitoring Shifts | Base Grant |   |  0.09 |  |   |   |  | **0.09** |
|   | **ROBERTSON, SALLY Total** |  |  | **0.09** |  |  |  |  | **0.09** |
| EN | STEZELBERGER, THORSTEN | Data Acquisition | Maintain DAQ Hardware  | NSF M&O Core |  | 0.15 |   |   |   |  | **0.15** |
|   | **STEZELBERGER, THORSTEN Total** |  |  | **0.15** |  |  |  |  | **0.15** |
| GS | LYU,YANG | Reconstruction | Starting event energy, muon bundles | Institutional In-Kind |   |  |    |   | 0.10 |  | **0.10** |
|   | **LYU, YANG Total** |  |  |  |  |  | **0.00** |  | **0.10** |
| IT | All, LBNL IT | Central Computing Resources | NERSC Data Archiving, Distributed Computing and Labor | Institutional In-Kind |   |  |   1.00 |   |  |  | **1.00** |
|   | **LBNL IT Total** |  |  |  | **1.00** |  |  |  | **1.00** |
| **LBNL Total**  |  |  | **0.13** | **0.24** | **1.08** |  | **0.00** |  | **1.45** |

LBNL is involved in many aspects of IceCube service. We built the DOM main boards, and many of our service tasks are related to that, including maintenance of DAQ hardware (contributing to firmware and online software updates). PI Klein is also on the writing committee for the new joint IceCube U. S. NSF proposal.

We are also heavily involved in software work National Energy Research Supercomputer Center (NERSC) at LBNL’s National Energy Research Supercomputer Center (NERSC). NERSC is responsible for storing a copy of all of IceCube’s raw data on their HPSS storage system. Currently, NERSC is storing over 2 Petabytes of data for IceCube. This is a lot of data, and we have been heavily involved in developing the data transfer procedures.

We also have a FY ‘18 allocation of 1,250,000 CPU hours (equivalent to 114 cores running 24/7/365) this year on NERSC supercomputer systems. IceCube computing has recently gotten IceProd working at NERSC, and used this time for production in March. Over the next few months, we need to develop a sustainable model for IceCube CPU usage at NERSC.

Our analysis efforts are focused in several areas.

Sally Robertson is working on a multi-year measurement of muon-neutrino absorption in the Earth.

 New graduate student Yang Lyu is starting to work on a study of high-energy down-going neutrinos. He plans to develop algorithms to select single muon events (developed for the forward muon search) to reject muon bundle background. In parallel track, we are working with a group of computer scientists (using their own funding) to make a similar selection using machine learning methods. So far, this is just using simulation, but early efforts are promising.

**Faculty:**

R. Stokstad – timing calibrations

S.R. Klein – PINGU coordination committee, Gen2 HEA/Surface working group, with a focus on particle physics and cosmic-ray topics; administrative oversight of raw data transfer from Madison to LBNL.

**Scientists and Post Docs:**

Lisa Gerhardt – Software and administrative support for raw data transfer and simulation at NERSC

Sally Robertson – Muon energy measurement methods. Oversight of simulation production at LBNL, programming and technical work on raw data transfer from Madison to LBNL

 Analysis topics: muon-neutrino cross-section measurement

**Grad Students:**

Yang Lyu – TBD: Could be PMT saturation corrections for analysis

 Thesis/Analysis topics: TBD, but tentatively energetic (PeV) downward-going muon neutrinos