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

**Scope of Work**

**Lawrence Berkeley National Laboratory**

**Spencer Klein**

**Ph.D Scientists** (Faculty Scientist/Post Doc Grads): **5** (3 2 3)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Labor Cat.** | **Names** | **WBS L3** | **Tasks** | **Funds Source** | **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 | 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 | TATAR, JOULIEN | Core Software | Computing Strike Team | Base Grant |  |  | 0.25 |  |  | **0.25** |
|  |  | Data Storage & Transfer | Maintain code and keep transfer running | Base Grant |  |  | 0.10 |  |  | **0.10** |
|  |  | Simulation Production | Simulation production site manager | Base Grant |  |  | 0.10 |  |  | **0.10** |
|  |  | Detector Monitoring | Monitoring Shifts | Base Grant |  | 0.09 |  |  |  | **0.09** |
|  | **TATAR, JOULIEN Total** | | |  |  | **0.09** | **0.45** |  |  | **0.54** |
| EN | STEZELBERGER, THORSTEN | Data Acquisition | Maintain DAQ Hardware | NSF M&O Core |  | 0.15 |  |  |  | **0.15** |
|  | **STEZELBERGER, THORSTEN Total** | | |  |  | **0.15** |  |  |  | **0.15** |
| GR | SANDRA, MIARECKI | Reconstruction/ Analysis tools | Algorithm for measuring muon energy | Base Grant |  |  |  |  | 0.10 | **0.10** |
|  | **SANDRA, MIARECKI Total** | | |  |  |  |  |  | **0.10** | **0.10** |
| BINDER, GARY | Reconstruction/ Analysis tools | PMT saturation corrections for analysis | Base Grant |  |  |  |  | 0.05 | **0.05** |
|  | **BINDER, GARY Total** | | |  |  |  |  |  | **0.05** | **0.05** |
| **LBNL Total** | |  |  |  | **0.13** | **0.24** | **0.53** | **0.00** | **0.15** | **1.05** |

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). Over the past year, PI Klein has gotten in the PINGU coordination committee, and the Gen2 HEA/Surface working group, where he is looking into complete event reconstruction for high-energy (i. e. TeV+)events containing a cascade plus a muon, and also looking at ‘forward muon’ events where a muon takes a large fraction of the air shower energy; this is an important background for downward-going neutrino events.

We are also heavily involved in software work. One new intiative, just getting started is to have LBNL’s NERSC store a copy of all of IceCube’s raw data on their HPSS storage system. The MOU envisions us storing 3.3 petabytes the end of the first year, increasing by about 700 terabytes/year. This is a lot of data, and we have been heavily involved in developing the data transfer procedures. Also this year, new postdoc Joulien Tatar joined the computing “Strike Force.” This is itself a 0.25 FTE commitment. He has also taken responsibility for a number of IceCube modules; most of these modules are badly in need of significant maintenance and upgrading to meet current IceCube coding standards.

We continue to maintain our original responsibilities, including the maintenance and upgrading (including ‘restandardization’) for the truncated mean ™ muon energy measurement. Gary Binder has been looking into an improved maximum likelihood method to further improve TM.

Our analysis efforts are focused in several areas.

The first is a search for extraterrestrial neutrinos, especially cascades, where we have multiple efforts covering different energy ranges. Gary Binder recently completed the first analysis of the flavor content of astrophysical neutrinos. He is now working on further ‘particle identification’ in these events. Chang Hyon Ha completed the most accurate measurement of the atmospheric e spectrum; we plan to revisit this with a multi-year data set.

Finally, Miarecki is working on a measurement of the neutrino-nucleon cross-section by measuring atmospheric neutrino absorption in the Earth; statistics permitting, this will be her PhD dissertation.

We use the National Energy Research Supercomputer Center (NERSC) to produce Monte Carlo event samples; this has mostly been cascade signal events. J. Tatar maintains the software installation and coordinates this production. For CY 2016, we have an allocation of 1,000,000 CPU hours on Cori Phase 1 (<http://www.nersc.gov/systems/cori/>), which uses 2.3 GHz Intel Haswell processors. Averaged over 365 days running 24/7, this is equivalent to 114 full-time processors. We have also been allocated enough tape and disk storage to story a complete copy of the IceCube raw data. We anticipate using the CPU time mostly for IceCube, but this is negotiable.

**Faculty:**

R. Stokstad – timing calibrations

D.R. Nygren – “Track Engine” trigger

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 – double muon reconstruction

Analysis topics: studies of high transverse momentum muons, studies of contained cascades

Joulien Tatar – Computing Strike Team Maintenance and upgrades for core-removal, truncated mean and credo, plus historical management of DOM simulator & DOM calibrator. After discussion with Alex Olivas, this is included in his 0.25 FTE for strike team. Simulation production at LBNL, programming and technical work on raw data transfer from Madison to LBNL

Analysis topics: TBD

**Graduate Students:**

Sandy Miarecki – Algorithm for measuring muon energy

Thesis/Analysis topics: muon energy measurement, atmospheric muon neutrinos, and the neutrino-nucleon cross-section

Gary Binder – PMT saturation corrections for analysis

Thesis/Analysis topics: contained cascades

Frederik Tenholt – Forward muon studies

Master’s thesis top: forward muons