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

**Scope of Work**

**Michigan State University**

**Tyce DeYoung**

**Ph.D Scientists** (Faculty Scientist/Post Doc Grads): **8** (5 3 9)

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| **Maintenance and Operations** | | | | | | | | | | | | |  |
| **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 | DeYOUNG, TYCE | Education & Outreach | Outreach | | Base Grants | 0.05 |  |  |  |  |  | **0.05** |  |
|  |  | Administration | Executive committee | | Inst. In-Kind | 0.05 |  |  |  |  |  | **0.05** |  |
|  | **DeYOUNG, TYCE Total** | |  | |  | **0.10** |  |  |  |  |  | **0.10** |  |
|  | GRANT, DARREN | Administration | Collaboration Spokesperson | | Inst. In-Kind | 0.50 |  |  |  |  |  | **0.50** |  |
|  | Administration | Executive committee | | Inst. In-Kind | 0.20 |  |  |  |  |  | **0.20** |  |
|  |  | Education & Outreach | Outreach | | Inst. In-Kind | 0.05 |  |  |  |  |  | **0.05** |  |
|  | **GRANT, DARREN Total** | | | | | **0.75** |  |  |  |  |  | **0.75** |  |
|  | KOPPER, CLAUDIO | Reconstruction | IceTray framework maintenance | | Inst. In-Kind |  |  |  |  | 0.05 |  | **0.05** |  |
|  | Reconstruction | Maintenance of clsim photon propagation tool | | Inst. In-Kind |  |  |  |  | 0.10 |  | **0.10** |  |
|  | Online Filter (P&F) | Diffuse WG co-chair | | Inst. In-Kind |  | 0.25 |  |  |  |  | **0.25** |  |
|  | Offline Data Production | Offline Processing Support / pass2 | | Inst. In-Kind |  |  |  | 0.10 |  |  | **0.10** |  |
|  | Simulation Production | GPU computing resources | | Inst. In-Kind |  |  |  | 0.05 |  |  | **0.05** |  |
|  | Education & Outreach | IceCube MasterClass | | Inst. In-Kind | 0.10 |  |  |  |  |  | **0.10** |  |
|  | **KOPPER, CLAUDIO Total** | | | | | **0.10** | **0.25** |  | **0.15** | **0.15** |  | **0.65** |  |
|  | TOLLEFSON, KIRSTEN |  |  | |  |  |  |  |  |  |  |  |  |
|  | **TOLLEFSON, KIRSTEN Total** | | | | |  |  |  |  |  |  | **0.00** |  |
|  | MAHN, KENDALL | Simulation Software | Integration/development of GENIE for low energy systematics | | Inst. In-Kind |  |  |  |  | 0.05 |  | **0.05** |  |
|  | **MAHN, KENDALL Total** | |  | |  |  |  |  |  | **0.05** |  | **0.05** |  |
| PO | NISA, MEHR | Detector calibration | In-situ DOM sensitivity / angular response calibration from muon neutrinos | | Inst. In-Kind |  |  |  |  |  | 0.10 | **0.10** |  |
|  | Detector monitoring | Monitoring shift | | Inst. In-Kind |  | 0.03 |  |  |  |  | **0.03** |  |
|  | **NISA, MEHR Total** | | | | |  | **0.03** |  |  |  | **0.10** | **0.13** |  |
|  | CLARK, BRIAN | Distributed Computing Resources | IceProd site manager at MSU HPCC | | NSF AAPF Fellowship |  |  | 0.10 |  |  |  | **0.10** |  |
|  | **CLARK, BRIAN Total** | | | | |  |  | **0.10** |  |  |  | **0.10** |  |
|  | HALLIDAY, ROBERT | Distributed Computing Resources | IceProd site manager at MSU HPCC | | NSF M&O Core |  |  | 0.25 |  |  |  | **0.25** |  |
|  | **HALLIDAY, ROBERT Total** | |  | |  |  |  | **0.25** |  |  |  | **0.25** |  |
| GR | NEER, GARRETT | Detector calibration | In-situ DOM sensitivity / angular response calibration from muon neutrinos | | Inst. In-Kind |  |  |  |  |  | 0.10 | **0.10** |  |
| **NEER, GARRETT Total** | | | | |  |  |  |  |  | **0.10** | **0.10** |  |
| NOWICKI, SARAH |  |  | |  |  |  |  |  |  |  |  |  |
| **NOWICKI, SARAH Total** | |  | |  |  |  |  |  |  |  | **0.00** |  |
| RYSEWYCK CANTU, DEVYN | Education & Outreach | IceCube Masterclass | | Inst. In-Kind | 0.05 |  |  |  |  |  | **0.05** |  |
| **RYSEWYCK CANTU, DEVYN Total** | | | |  | **0.05** |  |  |  |  |  | **0.05** |  |
| SANCHEZ HERRERA, SEBASTIAN |  |  | |  |  |  |  |  |  |  |  |  |
| **SANCHEZ HERRERA, SEBASTIAN Total** | | | | |  |  |  |  |  |  | **0.00** |  |
| MICALLEF, JESSIE | Education & Outreach | IceCube Masterclass | | NSF Grad Fellowship | 0.05 |  |  |  |  |  | **0.05** |  |
| Core Software | Software strike team / CLSim development and maintenance | | NSF Grad Fellowship |  |  |  |  | 0.20 |  | **0.20** |  |
| **MICALLEF, JESSIE Total** | |  | |  | **0.05** |  |  |  | **0.20** |  | **0.25** |  |
|  | PEISKER, ALISON |  | |  |  |  |  |  |  |  |  |  |  |
|  | **PEISKER, ALISON Total** | | | | |  |  |  |  |  |  |  |  |
|  | HARNISCH, ALEXANDER |  | |  |  |  |  |  |  |  |  |  |  |
|  | **HARNISCH, ALEXANDER Total** | |  | |  |  |  |  |  |  |  |  |  |
|  | TWAGIRAYEZU, JEAN PIERRE |  | |  |  |  |  |  |  |  |  |  |  |
|  | **TWAGIRAYEZU, JEAN PIERRE** | |  | |  |  |  |  |  |  |  |  |  |
|  | LE, HIEU | Detector calibration | | In-situ DOM sensitivity / angular response calibration from muon neutrinos | Inst. In-Kind |  |  |  |  |  | 0.20 | **0.20** |  |
|  | **LE, HIEU** | |  | |  |  |  |  |  |  | **0.20** | **0.20** |  |
| **MSU Total** | |  |  | |  | **1.05** | **0.28** | **0.35** | **0.15** | **0.40** | **0.40** | **2.63** |  |

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| **IceCube Upgrade** | | | | | | | | | | | |  |
| **Labor Cat.** | **Names** | **WBS L3** | **Tasks** | **Funds Source** | **WBS 1.1** | **WBS 1.2** | **WBS 1.3** | **WBS 1.4** | **WBS 1.5** | **WBS 1.6** | **Grand Total** |  |
| Project Management | Drilling | Sensors | Comms, Power, Timing | Calibration | Data Systems |  |
| KE | DeYOUNG, TYCE | CPT Management | Management | NSF / Inst. In-Kind |  |  |  | 0.50 |  |  | **0.50** |  |
|  | **DeYOUNG, TYCE Total** | |  |  |  |  |  | **0.50** |  |  | **0.50** |  |
|  | GRANT, DARREN | mDOMs | MSU mDOM production facility | Inst. In-Kind |  |  | 0.25 |  |  |  | **0.25** |  |
|  | **GRANT, DARREN Total** | |  |  |  |  | **0.25** |  |  |  | **0.25** |  |
| EN | NG, CHRISTOPHER | Downhole Cable Assemblies | Penetrator Cable Assemblies, Main cable mechanical/ string hardware | NSF |  |  |  | 0.75 |  |  | **0.75** |  |
|  |  | Northern Test System | Design, set up and maintain NTS | NSF |  |  |  | 0.25 |  |  | **0.25** |  |
|  | **NG, CHRISTOPHER Total** | | | |  |  |  | **1.00** |  |  | **1.00** |  |
|  | FERGUSON, BRIAN | Downhole Cable Assemblies | Main cable electrical, procurement support | NSF |  |  |  | 0.25 |  |  | **0.25** |  |
|  | **FERGUSON, BRIAN Total** | |  |  |  |  |  | **0.25** |  |  | **0.25** |  |
| PO | HALLIDAY, ROBERT | Downhole cable assemblies | Engineering support | Inst. In-kind |  |  |  | 0.25 |  |  | **0.25** |  |
| **HALLIDAY, ROBERT Total** | |  |  |  |  |  | **0.25** |  |  | **0.25** |  |
| **MSU Total** | |  |  |  |  |  | **0.25** | **2.00** |  |  | **2.25** |  |

**Faculty:**

Tyce DeYoung (IL) – ExecCom, outreach, Upgrade L2 for CPT, 100% IceCube

Darren Grant – Spokesperson, outreach, Upgrade DOM production 100% IceCube

Claudio Kopper – Diffuse WG co-convener, software development, offline processing support, outreach, 100% IceCube

Kirsten Tollefson – 50% IceCube (50% HAWC)

Kendall Mahn – low energy systematics/GENIE, 5% IceCube (95% DUNE, T2K)

**Scientists and Engineers:**

Chris Ng – engineering support for Upgrade WBS 1.3, 1.4, 100% IceCube

Brian Ferguson – engineering support for Upgrade WBS 1.4, 25% IceCube

**Post Docs:**

Mehr Nisa DOM response/simulation calibration using neutrino-induced muons, monitoring shifts, 50% IceCube (50% HAWC)

Thesis/Analysis topics: galaxy cluster search, Galactic sources search

Robert Halliday IceProd and distributed computing support, Upgrade cable design/engineering support, NTS timing support, 100% IceCube

Thesis/Analysis topics: multi-flavor source searches

Brian Clark (funded by NSF AAPF) IceProd and distributed computing support, 75% IceCube (25% ARA)

Thesis/Analysis topics: diffuse spectrum measurement, EHE neutrino searches

**Ph.D. Students:**

Garrett Neer DOM response/simulation calibration using neutrino-induced muons, 100% IceCube

Thesis/Analysis topics: dark matter search using LE contained events

Sarah Nowicki 100% IceCube

Thesis/Analysis topics: DirectReco event reconstruction, atmospheric muon neutrino measurements

Devyn Rysewyk Cantu

Thesis/Analysis topics: Extended Galactic source search, IceACT R&D

Sebastian Sanchez Herrera

Thesis/Analysis topics: Anti-neutrino tagging at low energy using Michel electrons

Jessie Micallef (funded by NSF Grad Fellowship) Core Software: Software strike team / CLSim development and maintenance, IceCube Masterclass

Thesis/Analysis topics: Next-generation oscillation analysis

Alison Peisker (funded by NSF Grad Fellowship) 30% IceCube (70% HAWC)

Thesis/Analysis topics: HAWC/IceCube transient searches

Alexander Harnisch 100% IceCube

Thesis/Analysis topics: TBD

Jean Pierre Twagirayezu 100% IceCube

Thesis/Analysis topics: TBD

Hieu Le DOM response/simulation calibration using neutrino-induced muons, 100% IceCube

Thesis/Analysis topics: TBD

**Computing Resources:**

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|  | **2019** | |
|  | **CPU Cores** | **GPU Cards** |
| **IceCube** | 750 | 100 |

The Michigan State IceCube group provides the collaboration access to several large computing clusters maintained and administered by the Michigan State High Performance Computing Cluster in the Institute for Cyber-Enabled Research. The HPCC includes more 21,716 computing cores and 478 GPUs (mix of Tesla V100, K80, and K20). The IceCube group has purchased 750 cores and 8 GPUs in the cluster.

Cluster scheduling policy allows opportunistic use of all compute resources by campus users with job lengths <4 hours. Jobs making use of specialized resources, such as GPUs, have priority over all other jobs queued for those nodes. When appropriate jobs are available from IceProd servers, average (peak) resource allocations of 1000 (3000) CPU cores and 150 (300) GPUs have been obtained.

A new compute environment was rolled out on HPCC in 2018 and we have not yet completed the process of adapting our local scripts to the new environment. The pledge represents a conservative estimate of resource allocation available to IceProd jobs of less than 4 hours duration once that process is complete.