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

**Pennsylvania State University**

**Doug Cowen**

**Ph.D Scientists** (Faculty Scientist/Post Doc Grads): **5** (1 4 4)

**Scope of Work**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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 | COWEN, DOUG  | Education & Outreach | Education & Outreach | Inst. In-Kind | 0.05 |  |  |  |  |  | **0.05** |
|   | Engineering and R&D | PINGU Co-Lead, Publication Committee | Inst. In-Kind | 0.45 |  |  |  |  |  | **0.45** |
|   | **COWEN, DOUG Total** |  |  | **0.50** |  |  |  |  |  | **0.50** |
| SC | ANDERSON, TYLER | Data Acquisition | DAQ Firmware Development | NSF M&O Core |  | 0.23 |  |  |  |  | **0.23** |
|  | **ANDERSON, TYLER Total** |  |  |  | **0.23** |  |  |  |  | **0.23** |
| PO | ELLER, PHILIPP  | Reconstruction | PISA Maintenance | Base Grants |  |  |  |  | 0.05 |  | 0.05 |
|  | Detector Monitoring | Monitoring Shifts | Base Grants |  | 0.03 |  |  |  |  | 0.03 |
|  | Data Acquisition | DAQ Firmware Development | NSF M&O Core |  | 0.20 |  |  |  |  | 0.20 |
|   | **ELLER, PHILIPP Total** |  |  |  | **0.23** |  |  | **0.05** |  | **0.28** |
|  | KEIVANI,AZADEH | Real-Time Alerts | Maintain IceCube integration with AMON; HESE reco | Inst. In-Kind |  | 0.05 |  |  |  |  | 0.05 |
|  | **KEIVANI, AZADEH Total** |  |  |  | **0.05** |  |  |  |  | **0.05** |
|  | AYALA, HUGO | Real-Time Alerts | Maintain IceCube integration with AMON;  | Inst. In-Kind |  | 0.10 |  |  |  |  | 0.10 |
|  | **AYALA, HUGO Total** |  |  |  | **0.10** |  |  |  |  | **0.10** |
| GR | HUANG,FEIFEI | Reconstruction  | Develop analysis tools for systematics study | Inst. In-Kind |  |  |  |  | 0.10 |  | 0.10 |
| Detector Monitoring | Monitoring Shifts | Base Grants |  | 0.03 |  |  |  |  | 0.03 |
|  | **HUANG, FEIFEI Total** |  |  |  | **0.03** |  |  | **0.10** |  | **0.13** |
|  | LANFRANCHI, JUSTIN | Reconstruction | Low energy event reconstruction quality; PISA maintenance | Inst. In-Kind |  |  |  |  | 0.15 |  | 0.15 |
|  | Detector Monitoring | Monitoring Shifts | Inst. In-Kind |  | 0.03 |  |  |  |  | 0.03 |
|  | **LANFRANCHI, JUSTIN Total** |  |  | **0.03** |  |  | **0.15** |  | **0.18** |
|  | DELAUNAY, JIMMY  | Reconstruction | Low energy neutrino pointing resolution | Inst. In-Kind |  |  |  |  | 0.33 |  | 0.33 |
|  |  |  |  |  |  |  | **0.33** |  | **0.33** |
|  | PANKOVA, DARIA | Data Acquisition | DAQ electronics hardware and firmware; background studies | Inst. In-Kind |  | 0.47 |  |  |  |  | 0.47 |
|  | Detector Monitoring | Monitoring Shifts | Inst. In-Kind |  | 0.03 |  |  |  |  | 0.03 |
|  | **PANKOVA, DARIA Total** |  |  |  | **0.50** |  |  |  |  | **0.50** |
| **PSU Total**  |  |  | **0.50** | **1.17** |  |  | **0.63** |  | **2.30** |

**Summary:**

Penn State contributions to the maintenance and operations of IceCube include:

**Faculty:**

Doug Cowen (L,+) - PINGU co-lead, outreach, 90% IceCube

**Scientists and Post Docs:**

Tyler Anderson – firmware maintenance, electronics support, 23% IceCube

 Analysis topics: n/a

Philipp Eller – simprod, distributed computing, PINGU systematics studies, monitoring, PISA maintenance, firmware development, 100% IceCube

 Analysis topics: Tau neutrino appearance, Neutrino Oscillations

Azadeh Keivani– Maintain IceCube integration with AMON, 5% IceCube (not on PSU IceCube base grant)

 Analysis topic: Realtime analysis, Point sources of high energy neutrinos

Hugo Ayala– Maintain IceCube integration with AMON, 10% IceCube (not on PSU IceCube base grant)

 Analysis topic: Realtime analysis, IceCube-HAWC coincidences

**Ph.D. Students:**

Feifei Huang - Gen-2 hardware requirements from IceCube data; Tau neutrino appearance with DeepCore, Cosmic ray muon background studies; 100% IceCube; Graduation expected summer 2018

 Thesis/Analysis topics: Tau neutrino appearance

Justin Lanfranchi – PINGU and low energy event reconstruction quality; PISA maintenance; 100% IceCube

 Thesis/Analysis topics: Neutrino mass ordering

Daria Pankova - Gen-2 DAQ electronics hardware and firmware; cosmic ray muon background studies; 100% IceCube

 Thesis/Analysis topics: n/a

Jimmy DeLaunay – Low energy neutrino resolutions; 33% IceCube

 Thesis/Analysis topics: IceCube+ γ coincidences

**Computing Resources:**

Cowen is co-PI on a GPU-centric MRI-funded cluster (“CyberLAMP”) along with colleagues in astronomy, materials science, and computer science. This cluster provides considerable resources for IceCube-related computation.

We use this resource to contribute to simulation production, including simulation of low energy neutrinos with GENIE, PINGU simulations and reconstructions, and simprod jobs run collaboration-wide. Substantial amounts of reconstruction development work are conducted using these resources.

**Note:** The activities and staffing levels in this MoU are appropriate for the period beginning May 1, 2018.

The numbers in the table below are maximum numbers available to IceCube since the CyberLAMP resource is shared.

|  |  |  |
| --- | --- | --- |
|  | 2017 | 2018 |
|  | CPU Cores | GPU Cores | CPU Cores | GPU Cores |
| IceCube | 3,200 Xeon cores and 300 Xeon Phi cores | 101 NVIDIA P100s | 3,200 Xeon cores and 300 Xeon Phi cores | 101 NVIDIA P100s |
| PINGU |
| High E Array |