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

**Scope of Work**

**M&O**

**Pennsylvania State University**

**Doug Cowen**

**Ph.D Scientists** (Faculty Scientist/Post Doc Grads): **6** (2 4 3)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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 | Upgrade Co-PI; Publication Committee | Inst. In-Kind | 0.35 |  |  |  |  |  | **0.35** |
| **COWEN, DOUG Total** |  |  | **0.40** |  |  |  |  |  | **0.40** |
| FOX, DEREK | Education & Outreach | Education & Outreach | Inst. In-Kind | 0.05 | 0.05 |  |  |  |  |  |
| **FOX, DEREK Total** |  |  | **0.05** |  |  |  |  |  | **0.40** |
| SC | ANDERSON, TYLER | Data Acquisition | DAQ Firmware Development | NSF M&O Core; Upgrade |  | 0.23 |  |  |  |  | **0.23** |
|  | **ANDERSON, TYLER Total** |  |  |  | **0.23** |  |  |  |  | **0.23** |
| PO | ELLER, PHILIPP  | Reconstruction | PISA Maintenance | Base Grants |  |  |  |  | 0.10 |  | 0.10 |
|  | Detector Monitoring | Monitoring Shifts | Base Grants |  | 0.03 |  |  |  |  | 0.03 |
|  |  | ? | Oscillation Tech. Lead | Base Grants | 0.20 |  |  |  |  |  | 0.25 |
|  |  |  | ICC member | Base Grants | 0.05 |  |  |  |  |  |  |
|  |  |  | DRAGON/GRECO data release | Base Grants |  |  |  | 0.05 |  |  |  |
|   | **ELLER, PHILIPP Total** |  |  | **0.25** | **0.03** |  | **~~0.05~~** | **0.10** |  | **0.43** |
|  | AYALA, HUGO | Real-Time Alerts | Maintain IceCube integration with AMON; HESE cascades | Inst. In-Kind |  | 0.15 |  |  |  |  | 0.15 |
| **AYALA, HUGO Total** |  |  |  | **0.15** |  |  |  |  | **0.15** |
| GR | 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 |  |  |  |  | 0.20 |  | 0.20 |
|  | **DELAUNAY, JIMMY Total** |  |  |  |  |  | **0.20** |  | **0.20** |
|  | PANKOVA, DARIA | Data Acquisition | DAQ electronics hardware and firmware | Inst. In-Kind |  | 0.15 |  |  |  |  | 0.15 |
|  | Detector Monitoring | Monitoring Shifts | Inst. In-Kind |  | 0.03 |  |  |  |  | 0.03 |
|  | **PANKOVA, DARIA Total** |  |  |  | **0.18** |  |  |  |  | **0.18** |
| **PSU Total**  |  |  | **0.70** | **0.62** |  | **0.05** | **0.45** |  | **1.82** |

**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 Office | Gen2 EHWD | Deep Ice Sensor Modules | Comms, Power, TIming | Calibration | M&O Data Systems |
| KE | COWEN, DOUG  | Project Management | Upgrade co-PI | In-kind | 0.05 |  |  |  |  |  | 0.05 |
|   | **COWEN, DOUG Total** |  |  | **0.05** |  |  |  |  |  | **0.05** |
| SC | ANDERSON, TYLER | Deep Ice Sensor Modules | Firmware Development | Upgrade |  |  | 0.25 |  |  |  | 0.25 |
|  | **ANDERSON, TYLER Total** |  |  |  |  | **0.25** |  |  |  | **0.25** |
|  | FIENBERG, AARON (joining Aug. 2019) | Deep Ice Sensor Modules | DAQ Firmware Development |  Upgrade |  |  | 0.25 |  |  |  | 0.25 |
| **FIENBERG, AARON Total** |  |  |  |  | **0.25** |  |  |  | **0.25** |
| GR | TBD | Deep Ice Sensor Modules | DAQ Firmware Development | Upgrade |  |  | 0.15 |  |  |  | 0.15 |
|  | **TBD Total** |  |  |  | **0.15** |  |  |  | **0.15** |
| **PSU Total**  |  |  | **0.05** |  | **0.65** |  |  |  | **0.70** |

**Summary:**

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

**Faculty:**

Doug Cowen (L,+) - PINGU co-lead, outreach, 60% IceCube

**Scientists and Post Docs:**

Tyler Anderson – Firmware maintenance, firmware development, electronics support, 23% IceCube M&O, 25% IceCube Upgrade

 Analysis topics: n/a

Philipp Eller – Oscillations Technical Lead, ICC member, DRAGON/GRECO data release coordination, Distributed computing, Upgrade systematics studies, monitoring, PISA maintenance, 100% IceCube; spent ~1 month at Pole in 2018

 Analysis topics: Tau neutrino appearance, Neutrino Oscillations

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

 Analysis topic: Realtime analysis, IceCube-HAWC coincidences, HESE cascade alerts

Aaron Fienberg– Firmware development, monitoring, 50% IceCube Upgrade

 Analysis topic: TBD (approximate starting date: Aug. 1, 2019)

**Ph.D. Students:**

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

 Thesis/Analysis topics: Neutrino mass ordering

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

 Thesis/Analysis topics: Tau Double Bang

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 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. 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, 2019.

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

|  |  |  |
| --- | --- | --- |
|  | 2018 | 2019 |
|  | CPU Cores | GPU Cores | CPU Cores | GPU Cores |
| IceCube | 2,200 Xeon cores and 300 Xeon Phi cores | 101 NVIDIA P100s | 2,200 Xeon cores and 300 Xeon Phi cores | 101 NVIDIA P100s |
| PINGU |
| High E Array |