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

**Pennsylvania State University**

**Doug Cowen**

**Ph.D Scientists** (Faculty Scientist/Post Doc Grads): **4** (1 3 3)

**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** | **Grand Total** |
| Program Management | Detector Maintenance & Operations | Compuing & Data Management | Triggering & Filtering | Data Quality, Reconstruction & Simulation Tools |
| KE | COWEN, DOUG | Education & Outreach | Education & Outreach | Inst. In-Kind | 0.05 |  |  |  |  | **0.05** |
|  | Engineering and R&D | PINGU Co-Lead | Inst. In-Kind | 0.35 |  |  |  |  | **0.35** |
|  | **COWEN, DOUG Total** | |  |  | **0.40** |  |  |  |  | **0.40** |
| 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 | Simulation Production | Simulation Production | Base Grants |  |  | 0.08 |  |  | 0.08 |
|  | Reconstruction/ Analysis tools | Develop analysis tools for systematics study; PISA development | Base Grants |  |  |  |  | 0.20 | 0.20 |
|  |  | Detector Monitoring | Monitoring Shifts | Base Grants |  | 0.03 |  |  |  | 0.03 |
|  |  | Computing Resources | Coordination and Support Grid distributed computing | NSF M&O Core |  |  | 0.25 |  |  | 0.25 |
|  | **ELLER, PHILIPP Total** | |  |  |  | **0.03** | **0.33** |  | **0.20** | **0.56** |
|  | KEIVANI,  AZADEH | Reconstruction/ Analysis tools | Integrate IceCube into AMON | Inst. In-Kind |  |  |  |  | 0.25 | 0.25 |
|  | **KEIVANI, AZADEH Total** | |  |  |  |  |  |  | **0.25** | **0.25** |
| GR | HUANG,  FEIFEI | Reconstruction/ Analysis tools | Develop analysis tools for systematics study; PISA development | Inst. In-Kind |  |  |  |  | 0.20 | 0.20 |
| Detector Monitoring | Monitoring Shifts | Base Grants |  | 0.03 |  |  |  | 0.03 |
|  | **HUANG, FEIFEI Total** | |  |  |  | **0.03** |  |  | **0.20** | **0.23** |
|  | LANFRANCHI, JUSTIN | Reconstruction/ Analysis tools | Low energy event reconstruction quality; PISA development | Inst. In-Kind |  |  |  |  | 0.47 | 0.47 |
|  | Detector Monitoring | Monitoring Shifts | Inst. In-Kind |  | 0.03 |  |  |  | 0.03 |
|  | **LANFRANCHI, JUSTIN Total** | | |  |  | **0.03** |  |  | **0.47** | **0.50** |
|  | PANKOVA, DARIA | Data Acquisition | DAQ electronics hardware and firmware | 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** | |  |  | | **0.40** | **0.82** | **0.33** | **0.00** | **1.12** | **2.67** |

**Summary:**

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

**Faculty:**

Doug Cowen (L,+) - PINGU co-lead, outreach, 100% 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 development and maintenance, 100% IceCube

Analysis topics: Neutrino Mass Hierarchy, Neutrino Oscillations

Azadeh Keivani– Integrating IceCube into AMON, 50% IceCube (on internal PSU funds, not PSU base grant)

Analysis topics: n/a

**Ph.D. Students:**

Feifei Huang - Gen-2 hardware requirements from IceCube data; Tau neutrino appearance with DeepCore, PISA development and maintenance; 100% IceCube

Thesis/Analysis topics: tau neutrino appearance

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

Thesis/Analysis topics: n/a

Daria Pankova - Gen-2 DAQ electronics hardware and firmware; 100% IceCube

Thesis/Analysis topics: n/a

**Computing Resources:**

We will be contributing roughly $40k to a $0.5M GPU/CPU cluster in April 2016 that will enable Penn State to once again contribute to simulation production. The current plan is for the cluster to have in excess of 800 CPU cores, plus GPUs in 7 nodes (5 K80s, 2 K40s and 1 Titan X). In addition, Cowen is again a co-PI on a roughly $1M GPU-centric MRI proposal to NSF along with colleagues in astronomy, materials science, and computer science. If approved, this MRI will provide considerable resources to IceCube computing. In anticipation grant approval, the handful of GPUs we purchase in April 2016 will enable us to test IceCube code on single- and double-precision GPUs (Titan X, K40 and K80) and allow us to optimize the GPU purchase for the MRI accordingly. Cowen has also applied for 500 core-months of local CPU resources in support of IceCube and PINGU related work. (As of March 2016, no response has been received.)

Our overarching goal is to “punch above our weight” in 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 will also be conducted using these resources.

**Note:** The activities and staffing levels in this MoU are appropriate for the period beginning October 1, 2015.

The numbers in the table below in parentheses are optimistic numbers that will obtain if applications for new computational resources are approved. The smaller number is the guaranteed average number of CPUs or GPUs, the second number after the dash is the possible burst level that we could obtain. The first number in parentheses is for the local resource application, the second for the NSF MRI (see text above for details). While the main emphasis will be on PINGU, GPU-centric IceCube jobs would certainly be welcome on the MRI cluster, if it is approved.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 2016 | | 2017 | |
|  | CPU Cores | GPU Cores | CPU Cores | GPU Cores |
| IceCube |  |  |  |  |
| PINGU | 50-800  (40; 400) | 1-6 K80, 1 TitanX  (0; 50) |  |  |
| High E Array |  |  |  |  |