



Examples of IceCube Community Engagement

Jim Madsen

Associate Director/IceCube E&O

Executive Director/WIPAC

University of Wisconsin–Madison

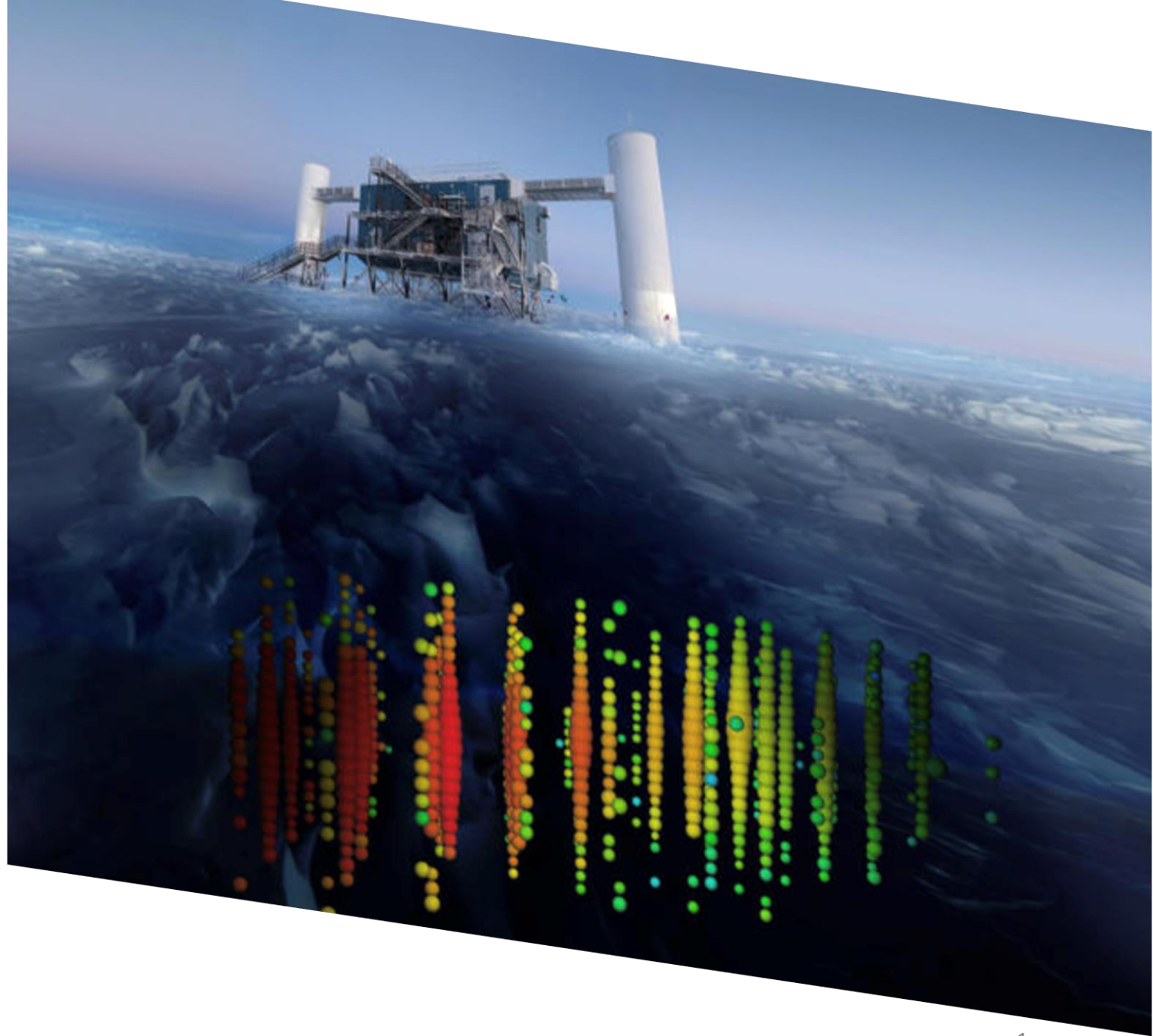


Snowmass, July24, 2022

Yuya Makino, IceCube/NSF
2022 IUPAP100 Photo Contest Winner

IceCube Neutrino Observatory

- Cubic-kilometer of instrumented ice
- 5,160 light sensors on 86 strings
- $\sim 2,500$ cosmic ray events/second
- ~ 10 neutrino events/hour
- ~ 10 astrophysical events/month
- 10+ years of full operation



 **AUSTRALIA**
University of Adelaide

 **BELGIUM**
UCLouvain
Université libre de Bruxelles
Universiteit Gent
Vrije Universiteit Brussel

 **CANADA**
SNOLAB
University of Alberta-Edmonton

 **DENMARK**
University of Copenhagen

 **GERMANY**
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ECAP, Universität Erlangen-Nürnberg
Humboldt-Universität zu Berlin
Karlsruhe Institute of Technology
Ruhr-Universität Bochum
RWTH Aachen University
Technische Universität Dortmund
Technische Universität München
Universität Mainz
Universität Wuppertal
Westfälische Wilhelms-Universität
Münster

 **ITALY**
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Pennsylvania State University
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and Technology
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University of Alabama
University of Alaska Anchorage
University of California, Berkeley
University of California, Irvine
University of Delaware
University of Kansas

University of Maryland
University of Rochester
University of Texas at Arlington
University of Utah
University of Wisconsin-Madison
University of Wisconsin-River Falls
Yale University

THE ICECUBE COLLABORATION

FUNDING AGENCIES

Fonds de la Recherche Scientifique (FRS-FNRS)
Fonds Wetenschappelijk Onderzoek-Vlaanderen
(FWO-Vlaanderen)

Federal Ministry of Education and Research (BMBF)
German Research Foundation (DFG)
Deutsches Elektronen-Synchrotron (DESY)

Japan Society for the Promotion of Science (JSPS)
Knut and Alice Wallenberg Foundation
Swedish Polar Research Secretariat

The Swedish Research Council (VR)
University of Wisconsin Alumni Research Foundation (WARF)
US National Science Foundation (NSF)

 **ICECUBE**
ANTARCTIC NEUTRINO OBSERVATORY
icecube.wisc.edu

IceCube Education & Outreach

The IceCube E&O program engages local, national, and international audiences of all ages

E&O is recognized at the collaboration level including a position for Associate Director for Education & Outreach

We utilize a variety of activities and outreach venues including:

- Science festivals and outreach events
- Educational programs
- Web-based materials and events

WIPAC's Role



The Wisconsin IceCube Particle Astrophysics Center (WIPAC) at UW–Madison serves as the lead IceCube institution and hub for collaboration-wide E&O activity

WIPAC E&O staff provides event coordination for webinars from the South Pole, posters and graphic design resources, collaboration-wide web materials, Masterclass materials, swag and other requests

Leveraging Efforts

IceCube E&O leverages efforts through partnerships with external programs and a volunteer base of scientists

This allows us to reach diverse audiences and sustain programming

Example partnerships:

- [PolarTREC](#) pairs educators with researchers who provide polar research experiences (10 for IceCube so far!)
- [UW-River Falls Upward Bound](#) Federally funded college prep program for low-income high school students
- [Wisconsin Institute for Discovery/Field Day](#)
 - Virtual reality experiences and outreach to rural libraries

Roadmap

Numerous E&O activities take place at IceCube institutions every month! It is truly a collaboration-wide effort

Today's talk will focus on:

- Programs for high school students
- Programs for the general public, educators and younger students with an emphasis on WIPAC programs



Programs for High School Students



IceCube Masterclass

Advanced high school physics students spend a day on campus learning about IceCube and completing a data analysis activity

- Inspired by [IPPOG Masterclasses](#) and [QuarkNet](#)
- Collaboration-wide effort (18/56 institutions in 2022)

<https://masterclass.icecube.wisc.edu/>

Website currently available in 5 languages!



IceCube Masterclass: Data Analysis

Participating institutions use one of two analysis activities, available through the masterclass website

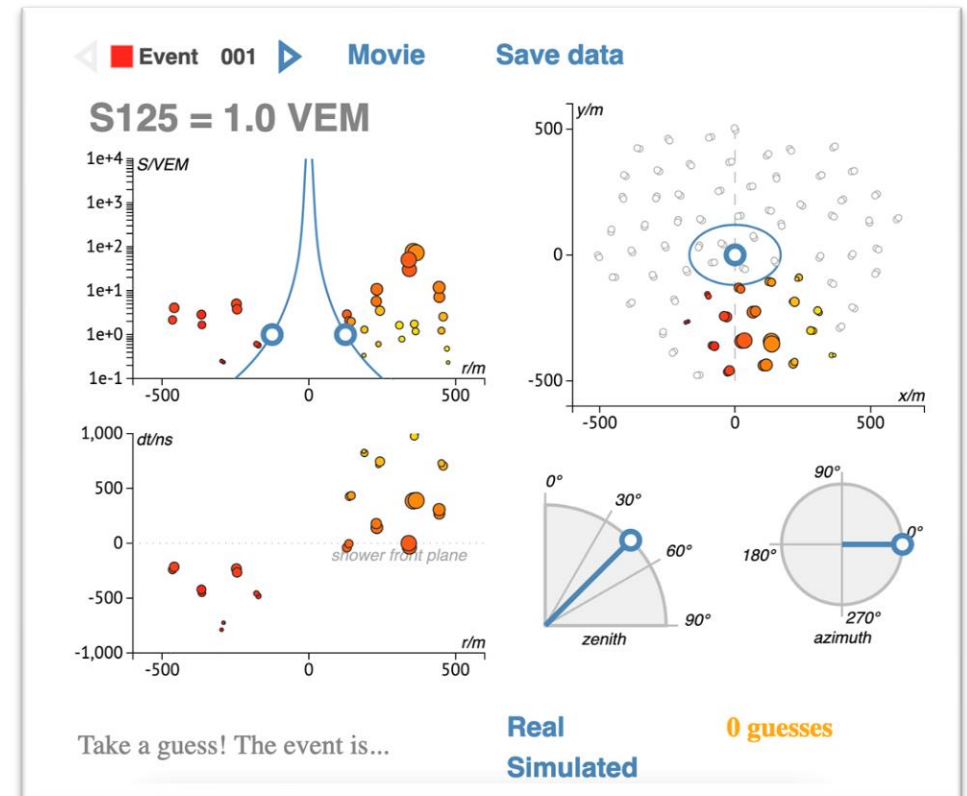
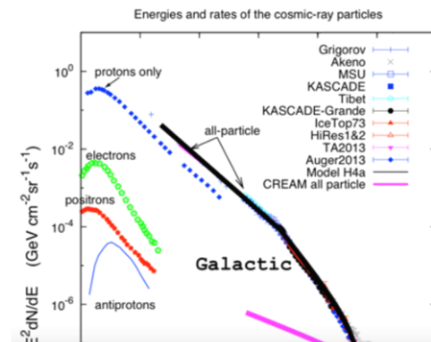
Cosmic-ray Energy Spectrum

»» ? shows where students could discuss/think about a topic/concept. » shows where an activity is introduced. »»

IceTop is a cosmic-ray detector. It is an array of instruments that observe the air showers of secondary particles created by cosmic rays when they interact with the Earth's atmosphere. This data allows us to study the composition of cosmic rays, the distribution of the cosmic-ray arrival directions, and the high-energy spectrum of cosmic rays.

Cosmic rays include particles such as electrons, protons, and heavier nuclei. Their sources are not yet known, but we expect them to be both galactic and extragalactic. The **energy spectrum of cosmic rays**, which is how the rate changes with increasing energy, has been measured by many detectors, including IceTop. Extragalactic sources are expected to be more abundant as energy increases and to be the only ones responsible for very high energy cosmic rays.

Precise measurements of the cosmic-ray energy spectrum can help us learn more about the transition from galactic to extragalactic sources and, thus, about the properties of the cosmic-ray sources.



WIPAC Internship

- Started in 2013 by then WIPAC Postdoc Naoko Kurahashi Neilson
- Theme and content was compiled by a lead postdoc or scientist
- Over time, harder and harder to find volunteers to lead the program

IceCube high school internship program launches in Madison, WI

By Megan Madsen —



Students working together on an LED activity.

WIPAC Internship

- Steady growth each year from ~12 -> 50+ applicants in 2019
- Evolved to 10-week after school program
 - ~4:00-6:00pm once per week
 - At WIPAC offices in downtown Madison
 - No cost to students but no stipends either

JOIN UW-MADISON RESEARCHERS AND LEARN ABOUT
MULTIMESSENGER ASTRONOMY AND COSMIC RAYS

ASTROPHYSICS

HIGH SCHOOL INTERNSHIP

AS AN INTERN, YOU WILL...

- Participate in real-world physics experiments
- Learn to program
- Get to know working astrophysicists
- Contribute to data processing


**NO BACKGROUND IN PHYSICS OR
PROGRAMMING REQUIRED!**


Internship will take place at WIPAC's offices:
222 W. Washington Ave, Suite 500 Madison, WI 53703

DEC 3, 2019-FEB 18, 2020
TUESDAYS 4:30PM-6:30PM
APPLY BY MONDAY, NOVEMBER 18, 2019

APPLY THROUGH OUR WEBSITE:
WIPAC.WISC.EDU/LEARN/CONNECT

Photograph by Kathrin Malhot, IceCube/NSF

 **WIPAC**
WISCONSIN ILLINOIS
PARTICLE ASTROPHYSICS CENTER

 **WISCONSIN**
UNIVERSITY OF WISCONSIN-MADISON

This is not a school-sponsored activity and the Madison
Metropolitan School District does not approve, support,
supervise, or endorse this program/activity.

WIPAC Internship to IceCube After School

- Pivot to virtual program with COVID
- Project-based and student-driven
- 10-weeks, 1.5 active hours/week
 - First 9 weeks includes a guest speaker who shares their path in physics and research
 - Final week is a student showcase of final projects



ARE YOU INTERESTED IN SPACE?

DO YOU LOVE DESIGN AND USING YOUR CREATIVITY?

If so, *IceCube After School: Journey to the Cosmos* is perfect for you!

Online: **January 18 - March 22, 2022, Tuesdays 5:00-7:00pm CST**
Application due: **January 5 @ 5:00pm CST**
Application link: go.wisc.edu/IceCubeAfterSchool
Questions? icecube-education@mailplus.wisc.edu

Learn from scientists who use instruments at the South Pole to study black holes and supernovas with tiny "ghost" particles that pass through your body every second. Then, design a game or app to teach others about what you've learned.

No computer coding experience? No problem! We will help you succeed by teaching the computer coding needed to build your project. Every week, you'll hear directly from an expert and improve your design. You'll create your own learning resource to show your friends, family, and teachers.

PHOTOGRAPHY: MARTIN WOLF, ICECUBE/NSF

IceCube After School: Journey to the Cosmos

Project-based and student-driven

- Students learn and use engineering design cycle and coding
- Use new coding skills to convey information about IceCube to audience of student's choice
- Peers and guests give feedback during final showcase

2021: 36 students

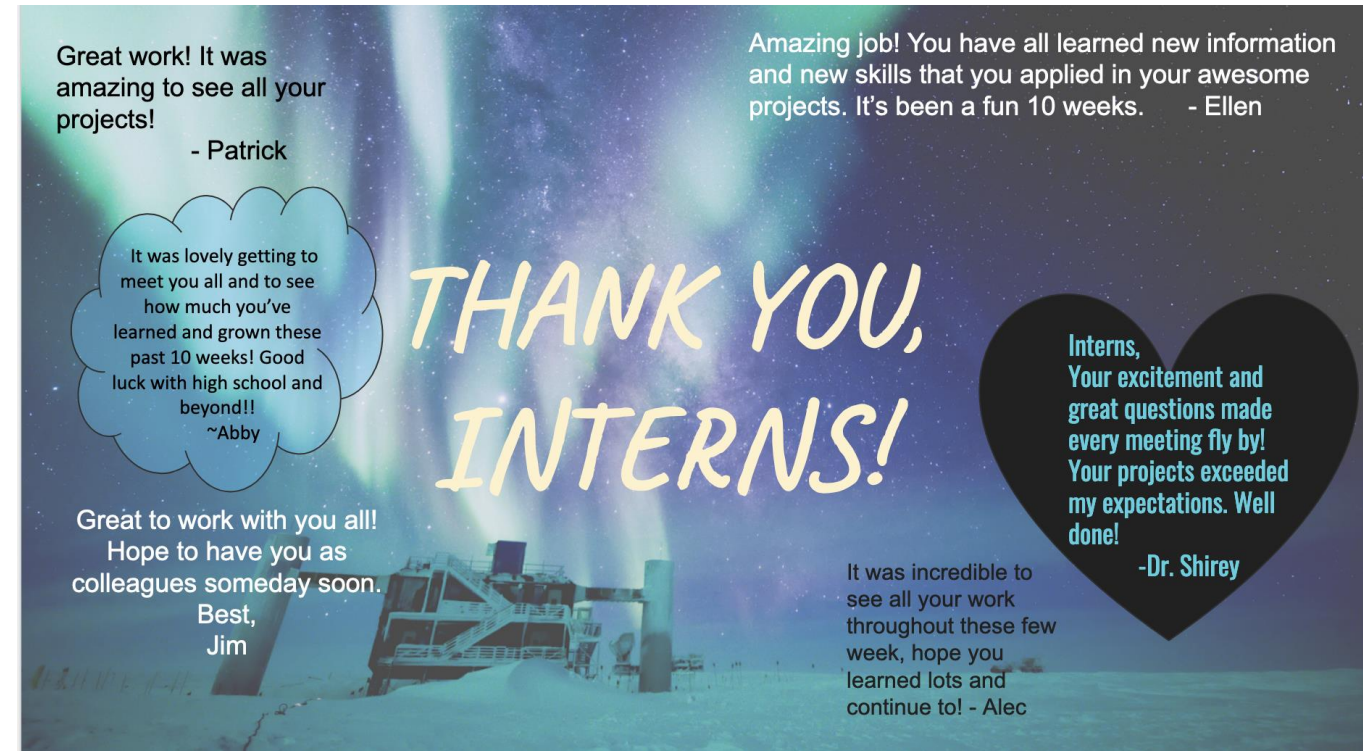
2022: 13 students

Partnered with regional institutions for a wider recruitment field

What It Takes



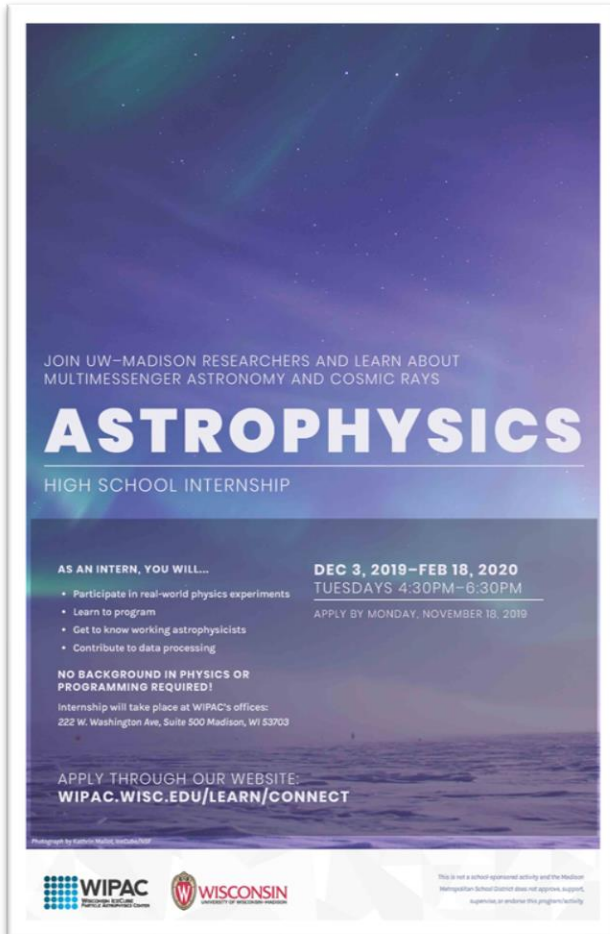
- People power
 - Dr. Katherine Shirey – program designer and facilitator
 - 9 volunteer guest speakers
 - 3 volunteer coding “experts”
 - 1-2 E&O staff
- Program site with lessons, recordings, agendas



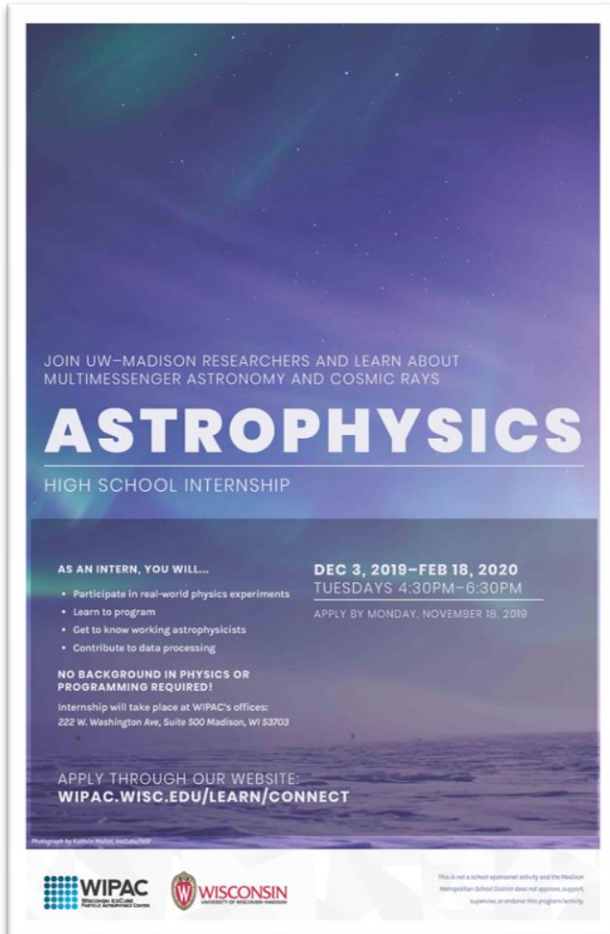
IceCube After School: Diversity and Inclusion

In 2020, a group of WIPAC staff looked at E&O recruitment and promotional materials with a diversity, inclusion, and equity lens

Q: Can you spot a few differences between the recruitment flyers for the 2019-2020 session (left) compared to the 2022 session (right)?



IceCube After School: Diversity and Inclusion



A: de-emphasized “astrophysics” as the main selling point.

A: focused on creative and artistic program components

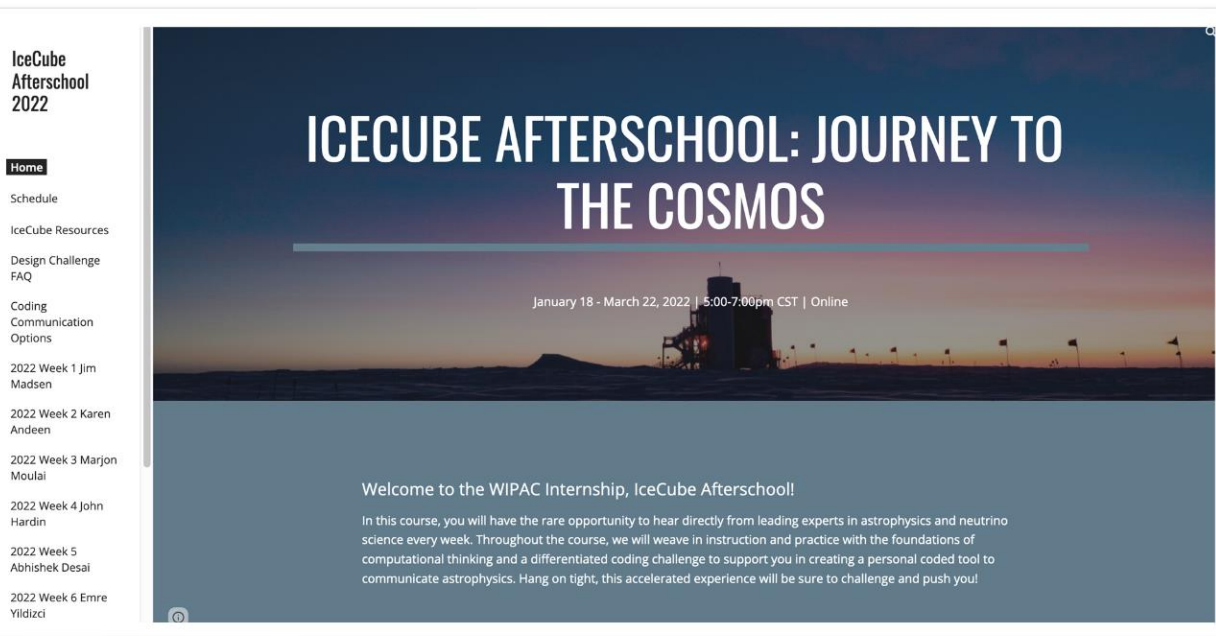
A: got rid of “internship”

A: told students program is a good fit for them.



IceCube After School: Website

Landing page and menu for program site



Weekly page with speaker bio



DR. KAREN ANDEEN

Dr. Andeen has spent her career on IceCube developing the cosmic ray composition analysis, which answers the questions: what are cosmic rays, where are they from and how do they get here? She will briefly discuss her work, but there will be more about cosmic rays in the coming weeks. Dr. Andeen will also discuss what it means to be a scientist and the varied paths that can lead to a career in science.

Biography

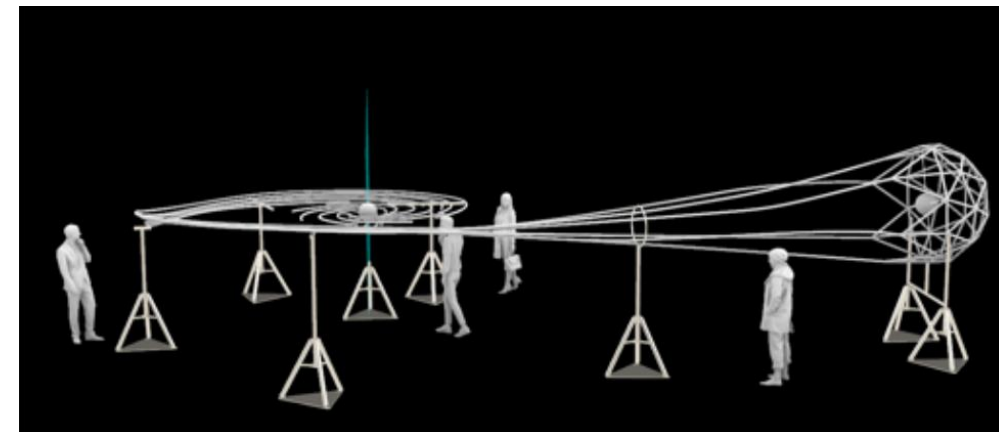
Dr. Karen Andeen is an Associate Professor in the physics department at Marquette University, Milwaukee, WI. She has worked on several experiments including IceCube, but also AMS-02 (on the international space station) and CMS (on the LHC at CERN, in Geneva Switzerland). Her specialty is cosmic ray physics, and she presently leads a research team focused on cosmic ray composition research with IceCube. Each year Dr. Andeen hires several undergraduate students in her lab to help analyze data and build and test detector upgrade prototypes for IceCube. Dr. Andeen has worked or studied on six continents, speaks a few languages, plays a handful of musical instruments, loves to read and to meet new people, and prefers tea over coffee. She has a family at home, including three young children (ages 6 years, 3 years, and 4 months), and in the winter, 'we all like playing in the snow and dancing in the kitchen.'

You can email Dr. Andeen at karen.andeen@icecube.wisc.edu



Other Experiences

- High school student research projects or 1:1 research mentoring
- Art-Science with UW Prof. [Faisal Abdu'Allah](#) and York U. Prof. [Mark-David Hosale](#)
 - Past projects focused on photography, light, and science identity
 - Working with ~6 at-risk youth on student-driven projects merging artistic interests with coding and science
 - [Fall GLEAM](#) Tidal Disruption Event light exhibit in Madison---large scale light installations created by local, regional, and international designers



Upward Bound at UW-River Falls

- 9-day residential summer science program
- Reaches underrepresented students and provides professional development opportunities for educators
- Leverages IceCube science and PolarTREC educator experience
- Focus is on science/engineering process rather than astrophysics
- Running for ~15 years, ~700 students total



Programs for General Public, Educators & Younger Students



South Pole Science Experiment Contest

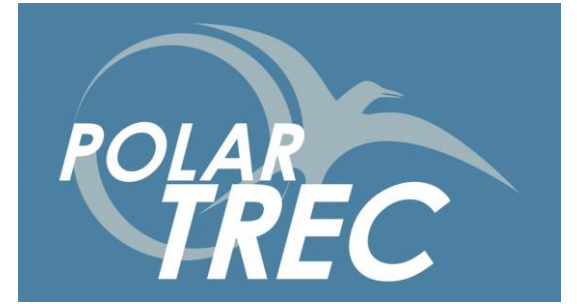
Challenge: come up with an experiment that will work in your hometown, but if repeated at the South Pole, would give a different result

- Open to student groups in Belgium
- A jury of IceCubers, science communication experts, and educators determines winners
- Winning experiments carried out at the South Pole
- Takes dedicated teachers to promote participation and guide students

A Program for Middle School Students!



PolarTREC

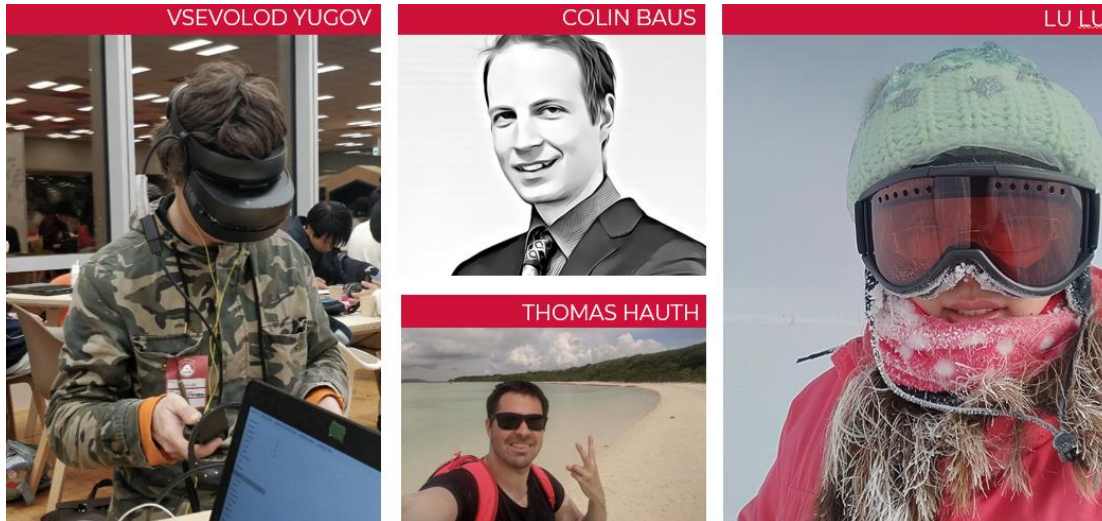


- Pairs science educators (teachers/informal) with Polar researchers who provide field experiences
- IceCube-PolarTREC partnership since 2009 (10 deployments!)
- Strong outreach component
 - [Jocelyn Argueta](#) aka “Jargie the Science Girl” deployed in 2019
 - Produced a blog, videos, webcasts, and [Tiny Ice videos](#)
 - [Elaine Krebs](#), lead educator at the California Science Center, is slated to deploy next



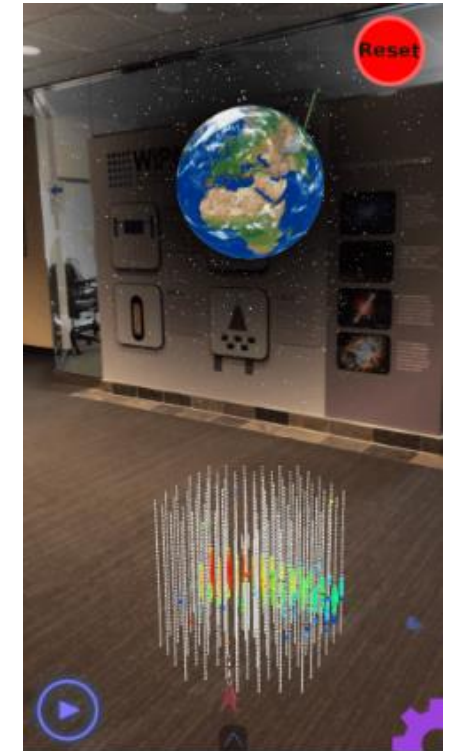
Augmented Reality App

- A free smart phone that allows users to get near real-time alerts for potential astrophysical neutrinos
- Displays event with a sound mapping



Development team

Snowmass 2022



iOS App Store



Google Play

Art-Science Collaborations

Artists include:

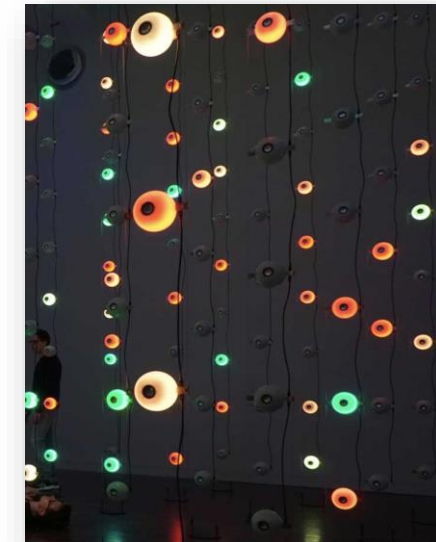
Faisal Abdu'Allah

Mark-David Hosale

Tim Otto Roth

Donald Fortescue

Michael Hoch



Synergy between Art and Science

Collaboration at the South Pole



Prof. Donald Fortescue,
California College of the Arts,
San Francisco



Dr. Gwenhaél de Wasseige,
IceCube Collaboration.

Outreach Events

- Participate in annual events such as WI Science Festival, Science Expeditions, Physics Fair, World Science Festival.
- Activities and materials include
 - Digital optical module
 - Scale model of the detector
 - Virtual reality game + gear; construction video
 - Cold weather gear
 - Bean bag toss
 - Stickers, tattoos
 - Posters and diagrams



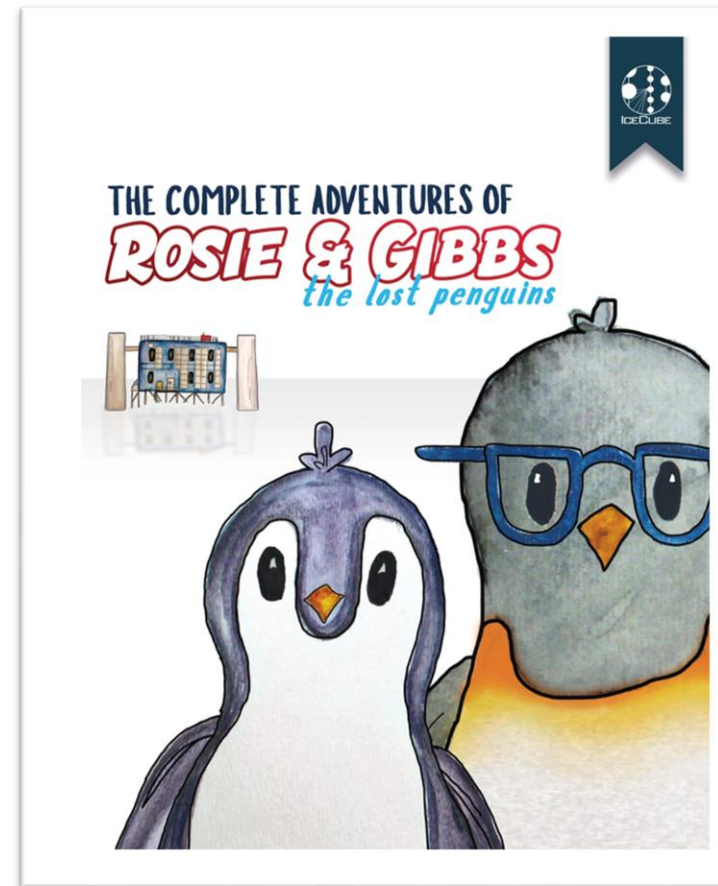
World
Science
Festival



Online Outreach Materials

For younger kids and kids at heart:

- Rosie & Gibbs comic
 - 11 languages for some editions!
- Tiny Ice videos
- Coloring pages
- Festive-themed crafts
- YouTube videos
- Social media



Lessons Learned

- Growing interest/demand for programming for high school students ... but, many high school students are overbooked and over-engaged
- Virtual programming with high school students takes extra time and resources to do well
- It takes concerted effort (i.e. paid staff) to sustain programming even if it's almost entirely volunteer-led
- Leveraging other programs makes resources go further, has mutual positive benefits for all groups involved, and adds sustainability
 - Find collaborators and learn about their needs
 - Develop programs to meet collaborators' needs

Thank You!

madsen@icecube.wisc.edu

Backup Slides

WIPAC E&O Staff

Five-seven roles at WIPAC contribute to E&O efforts.

- Outreach specialist
- Events and outreach coordinator
- Communications manager
- Technical editor
- Executive director
- Graphics designer
- Undergraduate assistant(s)

Each position also has several other responsibilities.

IceCube Masterclass

- Started in 2014; 8th edition in 2022 (cancelled 2020)
- High school students are registered by their teacher

Over 200 high school students joined the 2016 IceCube Masterclass

By Sílvia Bravo — Monday, March 14, 2016 - 1:00am



Students attending the IceCube Masterclass in River Falls.

The third edition of the IceCube Masterclass hosted over 200 students at 10 institutions in Belgium, Germany, and the US. WIPAC hosted the first edition in Spanish, attended by 28 Hispanic high school students. Masterclasses were held on March 2 and March 9.

IceCube Masterclass

Aside from data analysis, there is a lot of local variation in the schedule and activities

- At WIPAC, we have 3 talks about IceCube and grad school in the morning with the analysis activity occurring in the afternoon
- In the beginning...all institutions held their masterclass on the *same day* and connected virtually for student presentations and calls with the winterovers at the South Pole



Students attending the Spanish IceCube MasterClass in Madison.



Students attending the IceCube MasterClass in Brussels.

IceCube Masterclass: Through COVID

A virtual program is very difficult!

- Hard to help students troubleshoot without seeing screens
- WIPAC's virtual masterclass in 2021 had very low registration numbers

In-person programs in 2022 had hit-and-miss registration numbers

- Some institutions closed registration early or grew registration by 50%
- Other institutions cancelled due to lack of interest

A Sample Week

Over the 10 week program, each week has a different focus and new material that is covered

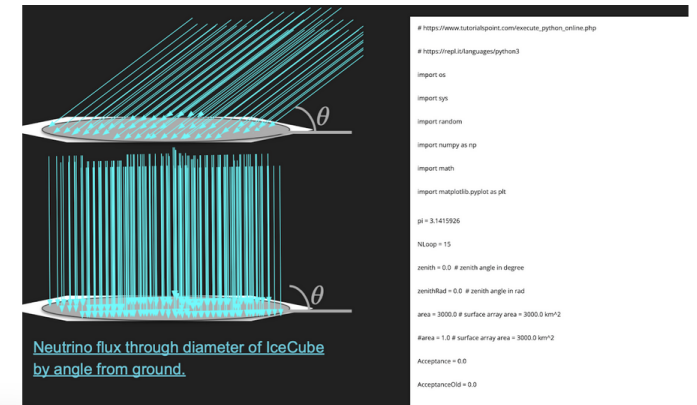
Students were able to give feedback on how things were going several times

Three-four volunteers experienced with python joined every week to give support

WEEK 4 AGENDA:

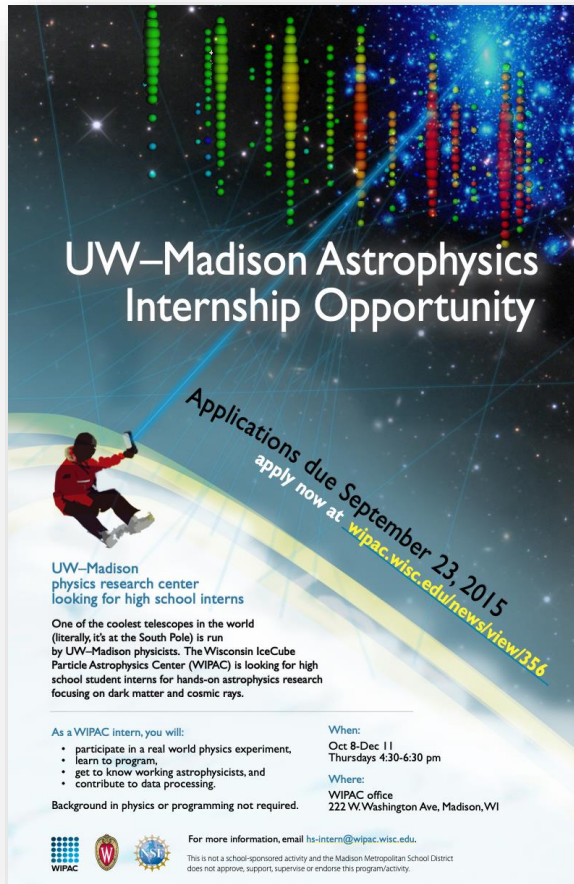
- Guest Speaker John Hardin (20 minutes + 10 min Q&A)
- Dr. Shirey's Week 4 [slides](#).
- Your feedback so far.
- Break (5 minutes)
- Next steps in the design challenge:
 1. Indicate your favorite design idea on your Phase 2: Design Exploration document ([Google Doc copy](#), [Microsoft Word download](#), [PDF download](#)).
 2. Email or share your Phase 2 Ideas doc to Dr. Shirey (katey@edukatey.com) by Sunday, February 13.
 3. Our Python experts will review, gather resources, comment back to you.
- Complete the Week 4 assignments of CodeHS.com by Sunday, February 13 (to give Dr. Shirey time to process your answers and steer next steps.)

Last year, Dr. Xinhua Bai spoke to IceCube Afterschool Interns. His lecture was on cosmic ray experiments, particle flux and detector geometric acceptance ([lecture recording here](#)). He also provided the Python code below which calculates potential particle flux based on zenith angle. Need-to-knows: Geometry, trigonometric functions, introductory-level calculus, online python compiler such as https://www.tutorialspoint.com/execute_python_online.php



Recruitment Flyer Progression

2015



UW-Madison Astrophysics Internship Opportunity

Applications due September 23, 2015
apply now at wipac.wisc.edu/news/view/356

UW-Madison physics research center looking for high school interns

One of the coolest telescopes in the world (literally, it's at the South Pole) is run by UW-Madison physicists. The Wisconsin IceCube Particle Astrophysics Center (WIPAC) is looking for high school student interns for hands-on astrophysics research focusing on dark matter and cosmic rays.

As a WIPAC intern, you will:

- participate in a real world physics experiment,
- learn to program,
- get to know working astrophysicists, and
- contribute to data processing.

Background in physics or programming not required.

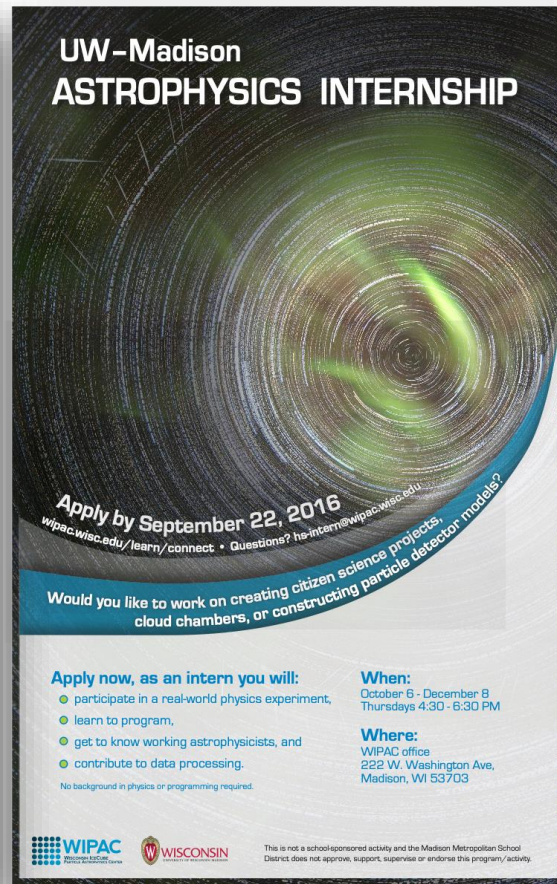
When:
Oct 8-Dec 11
Thursdays 4:30-6:30 pm

Where:
WIPAC office
222 W. Washington Ave, Madison, WI

For more information, email hs-intern@wipac.wisc.edu.

This is not a school-sponsored activity and the Madison Metropolitan School District does not approve, support, supervise or endorse this program/activity.

2016



UW-Madison ASTROPHYSICS INTERNSHIP

Apply by September 22, 2016
wipac.wisc.edu/learn/connect • Questions? hs-intern@wipac.wisc.edu

Would you like to work on creating citizen science projects: cloud chambers, or constructing particle detector models?

Apply now, as an intern you will:

- participate in a real-world physics experiment,
- learn to program,
- get to know working astrophysicists, and
- contribute to data processing.

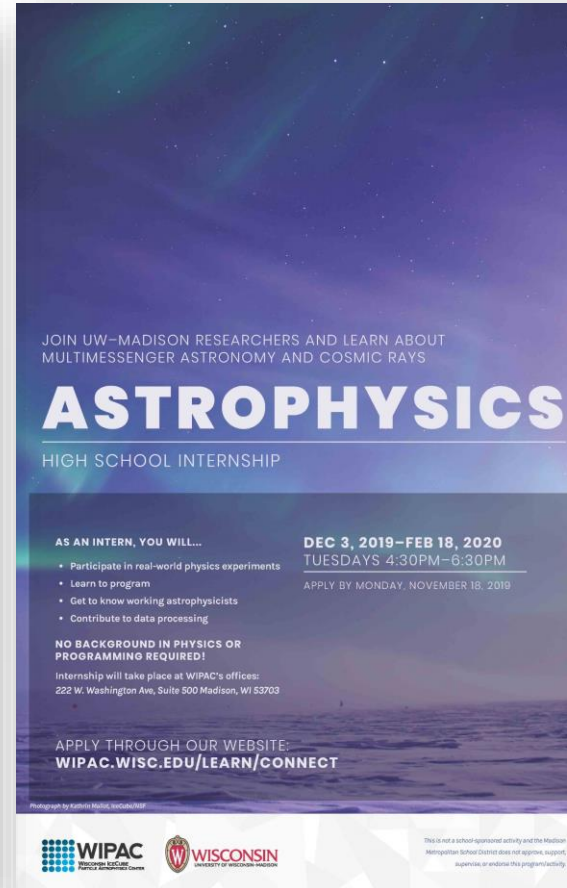
No background in physics or programming required.

When:
October 6 - December 8
Thursdays 4:30 - 6:30 PM

Where:
WIPAC office
222 W. Washington Ave,
Madison, WI 53703

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2019



JOIN UW-MADISON RESEARCHERS AND LEARN ABOUT MULTIMESSENGER ASTRONOMY AND COSMIC RAYS

ASTROPHYSICS
HIGH SCHOOL INTERNSHIP

AS AN INTERN, YOU WILL...

- Participate in real-world physics experiments
- Learn to program
- Get to know working astrophysicists
- Contribute to data processing

NO BACKGROUND IN PHYSICS OR PROGRAMMING REQUIRED!

Internship will take place at WIPAC's offices:
222 W. Washington Ave, Suite 500 Madison, WI 53703

DEC 3, 2019 - FEB 18, 2020
TUESDAYS 4:30PM - 6:30PM
APPLY BY MONDAY, NOVEMBER 18, 2019

APPLY THROUGH OUR WEBSITE:
WIPAC.WISC.EDU/LEARN/CONNECT

Photograph by Kristin Mottet, IceCube/NSF

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2022



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DO YOU LOVE DESIGN AND USING YOUR CREATIVITY?

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Questions? icecube-education@mailplus.wisc.edu

Learn from scientists who use instruments at the South Pole to study black holes and supernovas with tiny "ghost" particles that pass through your body every second. Then, design a game or app to teach others about what you've learned.

No computer coding experience? No problem! We will help you succeed by teaching the computer coding needed to build your project. Every week, you'll hear directly from an expert and improve your design. You'll create your own learning resource to show your friends, family, and teachers.

PHOTOGRAPH: MARTIN WOLF, ICECUBE/NSF

Logos: ICECUBE, WIPAC, WISCONSIN, MARQUETTE UNIVERSITY, SOUTH DAKOTA MINES

IceCube After School: Final Projects



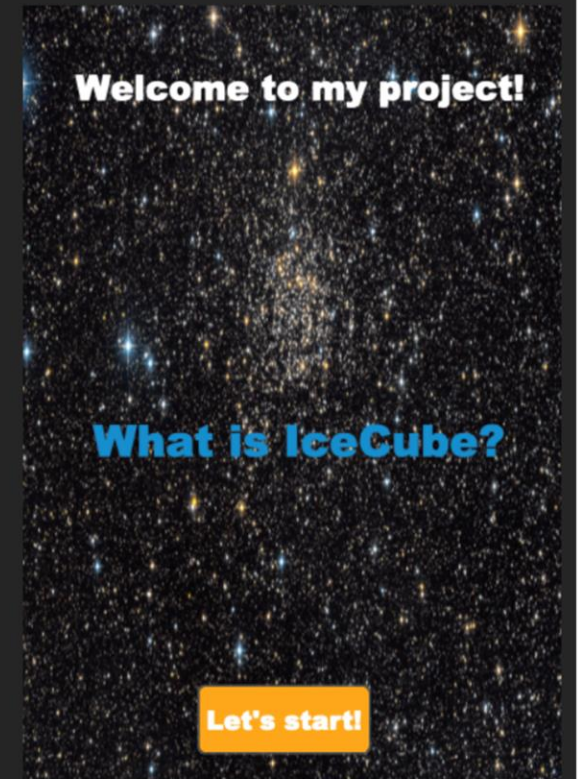
Design Project- Isabella

My project is a choose-your-adventure slideshow giving a brief understanding of IceCube's parts: the detector and the lab. This project targets people who would like a brief understanding of IceCube and what it consists of. It also offers additional links if anyone would like to learn more. The app is very visual, descriptive, and includes a lot of images to help my audience understand the basics.

I used conditional statements for the buttons. For example, if you click the "lab" button, the app will direct you to the first slide of the lab pages.



[Link to project](#)



IceCube After School: Final Projects

Finn P: Ice Cube Classroom Poster

Target Audience: Fellow Physics Students (High Schoolers in-school)

By creating a poster, it can serve as a massive source of information and an attractive way to catch attention within a classroom or hallway.

What did you want to show about Ice Cube?

I wanted to provide a general overview of the project, in an informative way that gets more people interested in it and physics projects like it.

Important elements: Attractive pictures and diagrams, readable/approachable

[Link to poster](#)



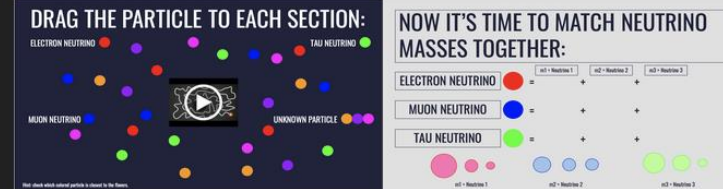
IceCube After School: Final Projects

Maddie: *My Design Challenge*

For my design challenge I chose to focus on neutrino oscillations and the detection of their different flavors. To do so, I made a game that would be a learning tool for students/young adults, and older, who have little prior knowledge of neutrinos and IceCube but are interested in learning about them both through a game.

Welcome to the IceCube Neutrino Observatory

Ready to explore some really, really, really small particles?



Through this game the player would mainly learn about what is absorbed in IceCube and an easy demonstration on how these particles work. To do this I made a google presentation and made multiple slides that the player would be able to flip through to engage in the game. The player would have to interact with the game by testing speed, memory, and their sorting abilities.

In terms of computational thinking the player would experience conditionals (an “If... then ...” statement) in the sorting part of the game which is mainly an unconscious act but still part of the game.

[Link for My Design Challenge.](#)

IceCube After School Feedback

“I really benefited from the constant engagement that was part of this program which helped me learn a lot more and make me more excited to continue learning about it.”

“The various guests is one of the coolest features in my opinion. It allows for a wider audience to be inspired or admire the subject of physics and provides a great range of approaches to all our favorite subjects.”

“Everything went well. I especially liked the programming aspect.”

Outreach Programs

- Group tours for fellowship programs, after school clubs
 - Intro talk on IceCube, tour of offices and local labs
- Webinars for societies and clubs
 - Live connection with winterovers at South Pole
- University outreach programming (Grandparent's University)
 - Talks, demos, and games about neutrino physics and living and working at the South Pole

