

## *Balzan Fellowship for a Postdoctoral Researcher*

**Francis Halzen**

**2015 Balzan Prize for Astroparticle Physics  
including neutrino and gamma-ray observation**

**Balzan GPC Advisers:** Bengt Gustafsson, Luciano Maiani

**Deputy Supervisor:** Kael Hanson

**Balzan Fellow:** Daan Van Eijk

**Affiliated Institution:** Wisconsin IceCube Particle Astrophysics Center (WIPAC) at the University of Wisconsin–Madison

**Period:** 2020-2022

Francis Halzen is the Hildale and Gregory Breit Distinguished Professor at the University of Wisconsin–Madison and Director of its Institute for Elementary Particle Physics.

The Wisconsin IceCube Particle Astrophysics Center (WIPAC) at the University of Wisconsin–Madison has created the Balzan Fellowship for an outstanding postdoctoral candidate to work with the IceCube neutrino experiment, with special emphasis on future technologies and/or multiwavelength campaigns to advance the future of neutrino astronomy.

The IceCube Neutrino Observatory, the first detector of its kind, was designed to observe the cosmos from deep within the South Pole ice. It does so by recording the interactions of a nearly massless subatomic particle called the neutrino. IceCube is also the world's largest neutrino detector, encompassing a cubic kilometer of ice. In 2013, IceCube discovered a flux of high-energy neutrinos reaching us from outside our own Galaxy, with one recent event exceeding an energy of 10,000 TeV, or about one thousand times the energy of the protons accelerated in the Large Hadron Collider beams. In 2017, a multimessenger campaign involving telescopes across the electromagnetic spectrum pinpointed a rotating supermassive black hole as the source of a 290-TeV IceCube neutrino. Thus, the first source of the highest energy cosmic rays was identified – a century after their discovery. The beam of cosmic neutrinos

provides the opportunity to study the neutrinos themselves, extending previous studies exploring atmospheric neutrinos to a new energy regime that far exceeds the reach of neutrinos produced by accelerator beams.

After an extensive international search, Daan Van Eijk was selected as the Balzan fellow. Van Eijk was previously employed as a scientist at NIKHEF, Amsterdam, as coordinator of the integration of KM3NeT digital optical modules. KM3NeT is, like IceCube, a kilometer-scale neutrino detector, but to be deployed in the Mediterranean sea and with a different design of its photosensors. The DOM, which is shorthand for digital optical module, is the basic detection element of the KM3NeT neutrino detector. Van Eijk's PhD research was performed at CERN, studying CP-violating decays using data from the LHC-B detector.

Van Eijk joined WIPAC in July 2017. Using his valuable expertise, Daan initiated a study of the KM3NeT DOM design for possible use as the detector element in a next-generation IceCube detector. Telescopes evolve. AMANDA, an experiment preceding IceCube, provided the proof of concept for a kilometer-scale detector by observing atmospheric neutrinos using natural ice as a particle detector. IceCube's discovery of a large flux of cosmic neutrinos has triggered the development of a next-generation instrument capable of observing thousands rather than hundreds of events in several years. The experience gained with IceCube has augmented the capability to instrument a ten-times-larger volume of ice on a budget similar to the one for IceCube. Daan Van Eijk's stay at WIPAC coincided with the decision of the National Science Foundation to fund an upgrade of IceCube that will also be a pathfinder mission to build the next-generation telescope.

Daan not only participated in completing the design of the instrument, coauthoring the white paper on the subject, "Neutrino astronomy with the next generation IceCube Neutrino Observatory." He completed an extensive study of novel photomultipliers that are considered for the next-generation detector, which is published in IOP's Journal of Instrumentation JINST. In the same context, novel technologies that do not necessarily involve the IceCube technique will also be researched, such as radio detectors and horizontal cosmic ray air shower arrays. Upon completing two years as a Balzan fellow at the lead institution of the IceCube project, Daan returned to a permanent position at NIKHEF. The search for his replacement is underway, and two excellent candidates have been identified.

## **Publications**

- Halzen, Francis, Daan Van Eijk and 400 other authors. “Neutrino astronomy with the next generation IceCube Neutrino Observatory.” *arXiv: High Energy Astrophysical Phenomena* (2019) arXiv:1911.02561 [astro-ph.HE].
- Eijk, Daan van, J. Dorant, Christoph Wendt and Albrecht Karle. “Characterization of the HZC Photonics XP82B20D and XP1805D Photomultiplier Tubes for Low-Temperature Applications.” *JINST* (2019) arXiv:1904.11897 [physics.ins-det].