

## CSC-RUB PhD Project Proposal

**Title:** Probing Active Galactic Nuclei as sources of high-energy neutrinos

**Sector of research:** Dr.rer.nat.

**Degree awarded:** Physics

**Keywords:** neutrinos, blazars, IceCube, data analysis, machine learning

### Supervisors of PhD project:

Prof. Dr. Anna Franckowiak, Chair for Multimessenger Astrophysics, Faculty of Physics and Astronomy, leader of Helmholtz Young Investigator Group at DESY Zeuthen

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Prof. Dr. Ralf-Jürgen Dettmar, Chair of Astronomy, Astronomical Institute, Faculty of Physics and Astronomy

### Research focus of supervisor:

Prof. Franckowiak's research focuses on multi-messenger astronomy. She is a member of the IceCube collaboration operating the largest neutrino telescope in the world at the South Pole, where she currently serves as the deputy analysis coordinator. Furthermore, she works with gamma-ray and optical data and is a member of the gamma-ray space telescope Fermi-LAT and the optical survey instrument ZTF. Her group collaborates with astronomers at the Weizmann Institute in Israel to build the Large Array Survey Telescope (LAST), where her group is especially interested to add the capability to measure polarization and the synergies with the next generation gamma-ray instrument, the Cherenkov Telescope Array. Her group was significantly involved in the detection of the first compelling neutrino source candidates: the blazar TXS 0506+056 and the tidal disruption event AT2019dsg. Her group has strong ties to Germany's leading center of astroparticle physics, DESY Zeuthen.

### Publications: more than 100 publications in the last 5 years., h-index 42

R. Stein, S. van Velzen, M. Kowalski, A. Franckowiak, ... et al., "A high-energy neutrino coincident with a tidal disruption event", *Nature Astronomy*, 5, 510 (2021)

X. Rodrigues, S. Garrappa, S. Gao, V. Paliya, A. Franckowiak, W. Winter, "Multi-wavelength and neutrino emission from blazar PKS 1502+106", *Astrophys.J.* 912 (2021)

A. Franckowiak, S. Garrappa, V. Paliya, ... et al., "Patterns in the multi-wavelength behavior of candidate neutrino blazars", *ApJ*, 893, 162 (2020)

M. G. Aartsen, M. Ackermann, J. Adams, ... **A. Franckowiak**, ... et al., "Multi-messenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A" *Science* 361, eaat1378 (2018)

**A. Franckowiak**, P. Jean, M. Wood, C. C. Cheung, S. Buson "Search for Gamma-ray Emission from Galactic Novae with the Fermi-LAT", *A&A* 609, A120 (2018)

### Summary of research plan

**Background:** High-energy neutrinos are considered the smoking-gun signature for sites of hadronic acceleration. IceCube discovered a diffuse flux of high-energy neutrinos in 2013. Its origin is still unknown. AGN are among the most promising neutrino source class and a first candidate, the gamma-ray blazar TXS 0506+056 was identified in spatial and temporal coincidence with a high-energy neutrino detected by IceCube realtime system.

**Study objective:** The goal is to probe the class of AGN and their subclasses as sources of high-energy neutrinos. The candidate will significantly contribute to this goal by studying systematic uncertainties (e.g. related to the unknown properties of the ice) and their influence on the reconstructed neutrino direction. A reliable angular reconstruction is the key to associate high-energy neutrinos to any source catalog. Furthermore, in collaboration with theorists at RUB a catalog of the most promising neutrino emitting AGN will be compiled to perform a dedicated search for neutrinos from those sources. The candidate will perform this search including the results of his study on systematic uncertainties.

**Expected Results:** Subclasses of AGN will be probed as neutrino sources. The work will result in two IceCube collaboration papers led by the candidate: A technical publication summarizing the results on systematic uncertainties and a second publication presenting the science results are foreseen.

**Methods:** The candidate will be trained to analyze IceCube neutrino data using likelihood and machine learning techniques. Monte Carlo simulation will be run with parallel computing infrastructure. The work will be performed within the IceCube collaboration, which entails regular presentations in the working group calls and the bi-yearly collaboration meeting.

**Candidate Requirements:** MSc degree in physics or astronomy is mandatory. Expertise in data analysis and a programming language such as python is strongly desired. Experience with machine learning applications is a plus. Good English language skills are essential. Soft skills and good communication is required to work successfully in the international team that this project is embedded in.

**Motivation for CSC application** (max 250 words): The candidate will become part of one of the world-leading multi-messenger astronomy groups (split between RUB and DESY Zeuthen),

which is involved and connected to a large number of multi-wavelength facilities. A broad scientific skill set will be taught that covers all aspects of statistical data analysis. The candidate will build up a large international network and naturally train their communication and presentation skills by working in a big collaboration. Furthermore, the project will be embedded in the Ruhr-University Research School and the candidate can become a fellow of the Weizmann-Helmholtz Research School, which offer additional soft-skill seminars, tutoring, and career development.