



## 2025 Helmholtz – OCPC – Program

for the involvement of postdocs in bilateral collaboration projects

### PART A

**Title of the project:**

Precision measurements of high-energy cosmic particles with the Square Kilometre Array

**Helmholtz Centre and/or institute:**

Karlsruhe Institute of Technology (KIT), Institute for Astroparticle Physics (IAP)

**Project leader:**

Dr. Tim Huege

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**Description of the project (max. 1 page):**

From the cosmos, high-energy particles possessing energies well beyond those reachable in human-made accelerators arrive at the Earth at all times. The sources of these particles have not yet been fully identified, and thus the study of these cosmic particles is a very active field of frontier research.

One detection technique to measure these particles has demonstrated its great potential over the past years: Measuring the pulsed radio signals that are emitted when the cosmic particles initiate cascades of secondary particles in the Earth's atmosphere. Experiments so far were measuring these radio signals with a limited number of antennas, and limited frequency bandwidth.

In the coming years, the Square Kilometre Array, in particular its low-frequency aperture array under construction in Australia, will provide a unique and unprecedented opportunity for precision measurements of cosmic particles through their radio emission. SKA-low will have an extremely densely instrumented core of more than 60,000 dual-polarized radio antennas within an area with 500 m diameter. In addition to this very high density, these



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antennas will furthermore possess a very broad bandwidth of 50-350 MHz, providing an unprecedented wealth of information on every single measured cosmic particle.

The project proposed here will have two components: One focus will be on the development of novel analysis and reconstruction methods allowing the full exploitation of the wealth of information provided by the measurement of particle cascades with SKA-low. This will likely include interferometric near-field analysis methods possibly in combination with machine-learning techniques such as Information Field Theory or deep neural networks. The other focus of the project will be the development of a radio-quiet particle detector array to be used as a basis for the triggering of data readout for SKA-low, as is currently being initiated at KIT.

The project will foster and strengthen existing cooperation between KIT and Chinese research institutions and build on the memberships of both Germany and China in the Square Kilometre Array.

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**Description of existing or sought Chinese collaboration partner institute (max. half page):**

Dr. Huege and the Institute for Astroparticle Physics at KIT already have a strong cooperation with several Chinese institutions such as the Purple Mountain Observatory (PMO), Nanjing University and Peking University through common participation in the Giant Radio Array for Neutrino Detection (GRAND). The researchers in China have ample experience both in terms of radio and particle detection of particle showers, and they have recently engaged also in the SKA science working group on High-Energy Cosmic Particles, of which Dr. Huege is one of the two chairs. The proposed Helmholtz OCPC project will strengthen and broaden these existing cooperation's.

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**Required qualification of the postdoc:**

- PhD in Astroparticle Physics, Astrophysics, Particle Physics or related fields
- Experience with extensive air showers and, ideally, their radio detection
- Experience with data analysis and/or simulation studies
- Experience with collaborative work in an international group
- Skills in software programming (Python, possibly C++, Linux, Root)
- Good command of the English language