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RAIMAD: Collaborative Development of On-Chip Astronomical Instruments

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Software

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Summary

RAIMAD is a parametric 2D computer aided design (CAD) program that is optimised for the creation of mask files for on-chip astronomical instruments, such as spectrometers and cameras.

RAIMAD comes with a library of built-in geometrical primitives, including rectangles, circles, and arcs. Users can combine these primitives into individual components, such as bandpass filters (Pascual Laguna et al., 2021), waveguides, and kinetic inductance detectors (Day et al., 2003). These components can then be assembled into a complete mask file for an astronomical instrument. This modular approach allows for streamlined collaboration and enables reuse of existing components among different instruments.

RAIMAD designs can be exported as a `.cif` (Caltech Intermediate Form) file (Sproull & Lyon, 1980), a format for storing mask files. Using these files, a process engineer is able to transfer the design onto the desired substrate using general lithography techniques.

RAIMAD components are created using Python ("Python: A dynamic, open source programming language," 2025) code, which allows for both simplicity and flexibility. RAIMAD itself is written in pure Python, making it easy to use on all major desktop operating systems. In order to allow users to share visual previews of their designs, a web-based component directory called RAIDEX has been developed. The name RAIMAD is a recursive acronym that stands for `RAIMAD Astronomical Instrument MAsk Designer`.

Statement of Need

The development of RAIMAD was initiated in order to fulfill the needs in the TIFUUN (Terahertz Integral Field Units with Unified Nanotechnology) project (Endo, 2022; Nishimura et al., 2025), to quickly design integral field units (IFUs) that are tailored to each astronomical science question as open-hardware (Shammah et al., 2024). Previously, a small number of integrated superconducting spectrometer chips were designed for TIFUUN's precursor project, DESHIMA (Deep Spectroscopic High-redshift Mapper) (Endo et al., 2019; Taniguchi et al., 2022), using an internally developed script. While that script proved to be a capable solution for the task at hand, its narrow scope and reliance on the end-of-life Python 2 made it unsuitable for use in TIFUUN. RAIMAD aims to build on the success of the script used in DESHIMA while also adhering to standard Python practices, such as the PEP8 style guide and relevant packaging conventions. Furthermore, the Ruff linter ("Ruff: An extremely fast Python linter and code formatter, written in Rust." 2025) and MyPy static checker ("MyPy: Optional static typing for Python," 2025) are employed to ensure code quality.

RAIMAD aims to be useful to the broader scientific community by enabling collaboration through

its modular approach to design. All RAIMAD components have a uniform Python interface, which streamlines the process of incorporating freely available components into a novel design. Existing components can be discovered in RAIDEX and installed trivially using pip, Python's standard package manager. This fosters an accessible environment with a low barrier of entry.

State of the field

RAIMAD seeks to enrich the growing ecosystem of analogue circuit CAD software by focusing on the specific niche of on-chip astronomical instrumentation. To this end, it draws key design inspirations from two existing programs with similar goals: Qiskit Metal and KLayout.

Qiskit Metal is a software platform for quantum device design ("Qiskit Metal | Quantum Device Design & Analysis (q-EDA)," 2024). Conceptually, it shares many similarities with RAIMAD, however its component library is geared towards quantum computing. We determined that developing RAIMAD from scratch would allow us more flexibility in implementation compared to retrofitting Qiskit for our specific use case.

KLayout is a mask file viewer and editor ("KLayout Package Manager (Salt)," 2024). One notable strength of its Salt package manager is its support for a wide variety of package formats, including Ruby macros, fonts, and binary extensions. In RAIMAD, we instead decided to establish a single uniform interface for all components in order to reduce complexity.

Availability

RAIMAD can be found on GitHub and is available for any platform that supports CPython, including Linux, Mac OS, and Windows. Documentation, installation instructions, and contributor guidelines can be found on the RAIDOC site, which also includes tutorials and sample code. Existing RAIMAD components are tracked in RAIDEX.

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