

RadioSkySim: A Flexible and Scalable Python Framework for Radio-Astronomical Sky Simulation

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RadioSkySim is a Python-based sky simulation framework developed within the BINGO Collaboration to support the modeling, analysis, and validation of radio-astronomical observations. Designed with an emphasis on modularity, extensibility, and computational efficiency, it provides a flexible environment for generating realistic simulated observations while maintaining a clear separation between scientific models and computational infrastructure.

The framework implements a library of instrumental beams with polarization support, astronomical radio sources, local sources, and GNSS satellites, enabling the construction of complex and configurable observing scenarios. These components can be combined to generate time-ordered data (TOD), currently stored in NetCDF format, and to support subsequent map-making and analysis workflows.

RadioSkySim adopts a hexagonal architecture that facilitates the integration of different computational backends and scientific models without coupling them to the core simulation logic. Its architecture also incorporates caching and database persistence mechanisms, together with multi-core execution capabilities, allowing simulations to be efficiently reused, scaled, and integrated into larger data-processing pipelines.

Beyond its current capabilities, the framework was designed as a foundation for more demanding simulation scenarios, including GPU-accelerated computation, additional classes of sky and foreground components, and increasingly sophisticated instrument models. This approach aims to provide the BINGO Collaboration with a sustainable simulation infrastructure capable of supporting both experimental development and scientific analysis.

In this talk, we present the architecture and main capabilities of RadioSkySim, discuss its current implementation and use cases, and illustrate how its design enables the progressive incorporation of new physical models, instrumental effects, and computational strategies.

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