SimCADO v2

The instrument data simulator for MICADO built on top of the ScopeSim simulation environment

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Contents

1 SimCADO v2 = ScopeSim + MICADO

SimCADO v2 combines the ScopeSim simulation engine with dedicated MICADO packages in ScopeSim's instrument reference database

This latest iteration of SimCADO is superior to the original version in the sense that the data needed to produce the MICADO optical model is completely decoupled from the code used to simulate the observations and from the code used to describe the target source.

In a word, SimCADO has been de-spaghetti-afied.

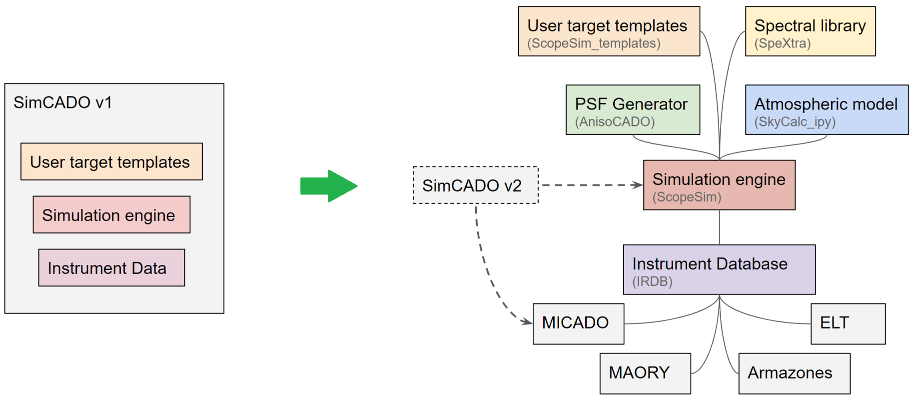

Figure 1: Left: SimCADO v1 contained everything needed to run a simulation for MICADO. However the inner algorithms were convoluted and interconnected. Right: The ScopeSim environment offers all the functionality of SimCADO v1, but with a decoupled code base. This allows each aspect of the simulation workflow to be updated and improved independently of all other systems. SimCADO v2 essentially now consists of a data package in the IRDB and utilises the in-built Effect object nativce to ScopeSim.

SimCADO v1 contained everything needed to run a simulation for MICADO. However the inner algorithms were convoluted and interconnected. The ScopeSim environment offers all the functionality of SimCADO v1, but with a decoupled code base. This allows each aspect of the simulation workflow to be updated and improved independently of all other systems. SimCADO v2 essentially now consists of a data package in the IRDB and a set of configuration files that utilise the in-built Effect objects native to ScopeSim.

A further advantage of using the ScopeSim architecture is that observations with MICADO can be compared directly with observations with other telescopes and instruments quickly and efficiently on a common platform.

2 Essentials: Documentation and Downloads

2.1 Online Documentation

Online documentation for the main packages in the ScopeSim environment can be found here:

- ScopeSim: https://scopesim.readthedocs.io/en/latest/
- ScopeSim_Templates: https://scopesim-templates.readthedocs.io/en/latest/
- IRDB: https://github.com/astronomyk/irdb

The original SimCADO package is described here:

- SimCADO: https://simcado.readthedocs.io/en/latest/

> **Note**
> In the near future we will release a wrapper for the ScopeSim engine and the MICADO instrument package.
> The doumentation for this will be added to the original SimCADO read-the-docs page

2.2 Downloading ScopeSim and the MICADO package

The ScopeSim engine is installed using pip:

```
$ pip install scopesim
```

The casual user will also probably want to install the templates package, which contains helper functions for generating descriptions of on-sky targets like elliptical galaxies or star clusters:

```
$ pip install scopesim_templates
```

Once ScopeSim is available to the local Python (version >= 3.5) installation, the user must download **ALL** the required instrument packages from the server:

```
from scopesim.server import download_package
download_package(["locations/Armazones",
                  "telescopes/ELT",
                  "instruments/MAORY",
                  "instruments/MICADO"])
```

> **Note**
> There are two (2) MICADO packages available: `MICADO` and `MICADO_Sci`.

For those interested in quick results, `MICADO_Sci` provides a reduced version of the MICADO package that contains all the major effects expected from the MICADO optical system. For those more concerned with accuracy, the standard `MICADO` package contains all expected optical effects. `MICADO` was originally developed for the development of the reduction pipeline, and therefore contains many effects that are beyond the scope of normal science case feasability studies.

2.3 Primary vs Support packages

`MICADO` and `MICADO_Sci` are primary packages. This means they contain detector modules that enable an on-sky target to be observed

`Armazones`, `ELT`, and `MAORY` are support packages. They do not contain detector modules.

Just like in real life, observing with only MICADO would be a difficult task. Therefore we encourage the user to also download the support packages needed by MICADO.

3 Basic functionality

- Quick look example for cluster in LMC with Ks and SCAO

4 Making on-sky Sources

4.1 ScopeSim Templates

An useful addition to the ScopeSim eco-system is the package `ScopeSim_templates`. This python package provides so-called helper functions for generating ScopeSim readable `Source` object for common astronomical objects. The documentation for ScopeSim templates can be found on Read-The-Docs

Here is a basic example of creating a star cluster using `ScopeSim_templates`:

```
from scopesim_templates.basic.stars import cluster

my_cluster = cluster(mass=1000, distance=50000,
                     half_light_radius=1)
```

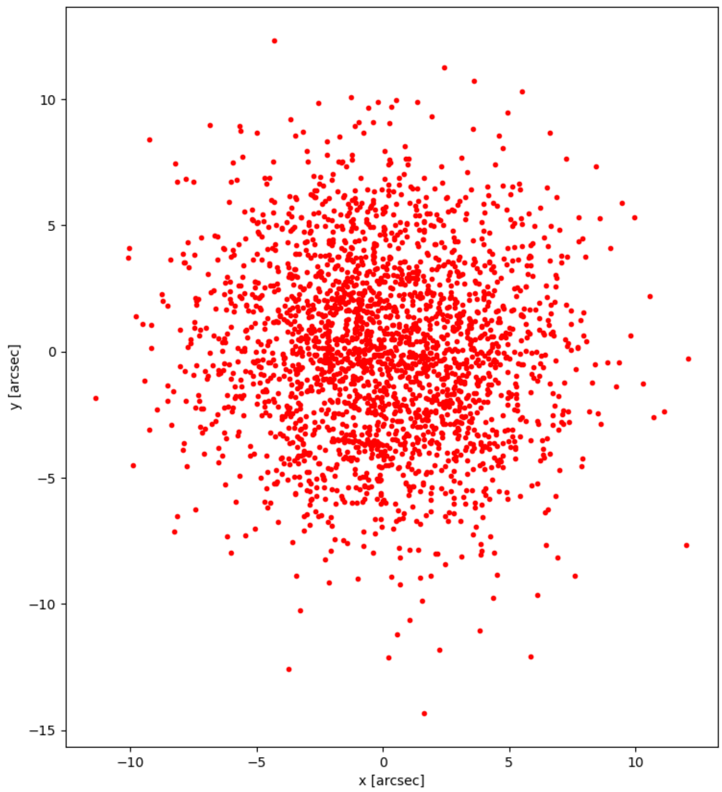

Figure 2: Left: the on-axis K-band (2.15mum) SCAO PSF for standrard atmospheric conditions. Right: the K-band SCAO-PSF at the position (15, -5) arcseconds from the natural guide star.

- What is inside a Source object
- **How to make source objects to observe**
  - Star cluster
  - Custom point source
  - Elliptical galaxy
  - Custom extended source
  - Combining sources

5 Simulating an Observation Run

5.1 General Workflow

- **Observing the Source**
    - Workflow

5.2 Contolling the simulation

- **Official MICADO modes**
    - SCAO, MCAO
    - 4mas, 1.5mas, Spec
- **Other major configuration parameters**
    - filter
    - dit / ndit
    - slit size
    - zenith distance
    - psf model

6 Science package use case examples

6.1 IMG: Extended Sources (4mas, MCAO, Ks filter)

- View a galaxy with star formation regions over the middle MICADO detector
- Use a strehl ratio of 35% in the Ks-filter
- Observe for 60 x 60s DITs and stack them

6.2 IMG: Point sources (1.5mas, SCAO, Pa-Beta filter)

- View a cluster of stars in the central detector
- Use a field varying PSF, with strehl of 20% in J, dropping off with radius from centre

6.3 IMG: Astrometric sub-pixel shifts (1.5mas, SCAO, J filter)

- Generate a group of stars with different velocities
- Observe the group at two epochs
- Extract the positions and show change in position

6.4 SPEC 50x15000, HK, slit aligned with parallactic angle, no ADC

6.5 SPEC 20x3000, J, slit at 45 deg to zenith

6.6 HCI (not yet implemented)

- possible hack to get this working