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Guide to simulate light curves using SNANA

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1. Introduction

SNANA is software used to simulate light curves using a specific survey. In this document, you are going to learn how to simulate light curves for the LSST survey. Due it is not yet operational, it is necessary to simulate light curves in order to create training sets for the survey, so it can be already trained when starts operations.

This document is part of an entire project. You can check its repository to find all the files indicated here (github.com/amigolucho/Light-Curves-Simulations-LSST/tree/main).

We highly recommend reading the entire documentation in the repository before starting your proyect.

2. Installing SNANA

For the correct usage of the SNANA software, you will need the "$SNDATA\_ROOT$" enviroment that you can download from zenodo.org/records/12655677. This environment includes public light curve data sets, filter transmissions, primary SEDs, calibration files, models for SNIa and CC, cadence and host-galaxy libraries for simulations, etc.

It will be necessary to create the following environment variables in your bashrc file (with your own path):

```
export SOFTDIR=my/directory/path
export SNANA_DIR=$SOFTDIR/SNANA
export SNDATA_ROOT=$SOFTDIR/SNDATA_ROOT
```

If you have access to the National Laboratory for High Performance Computing (NLHPC) cluster, you can skip to the next section, since it is already installed and you just need to load the SNANA module. Here you can find an introductory course for NLHPC beginners youtu.be/wF61xrKwArI.

Next, you must install GSL (ftp.gnu.org/gnu/gsl/) and CFITSIO (heasarc.gsfc.nasa.gov/fitsio/), before installing the SNANA software (git clone this github.com/RickKessler/SNANA/releases/tag/v11$_0$5t)

2.1. Linux/MacOS

For Linux/MacOS users, and you need more specific details about the installation, you can check the SNANA installation guide from the SNANA github repository github.com/RickKessler/SNANA/blob/master

2.2. Windows

For Windows users, you are doomed to use a virtual machine and follow the same steps for Linux/MacOS. But you can watch this step by step installation tutorial made by myself (creo que podría intentar hacer un tutorial)

3. First Steps

For using SNANA, you're gonna need at minimmun 4 principal files.

3.1. KCOR file

The KCOR file, despite its name, does not have the k-corrections. Instead, it takes filter throughputs, combines them with user-defined filter shifts and zero-point offsets, and creates an output FITS file that is used by the SNANA fitting and simulation programs. If it's needed, you can add a referential supernova to calculate the k-corrections.

For the LSST survey, this file is already created in the $SNDATA\_ROOT$ environment.

3.2. SEARCHEFF files

The search-efficiency file or SEARCHEFF file contains the probability of detection as a function of the magnitude. This file is essentially a two-column list for one or multiple filters that gives a magnitude and a probability of detection.

The SEARCHEFF LOGIC file just indicates to the simulation wich combination of detections in each filter must be considered "detections"for the purposes of the survey.

You can find both files for the LSST survey in the $SNDATA\_ROOT$ environment.

3.3. SIMLIB file

The SIMLIB file defines the parameters of the survey observations. At minimum, this requires a list of MJDs, filters, sky noise, and image zeropoints.

This file is one of the most important, because make the simulations realistic defining the cadency and transforming magnitudes in CCD counts.

You can create your own SIMLIB file for the LSST survey with the "$made\_SIMLIB.py$" code.

3.4. INPUT file

The INPUT file is executed with the command "$snlc\_sim.exe < inputfile >$ ". Contains the path to all the other files needed, the model that is going to be used, the filters where the curves are generated, and many values from the models and the simulation.

You can find an INPUT file template made by Isidora Mancilla in the repository. You can use it to create your owns INPUT files.

4. Simulating a light curve

Once you have all the necessary files, you can run your first simulation. In the repository you can find a test file for you to run and simulate your first light curve. You have an INPUT file there that needs to be executed with the command "*snlc_sim.exe AGN_test.input*". Make sure that all the paths to the files are rightly indicated in the INPUT file, or you can modify them.

After an effective execution, you have generated 400 light curves, and you should get 4 files in the path $\$SNDATA\_ROOT/SIM/AGN\_test$, but we only care about the "*PHOT*" and "*HEAD*" files. With these 2, you can use the "*make_Light_Curves.ipynb*" code to plot one of all the light curves simulated, in a specific band.

You will get something like this:

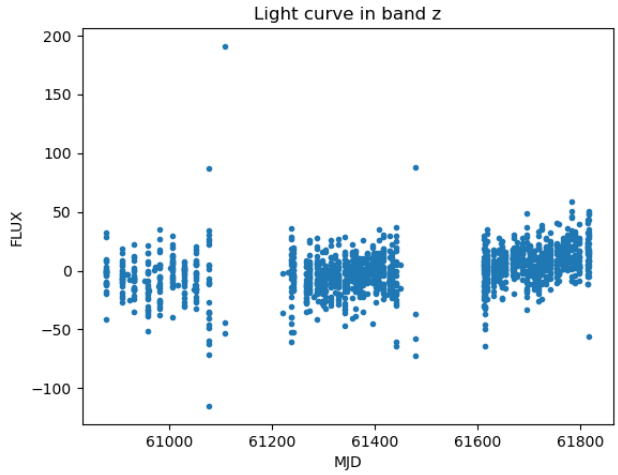

Figura 1: AGN light curve for band z

For any error you can check the part 6 of this guide to see if there is a solution.

5. Parallel execution

Now we are going to see how to make multiple simulations using the SLURM tool from the NLHPC, so if you don't have an account, you can aply in the form(formulario de cuentas).

As we said previously, here you don't have to install SNANA, you can simply load the last version module with the command "ml SNANA", that already has the "$SNDATA\_ROOT$" file, but you will have to copying it into your user directory, in order to save the simulations there (you cannot modify native NLHPC files).

Next, you will have to modify your environment variables with the new path to the "$SNDATA\_ROOT$" file. Then, you gonna need to create all the INPUT files you gonna use, indicating the amount of light curves that you are simulating per INPUT files. To keep order, we recomend to separate each kind of object in diferent folds. In each fold, you will create an ".sh" file with the following format:

```
#!/bin/bash
#---------------Script SBATCH - NLHPC ----------------
#SBATCH -J run_Object
#SBATCH -p general
#SBATCH -n 1
#SBATCH -c 1
#SBATCH --mem-per-cpu=1000
#SBATCH -o run_AGN_%A_%a.err.out
#SBATCH -e run_AGN_%A_%a.err.out
#SBATCH --mail-user=some@one
#SBATCH --mail-type=ALL

#-----------------Toolchain--------------------------
# ----------------Modulos-----------------------------
ml  SNANA
# ----------------Comando-------------------------
export SNDATA_ROOT=$SOFTDIR/my_SNANA/SNDATA_ROOT


snlc_sim.exe <your_INPUT.input>
```

... You can try diferent configurations for the tasks (n), cpu (c) and memory per cpu, but this have worked for us without the problem of over/sub usage.

6. Some considerations and error solutions

Now, you can find some considerations and error solutions in case you have any problems implementing any of the steps:

- If you are using the NLHPC and copy files from your local computer, you may have an error when you execute your tasks. Try giving permission to the directory you copied with the command "chmod -R u+w $< directory\_name >$ ".