

## **An Extragalactic Point Source Simulator for SIRTf Pipeline Testing**

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**Abstract.** We designed and developed a package which simulates extragalactic point source data within a given field of view and SIRTf band. Our method uses input empirical relations, such as known luminosity functions and galaxy spectral energy distribution templates. It also uses instrument filter information to produce a list of sources, their redshifts, positions, and fluxes. The output fluxes in the specified band are based on the user-specified luminosity and redshift evolution modes. We designed the simulator so that the empirical input and filter information can be easily modified. The simulator is modular and extensible to enable multi-wavelength simulations, has been optimized by utilizing parallel processing capabilities, and will be used to test pipeline software.

### **1. Design**

The extragalactic simulator has a modular, linear design and consists of six stand-alone C modules. These modules are represented in Figure 1 as (red) boxes labeled: in (1), “GENERATE...”, “EVOLVE”, and “DISTRIBUTION...”, in (2), “GENERATE FLUXES”, and in (3), “POSITION...” . There are several additional input tables of data and parameters which are bound to the modules via a single C-shell script. The design of the simulator is well-suited to future extensions. Each module can be run separately at the command line for testing and debugging purposes and also produces its own output and log files. All user-specified parameters reside in a separate file that can easily be up-to-dated with new inputs (e.g., SED templates, filter responses, etc.).

The simulator has been streamlined for high-speed processing and is capable of generating tens of thousands of extragalactic sources in minutes. This is enabled by splitting the most time consuming process over several processors (currently up to 20) and running them in parallel. Users can simply list available machines and run processes in the background of each machine.

### **2. Algorithm**

In the first stage of the simulator, a set of extragalactic sources is generated for a given set of input parameters. The simulated sources fall within a user-specified area on the sky and have three basic attributes—see part (1) of Figure 1:

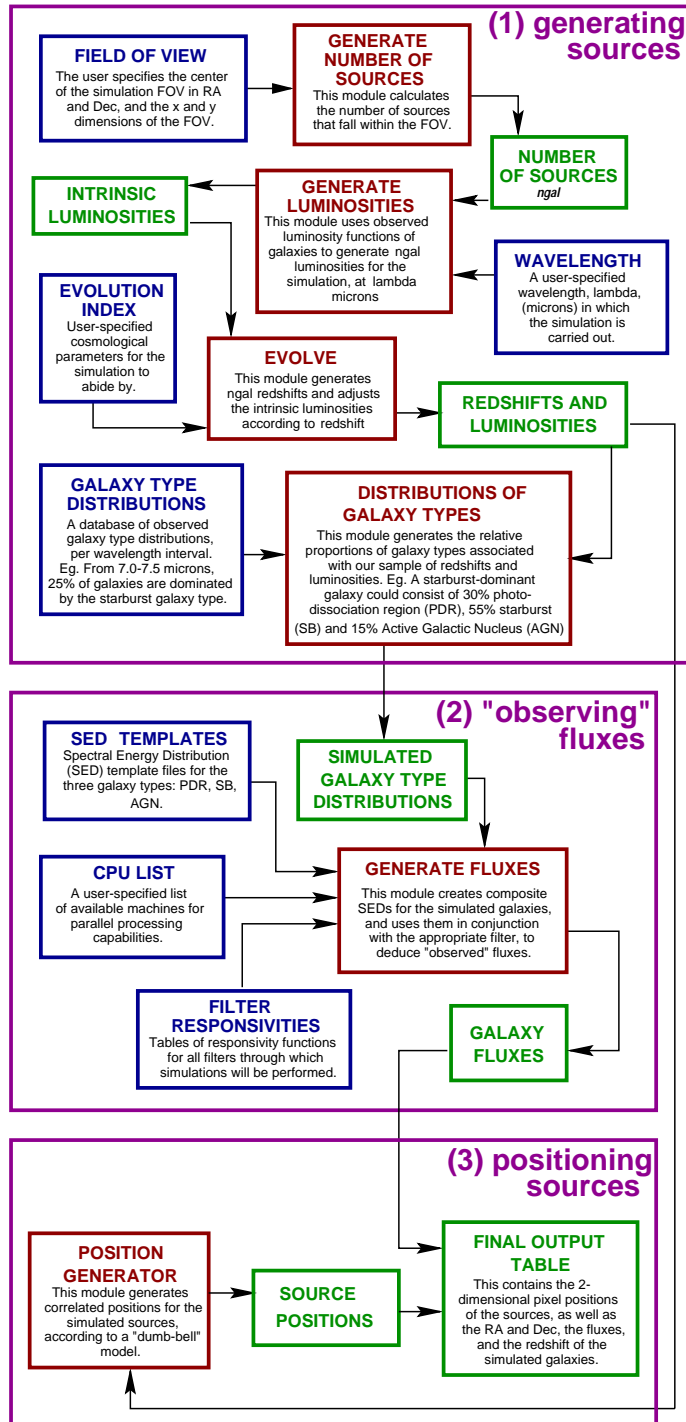


Figure 1. Schematic diagram of the extragalactic simulator illustrating its three main stages; see text. (In the on-line version of this article, blue boxes represent data input modules; red, data processing modules; and green, output modules.)

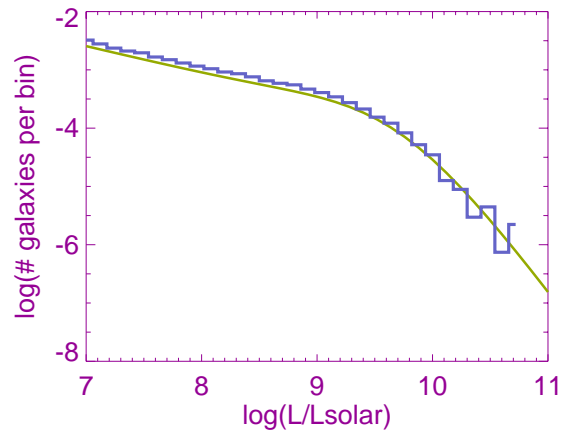


Figure 2. Distribution of simulated  $8\ \mu\text{m}$  luminosities. Overlaid smooth line is the parent  $12\ \mu\text{m}$  function from which luminosities are drawn.

- **Intrinsic luminosities** are chosen on the basis of an appropriate luminosity function (see Figure 2).
- **Redshifts** are derived independently for each galaxy using a  $(1+z)^{-\beta}$  distribution, appropriate for a co-moving density evolution.
- **Galaxy types** are determined from intrinsic luminosities and the band of interest and emission is modeled as a linear combination of the average emission from “Photo-dissociation Regions (PDR)”, “Star Bursts (SB)” and “Active Galactic Nuclei (AGN)”, determined from empirical data.

In the second stage of the simulator, available Spectral Energy Distribution (SED) templates for PDR, SB, and AGN galaxy types are used—see part (2) of Figure 1—to construct individual composite SEDs based upon the proportions of types calculated in the previous stage. With the filter response function of the specified SIRTf wavelength, the “integrated luminosities” of the galaxies are calculated by multiplying by the normalized SEDs and integrating to determine flux densities from the following relation:  $Flux_{Band} = L_{int}/4\pi D^2$  where  $L_{int}$  is the integrated luminosity, and  $D$  is the luminosity-distance of the galaxy.

In the last stage of the extragalactic simulator, galaxies are placed on the 2-dimensional sky—see part (3) of Figure 1—with correlated positions calculated according to a dumb-bell model of fractal structure (Soneira & Peebles 1978). The final output of the simulator contains luminosities, redshifts, fluxes, and positions in Right Ascension and Declination of the simulated galaxies.

### 3. Discussion

The extragalactic simulator has been tested for four filters on the SIRTf IRAC instrument:  $3.6\ \mu\text{m}$ ,  $4.5\ \mu\text{m}$ ,  $5.8\ \mu\text{m}$ , and  $8.0\ \mu\text{m}$ . The table look-up method used to generate the luminosities of the simulated galaxies works well at all four wavelengths (see Figure 2).

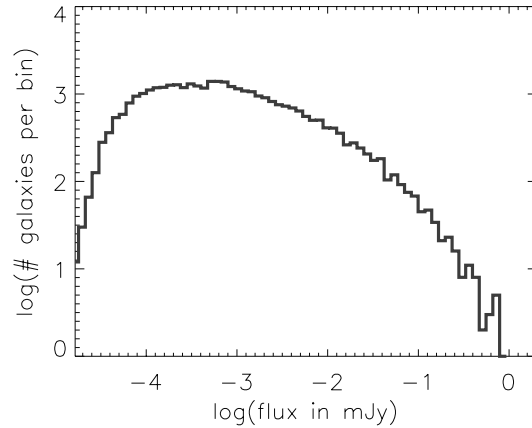


Figure 3. Log plot of number counts of 34,557 extragalactic sources vs. flux.

The extragalactic simulator is capable of generating large numbers of galaxies within a given patch of sky for SIRTf pipeline testing. Tens of thousands of galaxies can be simulated within minutes and further techniques to speed up the process are under consideration. This includes “table look-up” methods in the flux calculation module that could replace calculation of individual fluxes. When available, luminosity functions can be replaced by newer ones recorded at wavelengths close to SIRTf instrument wavelengths. SED templates can also be replaced by newer, more accurate ones when available. In order to simulate an observation of the real sky, this simulator will soon work in conjunction with the SKY model galactic simulator (Cohen 1993) to produce data sets that contain external galaxies as well as objects within our own.

A common test of cosmological models is a  $\log N - \log S$  plot of galaxies. An effective test requires a complete sample of galaxies out to relatively high redshifts, and Figure 3 shows a plot of  $\log N$  versus  $\log S$  for 34,557 simulated extra-galactic sources with redshifts in the range  $z=0$  to 5, “observed” using the IRAC  $8.0 \mu m$  filter. The extragalactic simulator produces galaxies with fluxes that are at the limit of IRAC sensitivity ( $\approx 1 \mu Jy$ ).

## References

- Cohen, M. 1993, AJ, 105, 1860  
 Soneira, R. M. & Peebles, P. J. E. 1978, AJ, 83, 845