# AGN Identification and Photometric Redshifts with SIRTF (GOODS)

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## Abstract

As part of the GOODS legacy proposal team for the mid-far IR telescope SIRTF (to be launched next year) I will present various tests and simulations that we are performing, in order to identify Active Galactic Nuclei (AGN) among the many thousands of galaxies that we will be detecting with SIRTF. We use a library of Spectral Energy Distributions (SED) of extragalactic objects and combine them with appropriate luminosity functions, evolution and cosmology, in order to develop efficient methods for finding AGN on the basis of multi-wavelength photometric data.

## 1 SIRTF and GOODS

The Space Infrared Telescope Facility (SIRTF) is the next infrared telescope, part of NASA's Great Observatories Program, that will be launched in July 2002. It offers unprecedented capabilities over previous and existing facilities, such as greatly improved sensitivity and large-format detector arrays. The Great Observatories Origins Deep Survey (GOODS) is a SIRTF legacy program to carry out a deep (25-100 hr), multi-$\lambda$ (3.6-24 $\mu$m), large area ($\sim$300 arcmin$^2$) survey, that builds upon existing deep surveys by HST, Chandra and XMM. GOODS will create a legacy dataset for exploring the distant Universe with the next generation of telescopes and instruments. In **Table 1** we list the sensitivities sought with SIRTF and with the complementary ground- and space-based observations.

**Table 1.** GOODS aimed Sensitivities

| | |
|---|---|
| **SIRTF** | |
| **IRAC:** | 0.6-1.2 $\mu$Jy at 3.6-8 $\mu$m |
| **MIPS:** | 22 $\mu$Jy at 24 $\mu$m |
| **Chandra Deep Field - South** | |
| **HST/ACS:** | $\sim$27 mag at $BV(griz)$ |
| **VLT/FORS+VIMOS:** | 27.5 mag at $UBVRI$ |
| **VLT/NIRMOS:** | $\sim$25 mag at $JH$ |
| **NTT/SOFI:** | 24.4 mag at $K$ |
| **VLT/FORS2:** | MOS to R$\sim$24 mag |
| **Hubble Deep Field - North** | |
| **KPNO/MOSAIC:** | 27.5 mag at $UBVRI$ |
| **KPNO/FLAMINGOS:** | $\sim$25 mag at $JHK$ |
| **MMT+GEMINI-N:** | $\sim$26 mag at $K$ |

GOODS aims to trace the mass assembly history of galaxies and the nature and distribution of their energetic output (from stars and AGN) over a broad span of cosmic history (up to $z$ $\sim$6). Furthermore, it is expected to improve the lower limits to the cosmic mid-IR background radiation. In order to achieve these we will need to first classify the deepest field sources through colour selection (optical, n-IR and mid-IR photometry in targeted z intervals). Then we will determine photometric redshifts, in particular for sources that are significantly fainter than current spectroscopic limits. We will carry additional optical spectroscopy to measure/confirm the redshifts of the brighter sources. The MIPS 24$\mu$m band will detect dust-obscured star-forming galaxies and AGN, up to z$\sim$2.5 with positional accuracy of $\sim$1", while deep Chandra and XMM follow-up observations will ultimately allow to distinguish between these two types of objects.

## 2 Simulations

In order to access and analyse the data that we expect to obtain with SIRTF and also in order to plan the necessary follow-up multi-$\lambda$ multi-site observations, we can perform a number of simulations under a variety of (theoretical and observational) assumptions. In particular, we are simulating the:

1. Number of objects of different types that will be detected in the GOODS fields and their approximate maximum redshift.
2. Fraction of sources detected w/GOODS at 24$\mu$m, that Chandra and XMM missions will also be able to detect.
3. Source counts and image simulations at different combinations of exposure times and SIRTF wavelengths.
4. Identification of galaxy types and redshift determination through multi-colour photometry.

Here I will present some work on the latter project, in which I am directly involved. As a first step, I compile a large number of individual SED for different types of active galaxies (radio-loud, radio-quiet, Seyfert 1, Seyfert 2, starbursts) and for normal galaxies with different morphological types. Then, I randomize the magnitude, redshift and SED type and add appropriate noise models, creating a simulated catalog of a large number of sources (1000 here). Finally, I convolve these SED with the filter response curves at the wavelengths of interest (here I have used 13 filters in the optical, near and mid-IR wavelengths), thus creating a grid of dimensions ($n_{filters}$,$n_{galaxies}$) of fluxes for each wavelength and galaxy type. I repeat this whole procedure for a set of average SED (one for each galaxy type), that I have constructed using the original data (first step) and normalizing at some appropriate wavelength (7000Å here). These are shown in **Figure 1**. The final product is a template matrix of dimensions ($n_{filters}$, $n_{redshifts}$, $n_{SEDtypes}$).

In **Figure 2** we show some of the colour-colour plots resulting from the simulated data of our (1000) galaxy catalogue. As we can see, the combination of such plots is a very powerful tool for identifying (with high levels of confidence) simultaneously the type and redshift of an observed source, solely on the basis of its position on these diagrams.

Furthermore, we perform a comparison (for instance a reduced $\chi^2$ test between the galaxy catalogue and the template matrix in order to test how well we can recover the input galaxy types on the basis on the basis of our (simulated) photometry. First results show that we can recover about 70-80% of each input type in the correct output bins. Obviously we can improve our methods described above, by both using more sophisticated software and enlarging our data base (galaxy types and magnitude/redshift/wavelength ranges). We hope to ultimately be able to simulate large data sets, representative of those we expect to obtain with GOODS, with very high accuracy and with complete coverage from X-rays to far-IR (and even radio) wavelengths.

## Acknowledgments

I would like to thank H. Teplitz and N. Collins who made available to me the initial versions of the codes on which the simulations presented here were based.

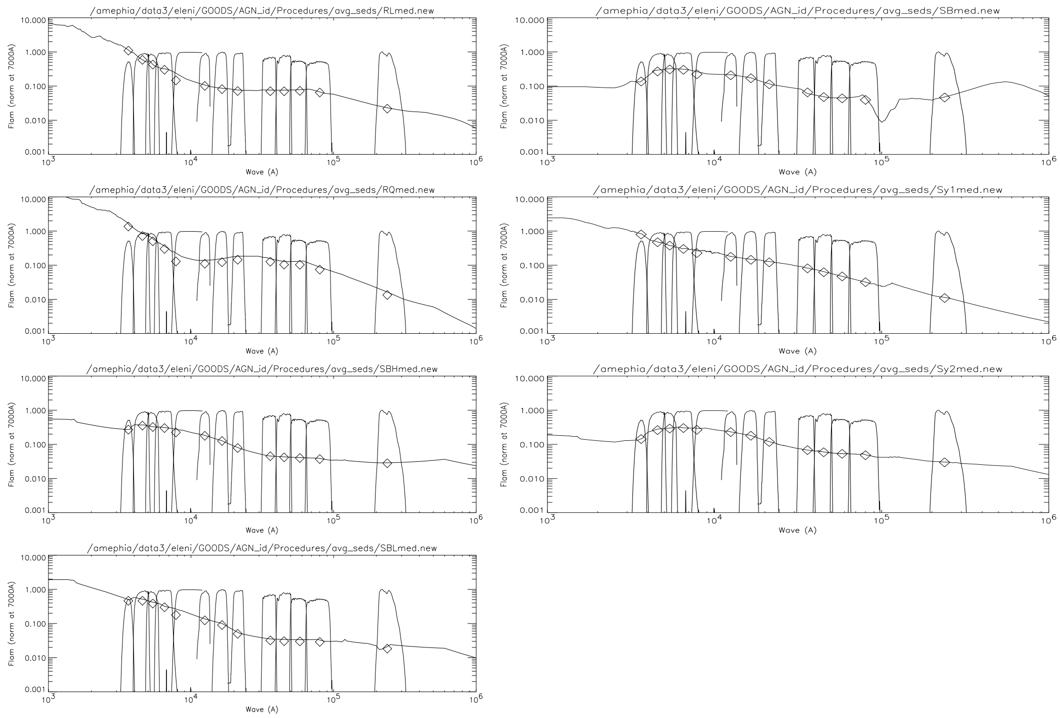


**Figure 1.** Average Spectral Energy Distributions for 7 different AGN types: Radio-Loud, Radio-Quiet, Seyfert 1, Seyfert 2 and Starburst with high and low internal absorption.Overplotted are the response curves of the 13 filters used in the current simulations. Both axes are represented in logarithmic scale.

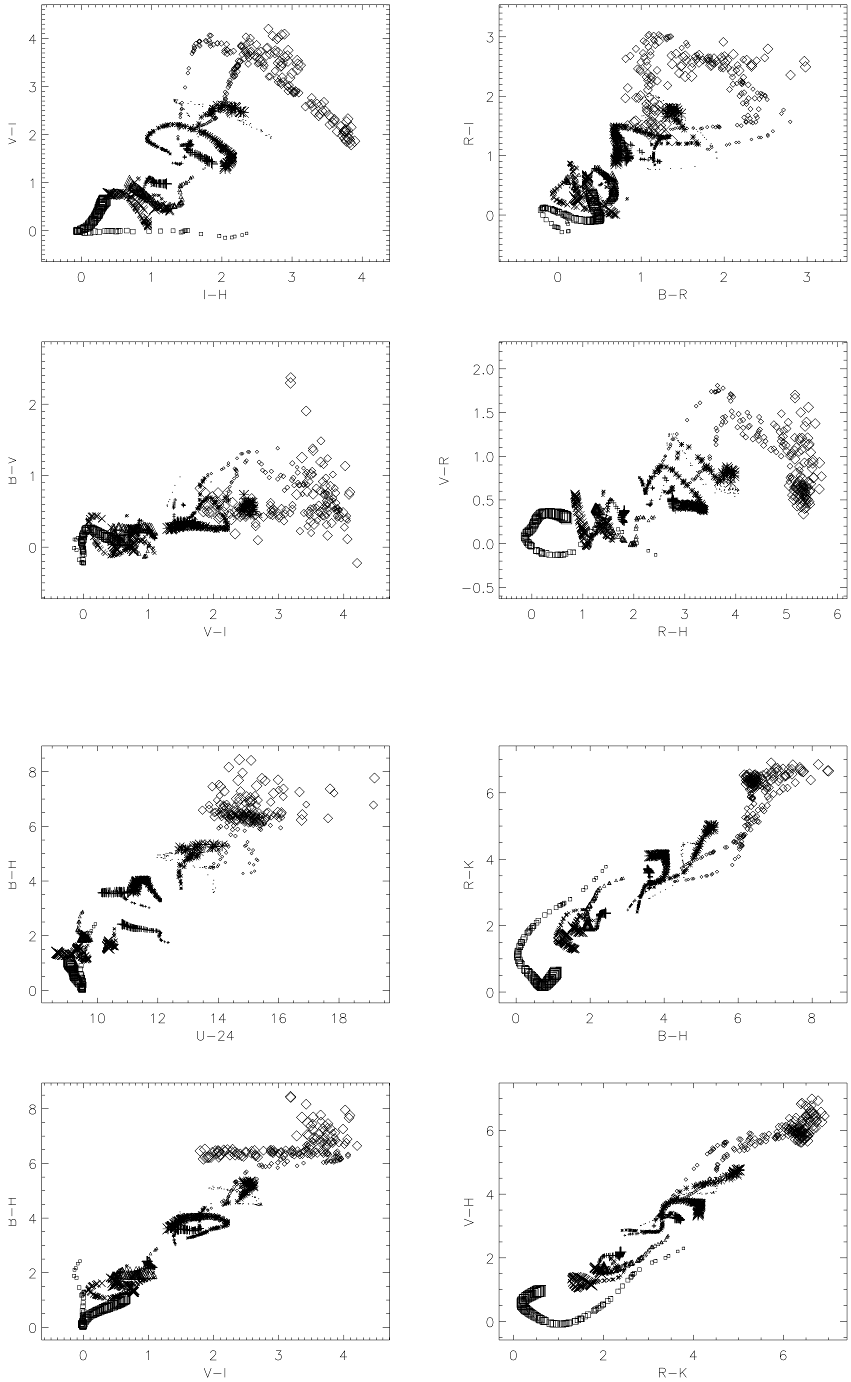


**Figure 2.** Colour-colour plots for 1000 simulated galaxies. Different symbols indicate different SED types: squares for radio-quiet, x for radio-loud (two types), triangles for Seyfert 1, diamonds for Seyfert 2 (two types) and stars+dots for Starburst galaxies (three types). Different symbol *sizes* indicate the redshift of the galaxy in question. For the illustrated simulation redshift runs from present day up to $z$=2