# The Search for Young Planetary Systems And the Evolution of Young Stars

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The Space Interferometer Mission (SIM) will provide a census of planetary systems by conducting a broad survey of 2,000 stars that will be sensitive to the presence of planets with masses as small as $\sim$ 15 Earth masses (1 Uranus mass) and a deep survey of $\sim$ 250 of the nearest stars with a mass limit of $\sim$ 3 Earth masses. The broad survey will include stars spanning a wide range of ages, spectral types, metallicity, and other important parameters. Within this larger context, the Young Stars and Planets Key Project will study $\sim$ 200 stars with ages from 1 Myr to 100 Myr to understand the formation and dynamical evolution of gas giant planets.

The SIM Young Stars and Planets Project will investigate both the frequency of giant planet formation and the early dynamical history of planetary systems. We will gain insight into how common the basic architecture of our solar system is compared with recently discovered systems with close-in giant planets by examining 200 of the nearest (<150 pc) and youngest (1-100 Myr) solar-type stars for planets. The sensitivity of the survey for stars located 140 pc away is shown in the planet mass-separation plane (Figure 1).

We expect to find anywhere from 10 (assuming that only the presently known fraction of stars, 5-7%, has planets) to 200 (all young stars have planets) planetary systems. We have set our sensitivity threshold to ensure the detection of Jupiter-mass planets in the critical orbital range of 1 to 5 AU. These observations, when combined with the results of planetary searches of mature stars, will allow us to test theories of planetary formation and early solar system evolution.

By searching for planets around pre-main sequence stars carefully selected to span an age range from 1 to 100 Myr, we will learn at what epoch and with what frequency giant planets are found at the water-ice "snowline" where they are expected to form. This will provide insight into the physical mechanisms by which planets form and migrate from their place of birth, and about their survival rate. With these data in hand, we will provide data, for the first time, on such important questions as: What processes affect the formation and dynamical evolution of planets? When and where do planets form? What is initial mass distribution of planetary systems around young stars? How might planets be destroyed? What is the origin of the eccentricity of planetary orbits? What is the origin of the apparent dearth of companion objects between planets and brown dwarfs seen in mature stars?

The observational strategy is a compromise between the desire to extend the planetary mass function as low as possible and the essential need to build up sufficient statistics on planetary occurrence. About half of the sample will be used to address the "where" and "when" of planet formation. We will study classical T Tauri stars (cTTs) which have massive accretion disks and post- accretion, weak-lined T Tauri stars (wTTs). Preliminary estimates suggest the sample will consist of $\sim$ 30% cTTs and $\sim$ 70% wTTs, driven in part by the difficulty of making accurate astrometric measurements toward objects with strong variability or prominent disks. The second half of the sample will be drawn from the closest, young clusters with ages starting around 5 Myr, to the 10 Myr thought to mark the end of prominent disks, and ending around the 100 Myr age at which theory suggests that the properties of young planetary systems should become

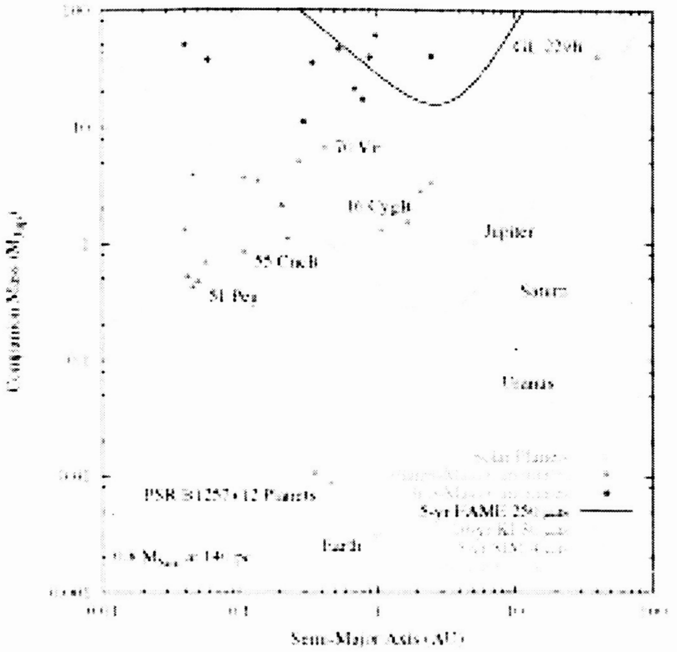


Figure 1: Comparison of our SIM survey, FAME, and the Keck Interferometer for the detection of planets around young stellar objects at a distance of 140 pc. We adopt single measurement accuracies of 4 $\mu$as for SIM, 250 $\mu$as for FAME (both for 5 yr missions), and 30 $\mu$as for the Keck-Interferometer (10 yr mission). We also show the sensitivity to planets for 30 m/s radial velocity measurements appropriate for young stars (10 yr survey).

indistinguishable from those of mature stars. The properties of the planetary systems found around stars in these later age bins will be used to address the effects of dynamical evolution and planet destruction (Lin et al. 2000).

The sample will consist mostly of stars in well known star-forming regions 125-140 pc away but will also include stars such as those in the TW Hydrae Association which are only 50 pc away. Only single stars meeting stringent requirements on photospheric stability, lack of nebulosity, and absence of a strong gas disk will be included in the sample. Such stars offer the stable photocenter needed for accurate astrometry. With proper selection, the effect of various astrophysical disturbances can be kept to less than a few $\mu$as.

A secondary goal of the program is put our knowledge of stellar evolution on a firmer footing by measuring the distances and orbital properties of $\sim 100$ stars precisely enough to determine the masses of single and binary stars to an accuracy of 1%. This information is required to calibrate the pre-main sequence tracks that serve as a chronometer ordering the events that occur during the evolution of young stars and planetary systems

SIM's census of planetary systems will address fundamental questions about the properties of planetary systems and the existence of terrestrial planets around the closest stars. The Young Star Key Project will provide the data needed to understand the formation and evolution of solar systems and address whether systems like our own are common or rare in the solar neighborhood.