Planetary Imaging Concept Testbed Using a Recoverable Experiment - Coronagraph (PICTURE - C)

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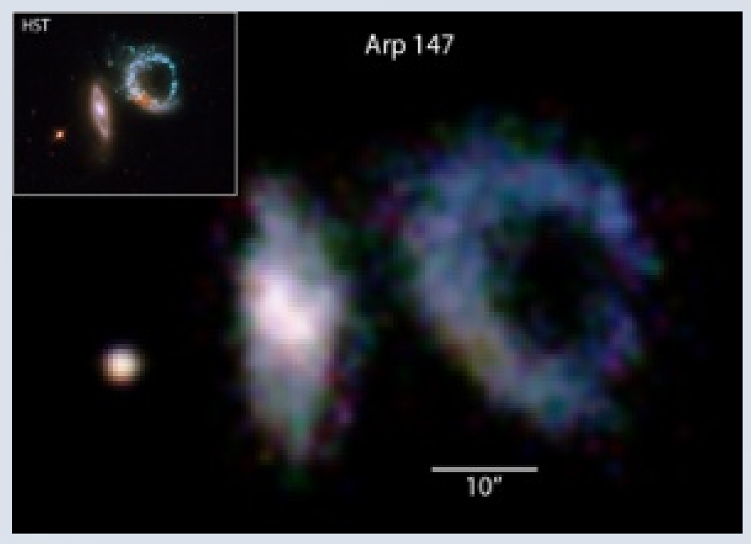
PICTURE C is a balloon payload that will be used on two balloon flights that take the next steps along the road to characterizing Earthlike planets, in Earthlike orbits, orbiting Sunlike stars. This project, like all suborbital missions, includes strong science exploration, technology development, and education components. It is the third mission in the *PICTURE* series (see poster 122.10 and talk 113.09).

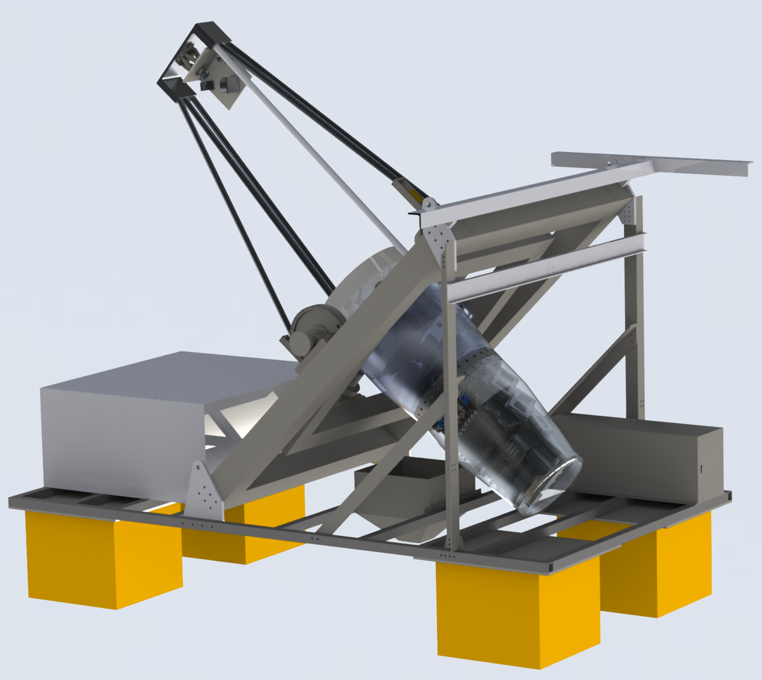
TECHNOLOGY

It has long been obvious that an exoplanet mission based on a high altitude balloon is the next logical step in NASA's quest to explore Earthlike planets. *PICTURE C* consists of two conventional balloon flights in a phased development plan to minimize development risks. The first flight builds on instrumentation developed in the *PICTURE* program and develops a high performance clear aperture telescope while the second flight adds a state of the art detector and coronagraph.



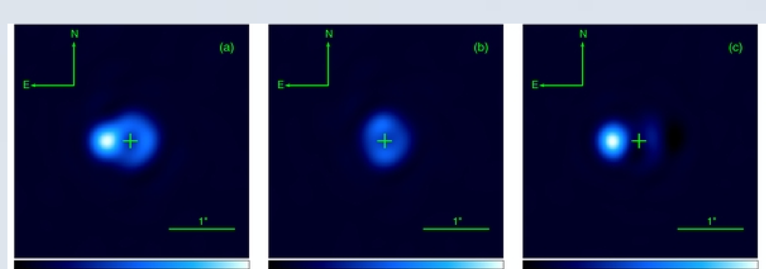
Flight one

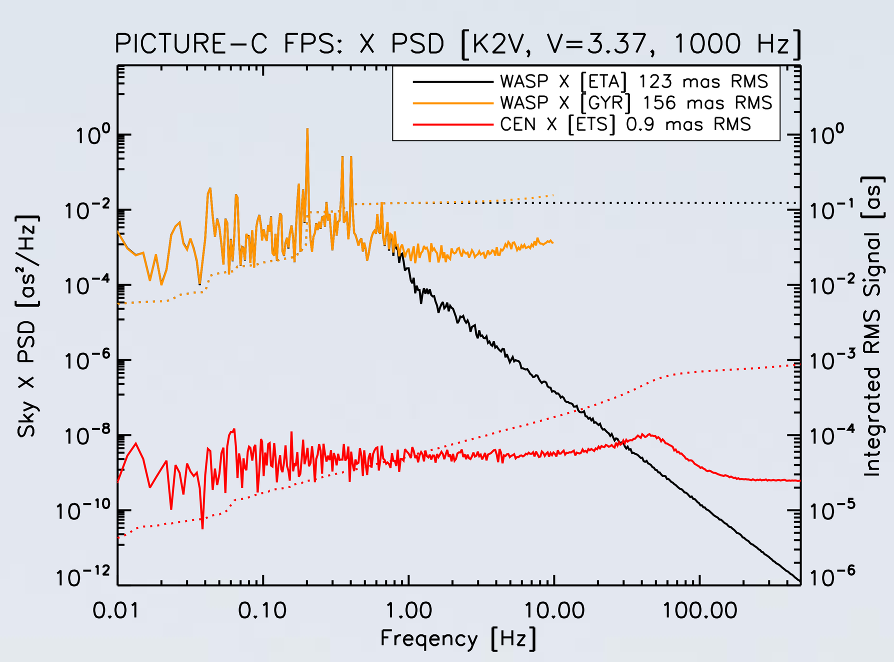
In its first flight *PICTURE C* will demonstrate our existing fine pointing system in conjunction with the WASP gondola. It will develop a 0.6 meter clear aperture balloon-borne telescope and low order wavefront control while delivering high value science results. By using the coronagraph, fine pointing system, high order wavefront control, and detectors developed for *PICTURE* (see 220.10), we minimize development risk.



Flight two

A number of technologies have been developed under NASA funding and await flight testing; this effort will move them from ground based telescopes to flight systems. Flight two will provide a flight demonstration of a high performance Vector Vortex Coronagraph (image below from Mawet et al., 2011) and raise the TRL of an integral field detector, the MKID (image at top from Mazin et al., 2013). Using these technologies will enable high contrast ($10^7:1$) imaging in four bands.

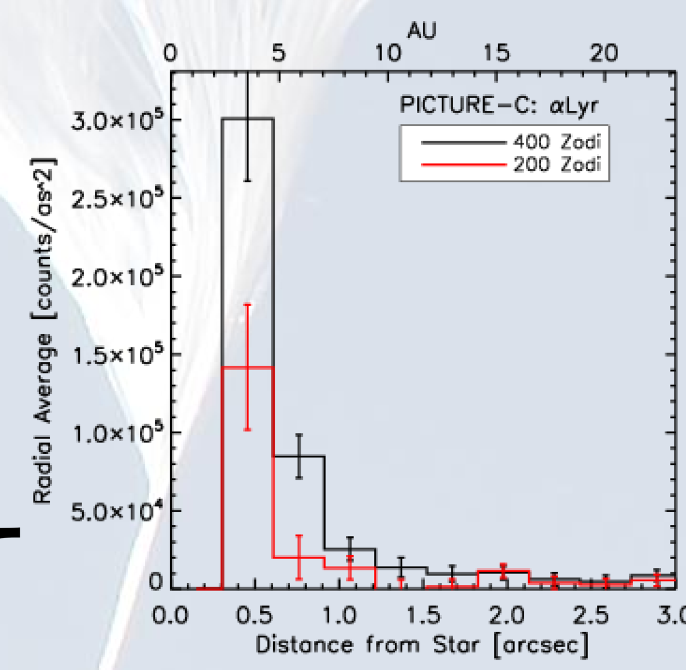




The best measured power spectrum of the WASP pointing (orange line; James Lanzi, private communication) is limited by the sensor noise floor at all frequencies above ~ 1 Hz. In order to estimate our pointing performance (red line) we have assumed the a high frequency roll off similar to that seen in *PICTURE* (black line). This is physically reasonable based on the payload's moments of inertia. A key result of flight 1 will be the higher frequency measurement needed to accurately model the pointing system performance.

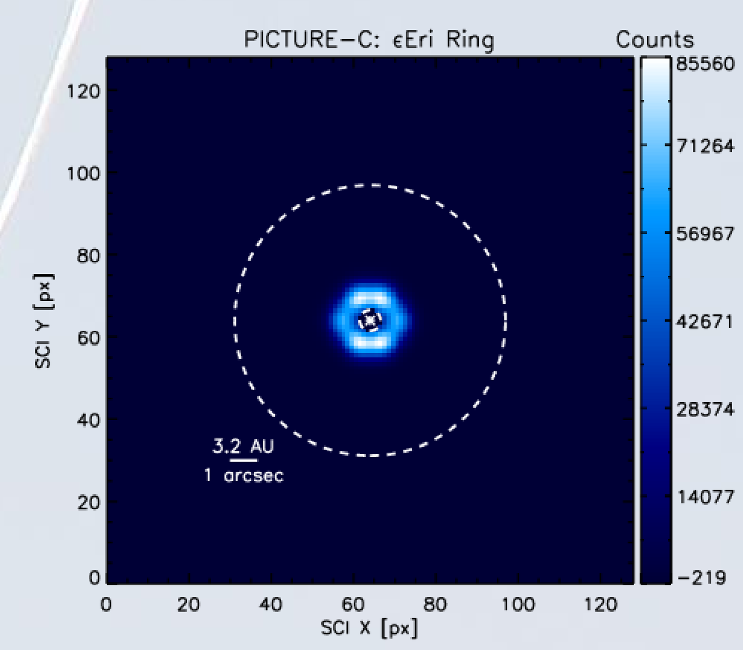
SCIENCE

The primary objective of *PICTURE C* is to image debris disks and exozodiacal light around at least five stars, including ϵ Eri, α Lyr, α Aql, σ Dra, and τ Cet. They have been selected because they are nearby, span a range of infrared excesses, stellar types and ages, and are positioned so that the observations can progress throughout the night. This work is necessary in order to characterize the background near to those stars, to study the disks themselves, and to look for planets in those systems. The background is a key uncertainty in the mission design of *any* exoplanet direct imaging mission. By imaging the exozodiacal brightness and structure we can begin to understand the scope of the problem that background light will create for future exoimaging missions.



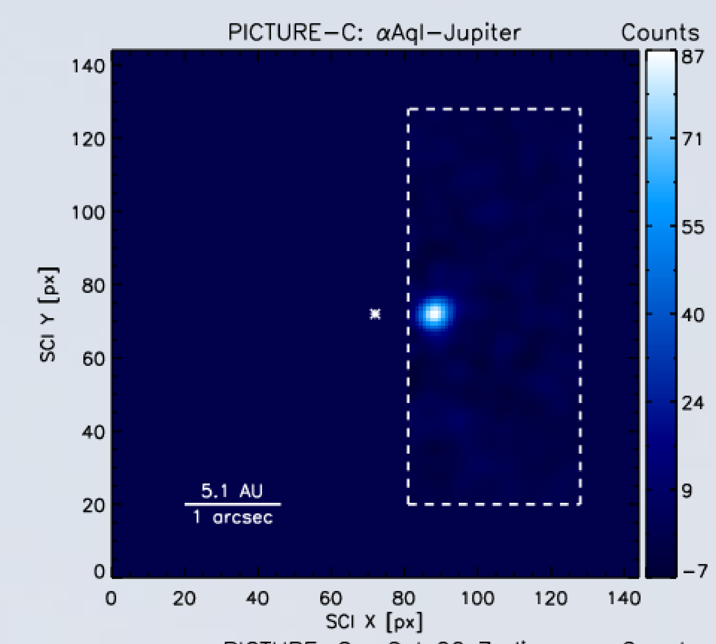
Flight one

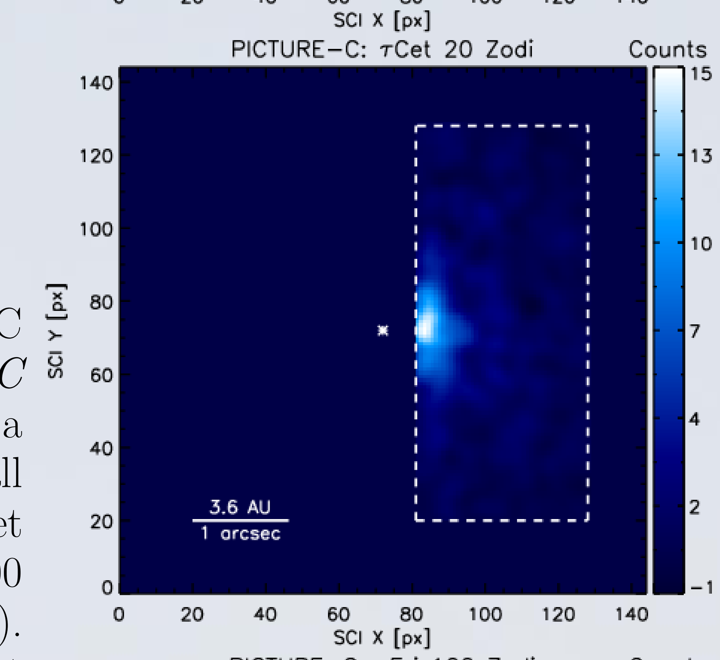
We have simulated the data from *PICTURE C* flight one (images to the left). In the top panel we show two possible disk radial profiles — the main flight one data product — for α Lyr. In the lower panel we show the known (Greaves et al., 1998) ring around ϵ Eri. The vertical null bars produced by the *PICTURE* VNC can be seen in the ϵ Eri ring.

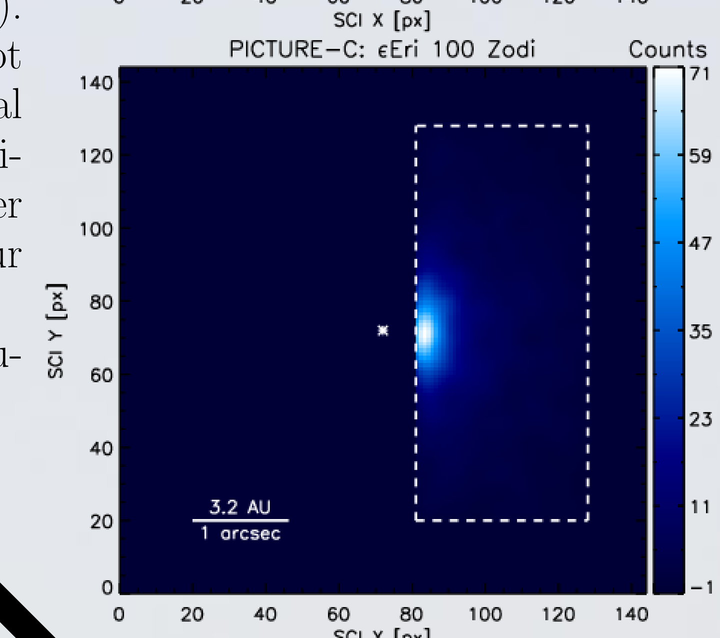


Flight two

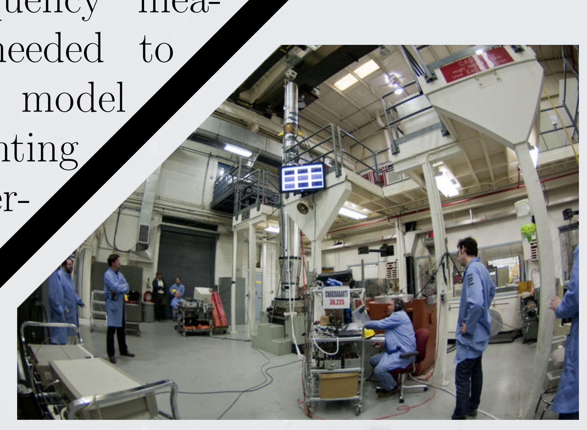
The images to the right, made using ZODIPIC (Kuchner, 2012), show the *PICTURE C* flight two capabilities. We have simulated a $1R_j$ planet around α Aql (top), a small (20 zodi) dust disk around τ Cet (middle), and a large one (100 zodi) around ϵ Eri (bottom). These simulations are not meant to show an actual planet or dust distribution but rather to highlight our capabilities; The instrument can detect $\lesssim$10 zodi disks. These simulations use HCIT data (Serabyn et al, in prep) to estimate speckle patterns, contrast, and IWA.

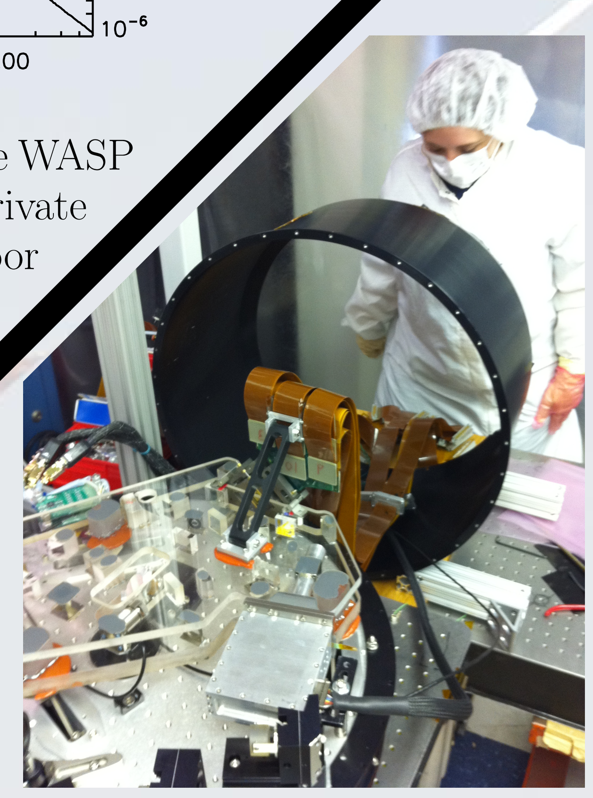






EDUCATION





Graduate Students

The suborbital program has trained PhD students for careers in academia, government, and industry. The low cost program allows the to gain hands-on experience.

Undergraduates

Undergraduates have always played a key role in the suborbital program, to our mutual benefit. They are involved in both our research programs and in dedicated student education launches. For the *SPECTRE* student launch (above), a team of students proposed (and won) the project, designed the experiment, built the hardware, integrated it with the launch vehicle, and analysed the data recorded during flight.

Others

The *PICTURE* team has a strong commitment to education at all levels. We have flown experiments developed by high school groups (above), developed curriculum modules for middle schools, and supported a wide variety of outreach efforts including the USA Science and Engineering Festival (right).

The NASA suborbital program, in general, and the *PICTURE C* program, in particular, have a strong commitment to training students and young professional at all levels — from elementary school students to graduate students — a point of emphasis in the NASA 2010 Strategic Plan.

Session 122.09 of the 224th Meeting of the American Astronomical Society – Monday, June 2, 2014
This work is supported by NASA grants NNX12AL33G, NNX13AD50G, and UML overhead funds