**Introduction:** The planetary community appears to be blessed with an "embarrassment of riches". On the one hand, vast quantities of planetary data, of all kinds, are available to the research community [eg. 1]. Furthermore, this store of data is constantly increasing, with each new successful mission. On the other hand, funds for data analysis never quite seem to be sufficient to address this vast store of data.

One possible solution to this dilemma is to tap into the large pool of university undergraduate students, who are often eager to participate in research endeavors, but are severely underutilized in this capacity. Programs where undergraduate students assist researchers in their planetary studies have been successfully conducted in the past [eg. 2]. Such programs, however, are often large-scale projects [eg. 2] that require a serious investment in personnel time, equipment, and money to initiate and run. The average member of the planetary community may not have access to the funds and resources necessary for such large-scale projects. Therefore, a more modest approach is recommended here; one that utilizes existing university infrastructure and resources, to get undergraduates conducting research, one or two students at a time.

**Approach:** The aim is to get undergraduates involved in research in a way that benefits both the student and the planetary researcher. I propose that this can be easily done through independent study courses. Many universities already have a structure in place that allows undergraduate students to complete a professor-supervised independent study project for credit. Such courses could easily be coopted by planetary science professors to create mini undergraduate research programs.

The problem with independent study courses is that, often, the onus is on the student to create their own project and to seek out a supervisor. Generally, this means that only students who already have a specific project in mind apply for these courses. Over the years, this can leave the supervisor with a hodgepodge of unrelated research, which can be difficult to consolidate and publish, thereby providing no benefit to the supervising professor. This system also excludes those students who are eager to do research, but are not sure what research they would like to pursue.

Both of these problems can be addressed by allowing the supervisor to take a more pro-active role in the independent study system. Professors could formulate small research projects, suitable for undergraduate students, and then advertise the availability of these projects where interested undergraduates would see them (such as a department undergraduate study lounge). Students could then pick and choose among projects that interest them and apply to the appropriate professor(s). This approach is beneficial to both the student and professor. It gives the professor a chance to plan an ongoing undergraduate research program that can provide useful and publishable results on a continuing basis. It also allows the student an opportunity to explore a research option they may not have considered themselves.

Such a system has been set up on a grand scale at the University of Toronto, Faculty of Arts and Science. The Research Opportunity Program (ROP) [3] gives undergraduate students a chance to conduct research in a wide range of fields, not just science. Faculty members submit project descriptions to the ROP Coordinator. Descriptions of all the projects are compiled and made available to the undergraduate community both in hardcopy and on line [3]. Interested students apply for specific projects. Faculty members review any applications for their projects, and conduct interviews with the students prior to making their selections. Selected students are notified and enrolled in a full year research course. During the year, they are required to have bi-monthly meetings with their supervising faculty member and make progress on the project. At the end of the year, the students present their results at a "research fair", which is effectively a large poster session. The ROP has been successfully operating for 8 years. Last year, it involved 127 students in 62 projects.

Not every university will have a such a centralized program in place. However, as suggested earlier, most universities do have some form of independent study credit, which can adapted by individual professors to create their own personal research opportunity program, geared to planetary studies.

**Benefits to the Student:** For the student, involvement in any kind of research project is full of benefits. These include the opportunity to participate in active research and thereby examine their interest in and suitability to a career in science. They learn new skills, and often gain experience operating sophisticated equipment.

The approach outlined in this paper brings additional benefits to the student. Because the project is
part of an ongoing research program, the results are more likely to be meaningful within a larger context of work. This increases the likelihood that the results will be published in a peer-reviewed journal, either by the student and supervisor together, or by the supervisor at some later time.

Another benefit of the independent study approach is that the student receives academic credit for their research. Even among the best students, course credit can be a strong motivator.

**Benefits to the Supervisor:** The main benefit of this type of approach to undergraduate research is the ability to get research done at relatively little cost in time, effort, and money.

If planned correctly, an independent study project should take up a minimal amount of time and effort for the planetary researcher. Projects should generally involve simple and often repetitive research tasks that the researcher or a graduate student would do if they had more time. All the facilities and equipment should already be in place, since no new techniques are being developed. Alternatively, if new techniques need to be developed, a separate research project could be created for that task. Training of the student(s) should be kept to a minimum, including only necessary equipment, procedures, etc. The result is a project with minimal start-up requirements. Other time commitments include periodic meetings with the student(s).

Taking advantage of independent study courses can be a very inexpensive way to do research. Undergraduates taking a course for credit provide their research time for free, unlike post-docs, graduate students, and research associates. Many universities and departments have teaching budgets that can be tapped into to purchase needed supplies for a project, such as planetary data for a remote sensing project, or lab materials for geochemical analysis. With a bit of planning, these funds provide a cost-effective way of acquiring non-consumables for future research projects. In addition, equipment and lab usage fees are often waived for education and teaching purposes. For example, at the University of Toronto, any services such as rock cutting, thin section preparation, or SEM time are billed to research budgets. The fees for these same services are waived when used for an independent study course. Therefore, it can be cheaper for an undergraduate student to conduct certain types of research than it is for a researcher or graduate student.

Student taking independent study courses bring all of the teaching facilities at a university to the research endeavour. Thus, facilities such as study space and computer labs, do not need to be provided. In addition, university or departmental computer banks may often exceed the capabilities of those of the individual researcher, thereby increasing overall computing power.

Overall, taking on undergraduate students to conduct research through an independent study course is a very efficient and cost-effective way to do research. This can be a particularly useful approach for the many members of the planetary community, who are overburdened with high teaching loads and plagued with a lack of research funds.

**Project Example:** I have designed a small scale project that will use the existing infrastructure of the Research Opportunity Program at the University of Toronto to assist me in my research. A student will use the undergraduate computing facilities to conduct multispectral studies of hidden mare deposits on the Moon. Clementine UVVIS data will be obtained from [1] for a nominal fee that will be covered by the teaching budget. Then using a software program already written and designed to assist with cryptomare identification, the student will study the data and collect spectra for analysis. The student and I will meet on a bi-weekly basis to discuss progress, assess data, and plot future work. I anticipate that the data will be utilized in a future publication(s).

**Conclusion:** The wealth of planetary data and the paucity of funds to study them means that planetary researchers need to be creative in their approach to planetary studies. I propose that undergraduates can be part of that creative approach. Small, modest research programs can be designed around undergraduate independent study courses. Undergraduate students should be sought out and recruited to participate in these designed independent study courses. The benefits of this approach include increased value to the student in the form of academic credit and publishable results, as well as increased value to the researcher in the form of continuity in research and publishable results.

Such a program may seem small, affecting only one or two students at a time. However, if most planetary researchers in academic positions took on undergraduate students in this manner, the way they take graduate students, the impact on the total amount of planetary research conducted could be large.