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NEWSLETTER

Space Telescope Science Institute

Lorretta Willers, Victoria Horne, and Tania Laguerra sort through Cycle 11 proposals during the afternoon-proposal-processing shift.

# The Cycle 11 Review Process

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## *New Science Opportunities in Cycle 11*

The Hubble Telescope Allocation Committee (TAC) and panels met in Baltimore between November 12 and 17, 2001, to select and recommend to the Director the suite of programs to be executed in Cycle 11.

Cycle 11 will provide the most powerful combination of instruments since the launch of the Hubble Space Telescope. Hubble's scientific capabilities will be greatly enhanced by upgrades during the next servicing mission, currently scheduled for February 2002. The Advanced Camera for Surveys (ACS) will provide a large increase in sensitivity and field of view, and the installation of a cryocooler will revive the Near Infrared Camera and Multi-Object Spectrometer (NICMOS). The Wide Field Planetary Camera 2 (WFPC2), the Space Telescope Imaging Spectrograph (STIS), and the Fine Guidance Sensor (FGS) will continue to be available.

In step with the enhanced technical and scientific capabilities of the observatory, we offered a number of important new opportunities in Cycle 11, which will enable science with Hubble to be carried out in fundamentally different ways. In particular, we are starting the Hubble Treasury Program, which was recommended by the Hubble Second Decade Committee to stimulate science that might not naturally be encouraged by the existing process, and in particular, to promote the creation of important data sets that one would regret not having obtained when Hubble is ultimately decommissioned. Treasury programs are expected to focus on opportunities to address multiple scientific problems with a single, coherent dataset. The data sets will carry no proprietary rights.

There were other novelties in Cycle 11. Given the rate of increase in the size of the Hubble data archive and the value of large, homogeneous data sets, we wished to stimulate a more ambitious Archival Research (AR) program by creating the new AR Legacy Program. Selected Legacy programs will perform a homogeneous analysis of a well-defined dataset in the Hubble archive and will generate data products of use to the scientific community (catalogs, software tools, web interfaces, etc.), which will allow a variety of new investigations.

Another important change in Cycle 11 was the start of the Hubble Theory Program, funded as part of the Hubble AR program. The Theory Program is in line with recommendations in the report from the Astronomy and Astrophysics Survey Committee of the National Research Council, which stressed the importance of funding theoretical research in conjunction with major observing facilities, in order to improve the interpretation and understanding of the data from these facilities.

## *Cycle 11 Results*

These Cycle 11 initiatives were widely advertised, and the community's response to these initiatives was overwhelmingly positive. We received a total of 1078 proposals! There were 859 GO proposals for a total request of approximately 25,000 orbits. Of these ~10,000 orbits were requested for Treasury and Large programs. Comparing the requested orbits to the total of 3,000 orbits available for Cycle 11, the over-subscription is a factor of 8. Slightly smaller, but still very significant over-subscription factors of 6 for

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WINTER [ 2002 ]

# REVIEWING THE REVIEW

**France Cordova, 2001 TAC Chair**

The review of HST proposals for Cycle 11 had many new features this year:

- A call for "Treasury" proposals, to allow large, multi-use programs that become, almost immediately, a public resource.
- A call for Archival "Legacy" proposals, to provide data products that allow a variety of new investigations from archived data.
- A call for Theory proposals, to respond to the decadal NRC report on astronomy and astrophysics, which advocated more support for theory, in this case theory relevant to HST observations and results.
- The largest over-subscription rate ever: In all, 1078 proposals were received, requesting almost a factor of ten more observing time than available.
- Enhancements to the SNAPshot program.
- The proposals reflected the fact with the 2002 reservicing mission the telescope will be outfitted with the Advanced Camera for Surveys (ACS), which will improve the survey efficiency of HST by about a factor of ten, and a revival of NICMOS by installing a cryocooler. The reservicing mission is expected to occur well before the start of Cycle 11 in July 2002.
- The review was compressed into a period of six full days and evenings, allowing for more communication between chairs and members of the various review groups than previous reviews that stretched over two weeks.
- The review was held at a hotel near the Baltimore airport, a convenience for travelers that also contributed, because of the bounded space (which lacked external distractions), to more discussions among the panel chairs during meals and breaks.

The review involved over 100 astronomers and a large contingent of Space Telescope Institute staff. The Telescope Allocation Committee (TAC), comprising the TAC Chair and Chairs of eleven panels, met for two days to review all the treasury proposals, archival legacy proposals, plus large guest observer, snapshot, and theory proposals. We were told at the beginning of the review that the amount of time that we would award by the week's end was valued at 0.5 billion dollars, when the total expenditures for HST over its lifetime are figured on an annual basis. If that didn't make us take our charge seriously, the prospect of completing a review of 80 TAC proposals in two days did. The oversubscription rate was unusually high this year. On one hand, it was a pleasure to see so many excellent proposals and to see the high demand for HST time; one the other hand, it was disheartening to realize that only a small fraction of the proposals could be accommodated.

The TAC review was followed by the eleven concurrent panel reviews, which lasted for three days. Panels were constituted around subject category. Each panel had 80 - 90 proposals to review. On the sixth day, the TAC convened again to review the rankings from both the TAC and panels. The TAC made decisions about final rankings, guided by nominal amounts of time allocated to various categories of proposals, weighing size (large or panel-size), specialty (by panel), and type (GO, SNAP, archival, theory, Treasury). Deciding factors were scientific impact and, when proposals overlapped in content, a proposal's ability to express the goals and approach most clearly. The TAC and panel chairs felt that by the end of the review a well-balanced program for Cycle 11 had been achieved. The TAC's work ended by sharing perspectives about the review process with Institute Director Steven Beckwith and the STScI staff. After ten previous reviews, the Institute has honed the process so that it runs like a finely-tuned engine. This did not stop us from offering modest suggestions for future reviews, which the Director received graciously.

For a large, complex undertaking, the proposal review process went very smoothly. This was because of the long hours contributed by the reviewers and the STScI staff. The latter, with years of past experience, had organized the proposals and panels with care, urged the reviewers to review and pre-rank proposals ahead of time, and tended to emerging snags in real time. During the review, the staff was constantly on-hand to deal with logistics, tabulate rankings, solve network connectivity problems, and field questions ranging from instrument capabilities and telescope operations in specific modes, to the lack of Starbucks coffee and omelets. Great care was taken throughout all parts of the review process to manage potential conflicts of interest. No Institute staff was a member of a review panel. The external reviewers did not participate in discussions or rankings of proposals on which they might have a potential for conflict of interest, either with respect to collaborator or institution.

Although it was definitely a lot of work and a large commitment of personal time, those of us who participated in this year's review felt that it was important to do so for the benefit of the community. We enjoyed our task. We learned more about this remarkable telescope's capabilities and how they translate into potential for significant, new understandings and discoveries in many fields, not just ones familiar to us. We had good 'off-line' science discussions with old and new colleagues, and we experienced occasional epiphanies when diverse perspectives engaged to elucidate a proposal's intent, claims, or approach.

The review experience reaffirmed for each of us that the Hubble Space Telescope is truly a modern-day wonder of the world. Its combination of optics and detectors provide an exquisite probe into the once and future Universe. HST images have transformed science textbooks (some of them authored by reviewers!), illuminating every chapter about the history and evolution of the universe and the stuff it comprises. As reviewers, we were happy to take a small part in furthering innovative science with HST.

Given that there were several new types of proposals this year, the characteristics of the winning proposals in the large categories (including Treasury and Archival Legacy) might be of interest to readers. The success rates for proposals across the different categories was similar. (The full, detailed results of the review are printed in this Newsletter.) Having a separate review for large proposals worked, in the TAC's opinion. We saw ambitious, but carefully delineated proposals that each showed promise for significant work on a fundamental question and, in the case of the Treasury and Archival Legacy proposals, opportunities for investigations of multiple questions. The successful proposals were written clearly and succinctly as to purpose and scientific impact, and had convincing methodology. In all but a few cases, the reviewers approved the requested number of orbits, on the basis that the requests were justified well. The bulk of the top-ranked TAC proposals requested 125 - 150 orbits, but one highly-ranked Treasury proposal to form part of a panchromatic data set requested 400 orbits, and a couple of successful TAC proposals requested 30 - 40 orbits for two consecutive cycles. The range of proposed science that emerged after the final rankings was broad in both the TAC and panel reviews, including extensive studies of solar system objects, farther galactic objects, nearby galaxies, and the distant universe. This confirmed that there is important research to be done with HST in all areas of astrophysics, with both small and large telescope allocations. Ω

*Cycle 11 Review from page 1*

SNAPS and 3.5 for AR and Theory proposals made the work of the Cycle 11 TAC and panels the most difficult in recent Hubble history.

The 61 Treasury and Large proposals, each requesting 100 or more orbits, for a total of about 10,000 orbits, were first reviewed by the TAC during the first two days of the meeting and then discussed again on the last day, after receiving inputs from the relevant panels. The TAC recommended the approval of ten Treasury and Large programs for a total of 1280 orbits. About 1,800 orbits were made available to—and allocated by—the 11 panels. Among the regular programs, requesting 99 orbits or fewer, the medium-size programs, requesting between 15-99 orbits, were favored via orbit subsidies in the review process.

The acceptance rate was essentially independent of the proposal size, i.e., number of orbits requested.

Treasury and Large programs were allocated approximately 40% of the total number of orbits available, a goal that our advisory committees had recommended should be achieved in the long term; we are proud to have achieved this goal in the first cycle in which the Treasury opportunity was advertised.

The detailed statistics of the proposals submitted in the various categories can be found in the following pages of this Newsletter.

## *The Review Process*

Prior to Cycle 9, the balance among scientific sub-disciplines was governed by proposal pressure and modified only slightly by subsequent TAC discussions. Except on proposals that were at the borderline of acceptance, value judgments about the relative importance of one sub-discipline versus another were not made. We have since changed the process. In Cycles 9 to 11, science balance between sub-disciplines was determined by in-depth discussions by experts in panels, which reviewed broad areas of science.

The panels allocated all the orbits available for regular programs, a total of 1800 orbits; the TAC allocated all the orbits (1200) available for Treasury and Large programs and discussed any proposal requesting a large amount of resources.

## *Twin Panels and More Experts*

Given the large number of proposals, to keep the workload reasonable, we established two more panels than in Cycle 10. Further, to improve the coverage of expertise, we added one additional expert to each panel. The panel members

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**Cycle 11 Review**
**from page 3**

were chosen to cover the entire range of science represented by the submitted proposals. We also made sure that theoreticians were included in each panel. As a result, we had two or three "twin" panels of nine reviewers each for various extragalactic and galactic science areas. We had one solar system panel.

## Conflicts of Interest

A major—and successful—goal of the present process is a substantial decrease in the number of conflicts of interest. The proposals were assigned by scientific categories to one of eleven panels covering five general science areas. Except in the case of the solar system panel, we could make use of the "twin" panels to avoid conflicts. Proposals in which a panelist was either a PI or a Co-I—or had other potential conflicts of interest—were assigned to the other "twin" panel, which minimized conflicts while still allowing experienced Hubble users to fully participate in the review process.

## Logistics

A major innovation from previous cycles was the off-site location of the Cycle 11 review process. It was held in a hotel near BWI airport rather than at the Institute. This move allowed us to host all eleven panels simultaneously, shortening the stay of the TAC members by three full days while increasing efficiency and communications between panel chairs. There was a broad consensus that this change of venue was very positive.

## Advice to Future Proposers

The present Hubble review process is widely perceived as successful, and we plan to use the same process in future cycles. This means future proposers should keep in mind the following advice drawn from experience.

- Remember that the scientific case must be compelling. Do no write proposals that are of interest to only a few experts in a narrow sub-discipline. Instead, present "the big picture". The most successful proposals include sufficient background information to provide a compelling context. They describe the importance of the investigation to all astronomy in a convincing manner. Because this point was an explicit criterion for evaluation, proposals were downgraded for failing to address it.
- Don't pad your request for time: fewer than 5% of the approved proposals were cut (and those only to avoid duplicate observations). Proposers either got the time they requested or were rejected.
- Start from the science. Write a compelling story for your fellow astronomers. Ask for the resources genuinely needed. Justify your need for the number of targets and orbits that you request.
- Justify the need for Hubble. For example, even if you request observations in the UV, it may not be obvious why you cannot achieve the science aims of your proposal in a different wavelength range. In the IR, justify your need for Hubble and NICMOS by comparison with AO systems on ground-based telescopes.

Because of the limited number of orbits available in a cycle, many truly excellent proposals must be turned down. Nevertheless, remember that rejected PIs are in very good company and that many of these proposals may succeed in future cycles.

## Final Remarks

With the Cycle 11 review now completed, we have been receiving extensive feedback from the panel and TAC members. This feedback reflects broad approval of the present system, even while including useful suggestions for further improvement in the future.

A total of about 100 members of the community gave their time to participate in the Cycle 11 review and we are most grateful to each of them for their dedication and professionalism. We are particularly grateful to France Cordova for her leadership as the Chair of the TAC.

As the reader can see from glancing at the titles of selected proposals, in Cycle 11, we will have arrived at truly outstanding scientific program. It will undoubtedly continue the Hubble tradition of breaking new ground across the frontiers of modern astrophysics. Ω

# Cycle 11: TAC and Panel Members

| Member | Institution |
|---|---|
| Dr. France Cordova, **TAC Chair** | University of California, Santa Barbara |
| **Extragalactic Panel 1** | |
| DR. MARTIN ELVIS, Chair | Harvard-Smithsonian Center for Astrophysics |
| DR. ANDREAS ECKART (ESA) | University of Cologne (Koeln), Physikalisches Institut |
| DR. GARY J. FERLAND | University of Kentucky |
| DR. JOHN E. HIBBARD | National Radio Astronomy Obs. |
| DR. CRYSTAL L. MARTIN | California Institute of Technology |
| DR. REYNIER PELETIER (ESA) | University of Nottingham, UK |
| DR. SUSAN RIDGWAY | The Johns Hopkins University |
| DR. JERRY SELLWOOD | Rutgers University |
| DR. SYLVAIN VEILLEUX | University of Maryland |
| **Extragalactic Panel 2** | |
| DR. NICHOLAS SCOVILLE, Chair | California Institute Of Technology |
| DR. ROBERT R. J. ANTONUCCI | University of California, Santa Barbara |
| DR. AARON J. BARTH | California Institute of Technology |
| DR. JULIAN H. KROLIK | The Johns Hopkins University |
| DR. DAN MAOZ | Tel-Aviv University |
| LAURA MARASCHI (ESA) | Osservatorio Astronomico di Brera, ITALY |
| DR. LYNN D. MATTHEWS | Harvard-Smithsonian Center for Astrophysics |
| DR. ISAAC SHLOSMAN | University of Kentucky |
| DR. STEPHEN E. ZEPF | Michigan State University |
| **Extragalactic Panel 3** | |
| DR. PETER BARTHEL, Chair (ESA) | U of Groningen, Kapteyn Sterrekundig Institute |
| DR. JACK A. BALDWIN | Michigan State University |
| DR. JEREMY GOODMAN | Princeton University Obs. |
| DR. DEIDRE ANN HUNTER | Lowell Observatory |
| DR. PAUL KIRPAL NANDRA | NASA/Goddard Space Flight Center. |
| DR. ROBERT D. JOSEPH | University of Hawaii, Institute for Astronomy |
| DR. JAMES SCHOMBERT | University of Oregon |
| DR. LINDA S. SPARKE | U of Wisconsin, Madison, Washburn Observatory |
| DR. LUTZ WISOTZKI (ESA) | U of Potsdam, Instutut fuer Physik, GERMANY |
| **Extragalactic Panel 4** | |
| DR. DONALD G. YORK, Chair | University of Chicago |
| DR. EDMUND BERTSCHINGER | Massachusetts Institute of Technology |
| DR. RICHARD F. GREEN | NOAO/KPNO |
| DR. ESTHER M. HU | University of Hawaii |
| DR. JEAN-PAUL KNEIB (ESA) | CNRS Laboratoire D,Astrophysique, Observatoire De Midi-Pyrenees |
| DR. DIETER REIMERS (ESA) | University Hamburg |
| DR. LISA J. STORRIE-LOMBARDI | SIRTF Science Center, California Inst. of Technology |
| DR. DAVID H. WEINBERG | Ohio State University |
| DR. EDWARD L. WRIGHT | University of California, Los Angeles |
| **Extragalactic Panel 5** | |
| DR. ROGIER A. WINDHORST, Chair | Arizona State University |
| DR. JOEL N. BREGMAN | University of Michigan |
| DR. JAMES E. FELTEN | NASA/Goddard Space Flight Center |
| DR. GUINEVERE KAUFFMANN (ESA) | Max-Planck Inst. fuer Astrophysik, GERMANY |
| DR. PIERO MADAU | Unversity of California, Santa Cruz, Lick Observatory |
| DR. VAHE PETROSIAN | Stanford University |
| DR. KATHERINE ROTH | Gemini Observatory |
| DR. MICHAEL A. STRAUSS | Princeton University |
| DR. HOWARD K.C. YEE | University of Toronto, CANADA |
| **Galactic Panel 1** | |
| DR. STEVEN D. KAWALER, Chair | Iowa State University |
| DR. MASSIMO DELLA VALLE (ESA) | Osservatorio Astrofisico di Arcetri, ITALY |
| DR. EDWARD F. GUINAN | Villanova University |
| DR. JOEL H. KASTNER | Rochester Inst. of Technology, Center for Imaging Science |
| DR. DERCK MASSA | Ratheon ITSS, NASA/Goddard Space Flight Center |
| DR. SALLY OEY | Lowell Observatory |
| DR. JOSEPH PATTERSON | Columbia University |
| DR. ULYSSES J. SOFIA | Whitman College |
| DR. DANIEL E. WELTY | University of Chicago |
| **Galactic Panel 2** | |
| DR. THEODORE P. SNOW, Chair | University of Colorado, CASA |
| DR. ERIC AGOL | California Institute of Technology |
| DR. MARTIN ADRIAN BARSTOW (ESA) | University of Leicester, UNITED KINGDOM |
| DR. LARS BILDSTEN | University of California, Santa Barbara |
| DR. ORSOLA DEMARCO | American Museum of Natural History |
| DR. BRUCE J. HRIVNAK | Valparaiso University |
| DR. MICHAEL G. RICHER | Observatorio Astronomico Nacional, MEXICO |
| DR. MEENA S. SAHU | NASA/Goddard Space Flight Center. |
| DR. WERNER SCHMUTZ (ESA) | Physikalisch-Meteorologisches Obs., SWITZERLAND |
| **Galactic Panel 3** | |
| DR. PHILIP A. CHARLES, Chair (ESA) | University of Southampton, UNITED KINGDOM |
| DR. THOMAS M. BANIA | Boston University |
| DR. BRAM S. BOROSON | The Claremont Colleges, Joint Science Department |
| DR. GEOFFREY C. CLAYTON | Louisiana State University |
| DR. LINDA J. SMITH | University College London, UNITED KINGDOM |
| DR. SARA R. HEAP | NASA/Goddard Space Flight Center. |
| DR. MARK MORRIS | University of California, Los Angeles |
| DR. GEORGE G. PAVLOV | Pennsylvania State University |
| DR. STEPHEN SMARTT (ESA) | University of Cambridge, Institute of Astronomy, United Kingdom |
| **Galactic Panel 4** | |
| DR. BRUCE W. CARNEY, Chair | University of North Carolina |
| DR. VERNE V. SMITH | University of Texas, El Paso |
| DR. BERNHARD R. BRANDL | Cornell University |
| DR. PATRICK COTE | Rutgers University |
| DR. JOHN S. GALLAGHER | University of Wisconsin, Madison |
| DR. WILLIAM I. HARTKOPF | US Naval Observatory |
| DR. ATA SARAJEDINI | University of Florida |
| DR. MICHAL SIMON | State University of NY, Stony Brook |
| DR. THIERRY FORVEILLE (ESA) | Observatoire de Grenoble, Lab. d,Astrophysique, FRANCE |
| **Galactic Panel 5** | |
| DR. JAMES W. LIEBERT, Chair | University of Arizona, Steward Observatory |
| DR. TAFT E. ARMANDROFF | National Optical Astronomy Obs., Kitt Peak National Obs. |
| DR. ISABELLE BARAFFE (ESA) | Observatoire de Lyon, FRANCE |
| DR. PURAGRA GUHATHAKURTA | University of California, Santa Cruz, Lick Observatory |
| DR. TAMMY A. SMECKER-HANE | University of California, Irvine |
| DR. ENRICO VESPERINI | University of Massachusetts, Amherst |
| DR. BEN M. ZUCKERMAN | University of California, Los Angeles |
| **Solar System** | |
| DR. KAREN JEAN MEECH, Chair | Institute for Astronomy, Hawaii |
| DR. LOTFI BEN-JAFFEL (ESA) | Institut d,Astrophysique de Paris, FRANCE |
| DR. MICHAEL E. BROWN | California Institute of Technology, Division of Geophysical & Planetary Science |
| DR. JOHN T. CLARKE | Boston University |
| DR. PHILIP D. NICHOLSON | Cornell University |
| DR. IMKE DE PATER | University of California, Berkeley |
| DR. MARK V. SYKES | University of Arizona, Steward Observatory |

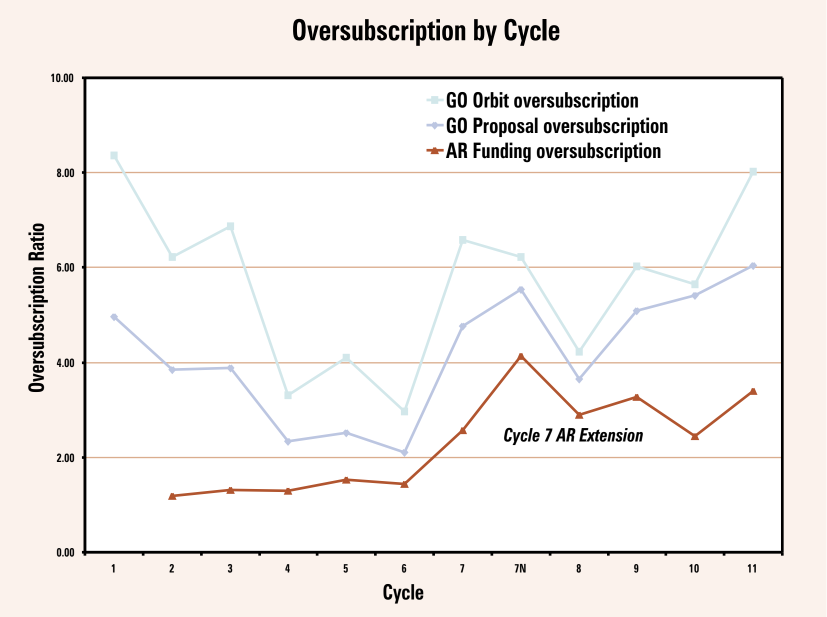
# Proposals By Country

| Country | Submitted | Approved |
|---|---|---|
| Argentina | 1 | 0 |
| Australia | 12 | 1 |
| Austria | 3 | 0 |
| Belgium | 2 | 0 |
| Canada | 16 | 3 |
| Chile | 4 | 0 |
| Denmark | 1 | 0 |
| Finland | 2 | 0 |
| France | 21 | 3 |
| Germany | 47 | 8 |
| India | 3 | 0 |
| Ireland | 3 | 0 |
| Israel | 6 | 1 |
| Italy | 20 | 3 |
| Japan | 3 | 0 |
| Korea | 1 | 0 |
| Mexico | 1 | 0 |
| New Zealand | 1 | 0 |
| Spain | 11 | 2 |
| Sweden | 4 | 0 |
| Switzerland | 2 | 0 |
| The Netherlands | 12 | 3 |
| United Kingdom | 57 | 7 |
| United States | 845 | 167 |

# Summary of Cycle 11 Results

| Proposals | Requested | Approved | % Accepted | ESA Accepted | ESA % Total |
|---|---|---|---|---|---|
| General Observer | 859 | 142 | 16.5% | 27 | 19.0% |
| Snapshot | 79 | 13 | 16.5% | 2 | 15.4% |
| Archival Research | 93 | 28 | 30.1% | | |
| Theory | 47 | 15 | 31.9% | | |
| **Total** | **1078** | **198** | **18.4%** | **29** | **18.7%** |
| Primary Orbits | 24667 | 3128 | 12.7% | 503 | 16.1% |

# Proposal Acceptance Ratio



# Proposal and Orbit Results By Science

| Panel | Gal1 | Gal2 | Gal3 | Gal4 | Gal5 | Exgal1 | Exgal2 | Exgal3 | Exgal4 | Exgal5 | Sosys | TAC | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Proposals Submitted*** | | | | | | | | | | | | | |
| GO | 86 | 85 | 77 | 82 | 81 | 69 | 76 | 71 | 69 | 61 | 41 | 61 | **859** |
| SNAP | 5 | 6 | 9 | 10 | 7 | 6 | 6 | 8 | 3 | 7 | 6 | 6 | **79** |
| AR | 7 | 6 | 11 | 9 | 12 | 16 | 11 | 13 | 11 | 22 | 10 | 12 | **140** |
| **Total** | **98** | **97** | **97** | **101** | **100** | **91** | **93** | **92** | **83** | **90** | **57** | **79** | **1078** |
| ***Proposals Approved*** | | | | | | | | | | | | | |
| GO | 14 | 10 | 12 | 11 | 12 | 9 | 18 | 14 | 8 | 14 | 10 | 10 | **142** |
| SNAP | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 1 | 1 | 1 | **13** |
| AR | 3 | 2 | 5 | 2 | 3 | 2 | 4 | 6 | 3 | 6 | 3 | 4 | **43** |
| **Total** | **19** | **13** | **18** | **14** | **16** | **12** | **23** | **22** | **11** | **21** | **14** | **15** | **198** |
| ***Submitted*** | 1088 | 1248 | 1003 | 1540 | 1236 | 1475 | 1453 | 1794 | 1726 | 1645 | 363 | 10096 | **24667** |
| ***Approved*** | 190 | 171 | 142 | 173 | 176 | 187 | 145 | 178 | 184 | 173 | 79 | 1330 | **3128** |
| ***Panel Fraction of Total Approved*** | | | | | | | | | | | | | |
| | 6.1% | 5.5% | 4.5% | 5.5% | 5.6% | 6.0% | 4.6% | 5.7% | 5.9% | 5.5% | 2.5% | 42.5% | - |
| ***Fraction of Orbits Approved/Submitted*** | | | | | | | | | | | | | |
| | 17.5% | 13.7% | 14.2% | 11.2% | 14.2% | 12.7% | 10.0% | 9.9% | 10.7% | 10.5% | 21.8% | 13.2% | **12.7%** |

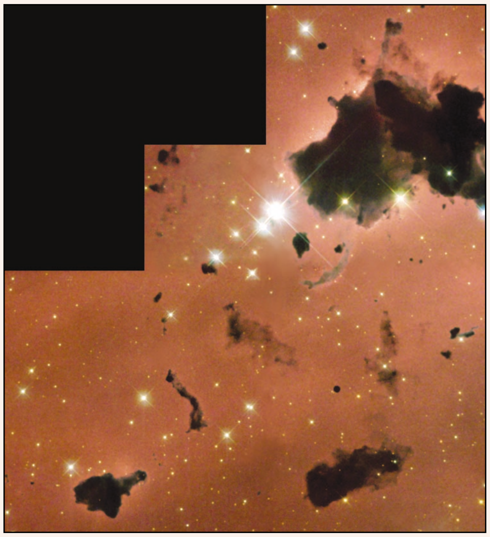
## Instrument Statistics

| Instruments | Mode | Requested Orbits | Percent | Approved Orbits | Percent | Subtotal |
|---|---|---|---|---|---|---|
| ACS/HRC | Imaging | 1632 | 5.2% | 237 | 6.5% | |
| ACS/HRC | Spectroscopy | 198 | 0.6% | 13 | 0.4% | |
| ACS/SBC | Imaging | 182 | 0.6% | 58 | 1.6% | |
| ACS/WFC | Imaging | 11564 | 36.9% | 1773 | 48.7% | |
| ACS/WFC | Spectroscopy | 287 | 0.9% | 13 | 0.4% | |
| | | | | | | 57.5% |
| FGS | Position mode | 189 | 0.6% | 27 | 0.7% | |
| FGS | Transfer mode | 48 | 0.2% | 6 | 0.2% | |
| | | | | | | 0.9% |
| NICMOS | Imaging | 4597 | 14.7% | 277 | 7.6% | |
| NICMOS | Spectroscopy | 367 | 1.2% | 45 | 1.2% | |
| | | | | | | 8.8% |
| STIS/CCD | Imaging | 1225 | 3.9% | 77 | 2.1% | |
| STIS/CCD | Spectroscopy | 1795 | 5.7% | 322 | 8.8% | |
| STIS/FUV | Imaging | 348 | 1.1% | 3 | 0.1% | |
| STIS/FUV | Spectroscopy | 2378 | 7.6% | 236 | 6.5% | |
| STIS/NUV | Imaging | 103 | 0.3% | 17 | 0.5% | |
| STIS/NUV | Spectroscopy | 1974 | 6.3% | 385 | 10.6% | |
| | | | | | | 28.6% |
| WFPC2 | Imaging | 4477 | 14.3% | 153 | 4.2% | |
| | | | | | | 4.2% |
| ***Total*** | | **31364** | **100.0%** | **3642** | **100.0%** | |

Orbits include coordinated parallel usage
Excludes Pure Parallel and Snapshot Programs

## US Proposals By State

| State | Submitted | Approved |
|---|---|---|
| AL | 11 | 2 |
| AZ | 80 | 14 |
| CA | 162 | 35 |
| CO | 40 | 7 |
| CT | 3 | 0 |
| DC | 14 | 1 |
| DE | 4 | 0 |
| FL | 7 | 1 |
| GA | 6 | 2 |
| HI | 19 | 5 |
| IA | 1 | 0 |
| IL | 24 | 3 |
| IN | 14 | 3 |
| KS | 1 | 0 |
| KY | 3 | 1 |
| LA | 2 | 0 |
| MA | 47 | 9 |
| MD | 165 | 37 |
| MI | 17 | 3 |
| MN | 11 | 3 |
| NC | 3 | 1 |
| NE | 2 | 0 |
| NH | 2 | 0 |
| NJ | 19 | 9 |
| NM | 10 | 2 |
| NV | 2 | 0 |
| NY | 30 | 3 |
| OH | 7 | 2 |
| OK | 4 | 1 |
| OR | 6 | 0 |
| PA | 51 | 9 |
| RI | 4 | 0 |
| SC | 2 | 1 |
| TN | 6 | 1 |
| TX | 29 | 7 |
| UT | 1 | 0 |
| VA | 8 | 1 |
| WA | 11 | 2 |
| WI | 15 | 2 |
| WV | 1 | 0 |
| WY | 1 | 0 |



# Thackeray's Globules in IC 2944

Strangely glowing dark clouds float serenely in this remarkable and beautiful image taken with the Hubble Space Telescope. These dense, opaque dust clouds—known as "globules"—are silhouetted against nearby bright stars in the busy star-forming region, IC 2944. Astronomer A.D. Thackeray first spied the globules in IC 2944 in 1950. Globules like these have been known since Dutch-American astronomer Bart Bok first drew attention to such objects in 1947. But astronomers still know very little about their origin and nature, except that they are generally associated with large hydrogen-emitting star-formation regions, called "HII regions" due to their glowing light of hydrogen gas. IC 2944 is filled with gas and dust that is illuminated and heated by a loose cluster of massive stars. These stars are much hotter and much more massive than our Sun.

***Credits:*** *NASA and The Hubble Heritage Team (STScI/AURA)*
***Acknowledgment:*** *Bo Reipurth (University of Hawaii)*

**Extra Galactic Programs**

| Name | Institution | Type | Title |
|---|---|---|---|
| Alessandra Aloisi | The Johns Hopkins University | GO | Searching for Primeval Galaxies: the promising case of SBS 1415+437 |
| Nahum Arav | University of California at Davis | SNAP | STIS/UV snapshot survey of bright AGN |
| David Bennett | University of Notre Dame | GO | Gravitational Microlensing in the NGC 3314A-B Galaxy Pair |
| John Biretta | Space Telescope Science Institute | GO | HST / Chandra Monitoring of the M87 Jet |
| Jean Brodie | Univ. of California Observatories / Lick Observatory | AR | The Structure of Young Massive Star Clusters in Spiral Galaxies |
| Michael Brotherton | National Optical Astronomy Observatories | GO | The Natural Occulting Disk and Host Galaxy of the Red BAL Quasar FIRST J1556+3517 |
| Nelson Caldwell | Smithsonian Astrophysical Observatory | GO | Ultra Low Surface Brightness Galaxies |
| Alessandro Capetti | Osservatorio Astronomico di Torino | GO | Revealing the nature of low luminosity radio-galaxies with imaging polarimetry |
| C. Marcella Carollo | Columbia University | GO | Is Bulge Formation Still Going-On? , An ACS Survey of Pseudo-Bulges |
| David Carter | Liverpool John Moores University | GO | Insights into Elliptical Galaxy Formation from HST Imaging of Shell Galaxies |
| Luis Colina | Instituto de Estructura de la Materia (CSIC) | GO | NGC 4303: A Seyfert 2 nucleus powered by stars? |
| Christopher Conselice | Space Telescope Science Institute | AR | The Dependence of Environment on the Galaxy Merger Rate |
| Michael Corbin | Space Telescope Science Institute | GO | Infrared Spectroscopy of z > 5 QSOs |
| Stephanie Cote | Herzberg Institute of Astrophysics, NRC | GO | Galaxy Dynamics at Very Large Radius using LyAlpha Absorption Lines |
| Julianne Dalcanton | University of Washington | GO | Galaxy Evolution in the Richest Clusters at z=0.8: the EDisCS Cluster Sample |
| Richard de Grijs | University of Cambridge | GO | Resolved halo stellar populations in the Milky Way analogue edge-on galaxy NGC 891 |
| Linda Dressel | Space Telescope Science Institute | GO | What Excites LINERs: The Brilliant Case of NGC 3998 |
| Richard Ellis | California Institute of Technology | GO | Characterizing the Star Formation History of a Highly Magnified z=5.6 Lyman Alpha Source |
| Michael Fall | Space Telescope Science Institute | AR/Theory | Dynamical Evolution of the Mass Function of Star Clusters in Different Host Galaxies |
| Laura Ferrarese | Rutgers University | GO | Nuclear Dynamics of NGC 205: Probing the Low-Mass End of the Relation |
| Jack Gallimore | Bucknell University | AR | The Role of Star-Formation in Active Galaxies: Uncovering Nuclear Star Clusters with NICMOS |
| Jonathan P. Gardner | NASA's Goddard Space Flight Center | GO | Pure Parallel Near-UV Observations with WFPC2 within High-Latitude ACS Survey Fields |
| Paul Goudfrooij | Space Telescope Science Institute | GO | The Evolution of Globular Cluster Systems in Merger Remnants |
| Norman Grogin | Space Telescope Science Institute | GO | Galaxy Formation in Nearby Voids: Reflections of the High-Redshift Universe? |
| William Harris | McMaster University | GO | Globular Cluster Systems in Supergiant E Galaxies |
| Cyril Hazard | University of Pittsburgh | GO | Unique Opportunities to Search for the Optical Counterparts to High-Z Damped LyAlpha Systems |
| Neal Jackson | University of Manchester, Jodrell Bank Observatory | GO | The lensing galaxy of JVAS B0218+357: determination of H_0 |
| Edward Jenkins | Princeton University Observatory | GO | The Sight-line toward PHL 1811: A Rare Chance to Probe a Lyman Limit System at Very Low Redshift |
| Vesa Junkkarinen | University of California, San Diego | GO | The Nature of the Close Binary Quasar LBQS 0103-2753 |
| Jelle Kaastra | Space Research Organization Netherlands | GO | Connecting the UV and X-ray Warm Absorbers in NGC 5548 |
| William Keel | University of Alabama | AR | Three-Dimensional Structure of Dust in Galaxy Nuclei |
| William C. Keel | University of Alabama | GO | A Powerful Double Radio Source from a Spiral Galaxy |
| Robert Kennicutt | University of Arizona | SNAP | Paschen-alpha Imaging of a SIRTF-Selected Nearby Galaxy Sample |
| Christopher Kochanek | Smithsonian Astrophysical Observatory | GO | The Host Galaxies of Time Delay Lenses: , An Independent Route to the Hubble Constant |
| David Koo | Univ. of California Observatories/Lick Observatory | AR | A Kinematic Study of Disk Systems in Galaxy Cluster Cl0024+16 at z=0.39 |

# CYCLE 11: Approved Observing Programs

| Name | Institution | Type | Title |
|---|---|---|---|
| Steven Kraemer | Catholic University of America | GO | STIS Observations of the Intrinsic UV Absorption in the Dwarf Seyfert Nucleus of NGC 4395 |
| Varsha Kulkarni | University of South Carolina | GO | Zinc Abundances in Damped Ly-Alpha Systems at z < 0.5: A Missing Link in the Chemical History of Galaxies |
| Daniel Kunth | Institut d'Astrophysique de Paris | GO | Deep Lyman alpha images of starburst galaxies |
| K.D. Kuntz | University of Maryland Baltimore County | GO | Stellar populations in M101: X-ray binaries, globular clusters, and more |
| Seppo Laine | Space Telescope Science Institute | GO | A NICMOS Study of Merging Nuclei in the Toomre Sequence: Finding Order Amid Chaos |
| Barry Madore | Carnegie Institution of Washington | GO | TRGB Distance to the Maser Galaxy NGC 4258 |
| Sangeeta Malhotra | The Johns Hopkins University | GO | Morphologies and faint neighbors of z=4.5 Lyman Alpha Emitting Galaxies |
| Matthew Malkan | University of California at Los Angeles | AR | Exploring the Bright Ages in the Other Northern Hubble Deep Field |
| Dan Maoz | Tel-Aviv University | SNAP | The Nature of the UV Continuum in LINERs: , A Variability Test |
| Andre Martel | The Johns Hopkins University | GO | Do the Most Powerful Radio Galaxies Host the Most Massive Black Holes ? |
| Paul Martini | Carnegie Observatories | AR | Using archival STIS kinematics to probe AGN fueling in the central 100 parsecs |
| Patrick McCarthy | Carnegie Observatories | GO | The NICMOS Parallel Observing Program |
| Evencio Mediavilla | Instituto de Astrofisica de Canarias | GO | Determination of Extragalactic Extinction Laws at UV wavelengths with gravitationally-lensed QSOs |
| David Merritt | Rutgers University | AR/Theory | Simulating Galaxies with Supermassive Black Holes |
| Neil Nagar | Osservatorio Astrofisico di Arcetri | GO | Milli-arcsec Registration of Nuclear Optical and Radio Structures in the Seyferts NGC 1068 and NGC 4151 |
| Peter Nugent | Lawrence Berkeley National Laboratory | GO | UV Observations of Hubble Flow Type Ia Supernovae |
| Christopher O'Dea | Space Telescope Science Institute | GO | Life Cycles of Radio Galaxies |
| Stephen Odewahn | Arizona State University | AR | Compact Groups in the HST Archive: Playing the morphology card |
| Paolo Padovani | Space Telescope Science Institute | GO | ACS Observations of the Optical Jet of MH 2136-428 |
| Joel Primack | University of California, Santa Cruz | AR/Theory | Galaxy Interaction Simulations for Interpretation of HST Observations |
| Andrew Ptak | The Johns Hopkins University | AR | Understanding Intermediate-luminosity X-ray Objects and their Environments |
| Kavan Ratnatunga | Carnegie Mellon University | GO | Cosmic Shear - with ACS Pure Parallel Observations |
| Dieter Reimers | Hamburger Sternwarte | GO | Intergalactic HeII absorption in CSO 118 = HS 1157+3143 |
| Marina Rejkuba | European Southern Observatory | GO | Reaching the Horizontal Branch in NGC 5128: Deepest Probe of a Giant Elliptical |
| James Rhoads | Space Telescope Science Institute | GO | ACS Pure Parallel Lyman-Alpha Emission Survey (APPLES) |
| Jason Rhodes | Goddard Space Flight Center | GO | Cosmic Shear With ACS Pure Parallels |
| Adam Riess | Space Telescope Science Institute | GO | Determining Hubble's Constant from Observations of Cepheids in the Host Galaxy of SN Ia 1994ae |
| Timothy Roberts | University of Leicester | GO | Unmasking the optical counterpart to the ultraluminous X-ray source, NGC 5204 X-1 |
| Henrique Schmitt | National Radio Astronomy Observatory | SNAP | Near Ultraviolet Imaging of Seyfert Galaxies: Understanding the Starburst-AGN Connection |
| Kartik Sheth | California Institute of Technology | AR | Using Bars as Signposts of Galaxy Evolution |
| Isaac Shlosman | University of Kentucky | AR/Theory | Observational Signatures of Nested Bars in Disk Galaxies |
| Michael Shull | University of Colorado, Boulder | AR/Theory | Theoretical Modeling of the Metagalactic Ionizing Radiation Background and IGM Metallicities |
| Linda Sparke | University of Wisconsin-Madison | AR/Theory | Dynamics of Stars and Gas in Double-Barred Galaxies |
| William Sparks | Space Telescope Science Institute | GO | Intriguing Transient Sources in M87 |
| John T. Stocke | University of Colorado, Boulder | SNAP | A Snapshot Survey of High Column Density, Low-Z Lyman Alpha Absorbers |
| Alan Stockton | Institute for Astronomy | GO | Spectroscopy in the Inner Region of the 3C 48 Host Galaxy |
| Michael Strauss | Princeton University | SNAP | A Snapshot Survey for Gravitational Lenses among z >= 4.0 Quasars |
| Harry I. Teplitz | NOAO/Goddard Space Flight Center | GO | The Duty Cycle of Star Formation : Far-UV imaging of the Hubble Deep Field |

| Name | Institution | Type | Title |
|---|---|---|---|
| David Thilker | National Radio Astronomy Observatory | AR | The influence of blending on synthetic model-based interpretation of the HII region luminosity function |
| David Thompson | California Institute of Technology | GO | Spatially Resolved Stellar Populations in Two z~2.5 Gravitational Arcs |
| Trinh Xuan Thuan | Astronomy Department, University of Virginia | GO | Are there young galaxies in the local universe: the age of the blue compact dwarf galaxy I Zw 18 |
| Scott Tremaine | Princeton University Observatory | AR/Theory | Binary galactic nuclei and binary black holes |
| Tommaso Treu | California Institute of Technology | AR | The distribution of dark matter in cD galaxies with giant arcs: combining kinematic and lensing tracers |
| David A. Turnshek | University of Pittsburgh | GO | The Size Scales of Line-Emitting Regions in the Cloverleaf QSO |
| William Vacca | Max-Planck-Institut fuer extraterrestrische Physik | GO | Masses and IMF Variations in Super Star Clusters |
| Pieter van Dokkum | California Institute of Technology | AR | Formation of Elliptical and S0 Galaxies in Clusters |
| Marianne Vestergaard | The Ohio State University | AR | Iron Emission: A Powerful Probe of the Quasar Central Engine |
| Fabian Walter | California Institute of Technology | GO | The Birth of a Dwarf Galaxy: The Star Formation History of the Tidal Arm near NGC 3077. |
| Rachel Webster | University of Melbourne | GO | Microarcsecond Imaging of a Gravitationally Lensed QSO: 2237+0305 |
| Michael West | University of Hawaii | GO | The Origin of the Intergalactic Globular Cluster Population in Abell 1185 |
| Beverley Wills | University of Texas at Austin | GO | The Radio-Loud BAL QSO PKS 1004+13: A Key to Understanding QSO Outflows? |
| Christine Wilson | McMaster University | GO | Young Cluster Systems in Two Super-Gas-Rich, Mergers: Arp 220 and Arp 299 |
| Lin Yan | California Institute of Technology | GO | ACS Grism Parallel Survey of Emission-line Galaxies at Redshift z ~ 7 |
| Min S. Yun | University of Massachusetts | GO | Origin and Evolution of IR Luminous Galaxies: Are z>=1 Dusty Starbursts and z=0 ULIRGs the Same? |
| Bodo Ziegler | University Observatory Goettingen | GO | Evolution of the Tully–Fisher Relation of Field Spiral Galaxies |

## Galactic Programs

| Name | Institution | Type | Title |
|---|---|---|---|
| Charles Alcock | University of Pennsylvania | SNAP | Systemic and Internal Proper Motions of the Magellanic Clouds from Astrometry with ACS |
| Carlos Allende-Prieto | University of Texas | GO | Spectrophotometry of Procyon A: Testing Metal Opacities |
| Jonathan Arons | University of California, Berkeley | AR/Theory | Dynamics of the Inner Crab Nebula |
| Francesca Bacciotti | Osservatorio Astrofisico di Arcetri | GO | Systematic Search for Rotation at the Base of Outflows from T Tauri Stars |
| John Bahcall | Institute for Advanced Study | GO | Observing the Next Nearby Supernova |
| Suchitra Balachandran | University of Maryland | GO | The Oxygen Abundance in the Metal-Poor Halo Star HD 140283 from UV-OH lines |
| John Bally | University of Colorado | GO | Irradiated Jets and Proto-Planetary Disks in the Outer Orion Nebula |
| G. Fritz Benedict | University of Texas | GO | FGS Astrometry of a Star Hosting an Extrasolar Planet: The Mass of Upsilon Andromedae d |
| Edwin Bergin | Smithsonian Astrophysical Observatory | GO | The FUV Flux Irradiating the Surfaces of Protostellar Disks |
| Lars Bildsten | University of California, Santa Barbara | AR/Theory | Compressional Heating of Accreting White Dwarfs and Classical Novae Ignition |
| Howard E. Bond | Space Telescope Science Institute | GO | Sakurai's Novalike Object: Real-Time Monitoring of a Stellar Thermal Pulse |
| Wolfgang Brandner | European Southern Observatory | GO | ACS Imaging and STIS Spectroscopy of Binary Brown Dwarfs |
| Joel Bregman | University of Michigan | GO | The Optical Counterpart of an Ultraluminous X-Ray Source |
| Fabio Bresolin | Institute for Astronomy, University of Hawaii | GO | Extragalactic Distances: the Need for Accurate Photometry of Blue Supergiants and Cepheids |
| Nuria Calvet | Smithsonian Astrophysical Observatory | AR/Theory | Physically Consistent Protoplanetary Disk Models |
| Roger Cayrel | Observatoire de Paris | GO | The Old Star CS 31082-001, the Age of the Universe, and the Nature of the r-process |
| David Charbonneau | California Institute of Technology | GO | Characterizing the Atmosphere of an Extrasolar Planet |

# CYCLE 11: Approved Observing Programs

| Name | Institution | Type | Title |
|---|---|---|---|
| Eugene Chiang | University of California at Berkeley | AR/Theory | Unified Models and Instabilities of Protoplanetary Disks |
| You-Hua Chu | University of Illinois | GO | A Definitive Test of the Nature of SN 1961V: Supernova vs. Luminous Blue Variable |
| Kem Cook | Lawrence Livermore National Lab | GO | Halo Microlensing: Direct Detection of a Microlens |
| Adrienne Cool | San Francisco State University | GO | Optical Counterparts for Low-Luminosity X-ray Sources in Omega Centauri |
| Stephen Eikenberry | Cornell University | GO | NICMOS Observations of Transient Infrared Jets in the Galactic Microquasar GRS1915+105 |
| Brian Espey | Space Telescope Science Institute | GO | UV Sounding of the M-Giant Atmosphere in the Symbiotic Binary EG-AND |
| Annette Ferguson | Kapteyn Institute | GO | Probing the Formation & Evolution of M31's Outer Disk and Halo |
| Alex Filippenko | University of California, Berkeley | AR | The Local Environments of Supernovae |
| Boris T. Gaensicke | Universitaets-Sternwarte Goettingen | SNAP | Towards a global understanding of accretion physics –, Clues from an UV spectroscopic survey of cataclysmic variables |
| Peter Garnavich | University of Notre Dame | GO | SBS 1150+599: A Population III Planetary Nebula? |
| Karl Gebhardt | University of Texas at Austin | AR | Surface Brightness Profiles for Globular Clusters |
| Douglas Gies | Georgia State University | GO | UV Spectrum of the Massive X-ray Binary LS 5039 |
| Nickolay Gnedin | University of Colorado at Boulder | AR/Theory | Confronting HST Observations of Dwarf Spheroidals with Theory |
| David Golimowski | The Johns Hopkins University | SNAP | Completing A Near-Infrared Search for Very Low Mass Companions to Stars within 10 pc of the Sun |
| Karl Gordon | University of Arizona | GO | Probing the Grains Responsible for Extinction Using Small Magellanic Cloud Sightlines |
| Edward Guinan | Villanova University | GO | Probing the Distance and Structure of the LMC Using Eclipsing Binaries: STIS Spectrophotometry |
| Todd Henry | Georgia State University | GO | Calibrating the Mass-Luminosity Relation at the End of the Main Sequence |
| Kenneth Hinkle | National Optical Astronomy Observatories | GO | Masses of AGB stars |
| J. Christopher Howk | The Johns Hopkins University | GO | The Galactic Warm Ionized Medium: the First Direct Measures of its Ionization and Abundances |
| Bruce Hrivnak | Valparaiso University | GO | H2 Imaging of Proto-Planetary Nebulae: Probing the Dynamics and Morphology |
| Robert Hynes | University of Southampton | GO | Understanding Irradiation and Dipping Behaviour in Low Mass X-ray Binaries |
| Edward Jenkins | Princeton University Observatory | AR | Interstellar Thermal Pressures from C I Fine-structure Excitation |
| Paul Kalas | Universty of California, Berkeley | GO | ACS coronagraphic survey for debris disks around nearby stars |
| David Kaplan | California Institute of Technology | GO | The Parallaxes and Proper Motions of Two Nearby Neutron Stars |
| Ivan King | University of California, Berkeley | GO | Calibration of the Geometric Distortion of ACS |
| Ivan King | University of California, Berkeley | GO | The Region of the Hydrogen-Burning Limit in Omega Centauri and 47 Tucanae |
| Robert Kirshner | Harvard College Observatory | GO | SINS: The Supernova INtensive Study–Cycle 11 |
| Konrad Kuijken | Kapteyn Institute | GO | Proper Motions of Bulge Stars at b=-6: The Shape of the Potential in the Central kpc of the Galaxy |
| David L. Lambert | University of Texas at Austin | GO | New Clues to the Origin of the Extreme Helium Stars |
| James Lauroesch | Northwestern University | SNAP | A SNAPSHOT Survey of the Hot Interstellar Medium |
| Alain Lecavelier des Etangs | Institut d'Astrophysique de Paris | GO | Composition and history of Beta Pictoris-like circumstellar gaseous disks |
| Jeffrey L. Linsky | JILA, University of Colorado | AR | Using the HST Archive to Compile a Comprehensive Inventory of LISM Structure and Physical Properties |
| Alex Lobel | Smithsonian Astrophysical Observatory | GO | A Direct Test for Dust-driven Wind Physics |
| Jesus Maiz-Apellaniz | Space Telescope Science Institute | GO | The Complete IMF of a Massive Young Cluster |
| Jesus Maiz-Apellaniz | Space Telescope Science Institute | AR | The Birth and Evolution of Superbubbles |
| Eduardo Martin | University of Hawaii | GO | Brown Dwarf Binaries as Tests of Substellar Evolution |
| Philip Massey | Lowell Observatory | GO | The Physical Parameters of the Hottest, Most Luminous Stars as a Function of Metallicity |
| Mario Mateo | University of Michigan | GO | The Ancient Stars of M32 |

| Name | Institution | Type | Title |
|---|---|---|---|
| Roberto Mignani | European Southern Observatory | GO | The Hunt for the Optical Counterpart of the Fastest Pulsar. |
| C. Robert O'Dell | Vanderbilt University | GO | Determining the Physical Processes, Origin, and Fate of Cometary Knots in the Helix Nebula |
| Bohdan Paczynski | Princeton University Observatory | AR/Theory | Astrometric Gravitational Microlensing: an HST perspective |
| Joseph Patterson | Department of Astronomy, Columbia University | GO | GD 552: The Oldest Cataclysmic Variable |
| Daniel Proga | JILA, University of Colorado | AR/Theory | Testing the magnetically and line-driven disk wind models of winds in cataclysmic variables |
| Marcia Rieke | University of Arizona | GO | NICMOS Observations of the Galactic Center: Environment of a Black Hole |
| Lawrence Rudnick | University of Minnesota | AR | A Multiwavelength Study of the Cassiopeia A Supernova Remnant |
| Steven Saar | Smithsonian Astrophysical Observatory | GO | Exploring the Role of Acoustic Heating in Cool Dwarfs and Subgiants |
| Raghvendra Sahai | JPL, California Institute of Technology | SNAP | Are OH/IR stars the youngest post-AGB stars? An ACS SNAPshot imaging survey |
| Carmen Sanchez Contreras | Jet Propulsion Laboratory/Caltech | AR | Unveiling the origin of post-AGB winds through STIS data |
| Divas Sanwal | Pennsylvania State University | GO | The Enigmatic Central Object of the RCW 103 Supernova Remnant |
| Ata Sarajedini | University of Florida | GO | The Field Stellar Populations of M33's Outer Halo |
| Kenneth Sembach | Space Telescope Science Institute | GO | Is the Compact HVC Toward Ton S210 Remnant Debris from the Formation of the Local Group? |
| Edward Sion | Villanova University | GO | The Response of the White Dwarf in WZ Sge to the Unexpected July 2001 Superoutburst |
| Stephen Smartt | Institute of Astronomy | GO | Direct imaging of the progenitors of massive, core-collapse supernovae |
| Ulysses Sofia | Whitman College | GO | The Cosmic Carbon Budget |
| George Sonneborn | NASA's Goddard Space Flight Center | GO | Probing the Halo and ISM of Low-Redshift Galaxies with Young Supernovae |
| Karl Stapelfeldt | Jet Propulsion Laboratory | GO | Externally Illuminated Circumstellar Material in the , Young Nebulous Cluster NGC 2024 |
| Rollin Thomas | University of Oklahoma | AR/Theory | Supernova Spectrum Synthesis for 3D Composition Models with the Monte Carlo Method |
| Susan Trammell | University of North Carolina at Charlotte | GO | The Role of Jets in Shaping Planetary Nebulae |
| Toshiya Ueta | University of Illinois at Urbana-Champaign | GO | NICMOS Imaging Polarimetry of Compact Proto-Planetary Nebula Dust Shells |
| Kim Venn | U.Minnesota, Macalester College | GO | Quantitative Constraints for Massive Star Evolution Models with Rotation |
| Peter Wannier | Jet Propulsion Laboratory, Caltech | GO | The Evolution of Molecular Clouds |
| Peter Young | Smithsonian Astrophysical Observatory | GO | AG Dra – a high density plasma laboratory |
| Albert Zijlstra | Department of Physics | SNAP | SNAPSHOT survey of the Planetary Nebulae population of the Galactic Bulge |
| **Solar System Programs** | | | |
| Gilda E. Ballester | University of Arizona | AR | HST Images of Jupiter's UV Aurora: Mirrors of a Strongly Corotational Magnetosphere |
| Marc W. Buie | Lowell Observatory | GO | High-Resolution Imaging of Pluto's Surface |
| David Goldstein | The University of Texas at Austin | AR | Modeling of HST Observations of O I Emissions of Io in Eclipse |
| Philip James | University of Toledo | GO | Ozone, Condensates, and Dust in the Martian Atmosphere |
| Erich Karkoschka | University of Arizona | GO | Saturn's Atmospheric Structure at Solstice |
| Erich Karkoschka | University of Arizona | AR | Characterization of Spatial Variations in the Transmission of WFPC2 Filter FQCH4N-D |
| Erich Karkoschka | University of Arizona | GO | Test of Efficient Subsampling for NIC3 by Smearing Images of Jupiter |
| Mark Lemmon | Texas A&M University | GO | Spatially-resolved polarimetry of Titan |
| Keith Noll | Space Telescope Science Institute | SNAP | Infrared Photometry of a Statistically Significant Sample of KBOs |

| Name | Institution | Type | Title |
|---|---|---|---|
| Mark Showalter | NASA Ames Research Center | GO | Jupiter's Ring Plane Crossing of 2002–2003 |
| John Spencer | Lowell Observatory | GO | The Composition of Io's Pele Plume |
| Lawrence Sromovsky | University of Wisconsin-Madison | GO | Dynamics and Cloud Structure of Neptune |
| Christian Veillet | Canada France Hawaii Telescope | GO | A binary system in the Kuiper Belt: 1998 WW31 |
| Harold Weaver | The Johns Hopkins University | GO | UV Spectroscopic Investigation of any Bright, Newly Discovered Comet |
| **Large Programs** | | | |
| Gary Bernstein | University of Michigan | GO | The Size Distribution of Kuiper Belt Bodies |
| Thomas M. Brown | Space Telescope Science Institute | GO | The Age of the Andromeda Halo |
| Patrick Cote | Rutgers, The State University of New Jersey | GO | The ACS Virgo Cluster Survey |
| Andrew Fruchter | Space Telescope Science Institute | GO | The Origin of Gamma-Ray Bursts |
| Sandhya Rao | University of Pittsburgh | GO | A Large Targeted Survey for $z < 1.6$ Damped Lyman Alpha Lines in SDSS QSO MgII-FeII Systems |
| Adam Riess | Space Telescope Science Institute | GO | The Deceleration Test from Treasury Type Ia Supernovae at Redshifts 1.2 to 1.6 |
| Hans-Walter Rix | Max-Planck Institute for Astronomy (MPIA) | GO | The Evolution of Galaxy Structure from 10,000 Galaxies with $0.1<z<1.2$ |
| **Hubble Treasury Programs** | | | |
| Kris Davidson | University of Minnesota | GO | Intensive Coverage of the Eta Carinae Event in 2003 |
| Mauro Giavalisco | Space Telescope Science Institute | GO | The Great Observatories Origins Deep Survey: Imaging with ACS |
| Ruth C. Peterson | Astrophysical Advances | GO | Mid-Ultraviolet Spectral Templates for Old Stellar Systems |
| **Archival Legacy Programs** | | | |
| Nahum Arav | University of California at Davis | AR | A New Approach in Studying AGN Intrinsic Absorbers |
| Thomas Ayres | University of Colorado | AR | CoolCAT |
| Stefano Casertano | Space Telescope Science Institute | AR | The WFPC2 Archival Parallels |
| Andrew Dolphin | National Optical Astronomy Observatories | AR | Star Formation Histories of Local Group Galaxies |

# Hubble's Rejuvenation by SM3B

**Chris Blades,** *blades@stsci.edu,*
**Carl Biagetti,** *biagetti@stsci.edu,* **Kerrie Bennett Sobering**

Since launch in 1990, Hubble has overcome problems and undergone improvements by means of three amazingly successful servicing missions. With Servicing Mission 3B (SM3B), scheduled for February, we will soon again witness the feats of brave astronauts, the heavy lifting power of the Space Shuttle, and the scientific benefits of an observatory that can be revisited, serviced, and upgraded in space.

On SM3B, astronauts will install Hubble's newest science instrument, the Advanced Camera for Surveys (ACS). The ACS is designed for ultraviolet and visible light imaging and consists of filters, dispersers, and three electronic cameras. The ACS Wide Field Camera (WFC) is a three-mirror optical design with high throughput, wide field of view, and high sensitivity across the visible wavelengths. With the WFC, searches for high redshift galaxies and clusters of galaxies in the early universe will be greatly facilitated. The WFC is designed to have a tenfold increase in discovery power compared to the existing Wide Field Planetary Camera 2 (WFPC2), where discovery power is the ratio of throughput times focal plane area for the two cameras.

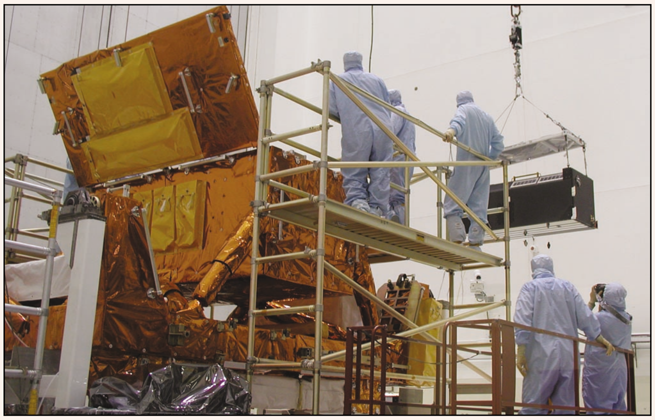
The ACS High Resolution Camera (HRC), also a three-mirror optical design, is optimized for high resolution and high-contrast imaging, including a coronagraph to improve near-bright-object contrast. A typical use of HRC will be diffraction-limited studies of the light in the centers of galaxies with massive black holes. The third ACS camera, the Solar Blind Camera (SBC), is a far ultraviolet camera with a two-mirror optical design. It will be used for faint object and extended object imaging. With its relatively high throughput, the SBC will be used to search for quasars, hot stars, and aurora on Jupiter, as examples. The WFC and HRC have CCD devices, and the SBC has a photon counting detector.

The ACS is a group effort. It was produced and readied for launch by Johns Hopkins University (JHU), Goddard Space Flight Center, Ball Aerospace Corporation, and the Space Telescope Science Institute. Scientists from universities in the United States and Europe have contributed to the effort, with most of the science team located at JHU and the Institute. The Principal Investigator for ACS is Professor Holland Ford of JHU.

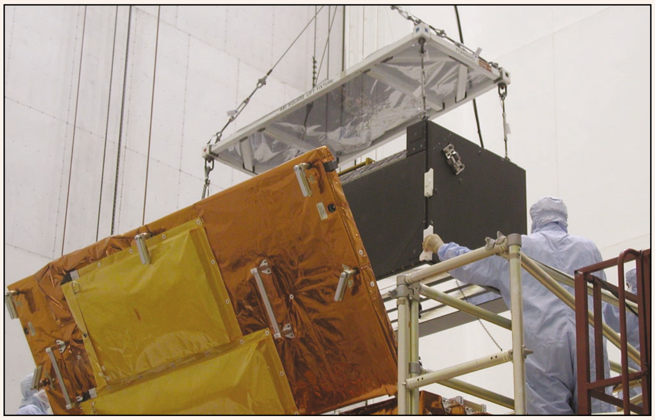
With installation of ACS, the legendary Hubble images are about to get even better. When first activated, ACS will image standard stars to verify performance by measuring known light levels. Later, ACS and a revived NICMOS will make early-release observations (EROs) of interesting objects, which will be available for public viewing after three months. The ACS science team's program will emphasize deep imaging of the sky to study high red shift galaxies and other phenomena. Starting with Cycle 11 in mid-July 2002, General Observers will begin using ACS to record fainter objects and to grasp wider views of the sky than ever before.

Astronauts on SM3B will perform other installations during five days of extra-vehicular activity (EVA) beginning two to three days after launch. The first two EVAs will be dedicated primarily to replacing the solar array wings. The current solar arrays, which were installed on SM1 to replace the original arrays, have been degraded by eight years of exposure to radiation and debris. The new solar arrays will be rigid and hardier than the two previous sets. They will produce thirty percent more power, offer increased resistance to temperature variations, and minimize the atmospheric drag on the spacecraft.

The third EVA will focus on the replacement of Hubble's Power Control Unit (PCU), which will require the first powering down of the entire system since launch. The installment of a new PCU is a central part of SM3B and will



*The SIPE (Science Instrument Protective Enclosure) waiting for ACS to be installed.*

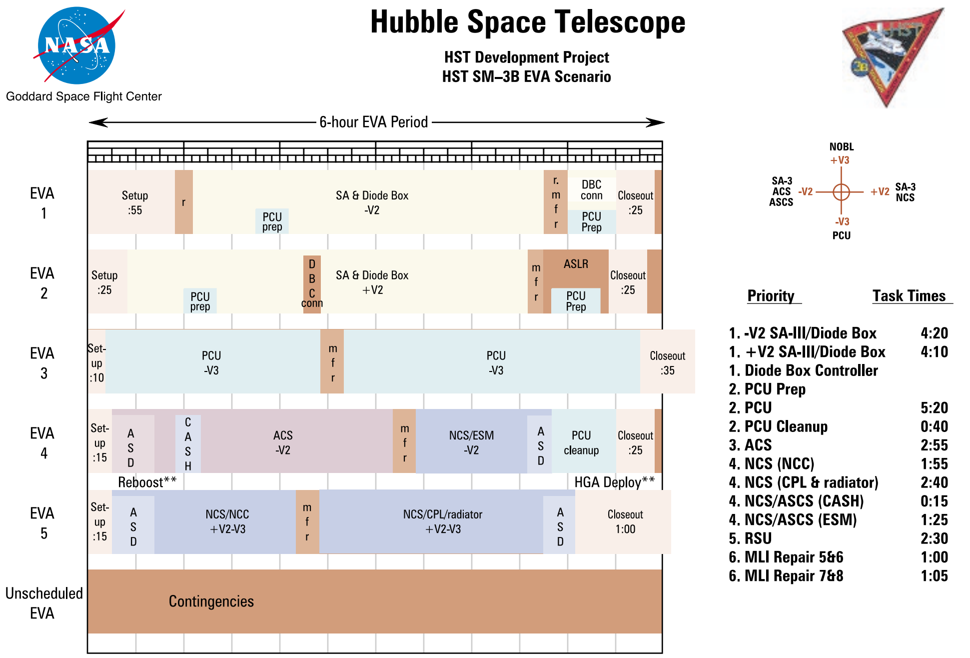


*ACS being lowered into the SIPE.*

present a special challenge to the astronauts, as the equipment is not designed to be removed and reset. The power-down should not last more than six hours.

The ACS claims the beginning of the fourth EVA, after which the astronauts will install the NICMOS cooling systems (NCS). NICMOS, the Near Infrared Camera and Multi-Object Spectrograph, has been dormant since 1997, when its supply of cryogen was depleted. The NCS is an experimental, super-quiet cooling system, which uses microturbines that can spin faster than 400,000 rpm. The NCS will re-cool the NICMOS detectors, revive their infrared sensitivity, and return this unique, important instrument to duty. The fifth EVA will also focus on NCS and its companion equipment.

Between EVA four and five, an orbital re-boost will increase Hubble's altitude by several kilometers, depending on the amount of fuel remaining. Despite the thin atmosphere at Hubble's orbit, atmospheric drag causes the spacecraft to lose altitude, which would result in uncontrolled de-orbiting if not corrected. Hubble's altitude will be increased during SM3B, as it was in SM1 and SM2, by the creative use of the Space Shuttle's thrusters.



| Priority | Task Times |
|---|---|
| 1. -V2 SA-III/Diode Box | 4:20 |
| 1. +V2 SA-III/Diode Box | 4:10 |
| 1. Diode Box Controller | |
| 2. PCU Prep | |
| 2. PCU | 5:20 |
| 2. PCU Cleanup | 0:40 |
| 3. ACS | 2:55 |
| 4. NCS (NCC) | 1:55 |
| 4. NCS (CPL & radiator) | 2:40 |
| 4. NCS/ASCS (CASH) | 0:15 |
| 4. NCS/ASCS (ESM) | 1:25 |
| 5. RSU | 2:30 |
| 6. MLI Repair 5&6 | 1:00 |
| 6. MLI Repair 7&8 | 1:05 |

*The HST Servicing Mission 3B Activities and EVA Scenario*

RM October 5, 2001

The five EVA spacewalks are to be performed by four astronauts, three of whom are veterans: John M. Grunsfeld, James H. Newman and Richard M. Linnehan. Michael J. Massimino will be embarking on his first flight. The commander, two-time shuttle veteran Scott Altman, will be joined on deck by Duane Carey, also making his first flight, and Nancy Currie, a three space flight veteran.

Hubble discoveries have inspired and informed scientists and the public for a decade now. In these times of conflict and uncertainty, Hubble can seem a metaphor for exploring deeper, transcendent realities—ones holding no fear but offering hope of new knowledge and better understanding. It is heartening to reflect that Hubble will never have been more capable of discovery than it will be in February 2002 after SM3B. And never has Hubble been needed more as a touchstone for science in the public interest. Ω

# Hubble Overview

**Rodger Doxsey,** *doxsey@stsci.edu*

At the Institute, we are in the last phase of preparing for Servicing Mission 3B (SM3B), which will install the Advanced Camera for Surveys (ACS) and attach a cooler to reactivate the Near Infrared Camera and Multi-Object Spectrograph (NICMOS).

All of our software systems and procedures, from proposal entry to the archive, have been updated to handle the ACS. Some changes have also been included for reactivated NICMOS operations, including the On-The-Fly Recalibration pipeline (see article by M. Dickinson). The proposals needed for the orbital verification (OV) of ACS and the re-verification of NICMOS and the other science instruments are being processed. The operations staff are building test versions of schedules for the OV period. Those on the staff who will directly participate in SM3B—whether at Goddard Space Flight Center, Johnson Space Center, or the Institute—have been participating in the joint Shuttle/Hubble Space Telescope simulations and training exercises for the mission. We are all hopeful that the February launch date will hold and look forward to the new and improved Hubble that the mission will bring us.

The Cycle 11 selection process has concluded (see article by D. Macchetto et al.). This cycle introduces several new proposal types, including the Treasury programs. With their size and scope, Treasury programs may need some extra attention on our part to ensure smooth implementation. Chris Blades has been asked to coordinate our operational activities in support of these programs. The Phase II deadline for successful Cycle 11 proposers will be February 15, 2002.

The Hubble website has been redesigned as part of the overall Institute web redesign. Users can reach the site via the 'HST' icon on the Institute page or directly via **http://hst.stsci.edu**. We have attempted to put this page together from the perspective of the proposers and users, in terms of navigation and front-page features. As you use it, you will find that it quickly leads to pages we have been supporting for a long time. Our plan is to continue to develop and improve the content at the lower levels of the site. In particular, the Space Telescope Imaging Spectrograph (STIS) and ACS sites have been redone, and the NICMOS site is in work. If you have any suggestions or thoughts on improvements we should make, please feel free to send an email to Matt Lallo (**lallo@stsci.edu**) or Mike Wiggs (**wiggs@stsci.edu**).

Finally, I should note that Hubble seems to have weathered the Leonids meteor shower again this year with no apparent damage. Ω

# NICMOS On-The-Fly Reprocessing

**Mark Dickinson,** *med@stsci.edu*

On 26 September 2001, NICMOS joined WFPC2 and STIS in using On-The-Fly Reprocessing (OTFR) as the standard mode for calibrated data retrieval from the Hubble archive.[1] In the last issue of the Newsletter, an article by Sylvia Baggett described OTFR for WFPC2 and STIS and its benefits for users. When a user requests calibrated Hubble data from the archive, OTFR goes back to the original telemetry (the "POD" files) to construct new, raw data in FITS format, and then carries out pipeline processing with the most up-to-date calibration reference files and software available.

For NICMOS data, OTFR has several immediate benefits. NICMOS had a brief on-orbit lifetime in Cycle 7, due to a thermal short circuit that accelerated cryogen exhaustion. During Cycle 7 and afterward, our understanding of NICMOS rapidly evolved, particularly about the instrument behavior and performance, the quality and pedigree of the calibration reference files, and the pipeline software. As a result, the quality of calibrated NICMOS data products in the archive was highly inhomogeneous. OTFR ensures that a user will always retrieve the most up-to-date pipeline calibrations available at the time

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[1] *Near Infrared Camera and Multi-Object Spectrograph (NICMOS), Wide Field Planetary Camera 2 (WFPC2), Space Telescope Imaging Spectrograph (STIS).*

the data are requested, and that all data retrieved together will be processed uniformly. This will often yield a substantial improvement over the calibrated data sets previously available from the archive.

For example, the ZSIGCORR (zero-read signal correction) step was added to the **calnica** pipeline software for NICMOS part way through Cycle 7 operations, and the BARSCORR ("bars" correction) processing step in **calnica** was added after Cycle 7 observations ceased. As another example, the NLINCORR (linearity correction) algorithm and reference files were updated after Cycle 7 to use higher order polynomial corrections and to apply corrections at all signal levels (they were previously made only for pixels which exceeded a certain threshold). Prior to the implementation of NICMOS OTFR, calibrated data in the archive did not have the bars correction or the improved nonlinearity corrections. Users wishing to take advantage of these steps had to retrieve raw data and reprocess them locally. Now, all retrievals of NICMOS data via OTFR will provide calibrated data processed with these steps and with the latest and best reference files.

The NICMOS pipeline software continues to improve even today, as we introduce new steps to handle previously uncorrected effects. The STScI NICMOS group is currently working on implementing and testing more changes to **calnica,** which, when completed, will further improve the quality of NICMOS data retrieved via OTFR.

Our first goal is to automate temperature-dependent dark correction. NICMOS dark current as well as the amplitude and structure of the bias "shading" are strong functions of detector temperature. NICMOS warmed up slowly throughout Cycle 7, resulting in changes to the dark and bias that are not reflected in the reference files used by OTFR. The effect is most pronounced for Camera 2, where the bias shading signal is strongest.

In 1999, the Institute NICMOS group released a web-based tool for generating synthetic dark reference frames appropriate for any given temperature. Many users have found that this step can significantly improve the quality of their reduced data, but it requires local reprocessing of the data at their home institutions. We are now testing an implementation of the temperature-dependent dark correction within **calnica,** which will allow this improved calibration to be applied automatically by OTFR. Pending the results of this testing, we hope to have this new version of **calnica** (v. 4.0) ready for the Orbital Verification program for Servicing Mission 3B and subsequently for Cycle 11. (The NICMOS Cooling System (NCS) to be installed on SM3B is expected to result in warmer operating temperatures for the instrument than previously.) Other, future improvements to the pipeline may include temperature-dependent flat fielding, correction for electronic cross-talk ghosts (fondly known as the "Mr. Staypuft effect"), and possibly automatic bias drift and offset ("pedestal") correction. Ω

# Fine Guidance Sensors

**Ed Nelan,** *nelan@stsci.edu*

A simple but significant upgrade to the flight software has recently improved astrometry with FGS1r. FGS1r is the Fine Guidance Sensor used as the astrometry science instrument on Hubble. The upgraded flight software is used to command the instrument. In Cycle 10, astronomers have been using FGS1r to observe objects that are fainter than those typically studied in the past. This stretch usage has revealed two unrelated problems, one in "position" mode and one in "transfer" mode.

Observing in position mode involves the acquisition and tracking of an object's interferometric fringe pattern. The values of the parameters involved in this process were derived from the amplitude and morphology of the fringes as they were in 1998, when FGS1r was commissioned as a science instrument. Unfortunately, there has been a slight evolution of the y-axis interferogram, specifically a growth in amplitude of a secondary fringe. During the fall of 2000, the Institute adjusted the acquisition parameters to ensure that the main fringe would be acquired while locking on to a star. Data gathered over the next few months seemed to support the notion that all was well. Nevertheless, when FGS1r was used in March 2001 to observe a very faint ($V > 16$) field of stars (Proposal 9167, PI Benedict), nearly 50% of the stars were not properly acquired. For those stars, FGS1r locked onto—and subsequently lost—the weak secondary fringe, which terminated that measurement of the star's position. (The stars that were acquired successfully yielded useful data, so the science was not completely lost).

Our analysis indicated a need to further refine the parameters used in the acquisition process for such faint targets. We introduced magnitude dependent adjustments and waited for the next scheduled visit to this same field of stars.

*Continued page 18*

**FGS**
**from page 17**

In September 2001, the observations executed with the new flight software—without a single failure! Moreover, the quality of the astrometry proved excellent, indicating that the accuracy of FGS1r's measurements does not degrade near its faint limit.

Because guide stars are relatively bright objects, this problem has never affected the ability of an FGS to guide the telescope.

Observing faint stars in transfer mode uncovered another problem with commanding an FGS as a science instrument. In this mode, the FGS scans its instantaneous field of view (IFOV) across the object. The resulting data permits the full interferometric fringe pattern to be reconstructed on the ground.

The FGS prepares for transfer mode observing by first locating the object's photocenter and then backing off the IFOV from it by one half of a scan length. Thus, when the scanning commences, the fringes should be well centered. For stars brighter than about V=15, the scans had always been well centered. But when fainter objects were observed, as is now being done in a search for binary systems composed of white dwarf stars (Proposal 9169, PI Nelan), we discovered that the fringes were not well centered. In some cases, when scan paths shorter than 0.5" were used, the fringes were not even present.

A quick analysis discovered the cause of the problem. When the FGS places its IFOV at the starting position of the first scan, it intentionally transitions into a false "fine lock" on the star. This prompts Hubble's main computer, which controls the FGS for the remainder of the observation, to commence scanning. During this sequence, it seems that the FGS is left on its own for about 1.6 seconds, during which time it tracks the photometric noise in the wings of the faint star's fringe. If the response parameters are set to high, the noise, which is interpreted as signal, can cause considerable wander of the IFOV can result.

To eliminate the problem, the Institute adjusted these parameters to their lowest possible values. A special test was executed in October 2001 to re-observe WD2048+263, a V=15.6 star that FGS1r failed to scan properly in an earlier attempt. The new commanding performed flawlessly, no wander of the IFOV occurred before the scanning commenced. This demonstrated the safety of very short scans, which consume less observing time. In a given Hubble orbit, more scans can now be executed and more time can be spent observing the fringes rather than the wings. This results in an improved signal-to-noise ratio, which makes objects as faint as V~16.5 accessible for high angular resolution investigations. Incidentally, the interferograms of WD2048+263 showed the object to be a very interesting binary, with a projected separation of only 16 milliseconds of arc. Ω

# PyDrizzle: Utility Software for ACS

**Warren J. Hack,** *hack@stsci.edu,* **Bill Sparks,** *sparks@stsci.edu*

Astronauts will soon install the new Advanced Camera for Surveys (ACS) on-board Hubble Space Telescope. Once operating, ACS will produce the largest single images ever taken with Hubble. To take full advantage of the wide ACS field of view, the Institute has created a special computer program—PyDrizzle—to remove optical distortions and facilitate the combination of ACS images. As a software advance, PyDrizzle demonstrates the benefits of the Python/PyRAF environment for providing powerful tools to help astronomers in their everyday work.

Drizzling is the task of intelligently resampling images on a new grid. There are several motivations, both technical and scientific, for resampling images. In the case of ACS, the most important reason is correcting the large (but predictable) optical distortions caused by the off-axis position of the instrument. If uncorrected, these distortions would introduce systematic errors in photometric and astrometric investigations based on ACS images. Also, the largest-format ACS images will be split across two Charge Coupled Device (CCD) chips, which means they must be stitched together using software. Finally, we expect that dithering (i.e., slight changes in telescope pointing between images) and creating mosaics will be common operations with ACS, because they promise to improve effective image resolution and field of view even further.

The IRAF (Image Reduction and Analysis Facility) program 'drizzle' was developed some years ago to resample images to remove optical distortions and combine separate images. PyDrizzle controls 'drizzle' within the new Python and PyRAF environment for running IRAF tasks.

Developed by the Institute's Science Software Group using the Python language, PyRAF allows users to run IRAF tasks either in the standard IRAF manner or from Python programs, which permits using Python's object-oriented programming techniques. The program PyDrizzle has been written to take advantage of these PyRAF features and to provide a helpful interface for 'drizzle' itself.

As of today, we have taught PyDrizzle to work with images from three Hubble instruments: ACS, Space Telescope Imaging Spectrograph, and Wide Field Planetary Camera 2 (WFPC2). PyDrizzle uses a separate table for each instrument to describe how detector pixels map onto the plane of the sky. In the future, we can upgrade the PyDrizzle tables to process images from the Near Infrared Camera and Multi-Object Spectrograph (NICMOS), Wide Field Camera 3, or even a ground-based imaging instrument.

Astronomers can use PyDrizzle to process either single images or sets of multiple, dithered images to provide a single, undistorted, output image with uniform, corrected, photometric, and astrometric properties.

PyDrizzle, like 'drizzle', works with count rates rather than counts, which makes combining images with differing exposure times straightforward.

The pipeline calibration soft-ware for ACS and NICMOS uses automatically generated associ-ation tables to define how mul-tiple images taken at different pointings relate to a single out-put image. Association tables can be manually generated for other instruments, such as WFPC2, or for sets of ACS images that were not originally associated. PyDrizzle relies on these association tables to correct and combine related sets observations, such as dithered observations at single pointings or in a mosaic.

In the ACS pipeline, PyDrizzle will rely strictly on the pointing information contained in each input image. It will use a con-servative default set of parameters. In PyRAF, an astronomer can PyDrizzle interactively to control many aspects of the processing, including the Right Ascension and Declination of the output image center, as well as the regular options familiar to current users of 'drizzle'. As a caveat for the initial pipeline implementation, PyDrizzle will not correct for cosmic rays observations taken at only one pointing. In future versions, as experience is gained with ACS data, it may be possible to add cosmic ray correction as an enhancement.

We tested PyDrizzle on both simulated ACS observations and actual WFPC2 observations. In Figure 1, we used PyDrizzle with one command to combine two WFPC2 images of M87 taken at orientations nearly 180 degrees apart. By comparison, if we had used 'drizzle', we would have had to compute the offsets ahead of time and then run 'drizzle' eight times with different parameters. This simplicity of operating PyDrizzle is a great benefit both in the automatic calibration pipeline environment and on the astronomer's desktop for manual reprocessing a dataset.

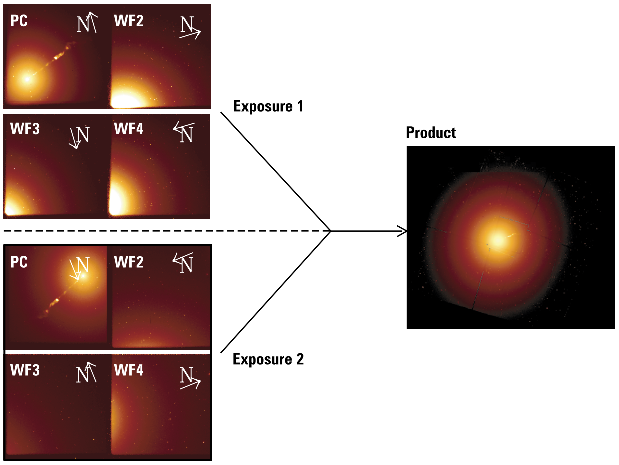


***Figure 1.*** *Demonstration of PyDrizzle on WFPC2 observations of M87 taken at orientations nearly 180 degrees apart. All four chips from each of the two WFPC2 exposures are shown on the left and the combined output created by PyDrizzle is shown on the right.*

PyDrizzle represents the first major example of how Python/PyRAF environment can be used to accomplish tasks that required large, fragile scripts in the standard IRAF environment. The ACS calibration pipeline can now automatically produce ACS images with high photometric and astrometric accuracy despite significant instrumental distortions. The astronomical community has gained a new tool that combines dithered images and corrects image distortion simply. For ACS and other cameras, astronomers can more easily apply the power of 'drizzling' in everyday work to improve their science. Ω

# NGST Elements Falling Into Place

**Roelof de Jong,** *dejong@stsci.edu,* **Don Figer,** *figer@stsci.edu,*
**Bernie Rauscher,** *rauscher@stsci.edu,* **Peter Stockman,** *stockman@stsci.edu*

Major NGST (Next Generation Space Telescope) elements are starting to fall into place as the project is moving from Phase-A (feasibility studies) to Phase-B (definition studies). NASA has started the selection process for many key elements of the NGST telescope. Perhaps the most important decision of all, selecting the prime contractor to build the telescope, is expected any moment now. Below you can read about other selections that have been made or are being made. To stay up-to-date, you can always find the latest news at our website: **http://ngst.stsci.edu/**.

## *NGST Science and Operations Center*

As announced earlier, NASA has designated Space Telescope Science Institute as the Science and Operations Center (S&OC) for NGST. The Institute will develop and operate all elements of the ground system. Also, it has critical roles in supporting the development of the entire observatory. Beginning in 2003, the Institute will deliver more capable versions of the ground system to the major development organizations, including science instrument developers and the optical telescope and spacecraft contractors. The S&OC systems, when mated to emulators of the flight computer, will exercise all the NGST elements during their development and assembly. By taking this approach—which is a lesson learned from HST—NASA expects to save money and reduce risk during the development of NGST.

The Institute will develop each step in the observing process carefully, to enable the science and ensure the safety of NGST. The basic elements of the process are observation planning, mission scheduling, commanding and monitoring the observatory, receiving science data, and archiving and distributing data to observers. In designing the ground system to support or implement these processes, we must ensure observer access to the full scientific potential of the NGST optics and instruments. The observer will normally only encounter the first steps in the planning process, which are the submission of science proposals and making the detailed descriptions of the observations, and the last step, which is retrieving the calibrated data. The middle steps—which plan, schedule, and command observations in the most safe and effective way—are usually invisible to the observer. Each step in the end-to-end observing process will be exercised in concert with other observatory elements during the development and assembly of NGST.

## *The Operations Concept*

Since 1999, the Institute has been leading the development of an operations concept—the vision for how astronomers and operators will use NGST. The concept must reflect the design of NGST, the implications of its location at the second Lagrange point (L2), the demands and capabilities of the science instrument payload (discussed in the fall 2002 Newsletter), and the ways in which astronomers might wish to plan their observations. The NGST project team of astronomers, engineers, and operators has had to consider a wide range of issues, such as cosmic rays, solar flares, data rates, guide stars, and scattered light from the Earth and Moon. The team's interim report (Ferguson et al. 2000, NGST doc. 583 at **http://ngst.gsfc.nasa.gov/**) assisted NASA and the prime contractors in developing requirements for the observatory. The current version (which yet is not available for release) has been a major influence on the Institute development plan.

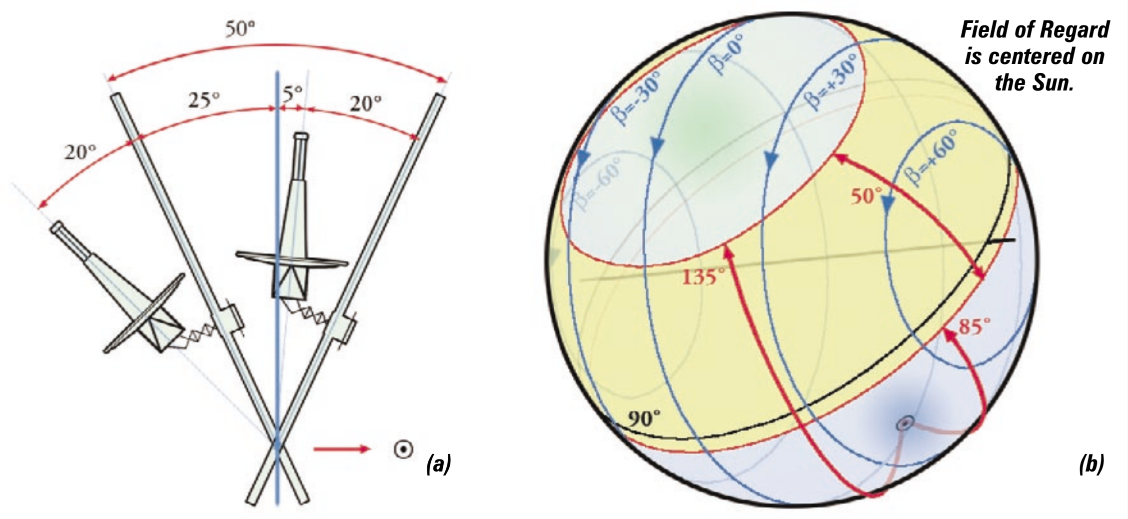
## *NGST S&OC Inheritance from Hubble Operations*

The NGST S&OC will use the best elements of Hubble operations wherever they are appropriate. We will use the Hubble peer review process for NGST and encourage large programs, similar to the Hubble Treasury programs and the SIRTF (Space Infrared Telescope Facility) Legacy programs. We will use the new Hubble tools for planning observations—the Astronomers Planning Tools (APT), which are replacing RSP2 (the Remote Proposal Submission 2 system)—and extend them for NGST. The goal is to have Hubble and NGST tools that are simple to use and have the same 'look and feel'. The NGST S&OC will share Hubble data pipeline processes, such as On-The-Fly Calibration, and store NGST data in the Multi-mission Archive at Space Telescope (MAST), which will utilize more advanced storage technologies at the time of NGST launch in 2009.

## *Differences Between Hubble and NGST Operations*

NGST will be a large, passively cooled telescope operating in the optical and infrared. It will be placed in a large halo orbit around L2, about 1.5 million km from Earth. NGST will have a large shade to block sunlight and permit it to cool to outer space. Thus, NGST will have viewing constraints that are quite different from Hubble in low Earth orbit.

Figure 1 shows the basic sunshade architecture and field of regard for NGST. We anticipate that the sunshield will permit the observatory to point in a 50-degree range of pitch from the sun line and to roll freely about the sun line. As a result, the instantaneous field of regard covers approximately 40% of the sky. Targets in the ecliptic plane become accessible for approximately 50 days twice a year. Near the ecliptic poles, targets can be viewed for half a year, and those within 5 degrees of the poles are viewable throughout the year. NGST viewing constraints are less severe than those for SIRTF but are more severe than those for Hubble, which can view any target farther than 50 degrees from the Sun. Nevertheless, the absence of Earth occultations and transits of the South Atlantic Anomaly make NGST (and SIRTF) much simpler to schedule than Hubble.



***Field of Regard is centered on the Sun.***

***Figure 1:*** *The NGST sunshade architecture (a) and field of regard (b). The sunshade shields the cold telescope from the sun and is oversized and offset from the telescope axis to permit a 50 degree range for pitch. The whole observatory may roll freely about the sunline. These limits on movements result in the instantaneous field of regard shown in Panel (b), with the direction of the Sun indicated at the bottom of the sphere. The blue arrows show how targets at different ecliptic latitude pass through this field of regard during the year.*

NGST orientation restrictions translate into restricted orientations of the focal plane on the celestial sphere. For Hubble, astronomers can specify any orientation of the cameras and spectrographic slits, although their observations might be delayed until a particular time of year. NGST observers will have less choice, except for targets near the ecliptic poles. (See Figure 2 on page 20.) At zero ecliptic latitude, the range of orientation angles is small, just 10 degrees. For intermediate ecliptic latitudes (say, for the galactic poles), the range increases to approximately 90 degrees when the ranges for the two viewing periods are combined. As a result of these restrictions, it will be important for astronomers doing mosaic imaging, multi-object spectroscopy, or perhaps long-slit spectroscopy to carefully choose the orientation of the field of view to maximize the scientific return from their observations. Once specified, this orientation will place the observation in a particular 10-50 day window in the NGST schedule.

We have not touched on the other complexities of planning NGST observations: variable zodiacal backgrounds during the year, earthlight and moonlight avoidance, and guide star availability. When planning NGST observations, users will need to consider earth- and moonlight avoidance and variations in zodiacal light background through the year. The NGST version of APT will make these tasks as straightforward as possible. By providing such powerful tools to the user, we hope to receive a majority of proposals ready to place on the NGST schedule without the need for a Phase 2 proposal submission similar to Hubble. Achieving this goal would minimize an observer's wait for data and maximize the chance that the observer can examine at least some results before writing his or her next proposal. We feel strongly that improving the proposal and planning process to speed data to observers is an important way to maximize the scientific impact of NGST.

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**NGST**
**from page 21**

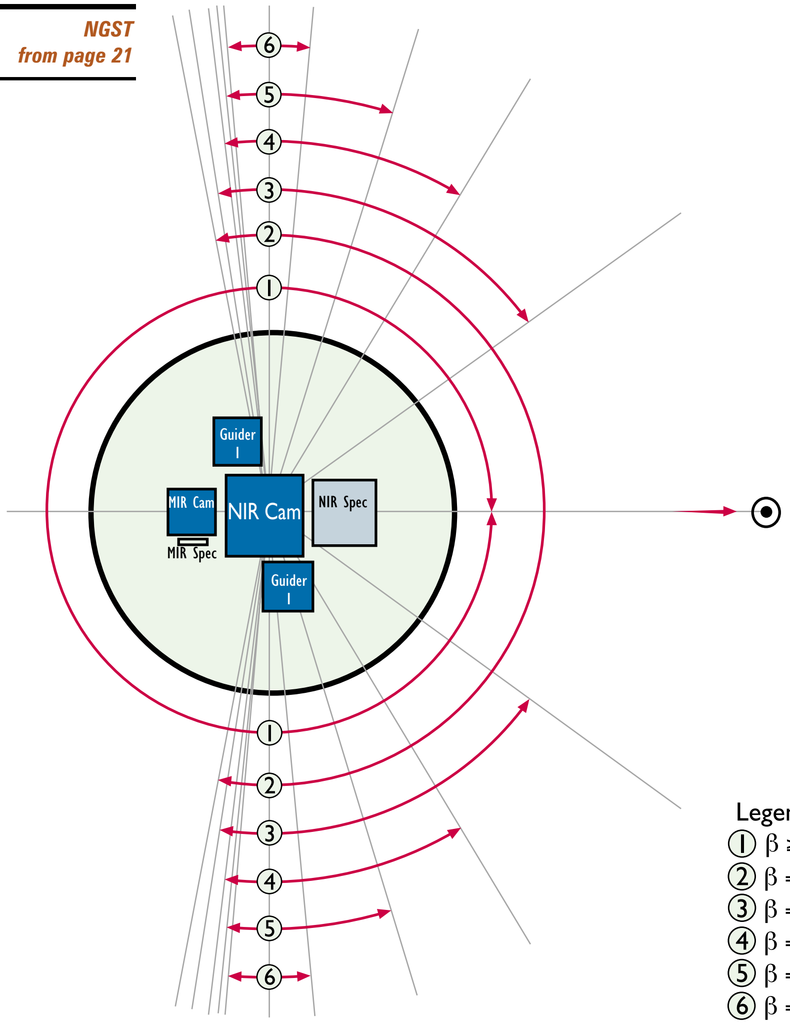

***Figure 2:** The NGST Science Focal Plane. The labeled apertures illustrate how the three instruments and dedicated guider may be oriented in the NGST focal plane. The figure also illustrates the range over which a celestial orientation (e.g. ecliptic north) may vary during the accessible observing periods for targets at different ecliptic latitudes and spacecraft roll angles (± 5 degrees). Note the disjoint and limited orientation ranges for targets near the ecliptic plane.*

## *NGST Detector Development and Testing*

The NGST must have great sensitivity to detect the first light in the universe and learn how galaxies first formed. This goal requires that NGST detect sources as faint as magnitude 33—which implies less than one photon per second at the detector! For this, NGST must employ detectors more sensitive than any flown on previous missions.

As illustrated in Figure 3(a), dark current and read noise must be extremely low to ensure that NGST imaging is limited by noise from zodiacal light. Indeed, NGST spectroscopy of faint sources will be limited by detector noise even if optimistic goals for read noise (3 $e^-$) and dark current (0.01 $e^-$/s) are met. By comparison, the HgCdTe detectors in NICMOS (Near Infrared and Multi-Object Spectrograph) on Hubble achieve a minimum read noise of 18 $e^-$ (25 samples, up-the-ramp) and a dark current of ∼0.05 $e^-$/s. And the InSb detectors on SIRTF are expected to exhibit a minimum read noise of 10 $e^-$(64 samples, Fowler sampling) and a dark current of <1 $e^-$/s. Figure 3(b) shows that the time required to execute the imaging and spectroscopic portions of the sample science mission (and any General Observer science) is directly related to basic detector properties like dark current and read noise.

The NGST project has the ambitious goal of procuring approximately 64 million pixels of flight qualified near-infrared detectors—more than the sum total of all such pixels employed in astronomy today. These detectors must cover the wavelength range 0.6 to 5.0 microns with high quantum efficiency (>95%), low system noise (<3 $e^-$ from read and dark current noise combined), non-existent image persistence, and high operability (>99.5% of the pixels meeting requirements).

The NGST detector program is already in high gear. Vendors are ramping up production of both near-infrared and mid-infrared detector prototypes. External laboratories are preparing to receive and evaluate the prototypes in 2002. The goal is to choose the final detector technologies and initiate the procurement of the flight detectors in 2003.

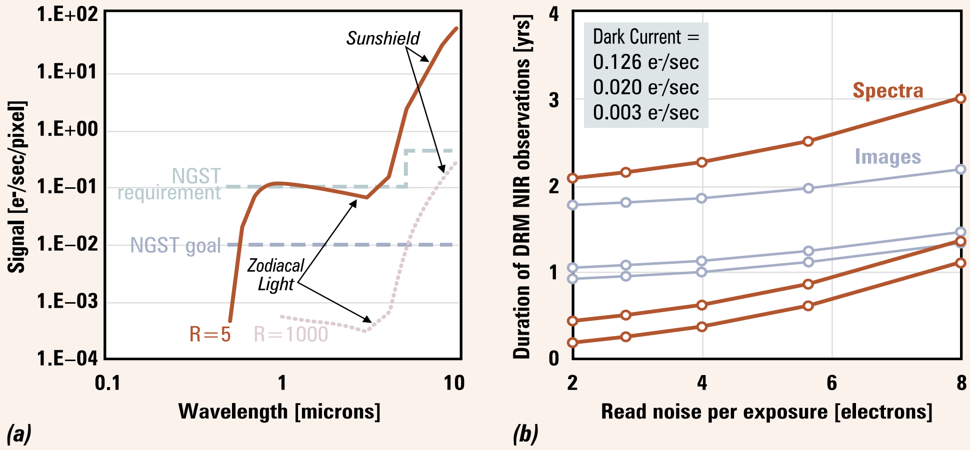

***Figure 3:*** *NGST detector noise and background (a) and detector noise versus mission accomplishment time (b). The NGST detector noise goals and requirements are very low to make optimal use of the very low background provided by the NGST observatory. Note how broadband observations will be barely background limited (red, solid line), while spectroscopy will be mostly detector limited (blue, dashed line). Panel (b) shows the time needed to complete the imaging (blue, dashed lines) and the spectroscopy (red, solid lines) part of the Design Reference Mission, a sample core science program for the NGST. Three different lines are shown for three levels of dark current. Mission completion time is clearly a strong function of the system noise of the detectors.*

NASA has funded four laboratories to develop and assess the quality of NGST prototype detectors. These are ultra-low background facilities, capable of measuring dark currents below 30 $e^-$/hour. The University of Hawaii lab (PI Don Hall) is developing and characterizing HgCdTe detectors manufactured by Rockwell Scientific. The University of Rochester lab (PI Bill Forrest) is doing the same for InSb detectors made by Raytheon Infrared Operations. The Independent Detector Testing Laboratory (IDTL; PI Figer; **http://idtl.stsci.edu/**) at Space Telescope Science Institute and the Johns Hopkins University will characterize both HgCdTe and InSb detectors in a comparative hardware setup. The lab at NASA Ames Research Center (PI McCreight) is developing and characterizing Si:As mid-infrared detectors. All labs are making good progress, with Dewar systems designed and procured and the detectors on the way.

***Figure 4:*** *Testing dewar in IDTL lab. Don Figer (left) and Bernie Rauscher (right) showing the new dewar in the Independent Detector Testing Laboratory at JHU/STScI that will be used to test and characterize competing detector technologies for the NGST.*

## *NASA Selects JPL to Lead Implementation of MIRI*

NASA's Astronomy and Physics Division has selected JPL in Pasadena, California, as the lead center for implementing the NGST Mid-Infrared Instrument (MIRI). The selection, which was announced on October 12th, followed a competitive round of oral and written proposals from three NASA centers: JPL, Goddard Space Flight Center, and NASA Ames Research Center. JPL will develop the MIRI in a NASA-led partnership with a European consortium sponsored by ESA. Each space agency will contribute about half the resources required for MIRI.

MIRI has an enormous discovery space afforded by its broad wavelength response (~5 to 28 microns) and outstanding sensitivity due to the cooled, 6-m class NGST telescope. The combination of these factors with diffraction-limited angular resolution and MIRI's moderate spectral resolution will enable many important observing programs, including key NGST mission goals, such as understanding the formation and evolution of galaxies beyond a redshift of 5, the physical processes of star formation, and the creation of the first heavy elements. MIRI will study the light from old stellar populations at red-shifts greater than 2. It will characterize active and starburst galaxies at redshifts between 2 and 10 using light at wavelengths longer than 5 microns. MIRI's imaging and spectroscopy will be invaluable for understanding the chemical evolution of the interstellar medium and the accretion process in the early stages of star formation, when most of a protostar's emission is in the mid- to far infrared.

A joint science team appointed by NASA and ESA will develop functional requirements for the MIRI instrument, oversee its construction, and carry out an initial science program. U.S. members of the science team will be selected through NASA solicitation AO-01-OSS-05, as detailed below.

JPL's Astronomy and Physics Directorate will manage the MIRI instrument development effort. Avinash Karnik is the Instrument Manager, and Gene Serabyn will serve as the MIRI Instrument Scientist. Work on this exciting new instrument commenced in early October 2001 on both sides of the Atlantic.

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**NGST**
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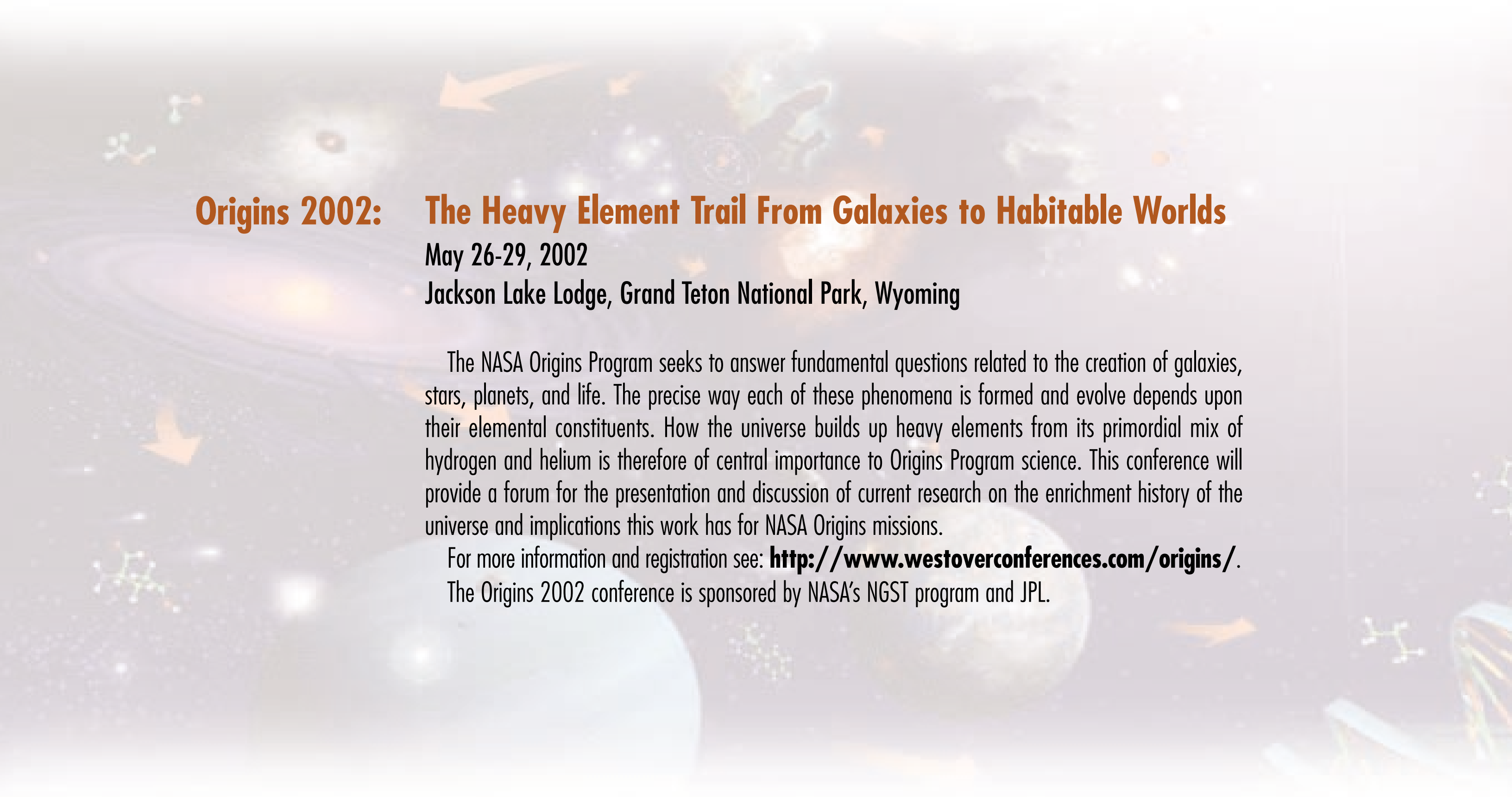
## *NGST Flight Investigations Announcement of Opportunity*

On November 30, 2001, NASA published the Announcement of Opportunity (AO) for NGST Flight Investigations, by which it will select scientists to participate in the developments of the NIRCam and MIRI instruments and the NGST telescope. Notices of intent to propose were due January 3, 2002, and the proposals are due March 5, 2002. The AO solicits science investigations for:

- The development of NIRCam in collaboration with the Canadian Space Agency
- The MIRI Science Lead
- Three other team members for the MIRI Science Team
- An NGST Telescope Scientist
- An NGST Facility Scientist
- Four NGST Interdisciplinary Scientists

Participation in this competition is open to all categories of organizations, foreign and domestic, including industry, educational institutions, nonprofit organizations, NASA centers, and other Government agencies. Details about the AO can be found at the AO-01-OSS-05 link at **http://research.hq.nasa.gov/code_s/open.cfm**. Ω



## Origins 2002: The Heavy Element Trail From Galaxies to Habitable Worlds

### May 26-29, 2002

### Jackson Lake Lodge, Grand Teton National Park, Wyoming

The NASA Origins Program seeks to answer fundamental questions related to the creation of galaxies, stars, planets, and life. The precise way each of these phenomena is formed and evolve depends upon their elemental constituents. How the universe builds up heavy elements from its primordial mix of hydrogen and helium is therefore of central importance to Origins Program science. This conference will provide a forum for the presentation and discussion of current research on the enrichment history of the universe and implications this work has for NASA Origins missions.

For more information and registration see: **http://www.westoverconferences.com/origins/**.

The Origins 2002 conference is sponsored by NASA's NGST program and JPL.

# MAST News at the Space Telescope Science Institute

**Paolo Padovani, on behalf of the MAST team,** *padovani@stsci.edu*

## *Hubble Data Archive Status*

The Hubble data archive now contains about 7.3 terabytes of data in about 251,000 science data sets. The archive ingests an average of 3.4 gigabytes per day. Lately, researchers have been retrieving data from the archive at a rate almost 6 times higher, about 20 gigabytes per day.

## *Transition to New Archive Media Completed*

We recently completed a project in the archive to move all Hubble and Far Ultraviolet Spectroscopic Explorer (FUSE) data from 12” optical disks to 5.25” magneto-optical disks. It took about a year to move approximately 6 terabytes of data spread over 1.3 million datasets. All data are now stored in new, more robust jukeboxes with plenty of room available for growth to accomodate new instruments. As all data are now on-line and no operator intervention is required, data retrieval times should be faster. Thank you for your patience while we were in the transition process!

## *An Enhancement to the MAST Scrapbook*

Archive users should by now be familiar with the MAST Spectral/Imaging Scrapbook (**http://archive.stsci.edu/scrapbook.html**), a World Wide Web (WWW) tool that permits the user to peruse representative spectra or sky images from mission data stored in the UV/optical/near-IR MAST archives. A new option has been added to this tool to allow WWW users to ‘co-plot’ selected representative spectra obtained from any of seven MAST instruments/missions with spectral data. These missions are the Berkeley Extreme and Far-UV Spectrograph (BEFS), Extreme Ultra Violet Explorer (EUVE), Faint Object Spectrograph (FOS), Goddard High Resolution Spectrograph (GHRS), International Ultraviolet Explorer (IUE), Hopkins Ultraviolet Telescope (HUT), Space Telescope Imaging Spectrograph (STIS), and Tuebingen Echelle Spectrograph (TUES).

After using the scrapbook to search on a specific target or position, the user may then select one or more entries from the table of displayed search results. Clicking the button ‘plot marked spectra’ will display all the selected spectra on a single plot showing calibrated flux versus wavelength—one broad-band spectrum combining results from multiple instruments/missions. The plot uses color to distinguish individual spectra. The interface offers options to rescale the fluxes, wavelengths, or plot size. (Note the ability to rescale the fluxes is particularly useful for spectra containing geocoronal Lyman alpha emission, which would otherwise dominate the display.) A summary of the displayed data sets is presented at the bottom of the page.

As usual, send any comments/questions/suggestions/praise you might have about this or other MAST capabilities to **archive@stsci.edu**.

*A color composite (clear and [O III] emission) STIS image of the Large Magellanic Cloud Planetary Nebula SMP 93. Highly processed data for this and many other Magellanic Cloud Planetary Nebulae are now available from MAST at:* ***http://archive.stsci.edu/hst/mcpn/***

## *Prepared Datasets on Planetary Nebulae in the Magellanic Clouds*

MAST provides access to highly processed datasets from the missions it supports, typically in the form of atlases and plots. These data products are also available in FITS or ASCII format (the latter for spectra only). Obtained by one of the NASA UV/optical platforms and organized and post-processed by scientists involved with the original observations, these prepared datasets are accessible at **http://archive.stsci.edu/hst/prepared_ds.html**. Previously existing contents include high-resolution, ultraviolet spectra of bright stars from GHRS, a library of white dwarfs echelle spectra from IUE, an IUE spectral atlas, and the Hubble Deep Fields and Medium Deep Survey data products.

We are pleased to announce the recent addition of the Magellanic Cloud Planetary Nebulae (MCPN) data to our collection of prepared datasets. The MCPN project is based on Hubble imaging with the Faint Object Camera, Wide Field Planetary Camera 2, and STIS, and optical and ultraviolet slitless spectroscopy. The MCPN project, which is led by Letizia Staghellini at the Institute, is a collaboration of ten astronomers at five institutions. The MCPN website (**http://archive.stsci.edu/hst/mcpn/**) provides project highlights, listings of observations, access to calibrated FITS data, a collection of GIF images for easy viewing and comparison, data catalogs, project papers, and links to related websites, which provide background and educational information. Only Hubble can resolve planetary nebulae in the Magellanic Clouds, measure their sizes and shapes, and detect their central stars. The MCPN data should prove invaluable to achieving a physical understanding of planetary nebulae and their central stars. Ω

# New Directions for the Office of Public Outreach

**Ian Griffin**, *griffin@stsci.edu*

The Office of Public Outreach (OPO) at the Institute was created to share the amazing discoveries of the Hubble Space Telescope with the American public. We are privileged to be the focal point of public attention for a storied NASA/ESA space science mission to which thousands of engineers, programmers, technicians, administrators, and scientists have devoted their professional gifts. During the last five years we have developed a multitude of products and programs that have capitalized on the intense interest in Hubble to inform and inspire millions of Americans and many others around the globe.

At the end of its first five years of existence, and with a new management team in place, the time is right for a re-examination of priorities for OPO. Following considerable internal debate, and after much discussion with the external communities we serve, a new strategic plan for outreach has been produced. This article is a summary of some of the content of this plan. The full plan is available for downloading at **http://outreachoffice.stsci.edu/mission/strategic2002.pdf**.

As Hubble moves into its second decade of operation, and as the Institute gears up to support the Next Generation Space Telescope (NGST) and other space science missions, the range of materials and services we offer will reflect and support the changing role of the Institute.

Our Education and Public Outreach (E/PO) program will continue with the five complementary strands that broadly define the communities we serve. These are:

- News
- Formal Education
- Informal Science Education
- Online Outreach
- Origins Forum

We see the full integration of news and public affairs into the outreach effort as a real strength of our program since it allows the latest results from Hubble to be made available to a wide variety of different communities very quickly. Under the mantra ‘one message, many media’ the considerable efforts that go into crafting news releases can serve education and online communities as well.

Each of our programs will strive to reach the widest possible public audience through innovative products, services, and partnerships. Though primarily focused on Hubble, and eventually on NGST, all of our efforts will emphasize leading our audience to an understanding of the bigger astronomical picture.

Each program will target a different audience but will share resources and staff to achieve maximum efficiency and ensure that good ideas, exemplary practices, and healthy innovation permeate OPO. Management will create a working environment that enables staff to realize their talents and become national leaders in their fields. We will develop products, services, and partnerships that are judged by our peers as being of the highest quality. We will proactively reach out to the astronomical community and create tools and materials that make outreach a natural extension of research.

An exhaustive internal evaluation process and a new external advisory panel will ensure that we apply rigorous professional standards to our E/PO materials, just as our science staff does to their research.

We will partner with existing experts and centers of excellence, extending the reach of our program to the widest possible audience. We will provide a wealth of opportunities to bring the benefits of our program to society as a whole.

## *Our Mission*

***We will share scientific knowledge of the universe in ways that inspire, excite, challenge, and educate.***

Since its deployment in 1990, NASA’s Hubble Space Telescope has given the universe a public face. From the awesome majesty of the Eagle Nebula’s now-iconic pillars to the dizzying depths of the Hubble Deep Field, Hubble has become a fount of profound and beautiful celestial wonder that captivates the public’s imagination.

To capitalize on the public association that has naturally developed between astronomy and Hubble, NASA has commissioned the Institute to develop substantial news/public information and education programs through its Office of Public Outreach (OPO).

OPO communicates and promotes scientific discoveries and technological advances made by

Hubble and other space science missions in a manner that is understandable, relevant, and exciting. We aim to bring Hubble science to the forefront of the American people's attention. As the home port for NASA's Origins Education Forum, we play a leading role in bringing results from all Origins missions to the public.

We will develop exemplary E/PO activities that inspire an interest in science, mathematics, and technology and enhance the science literacy of our audience. By engaging the astronomical community, we will make science research broadly accessible and relevant, and we will strongly support a research culture that encourages scientists and engineers to take an active role in science communication.

## Our Vision

### *We will achieve excellence in every project we undertake.*

OPO has established a banner reputation for producing quality science products. OPO's wide range of professional talent on product development teams, from scientists to evaluators, teachers to video animators, writers to graphic designers, has been critical to this success. We will strive continuously to improve the quality of our product teams and their output and to adjust the blend of talents as necessary to tackle new challenges.

### *We will serve as a resource for others who wish to share the excitement of astronomy.*

OPO has a rich repository of science products, including Hubble images, animations, illustrations, press releases, and Amazing Space educational activities. We will seek profitable partnerships with other groups to disseminate these products to the public. We will support space science missions that have goals for E/PO similar to ours by openly sharing our collective expertise. We will support scientists and educators seeking opportunities for outreach service by promoting and improving the NASA E/PO grants programs that we administer.

### *We will return to the public the fruits of their investment in space science.*

OPO's mission is bound to the ultimate purpose of space science missions. Scientists use the Hubble Space Telescope to achieve particular research goals under a great public mandate to explore the universe. The taxpayers who support our mission seek a return on their investment in the form of both science results they can understand and vistas of the universe that only space-based astronomy can deliver.

## Our Goals

### *We will use Hubble and other missions to engage the public in the adventure of astronomical discovery.*

Just a glimpse of the universe can be a memorable and moving experience. Hubble is unrivaled as a camera for capturing celestial landscapes, and the sheer majesty of what it sees creates, in educational parlance, the ultimate "pre-engagement." Once engaged, people seek deeper meaning —the stories behind the images—and the Institute is uniquely equipped to deliver these deeper stories.

Over the past eleven years Hubble has produced excellent science, receiving abundant press coverage and achieving wide public awareness, sometimes in surprising ways. (What other space mission can claim to have reached youth culture with an image used on the cover of a best-selling popular music CD like Pearl Jam's Binaural?) The images are only the beginning. As snapshots of hidden realities, they provoke profound questions.

### *We will address the fundamental questions that drive the public interest in astronomy.*

Even though space science missions such as Hubble work at the frontiers of scientific research, they address questions that children can frame. Astrophysical data gathered by Hubble, and the leverage provided by Hubble's high profile, provide tremendous opportunity for using genuine scientific data to immerse students and the public alike in some of the most fundamental questions of our time. As an important part of NASA's Origins Program, Hubble seeks to answer questions that have endured since the first campfires: Where do we come from? Are we alone?

OPO activities will stimulate people's natural curiosity about space, astronomy, and technology to bring the thrill of scientific discovery and technological accomplishment to a wide audience.

### *We will expand the cross section of the American public we reach.*

The night sky is among humanity's ultimate "overarching" commonalities; peoples of all times, places, and cultures have enjoyed pondering and studying its wonders. Yet research shows that, within contemporary American culture, the public audience is diverse, possessing varying levels of attentiveness. Hence, our outreach efforts need to take into account the diverse audiences we aim to serve. Our messages must be targeted to specific groups for specific purposes. We recognize that effective communication requires a range of approaches and a variety of media, depending upon the target audience.

Each avenue will offer opportunities to develop products, services, or partnerships that employ different media in order to address different audiences.

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*New Directions*
*from page 27*

For OPO to fulfill its mission, vision, and goals, we must either cultivate the necessary expertise within OPO or, where appropriate, build effective partnerships with communications professionals and dissemination experts who complement our in-house skills.

***We will provide resources and tools that support learning and teaching of science, technology, and mathematics.***

Hubble science data, blended with input from scientists, educators, and content developers, provides a potent brew from which many effective cross-curricular products can be distilled. We will ensure that every aspect of our work with the formal education community is targeted at the needs of the audience. We will use existing dissemination networks and modern technology to make information and materials easily and widely available. We will explore new possibilities for partnerships and experiment with new ways of bringing the results of Hubble and other space science missions to teachers, students, and the public.

***We will increase the efficiency and effectiveness of each area of OPO.***

We will constantly evaluate our news, education, and outreach products and programs for quality and effectiveness to assess the impact they are having. We will work to improve our internal processes to maximize the efficiency with which we deliver products and services. We will set annual goals in each area of our operation and report on progress against these goals.

An important part of our evaluation process will be the appointment of a new external advisory panel. With members drawn from the science, news, education, and outreach communities, this panel will act as a guide, a resource, and a robust review body for our activities.

***We will increase the participation and effectiveness of scientists in outreach activities.***

Our office will strive to increase the involvement of scientists in public outreach and their effectiveness in sharing the excitement of astronomical research with the people who fund it. Astronomers possess a deep knowledge of the subject material, which can lead to lucid explanations when properly channeled. As pioneers of space exploration they can engage the public with experiences from the frontiers of human knowledge. We will capitalize on OPO's privileged position at the Institute to broaden the participation of the entire astronomical community in outreach, to supply outreach materials that assist scientists in those activities, and to coach scientists in effective public communication skills.

An implementation plan describing how the OPO mission, vision, and goals identified above will be put into practice over the next five years is being enthusiastically developed by the OPO team, and it will be published soon. We hope that the readers of this article will support our outreach efforts, and we look forward to working with many of you in the future! Ω

# New Information Resource for General Observers

**Carol Christian,** *carolc@stsci.edu*

One important interface between the Institute and General Observers (GOs) provides information about status of GO programs. We are pleased to announce an upgrade of the program information resources available through the Institute website. Now, through one portal, GOs can track the status of their observations in detail, from the planning stage, through observation execution, the pipeline, and into the archive. The upgraded system provides electronic notification about incoming data. It allows GOs to probe the details of observational datasets in depth. For data that has been received and examined by the pipeline processing system, it links individual programs and visits directly to the archive. Now, the GO can submit requests for data transmission either through those links or through the archive pages.

The upgraded GO program status information is available through **http://hst.stsci.edu/** or directly at **http://www.stsci.edu/ public/propinfo.html**.

This upgrade of GO program information resources is one result of a continuing effort to revise and improve Institute operations through the 'Shark Cage' Innovation Workshop during the summer of 2001. (See **http://dti.stsci.edu**).

We would be pleased to receive feedback and suggestions for further improvements. Please send mail to **dti@stsci.edu**. Ω

# The Hubble Grant Funding Process

**Ray Beaser,** *beaser@stsci.edu,* **Elyse Wagner,** *wagner@stsci.edu*

How are decisions made about how to fund the research that is done with Hubble? Who does it? Why didn't you get what you requested? The TAC process—reviewing the scientific merit of a proposal and deciding how much Hubble observing time to award—is widely understood, because many astronomers have participated in it. On the other hand, the process for approving budgets is less well known. This article is intended to reduce confusion about that process.

U.S. scientists and foreign nationals working in U.S. institutions may receive funding from the Space Telescope Science Institute to conduct research with Hubble data. General Observers (GOs) and Archival Researchers (ARs) submit budgets requesting support as part of the Phase II process. The submission deadline for budgets occurs after the Phase I proposal deadline and the Telescope Allocation Committee (TAC) decisions to make it easier to propose for Hubble time. This phasing also ensures that submitted budgets are based on actual amounts of telescope time awarded and/or actual data to be analyzed, not based on the initial proposal.

The TAC reviews GO/AR proposals and delivers recommendations on their disposition to the Institute Director, who has the ultimate responsibility for deciding how much Hubble time to allocate to each GO program and which AR programs to fund. After the Director's decisions, the Institute notifies the Principal Investigators (PIs) whether or not their programs were approved and informs the GOs of how many orbits were allocated to their programs.

The Institute sends Phase II information to successful PIs, including a request for budget materials and the deadline for our receipt of GO and AR budgets. The deadline for Cycle 11 budgets that are submitted electronically, through our web-based Grants Management System, is March 1, 2002. For the few institutions still not using web access, the paper budget deadline is February 22, 2002. The Institute's Grants Administration Office receives the budgets and distributes them to the Financial Review Committee (FRC). The FRC makes funding recommendations to the Director, who has the ultimate responsibility for allocating funding for GO/AR programs.

The FRC consists of ten scientists. Currently, five FRC members are Institute staff scientists, and five are from the Hubble user community. The members are chosen for their expertise with Hubble instruments, data analysis, and hardware and software. The Institute Head of Administration chairs the FRC, and the Grants Administration Branch provides administrative support. The FRC scientists are all Hubble users, which ensures they are knowledgeable about the requirements for reducing and analyzing Hubble data. To avoid conflicts of interest, FRC scientists are never present when the FRC deliberates the budget for any program with which they are associated.

The FRC reviews each GO/AR budget individually. FRC members receive a documentary package for each program, which includes a scientific abstract, TAC comments and ranking, the budget and budget narrative, as well as a list of the Hubble-based publications of the PI. Each program is assigned a lead FRC member, who has chief responsibility for reviewing all the information about that program and presenting it to the Committee. The presentation includes a summary of the program and a critique of its proposed requirements and requested resources.

The budget narrative is the single most important component affecting the level of funding allocated to a GO/AR program. It must provide a justification of the level of support requested, especially for personnel, travel, and equipment. Unusual items (e.g. color page charges) must be specifically justified. If a program involves foreign investigators, the role of each investigator must be described, including the percentage of data analysis that will be performed by each U.S. and non-U.S. investigator.

The goal of the FRC is to recommend funding sufficient to enable investigators to reduce and analyze their data fully and publish the results in scientific journals.

The budget review process is intensive. For Cycle 10, the FRC reviewed budgets for 198 programs submitted for approved GO/AR programs in three days. Those programs requested ~$20.2 million, and the Director ultimately approved ~$16.6 million. Some 43% of funded programs received 100 % of their requested funding, 19% received 80% to 99%, and 27% received from 60% to 79%.

Information concerning the submission of budgets and allowable costs was provided to Cycle 10 GO/AR investigators in Phase II. In Cycle 11, the information was included in the Call for Proposals. Further information about allowable costs is contained in the General Grant Provisions at **http://www.stsci.edu/ftp/stsci/grants/**. Please note that NASA prohibits any GO/AR funds being provided to non-U.S. scientists (i.e., individuals affiliated with foreign institutions). This restriction includes travel and subsistence support. The Institute will generally provide one year of funding at a time, although that funding

*Continued page 30*

**Grant Funding from page 29**

can be expended over a two-year grant period. If additional funding is required after a program's approved funds are exhausted, the PI can submit a request for supplemental support to complete the analysis of data and publish the results.

Funding notification letters, signed by the Institute Director, are mailed to the PI of each funded GO/AR program. A copy of the notification is also sent by e-mail to the PI and each U.S. Co-Investigator (if applicable). The comments of the FRC are provided at the bottom of the letter. If the PI needs additional information about a funding reduction, he or she can contact the Grants Administration Branch directly (please see contact information below). However, unless specific funding restrictions are listed in the Director's letter, the PI may allocate the approved funds as deemed appropriate to achieve the scientific goals of the program. When revising a budget, the PI and Co-Is should bear in mind any specific recommendations in the Director's funding notification letter and that all costs must be reasonable and allowable as described in the General Grant Provisions. Investigators may appeal their funding allocation through the Grants Administration Office.

Unless revised, reduced budgets are required, GO preparatory grants are awarded shortly after the funding notification letter is sent. Regular GO grants are awarded upon receipt of the first Hubble observation. As in past cycles, this funding is awarded in time-phased increments over the term on the grant.

We strongly recommend that all budgets be submitted to us through the new electronic Grants Management System (GMS). The web site for the system is **http://gms.stsci.edu**. If you do not have a password for the system, please contact the authorizing official or research administration office of your institution. You can also send mail to **gms_mail@stsci.edu** for questions about the new system, including whether your institutional account is activated or who to contact at your institution. We would be happy to activate any institution that would like to submit budgets and receive notices and other administrative documents electronically. For other institutions, budget forms in spreadsheet format are available from the Grants Administration Office.

We hope you find this information about the allocation of Hubble GO/AR funding useful. Please direct questions about the process to us personally, Ray Beaser or Elyse Wagner (410-338-4200), or to **gms_mail@stsci.edu**. Ω

# OPUS: A Workable Solution

**Jim Rose,** *rose@stsci.edu* **and Daryl Swade,** *swade@stsci.edu*

OPUS is in the spotlight. Celera Genomics has selected OPUS for use in their data analysis pipelines (see sidebar). While OPUS was developed right here at the Institute, many still don't know what it is or for what it is used.

To most, OPUS is the science data processing pipeline that converts telemetry from Hubble into standard files for each of the Hubble instruments. While this is true, it is only a subset of the OPUS functionality. OPUS is a complete data processing environment. Or, as we advertise, *OPUS is a fully distributed pipeline processing system for any series of applications, an environment for running multiple instances of multiple processes in multiplepipelines on multiple nodes, and a set of monitoring tools to help you control the distributed pipeline—extensible, configurable, robust, scalable, and available.*

## Technobabble or Rocket Science?

Clearly, scientists are more concerned with the quality of their observations and the stability of their calibrations than with the mechanics of obtaining their data. That is exactly why OPUS has proven useful. In some recent low-budget missions, the amount of time spent by scientists dealing with the flow of engineering data and science telemetry from their instrument has overwhelmed their effort to understand and calibrate new data. Learning from such an experience, the scientists from the Far Ultraviolet Spectroscopic Explorer (FUSE) selected OPUS as their data processing environment. What did they get besides freeing up science time from the development of the calibration pipeline?

First they got a proven pipeline system: one that can keep up with a large flow of observations and engineering data automatically. A robust pipeline environment must manage a large number of processes operating on a large number of exposures. And the operations staff must have simple monitoring tools to inspect what is happening. OPUS provides all this and more.

But more than just a proven system, the FUSE team got an environment that they could tailor to their own needs. They fashioned each step in the FUSE pipeline to their situation, their naming conventions, and their own notions of associations between exposures. While the processing steps themselves involve code, OPUS controls the linking of these steps by simple text files.

Finally, the FUSE team got the experience of Hubble developers. The OPUS team has developed libraries of support services, utilities, and database interfaces. Our experience with support services, utilities, and database interfaces, and our understanding of spacecraft telemetry, helped make the FUSE pipeline operational in record time. Since its original delivery in 1997, the OPUS portion of the FUSE pipeline has required only minor tweaking and still operates today.

OPUS ports to a variety of platforms, including Solaris and Linux—at FUSE it operates under Solaris and at Celera, under Tru64 Unix. The OPUS environment has proven stable and reliable during more than six years of use at the Institute.

## *The Hubble Pipeline*

What happens to data that arrive at the OPUS front door at the Institute? That data is packaged as CCSDS (Consultative Committee for Space Data Systems) packets blocked in large files. The first step is to separate out the packets for each individual exposure and send that large file to the archive immediately. As each exposure is identified, it steps through the OPUS pipeline invoking various tasks depending on characteristics, such as instrument type (e.g., STIS/ACS), mode (e.g., Imaging /Spectrographic/Engineering), or class (e.g., Exposure/Association).

For science data, the next step extracts the proposal information from the planning database for the specific exposure. This is followed by a task that converts the engineering parameters from raw telemetry values to temperatures, voltages, filter/grating names, etc. Some of these parameters are compared with proposed values to verify that the exposure was taken as planned.

The "Generic Conversion" step repackages the raw science data, the proposal information, and the engineering values into standard FITS (Flexible Image Transport) files, either before or after collecting exposures into associations. Once exposures are converted into this standard format, the calibration tasks are fired up, producing the final products of the pipeline.

The final steps in the pipeline are delivering the data products to the Hubble archive, checking on successful completion of all tasks, and cleaning up the pipeline disks.

Certainly the Hubble science data pipeline is the most important OPUS-controlled pipeline at the Institute. Nevertheless, it is only one of seventeen being operated by the Archive, Catalogs, and Data Services Division (ACDSD). Other pipelines have been crafted to handle data receipt, archiving, Calibration Data Files, On-the-Fly Reprocessing (OTFR), and Engineering Telemetry analysis. As pipelines multiply here at the Institute, it is clear that OPUS has proven to be reliable, flexible, and extensible.

As demonstrated by experience with Hubble, FUSE, SIRTF, Chandra, Gemini, Integral, and other missions—and as reconfirmed by its selection by Celera Genomics—OPUS is not just a Hubble project. OPUS is a proven solution to a wide variety of operational problems. With OPUS, scientists spend more time pursuing science, understanding the peculiarities of their instruments, perfecting calibrations, and making breakthrough discoveries.

For more information about OPUS, see **http://www.stsci.edu/software/OPUS/**. Ω

### OPUS Named

The name "OPUS" grew out of the nomenclature of the original TRW-delivered ground system software for operating Hubble. When, in the early 1990s, we overhauled two systems—the Post Observation Data Processing System (PODPS) and the Observation Support System (OSS) — we needed a new name for their combination. We received many suggestions and culled through them with an eye to keeping the peace among the various interested—and opinionated—groups at the Institute. The winner was "OSS and PODPS Unified System" or "OPUS". Today, this acronym of acronyms is one of the last vestiges of the original TRW software.

## OPUS Software Licensed to Celera Genomics

The Association of Universities for Research in Astronomy, Inc. (AURA) has reached an agreement with Celera Genomics Group for them to use the OPUS software package developed at the Space Telescope Science Institute (STScI). Celera is an Applera Corporation business in Rockville, Maryland, which is currently collecting biological information to understand the human genome—"to read the book of life." The Institute originally developed OPUS to process astronomical data from the Hubble Space Telescope, and today many other space observatories and NASA projects use OPUS similarly. Celera, facing needs similar to astronomy but in the field of biology, is licensing OPUS to assist in the processing of their "bioinformatics" data.

"OPUS is an example of how the highly talented engineers working on the space program can invent products of practical benefit to such diverse enterprises as biological research, medicine, and industry," said Steven Beckwith, Institute Director. "We are delighted that the Hubble Space Telescope program produced this commercial benefit to complement its scientific research."

# Gravity's Lens

**Kailash C. Sahu,** *ksahu@stsci.edu*

The concept of gravitational lensing goes back to at least 1801,when the German scientist Johan Soldner postulated that the path of a ray of light passing close to a star would be bent by the star's gravity. However, Soldner's idea was based on classical Newtonian gravity, and his estimated deflection was only half the correct value predicted by Einstein's relativity. In the words of Einstein, "half of this deflection is produced by the Newtonian field of attraction [of the star], and the other half by the geometrical modification of space caused [by the star]." The ability of gravity to bend light rays means that a star, or even an entire galaxy, can form multiple images of a background source and thus act as a gravitational lens.

If the lens happens to be a galaxy or a cluster of galaxies, then the mass of the lens can be so large that the different images of the background source can take the form of distinct and resolved arcs. Figure 1 shows such an arc pattern as observed by the Hubble Space Telescope, caused by a cluster of galaxies. Since all the mass, visible or invisible, contributes to the gravitational effect causing these arc structures, they can be used as powerful probes to map the mass distribution within the cluster.

If the lens is a star—and this article mainly deals with this case—the image of the background star is split into two separate images. The angular separation of the two (micro) images is of the order of micro- to milliarcseconds (hence the term microlensing). The separation is generally too small to be resolved. But the lensing effect also amplifies the light, which can be readily observed. However, the chance of two stars lining up precisely enough to produce a microlensing event is very small. As Einstein put it, "there is no hope of observing such a phenomenon directly."

In 1986, Bohdan Paczynski pointed out that the advent of modern computer and detector technology should make it possible to monitor millions of stars simultaneously in order to find the extremely rare microlensing events. The best places to look for such events are the rich star fields of the Magellanic Clouds and the Galactic bulge. Such microlensing search programs were started by several groups in the early 1990's and quickly met with success. In 1993, three microlensing events were reported towards the Large Magellanic Cloud by the MACHO and EROS groups, and in the same year another event was detected towards the Galactic bulge by the OGLE group. Since then, microlensing survey groups have detected events in a steady stream. Today, they have detected more than 500 microlensing events towards the Galactic bulge and more than a dozen events towards the Magellanic Clouds.

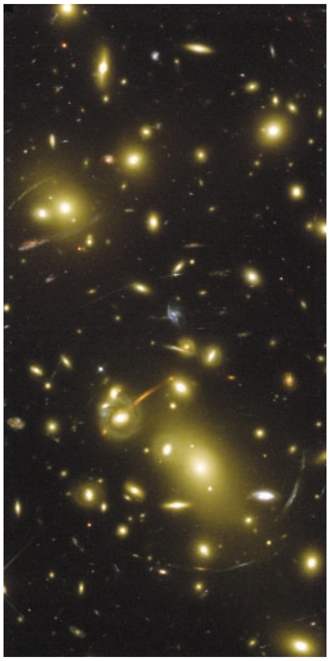


**Figure 1.** *Abell 2218 as observed by the Hubble Space Telescope.*

## The Nature of Dark Matter

The main objective of some of the microlensing search programs towards the Magellanic Clouds was to determine the nature of the dark matter in the Galactic halo—a subject that has remained a mystery for the past more than half a century. The two leading candidates for the dark matter have been the WIMPs (Weakly Interacting Massive Particles) and the MACHOs (Massive Compact Halo Objects), both of which would generally be invisible. However, if the dark matter is made up of MACHOs, they should cause microlensing of the background stars, which should be detectable by the microlensing search programs.

The number of microlensing events observed so far is however much smaller than what would be expected if the dark matter is entirely made up of MACHOs. To complicate the issue further, the simple microlensing light curves cannot tell us the location of the lenses along the line of sight because of a degeneracy between the distance, mass, and the proper motion of the lens. In a paper published in nature in 1994, I proposed that the stars within the Magellanic Clouds play a dominant role as lenses. Since then, there has been much controversy about the exact nature of the lenses, and in particular, whether the lenses are MACHOs in the halo or ordinary stars within the Magellanic Clouds. Direct determination of the location of the lenses in a few cases can potentially put this long-standing controversy to rest. Fortunately, if the lens is a binary, it provides us such an opportunity to determine directly the lens location.

A binary lens generally causes "caustics" which are lines of infinite magnifications in space. As the source passes over a caustic, the amplification rises suddenly producing a sharp peak in the microlensing light curve. The time taken by the source to cross the caustic provides a direct measure of the proper motion of the lens projected onto the source plane. If the lens is in the halo at a distance of ~15 kpc, then the time to cross the caustic would be of the order of half an hour, since the expected proper motion of the lens is about 200 km/s. If, on the other hand, the lens is within the Magellanic Clouds, the caustic crossing time is expected to be of the order of ten hours. Thus, monitoring a caustic crossing provides a powerful method to determine the location of the lens. Such an opportunity occurred in 1998 when a binary lens event was discovered towards the Small Magellanic Cloud (SMC).

The binary lens event, MACHO 98-SMC-1, was discovered by the MACHO collaboration. After the first caustic crossing was reported, the PLANET collaboration (more about which in the next section), with its 24-hour access to telescopes around the world, predicted a second caustic crossing and began monitoring this event, with a particular interest in fully sampling the second caustic crossing. The time for the caustic to cross was found to be ~8.5 hours, which demonstrated that the lens is within the SMC (Fig. 2). The result was further confirmed by the EROS, MACHO, and MPS collaborations, which also concluded that the lens is most likely within the SMC.

A few more such clear determinations of the lens locations will be very useful in clarifying the exact contribution of MACHOs, if any, to the dark matter in the halo.

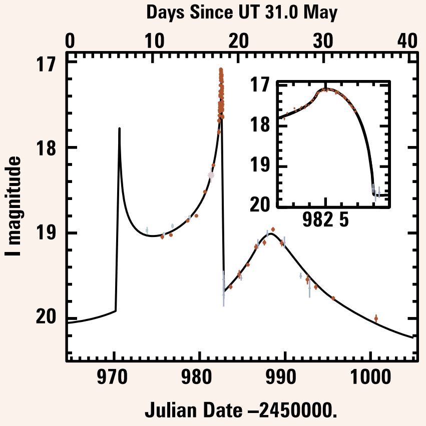


***Figure 2***. *Light curve of MACHO-98-SMC-1. The inset covers about 0.6 days, corresponding to less than one tick mark on the main figure. The fact that the source took about 8.5 hours to cross the caustic implies that the lens is within the Small Magellanic Cloud.*

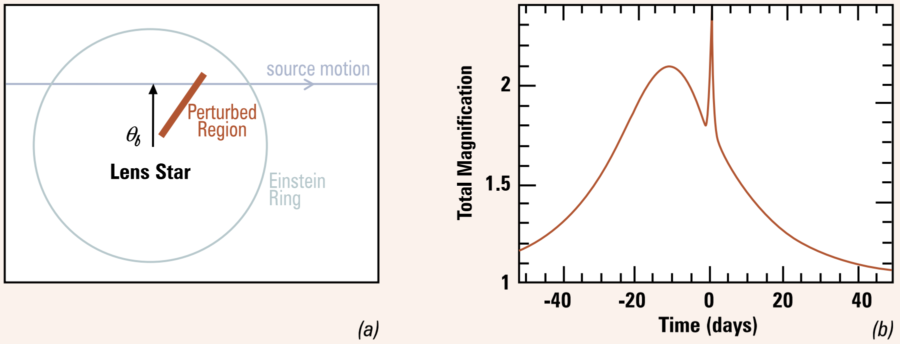
## *Search for Extra-Solar Planets*

If the lensing star has a planetary system—and most of the microlensing events towards the Galactic bulge are certainly caused by stars—then the effect of the planet is a sharp, extra peak in the microlensing light curve (Fig. 3). Detailed models by several authors show that, if every star has a Jupiter at a distance between 1 to 5 AU from the star, then 20% of the microlensing light curves should show a planetary signature with magnification larger than 5%. Thus, frequent monitoring of microlensing events provides a powerful method to find extra-solar planets. Indeed, microlensing is the only current method that is sensitive to Earth-mass planets.

The minimum duration of the extra feature due to the planet, to a first approximation, is the time taken by the source to cross a caustic, which can be about 1.5 to 5 hrs. The maximum duration of this feature is the same as the duration of an event caused by a single, isolated lens of planetary mass. Using a reasonable set of parameters (the lower mass of the planet is taken as that of the Earth, the higher mass is assumed to be that of Jupiter), the maximum duration will range from a few hours to a few days. Thus, one of the requirements for a monitoring program is the ability to monitor hourly so that the extra feature due to the planet is well sampled. Other requirements include 24-hour coverage and high photometric accuracy.

To meet this challenge, we began the PLANET (Probing Lensing Anomalies NETwork) collaboration in 1995. PLANET is a worldwide collaboration of astronomers with access to a set of four telescopes situated in Chile, South Africa and Australia. PLANET has now completed seven years of observing campaigns and has intensely monitored more than forty microlensing events, during which several binary events have been discovered and monitored.

**Continued page 34**



*(a)* *(b)*

***Figure 3.*** *The left panel schematically shows the geometry of the star-plus-planet lensing event and the right panel shows the resulting light curve. The mass of the planet is one thousandth the mass of the primary. As the source passes close to the lens, the two images formed by the primary move on opposite sides but close to the "Einstein ring" shown here. The planet is situated close to the Einstein ring.*

**Gravity's Lens from page 33**

No clear signatures of such planets have been detected. This implies that less than 1/3 of the lensing stars have Jupiter mass planets with orbital radii of 1.5-4 AU (Fig. 4). Since other planet-detection techniques have only begun to explore the outer portion of these orbital radii, PLANET observations provide the best current limits on extra-solar planets on wide orbits.

More information on the PLANET project can be found at **http://www.astro.rug.nl/~planet.**

## Microlensing Exotica

Over the past few years, gravitational microlensing has developed into an entire field of its own, and microlensing is being used as a tool in a variety of applications. I would like to end this article with two applications on which I have worked—the study of stellar structure and the determination of the mass function of low-mass objects.

The peak amplification in a microlensing event is a function of how close the source comes to the lens in the line of sight: the closer it gets, the higher is the amplification. Indeed, for high amplification microlensing events, there is a good chance that the lens actually passes across the face of the source star. Monitoring of such high amplification events thus provides an opportunity to use microlensing as an effective high angular resolution telescope, to resolve the source and derive its limb-darkening parameters. A caustic crossing offers a similar opportunity during which different parts of the source are amplified differentially. Three such microlensing events have been monitored by the PLANET collaboration. The sources are K-giants in the Galactic bulge, for which we have now determined limb-darkening parameters for these sources—the first for K-giants and the first for any stars so distant.

For most microlensing events—those towards Galactic bulge and the Magellanic Clouds—the distance to the lens is very uncertain, and, as a result, the observations cannot be used to determine the mass of the lens. However, in special cases, we can estimate the distances and motions of the lenses and the sources, in which case we can use the microlensing timescale to determine the mass of the lens. One such case is when a globular cluster observed against the dense stellar field of the Galactic bulge. Here, the probability is high that the lensing object is a member of the globular cluster, which means that the distances and kinematics of the lenses and the sources are well constrained. By monitoring about 80,000 stars in the direction of the globular cluster M22 with Hubble Space Telescope, we detected one well-resolved event with a timescale of about 18 days. The event is achromatic, as expected from microlensing. If this is a true microlensing event, the observed timescale would imply a lens mass of 0.13 solar masses. Since objects as small as planets can cause microlensing, this technique can be used to determine the mass function of low-mass objects down to planetary-mass objects. Ω

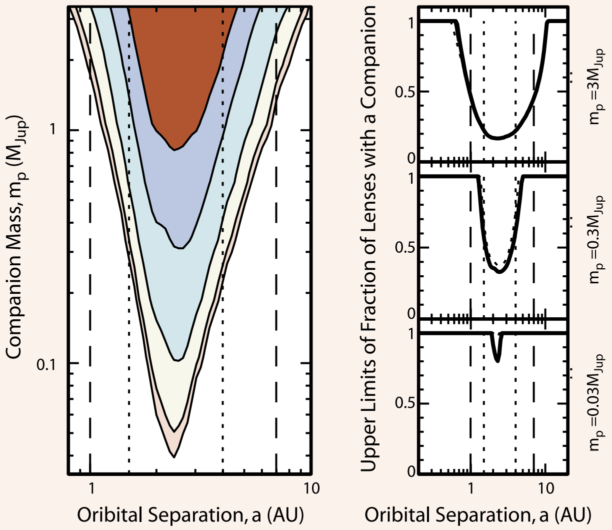


**Figure 4.** *Left panel: Planet exclusion contours as a function of planet mass and orbital separation. The solid black lines show exclusion contours of 75%, 66%, 50%, 33%, and 25% (outer to inner). Right panel: Horizontal cross-sections through the left panel. The curves show upper limits to the fraction of stars with planetary mass companions as a function of orbital separation.*

# Interview With John Bedke

*John Bedke has supervised the photo lab at the Space Telescope Science Institute since 1985.*

***John, you've had a long, interesting career in photography. How did you get started?***

As far back as I can remember, I've had a fascination with airplanes, and as I got into older childhood, I started taking pictures of airplanes. I was born in Pasadena, California and I grew up in that general area. I would go to the Ontario Airport, a little rural airport at the time. There was an Air National Guard wing there with jet fighters, and there were quite a few things I could get pictures of, even though I wasn't supposed to. There were signs posted everywhere, "No Photography," but I did anyway.

I used an old camera that belonged to my parents, a 1908 Brownie box camera No. 3, which used 120 film. This was in the summer of 1955. I was doing black-and-white imaging, which at that time was more common than color. I started doing darkroom work almost right away. About 1959, several single-lens reflex cameras were introduced to the marketplace from Japan, and that just revolutionized 35mm photography; at least for me. You could look through the lens of the camera while you were viewing the subject and focusing. I got a 35-millimeter camera and shooting slides, which in the fifties were much more common than now.

Photography was strictly a hobby for ten years. Then in 1965, I went into the U.S. Air Force as a photographer.

***Tell us about your experience in photoreconnaissance.***

You've seen those official U.S. Air Force photographs? At first, I was the one doing that, taking pictures of public affair events. I was lucky enough to get on flying status on occasion. I wish I could have done that more often—there's no thrill like going for a ride in a jet fighter in the back seat. A little bit later on, I was sent overseas to Udorn Royal Thai Air Base and put into a recon outfit that was flying RF4-C Phantoms. They carried six very large cameras, weighing 500 pounds each, at least.

The reconnaissance cameras were superb—made by Perkin-Elmer, the same people that made the Hubble telescope mirror. If there had been somebody on the ground you knew, you'd recognize them in the picture. The reconnaissance of today has not gotten any sharper—it was already diffraction limited back in those days. The only difference is the speed. Now it's essentially real-time, whereas in the sixties, it was on film that had to be developed and then examined by humans.

I processed the film and the guy next to me analyzed it. We looked at the film with slightly different interests. I was mainly making sure the process was still running correctly, because there was still film coming in. The photo intelligence guy would go, "Ah hah." And I would look and not see anything. He would say, "Look at the camouflage. There's a gun emplacement under that." Once he pointed it out, I could see it.

Astronomy and photoreconnaissance are very different, but the ability to pick up on something very subtle is incredibly good in both cases.

***You authored two atlases of galaxies with Allan Sandage at the Carnegie Observatories, where you worked in the photography lab. Tell us about your experiences there.***

When I left the Air Force, I started in 1970 with the Carnegie Observatories. At that time, photography was the primary data capture process in astronomy, and Kodak spectroscopic plates were the principal detector. I've used twenty-inch-square plates, the largest there are. Handling those plates in total darkness is physical labor. I think younger observers don't realize that—they have always worked in warm, well-lit data rooms, looking at a monitor with an auto-guided telescope. Those old-timers really worked in the cold and dark to get their data. And it was analog data; now, it's digital—a much better way to work!

When I started, some of the original staff members of Mt. Wilson were still around. Dr. Alfred Joy, was the oldest and the original secretary of Mt. Wilson Observatory, 1905, came into work every day. He was from a completely different era. Carnegie had a policy that if retired staff wanted to maintain their office, they were welcome—and they all did. It was a pleasure to be around these guys. I wouldn't say they were talkative; but if you would talk to them, they would certainly respond. I enjoyed listening to some of

**Continued page 36**

**Interview from page 35**

the stories of Mt. Wilson in the era of World War I, before the 100-inch went on line. The big telescope was the 60-inch, then the largest telescope in the world.

I was very fortunate to have known Ira S. Bowen. He had also been retired for a number of years. Occasionally I would have lunch and go for a walk with him. It was wonderful talking to him. He oversaw the construction of the Palomar 200 inch and was the director at the time. And to have actually known him—what an amazing thing. And then, people like Sandage were just magnanimous. They're icons when you get away from them. The same thing is happening here, though, with people who work right here at STScI. Because it's day in day out, it becomes so familiar that you almost lose that. You almost have to pinch yourself to recognize, "Where am I?" And it was that way at Carnegie, also. I probably would still be there if it hadn't been for a project of Hubble's scale coming along. I mean, why would I leave, right?

I've handled every photographic plate of Sandage—every one of them. Also Edwin Hubble, all of his plates.

My big break was being able to go observing. One day, Sandage happened to mention almost in passing that he had an observing run coming up, but the person he was going with had gotten sick at the last moment, and he didn't know how he was going to be able to handle that work load of the plate processing during the day and observing at night. I volunteered and got to go to the Palomar 200 inch. Very few people have been in the top of the 200-inch telescope up in the cage, but I have. It's like being in a submarine—great big wheels and stuff. I don't think anybody has actually been up to prime focus for many years. Today, with digital detectors installed, there's no reason to have a person there.

After that observing run with Sandage, the doors opened. Sometime later, a similar thing happened, somebody couldn't go to Las Campanas, Chile, where I went four times after that. I would operate the 100-inch du Pont telescope. Sandage simply gave me an observing list of the objects he needed, and I would acquire the target and do the observation.

The longest exposure I've ever done was five hours on a single object. That was exposing to red light, an O-9804 plate through a GG-610 filter. And that was a 20-inch plate. You would use a vacuum to bend those glass plates to fit the concave or convex focal plane. You would check the pressure gauge at the end of the exposure. If it was still the same, you hadn't broken the plate. I have never lost a finished plate on which time had been spent, but I've had plates break prior to exposing them.

***Sixteen years ago, you came to set up and operate our photo lab. How has photography at the Institute evolved and where is it heading?***

I wasn't sure what to expect when I came here. The photo lab was only an empty room. The raw plumbing was in, but the equipment wasn't there. It hadn't even been specified yet. They were kind of waiting for me to do that.

The Institute lab has more in common with a commercial lab than a scientific laboratory like Carnegie. The majority of images I see today are ones for the public outreach programs or the press releases. Typically, we produce hundreds of copies of the same image for a news release. We send the digital file from Hubble to a film recorder, which exposes a sheet of traditional film, which then we process and use to make traditional prints. It's hard to beat such a well-established technology in terms of bang for the buck.

Increasingly, digital techniques are replacing traditional photographic methods. For example, copy process cameras have completely gone away. We now use scanners or take a digital photograph. In my personal photography, I have gone to entirely digital printing. I had the traditional dark room with enlargers and chemical processing. I got rid of all that in 1997. Today, I use film and digital cameras, a computer, and an ink jet printer. The quality is so much better. The digital age gives you the ability to explore and try things. By the old means, you just couldn't make that many experiments. I am completely sold on digital.

***John, you and your wife Sharon have fostered over 180 unfortunate children, often with special needs. This was recently written up in the Washington Post.[1] How did this all come about? What advice would you have for readers who want to get similarly involved in their community?***

There was no grand scheme there. When we moved here, Sharon, my wife, and I considered adopting children. We looked into the process, which is very difficult. So we thought, "Well, we will still go ahead and do that. And in the interim, we will just do foster care." And, boy, is there ever a shortage of foster care parents—not nearly enough. That's why we've had so many children. There's also one other person here at the Institute that is doing this that I am aware of.

Foster care is meant to be a safe haven temporarily, until the problem is resolved and the children can be returned to the parents. Sometimes you can't resolve the problems, and some children legally become orphans and available for adoption. We've adopted six that way. Our first son is a birth child;

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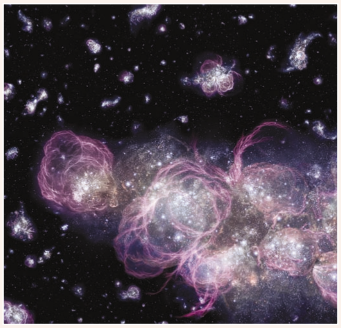
[1] *This article can be found on the "Washington Post" website at:* ***http://www.washingtonpost.com/wp-dyn/articles/A20229-2001May12.html***.

we have seven children altogether. Six are at home, with two more foster children, making eight in all at home. The foster children are ages one and two.

My wife Sharon is very active in a women's group, which works to do good things in the community. They raise money to then donate where it's needed—usually abused children or battered women. Sharon was inducted into the Women's Hall of Fame for Howard County for the year 2001 for this work. At the ceremony, it came up that we have had so many children. A reporter from the "Washington Post" just locked right into that and wrote the article.

For others who wish to get involved, just call the Department of Social Services of the county you live in. Just express what you are interested in, whether it be foster care or some other thing. As far as I know, every county is short on that kind of thing. There's a need, absolutely! Ω



***Science Credit:*** *NASA and K. Lanzetta (SUNY),*
***Artwork Credit:*** *A. Schaller for STScI*

# Stellar 'Fireworks Finale' Came First in the Young Universe

The deepest views of the cosmos from the Hubble Space Telescope yield clues that the very first stars may have burst into the universe as brilliantly and spectacularly as a fireworks finale. Except in this case, the finale came first, long before Earth, the Sun and the Milky Way Galaxy formed. Studies of Hubble's deepest views of the heavens lead to the preliminary conclusion that the universe made a significant portion of its stars in a torrential firestorm of star birth, which abruptly lit up the pitch-dark heavens just a few hundred million years after the "big bang," the tremendous explosion that created the cosmos. Though stars continue to be born today in galaxies, the star birth rate could be a trickle compared to the predicted gusher of stars in those opulent early years. **http://oposite.stsci.edu/pubinfo/pr/2002/02/.**

# Contact STScI:

The Institute's website is: *http://www.stsci.edu*

Assistance is available at *help@stsci.edu* or 800-544-8125. International callers can use 1-410-338-1082.

For current Hubble users, program information is available at: *http://presto.stsci.edu/public/propinfo.html.*

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SPACE TELESCOPE
European Coordinating Facility

# ST-ECF Newsletter

The Space Telescope - European Coordinating Facility publishes a newsletter which, although aimed principally at European Space Telescope users, contains articles of general interest to the HST community. If you wish to be included in the mailing list, please contact the editor and state your affiliation and specific involvement in the Space Telescope Project.

**Richard Hook *(Editor)***

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# The Lessons of X-ray Astronomy Applied to Hubble

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**& Rodger Doxsey,** *doxsey@stsci.edu*

*Adapted from an article in Exploring the Universe, A Festschrift in Honor of Riccardo Giacconi, H.Gursky, R.Ruffini & L.Stella, ed., World Scientific Publishing, 2000, p.327.*

Just before Memorial Day 1981, Riccardo Giacconi called together the senior staff of his High Energy Astrophysics Division at the Center for Astrophysics to announce that he had accepted an offer to become the founding director of the Space Telescope Science Institute (STScI). This close-knit group of X-ray astronomers was shocked. Many of them had worked with Riccardo since the 1960s. He was now the head of their division, the leader of their research group, and the long-term mentor of many present. In fact, the group was doubly stunned—by the news of his leaving and by his move into optical astronomy. In retrospect, this move seems obvious, both for "the father of X-ray astronomy" and for the optical-UV community that selected him for the great task of shepherding optical astronomy into space and conducting the science program of Hubble Space Telescope. Nevertheless, to his staff on that early summer day 20 years ago, it was all quite a surprise.

That year, Riccardo Giacconi swept from Cambridge to Baltimore on a tide of success in space and science. In the 1960s, he had become convinced that the X-ray domain, being characteristic of highly energetic physical processes, was essential to understanding many areas of astronomy and astrophysics. He became the visionary intelligence and executive for a progression of X-ray telescopes, from rocket-borne sensors to the Uhuru, Einstein, and future Chandra satellite observatories. By 1981, the results of X-ray astronomy had joined the mainstream of astronomy and—with non-X-ray astronomers using the Einstein Observatory through a guest observer program—so had its practice. It was a matter of faith in his X-ray group that these successes were rooted in Riccardo's concepts, principles, and ethics as a technical and scientific leader. Now they would be tested in a new arena, the development and operation of Hubble.


*Riccardo Giacconi was the first Director of STScI.*

The central concept in Riccardo's implementation of space astronomy was the scientist cast in the role of systems engineer as well as researcher. The scientist must ensure the ultimate performance of the observatory for science in an end-to-end sense, from proposal selection to observation to publication. For Hubble, such "science systems engineering" required a strong scientific research staff at STScI to engage all aspects of the project. Backed by an excellent technical and operational staff, Institute scientists would apply a rational approach to problems. They would provide the vitality of an active research environment. They would serve the astronomical community by representing it authoritatively to NASA and to the Hubble hardware and software contractors.

From long experience dealing with NASA and leading scientists, Riccardo approached Hubble with the highest regard for process and an ethic of ruthless intellectual honesty. With launch planned for 1985, STScI's influence would depend on sure-footed speed in penetrating the vast project, developing technical credibility, and asserting scientific authority.

As a starting point for the STScI staff, Riccardo realized that he needed to bring with him some of X-ray astronomy's proven expertise in space science operations and data systems. Thus, the first author of this story started commuting to Baltimore in June 1981, becoming STScI's second X-ray astronomer and first Chief Data and Operations Scientist. By the end of that summer, after assessing the true need for science operations expertise in the Hubble project, the second recruited a third X-ray astronomer, the second author, as his deputy.

One of the most exciting, sometimes daunting, aspects of being a staff member at STScI in 1981 was the realization that we were creating, essentially from scratch and nearly overnight, an organization destined to become one of the premier astronomy institutions in the world. Riccardo had not the slightest doubt about the position and essential nature of STScI.

> "Riccardo approached Hubble with the highest regard for process and an ethic of ruthless intellectual honesty."

To succeed, it must clearly become more than the purely operational unit that NASA was expecting, and it would necessarily have to achieve the scope envisioned by the National Academy's report, "Institutional Arrangements for the Space Telescope." This 1976 report, informally named for its chairman, Donald F. Hornig, recommended that STScI have substantial capacity and purview. It should, the report stated, fully engage the astronomy community, provide long-term guidance and support for Hubble science, carry out substantial technical activities and first-rank research, and become comparable in budget and manpower to other national astronomy facilities.

STScI produced its own first staffing plan and budget in December 1981. Even while the small staff got busy with immediate technical issues, Riccardo ensured that these management and cost proposals reflected long-range goals, including adequate research time for the science staff, research support facilities, graduate student programs, and realistic staffing estimates for operations, observing proposal solicitation and review, and user support. Riccardo understood that the very first proposals he submitted must reflect the outlines of the eventual Institute, even if they were guaranteed to be controversial.

Also in the winter of 1981/82, STScI began developing its own infrastructure for long-term operations, including administrative functions, computer services, and construction of a building. At times it seemed a little incongruous, writing about and budgeting for an organization of several hundred staff, when we could hold all-hands meetings in an old Hopkins physics department reading room, seated around one table. Meetings would get interrupted to send someone over to the new building site to quickly make some decision, as they were about to pour concrete. More than one procedure or process was invented on the fly the first time we found we needed it, but it was always based on logic and extrapolated from experience.

During the first year, the staff of the STScI took true ownership of the technical problems associated with science operations and found their independent voice representing all astronomers in Hubble Project deliberations. They began influencing the development of the ground system, defined the vision for the Guide Star Selection System and the Science Data Analysis System.

Many early official project meetings and reviews drew standing room only audiences, to see how the new guys on the project performed or fared (or to hear what outrageous idea they would suggest next.) The sense of invention—the enjoyment of participating in an adventure—came out frequently in one of Riccardo's common questions to us: "So what do you really want to do when you grow up?"

### Science System Engineering

Science system engineering involved looking at the entire system that was being developed—instruments, spacecraft, operations, calibrations, data systems, staffing—as a single system to do science. It was essential to look at the system from the standpoint of the end-users to understand what the operations staff and especially the astronomers would really need. Thus, if HST was supposed to be able to carry out moving target (planetary) observations, it was necessary to ask in detail how such observations would have to be carried out, then to look at the entire system and ask how each piece would do its part. In a project as big as Hubble, it was perhaps not surprising that some sub-systems would be built without full knowledge of how other subsystems would work. But it certainly was a surprise to find out that, although Hubble was expected to do first class planetary science, it would not be able to track planets!

A prime example of the science system engineering methodology brought from X-ray astronomy into the Hubble project was the establishment of the calibration database system. In high energy physics, the original discipline of many X-ray astronomers, devoting a great deal of attention to instrument calibration was taken for granted; exploring discovery space at the detection threshold of an instrument demanded a detailed understanding of instrumental characteristics. Riccardo's X-ray observatories were fully in keeping with this tradition. With the Einstein Observatory especially, a large effort was devoted to understanding mirror performance and calibrating the spatial and spectral response of the detectors—indeed, of the observatory as a whole. Equally important, software was developed for the pre-flight calibration of the observatory, which could later be used for the calibration of the science data itself. This level of attention to calibration was not originally envisioned in the Hubble program nor considered in scope. Nevertheless, STScI implemented a coherent program of observatory-level calibrations, adding to the instrument calibrations a set of standard star measurements, cross-calibrations, a set of software routines to be included in the data analysis system, and a database of calibrations to be included in the Hubble archive.

> "Not questioning a questionable decision was one of the worst sins."

Other examples of science system engineering emerged in reviewing the plans for operations, for planning and scheduling the telescope, and for selecting guide stars. For example, when the initial design for the planning and scheduling system was reviewed, it became apparent that, although the basic capabilities for entering observing proposals were incorporated, it would take some dozen keypunch operators working 24 hours a day to keep up. Thus, although subsystems might be built to meet their individual specifications, continuing attention to the overall system was necessary to meet the spirit of the requirements and to create an observatory that could actually be used.

Riccardo's attention to system engineering really paid off in the development of the guide star selection system. In reviewing the concept for target acquisition and guiding, we found that the plan called for digitizing individual areas of survey plates for each observation, to select guide stars for Hubble's fine guidance sensors to lock onto. This was impractical for several reasons. Placing the guide star selection process in line with planning and scheduling activities was a problem, because the availability of guide stars depends on the time of the observations, which is hard to know far in advance. Time-intensive scanning of small sections of thousands of survey plates in random order would lead to a nightmare of plate handling logistics and obvious risk. By looking at the entire process from the standpoint of what was really needed, it became clear that the answer was scanning all the plates in a well-defined order and creating a source catalog of potential guide stars over the entire sky. This catalog could then be referenced during the planning and scheduling process. This approach not only optimized science operations, it created a significant science resource in the Digitized Sky Survey and the Guide Star Catalog. These products, available via the Internet and on CD-ROMs, revolutionized ground-based and space-based astronomy, contributing to science projects and telescope operations around the world.

### Ruthless Intellectual Honesty

Riccardo insisted on an atmosphere of honesty and trust in the work environment. His original X-ray group was steeped in this tradition, and he made it an underpinning of STScI. The staff was asked to impose the same questioning approach to technical and programmatic tasks as they would to a research endeavor. This often led to conflict with other elements of the Hubble program. But by expecting serious debate on all issues, the pros and cons of the various approaches were thoroughly aired. Not questioning a questionable decision was one of the worst sins. This total respect for hearing all sides of an issue was combined with little respect for unfocused, academic deliberations—and zero respect for deceit, either of colleagues or of yourself. It was not uncommon to be told, "You're not thinking straight" —meaning you were indeed being heard and engaged in a communal decision making process. By the time a consensus was reached, nearly everyone owned the decision, and there was little confusion about what the decision was.

### The Ultimate Example

The culmination of the vision and methodology that Riccardo brought to Hubble was the process that led to the successful correction of the telescope's optical problem. Undistracted and undeterred by the system-wide depression and despair that followed the discovery of spherical aberration, STScI mobilized to attack it. The approach was to convene a "Strategy Panel" representing the best talent that could be assembled—astronomers, opticians, engineers, astronauts—to explore the broadest range of possible solutions. An atmosphere of honesty and trust was required. Nothing was too crazy to be considered. Science system engineering was applied, to look at all aspects of the problem, the system, and the potential solutions. The ultimate success of the approach is demonstrated with every Hubble discovery and every Hubble image that appears in the media.

### Vision

Riccardo Giacconi brought to Baltimore a vision of how to do science, how to attack problems, and how to build a cohesive group. This vision had enabled him and his X-ray group to become successful in X-ray astronomy. Applied to STScI, his vision dictated what the Institute had to do, how it had to function, and how to meet the needs of the community it had to serve. Such was the fortunate inheritance of one wavelength range from another. Ω

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| Phase 2 proposals due | | *February 15, 2002* |
| Budgets due | *(electronic)* | *March, 1 2002* |
| | *(paper)* | *February 22, 2002* |
| Routine observing begins | | *July 2002* |
| ***Servicing Mission 3B Launch*** | | *February 2002* |

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