JOHNS HOPKINS
U N I V E R S I T Y

Center for Astrophysical Sciences

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Title: A Proposal to Investigate Outstanding Problems in Astronomy

Period Covered: December 1, 2002 to November 30, 2003
P.I.: Holland Ford, Johns Hopkins University

During the past year the ACS science team has concentrated on analyzing ACS observations, writing papers, and disseminating our results to the astronomy community at conferences and workshops around the world. We also have put considerable effort in getting our results to the public via public lectures and through press releases. Taking a very broad view of our program, we are investigating the evolution of galaxies and clusters of galaxies from their birth, approximately one billion years after the beginning of the Universe, to the present. We have found and characterized a population of galaxies that are no more than 1.4 billion years old. These may well be the Universe's first generation of infant galaxies. Looking at the Universe 500,000 years later, we see what appears to be a cluster of galaxies just beginning to form (a proto-cluster) around a luminous radio galaxy. Moving forward in time and closer to the present, we are studying clusters of galaxies that are less than half the age of the Universe. Our observations and analysis lead us to the important conclusion that the elliptical galaxies in these clusters must have had their last significant star formation some three billion years earlier, which is about the time when the proto-cluster was forming. Coming still closer to home, we are observing nearby massive clusters of galaxies that are approximately 12 billion years old. The gravity from these large aggregates of dark and luminous matter is so strong it warps space-time itself, and makes the cluster act as a cosmic telescope that magnifies the distant galaxies behind the cluster. We used the magnified (or lensed) galaxies to map the distribution of the dominant matter within the clusters, which is the so-called dark matter (the matter is invisible, and its nature is unknown). We also are using these cosmic telescopes to study the distant lensed galaxies that would otherwise be too small and too faint to be seen even by Hubble and the ACS.

Within our home galaxy, the Milky Way, we have ACS coronagraphic observations of nearby stars that show new details in the dusty disks from which planets form. We may even see the "footprints" of a young planet in one of the disks. We are working on our first coronagraphic observations of the closest stellar system to the earth, Alpha Centaurus A and B, to see if we can detect a Jupiter-like planet. Although nature is unlikely to be so kind as to provide us with a detectable planet, we think the result would be so important for astronomy and the Hubble program that we are will to expend a modest number of orbits on this program. Even if we do not find a planet, we are demonstrating a new planet-searching technique that can be implemented in future space telescopes designed specifically to detect planets.

We have found that regular meetings of the ACS team are needed to insure that all of the important problems that can be addressed with our images are in fact being worked on by someone in the team. The team meetings also enable us to coordinate our work and bring scientists together where necessary to work on a particular problem, and to avoid duplication of

effort within the team. To this end we had two team meetings during the past year. The first was a meeting of those team members who are working on the evolution of galaxies and clusters of galaxies. The meeting was held at the Lorentz Center of the University of Leiden in the Netherlands, and was hosted by our two team members who are professors at the University (Miley, the department chair, and Franx). Four additional team members were resident in Europe at the time (Homier, Overzier, Rosati, and Zirm), and thus could easily attend the meeting. The meeting was viewed as scientifically successful by all of the participants. We had a second meeting of our entire team in early fall at the Aspen Physics Center in Aspen, Colorado. Both the Lorentz Center and the Aspen Physics Center are unusual in that both have conference rooms and offices where the participants can meet. We typically had meetings during the mornings, and small group discussions and work in the afternoons. The Aspen meeting was very successful in that informal groups and collaborations formed to carry out the research that we agreed needs to be carried out during the coming year.

Another important component of our research program is complementary and supporting observations made with the world's largest telescopes. As an example, deep ground based infrared observations are needed to discriminate between the first generation of galaxies and very dusty galaxies at half the age of the Universe. During the past year we used 8-m and 10-m telescopes in Hawaii and Chile to make observations to support our ACS program. We have developed a close collaboration with the Department of Astronomy, chaired by team member Leopoldo Infante, in the Pontificia Universidad Catolica in Santiago Chile. This collaboration is giving us access to the majority of the world's largest telescopes; further more, these telescopes on the western slopes of the Chilean Andes are at the world's best observing sites.

During the coming year four team members from Europe (Demarco, Mei, Miley, and Overzier) and one from Chile (Motta) will spend time at JHU to work with us on ACS observations.

One important aspect of science is training the next generation of scientists. At the present time we have six graduate students working with ACS team (Coe, Jee, Overzier, Rider, Sundar, and Zekser). Four of these students are already working on PhD theses that will be based on ACS data. Three of the theses deal with different aspects of gravitational lensing by clusters, and the fourth student is studying proto-clusters in the early Universe.

Attached at the end of this report is a summary of the observing programs that have been executed to date. The details of our scientific findings can be found in the papers listed elsewhere in this report that we have published in refereed journals.

Personnel:

During 2003, four new personnel joined the team at JHU, and one new hire (Holden) started at UCSC. In September, two assistant research scientists began. One (Goto) has expertise in clusters of galaxies and the other (Homier) in the area of star formation within galaxies. Two new graduate students also started in September and will be cutting their teeth on searches for active galaxies in ACS images (Rider) and a study of young stars and clusters in low surface brightness galaxies (Srinivasan).

A good portion of the year was spent searching for a software development project manager to oversee the integration of the ACS pipeline and ACS archive. In the end, we asked our current pipeline programmer to take on these new responsibilities and provide relief to the PhD astronomers who have been working in this role up until now. The search to replace the pipeline programmer is imminent. We had three scientists (Tsvetanov, Tran, and Sirianni) leave the team to take up positions at other facilities. We anticipate hiring two more postdoctoral fellows to begin in 2004.

Programming and Software Development:

Pipeline Programming Milestones:

The ACS pipeline group writes, manages, and runs the ACS GTO pipeline APSIS as well as the software needed to organize the input data and inspect the resultant output data. The pipeline group consists of K. Anderson (programmer), D. Magee (programmer), J. Blakeslee (scientist/programmer), N. Benitez (scientist/programmer), G. Meurer (scientist/manager), R. Bouwens, N. Cross (scientist), and F. Menanteau (scientist). In the past year the pipeline group has accomplished the following:

- 9 releases of APSIS up to version 2.3.4 addressing 25 separate enhancement requests and bug reports. Some of the major issues addressed include:
  - Incorporation of Galactic extinction calculation and correction.
  - Lanczos kernel interpolation in the final DRIZZLE product.
  - Cosmetic removal of amplifier step feature.
- Substantial development work towards the next major release (version 3.0) of Apsis pending in October or November of 2003.
- Creation of stand-alone script to do drizzling: QUCKDRIZ.
- Creation of a stand-alone script to improve the astrometry in the header of an image using a query to the HST Guide Star Catalog: FIXCRVALS. This task will be done as part of normal processing with APSIS under version 3.0.
- Full implementation of the program GROUPER which queries the Science Data Archive (SDA) and determines which data belongs together, primarily based on telescope pointing and the instrument plus detector combination. Subsequent enhancements to GROUPER allow parallel data to be grouped.
- Development and implementation of the "ACS Data Control Graphical User Interface" or ADCGUI. ADCGUI provides a graphical interface to GROUPER and APSIS, allowing the user to control the major aspects of the pipeline data flow including (1) logically grouping data in the SDA, (2) retrieving the data, (3) creating an APSIS job queue allowing APSIS jobs to be consecutively run.
- Full documentation of APSIS including a general description, module-level documents, an installation guide and a setup document. These are published under "Documentation" at http://acs.pha.jhu.edu/science/pipeline/development/
- Finally, Ken Anderson takes over the task of pipeline and SDA manager from Gerhardt Meurer and David Golimowski, starting mid October 2003.

Science Archive Milestones:

- Released several new versions of the ACS Science Data Archive (SDA) user interface:
  o v1.8 and v1.8.1 in March 2003
  o v1.8.2 in April 2003
  o v1.10 in June 2003
  o v1.10.1 in August 2003
  o v1.10.2 in September 2003
- Demonstrated SDA user interface for team members at JHU.
- Marshaled retrieval and ingest of ACS data from STScI and from GTO science data pipeline.
- Wrote SDA release notes and user guide for all major releases of the user interface.
- Some of the features added to the ACS Science Data Archive include:
  o A control panel in the Object Map that allows users to pan across three-color APSIS images with pixel bin settings of 1 to 8.
  o Form controls in the Object Map control panel for setting the dimensions of the field of view, overlaying Kron apertures, and inverting the color palette.
  o Function in the Object Map control panel which permits users to adjust the scaling of the image display ("stretch") or set the degree to which the intensity histogram is clipped before the image is displayed.
  o Option in the Object Map control panel to superpose a directional compass and pixel-scale bar on the image.
  o Function in the Object Map control panel which allows users to select the correspondence between filter images and the red, green, and blue channels of the color image map.
  o Ability to download Object Maps in PNG and PDF formats.
  o Caching scheme for previously viewed images (significantly reduces the time to redisplay the images and relieves the load off of the image server).
  o Conversion from circles to polygons for the footprints of large objects displayed in the Object Maps (minimizes interference with smaller objects in the Object Map).
  o External database query tool in the Object Summaries which searches for objects up to 10 arcmin from detected objects in the SIMBAD, NED, SDSS, MAST, and GSC2 databases.
  o Ability to download detection-image cutouts in FITS format from the Object Summaries and cutout array pages.
  o Default formats for Object Maps and color cutouts (or "postage stamp") images changed from PNG to JPEG.
  o Addition of extinction-corrected magnitudes (and errors) to the Object Summary pages and Photometry Catalog.
  o Filter magnitude and color constrained queries of the object catalogs are now supported.
  o Redesign of results display to show all the magnitude and/or color information available for the archive set(s) under examination.
  o Extensive section of example object-catalog queries compiled and published in the help section.

General Software Development and Management (Wm. J. McCann):

- Designed and implemented most of the functionality in the ACS Science Archive User Interface 1.6.x and 1.8.x releases.

- Continued to improve *fitscut* program that drives all the image functions in the ACS Science Data Archive and is used by team members to produce images and cutouts for papers and presentations.
- Put new, more powerful, and fully redundant workgroup server into production.
- Developed and started a Solaris to RedHat Linux workstation transition plan.
- Purchased and configured a powerful, dual 2.8GHz ACS Pipeline data processing system that uses RAID0 volume concatenation to maximize disk storage.
- Developed policies and customizations for new installations of RedHat Linux 8.0, RedHat Linux 9, Solaris 9, and very recently the, yet unnamed, next RedHat Linux release.
- Developed a new data recovery and security plan for users. This involves using RAID1 mirroring on all workstations that have more disk space than backup tapes can accommodate.
- Transitioned all computer equipment to a new IP address range.

Hardware:
- Installed and configured 7 workstations and 1 server
- Re-configured 25 workstations (includes hardware and/or OS upgrades)

JHU Travel:
- XVI Winter School of Astrophysics "Dark Matter and Dark Energy in the Universe" (18-29 November 2002, Canary Islands, Spain)
- University of Arizona colloquium talk on ACS (5 December 2002, Tucson, AZ)
- Gravitational Lensing Meeting (5-11 January 2003, Aussois, France)
- AAS Meeting (January 2003, Seattle, WA)
- Open Issues in Local Star Formation and the Early Stellar Evolution (5-10 April 2003, Ouro Preto, MG, Brazil)
- Observing: "Deep Infrared Imaging of ACS Fields: A Search for z > 7 Galaxies," Gemini North - NIRI, Mauna Kea Hawaii, 11-15 April 2003
- Observing: "Combining ACS and LDSS2: a Redshift Survey in the Abell 1689 Field," Las Campanas Observatory, 26-28 May 2003
- University of Wisconsin, talk on "Coronagraphic Observations of Debris Disks" (May 2003, Madison, WI)
- Observing: "Spectroscopy of Gravitational Arcs in One ACS Cluster," Gemini Observatory, May 2003
- Instituto de Astrofísica de Andalucia, Talk on "ACS Observations of A1689" (28 May 2003, Granada Spain)
- Instituto de Matemáticas y Física Fundamental, Talk on "ACS Observations of A1689" (30 May 2003, Madrid, Spain)
- Instituto de Física de Cantabria, Talk on "ACS Observations of A1689" (5 June 2003, Santander, Spain)
- Universidad del Pais Vasco, Talk on "ACS Observations of A1689" (4 June 2003, Bilbao, Spain)
- Arcetri Astronomical Observatory, talk on on ACS Performance (13 May 2003, Arcetri, Italy)
- Astronomical Observatory of Padova, (15 May 2003, Padova, Italy)
- ACS Clusters Group Team Meeting (25-29 May 2003, in Leiden, Netherlands)

- AAS Meeting (June 2003, Nashville, TN)
- Mykohos Multiwavelength Cosmology Conference (17-20 June 2003, Mykonos, Greece)
- IAU Meeting (July 2003, Sydney, Australia)
- SPIE Meeting (San Diego, CA)
- ACS Science Retreat Meeting (8-12 September 2003, Aspen, CO)
- ADASS Meeting (13-16 October 2003, Strasbourg, France)
- Search for Other Worlds Conference (13-15 October 2003, College Park, MD)
- STScI Calibration Meeting (October 17-18, 2002, Baltimore, MD)
- Spanish Astronomical Meeting (September 2003, Toledo, Spain)
- Observing: "Search for High Redshift Galaxies," Magellan Telescope, Chile
- University of Virginia colloquium talk on ACS (3 November 2003, Charlottesville, Virginia)

Accomplishments and on-going work of paid project personnel

SCIENTISTS

David Ardila, Ph.D., Astronomer
(100% FTE)

Observing Runs/Proposals
- Participated in the non-trivial task of selecting targets for Cycle 12 observations.

Papers/Talks/Posters
- Participated in the writing and analysis involved in "Hubble Space Telescope ACS Coronagraphic Imaging of the Circumstellar Disk around HD 141569A," (M. Clampin, first author) which appeared in AJ, 126, 385
- A popular science article for Scientific American on the "Vega Phenomenon," to appear in spring 2004
- "A Dynamical Model of HD141569," AJ (paper in preparation)
- January 2003, AAS Meeting, Seattle, WA, "The ACS Coronagraph" (poster)
- October 2003, Maryland Astrophysics Conference, College Park, MD: "A Dynamical Model of HD141569A" (poster)
- May 2003, U. Wisconsin, Madison, WI: "Coronagraphic Observations of Debris Disks" (talk)
- August 2003, National Astronomical Observatory, Bogota, Colombia: Workshop Circumstellar Disks (4 professional talks, one general public talk)

Narciso Benitez, Ph.D., Astronomer
(100% FTE)

Software Development/Operations
- Member of the pipeline team
- Mask design for several observing runs at Gemini, Magellan and Keck
- Supervised the work of graduate student Dan Coe
- Generated a new set of calibrated spectral templates that significantly improves the accuracy and reliability of photometric redshifts

- Determined, with extensive simulations, the optimal parameters and algorithms used to perform faint galaxy photometry and photometric redshifts.

Papers/Posters/Talks
- Benitez et al. "Faint Galaxies in Deep ACS Observations," ApJS, in press.
- January 2003, AAS Meeting, Seattle, WA: Press conference on 1689A.
- 28 May 2003, Instituto de Astrofísica de Andalucia, Granada, Spain: "ACS Observations of A1689" (talk)
- 30 May 2003, Instituto de Matemáticas y Física Fundamental, Madrid, Spain: "ACS Observations of A1689" (talk)
- 30 May 2003, Instituto de Física de Cantabria, Santander, Spain: "ACS Observations of A1689" (talk)
- 5 June 2003, Instituto de Física de Cantabria, Santander, Spain: "ACS Observations of A1689" (talk)
- 4 June 2003, Universidad del Pais Vasco, Bilbao, Spain: "ACS Observations of A1689" (talk)
- 24 September 2003, San Fernando, Cadiz, Spain: "ACS Observations of Galaxy Clusters" (talk)

John Blakeslee, Ph.D., Astronomer
(94% FTE)

Operations/Software Development
- Wrote python scripts ("pipeline") to generate postage stamp images and other input from an object catalog and image, then run "galfit" on all the postage stamps. Galfit performs 2-d parametric fits to get galaxy structural parameters, accounts for psf convolution, and simultaneously fits neighboring galaxies within the postage stamps.
- Wrote a standalone C program "bfclean" that implements the CLEAN image deconvolution algorithm; made scripts to run the program on arbitrary numbers of image postage stamps. This software was used for the published CL1252 analysis, the analysis of CL0152, and has been distributed to several team members for their purposes.
- Implemented and tested nonlinear "Lanczos3" drizzle kernel in Apsis using a new beta-version of drizzle from R. Hook; this kernel is now the default. Added options to set drizzle kernel, output pixel scale, and other parameters from Apsis command line.
- Added automatic detection and removal of residual (post-CALACS) amplifier bias discontinuities to Apsis.
- Completed testing and improvement of settings for cosmic ray rejection, sky subtraction, and output image size calculation including differential rotation among input images.
- Added an option (which has been made the default) to Apsis to flag areas of the final drizzled images which represent input from single 'flt' images, and not to catalog objects in these regions because they lack CR-rejection.

Papers/Talks/Posters
- Blakeslee et al. 2003, "Advanced Camera for Surveys Photometry of the Cluster RDCS1252.9-2927: The Color-Magnitude Relation at $z=1.24$," ApJ, 596, 143.
- Blakeslee et al. 2003, "Discovery of Two Distant Type Ia Supernovae in the Hubble Deep Field North with the Advanced Camera for Surveys," ApJ, 589, 693.

- July 2003, IAU, Sydney, Australia: "ACS Observations of Three High-Redshift Galaxy Clusters (talk)
- July 2003, IAU, Sydney, Australia: "Extreme Globular Cluster Systems" (talk)

**Nicholas Cross, Ph.D., Astronomer
(100% FTE)**

Software Development for Pipeline/Operations
- Wrote a code to give the extinction in each filter which Anderson incorporated into APSIS
- Edited the combFilter module, the detection Catalog module and the Catalogs module to produce a simple pipeline to run on Rychard's BUCS simulation output and produce catalogs.
- Finished writing the code to measure the half-light radius and Sersic parameter and compared the results against GALFIT
- Pipeline operator

Calibration (with Sirianni)
- Compared the photometry of stars in a globular cluster (NGC 104) in a crj image without drizzling but multiplied by the geometric distortion pixel map to a fully drizzled image

Data Analysis
- Worked with Postman and Blakeslee on morphologically classifying galaxies in the intermediate cluster program.

Papers/Talks/Posters
- "Evolution of Elliptical Galaxies in ACS-GTO Images" (paper in preparation) This looks at the space density of morphologically selected galaxies in 5 ACS fields: UGC10214, NGC4676, TN1338, TN0924 and the HDFN.

Observing Runs/Observing Proposals
- VLA Radio Proposal: With R. White, submitted a proposal to observe four intermediate redshift clusters at 6 cm on the VLA.

**David Golimowski, Ph.D., Astronomer
(100% FTE 12-01-02 to present)**

Operations
- Managed development of the IDT science data archive (SDA)
  o Released versions 1.8 in March 2003 and 1.10 in August 2003
  o Demonstrated SDA user interface to team members at JHU
  o Marshalled retrieval and ingest of ACS data from STScI archive and from GTO science data pipeline
  o Wrote SDA release notes and user guide
  o Attended and conducted planning meetings of science data pipeline and archive
- Selected and interviewed candidates for pipeline and archive management position

Observing Runs/Observing Proposals
- Assisted with the definition of the Cycle 12 observing plan for circumstellar disk targets.
- Planned successful HRC observations of L-dwarf binary LHS 102B

**Nicole Homeier, Ph.D., Astronomer
(100% FTE, 09-1-03 to present)**

Operations
- Created a webpage to list complementary (to ACS images) ground-based data from ACS team members

Data Analysis
- Analysis of ACS data of NGC3256; star cluster photometry
- Analysis of ACS intermediate-redshift cluster data; the spiral population in high density environments
- Analysis of ACS data of CL0152-1357; a strong lensing measurement of M/L for cluster ellipticals at z=0.8

Andre Martel, Ph.D., Astronomer
(70% FTE, 12-1-02 to 11-30-03)

Operations/Software Development
- Management, coordination, and updates to the ACS/GTO Phase 2 programs for Cycles 11 and 12.
- Continuing maintenance and updates to the ACS calibration Web pages

Data Analysis
- Phase 2 updates and analysis of the data of the ACS/GTO programs "Massive Black Holes in Early-Type Galaxies" and "Imaging of the Host Galaxy of 3C 273"

Observing runs and programs
- Co-I on ACS GO-9847 "The Structure and Physics of Extragalactic Jets" (Perlman et al.)
- Co-I on ACS GO-9814 "The Nature of the UV Excess in the Jet of 3C273" (Jester et al.)

Papers/Talks/Posters
- Martel et al. 2003, "Coronagraphic Imaging of 3C 273 with the Advanced Camera for Surveys," AJ, 125, 2964. (Results also presented as poster at AAS Seattle meeting and STScI press release 2003-03).
- Martel et al. "AGN Candidates in the Deep ACS Field of UGC 10214" (paper in preparation)
- Martel et al. "Emission-line Properties of Ten Nearby Early-Type Galaxies" (paper in preparation)

Felipe Menanteau, Ph.D., Astronomer
(100% FTE, 12-1-02 to 11-30-03)

Software Development
- Developed and wrote the software in used today by the pipeline group and pipeline operators to perform Quality Assessment (QA) of the data processed trough Apsis. It performs a number of tasks such as catalogs overlay over detection images, alignment and photometric check. It enables to check new datasets in only a matter if minutes. The software is written in Perl, and uses PDL and DS9 for image display.
- Wrote and implemented a stand alone python module that computes Central Concentration and Asymmetry parameters of ACS galaxies from the apsis products.

Observing Runs/Observing Programs

- May 26-28 2003: Las Campanas Observatory. "Combining ACS and LDSS2: a redshift survey in the Abell 1689 field," Infante, L., Benitez, N., Menanteau, F., Ford, H.
- May 2003: Gemini Observatory, "Spectroscopy of Gravitational Arcs in One ACS Cluster," Infante, L., Ford, H, Barrientos, F., Galaz, G., Benitez, N., Menanteau, F.

Papers/Posters/Talks

- Menanteau, et al. 2003, "Internal Color Properties of Resolved Spheroids in the Deep HST/ACS field of UGC 10214," ApJ, submitted
- Martel, A. Menanteau, F. et al. "AGN Candidates in the ACS Field of UGC 10214" (paper in preparation)
- June 2003, Multi-Wavelength Cosmology (Mykonos Island, Greece), "Resolving Spheroid Galaxies Using ACS/WFC Observations of UGC10214" (poster)
- January 2003, AAS, "Internal Color Properties of early-type galaxies on HST/ACS ERO UCG10214" (poster)

Gerhardt Meurer, Ph.D., Astronomer
(96% FTE)

Operations

- Coordination of the Dark Disk Galaxies program (9288).
- Continued role as pipeline manager through October 2003 (see pipeline group report).
- Representative on ACS STScI calibration working group.
- Pipeline plus SDA manager replacement selection.
- Student recruitment.

Papers/Talks/Posters

- Meurer et al. 2003, "Discovery of Globular Clusters in the Proto-Spiral NGC~2915: Implications for Hierarchical Galaxy Evolution," ApJ, submitted.
- Meurer et al. 2003, "Calibration of Geometric Distortion in the ACS Detectors, in The 2002 HST Calibration Workshop: Hubble after the Installation of the ACS and the NICMOS Cooling System," (STScI: Baltimore), S. Arribas, A. Koekemoer, and B. Whitmore, Eds., pp. 65-69 (poster paper).
- January 2003, AAS Meeting, Seattle, WA: "ACS Grism Spectra in the HDF-North" (poster)
- January 2003, AAS Meeting, Seattle WA: (with Tsvetanov, Z.I., Meurer, G.R., et al.) "ACS Grism Observations of Galaxy Clusters Abell 1689 and CL1252—2927" (poster)
- July 2003, IAU Symposium on Dark Matter in Galaxies, Sydney, Australia: "Dim Matter in the Dark Galaxy NGC 2915"

Marco Sirianni, Ph.D., Astronomer
(80%, FTE, 12-1-02 to 9-30-03)

Operations

- Led the effort to establish and publish the high level performance characteristics of the ACS. This task included:
  o the definition of a photometric system,
  o zeropoint calculation,
  o encircled energy and aperture correction measurement,

- o assessment of the impact of the red halo on aperture correction and zero point definition
- o Cómparison with existing data in the HST/WFPC2, ground Johnsons/Cousins and Sloan Digitized Sky Surveys (SDSS) photometric systems.
- o Evaluation of the color term for the transformation between the ACS and the other photometric systems.

Papers/Talks/Posters

- Analysis of GTO data from proposal 9300 of NGC1569 (paper in preparation)
- May 2003, Arcetri Astronomical Observatory, Arcetri, Italy: "The Advanced Camera for Surveys: performance and Early results" (talk)
- May 2003, Astronomical Observatory of Padova, Italy: "The Advanced Camera for Surveys: performance and Early results" (talk)
- May 2003, AAS Meeting, Nashville, TN "The photometric performance and calibration of ACS" (talk)
- August 2003, SPIE Meeting, San Diego, CA: "Performance of the CCDs of the Advanced Camera for Surveys after One Year in Orbit" (talk)

Hien Tran, Ph.D., Astronomer
(100% FTE, December 1, 2002 to January 11, 2003)

- Published the very first ACS paper, based on the ERO observations, Tran et al. 2003, ApJ (March Issue) (reported in previous annual report as "in press)
- Co-author with Ford et al. 2004 ACS and Keck Observations of the Tadpole Galaxy (paper in preparation)

Zlatan Tsvetanov, Ph.D., Astronomer
(100% 12-1-02 to 3-10-03)

- Before leaving Tsvetanov coordinated submission and follow-up of basically all GTO programs.

Wei Zheng, Ph.D., Astronomer
(50% FTE, 12-1-02-present)

Software Development
- carried out validation tests for the ACS Science Data Archive. The main purpose is to confirm that the data retrieved from the server match the actual catalog entries. A number of bug reports have been made, and the problems were then corrected.

Observing Runs/Observing Proposals
- In collaboration with Postman, Ford, Infante and other team members, he has proposed deep imaging photometry of the ACS fields with large ground-based telescopes. The purpose is to search for z-band dropouts which correspond to objects at redshift greater than 7. Data have been obtained from Gemini North and Magellan, and data reduction tasks are being developed.
- Wei Zheng also obtained archival GOODS data for the same search. Several potential candidates have been found, and follow-up observations are being proposed.

SYSTEMS/TECHNICAL SUPPORT

Terence S. Allen, Software Systems Specialist/Programmer
(100% FTE)

- Developed, implemented, and maintained several new features of the Science Data Archive (SDA) User Interface (UI).
- Provided end-user support and served as the contact point for any questions, problems, or suggestions for the SDA UI.
- Updated, maintained, and improved the data model as needed to support the release of new user interface features and ingestion of new data into the SDA.
- Performed database administration, configuration, and maintenance tasks as required for the SDA.
- Established release procedures to follow for all new releases of the SDA UI.
- Provided technical input to management for planning, feature, schedule, and release decisions affecting SDA activities as needed.
- Attended and participated in a poster presentation of the user interface at the 2003 ADASS conference.

Kenneth Anderson, Sr. Programmer/Analyst
(100% FTE)

- Consulted with ACS scientists to continue designing, developing and implementing a data processing/analysis software system for science team data
- Implemented, assembled and tested the software system to ensure integrity and robustness
- Pipeline Team member
- Worked throughout the fall and winter of 2002/2003 continued on Apsis and the new grouping software (Grouper). This code allows the ACS team to query the ACS Science Data Archive (SDA) and create logically grouped data easily, automatically, and consistently. Soon to follow was a fully integrated graphical user interface, called ADCgui, which not only allows a user easy access to running Grouper and creating datasets for Apsis processing but also to send a number of Apsis jobs to a job queue which can then be controlled by the user. New jobs can be added as Apsis jobs run in the background. The gui also displays to the user the final output datasets which are produced by Apsis. This work was presented at the ADASS XIII meeting, Oct 12-15, 2003.
- 9 releases of Apsis to production with the current version standing at v2.3.4, addressing 25 separate Bugzilla issues.
- 13,000 lines of code in current development version of Apsis (v2.3.4) in 11 package modules and 10 utility modules.
- Implementation of the Grouper module and the ACS Data Control graphical user interface (ADCgui).
- 4000 lines of code in Grouper and the ADCgui in 17 modules.
- Major effort to fully document Apsis with Apsis module-level documents, an installation guide and a setup document. Also published is a General Description Document for Apsis.
- CVS expertise for revision management of pipeline software and supporting files (DTDs, etc.)

Alex Framarini, Systems Manager
(100% FTE).
- Assisted with installation of hardware and software
- Provides user support
- Maintains printers
- Coordinates computing supplies ordering and set ups.

Wm. Jon McCann, Senior Systems Manager
(100% FTE)

In addition to items listed in Software and Hardware Development above ...
- Organized meetings with local science team members to discuss improvements to the ACS Science Archive. Developed plans and implementations for many of the ideas that were discussed.
- Supported a mixed architecture of UNIX-based workstations.
- Ensured the operational integrity of the computer facility and data processing systems including hardware and software installation and integration
- Continued to define incompatibilities, weaknesses, and possible points of failure in all computing systems and develop emergency recovery plans.
- Implemented solutions to ensure both computer and data security.
- Maintained world wide web (WWW) services for the team web site.
- Managed computer hardware and software contracts, warranties, and licenses.
- Maintained hardware and software inventory databases.
- Maintained a work/issue request database.
- Developed software tools to automate standard and routine systems management tasks.
- Performed user account and disk use management.
- Performed data backups for all critical project systems.
- Managed network service databases (NIS+, DNS, host tables)
- Kept abreast of latest releases of 250+ software packages; obtained updates as needed; performed software installations; configured packages to meet the needs of the group.
- Conducted product evaluations and provide recommendations on software needs.

STUDENT SUPPORT

Dan Coe, Graduate Student
(100% FTE)

Data analysis/Software Development
- Performing BPZ analysis of Abell 1689 using ACS + ground-based UBVRIZJHK images
- SExSeg: developed and testing a new program to:
  o allow SExtractor to import a segmentation map
  o create PSF-matched isophotal apertures, yielding robust colors
Observing Programs/Observing Runs

- April 11-15, 2003, Gemini North - NIRI, Mauna Kea Hawaii: "Deep Infrared Imaging of ACS Fields: A Search for z > 7 Galaxies"
  - created Phase II observation script, went on observing run
  - Found z-dropout candidates and performed SExSeg photometry

Papers/Talks/Posters
- Helped with Tom Broadhurst's A1689 strong lensing paper by creating images and performing SExSeg arc photometry and BPZ (paper in preparation)
- January 5-11, 2003: Gravitational Lensing Conference, Aussois, France: "Deep ACS and Keck Observations of Abell 1689" (poster)
- January 2004, AAS Meeting, Atlanta, GA: "Bayesian Photometric Redshift Analysis of Deep ACS and Ground-based Imaging of Abell 1689" (poster in preparation)

Myungkook Jee, Graduate Student
(100% FTE)

Data Analysis and Software Development
- Photometric Calibration of ACS
  - Created updated on-orbit CCD throughput curves for WFC and HRC to be adopted as official STScI release of ACS sensitivity table in SYNPHOT
  - Determined the photometric transformation parameters from ACS to WFPC2 and Johnson BVRI
  - Theoretical isochrone fitting on NGC2419 and 47 Tuc CMD
- Weak Lensing Analysis
  - Completed shapelet decomposition code
  - Completed direct mass profile reconstruction code from shear data
  - PSF analysis of WFC using 47 Tuc
  - Working on Maximum-Likelihood mass reconstruction code

Papers/Talks/Posters
- January 2003, AAS Meeting, Seattle, WA: "The Photometric Calibration of the Advanced Camera for Surveys" (poster)
- January 2003, AAS Meeting, Atlanta, GA: "Preliminary Weak Lensing Analysis on CL0152 and CL1056" (poster in preparation)

Sundar Srinivasan, Graduate Student
(100% FTE)

- First-year graduate student getting oriented to the software

Sundar Srinivasan, Graduate Student
(100% FTE)

- assisting in the analysis of grism data particularly in the Hubble Deep Field North. His project is to assess the best ways to identify interesting sources and determine their redshift.

Kerry Zekser, Graduate Student
(100% FTE at JHU 12-1-02 to 05-30-03; then at STScI working for ACS; 6-1-03 to present)

Data Analysis and Software Development
- Advancement of cluster lens modeling software
- Development of source reconstruction software to reconstruct background objects imaged by the cluster lenses
- NIRI data processing of cluster and brown dwarf data

Observing Runs/Observing Proposals
- April 11-15, 2003, Gemini North - NIRI, Mauna Kea Hawaii: "Deep Infrared Imaging of ACS Fields: A Search for $z > 7$ Galaxies"

Papers/Posters/Talks
- Broadhurst et al. 2004, "Strong Lens Analysis of Abell 1689," ApJ (paper in preparation)
- Zekser et.al. 2004 ApJ (paper in preparation)
- Blakeslee et.al. 2004, "Gravitational Lensing Analysis of a Field Galaxy Lens from the NICMOS UDF ACS-Parallel Observations," ApJ Letter (paper in preparation)
- A1689 Catalog, (paper in preparation)
- January 5-11, 2003, Gravitational Lensing Conference, Aussois, Savoie, France
- May 26-29, 2003, ACS Team Meeting, Leiden, Netherlands: "First Observations of Clusters with the Advanced Camera for Surveys of the Hubble Space Telescope" (talk)

Other
- Graduate Board Oral Exam, graduate qualifier scheduled 5 November 2003

ADMINISTRATIVE SUPPORT

Sharon Busching, Technical Administrative Assistant
(85% FTE, 12-1-02 to 9-30-03, 75% 10-1-03 to present)

- Coordinated second annual ACS science retreat meeting
- Ordered and performed follow-up where necessary on equipment, supplies purchases, and maintenance contracts
- Implemented searches for postdoctoral staff and software development manager
- Balanced monthly project budget statements
- Coordinated office space, supplies and payroll for new personnel

ACS RESULTS IN REFEREED PUBLICATIONS SINCE LAST REPORT:

For a list of all papers visit acs.pha.jhu.edu/science/papers

1. Benitez, N., Ford, H., Bouwens, R., Menanteau , F., Blakeslee, J., Gronwall, C., Illingworth, G., Meurer, G., Broadhurst, T.J., Clampin, M., Franx, M., Hartig, G.F., Magee, D., Sirianni, M., Ardila, D.R., Bartko, F., Brown, R.A., Burrows, C.J., Cheng, E.S., Cross, N.J.G., Feldman, P.D., Golimowski, D.A., Infante, L., Kimble, R.A., Krist, J.E., Lesser, M.P., Levay, Z., Martel, A.R., Miley, G.K., Postman, M., Rosati, P., Sparks, W.B., Tran, H.D., Tsvetanov, Z.I., White, R.L. and Zheng, W. 2003, **Faint Galaxies in Deep ACS Observations**, ApJS, in press.

2. Blakeslee, J.P., Franx, M., Postman, M., Rosati, P., Holden, B.P., Illingworth, G.D., Ford, H.C., Cross, N.J.G., Gronwall, C., Benitez, N., Bouwens, R.J., Broadhurst, T.J., Clampin, M., Demarco, R., Golimowski, D. A., Hartig, G. F., Infante, L., Martel, A. R., Miley, G. K., Menanteau, F., Meurer, G.R., Sirianni, M., White, R. L. 2003, **Advanced Camera for Surveys Photometry of the Cluster RDCS1252.9-2927: The Color-Magnitude Relation at z=1.24**, ApJ, 596, 143.

3. Blakeslee, J.P, Tsvetanov, Z.I., Riess, A.G., Ford, H.C., Illingworth, G.D., Magee, D., Tonry, J.L., Benitez, N., Clampin, M., Hartig, G.F., Meurer, G.R., Sirianni, M., Ardila, D.R., Bartko, F., Bouwens, R., Broadhurst, T., Cross, N., Feldman, P.D., Franx, Marijn, Golimowski, D.A., Gronwall, C., Kimble, R.A., Krist, J., Martel, A.R., Menanteau, F., Miley, G., Postman, M., Rosati, P., Sparks, W., Strolger, L.-G., Tran, H.D., White, R.L., and Zheng, W. 2003, **Discovery of Two Distant Type Ia Supernovae in the Hubble Deep Field North with the Advanced Camera for Surveys**, ApJ, 589, 693.

4. Bouwens, R.J., Illingworth, G.D., Broadhurst, T., Franx, M., Rosati, P., Lidman, C., Ford, H.C., Magee, D., Benitez, N., Blakeslee, J.P., Meurer, G.R., Clampin, M., Hartig, G.F., Ardila, D.R., Bartko, F., Brown, R.A., Burrows, C.J., Cheng, E.S., Cross, N., Feldman, P.D., Golimowski, D.A., Gronwall, C., Infante, L., Kimble, R.A., Krist, J.E., Lesser, M.P., Martel, A.R., Menanteau, F., Miley, G.K., Postman, M., Sirianni, M., Sparks, W.B., Tran, H.D., Tsvetanov, Z.I., White, R.L., and Zheng, W. 2003, **Star Formation at Z~6: i-dropouts in the ACS GTO Fields**, ApJ, 595, 589.

5. Clampin, M., Krist, J.E., Ardila, D.A., Golimowski, D.A., Hartig, G.F., Ford, H.C., Illingworth, G.D., Bartko, F., Benitez, N., Blakeslee, J.P., Bouwens, R., Broadhurst, T.J., Brown, R.A., Burrows, C., Cheng, E., Cross, N., Feldman, P.D., Franx, M., Gronwall, C., Infante, L., Kimble, R.A., Lesser, M., Martel, A.R., Menanteau, F., Meurer, G.R., Miley, G., Postman, M., Rosati, P., Sirianni, M., Sparks, W.B., Tran, H.D, Tsvetanov, Z.I., White, R.L., and Zheng, W. 2003, **HST/ACS Coronagraphic Imaging of the Circumstellar Disk around HD 141569**, AJ, 126, 385.

6. Martel, A.R., Ford, H.C., Tran, H.D., Illingworth, G.D., Krist, J.E., White, R.L., Sparks, W.B., Gronwall, C., Cross, N.J.G., Hartig, G.F., Clampin, M., Ardila, D.R., Bartko, F., Benitez, N., Blakeslee, J.P., Bouwens, R.J., Broadhurst, T.J., Brown, R.A., Burrows, C.J., Cheng, E.S., Feldman, P.D., Franx, M., Golimowski, D.A., Infante, I., Kimble, R.A., Lesser, M.P., McCann, W.J., Menanteau, F., Meurer, G.R., Miley, G.K., Postman, M., Rosati, P., Sirianni, M., Tsvetanov, Z.I., and Zheng, W. 2003, **Coronagraphic Imaging of 3C 273 with the Advanced Camera for Surveys**, AJ, 125, 2964.

7. Menanteau, F., Ford, H.C., Illingworth, G.D., Sirianni, M., Blakeslee, J.P., Meurer, G.R., Martel, A.R., Benitez, N., Postman, M., Ardila, D.R., Bartko, F., Bouwens, R.J., Broadhurst, T.J., Brown, R.A., Burrows, C.J., Cheng, E.S., Clampin, M., Cross, N.J.G., Feldman, P.D.,

Franx, M., Golimowski, D.A., Gronwall, C., Hartig, G.F., Infante, L., Kimble, R.A., Krist, J.E., Lesser, M.P., Miley, G.K., Rosati, P., Sparks, W.B., Tran, H.D., Tsvetanov, Z.I., White, R.L., and Zheng, W. 2003, **Internal Color Properties of Resolved Spheroids in the Deep HST/ACS Field of UGC 10214**, ApJ, submitted

8. Meurer, G.R., Blakeslee, J.P., Sirianni, M., Ford, H.C., Illingworth, G.D., Benitez, H., Clampin, M., Menanteau, F., Tran, H.D., Kimble, R.A., Hartig, G.F., Ardila, D.R., Bartko, F., Bouwens, R.J., Broadhurst, T.J., Brown, R.A., Burrows, C.J., Cheng, E.S., Cross, N.J.G., Feldman, P.D., Golimowski, D.A., Gronwall, C., Infante, L., Krist, J.E., Lesser, M.P., Martel, A.R., Miley, G.K., Postman, M., Rosati, P., Sparks, W.B., Tsvetanov, Z.I., White, R.L., and Zheng, W. 2003, **Discovery of Globular Clusters in the Proto-Spiral NGC 2915: Implications for Hierarchical Galaxy Evolution**, ApJL, submitted.

9. Miley, G.K., Overzier, R.A., Tsvetanov, Z.I., Bouwens, R.J., Benitez, N., Blakeslee, J.P., Ford, H.C., Illingworth, G.D., Postman, M., Rosati, P., Rottgering, H.J.A., Venemans, B.P., Zirm, A.W., Broadhurst, T.J., Ardila, D.A., Bartko, F., Brown, R.A., Burrows, C.J., Cheng, E.S., Clampin, M., Cross, N.J.G., De Breuck, C., Feldman, P.D., Franx, M., Hartig, G.F., Golimowski, D.A., Gronwall, C., Infante, L., Martel, A.R., Menanteau, F., Meurer, G.R., Sirianni, M., Kimble, R.A., Krist, J.E., Sparks, W.B., Tran, H.D., White, R.L., and Zheng, W. 2003, **Discovery of a Population of Lyman Break Galaxies in the Most Distant Known Protocluster**, Nature Letter, in press.

TALKS:

1. Blakeslee, J.P. et al. 2003, ACS **Observations of Three High-Redshift Galaxy Clusters**, 25th Meeting of the IAU, The Cosmic Cauldron, Joint Discussion 10, 18 July 2003, Sydney, Australia (talk).

2. Blakeslee, J.P. et al. 2003, **Extreme Globular Cluster Systems**, 25th Meeting of the IAU, Extragalactic Globular Clusters and their Host Galaxies, Joint Discussion 6, July 2003, Sydney, Australia (talk).

3. Ford, H. et al., **The Advanced Camera for Surveys: Performance and Early Results**, Colloquium at University of Arizona, December 2002, Tucson, AZ

4. Ford, H. et al. **The Advanced Camera for Surveys: Performance and Early Results** Baltimore Astronomical Society, March 2003, Baltimore, MD

5. Ford, H. et al. **The Advanced Camera for Surveys: Performance and Early Results** Johns Hopkins University Department of Physics and Astronomy Colloquium, March 2003, Baltimore, MD

6. Ford, H. et al. **The Advanced Camera for Surveys: Performance and Early Results**, STScI Colloquium, March 2003, Baltimore, MD

7. Ford, H. et al. **Early Results from the ACS Science Team: The Evolution of Galaxies and Clusters of Galaxies from z ~ 6 to the Present,** Colloquium at University of Virginia, November 2003, Charlottesville, VA

8. Sirianni, M., De Marchi, G., Gilliland, R., Jee, M.K., Mack, J., Ford, H.C., Illingworth, G.D., Clampin, M., Hartig, G., Cross, N., the ACS Science Team and the STScI ACS Team, 2003, **The Photometric Performance and Calibration of ACS**, AAS, 202, 1701 (talk).

9. Sirianni, M. 2003, **The Advanced Camera for Surveys: Performance and Early Results**, 13 May 2003, Arcetri Astronomical Observatory, Italy (talk).

10. Sirianni, M. 2003, **The Advanced Camera for Surveys: Performance and Early Results**, 15 May 2003, Astronomical Observatory of Padova, Italy (talk).

11. Sirianni, M. 2003, **Performance of the CCDs of the Advanced Camera for Surveys after One Year in Orbit**, 48th Annual SPIE Meeting, 3-8 August 2003, San Diego, CA (talk).

ABSTRACTS/POSTERS:

1. Allen, T. and McCann, Wm. J. 2003, **The ACS Science Data Archive**, Astronomical Data Analysis Software and Systems Conference, 12-15 October 2003, Strasbourg, France.

2. Anderson, K.R., Magee, D., and Blakeslee, J.P. 2003, **The Advanced Camera for Surveys: Apsis and the ACS Data Control Graphical User Interface**, Astronomical Data Analysis Software and Systems Conference, 12-15 October 2003, Strasbourg, France.

3. Ardila, D.A., Lubow, S.H., Krist, J.E., Golimowski, D.A., Clampin, M., Hartig, G.F., Ford, H.C., and Illingworth, G.D. 2003, **A Dynamical Model of the Debris Disk Around HD141569**, AAS, 203, submitted

4. Clampin, M., Ford, H.C., Illingworth, G.D., Hartig, G., Ardila, D.R., Benitez, N., Blakeslee, J.P., Bouwens, R.J., Cross, N.J.G., Feldman, P.D., Golimowski, D.A., Martel, A.R., Menanteau, F., Meurer, G.R., Sirianni, M., Sparks, W.B., Tran, H.D., Tsvetanov, Z.I., Zheng, W., White, R.L., Brown, R.A., Burrows, C.J., Krist, J.E., Postman, M., Sparks, W.B., Bartko, F., Broadhurst, T.J., Cheng, E.S., Kimble, R.A., Franx, M., Miley, G.K., Gronwall, C., Infante, L., Lesser, M.P., and Rosati, P. 2003, **Science Highlights from the First years of Advanced Camera for Surveys**, AAS, 202, 1702.

5. Coe, D., Benitez, N., Broadhurst, T.J., Zekser, K.C., White, R.L., Frye, B., Ford, H.C., Illingworth, G.D., and the ACS Team 2003, **Bayesian Photometric Redshift Analysis of Deep ACS & Ground-based Imaging of Abell 1689**, AAS, 203, submitted.

6. Cross, N., Benitez, N., Gronwall, C., Blakeslee, J.P., Menanteau, F., Bouwens, R., and the ACS Science Team, **The Space Density of Field Galaxies in the ACS-GTO Images**, Maps of the Cosmos, IAU Symp. 216, 14-17 July, 2003, Sydney, Australia

7. Golimowski, D.A., the NICMOS Nearby Star Survey Team, and the ACS GTO Team 2003, **Discoveries of Faint Companions to Nearby Stars with HST**, AAS, 203, submitted.

8. Jee, M., White, R.L., Ford, H.C., Benitez, N., and Illingworth, G.D. 2003, **Weak Lensing Analysis of Two z~0.8 Clusters with Advanced Camera for Surveys**, AAS, 203, submitted.

9. McCann, Wm. J. and Allen, T. 2003, **The ACS GTO Data Archive Tools**, Astronomical Data Analysis Software and Systems Conference, 12-15 October 2003, Strasbourg, France.

10. Menanteau, F. and the ACS Science Team, 2003, **Resolving Spheroid Galaxies Using ACS/WFC Observations of UGC10214**, Mykonos Multiwavelength Cosmology Conference, 17-20 June 2003, Mykonos, Greece.

11. Meurer, G.R., Blakeslee, J.P., Ford, H.C., Illingworth, G.D., Freeman, K.C., Bland-Hawthorn, J., Allen, R.J., Sirianni, M., Clampin, M., Kimble, R., and the ACS Science Team, 2003, **Dim Matter in the Dark Galaxy NGC 2915**, XXV Gen'l Assembly of the IAU, 13-16 July 2003, Sydney, Australia.

12. Zekser, K.C., White, R.L., Broadhurst, T.J., Benitez, N., Ford, H.C., Coe, D., and the ACS Science Team 2003, **Strong Lens Modeling of Advanced Camera for Surveys Observations of Abell 1689**, AAS, 203, submitted.

SUBCONTRACTS

Bartko Science and Technology
P.I. of subcontract: Frank Bartko

Accomplishments:
- participated in the ACS Science Workshop in Leiden.
- prepared and delivered a presentation for the ACS Aspen Science Workshop: "Galaxy mergers in 2 Clusters at $z=0.83$".

On-going work toward specific goals:
- The larger goal: working with Holland Ford and Marc Postman on the ACS Cluster Data Set to investigate the spatial, color, and frequency characteristics of mergers over a broad range of redshifts.
- A smaller goal: working with Marc Postman and Holland Ford to compare/contrast the merger characteristics in 2 clusters with a nearly identical redshift of $z=0.83$.

Relevant Papers/Reports submitted, in-press and in preparation:
- Paper in preparation on Comparison of Galaxy Merger Characteristics in 2 Clusters at $z=0.83$.
- Paper in preparation on Galaxy Mergers as a Function of Redshift.

Purchases/Expenditures Charged to Grant:
- Travel to ACS Science Workshop in Leiden, Netherlands
- Travel to ACS Science Workshop in Aspen, Colorado
- Travel to JHU, Baltimore, MD to collaborate with ACS Science Team members

University of California, Santa Cruz
P.I. of subcontract: Garth Illingworth

Personnel:

Postdoc, Rychard Bouwens, and Research Associate/Programmer, Dan Magee were fully supported by the ACS program during FY03. Postdoc Brad Holden came into the program in the middle of the year as a fully supported researcher. Graduate student Kim-Vy Tran moved on to a new position, but is still working with the team on some of the cluster programs, particularly MS1054.

Major activities:

This year was the first full post launch year, and it was great to see the remarkable data produced by the ACS. The deputy-PI continued his extensive support for the program, working closely with the PI to ensure that the science program will meet its objectives. With the successful launch of the ACS early in 2002 the effort of the Santa Cruz group focused first on data calibration issues, and then on exploring and recovering science from the first series of science images, particularly from the ERO data and the first cluster program results.

The deputy-PI continues to work closely with the PI in defining and supporting the program, and working with the science team members to help set the broad direction of the ACS GTO science program.

The team members have contributed as follows:

Rychard Bouwens continued the development of his cloning software which handles the projection of lower redshift samples to higher redshifts. This software has been valuable for making accurate comparisons across redshift space, where differences in the PSF, pixelization, surface brightness dimming, and effective rest-frame wavelength are all present. He has also extended the usefulness of this software to produce catalogs and redshift-clickable maps for a multi-wavelength set of images with a variety of noise and PSF characteristics, invaluable in an era where large multiwavelength data sets are becoming more and more ubiquitous.

Scientifically Rychard Bouwens has been investigating the manner in which the rest-frame continuum UV luminosity density and sizes evolve at high redshift using recent ACS observations. In an early paper using deep ACS cluster fields (RDCS1252-2927), combined with ACS GTO team images of the HDF-N, he found a 2x fall-off in the UV luminosity-density from z~3 to z~6. This paper has been accepted and has now appeared in the Astrophysical Journal. In two subsequent fields, the wide-area GOODS fields and ultra deep ACS parallel, he has confirmed this 2-3x fall-off in the UV luminosity density over this redshift range. He has also found an approximate 2x decrease in the visible sizes of high redshift objects from z~4 to z~6. These results have been written up and are nearly ready for submission. His findings based upon the new ACS data nicely confirm and extend the analyses he performed the previous year based upon the Hubble Deep Fields.

Dan Magee has continued work on the development of the data analysis pipeline (APSIS) which will be used to automatically process the GTO program observations. His primary focus has been in the development of a software package which automatically searches the Science Data Archive (SDA) for new and updated data, groups the data into logical data sets, and initiates an unattended APSIS pipeline run of the data sets. He also continues work with GTO archive team with development of software for SDA including a web-base interface to BUCS, an ACS image simulator. Dan has also provided support in the planning and implementation of ACS and ground base observations of GTO targets. He continues to provide system administration and support on Linux and Macintosh platforms for the UCSC component of the GTO team. His duties include maintaining and upgrading systems and equipment, troubleshoot and repair of malfunctioning equipment, and install, manage and support astronomy and scientific software packages. Dan also provides assistance in evaluation and implementation of new technologies which may benefit the GTO team. The ground-based observations with Keck are a key part of the complementary data needed to analyze the ACS data. Dan has supported the Keck runs with generation of the astrometric solutions for the fields and plays a major role in the preparation of the spectroscopic masks, as well as being an experienced observer.

Brad Holden began working on studying the evolution in the sizes, luminosities, and structural parameters of cluster galaxies. These measurements involve fitting surface brightness profiles,

which he has done with two different approaches. One is to use GIM2D which is based on a Monte Carlo fitting algorithm while the second is to use Galfit which fits using a more common steepest descent fitting algorithm and, therefore, is potentially less robust. He constructed a uniformly selected sample of cluster galaxies spanning a large range of redshift using both archival Hubble Space Telescope data along with data created for the Advanced Camera for Surveys Science Team. He is currently measuring the amount of evolution in the distribution of sizes and luminosities. In addition, he is playing a key role in the ground-based program to determine cluster membership, leveraging his previous experience with cluster redshift surveys.

Kim-Vy Tran's efforts with cluster datasets are now being applied to the MS1054 ACS data. She supplied her extensive Keck redshift catalog to the GTO team and is now part of projects designed to test the morphology-density relation at high redshift and the star formation rates in the cluster environment.

The deputy-PI has continued overseeing the efforts of the group, working closely with the individual members on planning and implementing the science programs. Extensive time and effort has been committed also to developing the team's overall science program in conjunction with the PI, as well as working with the PI to ensure that the science data processing techniques, the software resources, the science database, and the team personnel are being utilized effectively for our program. These responsibilities have required many trips to be taken to Baltimore to work with the PI at JHU.

The deputy-PI has also been very active this year in working with the PI on getting the first science results out at workshops, and making the results of the ACS GTO program visible to the community. Talks were given at two major workshops on (1) surveys of high redshift galaxies and (2) on the nature of galaxies at high redshift. A poster was given at another conference at the International Astronomical Union triennial conference.

Three Keck observing runs were also supported where the data and the science results will be used for our ACS science program -- the spectroscopic data will be used to constrain the evolution of galaxies in the cluster environment at redshifts $z>0.5$, and to calibrate the photometric redshifts and properties of the $z\sim6$ galaxies detected in several ACS fields. Such data will provide the baseline on which we will build our higher redshift ACS cluster results.

These activities are structured so as to allow us to have (1) a scientific program that keeps current with the latest developments in our field so that we can ensure that our observational program is up-to-date, and is focused on contemporary issues and questions, and (2) supports the team's efforts in getting scientific results out from the new ACS data as quickly as possible.

Significant equipment purchases and updates:

The group's desktop and laptop systems were upgraded at various times during the year to take advantage of significant improvements in personal computer hardware (memory, disk drives etc...) as the processing etc requirements began to increase with the new data. A first G4 Apple system was acquired as we begin to utilize the unique advantages of Apple computers. The stability of the software and the availability of interfaces make this a reasonable choice for

environments needing both unix capability and more general software tools, in addition to well-developed drivers for hardware devices. Two Apple Powerbooks have been acquired. An IBM Thinkpad was acquired for the new postdoc, Brad Holden.

Space Telescope Science Institute
P.I. of subcontract: Marc Postman

Marc Postman

M. Postman spent six months on sabbatical at JHU. Postman worked primarily on analyzing data acquired for the intermediate redshift cluster survey. Specifically, Postman provided visual morphological classifications for ~3000 galaxies in MS1054, RDCS0152-1357, and RDCS1252-2927. With Blakeslee, Franx, and Rosati, he used these classifications to characterize the evolution of the early-type red-sequence by determining the properties of the color-magnitude relation in RDCS1252 at a redshift of $z=1.24$. At the core of the cluster is an extensive early-type galaxy population surrounding a central pair of galaxies that show signs of dynamical interaction. The early-type population defines a very tight sequence in the CM diagram, with an intrinsic scatter in observed (i-z) of 0.029 +/- 0.007 mag based on 52 galaxies, or 0.024 +/- 0.008 mag for ~30 ellipticals. Simulations using the latest stellar population models indicate an age scatter for the ellipticals of about 34%, with a mean age > 2.6 Gyr (corresponding to $z > 2.7$), and the last star formation occurring no later than $z \sim 1.5$. Transforming to rest-frame (U-B), it was found that the slope and scatter in the CM relation for morphologically selected early-type galaxies shows little or no evidence for evolution out to $z \sim 1.2$. A paper presenting these results was published in October 2003.

Postman developed the software to derive the morphology-density relation from the ACS cluster image data. The relationship is clearly detected in our two $z=0.83$ clusters and is approximately consistent with that seen at lower redshift. A paper presenting these results is in preparation.

Postman was P.I. on two Gemini NIRI proposals to search for $z>7$ objects by identifying z-band dropouts. Both proposals were successful and the IDT received 40 hours of time to perform the survey. The targets for this program are the central regions of a handful of our strongly lensing clusters observed with ACS, where the magnification from the gravitational lensing can reach factors of 30 making detection of the dropout galaxies in the NIR J-band feasible with a few hours of integration time.

Postman is providing supervision for Tomo Goto, an ACS post-doctoral fellow who began his research position at JHU this summer. Postman gave two invited ACS related talks this year - one at CMU in Pittsburgh and one at the Carnegie Symposium on Galaxy Clusters in Pasadena. Postman also attended all off-site ACS science team meetings (Leiden and Aspen).

R. White

R. White has devoted most of his efforts to analysis of the ACS observations of strongly lensing clusters. The gravity from clusters of galaxies deflects the light coming from background galaxies and acts as a gravitational lens. The resulting images are often spectacular, with

magnifications greater than a factor of 100 and distorting small galaxy images into very long, thin arcs. White developed a new mass modelling program, based on idea by Broadhurst but with some significant improvements, and applied it to observations of Abell 1689. He is supervising two JHU graduate students, Kerry Zekser and James Jee, who are planning Ph.D. theses on the topic of gravitational lensing. Zekser extended White's lens modelling program to allow construction of delensed source images and plans to apply it to other strongly lensing clusters to be observed as part of the ACS GTO program. She is studying the mass distribution in the clusters, the magnified images of background galaxies, and the cosmological constraints that can be derived when there are multiply lensed images of background sources at a range of redshifts. Jee is analyzing weak lensing (which produces slightly distorted galaxy images) from ACS observations of z~1 clusters to derive mass models for those cluster.

GSFC
P.I.: Randy Kimble

- participated in technical discussions of WFC hot pixel annealing issue
- participated in science retreat, focusing on coronagraphic observations of protoplanetary disks and assisting with preparations for observations of DD0154 in dark-matter-dominated galaxy program

Efforts by our Off-site Collaborators (not subcontractors)

Thomas J. Broadhurst, Ph.D., Astronomer
(The Racah Institute of Physics, Hebrew University)

- Wrote software to model the mass distribution of galaxy clusters based on strong gravitational lensing effects.
- Using this software, more than 20 multiple lensed background galaxies have been identified, setting strong constraints on the cluster mass distribution and on the cosmological parameters.

Marijn Franx, Ph.D., Astronomer
(Leiden University)

- planning of future ACS observations
- planning of supporting ground based observations
- obtaining supporting ground based observations
- science analysis of existing data
- planning and editing of scientific papers
- organization of team meeting in Leiden in June 2003
- scientific discussions

Leopoldo Infante, Ph.D, Astronomery
Pontificia Universidad Catolica)

Science
- Searched for Ultra Compact Dwarfs (UCD) and un-resolved objects in the core of A1689, and a paper is being written to report the discovery of 7 new UCDs in A1689.
- Searched for Low Surface Brightness galaxies in the field of A1689.
- Led a study of dwarf galaxies in A1689 and found a faint end slope of -1.4. A paper is being written to report on these results.
- Led the development of tools to analyze galaxy clustering in catalogues from deep ACS images. So far, A1689 and CL0025 fields have been analyzed.

Observing Runs/Observing Proposals
- Secured telescope time to follow up ACS data; in particular, time to get spectra of faint arc-lets in A1689 and UDF fields with LDSS2 at Magellan 6.5m Baade telescope, and to detect z dropouts (galaxies at z=7) with the VLT/ISAAC and Magellan Panic.
- Wrote ESO and LCO telescope time proposals in order to follow up ACS data.

Other
- Coordinated a search to hire a postdoc to work on data analysis of ACS data in Chile as well as part-time in the U.S.

George Miley, Ph.D, Astronomer
(Leiden University)

Tasks
- Coordination of the distant radio galaxy/protocluster part of the ACS GTO program Planning of the Phase 1 and Phase 2 observations of the ACS distant radio galaxy/protogalaxy program
- Ground-based preparatory and followup observations for the ACS protocluster GTO program
- Reduction and analysis of data from the distant radio galaxy/protocluster part of the ACS GTO program
- Supervision of Leiden-funded ACS postdoc (Zirm) and ACS graduate student (Overzier)
- Interface between the ACS protocluster and cluster programs

Accomplishments
- Lead in planning and inputting the Cycle 11 and Cycle 12 GTO observations of distant radio galaxy/protoclusters
- Lead in the reduction and analysis of the data from the distant radio galaxy 1338-19 at z = 4.1
- Lead in an accepted Nature Letter reporting the discovery of a protocluster around 1338-19 at z = 4.1
- Lead in a VLT project to obtain infrared imaging and optical spectroscopic data for the ACS GTO protocluster targets

Piero Rosati, Ph.D, Astronomer
(ESO)

- Involved in integrating the ground-based imaging and spectroscopic data (obtained with the VLT) with the ACS data obtained for the first two clusters (at $z=0.83$ and $z=1.24$). This work is essential for the definition of a sample of spectroscopically confirmed galaxy members, whose spectrophotomeric and morphological properties can then be studied and compared with models.
- Developing the weak and strong lensing inversion techniques to obtain the mass distribution of distant galaxy clusters observed with ACS (in collaboration with Dr.Marco Lombardi, a postdoc at ESO-Garching).
- Involved in the search for very distant galaxies by the combination of ACS deep images with deep near-IR ground-based imaging.

Signed: _____
Holland Ford, P.I.

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Advanced Camera
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JOHNS HOPKINS
U N I V E R S I T Y

Last updated on 7 Nov 2003.

ACS GTO Science Programs	11	Cycle 12	13	Cycle 11 Executed Orbits	Cycle 12 Requested Orbits	Cycle 13 Requested Orbits	Total Orbits
Evolution of Galaxies and Clusters of Galaxies							
Low Redshift Cluster Gravitational Lensing Survey	9289	9717	-	23	36	27	86
Properties of Intermediate Redshift Cluster Galaxies	9290	9919	-	76	44	0	120
Formation of High Redshift Radio Galaxies	9291	-	-	32	0	19	51
The Nature of Galaxies at z > 4	9292	-	-	16	0	0	16
Photometry and Grism Spectroscopy in HDF North/South	9301	-	-	16	0	0	16
		Subtotal		**163**	**80**	**46**	**289**

ACS GTO Science Programs	11	Cycle 12	13	Cycle 11 Executed Orbits	Cycle 12 Requested Orbits	Cycle 13 Requested Orbits	Total Orbits
Active Galactic Nuclei							
Massive Black Holes in Early Type Galaxies	9293	9986	-	10	13	12	35
Imaging of the Host Galaxy of 3C 273	9294	-	-	6	0	0	6
		Subtotal		16	13	12	41
Stars and Stellar Systems							
Coronagraphic Search for Planets around Alpha Cen A, B	-	9703	-	0	24	0	24
Stars in Extended HI Disk Galaxies	9288	-	-	4	0	3	7
Coronagraphic Search for Disks around Nearby Stars	9295	9987	-	19	19	18	56
Geometric Measurement of Galaxy Distances	9299	-	-	12	0	0	12
Starbursts and their Population of Super Star Clusters	9300	9989	-	4	4	2	10
Investigating the Multiplicity of the L Dwarf LHS 102B	-	9990	-	0	1	0	1

ACS GTO Science Programs	11	Cycle 12	13	Cycle 11 Executed Orbits	Cycle 12 Requested Orbits	Cycle 13 Requested Orbits	Total Orbits
		Subtotal		39	48	23	110
Solar System Objects							
Comet Hale-Bopp at Large Heliocentric Distances	9302	-	-	2	0	0	2
Jovian Satellites - Ganymede and Europa	-	9296	-	0	5	0	5
	-	9716	-	0	0	5	5
Comets: Gas in the Inner Coma (ToO)	-	9985	-	0	4	0	4
		Subtotal		2	9	5	16
		Total		220	150	86	456
Total GTO Orbits							553
Withdrawn :							
Comets: Gas in the Inner Coma (ToO)	9297						
Kuiper Belt Objects Search	9298						
A Search for Planets around the Brown Dwarf Gliese 229B	9303						

http://acs.pha.jhu.edu/science/programs/phase2/