Sloan Digital Sky Survey II

2006 FOURTH QUARTER REPORT

October 1, 2006 – December 31, 2006

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Q4 PERFORMANCE HIGHLIGHTS

- The Supernova Survey completed its second observing season. We obtained over 6,000 square degrees of new imaging data and discovered 193 spectroscopically confirmed type Ia supernovae.
- We obtained 613 square degrees of new SEGUE imaging data, against a baseline goal of 430 square degrees. We completed at total of 16 plates (7 bright and 9 faint corresponding to 25 plate equivalents). This is roughly equivalent to completing 9 SEGUE tiles, against a baseline goal of 17 tiles.
- We completed 23 Legacy spectroscopic plates against a goal of 19 plates. Through Q4, we have completed 1,393 plates against the baseline goal of 1,370 plates.
- We recorded over 15 million hits on our SkyServer interfaces and processed over 1.8 million SQL queries. We also transferred over 19 terabytes of data through the Data Archive Server interfaces.
- Q4 cash operating expenses were $939K against a baseline budget of $969K, excluding management reserve. In-kind contributions were $229K against anticipated contributions of $154K. No management reserve funds were expended.

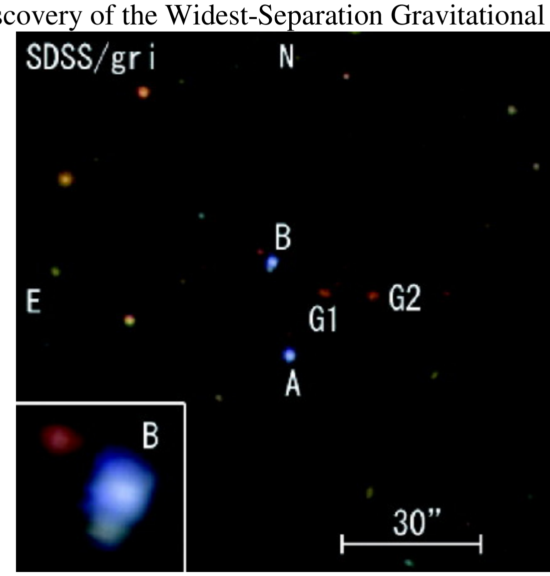
1. SOME RECENT SCIENCE RESULTS

A concentration of mass - for example, a galaxy or cluster of galaxies - bends light rays that pass by it. Since this bending is analogous to the action of a lens, we call the mass concentration a *gravitational lens*. If we view a distant object such as a quasar located directly behind the mass concentration, there could be two (or more) light paths from the quasar to us: one path on one side of the mass, and the other path on the other side. The result is that we see two or more images of the same quasar. The amount of separation between the images depends on the mass of the lens and the geometry of the paths. We know the separate images represent the same quasar because the spectra show identical redshifts. These split images are very useful astrophysical tools, since we can use the data to constrain the possible distribution of mass in the lens. This ability means we have a powerful probe of the amount and location of dark matter in the lens.

One of the first lenses to be discovered of this type had an image separation of 7 seconds of arc - this is like looking at two lights an inch apart from a distance of half a mile. This system held the record for the size of the splitting until one with 14 seconds of arc splitting was discovered in SDSS data. (The SDSS database is excellent for these kinds of discovery because of the enormous area of sky covered and the high quality of the color information - similar apparent colors for the separate images is the key to finding them.) This quasar image was the first to be shown to be lensed by the gravity of an entire cluster of galaxies, as opposed to a single massive galaxy.

Now, a new record-breaker (called SDSS J1029+2623) has been discovered with a separation of more than 22 seconds of arc, which is again modeled as due to the mass of a cluster of galaxies. The figure below shows the SDSS image, where A and B are the two images of the same distant quasar, and G1 and G2 are the brightest two galaxies in the foreground cluster. The galaxies G1 and G2 would normally be expected to mark the center of the cluster, and this expectation is supported by the distribution of fainter galaxies and by the location of a source of X-rays. The most interesting feature of the new lens system is apparent in the figure: the two quasar images are not symmetrical with respect to the supposed center of the cluster. This could suggest that the distribution of the mass is not simple geometrically or that the distribution of the mass is not closely related to the optical and X-ray light. There are many interesting questions raised by these observations that will be addressed with further research.

Discovery of the Widest-Separation Gravitational Lens



Reference:

1. SDSS J1029+2623: A Gravitationally Lensed Quasar with an Image Separation of 22″.5, by Naohisa Inada et al., 2006 Astrophysical Journal vol 653, L97.

2. SURVEY PROGESS

The period of accounting for this report includes two observing runs spanning the period from November 10 through December 28, 2006.

2.1. Legacy Survey

Table 2.1 compares the imaging and spectroscopic data obtained against the Legacy baseline plan. No new Legacy imaging data was obtained in 2006-Q4.

Table 2.1. Legacy Survey Progress in 2006-Q4

	2006-Q4		Cumulative through Q4	
	Baseline	Actual	Baseline	Actual[1]
Legacy Imaging (sq. deg)	0	0	7808	7577
Legacy Spectroscopy (tiles)	19	23	1370	1393

In Q4 we obtained slightly more than our baseline goal for new spectroscopic data. We completed 23 spectroscopic plates against a baseline goal of 19. Through the end of 2006, we have completed 1,393 plates, which is 2% ahead of the cumulative goal of 1,370 plates.

The following graphs show progress against the baseline plan. Figure 2.1 shows historical progress against the baseline plan for the Legacy Survey. Figure 2.2 shows progress on the spectroscopic survey. In order to provide a better view of progress against plan, the axis scales on Figure 2.2 have been adjusted to show progress made since July 2005, the start of SDSS-II operations.

[1] When the baseline plan for SDSS-II was prepared, we estimated that the total area to be imaged was 7808 “footprint” square degrees. We “closed the gap” in the imaging footprint at the end of June 2006 and declared the imaging survey to be complete. At that time, the actual area imaged was 7561 square degrees. Since then, and as time and conditions permit, we plan to continue obtaining small amounts of imaging data in order to fill in small missing areas on stripes 23 and 33.

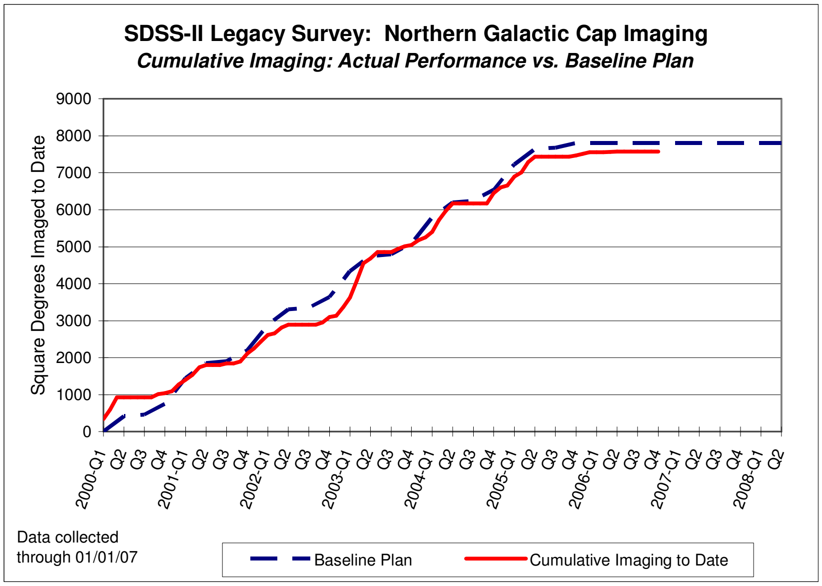


Figure 2.1. Imaging Progress against the Baseline Plan – Legacy Survey

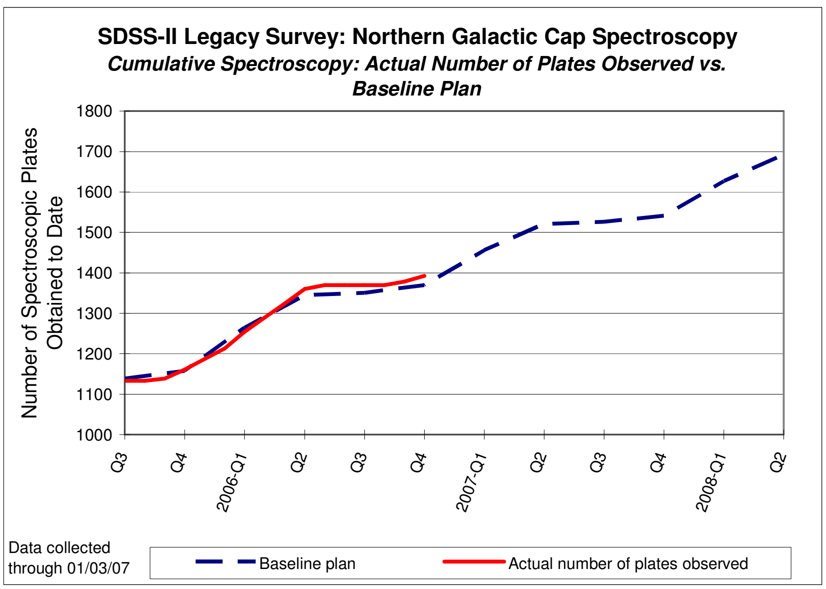


Figure 2.2. Spectroscopic Progress against the Baseline Plan – Legacy Survey

2.2. SEGUE Survey

Table 2.2 compares SEGUE progress against the baseline plan.

Table 2.2. SEGUE Survey Progress in 2006-Q4

	2006-Q4		Cumulative through Q4	
	Baseline	Actual	Baseline	Actual
SEGUE Imaging (sq. deg)	430	613	1,832	2,995
SEGUE Spectroscopy (bright plates)	17	7	85	88
SEGUE Spectroscopy (faint plates)	17	9	85	82

A total of 16 SEGUE plates (7 bright and 9 faint, corresponding to 25 plate-equivalents) were completed. This is roughly equivalent to completing 9 SEGUE tiles, against a baseline goal of 17 tiles. Recall that a SEGUE tile is considered complete when the faint and bright plate combination for a field is observed. Our observing strategy is arranged to complete plate pairs in roughly the same time frame, in order to maximize the scientific usefulness of each plate pair. However, it is not always efficient to complete plates in "pair combinations" given the many factors that affect observing operations (atmospheric conditions, available time, etc.) Therefore, we have elected to separately report progress in terms of the number of bright and faint plates completed, as opposed to combined bright/faint plate pairs (i.e., SEGUE tiles).

The SEGUE Survey is ahead of the baseline goal in imaging due to the acquisition of SEGUE data prior to July 2005, when commissioning and proof-of-concept observations were made. The SEGUE Survey is at baseline goal for spectroscopic observations, however the rate of collecting SEGUE plates is flat.

Figure 2.3 shows the current SEGUE layout and progress map, as of January 1, 2007. The plot can be found online at: http://segue.uchicago.edu/skycoverage.html

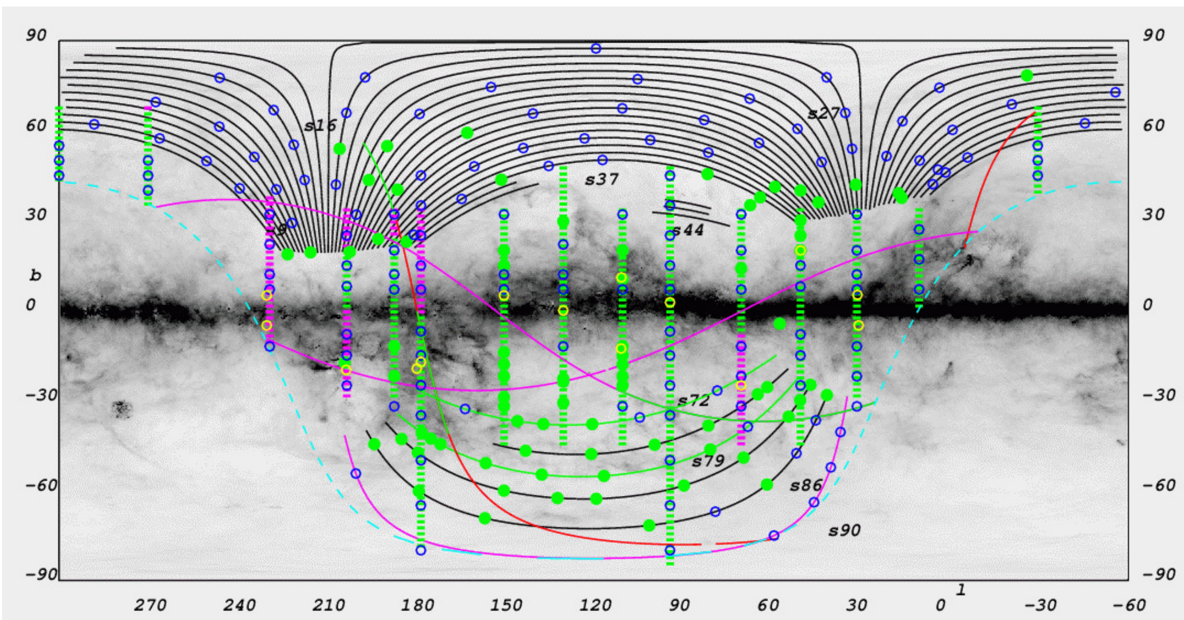


Figure 2.3. SEGUE imaging sky coverage and plate layout (as of January 1, 2007).

The following graphs illustrate SEGUE progress against the baseline plan. The imaging graph, Figure 2.4, presents a comparison of imaging progress against plan. The spectroscopy graph, Figure 2.5, shows the rate at which we have completed bright and faint plates separately.

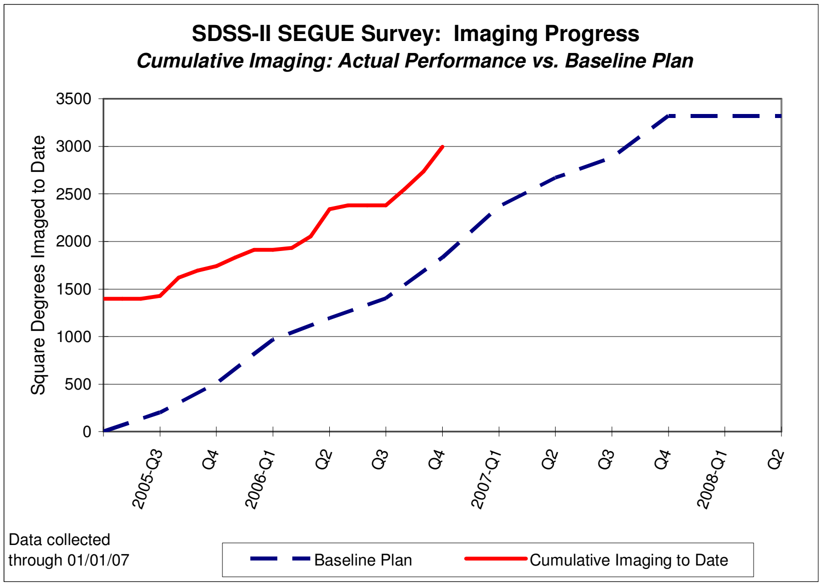


Figure 2.4. Imaging Progress against the Baseline Plan – SEGUE Survey

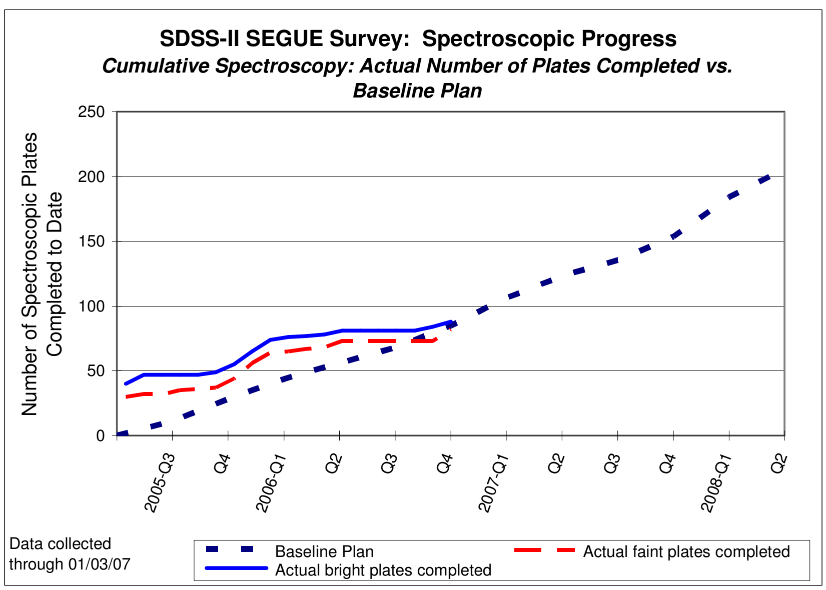


Figure 2.5. Spectroscopic Progress against the Baseline Plan – SEGUE Survey

2.3. Supernova Survey

The Supernova Survey completed its second of three observing seasons in Q4 2006. From September through November 2006, over 6000 sq. deg. of imaging data were taken on stripe 82. These data were promptly reduced using the SN compute cluster at APO.

In fall 2006, the team collectively scanned 14,441 objects, down considerably from the 190,020 objects scanned in fall 2005. This substantially reduced load enabled us to focus more human resources on analysis of the data and on spectroscopic follow-up. We achieved a more efficient search in 2006 versus 2005 by tuning the targeting of follow-up spectroscopic resources and also the fact that we were able to garner more spectroscopic time in 2006 than in 2005. In 2006, we discovered 193 spectroscopically confirmed type Ia supernovae, compared with 129 in 2005.

In addition, we were more efficient in getting these discoveries out to the public: (a) we disseminated confirmed and strongly suspected SNe more rapidly through electronic circulars, posting 26 of them throughout the Fall (twice the number of circulars as in 2005); (b) we notified the community of astronomers who follow up low-redshift supernovae directly by email when we found low-z candidates, before confirming them spectroscopically; (c) we made our web-based information about all SN candidates immediately available to the public; (d) we submitted SN and other interesting transients to the VOEvent system, a prototype for rapid communication of transients for robotic follow-up telescopes. In addition, as of mid-December, 28 of the stripe 82 runs from fall 2006 had been released to the public through the DRSN1 website. The remaining 2006 runs, several of which are still being processed at Fermilab, will be released soon.

For the near future, the remaining 2006 SN survey 2006 runs will be made public. On a longer timescale, calibrated versions of all the SN runs will be released.

3.0 OBSERVING EFFICIENCY

Observing efficiency is summarized according to the categories used to prepare the baseline projection.

3.1. Weather

The weather category reports the fraction of scheduled observing time that weather conditions are suitable for observing. Table 3.1 summarizes the amount of time lost to weather and Figure 3.1 plots the fraction of suitable observing time against the baseline forecast. Averaged over the quarter, the fraction of available observing time was slightly below the baseline plan. By month, weather conditions in October and November were much better than the baseline plan with suitable conditions for observing 62% and 72% respectively. Conditions in December were much worse, with 42% of the available time suitable for observing.

Table 3.1. Potential Observing Hours Lost to Weather in Q4

Observing Condition	Total hours potentially available for observing	Total hours lost to weather	Fraction of time suitable for observing	Baseline Forecast
Dark Time	471	193	59%	60%
Dark & Gray Time	670	279	58%	60%

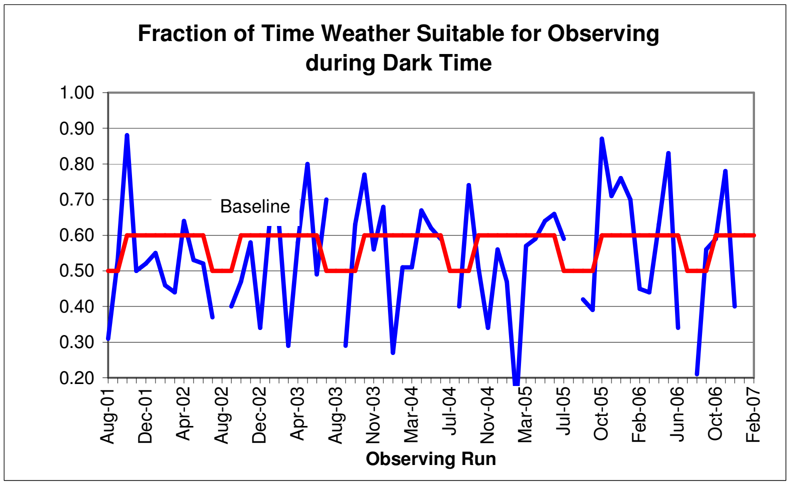


Figure 3.1. Percentage of Time Weather Suitable for Observing

3.2. System Uptime

System uptime measures the availability of equipment when conditions are suitable for observing. We averaged 98% uptime against a baseline goal of 90%. Table 3.2 summarizes the total amount of time lost to equipment or system problems and Figure 3.2 plots uptime against the baseline goal.

Table 3.2. Potential Observing Hours Lost to Problems in Q4

Observing Condition	Total hours potentially available for observing	Total hours lost to problems	System Uptime	Baseline Forecast
Dark Time	471	6	99%	90%
Dark & Gray Time	670	11	98%	90%

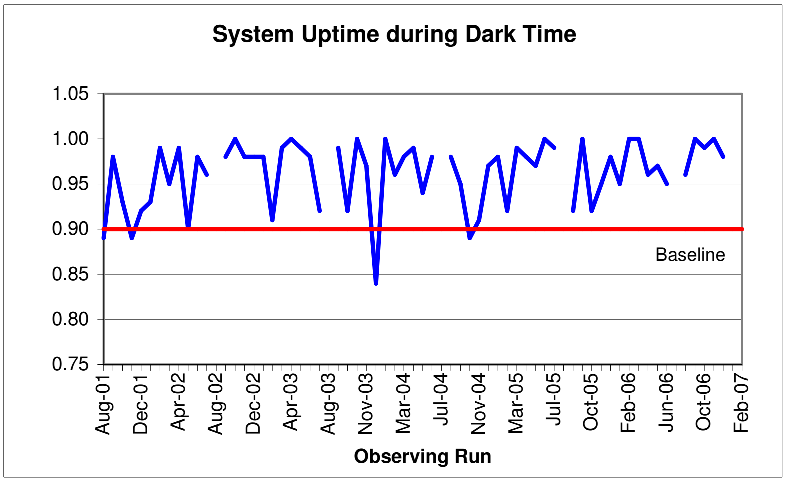


Figure 3.2. System Uptime

3.3. Imaging Efficiency

Imaging efficiency averaged 91% against a baseline goal of 86%. Longer imaging runs for the Supernova Survey helped to increase efficiency because setup and calibration time reflect a smaller fraction of the total time spent per scan. There were no imaging science runs in December.

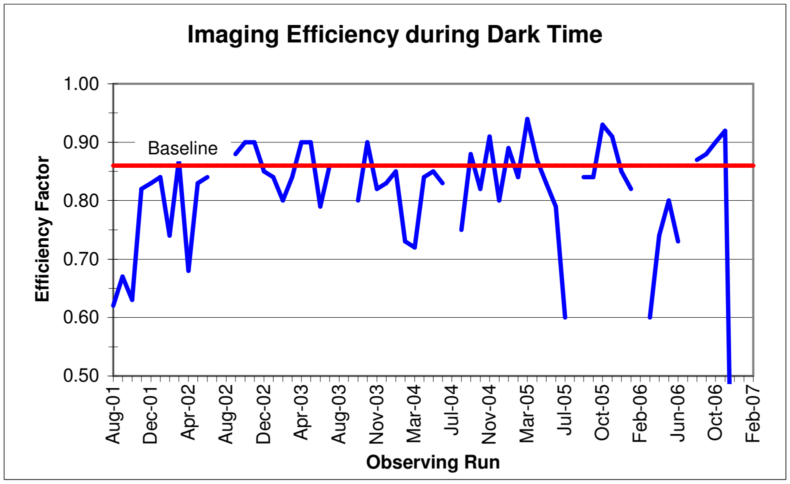


Figure 3.3. Imaging Efficiency

3.4. Spectroscopic Efficiency

Spectroscopic efficiency is derived by assessing the time spent performing various activities associated with spectroscopic operations. The supernova program used all the time in October that would have been allotted to spectroscopy. In November spectroscopy usually followed the supernova imaging which lead to lower than normal efficiency because instrument change times are higher than normal with all the switches from imager to spectroscopy. December spectroscopic efficiency was better than the baseline goal of 64%.

Table 3.3. Median Time for Spectroscopic Observing Activities

Category	*Baseline*	*Run starting Nov 10*	*Run starting Dec 9*
Instrument change	10	13	5
Setup	10	13	8
Calibration	5	5	5
CCD readout	0	3	3
Total overhead	25	34	21
Science exposure (assumed)	45	45	45
Total time per plate	70	79	66
Efficiency	0.64	0.57	0.68

Figure 3.4 plots spectroscopic efficiency over time.

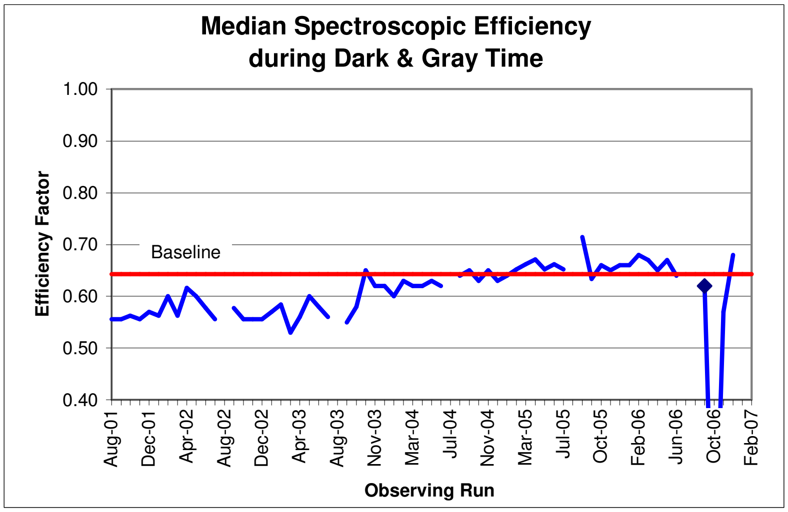


Figure 3.4. Spectroscopic Efficiency

4. OBSERVING SYSTEMS

Observing systems includes the instruments, telescopes, computers and various sub-systems that support observing operations at APO.

4.1. The Instruments

The Pfeiffer Vacuum Pump Station we use for the SDSS instruments had a catastrophic failure in its roughing pump. This pump was obsolete and its replacement was insufficient for the imager pumping needs. We did order it, however, but modified its input manifold to allow hooking up a secondary pump for roughing down the imager.

The Glentek amplifiers developed troubles at tracking speeds. After conferring with our axes control experts, it was decided that what was needed was a bench testing capacity to determine offsets in amp outputs. The spare Glentek amps are working well. The original problem had not been severe enough to cause any lost operational time. In Q1 2007 we will be looking into the design and fabrication of a bench testing system for the Glentek axes amplifiers. We will also evaluate the procedures to examine and modify the PID parameters for the axes drives. In addition, we will evaluate the cost for an upgrade to new axes drive amplifiers.

A long time problem with the Cloud Camera – an artifact that appears in its output image – worsened to an unacceptable level and required investigation. The solution required an upgraded power supply with a much higher current output. During the process of determining the cause of the problem, we discovered that the IR camera used in the system did not match the spare unit. The manufacturer declared the former unit obsolete. We decided to upgrade the camera to match the spare.

4.2. The 2.5m Telescope

During this quarter the SDSS telescope was plagued with a series of minor but persistent problems. These problems ranged from spectrograph humidity sensor evaluations to difficulties in resolving Cloud Camera malfunctions. Although none of these problems cause direct lost of operation efficiencies, they none-the-less, consumed a considerable amount of engineering labor. We have resolved all of the causes of these problems and rectified most of them. A small percentage remains to be completely resolved. We will complete the remaining repairs and upgrades in the coming quarter.

The following is a numbered series of short descriptions of the engineering work performed during this quarter.

1. Early in the quarter we began to experience a series of problems with the Spectrograph LN2 autofill system. Most the problems centered on the systems control circuit board. This board was a wire wrap version of an earlier prototype and had gone through a number of repairs in the past. We upgraded the old board to the new PC boards provided by Fermilab a couple of years ago. Once this new board was installed, the problems with the empty and full sensors became manifest. Age was the main culprit in this area, and we have been replacing and upgrading these as they fail. We will probably continue to have problems with these sensors throughout the coming quarter. Once all the old sensors have been replaced, the system should regain familiar stability.

2. An opportunity availed itself during this quarter to inspect the spectrograph red camera for oil streaking. We cleaned this camera over the summer shut-down, and we were concerned as to how long the lenses inside the lenses would remain clean. The inspection demonstrated that no oil streaking had occurred during the three months since the initial cleaning.

3. Our original oxygen deficiency hazard (ODH) sensors demonstrated at times an inability to detect an ODH condition. The failures were discovered by an engineer upon entering the enclosure with a handheld sensor that indicated an ODH condition while the wall mounted units indicated a normal condition. Further testing convinced us that we needed to upgrade to new sensors. We began upgrading the sensors this quarter and we plan to finish the upgrade in the first quarter of 2007.

4. We got the spectrograph humidity sensors working this quarter and will use them to investigate the humidity problem we have been experiencing in the central optics area. We determined that we have a problem with one of the purge flow meters on Sp1. Further testing is needed, and we will conduct testing during 1st quarter 2007.

5. A couple of good weather days during one of our Bright Times allowed us to install the enclosure east rollup door threshold. The threshold seems to be doing its job of keeping east wind-driven rain from entering and flooding the enclosure floor. However, we have yet to experience an extremely heavy east wind-driven rainstorm.

6. We started fabricating new PSS elephant trunk components in order to eliminate the cracking problem on the existing utility runs. This task will take at least one more quarter to finish.

7. We have assigned one individual from our engineering group to devote a percentage of his time to converting Vellum telescope drawings to SolidWorks drawings and depositing them on an FTP site for access by APO personnel and project collaborators.

8. ET project work continues to be incorporated into our engineering work schedules. To date we have been able to meet ET engineering needs without harming SDSS engineering operations.

During the first quarter of 2007, we will be examining our short- term staffing needs to accommodate the temporary loss of one of our technicians and the application of a “two man rule” for weekend operations. We also plan to implement modifications to the Imager Umbilicus Tower.

4.3. The Photometric Telescope

Over a year ago a leak developed in the PT Ion Pump housing. At that time, a new pump was unavailable in time to keep the PT operational. Also, we were told that the pump was used only as a vacuum gauge. We therefore decided to “blank off” its dewar flange and operate without the flange. During this quarter we received and installed a new pump. The timing for this installation coincided with the vacuum pumping on the spectrographs. The main pumping station, used on the spectrographs, failed. We had to remove the vacuum pump being used on the PT and substitute it for the failed pump on the spectrographs. The swap produced problems with the new PT ion pump by introducing contaminates into the PT dewar, thereby requiring a much longer time to get the PT ion pump functioning properly.

In an effort to gain greater stability and standardize our supply inventory for cryo gases, we converted the PT CryoTiger gas from PT-14 to PT-30. This was completed with minimal disturbance to both the telescope and its operations.

4.4. Operations Software and the Data Acquisition System

Very minor changes were made to the observing software.

4.5. Observatory Operations

Except during scheduled engineering shutdown periods, the SDSS telescope, instruments, and data acquisition systems were operated in science or test mode for the lunar dark and gray runs during the quarter, and for ET observing during bright time. Operations continued to run smoothly and there were no recordable personnel injuries. Nights of pre-run "shakedown" and post-run "shakeup" operations were planned and executed by the SDSS-II Observers, as were for other engineering nights used for software and other testing. During observing periods, the telescope and instruments were in use whenever weather and sky conditions permitted, the instruments were maintained in an operational state, plug-plate cartridges were staged and available when required, and data were written to disk and transferred to Fermilab over the internet. All site infrastructure support, such as the provision of liquid nitrogen, visitor housing, etc., was furnished as needed. The Photometric Telescope was also operated by the Observers.

5. DATA PROCESSING AND DISTRIBUTION

5.1. Data Processing

5.1.1. Software Development and Testing

Development work continued on the spectroscopic pipeline, the photometric pipeline, and photometric calibration.

On the spectroscopic 1d pipeline, we performed manual inspections on the Legacy spectroscopic plates. These are being processed to prepare for the DR6 data release. We also began modifying the 1d pipeline to accommodate the new data model in spectro 2d v5. In addition we began investigating the possibility of implementing dereddening inside 1d. Finally, we answered a handful of helpdesk questions regarding spectro.

The SDSS/SEGUE Spectroscopic Parameter Pipeline (SSPP) continue to evolve slightly, with new versions being mirrored for testing and verification of code at FNAL. Effort is being directed toward freezing a version of the SSPP for the DR6 collaboration and collaboration releases.

The highlights of fourth quarter's progress are:

- We continued obtaining high-resolution spectroscopy of SEGUE stars with predicted parameters from the present pipeline, so that calibration and refinement of these estimates can be carried out. To date, some 30 stars have available Keck spectroscopy, and of greatest importance, over 100 HET spectra have been obtained. Thus, a total of roughly 130 high-resolution spectra have now been obtained. We are in the process of deriving atmospheric parameters from these spectra, and will use them to evaluate the predictions of the SEGUE pipeline, and to derive corrections (if needed). These same spectra will be of use for establishing the actual velocity errors in SEGUE spectra, since the high-res data have errors on the order of 1 km/s. At present, it appears that we have already identified a zero point offset on the order of 7-10 km/s for SEGUE spectra. The origin of this offset (probably in the correlation templates) is being sought at present.

- We prepared and presented several posters and talks at the Seattle AAS meeting, describing the present version of the pipeline and validation efforts, as well as some initial science results.

In Q1 2007 we are planning submission of several papers describing the operation of the SSPP, and its validation via globular cluster observations and high-resolution observations. Lee et al. (2007) have already submitted the globular cluster paper to the SDSS publications mail archive, and will send to a journal once the three week collaboration period has expired. We are presently preparing the other papers.

We plan to finish incorporation of the ANN from MPIA (Heidelberg), as well as the Alende Prieto "hot extension" and the UW "cool extension" into the next version of the pipeline, which we envision to be V1.5. Unless other techniques come forward, we hope to freeze the present set of techniques during this coming quarter, at least for determination of the basic atmospheric parameters Teff, logg, and [Fe/H]. We will then begin development and refinement of techniques for obtaining estimates of additional abundances of interest, e.g., [C/Fe], [Mg/Fe], [Na/Fe], [Sr/Fe], etc. We will also be freezing the DR6 data model.

5.1.2. Data Processing Operations at APO

On-mountain SN processing went very smoothly and was able to keep up with the data flow. Use of the auto scanner software we developed enabled us to more efficiently select objects for humans to scan by eye in the search for SN candidates.

5.1.3. Data Processing Operations at Fermilab

In Q4, we processed 613 square degrees of SEGUE imaging data and 6,000 square degrees of new Supernova data. All imaging data were processed with the Legacy version of the photometric pipeline (photo v5_4_28). All data successfully passed the suite of standard QA tests.

5.2. Data Distribution

5.2.1. Data Usage Statistics

Through December, the general public and astronomy community have access to the EDR, DR1, DR2, DR3, DR4, and DR5 through the DAS and SkyServer interfaces. In addition, the collaboration has access to the Runs DB. A helpdesk has been established at Fermilab to respond to user questions, or to system problems reported by users. On average, the helpdesk continues to respond to 1-2 requests per day for help or information.

Figure 5.1 plots the number of web hits we receive per month through the various SkyServer interfaces. In Q4 we recorded 15 million hits, compared to 22.6 million hits in Q3 and 30 million hits in Q2. Total hits in Q4 are substantially below Q3. This is due in part to the exceptionally heavy usage we saw in the early part of Q3, when we received 10.4 million hits in the month of July alone.

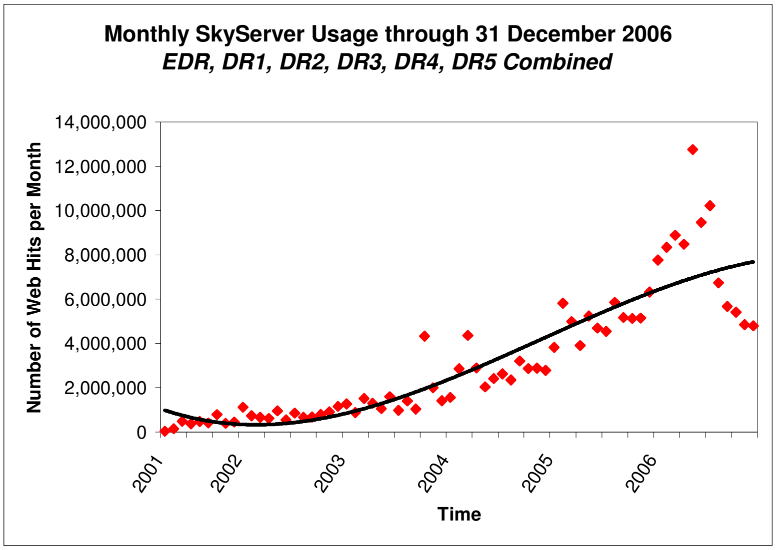


Figure 5.1. SkyServer usage per month, for all public releases combined.

Figure 5.2 shows the total number of SQL queries executed per month. We executed 1.8 million queries in Q4, compared to 4.1 million queries in Q3 and 2.2 million queries in Q2.

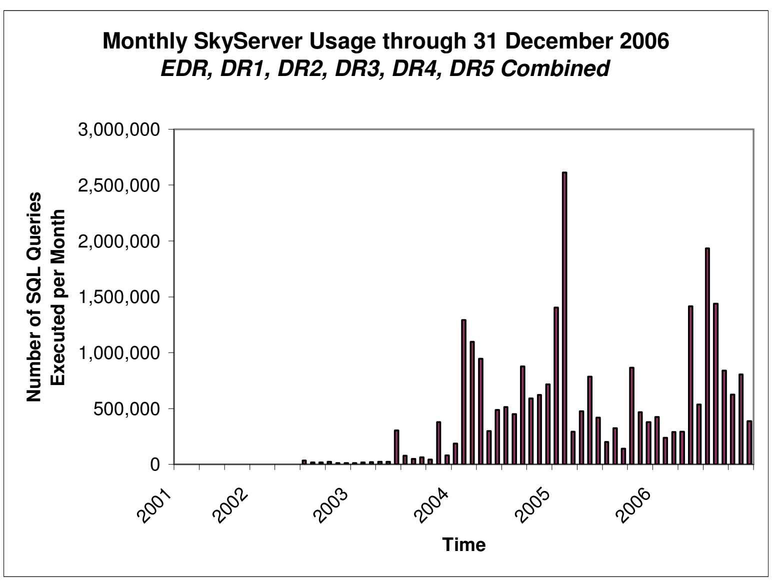


Figure 5.2. SkyServer usage, measured by the number of SQL queries submitted per month.

Through December 31, 2006, the SkyServer interfaces have received a total of 212 million web hits and processed over 25 million SQL queries. Over the past six months, the SkyServer sites received an average of 6.3 million hits and processed just over 1 million SQL queries per month.

Figure 5.3 shows the volume of data transferred monthly from the DAS through the rsync server. A total of 3 TB of data were transferred via rsync in Q4, compared to 10.5 TB in Q3. As we have seen in the past, the volume of data transferred varies significantly from month to month.

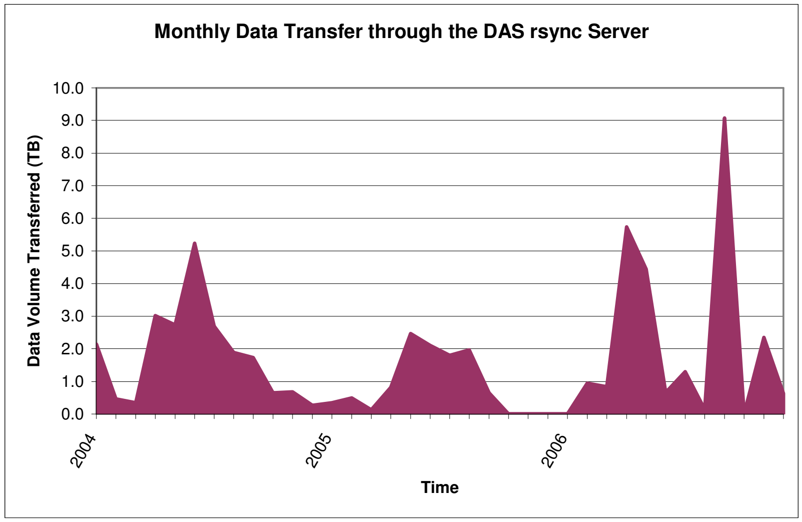


Figure 5.3. Monthly volume of data transferred via the DAS rsync Server.

Figure 5.4 shows the volume of data transferred monthly through the DAS web interface. A total of 16.8 TB of data were transferred via the web interface in Q4, compared to 4.3 TB in Q3. In the month of October a total of 10.7 TB were transferred. This corresponded to the announcement of the existence of a Data Release Supplement.

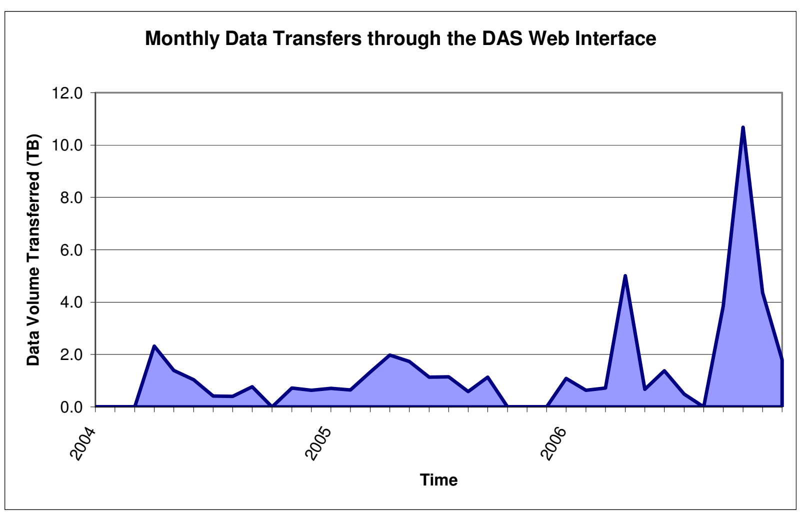


Figure 5.4. Monthly volume of data transferred via the DAS web interface.

Historically, the majority of data transfers have been made using rsync, suggesting that rsync is the preferred transfer method for large data transfers. In Q4, the volume of data transferred through the interfaces was in stark contrast to historical trends with 15% of the data transferred via the rsync interface and 85% via wget.

Figure 5.5 shows the total volume of data transferred from the DAS through the two access portals combined.

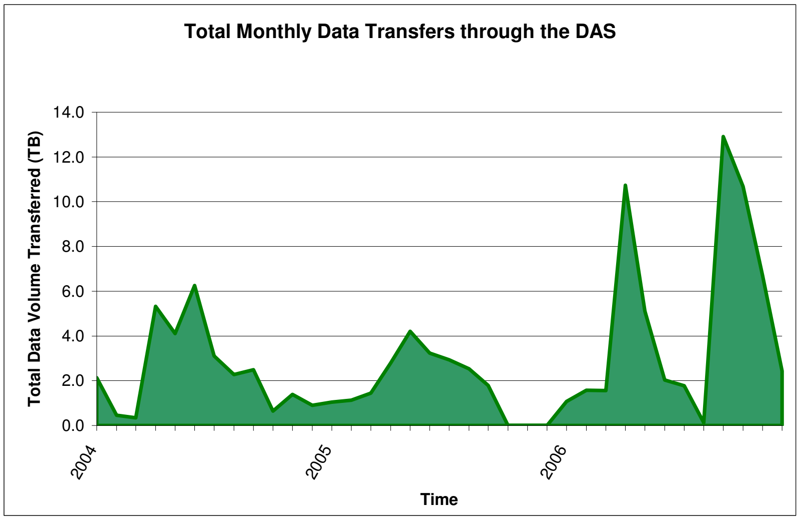


Figure 5.5. Total monthly volume of data transferred via the DAS

5.2.2. Data Archive Server

Work on the DAS included addressing problem reports, and providing general support for data distribution operations.

5.2.3. Catalog Archive Server

Work on the Catalog Archive Server (CAS) included addressing problem reports, preparing for the DR6 data load, and providing general support for data distribution operations.

In Q4, four problem reports filed through the SDSS Problem-Reporting Database were fixed and closed, including one filed against CasJobs.

The CasJobs site was upgraded to v3_0_1, which fixes a problem with the query plan feature and includes much faster table import and loading of data into MyDB tables using the SQL Server bulk loading capability. It also includes links to the new CasJobs User Forum, and the Contact link at the bottom of each page goes to the SDSS Help Desk contact form now rather than just being a mailto. This allows the server to collect some useful information and then send the help desk request on the server side rather than with the user's (client) mailer.

Some of the more important changes are:

- The SkyServer sample queries have been added to the query window,
- Compound queries are now supported with the GO syntax;
- Table upload (import) is much faster;

- There is better queue handling and the query and output queues are separated on different servers for better load-balancing and management;
- MyDB object browser is much nicer (e.g. table sizes, rows and ability to sort on these)
- A link to a new CasJobs user forum has been added (this is a bulletin board for users to share information on CasJobs issues).
- The Groups functionality has been upgraded so you can publish a table to a specific group rather than all groups that you are a member of. This required an API change.

6. SURVEY PLANNING

6.1. Observing Aids

Several programs are used to aid in planning and carrying out observations. No changes were made this quarter.

6.2. Target Selection

For this quarter, 81 plates were designed and drilled in two drilling runs. Of these, 51 were for the Northern survey area, 10 were for the normal exposure SEGUE plates, 10 were for double length exposure SEGUE plates, 3 were special SEGUE cluster plates, and 7 were test plates for the BAO program that is being proposed for post-2008 operations. The BAO test plates are located in an area sky where we do not have any Legacy or SEGUE plates remaining and thus do not interfere with the existing programs.

6.3. Survey Planning

The software that is used to track survey progress that is contained in this report is also used to prepared monthly observing plans. No changes have been made.

The modified observing strategy to increase the chances of SEGUE obtaining more imaging data was implemented in November and December. Most of the desired imaging was obtained, but one high priority scan remains.

7. EDUCATION AND PUBLIC OUTREACH

Two proposals were written to the M. J. Murdock Charitable Trust to fund high school teachers to do SDSS follow-up observations at the University of Washington’s Manastash Ridge Observatory (MRO) during the summers of 2007 and 2008. One proposal, involves observations of RR Lyra candidates that were derived from the SDSS database. The other proposal, involves observations of both known symbiotic stars and some candidates derived from the SDSS database. We expect to have a decision on funding for these proposals by the end of next quarter.

We continued follow-up work with some high school and college teachers who had been trained on the SDSS Skyserver education activities in June 2006. We led a discussion on using SDSS as part of classroom activities or laboratories at the Center for Astronomy Education Northwest Teaching Exchange meeting on November 18; at which several of the June workshop participants were in attendance.

We actively promoted the SDSS education workshop that we are presenting at the AAS/AAPT via the Space Grant K-12 educator e-letter and the Washington Science Teachers Association. We also promoted it to state community college instructors via Space Grant information networks.

We revised the SDSS bookmark and printed copies to hand out at the AAS/AAPT meeting in Seattle and in other venues. We provided SDSS materials to new graduate students in the University of Washington astronomy department. We also provided updates to the Education section of the sdss.org Web site.

We constructed an outline for an SDSS workshop that uses the "For Kids" section of the SkyServer Web site. This section is most useful for middle school and high school general science teachers, as well as for providers of after school programs.

Our plans for the next quarter include the following:

- We will host a workshop at the AAS/AAPT meeting and help with the SDSS exhibit booth. We will also give a presentation on EPO at the consortium mini-meeting on January 6.
- We will offer the Sloan Digital Sky Survey for Kids educator workshop in the spring, probably on the University of Washington campus. The audience will be teachers of grades 6-10.
- We plan to offer a workshop for educators in connection with the consortium meeting at Drexel University. To determine what content and workshop length would be most appropriate, we will consult with faculty members in the school of education at Drexel.
- We will work with UW on a proposal to the NSF Informal Science Education division. The proposal involves developing infrastructure to support the skybrowser.
- We will work with UW to initiate a SDSS database project on identifying objects that might be planetary nebulae in the halo of the Milky Way Galaxy. Candidate objects will be investigated by undergraduate assistants.

8. COST REPORT

The operating budget that the Advisory Council accepted and the Board of Governors approved for SDSS-II activities during the period January 1 through December 31, 2006 consists of $640K of anticipated in-kind contributions from Fermilab, the US Naval Observatory (USNO), the University of Chicago (UC), the Johns Hopkins University (JHU), the University of Washington (UW), and the Joint Institute for Nuclear Astrophysics (JINA); and $4,620K for ARC-funded cash expenses.

Table 8.1 shows actual cost performance for ARC-funded cash expenses in Q4. More complete tables comparing actual to baseline performance are included in the appendices of this report. Appendix 1 compares cash expenses to the budget and presents the revised cash forecast for 2006. Appendix 2 compares actual in-kind contributions to the budget and presents the revised in-kind forecast for 2006.

Table 8.1. Q4 Cash Expenses for 2006 ($000)

	2006 – 4th Quarter		2006 Operations Budget Total *(for the period Jan-Dec 2006)*	
Category	Baseline Budget	Actual Expenses	Baseline Budget	Actual Expenses

1. Survey Management	86	72	460	357
2. Survey Operations				
2.1. Observing Systems	165	192	725	715
2.2. Observatory Operations	418	415	1,672	1,642
2.3. Data Processing	174	159	777	674
2.4. Data Distribution	59	64	306	313
2.5. ARC Support for Survey Ops	21	3	96	10
3. New Development				
3.1. SEGUE Development	23	18	102	75
3.2. Supernova Development	0	0	0	0
3.3. DA Upgrade	0	1	0	10
3.4. Photometric Calibration	13	9	53	54
4. ARC Corporate Support	11	8	46	54
Sub-total	969	939	4,238	3,903
5. Management Reserve	98	0	390	0
Total	1,066	939	4,628	3,903

8.1. Q2 Performance - In-kind Contributions

The sum of in-kind contributions in Q4 was $229K against the baseline forecast of $154K and was provided by Fermilab, JHU, UW, and Michigan State University (MSU) for JINA, as follows:

- Fermilab provided support for survey management, data processing and data distribution activities. Effort was also provided to support oversight and planning, and development work for the SEGUE and Supernova projects. The level of effort provided to support data processing and distribution operations was greater than anticipated, as were some of the salary costs of the individuals performing this work.
- JHU provided support for the development, loading and hosting of the databases associated with the CAS, CasJobs, and SkyServer. The amount of effort provided was greater than anticipated.
- USNO provided support as required for the astrometric pipeline and other software systems they maintain. The amount of effort provided was greater than anticipated.
- UW contributed the overhead associated with the plate drilling operation as anticipated.
- MSU provided support for the SEGUE project, including development of the SEGUE stellar atmospheric pipeline. The level of effort provided was as anticipated.

8.2. Q2 Performance – ARC Funded Cash Expenses

ARC-funded expenses were $939K, or $30K (3%) below the budget of $969, before management reserve.

Survey management costs were $72K against a budget of $86K. Expenses for the Director, Project Scientist, Public Information Officer, and Project Management support staff were less than anticipated. Expenses for the ARC Business Manager, ARC Office of the Secretary/Treasurer and Collaboration Affairs were as anticipated. For the year, the actual Survey Management expenses were $357K, or $104K (23%) below the baseline budget of $460K.

Observing Systems costs were $192K against a budget of $165K. UW and Fermilab costs were greater than budgeted. Princeton expenses were in reasonable agreement with the budget. Expenses on other accounts were also in reasonable agreement with budgets. For the year, the actual Observing Systems expenses were $715K, or $10K (1%) below the baseline budget of $725K.

Observatory support costs were $415K against a budget of $418K. Salaries were slightly below the budget forecast for the quarter, in part stemming from observer departures. For the year, the actual Observatory Support expenses were $1,642K, or $30K (2%) below the baseline budget of $1,672K.

Data Processing costs were $159K against a budget of $174K. Actual expenses at Fermilab and Princeton were below budget because the level of effort required to support ongoing operations was less than anticipated. Expenses at the University of Chicago were also below budget. For the year, the actual Data Processing expenses were $674K, or $104K (13%) below the baseline budget of $777K.

Data Distribution costs were $63K against a budget of $59K. Fermilab expenses were higher than budget because we added additional personnel to support data distribution operations. JHU expenses were lower than budgeted because ARC-funded salary costs were less than anticipated. For the year, actual Data Distribution expenses were $313K or $7K (2%) above the baseline budget of $306K.

ARC Support for Survey Operations costs were $3K against a budget of $21K. For the year, the actual Survey Operations support expenses were $10K, or $86K (90%) below the baseline budget of $96K.

Expenses associated with development work for the SEGUE Survey were $18K against a budget of $23K. Expenses to support software development work at Princeton were higher than budget due to the addition of a post-doc in the latter half of the year to augment the level of effort going into software development. Expenses for development work at Fermilab related to SEGUE data distribution were less than budget due to the late start on development activities. For the year, the actual SEGUE Survey development expenses were $75K, or $27K (27%) below the baseline budget of $102K.

Expenses associated with photometric calibration efforts at Princeton $9K against a budget of $13K. For the year, the actual expenses were $54, or $1K (1%) above the baseline budget of $53K.

Miscellaneous ARC corporate expenses (i.e., audit fees, bank fees, petty cash, and APO trailer rentals) were $8K against a budget of $11K. For the year, actual expenses were $54K against the baseline budget of $46K. The increase largely reflects the addition of the capital improvement expenses.

8.3. Q2 Performance - Management Reserve

No management reserve funds were expended in Q4.

9. PUBLICATIONS

In Q4, there were 11 papers based on SDSS data that were published by members of the SDSS collaboration. There were also 38 papers published by individuals outside of the collaboration, using publicly available data. Exhibit 3 lists papers published by members of the SDSS Collaboration; Exhibit 4 lists papers published by individuals outside of the SDSS collaboration.

Exhibit 1. CY2006 Cash Budget Forecast ($000s)

SDSS-II CY2006 Actual Expense as of December 31, 2006

			Qtr 1 Jan-Mar	Qtr 2 Apr-Jun	Qtr 3 Jul-Sep	Qtr 4 Oct-Dec		CY2006 Total		
		Inst	Actual Expenses	Actual Expenses	Actual Expenses	Approved Baseline Budget	Actual Expenses	Approved Baseline Budget	Final Expenses	Variance (%)
OPERATIONS BUDGET - CASH EXPENSES										
1.0 Survey Management										
SSP-221	ARC Secretary/Treasurer	ARC	2	2	2	3	2	12	9	23%
SSP-234	ARC Business Manager	ARC	17	15	16	16	17	65	65	0%
SSP-246	PU Office of the Project Scientist	PU	.2	.3	59	4		73	60	18%
SSP-248	FNAL Support for Survey Management	FNAL	12	8	9	15	7	60	35	41%
SSP-267	UC Support for Survey Management	UC	11	12	33	14	13	79	70	12%
SSP-270	UW Support for EPO Coordinator	UW	4	18	8	9	11	35	42	-20%
SSP-291a	ARC Support for Public Affairs	ARC	2	17	2	0	5	16	27	-71%
SSP-291b	ARC Support for Spokesperson	ARC	1	2	1	4		14	4	74%
SSP-291c	ARC Support for Collaboration Affairs	ARC	4	5	4	1	1	34	14	59%
SSP-291i	ARC Support for Public Information Officer	ARC	10	4	3	7	5	30	21	29%
SSP-291K	ARC Support for Young Astronomers Travel Fund	ARC	0	0	0	10	10	10	10	0%
SSP-291L	ARC Support for EPO Webmaster and Teacher	ARC	.4	0	0	2	0	33		99%
	Survey Management Sub-total		**63**	**84**	**136**	**86**	**72**	**460**	**357**	**23%**
2.0 Survey Operations										
2.1 Observing Systems										
SSP-231	UW Observing Systems Support	UW	36	88	31	45	70	235	225	4%
SSP-232	PU Observing Systems Support	PU	11	11	13	11	9	46	43	7%
SSP-242	FNAL Observing Systems Support	FNAL	91	70	90	88	100	345	351	-2%
SSP-261	FNAL Data Acquisition System Support	FNAL	10	17	5	3	7	16	40	-151%
SSP-291d	ARC Observing Systems Support	ARC	17	9	24	18	5	84	56	33%
	Observing Systems Sub-total		166	195	162	165	192	725	715	1%
2.2 Observatory Support										
SSP-235	NMSU Site Support	NMSU	373	433	421	418	415	1,672	1,642	2%
2.3 Data Processing										
SSP-240	FNAL Software and Data Processing Support	FNAL	187	93	93	101	99	519	472	9%
SSP-238	PU Software and Data Processing Support	PU	22	24	43	62	55	212	144	32%
SSP-239	UC Software and Data Processing Support	UC	11	29	13	11	5	46	58	-26%
	Data Processing Sub-total		220	147	149	174	159	777	674	13%
2.4 Data Distribution										
SSP-268	FNAL Data Distribution Support	FNAL	84	82	49	45	61	257	276	-7%
SSP-237	JHU Data Archive Development and Support	JHU	14	15	5	14	3	49	37	24%
	Data Distribution Sub-total		98	97	54	59	63	306	313	-2%
2.5 ARC Support for Survey Operations										
SSP91f	ARC Additional Scientific Support	ARC	2	1	0	18	3	82	6	93%
SSP91h	ARC Observers' Research Support	ARC	.6	3	0	4	0	14	4	73%
	Data Distribution Sub-total		3	4	0	21	3	96	10	90%
	Survey Operations Sub-total		**859**	**876**	**786**	**837**	**832**	**3,577**	**3,354**	6%

Exhibit 1. CY2006 Cash Budget Forecast (continued)

SDSS-II CY2006 Actual Expense as of December 31, 2006

		Inst	Qtr 1 Jan-Mar Actual Expenses	Qtr 2 Apr-Jun Actual Expenses	Qtr 3 Jul-Sep Actual Expenses	Qtr 4 Oct-Dec Approved Baseline Budget	Qtr 4 Oct-Dec Actual Expenses	CY2006 Total Approved Baseline Budget	CY2006 Total Final Expenses	CY2006 Total Variance (%)
3.0 New Development										
3.1 SEGUE Survey Development										
SSP-138	PU Software and Data Processing Support	PU	14	15	15	13	18	53	63	-18%
SSP-268	FNAL Data Distribution Support	FNAL	0	0	12	9	0	49	12	75%
	SEGUE Development Sub-total		14	15	28	23	18	102	75	27%
3.2 Supernova Survey Development										
	No allocation		0	0	0	0	0	0	0	---
	Supernova Development Sub-total		0	0	0	0	0	0	0	---
3.3 Data Acquisition System Upgrade										
SSP-161	FNAL DA Upgrade		15	(5)	0	0		0	10	---
	DA Upgrade Sub-total		15	(5)	0	0		0	10	---
3.4. Photometric Calibration Development										
SSP-138	PU Software and Data Processing Support	PU	14	15	15	13	9	53	54	-1%
	Photometric Calibration Sub-total		14	15	15	13	9	53	54	-1%
	New Development Sub-total		**44**	**25**	**43**	**36**	**26**	**155**	**139**	11%
4.0 ARC Corporate Support										
SSP291e	ARC Corporate Support	ARC	14	15	7	11	8	46	44	3%
SSP291g	ARC Capital Improvements	ARC	0	10	0	0	0	0	10	---
	ARC Corporate Support Sub-total		**14**	**24**	**7**	**11**	**8**	**46**	**54**	-17%
Cash Budget Sub-total			**981**	**1,010**	**973**	**969**	**939**	**4,238**	**3,903**	8%
5.0 Management Reserve		ARC	0	0	0	98	0	390	0	100%
TOTAL CASH BUDGET			**981**	**1,010**	**973**	**1,066**	**939**	**4,628**	**3,903**	16%

Exhibit 2. CY2006 In-Kind Contribution Forecast ($000s)

SDSS-II CY2006 Actual Expense as of December 31, 2006

			Qtr 1 Jan-Mar	Qtr 2 Apr-Jun	Qtr 3 Jul-Sep	Qtr 4 Oct-Dec		CY2006 Total		
		Inst	Actual Expenses	Actual Expenses	Actual Expenses	Approved Baseline Budget	Actual Expenses	Approved Baseline Budget	Final Expenses	Variance (%)
OPERATIONS BUDGET: IN-KIND										
1.0 Survey Management										
SSP-248	FNAL Support for Survey Management	FNAL	35	32	31	34	36	133	134	-1%
	Survey Management Sub-total		**35**	**32**	**31**	**34**	**36**	**133**	**134**	-1%
2.0 Survey Operations										
2.1 Observing Systems										
SSP-xx	JPG Observing Systems Support	JPG	0	0	0	0	1	0	1	---
SSP-231	UW Observing Systems Support	UW	15	15	15	15	15	60	60	0%
SSP-261	FNAL Observing Systems Support	JPG	0	0	0	0		0		---
	Observing Systems Sub-total		0	0	0	15,000	16,411	60,000	61,411	-2%
2.3 Data Processing										
SSP-239	UC Software and Data Processing Support	UC	0	0	10	5	10	19	19	0%
SSP-240	FNAL Software and Data Processing Support	FNAL	88	79	99	46	93	185	358	-93%
SSP-257	USNO Software and Data Processing Support	USNO	0	0	0	10	12	42	12	73%
SSP-269	MSU SEGUE Software Development and Support	MSU	0		0	16	0	31	0	100%
	Data Processing Sub-total		88	79	109	77	114	278	389	-40%
2.4 Data Distribution										
SSP-237	JHU Data Archive Development and Support	JHU	26	28	24	16	8	82	85	-4%
SSP-268	FNAL Data Distribution Support	FNAL	11	14	14	7	16	26	55	-109%
	Data Distribution Sub-total		37	42	38	22	24	109	141	-29%
	Survey Operations Sub-total		**125**	**121**	**146**	**114**	**154**	**447**	**591**	-32%
3.0 New Development										
3.1 SEGUE Survey Development										
SSP-237	JHU Data Archive Development and Support	JHU	0	0	0	6	23	23	23	0%
SSP-269	MSU SEGUE Software Development and Support	MSU	16	16	16	0	16	31	63	-100%
	SEGUE Development Sub-total		16	16	16	6	39	55	86	-57%
	New Development Sub-total		**16**	**16**	**16**	**6**	**39**	**55**	**86**	-57%
TOTAL IN-KIND CONTRIBUTIONS			**176**	**169**	**193**	**154**	**229**	**635**	**811**	-28%
TOTAL OPERATING BUDGET (Cash and In-kind)			**1,157**	**1,179**	**1,166**	**1,220**	**1,168**	**5,263**	**4,714**	10%

Exhibit 3. Papers from within the SDSS Collaboration

1. The Fifth Data Release of the Sloan Digital Sky Survey. ApJ submitted – J. Adelman-McCarthy (for the Collaboration)

2. Luminosity dependence of the spatial and velocity distributions of galaxies: Semi-analytic models versus the Sloan Digital Sky Survey. MNRAS submitted - Cheng Li, et al

3. The Peculiar SN 2005hk: Do Some Type Ia Supernovae Explode as Deflagrations? PASP submitted M. M. Phillips, et al

4. The Clustering of Galaxy Groups: Dependence on Mass and other Properties. ApJ submitted - Andreas Berlind, et al

5. Clustering of High Redshift (z>2.9) Quasars from the Sloan Digital Sky Survey. AJ submitted - Yue Shen, et al

6. Topology of Structure in the Sloan Digital Sky Survey: Model Testing. ApJ submitted - J. Gott, et al

7. A New Survey for Giant Arcs. AJ Submitted - Joseph F. Hennawi, et al

8. Galaxy Colour, Morphology, and Environment in the Sloan Digital Sky Survey. MNRAS Submitted - Nick Ball, et al

9. Environment-Dependence of Properties of Galaxies in the Sloan Digital Sky Survey. ApJ accepted - Changbom Park – et al

10. SDSS J1029+2623: A Gravitationally Lensed Quasar with an Image Separation of 22.5 Arcseconds. ApJ 653 L97 - Naohisa Inada, et al

11. Internal and Collective Properties of Galaxies in the Sloan Digital Sky Survey. ApJ accepted – Yun-Young Choi, et al

Exhibit 4. Publications Based on Public Data

1. Multi-parameter estimating photometric redshifts with artificial neural networks. ChJAA accepted - Lili Li, et al

2. An Illustration of Modeling Cataclysmic Variables: HST, FUSE, SDSS Spectra of SDSSJ080908.39+381406.2. ApJ 654: 1036 (2007) – Albert P. Linnell, et al

3. Robust Machine Learning Applied to Astronomical Datasets II: Quantifying Photometric Redshifts for Quasars Using Instance-Based Learning. ApJ submitted – Nickolas M. Ball

4. An Explanation for the Observed Weak Size Evolution of Disk Galaxies. ApJ submitted – Rachel S. Somerville, et al

5. The 2dF-SDSS LRG and QSO Survey: The 2-Point Correlation Function and Redshift-Space Distortions. MNRAS submitted - Nicholas P. Ross, et al

6. The 2dF-SDSS LRG and QSO Survey: QSO clustering and the L-z degeneracy. MNRAS submitted - J. da Angela, et al

7. A Potential Galaxy Threshing System in the Cosmos Field. ApJS accepted - S. Sasaki, et al

8. White Dwarf Mass Distribution in the SDSS. MNRAS Accepted – S. Kepler, et al

9. The discovery of the first luminous z~6 Quasar in the UKIDSS Large Area Survey. MNRAS Letters Submitted – B. P. Venemans

10. Radio galaxies in the 2SLAQ Luminous Red Galaxy Survey: I. The evolution of low-power radio galaxies to z~0.7. MNRAS submitted - Elaine M. Sadler, et al

11. Statistical Properties of the GALEX/SDSS matched source catalogs, and classification of the UV sources. ApJS accepted – Luciana Bianchi, et al

12. A Balmer-line Broad Absorption Line Quasar. AJ in press – Patrick B. Hall

13. A Survey of Open Clusters in the u'g'r'i'z' Filter System: III. Results for the Cluster NGC 188. AJ submitted – Bartosz Fornal, et al

14. Cosmological parameters from the SDSS DR5 velocity dispersion function of early-type galaxies through radio-selected lens statistics. ApJL submitted - Kyu-Hyun Chae, et al

15. Ultraluminous and Hyperluminous Infrared Galaxies in the SDSS, 2dFGRS and 6dFGS. MNRAS accepted – Ho Seong Hwang, et al

16. Inclination-Dependent Luminosity Function of Spiral Galaxies in the Sloan Digital Sky Survey: Implication for Dust Extinction. ApJ accepted – Zhengyi Shao, et al

17. The Initial Cluster Mass Function of Super Star Clusters in Irregular and Spiral Galaxies. AJ submitted – Jayce D. Dowell, et al

18. The Radio-Loud Fraction of Quasars is a Strong Function of Redshift and Optical Luminosity. ApJ accepted - Linhua Jiang, et al

19. Estimation of Galactic model parameters with the SDSS and metallicity distribution in two fields in the anti-centre direction of the Galaxy. Astron.Nachr. 999 (2006) 1-6 – S. Ak, et al

20. How special are Brightest Group and Cluster Galaxies? MNRAS submitted – Anja von der Linden, et al

21. Simulating the COSMOS: The fraction of merging galaxies at high redshift. ApJ accepted – P. Kampczyk, et al

22. Is Ursa Major II the Progenitor of the Orphan Stream? MNRAS in press – M. Fellhauer, et al

23. The 8 o'clock Arc: A Serendipitous Discovery of a Strongly Lensed Lyman Break Galaxy in the SDSS DR4 Imaging Data. ApJL submitted - Sahar S. Allam, et al

24. Sloan/Johnson-Cousins/2MASS Color Transformations for Cool-Stars. PASP accepted – James R.A. Davenport, et al

25. Properties of Luminous Red Galaxies in the Sloan Digital Sky Survey. MNRAS submitted – T. Barber, et al

26. Refined Astrometry and Positions for 179 Swift X-ray Afterglows. AJ accepted – N. R. Butler

27. Discovery of a Faint Old Stellar System at 150 kpc. ApJL accepted – T. Sakamoto, et al

28. The flux ratio of the [OIII] 5007, 4959 lines in AGN: Comparison with theoretical calculations. MNRAS accepted – M.S. Dimitrijevic, et al

29. Reconstructing the Cosmic Evolution of Quasars from the Age Distribution of Local Early-Type Galaxies. ApJ submitted – Zoltan Haiman, et al

30. Correlation Properties of Galaxies from the Main Galaxy Sample of the SDSS Survey. Astron.Lett. 32 (2006) 721-726 – Anton V. Tikhonov

31. The properties of optical FeII emission lines of AGN with double-peaked broad emission lines. Rev. Mex. A&A accepted – Xue-Guang Zhang, et al

32. Empirical strong-line oxygen abundance calibrations from galaxies with electron temperature measurements. A&A in press - S. Y. Yin, et al

33. Galactic longitude dependent Galactic model parameters. New Astronomy accepted - S. Bilir, et al

34. Virgo cluster early-type dwarf galaxies with the Sloan Digital Sky Survey. II. Early-type dwarfs with central star formation. AJ accepted – T. Lisker, et al

35. Gemini spectra of 12000K white dwarf stars. MNRAS 372 (2006) 1799-1803 S. O. Kepler, et al

36. Supernovae in Low-Redshift Galaxy Clusters: the Type-Ia Supernova Rate. ApJ submitted- Keren Sharon, et al

37. SDSS J160531.84+174826.1: A Dwarf Disk Galaxy with an Intermediate-Mass Black Hole. ApJ accepted – Xiaobo Dong, et al

38. Environment and the cosmic evolution of star formation. ApJL 650:25 (2006) - Ravi K. Sheth, et al