Sloan Digital Sky Survey

2004 Annual Report

March 16, 2005

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PERFORMANCE HIGHLIGHTS

- There were 186 refereed papers published in 2004 that were based wholly or in part on SDSS data or discoveries. Over half of these papers were written by people outside the SDSS collaboration.
- We revised the Five-Year Baseline Plan by recasting imaging progress on the NGC in terms of "footprint" square degrees. The change was necessary to reveal the remaining imaging area between stripes 10 and 37.
- On the Northern Galactic Cap (NGC), we obtained 1,395 square degrees of new "footprint" imaging data in 2004 against the revised baseline goal of 1,446 square degrees (96%). We also completed 208 standard survey plates against the established baseline goal of 343 plates (61%).
- Through the end of 2004, the imaging survey on the NGC is 85% complete against the revised baseline plan and the spectroscopic survey is 76% complete against the original baseline plan.
- On the Southern Equatorial Stripe, we obtained 913 square degrees of new "unique" imaging data in 2004 against the established baseline goal of 1,378 square degrees (66%). We also completed 18 standard survey plates, 24 special program plates and 47 SEGUE plates. Converting these to plate-equivalents, we completed 113 plate-equivalents against the established goal of 111 plates (102%).
- Through the end of 2004, we have obtained a total of 3,470 square degrees of "unique" imaging data on the Southern Equatorial Stripe and have imaged all areas of the stripe at least six times. Some areas have been observed as many as 15 times.
- The weather was clear enough to obtain useful data 51% of the time. Our baseline plan anticipated that weather conditions would be suitable for observing 60% of the time; the shortfall impacted data yield.
- We released DR2 to the public on March 4 and DR3 to the public on September 27. These releases satisfy commitments in the approved data distribution plan.
- We released DR4 to the SDSS collaboration on December 22. The public release of DR4 is scheduled for July 2005, in accordance with the approved data distribution plan.
- Data archive use continues to grow. Through the end of December, the public SkyServer had received just over 65 million web hits and executed 9.3 million SQL database queries.
- 2004 cash operating expenses were $3,104K against a baseline budget of 3,248 (-4%), excluding management reserve. In-kind contributions were $1,352K against anticipated contributions of $1,806K (-25%). No management reserve funds were expended in 2004.

1. SCIENCE RESULTS

There were 186 refereed papers published in 2004 using SDSS data. Over half of these papers were written by people outside the SDSS collaboration. The following are brief summaries of some of the more exciting of those discoveries.

The measurement of the large-scale distribution of galaxies was one of the original scientific goals of the SDSS. Max Tegmark led a team which calculated the galaxy power spectrum on large scales; the results are widely seen as the definitive measurement of this cosmologically crucial function. These results (early versions of which were highlighted as the top science results of the year by Science Magazine in late 2003) show spectacular agreement with the standard inflationary cosmology, with smaller error bars than were available before. In particular, when combined with constraints from the measurement of fluctuations in the cosmic microwave background and high-redshift supernovae, the SDSS data greatly strengthen the case for dark energy, and for a primordial power spectrum with a constant power-law slope of unity, just as inflationary models predict. The data also give stronger limits on the mass of the neutrino than were possible before. The resulting papers are the first and fourth most cited papers in all of astrophysics published in 2004. We anticipate further constraints on the standard cosmological model in 2005, from SDSS analyses of the Lyman-alpha forest in quasar spectra, and from the large-scale clustering of Luminous Red Galaxies.

The SDSS has also made breakthroughs in the clustering of galaxies on smaller scales. The correlation function of galaxies is extremely well-fit by a power law, although it has been a mystery for 20 years why this should be so. Idit Zehavi and her colleagues have found a subtle break in that power law on scales of 1-2 Mpc, which can be interpreted as due to the transition in clustering between galaxies *within* a given dark matter halo, and the clustering of the halos themselves. These results can be fit with a simple model, which gives for the first time a proper physical explanation why the correlation function has the form that it does.

The SDSS has been responsible for the discovery of the 16 highest redshift quasars known, with redshifts ranging from 5.7 to 6.4. We are seeing these objects at a time roughly 900 million years after the Big Bang, i.e., when the universe was about 6% of its present age. This is a particularly interesting frontier in modern astrophysics, as it is becoming increasingly clear that this is the time when galaxies started to form in large numbers. One particularly exciting discovery of 2004 is the presence of large quantities of molecular gas (CO) in the host galaxy of the z=6.4 SDSS quasar. Quasars are powered by supermassive black holes into which material is falling via an accretion disk. To feed the accretion disk requires a substantial amount of gas in the quasars' host galaxy. An extremely deep exposure with the VLA by Fabian Walter and colleagues has shown that this gas is resolved in a disk around the quasar itself. Thus the direct connection between the interstellar medium of host galaxies and quasars seen at lower redshift is spectacularly mirrored at high redshift.

These high-redshift quasars have shown evidence, in the absorption of their spectra by neutral hydrogen, for the end of the epoch in the Universe's history when hydrogen in the intergalactic medium was neutral. It is believed that it was ionized by high-energy photons emitted from early generations of stars in young galaxies. However, the intergalactic medium also contains a substantial amount of helium. With its higher ionization potential, one expects the helium to be ionized at lower redshifts than hydrogen, and this expectation has now been verified with Hubble-Space Telescope spectroscopy of specially selected SDSS quasars, in a study led by Wei Zheng. There is evidence for an appreciable column density of singly ionized helium at redshift 3.5, implying that the complete ionization of helium occurs at a lower redshift.

Brian Wilhite's PhD thesis consisted of a study of quasar variability, comparing the photometry and spectroscopy from the SDSS data. The SDSS spectroscopic data are photometrically calibrated to 5% or better, unprecedented in this kind of work, and making the variability analysis possible. Quasars vary on timescales from days to years, with variability larger on longer timescales and at shorter wavelengths. More luminous quasars vary less on a given timescale than do less luminous quasars, while X-ray-loud quasars vary more. These relationships, now quantified exquisitely well with SDSS data, represent a major challenge for modern models of quasar activity.

Nadia Zakamska has found a substantial number of dust-enshrouded quasars in the SDSS. The dust blocks optical emission from the central engine; only the more broadly distributed narrow-line region is apparent. She was able to demonstrate that these objects are quasars nevertheless, by measuring the emission of the dust at mid-infrared wavelengths from archival data from the IRAS satellite. There is an increasing consensus from X-ray and other studies that roughly half of all low-luminosity quasars are dust-enshrouded; Zakamska's work is the first to quantify this well at the high-luminosity end.

It has long been known that galaxies are surrounded by substantial quantities of dark matter. However, astronomers have had only a few handles on the full distribution of the dark matter. Erin Sheldon and colleagues have used SDSS to measure the effects of weak lensing (the systematic distortion of distant galaxy shapes due to the gravity of foreground objects) by nearby galaxies. This work has given the most complete measurement to date of the extent of galaxies' dark matter halos on scales from 25 kpc to 10 Mpc. The dark matter halos follow the same power law as that of the galaxy-galaxy correlation function, implying no dramatic change in the bias as a function of scale. The halo masses do depend on galaxy luminosity, in a way that is at least in rough agreement with a constant ratio of luminosity to dark matter.

The Milky Way disk shows an older population more extended perpendicular to the disk than that traced by young stars: this population is referred to as the "thick disk". Stefano Zibetti, in his PhD thesis, has stacked the SDSS images of hundreds of edge-on spiral galaxies, to demonstrate the presence of the thick disk and extended halo in this population, and has measured the properties of these components to far greater precision than was possible in the past. The measurements of the colors of these halos supports the model, suggested independently by other SDSS data on Milky Way stars, that galaxy halos are formed via the merging of satellite galaxies.

The SDSS has scanned the Andromeda galaxy, allowing highly detailed studies of its halo as well. Dan Zucker and colleagues have found several extremely low-luminosity companions to Andromeda, perhaps the lowest-luminosity galaxies ever seen. Theoretical models of galaxy formation predict many more low-luminosity galaxies than are readily apparent in surveys, which some have attributed to incompleteness in galaxy catalogs. The SDSS data in Andromeda may point to some of this previously missing population, although it is not yet clear whether there are enough such low-luminosity galaxies to match theoretical predictions.

The SDSS data allow exquisite measurements of the positions and motions of stars in the halo of our Milky Way. In particular, we have spectra of tens of thousands of halo stars, which allow the dynamics of the halo to be mapped out in much more detail than was possible before. Ed Sirko and colleagues carried out by far the most precise measurement to date of the velocity dispersion ellipsoid of halo stars over large scales, which encodes valuable clues for the way in which the halo formed. They were able to show unambiguously that the halo of our galaxy does not rotate, while the disk of our galaxy does.

The SDSS has discovered many tens of the coolest stars known, the so-called methane brown dwarfs. David Golimowski and colleagues have carried out detailed studies of their properties: parallaxes have allowed determination of their luminosities and therefore radii, while L and M band photometry and near-infrared spectroscopy have constrained models for their atmospheres. There are variations in the colors of these objects at a given temperature, which is almost certainly due to the changes in the altitude clouds form in their atmospheres.

Scot Kleinman and colleagues have scoured the SDSS spectroscopic data for white dwarfs, and have published a catalog of several thousand of them, more than the total known to date. SDSS white dwarfs come in a bewildering range of types, distinguished by surface temperature, surface chemical composition, and variability properties. The SDSS is the first survey to discover white dwarfs over the full range of properties, and should allow definitive measurements of the relative numbers of these different types, which constrains models of white dwarf formation and the history of star formation in the Milky Way disk.

Main-belt asteroids can be detected in the SDSS from their apparent motion in the sky in the time it takes to traverse the five filters. The SDSS has made accurate measurements of the colors of over one hundred thousand asteroids. Mario Juric has led a project to look at the relatively rare cases in which a given asteroid has been observed more than once. Subtle differences in the colors of the asteroids with time are due to varying chemical composition on their surfaces, and the rotation of the asteroid with time. This is the first large statistical sample in which the variation in asteroid surface composition can be mapped out in detail.

2. SURVEY PROGESS

2.1. Revision of the Five-Year Baseline Plan

The SDSS Five-Year Baseline Plan provides the expected rate of data collection with respect to time, separately for imaging and for spectroscopy, and separately for the North Galactic Cap region and for the fall, or "Southern," sky. It was developed in 2001 to provide a way to measure actual progress on the survey with respect to reasonable goals. A benchmark is useful to the extent it does not shift around; we have been careful to maintain the 2001 plan for this reason, despite significant changes in strategy (for example, undertaking imaging in the final observing season, whereas the Plan assumed that the final season would consist of only spectroscopy).

Until now the Five-Year Baseline Plan has served its purpose well, providing a consistent basis for reporting in our quarterly reports and annual reports. However, a feature of the accounting for imaging data, which was originally sensible, is now leading to an inaccurate picture for the status of the survey. (These statements do not apply to the spectroscopic survey nor to the imaging and spectroscopy in the South Galactic Cap.) We therefore propose to re-cast the Five-Year Baseline Plan for imaging in a way that properly shows the status of the sky coverage, leading up to the completion of the SDSS. We emphasize that the survey goal is not being relaxed: the change concerns only the way in which we account for the imaging data.

The original accounting used a category we call "unique" imaging data. This category corrects for overlaps at the ends of strips and in between strips in a stripe. Each hour of observing time results in (potentially) 18.75 square degrees of "unique" imaging data. The direct scaling of time into area for this category was useful because all projections were based on the amount of observing time that was expected to be available.

Another category of imaging data is called "footprint," which corrects for overlaps between stripes due to the convergence of the system of great circles. We did not use this at the beginning since it does not scale in a simple way with time - each new observation will yield a different number of "footprint" square degrees, depending on where it falls with respect to earlier observations. (As a rough indication, "footprint" area is smaller than "unique" area by about 20%.) At this time in the survey, we are trying to finish observations within a specific area of the sky, and the "footprint" metric is far more meaningful.

The Five-Year Baseline Plan was a projection of the amount of data that could be collected within the North Galactic Cap, but it made no explicit assumptions of where the data would be within the pi steradians of the NGC. We are motivated to leave a legacy of a survey within a contiguous area, specifically completing stripes 10 through 37. This goal is more demanding: we now have a goal not just of a total area, but of a particular area. Nevertheless our progress on the imaging survey is very close to what we had projected in the Five-Year Baseline Plan.

The need for a revision in our accounting and reporting is clear from the following: the Five-Year Baseline Plan stipulates 7700 square degrees of "unique" imaging data in the North Galactic Cap. As of 31 December 2004, we have collected 7831 square degrees of "unique" imaging data. Despite this, as of the end of 2004 Q4, we were still missing over 1300 square degrees of "unique" imaging data in the critical region between stripes 10 and 37. The new reporting is intended to reveal this remaining amount of imaging and to provide a way to track progress in completing it from now until the end of the SDSS (30 June 2005).

As just mentioned, the specific goal is to complete, in the imaging survey, the region between and including stripes 10 and 37 by 30 June 2005. This is an area of 7000 footprint square degrees. In addition, we have already scanned about 700 footprint square degrees in the NGC that are on adjacent stripes, or in the Spitzer First Look Survey region. Thus the new reporting needs to reflect a goal of acquiring a total of 7700 footprint square degrees by 30 June 2005. For reference, 7,700 footprint square degrees corresponds to approximately 9,370 unique square degrees.

The simplest projection is to assume an average rate of acquiring data that sums to 7700, given that the start of the survey is defined to be 1 April 2000 (as we did before). Figure 1.2 shows this projection, and provides the actual data-collection rate in the same terms. As of the end of Q4 2004, the actual amount of "footprint" imaging data in the NGC was 6458 square degrees, which is very close to that required if we are to meet our goal in the next two quarters.

2.2. Imaging

Table 2.1 summarizes imaging progress in 2004. We collected 1,395 square degrees of imaging data on the NGC against the baseline goal of 1,446 square degrees (96%). We also collected 913 square degrees of imaging data on the Southern Equatorial Stripe against the baseline goal of 1,378 square degrees (66%). We did not lose any potential imaging time to equipment or system problems. The shortfall, particularly on the Southern Equatorial Stripe, was the result of marginal weather conditions. The amount of time suitable for imaging in 2004 was less than anticipated in the baseline plan.

Table 2.1. Imaging Survey Progress in 2004

	Imaging Area Obtained (in Square Degrees)			
	Jan-Dec 2004		Cumulative through 2004	
	Baseline	Actual	Baseline	Actual
Northern Survey[1]	1446	1395	6538	6458
Southern Survey[1]	0	0	745	738
Southern Equatorial Stripe[2]	1378	913	4808	3470

1. "Footprint" area
2. "Good minus Unique" area.

As the Southern Equatorial Stripe is not visible from APO during the spring, 2004 marked the end of observing on this area of the sky and the completion of the Survey of the Southern Equatorial Stripe. In total, we obtained 3470 square degrees of unique imaging data against our target of 4808 square degrees (72%). Imaging of the Southern Equatorial Stripe consisted of repeated scans over an area of the sky covering approximately 205 square degrees. All portions of the stripe were observed at least 6 times, with some areas observed as many as 15 times.

The baseline goal for the NGC imaging survey is to acquire 7642 “footprint” square degrees of imaging data by June 30, 2005. As noted, through December 2004, we have acquired 6458 square degrees, or 85% of the goal. We therefore need to collect an additional 1,184 square degrees of imaging data during the period Jan-Jun 2005 to meet the NGC baseline goal. Figure 2.1 shows the amount of imaging data collected on the NGC during each of the last four years. Although the annual collection rate is 1095 square degrees, there have been significant year-to-year variations due to weather. We will clearly need better than average weather conditions in the first half of 2005 to meet our baseline goal for the NGC.

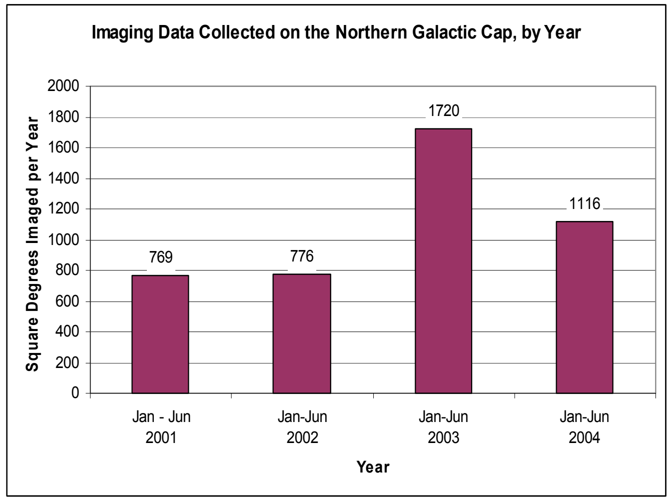

Figure 2.1. Imaging data collection per year

The following graphs show progress against the imaging goals for the Northern Galactic Cap and the Southern Equatorial Stripe through the end of 2004. These progress graphs are updated monthly on the SDSS website to provide a current view of survey progress.

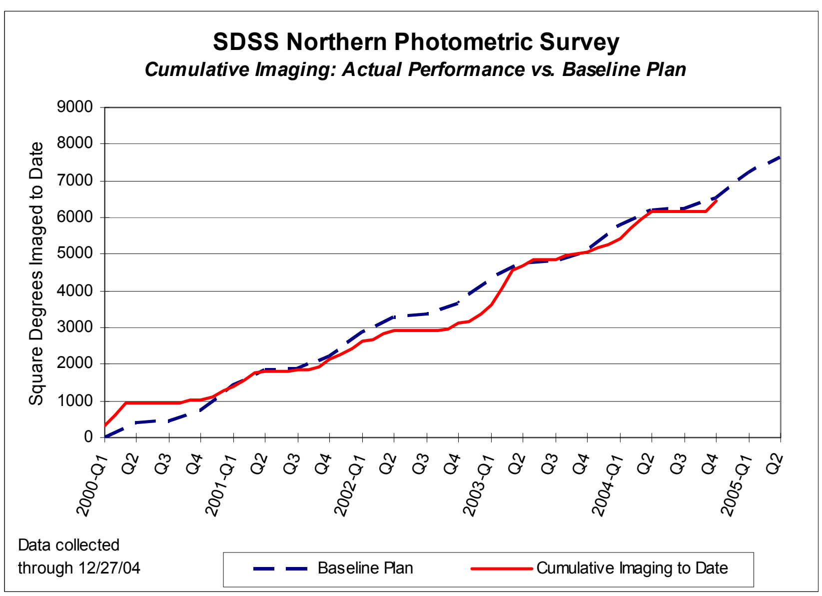

Figure 2.2. Imaging Progress against the Baseline Plan – Northern Survey

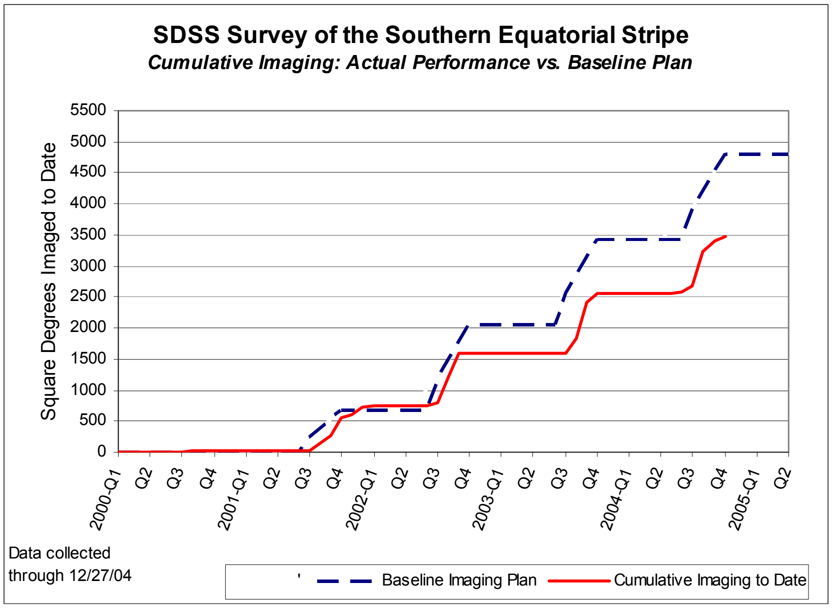

Figure 2.3. Imaging Progress against the Baseline Plan – Southern Equatorial Survey

In addition to standard survey scans, we collected imaging data for the SEGUE and Supernova programs in 2004. Data collection for the SEGUE and Supernova programs was set to a lower priority than standard survey scans, and therefore did not impede progress against our baseline goals. Work on the SEGUE and Supernova programs is discussed in Section 9.

2.3. Spectroscopy

Spectroscopic progress is reported in terms of the number of plates observed and declared done. In 2004, we completed a total of 279 spectroscopic plates on the NGC and Southern Equatorial Stripe. Since each plate typically yields 640 unique spectra, we obtained spectra for approximately 179,000 objects.

Of the 279 plates completed in 2004, 208 were standard survey plates, 24 were special program plates, and 47 were SEGUE plates. Some of the special program and SEGUE plates required longer exposure times than standard plates. Specifically, we would have completed 40 standard survey plates in the time it took to complete the 24 special plates, and 56 standard plates in the time it took to complete the 47 SEGUE plates. Summing together the 208 standard survey plates, 40 special program plate-equivalents, and 56 SEGUE plate-equivalents, we completed 304 plate-equivalents against a baseline goal of 454 plates for all areas combined (67%).

Spectroscopic progress on the NGC in 2004 was compromised by marginal weather. We obtained a total of 208 plates on the NGC in 2004, against a baseline target of 343 plates (61%). Through December 2004, we have obtained a total of 935 plates against a goal of 1228 plates (76%).

The NGC will remain visible from APO through the end of Survey Operations (June 2005) and so we will continue to complete plates in this area as weather permits. However, it is unlikely that we will achieve our baseline goal of 1540 plates by the end of June 2005, since this would mean completing 605 plates in the next six months. Over the past three years, we have completed an average of 234 plates per year on the NGC. If this trend holds, we will only complete a total of 1170 plates by the end of June, or 76% of our baseline goal of 1540 plates.

The following graphs show spectroscopic progress against the baseline goal. Progress is reported in plate-equivalents for the special program plates, which allows for a direct comparison with baseline goals.

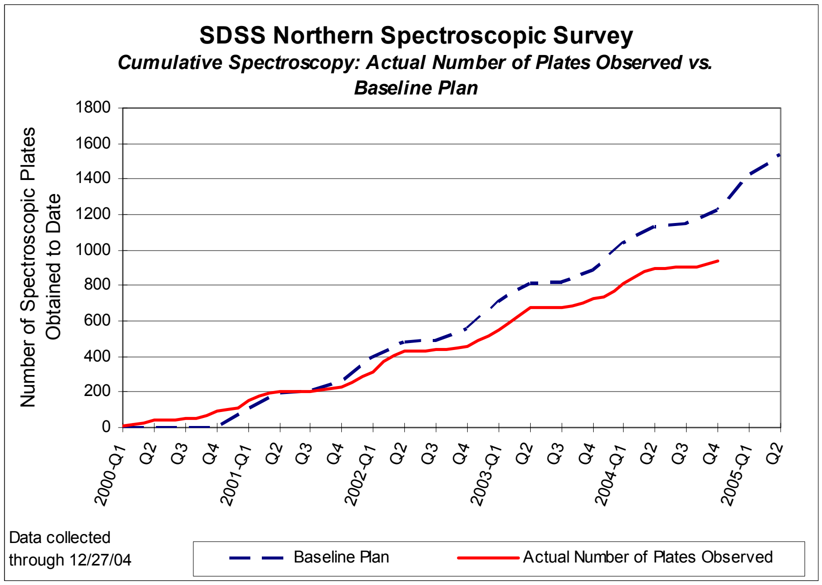

Figure 2.4. Spectroscopic Progress against the Baseline Plan – Northern Survey

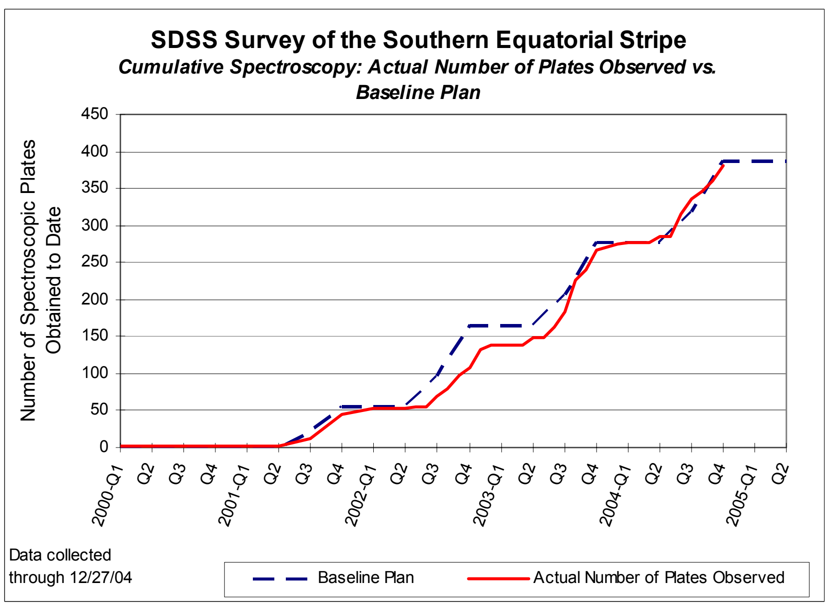

Figure 2.5. Spectroscopic Progress against the Baseline Plan – Southern Equatorial Survey

3.0 OBSERVING EFFICIENCY

3.1. Weather

The weather category reports the fraction of scheduled observing time that weather conditions were suitable for observing. Table 3.1 summarizes the total amount of time lost to poor weather in 2004. Figure 3.1 plots the fraction of suitable observing time against the baseline forecast through December 2004.

Table 3.1. Potential Dark Time Observing Hours Lost to Weather in 2004

Observing Period	Total hours potentially available for observing	Total hours lost to weather	Fraction of time suitable for observing	Baseline Forecast
Q1 (Jan-Mar)	416	255	39%	60%
Q2 (Apr-Jun)	311	114	63%	60%
Q3 (Jul-Sep)	226	98	57%	60%
Q4 (Oct-Dec)	431	206	52%	60%
Total	1,384	673	51%	60%

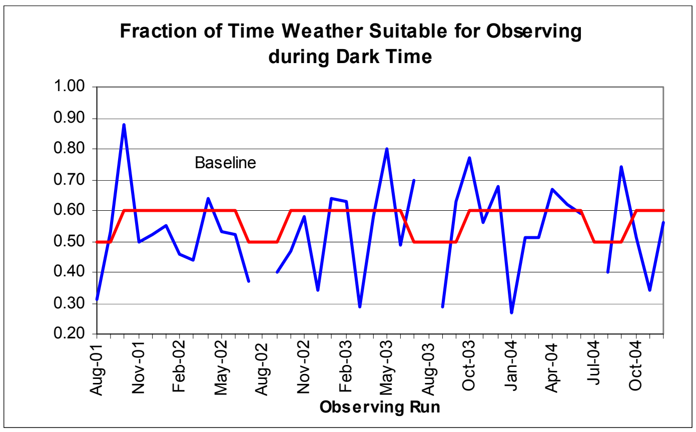

Figure 3.1. Fraction of Time Weather Suitable for Observing

3.2. System Uptime

System uptime measures the availability of equipment when conditions are suitable for observing. We averaged 96% uptime in 2004 against a baseline goal of 90%. Table 3.2 summarizes the total amount of time lost per quarter to equipment or system problems. Figure 3.2 plots monthly uptime against the baseline goal. The majority of time lost in 2004 was due to minor equipment problems. The problem that caused the largest amount of lost time was associated with the spectrograph collimator actuator assemblies. Identifying the root cause of the problem was difficult and took quite a bit of time. The solution required complete disassembly and re-lubrication of the actuator assemblies, and the implementation of the preventive maintenance program to preclude further problems in this area.

Table 3.2. Potential Observing Hours Lost to Problems in 2004

Observing Period	Total hours potentially available for observing	Total hours lost to problems	System Uptime	Baseline Goal
Q1 (Jan-Mar)	416	9	98%	90%
Q2 (Apr-Jun)	311	9	97%	90%
Q3 (Jul-Sep)	226	8	96%	90%
Q4 (Oct-Dec)	431	32	93%	90%
Total	1,384	58	96%	90%

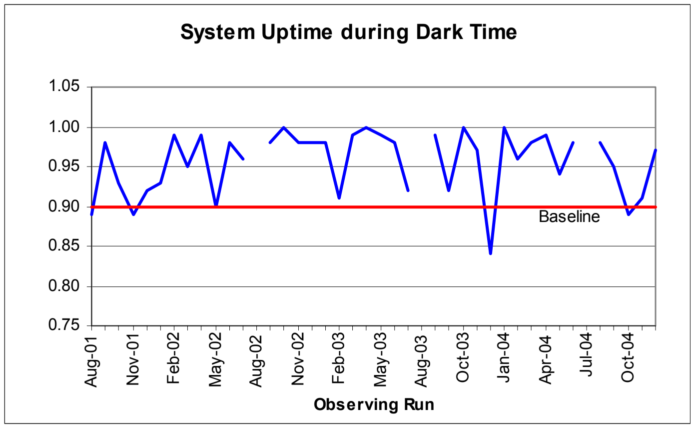

Figure 3.2. System Uptime

3.3. Imaging Efficiency

The imaging efficiency ratio is defined as the ratio of science imaging time to the sum of science imaging time plus imaging setup time. Imaging efficiency averaged 0.84 during 2004 compared to the baseline goal of 0.86. When the weather is poor, imaging efficiency drops because the observers often take more time than usual to finish setup and calibration; setup and calibration can be performed while waiting for the weather to clear. Imaging efficiency has been consistently close to the baseline for the past several years.

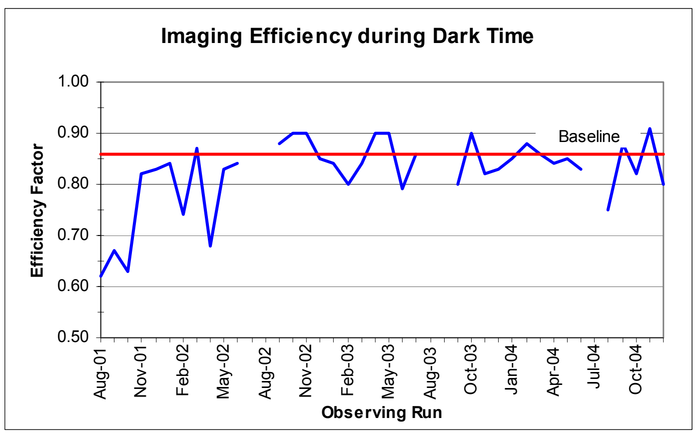

Figure 3.3. Imaging Efficiency

3.4. Spectroscopic Efficiency

Spectroscopic efficiency is derived by assessing the time spent performing various activities associated with spectroscopic operations. Table 3.3 provides the median time, by dark run, for various overhead activities associated with spectroscopic operations. Units for all categories are minutes except for efficiency, which is given as the ratio of baseline science exposure time (45 minutes) to total time required per plate. Using these measures, we averaged 63% in 2004, compared to the baseline goal of 64%.

Table 3.3. Median Time for Spectroscopic Observing Activities (*in minutes*)

Category	*Baseline*	*Q1 (Jan-Mar)*	*Q2 (Apr-Jun)*	*Q3 (Jul-Sep)*	*Q4 (Oct-Dec)*	*Average*
Instrument change	10	5	5	4	5	5
Setup	10	15	13	12	11	13
Calibration	5	6	6	6	6	6
CCD readout	0	3	3	3	3	3
Total overhead	25	29	27	25	25	27
Science exposure (assumed)	45	45	45	45	45	45
Total time per plate	70	74	72	70	70	72
Efficiency (1)	0.64	0.61	0.63	0.65	0.65	0.63

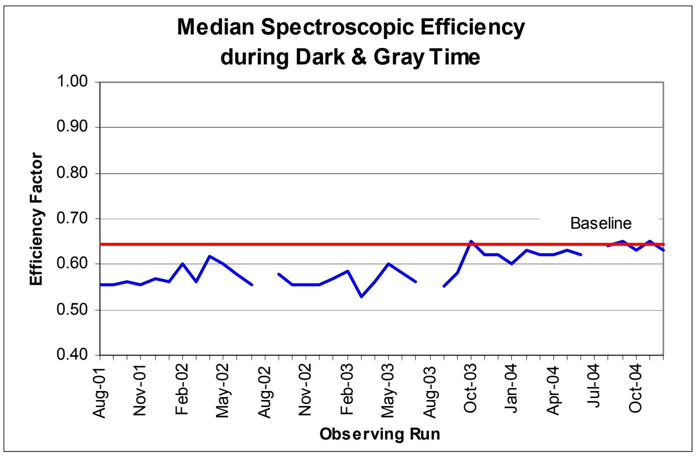

Figure 3.4. Spectroscopic Efficiency

4. OBSERVING SYSTEMS

Observing systems includes the telescopes, instruments, ancillary support systems, equipment, and software used at APO to collect data for the survey.

4.1. The Instruments

The imaging camera worked relatively well throughout the year. The U3 chip became quite noisy during one particularly cold night in January, but the event was a one-time occurrence in 2004. A pinched ion pump cable, which was routed near the camera body, caused bias variations in one of the camera dewars but was quickly found and repaired. Summer maintenance work was performed as needed. Late in the year, we began seeing banding in bias levels across the CCDs in dewar 1. The exact cause of the banding is still under investigation; fortunately, data quality has not been affected.

A series of calibration measurements were made on the imaging camera. Linearity measurements were made and found to be consistent with measurements taken in 1999. The wavelength of the imager band responses was measured and compared to measurements made in July to determine temperature sensitivity. A preliminary review of the data indicates that band widths in *i*, and possibly *r,* are approximately 2 nm broader than similar data taken in July. A report summarizing the measurements and results is being prepared.

We had a few mechanical problems with the spectrographs during the year. Most notably, we had problems with the actuator assemblies for the spectrograph collimator motors, which affected spectrograph focus and impacted observing operations. We looked into replacing the actuator assemblies but found that certain components are obsolete and no longer available. Modifying the system to accept new actuator assemblies will be time-consuming and costly and is being postponed pending the approval of SDSS-II. In the interim, the engineering crew designed and fabricated tooling to allow us to disassemble, inspect, and re-lubricate the existing actuator motors and gear heads. In Q4, the actuator assemblies were disassembled and re-lubed; the system has worked well since this maintenance work was performed. The engineering team has also developed and implemented a new preventive maintenance procedure for the actuators to preclude further problems through the end of survey operations. During summer maintenance work, we attempted to replace the optical couplant mating together with the spectrograph camera lenses. Over time, we have noticed growing voids in the couplant. While the voids have not affected data quality, we are concerned about potential increases in light loss and scattering should be voids become worse. Unfortunately, we were unable to disassemble the lenses to replace the couplant. Rather than risk breaking a lens, we decided to postpone lens disassembly indefinitely.

4.2. The 2.5m Telescope

A preventive maintenance program has been implemented by the telescope engineering team to make sure that the telescope, instruments, and various support systems remain operational and in good shape. In addition, a substantial amount of work was done in 2004 to improve the spares situation at APO. A number of systems were reviewed and sparing needs assessed, and parts ordered as appropriate. A database was created to keep track of the spare components for the various systems. The database maintains information on the quantity and location of spare parts on hand.

A significant amount of work was performed during the summer shutdown on a wide variety of systems. Throughout the year, work was performed on a number of engineering, maintenance and repair tasks. Significant tasks included re-aluminizing mirrors on the 2.5-meter and Photometric telescopes, replacing telescope drive bearings, and installing a re-designed telescope fiducial read-head to improve observing efficiency. Descriptions of the summer maintenance work, as well as the more significant tasks performed throughout the year, are documented in the quarterly progress reports. Overall, the engineering team is doing a good job of keeping the telescope and systems ready and available for observing, as evidenced by the strong systems uptime record.

4.3. The Photometric Telescope

The Photometric Telescope (PT) performed reasonably well throughout the year. We did discover a filament or thread of some sort sitting on the surface of the PT CCD. We have been monitoring the position of the filament over time and as long as it does not move, we are able to flat-field out the filament from the corrected frames during data processing. Removing the filament requires warming the CCD, which we intend to postpone until scheduled maintenance time or the filament becomes problematic.

We had a number of problems throughout the year with the closed-cycle refrigerator (the Cryotiger) used to cool the PT CCD. During the first half of the year, the Cryotiger system occasionally had trouble keeping the PT CCD at operating temperature. Suspecting that the system had become contaminated, we swapped the system with a spare unit and sent the primary unit back to the vendor for refurbishment. While the primary system was off-site, the spare system started acting erratically. Once the primary system was back on site, we sent the spare to be refurbished. In the process of all of this, we learned that these units are nearing the end of their expected lives. We fully expect them to remain functional through the end of this observing season, but they will certainly need to be replaced if operations are to continue beyond mid 2005.

4.4. Operations Software and the Data Acquisition System

All observing software remains under formal version control and all changes are reviewed and approved before work is done. Very few observing software programs were modified in 2004. The following is a brief summary of the changes that were made in 2004:

- The Imaging Observers Program (IOP) was modified to help observers avoid wrapping the telescope during imaging scans. IOP was also modified to accommodate SEGUE imaging scans as well as standard survey scans.
- A new version of astrom was implemented and tested; v3_8b fixes the operational problem of goStare writing the opConfig file before goDrift is executed.
- New code was implemented for the M2 Galil controller, which is part of the M2 mirror control system. The new M2 code outputs piezo data to the TMP (via the Galil's auxiliary port) and the TPM displays the new data.
- The Telescope Control Computer (TCC) code was modified to accommodate the 2.5m telescope azimuth tilt correction.
- The MCP and interlock PLC code were updated to reflect the change in the position of the telescope azimuth soft limits. Due to dependencies, this also required updating IOP and the watcher/interlock display.
- Several upgrades were made to the Telescope Performance Monitor (TPM).
    - An array initialization problem in the routine that filters serial link communication status was fixed.
    - A new serial interface to the imager UPS was implemented to record and report alarms generated by the imager UPS system.
    - The TPM channels that refer to TCC position-velocity-time (PVT) triplets now contain the information from the *tccmove* structure in dataCollection.h, rather than duplicating the PVT structure that holds the MCP PVTs.

There were no problems with the data acquisition system that prevented us from acquiring data. Throughout the year we had occasional problems with the PTVME link, but existing workarounds kept these problems from affecting our ability to collect data. Planning began on the proposed DA upgrade, which will address component obsolescence issues, replace aging computers, and mitigate the PTVME link problem. Preliminary development work on the upgrade will occur in early 2005.

4.5. Plug Plate Production

A new drilling fixture was fabricated and put into regular use in 2004. The new fixture allows plates to be installed and removed much quicker, which greatly improves the efficiency of the drilling operation. In addition to this benefit, we now have a spare fixture (the original unit) that can be used to qualify a back-up plate vendor, should it be deemed necessary. Other aspects of the plate production operation, from plate design and drilling, through plate QA inspection and shipment to APO, continue to operate very smoothly.

5. DATA PROCESSING AND DISTRIBUTION

5.1. Data Processing

5.1.1. Pipeline Development and Testing

No changes were made to the photometric pipeline, *Photo*, used to process standard survey data.

Work began in 2004 to revise the spectroscopic pipeline, *idlspec2d*, to apply a reddening correction to the spectra. The revised code will also provide improved spectrophotometry and output the specific sky that was subtracted from each spectrum during data processing. Outputting the sky spectra provides users with the ability to get back the non-sky-subtracted spectrum of specific objects, if desired. When finished, the code will be tested and verified by the data processing (DP) factory before being put into production use. Incorporating the new code requires a data model change, as well as revisions to the spectroscopic pipeline, *Spectro1D*, and revisions to the Catalog Archive Server (CAS). It is anticipated that these changes will be finished, tested and declared production-ready in time for inclusion in DR5.

The astrometric pipeline is mature and stable; no major upgrades or changes were made or are foreseen. In the second half of the year, new Known Object files for the SEGUE stripes were prepared and placed on the SDSS computer cluster at Fermilab. Both Tycho2 koCat files (for use at APO) and UCAC koCat files (for astrom pipeline reductions at Fermilab) were also completed and submitted. Work is currently underway to prepare UCAC koCat files for the entire SDSS observing area based upon the newly completed preliminary all-sky UCAC catalog. The goal it to complete the UCAC catalog in time for the NGC observing season.

5.1.2. Data Processing Operations

Data processing operations continue to run very smoothly. In 2004, we processed data from 112 imaging runs, 279 spectroscopic plates, and 267 unique PT patches.

Quality assurance (QA) tests are performed on all imaging data and the results posted on the runQA web page. QA inspections are made on all spectroscopic data and the results summarized on the spectro QA web page. In addition, during observing periods, e-mail messages summarizing the results of the most recent reductions are posted daily by the DP group. These messages provide prompt feedback to the observing and engineering teams regarding the quality of recently acquired data and alert people to potential problems.

To ensure data reliability, we implemented a system that automatically compares checksums against all of the data in the data release datasets weekly. Corrupt files are promptly replaced when discovered. To further ensure data availability, the DP group regularly backs up critical SDSS data into a tape robot at Fermilab.

In the first half of 2004, a number of new computers were brought online as part of the on-going factory upgrade project. We installed new disk servers, retired aged servers, and increased data storage capacity by 20 terabytes (TB), to a total of 65 TB.

A new version of the imaging QA tool, runQA, was implemented in 2004. The new code incorporates a field quality algorithm that assigns a quality rating to each processed field. Other improvements include ignoring fields known to be bad when reporting problems, and more detailed reports. In particular, html tables now report maximum deviations of median principal color, the locus width, and also measure the behavior of the distribution tails. Problems can be traced on a field-by-field basis. In addition, there is new code to post-process runQA outputs for a large set of runs and present summary statistics in tabular and histogram format.

In addition to processing data and preparing for data releases, data processing personnel were involved with the implementation and testing of data reduction software for the SEGUE program; and in the development, installation and commissioning of a prototype Supernova data reduction system at APO. Work performed in these areas is discussed in Section 8.

5.2. Data Distribution

2004 was a big year for SDSS data releases. On March 15, we released DR2 to the public. On September 27, we released DR3 to the public. On December 22, we released DR4 to the collaboration. The public currently has access to 5,282 square degrees of imaging data, an imaging data catalog containing 141 million objects, and spectroscopic data for 529,000 objects. The SDSS collaboration currently has access to 6,670 square degrees of imaging data, an imaging data catalog containing 180 million objects, and spectroscopic data for 673,000 objects. DR4 will be made available to the public in July 2005, in accordance with the approved data distribution plan.

5.2.1. Data Releases

Table 5.1 summarizes the sky coverage and data volumes associated with DR2, DR3, and DR4. DR2 and DR3 each contain two versions of the imaging data: *Target* and *Best*. The *Best* version contains images and photometric catalogs with the highest quality data at the time of the data release. The *Best* imaging data was processed with *Photo* v5_4_18 or greater, with the majority of data processed with *Photo* v5_4_25. The *Target* version contains those imaging data at the time the target selection algorithm was run for that part of the sky. *Target* data was processed with the version of *Photo* current at the time the target selection algorithm was run. DR4, which is only available to the collaboration, contains one version of the imaging data: *Best*. We encountered a number of problems when loading the *Target* version that threatened to delay the DR4 release to the collaboration. In the spirit of getting data to the collaboration as quickly as possible, we decided to release the *Best* version of DR4, along with the corresponding spectra, in December. We will finish loading the Target version early in 2005 and make it available to the collaboration as soon as possible.

Table 5.1. Data Release Contents

	DR2 Contents	*DR3 Contents*	*DR4 Contents*
Imaging			
Footprint area (sq deg)	3,324	5,282	6,670
Imaging catalog (unique objects, in millions)	88	141	180
Data volume (TB)			
Images	5.0	6.0	8
Catalogs (DAS, FITS format)	0.7	1.2	2
Catalogs (CAS, SQL database)	1.4	2.3	3
Spectroscopy			
Spectroscopic area (sq deg)	2,627	4,188	5,320
Spectroscopic catalog			
Total spectra	367,360	528,640	672,640
Galaxies	260,490	374,767	478,887
Quasars (redshift < 2.3)	32,241	45,260	56,340
Quasars (redshift > 2.3)	3,791	5,767	7,478
Stars	34,998	50,369	62,401
M stars and later	13,379	20,805	26,837
Sky spectra	18,767	26,819	34,022
Unknown	3,694	4,853	6,675
Data volume (GB)			
Calibrated spectra	27	41	51
Spectra, redshifts, line measurements	73	110	140

Each public data release is documented in a technical paper that provides information specific to that release. DR2 is documented in the paper Abazajian, K. et al. "The Second Data Release of the Sloan Digital Sky Survey,² which was published in The Astronomical Journal, vol 128, p. 502 (2004). DR3 is documented in the paper Abazajian, K. et al. ³The Third Data Release of the Sloan Digital Sky Survey,² which was published in The Astronomical Journal, vol 129, p. 1755 (2005).

The DR2 and DR3 public releases satisfy commitments specified in the approved data distribution plan. Table 5.2 compares actual release dates against the approved data release schedule. With the release of DR4 to the collaboration in December, we are fully on track to release DR4 to the public on schedule.

Table 5.2. SDSS Data Release Schedule

	Scheduled Release Date	*Actual Release Date*
Early Data Release	---	5-Jun-2001
Data Release 1	1-Jan-2003	4-Apr-2003
Data Release 2	1-Jan-2004	15-Mar-2004
Data Release 3	1-Oct-2004	27-Sep-2004
Data Release 4	1-Jul-2005	---
Data Release 5	1-Jul-2006	---

5.2.2. Data Usage Statistics

Access to SDSS data is provided through a variety of interfaces: the Data Archive Server (DAS), Catalog Archive Server (CAS), SkyServer, and CasJobs. The DAS provides access to the data in the form of flat files. Figure 5.1 shows the volume of data transferred monthly from the DAS since April 2004. In April, we implemented a new system for recording the volume of data transferred; hence data transfer rates are shown from that point forward.

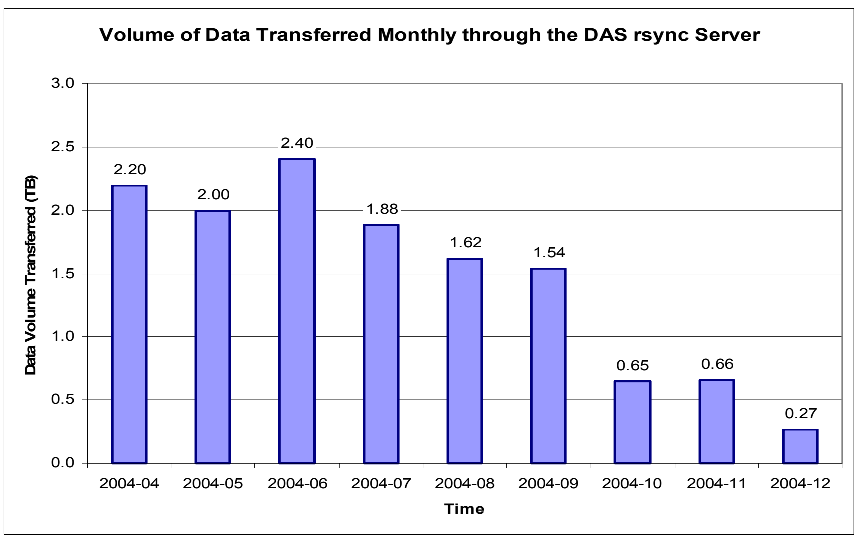

Figure 5.1. Monthly data transfer through the DAS rsync Server

We saw a significant drop in the rate of data transfer from the DAS in the last quarter of 2004. Historically, monthly data transfers have been characterized by many small data transfers and one or two large transfers, which we believe to be institutions transferring much if not all of the data set. Looking at the data transfer logs, there were fewer large institutional transfers in Q4, which partly explains the dramatic drop in data transfer rates. A second factor may be that over time, users are becoming more familiar with accessing data through the CAS and SkyServer interfaces. As CAS usage increases, it is possible that fewer users are finding it necessary to copy large volumes of data, in the form of flat files, to their local workspace.

Figure 5.2 plots the number of web hits we receive per month through the various SkyServer interfaces. In Q4 we recorded a total of 8.5 million web hits, compared to 8.2 million web hits in Q3 and 7.4 million hits in Q2. Through December 31, 2004, the various SkyServer interfaces have received a total of 65 million web hits and have processed over 9.3 million SQL queries. As the graph shows, the rate at which the user community is accessing SDSS data continues to grow.

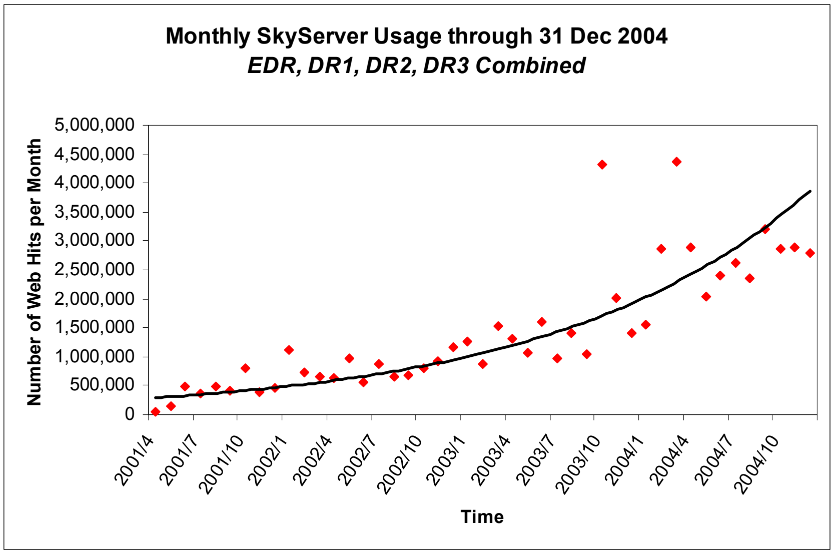

Figure 5.2. SkyServer usage per month, for all public releases combined.

We also measure usage by the number of SQL queries executed. Figure 5.3 shows the total number of SQL queries executed per month. We recorded 1.93 million queries in Q4, compared to 1.84 million in Q3 and 1.73 million in Q2.

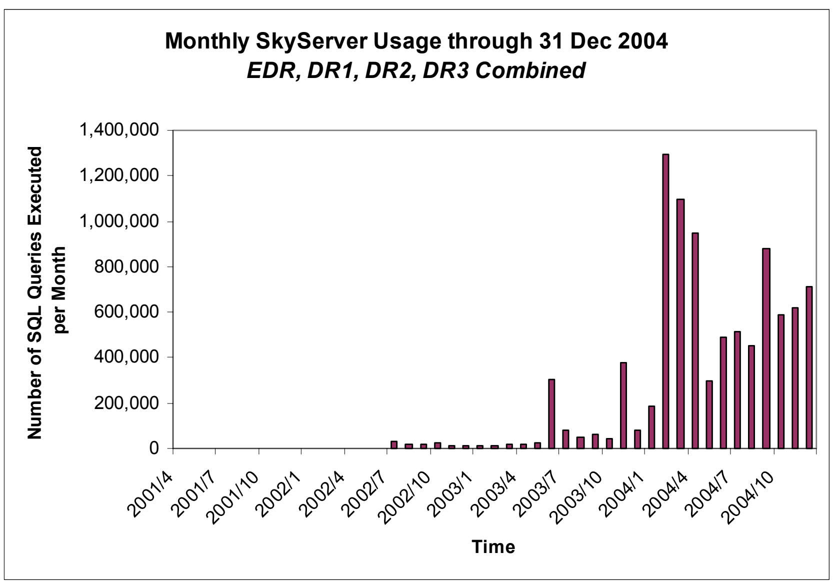

Figure 5.3. SkyServer usage, measured by the number of SQL queries submitted per month.

5.2.3. Data Archive Server

The Data Archive Server (DAS) and its associated interfaces continue to be stable and reliable. The DAS is currently serving up the DR1, DR2 and DR3 to the public and collaboration; and DR4 to the collaboration.

A modest amount of work was performed in preparation for each of the data releases in 2004. DAS web pages were updated and new links were generated for the new data files associated with each release. After the new pages and links were created, each DAS web page and data retrieval interface was carefully tested to verify readiness for collaboration and/or public use.

An automated system has been put into place to monitor data integrity by regularly scanning all data files on the DAS server and comparing checksums against baseline values. One corrupt file was found and replaced in Q1; there have been no file corruption problems or unscheduled downtime associated with the DAS since.

5.2.4. Catalog Archive Server

We held an internal review of the CAS in March 2004 to help assess the state of CAS development, the readiness of the CAS for production use, and the status of CAS implementation in the production environment at Fermilab. The review committee comprised individuals from within and outside of the SDSS project with relevant technical expertise in the development and deployment of large scientific databases. The full report of the review committee is posted on the SDSS website. Among the most significant of the committee's recommendations was that the CAS data model and schema be frozen. The committee recognized that changes to the data model prior to and during past releases contributed to long delays and additional effort to deploy the CAS at Fermilab. We have followed this recommendation by using the same data model to load DR3 that was used to load DR2. A second key recommendation was to supply a full-time person with Windows and SQL Server expertise at Fermilab to support the CAS. We have acted on this recommendation by hiring a full-time, experienced database administrator who is now working on troubleshooting and resolving database problems at the primary hosting site, Fermilab. An additional 0.25 FTE of database computer professional support is being provided by the Fermilab Computing Division to support the CAS hosting operation.

Work on the CAS software in 2004 was associated with finishing the DR2 load for public release, preparing and finishing the DR3 loads for collaboration and public release, and preparing the DR4 load for collaboration release. We are also in the process of developing and implementing tools and procedures that will verify the integrity of the data at various points in the loading process, and will allow us to more accurately purge and reload corrupt or suspect data. We are also implementing a more stringent version control structure in our production operation to better manage and track code changes. We anticipate that a more structured loading environment, along with the implementation of these tools, will improve the efficiency of future data loads. Details of CAS work are included in the quarterly reports.

The CAS production deployment system is hosted at Fermilab. The production system consists of all of the computer hardware and software necessary to load and serve data to the collaboration and public. To improve the reliability and robustness of the system, responsibility for the support and maintenance of the computer hardware associated with the CAS production cluster was transferred to the Core Support Services department within the Fermilab Computing Division. The result has been a marked increase in system performance and uptime.

6. SURVEY PLANNING

6.1. Observing and Survey Planning Aids

Several software programs are used to aid in planning and carrying out observations, and to track survey progress. Minor bug fixes were made during the year; there were no development efforts in 2004.

6.2. Target Selection

A total of 404 plates were designed and drilled over the course of the year. Of these, 304 were for the Northern survey area, 10 were for the low-redshift galaxy program, and 90 were for the SEGUE program.

In past years, we had reported that plate design and fabrication was occurring in a just-in-time manner, due to a shortage of imaging data. This is no longer the case. We now have a substantial inventory of plates ready to observe at APO to the point that space for plate storage at APO occasionally becomes tight. To help alleviate this, plates are occasionally retained at UW after they are drilled until they are actually needed for observing. In addition, we routinely move to long-term storage plates that have been observed and declared "good," which frees up space for new incoming plates.

7. COST REPORT

The operating budget that the Advisory Council approved for the year 2004 consists of $1,806K of in-kind contributions from Fermilab, US Naval Observatory (USNO), Los Alamos National Laboratory (LANL), and the Japan Participation Group (JPG); and $3,400K for ARC funded expenses

7.1. Cost Performance - In-kind Contributions

The estimated value of in-kind contributions received in 2004 was $1,352K against the baseline forecast of $1,806K and was provided by Fermilab, Los Alamos, and the U.S. Naval Observatory (USNO).

Fermilab provided personnel support for survey management; telescope engineering and maintenance; and data processing and distribution as agreed. Fermilab also provided support in the form of computer hardware for the data processing systems at Fermilab. The level of support provided met project needs. The estimated value of the Fermilab contribution was $1,123K against a baseline forecast of $1,451K (77%). Differences between the baseline forecast and actual contribution are explained as follows:

- The level of administrative support for the Director was less than anticipated when the baseline was prepared. The estimate had been based on the needs of the previous Director, which were different than those of the present Director.
- The level of in-kind engineering support at APO was less than the baseline forecast because the engineer who serves as the SDSS Telescope Engineer became involved in another Fermilab astrophysics project in Q1. As a result, his level of support for the SDSS project was reduced from 100% to 50% through most of the year.
- The level of in-kind effort for Software and Data Processing support at Fermilab was less than the baseline forecast; the actual level of effort required to support on-going operations was less than we had anticipated would be required when the baseline was prepared.

Los Alamos provided programming support for the Telescope Performance Monitor and testing support for data releases, and assisted with the preparation of a technical paper documenting the Photometric Telescope data reduction pipeline, MTPIPE. The estimated value of the Los Alamos contribution was $167K against a baseline forecast of $222K (75%). Although the level of in-kind infrastructure support provided was substantially less than the baseline forecast, it was sufficient to complete the majority of the necessary work.

USNO provided support as required for the astrometric pipeline and other software systems they maintain. The estimated value of the USNO contribution was $63K against a baseline forecast of $133K (47%). In prior years, the level of in-kind effort provided by the USNO was approximately 1 FTE per year. In 2004, the level of effort was reduced to reflect the fact that going forward, less effort is required to maintain existing software, provide testing support for data releases, and complete the assembly of the UCAC catalog. The baseline budget, when prepared, did not properly reflect the lower level of anticipated support.

7.2. Cost Performance – ARC-Funded Cash Expenses

Table 7.1 shows the actual cost performance by project area for ARC-funded cash expenses in 2004. A more complete table comparing actual to baseline performance is included as an attachment to this report.

Table 7.1. Cost Performance for 2004: Cash Expenses ($K)

Category	Approved Budget	Actual Expenses	Variance
1.1. Survey Management	294	264	(10%)
1.2. Collaboration Affairs	16	5	(69%)
1.3. Survey Operations			
1.3.1. Observing Systems	648	609	(6%)
1.3.2. Data Processing & Dist.	593	603	2%
1.3.3. Survey Coordination	0	0	-----
1.3.4. Observatory Support	1,522	1,559	2%
1.4. ARC Corporate Support	176	63	(64%)
Sub-total	3,248	3,104	(4%)
1.5. Management Reserve	152	0	
1.6. Capital Improvements	0	43	
Total	3,400	3,147	(7%)

Survey management costs were $264K against a budget of $294K (-10%). The budget provides support for management and activities associated with public affairs. Salary and travel costs were as expected. Costs for equipment, materials and supplies varied across accounts and more or less cancelled each other out. For example, “Support for Survey Management” at Fermilab was overspent because computing hardware to support the data distribution effort was charged to this account. A new account has been established to properly capture these costs in 2005. The over run in this account was more than offset by under spending in other accounts. The budget for Public Affairs was under spent because we had budgeted $10K for data release brochures but decided during the year that such brochures were not necessary. AAS meeting expense costs were also less than anticipated. Additionally, actual expenses for the Public Information Officer were significantly less than anticipated.

The budget for Collaboration Affairs provides for Working Group travel and technical page charges and is held in an ARC corporate account. Actual expenses were $5K against a budget of $16K (-69%). We had anticipated that a number of technical papers would be completed in 2004 and had budgeted for page charges accordingly. Since few of these papers were actually completed, the budget for page charges went unspent.

Observing Systems costs were $610K against a budget of $648K (-16%). Salary and travel expenses incurred at Fermilab and Princeton were as expected. Salary expenses at the University of Washington were lower than expected because the amount of off-site engineering and technical effort required to support on-going operations was less than we had anticipated when the budget was prepared. The largest variations between the budget and actual expenses were as follows:

- The budget for Fermilab observing systems support appears overspent because expenses to maintain the hardware at APO were greater than budgeted. Unanticipated expenses included the fabrication of tooling to remove and replace telescope drive bearings; and the fabrication and assembly of replacement azimuth drive rollers.
- The budget for Fermilab support for the observing programs and data acquisition system was under spent because less support was required than had been anticipated when the budget was prepared.
- The budget for Observing Systems Support held in an ARC account was under spent. Expenses covered under through this account included mirror aluminizing and the usage fee for the drilling machine used to fabricate spectroscopic plug plates. Funds are also set aside in this account to cover unanticipated expenses associated with equipment and systems at APO. Some of these funds will be used to offset the costs noted above. Remaining funds have been carried forward into 2005.

Data Processing and Distribution costs were $603K against a budget of 593K (2%). Fermilab expenses exceeded the budget slightly due to computer hardware purchases associated with data distribution operations. Due to procurement system peculiarities, some computer hardware purchases for data distribution were charged to an existing data processing code, and some charged to a Survey Management code, as noted above. As also noted above, a new account has been put into place to more properly account for data distribution expenses going forward. Princeton expenses were substantially less than the baseline due to a credit for effort that was incorrectly charged to the account earlier in the year. JHU costs were slightly less than budgeted and UC costs were in close agreement with the budget. All necessary work was completed as required and planned.

Observatory Support costs were $1,559K against a budget of $1,522K (2%). Salary costs exceeded the baseline slightly because we added a part-time observer to our staff after the baseline budget was prepared. Given the steep learning curve associated with operating the telescopes and instruments, we felt it to be prudent to have additional trained staff on hand in the event that one of the existing observers chose to leave the project before June 30, the scheduled end of survey operations. Other observatory operating expenses were in line with expectations.

ARC Corporate Support costs were $63K against a budget of $176K (-64%). Miscellaneous ARC corporate expenses (i.e., audit fees, bank fees, petty cash, and APO trailer rentals) were as expected. Expenses charged against the observers' development fund were approximately 66% of that budgeted. No expenses were charged against the funds set aside for Additional Scientific Support. Unspent funds from the accounts have been moved forward into 2005.

7.3. Management Reserve

No management reserve funds were expended in 2004. Given estimated final cash expenses of $3,147K, we anticipate moving $253K in unspent funds into 2005 to complete the survey and pay down unpaid invoices. The final amount moved forward will be established once final 2004 invoices are received and paid.

8. PUBLICATIONS

Exhibit 3 contains a list of publications in 2004 using SDSS data. There are 186 papers listed, of which 76 are from the SDSS collaboration. The fact that over half the SDSS papers were written by people outside the collaboration suggests that the broader astronomical community is making good use of the public data.

Through December 31, 2004 there are 633 published refereed papers that include 'SDSS' or 'Sloan' in their title and/or abstract. These papers have been cited a total of 13,143 times, including 23 papers cited more than 100 times and 64 papers with 50 or more citations. In addition, there have been 921 un-refereed papers with "SDSS" or "Sloan" in the title and/or abstract.

The York et al (2000) paper has been cited over 500 times, which puts it in the category of "renowned" papers. The Tegmark et al. (2004) paper on cosmological parameter estimation is the single most cited paper in all of astrophysics, published in 2004 (SPIRES gives it over 300 citations). The number of SDSS papers is growing exponentially, with a doubling time of 1.5 years; the number of citations to those papers is also growing exponentially, with a doubling time of 1.2 years.

9.0. SDSS-II DEVELOPMENT WORK

9.1. Progress on the SEGUE Survey

In 2004, the SDSS Management Committee and the Advisory Council, with input from the collaboration, approved scheduling and observations of some 'low-Galactic latitude' SEGUE stripes as well as some SEGUE spectroscopy to take place during the Fall 2004 'southern' observing session, specifically during Aug 2004 and Sep 2004 when remaining SDSS-NGC sky was not available.

During August and September, SEGUE imaging included scans on southern stripe 72, which extends the SDSS areal coverage in the south and potentially allows increased Large Scale Structure baselines. From October through mid-November, SEGUE observing (both imaging and spectroscopy, depending on photometricity) was interleaved with SN repeated imaging. After November 17, 2004, SEGUE observing was obtained when Legacy NGC plates or imaging was not available due to hour angle or airmass constraints. SEGUE imaging data obtained in Q4 included some scans at relatively southern declinations (stripe 90), near dec = -20 deg, near the limit of what the SDSS system can do without significant degradation of image quality. The total amount of SEGUE imaging data obtained in 2004 was approximately 1050 square degrees.

A total of 47 SEGUE spectroscopic plates (corresponding to about 56 plate equivalents, as some of the SEGUE plates require longer exposure times) were completed in 2004. The SEGUE spectroscopy obtained in Q4 was the first to test the SEGUE target selection v3_0 code and the first to test the longer faint plate exposure S/N^2 limits, which were empirically determined in Q3 to be somewhat too short. The new faint plate exposure guidelines are for the observers to integrate until the $(S/N)^2$ recorded on the mountain for the faint plate for all cameras exceeds 50 (previous limit 30). Preliminary inspection and reductions of these faint SEGUE plates indicates that this increased exposure is sufficient to obtain metallicity parameters for faint stars not available at lesser exposures. We will continue to operate with these limits for the faint plates, pushing our effective plate-equivalents per plate-pair ratio to 3.0, up from 2.6.

Additionally, SEGUE obtained spectroscopic exposures of three globular clusters of known metallicity and gravities, and successfully demonstrated that the stellar atmosphere parameter measuring code techniques of Beers/Allende-Prieto/Wilhelm/Norris can recover the metallicities of these stars to accuracy of better than one sigma = 0.3 dex for stars of relatively high S/N, a main technical goal of the SEGUE science program.

Development work was also completed on allowing the SDSS telescope to scan along SEGUE stripes and record the scanning information in a rational fashion, as a natural extension of regular SDSS observing.

Contacts with experts in stellar atmosphere parameter estimation (gravities, metallicities, effective temperatures) were pursued within and beyond the SDSS project, and a draft plan for pipelining the determination of these important parameters was laid out.

Through the end of 2004, SEGUE has obtained approximately 1050/3500 square degrees of imaging and approximately 47/400 plates (56/600 plate equivalents) towards its baseline goal. A visual of SEGUE progress is shown in Figure 9.1. Progress is given by the black stripes and black dots (indicating completed scans and plates).

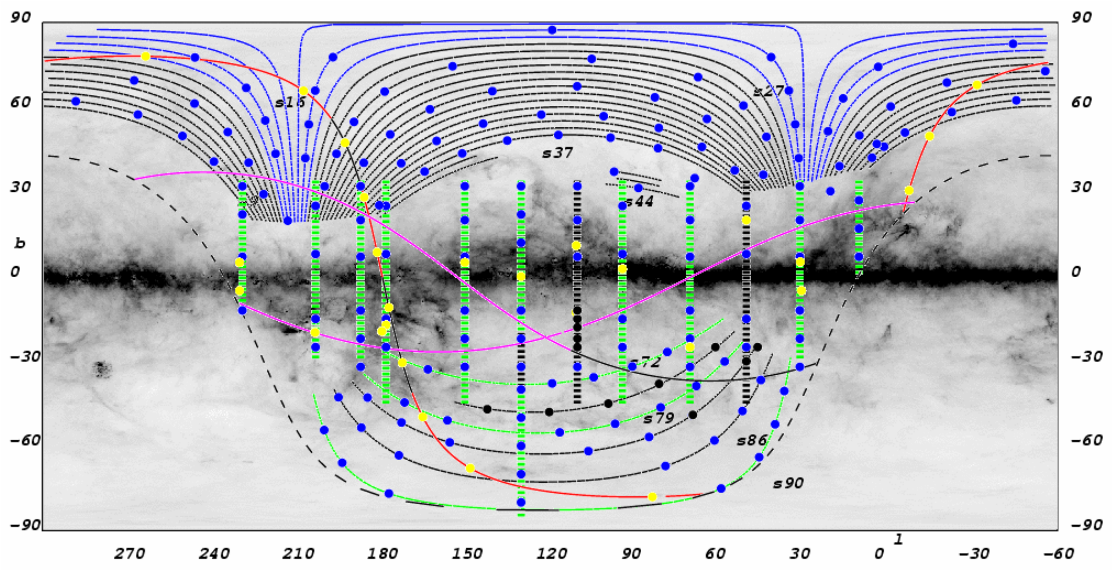

Figure 9.1. SEGUE Observing Scans and Progress through December 31, 2004.

9.2. Progress on the Supernova Survey

In 2004, the SDSS Management Committee allocated 20 nights of time on the SDSS 2.5 meter telescope, from late September through mid-November, for an early science and test/engineering run for the Supernova Survey. Supernova imaging during these nights was focused on stripe 82N.

Work in preparation for the Supernova (SN) imaging run began in earnest in Q2 and was essentially completed in Q3. Work included the assembly and configuration of a computer cluster to process SN data at APO; development of the data reduction software; development of a database to hold outputs from the data reduction pipeline and perform certain computations; and development of web interface for capturing hand-scanned candidates, displaying photometric information, cutout images, finding charts, etc. Additional details on the development work are contained in the Q3 and Q4 reports.

The early science and test/engineering run of the SDSS II Supernova Survey took place as planned. Unfortunately, due to weather, only about half of the allocated nights turned out to be scientifically useful.

The imaging data were processed through the compute cluster set up at APO for this purpose. Data were spooled from tape, processed through *Photo* up to corrected frames, processed through a frame subtraction pipeline (g and r only), and placed into a database, where object positions were matched in g and r (to veto asteroids) and matches with known variables (stars and AGN) were also vetoed. The resulting candidates were then inspected by eye using ds9 and ranked by the SN team for possible spectroscopic follow-up. Promising candidates were displayed on a web page and were followed up spectroscopically using the ARC 3.5m, the HET, and, in one case, the SN Factory using the UH 88-in. Additional imaging follow-up using the ARC 3.5m and the NMSU 1m, especially after the SDSS run ended, proved quite useful. Generally, the processing went smoothly, though there were occasional hardware glitches; in addition, since this was a test run, parts of the pipeline were updated during the run, though the bulk of development work upstream of the handscanning environment was done in Q3. When the system was working well, a full night of 6-column data could be processed through the system in 50-60 hours, close to our goal of 48 hours. Since there are 3 stripe 82N template image regions and these were processed sequentially, we were often starting human inspection of candidates within ~30-40 hours.

The test run produced 16 spectroscopically confirmed supernovae of type Ia, 5 confirmed type II, and 1 type Ibc. Several other type Ia's are probable but were not spectroscopically confirmed. The confirmed supernovae were published in an IAU circular, with designation sn2004ht-io. Near the end of Q4, a pipeline for precision photometry of these supernovae was under development. In addition, the team was studying the usefulness and quality of the data that was either non-photometric and/or moony; preliminary indications are that data extending significantly into bright time will be scientifically useful and, according to our Monte Carlo simulations, necessary to achieving the desired number of high-quality SN lightcurves.

Post-run studies also commenced of our SN detection efficiency. While the number of quality lightcurves we obtained in the test run was about that predicted by the simulations, the total number of SN detected was lower than expected particularly beyond z~0.25. Subsequent tests of the frame subtraction code, examination of the i-band test run data, and tests on supernovae found in Fall 2002 SDSS data, have revealed that the parameters set in the object identification code in the frame subtraction pipeline were improperly weeding out faint objects in the subtracted frames. In SDSS II, we will correct this, add real-time i-band subtraction, and also introduce artificial supernovae into the data stream to monitor detection efficiency in real time.

Exhibit 1. CY2004 Actual Cash Expenses (Preliminary)

SDSS CY2004 Budget Forecast as of December 31, 2004 (*in $000s*)

		Qtr 1 Jan-Mar	Qtr 2 Apr-Jun	Qtr 3 Jul-Sep	Qtr 4 Oct-Dec			CY2004 Budget Forecast		
		Actual Expenses	Actual Expenses	Actual Expenses	Approved Budget	Actual Expenses	Variance (%)	Approved Budget	Final Expenses	Variance (%)
ARC-FUNDED BUDGET										
1.1 Survey Management										
SSP21	ARC Secretary/Treasurer	2	2	2	3	2	-31%	12	9	-22%
SSP34	ARC Business Manager	10	19	14	15	15	-1%	58	58	0%
SSP46	PU Office of the Project Scientist	1	.2	55	8	2	-69%	59	58	-1%
SSP48	FNAL Support for Survey Management	12	14	18	9	10	7%	36	54	49%
SSP67	UC Support for Survey Management	12	12	30	14	15	5%	79	69	-12%
SSP91a	ARC Support for Public Affairs	2	.2	0	0	3	----	24	5	-80%
SSP91i	ARC Support for Public Information Officer	4	2	2	6	4	-32%	27	12	-57%
	Sub-total	42	49	121	55	51	-7%	294	264	-10%
1.2 Collaboration Affairs										
SSP91c	ARC Support for Collaboration Affairs	2	1	2	4	0	-100%	16	5	-69%
	Sub-total	2	1	2	4	0	-100%	16	5	-69%
1.3.1 Observing Systems										
SSP42	FNAL Observing Systems Support	62	48	75	38	36	-4%	149	221	48%
SSP61	FNAL Observing Programs and DA Support	1	3	2	5	3	-46%	23	9	-64%
SSP31	UW Observing Systems Support	66	57	88	72	45	-37%	288	257	-11%
SSP32	PU Observing Systems Support	10	12	18	15	18	23%	59	59	-1%
SSP91d	ARC Observing Systems Support	6	24	21	29	14	-52%	128	64	-50%
	Sub-total	145	145	204	158	116	-26%	648	610	-6%
1.3.2 Data Processing and Distribution										
SSP40	FNAL Software and Data Processing Support	48	54	49	27	33	23%	128	185	44%
SSP38	PU Software and Data Processing Support	56	47	24	33	1	-97%	148	128	-13%
SSP39	UC Software and Data Processing Support	9	10	10	11	10	-2%	42	40	-6%
SSP37	JHU Data Archive Development and Support	65	51	51	57	49	-14%	240	215	-10%
SSP33	UC Operations Support	8	9	9	9	9	8%	35	35	2%
	Sub-total	186	171	143	137	103	-24%	593	603	2%
1.3.4 Observatory Support										
SSP35	NMSU Site Support	384	391	380	380	405	6%	1,522	1,559	2%
	Sub-total	384	391	380	380	405	6%	1,522	1,559	2%
1.4 ARC Corporate Support										
SSP91e	ARC Corporate Support	10	17	14	12	15	23%	62	55	-11%
SSP91f	ARC Additional Scientific Support	0	0	0	18	0	-100%	102	0	-100%
SSP91h	ARC Observers' Research Support	0	4	4	3	0	-100%	12	8	-36%
	Sub-total	10	21	18	33	15	-56%	176	63	-64%
SUBTOTAL		769	778	868	767	690	-10%	3,248	3,104	-4%
SSP91g	Capital Improvements	0	43	0	0	0	---	0	43	---
SSP91	Management Reserve[1]	0	0	0	32	0	-100%	152	0	-100%
TOTAL ARC-FUNDED BUDGET		769	778	868	799	690	-14%	3,400	3,147	-7%

Exhibit 2. CY2004 In-Kind Contributions (Preliminary)

SDSS CY2004 Budget Forecast as of December 31, 2004 (*in $000s*)

		Qtr 1 Jan-Mar	Qtr 2 Apr-Jun	Qtr 3 Jul-Sep	Qtr 4 Oct-Dec			CY2004 Budget Forecast		
		Actual Expenses	Actual Expenses	Actual Expenses	Approved Budget	Actual Expenses	Variance (%)	Approved Budget	Final Expenses	Variance (%)
IN -KIND CONTRIBUTION										
1.1 Survey Management										
SSP48	FNAL Support for Survey Management	42	41	38	49	38	-23%	191	159	-17%
	Sub-total	42	41	38	49	38	-23%	191	159	-17%
1.3.1 Observing Systems										
SSP42	FNAL Observing Systems Support	50	52	55	68	42	-39%	267	198	-26%
SSP58	LANL Observing Systems Support	59	40	30	57	39	-31%	222	167	-25%
SSP61	FNAL Observers' Programs and DA Support	5	2	7	13	0	-100%	52	14	-74%
	JPG Observing Systems Support	0	0	0	0	0	---	0	0	---
	Sub-total	114	93	91	138	81	-42%	541	378	-30%
1.3.2 Data Processing and Distribution										
SSP40	FNAL Software and Data Processing Support	293	167	126	229	165	-28%	941	752	-20%
SSP57	USNO Software and Data Processing Support	16	14	17	34	15	-54%	133	63	-53%
	Sub-total	310	181	143	263	181	-31%	1,074	815	-24%
TOTAL IN-KIND CONTRIBUTION		465	316	273	450	299	-34%	1,806	1,352	-25%
TOTAL BUDGET		1,234	1,093	1,141	1,249	989	-21%	5,206	4,500	-14%

Exhibit 3. Publications in 2004

(*Asterisks denote papers by members of the SDSS Collaboration*)

1. Running-mass inflation model and WMAP
PhRvD 70: 123521 - Covi, L., and 3 colleagues

2. Observables sensitive to absolute neutrino masses: Constraints and correlations from world neutrino data
PhRvD 70: 113003 - Fogli, G. L., and 6 colleagues

3. Irradiation of accretion discs in active galactic nuclei due to the presence of a warm absorber
MNRAS 355: 1080 - Loska, Z., B. Czerny, and R. Szczerba

4. Star formation in close pairs selected from the Sloan Digital Sky Survey
MNRAS 355: 874 - Nikolic, B., H. Cullen, and P. Alexander

5. The mass function of the stellar component of galaxies in the Sloan Digital Sky Survey
MNRAS 355: 764 - Panter, B., A. F. Heavens, and R. Jimenez

6. Photometric and polarimetric observations of the eclipsing polar SDSS J015543.40+002807.2
MNRAS 355: 689 - Wiehahn, M., and 3 colleagues

7. *Efficient Photometric Selection of Quasars from the Sloan Digital Sky Survey: 100,000 $z < 3$ Quasars from Data Release One
ApJS 155: 257 - Richards, G. T., and 18 colleagues

8. *An Empirical Algorithm for Broadband Photometric Redshifts of Quasars from the Sloan Digital Sky Survey
ApJS 155: 243 - Weinstein, M. A., and 9 colleagues

9. QUEST1 Variability Survey. II. Variability Determination Criteria and 200k Light Curve Catalog
ApJ 617: 184 - Rengstorf, A. W., and 33 colleagues

10. *Photometric Properties of Void Galaxies in the Sloan Digital Sky Survey
ApJ 617: 50 - Rojas, R. R., and 3 colleagues

11. Comparing Spectroscopic and Photometric Stellar Mass Estimates
ApJ 616: L103 - Drory, N., R. Bender, and U. Hopp

12. *The V1647 Orionis (IRAS 05436-0007) Protostar and Its Environment
ApJ 616: 1058 - McGehee, P. M., and 7 colleagues

13. Absolute Flux Distribution of the SDSS Standard BD +17 4708
AJ 128: 3053 - Bohlin, R. C. and R. L. Gilliland

14. *The Environmental Dependence of Galaxy Properties in the Local Universe: Dependences on Luminosity, Local Density, and System Richness
AJ 128: 2677 - Tanaka, M., and 4 colleagues

15. Models of the Giant Quadruple Quasar SDSS J1004+4112
AJ 128: 2631 - Williams, L. L. R. and P. Saha

16. *Spectral Classification of Quasars in the Sloan Digital Sky Survey: Eigenspectra, Redshift, and Luminosity Effects
AJ 128: 2603 - Yip, C. W., and 12 colleagues

17. Synthetic photometry for non-radial pulsations in subdwarf B stars
A&A 428: 209 - Ramachandran, B., C. S. Jeffery, and R. H. D. Townsend

18. The first XMM-Newton study of two Narrow-Line Seyfert 1 galaxies discovered in the Sloan Digital Sky Survey
A&A 428: 51 - Foschini, L., and 8 colleagues

19. Model of inflation independent of the initial conditions, with bounded number of e-folds and n_s larger or smaller than one
PhRvD 70: 103521 - Germ_,AC!n, G. and A. de La Macorra

20. *Cross-correlation of CMB with large-scale structure: Weak gravitational lensing
PhRvD 70: 103501 - Hirata, C. M., and 4 colleagues

21. The local hole in the galaxy distribution: new optical evidence
MNRAS 354: 991 - Busswell, G. S., and 4 colleagues

22. Evidence for X-ray obscuration in Type II quasar candidates from the Sloan Digital Sky Survey
MNRAS 354: 720 - Vignali, C., D. M. Alexander, and A. Comastri

23. Constraining the topology of reionization through Ly alpha absorption
MNRAS 354: 695 - Furlanetto, S. R., L. Hernquist, and M. Zaldarriaga

24. *Metals and Dust in Intermediate-Redshift Damped Ly_,AN1 Galaxies
ApJ 616: 86 - Khare, P., and 5 colleagues

25. *A Second Stellar Color Locus: a Bridge from White Dwarfs to M stars
ApJ 615: L141 - Smolcic, V, and 16 colleagues

26. The Bimodal Galaxy Color Distribution: Dependence on Luminosity and Environment
ApJ 615: L101 - Balogh, M. L., and 5 colleagues

27. Resolved Molecular Gas in a Quasar Host Galaxy at Redshift z=6.42
ApJ 615: L17 - Walter, F., and 7 colleagues

28. The Nature of Nearby Counterparts to Intermediate-Redshift Luminous Compact Blue Galaxies. I. Optical/H I Properties and Dynamical Masses
ApJ 615: 689 - Garland, C. A., and 4 colleagues

29. *Sloan Digital Sky Survey Imaging of Low Galactic Latitude Fields: Technical Summary and Data Release
AJ 128: 2577 - Finkbeiner, D. P., and 88 colleagues

30. *XMM-Newton Observations of the Extremely Low Accretion Rate Polars SDSS J155331.12+551614.5 and SDSS J132411.57+032050.5
AJ 128: 2443 - Szkody, P., and 8 colleagues

31. Are E+A galaxies dusty-starbursts?: VLA 20 cm radio continuum observation
A&A 427: 125 - Goto, T.

32. Dust-reddening and gravitational lensing of SDSS QSOs due to foreground damped Lyman _,AN1 systems
MNRAS 354: L31 - Murphy, M. T. and J. Liske

33. The clustering of luminous red galaxies around MgII absorbers
MNRAS 354: L25 - Bouch_,AC), N., M. T. Murphy, and C. P_,AC)roux

34. Morphology of mock SDSS catalogues
MNRAS 354: 332 - Sheth, J. V.

35. Physical state of the intergalactic medium at redshifts z= 2-4
MNRAS 354: 183 - Demia

36. The Needles in the Haystack Survey: searching for X-ray-selected normal galaxies
MNRAS 354: 123 - Georgakakis, A. E., and 4 colleagues

37. The relationship between radio luminosity and black hole mass in optically selected quasars
MNRAS 353: L45 - McLure, R. J. and M. J. Jarvis

38. SDSS J022119.84+005628.4: A Radio-Loud Narrow-Line Seyfert 1 Galaxy with Star Formation in its Nucleus
ChJAA 4: 415 - Wang, J., J. Wei, and X. He

39. Modeling Galaxy-Mass Correlations in Dissipationless Simulations
ApJ 614: 533 - Tasitsiomi, A., and 3 colleagues

40. Black Hole Mass and Accretion Rate of Active Galactic Nuclei with Double-peaked Broad Emission Lines
ApJ 614: 91 - Wu, X. and F. K. Liu

41. Fe II/Mg II Emission-Line Ratios of QSOs. II. z > 6 Objects
ApJ 614: 69 - Iwamuro, F., and 6 colleagues

42. *The Origin of the Mass-Metallicity Relation: Insights from 53,000 Star-forming Galaxies in the Sloan Digital Sky Survey
ApJ 613: 898 - Tremonti, C. A., and 11 colleagues

43. *Cataclysmic Variables from the Sloan Digital Sky Survey. III. The Third Year
AJ 128: 1882 - Szkody, P., and 19 colleagues

44. *The environmental dependence of the relations between stellar mass, structure, star formation and nuclear activity in galaxies
MNRAS 353: 713 - Kauffmann, G., and 7 colleagues

45. *Galaxy-galaxy weak lensing in the Sloan Digital Sky Survey: intrinsic alignments and shear calibration errors
MNRAS 353: 529 - Hirata, C. M., and 11 colleagues

46. Observational constraints on cosmic strings: Bayesian analysis in a three-dimensional parameter space
JCAP 9: 8 - Pogosian, L., M. Wyman, and I. Wasserman

47. Obscured and Unobscured Active Galactic Nuclei in the Spitzer Space Telescope First Look Survey
ApJS 154: 166 - Lacy, M., and 20 colleagues

48. The Far- and Mid-Infrared/Radio Correlations in the Spitzer Extragalactic First Look Survey
ApJS 154: 147 - Appleton, P. N., and 20 colleagues

49. Rest-Frame Mid-Infrared Detection of an Extremely Luminous Lyman Break Galaxy with the Spitzer Infrared Spectrograph (IRS)
ApJS 154: 103 - Teplitz, H. I., and 10 colleagues

50. *Present-Day Growth of Black Holes and Bulges: The Sloan Digital Sky Survey Perspective
ApJ 613: 109 - Heckman, T. M., and 5 colleagues

51. Constraints from Gravitational Recoil on the Growth of Supermassive Black Holes at High Redshift
ApJ 613: 36 - Haiman, Z.

52. *Discovery of New Ultracool White Dwarfs in the Sloan Digital Sky Survey
ApJ 612: L129 - Gates, E., and 16 colleagues

53. *Andromeda IX: A New Dwarf Spheroidal Satellite of M31
ApJ 612: L121 - Zucker, D. B., and 21 colleagues

54. *A New Giant Stellar Structure in the Outer Halo of M31
ApJ 612: L117 - Zucker, D. B., and 19 colleagues

55. *Redefining the Empirical ZZ Ceti Instability Strip
ApJ 612: 1052 - Mukadam, A. S., and 5 colleagues

56. *Dust Reddening in Sloan Digital Sky Survey Quasars
AJ 128: 1112 - Hopkins, P. F., and 9 colleagues

57. *Candidate Type II Quasars from the Sloan Digital Sky Survey. II. From Radio to X-Rays
AJ 128: 1002 - Zakamska, N. L., and 4 colleagues

58. Radio Continuum Imaging of Far-Infrared-Luminous QSOs at $z > 6$
AJ 128: 997 - Carilli, C. L., and 10 colleagues

59. The cosmological evolution of quasar black hole masses
MNRAS 352: 1390 - McLure, R. J. and J. S. Dunlop

60. High-speed photometry of SDSS J013701.06 - 091234.9
MNRAS 352: 1056 - Pretorius, M. L., and 5 colleagues

61. The cosmic evolution of low-luminosity radio sources from the Sloan Digital Sky Survey Data Release 1
MNRAS 352: 909 - Clewley, L. and M. J. Jarvis

62. Discovery of CVs ROTSE3 J151453.6+020934.2 and ROTSE3 J221519.8-003257.2
IBVS 5559: 1 - Rykoff, E. S., and 13 colleagues

63. Strong Emission Line H II Galaxies in the Sloan Digital Sky Survey. I. Catalog of DR1 Objects with Oxygen Abundances from T_e Measurements
ApJS 153: 429 - Kniazev, A. Y., and 4 colleagues

64. Linking Gas Fractions to Bimodalities in Galaxy Properties
ApJ 611: L89 - Kannappan, S. J.

65. Evidence of a Cosmological Stromgren Surface and of Significant Neutral Hydrogen Surrounding the Quasar SDSS J1030+0524
ApJ 611: L69 - Mesinger, A. and Z. Haiman

66. The X-Ray Spectrum of the z=6.30 QSO SDSS J1030+0524
ApJ 611: L13 - Farrah, D., and 4 colleagues

67. *The Clustering of Active Galactic Nuclei in the Sloan Digital Sky Survey
ApJ 610: L85 - Wake, D. A., and 8 colleagues

68. Chandra Observations of X-Ray-weak Narrow-Line Seyfert 1 Galaxies
ApJ 610: 737 - Williams, R. J., S. Mathur, and R. W. Pogge

69. Active Galactic Nuclei with Candidate Intermediate-Mass Black Holes
ApJ 610: 722 - Greene, J. E. and L. C. Ho

70. *Microlensing of the Broad Emission Line Region in the Quadruple Lens SDSS J1004+4112
ApJ 610: 679 - Richards, G. T., and 16 colleagues

71. Effects of Triaxiality on the Statistics of Large-Separation Gravitational Lenses
ApJ 610: 663 - Oguri, M. and C. R. Keeton

72. Ionizing Radiation Fluctuations and Large-Scale Structure in the Ly alpha Forest
ApJ 610: 642 - Croft, R. A. C.

73. *Distributions of Galaxy Spectral Types in the Sloan Digital Sky Survey
AJ 128: 585 - Yip, C. W., and 14 colleagues

74. Nitrogen-Enriched Quasars in the Sloan Digital Sky Survey First Data Release
AJ 128: 561 - Bentz, M. C., P. B. Hall, and P. S. Osmer

75. *A Quasar without Broad Ly alpha Emission
AJ 128: 534 - Hall, P. B., and 6 colleagues

76. *A Survey of z>5.7 Quasars in the Sloan Digital Sky Survey. III. Discovery of Five Additional Quasars
AJ 128: 515 - Fan, X., and 21 colleagues

77. Photometric redshifts with the Multilayer Perceptron Neural Network: Application to the HDF-S and SDSS
A&A 423: 761 - Vanzella, E., and 10 colleagues

78. *Color-Induced Displacement double stars in SDSS
A&A 423: 755 - Pourbaix, D., and 4 colleagues

79. *RASS-SDSS Galaxy clusters survey. I. The catalog and the correlation of X-ray and optical properties
A&A 423: 449 - Popesso, P., and 4 colleagues

80. The LEDA galaxy distribution. I. Maps of the local universe
A&A 423: 27 - Courtois, H., and 3 colleagues

81. The Sloan Digital Sky Survey Damped Ly alpha Survey: Data Release 1
PASP 116: 622 - Prochaska, J. X. and S. Herbert-Fort

82. The XMM-Newton/2dF survey - IV. The X-ray spectral properties of the hard sources
MNRAS 352: 91 - Georgantopoulos, I., and 6 colleagues

83. Redshift distortions in one-dimensional power spectra
MNRAS 351: 1395 - Desjacques, V. and A. Nusser

84. The shallow slope of the z~ 6 quasar luminosity function: limits from the lack of multiple-image gravitational lenses
MNRAS 351: 1266 - Wyithe, J. S. B.

85. *The physical properties of star-forming galaxies in the low-redshift Universe
MNRAS 351: 1151 - Brinchmann, J., and 6 colleagues

86. High-speed photometry of faint cataclysmic variables - IV. V356 Aql, Aqr1, FIRST J1023+0038, H_,AN1 0242-2802, GI Mon, AO Oct, V972 Oph, SDSS 0155+00, SDSS 0233+00, SDSS 1240-01, SDSS 1556-00, SDSS 2050-05, FH Ser
MNRAS 351: 1015 - Woudt, P. A., B. Warner, and M. L. Pretorius

87. The XMM-Newton/2dF survey - III. Comparison between optical and X-ray cluster detection methods
MNRAS 351: 989 - Basilakos, S., and 6 colleagues

88. Second order general slow-roll power spectrum
JCAP 7: 12 - Choe, J., J. Gong, and E. D. Stewart

89. The Method of a Two-Point Conditional Column Density for Estimating the Fractal Dimension of the Distribution of Galaxies
AstL 30: 444 - Baryshev, Y. V. and Y. L. Bukhmastova

90. The Transverse Proximity Effect: A Probe to the Environment, Anisotropy, and Megayear Variability of QSOs
ApJ 610: 105 - Schirber, M., J. Miralda-Escud_,AC), and P. McDonald

91. *Double-damped Ly_,AN1 Absorption: A Possible Large Neutral Hydrogen Gas Filament near Redshift z=1
ApJ 609: L53 - Turnshek, D. A., and 5 colleagues

92. On the Environmental Dependence of the Cluster Galaxy Assembly Timescale
ApJ 609: L45 - Carretero, C., and 4 colleagues

93. Detections of the 2175 A Feature at 1.4<~z<~1.5 from the Sloan Digital Sky Survey
ApJ 609: 589 - Wang, J., and 4 colleagues

94. The Dark Side of the Halo Occupation Distribution
ApJ 609: 35 - Kravtsov, A. V., and 6 colleagues

95. *The Second Data Release of the Sloan Digital Sky Survey
AJ 128: 502 - Abazajian, K., and 152 colleagues

96. *Spectroscopic Properties of Cool Stars in the Sloan Digital Sky Survey: An Analysis of Magnetic Activity and a Search for Subdwarfs
AJ 128: 426 - West, A. A., and 10 colleagues

97. The environment of Low Surface Brightness galaxies
A&A 422: L5 - Rosenbaum, S. D. and D. J. Bomans

98. Theoretical isochrones in several photometric systems. II. The Sloan Digital Sky Survey ugriz system
A&A 422: 205 - Girardi, L., and 3 colleagues

99. Current cosmological bounds on neutrino masses and relativistic relics
PhRvD 69: 123007 - Crotty, P., J. Lesgourgues, and S. Pastor

100. Exact likelihood evaluations and foreground marginalization in low resolution WMAP data
PhRvD 69: 123003 - Slosar, A., U. Seljak, and A. Makarov

101. *Three-Point Correlation Functions of SDSS Galaxies in Redshift Space: Morphology, Color, and Luminosity Dependence
PASJ 56: 415 - Kayo, I., and 12 colleagues

102. *Stellar and dynamical masses of ellipticals in the Sloan Digital Sky Survey
NewA 9: 329 - Padmanabhan, N., and 11 colleagues

103. Submillimetre observations of z > 6 quasars
MNRAS 351: L29 - Robson, I., and 3 colleagues

104. The cluster galaxy circular velocity function
MNRAS 351: 265 - Desai, V., and 5 colleagues

105. Collisional evolution of the asteroid belt
Icar 169: 357 - Cheng, A. F.

106. Elucidating the Correlation of the Quasar Fe II/Mg II Ratio with Redshift
ApJ 608: L85 - Verner, E. M. and B. A. Peterson

107. *On Departures from a Power Law in the Galaxy Correlation Function
ApJ 608: 16 - Zehavi, I., and 27 colleagues

108. Thirty-Five New Pulsating DA White Dwarf Stars
ApJ 607: 982 - Mukadam, A. S., and 17 colleagues

109. *Cosmological Parameters from Eigenmode Analysis of Sloan Digital Sky Survey Galaxy Redshifts
ApJ 607: 655 - Pope, A. C., and 25 colleagues

110. *Near-Infrared Photometry and Spectroscopy of L and T Dwarfs: The Effects of Temperature, Clouds, and Gravity
AJ 127: 3553 - Knapp, G. R., and 28 colleagues

111. *L' and M' Photometry of Ultracool Dwarfs
AJ 127: 3516 - Golimowski, D. A., and 18 colleagues

112. *Spatial Variations of Galaxy Number Counts in the Sloan Digital Sky Survey. I. Extinction, Large-Scale Structure, and Photometric Homogeneity
AJ 127: 3155 - Fukugita, M., and 7 colleagues

113. *A Ly alpha-only Active Galactic Nucleus from the Sloan Digital Sky Survey
AJ 127: 3146 - Hall, P. B., and 24 colleagues

114. What drives the Balmer extinction sequence in spiral galaxies? Clues from the Sloan Digital Sky Survey
A&A 420: 475 - Stasinska, G., and 3 colleagues

115. Detection of X-ray clusters of galaxies by matching RASS photons and SDSS galaxies within GAVO
A&A 420: 61 - Schuecker, P., H. Bohringer, and W. Voges

116. *Cosmological parameters from SDSS and WMAP
PhRvD 69: 103501 - Tegmark, M., and 66 colleagues

117. The effects of ultraviolet background correlations on Ly alpha forest flux statistics
MNRAS 350: 1107 - Meiksin, A. and M. White

118. Proper-Motion Catalog from SDSS USNO-B
ApJS 152: 103 - Gould, A. and J. A. Kollmeier

119. *A Catalog of Spectroscopically Identified White Dwarf Stars in the First Data Release of the Sloan Digital Sky Survey
ApJ 607: 426 - Kleinman, S. J., and 25 colleagues

120. *A Helium White Dwarf of Extremely Low Mass
ApJ 606: L147 - Liebert, J., and 6 colleagues

121. The Faintness of the 158 Micron [C II] Transition in the z=6.42 Quasar SDSS J1148+5251
ApJ 606: L101 - Bolatto, A. D., J. Di Francesco, and C. J. Willott

122. *The Three-Dimensional Power Spectrum of Galaxies from the Sloan Digital Sky Survey
ApJ 606: 702 - Tegmark, M., and 64 colleagues

123. *An Improved Proper-Motion Catalog Combining USNO-B and the Sloan Digital Sky Survey
AJ 127: 3034 - Munn, J. A., and 11 colleagues

124. *A Strategy for Finding Near-Earth Objects with the SDSS Telescope
AJ 127: 2978 - Raymond, S. N., and 23 colleagues

125. *Preliminary Parallaxes of 40 L and T Dwarfs from the US Naval Observatory Infrared Astrometry Program
AJ 127: 2948 - Vrba, F. J., and 14 colleagues

126. *Faint High-Latitude Carbon Stars Discovered by the Sloan Digital Sky Survey: An Initial Catalog
AJ 127: 2838 - Downes, R. A., and 9 colleagues

127. Optical Properties of faint FIRST Variable Radio Sources
AJ 127: 2565 - de Vries, W. H., and 3 colleagues

128. *The Galaxy-Mass Correlation Function Measured from Weak Lensing in the Sloan Digital Sky Survey
AJ 127: 2544 - Sheldon, E. S., and 10 colleagues

129. *The H alpha Luminosity Function of Morphologically Classified Galaxies in the Sloan Digital Sky Survey
AJ 127: 2511 - Nakamura, O., and 3 colleagues

130. Mass distribution of DA white dwarfs in the First Data Release of the Sloan Digital Sky Survey
A&A 419: L5 - Madej, J., M. Nale_,AE<yty, and L. G. Althaus

131. ANNz: Estimating Photometric Redshifts Using Artificial Neural Networks
PASP 116: 345 - Collister, A. A. and O. Lahav

132. Spectroscopy of Seven Cataclysmic Variables with Periods above 5 Hours
PASP 116: 300 - Thorstensen, J. R., W. H. Fenton, and C. J. Taylor

133. *SDSS J1335+0118: A New Two-Image Gravitational Lens
PASJ 56: 399 - Oguri, M., and 15 colleagues

134. Chemical enrichment of the intracluster and intergalactic medium in a hierarchical galaxy formation model
MNRAS 349: 1101 - De Lucia, G., G. Kauffmann, and S. D. M. White

135. Modeling the two-point correlation function of galaxy clusters in the Sloan Digital Sky Survey
MNRAS 349: 882 - Basilakos, S. and M. Plionis

136. The Millennium Galaxy Catalogue: the photometric accuracy, completeness and contamination of the 2dFGRS and SDSS-EDR/DR1 data sets
MNRAS 349: 576 - Cross, N. J. G., and 7 colleagues

137. *Observations and Theoretical Implications of the Large-Separation Lensed Quasar SDSS J1004+4112
ApJ 605: 78 - Oguri, M., and 27 colleagues

138. *Merging Galaxies in the Sloan Digital Sky Survey Early Data Release
AJ 127: 1883 - Allam, S. S., and 7 colleagues

139. *Sloan Digital Sky Survey Spectroscopic Lens Search. I. Discovery of Intermediate-Redshift Star-forming Galaxies behind Foreground Luminous Red Galaxies
AJ 127: 1860 - Bolton, A. S., and 4 colleagues

140. *A Catalog of Compact Groups of Galaxies in the SDSS Commissioning Data
AJ 127: 1811 - Lee, B. C., and 21 colleagues

141. Large scale structure in the SDSS galaxy survey
A&A 418: 7 - Doroshkevich, A., and 3 colleagues

142. *Fifteen DO, PG 1159 and related white dwarf stars in the SDSS, including two DO stars with ultra-high excitation ion lines
A&A 417: 1093 - Krzesinski, J., and 7 colleagues

143. Extinction due to amorphous carbon grains in red quasars from the Sloan Digital Sky Survey
MNRAS 348: L54 - Czerny, B., and 3 colleagues

144. Galaxy ecology: groups and low-density environments in the SDSS and 2dFGRS
MNRAS 348: 1355 - Balogh, M., and 36 colleagues

145. *Galaxy types in the Sloan Digital Sky Survey using supervised artificial neural networks
MNRAS 348: 1038 - Ball, N. M., and 6 colleagues

146. *Colour variability of asteroids in the Sloan Digital Sky Survey Moving Object Catalog
MNRAS 348: 987 - Szabo, G. M., and 4 colleagues

147. A sample of radio-loud QSOs at redshift ~ 4
MNRAS 348: 857 - Holt, J., and 7 colleagues

148. The supernova relic neutrino backgrounds at KamLAND and Super-Kamiokande
JCAP 3: 7 - Strigari, L. E., and 3 colleagues

149. Constraints on braneworld inflation from CMB anisotropies
JCAP 3: 1 - Tsujikawa, S. and A. R. Liddle

150. Obscured Binary Quasar Cores in SDSS J104807.74+005543.5?
ApJ 604: L33 - Zhou, H., and 4 colleagues

151. The Search for Galaxy Clustering around a Quasar Pair at z=4.25 Found in the Sloan Digital Sky Survey
ApJ 603: L65 - Fukugita, M., and 4 colleagues

152. *SDSS J115517.35+634622.0: A Newly Discovered Gravitationally Lensed Quasar
AJ 127: 1318 - Pindor, B., and 14 colleagues

153. *A Snapshot Survey for Gravitational Lenses among z>=4.0 Quasars. I. The z>5.7 Sample
AJ 127: 1305 - Richards, G. T., and 9 colleagues

154. *Preparing Red-Green-Blue Images from CCD Data
PASP 116: 133 - Lupton, R., and 6 colleagues

155. SDSS J161033.64-010223.3: a second cataclysmic variable with a non-radially pulsating primary
MNRAS 348: 599 - Woudt, P. A. and B. Warner

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