Pan-STARRS Synthetic Photometry Catalog

PS1 3π Survey Source Count Predictions

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## Revision History

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<th>Release Date</th>
<th>Description</th>
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<td>2007-01-18</td>
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1 Overview

We have used several all-sky optical and near-IR photometry catalogs to construct a synthesized all-sky photometry catalog in the Pan-STARRS filter set, $grizy$. We have used the resulting source count distributions to predict the total source counts expected from the PS1 3$\pi$ Survey. We use the photometry measurements from the USNO-B (Monet et al., 2003), 2MASS (Cutri et al., 2003), and Tycho (Høg et al., 2000) catalogs to predict the photometry in the Pan-STARRS bands. To generate the synthetic photometry, we have determined the best-fitting Kurucz (1993) stellar atmospheric models and extinctions for all objects for the available photometry, applying the Pan-STARRS filters to the models to determine photometry in $grizy$. Using the simulated catalog of Pan-STARRS measurements, we fit the magnitude distribution for all 1 square degree patches on the sky, and extrapolate to the sensitivity limits of the PS1 telescope in order to predict the total number of sources that will be detected by Pan-STARRS. We predict a total of $\sim$ 11 billion detections across all filters for single epoch images from the 3$\pi$ Survey at the $5\sigma$ limit, using a crowding-insensitive linear fit to the constructed magnitude functions, and capping the PS1 observations at $10^7$ sources per square degree per filter. We also present expected totals from other aspects of the 3$\pi$ Survey. These numbers can be used to estimate the throughput requirements of the Image Processing Pipeline and the storage requirements for both the IPP photometry database and the PSPS full science database. We estimate a typical nightly throughput of $\sim$ 600 kB/sec and total storage of 12.5 TB for IPP database for the complete 3$\pi$ Survey. These numbers are somewhat sensitive to the choice of the fit to the luminosity function and our assumptions about the crowding limits of the PS1 survey.
2 The Pan-STARRS Synthetic Photometry Catalog

We have generated an all-sky photometry catalog in the Pan-STARRS filters (grizy). The photometry in these bandpasses was synthesized from the existing photometry from several all-sky surveys: Tycho (Høg et al., 2000), USNO-B (Monet et al., 2003), and 2MASS (Cutri et al., 2003). The observed photometry for each source was compared with photometry for a range of spectral models. The best-fit spectral model was then used to generate the corresponding magnitudes in the Pan-STARRS filter system.

The process of generating the synthetic photometry starts with a collection of stellar spectra (model or empirical) and the transmission functions for the filters of interest. These stellar spectra are integrated for each of the filter band-passes, yielding a set of magnitudes for each model. For this analysis, we used the Kurucz model spectra, although the software is capable of using a number of other sources including the Pickles spectra library.

All of the analysis was performed either with the vector math functions available as part of the DVO (the Desktop Virtual Observatory) shell tool, or with DVO-specific programs. In Appendix A, we discuss the technical details of the DVO macros and programs used to perform each of the analysis steps.

2.1 Characterizing the Filters

The first step for each filter was to determine the zero-point which will yield magnitudes consistent with the survey data. The DVO macro 'calmags' was used for this process.

First, the program loads the profiles for each of the filters of interest. For this analysis, we used the following filter sets: Pan-STARRS (g<sub>PS</sub>, r<sub>PS</sub>, i<sub>PS</sub>, z<sub>PS</sub>, y<sub>PS</sub>), Johnson (B<sub>J</sub>, V<sub>J</sub>), 2MASS (J<sub>2MASS</sub>, H<sub>2MASS</sub>, K<sub>2MASS</sub>), Tycho (B<sub>TY</sub>, V<sub>TY</sub>), and USNO-B (B<sub>USNO</sub>, R<sub>USNO</sub>). For the purposes of this program, the USNO B an R filters correspond to the O and E emulsion profiles. The profiles for 2MASS, Tycho and USNO-B filters were downloaded from the web sites for these projects. The Pan-STARRS transmission functions were supplied by the Pan-STARRS team, and the Johnson transmission functions were taken from (REF).

A common wavelength vector is then created with a resolution of 1 nm. Pan-STARRS 1 (PS1) grizy filter profiles are also modified by the expected chip response and the atmospheric transmission (airmass set to equal 1.0). The transmission curves from the other projects either incorporate the effects of the atmosphere (eg, 2MASS, Johnson), have large enough errors that the atmosphere can be ignored (USNO-B), or are from space-born instruments (Tycho).

Zero points are calculated for all the filters in both the AB and Vega magnitude systems. Since Pan-STARRS photometry will use AB magnitudes, the programs used in this analysis work primarily in the AB system and convert input data from Vega to AB measurements when necessary. The AB system defines zero magnitude to correspond to a source of constant $F_0 = 3631 \times 10^{-23} \text{ erg s}^{-1} \text{ cm}^{-2} \text{ Hz}^{-1}$. This flux value is convolved with the filter profiles and integrated across the wavelength range for each filter in order to determine the zero point for the filter. The results are listed in Table 1.

Some of the analysis steps below require the effective wavelength of the filter. This is calculated as the wavelength average of the filter weighted by the filter transmission. These values are listed in Table 1.

The Vega system zero points are determined in the same way as the AB zero points, except that the constant flux source is replaced with a high-resolution model of the Vega spectrum ($\Delta \lambda \lesssim 1$-few nm). The AB-Vega zero point offsets are then calculated for each filter, and can be used to convert between the two magnitude systems. These values are also given in Table 1, and those of the Johnson and 2MASS filters agree with the offsets listed in the literature.
Table 1. Filter Information

<table>
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<th>Filter</th>
<th>$\lambda_{\text{min}}$ (nm)</th>
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<th>Vega Zero Point</th>
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2.2 Model Selection

After the filter transmission curves are defined, we next apply them to a collection of stellar spectra which will be used to fit the photometry data. In selecting spectra on which to perform the synthetic photometry, the priority concern was to have as fine a grid of models as possible in order to search the full parameter space for the best spectral matches to the input data. In this analysis, we only considered the spectra of main-sequence stars to limit the numbers of free parameters. Since giants and dwarfs have generally similar colors across a range of bandpasses, this is not a poor approximation. We selected Kurucz’s atmospheric models available at:

http://kurucz.harvard.edu/grids.html

The GRIDP00ODFNEW grid are solar metallicity models with no convective overshoot (which are noted on the website as the preferred models). The grid was then limited to the log $g$ values best suited to MS stars at a given temperature. The effective temperature range of the chosen models runs from 3500 K to 50000 K. The software is flexible and can use other model sets in the future as needed to provide fitting to more types of objects.

2.3 Generating Photometry Tables

2.3.1 Color and Absolute Magnitude Tables

We next measured the magnitudes in the filter band passes for each model. The flux for the model is determined by multiplying the model by the filter transmission function and integrating across the filter band pass. The flux is converted to a magnitude and the calculated zero-points are applied to determine the AB magnitude. The differences in the magnitudes were used to construct color tables. Due to its wide use in the literature, the $V_{J}$ band was used to link all the different filter sets together. As long as one absolute magnitude is known, all other magnitude values can be calculated for each spectrum.
Absolute magnitudes are calculated by determining the flux received from each model atmosphere when placed at 10 pc distance. Model fluxes are initially given in units of erg s\(^{-1}\) cm\(^{-2}\) Hz\(^{-1}\) ster\(^{-1}\). To convert from the Kurucz model fluxes units, we need to know the stellar radius. To estimate the radius of a main-sequence star with a given temperature, we use the radius-color relation for MS stars from Gray (1992):

\[
\log \left( \frac{R}{R_\odot} \right) = 0.2925 - 0.5764(B_J - V_J) + 1.3852(B_J - V_J)^2 - 4.5016(B_J - V_J)^3 + 5.631(B_J - V_J)^4 - 2.9014(B_J - V_J)^5 + 0.5203(B_J - V_J)^6
\]  

(1)

The models are then multiplied by the term \(2\pi \left( \frac{R}{10\text{pc}} \right)^2\) in order to remove the units of steradians from the flux values. The fluxes can then be converted into absolute magnitude values using the color information. The final table consists of unreddened absolute magnitudes for main sequence stars for the complete range of temperatures.

### 2.3.2 Model Extinction Grid

To make our photometry fitting somewhat more realistic, we decided to fit the extinction for each source as well as the temperature and absolute magnitude. We generated a complete search grid by reddening all of our calculated magnitudes by \(A_V = 0.1 - 9.8\) in increments of 0.1. The reddening law used was that of Cardelli, Clayton, & Mathis (1989). This produced a set of \(T_{\text{eff}}, A_V\) tables that we could use to search for the best-fit values of real input magnitudes.

### 2.4 Merged DVO Database

The input data for this analysis consists of the Tycho catalog, the USNO-B catalog, and the 2MASS All-Sky catalog. We constructed a DVO database in which we merged the measurements from these three distinct sources. Since the goal of this analysis is to produce estimates of the populations, we are able to treat the merging process in a somewhat relaxed manner. We first loaded the full 2MASS catalog into a single DVO database. We then added the USNO-B sources, using a correlation radius of 1 arcsecond. Any measurement from the USNO-B catalog which landed within this distance of an existing 2MASS source was joined to that source. If more than one 2MASS source and USNO-B source matched, the closest matches were kept. The Tycho sources were then added with the same rules. We did not attempt to use the brightness information when merging sources, nor did we attempt to account for different seeing, etc. However, if the resulting merge mis-matches a small fraction of sources, this error will not strongly affect the conclusions of the population analysis.

### 2.5 Least Chi-Squared Fitting

Armed with the set of model absolute magnitudes and the complete merged database, we are able to find the best fit model for every object. For this analysis, we used the DVO program called ’sedstar’. This program loads the model magnitude information, and the crawls through the database tables, fitting the stars one-by-one (we assume all objects are stars). To optimize the fitting process, the program first sorts the model magnitudes by a specific color index (eg, \(J - K\)). For each object, the program can quickly find the range of models which match the color of the object. It then examines in detail all objects within a range of colors about the best match. For each model, the program need only solve for a single free parameter, the normalization (equivalent to the log of the distance). The elements of the \(\chi^2\) for any object and model are given by:

\[
(m - M)_{\text{fit}} = \frac{\sum m_{\text{obs}} - m_{\text{mod}}}{\sum \sigma^{-2}},
\]

(2)
where \( m_{mod} \) is the corresponding magnitude values from model magnitude table. The reduced \( \chi^2 \) is:

\[
\chi^2_{red} = \frac{\sum (m_{obj} - m_{mod} - (m-M)_{fit})^2}{\sigma^2 N_{fil} - 1}
\]  (3)

where \( N_{fil} \) is the total number of input measurements for the object.

The program calculates the \( \chi^2 \) for every model within the color range, after the normalization is applied. The minimum \( \chi^2 \) model is chosen as the best fit. In the current analysis, we do not quantify the error on the fit. The fitted model is then used to create magnitude measurements for this object in the output database. Any set of filter magnitudes may be constructed by the software. For this analysis, the Pan-STARRS grizy magnitudes were written to the output database. In the current analysis, in order to be fitted, an object must have at least all three 2MASS measurements available.

The final result is a DVO database consisting of predicted Pan-STARRS magnitudes in all five filters, grizy, essentially for all objects detected by 2MASS. The 2MASS photometry strongly constrains the fits. In the cases that USNO-B is also available, they only weakly constrain the fit because of the large errors. In practice, since the colors of stars are strongly correlated, the 2MASS measurement is a reasonable estimator for the Pan-STARRS filter magnitudes.

## 3 The Distribution of Detectable Pan-STARRS Sources

### 3.1 Producing Magnitude Functions

With the synthetic PS1 photometric catalog in place, we can now count the sources detectable by Pan-STARRS as a function of magnitude and position on the sky. First, we generated a list of galactic coordinates spaced equidistantly across the sky. Our chosen grid consists of 1 square degree regions from -89 to 89 degrees galactic latitude. Corresponding longitude coordinates were calculated to be spaced according to the Cosine of the latitude so that all the regions covered the same real area on the sky. Since DVO extracts data using celestial coordinates, the DVO program csystem was used to generate RA/DEC coordinates for our grid. This list was then fed into the DVO macros glat_loop and glat_test. These function apply the RA and DEC limits for each region to be analysed. DVO extracts sources only from regions of fixed size, the programs include only those sources that lie within the 1 square degree area around each grid point. Next, histograms (magnitude functions) are generated for each grid region using 0.1 magnitude bins in all five PS1 filters. The histograms are given as the base 10 logarithm of the number of sources per square degree per magnitude bin vs. the magnitude.

Since our grid consists of around 45,000 points, each with \(10^3\) to \(10^7\) sources that need to have their positions checked before entry into the histograms, the DVO macros require around 2 days to process the entire sky.

### 3.2 Counting Sources

The histograms created in §3.1 have the following common characteristics (see Figure 1):

- A region of saturation at brighter magnitudes.
- An approximately linear rise in log-space.
- A turn-over point, caused either by the sensitivity limit and/or the confusion limit (ie, for 2MASS), especially for regions in or near the galactic plane. Histograms encountering the confusion limit also exhibit a flat plateau around the peak.
• A fast drop-off beyond the sensitivity/confusion limit.

The fit_high_low program fits each histogram based on this general shape. First, a fitting region is defined between the point where the histogram rises above a log value of 1 (a minimum of 10 sources per square degree) and where the peak value occurs in the histogram. A line is then fit to this region (the “faint sources” fit), where 3 iterations are performed, each eliminating points lying beyond 3 standard deviations from the fit. A similar fit is then performed for the region between the log-of-1 minimum threshold and half the magnitude distance to the peak value (the “bright sources” fit). This alternate fit is less sensitive to crowding effects and provides an upper-limit to the total number of detections for regions close to the galactic plane. Finally, both fits are extrapolated out to the predicted PS1 5σ and 25σ sensitivity limits for each filter (see Table 2). An integration is then performed up to these limits, resulting in the total number of sources detectable per square degree in each filter. Example fits in the i-band for regions both on the galactic plane and far off the plane are shown respectively in Figures 1 and 2.

Figure 1 A histogram of the predicted sources detectable in the PS1 i filter per square degree in an area of the sky around the galactic center (b=0,l=0). The lines are the linear fits to the bright sources only (blue) and the sources up to the turn-over point (red). Note that the crowding effect has caused the bright source fit to predict more counts than the faint source fit.
Figure 2 Same as Figure 1, but for a high galactic latitude (b=85,l=183). Note that the low number of points in the fitting region has caused the faint source fit to rise above the bright source fit at dimmer magnitudes.

3.3 Analysis

After the histograms have been fit, we can now assess the total number of sources we will detect across the full sky in each filter (Table 3) along with diagnostic information (Table 4). We include in this analysis an estimate of the impact of the confusion limit in the PS1 observations. We examine the case in which the maximum number of sources per square degree measured by PS1 is limited to $10^7$. This maximum density limit corresponds to approximately 0.8 sources per square arcsecond on the sky (about 14 pixels on the camera). Without this cap, our total 5σ counts are larger by a factor of 2 or 3 due to a small amount of very high density galactic plane regions (see Figure 4). For the whole sky, the average source count per filter yields $\sim2$ billion ($\sim400$ million) sources for 5σ (25σ) detections using the faint source fits. For the bright source fits we calculate $\sim4$ billion ($\sim900$ million) detections at 5σ (25σ). However, Pan-STARRS will not be imaging sources below -30 degrees DEC. For the Pan-STARRS visible sky, the average totals are: $\sim900$ ($\sim200$ million sources for 5σ (25σ) detections using the faint source fits and $\sim2$ billion ($\sim500$ million) sources for 5σ (25σ) detections using the bright source fits.
Table 2. PS1 Limiting Magnitudes

<table>
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<th>Filter</th>
<th>$m_{5\sigma}$</th>
<th>$m_{25\sigma}$</th>
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<th>$m_{5\sigma} \times 8$</th>
<th>$m_{5\sigma} \times 12$ (The Static Sky)</th>
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<td>24.5</td>
<td>24.8</td>
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<td>24.0</td>
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<tr>
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<td>21.4</td>
<td>21.7</td>
<td>21.9</td>
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3.4 Comparison with Other Observations

The analysis above is making a significant extrapolation of the magnitude function from the detection limit relevant to 2MASS to that for PS1. In order to judge the quality of the extrapolation and the overall procedure, we made a few selected comparisons with images from the CFH 3.6m Telescope using MegaCam ($r$ and $i$) and CFH12K ($R$) images. These images are much deeper in these filters than the equivalent 2MASS limits or the PS1 3π Survey limits, and thus probe the lower-end of the magnitude distributions.

We used Sextractor to perform photometry of a number of Megacam and CFH12K images. We then generate histograms of the sources counts as a function of magnitude for each image. Applying the CFHT reference zero points to calibrate the magnitudes, and correcting the density by the area of the detector, we measure the equivalent histogram for the CFHT data that we have measured above from our synthetic photometry database. We can then compare these histograms to those from the same regions in the sky as observed by the CFHT images. Our histograms made from the PS1 preliminary photometric catalog agree well with the slopes of those histograms created from the Megacam/CFHT12K images (Figure 5). These comparison fields were chosen to be generally in low-galactic latitude regions. This result provides us with confidence that our source counts are accurate as an estimate for the total number of sources Pan-STARRS should expect to detect during its operation.

4 Predictions for the PS1 3-Pi Data: IPP Throughput and Storage

With our results from the source counting, we can now calculate the implications for the throughput and storage requirements of the 3π Survey. The mean throughput is defined as:

$$\bar{\dot{N}} = \frac{N_{tot}}{t_{3\pi}},$$

where $N_{tot}$ is the total number of detections across all 5 PS1 filters and $t_{3\pi}$ is the total survey time (~3.5 yrs). We calculate about 1200 $5\sigma$ and 300 $25\sigma$ detections per second. The nightly throughput can be estimated with:

$$\dot{N}_n = \frac{N_n * \rho * A}{t_n},$$

where $N_n$ is the typical number of images over a single night (800 images), $\rho$ is the density of sources in the sky, $A$ is
Table 3. Predicted Source Counts in the PS1 Filters

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<th>Filter</th>
<th>$N_{5\sigma} \times 10^6$</th>
<th>$N_{25\sigma} \times 10^6$</th>
<th>$N_{5\sigma} \times 10^6$</th>
<th>$N_{25\sigma} \times 10^6$</th>
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<td>1315</td>
<td>283</td>
<td>3449</td>
<td>1137</td>
<td>17460</td>
<td>1525</td>
</tr>
<tr>
<td>$y_{PS}$</td>
<td>597</td>
<td>134</td>
<td>2078</td>
<td>554</td>
<td>6926</td>
<td>612</td>
</tr>
<tr>
<td>total</td>
<td>10754</td>
<td>2040</td>
<td>19728</td>
<td>4705</td>
<td>50748</td>
<td>5374</td>
</tr>
<tr>
<td>avg</td>
<td>2151</td>
<td>408</td>
<td>3946</td>
<td>941</td>
<td>10150</td>
<td>1075</td>
</tr>
</tbody>
</table>

*aTotals capped at a maximum of $10^7$ sources per square degree

Table 4. Diagnostics from the Histogram Fits and Source Counting

<table>
<thead>
<tr>
<th>Diagnostic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of sky imaged by Pan-STARRS:</td>
<td>75.0%</td>
</tr>
<tr>
<td>Regions successfully fit (faint sources):</td>
<td>100%</td>
</tr>
<tr>
<td>Regions successfully fit (bright sources):</td>
<td>99.8%</td>
</tr>
<tr>
<td>Fits capped at $10^7$ sources/square degree (faint,5$\sigma$):</td>
<td>0.3%</td>
</tr>
<tr>
<td>Fits capped at $10^7$ sources/square degree (faint,25$\sigma$):</td>
<td>0%</td>
</tr>
<tr>
<td>Fits capped at $10^7$ sources/square degree (bright,5$\sigma$):</td>
<td>1.3%</td>
</tr>
<tr>
<td>Fits capped at $10^7$ sources/square degree (bright,25$\sigma$):</td>
<td>0.2%</td>
</tr>
</tbody>
</table>
**Figure 3** A plot of the number of sources per square degree detected in $z$-band as a function of galactic latitude. The two secondary spikes in the southern sky correspond to the locations of the Magellanic Clouds. Totals are calculated using the faint source fits.

The field-of-view for the PS1 telescope (7.5 square degrees), and $t_n$ is the time period of a typical night (10 hrs). For the average source density on the sky ($\rho(5\sigma) = 5.2 \times 10^4$ and $\rho(25\sigma) = 1.3 \times 10^4$ sources per square degree), the mean nightly throughput is: $N_n(5\sigma) = 8.7 \times 10^3$ and $N_{25\sigma} = 2.2 \times 10^3$ detections per second. These rates can be transformed into bytes/sec assuming a typical memory size per object (64 bytes).

Storage estimates for the single and stacked images can also be made from the detection totals resulting from the appropriate magnitude limits for different image stacks (see Table 2). The calculations discussed in this section are summarized in Table 5.
Figure 4 Same plot as Figure 3, except that the totals are calculated using the bright source fits. Note the effect of the $10^7$ cap near the galactic plane.

## 5 Summary

We have fitted Kurucz atmospheric models of main-sequence stars to input photometry from the USNOB, 2MASS, and Tycho surveys in order to predict the PS1 filter photometry of point sources across the Pan-STARRS visible sky. After generating this simulated PS1 Photometric catalog, we then produced magnitude functions for every 1 square degree of sky area and extrapolated them out to the estimated PS1 sensitivity limits for each filter. Our counting results in a range of $\sim$5-30 ($\sim$1-3) billion $5\sigma$ ($25\sigma$) detections for the PS1 visible sky depending on the fit used (sensitive or insensitive to crowding effects) and whether the totals are capped at $10^7$ sources per square degree. These totals suggest a nightly IPP throughput on the order of a few hundred kB/sec and a total storage prediction of 12-13 TB for the single and stacked images over the 3.5-year $3\pi$ survey.
Figure 5 Comparison between i-band data from Megacam (black dots) and our simulated counts for Pan-STARRS in i-band (red dots) for the same region of sky. The two slopes match well up to the simulated data’s sensitivity limit.

6 Appendix A : Program Details

All the programs listed here are run on the Desktop Virtual Observatory (DVO) software package.

Program: /home/panstarrs/pitts/scripts/calmags.dsc

USAGE: calmags (input file list) (pick/kur)

input file list: The input list of spectra

pick/kur: Specifies whether the spectra come from the Pickles empirical spectra archive or Kurucz’s model spectra (*for this document, we use the Kurucz models*)

The profiles are available at:

/home/panstarrs/pitts/scripts/profiles/

The output file is at:
Table 5. IPP Analysis Results

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Objects</th>
<th>Memory (64 bytes/object)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPP Throughput from $3 \pi$ Survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Data Throughput ($5\sigma$):</td>
<td>1,173 detections/sec</td>
<td>75 kB/sec</td>
</tr>
<tr>
<td>Average Data Throughput ($25\sigma$):</td>
<td>296 detections/sec</td>
<td>19 kB/sec</td>
</tr>
<tr>
<td>Nightly Throughput ($5\sigma$):</td>
<td>8,704 detections/sec</td>
<td>557 kB/sec</td>
</tr>
<tr>
<td>Nightly Throughput ($25\sigma$):</td>
<td>2,197 detections/sec</td>
<td>141 kB/sec</td>
</tr>
<tr>
<td>IPP Storage for $3 \pi$ Survey ($5\sigma$ limit)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase 2 (Single Images) x12 visits:</td>
<td>$1.3 \times 10^{11}$ detections</td>
<td>8.3 TB</td>
</tr>
<tr>
<td>Phase 4 1st Epoch (4 stacked):</td>
<td>$1.8 \times 10^{10}$ detections</td>
<td>1.2 TB</td>
</tr>
<tr>
<td>Phase 4 2nd Epoch (8 stacked):</td>
<td>$2.2 \times 10^{10}$ detections</td>
<td>1.4 TB</td>
</tr>
<tr>
<td>Phase 4 3rd Epoch (12 stacked):</td>
<td>$2.5 \times 10^{10}$ detections</td>
<td>1.6 TB</td>
</tr>
<tr>
<td>Total Storage:</td>
<td>$2.0 \times 10^{11}$ detections</td>
<td>12.5 TB</td>
</tr>
</tbody>
</table>

/home/panstarrs/pitts/scripts/outputs/calmags_out/calmags_finfo.txt

The models we use are saved in:

/home/panstarrs/pitts/scripts/spectra/kurucz/

The color table output is placed into the file:

/home/panstarrs/pitts/scripts/outputs/calmags_out/calmags_abcol.txt

The output is sent to the file:

/home/panstarrs/pitts/scripts/outputs/calmags_out/calmags_abmag.txt

The extinction grid is produced in the file:

/home/panstarrs/pitts/scripts/outputs/calmags_out/calmags_abext.txt

Programs: /home/panstarrs/pitts/scripts/mag_dmag.dsc and fit_dmag.txt

USAGE: mag_dmag (filter to plot)

USAGE: fit_dmag (filter curve to fit) (transition point) (max mag) (min err)

Transition point: magnitude value where the constant error becomes a power-law
Max mag: Maximum magnitude that can be fitted
Min err: Minimum error value that can be considered for the fit

The data is saved under:

/home/panstarrs/pitts/scripts/outputs/dmag_plots/mag_dmag_(fil).txt,

where (fil) is the filter abbreviation. Likewise, the actual plots are saved as:

/home/panstarrs/pitts/scripts/outputs/dmag_plots/mdm_(fil).png
The fits overlaid on the plots are provided in the files:

/home/panstarrs/pitts/scripts/outputs/dmag_plots/fit_dmag_(fil).png

### 6.1 Fitting Diagnostics

**Program:** /home/panstarrs/pitts/scripts/model_comp.dsc

**USAGE:** model_comp.dsc (object id #) (fit to use, 1-3)

To visually inspect the adequacy of the fitting, this program plots the input data, the fitted magnitudes, and the model spectrum all on the same scale. The model spectrum with the fitted temperature is converted from flux units into AB magnitudes, then reddened and shifted by the fitted values of the extinction and distance modulus. The residuals from the fitted and input data are also plotted. The diagnostic plots are outputted to the files:

/home/panstarrs/pitts/scripts/outputs/mcomp_plots/mcomp_(id #)_(_fit #).ps

Figure 6 shows one of these diagnostics.

![Diagnostic Plot](image)

**Figure 6** A comparison of the real input photometry (red dots), the chosen model spectrum to fit the data (black line), and the output photometry from the model (blue dots). Residuals from the real photometry versus the fitted values are plotted at the bottom (green dots), measured from the zero value (green line).
Program: /home/panstarrs/pitts/scripts/glat_loop.dsc and glat_test.dsc

Usage: glat_loop (staring/resuming index)
Usage: glat_test (ra) (dec)

The output of the program is sent to the files:

/home/panstarrs/pitts/scripts/outputs/skygrid/glat_(glat)/reg_(glat)_(glong)_PS_(fil).txt,

where (glat) and (glong) are the galactic latitude and longitude coordinates, respectively, and (fil) is the selected PS1 filter.

Program: /home/panstarrs/pitts/scripts/fit_high_low.dsc

Usage: fit_high_low (starting/resuming index)

The output is placed into the files:

/home/panstarrs/pitts/scripts/outputs/skygrid/fit.hl_PS_(fil).txt, where (fil) is the selected PS1 filter. The files are ASCII tables with the following columns: 1) galactic latitude, 2) galactic longitude, 3) RA, 4) DEC, 5) the minimum magnitude used to generate the linear fit, 6) the maximum magnitude for creating the faint sources fit (the sensitivity/crowding limit), 7-8) the constant and slope of the faint sources fit, 9-10) the constant and slope of the bright sources fit, and 11-14) the log of the total number of detectable sources based on the extrapolation of each fit to the predicted sensitivity limit.

Program: /home/panstarrs/pitts/scripts/count_plots.dsc

Program: /home/panstarrs/pitts/scripts/str_cnt_test.dsc

Usage: count_plots
Usage: str_cnt_test (filename) (megacam/cfht12k)

Filename: Input file containing actual image data
megacam/cfht12k: Is the input data from the Megacam or CFHT12K instrument?

The "count_plots" program generates plots from the results of §3.2 and outputs them into postscript files under:

/home/panstarrs/pitts/scripts/outputs/skygrid/plots/

The naming format is given as:

cplt_PS_(fil)_(x)_(y).ps = Plots of the parameters (x) vs. (y) for the filter (fil) (see example plots in Figure 3 and 4). The parameters currently available are:

- glat = galactic latitude
- dec = declination
- nrat = log of the ratio between the total source count of the faint source fit to the bright source fit
- c1rat = ratio of the slope of the faint source fit to that of the bright source fit
- delmag = the difference between the min and max magnitudes of each faint source fit (by definition, each bright source fit would cover a range 50% less); this calculation is done after editing out bad regions (where there are insufficient data for the fits to be made)
- fulldel = a version of the "delmag" calculation performed before editing out bad regions
• logn5b = log of the total number of sources in a region using the bright source fit and the 5σ sensitivity limit
• logn5f = log of the total number of sources in a region using the faint source fit and the 5σ sensitivity limit

These histograms are listed as:

/home/panstarrs/pitts/scripts/outputs/starcounts/realdatalonglantfil.txt,

where they are labeled by galactic coordinates and instrument filter in a similar way as the histograms generated in §3.1.

References