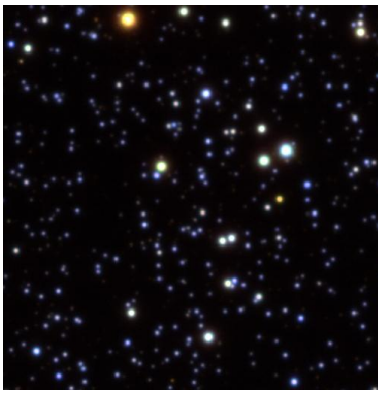
# PS1 Stack images



The PS1 stack images, described in detail in Waters et al., are the 'optimal' combination of multiple warps on the same skycell. For the 3pi survey there are in general 12 warps per filter, but for the Medium Deeps it can be several hundred. Stacks are also astrometrically and photometrically calibrated. These images are part of DR1 and can be accessed and downloaded through the PS1 archive image cutout interface.

**The following information is taken from Waters et al., which should be cited appropriately.**

**Contents**


- Exposure time
- Photometric calibration
- Coverage
- Medium Deep Fields


The skycell images generated by the Warp process are added together to make deeper, higher signal-to-noise images in the Stack stage. The stacks also fill in coverage gaps between different exposures, resulting in an image of the sky with more uniform coverage than a single exposure. The stacks are on the same PS1 Sky tessellation patterns as the PS1 Warp images. See Waters et al. for details on the stack combination algorithm.

In the IPP processing, stacks may be made with various options for the input images. During nightly science processing, the 8 exposures per filter for each Medium Deep field are combined into a set of stacks for that field. These so-called ‘nightly stacks’ are used by the transient survey projects to detect the faint supernovae, among other transient events. For the PV3 3 analysis, all filter images from the 3 su rvey observation were stacked together to generate a single set of images with 10  20 times the exposure of the individual survey exposures. The signal, variance, and mask images resulting from these deep stacks are part of the DR1 release and are available through the PS1 archive image cutout interface . Stack images have filenames that include '.unconv' because the are constructed by combining warp images having observed (variable) PSFs. The PS1 pipeline also generated stacked images with seeing convolved to a fixed value before stacking. The convolved image products are not included in the public archive because it was found that the unconvolved images are always preferred for scientific data analysis.

As well as the standard masks and weights, stacks come with three other auxiliary image files:

- 'mask' images indicate which pixels in the stack are good and which are bad
- 'wt' images are the stack variance images
- 'num' images contain the number of warps with valid data which contributed to each pixel
- 'exp' images contain the exposure time in seconds which contributed to each pixel
- 'expwt' images are weighted exposure time maps

You might want to check out the page on image format quirks before downloading any data.

## Exposure time

The exposure time for a stack is given in the FITS header (keyword EXPTIME). It consists of the unweighted sum of the individual warp exposures which were passed to the stacking process (these are visible as keywords EXP_nnnn). Note that during the stacking process some of these warps can be excluded. This is not reflected in the exposure time, so the actual on-sky time for each stack is not necessarily the same as the exposure time given in the header.

The actual exposure time per pixel is available as the auxiliary 'exp' image for each stack.

## Photometric calibration

At the time of stacking, the pixel values in stacks are rescaled to a zero-point of 25 + 2.5* log10(exposure time), based on the input warp calibration (see keyword HIERARCH FPA.ZP in the FITS header - the individual warp zero-points are also in the header, ZPT_nnnn, as are the relative scaling factors applied to each, SCL_nnnn). However, as the final ubercalibration of the data has not taken place at this time, this zero-point may be slightly incorrect (usually at the hundredths of a magnitude level). In contrast, the stack fluxes/magnitudes in the PSPS catalog database have undergone the final calibration process and are more accurate.

So to measure your own magnitudes off a stack image, you need to apply the following formula:

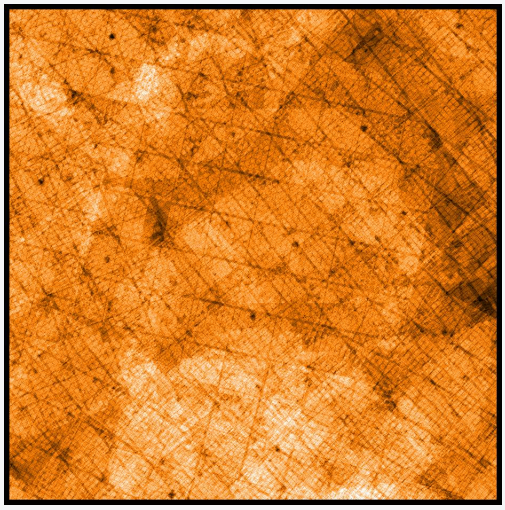
MAG=-2.5*log10(data-units)+25+2.5*log10(EXPTIME)

Note that due to the complicated nature of the stacking process, the data-units in a stack are not easily related to actual photons from the target.

## Coverage

Due to the gaps between the OTAs , and general cosmetic masking, the number of input warps per pixel with valid data on a stack varies. This variation can be quite large in the 3 images (it is not so much of an issue on the Medium Deeps). As a result the true PSF at a given location on a stack can vary discontinuously between pixels (if the input warps have different FWHM). This acts as an increased source of error in the stack PSF photometry, as the PSF model fitted to the stack is continuous. Better results may therefore be obtained by using the Forced Mean Warp data (as the true PSF is expected to be continuous over a warp).

The actual number of warps used in each pixel is available as the auxiliary 'num' image for each stack.



**Typical coverage (number of warps contributing to a pixel) in a g-band 3pi projection cell (4 degrees on a side). Black is zero, white is 17 (note this image is produced from a summary stack, so the pixels here are 4" across and do not show the full PS1 resolution).**

## Medium Deep Fields

For the processing of the Medium Deep fields, stacks have been generated for the nightly groups and for the full depth using all exposures (deep stacks). In addition, a 'best seeing' set of stack have been produced. We have also generated out-of-season stacks for the Medium Deep fields, in which all image not from a particular observing season for a field are combined into a stack. These later stacks are useful as deep templates when studying long-term transient events in the Medium Deep fields as they are not (or less) contaminated by the flux of the transients from a given season. The Medium Deep fields will be made public in DR3.