PS1 PSF photometry of detections

PSF photometry is one of the major ways to measure the flux of sources (detections) in PanSTARRS1 data. It is based on fitting a predefined analytical shape to the counts reported for each detection, and then applying a zero point conversion to the total object count rate thus obtained.

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The starting point for the PS1 data archive is at Pan-STARRS1 data archive home page.

PSF Photometry

Obtained from fitting a predefined PSF form to all detections. The quality of the fit can help determine whether a source is indeed a point source, it is extended, or it is spurious. PSF photometry is performed on warps by a module called PSFPHOT and on stacks by PSPHOTSTACK. The result of the fit is reported in the Detection table (or StackDetection table for stacks). Values reported include flux, uncertainty, position, elliptical size, and quality parameters.

The PSF Model

The PSF model takes the form of an analytical function plus residuals. The fitted parameters and residuals vary with position, but are actually determined at 9 positions (in a regular 3x3 grid pattern) per skycell then interpolated to other positions.

Analytical functions tested include:

- GAUSS : exp (-z)
- PGAUSS : $(1 + z + z^2/2 + z^3/6)^{-1}$
- QGAUSS : $(1 + kz + z^{2.25})^{-1}$
- RGAUSS : $(1 + z + z^k)^{-1}$
- PS1_V1 : $(1 + kz + z^{1.67})^{-1}$

where z is the elliptical contour (akin to a radius squared):

- $z = x^2/(2^2_{xx}) + y^2/(2^2_{yy}) + {}_{xy}XY$

The PS1_V1 model is the current default value for PS1 analysis.

Variability over the image is formally represented as:

- PSF = F[dx,dy;ai(x,y)] + R0[dx,dy] + x Rx[dx,dy] + y Ry[dx,dy]

Existing documentation states that a global linear fit is performed in which the fluxes of all objects is fitted for simultaneously with the following considerations:

- Simultaneous fit of fluxes for all objects in the image
- Chi-square fit:
  - $^2 = (f_i - (A_j F_{ij})^2 W_i$ (i : pixels; j : objects)
  - W_i – weighting function
    - now constant (from mid-2012), was inv variance
    - using a constant weight removes a photometric bias found for faint sources
- minimization of A_j requires inversion of large square matrix
  - N (number of objects) may be up to 100k
  - but, highly diagonal, so inversion is actually fast
- ~ 1 second for 100k objects (unless they grow too large)

Photometric and astrometric parameters from PSF fitting

The **PS1 Detection table fields** table contains the following parameters related to PSF photometry:

xPos	raw pixels	REAL	4	-999	PSF x center location.
yPos	raw pixels	REAL	4	-999	PSF y center location.

xPosErr	raw pixels	REAL	4	-999	Error in PSF x center location.
yPosErr	raw pixels	REAL	4	-999	Error in PSF y center location.
psfFlux	Janskys	REAL	4	-999	Flux from PSF fit.
psfFluxErr	Janskys	REAL	4	-999	Error on flux from PSF fit.
psfMajorFWHM	arcsec	REAL	4	-999	PSF major axis FWHM.
psfMinorFWHM	arcsec	REAL	4	-999	PSF minor axis FWHM.
psfTheta	degrees	REAL	4	-999	PSF major axis orientation.
psfCore	dimensionless	REAL	4	-999	PSF core parameter k, where F = F0 / (1 + k r^2 + r^3.33).
psfQf	dimensionless	REAL	4	-999	PSF coverage factor.
psfQfPerfect	dimensionless	REAL	4	-999	PSF weighted fraction of pixels totally unmasked.
psfChiSq	dimensionless	REAL	4	-999	Reduced chi squared value of the PSF model fit.
psfLikelihood	dimensionless	REAL	4	-999	Likelihood that this detection is best fit by a PSF.

The equivalent stack measurements are to be found in **PS1 StackObjectAttributes table fields**.

Note that psphot actually returns PSF_MAJOR and PSF_MINOR, whose relation to FWHM depends on the value of k (reported as psfCore) for the PS1_V1 profile. For k=0, FWHM=PSF_MAJOR*2*sqrt(2) *pixel_size.