

Astro Glossary

This glossary covers astronomical terms, or other LSST terms related to the astronomy domain. See the [DMS Glossary](#) for technical terms related to the Data Management System software. Many terms (and in fact, algorithms) are borrowed from the vocabulary of SDSS. Actually, some of the definitions below are taken almost verbatim from the [SDSS Glossary](#) for terms in common. We gratefully acknowledge the curators of this excellent resource, however quotations are omitted in the interest of clarity in this Glossary.

Here are quick links to the alphabetized glossary terms:

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A

Adaptive moments

The second moments of the source intensity distribution, which are used for measuring source shapes. This approach is close to optimal for measuring the shapes of faint galaxies.

Airmass

The pathlength of light from an astrophysical source through the Earth's atmosphere. It is given approximately by $\sec z$, where z is the angular distance from the zenith (the point directly overhead, where airmass = 1.0) to the source.

Amplifier

An electronic component of a [CCD](#) that is used to recover the signal during read-out. For LSST, multiple amplifiers on each [CCD](#) will enable simultaneous read-out of adjacent regions of each detector. Often this term is used, not quite correctly, as a synonym for a read-out [channel](#).

Alert

Refers to the structured communication that is issued rapidly via the internet to the community during the [Alert Production](#). It is intended to characterize the detection of one or more sources that are new, or have changed significantly in position or brightness, relative to the applicable [image template](#).

Apparition

The appearance of a known [object](#) after having been invisible (or, undetected).

Aperture correction

A correction that is applied to fluxes of sources that were measured within a finite aperture, to account for the source flux that lies outside the aperture. This correction is usually based upon a model of the [PSF](#) as derived from bright, isolated stars. From the model one can derive the magnitude of the correction with aperture size and its variation with position in the image, which asymptotically approaches 1.0 at infinite aperture. Fluxes of sources in crowded fields are often measured with small apertures to avoid contamination, and then corrected with this approach.

Astrometry

In astronomy, the sub-discipline of astrometry concerns precision measurement of positions (at a reference epoch), and real and apparent motions of astrophysical objects. Real motion means 3-D motions of the object with respect to an inertial reference frame; apparent motions are an artifact of the motion of the Earth. Astrometry *per se* is sometimes confused with the act of determining a World Coordinate System ([WCS](#)), which is a functional characterization of the mapping from pixels in an image or spectrum to world coordinate such as ([RA](#), [Dec](#)) or wavelength.

B

Background

In an image, the background consists of contributions from the sky (e.g., clouds or scattered moonlight), and from the telescope and camera optics, which must be distinguished from the astrophysical background. The sky and instrumental backgrounds are characterized and removed by the processing software using a low-order spatial function whose coefficients are recorded in the image metadata.

C

Cadence

The sequence of pointings, visit exposures, and exposure durations performed over the course of a survey.

Calexp

A fully qualified, calibrated science image, consisting of science pixels, a quality mask, a **PSF** characterization, and a **WCS** mapping.

Camera

An imaging device mounted at a telescope focal plane, composed of optics, a shutter, a set of **filters**, and one or more **sensors** arranged in a **focal plane array**. For details see [Representation of a Camera](#) in the **LSST Stack**.

Camcol

In the **SDSS** survey, a *camera column* is the range (in declination) covered by a single **sensor** in the **camera**.

CCD

A *Charged-Coupled Device* is a particular kind of solid-state **sensor** for detecting optical-band photons. It is composed of a 2-D array of pixels, and one or more read-out **amplifiers**.

CFHT-LS

A 5-passband legacy imaging survey conducted at the Canada-France-Hawaii Telescope from 2003-2008.

Channel

The raw data from a read-out **amplifier** of a **sensor**. For LSST there are 16 amplifiers for each science **sensor**, resulting in 16 parallel data channels from each device.

Chi-squared Co-Add (image)

An image that is the weighted sum of multiple input images, where for each input:

```
coadd.image += image.image**2 / image.variance
coadd.mask |= image.weightMap += weight
```

For bad pixels, `coadd` and `weightMap` are not altered. Note that the inputs must be aligned to a common projection and pixel grid and corrected to the same photometric scale and zero-point.

Co-add image

An image that is the combination of multiple input images. The inputs are aligned to a common projection and pixel grid, corrected to the same photometric scale and zero-point, with bad pixels and artifacts rejected. (Image **PSFs** may also be matched prior to co-addition.) *Co-Add images* have had non-astrophysical background removed.

D

Deblend

Deblending is the act of inferring the intensity profiles of two or more overlapping [sources](#) from a single [footprint](#) within an image. Source [footprints](#) may overlap in crowded fields, or where the astrophysical phenomena intrinsically overlap (e.g., a supernova embedded in an external galaxy), or by spatial coincidence (e.g., an asteroid passing in front of a star). Deblending may make use of *a priori* information from images (e.g., deep [Co-Adds](#) or visit images obtained in good [seeing](#)), from catalogs, or from models.

Declination

Often abbreviated *Dec*, it is a part of an [equatorial coordinate](#) pair that expresses the angular distance (usually expressed in degrees) from the Celestial Equator, measured along great circles that intersect the Equatorial poles. Positions south of the equator are given negative sign.

deVaucouleurs profile

The radial distribution of flux of an astronomical source that is characterized as:

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An elliptical version of this profile can be fit to every detected source, yielding the deVaucouleurs parameters. See the page on [Measurement in the LSST Stack](#) for details.

DIA Object

A *DIA object* (often concatenated as *DIAObject*) is one that has been detected during [difference image processing](#). It is distinguished from a regular [object](#) in that its brightness varies in time.

DIA Source

A *DIA source* (often concatenated as *DIASource*) is one that has been detected during [difference image processing](#). It is distinguished from a regular [source](#) by at least one of the following properties: its uniqueness (i.e., no association to known objects); its variability in brightness; or, if it is associated with a [Solar System Object](#), a change in coordinates.

Difference image

Refers to the result formed from the pixel-by-pixel difference of two images of the sky, after warping to the same pixel grid and scaling to the same photometric scale. The pixels in a difference thus formed should be zero (apart from noise) except for sources that are new, or have changed in brightness or position. In the LSST context, the difference is generally taken between a [visit image](#) and [template](#).

Difference image processing

A pipeline that constructs differences between two images (usually a recent visit exposure and a [template image](#)) in order to detect [sources](#) that are new or that have changed brightness. The input images are transformed to a common grid, scaled to the same photometric response, and matched to the same PSF. Sources are detected above a configurable threshold on the difference image. This pipeline feeds the Alert processing.

E

Eimage

An output product of [PhoSim](#), an *Eimage* is a simulation of the response of a single [sensor](#), where the outputs of the constituent [amps](#) have been integrated, and the effects of variations in pixel-to-pixel sensitivity and amplifier gains have been removed.

Epoch

TBA.

Ephemeris

An *ephemeris* (pl: *ephemerides*) gives the predicted positions of astronomical **objects** or artificial satellites in the sky with time. The ephemerides are computed from mathematical models of motion of the object and the Earth.

Exponential profile

The radial distribution of flux of an astronomical source that is characterized:

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The normalization 1.68 is chosen so that the model radius is a half-light radius. An 2-dimensional elliptical version of this profile is fit to every detected source.

F

Filter

A *filter* in astronomy is an optical element used to restrict the **passband** of light reaching the focal plane—i.e., it transmits a selected range of wavelengths. Filters elements are often named after standard photometric passbands, such as those used in the **SDSS** survey: *u, g, r, i, z*.

FITS

Flexible Image Transport System, an international standard in astronomy for storing images, tables, and metadata in disk files. See the [IAU FITS Standard](#) for details.

Footprint

Shorthand for the spatial extent of a **source** in an image, or of the (often complex) boundary of an image, a **co-add image**, or a survey. For a **source**, the *footprint* is the set of image pixels that that contain flux from that **source**.

Flux

Shorthand for *radiative flux*, it is a measure of the transport of radiant energy per unit area per unit time. In astronomy this is usually expressed in *cgs* units: $\text{erg}/\text{cm}^2/\text{s}$.

Focal plane array

A *focal plane array* (FPA) is the arrangement of multiple **sensors** in the focal plane of a **camera**. For LSST, the FPA is divided into an array of contiguous **rafts**, upon which 9 science **sensors** are mounted 3x3. Additional engineering **sensors** are mounted on **rafts** near the periphery to support wavefront sensing and telescope guiding.

Forced photometry

A measurement of the photometric properties of a source, or expected source, with one or more parameters held fixed. Most often this means fixing the location of the center of the brightness profile (which may be known or predicted in advance), and measuring other properties such as total brightness, shape, and orientation.

H

HTM

The *Hierarchical Triangular Mesh* (HTM) is a partitioning scheme to divide the surface of the unit sphere into spherical triangles. It is a hierarchical scheme and the subdivisions have roughly equal areas. HTM is used to index the coordinates in the object databases for faster querying speeds.

I

Image template

A co-added, single-band image of the sky that is deep, and where all transients, SSO objects, and artifacts have been removed. Constituent images for Image Templates may be selected from a limited range of quality parameters, such as **PSF** size or **airmass**. Such images are used as templates to perform **difference image processing** in order to detect variable, transient, and Solar System astrophysical **objects**.

Instance Catalog

A catalog of astronomical sources containing source type, coordinates, brightnesses, and **SEDs** for use in creating simulated LSST images with **PhoSim**.
Synonym with **trim file**.

J

Julian Date

The *Julian Date* (JD) of any instant is the Julian day number for the preceding noon (UTC), plus the fraction of the day elapsed since that instant. The Julian day number is a running sequence of integral days, starting at noon, since the beginning of the Julian Period; JD 0.0 corresponds to noon on 1 January 4713 BCE. Various **Julian Date converters** are available on the Web. For example, 18h 00m 00.0s UT on 2014-July-01 (near the start of LSST construction) corresponds to JD 2456840.25.

M

Magnitude, Pogson

Usually simply *magnitude*, it is a logarithmic measure of integrated source brightness, usually within a standard photometric passband, such that:

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, where the zero-point flux is defined by a photometric standard.

Magnitude, Petrosian

A magnitude determined from a fit to a Petrosian brightness profile:

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Appropriate for galaxies.

Magnitude, PSF

For isolated stars that are well described by the **PSF**, the optimal measure of the total flux is determined by fitting a PSF model to the object.

MJD

The *Modified Julian Day* is shorthand for the Julian Day: $MJD = JD - 2400000.5$, which makes $MJD=0$ correspond to UT midnight in 1858-Nov-17. The half-day offset from JD aligns the start of the day with modern civil timekeeping.

O

Object

Refers to an astronomical object, such as a star, galaxy, asteroid, or other physical entity. Objects can be static, or change brightness or position with time. Generally an object will be associated with more than one instance of a [source](#) detection.

Overscan

Refers to the portion of the [channel](#) read-out of either a) non photo-active pixels, or b) additional read-out of the serial register after all science pixels have been accumulated (sometimes called *virtual overscan*). The *overscan* is often appended to the science pixels in the assembled amplifier image as a separate region. This region is useful to science processing software for estimating the stability of the DC offset in the read-out electronics.

P

Passband

The window of wavelength or the energy range admitted by an optical system; specifically the transmission as a function of wavelength or energy. Typically the *passband* is limited by a [filter](#). The width of the passband may be characterized in a variety of ways, including the width of the half-power points of the transmission curve, or by the equivalent width of a filter with 100% transmission within the passband, and zero elsewhere.

Photo-z

Redshift (of a galaxy) determined from multi-band photometry. Generally determined from a fit of source colors to grid of model SEDs with redshift.

Precover

In astronomy, this is an exercise to find detections of a newly discovered object in prior-epoch images. For example, finding the progenitor of a supernova, or prior apparitions of a solar system object at predicted locations in archived images, based on orbit parameters.

PSF

The *Point-spread function* is the distribution of intensity on a [sensor](#) (or image) originating from an unresolved point-source (i.e., a star). Often the PSF is not the same [Airy shape](#) as would be expected from a finite-aperture optical system, owing primarily to atmospheric effects and imperfections in the optical system and the detector.

R

Raft

The [sensors](#) in the LSST camera are packaged into replaceable electronic assemblies, called *rafts*, consisting of 9 [sensors](#) in a 3x3 mosaic.

Raw Exposure

A *raw exposure* is the output from a [camera](#), consisting of a set of image sections from each [amplifier](#) on each [sensor](#) on the [focal plane array](#), including [overscan](#).

Right Ascension

Often abbreviated *RA*, it is a part of an [equatorial coordinate](#) pair that expresses the angular distance along the Celestial Equator. It is analogous to terrestrial longitude. RA increases to the east along the projection of the Earth's equator, from the origin (i.e., the Vernal Equinox). Positions are customarily expressed in degrees ($0 < RA < 360$), or hours ($0 < RA < 24$, usually in sexagesimal format).

Raft

The **sensors** in the LSST camera are packaged into replaceable electronic assemblies, called *rafts*, consisting of 9 **sensors** in a 3x3 mosaic.

S

SDSS

Sloan Digital Sky Survey is a digital survey of roughly 10,000 square degrees of sky around the north Galactic pole, plus a ~300 square degree stripe along the celestial equator.

SED

Spectral Energy Distribution, the radiated energy of an astrophysical **object** as a function of energy (or wavelength) across the entire spectrum of light.

Seeing

An astronomical term for characterizing the stability of the atmosphere, as measured by the width of the **point-spread function** on images. The **PSF** width is also affected by a number of other factors, including the airmass, passband, and the telescope and camera optics.

Sensor

A *sensor* is a generic term for a light-sensitive detector, such as a **CCD**. For LSST, sensors consist of a 2-D array of roughly 4K x 4K pixels, which are mounted on a **raft**.

Shape

The *shape* of an **object** is a functional characterization of its spatial intensity distribution. The integral of the shape is the flux. A functional characterization has the advantages of offering an analytical form that can be convolved with another function, distinguished from overlapping source shapes, and integrated to large radius to obtain the **source** flux.

Sky map

An all-sky tessellation for LSST. The Stack includes software to define a geometric mapping from the representation of World Coordinates in input images to that used for LSST.

Sky patch

An quadrilateral sub-region of a **sky tract**, with a size in pixels chosen to fit easily into memory on desktop computers.

Sky tract

A portion of sky, a spherical convex polygon, within the LSST all-sky tessellation. The implementation for SDSS **Stripe 82** divided this equatorial band into quadrangular tracts, bounded by constant **RA** and **Dec**. Each tract was subdivided into **sky patches**.

Snap

In normal LSST operations, a standard visit consists of two *snaps*, or two consecutive exposures with the same exposure time, telescope alignment, and filter.

Solar system object

A *solar system object* is an astrophysical **object** that is identified as part of the Solar System: planets and their satellites, asteroids, comets, etc. This class of **object** had historically been referred to within the LSST Project (rather imprecisely) as *Moving Objects*. (Everything moves, if you wait long enough.)

Source

A single detection of an astrophysical **object** in an image, the characteristics for which are stored in the Source Catalog of the science database. The Data Management System attempts to associate multiple source detections to single **objects**, which may vary in brightness or position over time.

Source association

The process of associating **source** detections on multiple images taken at different epochs, or in multiple **passbands**, with a single astronomical **object**.

Stripe 82

A 2.5° wide equatorial band of sky covering roughly 300 square degrees that was observed repeatedly in 5 **passbands** during the course of the **SDSS**. In part for calibration purposes.

T

Transient

A *transient source* is one that has been detected on a difference image, but has not been associated with either an astronomical **object** or a **solar system body**.

V

Visit

A sequence of one or more consecutive exposures at a given position, orientation, and filter within the LSST **cadence**. The baseline *visit* for the main survey consists of two **snaps** of 15 s duration.

W

WCS

A *World Coordinate System* is a mapping from image pixel coordinates to physical coordinates; in the case of images the mapping is to sky coordinates, generally in an equatorial (RA, Dec) system. The *WCS* is expressed in FITS file extensions as a collection of header `keyword=value` pairs (basically, the values of parameters for a selected functional representation of the mapping) that are specified in the **FITS Standard**.
