Single-epoch Measurement Algorithms

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Outline

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Coaddition: Detection, Association, and Deblending
Background Estimation

- One of the unsolved issues in image processing
- Goal: measure the \textbf{mean} flux of all non-detected objects
- Danger: subtracting power from the wings of extended objects
Background Matching for Coadds

Proposal: estimate the *difference* between successive (dithered) exposures.

- This means that the real objects subtract out, leaving
  - Changes in the sky
  - Ghosts
  - Glints

- One realisation of the sky survives, but we can subtract this at high S/N
source detection

Convolve with a spatial filter: convert an picture to a likelihood image

\emph{n.b.} a single pixel is significant – remember to grow by the size of the spatial filter.
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Discussion of choice of spatial filters (will use PSF + extended templates (e.g. 2xPSF)).
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Accounting for detector characteristics

- We’ll correct for all standard effects (\textit{e.g.} nonlinearity)
- Deep depletion devices have their own foibles:
  - Those due to the Si (\textit{e.g.} tree-rings, anti-bleed stops)
  - Those due to charge in pixels (\textit{e.g.} pixel correlations, intensity-dependent PSFS)
PSF estimation

- Current state-of-the-art is to use some basis functions (e.g. PCA) and a spatial model (e.g. polynomials).
  Details vary (oversampling; colour dependence)
- Jarvis and Jain modelled the eigen-components of Blanco’s optics/tracking
- EUCLID’s using wavefront reconstruction from images
  **RHL: check what Miller did in CFHTLens.**
- PSF model is implemented as a plugin; options currently include pcaPsf, psfexPsf, stackfitPsf
- LSST plans to estimate the telescope part from the wavefront sensors, and estimate the atmospheric part using e.g. PCA + Kriging
- We will estimate the zero-intensity PSF
Astrometry

– MLE PSF estimates for stars, and more extended object models for larger sources.
– Will handle trailing
– We are aware of the mapping from the pixel grid to focal plane mm

\textit{N.b.} final centroids (and motions/parallax) come from multifit
Photometry

- Stars
- Galaxies
  - PSF-convolved models
  - Elliptical apertures
  - Kron/Petrosian
  - No isophotal!
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- If all frames are equivalent, the coadd has all the information in the input frames

N.b. this assumes per-pixel weighting.

- If all frames have the same seeing, it's usually OK to use the coadd
  The exception is things that move or vary:
  - Cosmic rays and other defects
  - Stars that move (nearby and/or fast moving)
- If the seeing varies, the coadd is never optimal
  … but it may not matter much
  Some things are OK:
  - Detection of extended objects
  - Background estimation (if using background matching)
  Some things are not:
  - Unrecognised cosmic rays and moving objects
  - Optimal photometry and shapes
  - How much we lose by working on a coadd is a numerical question
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- Coadds are good for studying anything large or low-surface brightness
Detection on Multi-Epoch Multi-Band Data
Single Band:

Detection on a coadd is basically the same as on a single image, with the added complexities that:

- the noise is correlated
- the psf (and thus the map from image to likelihood) may be strongly spatially variable

Multiple band:

- given an SED convolve in space and filter
- given no information about the SED you recover a $\chi^2$ detection
- proposal: detect in each band separately and $\chi^2$ to e.g. $4.5\sigma$, merge, and cut at e.g. $5.5\sigma$ with your favourite SEDs

RHL: shall I include the mathematics here?
Source Association

Tricky. You need to handle astrometric errors and generate a believable list of Peaks within each source.
Deblending

The proposal is to run an SDSS-style deblend on the coadd. We will then propagate the outputs to the individual frames in a way TBD.
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Kinds of Coadds
Colour Measurements Designed to Enable Photo-zs

- Constant Seeing in all Bands
  - If the seeing's fixed you can use any model you like.
  - Simple apertures waste S/N (about 11% for a Gaussian profile and an optimal aperture of 0.67 FHWM)
  - We'll be calculating models anyway.
  - There's nothing magic about the total light; you can choose the model to maximise the S/N in the photo-z — e.g. overweight the bulge.

- Variable Seeing
  - You (we) can homogenize the seeing, but at some cost
  - If your models are flexible enough to measure a total flux, the seeing doesn't matter (remember that they are PSF convolved)
  - In practice, this probably means allowing the Sérsic index or B/D ratio to float, but not other structural parameters
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