Photometric Data Reduction

StarDICE workshop

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CPPM Centre de Physique des Particules de Marseille

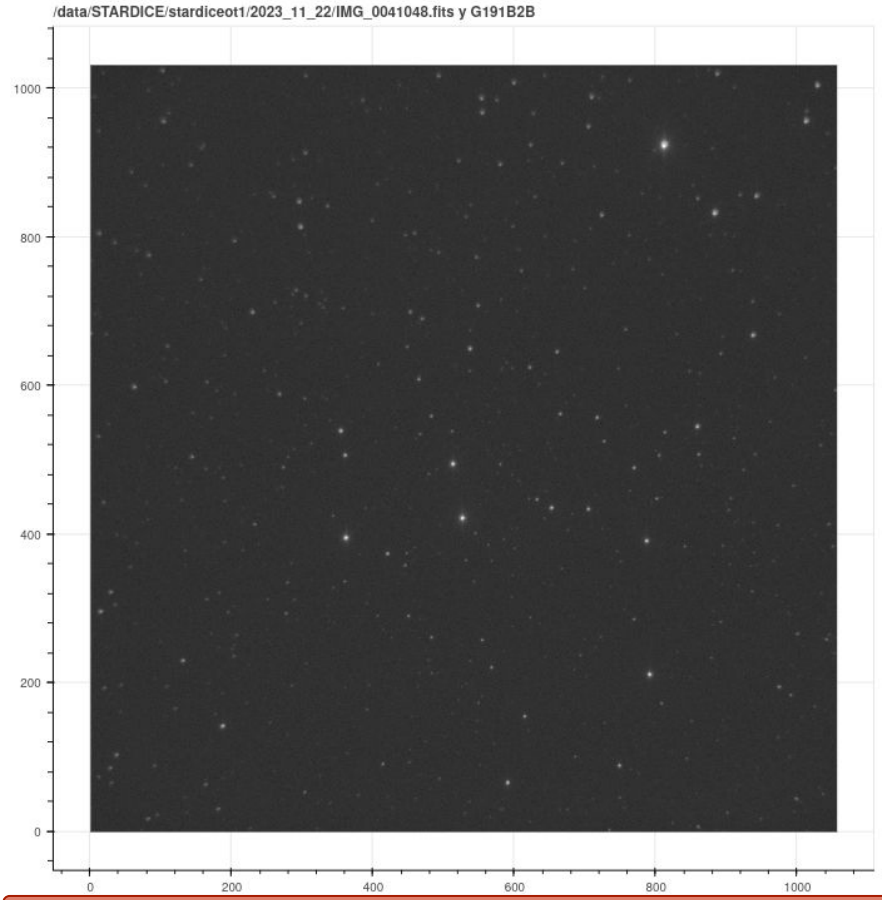
IJCLab Irène Joliot-Curie Laboratoire de Physique des 2 Infinis

Harvard

LSST DESC Dark Energy Science Collaboration

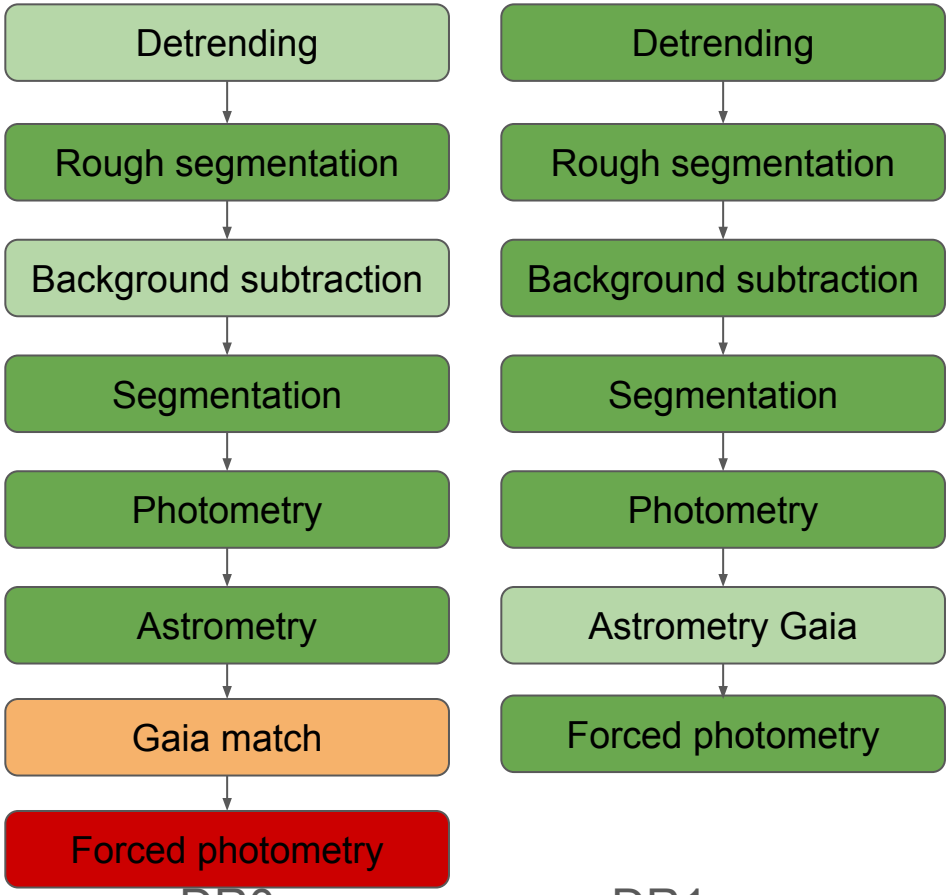
Vera C. Rubin Observatory

Photometric data summary



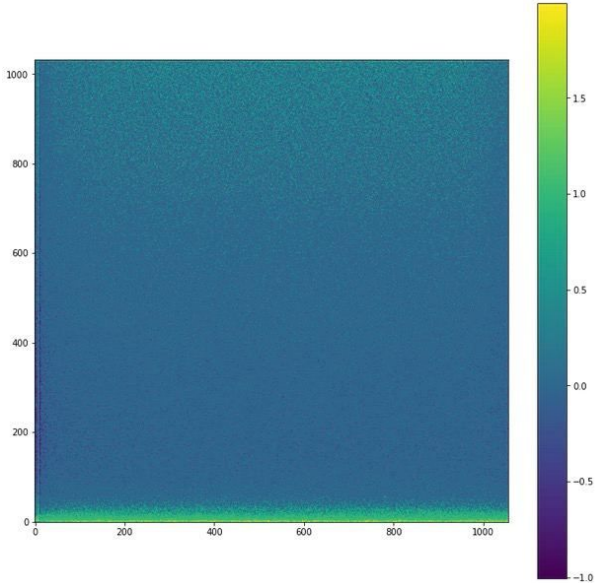
- 78 nights with data since first light on 2022-12-06
- Production of the entire DR1 reduction of this dataset is running

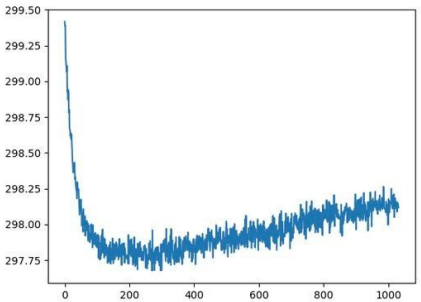
Image reduction : Change with respect to DR0

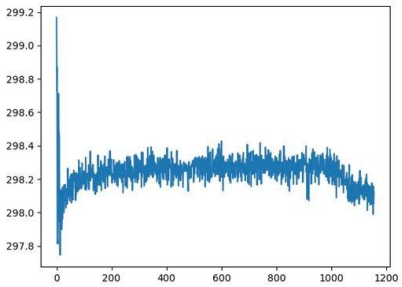


- Green: Done
- Light green: known issues, to be modified
- Orange: outside the online pipeline
- Red: to be done
- We suppressed the dependency to astrometry.net which was causing installation issues and failed to resolve about 55% of images using the default debian installation
- The astrometry is directly tied to Gaia
- We now perform forced photometry of all gaia stars with a low resolution spectrum in the field

Detrending

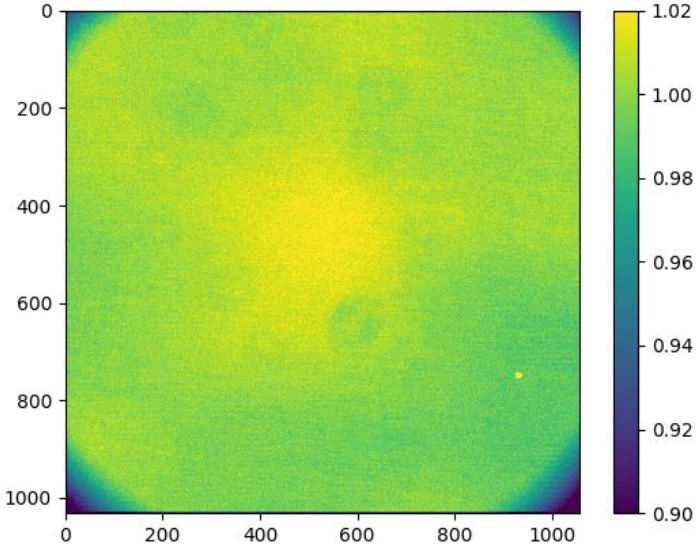






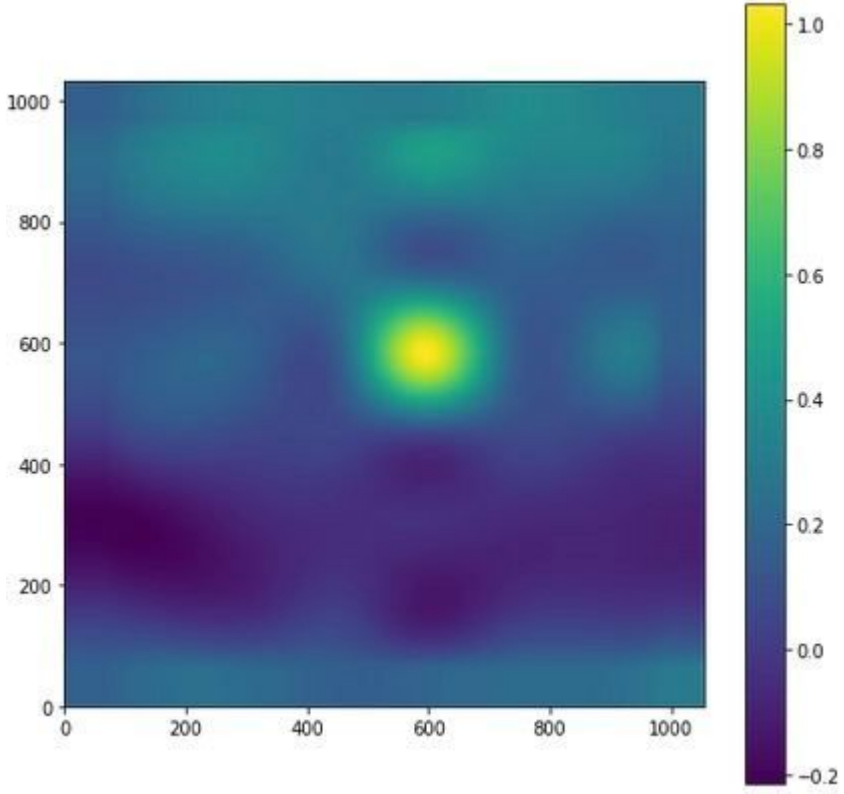
- No dark subtraction
- No master bias
- No flat
- We have switch to a line overscan subtraction to subtract the shape noticed in CBP studies
- We may want to dedicate a few hours to acquire master bias, but this is low priority as the issue is so small
- Volunteers to study master bias are welcome

Do we want to flat-field the images ?



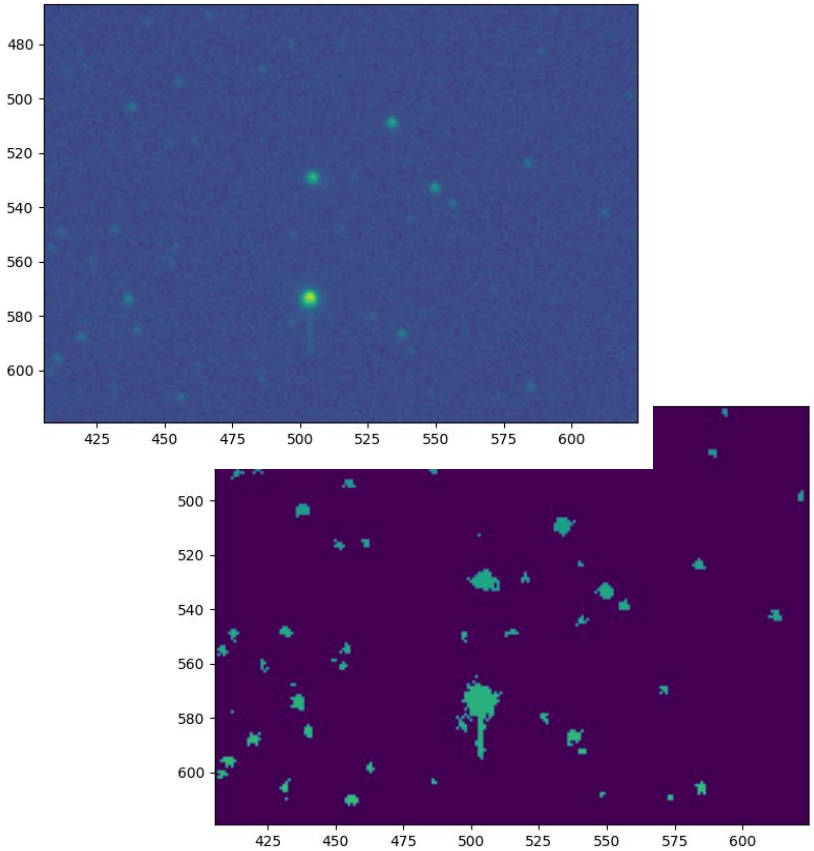
- The flat-field contains a mix of effects, some of them not relevant to point-source photometry (distortions mainly)
- A flat-field obtained from 69 twilight images
- The corner looks vignetted which is a bit surprising because the secondary was designed so that the sensor is fully illuminated
- We have a physical model that can be used to predict the vignetting, and also platescale distortion let us see if we can make sense of this picture
- We can also measure the response to point-source illumination (dithered fields or artificial star when available)
- According to the picture this is potentially an issue at the level of a few percents so worth investigating for the pre-survey
- Any look at the flat-field shape and stability of the flat-fields is welcome

Background subtraction



- Objects above a 5-sigma threshold are detected and masked up to the 3-sigma isophotal
- The masked image is split in superpixels of 129x132 pixels (because the images are 1032x1056)
- A iterative mean with 3-sigma clipping is computed on each superpixels to form the miniback map
- The miniback map is interpolated to full resolution using a bicubic bspline
- We also build a variance map
- The interpolated map is subtracted from the original image
- We know from the analysis of CBP data that this procedure is eating a small fraction of the flux.
- Due to the differences in PSF, the flux fraction is chromatic
- A way to look at this is to fit profiles on the forced photometry catalogs

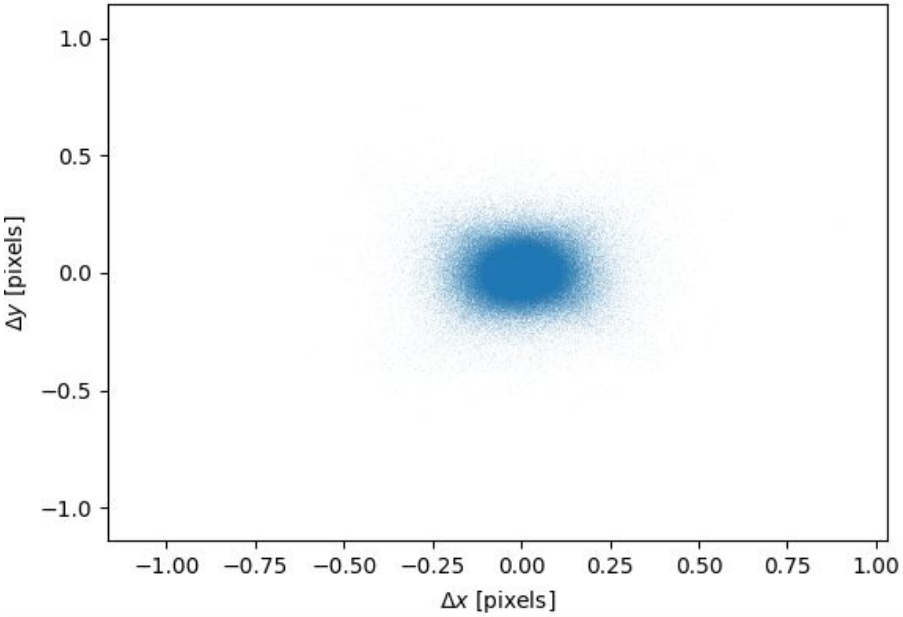
Object detection and centroiding



- Objects in the background subtracted images are detected at the 4-sigma level,
- Barycentre and 2nd moments of the 2-sigma isophotal area are computed (keys x, y, mxx, myy, mxy, area, fluxmax in the catalogs
- The positions and shapes are refined through gaussian weighting
- gwx, gwy, gwmxx …

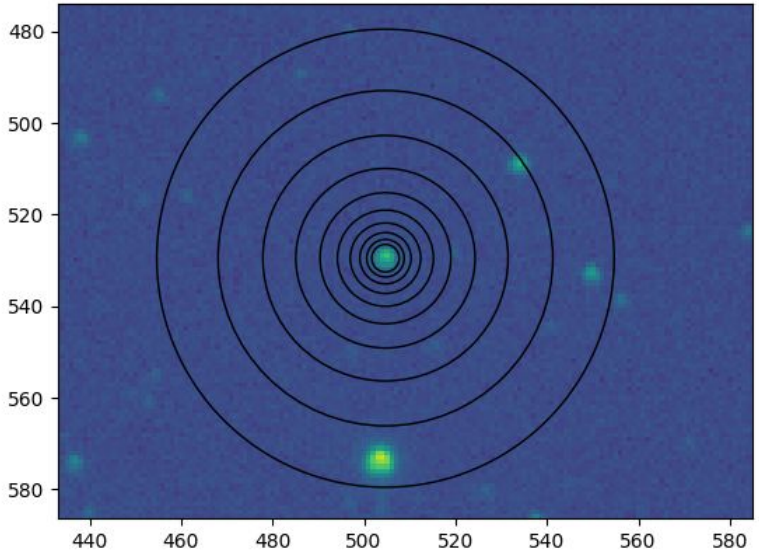
The resulting catalog is matched to gaia

Astrometric residuals for a full night of data



- The astrometric model is tangent plane projection, combined with a 2nd order (max total order) polynomial to absorb optical distortion
- RMS of the astrometric residuals is
  - x: 0.1002 pixels
  - y: 0.1010 pixels
- Typical of all tested nights
- Contribution of the noise on the position measurement is not subtracted from these figures
- Could improve, but looks good enough to perform forced aperture photometry
- Astrometry solves about 90% of images on G191B2B (GRISM included)
- Investigating the remaining images to check that the fails are legit

Aperture photometry



- Photometry is performed in a series of aperture centered around the predicted gaia position of all stars with G<17
- 10 radii, log-spaced between 3-50 pixels: 3. , 4.1, 5.6, 7.7, 10.5, 14.3, 19.6, 26.8, 36.6, 50
- apfl: sum of the pixels in the aperture
- apvar: sum of the variance map in the aperture. Does not contain the object poisson fluctuation, but contains the measured background variance (including the readout noise)
- apother: should contain the sum of the pixel segmented as another object in the aperture, but left blank for now

Extra fields in the catalog

- 'SOURCE_ID', 'ra', 'dec', 'pmra', 'pmdec', 'ref_epoch', 'parallax', 'phot_g_mean_mag', 'phot_bp_mean_mag', 'phot_rp_mean_mag', 'has_xp_sampled', 'dist': subsample of the gaia catalog
  - ‘has_xp_sampled’ means that the low res XP spectroscopy is available for the star
- 'x', 'y', 'airmass', 'fluxmax', 'alt', 'az', 'mjd', 'exptime', 'filter', 'pressure', 'temperature', 'humidity', 'focuspos', 'mounttemp', 'expnum', 'cameratemperature'
  - x, y is the gaia predicted position of the star
  - airmass is the airmass computed for each star according to the astrometric elevation using the Pickering formula, at low altitude the airmass varies slightly accross the field
  - fluxmax is the flux in the x, y pixel, useful to discriminate measurement reaching the saturation limit
  - pressure, temperature, humidity are measurements from the meteo station

Conclusion

- We have a complete pipeline with all the steps we had in mind to reduce the photometric data
- Still a few pieces of work:
  - Check astrometric fails, tune for fields with fewer stars
  - Implement contamination measurement of apertures
- There are open studies
  - Flatfielding/photometry uniformity
  - Background subtraction
  - Linearity
  - Growth curves
  - What about growth curves and background on the artificial star ?
- In some cases we need numbers that might require dedicated data sets