Building a joint Euclid-LSST photometric catalog

Abstract

The European Space Agency's Euclid mission and the Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST) are poised to revolutionize astrophysics. Euclid delivers razor-sharp space-based Euclid imagery in one wide optical band with additional photometry in three NIR filters while LSST provides deep multi-band photometry across six filters (*u*, *g*, *r*, *i*, *z*, *y*). Individually, these surveys offer considerable scientific potential. The combination of the two promises to unlock new frontiers in cosmological and astrophysical research. The scientific rationale and the derived data products (DDPs) are described extensively in Guy et al. 2022. This work is timely: currently small subsets of both surveys exist: the LSST Data Preview 1 and the Euclid Quick Release 1 which overlap in the Euclid Deep Field South. The simplest solution to providing a joint catalog is to do a spatial join between the two catalogs. This is referred to as DDP-1 . The next, more sophisticated approach (DDP-2) starts with object detection from images in one survey and measures fluxes (PSF, aperture, total) using matched images from the other survey. Three software packages are being explored: AstroPhot, SourceExtractor++, and LSSTpipe. All three are built with the goal of doing accurate, multi-band forced photometry. This presentation explores these DDPs on the Euclid Deep Field South with a view to expanding the process when the larger data releases from both surveys become available.

The goal: Build the best possible photometric catalog by merging Euclid and LSST

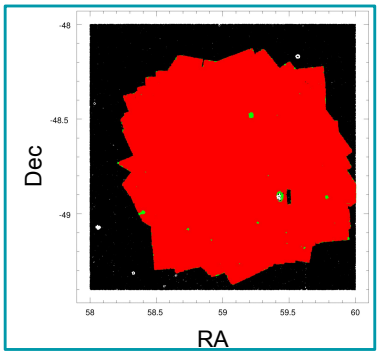
Derived Data Products (DDP) defined in Guy, Cuillandre et al (2022)

- DDP-1: Multi-band Rubin+Euclid list-driven photometry catalogs
- DDP-2: Multi-band Rubin+Euclid forced photometry catalog based on joint-pixel processing
- DDP-3: Multi-band Rubin+Euclid deblended photometry catalog from joint-pixel processing
- DDP-4: Galaxy "pixel" photometric redshifts with machine learning

Current data releases:

- Euclid:
  - Quick Release 1 (Q1)
  - Data Release 1 (DR1)
- LSST:
  - Data Preview 1 (DP1)
- Overlap regions: Euclid Deep Field South, Chandra Deep Field South and Fornax

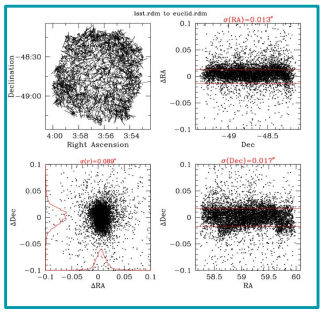
Both Euclid and LSST are available at the CADC, through a common interface



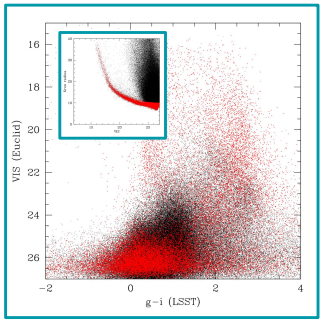
Black: Euclid Q1: sources
Green: LSST DP1 sources
Red: Common sources

DDP1: Merge by catalog

- Quick and simple crossmatch
- Advantage: both Euclid and LSST have pipelines optimized to their data
- There are astrometric offsets between LSST-DP1 and Euclid-Q1
- Use Kron radius to identify stars
- Euclid/LSST stellar colour-magnitude diagram



Astrometric residuals between LSST DP1 and Euclid Q1



Stellar colour-magnitude diagram mixing Euclid and LSST photometry
Inset: Star-galaxy separation using Euclid VIS data

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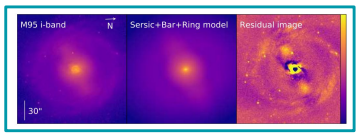
DDP2: Detect on Euclid, measure on LSST

- Euclid VIS band is the reference image (best PSF)
- Measure in other bands Euclid YJH, LSST ugrizy
- Three options are being explored:

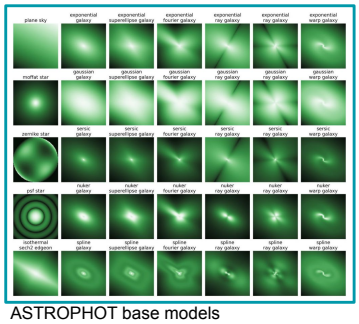


Sample of SourceXtractor++ modeling and residuals

SourceXtractor++ (Kümmel et al. ADASS 2022)

https://astrorama.github.io/SourceXtractorPlusPlus/index.html

- Detection and deblending in one band
- Measurement in multiple bands
- Already used by Euclid MER team

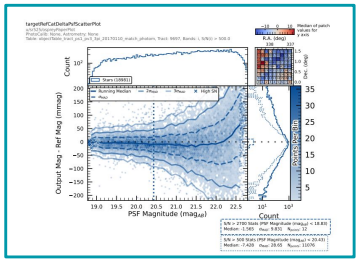


ASTROPHOT base models

ASTROPHOT (Stone et al. 2023)

https://github.com/Autostronomy/AstroPhot)

- Very sophisticated, multi-model fitting of sources
- Requires list of input sources
- Used on Euclid ERO data



Sample of LSSTpipe diagnostic plot

LSSTpipe (Bosch et al. 2018,2019)

https://pstn-019.lsst.io/

- Very sophisticated, purpose-built software
- Used by LSST and HSC
- Multi-band detection and deblending
- Could also be used to achieve DDP-3
- Requires ingestion of Euclid data into DataButler

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