Euclid Detections and Science Challenge 3

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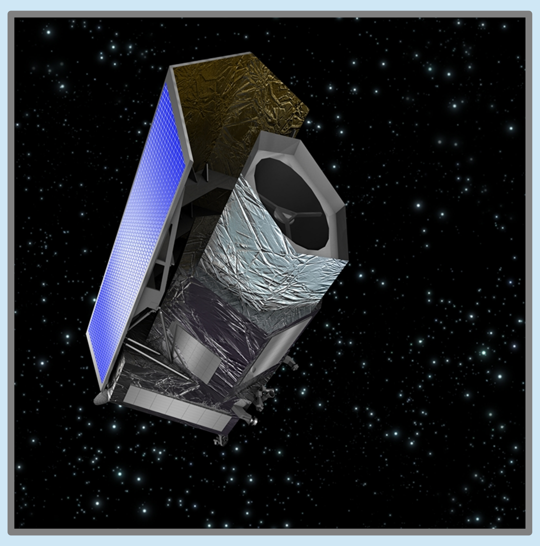

Abstract

The Euclid satellite is an **ESA** mission scheduled for launch in 2020. It will observe an area of 15,000 deg^2 with two instruments, the Visible Imaging Channel (**VIS**) and the Near IR Spectrometer and imaging Photometer (**NISP**). Ground based imaging data in griz from large surveys (DES, CFIS, JPASS, LSST) complement the Euclid data to enable photo-z determination. Generating the multi-wavelength catalog from Euclid data with the expected 10^9 objects is a central part of the entire Euclid data reduction pipeline implemented by the Science Ground Segment. In order to find the best strategies and concepts for object detection we have set up a simulation pipeline to generate Euclid images with the expected depths and resolution. We present the results of applying different detections to the simulated data and discuss their advantages. We describe the entire pipeline for detection and photometry, which is currently being implemented for the Euclid Science Challenge 3 (**SC3**).

Telescope	1.2m Korsch, 3 mirror anastigmat., f=24.5m				
Instrument	VIS	NIR			
Field-of-View	0.787x0.709 deg^2	0.763x0.722 deg^2			
Capability	Visual Imaging	NIR Imaging Photometry			NIR Spectroscopy
Wavelength range	550-900 nm	Y (920-1146 nm)	J (1146-1372 nm)	H (1372-2000 nm)	1100-2000 nm
Detector Technology	36 arrays 4k x 4k CCD	16 arrays 2k x 2k NIR sensitive HgCdTe detectors			
Pixel Size/FWHM	0.1" / 0.2”	0.3 " / 0.3”			0.3 "/
Spectr. Res.	-	-			R=250

Table 1: Payload of the Euclid satellite

1. The Euclid satellite

Euclid [1,2] is a cosmology and fundamental physics mission expected to be launched in 2020. The satellite will detect the imprints of dark energy and gravity from their signatures on the expansion rate of the Universe and the growth rate of cosmic structures using gravitational lensing effects on galaxies (weak lensing) and the properties of galaxy clustering. The **Euclid** payload (see **Table 1**) is a 1.2m Korsch mirror and two instruments, the VISible Imaging Channel (**VIS**) and the Near IR Spectrometer and imaging Photometer (**NISP**) which both cover the common field-of-view of 0.54deg^2. The Euclid mission requires external data from deep surveys such as **DES** [2,3] to compute photometric redshifts for the background galaxies used in the Weak Lensing (WL) analysis. **Table 2** lists the survey parameters and the expected limiting magnitudes. **Figure 1** shows the filter curves for the VIS instrument (blue), the NIR instrument (red) and the external data (green).

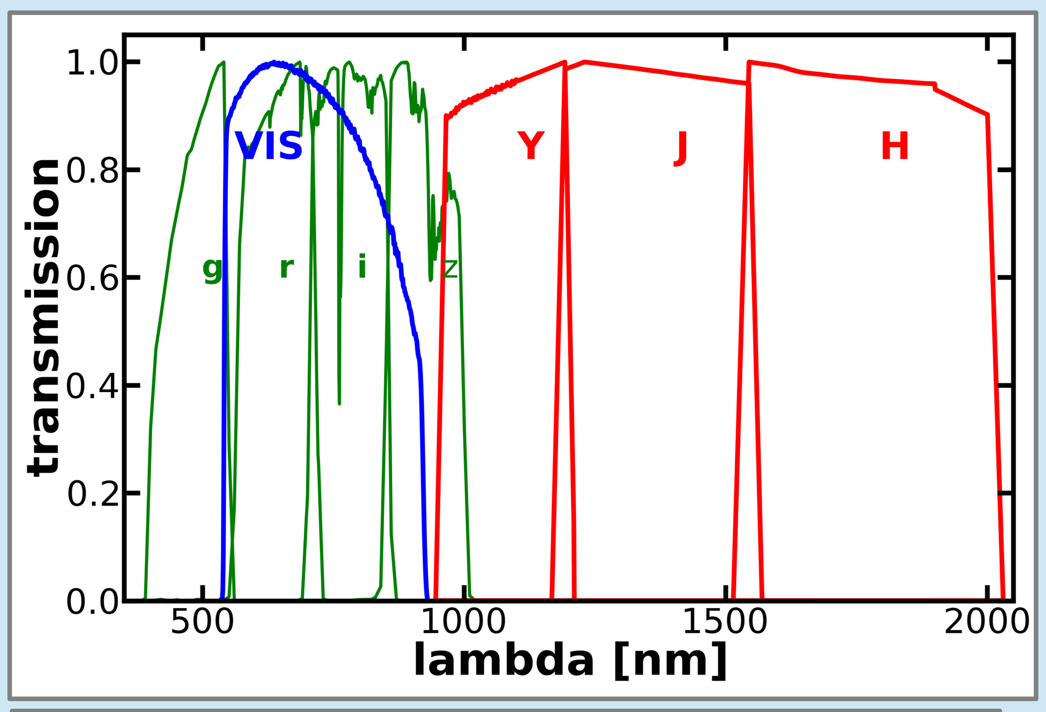

Figure 1: Instrument throughput curves in Euclid

2. Simulating Euclid detections

The Euclid Weak Lensing experiment requires galaxies selected in the VIS band. For photometric redshifts and NIR spectroscopy all objects in Y/J/H need to be detected, so the goal is to detect all galaxies on the Euclid data VIS/Y/J/H. To have samples of galaxies with realistic properties we use the EGG software [5], which is a tool designed to generate arbitrarily large mock galaxy catalogs with realistic fluxes and morphologies. EGG uses the most recent system transmissions from the mission database (see Fig.1) to produce galaxy samples. These samples are then fed to the Skymaker software [9] to simulate Euclid images with the correct pixel size, resolution and depth (see Tabs.1 and 2). A standard detection is then done with the SExtractor software [5] on the single band images as well as combined images. For the detections on the various input images the detection parameters were modified such that only ~1% of the detected objects were fake objects. Due to this “calibration” the number of detected objects is a direct measure of the overall performance of the detection process. Figure 2 compares the completeness as a function of the VIS brightness and the number of objects detected in an area of 0.1 deg^2 for the detection on the following images:

- **Red**: VIS image; # of objects: 1210;
- **Blue**: coadded image Y/J/H; # of objects: 1043;
- **Green**: coadded image VIS/Y/J/H: # of objects: 1247
- **Grey**: chi-square image [10] VIS/Y/J/H: # of objects: 1110

Both the completeness and the absolute object numbers indicate that the best detection in Euclid is done either on the VIS image alone or on the coadded VIS/Y/J/H image. While obviously very competitive, a detection on the VIS image alone would miss all red objects that are above the detection threshold in the NIR bands. A crossmatch of the detections shows indeed that there is a significant number of objects (190) on the coadded Y/J/H images that are absent in the VIS detections, which would make a VIS detection supplemented by the “missing” Y/J/H sources the ideal choice for the Euclid detection.

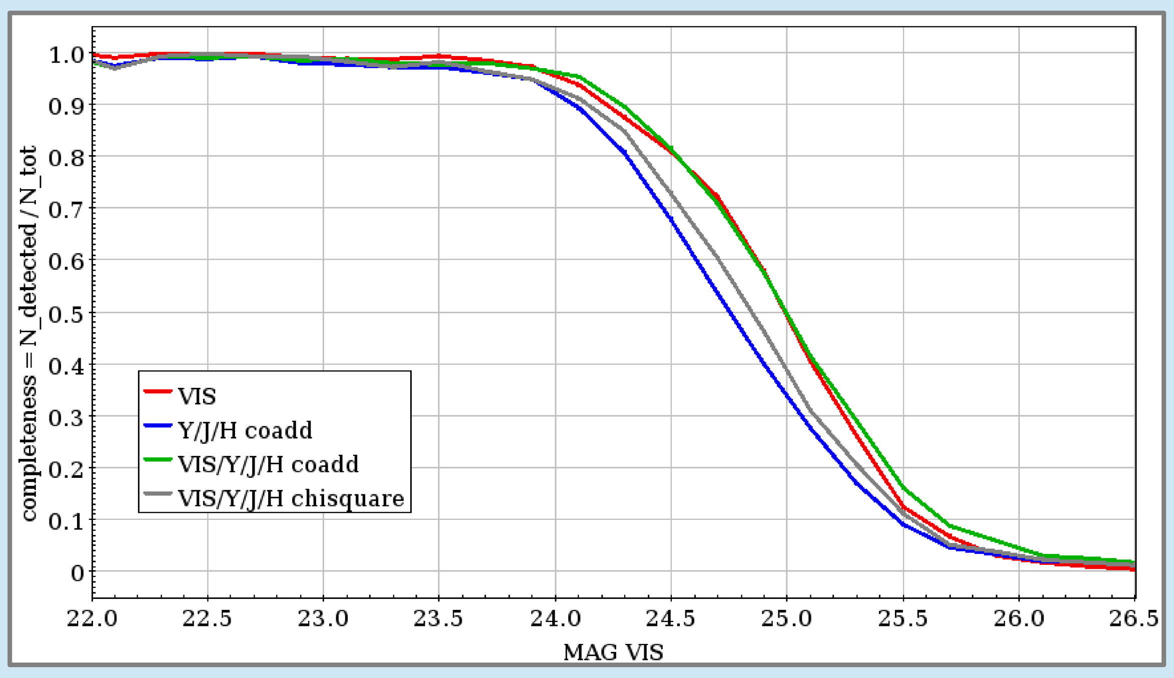

Figure 2: Comparison of the completeness on different detection images

Name	Area [deg^2]	Euclid Data	External Data
Wide survey	15,000 (required) 20,000 (goal)	Y/J/H=24.0mag, 5σ VIS=24.5mag, 10σ	g/r/i = 25.2/24.8/24.0mag 10σ
Deep survey	40	Y/J/H=26.0mag, 5σ VIS=26.5mag, 10σ	g/r/i = 27.2/26.8/26.0mag 10σ

Table 2: The Euclid surveys

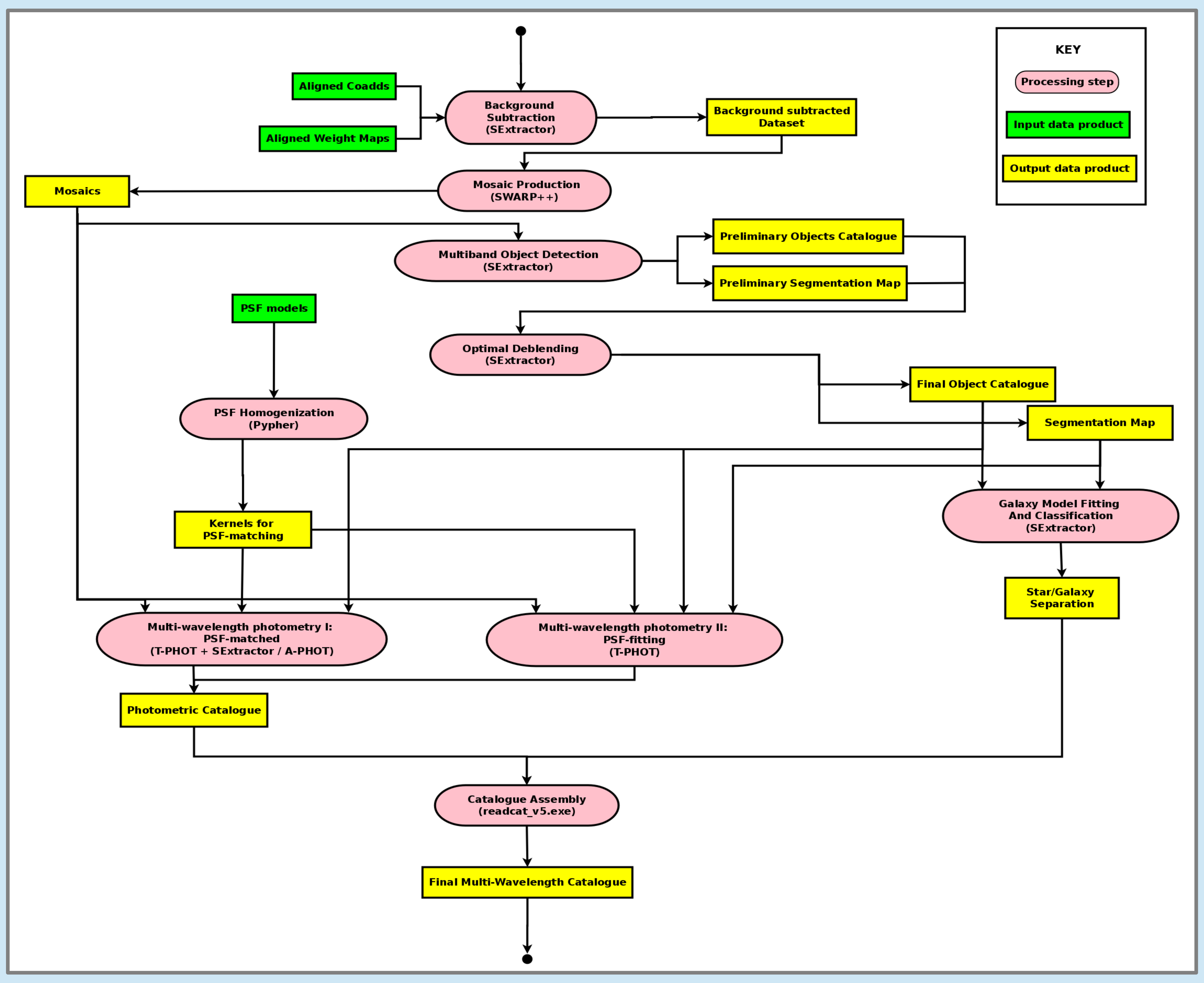

Figure 3: The detection and photometry pipeline for Science Challenge 3

3. Detection and Photometry in Science Challenge 3 (SC3)

Euclid Science Challenges aim at implementing and running parts of the entire Euclid data processing pipeline within the Euclid computing environment, which consists of a set of computing centers running predefined Virtual Machines. Based on simulated data for VIS, Y/J/H and external data, SC3 runs through the standard reduction, photometric and astrometric calibrations down to the object detection and photometry. The goal is to prove that the pipelines deliver products that fulfill the essential requirements to reach the science goals of the Euclid mission. Figure 3 shows an overview on the detection and photometry pipeline deployed in SC3:

- **Background subtraction:** does the background subtraction on all input images;
- **Mosaicing:** produces co-added images for all filters following a pre-defined tiling strategy;
- **Multiband Object Detection:** detects the objects according to the methods described above;
- **Optimal Deblending:** separates physically distinct objects that partially overlay on the detection image;
- **PSF Homogenization:** provides kernels to homogenize images or image cutouts for photometry [6];
- **Galaxy Classification:** separates point-like objects from extended objects and measures the size of extended objects;
- **Multi-Wavelength Photometry I and II:** measures the objects brightness in all Euclid bands, which is done in two different ways: photometry I is an aperture photometry performed on PSF-homogenized images to avoid systematic effects from different sized PSF's (from 0.2” in VIS to 0.8” in EXT); photometry II is a PSF fitting photometry with TPHOT [7,8], which transforms the object shape from the better resolved to the less resolved image before fitting the total brightness;
- **Catalog Assembly:** combines the information in the various photometry and other lists to the final object catalog;

The Science Challenge 3 started in October and will finish March 2017. The quality of the detection and photometry will be tracked with intrinsic validation tests (such as colour-colour diagrams) as well as a comparison to the true universe data, which serves as the input for the simulated data. The data simulated for the SC3 spans an area of 6 deg^2 including a 3x3 pointing, thus mimicking closely the observations by the Euclid satellite. An important result will also be the computational requirements (# of cores, RAM, storage, wall time) for the pipeline in order to estimate the necessary resources for the full survey.

4. Discussion and Outlook

While the detection simulations in 2. do point to a winning procedure, an implementation of such a NIR supplemented VIS detection is much more complicated than a detection on a single image. It involves a cross-identification of sources detected on images with different sampling and resolution and possibly even a cross-matching of the individual pixels above the detection limit in the detection images to clearly identify the excess sources in Y/J/H. Also the simulations presented here do not include many instrumental effects such as dithering, bad pixels, non-linearity and CTI (for VIS), which may influence the detection. Hence we decided to use a VIS based detection for the Science Challenge 3 and repeat the investigation on the basis of the SC3 data, which include many of those effects.

References

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