|  |  |  |  |
| --- | --- | --- | --- |
| **Title:** | The effect of variable transmissons on photometric redshifts | | |
| **Date:** | 03/05/2018 | **Issue:** | 0.2 |
| **Reference:** | EUCL-UOG-TN-8-001 | | |
| **Custodian:** | Name\_1 Surname\_1, Name\_2 Surname\_2 | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **Prepared by:** |  | **Date:** | **Signature:** |
| J. Coupon | OU-PHZ |  |  |
| **Contributors** |  | **Date:** |  |
| N. Apostolakos | SDC-CH |  |  |
| S. Paltani | OU-PHZ lead |  |  |
| et al. (TBC) |  |  |  |
| **Authorised:** |  | **Date:** | **Signature:** |
| John Hoar  Fabio Pasian | SOC Development Manager  EC SGS Manager |  |  |
| **Agreed by:** |  | **Date:** | **Signature:** |
|  |  |  |  |
| **Approved:** |  | **Date:** | **Signature:** |
|  |  |  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Issue | Date | Page | Description Of Change | Comment |
| 0.1 | 03/05/18 | all | First (empty) draft |  |
| 0.2 | 0.3/05/18 | All | First draft |  |

**Table of Contents**

1. Purpose and Scope 3

2. Related Documents 4

2.1. Applicable documents 4

2.2. Reference documents 4

2.2.1. Euclid Project Reference Documents **Error! Bookmark not defined.**

3. Acronyms and abbreviations 5

3.1. Acronyms 5

4. Fourth section 6

4.1. First subsection 6

4.2. Second subsection 6

4.3. Third subsection 6

5. Fifth section 7

5.1. First Subsection 7

5.2. Second Subsection 7

5.2.1. First Subsubsection 7

# Purpose and Scope

The document studies the impact of filter variation on photo-z’s. In this study we model a range of typical variations, based on input from various people reporting the behavior of different instruments, and to estimate the corresponding impact on photo-*z* accuracy. Therefore, this document must serve as a reference for evaluating the impact *when the exact variations are known*, which will depend on the exact instrument and observing conditions of ground-based data used for Euclid. We stress that this document is *not* the actual prediction of systematics in mean redshift that will exist in the Euclid survey.

# Related Documents

## Applicable documents

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| AD | Title / Author | Document  Reference | Issue | Date |
| 1 | Euclid Science Management Plan | Euclid\_SA\_Dc\_00004\_SMP | 2.2 | 04/07/11 |
| 2 | Euclid Science Implementation Requirements Document | EUCL-ESAC-RS-8-001 | 0.7 | 21/12/12 |
| 3 | Euclid Ground Data Processing Requirements Document | EUCL-EST-RS-8-001 | 2.0 | 20/12/12 |

## Reference documents

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| RD | Title / Author | Document  Reference | Issue | Date |
| 1 | ECSS Tailoring for the Euclid SGS |  | 0.1 | 29/01/13 |
| 2 | Euclid SGS Science Operations Concept Document | Euclid\_OD\_Dc\_00005\_SOCD | 0.6 | 15/07/11 |
| 3 | Euclid Science Requirements Document | DEM-SA-Dc-00001 | 6.0 | 06/09/11 |
| 4 | Euclid SOC Science Implementation Plan | Euclid\_SO\_Dc\_00007\_SIP | 0.5 | 02/09/11 |
| 5 | EC SGS Science Implementation Plan | EUCL-OAT-SGS-PL-00003 | 2.0 | 14/11/11 |
| 6 | EC Management Plan | EUCL-IAP-EUC-PL-00148 | 2.1 | 28/12/12 |
| 7 | Euclid SGS Preliminary Requirements Review: Approach and Schedule | EUCL-ESAC-TN-8001 | 1.0 | 18/10/12 |
| 8 | Euclid Legacy Ground Data Processing Requirements Document | EUCL-LEI-SGS-REQ-00269 | 1.0 | 01/05/12 |
| 9 | Euclid SGS Document Delivery List |  |  |  |
| 10 | ECSS Compliance Matrix |  |  |  |
| 11 | Euclid Archive Development Strategy | EUCL-OTS-SOW-8-001 | 1.0 | 27/02/13 |
| 12 | Euclid SGS Project Milestones | EUCL-EST-PL-8-001 | 1.0 | 28/01/13 |
| 13 | EC SGS Work-Package Breakdown and Description | EUCL-OTS-SGS-WPD-00082 | 2.0 | 14/11/11 |
| 14 | Euclid SGS Configuration Management Plan | EUCL-OTS-PL-8-002 |  | TBW |
| 15 | Euclid SOC Management Plan | EUCL-SOC-PL-8-xxx |  | TBW |
| 16 | EC SGS Management Plan | EUCL-OTS-PL-8-005 |  | TBW |

# Acronyms and abbreviations

## Acronyms

To be corrected and completed….

AVM (instruments) Avionic Model

EA Euclid Archive

EC Euclid Consortium

EC SGS part of the Science Ground Segment c/o the Euclid Consortium

ECSS European Cooperation for Space Standardization

ELA Euclid Legacy Archive

EMA Euclid Mission Archive

EnEI non Euclid Imaging

ESA European Space Agency

ESST Euclid Science Study Team

EST Euclid Science Team

FM (instruments) Flight Model

I/F Interface

ICD Interface Control Document

IOT Instrument Operations Team

MOC Mission Operations Centre

OU Organisation Unit

NIS Near Infrared Spectrograph

OGS Operations Ground Segment

OU Organisation Unit

PA/QA Product Assurance / Quality Assurance

PAP Product Assurance Plan

Photo-z Photometric redshift

PRR Preliminary Requirements Review

PT Product Tree

SciRD Science Requirement Document

SCMP Software Configuration Management Plan

SDC Science Data Centre

SGS Science Ground Segment

SIP Science Implementation Plan

SIRD Science Implementation Requirements Document

SMP Science Management Plan

SOC Science Operations Centre

SQAP Software Quality Assurance Plan

ST System Team

SWG Science Working Group

S/C Spacecraft

S/W Software

TBC To Be Confirmed

TBD To Be Defined

TBW To Be Written

VObs Virtual Observatory

WBS Work Breakdown Structure

WP Work-Package

WPD Work-Package Description

# Abstract

The variation of the photometric transmissions affects the computation of photo-*z*’s and the color selection of cluster-*z*’s. The biggest impact of variable transmissions on photo-*z*’s is a shift in mean redshift for an ensemble of galaxies (as per tomographic bin), mainly caused by a shift or a skewing of the transmission (from manufacturing or incidence angle). A shift as small as 10 Angstroms (1 nm) creates a bias on an ensemble of galaxies which is on the same order of magnitude as the requirement on the mean redshift estimate (∆*z* = 0.002(1 + *z*)) per tomographic bin and therefore cannot be ignored in the photo-*z* processing for cosmic shear analysis. For an individual galaxy the effect will be small (excluding the rare cases where a strong emission line lies at the edge of the filter), so that the performances on scatter and outlier rate will be hardly affected. For instance, one must pay a particular attention at the variations occurring on scales where the shear-shear 2-point correlation is measured (typically a few arcmin scale), and where a variation in mean redshift will artificially boost the amplitude of the power spectrum on those scales.

# Introduction

This document aims to address the impact of variable photometric transmissions on Euclid photometric redshifts (hereafter photo-*z*’s).

In each tomographic bin, the mean redshift of the ensemble of galaxies used for cosmic shear must be known to very high accuracy and is highly sensitive to systematics in color space. So, the most problematic impact from transmissions with variable responses is expected to be a scale-dependent systematic error on the mean redshift, i.e. the *unknown* difference between the measured and true mean redshift per tomographic bin (the known difference, the "bias", being calibrated with spectroscopic redshifts and not expected to vary as a function of position in the sky). Variable transmissions will also affect the scatter (and to a lesser extent the number of catastrophic errors) but we assume that the mean redshift issue will largely dominate over the others and therefore we restrict ourselves to quantify the shift on the mean redshift only.

To quantify the effect, we use real galaxies from COSMOS with emulated fluxes. To measure the shift in mean redshift, we first emulate the fluxes and compute the photo-*z*’s assuming reference (fixed) transmissions in both steps. Then, we vary the transmissions to emulate new fluxes, and we compute again photo-*z*’s with the reference transmissions.

The approach we take in this study is to model a range of typical variations, based on input from various people reporting the behavior of different instruments, and to estimate the corresponding impact on photo-*z* accuracy. Therefore, this document must serve as a reference for evaluating the impact *when the exact variations are known*, which will depend on the exact instrument and observing conditions of ground-based data used for Euclid. We stress that this document is *not* the actual prediction of systematics in mean redshift that will exist in the Euclid survey.

# Problem

The photo-*z* requirements for Euclid fall into two broad categories: 1) photo-*z* precision and 2) mean redshift accuracy. The former translates into the traditionally quoted scatter and catas- trophic failure (or outlier rate) estimates. Those have been revised by the Euclid science ground segement to be expressed as probability distribution functions (PDF) but, on point estimates, would be equivalent to a scatter smaller than 0.05 × (1 + *z*) and an outlier rate smaller than 10% for galaxies used in the cosmic shear probe. The main leverage to increase the precision is to improve the photometry signal-to-noise ratio (SNR) per source and photo-*z* algorithms (we con- firmed within OU-PHZ that a combination of template fitting and machine learning is the best tool to achieve the precision goals).

The specification on accuracy is that, per tomographic bin (there will be 10 bins between 0.2 < *z* < 2.0), the mean redshift of the ensemble must be known with better accuracy than ∆*z* = 0.002 × (1 + *z*). The current baseline of OU-PHZ is to use spectroscopic redshifts (hereafter spec- *z*’s), matched in color to the Euclid galaxies, to correct for the residual redshift bias. The validation of this procedure will be done with clustering redshifts (hereafter cluster-*z*).

Hence the Euclid galaxies must be observed with stable transmissions, identical to that of the galaxies with spec-*z*’s used for the mean redshift calibration. The problem we address here is when Euclid galaxies are observed in different transmissions compared to the spec-*z* sample. What is the impact on the mean redshift and from what point do we fail to meet the accuracy requirement, given a type and strength of variation?

# Theory

**7.1 Definition of a variable transmission**

A "photometric transmission" is everything between the source and the detector. It includes (starting from the source itself) the inter-galtic medium (IGM), the Milky Way extinction, the at- mosphere (for ground-based facilities), the instrument sensitivity, the photometric filter and the quantum efficiency of the detector. In most cases, the Milky Way extinction and the photometric filter will be the main source of variations. In this study our main focus is on the filter variations. So in the rest of the document, "transmission" means filter response.

**4.2 Impact on photo-***z***’s**

The photometric redshift method is a way to predict a galaxy redshift PDF from a set of colors and brightness (or simply fluxes - the difference between the two set of quantities being in the way to optimise the photometry measurement). In principle any photo-*z* method makes use of all the color information but the most informative pieces of information is when the galaxy SED strongest features are moving through the filters.

The most prominent features are the Lyman (∼ 1000 Angstroms) and Balmer (∼ 4000 Angstroms) breaks. The Euclid-survey filter set is optimised to properly constrain the Balmer break in the range 0.2 < *z* < 2.0 with a filter set going from 3000 to 10000 Angstroms (*ugrizYJH* and *vis* filters).

In the forthcoming sections, we will quantify the exact impact but, to first order, the main impact on photo-*z*’s is when the Balmer break at a given redshift enters a filter whose transmission varies (this is what we will focus on). As an example, a galaxy will have its Balmer break enter the *r*-band at *z* ∼ 0.6:

# Fifth section

## First Subsection

Again text.

## Second Subsection

And more text.

First Subsubsection

#### And a Subsubsubsection

Empty Figure 5.1, put here for the caption’s format.

Figure 5.1: Caption

END OF DOCUMENT