Spectroscopic Simulations for the Euclid Mission

Relative In-Flight Flux Self-Calibration

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International conference PUMA22
Probing the Universe with Multimessenger Astrophysics

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Spectroscopic Redshift Measurement

The measurement of spectroscopic redshift involves:

1. Dispersion of light $\rightarrow$ NISP instrument (**C. Sirignano**'s talk)
2. Spectra Extraction
3. Identification of the emission lines

The Spectroscopic Flux Calibration

The precision of the redshift measurement dramatically depends on a **complete calibration** of the scientific instruments.

The response of NISP spectroscopic channel is not uniform and it will degrade with time due to:

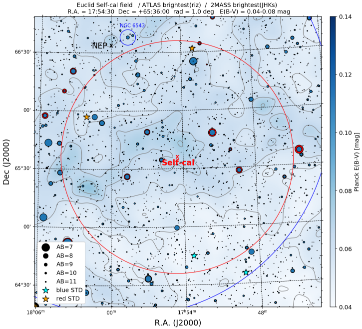
- dust pitting
- radiation damage
- material outgassing

$\rightarrow$ an in-flight calibration program has been specifically developed to determine and monitor the evolution of the response of the instrument with great accuracy.

The Self-Calibration Field

Euclid will monthly observe the same sky area, called **Self-Calibration field**:

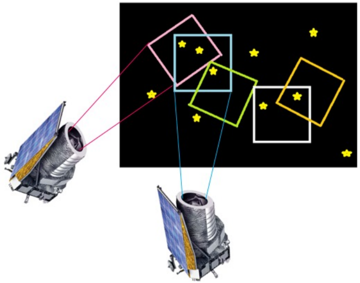
- Circular field of $\sim 3.2\,\text{deg}^2$
- Near the North Ecliptic Pole (NEP)
- It provides both a sufficient number of stars and a low background level from the galactic disk



Credits: Euclid Consortium.

The in-flight Self-Calibration Procedure

- The self-calibration is based on the **multiple observations** of the same sources at different positions in the focal plane
- **Self**-Calibration → does not require the knowledge of the flux
- **Relative** → reconstruction of the response function up to a uniform scale factor



Simulation of the Self-Calibration Survey

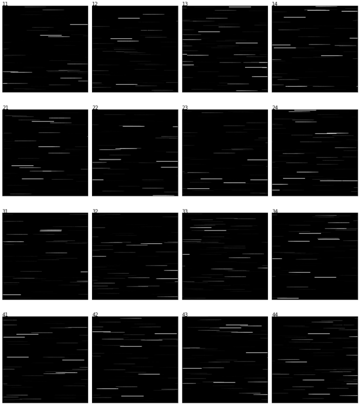
The simulation of the entire Self-Calibration survey is required to validate the pipelines and optimize the procedure.

1. Spectroscopic and realistic simulations → Euclid's official code
2. Spectra extraction → Euclid's official code
3. Reconstruction of the response function → general method[1]

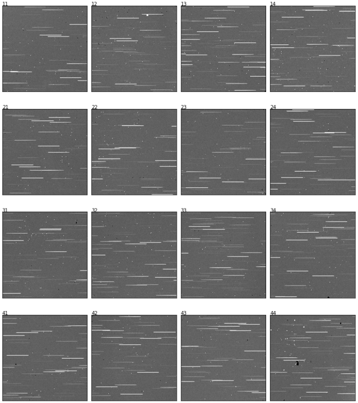
[1] S. Davini al. *A Proposal for Relative In-flight Flux Self-calibrations for Spectro-photometric Surveys*

Spectroscopic and Realistic Simulations

- spectroscopic mode: **overlapping of spectra**

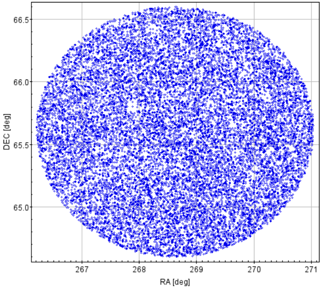


- spectroscopic mode: **overlapping of spectra**
- introduction of **systematic effects**
  - Readout noise
  - Dark current
  - Bad pixels
  - Zodiacal light



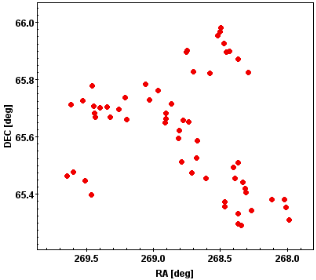
Spectroscopic and Realistic Simulations

- spectroscopic mode: **overlapping of spectra**
- introduction of **systematic effects**
- realistic **catalogs** of sources



Spectroscopic and Realistic Simulations

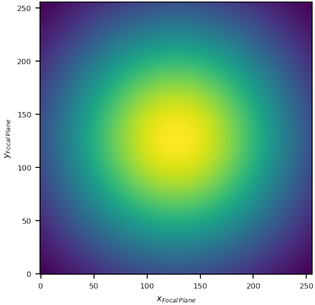
- spectroscopic mode: **overlapping of spectra**
- introduction of **systematic effects**
- realistic **catalogs** of sources
- optimized **pointing** sequence
  - 60 exposures
  - Monte Carlo approach
  - Proper sampling of all spatial scales observed in the survey



[I. Risso, S. Caprioli, F. Passalacqua, S. Davini, M. Schirmer. *Selection of the Best Pointing Pattern for the Self-Calibration Procedure of the Euclid Satellite*, In Preparation.]

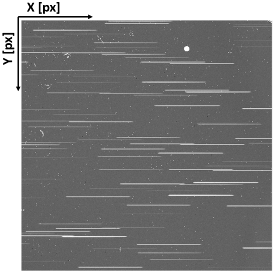
Spectroscopic and Realistic Simulations

- spectroscopic mode: **overlapping of spectra**
- introduction of **systematic effects**
- realistic **catalogs** of sources
- optimized **pointing** sequence
- different **response functions**

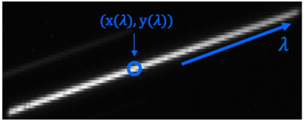


Spectra Extraction

1. Pre-Processing



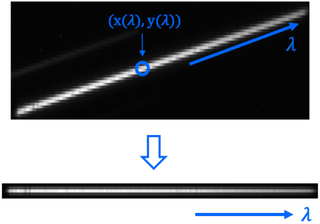
Spectra Extraction



1. Pre-Processing
2. Spectra Location

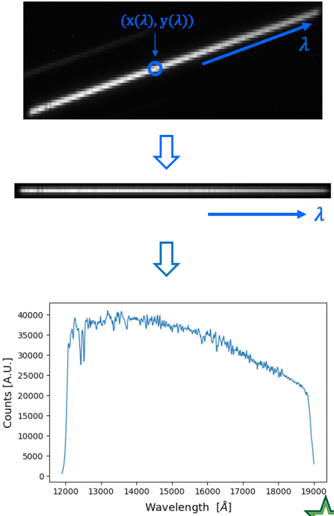
Spectra Extraction

1. Pre-Processing
2. Spectra Location
3. 2D counts



Spectra Extraction

1. Pre-Processing
2. Spectra Location
3. 2D counts
4. 1D counts



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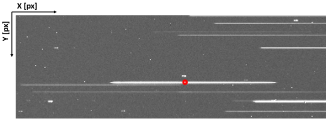
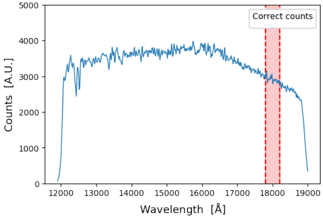
Reconstruction of the Response Function

1. Location of each observed source: **center** of the spectrum



2. Extraction of the counts → **integration** of the counts in a range of ∼ 400 Å

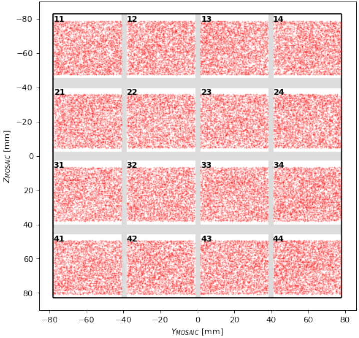


3. Reconstruction of the response function → χ^2 **minimization**

Different extraction ranges → response function as a function of the wavelength

Preliminary Results and Outlooks

- The large number of sources and observations allows the entire focal plane to be sampled
- So far, we have reconstructed uniform response functions
- We are increasing the precision to be able to reconstruct non-uniform response functions



Thank you
for your attention

Credits:
Thales Alenia Space

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Reconstruction of the Response Function

$$\chi^2 = \sum_k \sum_{i \in k} \frac{\left(c_{i(k)} - \hat{f}(x_i, y_i|\mathbf{q}) r_k t_i\right)^2}{\sigma^2_{i(k)}}$$

Index:

- k: k-th source
- i: i-th exposure

- c measured counts
- $\hat{f}$: reconstructed response function
- (x, y): position on the focal plane
- $\mathbf{q}$: parameters of the response function
- r: measured rates of the source
- t: exposure time
- σ^2: variance (Poisson + noise)