[Key Project]

Measuring the Selection Function of the Euclid Spectroscopic Catalog

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The Selection Function

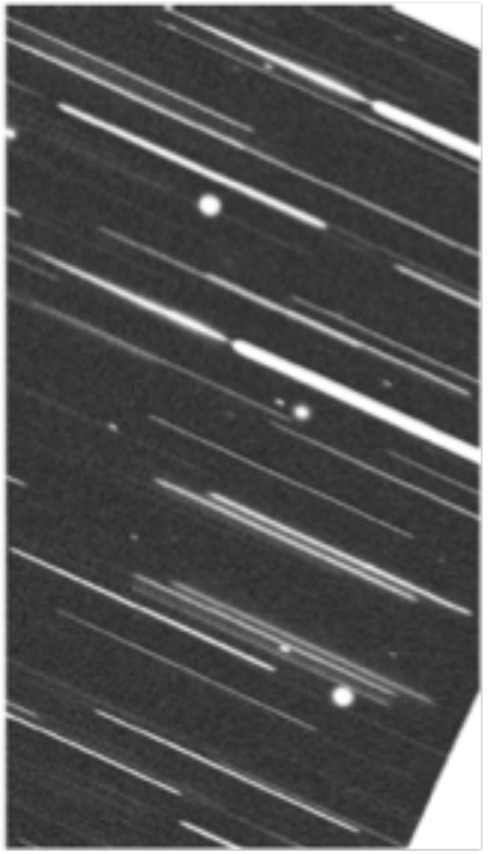
- The survey selection function characterizes the statistical completeness of the target galaxy sample as a function of position (RA, Dec, redshift)
- Precision is required to uncover the slight fluctuations in galaxy density that encode the cosmological signal on large scales (eg baryon acoustic oscillations, redshift-space distortions).
- Well-known examples:
  - VIPERS - Angular footprint mask, Cut-outs around stars, Target Sampling Rate (TSR), Spectroscopic Success Rate (SSR), Color Sampling Rate (CSR) (Scodeggio+18, Pezzotta+17)
  - SDSS BOSS - Angular footprint mask, Fiber collision weights, Redshift failures, X-correlation weights: Stellar density, Seeing, Sky background, Airmass, Extinction (Ross+17)

Going Slitless

- Multi-object spectrographs (eg VIMOS) observations use photometric selection for targeting
- Euclid NISP-S will detect emission line galaxies *without* pre-selection
  - Line flux is not highly correlated with continuum flux
- Completeness weights for Euclid cannot be constructed in the same way as done for MOS surveys.

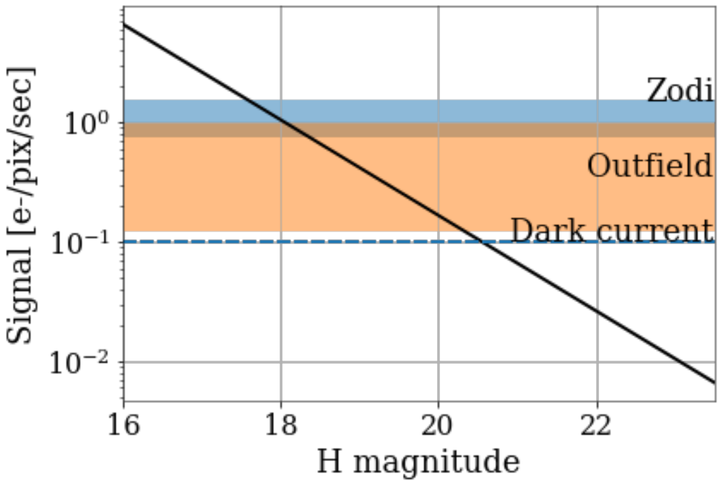
NISP Image YJH

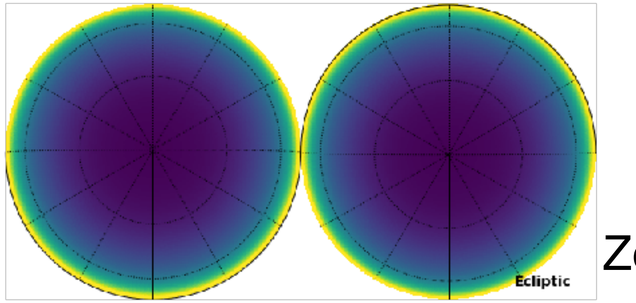
NISP-S Red Grism



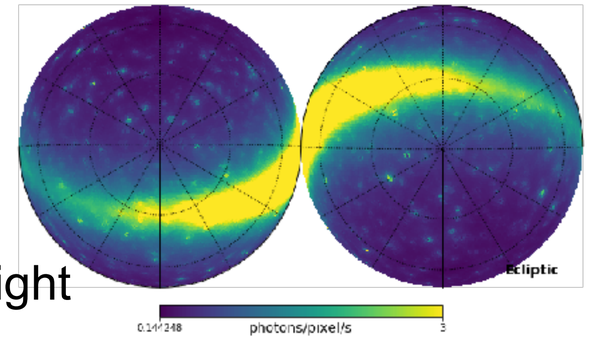
Many challenges

- Near-IR slitless spectroscopy is background dominated: zodiacal light, scattered starlight (Continuum contamination important at H<20)
- Wide survey aims for emission lines at low SNR
- Detection efficiency will be modulated by foregrounds. Mitigation required to measure fluctuations in galaxy density.
- Slitless spectroscopy couples line-of-sight and transverse modes in the mask.





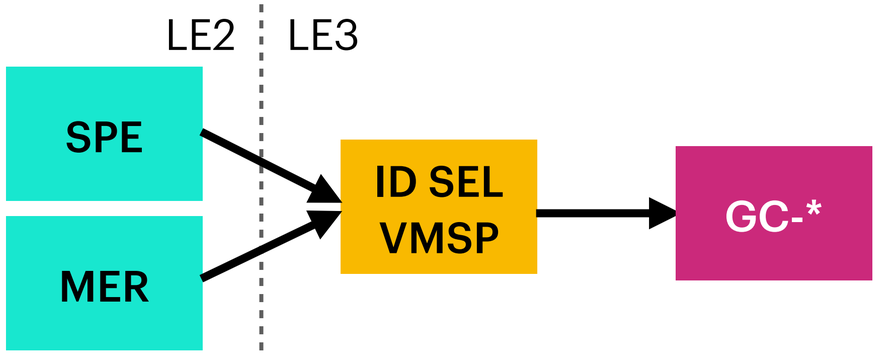
Zodi



Out-field straylight

Spectroscopic Pipeline

- The spectroscopic galaxy sample is built and characterized by the Internal Data processing functions of LE3:



  - SEL selects galaxies and randoms and produces subsample catalogs for clustering analyses
  - VMSP (spectroscopic visibility mask) characterizes the selection function in the form of a random catalog

LE3 ID SEL-VMSP Team

Partecipazione **fondamentale**:
E.Branchini, M.Scodeggio, P.Monaco, S.Galeotta, D.Tavagnacco

- Managers: F. Beutler, S. Nadathur
- VMSP dev: B. Granett (IT)
- SEL dev: L. Samushia (USA)
- Validation: welcome L. Fonseca de la Bella (prev S. Nadathur) (UK)
- SDC responsible: UK

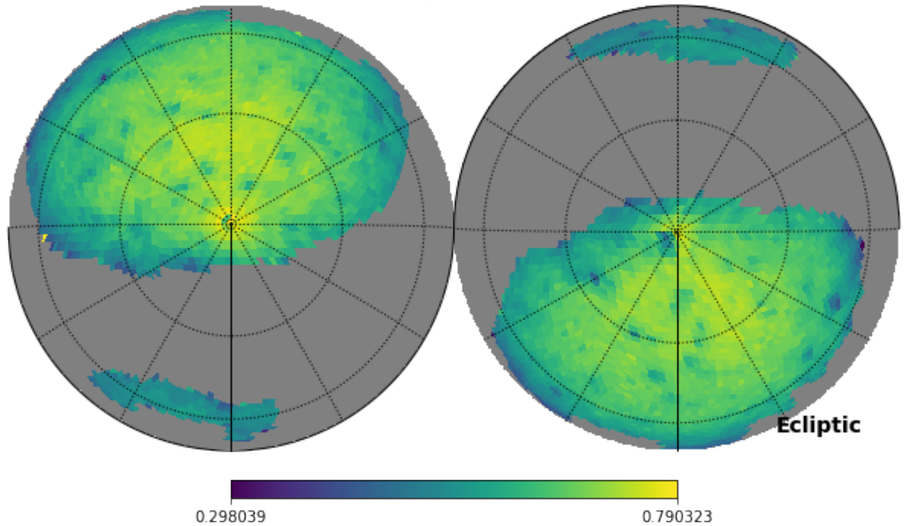
Key Project Scope

- Describe the procedure by which, using LE2 data, we extract a spectroscopic catalog and its sub-samples suitable for galaxy clustering analyses,
- the procedure to evaluate the purity and completeness of these samples,
- the strategy to estimate the selection of the Euclid sample in the form of a “random” catalog of synthetic objects with no intrinsic clustering properties,
- description of the tests used to validate these steps and their results,
- the strategy to trace the propagation of errors down to the clustering analyses.

- Proposed KP co-coordinator: B. Granett

Pipeline Summary

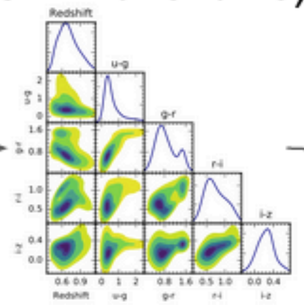
- The sample completeness of the Wide Survey will be characterized starting from the Deep fields
- Two parallel approaches:
  - Analysis of Wide-like stacks of the Deep exposures (SEL)
  - Forward modeling: Inject synthetic sources, estimate SNR and detection probability (VMSP)
- The Deep fields will be used to infer the intrinsic galaxy distribution: distribution of redshift, emission line fluxes, galaxy size, broadband magnitudes.



Completeness

VMSP Forward Model Overview

Model distribution of galaxy properties (GMM or shuffle)



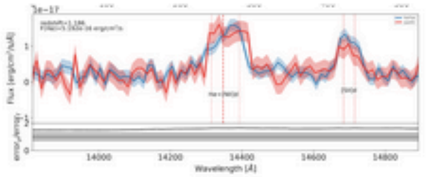
Deep catalog

Sample properties (Ha flux, magnitude, etc)

NISP exposures

Sample RA, Dec

Random catalog

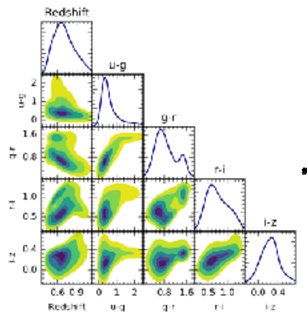


Estimate SNR of randoms with NISP exposures (SIR-SPE bypass)

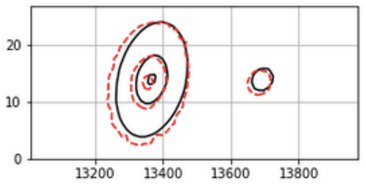
Assign detection probability

Bypass Simulations

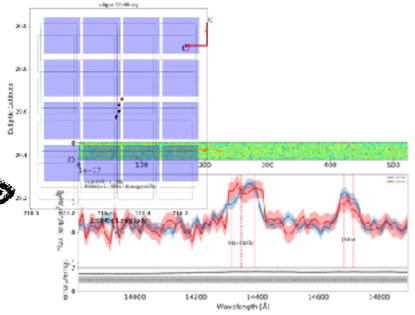
- The random catalog consists of 50x number of target galaxies, therefore simulation must be fast.
- Bypass SIR and SPE.
- Working assumption: redshift measurement in slitless spectroscopy depends *only* on the SNR of the emission lines.



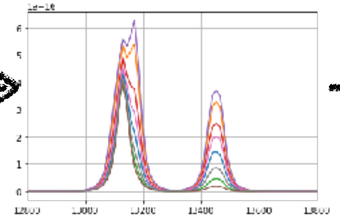
Synthetic catalog



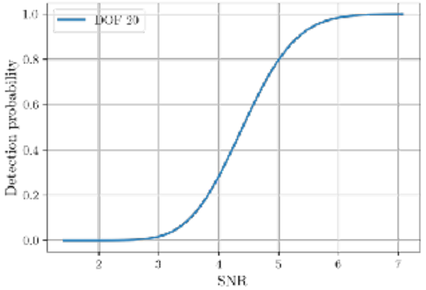
Simulation of emission lines



Exposure map & noise sources



SNR

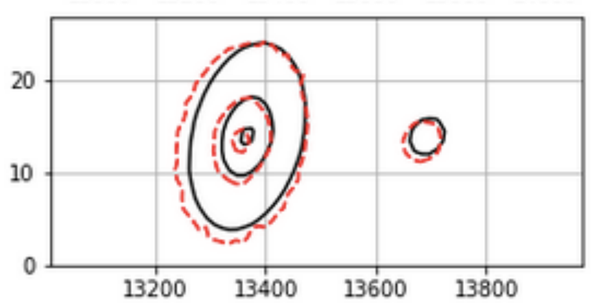


Measurement probability

- Development in the GC-E2E work package

In more detail: the signal

- VMSP uses a 2D Gaussian emission line profile model (based on the galaxy half-light radius).
- The NISP double Gaussian PSF model is used.
- Assumes perfect extraction with Gaussian window and stacking without contamination.
- Attenuation from Galactic extinction - GALEXT-ED + extinction curve.



Pypelid vs FastTIPS image comparison (Granett, Delaire)

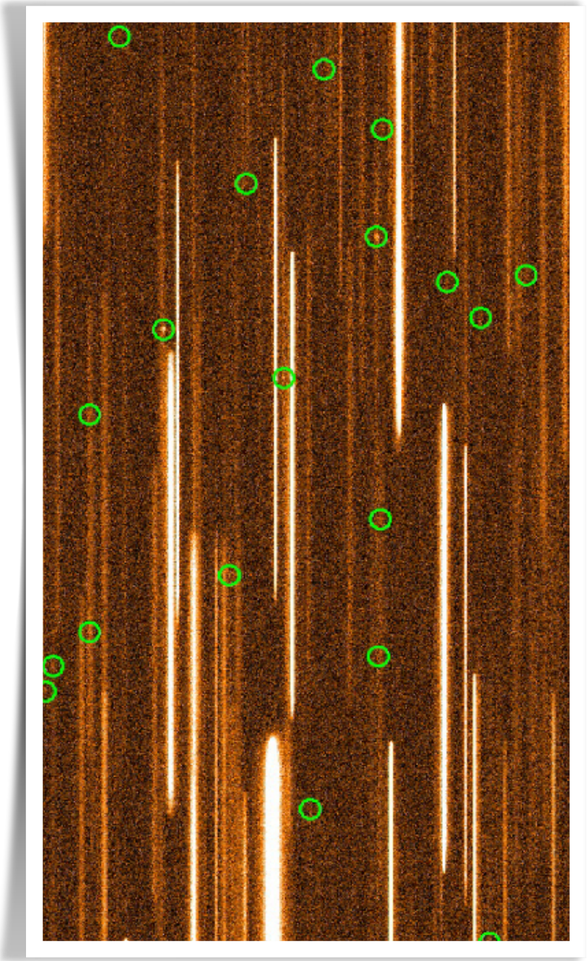
GC E2E WP

Coordinators: M.Moresco, S.de la Torre, B.Granett

Italian Collaborators: M.Bolzonella, B.Garilli, B.Granett, M.Moresco, L.Pozzetti, M.Scodeggio

In more detail: the noise

- (RA, Dec, redshift, wavelength, order) of synthetic emission line maps to pixel (x,y) on the detector.
- The noise at the location of the emission lines is measured directly in the NISP-S science frames using the variance data product (e/s/pix)^2.
- spectrophotometric calibration is available to convert [e/s/pix]^2 to [erg/s/cm2/pix]^2.
- This noise measurement includes all contributions astrophysical and instrumental.
- Pixel variance is summed for the stacked exposures.



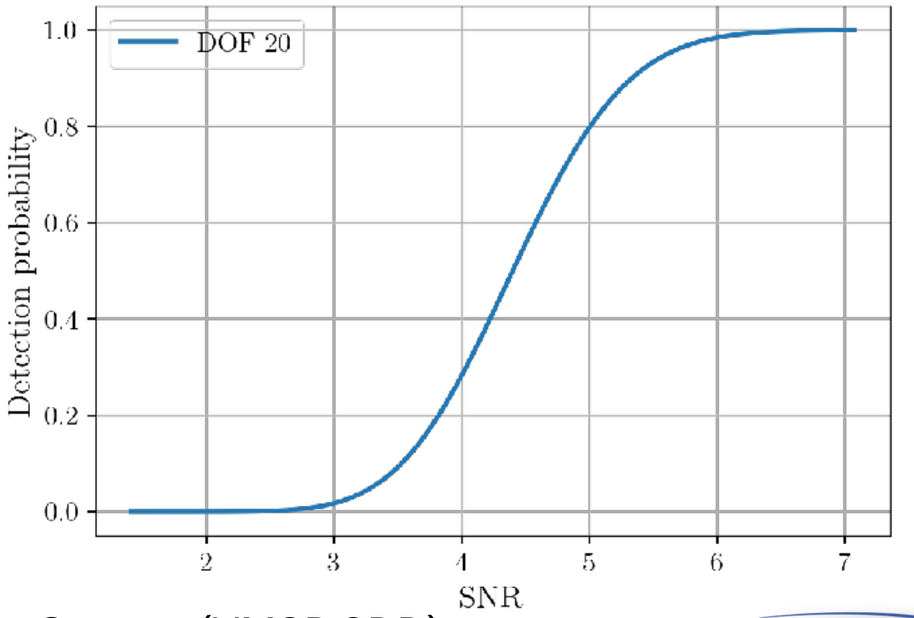
NISP-S science frame simulation (B. Garilli)

In more detail: SNR and detection

- The signal [erg/s/cm2] and background [erg/s/cm2/pix] estimates are used to derive the SNR

$$SNR^2 = \sum_i s(\lambda)^2 \sigma^{-2}(\lambda)$$

- Hypothesis: SNR can be mapped to the SPE quality flag
- SNR maps to the measurement probability (modeled with the chi2 distribution function with degrees of freedom as free parameter).



Granett (VMSP SDD)

Critical Interfaces

- SEL and VMSP are critical links in the spectroscopic analysis chain.
- Bypass algorithms in VMSP must be calibrated and validated:
  - Validate bypass SNR and detection probability against OU SIM / SIR simulations
  - Interface noise estimation with NISP-S data products
  - Map emission line SNR to SPE redshift quality flag
- Interface with photometric mask (VMPZ)
- The internal purity and completeness assessments in SEL require catalogs built from Wide-like stacks of the Deep exposures. These are not yet produced in the science challenge.

Critical issues for the science

- Deep field sample variance for calibration of the galaxy distribution functions (Redshift distribution, Halpha luminosity function, etc).
- Propagation of systematic uncertainty due to purity and completeness of the Deep.
- Development of weights.
- Random catalog for the Deep fields.
- Cross-correlation analyses to validate the random catalog and identify unknown or un-modeled systematics.

Prospects: Key Project Papers

- Measuring Galaxy Clustering for Euclid with a visibility mask
  - This paper presents the use of forward modelling to generate the random catalog for galaxy clustering analyses. The method is demonstrated on the Flagship mock with varying levels of complexity in the survey selection function.
- Validating the codes to generate the Euclid spectroscopic catalogs and their selection functions.
  - This paper describes the SEL and VMSP implementations in detail. The use of the Deep survey to infer estimate purity and completeness is described. The performance of the pipeline is demonstrated with the results of validation tests.
- Galaxy Clustering covariance with the Euclid visibility mask (in common with KP3)
  - This paper describes the contribution of the Euclid visibility mask to the full covariance and how it is estimated. The propagation of uncertainty due to sample variance in the deep field is estimated.

Thanks! New participants are welcome!