# *NIS Performance Analysis*

***on behalf the NISP team***

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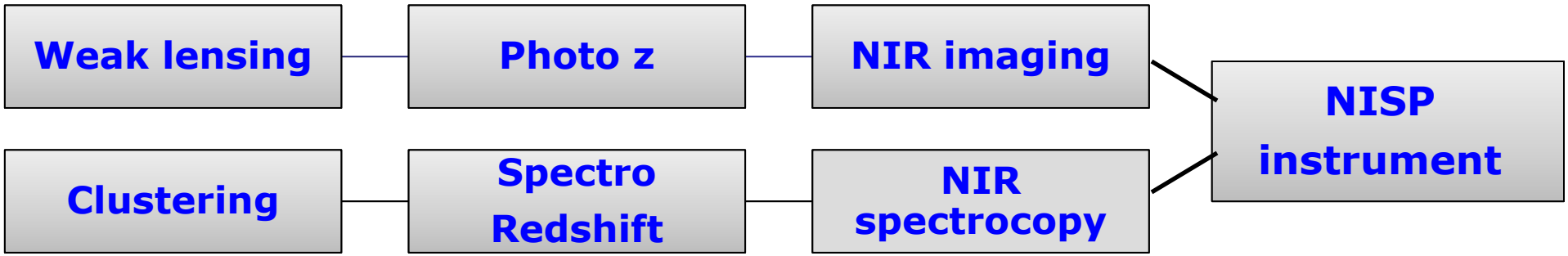
(NISP Spectroscopy Scientist)

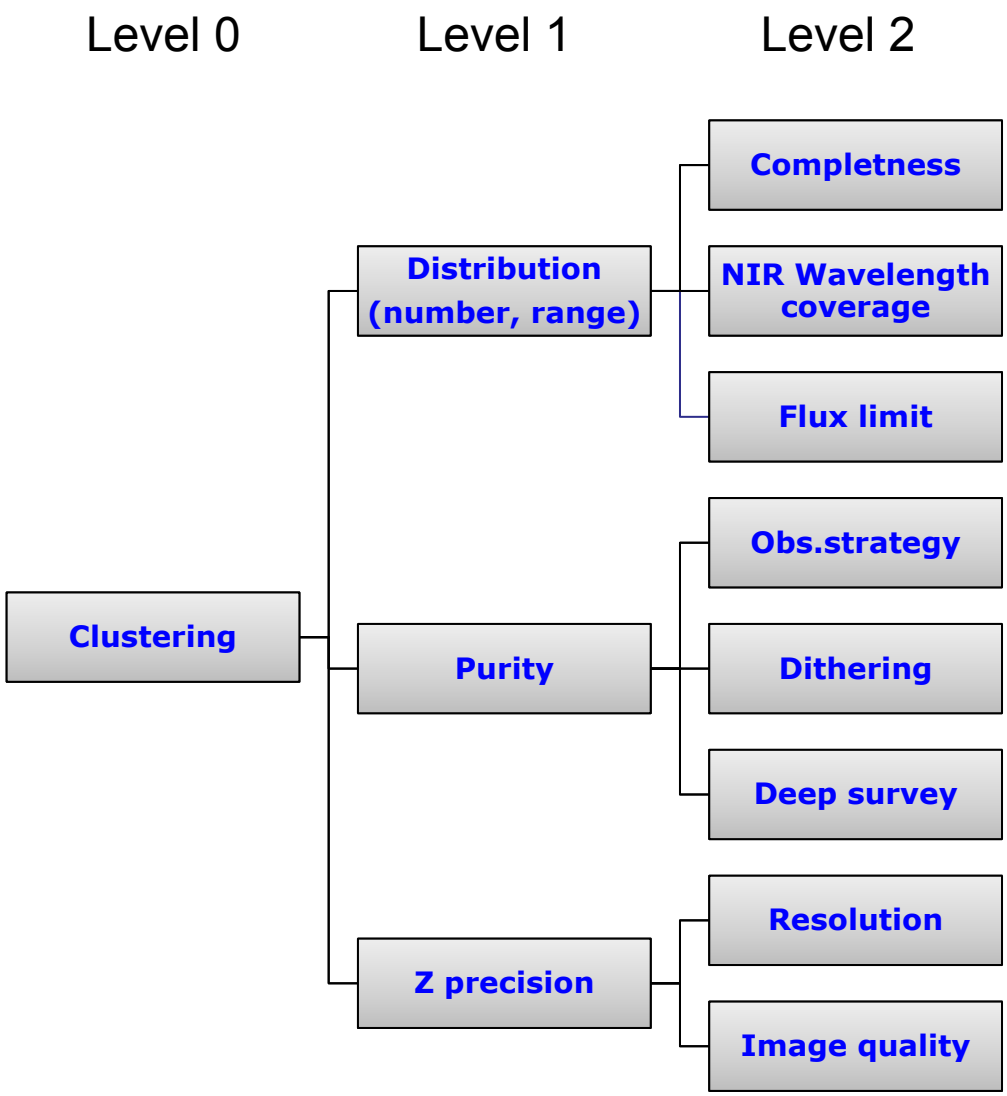
# NISP requirements





# NISP Requirements





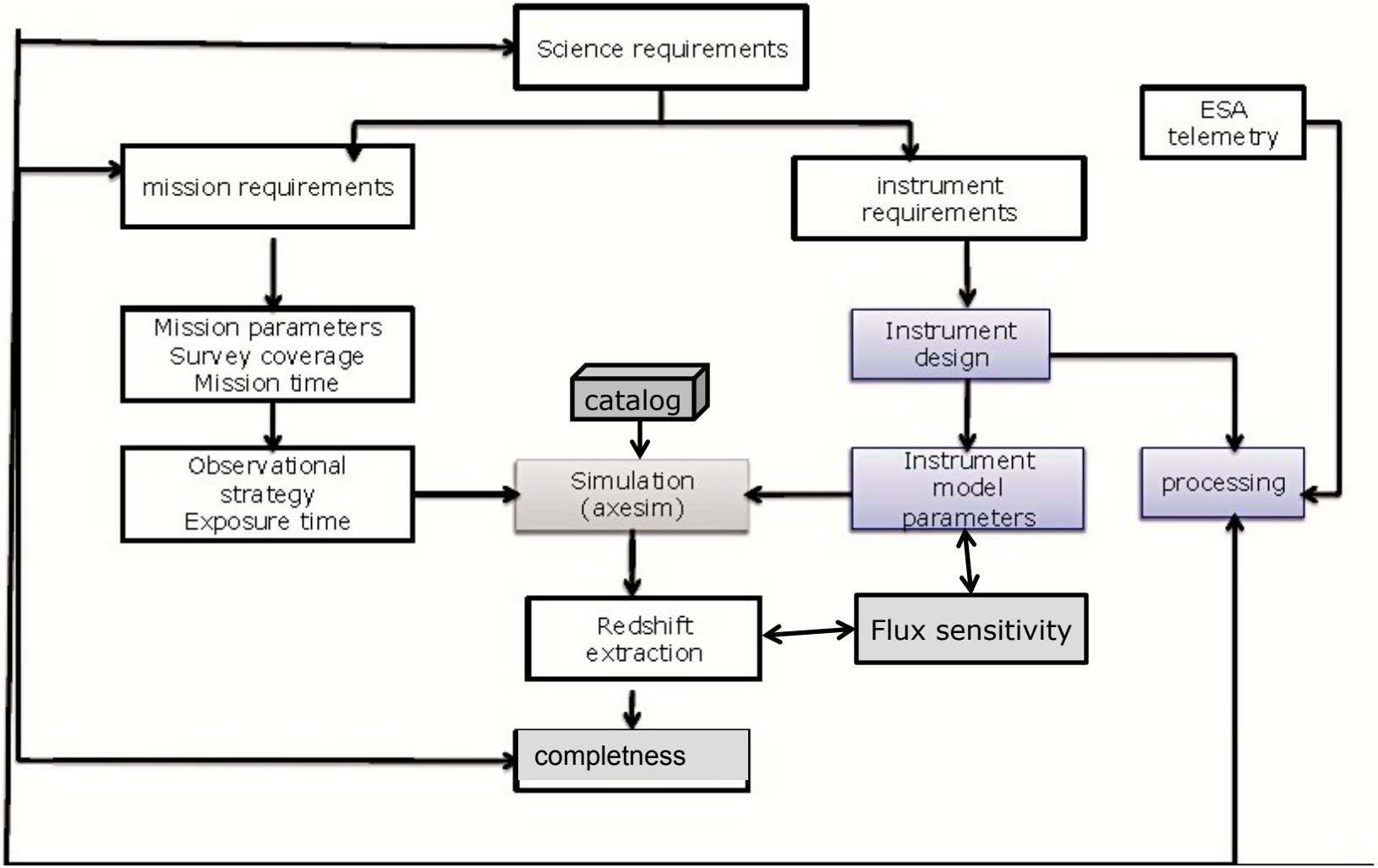
# Spectroscopy verification



| Description | Requirement | implementation |
|---|---|---|
| Flux limit on a 1'' object | $< 3\times10^{-6}$ erg cm$^{-2}$ s$^{-1}$ (3,5 σ 1600 nm) | Performance |
| Completeness | >45% (Goal 65%) | Performance |
| Variation in Flux limit vs. wavelength | <20% | Performance |
| Spectral range limits | 1.1micron* to 2.0 micron | Instrument |
| Spectral resolution | >250 | Instrument |
| Resolution element | sampled by> 2 pixels | Instrument |
| Wavelength error | f < 0.25 | Calibration |
| PSF size and shape in spectroscopic mode | FWHM<0.6" and * EE80 radius <0,6'' | Instrument |
| Stray light | <20% of Zodiacal light at ecliptic poles | Instrument |
| Dithering | >= 4 dithers | Survey/simu |
| spectroscopic obs stratgy | ≥4 dith/rotation | Survey/simu |
| NIR image for spectro | allows association | Survey/simu |
| NIR integration time | Sufficient to reach flux limit | Survey/simu |

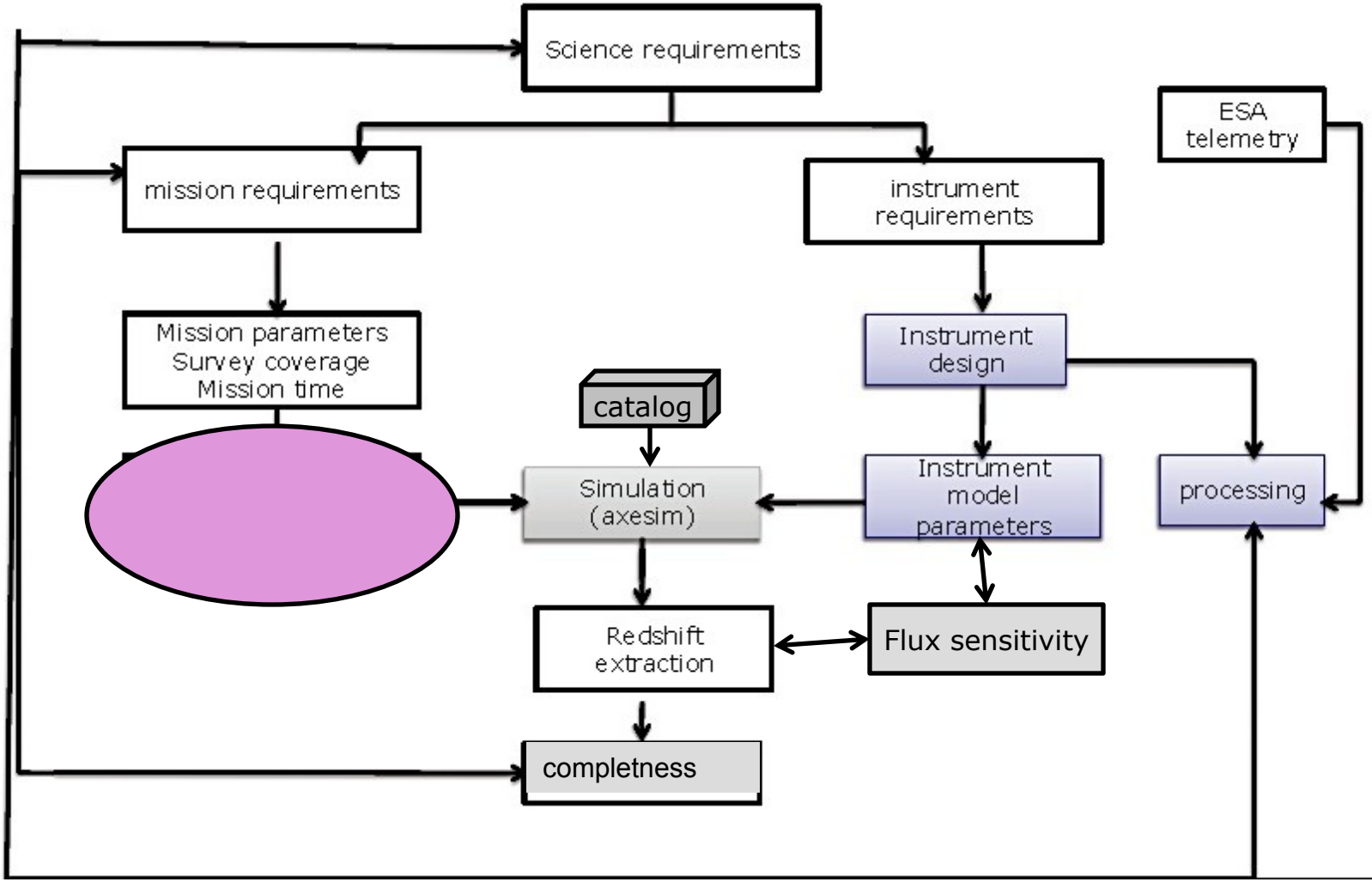
# Performance loop





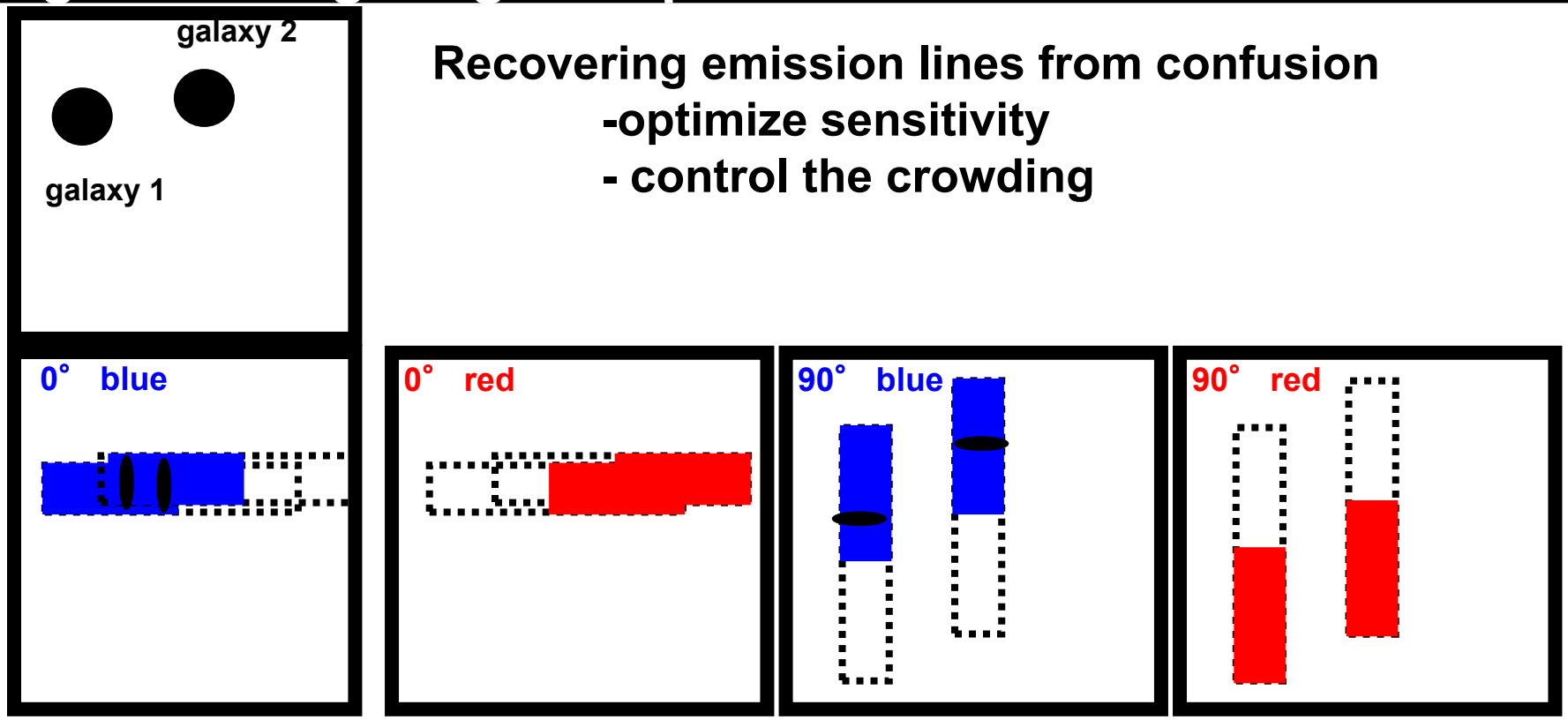
# Performance loop





# A goal = Mitigating the spectral confusion





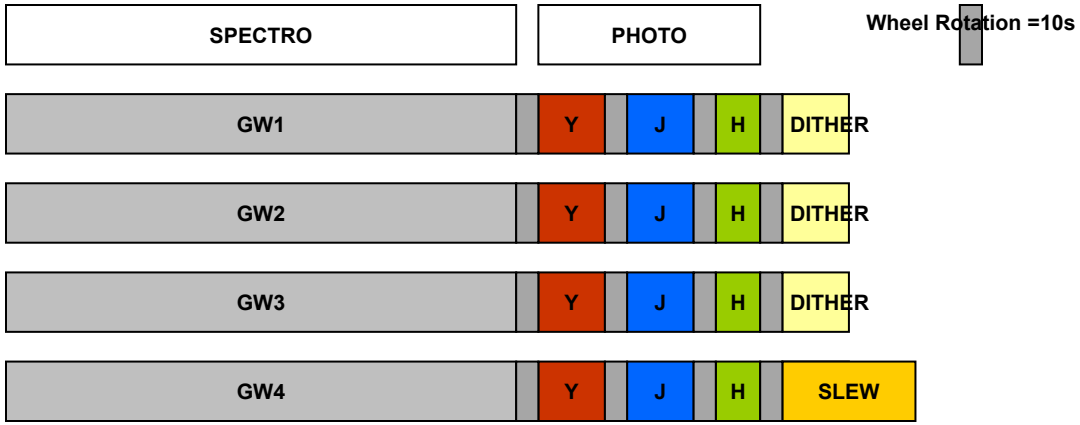

**Recovering emission lines from confusion**
**-optimize sensitivity**
**- control the crowding**

**4 sub-integrations (dithers)**
**2 roll angles of the dispersion axis (0° , 90° )**
**2 spectral ranges (2 grisms) ➔ shorter spectra but same S/N**

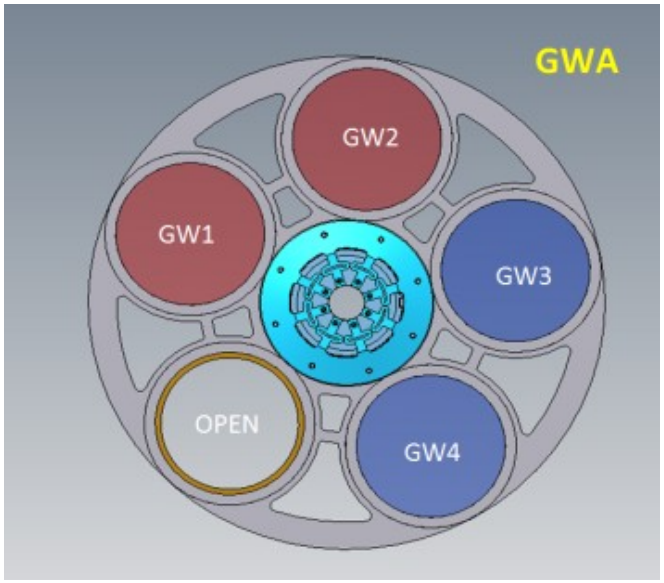
**Sequence : 0° -blue – 0° -red – 90° -blue – 90° -red**

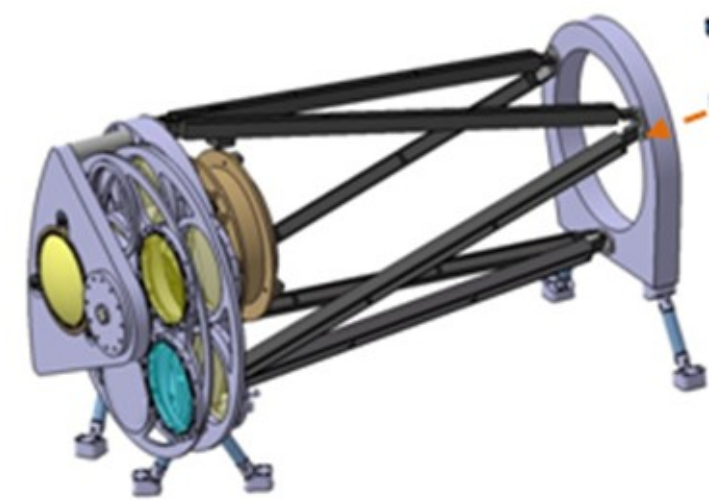
# Implementation






540s integration time for each Grism GW i



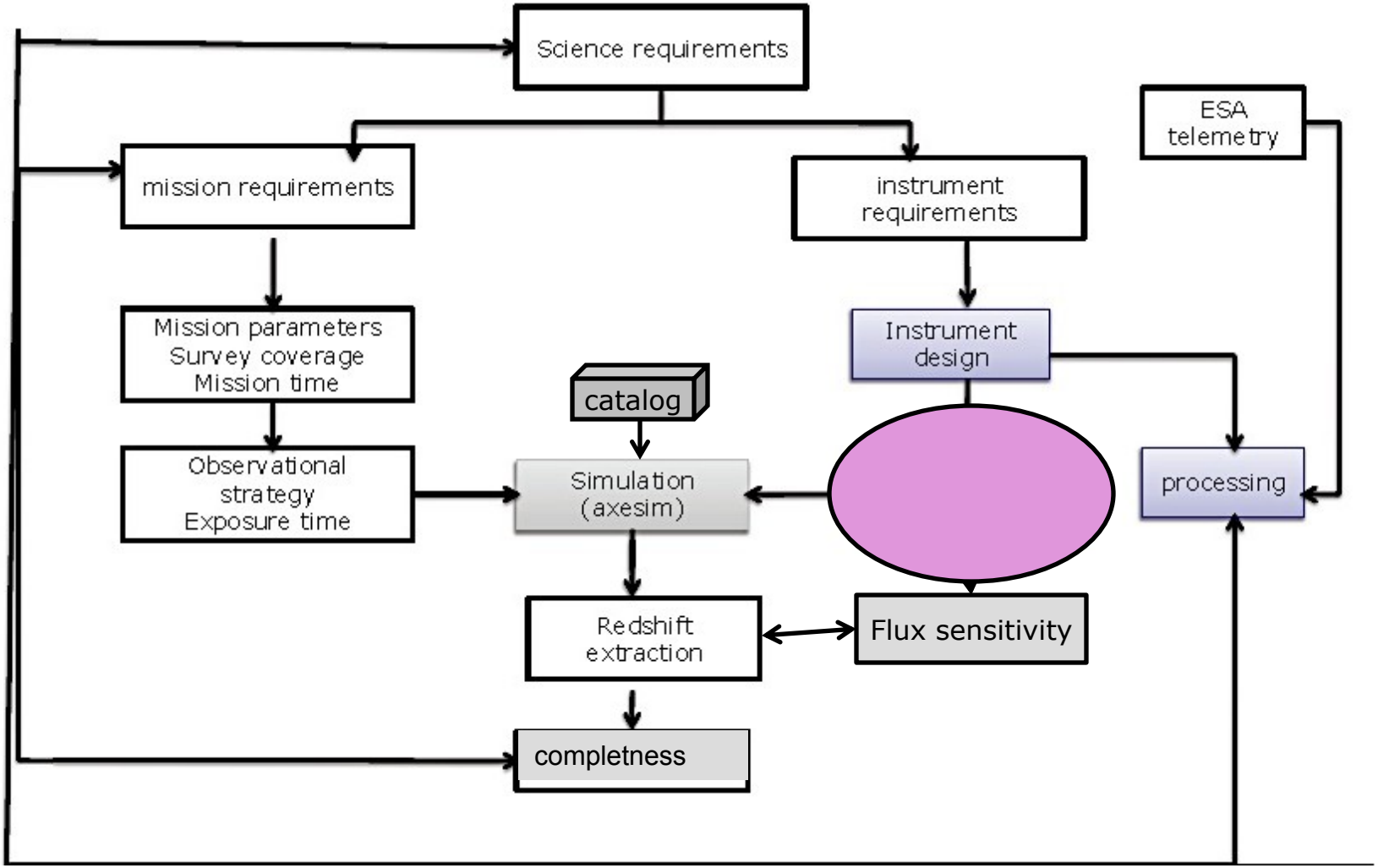
Grism positions

1. GW1 0° disp. : 1100-1457nm
2. GW2 90° disp. : 1100-1457nm

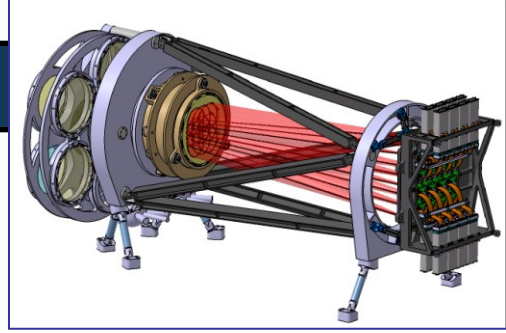
1. GW3 0° disp. : 1445-2000nm
2. GW$ 90° disp. : 1445-2000nm

# Performance loop



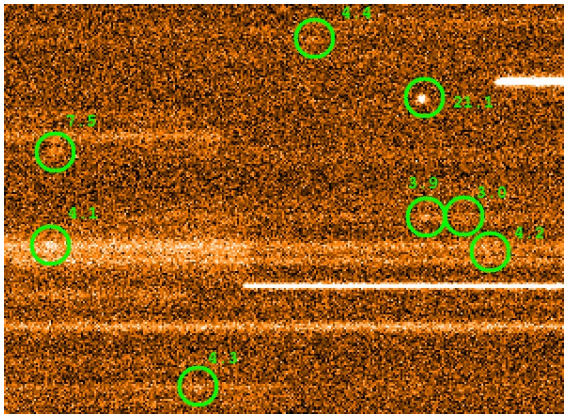


# Optical quality

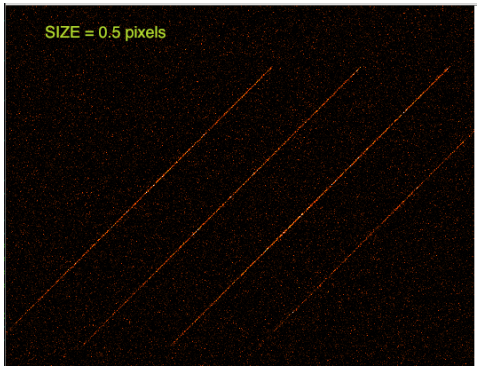


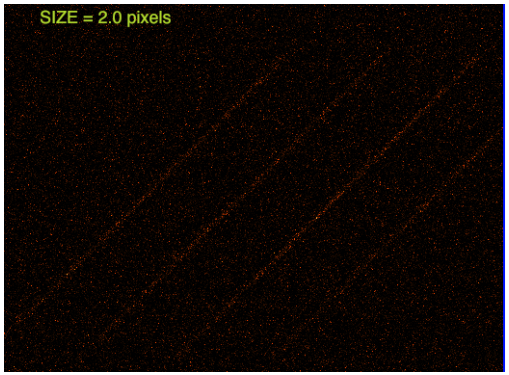
| Parameter | Value in IPRR |
|---|---|
| Grism bands (nm) | Blue=1100-1457<br>Red=1445-2000 |
| Dispersion/pixel | 9.8A/pix |
| Optical PSF<br>EE in radius (asec) | Double Gaussian<br>Blue EE50= 0,2'' EE80 = 0,45'' RedEE50=0,225'' EE80 = 0,55'' |

**Slitless**
**Spectral Resolution => δλ =cst = 9,8 A/pixel**



| PSF contribution (arcesec) | Blue | Red |
|---|---|---|
| EE50 radius (arcsec) | 0,2 | 0,225 |
| EE80 radius (arcsec) | 0,45 | 0,55 |
| Optical FWHM | 0,44 | 0,5 |
| detector | 0,066 | 0,066 |
| AOCS | 0,05 | 0,05 |
| total | 0,45 | 0,51 |




-EE80 minimize pixel under the line

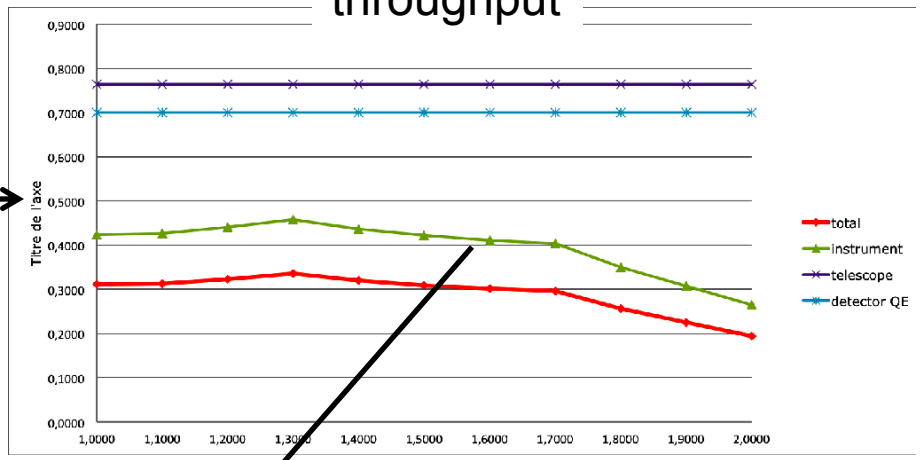
-EE50 ensure imagequality to extract lines of faint objects on the full Image

# The sensitivity parameters

Euclid Consortium

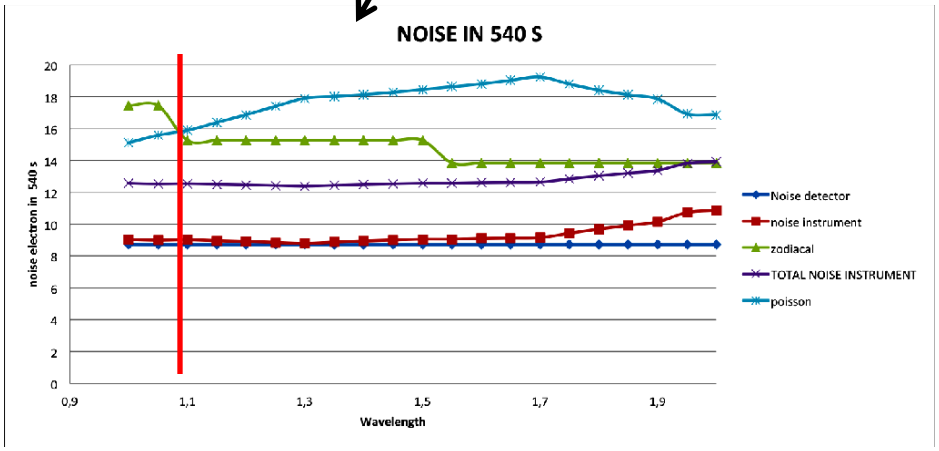
| Parameter | Value in IPRR |
|---|---|
| Grism bands (nm) | Blue=1100-1457<br>Red=1445-2000 |
| Out of band | 10-3 |
| transmission | See curve |
| Degradation from contamination | 4% |
| Zodi noise (entrance) | Blue = 1,4 e $s^{-1}$ $pix^{-1}$<br>Red = 1,3 e $s^{-1}$ $pix^{-1}$ |
| Extra noise | 20 % of zodiacal noise |

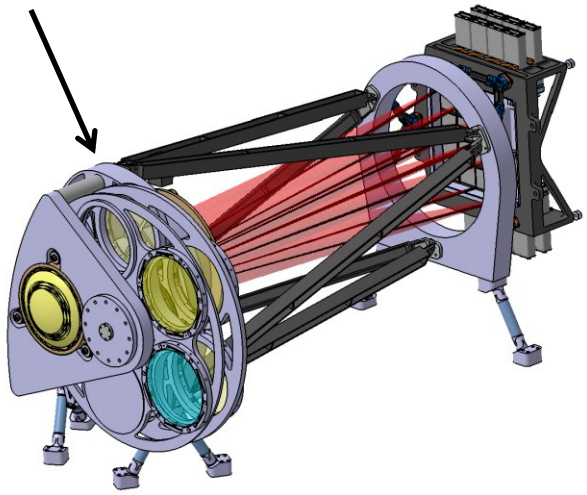
throughput




| wavelength | 1,1000 | 1,5000 | 1,7000 | 2,0000 |
|---|---|---|---|---|
| collimator | 0,98 | 0,978 | 0,984 | 0,97 |
| grism | 0,7 | 0,7 | 0,75 | 0,68 |
| Filter | 0,9400 | 0,9400 | 0,9400 | 0,9400 |
| camera | 0,9440 | 0,9360 | 0,8320 | 0,6100 |
| **total** | 0,60872 | 0,6023 | 0,5772 | 0,378 |

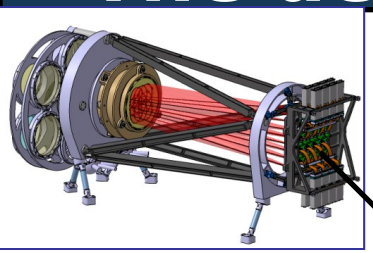
noise

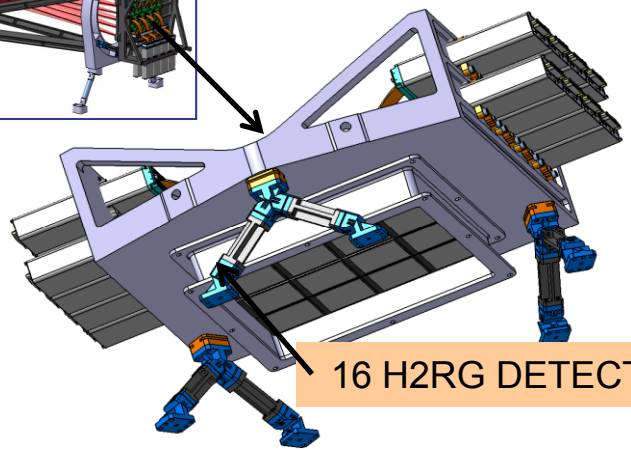


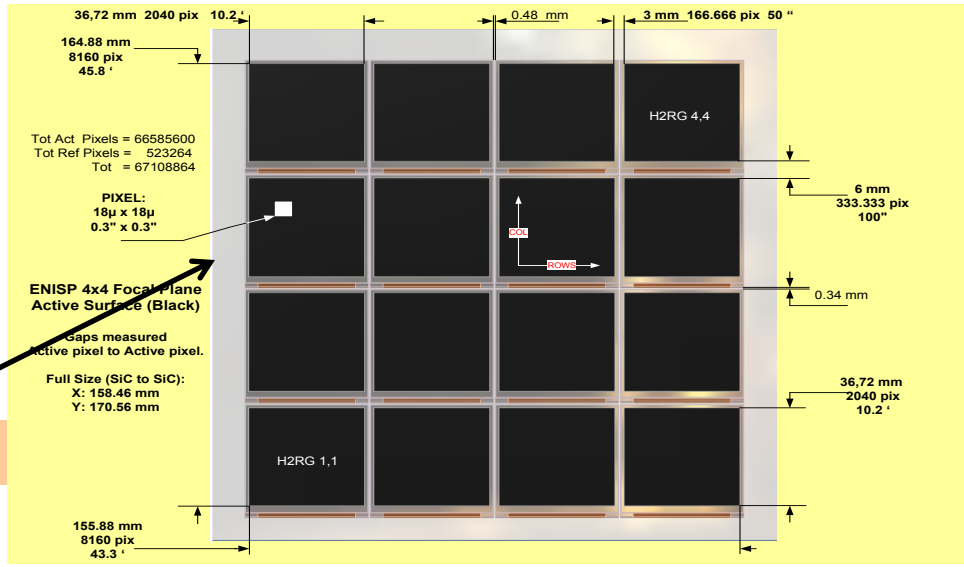
# The detectors (NIS and NIP)







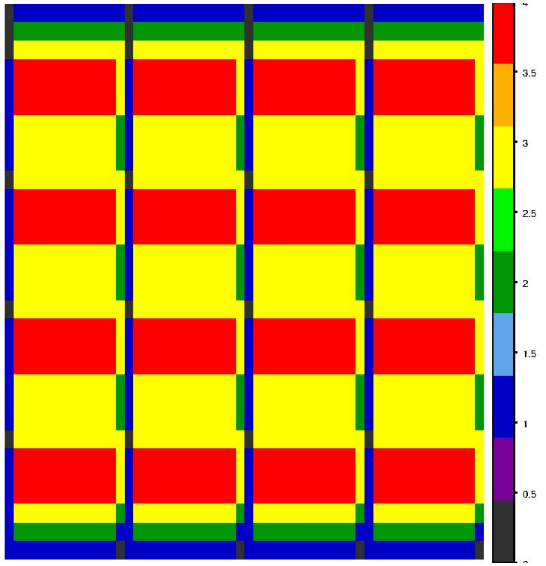
16 H2RG DETECTORS




| Parameter | Value |
|---|---|
| Pixels per Detector | 2040 × 2040 , 18 micron each |
| Active Area | 36.72 × 36.72 mm |
| Number of Detectors | 4 × 4 |
| Pixel size (arcsec) | 0,3'' |
| Gaps between Detectors | 3 × 6 mm |
| Quantum Efficiency | 0.7 |
| Total noise in 540 s | 9 e- |
| Detector PSF | Gaussian, FWHM = 4 µm |
| Detector Cut-off | 2 .1(2.5) µm |
| Readout mode for spectro | Up the Ramp |
| Cosmic rejection | Yes/on board |

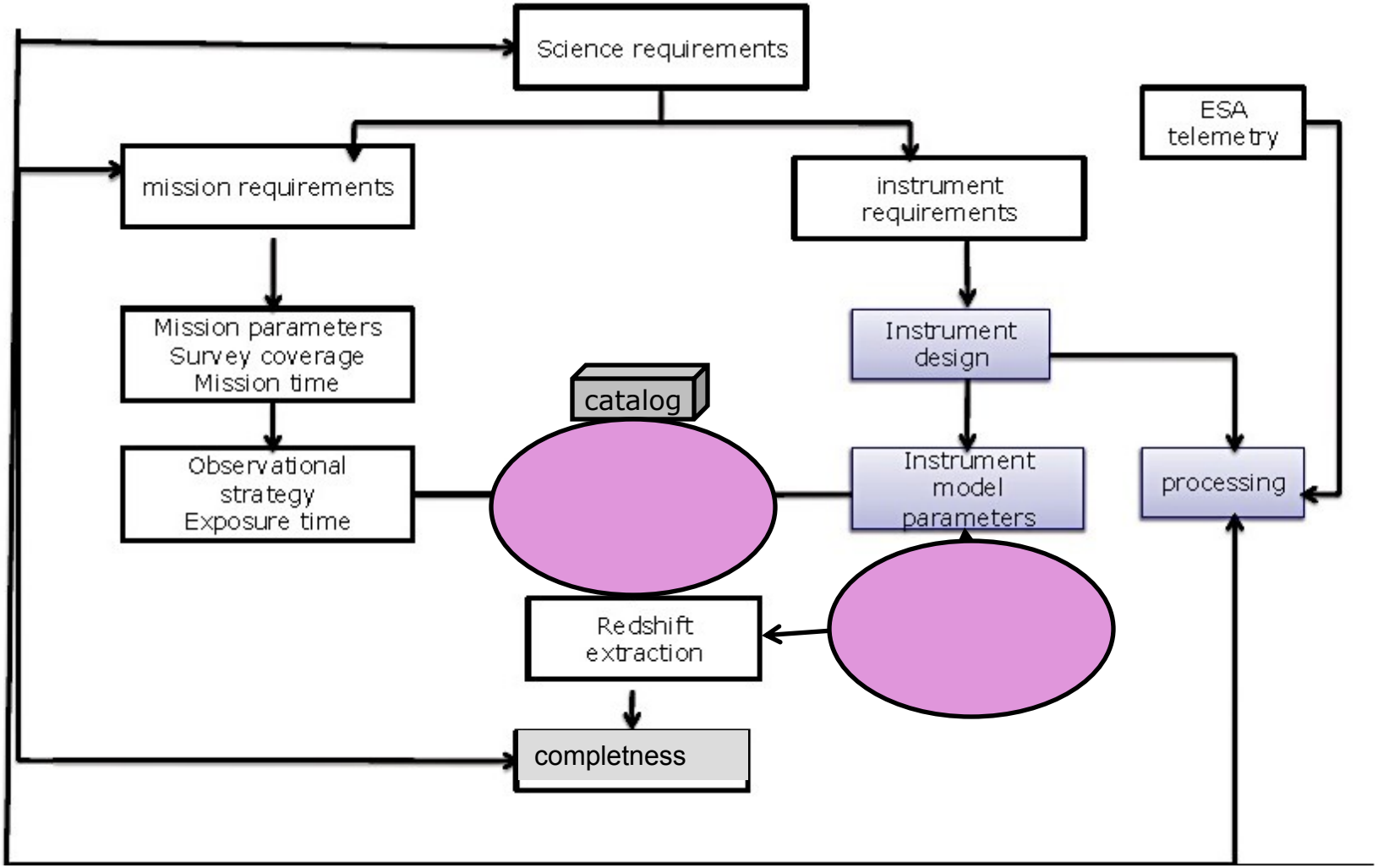
## Dithering strategy

| Dither Step | Step X | Step Y |
|---|---|---|
| Step 1 | 100'' | 50'' |
| Step 2 | 100'' | 0'' |
| Step 3 | 100'' | 0'' |



# Performance loop

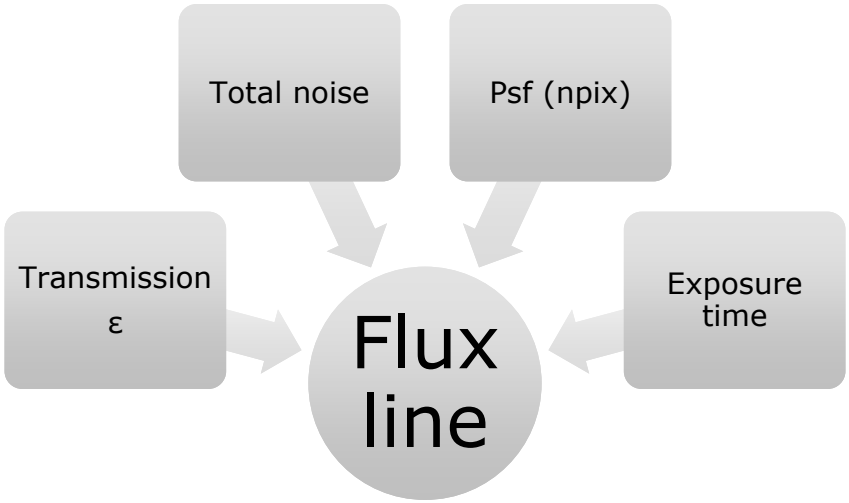




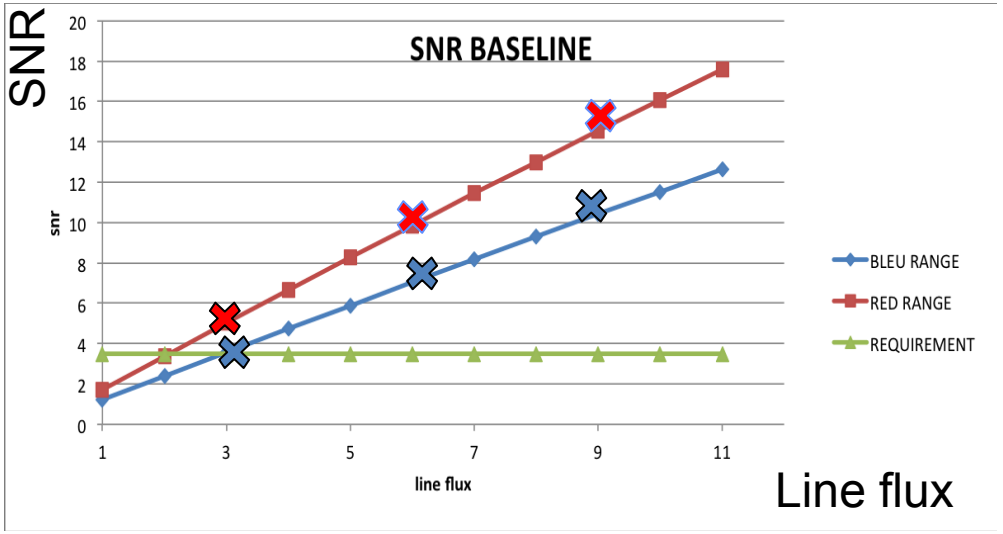
# The expected sensitivity



*R-GC.2.1-1: the effective H-alpha-line flux limit from a 1-arcsec diameter source shall be lower than or equal to 3 ×10$^{-16}$ erg cm$^{-2}$ s$^{-1}$ at 1600 nm. The flux limit is defined as the flux for which the signal-to-noise is > 3.5*



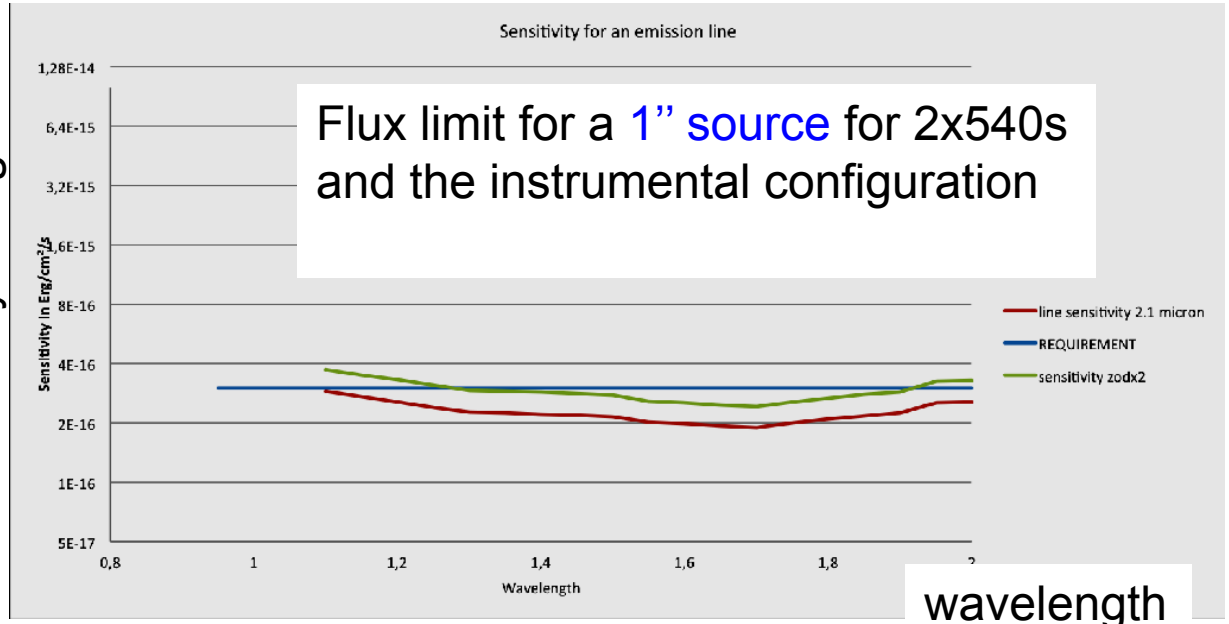

Use an exposure time calculator
To optimise the different contributions



# Spectroscopy line flux limit



Sensitivity in erg/cm2/s




Flux limit for a 1" source for 2x540s and the instrumental configuration

wavelength

Red baseline

Green zod noise x 2

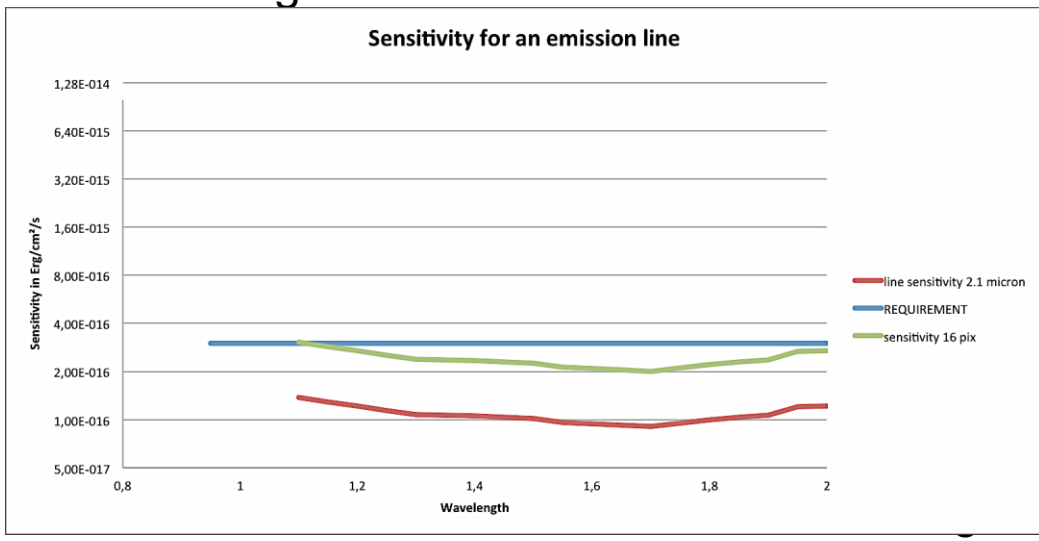
Blue requirement

$= 3 \times 10^{-16}$ erg cm$^{-2}$ s$^{-1}$

Variation with the object size

*For 1" < 3 $\times 10^{-16}$ erg cm$^{-2}$ s$^{-1}$*

*For 0,4" <1.3 $\times 10^{-16}$ erg cm$^{-2}$ s$^{-1}$*



# Completness



*R-GC.2.1-2: The completeness of redshift measurements from NISP spectra shall be larger than 45%. (goal 65%)*

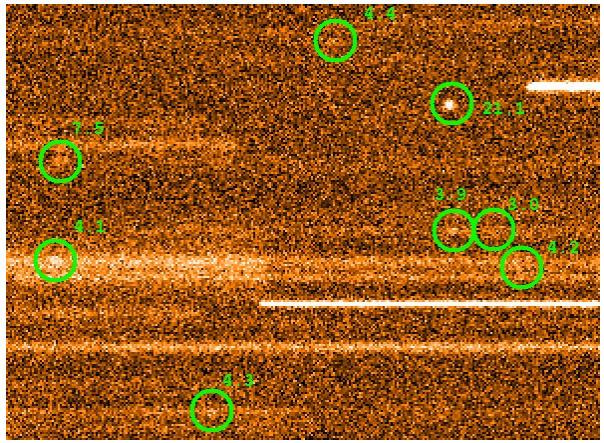
*T-GC.2.1-2:The completeness is the number of galaxies for which a redshift is measured, divided by total number of galaxies at the flux limit specified by R-GC.2.1-1*

the completness is affected by the crowding in a field:

⇒Validation with pixel level simulation and object extraction

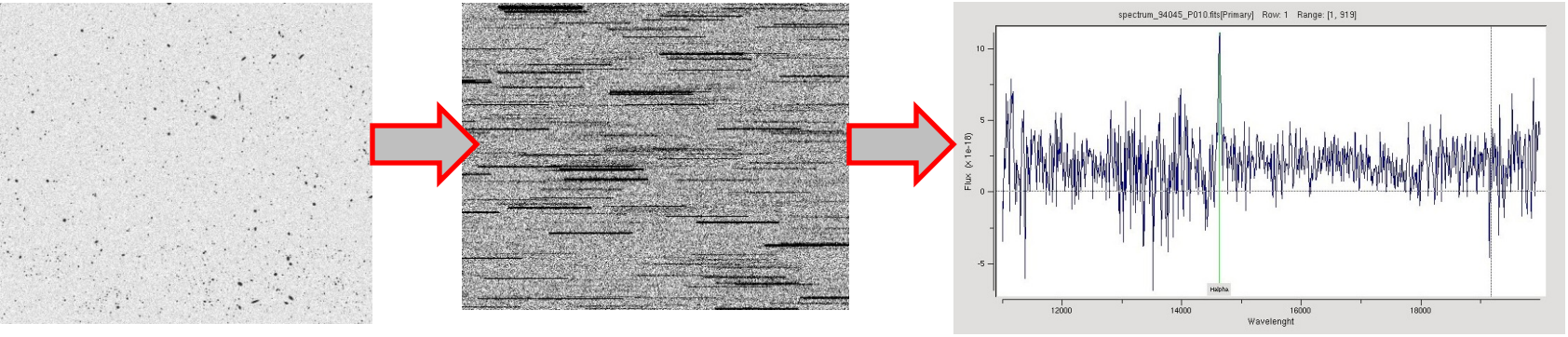
(end to end )

- ⇒simulate a field
- ⇒Extract spectra
- ⇒Extract redshift
- ⇒contamination/confusion estimation



# Completeness

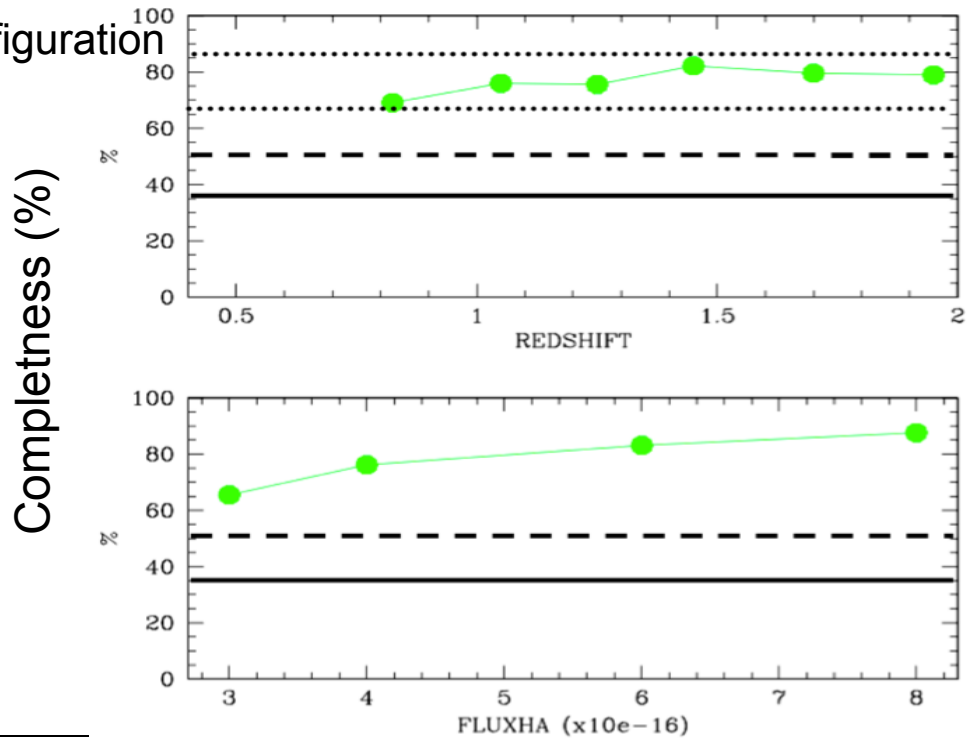





(see B.Garilli presentation for details)

- Use a representative catalog
- Use AXESIM with the same instrument configuration
- Simulate the observational strategy

| Parameters | Value in IPRR |
|---|---|
| Grism bands (nm) | Blue=1100-1457<br>Red=1445-2000 |
| Plate scale | 0,3” |
| Dispersion/pixel | 9.8A/pix |
| transmission | See curve |
| | |
| PSF, EE in radius (asec) | Blue EE50= 0,2’’ EE80 = 0,45’’<br>RedEE50=0,225’’ EE80 = 0,55’’ |
| Detector total noise | 9e |
| Zodi noise (entrance) | aldering |
| Extra noise | 20 % of zodiacal noise |
| Array size | 16x 2040x2040 |
| Gap x/gap y | 3/6 mm |
| Dither pattern | 4 dithers |
| Observational strategy | 2 rolls, 2 bands |
| Exposure time | 540s |
| Field Overlap | no |



# Conclusion



NISP instrument performance has been validated through a full loop of verification

- Verify the instrument parameters (PSF, transmission and detector performances) and check faisability
- Verify the performance of observational strategy (dithering efficiency , rolls/filters efficiency)
- Verify the scientific objectives (sensitivity, completness, purity) through a full end to end simulation

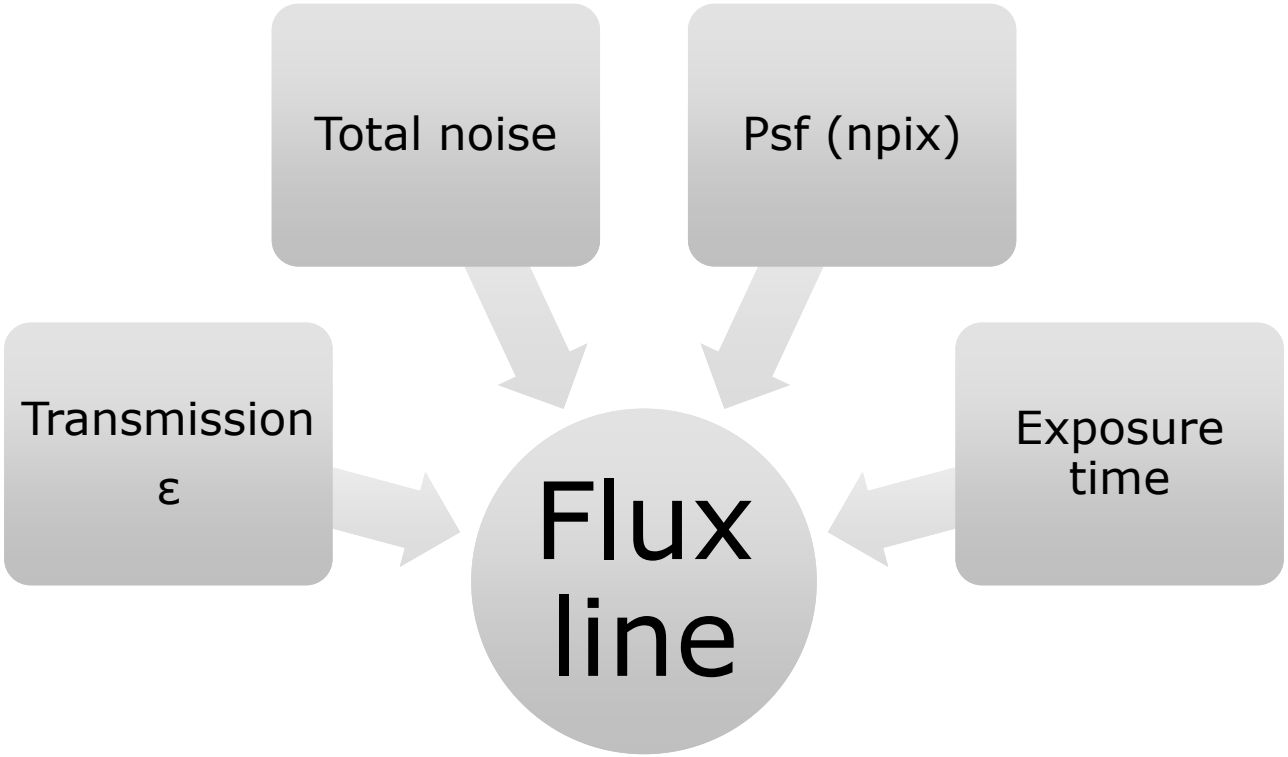
See B.Garilli talk for more details on this part

# Spectroscopy L2 verification

Euclid Consortium

| Reference | Description | Requirement | implementation | compl |
|---|---|---|---|---|
| GC.2.1-1 | Flux limit | < $3\times10^{-6}$ erg cm$^{-2}$ s$^{-1}$ (3,5 σ 1600 nm) | **Performance/Simulation** | ✔ |
| GC.2.1-2 | Completeness | >45% (Goal 65%) | **Performance/Simulation** | ✔ |
| GC.2.1-3 | Variation in Flux limit vs. wavelength | <20% | **Instrument/simulation** | ✔ |
| GC.2.1-4 | Spectral range limits | 1.1micron* to 2.0 micron | **Instrument** | ✔ |
| GC.2.1-5 | Spectral resolution | >250 | **Instrument** | ✔ |
| GC.2.1-6 | Resolution element | sampled by> 2 pixels | **Instrument** | ✔ |
| GC.2.1-7 | Wavelength error | f < 0.25 | **Calibration** | ✔ |
| GC.2.1-8 | PSF size and shape in spectroscopic mode | FWHM<0.6" and * EE80 radius <0,6'' | **Instrument** | ✔ |
| GC.2.1-9 | Stray light | <20% of Zodiacal light at ecliptic poles | **Instrument** | ✔ |
| WS.2.2-5 | Wide Survey field overlap | No* | **Survey/simu** | ✔ |
| WS.2.2-6 | Dithering I | >= 4 dithers | **Survey/simu** | ✔ |
| WS.2.2-7 | Dithering II | >92%with >=3 dithers | **Survey/simu** | ✔ |
| WS.2.2-8 | spectroscopic obs stratgy | ≥4 dith/rotation | **Survey/simu** | ✔ |
| WS.2.2-10 | NIR image for spectro | allows association | **Survey/simu** | ✔ |
| WS.2.2-11 | NIR integration time | Sufficient to reach flux limit | **Survey/simu** | ✔ |

*request of modification




Flux % npix*(flux+total noise)

# Performance verification approach



- Define instrument/observational parameters versus design (optical design, detectors, dithering strategy)
- Validate instrument parameter requirements against current instrument design at instrument level
- Validate Spectroscopy performance (sensitivity and completness) against Level 2 science requirement with simulation