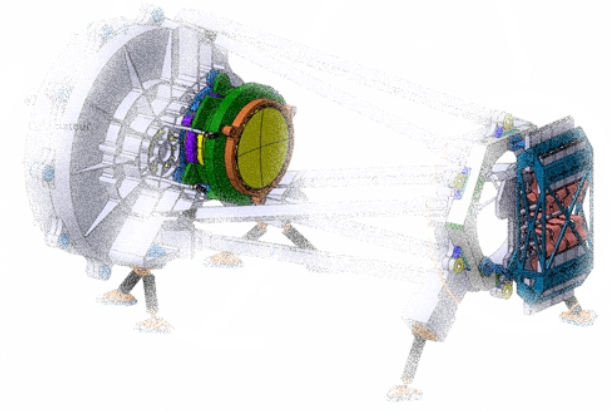
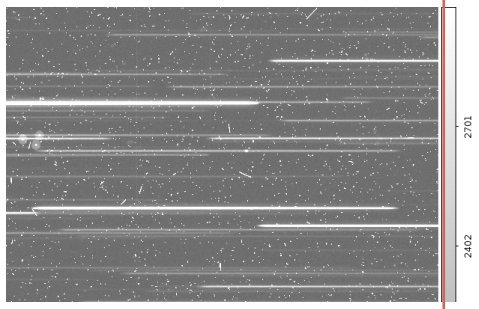


The NISP Spectroscopy performance

Evaluation done for the MPDR

A.Ealet
CPPM

WITH
J.Amiaux, ,B.Garilli, L. Guzzo, W.Percival,
E. Prieto, D. Markovic, S. De la Torre, J.Zoubian
and
the NISP spectro tiger team



Verification of the spectroscopic requirements with straylight and persistence using an E2E simulation chain

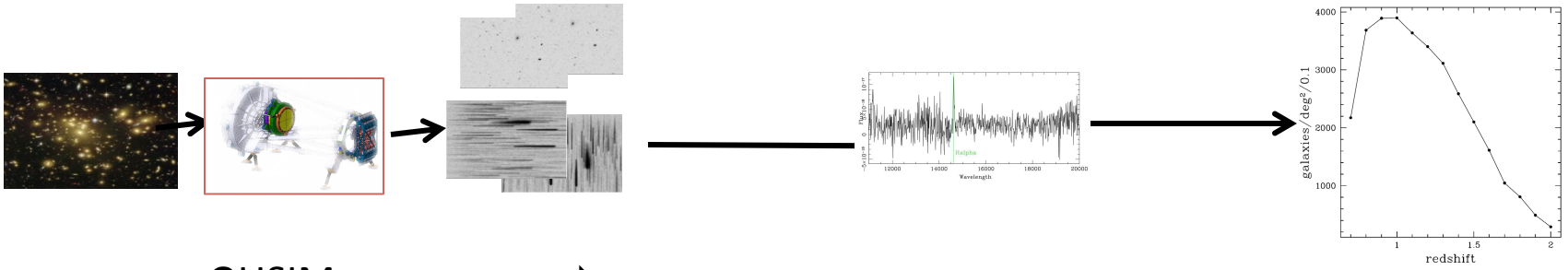
Sensitivity requirements in spectroscopy (level 2)

	sensitivity	Requirement	Comment
R-GC.2.1-1	NISP-S SNR @ 1.6 μm For flux >= 2 10^{-16} $erg.cm^2.s^{-1}$ For a 0.5 '' object size.	3.5	This is a mean case for science -should be verified on all objects -should be verified for >95 % pixels in the field
R-GC.2.1-2	Completeness	>45 % (goal 65 %)	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
R-GC.2.1-11	Purity	> 80 %	The purity is the number of galaxies that satisfies R-GC-1.1-3 (i.e $\sigma(z)<0.001(1+z)$) Divided by the number of galaxies that Satisfied R-GC.2.1-1 and R-GC.2.1-2 *

Verification of the spectroscopic requirements with straylight and persistence using an E2E simulation chain

=>compute SNR, completness and purity from 'realistic images'

Performance E2E verification chain



OUSIM

Image simulation

- Sky
- Instrument models
- Survey strategy

OUSIR-OUSPE

Processing

- Reduction
  - Calibration
  - Object identification
  - Spectra extraction
- Redshift determination
  - Spectra combination
  - Redshift measurement
  - Redshift reliability

OULE3

Analysis

- Completeness
- Purity
- Dn/dz

=> SNR sensitivity analysis

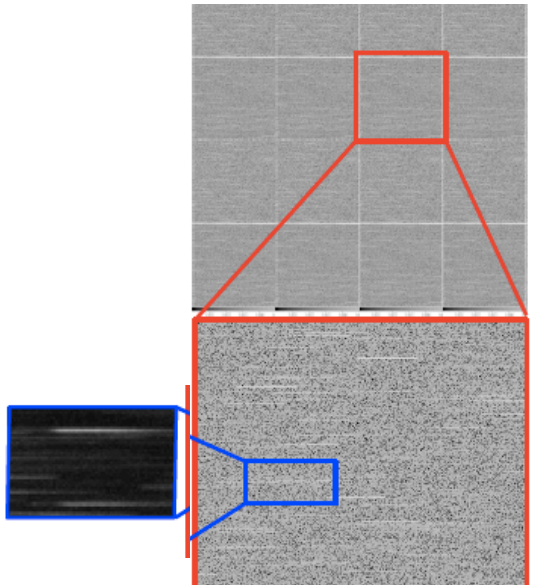
=> completeness and purity

VALIDATION CHAIN

E2E Simulation Pipeline

-TIPS : (OUSIM) (Zoubian etal.)
Pixel image simulator

Produce the 16 detector focal plan
Can add all instrumental effects
in a modular way

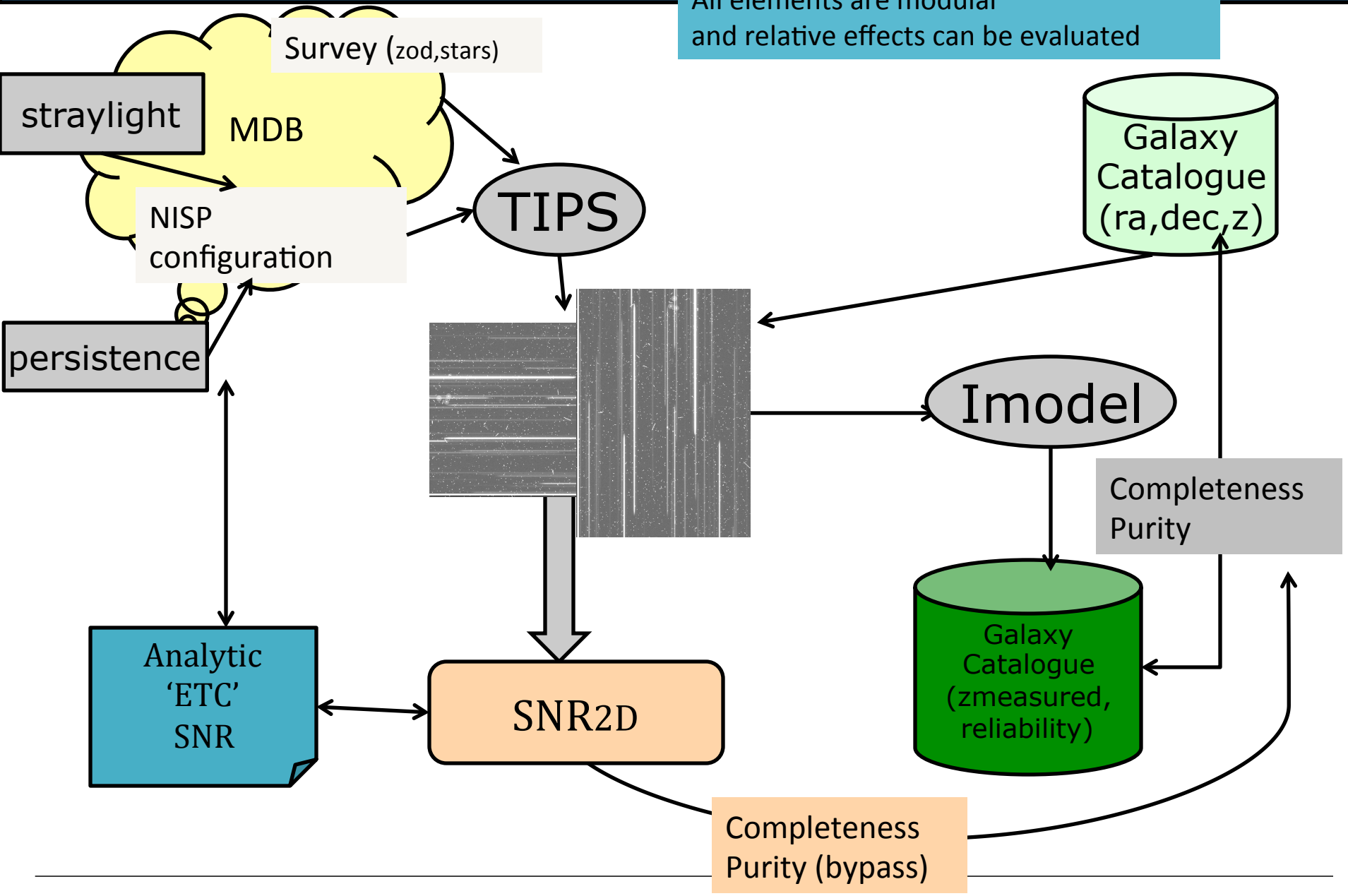


Imodel: OUSIR-SPE-LE3 *(B.Garilli et al)*
Prototype of pipeline to compute redshift and reliability, completeness and purity on images.

-Do a full extraction of 1D spectra in images using AXE
-Do a combination of rolls taking dithering and gaps into account
-Do a blind search of emission line
-Evaluate completness and Purity

Validation chain

All elements are modular
and relative effects can be evaluated



Method

1 - Define 9 representative pointing (scenarios) of the 'reference survey'

Compute for each, the zodiacal noise and the star density based on 2mass

2 - Simulate pixel images for the 9 scenarios (TIPS)

Use the pixel level simulator to generate images with :

- The nominal NISP configuration and observational sequence
- The previous sky noise and stars
- **A noise model of the telescope straylight**
- **A model of the persistence noise decay from the detectors**
- **Cosmic rays**

COMPUTE SNR on images to verify the compliance of each scenario

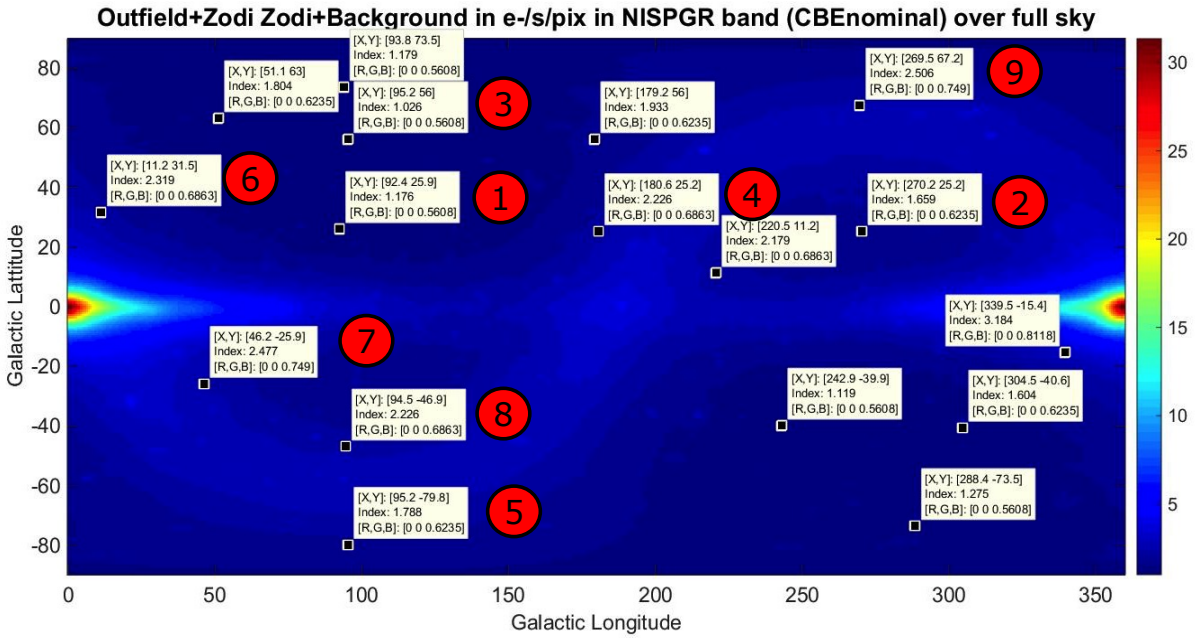
3 - Compute completeness/purity for each scenario (IMODEL)

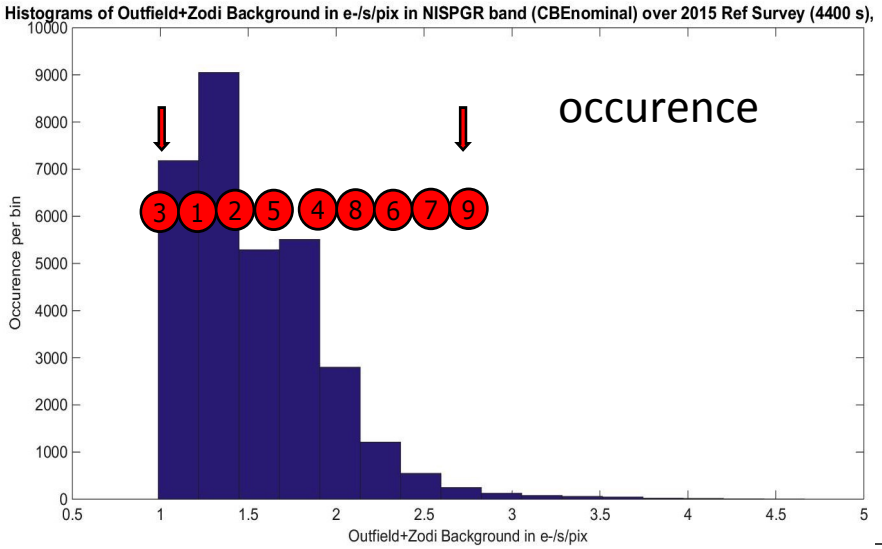
- Add galaxies on each image from a representative catalogue
- Do a full processing of the image with galaxies to 1D spectra
- Do a redshift evaluation and reliability

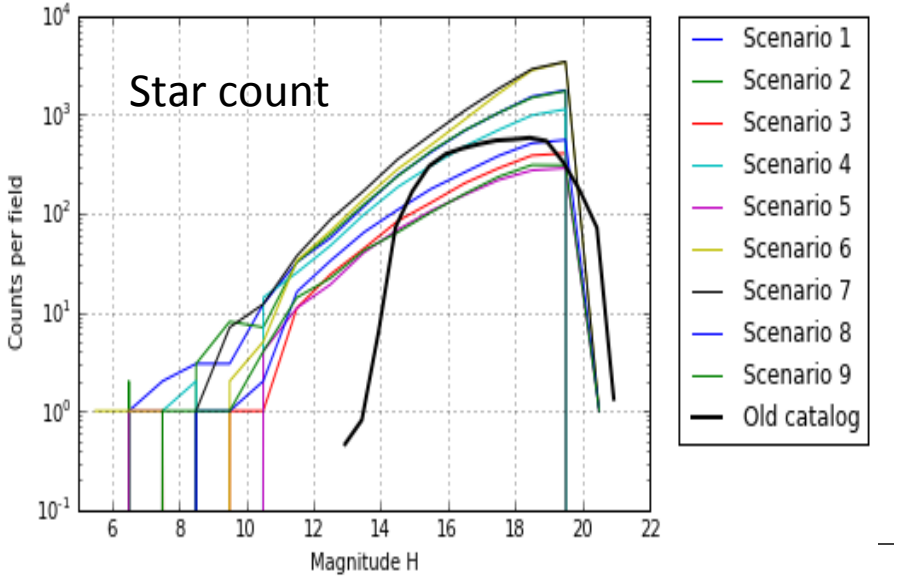
4- Final estimation on the mean reference survey

The reference survey

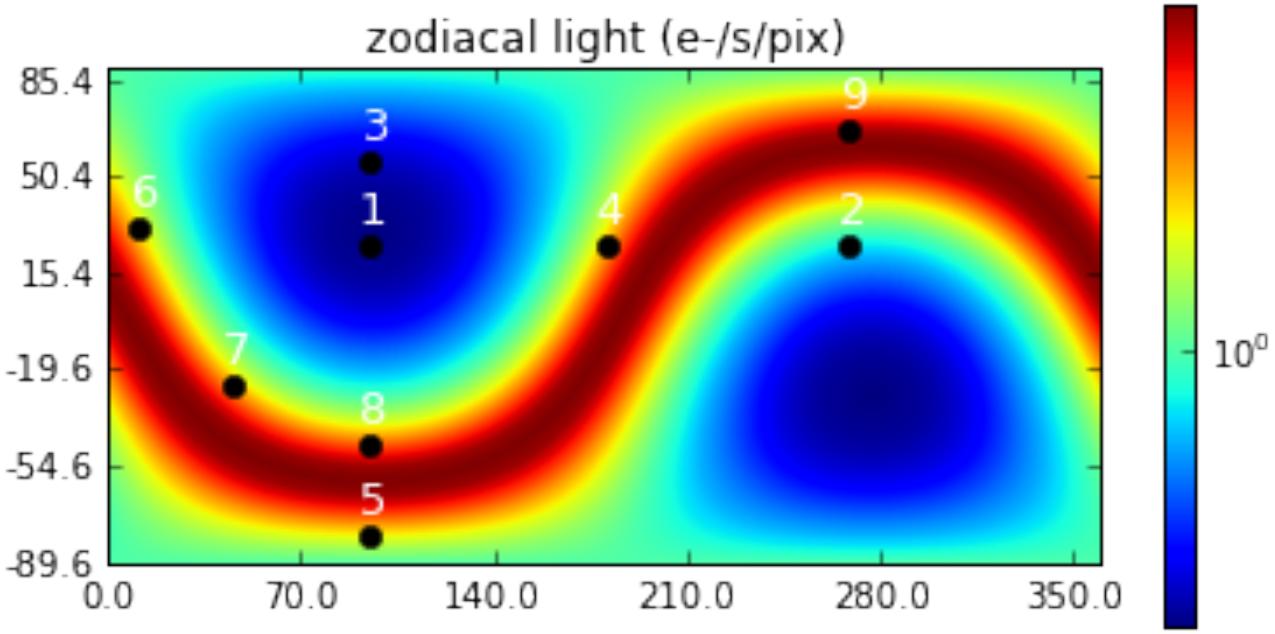
- 9 fields distributed within all representative regions of the reference survey, including the borders, have been selected.
- Called *observing scenarios #1-9*

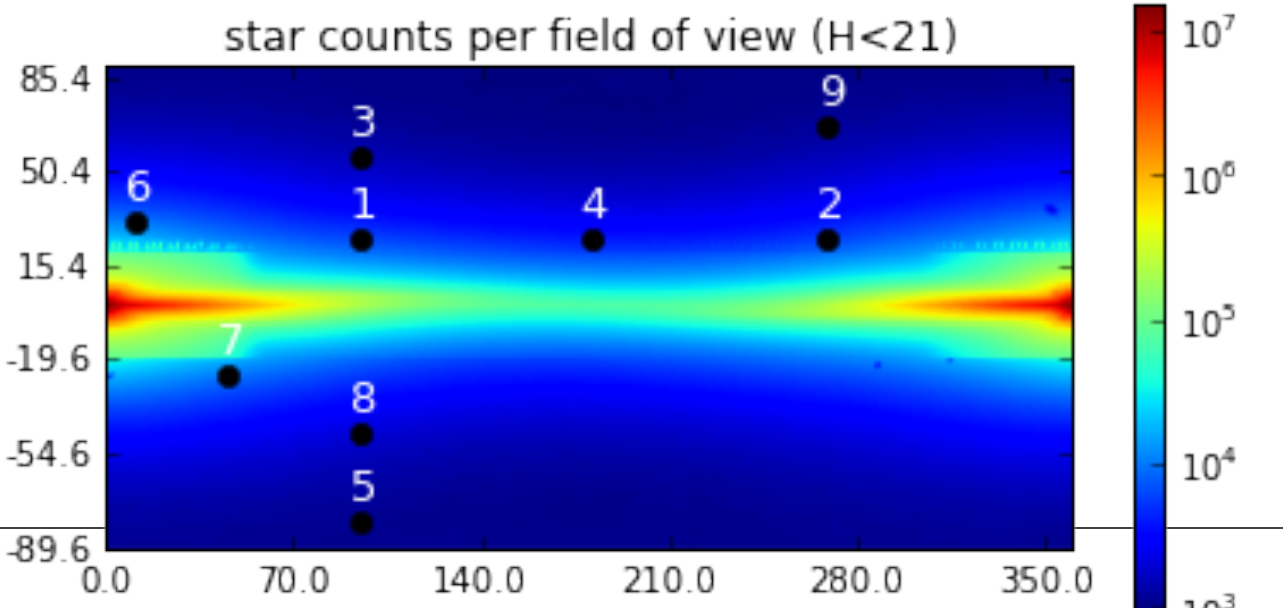




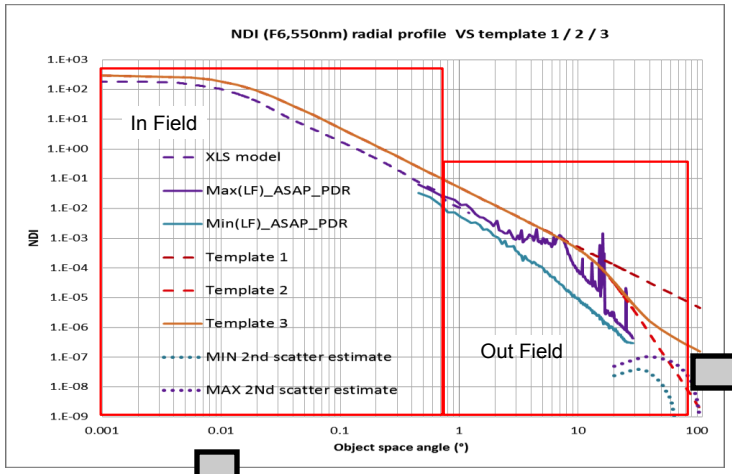


Reference survey maps



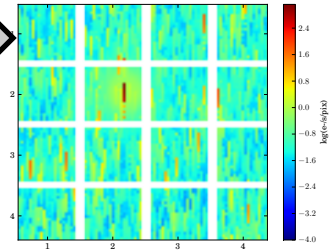


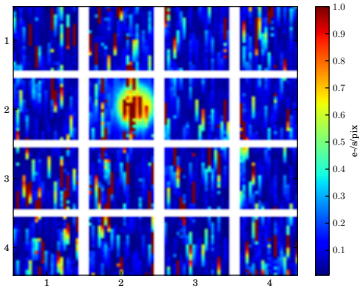
The straylight model (from the system team)



Out-of-Field

- Flat diffuse noise on the FOV
- % to the total star count
- Added to the sky contribution

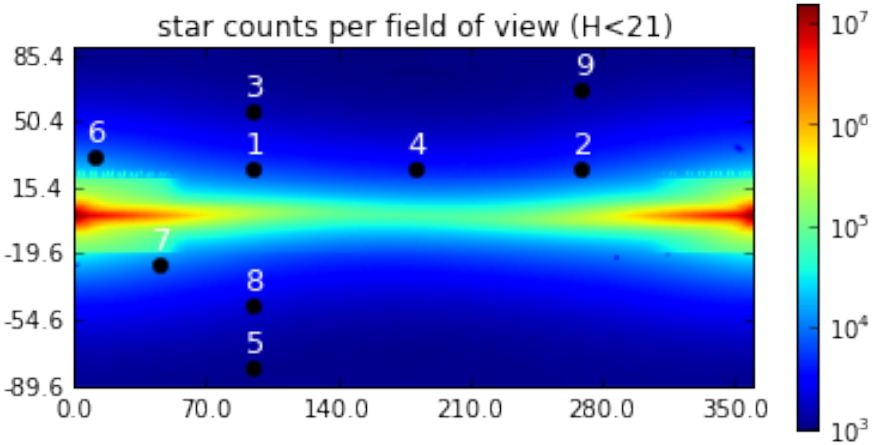


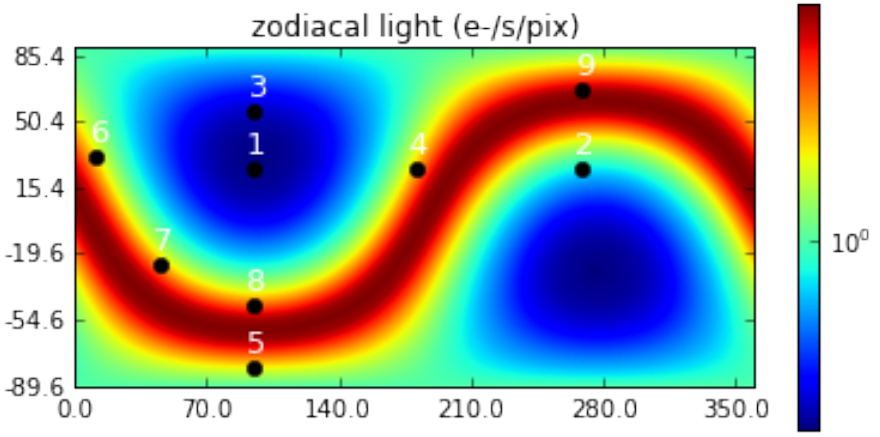


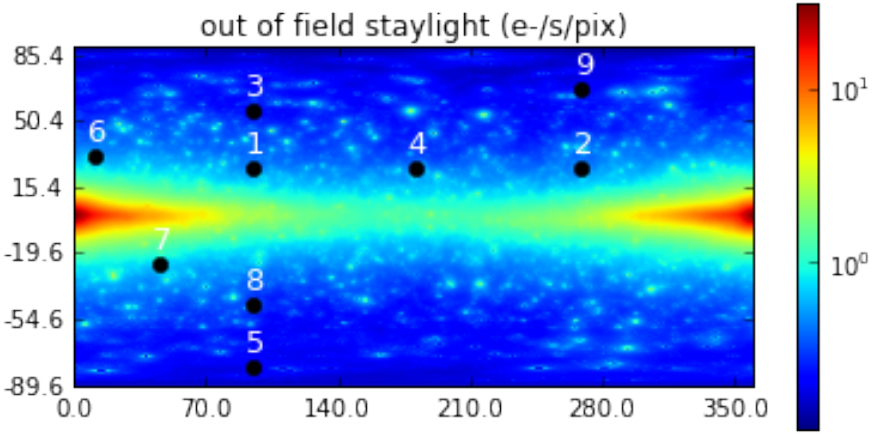
In- Field

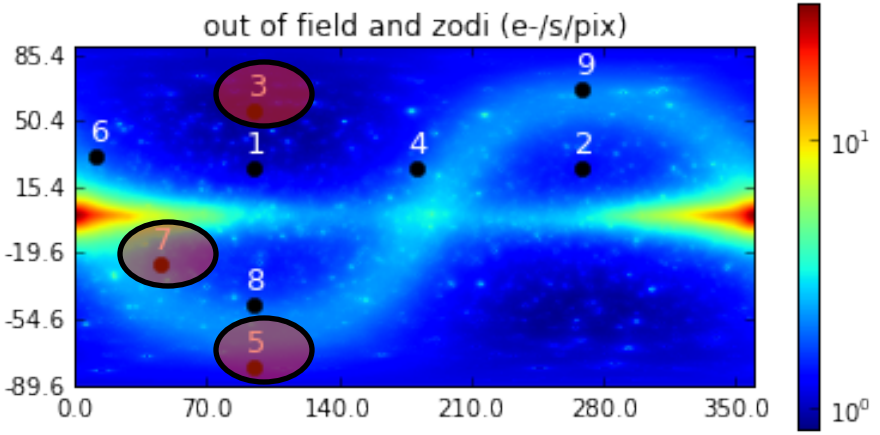
- Noise around bright objects
- Very local effect
- % to object flux

Defined for the 9 representative pointings : star density + telescope out of field







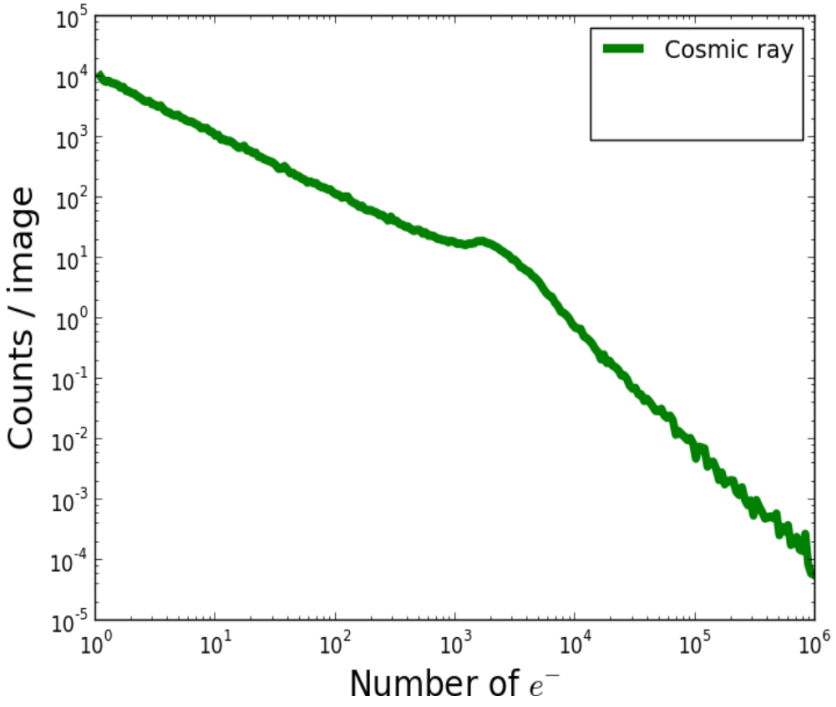


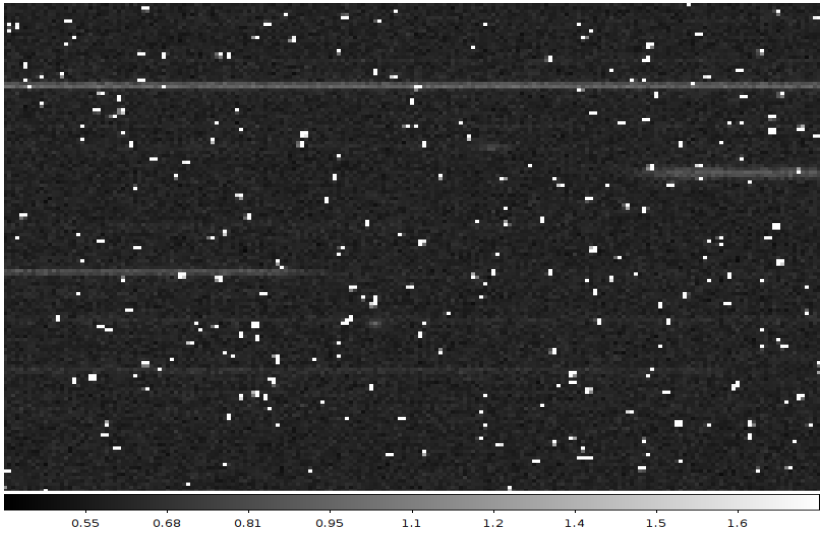
ADDING COSMIC AND PERSISTENCE

Cosmic ray model

-Use CREME9 (https://creme.isde.vanderbilt.edu/]) to generate the primary spectrum (no secondaries)

- Run a simulation of the number of electron for the primary spectrum inside the H2Rg detectors

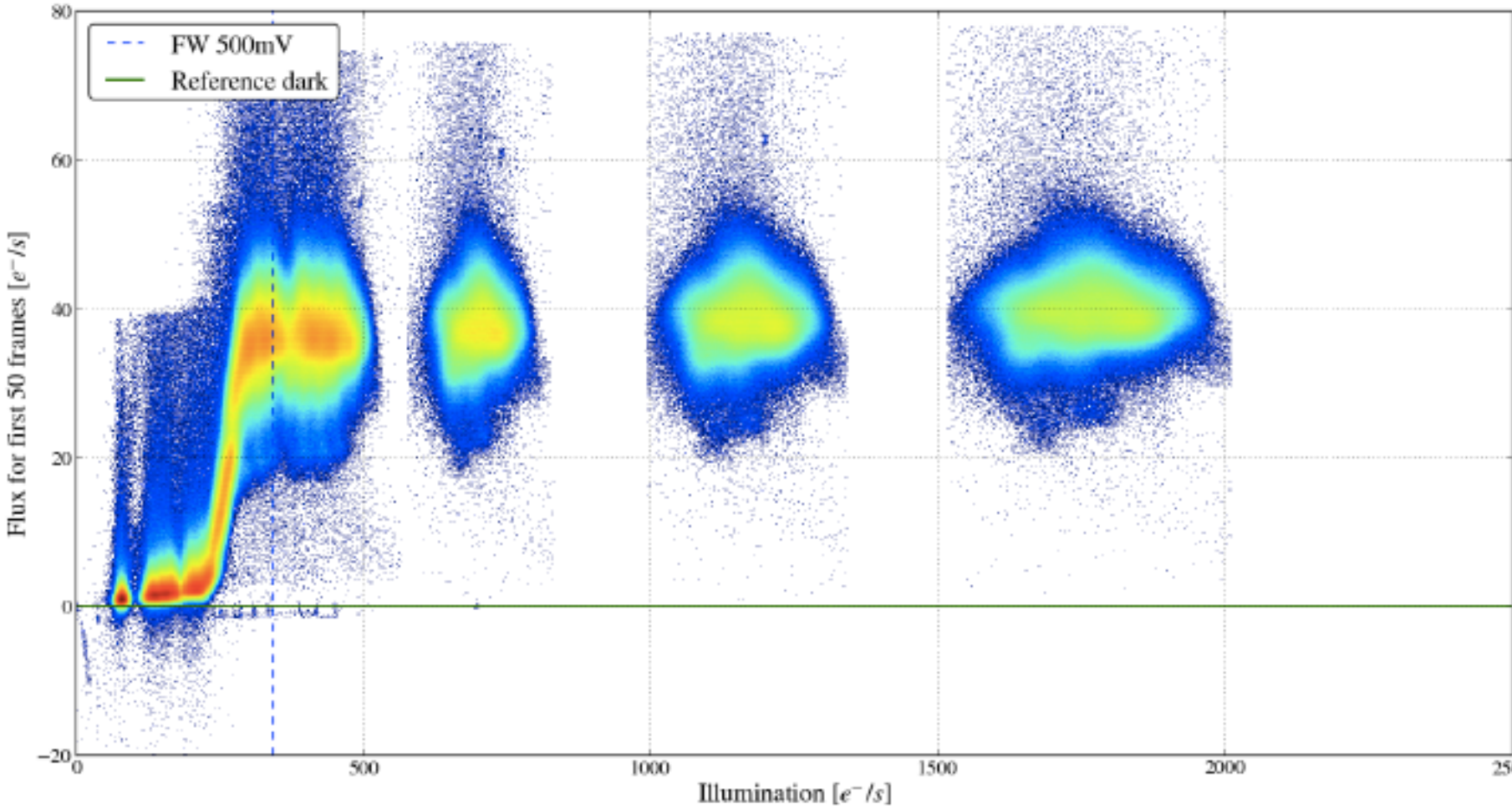


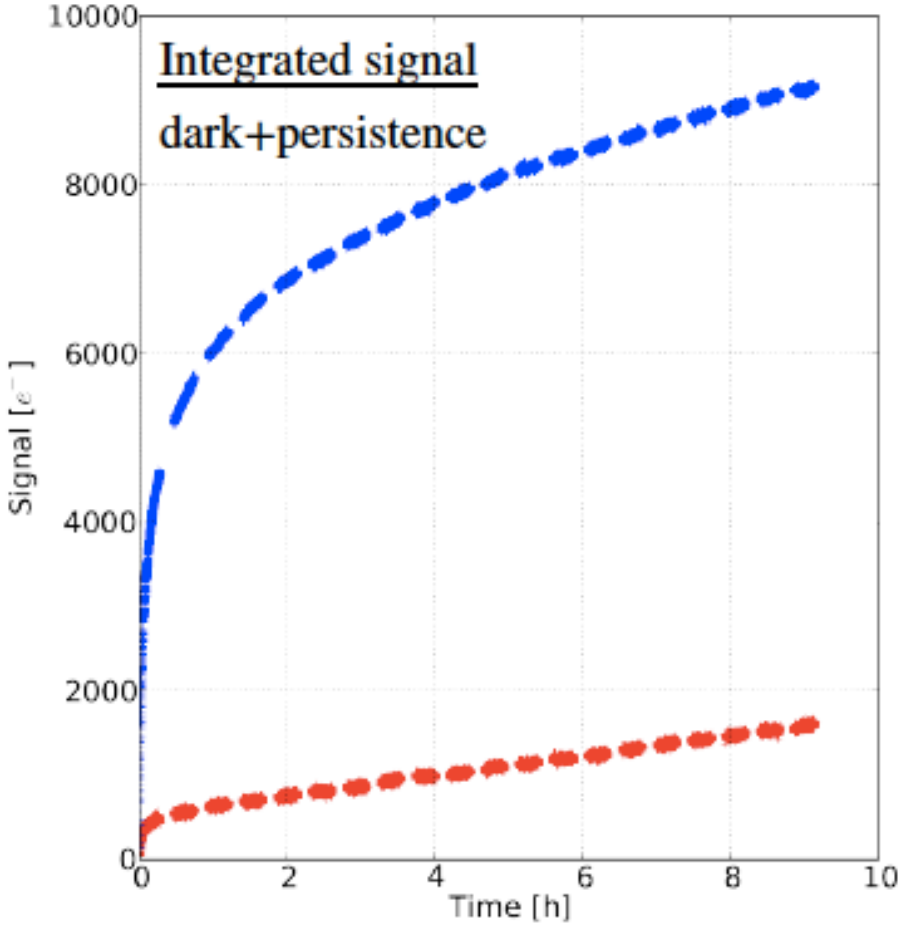


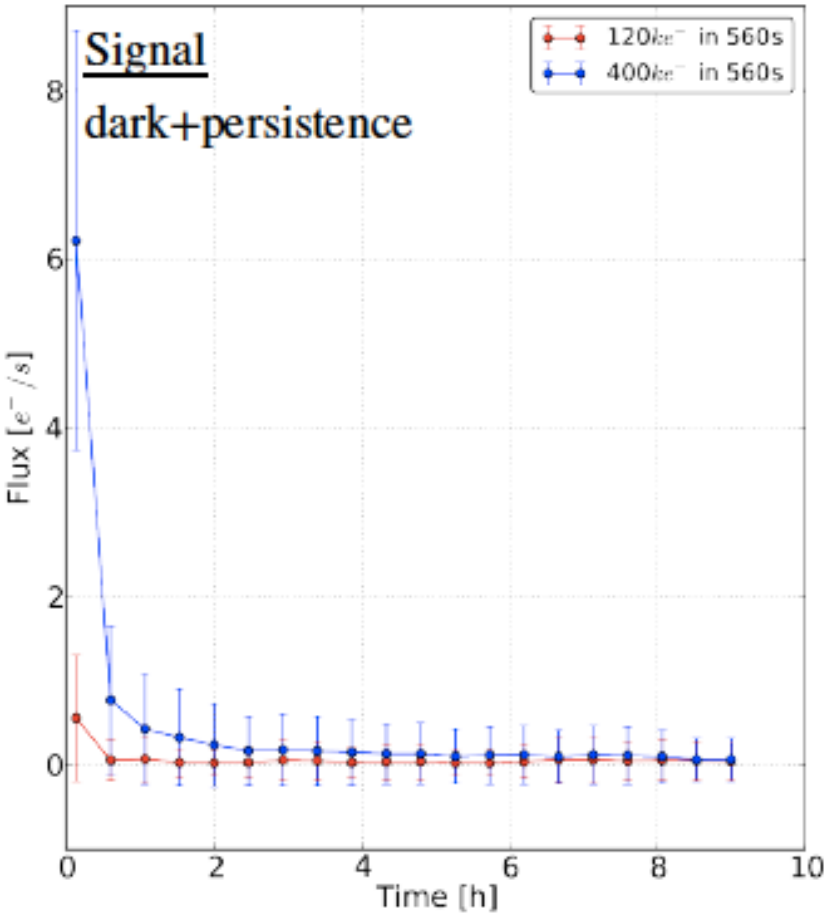
Persistence model

- We have used one detector in Euclid specifications to fit the persistence on a large range of pixels and for different illuminations and configurations.
- We have checked that one modelisation is able to reproduce the decay of all the pixels within the errors.
- We find that a multi exponential-law model of the persistence signal is well adapted

Persistence signal 70s after illumination





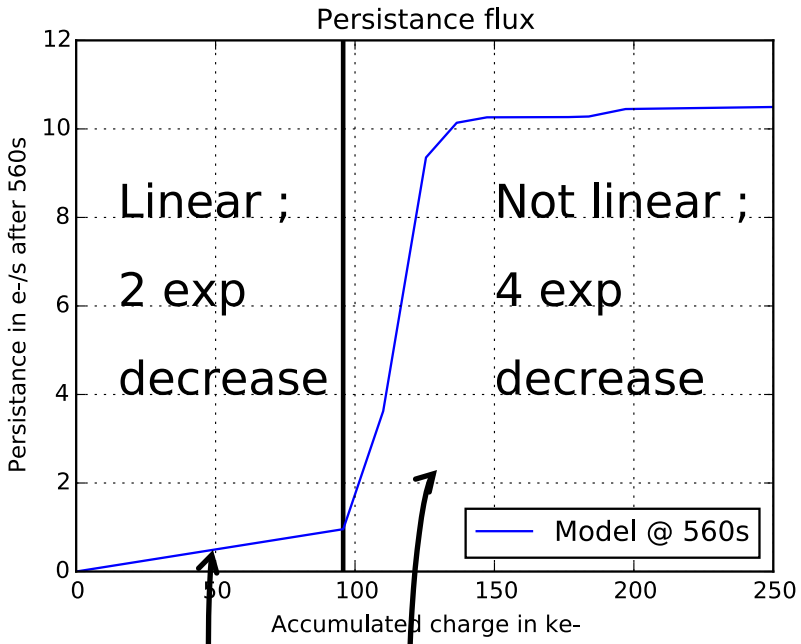


Under full well: Persistence decays to dark values within **2 hours**

Over full well: After **8 hours**, almost at the reference dark levels.

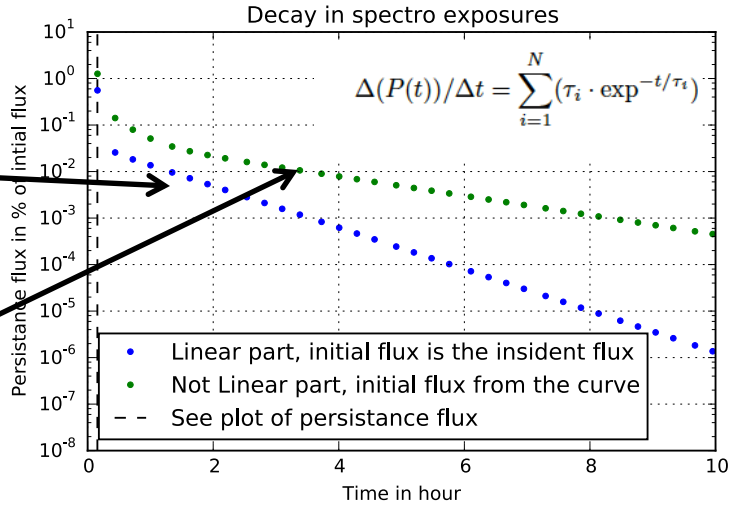
Model used for simulation

$$P(t) = \sum_{i=1}^{N} c_i \cdot e^{-t/\tau_i}$$



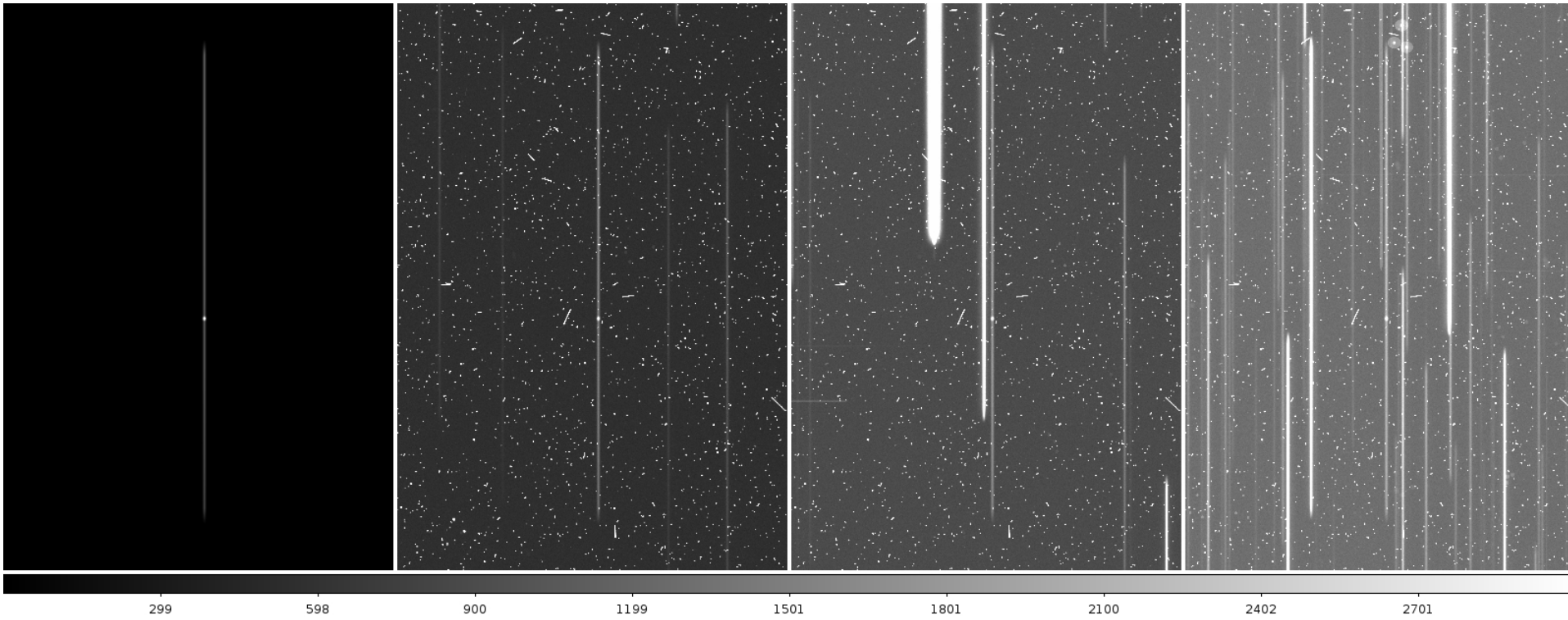
Below full well		
c_i [ADU/s]	2.0	0.039
τ_i [s]	170.0	3500.0

Above full well				
c_i [ADU/s]	51.7	12.7	1.54	0.285
τ_i [s]	19.8	170.0	1210.0	7510.0



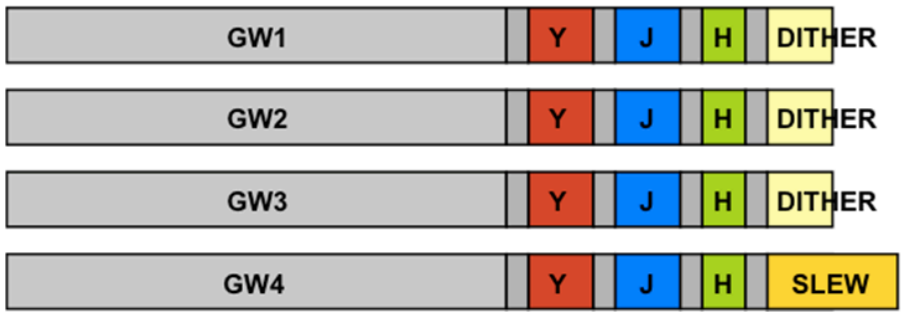
Zodi light + Dark + Readnoise + star + straylight + persistence + cosmic rays

Source BEST MEAN WORST

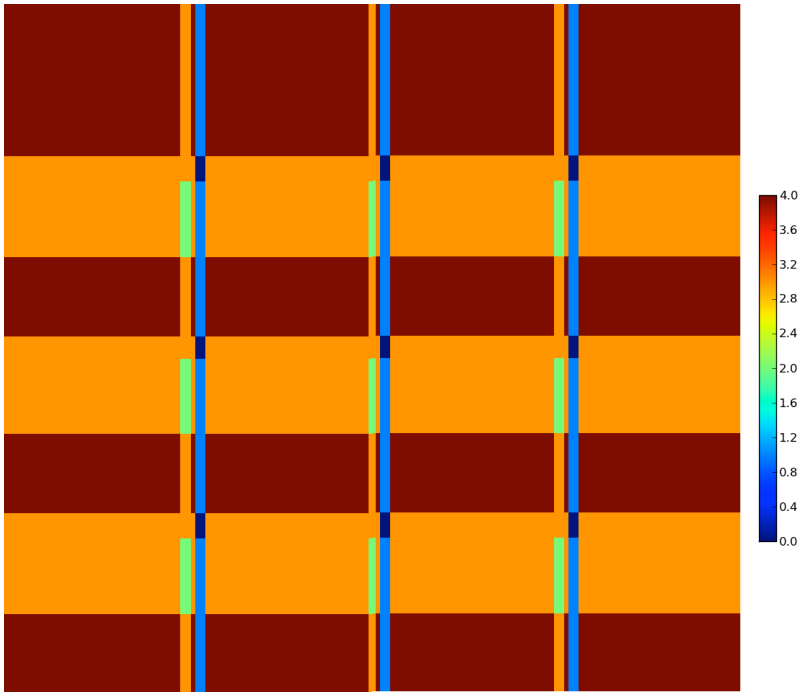


The NISP observational sequence

EUCLID CONSORTIUM



Observation mode	Red grism	Y	J	H
Exposure time (s)	560	105	83	82
Integration time (s)	565	110	88	87
Drift time (s)	30	20	20	60



Exposure sequence	1	2	3	4
Dither (arcsec)	(0,0)	(100, 50)	(100, 0)	(100, 0)
Grism	red 0deg	red 90deg	red 180deg	red 90deg

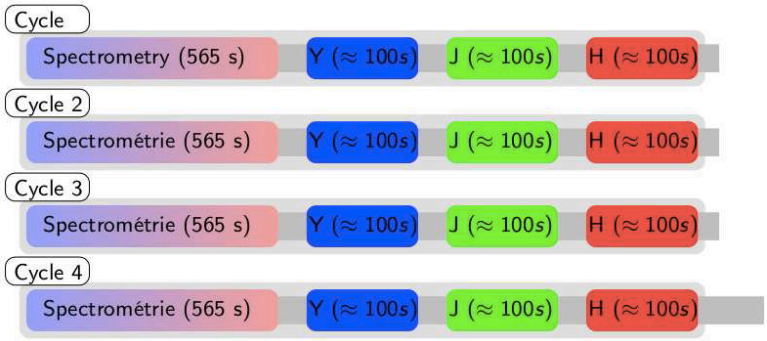
Only 50 % of the objects have 4 exposures.

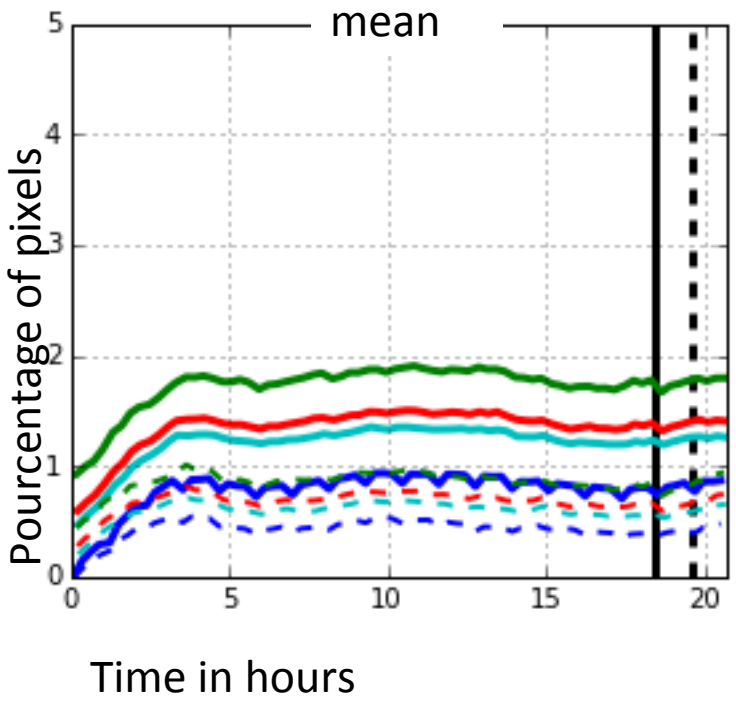
Persistence effect estimations

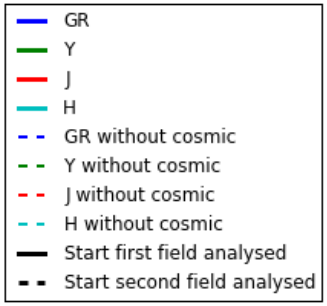
EUCLID CONSORTIUM

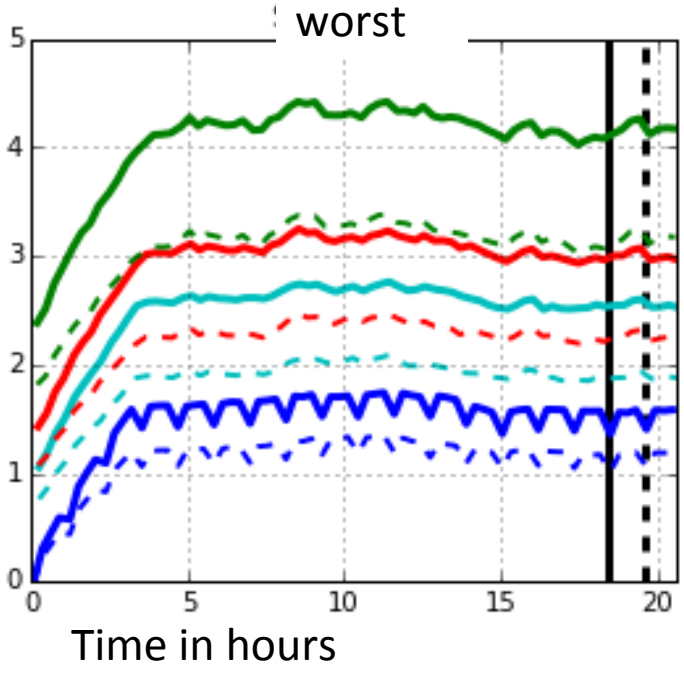
-Simulation of 16 full observational sequences
Grism + filters (18 hours)
-Analyse 2 next observations

Count pixel with persistence flux > 0.1 e^-/s

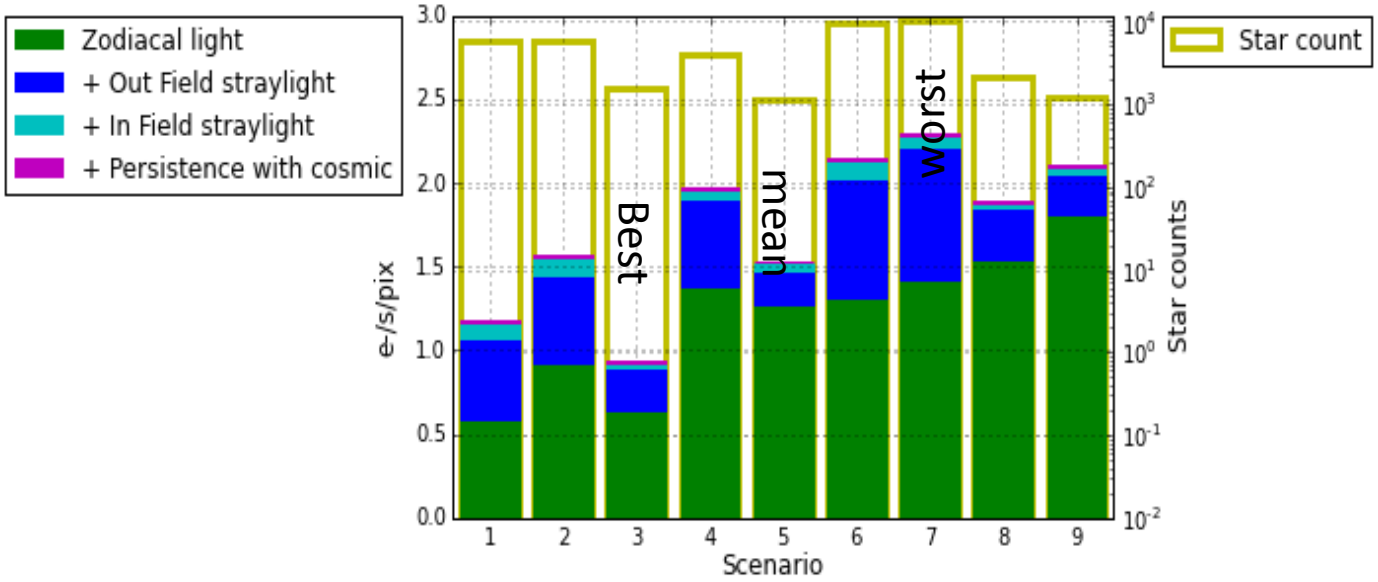




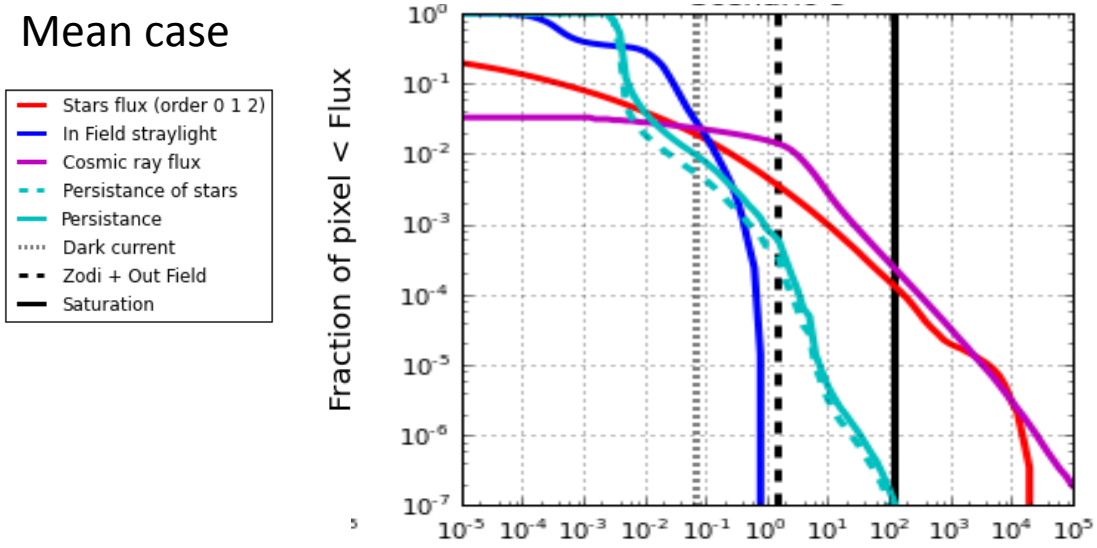




Adding all contaminations in the 9 scenarios



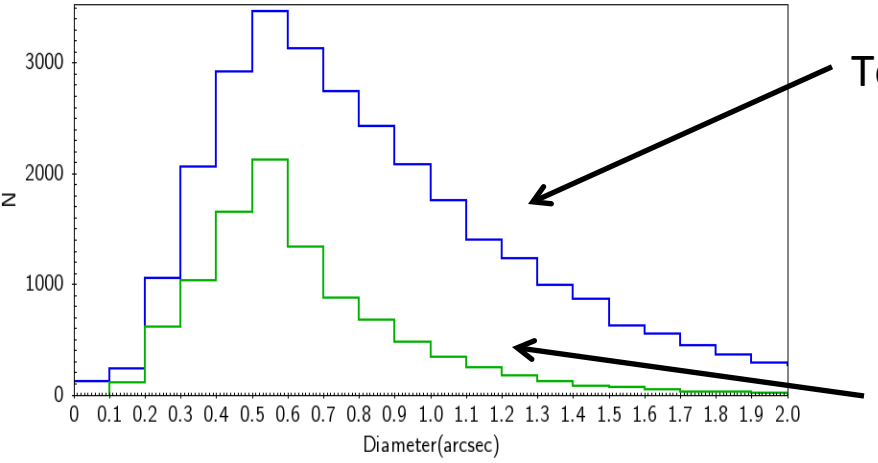
Mean case



COMPLETENESS AND PURITY EVALUATION

Imodel pipeline simulation

- Add galaxies with the same catalogue as in previous studies
- Add noise maps (= only the poisson effect)
- Run each pointing in the Imodel pipeline
- Compute redshift , completeness and purity

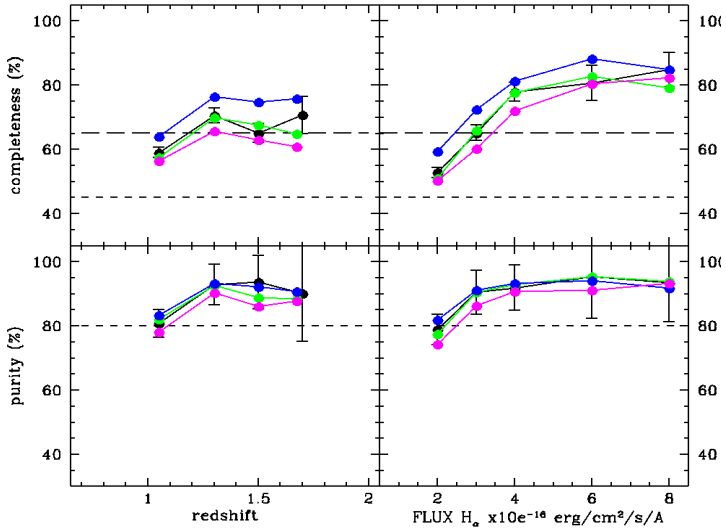


Total # galaxies of the catalogue

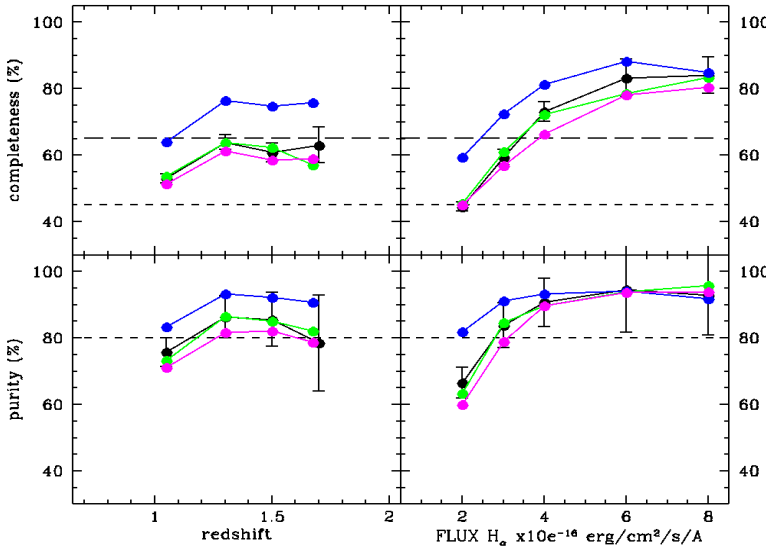
galaxies of the catalogue with Hα flux > 2 10^{-16} e/s/pixel and 0.9 < z < 1.8 used to compute Purity (P) and Completeness (C)

Imodel

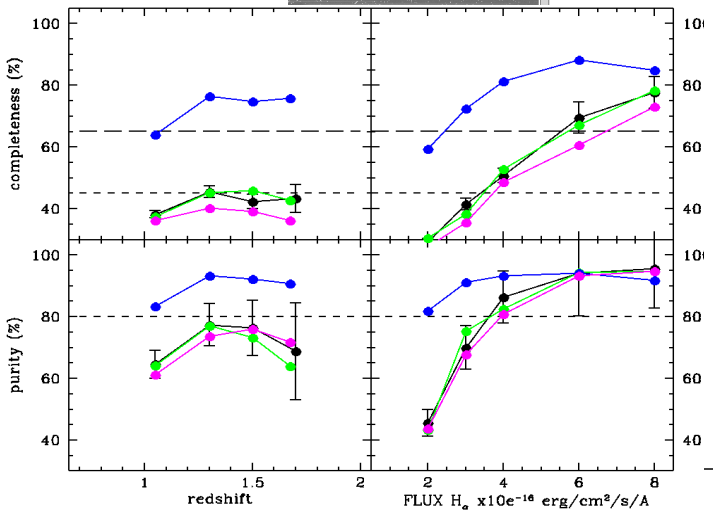
BEST



MEAN



WORST



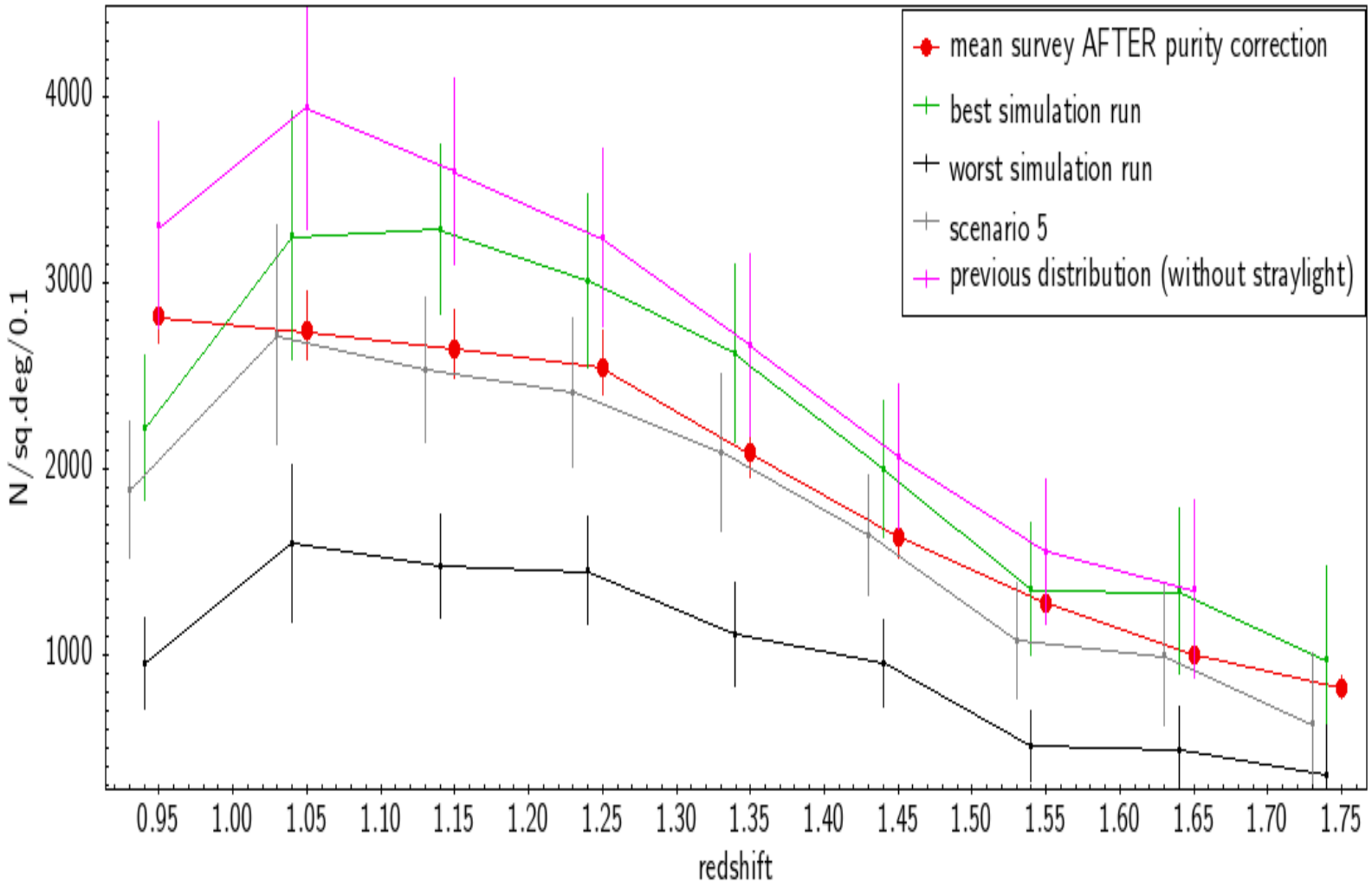
Only sky

+ stars+ out-of-field + in field

+ persistence

+ cosmic

Final distribution Dn/dz (level 1)



*Need a luminosity function : based on (Pozetti et al 2015)

Summary of the studies

Test	Sample*	Completeness	Purity	N_{gal} (sq.deg) (before purity)	N_{gal} (sq.deg) (after purity)
Minimal zodiacal light only	Scenario 3	0.67	0.87	2627	2284
Stray light contribution	Scenario 3	0.60	0.85	2362	2010
Stray light contribution	Reference survey	0.53	0.79	2087	1641
Stray light contribution,	Scenario 5	0.53	0.76	2100	1605
Stray light + persistence	Scenario 5	0.54	0.75	2117	1597
Stray light + persistence + cosmic with persistence	Scenario 5	0.52	0.72	2054	1470

-Scenario 5 has been found to be the most representative of the mean reference survey :

-This scenario is compliant with the SNR requirement and the completeness requirement

-Purity is below requirement of 0.8

Conclusions

- The addition of straylight noises, inside NISP images, results in a relative decrease of the completeness of about 10-15% and a relative decrease of purity of 5%-10% as well.

- This nuisance is primarily caused by the Out-of-Field stray light contamination that is increasingly growing when the star density increases.

- Contaminations of NISP by persistence effects (bright sources and cosmic rays hits) have a relative impact on completeness 2 to 3 times smaller than stray light.

- Star density is a parameter that directly impacts on NISP spectroscopy

⇒ it should be seriously taken into account during the field selection process and survey optimisation.

SNR ETC versus SNR 2D

Method	SNR ETC	SNR 2D
Principle	Analytic formulae: $\frac{\int_0^r Signal}{\sqrt{\int_0^r S + B + RN^2}}$	Numerical with images: $\frac{\Sigma}{\sqrt{\Sigma}}$
Resolution	Radius at EE80	Pixel – radius..
Computation	Fast	Slow
Application	Requirement flow down Bypass	Validation at the image level

SNR 2D CAN BE USED to compute SNR with :
- One pixel
- Synthetic object with known size and flux (convolved with EE80)
- Real galaxy profile (convolved with EE80)
- A full image -> SNR for all pixels with different realizations and all effects->BYPASS

Imodel simulation Pipeline

Prototype of pipeline to compute redshift and reliability, completeness and purity on images. *(B.Garilli et al)*

-Do a full extraction of 1D spectra in images using AXE
-Do a combination of rolls taking dithering and gaps into account
-Do a blind search of emission line

Assign a reliability flag to each measure (EZ,Garilli et al. 2010, PASP 122, 827)

- given the redshift, *back* search on spectrum all expected emission lines (Hα, SII, OIII, Hβ…) with a lower S/N threshold (S/N≥2)

– all/most expected lines are found	**reliability >= 90%**
– half of expected lines are found (and half >=2)	**reliability = 75%**
– Only one line is expected and found	
S/N>5	**reliability 65%**
S/N<5	**reliability 50%**
– No emission line found	**reliability 0%**

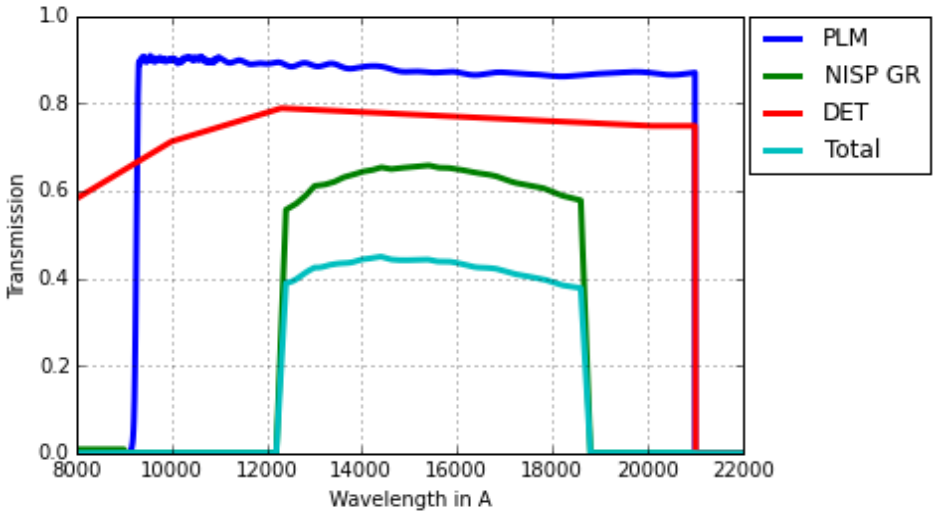
Completeness = objects for which measured redshift has reliability ≥ threshold

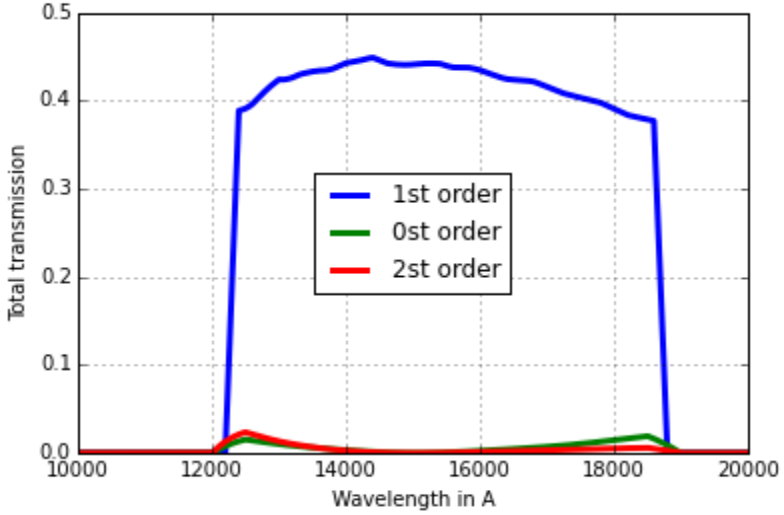
Purity = reliable objects for which redshift is correct within 3σ

The NISP instrument model

EUCLID CONSORTIUM

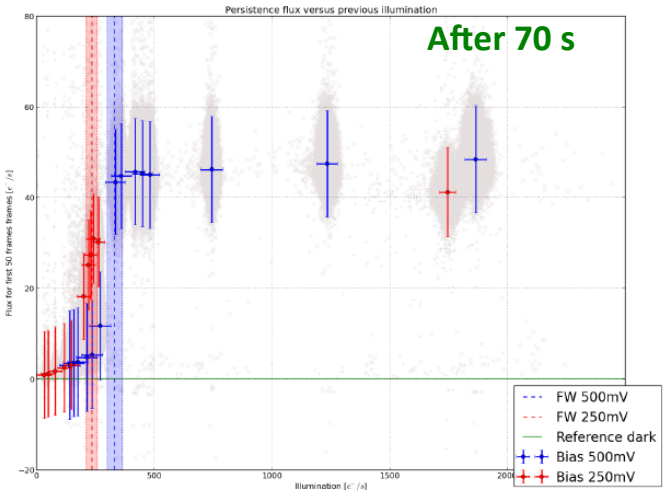
Collecting area	10066.0 cm²	Number of detector	4x4
Grism	Red grism 0deg	Gap in the X direction	3mm + 8 ref. pixels
	Red grism 90deg	Gap in the Y direction	6mm + 8 ref. pixels
	Red grism 180deg	Field of view limit	5mm
	Blue grism	Number of pixel	2040x2040 pix per det.
Dispersion	13.4 Angstrom/pixel	Pixel size	18µm
PSF EE50	0.355 arcsec	Pixel scale	0.3 arcsec
PSF EE80	0.684 arcsec	Total noise	

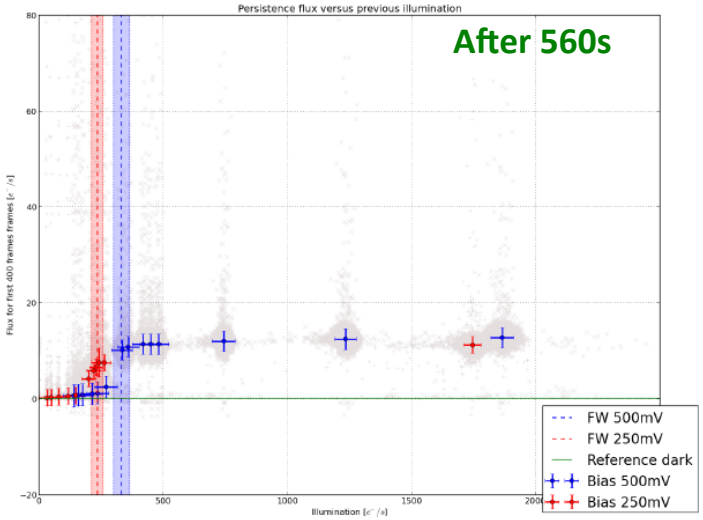


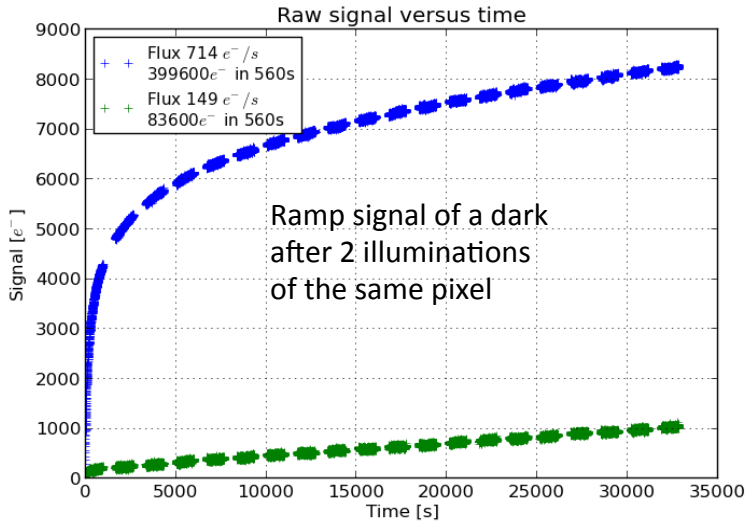


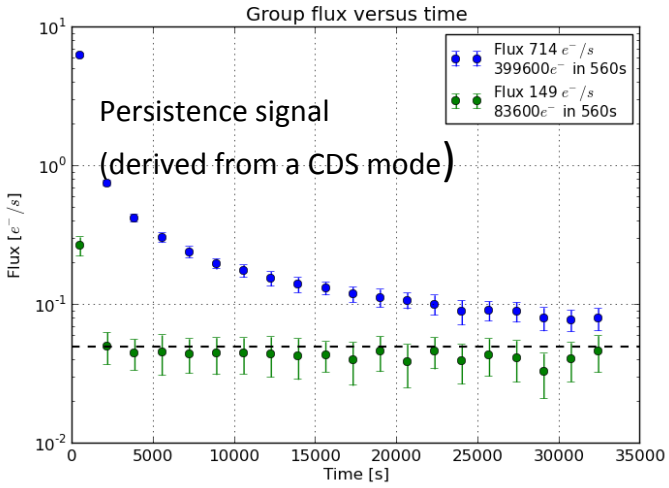
Persistence data

As function of the incoming flux

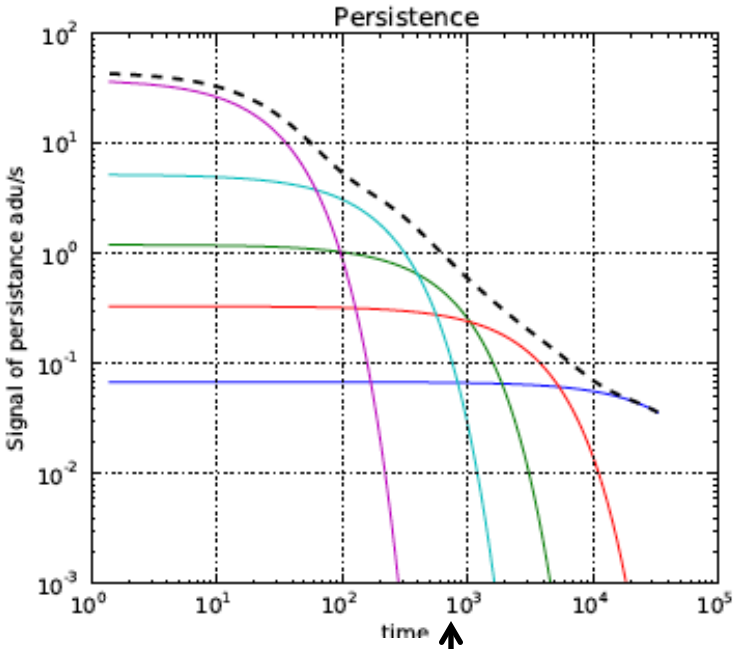


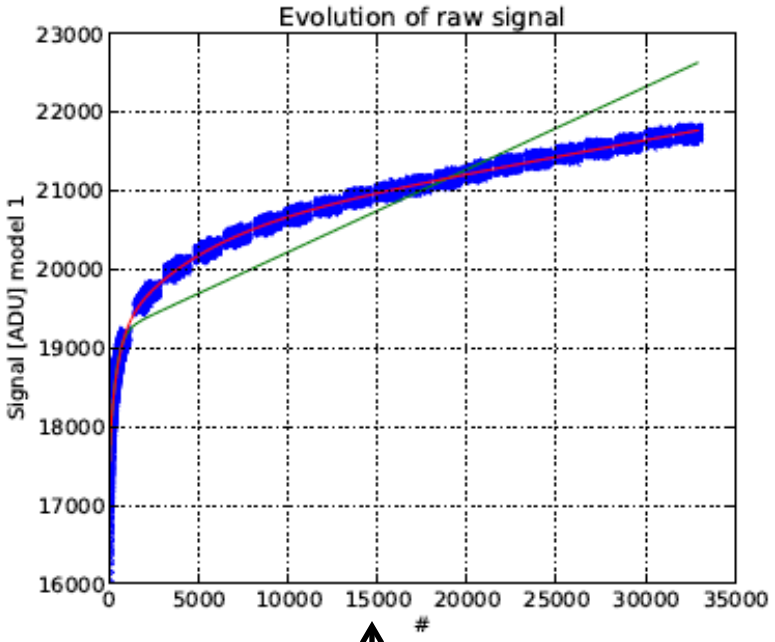






Model = sum of exponential decay laws



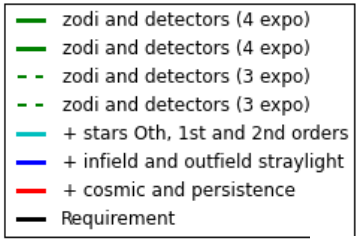


$$\Delta(P(t))/\Delta t = \sum_{i=1}^{N} c_i \cdot \exp^{-t/\tau_i})$$

$$P(t) = \sum_{i=1}^{N} (c_i \tau_i \cdot (1 - \exp^{-t/\tau_i}))$$

SNR2D comparison of effects

EUCLID CONSORTIUM

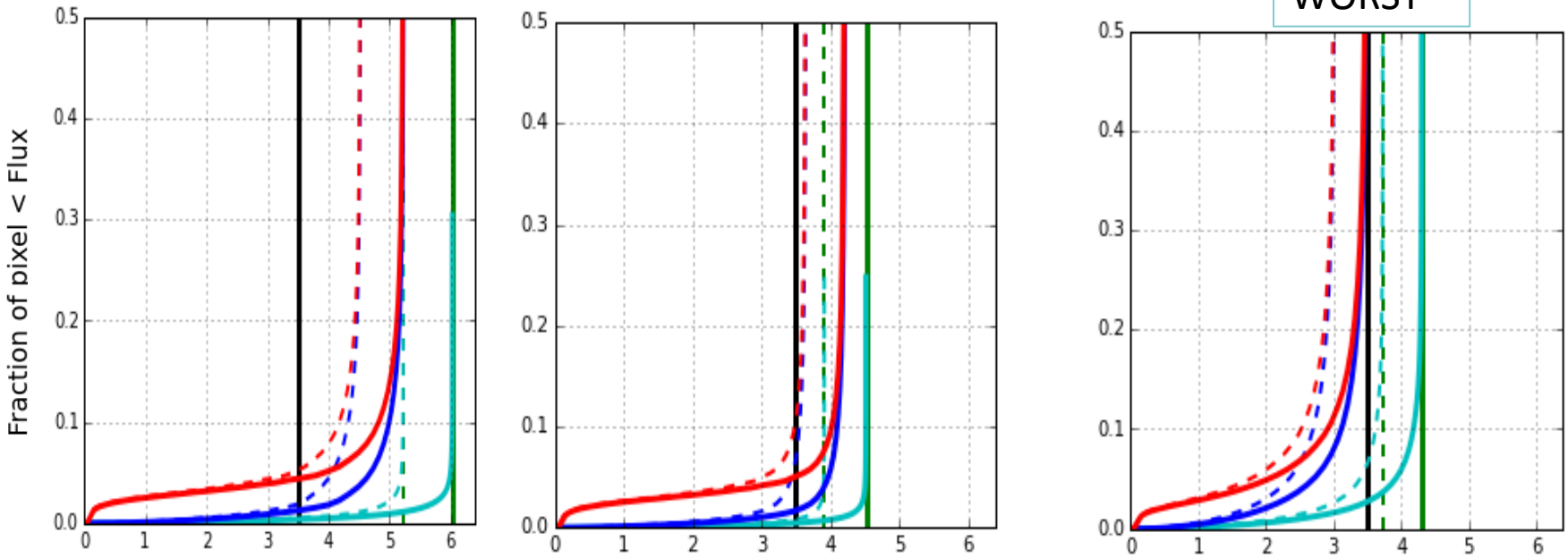


2 10^{-16} erg.cm2.s-1 @1.6micron and size =0.5''

BEST

MEAN

WORST



Zod + stars

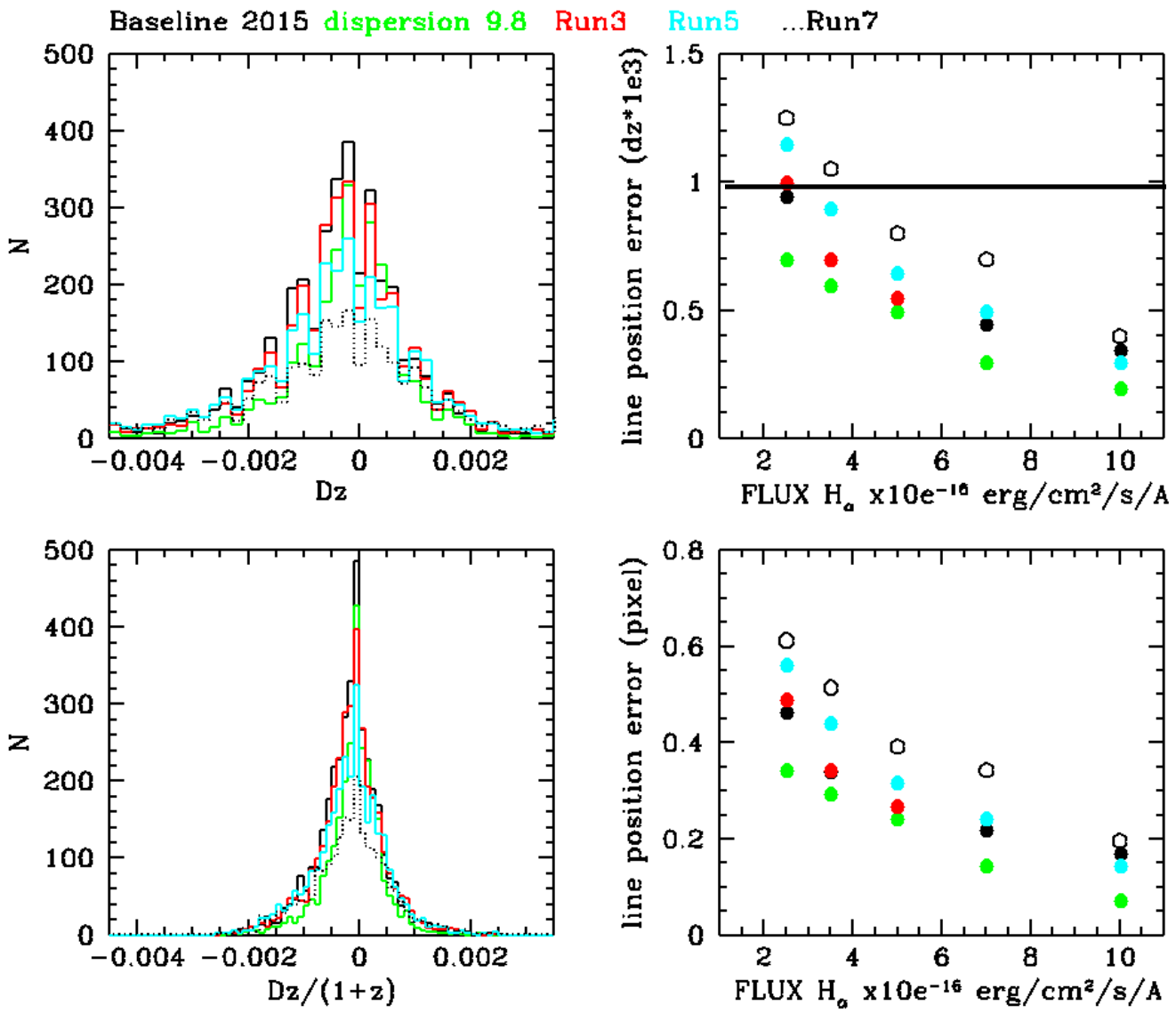
+ Straylight

SNR

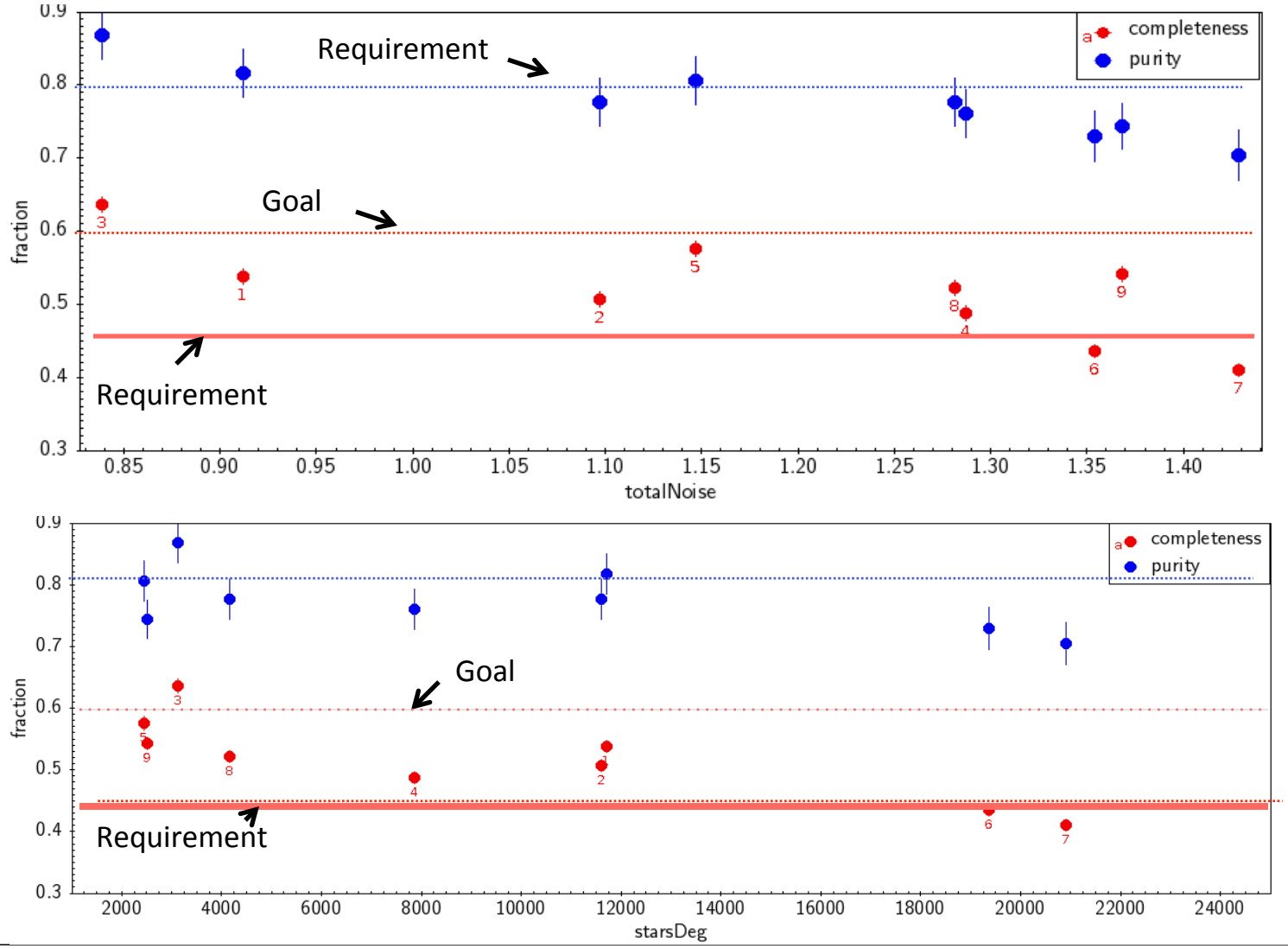
+ cosmic
+ persistence

Signal to Noise Ratio

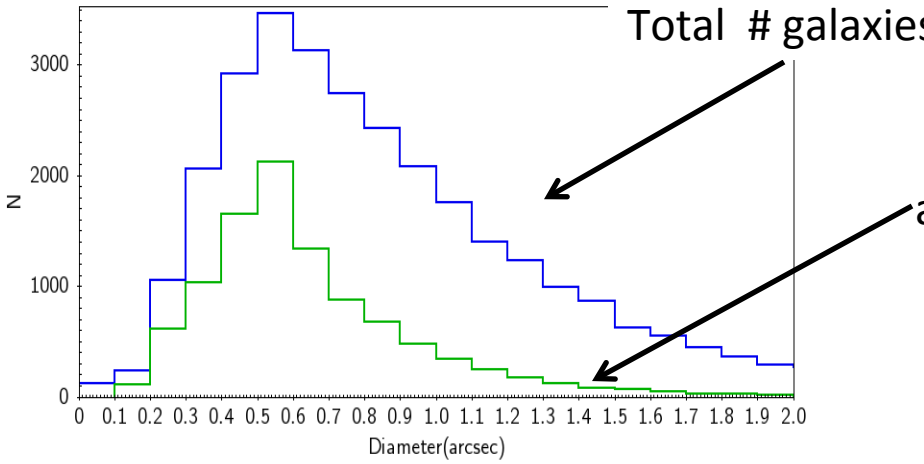
Redshift error (< 0,001(1+z))- level



Global results with Imodel



Completeness and Purity



galaxies with Hα line flux > 2 10^{-16} e/s/pixel and 0,9<z<1,8 = Ntotal(zt, F)

- ✧ zt = true redshift
- ✧ zm= measured redshift

COMPLETENESS = $$C(z,F) = \frac{N(z_m,F)}{Ntotal(zt,F)}$$

PURITY = $$P(z,F) = \frac{N((z_m - zt) < 0{,}001(1+z), F)}{N(z_m,F)}$$

The NISP instrument model

EUCLID CONSORTIUM

Collecting area	10066.0 cm²	Number of detector	4x4
Grism	Red grism 0deg	Gap in the X direction	3mm + 8 ref. pixels
	Red grism 90deg	Gap in the Y direction	6mm + 8 ref. pixels
	Red grism 180deg	Field of view limit	5mm
	Blue grism	Number of pixel	2040x2040 pix per det.
Dispersion	13.4 Angstrom/pixel	Pixel size	18µm
PSF EE50	0.355 arcsec	Pixel scale	0.3 arcsec
PSF EE80	0.684 arcsec	Total noise