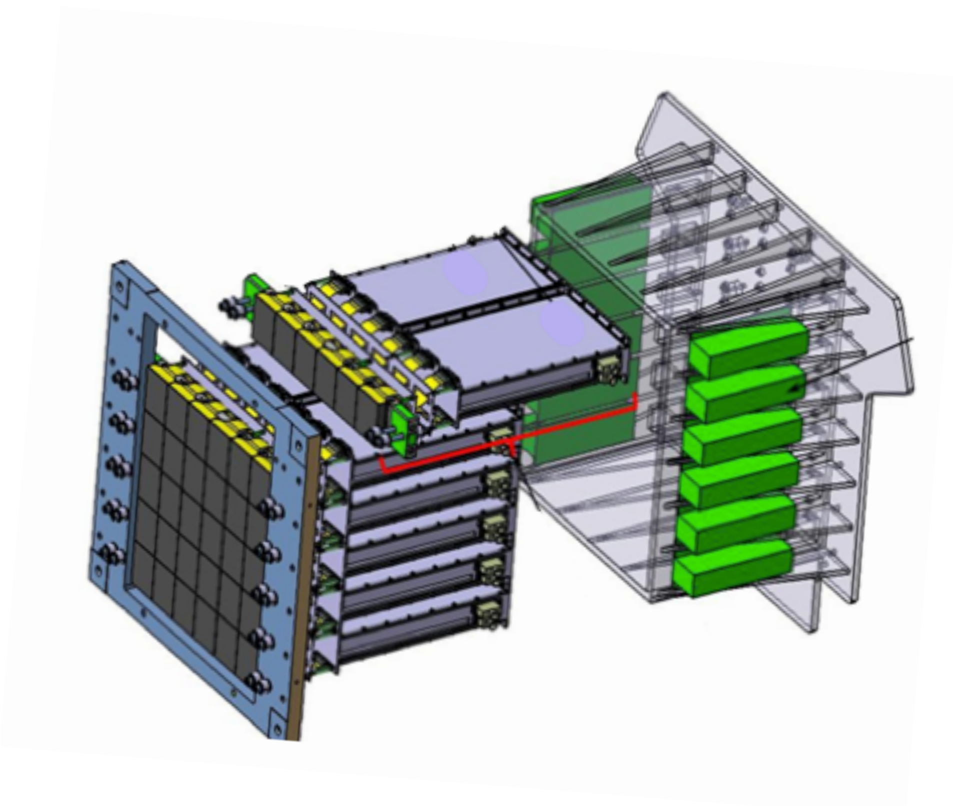
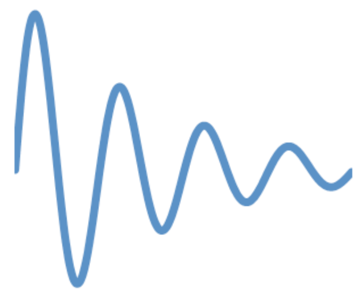
OU-VIS





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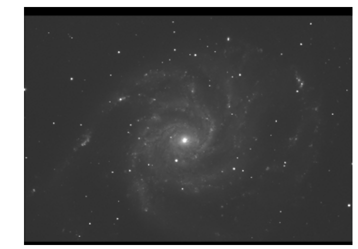
Calibrated images



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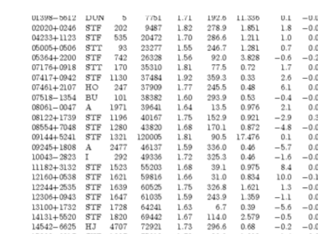
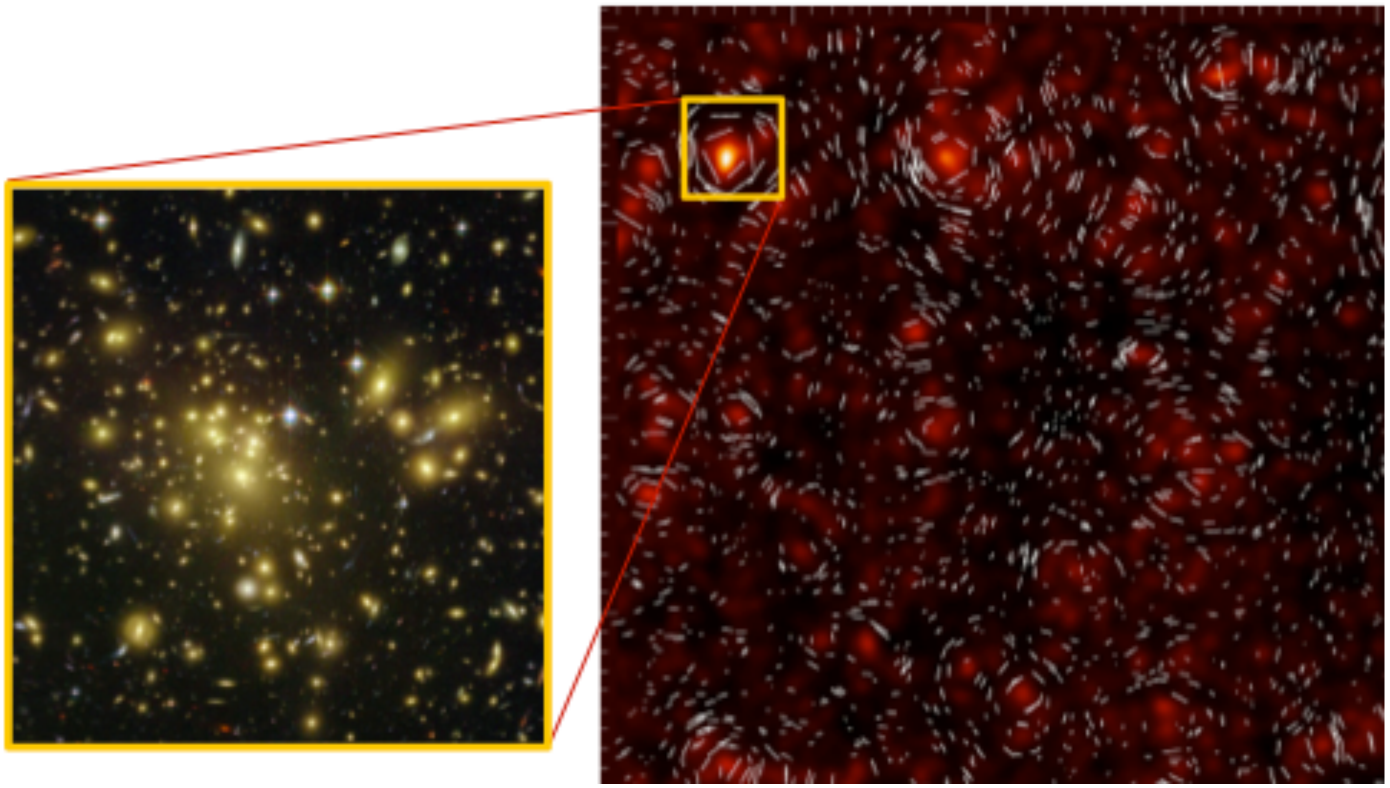
Catalogues

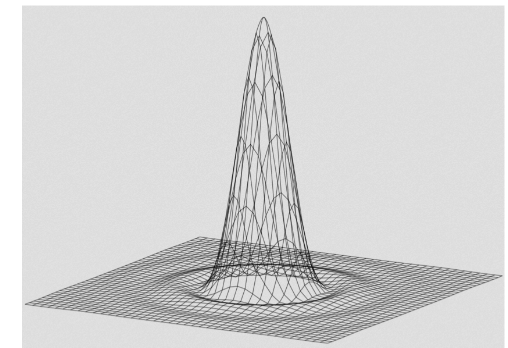


Patrick Tisserand (IAP)

OU-VIS team : *Catherine Grenet, Henry Joy McCracken, Kevin Benson, Sibylle Techene, Olivier Herent, Patrick Hudelot, Raphael Gavazzi, Richard Massey, Israel Holger, Mike Irwin, Eduardo Gonzalez-Solares, Marco Riello, Chris Dolding, Mark Cropper and Ruyman Azzollini*

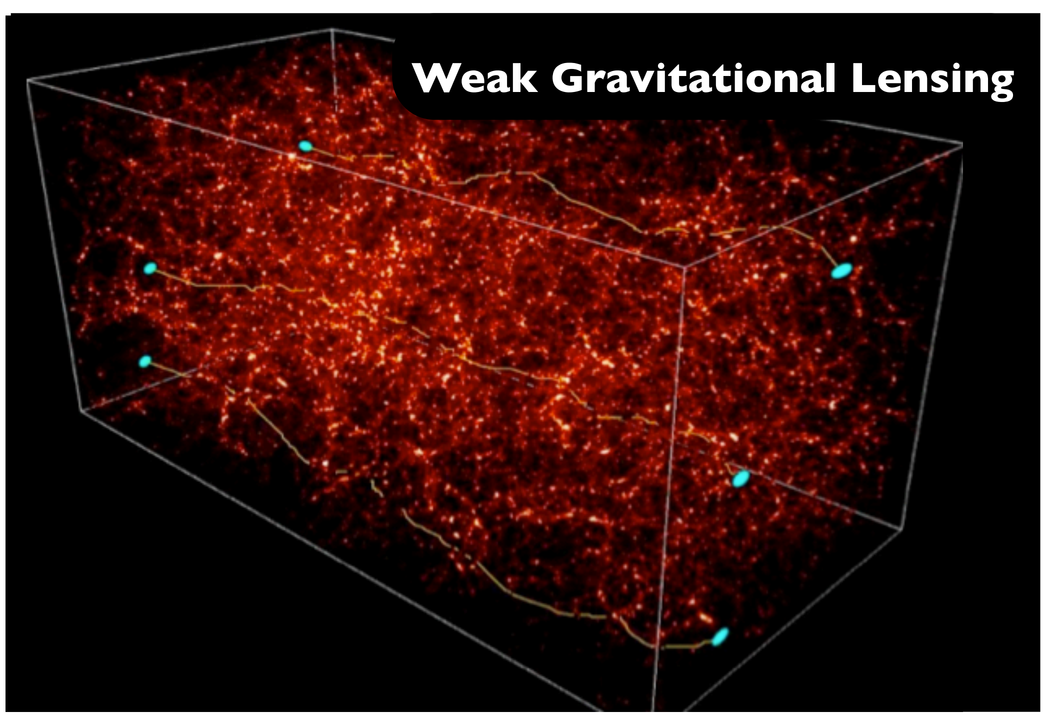
VIS: focus on PSF





PSF variation in wavelength, flux and position across the field

➡ It drives most of the VIS requirements



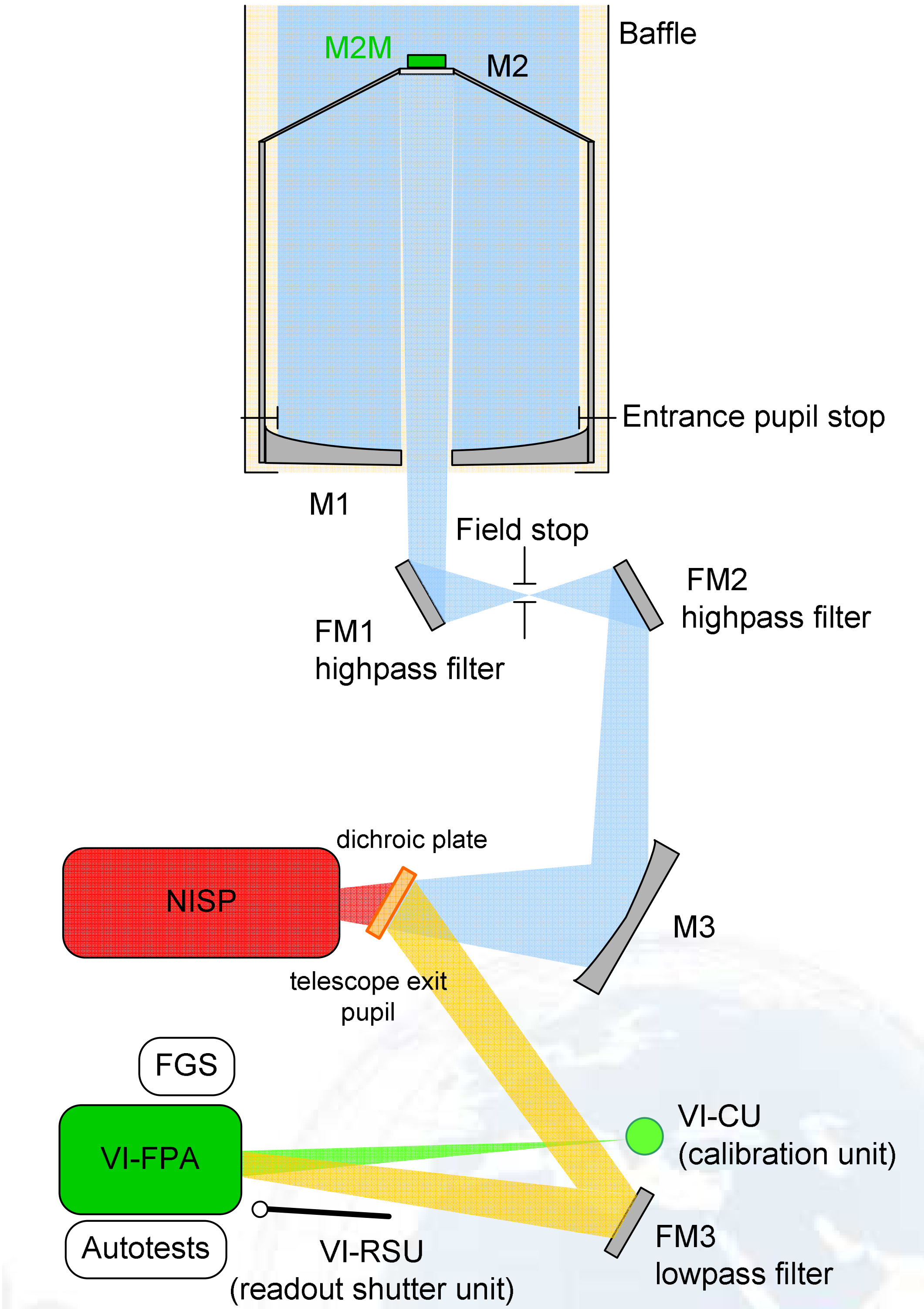
Calibrate VIS images: remove all known instrumental effects
related to the optics, detectors and electronics

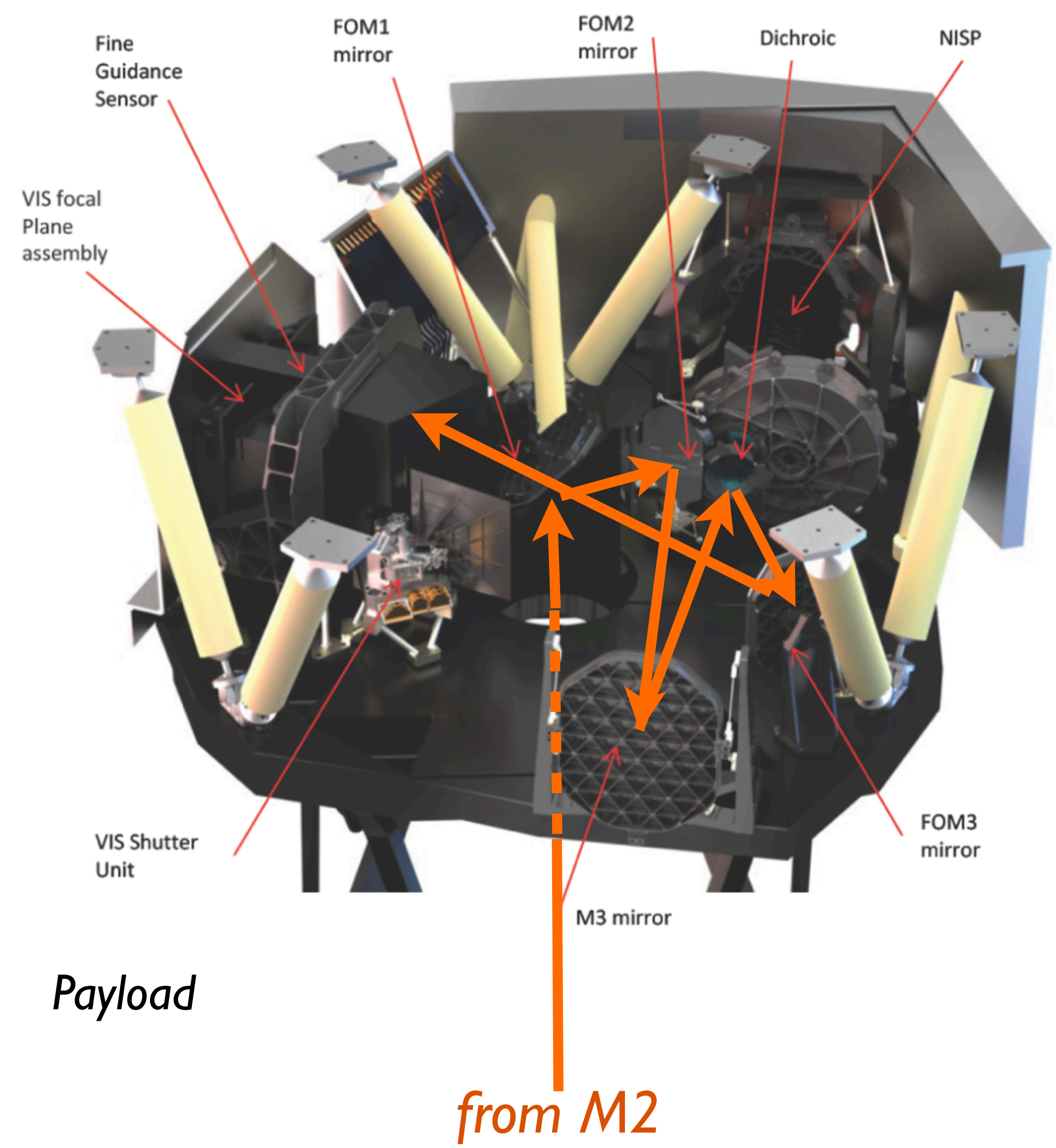
Knowledge of the systematics and their evolution is crucial !

➡ Use of specific calibrations images to estimate them.

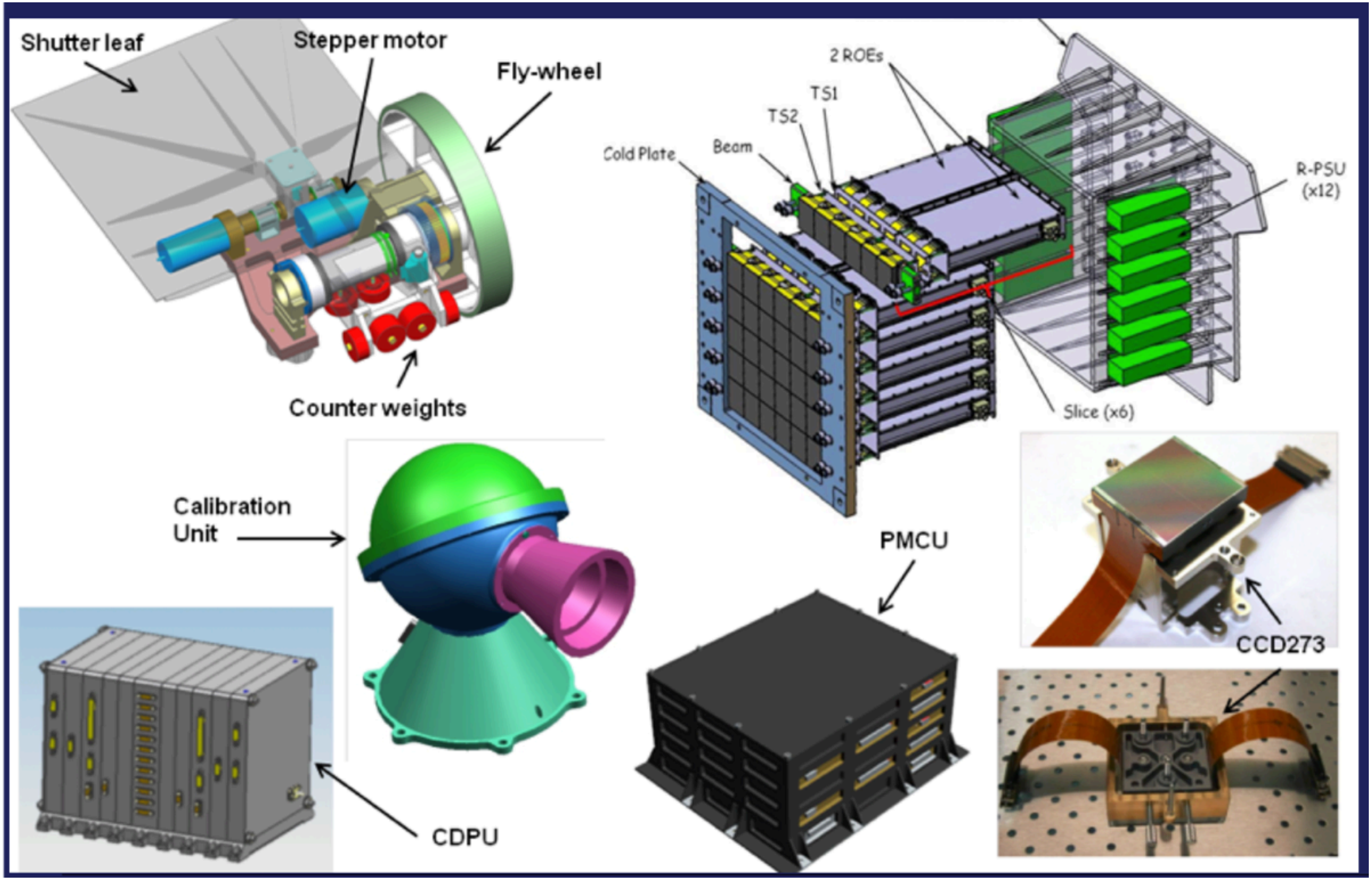
Optical path

Korch telescope , anastigmat, 1.2 m diameter



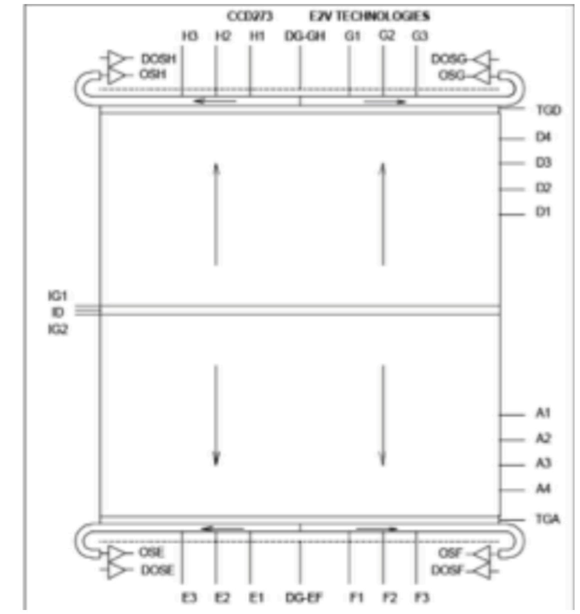


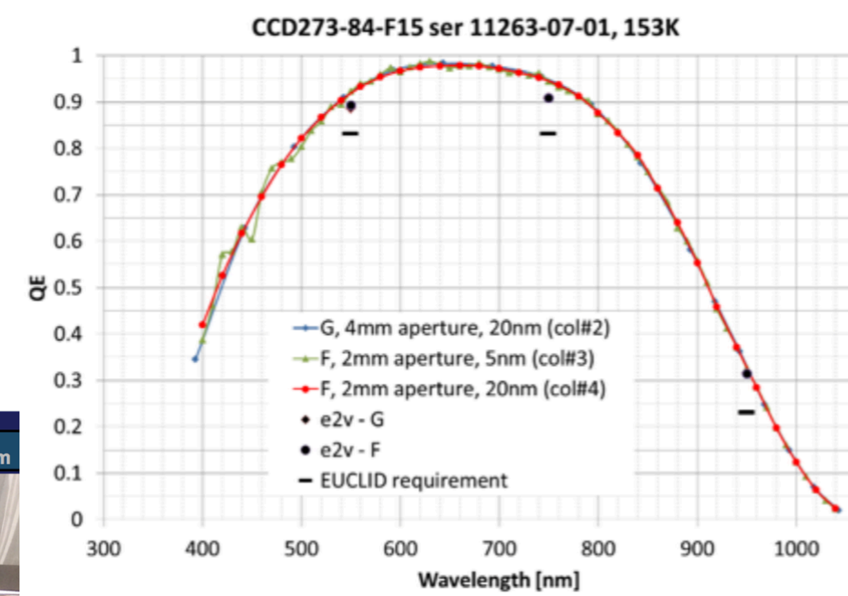
VIS subsystems

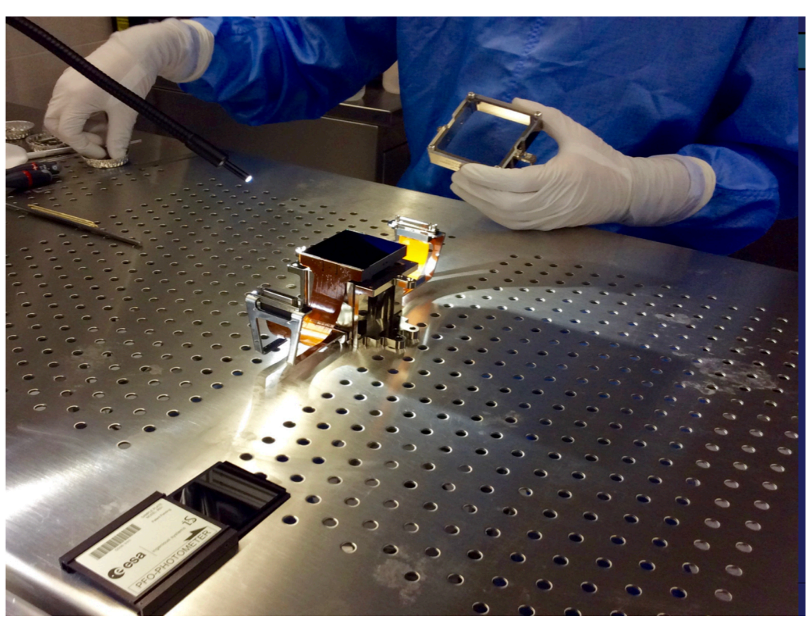


Some characteristics

- Camera : 0.54 deg^2 FoV
- 0.55 < lambda < 0.9 microns
- 36 4kx4k e2v CCD-273
    - 12x12 micron pixel size
    - 4 read-out circuits
    - back-thinned to 40 micron
    - read noise < 4.5 e-
    - charge injection line
- Pixel: 0.1 x 0.1 arcsec
- PSF FWHM : 0.18 arcsec
- 565 s exposure (+ possibilities of shorter exposures)
- gap between CCDs : ~50 arcsec..

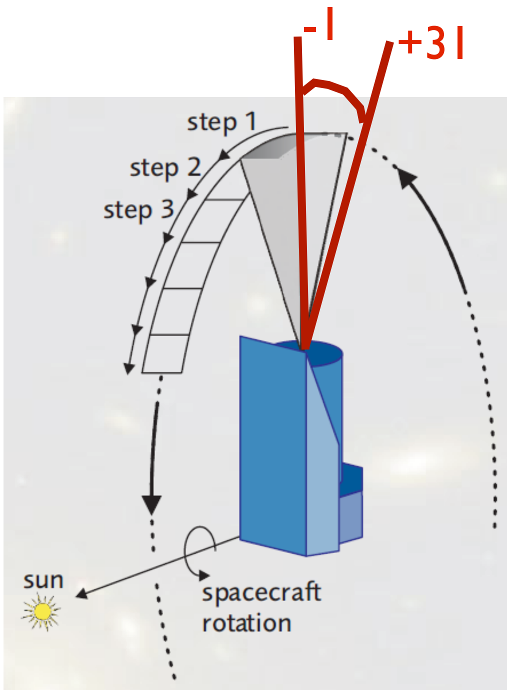


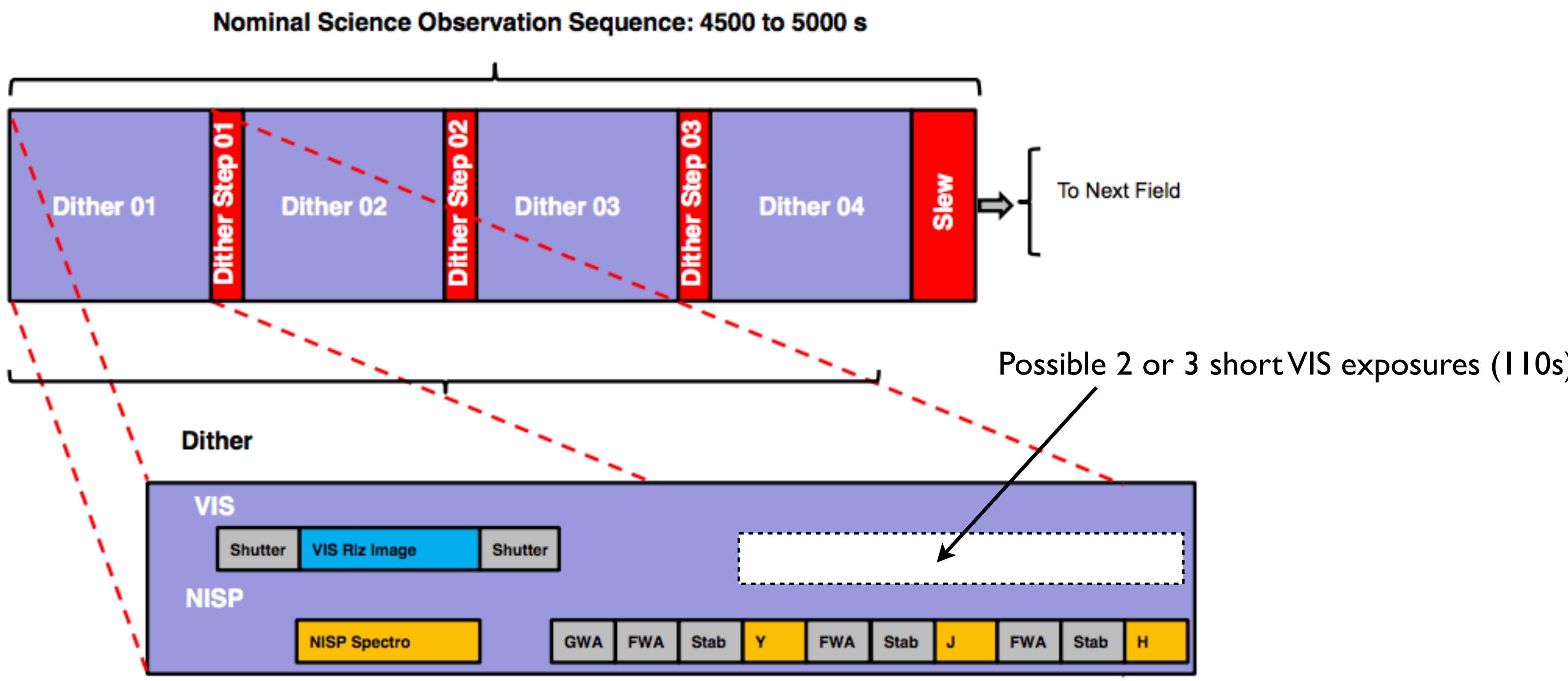


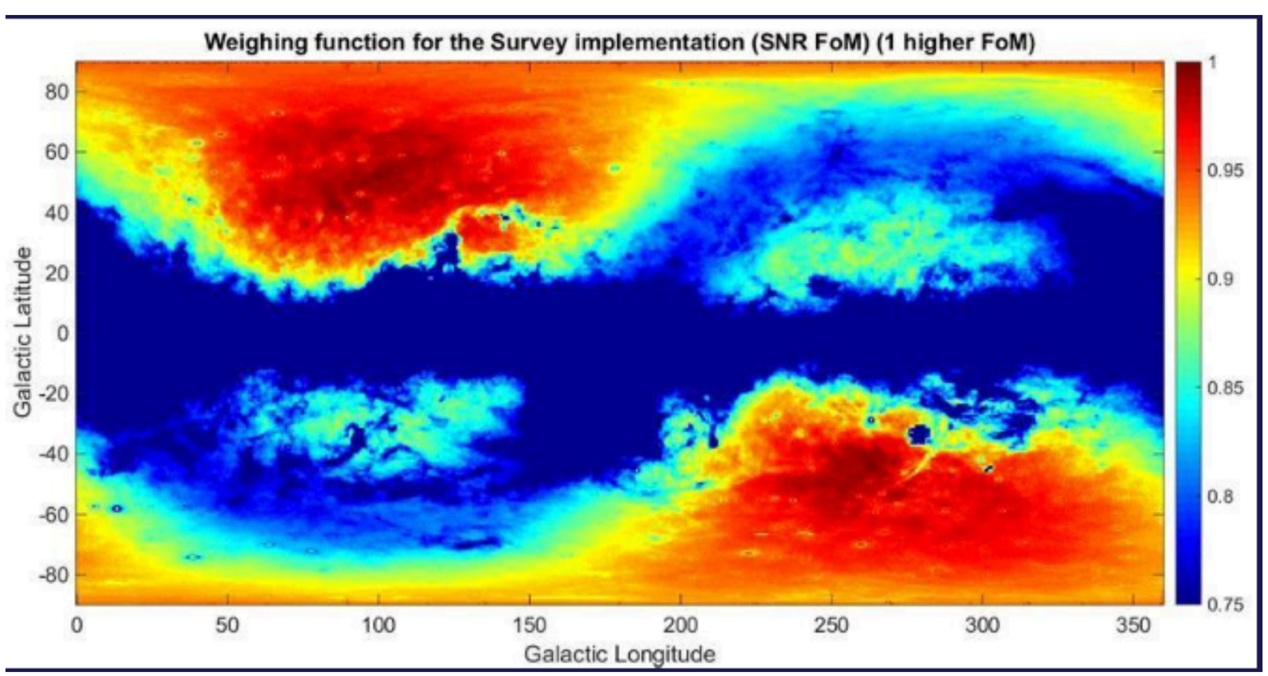


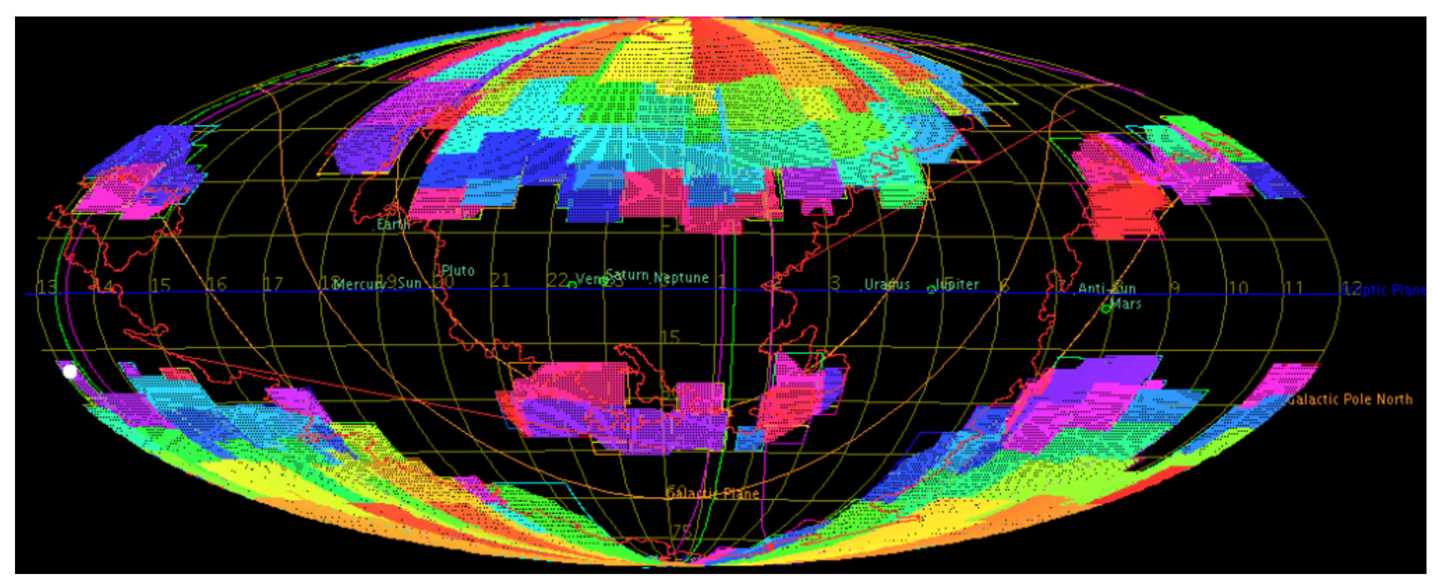
Euclid Wide Survey

Wide field survey of 15 000 deg^2 with |b| > 30 deg
Strong constraints on: Galactic extinction, stellar density, zodiacal light









Preliminary simulation of the scheduler
(colour coded per year)

OU-VIS Processing function

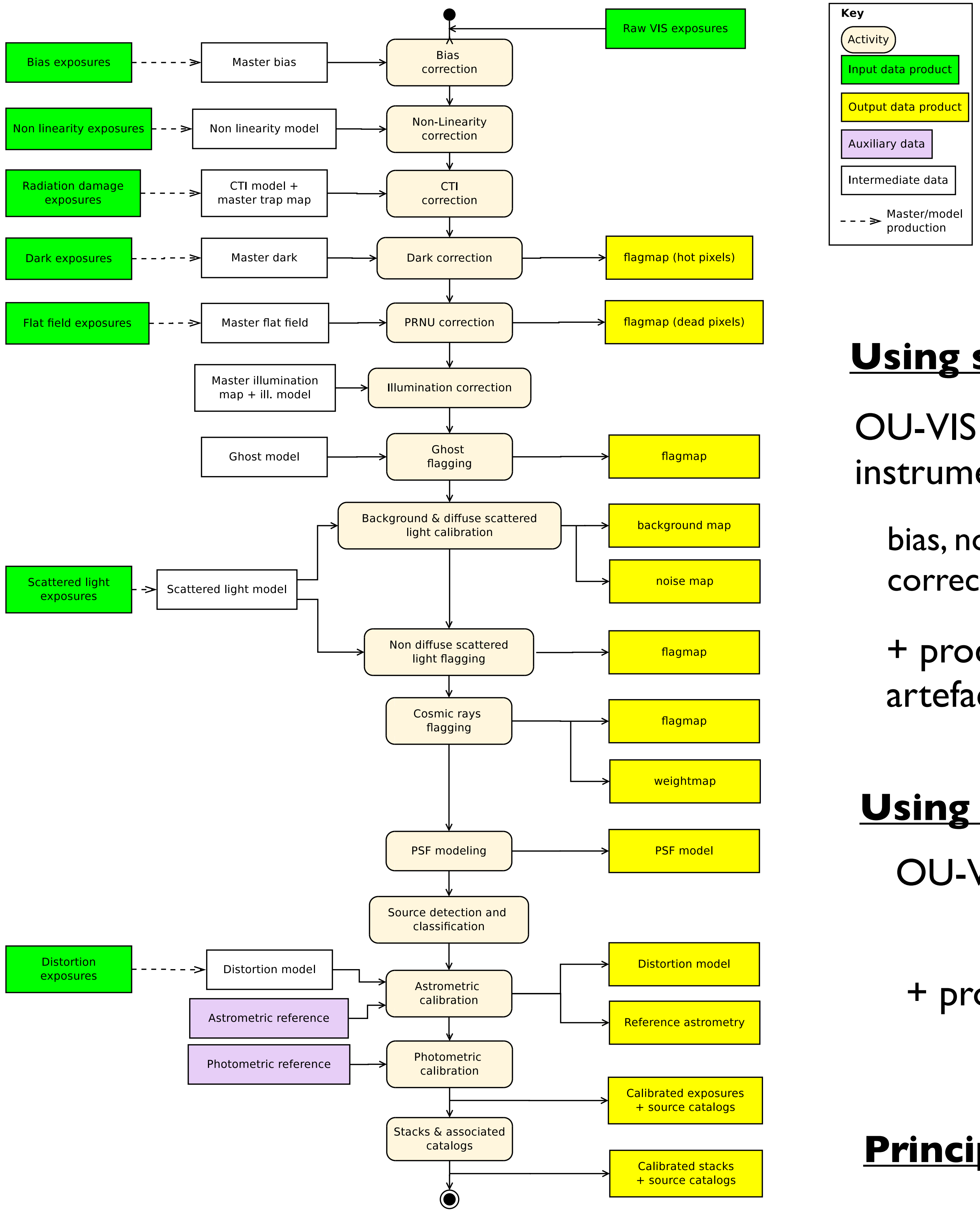


Figure 5-2: VIS processing function activity diagram

Using specific calibration data:

OU-VIS should correct every raw exposure from the instrumental effects:

bias, non-linearity, CTI, pixel-pixel non-uniformity, illumination correction, scattered light..

+ produce maps of artifacts (cosmics rays, ghosts, electronic artefacts..) and of the background / noises.

Using external data:

OU-VIS should produce the *astrometric* and *photometric* solution for every exposure

+ produce stack images, and catalogue of sources

Principal clients: OU-SHE and -MER, but also -NIR and -EXT

OU-VIS PF roadmap

VIS PF development is done by successive versions. The schedule of the major versions is recalled below:

Version	Status - Constraints	Delivery date	Required maturity level
v0	Breadboard - SC#2, TK1	2016 April	2A
v1	Breadboard - SC#3	2016 December	2A
v2	Development - SC#4,5,6	2017 September	3A
v3	Development - TK2	2018 April	3A
v4	Operational - SC#7	2019 March	3B
v5	Operational - SC#8	2020 March	3B

For each processing elements (PE) , we defined 4 major development levels which has to follow the VIS simulator capabilities for tests and validations, and the avaibility VIS instrument data and models :

L0: basic implementation of the algorithm

L1: refinements or complements, e.g. handling of wavelength dependency after a first, purely monochromatic, implementation. This process may consist of several steps depending on PE complexity and simulations availability.

L2: upgrade and refinements of the algorithms based on a better understanding instrumental data, when available (electronic or optical)

L3: a new version will be released after exploration of the different parameters and determining for which range the requirements are met, and after computing optimization.

Processing element	Responsability per Institute	v0	v1	v2	v3	v4	v5
Bias correction	MSSL	L0	L1,L2		L3		
Non linearity correction	MSSL	L0	L1	L2	L3		
CTI correction	Durham	L0	L1.1	L1.2	L2	L3	
Dark correction	MSSL			L0	L1,L2,L3		
Saturated pixel masking	IAP		L0,L1		L2,L3		
PRNU correction	MSSL	L0	L1	L2	L3		
Cosmic ray flagging	IAP	L0	L1		L2	L3	
Illumination correction	MSSL			L0	L1,L2	L3	
Ghost flagging	IAP	L0	L1.1	L1.2	L2	L3	
Background calibration	IAP		L0	L1	L2	L3	
Scattered light flagging	IAP			L0	L1,L2	L3	
PSF modeling quality flag	MSSL		L0		L1,L2	L3	
Source detection & classif	IAP	L0		L1	L2	L3	
Astrometric calibration	IoA	L0	L1	L2		L3	
Photometric calibration	IAP		L0	L1	L2	L3	
Stacking	IAP	L0	L1			L2,L3	

OU-VIS Requirements examples

Driven by the impact of each correction on the PSF size and ellipticity

	ID	Requirement	Parent	Rationale Text
Bias	R-GDP-CAL-052	Utilizing the bias calibration data described in P-R-VS-CAL-F-0001 and R-CAL-B-VS-2110, the ground data processing shall be able to correct the bias with a mean error < 0.05 e^- (TBC) in the floor level and < 0.3 e^- (TBC) on the slope of the floor level in the local PSF on a scale of 60 × 60 pixels.	R-CAL-B-VS-2110, R-CAL-B-VS-1110, R-CAL-B-VS-4260	(none)
PRNU	R-GDP-CAL-054	Utilizing the calibration data described in P-R-VS-CAL-F-002, the ground data processing shall be able to correct the pixel-to-pixel non-uniformity with an rms error < 1×10^{-4} (TBC) on a scale of 60 x 60 pixels.	R-CAL-B-VS-1200, R-CAL-B-VS-2200	(none)
Non-linearity	R-GDP-CAL-058	Utilizing the calibration data described in R-CAL-B-VS-1410 and R-CAL-B-VS-2410, the ground data processing shall be able to correct the detector chain non-linearity on a scale of a detector quadrant to better than 2 10^{-4} (TBC) at any flux level up to 90% of the dynamical range of the detector.	R-CAL-B-VS-1400, R-CAL-B-VS-2400, R-CAL-B-VS-4280	(none)
CTI	R-GDP-CAL-010	The residuals of the correction of the contribution of CTI to the ellipticity of the system PSF shall be less than 1.1×10^{-4} (1-sigma) per VIS exposure per ellipticity component.	MRD-WL-018	This allocation is for the residual after the data processing step of correcting for the CTI effect in the images. This assumes: - a level of shielding limiting the exposure of the VIS CCDs to a proton fluence of 4.8×10^9 equivalent 10MeV protons per cm2 at EOL (SRD-PLM-32 + factor 2 margin according to EIR-046). - a VIS detection chain readout noise lower than 4.5 electron rms (R-VIS-P-021). - the availability of on-ground CTI calibration and characterization data (including trap constant variation) as a function of the TID.

PRNU

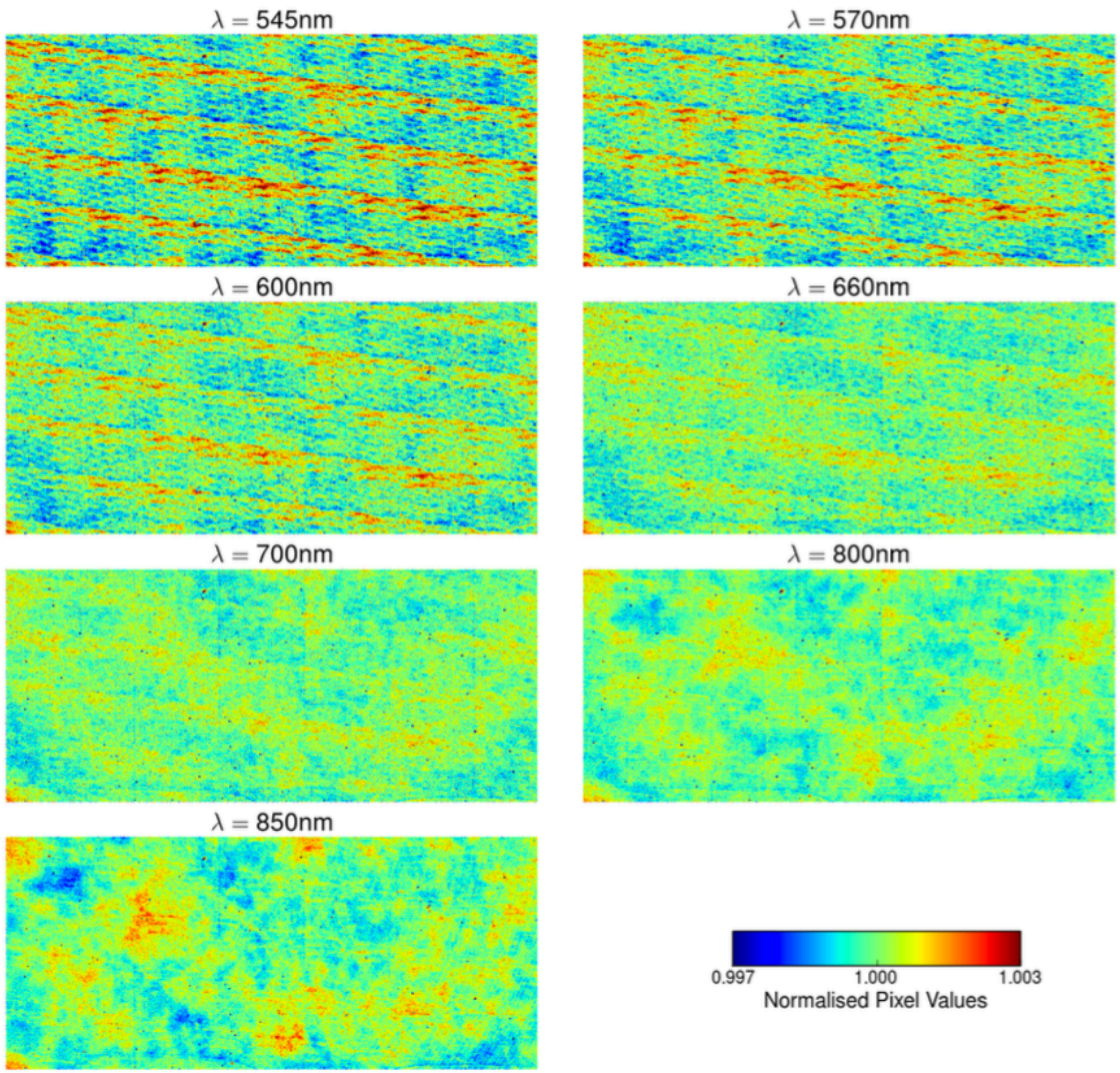
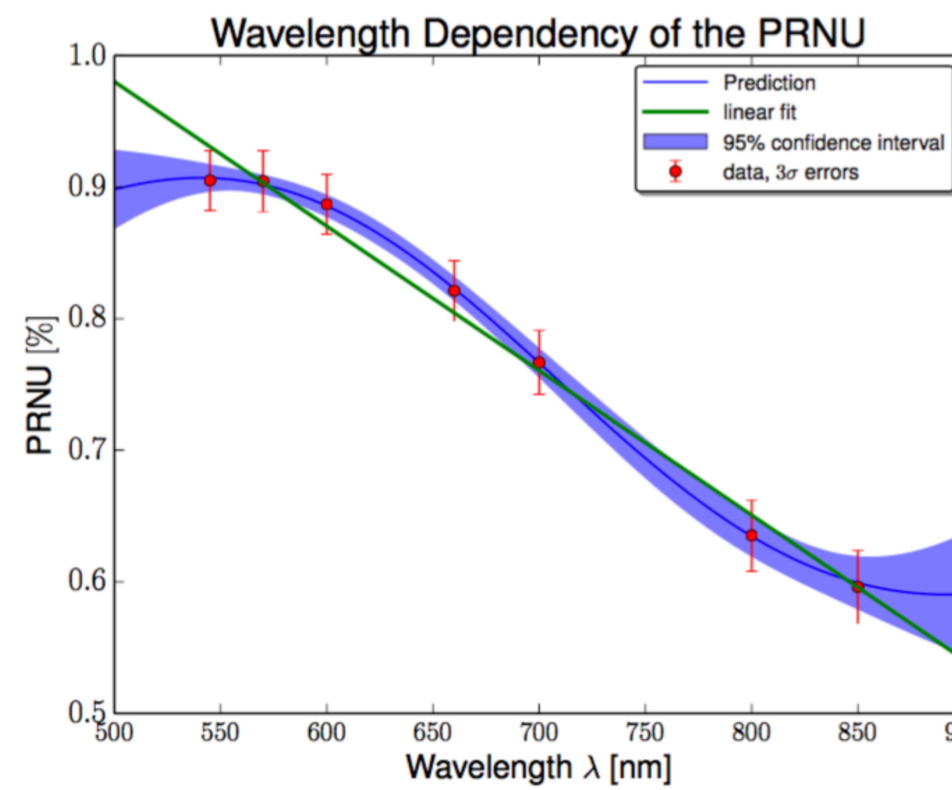


Figure 5.2.: Gaussian smoothed PRNU maps. The smoothing has been applied to enhance small-scale features and is applied for visualisation purposes only. The area shown for each cutout is about 3200 × 1400 pixels.

Need of multiple LEDs to characterise the pixel-to-pixel variation



Each PRNU maps will be produced and a yellow correction will be applied on each image.

OU-SHE will use these informations to optimise their PSF model.

Possible improvement for legacy: correction depending of each object's SED

Ground calibration

"VIS Calibration Plan" (Niemi 2014)

Level of each CCD+ROE individually

(function of temperature, CCD operating parameters (voltage) and wavelength.)

Bias level and read noise
Dark
Flat-field
Non-linearity and gain
PSF - charge diffusion

Level of the FPA:

(at nominal temperature and operating voltage)

Position of each CCD (tilt, rotation, relative distances)
Bias level and read noise
Flat-field and gain

Level of Payload: study of cross-talk

(at nominal temperature and operating voltage)

Bias level and read noise
Flat-field and gain

Each CCD's bandpass should also be done on the ground.
Measure of the transmission / reflection curve of each optical elements?

On-sky calibration

PV Phase (2 months)

"VIS Calibration Plan" (Niemi 2014)

Scattered Light Map : multiple observations (rotation / angular distance) near bright stars

Geometric distortion model + PSF model : dense stellar field observation

→ function of: focal plane position, rotation, wavelength, temperature, instrument state, SAA

Other ideas:

Out of focus images: constraint on the optical model, energy distribution

Series of bias exposures: electronic temporal variation + with temperature

Interferences studies between EUCLID instruments: optical and electronic (cross-talk)

many more..

On-sky calibration

Nominal operation

"VIS Calibration Plan"

Observing Condition: Each exposure must be taken under conditions, which are as similar as possible to the Wide Survey observations.

(worry: the 110 deg of SAA for the South Deep field)

Bias

1 daily

Tot duration: 80s

Outputs:
ADC offset level and variations + readout noise per node.

↕

Only one, no study of electronic temporal evolution with consecutive epochs

Flat-field

6 per day, one per LED

Tot duration: 6x(20+80) = 600s

Outputs:
CCD pixel-to-pixel variations as a function of wavelength, dead pixels, and detection chain gain.

↕

PRNU map made monthly

Non-linearity

monthly sequence

Tot duration: 10s, 50s, 150s, and 565s (+4x80s) = 1095s

Outputs:
Detection chain non-linearity curve for each output node.

↕

Strategy not well defined yet:
- high density field ?
- CU lamp illumination ?
- Charge injection ?

CTI

14 exposures per day (charge injection exp. + trap pumping)

Tot duration: ~14x100 = 1400s

Outputs:
Refine the radiation damage model + location of traps

cosmetic

4 dark exp. daily

Tot duration: 4x(350+80) = 1720s

Outputs:
dark current, Hot and warm pixel maps, cosmic ray fluence

+ PSF model

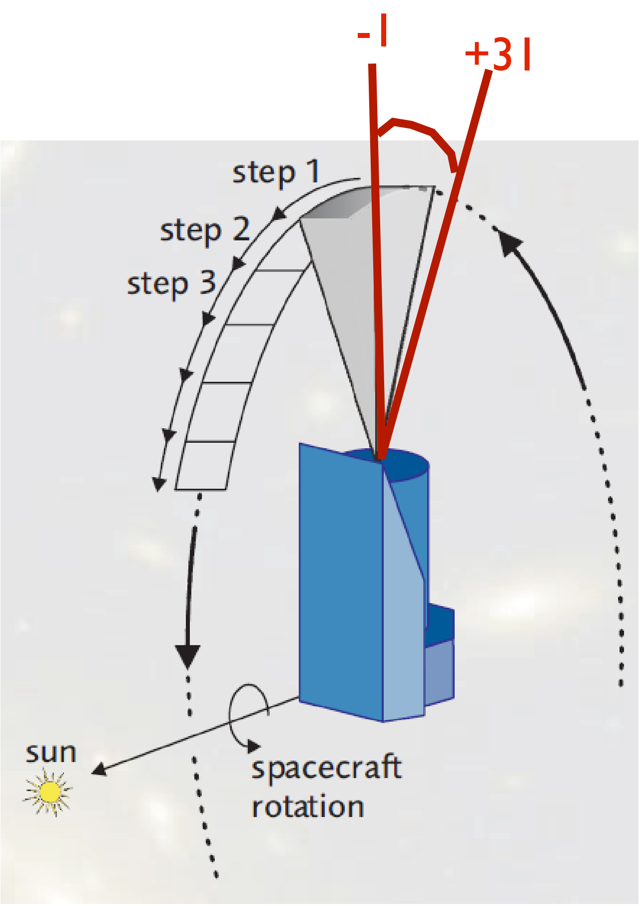
monthly obs. of dense stellar fields for PSF colour dependance

Main influence on the photometry

We expect the overall system to be stable - advantage !

Successful relative photometric calibration will come first from a good understanding and correction of the electronic / photometric biases

Wide band 550-900 nm (griz): optical + electronic



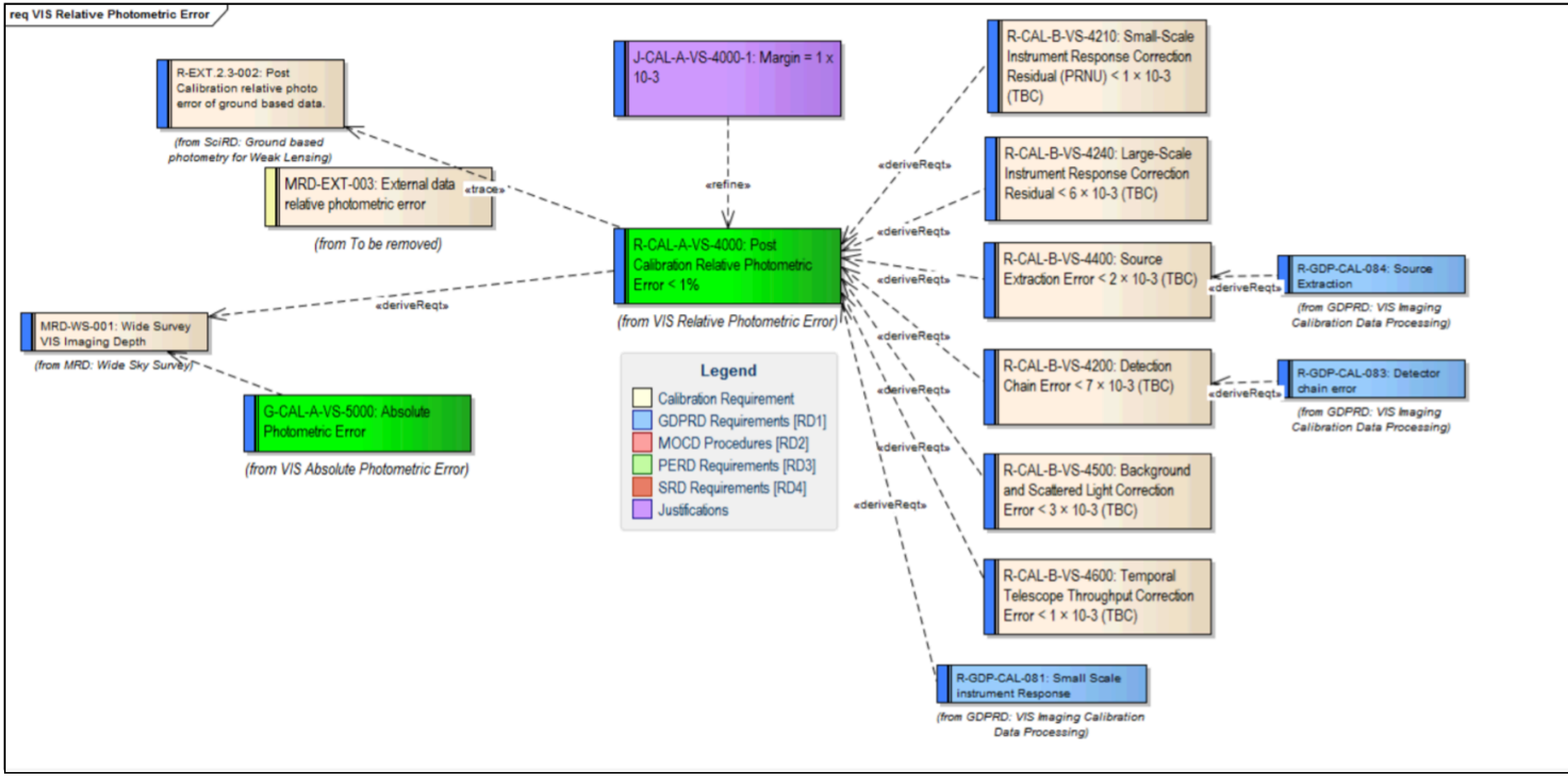
<u>Variabilities</u>:

- wavelength - PSF variation
- across focal plane:
    - geometric distortion
    - background (large and small scale)
    - ghosts from dichroic
    - illumination (shutter)
- temporal variability :
    - temperature variation (SAA)
    - CTI aggravating
    - Flat-field, cosmetic, ..
    - optical focus shift ?

<u>Source detection and photometry:</u>

- PSF fitting on S/N > 30
- compare with simple aperture photometry on isolated objects
- good knowledge of the background needed
- Actual tools: Astromatic (SExtractor and PSFEx)

VIS relative photometry budget



Calibration Concept Document: Part B

Homogeneisation of the photometry accross all the fields taking care of the variabilities (temporal, focal plane, wavelength)
Then pin down with standard stars for the absolute photometry.

Relative photometry :

- Colour correction: need of OU-MER informations on objects SED for colour informations(from NISP, CFHT, LSST, DES..)
- Dithering : using common area of the same fields and adjacent fields is a good cross-check, but not sufficient as we do not cover up the large scale variation across the field.
- Using deep fields images : different rotations, perhaps larger dither too(?)
- Short VIS exposures: useful for detector response linearity check
- Special photometric sequence : logarythm increasing steps like SNLS (Regnault et al., 2009) on dense stellar field

Absolute photometry (AB mag) :

- Secondary standard stars (fainter than 16 mag), .. brighter OK with shorter exposures
- Numerous red dwarfs in our fields: GAIA distance, NISP spectra, SED from OU-MER
- Star clusters

R-GDP-CAL-087	Utilizing the calibration data described in P-R-CAL-F-009, the ground data processing must be able to calibrate the VIS absolute photometric error < 5 % (TBC).	G-CAL-A-VS-5000	