EUCLID scientific specifications and performances

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CPPM

Overview

- Scientific objectives
- Scientific requirements
- Performance verification status
- The next steps

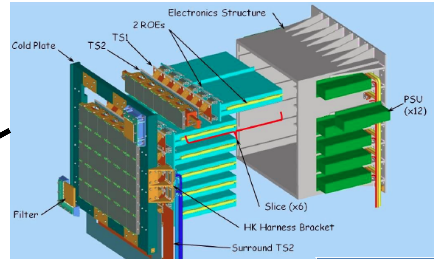
Scientific objectives

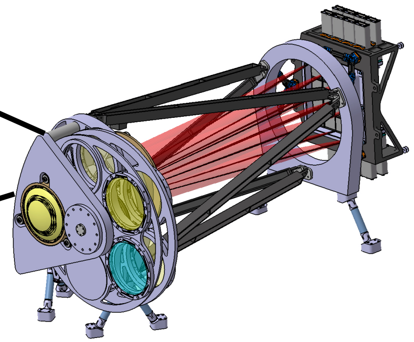
	Modified Gravity	Dark Matter	Initial Conditions	Dark Energy		
Parameter	γ	m_ν/eV	f_{NL}	w_p	w_a	*FoM*
Euclid Primary	0.010	0.027	5.5	0.015	0.150	430
Euclid All	0.009	0.020	2.0	0.013	0.048	1540
Euclid+Planck	0.007	0.019	2.0	0.007	0.035	4020
Current	0.200	0.580	100	0.100	1.500	~10
Improvement Factor	**30**	**30**	**50**	**>10**	**>50**	**>300**

These numbers have a meaning only if we can control the systematic errors

Top level requirements

Level 0	Level 1	Level 2	Level 3
Weak lensing	Shear	VIS imaging	(see figure)
	Photo z	NIR photometry	(see figure)
Clustering	Spectro Redshift	NIR spectroscopy	(see figure)





	Wide survey	Deep survey
Survey		
size	15000 deg^2	40 deg^2 N/S
VIS imaging		
Depth	n_{gal} > 30/$arcmin^2$ → M_{AB} =24.5 → <z> ~0.9	M_{AB} = 26.5
PSF size knowledge	$\sigma[R^2]/R^2<10^{-3}$	
Multiplicative bias in shape	$\sigma[m]<2\times10^{-3}$	
Additive bias in shape	$\sigma[c]<5\times10^{-4}$	
Ellipticity RMS	$\sigma[e]<2\times10^{-4}$	
NIP photometry		
Depth	24 M_{AB}	26 M_{AB}
NIS spectroscopy		
Flux limit ($erg/cm^2/s$)	3 10^{-16}	5 10^{-17}
Completness	> 45 %	>99%
Purity	>80%	>99%
Confusion	2 rotations	>12 rotations

- WL and systematics

$$\gamma^{obs} = (1+m)\times\gamma^{true} + c$$

$$C_l^{true} \approx \left[1+2\langle m\rangle\right]\times C_l^{obs} + \langle c\rangle^2$$

→ $m < 2\times10^{-3}$: multiplicative bias
$\sigma^2_{sys} \approx \langle c^2\rangle < 10^{-7}$: additive bias

→ Small PSF
→ Knowledge of the PSF size
→ Knowledge of distortion
→ Stability in time
→ External visible photometry for photo-z accurary: 0.05x(1+z)
(+ Methods to correct distortion)

- GC and GC systematics

→ Catastrophic z < 10%
→ <z>/(1+z)<0.002

→ Understand selection→Deep field
- Completeness
- Purity

Context for performance validation

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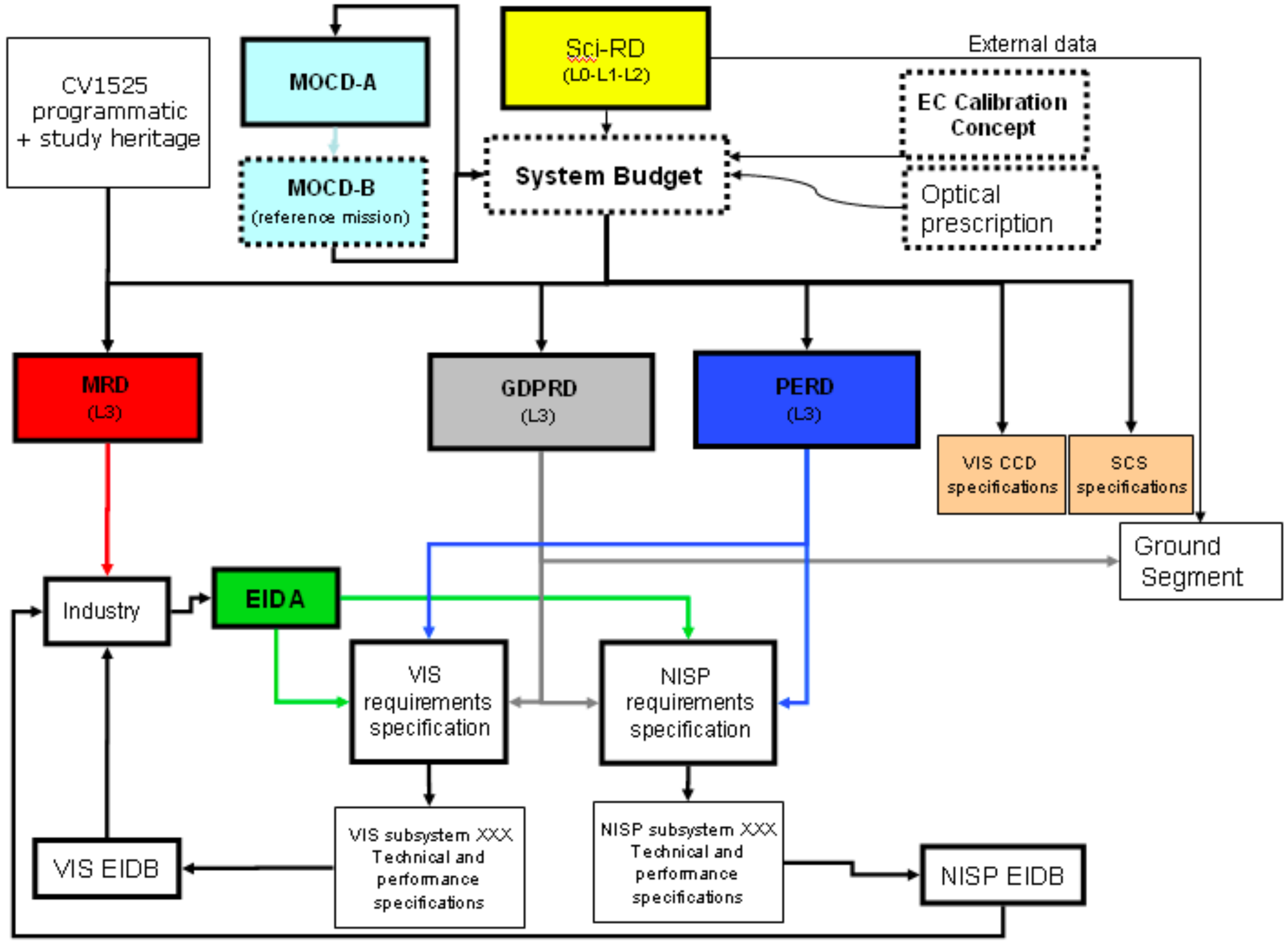
- From scientific to instrument /survey/processing requirements and performance validation (verification of requirements)

Scientific requirements are in ScIrD

Flow down through ESA documents at system level

Go back for a full loop through simulation



Context for performance validation

Phase A : instrument simulation + survey simulation

Performance review January 2012 :

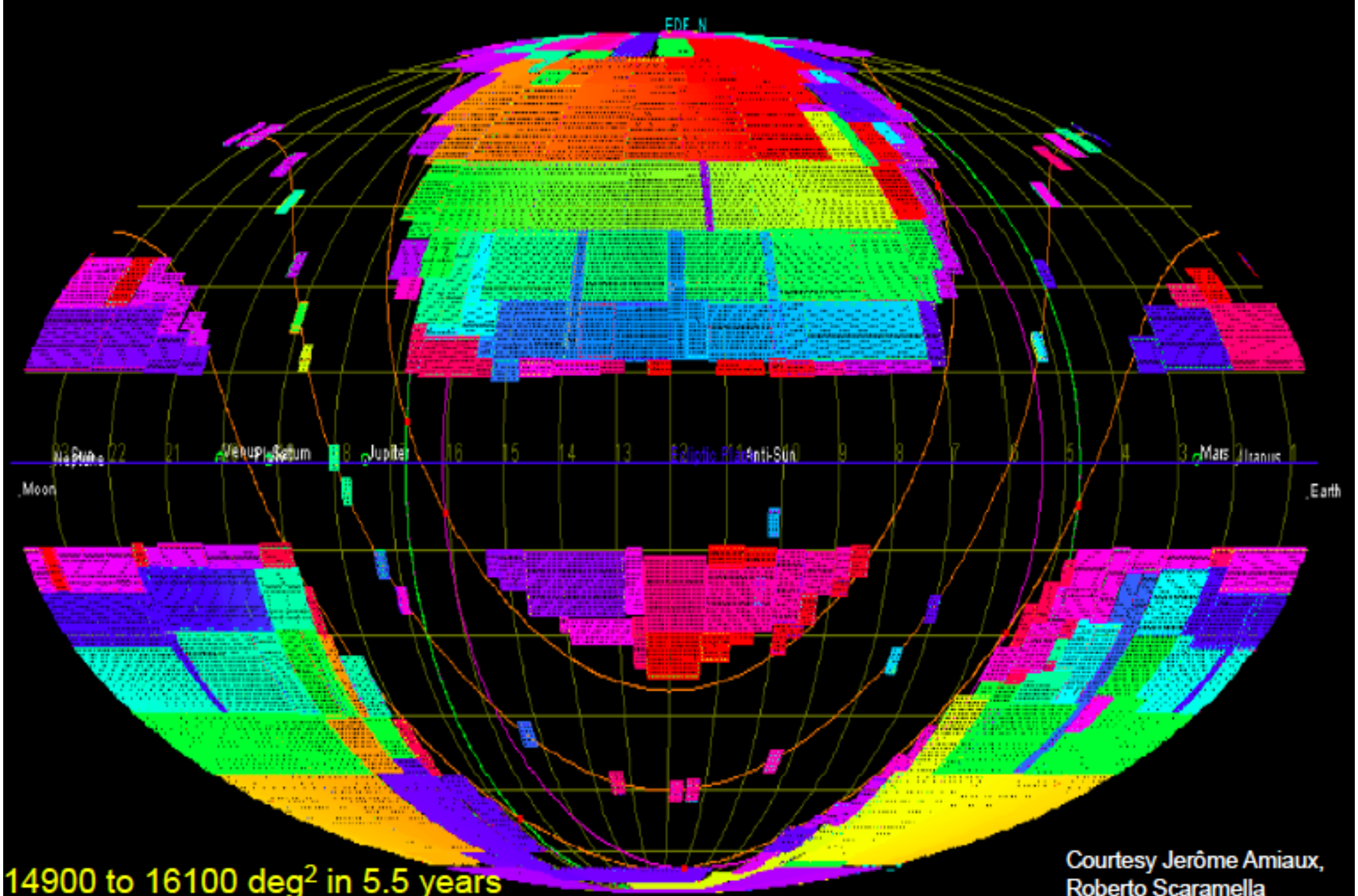
-Use simulator and instrument models
-Implementation of an observational strategy
-Study main instrumental systematical effects through simulation with complete image pixel simulation + observational strategy
-No calibration and/or data processing verification

Conclusion

Almost all requirements was fulfilled
No margin in survey coverage and instrument

Euclid Deep+Wide surveys feasible in 5.5 years

Euclid Consortium



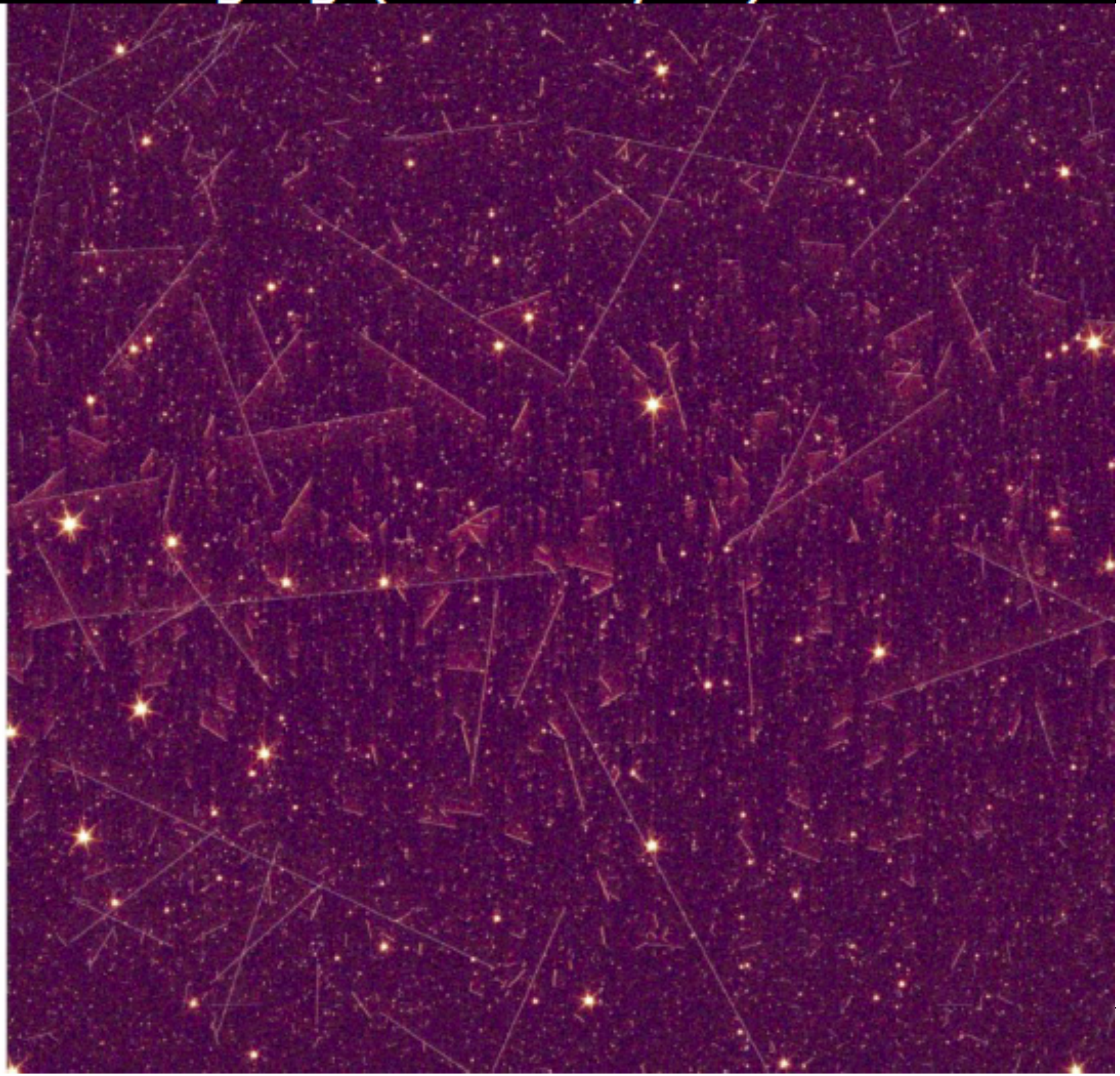
14900 to 16100 deg^2 in 5.5 years

Courtesy Jerôme Amiaux, Roberto Scaramella

VIS performance:imaging (EC analysis)

A 4kx4k view of the Euclid sky

VIS image: cuts made to highlight artefacts



- Charge Transfer Inefficiency (CTI) of CCDs
- Tested in the worse case scenario (End of Life, pixels at extreme distance from the output)

- can be corrected to the required level of accuracy.

- EC analysis: CTI has NO impact on the P(*k*) and the cosmology core program

Next step in VIS… where to go…

Shape measurements/systematics

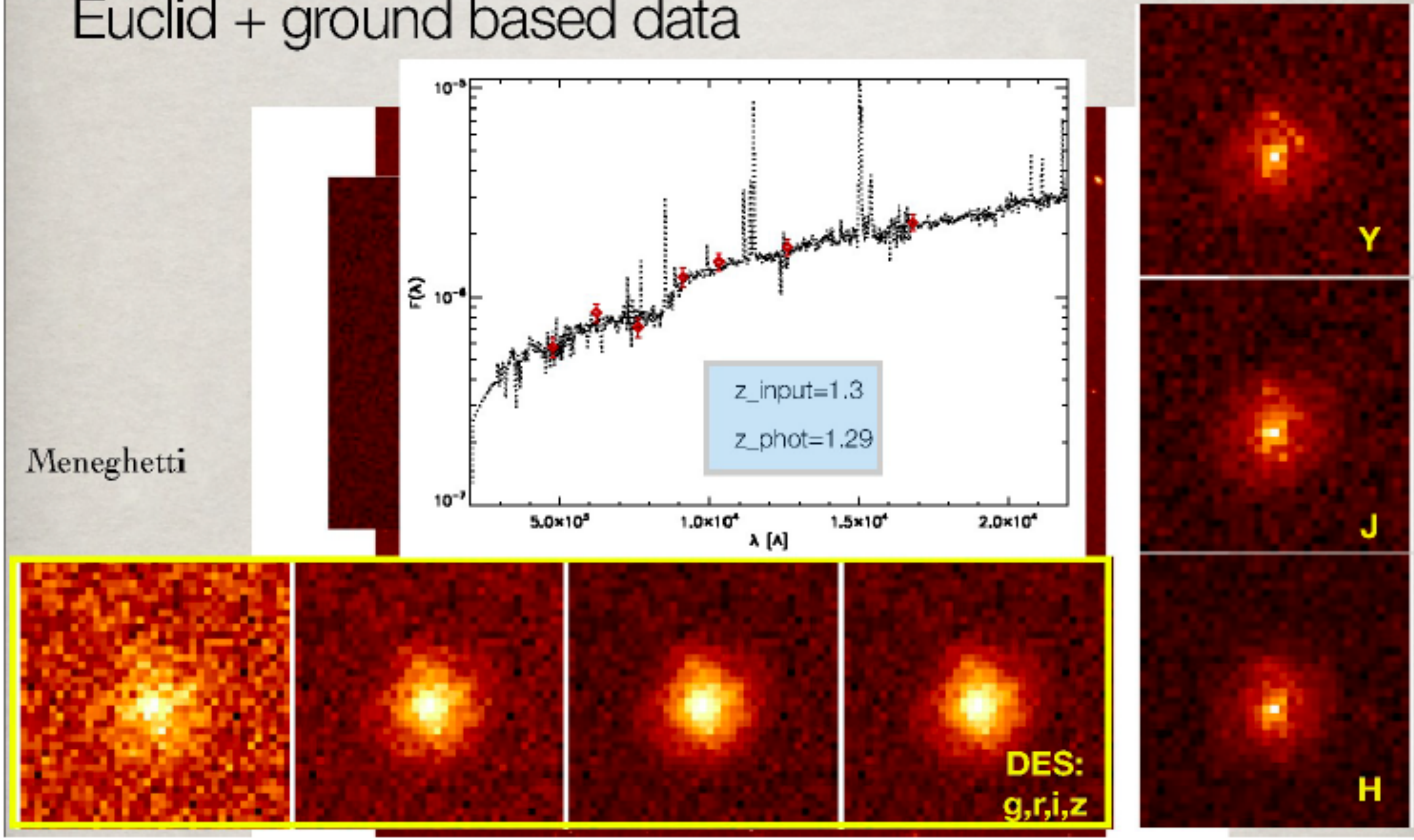
- Coordination of all teams (UK, FR, NL, DE, CH, US/NASA)
- Control of both multiplicative and additive biases
- Manpower for data challenges
- Plan for selection of methods dev., test, validation, operation, quality control

- Photo-z:
  - Ground based photometry: enough bands, deep enough, over the whole 15,000 deg^2 (i.e. north and south)

Numerical simulations with power spectrum to a 1% accuracy :

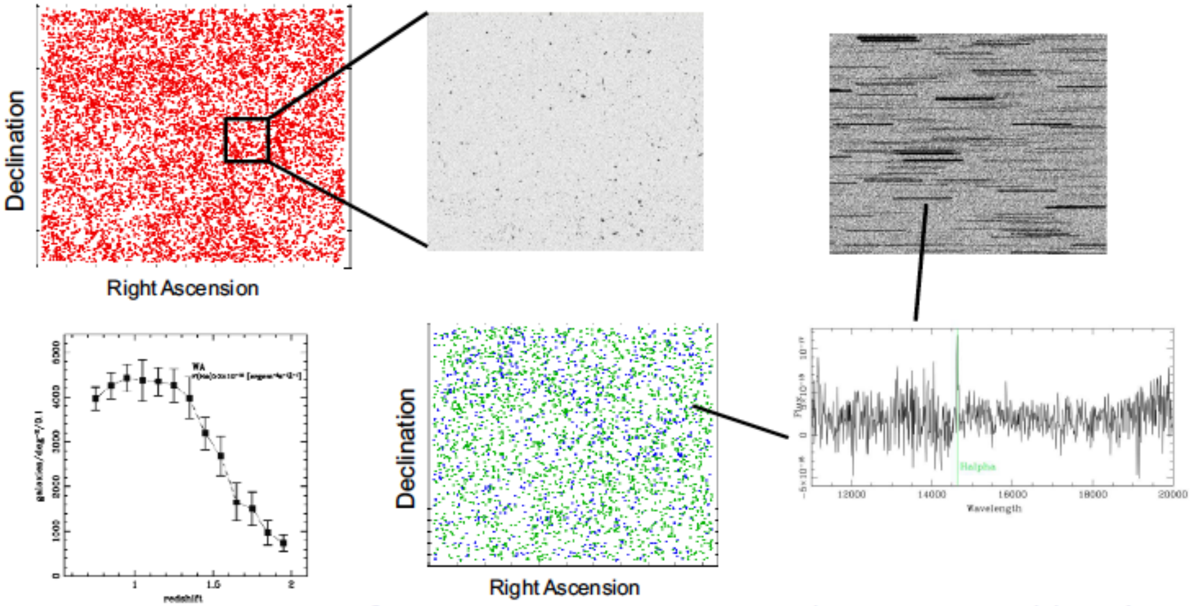
- Resolution
- Underlying physics: e.g. numerical simulations with baryons
- Manpower, tools for post-processing
- Coordinations of all teams (UK, FR, SP, DE, US/NASA): 3 SIM projects
- Numerical simulation of a large number of DE, GR models: resolution grids of models, which scales are important?

Image simulations:
Euclid + ground based data



NIS spectroscopy chain

- FULL END TO END simulations from observation to final products



- Areas of the order of 1 square degree (1.3 sq. deg. presented here)
- Statistically evaluate level 1 (2) requirements

The full chain including a pixel level image simulator and a prototype of redshift extraction has been used for verification of the completness and purity of the final sample

This has shown that the current strategy meet the requirements but very low margins

Spectroscopy next steps

- Consolidate instrument model (PSF, detector effects)
- Consolidate procedures
  - Add the calibration and reduction procedure steps of dispersed images
  - Cross calibration of direct-dispersed images
  - Improve de-contamination performance
- Evaluation of the selection function
  - Mask simulation and evaluation (star density, cosmic ray impact, detector degradation)
- Deep field analysis for control of purity/completness

All these studies need a new catalog:

- statistic of 1 deg^2 'cosmos like' is too limited in the NIR range
- => need larger statistic => large N body mock catalogs of 10 to 30 deg2 with correct clustering representativity.

Strong link between simulation and SWG needed

Performance next steps

Phase B : started now at mission level:

✓ Calibration: full plan and implementation/simulation

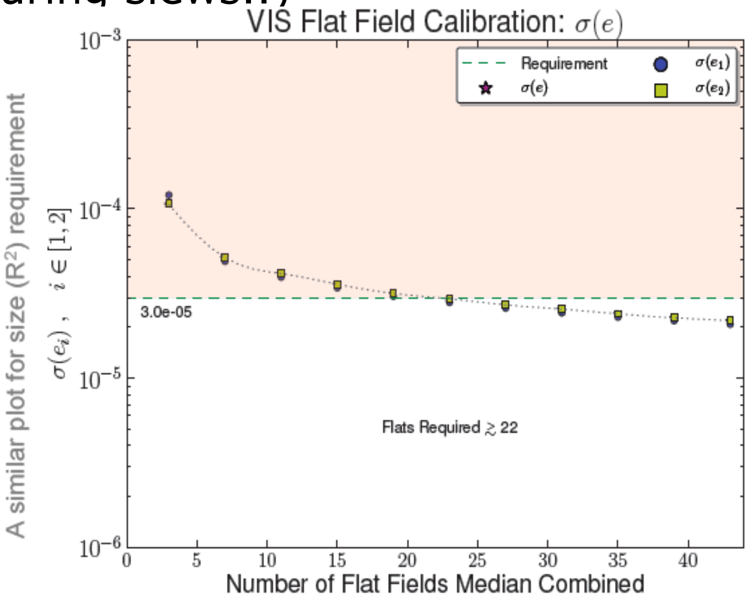
- Calibration plans are captured in instrument documents but missing high level science calibration requirements.
- New : Calibration Concept Documents (CalCD-A/B) capture now all requirements and calibration modes needed for the mission and science
- Simulation and implementation optimisation going on

✓ Data processing : simulation and validation

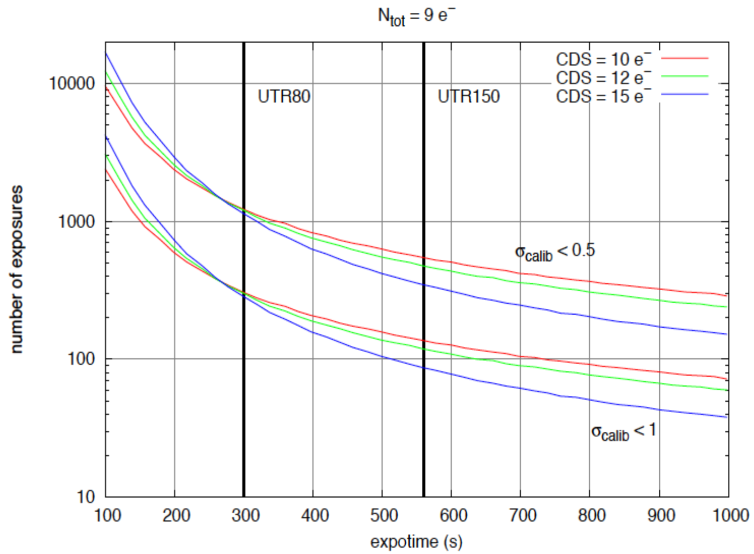
- A new redefinition of the requirements in the GDPRD document to link the flow down to the data processing (SGS)
- A development plan for the SGS review (mid 2013) including an E2E verification chain / data challenges
- First prototypes and identification of key issues in 2012

Calibration and validation …

- Calibration plan are up to now captured in instrument documents
- New : Calibration Concept Documents (CalCD-A/B) capture all requirements and calibration modes needed for the mission and science
- Detailed simulations to study and optimised the calibration in the survey are now performed
- Implementation are verified (VIS calibration during NISP photometry, NISP cal. during slews..)



Flat field for the VIS



Number of dark for the NISP

Conclusion

- **Performance review:** A first requirement verification from science to instrument and mission with simulation has shown to be compliant
- Very detailled simulation of key points has been performed to show that with current instrument parameters (PSF, detector properties), we can control the main systematics for weak lensing and clustering.

- **Next steps:**
  - finalize the calibration and GDPRD (processing) requirements
  - develop a full simulation and validation tools to go back to the science ScRiD requirements.

This will allow to have a full E2E chain validation for scientific performance verification

- spares

Performance

- Survey = observational scenario and optimisation tool
- VIS imager
  - Throughput
  - Optical PSF modeller
  - Detector noise, cosmetics,cosmic rays,radiation damage model
  - + advance PSF analyse
- NIP photometry (Imagem)
  - 3 bands images with optical PSF, throughput, detector noise and some cosmetics
- NIS slitless spectroscopy
  - Slitless images with Axesim (throughput, PSF, detector noise)
  - + end to end approach
  - + observational strategy (rotation, dither)
  - + spectra and redshift extraction

Survey simulation

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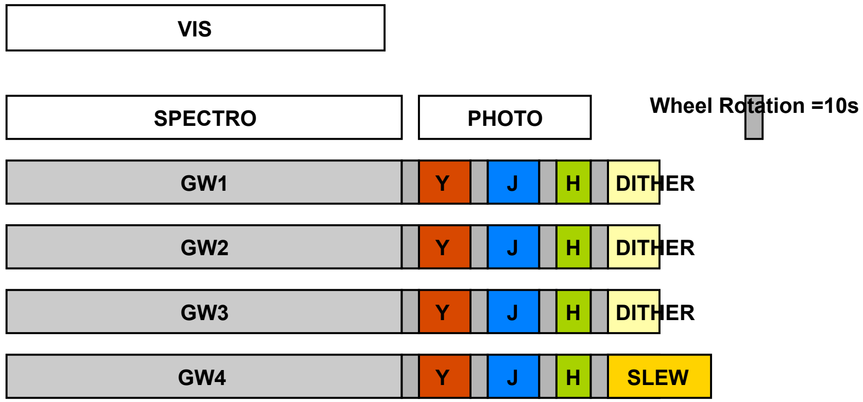
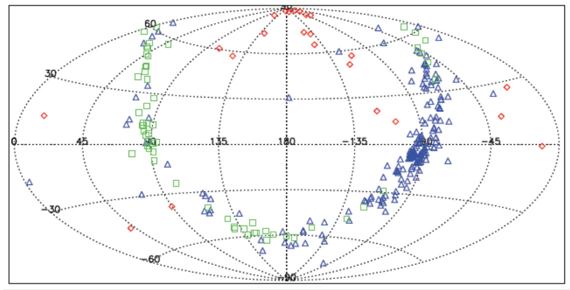
- Reference survey
- Operational scenario
- Dithering pattern



- Sky survey strategy includes:
  - Instrument calibration with specific targets
  - Wide and Deep field



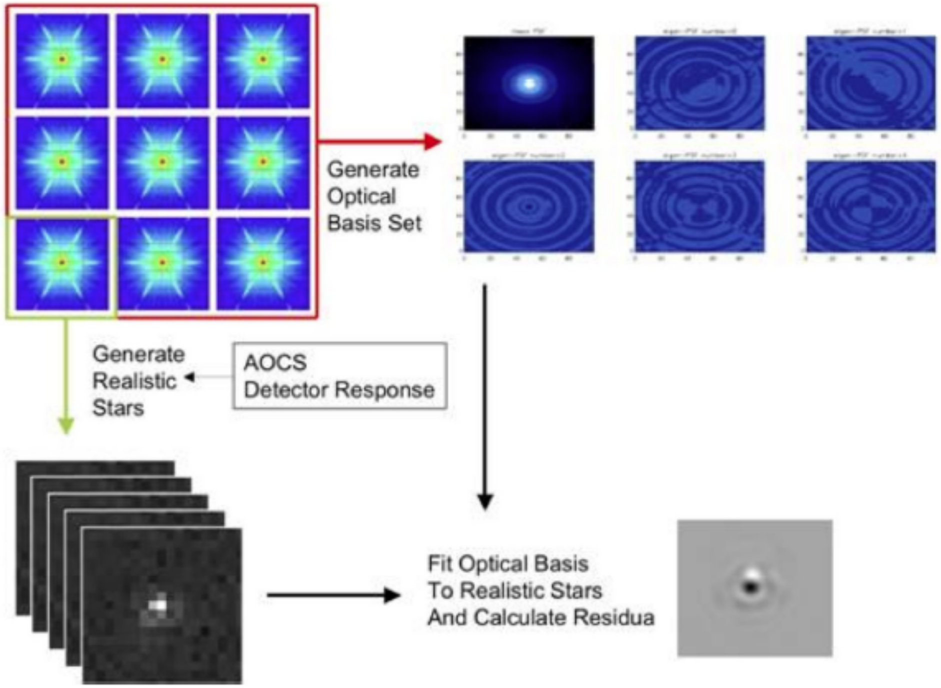
A new optimisation has been redone with new tools

Feasability in 5.5 years

Allow margins + extra surveys?

VIS PSF knowledge(PCA)

- PSF knowledge =>PCA analysis
  - Decompose PSF into a basis set using PCA
  - Use model data to establish PSF basis set
  - use real stars to get component coefficients (1800 stars available by field)
  - Verify the reconstructed PSF



VIS CTI modelling and correction

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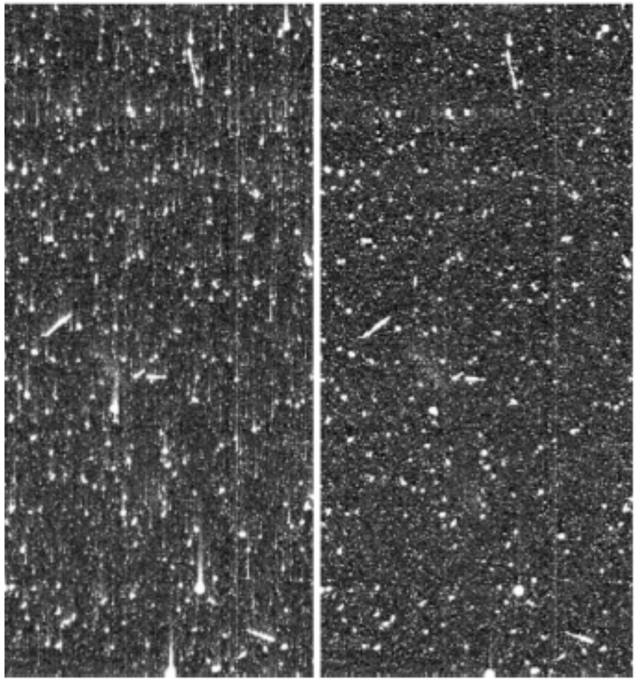
- CTI can degrade ellipticity
- CTI can be modelled and corrected

Model parameters can be adjusted to null out residual CTI effects on detector coordinates → model imperfections can be reduced sufficiently

- Bristow & Alexov (2003) algorithm further developed for HST data processing by Massey, Rhodes et al.
- "Read" image through CTI model (eg CDM03) in combinations and make linear combinations



NIR performance :photometry

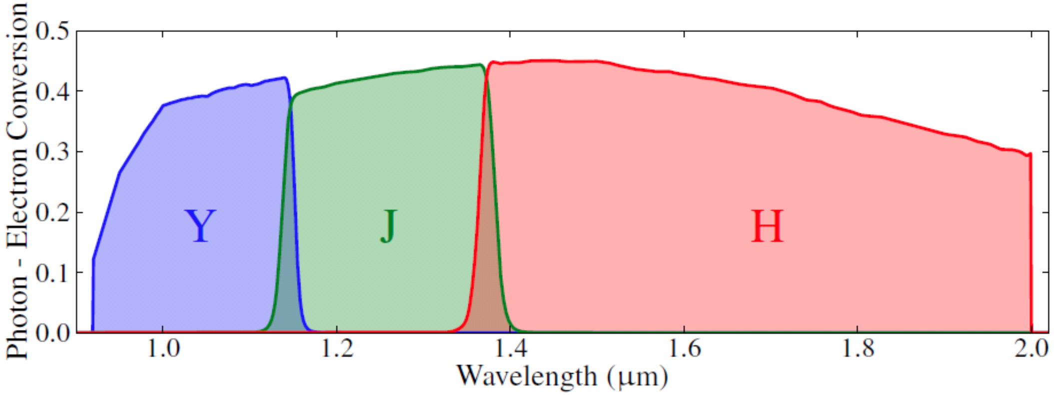
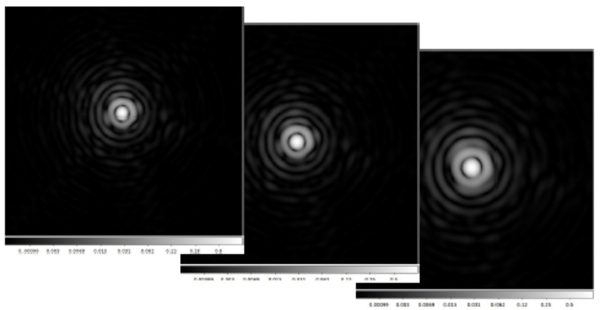
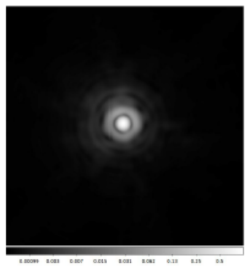


Imagem :Allow to study performance of the NIR Imaging channel

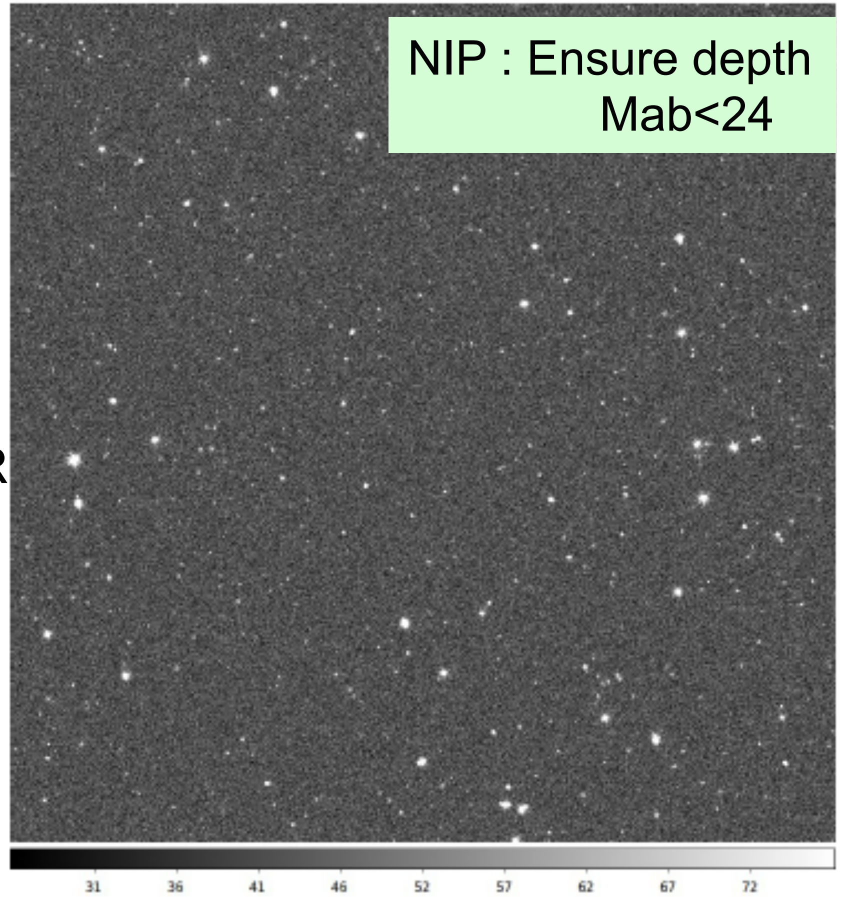
Implementation of optical PSF in the field



PSFs at 1.4, 1.6 and 2um, field position 1, central 522x522 1µm^2 sub-pixels, logarithmic scaling



combined H-band PSF

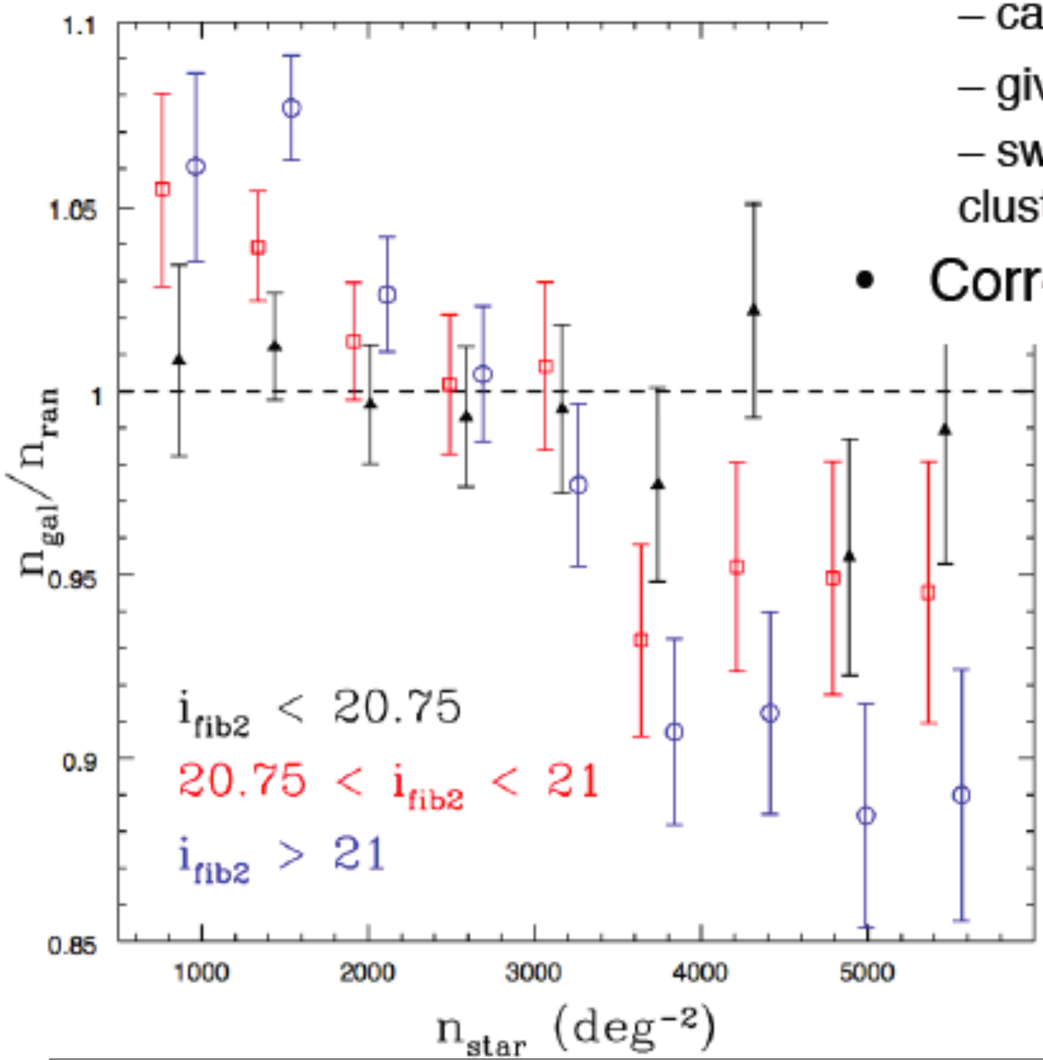


H band frame, 2040x2040 pixels

Skylens: source image oversampled with 6x6 sub-pixels

imagem: optical and detector effects

- Target density correlates with stellar density and brightness
  - caused by the data reduction pipeline
  - gives systematic angular distortions
  - swamp any large-scale cosmological clustering signal
- Corrected by weighting



Scientific performance analysis chain

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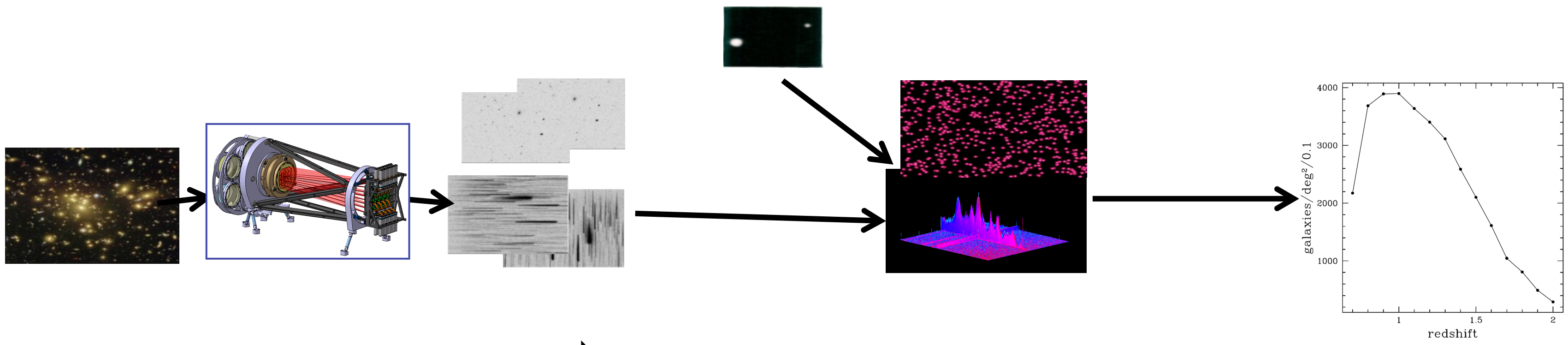


Data

- Sky
- Spectra
- Instrument
- Survey

Processing

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

Analysis

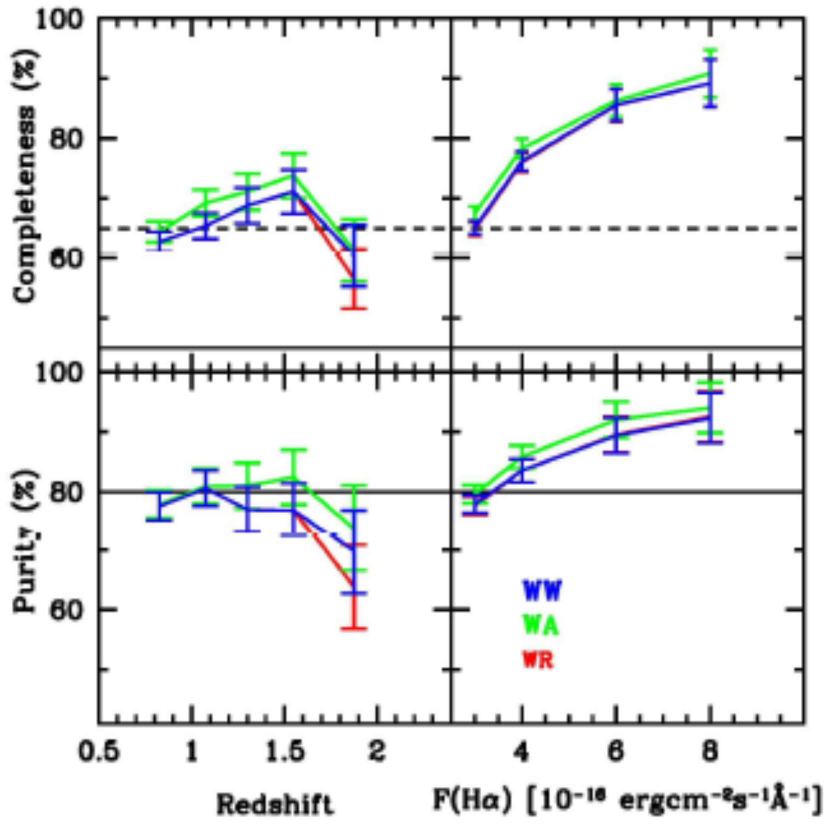
- Completness
- Purity
- Dn/dz
- Accuracy
- FOM

Spectroscopy performance

In current simulations, completness is compliant
Purity is marginal

Completeness: fraction of spectra **measured** above a given line flux limit

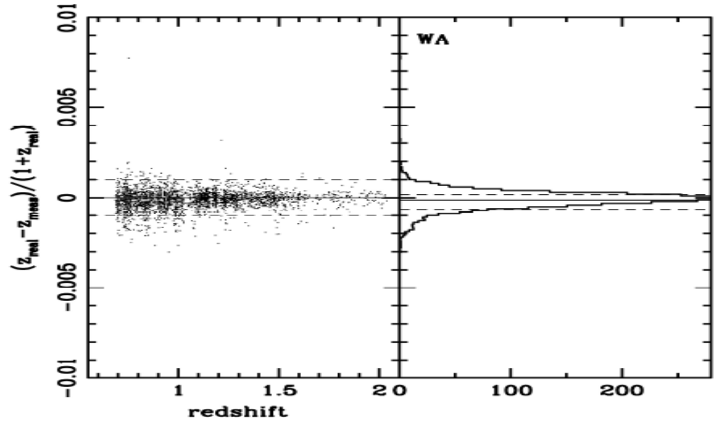
Purity: fraction of spectra **correctly measured** above a given line flux limit. Complement to the fraction of catastrophic redshifts (required to be less than 20%)



B.Garilli et al.

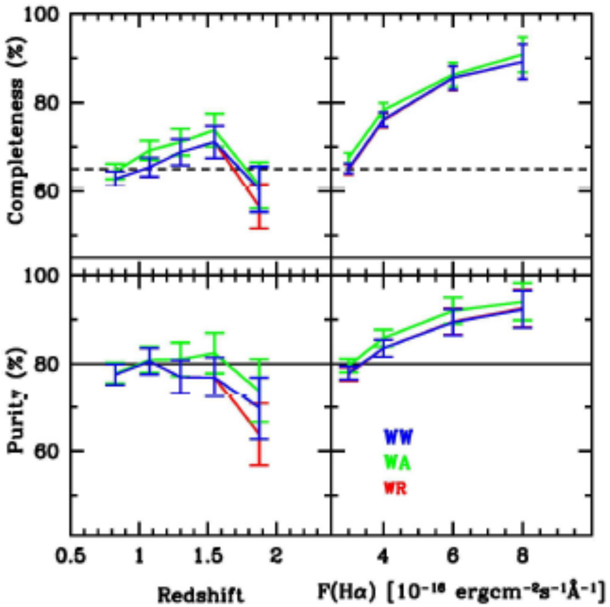
Clustering performance evaluation

- Control of offset
- 70 % galaxies have $\sigma(z)<0.001(1+z)$
- Offset < 6 10^{-5}



- Control of the selection function

Wide survey



Deep survey