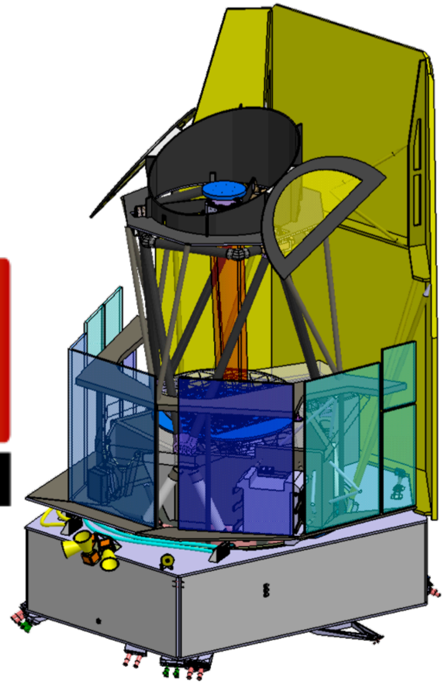
The PAU & Euclid surveys, state of the art in LSS



Francisco Javier Castander
on behalf of the PAUS collaboration &
the Euclid Consortium

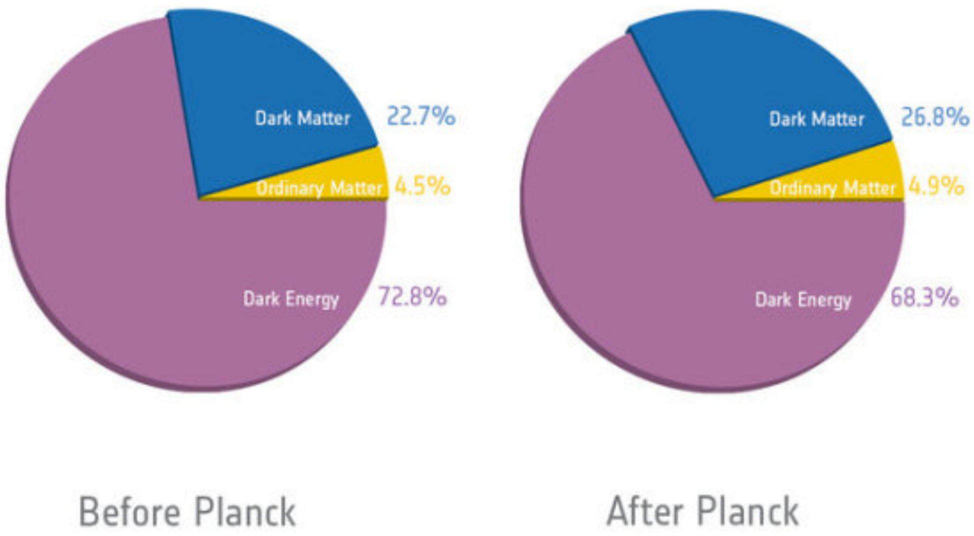
Institut de Ciències de l'Espai, ICE (IEEC/CSIC),
Barcelona

ICE CSIC IEEC
Consejo Superior de Investigaciones Científicas
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

IFAE Institut de Física d'Altes Energies
UAB Universitat Autònoma de Barcelona
PIC port d'informació científica
ift Instituto de Física Teórica UAM/CSIC
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

Questions in Cosmology

- What is the physical cause of cosmic acceleration?
  - Dark Energy or modification of General Relativity?
    - If Dark Energy, is it Λ (the vacuum) or something else?
      - What is the DE equation of state parameter *w*?



ESA

PAU motivation

Probing Cosmology

- Cosmology is probed mainly measuring the expansion rate of the universe H(z) and the growth rate of structure g(z)

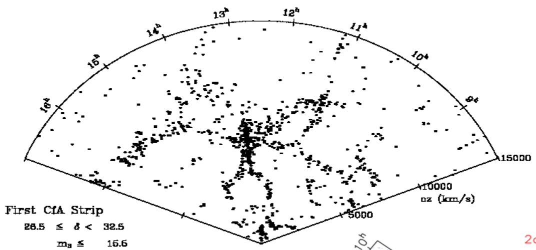
PAU motivation

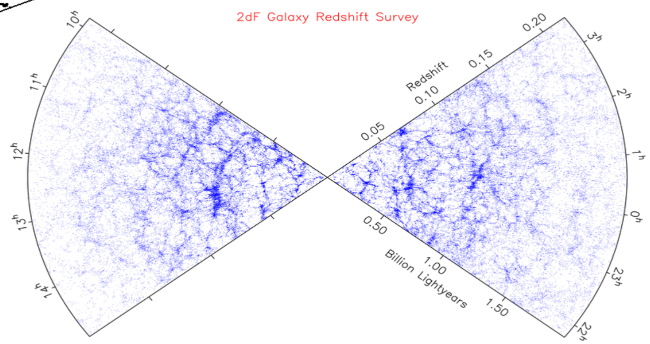
Main observational probes

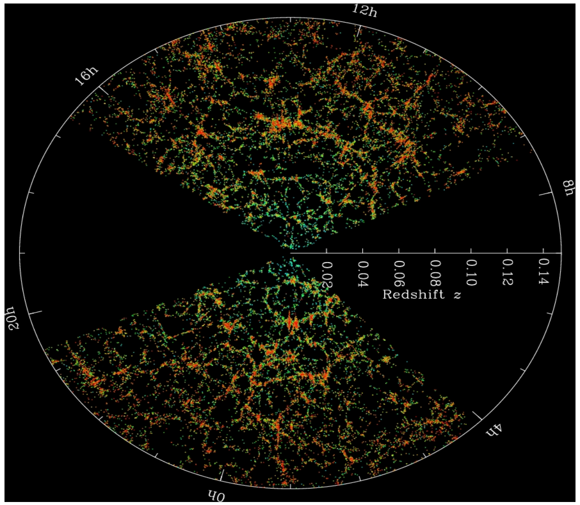
- Weak lensing (geometry & growth)
- Clustering: BAO, RSD, P(k) (geometry & growth)
- Supernovae (geometry)
- Clusters of Galaxies (growth & geometry)

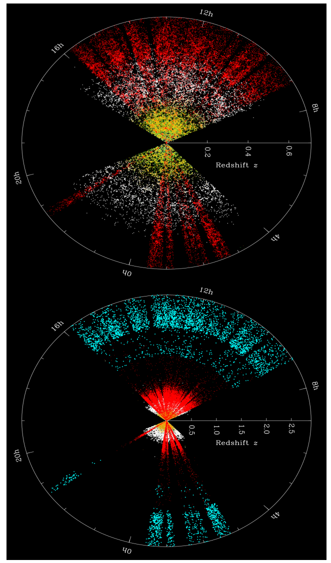
Probing Cosmology

- Cosmology is probed mainly measuring the expansion rate of the universe H(z) and the growth rate of structure g(z)
- One way: measure the distribution of matter P(k,z) with galaxies as tracers carrying out large surveys









Survey requirements

- The precision to which the galaxy power spectrum can be measured depends on:
  - Sample variance: how many independent samples of the relevant scale (~100 Mpc/h for BAO) one probes ⇒ volume
  - Shot noise (Poisson): how many galaxies included in each sample ⇒ density

Feldman, Kaiser, Peacock, ApJ 426,23 (1994)

$$\frac{\Delta P(k)}{P(k)} \propto \frac{1}{\sqrt{V}}\left(1+\frac{1}{nP(k)}\right)$$

P(*k*): power spectrum

n: galaxy density

PAU motivation

Requirements for Cosmology Survey

- Sample large volumes
- Sample enough (many) objects
- Determine distance (how accurate?)

PAU motivation

PAU strategy

- Many cosmological applications only require "rough" spectroscopic precision (~10 Mpc/h)
- Use photometry to obtain redshifts
- Broad band imaging does not provide enough resolution
- Need sufficient spectral resolution to obtain accurate photometric redshifts => narrow band filters
- Previously: COMBO-17, ALHAMBRA, COSMOS, Subaru
- Simulations: MICE

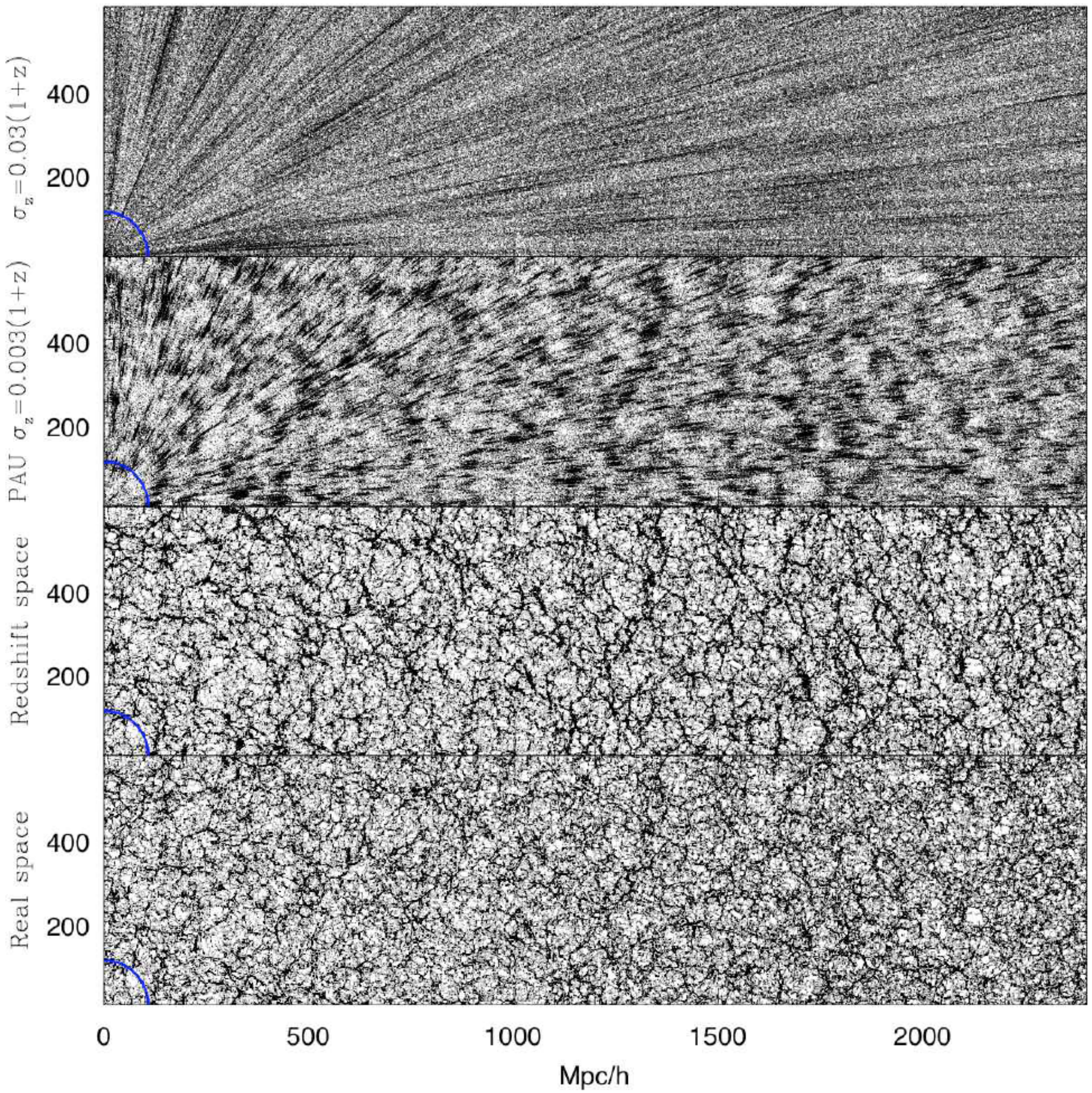
PAU motivation: visual impression of importance of z resolution

z-space, Δz = *0.03(1+z)* + peculiar velocities

z-space, Δz = *0.003(1+z)* + peculiar velocities

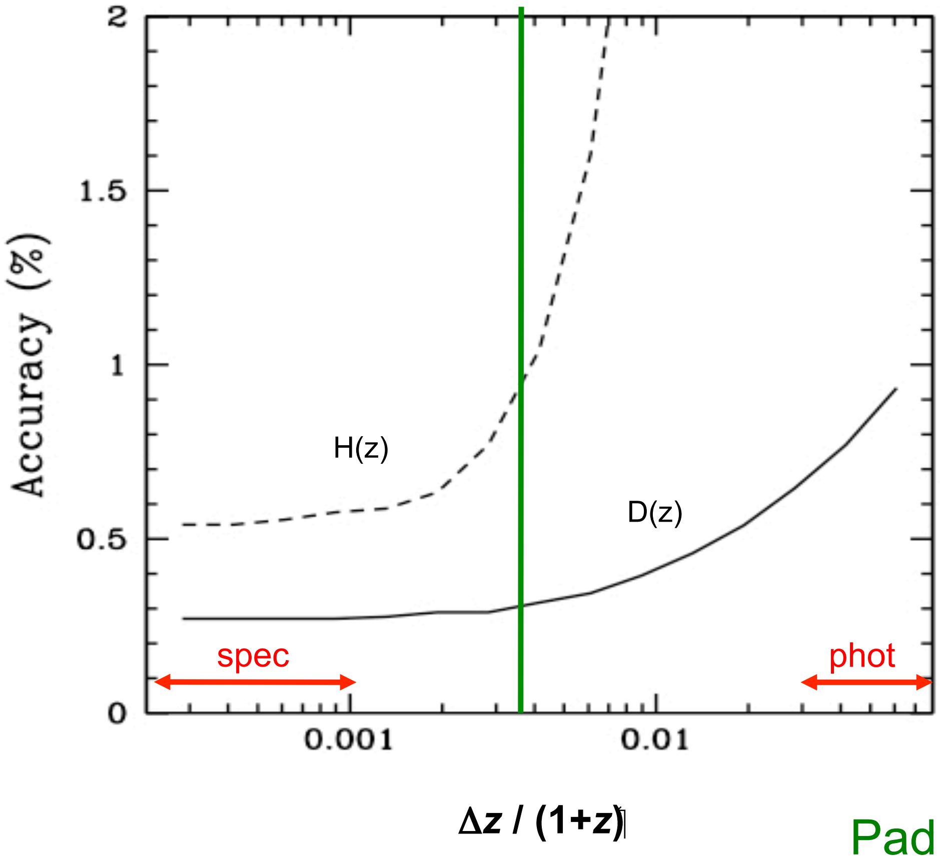
z-space, perfect z-resolution + peculiar velocities

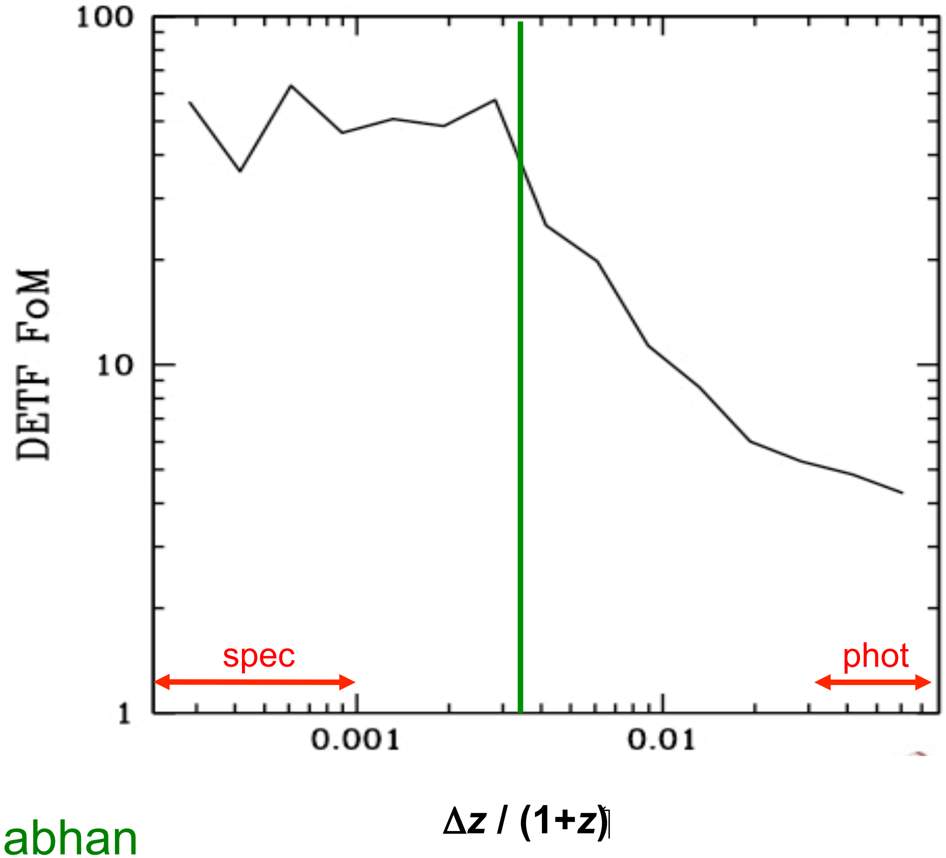
Real space, perfect resolution



PAU motivation

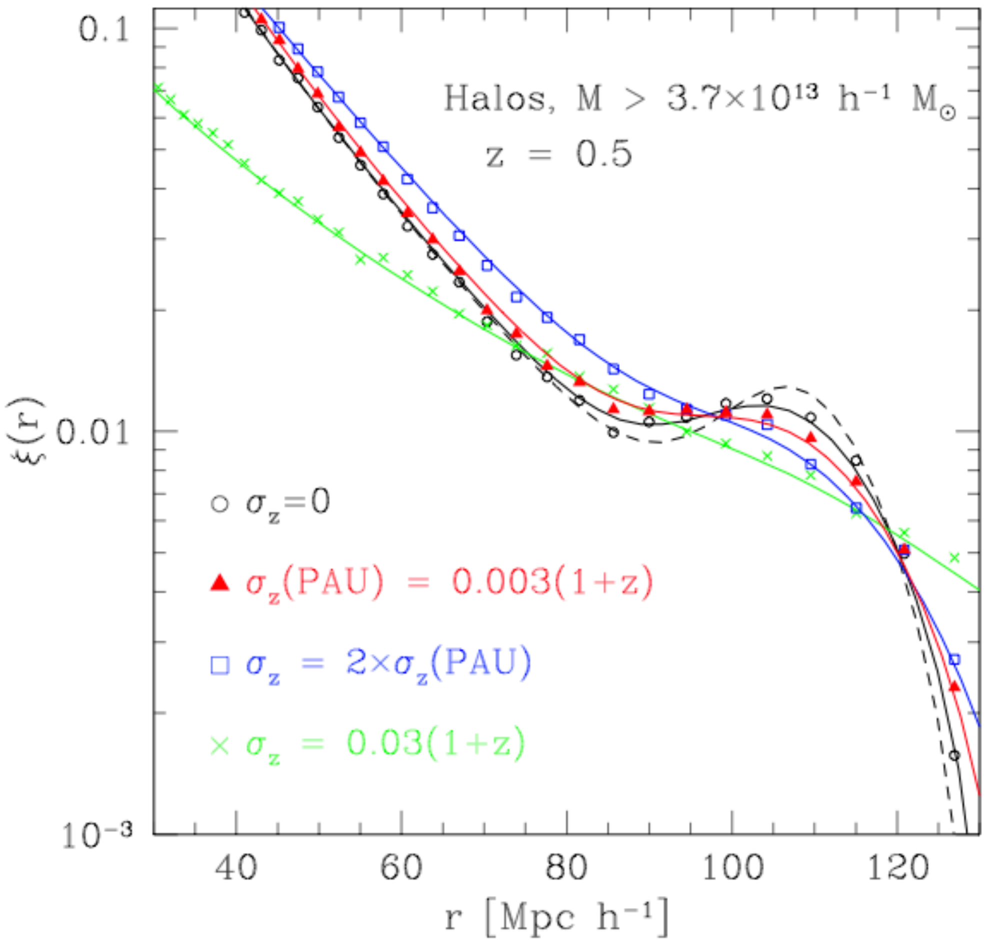
BAO

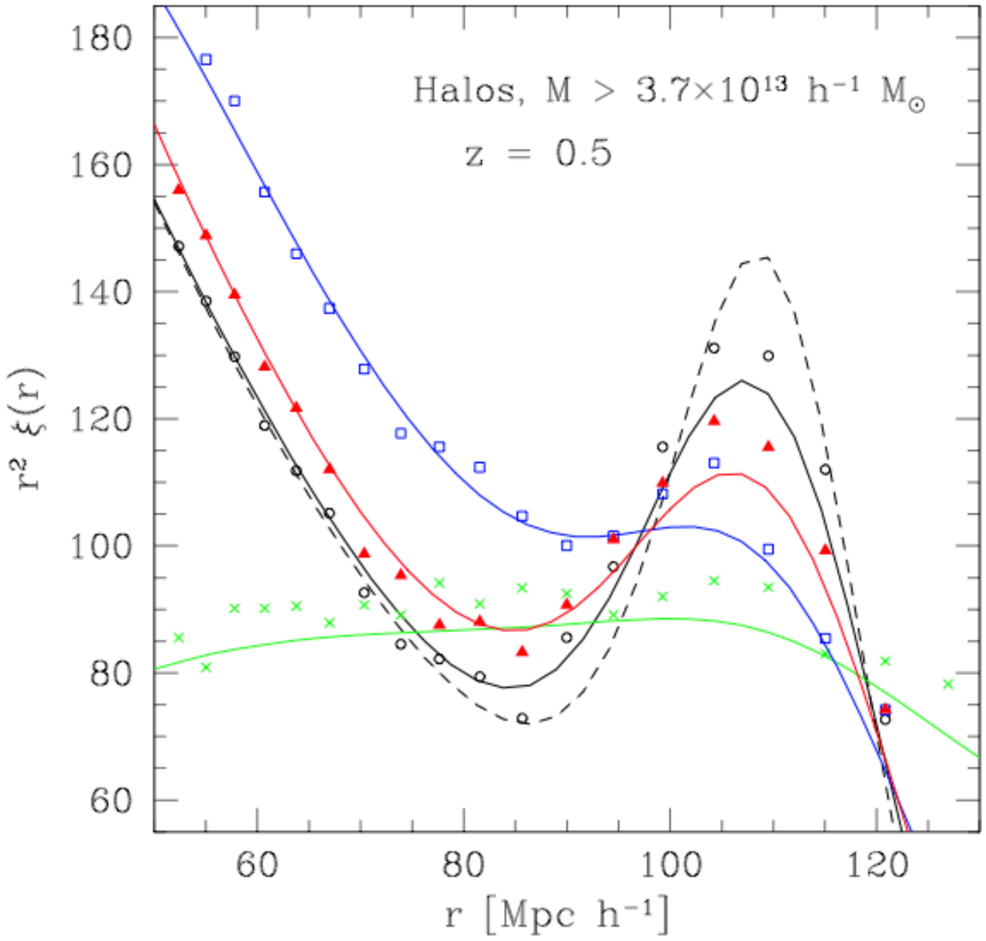




Padmanabhan

PAU motivation



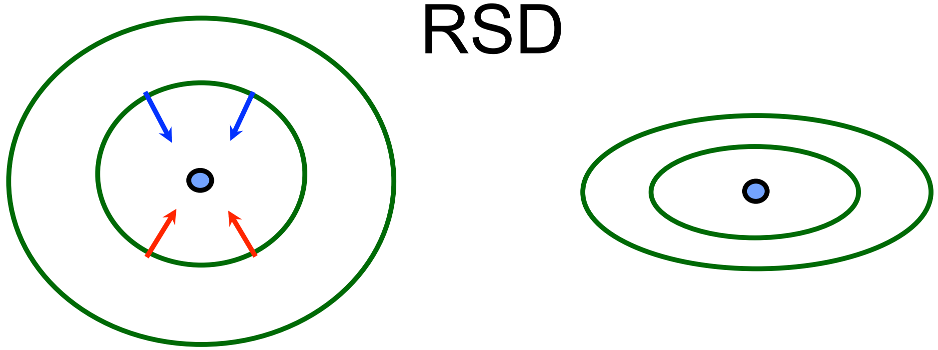


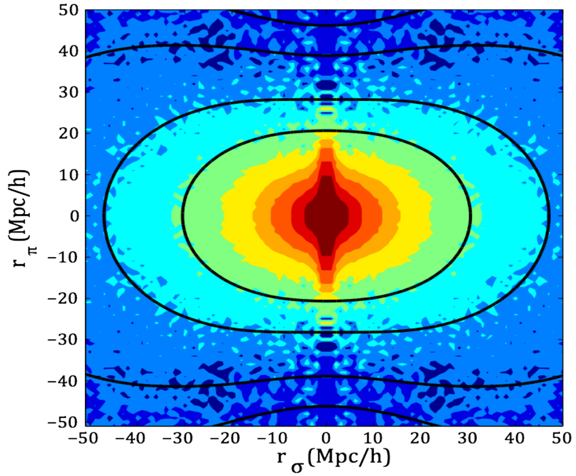
Benitez et al 2009

PAU motivation

- There is significantly more information in the galaxy power spectrum than just the information from BAO
  - Growth rate
  - Neutrinos
  - Inflation

RSD

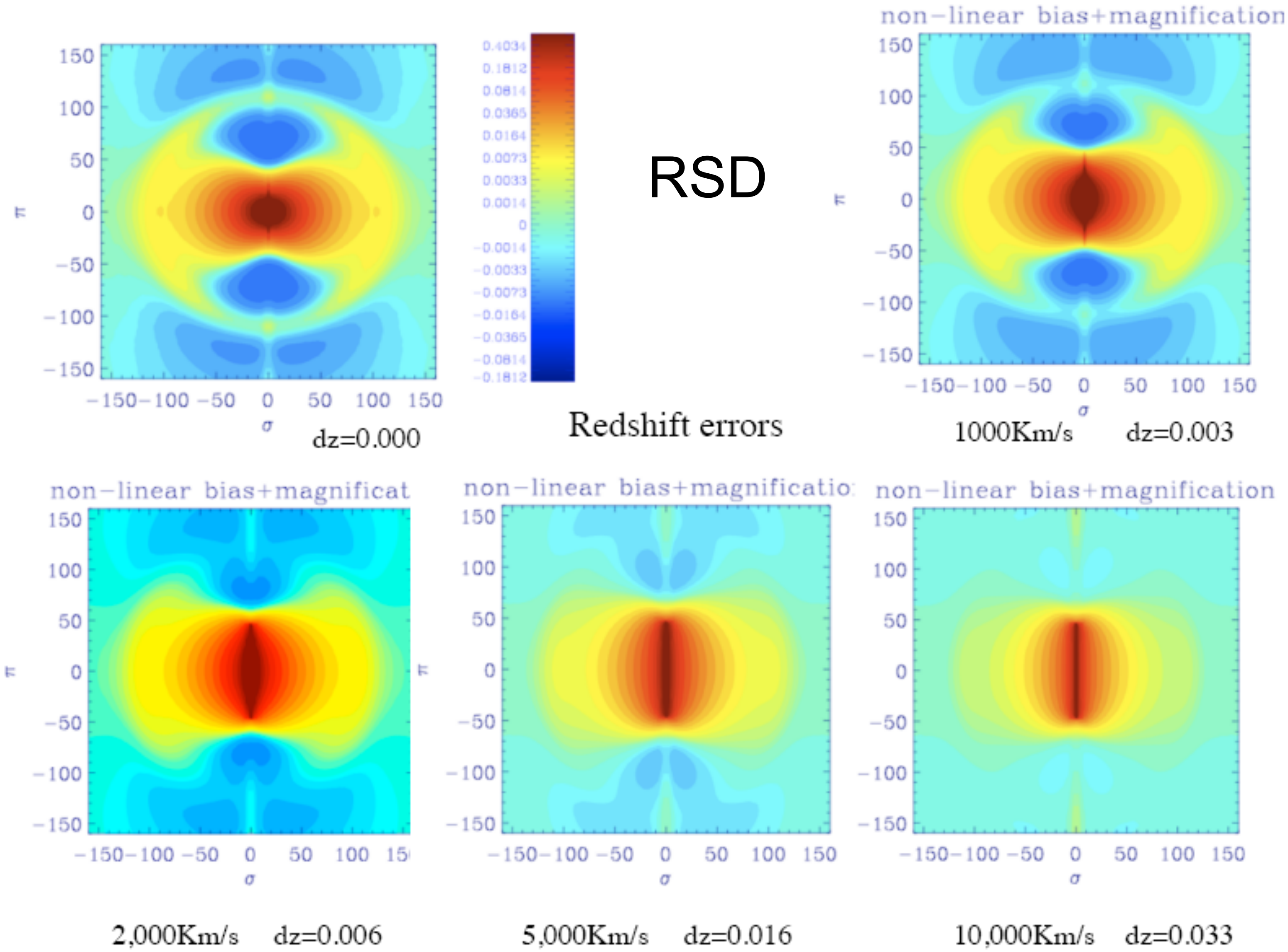




observed redshift space distortions from BOSS

- **Anisotropy in the correlation function constrains $f\sigma_8$, where *f* is the growth rate**
- **Produces a test of GR**

PAU motivation

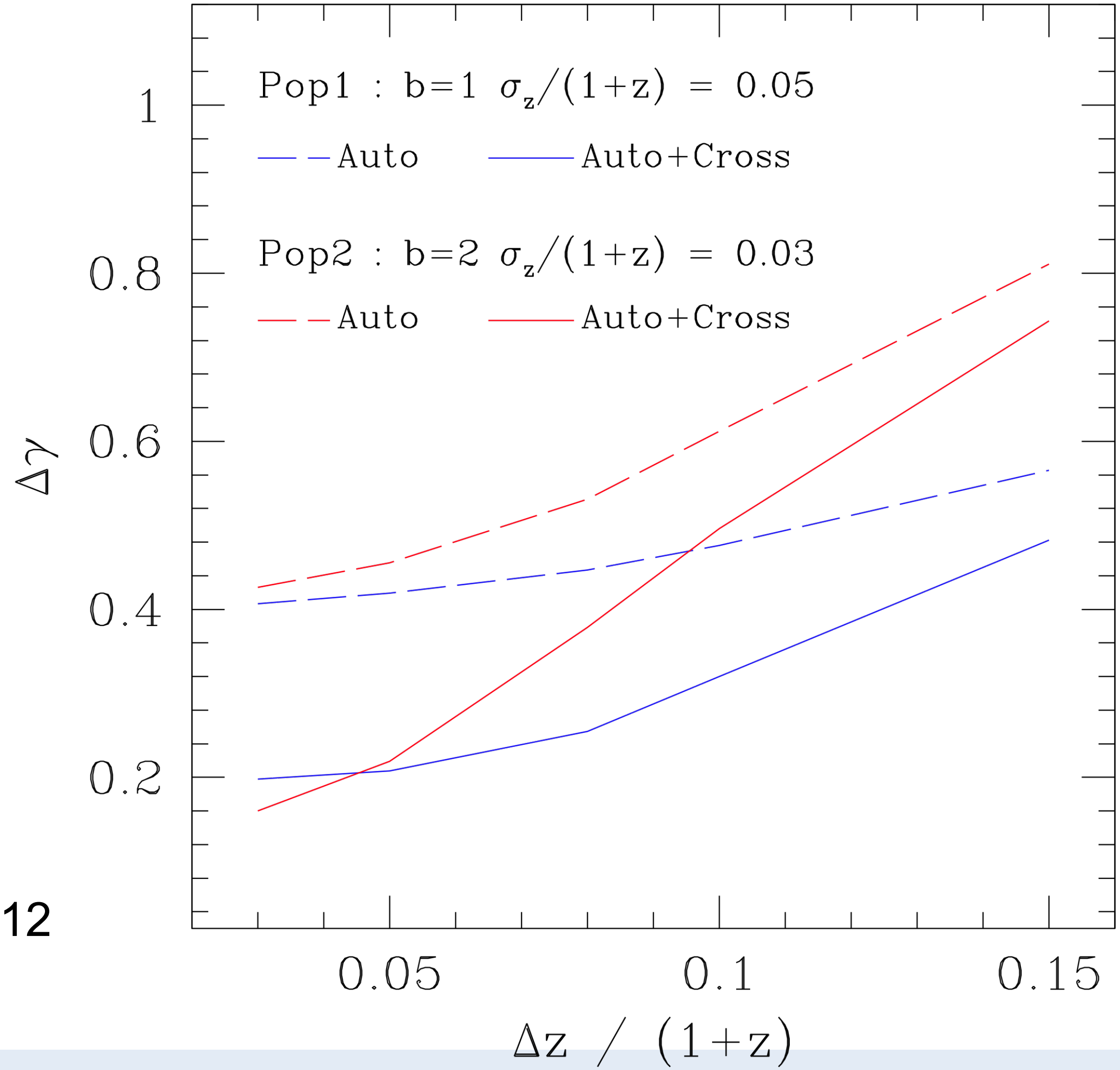


PAU motivation

- For some cosmological applications redshift do not need to be very precise

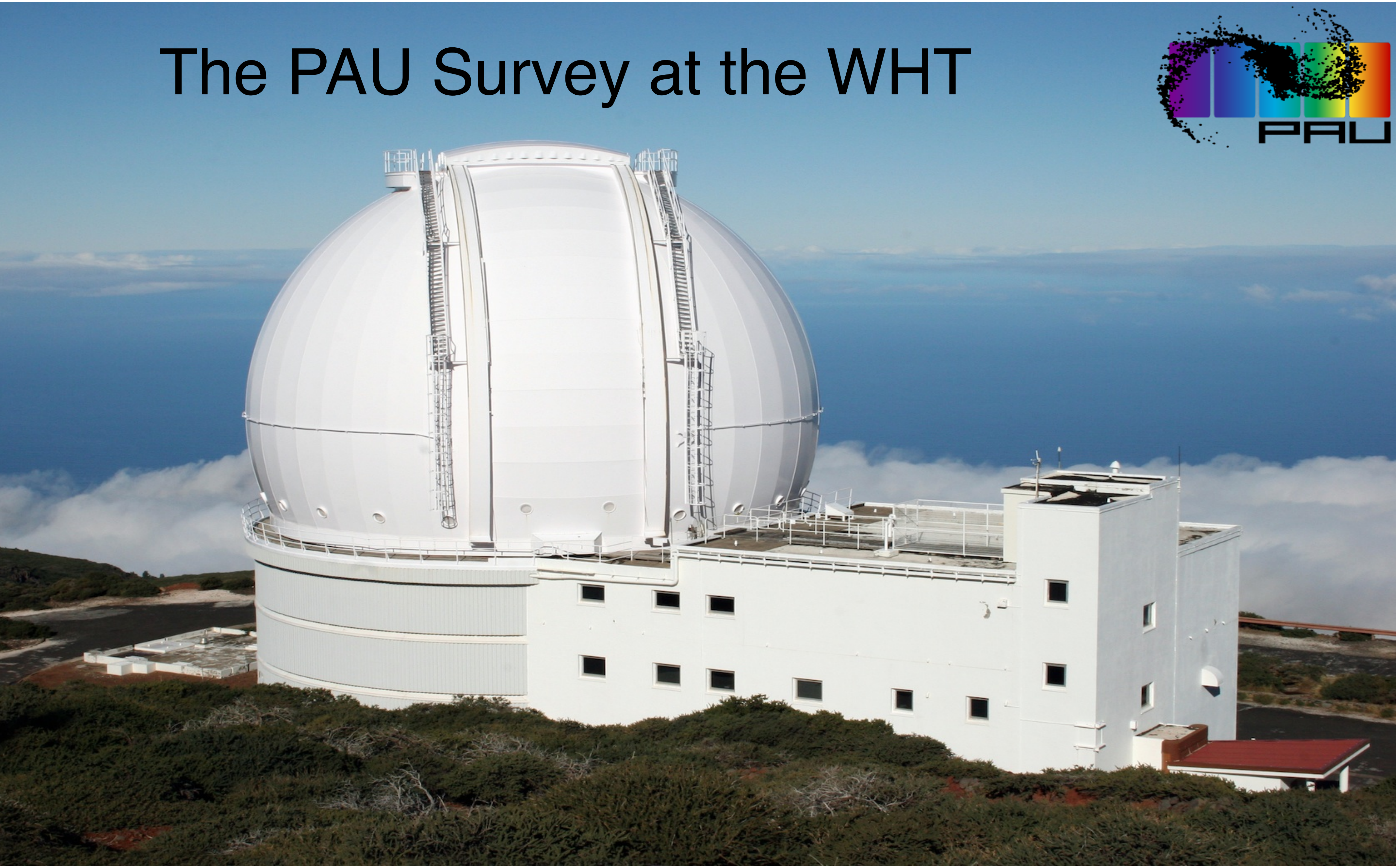
- Good sampling allows to select several samples in same volume helping to beat cosmic variance

PAU motivation



Asorey et al 2012

The PAU Survey at the WHT



PAU at the WHT

PI : E. Fernández (UAB/IFAE)
Co-Is: E. Sánchez (CIEMAT), E. Gaztañaga(IEEC/CSIC), R. Miquel (IFAE), J. García-Bellido (IFT/UAM), M. Delfino (PIC)

PAUCam PI: F. J. Castander
Instrument Scientist: C. Padilla; **System Engineer**: L. Cardiel, **DAQ:** J. de Vicente; **Mechanics**: F. Grañena, L. Lopez, J. Gaweda; **Control**: O. Ballester, C. Pio; **Optics and integration**: R. Casas, J. Jiménez.

PAUDM & Science PI: E. Gaztañaga
Simulations: F.J. Castander; **Operation**: N. Tonello; **Data Reduction**: S. Serrano; **QA&Validation**: N. Sevilla.

The Survey Team:

D. Alonso[4], J. Asorey[2], O. Ballester[3], A. Bauer[2], C. Bonnett[2], A. Bueno[4], J. Campa[1], L. Cardiel[3], J. Carretero[2], R. Casas[2], F.J. Castander[2], J. Castilla[1], M. Crocce[2], M. Delfino[5], J.F. de Vicente[1], M. Eriksen[2], S. Farrens[2], E. Fernández[3], P. Fosalba[2], J. García-Bellido[4], E. Gaztañaga[2], F. Grañena[3], A. Izard[2], J. Jiménez[2], C. López[2], L. C. López[3], F. Madrid[2], M. Maiorino[3], P. Martí[3], G. Martínez[1], R. Miquel[3], C. Neissner[5], L. Ostman[3], A. Pacheco[5], C. Padilla[3], C. Pio[3], A. Pujol[2], J. Rubio[4], E. Sánchez[1], D. Sapone[4], S. Serrano[2], I. Sevilla[1], P. Tallada[5], N. Tonello[5].

[1] CIEMAT, Madrid — Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

[2] ICE,IEEC/CSIC Barcelona — Institut de Ciències de l'Espai CSIC

[3] IFAE/UAB, Barcelona — Institut de Física d'Altes Energies; Universitat Autònoma de Barcelona

[4] IFT/UAM, Madrid — Instituto de Física Teórica UAM/CSIC

[5] PIC, Barcelona — PIC port d'informació científica

PAUCam: a complete experiment

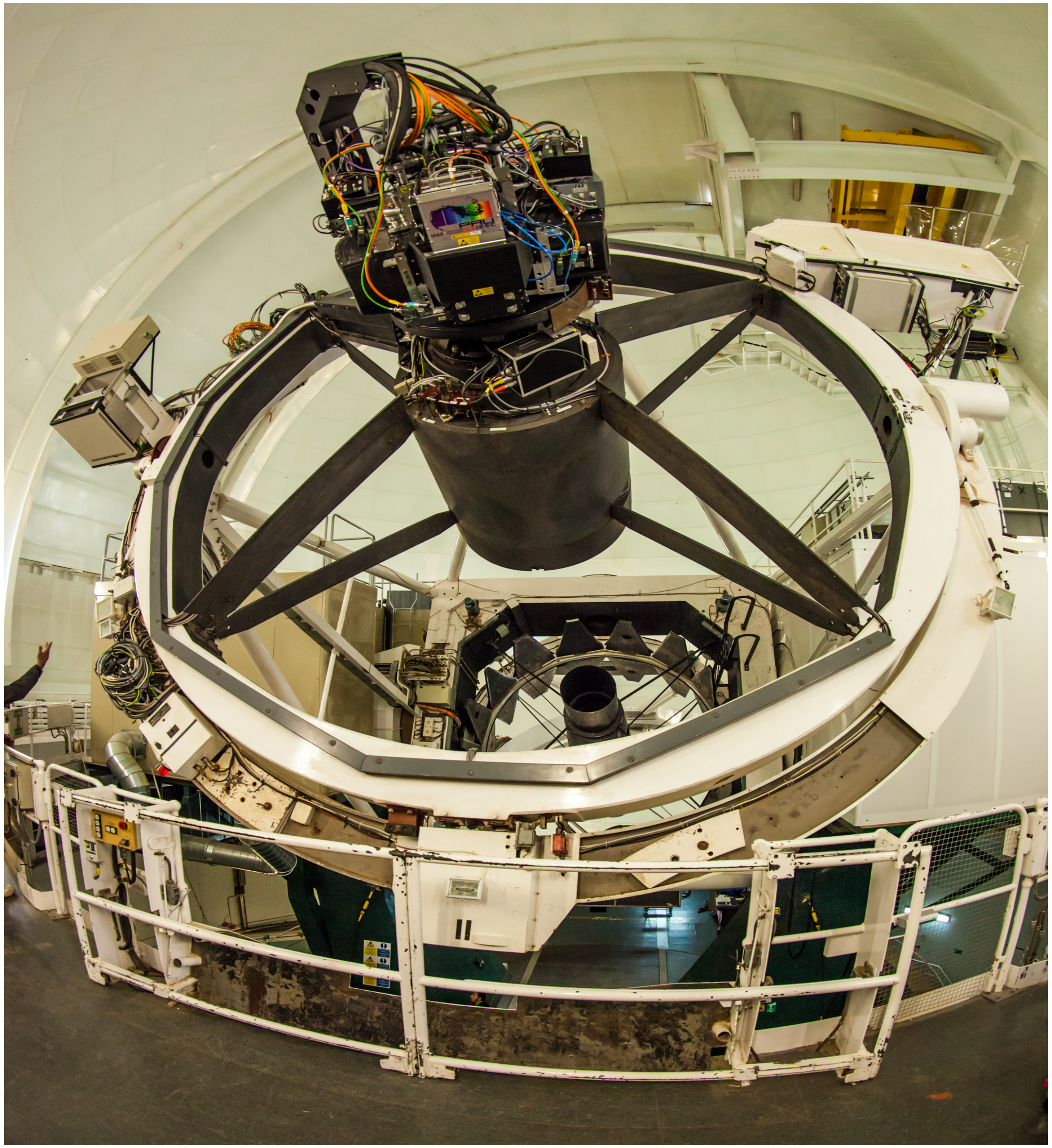
- The PAU collaboration has designed and built/developed the complete experiment
  - Science goals
  - Design
  - Mechanics
  - Electronics
  - Detector characterization
  - Filter specification and characterization
  - Computing
  - DAQ and Control software
  - Data transfer and storage
  - Data reduction software and strategy
  - Calibration and analysis software
- ..and is responsible of
  - Camera operation
  - Scientific exploitation
  - …

PAUCam at WHT

WHT Telescope

- Diameter: 4.2 m
- Prime focus: 11.73 m
- Focal ratio: f/2.8
- FoV: 1 deg ∅, 40’ unvignetted
- Scale: 17.58’’/mm ⇔ 0.265”/pixel

PAUCam successfully commissioned on June 3-7



PAUCam mechanics

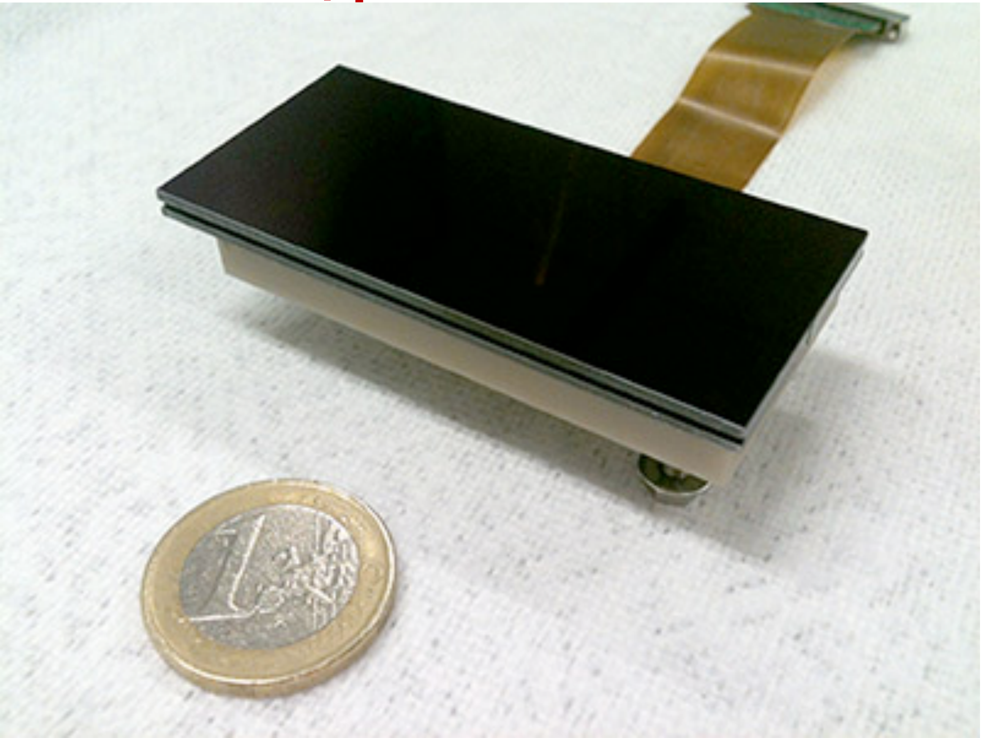
• Body of camera made of carbon fiber, shaped to minimize wall thickness and reduce weight

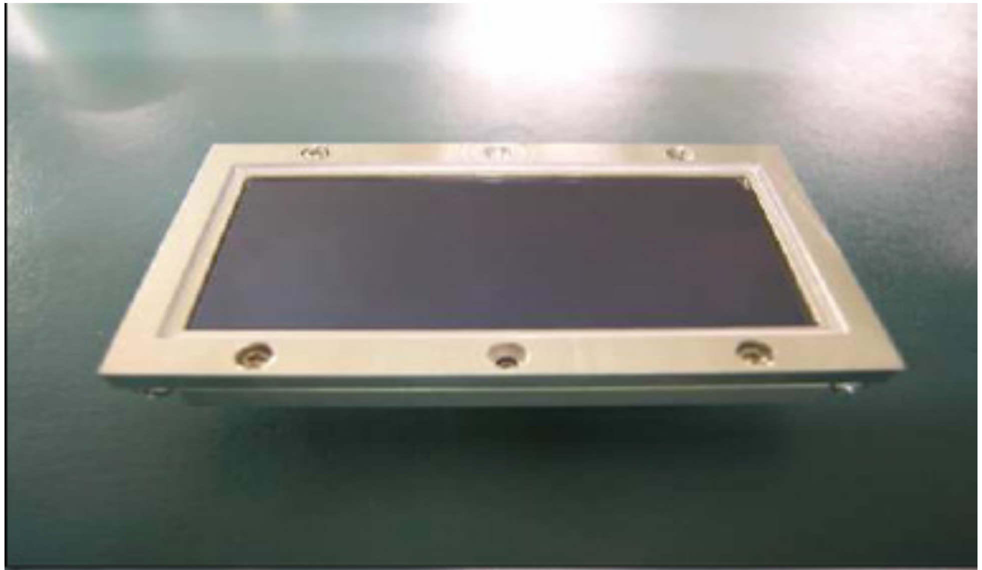
PAUS CCDs

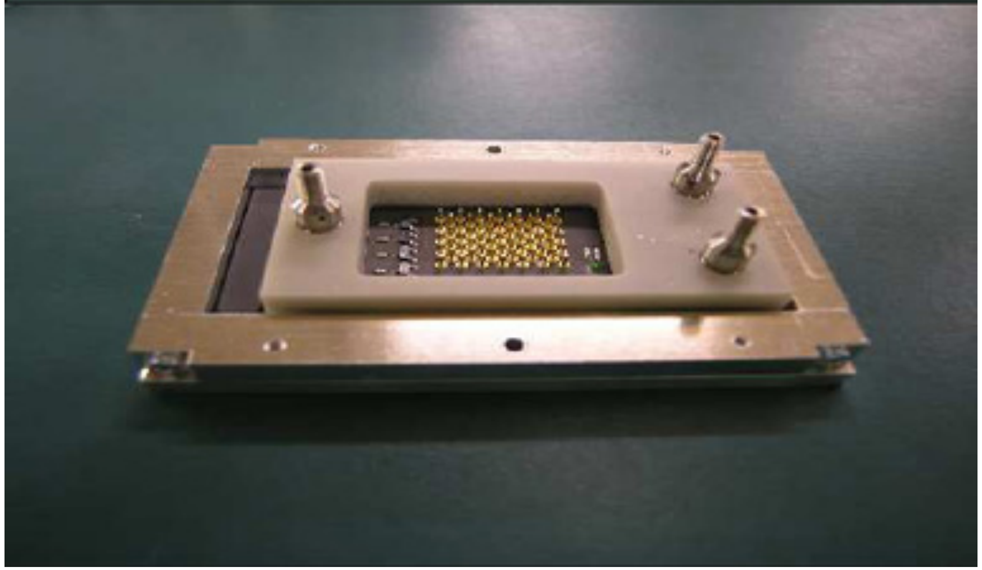
Detectors

- **Hamamatsu photonics (2k X 4k) 200µm thick fully depleted: 15µm pixels**

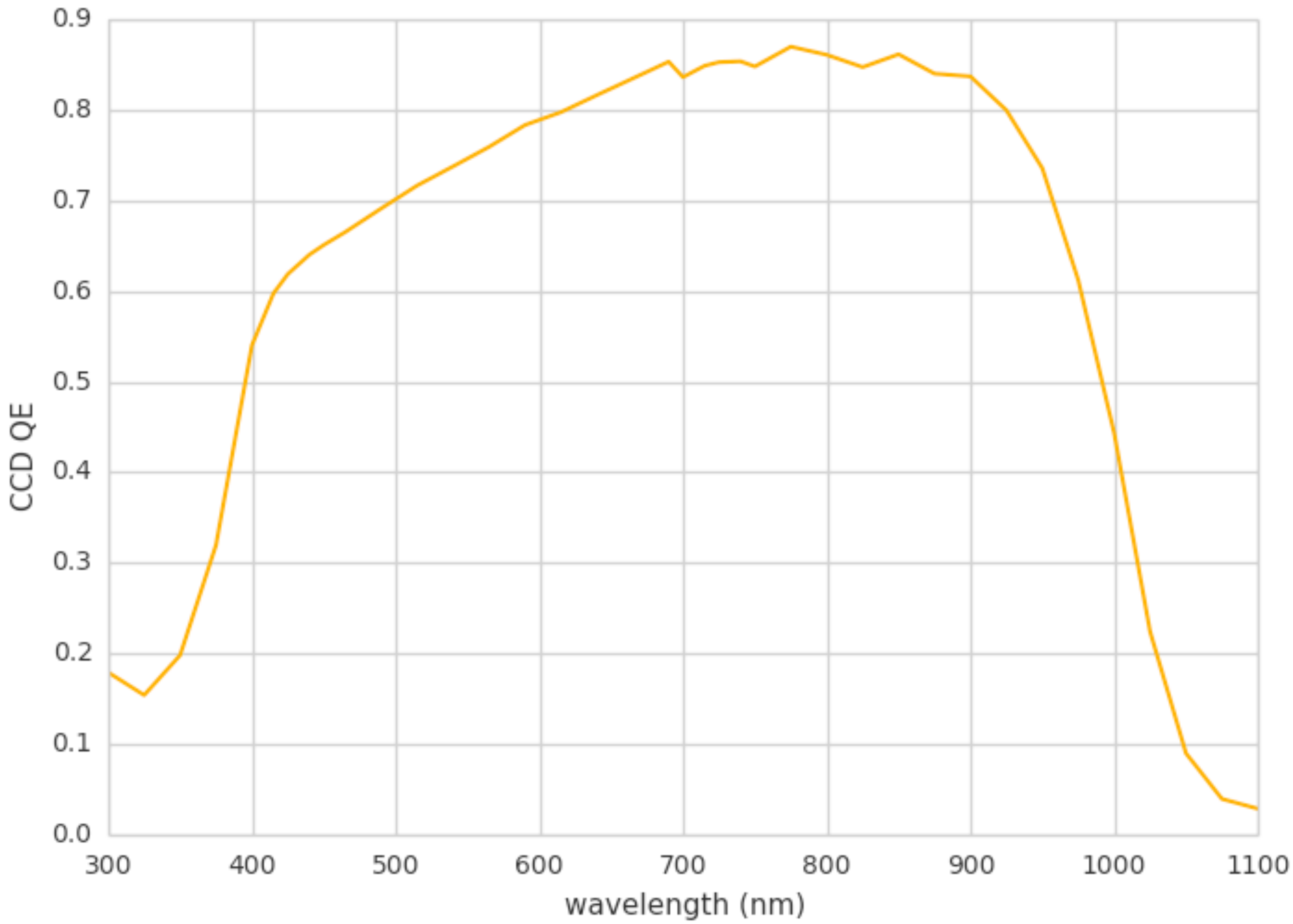
- **Telescope f/2.8 ➔ 0.26" /pixel.**



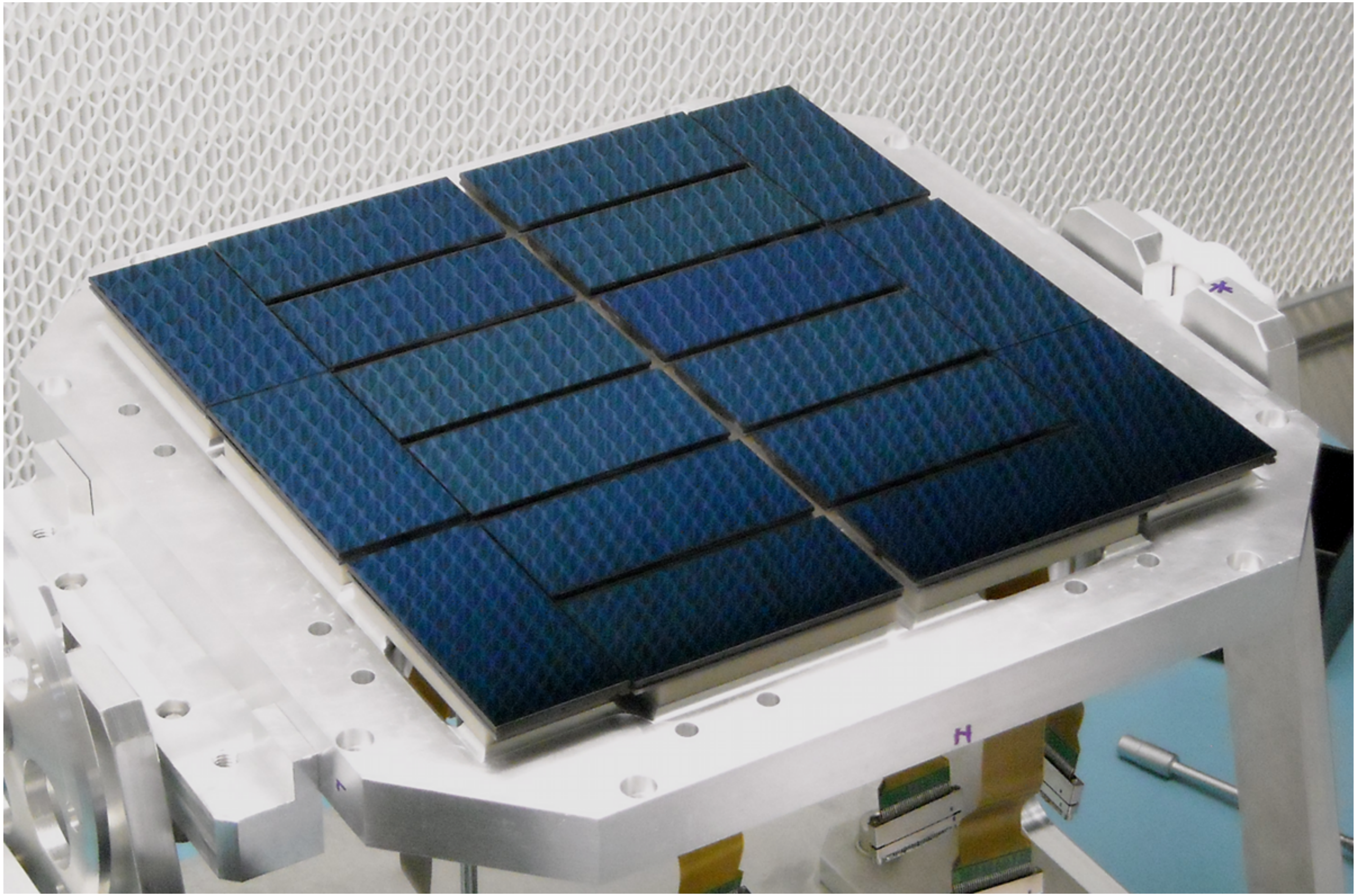




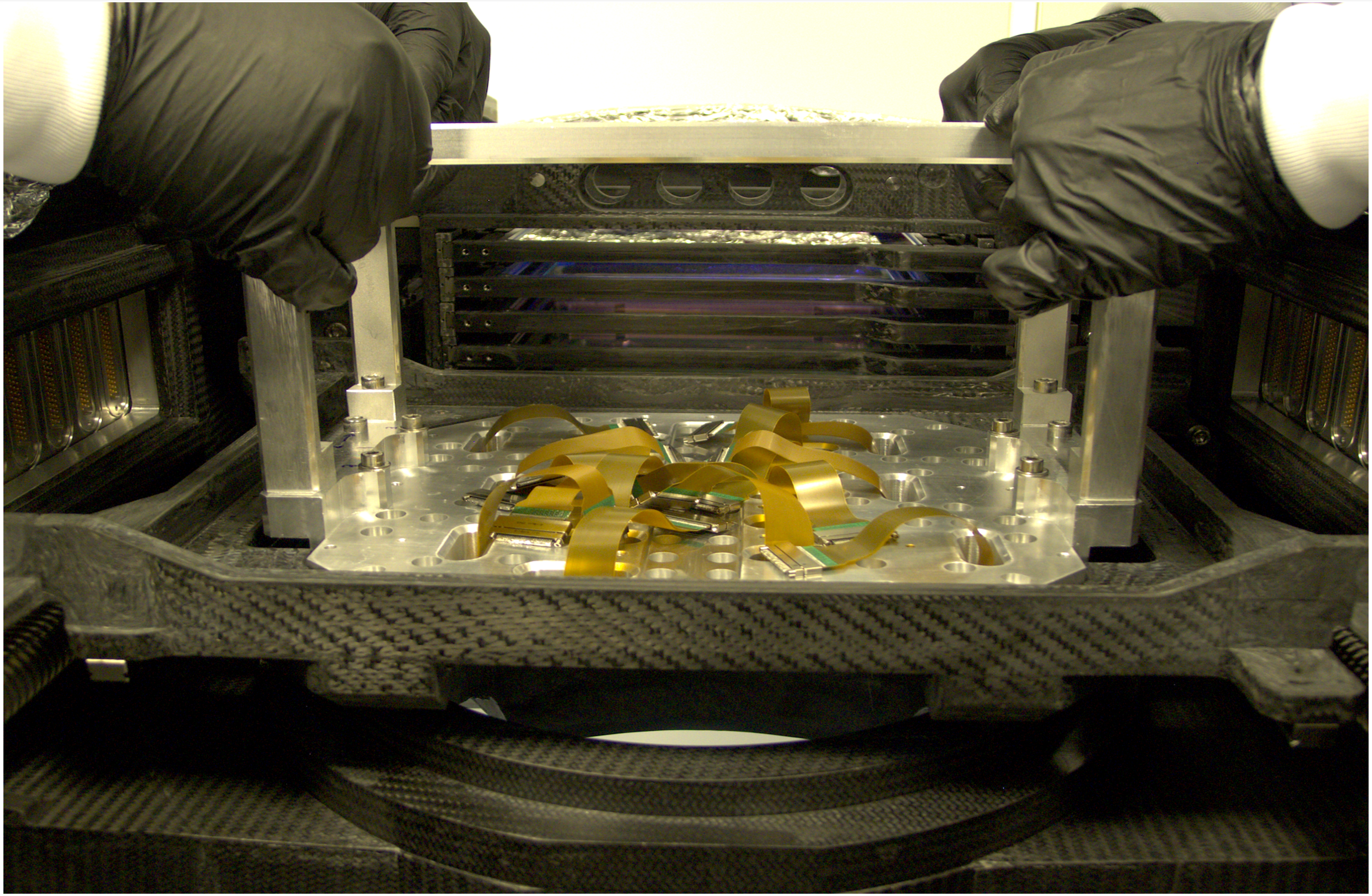
PAUS CCDs: Quantum efficiency



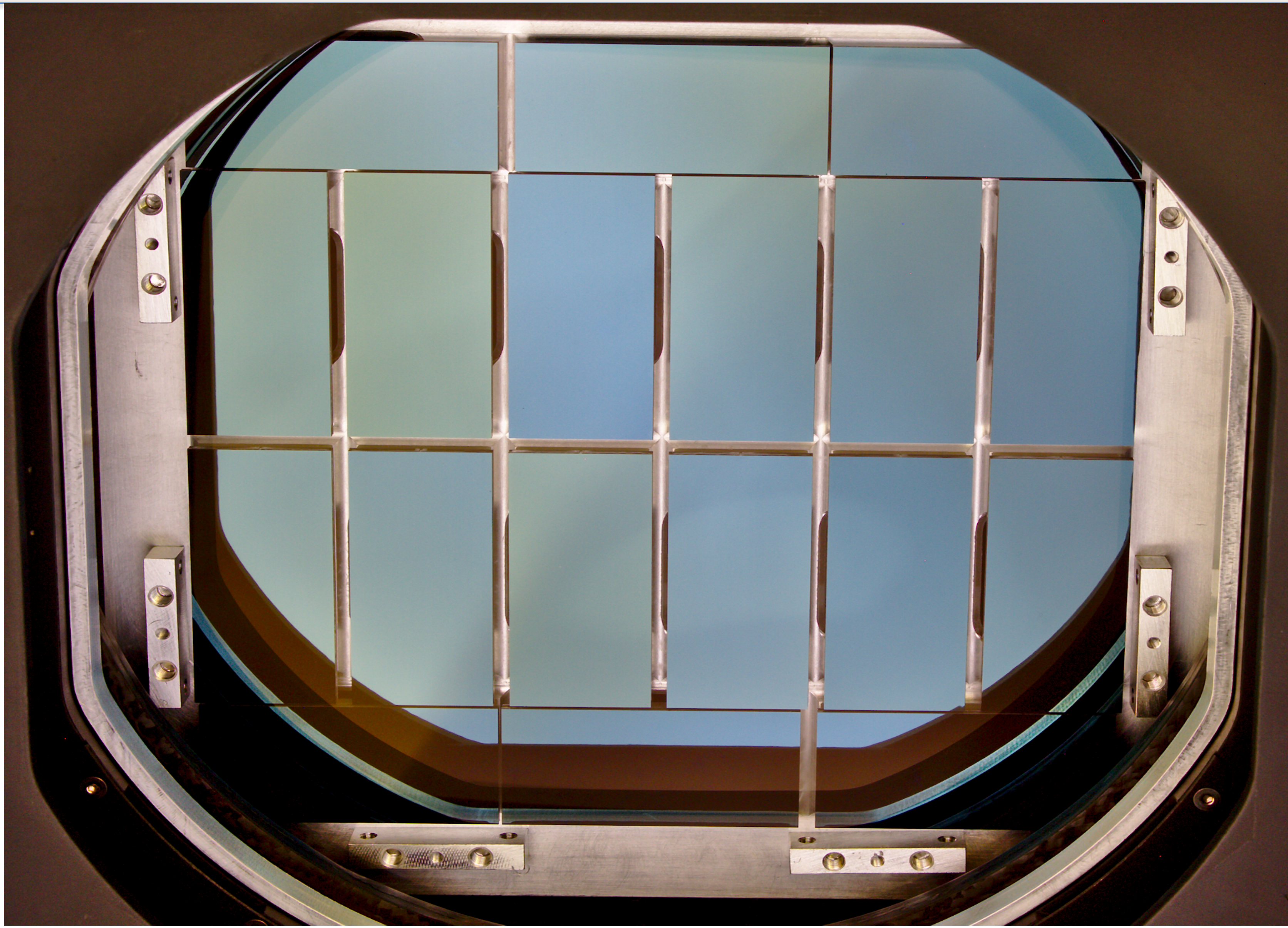
PAUCam focal plane



PAUCam focal plane



PAUCam focal plane



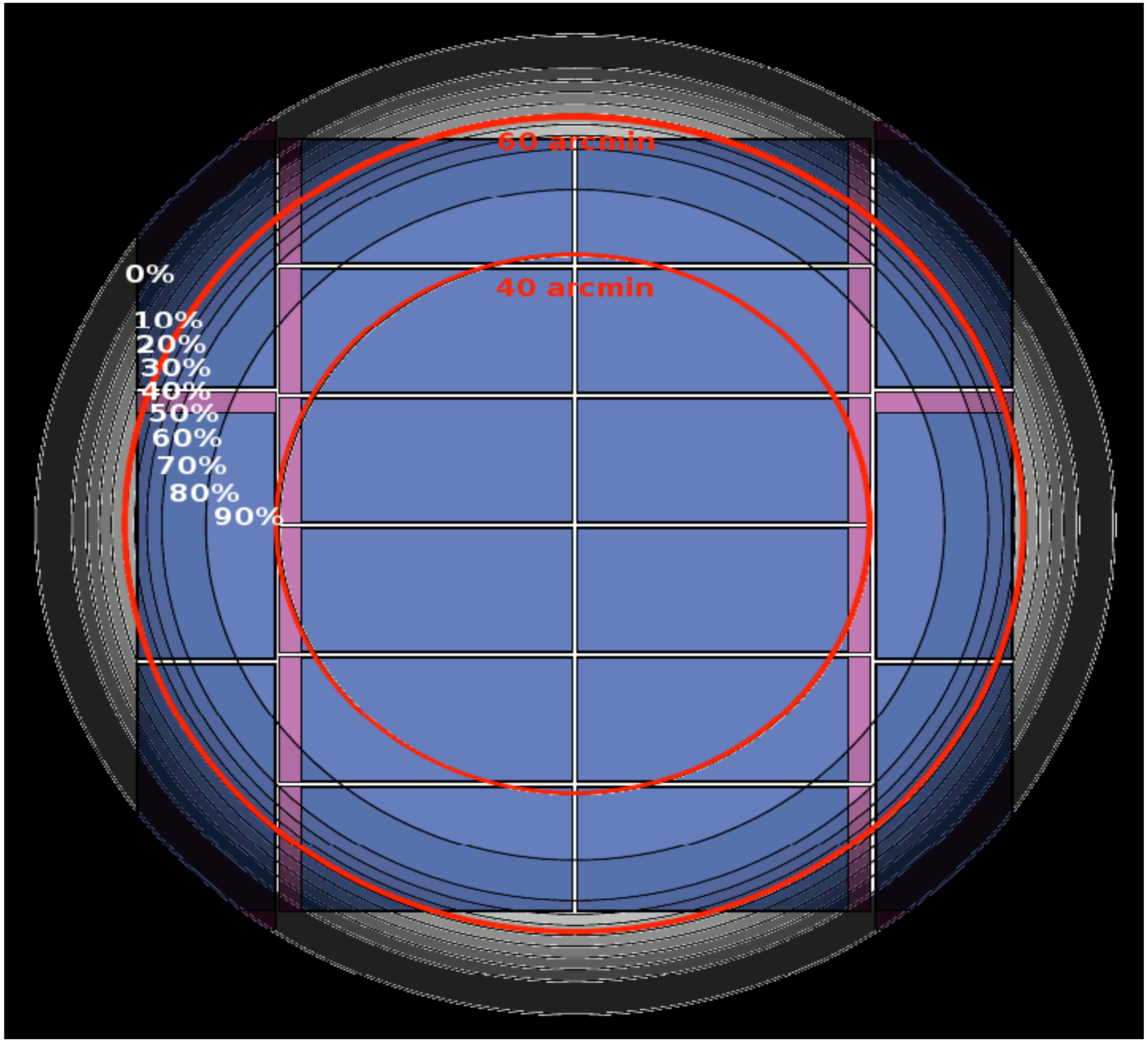
PAUCam focal plane

8 central CCDs with almost 100% exposure for imaging.

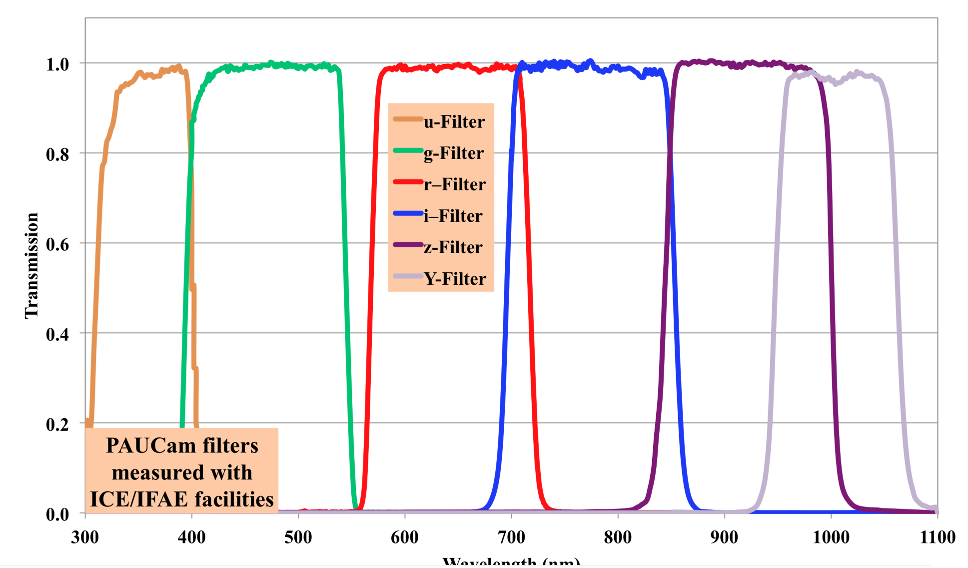
Rest of the CCDs:
2 for guiding
8 for additional photons

40 narrow band (10nm) filters covering the range ≈ 450-850 nm
6 BB filters u g r i z Y.

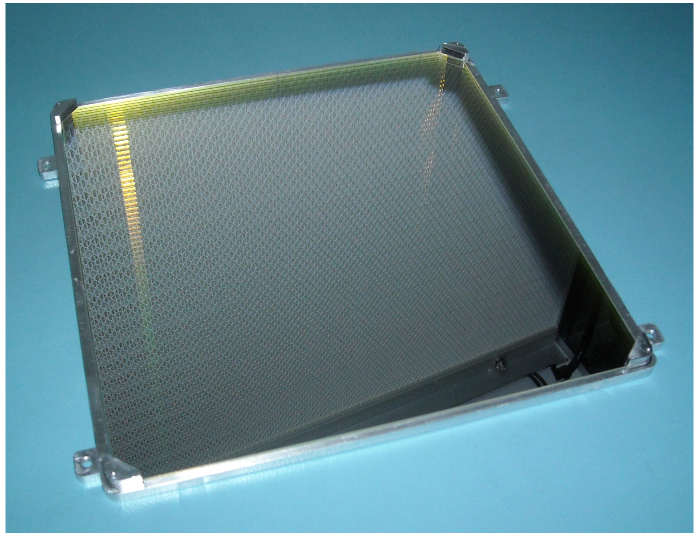
Optimization: central CCDs will have 8 NB, others BB

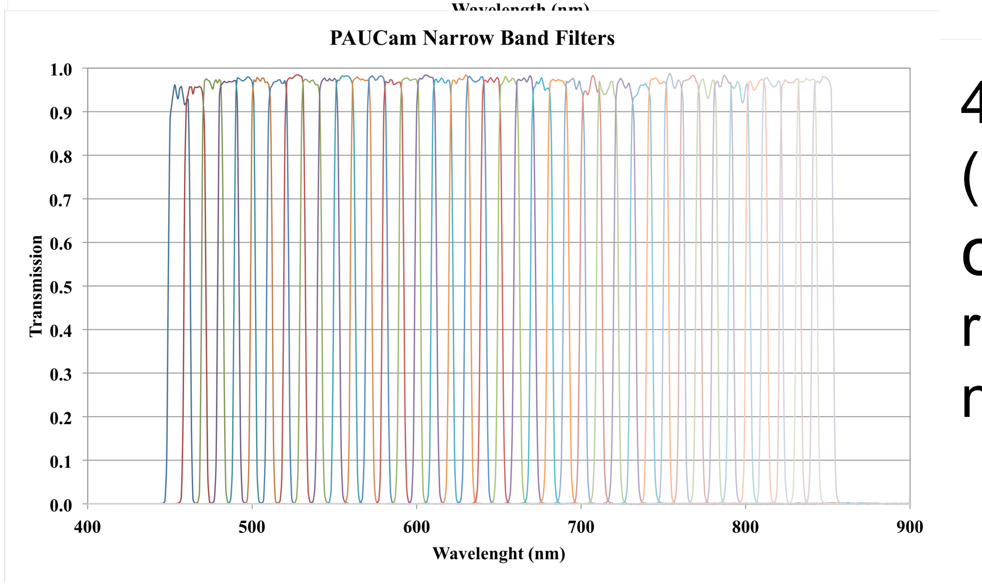


PAUCam filters

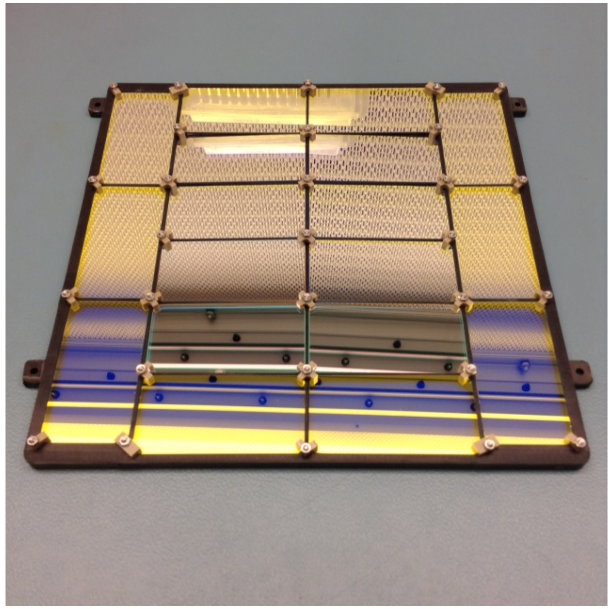


6 BB filters:
u g r i z Y.

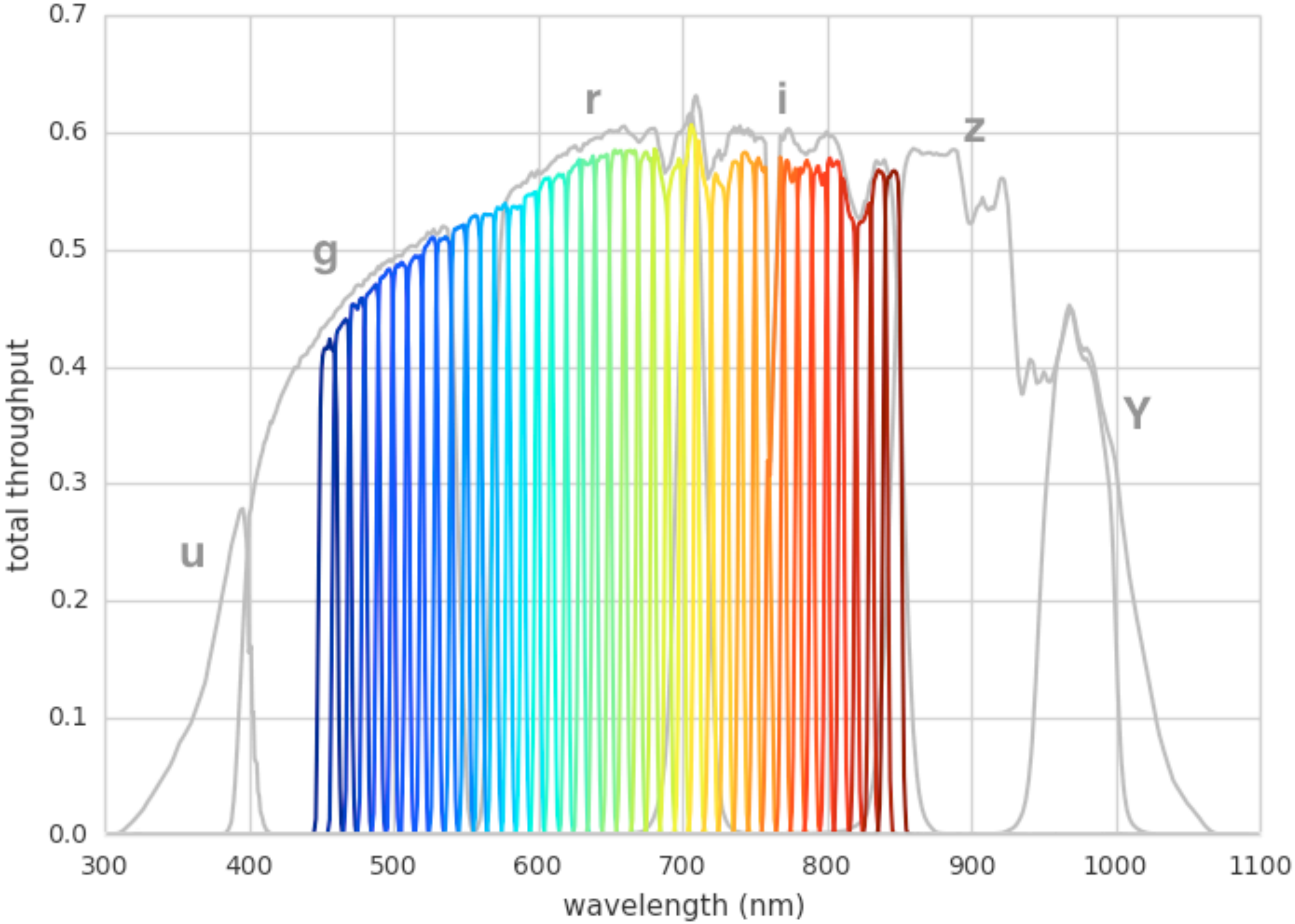




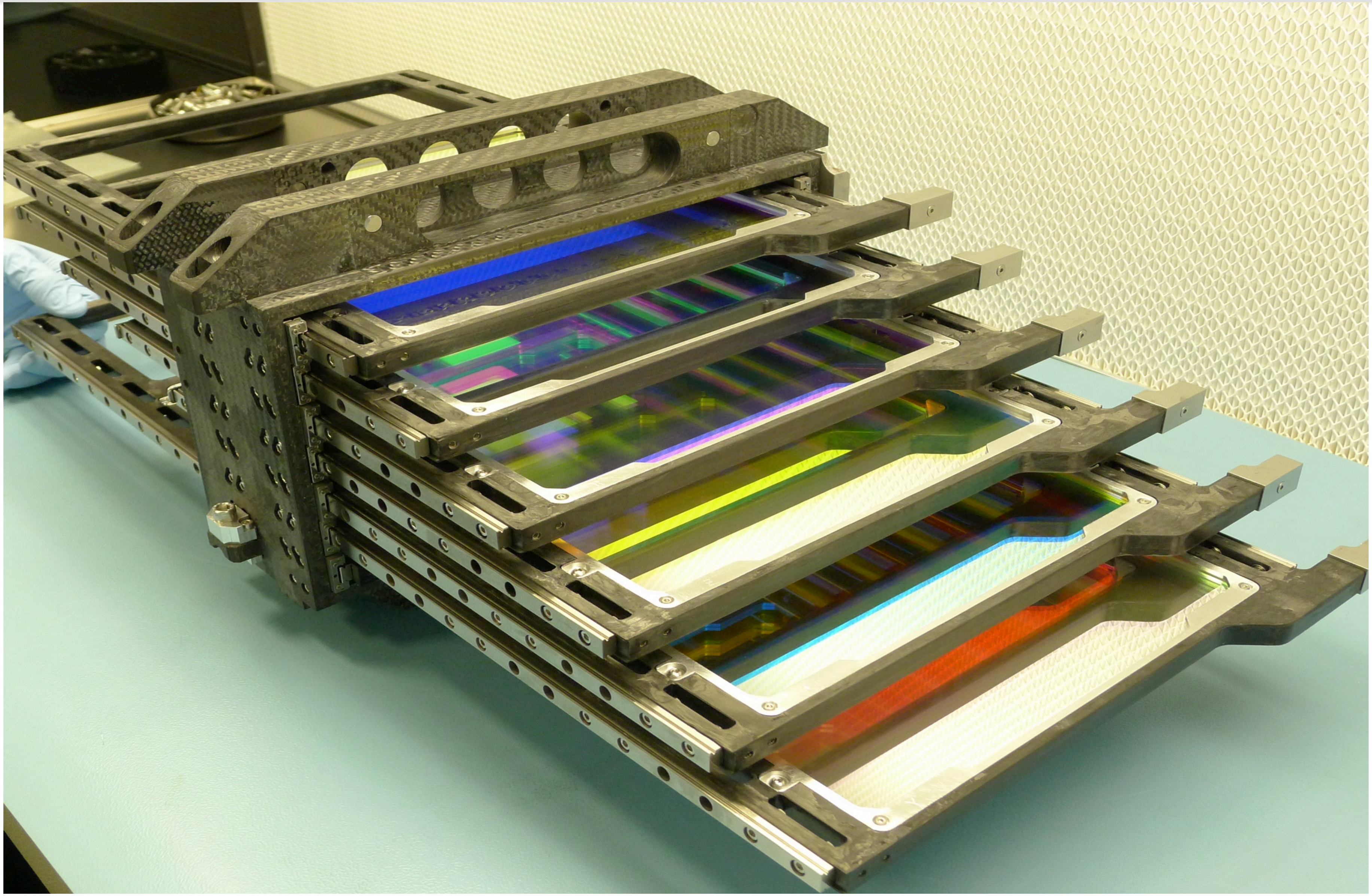
40 narrow band (10nm) filters covering the range ≈ 450-850 nm



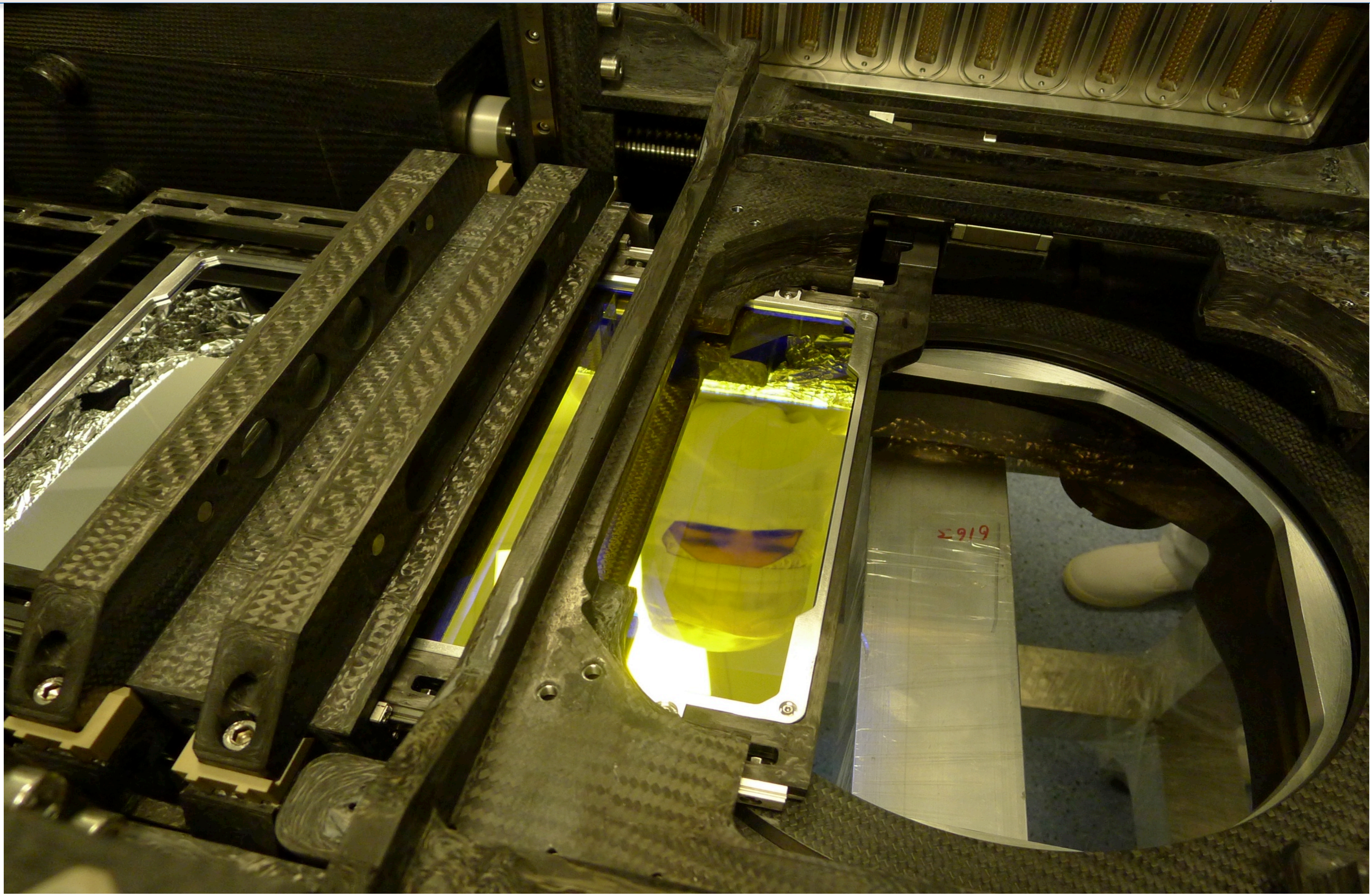
PAUCam filters: system transmission



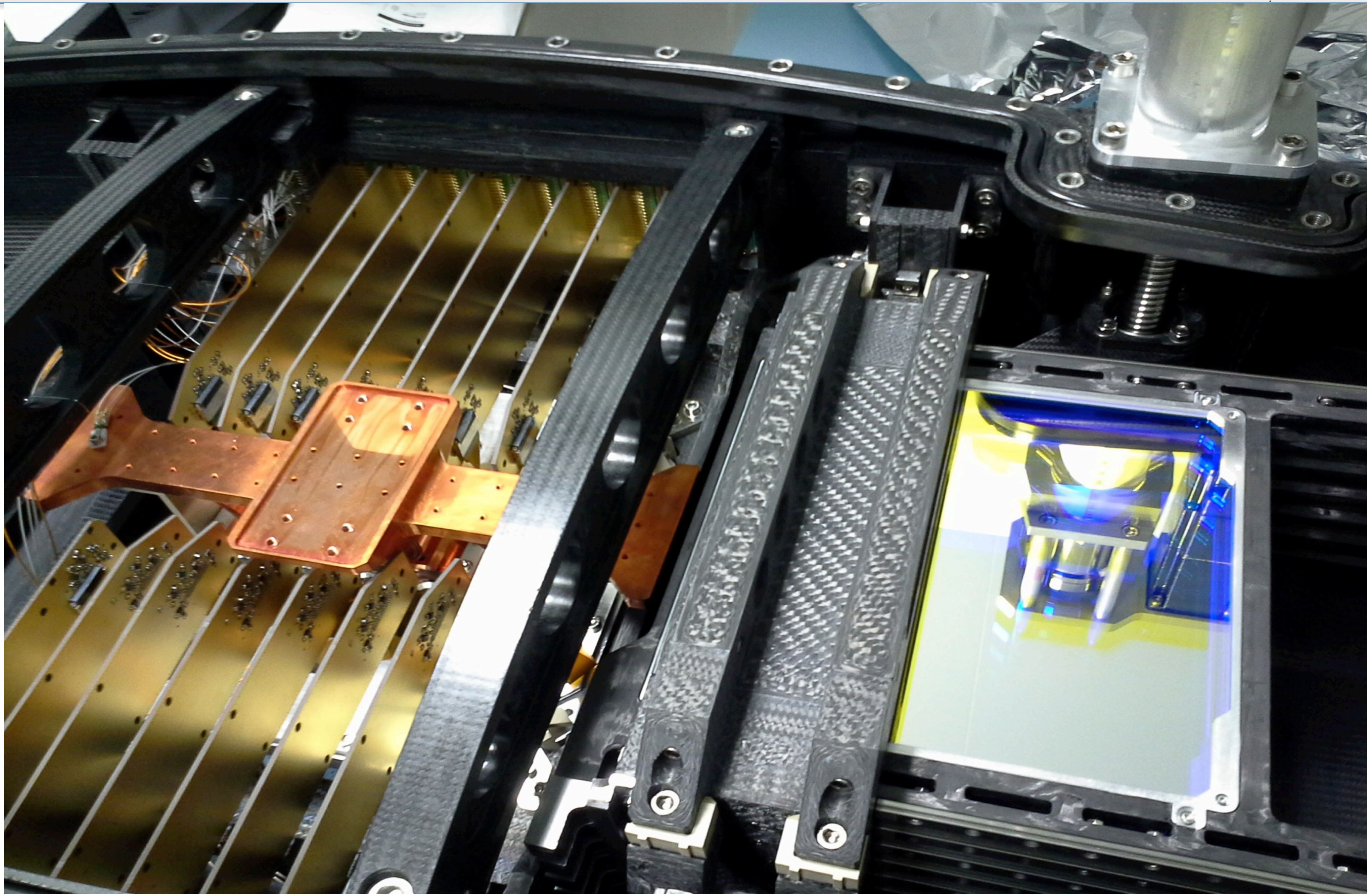
PAUCam jukebox



PAUCam jukebox



PAUCam jukebox



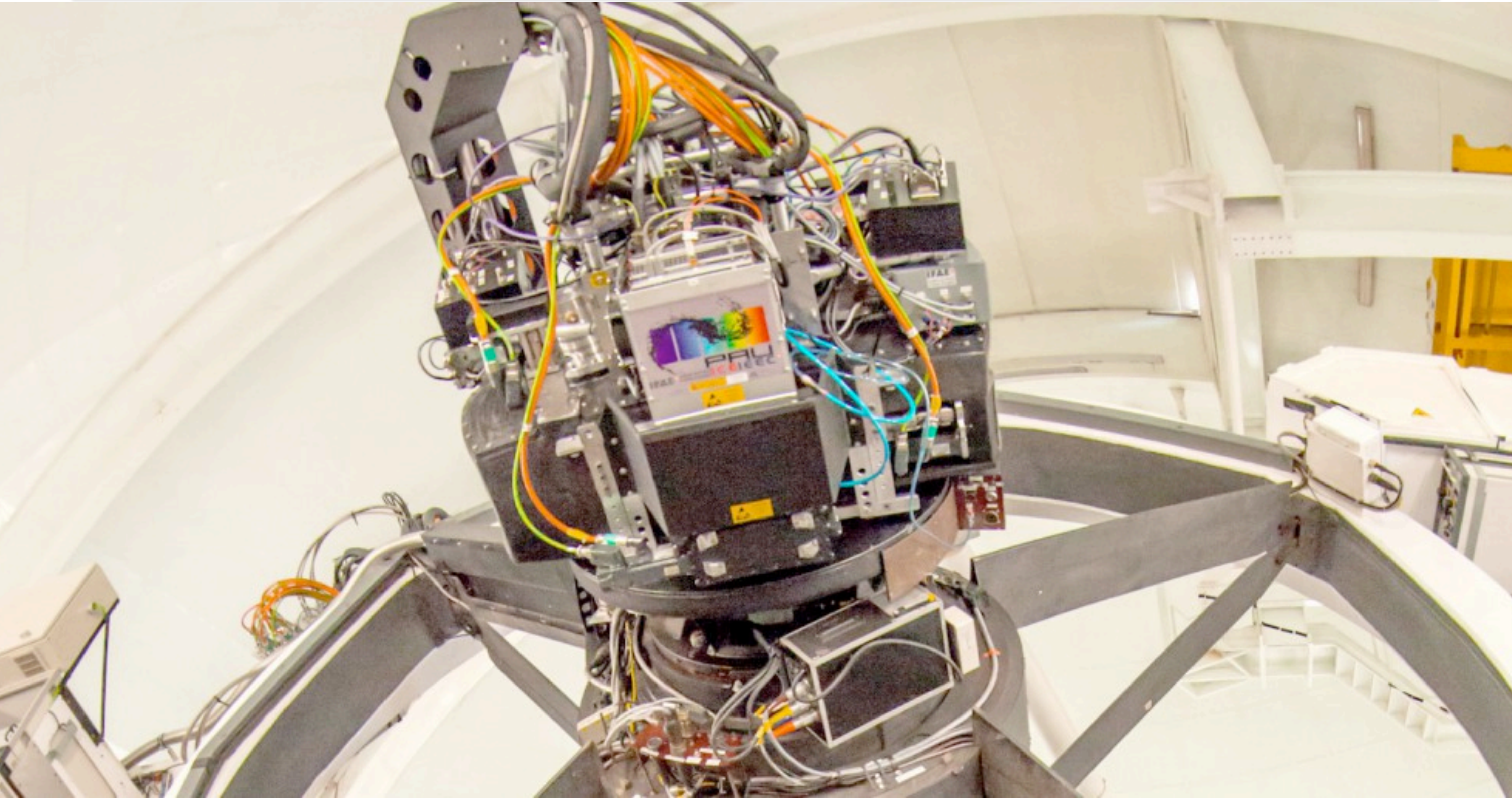
technical specifications summary

- FOV 1 deg x 1 deg
- Pixel Scale 0.265″
- 18 Hamamatsu Fully-Depleted 4K x 2K CCD detectors
- Detectors gain: 0.6 – 0.7
- Detectors dark current (@173K): ~ 1 e– pix/h
- Detectors full well: 210000 e–
- Bias signal: ~ 30k ADU
- ADC range: 18 bits
- Readout noise: ~ 9 e–
- Readout time: 20 s
- 40 narrow-band filters (13 nm wide in steps of 10 nm)
- 6 wide-band filters: u, g, r, i, z, Y

PAU commissioning

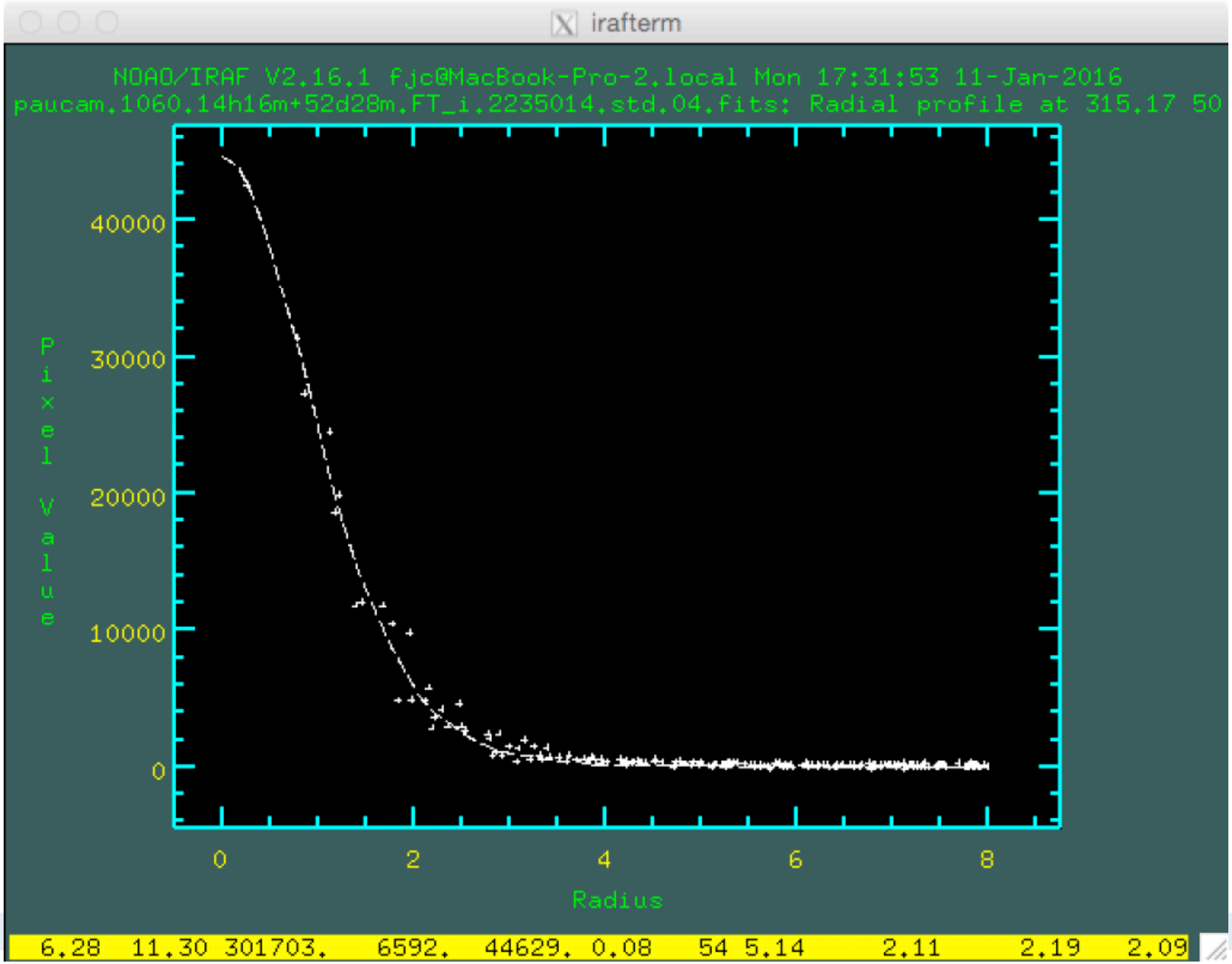
- We commissioned the camera on June 3-7

PAU commissioning



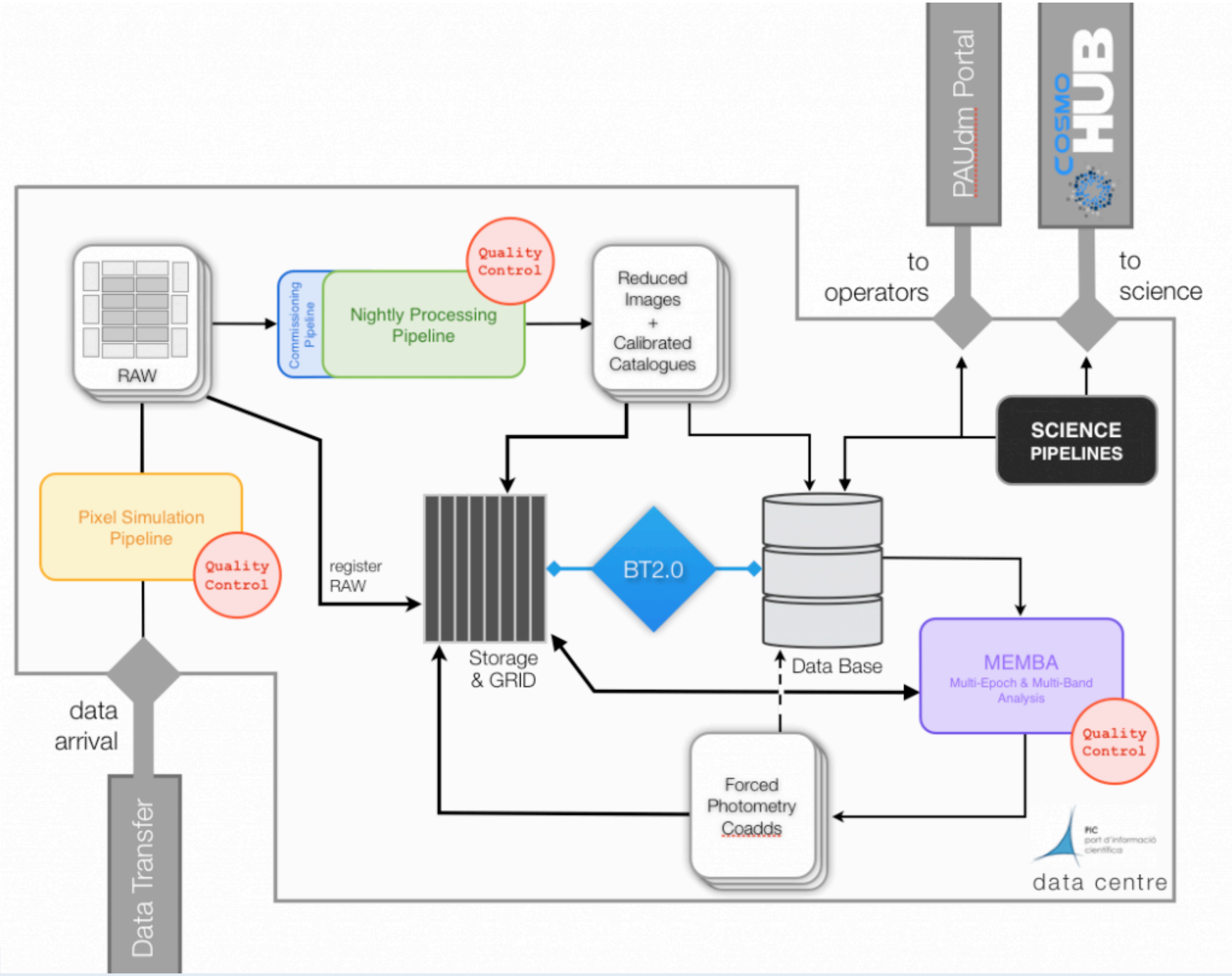
PAUCam commissioning: Image quality

Radial profile of a point source on a science exposure of 120s. The PSF has a seeing of 0.6”



PAUCam : data processing

The PAU data management system aims to transfer, archive, process, calibrate and distribute the data received from the instrument. All the information is stored and processed at the Port d'Informació Científica (PIC). A custom job orchestration system (BrownThrower 2.0) has been developed specifically for PAU, allowing a powerful and flexible pipeline to be quickly analyzed few hours after the observation.



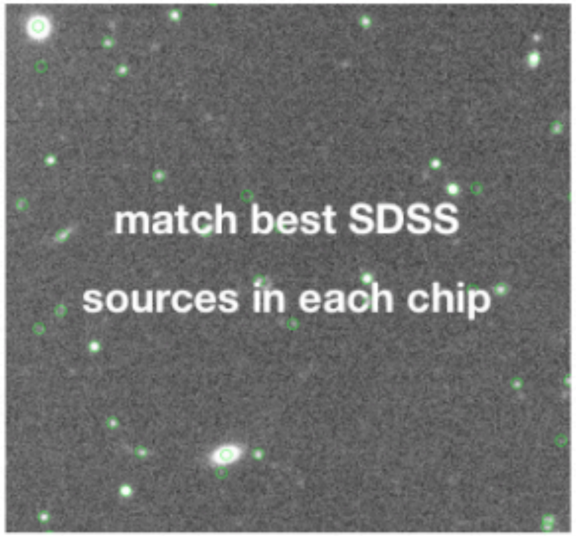
PAUCam: pipeline

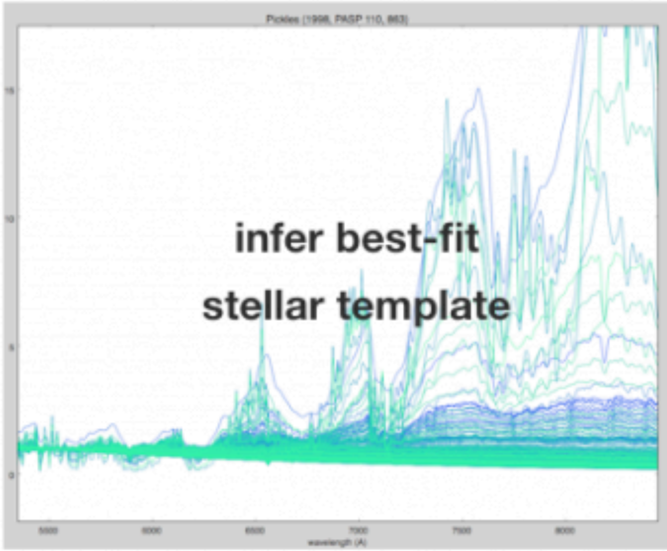
RAW

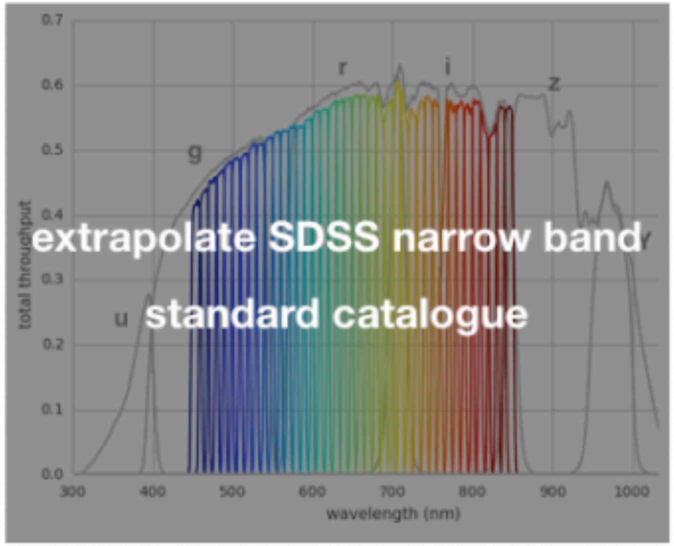
Detrended & Masked

The nightly pipeline delivers basic image detrending (flat-fielding, cosmic ray rejection, optical distortion correction…) and an innovative photometric calibration to deliver accurate zeropoints over broad and narrow band images.

PAUCam: pipeline



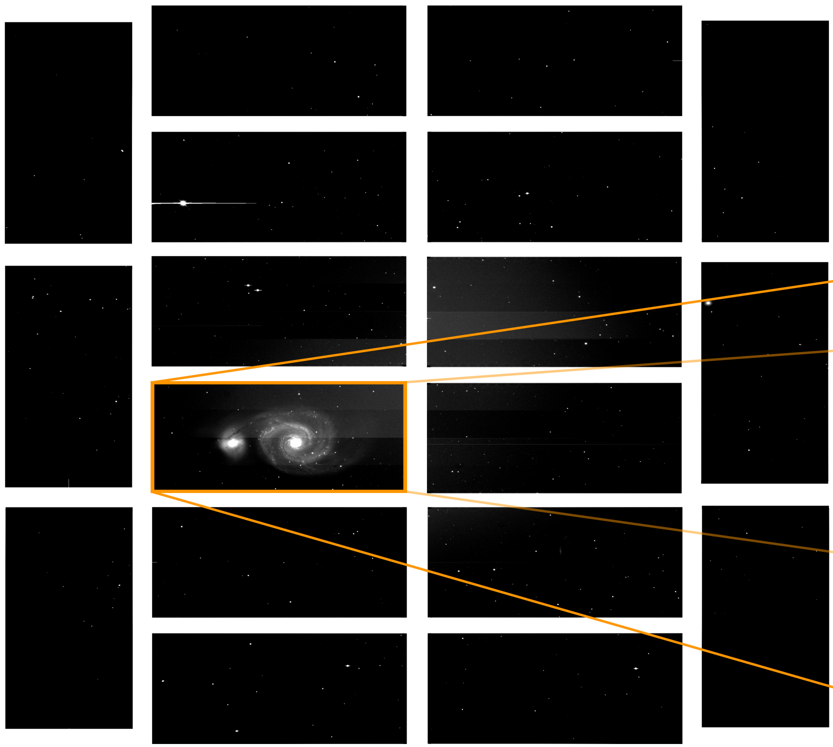




The nightly pipeline delivers basic image detrending (flat-fielding, cosmic ray rejection, optical distortion correction…) and an innovative photometric calibration to deliver accurate zeropoints over broad and narrow band images.

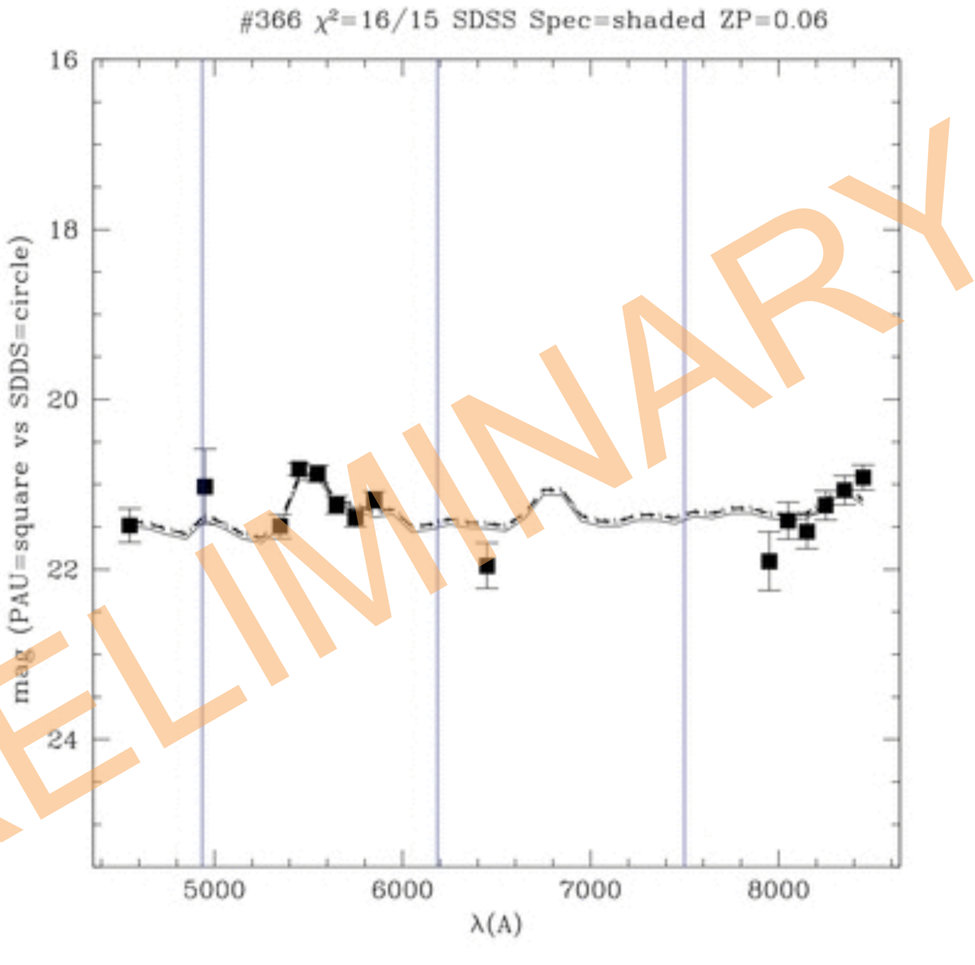
Whirlpool Galaxy

M51- Whirlpool Galaxy
First night of PAUCam in WHT. June 4, 2015.
Single exposure image using **g r i** filters.

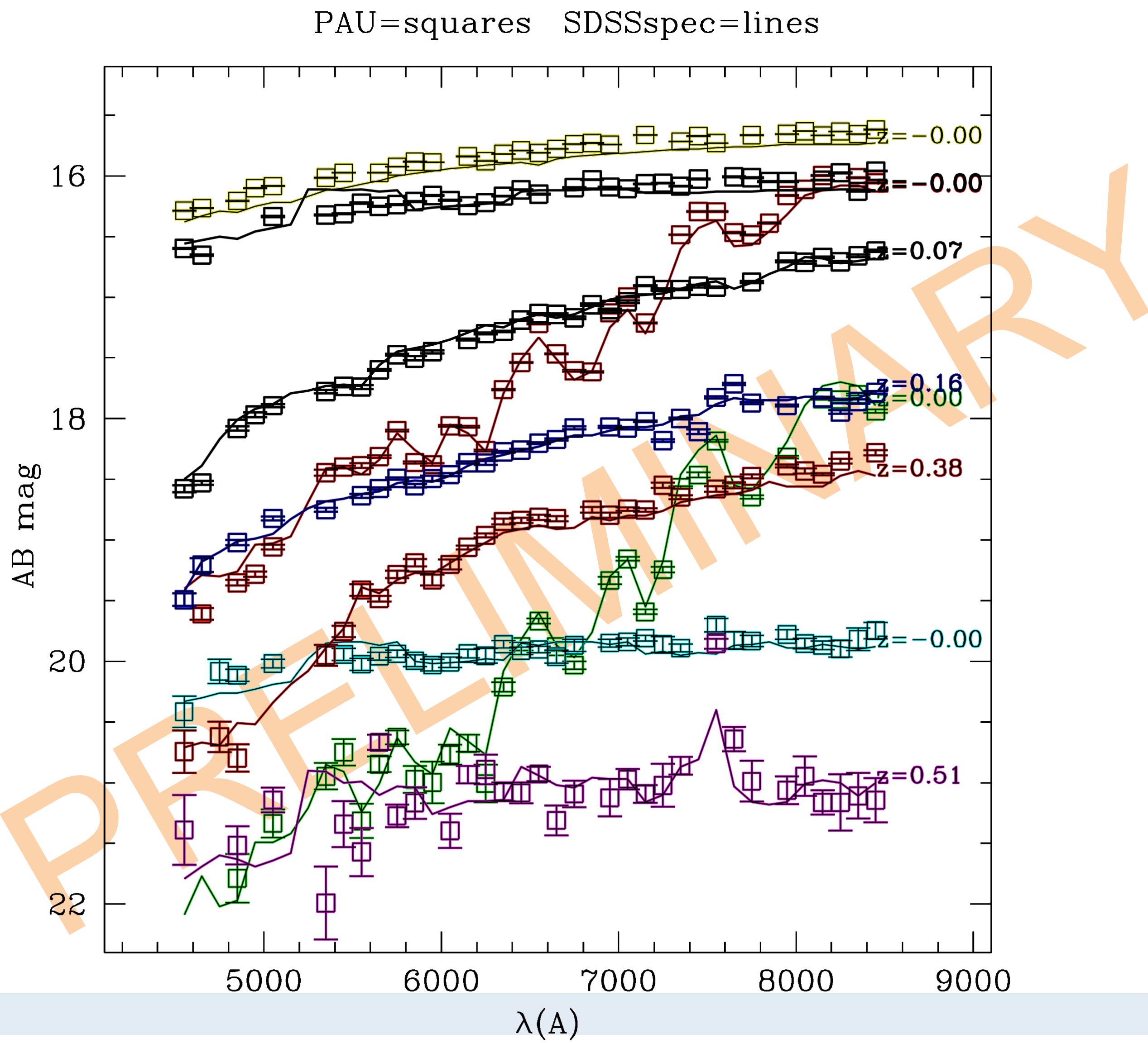


PAUCam commissioning: preliminary results

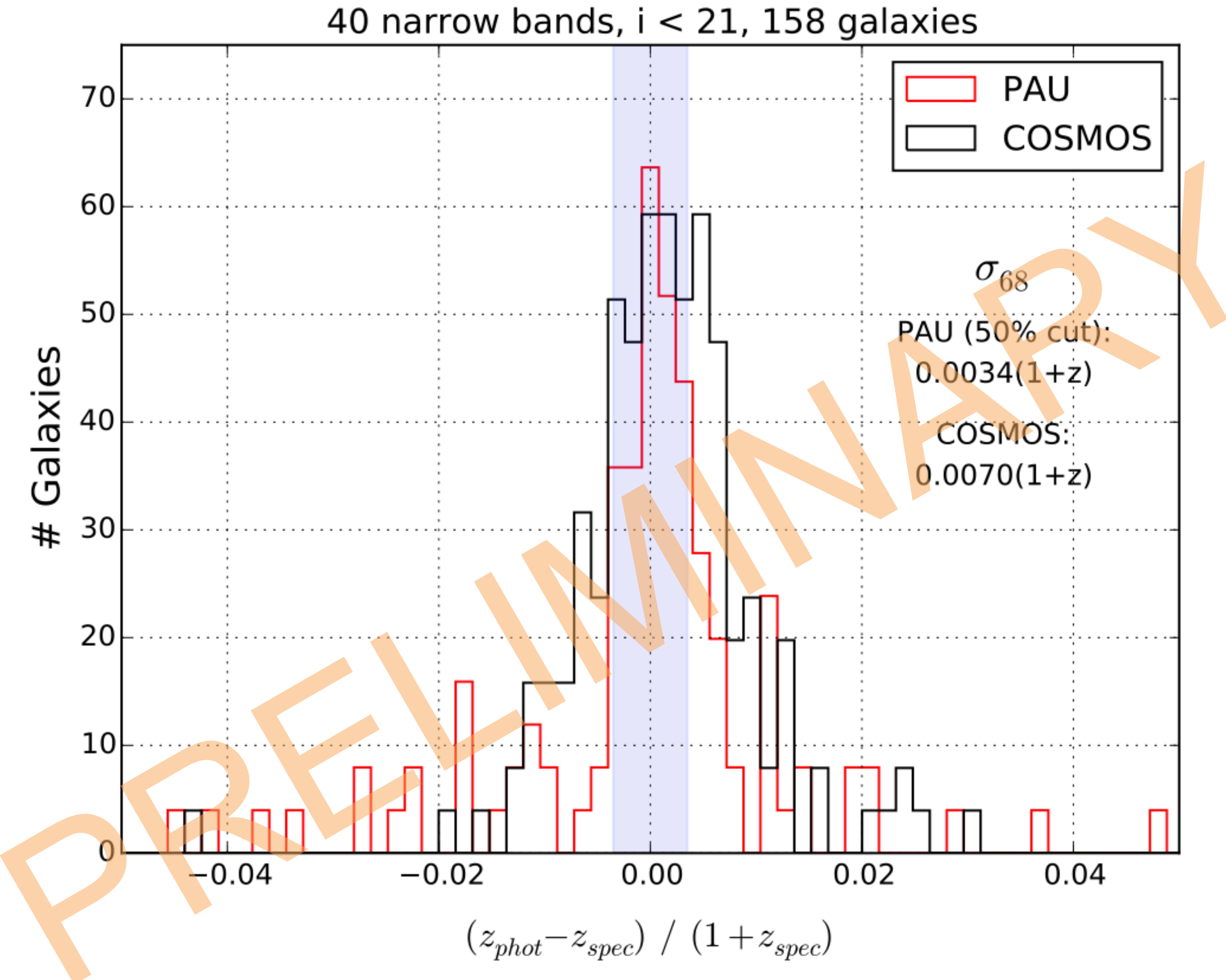
This is a sample sequence of (preliminary/incomplete) PAU data taken during last night of commissioning in June 2015. Here we compare the PAU Narrow Band measurements with SDSS Spectra to validate the camera and data reduction. This a first pass. There is room for improvement/optimization in the data reduction processing/ calibration to eliminate some remaining outliers. However the spectro-photometric system of PAU seems to behave as expected.



PAUS: preliminary results



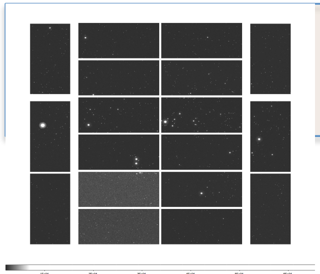
PAUS: preliminary results



PAU Survey

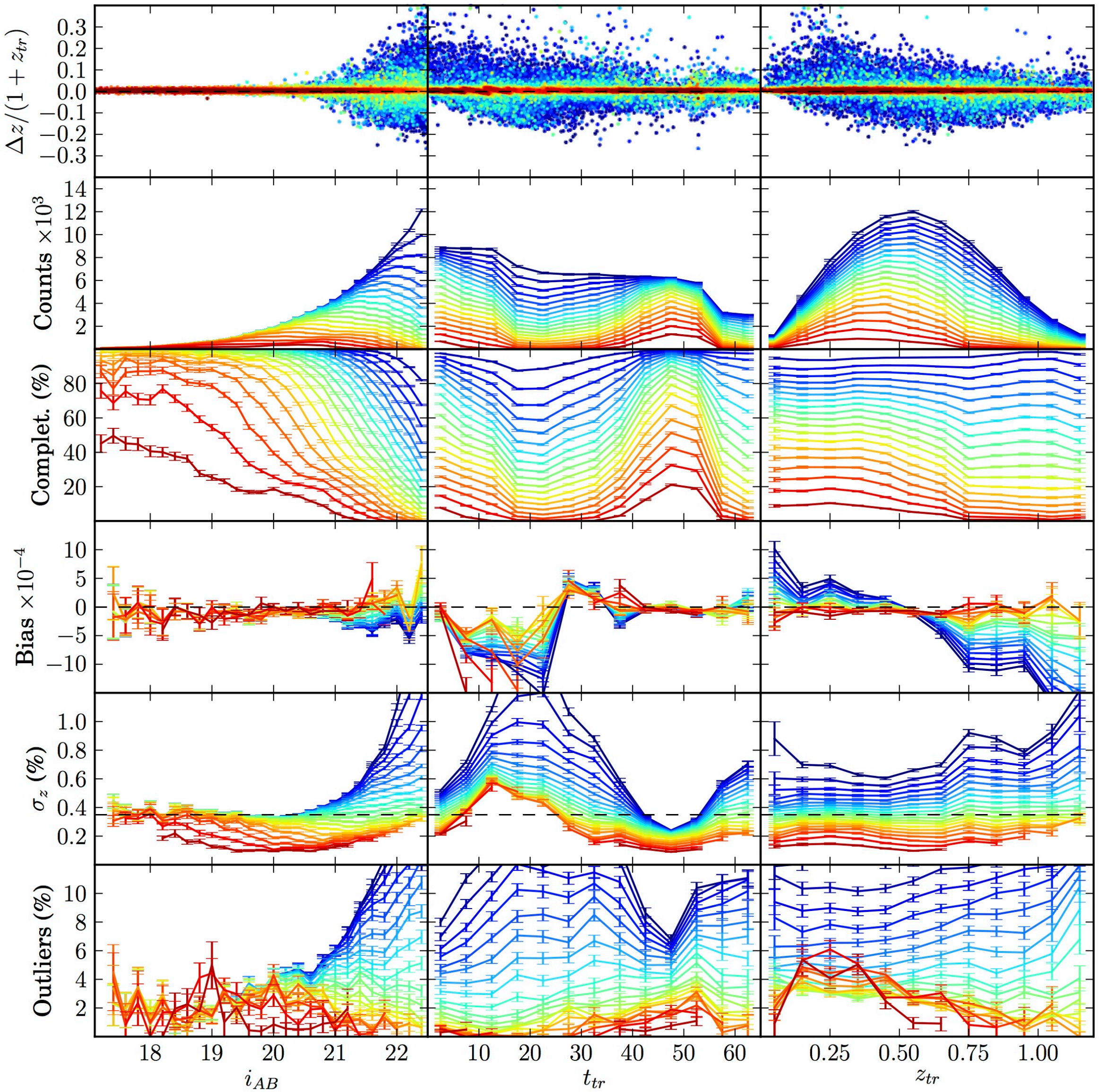
- Just started: two observing runs
  - November 2015
  - April 2016
- Bad weather
- Covered CFHTLenS/KiDS/DES fields and COSMOS
- Covered ~5 deg^2
- http://www.pausurvey.org

PAU Survey Strategy



- Use 8 central CCDs to define the survey footprint
- Each central CCDs covers the whole survey area three times.
- 5 filters trays with 8 central having NB filters
- Target well-sampled “lensing” fields by CFHT-Lens, KiDS and DES
- Select objects in the broad bands, and then get flux in the narrow bands.
- Push to low signal to noise.
- Surveying capability: sample ~1 deg2 / night to i_{AB} <23 mag in NBs ➜ >30000 galaxies / night
- photo-z performance $\Delta z/(1+z) \sim 0.0035$
- Exposure times depend on tray: ~200 s for bluest, ~400 s for reddest.
- No selection effects.

PAU PHZ Performance



Marti et al 2014

PAUCam scientific design

- The PAU Camera has been designed to provide sufficiently adequate photometric redshifts for cosmological surveys and to cover the largest area available by the WHT corrector
- Current science case is based on cosmology with cross-correlations, exploring the intrinsic alignments, obtaining low resolution SEDs
- PAUCam also includes features to allow the widest possible use by the ING general community: broad band filters, additional narrow band filters in the blue (not yet), additional external trays and a community pipeline

PAUS Science: cross-correlations

The cross-correlation scientific case, has been published in
(Gaztañaga et al. 2012, MNRAS)

The paper explores several possibilities:

B

F

F + B (different areas)

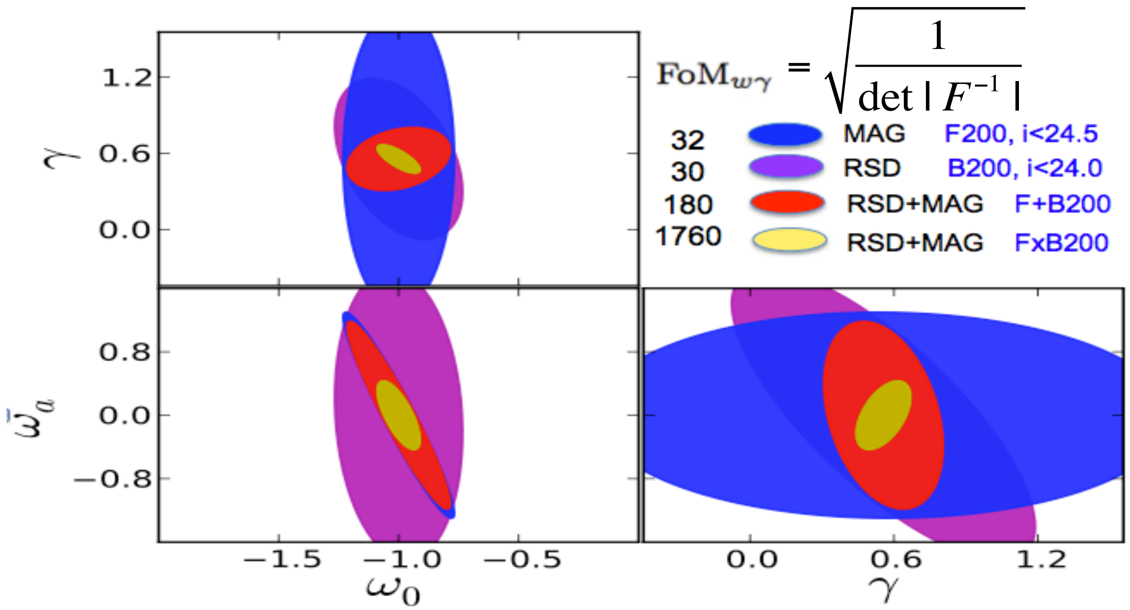
F x B (same area) ← substantial improvement.

B can be seen as a spectroscopic follow-up of a photo-z F sample.

PAU Science: cross-correlations

Effects (WL and RSD) are sensitive to both the equation of state parameter, w = w0 + wa (1-a), and structure growth γ.

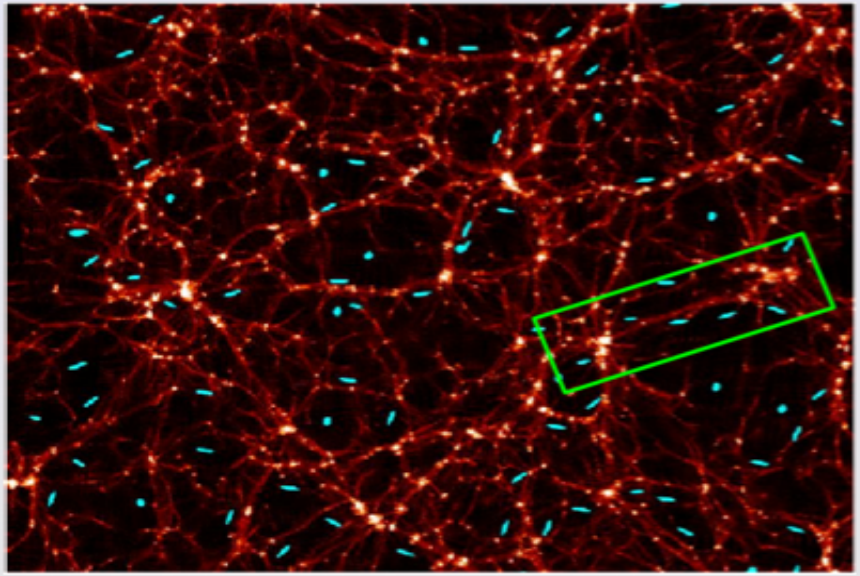
The combination of RSD and WL in the same dataset is very powerful in breaking degeneracies between cosmological parameters
➔A unique advantage of PAU.



Gaztañaga, Eriksen, Crocce, Castander, Fosalba, Martí, Miquel, Cabré, MNRAS, 422,2904G (2012)

PAU Science: intrinsic alignments

2pt correlation: $\underbrace{\langle \epsilon_i \epsilon_j \rangle}_{\text{observed}} = \underbrace{\langle \gamma_i \gamma_j \rangle}_{\text{GG}} + \underbrace{\langle \epsilon_i^s \epsilon_j^s \rangle}_{\text{II}} + \underbrace{\langle \gamma_i \epsilon_j^s \rangle + \langle \epsilon_i^s \gamma_j \rangle}_{\text{GI}}$

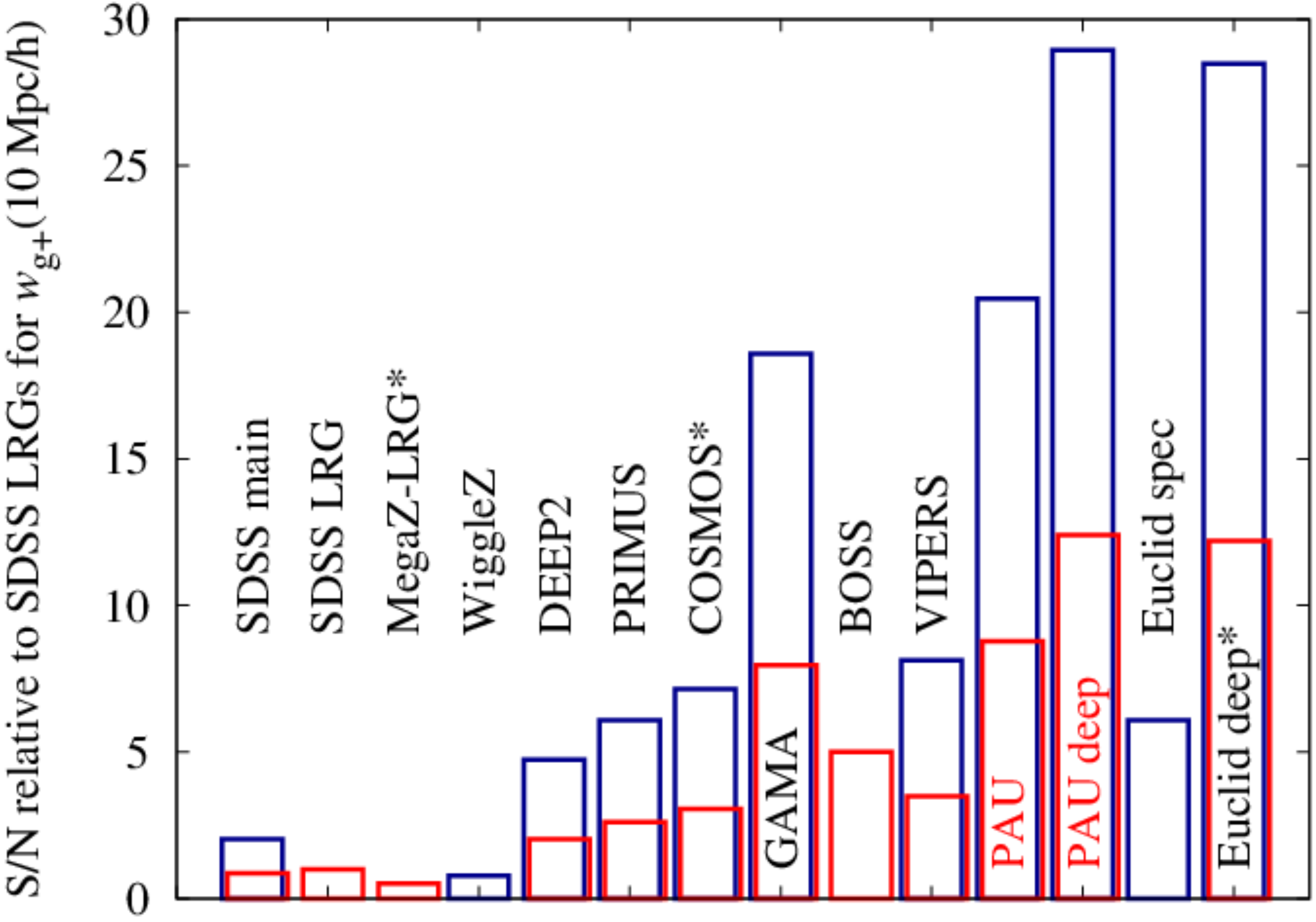


tidal gravitational field generates torques & shear forces

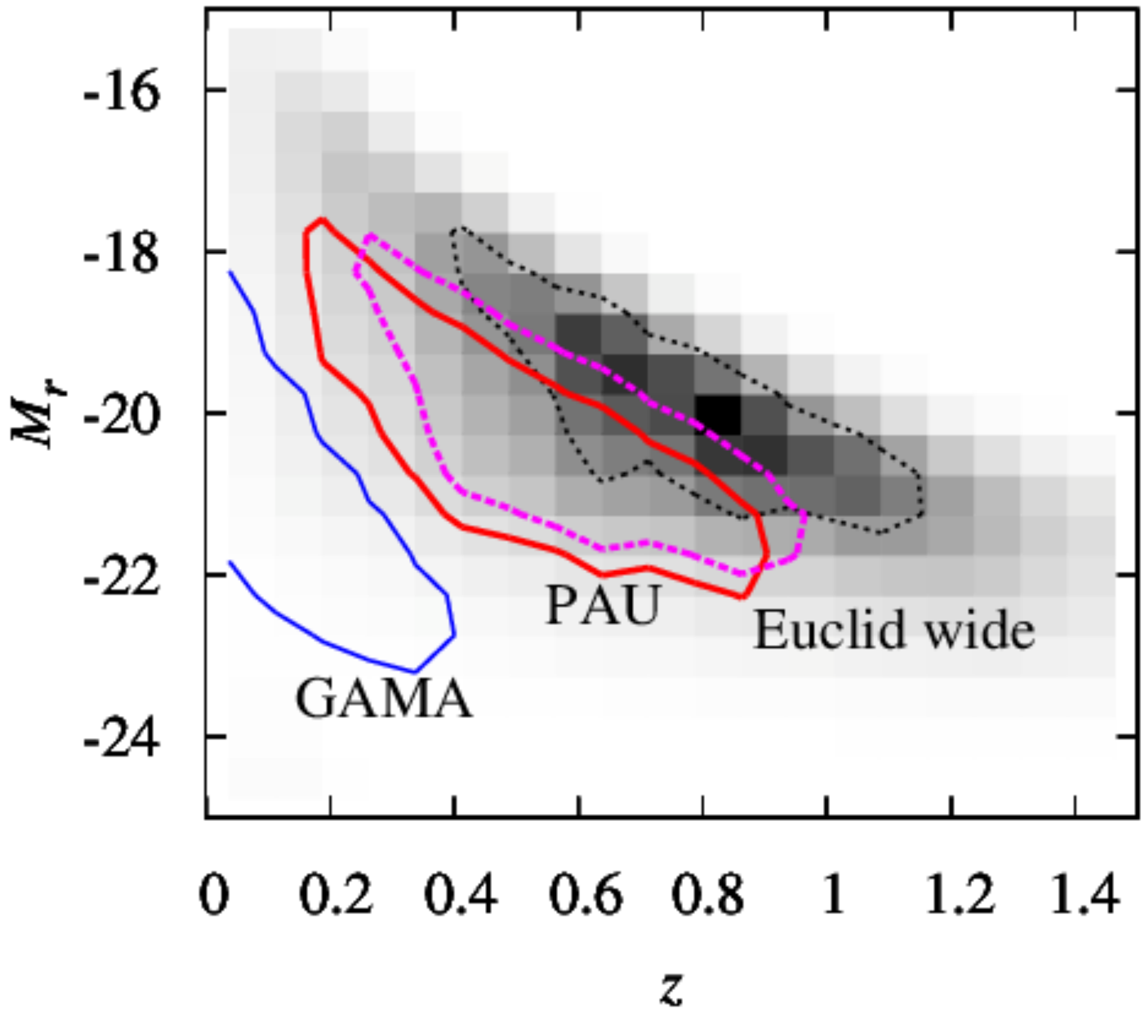
→ angular momenta & shapes of haloes become correlated

→ galaxy ellipticities become correlated

PAU science: intrinsic alignments



PAU science: intrinsic alignments

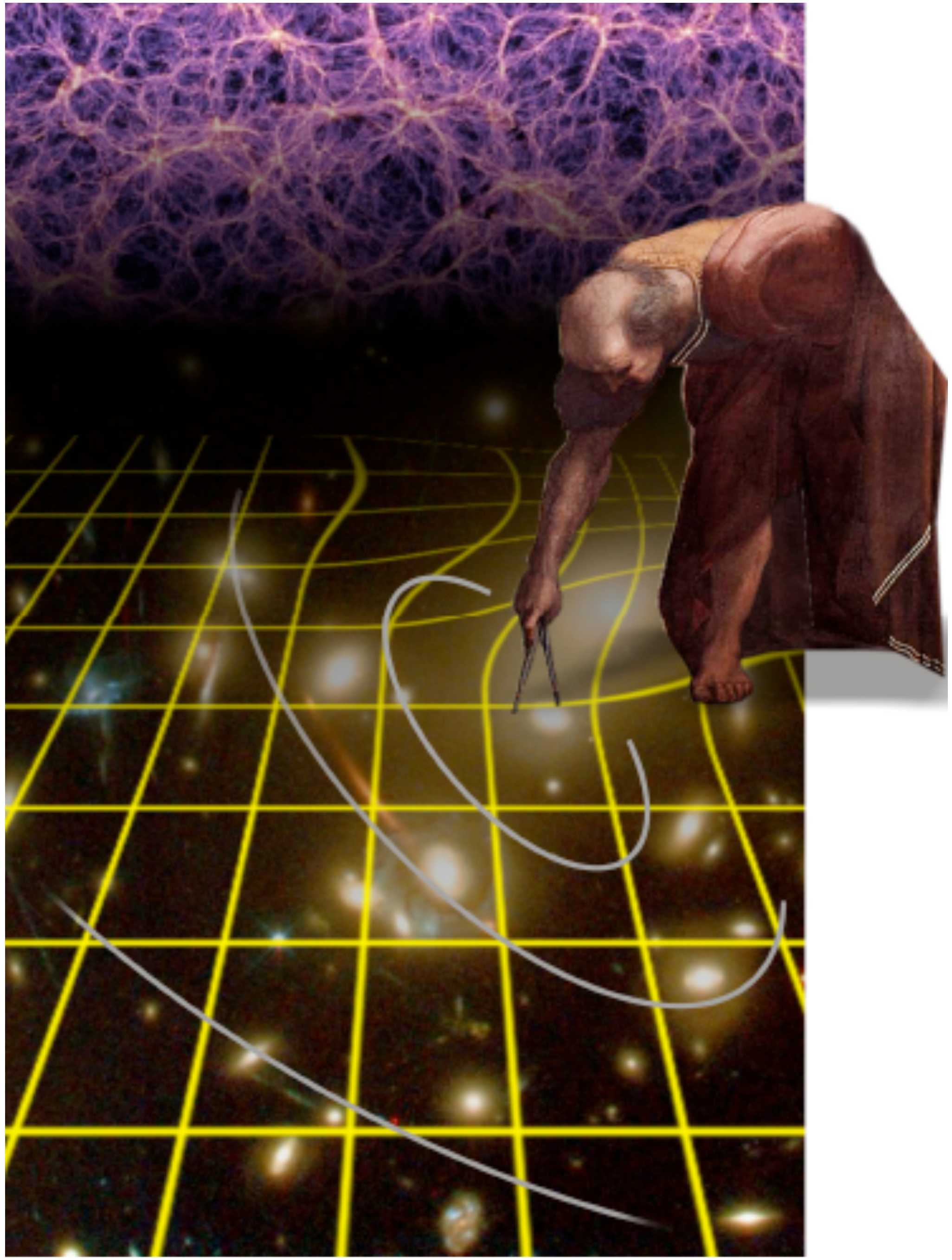


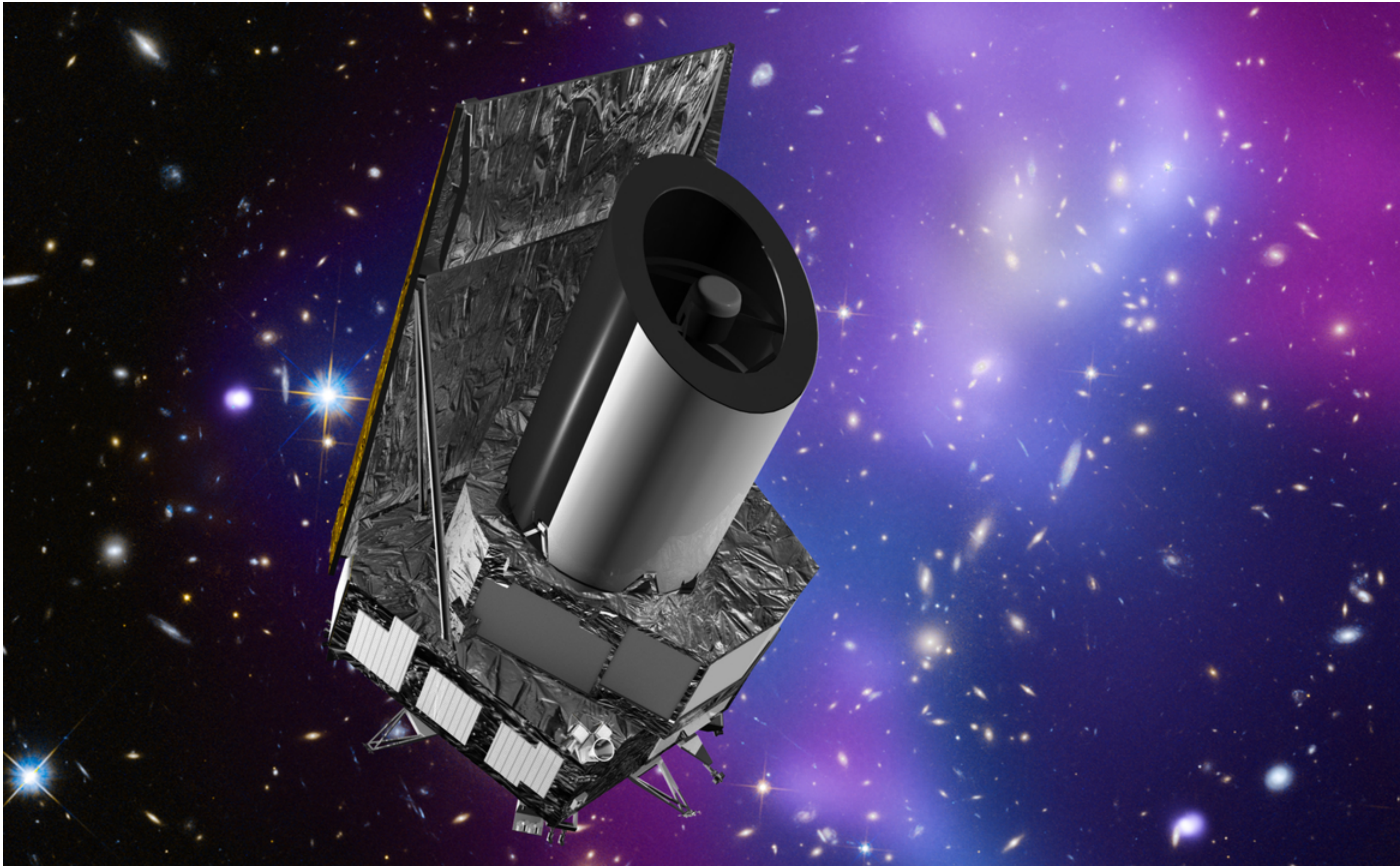
PAUCam

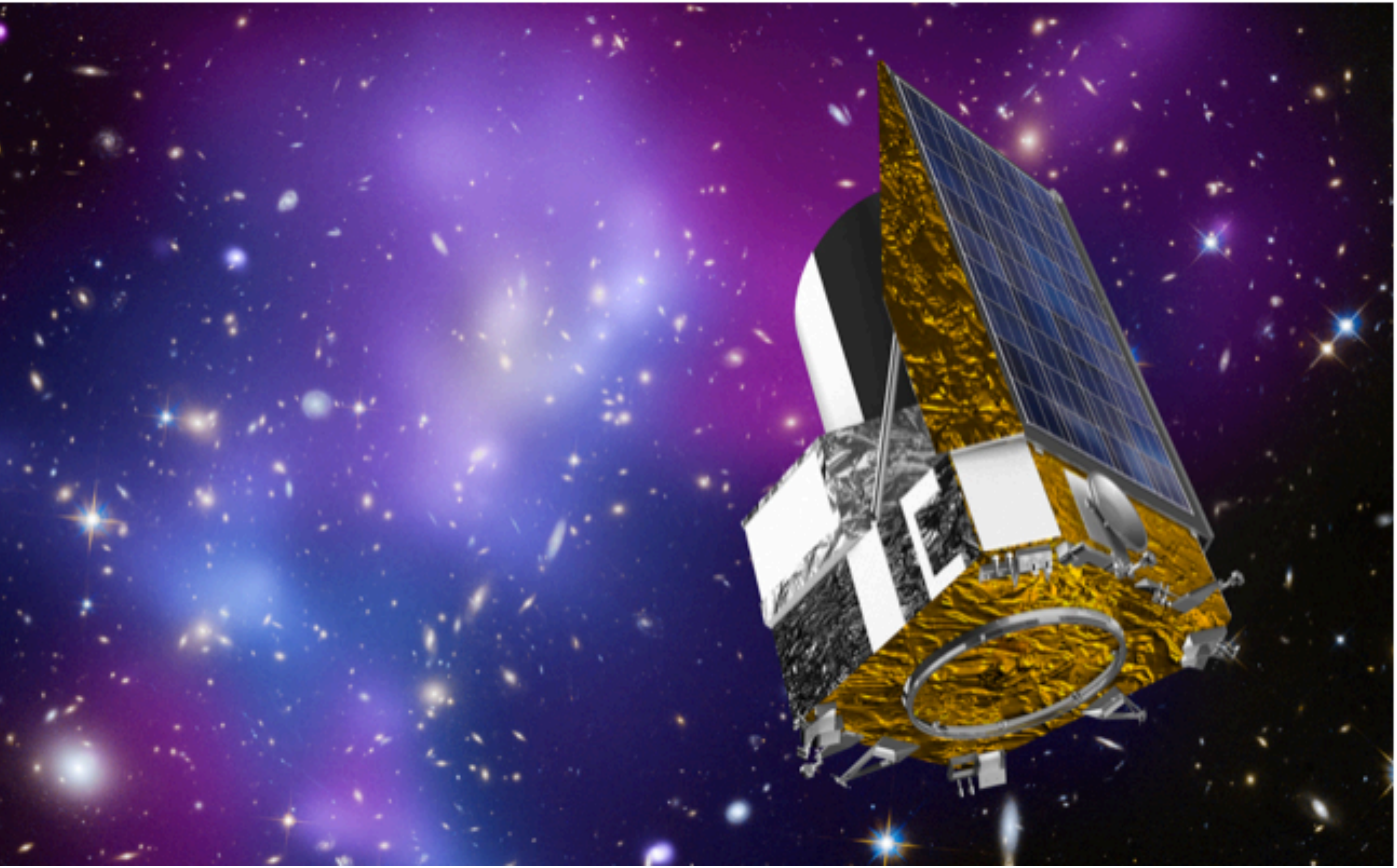
- The PAU Camera was successfully commissioned last June
- We have started the survey, two runs with bad weather. Preliminary results consistent with simulation predictions.
- It is offered to the ING general community
- We encourage people to use it
- http://www.pausurvey.org

Euclid

- Cosmology mission to study the accelerated expansion of the universe aka dark energy
- Selected by ESA on October 4th 2011
- Adopted June 19th 2012
- M class mission
- M2 launch slot
- launch Q4 2020







Euclid Science Objectives

Issue	Euclid's Targets
What is Dark Energy	**Measure the Dark Energy equation of state parameters** w_p and w_a to a precision of 2% and 10%, respectively, using both expansion history and structure growth.
Beyond Einstein's Gravity	**Distinguish General Relativity from modified-gravity theories**, by measuring the galaxy clustering growth factor exponent γ with a precision of 2%.
The nature of dark matter	**Test the Cold Dark Matter paradigm** for structure formation, and measure the sum of the neutrino masses to a precision better than 0.04eV when combined with Planck.
The seeds of cosmic structure	**Improve by a factor of 20 the determination of the initial condition parameters** compared to Planck alone. n (spectral index), σ_8 (power spectrum amplitude), f_{NL} (non-gaussianity)

Euclid Mission concept

- Optimize the mission for galaxy clustering and weak lensing, two dark energy complementary probes
- Two instruments: optical imager (VIS) and near-infrared spectrophotometer (NISP)
- Minimum survey area of 15000 deg2 → 6 years nominal mission

Weak Lensing: → VIS imager + NIR photometer

- Shapes and shear of galaxies with a density of >30 galaxies/arcmin^2 (~10^9 galaxies)
- Very high image quality, high stability
- Minimum Systematics $\sigma_{sys} < 10^{-7}$
- Redshift accuracy dz/z ~ 0.05, down to z~2

Galaxy clustering → NIR slitless spectrometer

- Redshifts for >3500 galaxies/deg^2 (~50 10^6 galaxies)
- Redshift range $0.7 < z < 2.0$
- Redshift accuracy dz/z < 0.001 in same volume as WL
- Line Flux limit < 2 10^{-16} erg cm^{-2}s^{-1}

Euclid

Euclid Consortium Institutions

EUCLID CONSORTIUM

CCIN2P3 · Ciemat · cnes · CPPM · CSIC

DLR · Durham University · École Polytechnique Fédérale de Lausanne · Instituto de Astrofísica de Canarias · IAP · IAS · ICE · ICG Portsmouth · IEEC · IFAE

CNRS IN2P3 · Imperial College London · INAF · Institute for Astronomy · institut für astronomie Universitätssternwarte Wien · CNRS INSU · ioa · IPNL · irap

Irfu cea · ISDC · ISS · UiO Institute of Theoretical Astrophysics University of Oslo · Liverpool JMU · JPL Jet Propulsion Laboratory California Institute of Technology

LAM Laboratoire d'Astrophysique de Marseille · LMU USM · LPNHE Paris · Manchester 1824 The University of Manchester · MPE · Max-Planck-Gesellschaft · NOVA · NWO Netherlands Organisation for Scientific Research

Observatoire de la Côte d'Azur · OmegaCEN · The Open University · PIC · Queen's University Belfast · Space Science Center · SRON Netherlands Institute for Space Research · Alma Mater Studiorum Università di Bologna

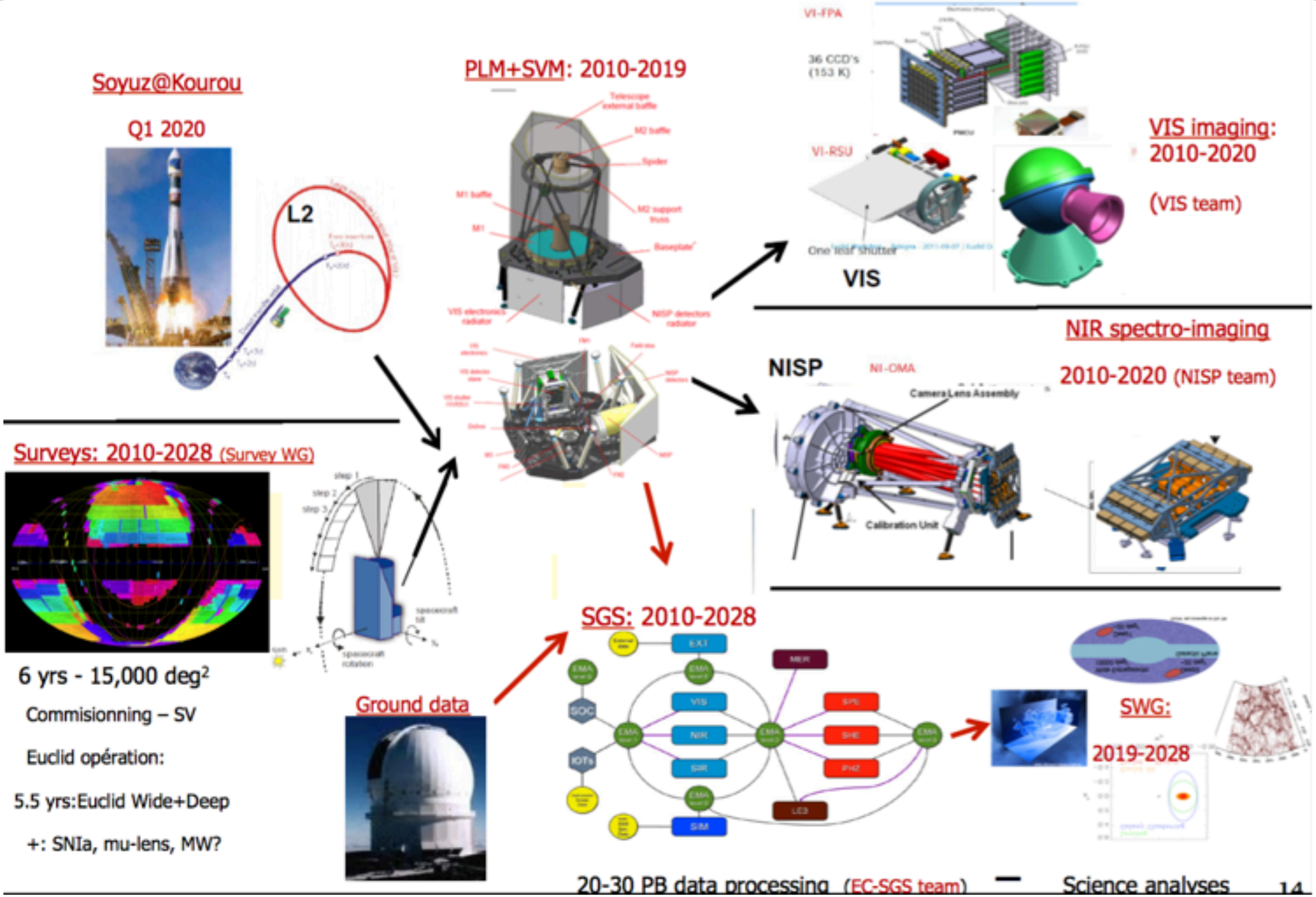
UCL · Université de Genève Faculté des Sciences · Université de Genève Faculté des Sciences · university of groningen · faculty of mathematics and natural sciences · kapteyn astronomical institute · University of Helsinki · Universiteit Leiden

The University of Nottingham · University of Oxford · Universidad Politécnica de Cartagena · UPMC Sorbonne Universités · US University of Sussex · Target · UK Astronomy Technology Centre

CAAUL · Centro de Astrofísica da Universidade do Porto · Caltech · UAM Universidad Autónoma de Madrid · agenzia spaziale italiana · King's College London Founded 1829 · Aix Marseille université

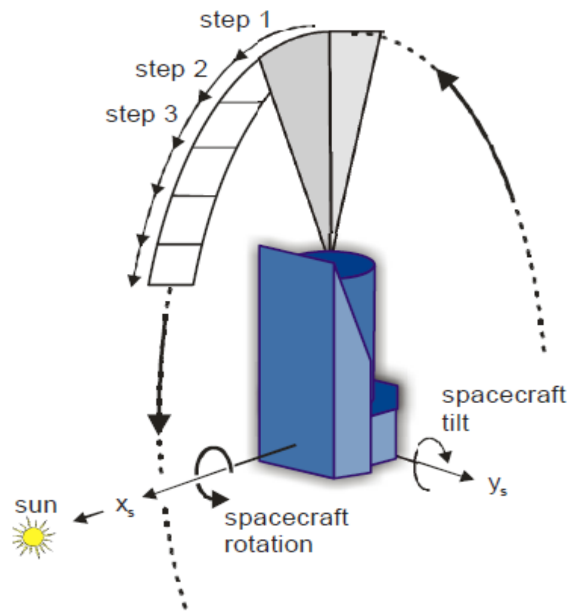
Euclid — Euclid Summary

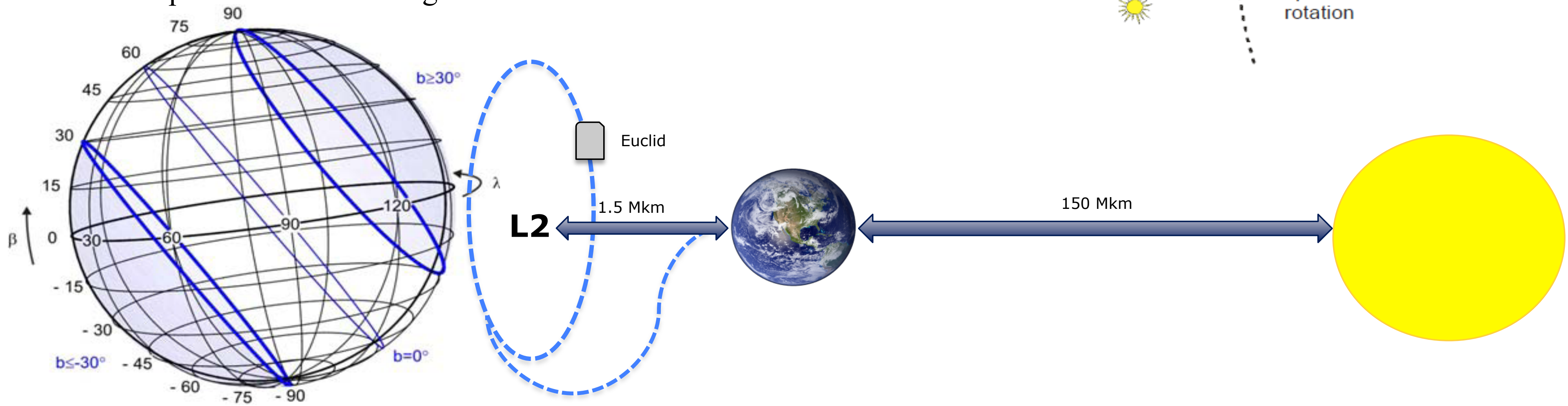
EUCLID CONSORTIUM



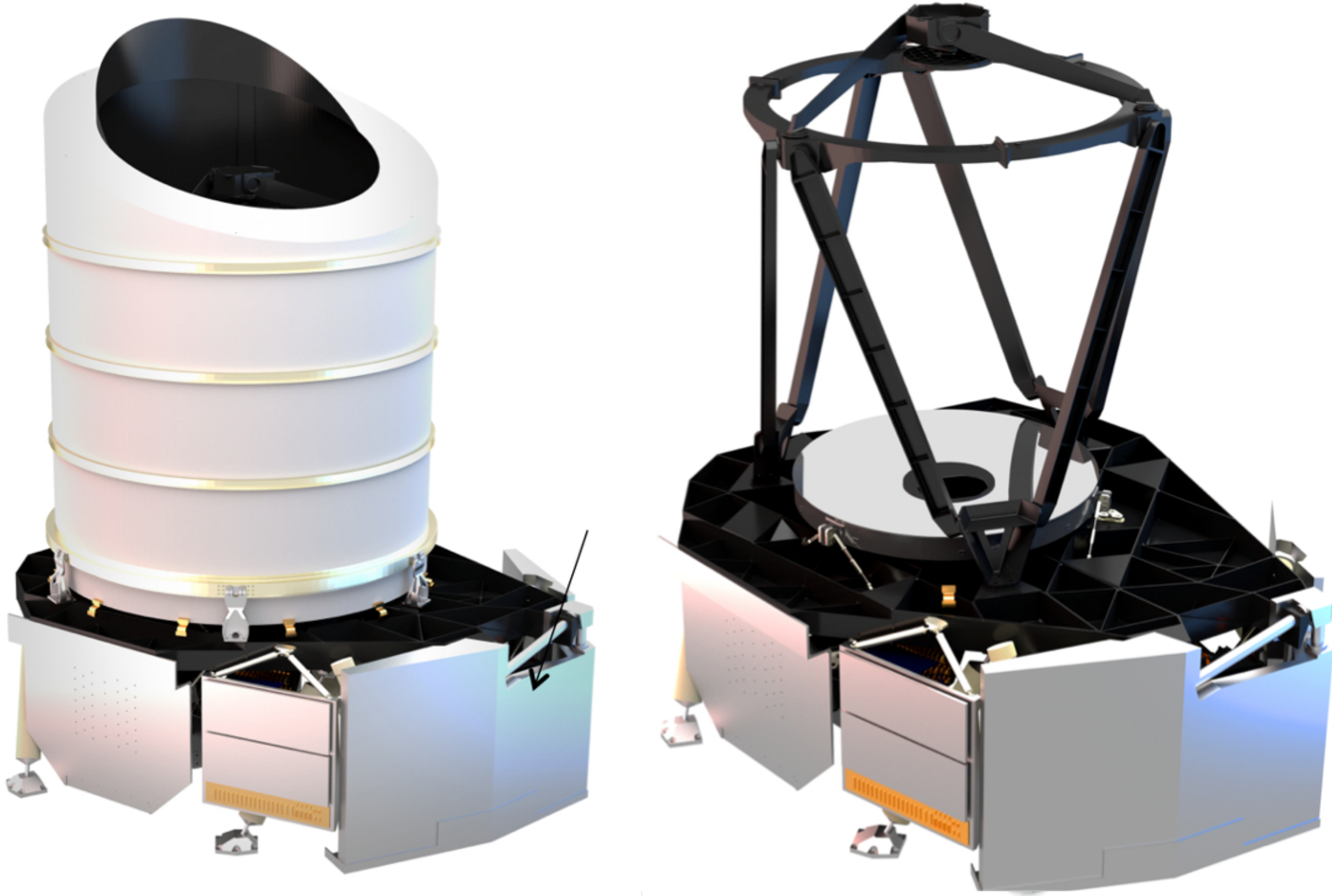
Euclid Mission orbit

- Euclid is fundamentally a telescope taking pictures and spectra of galaxies for a large part of the extragalactic sky. Quality of images requires a high pointing stability and extreme telescope quality
- Euclid is launched from Kourou with Soyuz and injected directly to a trajectory leading it to an orbit revolving around L2. The propulsion system is used to make small corrections
- Once in L2, the spacecraft performs rotations in steps and taking pictures at every step to have a complete coverage of the sky. The spacecraft rotates fundamentally on a plane perpendicular to the sun direction.
- As the earth revolve around the sun, the rotation plane of Euclid rotates and allow the completion of the coverage.

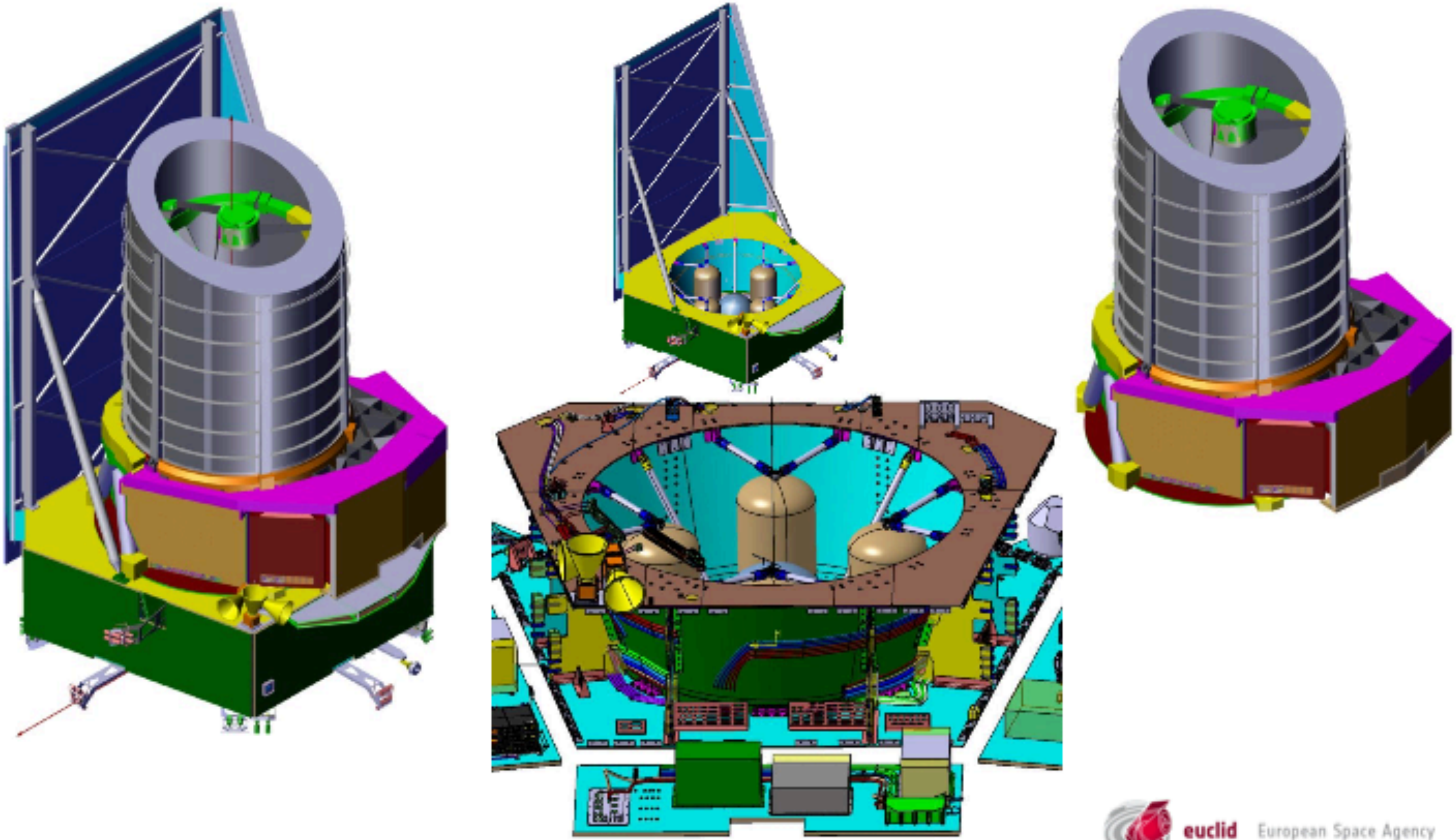




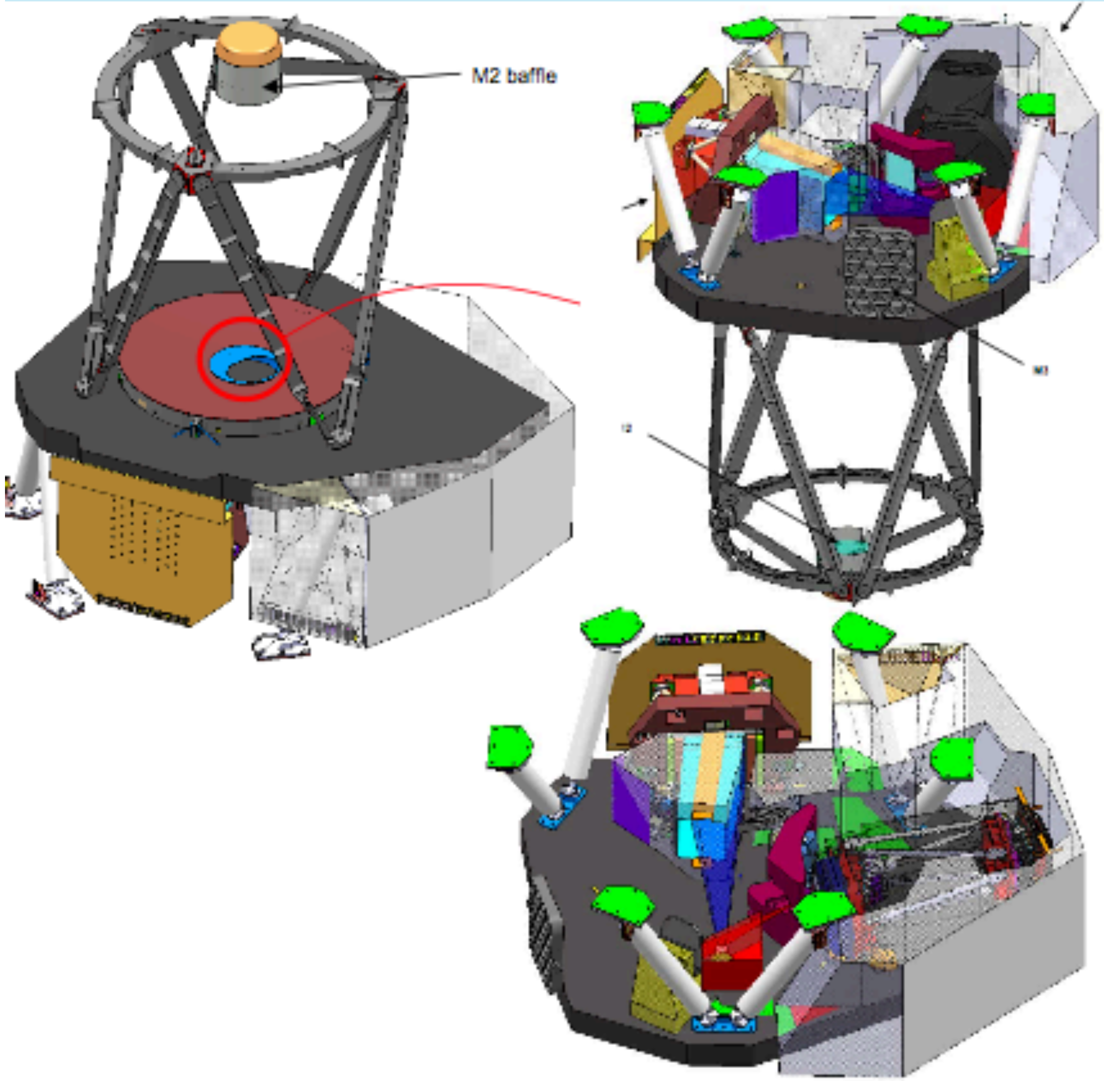
Euclid – Spacecraft Configuration

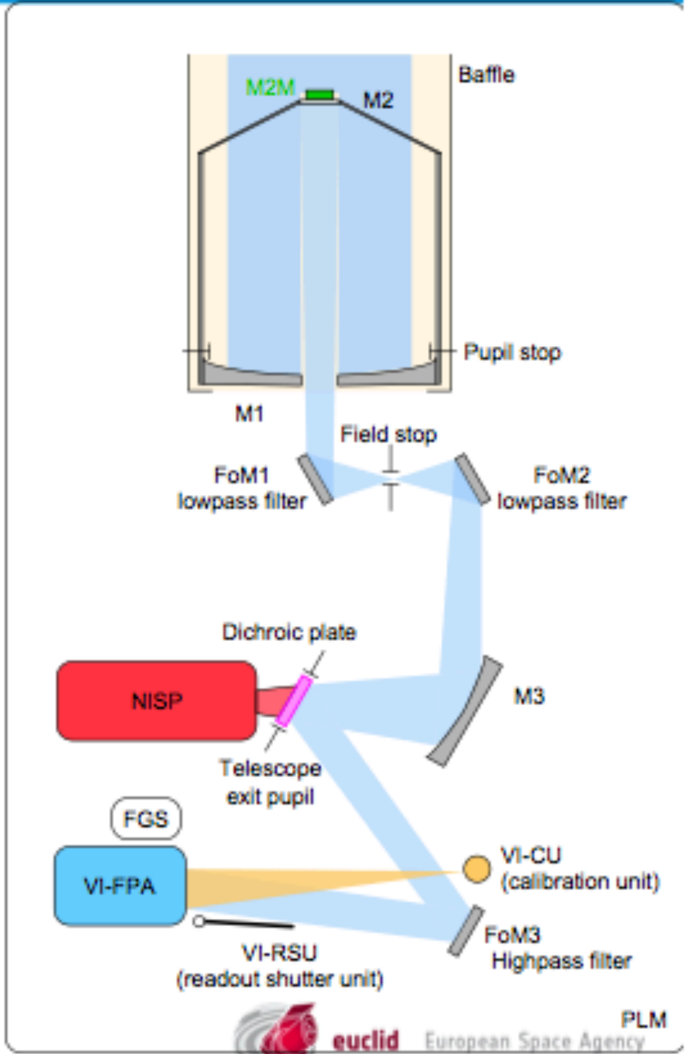


Euclid – Spacecraft Configuration



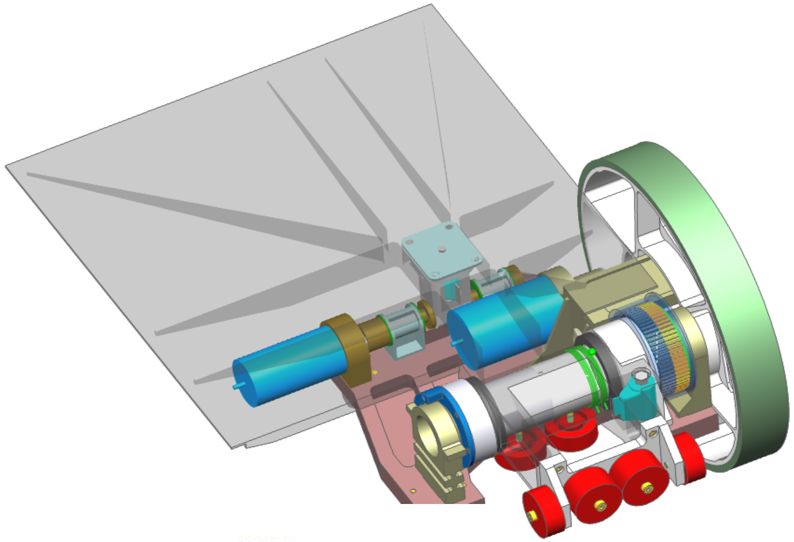
Euclid – Payload Module

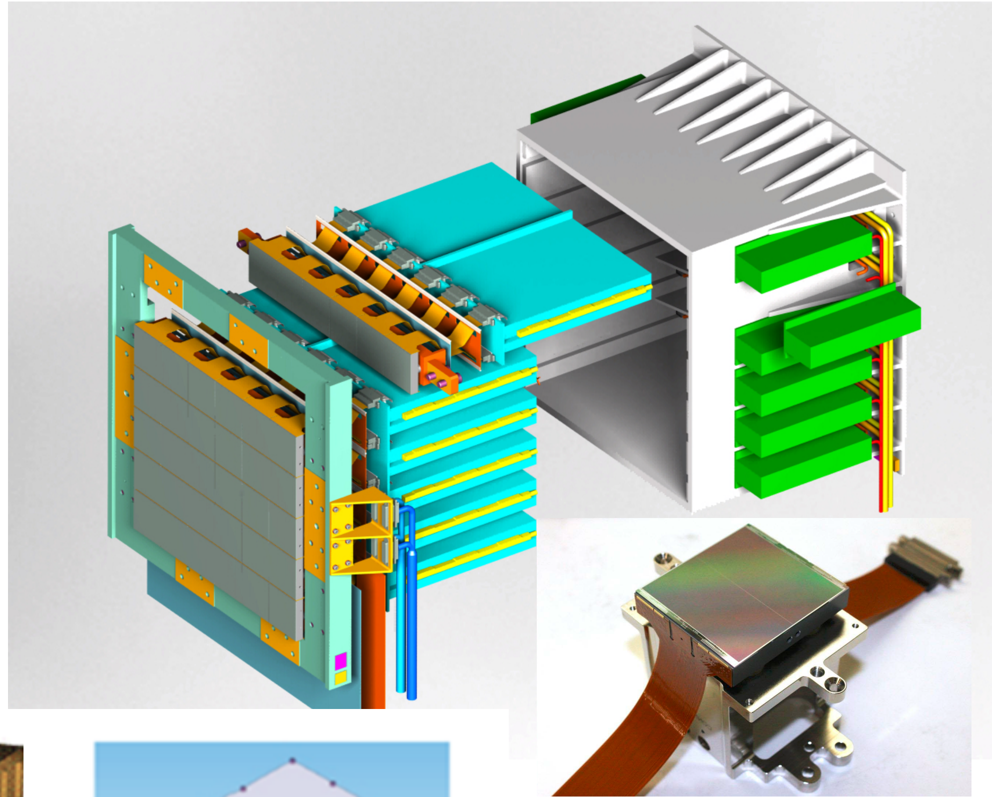


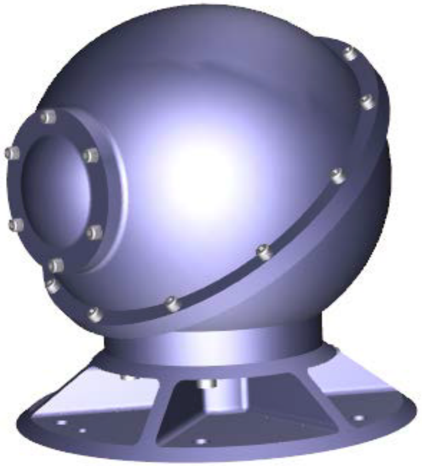


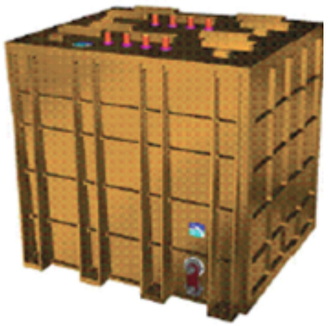
Euclid VIS

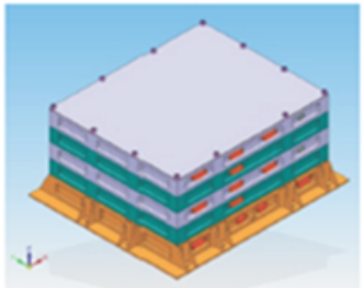
EUCLID CONSORTIUM

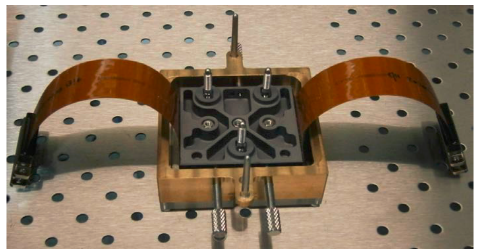




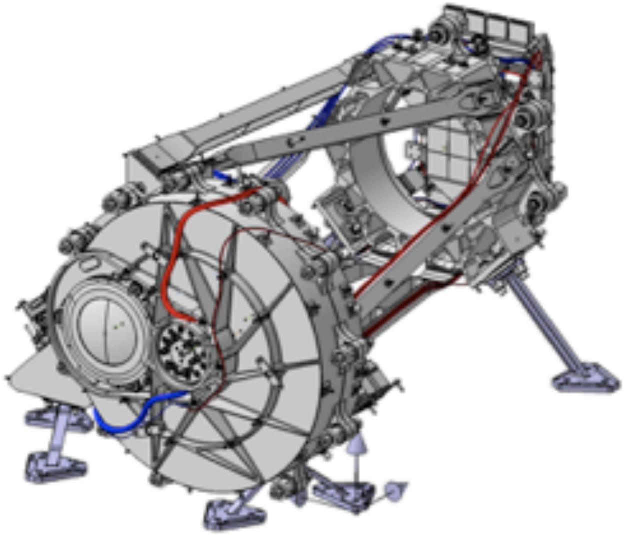


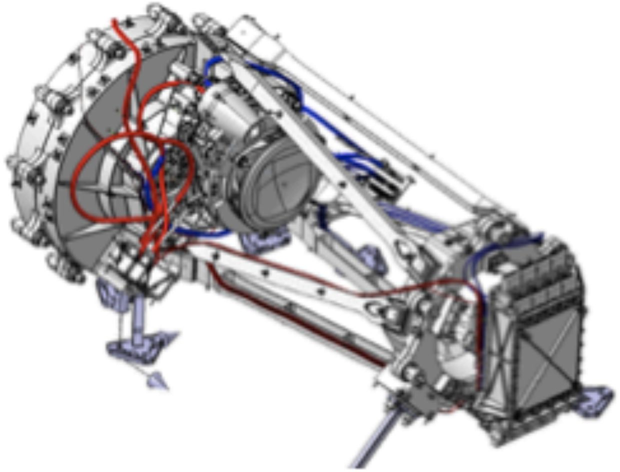


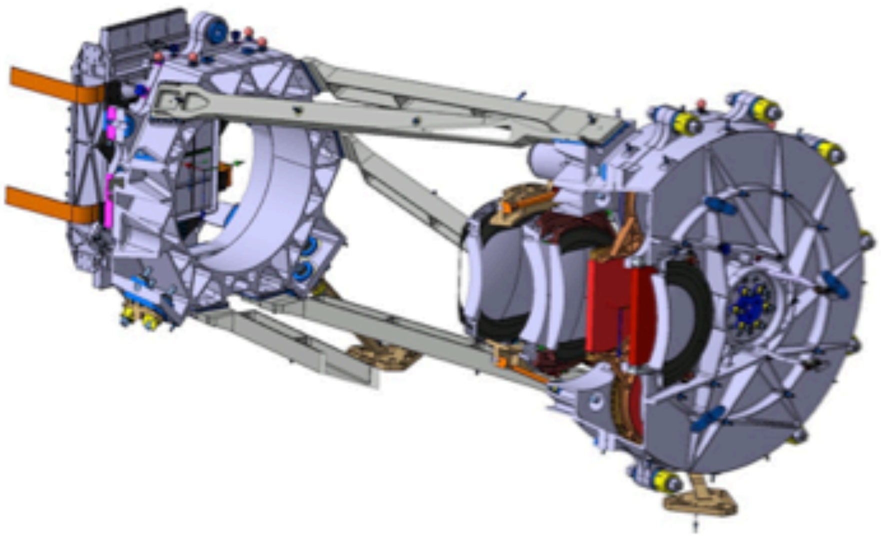


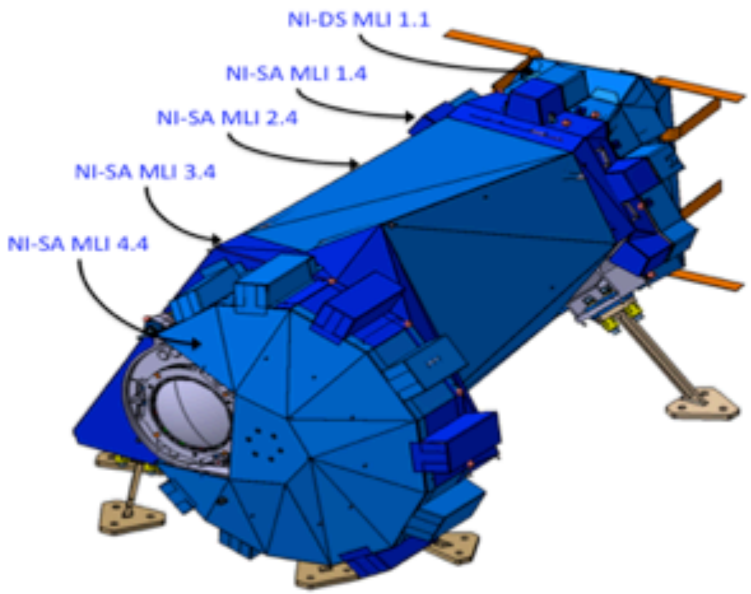


NISP

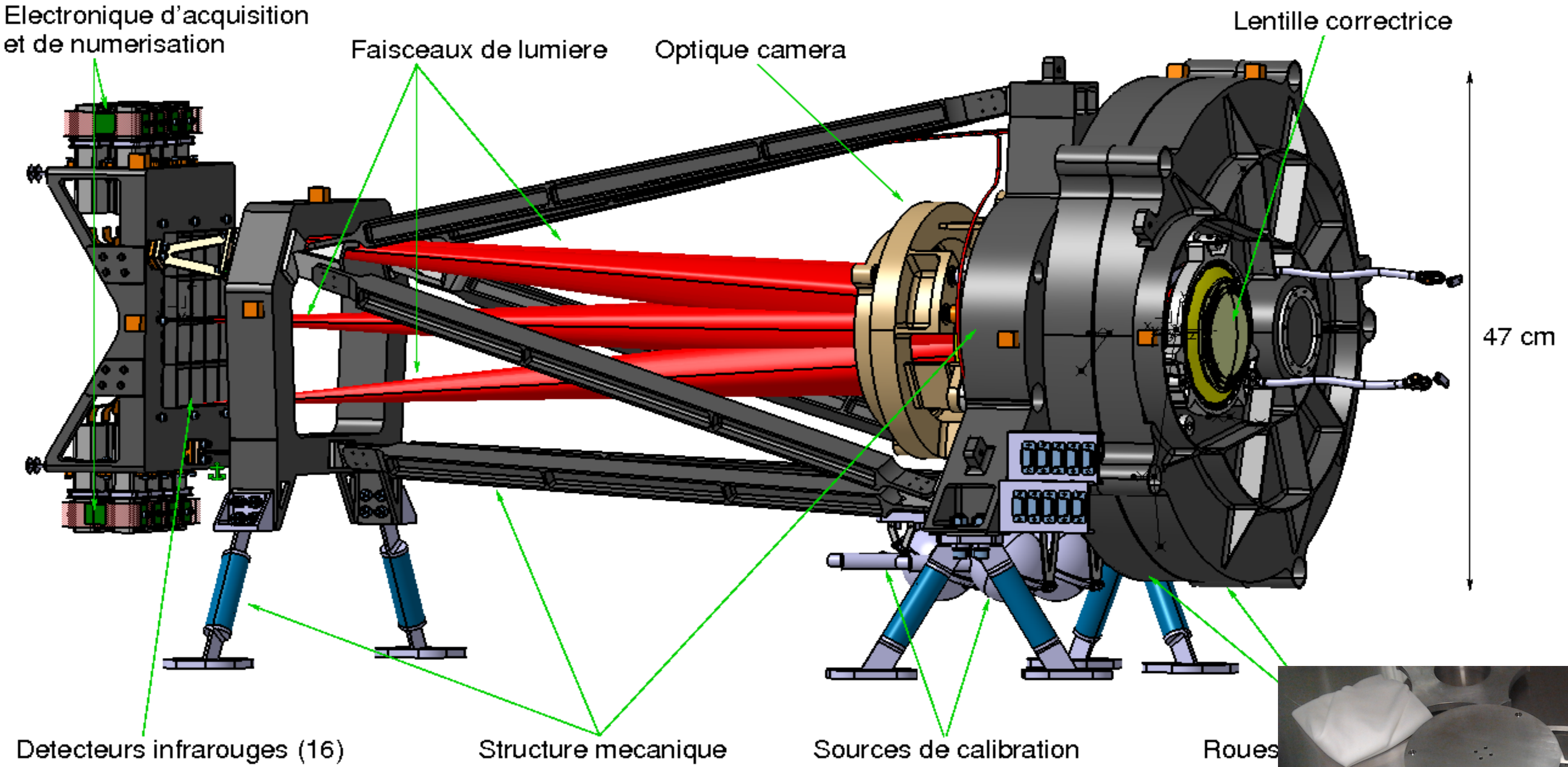


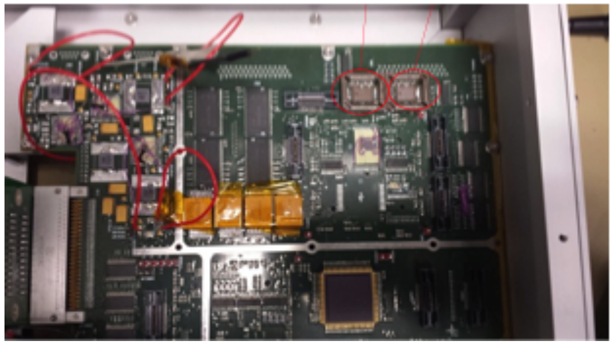


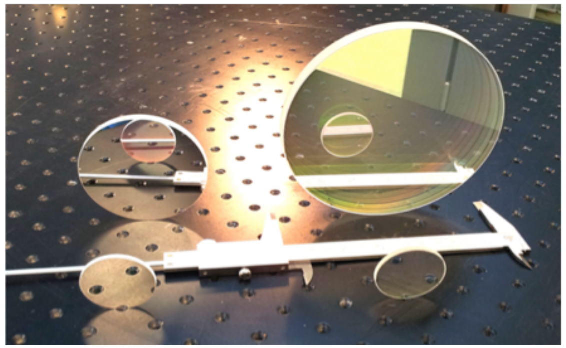




The NISP instrument: Near Infrared Spectrometer and Photometer







Euclid Focal planes

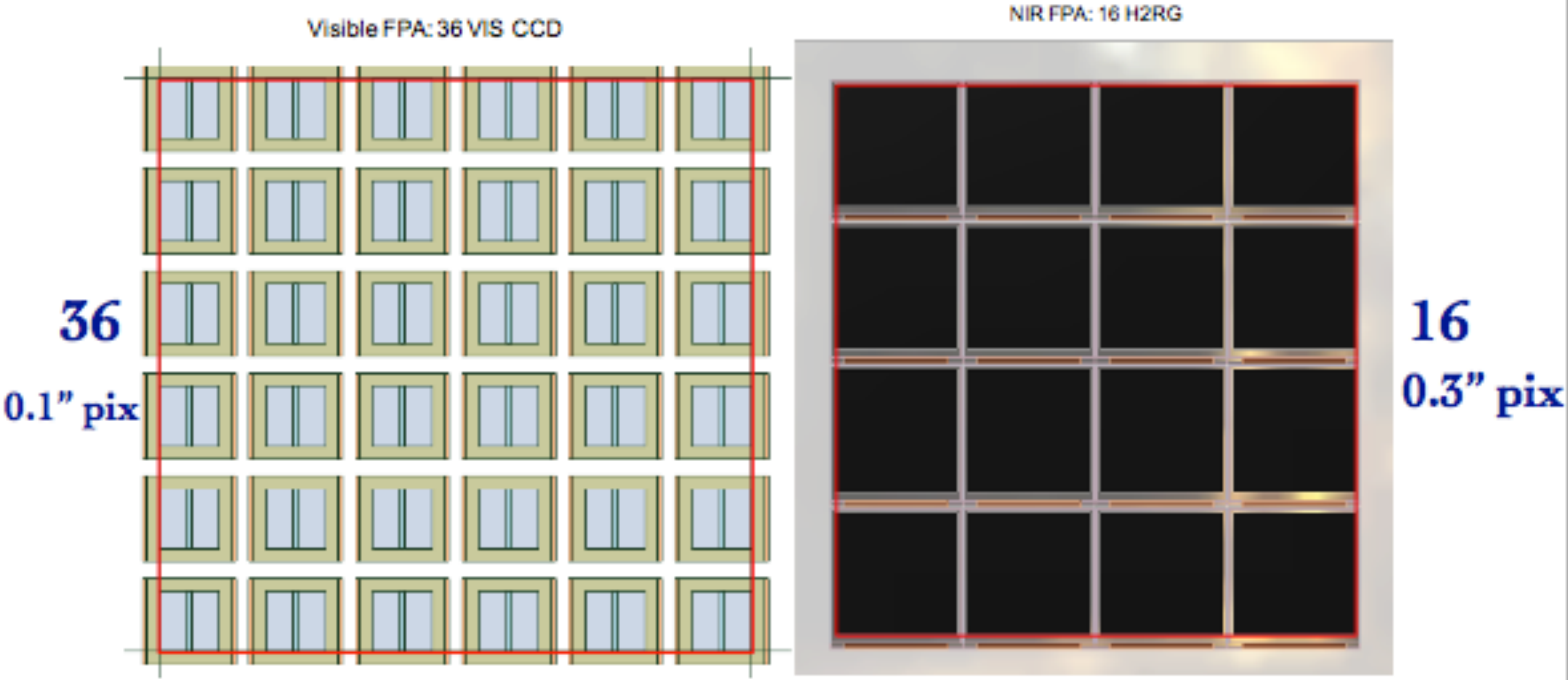


Figure 6-1: VIS (left red ensquared area) and NISP (right red ensquared area) Geometrical FoV.

Euclid — Exposure sequence

4 exposures ~1 full field -0.5 sq deg- / 1.25 hr (~ 19/day ≈10 sq deg/day)

Observing sequence for each field + move to next one ~4500 s

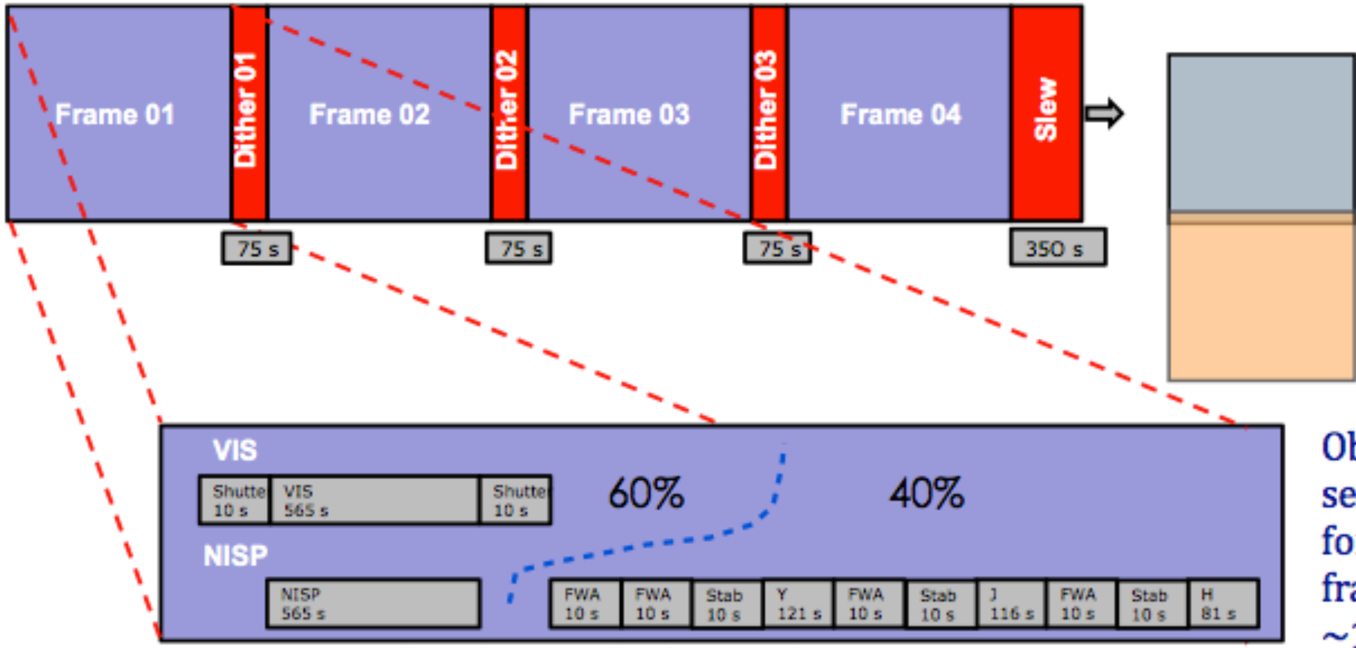


Figure 5-4: Nominal Field Observation Sequence.

area coverage
50% 3 exp
50% 4 exp

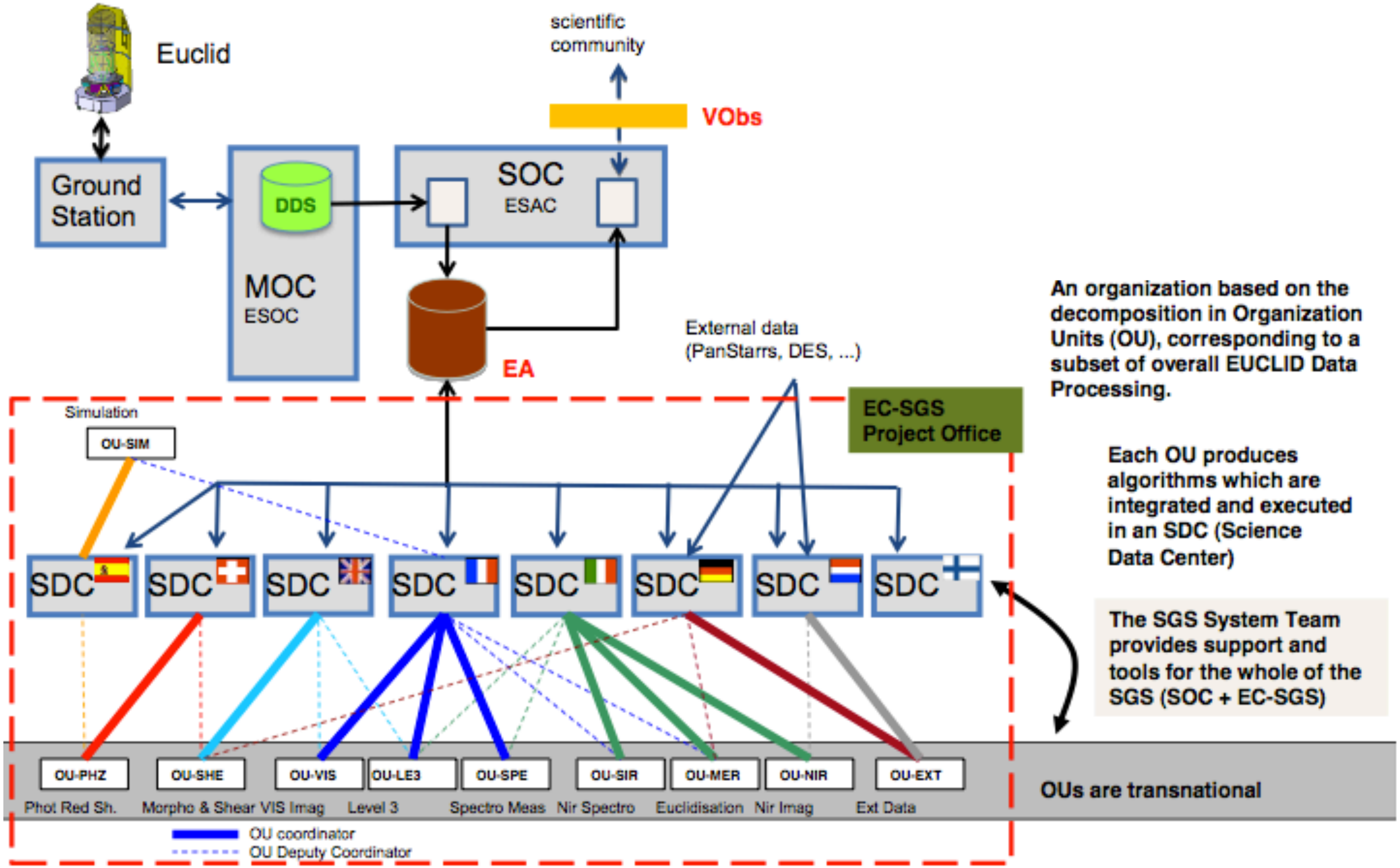
Observing sequence for each frame ~1000 s

NIR: first spectroscopy contemporarily to VIS, then imaging (filter/grism wheel motion perturbs VIS)

Slitless: **Blue**, then **Red** grism, then again at 90 degs (--> 4 dithers)

Euclid Ground Segment

EUCLID CONSORTIUM



An organization based on the decomposition in Organization Units (OU), corresponding to a subset of overall EUCLID Data Processing.

Each OU produces algorithms which are integrated and executed in an SDC (Science Data Center)

The SGS System Team provides support and tools for the whole of the SGS (SOC + EC-SGS)

OUs are transnational

Euclid Surveys

Two Survey Strategy

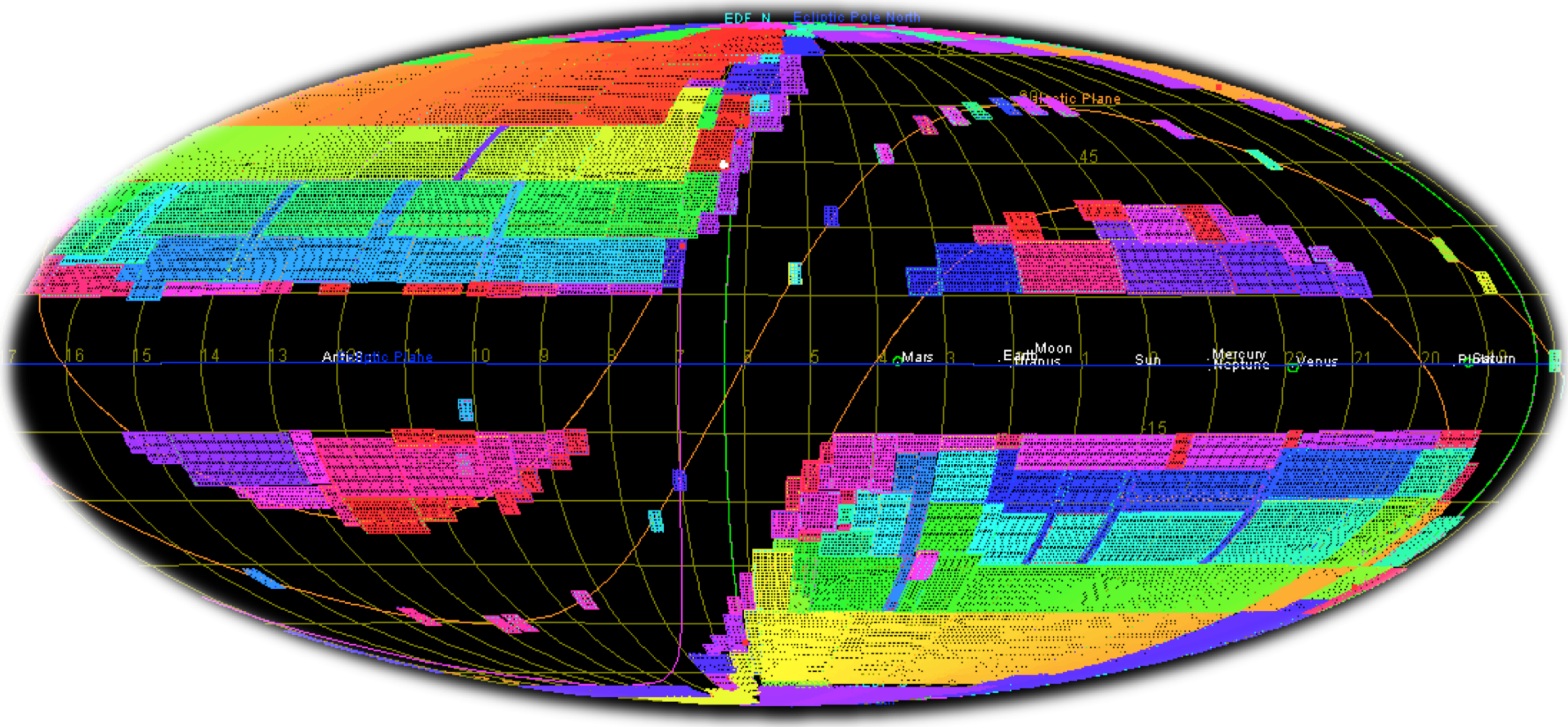
Wide Survey

- Area: 15000 deg2; goal 20000 deg2
- Avoid galactic plane, ecliptic plane and high extinction
- Imaging depth: $RIZ_{AB} = 24.5$ at 10σ; NIR $(Y_{AB}, J_{AB}, H_{AB}) = 24.0$ at 5σ
- Spectroscopic depth: $2\ 10^{-16}$ erg $cm^{-2}\ s^{-1}$ in line flux

Deep Survey

- Area: 40 deg2, in two/three pointings
- Location TBD, but most likely in ecliptic poles + ECDFS
- Depth: 2 magnitudes deeper than wide survey

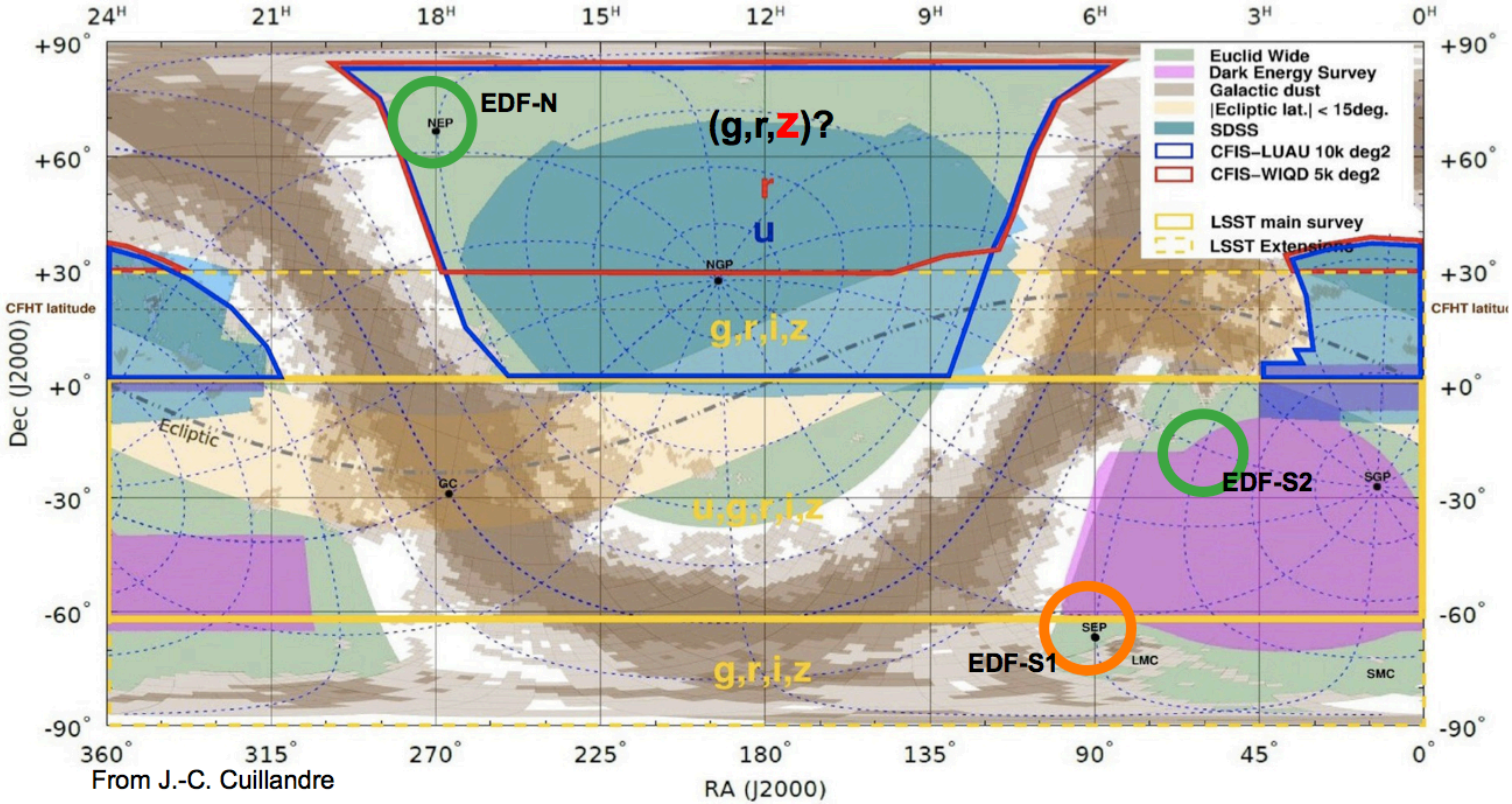
Euclid Sky coverage



- Ecliptic plane avoided (zodiacal light, |β|<15 deg) and low (|b|<25 deg) galactic latitudes and high extinction regions E(B-V) < 0.08
- Different colours indicate different survey years
- Calibration fields along the galactic plane

Euclid Ground Based Observations

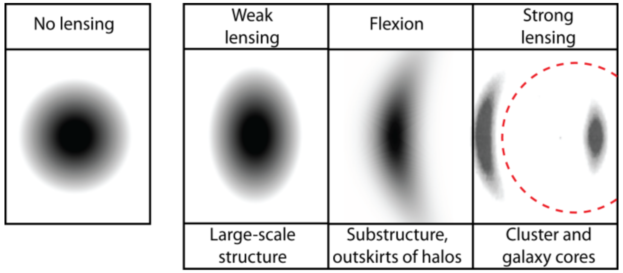
EUCLID CONSORTIUM

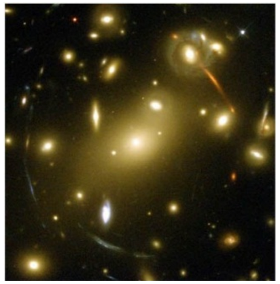


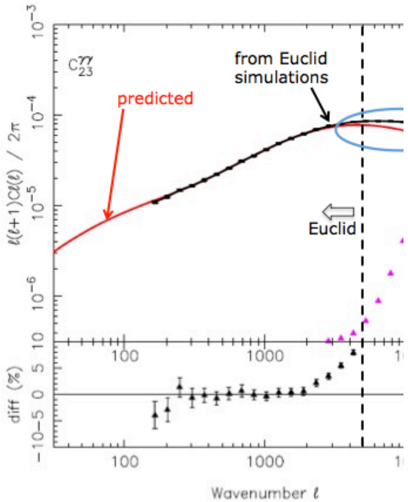
From J.-C. Cuillandre

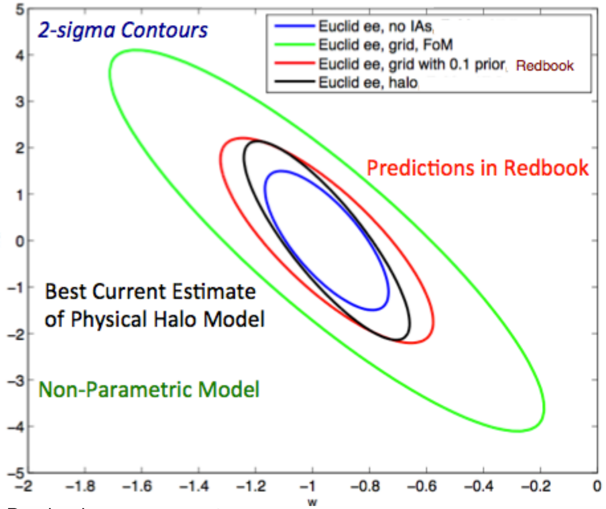
Euclid Weak Lensing

EUCLID CONSORTIUM



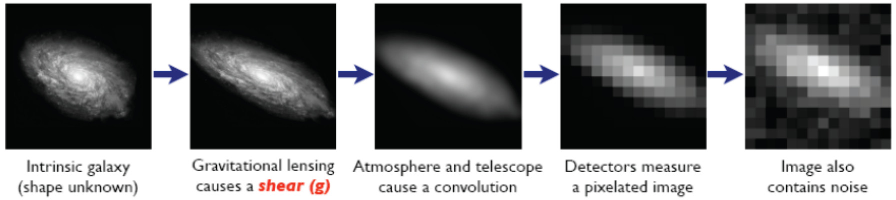




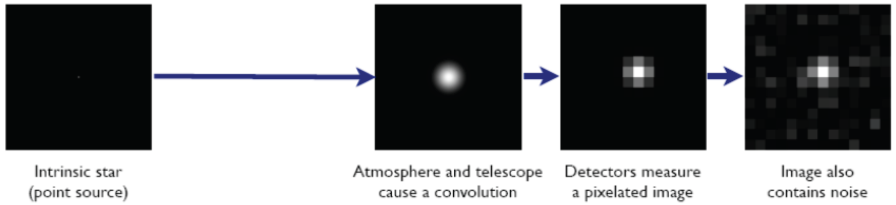


The Forward Process.

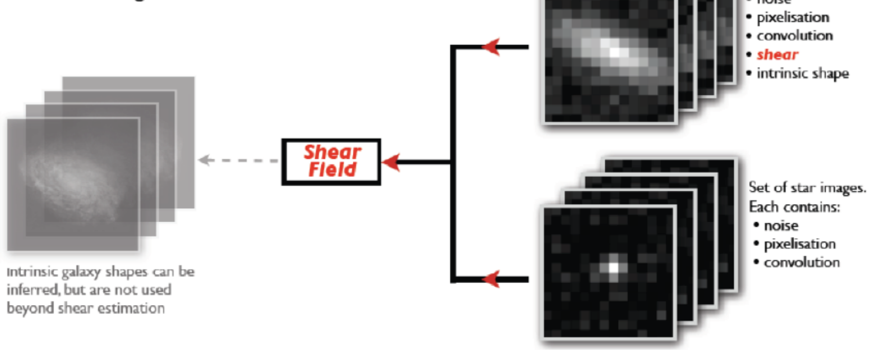
Galaxies: Intrinsic galaxy shapes to measured image:

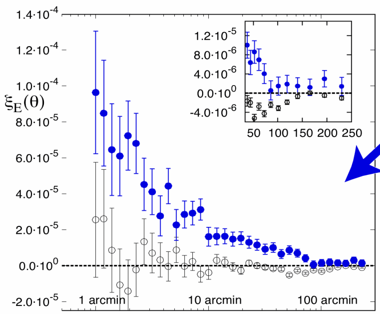


Stars: Point sources to star images:



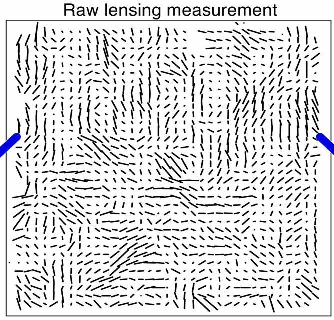
The Inverse Problem:
Measured images to *shear*

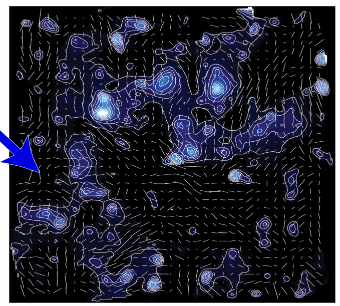




Correlation function

Raw lensing measurement

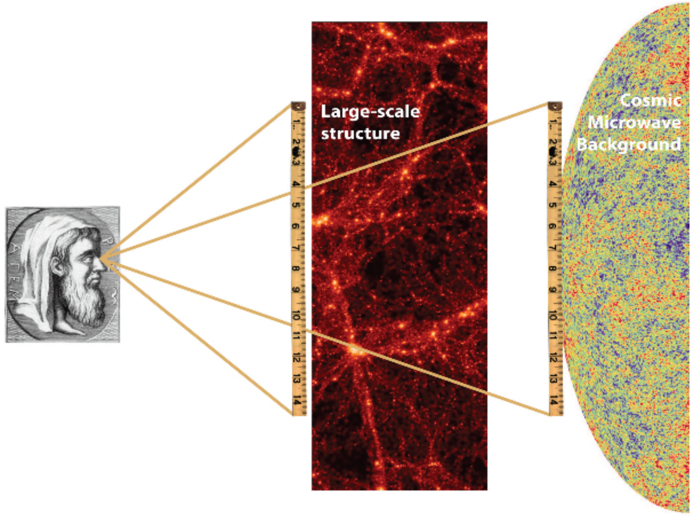


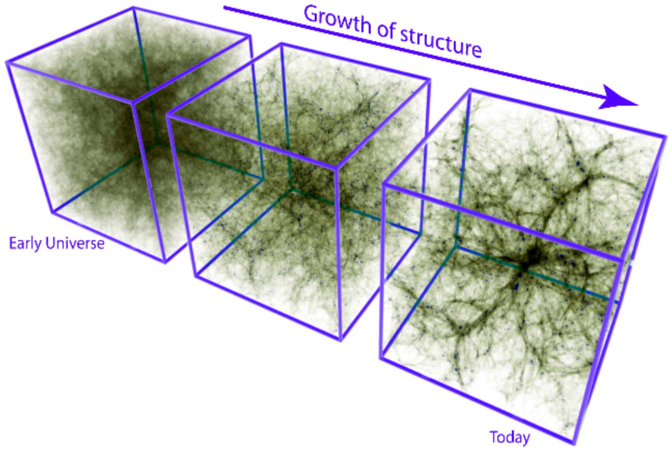


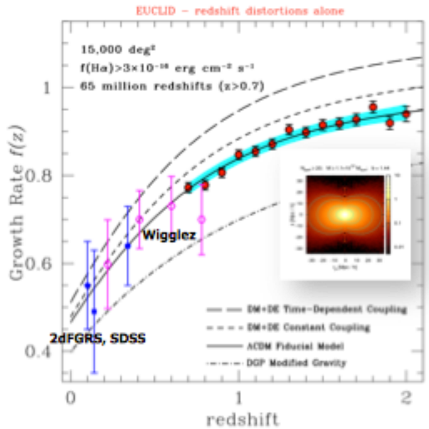
Dark matter distribution

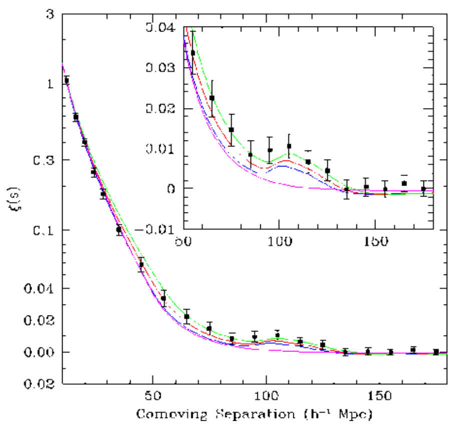
Euclid Galaxy clustering

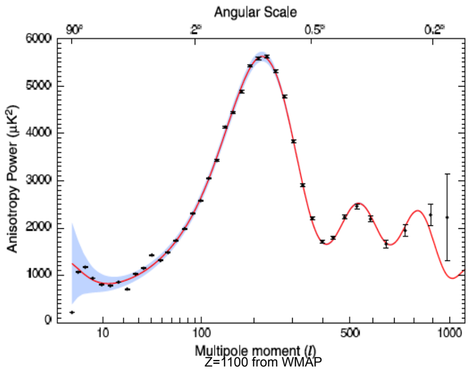
EUCLID CONSORTIUM

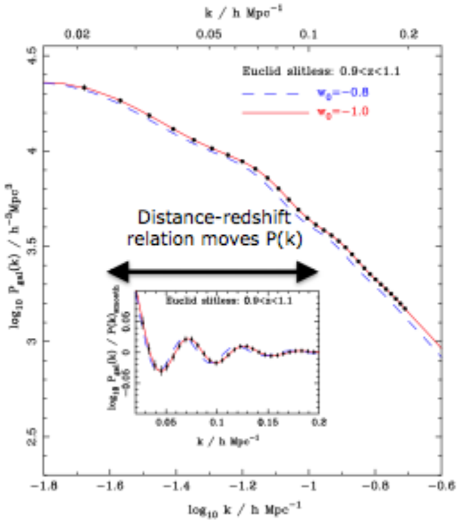


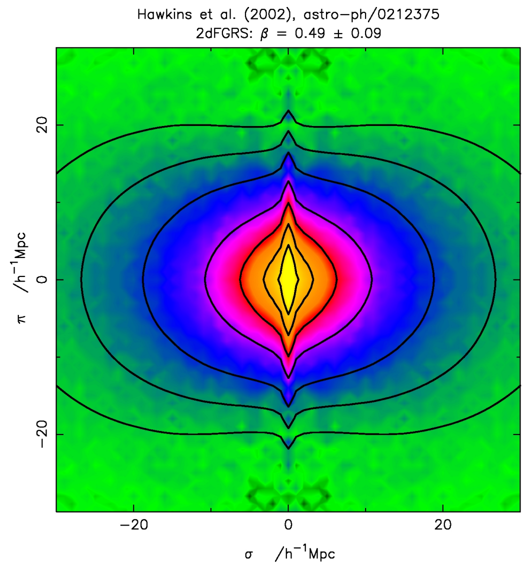










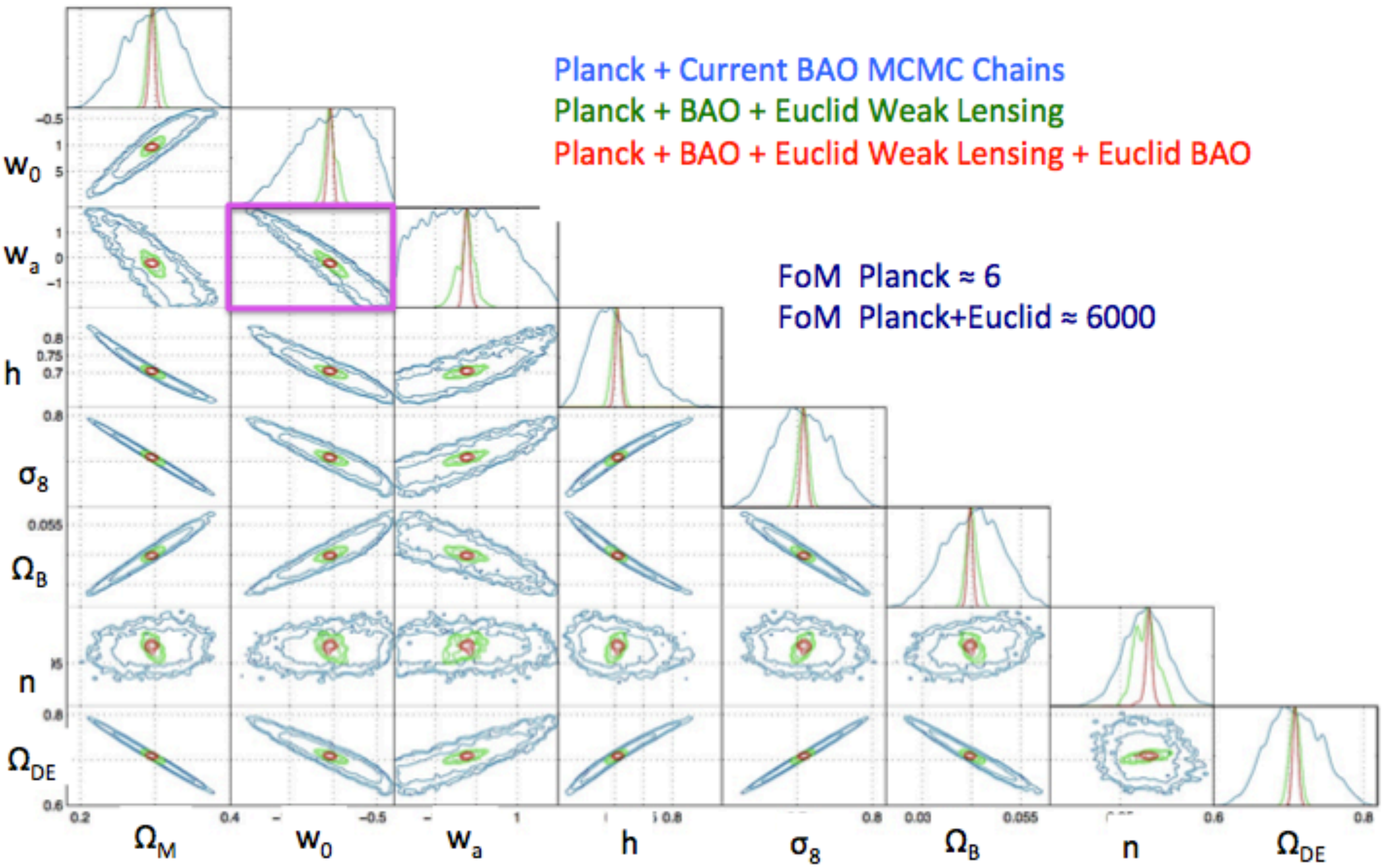


Euclid Science Prediction

Red Book Predictions

	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**

Euclid Science prediction



Components of Likelihood

IST

$$2 \ln L \propto (D - M) C^{-1} (D - M)^T$$

SGS

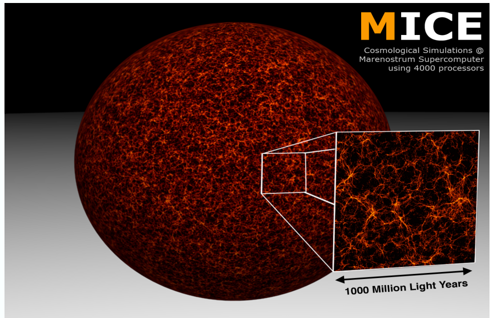
CosmoSimSWG

IST and SWGs have also started addressing how all these elements need to come together:

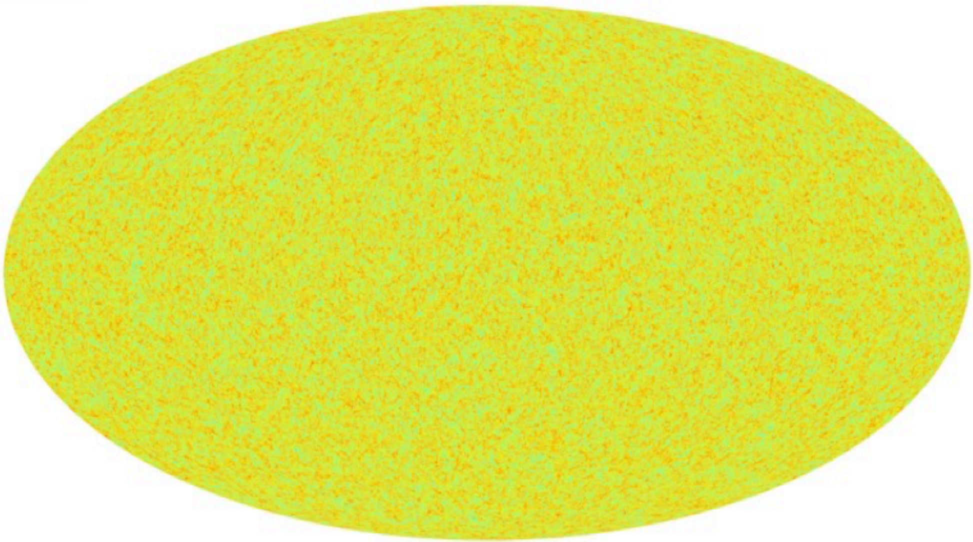
major activity over the next year

2 trillion particles Flagship: *Euclid Simulation*

Data products for the E2E simulation pipeline (expected end of 2016)



- FOF (0.2) halo catalogue on a "Full Sky" light cone up to z=2.3
- 100 Healpix maps (nside=8192) of the projected matter density and potential density in 100 redshift slices
- 10 different HOD galaxy catalogues with basic filters and spectra.
- Consistent mocks for WL and GC data.
- SED fitting with 23 bands from u to IRAC at fixed redshift with 213 Bruzual&Charlot models with different ages and star formation histories, including dust absorption, with normalisation fixed to reproduce H-band photometry.
- Galaxy sizes and morphologies
- **Official release Jan. 15 2017**



- Key innovation: analysis is done entirely on the fly (light cone and halo catalogue)

Legacy Science Working Groups

Extra-solar planets

Milky Way and Resolved Stellar Pops

Local Universe

Galaxies and AGN evolution

Primeval Universe

Clusters of Galaxies

Supernovae and transients

Strong lensing

CMB Cross-correlations

Cosmological Theory

Cosmological simulations

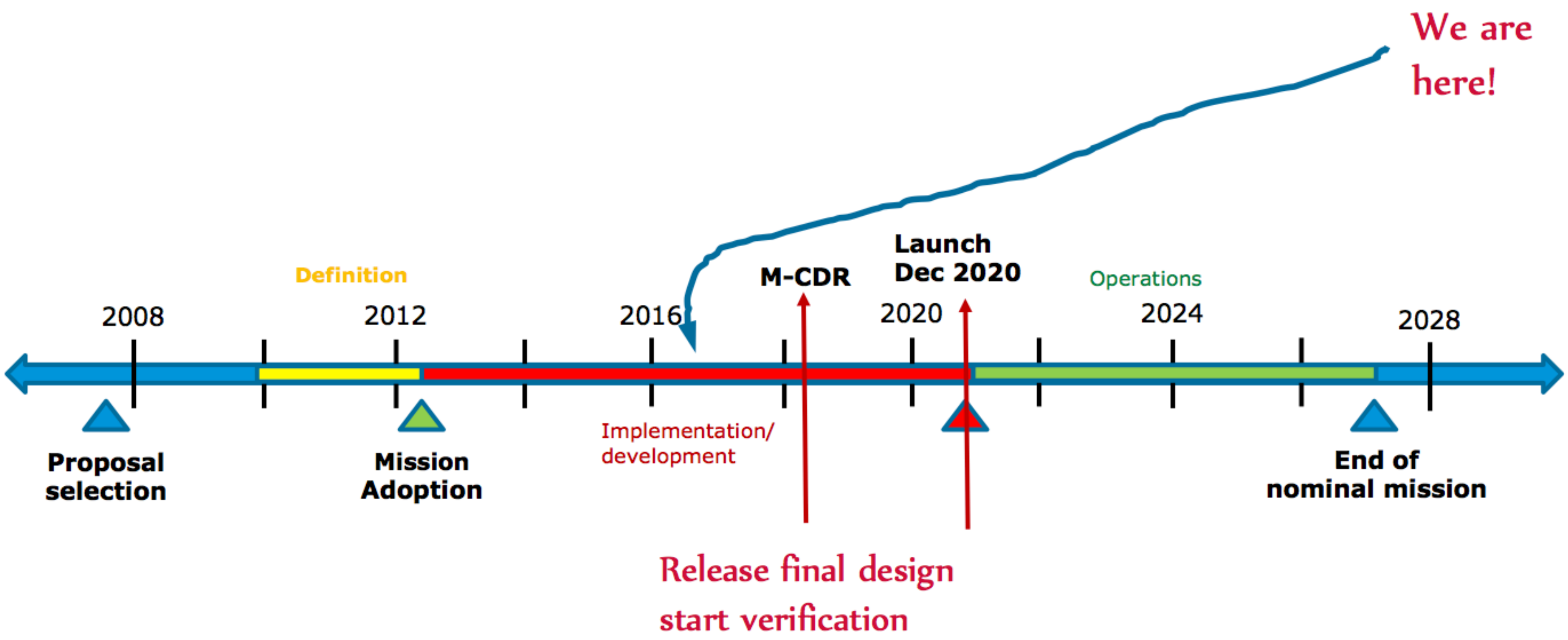
Euclid Science prediction

Euclid legacy in numbers

What	Euclid	Before Euclid
Galaxies at 1<z<3 with good mass estimates	$\sim 2\times10^8$	$\sim 5\times10^6$
Massive galaxies (1<z<3) w/ spectra	~few x 10^3	~few tens
Hα emitters/metal abundance in z~2-3	$\sim 4\times10^7/10^4$	$\sim 10^4/\sim 10^2$?
Galaxies in massive clusters at z>1	$\sim 2\times10^4$	$\sim 10^3$?
Type 2 AGN (0.7<z<2)	$\sim 10^4$	$<10^3$
Dwarf galaxies	$\sim 10^5$	
T_{eff} ~400K Y dwarfs	~few 10^2	<10
Strongly lensed galaxy-scale lenses	~300,000	~10-100
z > 8 QSOs	~30	None

Euclid timeline

- Project: a few years from launch!
- Scientist: at the halfway point…



Conclusions

- Euclid: cosmology mission to study the structure of the universe and the nature of dark energy
- Optimized for galaxy clustering and weak lensing, two dark energy complementary probes
- will produce large amount of imaging and spectroscopic data with a huge potential for astronomical science in many fields
- Two instruments: optical imager (VIS) and near-infrared spectrophotometer (NISP)
- Science Ground Segment will deal with all data to produce science ready products and distribute them to the community
- Launch scheduled for Q4-2020