PAU, a fully depleted mosaic imager with narrow band filters

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the Camera

PAUCam is a new camera to be installed at the prime focus of the WHT in La Palma. The instrument covers the entire 1-degree FoV of the 4.2-meter telescope with 18 2k x 4k Hamamatsu CCDs, with a 0.26"/pixel plate scale, with 15μm pixels.

A set of 40 narrow-band filters and the 6 standard ugrizY broadband filters will be mounted in the camera covering the entire wavelength range from 0.3 to 1 μm.

PAUCam's innovative filter changing mechanism, operating inside the cryostat. Fourteen filter trays (7 each side) holding 18 filters each are stored in an elevator-like structure, and slide in an out of the focal plane.

The focal plane of PAUCam, The survey footprint uses the 8 central, unvignetted CCDs.
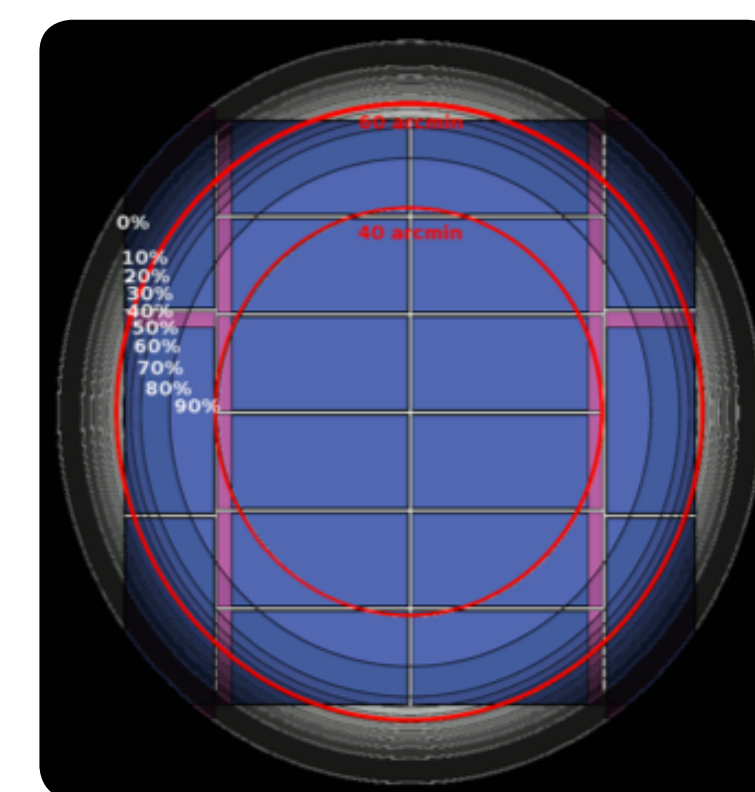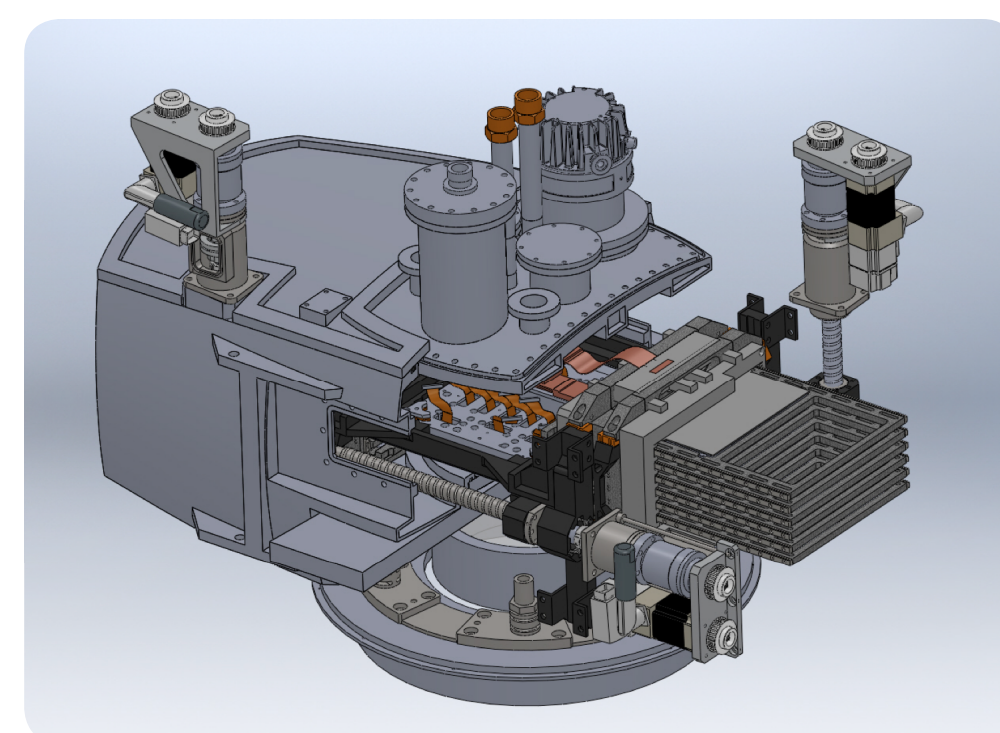
PAUCam's HPK Fully Depleted CCD Detectors
Characterization

The CCD detectors used to build PAUCam are manufactured by Hamamatsu Photonics K. K. with the reference S10892-04(X). The active size is composed by 2K × 4K square pixels of 15 μm. The device is n-type and uses four outputs.

The focal plane is composed by a mosaic of 18 CCDs. All CCDs can be used as science sensors, but, alternatively, two of them can be used to guide the telescope for large exposure times.

30 minute **dark exposure**, with cosmic rays.

Combining these images, to remove the cosmic ray events, we can evaluate a good value of the dark current.

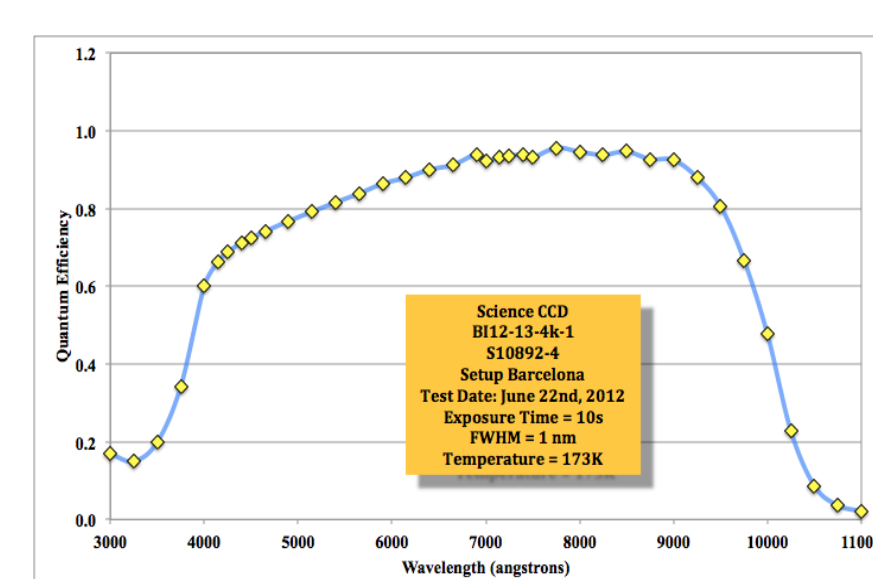**Laboratory Ilumination image (high contrast)**

In the top and bottom borders chained half moons are visible, due to the assembly manipulation.

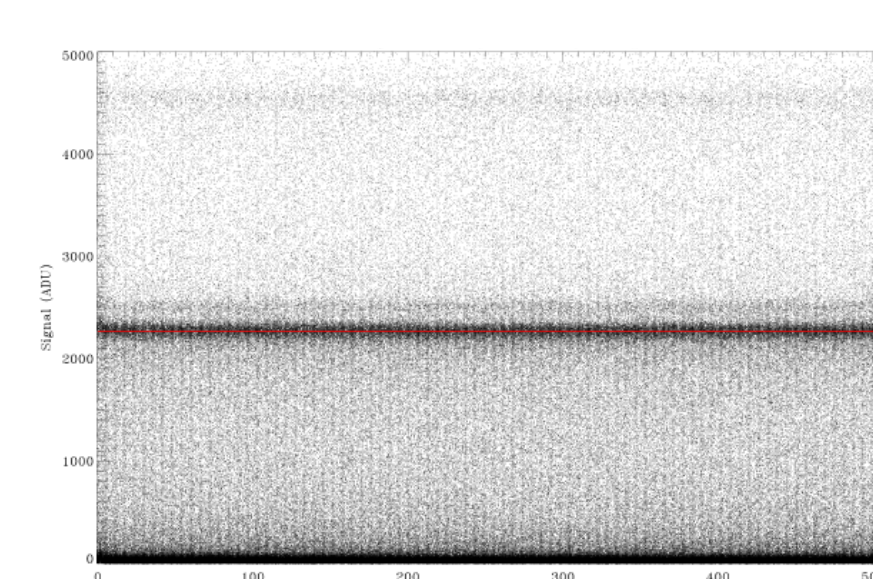The fainter, larger circles are due to dust in the cryostat window.

The illumination pattern shows an axial symmetry due to the not-flat illumination given by the integrated sphere.
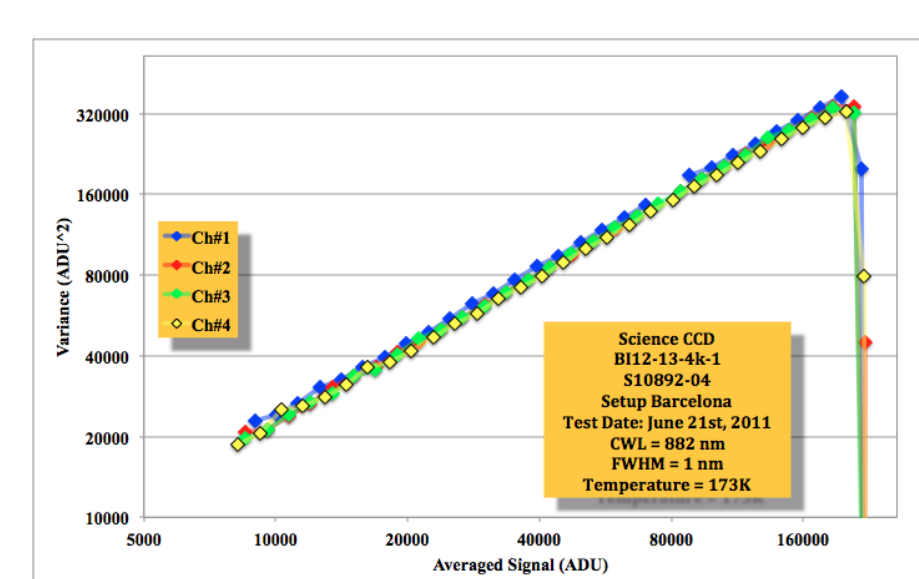
Flat-Field Image
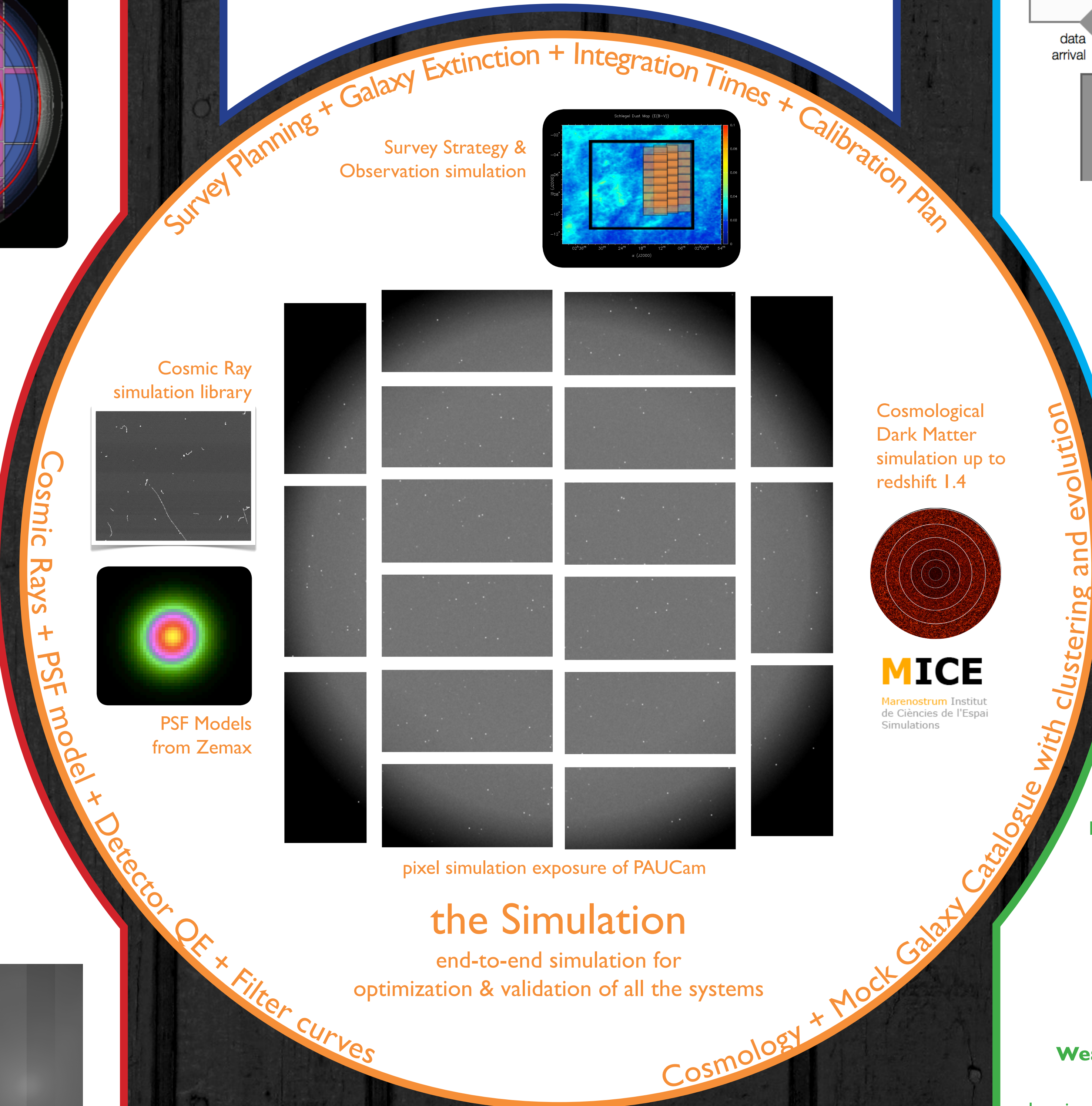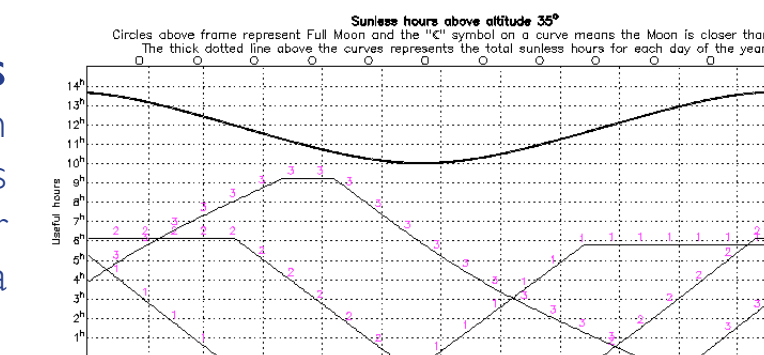
Photon Transfer Curve

Quantum Efficiency

X-Ray Horizontal Transfer (CTE)

the Survey

The PAU Survey studies the existence and properties of **dark energy** from the observations of ~10^7 galaxies in 200 deg^2 of extragalactic sky area up to redshift 1.

The 40 narrowband filter set will allow precision redshift measurements of σ ~$0.0035×(1+z)$ for galaxies with **iAB < 22.5**, and σ~$0.035×(1+z)$ for galaxies with 22.5 < iAB < 24.0.

Field location considerations
low dust extinction
minimize field isolation & airmass
right ascension distribution over the year
overlap with precise external data

the Simulation

Survey Planning + Galaxy Extinction + Integration Times + Calibration Plan

Survey Strategy & Observation simulation

Cosmic Ray simulation library

PSF Models from Zemax

Cosmological Dark Matter simulation up to redshift 1.4

M**ICE**
Marenostrum Institut de Ciènces de l'Espai Simulations

Cosmic Rays + PSF model + Detector QE + Filter curves

Cosmology + Mock Galaxy Catalogue with clustering and evolution

pixel simulation exposure of PAUCam

the Simulation
end-to-end simulation for optimization & validation of all the systems

the Data Management

Transferring, processing, calibrating, archiving and distributing 350GB of raw data per night.
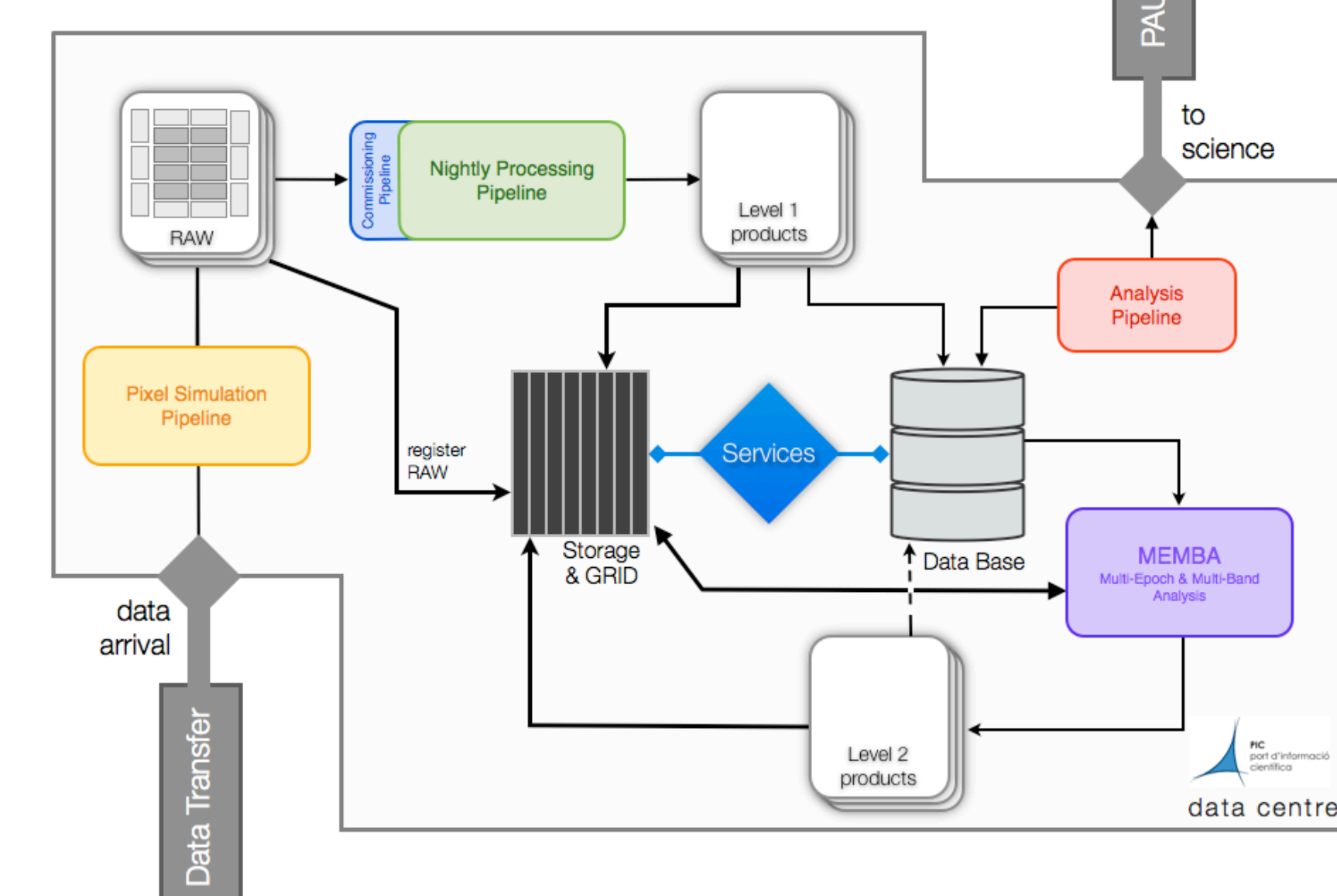
The data managent system is integrated at the **PIC data centre** with GRID technology.

A PostgreSQL **database** ochestrates ~1PB of data and ~10^8 detections.

Job submission over in the 4000-core cluster system.

Continuous **quality control** system provides alerts on any stage of the processing system.

Web portal for performance and quality monitoring and distribution of data.

Photometric Calibration
Nightly strategy I:
use the broad band calibration to determine the extinction of all chips in the focal plane

Nightly strategy II:
determine best fit SED template to extrapolate the standard catalog to all PAU filters

Global Übercalibration:
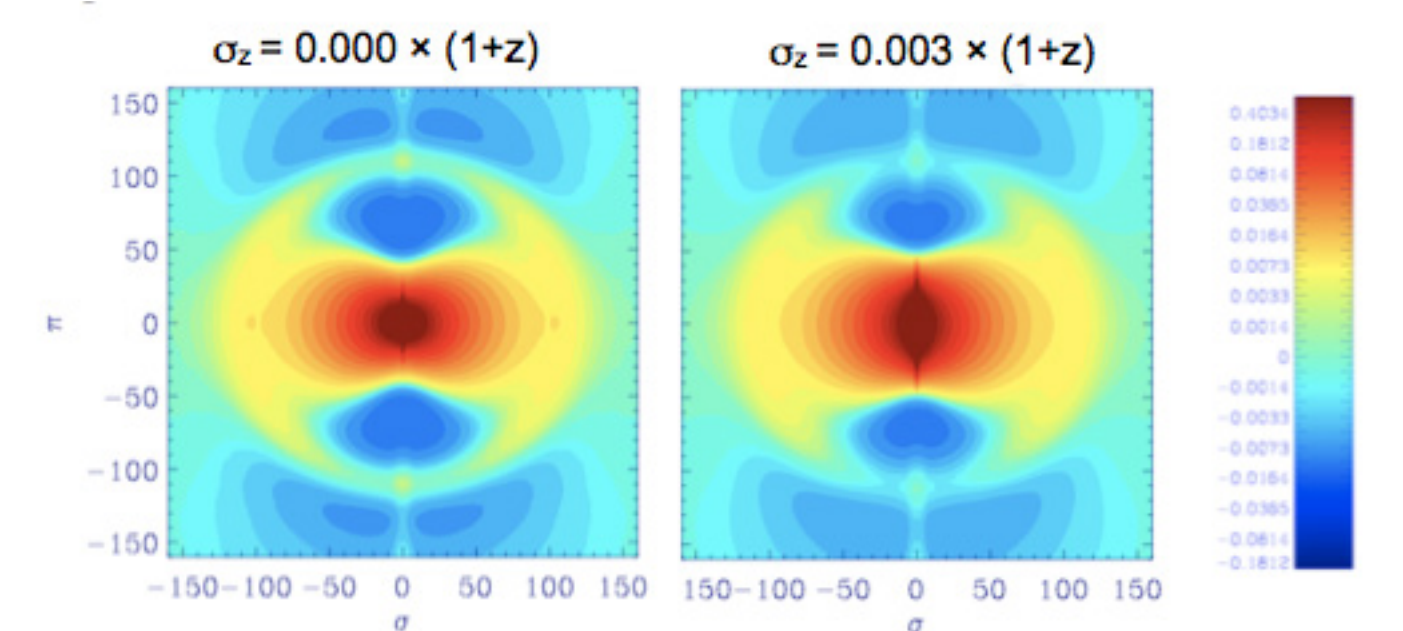find ZPs that minimize the photometric offset between observations over the same area
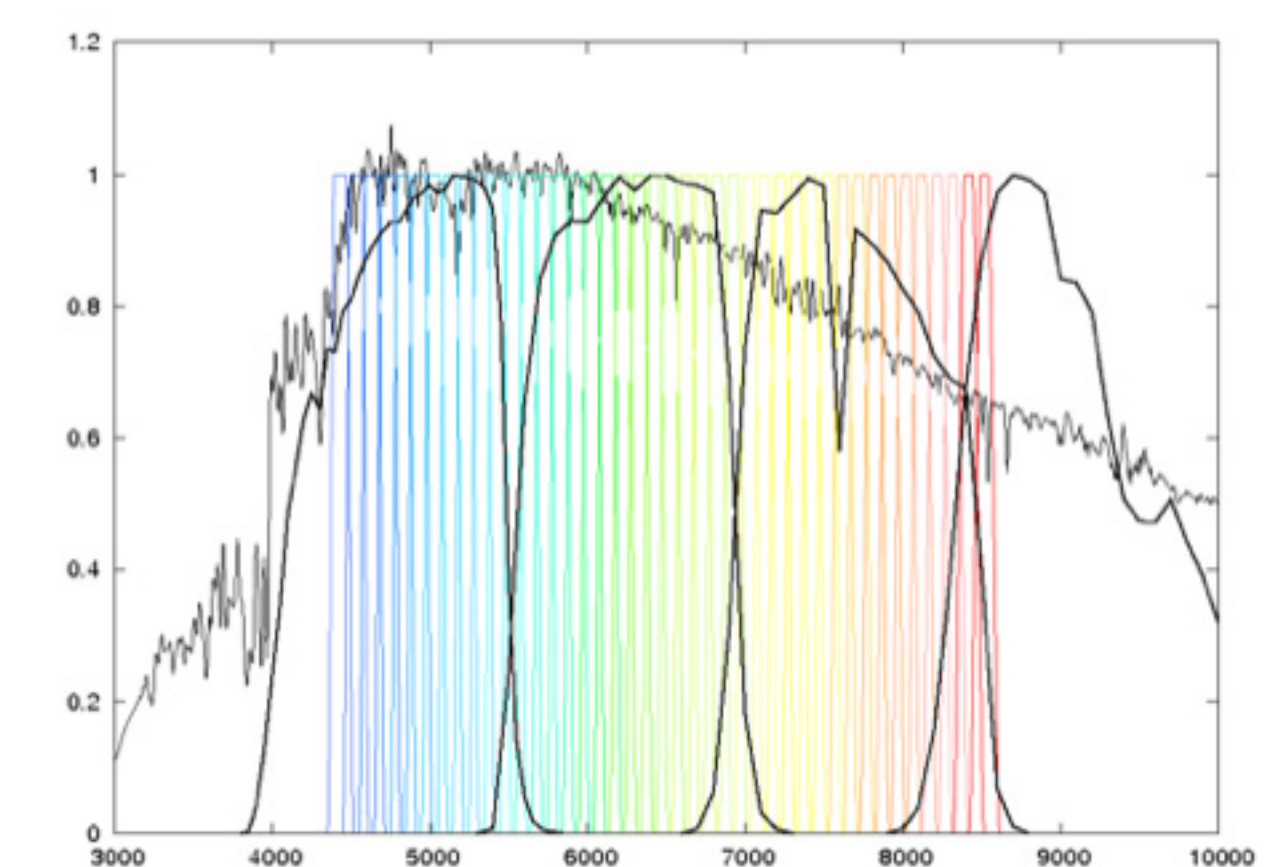
the Science

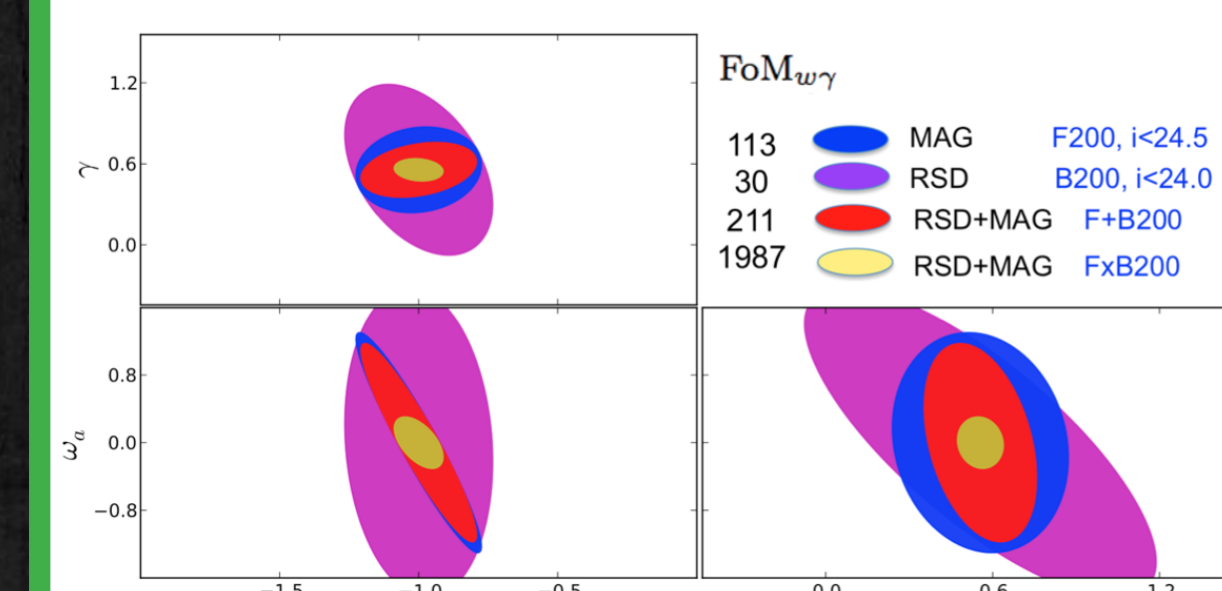### Two Complementary Probes of Dark Energy

Redshift Space Distortions (RSD):
Typical of spectroscopic surveys
PAUCam radial accuracy is enough to measure the velocity divergence and therefore growth of structure.

$\sigma_z = 0.000 \times (1+z)$
$\sigma_z = 0.003 \times (1+z)$

Weak Lensing Magnification (MAG):
Typical of imaging surveys
Lensing magnifies fluxes and alters the area observed, changing the number and fluxes of observed objects.

Very precise photo-zs allow PAU to perform cross-correlations between well-defined narrow redshift bins and precisely measure magnification.

the Science Pipeline

$FoM_{w\gamma}$	
113	MAG F200, i<24.5
30	RSD B200, i<24.0
211	RSD+MAG F+B200
1987	RSD+MAG FxB200

Model
Cosmological Model Selection & priors
Mask
Pixel level weight
Galaxy Catalogue
Magnitudes + errors
Redshift + errors
Likelihood
Sample Selection & Mask
Photo-z
Spectroscopic data
Clustering

ICE CSIC
IEEC
IFAE
PIC port d'informació científica
Ciemat