

Cosmology with the Euclid satellite

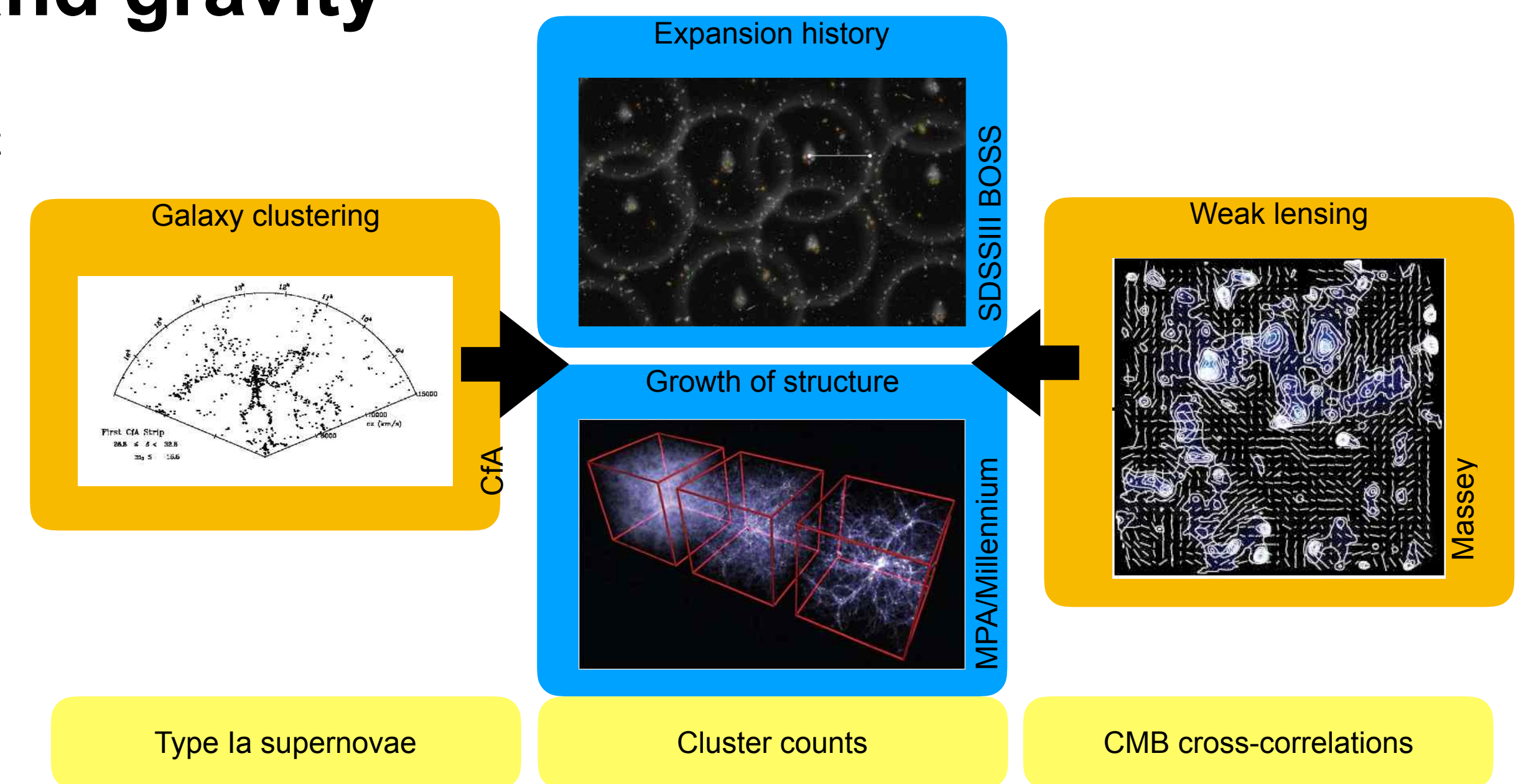
Ben Granett, Carmelita Carbone, Adam Hawken, Matteo Zennaro, Davide Maino, Luigi Guzzo

Joint probes of dark energy and gravity

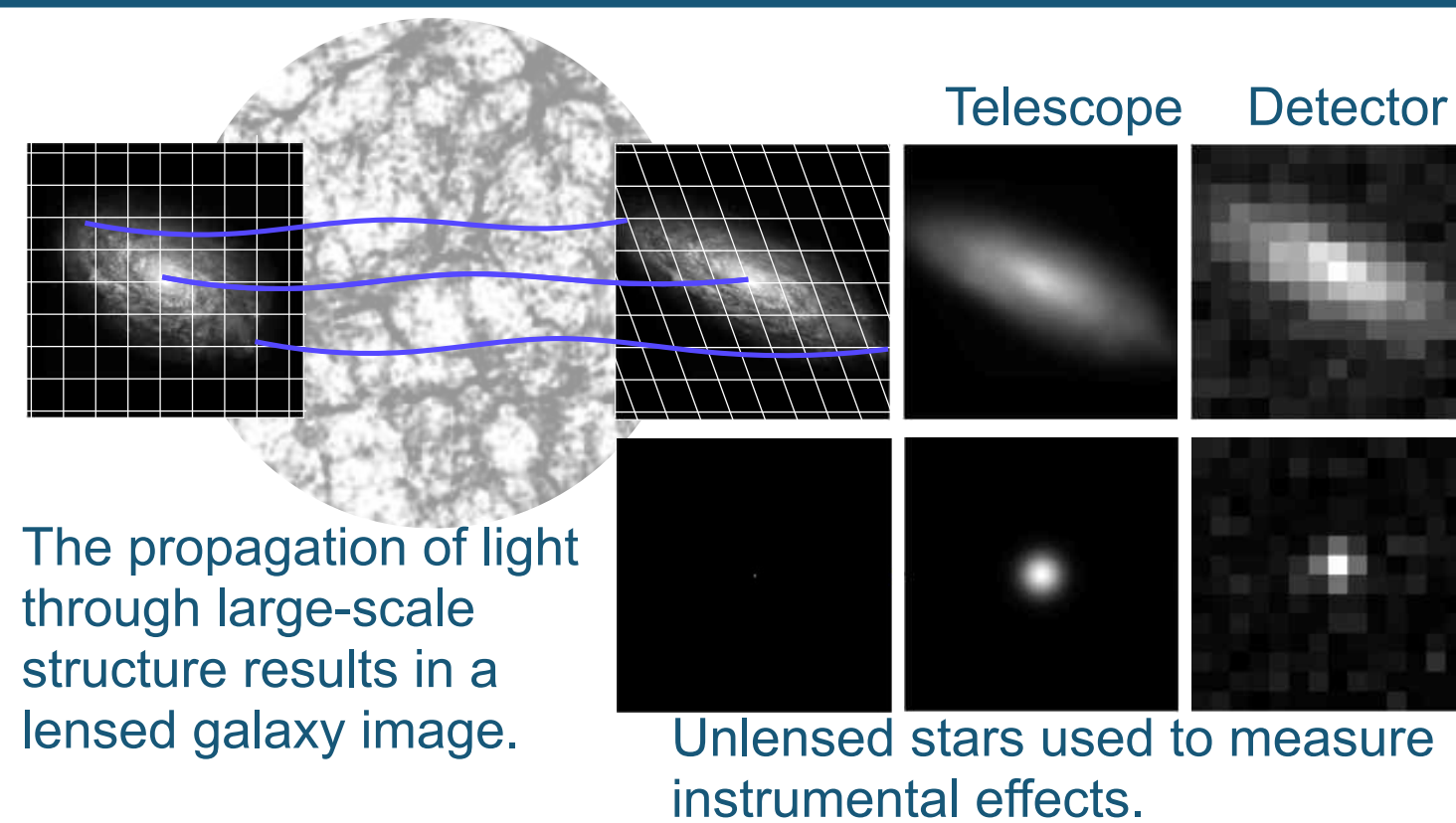
The **ESA Euclid** mission will launch in 2021 with combined visible and infrared imaging and slitless spectroscopy over 15,000 square degrees of sky. The two primary experiments, **weak gravitational lensing and galaxy clustering** represent the most sensitive probes of dark energy and of the theory of gravity on cosmological scales. Their combination probes the cosmological expansion, the growth of structure and the relation between dark and luminous matter, providing fundamental cross-checks and cross-calibrations of the systematic effects of each probe.

The volume of the Universe to be mapped by Euclid is unprecedented and the visible and near IR data will enable a wide range of science. In particular Euclid will:

- Detect 100 000 **galaxy clusters** providing an additional cosmological probe.
- Measure **galaxy morphologies** at high redshift for galaxy evolution and environmental studies
- Provide a census of **AGN** at $1 < z < 3$
- Identify the **highest redshift galaxies** with Lyman break sources at $z > 7$ and the first quasars at $z > 8$.
- Detect the **coolest stars** at near IR wavelengths
- Resolve the stellar populations in **nearby galaxies**



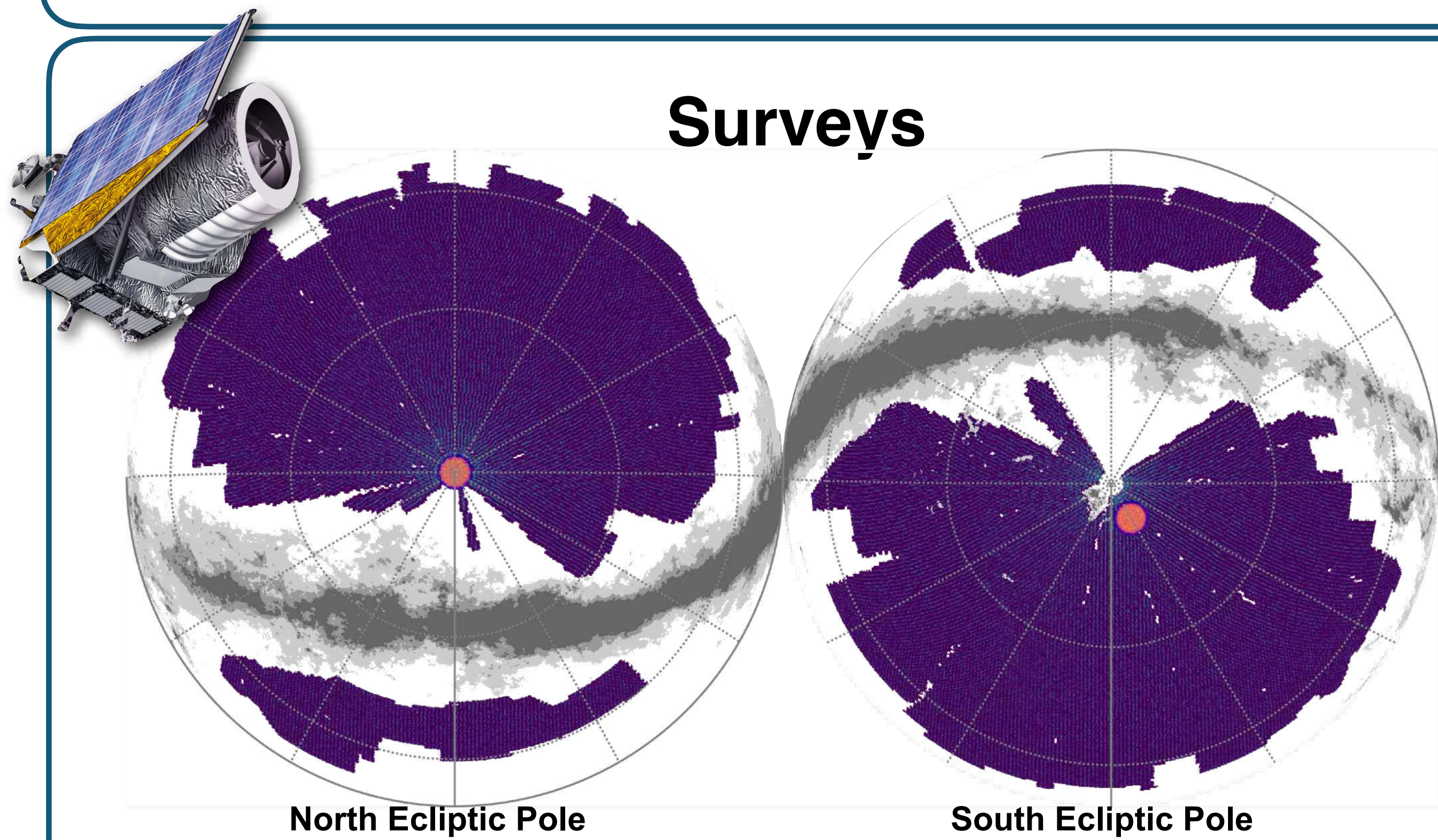
Weak gravitational lensing



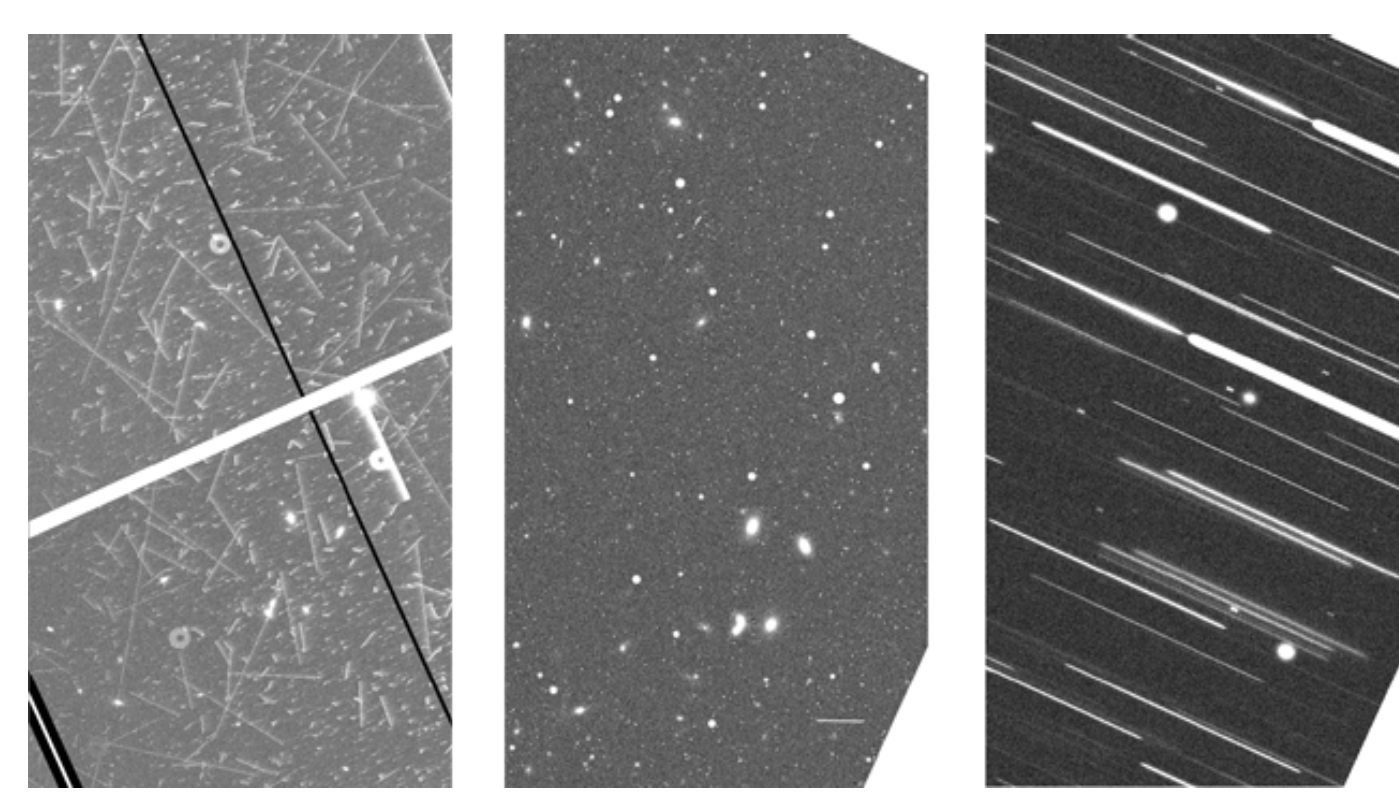
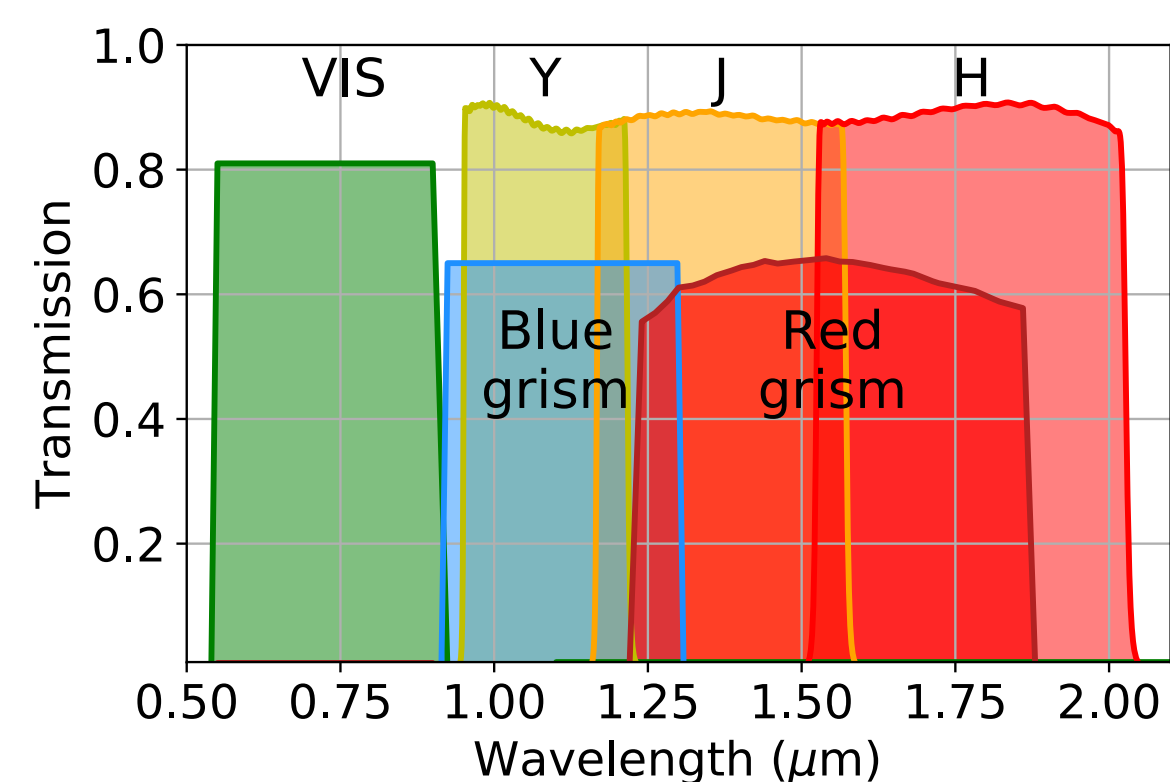
The visible imaging survey will permit the precise measurement of the shapes of **30 galaxies per square arcminute** to probe the matter field through gravitational lensing. With photometric redshift information, this will allow us to reconstruct the history of the formation of structure over redshifts $0 < z < 3$.

Weak lensing induces changes in ellipticity at the level of 10^{-3} , much smaller than the intrinsic variations in galaxy shapes. The slight cosmological signal can only be extracted by correlating the measured ellipticity of millions of galaxies. To be successful, the distortions induced by the Euclid telescope optics must be measured to high precision and corrected.

Surveys

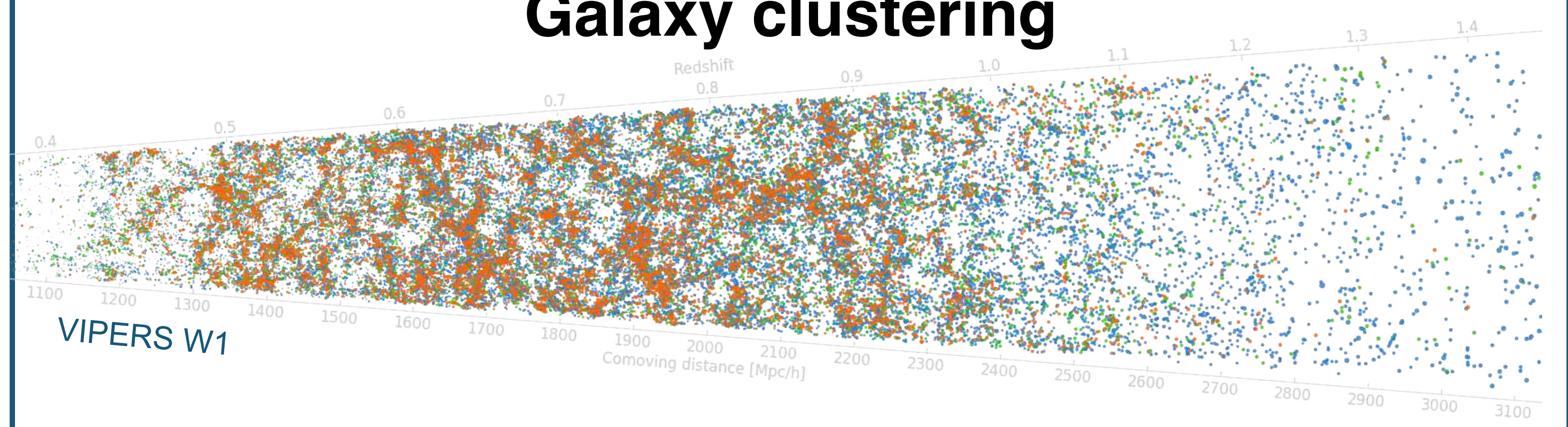


The **Wide survey** will cover 15,000 square degrees in the visual and infrared bands including the red grism (see below). The **Deep survey** will reach 2 magnitudes deeper and cover 40 square degrees.



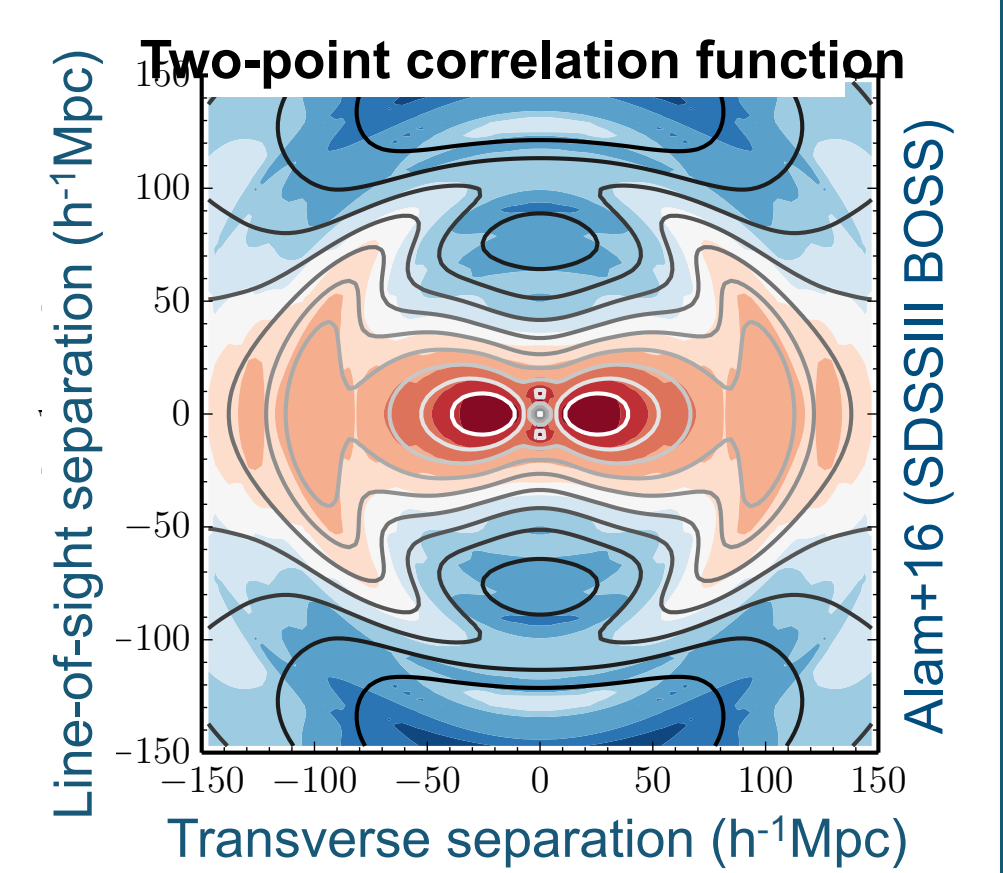
Simulated images for the same field of view; only a small region of the FoV is shown. Note that cosmic rays are not included in the NIR and grism simulated images.

Galaxy clustering

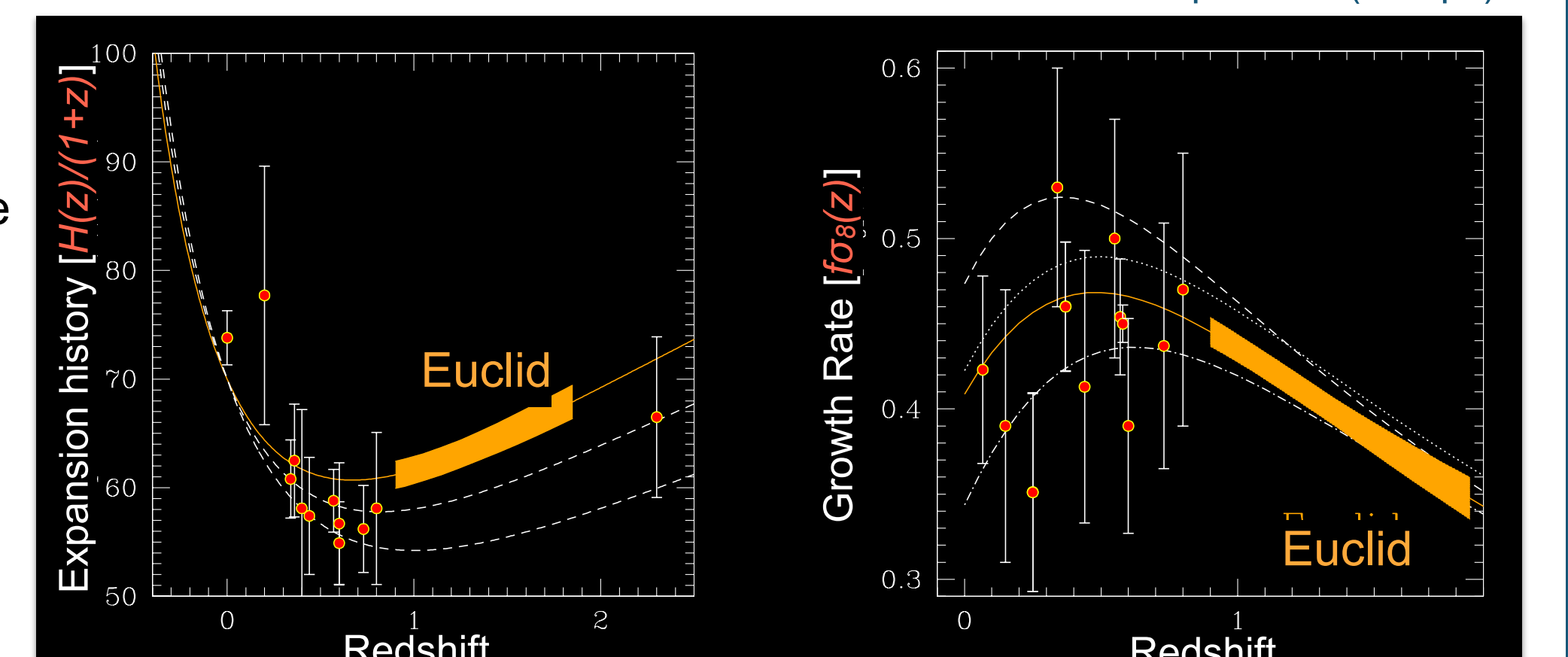


The Euclid near-IR spectrograph NISP will measure redshifts of over **30 million H α emitting galaxies** between redshift 0.9 and 1.8. These redshifts will allow us to map the 3D distribution of galaxies to reveal the cosmic web of groups, filaments and voids, as seen for the first time at redshift 1 in the VIPERS data, above.

Large-scale structures grow over time through gravitational collapse and the evidence of these processes can be measured directly from the two-point correlation function of galaxies in redshift-space. The line-of-sight direction is affected by the velocities of galaxies leaving an anisotropic signature in the correlation function. The Kaiser effect describes the **redshift-space distortion** from coherent velocity flows and allows us to estimate the **growth rate $f(z)$** . Accurately inferring the growth rate from the high quality Euclid data will require advanced theoretical modeling and simulations. Development of these techniques has been one of the main goals of the ERC Advanced Grant Project 'Darklight.'

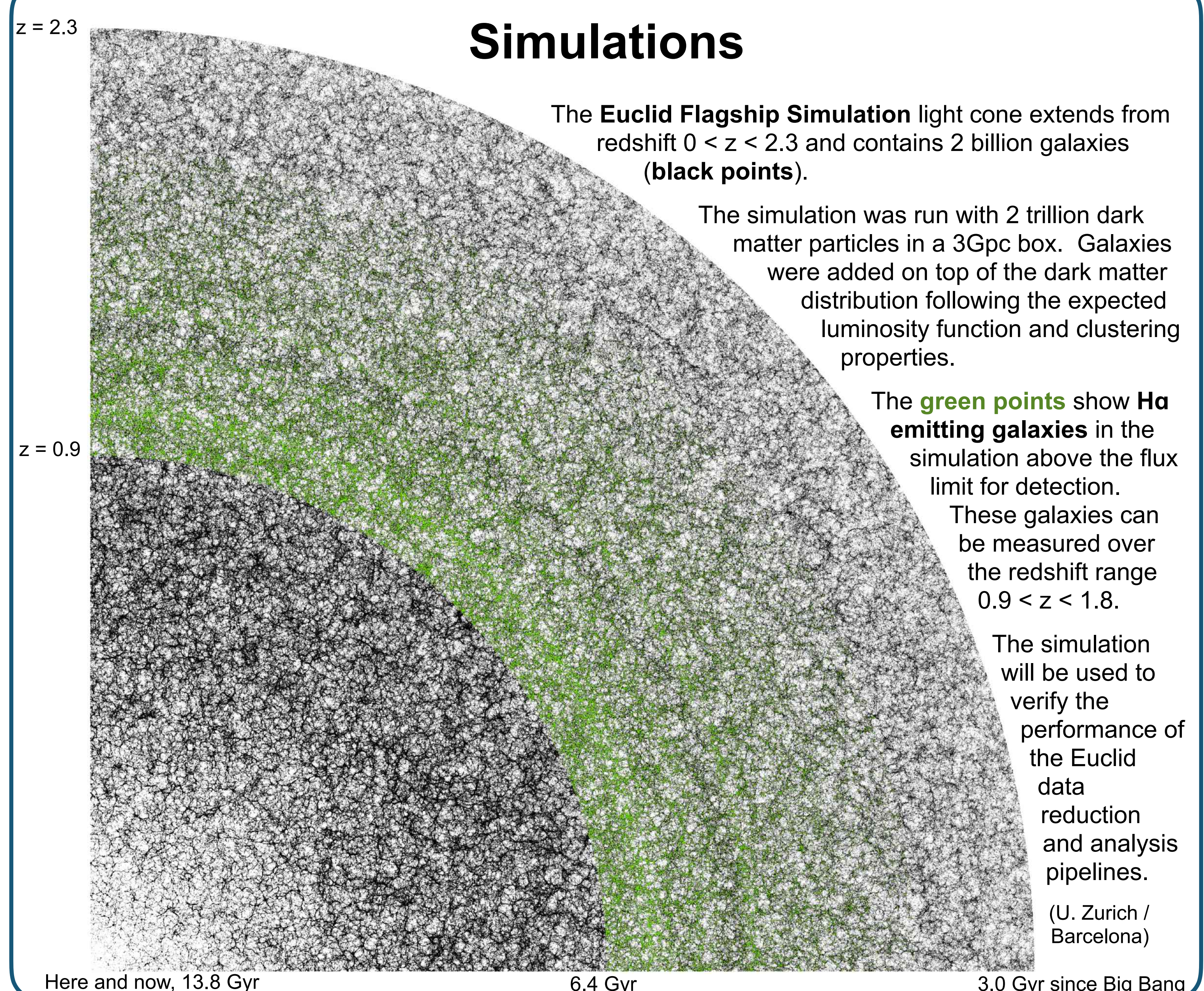


In addition, measurements of the **Baryon Acoustic Oscillations** in the galaxy correlation function provide a standard ruler that can be traced back to the acoustic peaks seen in the CMB temperature power spectrum. With this technique Euclid will measure the expansion history $H(z)$ and the angular diameter distance relation $d_A(z)$ that provide direct constraints on the physics of dark energy.



Together, the two probes will lead us to understand whether the observed cosmic acceleration represents a dynamical component in the Universe or if it is a manifestation of a failure of Einstein's general theory of relativity to describe gravity on cosmological scales.

Simulations



The **Euclid Flagship Simulation** light cone extends from redshift $0 < z < 2.3$ and contains 2 billion galaxies (**black points**).

The simulation was run with 2 trillion dark matter particles in a 3Gpc box. Galaxies were added on top of the dark matter distribution following the expected luminosity function and clustering properties.

The **green points** show **H α emitting galaxies** in the simulation above the flux limit for detection. These galaxies can be measured over the redshift range $0.9 < z < 1.8$.

The simulation will be used to verify the performance of the Euclid data reduction and analysis pipelines.

(U. Zurich / Barcelona)

Here and now, 13.8 Gyr

6.4 Gyr

3.0 Gyr since Big Bang

Euclid @ UniMi

The **Euclid group at UniMi** (formerly at INAF Brera) is among founders of the mission, who directly contributed to the original "SPACE" proposal to the ESA "Cosmic Vision" call of 2007. SPACE was the spectroscopic survey experiment that was then merged with the parallel "DUNE" proposal for an imaging survey, to make Euclid. As such, the group members cover some key roles inside the Euclid Consortium:

- **Luigi Guzzo** - Core Science co-Coordinator; Galaxy Clustering Science WG lead
- **Davide Maino** - Deputy Lead and Science Coordinator of Science Data Center Italy
- **Carmelita Carbone** - Cosmological forecasts and simulations with neutrinos; CMB weak lensing and cross-correlation with cosmic structures
- **Ben Granett** - Galaxy Clustering: estimators, systematic effects, end-to-end sims
- **Adam Hawken** - Galaxy Clustering: additional cosmological probes and cosmic voids
- **Matteo Zennaro** (PhD Student) - Cosmological simulations and neutrinos

The UniMi group works in close collaboration with the Euclid group at INAF IASF, including in particular **Bianca Garilli**, **Marco Scodreggio** and **Paolo Franzetti**.

