Euclid Legacy Science

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on the basis of the work of legacy coordinators and EC members, and using information from Jarle Brinchmann

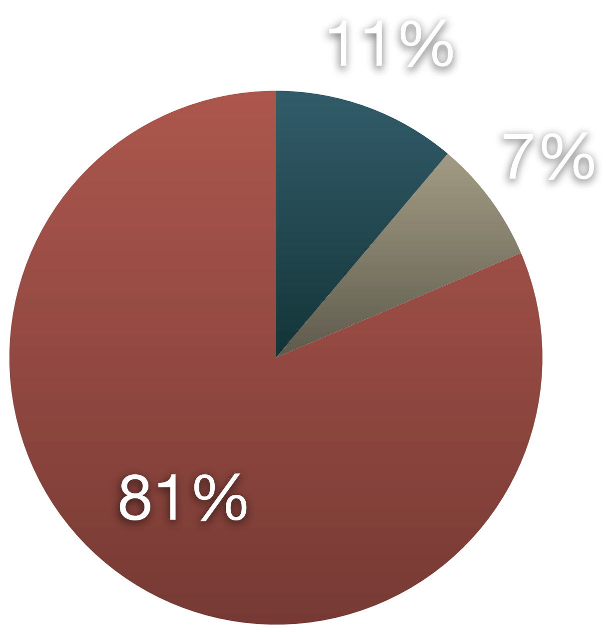
The importance of legacy science

- Experience has shown us that good surveys that are easy to use/access for the general astronomers have major and lasting impact (e.g. POSS, IRAS, SDSS, H(U)DF).
- Early in the mission legacy will be the **main** conduit of scientific results and will be responsible for the image of the mission.
- The number of legacy science papers is likely to significantly exceed that of cosmology papers.
- With a good data archive and a survey that as far as possible optimises for legacy science Euclid will likely be a cornerstone of extra-galactic astronomy for a decade or more

The SDSS lesson

Out of 834 "official" SDSS journal papers:

Area	# papers	Percentage
Cosmology	93	11.2%
Supernovae	62	7.4%
Legacy	679	81.4%



But many more (>4500) papers have been written using SDSS data by others: **It is crucial that the data can be used by the whole astronomical community.**

Legacy Science Working Groups

Extra-solar planets
Lead: Beaulieau, Zapatero-Osorio, Kerins

Milky Way and Resolved Stellar Pops
Lead: Tolstoy, Ferguson

Local Universe
Lead: Poggianti, Warren

Galaxies and AGN
Lead: Elbaz, Cimatti, Brinchmann

Primeval Universe
Lead: Cuby, Finbo

Clusters of Galaxies
Lead: Weller, Moscardini, Bartlett

Supernovae and transients
Lead: Tao, Hook, Cappellaro

Strong lensing
Lead: Kneib, Meneghetti

CMB Cross-correlations
Lead: Agnanim, Baccicalupi

Cosmological Theory
Lead: Amendola, Kunz

Cosmological simulations
Lead: Fosalba Teyssier

Legacy Science Working Groups

Extra-solar planets

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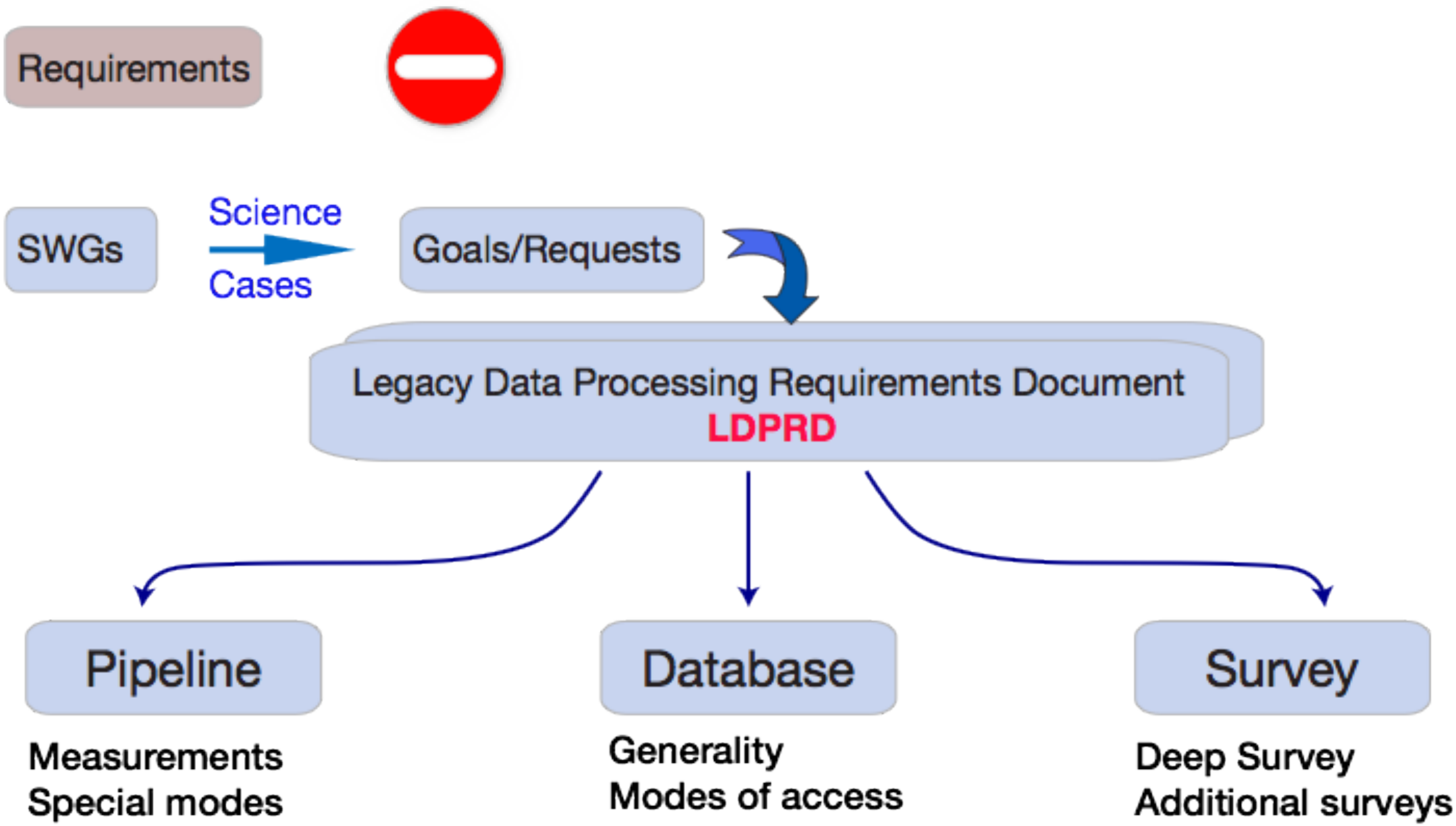
Cosmological simulations

The role of legacy in Euclid



Additional surveys

Two suggestions:

★Exoplanet Euclid Legacy Survey (~4 months)
★ SN Type Ia survey to provide additional constraints on cosmology. (~6 months)

In common:

Need a difference cadence to the standard survey - can not (easily) be incorporated in the main survey. Thus will take place towards the end if at all.

Additional benefits:

Co-adding data gives ultradeep final images H_{AB} ~ 28 for SNe survey over several deg^2.

Exoplanet Euclid Legacy Survey

(ExELS)

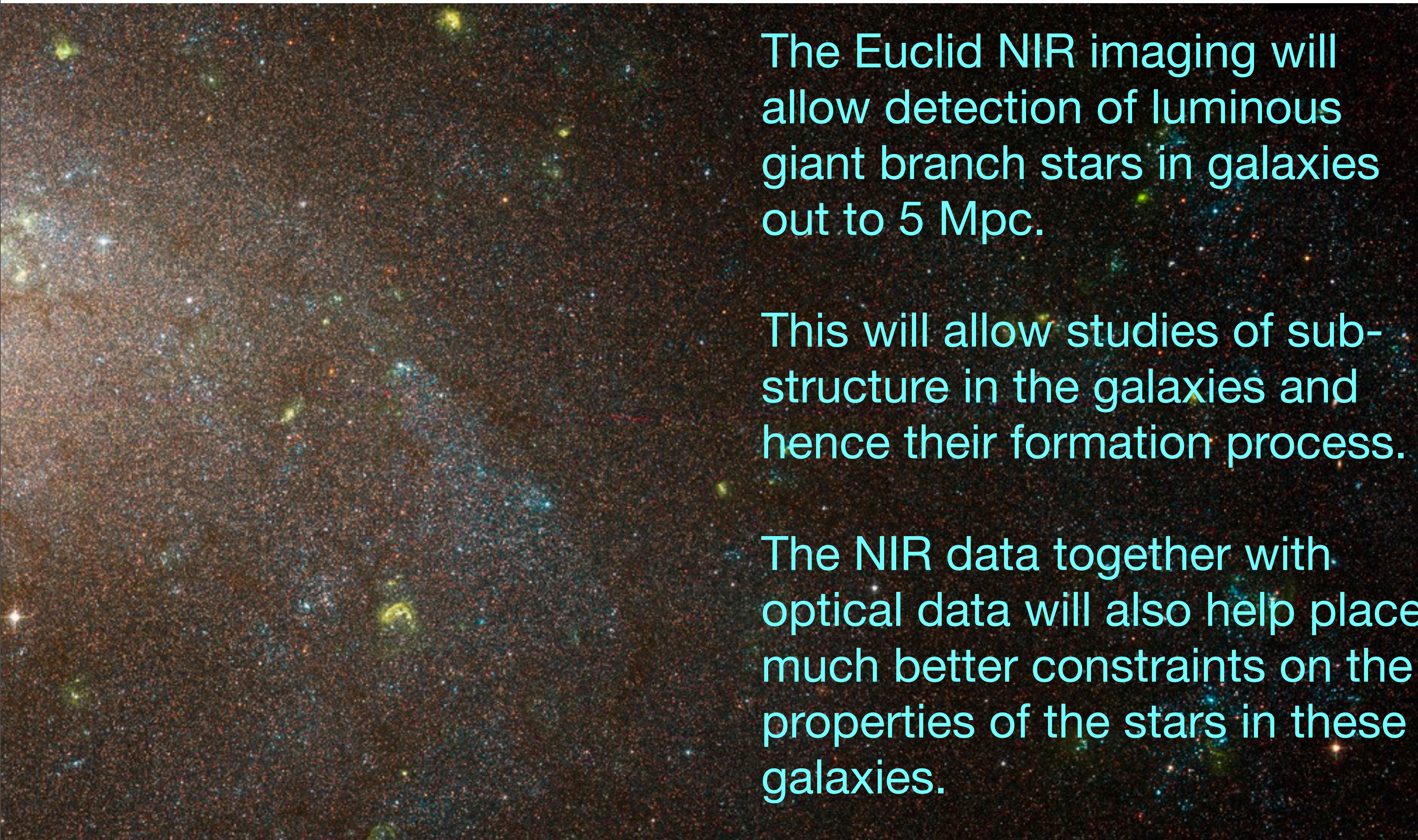
Exoplanet SWG leads: Beaulieau, Kerins, Zapatero Osorio

Primary survey objectives	**Yield**	**Science**
Measure the abundance of cool exoplanets down to Earth mass with host separation > 1 AU to at least 3-sigma precision	Around 35 cool planets per month, including 4.5 Earths and 14 Neptunes per month.	Cool exoplanet regime is crucial for testing planet formation theories and constraining abundance of planets in outer Habitable zone.
Measure the abundance of free-floating planets	Around 15 free-floating Jupiters per month if there is one per Galactic star.	Unbound planets are predicted by planet formation theories. Young counterparts have been observed in clusters. Older population tentatively observed with ground-based microlensing

Full science study presented in
Penny et al (2013): arXiv:1206.5296

SWG: Milky Way and Resolved Stellar Populations

Lead: Tolstoy & Ferguson



The Euclid NIR imaging will allow detection of luminous giant branch stars in galaxies out to 5 Mpc.

This will allow studies of sub-structure in the galaxies and hence their formation process.

The NIR data together with optical data will also help place much better constraints on the properties of the stars in these galaxies.

NGC 300 from the ANGST survey - see http://www.nearbygalaxies.org

SWG Local Universe and Galaxies

- What Euclid will provide us with.

- Galaxy formation science with Euclid

  - Very large samples → distribution functions

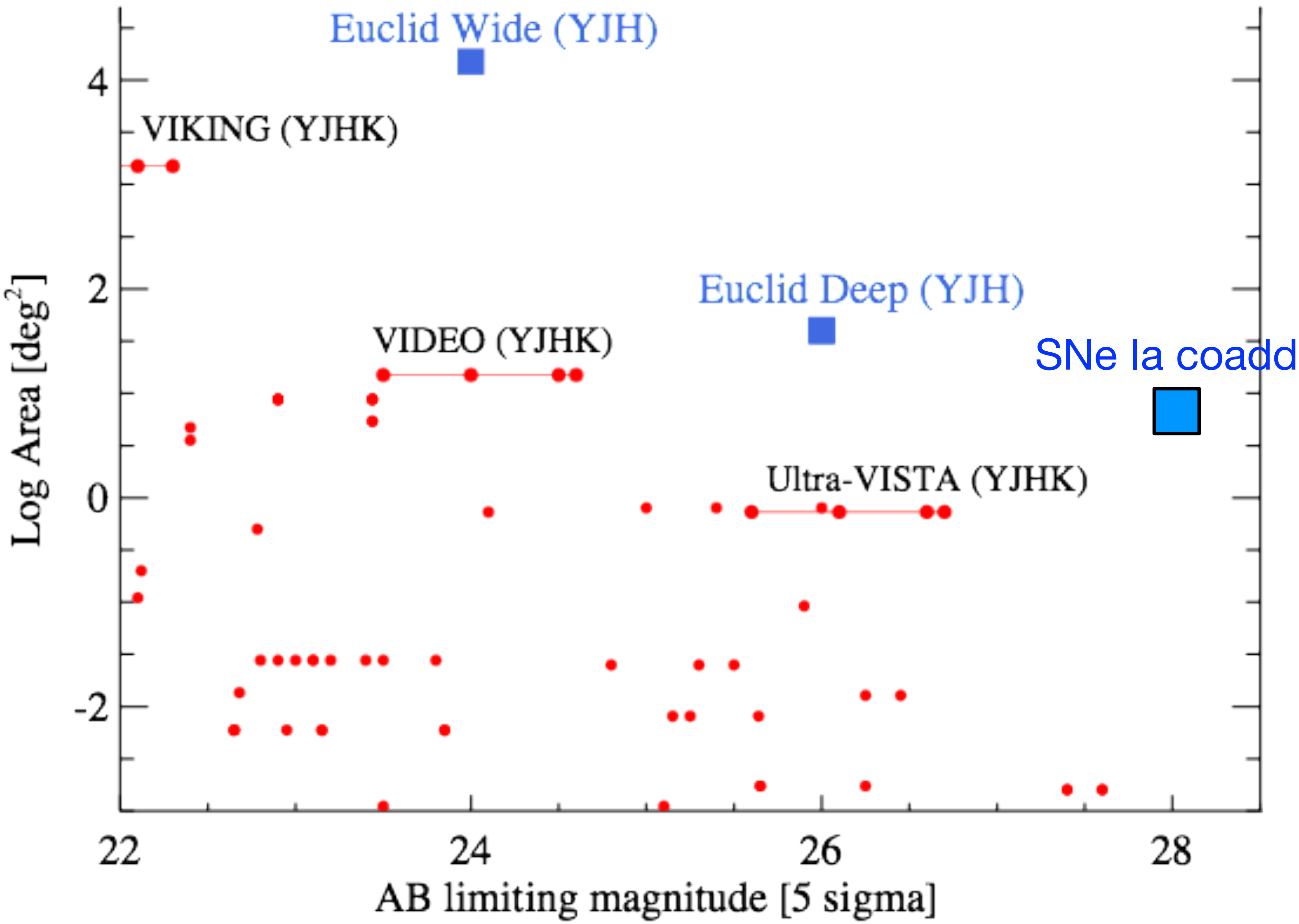
  - Exquisite imaging → morphological studies, mergers, strong galaxy-scale lenses, ..

  - Weak lensing → Galaxy evolution as a function of halo properties, galaxy alignment, ...

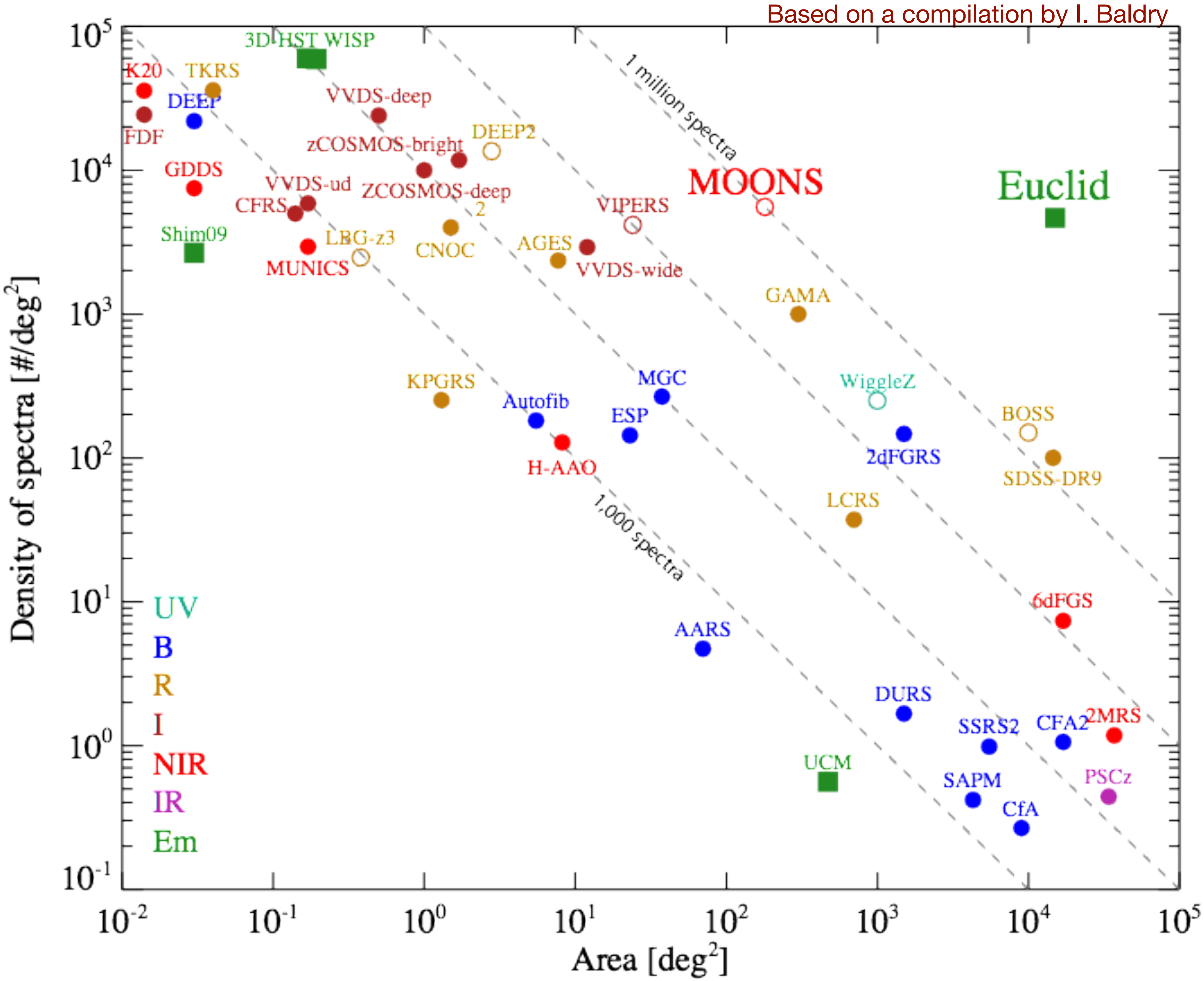
  - Very large volume → Rare sources, probing the extremes

Euclid compared to ground-based surveys

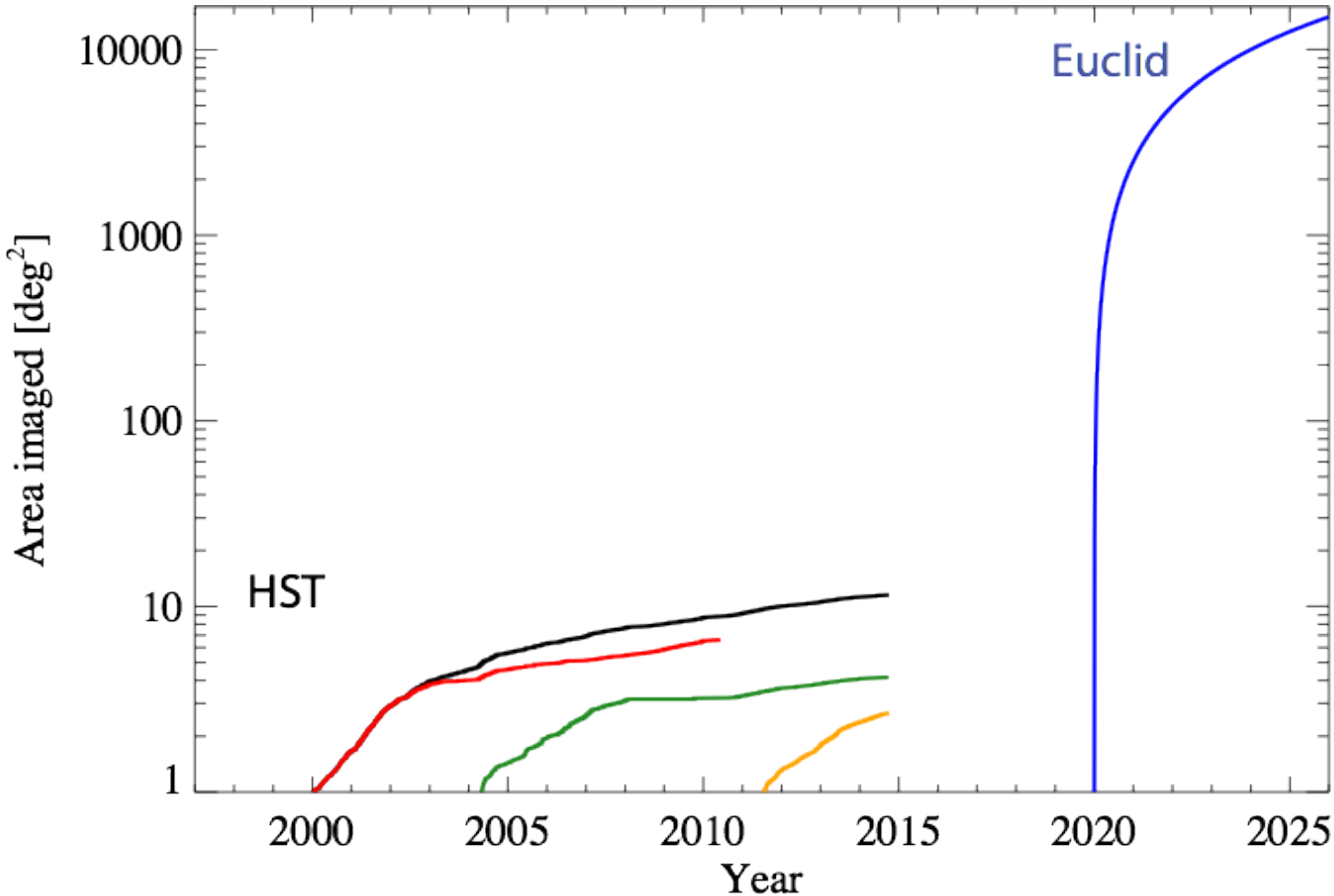
NIR imaging depth is similar to the deepest images from the ground.



Euclid compared to ground-based surveys



The leap in high resolution imaging

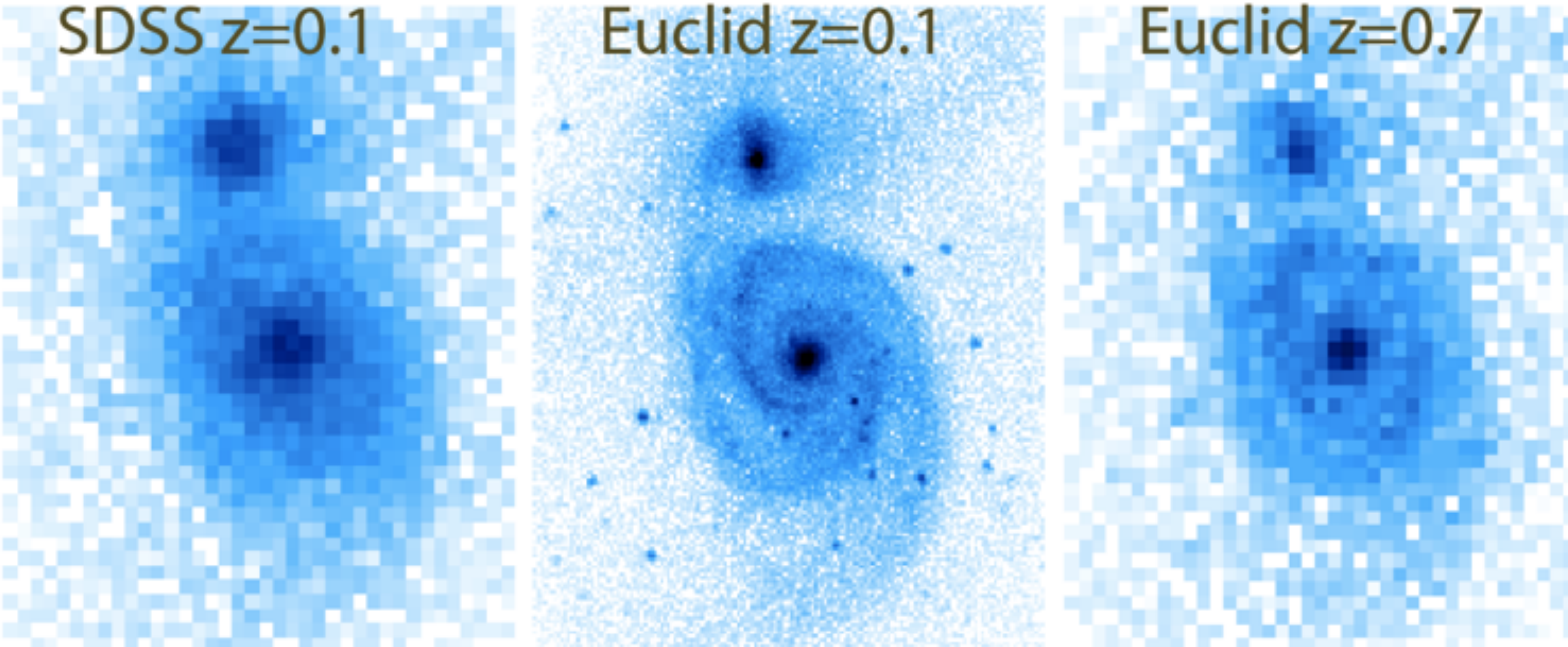


Euclid legacy in numbers

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	$\sim$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	$\sim$few 10^{2}	<10
Strongly lensed galaxy-scale lenses	~300,000	~10-100
z > 8 QSOs	~30	None

SWG Local Universe (z < 0.1)

Lead: Steve Warren, Bianca Poggianti



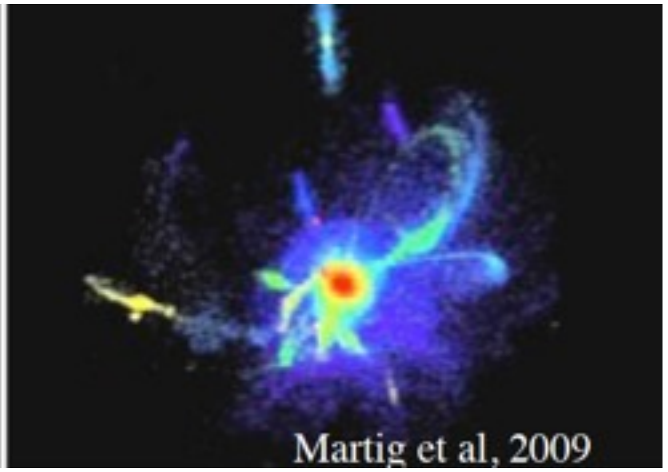
In Leiden WP Morphology, Clusters and Distance Measurements.

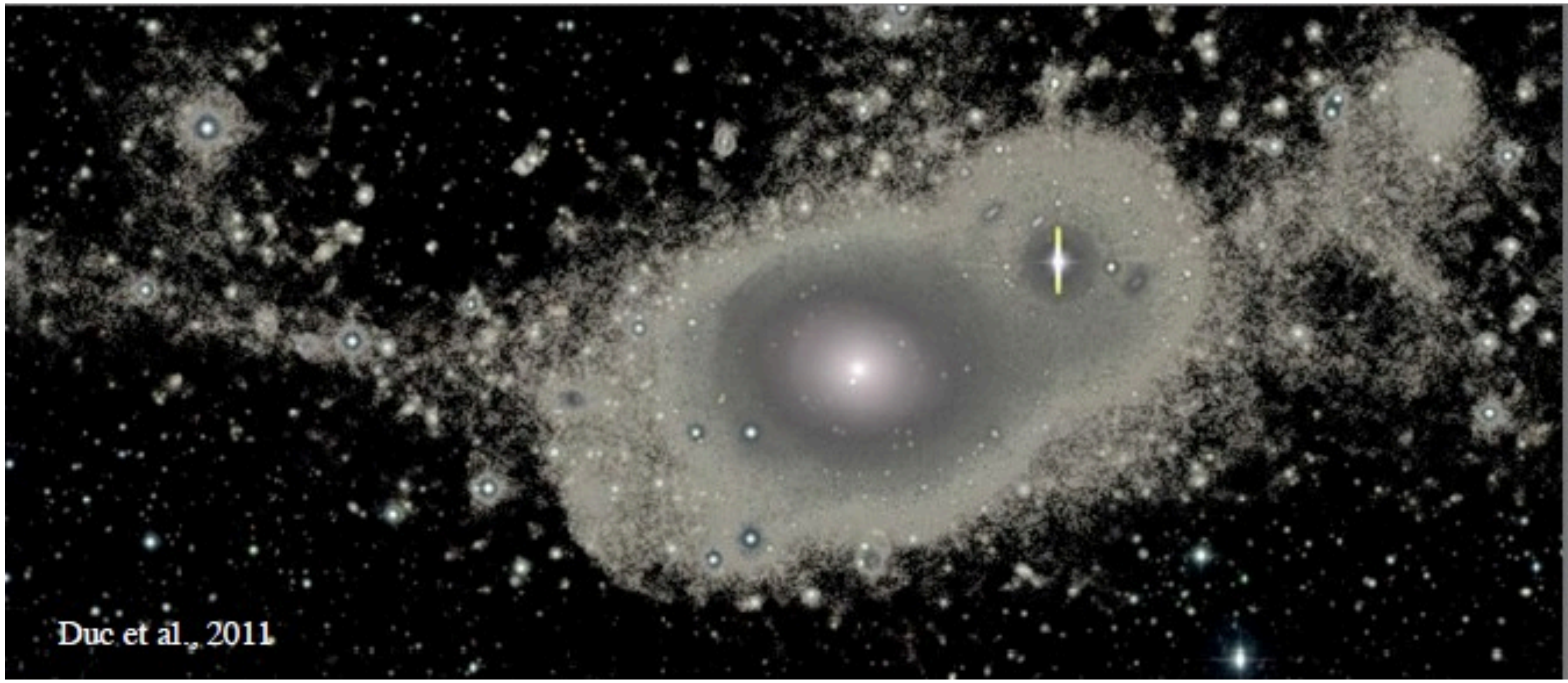
Merger history and streams

- Cosmological simulations predict significant substructure in the halos. Tracing this helps constrain the merger history.

And observations show these structures in deep images.


Bournaud et al, 2009

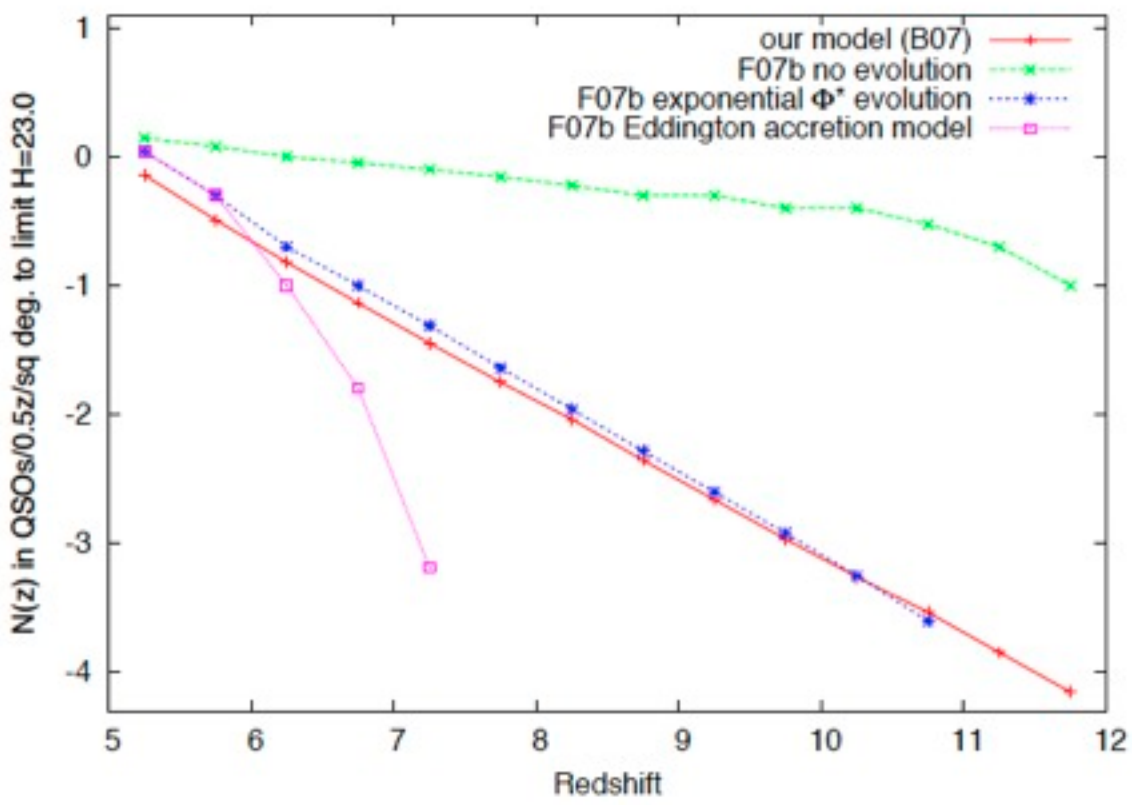

Martig et al, 2009

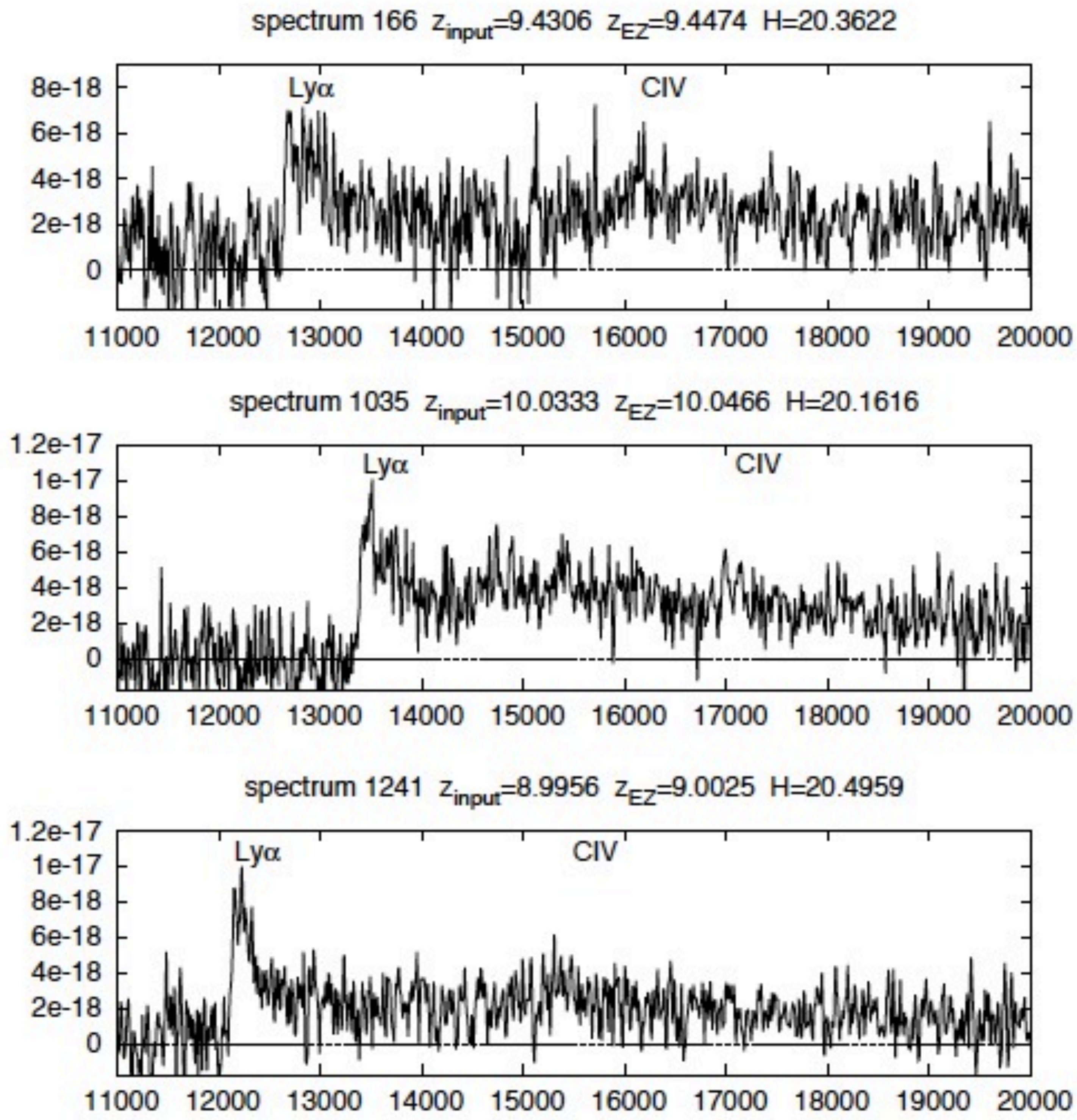

Duc et al., 2011


Paudel et al., 2013

SWG Primeval Universe

Lead: Cuby & Fynbo





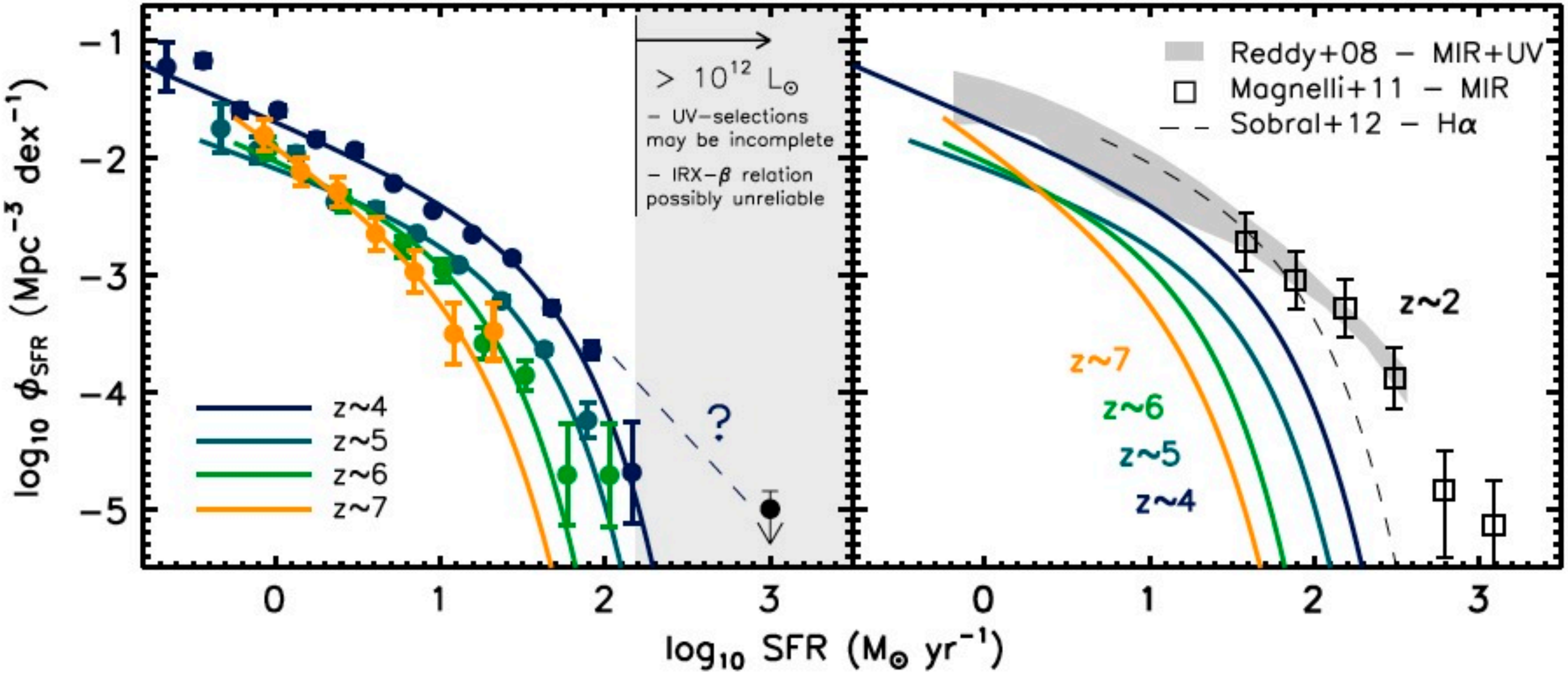
Are there QSOs at z>8-9?
Euclid should be able to get spectra of the brightest.

Roche et al (2012)

SWG Primeval Universe

The high-z star-formation history of the Universe

Smit et al (2012)



The highest SFR galaxies at any redshift are rare. Euclid will be very good for finding these (at least candidates), and out to z~4.3 detect them in [O II]3727.

These are excellent targets to follow-up from the ground with >8m-class telescopes or with JWST.

How can I get involved?

See EC Newsletter#3

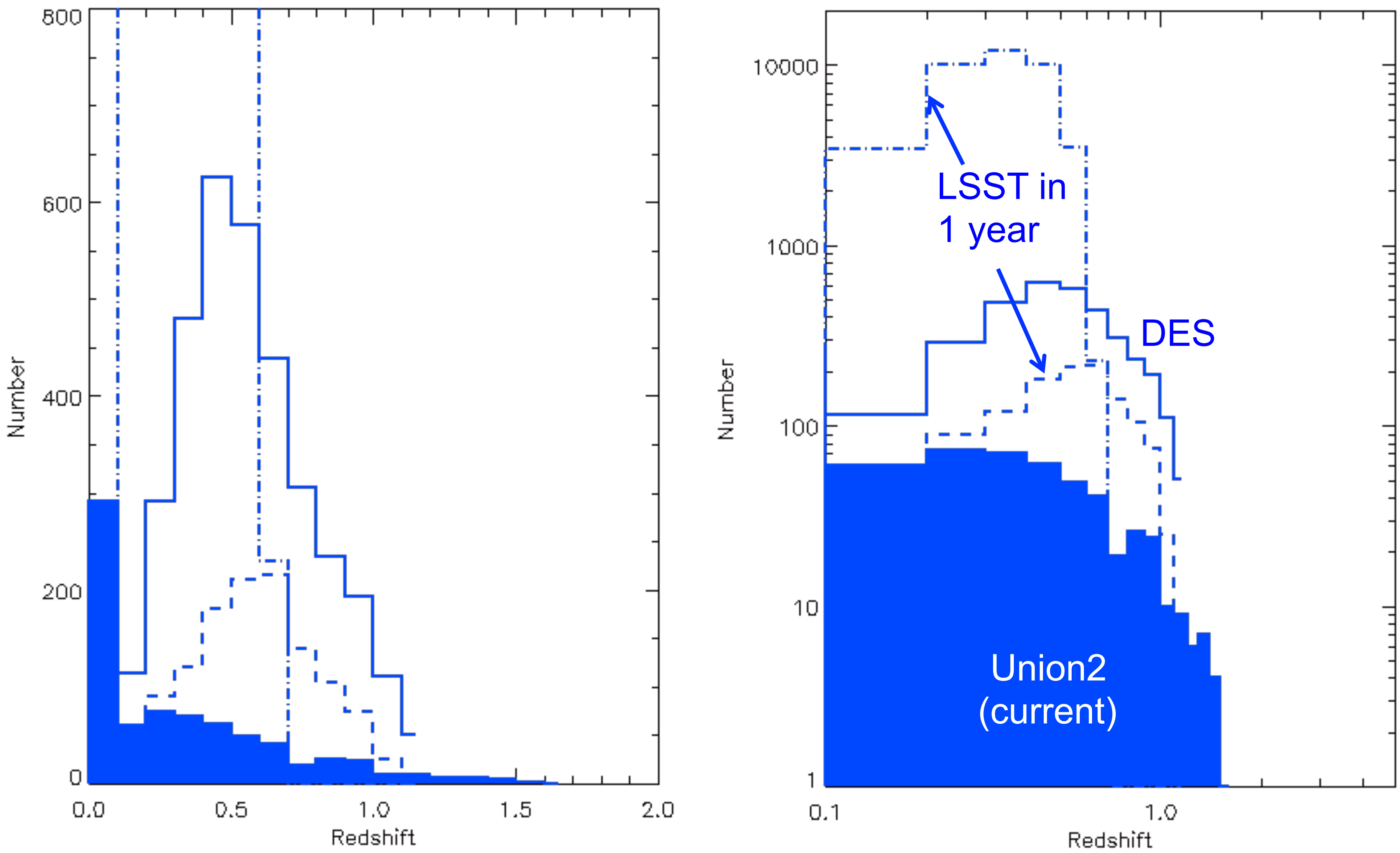
see: http://www.euclid-ec.org/

The Euclid webpage has a list of names and contacts for the SWG coordinators.

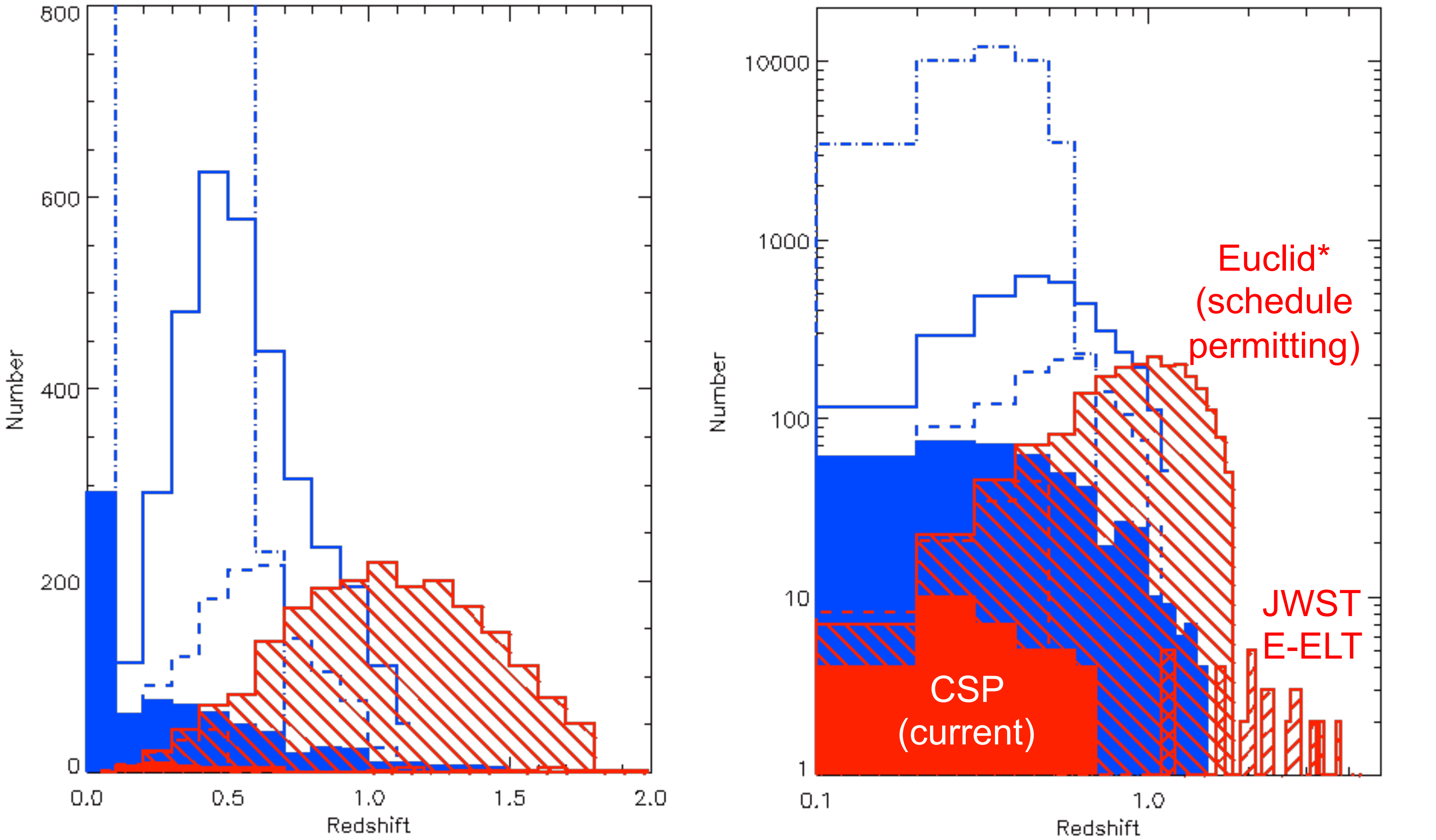
Think about what you can contribute/are interested in and discuss with the SWG leads to clarify this.

If you want to start something completely new, contact the legacy coordinators:
Steve Warren and Jarle Brinchmann

Supernovae & Transients SWG

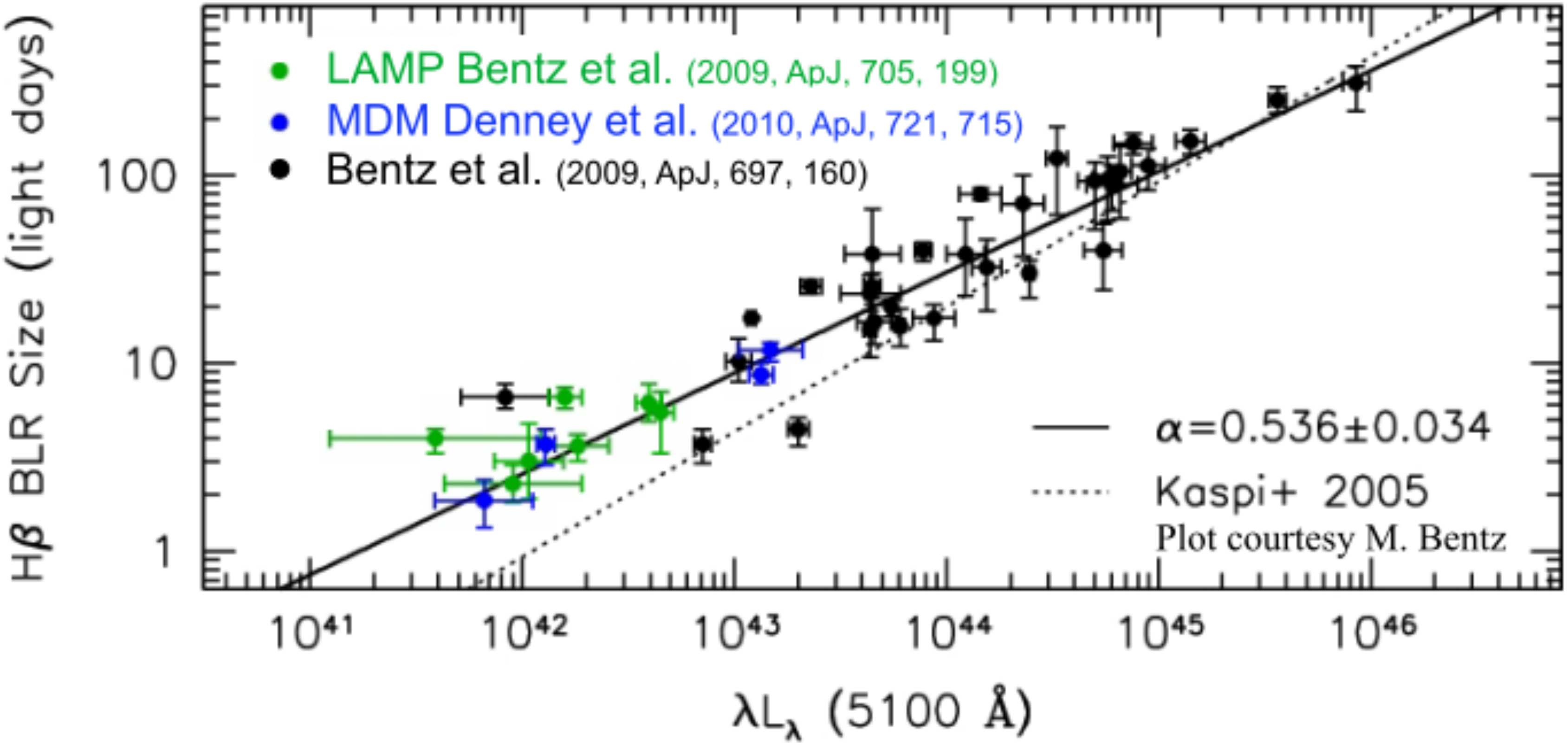


Supernovae & Transients SWG



Luminosity Relationship

Denney AAS 2012



Behind the Radius-Luminosity Relationship – The BLR size, R, scales tightly with the nuclear luminosity, $R \sim L^{\alpha}$ --- a consequence of the photoionization physics responsible for regulating the production of line emission from the BLR. This physics dictates that $U = L_{ion}/(4\pi R^2 nc)$, where U is the BLR ionization parameter, L_{ion} is the ionizing luminosity, and n is the BLR gas density. The empirically-calibrated relation based on reverberation measurements shows a tight correlation with a slope consistent with the phyical expectation of $R \sim L^{0.5}$.

Theory SWG

- Review document
  - arXiv: 1206.1225 (60 authors, 200+ pages)
  - Published: Living Rev. Relativity 16 (2013), 6
  - Bi-annual new releases, new cycle just started
  - Editor in chief: Valeria Pettorino
- Parameter definition document
  - Defines cosmological parameters in model context, including fiducial values
  - Links to review doc, forecast and sim docs
- Work packages

Planck 2013 parameter values

Parameter	Fid. Value
Ω_k	0
Ω_Λ	0.68
Ω_m	0.32
$\Omega_c h^2$	0.12
$\Omega_b h^2$	0.022
h	0.67
$N_{\rm eff}$	3.046
M_ν	0.06
Neutrino hierarchy	normal
w_{de}	-1
σ_8	0.83
n_s	0.96

3.2 Fiducial cosmology

The current fiducial cosmology was agreed at the SWG coordinators meeting in Munich in June 2013 and reported to the ECCG. The basic fiducial cosmological model is defined through:

- General Relativity
- Friedmann-Lemaître-Robertson-Walker metric

Simulation SWG

- Production of "true sky"
- Fiducial cosmology (theory SWG)
- Other cosmologies – which ones? (theory SWG)
- Enormous challenge
  - ~10^5 N-body simulations for primary cosmology work
  - Mock catalogs
- Input for instrument (Euclid + EXT) simulators

http://internal.euclid-ec.org/?page_id=1551

Euclid Consortium – Internal

A space mission to map the Dark Universe

Home The Mission Euclid Consortium News Publications Careers Contacts **Internal EC**

Available simulations
- WL SUNGLASS
- Euclid-MICE Mocks
- Durham GALFORM Mocks

EC Cosmological Simulations

This is the central point of access for **Cosmological Simulations of the Euclid mission**.

The current list of synthetic galaxy catalogs that can be accessed are listed below:

Mocks based on Halo Occupation Distribution (HOD)

MICE galaxy mocks (v0.4)

The Euclid-MICE lightcone galaxy mock includes photometric information in the Euclid VIS+NIR bands for about 20 million galaxies over an area of 500 sq.deg, in the redshift range $0 < z < 1.4$. It includes lensing properties (shear, convergence, lensed positions). No H-alpha emission information is yet available. Future versions of the galaxy mocks will be more complete by including fainter galaxies at low redshifts. We also plan extend the mocks to larger areas of the sky to match the full Euclid survey area.

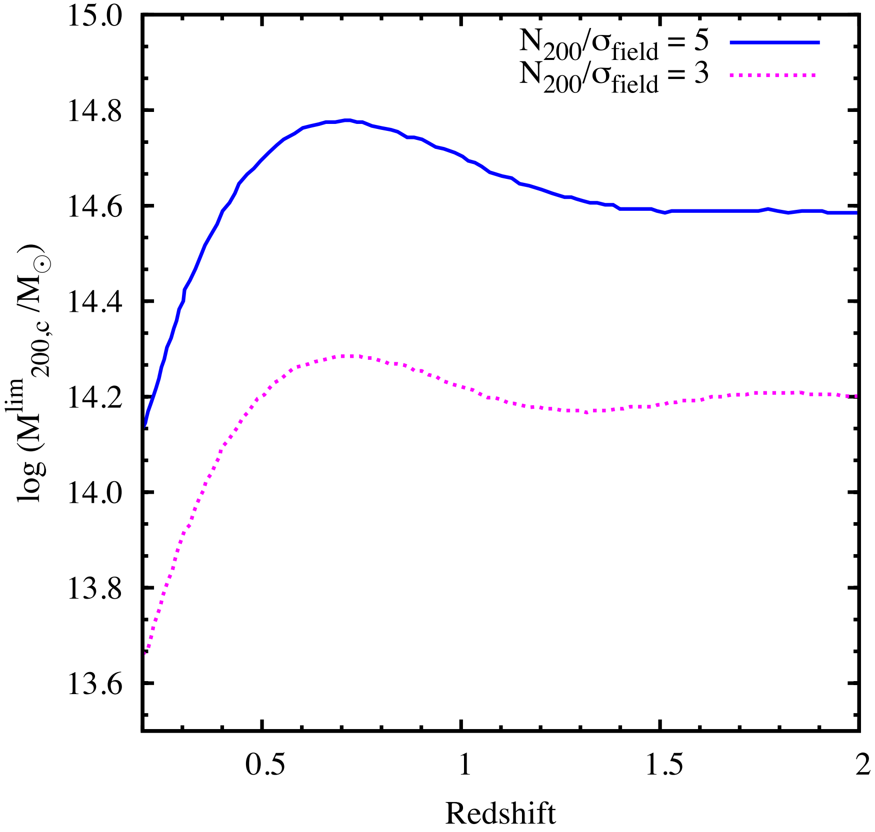
Currently available Euclid-MICE mocks can be downloaded from the PIC simulations portal: http://catalog.cosmo.pic.es/

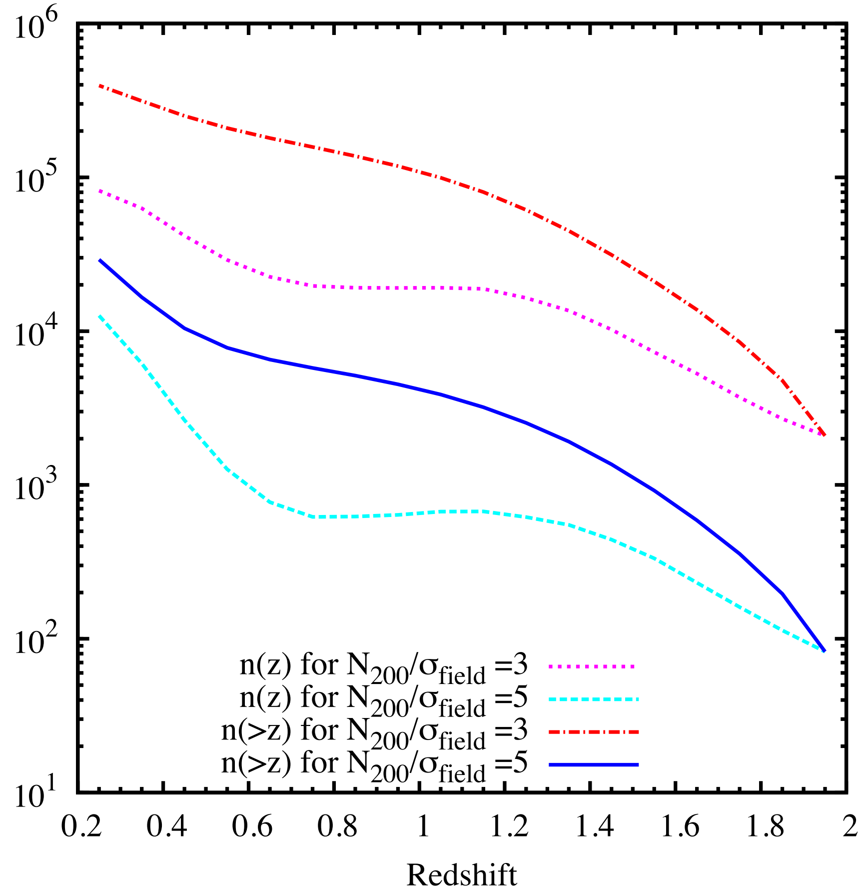
See the Readme, also available at the portal for further details about the released galaxy mock. Please follow the MICE data policies also described at the portal.

Galaxy Cluster SWG

- Euclid Cluster Cosmology Paper
- Work package homogenization
  - Requirements on cluster catalog and measurements
  - Cosmological and Legacy science analyses
- SWG-OU-LE3 joint meeting, Nice Dec. 2013

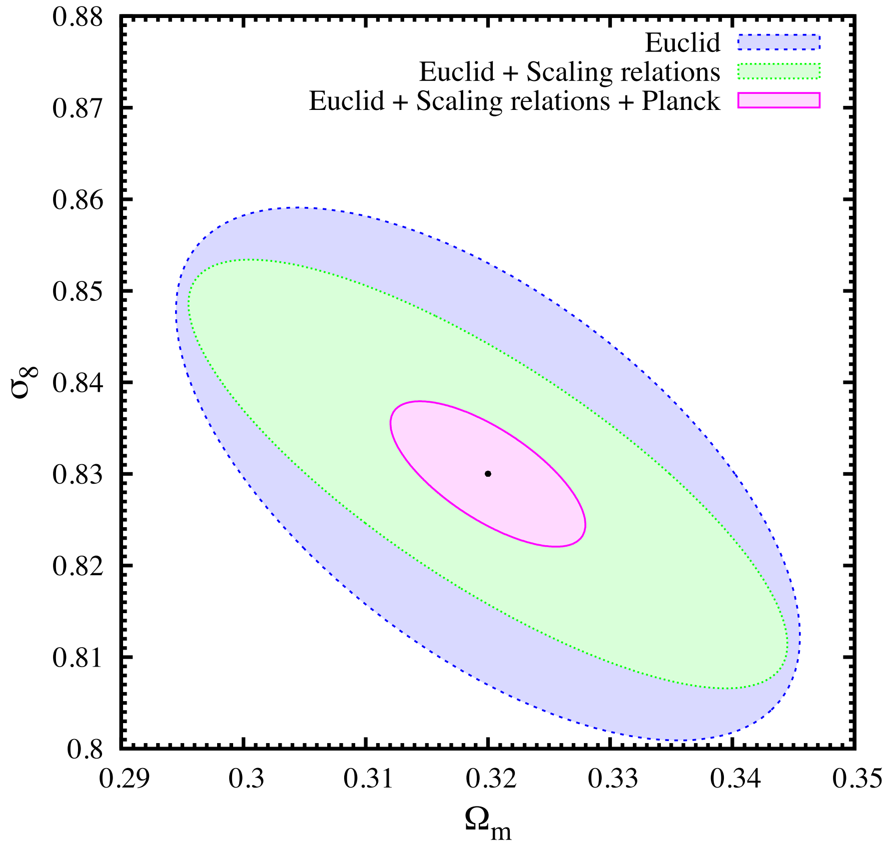
Cluster Cosmology Studies

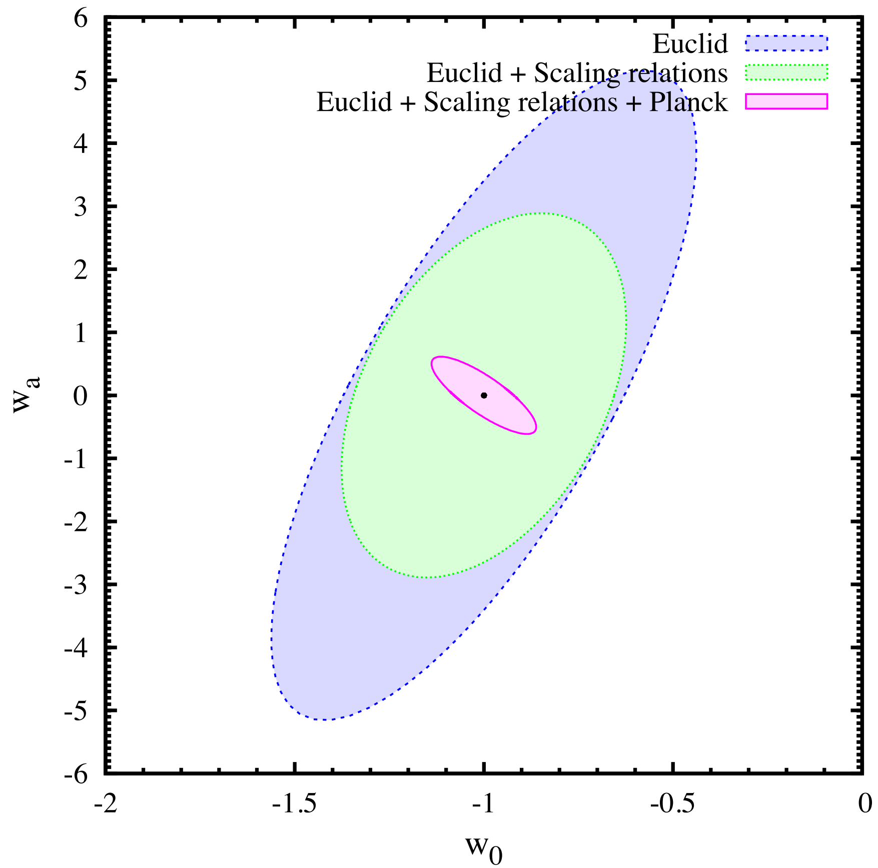




Courtesy of B. Sartoris on behalf of the Galaxy Cluster SWG

Cluster Cosmology Studies





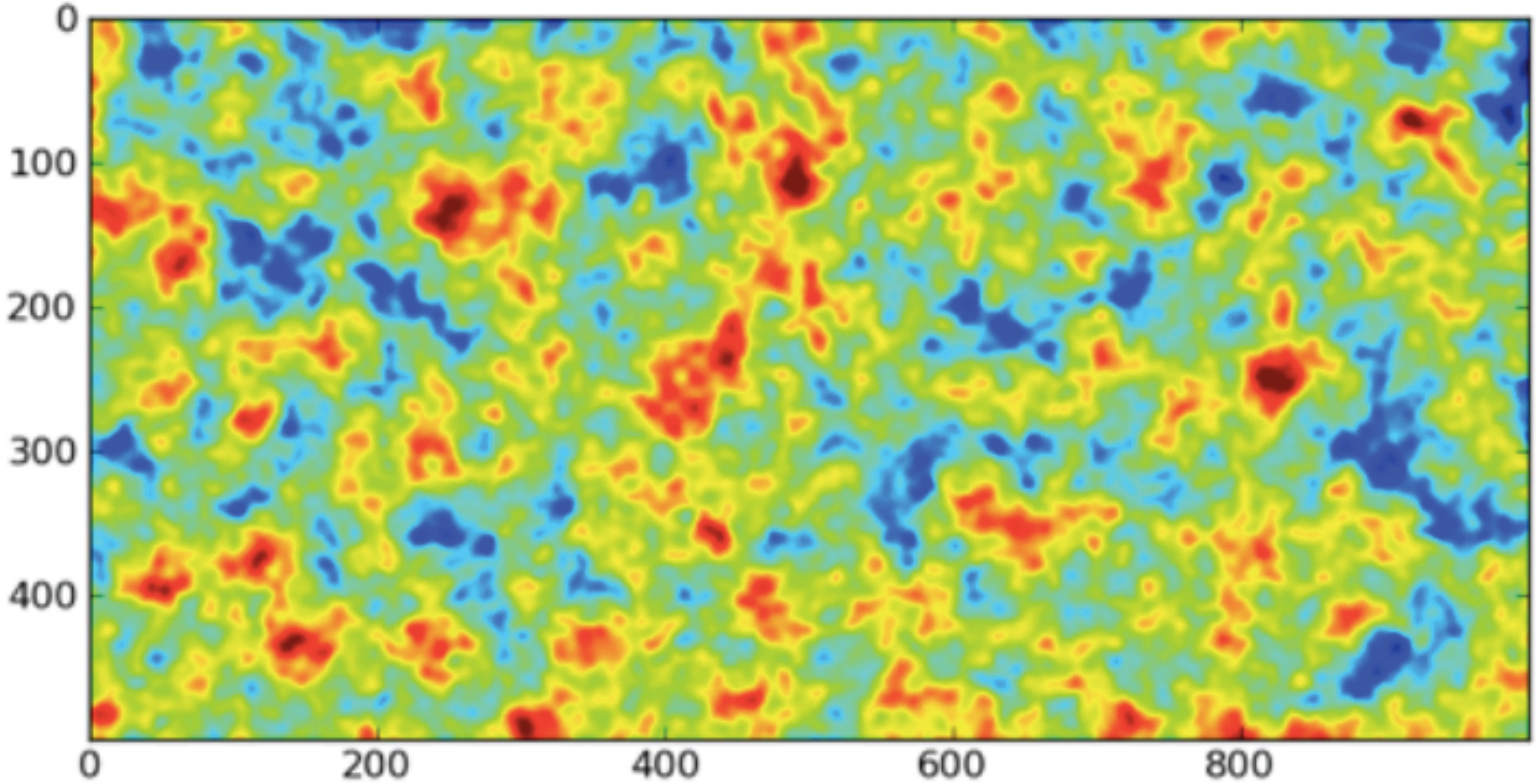
Courtesy of B. Sartoris on behalf of the Galaxy Cluster SWG

CMB Cross-Correlations

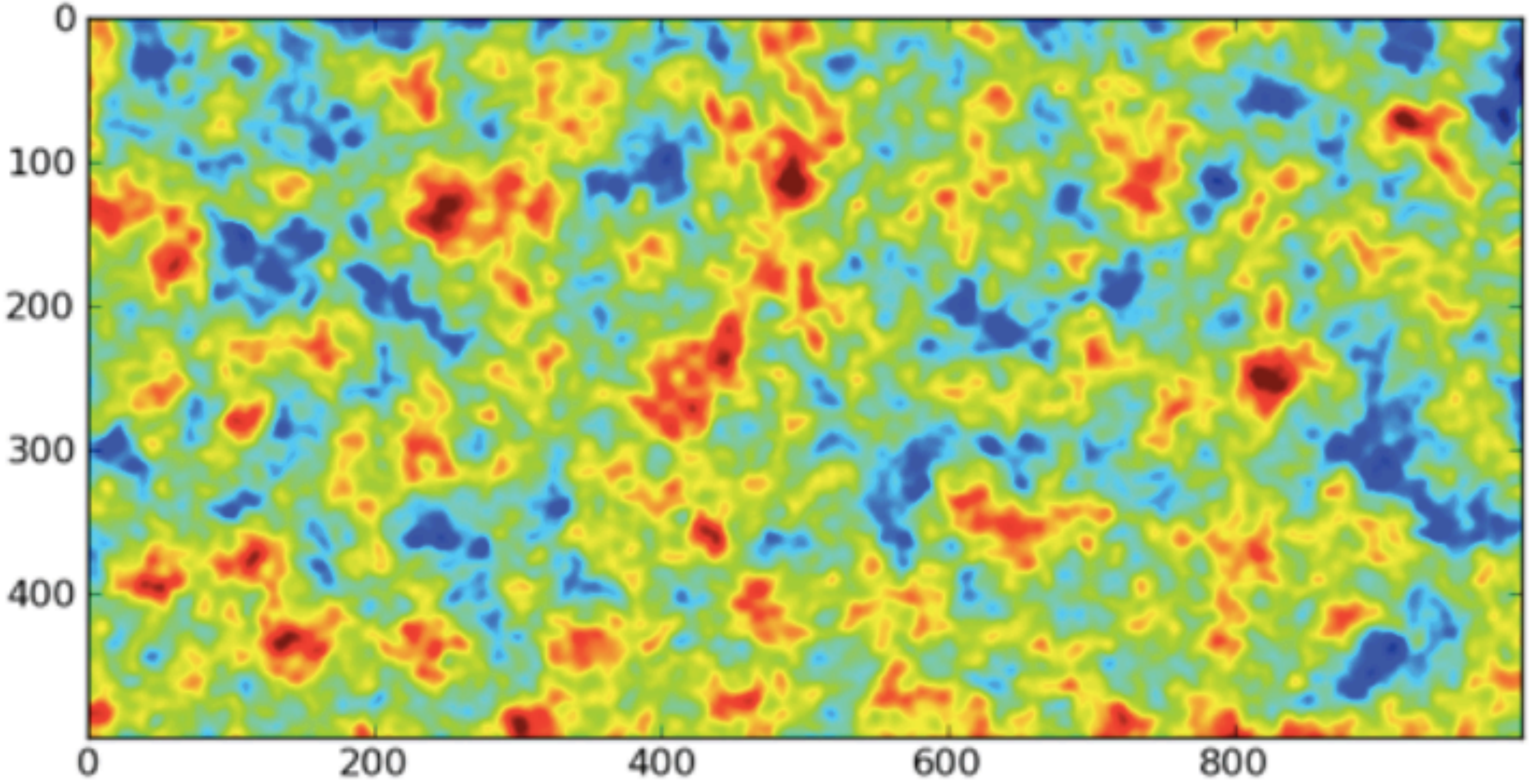
- Integrated Sachs Wolf effect
- CMB lensing
- Clusters

- Example: Das et al (2013) use CMB lensing to calibrate shear multiplicative bias

CMB lensing

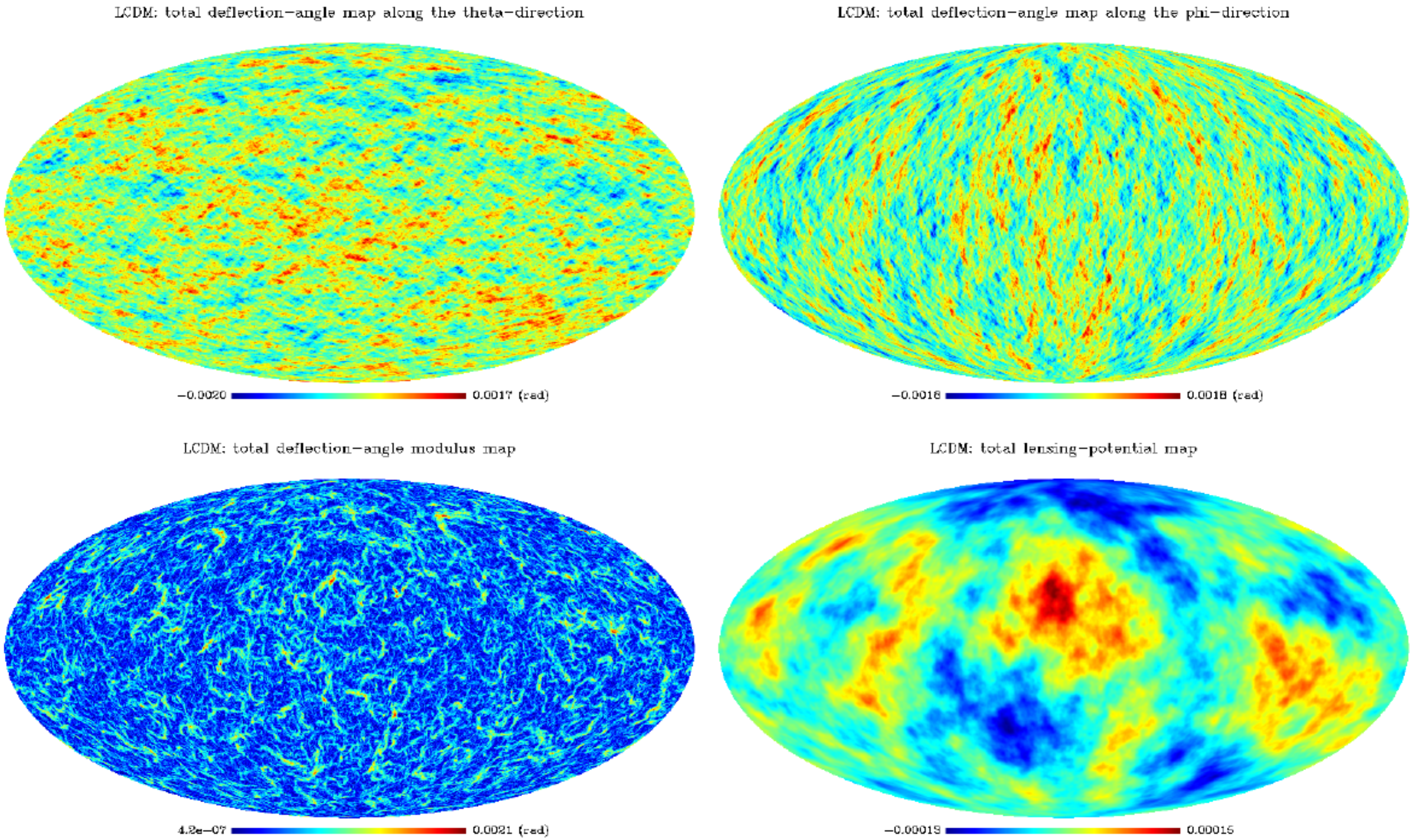


CMB lensing



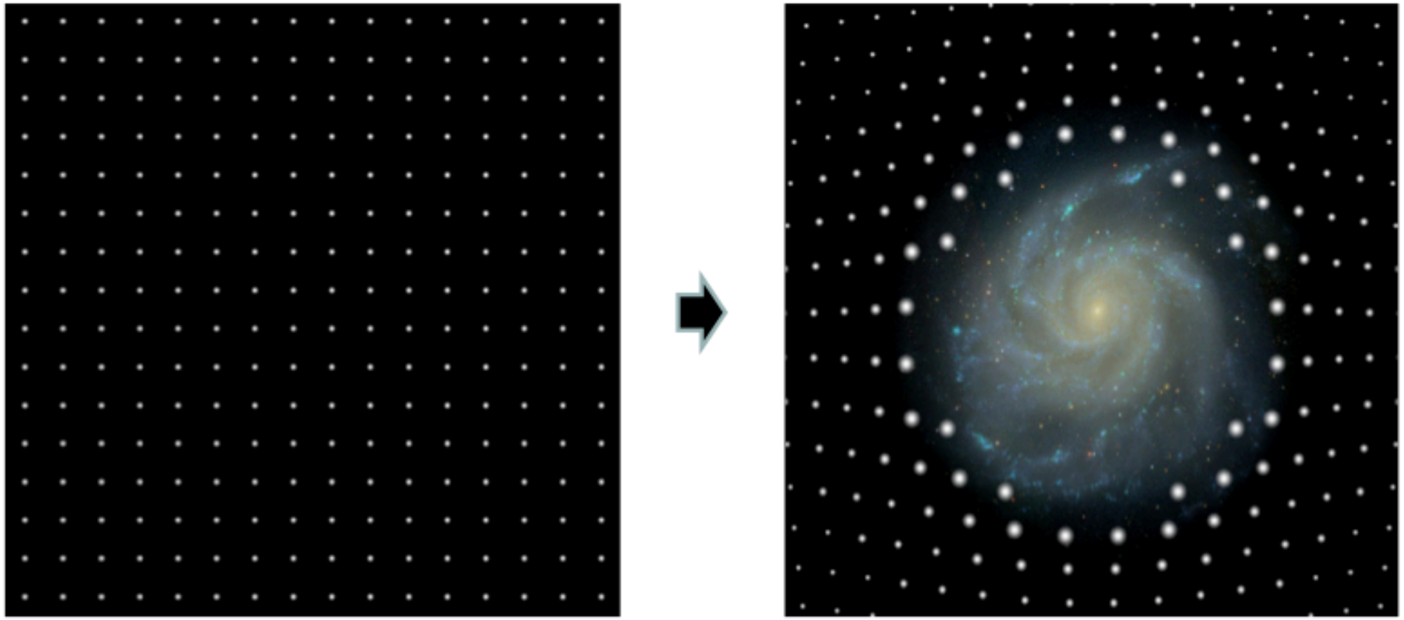
Deflection typically ~2 arcmins and coherent over several degrees

CMB Lensing Simulations



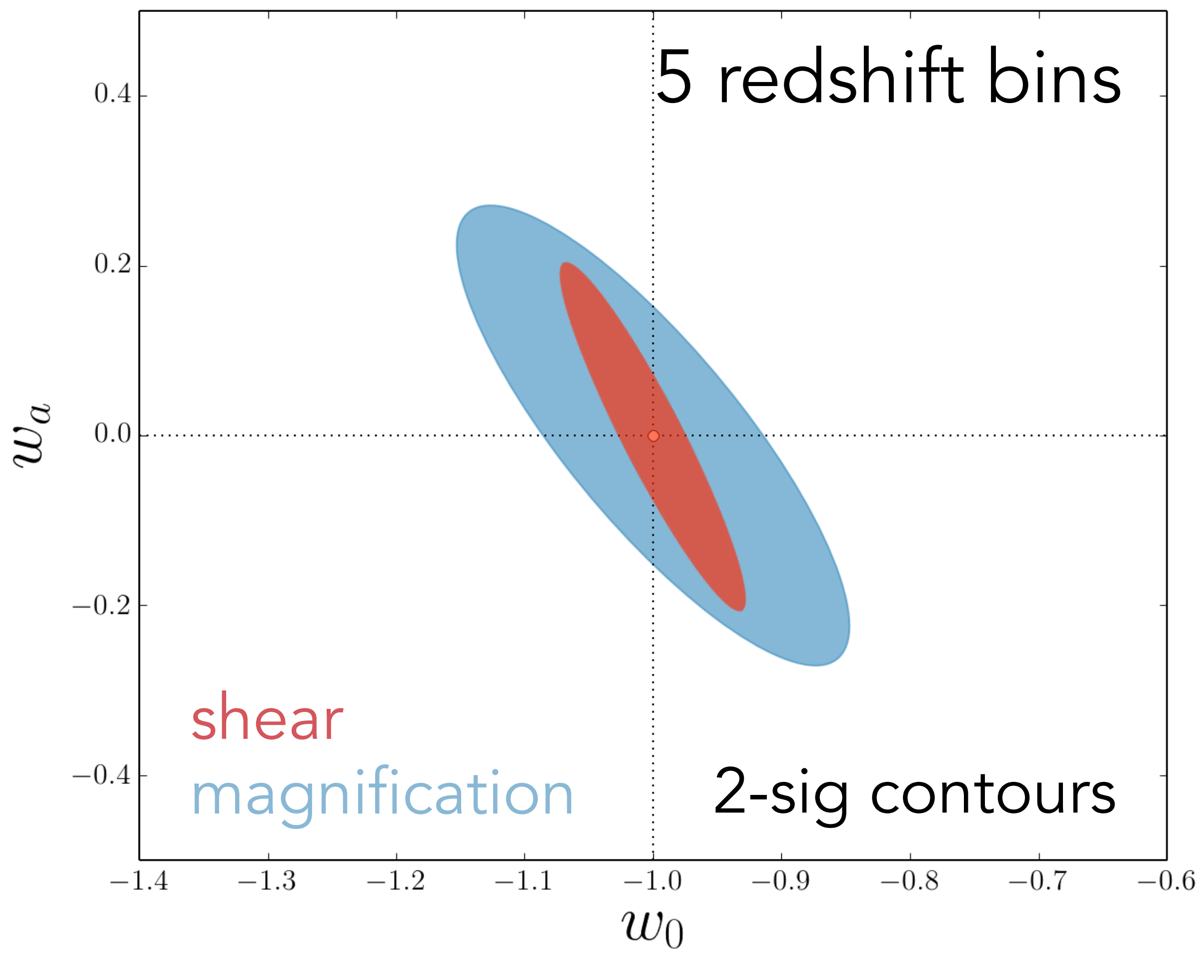
Carbone et al. 2013

Legacy Lensing: magnification



- Number magnification (Boucaud & Bartlett 2013, Duncan et al. 2013)
- Size magnification (Heavens et al. 2013)

Tomographic Constraints
complementary to shear



Boucaud & Bartlett (2013)

Figure of merit:

magnification	**66**
shear	250

Euclid Archive Users Group

Rotating Co-Chairs: B. Altieri, M. Sauvage

- How to structure the Euclid Mission Archive (EMA)
- Use cases from the SWGs
  - http://euclid.roe.ac.uk/projects/wlswg-gi/wiki/_UserStories__