EUCLID Imaging (EIC): overview and synergies with WFXT

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EUCLID Science Objectives

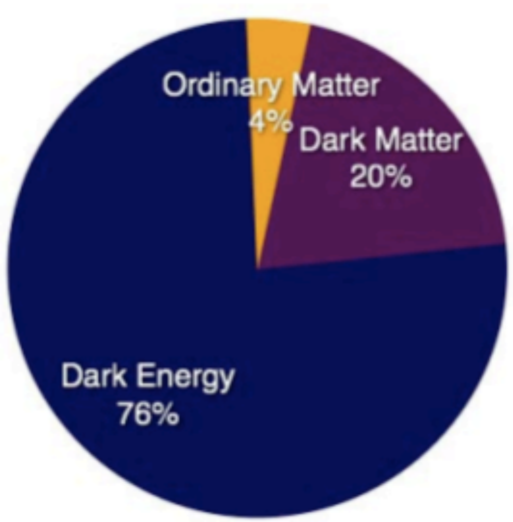
Oustanding questions in cosmology:

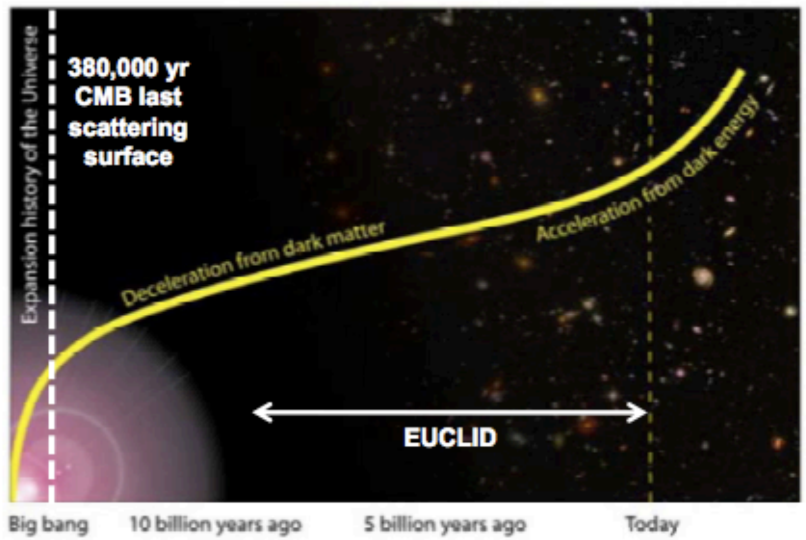
- the nature of the Dark Energy
- the nature of the Dark Matter
- the initial conditions (Inflation Physics)
- modifications to Gravity

These are the Euclid's primary science objectives

Secondary objectives: Legacy Science

Two main probes: BAO (E-NIS) and weak lensing (EIC)

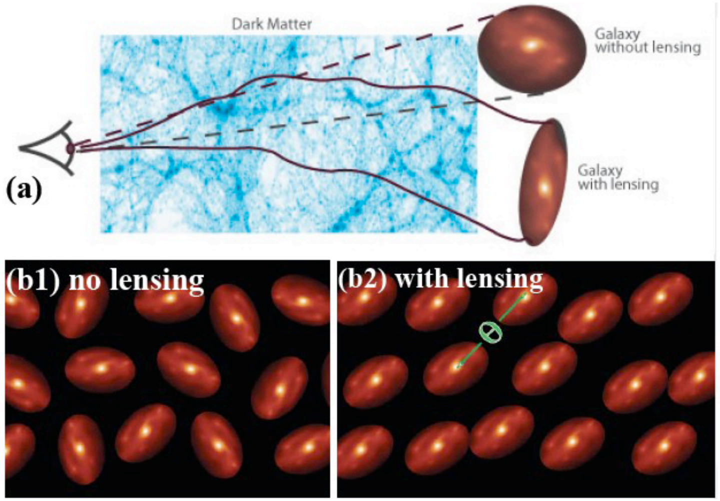


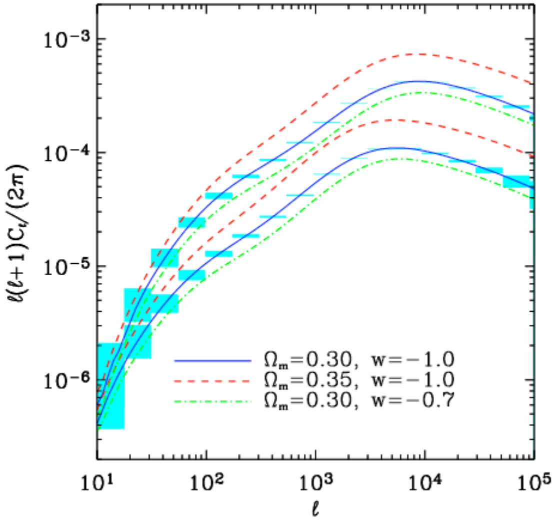


EUCLID Imaging (EIC): Weak Lensing as main probe

- Shape of background galaxies distorted by foreground DM
- Typical cosmic shear is ≈1% and must be measured with high accuracy
- Tomography: H(z), G(z)

➔ address all sectors of the cosmological model





Weak Lensing

Space:

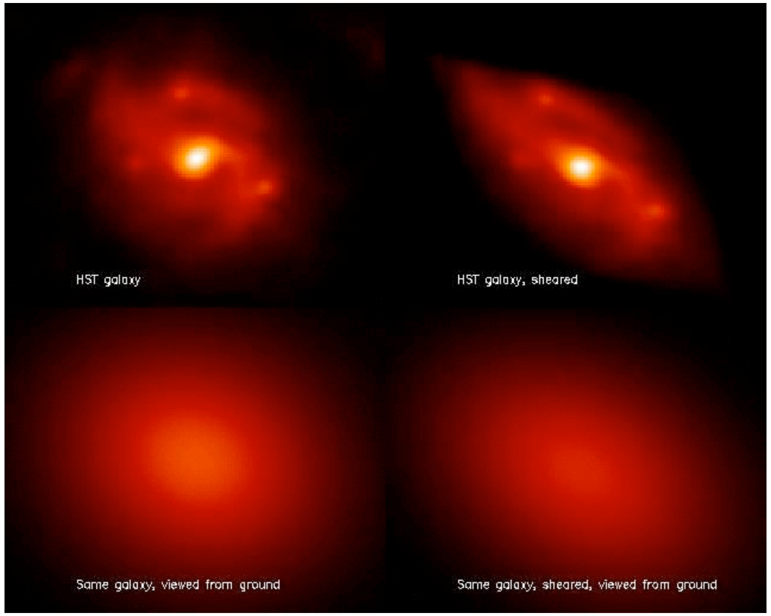
- small and stable PSF

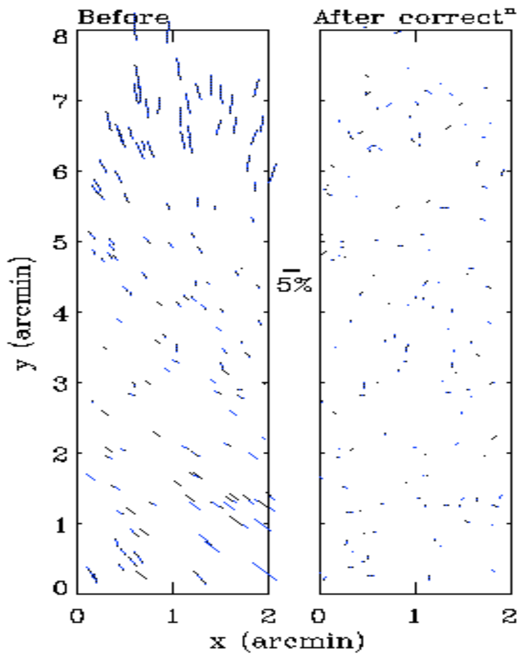
➔ larger number of resolved galaxies

➔ reduced systematics

- wide rather than deep

➔ need 20000 deg^2





EUCLID essential requirements for science

Category	Item	Requirement
WL Survey Geometry	Survey Area	20 000 deg^2 extragalactic, contiguous
	Galaxy distribution	30 galaxies/$arcmin^2$ (required, 40 $arcmin^{-2}$ goal) usable for WL with a median redshift $z_m>0.8$
WL Systematics	Shear measurement	shear systematics variance $\sigma_{sys}^2 < 10^{-7}$
WL Photometric redshifts	Statistics	$\sigma(z)/(1+z)<0.05, 0.03$ (requirement, target) with low catastrophic failure rate to build redshift bins
	Calibration	Error in the mean of the n(z) distribution of each bin <0.002, achievable with a subsample of 10^5 spectra

Deep spectro-scopic sample	Photo-z calibration	At least 10^5 redshifts down to H(AB)=24 mag

EUCLID wide survey requirements

Weak lensing wide survey requirements		
Duration	Less than 4.5 year	
Survey Strategy	Area	20000 sq degrees, $\|b\| > 30^{o}$
	Contiguous patches	$>20^{o}\times 20^{o}$
	Overlap	2.5% on each side of an image
	Dithers	$\geq$ 3-4 dithers covering detector gaps
Depth	Shape Measurement Channel	$R+I+Z_{AB} > 24.5$ (10σ extended source)
	Photometric Channel	$Y_{AB} > 24$ (5σ point source)
		$J_{AB} > 24$ (5σ point source)
		$H_{AB} > 24$ (5σ point source)

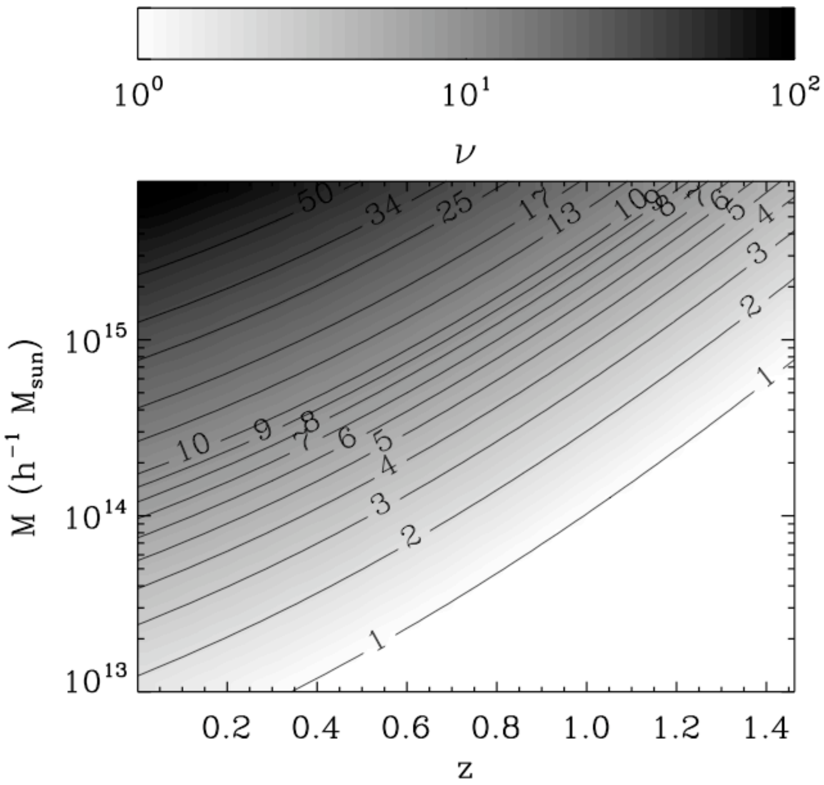
Galaxy Cluster Counts with the Euclid Imaging Survey as complementary cosmological probe

Jochen Weller (LMU,EXC, MPE)

Filipe Abdalla (UCL), Nabila Aghanim (Orsay), Adam Amara (ETH), Joel Berge (JPL), Marian Douspis (Orsay), Tom Kitching (Edinburgh), Lauro Moscardini (Bologna), Alexandre Refregier (Saclay), Stella Seitz (LMU, MPE)

Selection Clusters with Euclid

- Weak lensing: e.g. peak statistics



Berge' et al. 2009

Matched-filter approach for the signal-to-ratio created by a halo.

Assumed redshift distribution:

$$n(z) = z^2 \exp\left[-\left(\frac{z}{z_0}\right)^{3/2}\right]$$

z_0=zmed/1.412

40 galaxies per arcmin^2

ν = 6 safe choice (Pace et al. 2007) for threshold

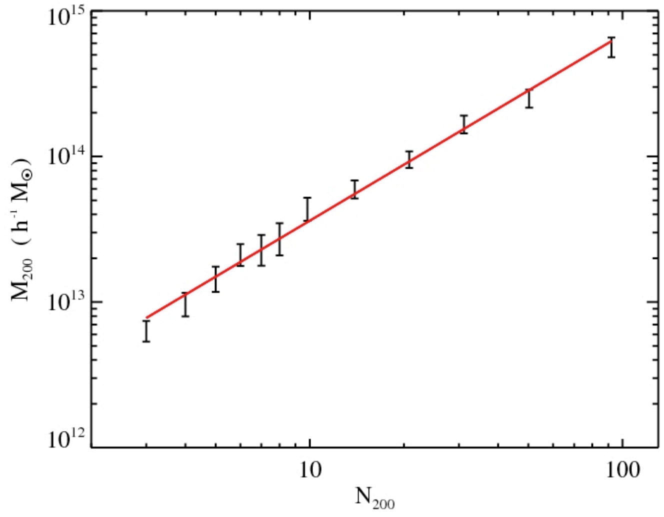
Selection Clusters with Euclid

- Weak lensing: e.g. peak statistics
- Galaxy overdensities
  - maxBCG
  - Voronoi Tesselation
  - Matched filters
  - Counts in Cells
  - Percolation Algorithms (FoF)
  - smoothing kernels
  - surface brightness enhancements
  - …

maxBCG as Baseline Method

- Brightest Cluster Galaxy (BCG) at centre of every cluster
- tight color-magnitude relation of BCG
  - used to (pre-) select
- Identifying ridgeline galaxies
  - use model for radial and color distribution
- maximize the two models as a function of redshift: estimate of redshift of cluster
- Iterative scheme: removal of most likely clusters and their satellites
- Apply probability chain, which has been calibrated with mock observations
- Successfully applied to SDSS sample (Rozo et al.)
- Biggest problem: Completeness and Purity of Sample
  - projection effects along line of sight; misestimate of cluster members

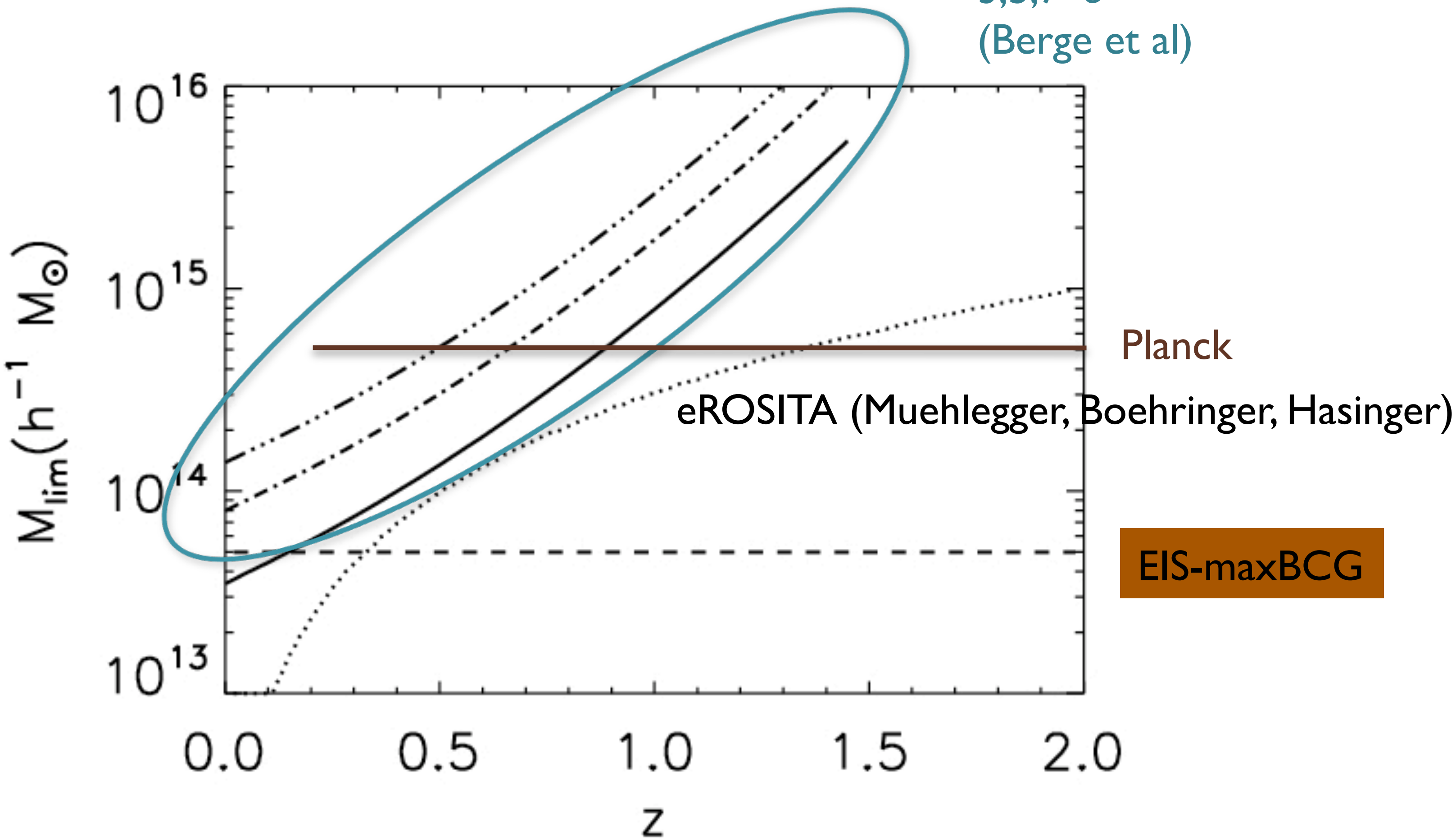
maxBCG Selection SDSS: A Lesson for Euclid ?



Johnston et al. 2007

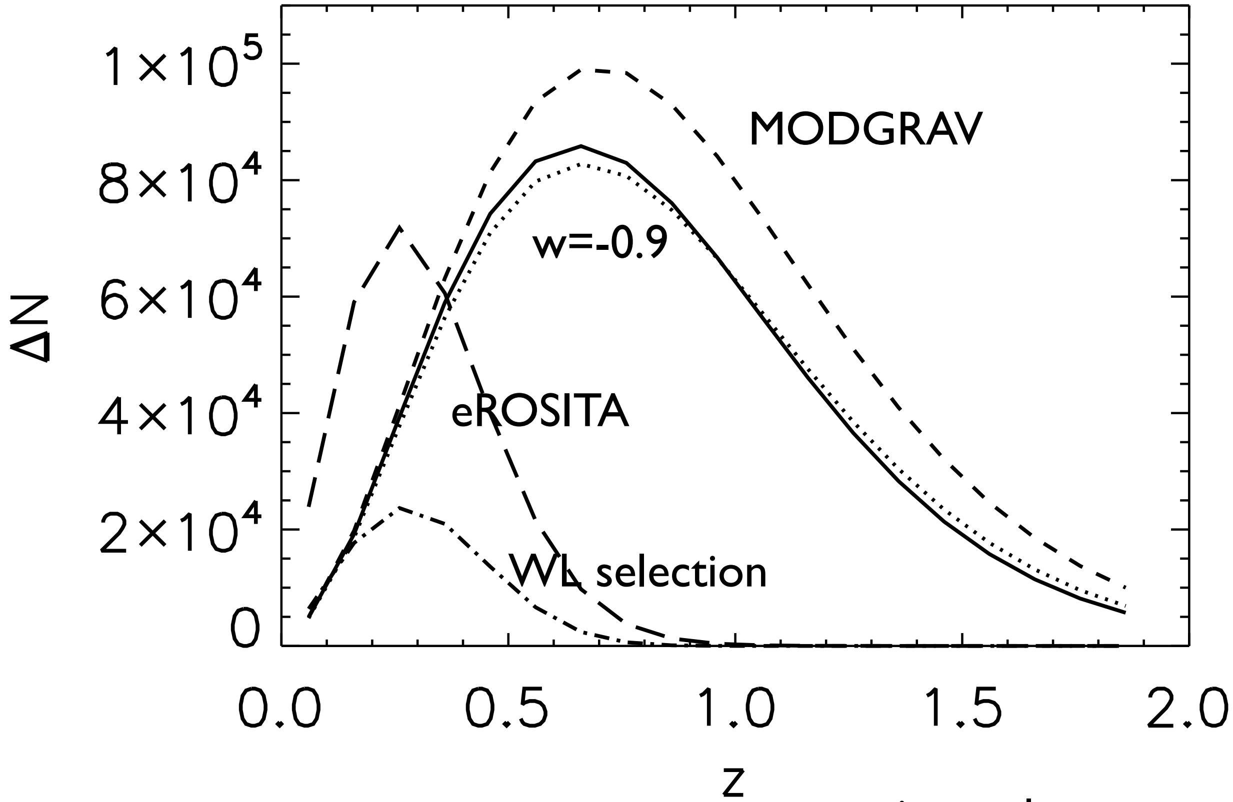
- Mass – Richness relation
  - calibrated with statistical weak lensing measurements (for 130,000 groups)
  - Johnston et al. 2007
- Good purity and completeness to about: $M \sim 10^{13.5}\, h^{-1} M_\odot$
- however for SDSS only to: z ~ 0.3
- depth of Y, J and H filters
  - should be able to find ridgeline galaxies out to z=1.3-2.0
  - how far out do we find robust red sequence ?

Mass Limit for Euclid



Weller et al. in prep.

Cluster Numbers for Euclid



solid: Λ CDM

Weller et al. in prep.

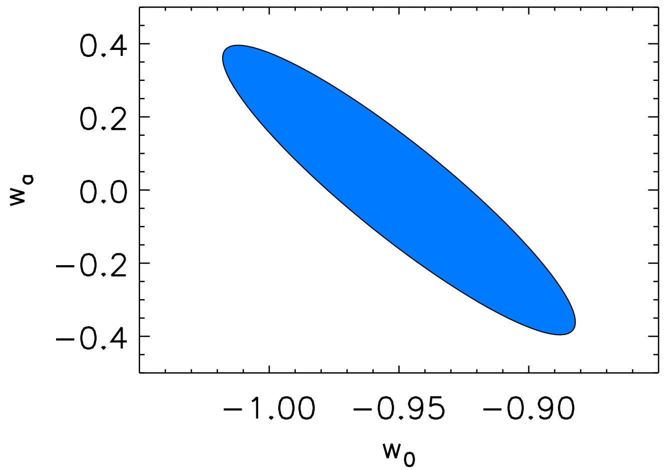
in total:
well over 750,000#

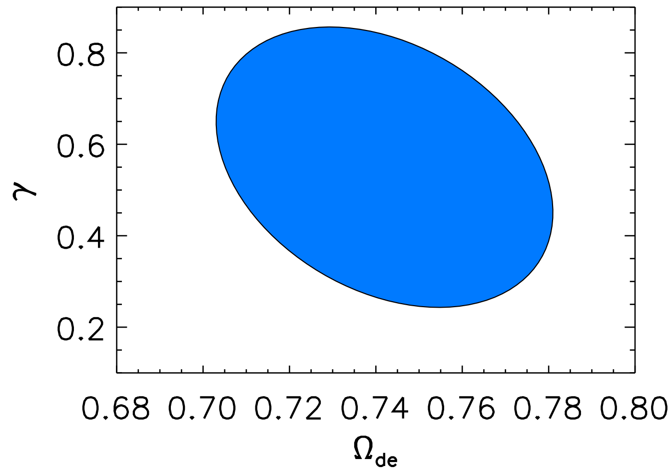
Uncertainty in Mass Limit

- Mean mass observable relation
  - scaling laws dependent on method – not entirely determined: redshift and mass dependence
  - different methods can be used for cross calibration
- individual scatter in mass observable relation
  - how behave the tails
    - high redshift, low mass, high mass, etc.
  - degenerate with cosmology
  - can also be estimated by surveys
    - Rozo et al.: optical, x-ray and weak lensing find 0.45±0.20

Possible strategy: self-calibration

Constraints from EIS Cluster Counts



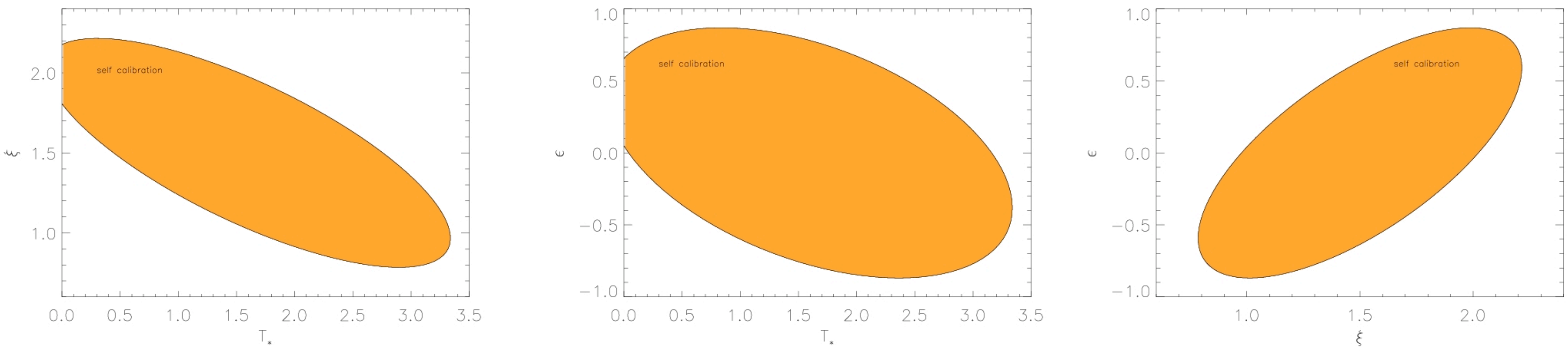


Including Planck priors and 5 cluster nuissance parameters; prior on scatter: 25%

1 sigma joint likelihood

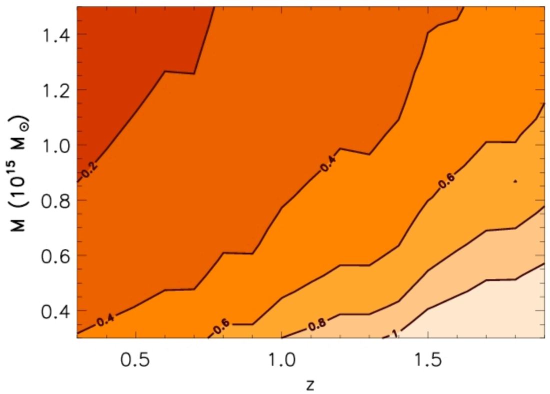
Self-Calibrate Uncertainty in Mass – Temperature Relation

- Relevant for SZ and X-ray surveys
- In addition to cosmological parameters fit for cluster parameters $T_* ; \xi ; \varepsilon$



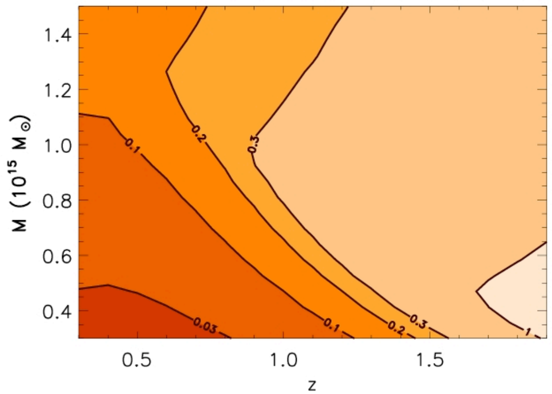
Weak Lensing Calibration of Mass - SZ Observable Relation

- Here simple estimate: 15 background (DES) galaxies/sq. arcmin
- Distribution: $dn/dz = \exp(-z/z_c)$; $z_c=0.5$



Projected errors on single cluster

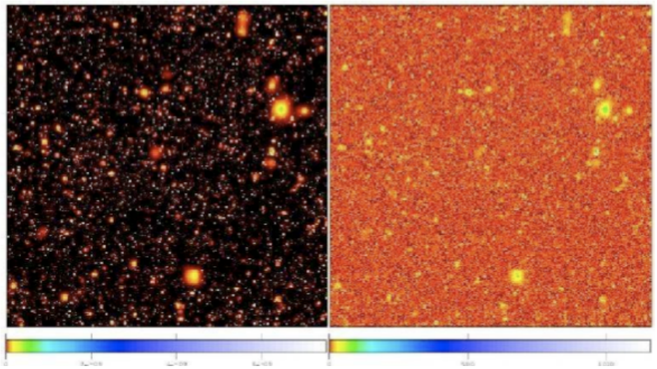
Dodelson & Weller: DES and SPT

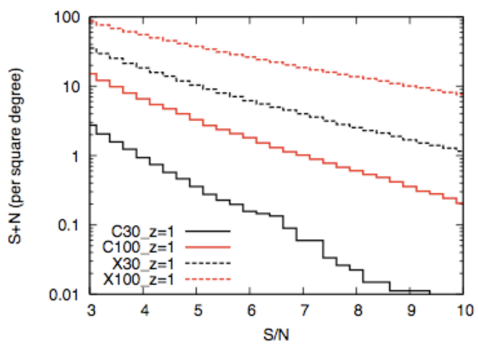


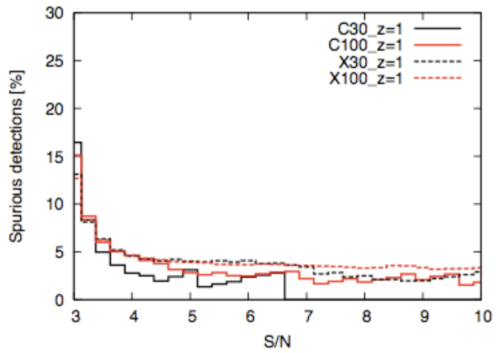
Fractional errors on cluster mass after stacking in redshift bins $\Delta z = 0.1$ and $\Delta M = 10^{14} M_\odot$

Towards a multi-band optimal filter

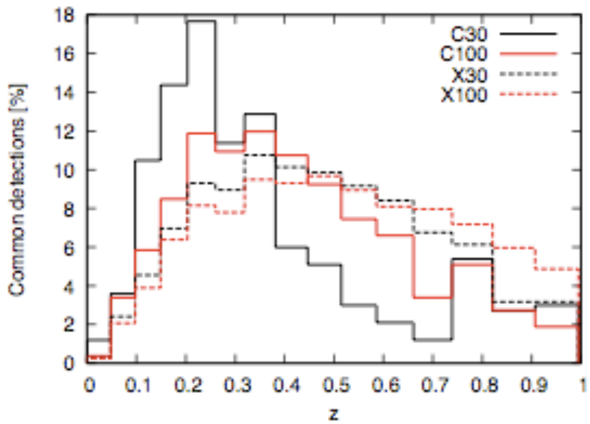
- Weak lensing: DONE (e.g. Maturi et al.)
- Sunyaev-Zel'dovich: DONE (Pace et al.)
- X-rays: DONE (Pace et al.)

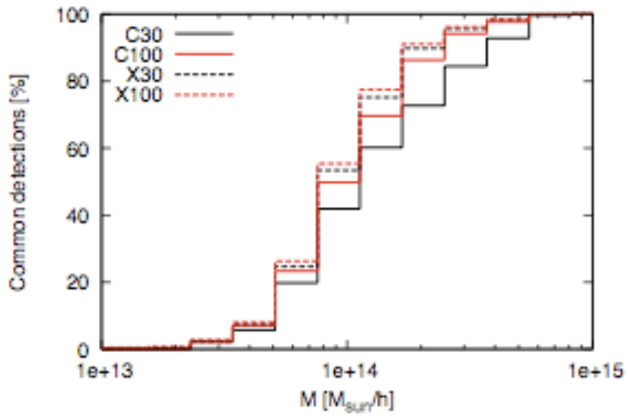






X-rays
vs.
SZ



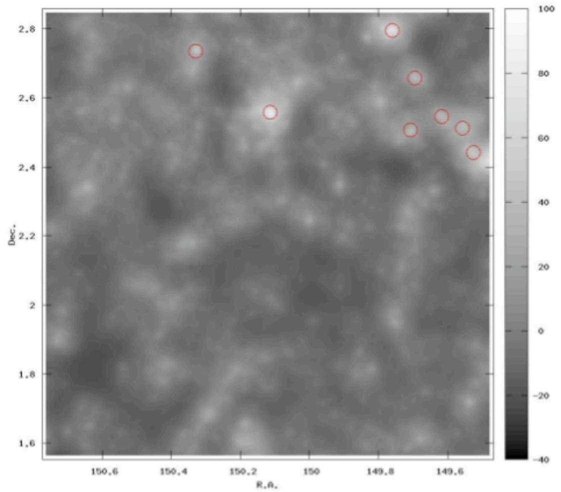


Towards a multi-band optimal filter

- The missing ingredient: a cluster optimal optical filter: DONE (Bellagamba et al. in prep.)

An example of application:

the COSMOS richness field at z=0.5

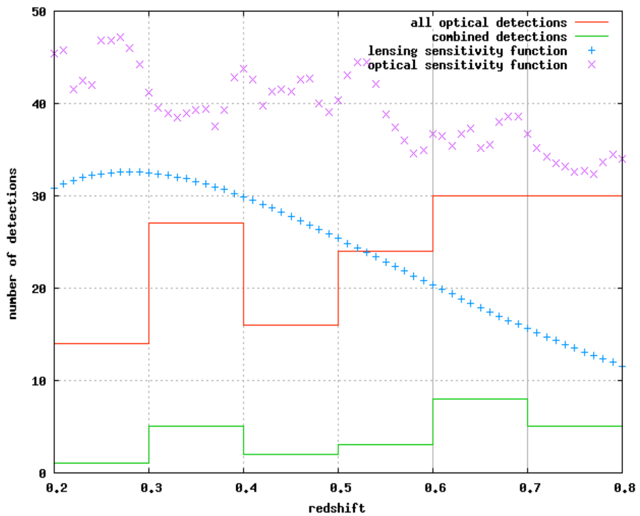


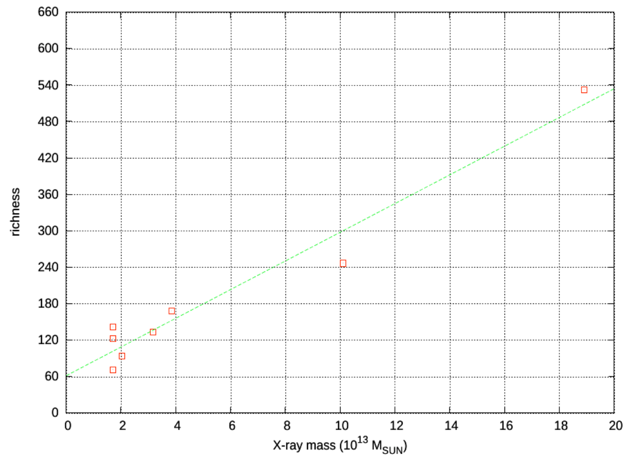
In total ≈140 peaks with $0.1<z<0.8$

26 lensing confirmed

7 correspond to galaxy clusters

Good correlation between opt. richness and X-ray mass





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  - smoothing kernels
  - surface brightness enhancements
  - …
- Strong Lensing

SKYLENS steps towards the final image

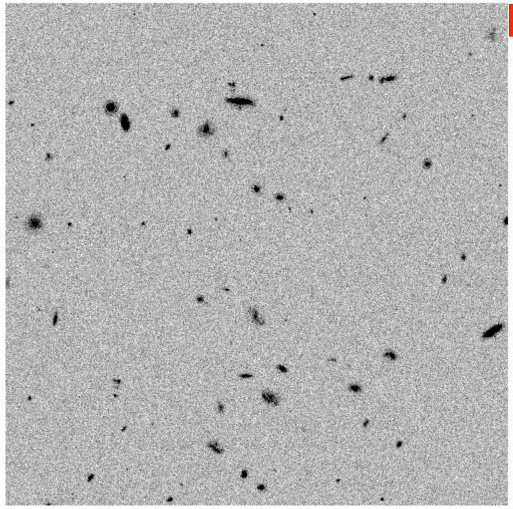
Meneghetti et al. 2008

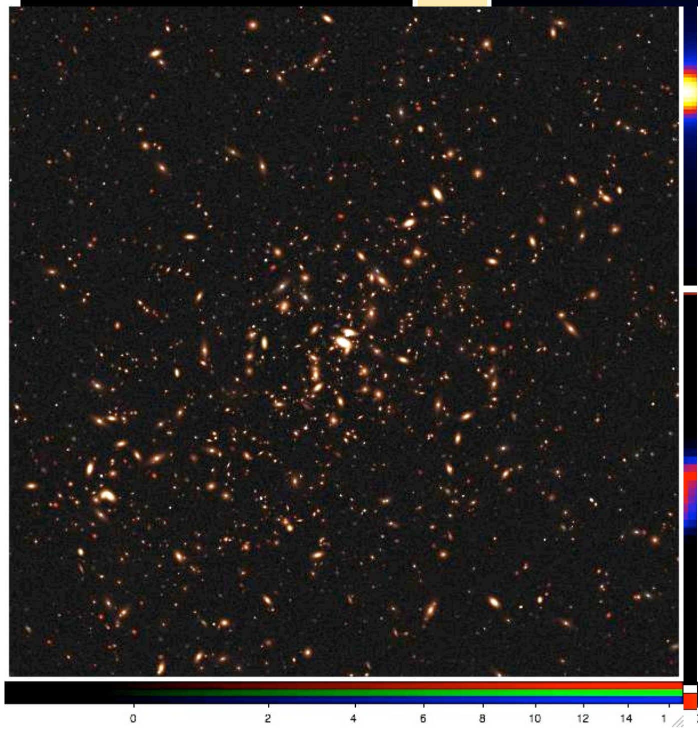
- Initialization
- Targets
- Access DB
- PSF, lensing, noise
- composition
- Final image

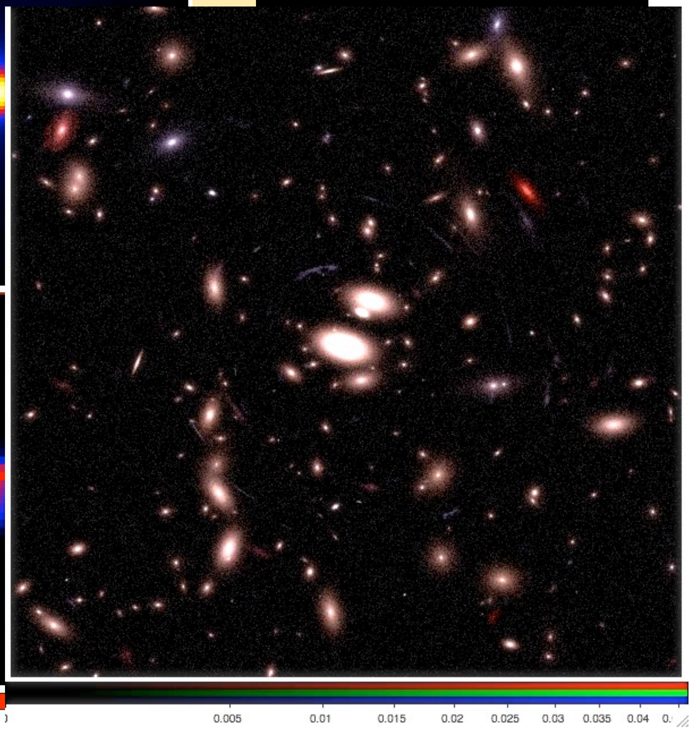
Config file

- ✓ Convolutio
- ✓ Lensing effe
- ✓ Sky backgro
- ✓ Photon nois

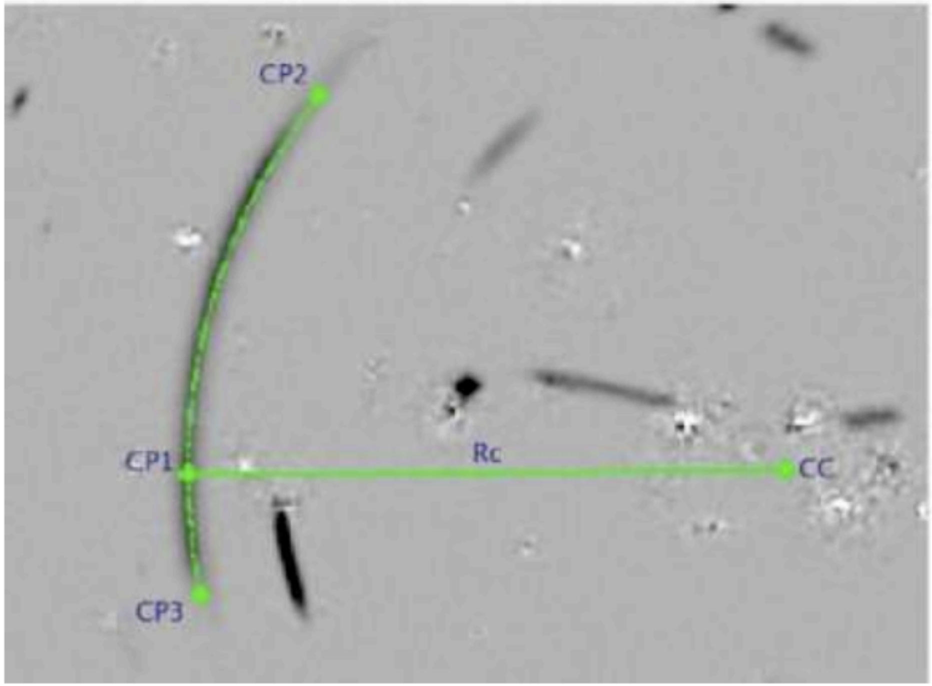
[redacted]







Detecting arcs with EIC



Meneghetti et al. 2008

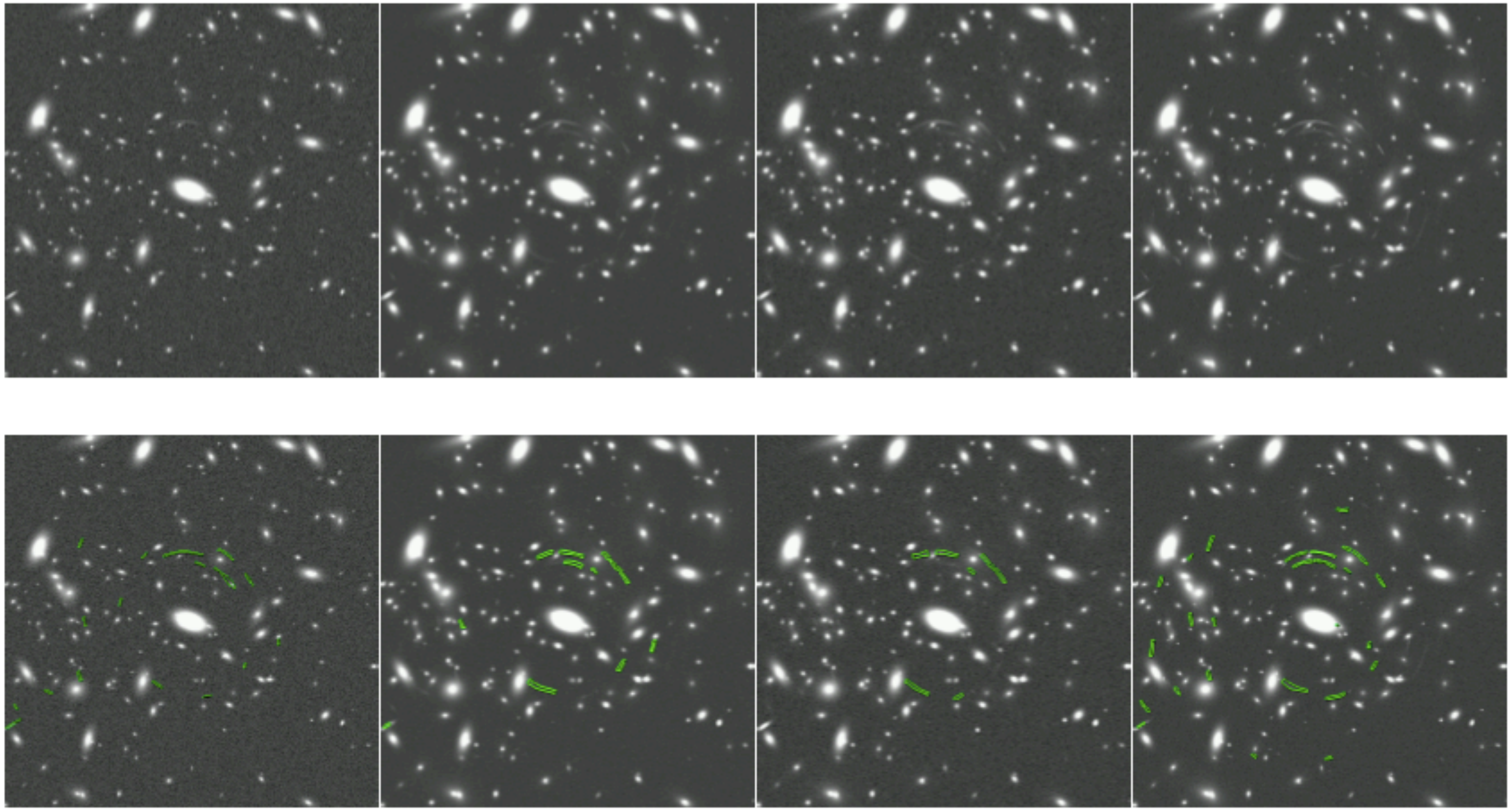
Expected number of clusters with strongly lensed arcs (L/W>10): approx. 5000

Possible detections up to an apparent magnitude of $m_{RIZ}=27$

➔ Allow much better reconstruction of the lens potential in combination with weak lensing, X-ray and SZ

Arc detections and measurements

Seidel et al. in prep.



HST SUBARU CFHT EUCLID

Conclusions

- EUCLID: a high-precision cosmological survey of imaging and spectroscopy, aimed at weak lensing (EIC) and baryon acoustic oscillations (NIS) over 20000 deg^2
- EUCLID Imaging Survey (EIS): optimised to achieve definitive constraints on Dark Energy
- EIS cluster counts complementary to primary science drivers
- crucial to understand and control systematic, scatter and scaling; 'self-calibration' together with Euclid Spectroscopic Survey
- Strong complementary to other full sky cluster probes, like SZ and X-rays cluster surveys: better calibration of scaling relations, better understanding of cluster structure