CLUSTER SELECTION FUNCTIONS FOR NEXT-GENERATION SURVEYS

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OUTLINE

① Next-generation surveys.

② Creating realistic mock catalogues

③ Mass-Observable Relation

④ Cluster selection functions

APPLES TO APPLES: A²

Cluster-related project to

1. Use the same mock catalogues to compare photometry and photo-z properties
2. Obtain cluster Selection Functions and Mass-Observable relations
3. Forecast cosmological constraints

Stage IV Optical Surveys considered:

- Euclid
- LSST
- J-PAS

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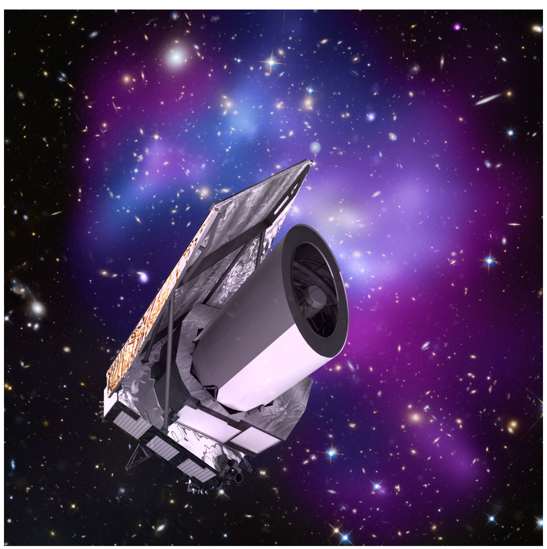
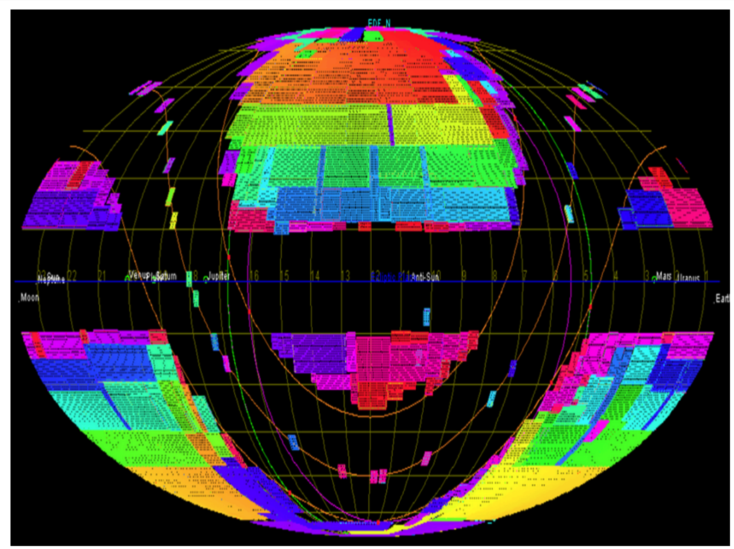
EUCLID IN A NUTSHELL

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

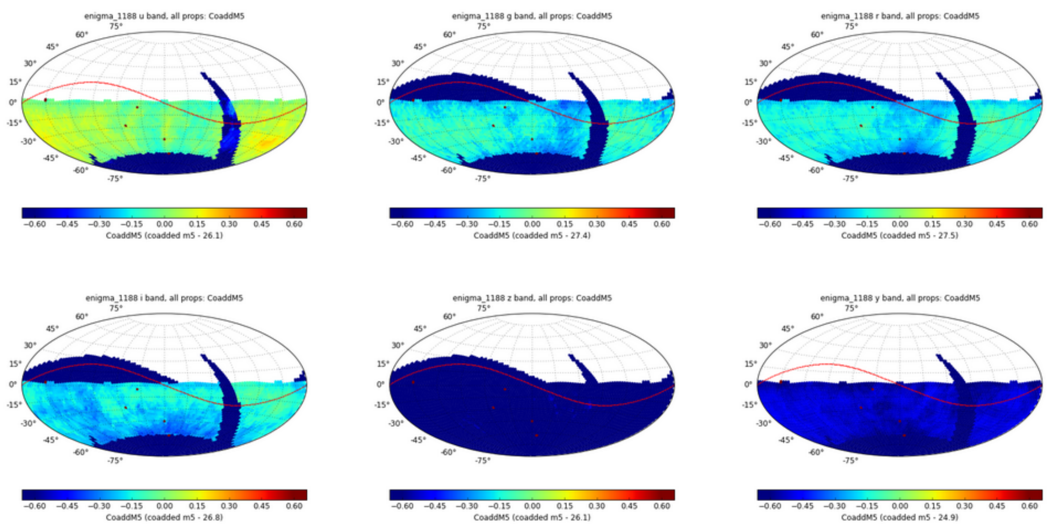
SURVEYS					
	Area (deg2)			Description	
Wide Survey	**15,000 deg²**			Step and stare with 4 dither pointings per step.	
Deep Survey	**40 deg²**			In at least 2 patches of > 10 deg² 2 magnitudes deeper than wide survey	
Wavelength range	550– 900 nm	Y (920-1146nm),	J (1146-1372 nm)	H (1372-2000nm)	1100-2000 nm
Sensitivity	24.5 mag 10σ extended source	24 mag 5σ point source	24 mag 5σ point source	24 mag 5σ point source	3 10^{-16} erg cm-2 s-1 3.5σ unresolved line flux
	Shapes + Photo-z of $n = 1.5\times10^9$ galaxies			z of $n=5\times10^7$ galaxies	





LSST IN A NUTSHELL

Survey Property	Performance
Main Survey Area	18000 sq. deg.
Total visits per sky patch	825
Filter set	6 filters (ugrizy) from 320 to 1050nm
Single visit	2 x 15 second exposures
Single Visit Limiting Magnitude	u = 23.5; g = 24.8; r = 24.4; I = 23.9; z = 23.3; y = 22.1
Photometric calibration	2% absolute, 0.5% repeatability & colors



J-PAS IN A NUTSHELL

http://j-pas.org

8600 sq. deg. survey with 56 filters with 136A width, 100A spacing I~22
2.5m tel. + 5sq. Deg. Cam, 1.2Gpix, etendue=1.5xPS2
Starting in September 2016.

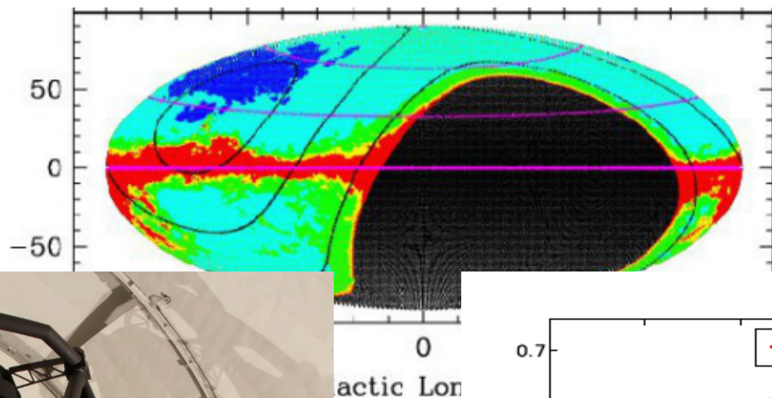
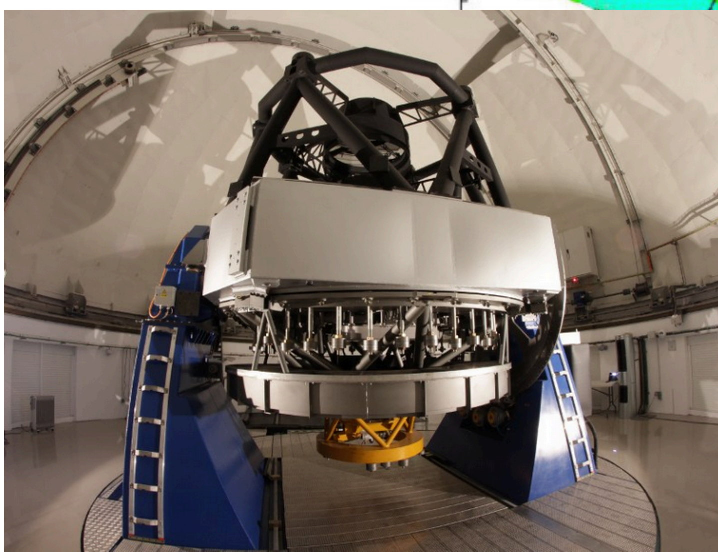
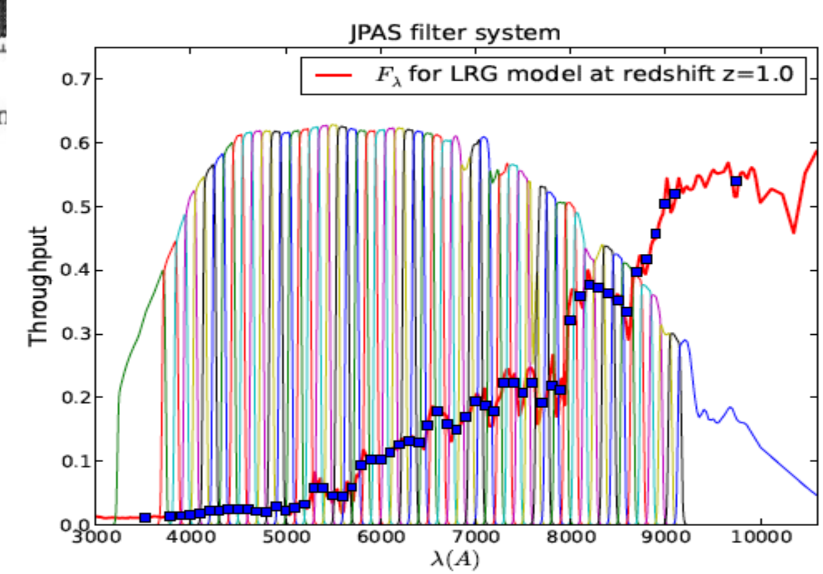
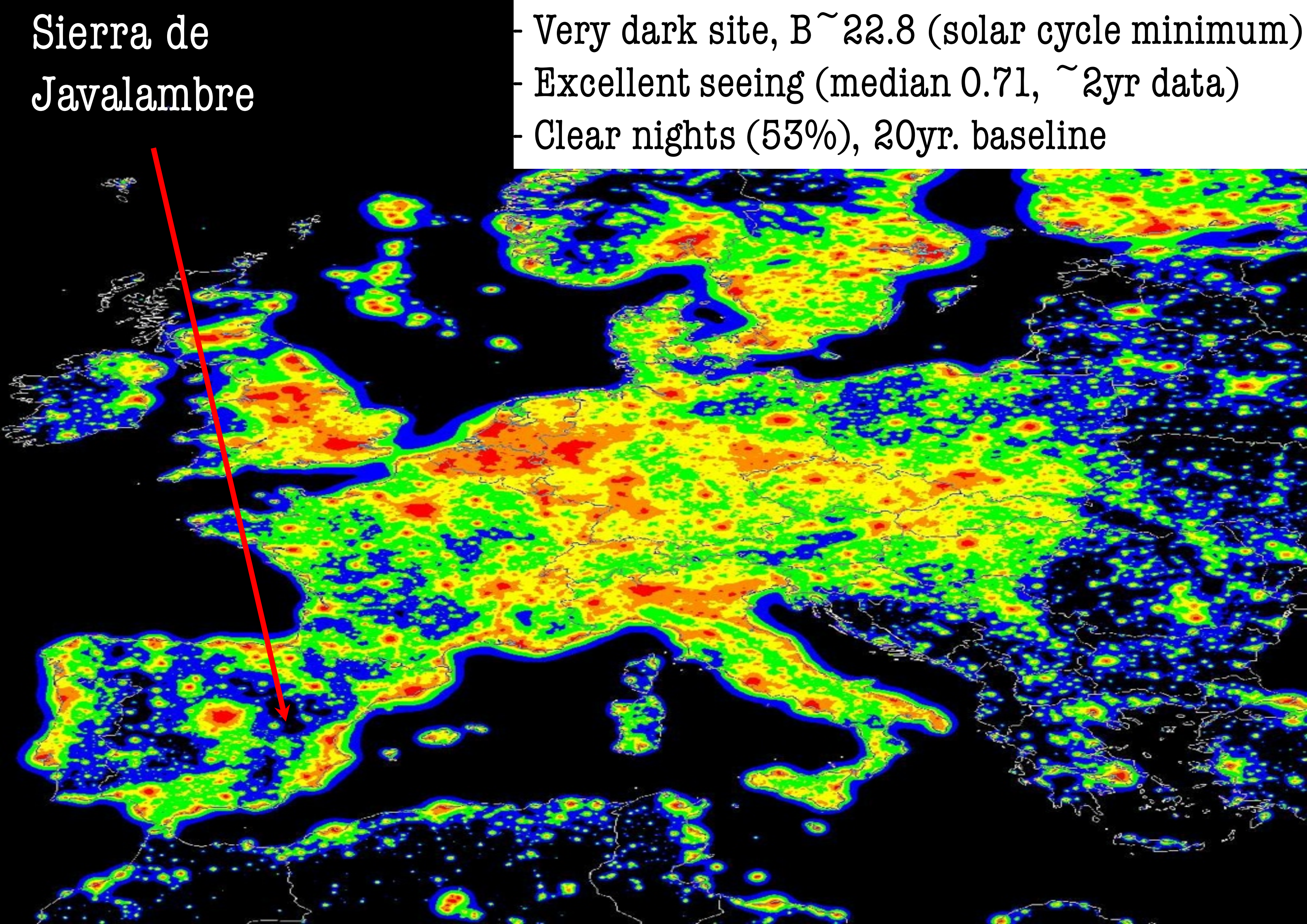


Photo-z precision: 0.003(1+z)

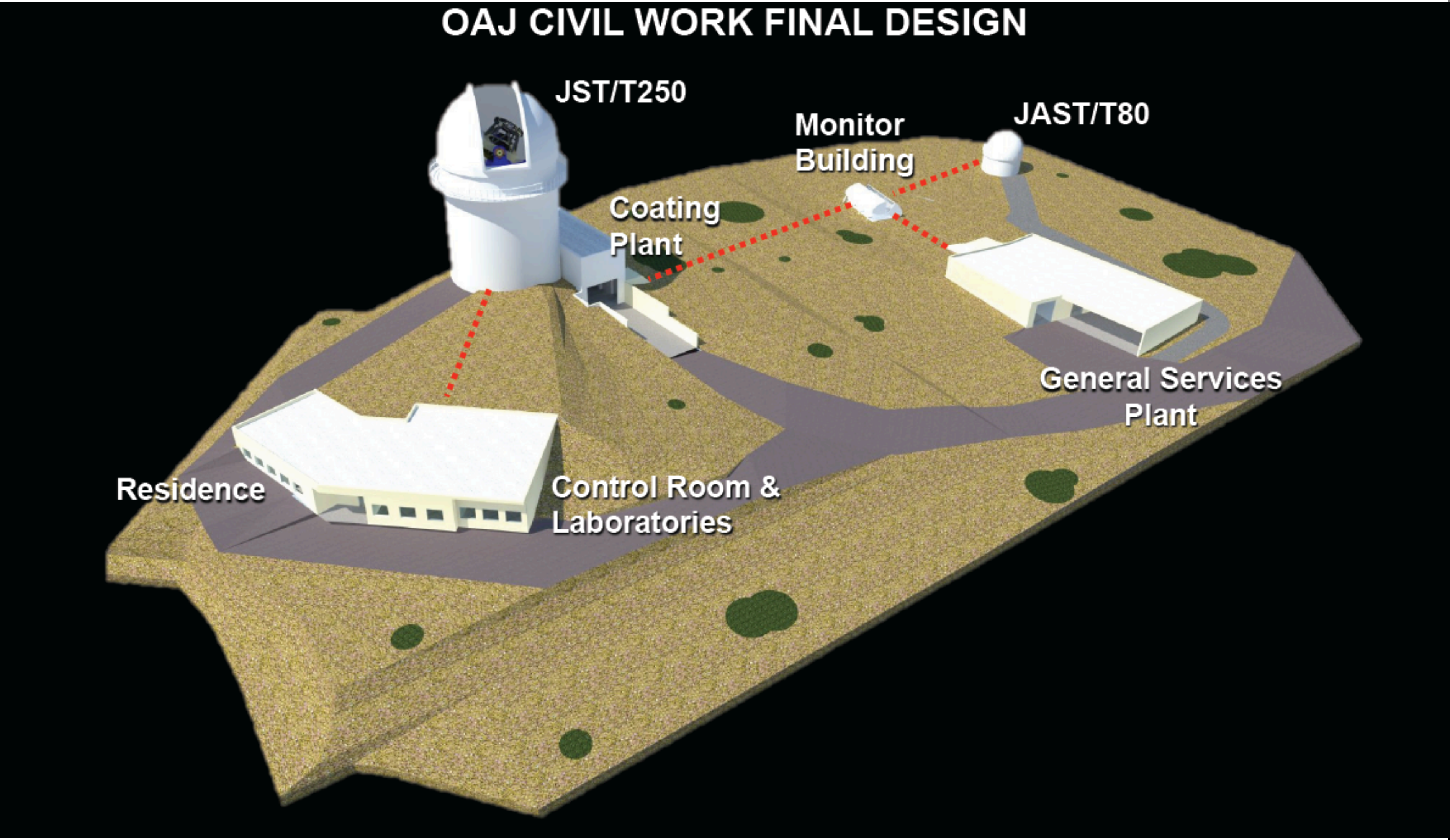




- Pico del Buitre 1957m, 40º02N, 01º01’W
- Very dark site, B~22.8 (solar cycle minimum)
- Excellent seeing (median 0.71, ~2yr data)
- Clear nights (53%), 20yr. baseline



OAJ


OAJ CIVIL WORK FINAL DESIGN
JST/T250
Monitor Building
JAST/T80
Coating Plant
General Services Plant
Residence
Control Room & Laboratories

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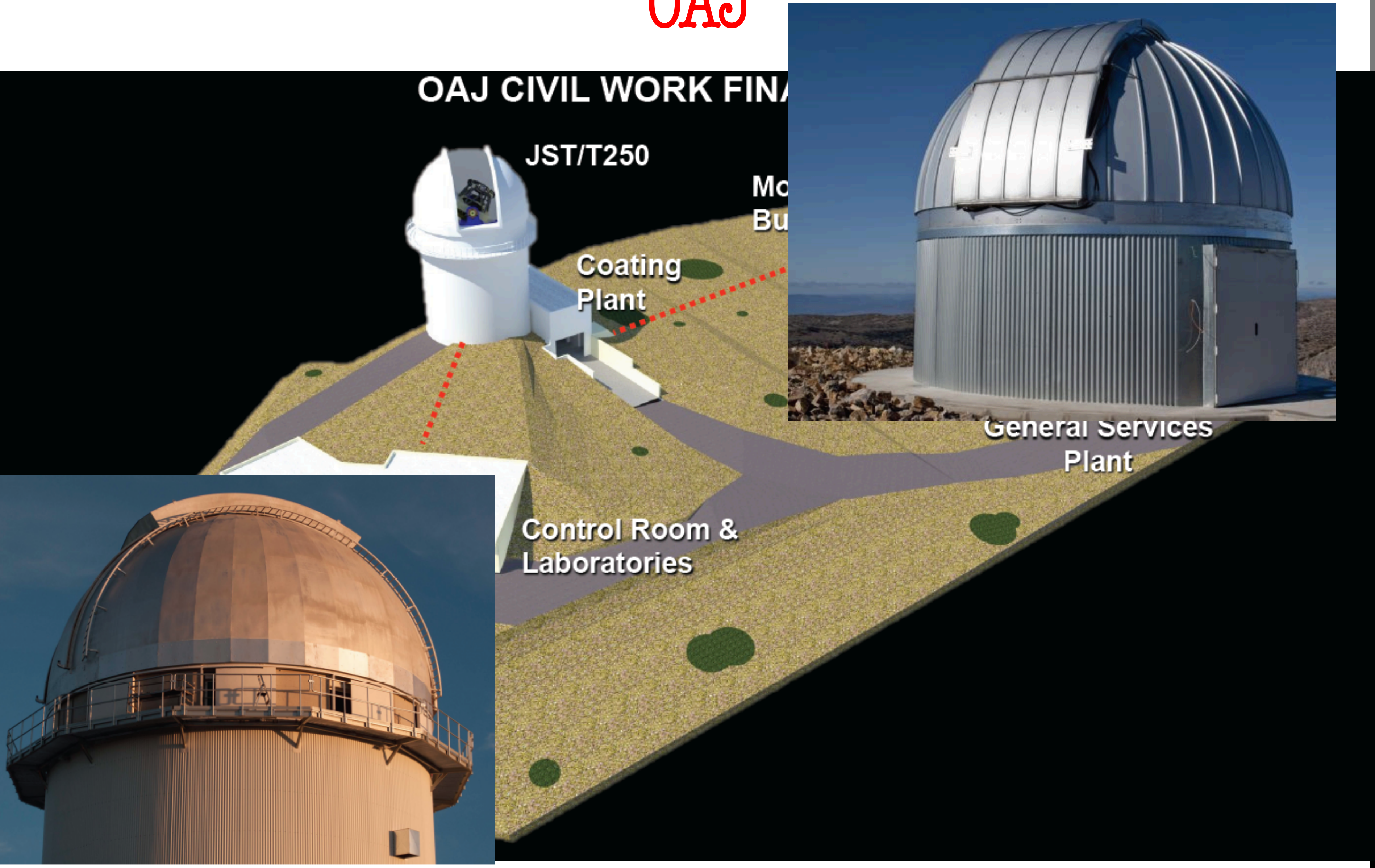
OAJ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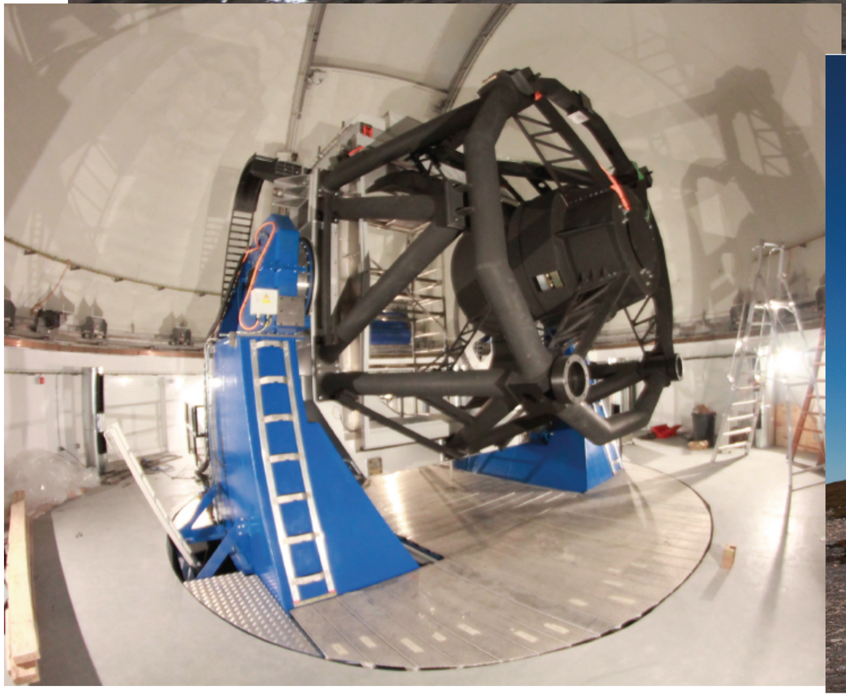
March 2014



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WORKING WITH COSMOLOGICAL SIMULATIONS

Starting from the 500 deg^2 EUCLID public lightcone mock catalogue *(Merson et al. 2013*) down to H=24 AB

- N-body simulation from the Millennium Run
- Semi-analytic models of galaxy formation (Galform)

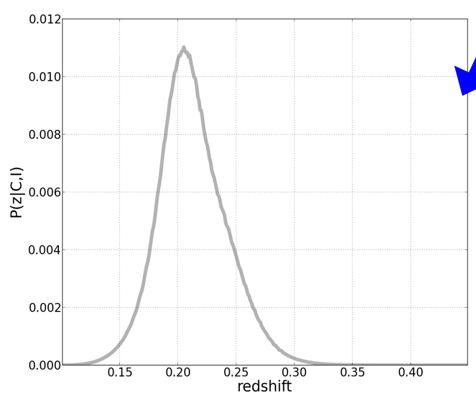
We used PhotReal (*Ascaso et al. 2015b)* to create four new mock catalogues:

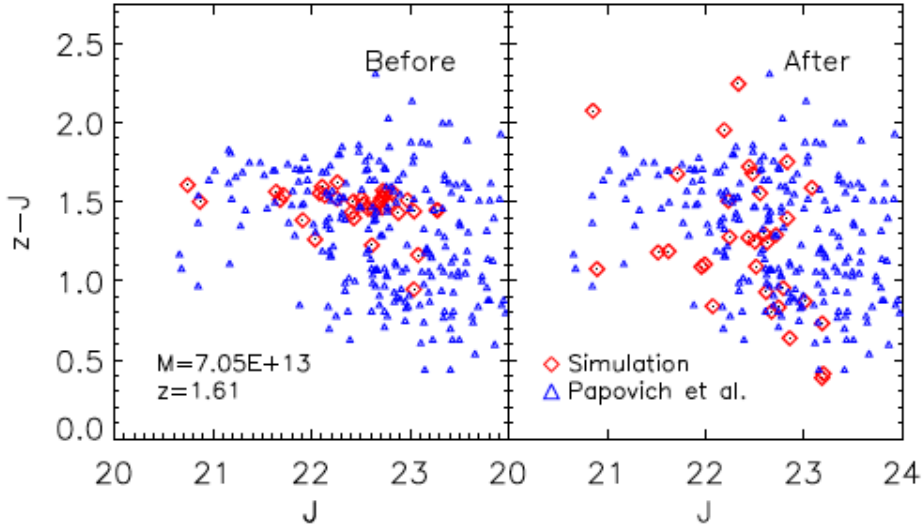
- Euclid-Pessimistic (using an optical counterpart just from DES)
- Euclid-Optimistic (using an optical counterpart from DES+LSST)
- LSST
- J-PAS

MAIN MOTIVATION

Use PhotReal to add parameters to existing mock catalogues:

- Realistic photometry, colors and photometric errors
- Realistic photometric redshifts and derived parameters
- Realistic P(z)





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MOCKS TRANSFORMED WITH PHOTREAL

ALHAMBRA	J-PAS	J-PAS	LSST	EUCLID-W	EUCLID-D
Merson+13	*Zandivarez+14*	*Merson+13*	*Merson+13*	*Merson+13*	*Merson et al. in prep*
N-body simulation (Millenium)+SAM (Galform)	N-body simulation (Millenium)+SAM (*Guo+11*)	N-body simulation (Millenium)+SAM (Galform)	N-body simulation (Millenium)+SAM (Galform)	N-body simulation (Millenium)+SAM (Galform)	N-body simulation (Millenium)+SAM (Galform)
200 deg^2	17.6 deg^2	500 deg^2	500 deg^2	500 deg^2	20 deg^2
F814W<24.5	i<22.5	H<24.0	H<24.0	H<24.0	H<27.0
0<z<2	0<z<2	0<z<3	0<z<3	0<z<3	0<z<6
$M_h>10^{10}M_\odot$	$M_h>10^{8}M_\odot$	$M_h>10^{10}M_\odot$	$M_h>10^{10}M_\odot$	$M_h>10^{10}M_\odot$	$M_h>10^{10}M_\odot$
Ascaso et al. 2015a, MNRAS, 452, 549	*Zandivarez et al. 2014, A&A, 561, 71*	*Ascaso et al. 2016a, MNRAS, 456, 4291*	*Ascaso et al. 2015b, MNRAS, 453, 2515*	*Ascaso et al. 2015b, MNRAS, 453, 2515*	Euclid consortium

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COSMOLOGY WITH CLUSTER COUNTS

$$\frac{dN}{dM_{obs}dz} = \underbrace{\Phi(M_{obs}, z, \Omega)}_{\text{Selection function}} \int dM \, \underbrace{P(M_{obs}|M, z)}_{\text{Mass-Observable relation}} \frac{dN}{dV\,dM} \frac{dV}{dz dM_{obs}}$$

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CLUSTERS IN THE OPTICAL

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COSMOLOGY WITH CLUSTER COUNTS

$$\frac{dN}{dM_{obs}dz} = \underbrace{\Phi(M_{obs}, z, \Omega)}_{\text{Selection function}} \int dM \, \underbrace{P(M_{obs}|M, z)}_{\text{Mass-Observable relation}} \frac{dN}{dV dM} \frac{dV}{dz dM_{obs}}$$

Selection function

Mass-Observable relation

OPTICAL CLUSTERS ARE COMPLICATED!

- Completeness / Purity computation
- Definition of a cluster / halo
- Matching procedures
- Mass / Richness cuts imposed in cluster / halo catalogues

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CLUSTER OPTICAL DETECTORS

MATCHED FILTER TECHNIQUES

Matched Filter *(Postman et al. 1996, 2002)*
Adaptative Kernel *(Gal et al. 2000, 2003, 2006)*
Hybrid Matched Filter *(Kepner et al. 1999)*
Adaptative Matched Filter *(Kim et al. 2002)*
3D-Matched Filter *(Milkeraitis et al. 2010)*
Adami & MAzure Cluster Finder *(Durret et al. 2011, 2015)*
Bayesian Cluster Finder *(Ascaso et al. 2012, 2014a, 2015a)*

GEOMETRICAL TECHNIQUES

Voronoi Tessellation *(Kim et al. 2002, Ramella et al. 2001, Lopes et al. 2004),*
Counts in cells *(Couch et al. 1991, Lidman & Peterson 1996),*
Percolation FoF Algorithm *(Dalton et al. 1997)*

RED SEQUENCE METHODS

MaxBCG *(Koester et al. 2007)*
The Cluster Red Sequence Method *(Gladders & Yee 2000, 2005)*
Cut-and-enhance *(Goto et al. 2002)*
C4 clustering algorithm *(Miller et al. 2005)*
RedMaPPer *(Rykoff et al. 2014)*
RedGold *(Licitra et al. 2016)*

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THE BAYESIAN CLUSTER FINDER

(Ascaso et al. 2012, 2014a, 2015a, 2016a,b)

$$\ln L(X,Y,N_g,R_c,z_c) = \sum_i \underbrace{P(r(x_i,y_i|X,Y,z_c))}_{\text{Cluster Spatial Prof}}\underbrace{L(m_i,z_i|z_c)}_{\text{Cluster Lum Prof}}\underbrace{p(z_i|z_c)}_{\text{Redshift prob distrib}}$$

The prior (introduction of a CMR, BCG prior)

$$p(X,Y,N_{\rm g},R_{\rm c},z_{\rm c}|I) = \underbrace{p(col_i)}_{\text{Expected cluster colors}}\underbrace{p(m_{\rm BCG}(z))}_{\text{Expected BCG mag}}$$

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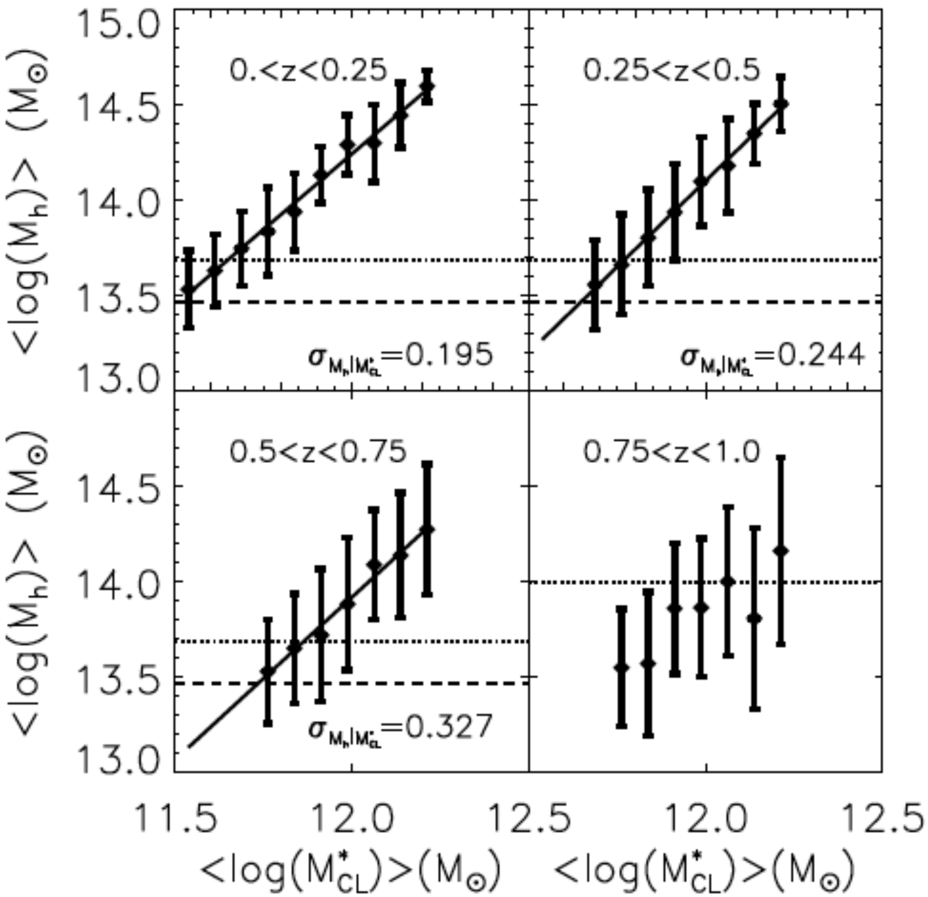
APPLICATIONS TO REAL SURVEYS

CFHTLS	DLS	ALHAMBRA
Ascaso et al. 2012, MNRAS, 420, 1167	*Ascaso et al. 2014a, MNRAS, 439, 1980*	*Ascaso et al. 2015a, MNRAS, 549, 65*
1246 structures ~ 33.7 /deg^2	882 structures ~ 44.1 /deg^2	348 structures ~125.18 /deg^2
$0.1<z<1.2$	$0.25<z<1.2$	$0.2<z<1.2$
$M>10^{14.2}M_\odot$	$M>10^{14}M_\odot$	$M>10^{13.6}M_\odot$
Good match with optical surveys: *Adami et al. 2010, Olsen et al. 2008*; and X-ray: *Pacaud et al. 2009*	Good agreement with spectroscopy, WL, X-rays and optical detections. Allow the study of systematic.	Good agreement with COSMOS (+ pretty unknown fields)

MASS-OBSERVABLE RELATIONS

Ascaso et al. 2016 a,b

J-PAS



J-PAS

$\sigma_{Mh|M^*CL}$~0.24 dex to M~$3\times10^{13}M_\odot$

Euclid

$\sigma_{Mh|M^*CL}$~0.20-0.25 dex to M~$5\times10^{13}M_\odot$

LSST

$\sigma_{Mh|M^*CL}$~0.22 dex to M~$5\times10^{13}M_\odot$

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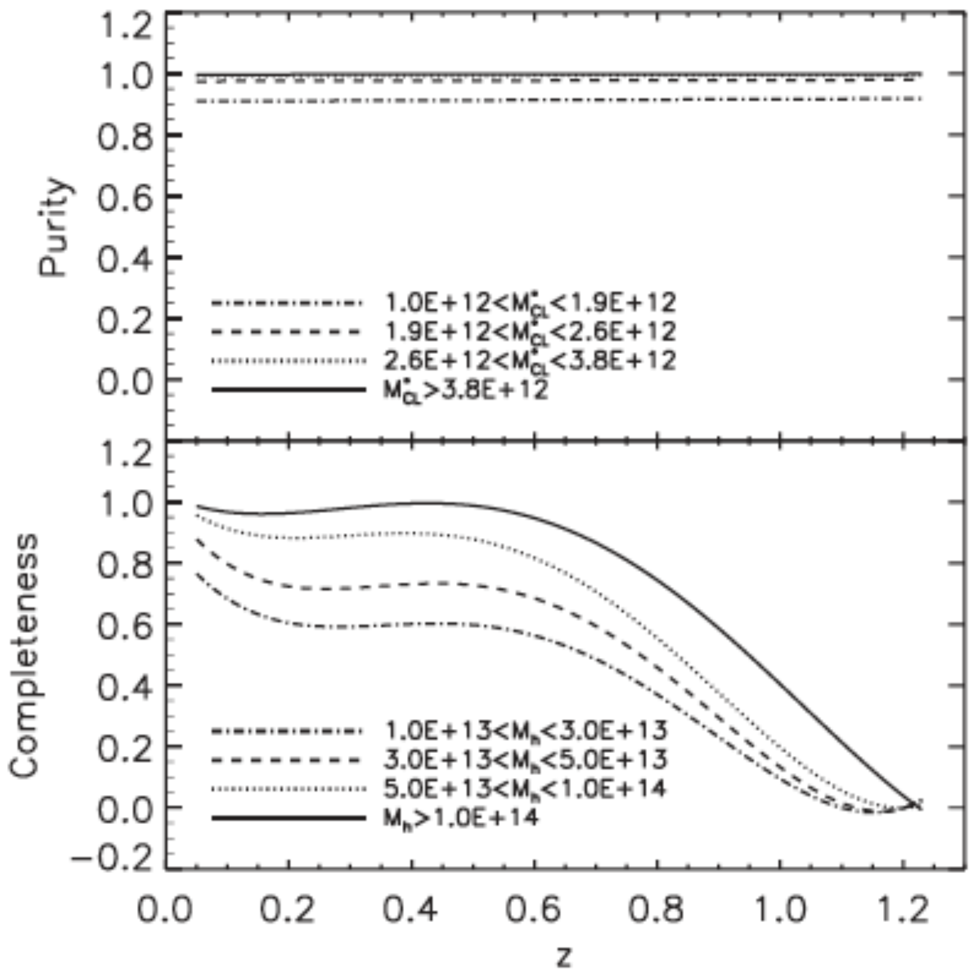
2. Creating realistic mock catalogues: PhotReal
3. Mass-Observable Relation
4. Cluster selection function

COMPLETENESS-PURITY RATES

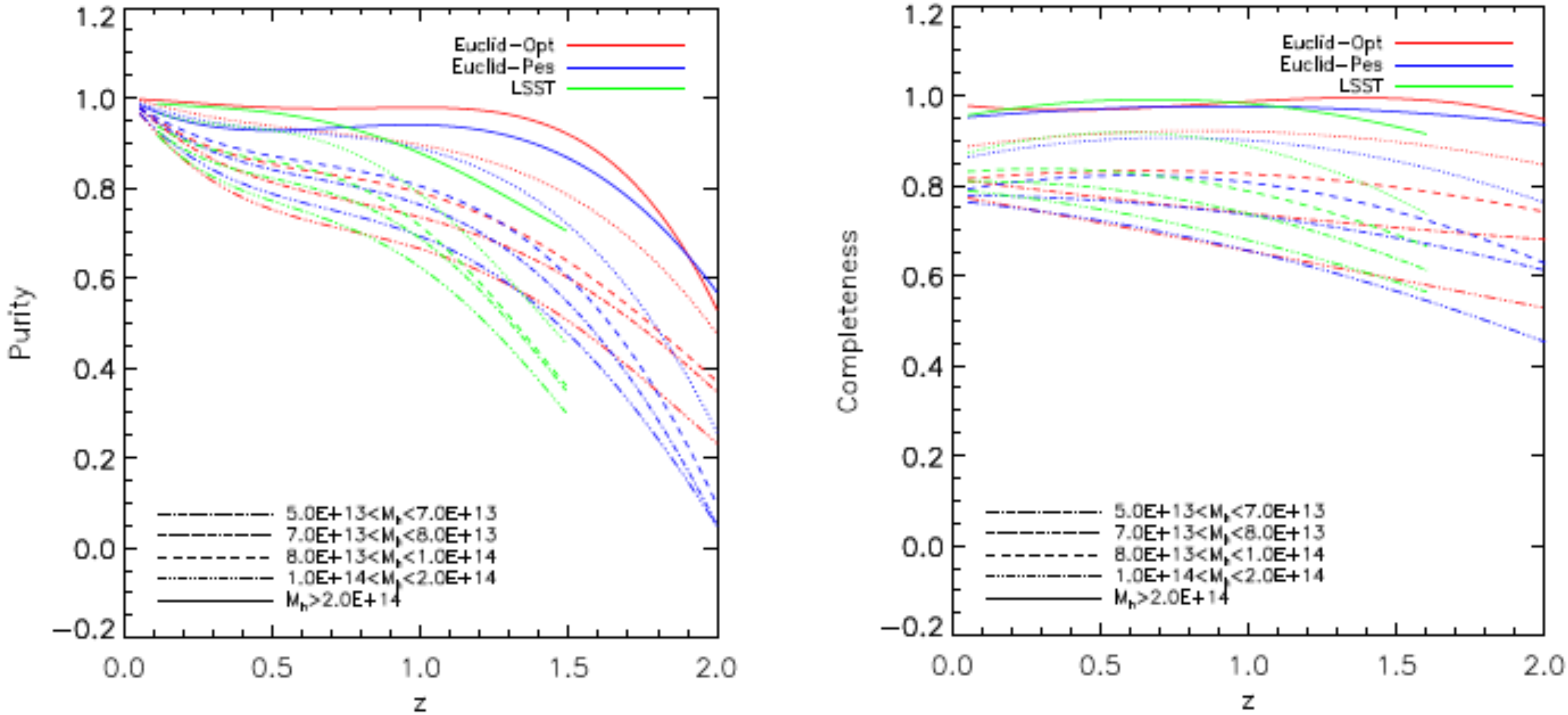


J-PAS

Ascaso et al. 2016a, MNRAS, 456, 4291

COMPLETENESS-PURITY RATES

Euclid and LSST



Ascaso et al. 2016b, arXiv:1605.07620

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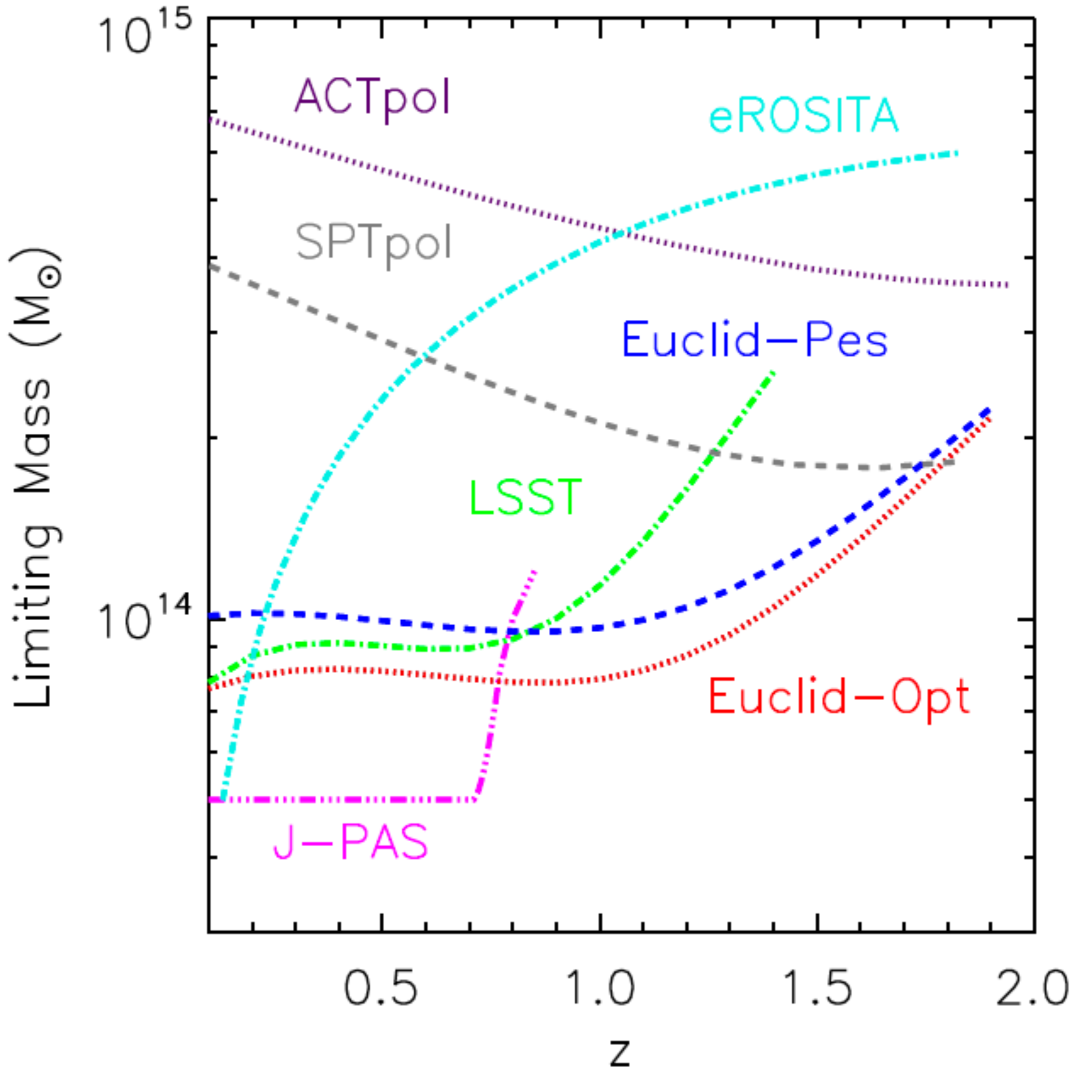
FINAL SELECTION FUNCTIONS



Ascaso et al. 2016b, arXiv:1605.07620

Non optical curves from Weinberg et al. 2013

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CONCLUSIONS

- Consistent comparison between three next-generation stage IV optical surveys: Euclid / LSST / J-PAS
- Mock catalogues emulating realistically the surveys with PhotReal
- Mass-Observable calibrated relation ($\sigma_{Mh|M^{*}CL}$~0.24 down to M~$3 \times 10^{13} M_{\odot}$ for J-PAS and $\sigma_{Mh|M^{*}CL}$~0.20 dex down to M~$5 \times 10^{13} M_{\odot}$ for Euclid/LSST.)
- Completeness and purity rates and robust estimation of the selection functions.
- Optical clusters are crucial to sample correctly the mass function. Synergies with X-rays and SZ.

EFGARISTÓ! THANKS!

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