JPAS

A STAGE IV EXPERIMENT FROM SPAIN

TXITXO BENÍTEZ

IAA(CSIC), GRANADA, SPAIN

JPAS = ALL SKY IFU

JPAS = Javalambre-*Physics of the Accelerated Universe* Astrophysical Survey, Spanish-Brazilian collaboration

8600 sq.deg. survey with 56 filters with 136A width, 100A spacing I~22

2.5m tel. + 5 sq.deg. cam, 1.2Gpix, etendue = 1.5 x PS2

Dark site with ~0.7 arcsec seeing: Javalambre in Teruel, Spain

It will measure 0.003(1+z) photo-z for ~100M galaxies

It will measure 0.01(1+z) photo-z for ~300M galaxies

It will measure radial BAOs up to z~1.3: 11 $(Gpc/h)^3$

Clusters, Weak lensing, SN, QSOs, Galaxy evolution, Stars, Solar system

Total budget ~30M euros

Start= 2014 End= 2020

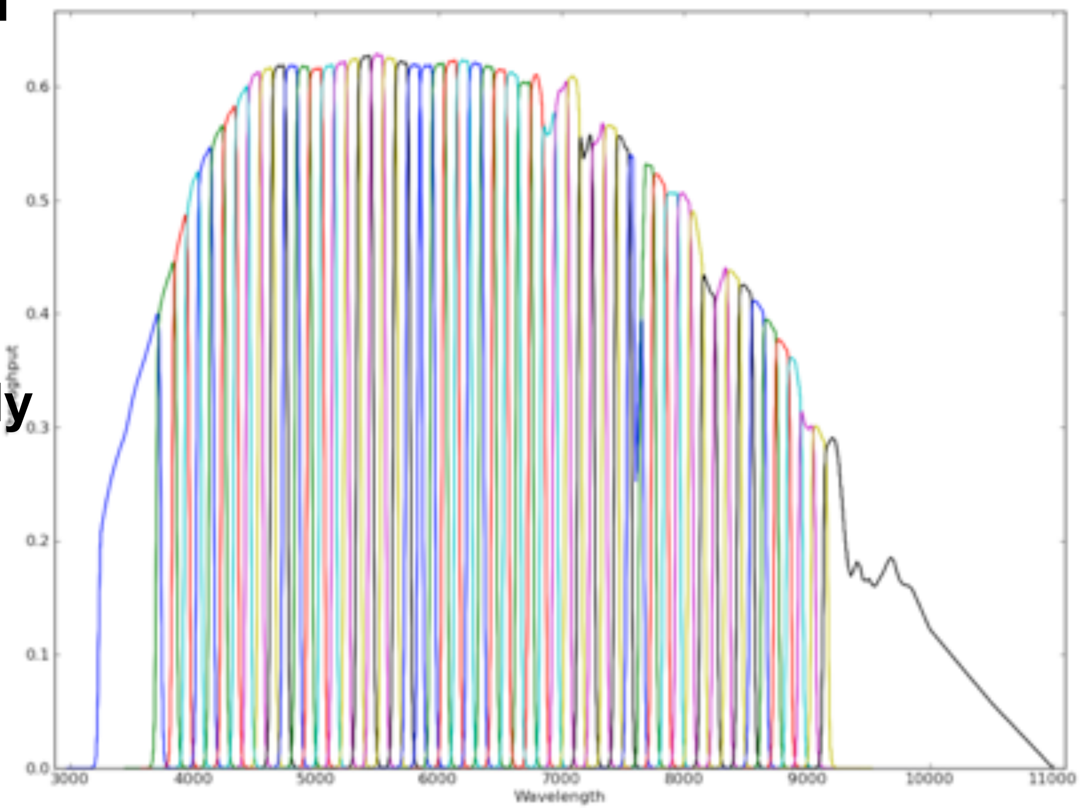
http://j-pas.org/

JPAS = ALL SKY IFU

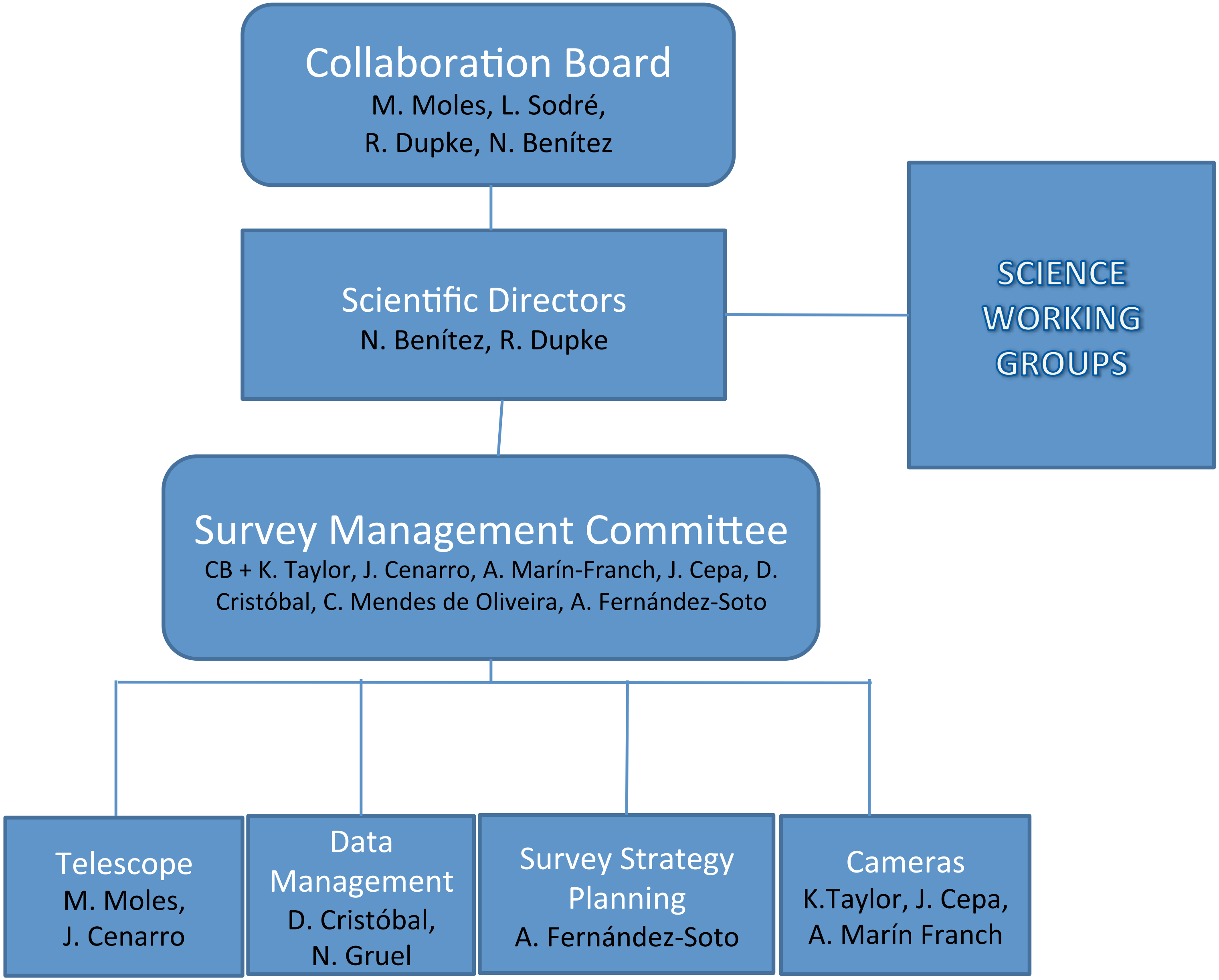
Basic idea: you don't need spectroscopic redshift precision to measure the BAO scale; 0.003(1+z) photo-z are enough

Obtained data are extremely useful for many areas of Astrophysics

Motivation, requirements: Benitez et al 2009 (PAU)



- IAA-CSIC (MICINN)
- CEFCA
- Observatorio Nacional, Río de Janeiro
- Departamento de Astronomia, Universidade de São Paulo
- Centro Brasileiro de Pesquisas Físicas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M. Moles, L. Sodré,
R. Dupke, N. Benítez
Scientific Directors
N. Benítez, R. Dupke
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WORKING
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Telescope
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J. Cenarro
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D. Cristóbal,
N. Gruel
Survey Strategy
Planning
A. Fernández-Soto
Cameras
K.Taylor, J. Cepa,
A. Marín Franch

JPAS-SPAIN

CEFCA: Mariano Moles, Javier Cenarro, David Cristóbal, Antonio Marín-Franch, Nicolás Gruel, Carlos Hernández-Monteagudo, Alessandro Ederoclite, Jesús Varela López, José Luis Lamadrid, Kerttu Vironen, Luis Alberto Díaz, Luisa Valdivieso, Natalio Maicas, Sergio Chueca, Susana Gracia,

IAA: Txitxo Benítez, Emilio Alfaro, Teresa Aparicio, Carlos Barceló, Rosa González, Javier Gorosabel, Matilde Fernández, Yolanda Jiménez-Teja, Alberto Molino, William Schoenell

Universitat de Valencia: Vicent Martínez, Pablo Arnalte, Juan Fabregat, Alberto Fernández-Soto, Vicent Peris, Vicent Quilis, Fernando Ballesteros

IAC: Jordi Cepa, José Miguel Rodríguez-Espinosa, Angel Bongiovanni, José Alfonso López-Aguerri, Elena Ricci, Ignacio Trujillo, Alexander Vazdekis,
IFCA: Enrique Martínez-González, José María Diego, Ignacio González- Serrano, Patricio Vielva, Airam Marcos Caballero
Universidad Complutense de Madrid: Javier Gorgas, Nicolás Cardiel, Patricia Sánchez-Blázquez, Jesúys Gallego
Universidad del País Vasco-EHU: Tom Broadhurst, Irene Sendra
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PAU-BRAZIL

UFSC Abilio Mateus, André Luiz de Amorim, Antonio Kanaan, Eugenia Díaz
USP Ariel Zandivárez, Claudia Mendes de Oliveira, Laerte Sodré, Paulo Penteado, Raúl Abramo, Robert Proctor
UFRJ Ioav Waga, Mauricio Calvao, Ribamar Reis
Observatorio Nacional Daniela Lazzaro, Jailson Alcaniz, Jorge Carvano, Keith Taylor, Renato Dupke, Simone Daflon,
INPE Fernando Jablonski
CBPF/TEO Marcelo Rebouças
NAT Paula Coelho

CIDA Gustavo Bruzual

Universidad de Florida: Rafa Guzmán
INAF/Padova Bianca Poggianti
UPenn Masao Sako, Henrique Xavier

56 FILTERS !!??

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Compare imaging with N_F filters to a spectrograph

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v_S for spectroscopy: $N_{max} \times \eta$

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Spectroscopy (BOSS): $N_{max}=1000$ $v_S \sim 250$

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Compare imaging with N_F filters to a spectrograph

v_S for spectroscopy: N_{max} x η

v_S for imaging: n_g x A x η_i / N_F = $(n_g A) x (\eta_I / N_F)$ = N_{max} x η

We can compare N_{max} with $n_g A$ and η with η_I / N_F

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Spectropic η ~ 0.25 filter imaging η_I / N_F ~ 0.02

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JPAS N_{max}= 12000x5= 60000 (!!) so v_S~1200

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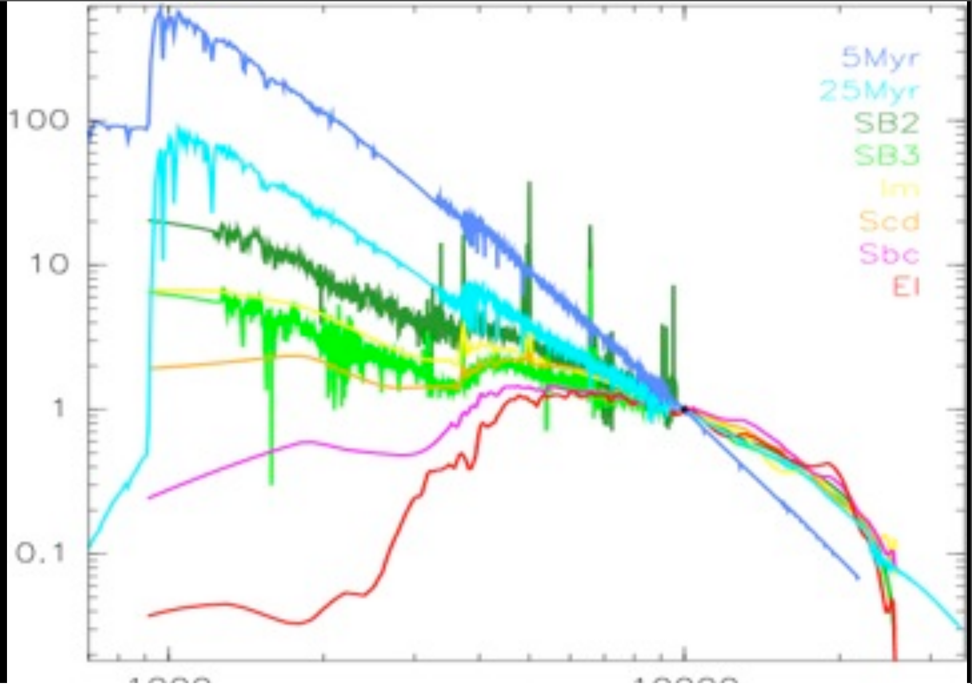
Instrument costs 7M$

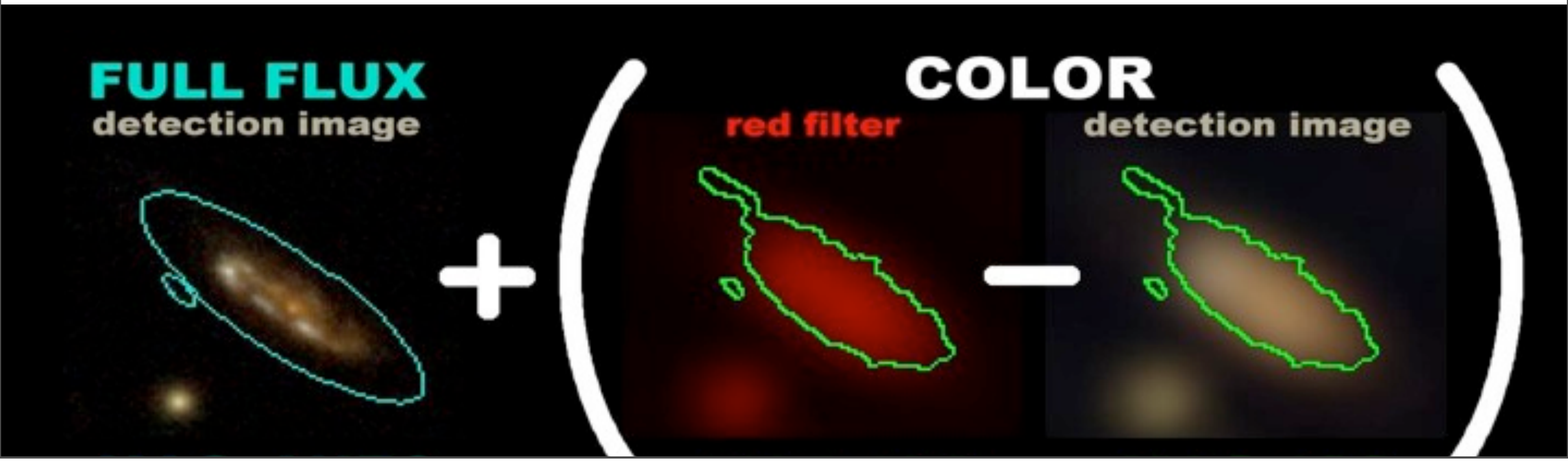

WIRED
FANTASTIC VOYAGE

Photo-z ingredients:

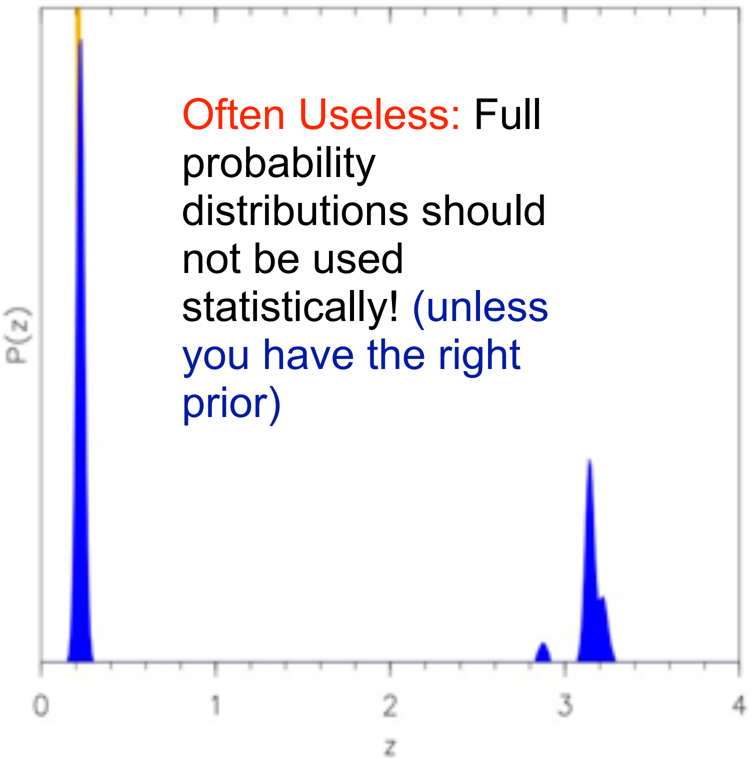
- Photometry
- Template library
- Statistical method



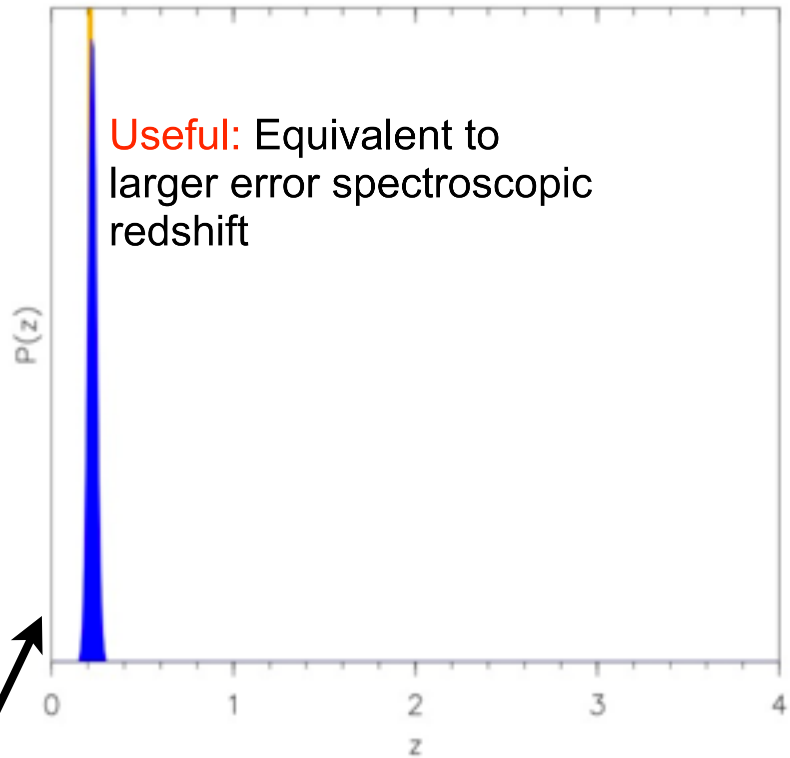
$$p(z\,|\,C, m_0) = \sum_T p(z, T\,|\,C, m_0) \propto \sum_T p(z, T\,|\,m_0)\,p(C\,|\,z, T)$$



PHOTOMETRIC REDSHIFT DEPTH
≠
PHOTOMETRIC DEPTH!!!



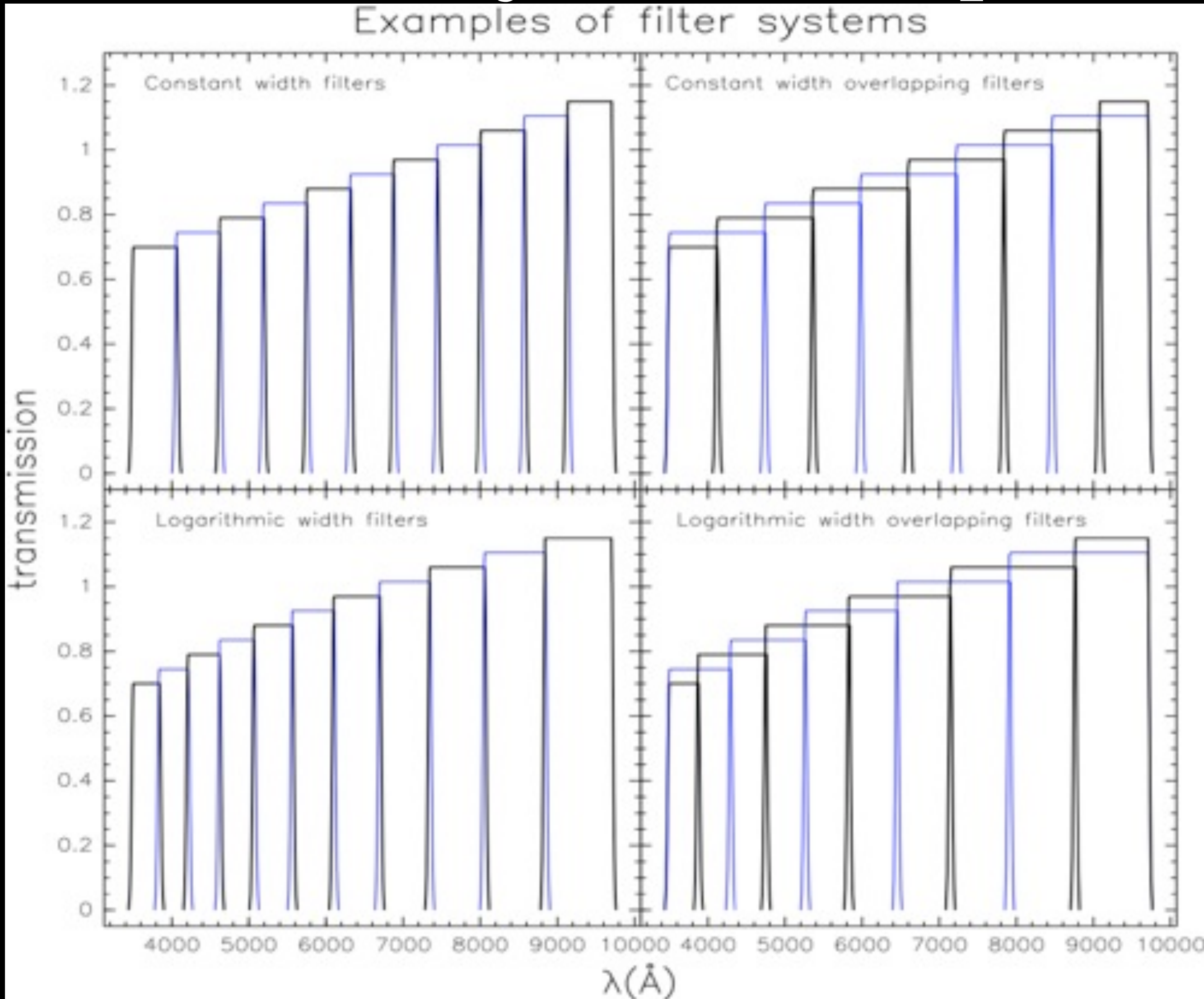
Often Useless: Full probability distributions should not be used statistically! (unless you have the right prior)



Useful: Equivalent to larger error spectroscopic redshift

HOW DO YOU GET MORE OF THESE?

Optimal filter systems for photo-z

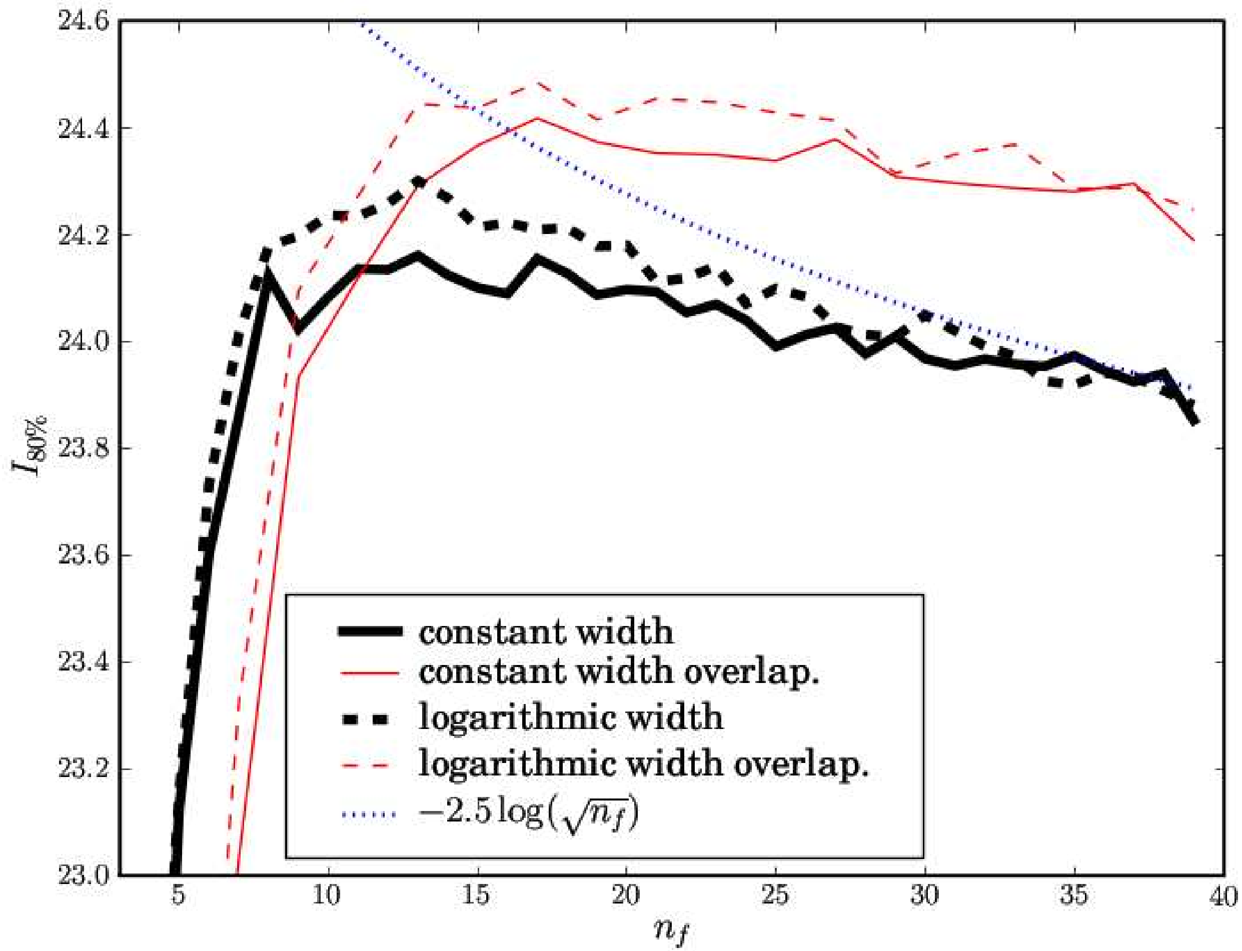


Benítez et al. 2009, ApJL, 692, L5

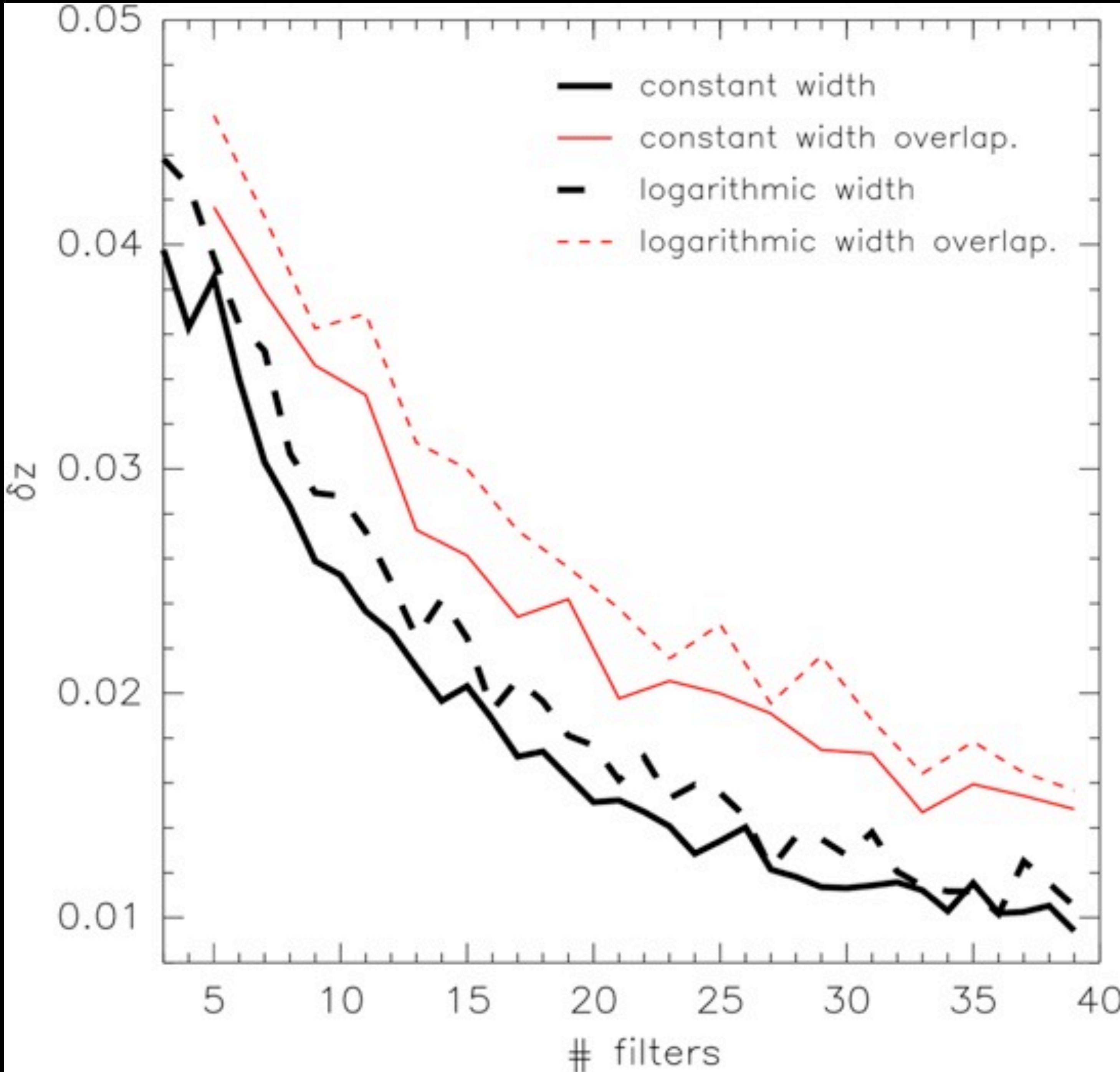
MOST PROJECTS BENEFIT FROM INCREASING THEIR PHOTOMETRIC REDSHIFT DEPTH, NOT THEIR PHOTOMETRIC DEPTH

5-6 photometric systems with contiguous, non-overlapping filters are very inefficient to obtain good-quality photo-z

Smart use of broad band filters: CLASH, 16 overlapping optical-UV broad band filters

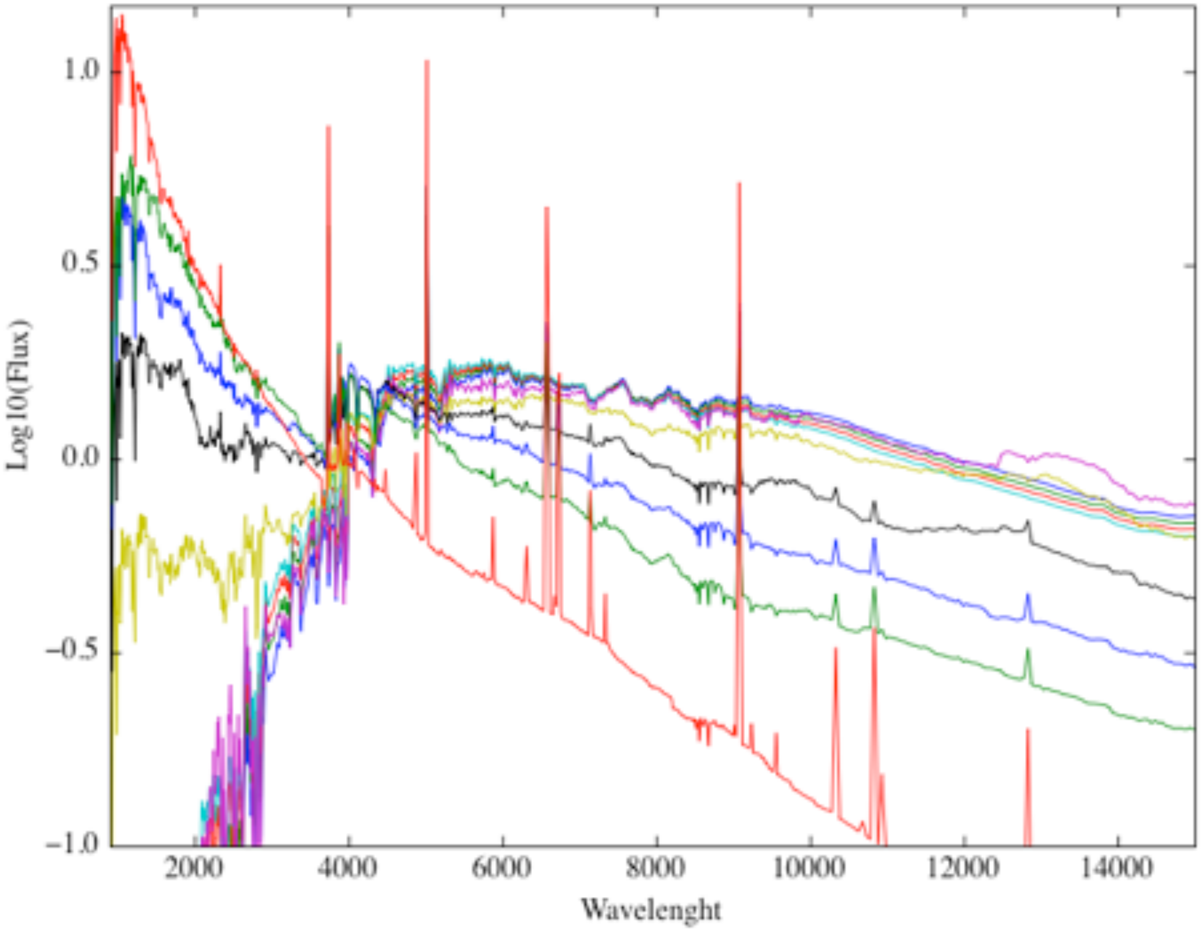


Benitez et al. 2009, ApJL,692, 5



constant width
constant width overlap.
logarithmic width
logarithmic width overlap.
δz
0.05
0.04
0.03
0.02
0.01
5
10
15
20
25
30
35
40
filters

Template libraries



Benítez 2012 (in preparation)

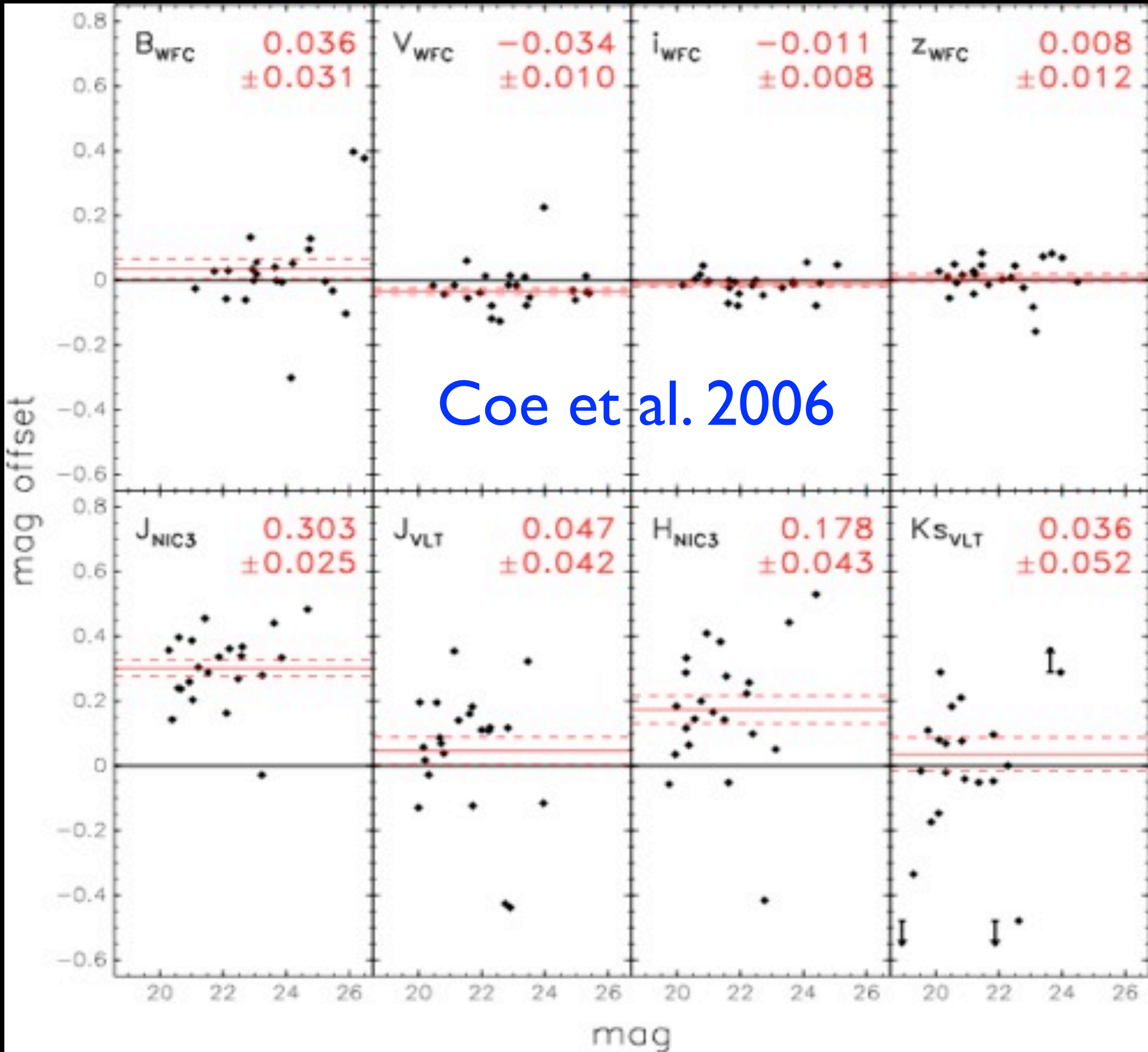
- Start with 6 PEGASE templates (close to Benitez et al. 2004)

- Calibrate them with the FIREWORKS photometric catalog

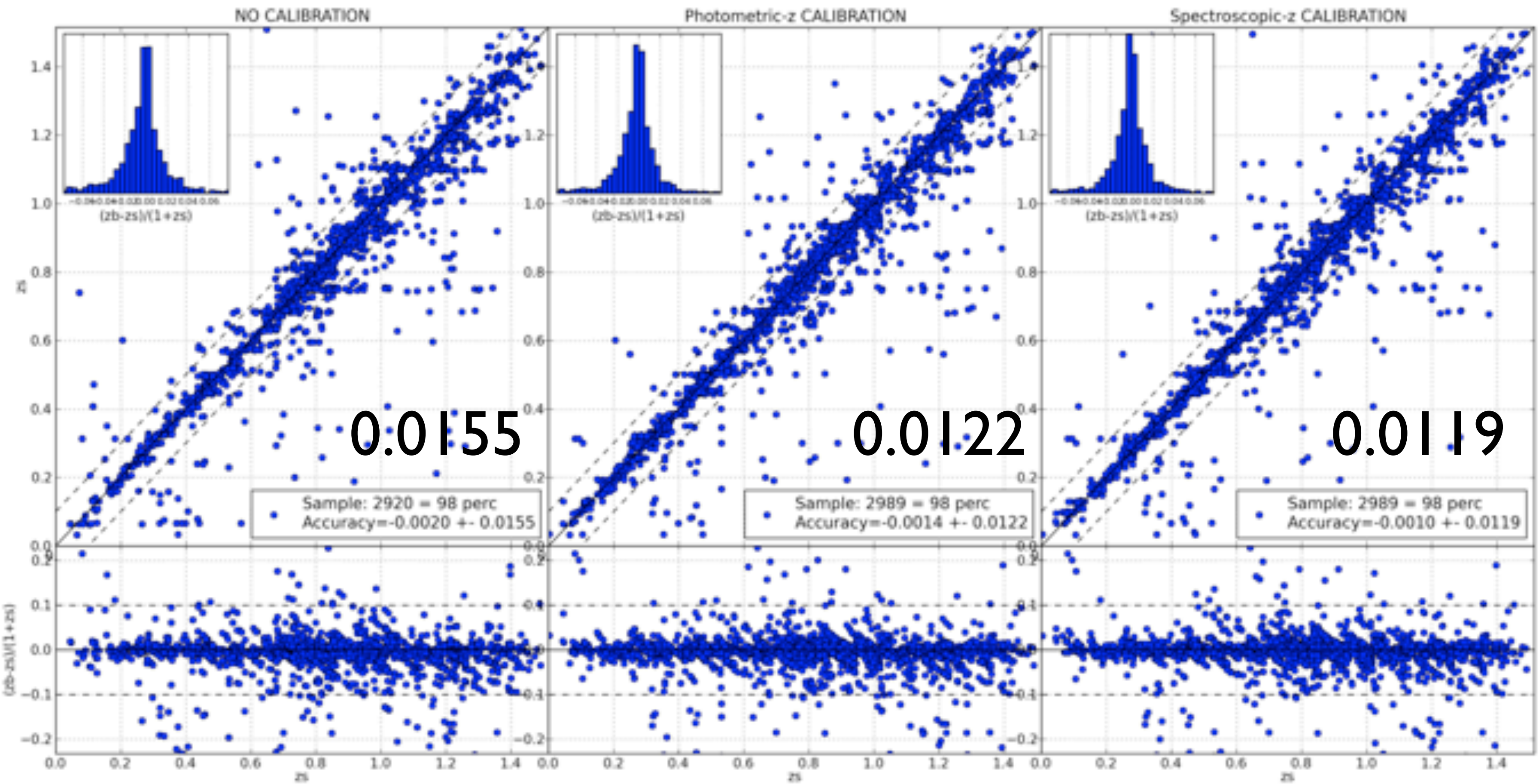
- Add 4 GRASIL templates for fine grained LRG types:

-11 templates overall + interpolation but slightly more precise than Le Phare:
dz< 0.007(1+z) photo-z with COSMOS 30 bands
(dz =0.005(1+z) for LRGs with high quality redshifts)

Photometry: ZP correction

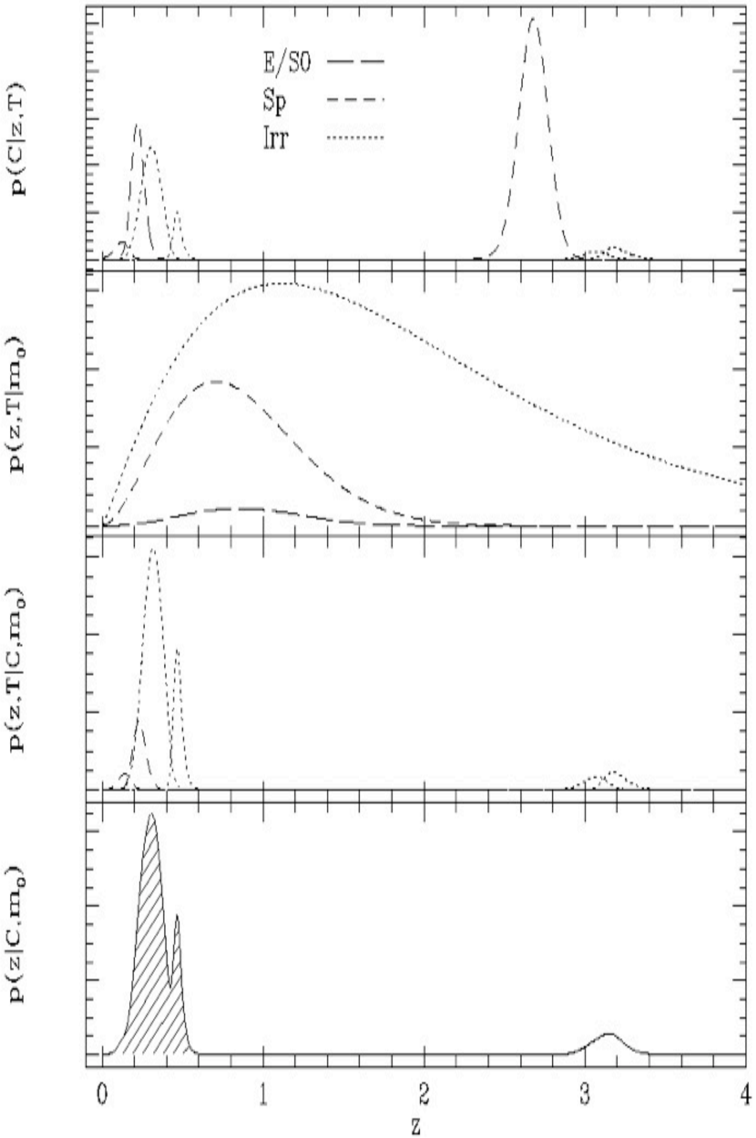


Photometric ZeroPoint Calibrations



Molino, Benítez et al 2012

Expected precision from mocks: 0.015



BAYESIAN PHOTO-Z

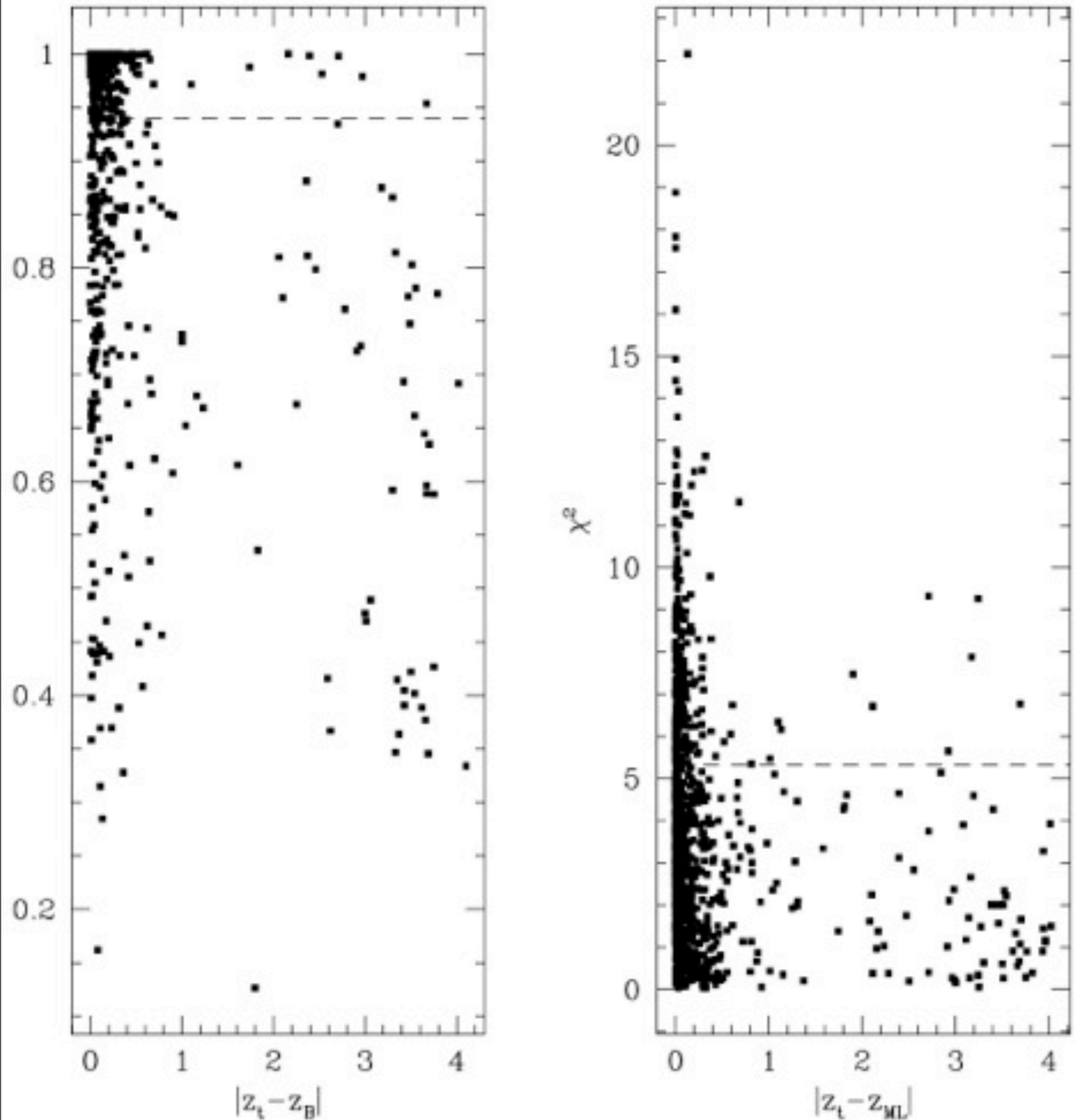
Bayesian approach (Benítez 2000) increases unimodal photo-z

It offers an easy and efficient way of selecting high-quality photo-z: Bayesian Odds

You are always using a prior, even if you are not aware of it!!

ML or χ^2 ~ flat redshift prior = extremely strong luminosity evolution prior

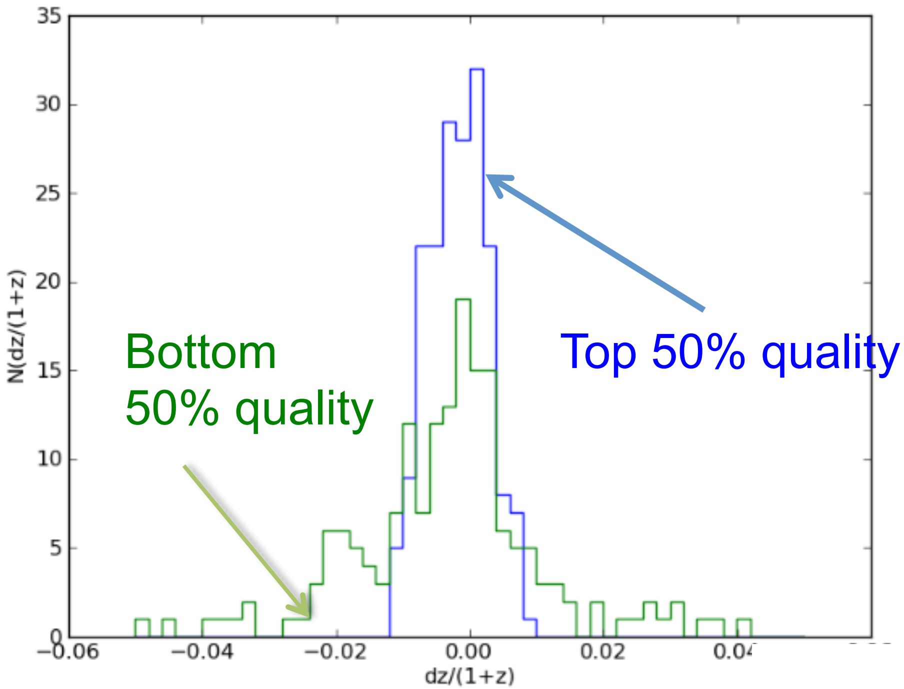
Full probabilities from flat priors will be wrong



Bayesian Odds:

Integrate p(z) in a small interval around z_B

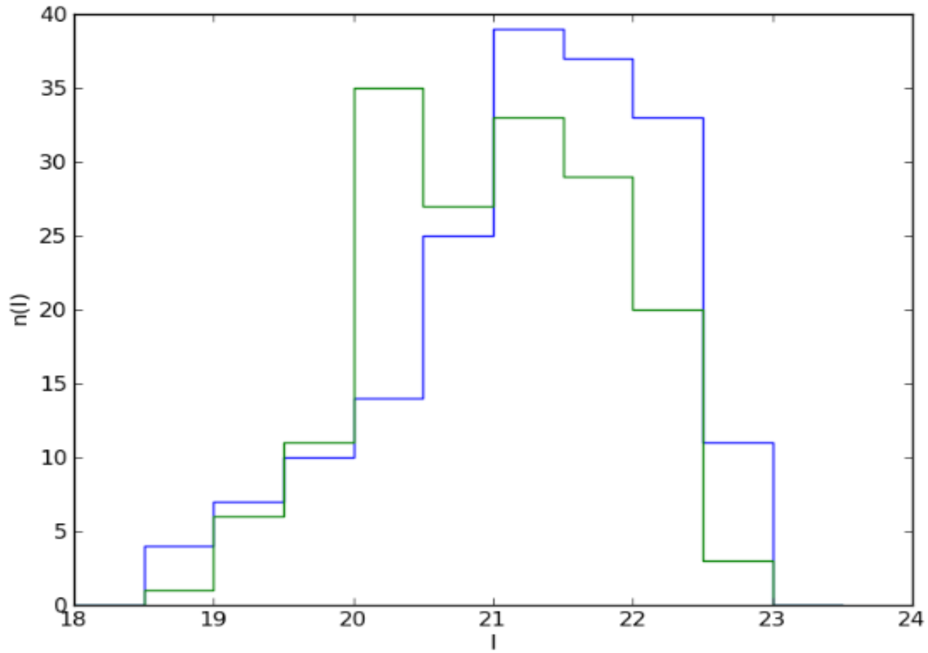
Excellent photo-z quality indicator

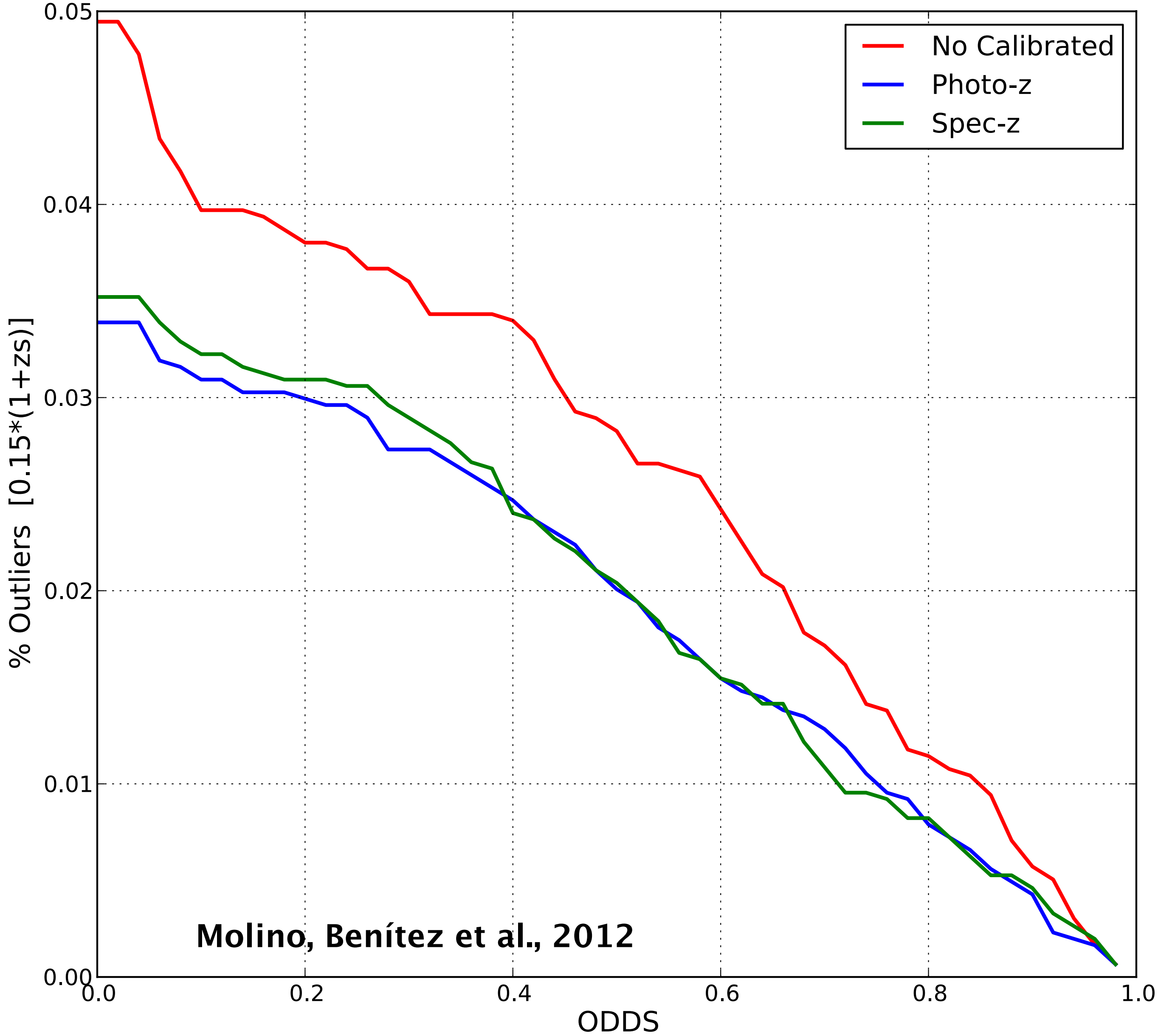


-COSMOS (Ilbert et al. 2009) catalog
~300A filters
-Photo-z with high odds 0.0045(1+z)

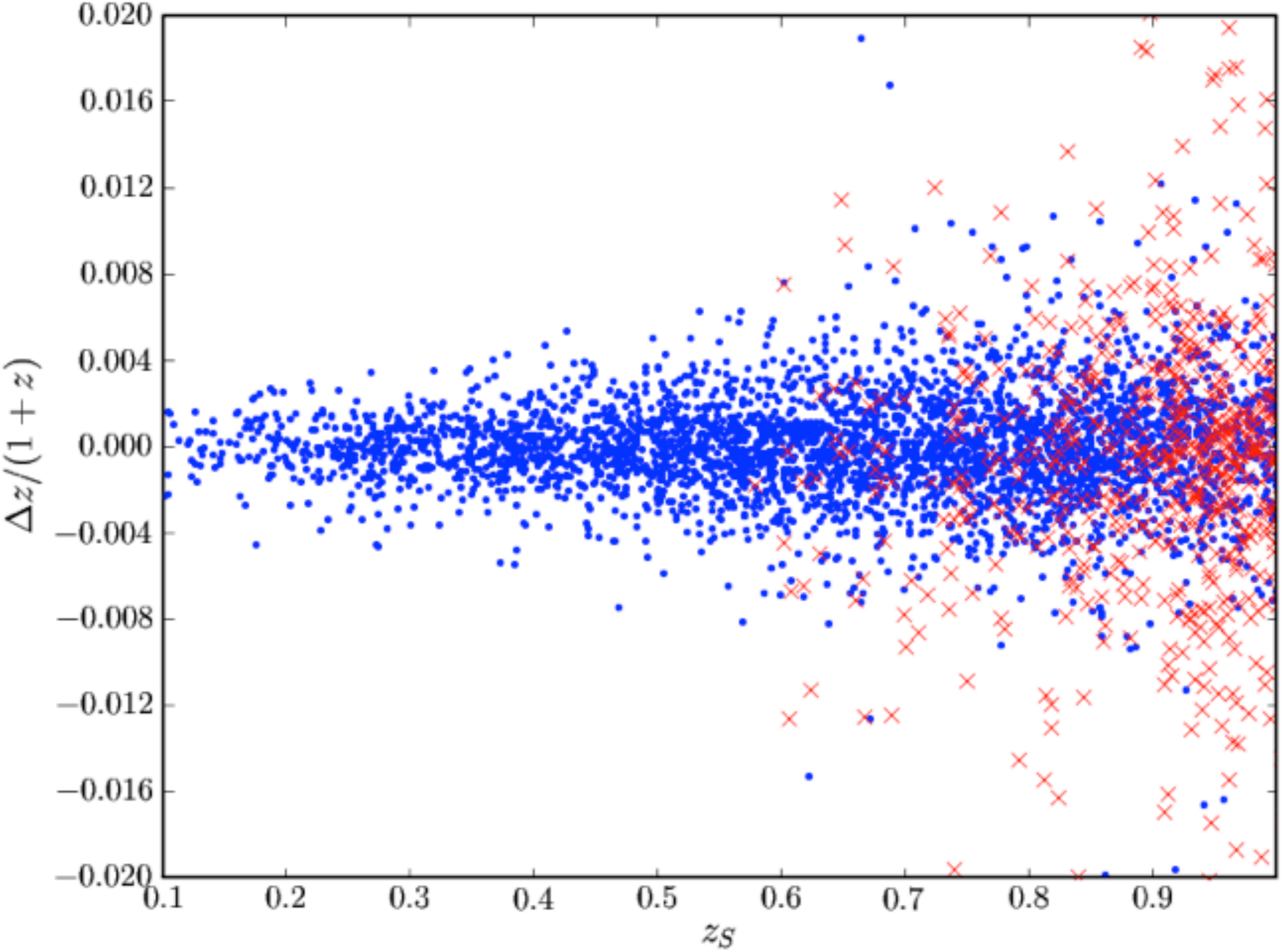
Bayesian Odds provide a reliable precision predictor!

- Magnitude or S/N cuts are not Efficient
- Need to use Bayesian approach with a quality indicator
- “Battle tested”





No Calibrated
Photo-z
Spec-z
Molino, Benítez et al., 2012
% Outliers [0.15*(1+zs)]
ODDS
0.00
0.01
0.02
0.03
0.04
0.05
0.0
0.2
0.4
0.6
0.8
1.0



0.020
0.016
0.012
0.008
0.004
0.000
−0.004
−0.008
−0.012
−0.016
−0.020
$\Delta z/(1+z)$
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
z_S

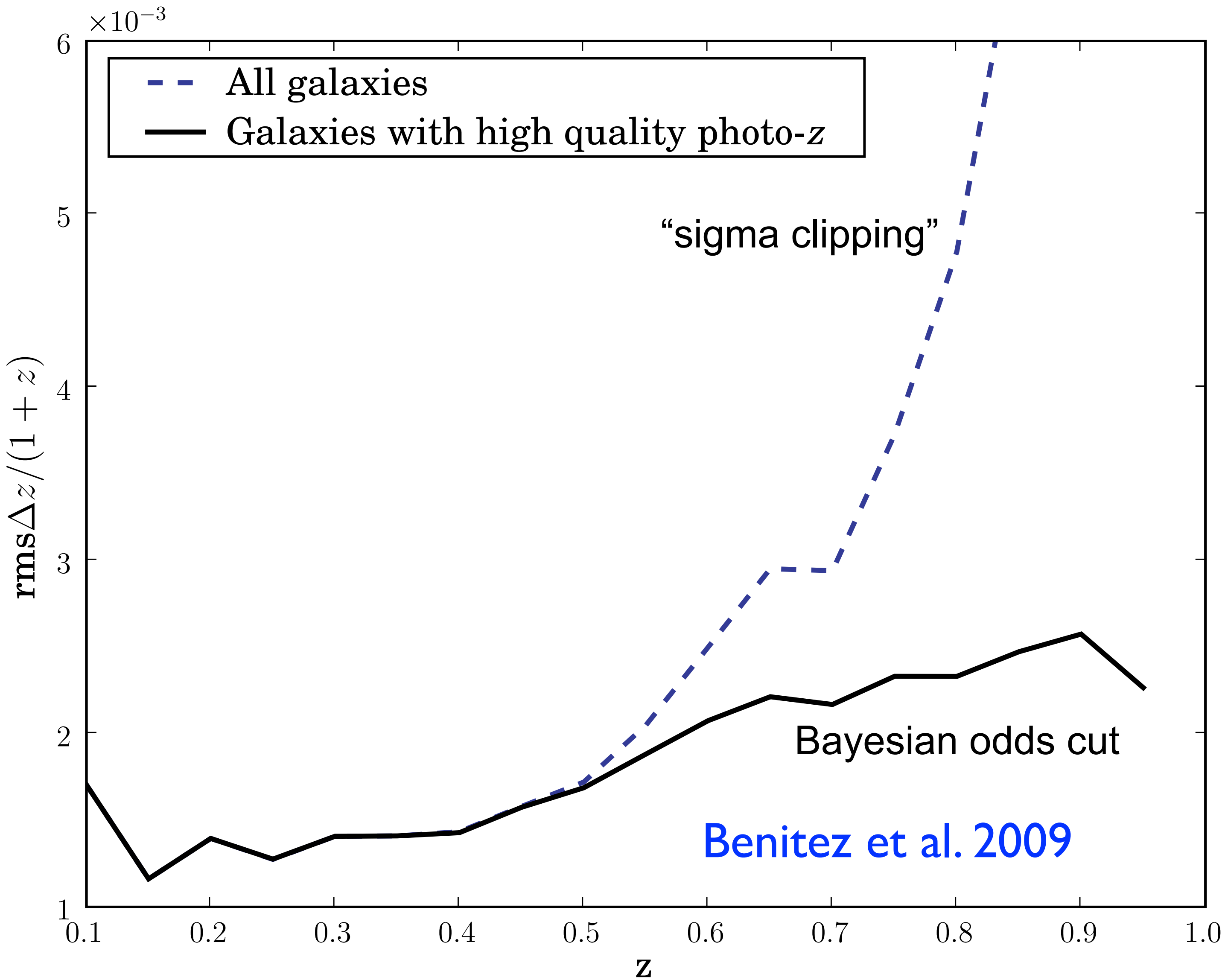


Figure 13. Photometric redshift error as a function of redshift, for all $L > L_\star$, $I < 23$ red galaxies, and for the subset with high-quality photo-z.

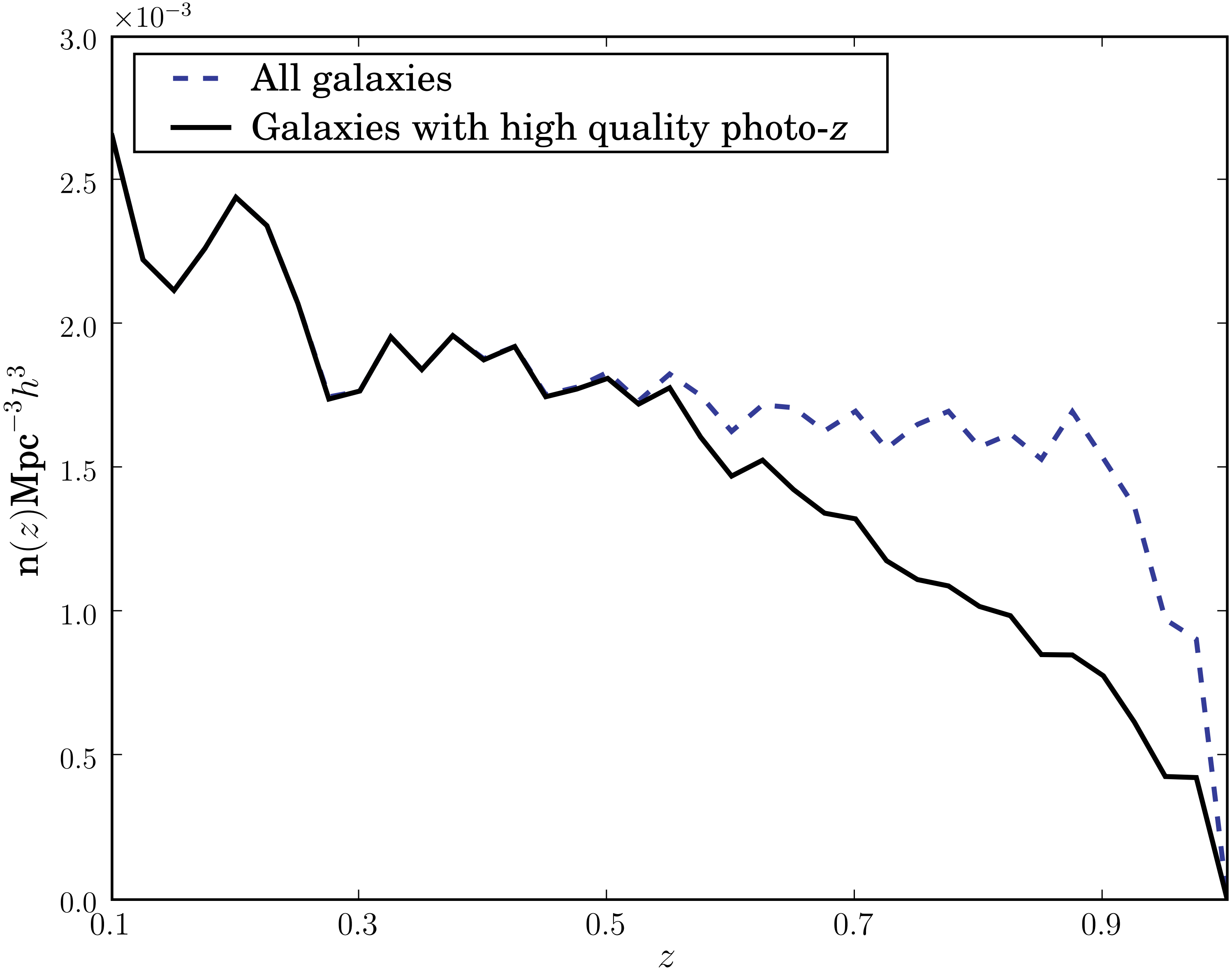


Figure 14. Spatial density as a function of redshift, for all $L > L_\star$, $I < 23$ red galaxies, and for the subset with high-quality photo-z.

JPAS MOCKS

- Fully empirical inputs: use 2sq.deg. COSMOS catalog to determine type, magnitude, redshift distribution (dz/(1+z)~0.008 at I=22.5, 0.7% outliers)

- Heavily randomize redshifts, types

- Generate realistic photometric noise simulations

  - Use RON=6e, 4 exposures per filters, 1800 useful hours/year (60%), 12s readouts
  - Exposure times 231s-462s
  - Take into account filter “scrambling” to reduce pupils ghost
  - Use directly measured Javalambre sky corrected by moon phase, solar cycle
  - Reduce theoretical S/N by 25%-10% (empirical corrections)
  - On top of that, add 6%-8% photometric noise due to photometric systematic noise (calibrated to reproduce photo-z performance on real data)

- Total available area 8600 sq.deg.

- About 10% of the time available for repeat observations

- Complement observations with u,g from T80 telescope

JPAS MOCKS

Three scenarios/survey speeds

- 28 filters: 2500 sq.deg/year, 3.6 yrs : 2014- 2018

(0.7<z<1.4) galaxies

- 42 filters: 1875 sq.deg/year, 4.8 yrs : 2014- 2019
- 56 filters: 1500 sq.deg/year 6yrs : 2014- 2020

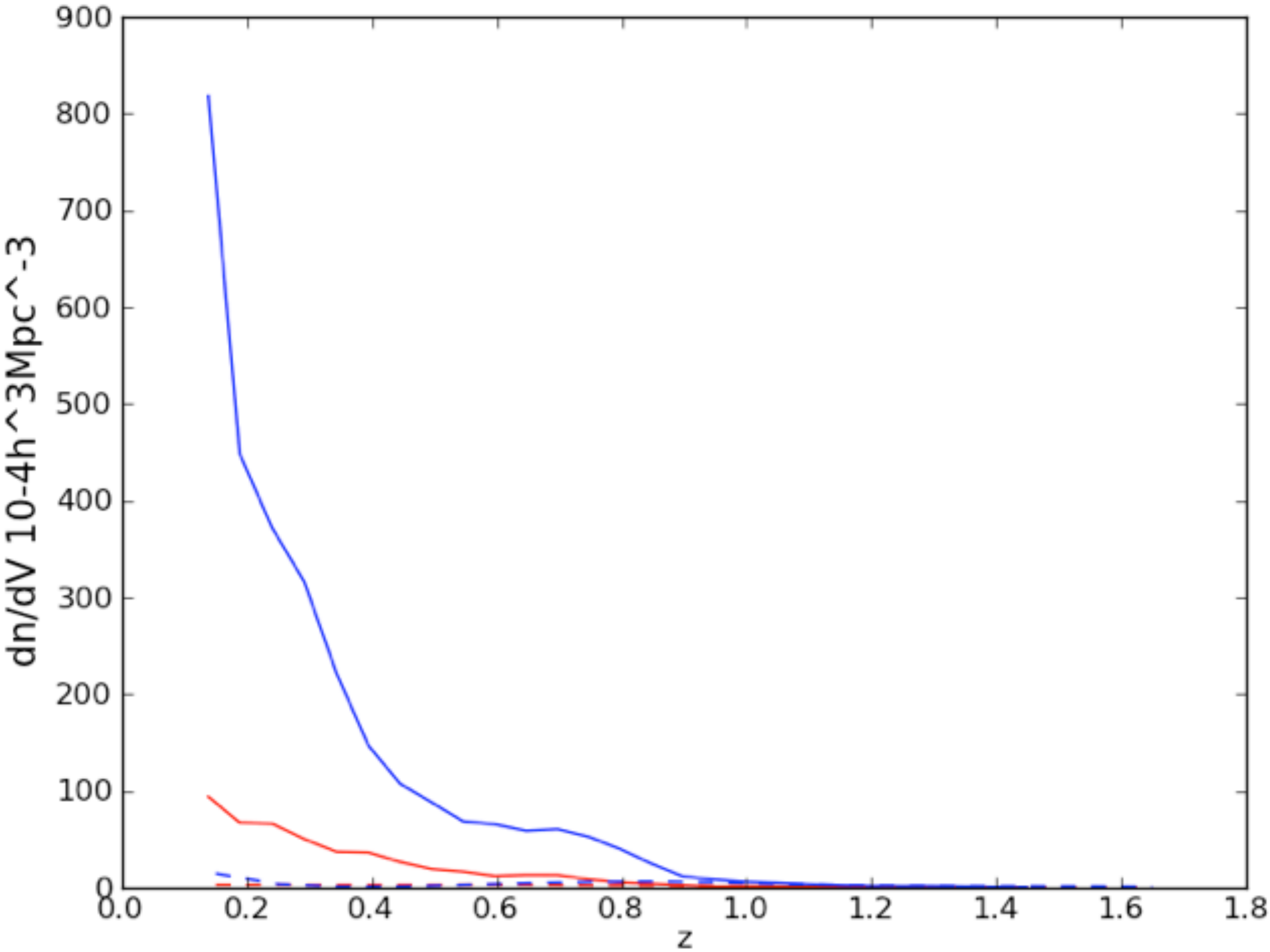
Effective volume

$$V_{\rm eff}(k,\mu) = \int \left[\frac{n(\vec{r})P(k,\mu)}{n(\vec{r})P(k,\mu)+1}\right]^2 d\vec{r}$$

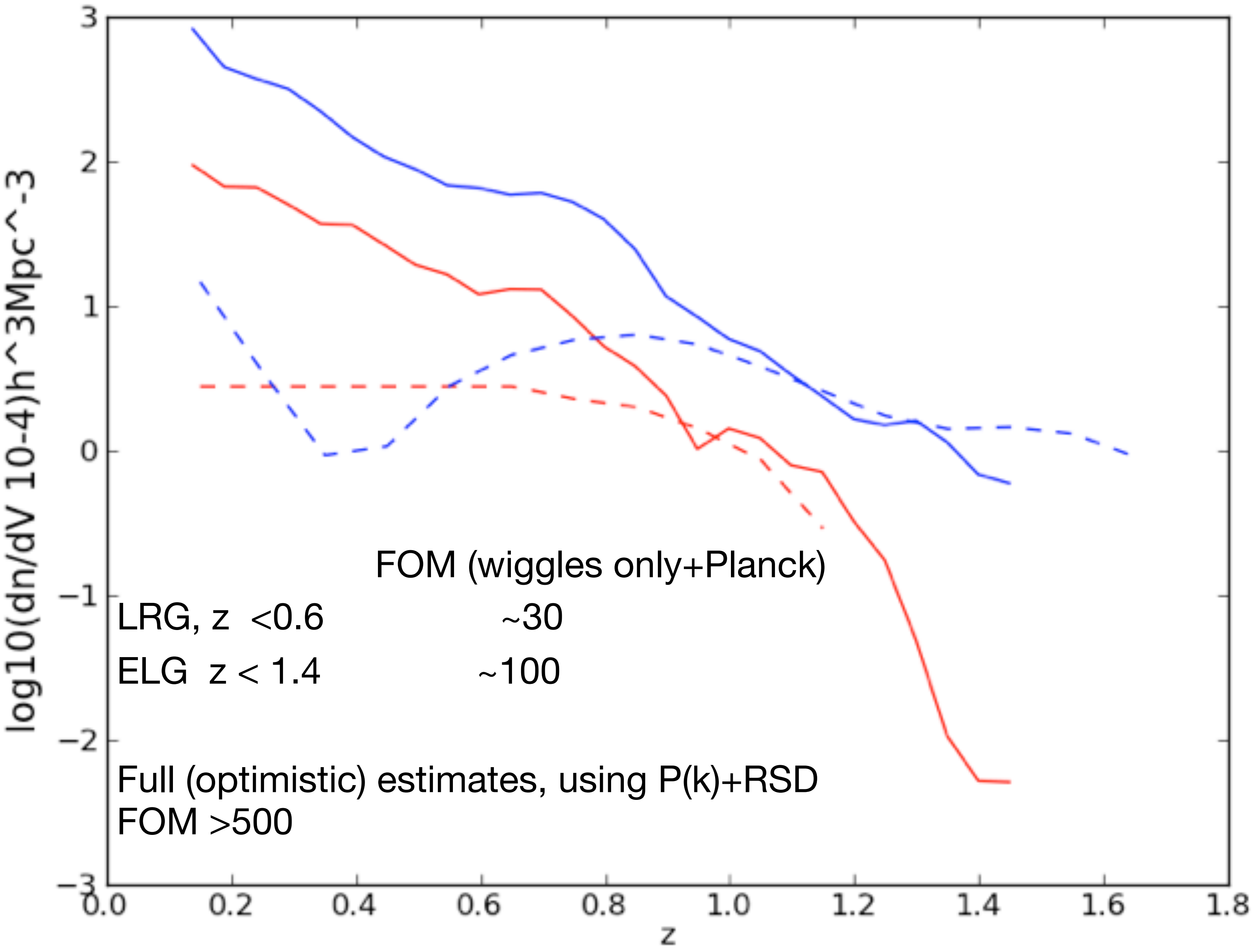
$$= \left[\frac{nP(k,\mu)}{nP(k,\mu)+1}\right]^2 V_{\rm survey},$$

All other things being equal, we want to...

- Sample as much volume as possible
- Keep nP > 1



dn/dV 10-4h^3Mpc^-3
900
800
700
600
500
400
300
200
100
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
z


FOM (wiggles only+Planck)
LRG, z <0.6 ~30
ELG z < 1.4 ~100
Full (optimistic) estimates, using P(k)+RSD
FOM >500
log10(dn/dV 10-4)h^3Mpc^-3
z
3
2
1
0
−1
−2
−3
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8

JPAS non-BAO science

SN-all types

- Automatic census of ***all*** SN types in regions of the survey with appropriate cadence
- Multiband observations provide automatic classification by type

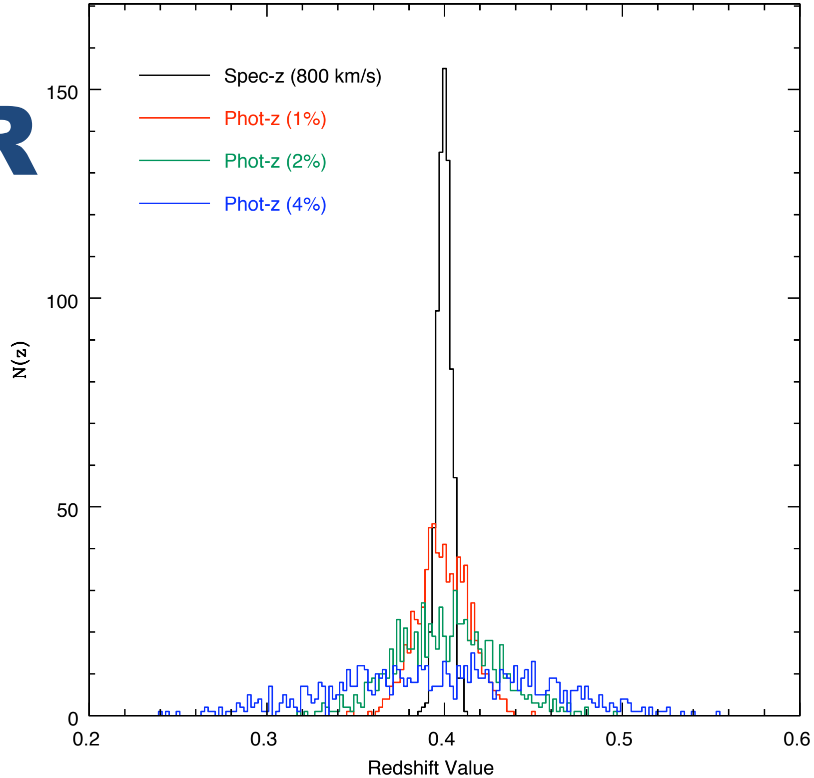
Weak lensing

- Javalambre has excellent seeing conditions (median ~0.7 arcsec)
- Good seeing is quite stable in time
- Broad band “detection image”: unique resource for lensing

Cluster counting

- Automatic census of most $L > L^*$ galaxies for $z < 1$
- High photo-z resolution: lower mass detection threshold
- Best optical cluster catalog available for $z < 1$
- SED information available: use stellar mass as calibrator for total mass

OPTICAL CLUSTER DETECTION



- $S/N \sim N_{200} / (N_{back})^{0.5}$
- $N_{200} \sim M_{200}^{0.8}$ (Hansen et al. 2010)
- $N_{back} \sim r_{200}^{2} \Delta z \sim N_{200}^{0.84} \Delta z$
- $S/N \sim N_{200}^{0.58} \Delta z^{-0.5} \sim M_{200}^{0.46} \Delta z^{-0.5}$

$$(M_{200})_{S/N} \sim (\Delta z)^{1.09}$$

Broad band surveys Δz~0.04, JPAS Δz~0.003

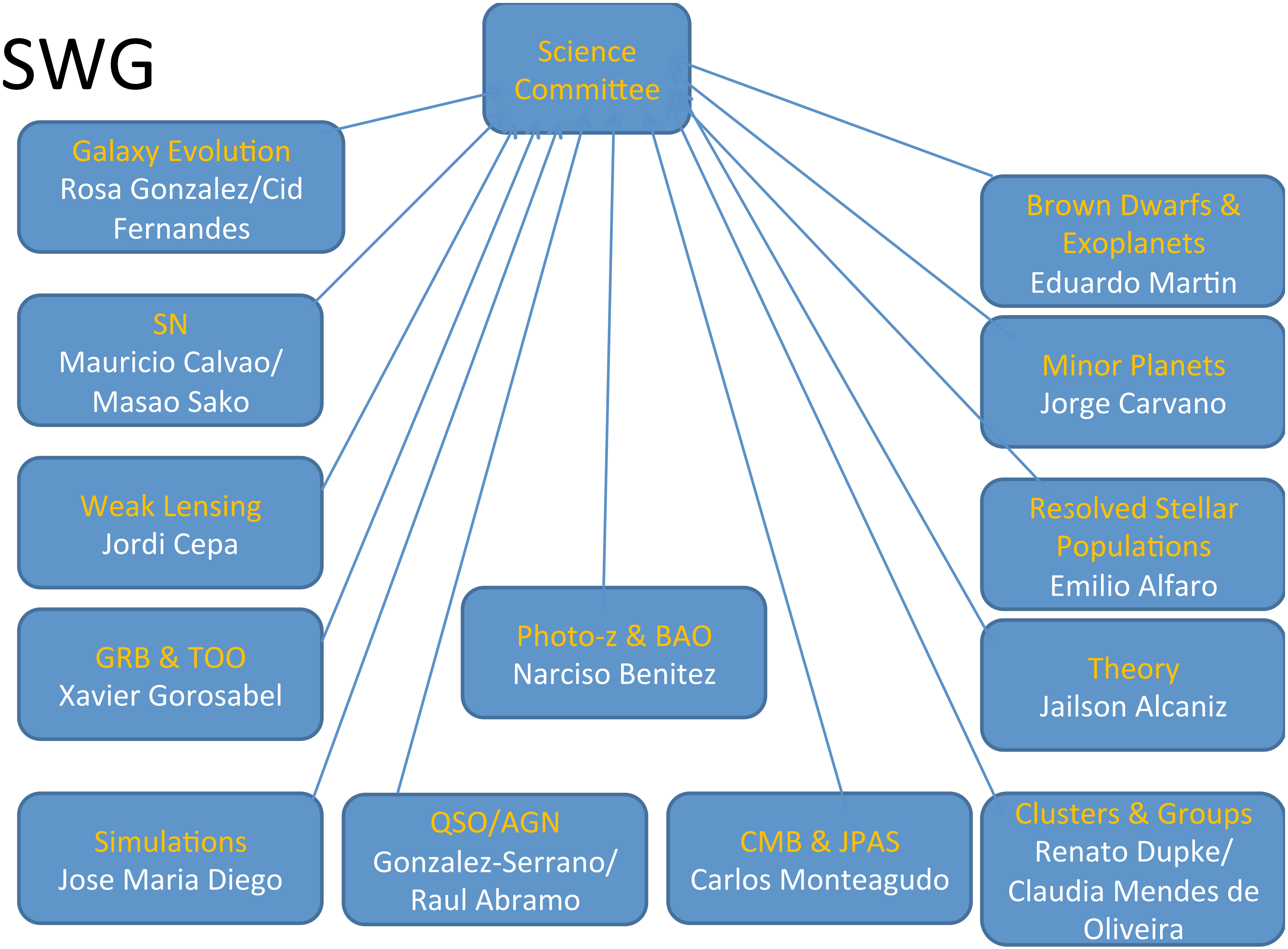
Galaxy Evolution

- Low-res spectroscopy of everything up to $I<22.5$
- Filter set carefully designed to detect emission lines in the local universe
- Redshifts for every $L>L^*$ for $z<1$
- High quality broadband imaging: morphological classification, mergers

More Science

- QSOs: Unique survey, few M QSOs with 0.2-0.3% photo-z to $1<z<3$
- Stars: halo + area in the galaxy
- Asteroids: rotation spectrum
- GRBs
- Low-res spectroscopy of transients!
- Serendipitous discoveries, low frequency objects, etc.

SWG



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GRB & TOO
Xavier Gorosabel
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Jorge Carvano
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Theory
Jailson Alcaniz
Clusters & Groups
Renato Dupke/ Claudia Mendes de Oliveira

WHEN?

T250

March 2010: T250 contracted with AMOS

December 2011: T250 camera contracted

February 2012 : 1st E2V CCD

Fall 2012 : T250 telescope delivered

November 2012 : 16th CCD delivered

Fall 2013: T250 operational

Winter 2014: T250 camera delivered

2014: JPAS survey starts

2017-2018: $0.6 < z < 1.3$ BAO survey finished

End 2020: Full survey finished

T80:

November 2011: T80 Camera contracted

Fall 2012: T80 operacional

November 2012: T80 camera delivered

Spring 2013: T80 camera operational: miniJPAS starts

JPAS

Spanish-Brazilian Stage IV "experiment": FoM > 100 by ~2018

Equivalent to 720 nights at a 4m telescope with a 5000 fiber spectrograph

~100M galaxies with 0.3% photo-z

~300M galaxies with 1% photo-z

~ few M QSOs with 0.3% photo-z

~0.7 arcsec image of the Northern Sky

- Extremely mass sensitive optical cluster catalog

- Excellent characterization of low-z SN systematics

- Pixel-by-pixel low-res spectrum of the whole northern sky up to m~23/arcsec^2

Unique, fundamental data for many Astrophysical areas

COMING SOON!