Ground-based requirements
or
Euclid photo-*z*performance **

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** based onBordoloi, Lilly &Amara, 2009, arXiv: 0910.5735

Photo-z for weak lensing tomography

(1) Construction of redshift bins → source planes

To minimiseoverlap and intrinsic alignment effects: sets a requirement on individual photo-zdispersion around a mean: **$\sigma_z < 0.05(1+z)$**

(2) Determination of $N(z)$ of these bins to map to cosmology

Must measure ensemble<z> with a bias in the mean **$\sigma_{<z>} < 0.002(1+z)$**

(1) is required for all objects, so must be based on photo-z. However, lensing is robust to "a priori" exclusion of subsets of the data.
(2) can be done with "direct spectroscopic calibration" or with continued reliance on photo-z

Photo-z codes

<table>
<tr><th>“Template fitting”</th><th>“Training” (e.g. artificial neural nets)</th></tr>
<tr><td>• Based on limited dimensionality of SED in population
• Easy to include reddening etc. as extra parameter(s)
• Can iteratively self-correct photometric zero-points, effective wavelengths etc.
• Wrong or evolving templates? Can iteratively adjust templates using spectro-z(on brighter sample, or subset with better photometry?)</td><td>• Empirical - no assumptions about galaxies
• Training with spectro-z (or templates)</td></tr>
<tr><td colspan="2">Both approaches:
• Can produce P(z) for each galaxy, usually including some Bayesian prior
• Can yield “goodness of match” for individual galaxies, i.e. confidence
• Obviously benefit from higher S/N and more photometric bands</td></tr>
</table>

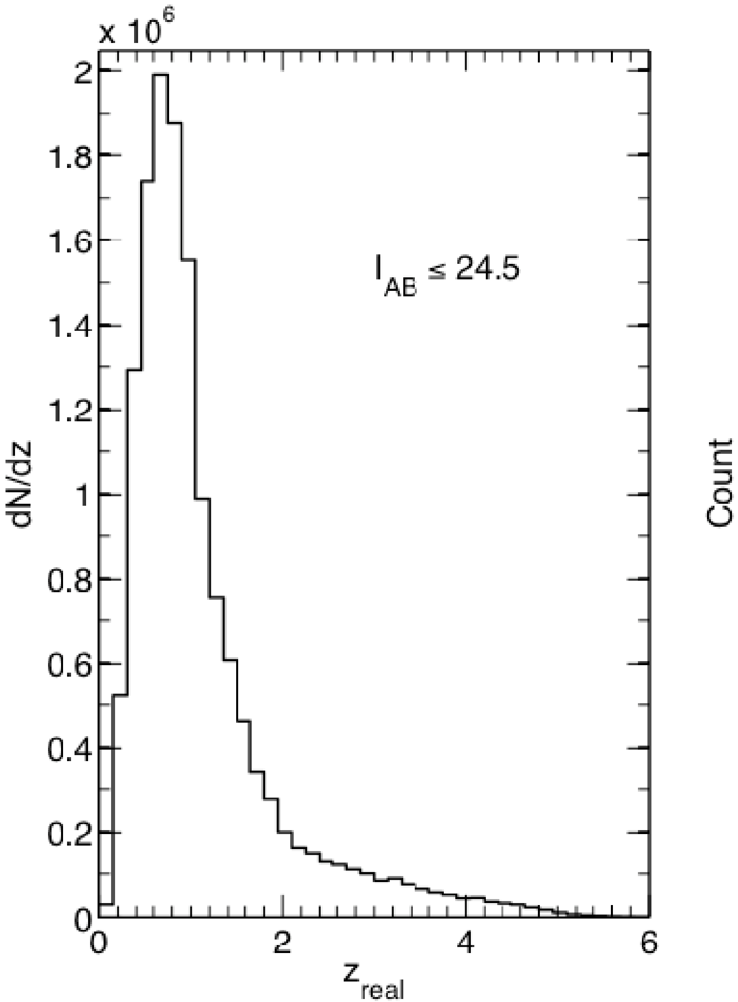
Choice between these is probably not the issue....

Photometric mock catalogues

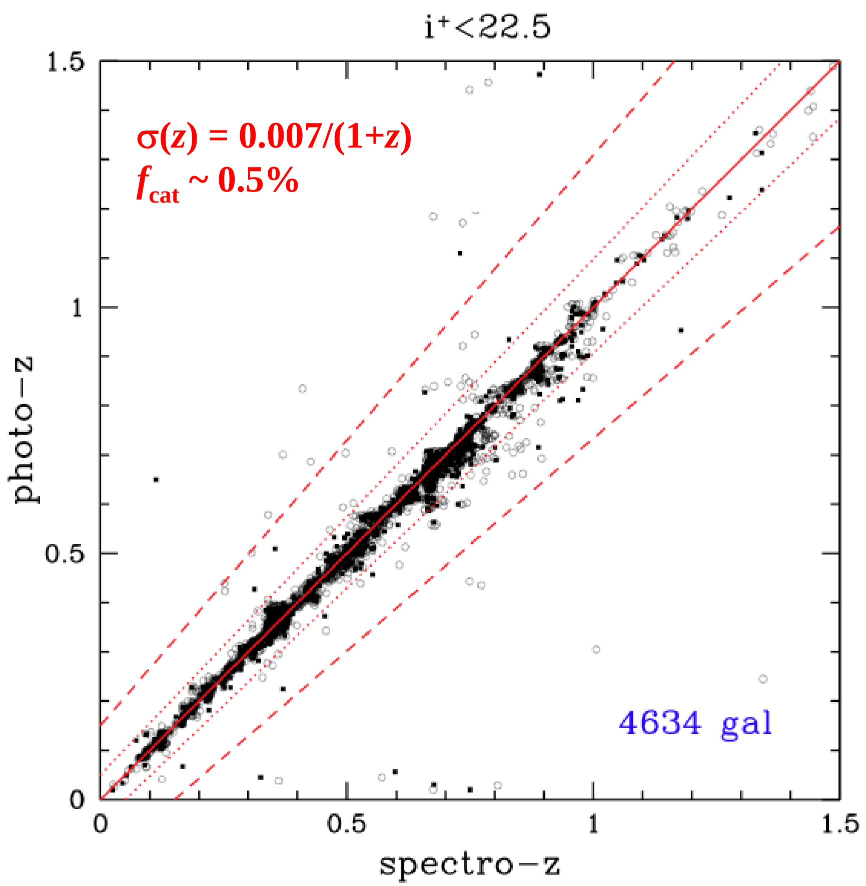
Generated from 10,000 templates** fitted to Kitzbichler& White (2007) Millenium mock COSMOS catalogues

Band	Survey-A	Survey-B	Survey-C
g	24.66	25.53	26.10
r	24.11	24.96	25.80
i	24.00	24.80	25.60
z	22.98	23.54	24.10
y	21.52	22.01	22.50
	Euclid	NIR	
Y	24.00	24.00	24.00
J	24.00	24.00	24.00
H/K	24.00	24.00	24.00
	PS-1	**PS-2 or DES**	**PS-4 or LSST**

** as used in our ZEBRA template fitting photo-z code



COSMOS: there appear to be no intrinsic limitations (yet) to photo-zperformance



Ilbert et al. (2009) using COSMOS deep 30-band photometry, LePhare template fitting and very secure spectro-z from zCOSMOS

•relatively bright (I_{AB}< 22.5), high S/N

•relatively low redshift (z< 1)

•approx 20% rejection, primarily for photometrically masked areas

•open symbols eliminated due to bi-modal *L*(z)

but

•did have to deal with issues of very different PSFs

→no evidence for any *systematic* problems at the required level

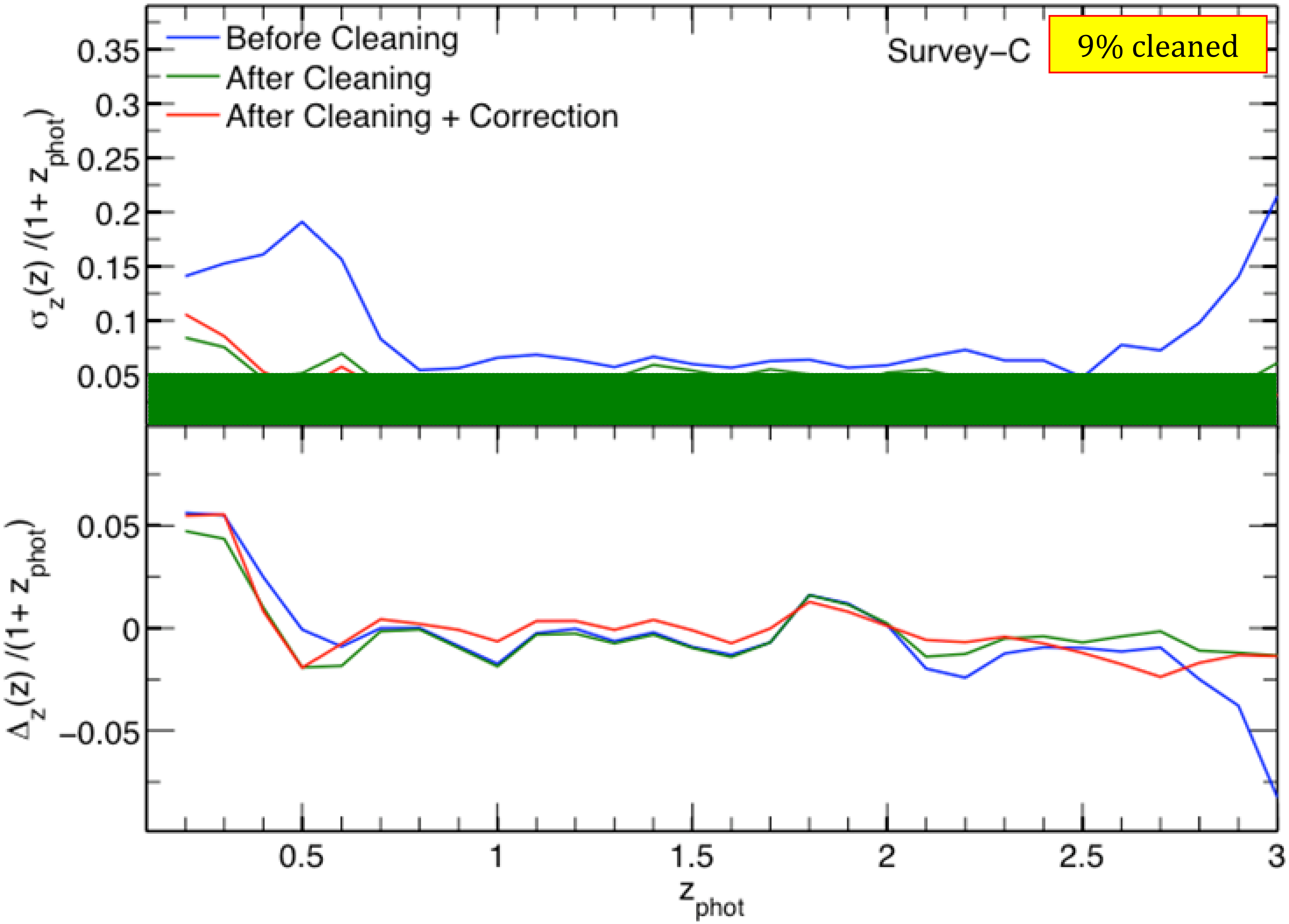
•better NIR →same performance z> 1

•easy to model degraded photometry performance (S/N, missing bands etc).

Issues to be covered

- What is needed from the photometry and from cleaning techniques to reach $\sigma_z < 0.05(1+z)$?
- Issues with the direct spectroscopic determination of $N(z)$ – esp.the effects of Large Scale Structure (cosmic variance).
- How to construct $N(z)$ from the photo-z themselves to reach $\sigma_{<z>} < 0.002(1+z)$?
- What are the effects of incorrect Galactic reddening and can A_V be determined from the photometric data ?
- What are the effects of photometrically merged galaxies in terms of the photo-z from their composite SEDs ?

σ(z) performance on individual objects



Nominal Euclid 3-band NIR plus 5-band PS-2 or DES-like depth is good enough with ~13% of objects a priori rejected

Direct spectroscopic calibration on N(z)

Abdalla et al (2007): Mean z must be known to $\sigma_{<z>} \sim 0.002(1+z)$, or 1% of typical bin width $\sim 0.2(1+z)$, implying of order 10^4 redshifts per bin.

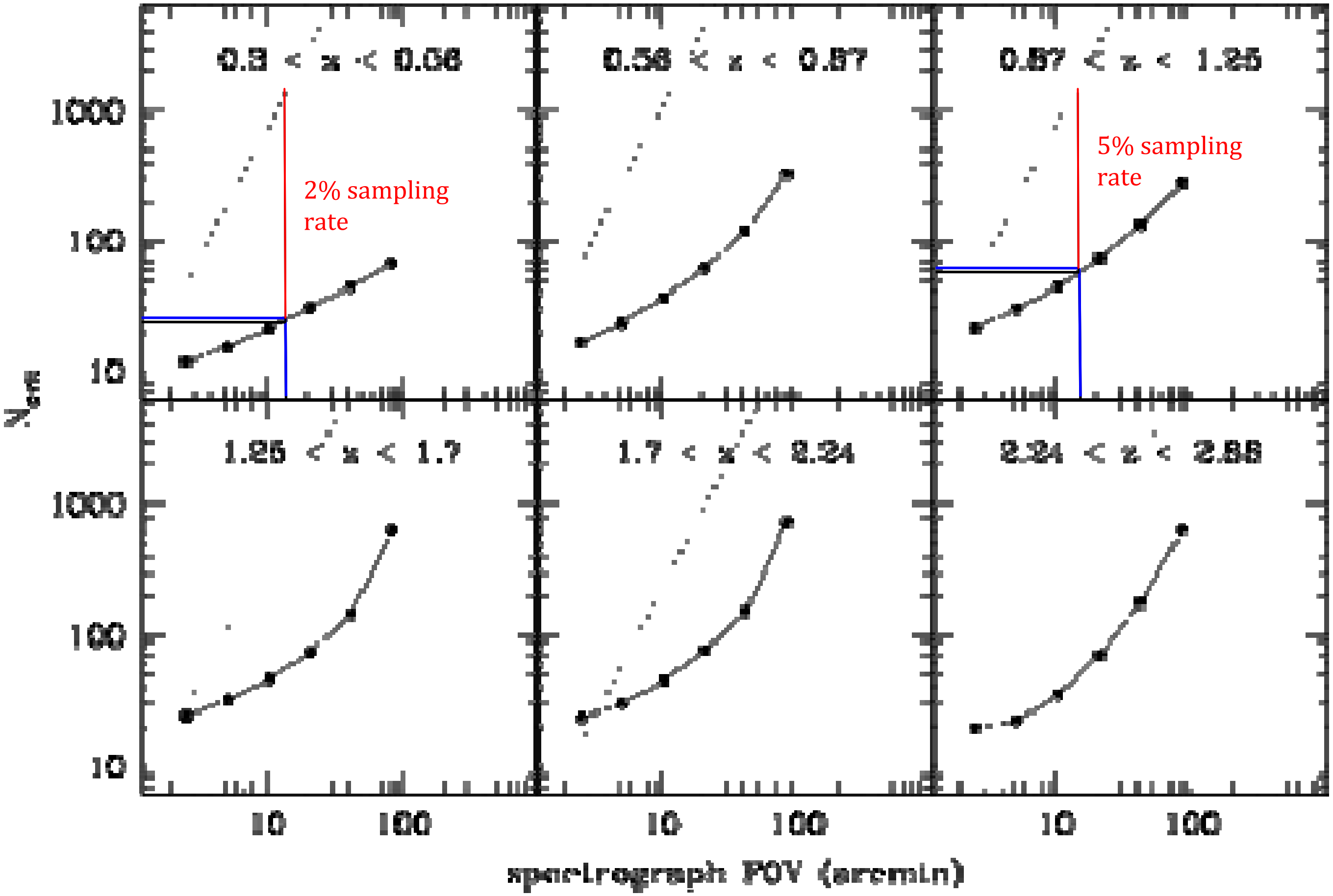
Must be:

•highly representative in (a priori) selection
•highly "complete" in redshift success
•redshifts highly reliable
•must sample range of e.g. A_V

•significant issues of Large Scale Structure in spectroscopic survey field(s)

Effects of lSS on spectroscopic surveys

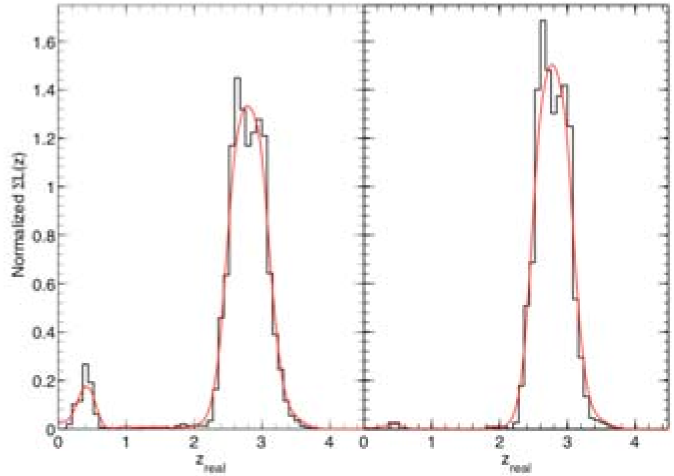
How many redshifts can you measure in a field before the <z> is dominated by the effects of large scale structure rather than Poisson variance?



Need 10^4 galaxies per bin at low sampling rates, implying many independent fields (~ 1000)

Photo-z measurement of N(z)

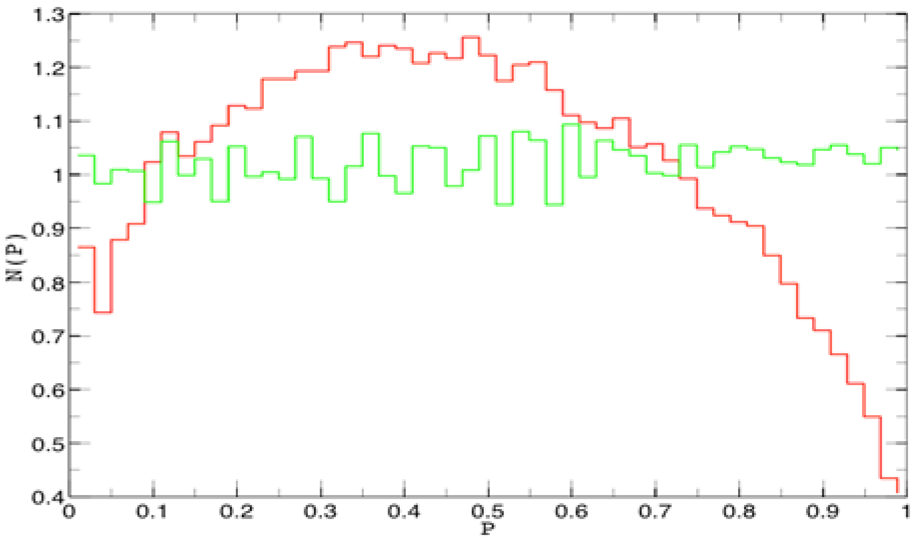
- Use z_{ML} as in bin construction ? ✗
- Use $N(z) = \Sigma L(z)$? ✗
- Use $N(z) = \Sigma L(z)$ with modified $L(z)$? ✓



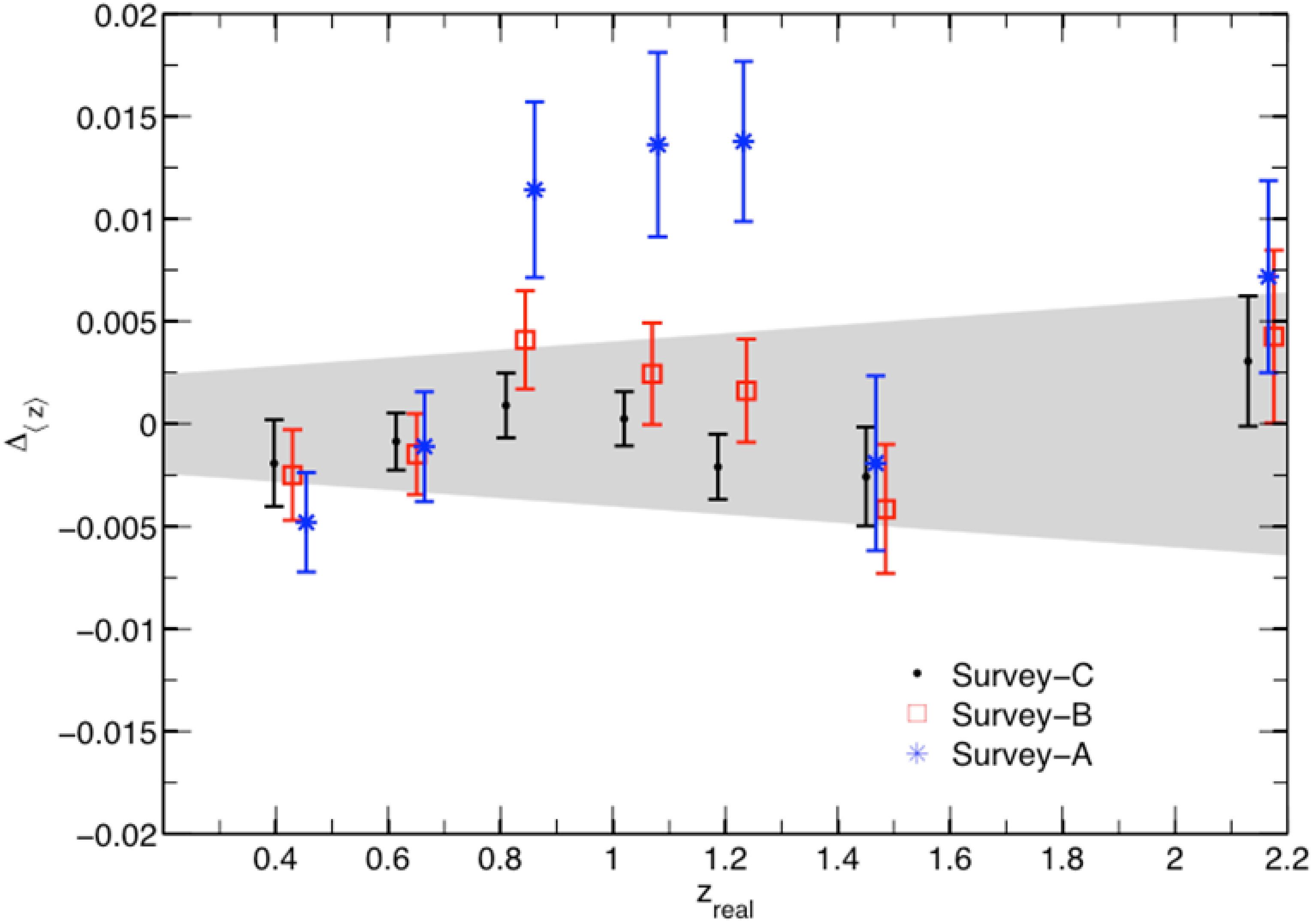
Measure redshifts for some subset of objects and define for each object P_i

For any set of objects, $N(P)$ should be flat. If it is not flat, apply correction to $L(P)$ to all objects to make it so.

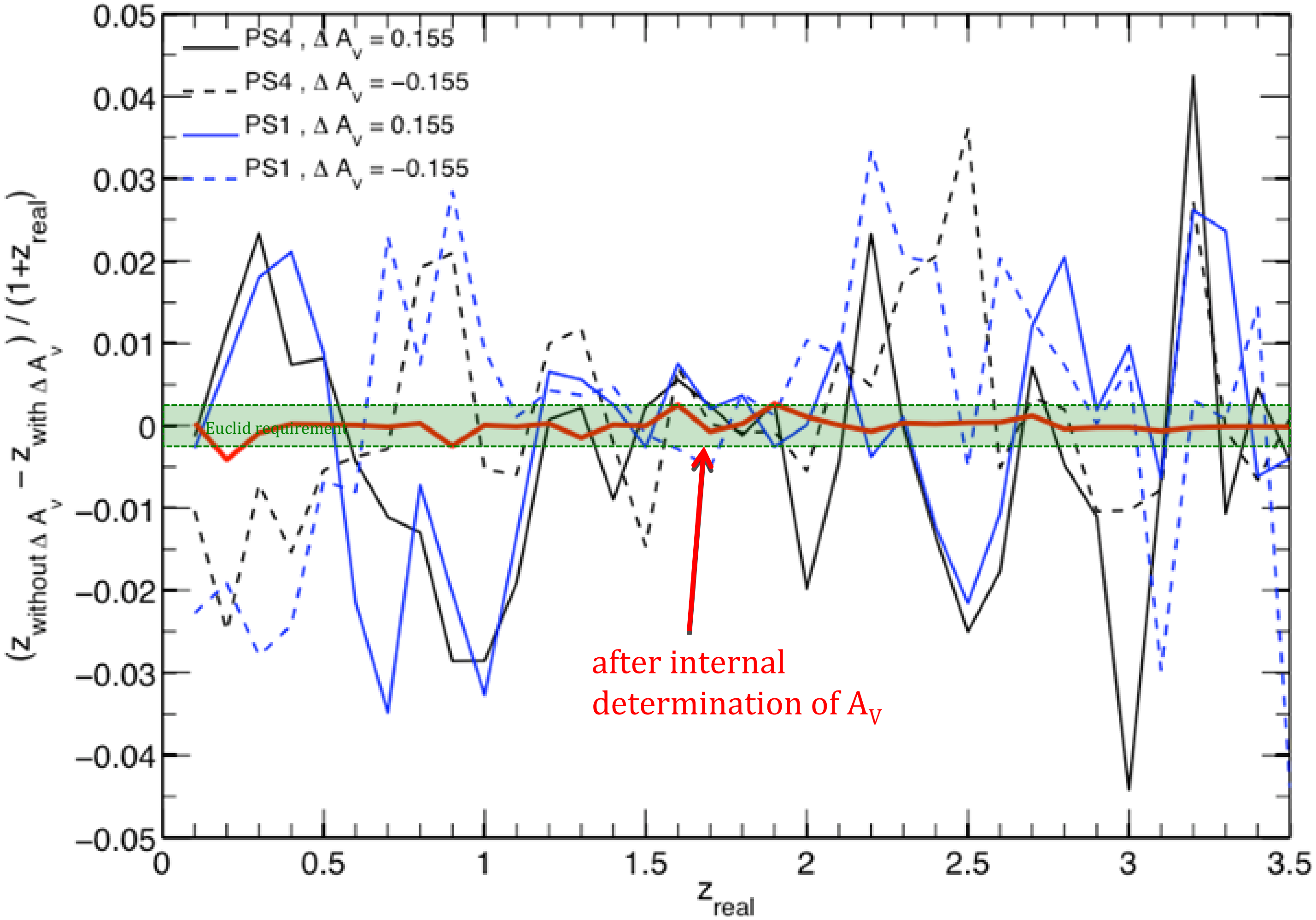
Use these corrected $L'(z)$ to construct the $N(z)$ for that bin



Estimation of Δ<z>after correction of L(z) using N(P)

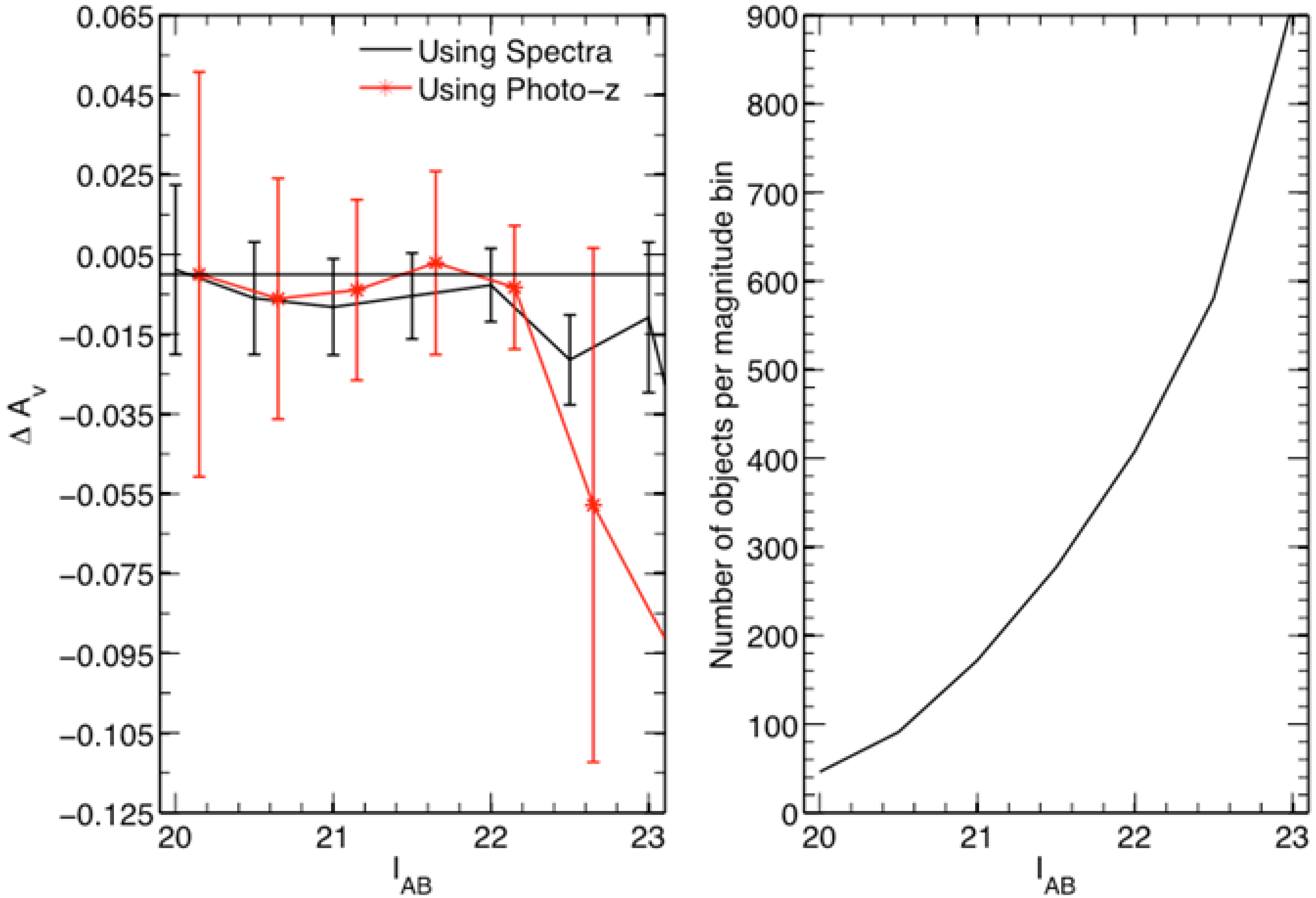


Effect on incorrect foreground Galactic extinction



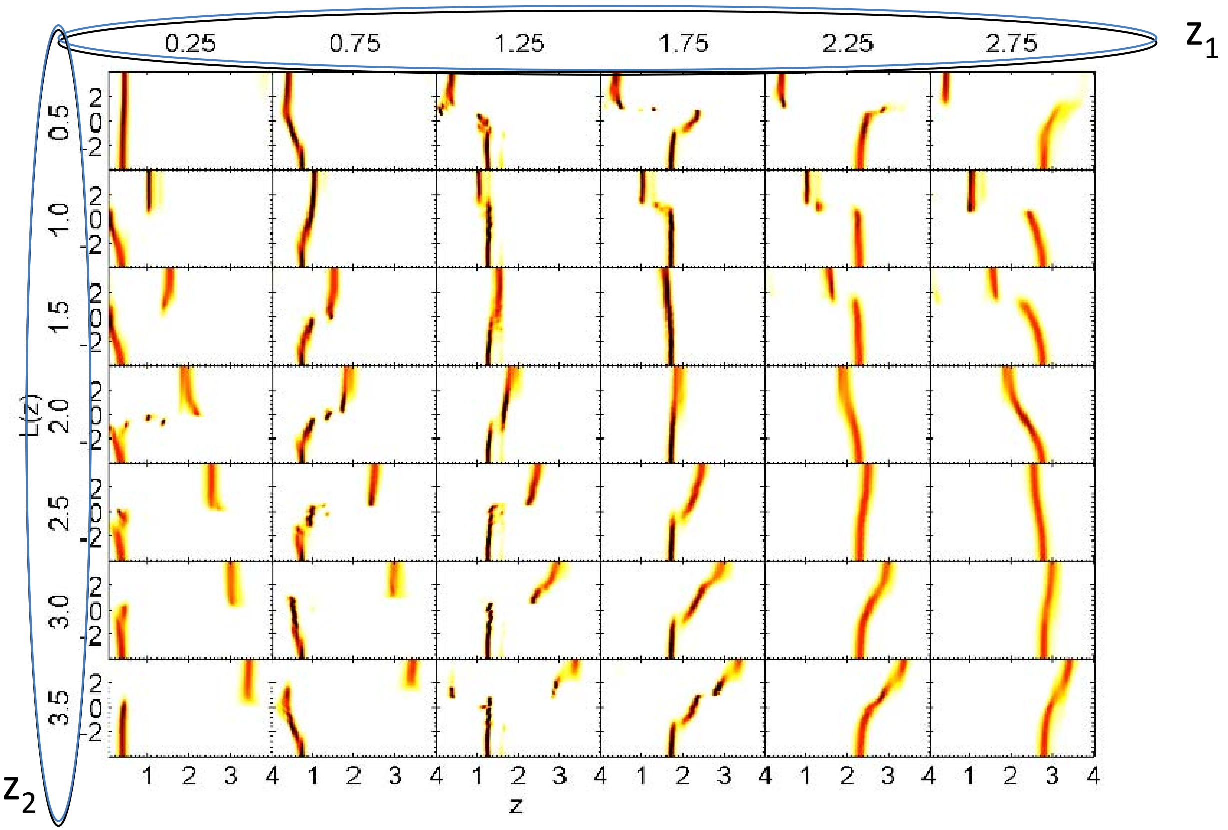
Can use either objects with spectro-z or unknown z

Required numbers correspond to of order 0.1 deg^2



Effects of superposed objects

Two SEDs at z_1 and z_2 superposed, always with I_{AB} = 23.5. How does L(z) output vary with magnitude difference Δm_{12} over $-4 < \Delta m_{12} < 4$

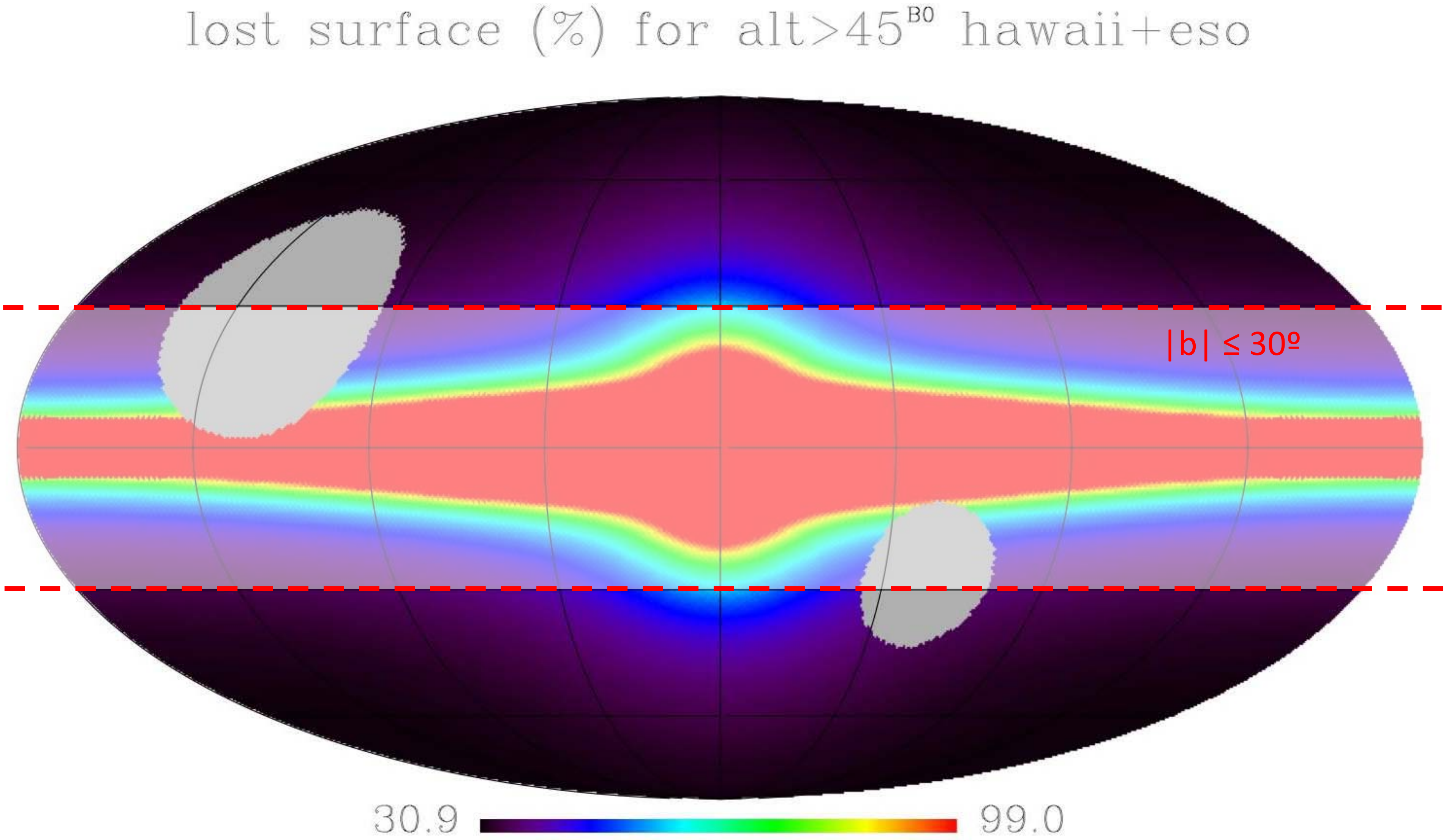


Safe for $|\Delta m_{12}| > 2$. Otherwise, complex behaviour: these objects are best removed from lensing analysis

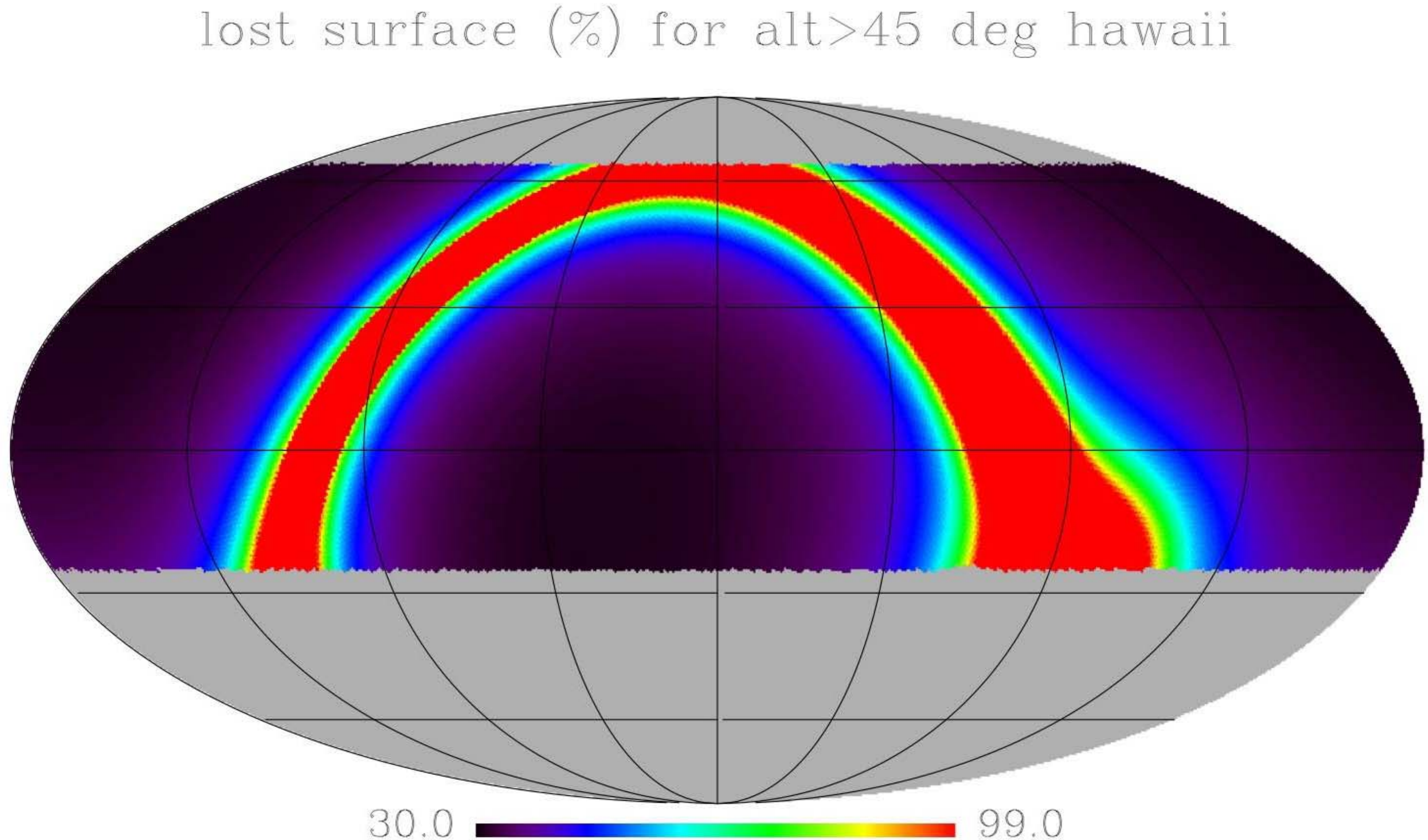
Summary

All sky photo-z performance at the level required for Euclid's weak lensing science goals will be demanding.

However, these goals are plausibly attainable with:
•foreseeable ground-based complements (e.g. PS-2)
•plus Euclid's own 3-band near-IR photometry.
• simple developments of existing photo-z techniques
- a priori elimination of most outliers (with some unavoidable "wastage") from $L(z)$ shape;
- use of $\Sigma L(z)$ to construct $N(z)$ with modification of $L(z)$ using $N(P)$, as an alternative to the difficult direct spectroscopic construction;
- "internal" measurement and correction of foreground Galactic reddening;
- morphological recognition and elimination of photometrically merged objects with Δm <2 mag.



less than 1.4 airmass (zenith angle ≤45º) from Hawaii and Chile



Assumed PanStarrs-1 coverage (2.65π sr *vs.* 3π sr planned)