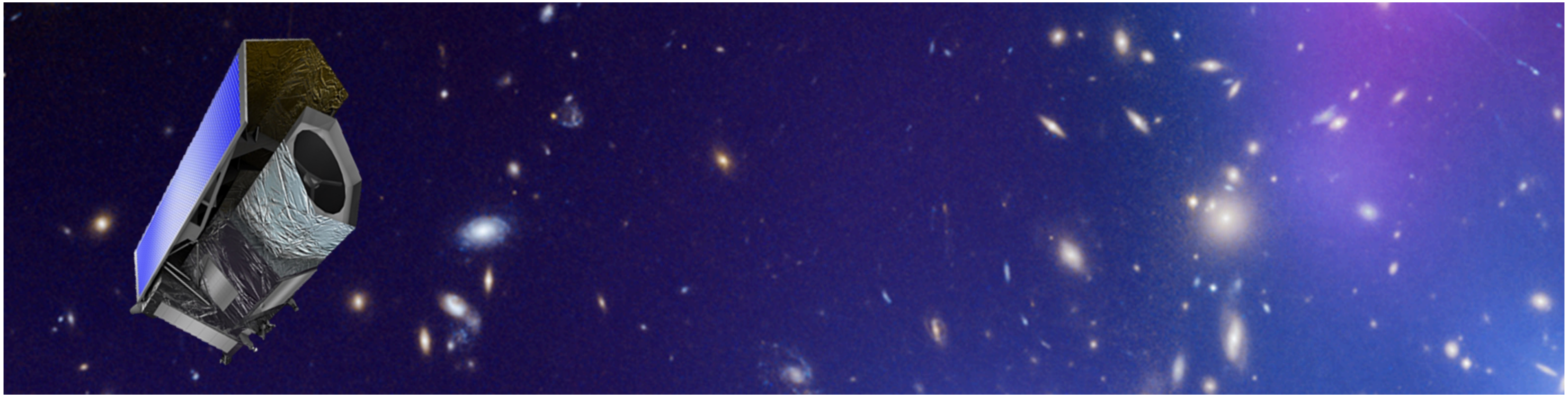
SED-dependent Galactic Extinction Prescription for Euclid and Future Cosmological Surveys



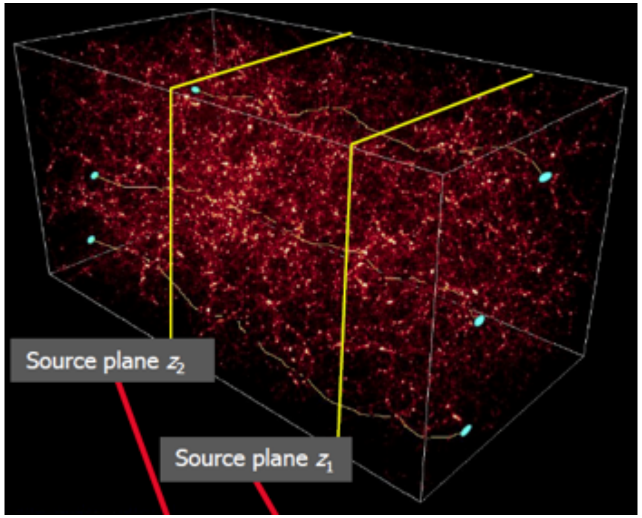
Audrey Galametz - MPE, Garching
On behalf of the OU-PHZ / SDC-CH Template-fitting Working Package

Galametz et al. 2016, A&A, "accepted", on astroph soon

Photometric redshift accuracy for WL

Weak-lensing analysis challenges:

- Accurate WL distortion measurement (high-resolution imaging)
- Accurate estimation of distances (photo-z)



Lensing tomography approach:

Binning galaxies in a number of tomographic bins

Cross-correlating the shape measurements between two planes of redshifts to extract shear signal

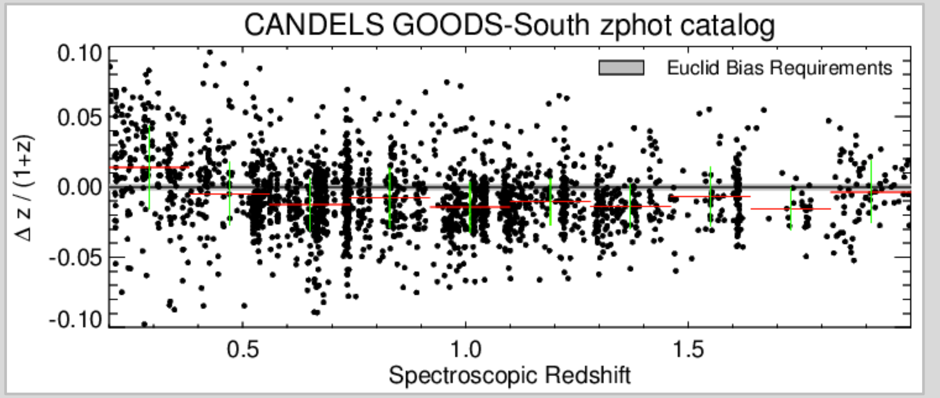
Accurate redshift information:

Construction of the bins:

$\sigma_z < 0.05(1+z)$

Knowledge of the mean of the bins.

$|z - z_{real}| < 0.002(1+z)$

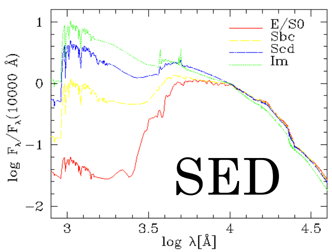


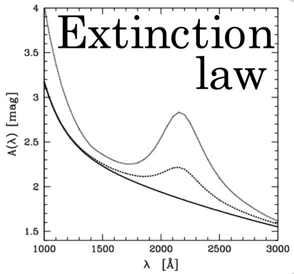
See Dahlen et al. 2013

The template-fitting algorithm

SED+Parameter Space

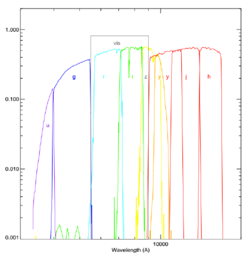
$\mathrm{IntE}_{B\text{-}V}$





Redshift grid

Filters



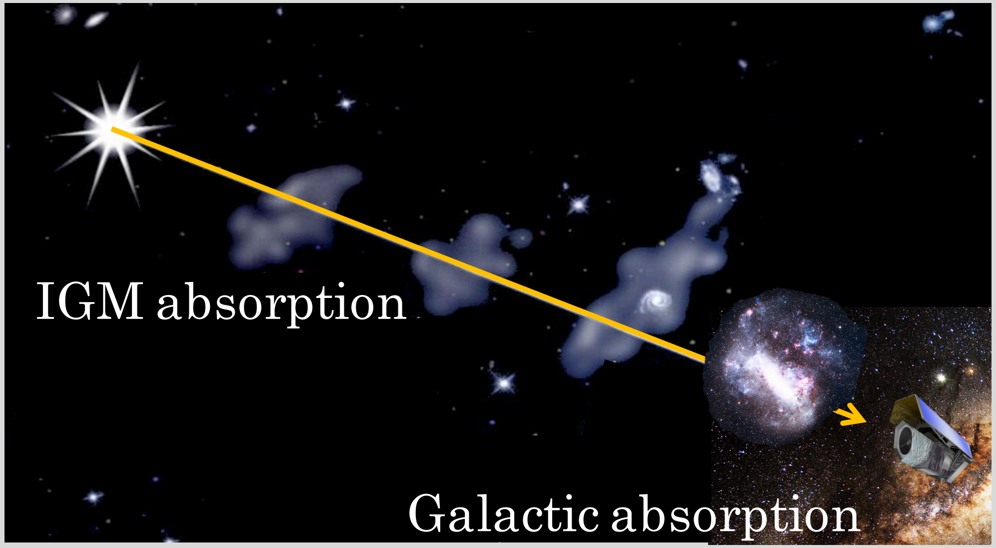
Template Flux catalogue

$$\chi^2(z, SED) = \sum_{i=1}^{Nfilt} \frac{(F_{i,obs} - \alpha F_{i,temp}(z, SED))^2}{\sigma(F_{i,obs})}$$

$$\alpha = \sum_j \frac{Fj,obs\, Fj,temp}{\sigma j^2} \Big/ \sum_j \frac{Fj,temp^2}{\sigma j^2}$$

$$\mathcal{L}(\mathrm{type_{SED}}, \mathrm{EXT\_LAW}, \mathrm{E(B\text{-}V)}, z) = e^{-\frac{\chi^2}{2}}$$

Observed Flux catalogue



Priors

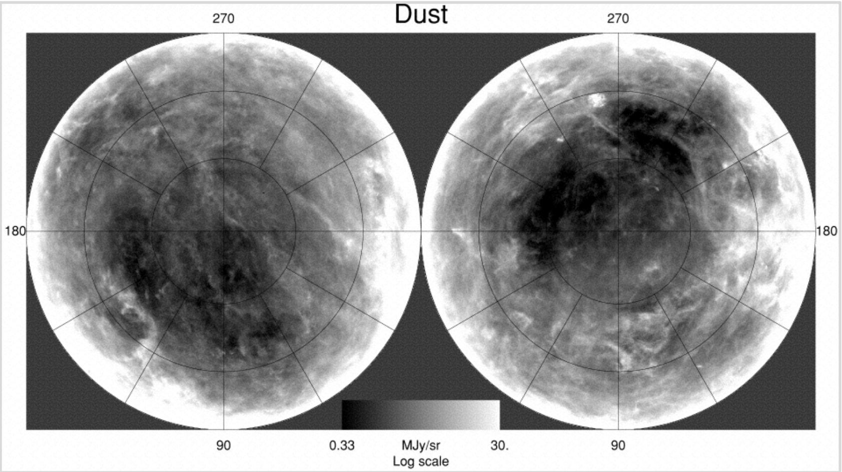
PDF(z)

Galactic extinction / E_{B-V} maps

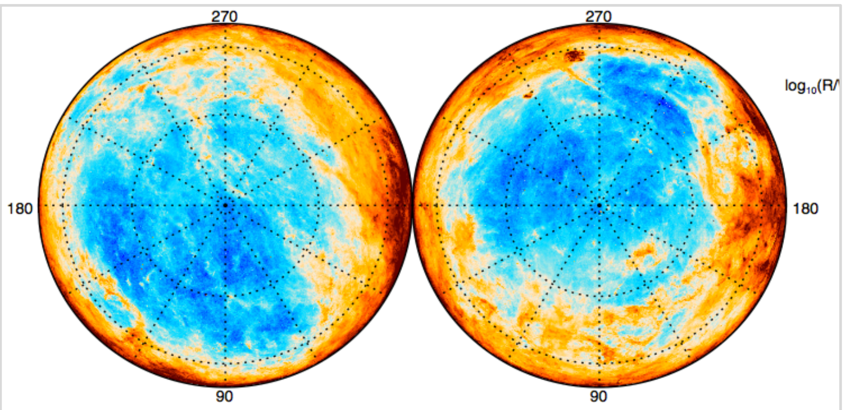
- Dust maps derived from:
    - Thermal emission in far-IR

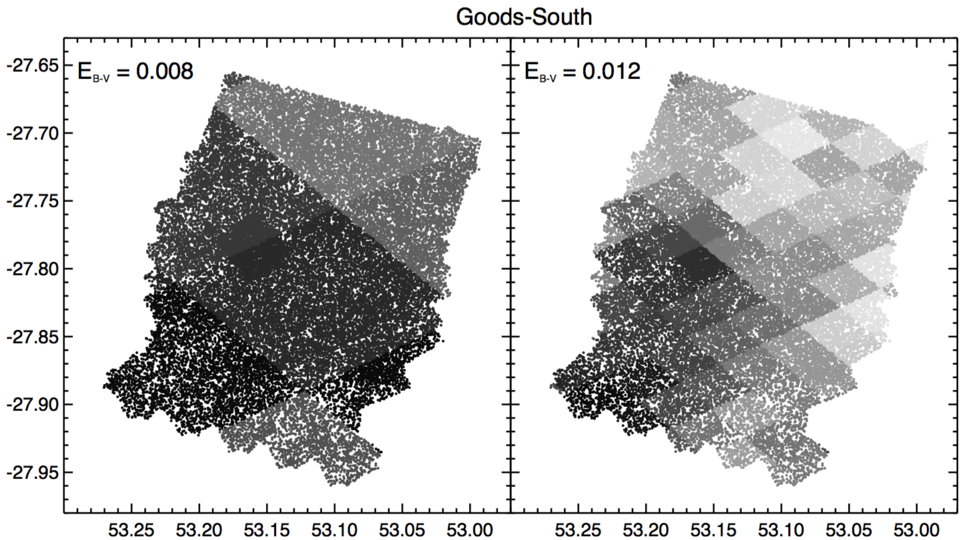
      100µm DIRBE+IRAS 6.1' resolution map (Schlegel 98)
    - Thermal dust radiance map: *Planck* (*Planck* XI 2014)

Schlegel et al. 1998



Planck XI 2014

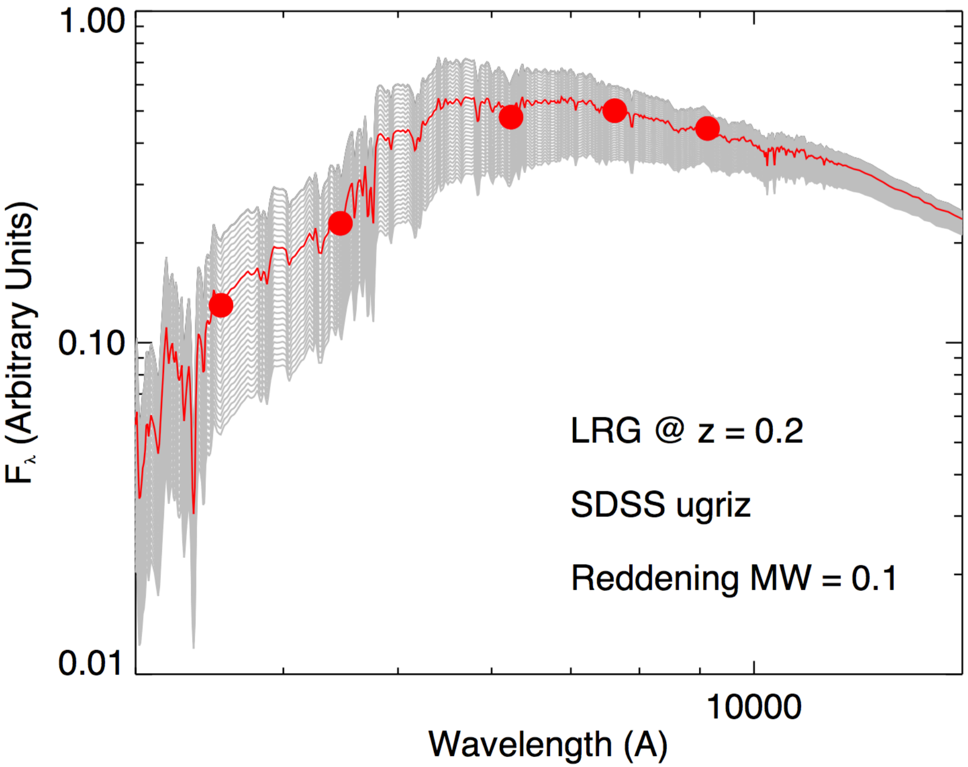


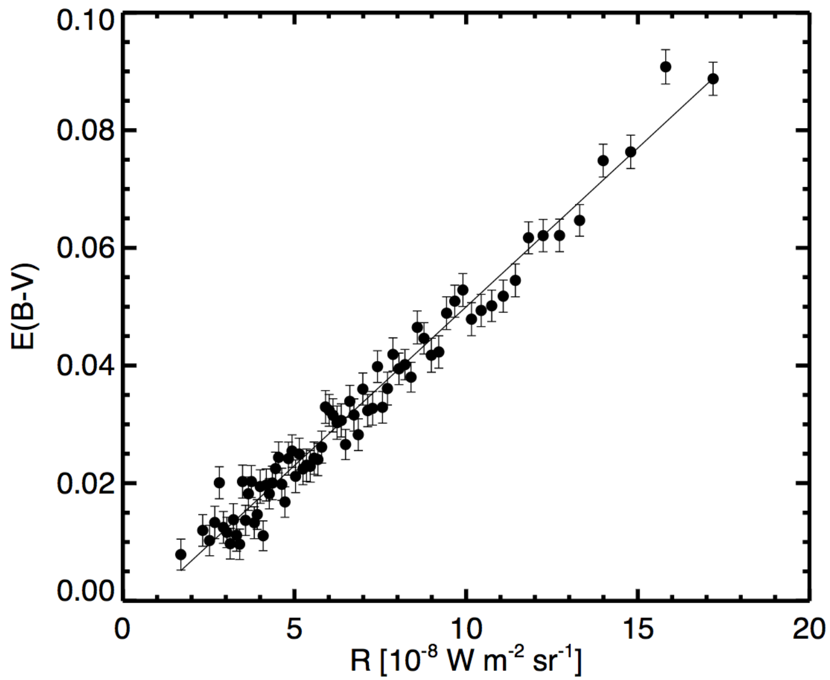


Schlegel 1998 Planck 2014

Calibrating Galactic extinction / E_{B-V} maps

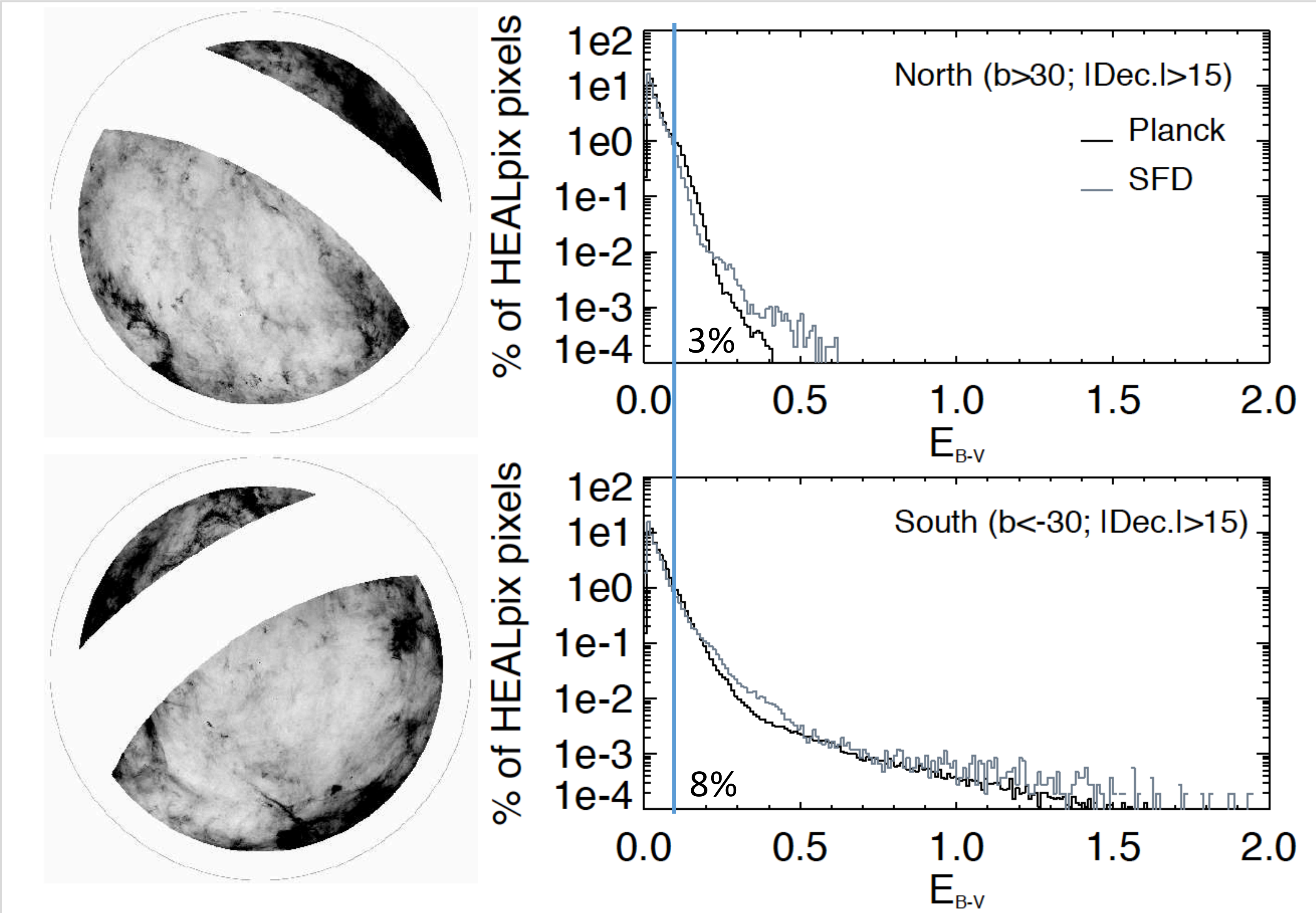
- Linearly rescaling dust column density maps ($E_{B-V} = pD$) i.e., deriving the scaling factor p from the observed color excesses of stars or standard cosmological sources with known SED





Planck Collaboration XI (2014)

Galactic extinction in the Euclid Wide Survey

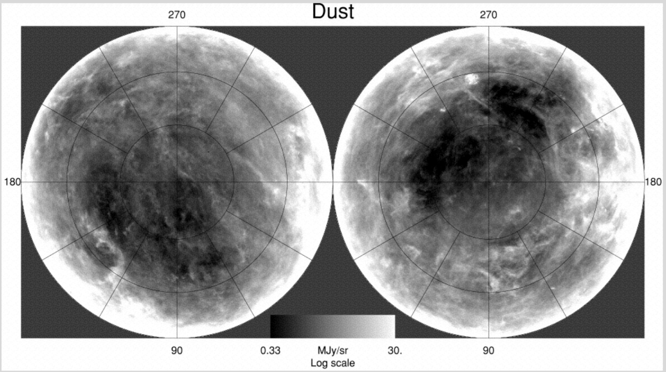


Classic Implementation of Galactic Reddening

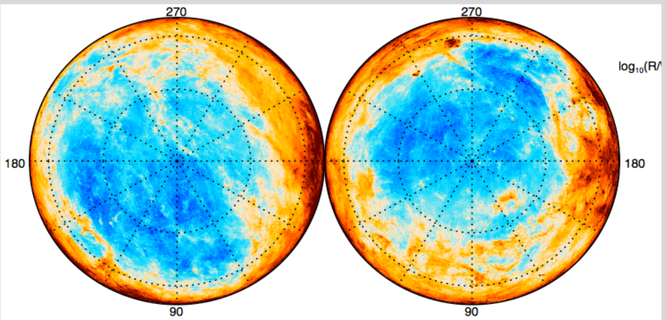
$$f_{int,X} = \frac{\int_X f_{sed}(\lambda)\, F_X(\lambda)\, d\lambda}{\int_X F_X(\lambda)\, \frac{c}{\lambda^2}\, d\lambda} \qquad f_{obs,X} = \frac{\int_X f_{sed}(\lambda)\, 10^{-0.4 E_{B-V} k_\lambda}\, F_X(\lambda)\, d\lambda}{\int_X F_X(\lambda)\, \frac{c}{\lambda^2}\, d\lambda}$$

Line-of sight E_{B-V}

Schlegel et al. (1998)

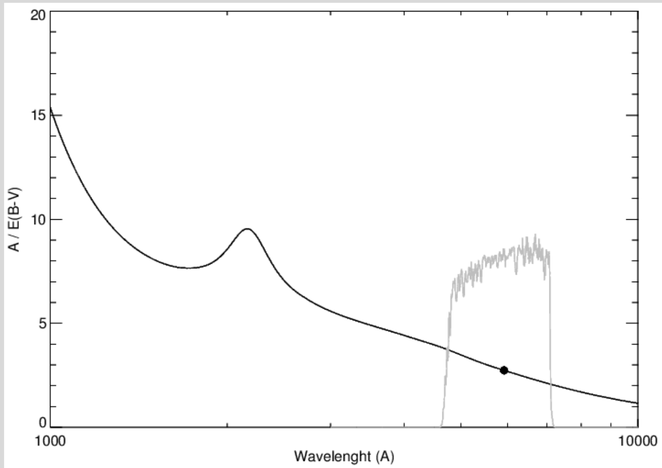


Planck XI (2013)



X

Milky Way Absorption curve



e.g., Fitzpatrick (1999) with $R_V = 3.1$
k_λ at pivot wavelength of DES R-band

➔ $\Delta m = k_{pivot} \times E_{B-V}$

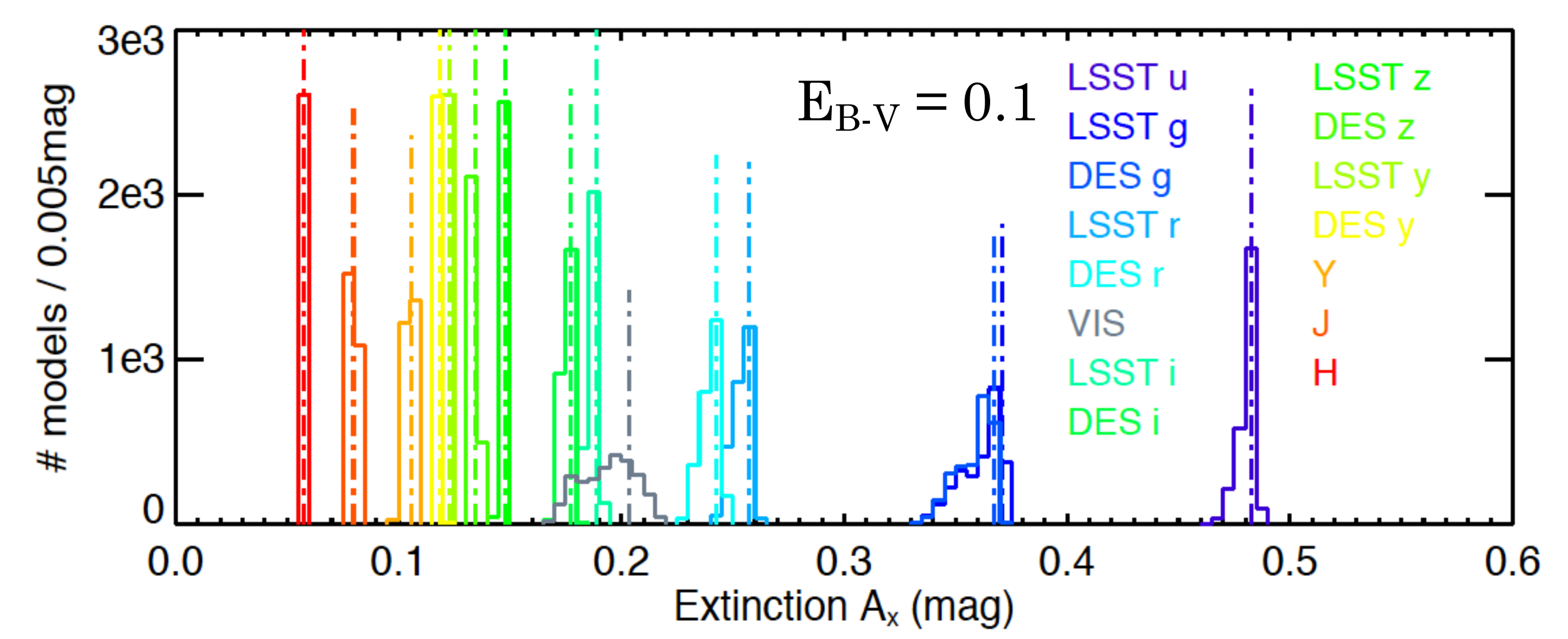
➔ $F_{obs} = F_{int} * 10^{-0.4\Delta m}$

Correction usually applied on the observed flux catalogue ('de-reddening')

Dependence of Galactic extinction with SED

If fluxes are measured through broad-band filters, the galactic extinction will depend on the source SED.

$$f_{obs,X} = \frac{\int_X f_{sed}(\lambda)\, 10^{-0.4 E_{B-V} k_\lambda}\, F_X(\lambda)\, d\lambda}{\int_X F_X(\lambda)\, \frac{c}{\lambda^2}\, d\lambda}$$



Relevant along high-reddening lines-of-sight and for broad/blue filters

Additional caveat in $E_{B\text{-}V}$ map calibration

- E_{B-V}^{sed}

$$= -2.5\log\left(\frac{\int_B f_{sed}\, 10^{-0.4\; E_{B-V}^{sed}\; k_\lambda}\; F_B\, d\lambda}{\int_V f_{sed}\, 10^{-0.4\; E_{B-V}^{sed}\; k_\lambda}\; F_V\, d\lambda} \;\; \frac{\int_V f_{sed}\, F_V\, d\lambda}{\int_B f_{sed}\, F_B\, d\lambda}\right)$$

where $k_\lambda = {}^{A_\lambda}\!/_{E_{B-V}}$

Additional caveat in E_{B-V} map calibration

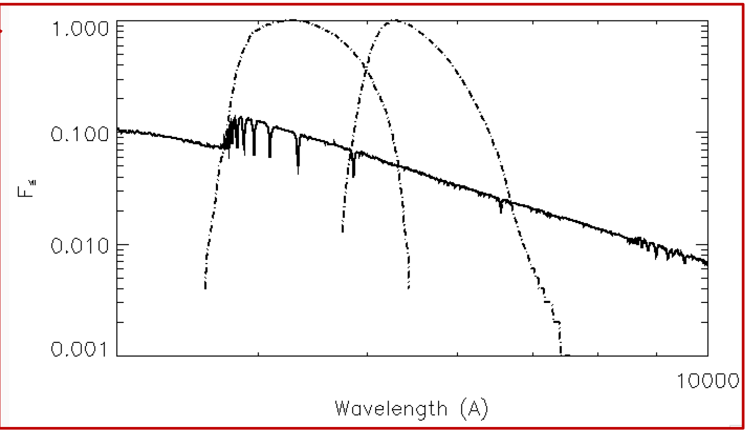
0.10

0.10

$$E^{B5}_{B-V} = -2.5\log\left(\frac{\int_B f_{B5}\ 10^{-0.4\ E^{B5}_{B-V}\ k_\lambda}\ F_B\, d\lambda}{\int_V f_{B5}\ 10^{-0.4\ E^{B5}_{B-V}\ k_\lambda}\ F_V\, d\lambda}\ \frac{\int_V f_{B5}\ F_V\, d\lambda}{\int_B f_{B5}\ F_B\, d\lambda}\right)$$

where $k_\lambda = {}^{A_\lambda}/_{E_{B-V}}$

k_λ from Fitzpatrick et al. 1999
Calibrated with B5 stars



Additional caveat in E_{B-V} map calibration

0.09

0.10

- E_{B-V}^{sed}

$$= -2.5\log\left(\frac{\int_B f_{sed}\, 10^{-0.4\, E_{B-V}^{sed}\, k_\lambda}\, F_B\, d\lambda}{\int_V f_{sed}\, 10^{-0.4\, E_{B-V}^{sed}\, k_\lambda}\, F_V\, d\lambda}\;\frac{\int_V f_{sed}\, F_V\, d\lambda}{\int_B f_{sed}\, F_B\, d\lambda}\right)$$

- The first estimate of Galactic extinction uses the Schlafly & Finkbeiner 2011 **(ApJ 737, 103, 2011)** recalibration of the Schlegel, Finkbeiner & Davis 1998 **(ApJ 500, 525, 1998; SFD98)** extinction map based on dust emission measured by COBE/DIRBE and IRAS/ISSA. The recalibration assumes a Fitzpatrick (1999) reddening law with R_V = 3.1 and a different source spectrum than SFD98.

- The original SFD98 extinction values are also returned for comparison purposes. The individual values of the total absorption at each waveband are calculated from the list of A/E(B-V) in Table 6 of Schlegel et al (ApJ 500, 525, 1998). We have adopted the standard Landolt UBVRI and SDSS ugriz filters for the optical total absorptions, and the UKIRT JHKL' filters for the near-infrared total absorptions. Please note that Schlegel et al. calculated the values of A/E(B-V) for these specific bandpasses using a spectral energy distribution for an elliptical galaxy. **Therefore, the numbers displayed by NED for a specific object may not be appropriate for other closely related bandpasses or other galaxy types. The total absorptions are nominally consistent with an average R = A/E(B-V) = 3.1, but do not agree numerically with this average.** See Appendix B of Schlegel et al (ApJ 500, 525, 1998) and references therein for additional details.

Additional caveat in $E_{B\text{-}V}$ map calibration

0.19

0.10 / 0.9

$$E^{sed}_{B-V} = -2.5\log\left(\frac{\int_B f_{sed}\, 10^{-0.4\, p_{sed} D\, k_\lambda}\, F_B\, d\lambda}{\int_V f_{sed}\, 10^{-0.4\, p_{sed} D\, k_\lambda}\, F_V\, d\lambda}\ \frac{\int_V f_{sed}\, F_V\, d\lambda}{\int_B f_{sed}\, F_B\, d\lambda}\right)$$

k_λ from Fitzpatrick et al. 1999
Calibrated with B5 stars

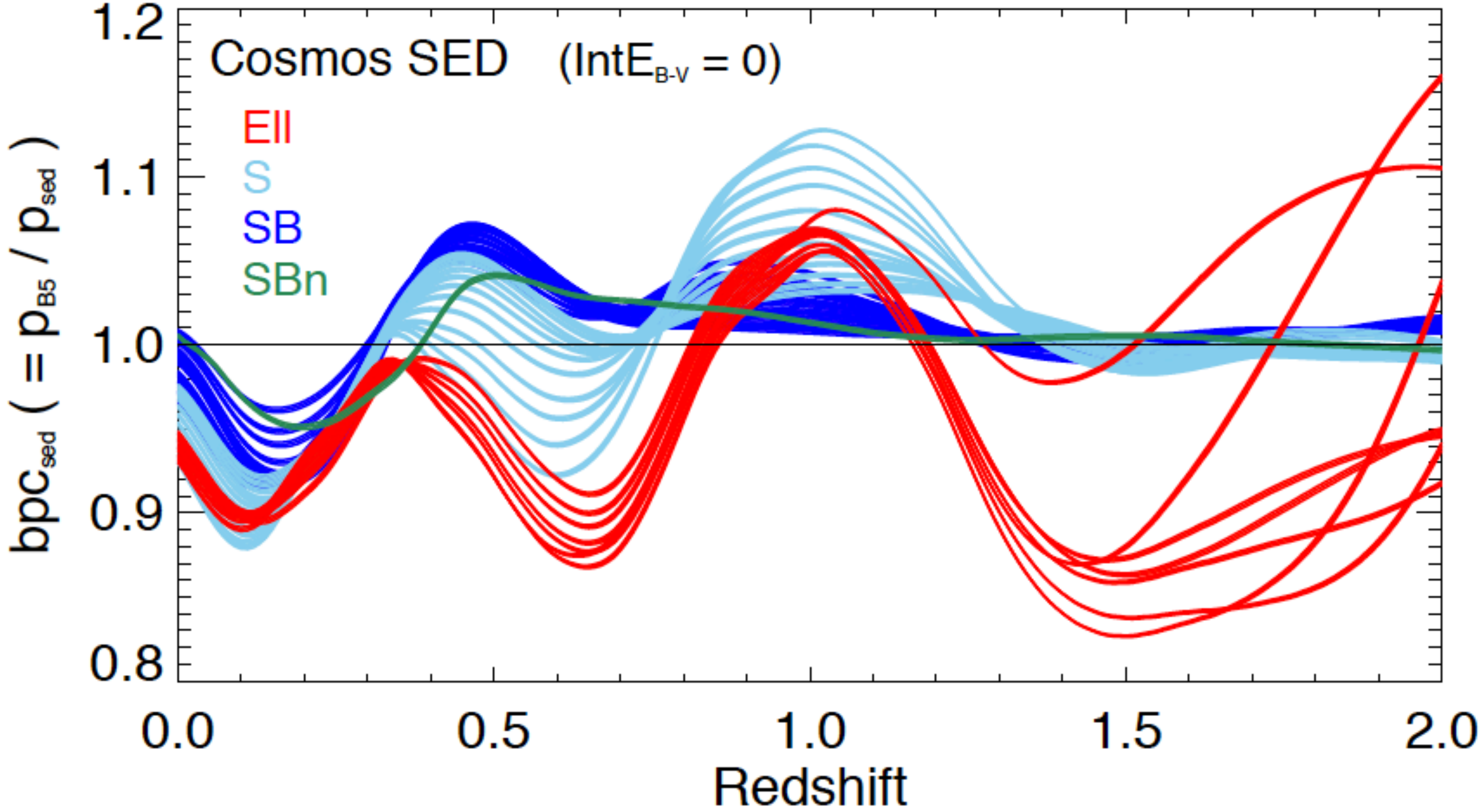
f_{int} = Passive galaxy at z = 0.1

Need to apply bandpass correction to re-evaluate the normalization of the reddening curve for a given SED.

For a fixed k_λ:

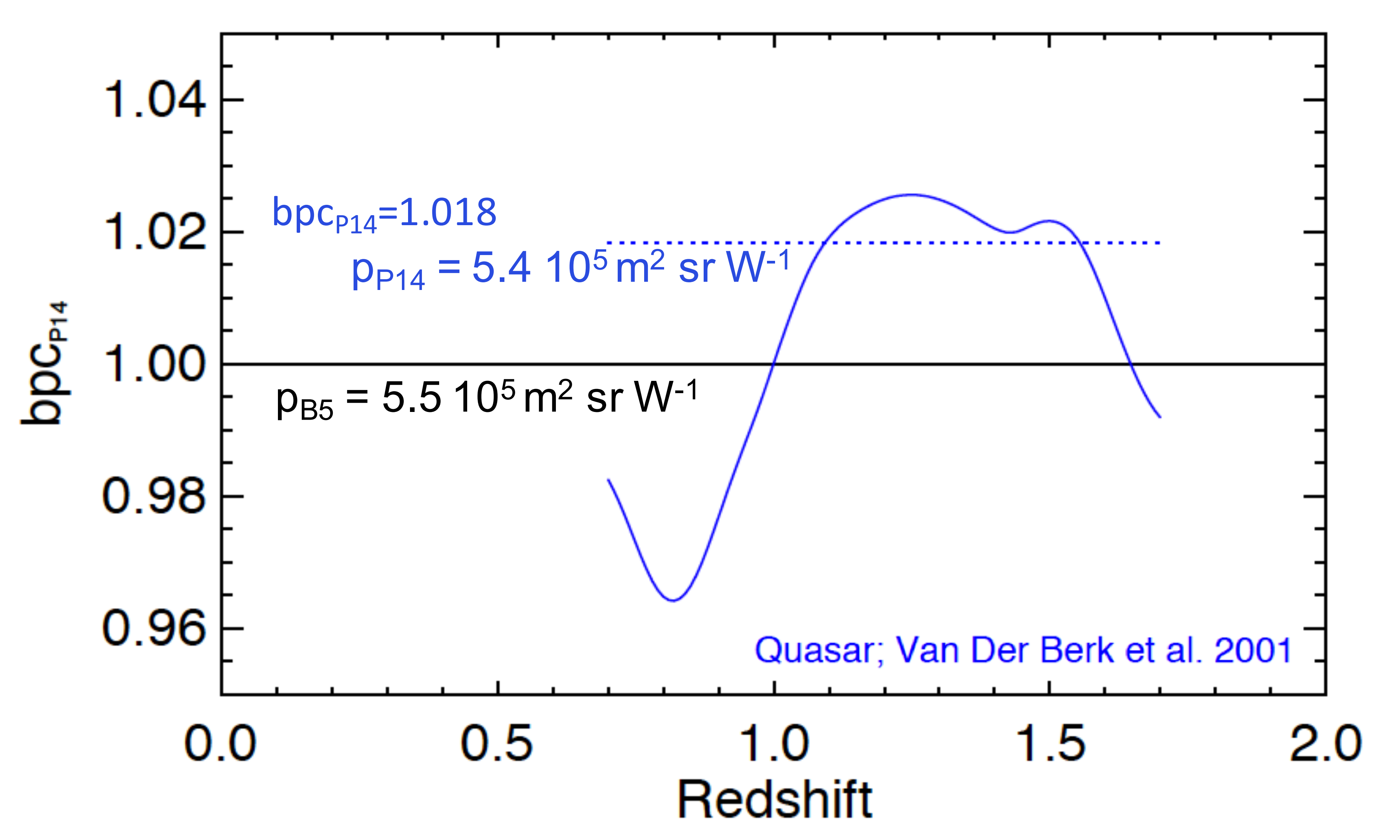
$$p_{sed} D k_\lambda = \frac{p_{B5} D k_\lambda}{bpc_{sed}}$$

Band-pass corrections



Band-pass corrections

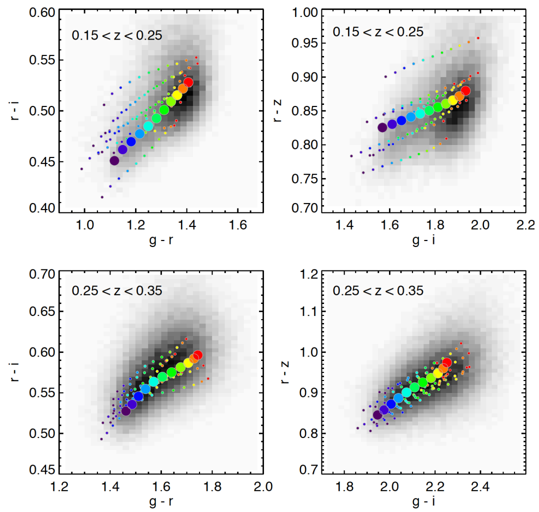
Quasar sample used in the Planck XI 2014 E_{B-V} map calibration

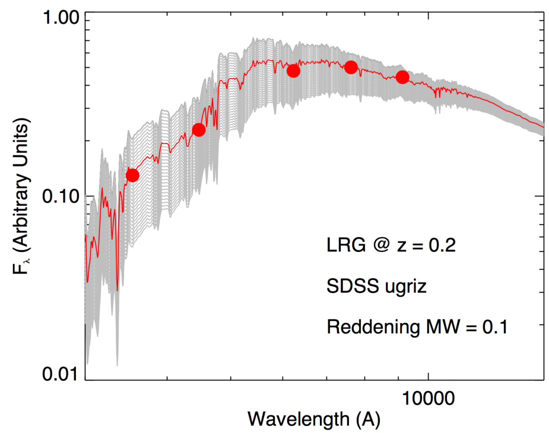


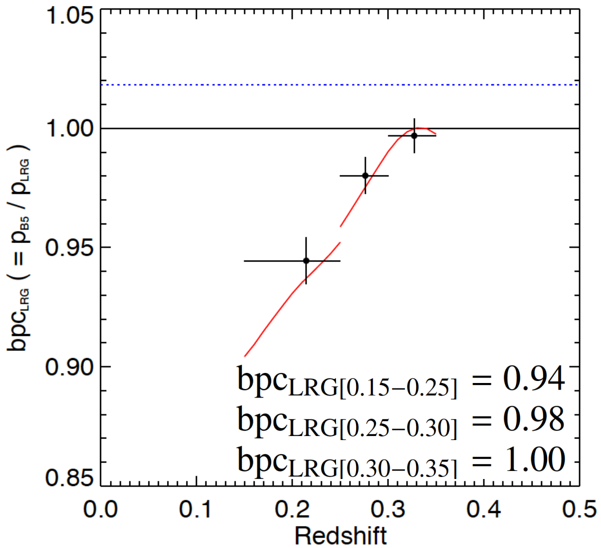
Re-calibrating reddening maps using LRG

Sample of luminous red galaxies at z~0.2-0.3 in SDSS using griz

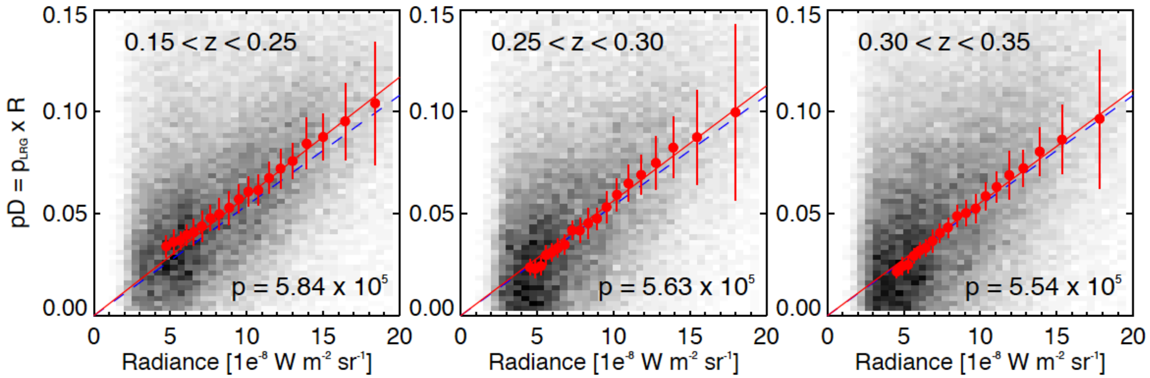
Modelised by LRG templates from Greisel et al. 2013





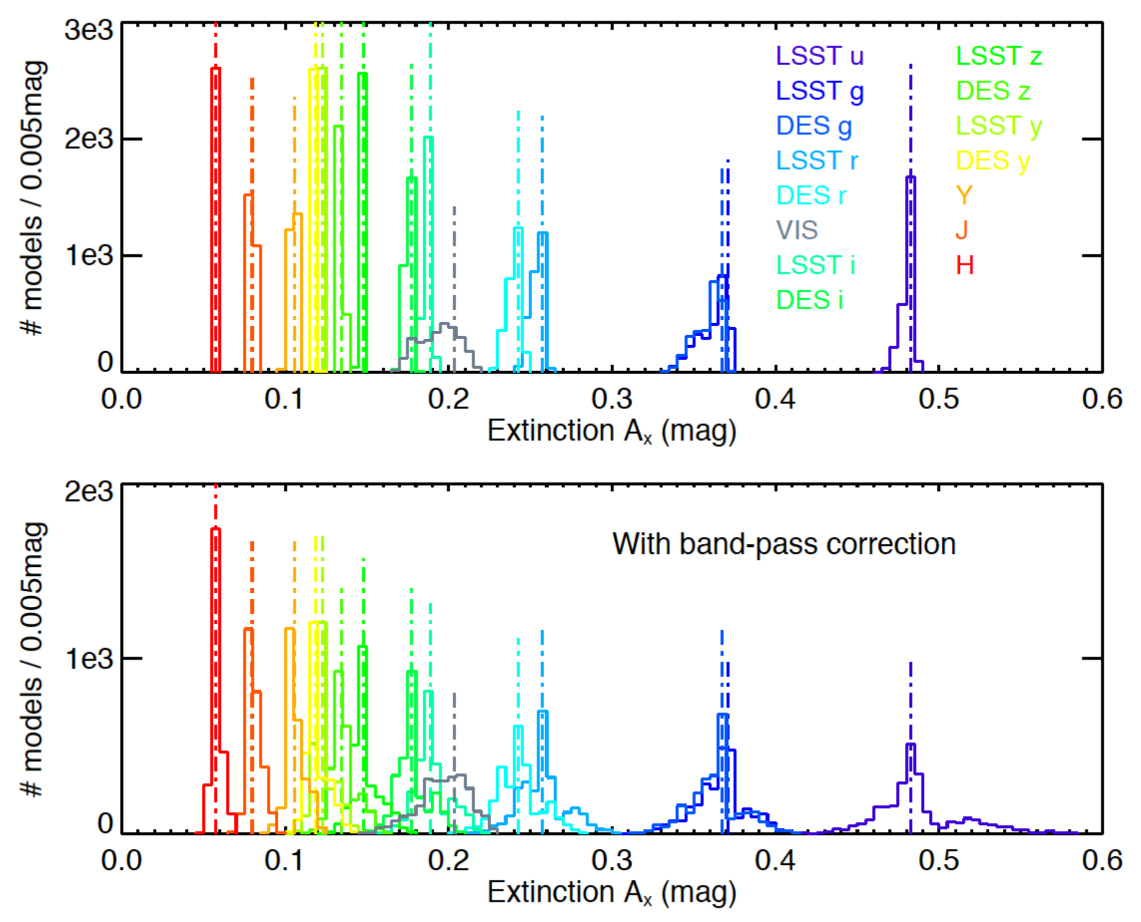


k_λ from Fitzpatrick et al. 1999 - Planck Radiance Map



$$p_{LRG[0.15-0.25]} = (5.84 \pm 0.06) \times 10^5 \text{ m}^2 \text{ sr W}^{-1}$$
$$p_{LRG[0.25-0.30]} = (5.63 \pm 0.04) \times 10^5 \text{ m}^2 \text{ sr W}^{-1}$$
$$p_{LRG[0.30-0.35]} = (5.54 \pm 0.04) \times 10^5 \text{ m}^2 \text{ sr W}^{-1}$$

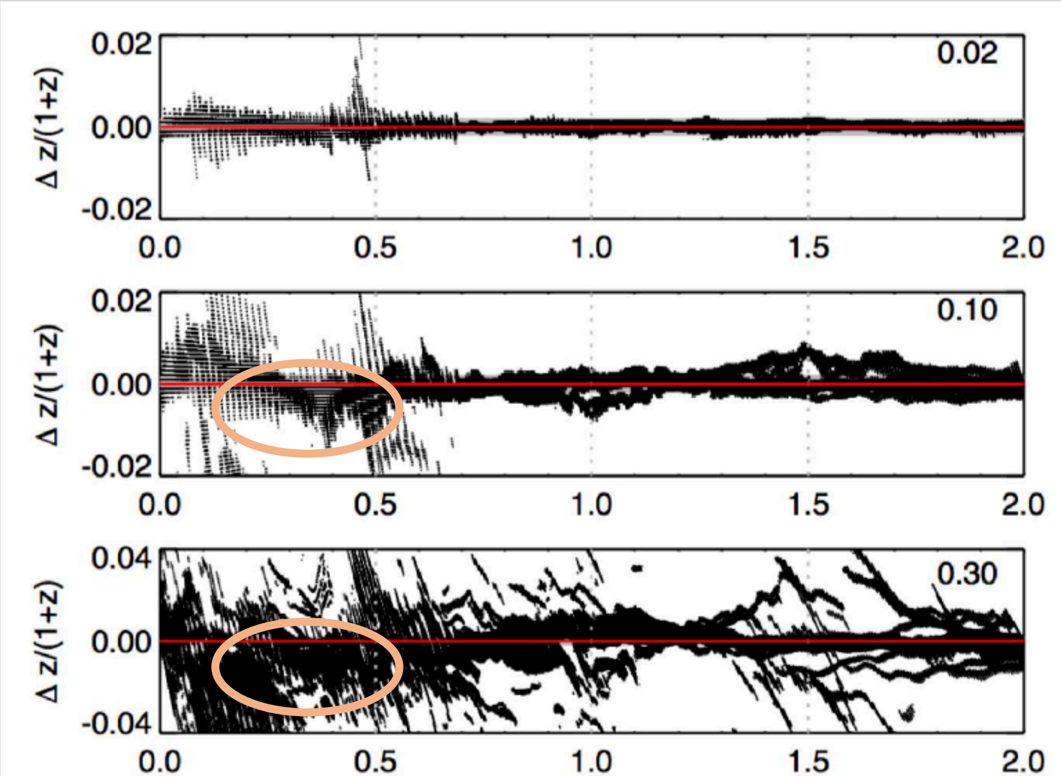
Dependence of Galactic extinction with SED

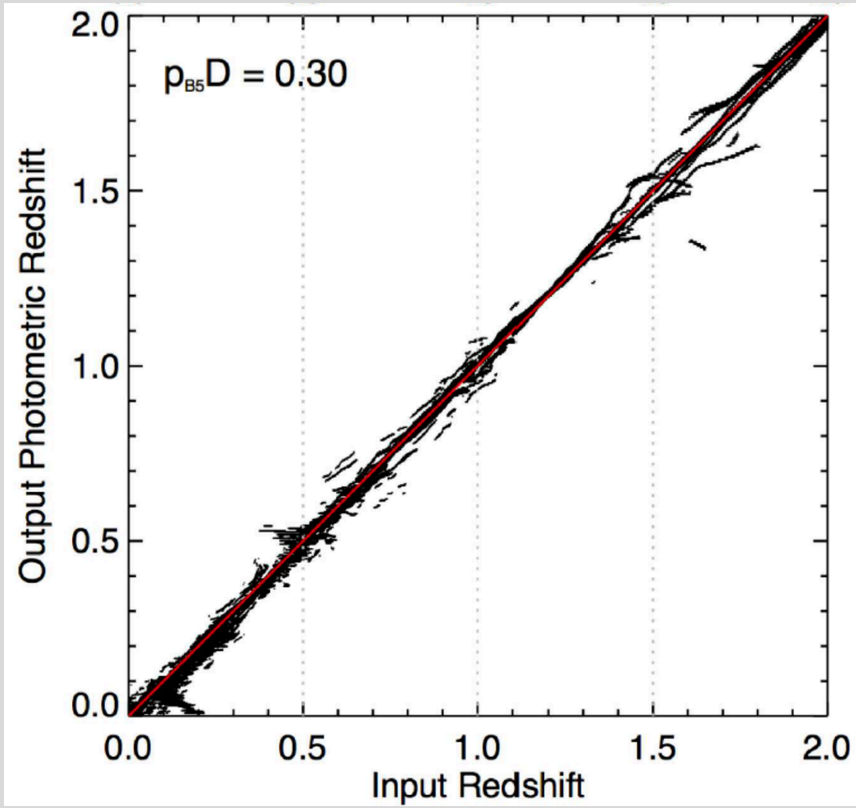


Filter	Pivot nm	A_X @pivot (1)	A_X median SED (2)	ΔA_X max-min SED (3)
LSST u	358.3	0.483	0.483	0.167
LSST g	477.0	0.371	0.368	0.108
PS1 g	484.9	0.363	0.361	0.109
DES g	482.0	0.367	0.365	0.108
LSST r	618.5	0.257	0.258	0.089
PS1 r	620.1	0.256	0.257	0.089
DES r	642.3	0.243	0.244	0.080
VIS	725.0	0.204	0.198	0.081
LSST i	751.8	0.189	0.189	0.065
PS1 i	753.5	0.188	0.188	0.065
DES i	780.7	0.177	0.177	0.062
LSST z	868.3	0.148	0.148	0.053
PS1 z	867.4	0.148	0.148	0.053
DES z	915.8	0.135	0.135	0.048
LSST y	966.7	0.123	0.123	0.042
PS1 y	962.8	0.124	0.124	0.042
DES Y	986.7	0.118	0.119	0.040
Y	1055.0	0.106	0.105	0.034
J	1248.6	0.080	0.080	0.029
H	1537.0	0.057	0.058	0.020

$p_{B5}D = 0.1$

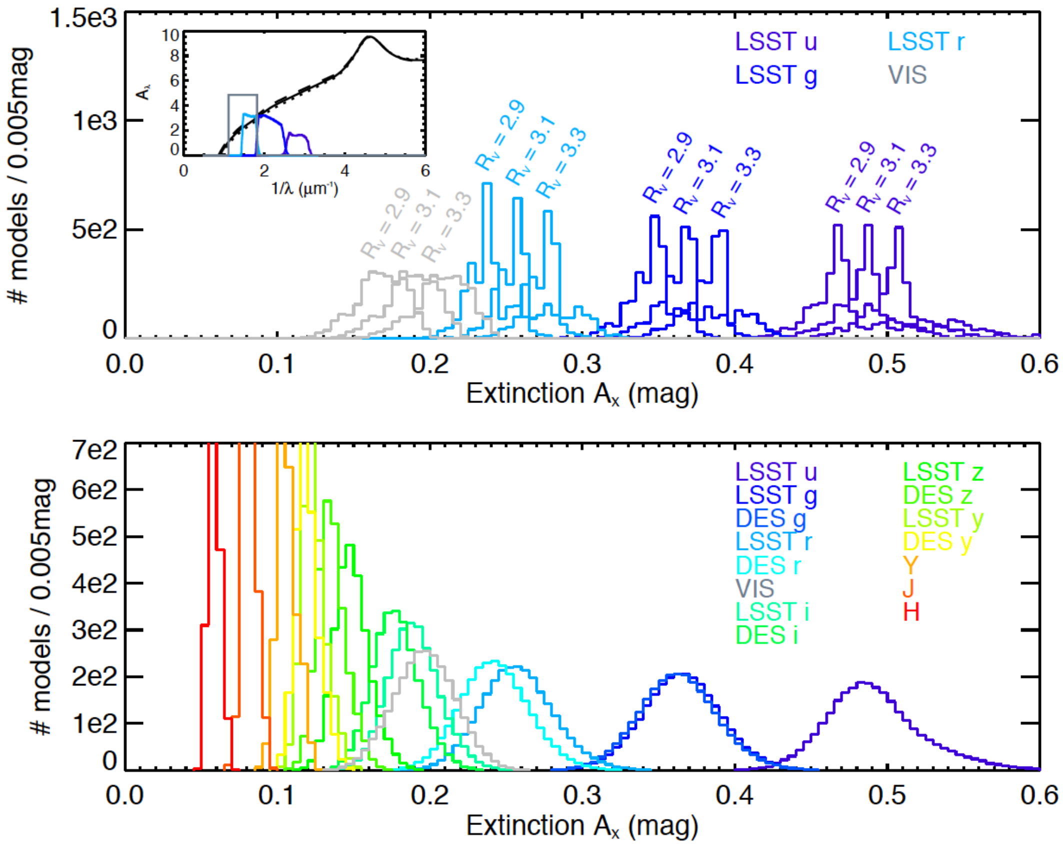
Impact on photometric redshifts

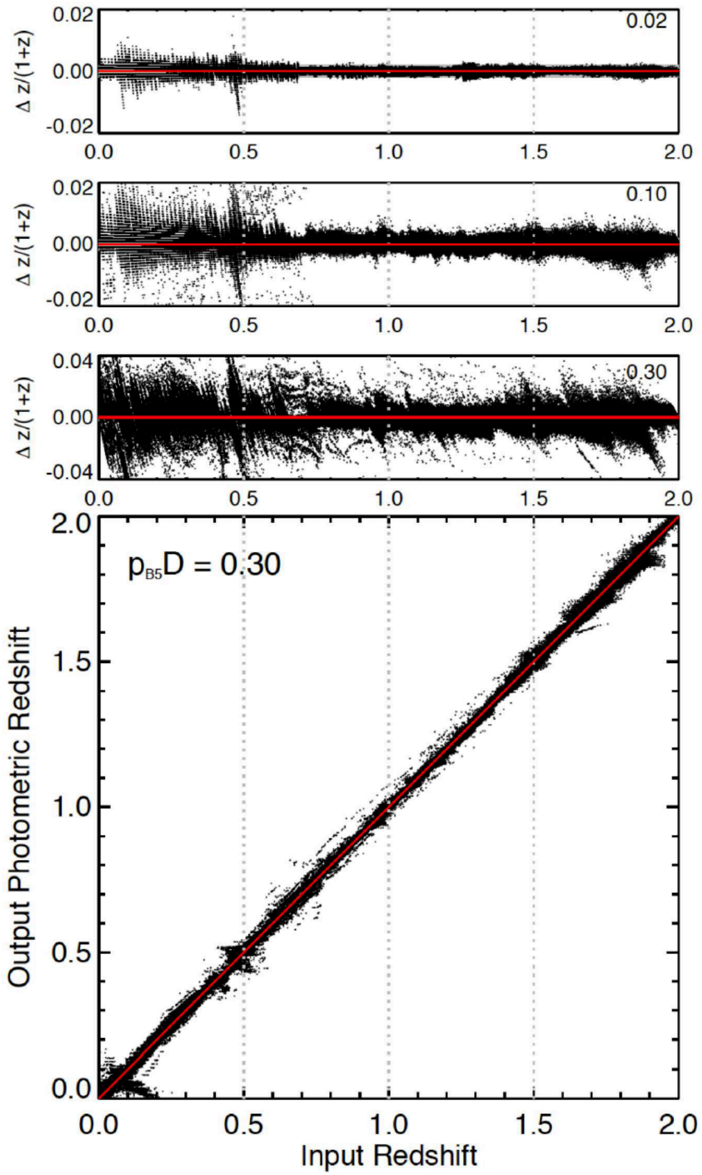




At pD = 0.1, 20% of the source photo-z (at all redshift) are not recovered within 0.2%(1+z)

Impact of the uncertainties on R_V





More limited bias (< 0.1%(1+z))
Higher scatter

Conclusions / Perspectives

- New prescription of the galactic reddening for the Euclid TFA
- Tests on ‘real’ extragalactic fields with strong LOS reddening
- Extend this study to others Euclid units/WP:
    - Machine-learning?
    - SOM?
    - Calibrations based on colours for OU-MER?
    - Distortion measurements versus color gradients in galaxies?