



DARK ENERGY
SURVEY

Absolute Normalization of the DECAL Scan Response Functions

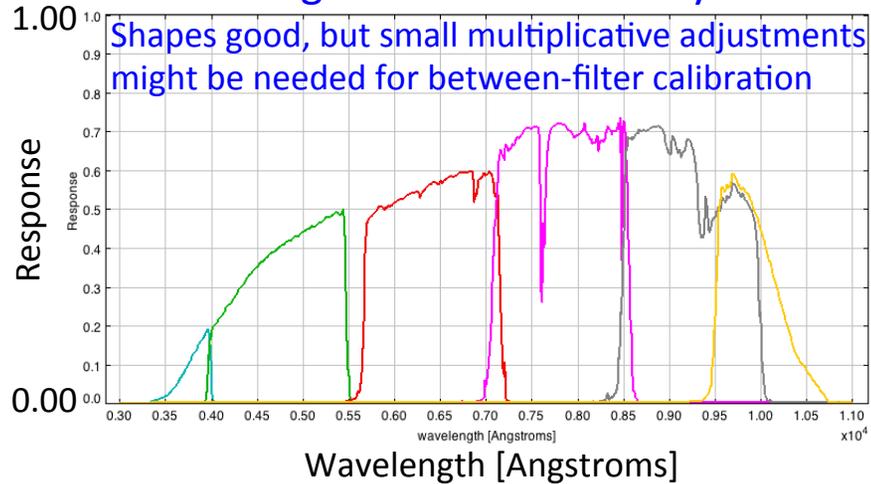
Douglas L. Tucker
27 February 2014



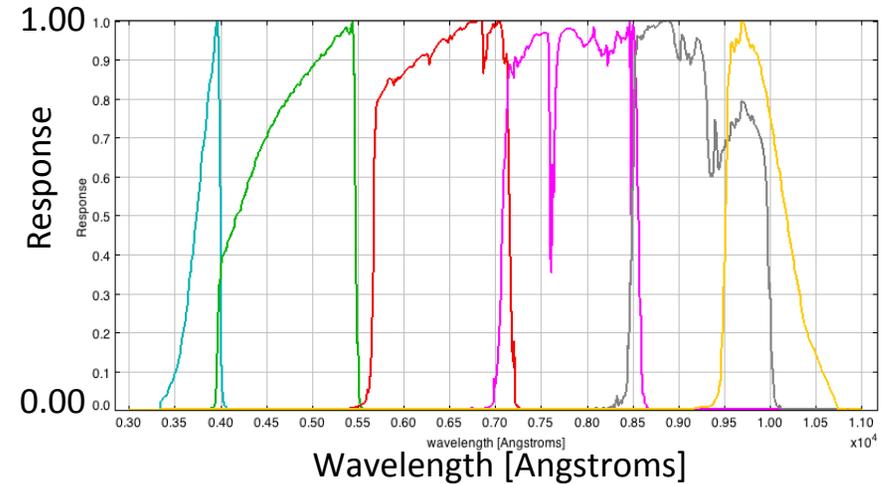
Examples of Normalizations for Response Functions

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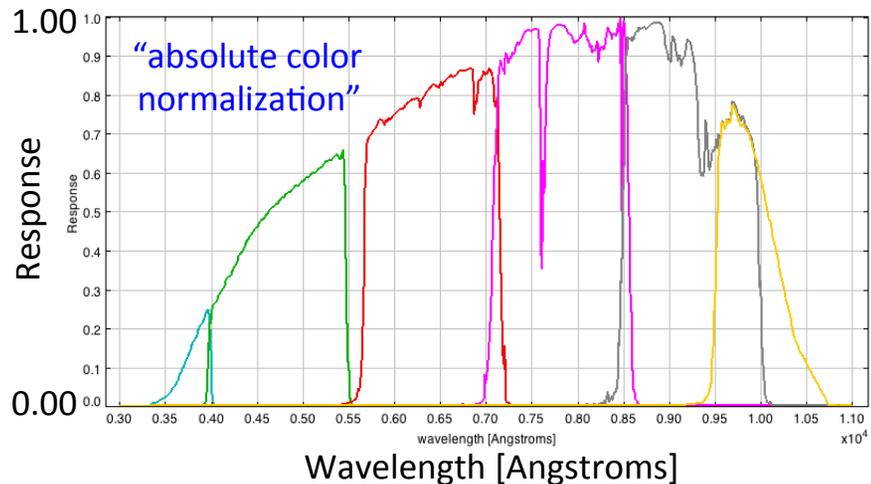
Straight from DECal Analysis



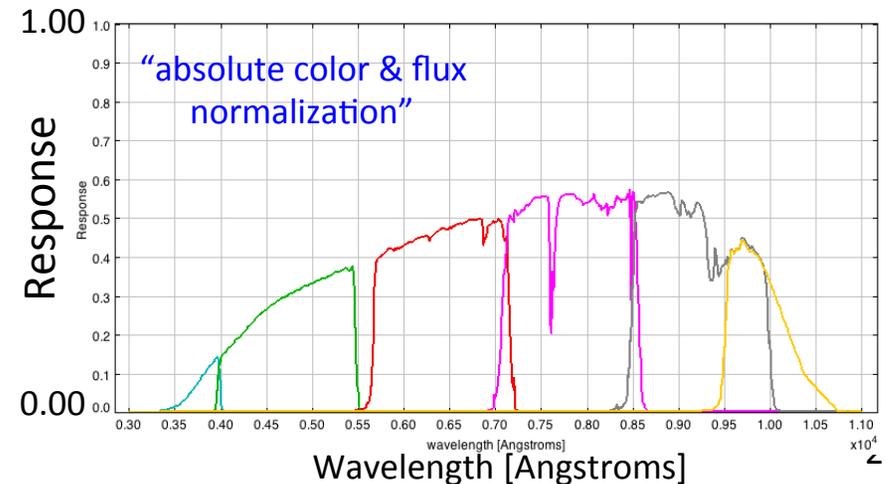
Each Filter Normalized to Peak



All Filters Normalized to Peak of i-band



Absolute Normalization





Synthetic Magnitudes

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- Only the un-normalized **shapes** of the response curves are needed for generating synthetic magnitudes if one uses the definition of a broad-band AB magnitude given by eqn. 7 of Fukugita et al. (1996):

$$m = -2.5 \log \frac{\int d(\log \nu) f_\nu S_\nu}{\int d(\log \nu) S_\nu} - 48.60,$$

where S_ν is the filter passband's response curve, ν is the frequency, and f_ν is the object's SED in ergs/sec/cm²/Hz.

- Effectively, an AB mag is the brightness in a given filter passband of an object **relative** to that of a constant SED with $f_\nu = 3.631 \times 10^{-20}$ ergs/sec/cm²/Hz (= 3631 Jy).
- An AB mag can also be thought of as the mag of the photon-weighted mean flux within the filter passband.
- In either case, the normalization of S_ν cancels out.



Synthetic AB Magnitudes for BD+17 4708 (SDSS, PreCam, & DES)

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Filter Set Response Curve	u	g	r	i	z	Y
SDSS u'g'r'i'z' (USNO-1m)*	10.50	9.66	9.35	9.26	9.23	N/A
SDSS ugriz (SDSS-2.5m, DR7)	10.528	9.647	9.351	9.255	9.239	9.248**
PreCam (DES-doc#4769)	N/A	9.624	9.329	9.248	9.239	9.244
DES (DES-doc#6229)	N/A	9.622	9.333	9.255	9.258	9.259
DES (20130322)	10.238	9.614	9.328	9.248	9.239	9.245
DES (20140225)	10.222	9.614	9.328	9.249	9.240	9.246

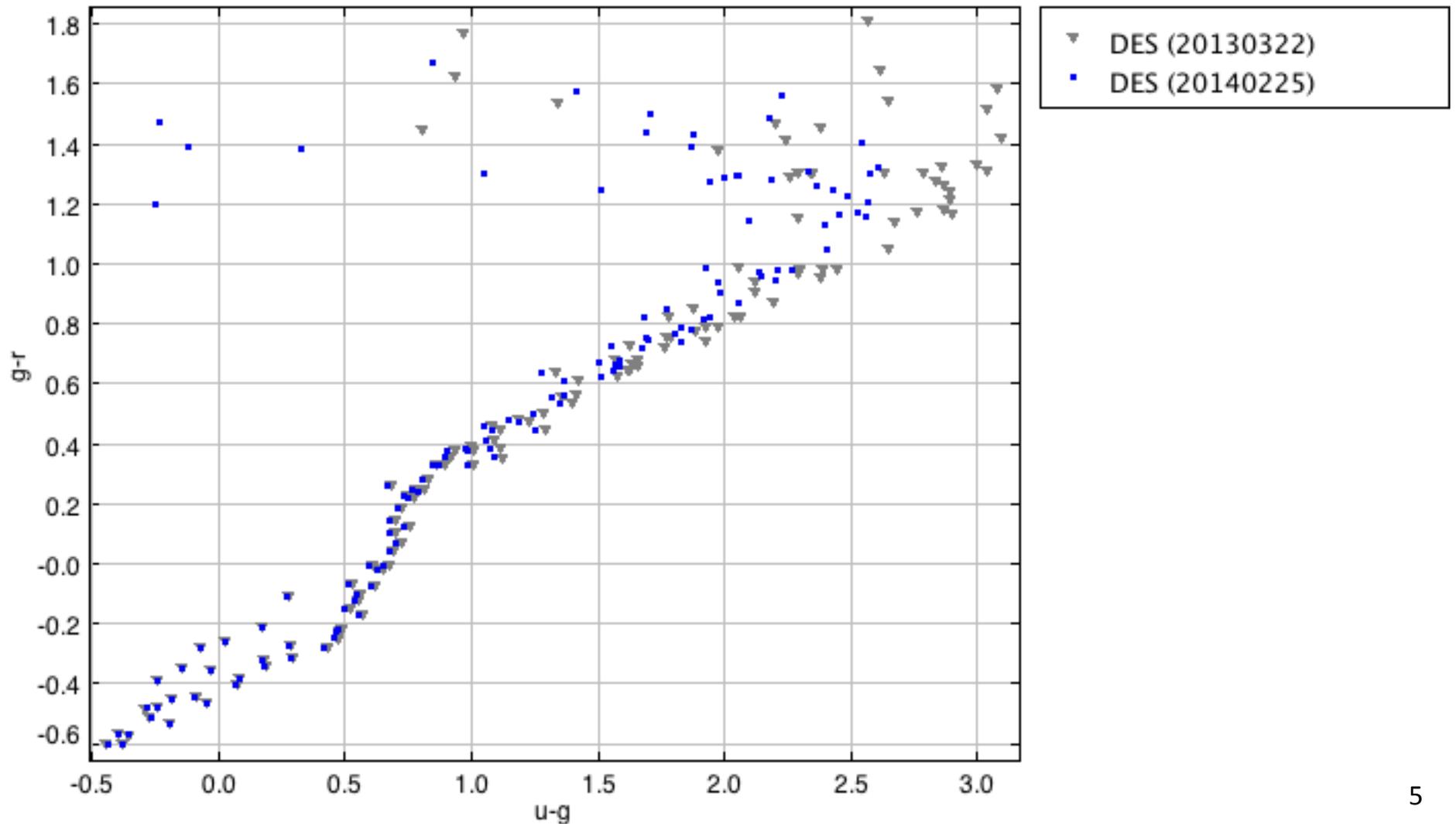
*Fukugita et al. (1996), with AB offset corrections from Betoule, Mairiner Regnault et al. (2013).

** Y-band mag is the AB Y-band mag based on the UKIDSS DR8 response curve.



Synthetic AB Colors for the Pickles (1998) Stellar Library: ugr

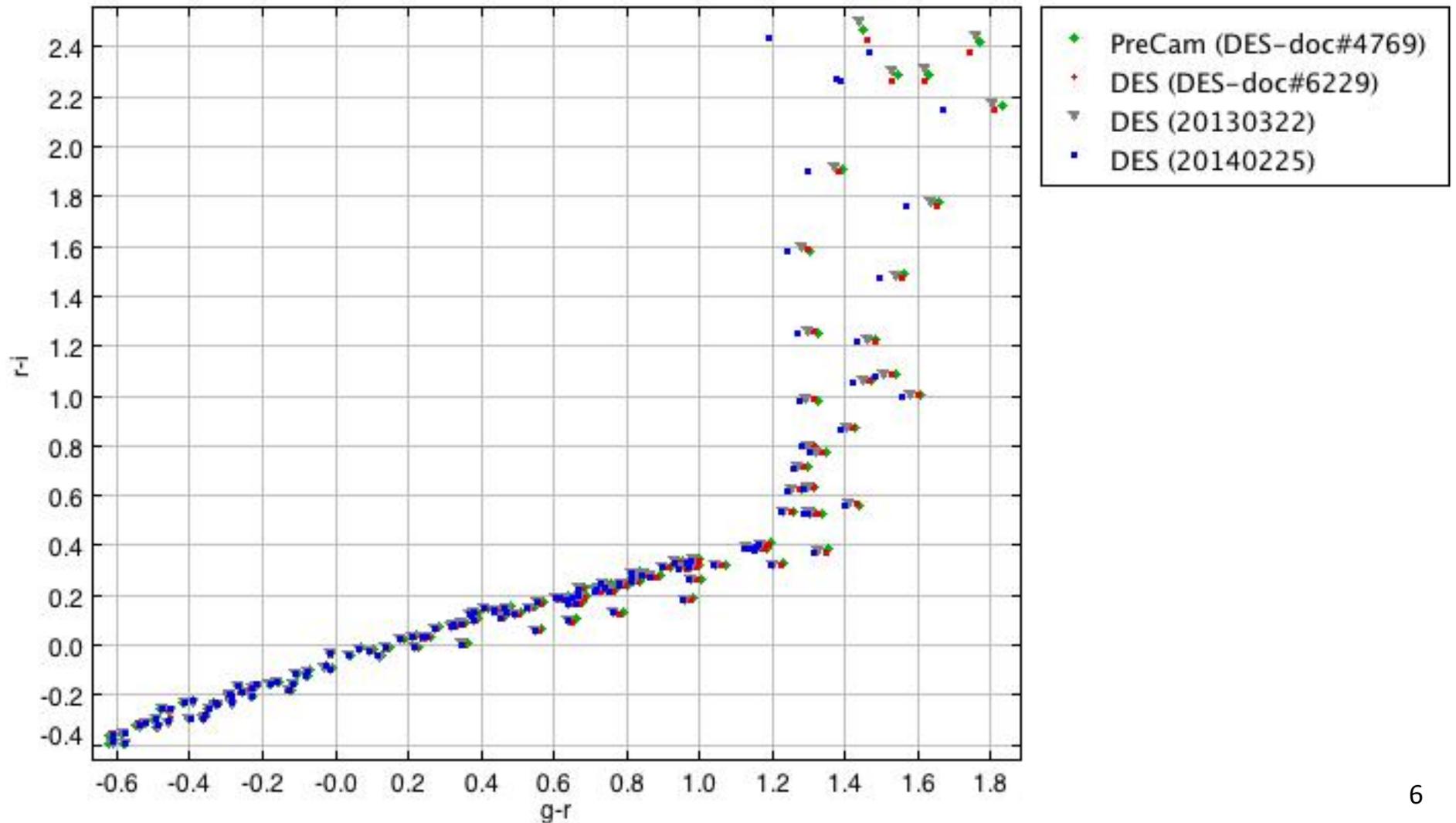
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Synthetic AB Colors for the Pickles (1998) Stellar Library: gri

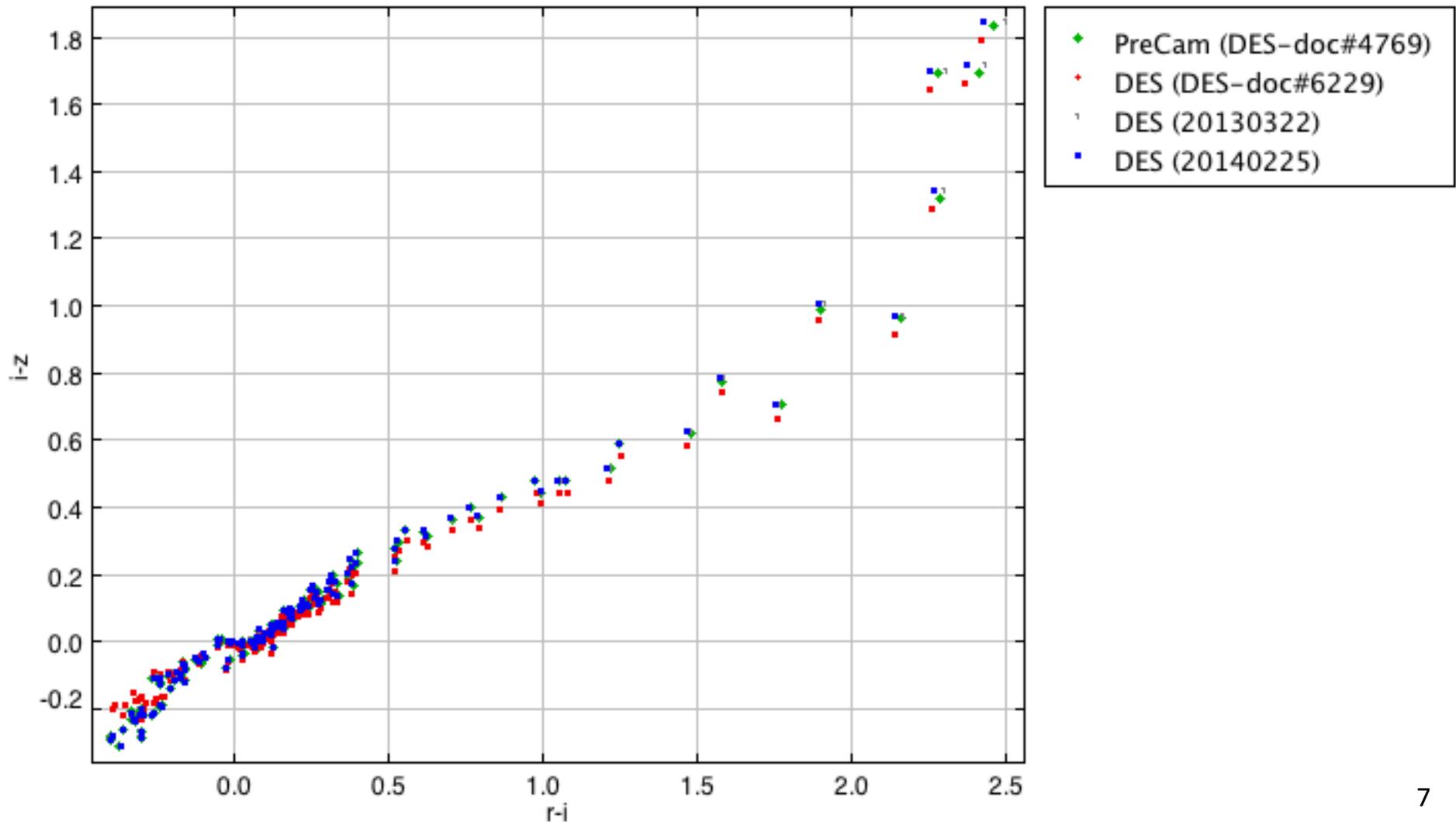
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Synthetic AB Colors for the Pickles (1998) Stellar Library: $r-i$

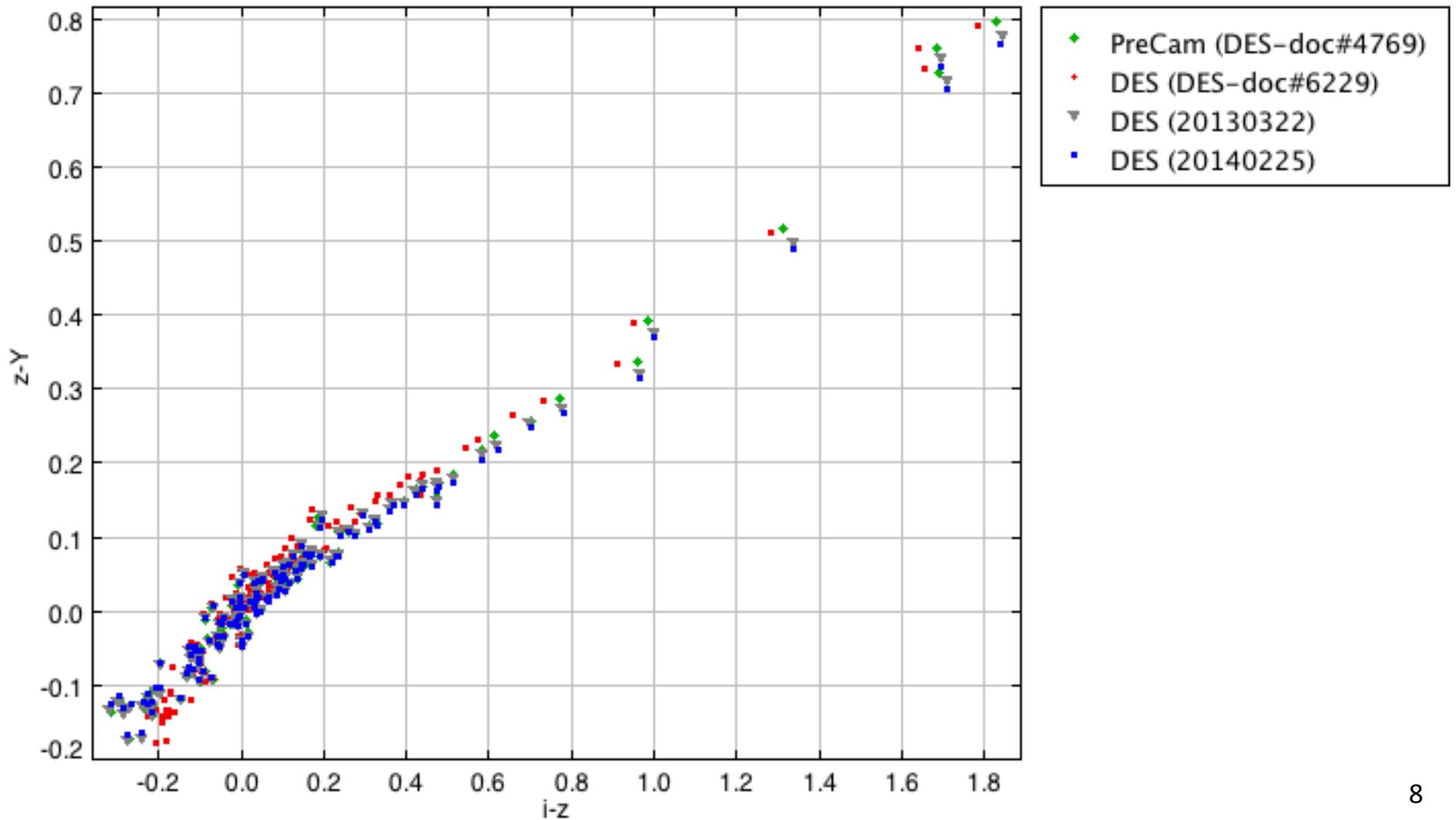
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Synthetic AB Colors for the Pickles (1998) Stellar Library: izY

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Exposure Time Calculations

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- Here, the absolute calibration of the filter response curves is needed in order to get a measure of the total number of photons detected; e.g.:

$$N_* = A t \int \frac{\lambda}{hc} f_\lambda S_\lambda d\lambda$$

where we have converted to the λ relation for simplicity and where

- N_* is the total # of photons detected over the filter passband
- A is the effective area of the telescope primary
- t is the exposure time
- S_λ is the response curve as a function of λ
- f_λ is the SED in λ -space (ergs/sec/cm²/Angstrom)
- λ/hc converts f_λ converts to f_{photon} (# photons/sec/cm²/Angstrom)



Using Expected Count Rates for Absolute Calibration of the Filter Response Functions

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- During the SV tests, an equation very similar to the one on Slide 9 was used to calculate expected count rates for DECam from stars with known calibrated SEDs and then compared with measured count rates; see:
 - <https://cdcv.s.fnal.gov/redmine/projects/des-sci-verification/wiki/Sig-R2>
 - <https://cdcv.s.fnal.gov/redmine/projects/des-sci-verification/wiki/Photometry>
- Let us use the observed count rates for an AB mag=20 star from SV to calibrate the absolute throughputs of the newest set of DECam scan results (20140225) from William Wester.



Using Expected Count Rates for Absolute Calibration of the Filter Response Functions

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Count Rates (e-/sec for an AB mag=20 point source)

Filter	DES-doc#6229 Response		SV Observed	20140225 Response	Correction Factor (=SV Obs./20140225)
	Huan	Douglas			
u	92	N/A	79	79	1.00 (0.75)**
g	590	584	519	688	0.754
r	588	582	623	748	0.833
i	566	560	589	754	0.781
z	466*	441*	457	576	0.793
Y	159	157	187**	237	0.789 (0.75)**

*Huan's and Douglas's values for the expected z-band count rate are discrepant at the 6% level.

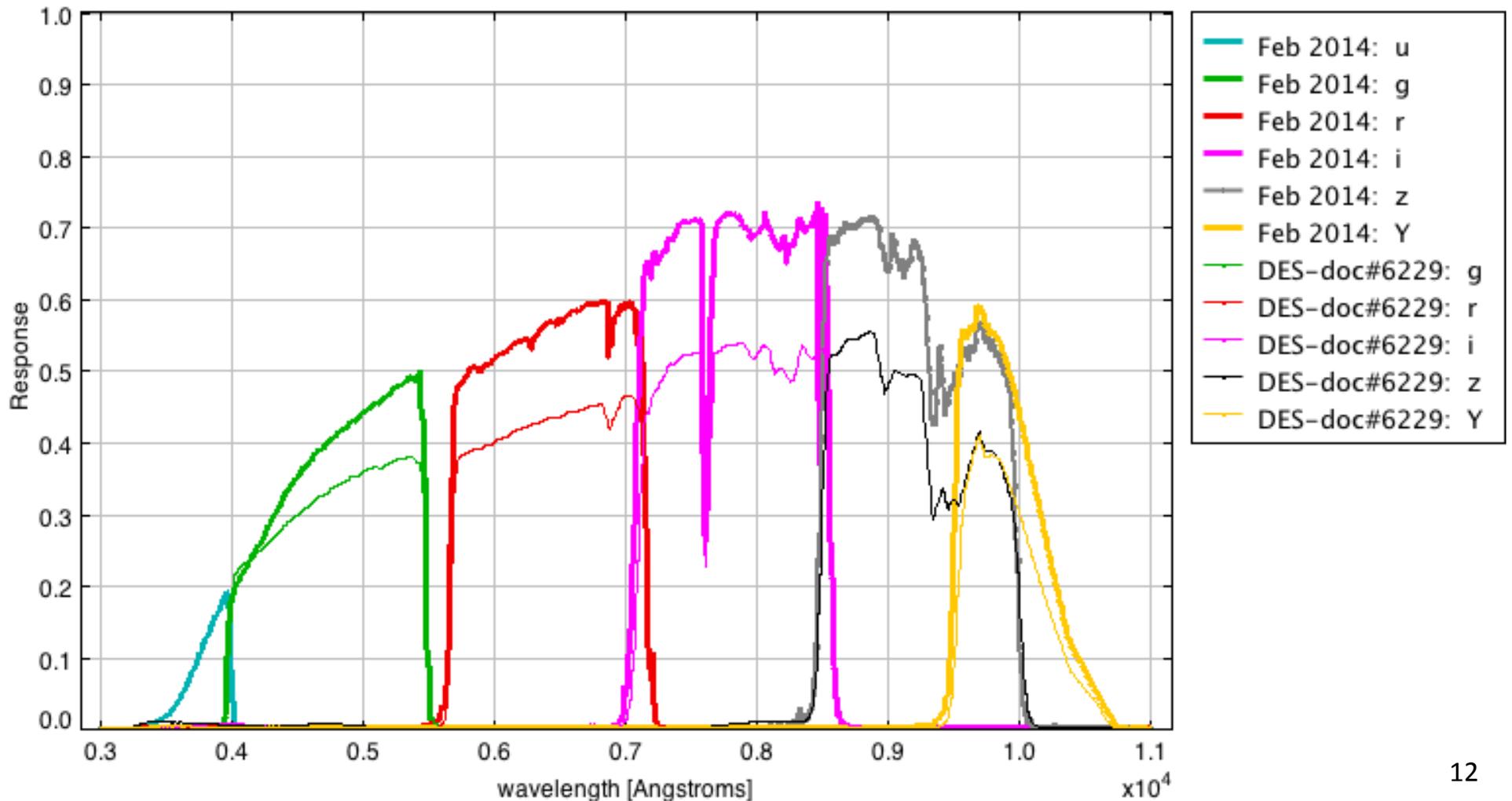
**The SV observed value for Y band is a combination of Huan's and Paul Martini's measurements.

***The correction factor in parentheses appears to do a better job matching to the adjacent filter. 11



DES-doc#6229 and 20140225 Responses: Before Calibration to SV Observed Count Rates

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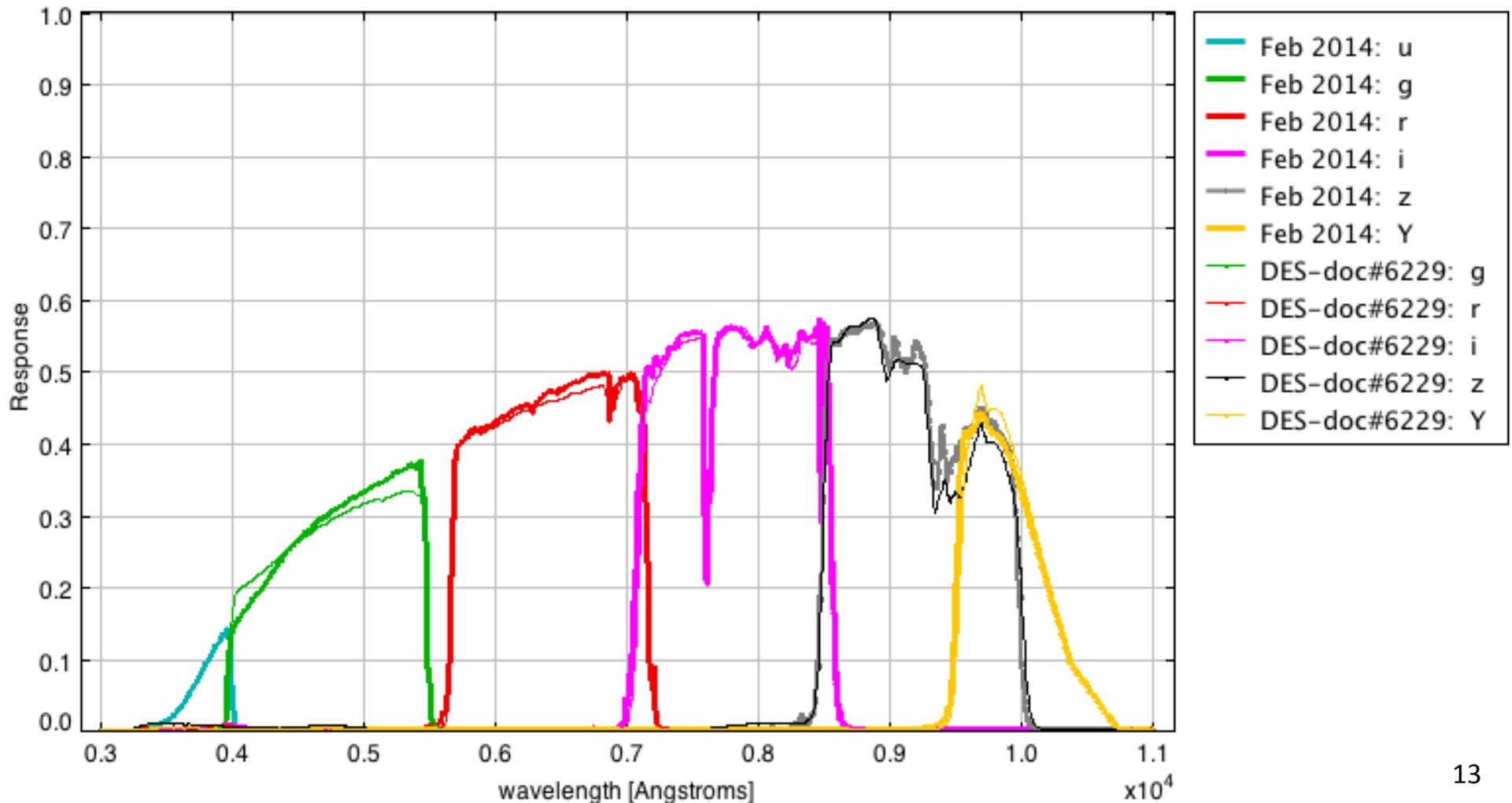




DES-doc#6229 and 20140225 Responses: After Calibration to SV Observed Count Rates

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(Note: DES-doc#6229 z-band includes additional 1.06 multiplicative fudge factor to correct for discrepancy between Huan's and my values for expected count rates in z; see Slide 11.)





Recommendations

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- For the absolute calibration/normalization of the DES 20140225 response curves, it is recommended that the response for each filter be multiplied by the following values based on the analysis described in Slides 9-13:

Filter:	u	g	r	i	z	Y
Factor:	0.75	0.754	0.833	0.781	0.793	0.75

- The above values are not perfect (especially for u and Y bands). Future iterations with the SDSS catalog and with spectrophotometric standards (e.g., the ongoing DA white dwarf program) will improve these values.
- For synthetic mags, it is recommended that one uses the Fukugita et al. (1996) equation for broadband AB mags, where only the shape of the curve matters, so uncertainties in the absolute normalization do not matter.



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Extra Slides