SKYSURF

Preliminary EBL Constraints

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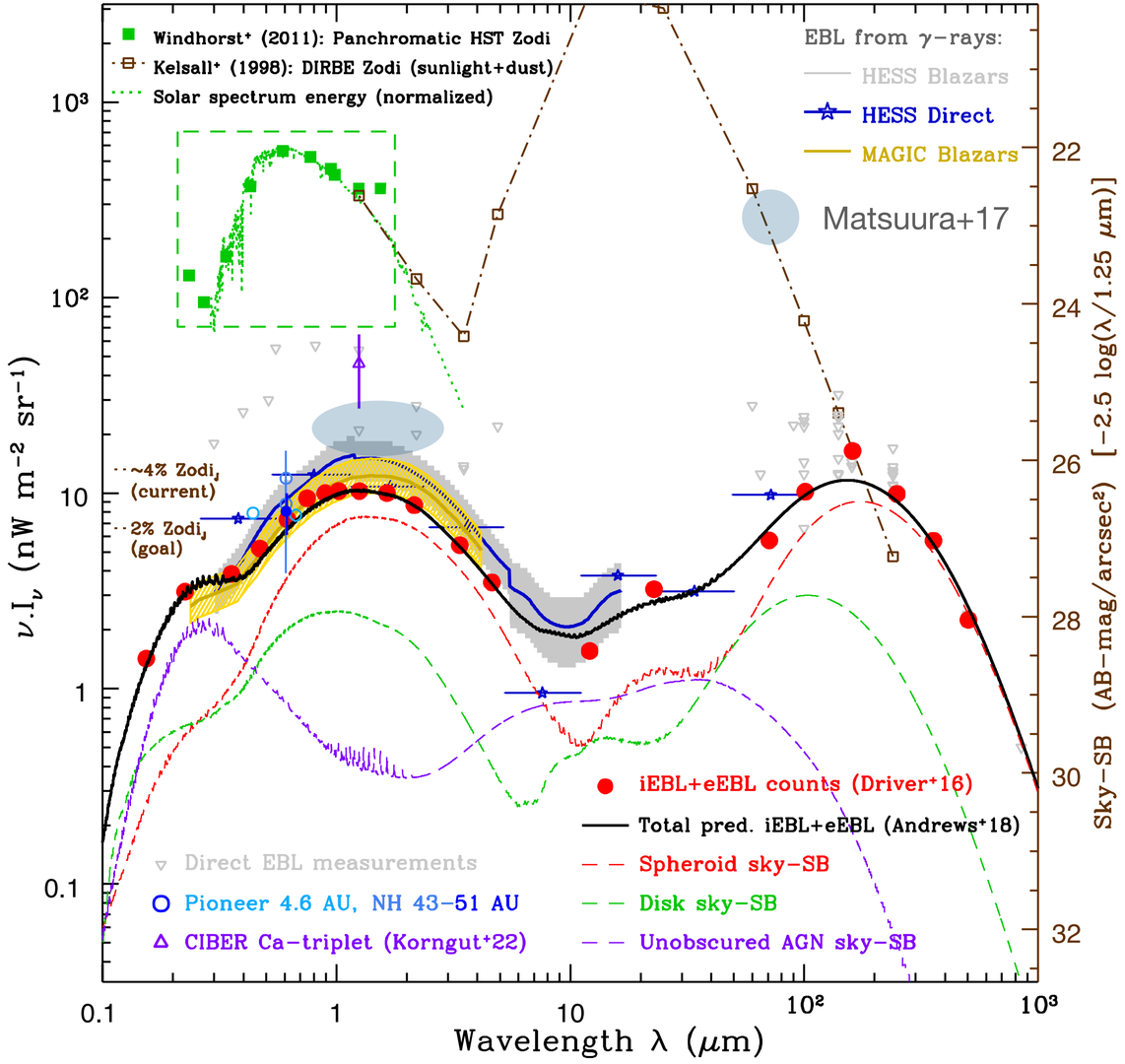
Extragalactic Background Light

Direct EBL measurements and limits (grey triangles) are substantially above predictions from galaxy counts (red)

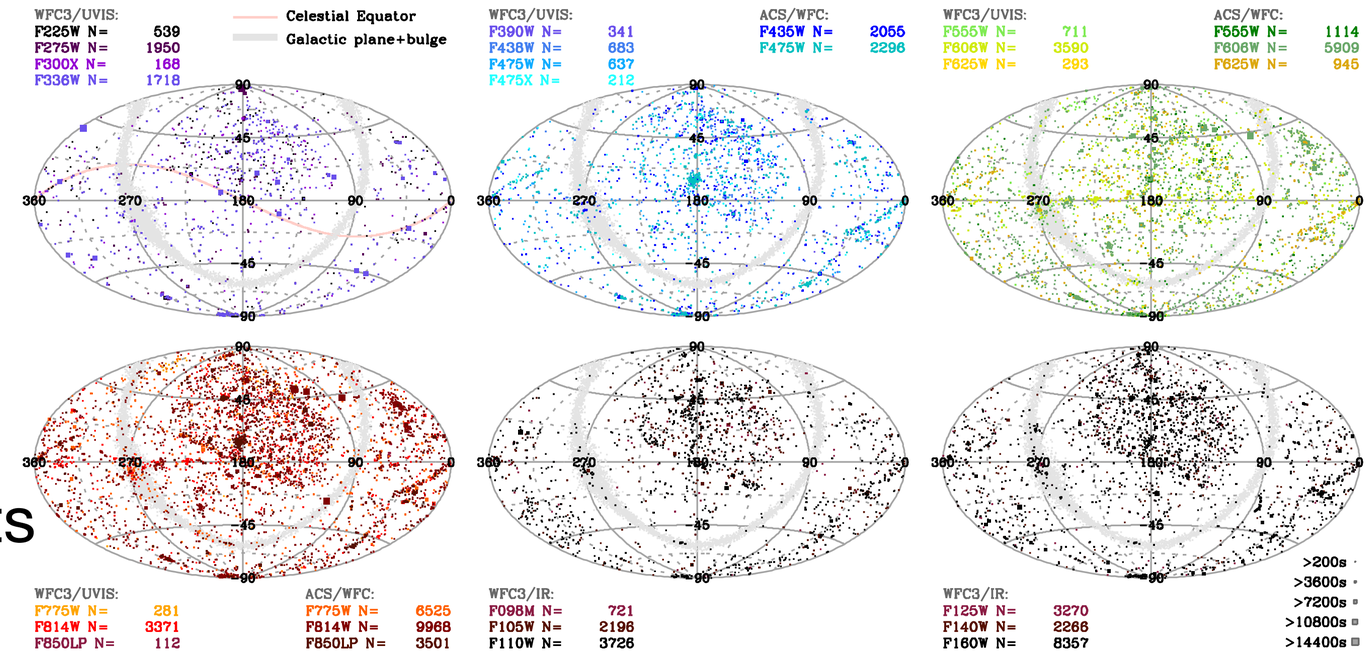
Indirect measurements (grey and yellow shaded regions) and outer solar system probes (blue points) agree more with those predictions

SKYSURF uses the large HST archive to study this discrepancy



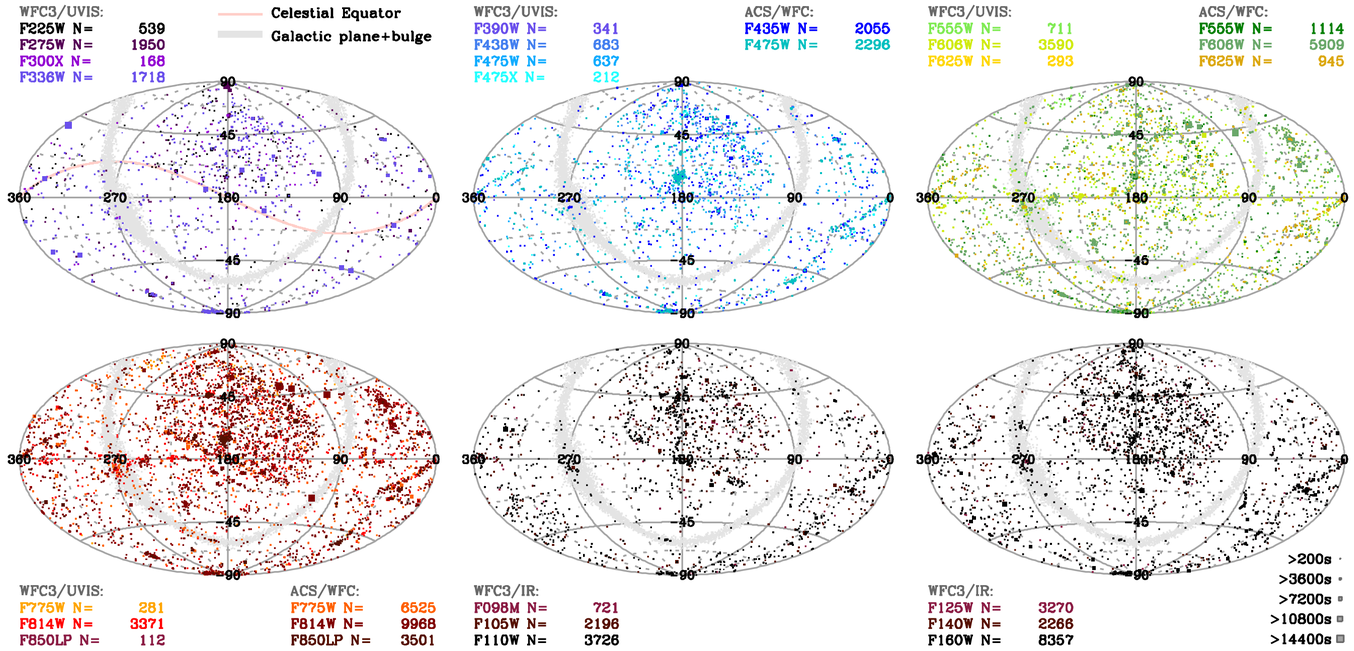
HST Archive

- Very stable (zero point, dark current variations ~1-2%)
- >20 years of archival data to study variations
- Sensitive to ~25 AB mag objects
- -> Can study discrete & diffuse optical-near-IR background



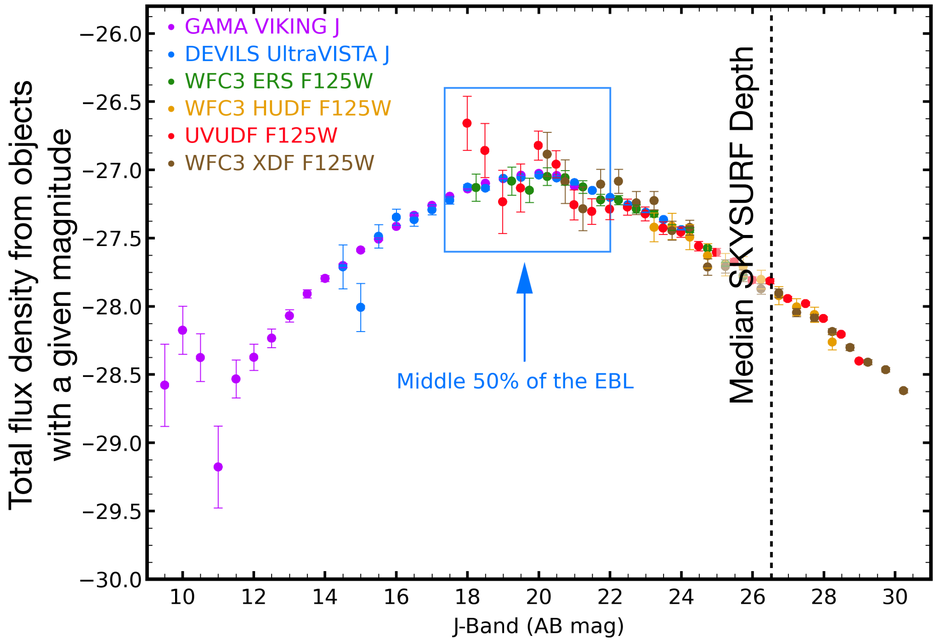
SKYSURF Archive

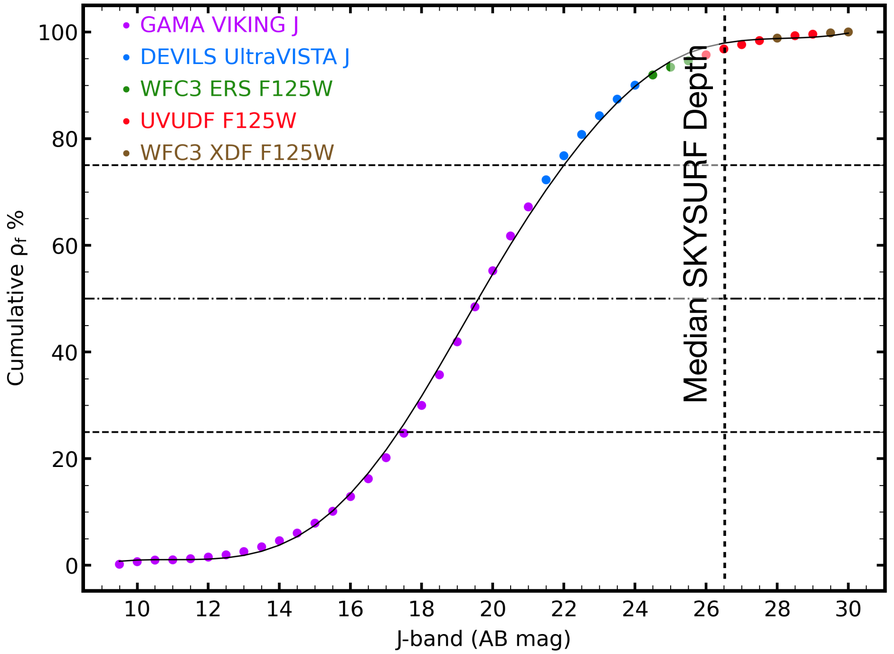
- Select images in regular filters (no grism, polarizers, ramps, narrow bands, subarrays, moving targets, spatial scans)
- >250000 images -> ~25TB
- ~15000 independent pointings
- UV-near-IR wavelengths



SKYSURF

- Strength - avoid resolved sources
  - In particular, *median* completeness to resolved objects down to ~26, which covers ~95% of EBL from resolved sources
  - Deeper exposures help us correct for remaining 5%



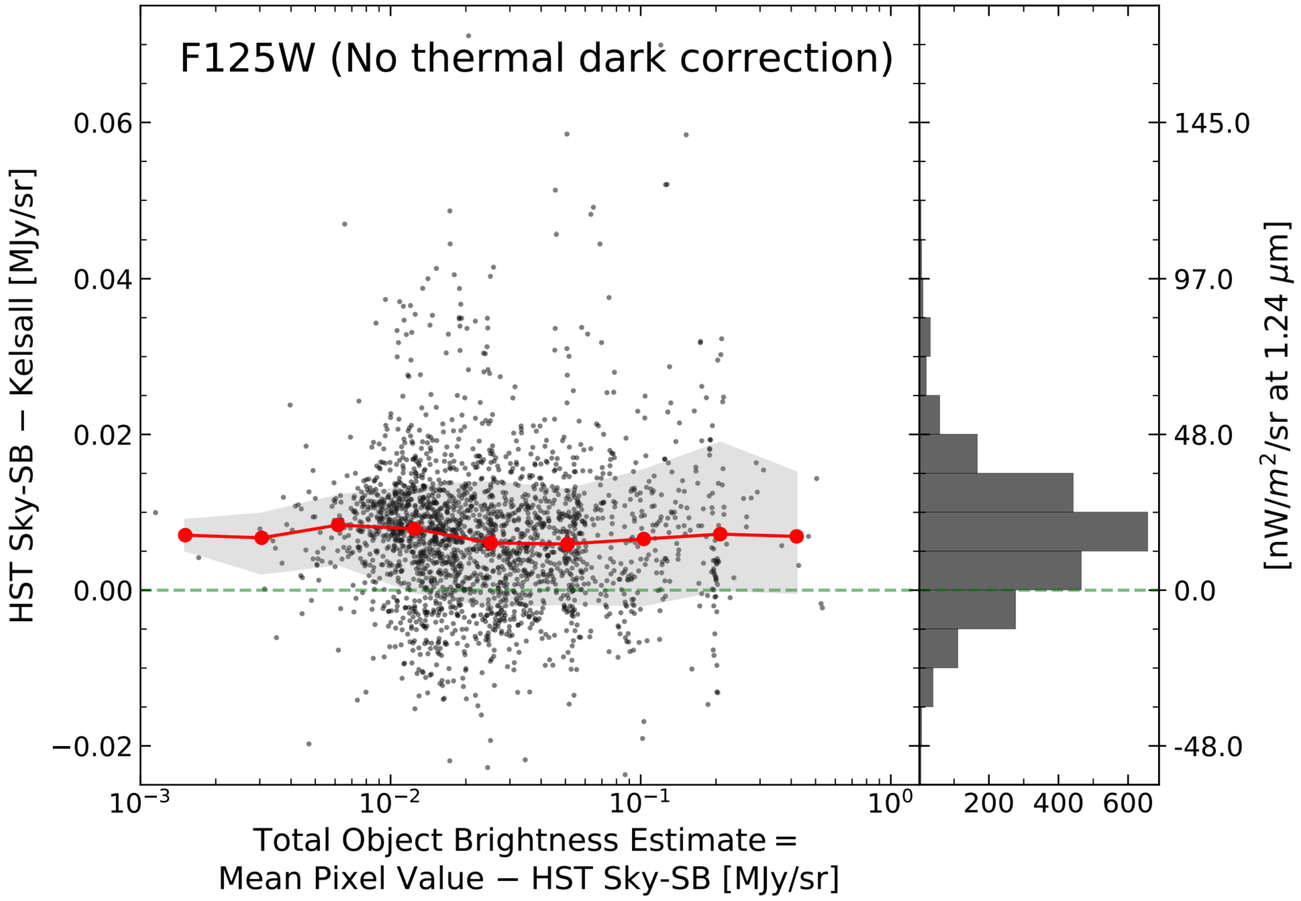


SKYSURF Error Budget

Source of Error	WFPC2	ACS/WFC	WFC3/UVIS	— WFC3/IR —			(§§)
				F125W	F140W	F160W	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bias/Darkframe subtraction	∼1.0%	∼1.5%	∼1.5%	∼1.0%	∼1.0%	∼1.0%	4.1
Dark glow subtraction	∼2%	—	—	—	—	—	4.1.1
Postflash subtraction	—	∼1%	∼1%	—	—	—	4.1
Global flat-field quality[b]	∼1–3%	0.6–2.2%	∼2–3%	∼0.5–2%	∼0.5–2%	∼0.5–2%	4.1
Numerical accuracy of LES[c]	≲0.2–0.4%	≲0.2–0.4%	≲0.2–0.4%	≲0.2–0.4%	≲0.2–0.4%	≲0.2–0.4%	4.2.3
Photometric zeropoints[d]	∼2%	0.5–1%	0.5–1%	∼1.5%	∼1.5%	∼1.5%	4.1.5
Thermal Dark signal[e]	—	—	—	∼0.2%	∼0.5%	∼2.7%	4.1.4, SKYSURF-2
Total Error[f]	∼4.3%	∼3.0%	∼3.7%	∼2.7%	∼2.8%	∼3.8%	
Sky-SB low-avg ($nW/m^2/sr$)	—	—		262–534	251–513	240–496	
Sky-SB error ($nW/m^2/sr$)	—	—		7–14	7–14	15–19	

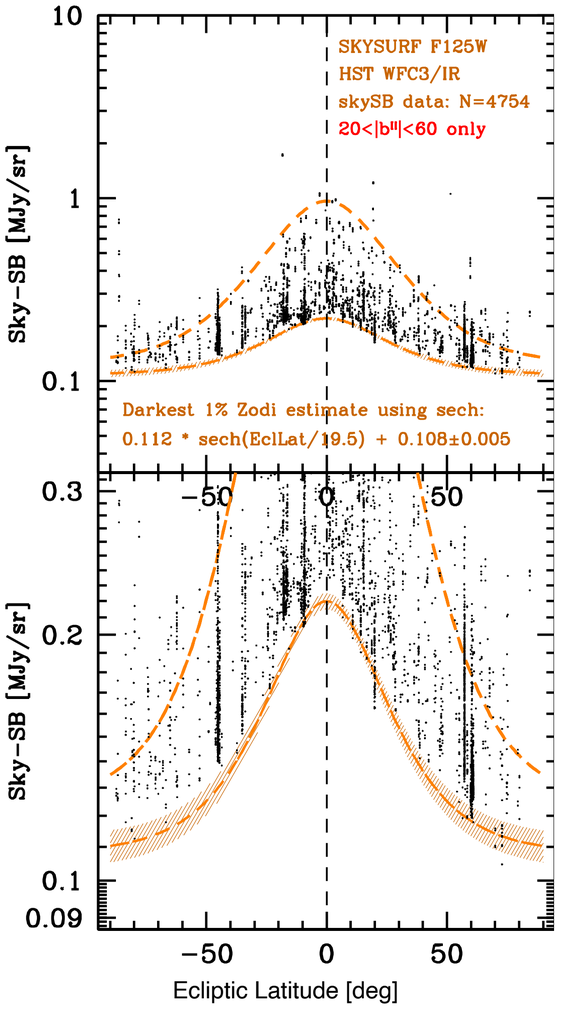
SKYSURF Sky Measurements

- We carefully tested our ability to measure sky background with simulated images
- Sky measurements uncorrelated with object brightness - avoiding bias from objects and object straylight



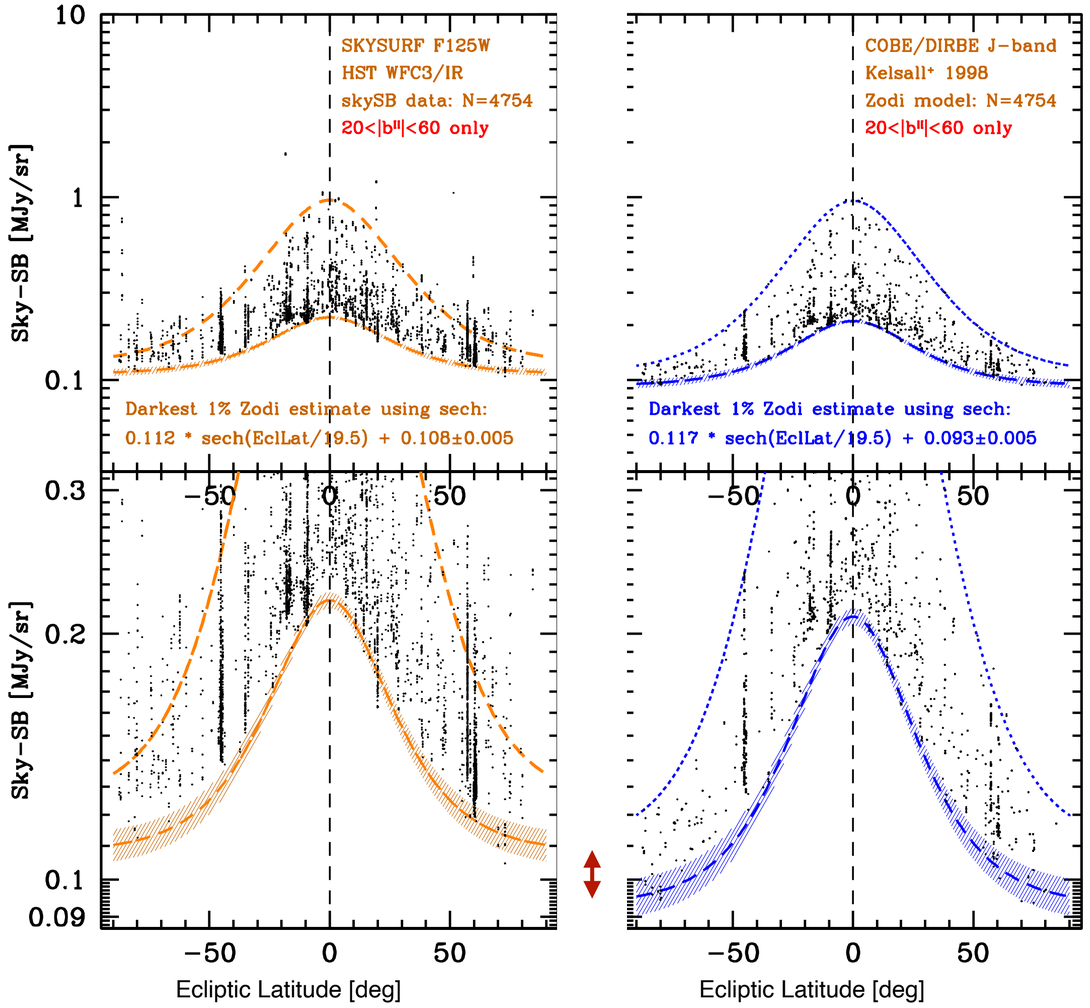
SKYSURF Results

- First focused on F125W, F140W, and F160W where ZL models exist
- Preliminary sky measurements (final sky measurements will be presented in O'Brien et al. 2022 in prep.)
- General philosophy - consider lowest sky level as most accurate (errors most likely from stray light, other contaminants)



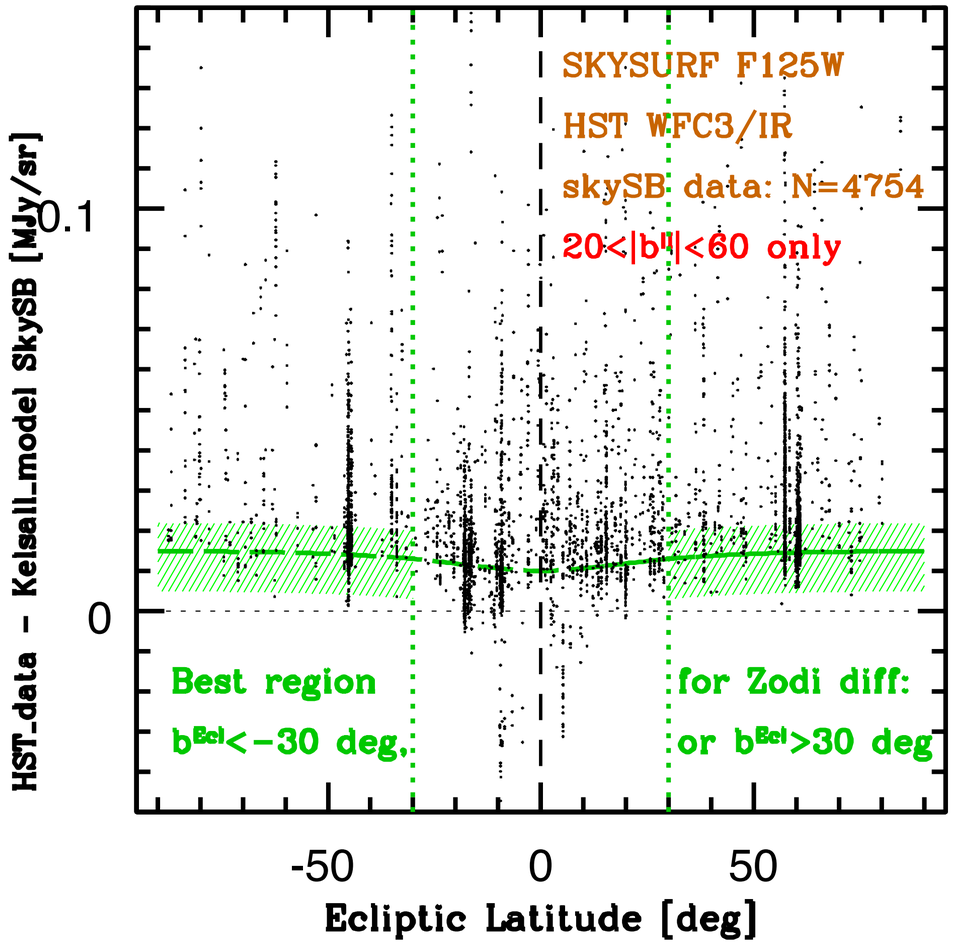
SKYSURF

- Offset of 0.0145 MJy/sr compared to Kelsall ZL model observed



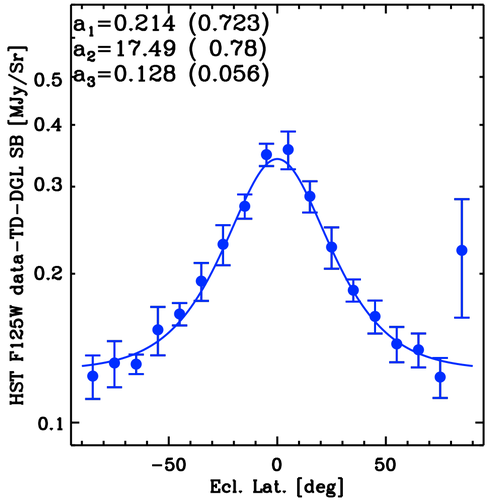
SKYSURF

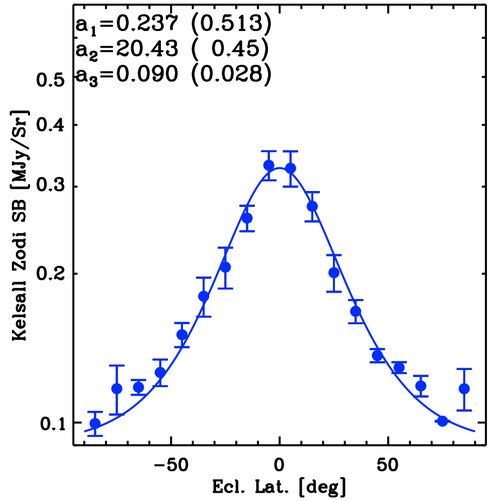
- Offset of 0.0145 MJy/sr compared to Kelsall ZL model observed
- Offset is isotropic!



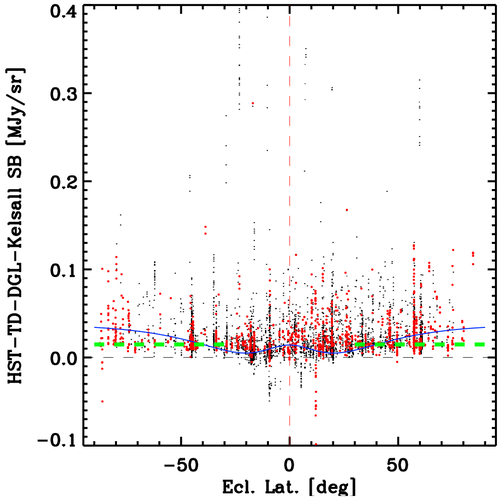
SKYSURF

- Offset of 0.0145 MJy/sr compared to Kelsall ZL model observed
- Offset robust to fitting technique



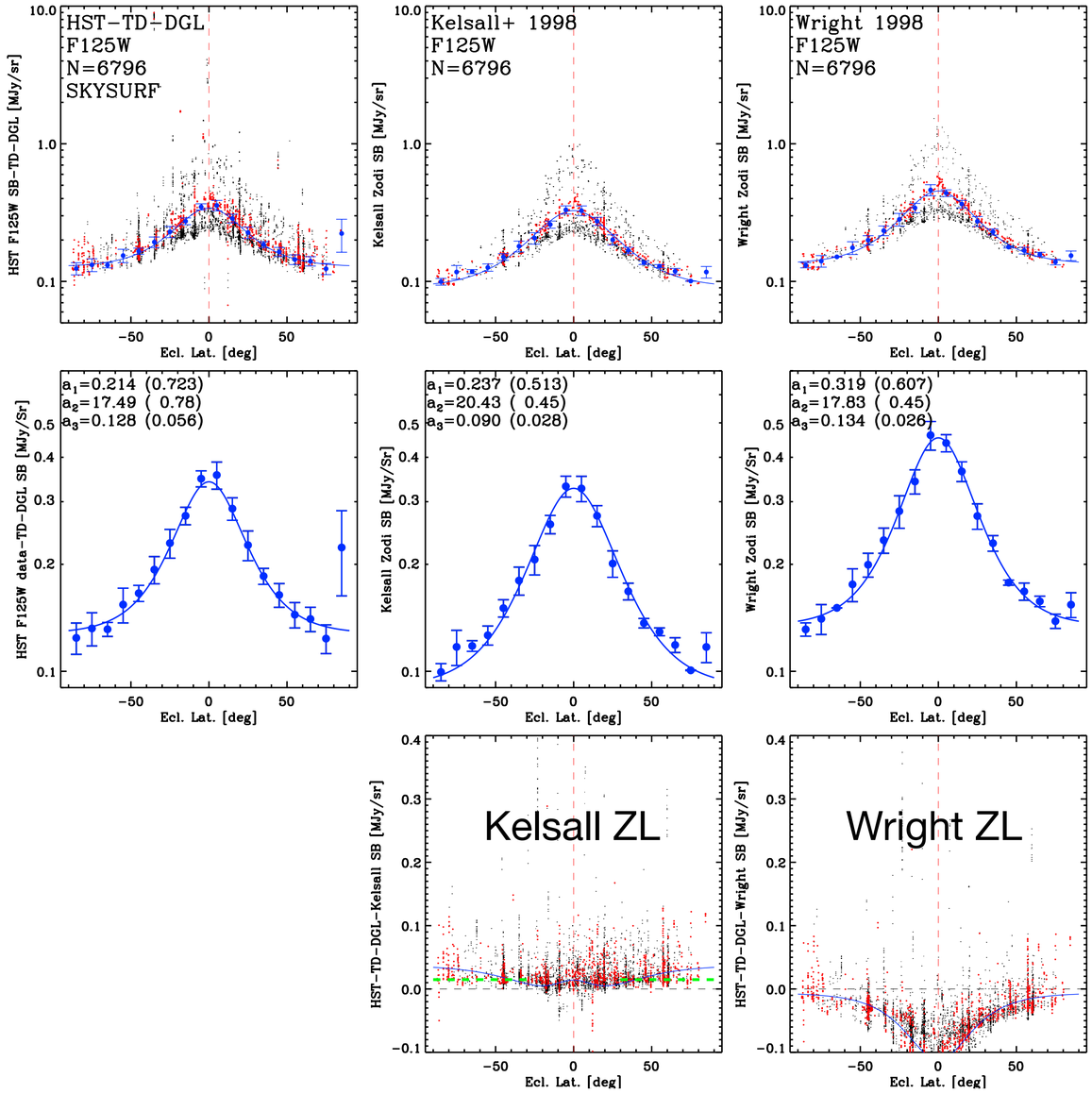


Here we fit observations with a given sun angle rather than the lowest envelope



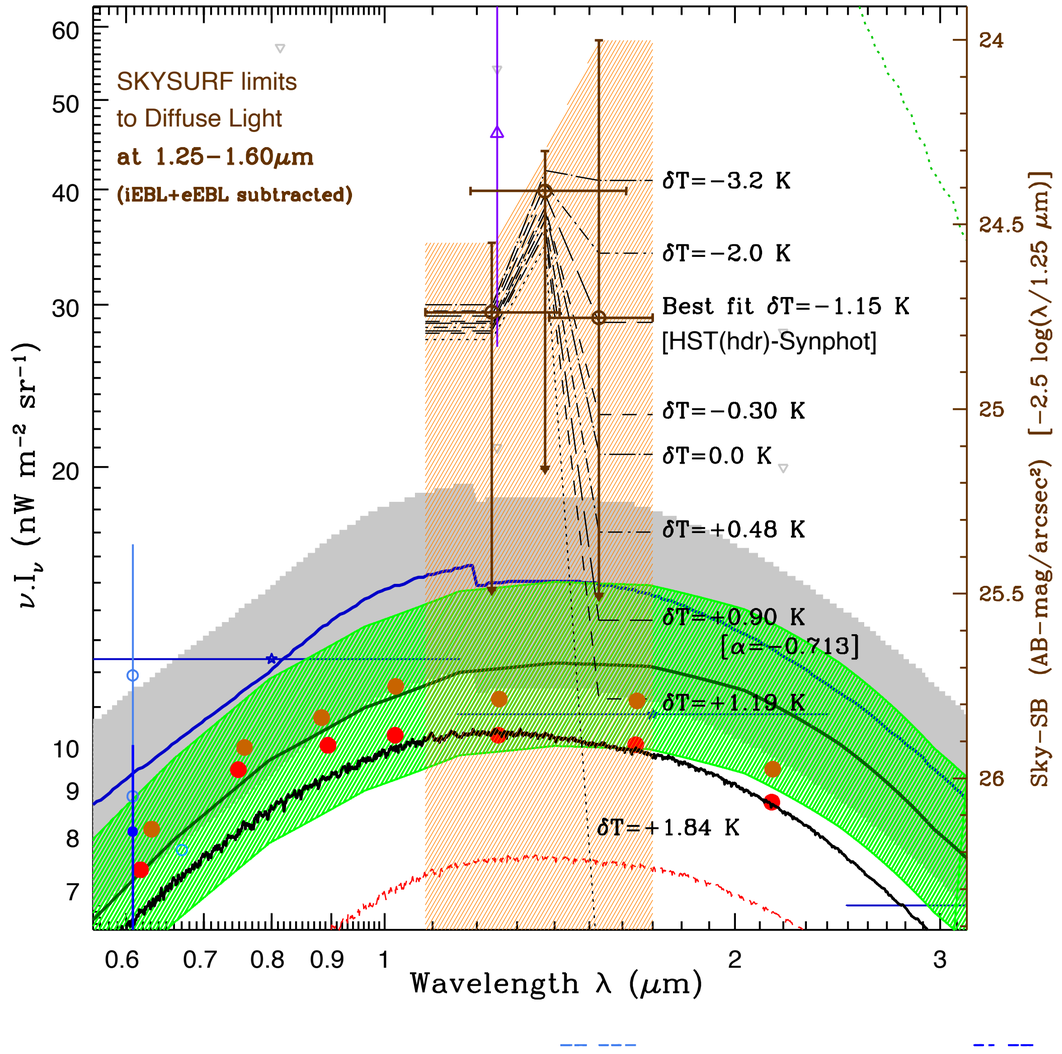
SKYSURF

- Offset of 0.0145 MJy/sr compared to Kelsall ZL model observed
- Offset ***not*** robust to changes in ZL model (Wright ZL model sees no offset)



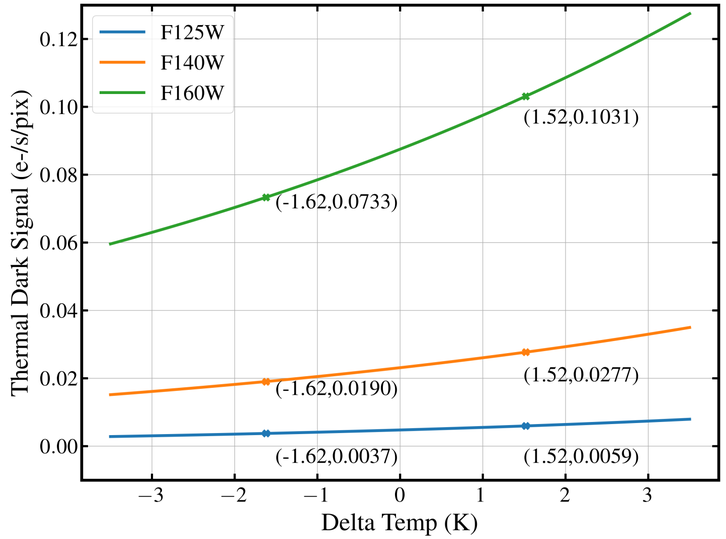
SKYSURF - Instrumental Thermal Emisssion

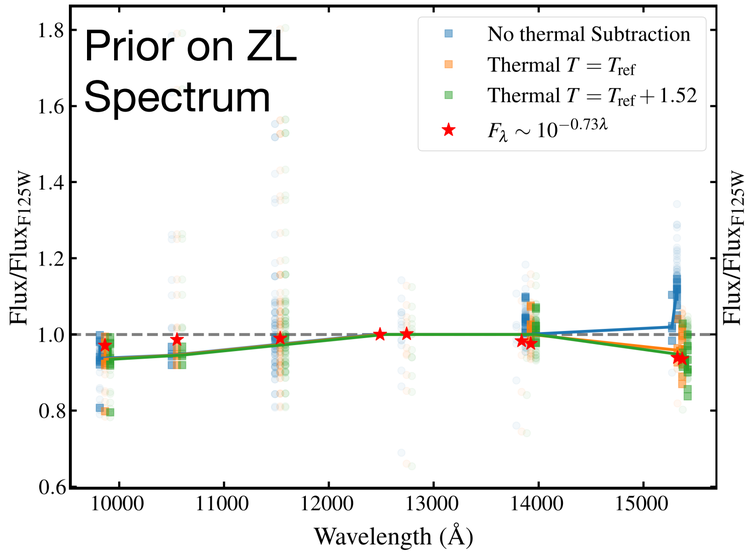
- Thermal emission from HST could mimic isotropic signal
- We modeled that signal as a function of temperature; for a reasonable range in temperatures offset remains

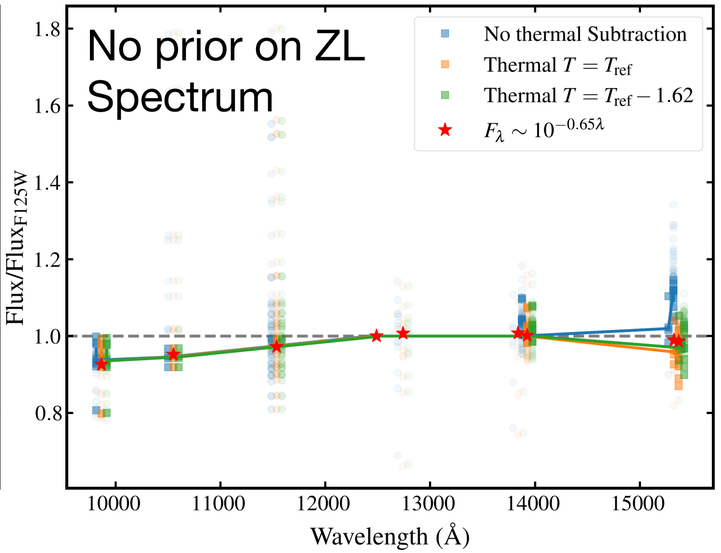


SKYSURF - Instrumental Thermal Emisssion

- Thermal emission from HST could mimic isotropic signal
- We modeled that signal as a function of temperature; for a reasonable range in temperatures offset remains
- We are investigating thermal behavior of HST more
  -model SED of background as ZL emission+thermal component





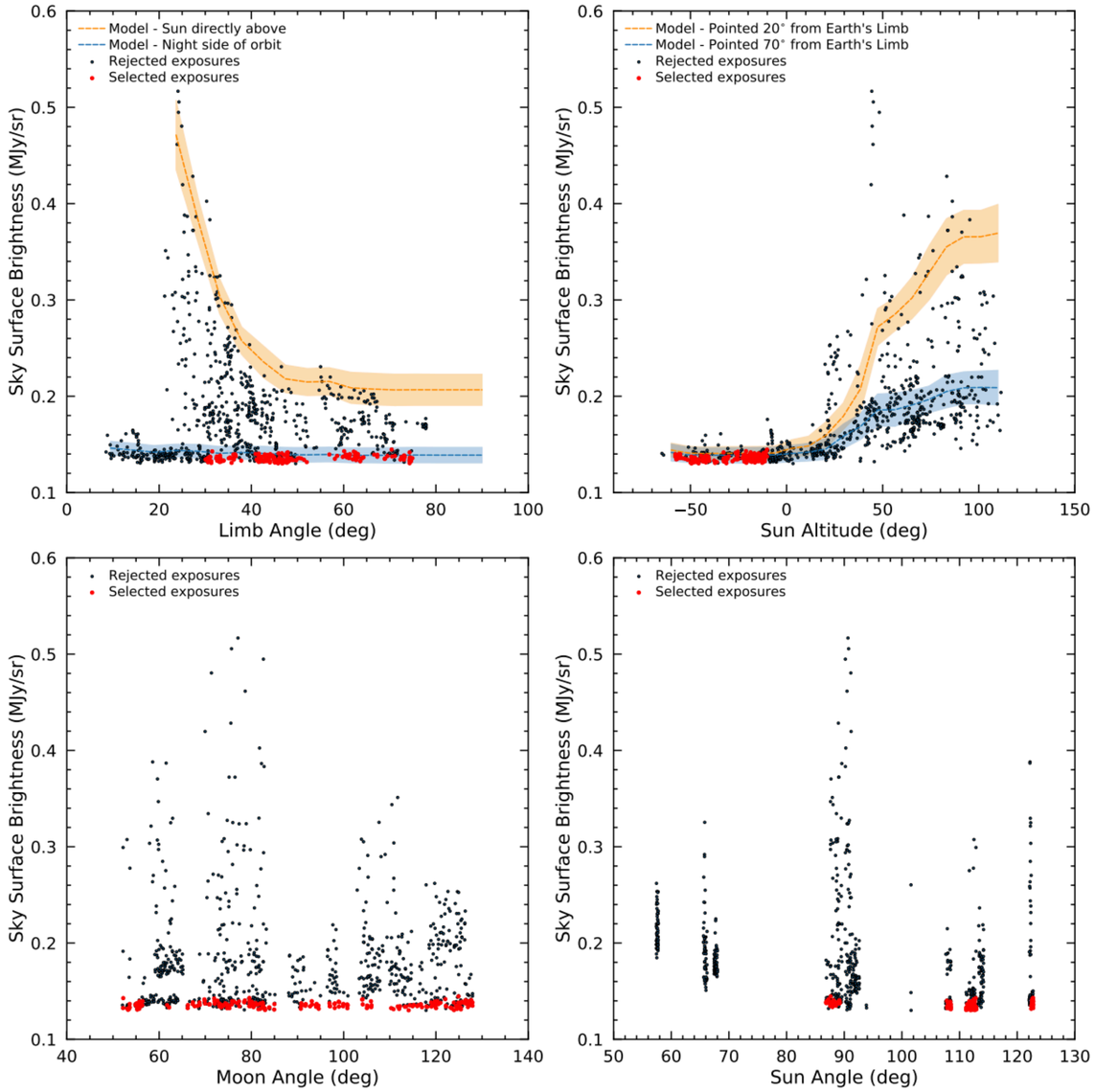


SKYSURF Earthshine

- We study sky in GOODSS (which should be low and constant) to identify contamination based on orbital parameters (also see Caddy+22)

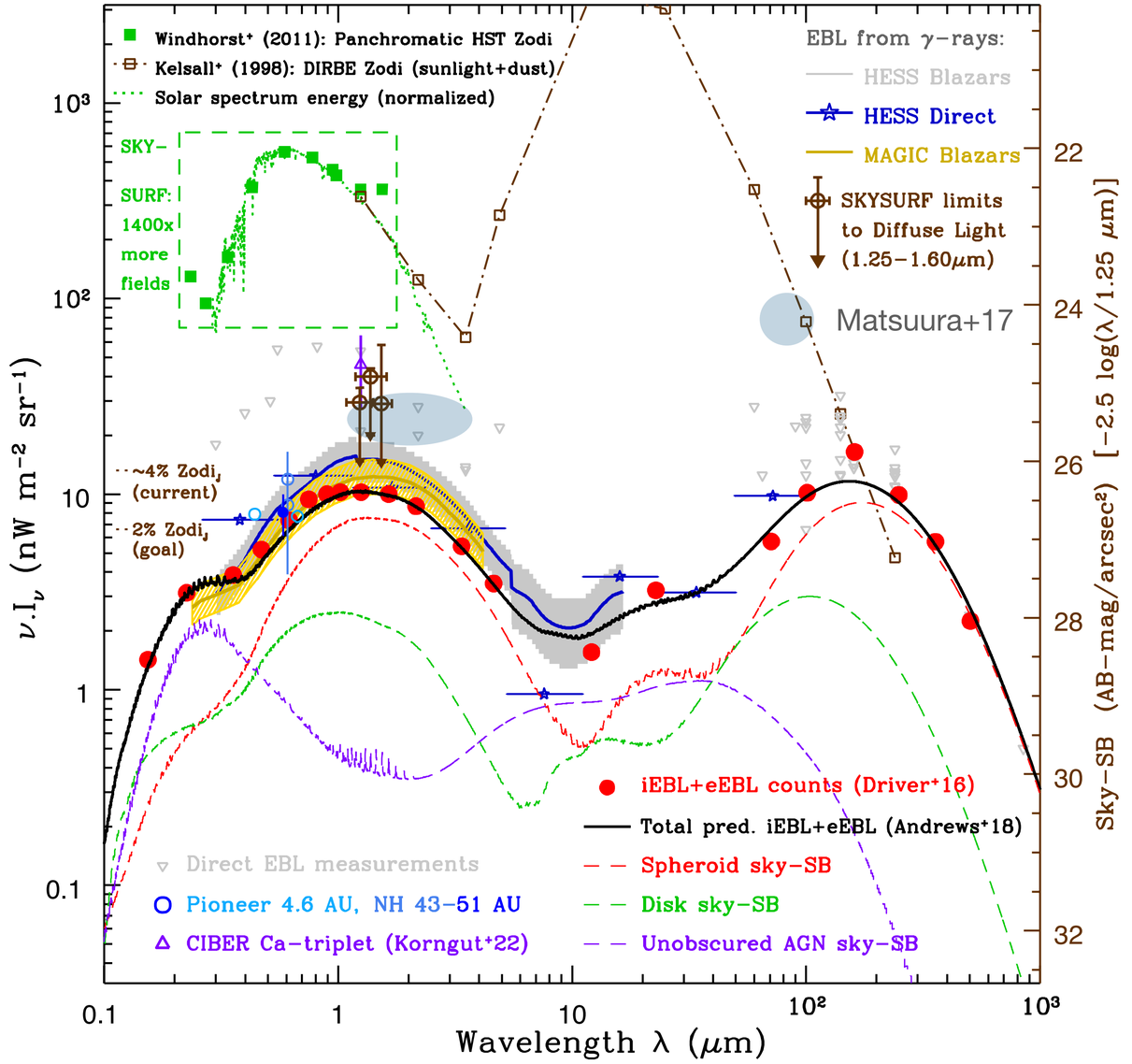
- Images with:
  Large object (<70% sky): 9%
  Sun altitude>0: 44%
  Sun Angle<80: 17%
  Moon Angle<50: 13%
  Limb Angle<50: 44%

Remaining: ~10%; still >750 images



SKYSURF - Results

- Final result - we observe a diffuse sky component of ~30 nW/m^2/sr, but it depends on ZL model assumed, so we quote it as an upper limit
- In particular, possibility of ~spherical comet cloud could mimic EBL signal



SKYSURF - Future

- All wavelength Sky-SB measurements
- Improved ZL models
- Improved thermal characterization
- Galaxy/star counts

SKYSURF Sky Measurements

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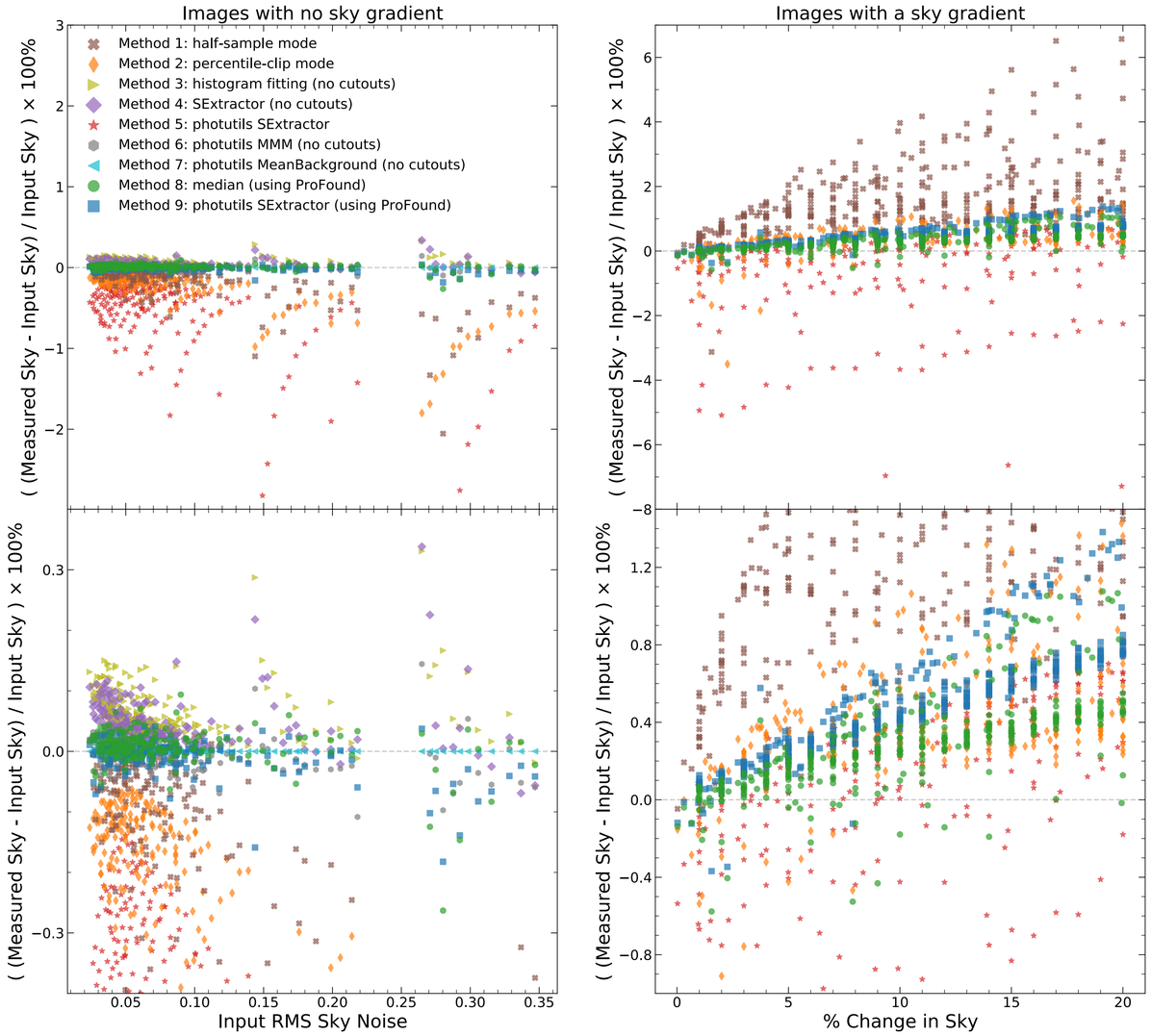
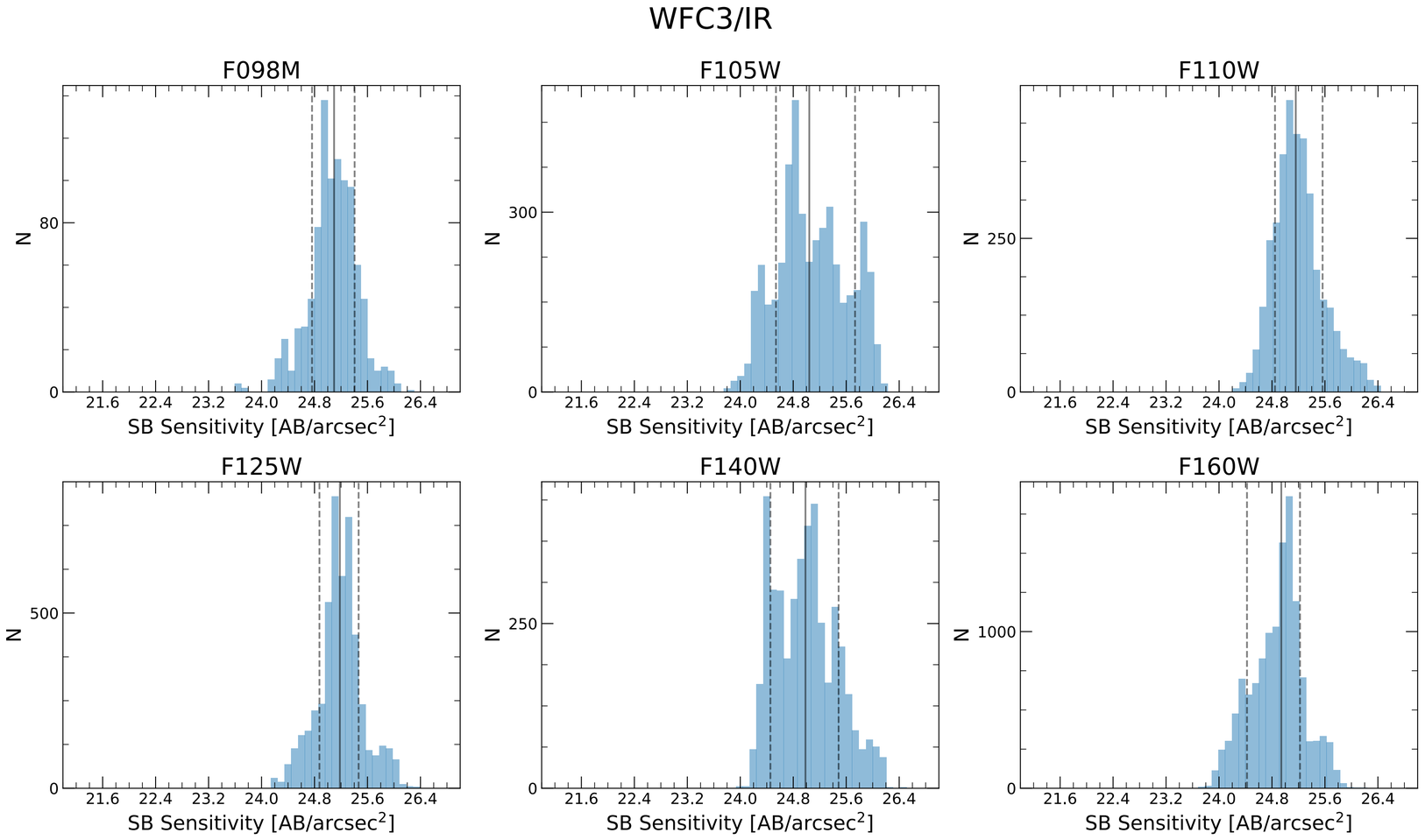
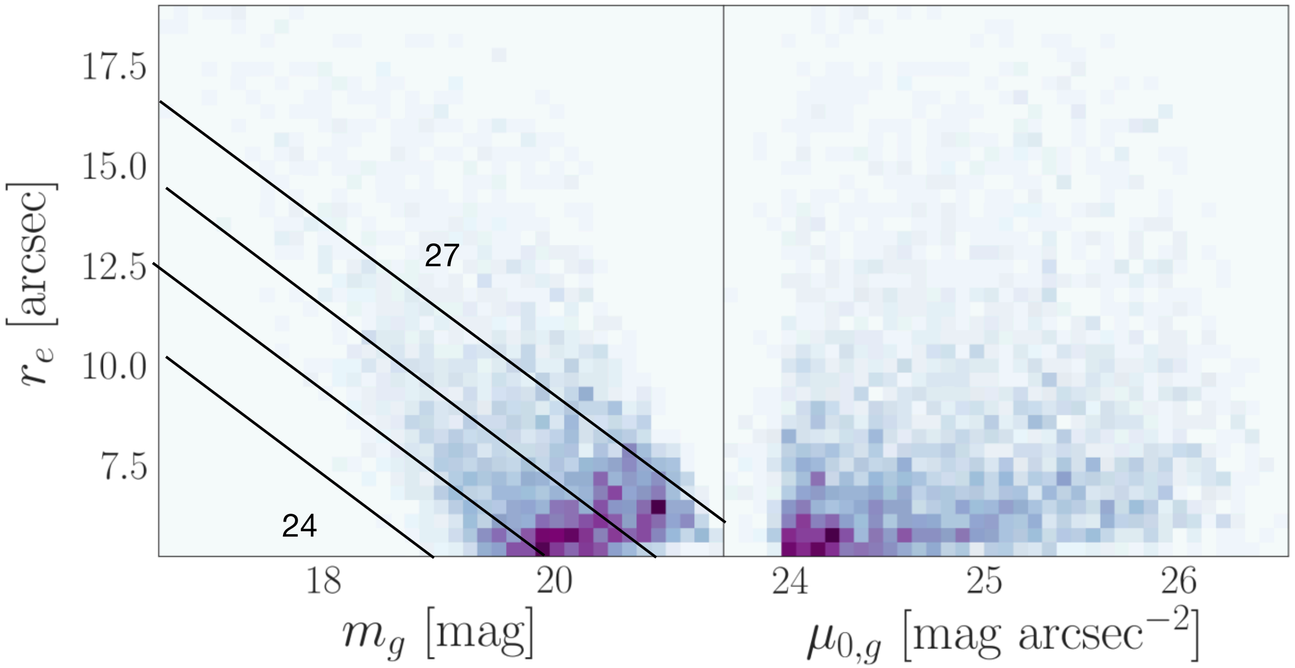
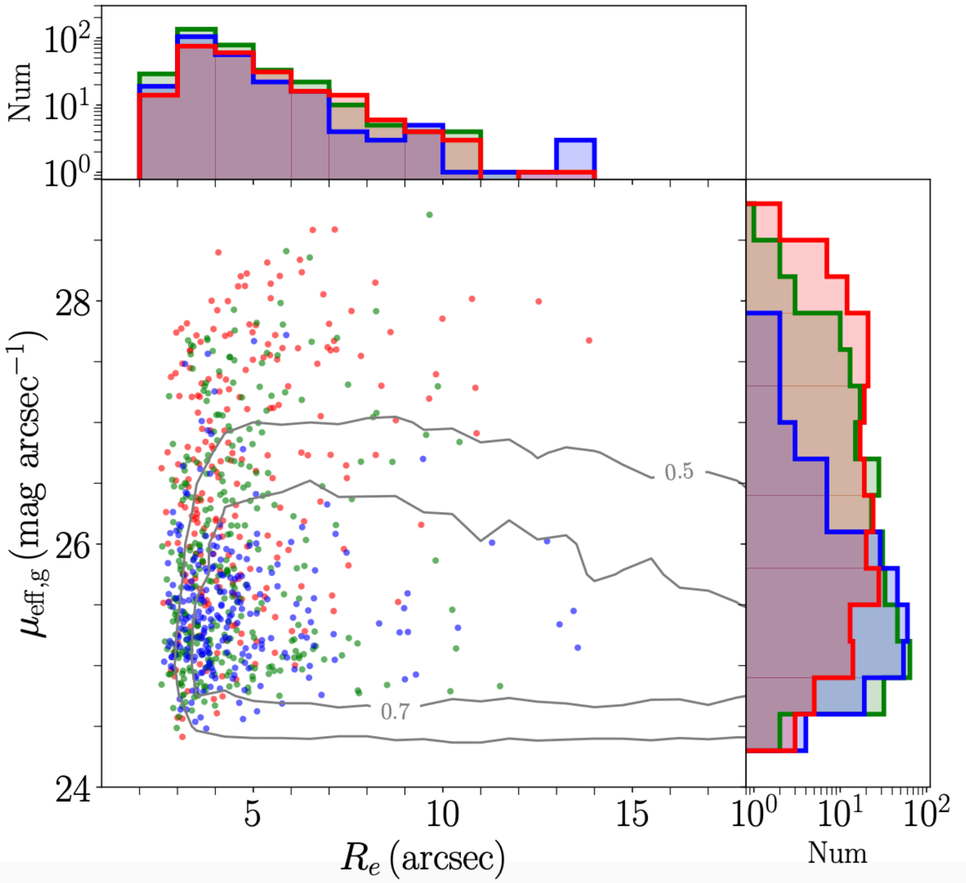


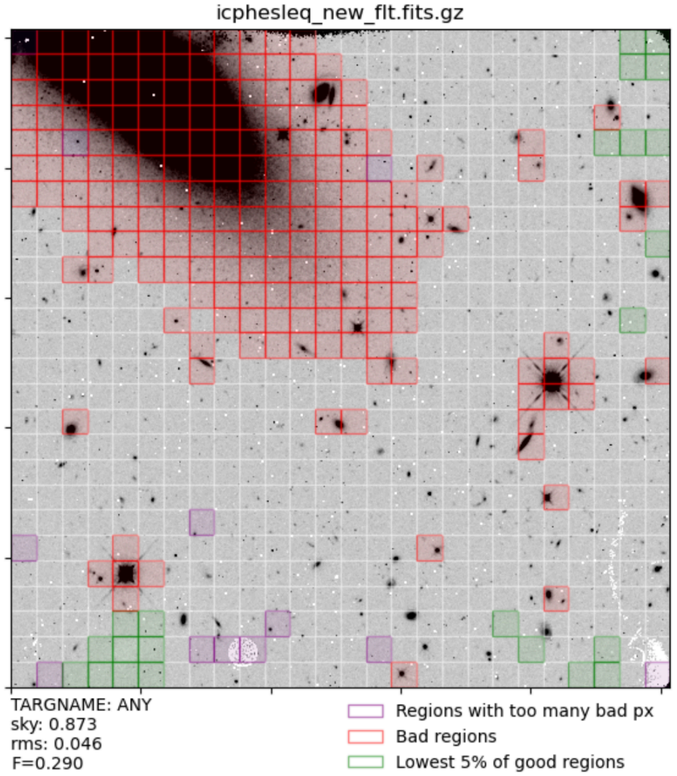

WFC3/IR
F098M
F105W
F110W
F125W
F140W
F160W
N
SB Sensitivity [AB/arcsec^2]
21.6
22.4
23.2
24.0
24.8
25.6
26.4
0
80
300
250
500
1000

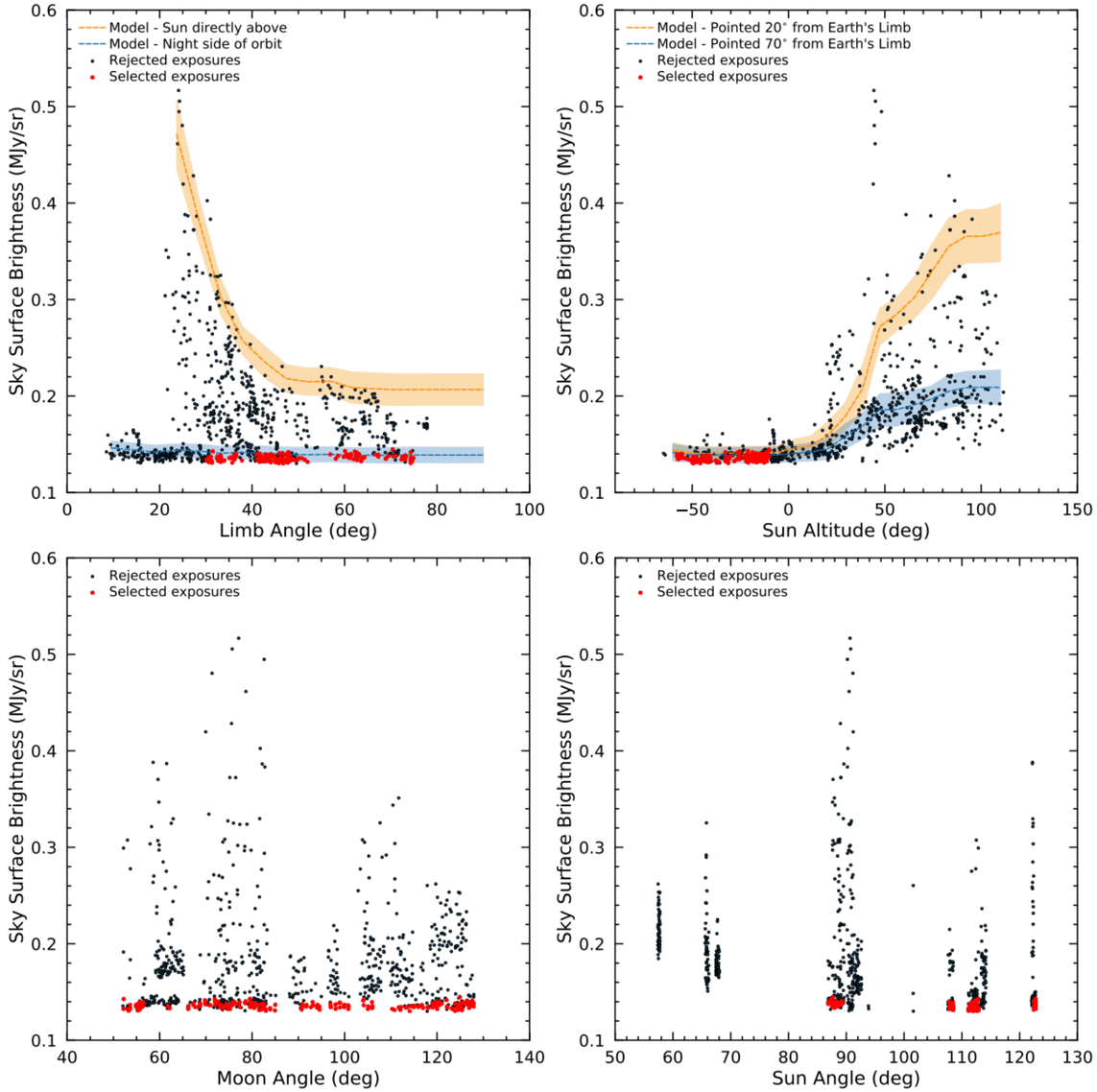


From SMUDGES survey (Zaritsky+22): abundance of diffuse objects drops significantly for objects with sizes >5”



Similar result from HyperSuprime Cam (Greene+22)


icphesleq_new_flt.fits.gz
TARGNAME: ANY
sky: 0.873
rms: 0.046
F=0.290
Regions with too many bad px
Bad regions
Lowest 5% of good regions



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