

# **CSFD: A More Accurate Galactic Dust Map**

by Tomographically Correcting for the Extragalactic Imprints in SFD

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**ASIAA**

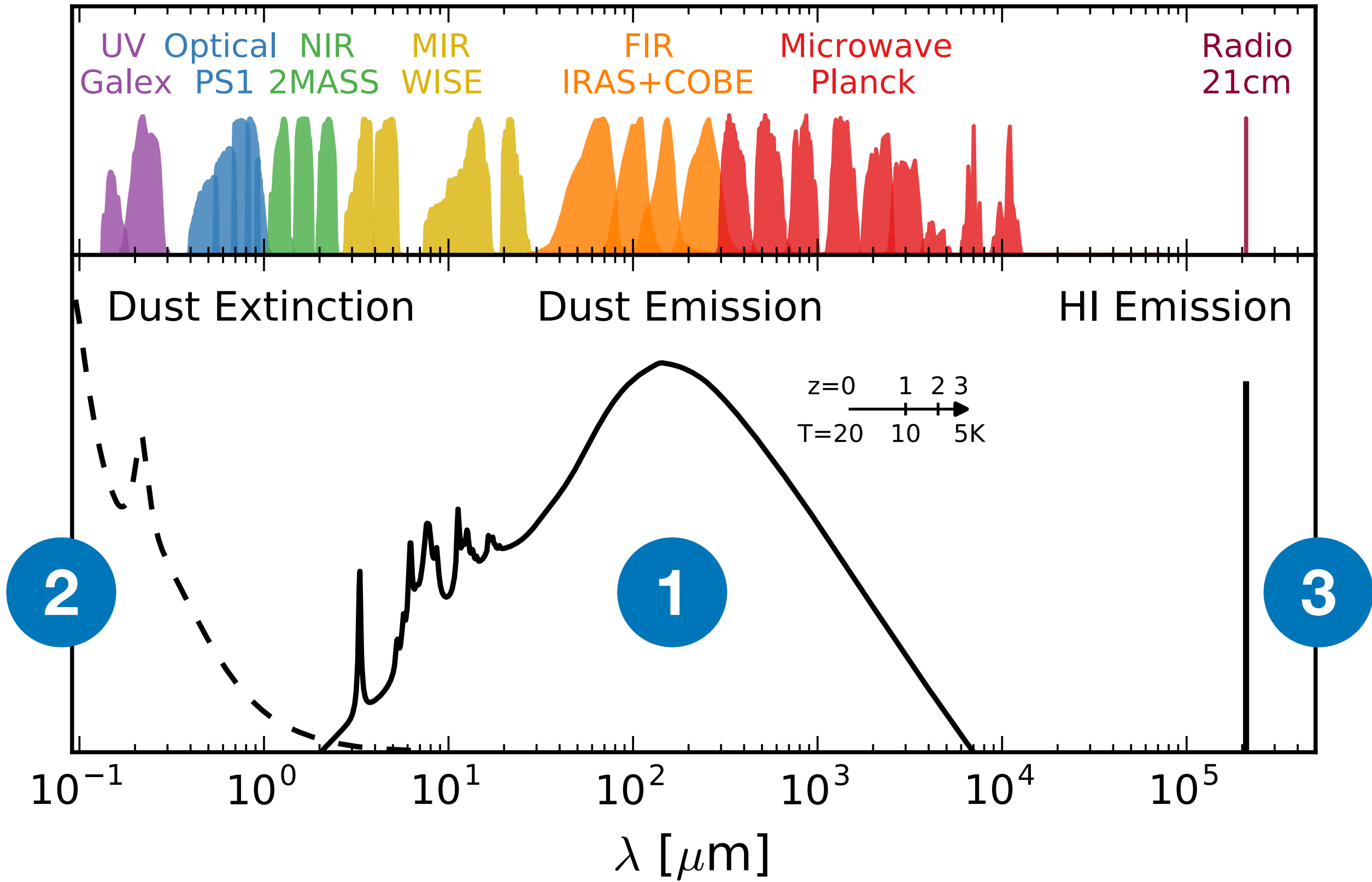
Cosmology from Home 2023

Talk base on [arXiv: 2306.03926](https://arxiv.org/abs/2306.03926)





# 3 ways to probe Galactic dust reddening



- 1. IR thermal emission
- 2. Stellar (or galaxy) reddening
- 3. HI 21 cm

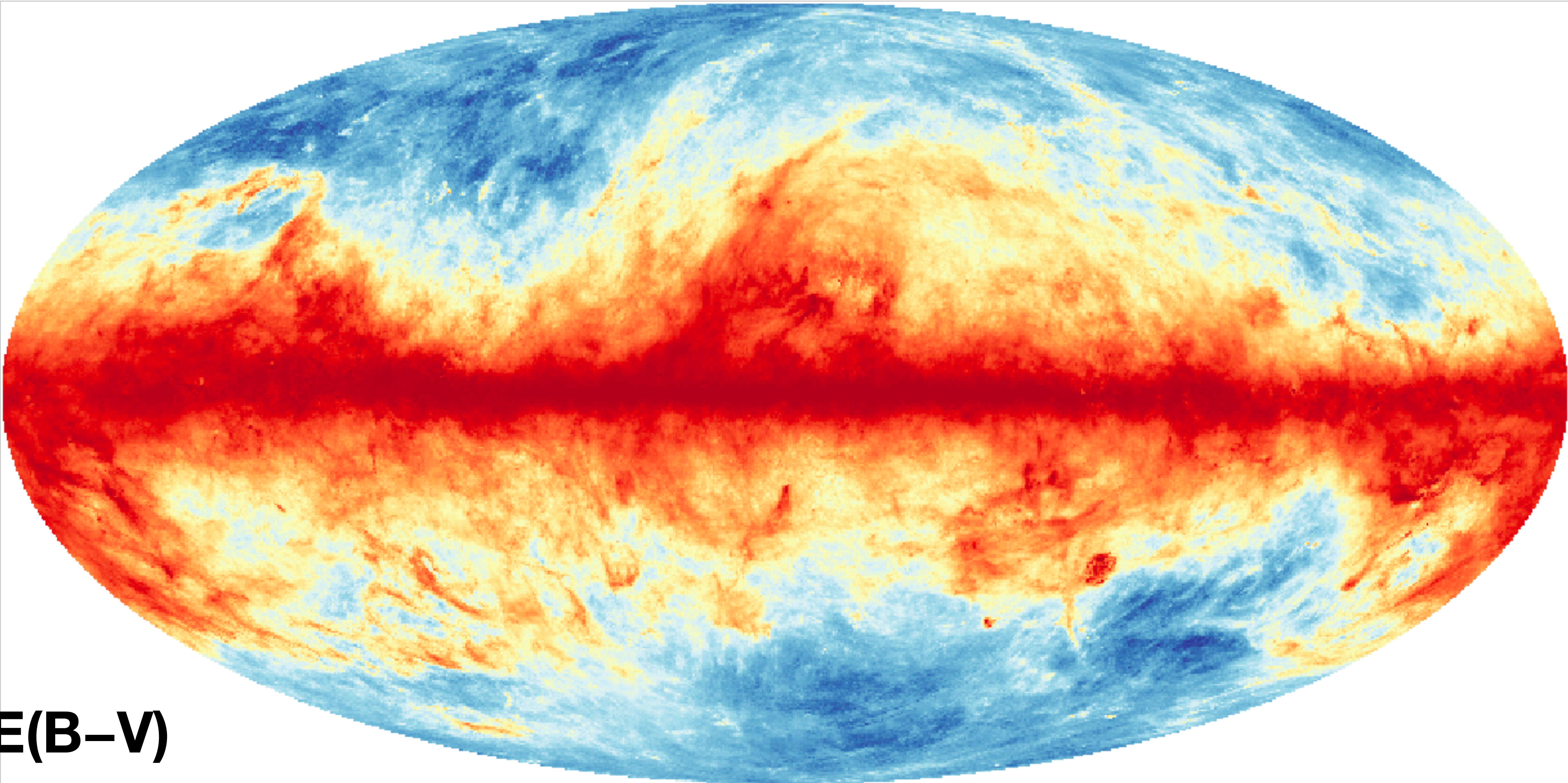
**Pros**  
 high SNR & resolution  
 direct reddening, 3D\*  
 pure-Galactic

**Cons**  
 CIB contamination  
 low SNR  
 dust-to-gas varies



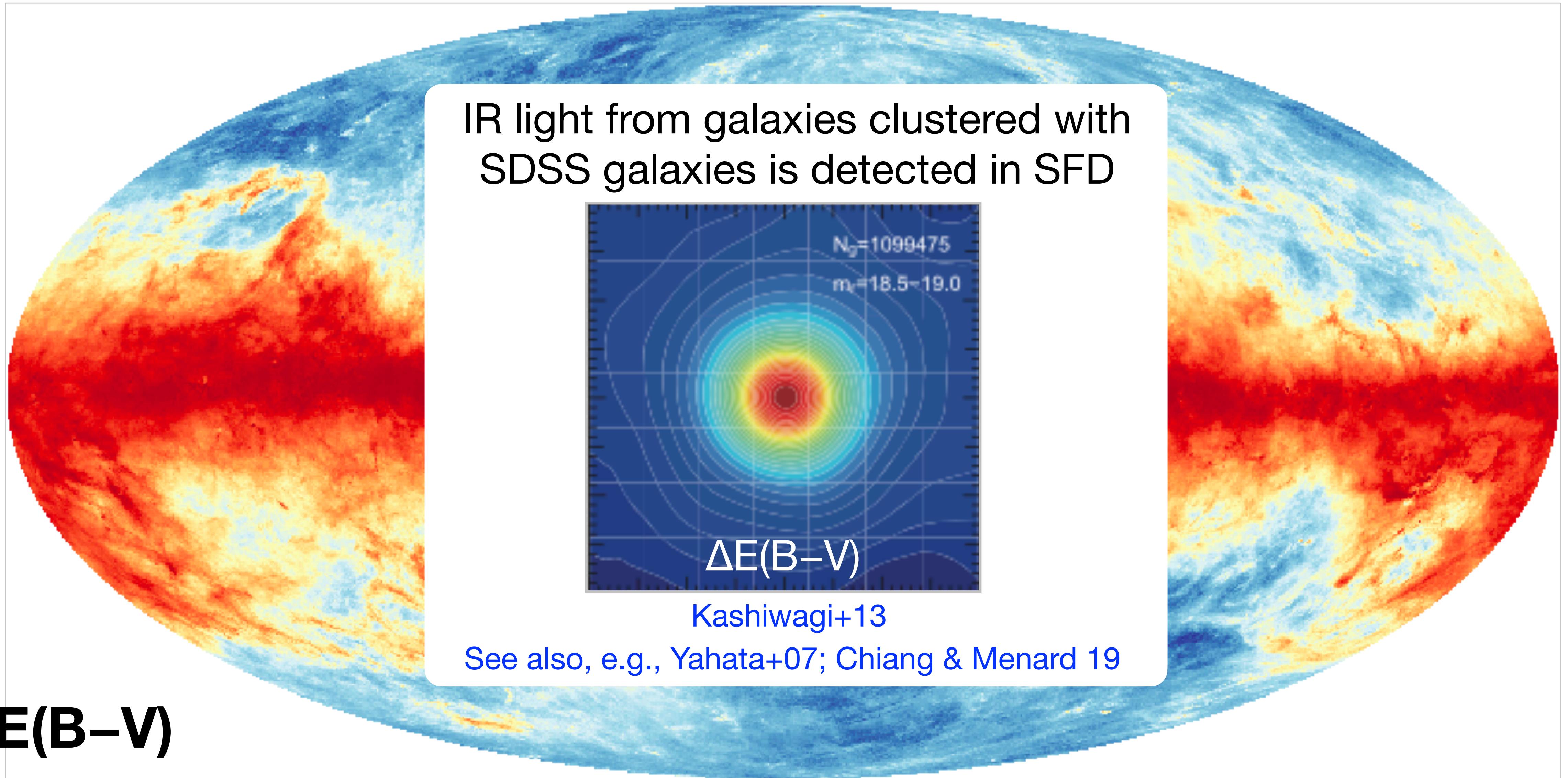
# Schlegel, Finkbeiner, Davis (SFD) 1998 dust map

IRAS 100  $\mu\text{m}$  + COBE/DIRBE temperature correction



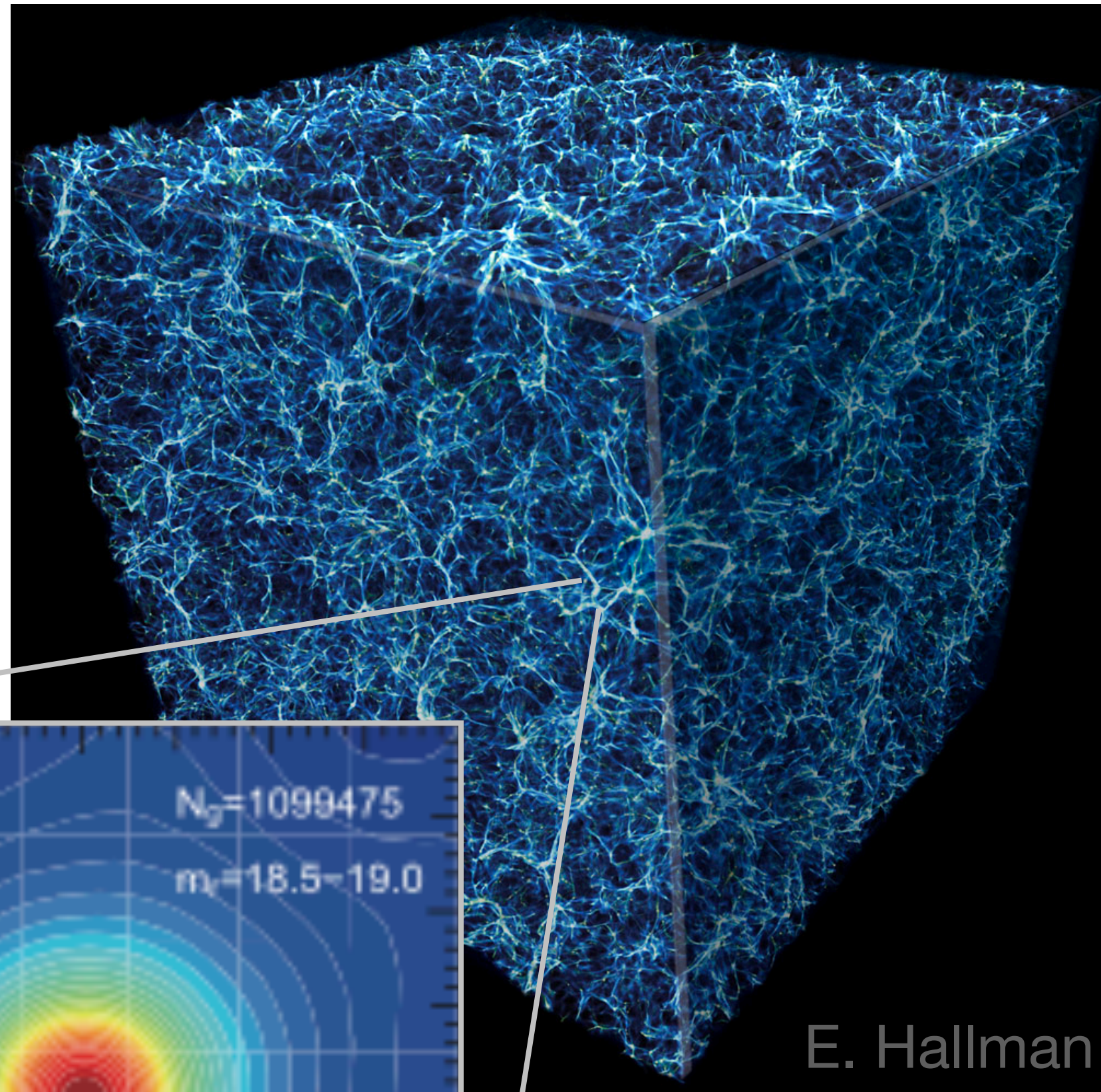


# Cosmic IR background (CIB) contamination in SFD





# Percent-level biases in photometry and cosmology



Kashiwagi+13

## Direct effect:

Extinction is **over-corrected** around every galaxy in a **spatial & redshift-dependent** manner

## Impact:

Supernova Ia distances

lensing magnification

galaxy clustering

small-scale (neutrino, astrophysics)

large-scale (fNL, M-R equality)

See Chiang & Menard 19



## Removing the CIB in SFD to get pure Galactic reddening

$$E(B - V)_G(\phi) = E(B - V)_{\text{SFD}}(\phi) - I_{\text{CIB}}(\phi)$$

↑  
need a map-level reconstruction of the CIB

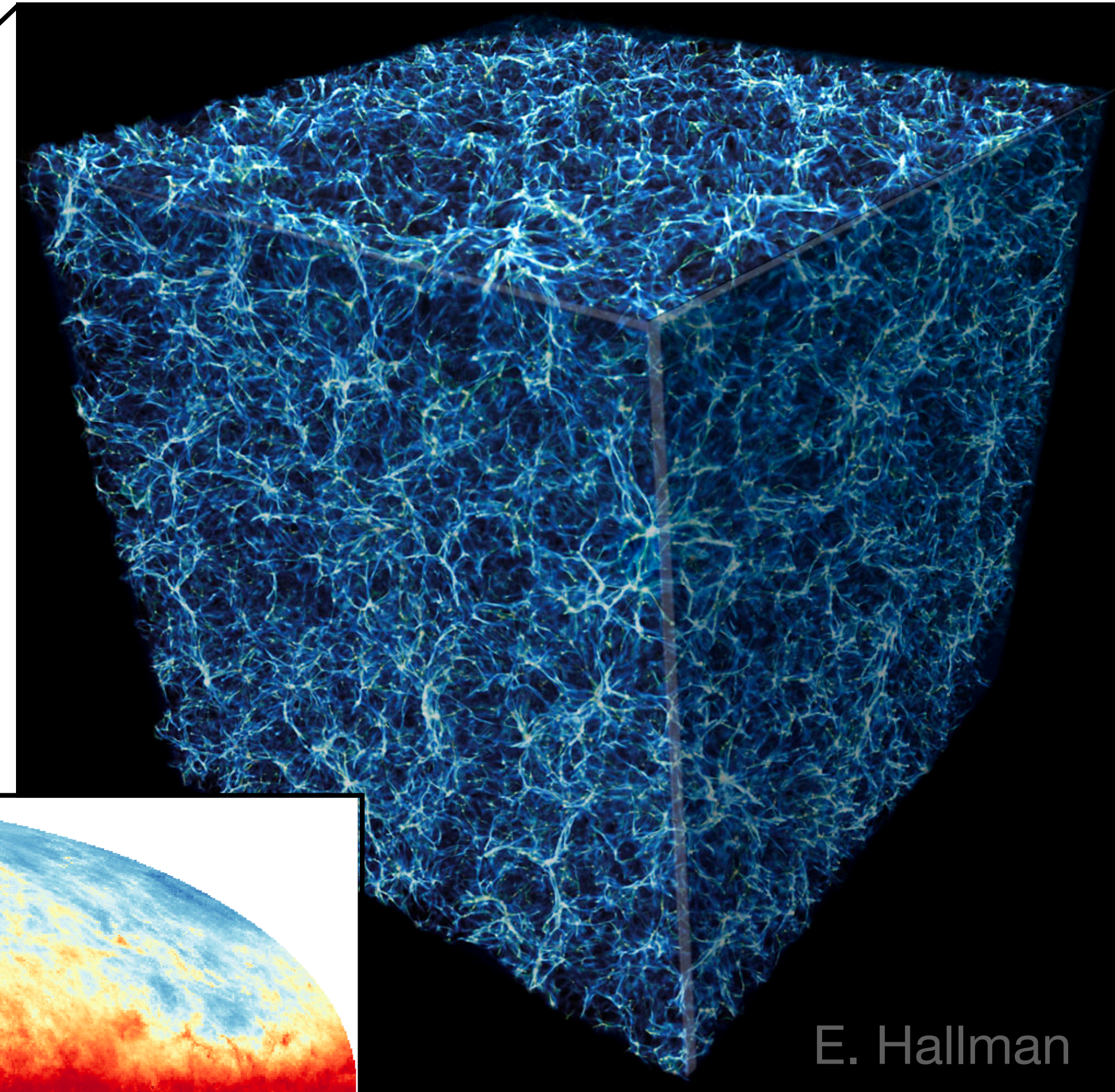
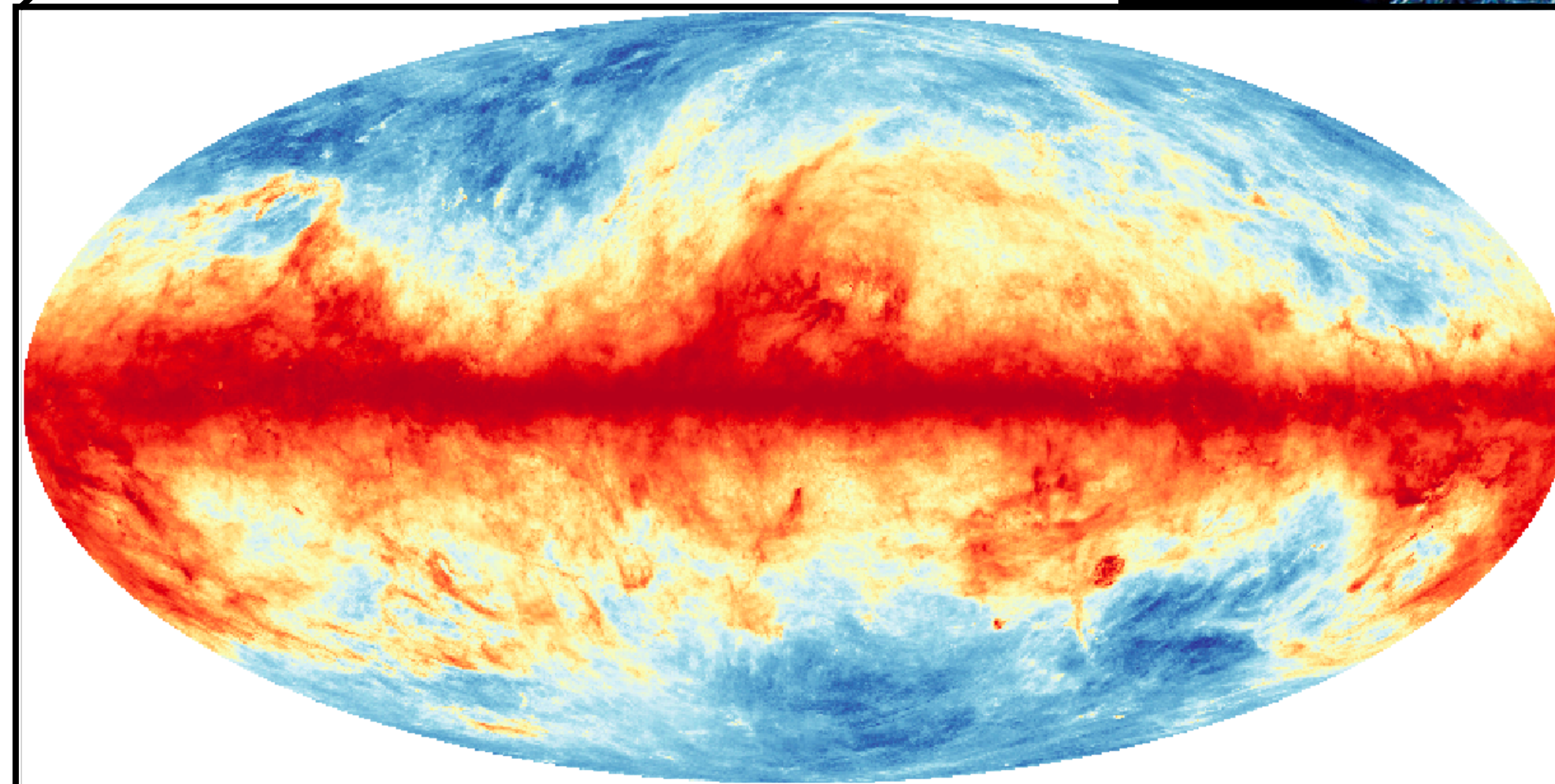
**Step 1: get CLB statistics via cross-correlations**



# CIB statistics are intrinsically high-dimensional

CIB fluctuations are **angular** and **redshift** dependent

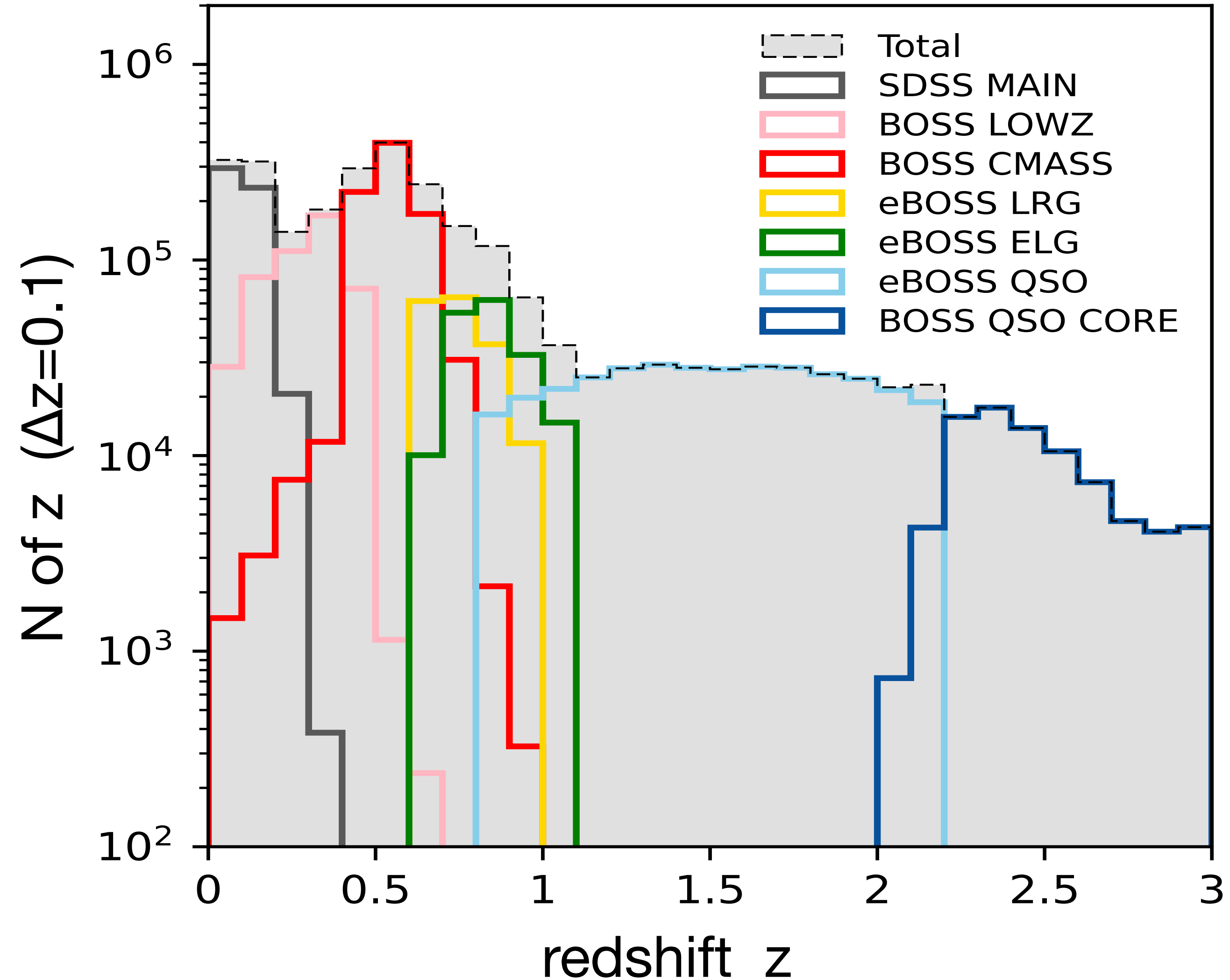
To describe it fully,  
need essentially  $P(k)$   
or  $W(\theta)$  at all  $z$





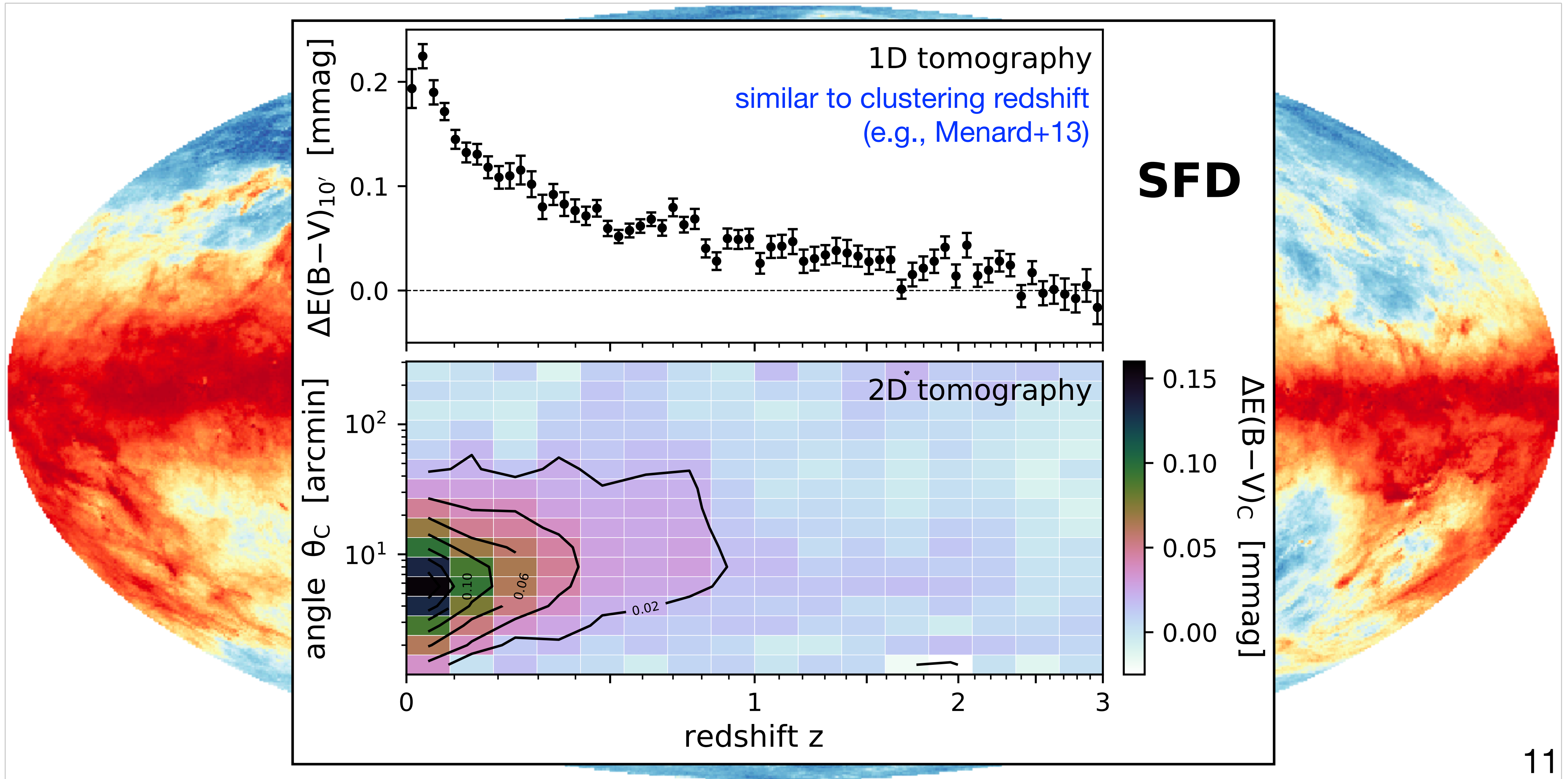
# Reference objects for cross-correlations

2.7 million spectroscopic galaxies and QSOs in SDSS





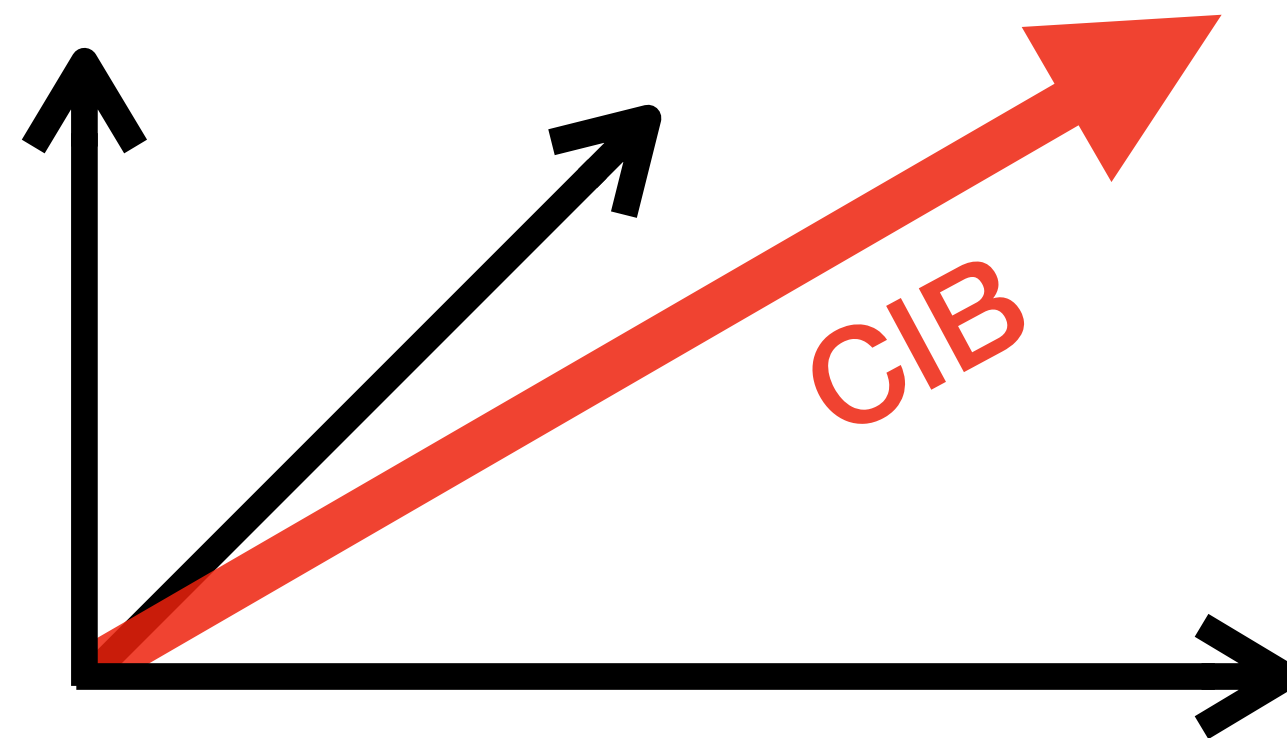
# CIB statistics: SFD cross SDSS references vs $z$ & $\theta$



## Step 2: map-level CIB reconstruction

$$I_{\text{CIB}}(\phi) = \sum_{i=1}^N C_i \times T_{LSS,i}(\phi)$$

Linear combination of templates as basis vectors



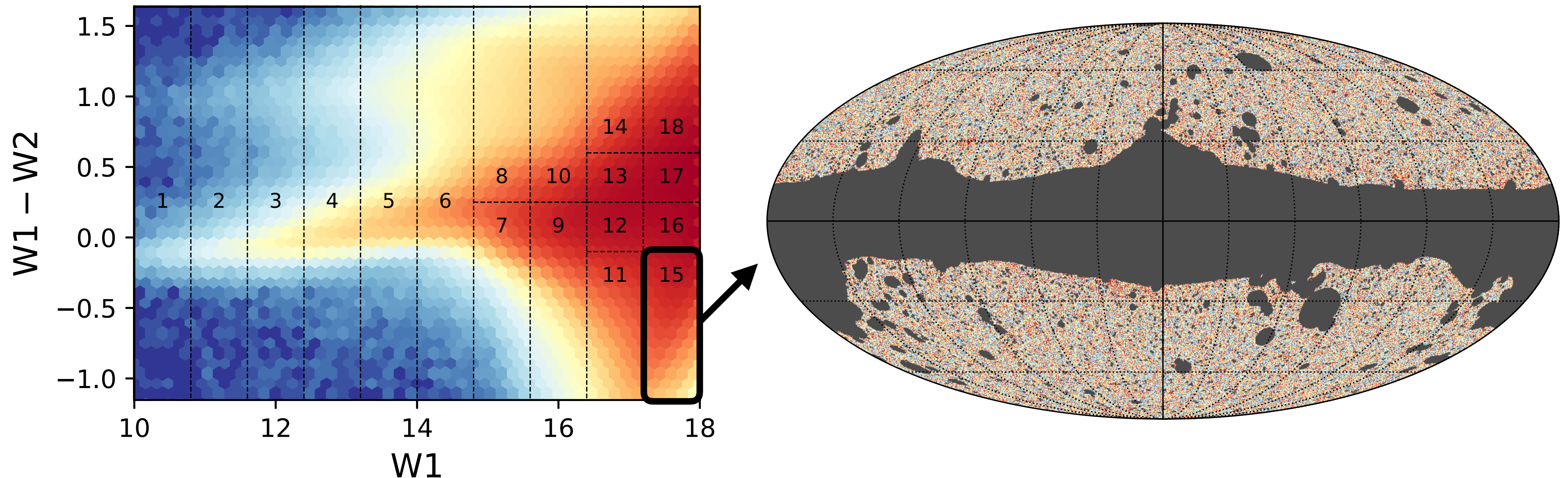


# LSS templates needed for phases of cosmic web

i.e., the exact locations of filaments, clusters, & voids

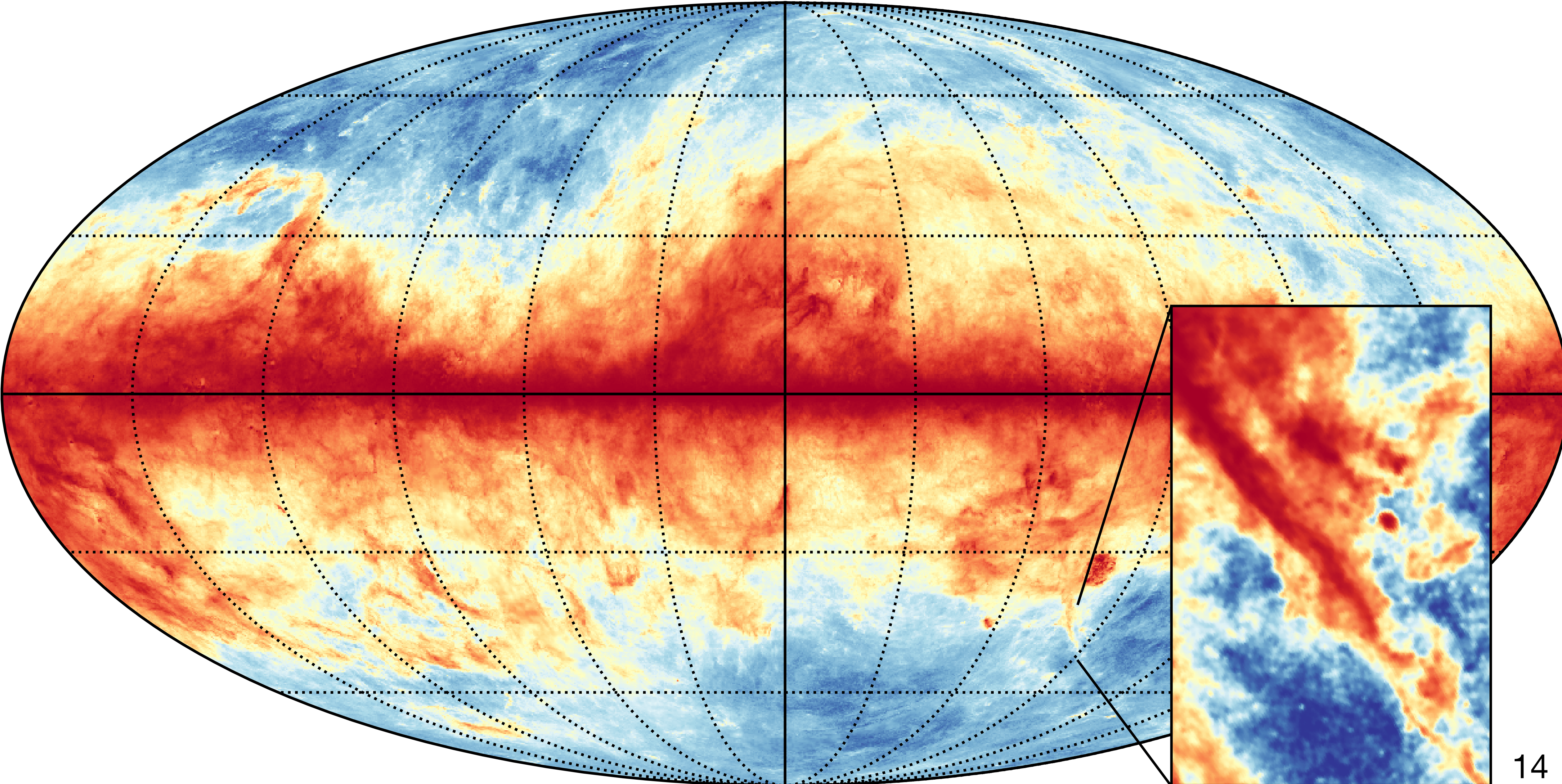
## WISE galaxy density fields:

- redshift range is wide enough for CIB reconstruction
- # of galaxies is high (440M has W1+W2; 16M has photo-z)





# Unlike SFD, the LSS templates are foreground-free

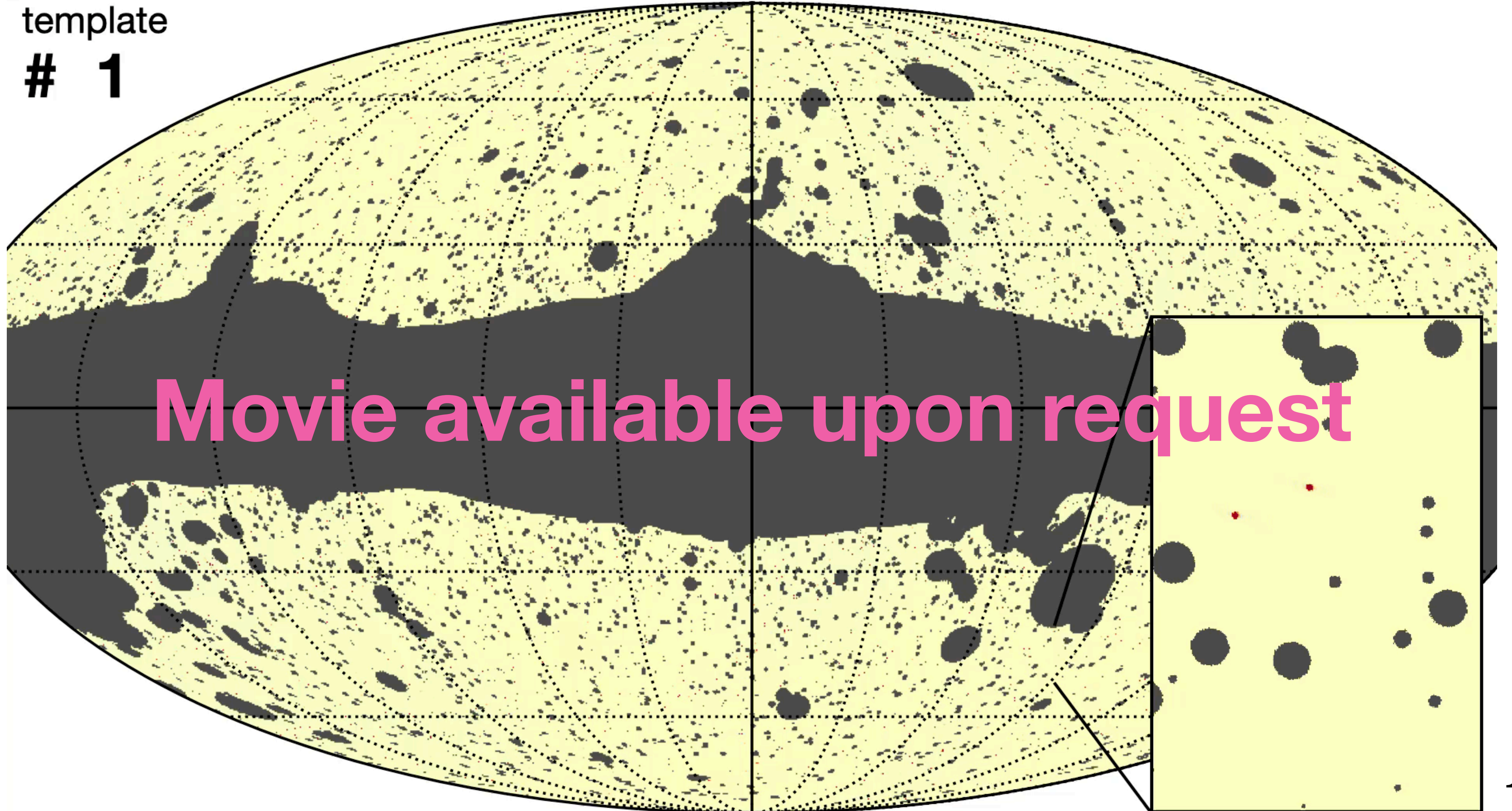




**180 LSS templates = 30 WISE samples × 6 beams**

template

**# 1**

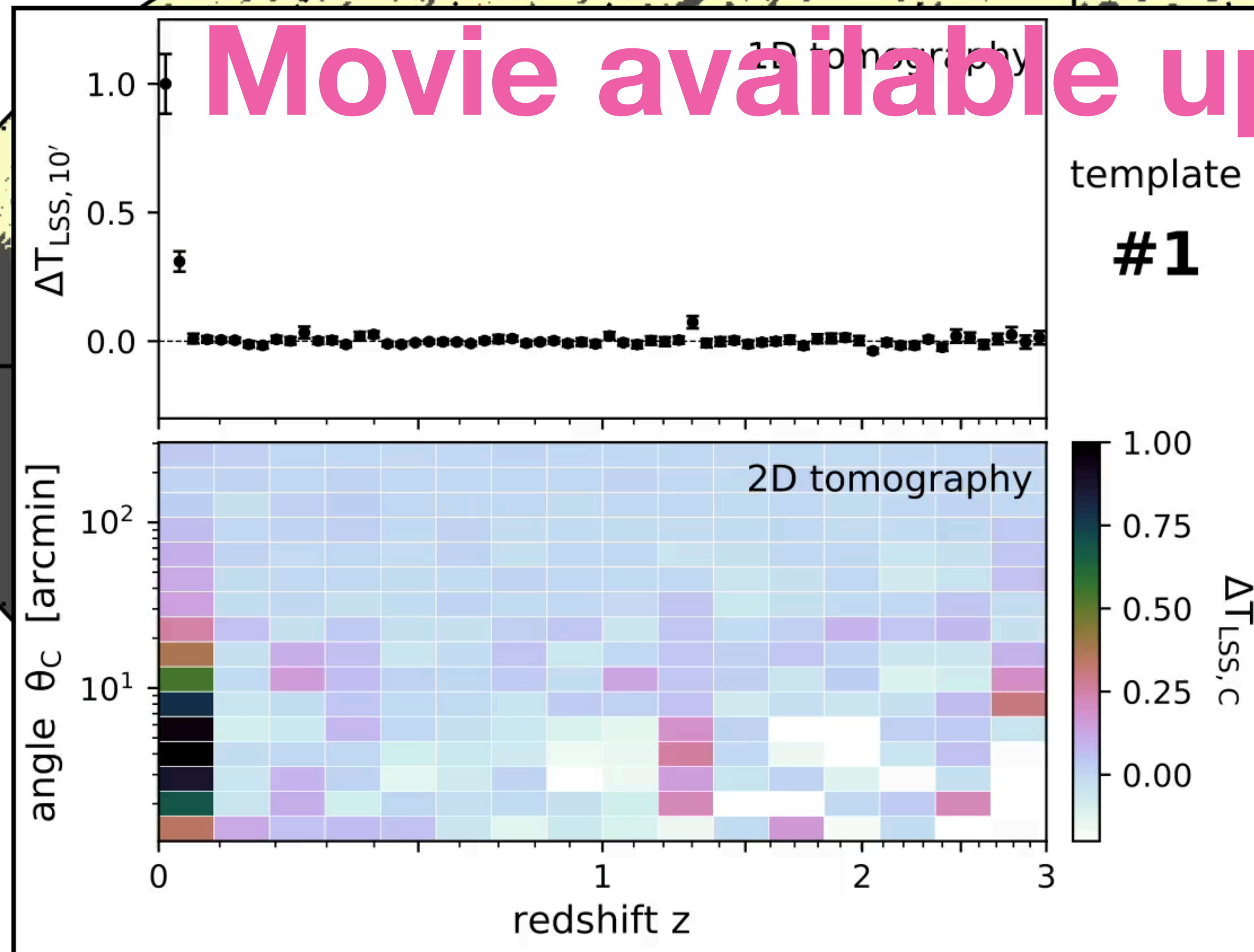




# Measure the same set of tomographic statistics

template

# 1



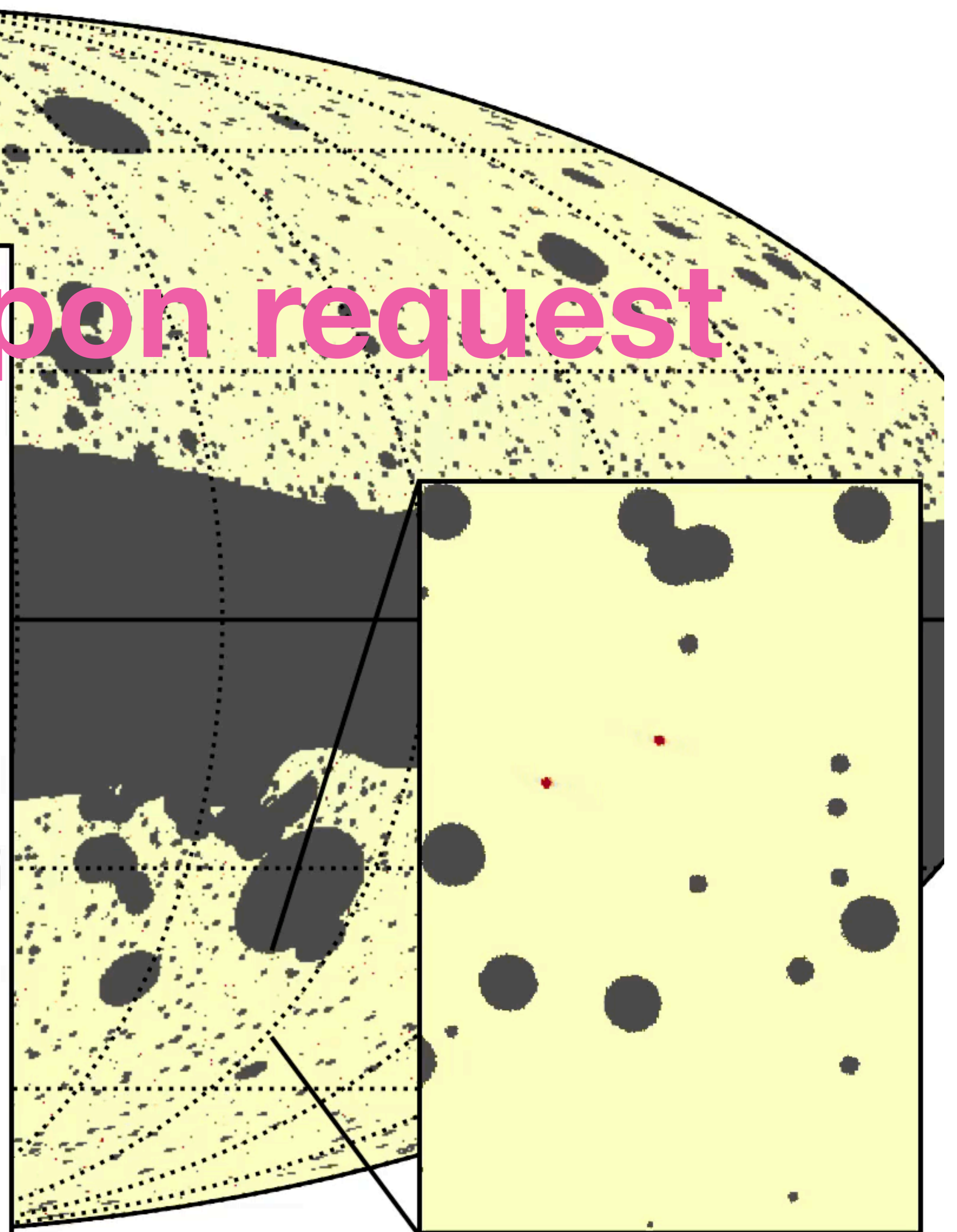
Movie available upon request

template

# 1

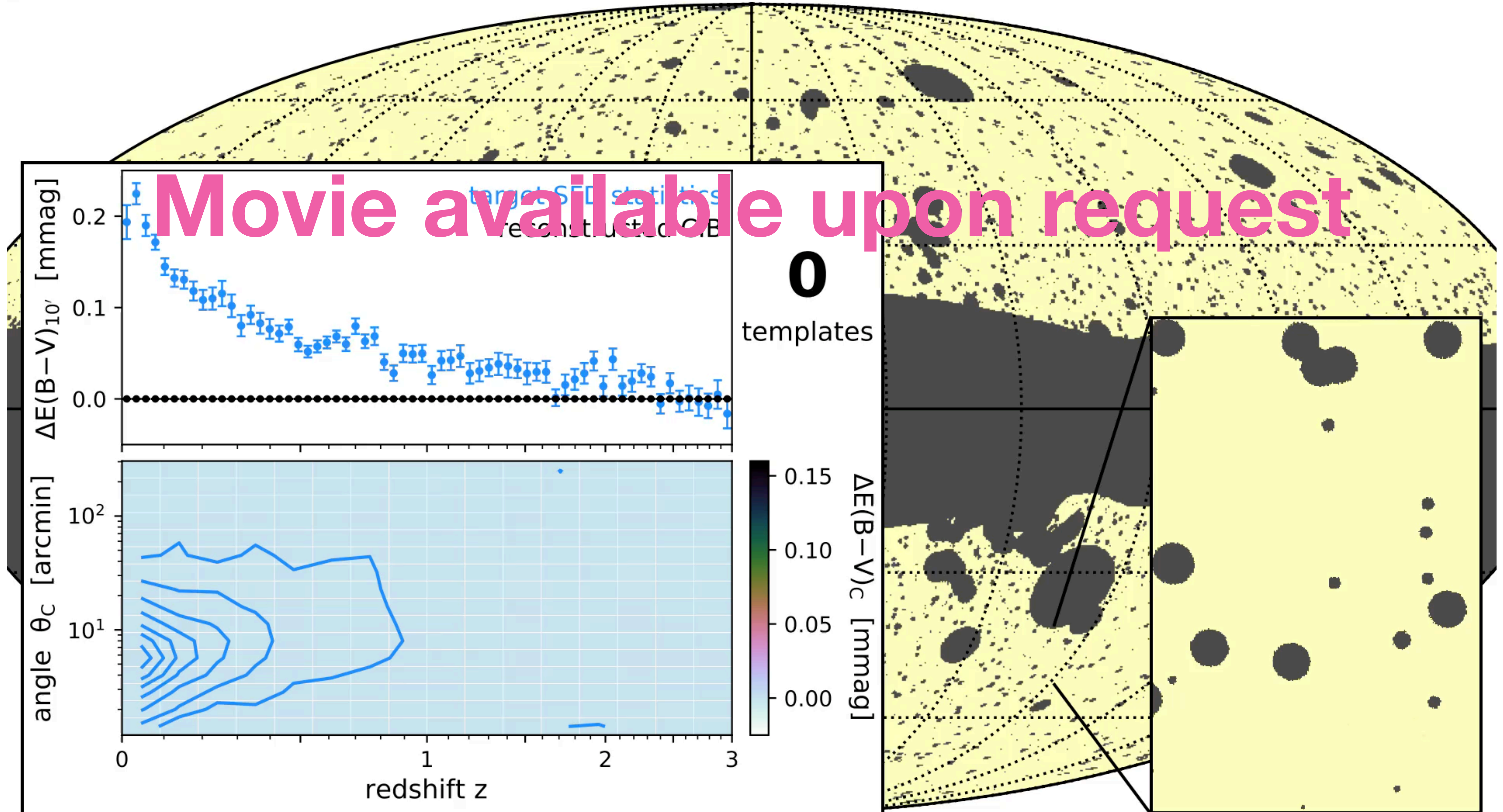
$\Delta T_{LSS,C}$

1.00  
0.75  
0.50  
0.25  
0.00



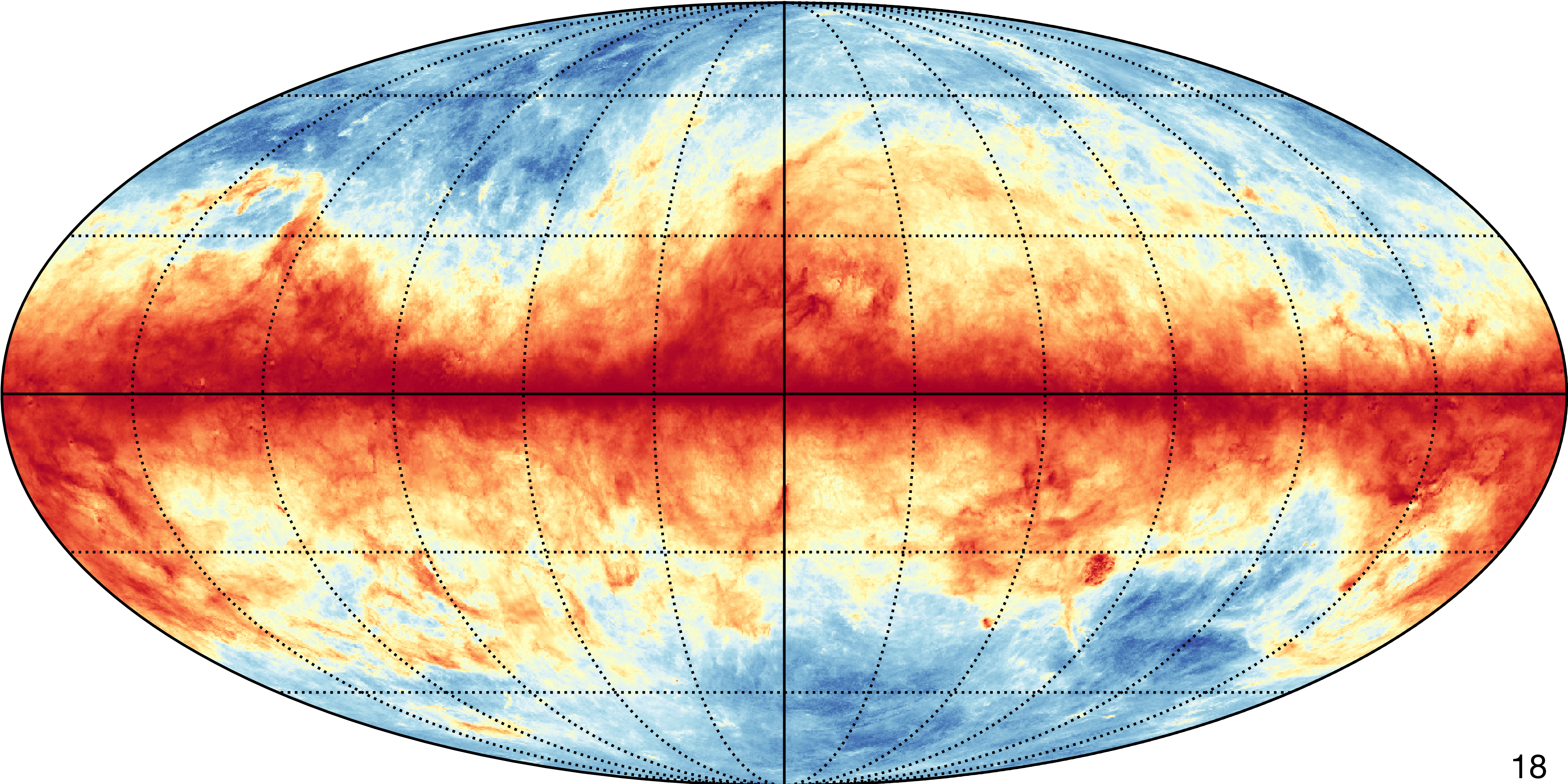


# CIB reconstruction: linear combination of LSS basis





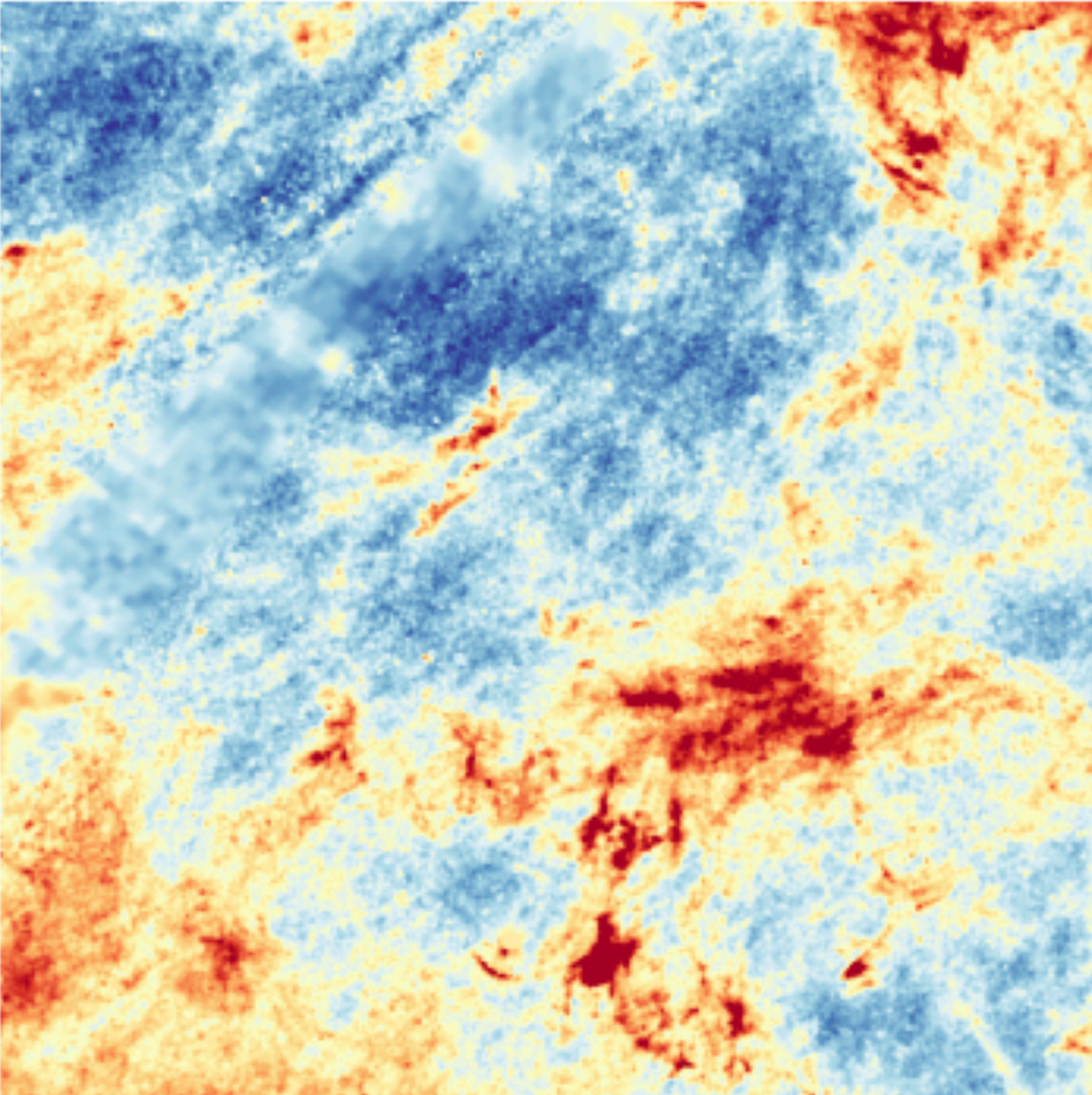
**Corrected SFD (CSFD) = SFD - CIB**



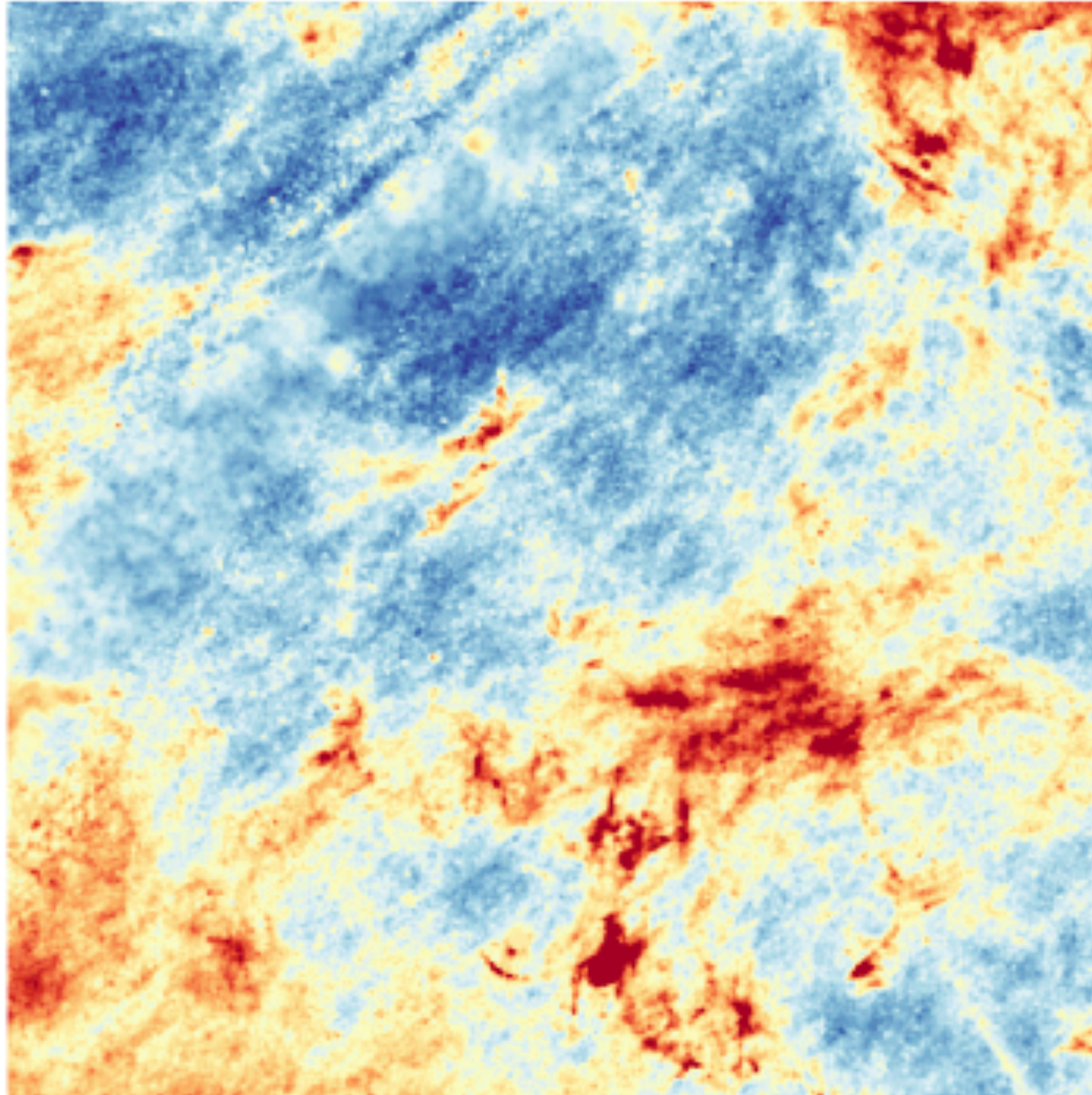


# Corrected SFD (CSFD) = SFD - CIB

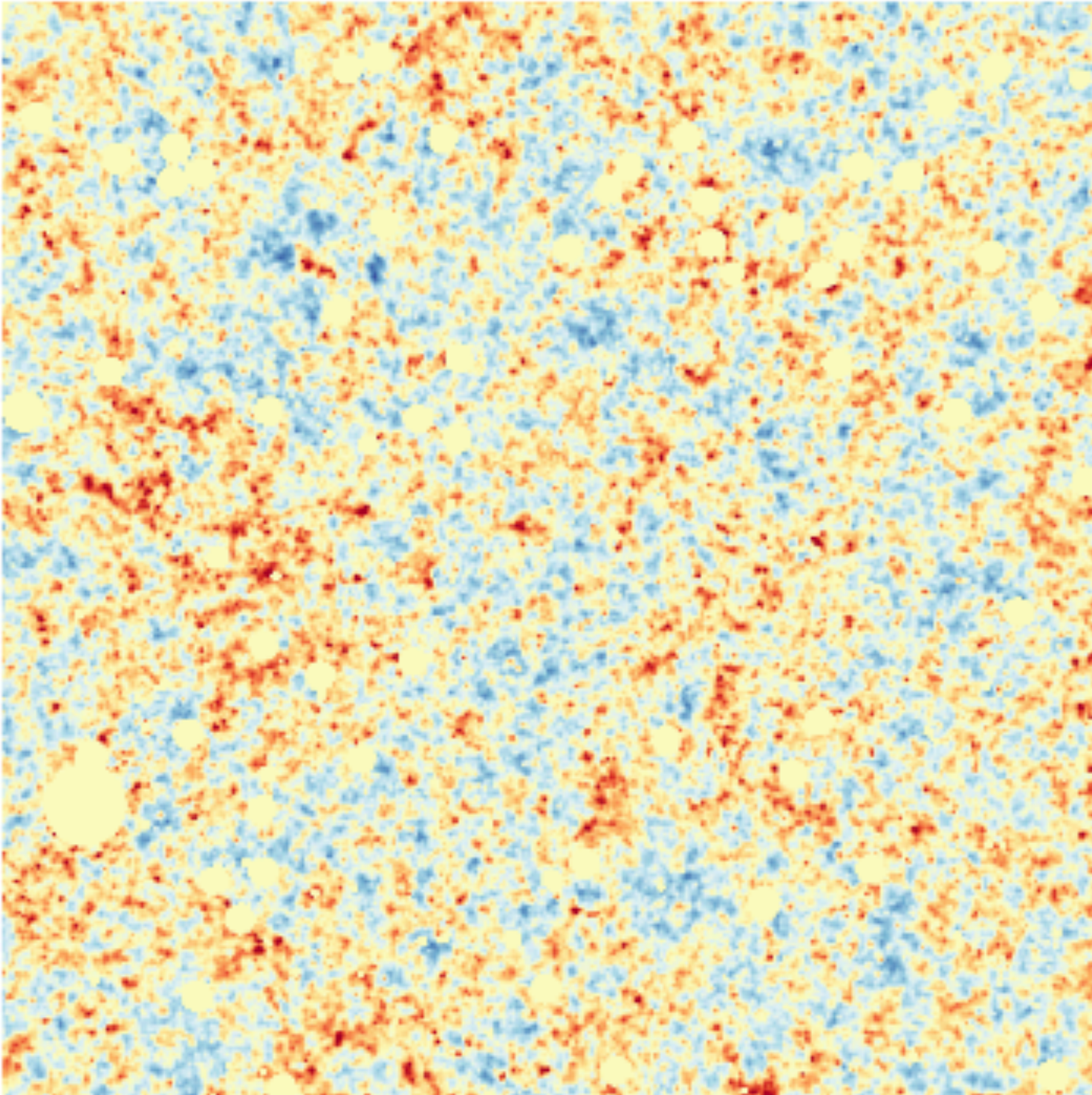
SFD



CSFD



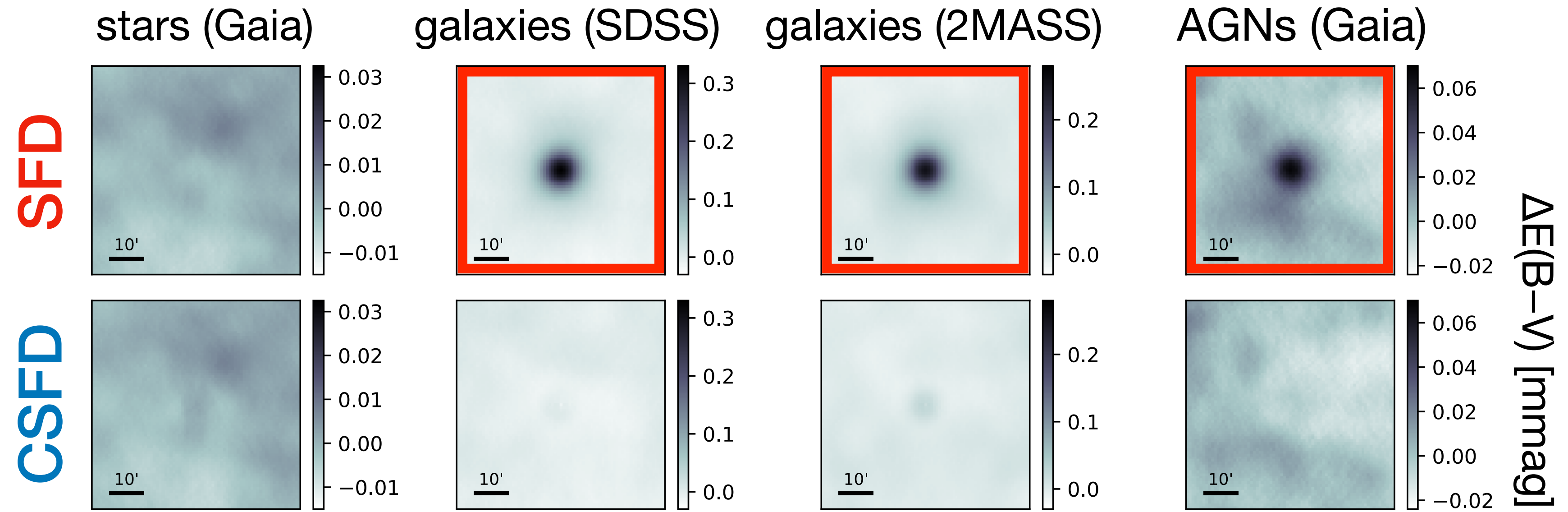
Reconstructed CIB



per-pixel CIB correction is a few (up to a few tens) percent  
SNR  $\sim 2.5$  for every resolution element (combined SNR  $> 1000$ )

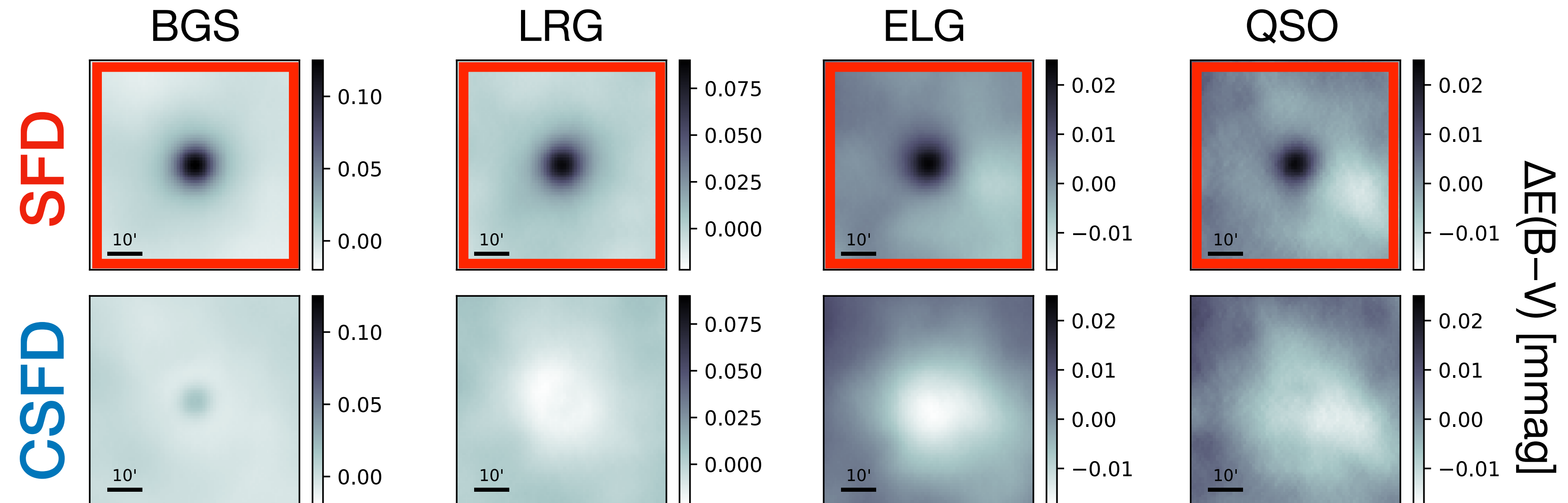


# Independent validation via image stacking



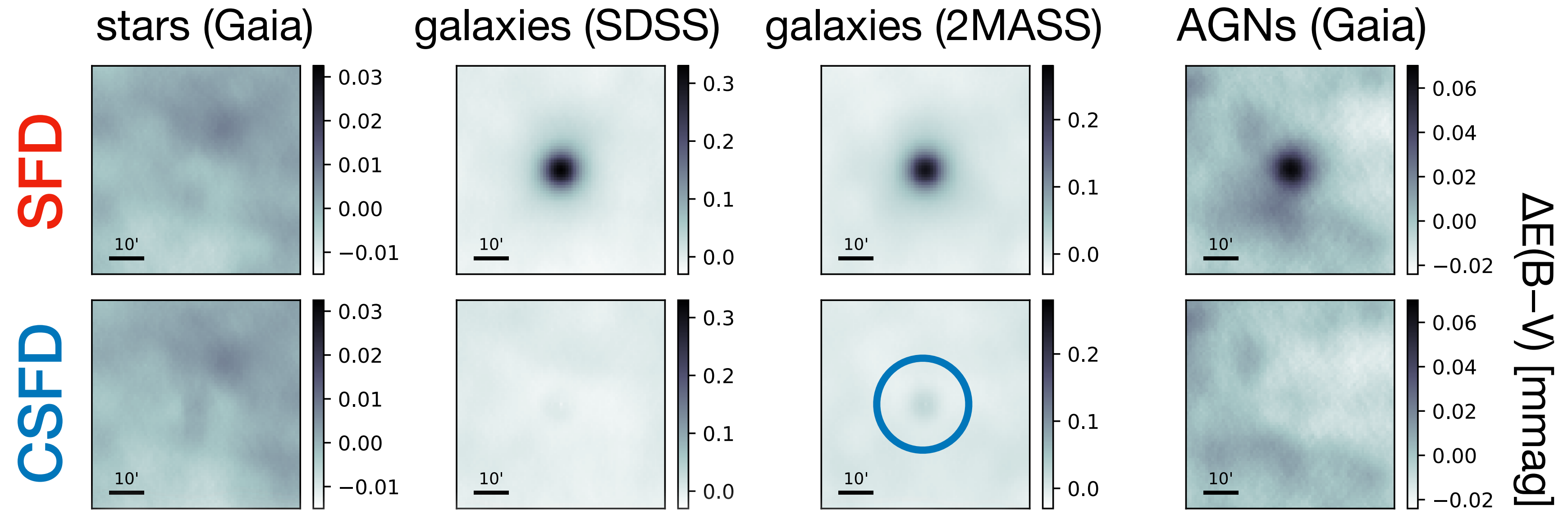
**CIB contamination**

DESI  
targets:



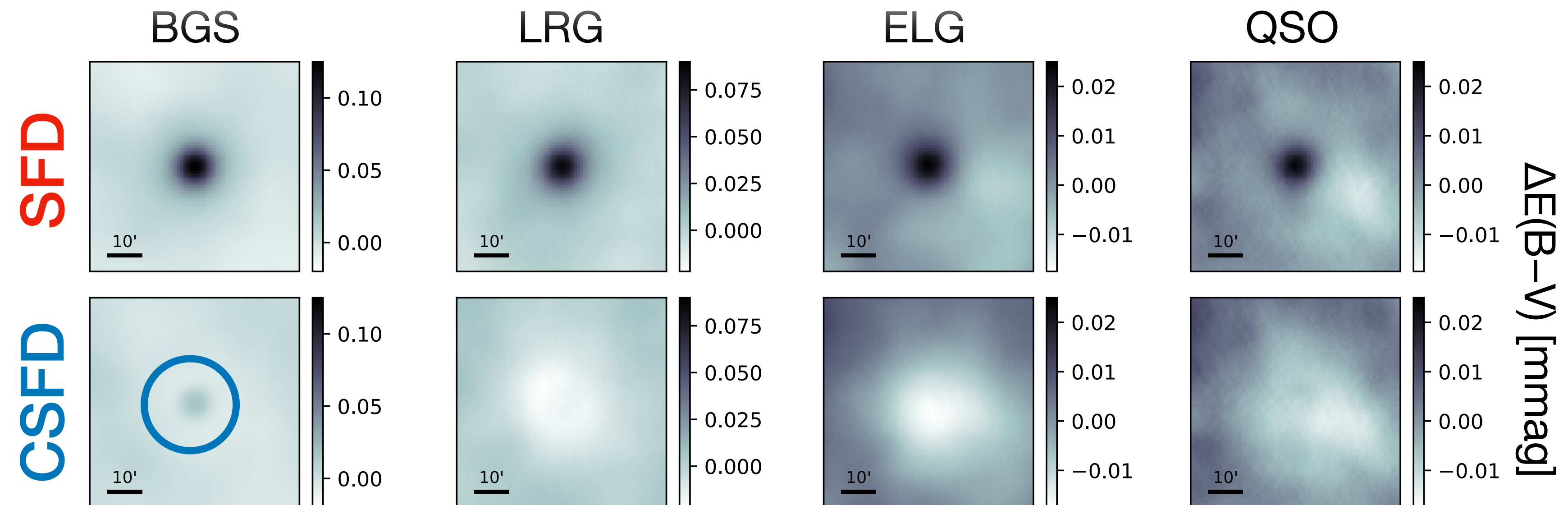


# Independent validation via image stacking



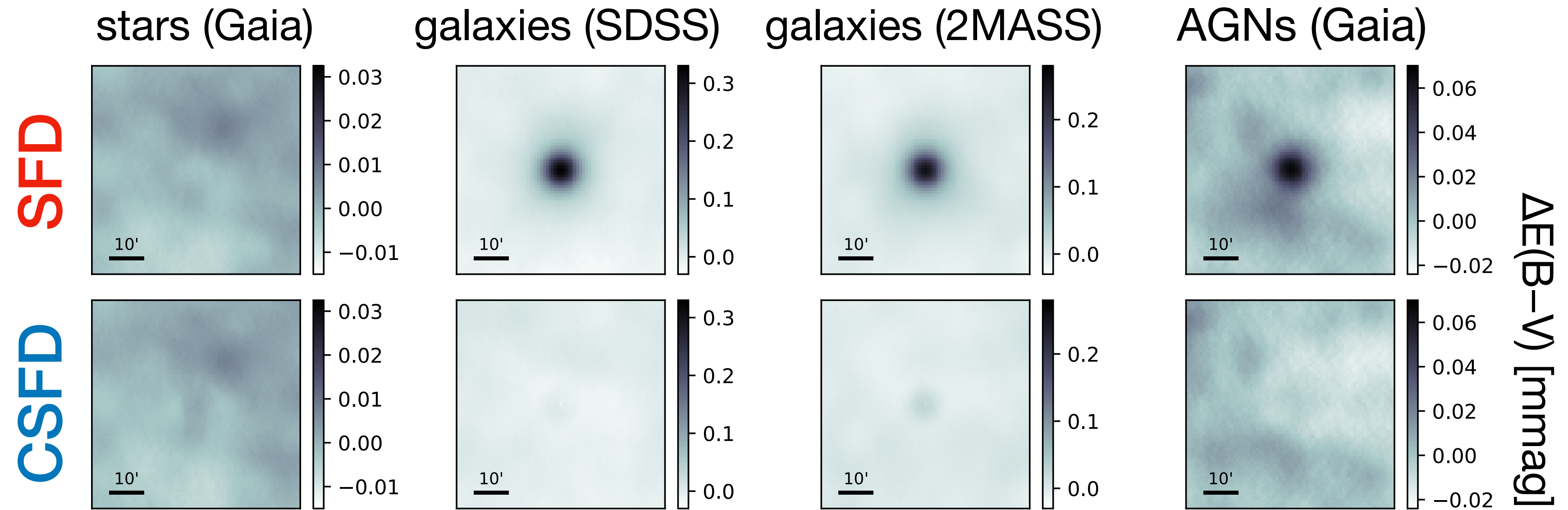
## Small one-halo term CIB residual

DESI  
targets:

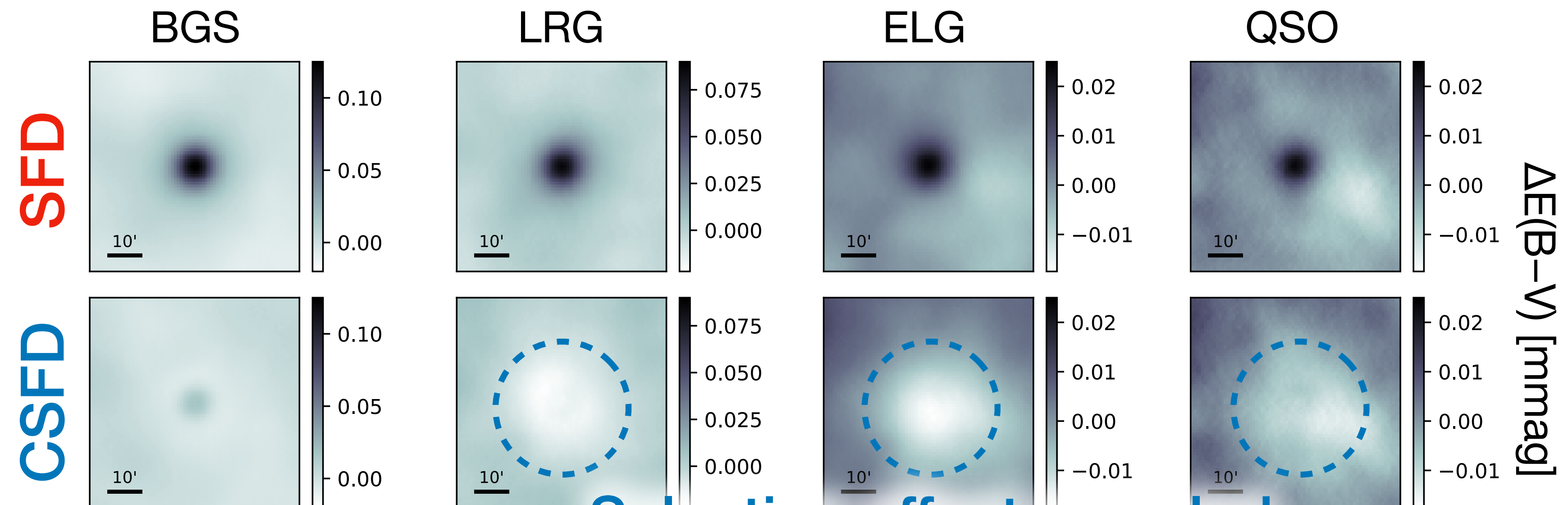




# Independent validation via image stacking



DESI  
targets:



Selection effect revealed



# Summary

1. We release CSFD, a corrected SFD Galactic dust map for precision cosmology and astrophysics
2. CSFD keeps all Milky Way dust features, with greatly suppressed CIB contamination
3. The CIB map reconstruction is a template basis decomposition constrained by cross-statistics

