Daniel Lenz

COSPAR 2018, Pasadena

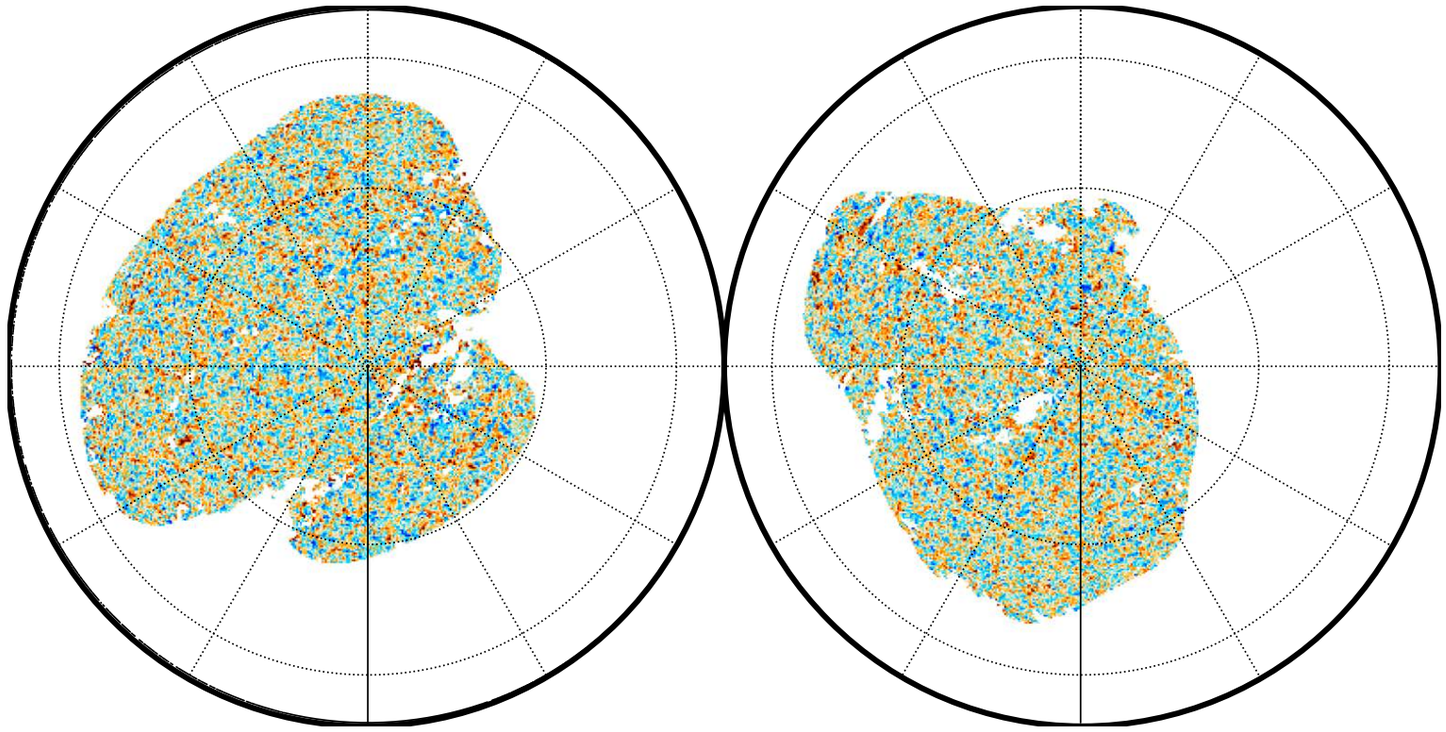
July 20th

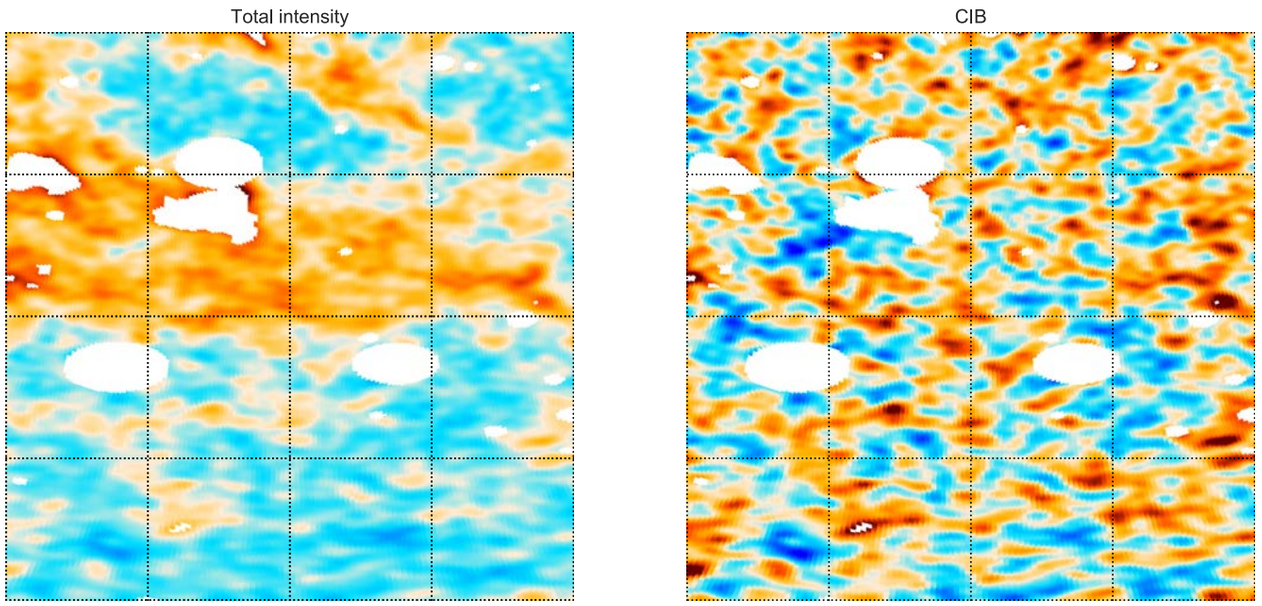
New large-scale CIB maps from Planck data

in collaboration with O. Doré, G. Lagache, B. Hensley

Conclusions

- New CIB maps for ~30% of the sky, 217-857 GHz
- Fewer systematics, larger sky fraction than previous work
- Powerful for cross-correlations and de-lensing





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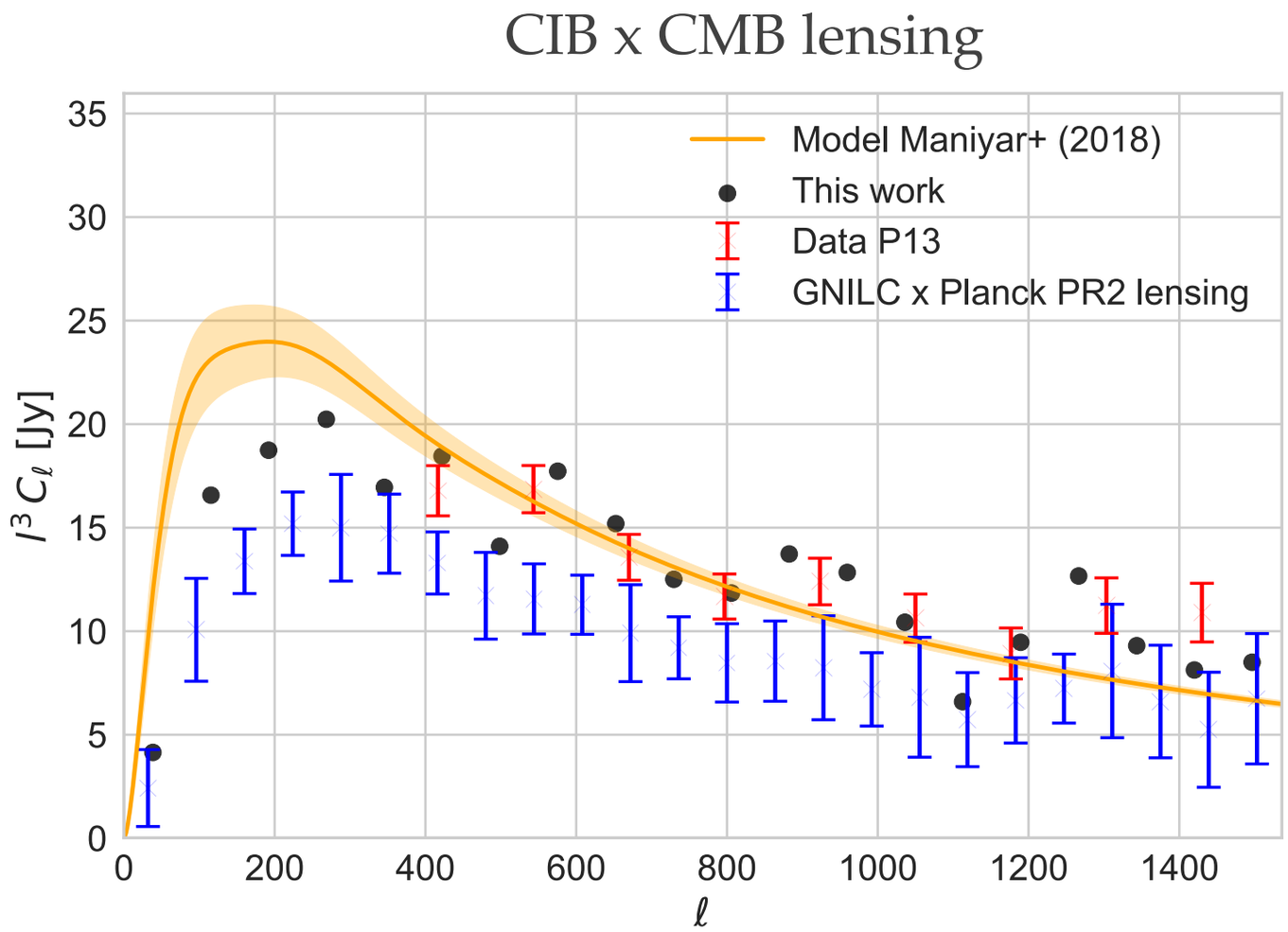
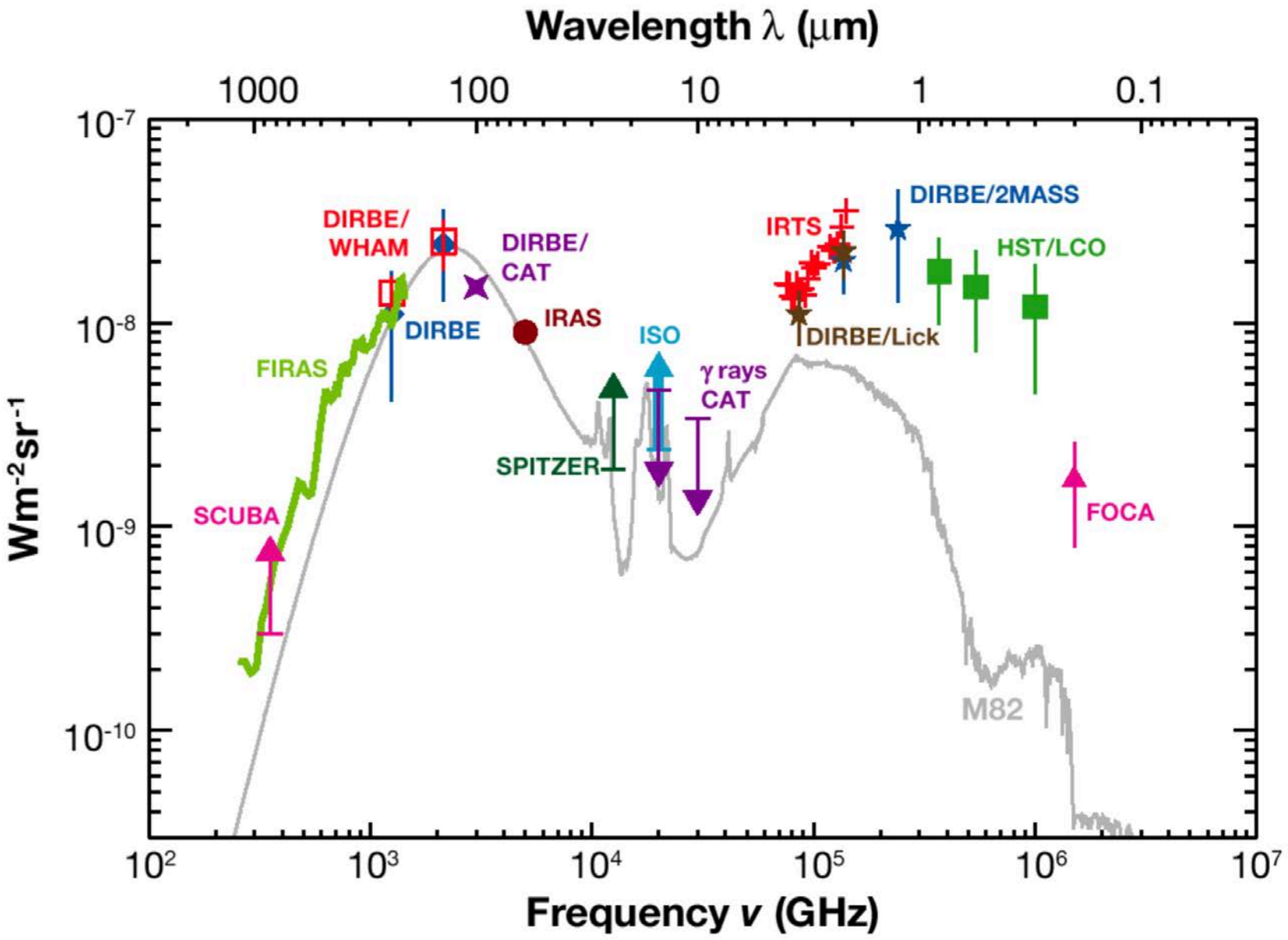


What is the CIB?

Extragalactic background light



- Made up from dust in galaxies at z=1-3
- First detected in FIRAS data (Puget+ 1996)

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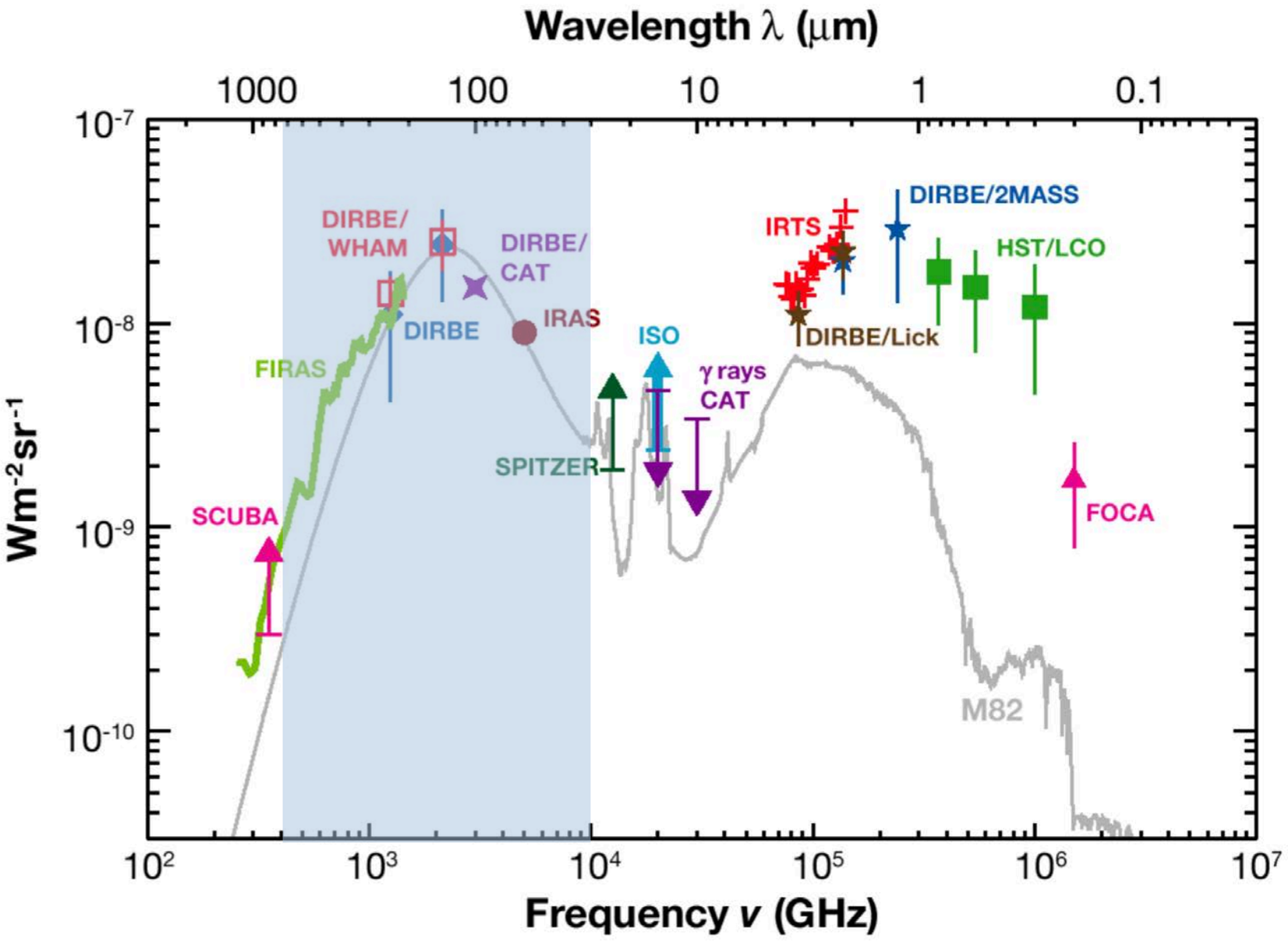

- Made up from dust in galaxies at z=1-3
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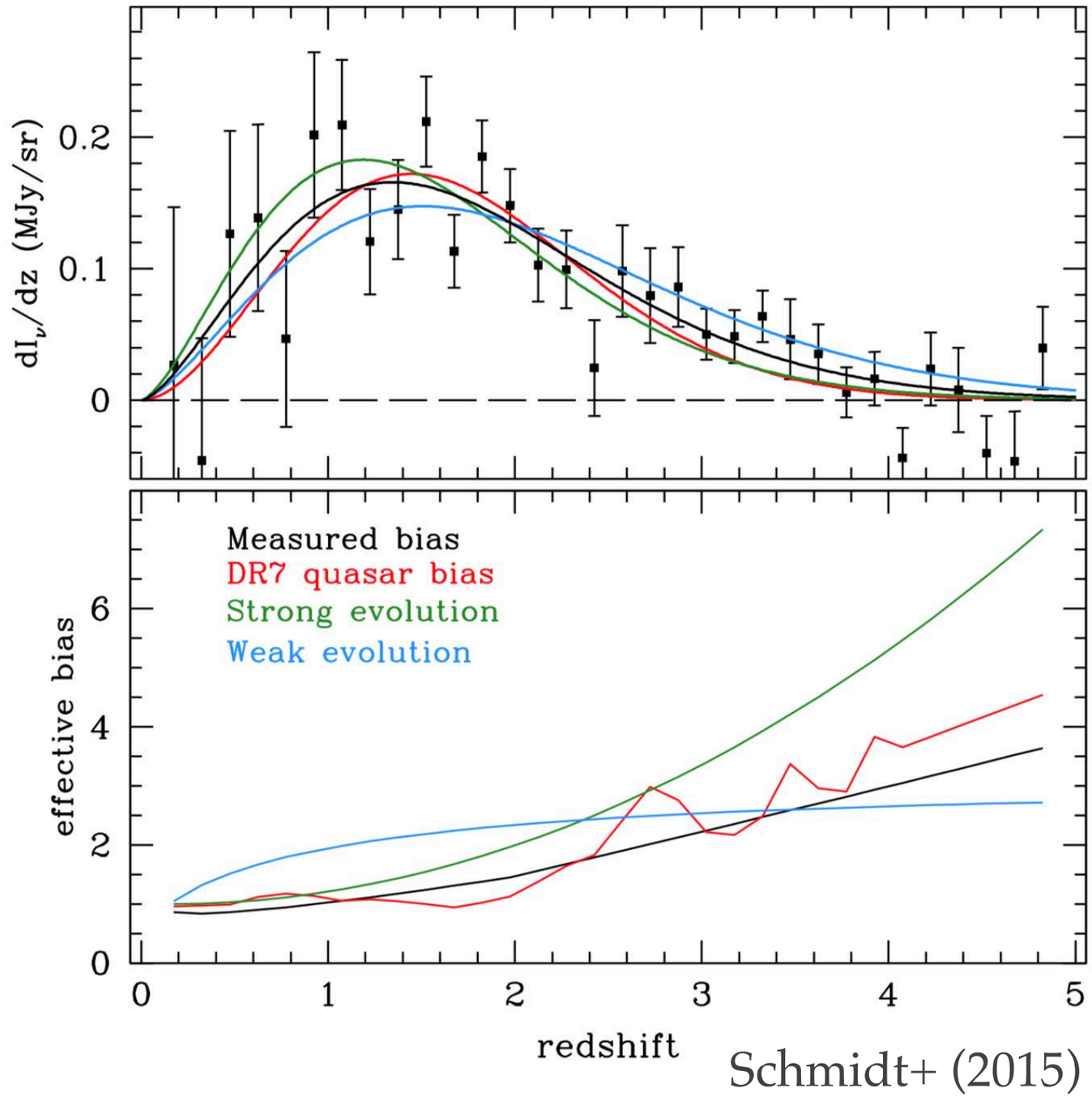
Why study the CIB? Star-formation!

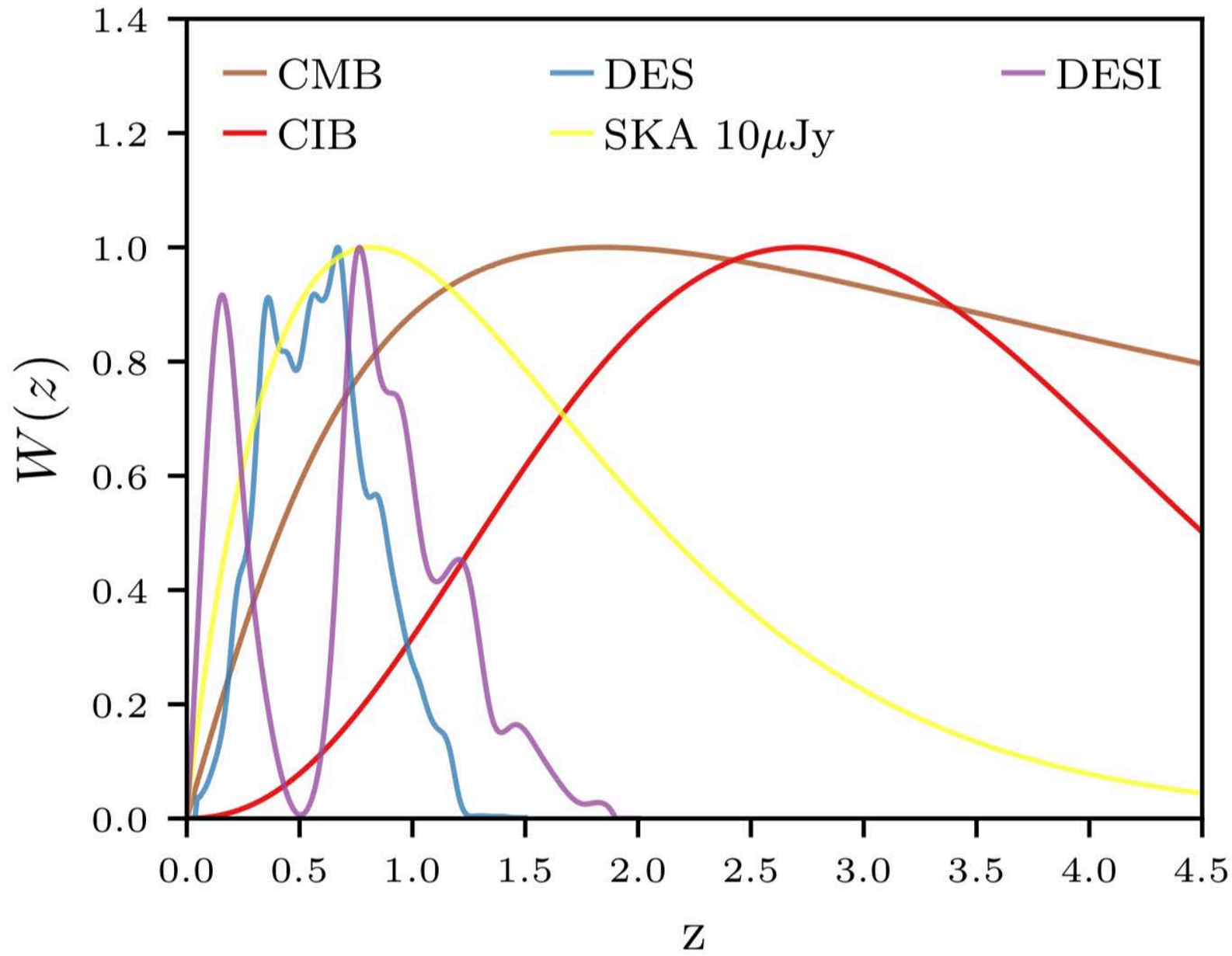
- Strong constraints on star formation history
- Probe dust temperature across cosmic times
- Understand star formation in DM halos



Schmidt+ (2015)

Why study the CIB? Grav. lensing!

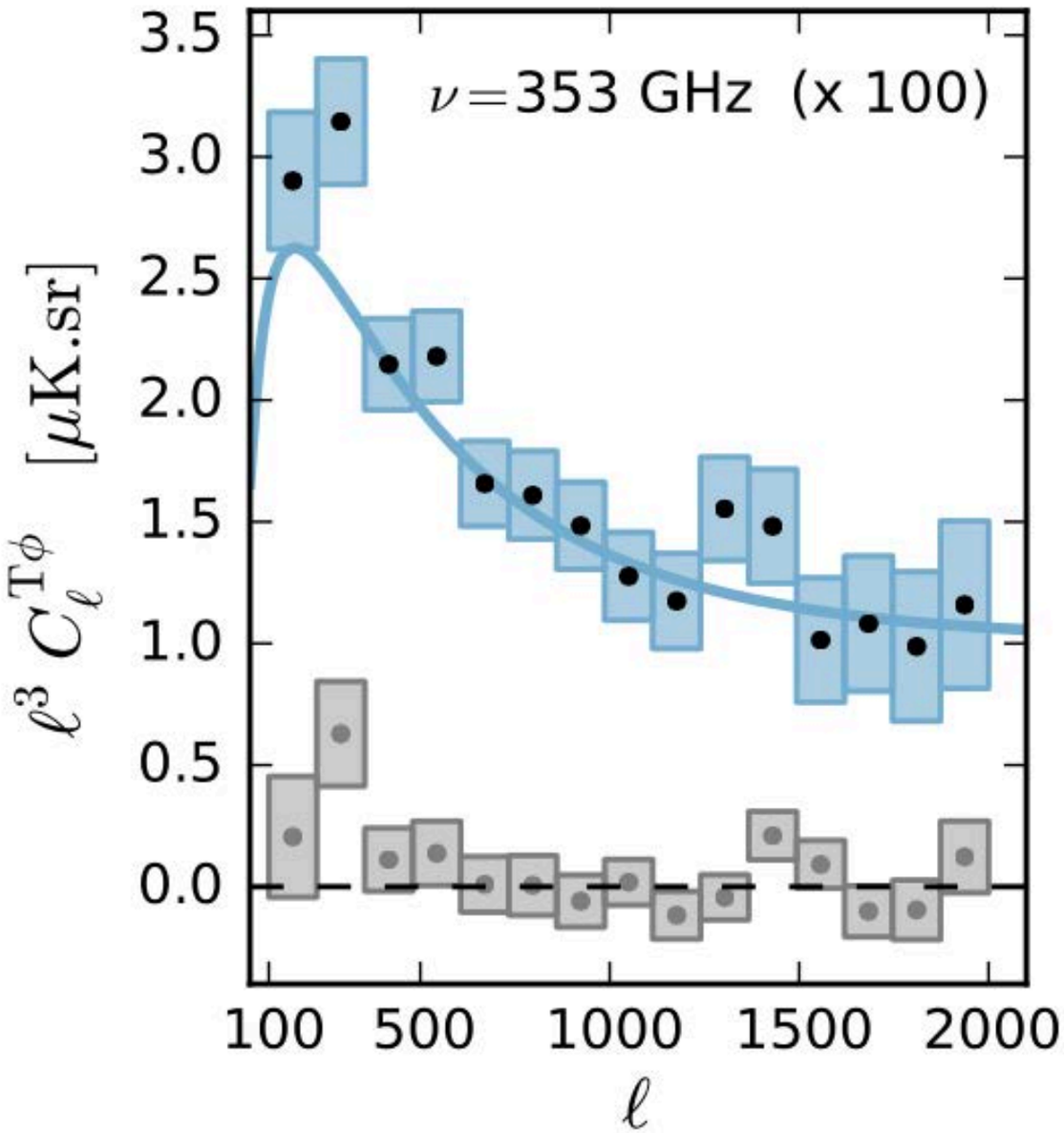
- CIB kernel and the CMB lensing kernel are well matched
- Internal de-lensing and CIB is very complimentary for BB reconstruction



Manzotti (2017)

Why study the CIB? Grav. lensing!

- Cross-correlation of CIB and CMB lensing strongly detected in Planck data
- Lots of room for improvement: Sky fraction, CIB data, new CMB lensing map



Planck collaboration (2013, XVII)

How to obtain CIB maps?

- Galactic thermal dust and CIB dust dominate on large scales at ~200 to 1000 GHz
- How to disentangle them?

How to obtain CIB maps?

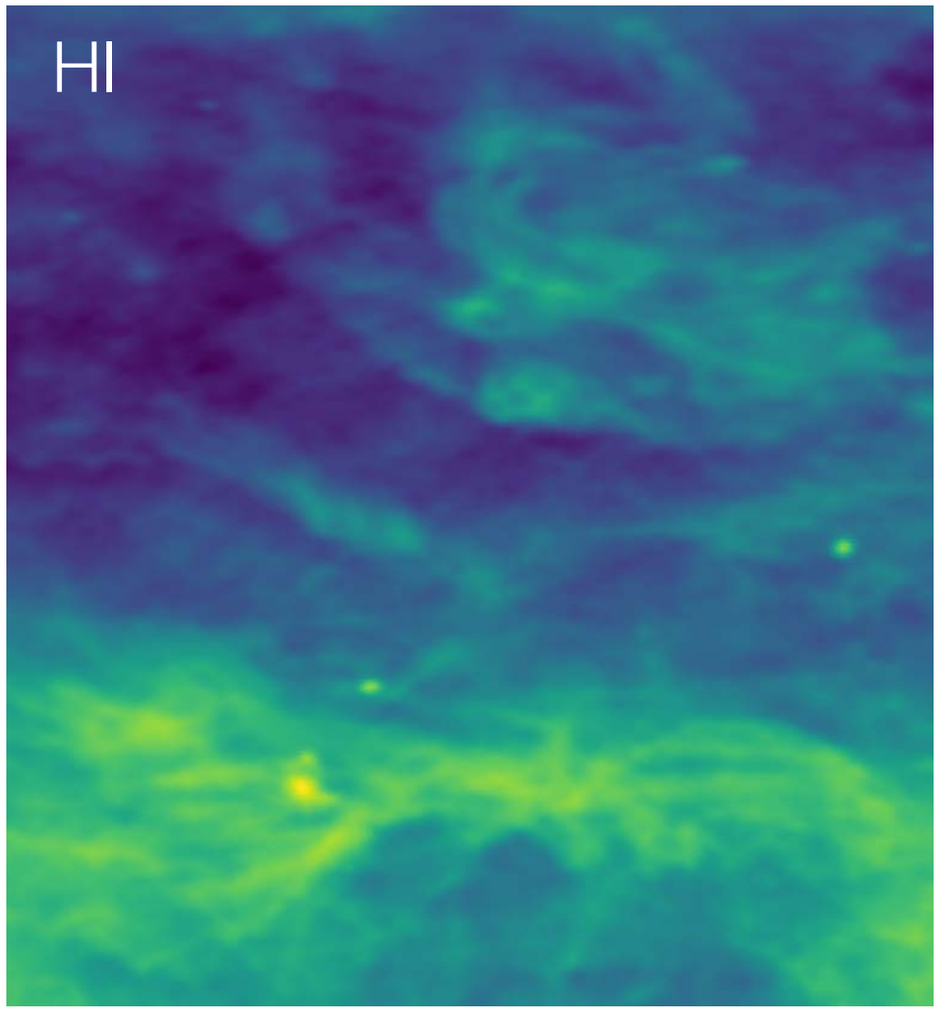
- Galactic thermal dust and CIB dust dominate on large scales at ~200 to 1000 GHz
- How to disentangle them?

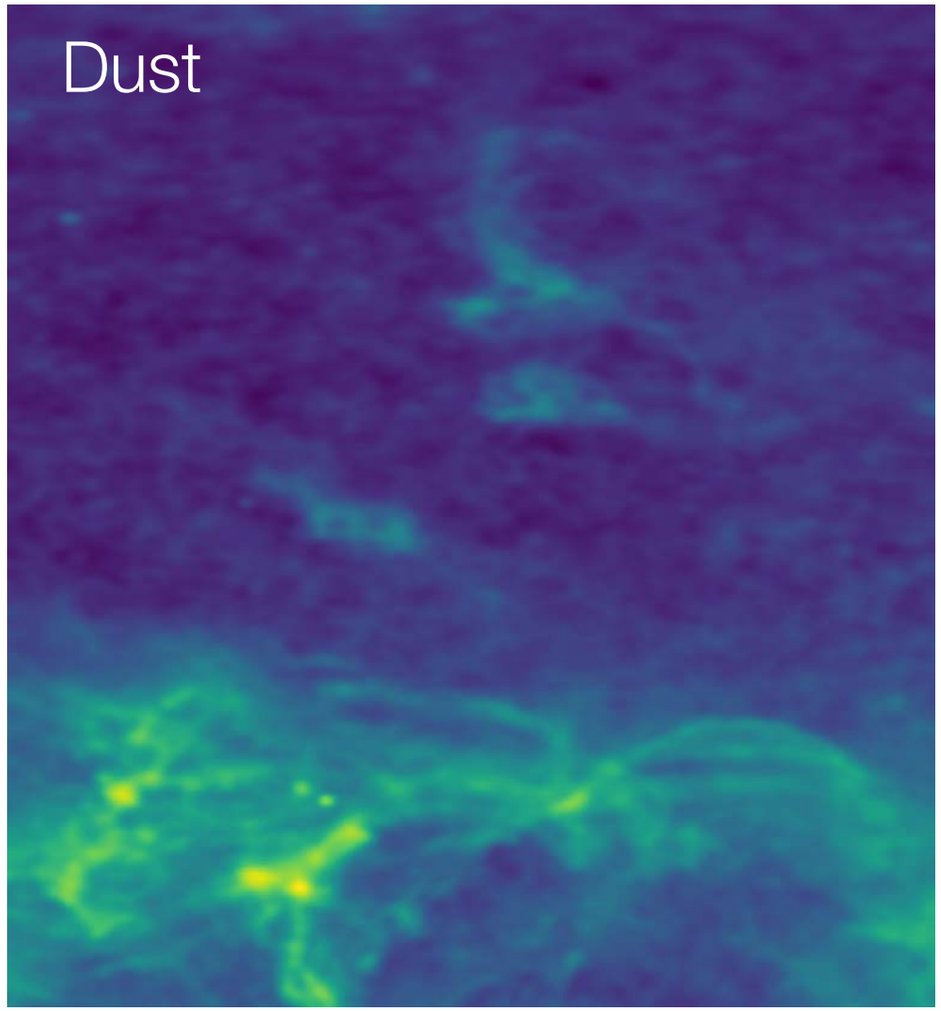
A. Fit different frequency channels with modified blackbody spectra

B. Use the different angular power spectra of these components (GNILC)

C. Use template maps of Galactic dust (e.g. HI-based)

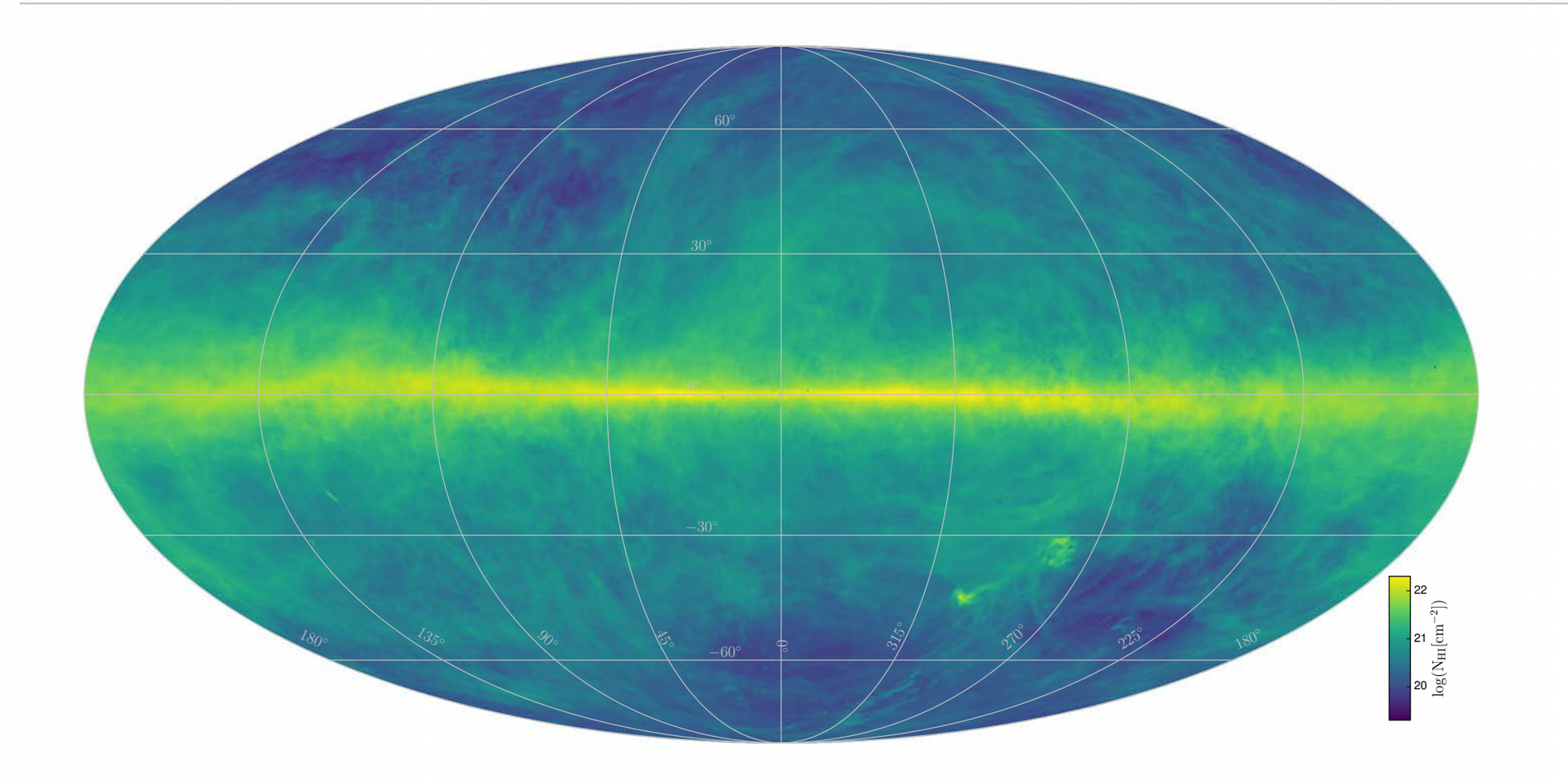
Correlation of dust and gas





- Linear relation to first order (Boulanger+ 1996)
- But better model required to get to CIB levels

HI4PI Survey



HI4PI collaboration (2017)

- Merges data from Effelsberg and Parkes
- Replaces LAB as state-of-the-art full-sky HI survey
- Higher sensitivity & resolution, fewer systematics, full sampling

Two challenges

- Spectrally
  - O(1000) velocity channels in HI
  - Need to control overfitting

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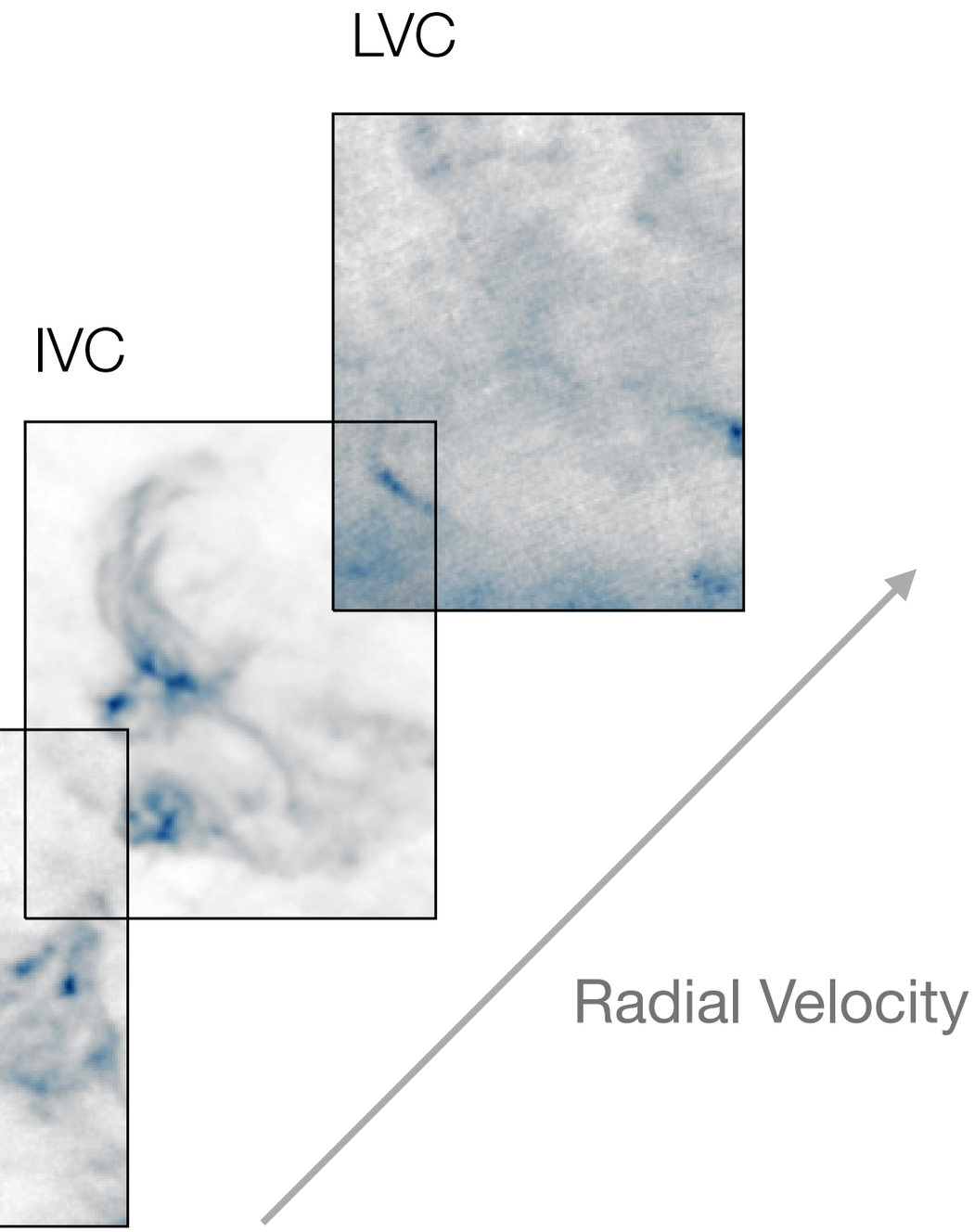
- Spectrally
  - O(1000) velocity channels in HI
  - Need to control overfitting
- Spatially
  - Dust-to-gas ratios vary over the sky
  - Need to preserve large-scale CIB power

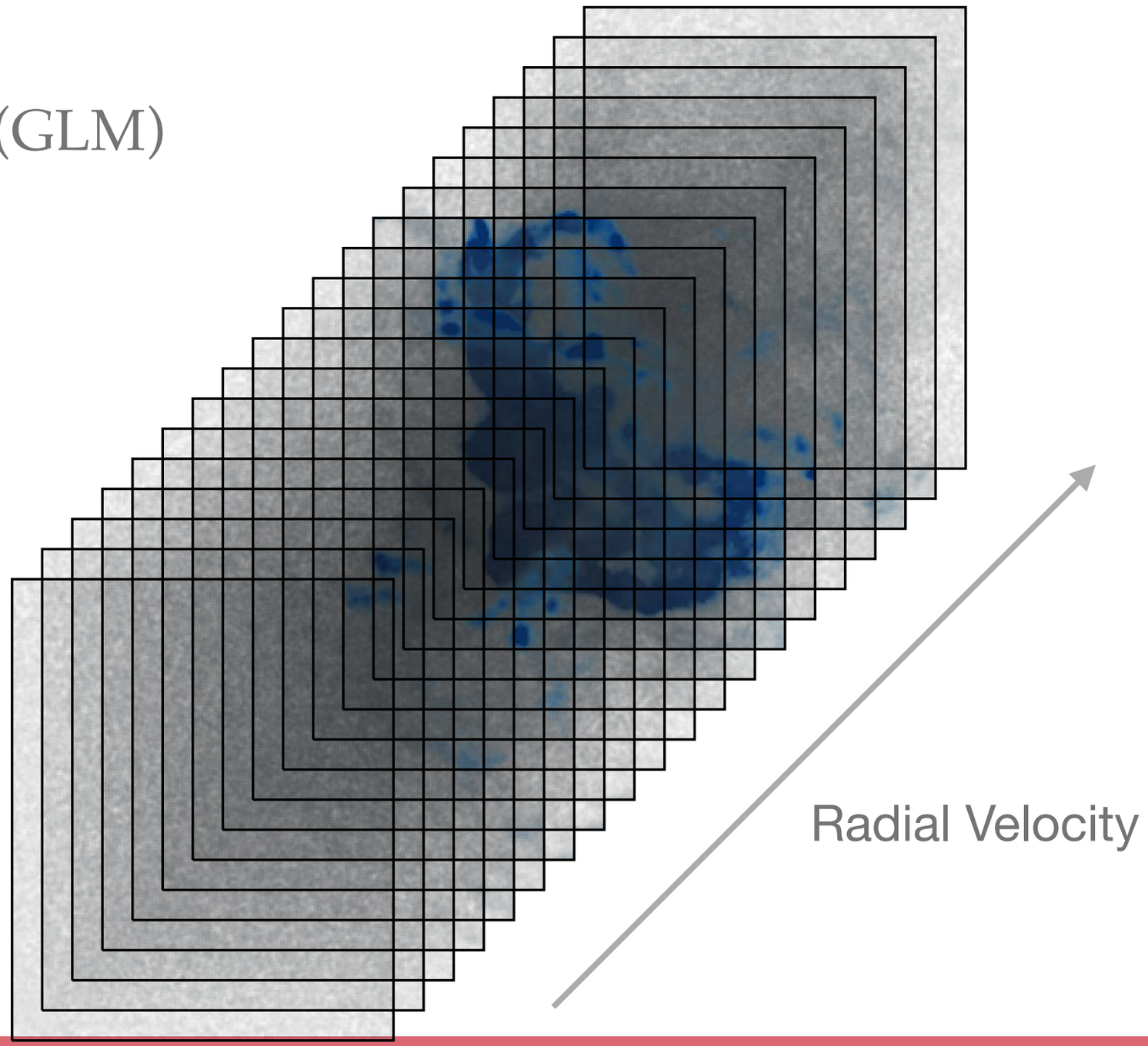
HI-based dust models

- $I = \epsilon^{\mathrm{HVC}} N^{\mathrm{HVC}} + \epsilon^{\mathrm{IVC}} N^{\mathrm{IVC}} + \epsilon^{\mathrm{LVC}} N^{\mathrm{LVC}}$
- Velocity separation difficult for complex structures and large scales



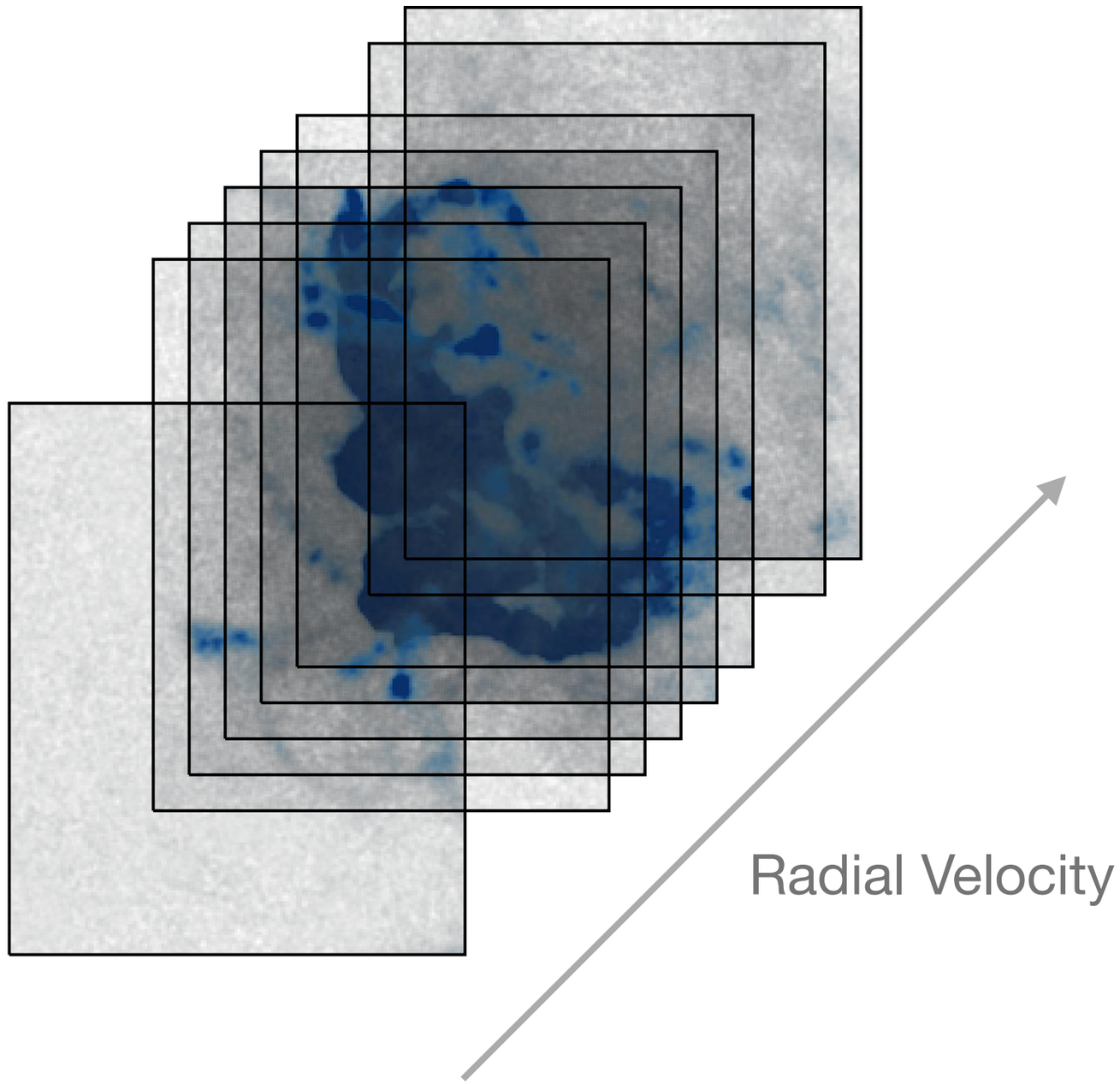
HI-based dust models

- Generalised linear model (GLM)
- $I = \sum_i \epsilon^i T_B^i$



HI-based dust models

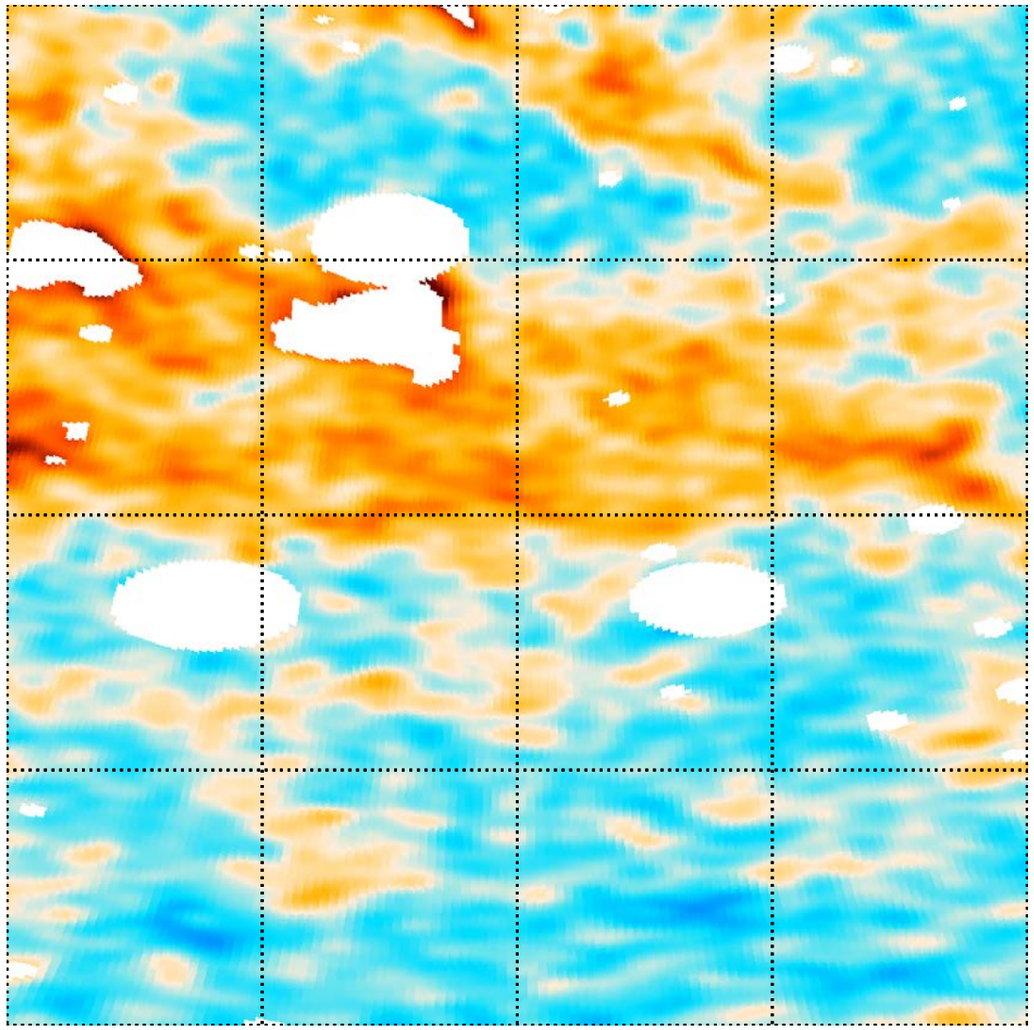
- Generalised linear model (GLM)
- $I = \sum_i \epsilon^i T_B^i$
- Regularised:
- $|\mathrm{Data}_i - \mathrm{Model}_i|^2 + \alpha \cdot |\epsilon_i|$
- Accounts for all features along line of sight



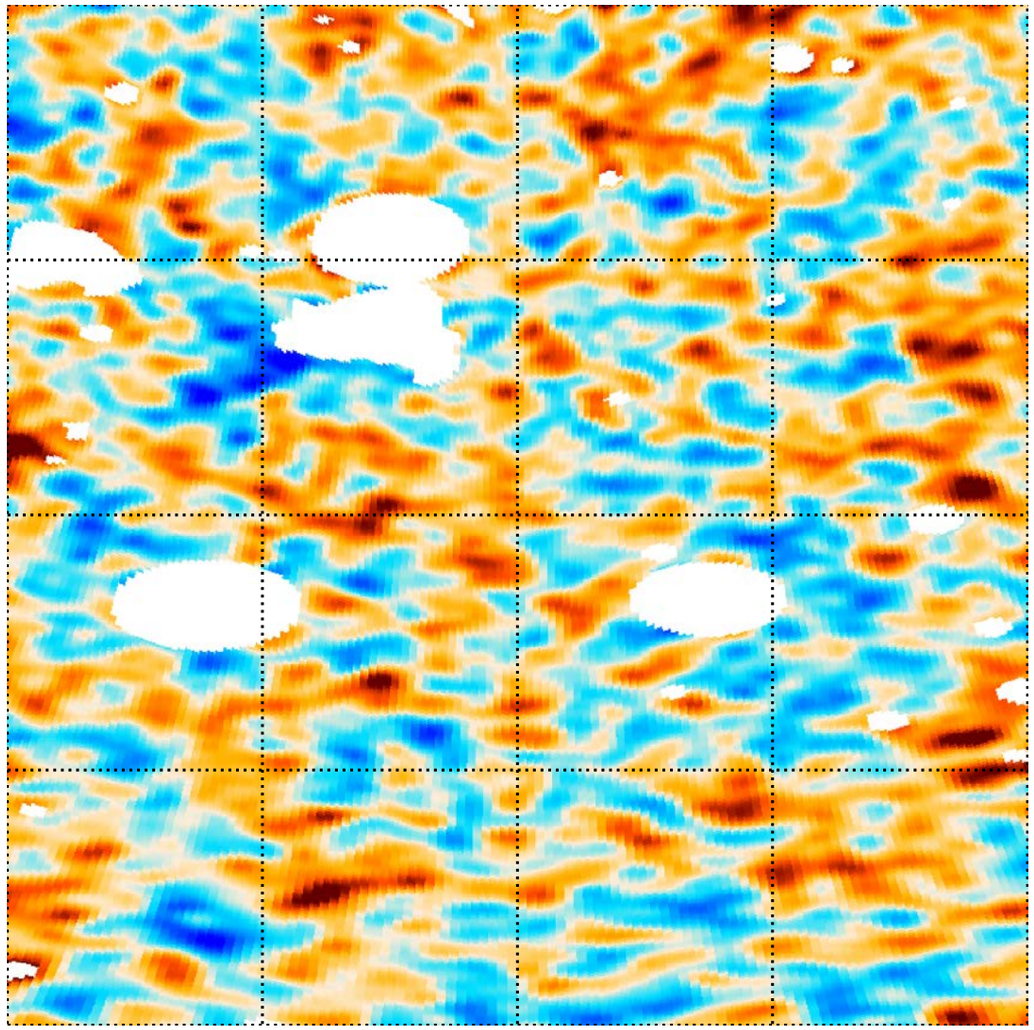
Preliminary Results
(give us two weeks)

Maps: Smaller regions

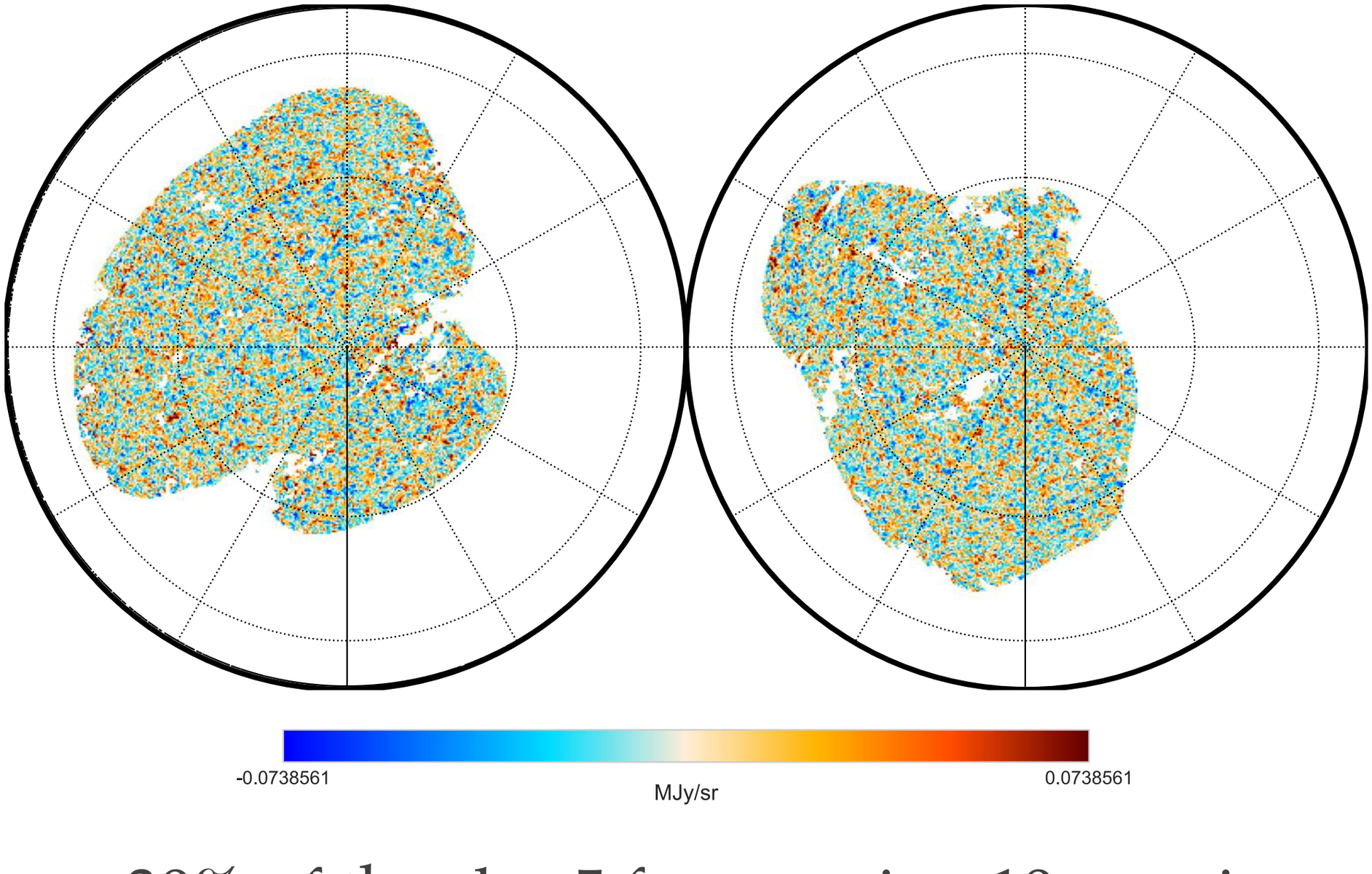
Total intensity



CIB

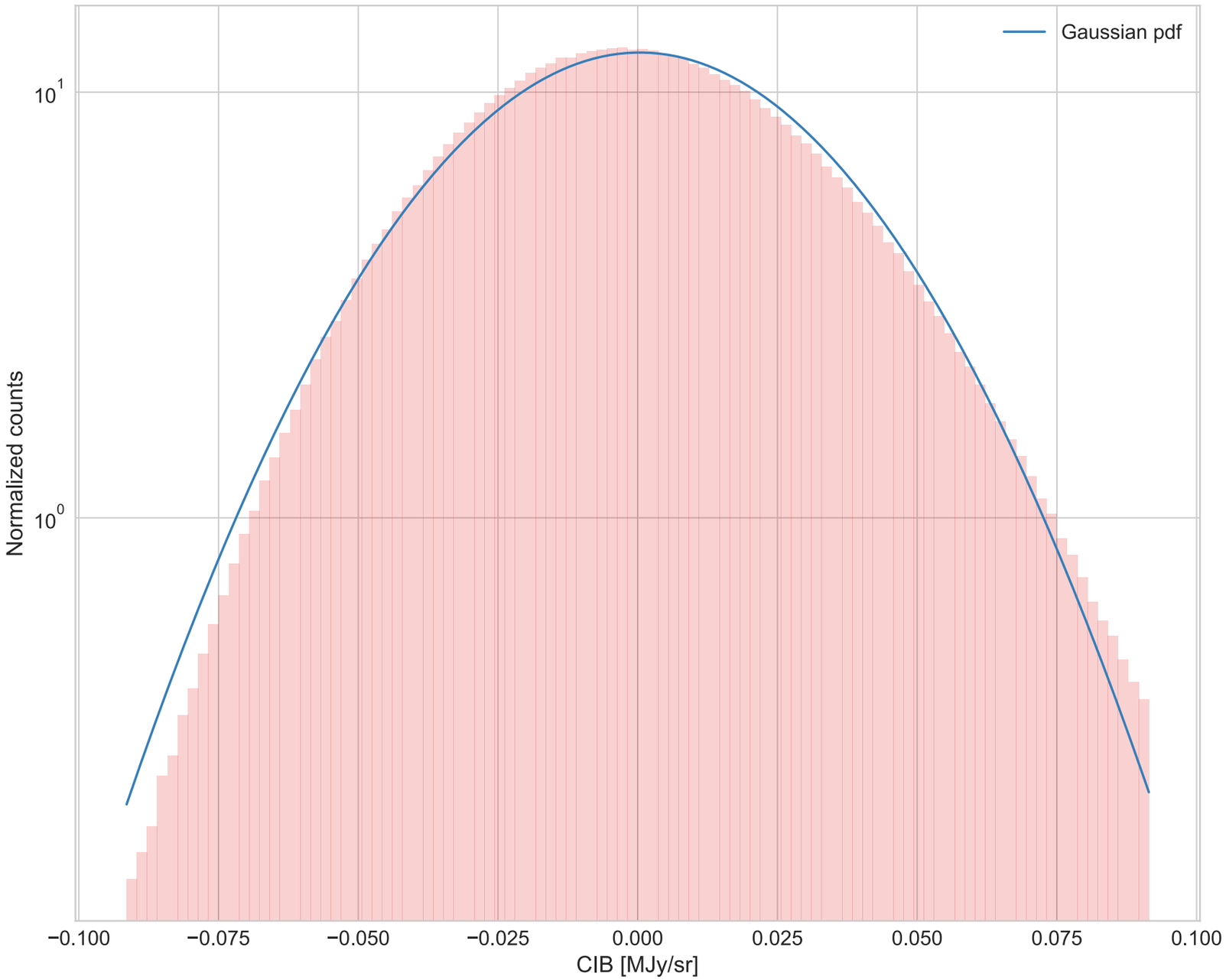


Maps: Large-scale map



~30% of the sky, 5 frequencies, 10 arcmin

Gaussianity



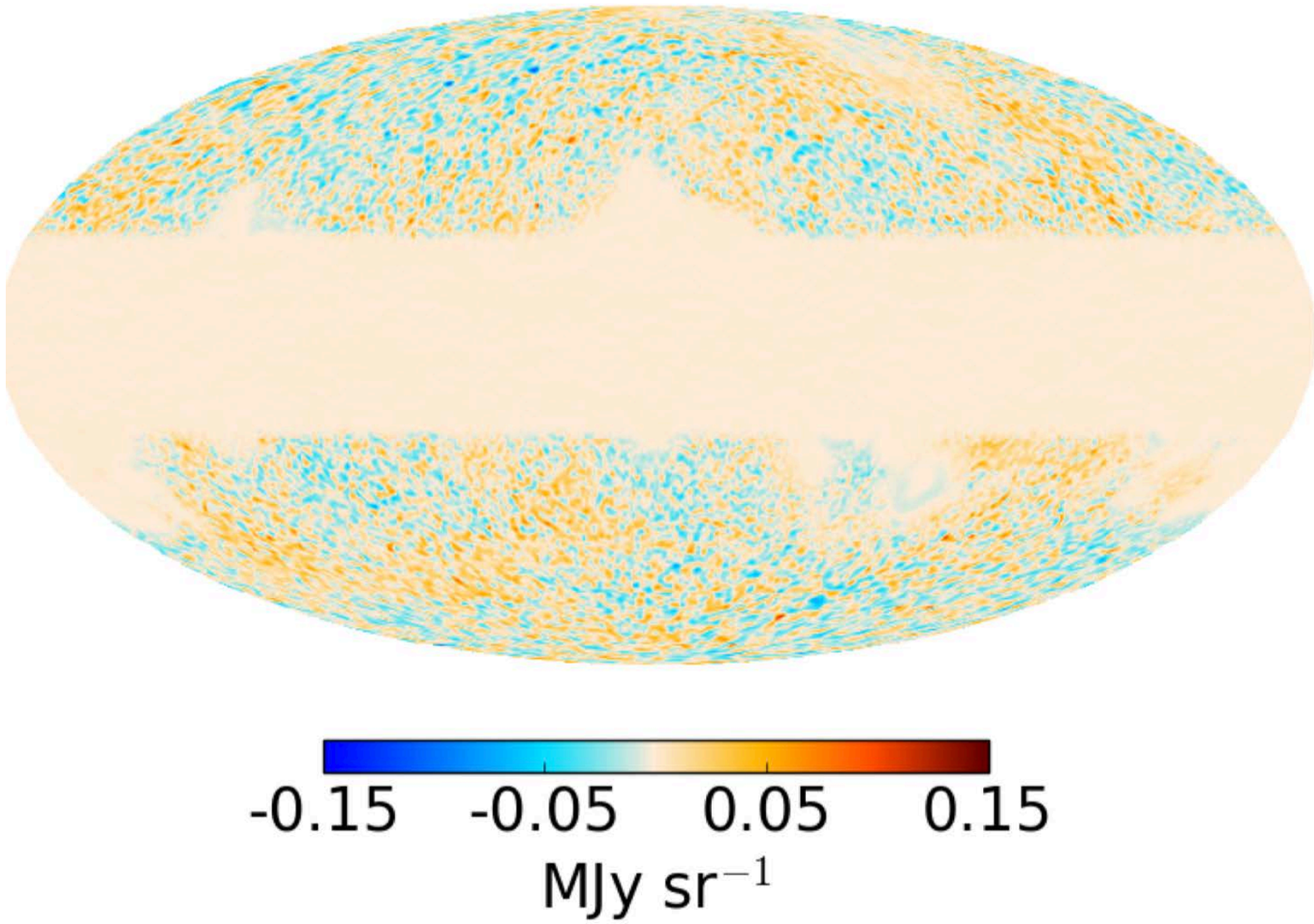
- Patch-by-patch analysis
- Full sky PDF very Gaussian
- Molecular gas adds skewness

Comparison to earlier work

Maps

Based on spatial information: GNILC

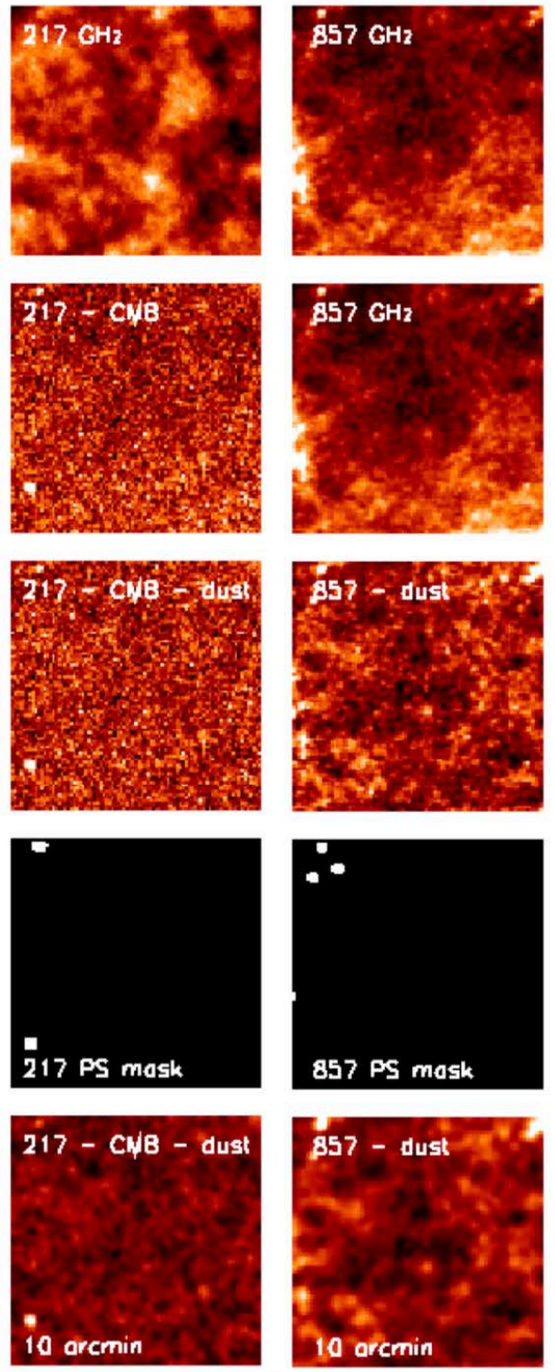
- Power-spectrum based
- Designed to remove CIB from Galactic dust maps
- Over-subtraction of CIB



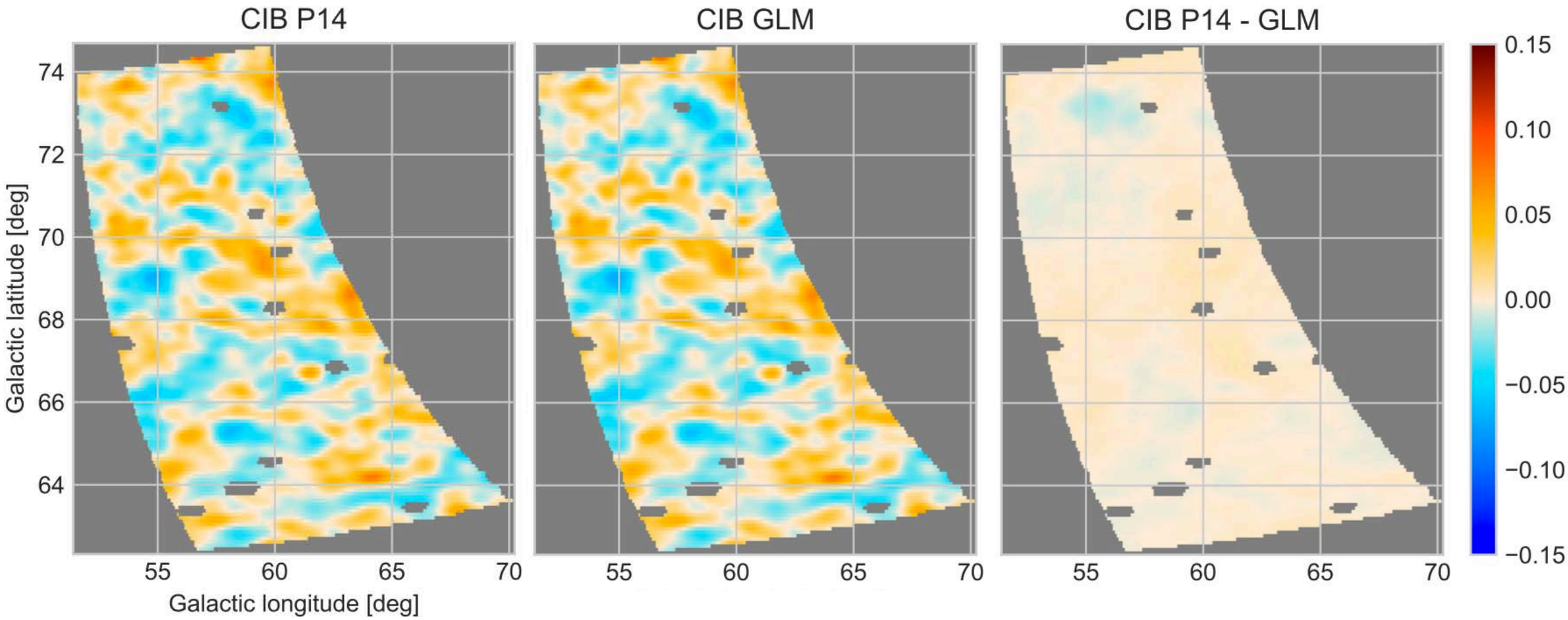
Planck (2016 XLVIII)

HI-based: Planck (2014 XXX)

- ~10 individual fields, HI data from the GBT
- Two larger fields from EBHIS and GASS
- One field cleaned at a time
- Manual fine-tuning



Comparison to earlier work: Small fields



- Different data sets, resolutions, sky regions
- Apples-to-apples comparison yields great agreement

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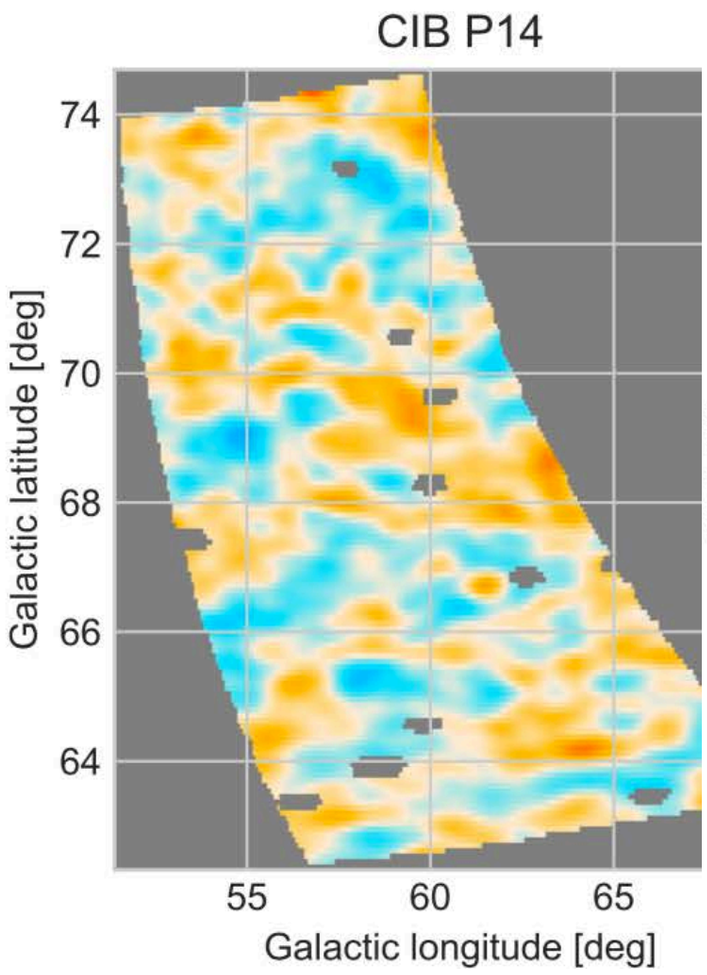

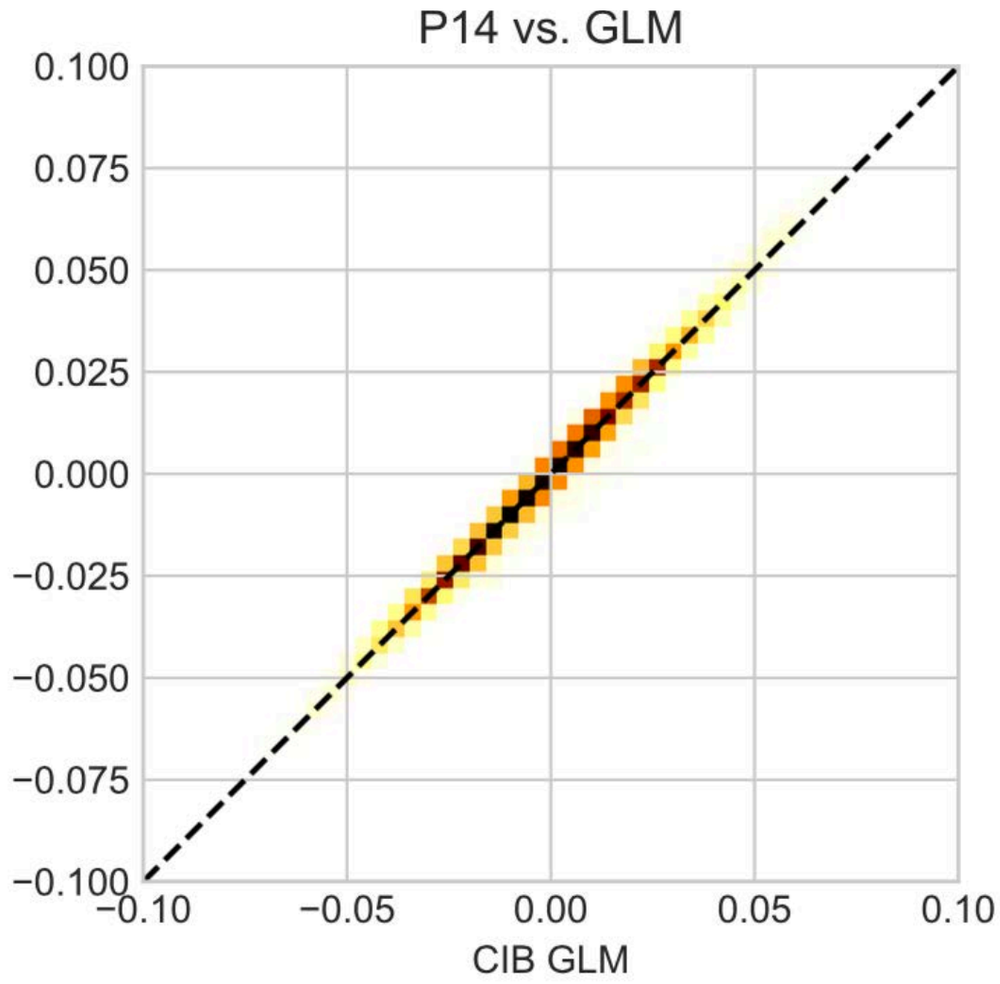

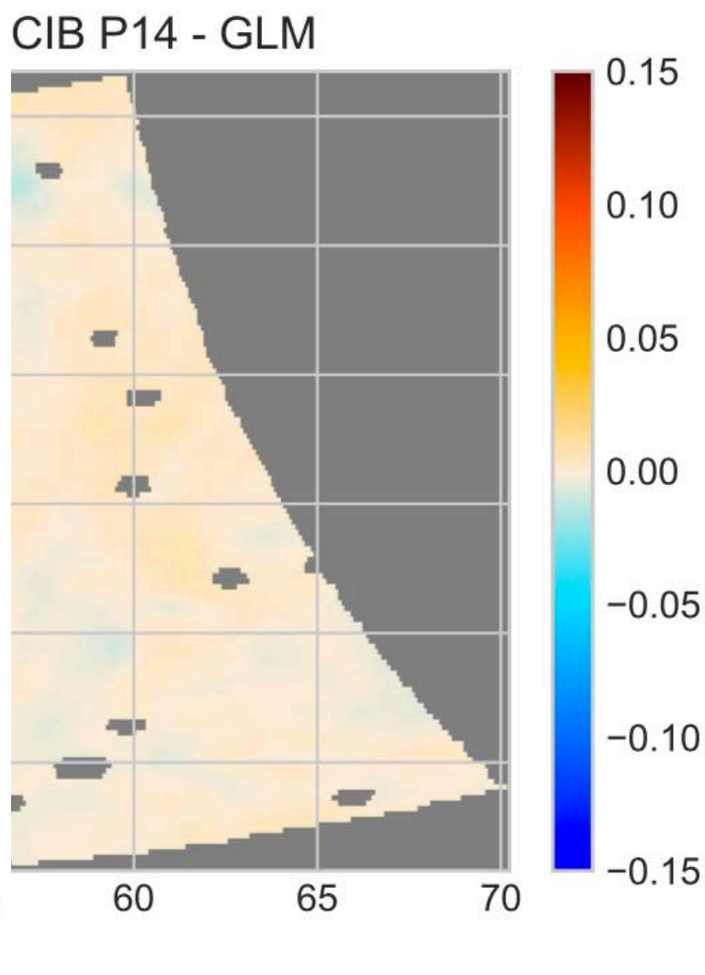

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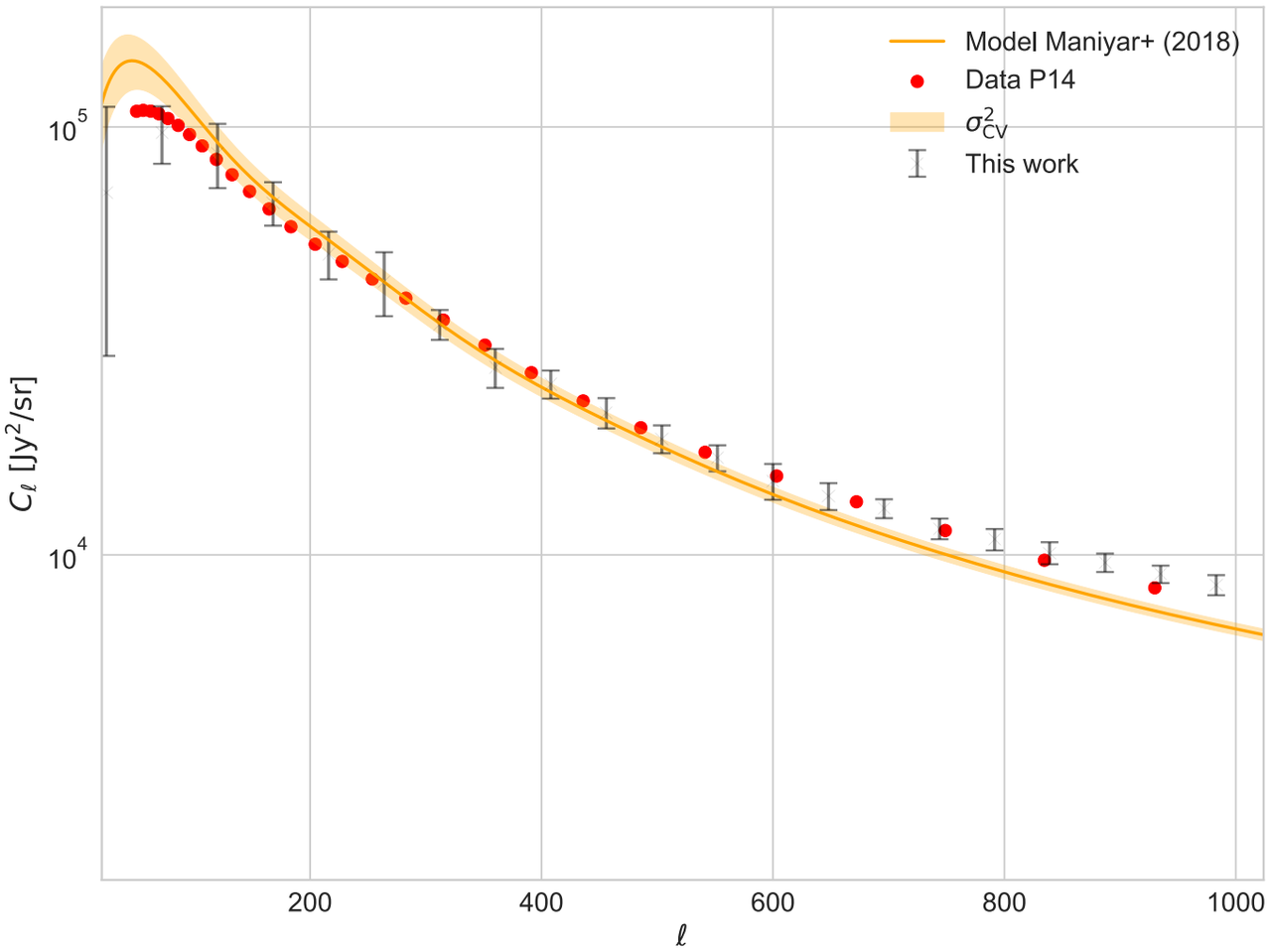
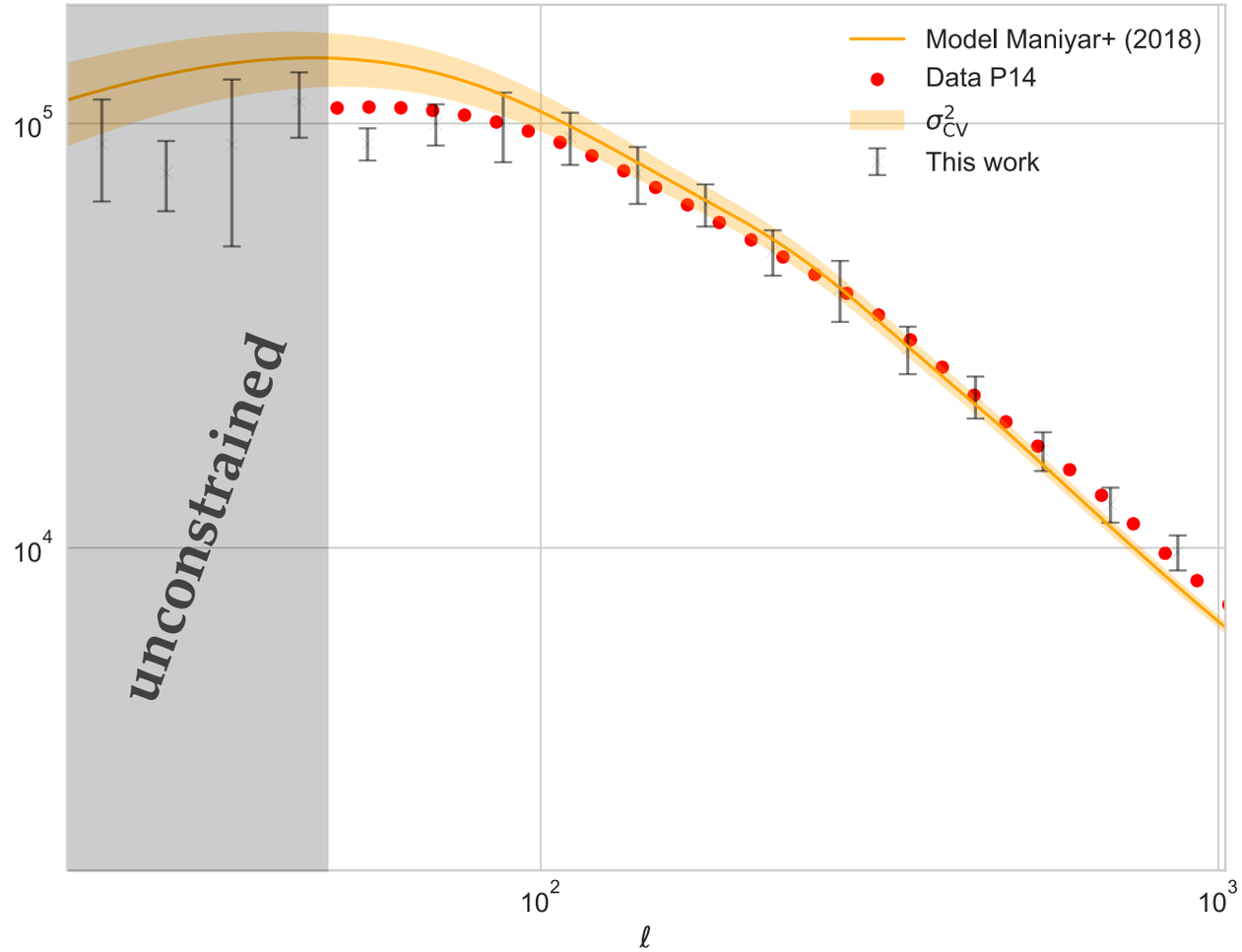
Comparison to earlier work

Power spectra

CIB auto power spectra

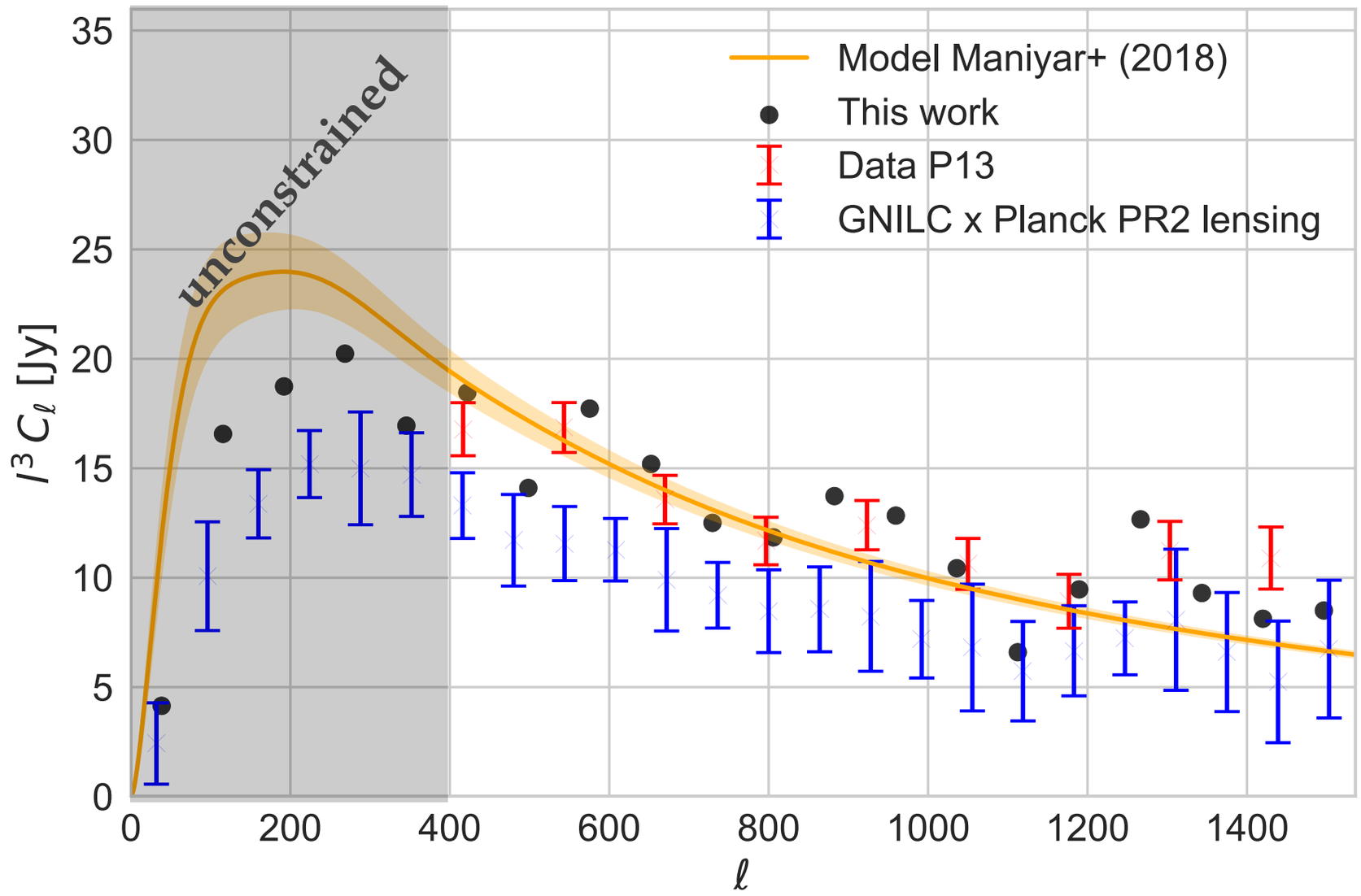




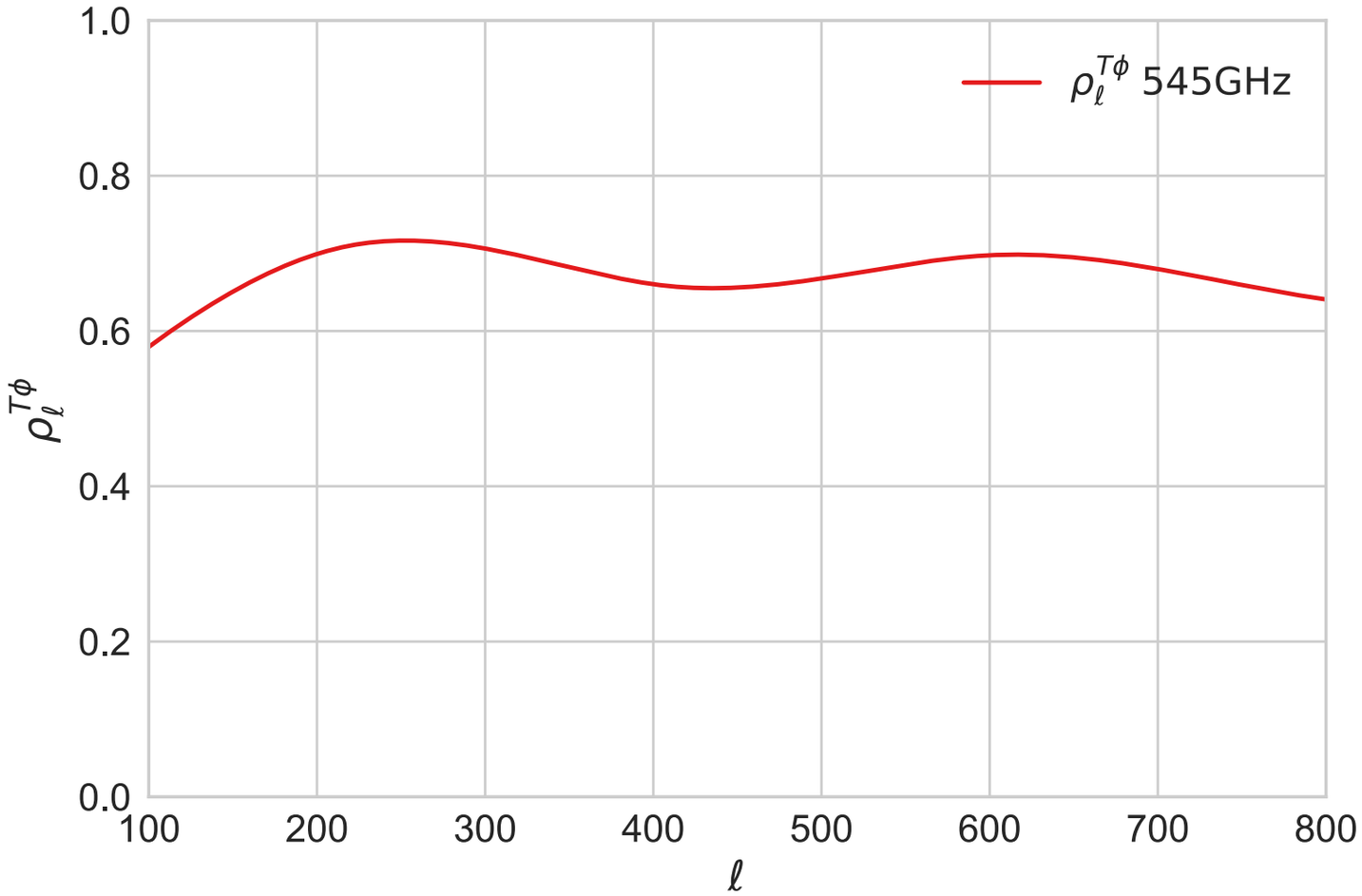
- Great agreement with Planck (2014 XXX)
- Extends to larger scales
- Maps will be public

CIB - CMB lensing cross power

- Great agreement with Planck (2013 XVIII)
- Extends to larger scales
- GNILC x Phi shows weaker correlation



CIB - CMB lensing cross correlation coefficient



- > 60% correlation for l >= 100
- ~10-15% higher than with GNILC CIB
- Powerful in combination with Planck lensing map for BB de-lensing

Conclusions

- Large-scale Planck CIB maps for 5 frequencies
- Significant improvement in component separation
- Better understanding of systematics
- Large scales are challenging!

Conclusions

- Large-scale Planck CIB maps for 5 frequencies
- Significant improvement in component separation
- Better understanding of systematics
- Large scales are challenging!

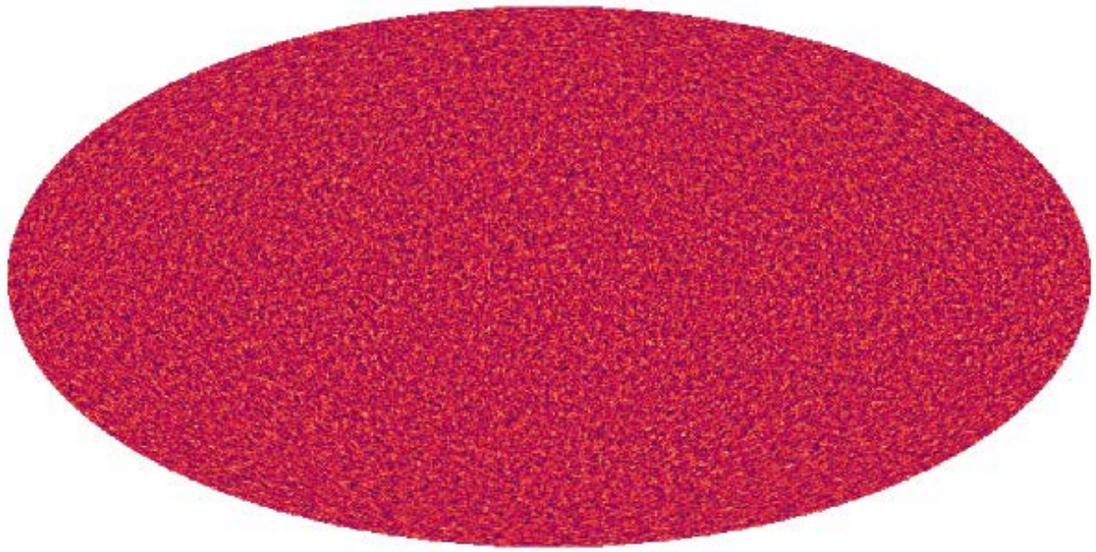
- CIB is powerful probe of large-scale structure
- Study cosmic star-formation
- De-lensing for current and future CMB experiments

Thank you!

Backup

Large-scale bias

Input CIB



Large-scale bias

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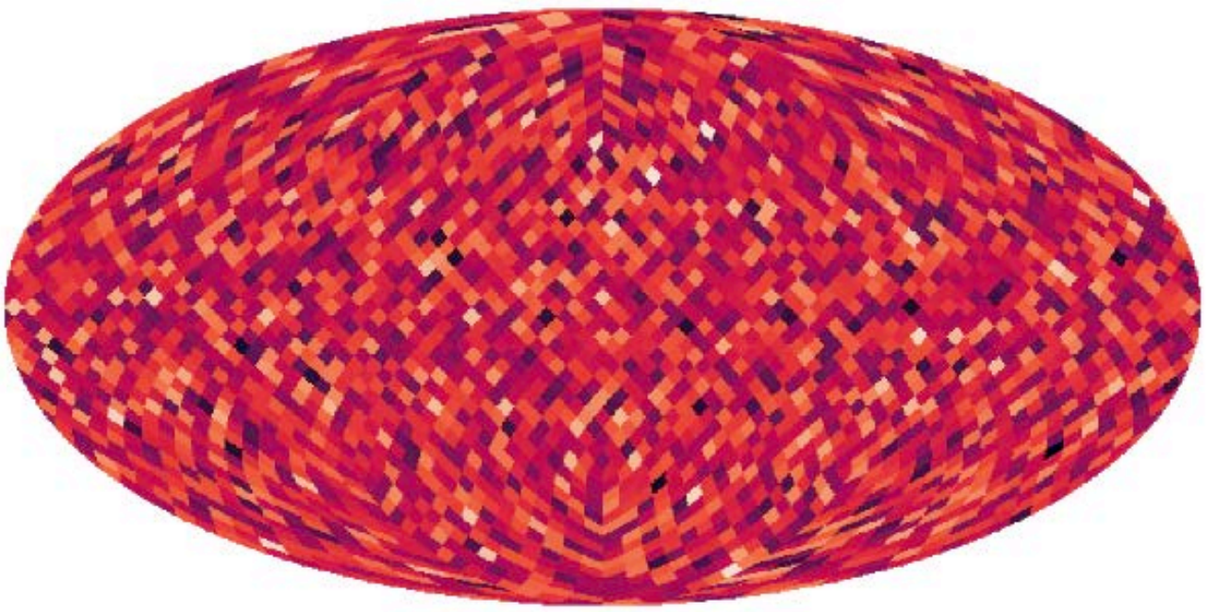
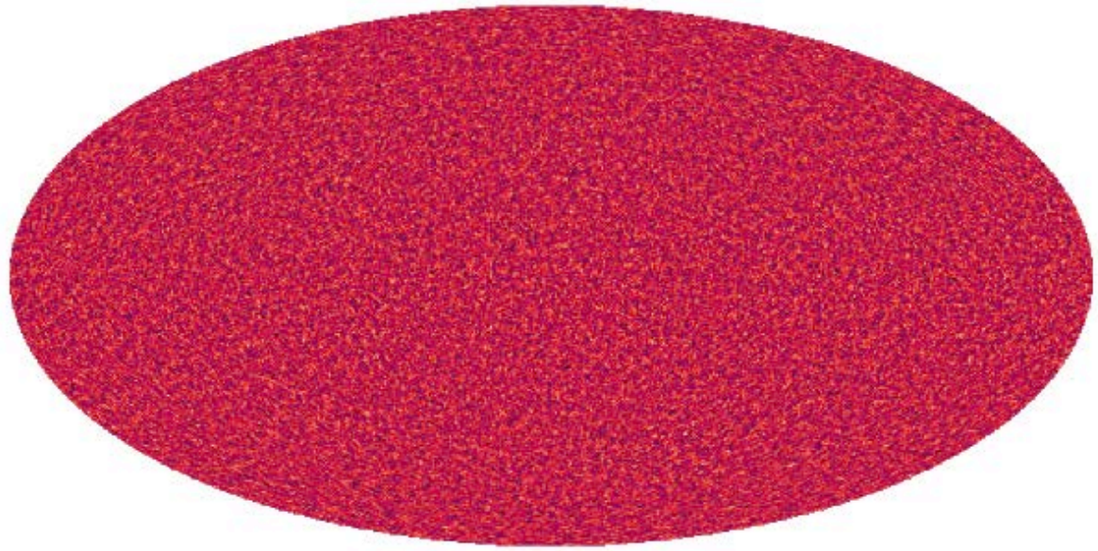
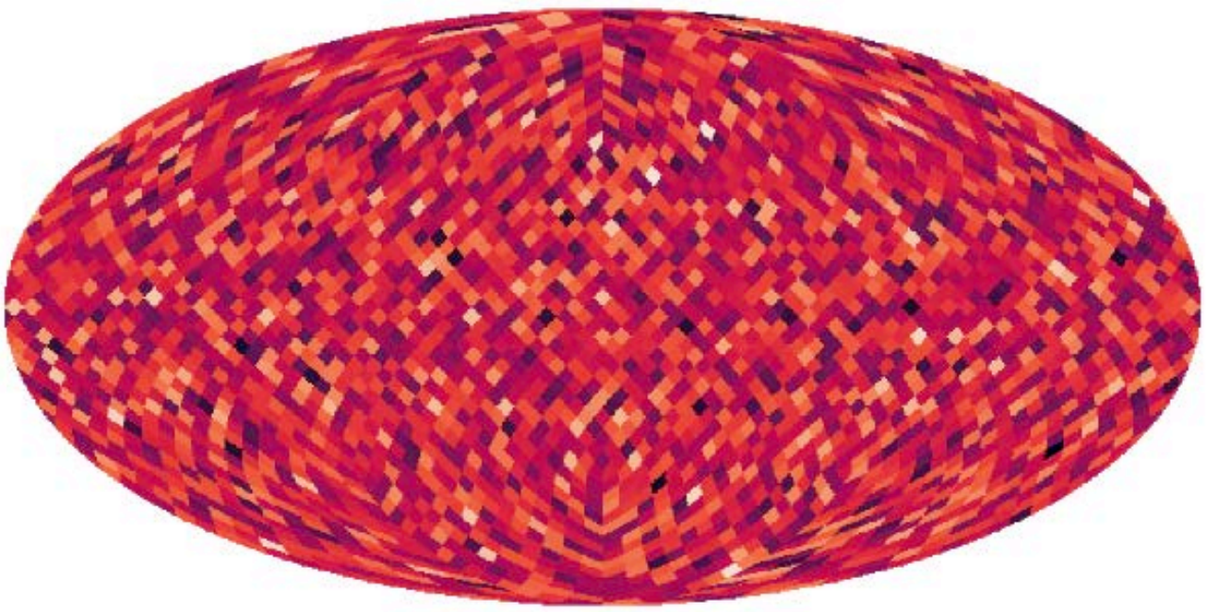


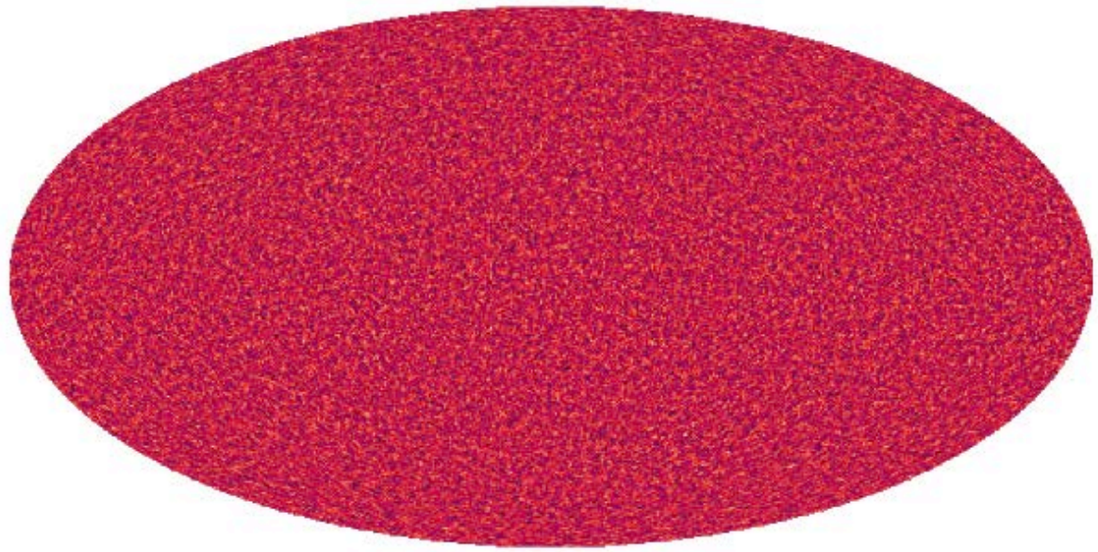


Mean per field

Large-scale bias

Input CIB





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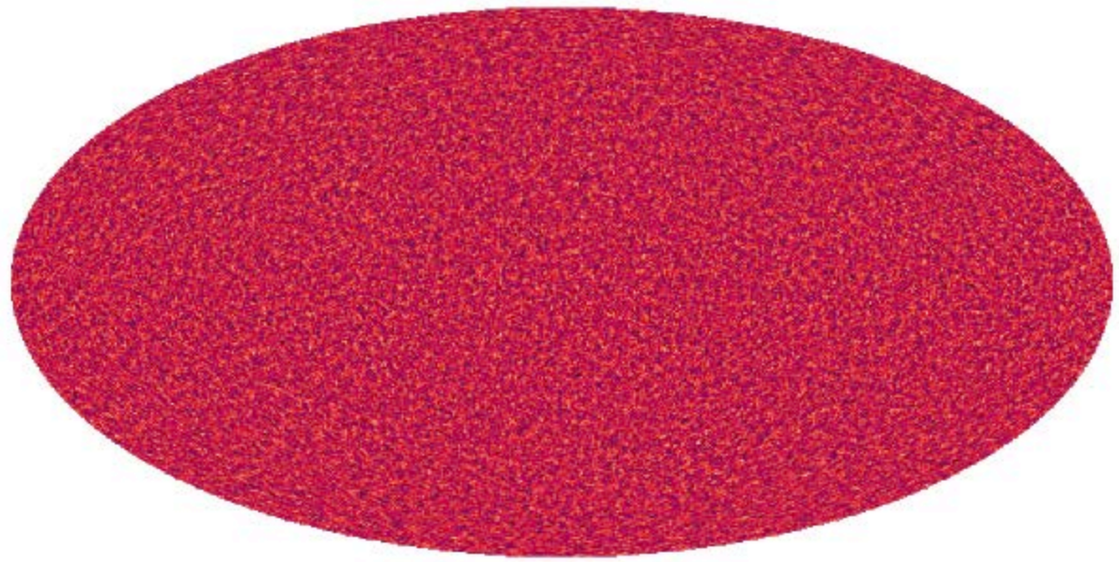
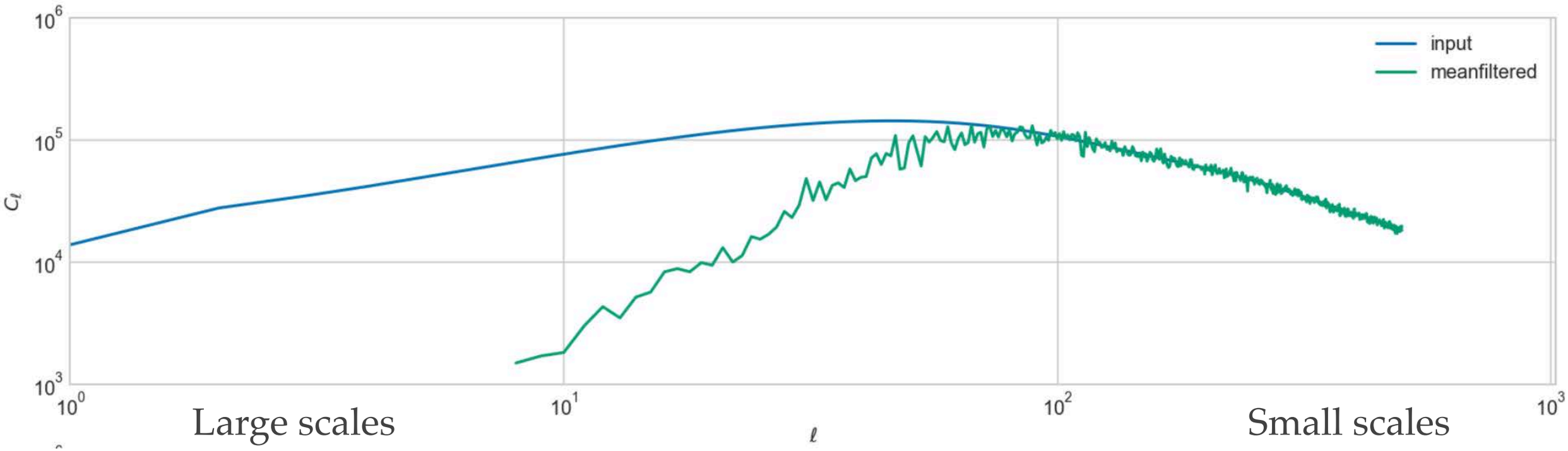


After mean subtraction

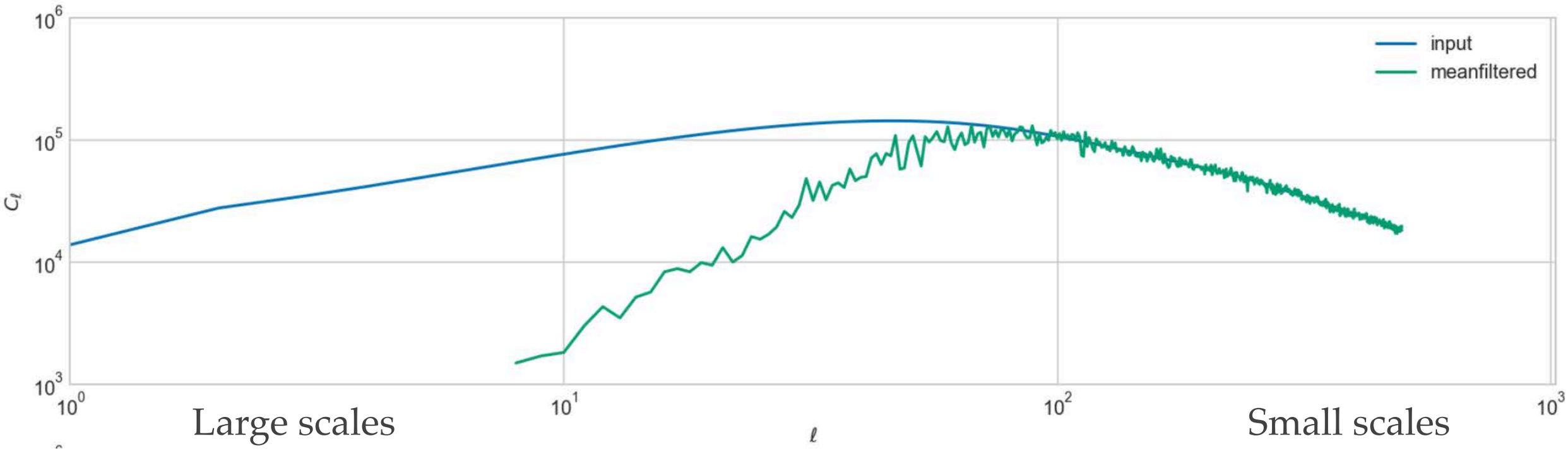
Large-scale bias



Large scales

Small scales

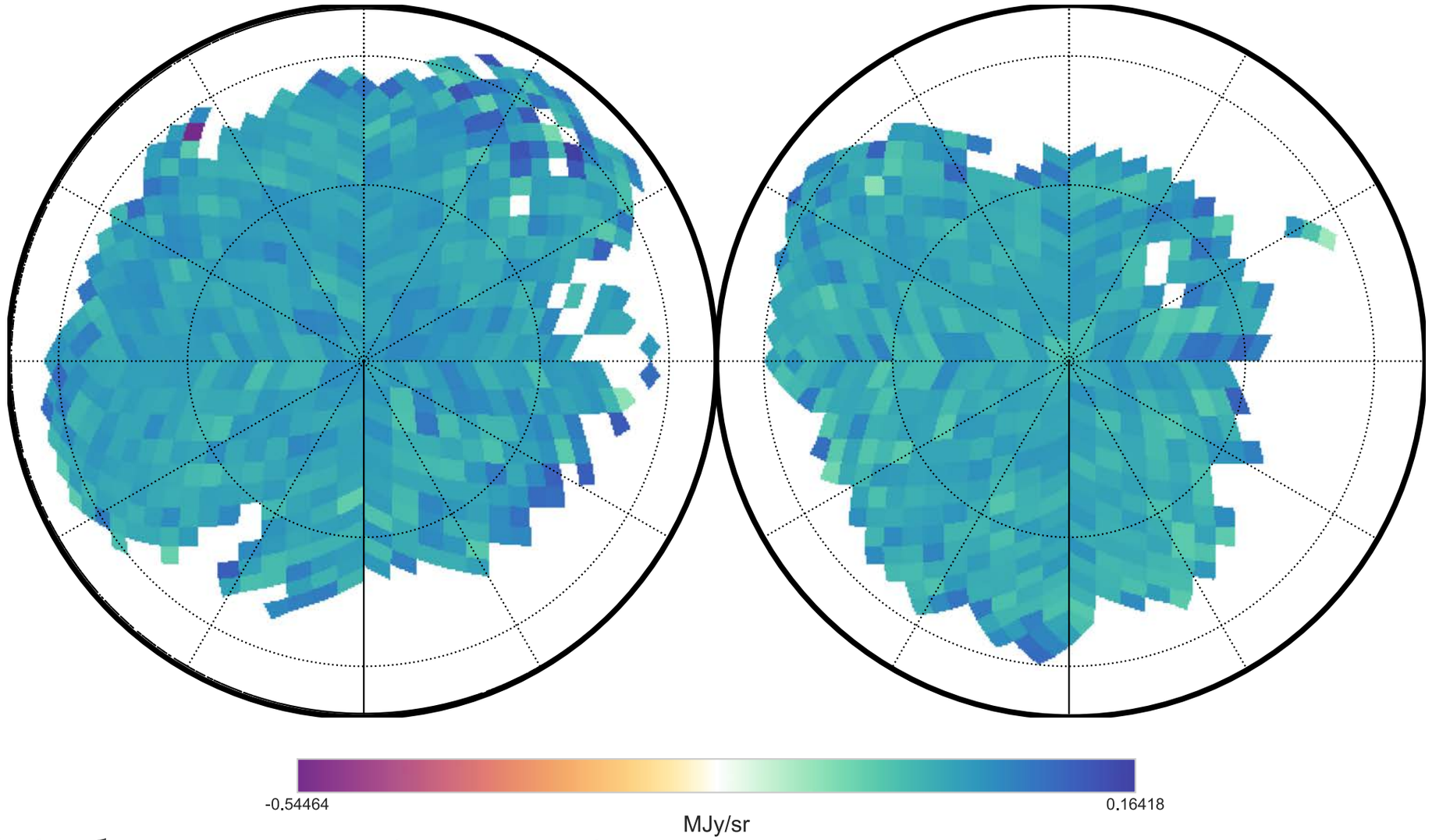
Large-scale bias



- Separating one region at a time removes large-scale power
- Essential for CIB reconstruction at low l

Spatial selection

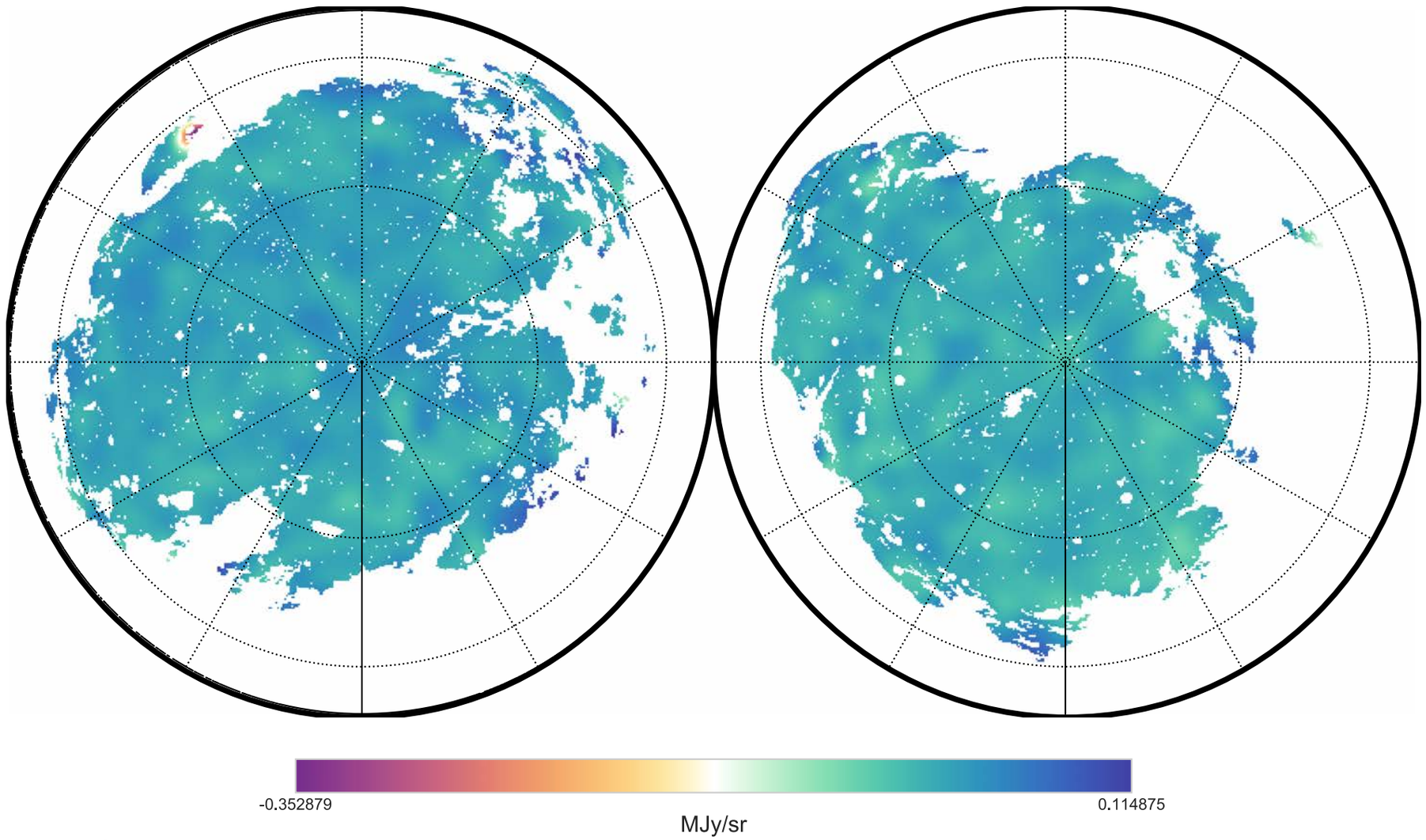
Offsets in the HI/dust correlation



- Build dust models that preserve large-scale power
- Use consistency checks and cross correlations
- Difficult trade-off!

Spatial selection

Offsets in the HI/dust correlation (smoothed)



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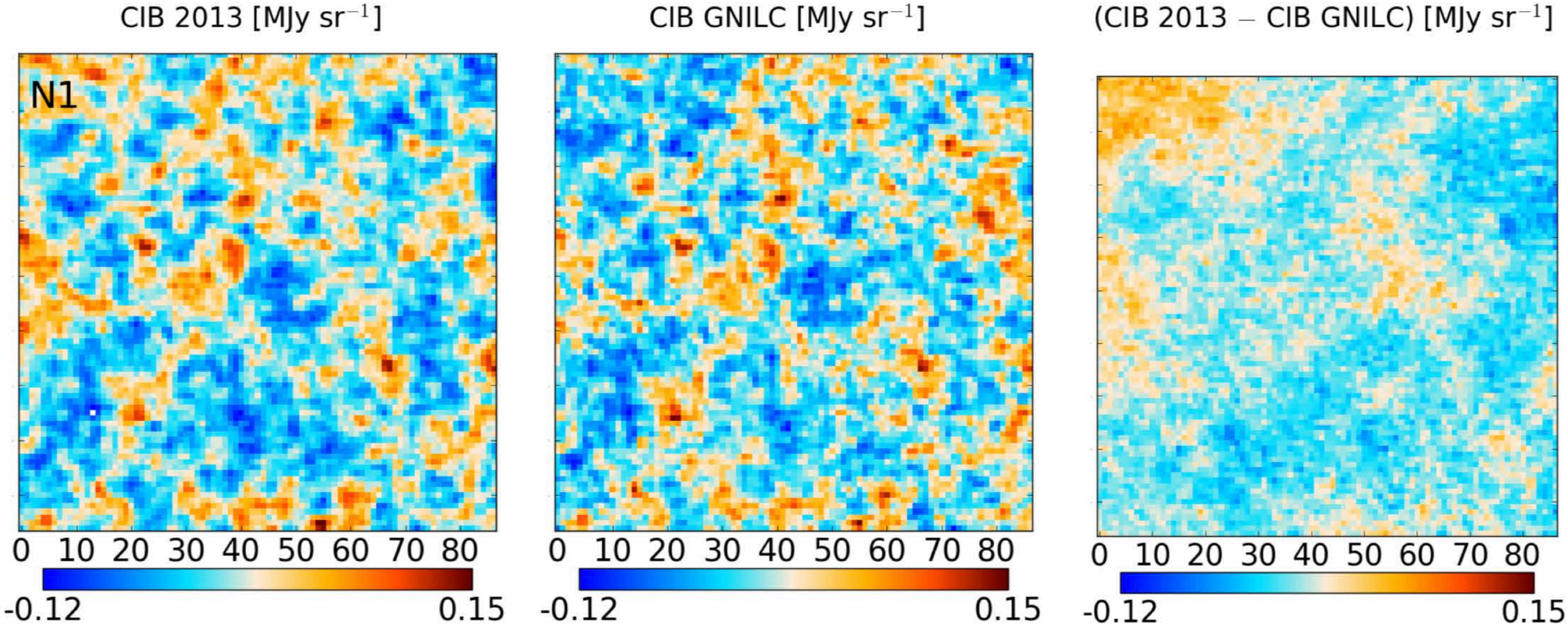
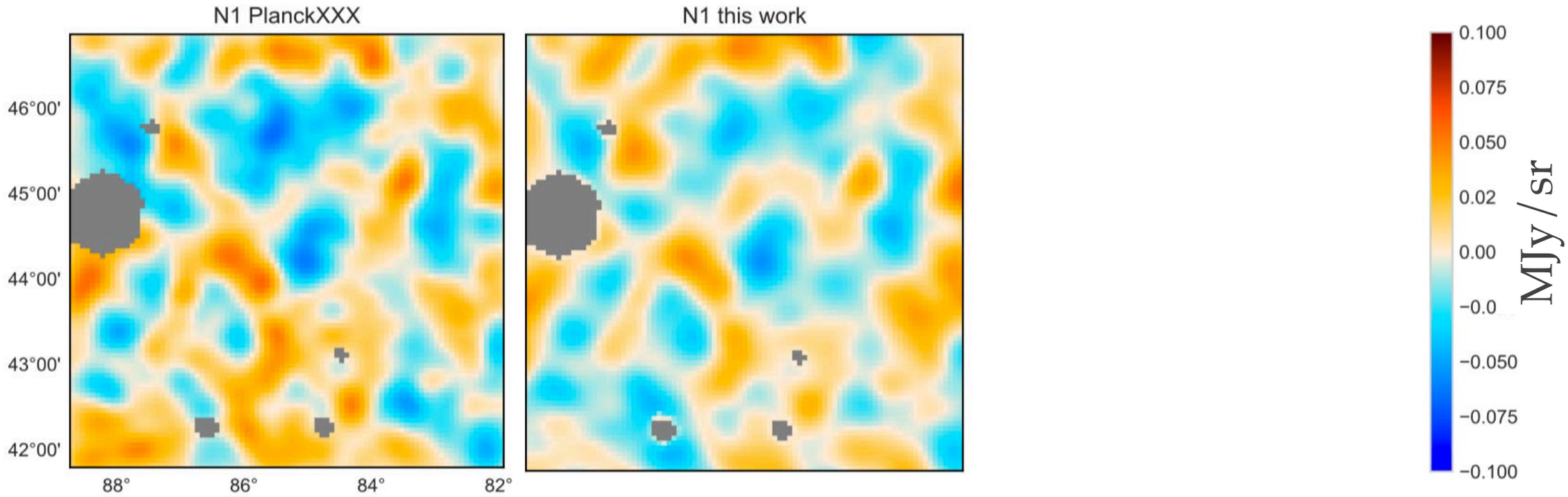
Based on spatial information: GNILC



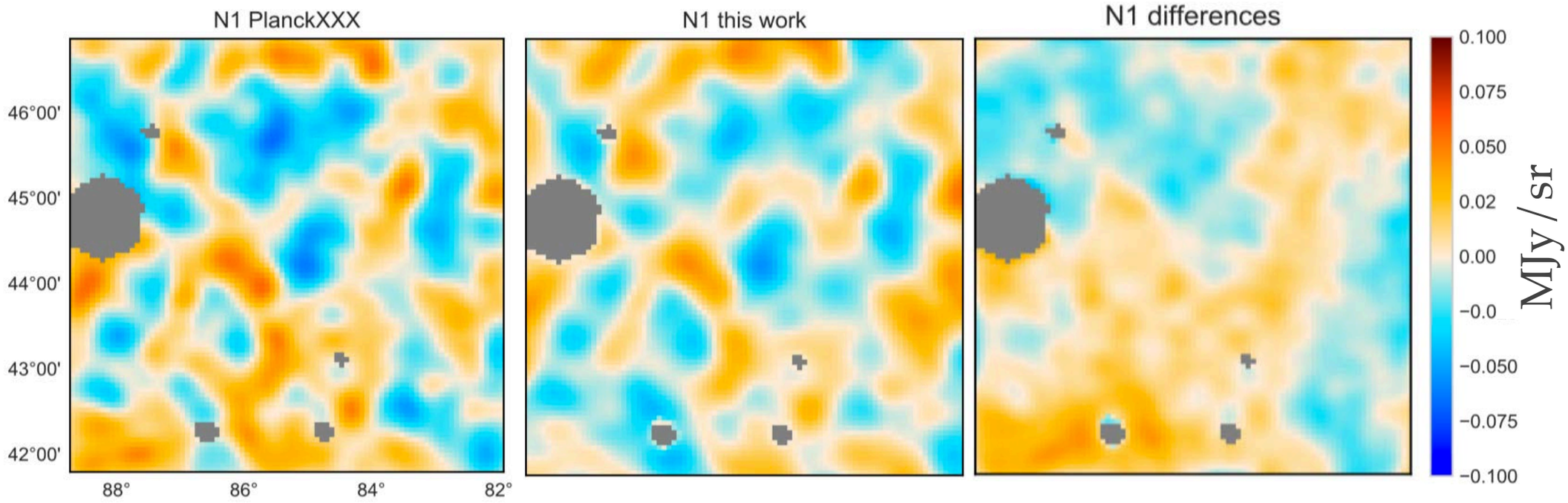
Planck (2016 XLVIII

Comparison to earlier work: Small fields



- Very similar morphologies despite totally different spatial selections
- Yet differences remain!

Comparison to earlier work: Small fields



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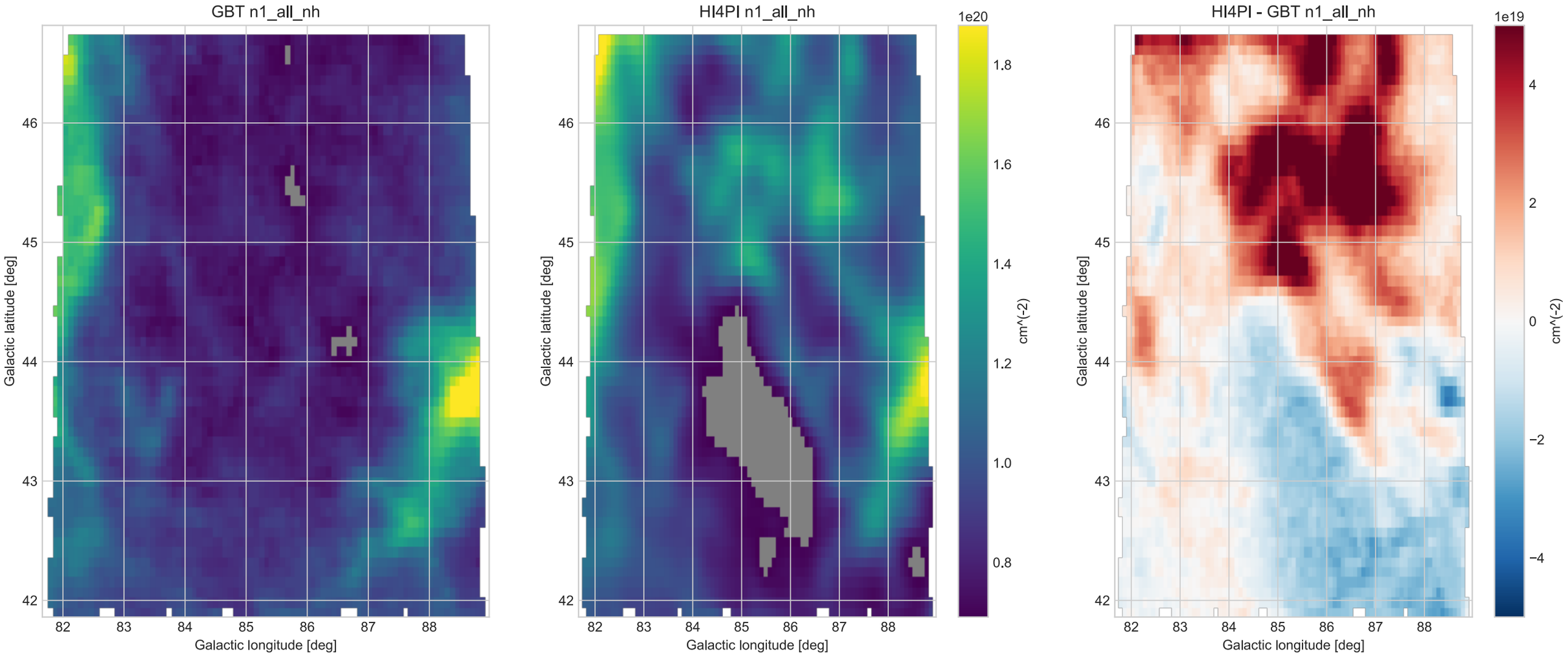

- Differences can be partially attributed to the underlying HI data
- Radial velocity cuts have strong effect

Comparison to earlier work: Large field

Planck (2014 XXX)

This work

Comp e field