Méthode de séparation de sources
Modèles et algorithmes

Applications en Astrophysique

Applications in astrophysics

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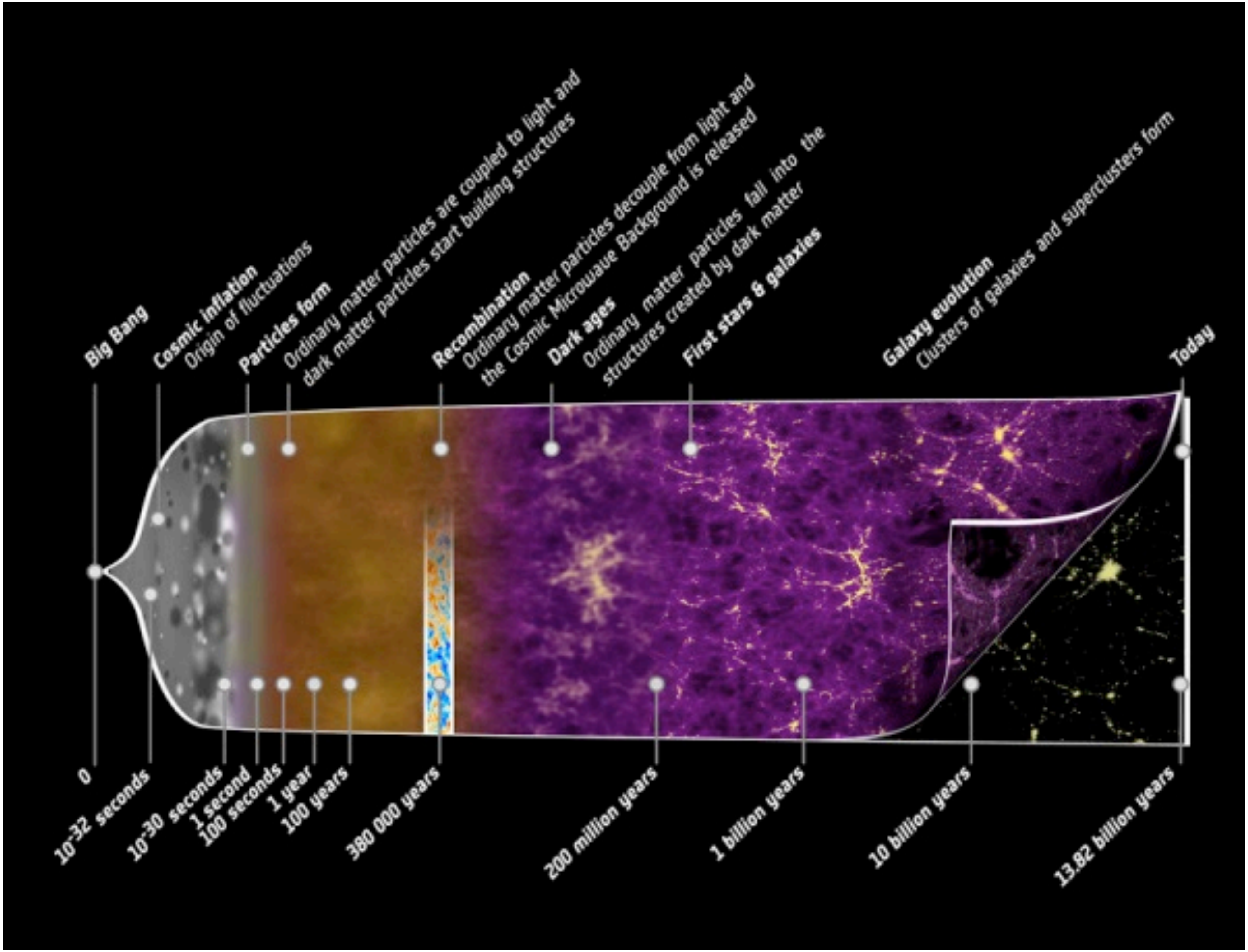
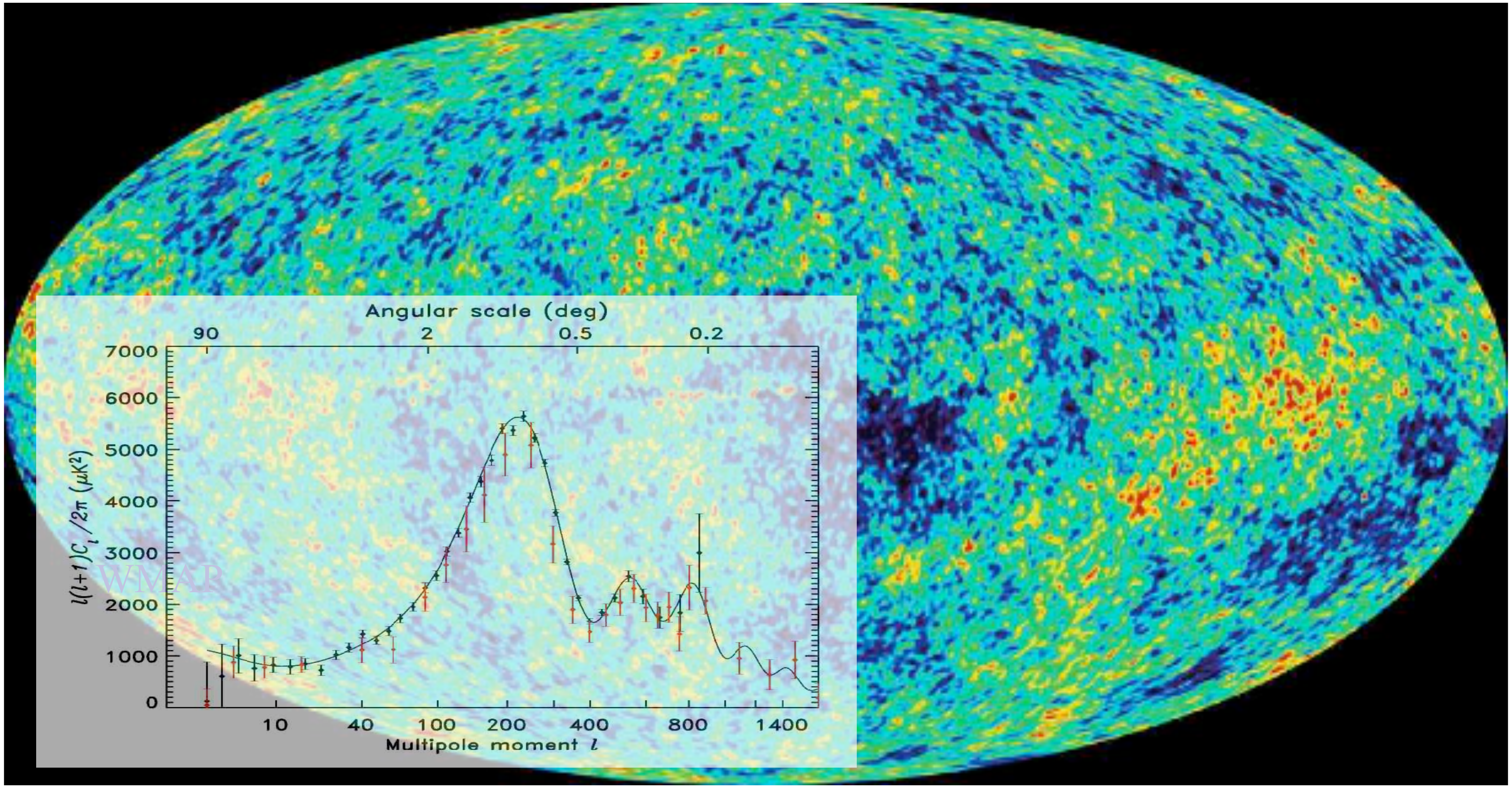
Application to CMB estimation



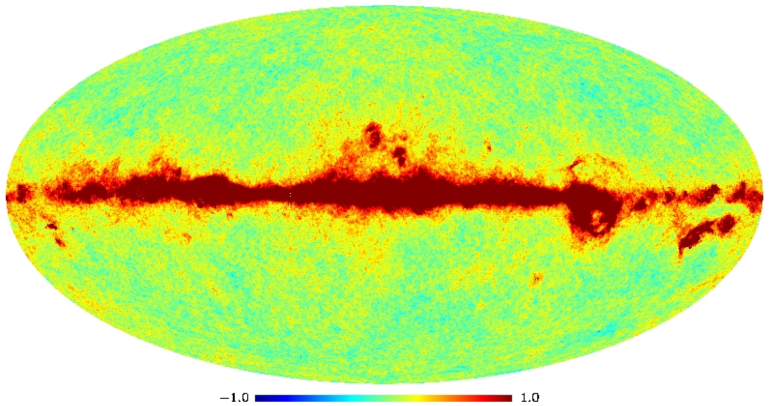
Cosmic Microwave Background (CMB)

The CMB exhibits Fluctuations

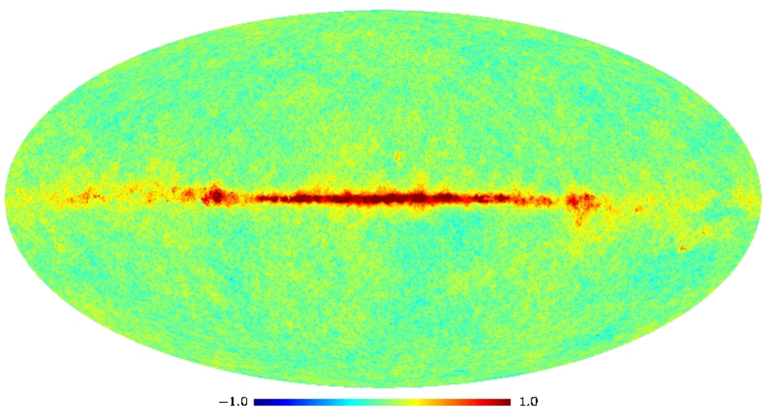


Application to CMB estimation

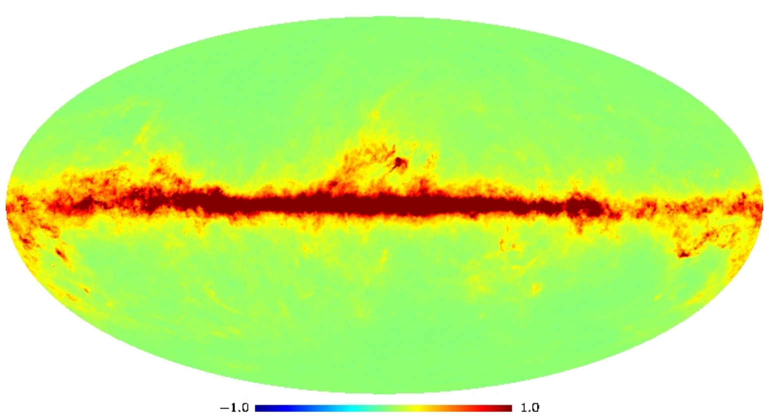
Canal 30GHz (en mK)

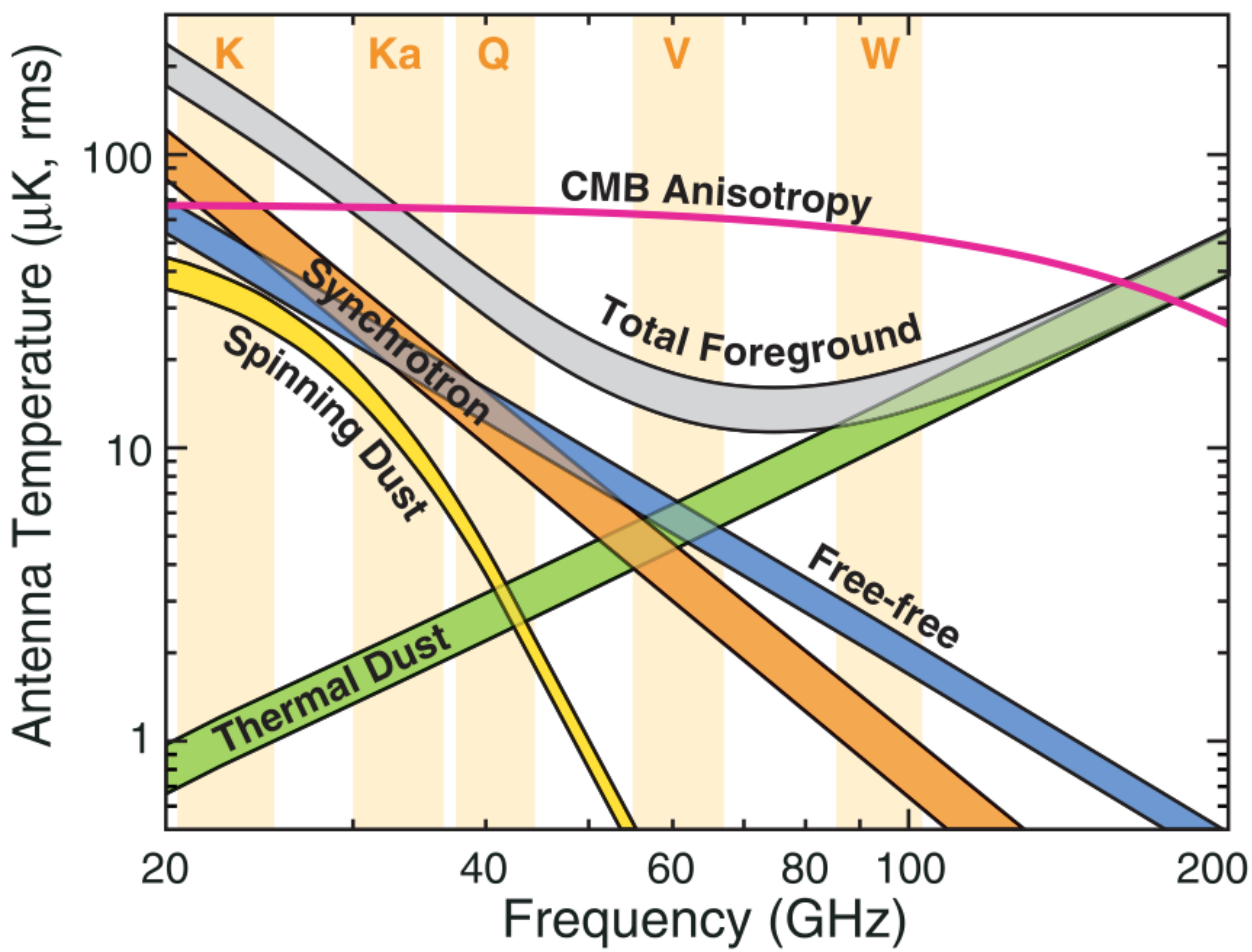


Canal 100GHz (en mK)



Canal 353GHz (en mK)

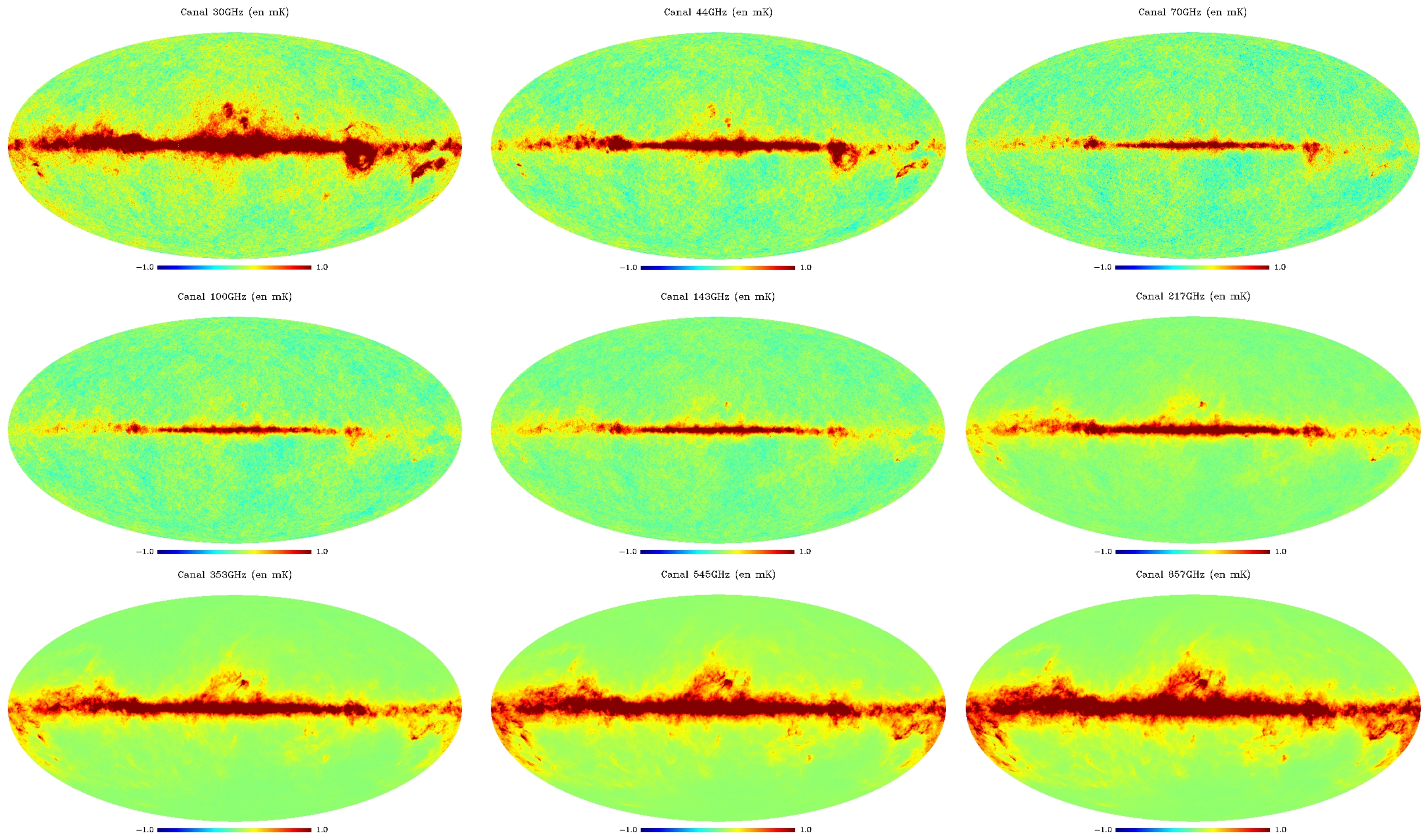




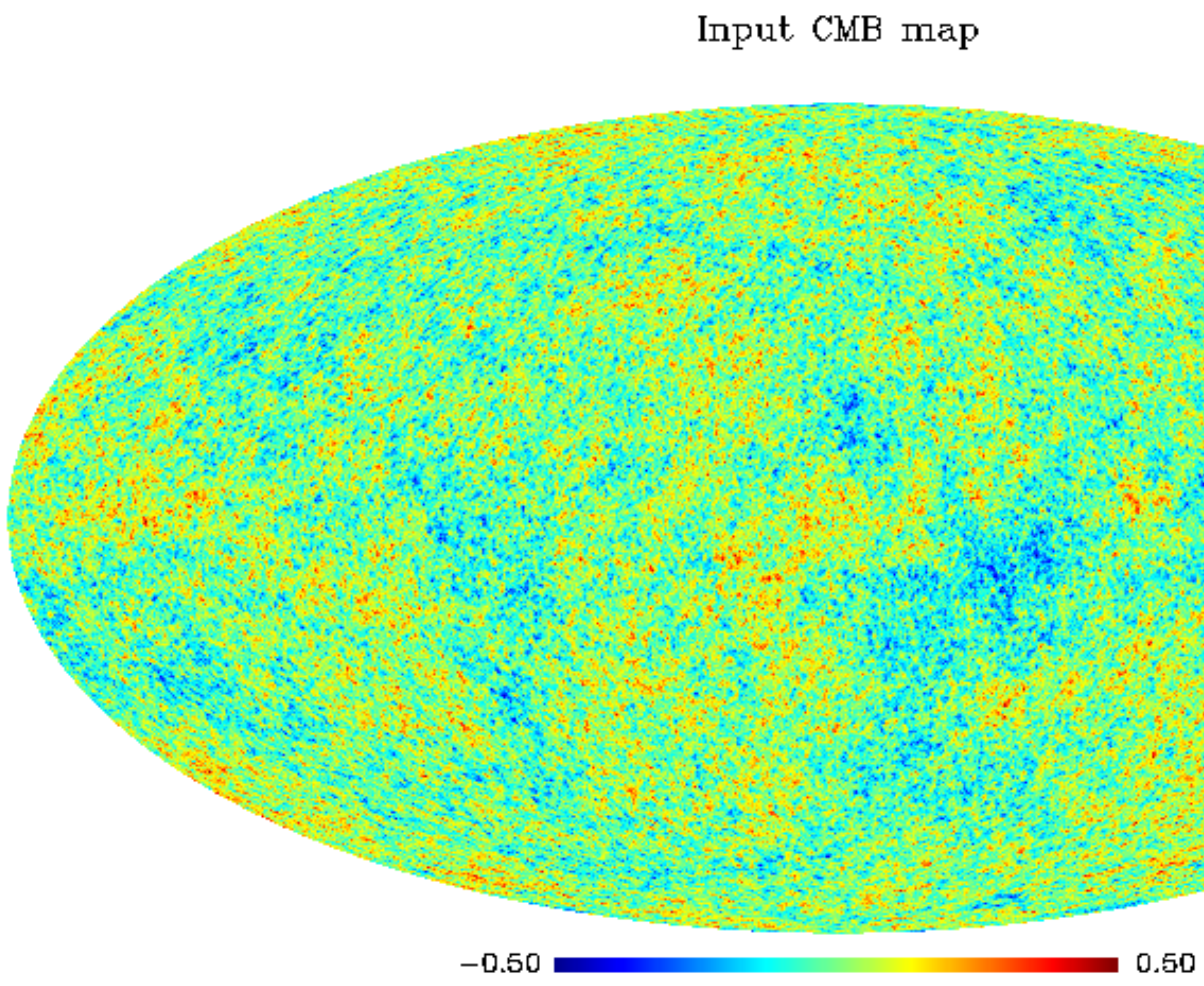
For the sake of evaluation, L-GMCA has been applied to simulated but realistic data (Leach et al. 2008)

Planck sky modeling : CMB, SZ, free-free, synchrotron and dust emission, spinning dust

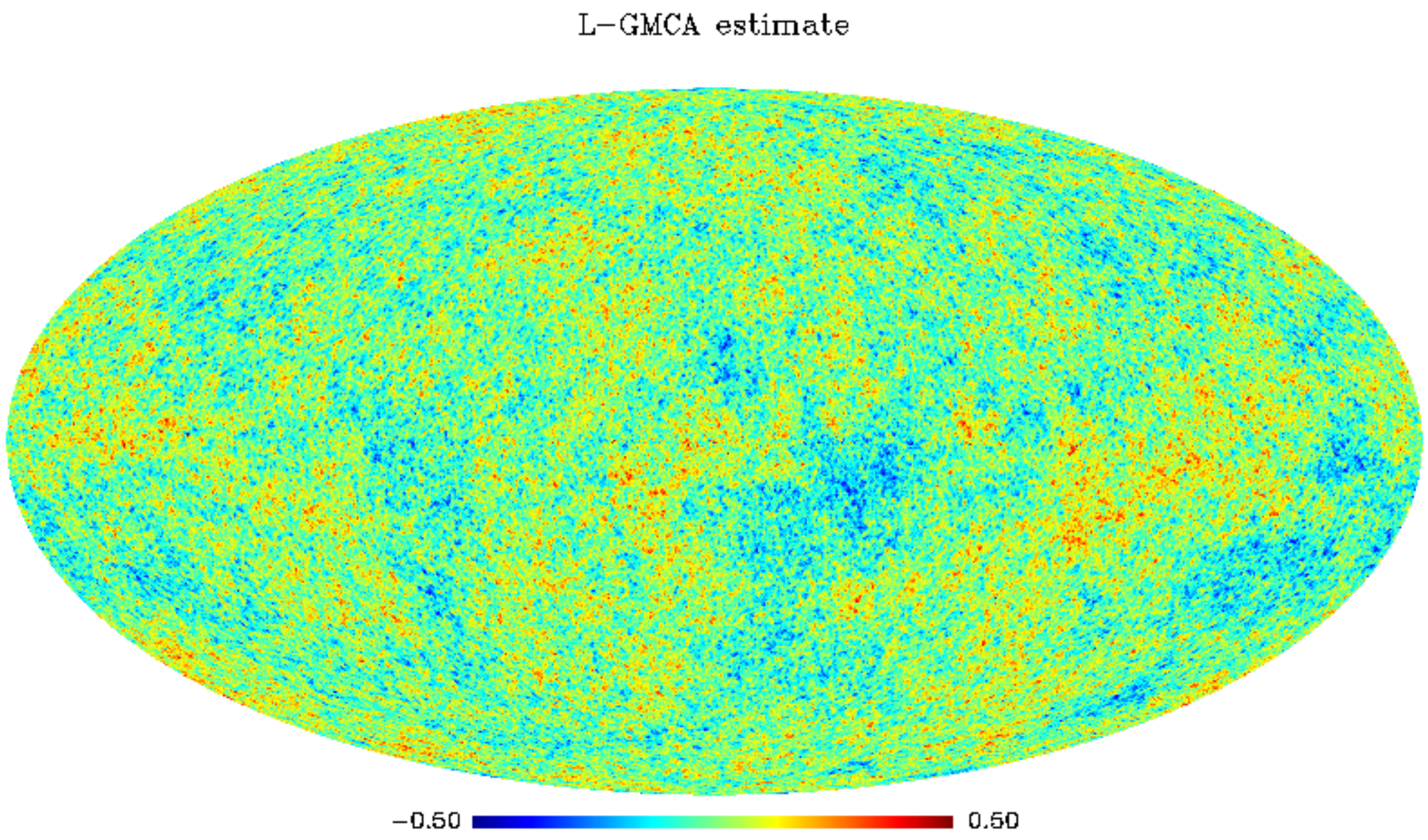
Instrumental modeling: decorrelated but non-stationary gaussian noise, perfect isotropic gaussian beams



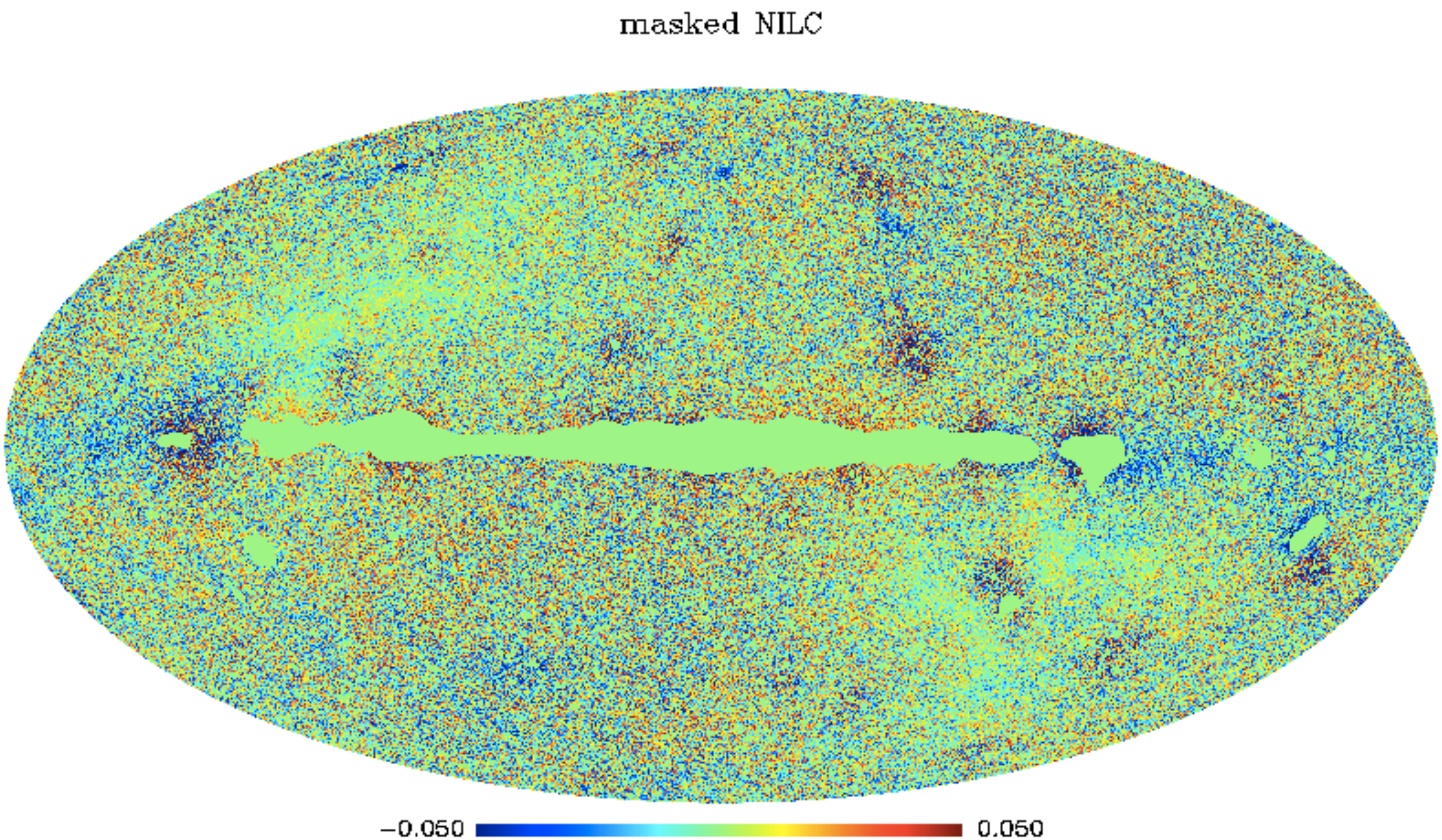
Results



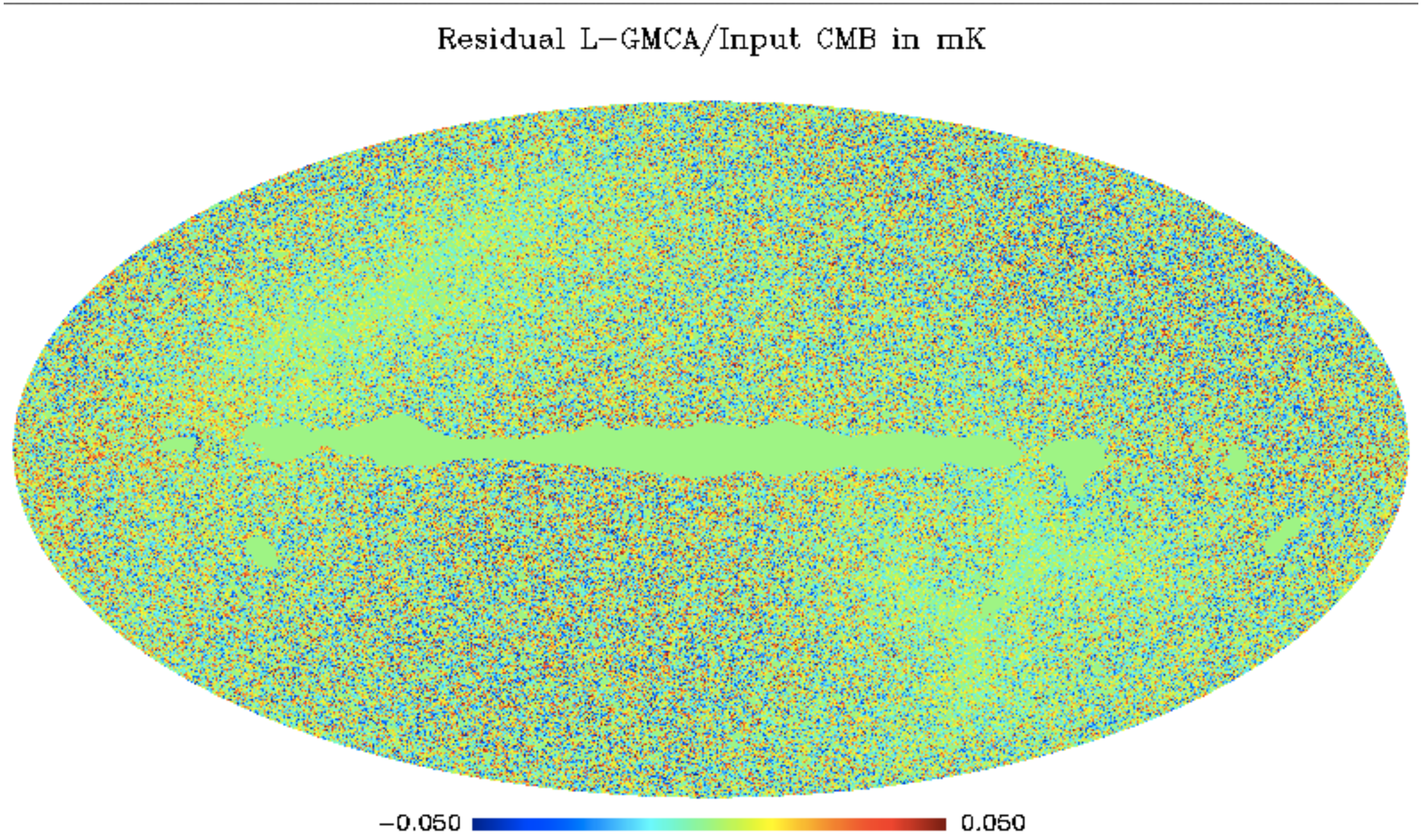
Application to CMB estimation



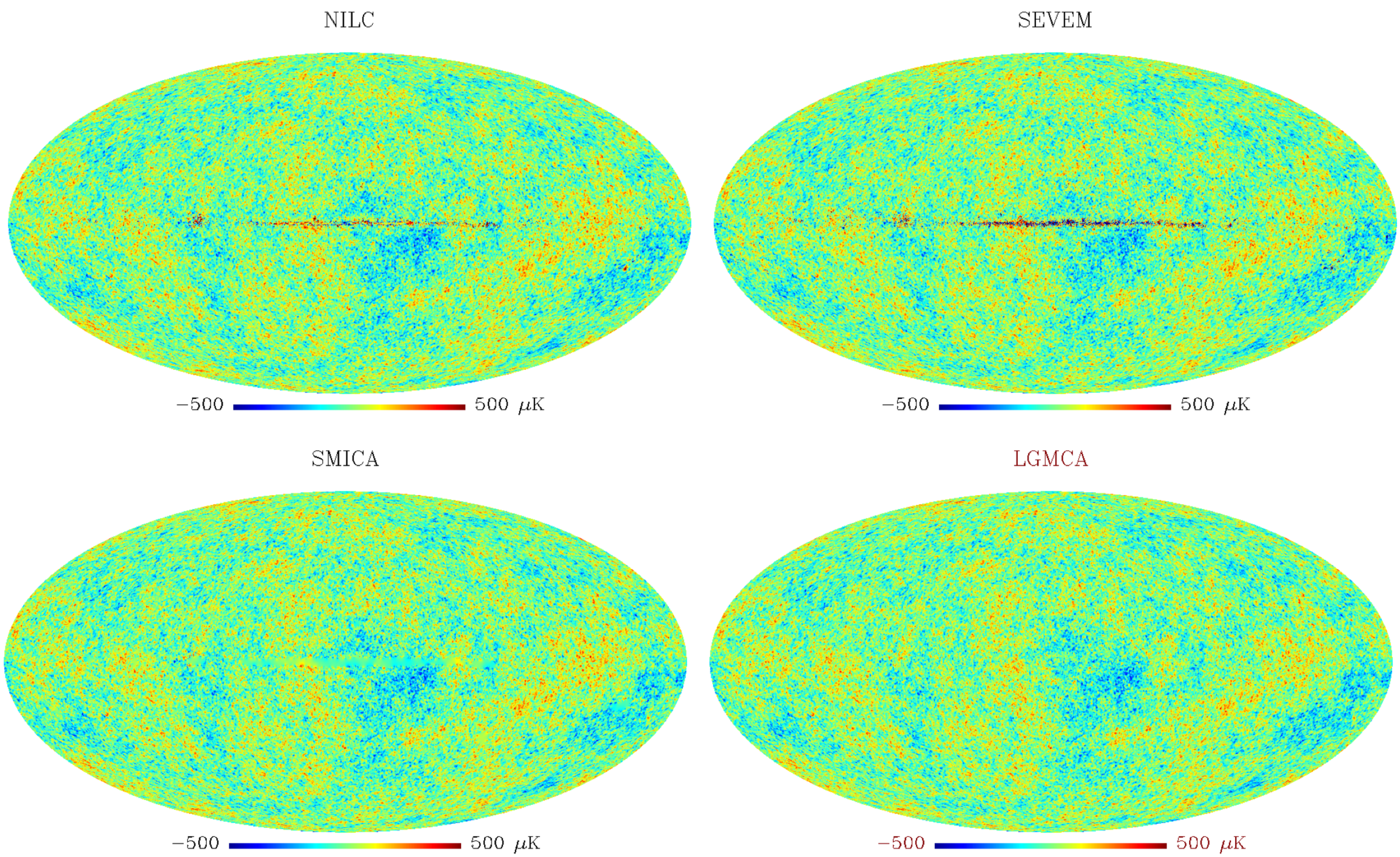
Application to CMB estimation



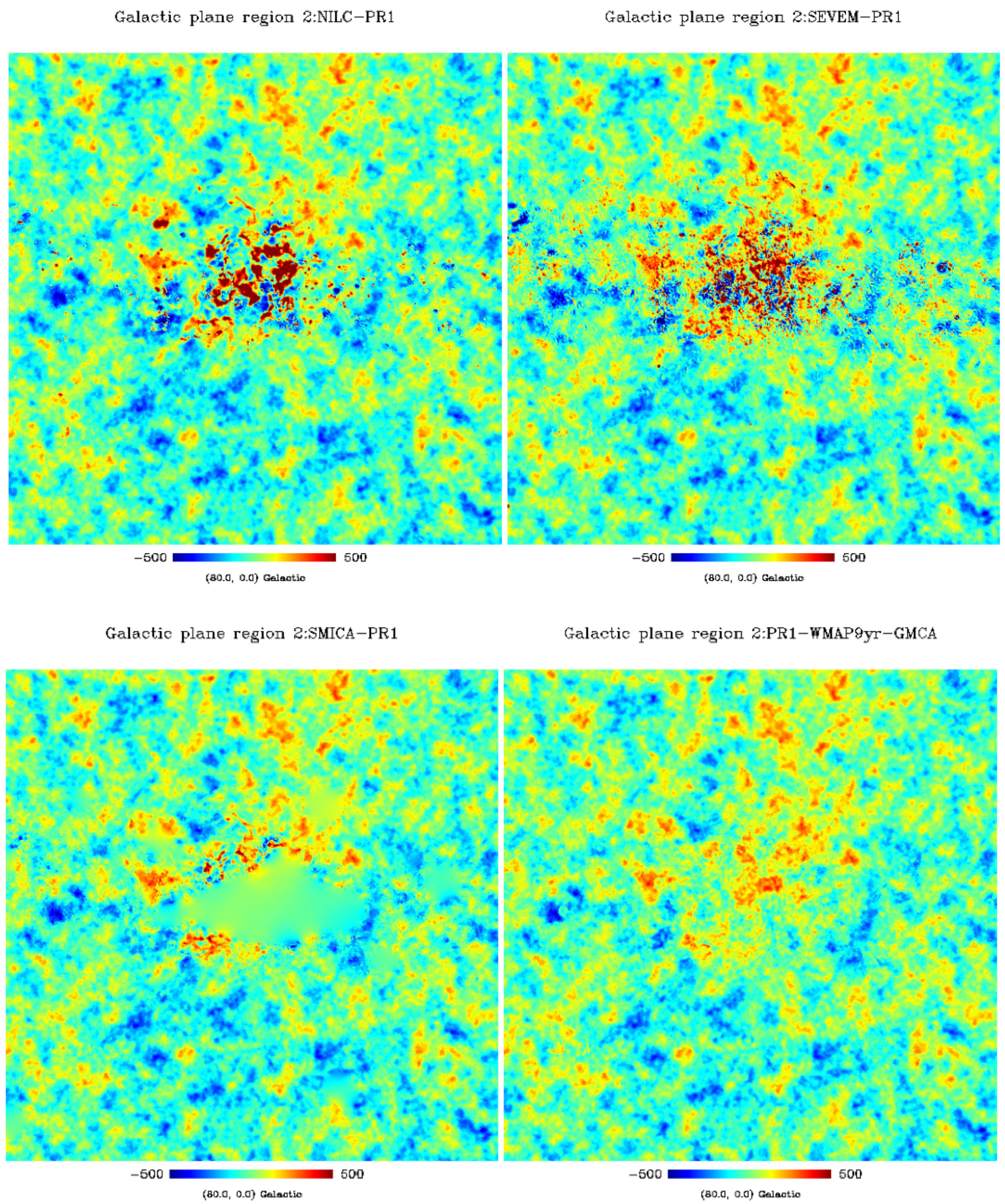
Application to CMB estimation

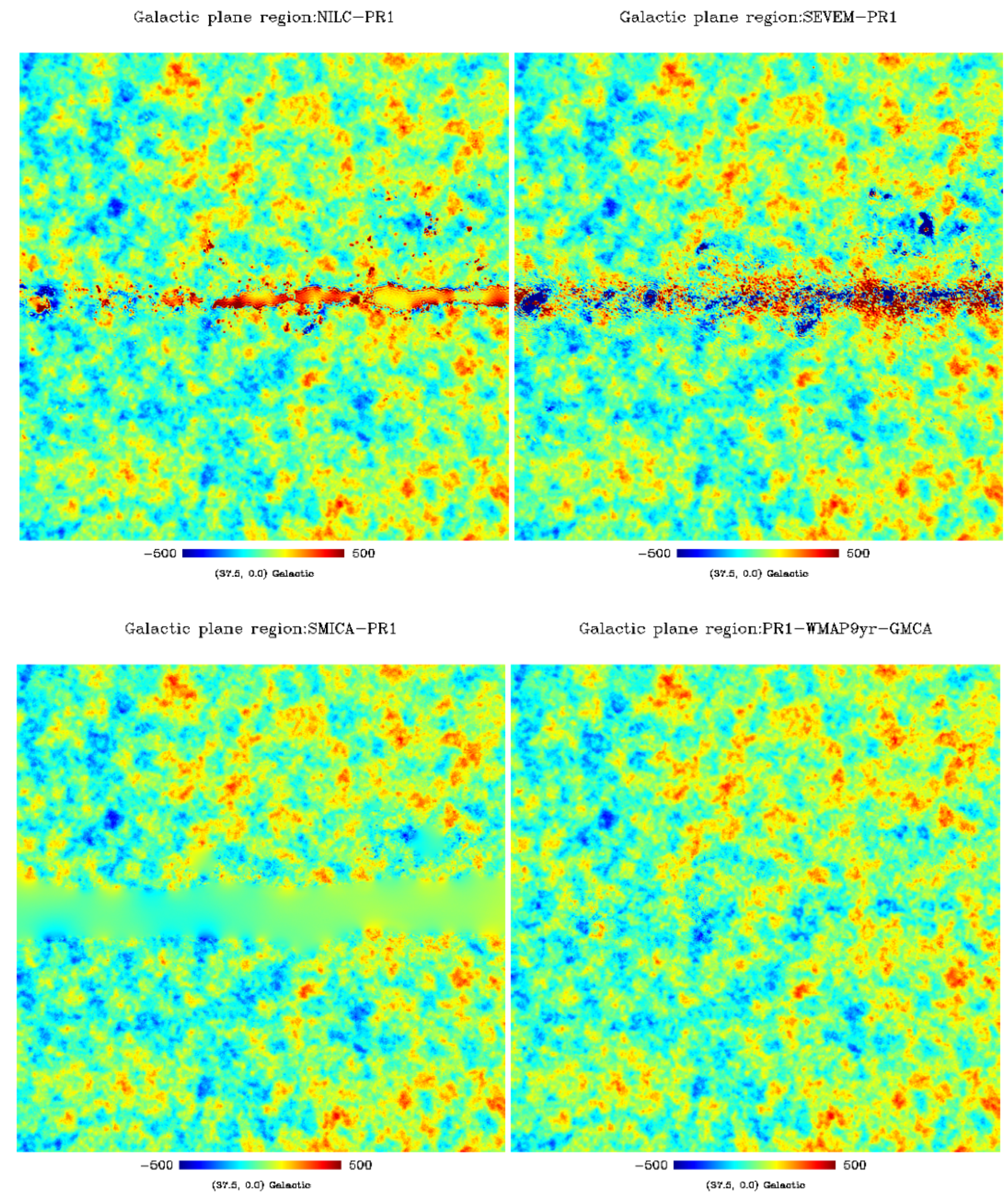


Real data !


NILC
−500
500 μK
SEVEM
−500
500 μK
SMICA
−500
500 μK
LGMCA
−500
500 μK

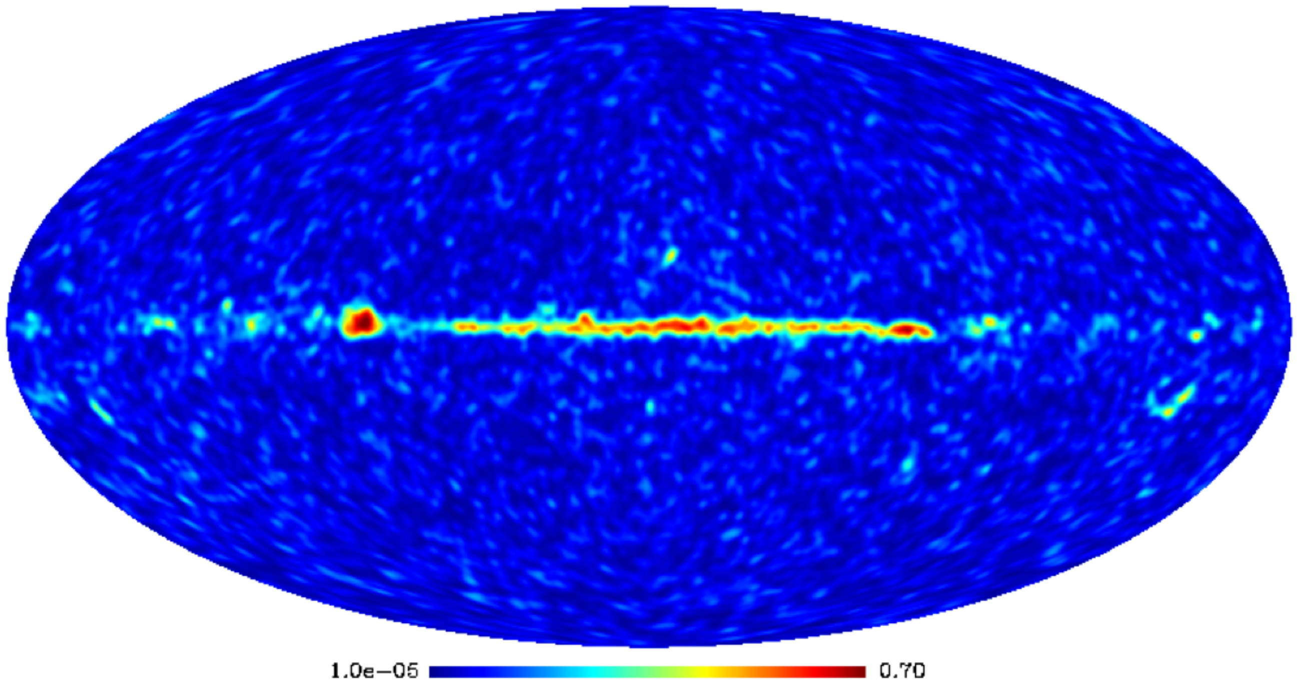
Application to CMB estimation



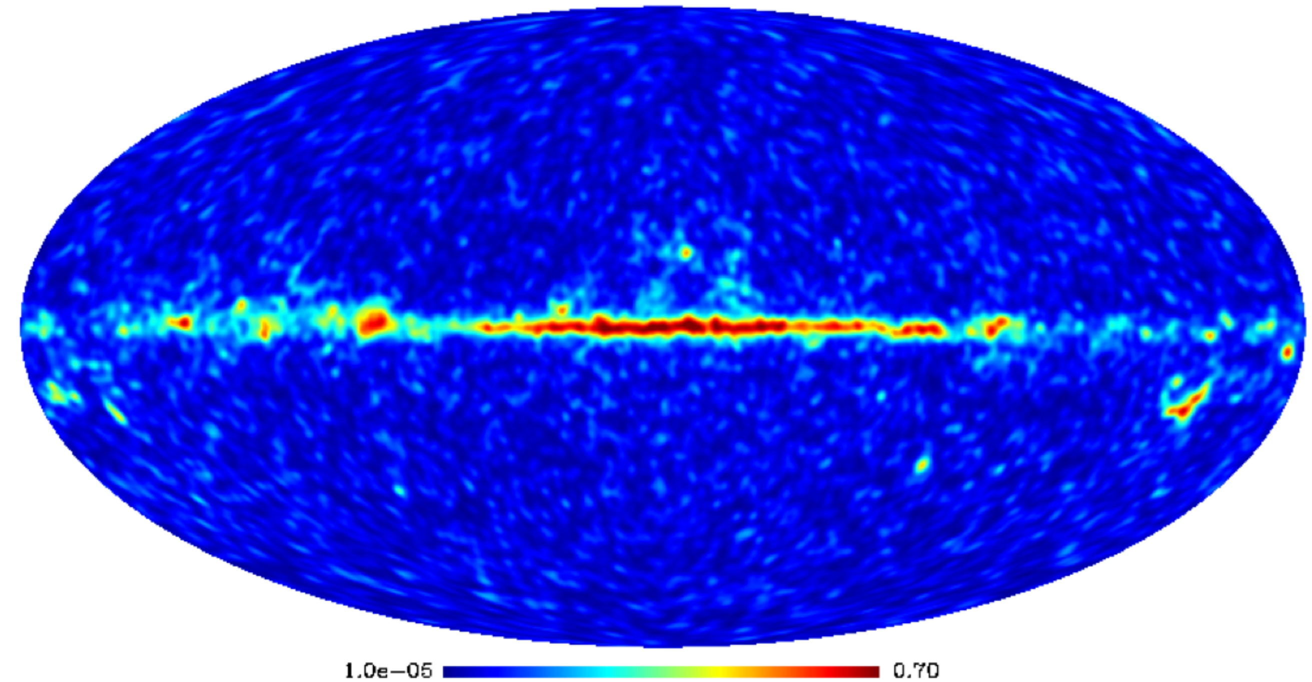


Real data !

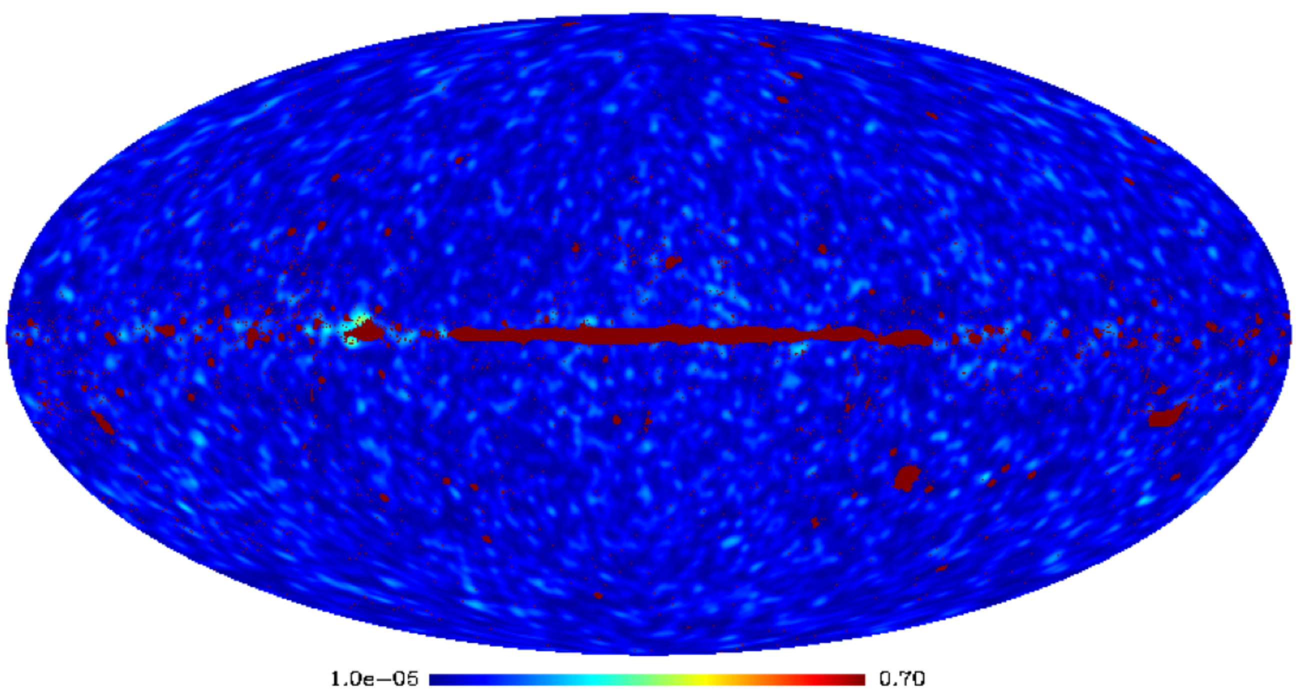
Quality Map: PR1−NILC



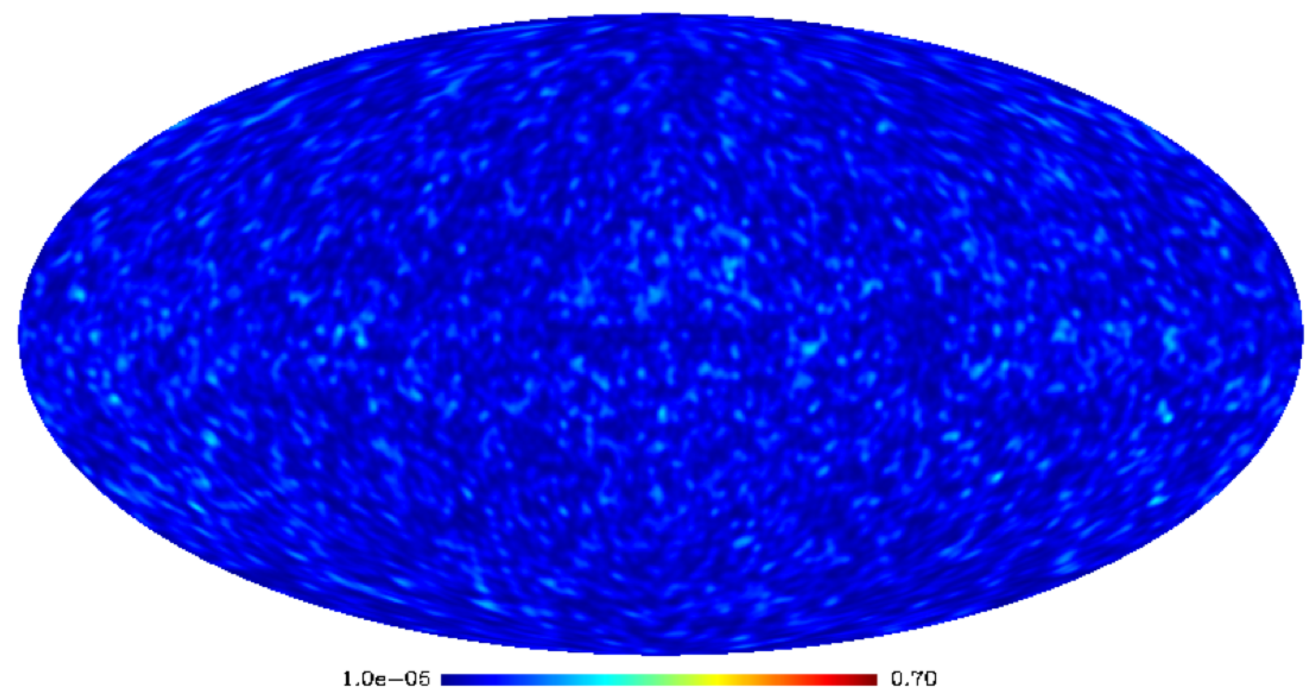
Quality Map: PR1−SEVEM



Quality Map: PR1−SMICA



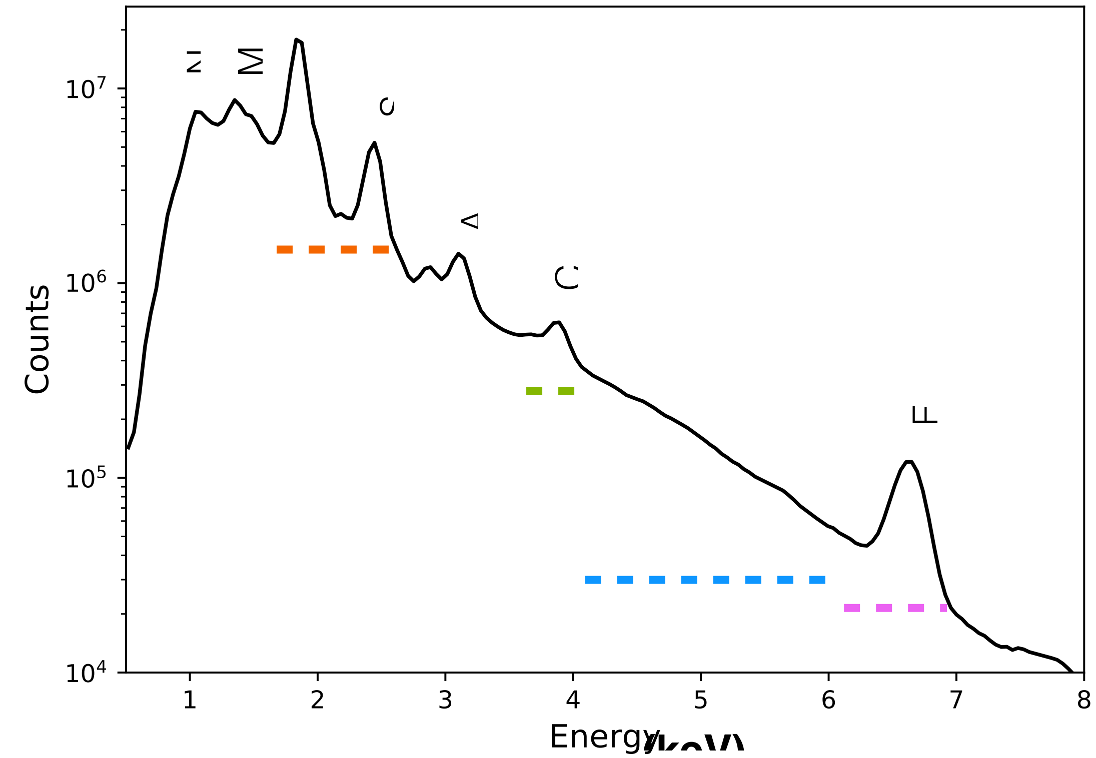
Quality Map: PR1−WMAP9yr−GMCA

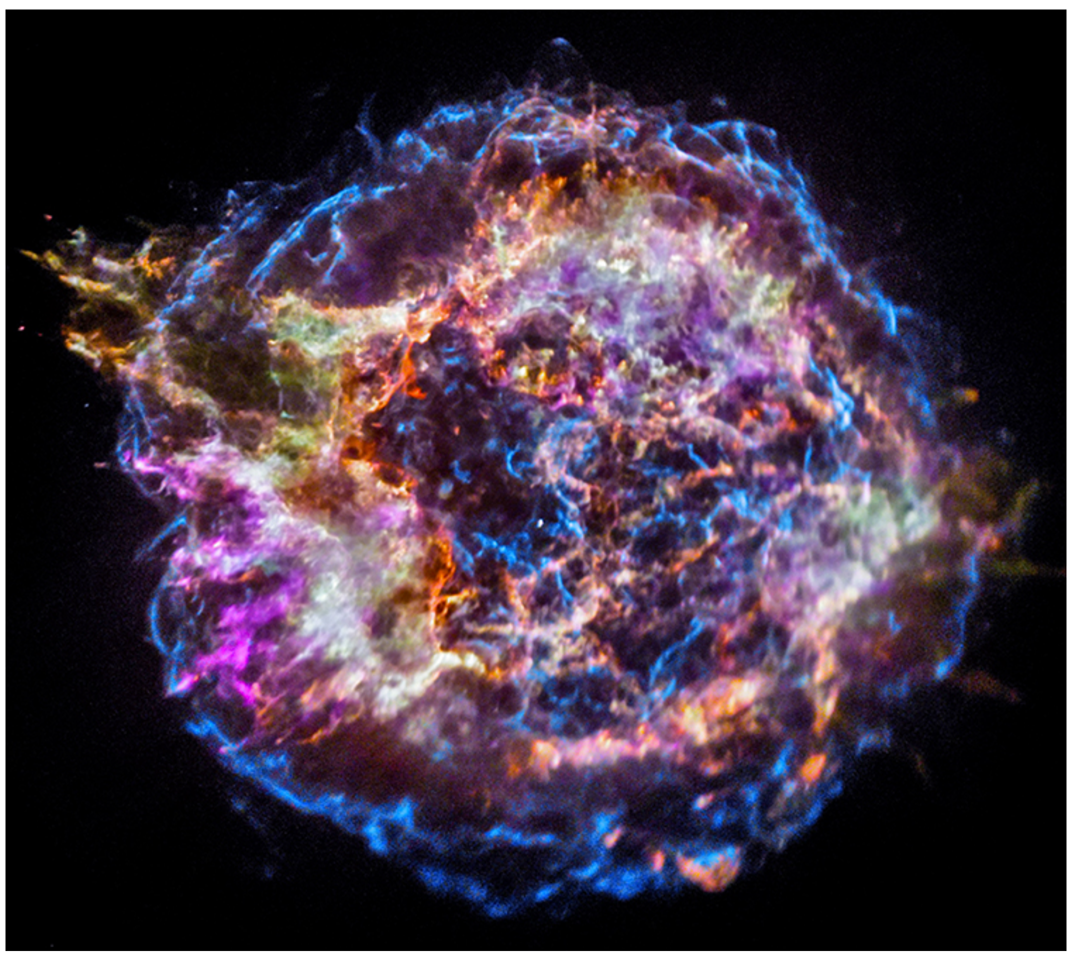


Application to X-ray imaging

Supernova remnants as seen in X-rays

- Ejecta thermal emission gives insight on :
  - Individual elements distribution
  - Morphology, asymmetries
  - Velocities

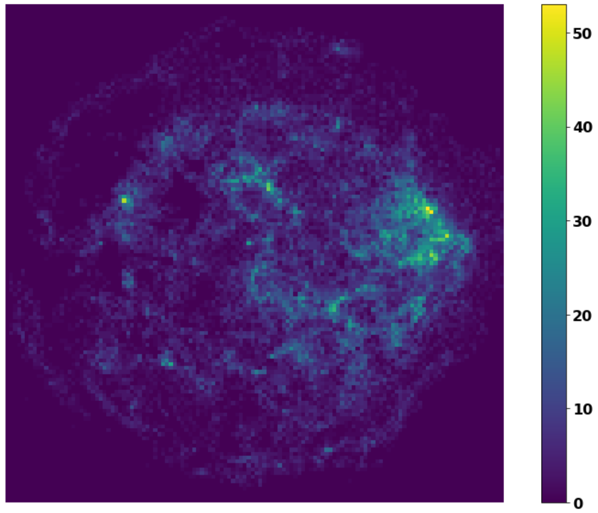




Hard unsupervised component separation problem:

- High dynamic range between the sources (> 2 orders of magnitudes)
- Low signal-to-noise ratio
- Strong synchrotron background
- Correlated spectra and sources

Application to X-ray imaging



Extending sparse BSS to account for the Poisson statistics of the measurements

$$\min_{\mathbf{A}\in\mathcal{C},\mathbf{S}\geq 0} \left\|\mathbf{\Lambda} \odot \mathbf{S}\mathbf{\Phi}^T\right\|_{\ell_1} + \mathcal{L}\left(\mathbf{X}|\mathbf{A},\mathbf{S}\right)$$

$$\mathcal{L}\left(\mathbf{X}|\mathbf{A},\mathbf{S}\right) \;=\; \mathbf{AS} - \mathbf{X} \odot \log(\mathbf{AS})$$

Poisson neg-loglikelihood

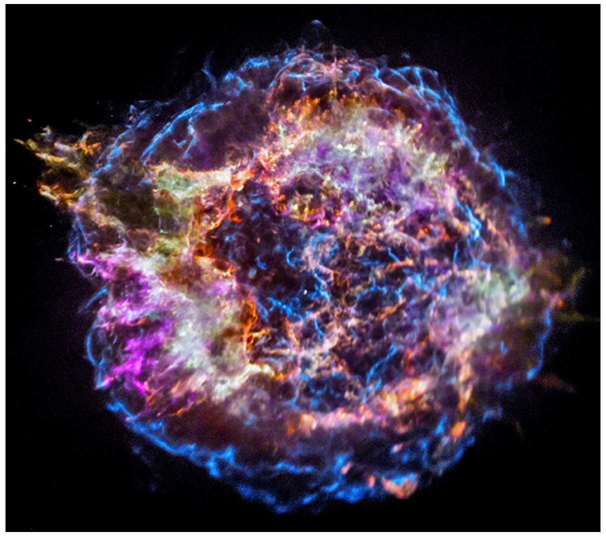
- Multi-convex problem with non-smooth data fidelity term

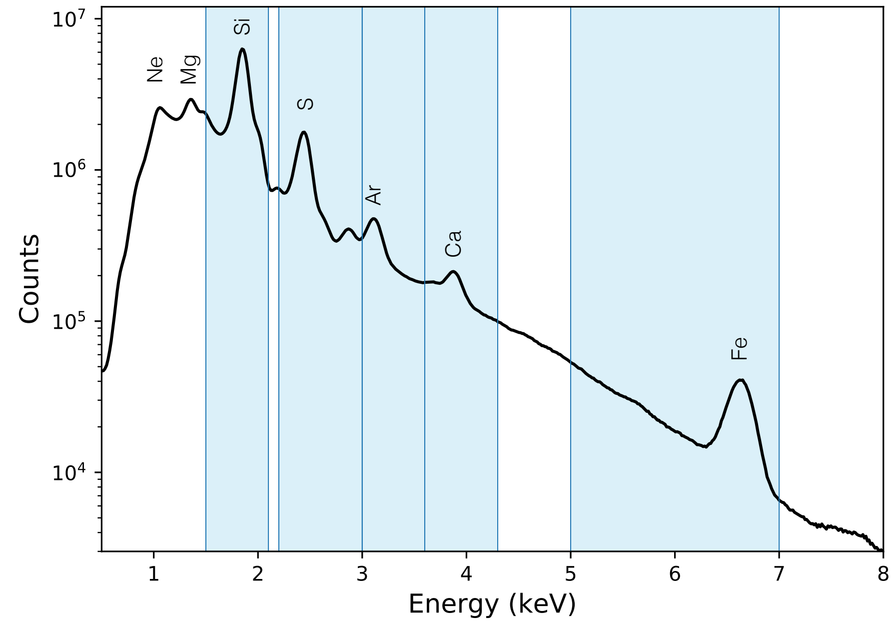
  standard methods (e.g. PALM, BCD) are not applicable

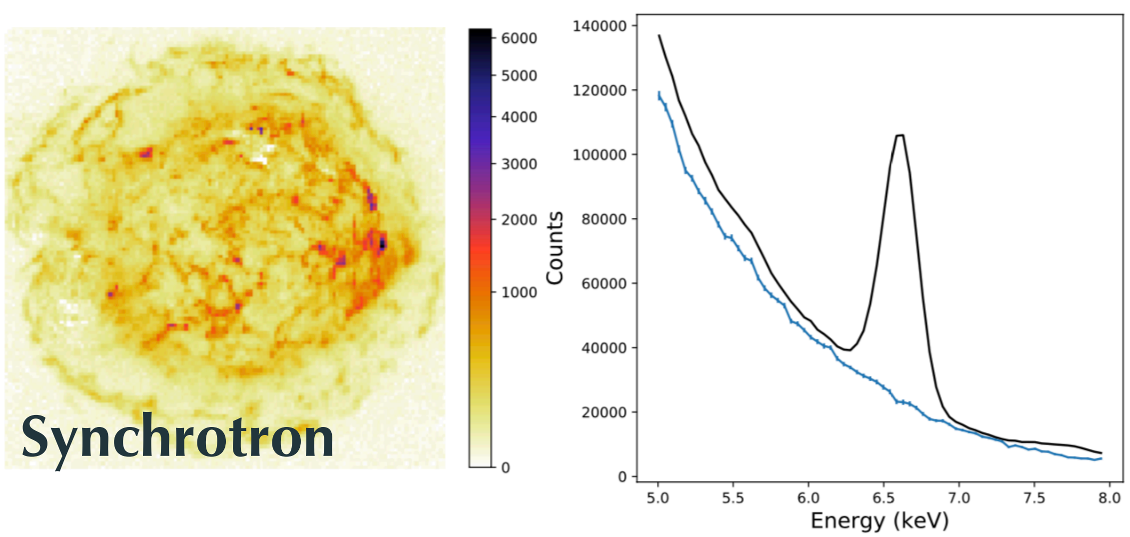
- The curvature of the data fidelity term soars at the vicinity of 0 $\propto 1 \oslash (\mathbf{AS} \odot \mathbf{AS})$

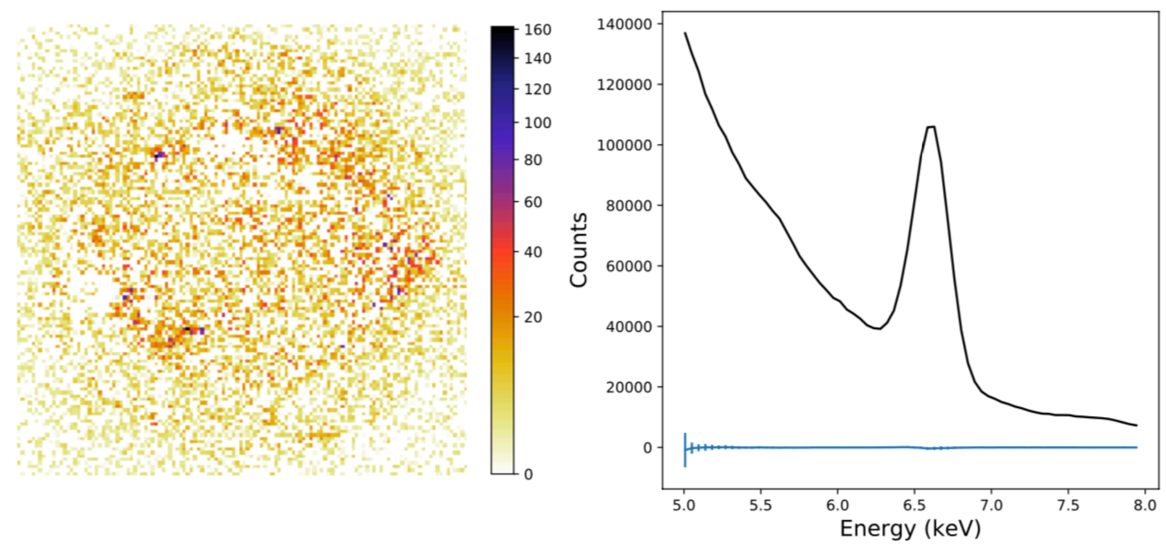
- How to choose the regularisation parameters $\mathbf{\Lambda}$?

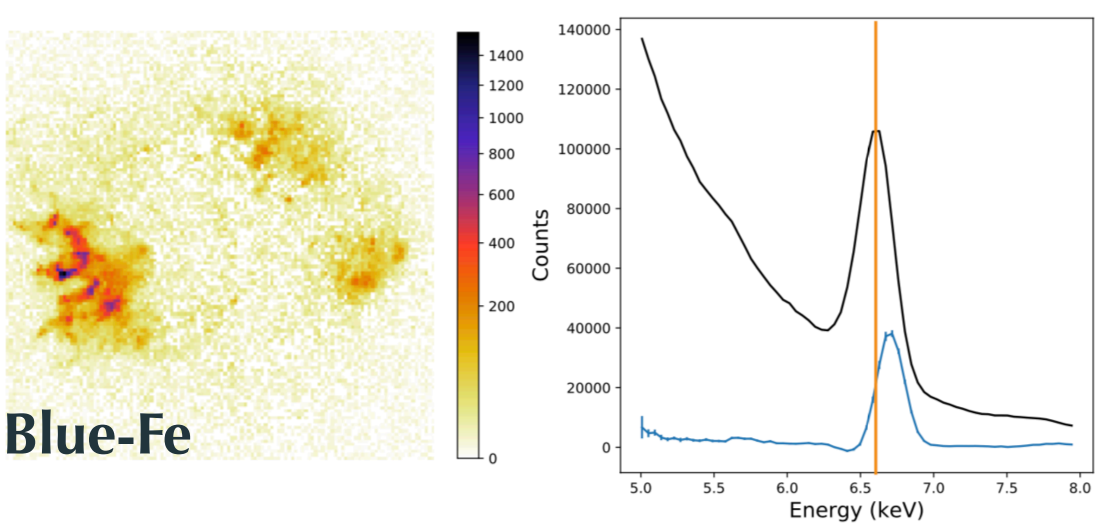
Sparse component analysis

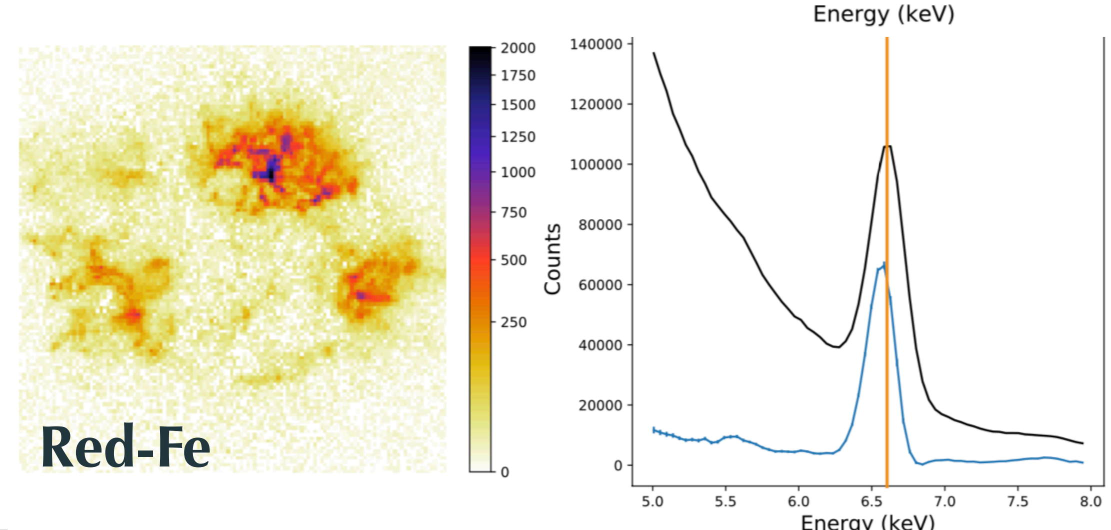




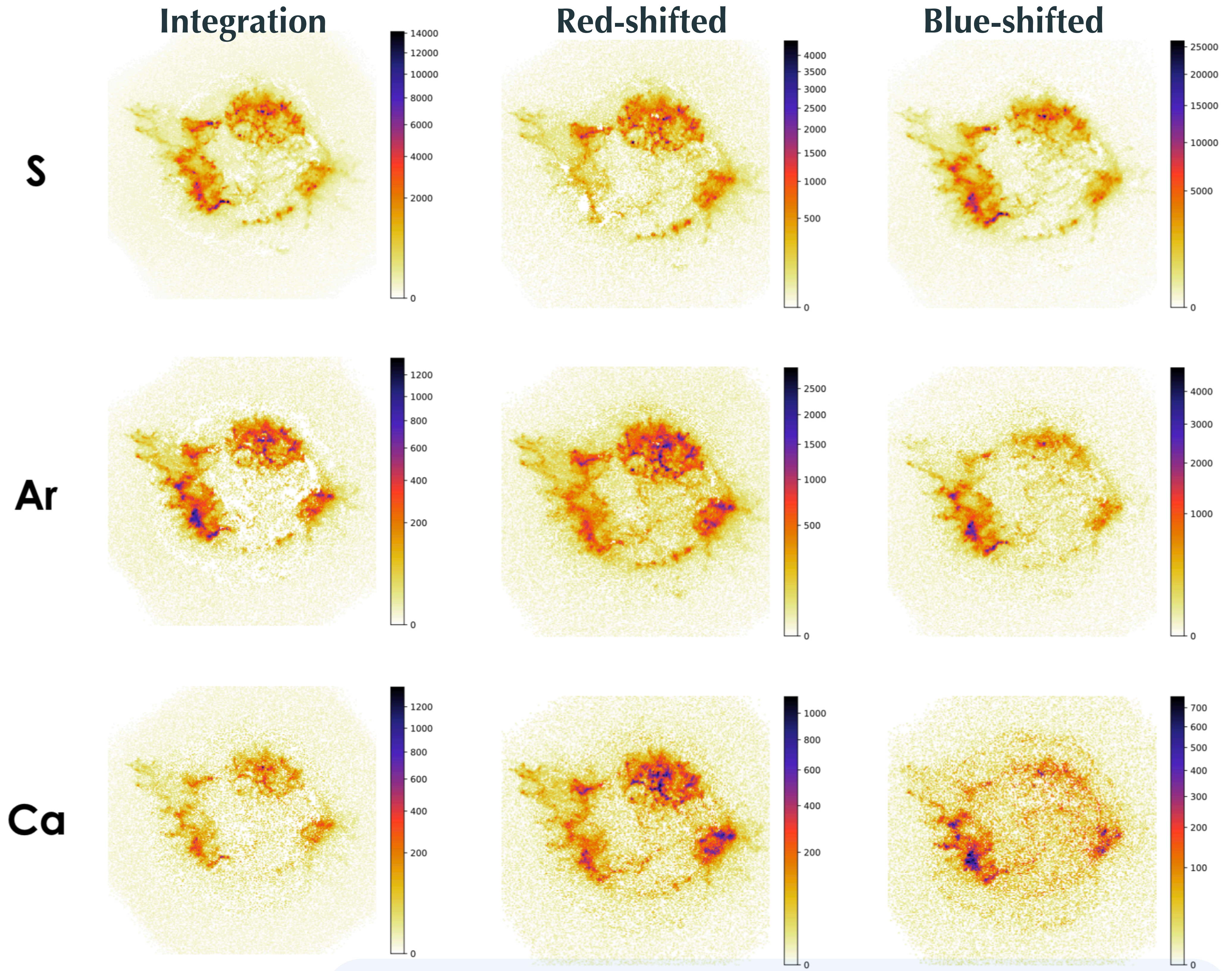








Sparse component analysis



Picquenot et al, 2020.

Blindly estimates red/blue-shifted atomic components !

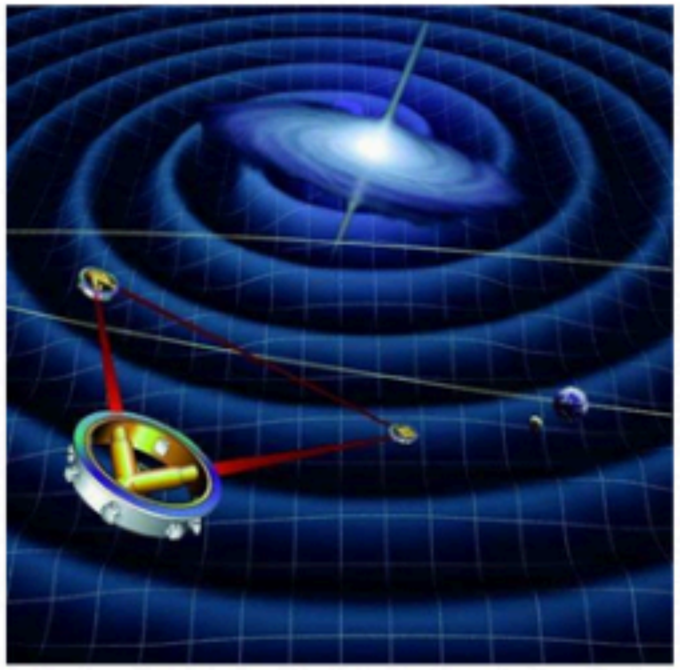
Chase of gravitational waves

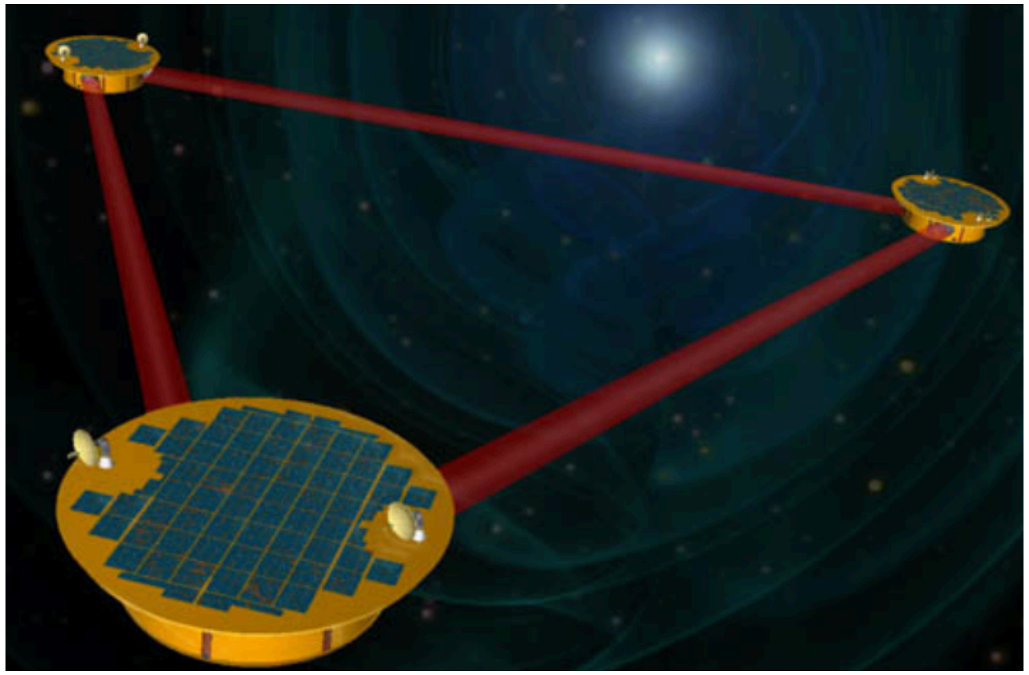
Ground-based: LIGO (US), VIRGO (EU)

Arms length limited to few kilometres

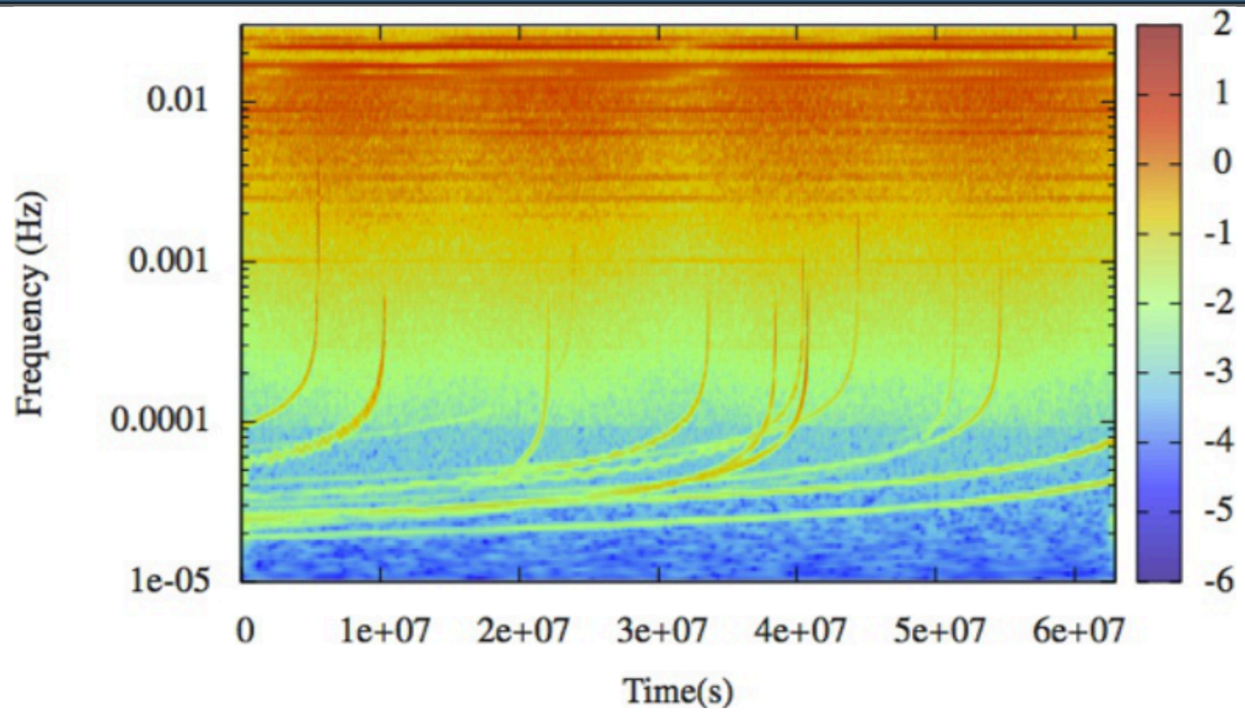
Need to go to space (up to 2.5 million km arms !)

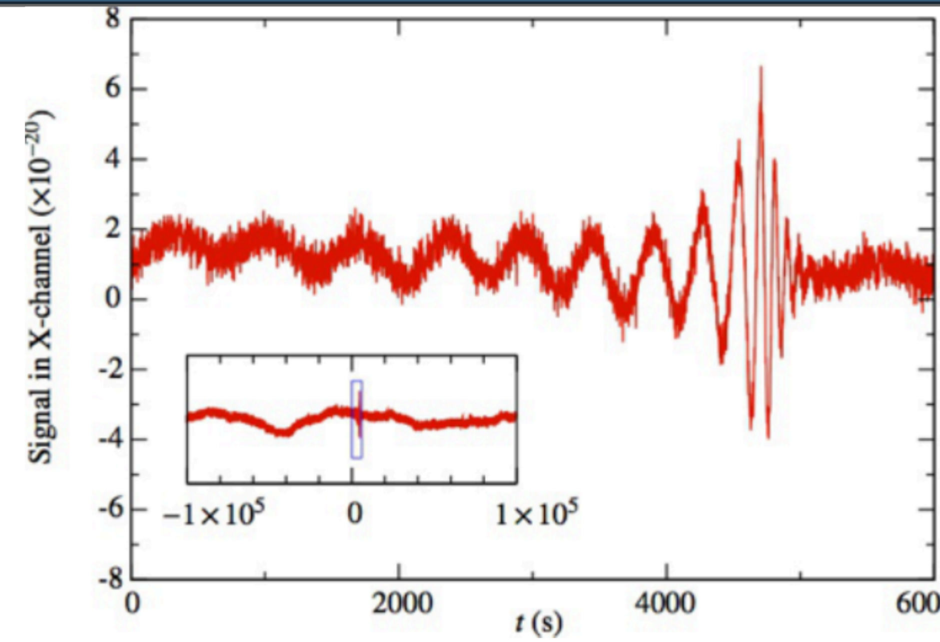
Higher sensitivity, GW at lower frequencies





Chase of gravitational waves

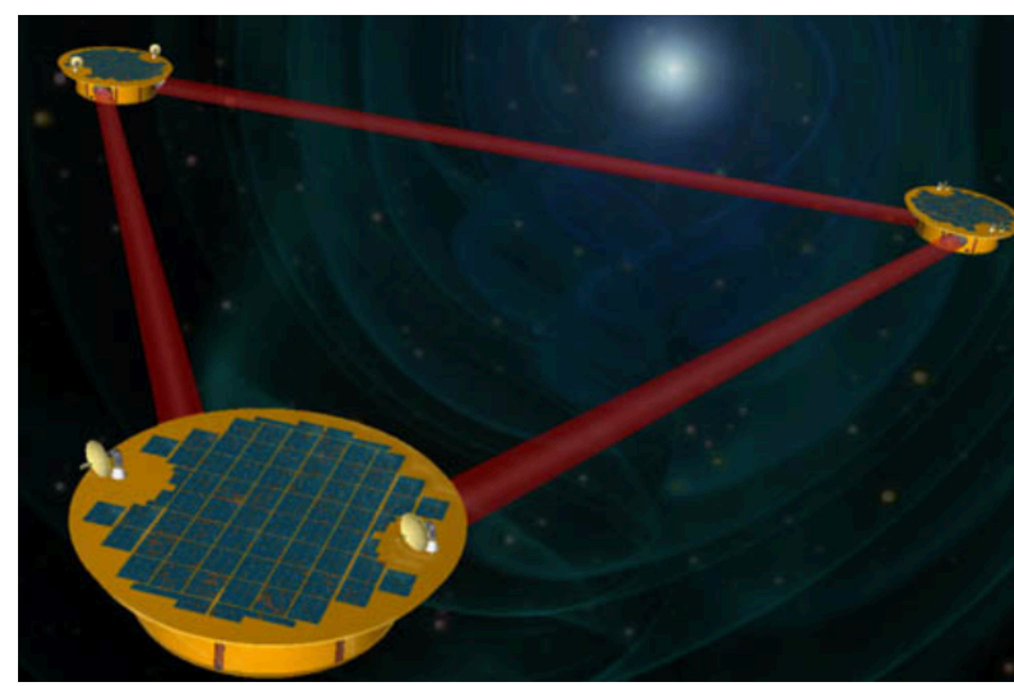




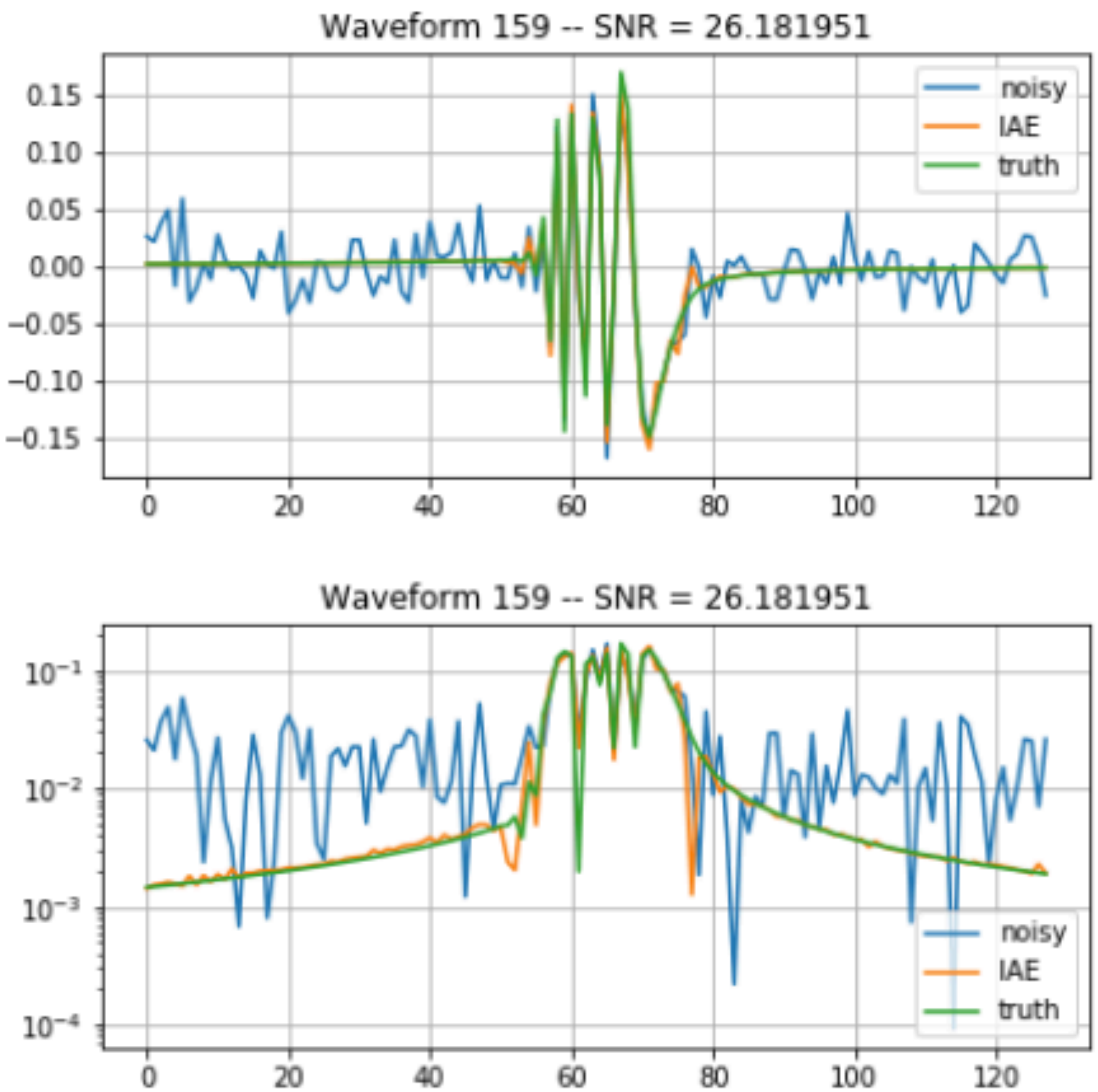
The measurements are composed of 3 time series

Superimposition of :

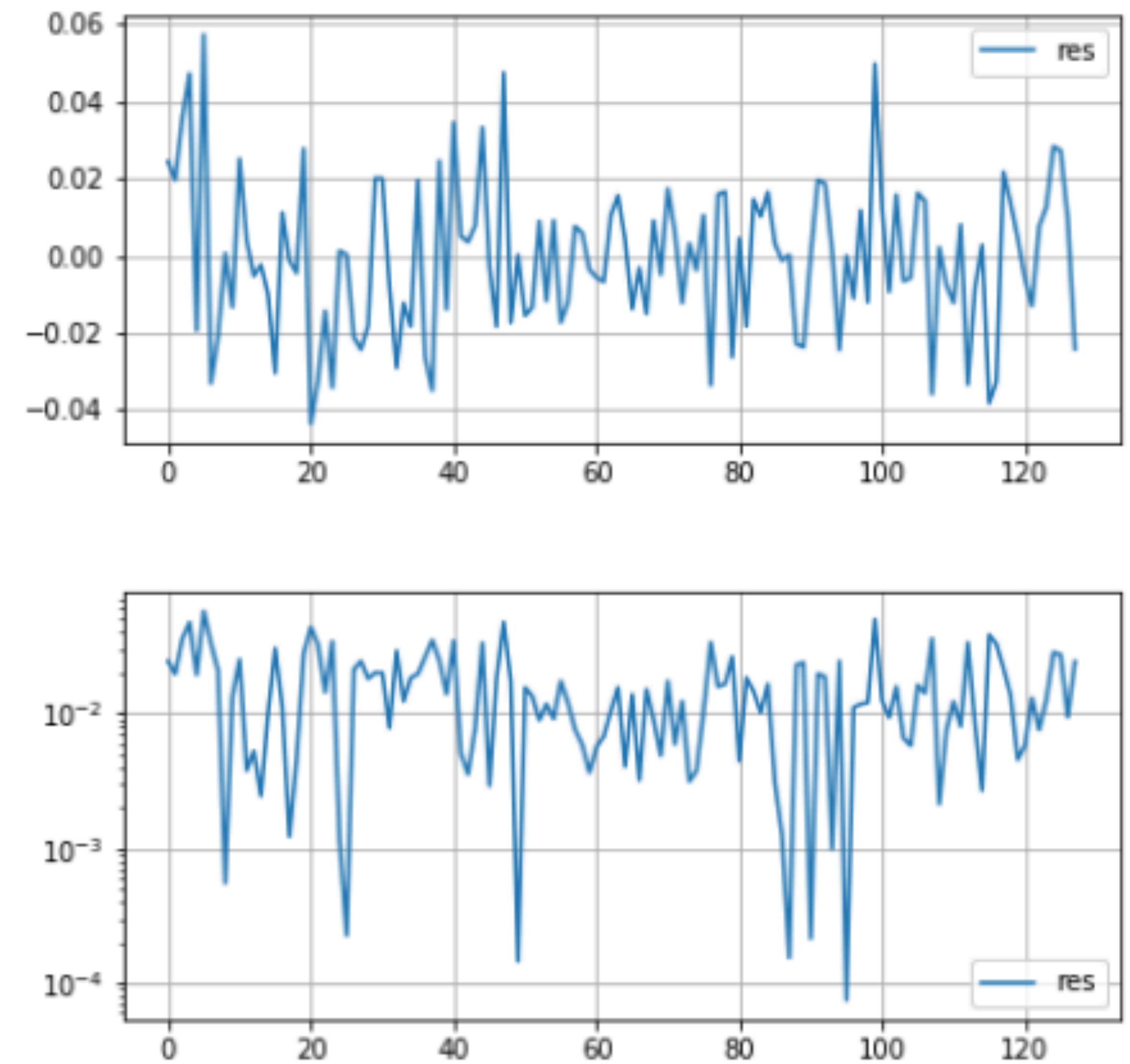
- > 1000000 Galactic binaries
- 10 to 100 SMBHB/year
- Thousands of Stellar Mass BHB
- Hundreds of Extreme Mass Ratio Inspirals



Most have never been observed



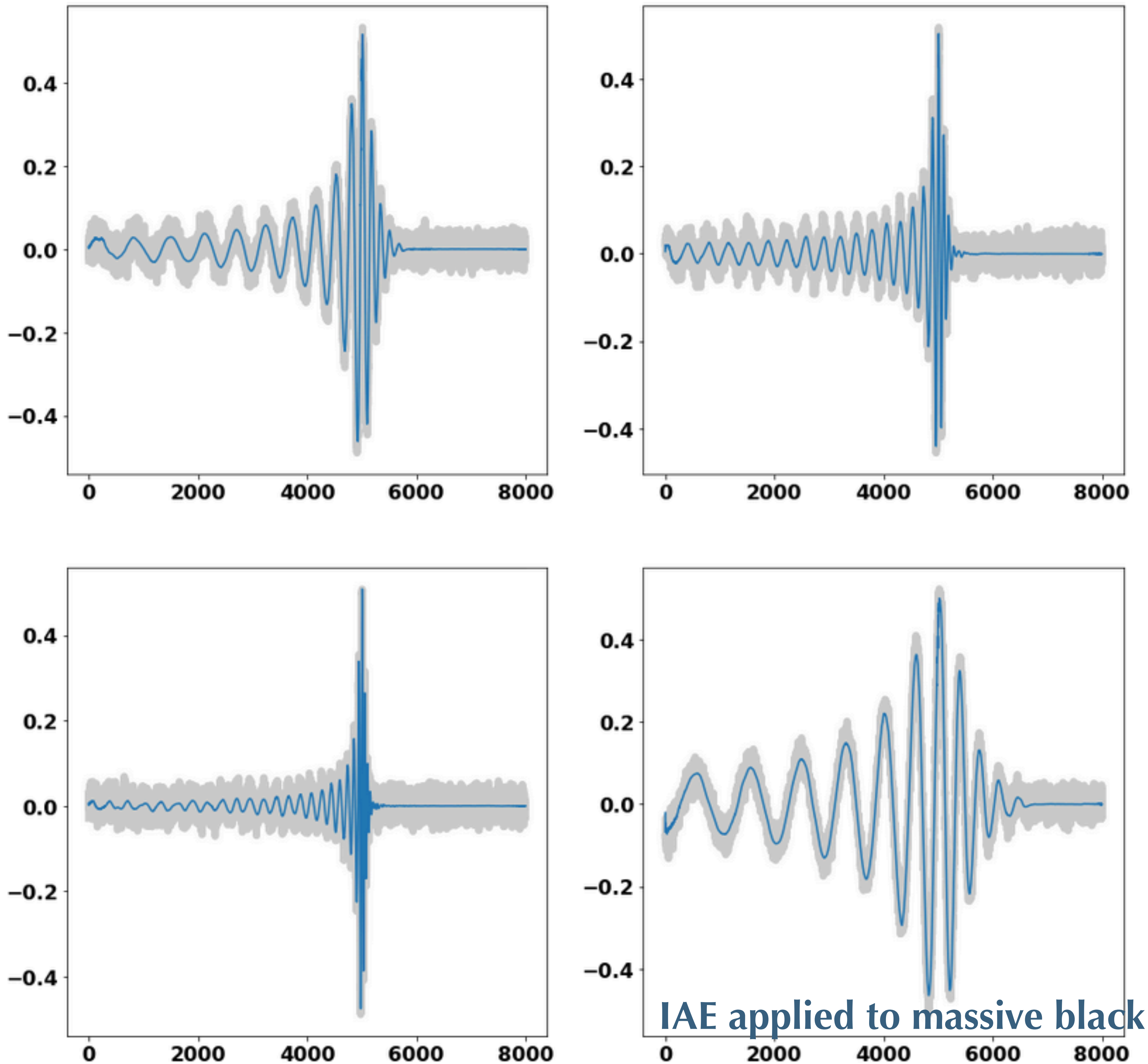
Recovered galactic binary



Residual

IAE applied to galactic binary recovery

Chase of gravitational waves



IAE applied to massive black hole merger recovery