Investigating the bias from foreground removal in intensity mapping surveys

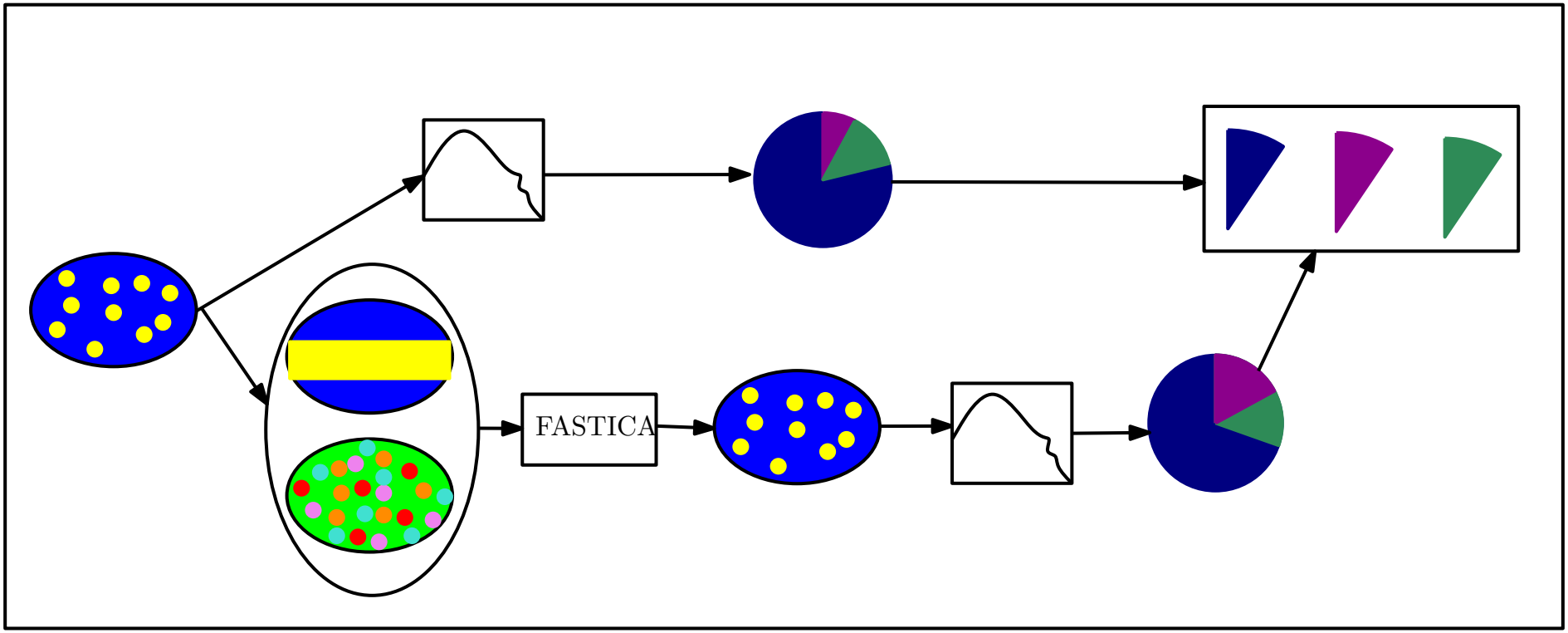
Laura Wolz[12]
Filipe B. Abdalla[1], Chris Blake[3], Richard Shaw[4], Emma Chapman[1]

[1] University College London, UK
[2] University of Oxford, UK
[3] Swinburne University of Technology, Australia
[4] Canadian Institute for Theoretical Astrophysics, Canada

23 November 2012

Overview

From galaxy catalogue to cosmological bias of foreground removal in intensity mapping surveys



Intensity Mapping: Survey Details

- Survey area 20,000 deg^2
- Pixel area is Gaussian beam with FWHM 0.3 deg
- Integration time per pointing is 77s
- Total survey time 6 month

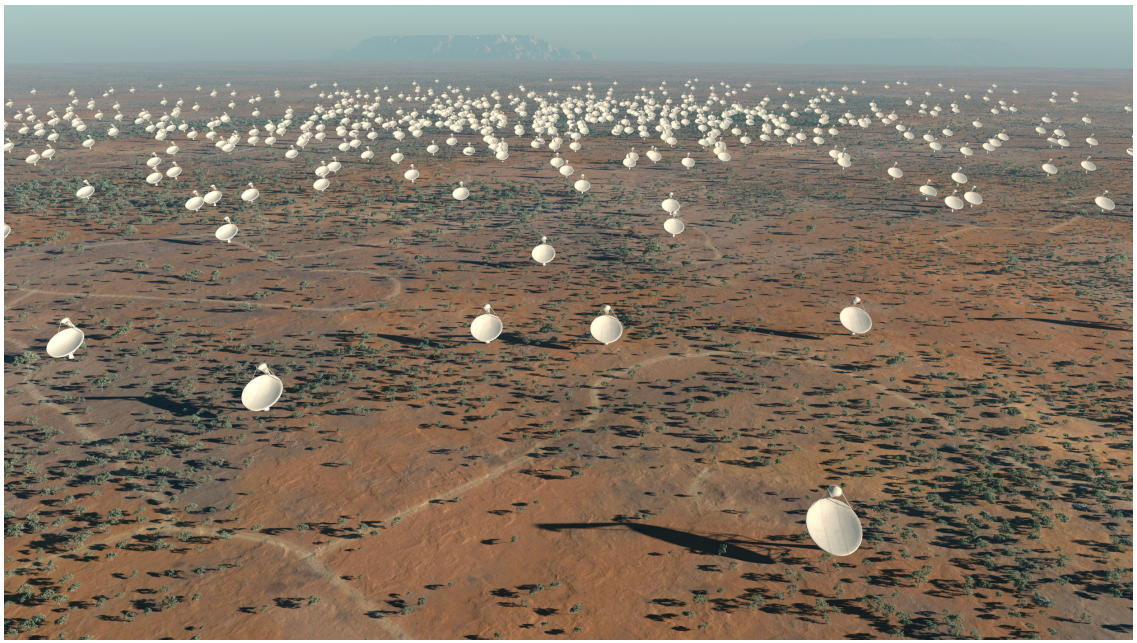


image credit: SKA Organisation/TDP/DRAO/Swinburne Astronomy

image credit: SKA Organisation/Swinburne Astronomy

Two cases:

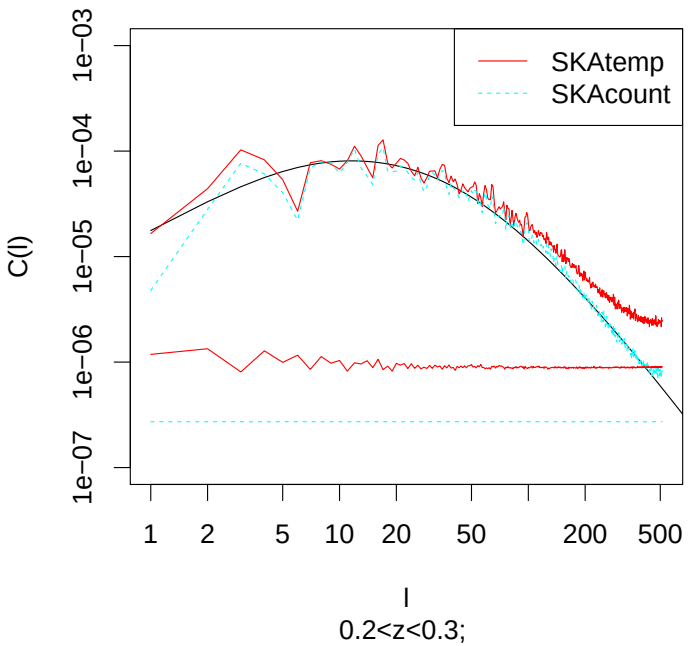
- Full SKA: $A_{\rm eff}/T_{\rm sys} = 10^4 m^2/K$
- 10 percent SKA

SKA Simulation Details

Power Spectrum Estimation

Density field expanded in spherical harmonics

$$\sigma(\theta,\phi) = \sum_{l=0}^{\infty} \sum_{m=-l}^{l} a_{lm} Y_{lm}(\theta,\phi)$$



Power spectrum is the variation of the density field;

$$C_l = \frac{1}{2l+1} \sum_{m=-l}^{l} |a_{lm}|^2$$

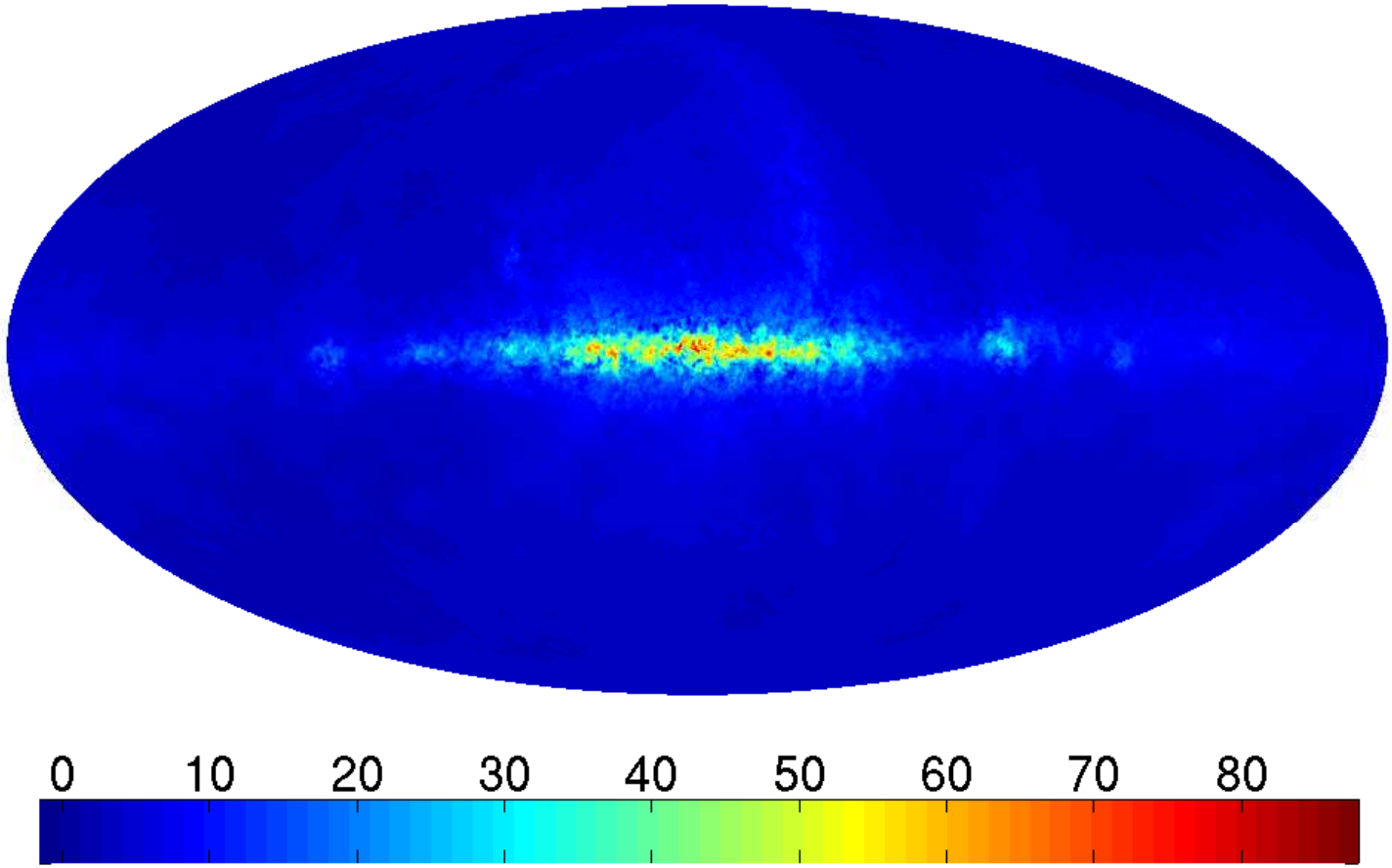
Peebles approximation for incomplete sky coverage;
Conversion from galaxy counts to temperatures;

$$T = \frac{3A_{12}hc^2}{32\pi m_{\mathrm{H}} k} \frac{M_{\mathrm{HI}}}{\chi^2(z)\Delta\nu\nu_{21}\Omega_{\mathrm{pix}}}$$

Foreground Simulation

- Global sky model by Oliveira-Costa et al (2008)
- Extended with with small scale variation

R. Shaw, in preparation

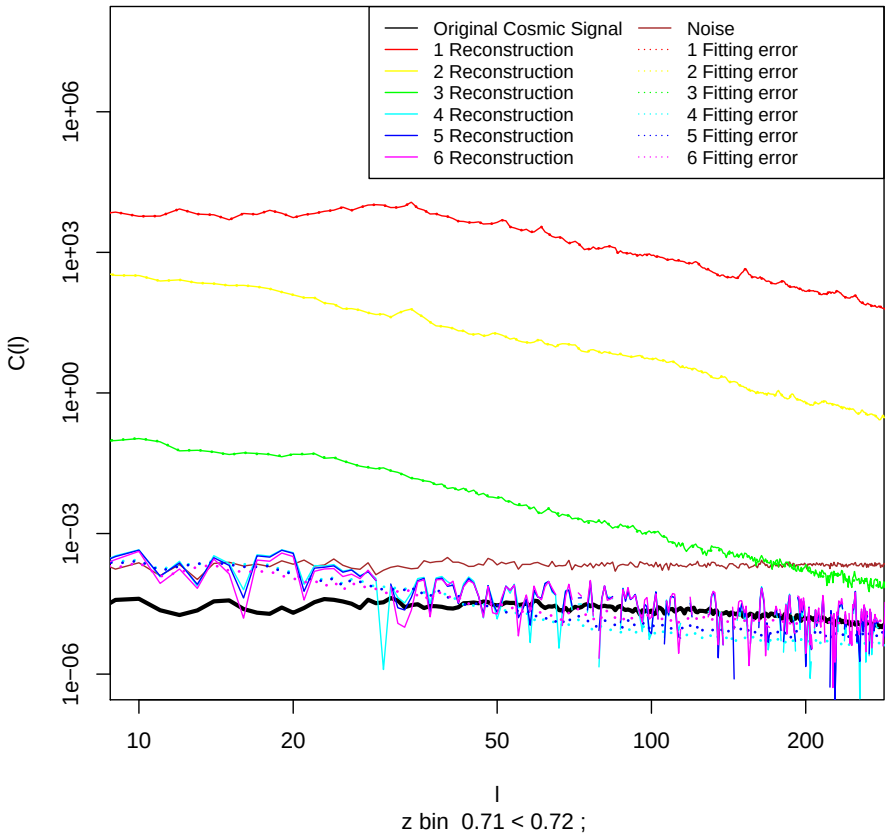


Foreground Removal 1: FASTICA

- **Independent component analysis** separates a multicomponent signal into subcomponents
- Independent components of analysis are constituents of the galactic foreground
- Residual of analysis are the reconstructed cosmological signal plus receiver noise
- Medium temperature of the cosmological signal is part of the IC since it is smooth in redshift

Foreground Removal 2: Results

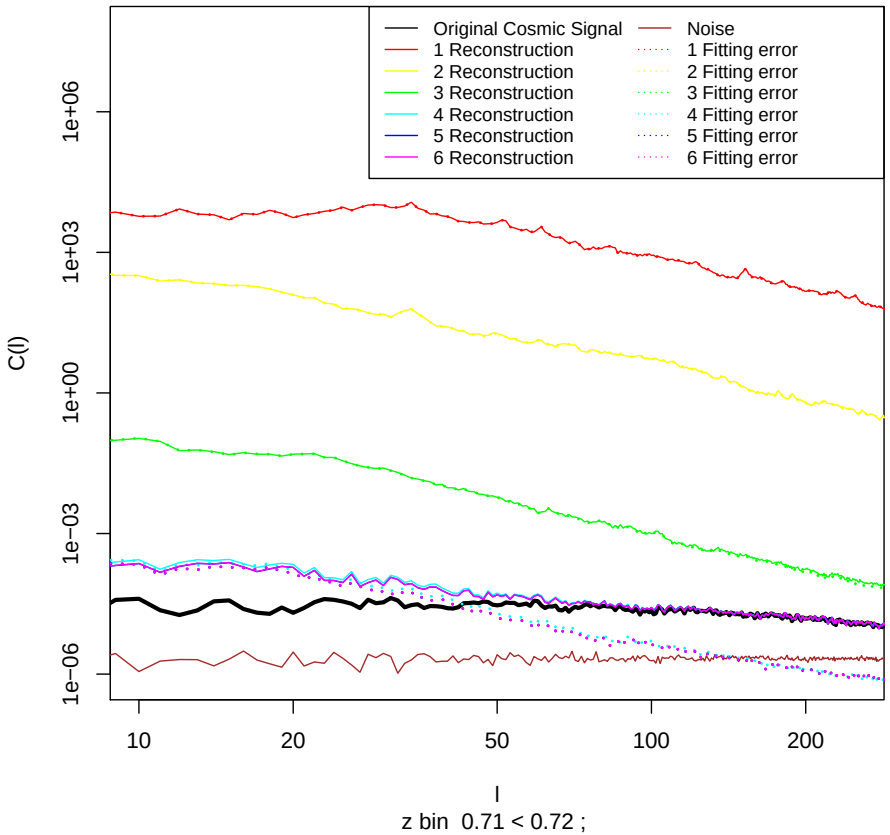
10% SKA



- Power spectrum estimation in spherical harmonics of original cosmological signal in comparison to reconstructed signal
- **Fitting error** via reconstructed signal minus original signal and noise

Foreground Removal 2: Results

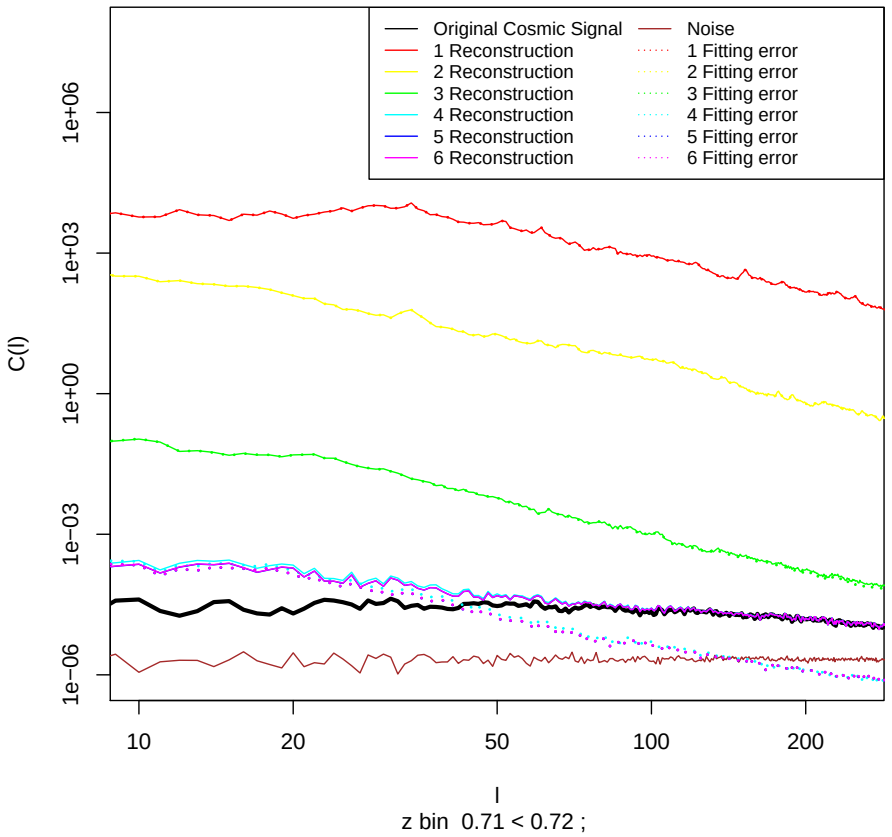
Full SKA



- Power spectrum estimation in spherical harmonics of original cosmological signal in comparison to reconstructed signal
- **Fitting error** via reconstructed signal minus original signal and noise

Foreground Removal 2: Results

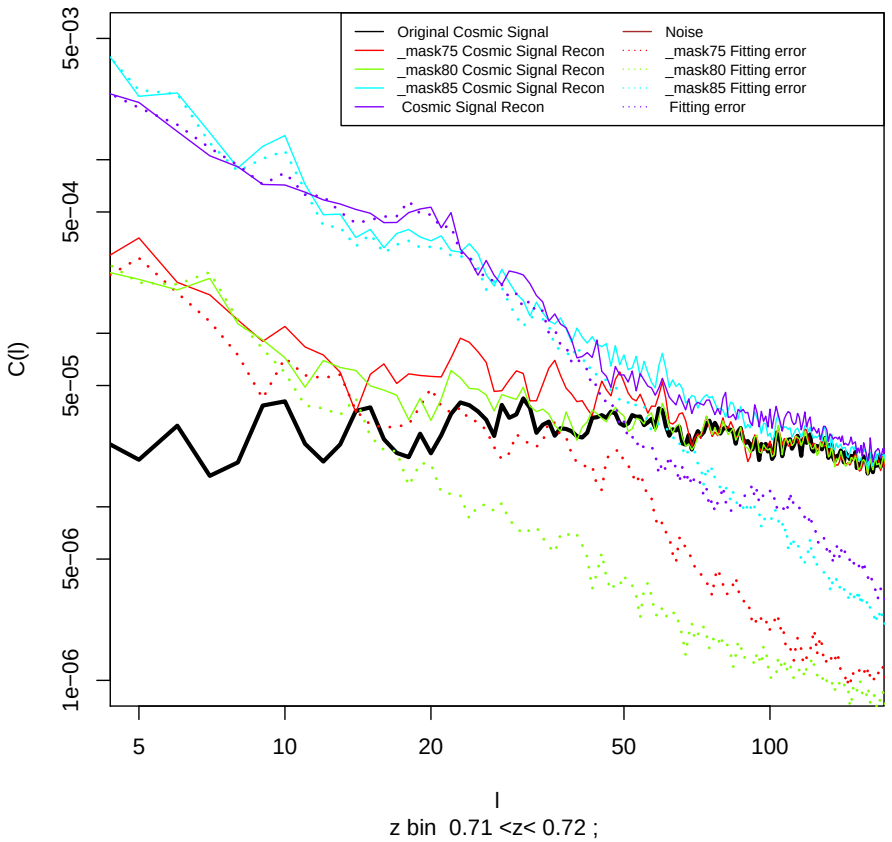
Full SKA



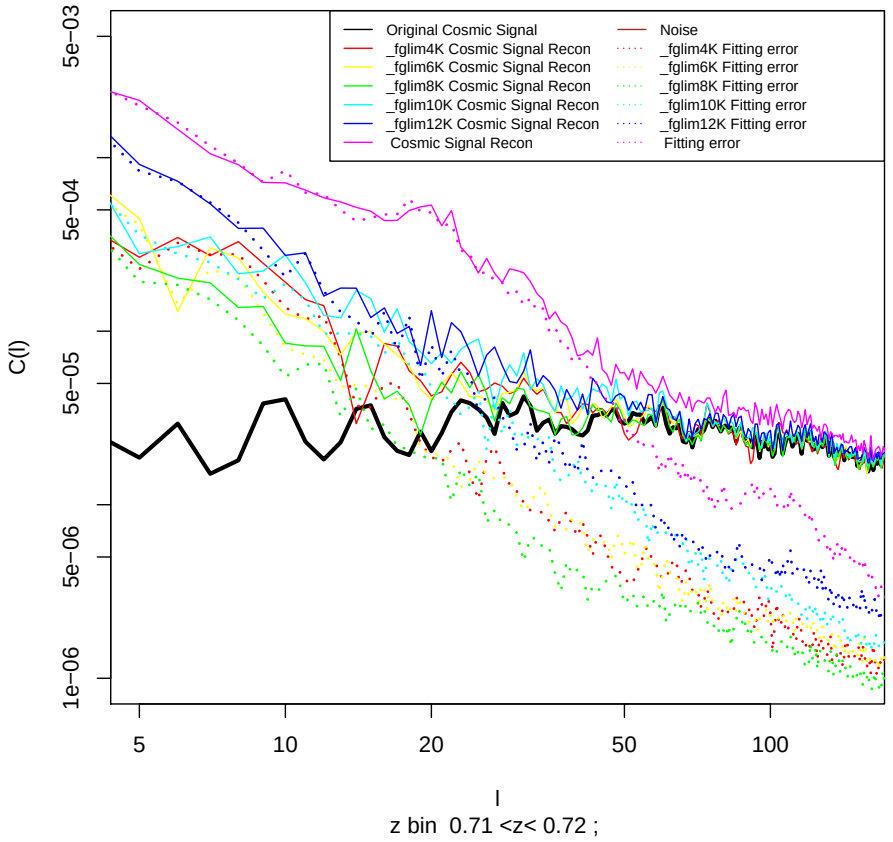
- Power spectrum estimation in spherical harmonics of original cosmological signal in comparison to reconstructed signal
- **Fitting error** via reconstructed signal minus original signal and noise
- 4-6 independent components analysis works very well on small scales
  $\rightarrow$ 4 Independent components
  $\rightarrow$ optimal masking to improve performance on large scales

Optimal Masking

Constant cut in the latitude of the galactic plane θ =5deg, 10deg and 15deg

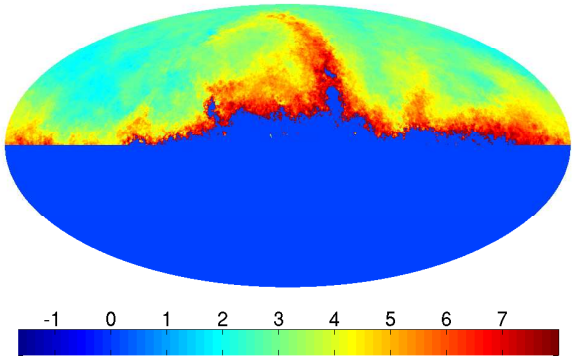


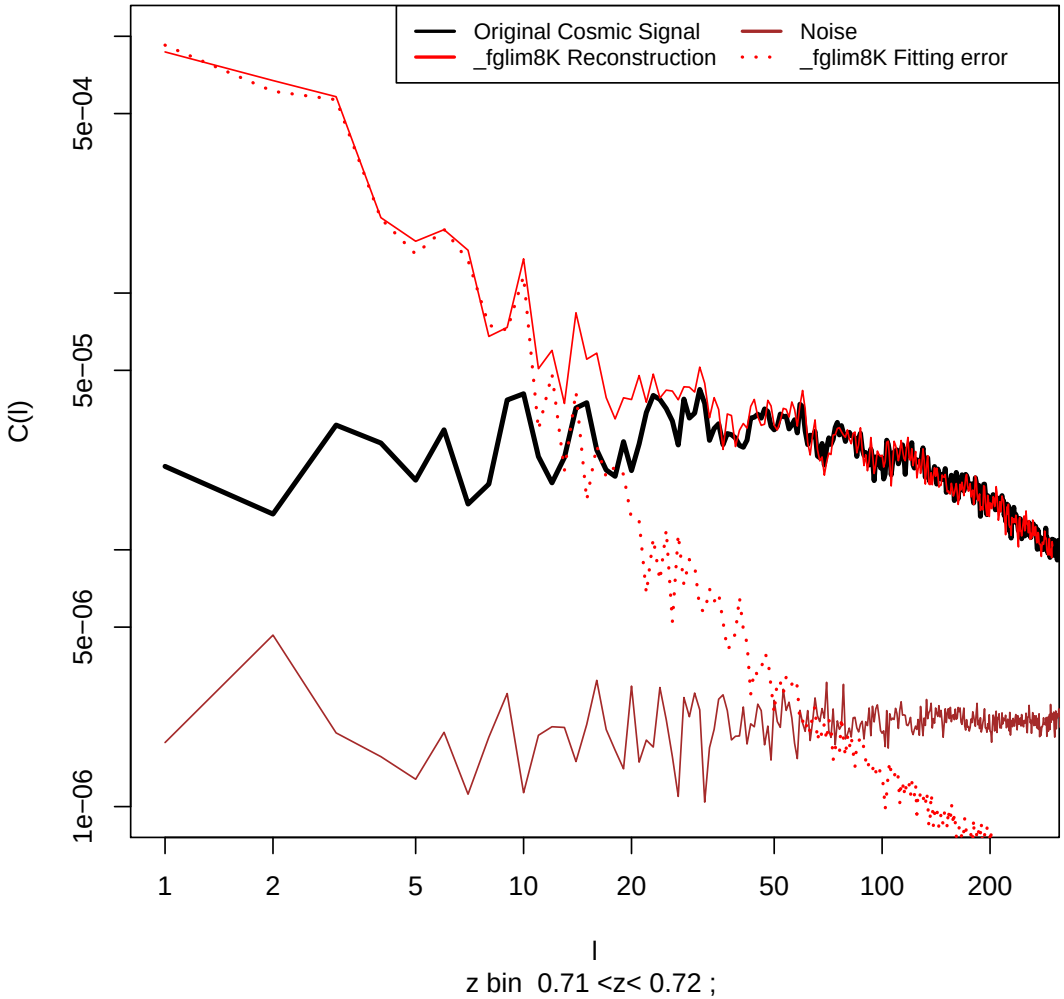
Cut in the temperature of the galactic foreground emission T=4K, 6K, 8K, 10K and 12K



Result

Foreground removal with
4 independent components in FASTICA
optimal mask with foreground temperature cut-off 8K





Conclusions

- On scales $l > 20$ the cosmological signal is recovered very well
- For small scales $l < 20$ the reconstruction is contaminated

Future Work:

- Covariance matrix for parameter estimation with lognormal realisations
- Parameter estimation via MCMCs
- Bias on cosmological parameter