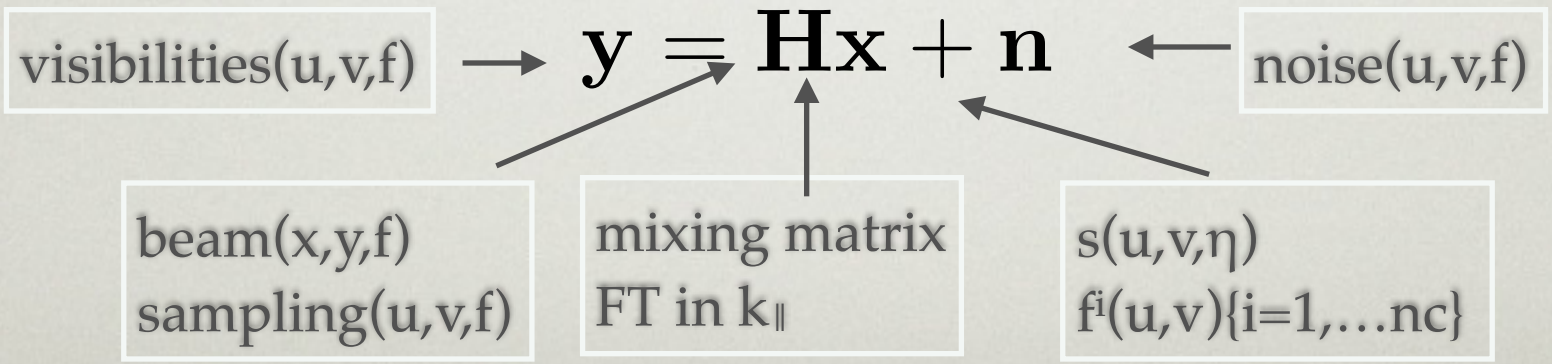
HIEMICA

- HI Expectation-Maximization Independent Component Analysis
- Extension of the Independent Component Analysis (ICA) from 2D CMB maps to 3D 21-cm signal
- Bayesian inference of power spectra and maps and separates foregrounds from signal based on the diversity of their power spectra

Measurement equation:



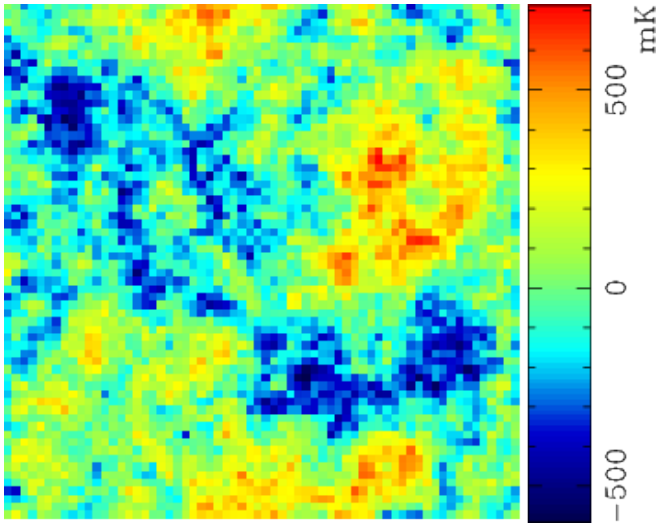
$$Q(\boldsymbol{\theta}|\boldsymbol{\theta}^n) = \mathrm{E}\left[\log p(\mathbf{y},\mathbf{x}|\boldsymbol{\theta})|\mathbf{y},\boldsymbol{\theta}^n\right]$$
$$= \int \log p(\mathbf{y},\mathbf{x}|\boldsymbol{\theta}) p(\mathbf{x}|\mathbf{y},\boldsymbol{\theta}^n) d\mathbf{x}$$

$$Q(\boldsymbol{\theta}|\boldsymbol{\theta}^n) = cst. - \log|\mathbf{N}| - \log|\mathbf{C}| + \mathrm{Tr}\left[\mathbf{C}^{-1}\widehat{\mathbf{R}}_{xx}^{\dagger}\right]$$
$$-\mathrm{Tr}\left[\mathbf{N}^{-1}\left(\widehat{\mathbf{R}}_{\mathbf{yy}} - \mathbf{H}\widehat{\mathbf{R}}_{\mathbf{yx}}^{\dagger} - \widehat{\mathbf{R}}_{\mathbf{yx}}\mathbf{H}^{\dagger} + \mathbf{H}\widehat{\mathbf{R}}_{\mathbf{xx}}\mathbf{H}\right)\right]$$

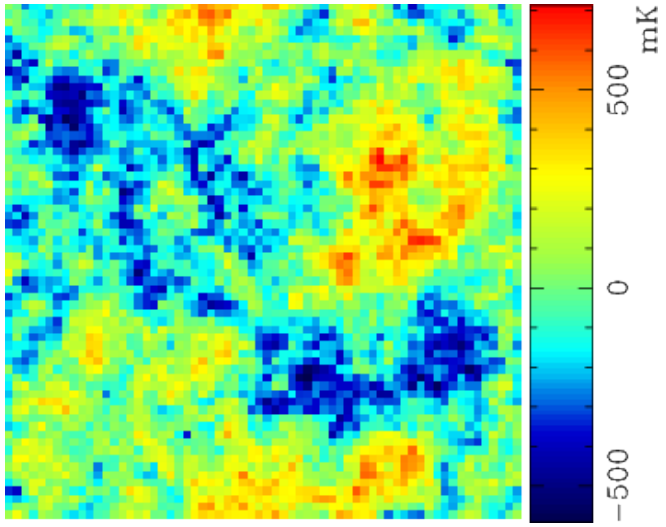
where

$$\widehat{\mathbf{R}}_{\mathbf{yy}} = \mathbf{y}\mathbf{y}^{\dagger} \quad (27)$$
$$\widehat{\mathbf{R}}_{\mathbf{yx}} = \mathbf{y}\mathbf{x}_{\mathbf{wf}}^{\dagger} \quad (28)$$
$$\widehat{\mathbf{R}}_{\mathbf{xx}} = \boldsymbol{\Sigma} + \mathbf{x}_{\mathbf{wf}}\mathbf{x}_{\mathbf{wf}}^{\dagger} \quad (29)$$

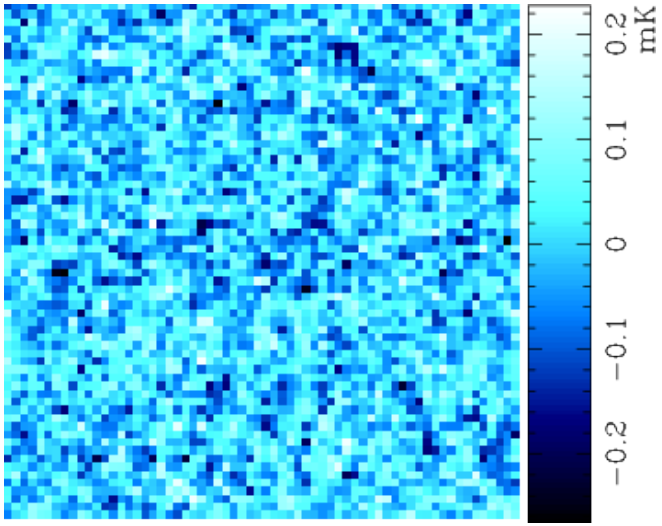
In order to obtain the parameter $\theta^{n+1} = M^{n+1}, C^{n+1}$ at the iteration n+1, we solve the gradient equation with respect to M and C to maximize the functional Q



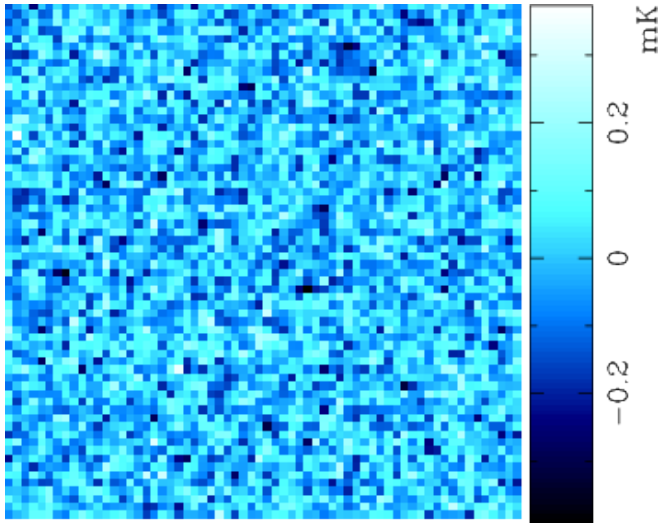
(a) Input total foregrounds



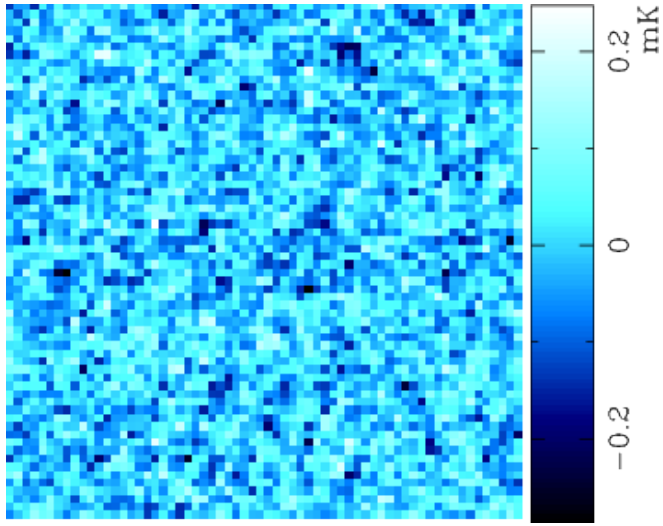
(b) Recovered total foregrounds



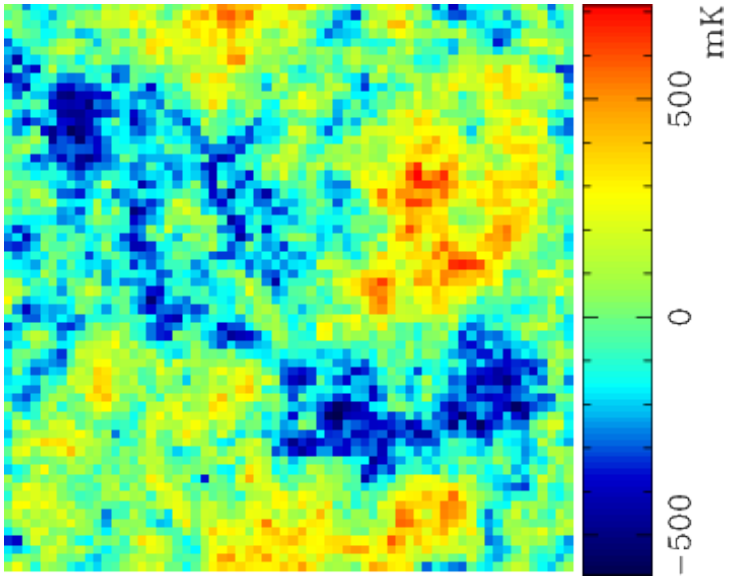
(c) Input 21-cm signal



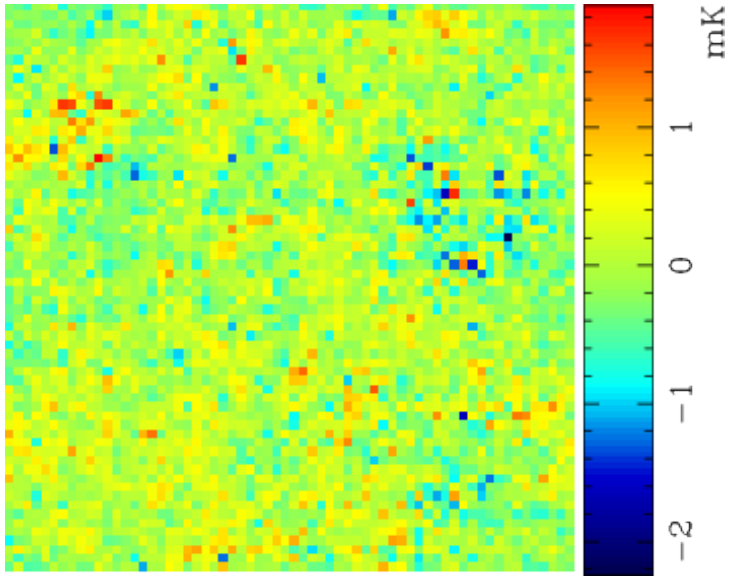
(d) Recovered 21-cm signal (S/N=1)



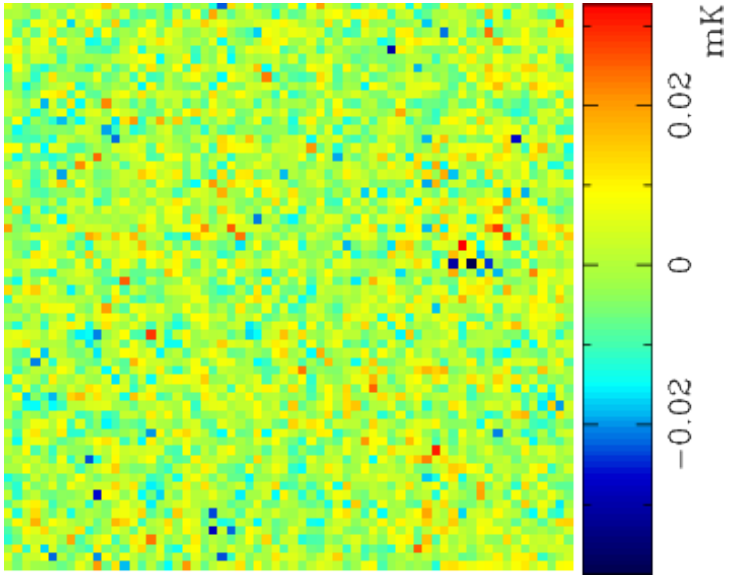
(e) Recovered 21-cm signal (S/N=5)



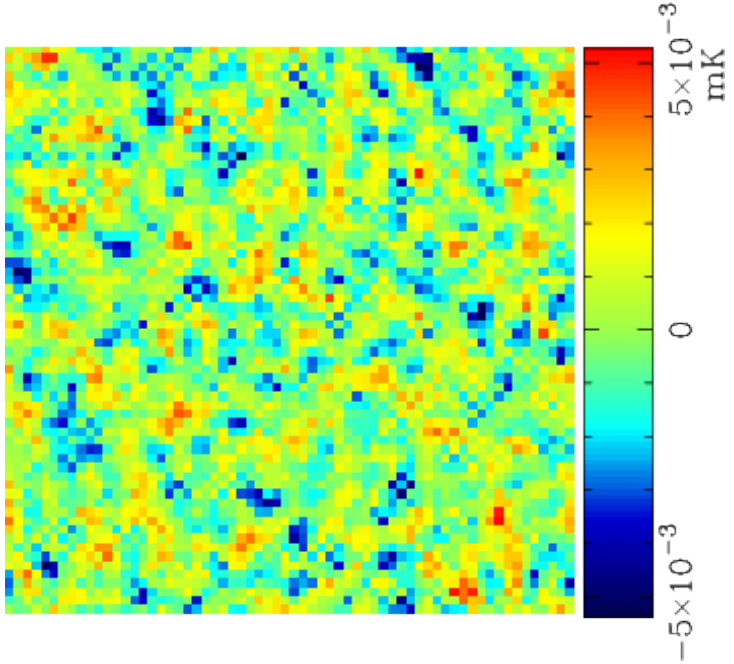
(a) The first foreground component



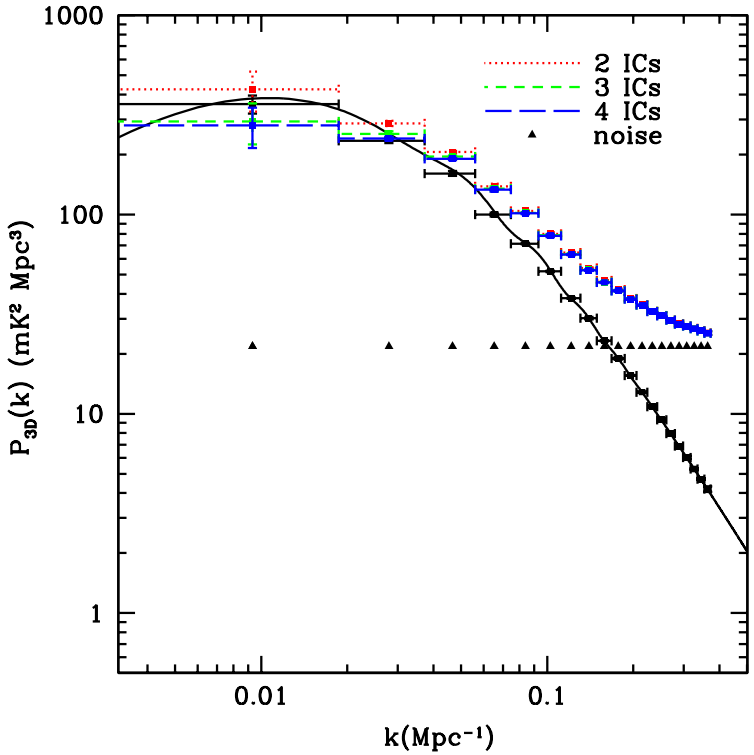
(b) The second foreground component



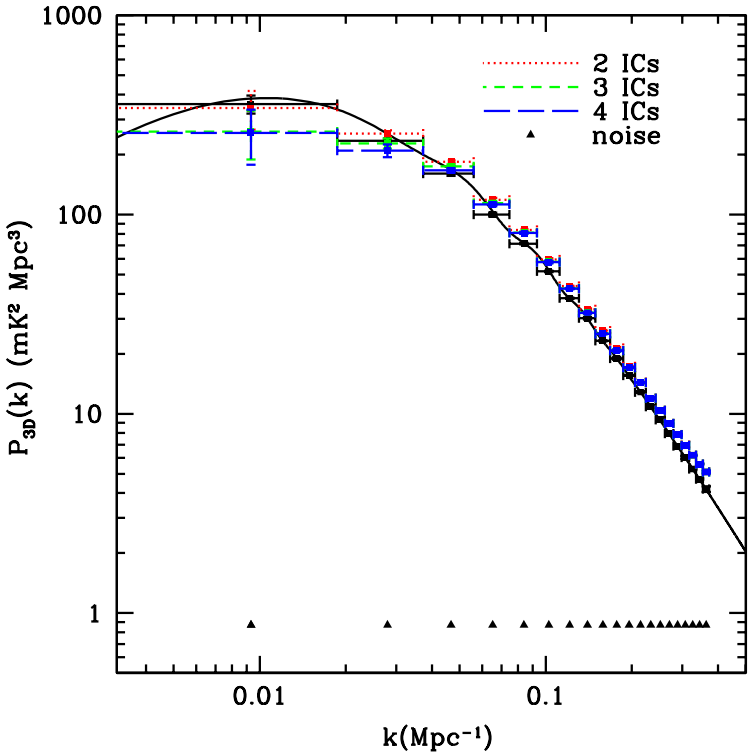
(c) The third foreground component



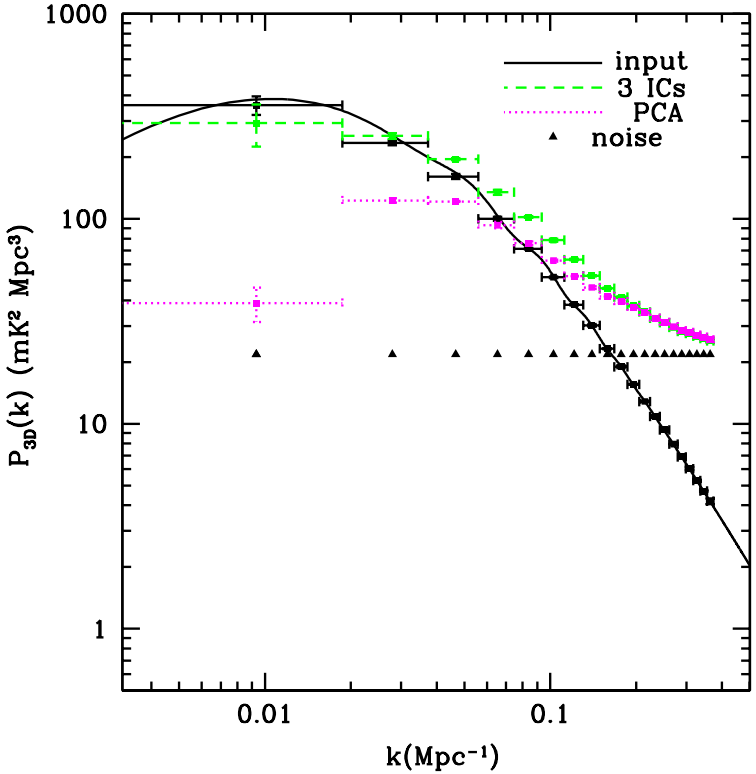
(d) The fourth foreground component

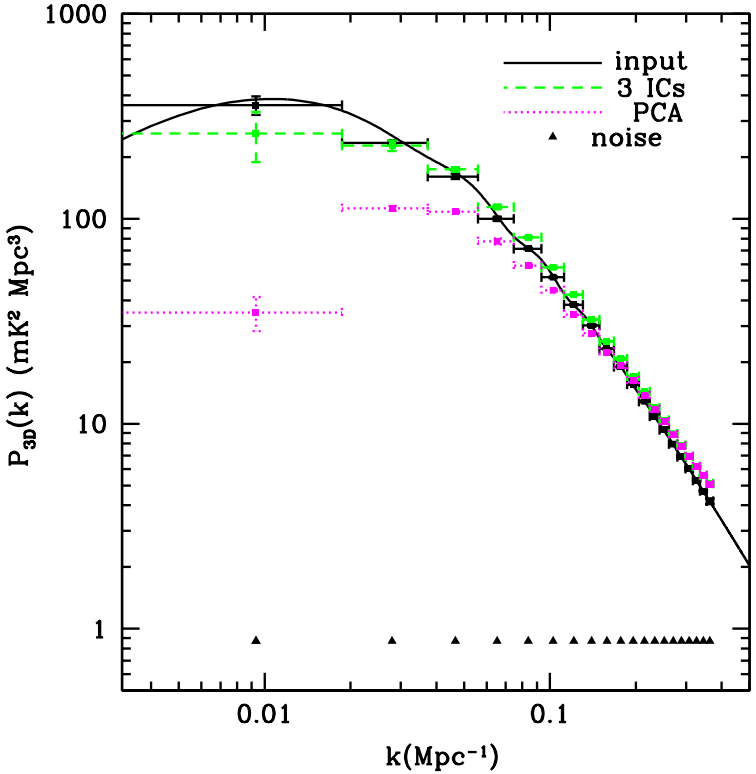

2 ICs
3 ICs
4 ICs
noise
1000
100
10
1
0.01
0.1
k(Mpc⁻¹)
P3D(k) (mK² Mpc³)

(a) S/N=1


2 ICs
3 ICs
4 ICs
noise
1000
100
10
1
0.01
0.1
k(Mpc⁻¹)
P3D(k) (mK² Mpc³)

(b) S/N=5


input
3 ICs
PCA
noise
1000
100
10
1
0.01
0.1
k(Mpc⁻¹)
P3D(k) (mK² Mpc³)


input
3 ICs
PCA
noise
1000
100
10
1
0.01
0.1
k(Mpc⁻¹)
P3D(k) (mK² Mpc³)