Extracting SZ signals in multi-component sky emission

Jacques Delabrouille
Laboratoire APC, Paris, France

In collaboration with J.-B. Melin, M. Remazeilles, M. Roman

Outline

- Introduction
- Multi-component sky emission models
- Component separation
  - Planck SZ challenges
  - ILC, MF and MMF
- ILC biases
- Improving cluster counts
- Conclusion

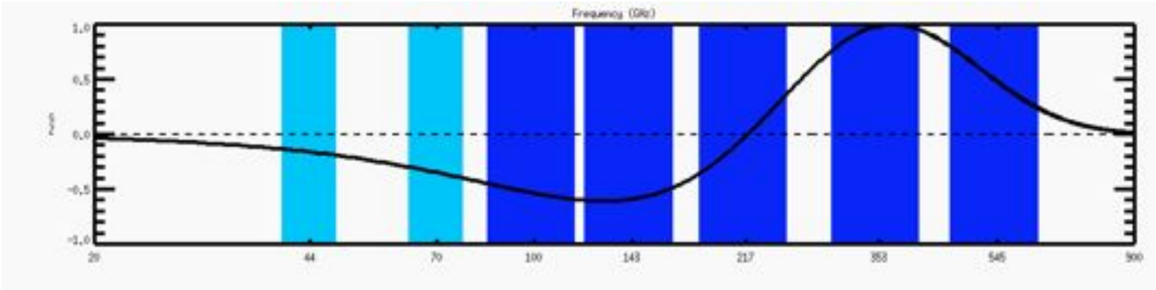
The multi-component sky

- Cosmic microwave background
  - Known emission law
  - Known spectrum (or nearly so)
  - Gaussian (or nearly so)

- Large scale structures
  - Dark matter haloes and filaments
  - Populated by galaxies (radio, infrared) and ***clusters of galaxies***
  - Generates SZ effects
  - Generates lensing and ISW effect
  - Far infrared background from numerous distant unresolved sources

- Galactic Interstellar medium
  - Highly complex
  - Synchrotron from hot gas, Free-free from warm gas, thermal emission from cold dust, molecular lines, spinning dust…

SZ signals



- Thermal SZ
  - Known emission law
  - But relativistic corrections
  - Good guess about profile (parametric model)
  - Contamination of clusters by radio and infrared sources

- Kinetic SZ
  - Known emission law (but that of the CMB!)
  - Very faint

- Both effects originate primarily from galaxy clusters
  - But look for filaments
  - Patchy reionisation may generate detectable kSZ

SZ information

- Number counts $dN/dMdV$
  - Growth of structures
  - Spectrum $P(k)$
- Number counts $dN/dMdz(d\Omega)$
  - Geometry $D_A(z)$, $H(z)$
- Cosmological tests
  - Velocity flows
  - Correlations (SZ, ISW, lensing…)
  - Power spectrum of thermal and kinetic SZ
- Angular vs. physical size
- Gas fraction M_g/M_{tot}
- Cluster physics

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Simulations

- Accurate and consistent simulations are needed
  - Of the SZ emission itself
  - Of all other components

- They are critical for developing, testing, understanding methods for the extraction of SZ information, and validating data pipelines.

- The Planck Sky Model (PSM)
  - Originally started for preparing Planck data analysis
  - Multi-component sky emission model
  - Consistency between the components
  - Based on interpretation of existing data
  - Prediction and simulation of sky emission (data/theory driven)
  - Contributions and suggestions welcome

- Web site
  - http://www.apc.univ-paris7.fr/~delabrou/PSM/psm.html

The PSM

- Developed originally as part of Planck WG2 – collective work !

- About 10 main developers, many more contributors provided inputs
  - Templates (e.g. non gaussian CMB from F. Elsner & B. Wandelt)
  - Point source catalogues (e.g. IRAS sources from D. Clements)
  - Small pieces of code (e.g. free-free spectrum from C. Dickinson)
  - Suggestions & bug reports

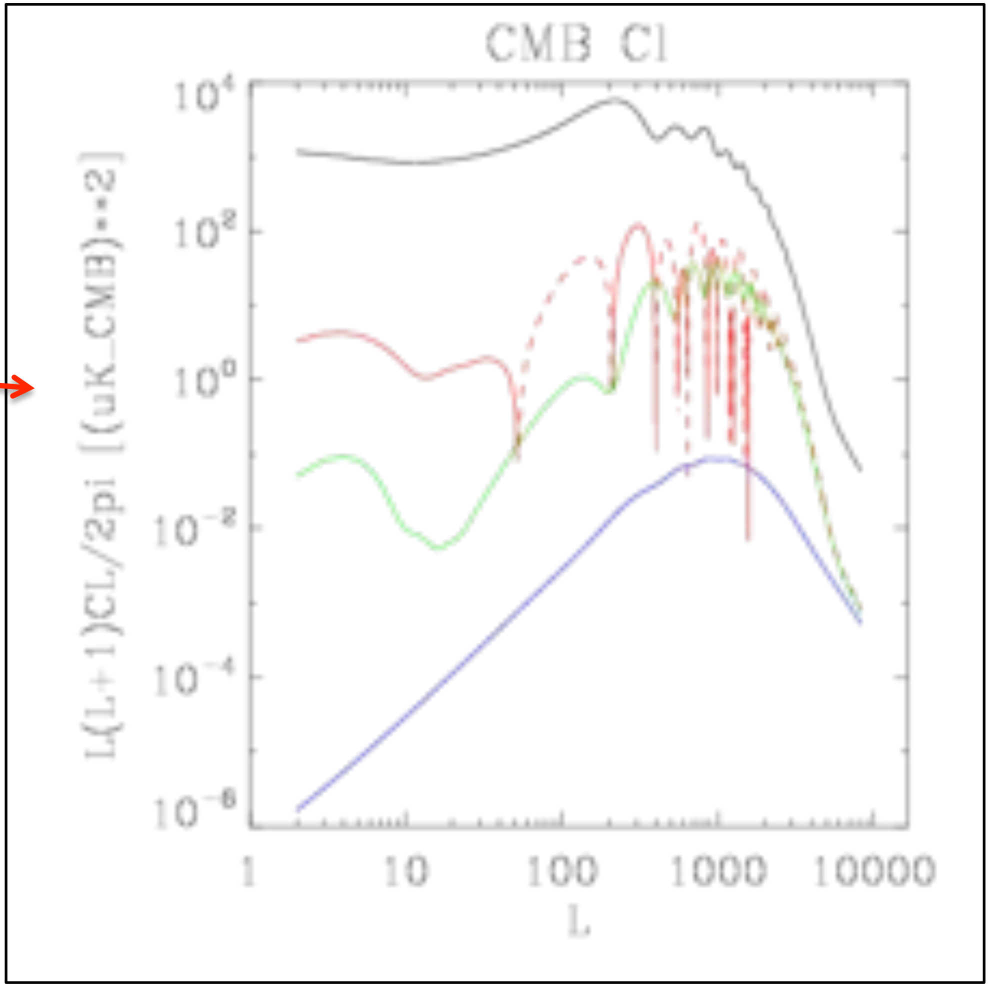
- Currently 6 main elements to the code
  - General architecture (scientific and software)
  - CMB models
  - The galaxy (Marc-Antoine Miville Deschênes)
  - SZ effects (Jean-Baptiste Melin)
  - Point sources including FIRB (Joaquin Gonzalez-Nuevo)
  - Observation with mock instruments

CMB models in the PSM

- Gaussian models
  - Use C_l from current best fit model

    or

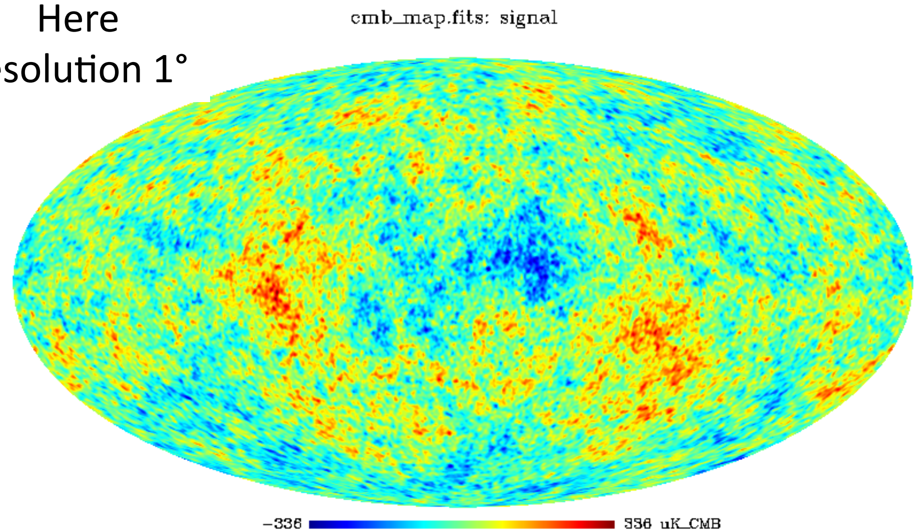
  - use C_l from CAMB (cosmological parameters set by the PSM user)



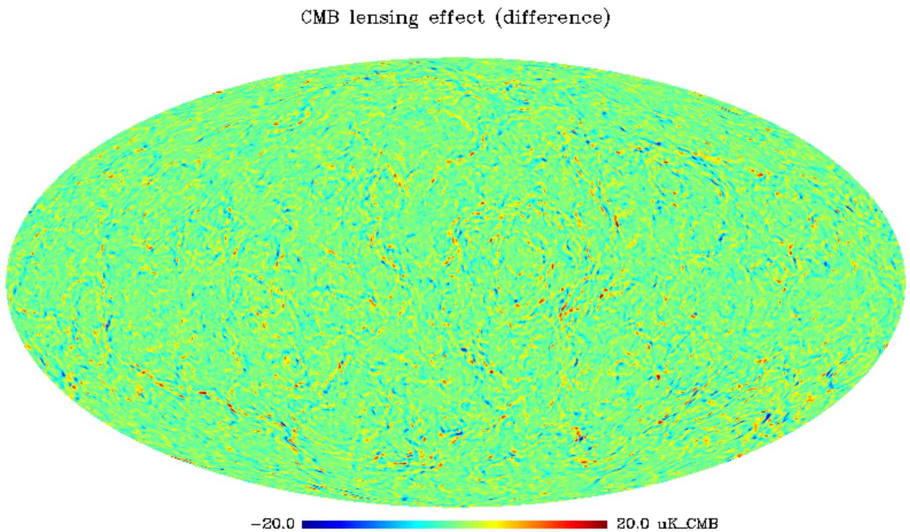
CMB models in the PSM

- Lensed CMB
  - Gaussian approximation (lensed spectra)
  - Or Lensing of CMB map

Here resolution 1°



Scale ± 336 μK



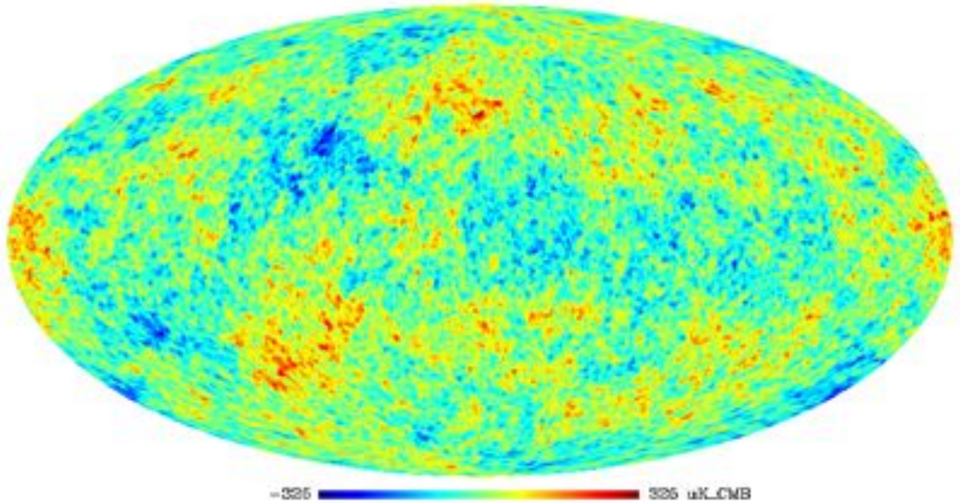
Scale ± 20 μK (saturated, original ± 25 μK)

Basak et al. A&A 508, 53 (2009)

Non-Gaussian CMB model in the PSM

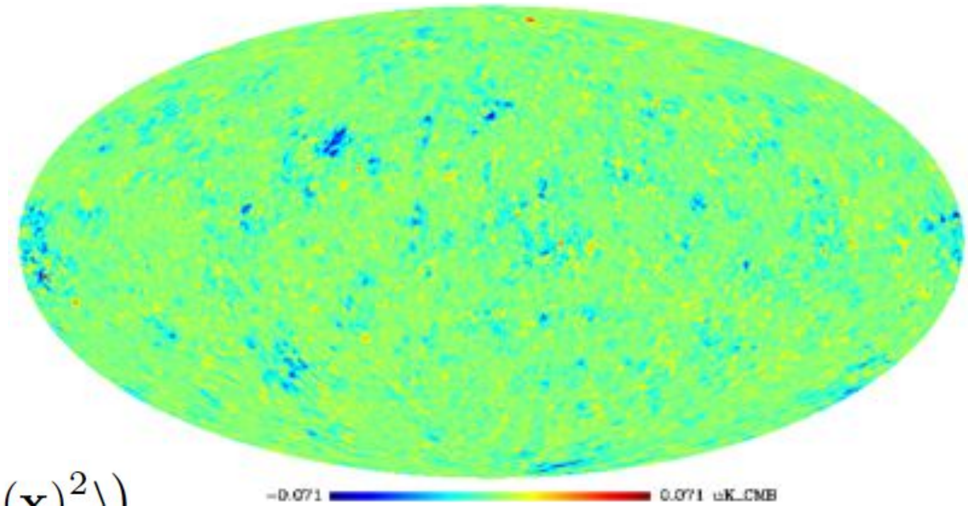
Linear part

Elsner & Wandelt, ApJS 184, 234 (2009)



Scale ± 325 μK

Non-linear correction (for f_{NL}=1)

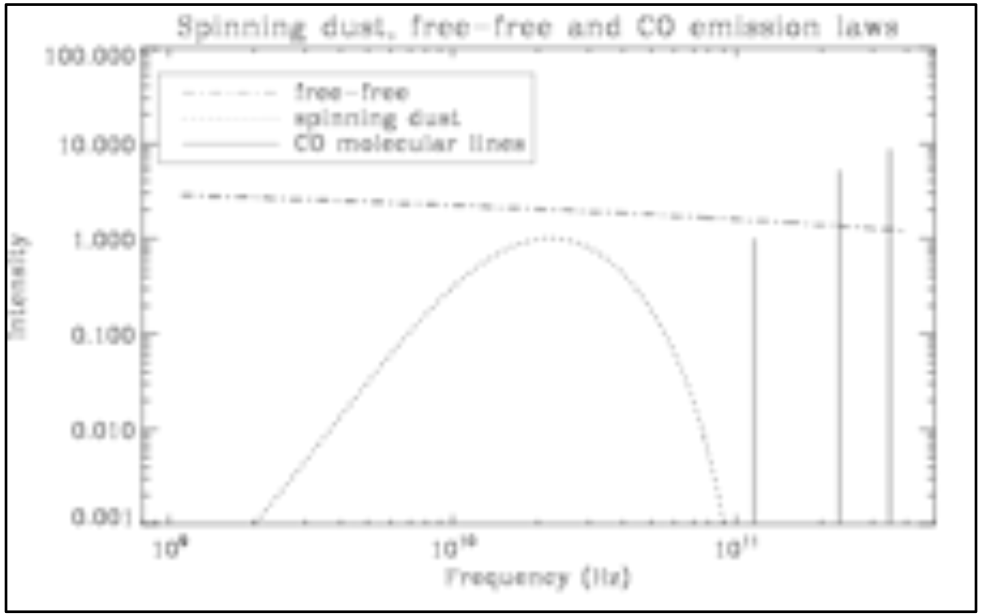


Scale ± 0.071 μK

$$\Phi(\mathbf{x}) = \Phi_{\mathrm{L}}(\mathbf{x}) + f_{\mathrm{NL}}\left(\Phi_{\mathrm{L}}(\mathbf{x})^2 - \langle \Phi_{\mathrm{L}}(\mathbf{x})^2 \rangle\right)$$

Galactic emission in the PSM

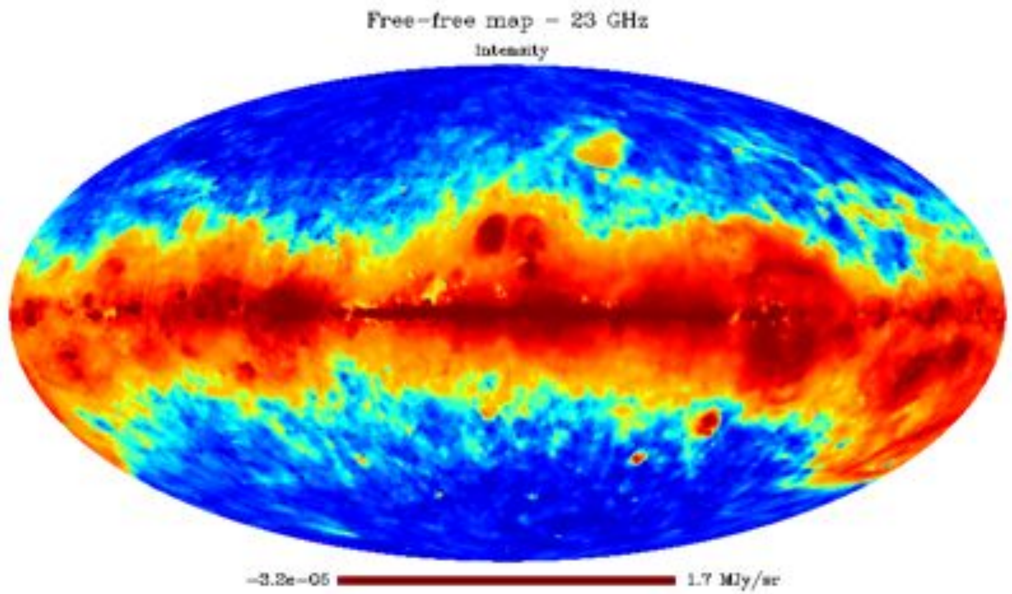
- 5 components
  - Synchrotron (polarised)
  - Free-free
  - Thermal dust (polarised)
  - Spinning dust
  - CO emission lines



- Emission templates from
  - WMAP
  - Haslam et al. 408 MHz data
  - Schlegel, Finkbeiner & Davis 100 micron map (IRAS+DIRBE)
  - Dame et al (CO survey)

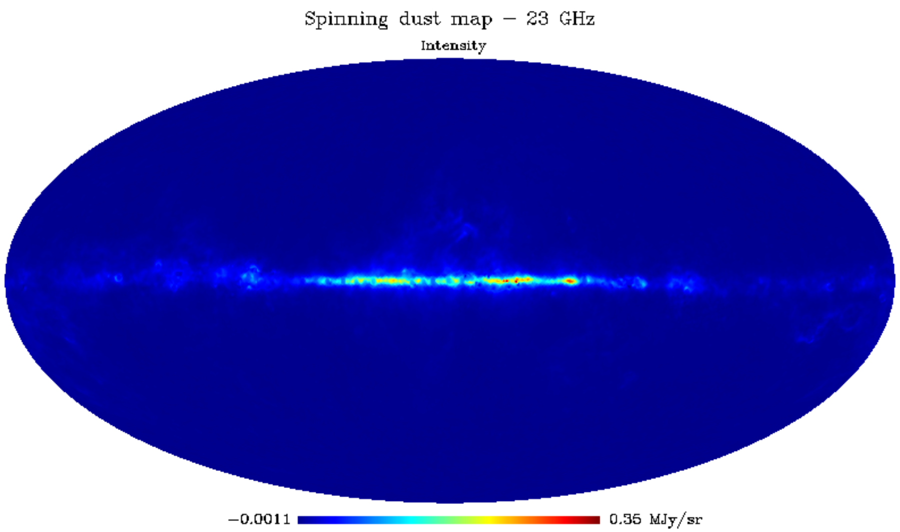
Free-free

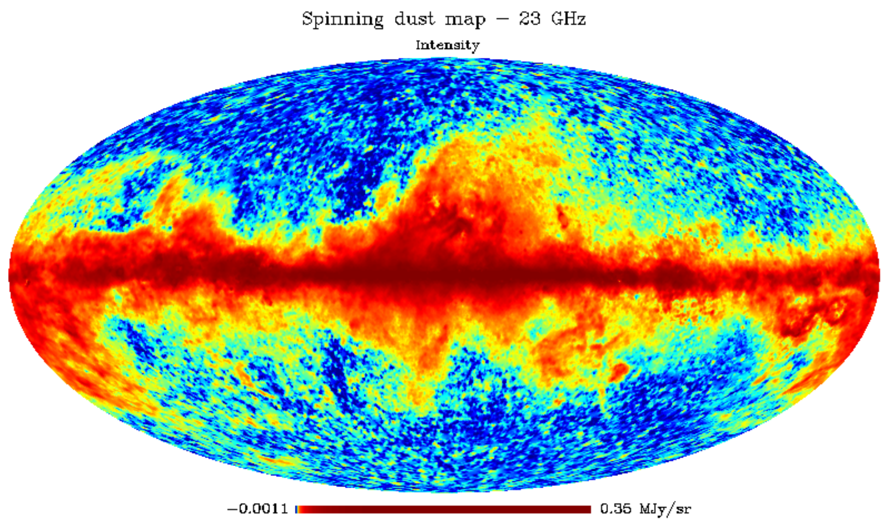
- Composite template map
  - In dense regions (E(B-V) >2) use WMAP MEM decomposition
  - Elsewhere use estimate from Hα, except where WMAP MEM estimate is lower
  - Resolution 1°



Spinning dust

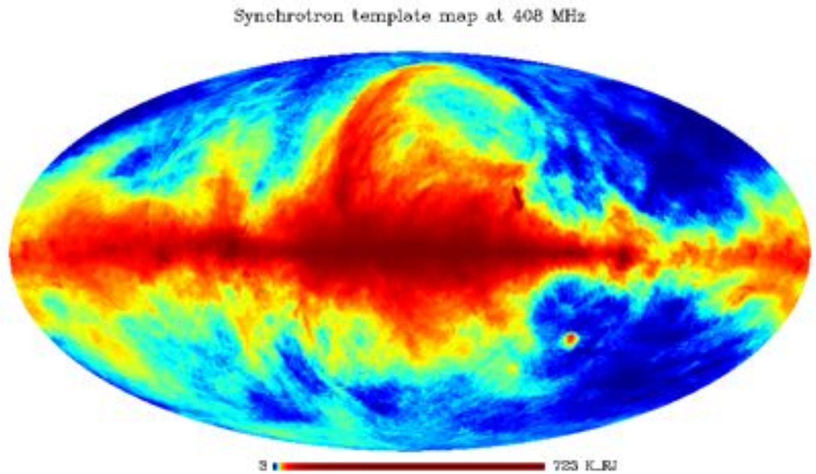
- Residual of WMAP 23GHz map after subtracting the synchrotron, free-free, and thermal dust



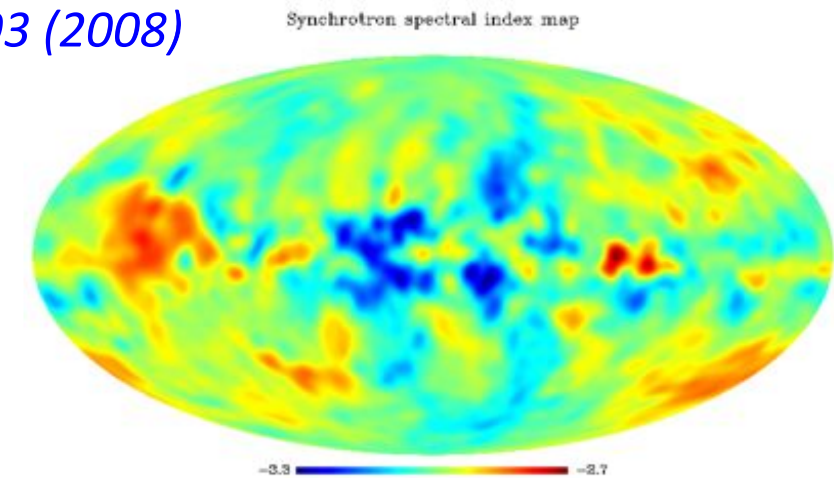


Synchrotron

- Template temperature map
  - *Haslam et al. A&AS, 47, 1 (1982)*



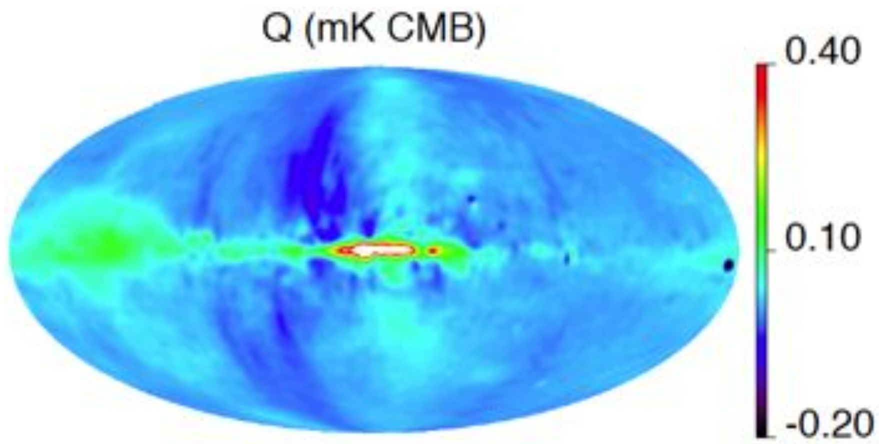
- Spectral index
  - From model of synchrotron polarisation fraction at 23GHz
  - *Miville-Deschênes et al. A&A, 490, 1093 (2008)*

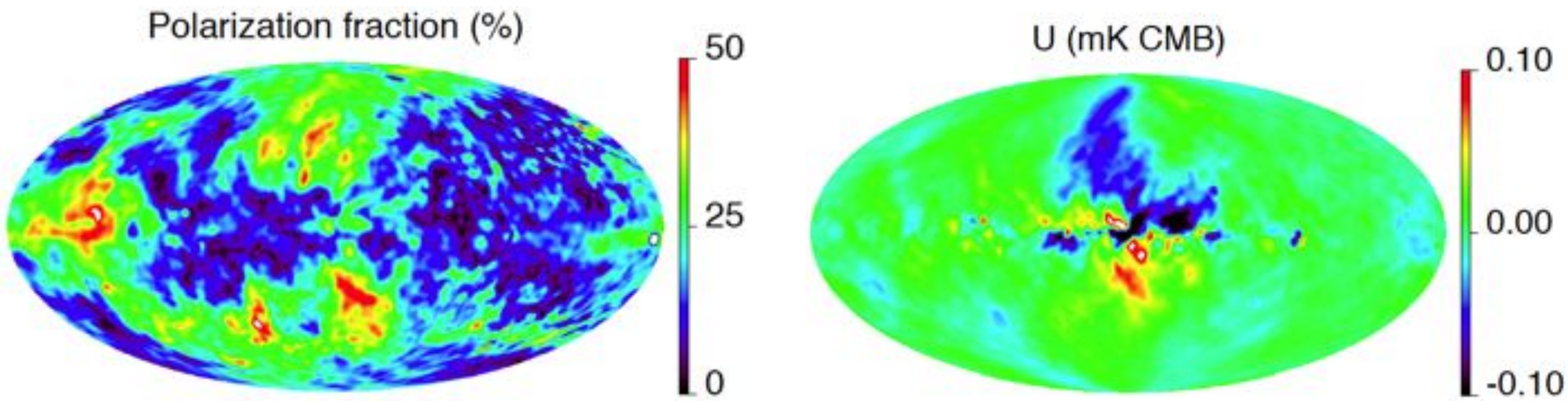


- Resolution 1° (5° for spectral index)

Synchrotron polarisation

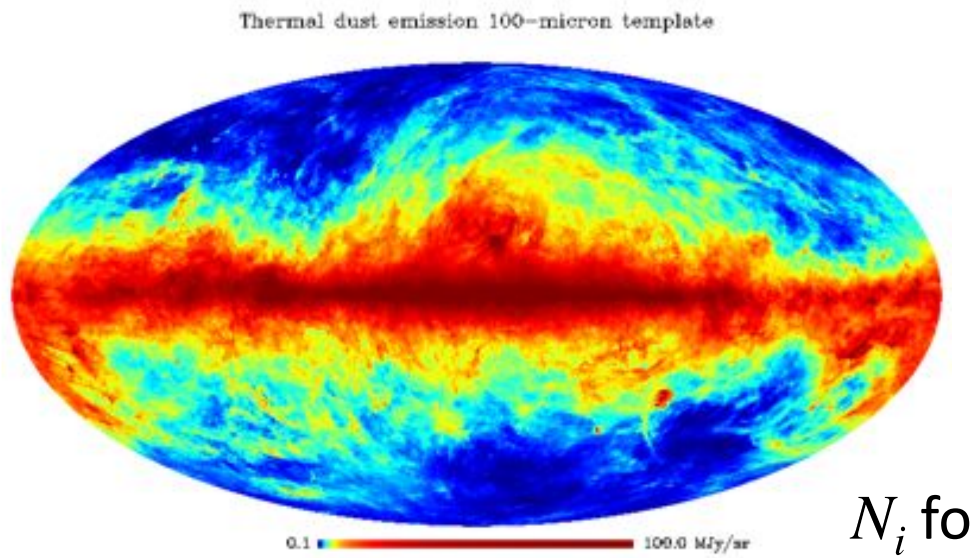
- Polarisation
  - From WMAP 23GHz
  - Same spectral index as temperature





Thermal dust

- Based on IRAS+DIRBE+FIRAS
  - Model 7 of *Finkbeiner, Schlegel, Davis, ApJ, 524, 867 (1999)*



$$I_\nu = \sum_{i=1}^{2} N_i \, \epsilon_i \, \nu^{\beta_i} \, B_\nu(T_i)$$

Column density

Opacity

N_i for two populations is obtained from color ratio $I_{100\mu m}/I_{240\mu m}$

$\beta_1 = -1.5$
$\beta_2 = -2.6$

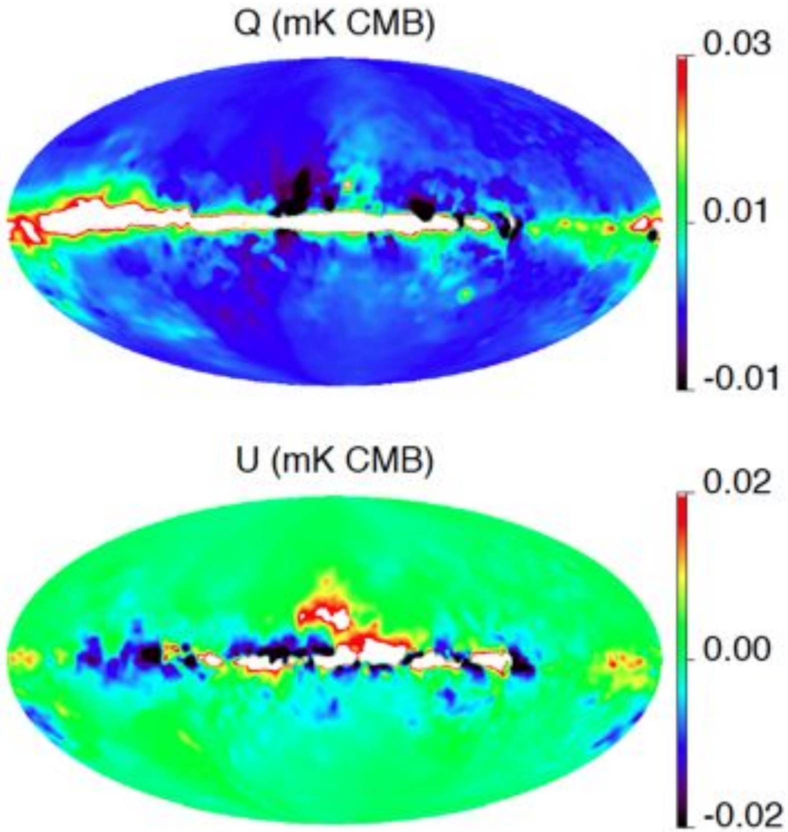
Thermal dust polarisation

$$Q_\nu(p) \quad = f_d\, g_d(p)\, I_\nu(p)\, \cos(2\gamma_d(p))$$
$$U_\nu(p) \quad = f_d\, g_d(p)\, I_\nu(p)\, \sin(2\gamma_d(p))$$

intrinsic polarisation fraction = 0.15

geometric depolarisation factor

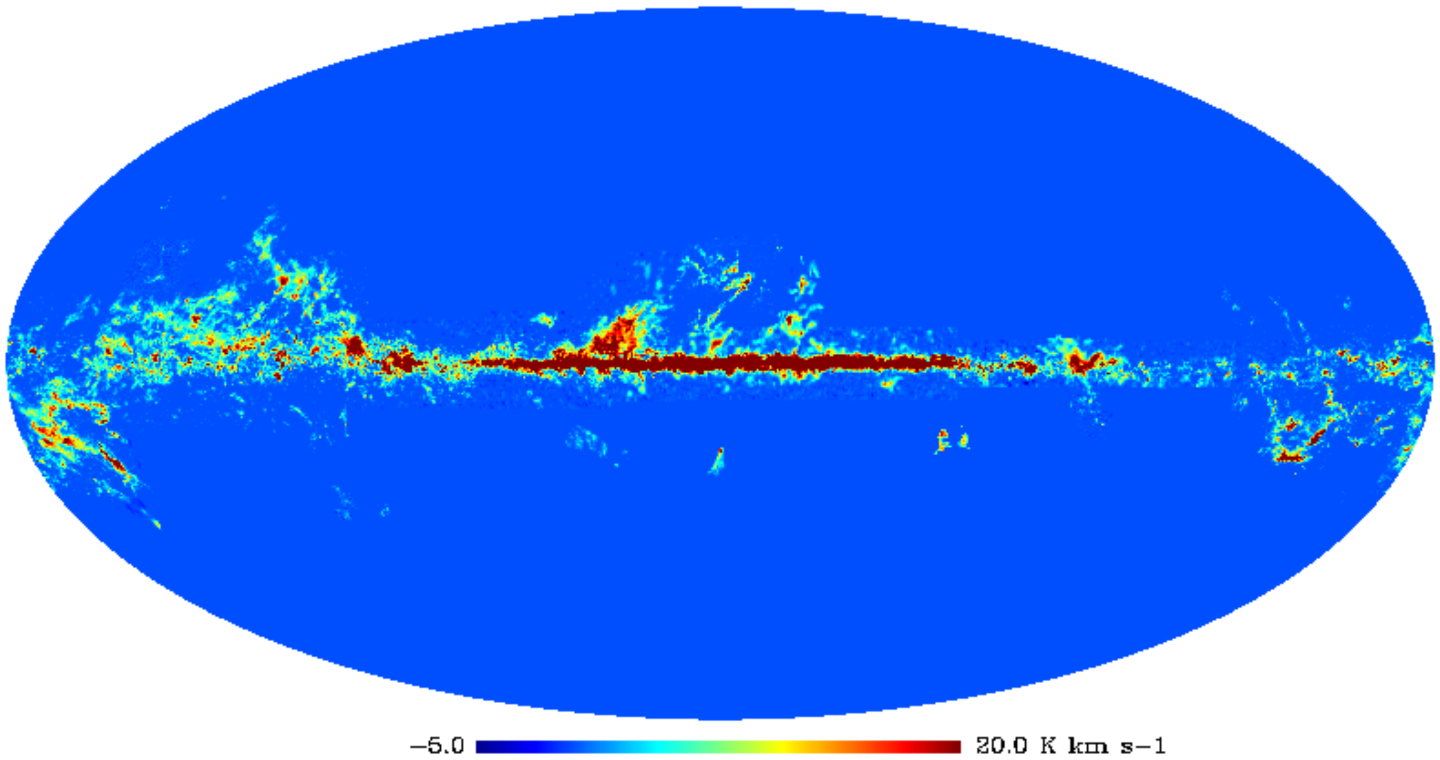
polarisation angle



At 200 GHz

CO line emission

- Template of Dame et al. from the LAMBDA web site.



Small scales

- Galactic templates are at various resolutions
  - Synchrotron, free-free, spinning dust at ≈ 1°
  - Thermal dust at ≈ 6'

- This is not appropriate for testing the extraction of SZ clusters (practically no galactic foregrounds on small scales)

- Random small scale fluctuations are added

Point sources

- Five main populations
  - Radio sources: from radio observations, extrapolated to higher frequencies
    - Two sub-populations: steep and flat
  - IRAS sources: catalogue from D. Clements, extrapolated to lower frequencies
  - FIRB: simulated map from Gonzalez-Nuevo et al.
  - WMAP sources: WYSIWYG
  - Ultra compact H-II regions: fit with greybody + free-free

SZ emission in the PSM

- Complete simulation of DM and gas in a Hubble volume
  - impractical
- N-body simulations of dark matter
  - Still computationally demanding
  - Need a prescription to add the baryons
- Using known clusters
  - Quite limited
  - Need a prescription to estimate the SZ effect from X or optical
- From number counts
  - Need a mass function
  - Need a prescription for y (profile as a function of mass)

Original work

- Press-Schechter formalism, cluster counts dN/dMdz
- Random generation of density contrast in a box
  - e.g. 600×600×6000 Mpc comoving, with 20Mpc cells, for 3°×3° field
- Linear growth only
- Clusters distributed at each redshift proportionally to (1+bδρ/ρ)

- Kinetic and polarised SZ effect from velocity field (assumed irrotational)

Newtonian potential $\nabla^2\Phi = 4\pi G a^2 \delta\rho$

$$v = -\frac{2}{3}\frac{f(z)}{\Omega_m(z)H(z)}\frac{\nabla\Phi}{a}$$

with

$$f \equiv d\ln D_g(z)/d\ln a$$

Linear growth factor

Examples of SZ patches

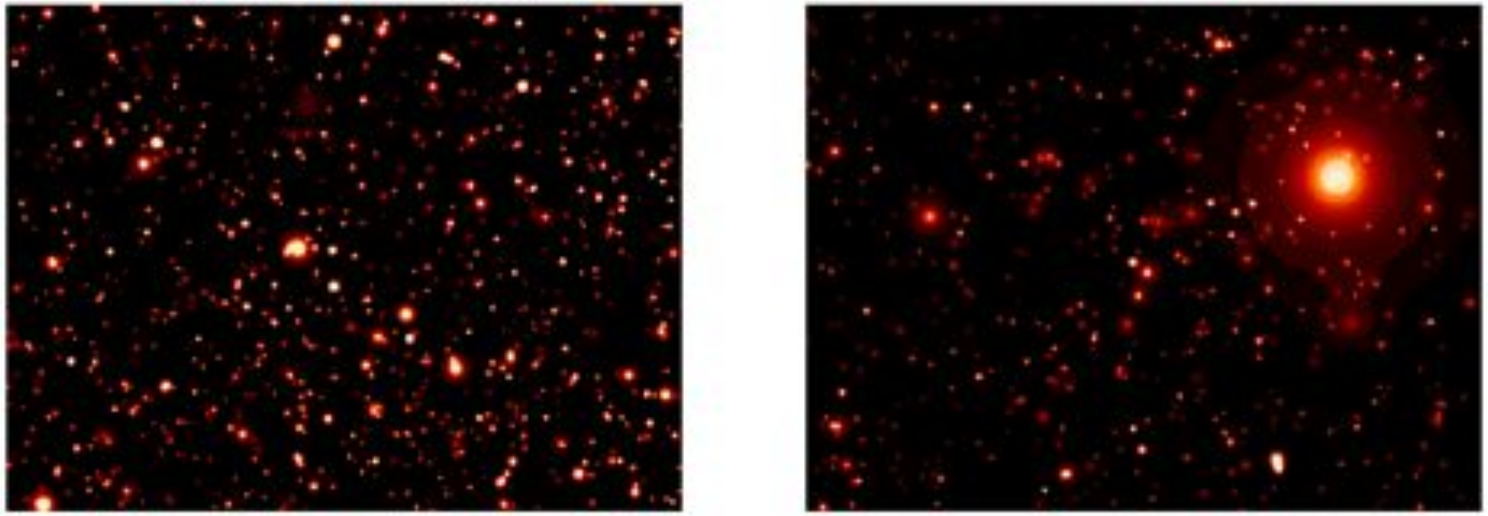
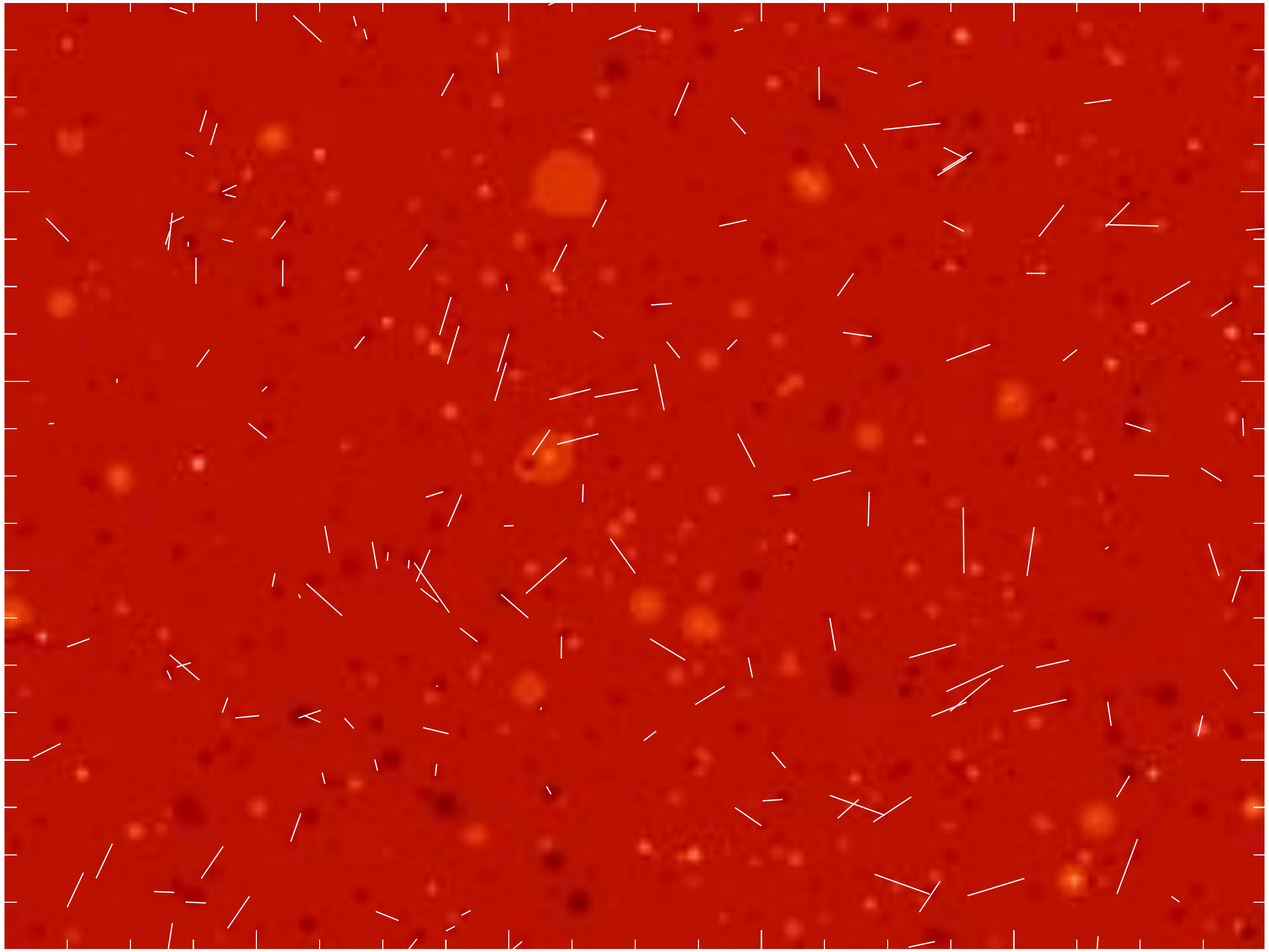


Figure 1. Thermal SZ map of 3 by 4 square degrees for a universe with $\Omega_m = 0.3$, $\Lambda = 0.7$, $h = 0.65$, $\Omega_b = 0.05$ (left panel), and with $\Omega_m = 1$, $\Lambda = 0$, $h = 0.5$, $\Omega_b = 0.07$ (right panel). Note that because of the different baryon fraction, the Λ universe clusters are brighter in SZ (respective color scales have been chosen such that they range from $y = 0$ to $y = 4 \times 10^{-5}$ on the left panel , and from $y = 0$ to $y = 1.5 \times 10^{-5}$ on the right one, with higher values saturated.

Delabrouille, Melin, Bartlett, AMIBA 2001 ASP conf. proc. 257 (2002)

Velocity flows



SZ in the PSM

- Catalogue from a mass function
  - Tinker et al. mass function (default, others implemented as well)
  - Y from Planck M-Y scaling relation, universal profile
  - Cluster velocities drawn at random according to v(z)
  - Cosmological parameters consistently used for cluster counts, scaling laws, velocities, CMB

- Constrained catalogue: replace randomly generated clusters by observed ones (with similar mass, redshift, direction)
  - MCXC, MaxBCG, or both

SZ in the PSM

- Prediction of SZ from known clusters
  - MCXC catalog of Piffaretti et al. (2010)
    - 1743 ROSAT clusters

$$E(z)^{-7/3}\left(\frac{L_{500}}{10^{44}\,\mathrm{erg\,s^{-1}}}\right) = C_{LM}\left(\frac{M_{500}}{3\times10^{14}\,M_\odot}\right)^{\alpha_{LM}}$$

$\alpha_{LM} = 1.64$

$\log(C_{LM}) = 0.274$

1 / 0.561

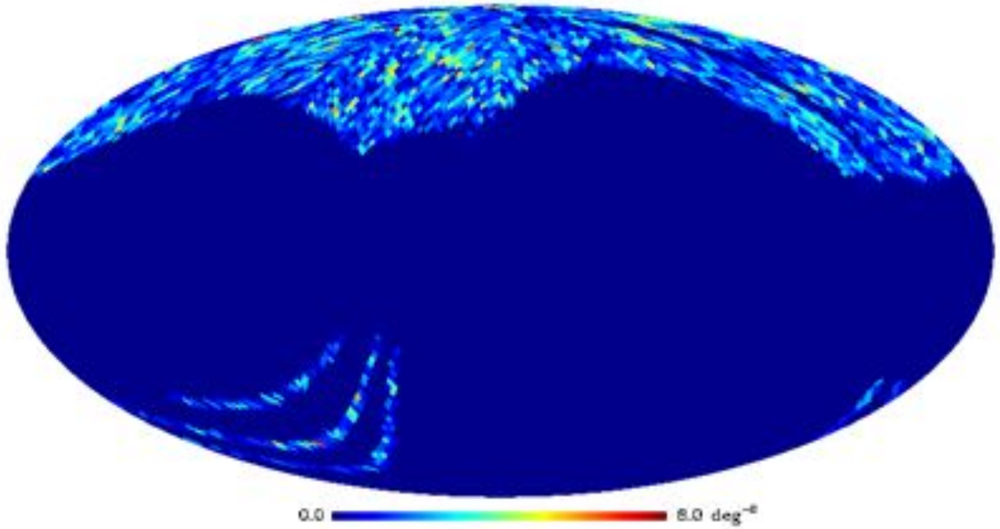
$$Y_{500} = 1.383\times10^{-3} I(1)\left(\frac{M_{500}}{3\times10^{14}\,M_\odot}\right)^{\frac{1}{\alpha_{MY_X}}} \times E(z)^{2/3}\left(\frac{D_\mathrm{A}(z)}{500\,\mathrm{Mpc}}\right)^{-2}\mathrm{arcmin}^2$$

0.6145

Pratt et al. 2009
Arnaud et al. 2010
Planck collaboration 2011

SZ in the PSM

- SZ from known clusters
  - MaxBCG catalog
  - Koester et al. (2007)
  - 13823 optical clusters



We compute the SZ flux Y_{500} using the $Y_{500} - N_{200}$ relation derived by the Planck Collaboration

$$Y_{500} = Y_{20} \left(\frac{N_{200}}{20}\right)^{\alpha_{20}} E^{2/3}(z) \left(\frac{D_{\rm A}(z)}{500\,{\rm Mpc}}\right)^{-2} {\rm arcmin}^2$$

where N_{200} is the cluster richness, $Y_{20} = 7.4\,10^{-5}{\rm arcmin}^2$ and $\alpha_{20} = 2.03$.

SZ in the PSM: N-body + hydro simulations

- Hydro+N-body model
  - Local ($z<0.025$) from Dolag et al. (2005)
  - High z from Schäfer et al. (2006)

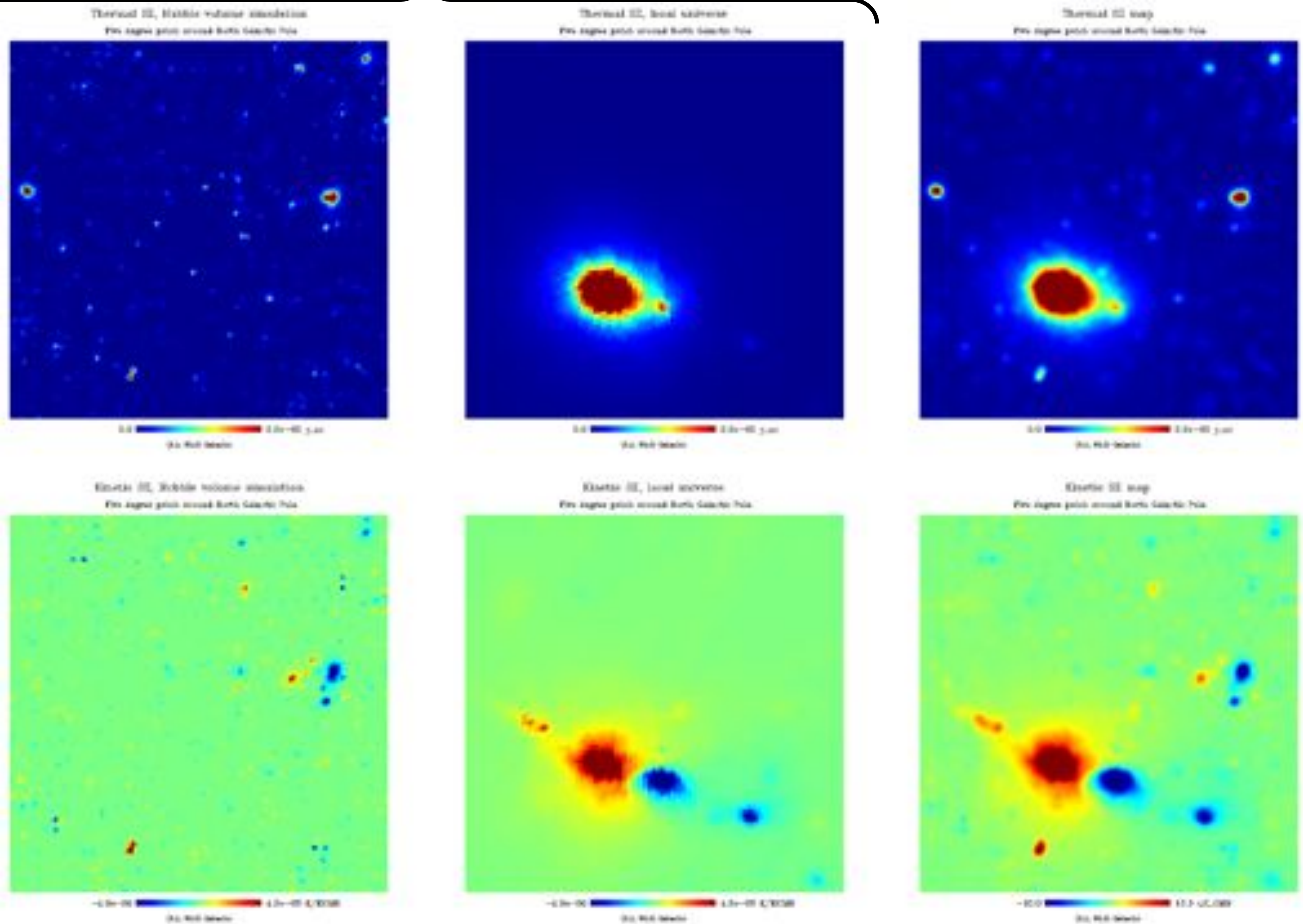
- Advantages and drawbacks
  - SZ from LSS more realistic
  - Fixed cosmology ($h=0.7$, $\Omega_\Lambda=0.7$, $\Omega_m=0.3$, $\Omega_b=0.04$, $\sigma_8=0.9$, $n_s=1$)
  - Clusters found in DM by post-processing – low mass objects may be missing or inaccurate
  - Replication of structures

Input simulations

Total PSM maps

Thermal SZ

Kinetic SZ



SZ in the PSM: hybrid model

- Hydrodynamical simulations at low z ...
  - From Antonio da Silva

- ... completed by mass function simulations at high z !

PSM summary

- The PSM is not a physical simulation tool
- It is a phenomenological model which permits us to generate tuneable simulated sky emissions for
  - Developing and validating data analysis pipelines
  - Monte Carlo simulations of a complete pipeline for error propagation
  - Investigating modelling uncertainties and biases
- Public release planned for the near future
  - Not completely user-proof yet
  - Soon: release of simulated data sets
  - Software restricted at present to the Planck collaboration

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Component separation

- Objective 1: extract SZ information alone
  - SZ map — component separation (e.g. ILC)
  - Detect clusters — objects of assumed shape (MF)
  - Cluster parameters — parametric fit
    - (location, Y, kSZ, profile, temperature…)
  - Power spectrum — spectral fit/matching (e.g. SMICA)

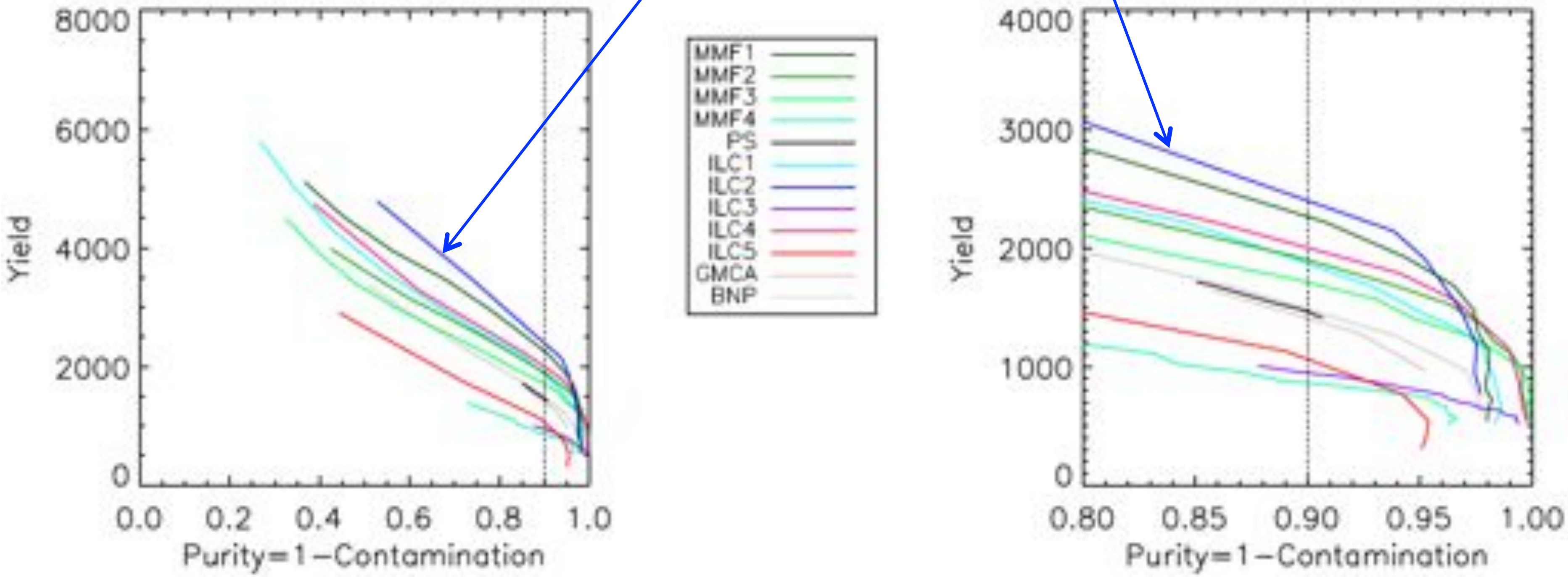
- Objective 2: joint analyses
  - Cross-correlate SZ with other signals

SZ data-challenges in Planck

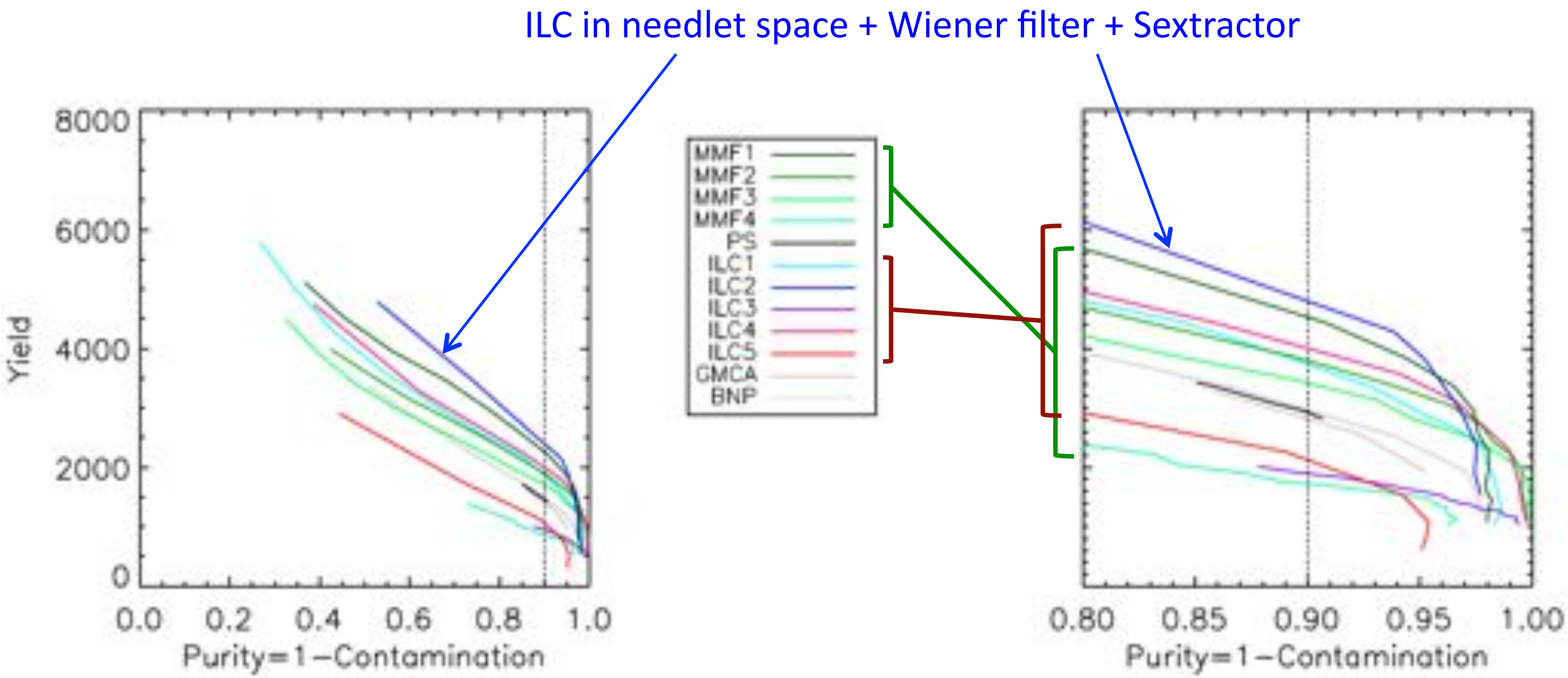
- Objective: test and compare algorithms for cluster detection on the same original data sets
- PSM simulations of Planck 14 month data
- 10 teams, 12 algorithms/pipelines
- Several challenges
  - First challenge blind, Sheth-Tormen mass function, beta-model for clusters, σ_8=0.85
  - Second challenge blind, Jenkins mass function, universal profile from Arnaud et al. 2009, σ_8=0.798
  - Third challenge: same as second, but inputs available to challengers

First challenge results

ILC in needlet space + Wiener filter + Sextractor

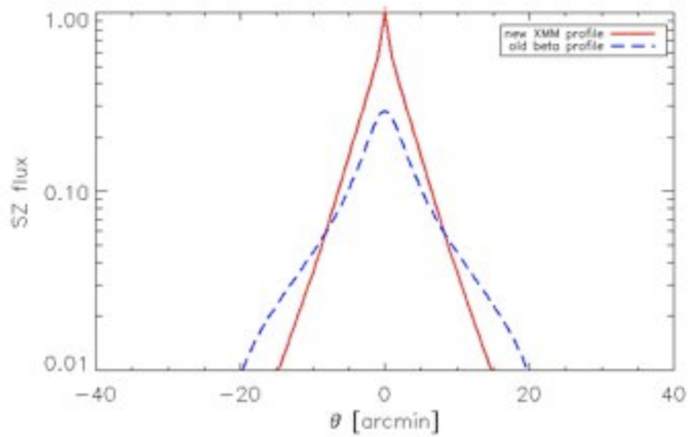


First challenge results

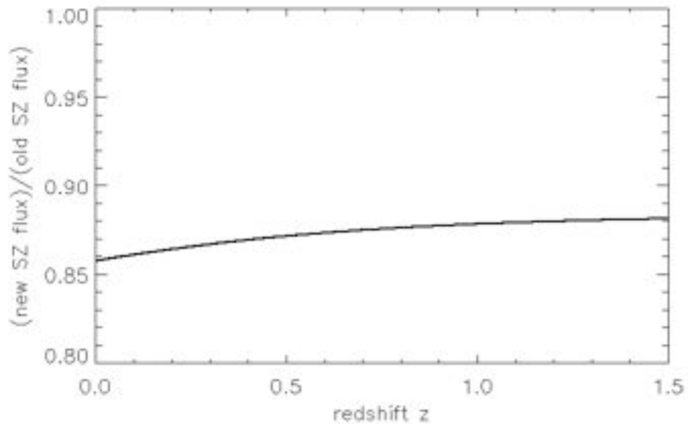


SZ updates

- New cluster profiles



- New normalisation



Number of detected clusters cut by half on recent simulations !

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Data models and linear filters

$$x(\nu_i,p) = \sum_j s_j(\nu_i,p) + n_i(p)$$

Cosmologist's model

$$x_i(p) = a_i s(p) + n_i(p)$$

$$\mathbf{x}(p) = \mathbf{a}s(p) + \mathbf{n}(p)$$

$$\widehat{s}(p) = \frac{\mathbf{a}^t \boxed{\mathbf{R}_n^{-1}}}{\mathbf{a}^t\mathbf{R}_n^{-1}\mathbf{a}}\mathbf{x}(p)$$

Inverse of the noise covariance matrix

Astrophysicist's model

$$x_i(p) = \sum a_{ij} s_j(p) + n_i(p)$$

$$\mathbf{x}(p) = \mathbf{A}\mathbf{s}(p) + \mathbf{n}(p)$$

$$\widehat{\mathbf{s}}(p) = \left[\mathbf{A}^t\mathbf{R}_n^{-1}\boxed{\mathbf{A}}\right]^{-1}\mathbf{A}^t\mathbf{R}_n^{-1}\mathbf{x}(p)$$

Mixing matrix

The ILC

$$\mathbf{x}(p) = \mathbf{a}s(p) + \mathbf{n}(p) \qquad\qquad \widehat{s}(p) = \frac{\mathbf{a}^t\mathbf{R}_n^{-1}}{\mathbf{a}^t\mathbf{R}_n^{-1}\mathbf{a}}\mathbf{x}(p)$$

- The “noise” covariance matrix is not known a priori
- But…

$$\boxed{\begin{aligned}\mathbf{R}_x^{-1} &= \left[\mathbf{a}\mathbf{a}^t\sigma^2_{\mathrm{cmb}} + \mathbf{R}_n\right]^{-1} \\ &= \mathbf{R}_n^{-1} - \sigma^2_{\mathrm{cmb}}\frac{\mathbf{R}_n^{-1}\mathbf{a}\mathbf{a}^t\mathbf{R}_n^{-1}}{1+\sigma^2_{\mathrm{cmb}}\mathbf{a}^t\mathbf{R}_n^{-1}\mathbf{a}}\end{aligned}}$$

- And hence

$$\begin{aligned}\mathbf{a}^t\mathbf{R}_x^{-1} &= \mathbf{a}^t\mathbf{R}_n^{-1} - \sigma^2_{\mathrm{cmb}}\frac{\mathbf{a}^t\mathbf{R}_n^{-1}\mathbf{a}\,\mathbf{a}^t\mathbf{R}_n^{-1}}{1+\sigma^2_{\mathrm{cmb}}\mathbf{a}^t\mathbf{R}_n^{-1}\mathbf{a}} \\ \mathbf{a}^t\mathbf{R}_x^{-1} &\propto \mathbf{a}^t\mathbf{R}_n^{-1}\end{aligned}$$

The ILC

$$\widehat{s}(p) = \cancel{\frac{\mathbf{a}^t \mathbf{R}_n^{-1}}{\mathbf{a}^t \mathbf{R}_n^{-1} \mathbf{a}}} \mathbf{x}(p) = \frac{\mathbf{a}^t \mathbf{R}_x^{-1}}{\mathbf{a}^t \mathbf{R}_x^{-1} \mathbf{a}} \mathbf{x}(p)$$

- Actual implementation $$\widehat{s}_{\mathrm{ILC}}(p) = \frac{\mathbf{a}^t \widehat{\mathbf{R}}_x^{-1}}{\mathbf{a}^t \widehat{\mathbf{R}}_x^{-1} \mathbf{a}} \mathbf{x}(p)$$
  - Uses the empirical covariance matrix of the observations (and this is a very important distinction)

- Usually derived as the (internal) linear combination of the input maps which minimizes the variance of the output, with unit response to the CMB (or SZ)

$$\boxed{\widehat{s}_{\mathrm{ILC}}(p) = \sum_i w_i x_i(p) = \mathbf{w}^t \mathbf{x}(p)}$$

$$\boxed{\sum_i w_i a_i = \mathbf{w}^t \mathbf{a} = 1}$$

$$\boxed{\text{minimize } \sum_p |\widehat{s}(p)|^2}$$

ILC localisation

$$\widehat{s}_{\mathrm{ILC}}(p) = \frac{\mathbf{a}^t \widehat{\mathbf{R}}_x^{-1}}{\mathbf{a}^t \widehat{\mathbf{R}}_x^{-1} \mathbf{a}} \mathbf{x}(p)$$

Can be implemented independently

- in different regions
- on different scales

- or both: covariance matrix as a function of pixel and scale

Needlets

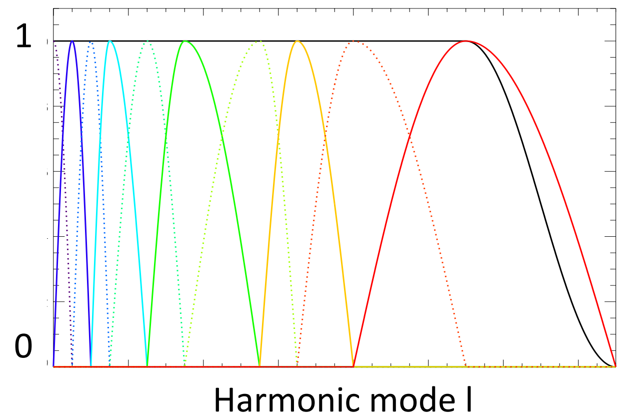
- Needlets are just wavelets on the sphere
  – Narcowitch, Petrushev & Ward, SIAM J. Math. Anal., 38, 574 (2006)
  – Marinucci et al., MNRAS, 383, 539 (2008)

- Very easy to implement
  – Choose a set of functions $h_j(l)$ such that

$$\Sigma[h_j(l)]^2=1$$

  – Make a set of filtered maps

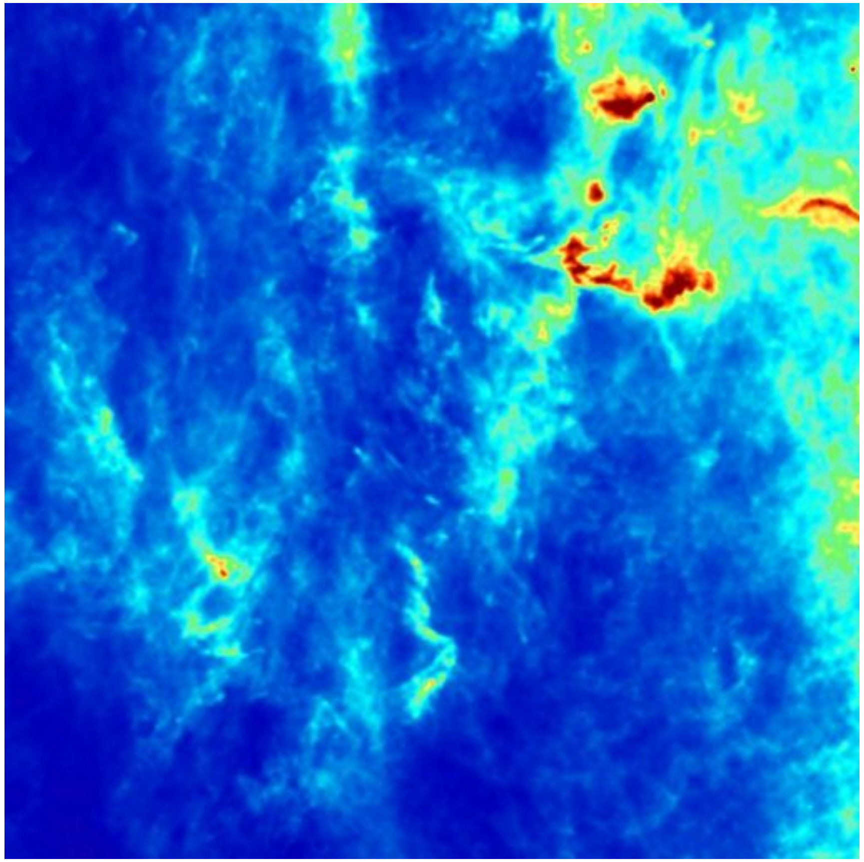
$$\beta_j(k) = SHT^{-1}(a_{lm}h_j(l))$$



  – Work on the needlet coefficients $\beta_j(k)$
  – Re-synthesize a map from the sum of the $\beta_j(k)$ maps filtered using the same $h_j(l)$

- For experts
  – Needlets constructed in this way form a tight frame (= a redundant basis)
  – Parseval's theorem holds
  – Needlet analysis and synthesis using the same spectral windows

Why are they useful?



Non stationary foregrounds require localised processing

Small patches ?

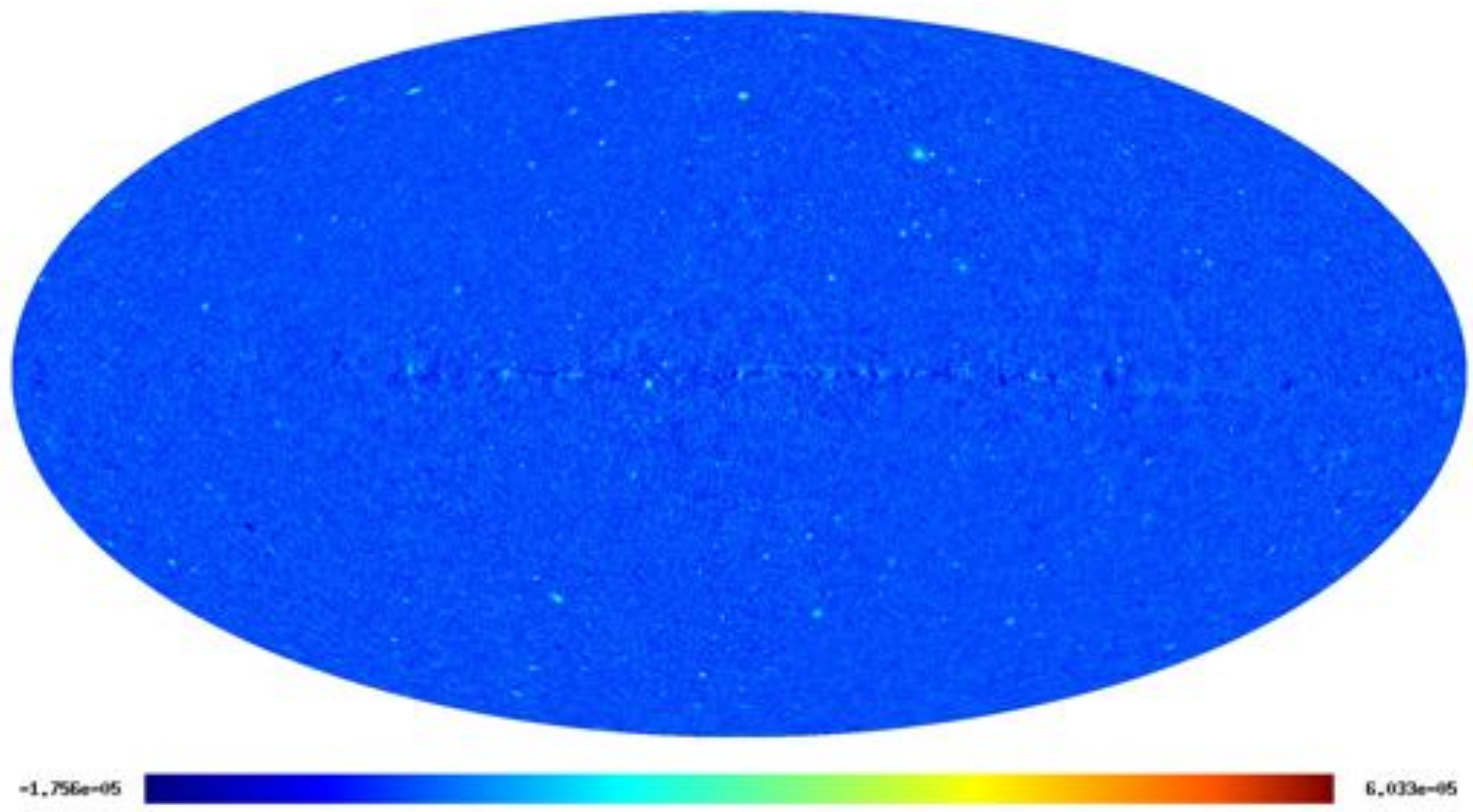
Difficult trade-off between the adequacy to local contamination and the variance of estimated filters

Needlets !

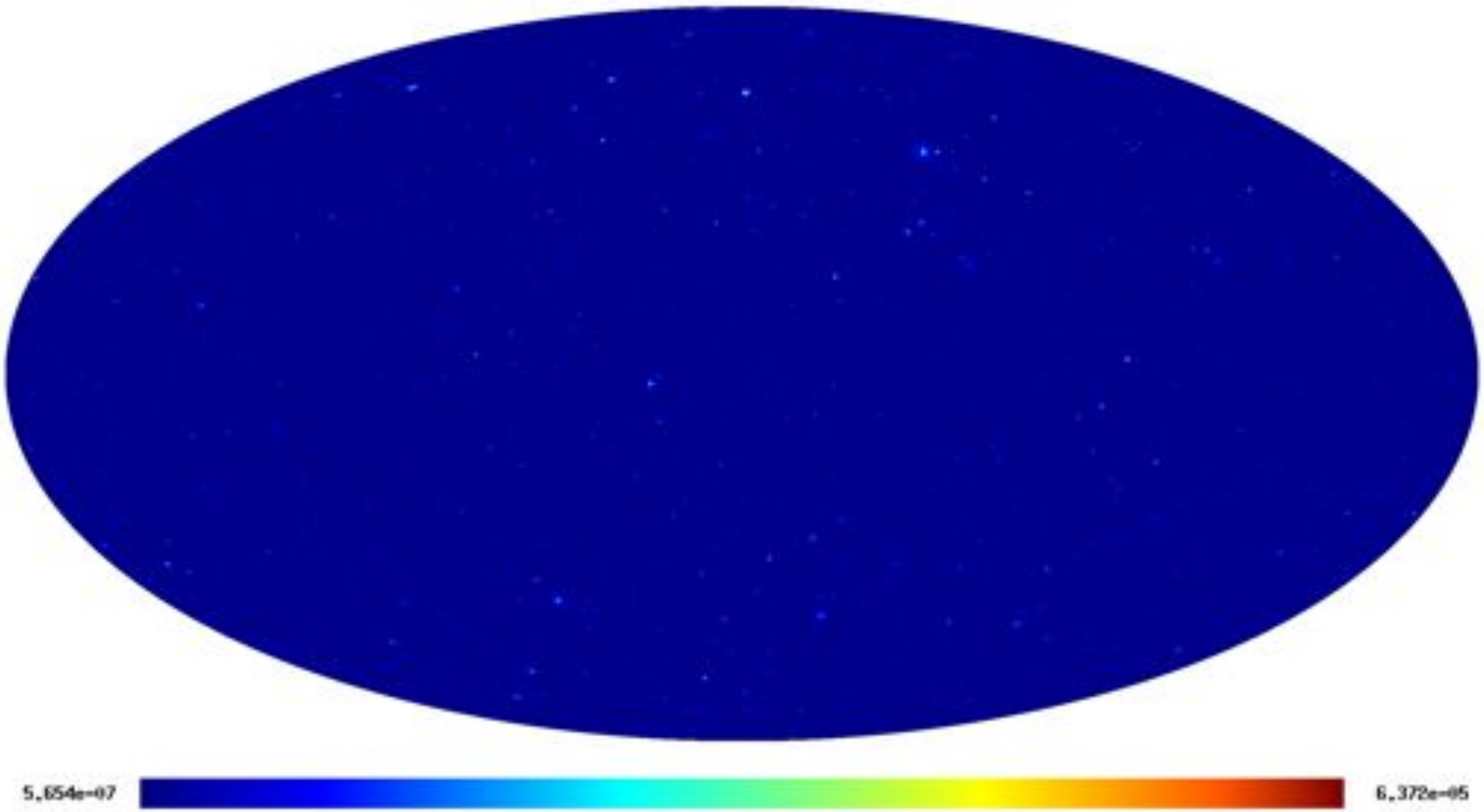
Big patches for large scales, small patches for small scales!

Needlet ILC map

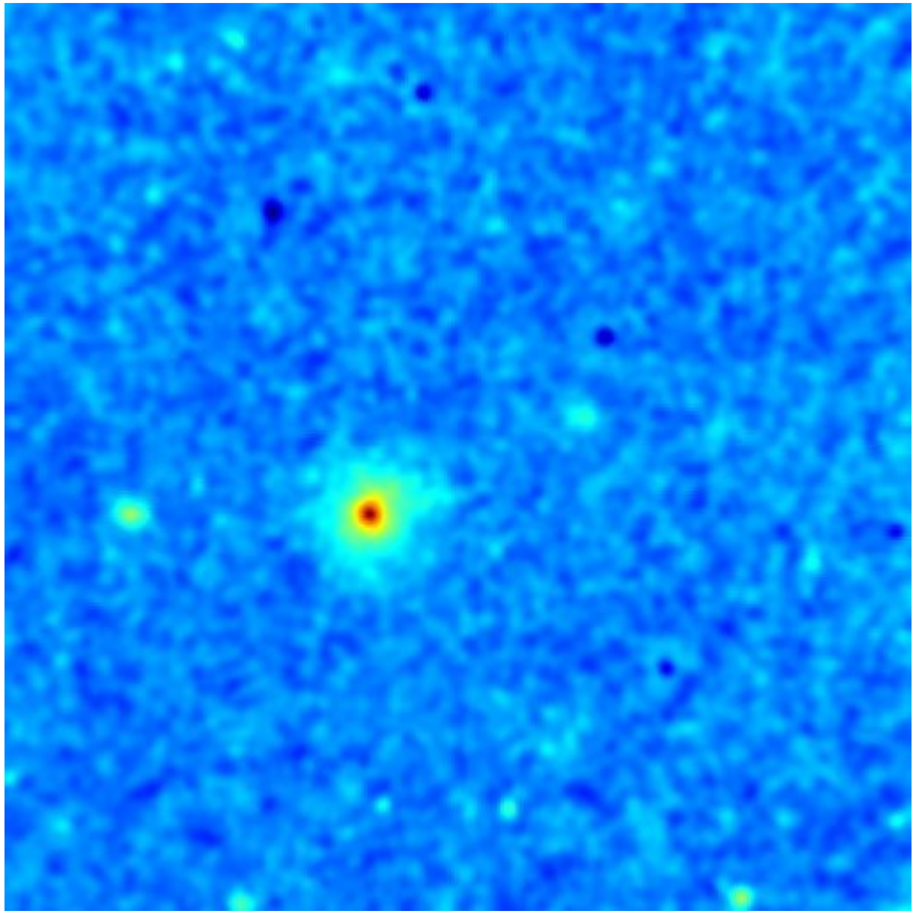
With Maude Le Jeune, Jean-Baptiste Melin, Marc Betoule



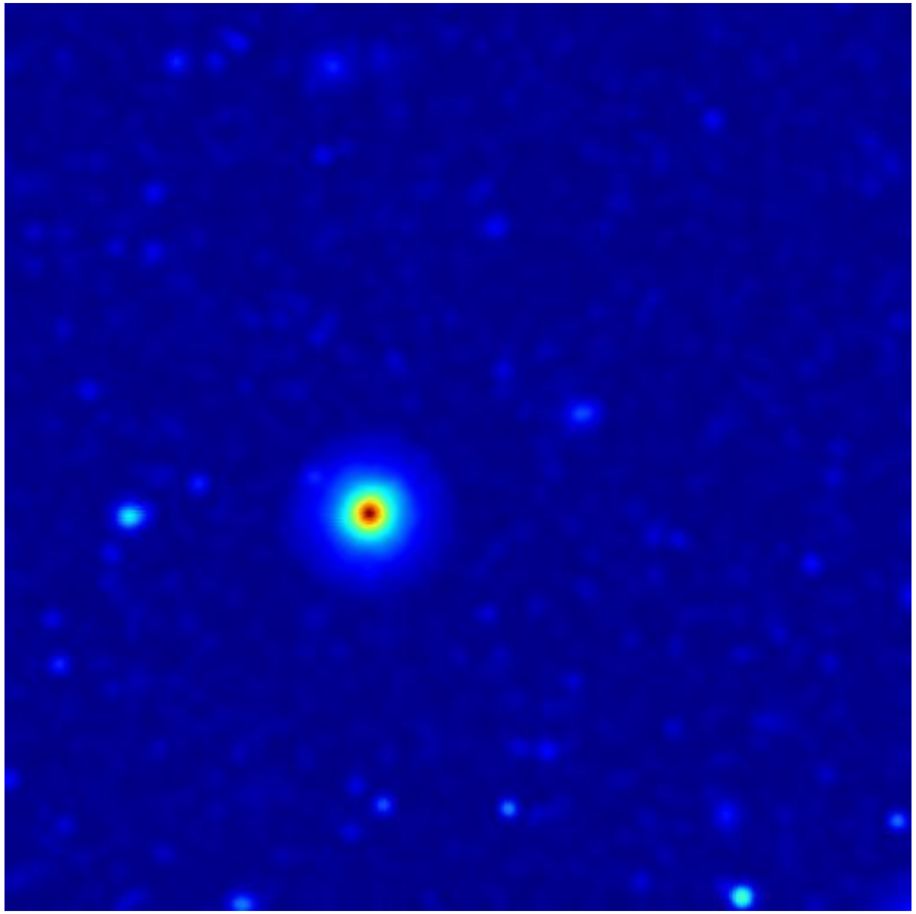
Input map



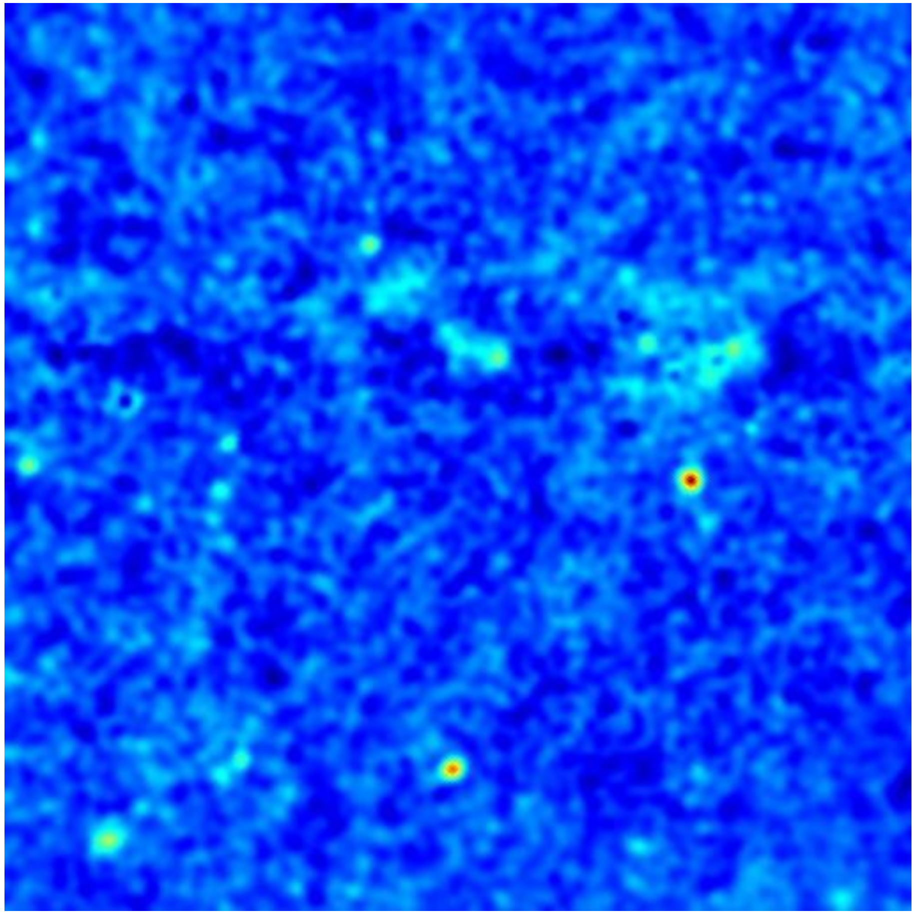
Needlet ILC map: Coma area



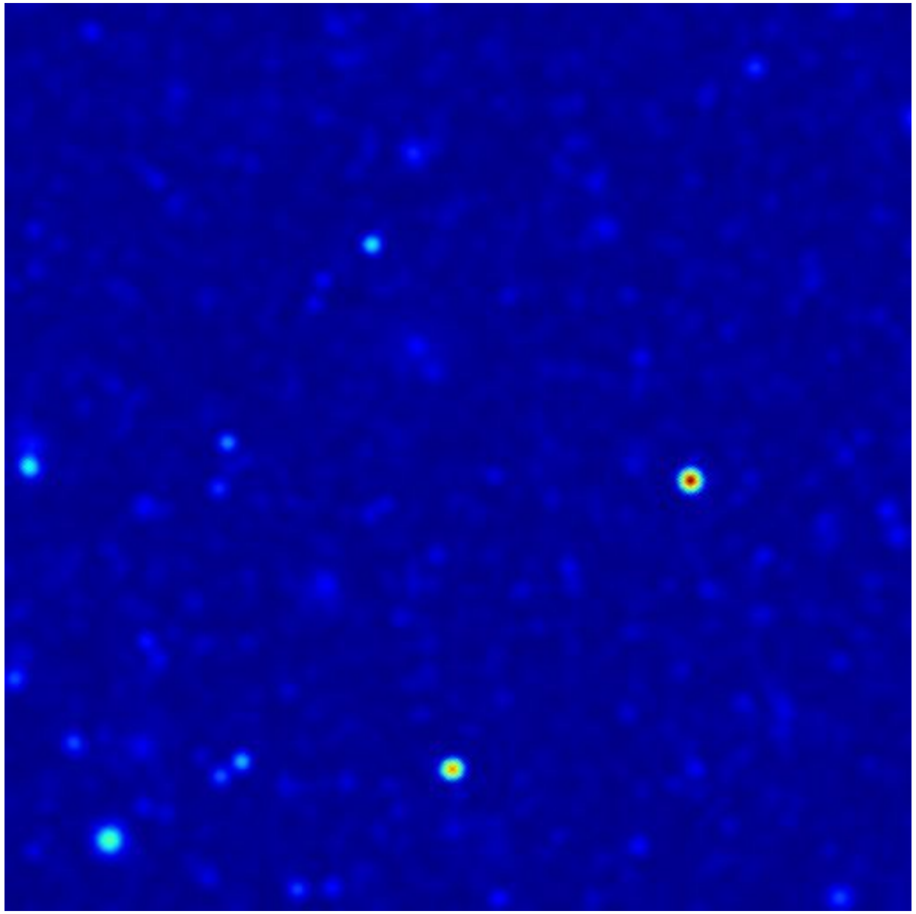
Input map: Coma area



Needlet ILC map: galactic plane (!)



Input map: galactic plane



ILC+MF vs. MMF what is best ??

If we look for a single SZ component in noisy observations (noise including foregrounds) modeled as

$$\mathbf{x}_{lm} = \mathbf{a}\, y_{lm} + \mathbf{n}_{lm}$$

The ideal map filtering solution (GLS, implemented in practice using an ILC in harmonic space) is

$$\widehat{y}_{lm}^{\mathrm{GLS}} = \frac{\mathbf{a}^t \mathbf{N}_l^{-1}}{\mathbf{a}^t \mathbf{N}_l^{-1} \mathbf{a}} \mathbf{x}_{lm}$$

The multifrequency matched filter (MMF) solution, assuming a known (symmetric) cluster profile p_l, such that $y_{lm} = y^0\, p_l$, is

$$\widehat{y}^0 \propto \mathbf{a}^t \mathbf{N}_l^{-1} \mathbf{x}_{lm}\, p_l$$

The covariance of the noise in the GLS map is $1/\mathbf{a}^t \mathbf{N}_l^{-1} \mathbf{a}$, and thus a simple matched filter applied on the GLS map gives

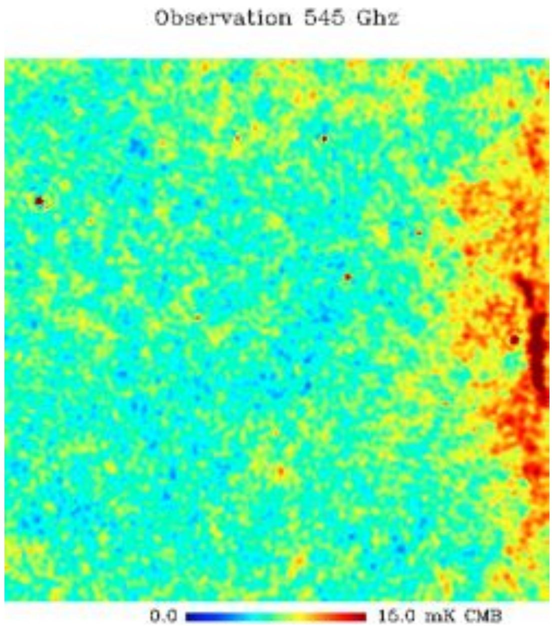
$$\widehat{y}^0 \propto \mathbf{a}^t \mathbf{N}_l^{-1} \mathbf{a}\, \widehat{y}_{lm}^{\mathrm{GLS}} p_l = \mathbf{a}^t \mathbf{N}_l^{-1} \mathbf{x}_{lm}\, p_l$$

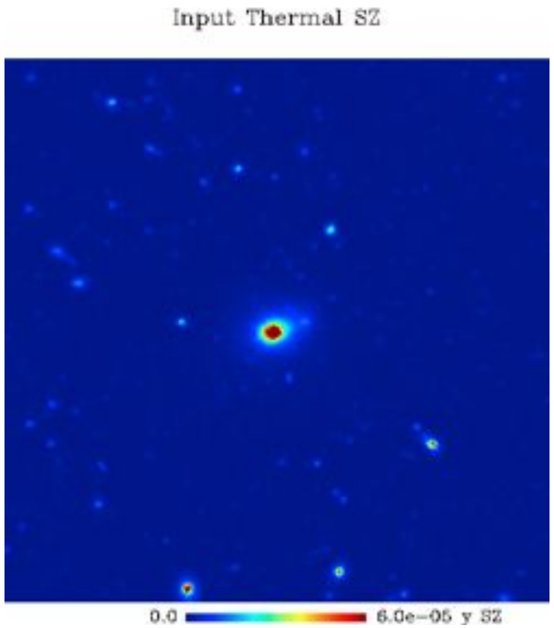
The MMF is hence equivalent to doing a single frequency matched filter on the GLS map.

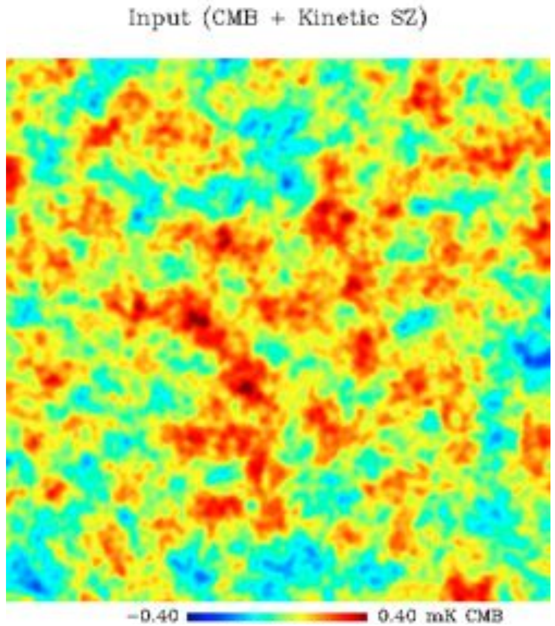
kSZ + tSZ with constrained ILC

- The kSZ and the CMB have the same colour
  – Impossible to distiguish them on this basis
  – Morphological information (shape) hence MF

- How critical is the leakage of thermal SZ into CMB (+kSZ) maps after an ILC ?



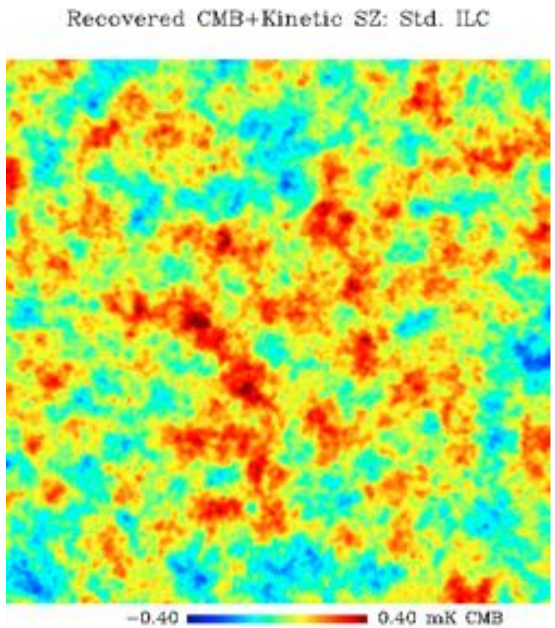


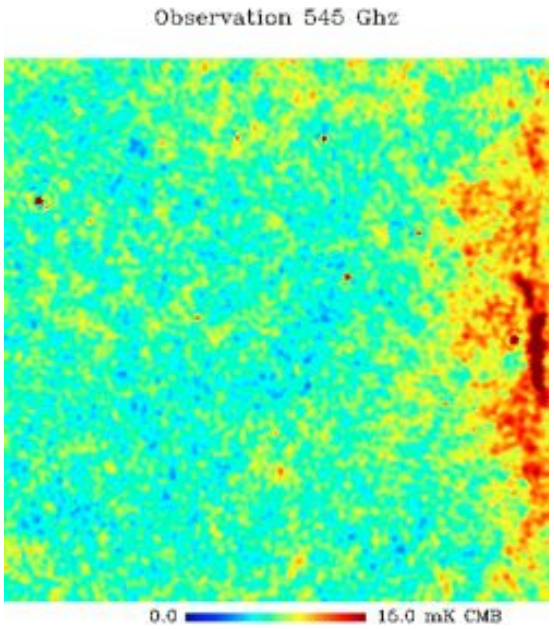


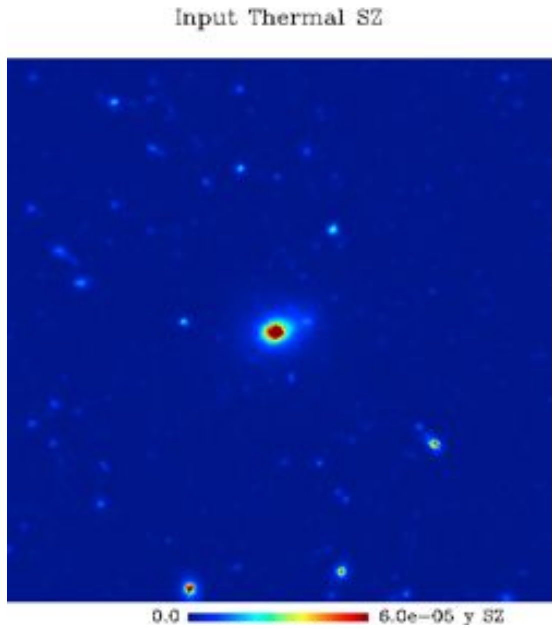
Around *l,b = (33°,89°)* – Coma cluster neighbourhood

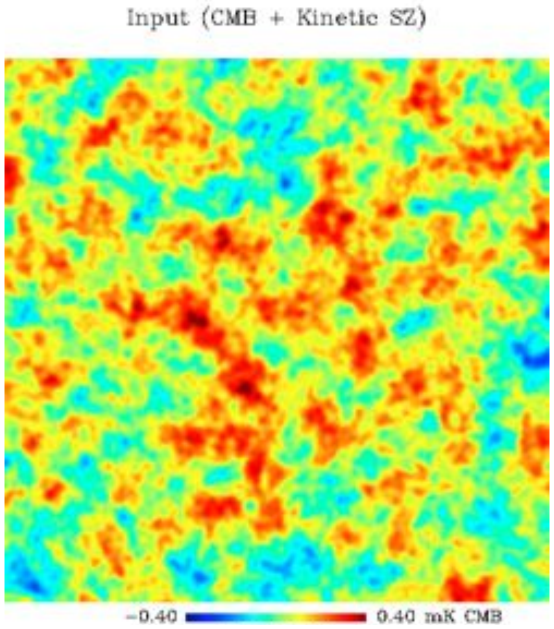
$$\mathbf{x}(p) = \mathbf{a}s(p) + \mathbf{n}(p)$$

$$\widehat{s}_{\mathrm{ILC}}(p) = \frac{\mathbf{a}^t \widehat{\mathbf{R}}_x^{-1}}{\mathbf{a}^t \widehat{\mathbf{R}}_x^{-1} \mathbf{a}} \mathbf{x}(p)$$









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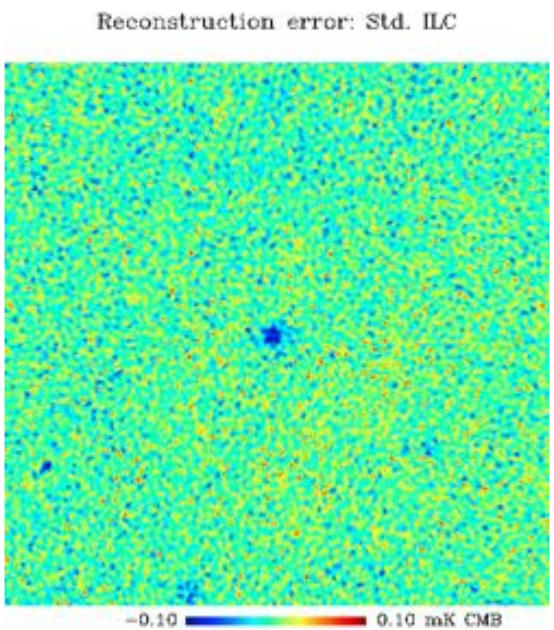


Constrained ILC

$$\mathbf{x}(p) = \boxed{\mathbf{a}s(p)} + \boxed{\mathbf{b}z(p)} + \boxed{\mathbf{n}(p)}$$

CMB

Thermal SZ

Everything else

$$\boxed{\widehat{s}_{\mathrm{ILC}}(p) = \sum_i w_i x_i(p) = \mathbf{w}^t \mathbf{x}(p)}$$

$$\boxed{\text{minimize } \sum_p |\widehat{s}(p)|^2}$$

Two constraints

$$\sum_i w_i a_i = \mathbf{w}^t \mathbf{a} = 1$$

$$\sum_i w_i b_i = \mathbf{w}^t \mathbf{b} = 0$$

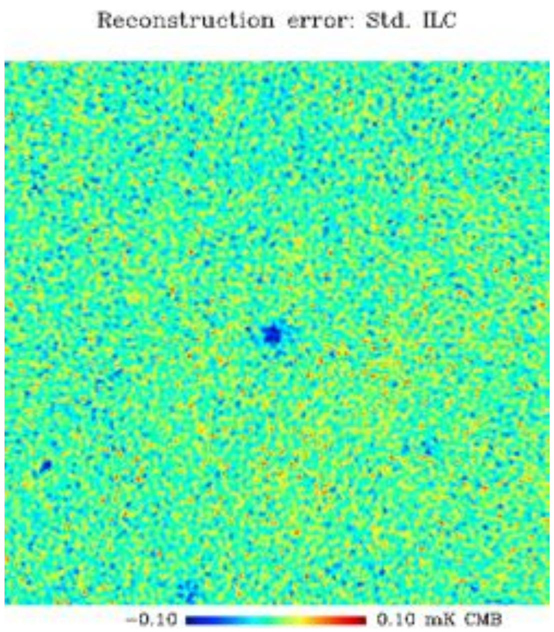
$$\widehat{s}_{\mathrm{constr.ILC}}(p) = \frac{(\mathbf{b}^t \widehat{\mathbf{R}}_x^{-1} \mathbf{b}) \mathbf{a}^t \widehat{\mathbf{R}}_x^{-1} - (\mathbf{a}^t \widehat{\mathbf{R}}_x^{-1} \mathbf{b}) \mathbf{b}^t \widehat{\mathbf{R}}_x^{-1}}{(\mathbf{a}^t \widehat{\mathbf{R}}_x^{-1} \mathbf{a})(\mathbf{b}^t \widehat{\mathbf{R}}_x^{-1} \mathbf{b}) - (\mathbf{a}^t \widehat{\mathbf{R}}_x^{-1} \mathbf{b})^2} \mathbf{x}(p)$$

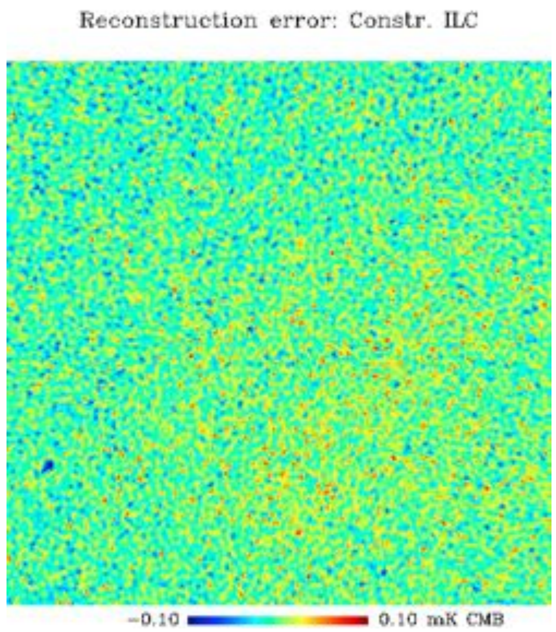
Constrained ILC

M. Remazeilles, J. Delabrouille, J.-F. Cardoso, MNRAS 408, 2481 (2011)

Standard ILC
Reconstruction error

Constrained ILC
Reconstruction error



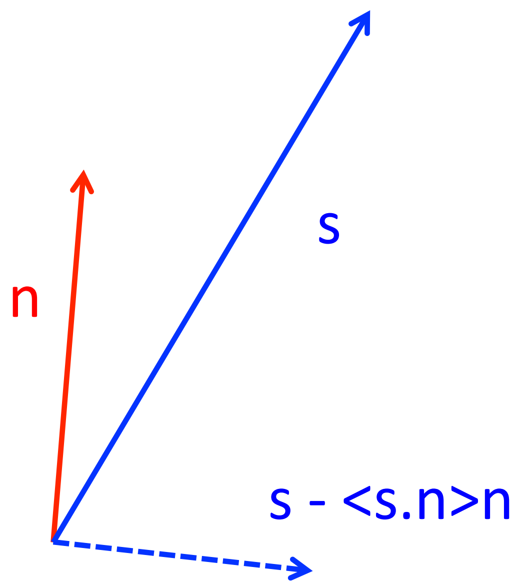


Outline

- Introduction
- Multi-component sky emission models
- Component separation
  - Planck SZ challenges
  - ILC, MF and MMF
- ILC biases
- Improving cluster counts
- Conclusion

ILC bias 1

- Example: suppose
  - x1 = s   pure signal
  - x2 = n   pure noise



- ILC solution:
  - minimize the norm of w1x1 + w2x2 with w1=1
  - Solution: w1=1, w2=-<s.n>

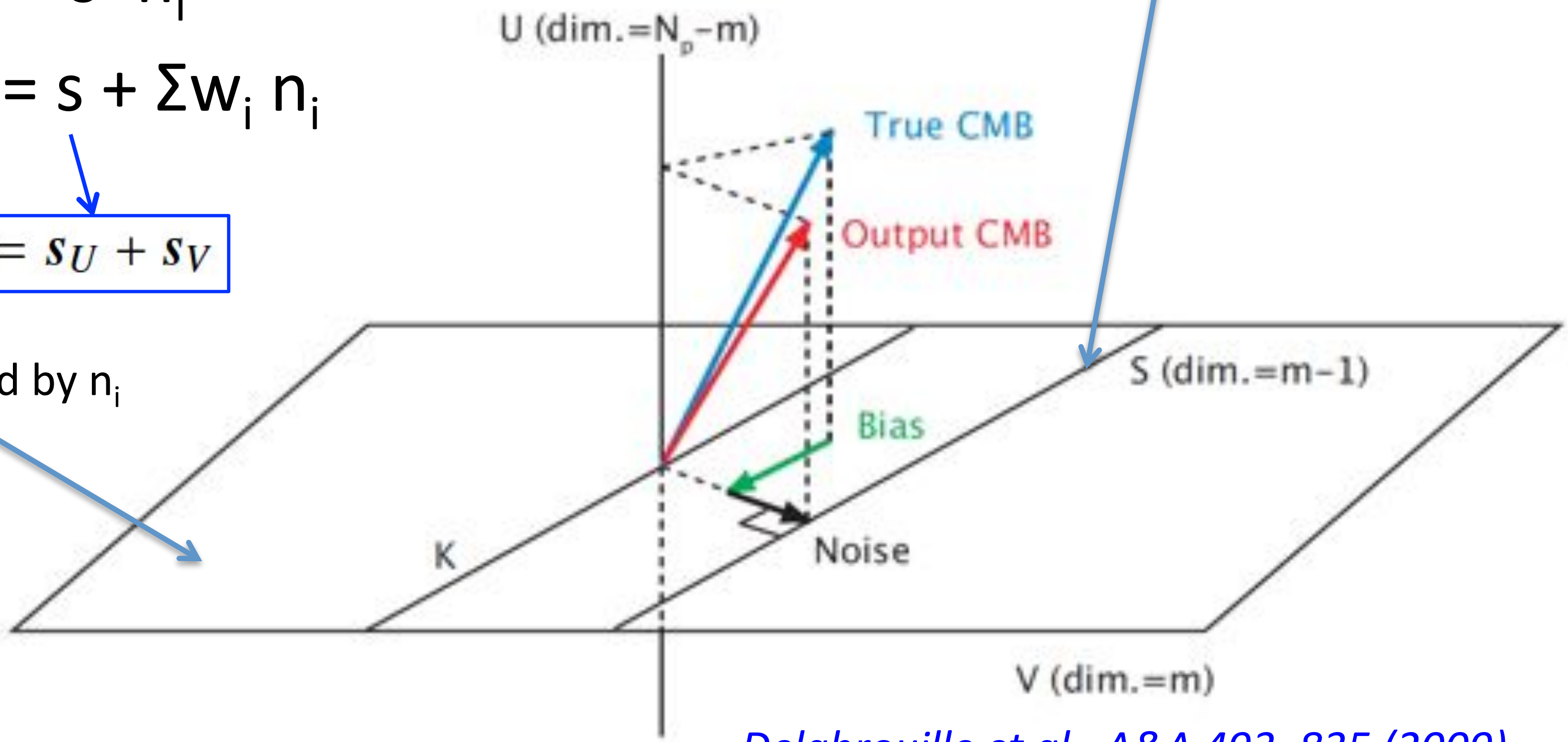
ILC bias 1

- General case:
  - $x_i = s + n_i$
  - $\underline{s} = s + \Sigma w_i\, n_i$

$$\boxed{\boldsymbol{s} = \boldsymbol{s}_U + \boldsymbol{s}_V}$$

Affine space
of all vectors $\Sigma w_i\, n_i$
such that $\Sigma w_i = 1$

Space spanned by n_i



Delabrouille et al., A&A 493, 835 (2009)

ILC bias 2

- Suppose that the data is miscalibrated
  - $x_i = (a_i+\delta_i)s + n_i$
  - The constraint $\Sigma w_i a_i=1$ does not guarantee anymore that the component of interest is conserved
  - $s = s\ (1+\Sigma w_i a_i) + \Sigma w_i n_i$
  - Example: if no noise the recovered map vanishes!

Dick, Remazeilles & Delabrouille, MNRAS 401, 1602 (2010)

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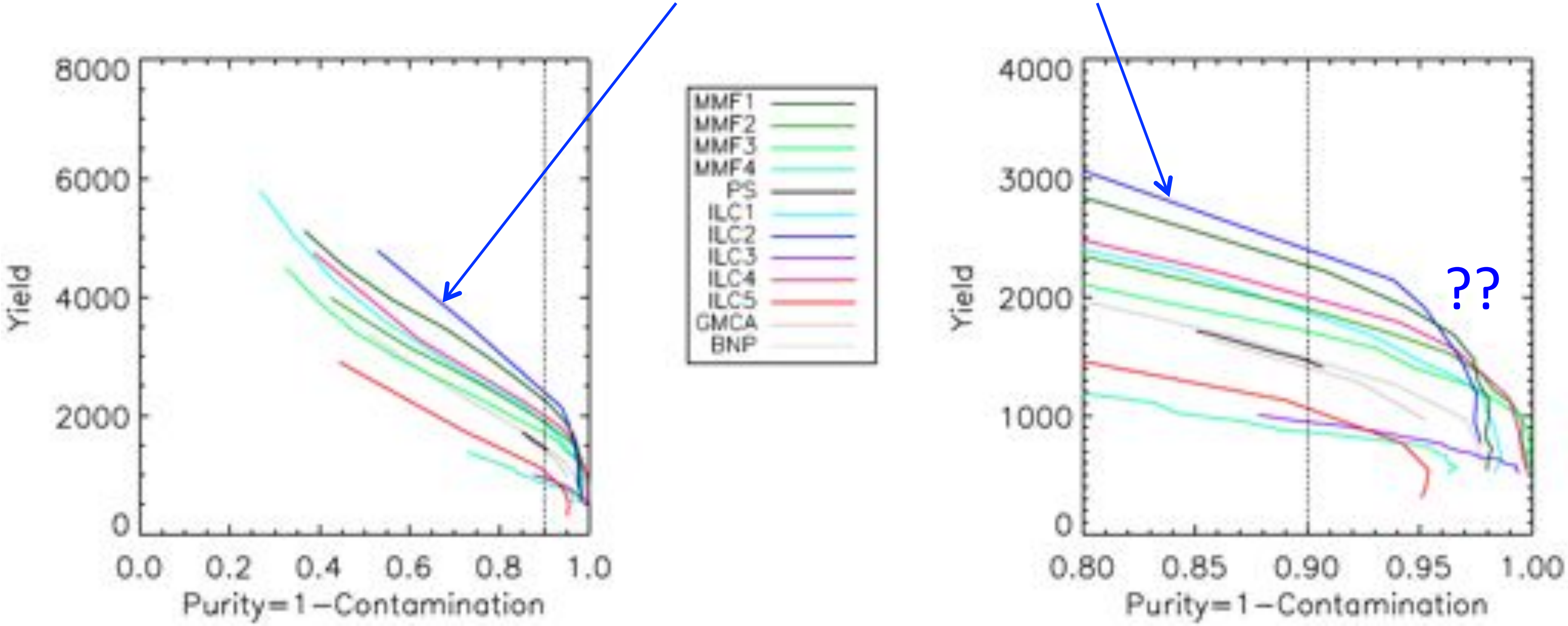
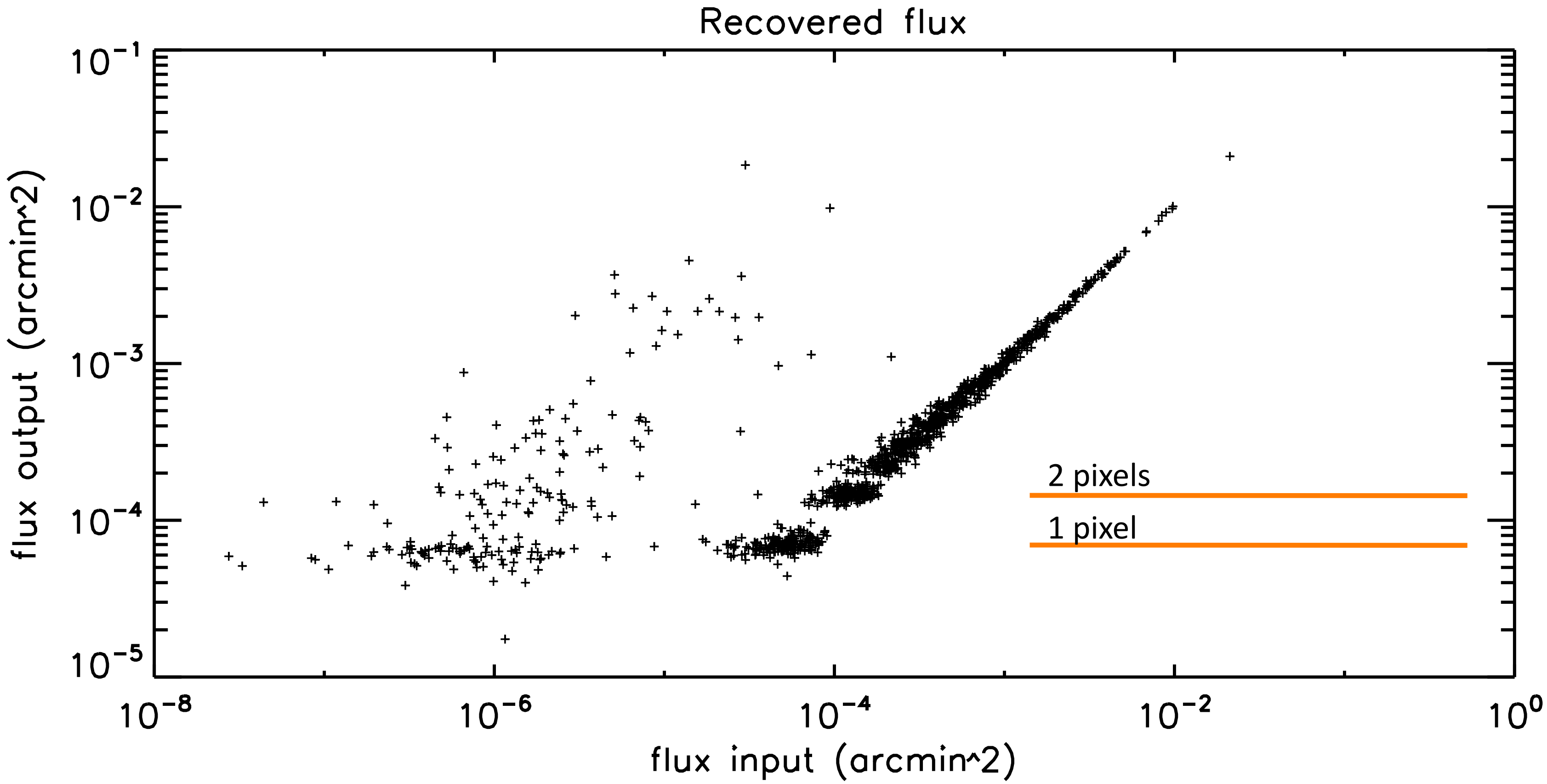
First challenge results

ILC in needlet space + Wiener filter + Sextractor

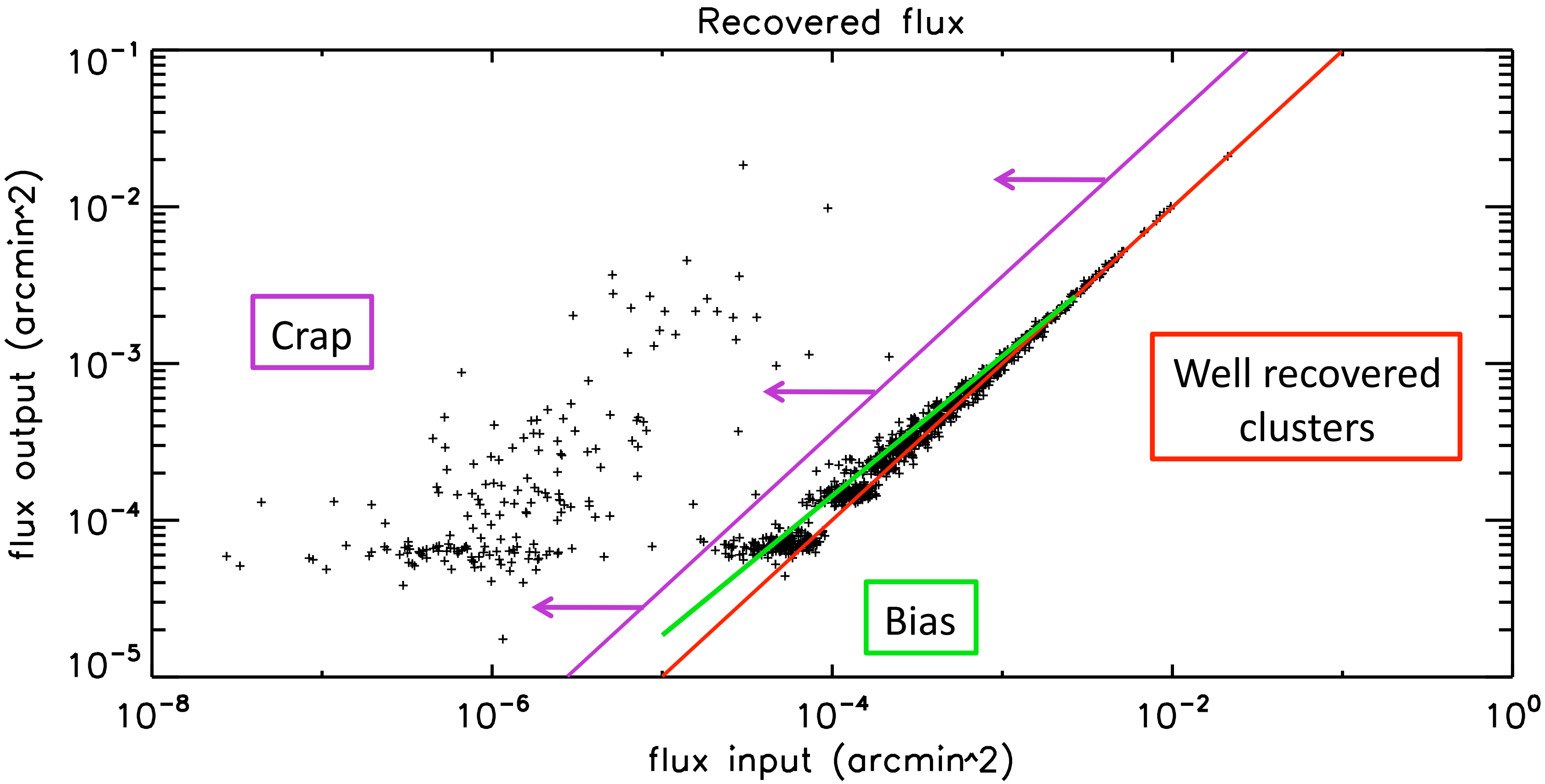


Fluxes (here sum of > 4σ pixels)

Detection of 4σ outliers in needlet ILC map of y

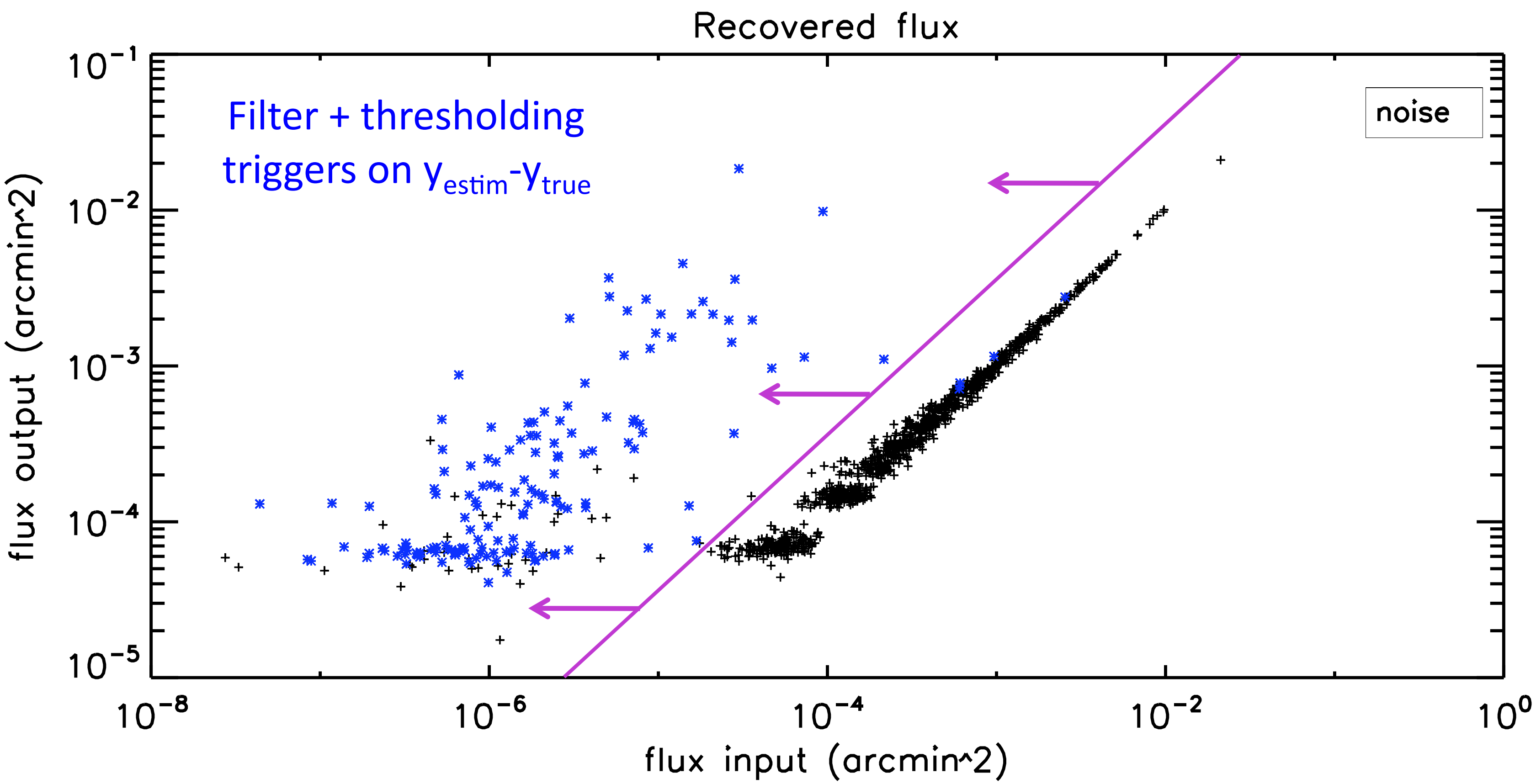


Fluxes

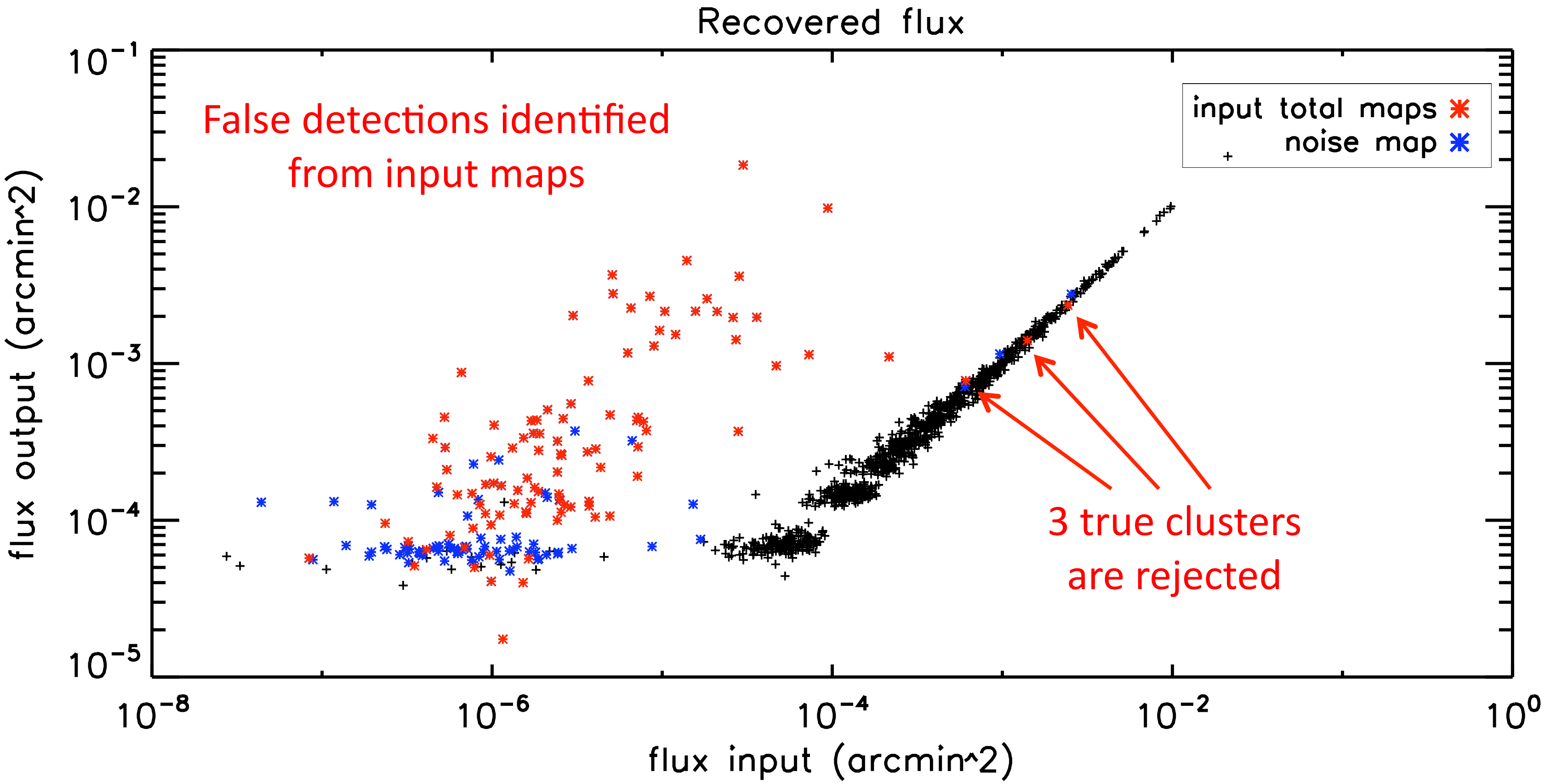


Recovered flux
flux output (arcmin^2)
flux input (arcmin^2)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-8}
10^{-6}
10^{-4}
10^{-2}
10^{0}
Crap
Well recovered clusters
Bias

False detections on error map



False detections on frequency maps



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Conclusion

- The optimisation of data analysis methods for extraction of SZ information is not trivial
- Simulations are important
- Very sensitive data sets deserve optimised analyses
- Ongoing work in the Planck collaboration