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Sparse spectral-imaging and component separation algorithms

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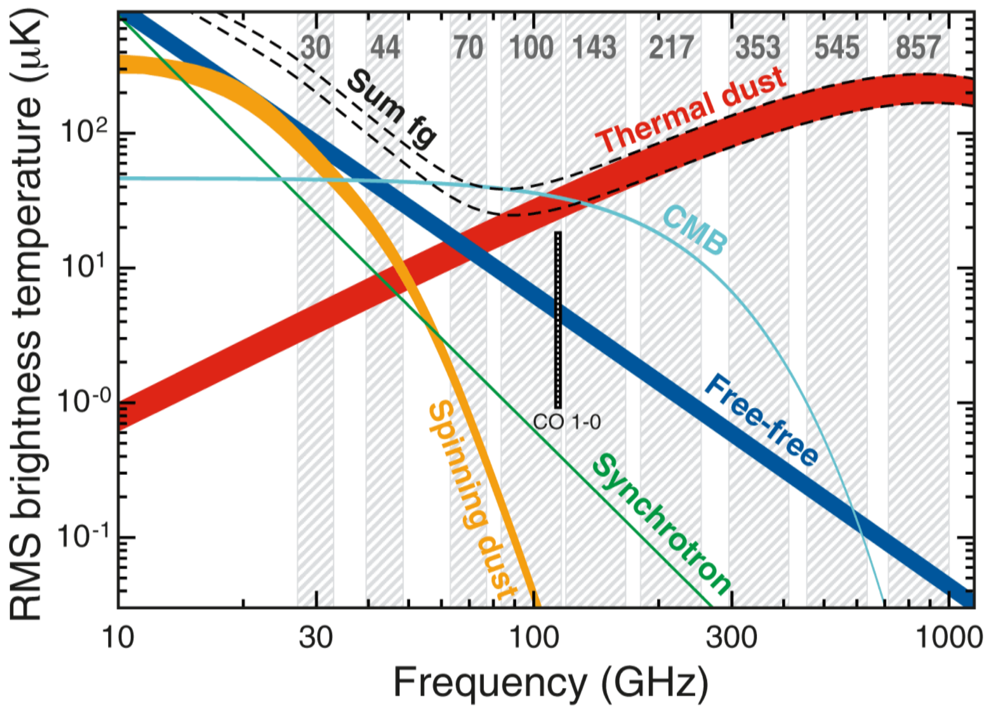
Scientific Rationale

Sparse spectral-imaging and component separation algorithms for targeted and all-sky observations in the X-ray and mm bands for Galaxy cluster analysis.



Scientific problem:

Contaminations from dust content of our Galaxy, CMB, point sources, etc.

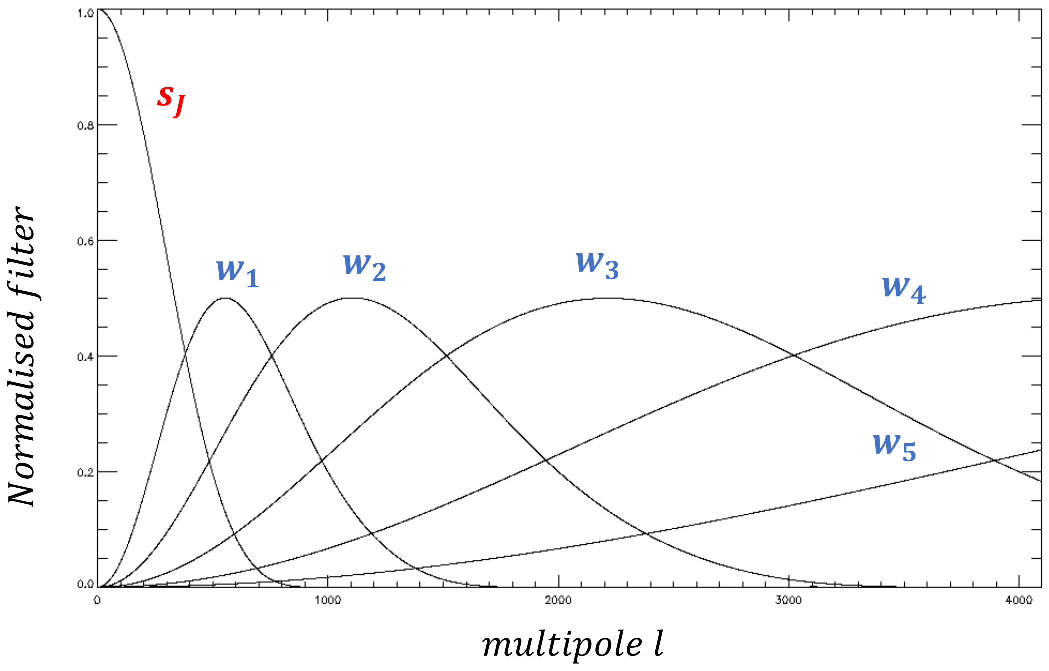
We need a component separation algorithms (on the sphere):

- Evolution of Bourdin et al. (2015), Baldi et al. (2020) method: Spectral imaging of the thermal Sunyaev–Zel'dovich effect.
- Planck HFI signals are recovered using wavelet transform.

Technical Objectives, Methodologies and Solutions

The Algorithm, in brief:

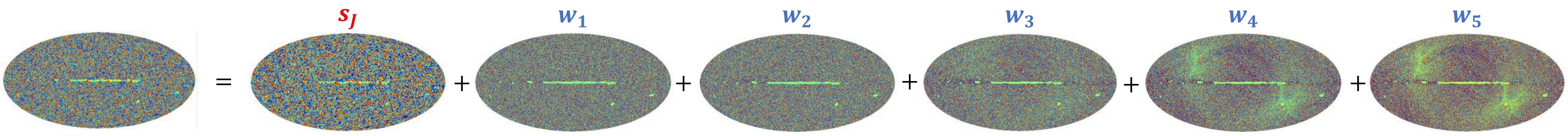
1. Produce a wavelet decomposition of the observed signal and of the (spectral) parametric component separation model;
2. The spatially variable template are then estimated considering a weighted χ^2 estimate.



Wavelet Reconstruction (over the sphere):

$$s_0(\theta,\phi) = s_J(\theta,\phi) + \sum_j w_j(\theta,\phi)$$

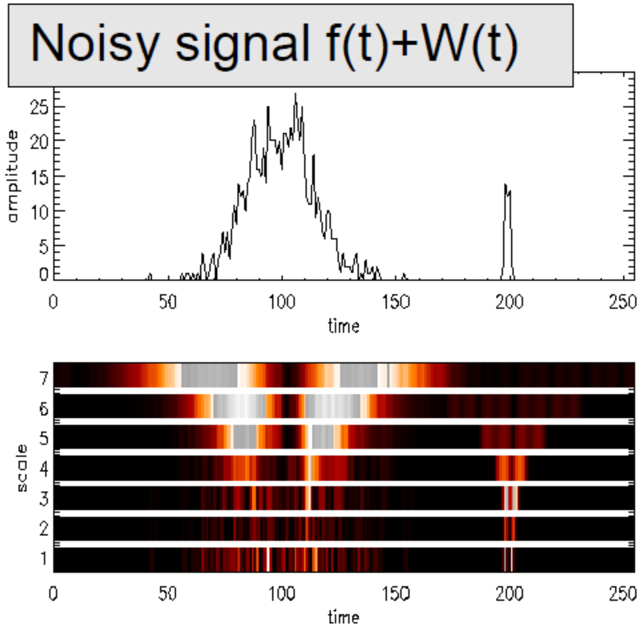
Reconstructed signal **Coarse smoothed map** **Fitted j-th wavelet scales**



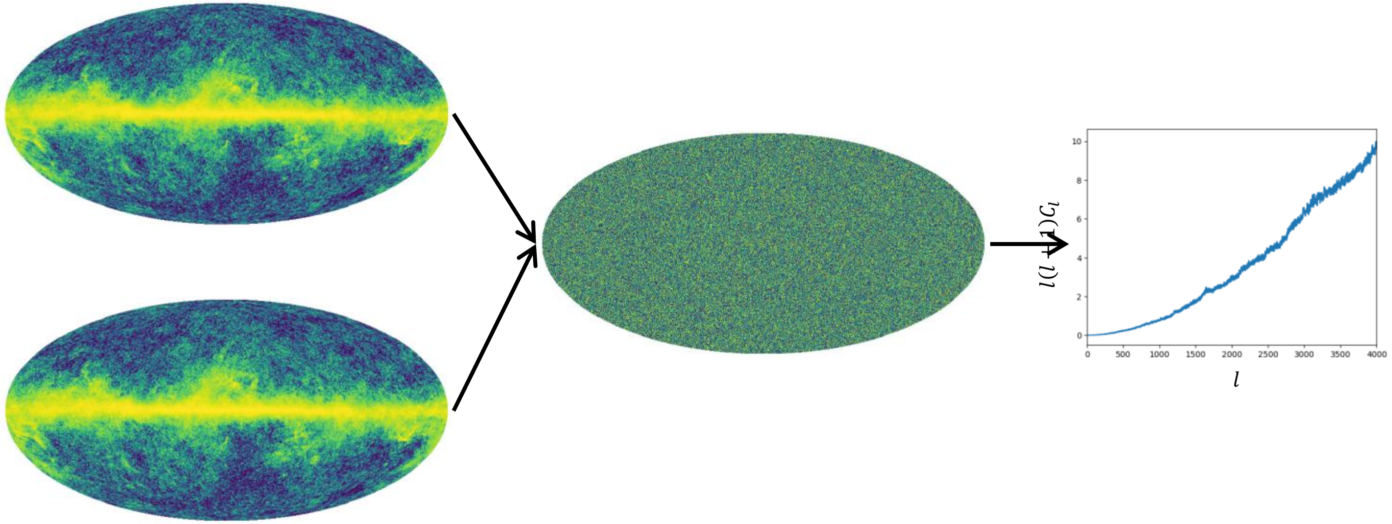
Technical Objectives, Methodologies and Solutions

Advantages of wavelet formalism:

Representation of the signals in both the time and frequency domains. Signal is sparse in wavelet bases, noise is dense (can be removed via thresholding).



Noise characterization: noise PS from Planck half ring maps:



Main Results

M9

M10-i

M10

Implementation of the deconvolution algorithm for the Sparse representations for spectral-imaging codes. ✓

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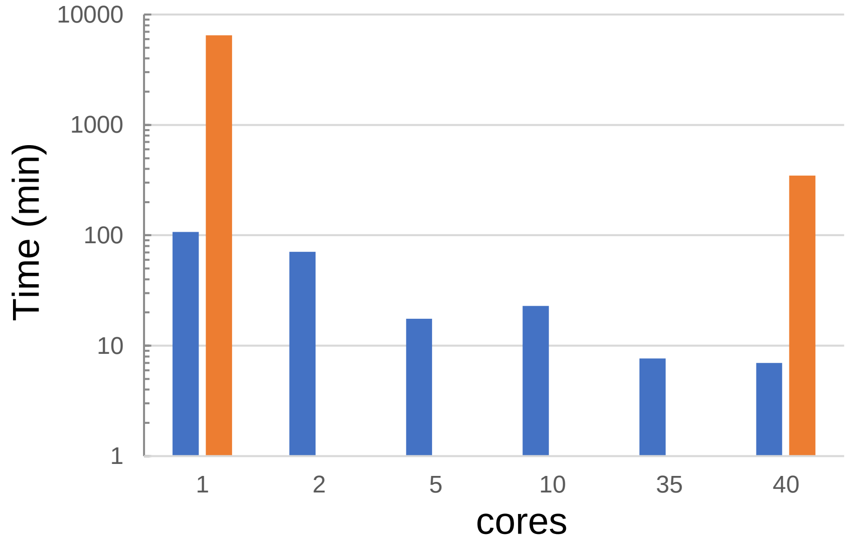
Testing application on HPC/HTC Clusters.
Performed on INAF Pleiadi: tested scaling and portability (e.g. with Apptainers) on HPC systems.



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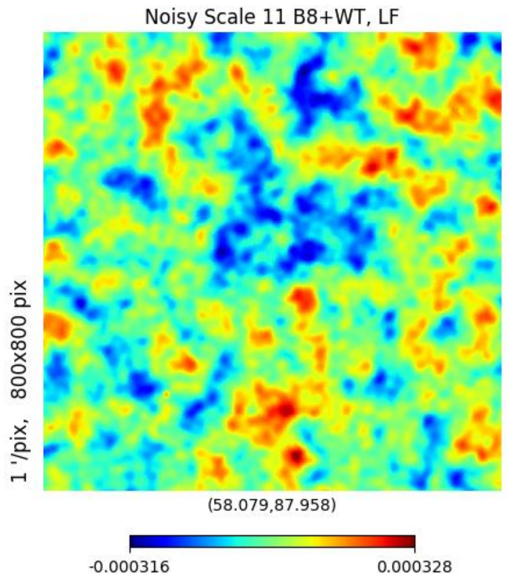
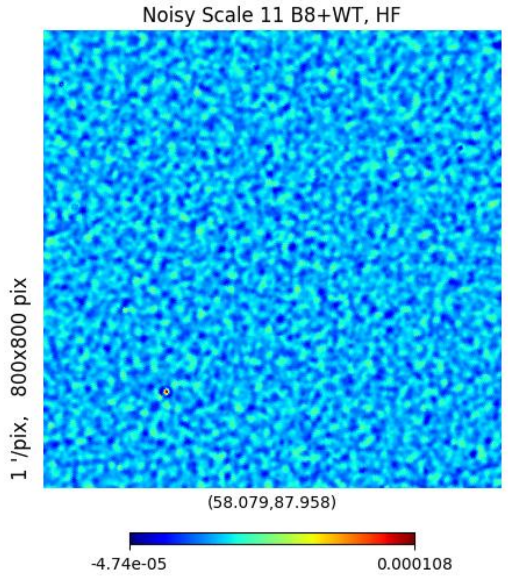
Coding the noise estimate and its propagation to the results with noise simulations (ongoing, but in time with timescales)





Final Steps

- **Codes optimization;**
- **Final validation of the noise simulation code;**
- **Perform of the noise simulations;**

Q&A

Are the results in line with timescale, milestones and KPIs identified?

- Yes.

What are the key bottleneck?

- I/O operations and disk space: final maps ~3GB, intermediate ~46GB (for each scale)!

What resources may you need?

- For 100 simulations we require up to 23TB (if all must be stored, if only final results, "just" 1.5TB…)

Thanks for the attention!