Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
ICSC Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

SPARSE REPRESENTATIONS FOR SPECTRAL IMAGE ALGORITHMS

S. Ferretti, F. De Luca, H. Bourdin, P. Mazzotta

Spoke 3 II Technical Workshop, Bologna Dec 17 -19, 2024

Scientific Rationale

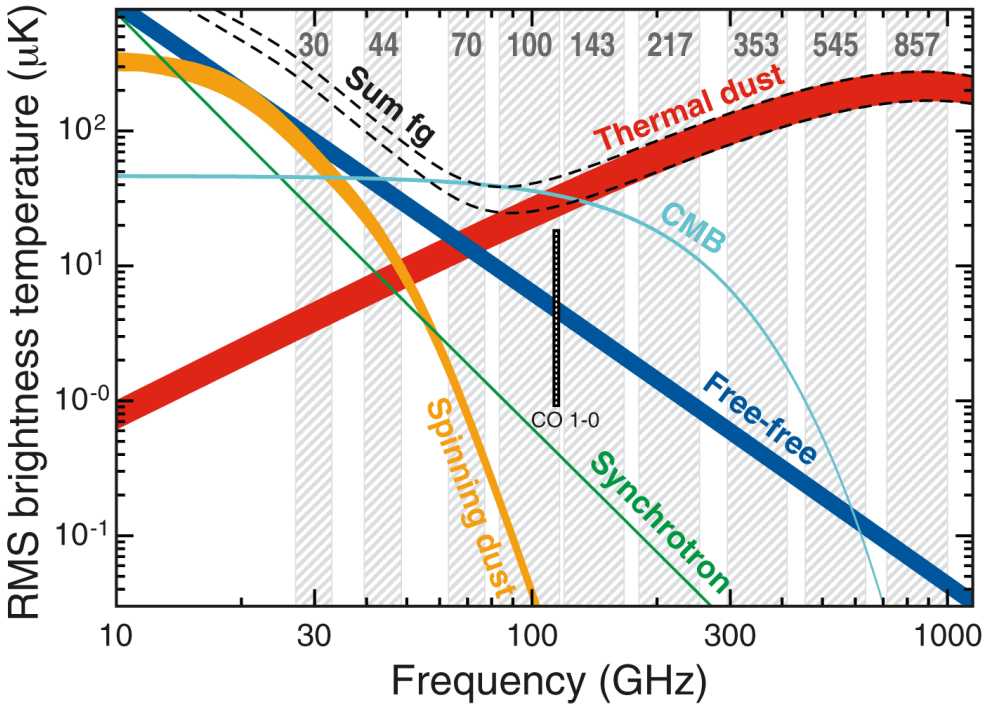
Sparse spectral-imaging and component separation algorithms for targeted and all-sky observations in the X-ray and mm bands for Galaxy cluster analysis.

Scientific problem:

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

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

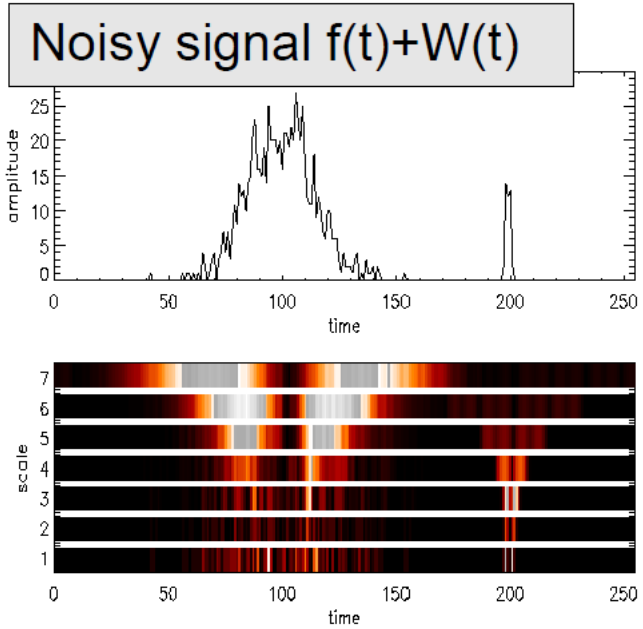
- Evolution of Bourdin et al. (2015), Baldi et al. (2020) method: Spectral imaging of the thermal Sunyaev–Zel'dovich effect.
- Planck HFI signals are recovered using wavelet transform.

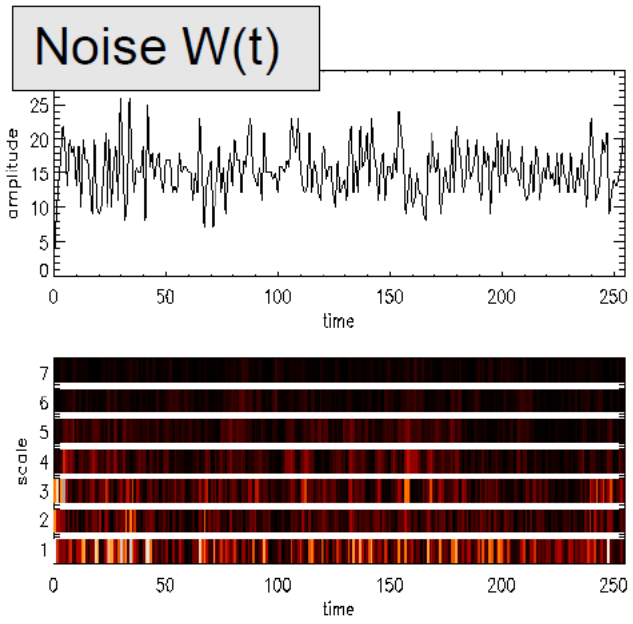


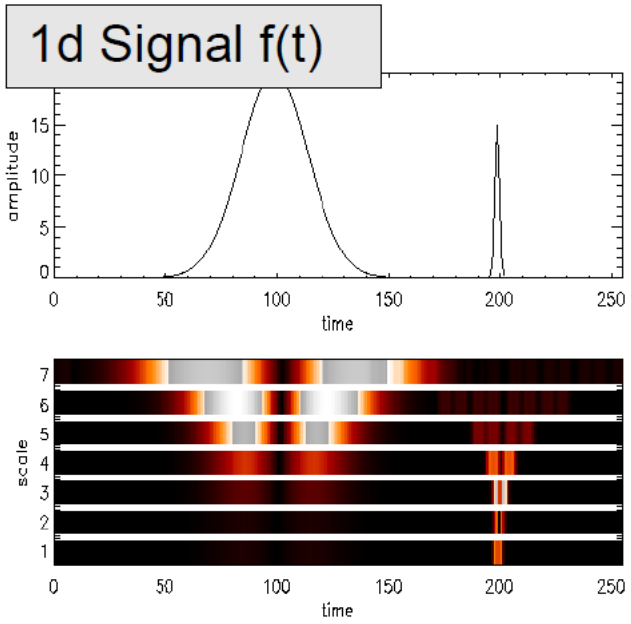
Technical Objectives, Methodologies and Solutions

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).



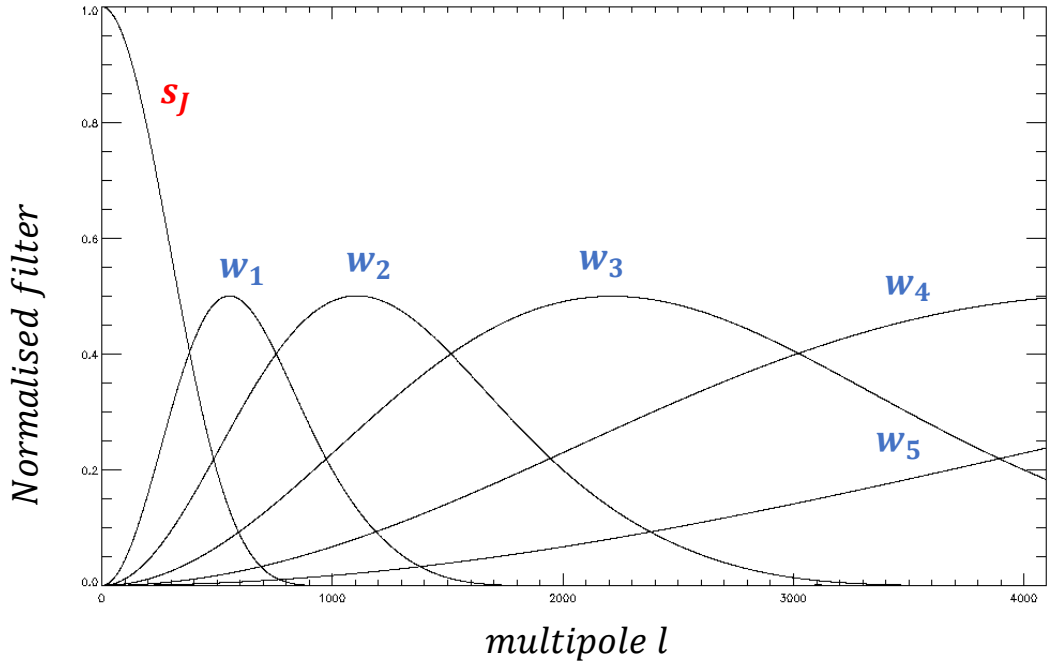




Technical Objectives, Methodologies and Solutions

The Algorithm, in brief:

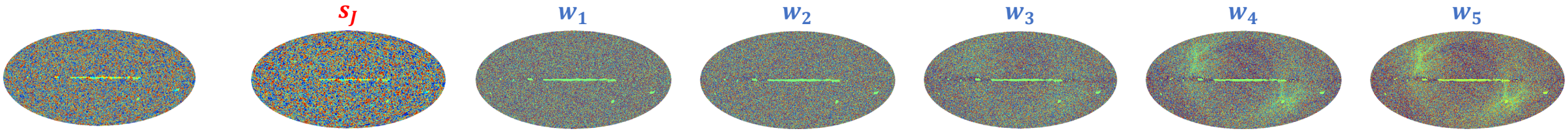
1. Produce a wavelet decomposition of the observed signal and of the (spectral) parametric component separation model;
2. The spatially variable template are then estimated considering a weighted χ^2 estimate.



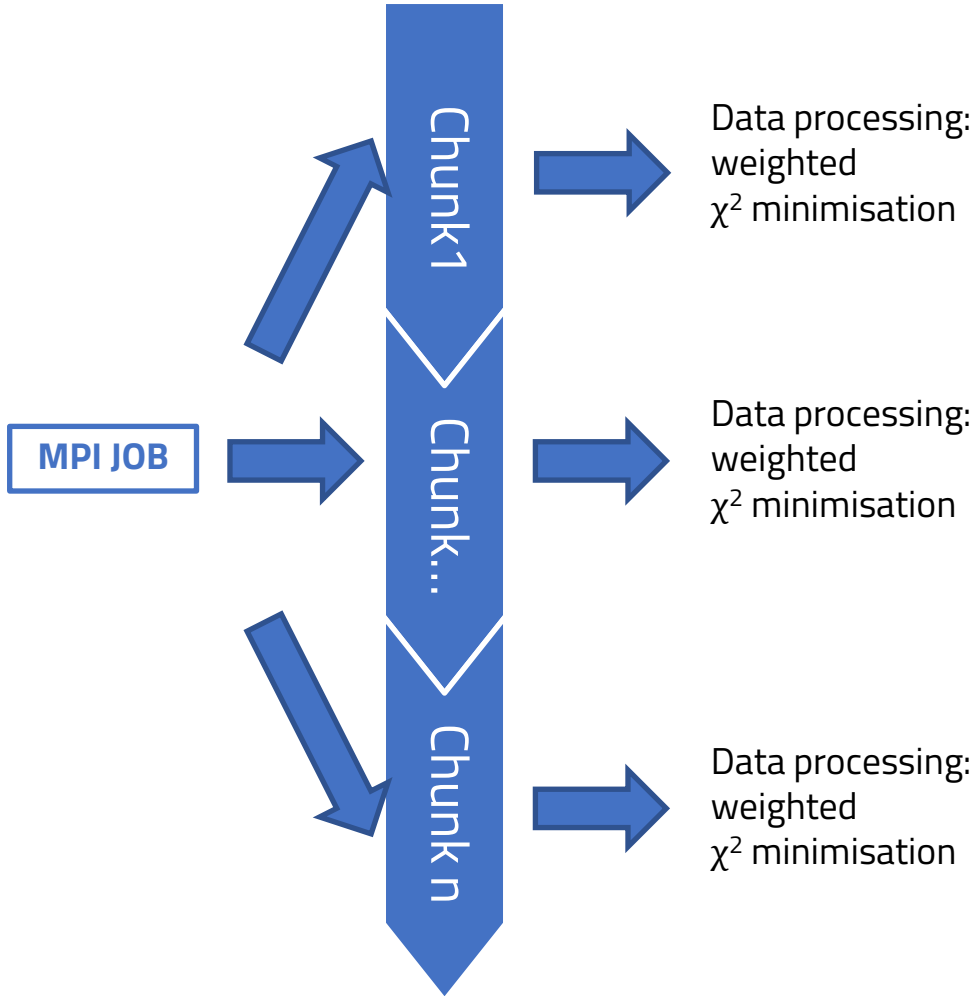
Wavelet Reconstruction (over the sphere):

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

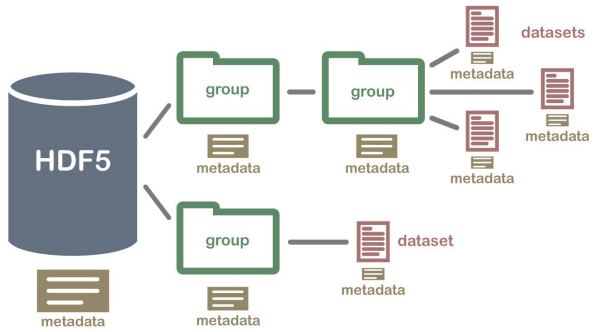
Reconstructed signal **Coarse smoothed map** **Fitted j-th wavelet scales**



Technical Objectives, Methodologies and Solutions



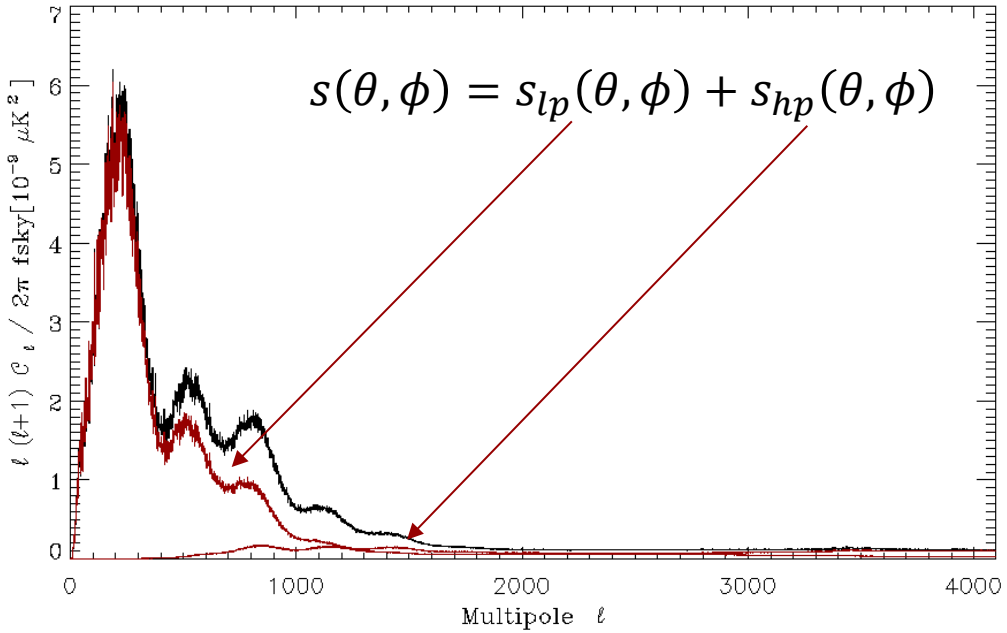
- Chunk subdivision
  - MP(I) dataset subdivision
- Parallel I/O
  - H5Pset_fapl_mpio(...);
  - H5FD_MPIO_COLLECTIVE
- Memspace/Dataspace



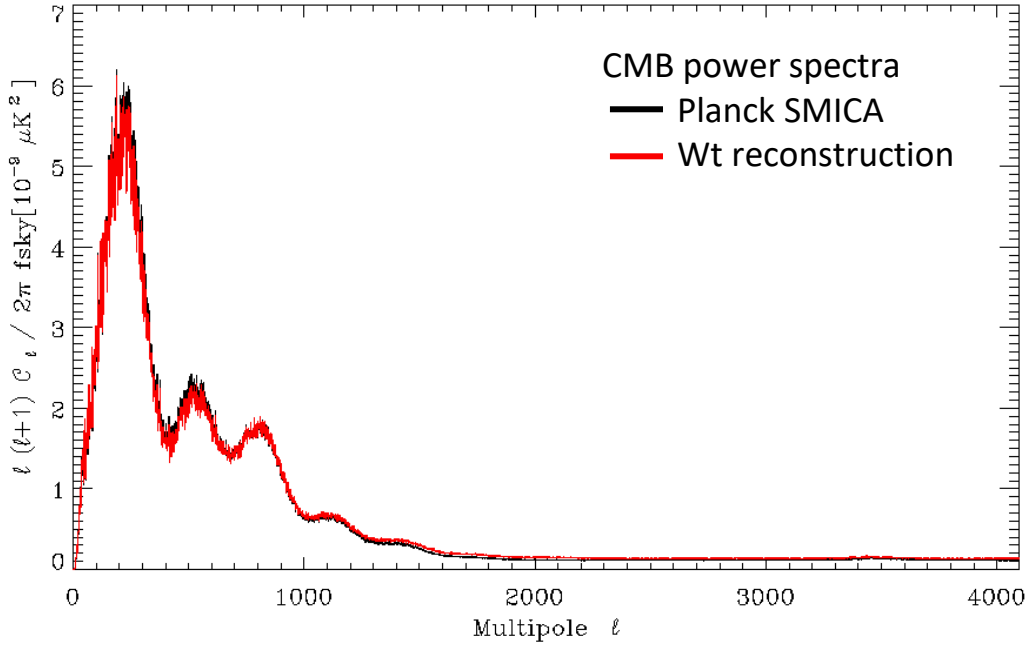
Main Results

HFI Channels have different resolutions. Need a deconvolution scheme to account for the different beam sizes. Achieved dividing the data in two with a low-pass (>10′) and high-pass filter.

100GHz	143GHz	217GHz	353GHz	545GHz	857GHz
9.66’	7.27’	5.01’	4.86’	4.84’	4.63’



Target component separation maps resolution: 5′



Final Steps

Codes optimization;

Full portability of all the codes;

Uncertainties estimation of the scientific method and deconvolution;

Q&A

Could you complete the project by February 2026?

- Yes.

What are the key bottleneck?

- Possible hardware failures (let's hope not).

What resources do you need?

- Towards the completion of the last code, we can have a real prediction of this.


Thanks for the attention!