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ICSC Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

SPARSE REPRESENTATIONS FOR SPECTRAL IMAGE ALGORITHMS

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Scientific Rationale

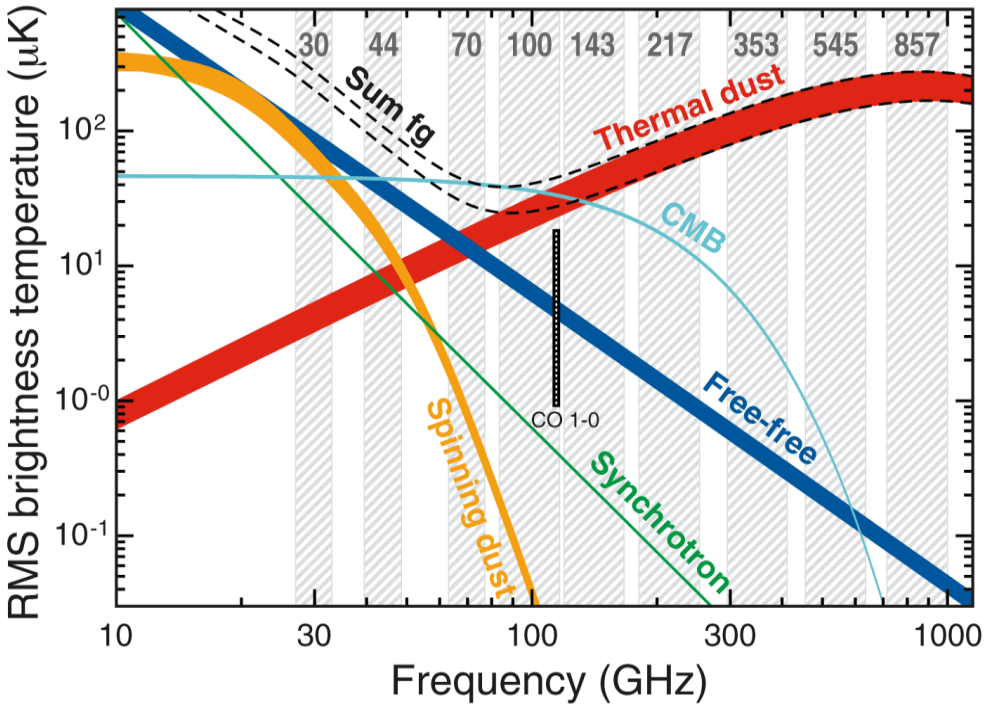
Sparse spectral-imaging and component separation algorithms for targeted and all-sky observations in the X-ray and mm bands for Galaxy cluster (or CMB) analysis.

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

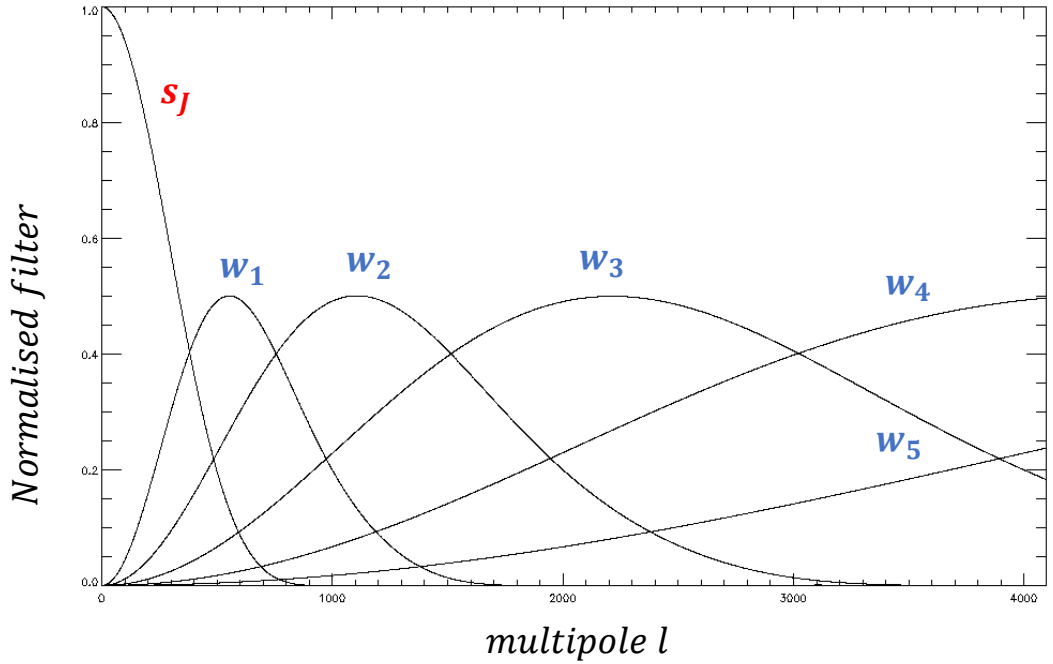
Advantages of wavelet formalism:

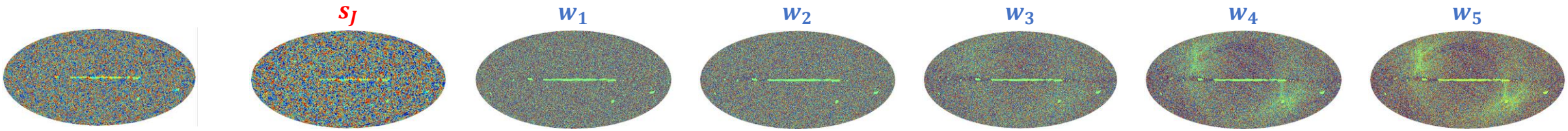
Representation of the signals in both the time and frequency domains. Signal is sparse in wavelet bases, noise is dense (can be removed via thresholding). The spatially variable template are then estimated considering a weighted χ^2 estimate.

Wavelet Reconstruction (over the sphere):

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

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





Technical Objectives, Methodologies and Solutions

Technical Objectives

- Use Open-Source Programming Language
- Meet IVOA requirements
- Optimize the code
- Make the code usable in HPC Clusters

Methodologies and Solutions

- Code Versioning
- Open libraries
- Open debug tools
- HTC cluster for testing

Timescale, Milestones and KPIs

03/23 Start
- Project kick off.

06/23 Catania report
- **IDL to C** porting of BSP map reconstruction code;
- Single core to **Multi-threads** code **with openMP**;
- I/O from proprietary IDL **.sav** file to **.fits** format.

10/23 Trieste
- New parallel scheme: openMP **to MPI**;
- New I/O formats: from **.fits** to **HDF5**;
- Code review.

05/24 Elba
- **IDL to C** porting of Wavelet reconstruction code, **MPI, HDF5**;
- Codes optimization & review;
- Test on clusters.

Next Milestones
- Deprojection code;
- Uncertainties estimation of the scientific method;
- New algorithms.

KPIs

Computation time Optimization
- At least a factor 2 *wrt* the IDL version.
- LT 4.5GB per cpu (on 40 cores).

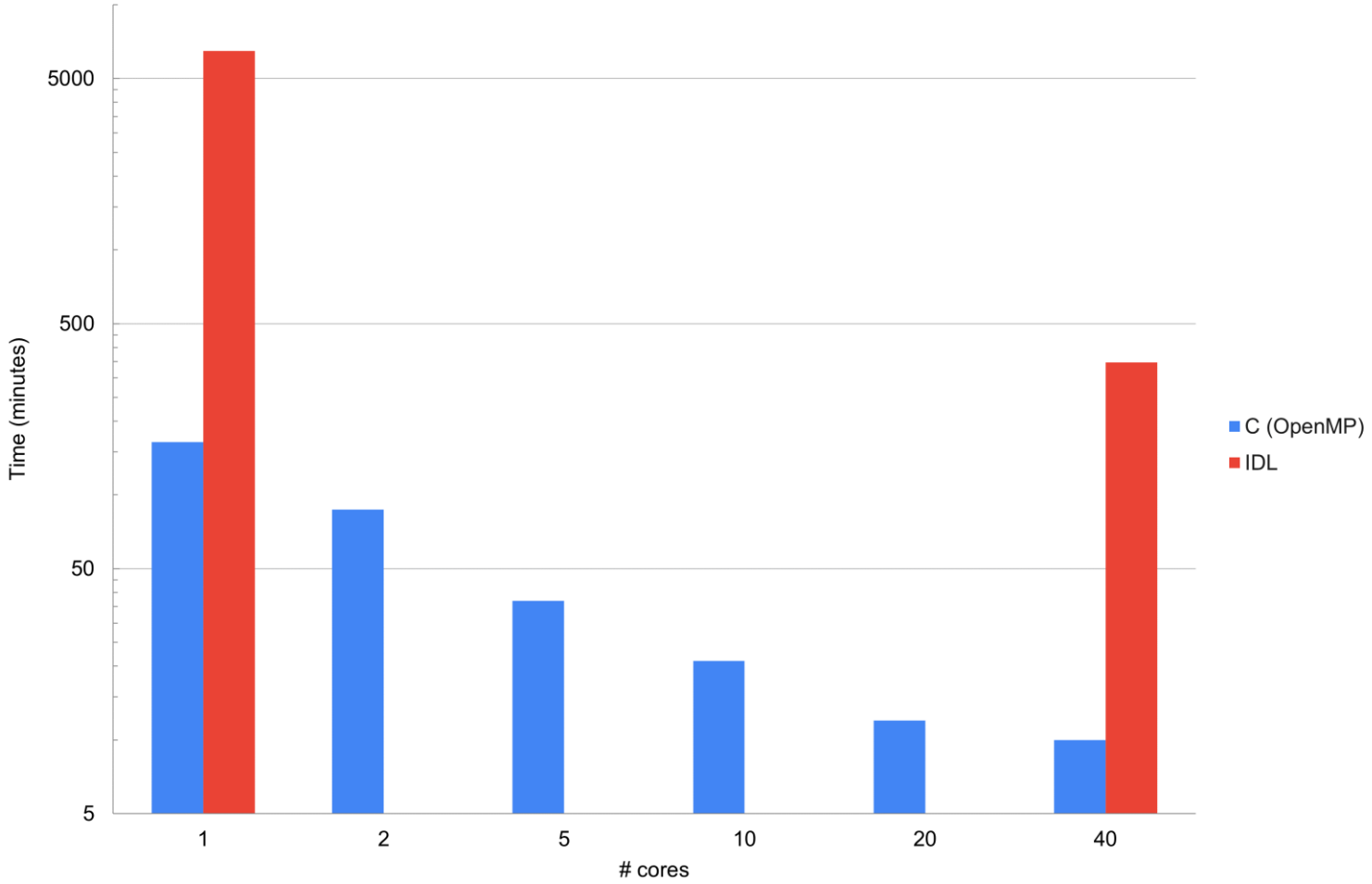
Memory Optimization
- Chunks/Hyperslab subdivision for I/O.

Documentation
- w/ Subversioning.

Accomplished Work, Results

Comparison in time performance between the original IDL implementation of the BSP (s_J) fit and the C+OpenMP porting and with I/O using HDF5.

Similar performances also for the wavelet scales code.



Next Steps and Expected Results

- **Uncertainties estimation of the scientific method and deconvolution;**
- **More astrophysical components;**
- **Possible inclusion of more instrument with different angular resolutions;**
- **Full portability of the codes;**
- **Codes optimization;**
- **Starting code review of TEPID-WINE.**


Thanks for the attention!