
Scholar:

Alyssa Johnson

Humboldt State University

Mentor:

Kevin Hufferberger

Florida State University

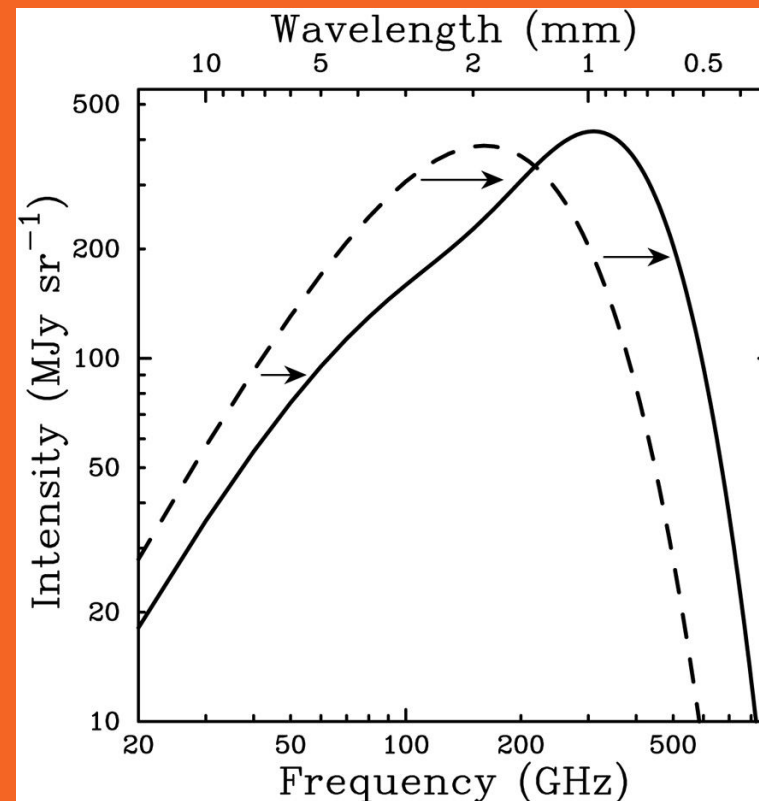
SZ galaxy clusters and dust emission in Planck data

Looking at the positions of ACTPol SZ galaxy clusters (~200) in Planck Legacy Archive data at 353, 545, 857 GHz to look for dust emission.

Sunyaev-Zeldovich Effect

“The Sunyaev-Zel'dovich (SZ) effect is the name given to the process by which the CMB blackbody spectrum is distorted by the presence of galaxy clusters. Galaxy clusters are the largest gravitationally-collapsed (virialized) structures in the universe, whose abundance and structure provide powerful probes of cosmology.”

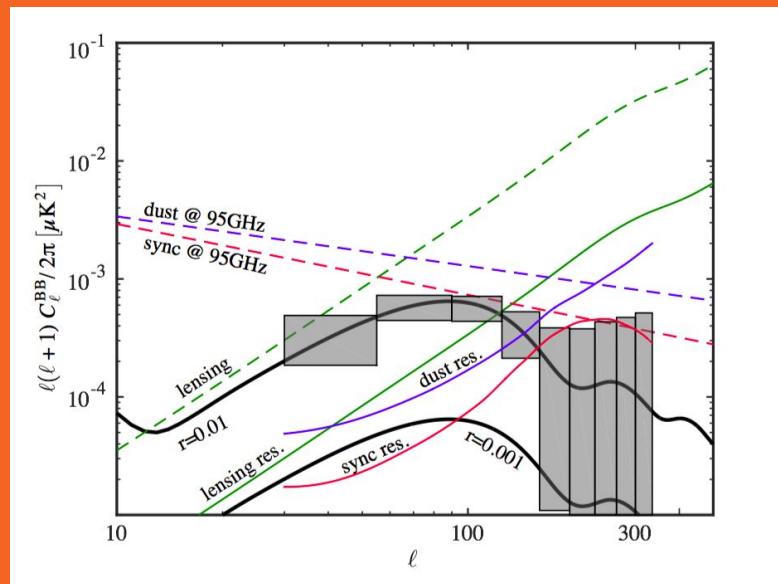
SOURCE: <https://astro.uni-bonn.de/~bertoldi/projects/sz/ringberg/img1.html>



SOURCE: Carlstrom, John E., Gilbert P. Holder, and Erik D. Reese. "Cosmology with the Sunyaev-Zel'dovich effect." *Texts in Annual Review of Astronomy and Astrophysics* 40.1 (2002): 643-680

Galactic Foregrounds & Dust Emission

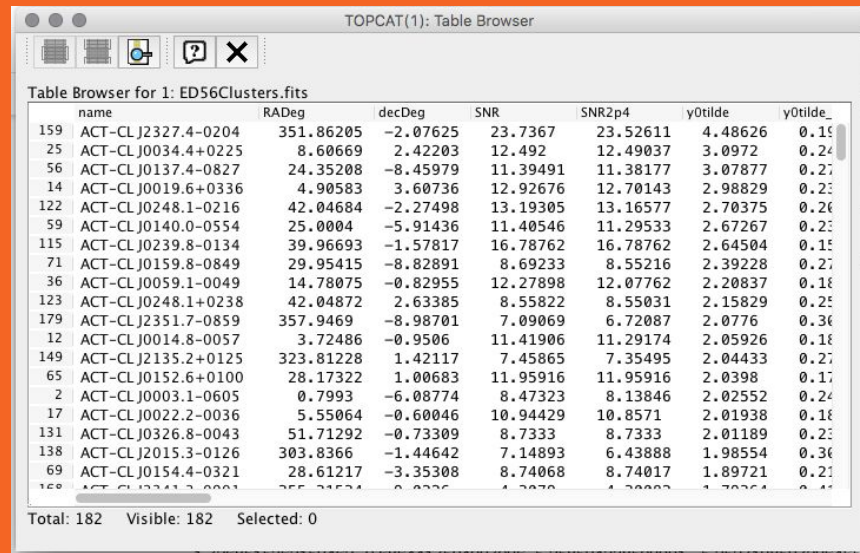
Catalogs are built locating their positions but often can be incomplete due to other emissions. Dust emission in particular can impact the completeness of a catalog.



ACTPol Cluster Catalog and Planck Legacy Archive Maps

The Atacama Cosmology
Telescope (ACT) produced catalog
SZ cluster catalog.

**List organized according to size.*



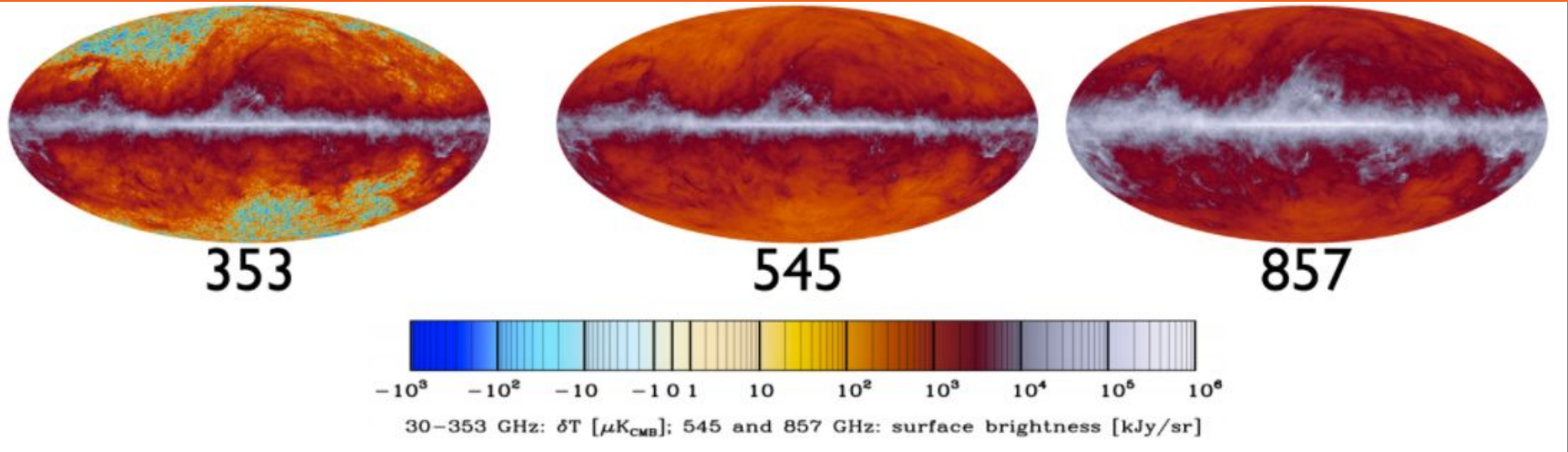
TOPCAT(1): Table Browser

Table Browser for 1: ED56Clusters.fits

	name	RADeg	decDeg	SNR	SNR2p4	y0tilde	y0tilde_
159	ACT-CL J2327.4-0204	351.86205	-2.07625	23.7367	23.52611	4.48626	0.19
25	ACT-CL J0034.4+0225	8.60669	2.42203	12.492	12.49037	3.0972	0.24
56	ACT-CL J0137.4-0827	24.35208	-8.45979	11.39491	11.38177	3.07877	0.27
14	ACT-CL J0019.6+0336	4.90583	3.60736	12.92676	12.70143	2.98829	0.23
122	ACT-CL J0248.1-0216	42.04684	-2.27498	13.19305	13.16577	2.70375	0.26
59	ACT-CL J0140.0-0554	25.0004	-5.91436	11.40546	11.29533	2.67267	0.23
115	ACT-CL J0239.8-0134	39.96693	-1.57817	16.78762	16.78762	2.64504	0.15
71	ACT-CL J0159.8-0849	29.95415	-8.82891	8.69233	8.55216	2.39228	0.27
36	ACT-CL J0059.1-0049	14.78075	-0.82955	12.27898	12.07762	2.20837	0.18
123	ACT-CL J0248.1+0238	42.04872	2.63385	8.55822	8.55031	2.15829	0.25
179	ACT-CL J2351.7-0859	357.9469	-8.98701	7.09069	6.72087	2.0776	0.36
12	ACT-CL J0014.8-0057	3.72486	-0.9506	11.41906	11.29174	2.05926	0.18
149	ACT-CL J2135.2+0125	323.81228	1.42117	7.45865	7.35495	2.04433	0.27
65	ACT-CL J0152.6+0100	28.17322	1.00683	11.95916	11.95916	2.0398	0.17
2	ACT-CL J0003.1-0605	0.7993	-6.08774	8.47323	8.13846	2.02552	0.24
17	ACT-CL J0022.2-0036	5.55064	-0.60046	10.94429	10.8571	2.01938	0.18
131	ACT-CL J0326.8-0043	51.71292	-0.73309	8.7333	8.7333	2.01189	0.23
138	ACT-CL J2015.3-0126	303.8366	-1.44642	7.14893	6.43888	1.98554	0.36
69	ACT-CL J0154.4-0321	28.61217	-3.35308	8.74068	8.74017	1.89721	0.21
168	ACT-CL J2321.3-0001	355.31524	0.00226	4.3878	4.38883	1.70364	0.41

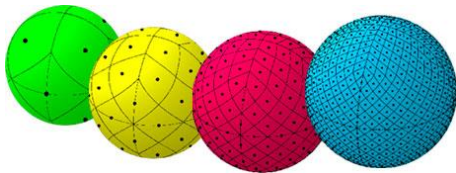
Total: 182 Visible: 182 Selected: 0

Planck Legacy Archive Maps

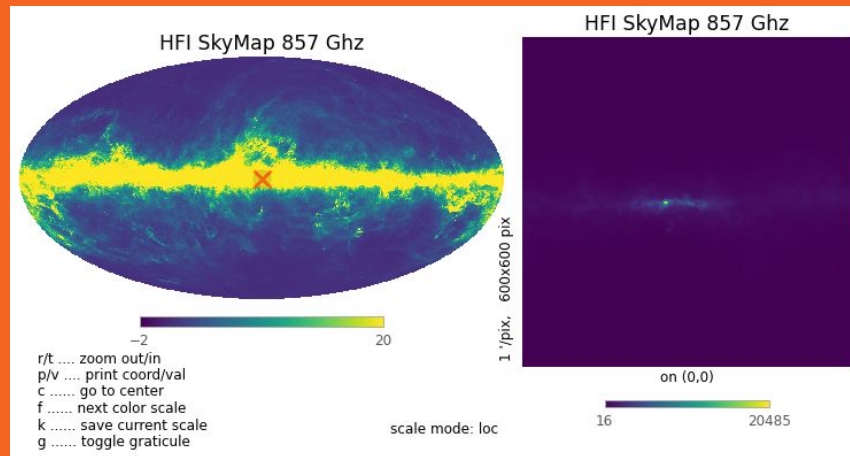


HEALPix / healpy

healpy is a Python package to handle pixelated data on the sphere. It is based on the [Hierarchical Equal Area isoLatitude Pixelization \(HEALPix\)](#) scheme and bundles the HEALPix C++ library.



Mollweide and Gnomview Projections of Planck map



TOPCAT

“TOPCAT is an interactive graphical viewer and editor for tabular data. Although a general purpose tool capable of handling large and sparse datasets with correlation functionality its specialist application area is astronomy and it was initially designed to support virtual observatories.”

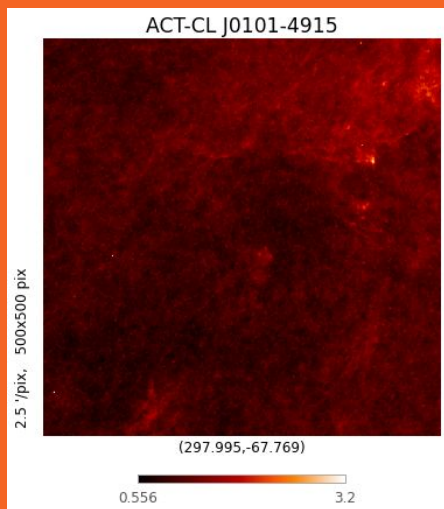
TOPCAT(1): Table Browser

Table Browser for 1: ED56Clusters.fits

	name	RADeg	decDeg	SNR	SNR2p4	y0tilde	y0tilde_
159	ACT-CL J2327.4-0204	351.86205	-2.07625	23.7367	23.52611	4.48626	0.15
25	ACT-CL J0034.4+0225	8.60669	2.42203	12.492	12.49037	3.0972	0.24
56	ACT-CL J0137.4-0827	24.35208	-8.45979	11.39491	11.38177	3.07877	0.27
14	ACT-CL J0019.6+0336	4.90583	3.60736	12.92676	12.70143	2.98829	0.23
122	ACT-CL J0248.1-0216	42.04684	-2.27498	13.19305	13.16577	2.70375	0.24
59	ACT-CL J0140.0-0554	25.0004	-5.91436	11.40546	11.29533	2.67267	0.23
115	ACT-CL J0239.8-0134	39.96693	-1.57817	16.78762	16.78762	2.64504	0.15
71	ACT-CL J0159.8-0849	29.95415	-8.82891	8.69233	8.55216	2.39228	0.27
36	ACT-CL J0059.1-0049	14.78075	-0.82955	12.27898	12.07762	2.20837	0.18
123	ACT-CL J0248.1+0238	42.04872	2.63385	8.55822	8.55031	2.15829	0.25
179	ACT-CL J2351.7-0859	357.9469	-8.98701	7.09069	6.72087	2.0776	0.34
12	ACT-CL J0014.8-0057	3.72486	-0.9506	11.41906	11.29174	2.05926	0.18
149	ACT-CL J2135.2+0125	323.81228	1.42117	7.45865	7.35495	2.04433	0.27
65	ACT-CL J0152.6+0100	28.17322	1.00683	11.95916	11.95916	2.0398	0.17
2	ACT-CL J0003.1-0605	0.7993	-6.08774	8.47323	8.13846	2.02552	0.24
17	ACT-CL J0022.2-0036	5.55064	-0.60046	10.94429	10.8571	2.01938	0.18
131	ACT-CL J0326.8-0043	51.71292	-0.73309	8.7333	8.7333	2.01189	0.23
138	ACT-CL J2015.3-0126	303.8366	-1.44642	7.14893	6.43888	1.98554	0.36
69	ACT-CL J0154.4-0321	28.61217	-3.35308	8.74068	8.74017	1.89721	0.21
158	ACT-CL J2327.4-0204	351.86205	-2.07625	23.7367	23.52611	4.48626	0.15

Total: 182 Visible: 182 Selected: 0

ACT-CL J0102-4915 El-Gordo

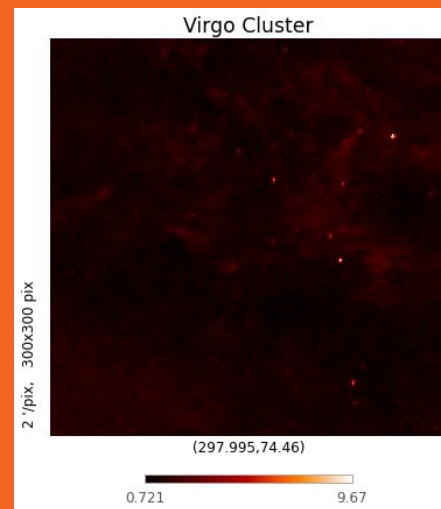


Gal coord. (ep=J2000) : 297.99465; -67.76902

SOURCE: Simbad - Basic Data

<http://simbad.u-strasbg.fr/simbad/sim-id?Ident=ACT-CL+J0102-4915>

Virgo Cluster



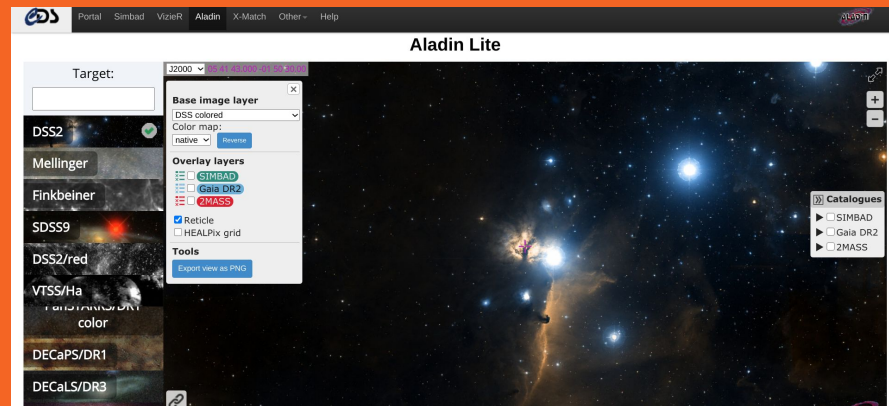
Gal coord. (ep=J2000) : 279.6763; +74.4596

SOURCE: Simbad - Basic Data

<http://simbad.u-strasbg.fr/simbad/sim-id?Ident=Virgo+Cluster>

Aladin Lite

“Aladin lite is a lightweight version of the Aladin Sky Atlas, running in the browser and geared towards simple visualization of a sky region.”



Matched Filtering

Matched filtering is a process for detecting a known piece of signal or wavelet that is embedded in noise.

```
# Matched filter, I use the noise spectra as the filter
# this is the denominator in the matched filter equation
norm = np.sum( (2*ell_arr + 1) * b_ell**2 / Nell ) / (4*np.pi)
#norm = np.sum( b_ell**2 / Nell)

# This is the filter
f_ell = norm2 * b_ell / Nell / norm

# I need the harmonic transform of the map
alms_tot = hp.map2alm(total_map,pol=False)
# I multiply the alms with the matched filter
alms_tot = hp.almxfl(alms_tot,f_ell)
# transform back to real space
total_MF_map = hp.alm2map(alms_tot,nside)

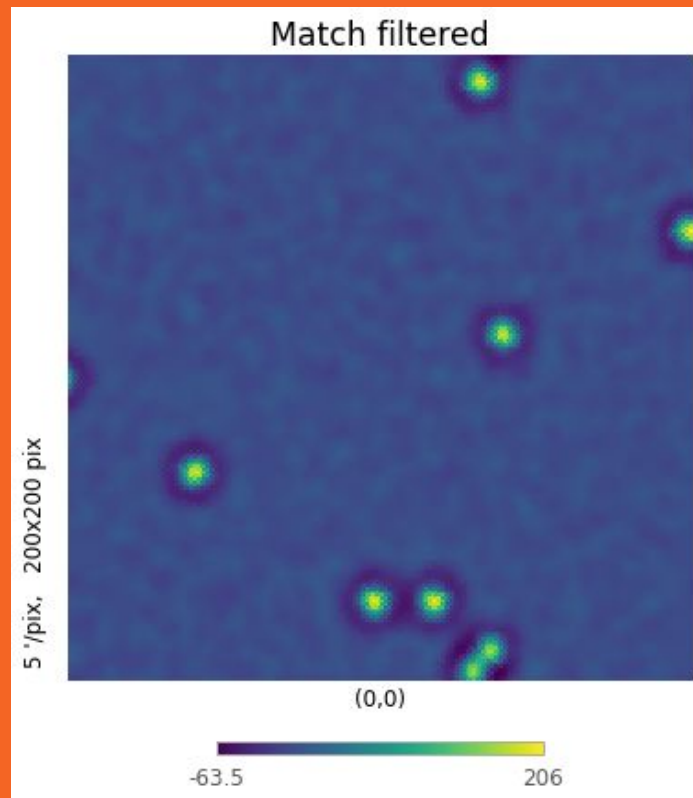
#The beam area Omega_B, in sr
Omega_B = (np.pi / 4 / np.log(2)) * np.radians(fwhm/60)**2

# total_MF_map is in uK/sr, so we need to transform back to mJy/sr now
# multiplying for the dJyK factor,
# and also multiplying by the beam solid angle in sr
total_MF_map = total_MF_map*dJyK*Omega_B

# Now total_MF_map is in mJy
hp.gnomview(
    total_MF_map,
    reso=5,
    title="Match filtered",
    cmap='viridis')
pl.show()
```

Matched Filtering

Matched filtering is a process for detecting a known piece of signal or wavelet that is embedded in noise.



Matched Filtering

Matched filtering is a process for detecting a known piece of signal or wavelet that is embedded in noise.

- Correct for dust emission
 - Neglecting to correct for dust changes the mass of the SZ cluster (other emissions include thermal and synchrotron)
 - Dust emission in particular can impact the completeness of a catalog- in the Planck mission ~9% of galaxy clusters were missing in the redshift range [0.5-0.8] (Melina et al. 2020).
-

SO-NSBP Project

- Python, TopCat, AladinLite, Healpix/healpy/astropy
- Image and data visualization techniques
- Exposure to research group settings and dynamics
- Amazing Scientist Talks and Professional Development Program
- Access to grad students for mentorship & grad school advice
- Great pathway for future
——Cosmo research

Research in the time of COVID-19

- Coding [Python, Mathematica]
- Remote learning as a great collaborative tool
- Exposure to research

Special Thanks:

Kevin Hufferberger, Florida State University
Carlos Hervias Caimapo, Florida State University
Chika Onubogu, Florida State University
Gabriela Marques, Florida State University
National Society for Black Physicists
Simons Observatory
and Kasey Wagoner, Princeton University
