Characterizing SPT-3G Extended Field Observations for Galaxy Cluster Searches

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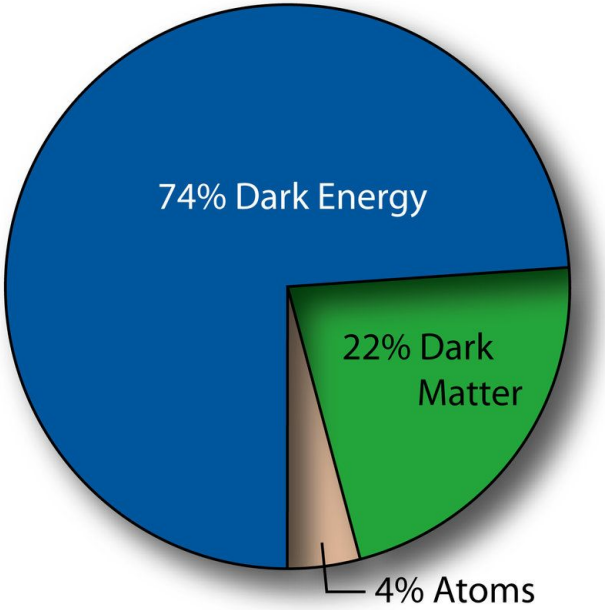
What are the mysterious dark components in our universe?

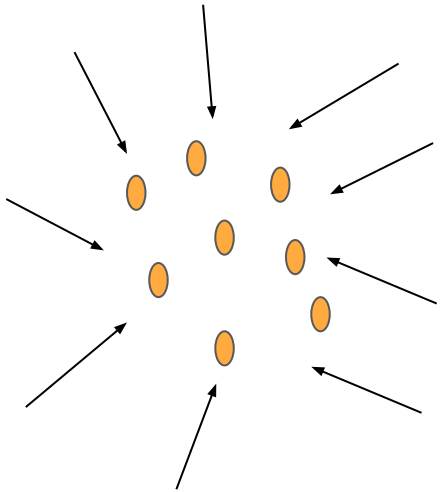
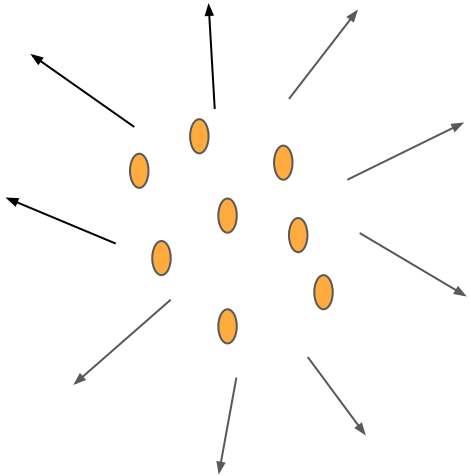


Credit: NASA/WMAP Science Team.

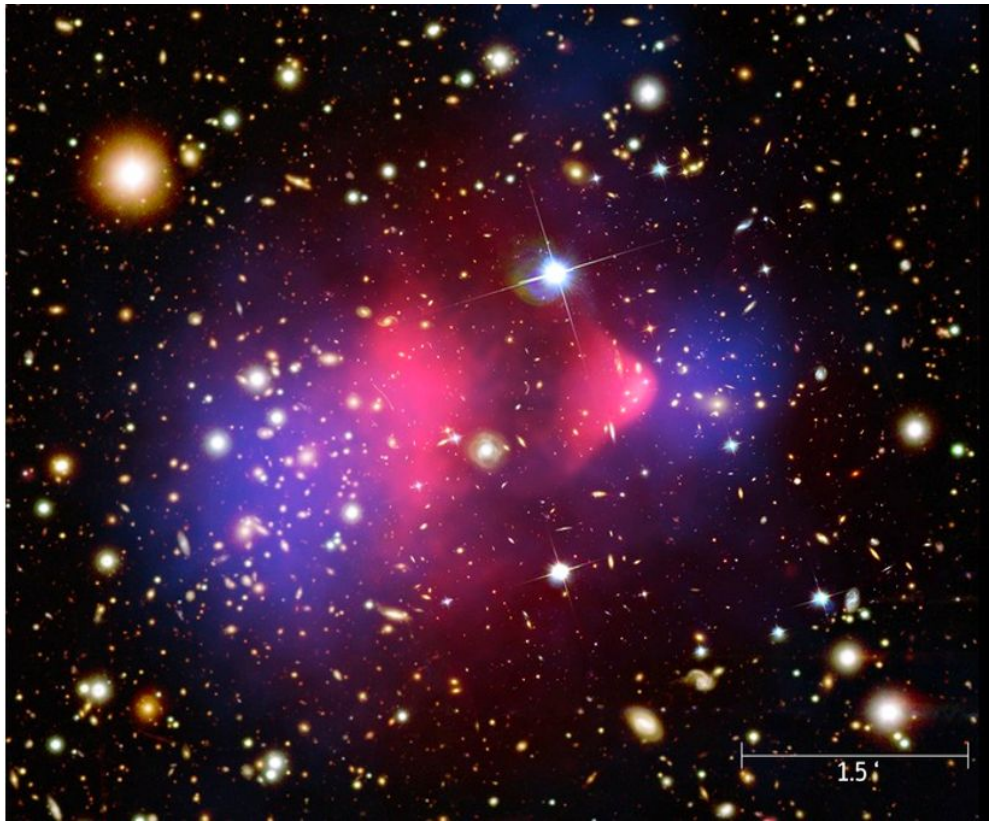
What is the nature of these dark components?

- Dark energy is a form of energy that is thought to be responsible for the accelerated expansion of the universe.

- Dark matter draws together through gravity but has not been detected.

DARK MATTER	DARK ENERGY
	
Dark matter amplifies structure formation.	Dark energy slows structure formation.

Galaxy clusters are the largest structures in the universe

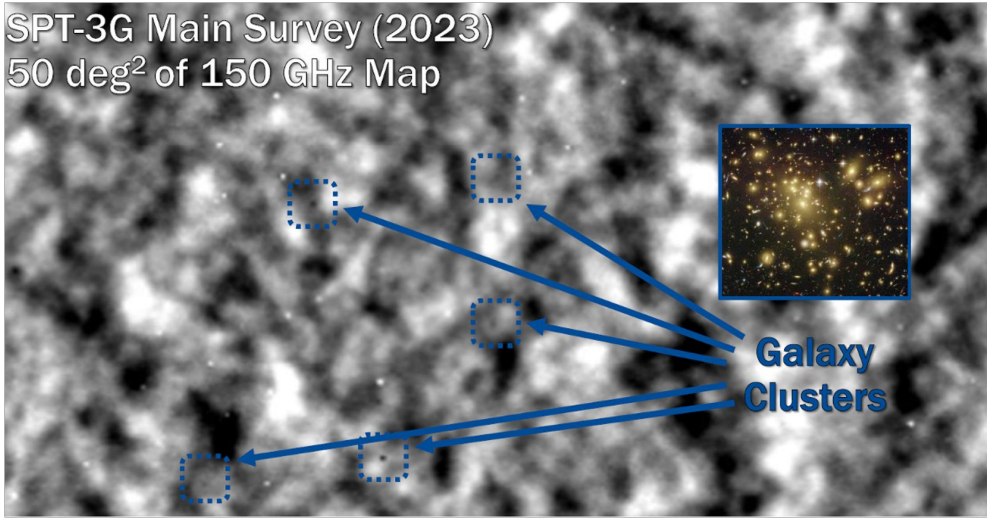


- Galaxy clusters are composed of hundreds to thousands of galaxies.
- Dark matter is 85-90% of their total mass.
- Hot gas emits X-rays and makes up 10% of the mass.
- Galaxies emit optical light and make up a small portion of the mass.
- Optical and X-ray observations dim at far distances.

Credit: NASA/WMAP Science Team.

Cosmic Microwave Background Can Be Used To Detect Clusters

- 380,000 years after the Big Bang, the CMB decoupled from matter in early universe
- Sunyaev-Zel'dovich (SZ) effect occurs when the CMB photons are blocked by galaxy clusters, creating shadows in the CMB.
- This method does not dim with distance because the CMB acts as a backlight.



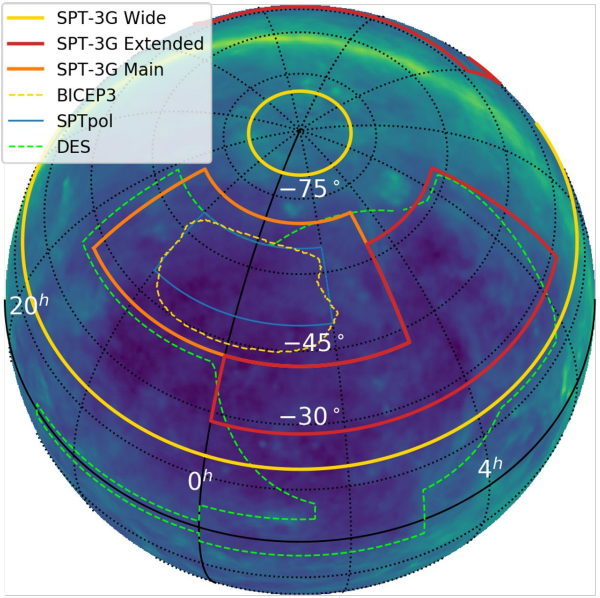
Credit: Joshua Sobrin

The South Pole Telescope measures the CMB and galaxy clusters

- The south pole is a great location to observe the CMB and galaxy clusters.
  - Atmosphere is very thin
  - Can look at same sky patch 24/7
- SPT-3G is a great instrument for improving the view of the CMB and galaxy clusters.
  - SPT-3G views the at 90,150, 220 GHZ.
  - It has 10 times more detectors than previous experiments.
  - SPT has arcminute resolution.

Credit: Daniel Luong-Van

My Project focused on the SPT extended fields.

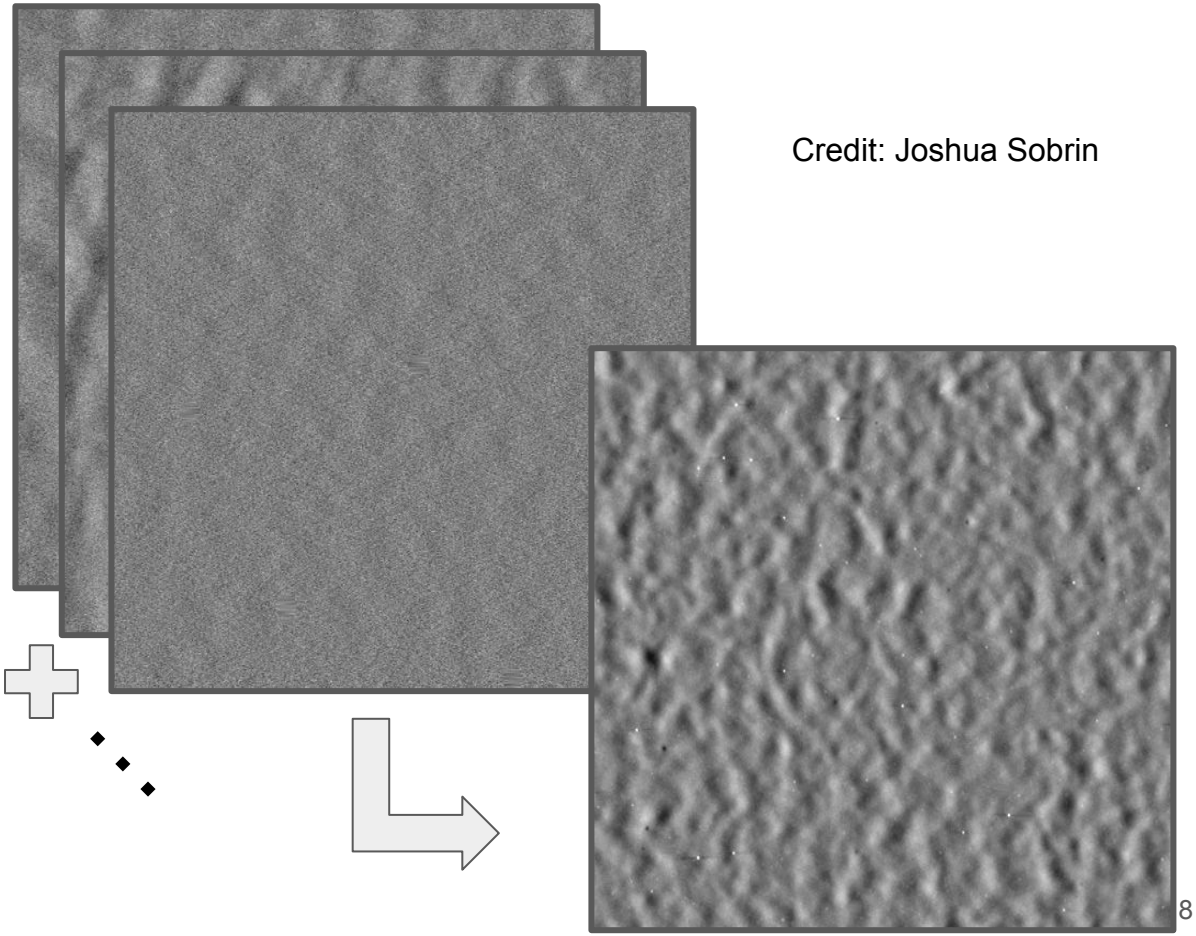


- The extended fields are observed during the austral summer because the sun infects the sky in the main field during this time.
- The extended fields are expected to detect 3 times the amount of galaxy clusters as the main field.

Credit: Brad Benson

Co-adding maps are essential for accurately finding clusters.

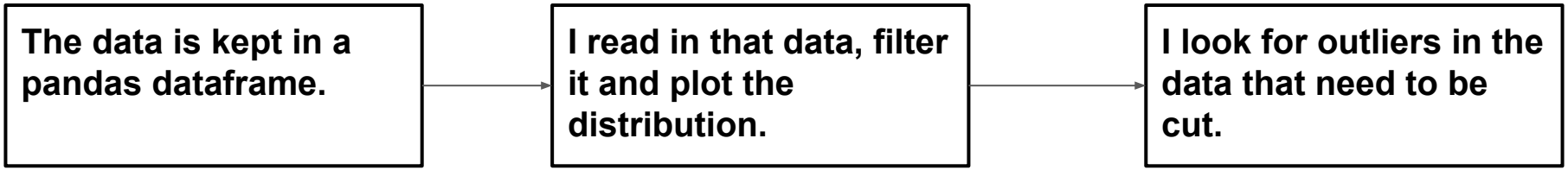
- Single observation maps have a lot of noise.
- Co-adding adds all the maps taken from the observations together.
- Co-adding result in a high signal and low noise map where we can see galaxy clusters.



Credit: Joshua Sobrin

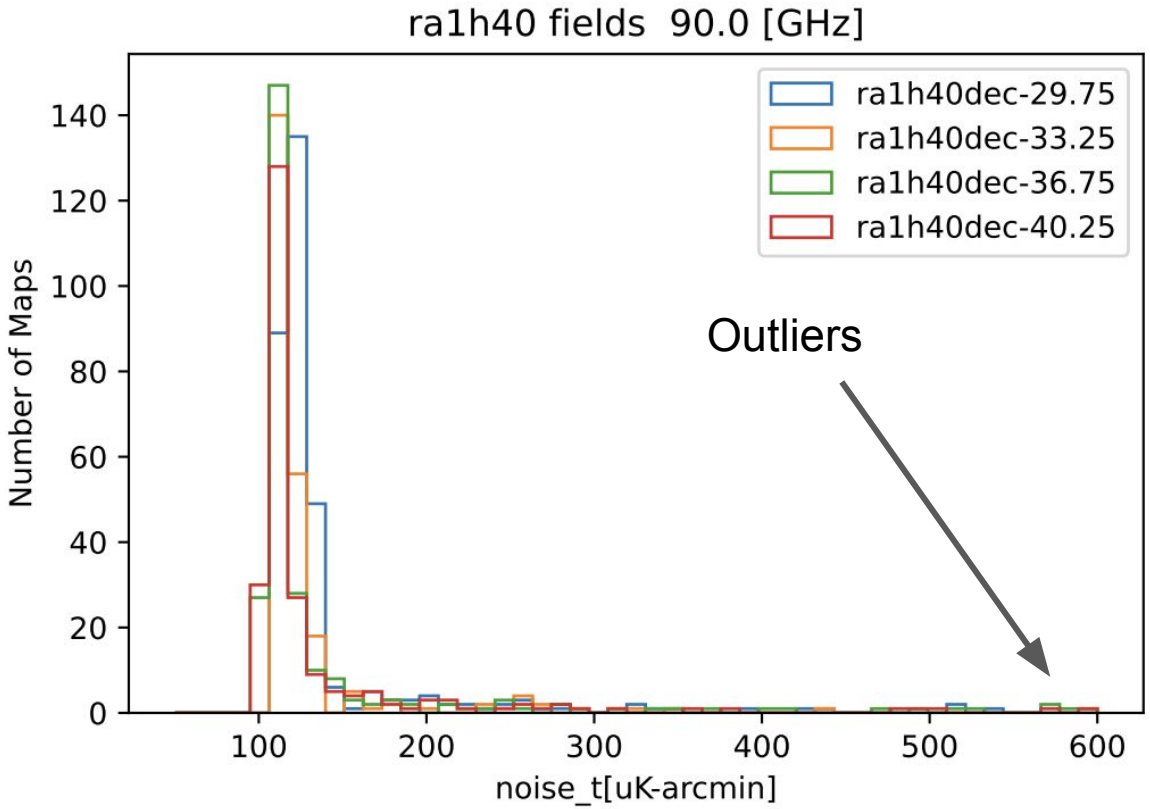
Certain observations need to be cut from the coadd

- Observation cuts allow us to exclude data with known issues that would contaminate the final co-added maps.
- Every ~hour long observation has calibration measurements which tell us how responsive and stable the data is.



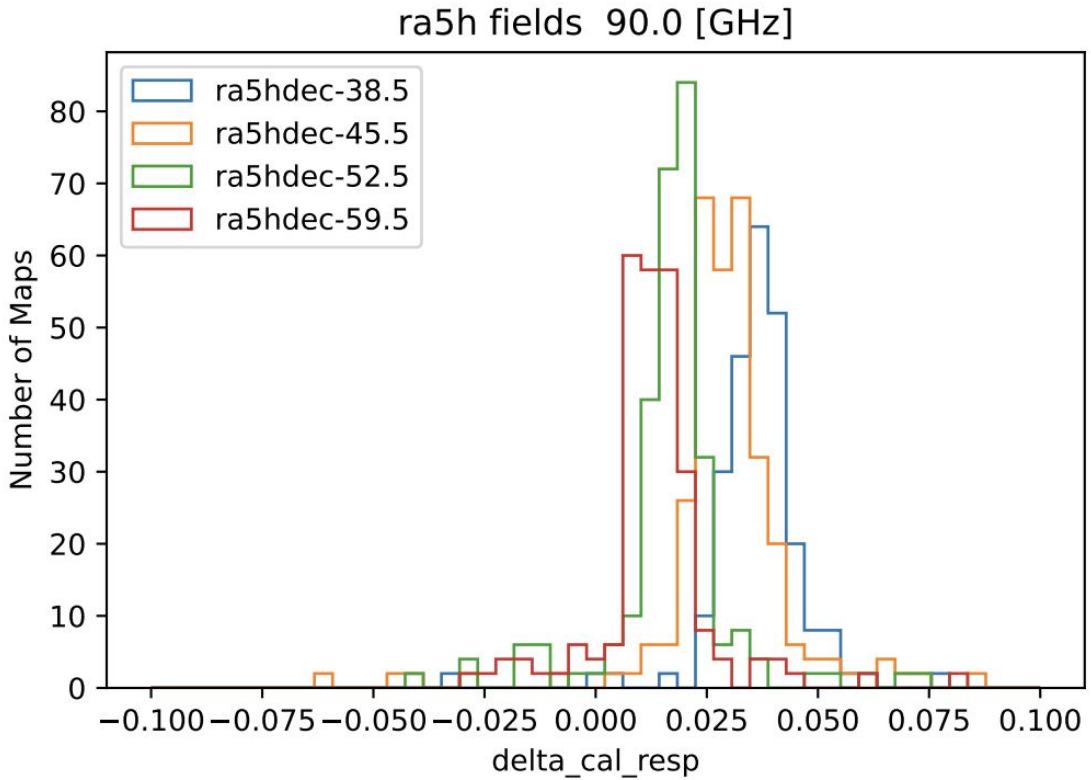
Noise Distribution

Noise helps us to know about the quality of an observation.



Change in Calibrator Response Distribution

- The calibration response measures the responsiveness and sensitivity of the detectors.
- Delta_cal_resp is the change in calibration response between the start and end of an hour observation which tell us about stability.
- The main distribution is centered around 1 to 3% which is very stable.



Summary

- Galaxy clusters help us know more about dark energy and dark matter.
- SPT observes the CMB to detect galaxy clusters.
- I focused on looking at the quality of the data in the SPT extended fields.
- I developed the first set of cuts to the extended field observations.
- I found that the quality of the data is better than expected and can be analyzed with minor cuts.
- This work will be used to create the co-added maps and look for clusters.

Thank you

Joshua Sobrin

Sara Simon

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Fermilab

South Pole Telescope

CMB group at Fermilab