THE LWA1 LOW FREQUENCY SKY SURVEY

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SRB 2017

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OVERVIEW

- Motivation
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- A
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  -
- Maps & Spectral Indicies
- The Low Frequency Sky Model
- Conclusions

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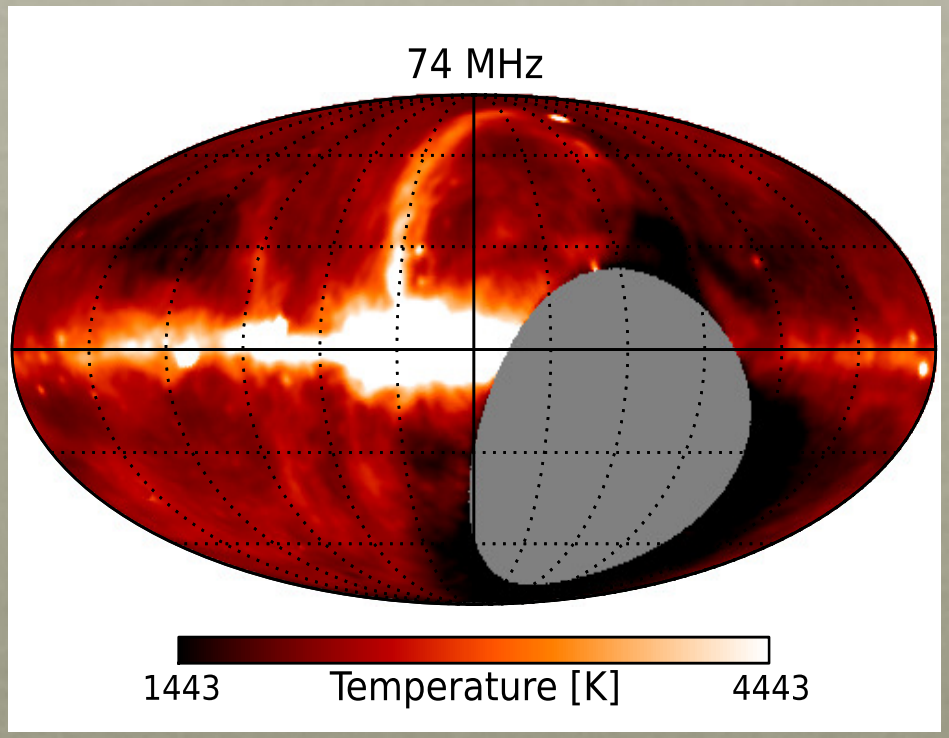
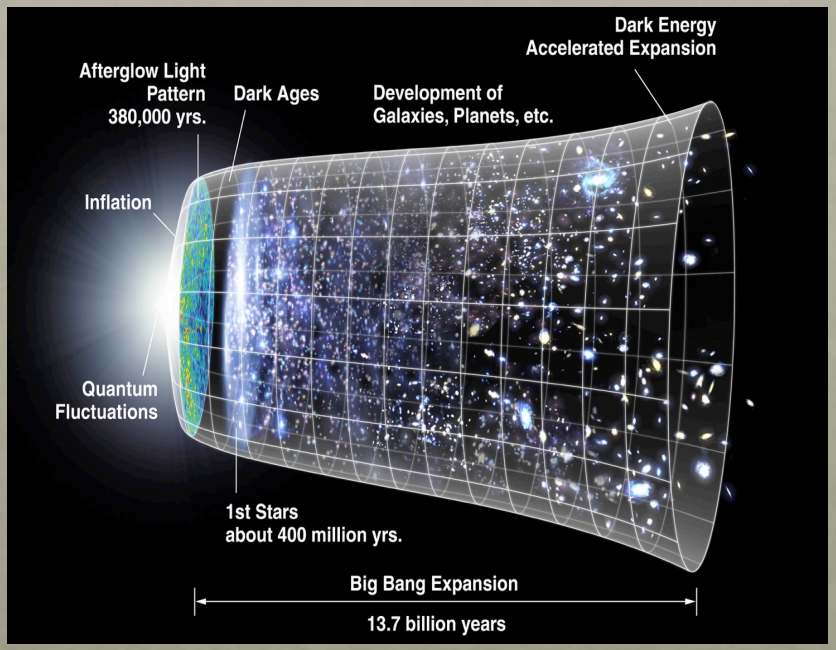
Namir Kassim (NRL)
Kevin Stovall (UNM/NRAO)

OVERVIEW

- Motivation
- LWA1
- Approach
  - Data acquisition
  - Calibration
  - Missing spacing correction
- Maps & Spectral Indices
- The Low Frequency Sky Model
- Conclusions and Future Directions

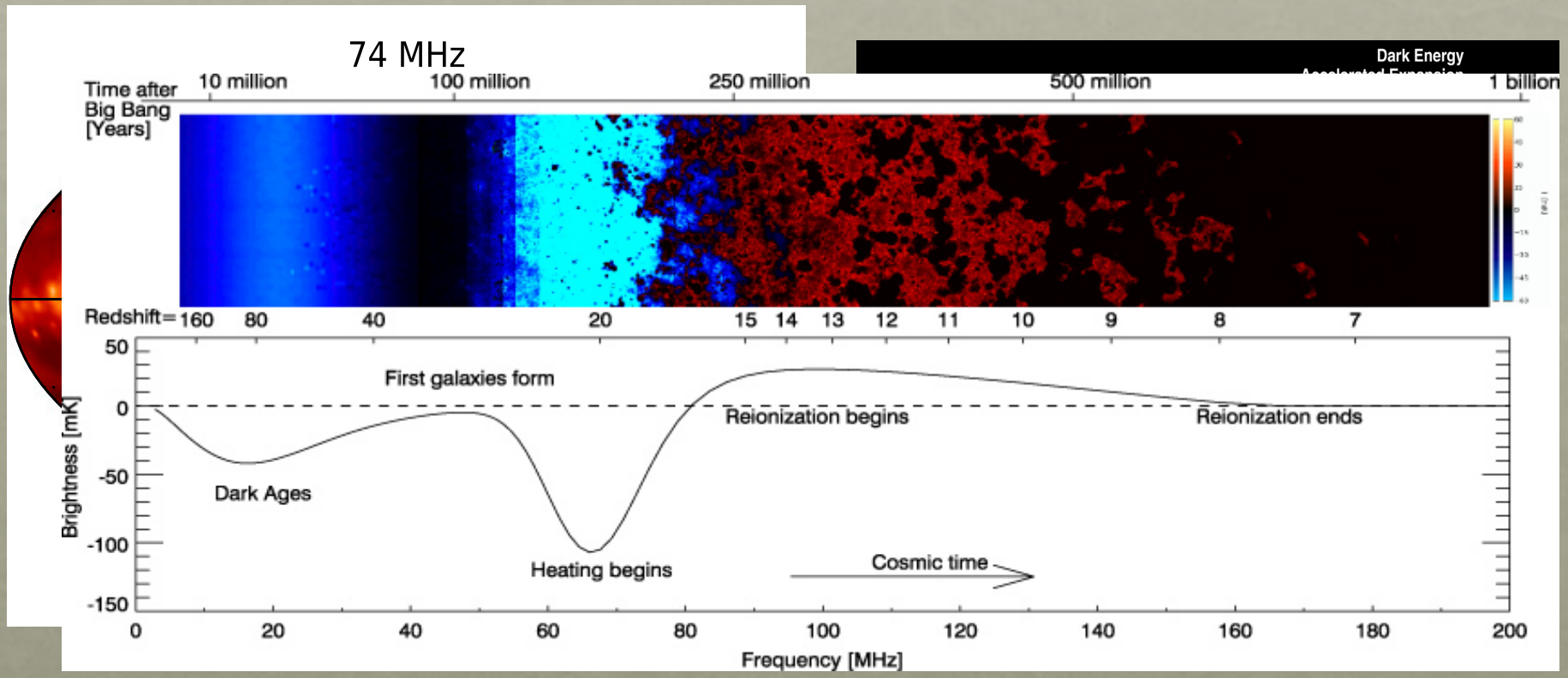
MOTIVATION





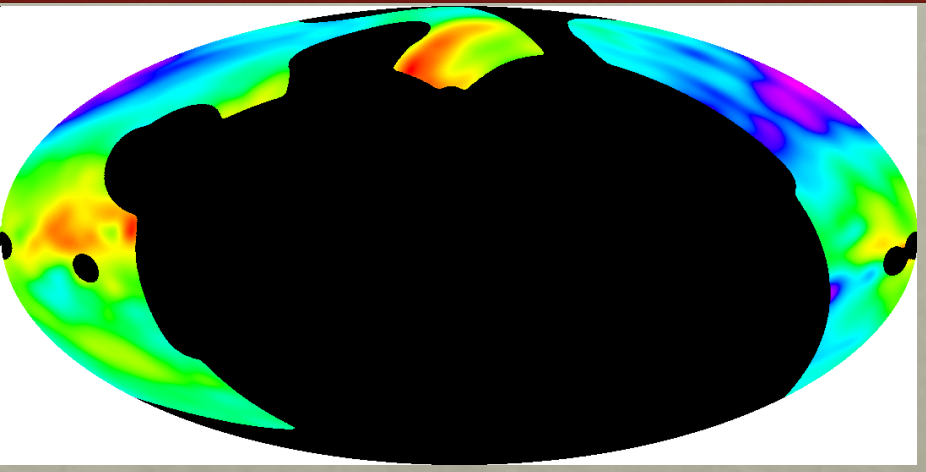
NASA/WMAP Science Team

MOTIVATION



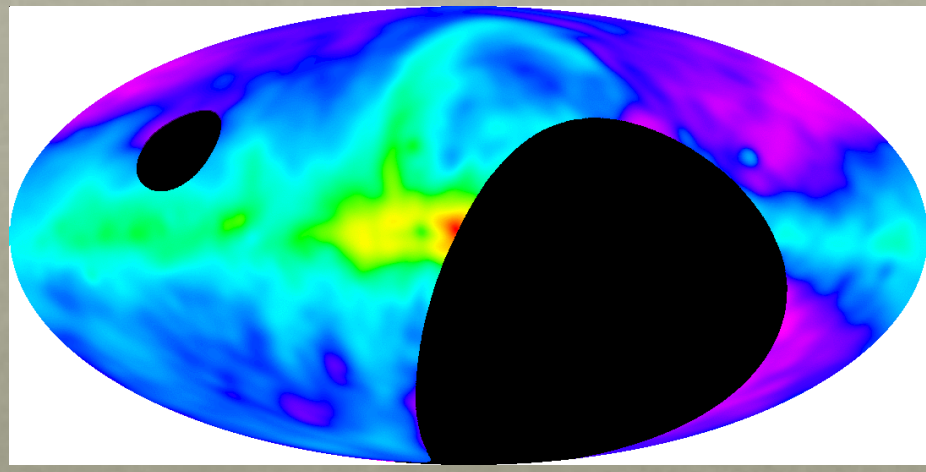
Pritchard & Loeb (2012)

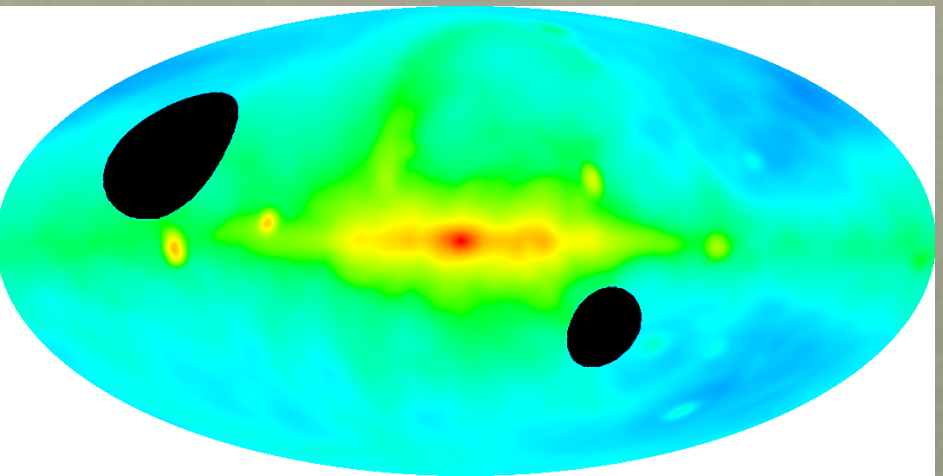
MOTIVATION



Caswell (1976) - 10 MHz

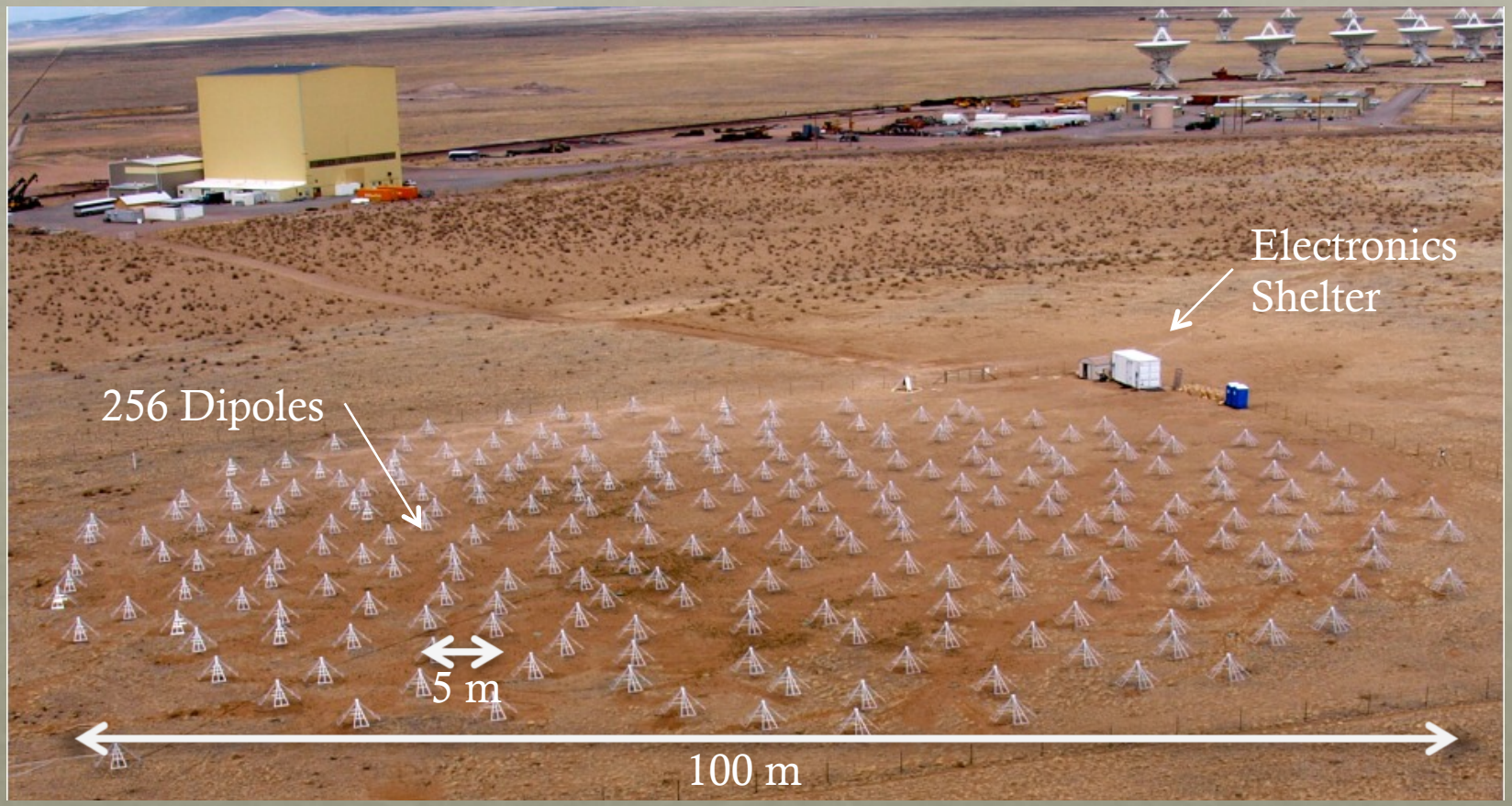
Rogers et al. (1999) - 22 MHz





Alvarez et al. (1997);
Maeda et al. (1999) – 45 MHz

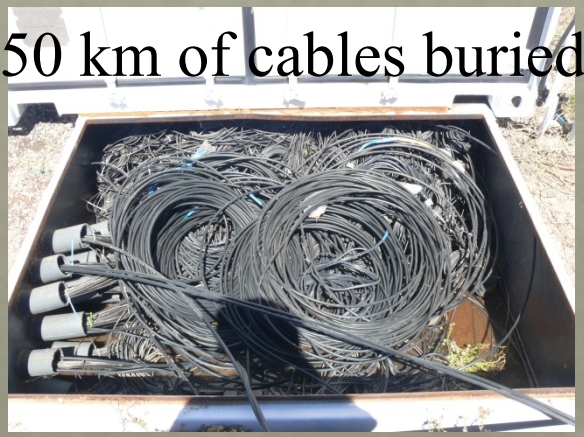
LWA1

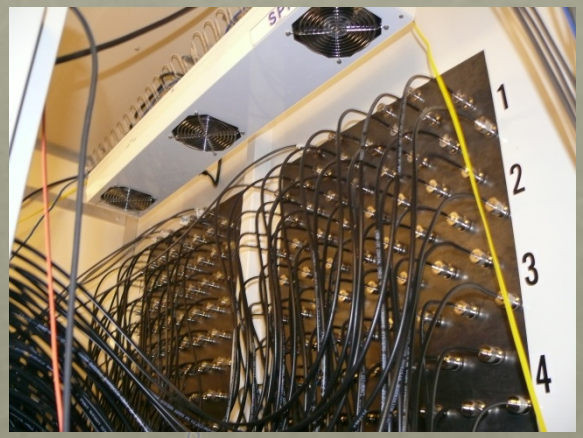


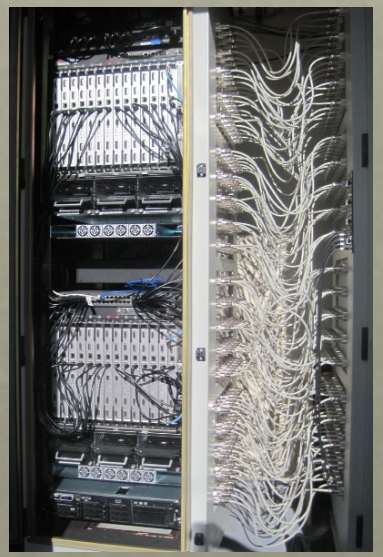
LWA1

LWA1 shielded electronics shelter
(100 dB shielding w/ RF tight racks)

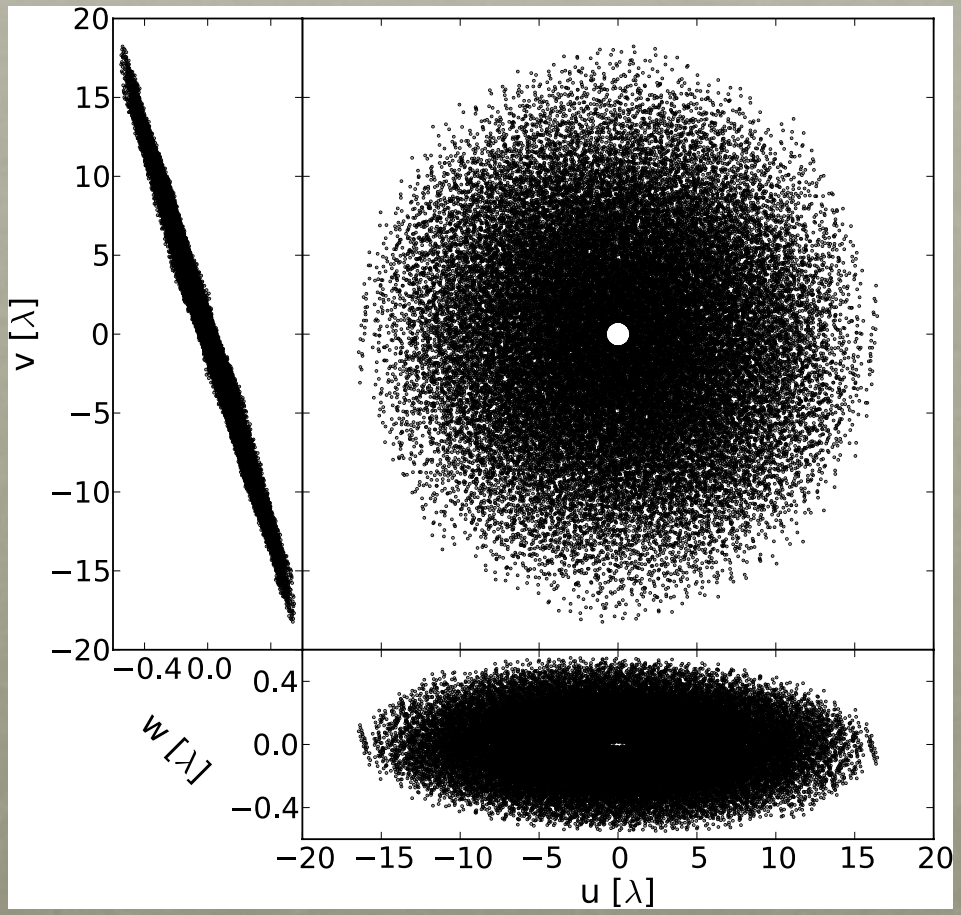
~50 km of cables buried



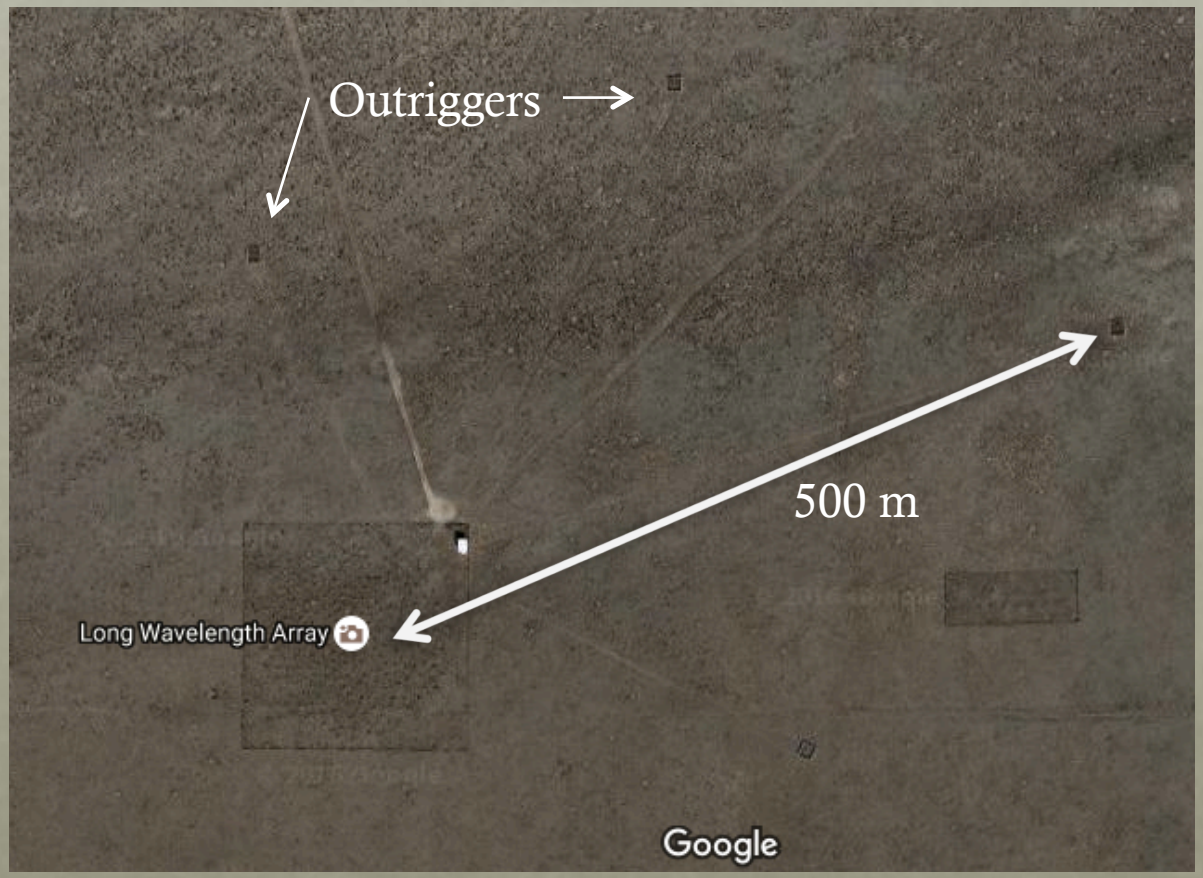




LWA1



LWA1



LWA SCIENCE

Astrophysics

Cosmology
Observing cosmic dawn through redshift 30 absorption of the 21 cm line. High redshift radio galaxies, containing the earliest black holes

Acceleration, Propagation & Turbulence in the ISM
Origin, spectrum & distribution of Galactic cosmic rays, Supernova remnants & Galactic evolution, Pulsars and their environments

Solar Science & Space Weather
Radio heliography of solar bursts & coronal mass ejections, Solar magnetic fields

Exploration of the Transient Universe
New coherent sources, GRB prompt emission, poorly explored parameters space …

Iono- & Atmospheric Physics

Unprecedented continuous spatial & temporal imaging of the ionosphere

Test and improve global ionospheric models

High-time-resolution Imaging of Lightning

Your ideas?
All of LWA1 time is open skies. Your observing proposals are welcome!

APPROACH - DATA

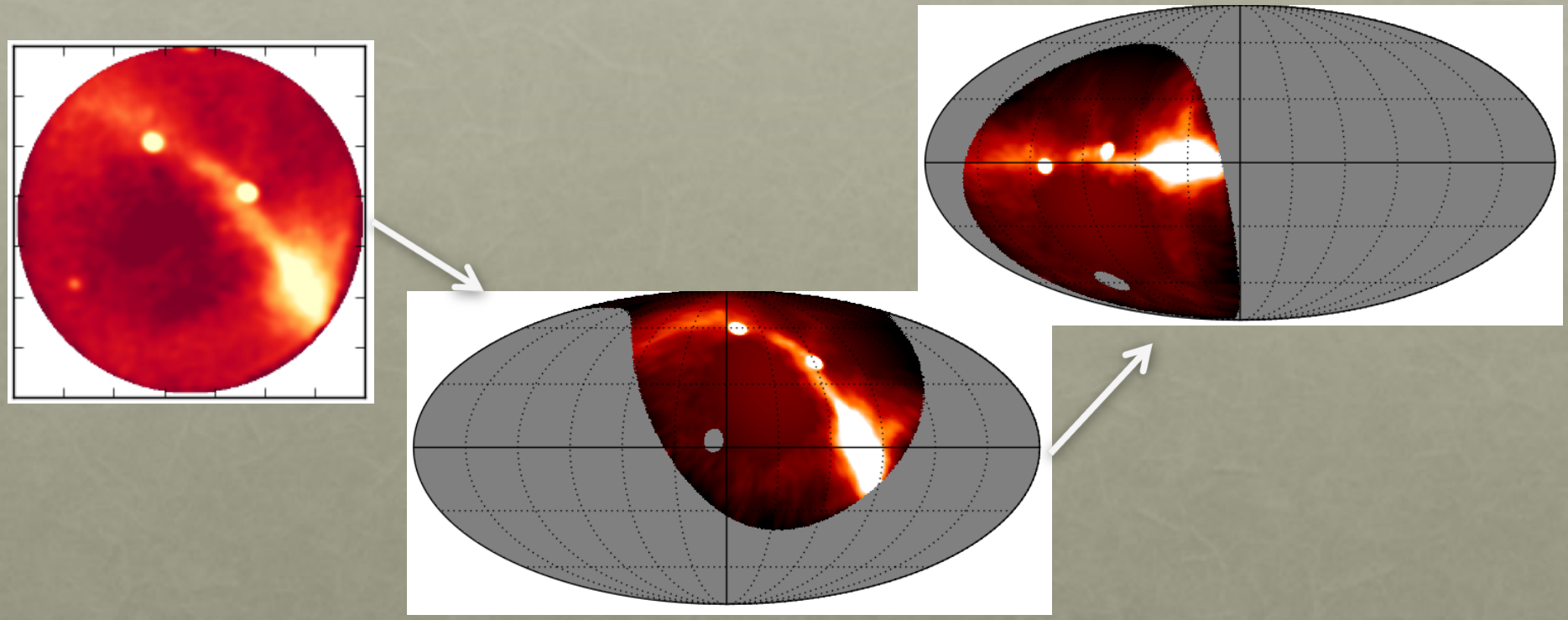
- Three methods of data collection at LWA1:
  - TBN, TBW, and Beamforming
- Used TBW to gather all of the bandwidth in 61 ms chunks
  - 61 ms is short but not so short as to be uninteresting
    - Confusion limited at degree resolutions
  - Each capture is ~10 GB
  - Use many captures to build up sky coverage
    - Snapshots every 15 minutes over a 24 hour period
    - Multiple epochs to help remove the Sun

APPROACH - CALIBRATION

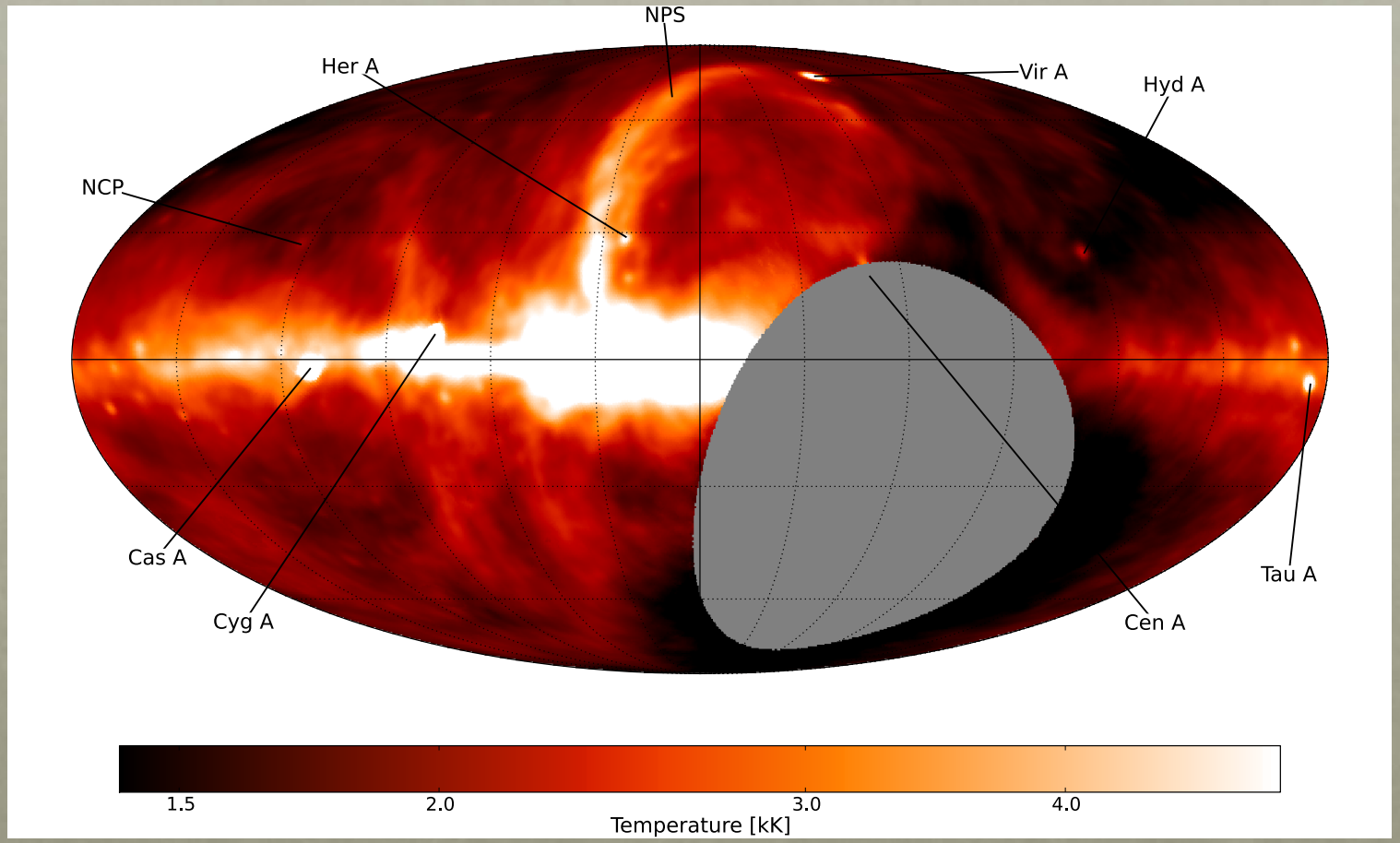
- Three main problems: flux calibration, imaging, and missing spacings
- Multi-part strategy
  - Use lab measurements to constrain what we can
    - Front end and analog receiver electronics
  - Use simulations for things we can't easily measure
    - Beam pattern and impedance mis-match loss
  - Tie the brightness of "A team" sources to an existing flux scale, like Baars
  - Use the LEDA total power system to constrain the total flux
  - Used MFS + forward modeling to constraint the missing scales

APPROACH - MOSAICING

- Re-project the snapshots onto a sphere and co-add
- Used HEALpix for the final maps

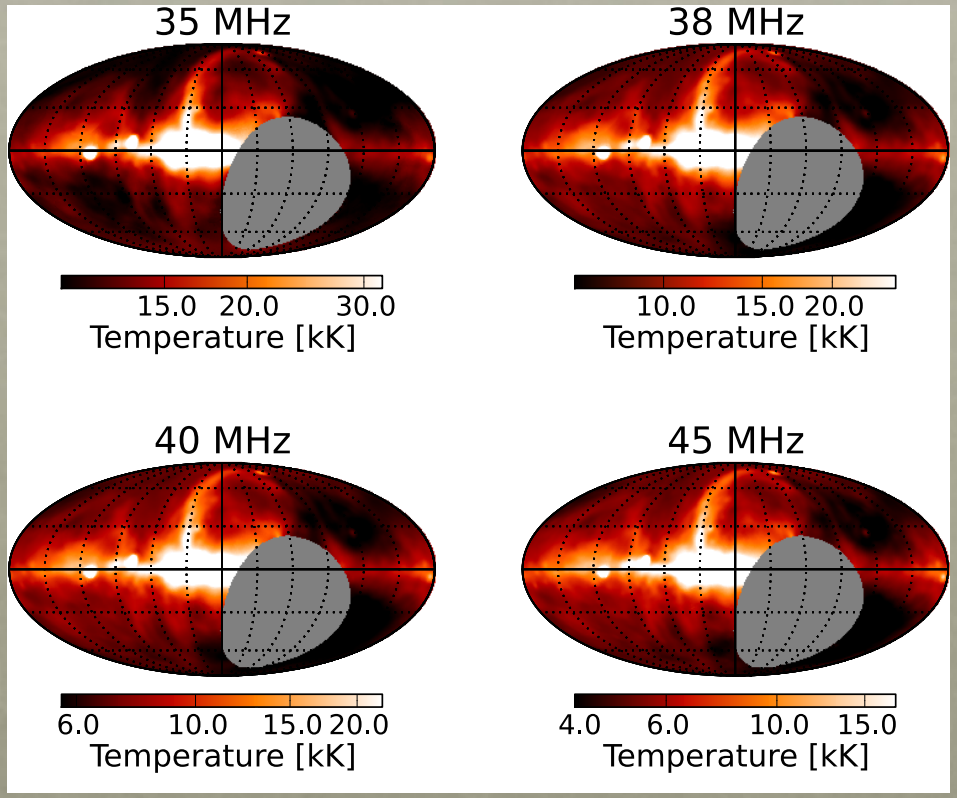


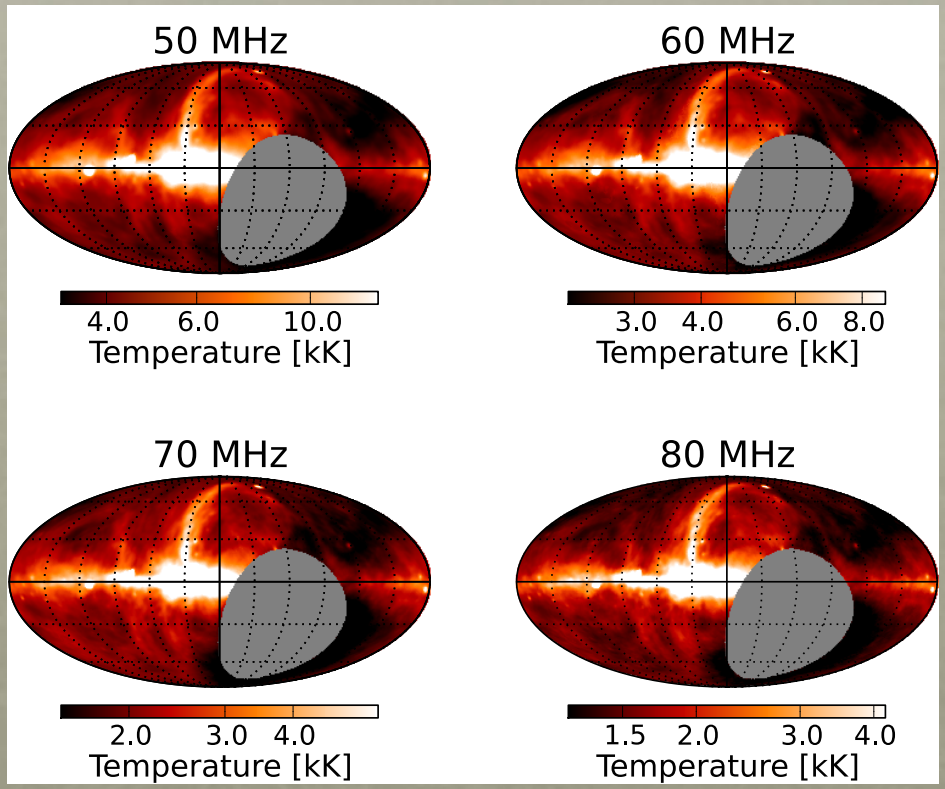
MAPS


NPS
Her A
Vir A
Hyd A
NCP
Cas A
Cyg A
Cen A
Tau A
1.5
2.0
3.0
4.0
Temperature [kK]

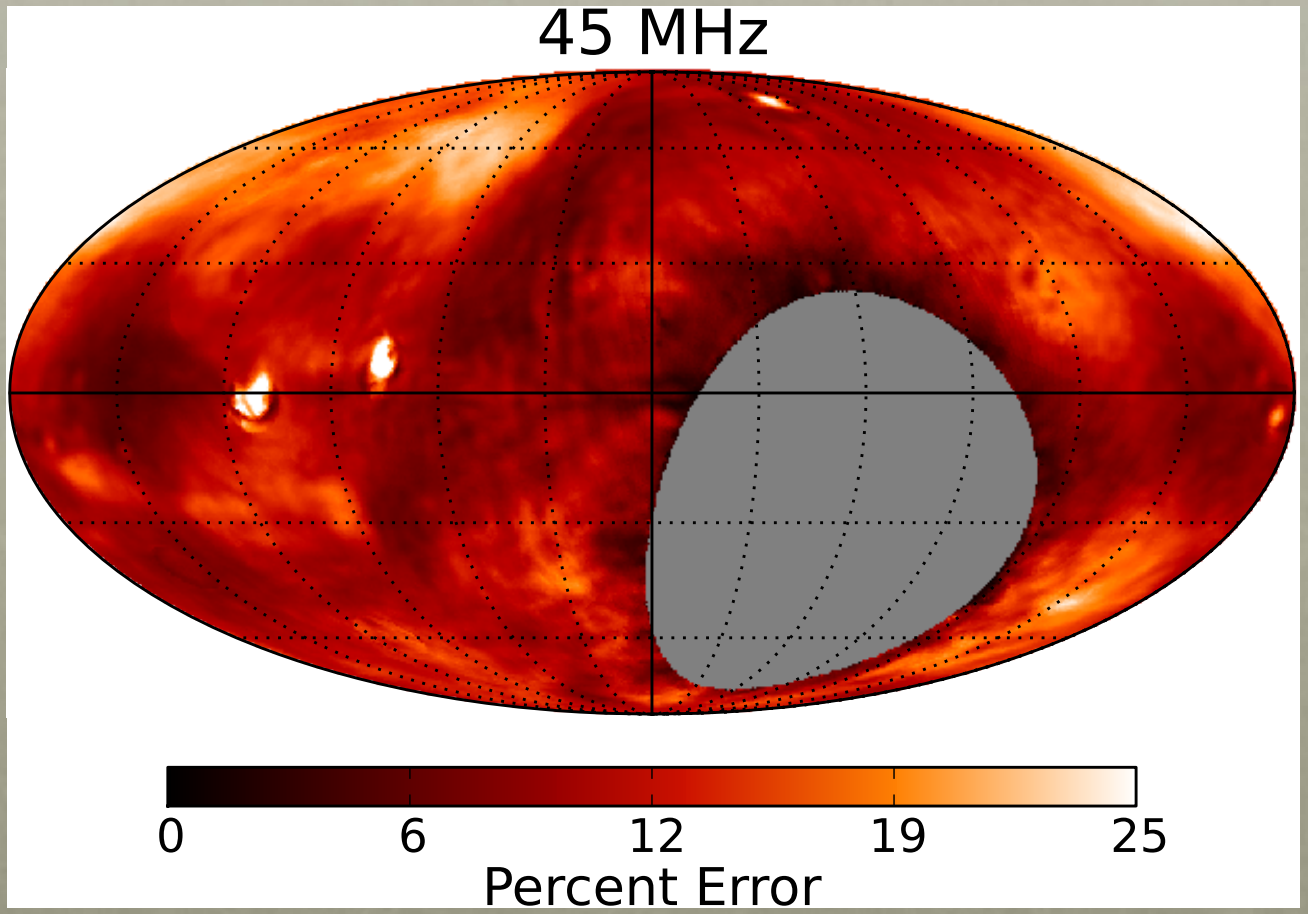
74 MHz

MAPS

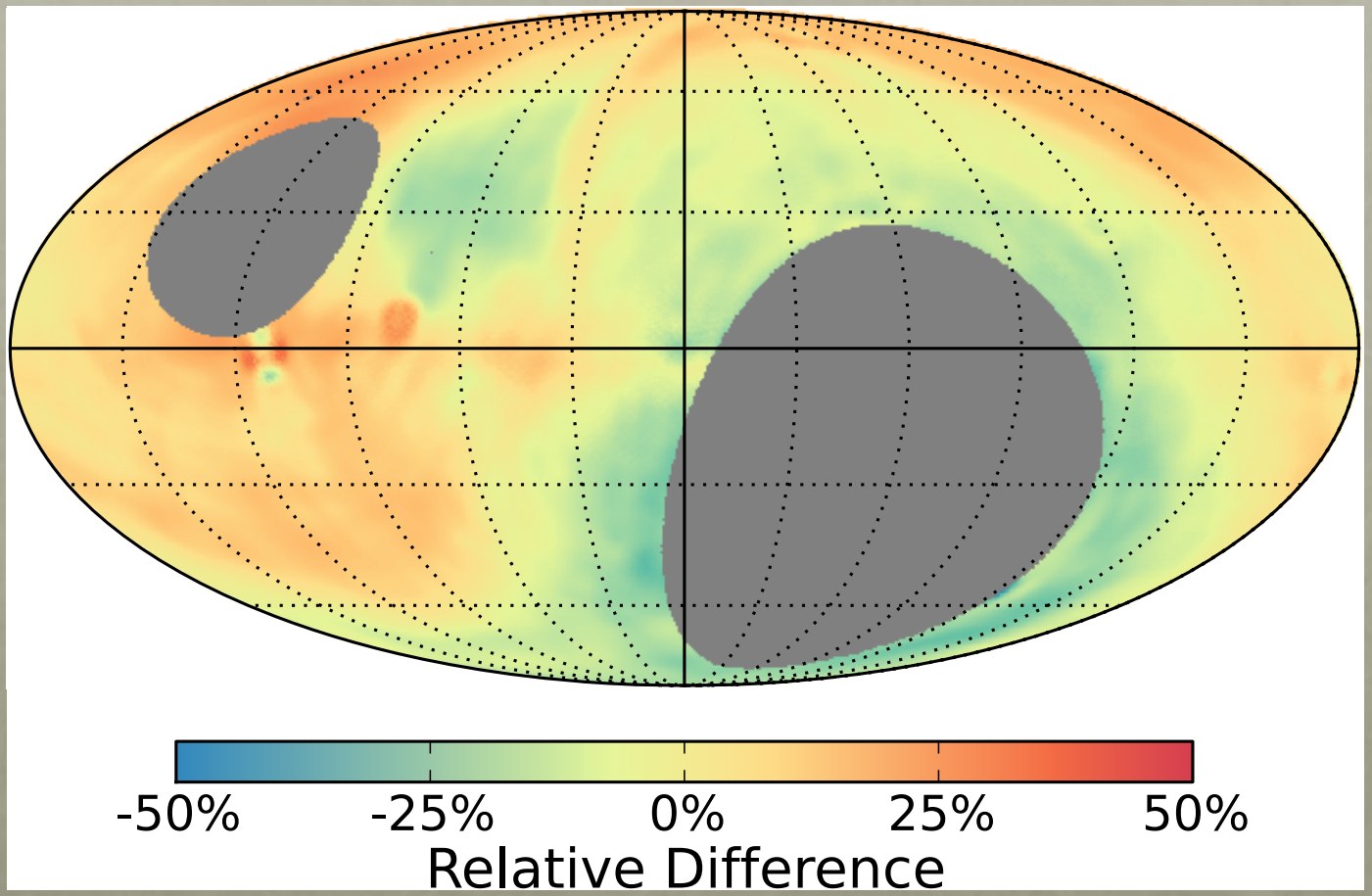

35 MHz
15.0 20.0 30.0
Temperature [kK]
38 MHz
10.0 15.0 20.0
Temperature [kK]
40 MHz
6.0 10.0 15.0 20.0
Temperature [kK]
45 MHz
4.0 6.0 10.0 15.0
Temperature [kK]


50 MHz
4.0 6.0 10.0
Temperature [kK]
60 MHz
3.0 4.0 6.0 8.0
Temperature [kK]
70 MHz
2.0 3.0 4.0
Temperature [kK]
80 MHz
1.5 2.0 3.0 4.0
Temperature [kK]

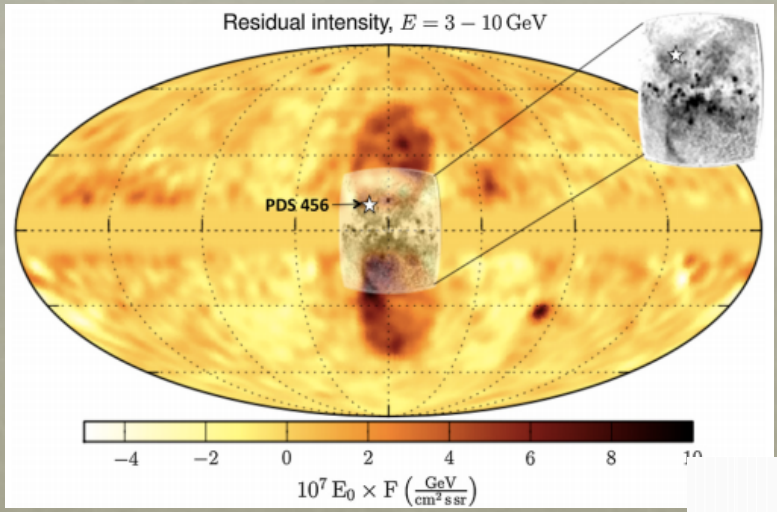
UNCERTAINTY



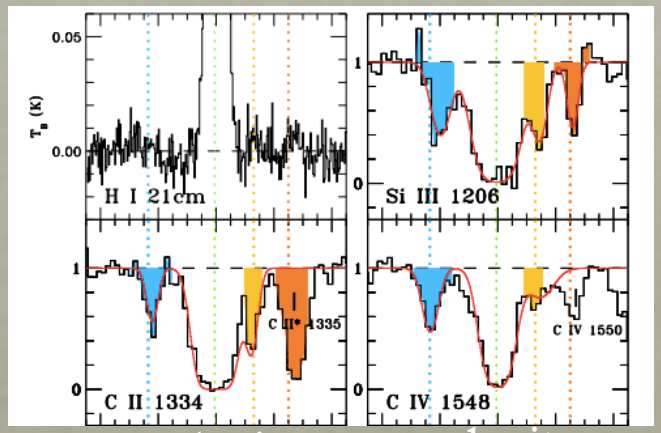
COMPARISONS

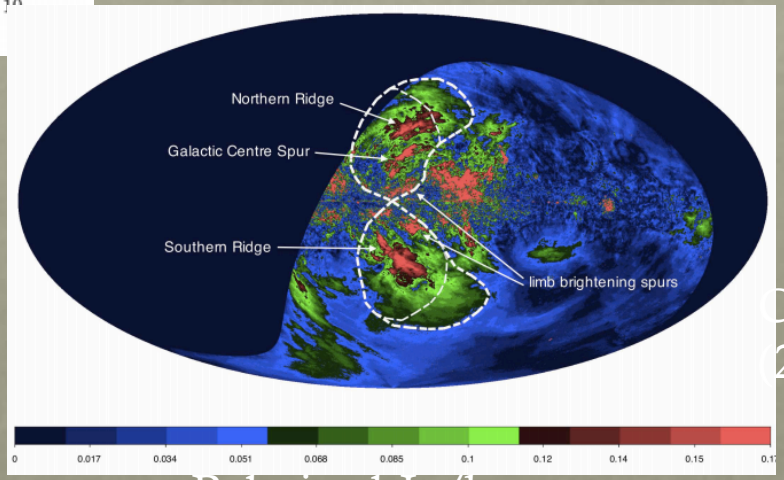


FERMI BUBBLES



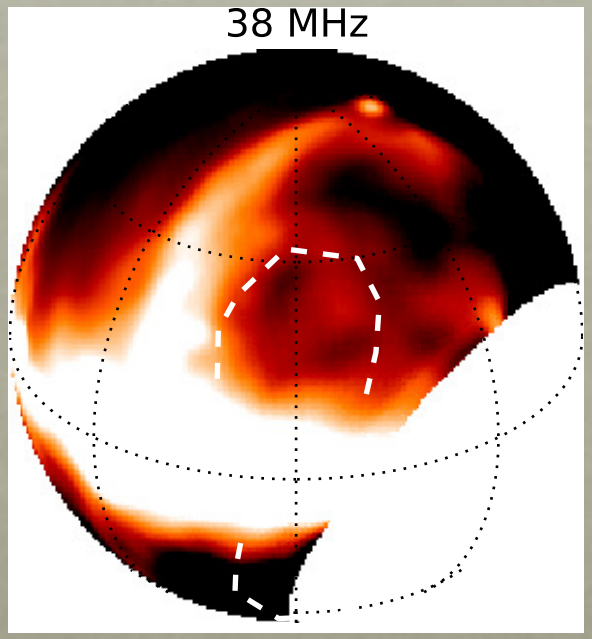
Gamma Ray + X-ray
Fox et al. (2015)
Ackermann et al. (2014)

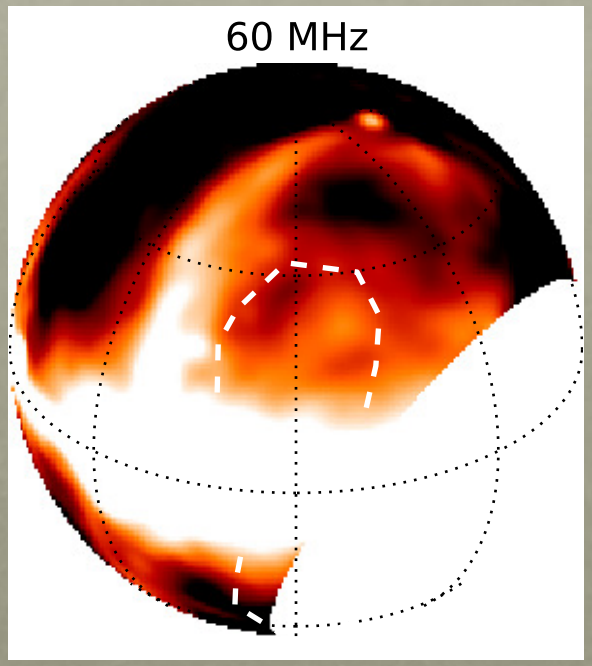


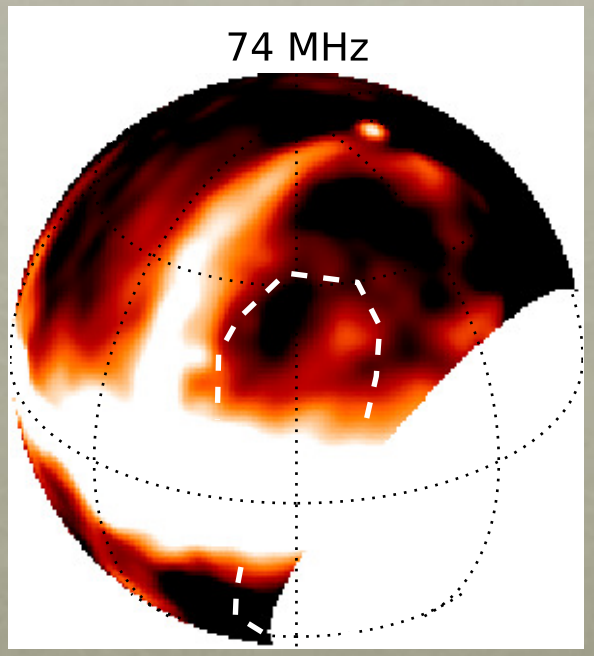


Carretti et al. (2013)

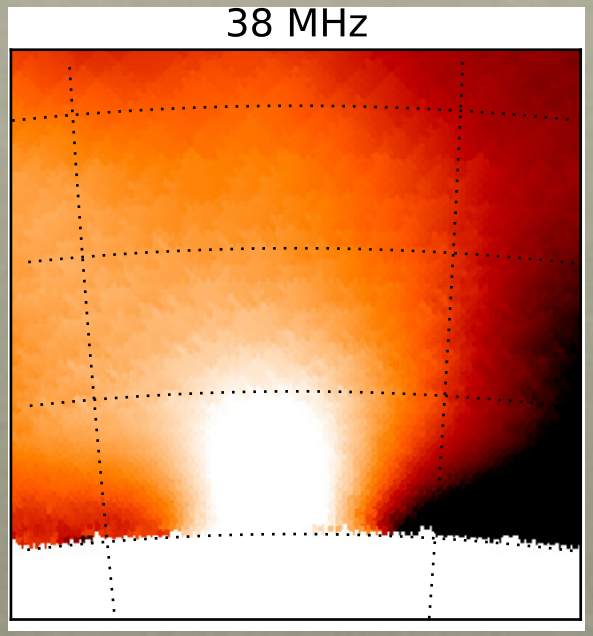
FERMI BUBBLES

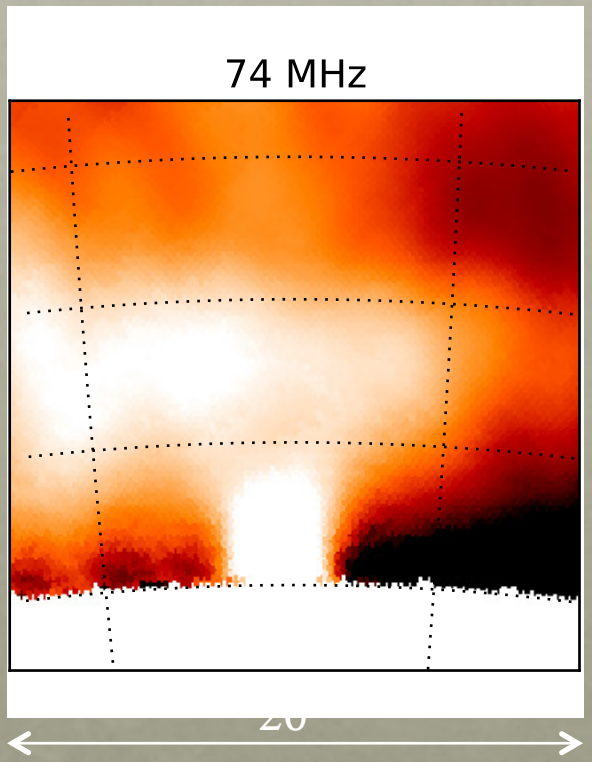


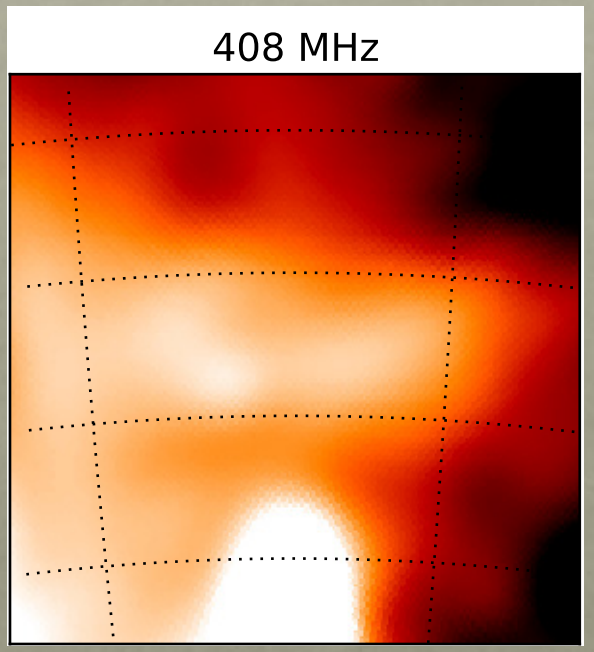




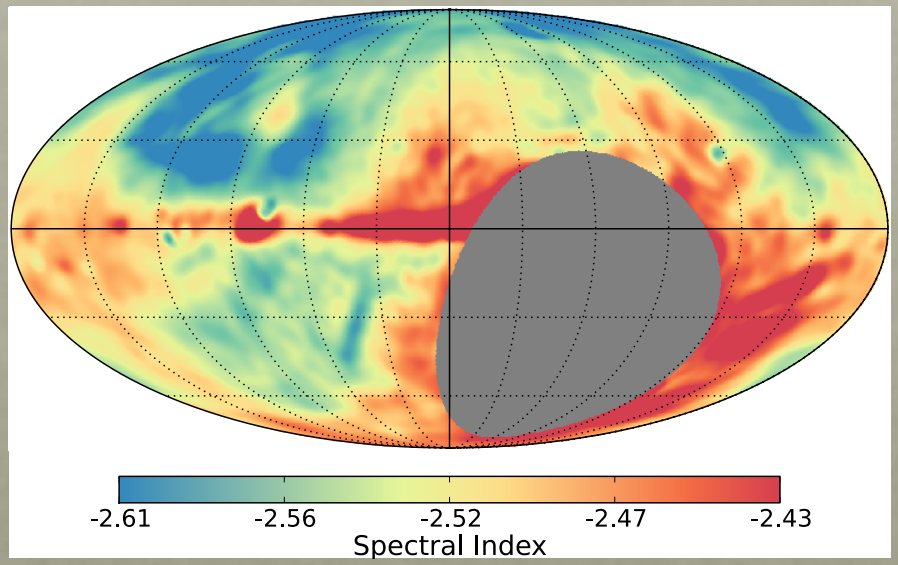
CENTAURUS A

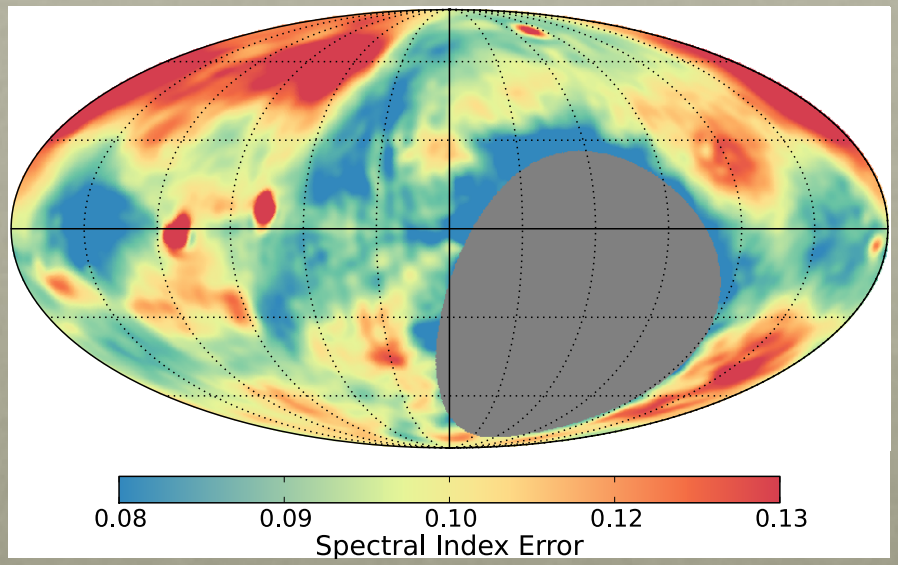




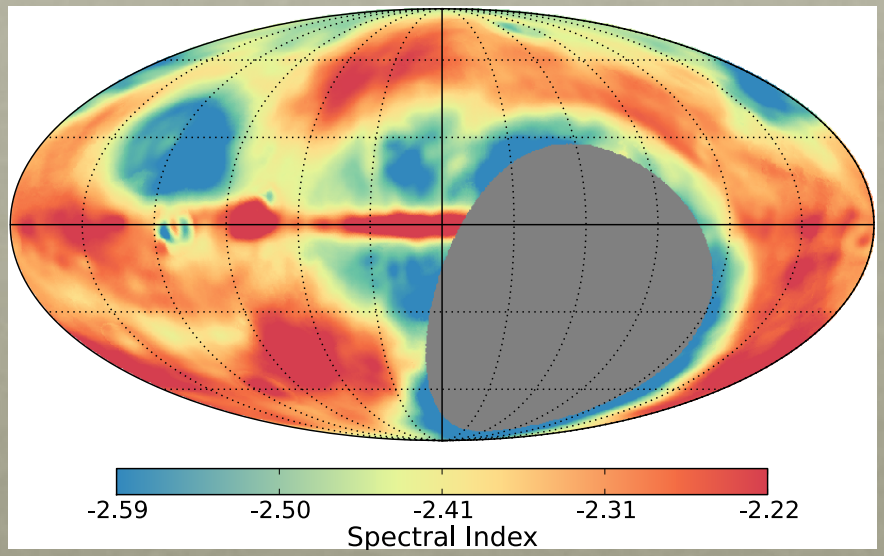


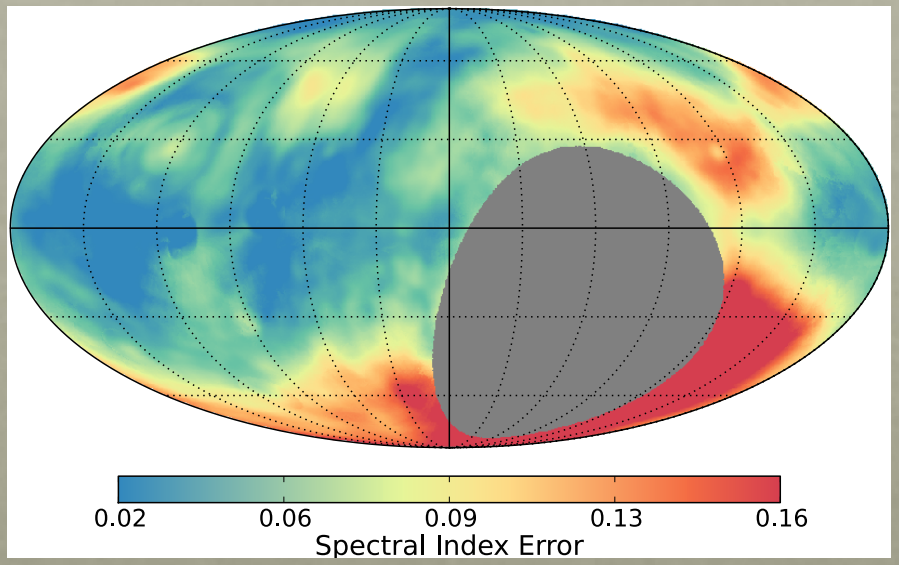
SPECTRAL INDEX



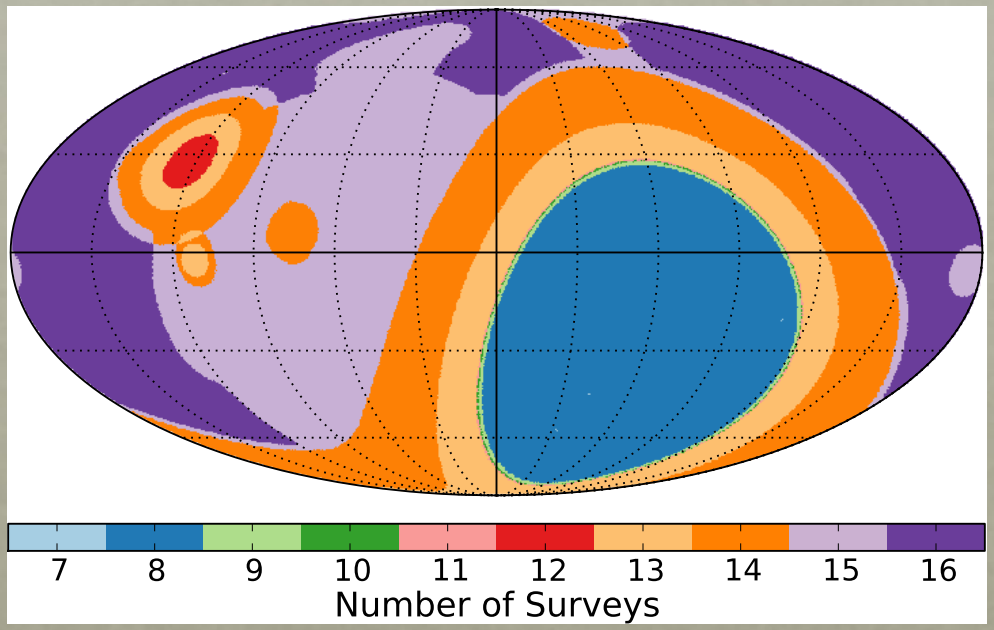


SPECTRAL INDEX

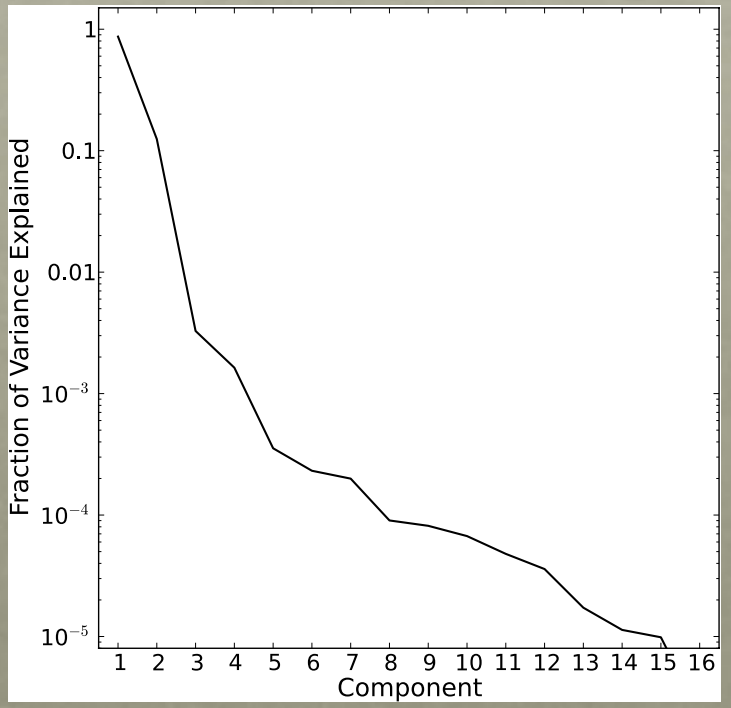




LOW FREQUENCY SKY MODEL



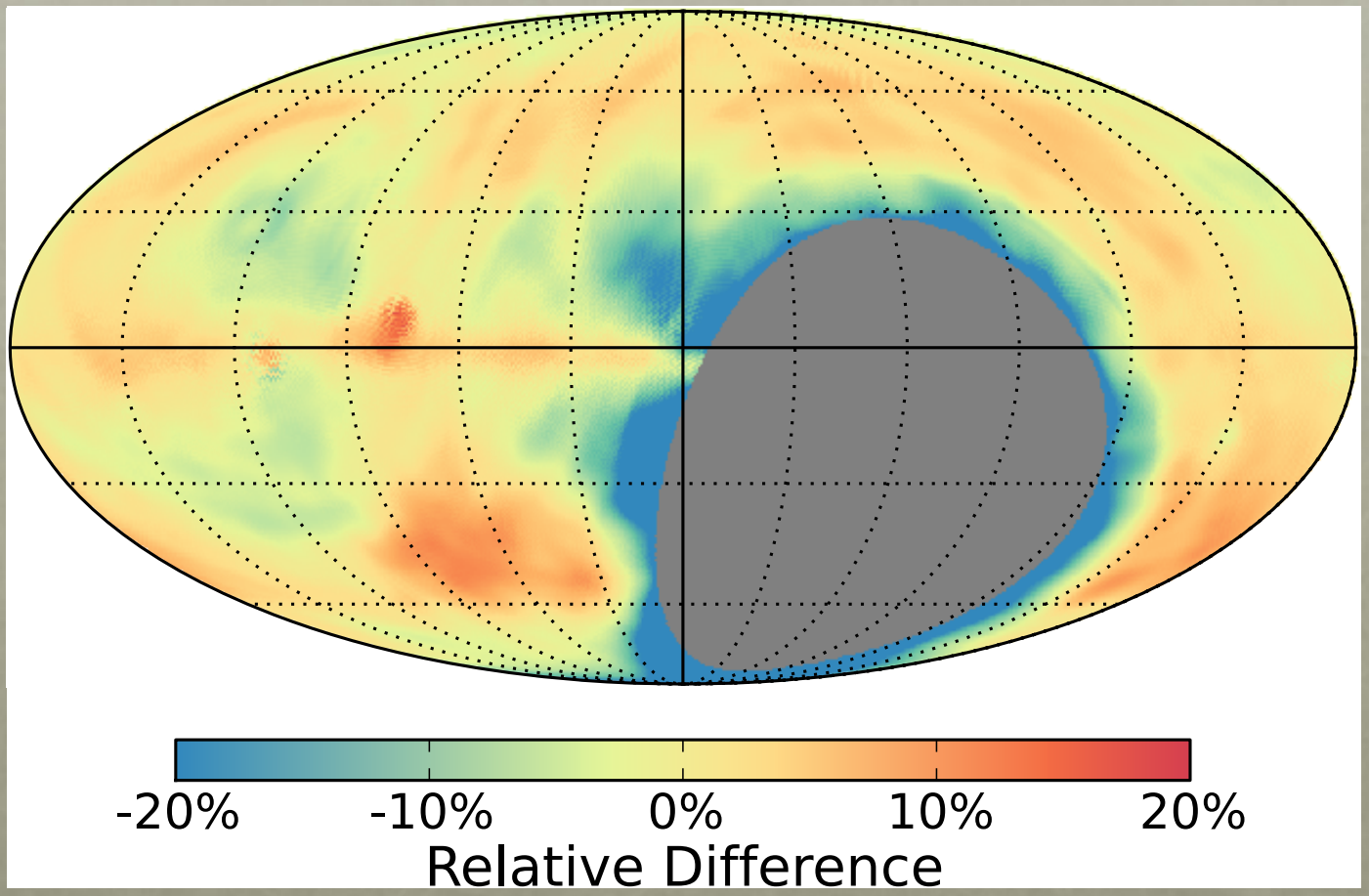
GSM-style
principle component analysis



Our maps, plus literature maps at:

- 10, 22, 45 MHz
- 408 & 820 MHz
- 1.4 GHz
- WMAP bands

THE LOW FREQUENCY SKY MODEL

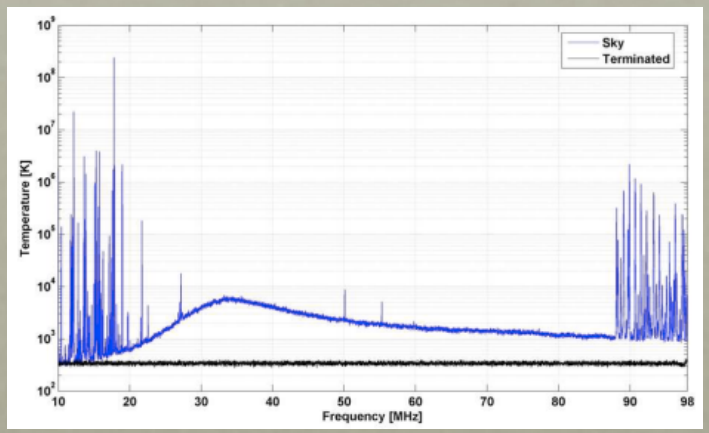


74 MHz

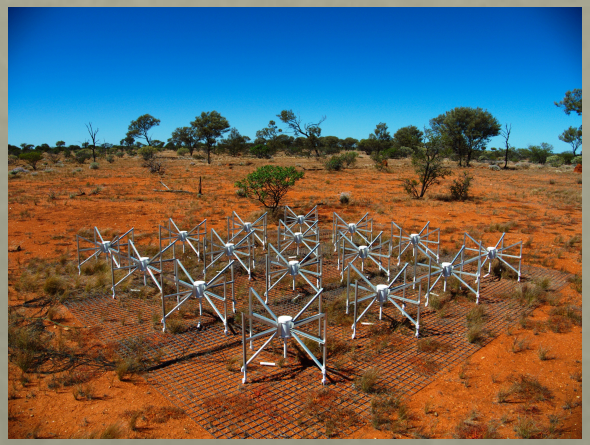
CONCLUSIONS

- The LWA1 Low Frequency Sky Survey covers:
  - Nine frequency bands between 35 and 80 MHz of
  - The radio sky north of −40° at a
  - 2 to 5 degree resolution
    - MNRAS (2017) 469, 4537-4550
- The sky has been combined with existing data to create a new model for the low frequency radio sky
  - Uses new data to create an updated model of the sky below 400 MHz
- The survey maps and the model are available at:
  - https://lda10g.alliance.unm.edu/LWA1LowFrequencySkySurvey/

FUTURE DIRECTIONS



Henning et al. (2010)



MWA (Wikipedia)

- Better understanding of the instrument
  - Dipole beam pattern
  - Frequency dependent losses
- Push to lower frequencies
  - Opens up new possibilities for absorption studies, new modeling methods
- Combine data with other instruments, investigate new approaches to imaging