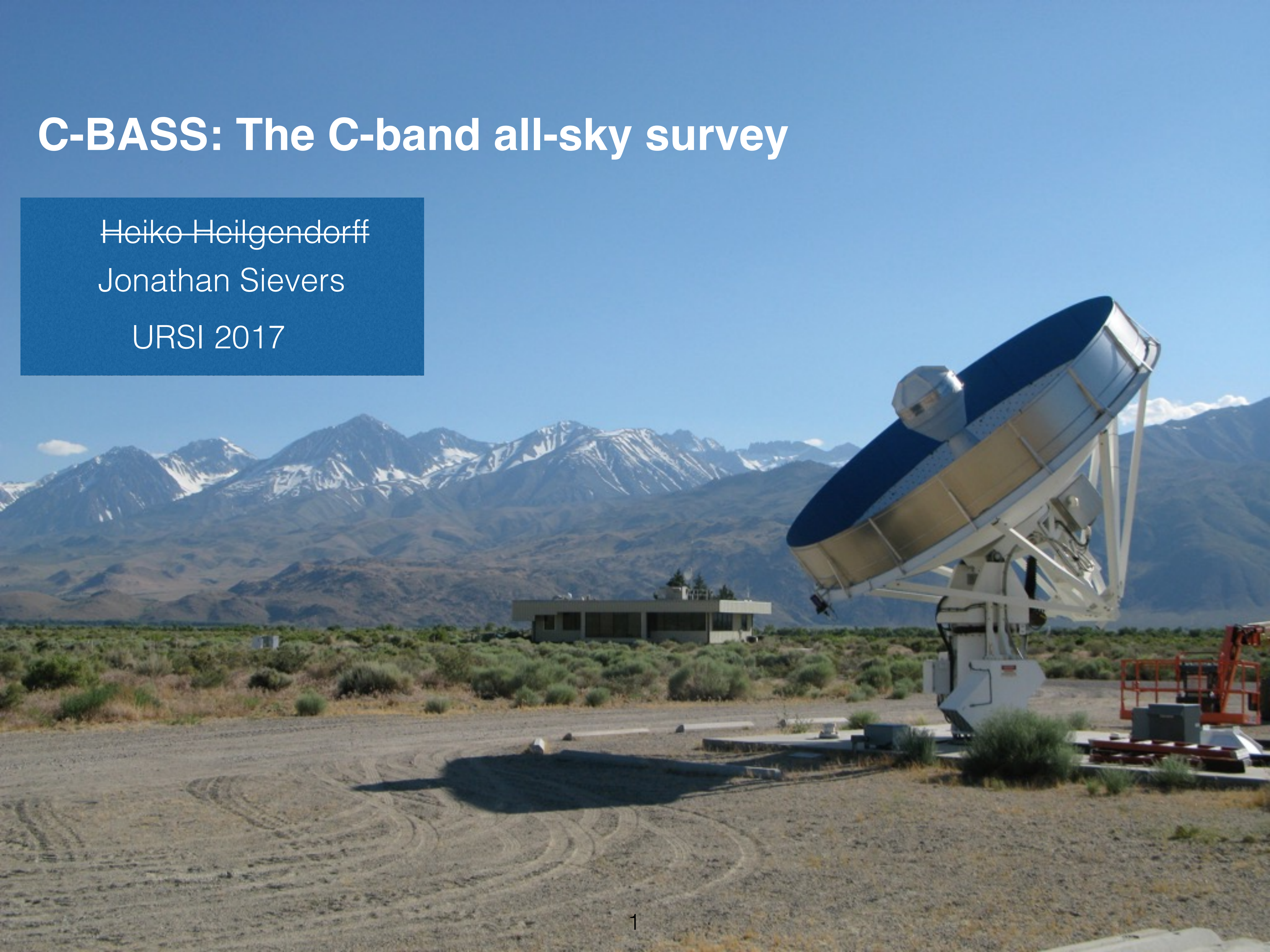
C-BASS: The C-band all-sky survey

~~Heiko Heilgendorff~~
Jonathan Sievers

URSI 2017



First…

https://jobregister.aas.org/job_view?JobID=58436

AAS - Job Register

Search this site: Search

AAS Home | Renew Your Membership | Member Directory | Calendar | Contact Us | FAQ | Journals Home | Donate

Job Register

Current AAS Job Register
Job Register Archives

Log In To Job Poster Account
Create Job Poster Account!

Search Job Register

Search this site: Search

Other JR Pages

- Career Center
- How To Submit Job Ad
- Job Register Editorial
- Publication Policy
- Tips for Successful Recruitment

Home

HIRAX Project Director - JRID58436

Submitted by jsievers on Thu, 2016-12-15 14:14

Submission Dates

Post Date: January 1, 2017
Archive Date: January 31, 2017
Deadline to Apply for Job: February 15, 2017

Job Details

Job Category: Science Management
Institution/Company Name: University of KwaZulu-Natal
Institution Classification/Type: Large Academic

Submission Address for Resumes/CVs

Attention To: Jonathan Sievers
Title: Professor
Organization: University of KwaZulu-Natal
Email: sieversj@ukzn.ac.za

Contact Information For Inquiries About Job

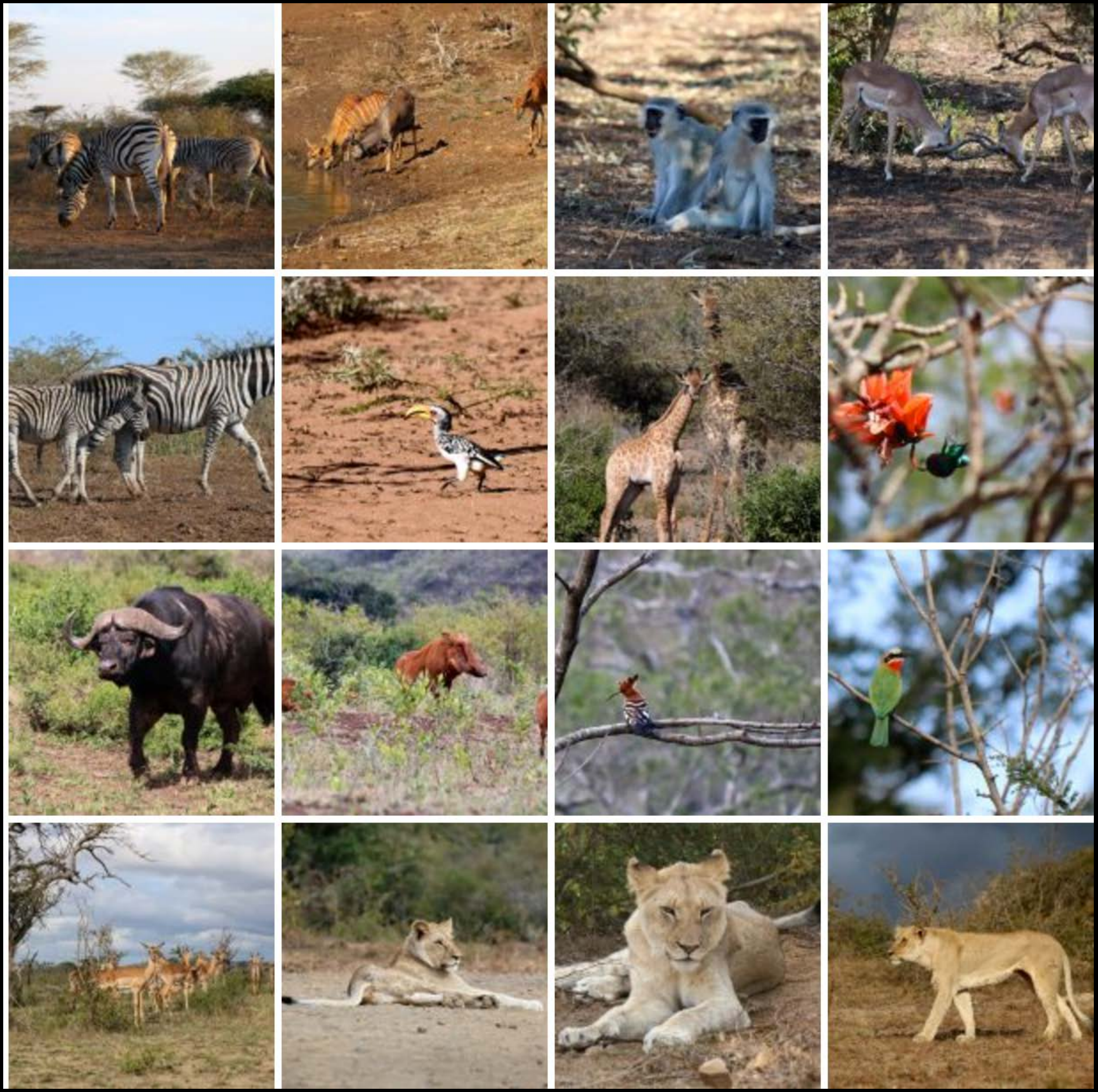
Email Address for Inquiries: sieversj@ukzn.ac.za

Related URLs

Related URLs:
HIRAX Project Director Official Ad
HIRAX Webpage

HIRAX Project Director ad now live - please let interested people know!

http://www.acru.ukzn.ac.za/~cosmosafari2017/



Adam Amara
*Brad Benson
Francois Bouchet
*Fernando Camilo
*John Carlstrom
Ryan Cooke
Cora Dvorkin
*Mark Halpern
Henk Hoekstra
Lerothodi Leeuw
Lyman Page
Jeff Peterson
Alexandre Refregier
Mario Santos
Eva Silverstein
Kendrick Smith
Glenn Starkman
Petri Vaisanen
Sahal Yacoob

C-BASS: The C-band all-sky survey

- *C-BASS is a collaborative project between:*
- Oxford University (UK) *supported by Oxford University, STFC, and the Royal Society*
  - Angela Taylor, Mike Jones, Christian Holler, Jamie Leech, <u>Luke Jew</u>
- Manchester University (UK)
  - Clive Dickinson, Paddy Leahy, <u>Mel Irfan</u>, Rod Davies, Richard Davis, Mike Peel, Joe Zuntz
- California Institute of Technology (USA) + OVRO + JPL *supported by the National Science Foundation AST 1212217*
  - Tim Pearson, Stephen Muchovej, Tony Readhead, Oliver King, Erik Leitch, <u>Matthew Stevenson</u>
- Hartebeesthoek Radio Astronomy Observatory (South Africa), Rhodes University, U. KwaZulu Natal *supported by the Square Kilometre Array project*
  - Justin Jonas, Charles Copley, Cynthia Chiang, Jon Sievers, Moumita Aitch, <u>Heiko Heiligendorff</u>, <u>Johannes Allotey</u>
- KACST: King Abdulaziz City for Science and Technology (Saudi Arabia)
  - Yaser Hafez

C-BASS: The C-band all-sky survey

- The C-Band All-Sky Survey (C-BASS) is a project to produce high signal-to-noise all-sky maps at a central frequency of 5 GHz in <u>intensity and linear polarization</u> (Stokes *I*, *Q*, and *U*).
- Primary goal: a synchrotron template for use in CMB foreground subtraction.
  - *a "low frequency channel" for Planck*
- Secondary goals:
  - understand emission mechanisms in the diffuse interstellar medium and the magnetic fields
  - constrain models of Galactic structure

C-BASS: The C-band all-sky survey

- High signal-to-noise all-sky maps at a central frequency of **5 GHz** in intensity and linear polarization (Stokes *I*, *Q*, and *U*).
- C-BASS uses two telescopes, one in the northern hemisphere at the Owens Valley Radio Observatory in California, and one close to the South African SKA site. Angular resolution 0.73°.
- Novel optical design to minimize sidelobes.
- Nominal bandwidth 1 GHz.
- Thermal noise sensitivity is ~3 mK√s in *I* and ~2 mK√s in *Q*/*U*, with a target survey thermal noise level of 0.1 mK.
- Maps at this frequency are dominated by synchrotron radiation and largely uncorrupted by Faraday rotation.

Two Telescopes

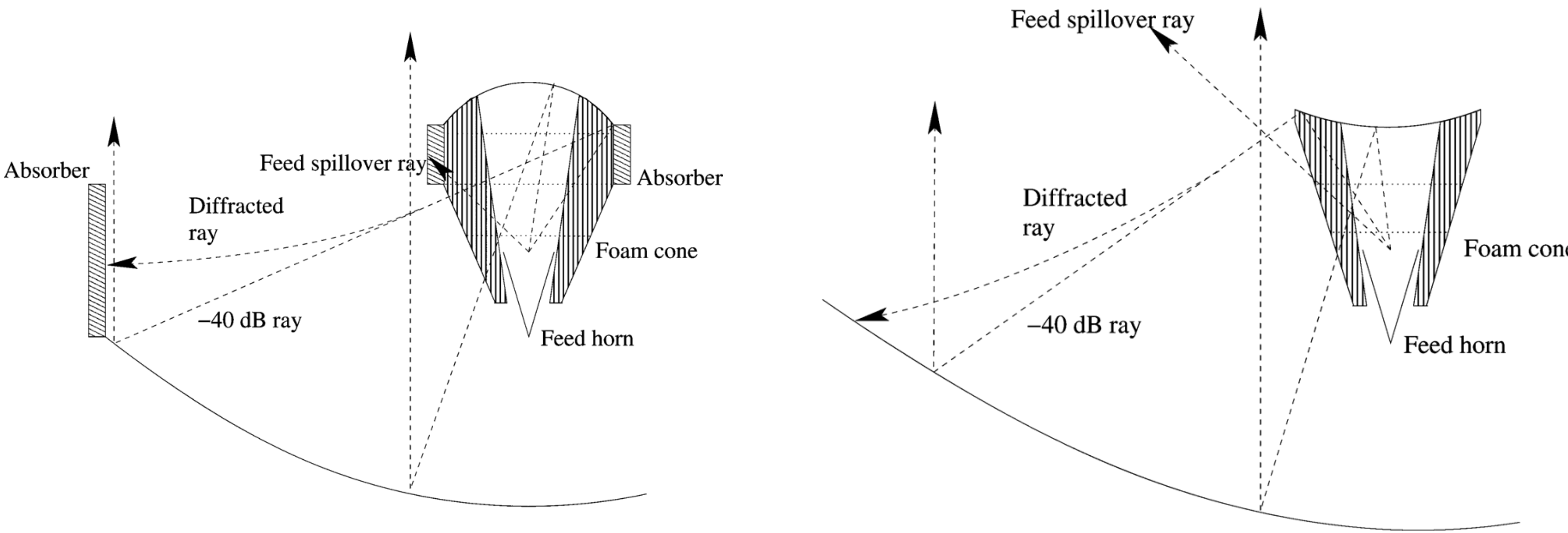
OVRO

Klerefontein

Why 5 GHz?

- Halfway (in log ν) between surveys at 1.4 GHz (Stockert: Reich & Reich) and 23 GHz (WMAP).
- Expected high-latitude Faraday rotation a few degrees, c.f. ~30° at 2.3 GHz.
    - residual correction at high latitude via 1.4 GHz polarization survey from Penticton (Wolleben) / Villa Elisa (Testori, Reich & Reich)
- Below main emission from anomalous dust, so predominantly synchrotron.
    - helps to constrain AME models
- Signal still strong enough (few mK) to measure in a reasonable time (< 1 year) with a single receiver.

Optics



Not-to-scale schematic ray diagrams of the northern 6.1-m antenna (left) and the southern 7.6-m antenna (right).

C. M. Holler et al. IEEE Antennas and Propagation, 61, 117, 2013

Optics

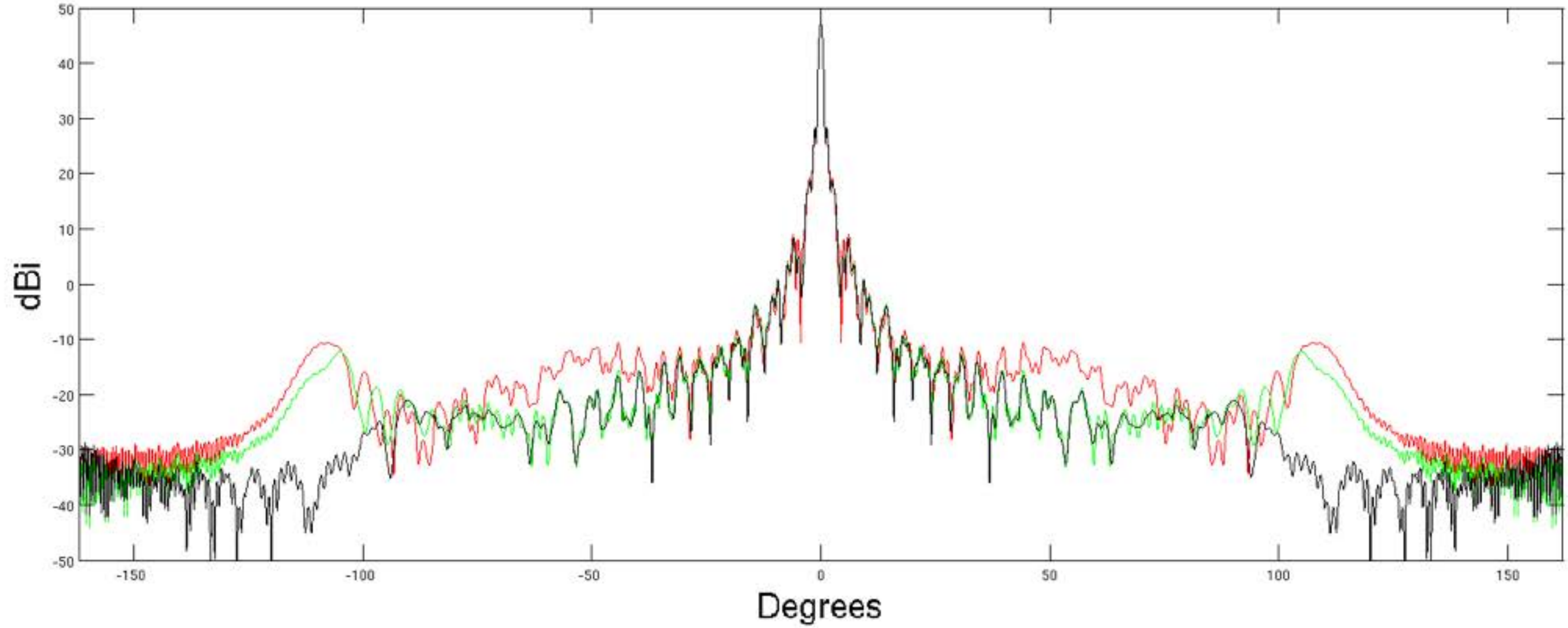
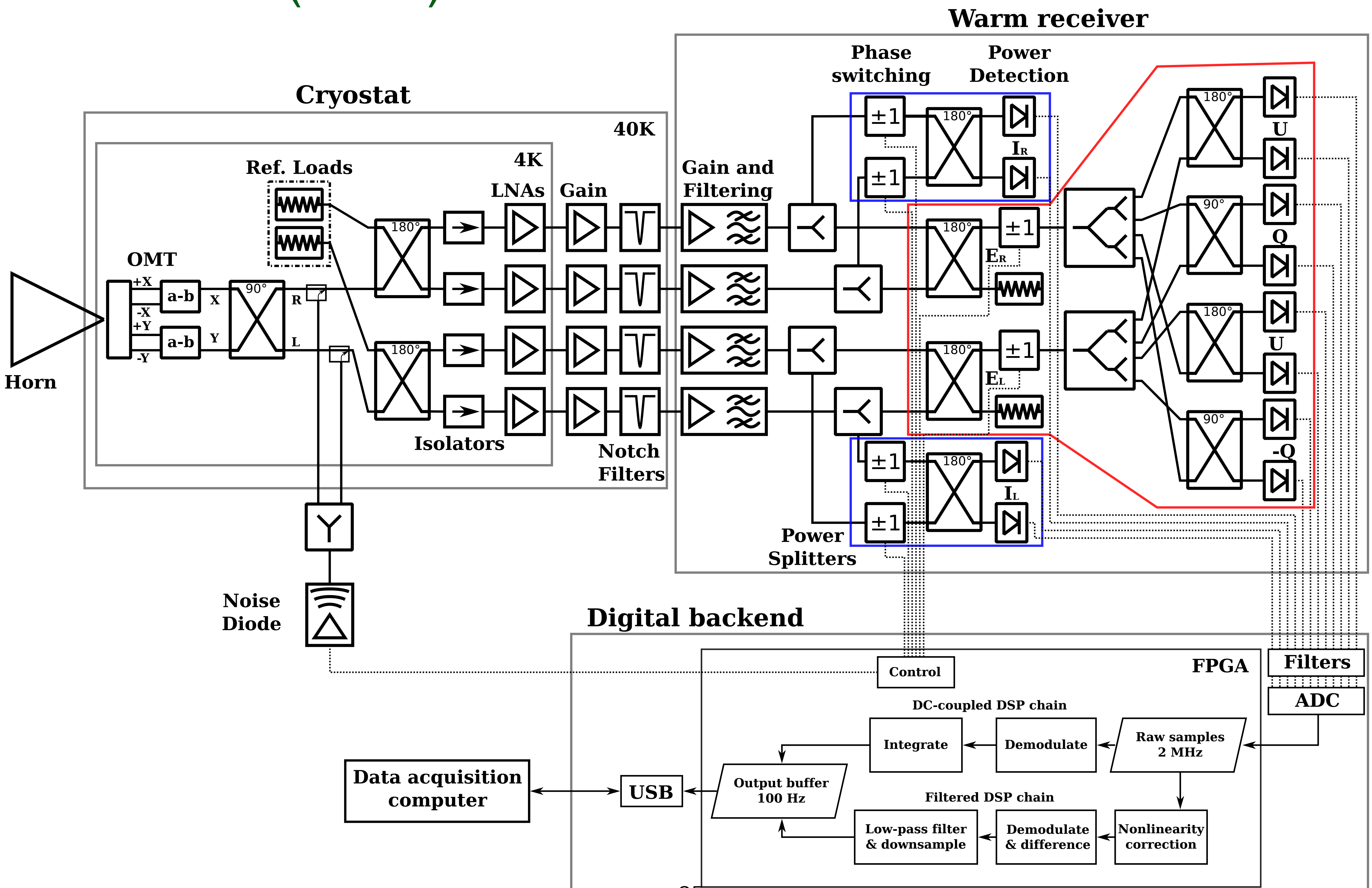


Figure 4: Simulated beam pattern of the 6.1-m antenna at 4.5 GHz, without baffles (red), with secondary baffle only (green)

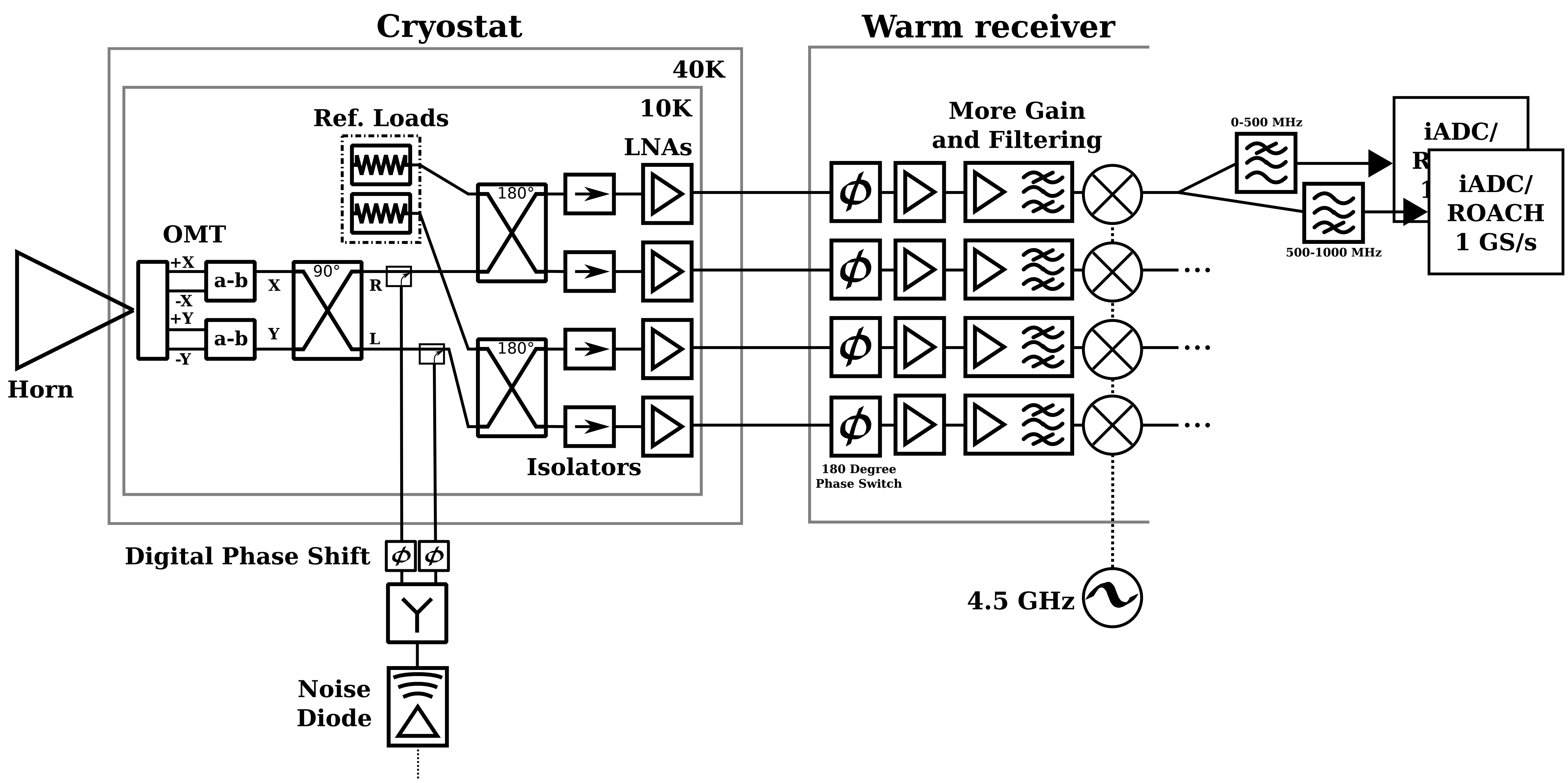
Receivers

- A continuous-comparison radiometer (comparison with a regulated cold load) to measure *I*, and a correlation polarimeter to measure *Q* and *U*.
- The northern system is fully analog, and uses notch filters to remove in-band interference.
- The southern system digitizes the signals after downconversion and implements the correlation and differencing in an FPGA. This also channelizes the data in to 128 frequency channels, allowing efficient excision of RFI.
- Phase switching in the northern system is used to cancel out gain and phase imbalances, resulting in extremely low instrumental cross-polarization (I to Q, U leakage of less than 0.5%).
- In the southern system complex gain corrections can be applied to the signals before correlation to achieve the same effect.

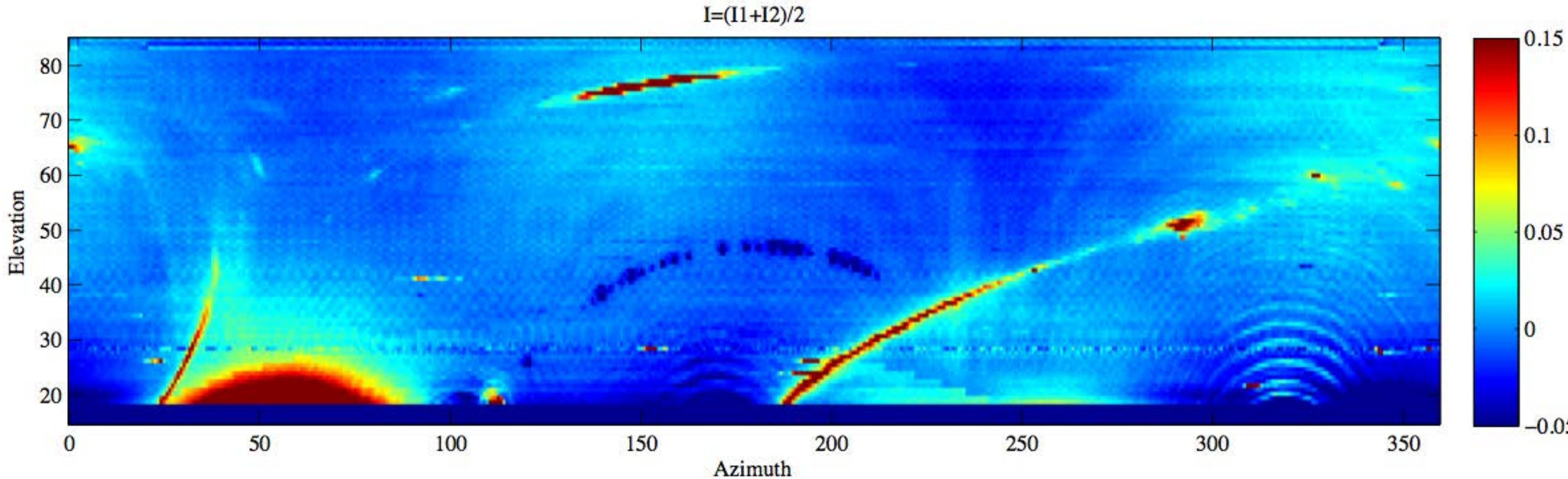
Receiver (north)

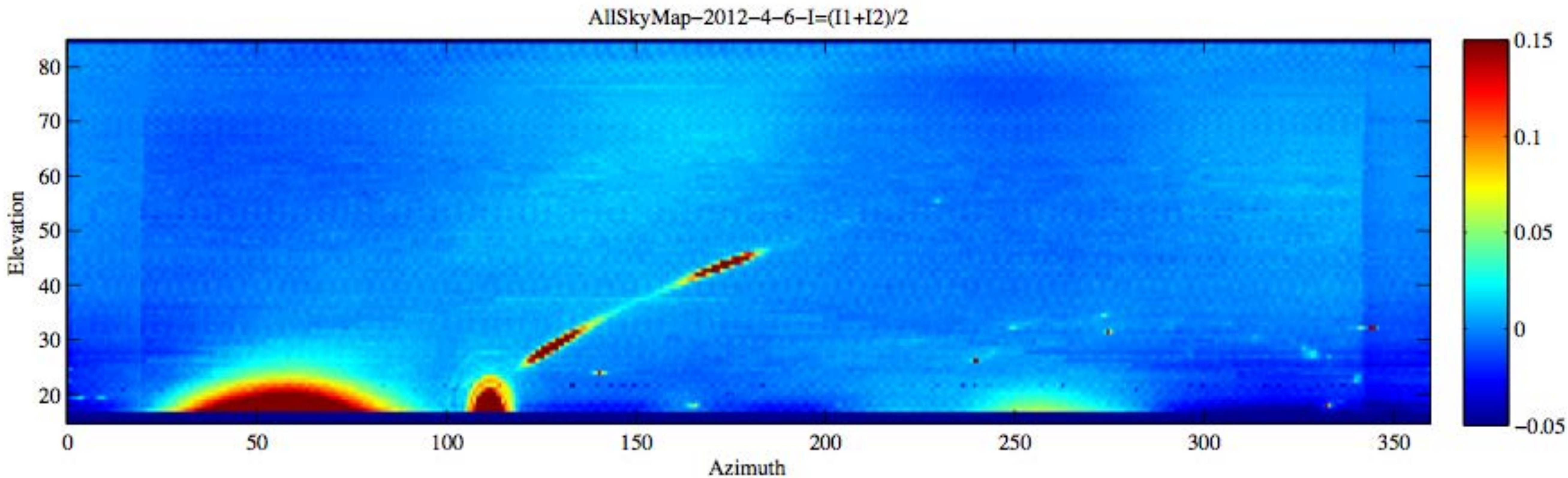


Receiver (south)



Effect of Notch Filters





RFI Routine Overview

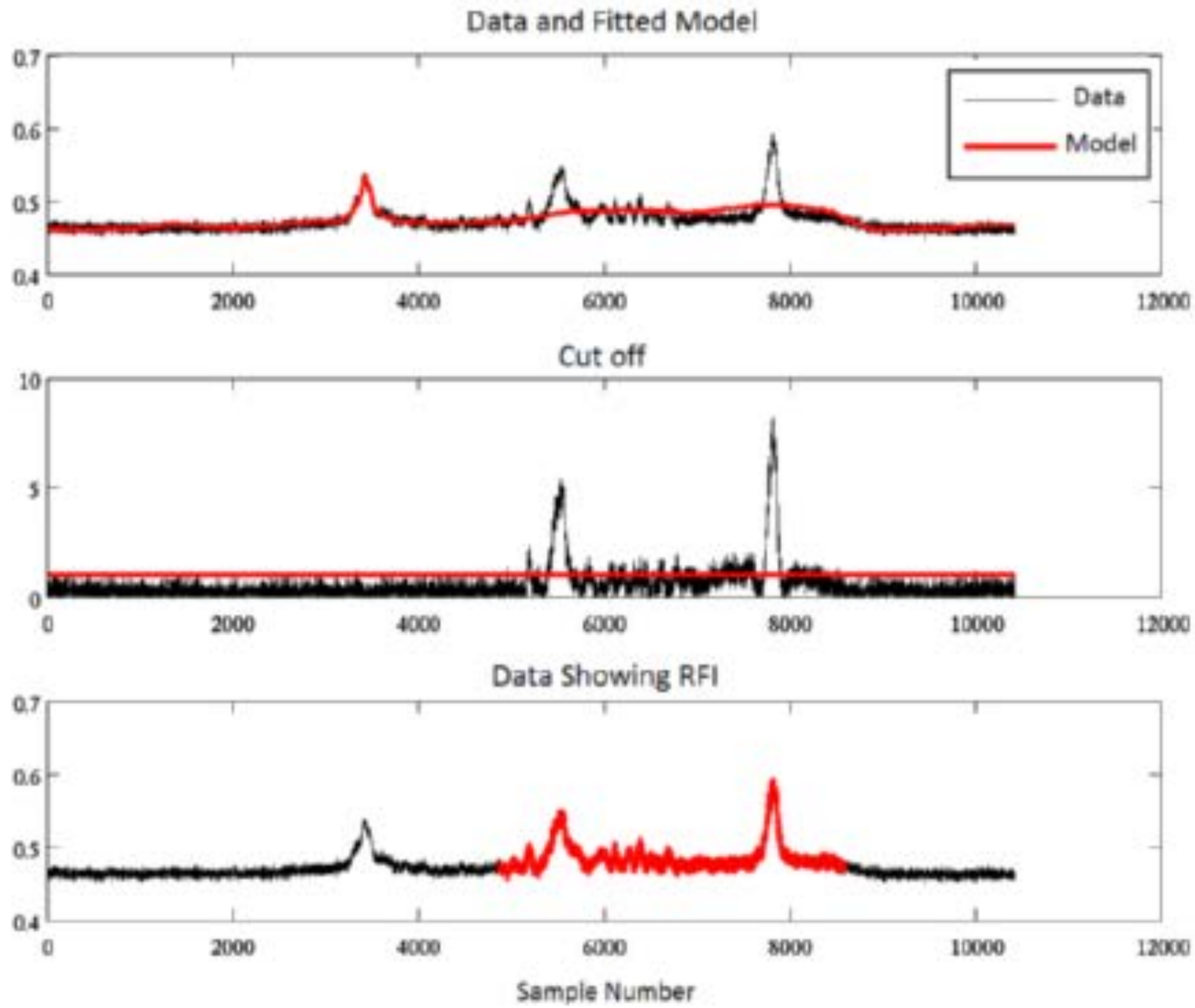
- Flag on the following metric:

$$RFI = \left| \frac{TOD - Model}{\sigma} \right| > \eta$$

σ = RMS of residual
η = cut off value

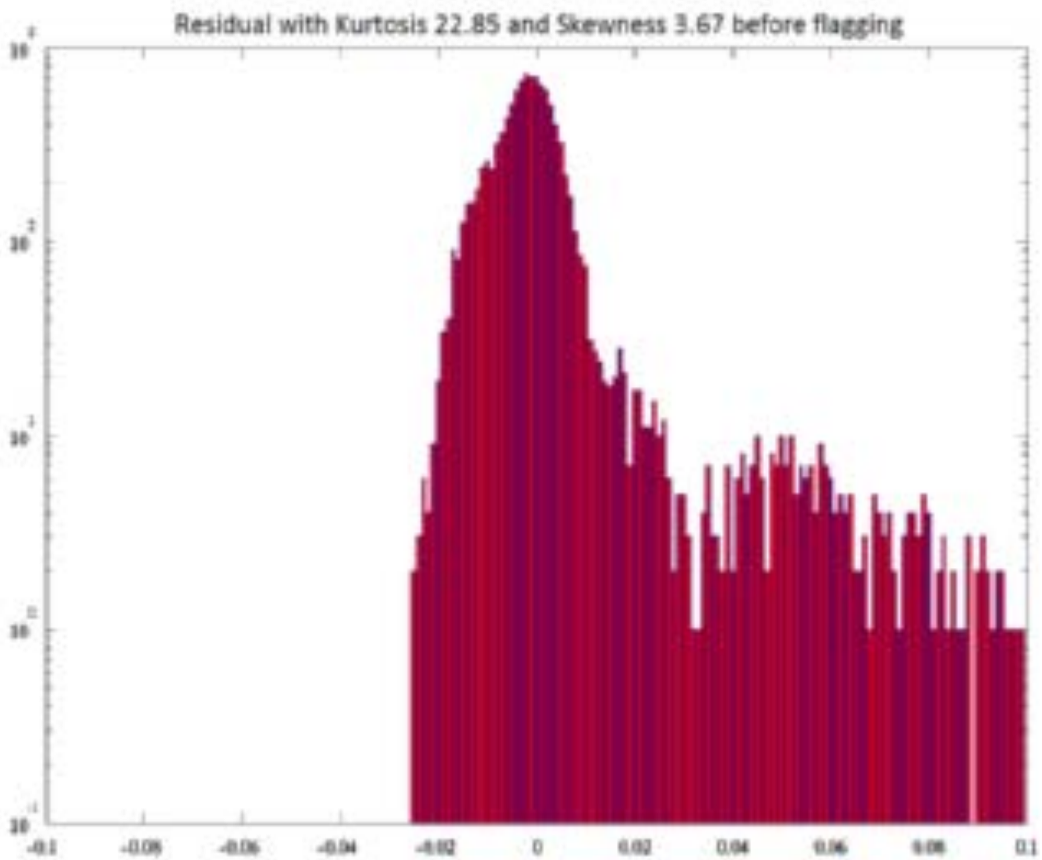
- Start with η = 6 and flag all elements above this value
- Evaluate skewness and kurtosis of the histogram of the residual
- Repeat process with decreasing η until skewness and kurtosis criterion are satisfied
- Add wings to ensure all RFI is flagged

RFI Flagger at Work

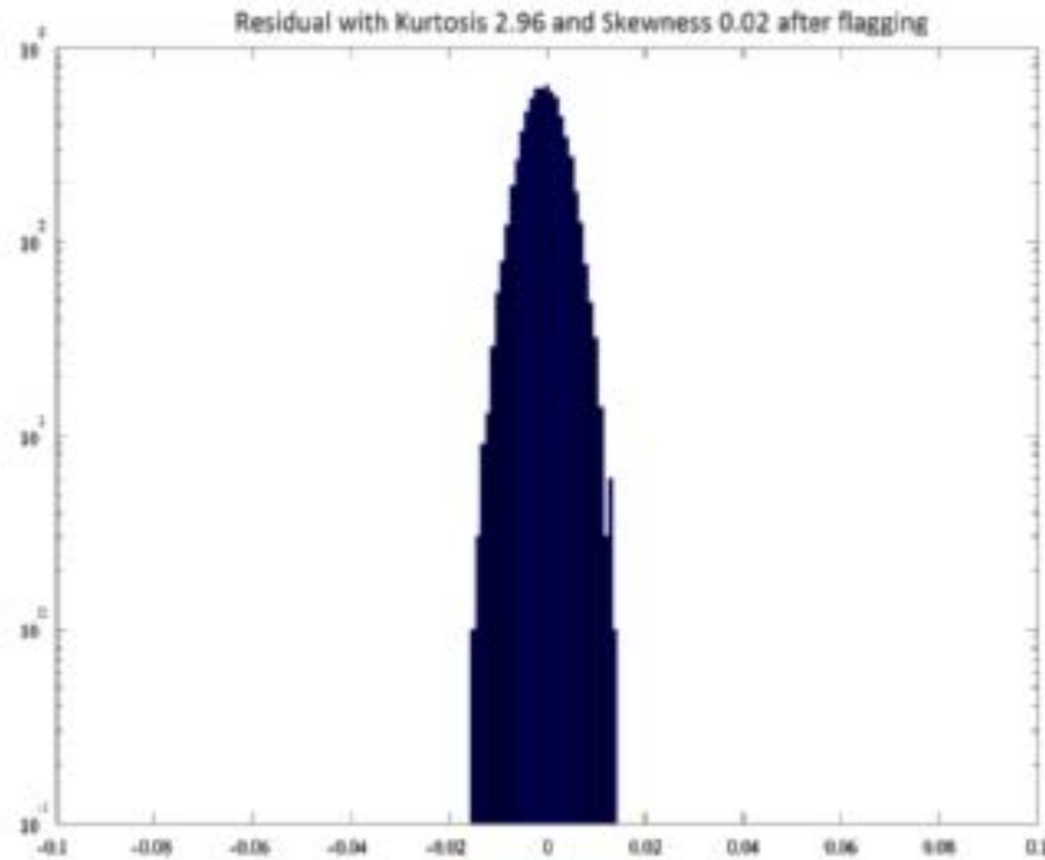


Single azimuth scan – large RFI

RFI Flagger at Work



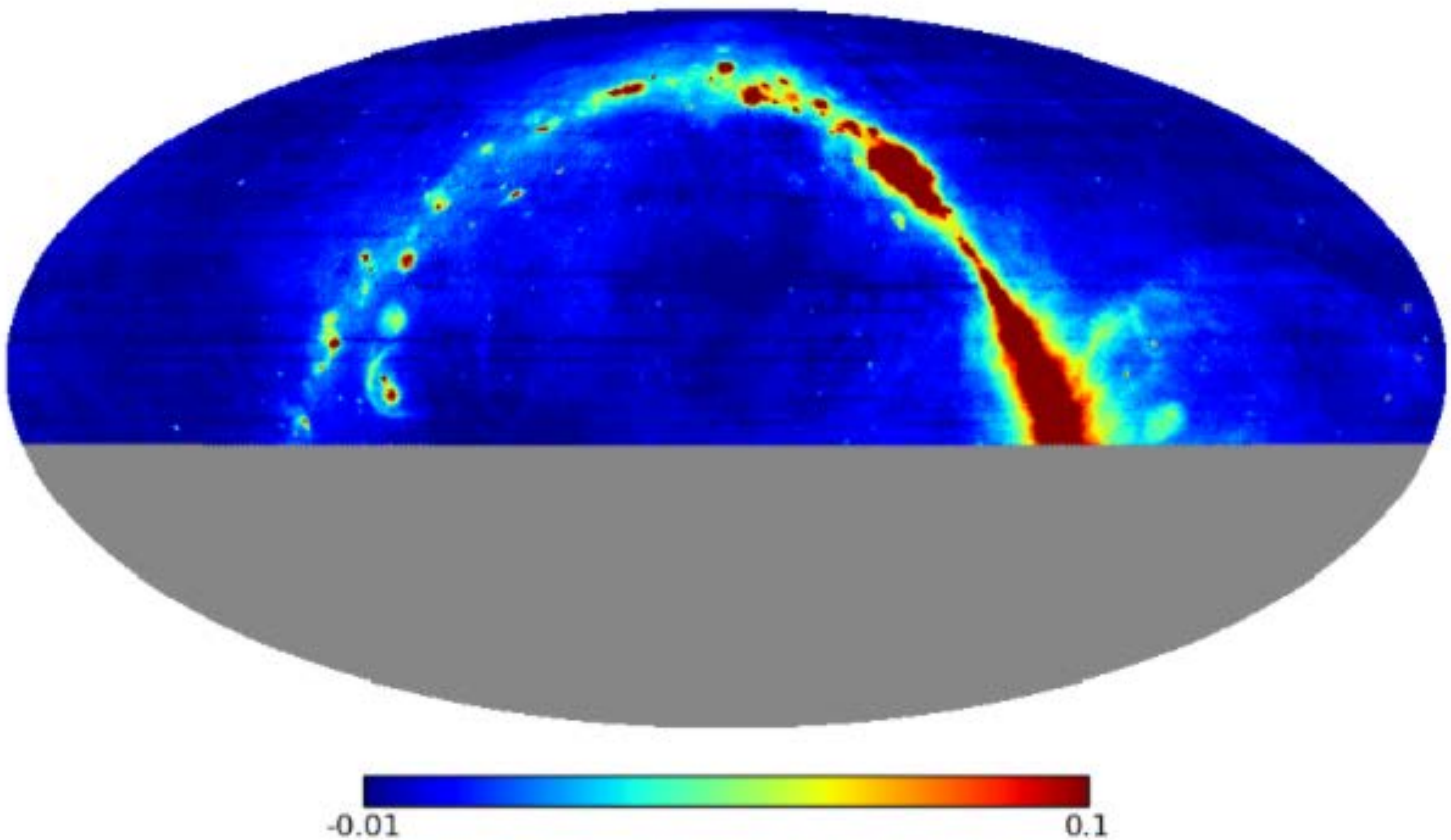
Before Flagging



After Flagging

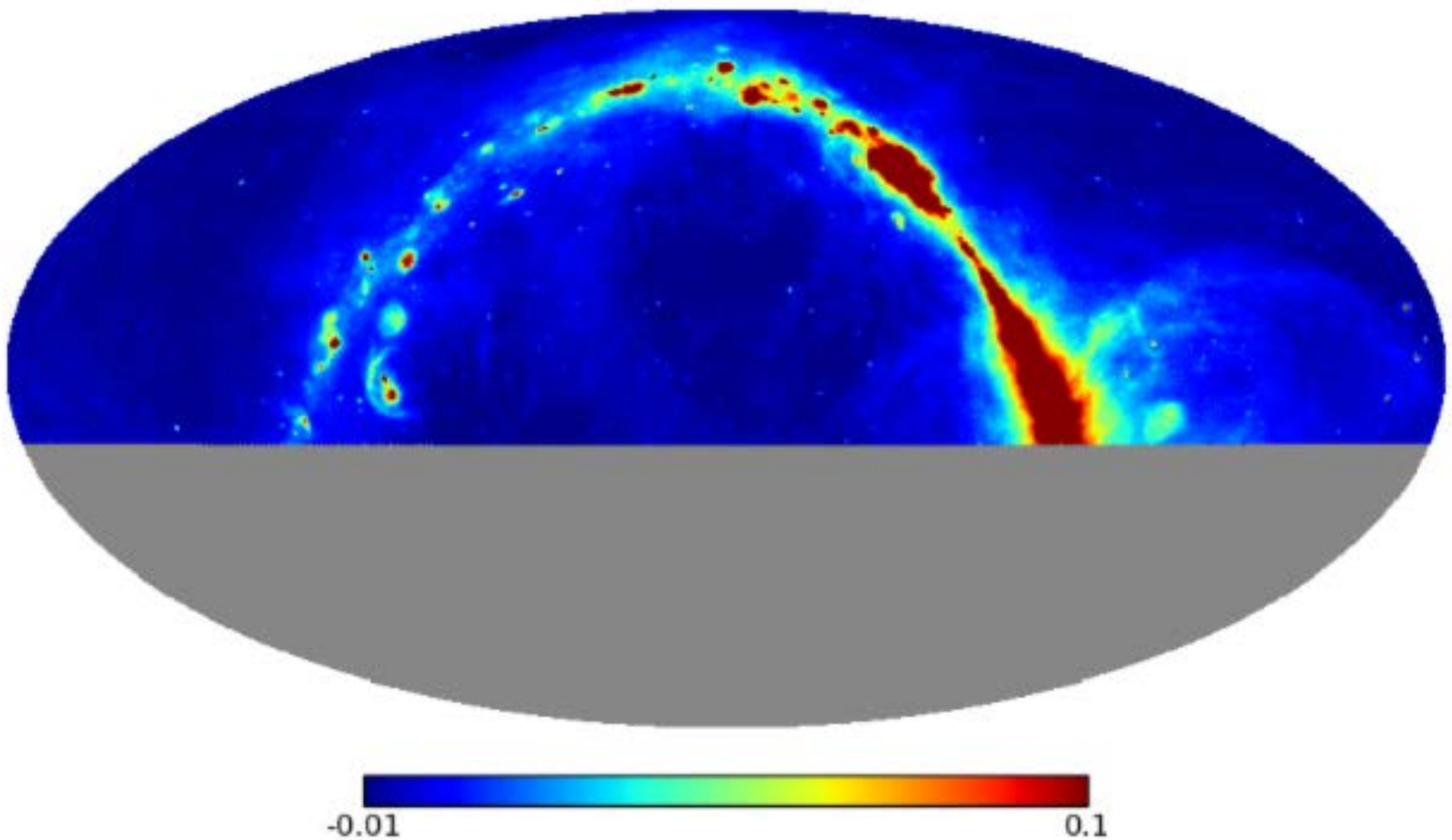
	Before	After
Skewness	3.67	0.02
Kurtosis	22.86	3.00

Elevation 37 Dataset Comparison



Unflagged Data

Elevation 37 Dataset Comparison



Flagged Data

Mapmaking

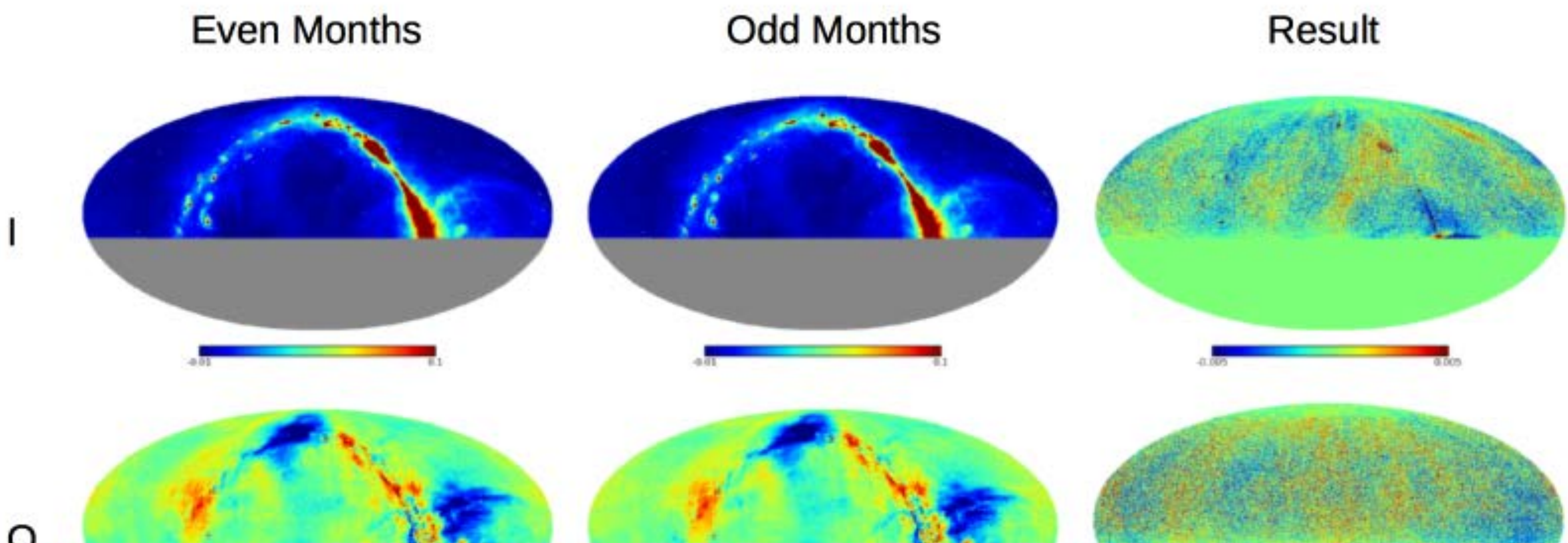
- Using both DESCART (destriping) and Ninkasi (maximum likelihood) for mapmaking.
- M. Aich (UKZN) leading Ninkasi mapmaking.
- Maximum likelihood allows e.g. notching of 1.2 Hz cooler line w/out biasing maps.
- Destriping faster, but C-BASS data small enough that even ML runs are trivially fast.

Jackknife Data Quality Tests

- General – interleaved months
- Pointing – scan speed and direction
- Diurnal variations – day vs night
- Ground contamination - elevation

Concept:
- Split the data into two sets
- Subtract one from the other
- Determine the power spectrum of the difference
- Compare the differenced power spectrum to the expected noise

Interleaved Months



C-BASS Current Status

- Northern data almost ready for science!
- Southern system about to start science observations!