Significant improvements to the GBT surface accuracy via high-resolution radio holography

Todd Hunter (NRAO)

Frederic Schwab, Steven White, John Ford, Frank Ghigo, Ron Maddalena, Brian Mason, Jack Nelson, Richard Prestage, Jason Ray, Robert Simon, Sri Srikanth, Pete Whiteis (NRAO)

- 100m unblocked aperture located within the National Radio Quiet Zone in Green Bank, WV (Elevation ~ 2700 ft)
- Commissioned in 2000
- Large frequency range: 0.3 – 115 GHz
- Active surface

My history with GBT

Before coming to NRAO in 2006, I worked on the SMA for 10 years in Cambridge MA (and Mauna Kea, Hawaii)

I first met John Payne in 2000 at SMA review committee meeting.

When I interviewed for NRAO Sci Staff position, John Payne came to find me at Edgemont Road to say how the GBT really needed a scientist to oversee the surface improvements – he was still thinking laser ranging at the time.

ALMA couldn't hire me for more than 10% effort yet, so I spend most of my weekdays in Green Bank trying to lead the PTCS effort.

1) First priority was recovering from azimuth track repair: Joe Brandt implemented new track map term developed by Kim Constantikes'
2) Second priority was getting Bojan's OOF holography more routine (AutoOOF), which Melindo Mello and Pam Ford integrated. (This was my first project in python, and I never looked back).
3) My primary goal was to measure the surface at high resolution with satellite holography to improve the actuator setting. A team effort of whole staff, but Fred Schwab was the key to its ultimate success.

Holographic Measurement and Improvement of the Green Bank Telescope Surface

Show affiliations

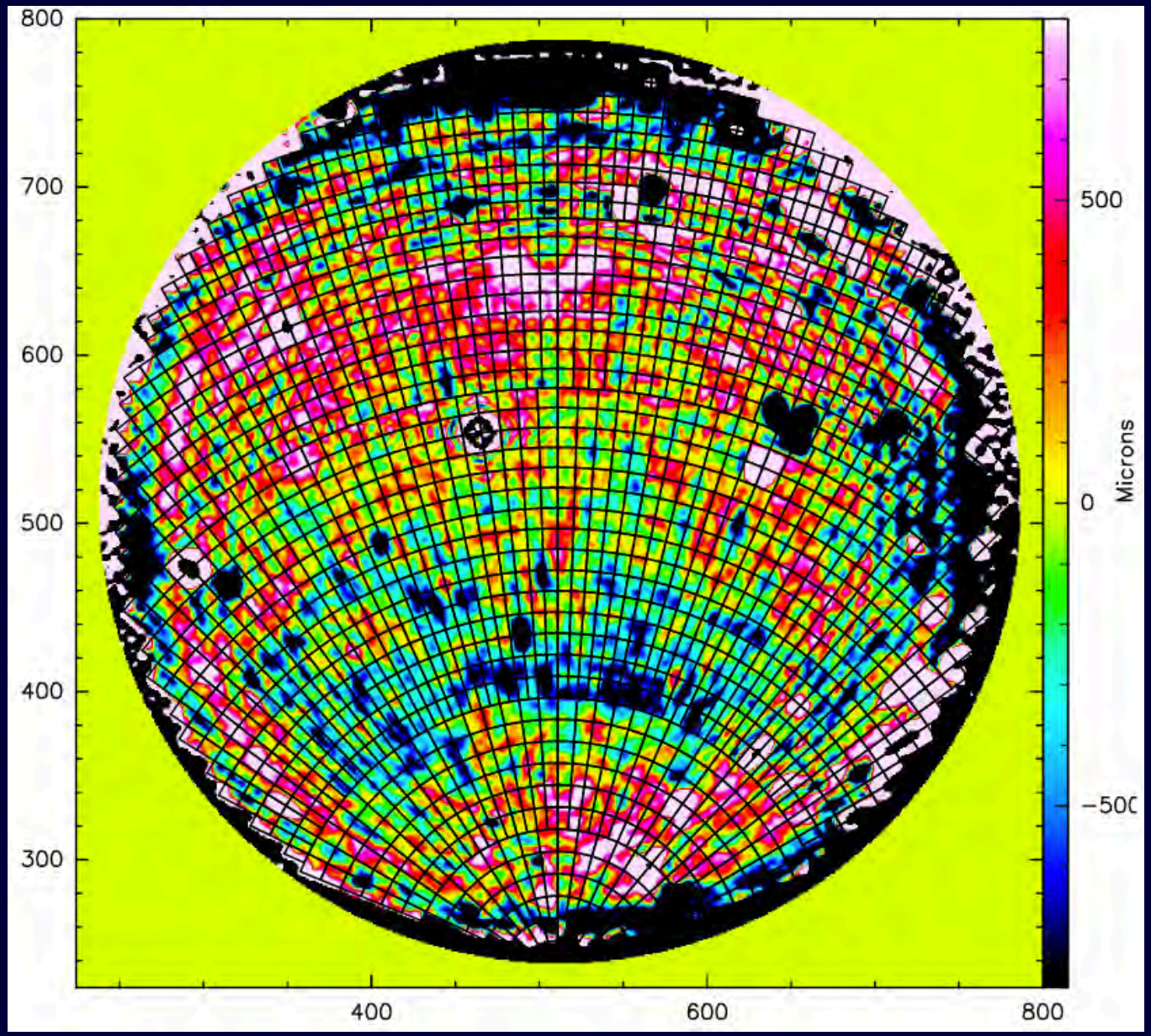
Hunter, Todd R.; Schwab, Frederic R.; White, Steven D.; Ford, John M.; Ghigo, Frank D.; Maddalena, Ronald J.; Mason, Brian S.; Nelson, Jack D.; Prestage, Richard M.; Ray, Jason; Ries, Paul; Simon, Robert; Srikanth, Sivasankaran; Whiteis, Peter

Publication: Publications of the Astronomical Society of the Pacific
Pub Date: September 2011

longer presentation given in Socorro in 2010:
https://safe.nrao.edu/wiki/pub/GB/PTCS/PresentationsAndProceedings/HunterAOC2010.ppt

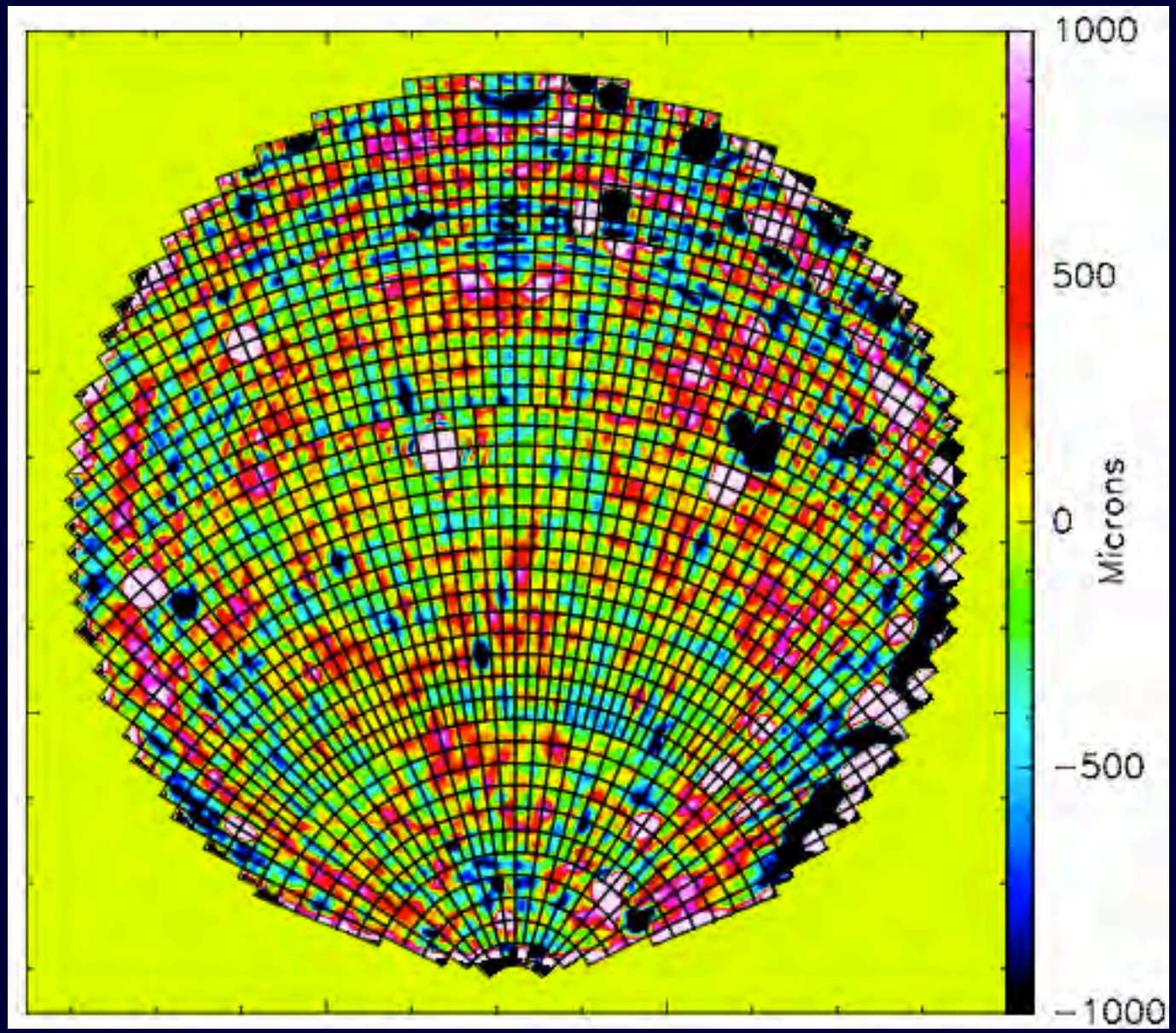
First high-res. map - January 2009

"we have a lot of work to do"



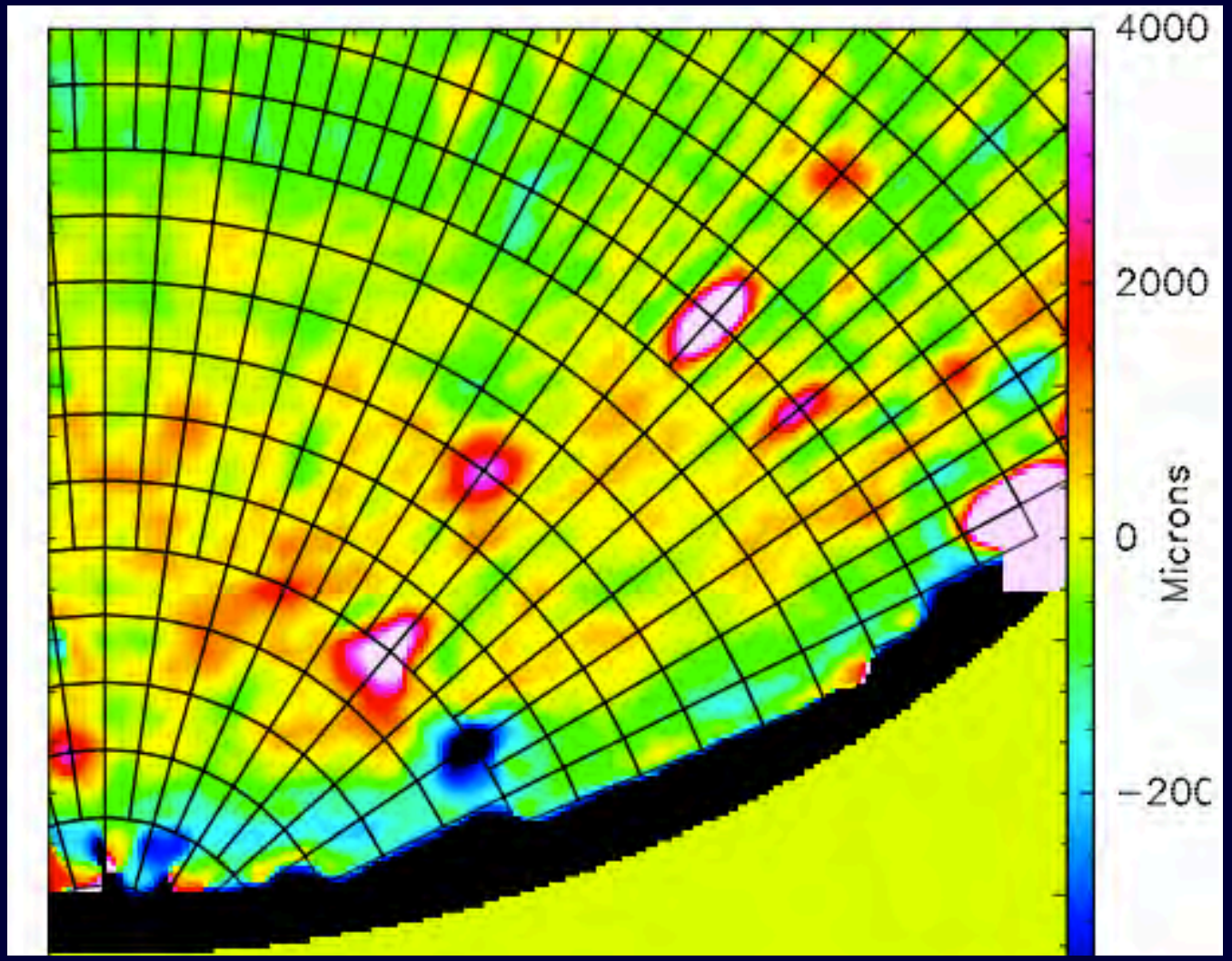
First high-res. map - January 2009

55 Zernike terms removed



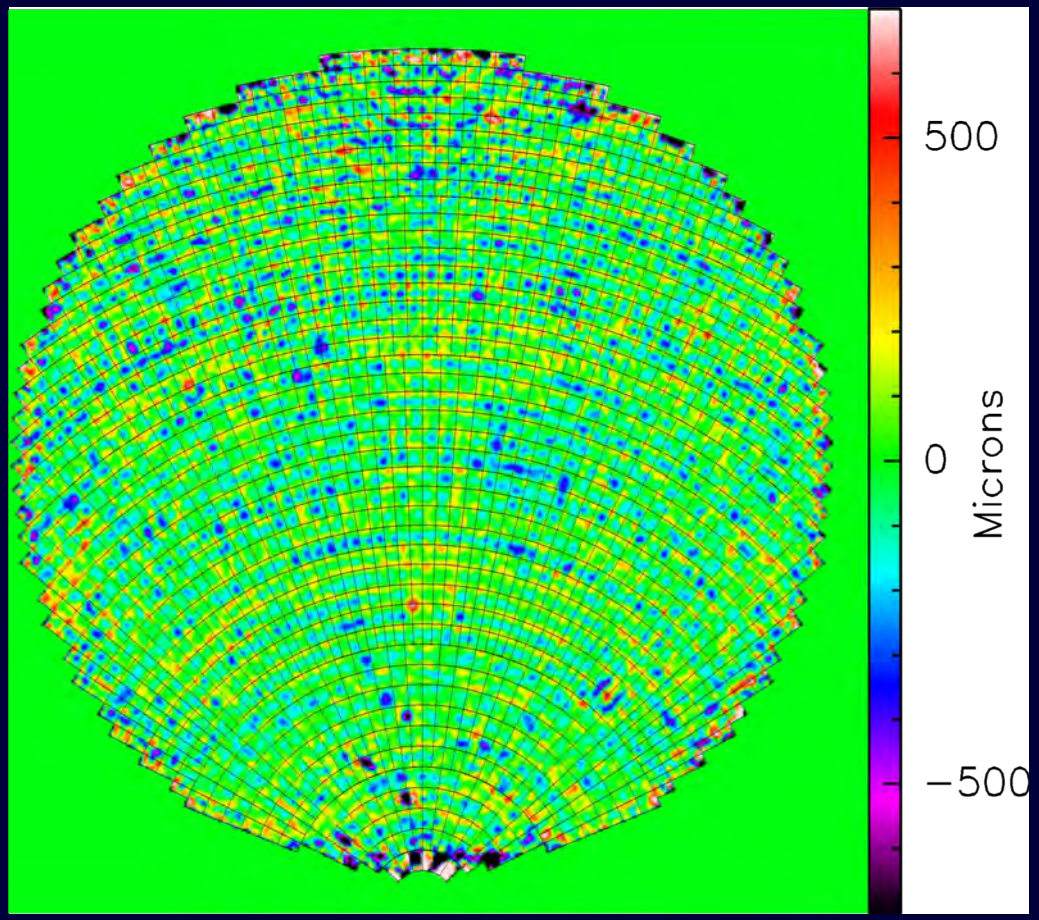
First high-res. map - January 2009

reveals actuator “influence function”: it works!

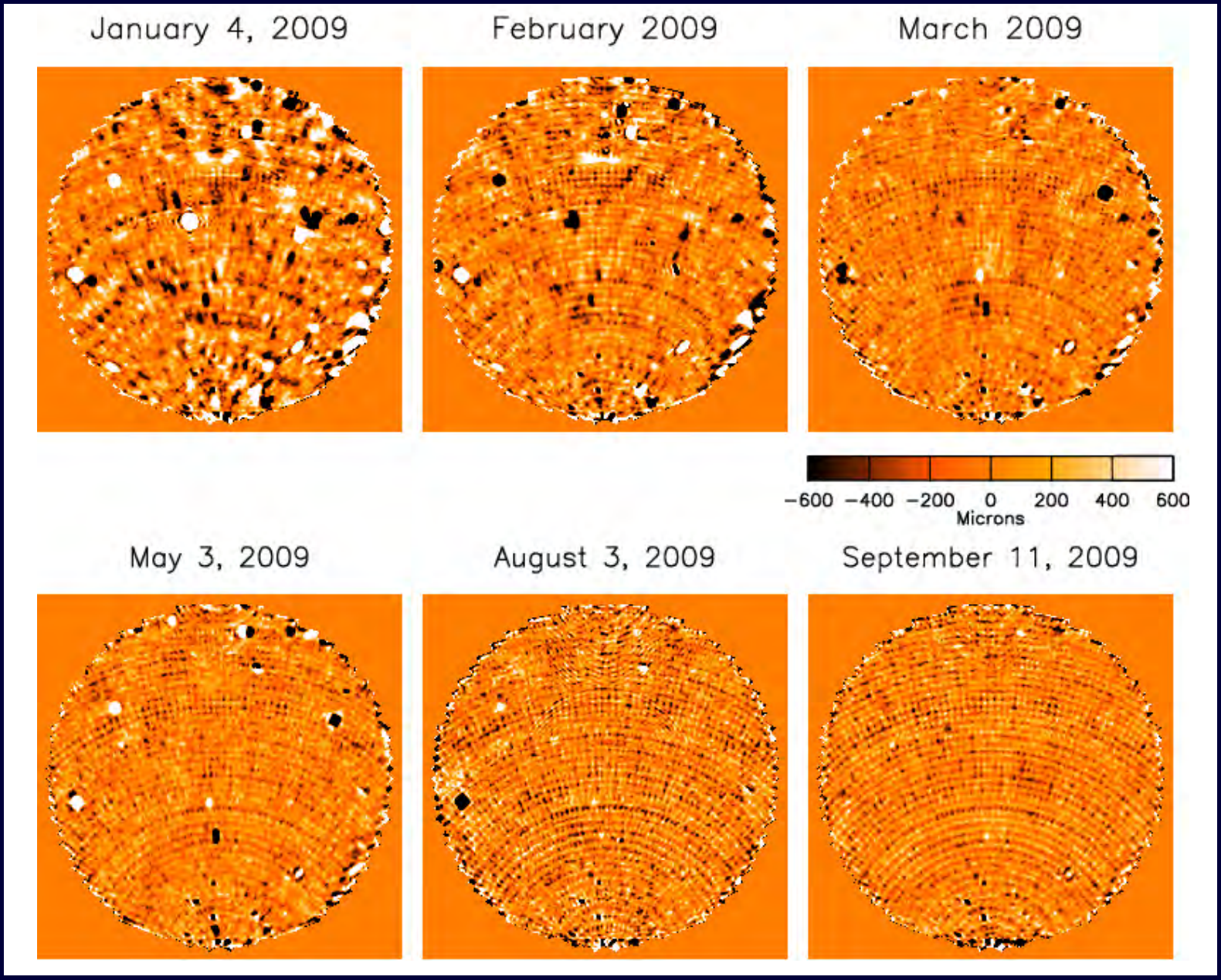


Iteration sequence

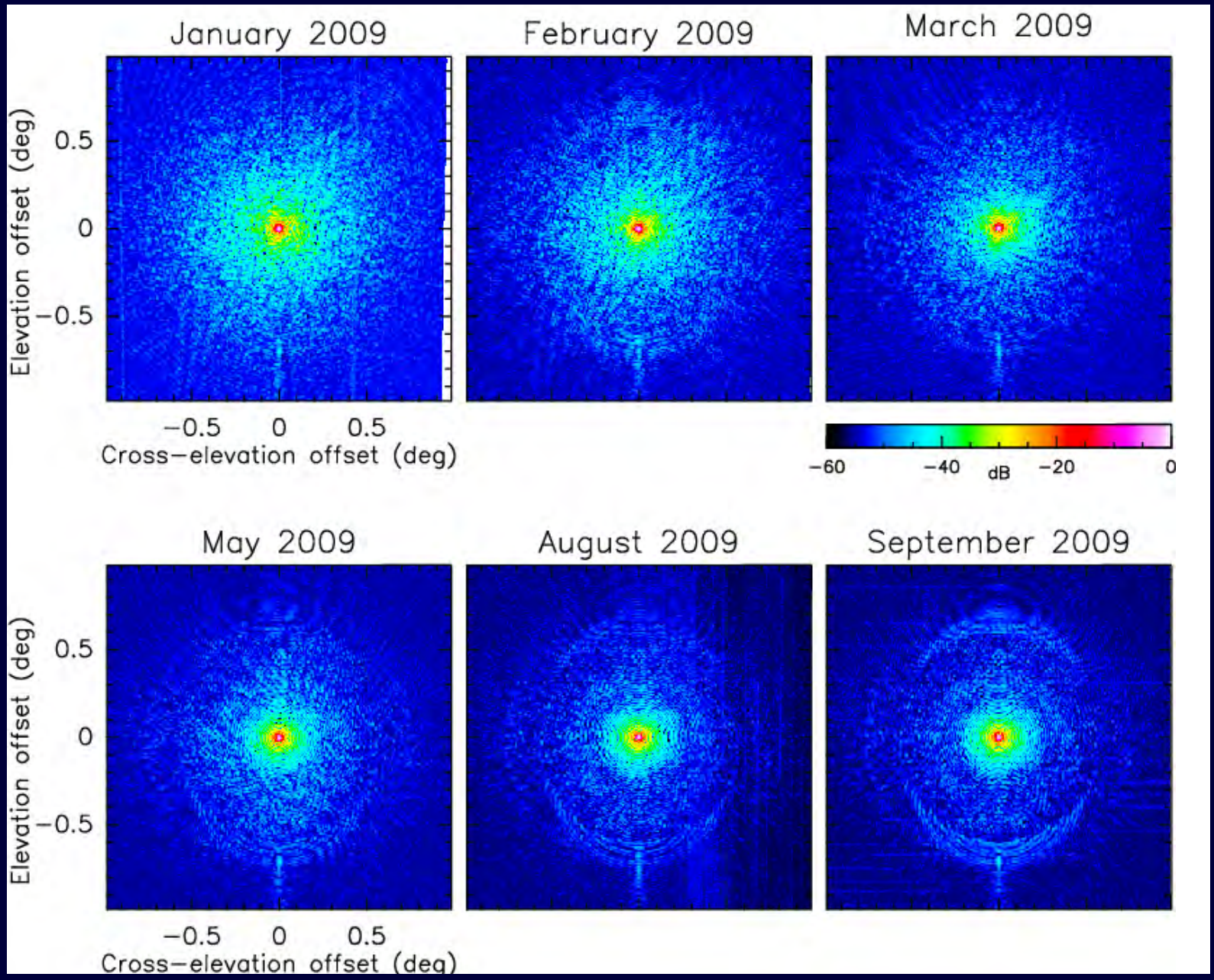
1. Obtain holography map
2. Remove any large-scale structure
3. Determine corrections for all actuators
4. Apply corrections (scaled by 0.5)
5. Confirm efficiency improvement at 90 GHz with MUSTANG bolometer camera
6. Repeat



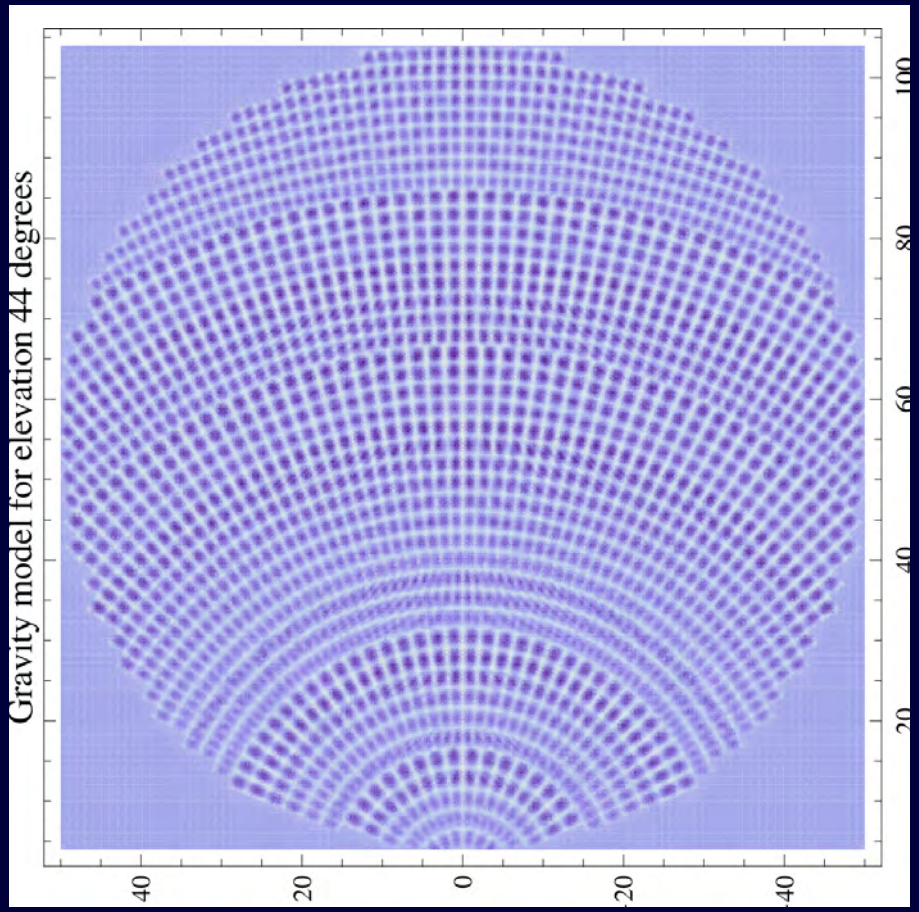
Progression of surface adjustments



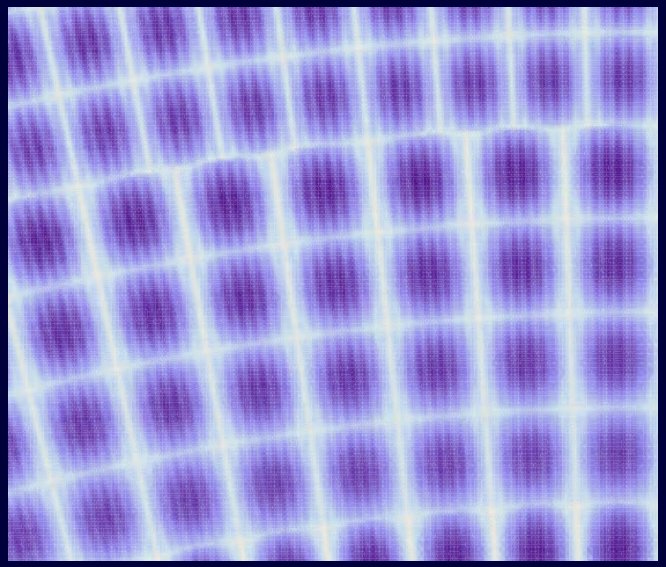
Amplitude beam patterns



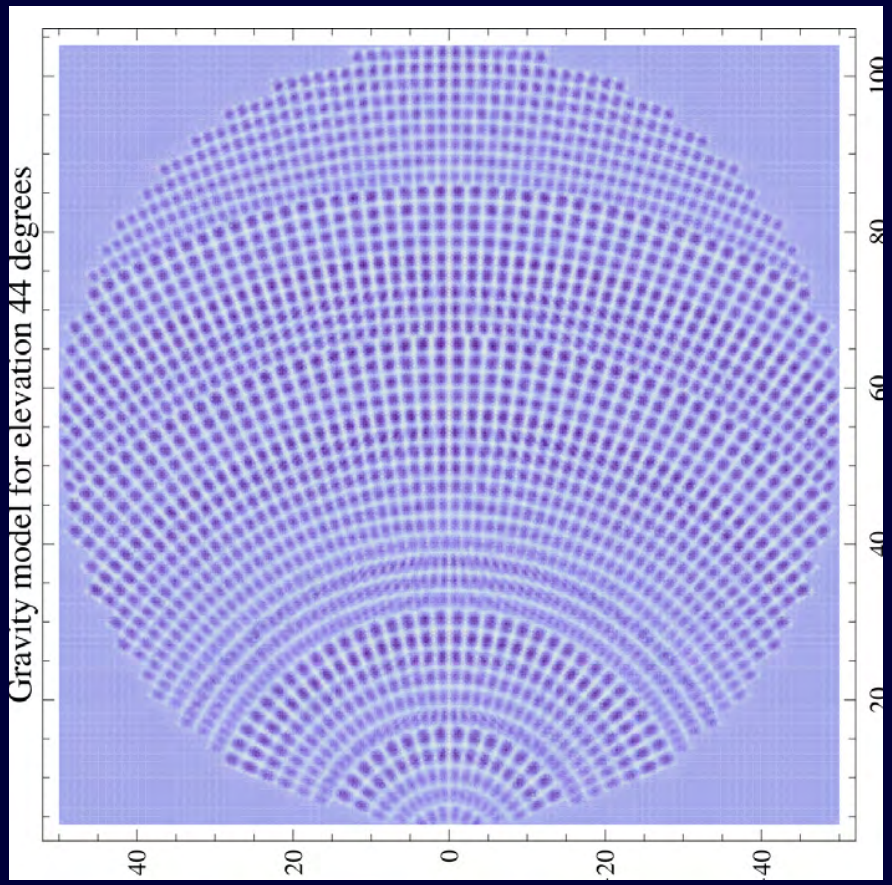
FEM Model of panel gravitational deflection



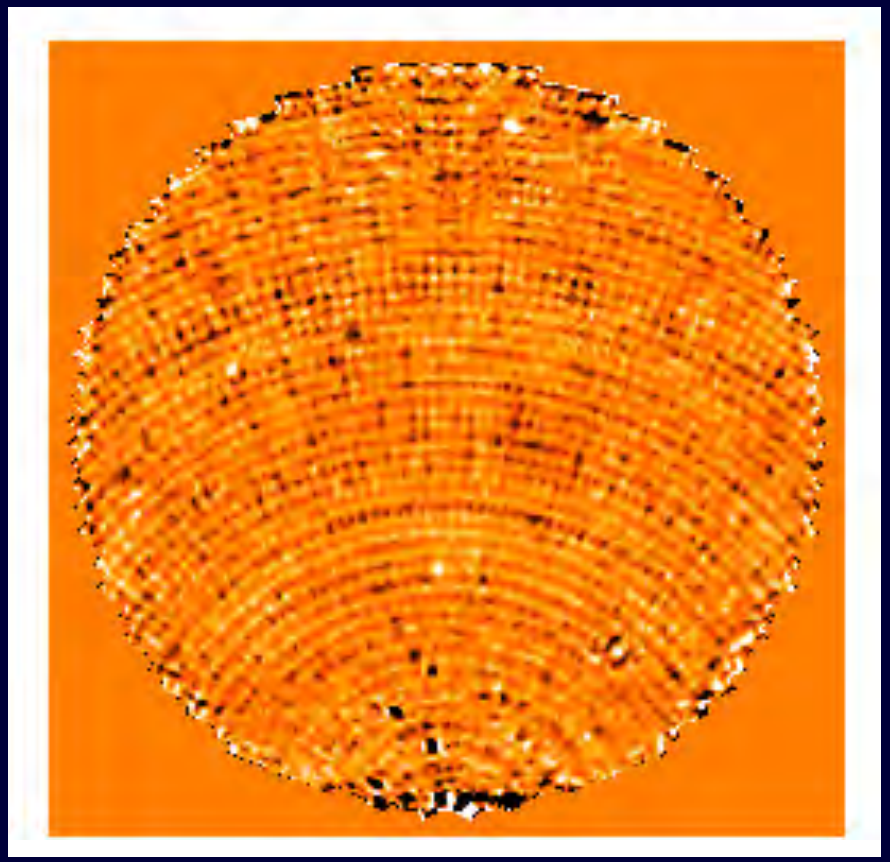
Zoom (showing panel rib structure)



Model of panel gravitational deflection



Observed surface error



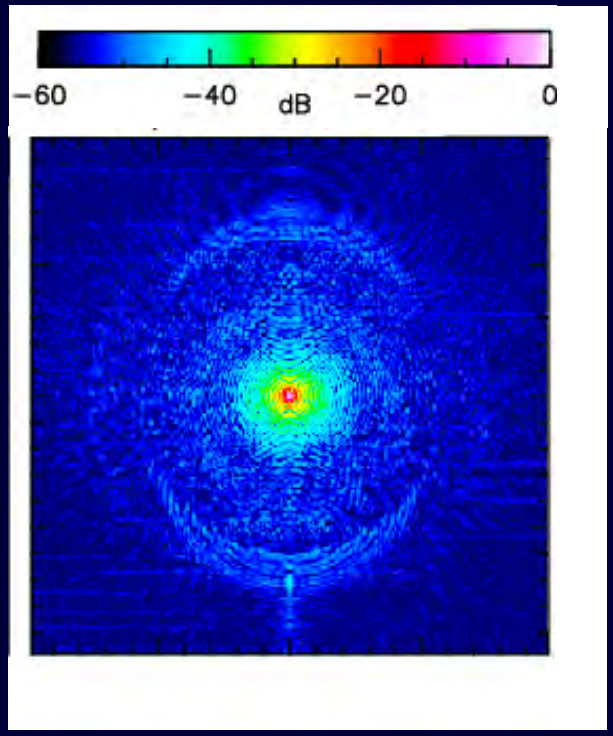
"We got the telescope we paid for…"

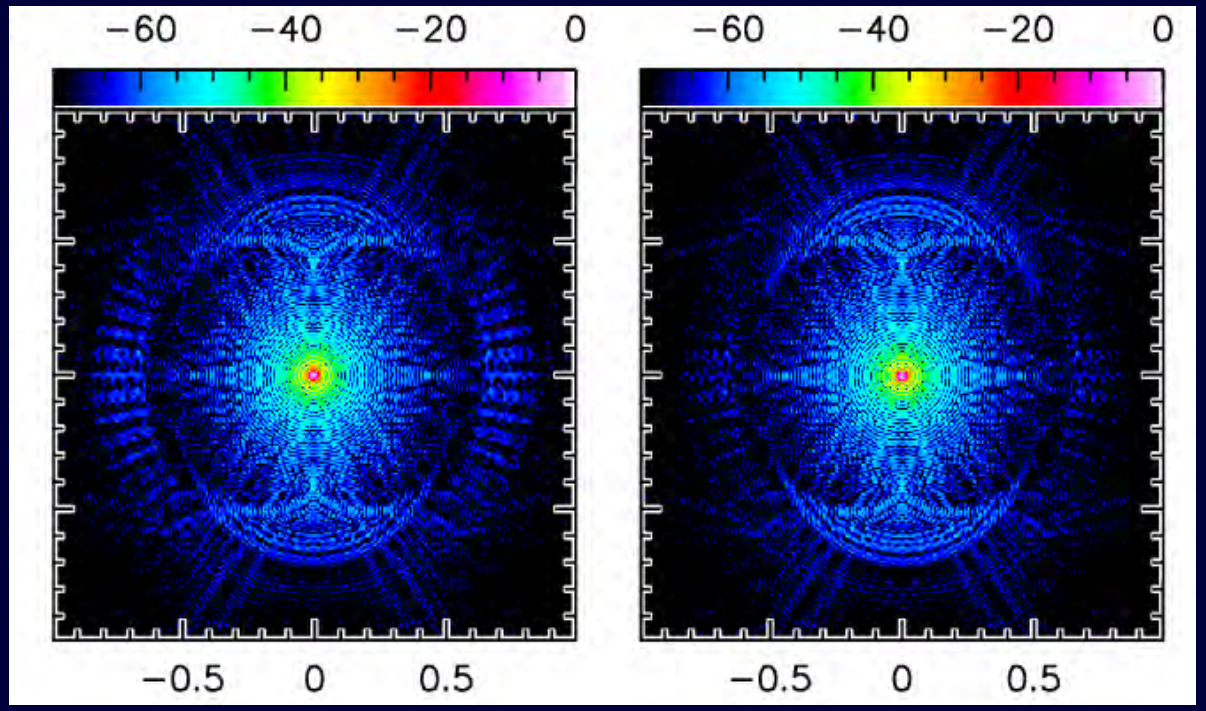
Observed beam

Predicted beam

Gravity error

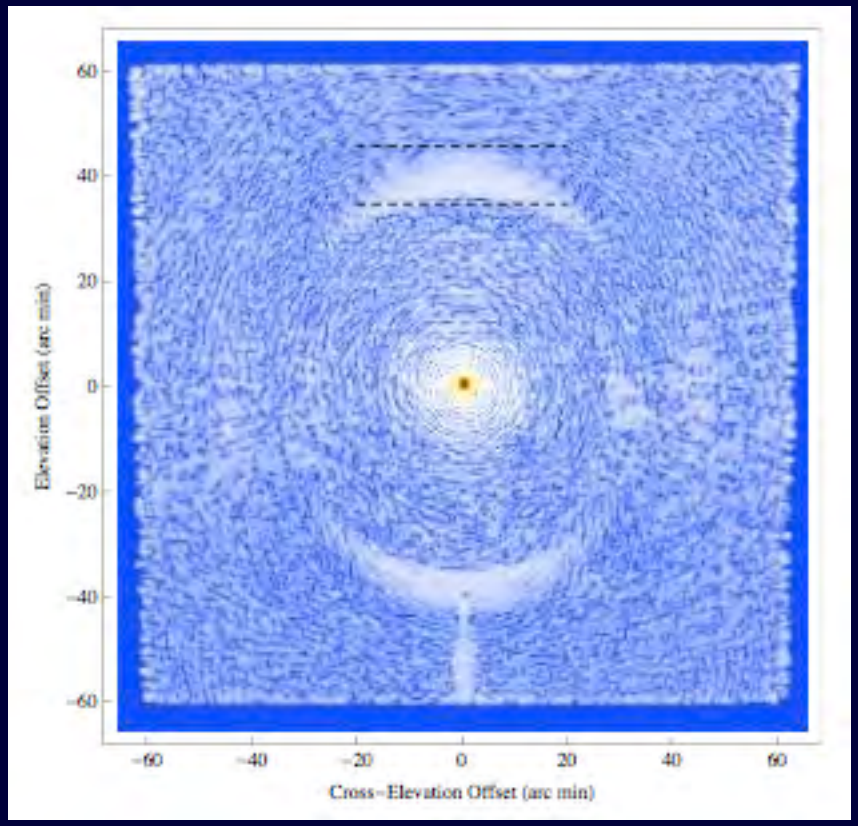
Thermal error (ΔT=2°)



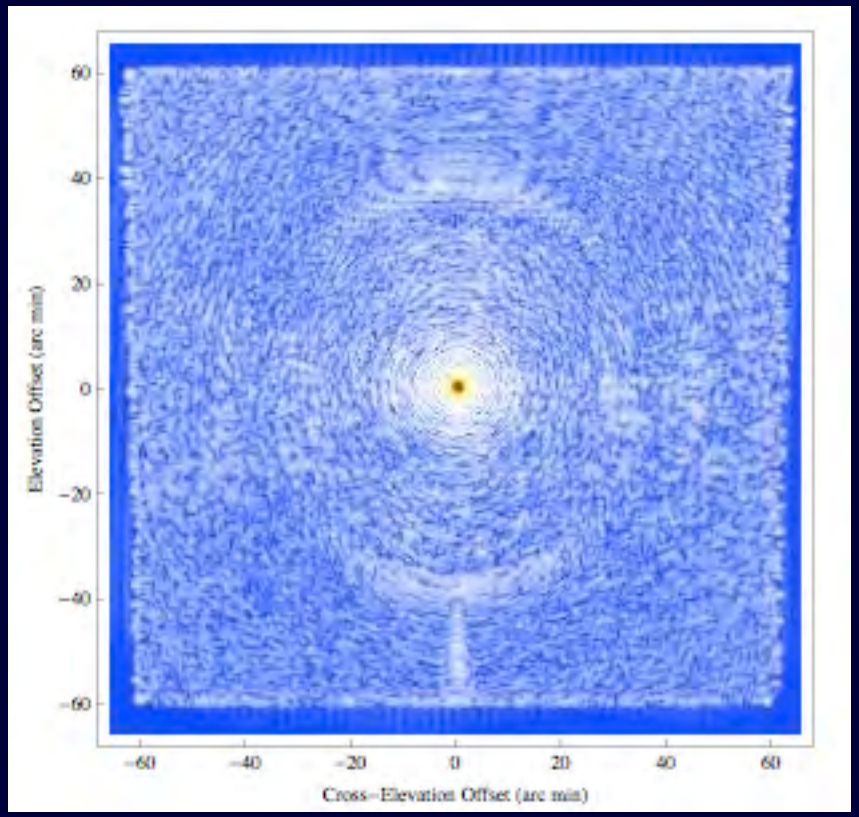


Two nighttime maps

Clear skies (ΔT = -2°)

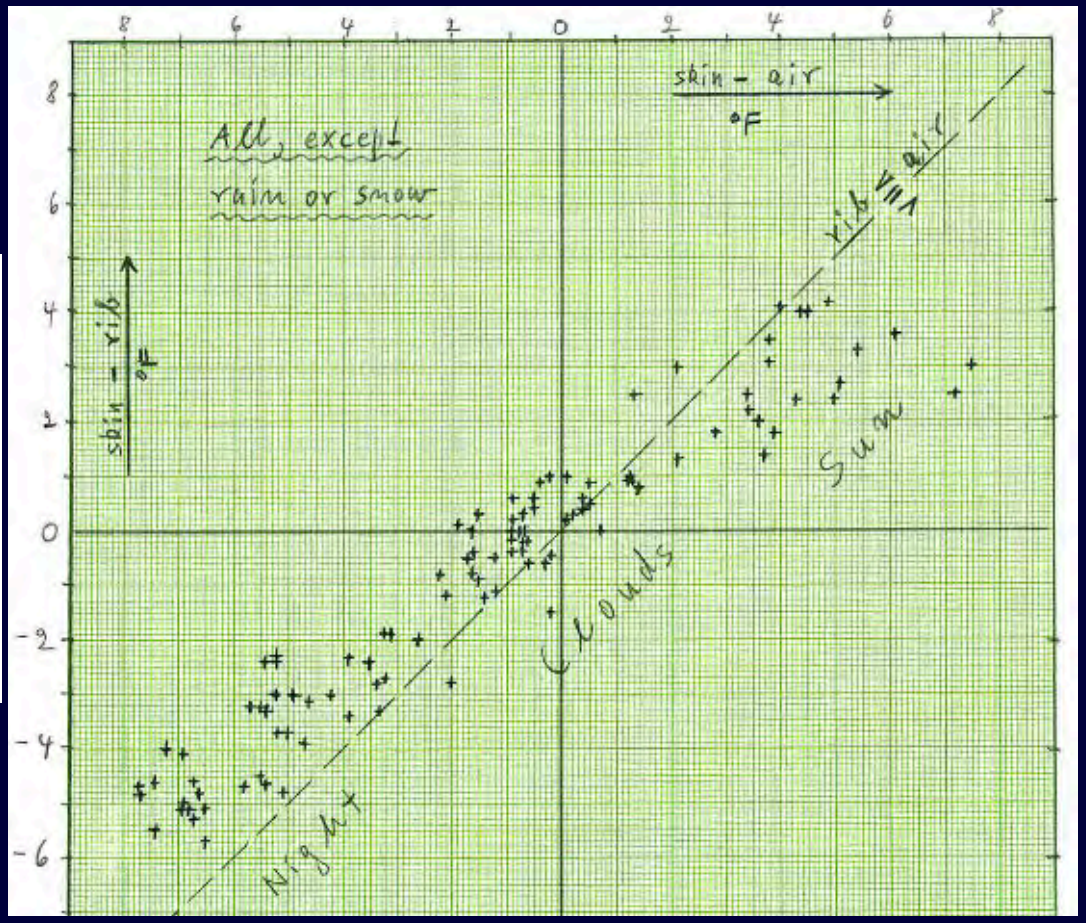


Cloudy skies (ΔT~0°)

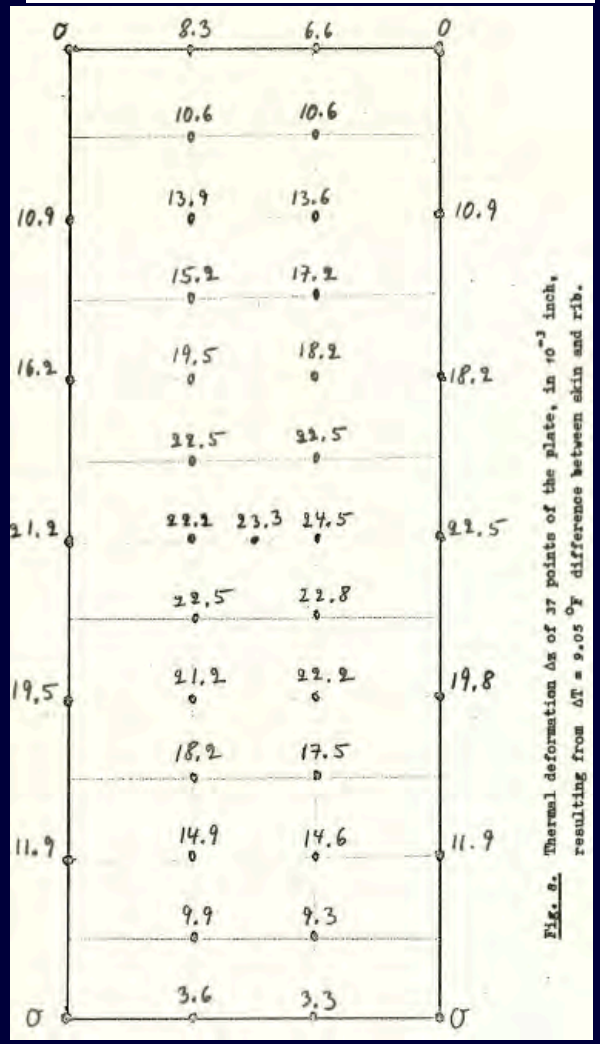


S. von Hoerner (January 1971)

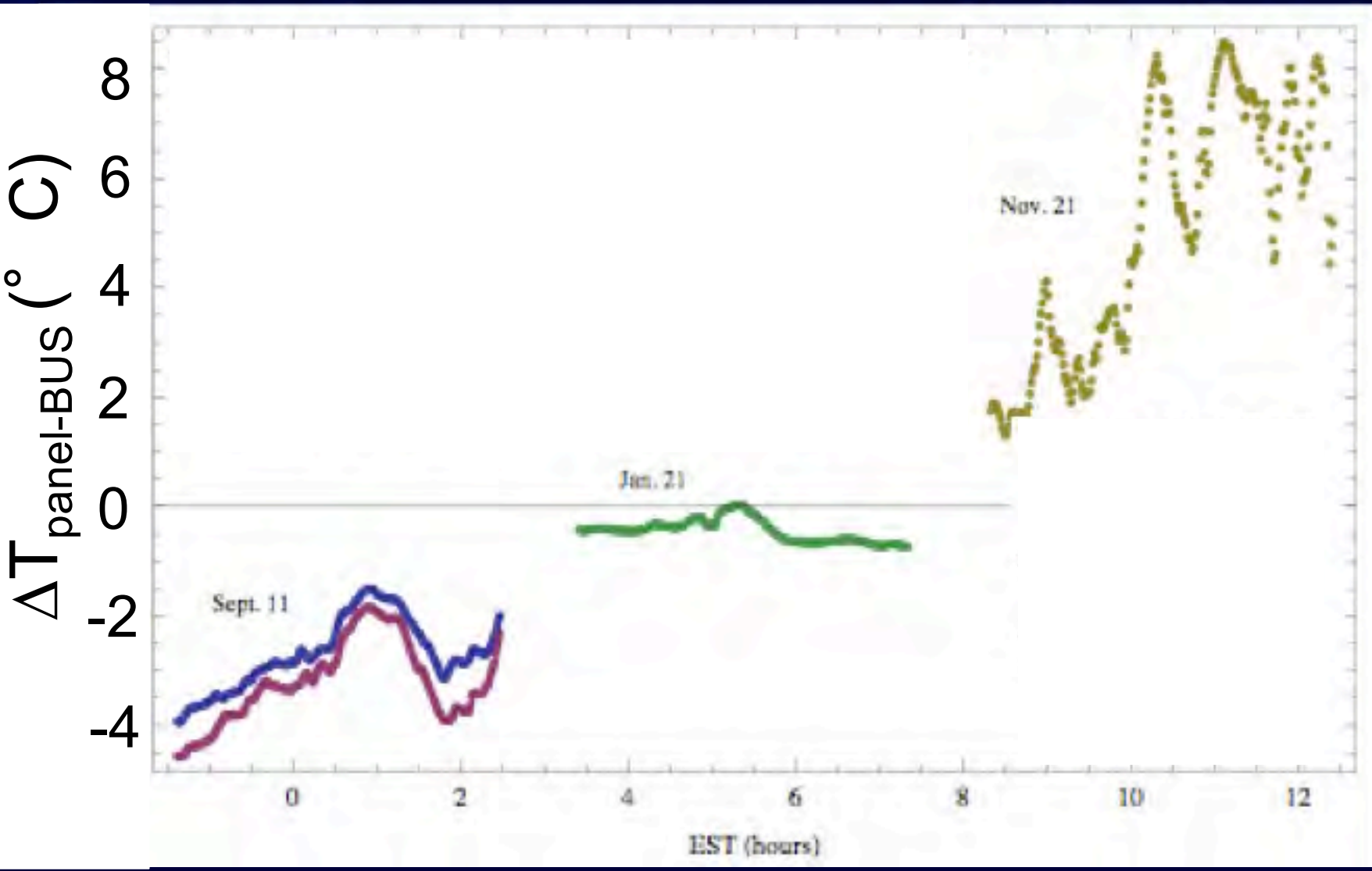
Measured panel temperature gradients



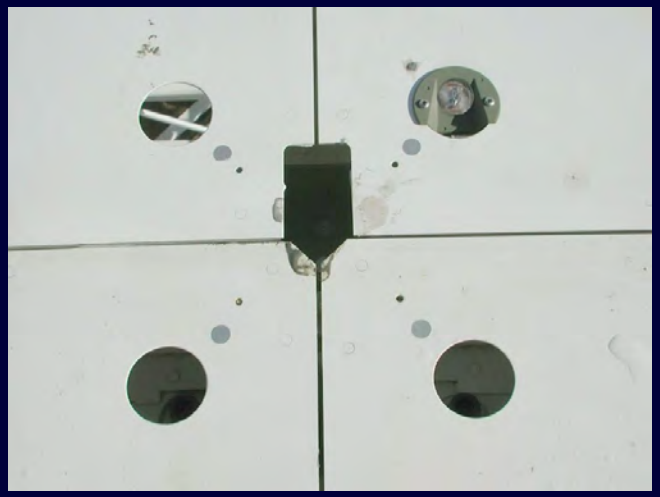
Panel deflection (mils)

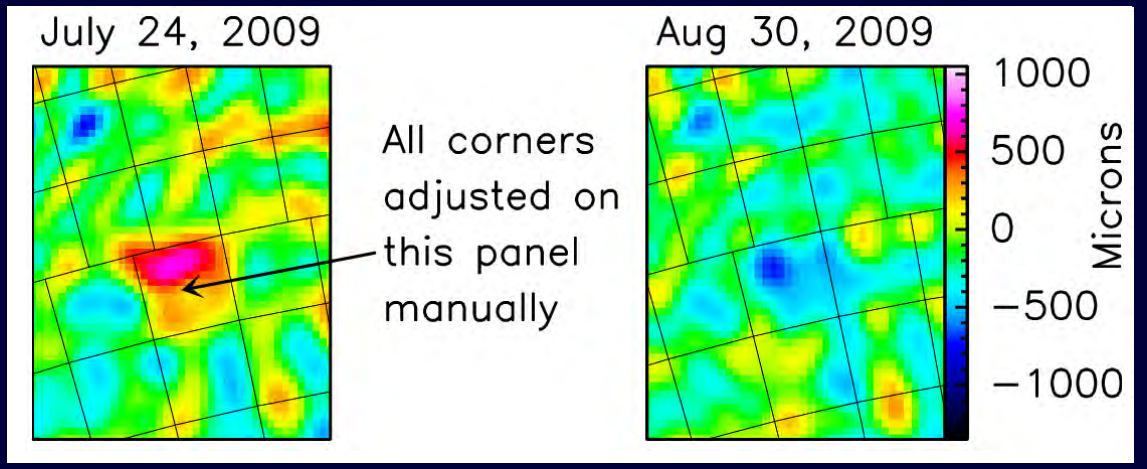


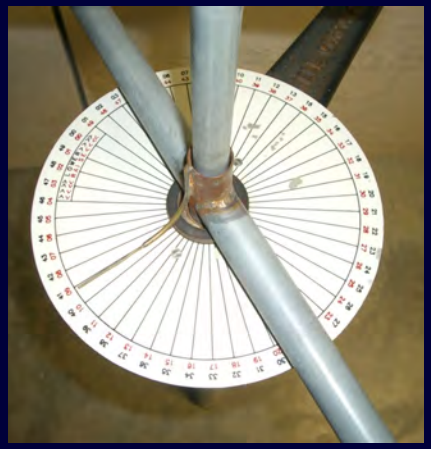
GBT panel temperature gradients during three recent holography maps

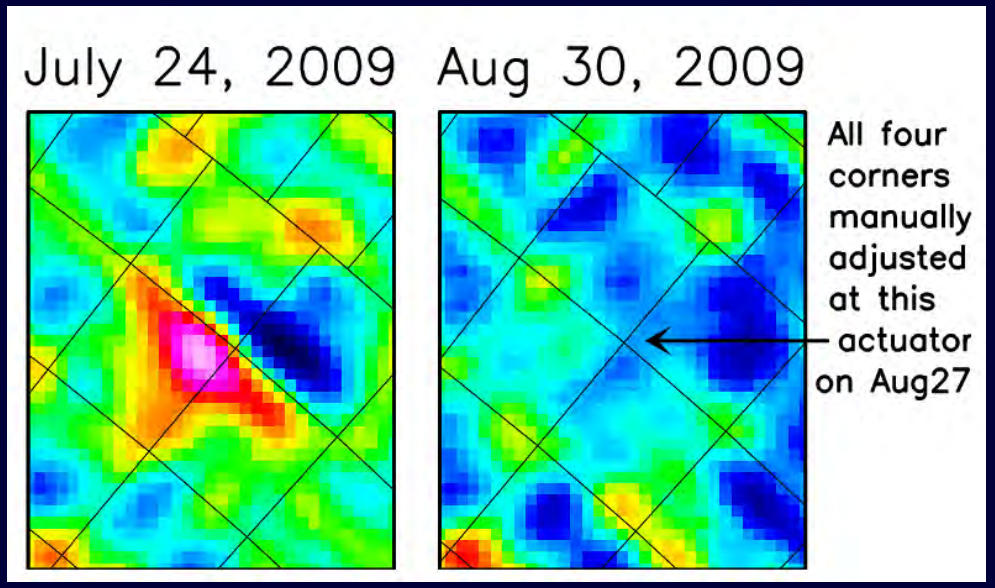


A Few Manual Adjustments to the Surface



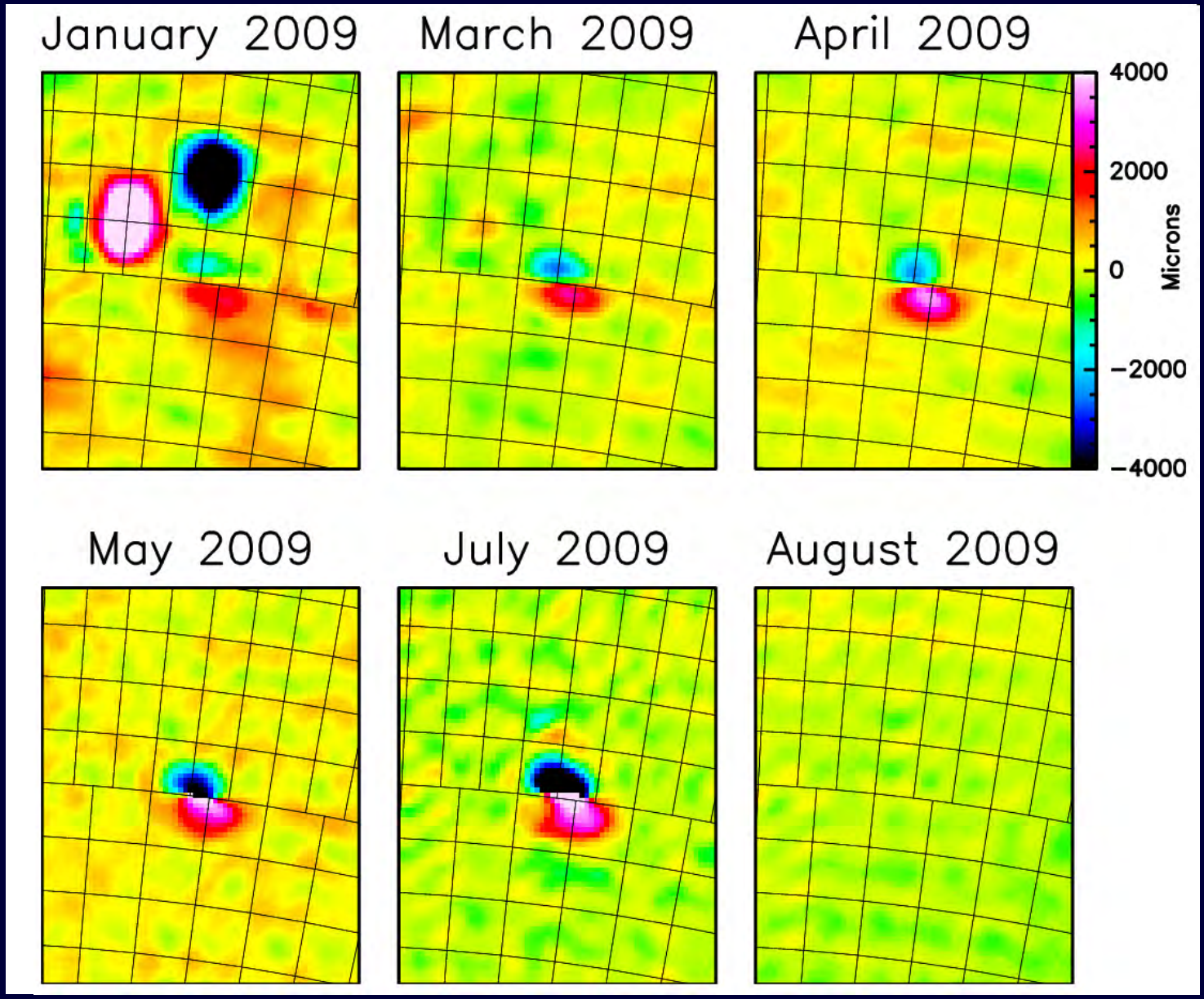






One pair of swapped wires was discovered!

(Those two actuators kept getting worse instead of better)



43 GHz Aperture Efficiency improvement since 2003