

# Cosmic Foreground Explorer: A Balloon-borne Study of the Cosmic Microwave Background Radiation

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# Cosmic Microwave Background Radiation (CMBR)

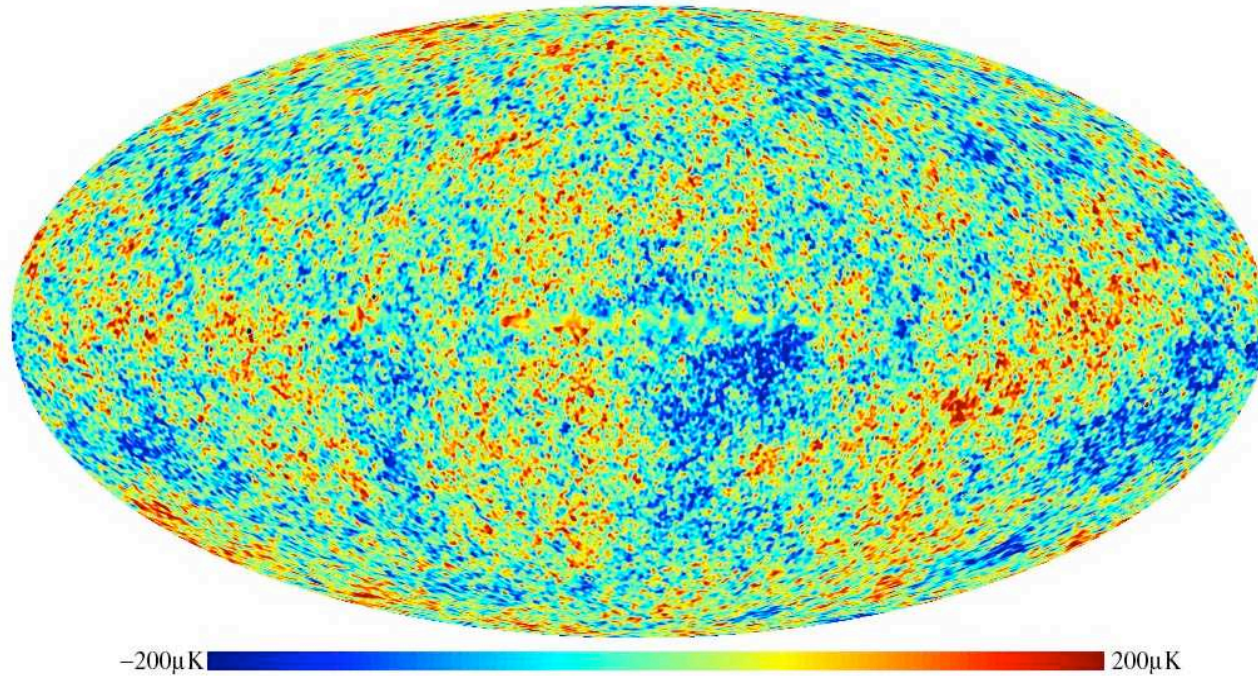
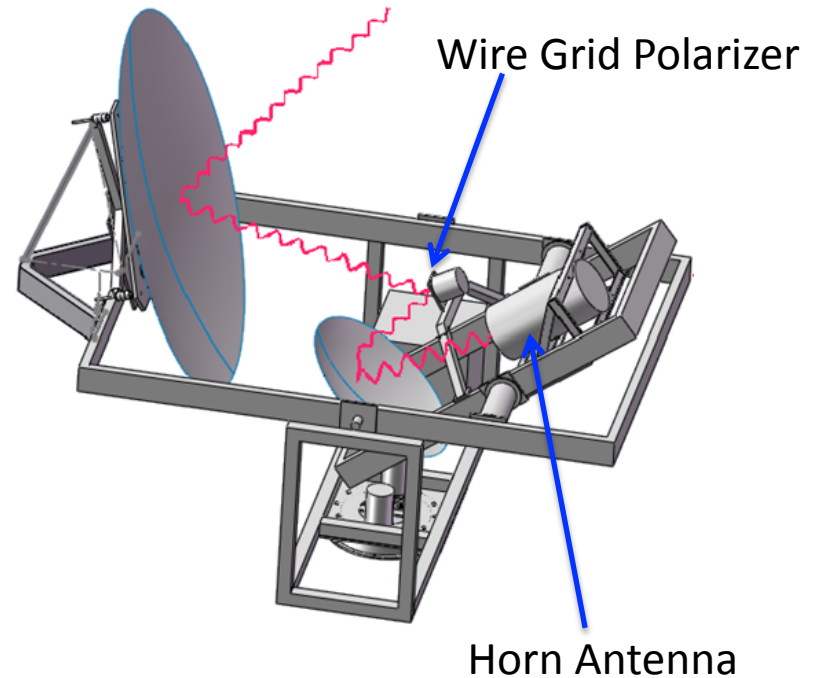
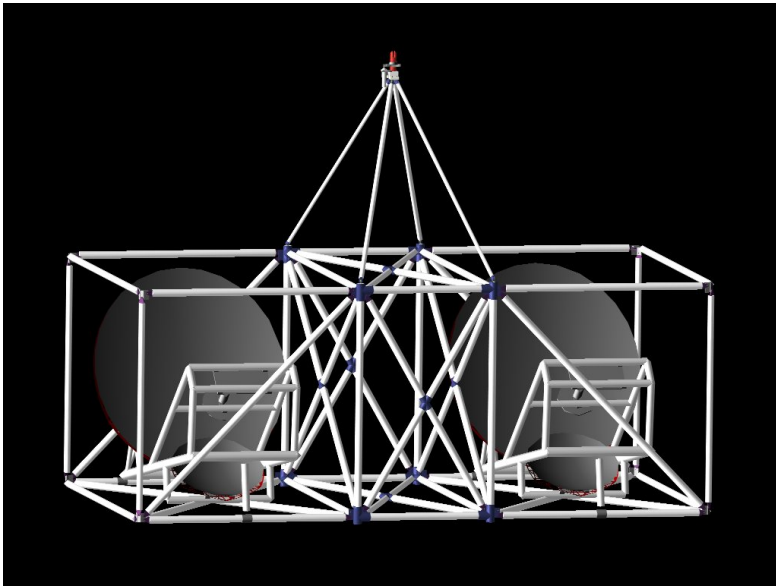


Image from [http://lambda.gsfc.nasa.gov/product/map/current/m\\_images.cfm](http://lambda.gsfc.nasa.gov/product/map/current/m_images.cfm)

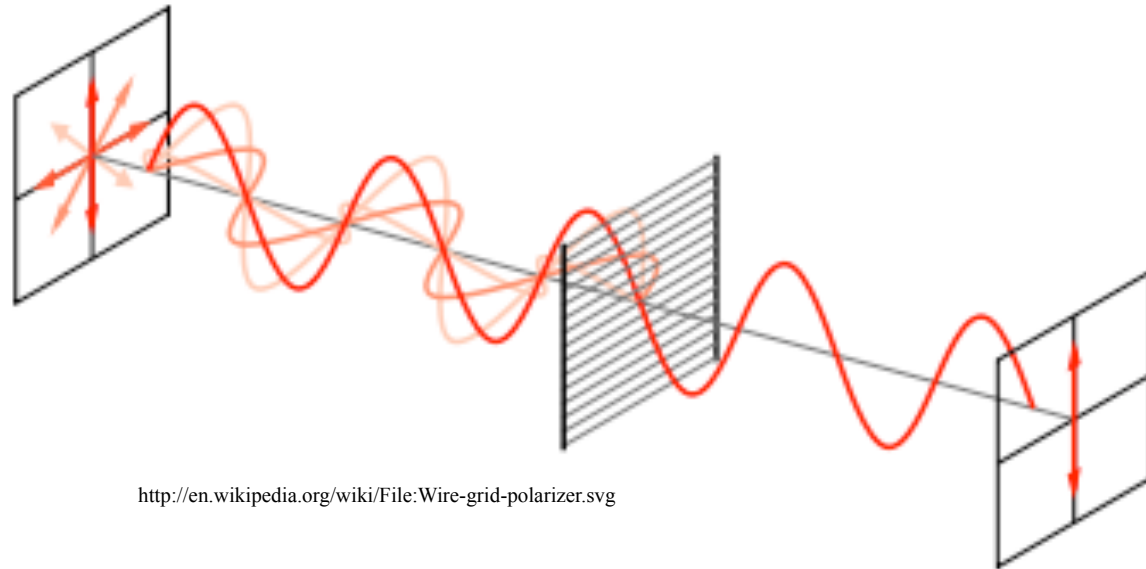
- The CMBR is radiation from 300,000 years after Big Bang, when light and matter separated, about 14 billion years ago
- Not much is known about the CMBR except that it is uniform in all directions

# Cosmic Foreground Explorer



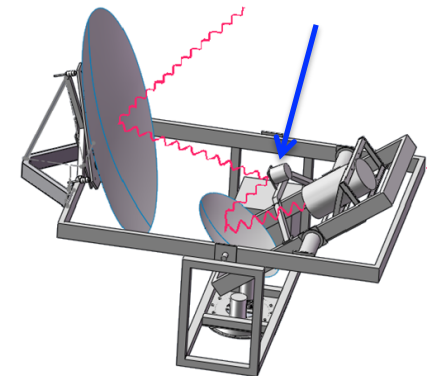
- Our goal is to measure the polarization at 10 GHz and 15 GHz
- Magnitude of the effect is in the microKelvins, which is one part in 100,000

# Measuring the Polarization

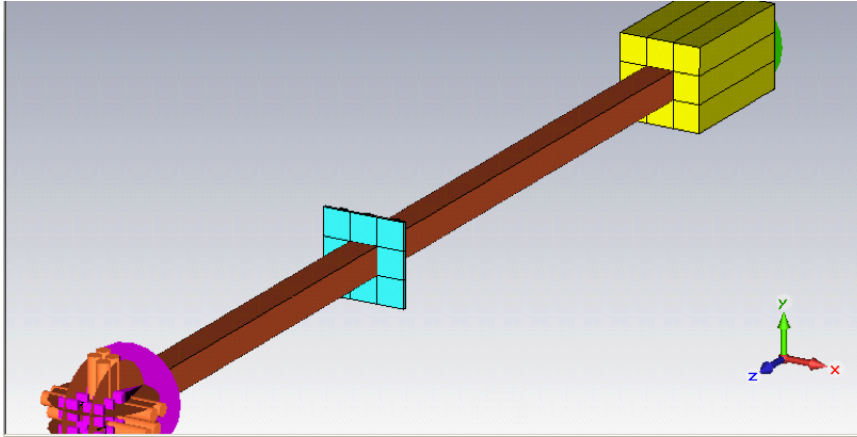


<http://en.wikipedia.org/wiki/File:Wire-grid-polarizer.svg>

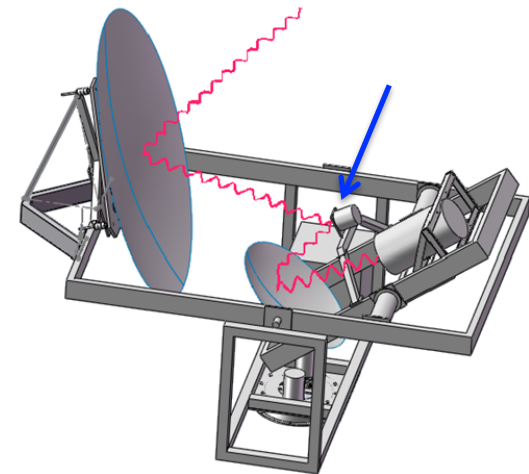
- The wire grid polarizer rotates allows us to measure the polarization
- The direction of the polarization is the same regardless of the orientation of the grid



# Minimizing the Loss

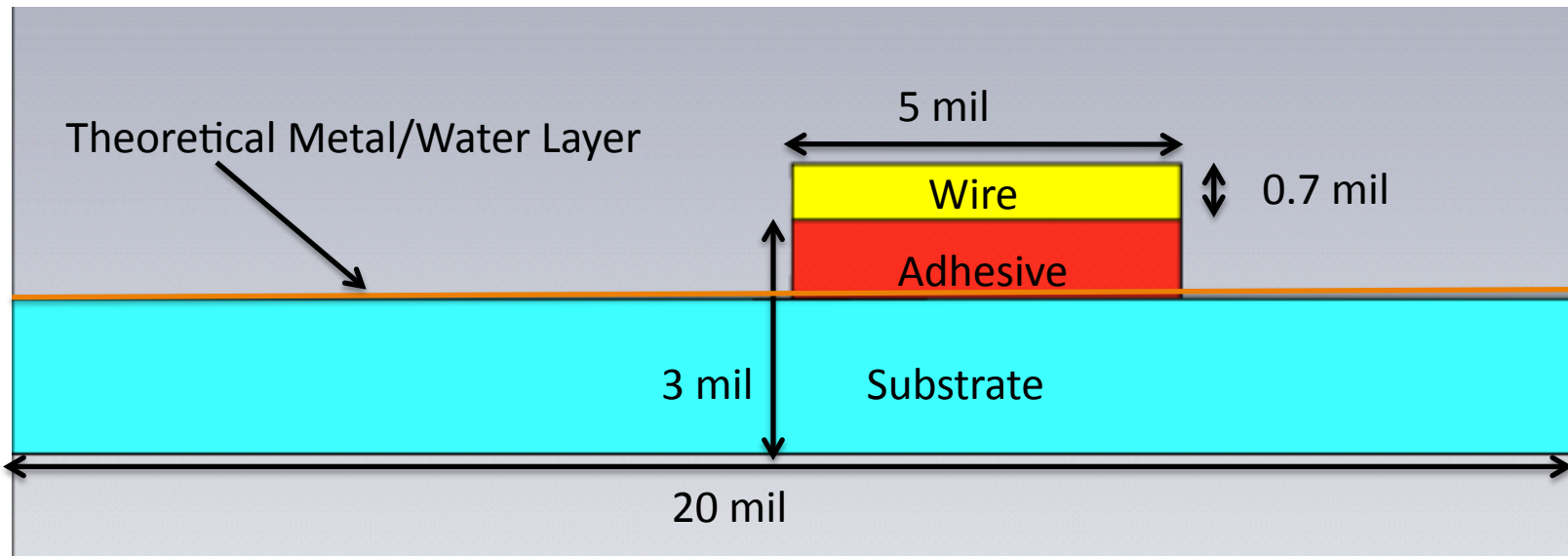


- Determine the cause of unexpected loss in transmission
- Use CST Microwave Studio® to model the problem



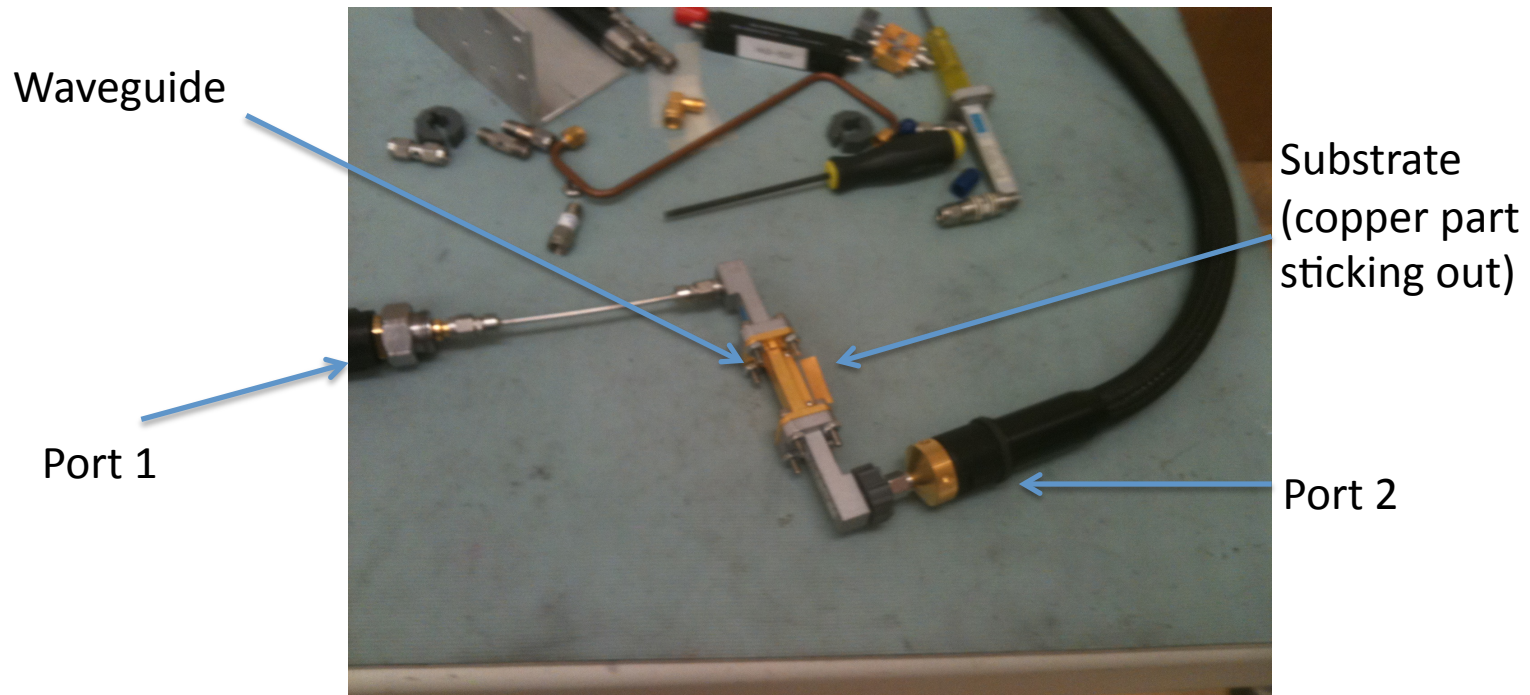
# Computer Simulation

- The wire grid polarizer was modeled in CST Microwave Studio®
- The program calculates the transmission and reflection using Maxwell's equations.
- Etching may not have completely removed all metal or water.



# Analyzing the Material

- Placed the substrate and other materials in a waveguide and measured with a vector network analyzer



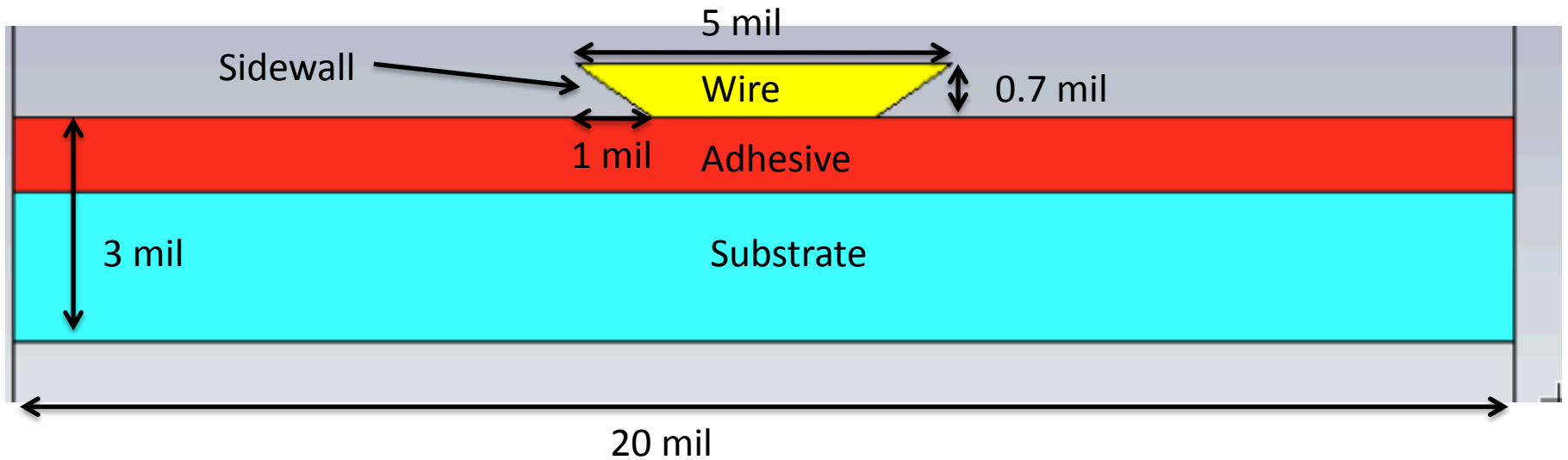
# Comparing the Reflection and Transmission of Radiation

Material	Reflection (at 30.02 GHz) in Relative Amplitude	Transmission (at 30.02 GHz) in Relative Amplitude
Substrate (Theoretical)	$2.40 \times 10^{-3}$	$9.99 \times 10^{-1}$
Excess copper (Theoretical)	$9.99 \times 10^{-1}$	$4.55 \times 10^{-6}$
Excess water (Theoretical)	$1.68 \times 10^{-1}$	$9.70 \times 10^{-1}$
Substrate (Actual)	$7.99 \times 10^{-3}$	$7.25 \times 10^{-1}$

- No strong evidence for excess metal or water
- Actual result does not align with any theoretical calculation, which have been a result from the VNA not properly calibrated
- X-ray photoelectron spectroscopy tests revealed the absence of metal



# Etching Problems?



- Our next theory hypothesized that the loss of the actual wire could cause the loss in transmission

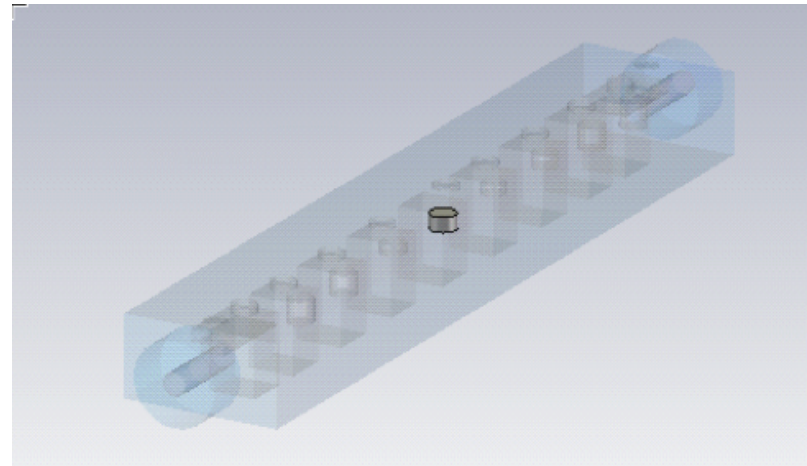
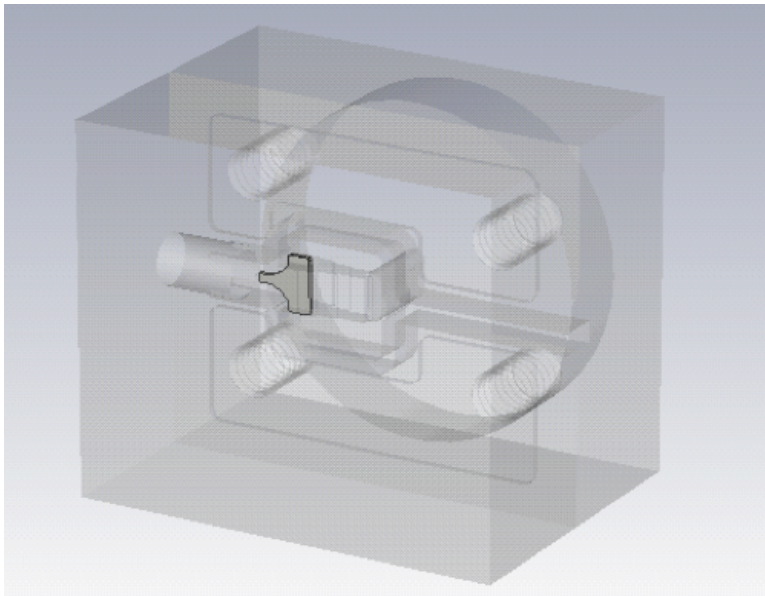
# Trends in the Transmission of the Transverse Magnetic and Electric

Size of Sidewall on each side (in mil)	Fraction of TM Transmission at 10.004 GHz	Fraction of TE Transmission at 10.004 GHz
0 (Theoretical block)	0.99970980	0.99939292
0.6	0.99970240	0.99942526
1.0	0.99966635	0.99943166
1.2	0.99965691	0.99943377
1.8	0.99975673	0.99943693
2.4	0.99962890	0.99944153

- The transmission remained relatively constant with very slight differences
- The differences were too small to cause the loss in transmission

# Final Thoughts and Projects

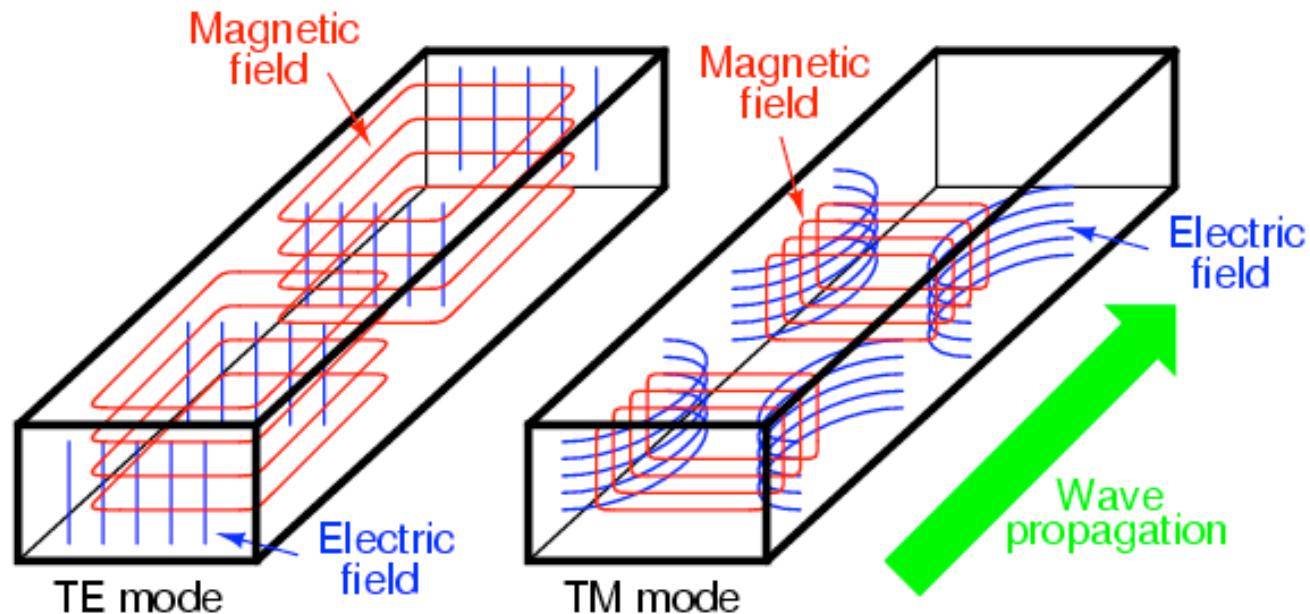
- We are still testing new hypotheses on the loss in transmission
- The telescope is now being assembled at a NASA site in Fort Sumner, NM and will be launched for a test flight this week
- The data from the test flight may give us clues on what the problem is
- Thank you to NASA, CNSI, EUREKA, and Arica and Phil Lubin



# Backup

# Transverse Electric and Magnetic

- **TE mode** (Transverse Electric) has no electric field in the direction of propagation. **TM mode** (Transverse Magnetic) has no magnetic field in the direction of propagation. [http://en.wikipedia.org/wiki/Transverse\\_mode](http://en.wikipedia.org/wiki/Transverse_mode)
- <http://www.faqs.org/docs/electric/AC/02407.png>



*Magnetic flux lines appear as continuous loops*  
*Electric flux lines appear with beginning and end points*

# Websites to Visit

- <http://en.wikipedia.org/wiki/CMB>
- <http://background.uchicago.edu/~whu/intermediate/intermediate.html>