

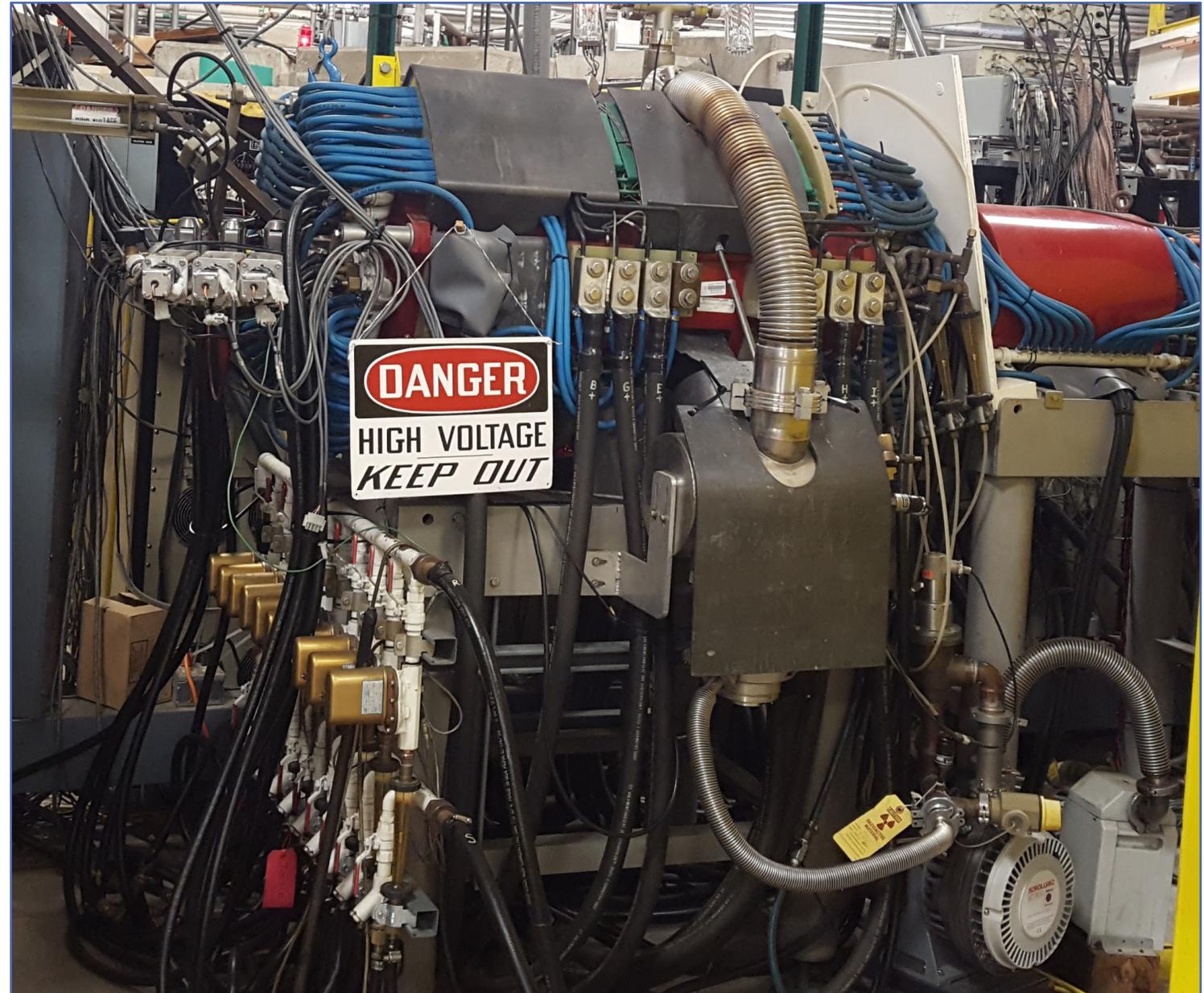
Designing a Dichroic Filter As Part of a Microwave Camera to Study ECR Ion Sources

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Outline

- ❖ Scientific Motivations
- ❖ Camera overview
- ❖ Initial design
- ❖ MEEP
- ❖ Second design
- ❖ Future work

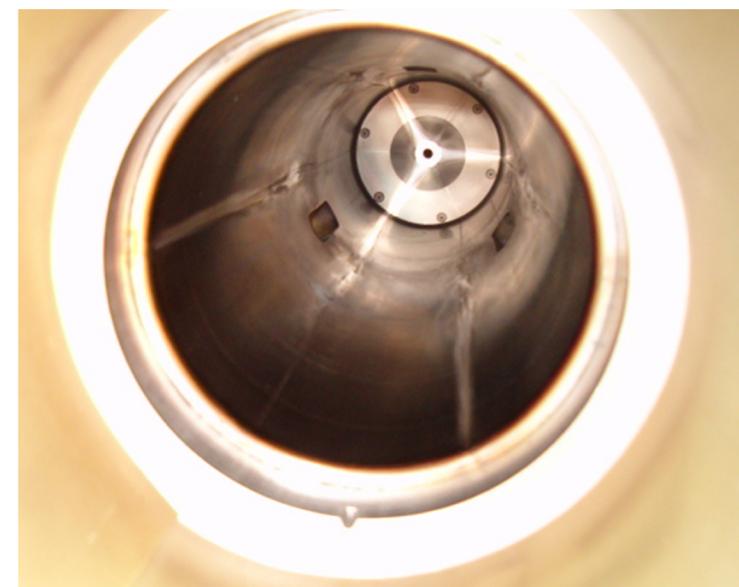
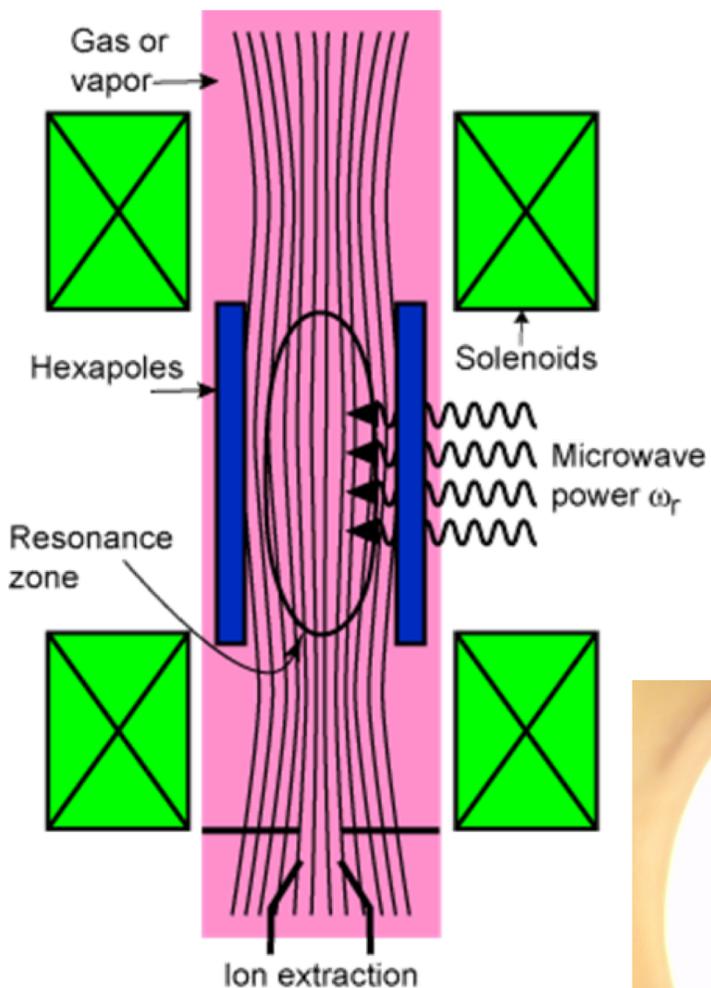


ECR Ion Sources

- ❖ Works thru ECR surprisingly enough
- ❖ e^- confined by solenoid and hexapole magnets
- ❖ Undergo cyclotron motion with

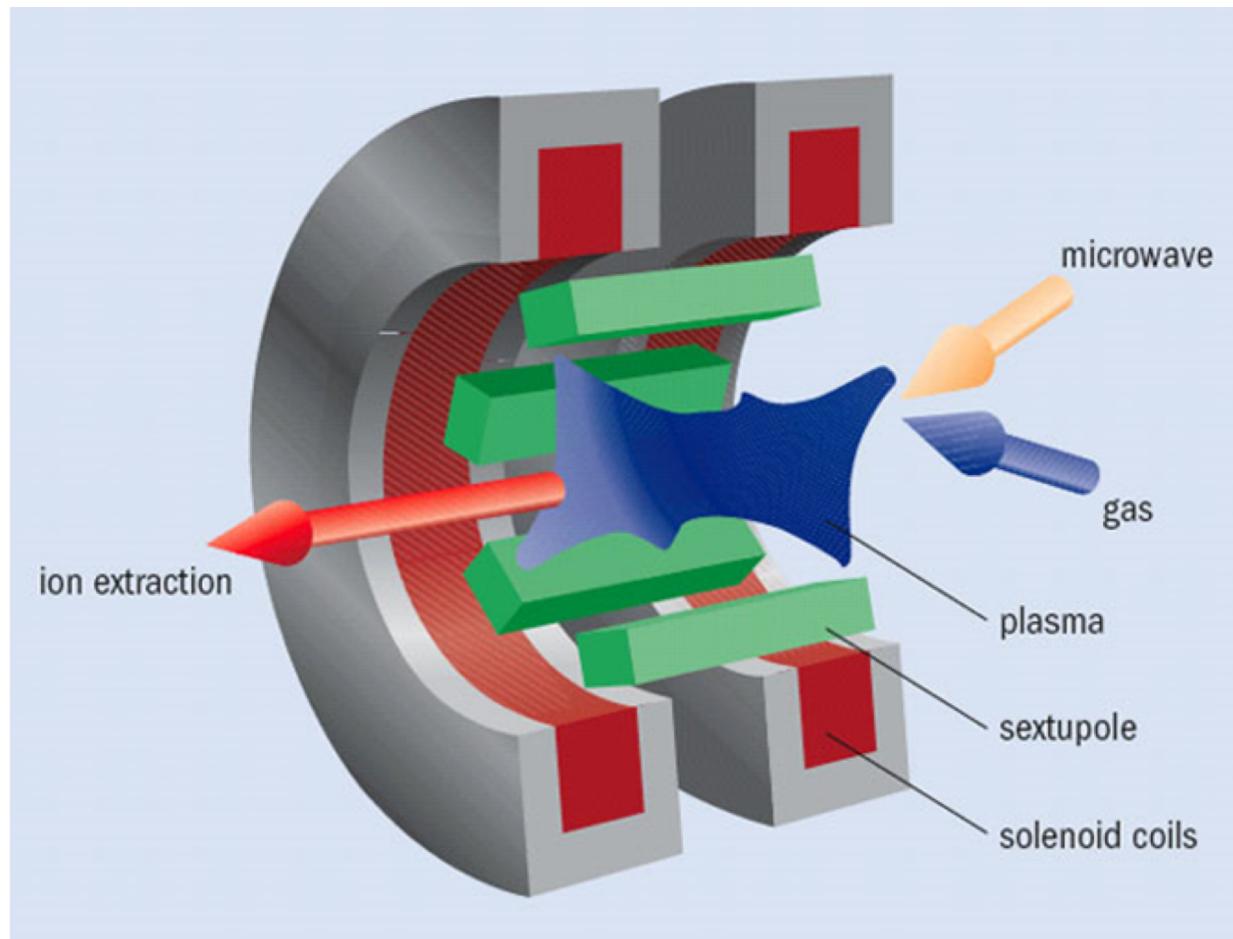
$$\omega = \frac{eB}{\gamma m_e}$$

- ❖ Excited by microwaves
- ❖ Ionize neutral atoms
- ❖ yay

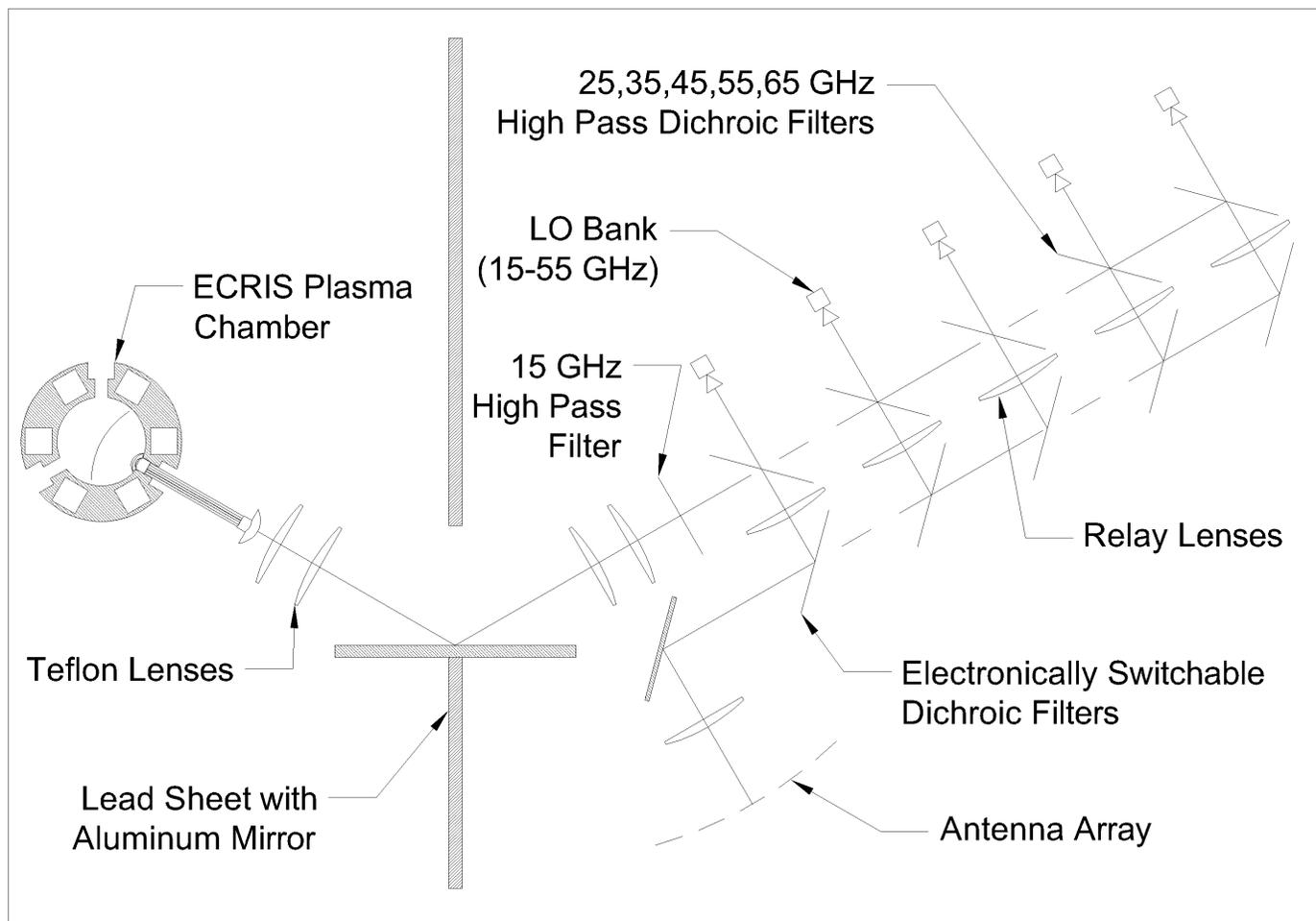


ECR Ion Sources

- ❖ Very Important
- ❖ Plasma dynamics are not well understood
- ❖ Could be an electrostatic well
- ❖ More efficiency in extracting high charge states → higher power in beam

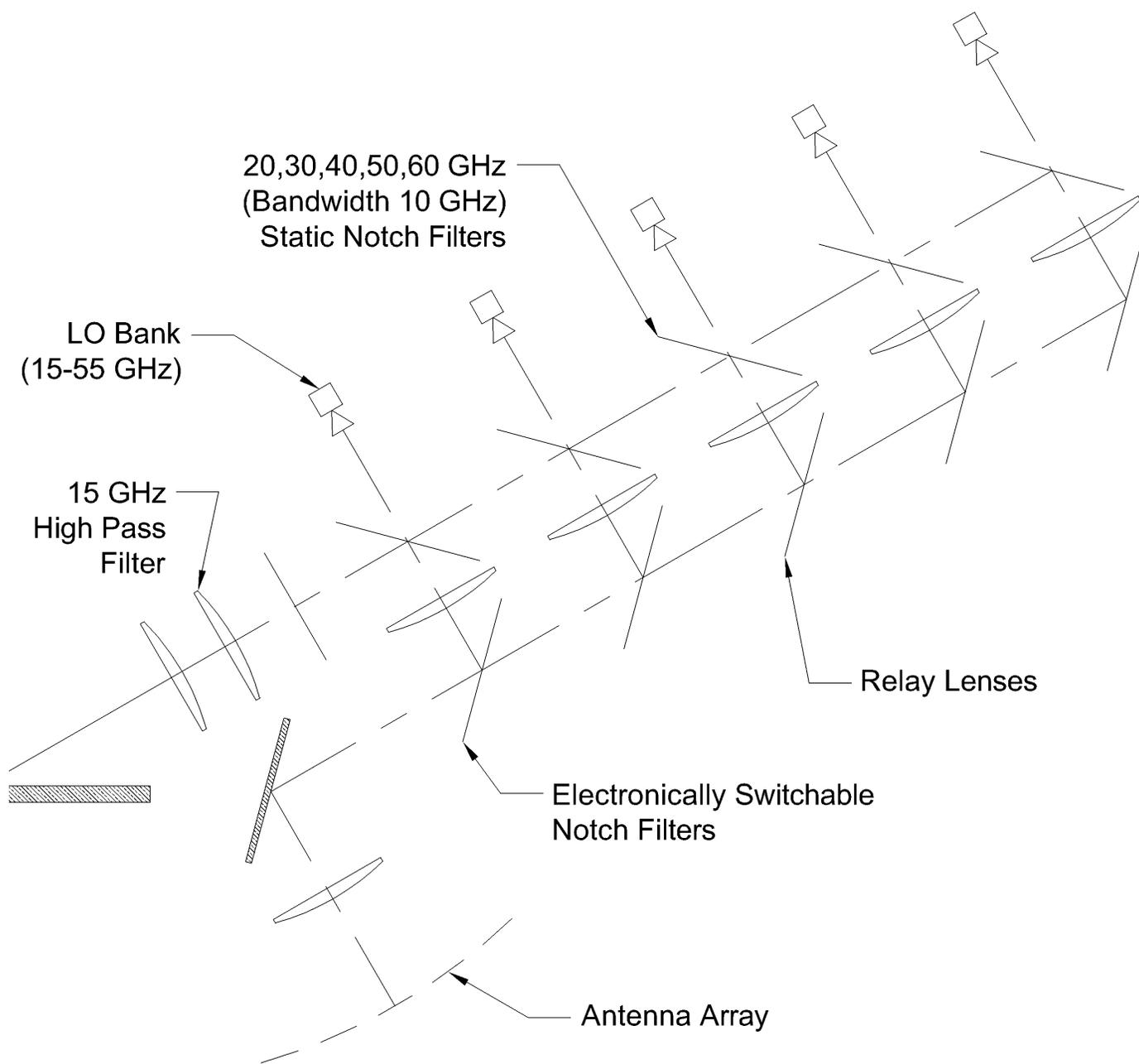


Electron Cyclotron Emission Camera Optical Train



Camera

- ❖ Will image electron cyclotron emission spectrum
 - ❖ 15-65 GHz
- ❖ Does not disrupt plasma
- ❖ Microwaves extracted from ECR ion source
 - ❖ Passed through filter set
 - ❖ Added known oscillator signals from Gunn diodes
 - ❖ Sent to antenna array, superheterodyne receiver
 - ❖ Mixed and digitized

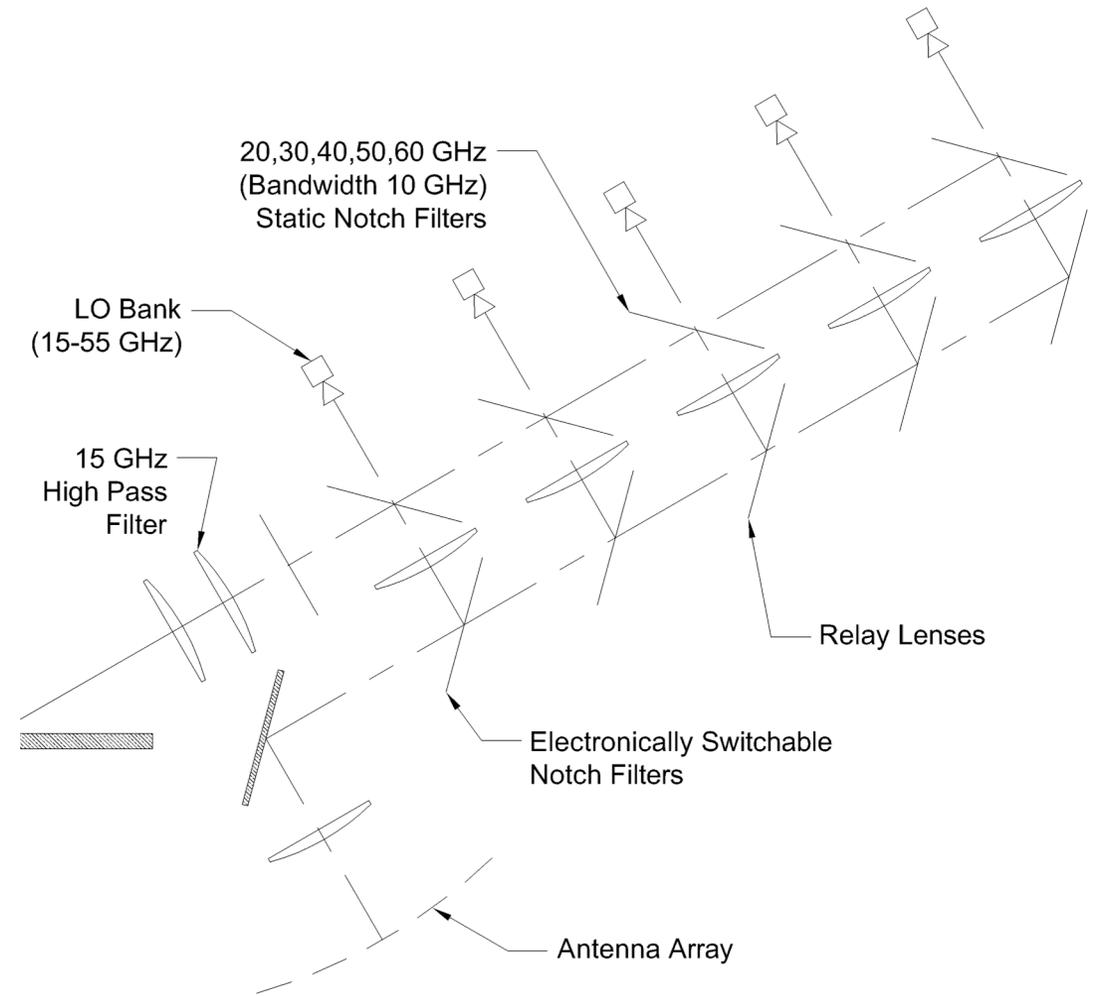
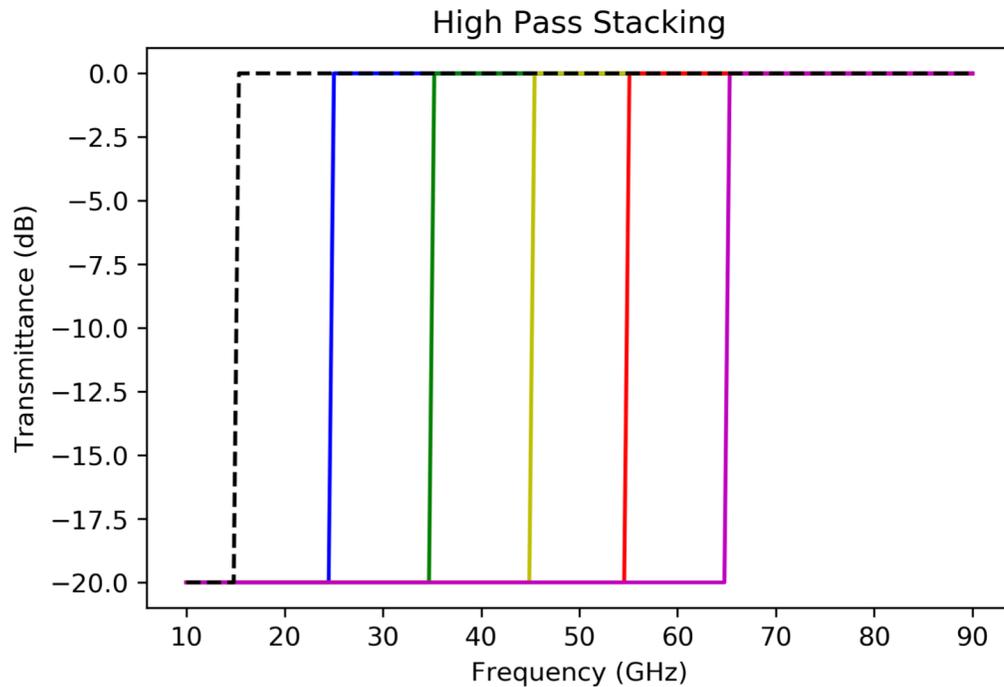


Dichroic Filter Set

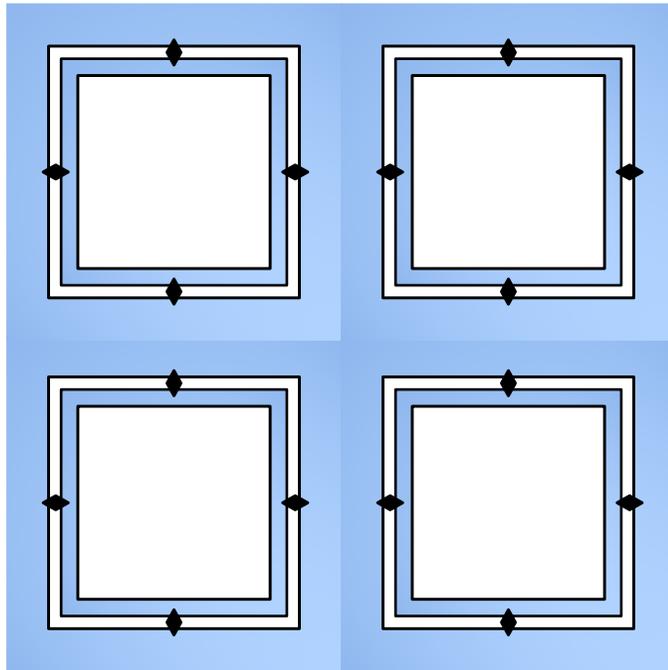
- ❖ Selects bandpass of 10GHz
- ❖ Static filters reflect specific frequencies
- ❖ Switchable filters reflect when on
 - ❖ Transmit signal to beam dump when off

Static Filter Design

- ❖ High Pass filters
- ❖ Single Aperture
- ❖ High passes stack to select passbands

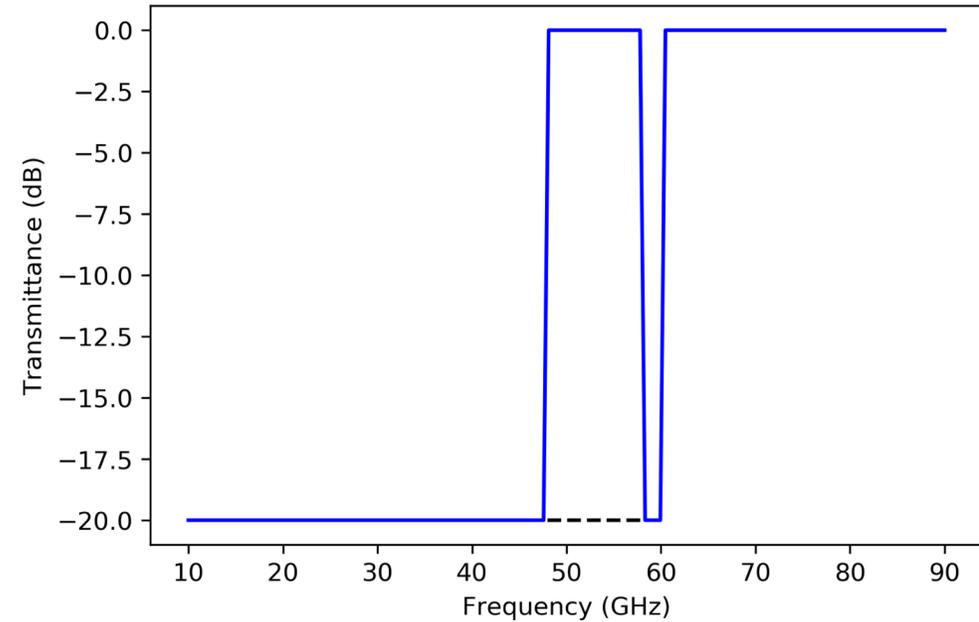


Initial Design

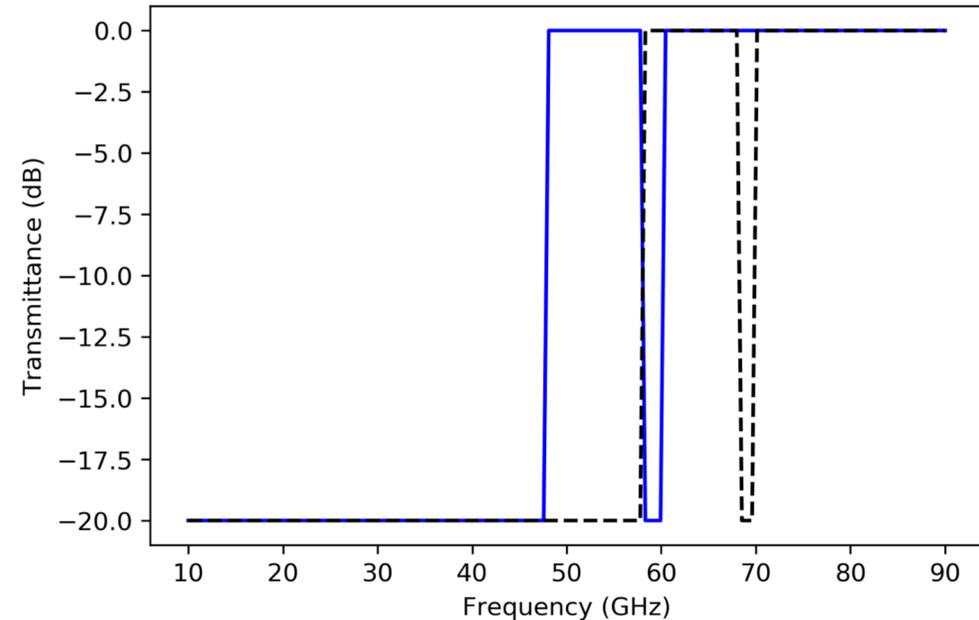


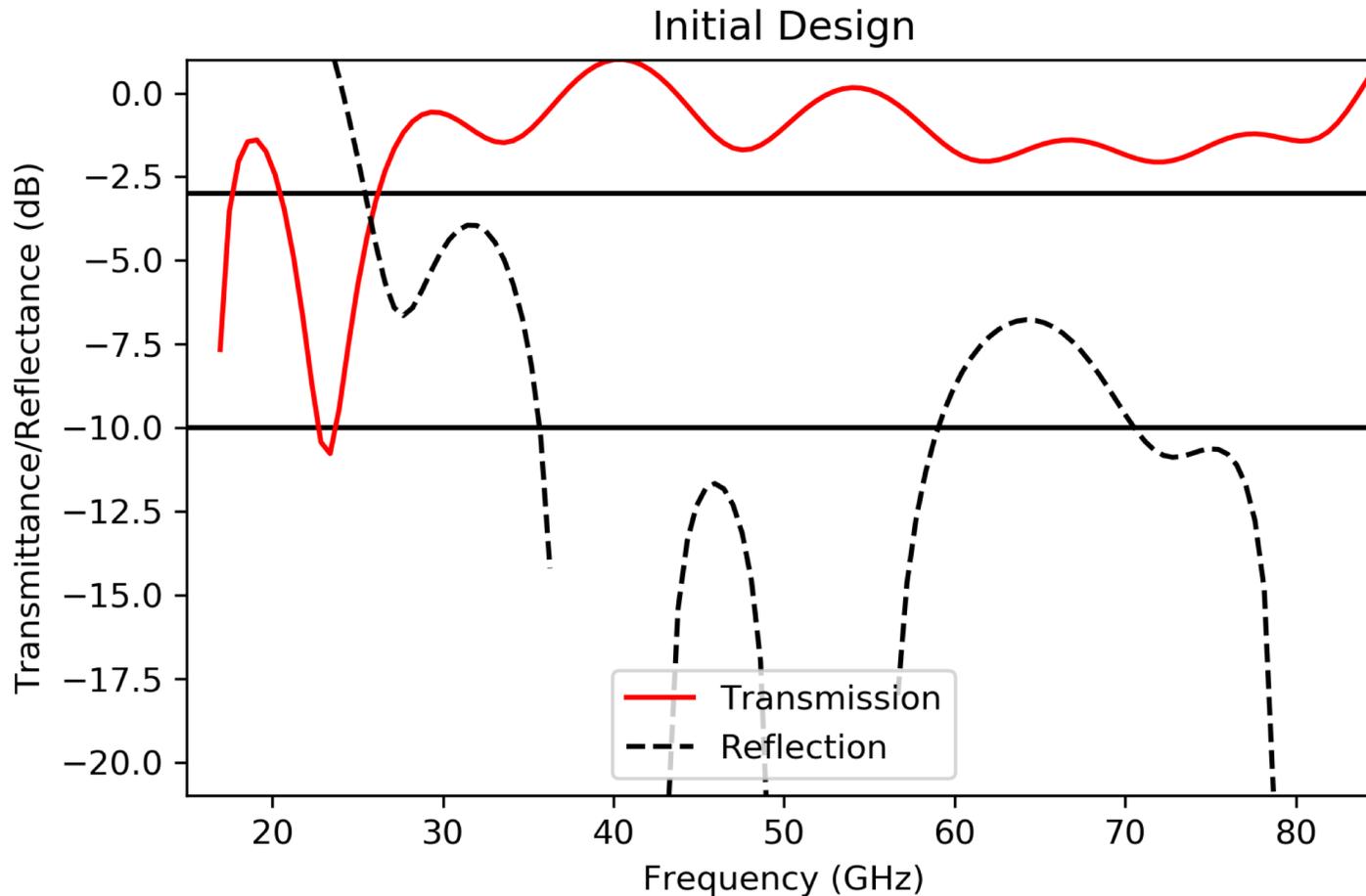
- ❖ Acts as a high pass with a lower frequency bandpass
 - ❖ This is what the diodes remove
- ❖ Stacks, but backwards
- ❖ Bandgaps are not reflected
- ❖ This design eliminates low frequency noise

Goal Function Design 1



Band gap stacking



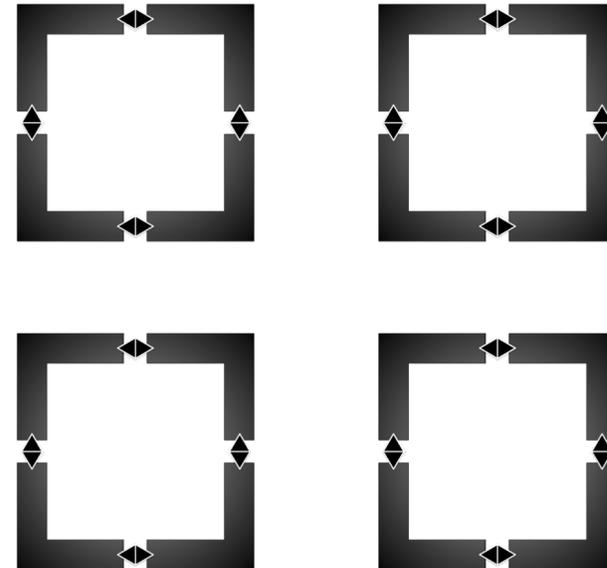
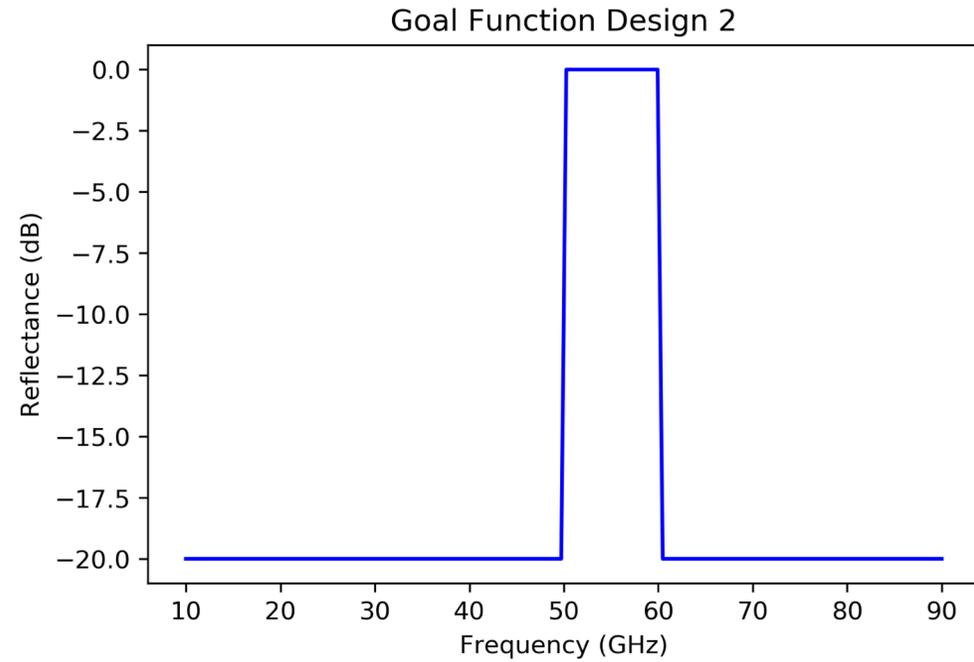


MEEP

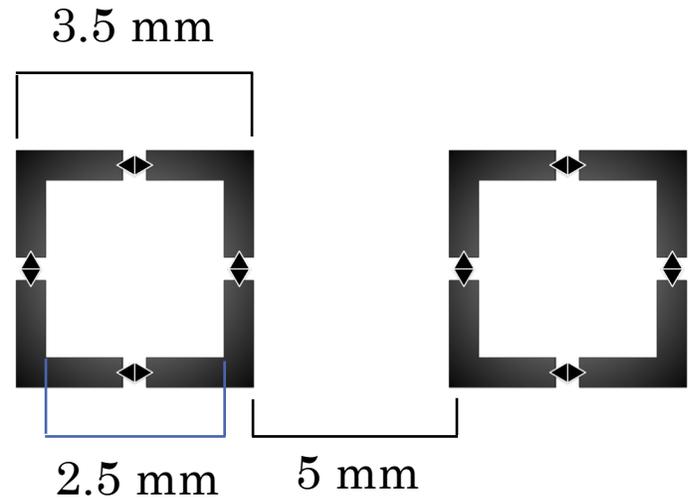
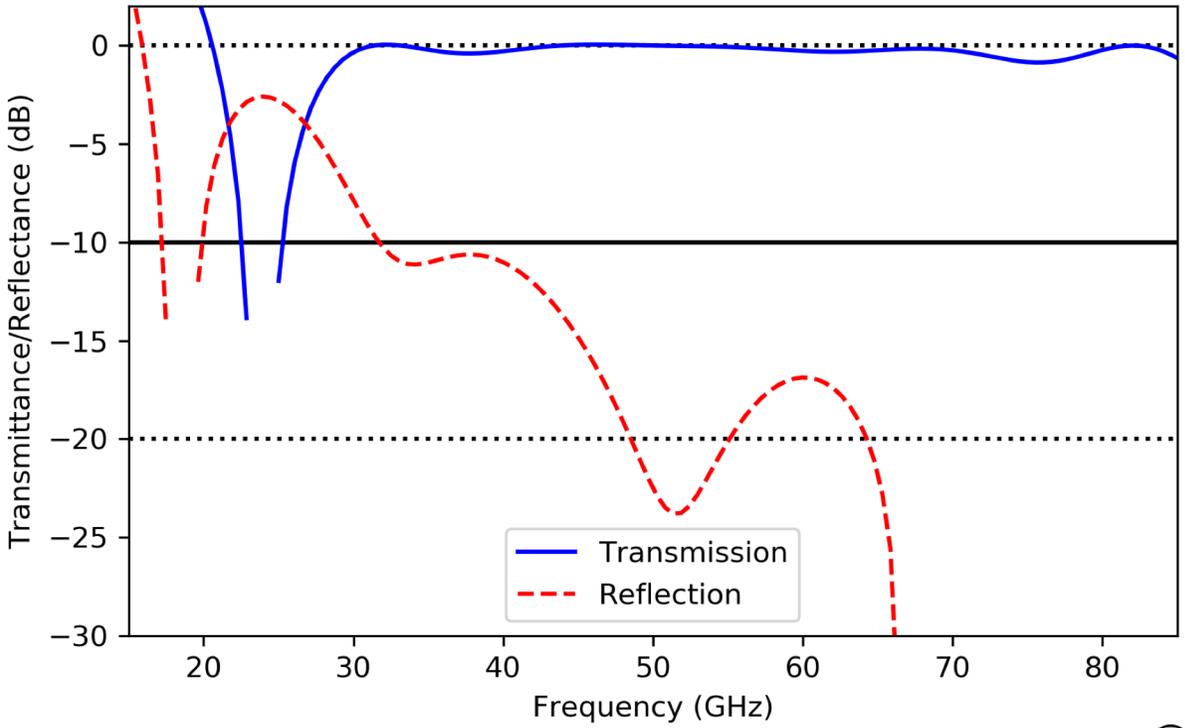
- ❖ Uses the Finite Difference Time Domain method
- ❖ Tested parameters to get transmission spectrum
 - ❖ Found no good match
- ❖ Resonances too broad
- ❖ No bandgap
- ❖ bad behavior comes from complicated geometry

Second Design

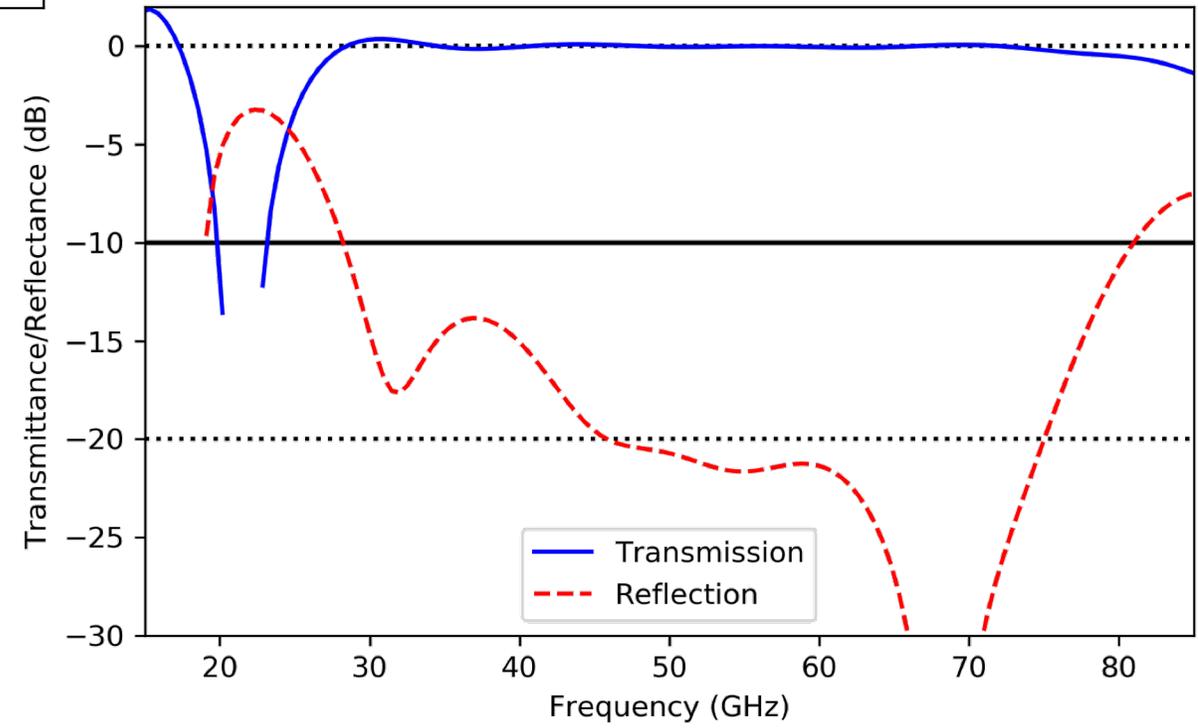
- ❖ Simplified the design to just the inner ring
 - ❖ Diodes break ring and stop resonance
- ❖ Acts as a notch filter
- ❖ Bandgaps still stack



Single Ring Without Gaps



Single Ring With Gaps



- ❖ 35 GHz peak is the aperture resonance
- ❖ Gaps produce 60% drop in reflection
 - ❖ Change of -4 dB
- ❖ This isn't optimized but it is what we're looking for!

Future Work

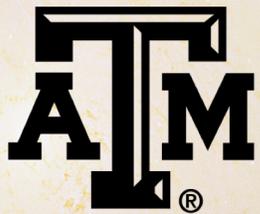
- ❖ Design of the camera is mostly done
- ❖ A design for the dichroic filters has been found
- ❖ Dichroic filters still need to be optimized
 - ❖ Fine tuning done with a hill climbing algorithm
- ❖ Fabrication should be complete by summer 2019



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