

# Electromagnetic Compatibility at Green Bank: Evaluation and Mitigation

National Radio Astronomy Observatory



**John Ford**

Green Bank Electronics Division Head

**Carla Beaudet**

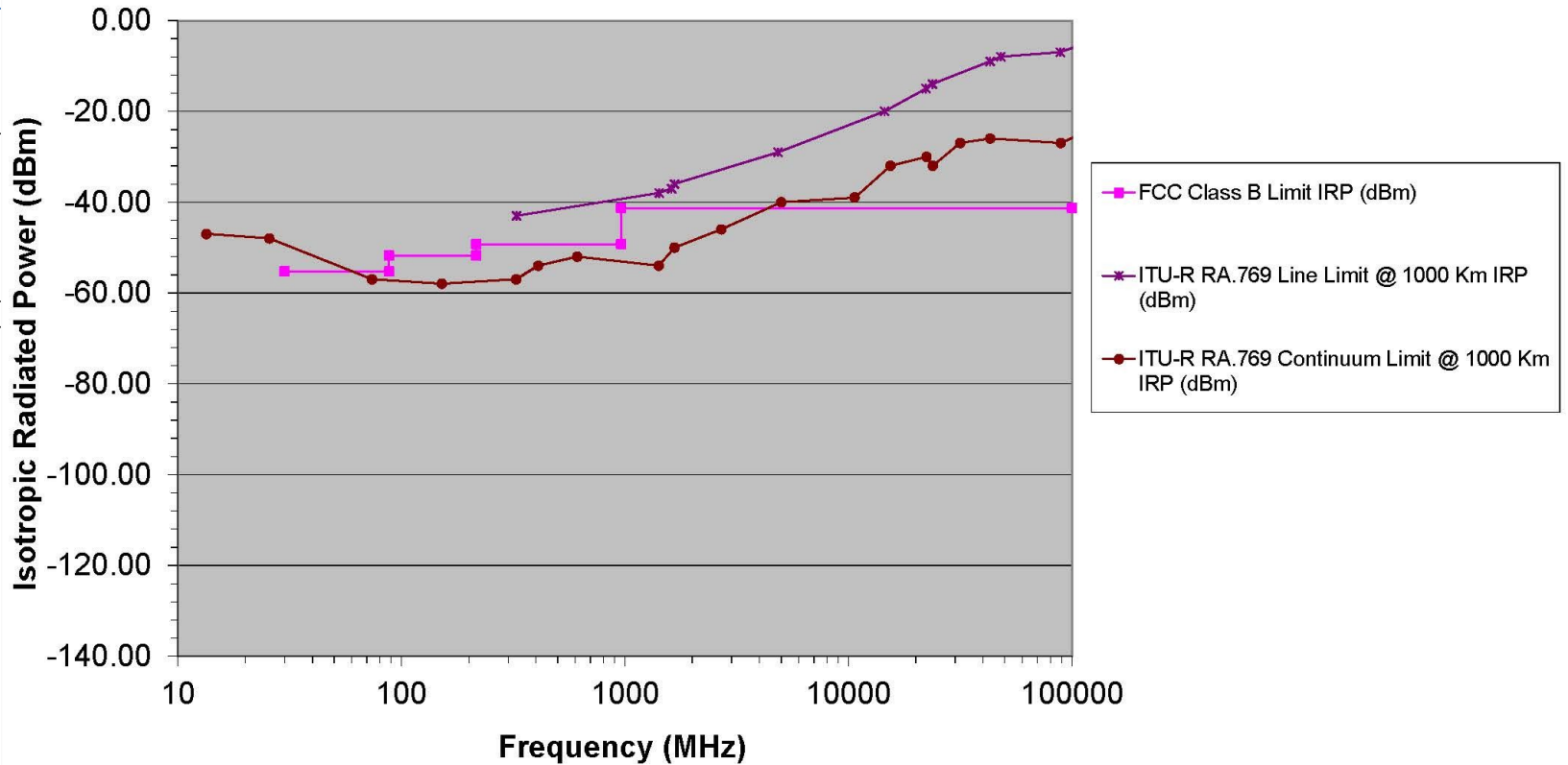
Green Bank RFI  
Engineer

Atacama Large Millimeter/submillimeter Array  
Expanded Very Large Array  
Robert C. Byrd Green Bank Telescope  
Very Long Baseline Array



# Emissions Evaluation: Standards

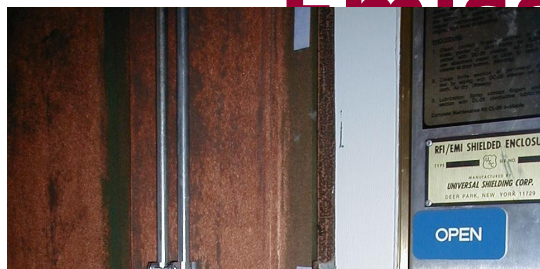
Limits Comparison, Tx @ 1000 Km Distance



(1) An integration time of 2 000 s has been assumed; if integration times of 15 min, 1 h, 2 h, 5 h or 10 h are used, the relevant values in the Table should be adjusted by +1.7, -1.3, -2.8, -4.8 or -6.3 dB respectively.

(2) The interference levels given are those which apply for measurements of the total power received by a single antenna. Less stringent levels may be appropriate for other types of measurements, as discussed in § 2.2. For transmitters in the GSO, it is desirable that the levels need to be adjusted by -15 dB, as explained in § 2.1.

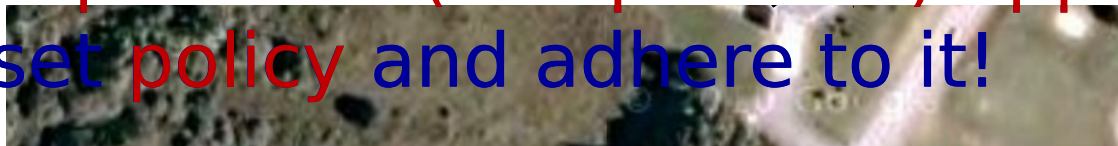
# Emissions Evaluation: Limitations and Policy



Dream  
On

Options for not creating **self**-interference:

- ~~1000km! radius electronic device free zone!!!!~~
- Contain **ALL? Really?** electronic equipment on site with large enclosures, or position facilities behind natural obstacles.
- Use a **practical (compromise) approach**, but set **policy** and adhere to it!



# Emissions Evaluation: Practical Limitations and Policy

## Zone 2 Policy:

- No transmitters! (except site radios)
- Electronics that will be mitigated to comply with ITU-R RA.769 include:
  - Anything that cannot be easily powered off
  - Anything that radiates in excess of FCC part 15 class B levels.



# Communicating Site Policy

## YOU ARE ENTERING THE RADIO ASTRONOMY INSTRUMENT ZONE

JOIN US IN KEEPING THE RADIO ASTRONOMY INSTRUMENT ZONE CLEAN, PLEASE NO ELECTRONIC DEVICES SUCH AS:



FILM CAMERAS ARE PERMITTED IN THE RADIO ASTRONOMY INSTRUMENT ZONE

**THANK YOU FOR YOUR COOPERATION!**

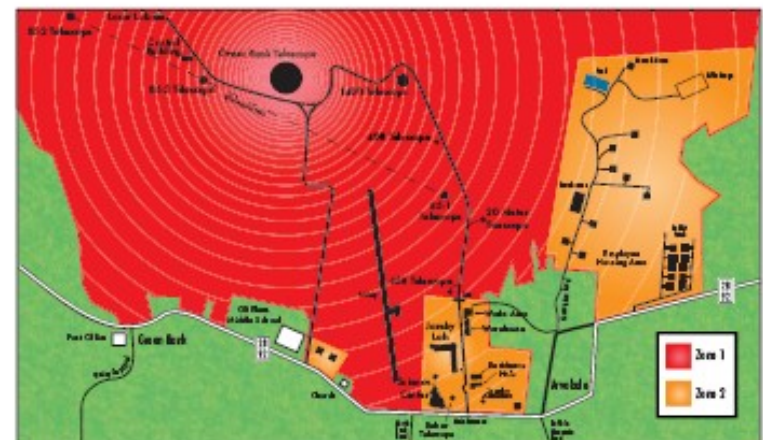


Interference Protection Group - National Radio Astronomy Observatory

*"We have met the Enemy, and He is Us."*

**NRAO Green Bank Site RFI Regulations for Visitors.  
PLEASE READ!**

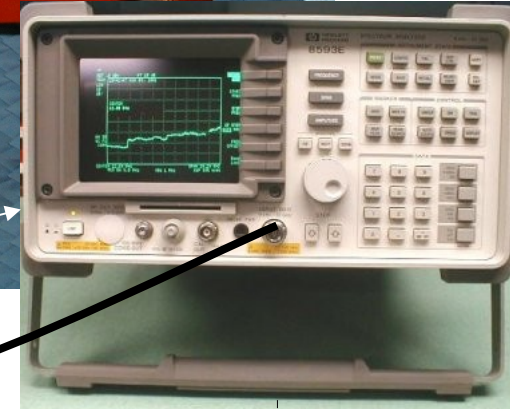
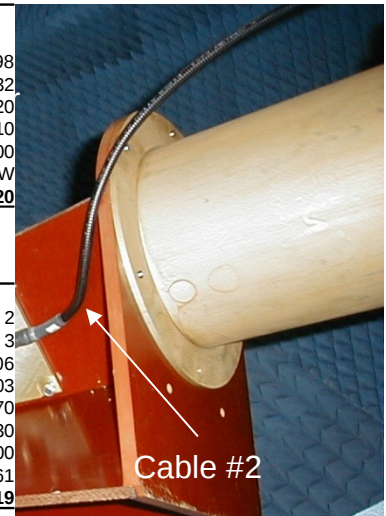
The NRAO Green Bank Site is a unique resource for Radio Astronomy. We are located in the National Radio Quiet Zone (NRQZ) which provides protection from permanent, fixed, licensed transmitter services. Our location, surrounded by National Forest and the mountainous terrain of West Virginia, also serves to protect observations. Additionally, the West Virginia Radio Astronomy Zoning Act allows us to prohibit the use of any electrical equipment within a ten mile radius that causes interference to Radio Astronomical Observations. On the Green Bank Site itself, our protection policy differentiates two zones, one for the laboratory, housing, and visitor facilities (*Zone 2*), and one for the Radio Astronomical Instruments themselves (*Zone 1* aka the Radio Astronomy Instrument Zone) as illustrated on the following map:



continuation 020

# Emissions Evaluation: Assessing Equipment for Compliance with ITU-R

	1	2	3	4
<b>Spectrum Observations</b>				
Measured	210.13	270.92	154.83	924.98
Corrected	1.43	1.11	1.94	0.32
Measured Spectral	-64.00	-71.00	-66.50	-67.20
Measured Signal	0.010	0.010	0.010	0.010
Measured Signal	0.0100	0.0100	0.0100	0.0100
Measured Signal	CW	CW	CW	CW
Measured Signal	<b>-134.00</b>	<b>-141.00</b>	<b>-136.50</b>	<b>-137.20</b>
<b>Test Setup</b>				
Test A	2	2	2	2
Test A	3	3	3	3
Test A	3.73	3.73	2.00	6.06
Equivalent	0.38	0.23	0.47	0.03
Total	1.10	1.10	0.80	4.70
Preamp	53.30	53.30	53.30	53.30
Distance	7.00	7.00	7.00	7.00
Calculated	32.06	34.27	31.14	42.61
<b>Total R</b>	<b>-154.14</b>	<b>-158.93</b>	<b>-157.86</b>	<b>-143.19</b>
<b>Predictions</b>				
Anticipated	11	11	11	11
Calculated	<b>-185.96</b>	<b>-190.75</b>	<b>-189.68</b>	<b>-175.01</b>
<b>Predictions</b>				
Corresponding Target GBT CONTINUUM Limit ( dBW/m <sup>2</sup> /Hz )	3.00	3.00	1.00	20.00
Calculated Field Strength Per Unit CONTINUUM Bandwidth ( dBW/m <sup>2</sup> /Hz )	-244.50	-244.50	-241.00	-248.80
Calculated Field Strength Per Unit CONTINUUM Bandwidth ( Jy )	-210.73	-215.52	-209.68	-208.02
Calculated Field Strength Per Unit CONTINUUM Bandwidth ( Jy )	8.46E+04	2.81E+04	1.08E+05	1.58E+05
<b>Feature Exceeds Target CONTINUUM Limit By... ( dBW/m<sup>2</sup>/Hz )</b>	<b>33.77</b>	<b>28.98</b>	<b>31.32</b>	<b>38.78</b>



- Gamplifier(dB) + Lcables(

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<b>Predictions for SPECTRAL LINE OBSERVATIONS</b>				
Corresponding Target GBT SPECTRAL LINE Bandwidth ( MHz )	2.00	2.00	1.00	8.00
Corresponding Target GBT SPECTRAL LINE Limit ( dBW/m <sup>2</sup> /Hz )	-241.40	-241.40	-238.80	-241.60

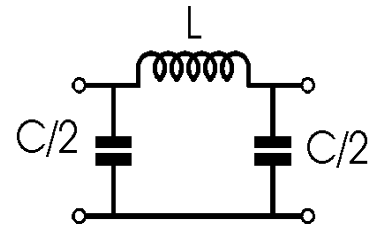
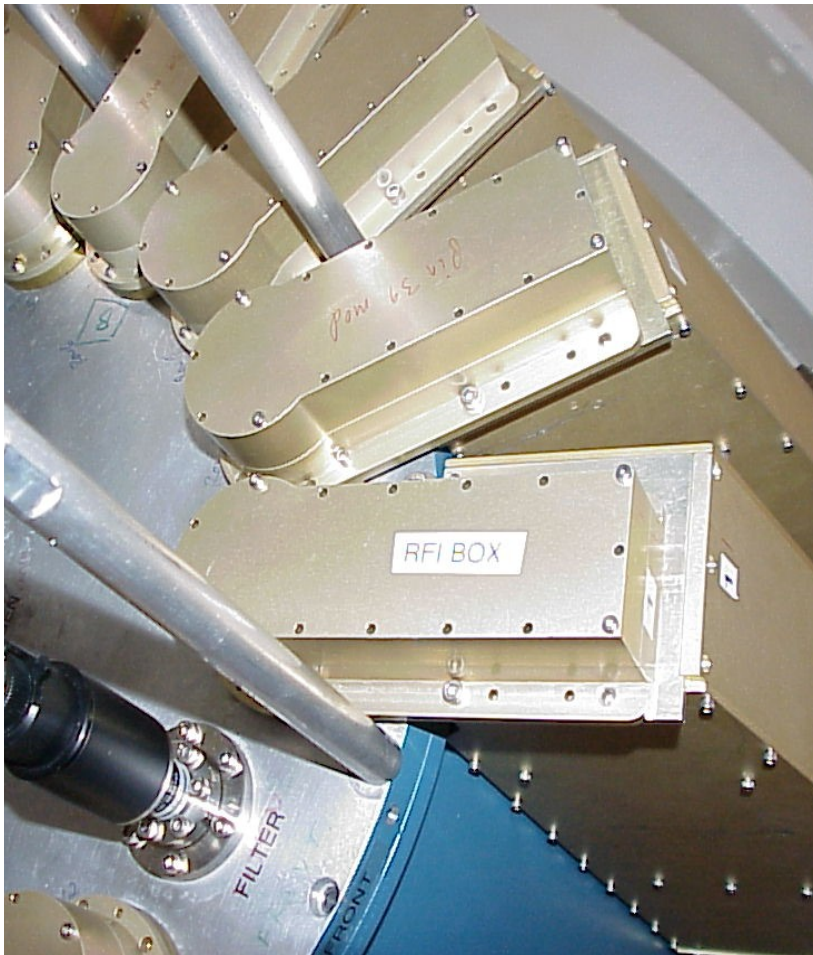


# Emissions Evaluation: Assessing Equipment for Compliance with ITU-R RA.769

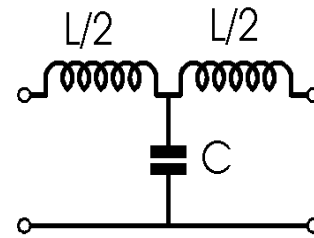
Faraday Cages

Low-Pass Filters

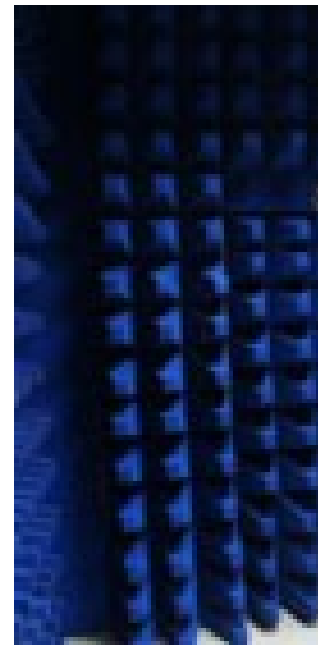
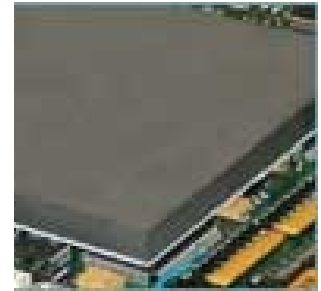
RF Absorber



Pi section filter

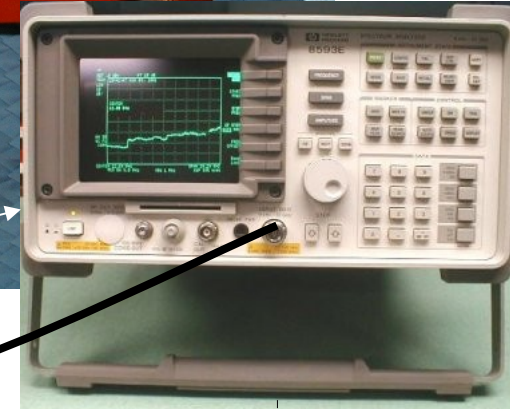
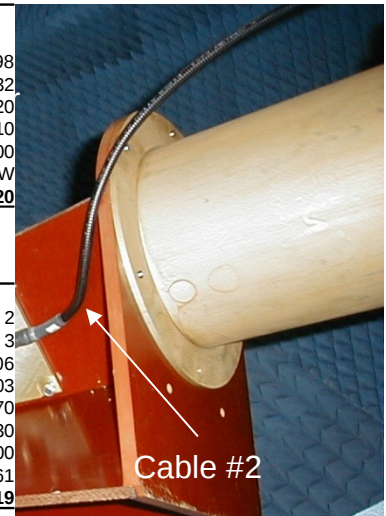


T section filter



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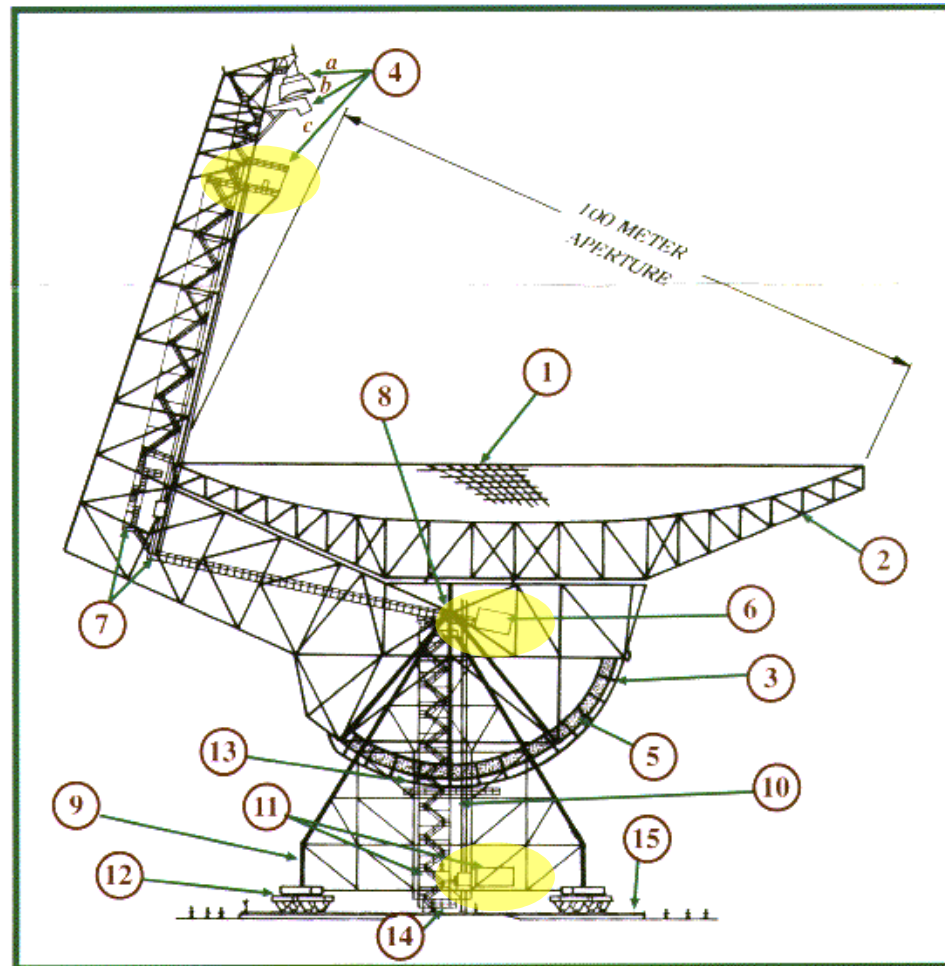
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# Shield Effectiveness Evaluation

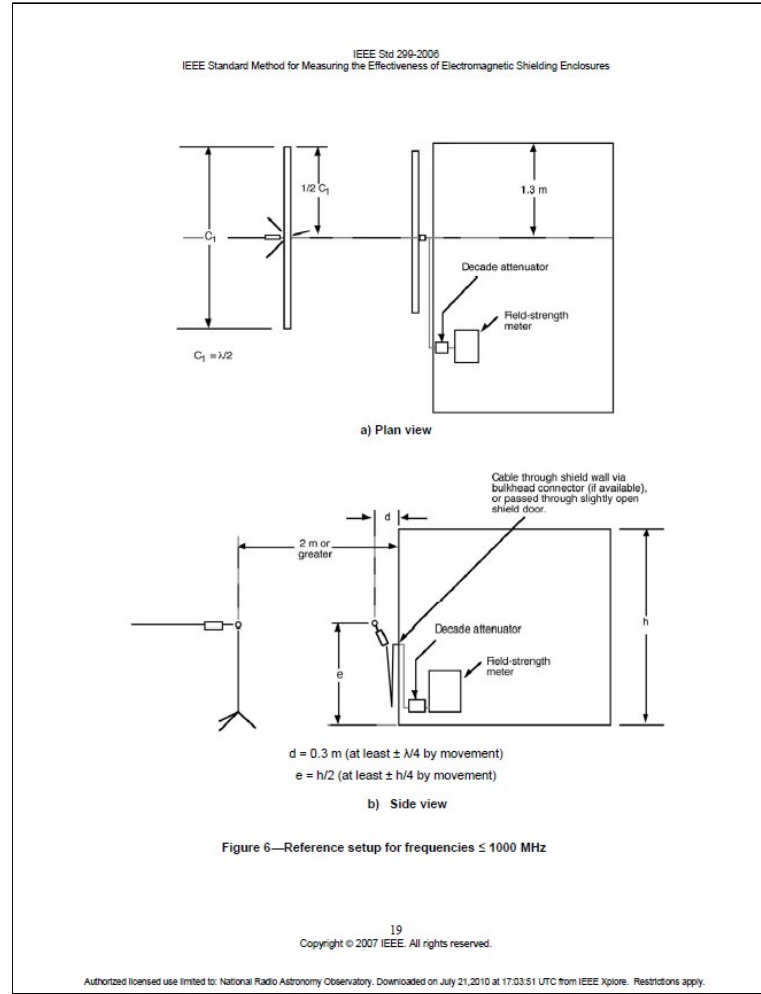
## Key to Diagram

1. Primary Reflector Surface
2. Reflector Support Structure
3. Elevation Wheel
4. Secondary Reflector  
(a) subreflector (b) prime focus  
(c) receiver room
5. Counterweight
6. Active Surface Control Room
7. Access Way to Focal Point
8. Elevation Bearing
9. Alidade
10. Elevator
11. Equipment Room
12. Azimuth Trucks and Drives
13. Elevation Drives
14. Pintle Bearing
15. Azimuth Track





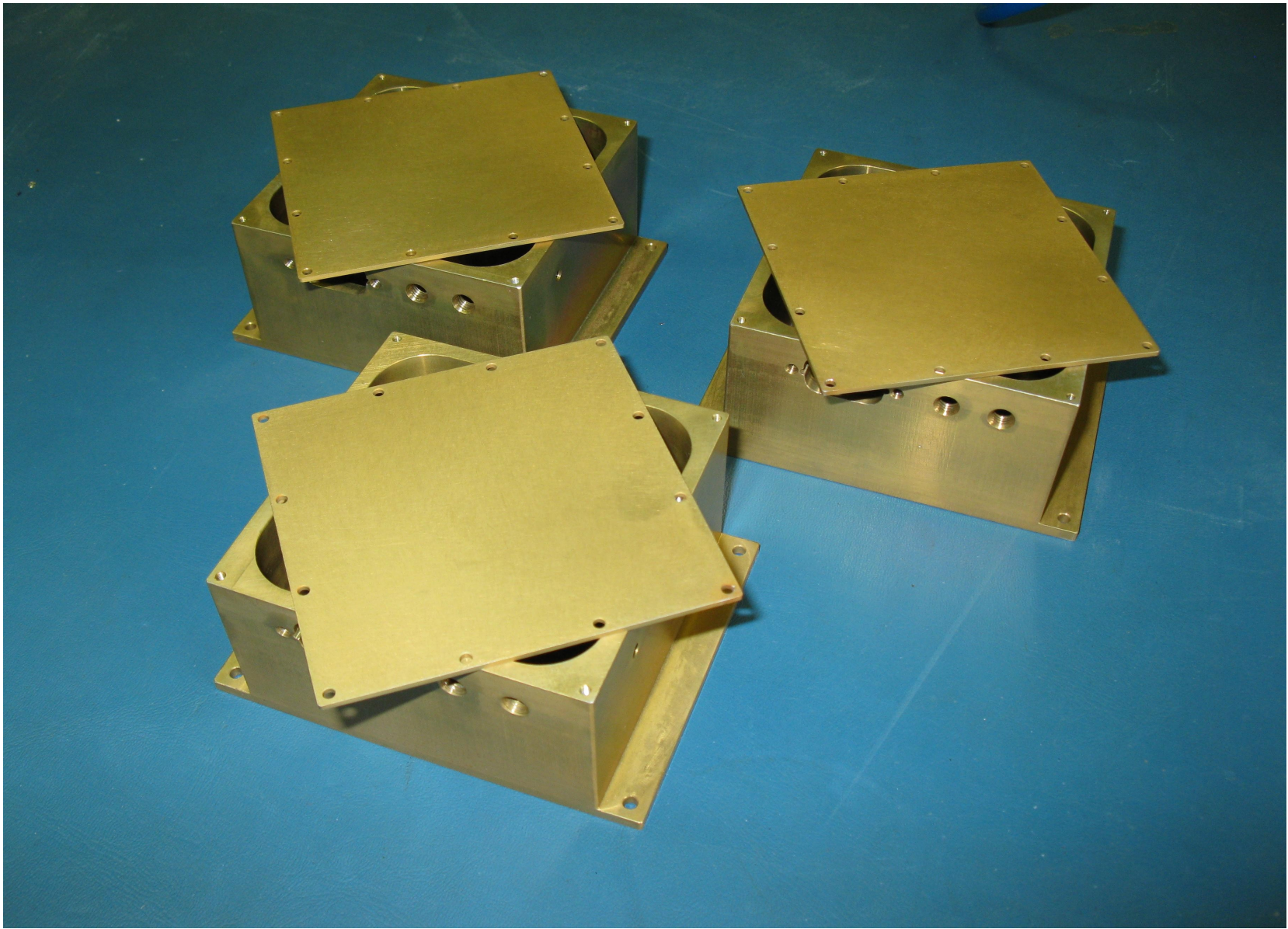
# Shield Effectiveness Measurement Standard



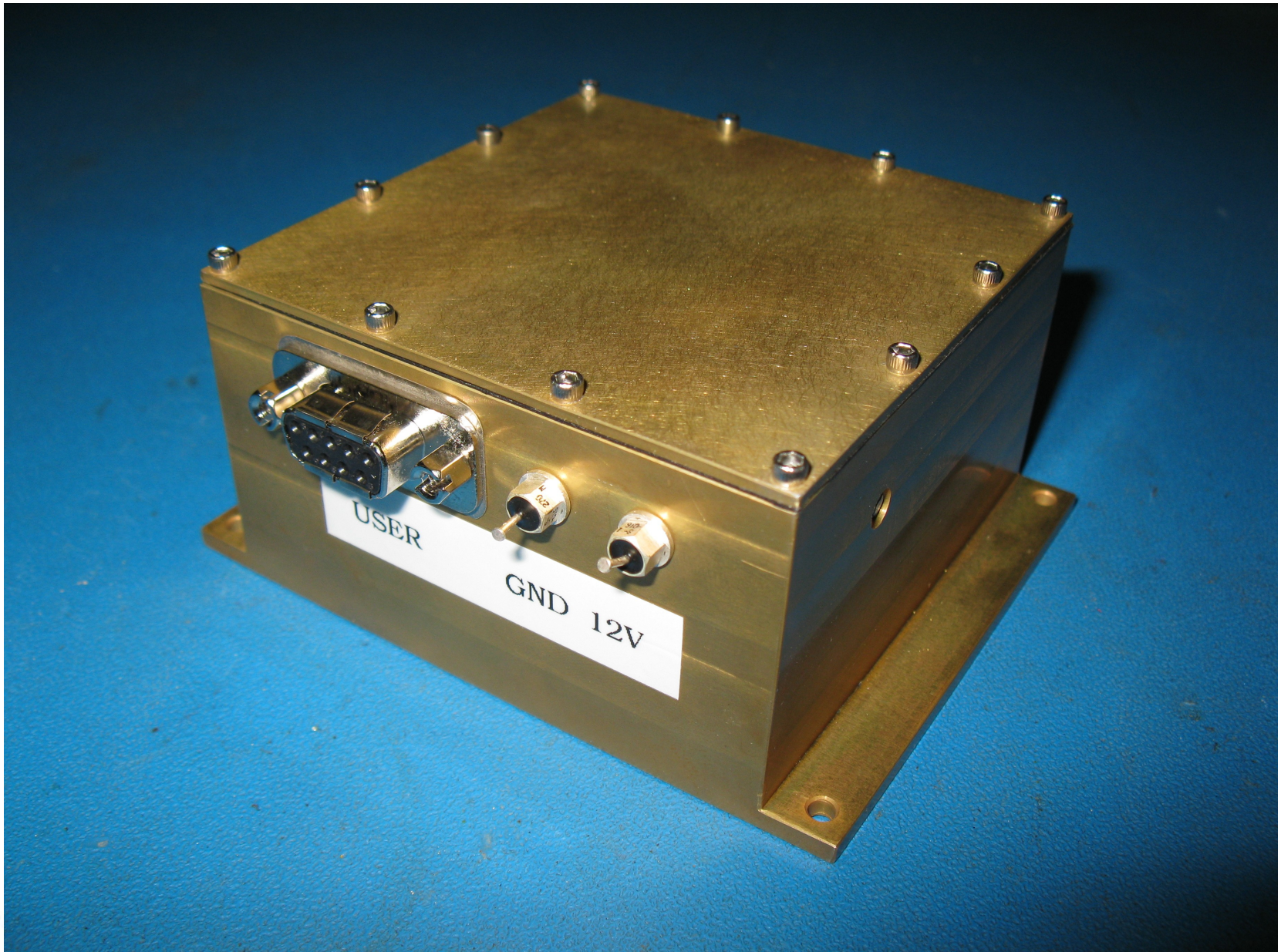
# Shield Effectiveness Evaluation

## Highlights of the Test Procedure:

1. Obtain Reference Measurements at distance  $D$ .
2. Receiver set to MAX HOLD while moving Rx antenna in a plane parallel to enclosure surface at distance  $D$ .
3. Many Measurement locations for most reliable results and to identify problem areas.



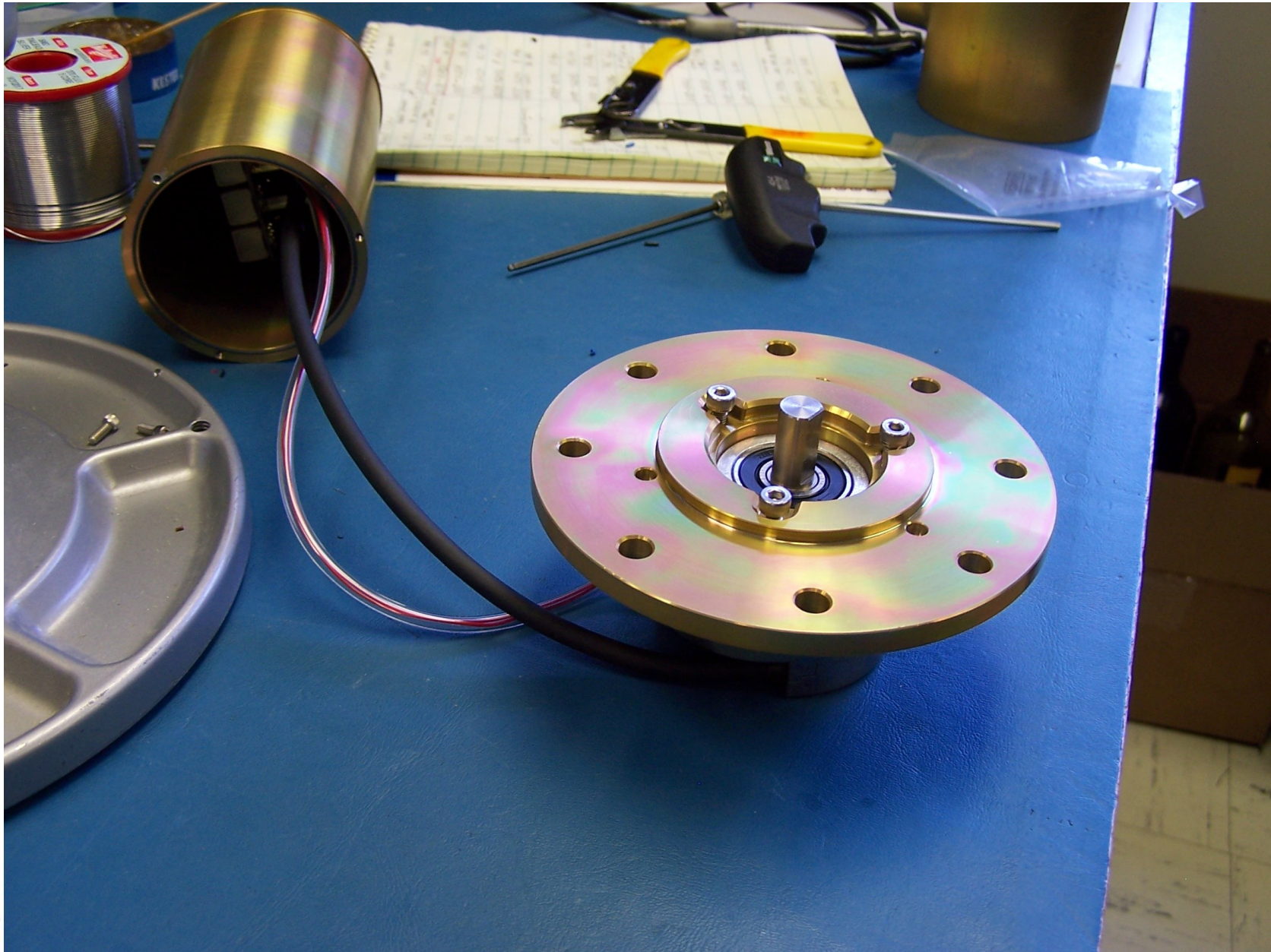








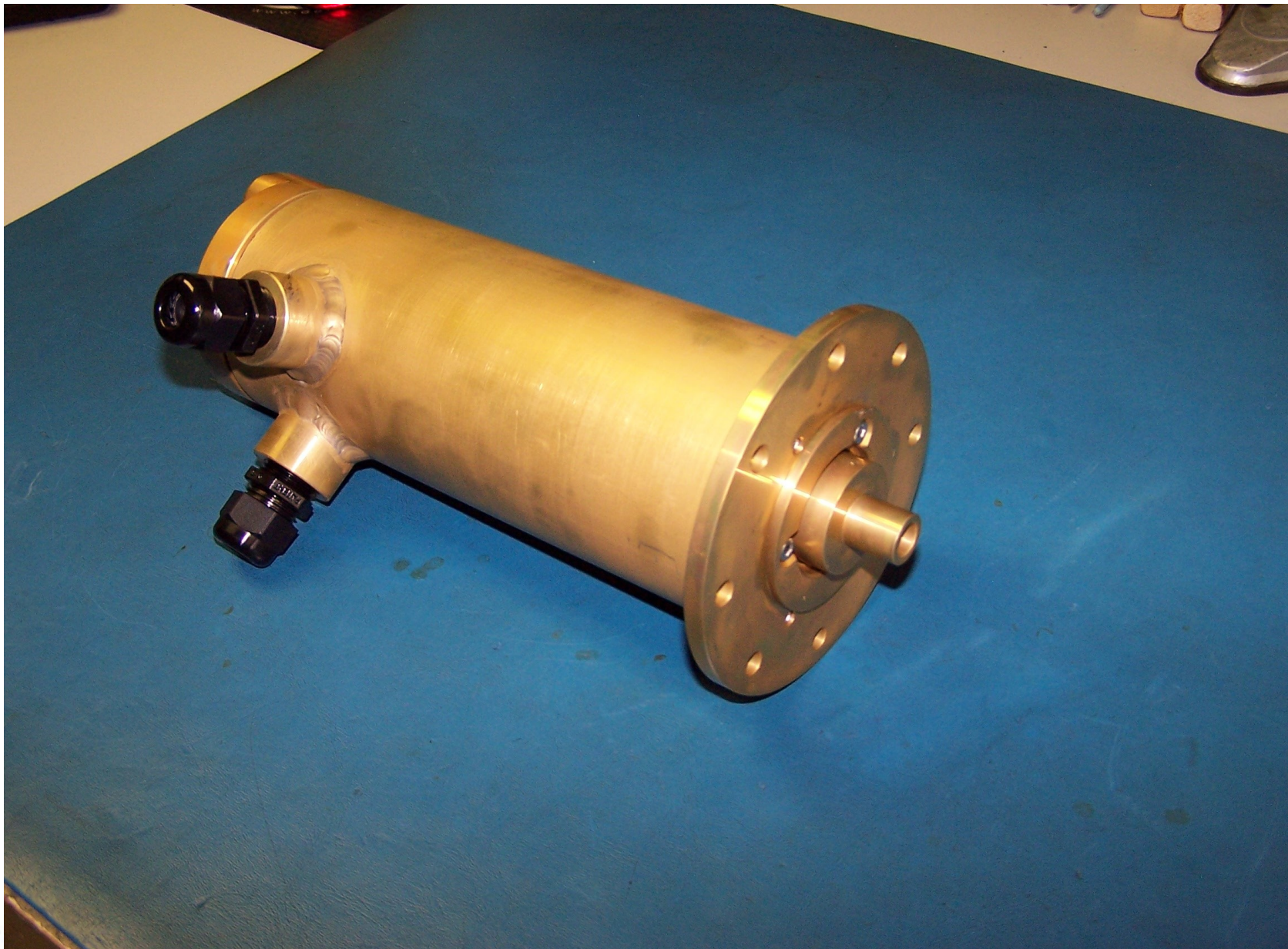














**Thank You!**

