

National Aeronautics and Space Administration
Goddard Space Flight Center

*Soil Moisture
Active Passive
(SMAP) Mission*

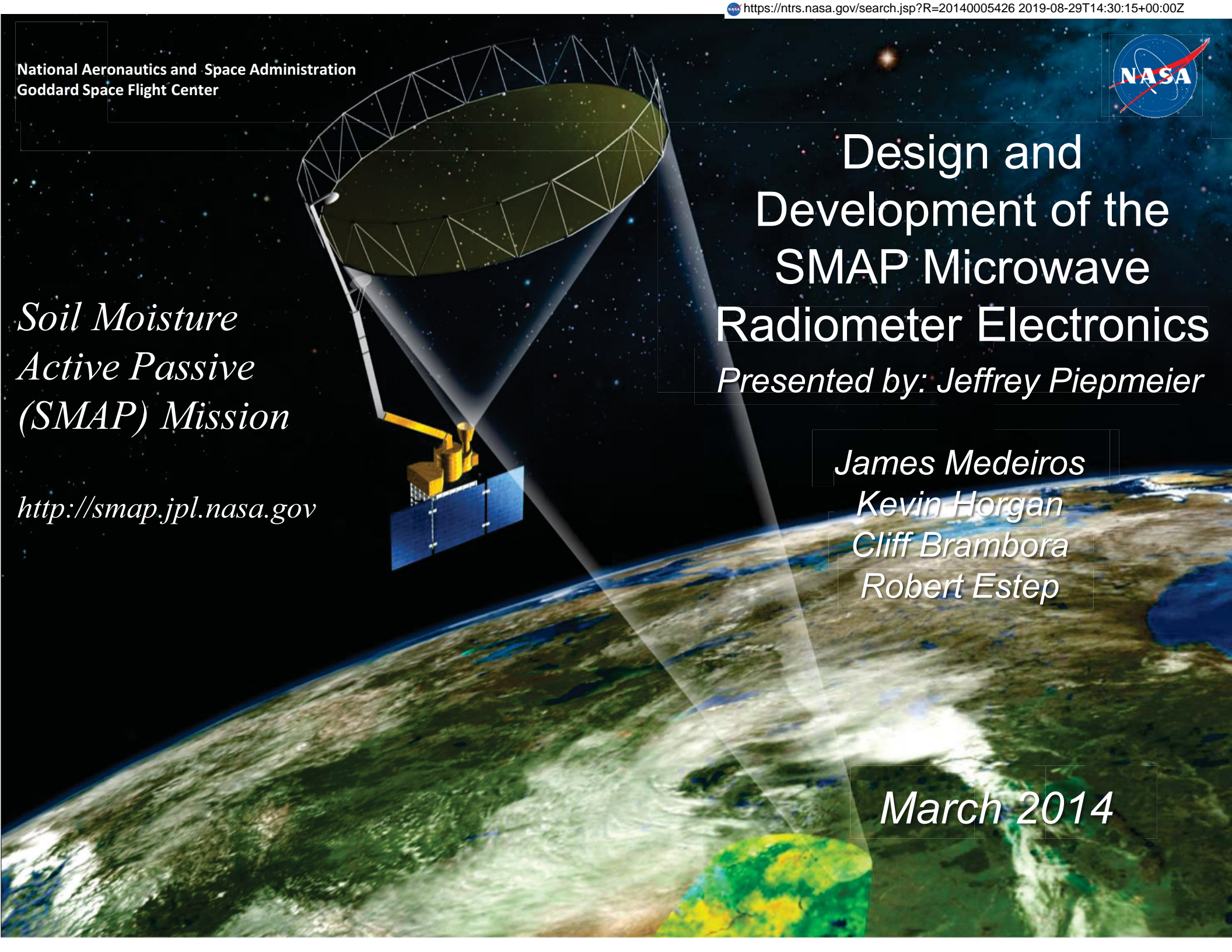
<http://smap.jpl.nasa.gov>

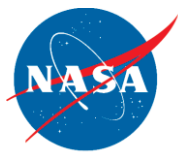
Design and Development of the SMAP Microwave Radiometer Electronics

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Cliff Brambora
Robert Estep*

March 2014

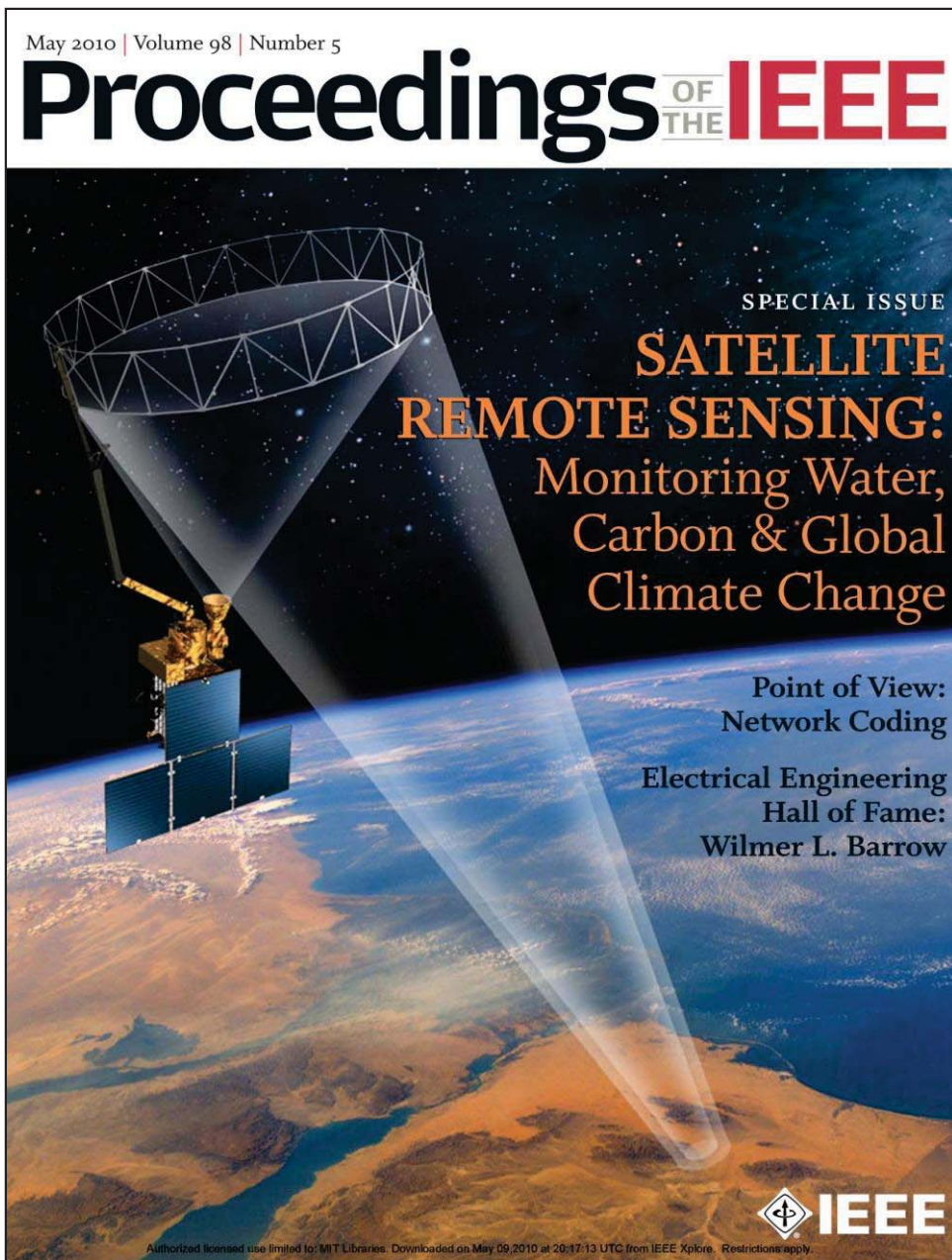




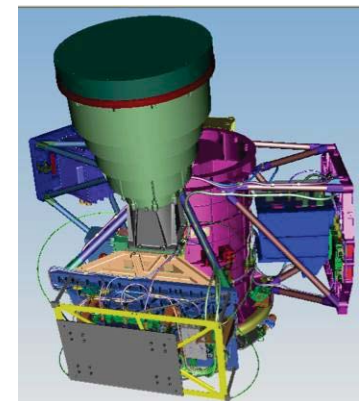
National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

SMAP Mission Concept

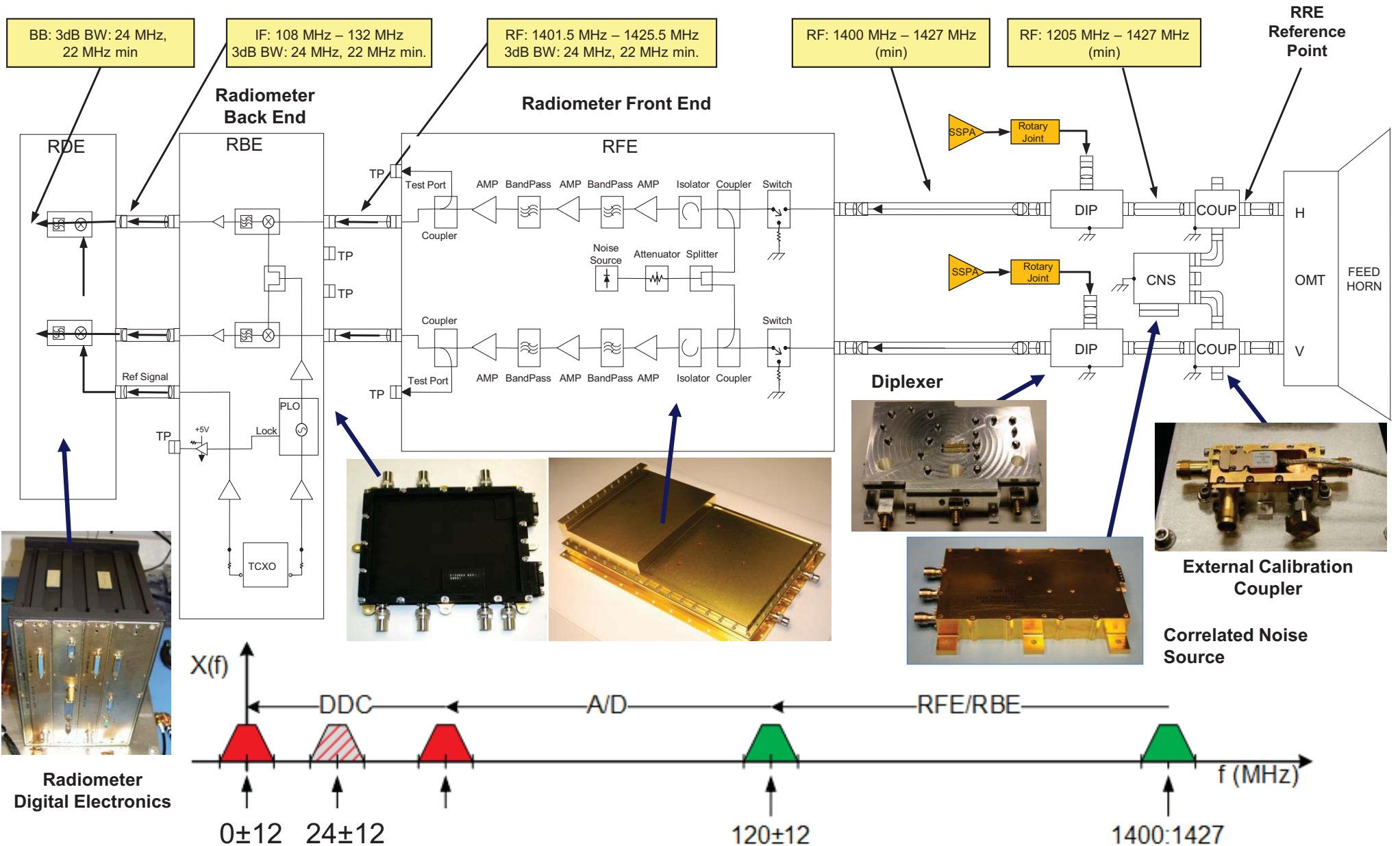


- L-band Unfocused SAR and Radiometer System, Offset-Fed 6 m Light-Weight Deployable Mesh Reflector. Shared Feed For
 - 1.26 GHz Radar at 1-3 km (HH, VV, HV) (30% Nadir Gap)
 - 1.4 GHz Polarimetric Radiometer at 40 km (H, V, 3rd & 4th Stokes)
- Conical Scan at Fixed Look Angle
- Wide 1000 km Swath With 2-3 Days Revisit
- Sun-Synchronous 6am/6pm Orbit (680 km)
- Launch 2014
- Mission Duration 3 Years

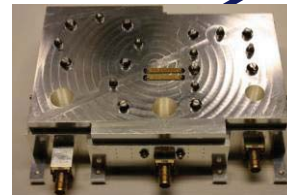
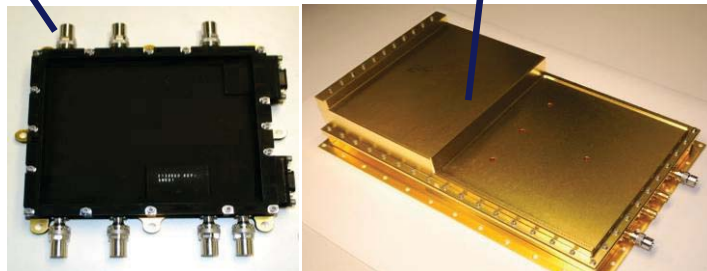




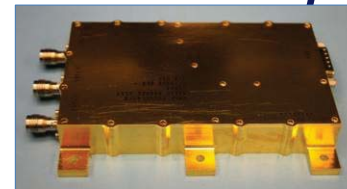
SMAP Radiometer Block Diagram and Frequency Plan



Radiometer Digital Electronics



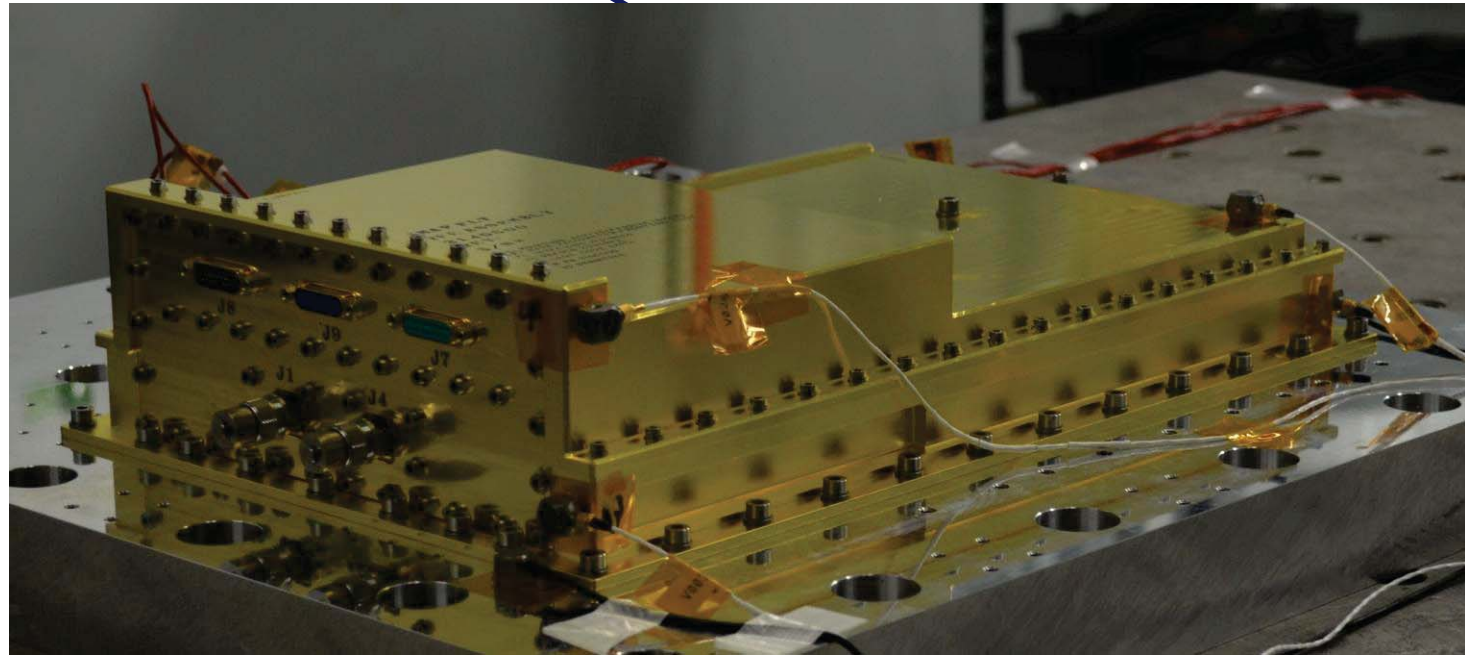
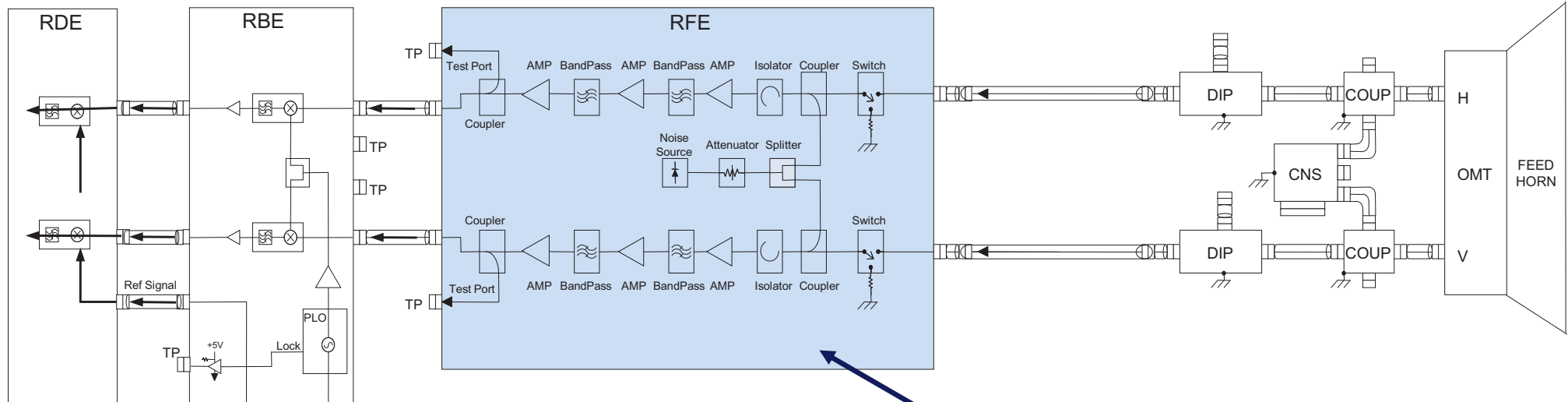
External Calibration Coupler



Correlated Noise Source



SMAP Radiometer Front End (RFE) Assembly

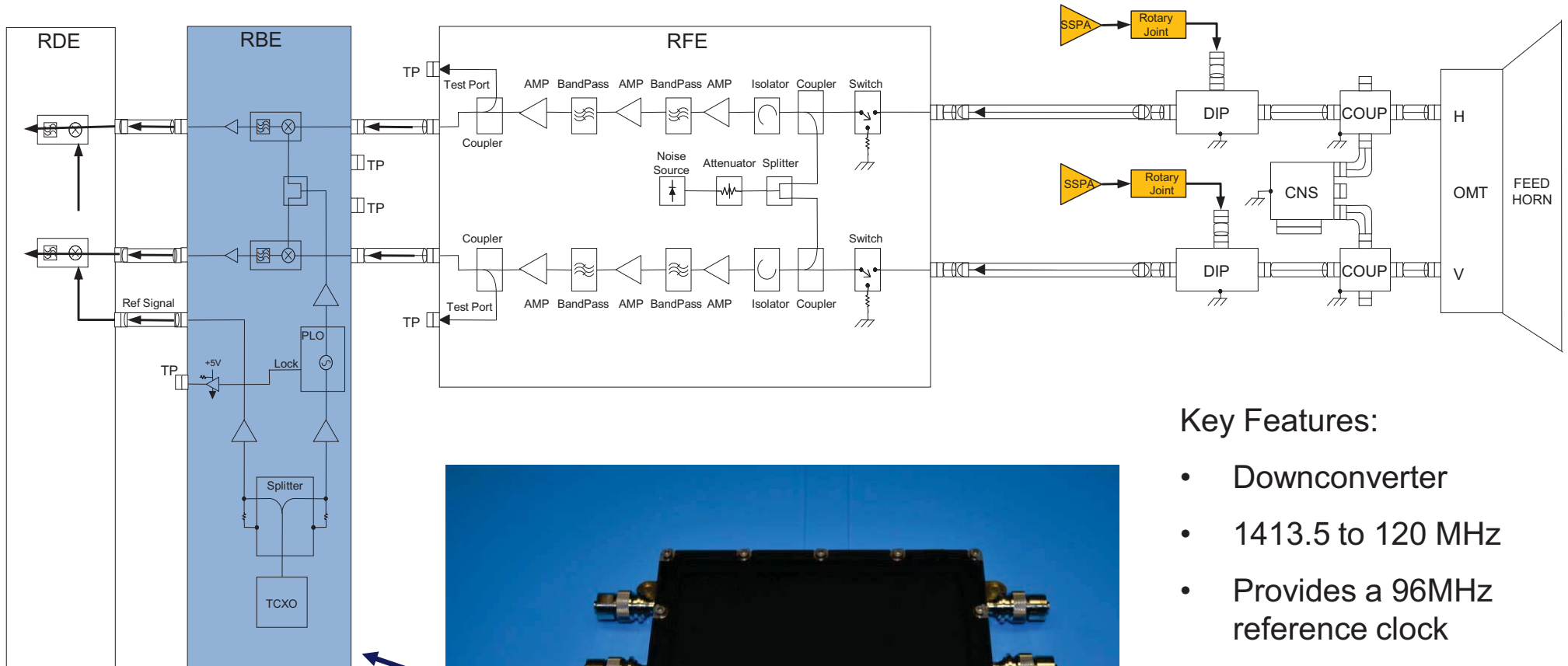


Key Features:

- Two-channels
- Cal ref switch
- Correlated Noise Source

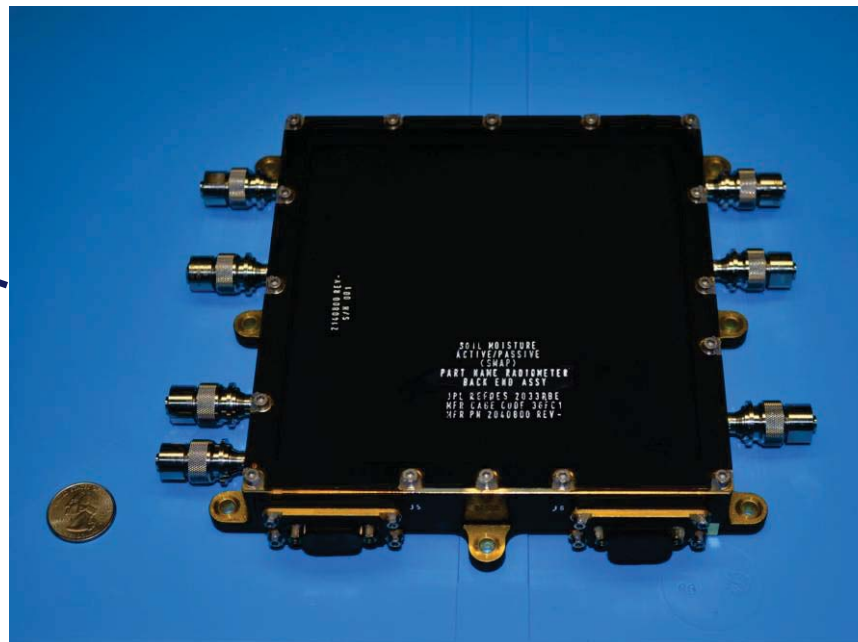


SMAP Radiometer Back End (RBE) Assembly



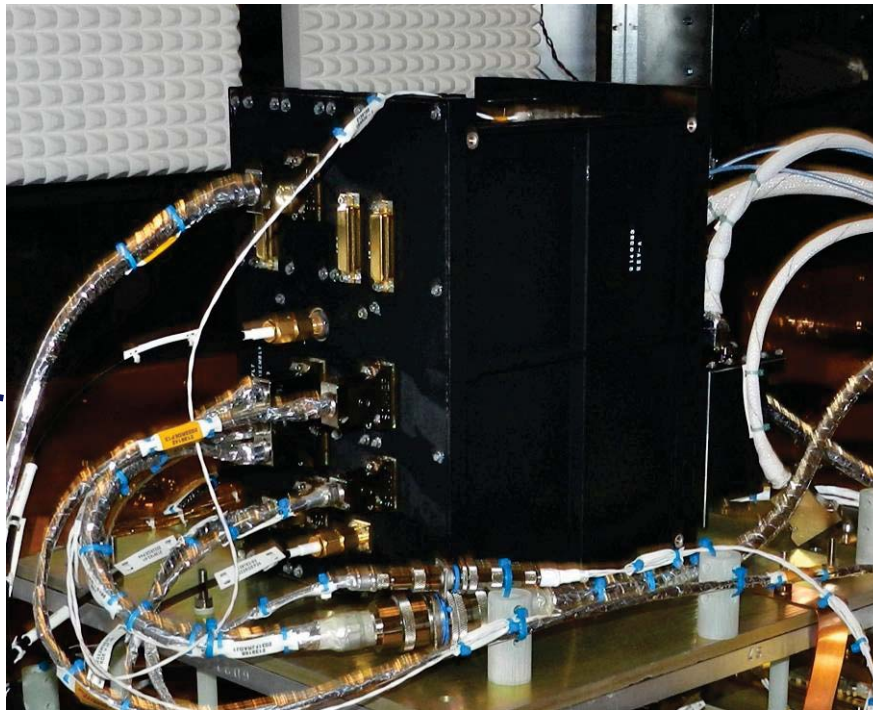
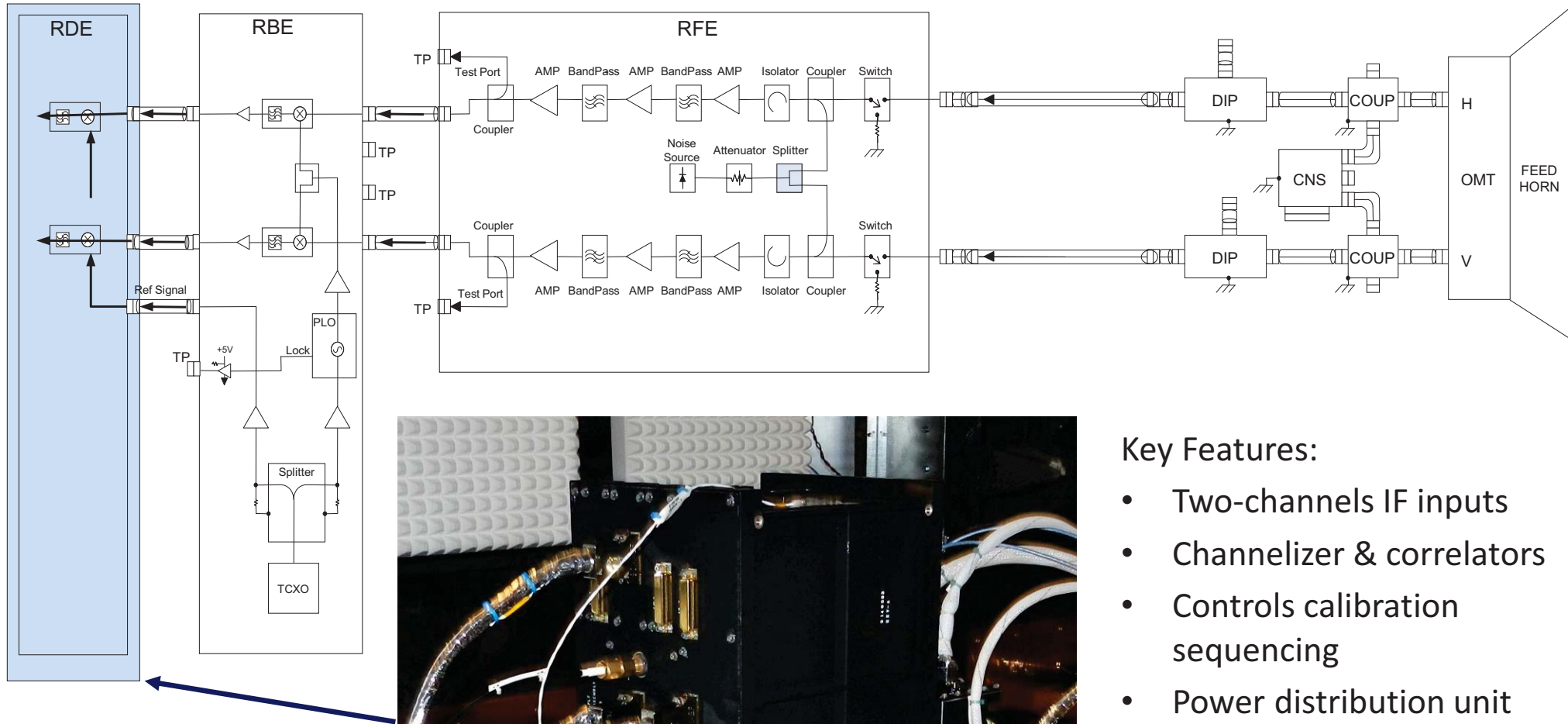
Key Features:

- Downconverter
- 1413.5 to 120 MHz
- Provides a 96MHz reference clock





SMAP Radiometer Digital Electronics (RDE) Assembly

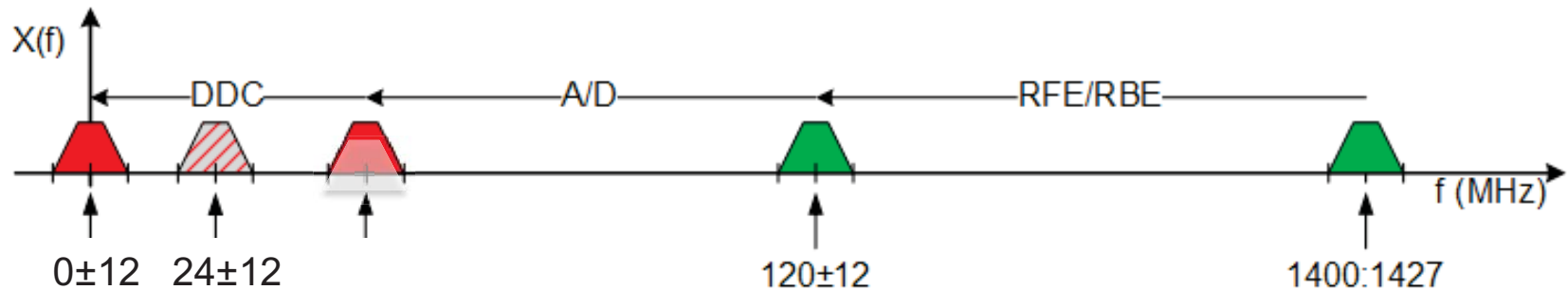
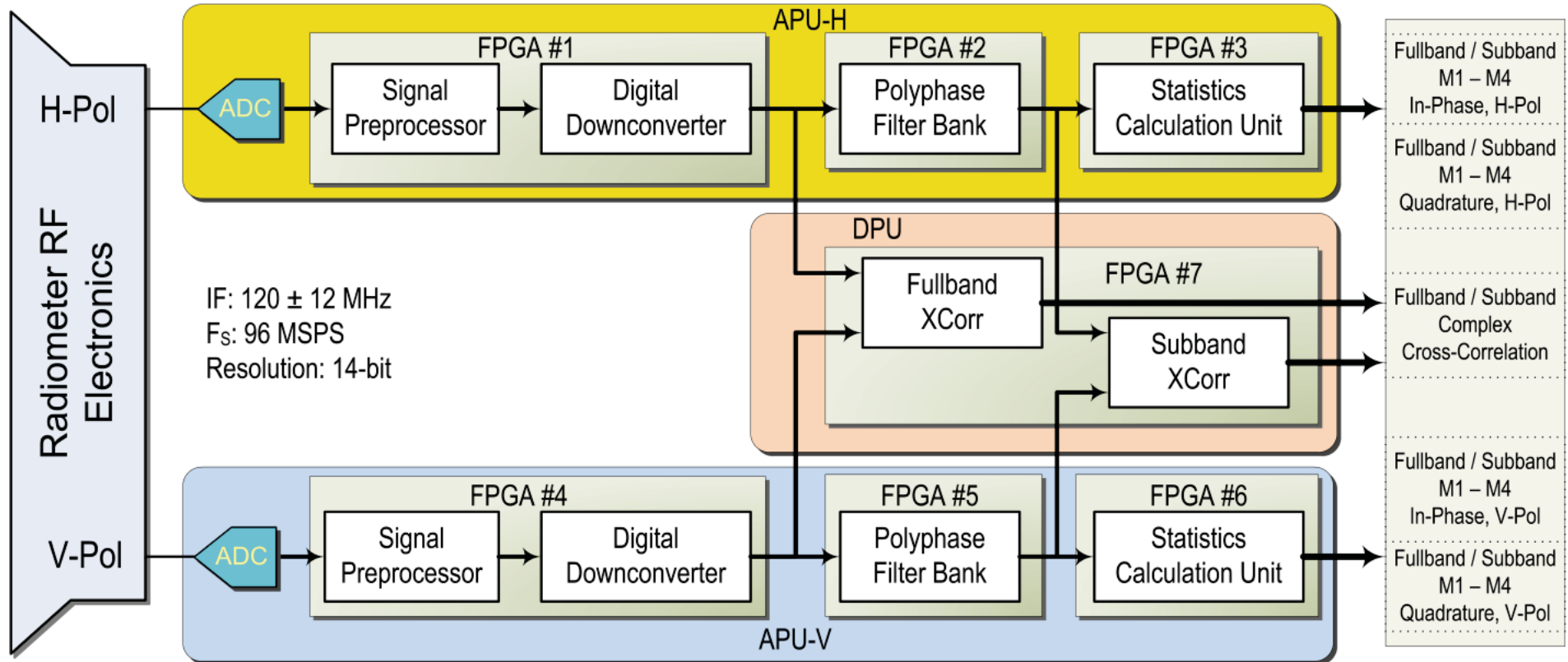


Key Features:

- Two-channels IF inputs
- Channelizer & correlators
- Controls calibration sequencing
- Power distribution unit



RDE Architecture: DSP Data Flow

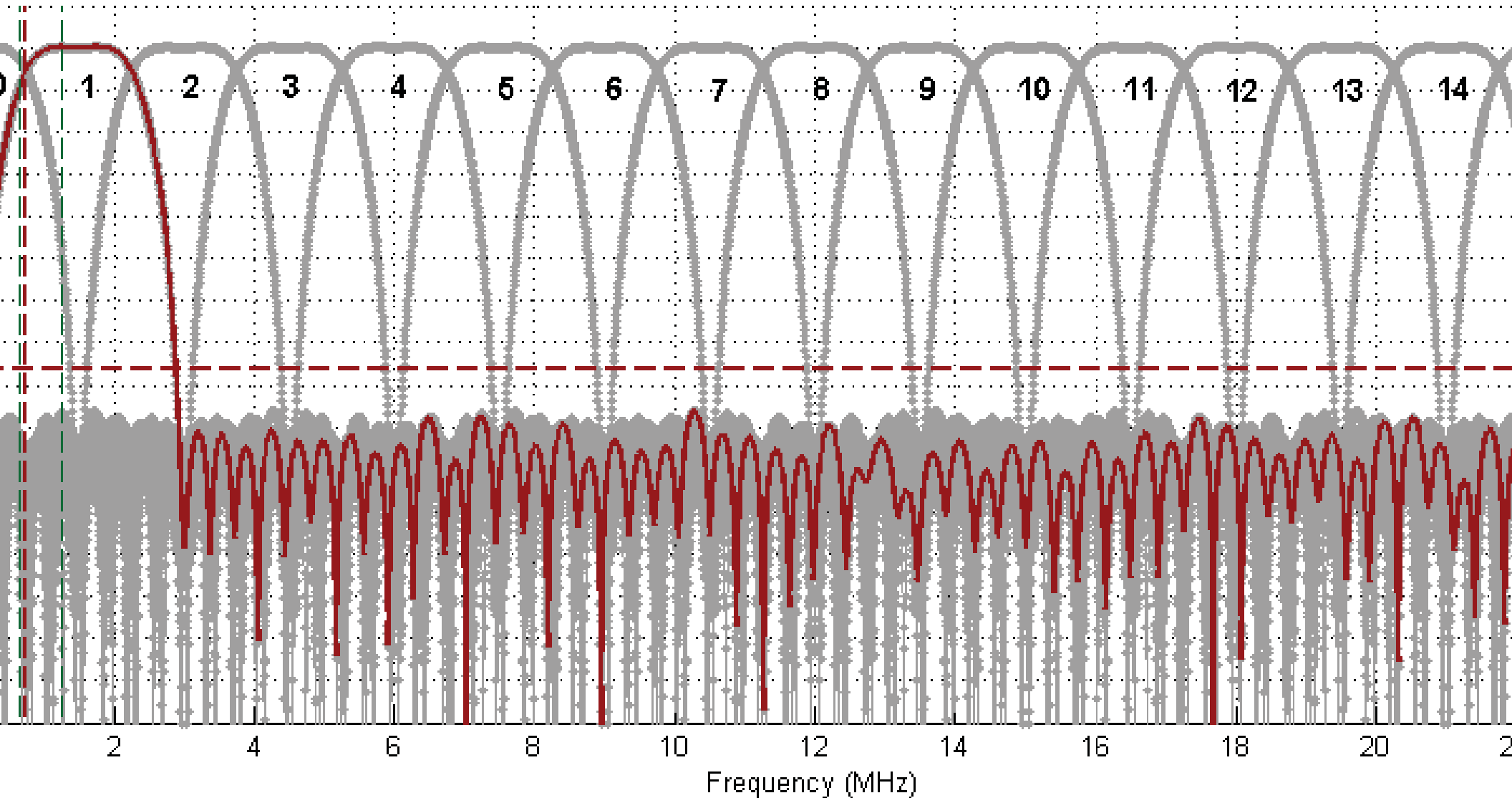




Filterbank Frequency Response

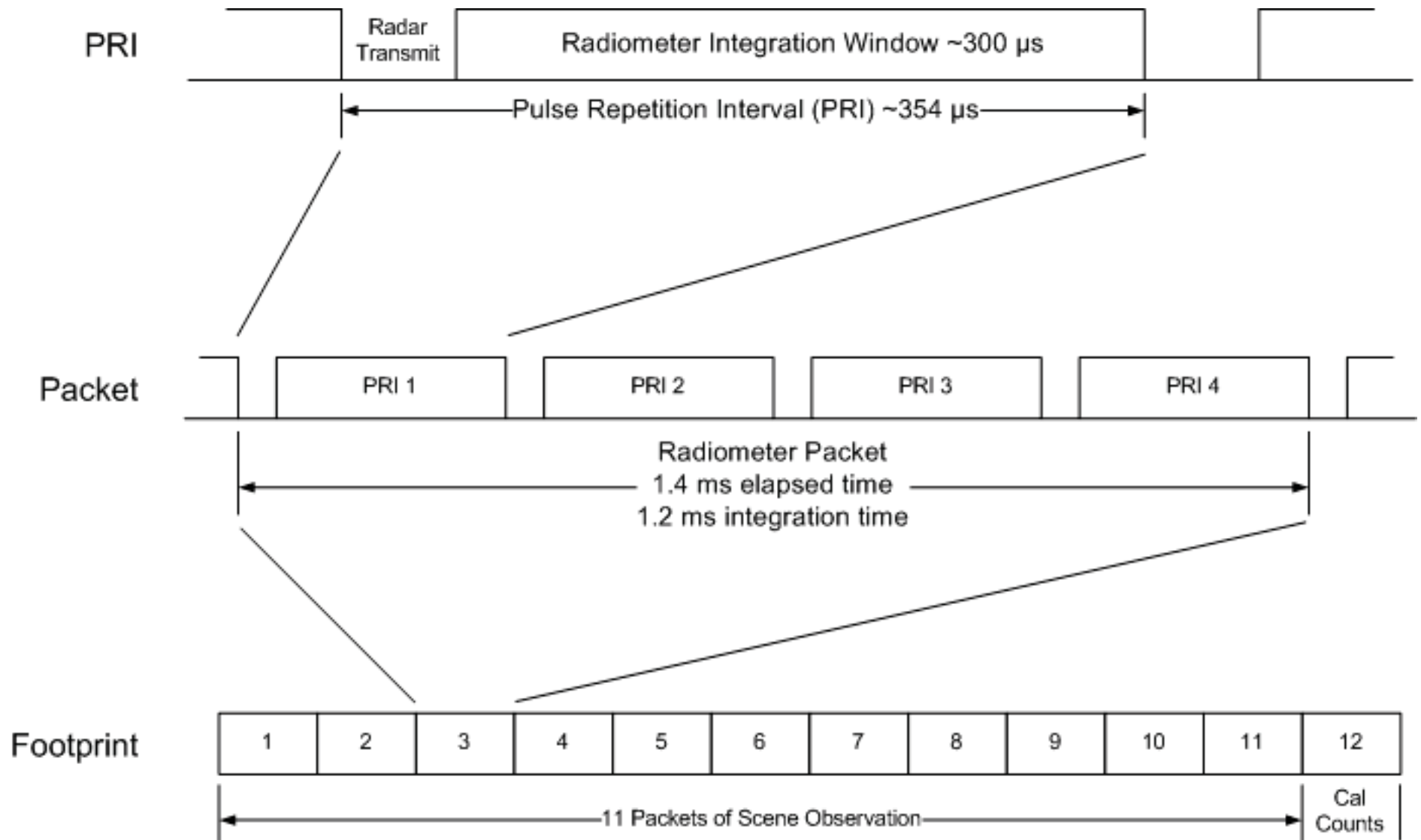


PFB Filter Response





Radiometer Timing

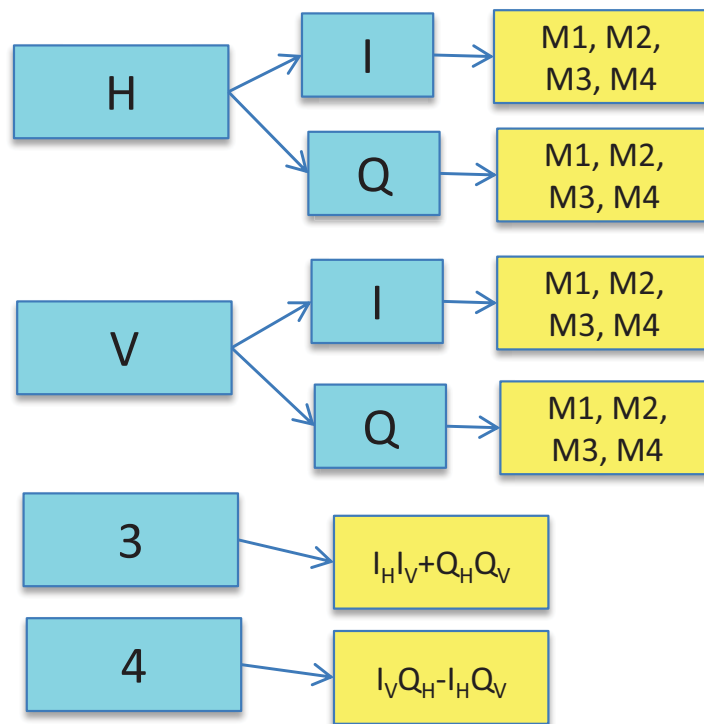




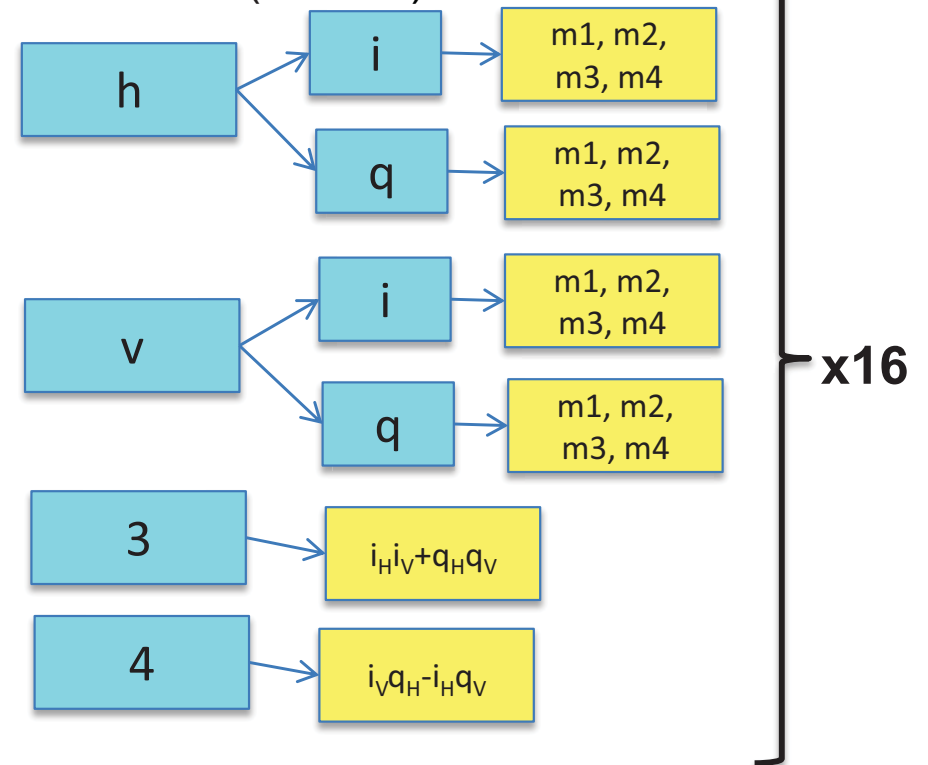
SMAP Radiometer “Detector” Counts



- Full-band high-rate, every PRI (300 us)
 - V, H
 - 1st, 2nd, 3rd, 4th moments, I, Q
 - 3rd and 4th Stokes
 - PRF (3.5 kHz) rate



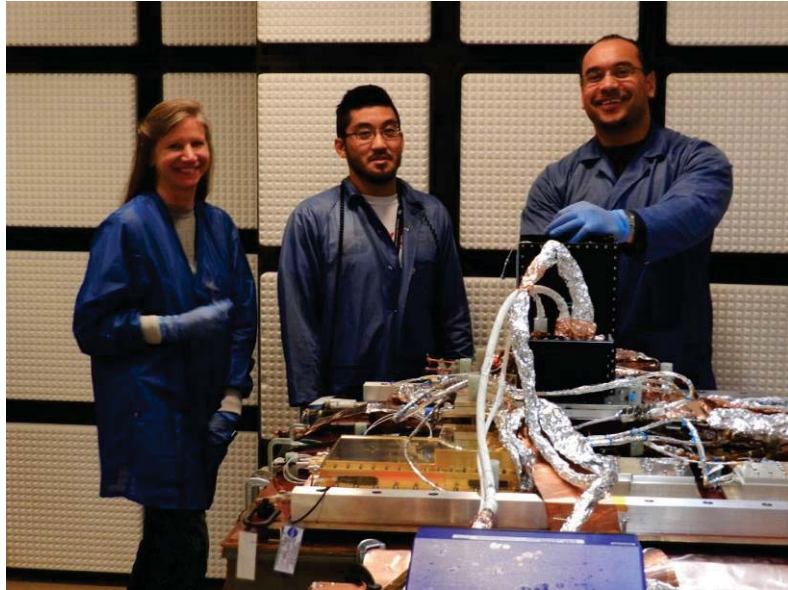
- Sub-banded data, **16 subbands**, every 4 PRIs, (1200 us)
 - V, H
 - 1st, 2nd, 3rd, 4th moments, I, Q
 - 3rd and 4th Stokes
 - ¼ PRF (875 Hz)



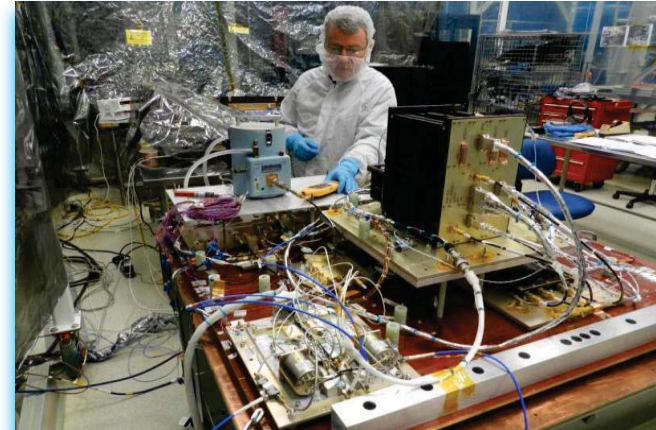
Time/Frequency diversity: 360 words every ~1ms (packet)



GSFC Integration and Test



EMC/EMI



LN2
Cal



TVAC Initial Power Up



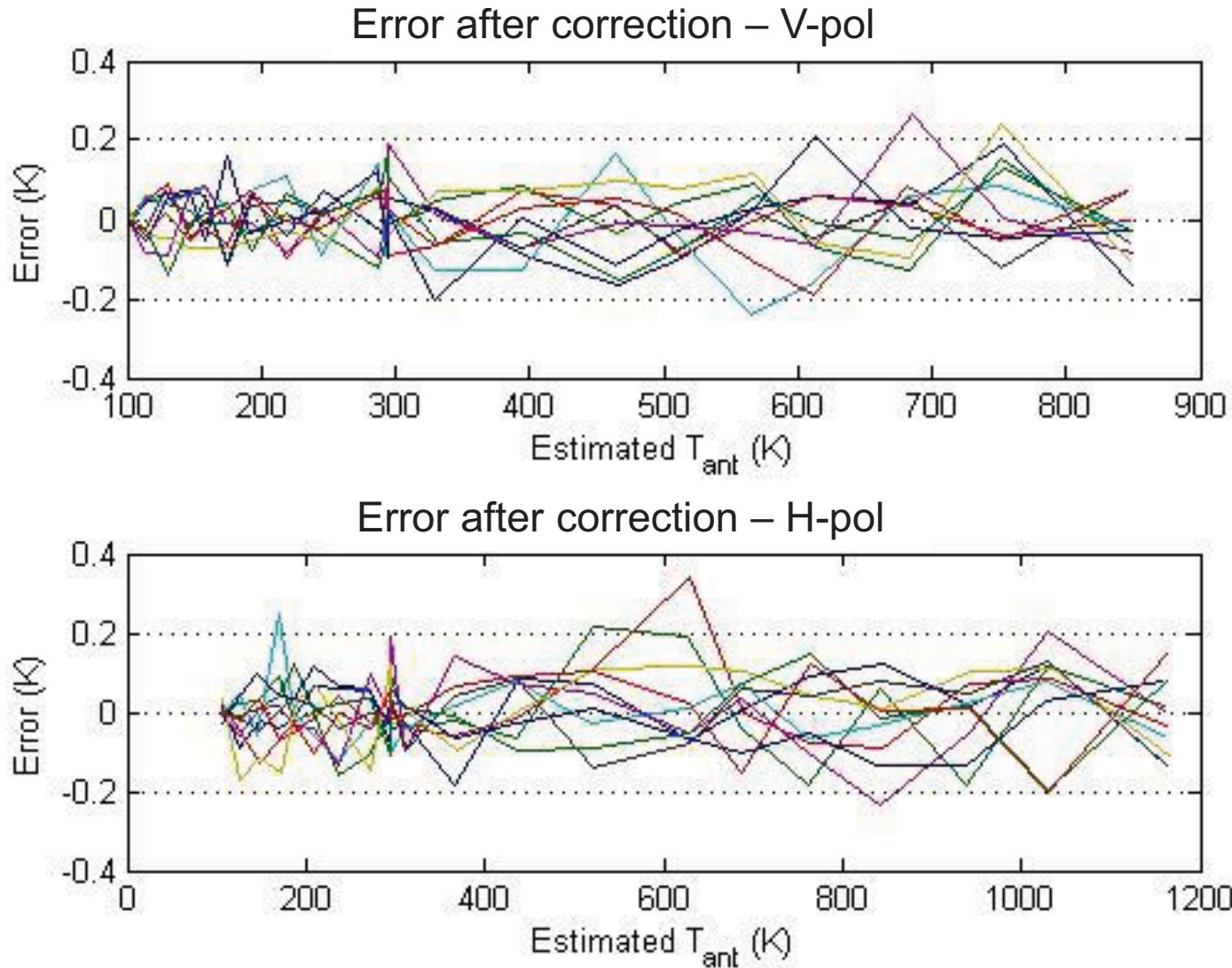
Error Budget < 1.3 K



| Error Term | Allocation | Current CBE |
|--|------------|------------------|
| Antenna Pattern Correction | 0.6 K | 0.42 K |
| NEAT | 0.65 K | 0.47 K |
| Antenna Temperature Calibration | 0.5 K | 0.45 K |
| RFI | 0.3 K | 0.22 K |
| Long Term Drift | 0.4 K | <0.2 K |
| Atmospheric Correction | 0.1 K | 0.04 K |
| RSS Total | 1.1 K | 0.83 K |
| Requirement | 1.3 K | 1.3 K |
| Margin (Unencumbered RSS) | 0.6 K | 1.0 K |
| Margin (Unencumbered Linear) | 0.2K | 0.47K |



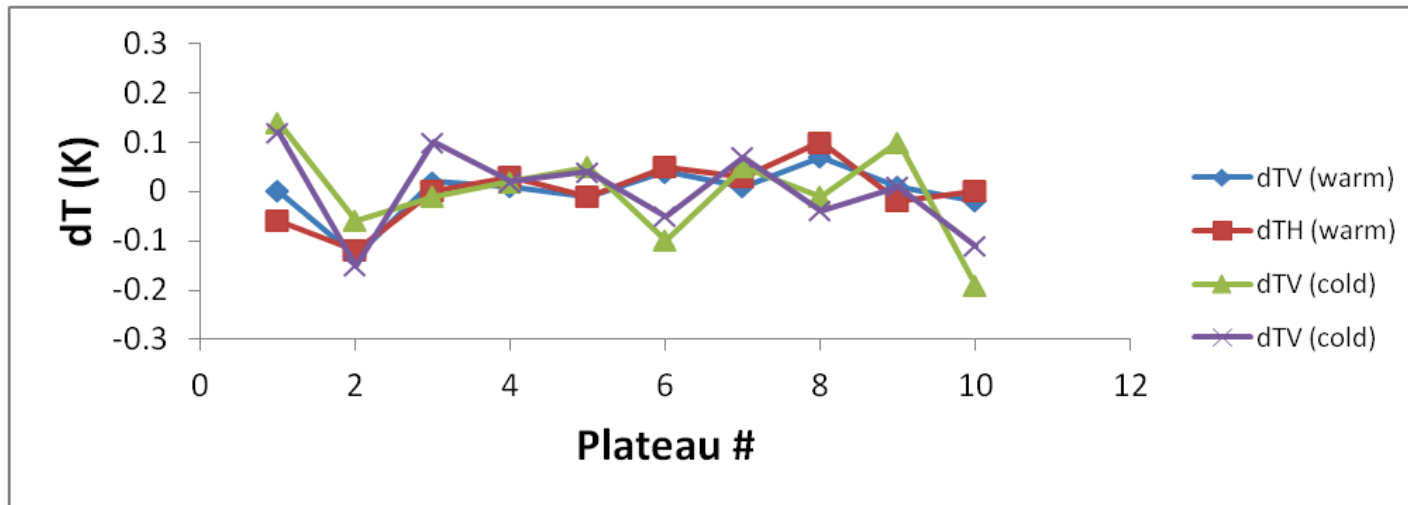
Linearity



- Error : 0.20 K without correction, 0.04 Krms with correction



Repeatability Results



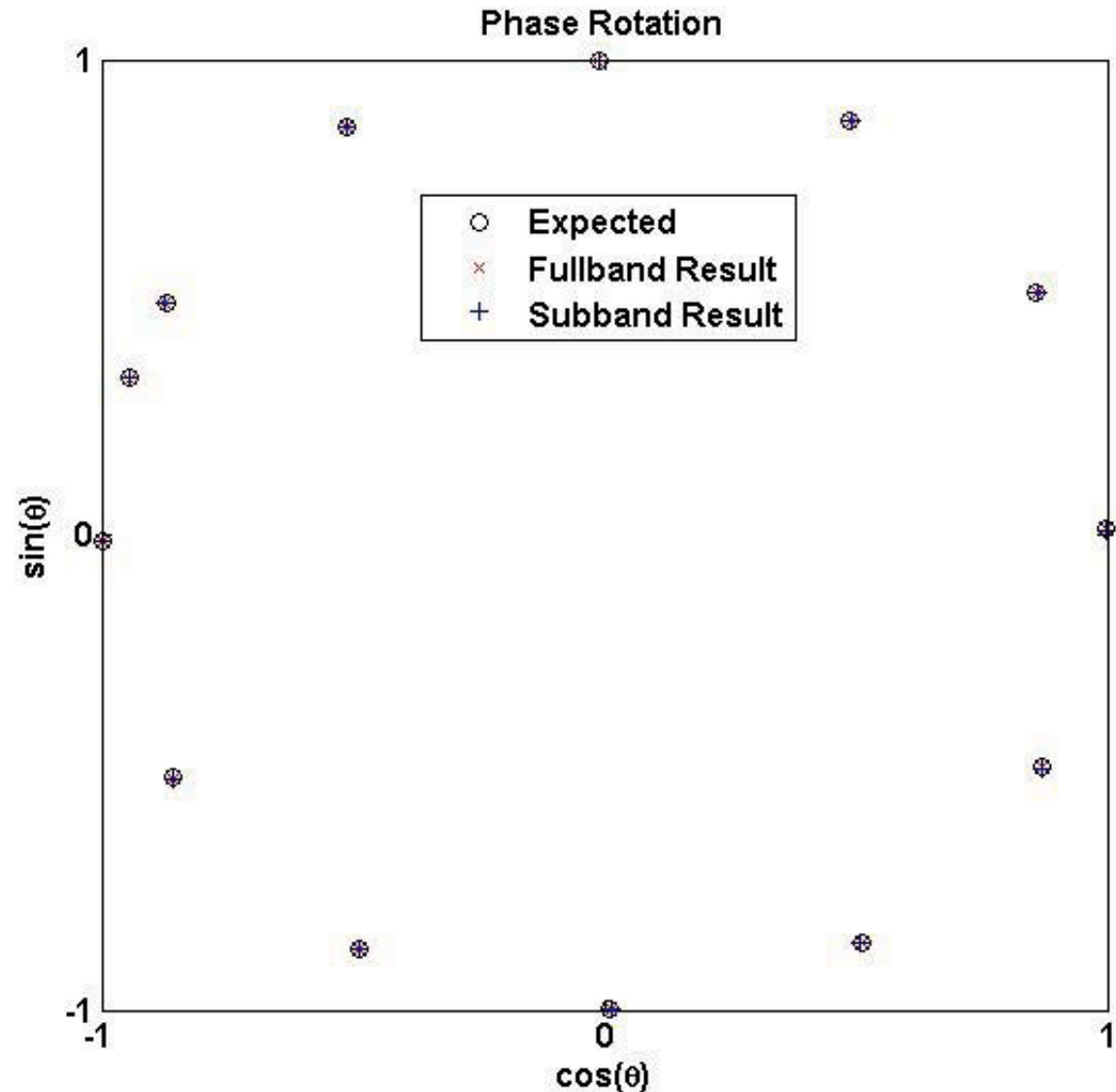
| Plateau | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|-------------------------|------|------|------|-----|------|------|-----|------|------|------|
| ΔT_H , warm (K) | 0.00 | -.13 | .02 | .01 | -.01 | .04 | .01 | .07 | .01 | -.02 |
| ΔT_V , warm (K) | -.06 | -.12 | 0.00 | .03 | -.01 | .05 | .03 | .10 | -.02 | 0.00 |
| ΔT_H , cold (K) | .14 | -.06 | -.01 | .02 | .05 | -.10 | .05 | -.01 | .10 | -.19 |
| ΔT_V , cold (K) | .12 | -.15 | .10 | .02 | .04 | -.05 | .07 | -.04 | .01 | -.11 |



Polarimetry

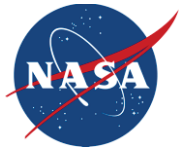


- Differential group delay
 - 155 ps (measured)
- Phase rotation
 - $< 0.1^\circ$ with integration time 4 seconds.
- Correlator efficiency
 - 0.998

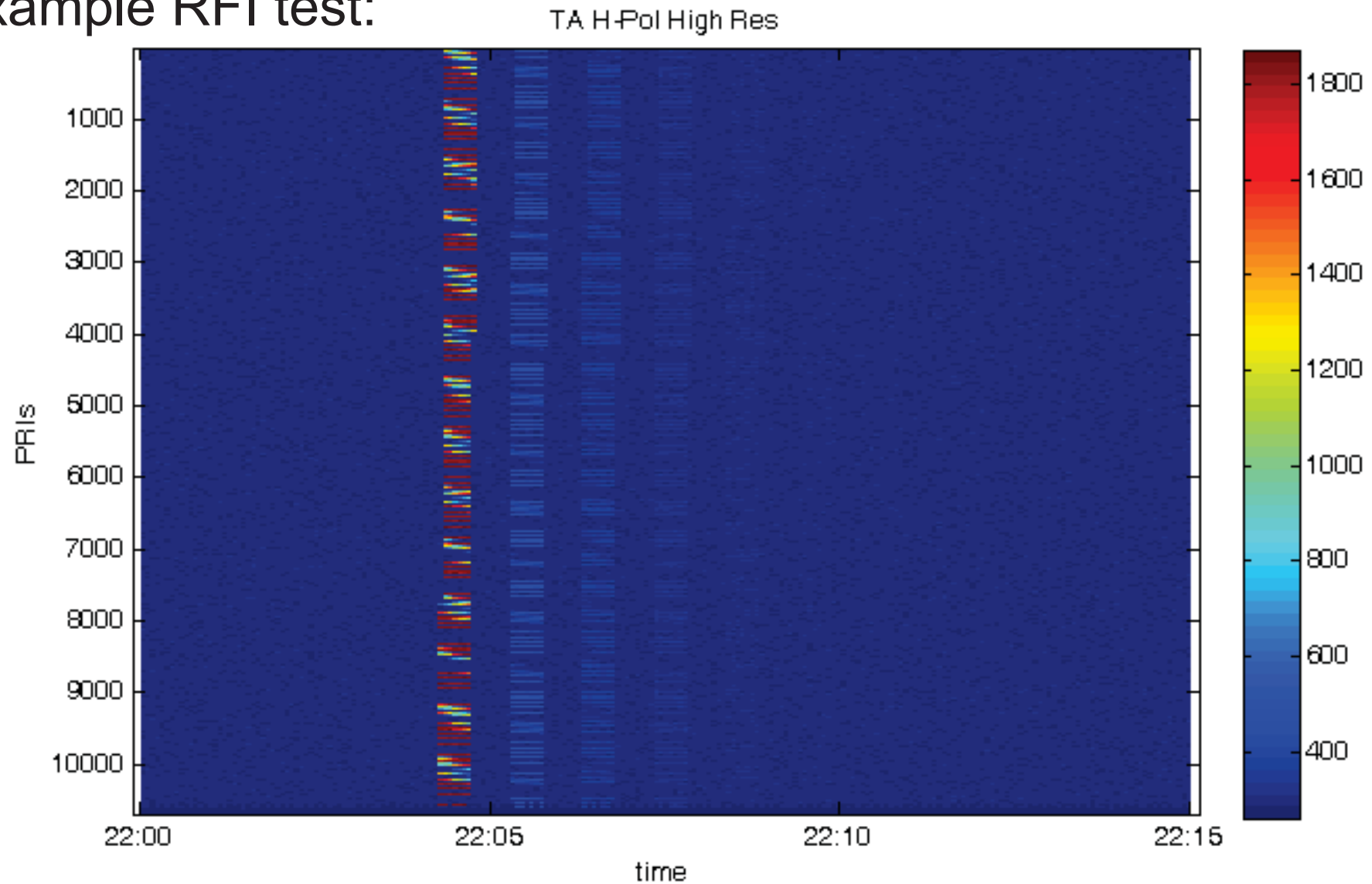




Pulsed RFI Evident in TA Data

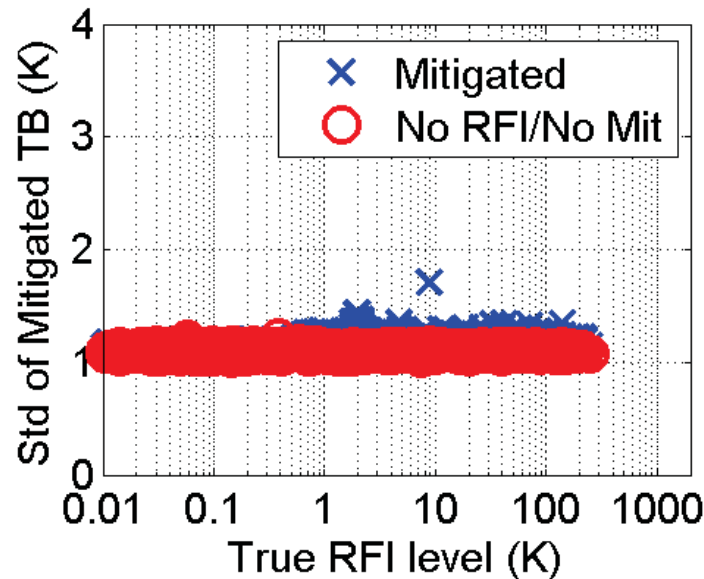
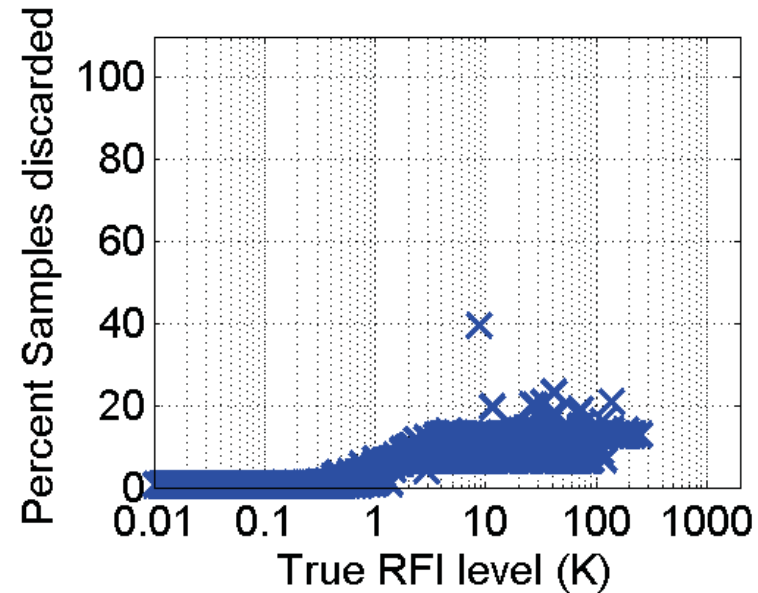
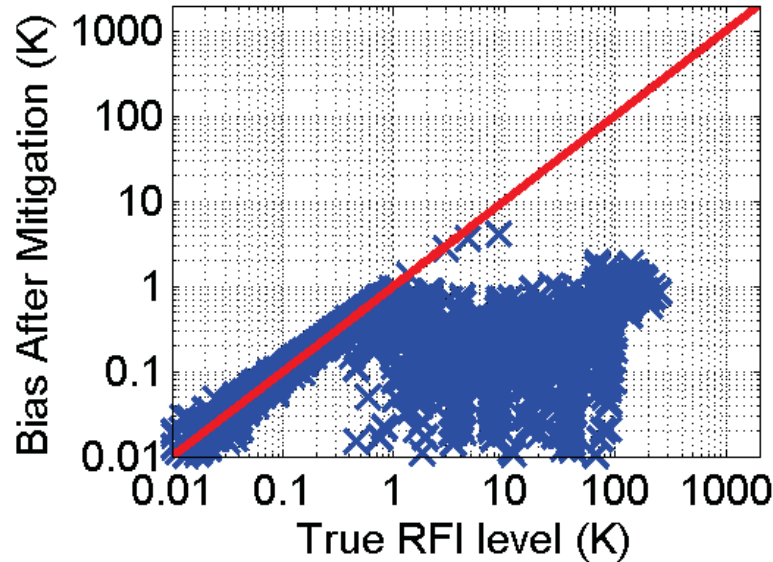


Example RFI test:





RFI Mitigation Performance



“Radio-Frequency Interference Mitigation for the Soil Moisture Active Passive Microwave Radiometer,” *IEEE Trans. GRS*, vol.52, no.1, part 2, 2014.



GSFC SMAP Radiometer Team



Mar 24-27,
2014

SMAP-17