

National Aeronautics and Space Administration
Goddard Space Flight Center



Design and Development of the SMAP Microwave Radiometer Electronics

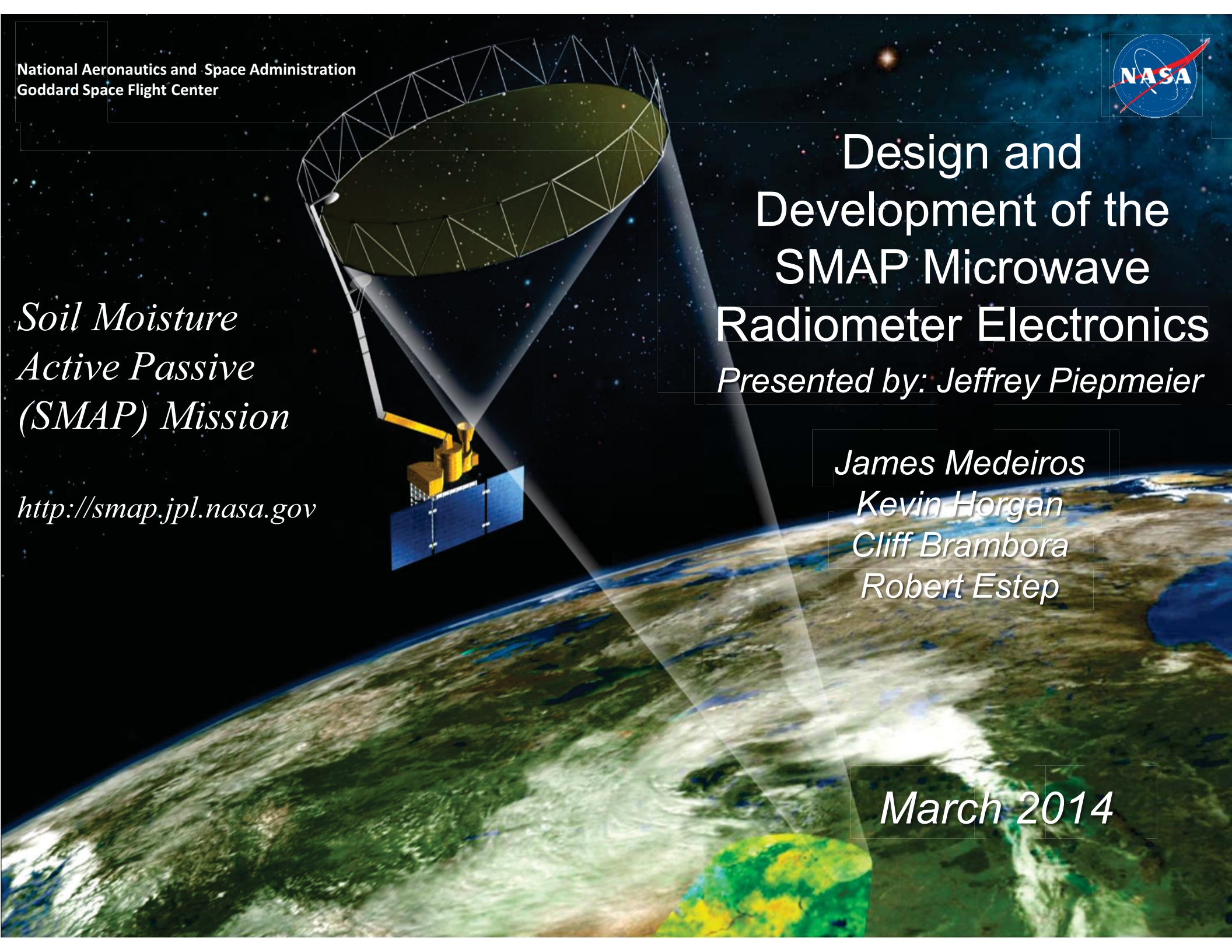
Presented by: Jeffrey Piepmeier

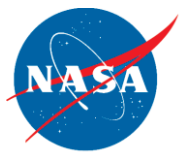
*James Medeiros
Kevin Horgan
Cliff Brambora
Robert Estep*

*Soil Moisture
Active Passive
(SMAP) Mission*

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

March 2014

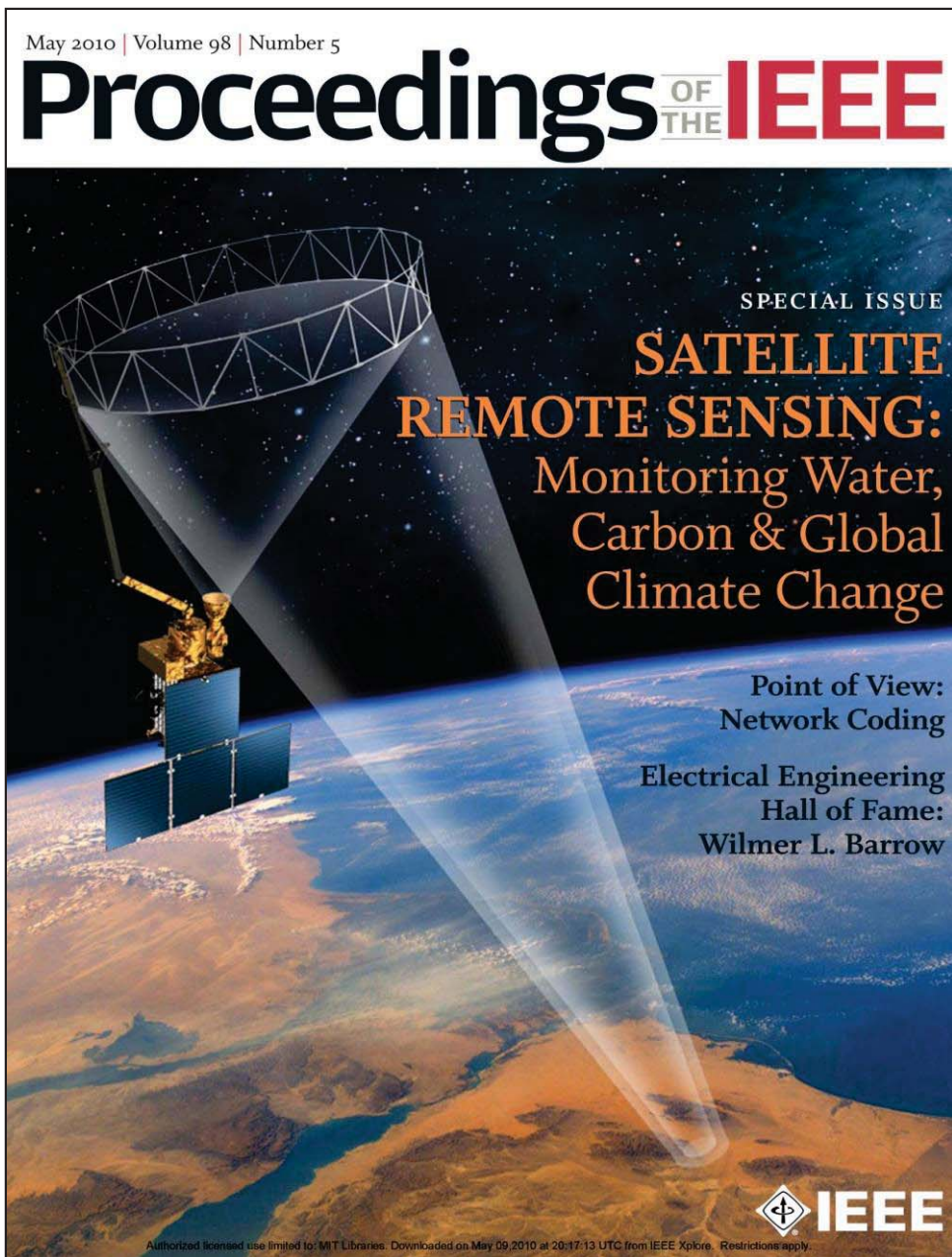




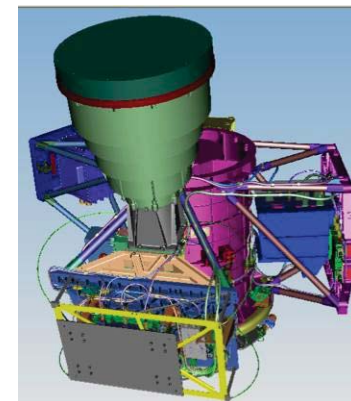
National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

SMAP Mission Concept

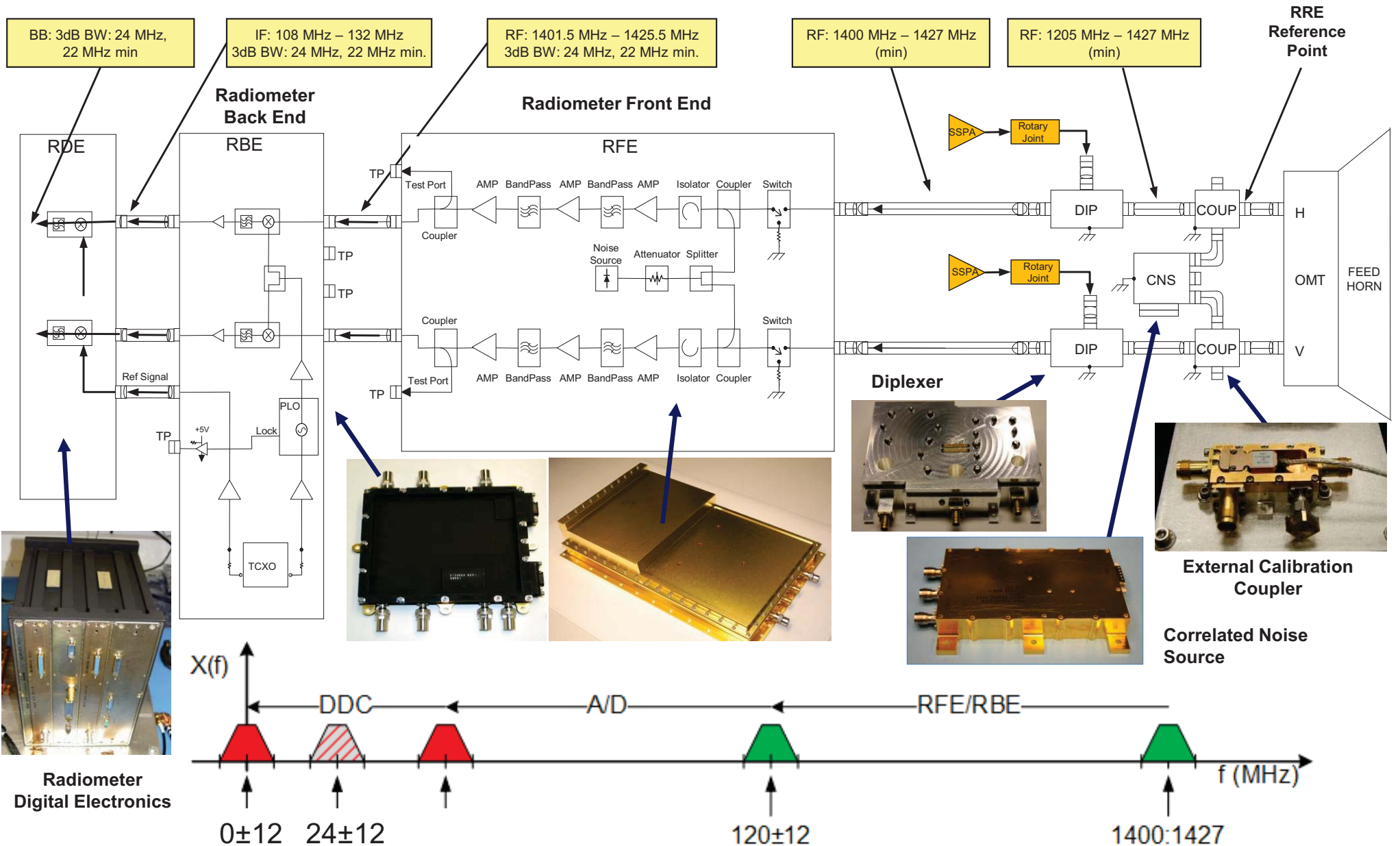
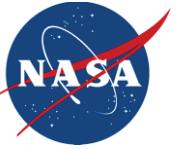


- L-band Unfocused SAR and Radiometer System, Offset-Fed 6 m Light-Weight Deployable Mesh Reflector. Shared Feed For
 - 1.26 GHz Radar at 1-3 km (HH, VV, HV) (30% Nadir Gap)
 - 1.4 GHz Polarimetric Radiometer at 40 km (H, V, 3rd & 4th Stokes)
- Conical Scan at Fixed Look Angle
- Wide 1000 km Swath With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





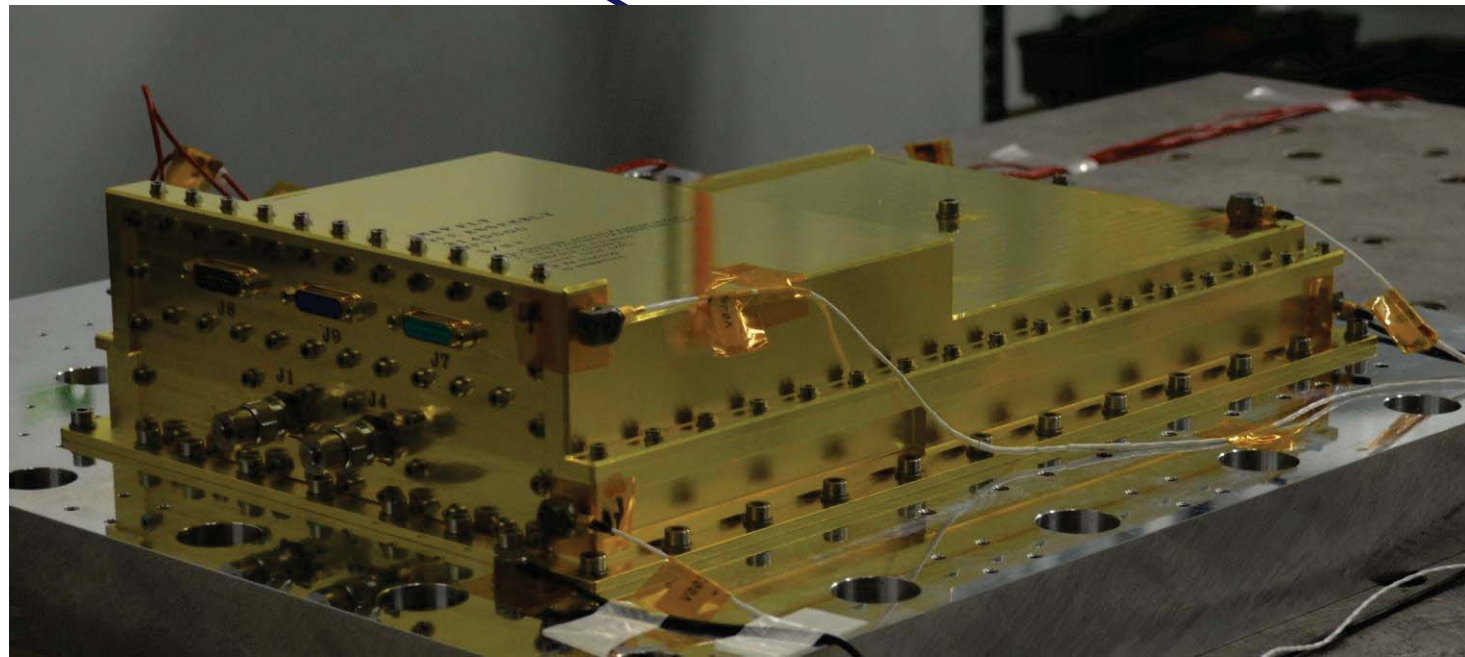
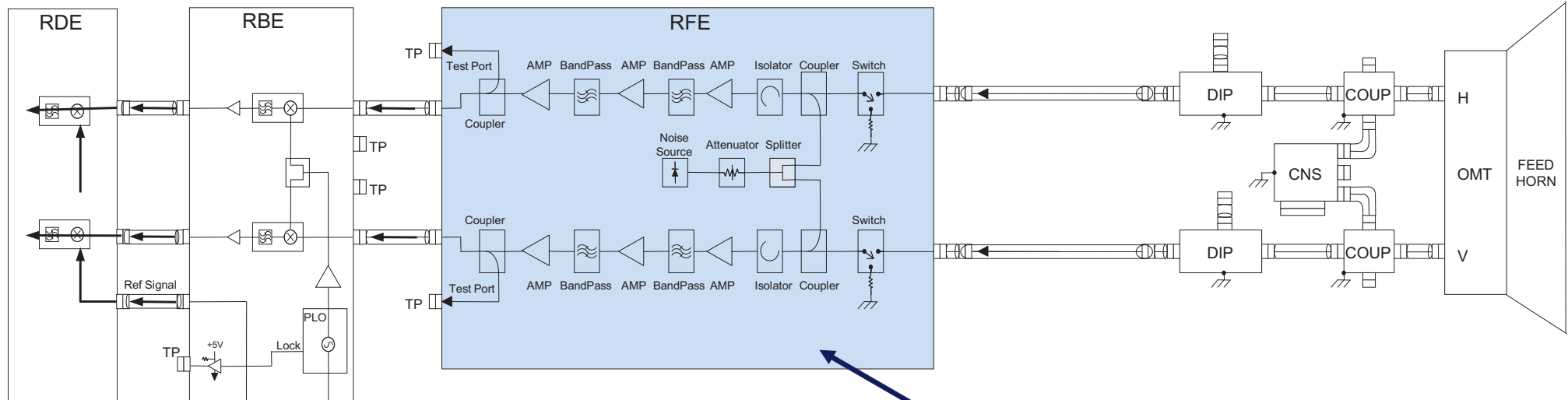
SMAP Radiometer Block Diagram and Frequency Plan



Radiometer Digital Electronics



SMAP Radiometer Front End (RFE) Assembly

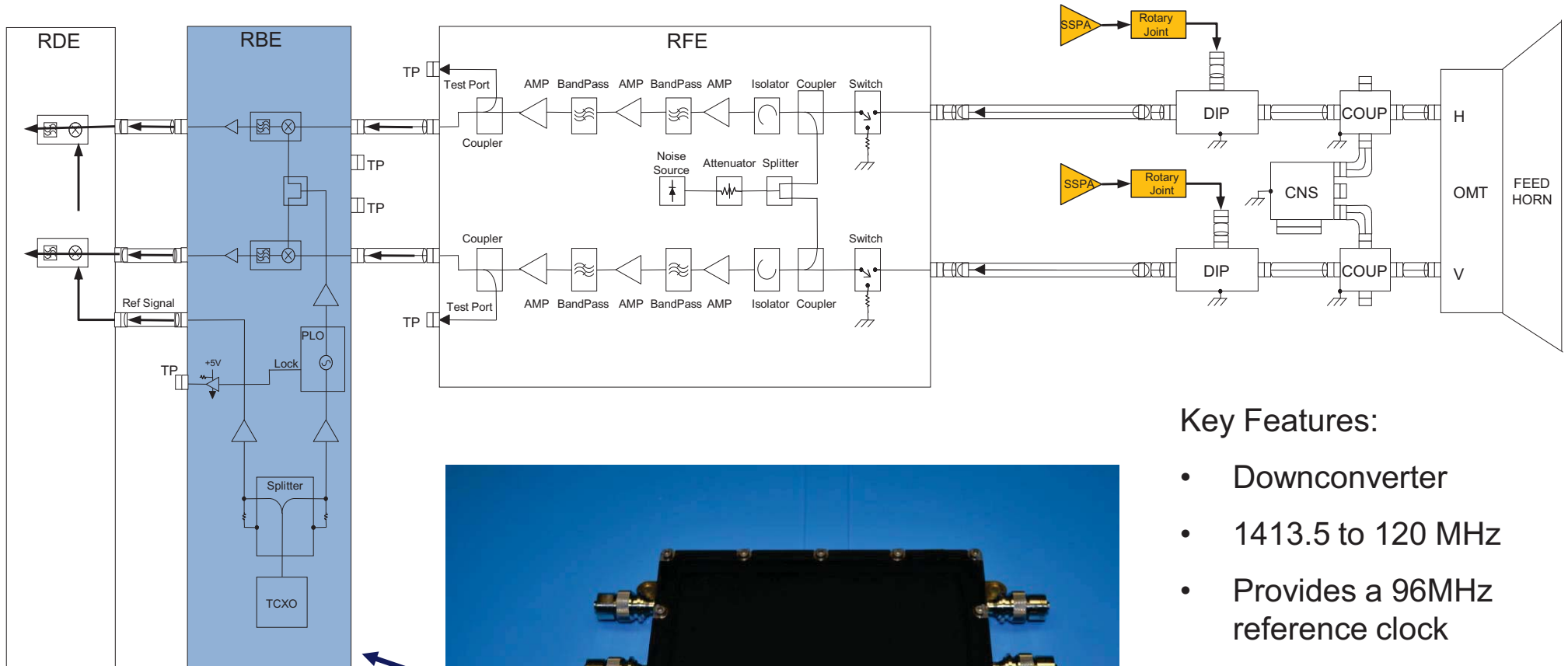


Key Features:

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



SMAP Radiometer Back End (RBE) Assembly



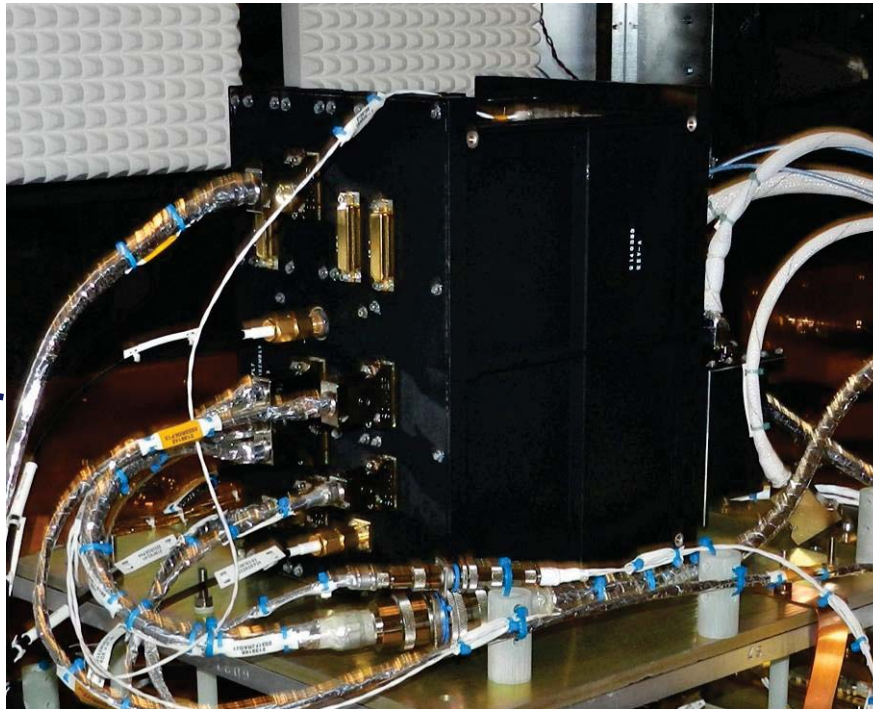
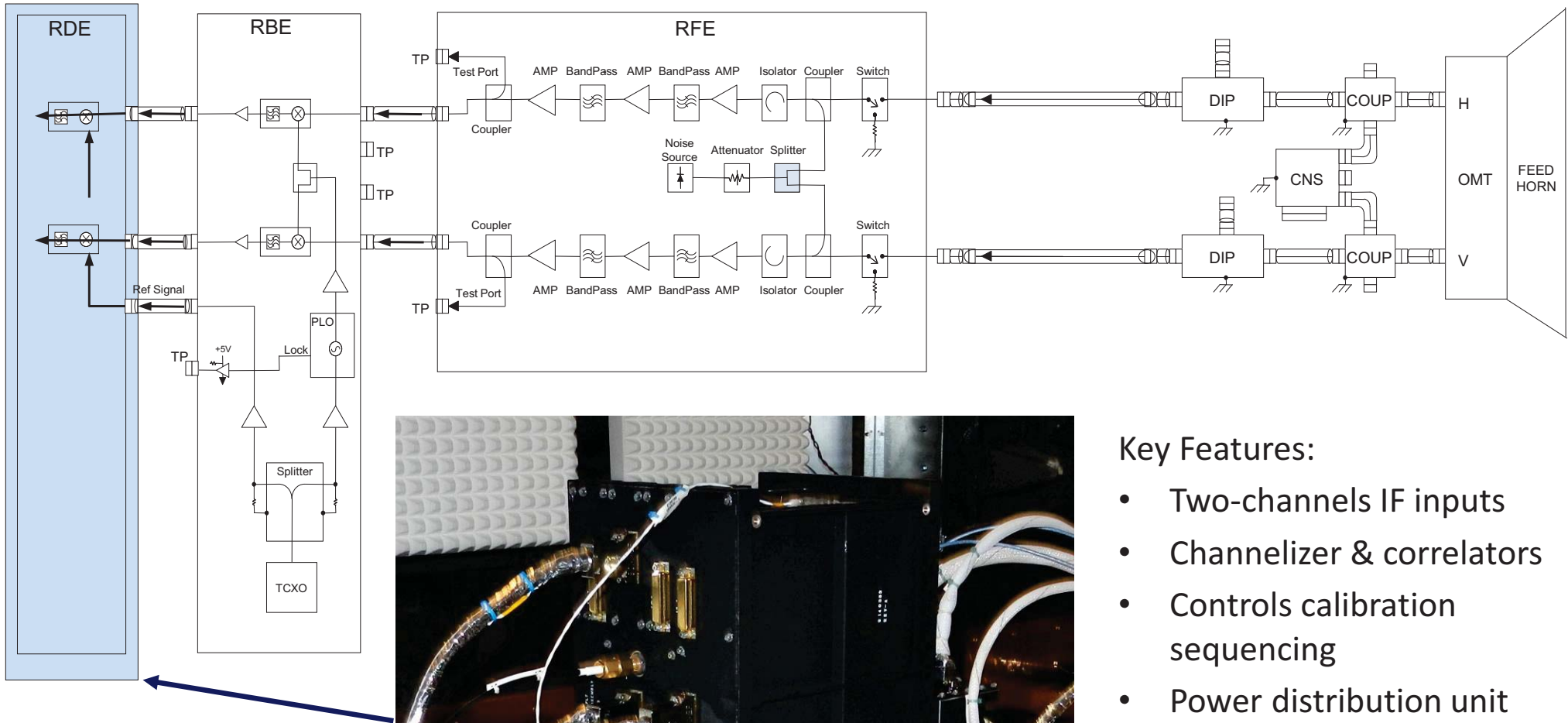
Key Features:

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





SMAP Radiometer Digital Electronics (RDE) Assembly

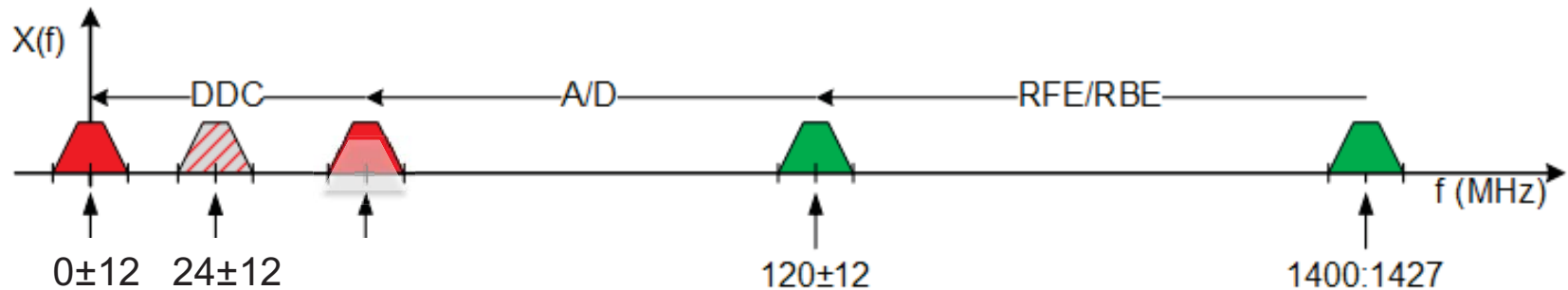
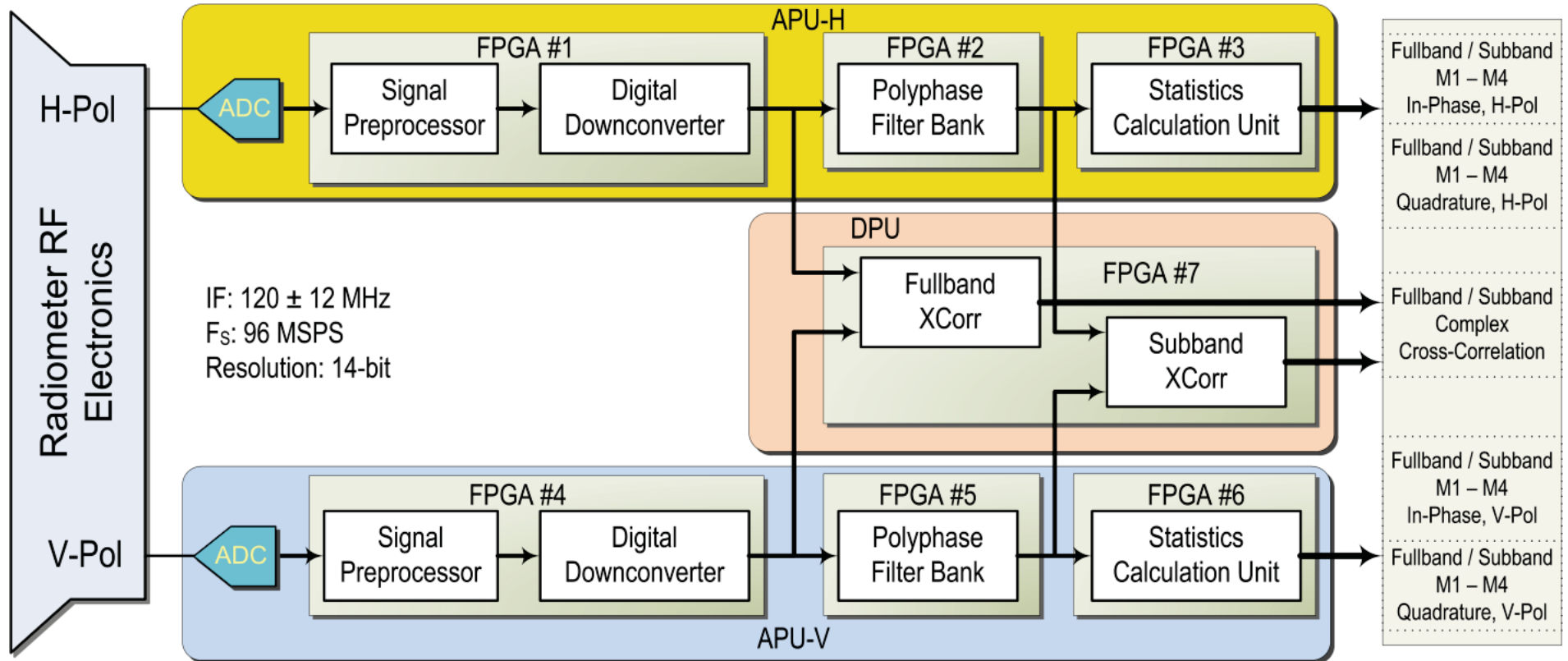


Key Features:

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



RDE Architecture: DSP Data Flow

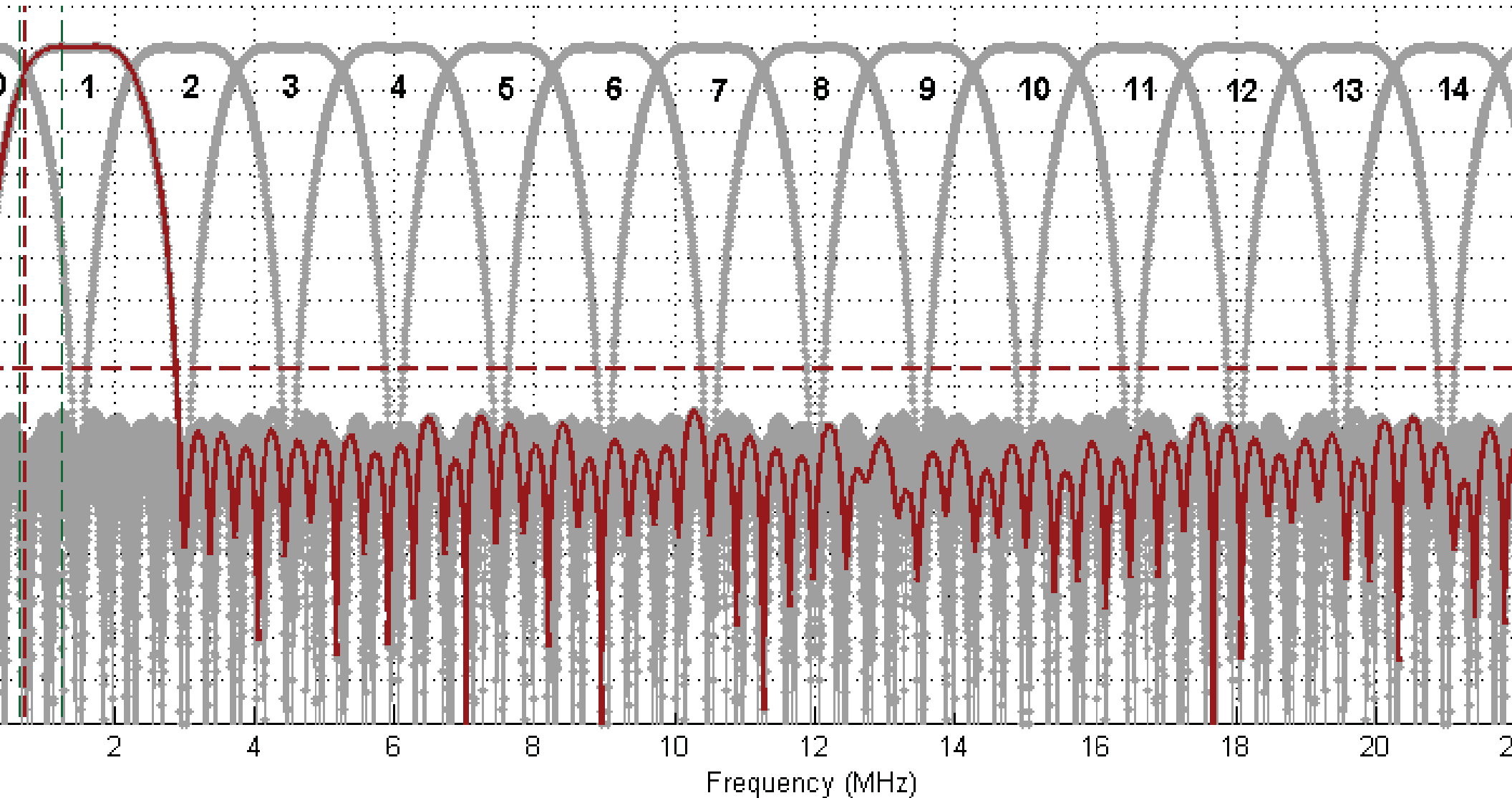




Filterbank Frequency Response

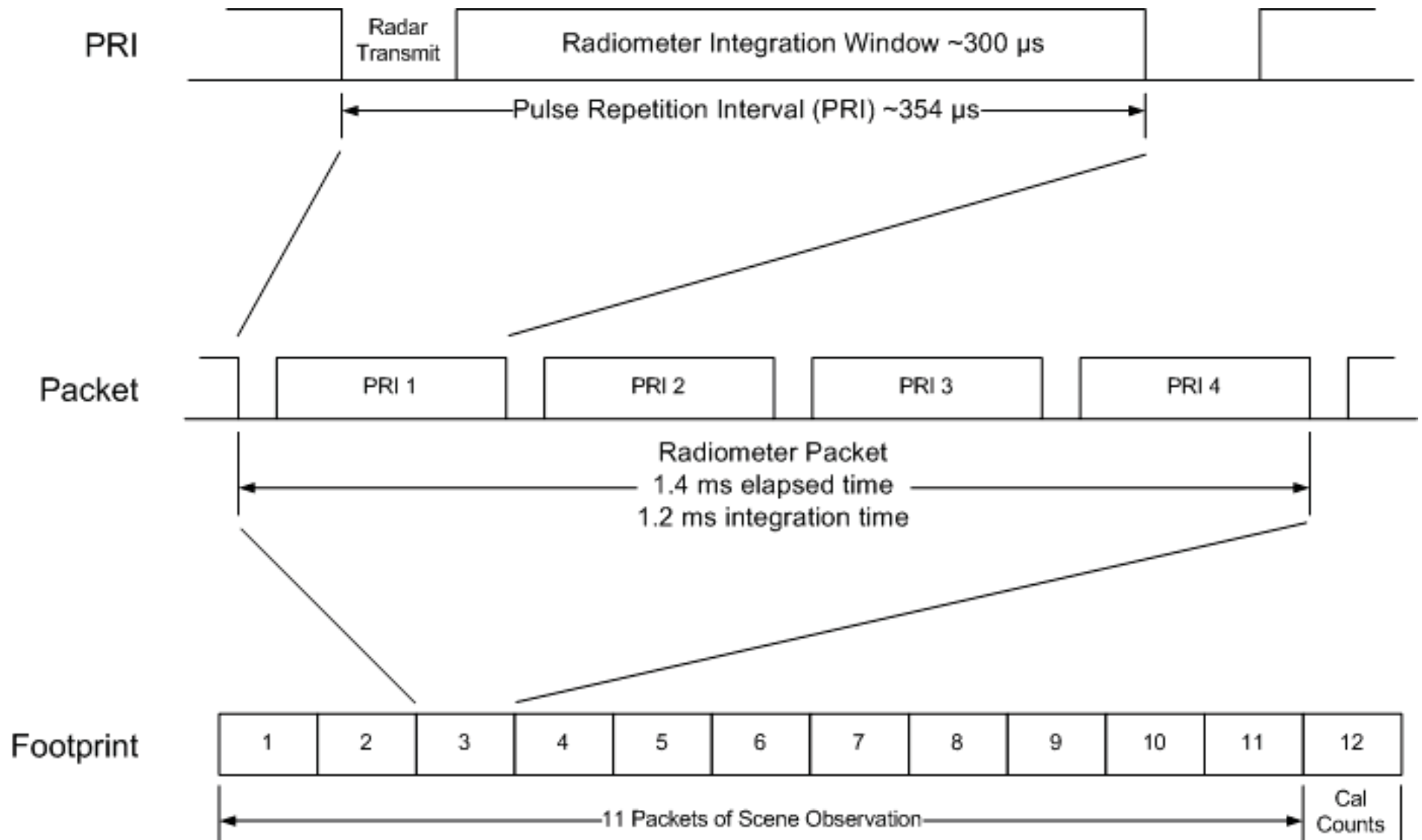


PFB Filter Response



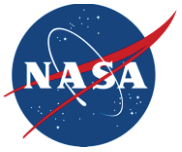


Radiometer Timing

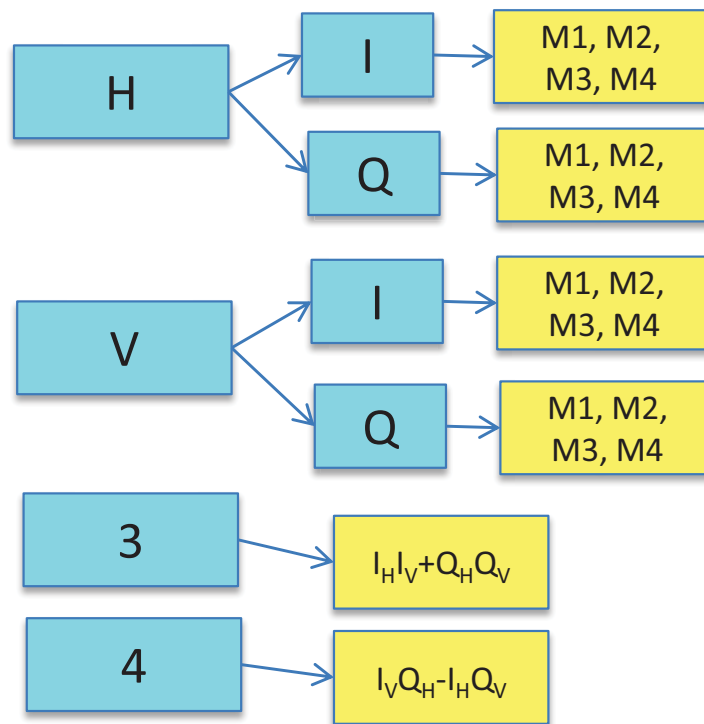




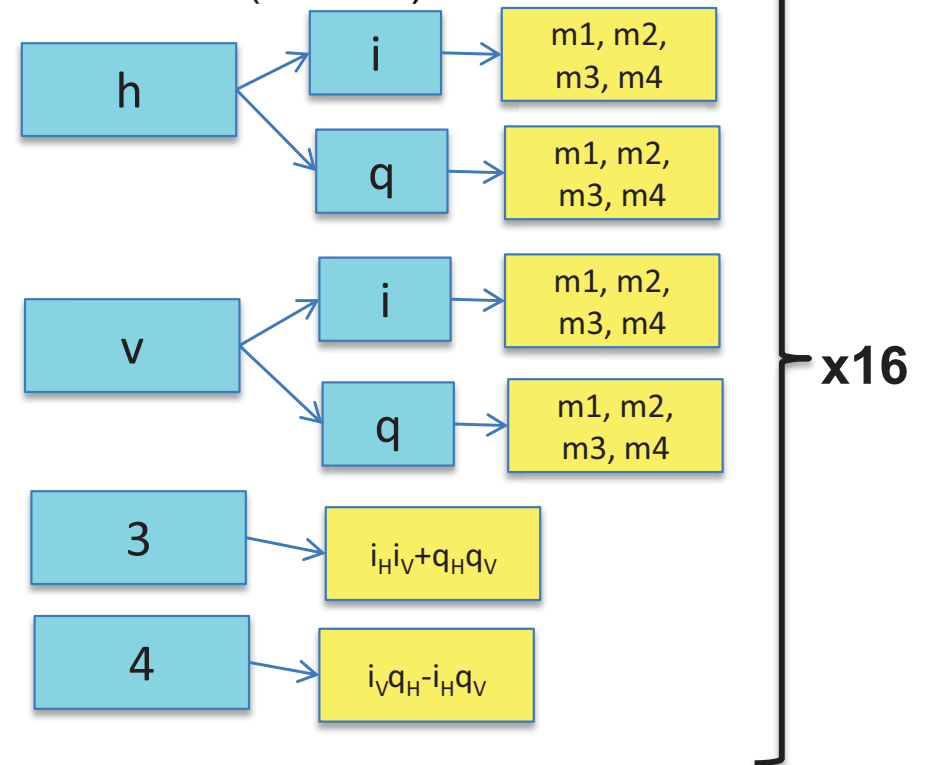
SMAP Radiometer “Detector” Counts



- 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



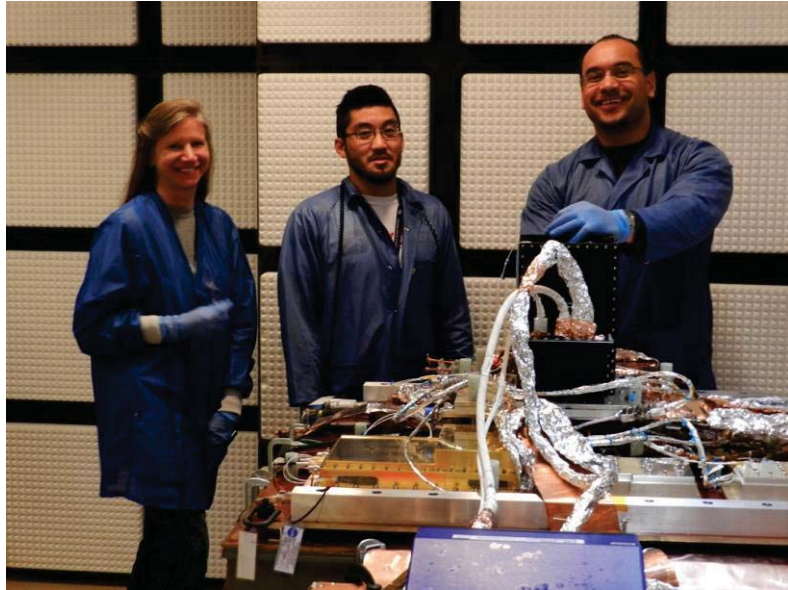
- Sub-banded data, **16 subbands**, every 4 PRIs, (1200 us)
 - V, H
 - 1st, 2nd, 3rd, 4th moments, I, Q
 - 3rd and 4th Stokes
 - ¼ PRF (875 Hz)



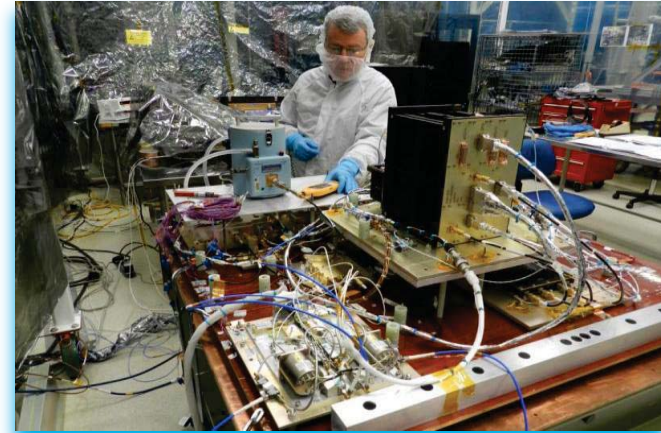
Time/Frequency diversity: 360 words every ~1ms (packet)



GSFC Integration and Test



EMC/EMI



LN2
Cal



TVAC Initial Power Up



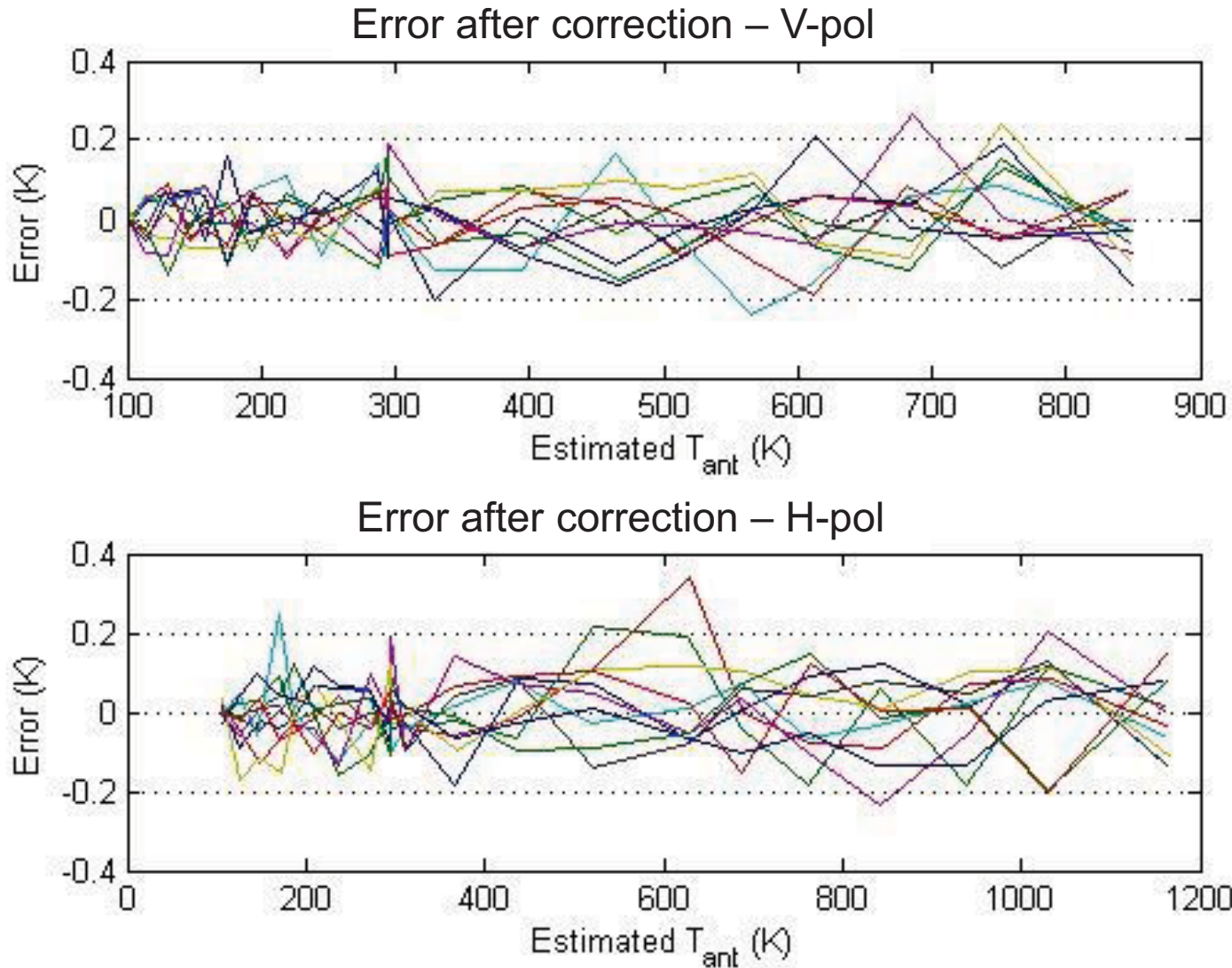
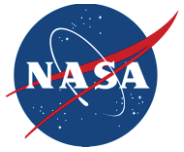
Error Budget < 1.3 K



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



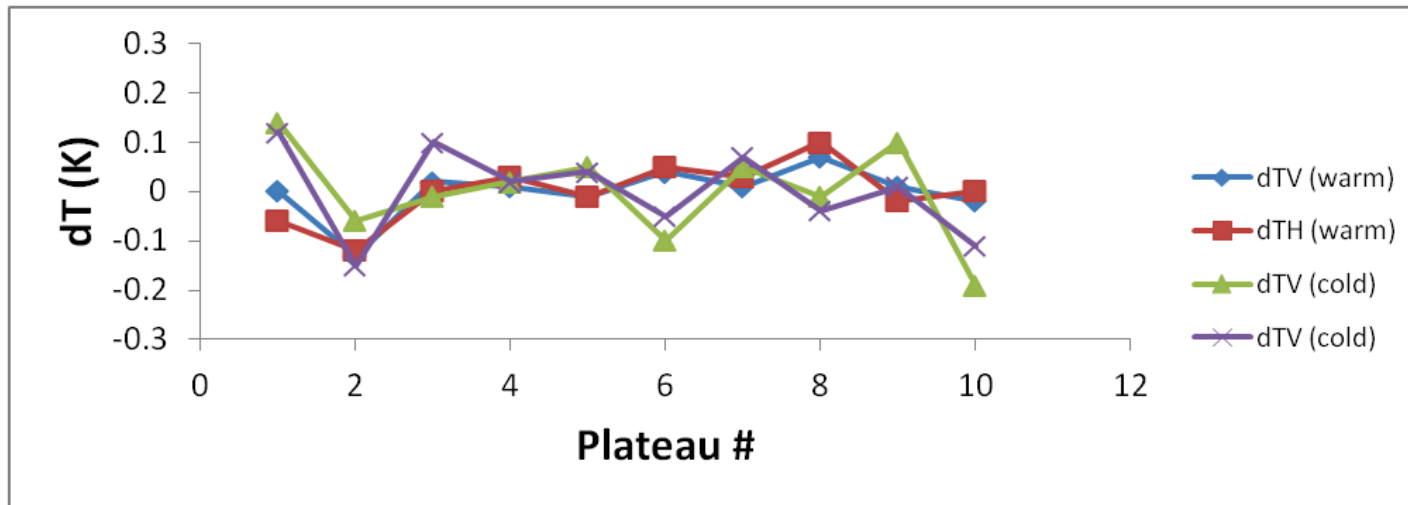
Linearity



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



Repeatability Results



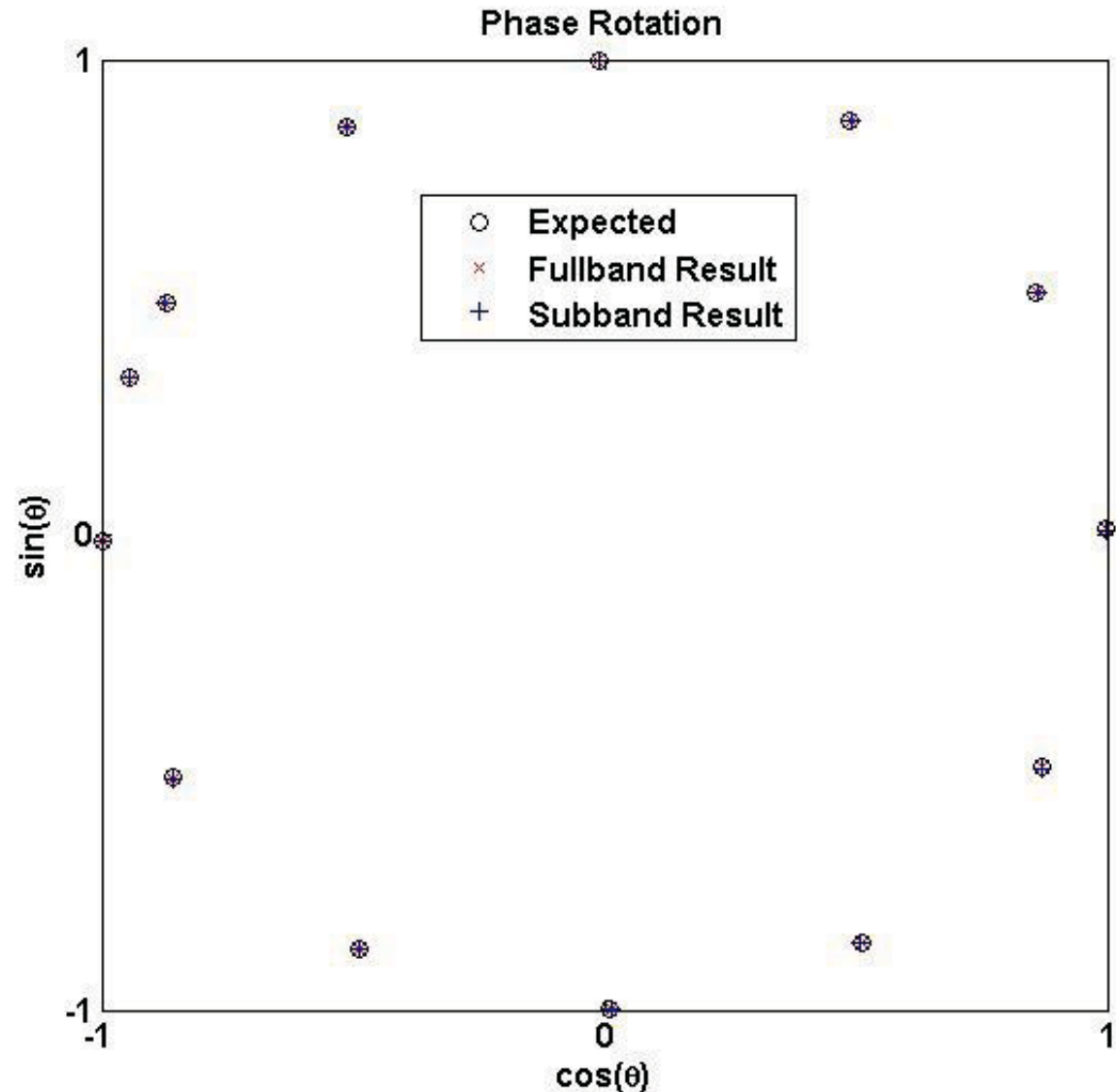
Plateau	1	2	3	4	5	6	7	8	9	10
ΔT_H , warm (K)	0.00	-.13	.02	.01	-.01	.04	.01	.07	.01	-.02
ΔT_V , warm (K)	-.06	-.12	0.00	.03	-.01	.05	.03	.10	-.02	0.00
ΔT_H , cold (K)	.14	-.06	-.01	.02	.05	-.10	.05	-.01	.10	-.19
ΔT_V , cold (K)	.12	-.15	.10	.02	.04	-.05	.07	-.04	.01	-.11



Polarimetry



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

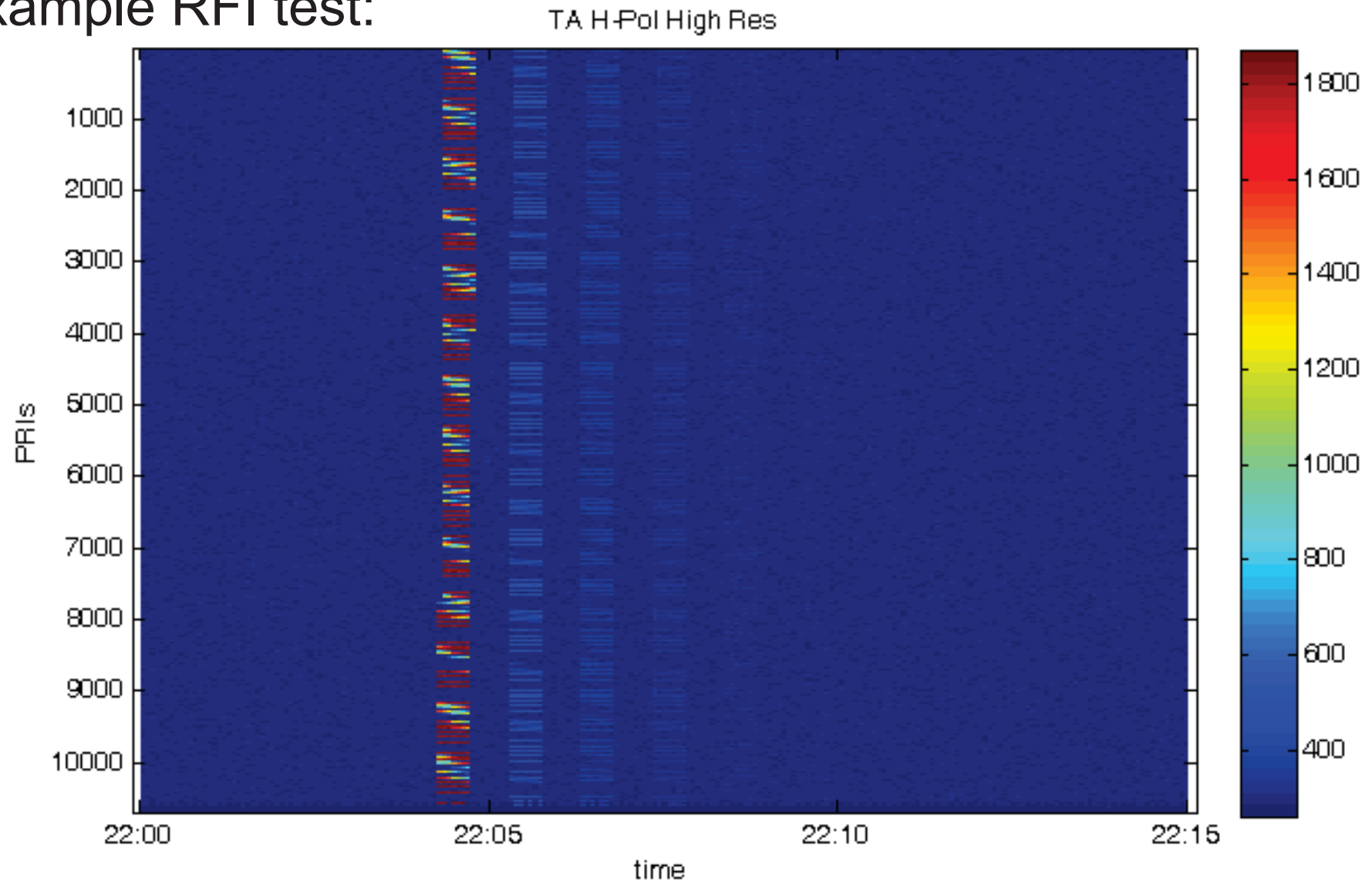




Pulsed RFI Evident in TA Data

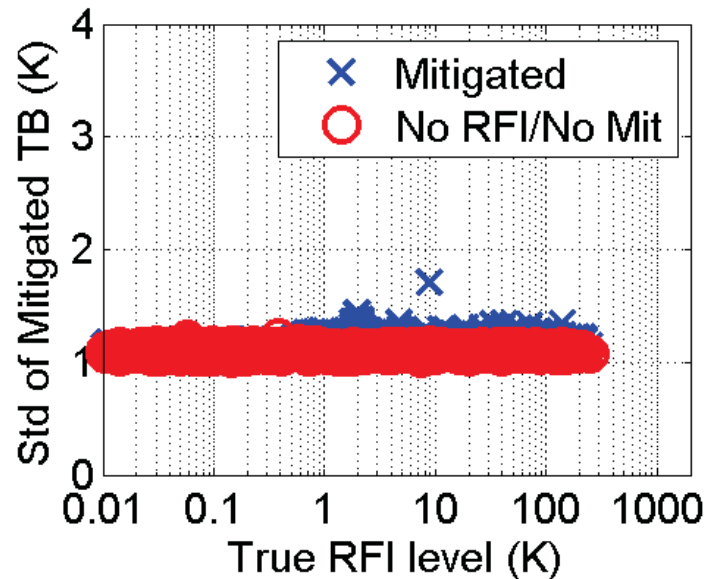
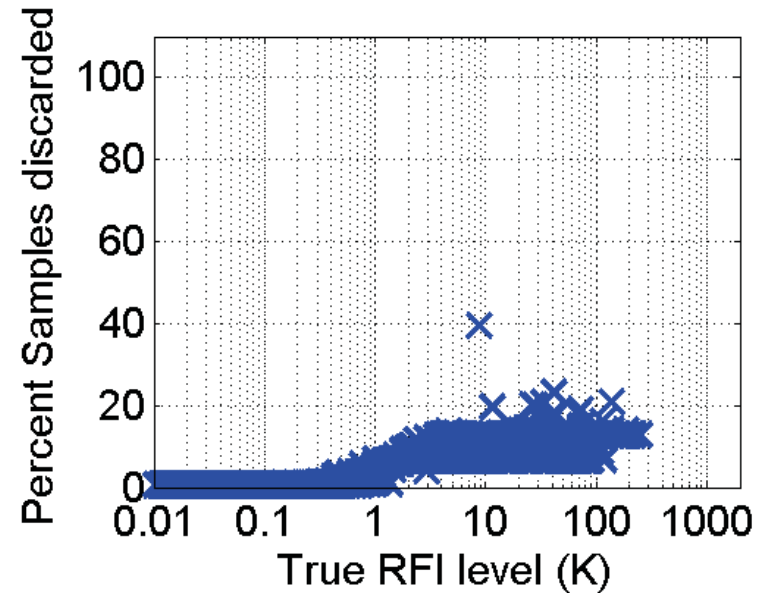
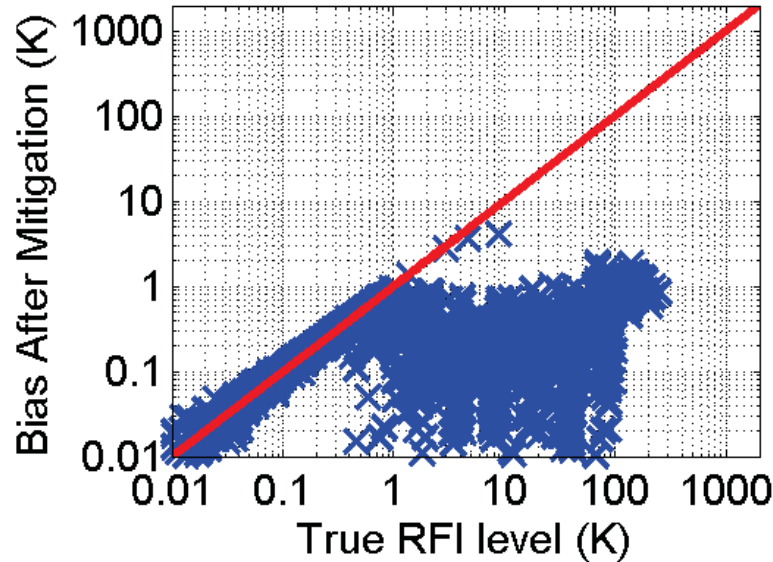


Example RFI test:





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