

# **The TriG Radio-Occultation System on COSMIC-2. Early Performance Assessment**

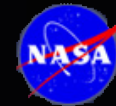
**Sept. 19, 2019**

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Chi Ao, Chad Galley, Da Kuang**

Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, CA USA

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Government sponsorship acknowledged.

# Topics

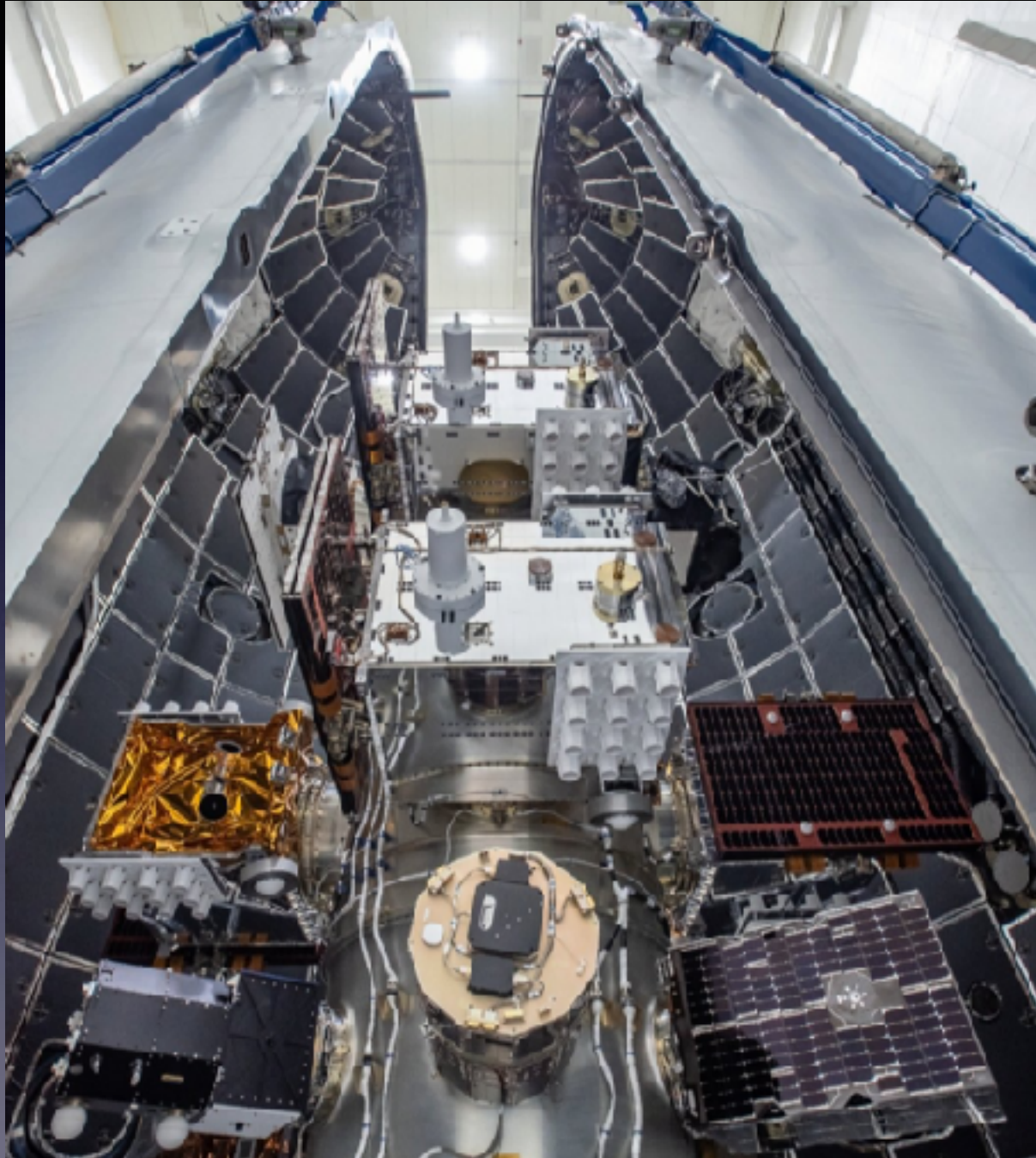


- Recent Events
- TGRS C2 Configuration
- Space Weather
- Neutral Atmosphere
- Post-launch Assessment



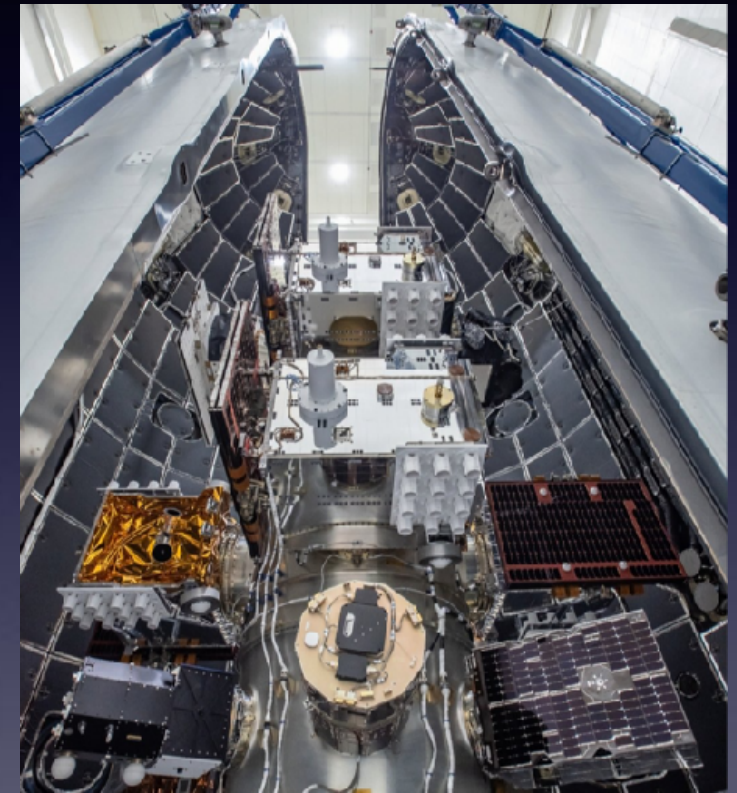
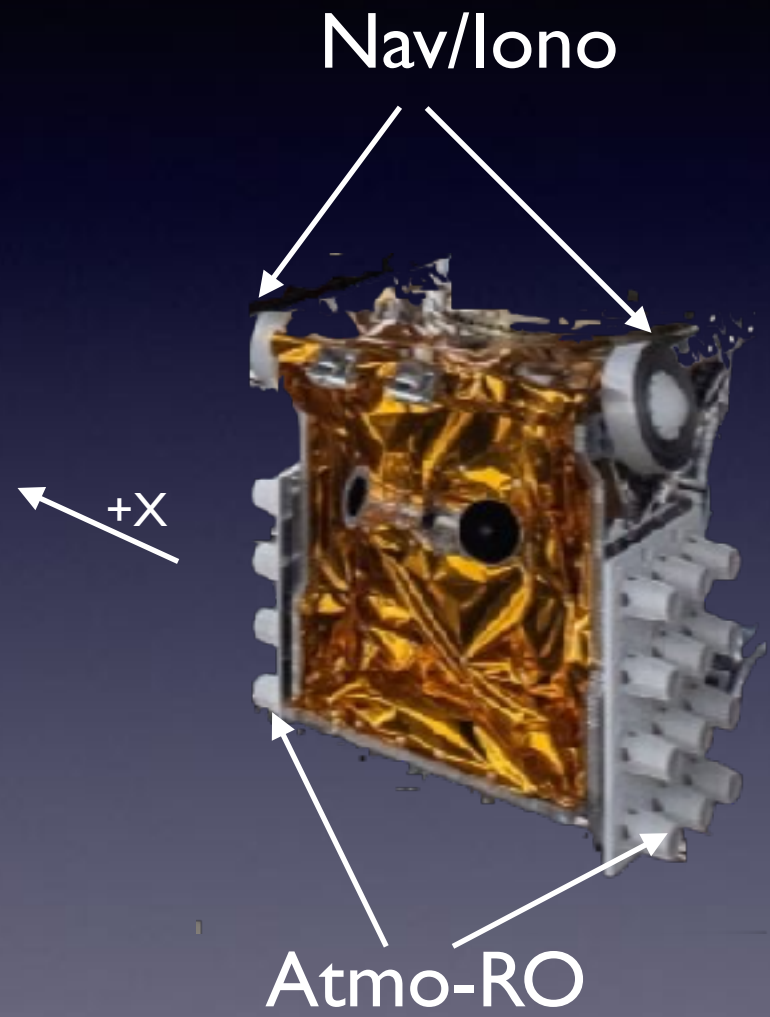
- Oscillator
- POD
- On-board Nav
- SEU Effects

## TGRS Antenna Orientation





# TGRS / C-2 TGRS Antenna Orientation



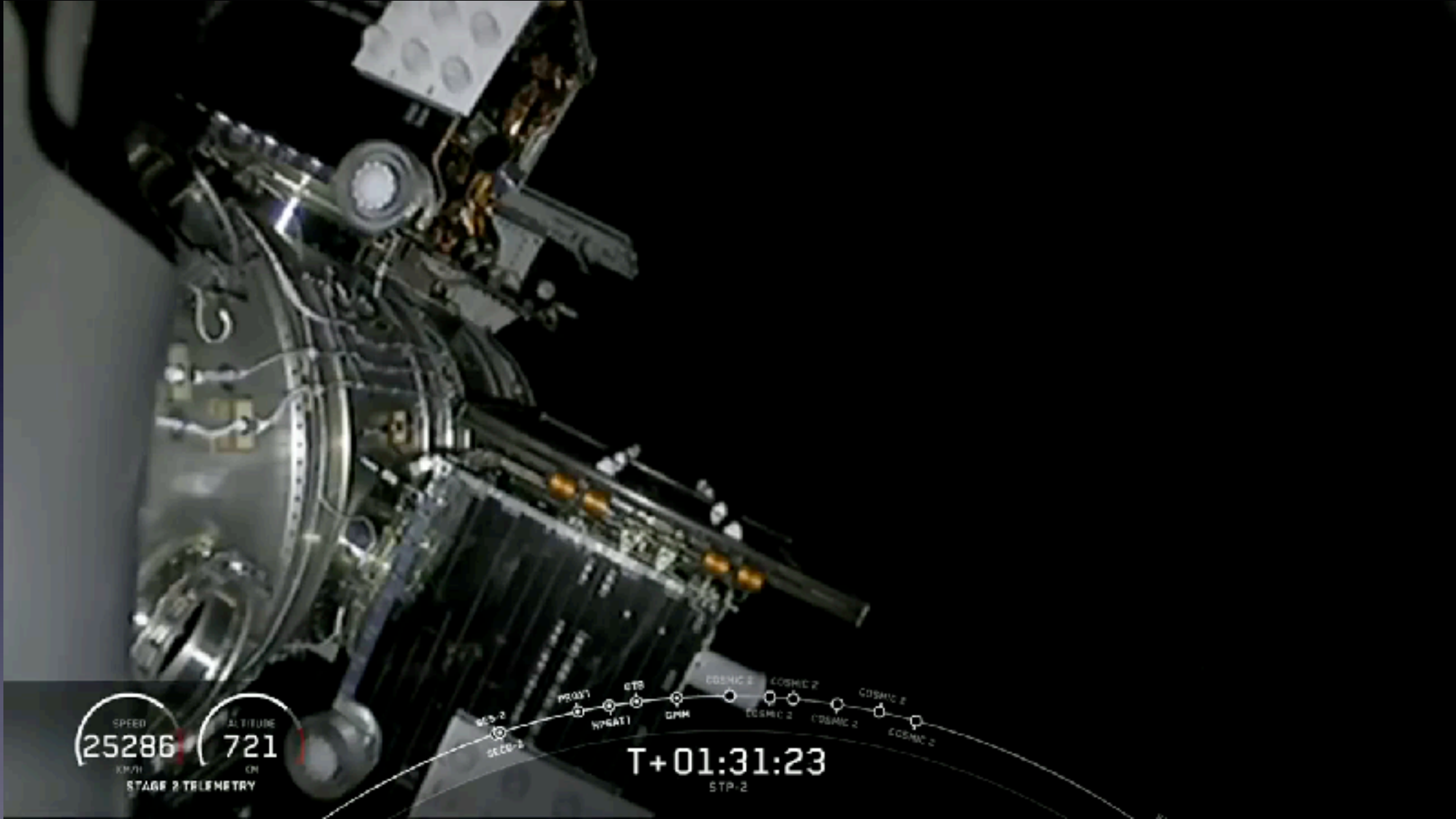


# TGRS / C-2

## Rumble in the Jungle



# TGRS / C-2 Launched and Deployed



SPEED  
**25286**  
KM/H

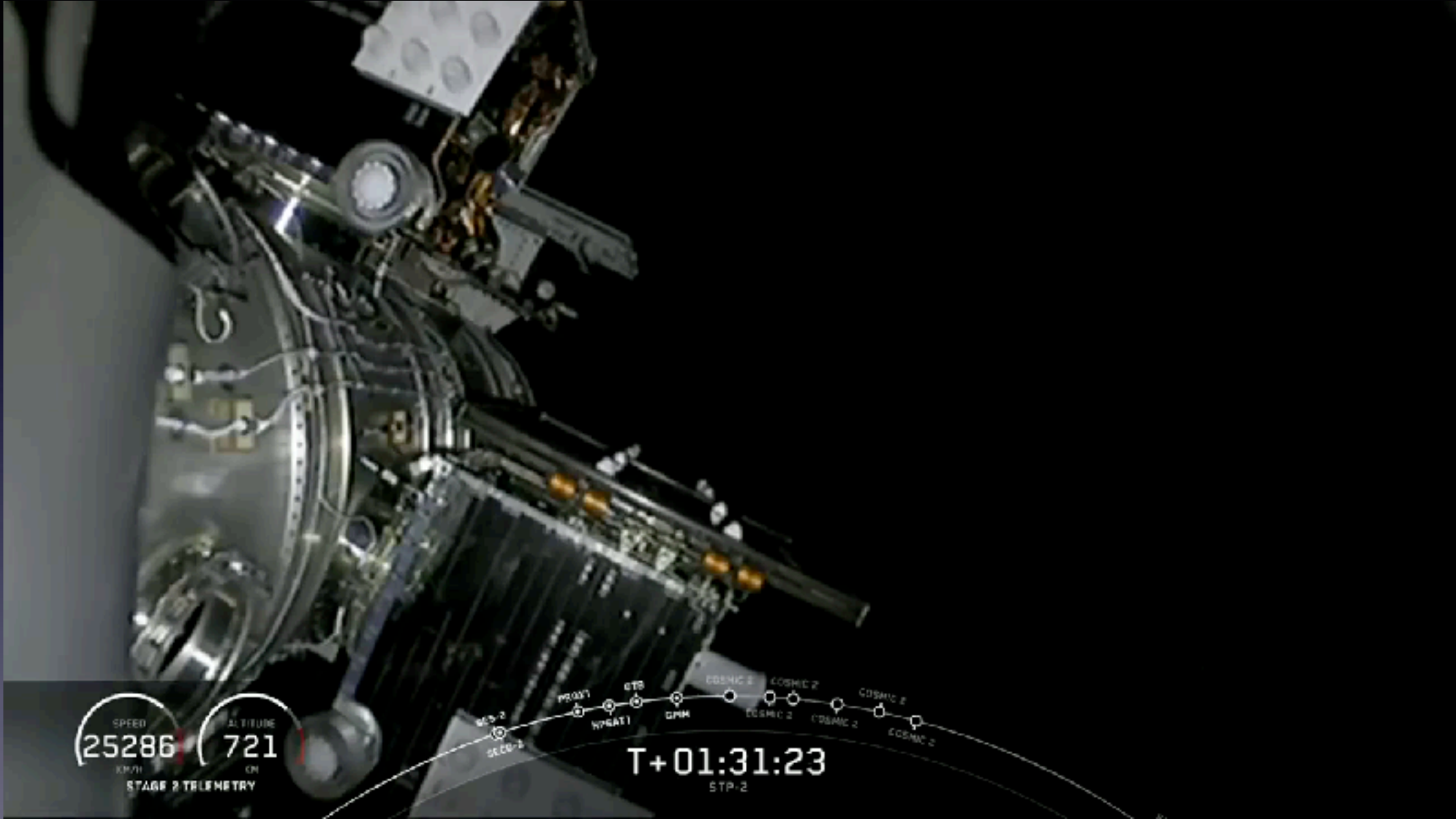
ALTITUDE  
**721**  
KM

STAGE 2 TELEMETRY

T+01:31:23  
STP-2



# TGRS / C-2 Launched and Deployed





- 1015 Ionospheric Occultations / Day  
Settable Azim, Altitude Range
- 550 Ionospheric Arcs / Day
- High-rate ( $\geq 50$  Hz) S4, L1, L2 Phase  
& Power over Ionospheric Occ Region
- POD ( $\sim 10$ cm, 0.1mm/sec)
- 1100 Atmospheric Occultations / Day  
Settable Azimuth, Altitude Range, BF





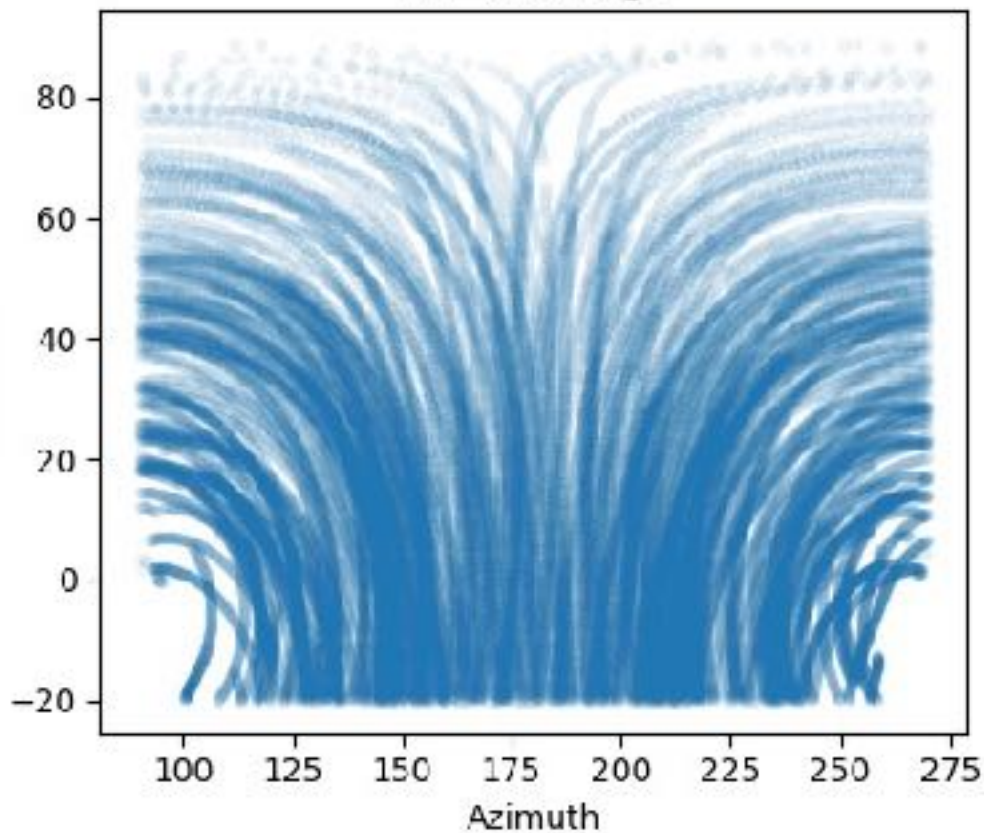
## Space Weather Instrument

- Fore/aft Navigation Antennas Used for Space Weather
- ~1000 GPS / GLONASS Ionosphere Occultations (550 km - 60 km) per Day
- Phase/Range at 1-sec. S4 every 10-sec based on 50 Hz (GPS) or 100 Hz (GLO)
- All GLONASS processed open-loop
- High-rate scintillation data can be produced either by schedule or by triggering above settable S4 levels

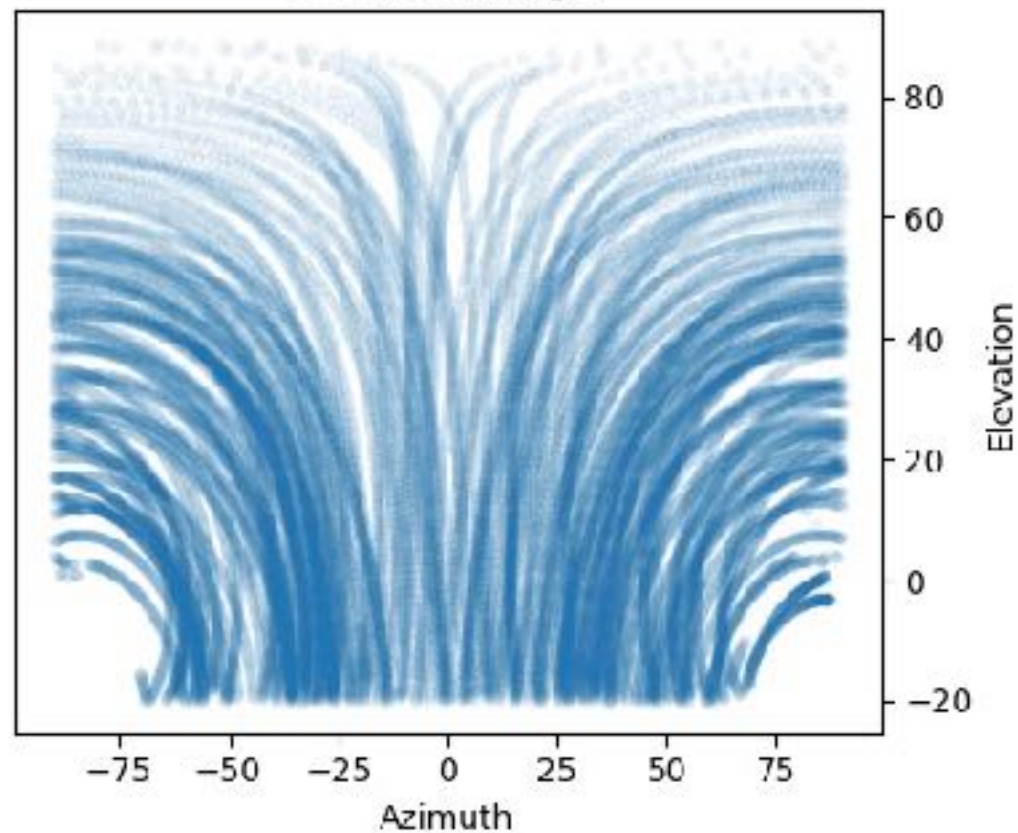
# TGRS / C-2

## GPS Ionosphere Coverage

AFT Coverage



FWD Coverage



# POD/Iono Antenna Performance

LEO ID: 005

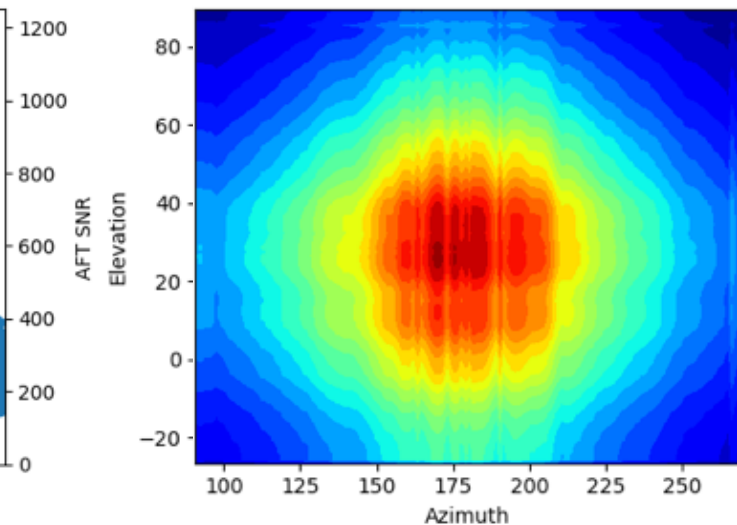
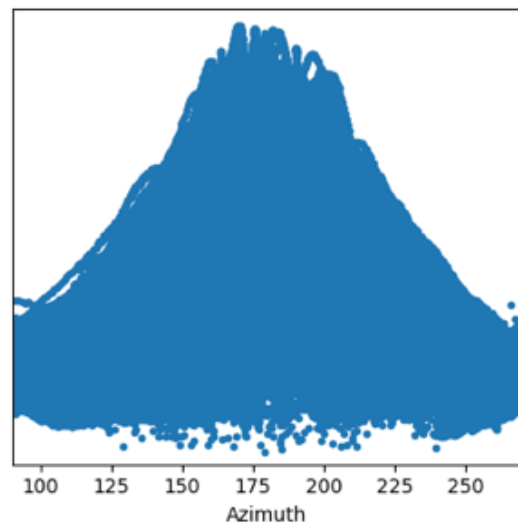
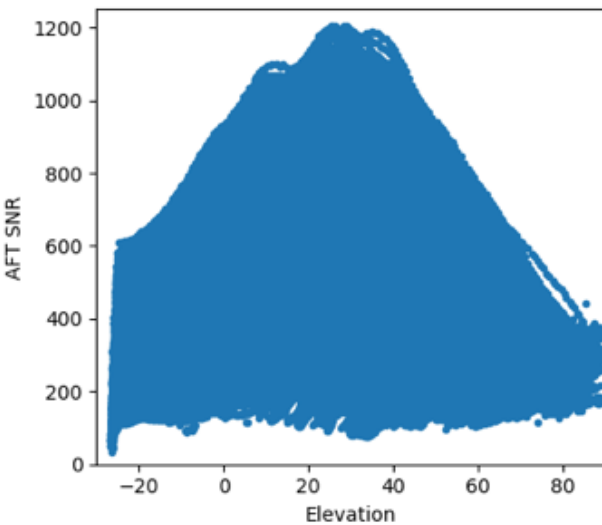
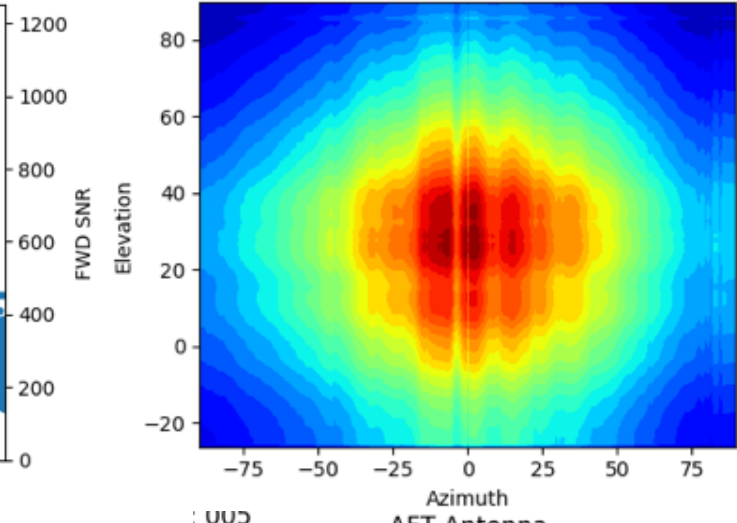
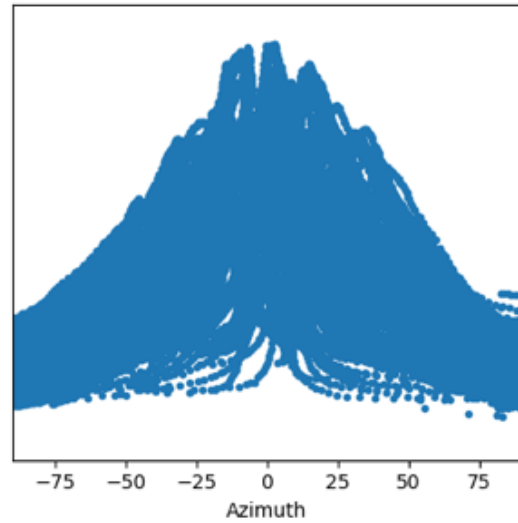
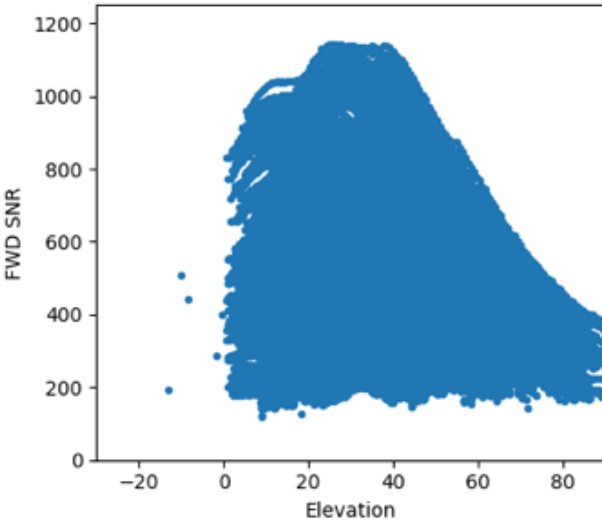
LEO ID: 005

SNR with Elevation

SNR with Azimuth

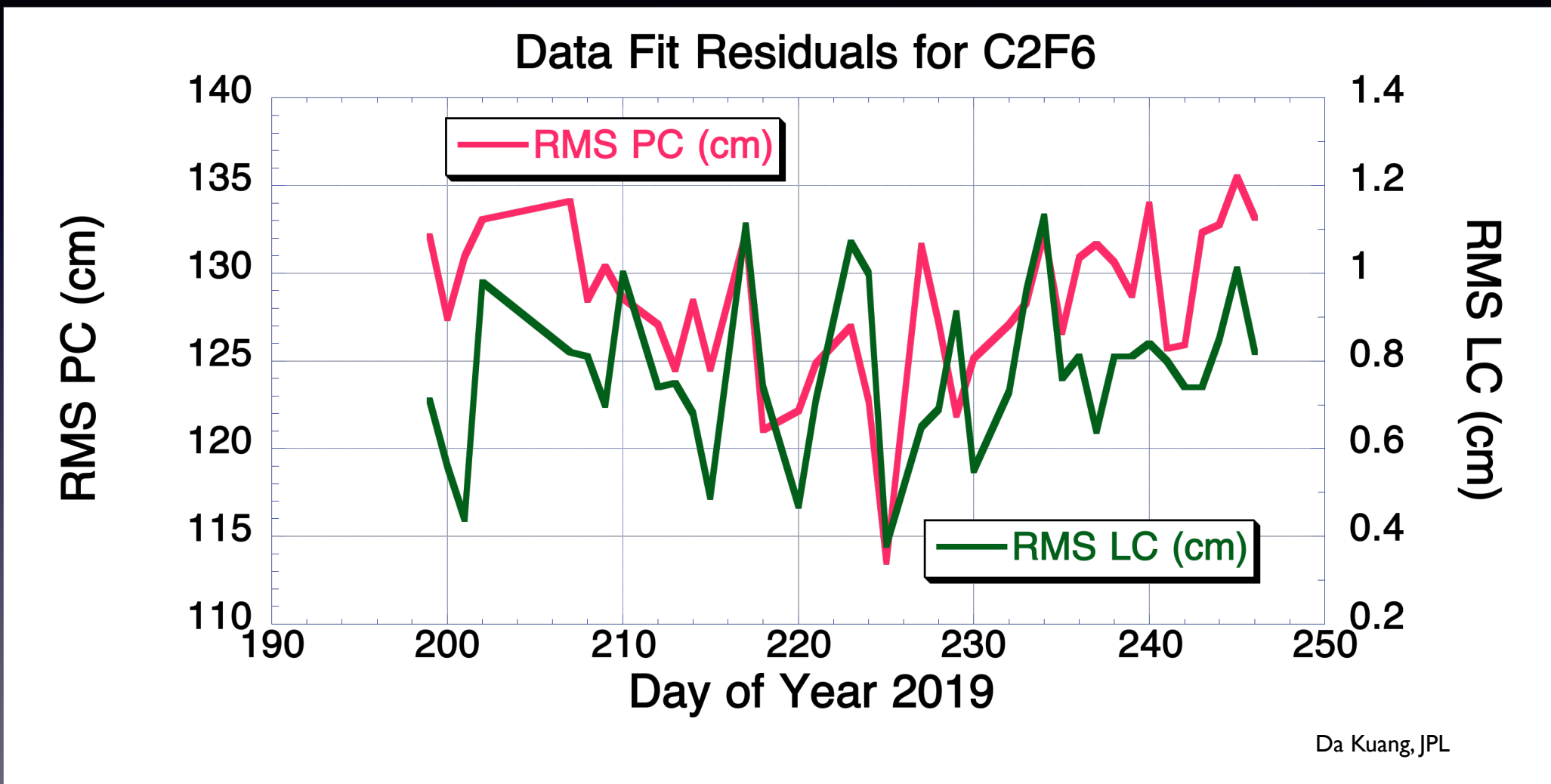
FWD Antenna

AFT Antenna

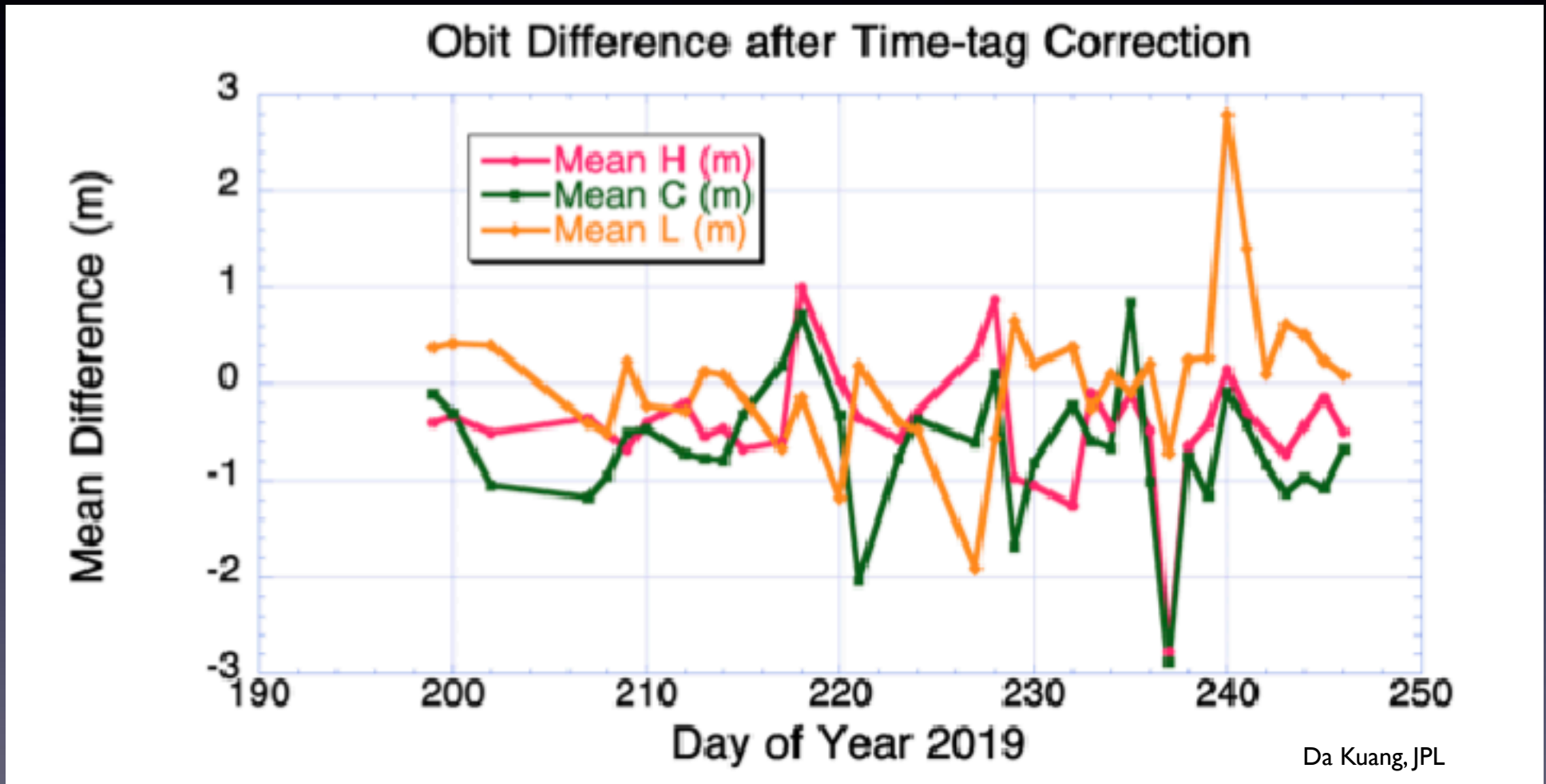




# Post Processed POD Solution

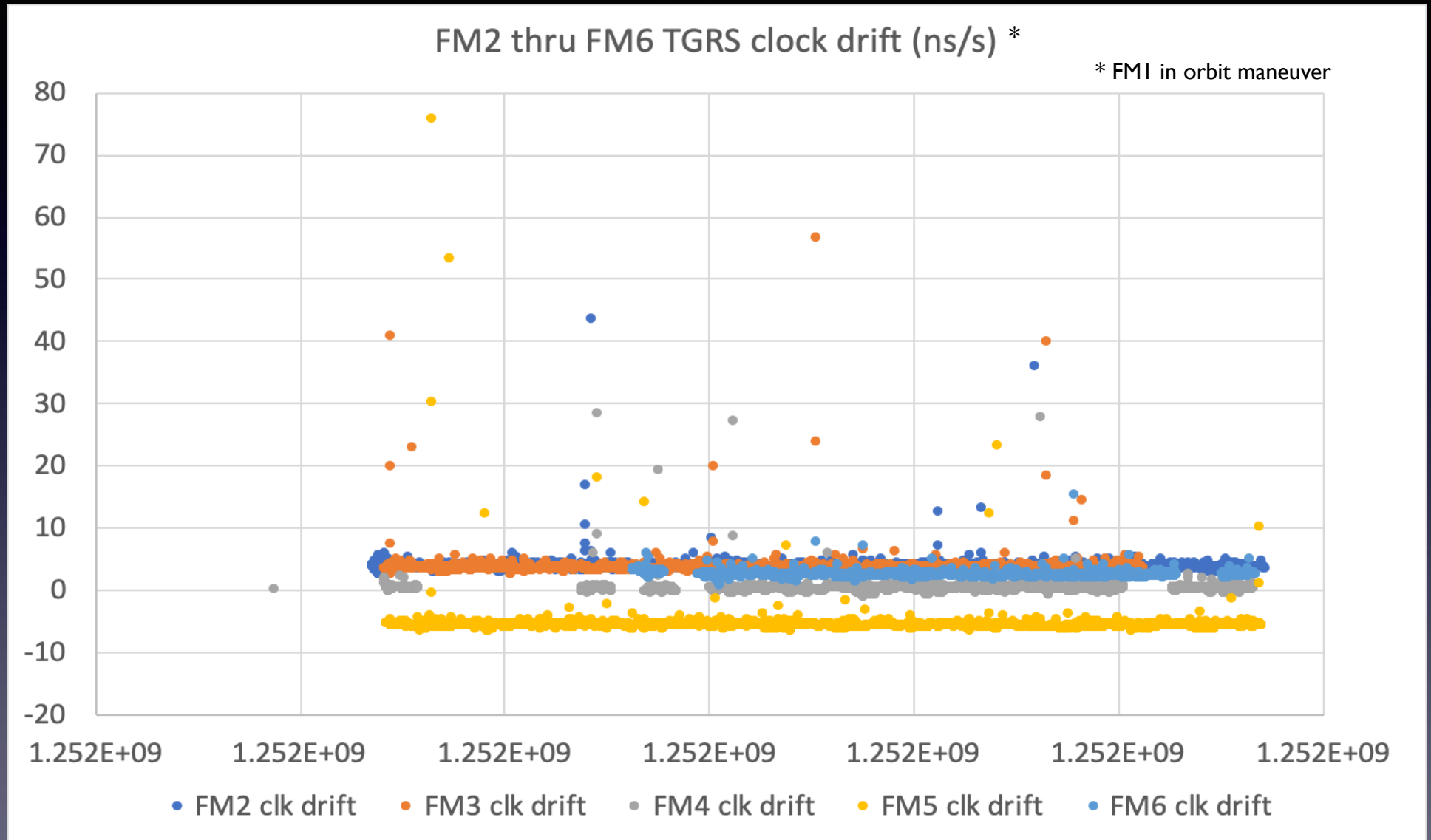


# Post Processed vs Onboard Real-time Nav





# TGRS Oscillator Drift

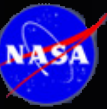




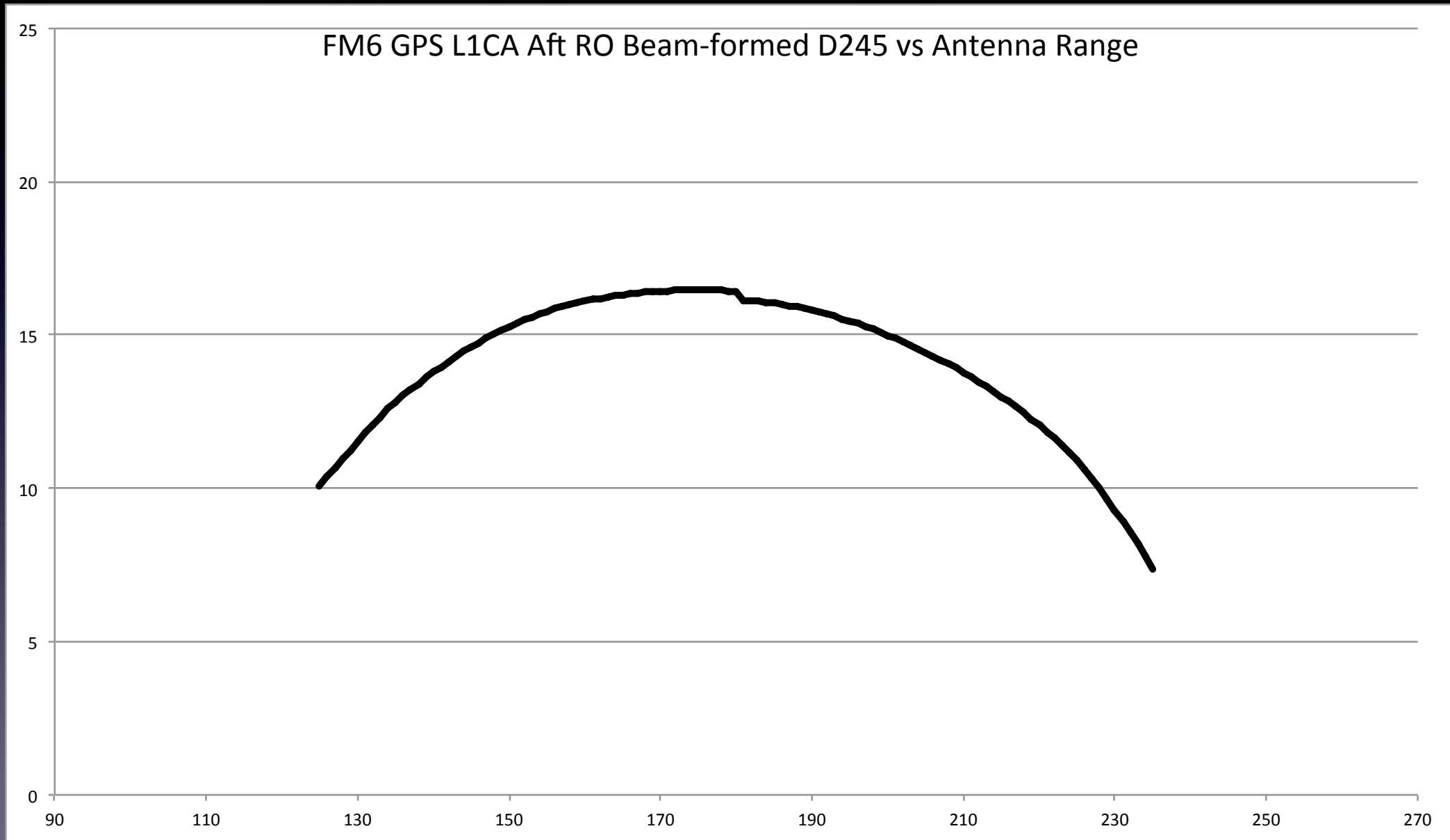


## RO Antenna with Beam Forming

- **Fore/Aft Orientation Phased Towards Earth Limb**
- **Wide-band to accept all GNSS**
- **Expect >2x Better Precision ( COSMIC-1 )**

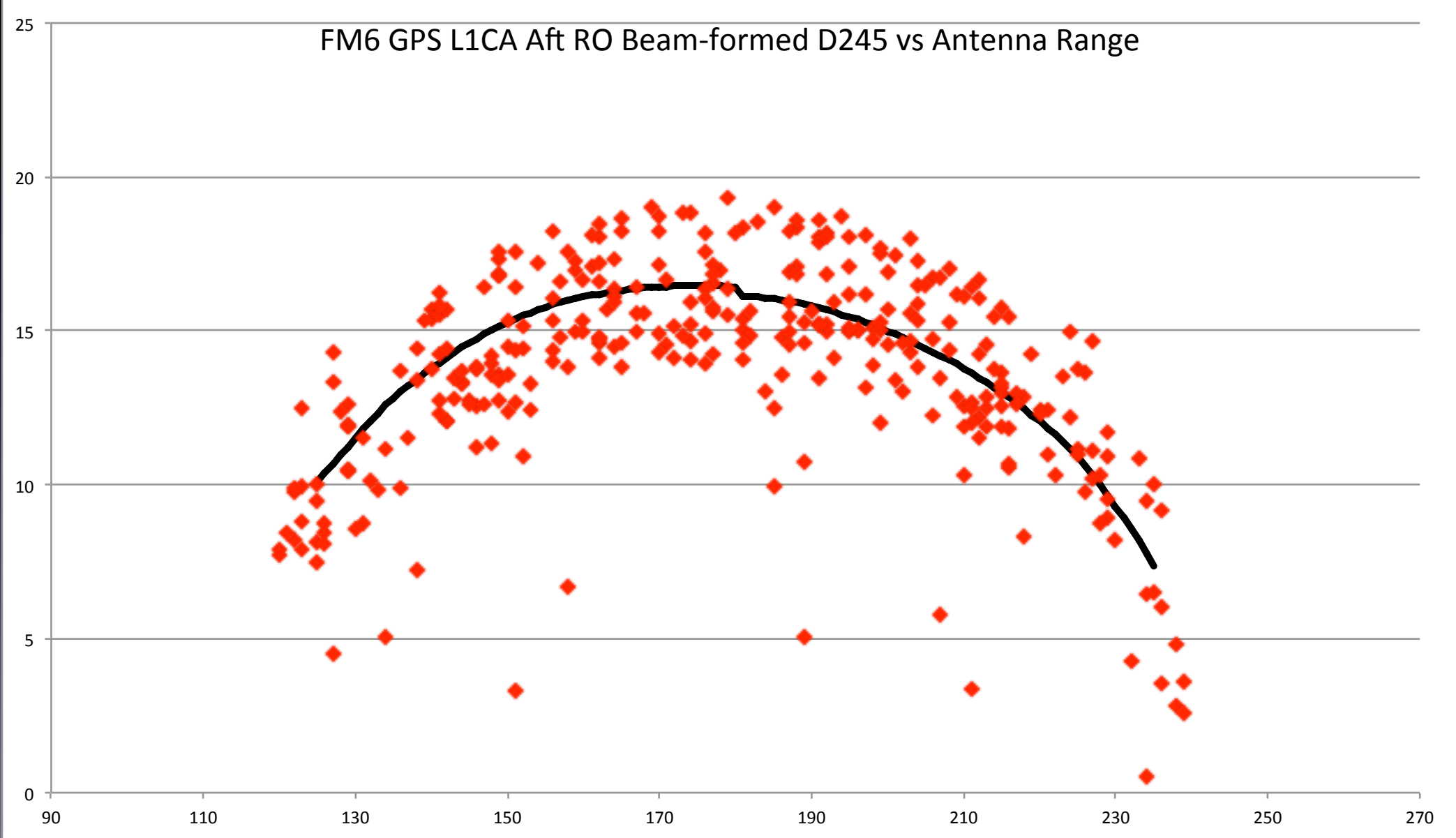


# RO Beam forming performance



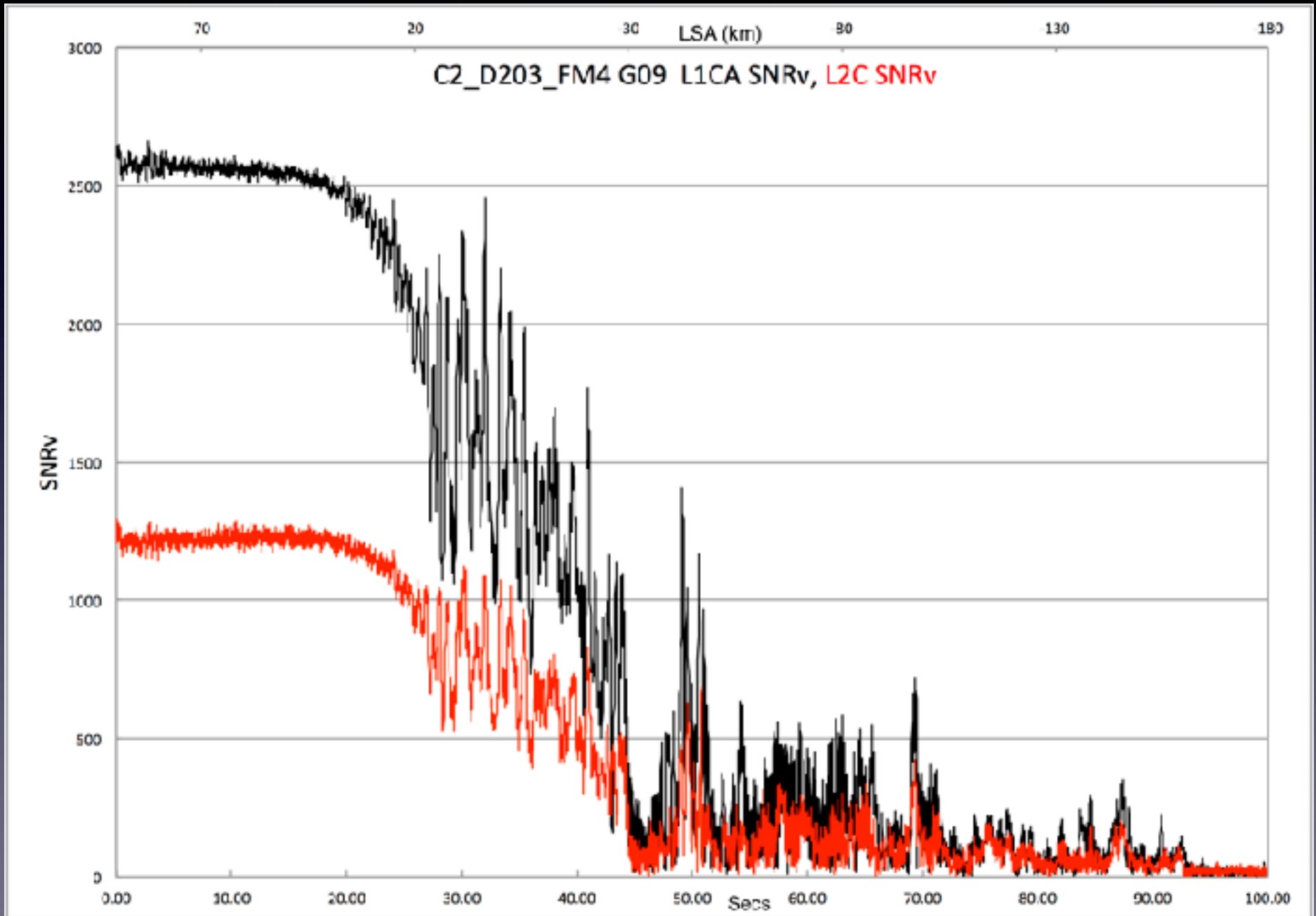


## RO Beam forming performance



# TGRS / C-2

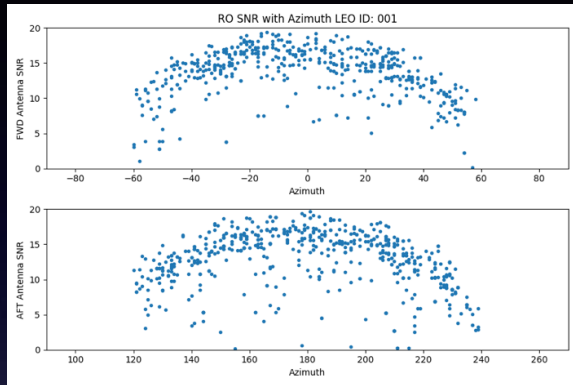
## RO Beam Forming Performance



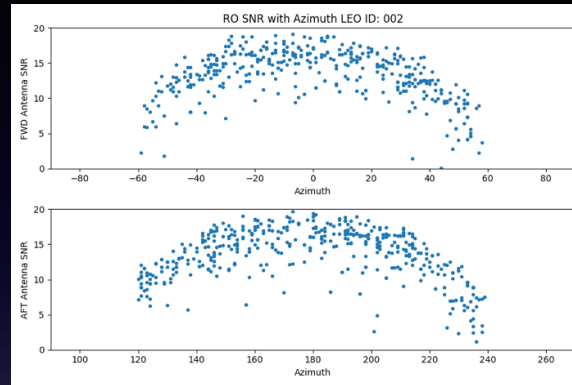


## All TGRS, Beam forming is ON Consistent SNRs

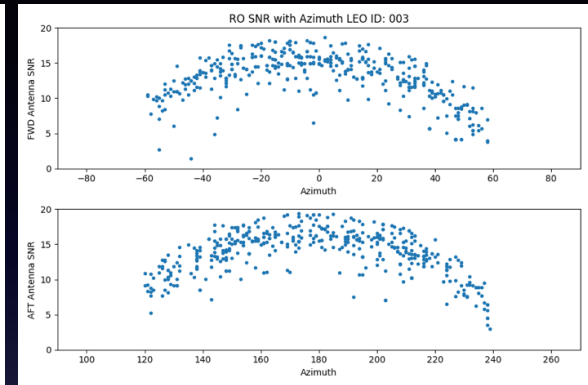
### FM1



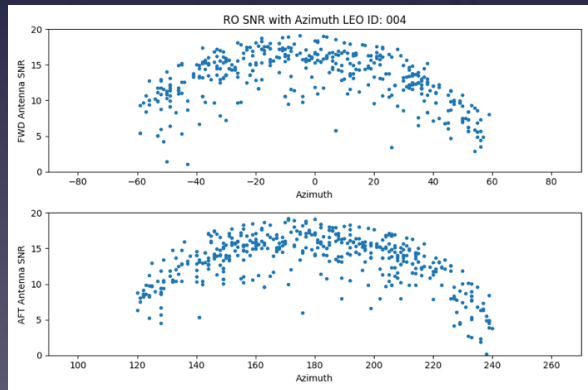
### FM2



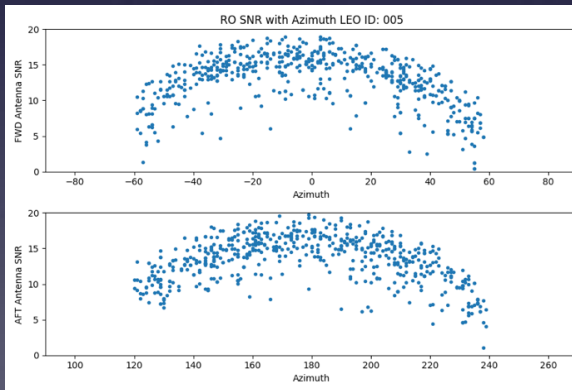
### FM3



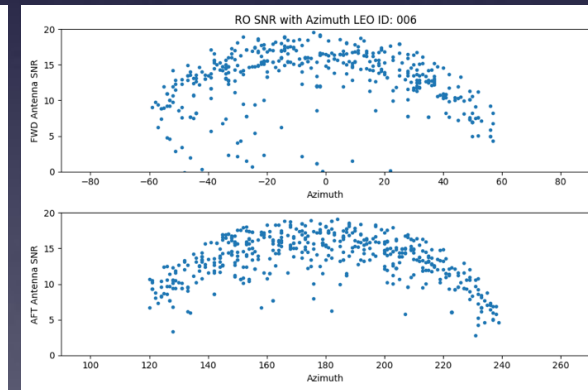
### FM4



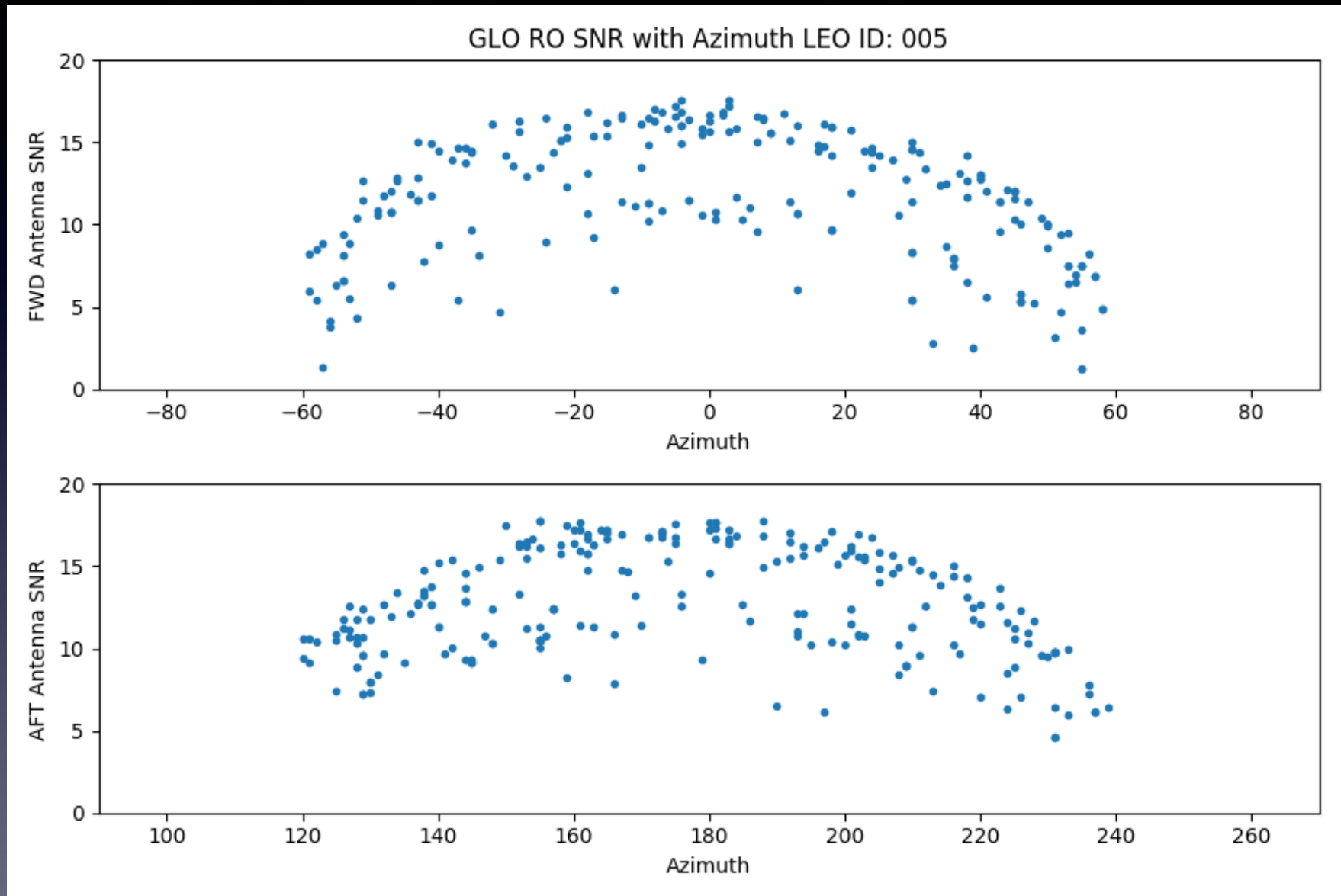
### FM5



### FM6



# GLONASS RO L1 Gain Similar to GPS



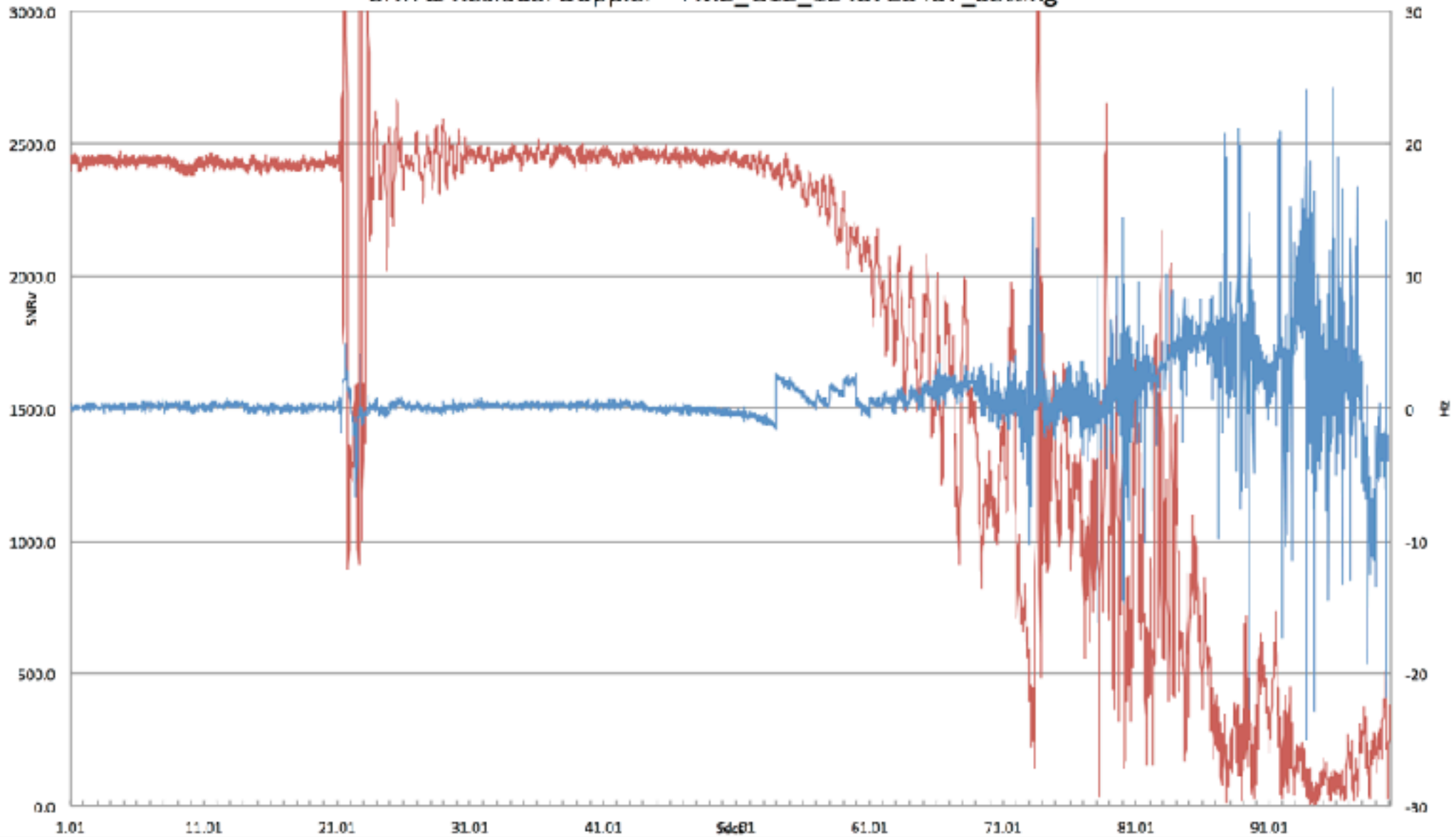




# TGRS / C-2

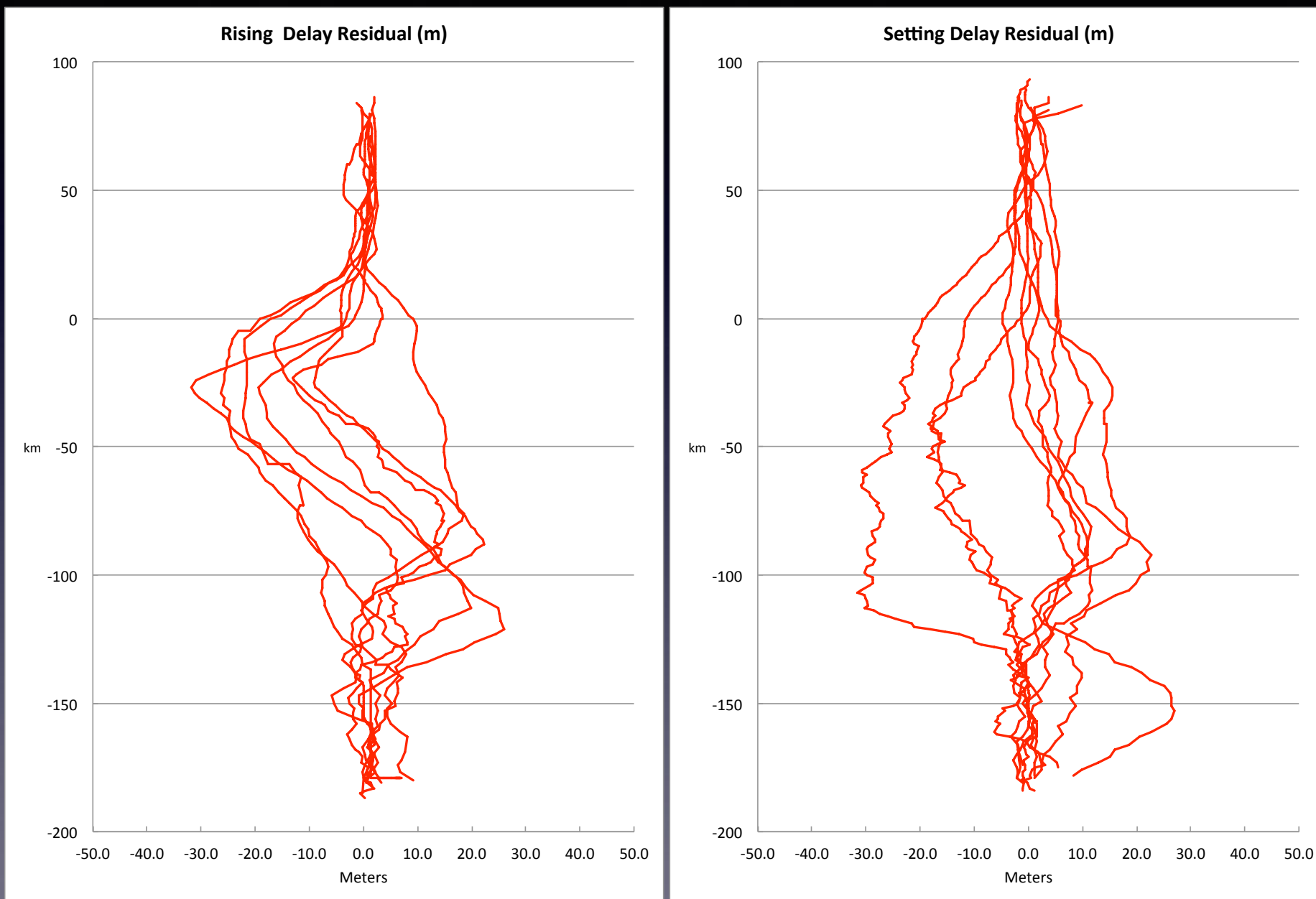
## RO Frequency Model Check

SNR & Residual Doppler FM2\_G12\_1248728437\_Setting





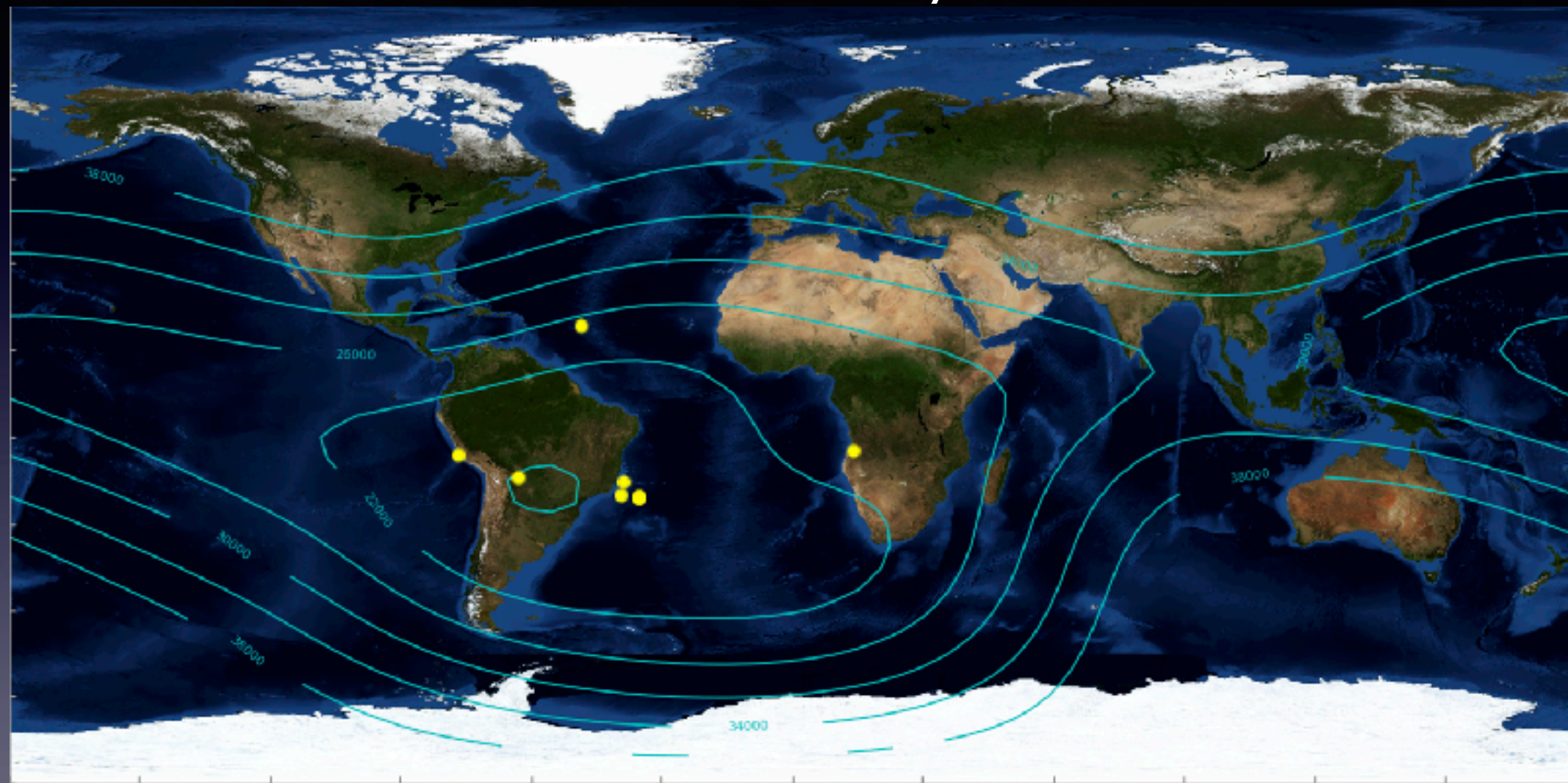
# TGRS / C-2 RO Delay Model Check



# TGRS / C-2

## Single-event Effects

### FM1 over 3 Days



# TGRS / C-2 Assessment



Thus far, all 6 TGRS show:

- Stable Oscillator Performance
- Excellent SEU Tolerance
- Expected SNRs for Nav/POD
- Expected POD Accuracy
- Expected OL Model Accuracy
- High RO SNR Over Required Azimuth Range



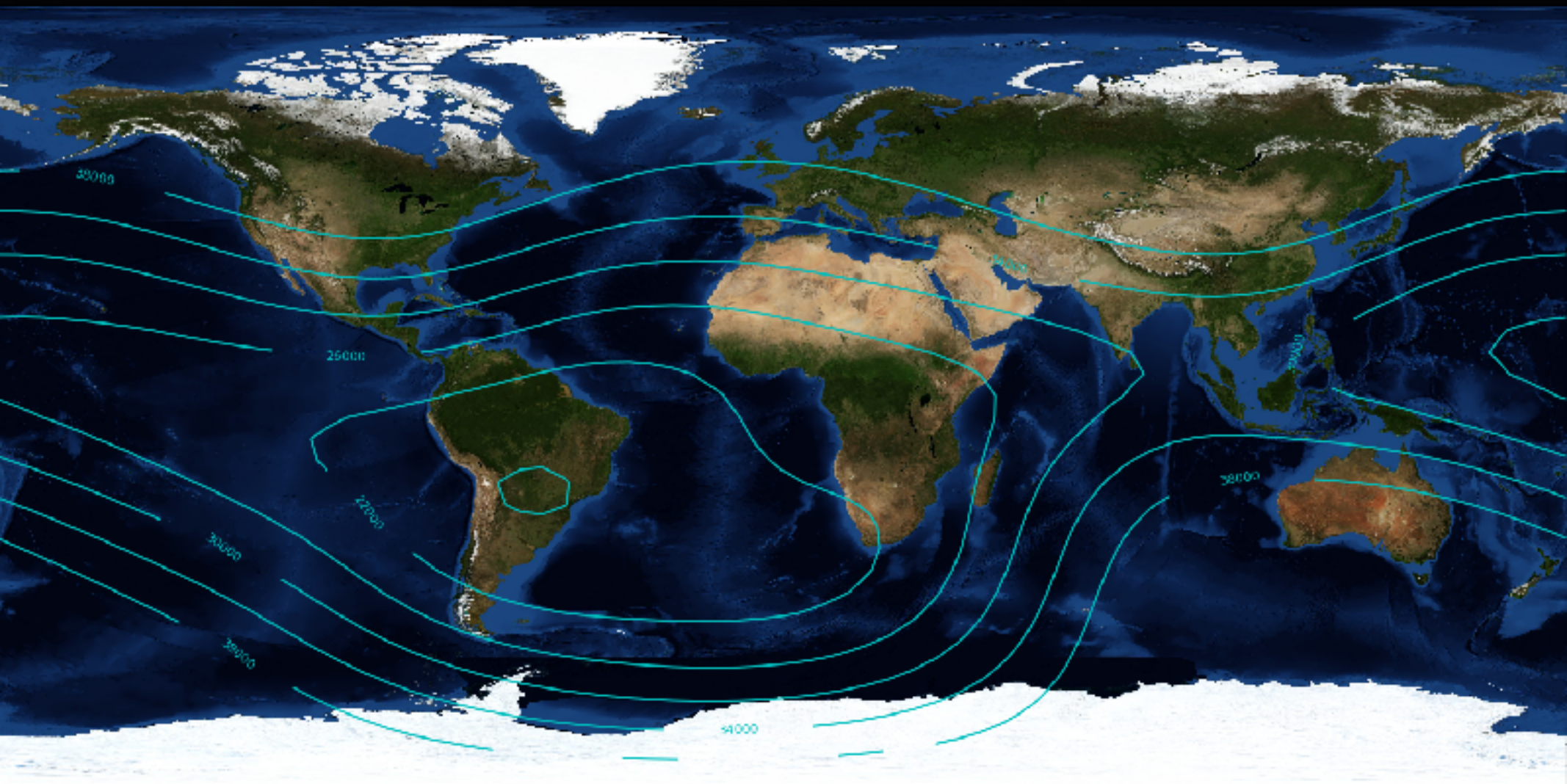
# Thank You

# Backups

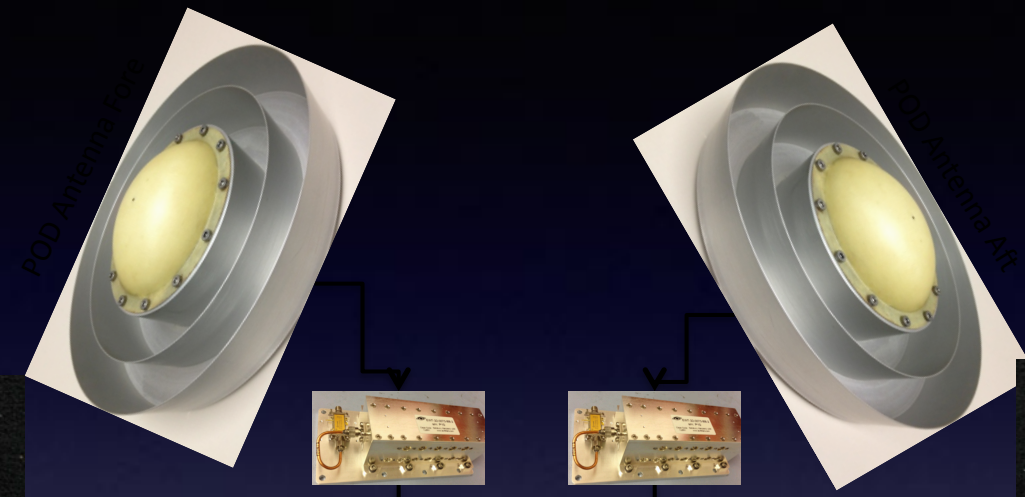




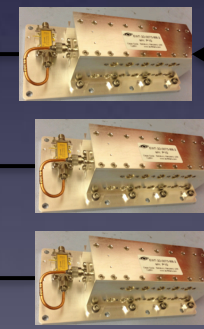
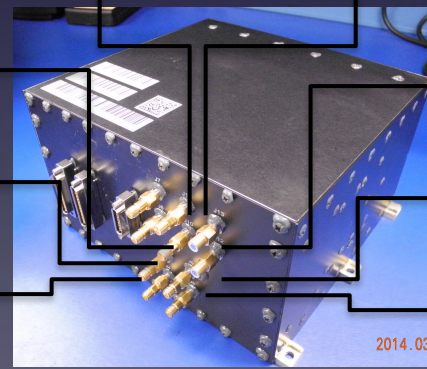
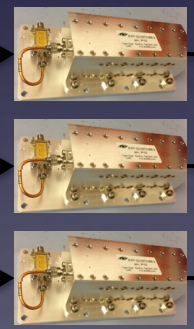
# TGRS / C-2



# TGRS Refresher



Filter/LNA  
Assemblies (8)



RO Antenna Fore

RO Antenna Aft