

# Programming the TriG for Better Science

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Government sponsorship acknowledged.



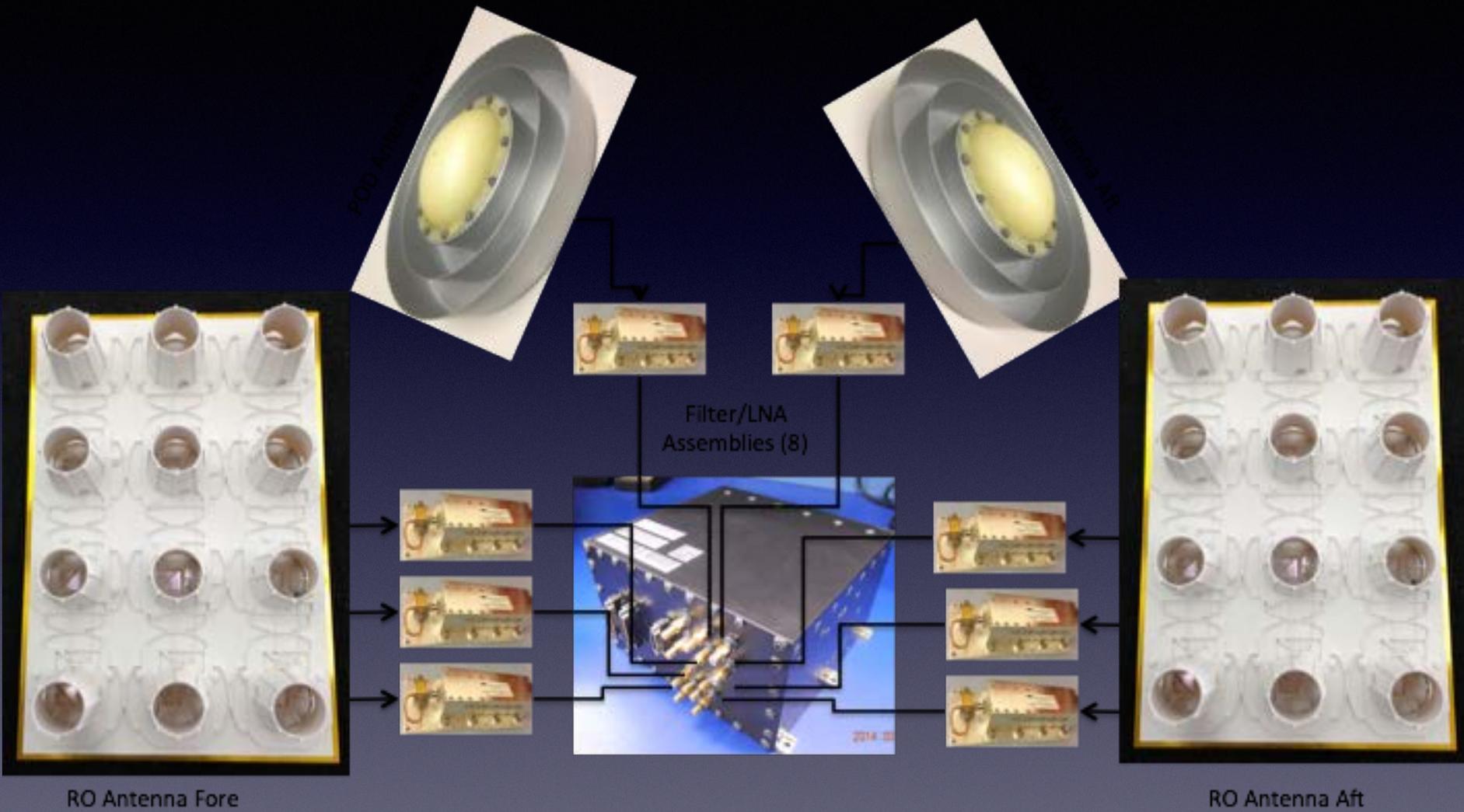
Design So  
 Computer So Building  
 Feet  
 Project Design Feet  
 Aircraft Problem  
 Computer  
 Oxygen So  
 Project Building  
 Building Girls Building  
 Girls Oxygen

# Topics

- TGRS refresher
- Beyond software requirements
- TGRS / C-2 hardware status
- Software status and schedule

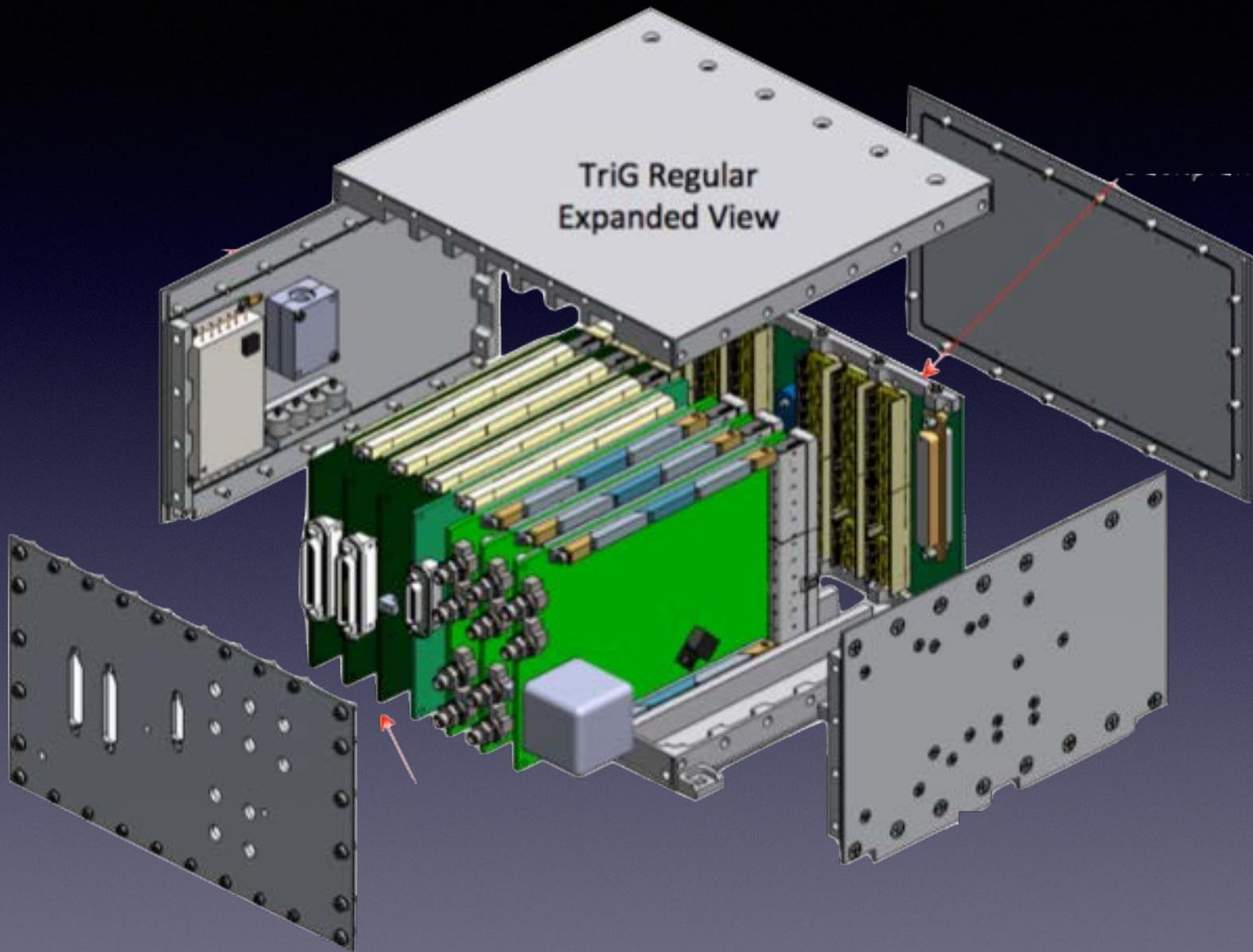


# TGRS Refresher



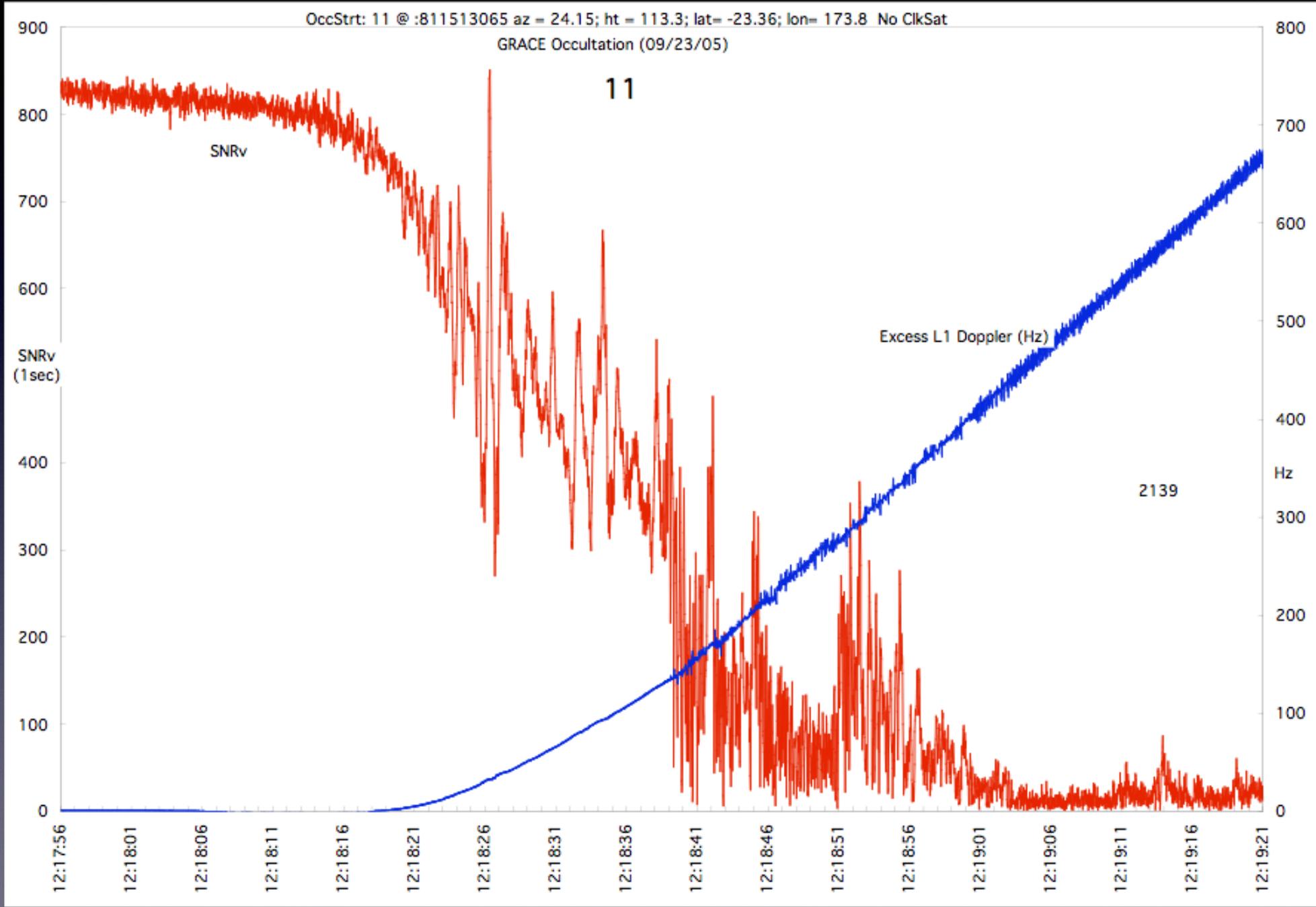


# TGRS Refresher TriG





# TGRS Processing

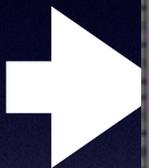




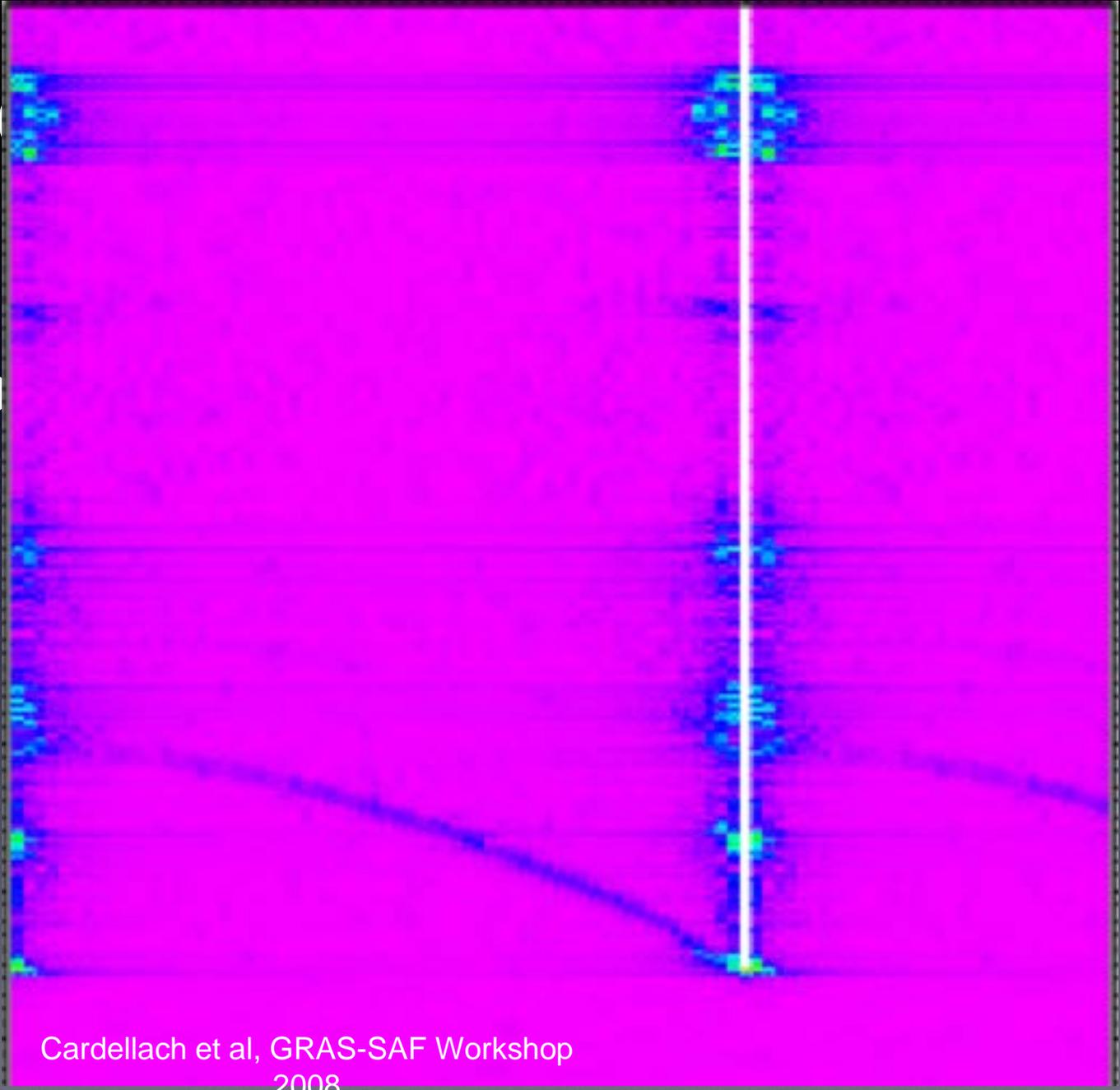
# TriG SciP Processing

200,000

PRN, Time, Lat, Lon  
Ht. Tau, Tau-dot...



Meta data



Cardellach et al, GRAS-SAF Workshop  
2008

# Beyond Software Requirements

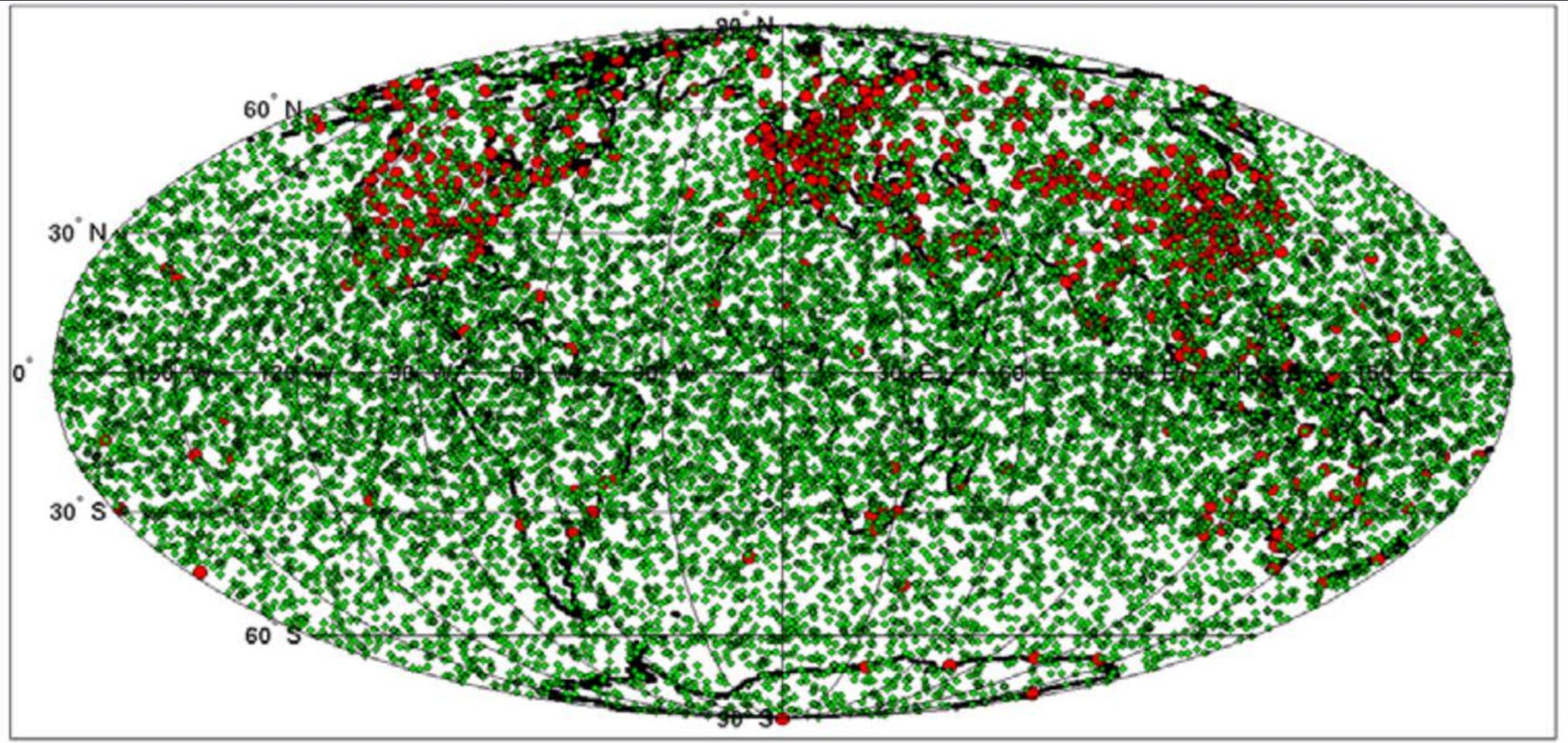
## What am I talking about?

- TGRS has a latent data set of scope that is far beyond what is sent to the ground
- That data can be accessed via a combination of standard Linux IPC calls, scripts and applications.
- This could open the instrument processing to the broader science community
- Essentially, post-launch, we could have a new instrument



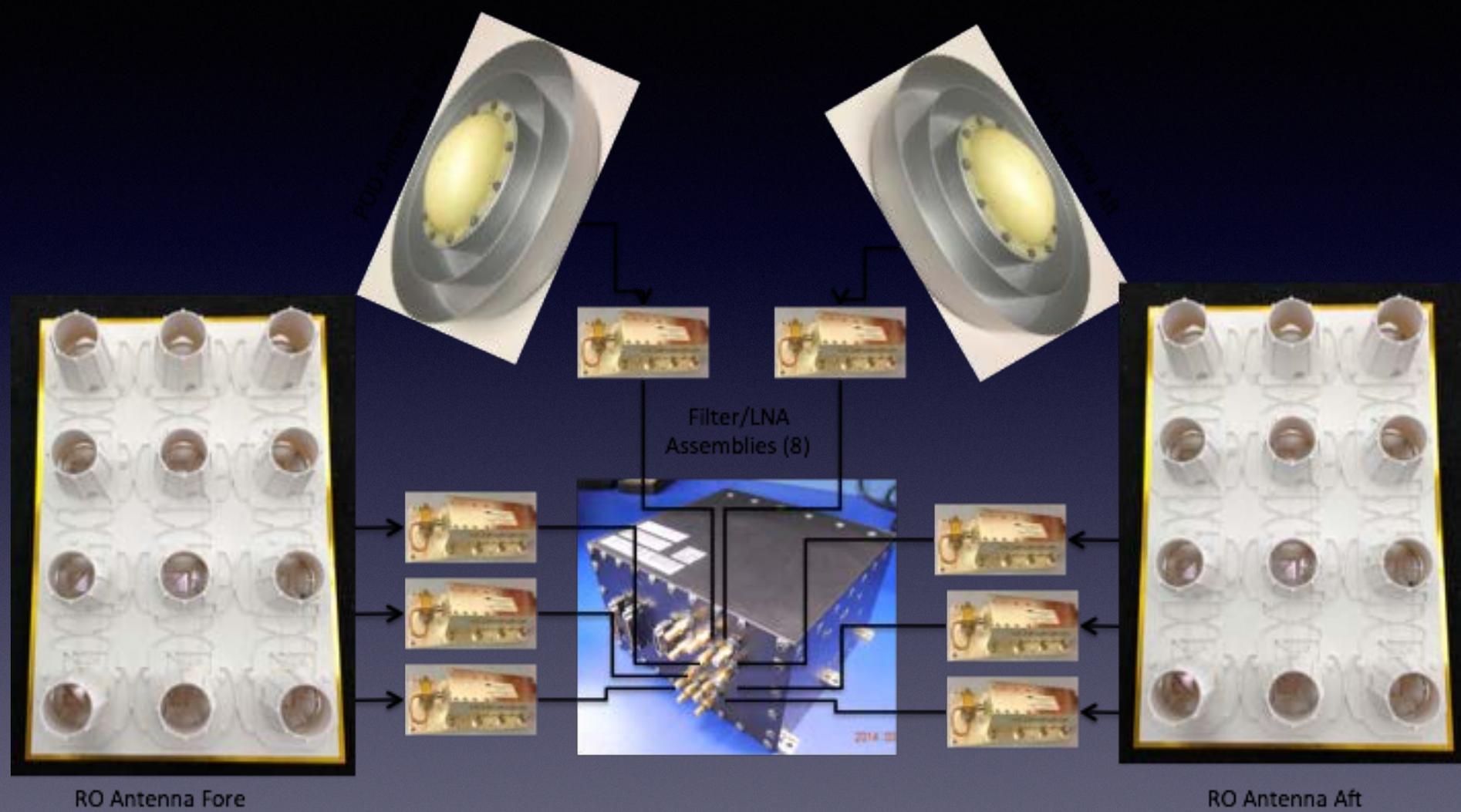
# Beyond Software Requirements

We still have to respect and maintain this:





# TRGRS / C-2 Hardware Status





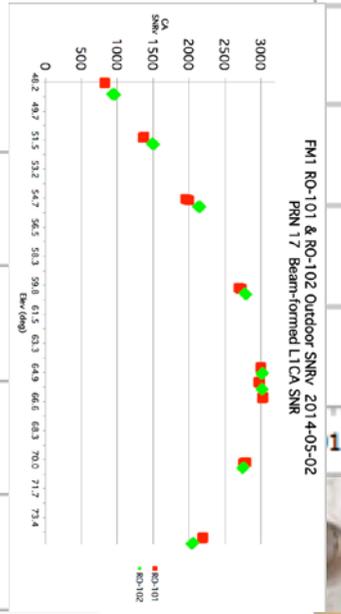
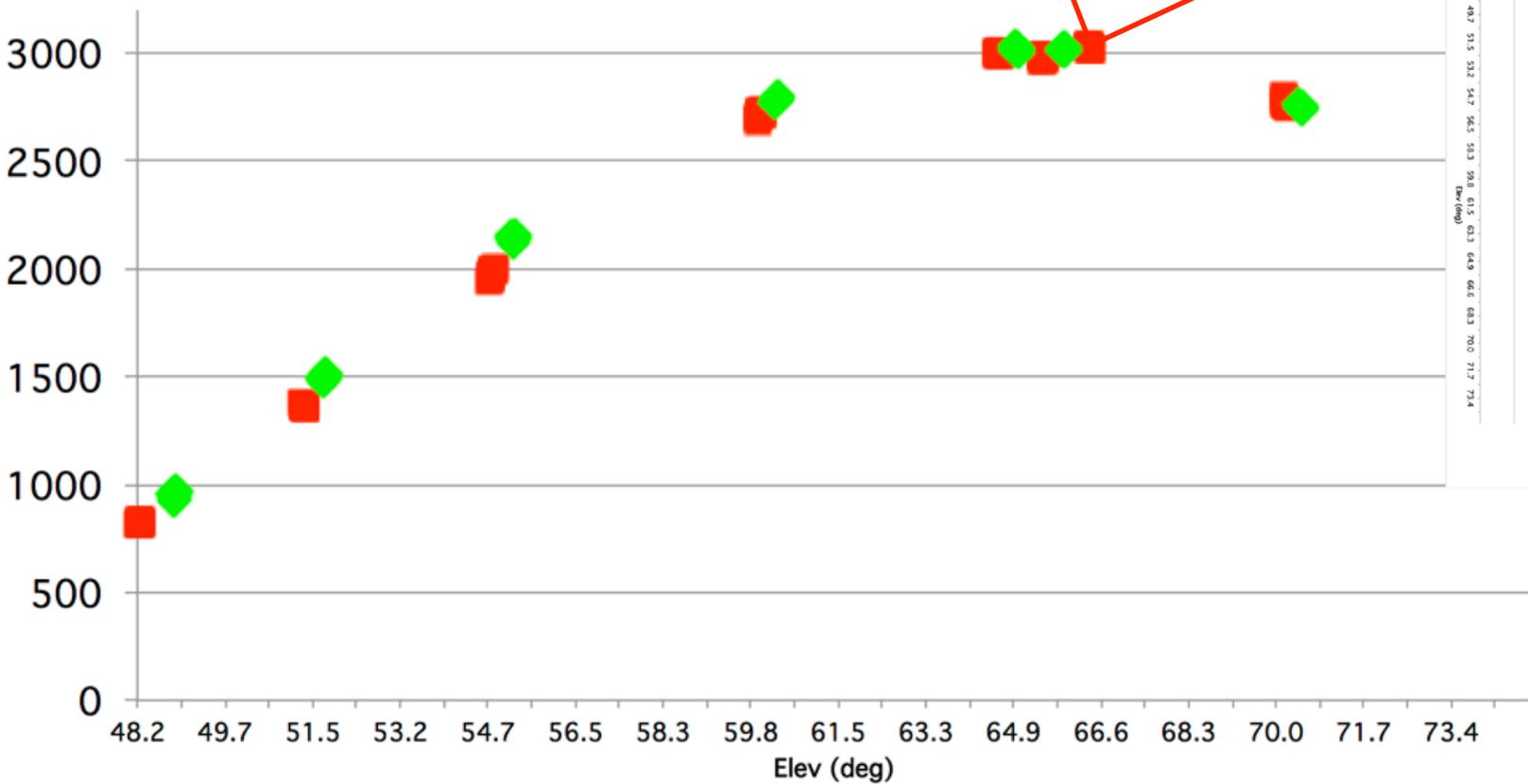
# TGRS / C-2 Hardware Status



### FM1 RO-Ant 100Hz SNRv (1s)



### FM1 RO-101 & RO-102 Outdoor SNRv 2014-05-02 PRN 17 Beam-formed L1CA SNR





- Six Flight Models Built
- Four completed System testing
- FM1 delivered to SSTL and integrated onto satellite
- FM5 is awaiting system testing at JPL
- FM6 is in test at Moog-BRE

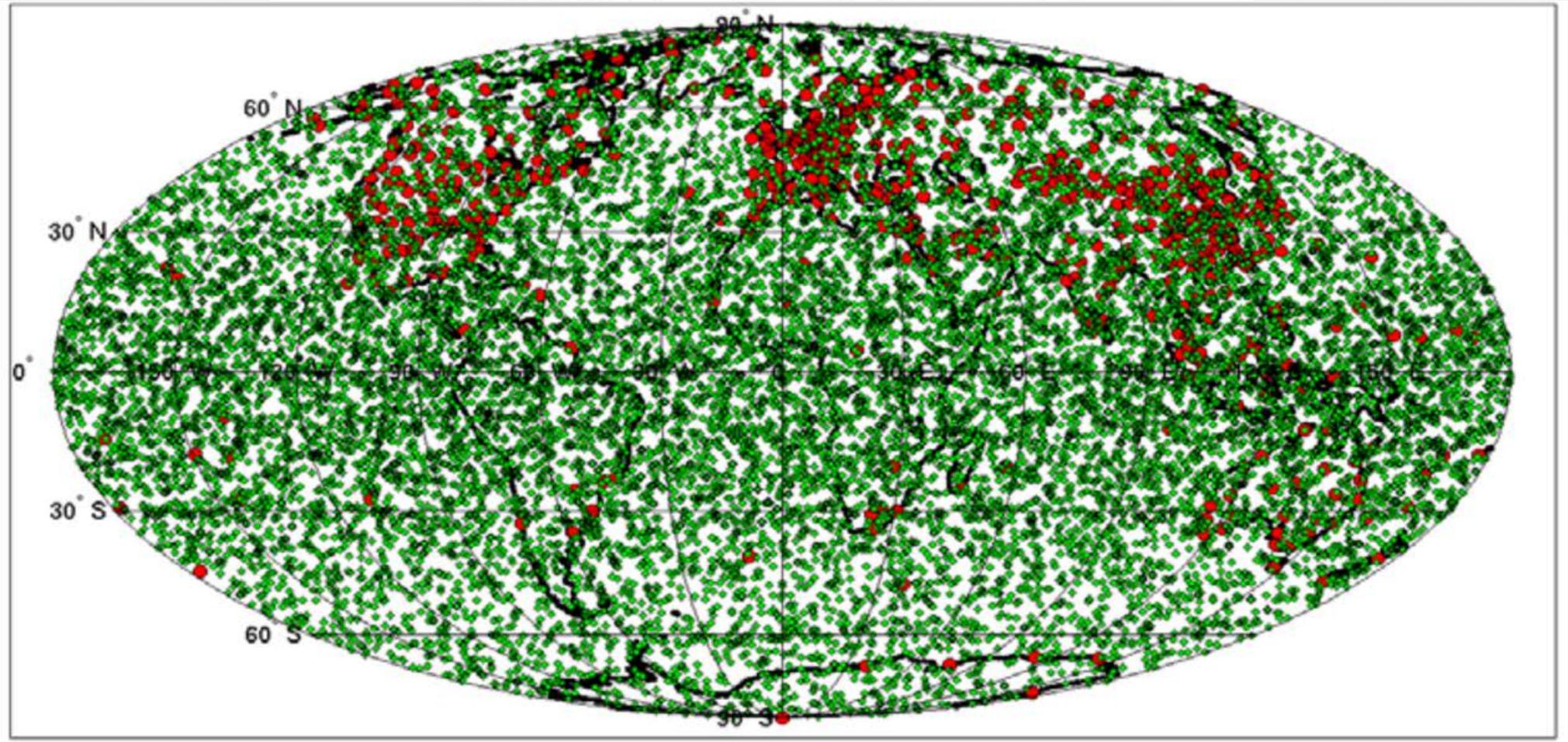


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# TriGRS / C-2 Hardware Status



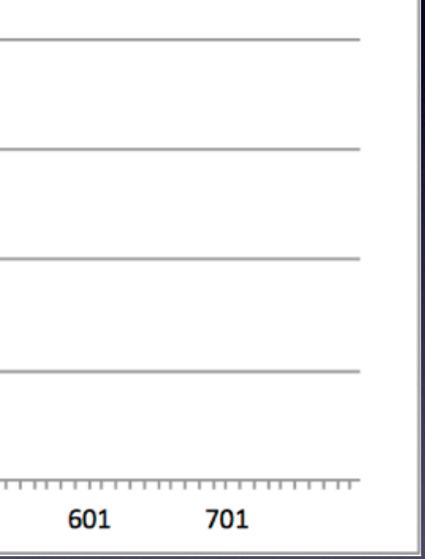
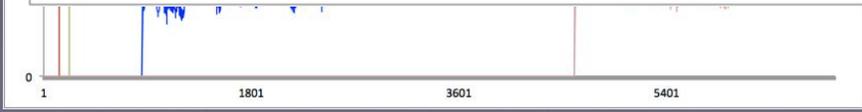
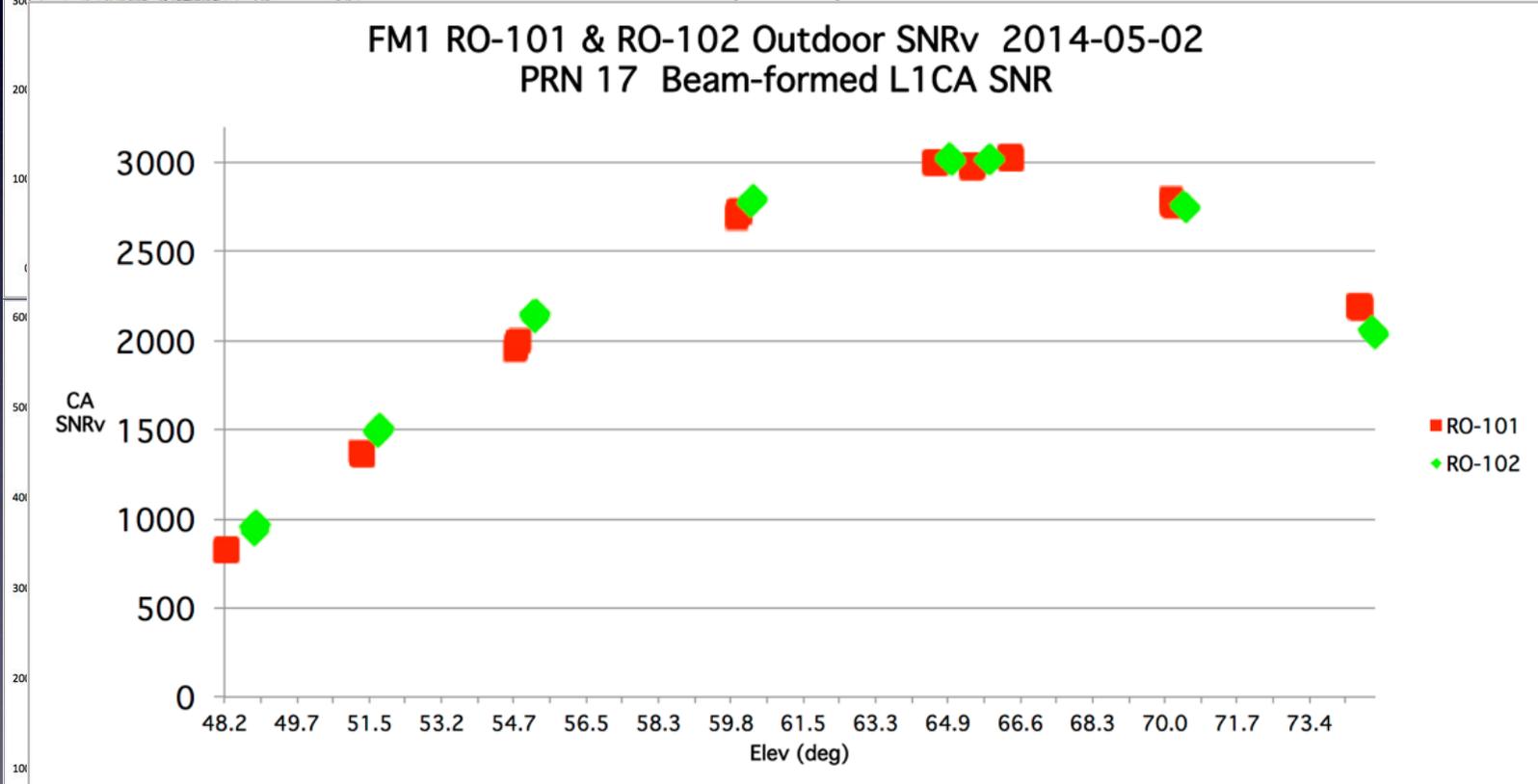
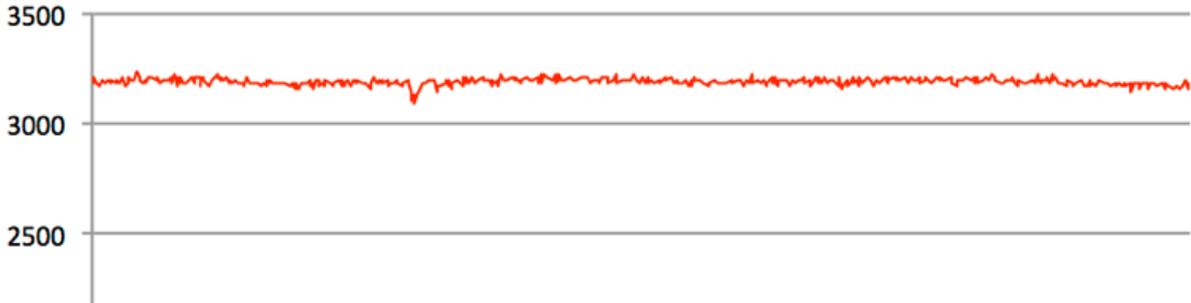
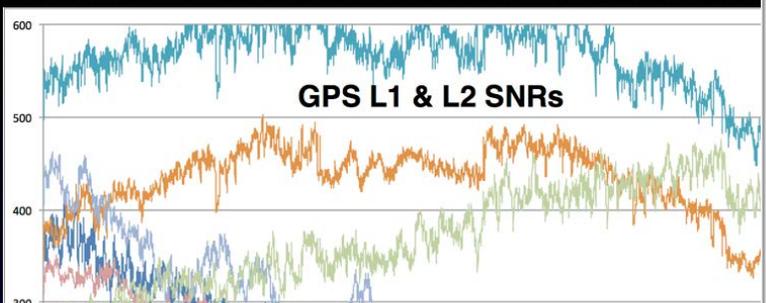
L5-SW-002	The TGRS software (SW) shall provide navigation data with 0.1 Hz cadence to the Spacecraft Bus through a RS-422 interface with data rate of 115 kbps
L5-SW-003	The TGRS SW shall provide neutral atmosphere soundings of 1100/day.
L5-SW-005	The TGRS SW shall provide occultation limb soundings of 1015/day



L5-SW-037	The TGRS SW navigation processor shall track at least 16 dual frequency channels simultaneously with at least 7 channels dedicated to top-side arcs
L5-SW-038	The TGRS SW navigation processor shall track at least 16 dual frequency channels simultaneously with at least 9 channels dedicated to ionosphere occultations



# TriG RF Processing

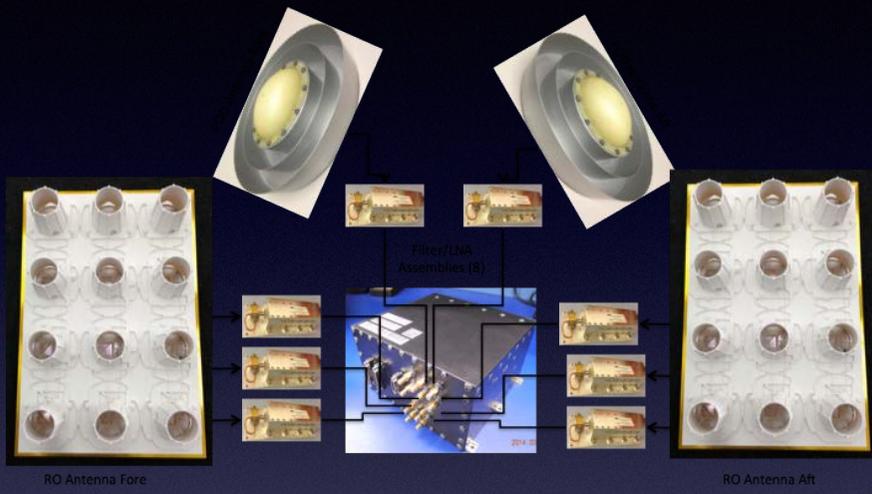


# TriG RF Processing

<b>L5-SW-002</b>	The TGRS software (SW) shall provide navigation data with 0.1 Hz cadence to the Spacecraft Bus through a RS-422 interface with data rate of 115 kbps
<b>L5-SW-003</b>	The TGRS SW shall provide neutral atmosphere soundings of 1100/day.
<b>L5-SW-005</b>	The TGRS SW shall provide occultation limb soundings of 1015/day
<b>L5-SW-007</b>	The TGRS SW shall provide State of Health telemetry to the Spacecraft through an RS-422 serial bus UART interface
<b>L5-SW-010</b>	The TGRS SW shall be capable of accepting an update to the NAV DSP and Science DSP FPGAs.
<b>L5-SW-015</b>	The TGRS SW shall implement open loop recording on L1 and L2 when making RO neutral atmosphere measurements below a settable altitude.
<b>L5-SW-016</b>	The TGRS SW shall have the ability to collect ionospheric phase and amplitude data at 1 or 50 Hz based on altitude of the line-of-sight tangent point or as commanded.
<b>L5-SW-020</b>	The TGRS SW shall track GPS/GLONASS FDMA satellites with less than 1 phase break per 10 occultations when the 1 sec SNRv is above 200
<b>L5-SW-023</b>	The TGRS SW shall be capable of tracking 18 occultation signals simultaneously from a mixture of GPS and GLONASS FDMA satellites.
<b>L5-SW-026</b>	The TGRS SW shall be capable of digitally steering each beam of each RO antenna (total of 3 beams per RO antenna and 2 RO antennas)
<b>L5-SW-031</b>	The TGRS SW shall have the ability to collect occultation phase and amplitude data of 50 or 100 Hz based on altitude of the line-of-sight tangent point or as commanded.
<b>L5-SW-032</b>	Line-of-sight tangent point heights for which atmospheric occultation data are collected shall be configurable from 200 km to -400 km at 10 km intervals.
<b>L5-SW-033</b>	The TGRS SW shall be capable of updating FPGA firmware, and user processor software on orbit
<b>L5-SW-037</b>	The TGRS SW navigation processor shall track at least 16 dual frequency channels simultaneously with at least 7 channels dedicated to top-side arcs
<b>L5-SW-038</b>	The TGRS SW navigation processor shall track at least 16 dual frequency channels simultaneously with at least 9 channels dedicated to ionosphere occultations



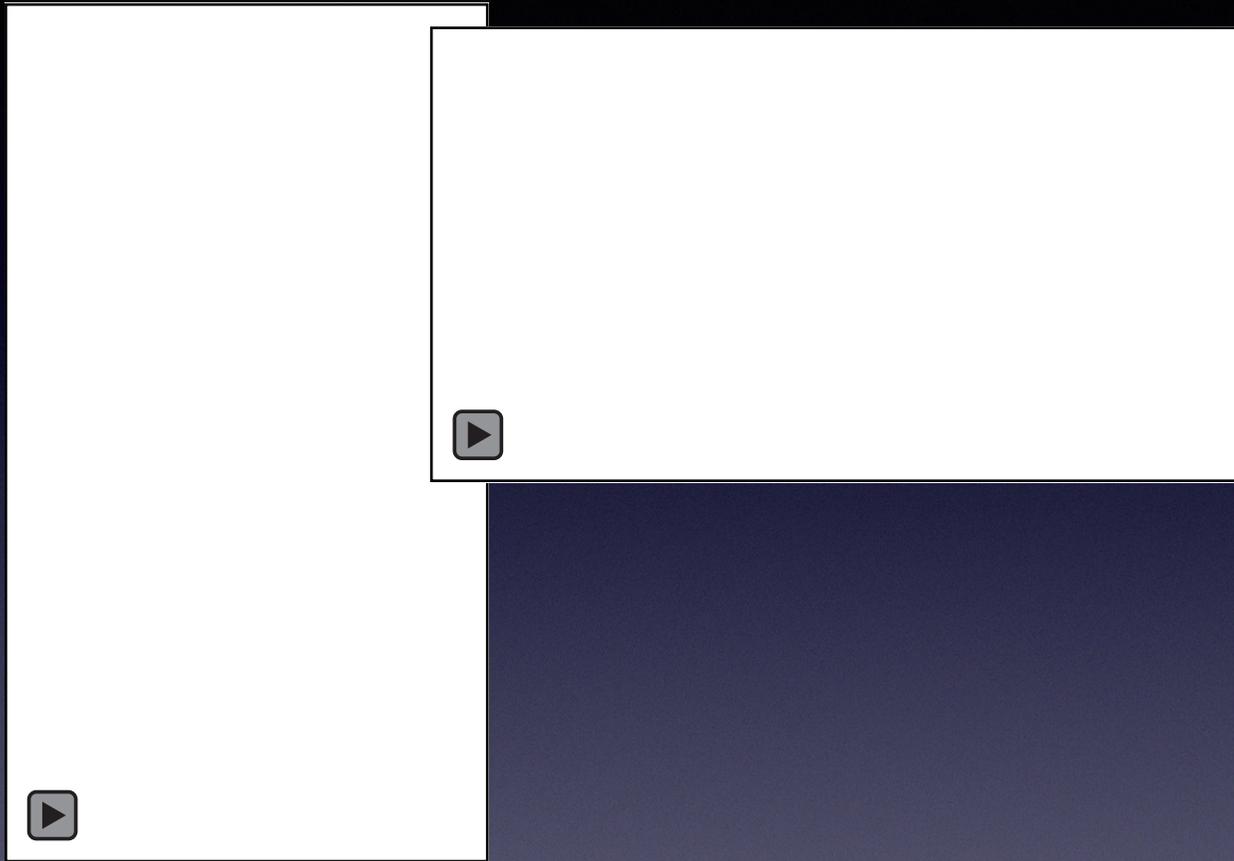
## Grass Roots



TGRS  
 ~15 kg  
 60 W  
 40x60x50

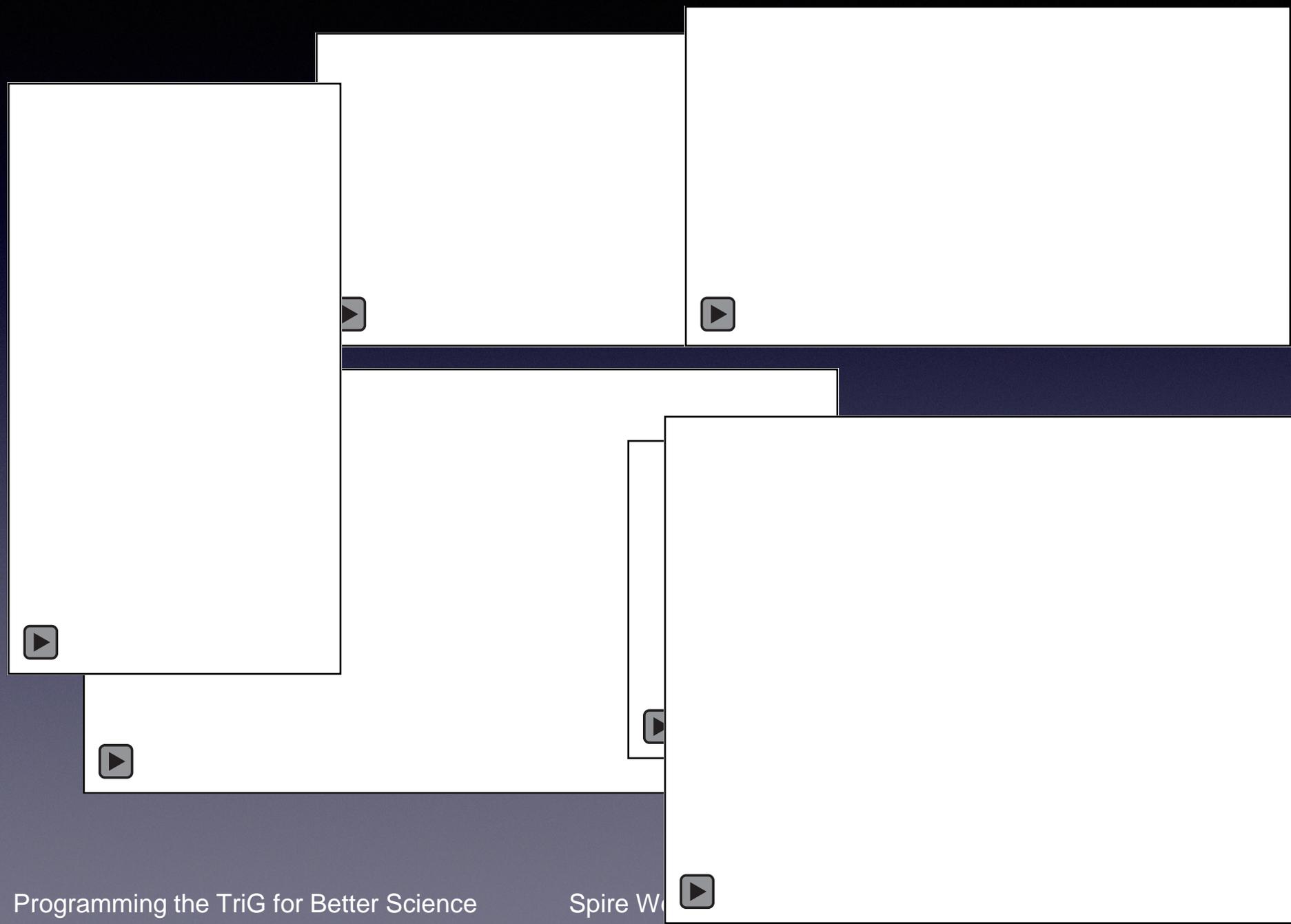
L5-SW-002	The TGRS software (SW) shall provide the Spacecraft Bus through a RS-422
L5-SW-003	The TGRS SW shall provide neutral atmosphere measurements
L5-SW-005	The TGRS SW shall provide occultation data
L5-SW-007	The TGRS SW shall provide State of the Planet (SOP) data through an RS-422 serial bus UART
L5-SW-010	The TGRS SW shall be capable of processing Science DSP FPGAs.
L5-SW-015	The TGRS SW shall implement open-loop control making RO neutral atmosphere measurements
L5-SW-016	The TGRS SW shall have the ability to output amplitude data at 1 or 50 Hz based on the sampling point or as commanded.
L5-SW-020	The TGRS SW shall track GPS/GLO navigation phase break per 10 occultations when available
L5-SW-023	The TGRS SW shall be capable of tracking GPS/GLO simultaneously from a mixture of GPS/GLO
L5-SW-026	The TGRS SW shall be capable of directing the antenna (total of 3 beams per RO antenna)
L5-SW-031	The TGRS SW shall have the ability to output amplitude data of 50 or 100 Hz based on the sampling point or as commanded.
L5-SW-032	Line-of-sight tangent point heights for occultations are collected shall be configurable from 100 to 1000 km intervals.
L5-SW-033	The TGRS SW shall be capable of uplinking navigation processor software on orbit
L5-SW-037	The TGRS SW navigation processor shall track 3 channels simultaneously with at least 100 Hz
L5-SW-038	The TGRS SW navigation processor shall track 3 channels simultaneously with at least 100 Hz occultations

## Grass Roots



Zuma  
~15 kg  
60 W  
30x60x30

- L5-K9-01  
Sit
- L5-K9-02  
Stay
- L5-K9-03  
Walk nicely on  
leash
- L5-K9-04  
Drink from  
water bowl  
only
- L5-K9-05  
Stay in the  
yard





# Programming the TriG for Better Science

Design So  
 Computer So Building  
 Feet  
 Project Design Feet  
 Aircraft Problem  
 Computer  
 Oxygen So  
 Project Building  
 Building Girls Building  
 Girls Oxygen



