Observation Overview

Thank you for Rev 274!
11 tracks, 1 added in real-time

- S99 Rev 275 RSS observations
  - Include
    - Gravity observation (24hrs in duration)
    - Periapse ring occultation
    - Distant ingress and egress ring occultations
  - 2-way/3-way mode
  - Periods of Telemetry OFF, Ranging OFF, 2-way/3-way mode (during occultations)
  - Playbacks planned during gravity observation when TLM is not off
  - 9 tracks scheduled
    - 7 DSN, 2 ESA

Science Highlights

Gravity Observation - From Luciano Iess

Rev 275 is the third of six orbits devoted to the determination of Saturn's gravity field and the mass of the B ring. The spacecraft will collect gravity and magnetic field data from a distance as close as 3000 km from the cloud level. Those data are crucial to build interior models of the planet and to determine the depth of zonal winds.

The Cassini radio science investigation will measure Saturn gravity field and the ring mass by means of range rate measurements enabled by the onboard X band (7.2-8.4 GHz) radio system, and the antennas of NASA's Deep Space Network and ESA's tracking network. The gravity determination is obtained by fitting the radial velocity of the spacecraft with accuracies of about 0.05 mm/s (at a time scale of 60 s) with a model of the spacecraft dynamics. Due to the large Doppler rate, the measurements are aided by predictions obtained from a model of the orbital dynamics.

Cassini orbital geometry is crucial for the gravity experiment. The highly eccentric 6-day orbit has a pericenter close to Saturn's clouds, within the inner edge of the rings. With Cassini passing between the rings and the planet, Cassini will be able to disentangle the strong acceleration due to Saturn's oblateness from that due to tiny pull of the rings. In addition, going close to Saturn Cassini will be affected by tiny density inhomogeneities inside the planet, thus providing clues on their structure.

Cassini gravity passes will be able to provide the density distribution inside Saturn. In particular, it will tell us how massive the core is (we are expecting something like 20 Earth masses of heavy elements in the central part of the planet). The gravity field of Saturn as measured by Cassini depends on how mass is distributed inside the planet. We may imagine that layers of different densities give different contributions to the total gravity. However, it is only the fast rotation of the planet that makes the shape oblate and generates sufficient latitudinal gravity variations to allow inferring the density profile at depth. We know the planet's bulk density from it's mass and radius. (Radius gives us the volume.) The gravity field yields the density as a function of radius in the H/He envelope of the planet. So, in a sense, since we know the density of the whole planet, and the density of the H/He envelope, we can infer that we are, or are not, "missing" mass in the deep interior of the planet, based on how dense the H/He mixture would be extended to very deep interior conditions. If we are missing mass, one can calculate out how much that is, and that is the core mass.

Science Highlights Cont'd

Gravity Observation Cont'd - From Luciano Iess

The tiny pull of the hemispherically asymmetric gravity field we'll also allow Cassini to tell us how deep the winds are inside Saturn. We know that the winds at the cloud level are up to 300 km/h strong, but we do not know if the flow goes down to just 100, or 1000, or even 10000 km. This is another important science goal of the Grand Finale.

The mass of the rings (concentrated mostly in the B ring) remains uncertain. Its value, generally expressed in terms of Mimas masses, bears crucial information on how and when the rings formed, and their relation with Saturn and its moons. Models predict that a large ring mass implies that the rings are old, dating back to the formation of the Saturnian system 4.5 billion years ago. A small mass implies that the rings are much younger, possibly formed by the impact with a comet.

By the end of July Cassini will tell us a lot about the interior structure and the formation of the Saturnian system. We are anxious to analyse the data, and proud to be part of this endeavor which sees the effort of so many people in the Project and the DSN.

Science Highlights Cont'd

Ring Occultations - From Essam Marouf

The Rev 275 RSS periapse, ingress, and egress ring occultations are the second group in a unique Grand Finale (Proximal Orbits) campaign of Cassini radio occultations of Saturn's ring system. The campaign takes advantage of occultation track geometry that systematically sweeps across the ring system. Collectively, the occultation tracks capture a spread in: 1) Earth relative longitude , and 2) inertial ring longitudes. The first allows characterization of the virtual azimuthal ring asymmetry due to gravitational wakes known to permeate Rings A and B. The second allows characterization of true azimuthal ring asymmetry driven by ring dynamics, including sharp edges and resonant interaction with the satellites and with Saturn's interior structure. Also unique about the campaign is that the rings are close to their maximum opening angle (B~26-27°) as seen from the Earth, possible only near the 2017 epoch of the Proximal Orbits. The large *B*-angle allows maximum penetration of the radio signals of optically thick features, especially Ring B, the many density and bending waves everywhere, confined optically thick ringlets including the Ring C plateaus. Radio occultations enjoy the advantage of measurements using three coherent observation wavelengths (0.94, 3.6, and 13 cm; Ka-, X-, and S-band), allowing not only profiling of ring structure but also constraining the structures physical properties.

The Grand Finale campaign includes ring occultations on the 6 RSS gravity orbits (Revs 273, 274, 275, 278, 280 and 284) and two on Rings segments (Revs 276 and 282). The 6 on the gravity orbits include never before attempted close occultations observing the rings from a distance < ~1 RS near orbit periapse. Dubbed "periapse ring occultations," they start almost immediately after Cassini dives through the ring plane and are short in duration (< 26 m) but cover the complete main ring system. High spatial resolution scattered and direct signals measurements are expected because of the small HGA footprint and the small Fresnel scale, respectively. The collective ring coverage of the RSS Grand Finale occultations is unprecedented in the Cassini Mission.

DSN and ESA Antennas

- DSN Coverage

		Pre	BOT	EOT	Post					
17	141	1205	1335	2220	2235	DSS-35 CAS	TP RSS GRAVOC L3	7178	N750	1A1
17	141	1715	1800	0000	0015	DSS-74 CAS	RSS GRAV/OCC	7179	0142	1A1
17	141	2030	2200	0555	0610	DSS-55 CAS	TP RSS GRAVOC L3	7178	N750	1A1
17	141	2305	2350	1000	1015	DSS-84 CAS	RSS GRAV/OCC	7178	0142	1A1
17	142	0200	0300	0600	0615	DSS-63 CAS	RSS GRAV/OCC L3	7178	1647	1A1
17	142	0345	0515	1345	1400	DSS-25 CAS	RSS GRAV/OCC L3	7178	N748	1A1
17	142	0415	0515	1345	1400	DSS-14 CAS	TP RSS GRAVOC L3	7178	1647	1A1
17	142	0755	0925	1840	1855	DSS-35 CAS	RSS GRAV/OCC L3	7179	N750	1A1
17	142	0815	0915	1840	1855	DSS-43 CAS	RSS GRAV/OCC L3	7179	1647	1A1

- DSS-35, DSS-74, DSS-55, , DSS-84, DSS-14, DSS-43 will be providing the uplink

DSN and ESA Antennas Cont'd

Receivers scheduled

- 2 closed-loop receivers per antenna
- DSN Open-loop receivers (RSRs, WVSRs, VSRs, PRSRs)
- PRSR at Malargue and New Norcia
- Open-loop data are prime for occultations and gravity. Closed-loop data are also required for gravity
- Only RCP will be recorded
    - 2-way/3-way and 1-way modes

S99 Rev 275 Open-Loop Receiver Assignment

STILL BEING WORKED

DSS Prdx Mode	Operator (S) Scripted By	Ops Machine	Open-loop Receiver	Channels	Subchannels	Bandwidths KHz
DOY 141						
35 1-/2-way	Elias/Danny/ Clement (S)Elias	rsops1	RSR1	RSR1A -> XRCP RSR1B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
35 1-/2-way	Danny (S)Danny	rsops4	WVSR1	WVSR1A -> XRCP WVSR1B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
35 1-/2-way	Danny (S)Danny	rsops4	WVSR2 Precision Mode	WVSR2A -> XRCP WVSR2B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
74 2-/3-way	Aseel	rsops6/ psdg5	PRSR 134.159.181.84	PRSR -> XRCP	1, 2, 3, 4	1, 16, 50, 100
55 1-/2-/3-way	Clement (S)Clement	rsops1	RSR2 RSR1	RSR2A -> XRCP RSR1B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
55 1-/2-/3-way	Danny/Aseel (S)Danny	rsops4	WVSR1	WVSR1A -> XRCP WVSR1B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
55 1-/2-/3-way	Danny/Aseel (S)Danny	rsops4	WVSR2 Precision Mode	WVSR2A -> XRCP WVSR2B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, 100 1, 16, 50, 100
84 2-/3-way	Aseel	rsops6/ psdg5	PRSR 168.96.250.72	PRSR -> XRCP	1, 2, 3, 4	1, 16, 50, **16**
DOY 142						
14 2-/3-way	Elias/Clement (S)Elias	rsops2	RSR3	RSR3A -> XRCP RSR3B -> SRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, **16** 1, 16, 50, 100
14 1-way	Jay/Danny (S)Jay	rsops5	WVSR2	WVSR2A -> XRCP WVSR2B -> SRCP	1, 2, 3 4, 5, 6, 7 8 1, 2, 3 4, 5, 6, 7	1, 16, 50 1, 16, 50, 100 (with offset) **16** (with offset) 1, 16, 50 1, 16, 50, 100 (with offset)

S99 Rev 273 Open-Loop Receiver Assignment

STILL BEING WORKED

DSS Prdx Mode	Operator	Ops Machine	Open-loop Receiver	Channels	Subchannels	Bandwidths KHz
25 2-/3-way	Elias/Danny (S)Elias	rsops2	RSR1	RSR1A -> XRCP RSR1B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, **16** 1, 16, 50, 100
25 2-/3-way	Elias (S)Elias	rsops2	RSR2 Precision Mode	RSR2A -> XRCP RSR2B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, **16** 1, 16, 50, 100
25 1-way	Jay/Danny (S)Danny	rsops3	VSR1	VSR1A -> KRCP	1, 2, 3, 4	1, 16, 50, 100 (with offset)
43 2-/3-way	Elias/Clement (S)Clement	rspos1	RSR1	RSR1A -> XRCP RSR1B -> SRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, **16** 1, 16, 50, 100
43 1-way	Jay/Danny (S)Jay	rsops4	WVSR1	WVSR1A -> XRCP WVSR1B -> SRCP	1, 2, 3 4, 5, 6, 7 1, 2, 3 4, 5, 6, 7	1, 16, 50 1, 16, 50, 100 (with offset) 1, 16, 50 1, 16, 50, 100 (with offset)
35 2-/3-way	Elias/Danny (S)Clement	rsops1	RSR2	RSR2A -> XRCP RSR2B -> KRCP	1, 2, 3, 4 1, 2, 3, 4	1, 16, 50, **16** 1, 16, 50, 100
35 1-way	Jay/Danny (S)Jay	rsops4	WVSR2	WVSR2A -> XRCP WVSR2B -> KRCP	1, 2, 3 4, 5, 6, 7 1, 2, 3 4, 5, 6, 7	1, 16, 50 1, 16, 50, 100 (with offset) 1, 16, 50 1, 16, 50, 100 (with offset)

WVSR1A at Goldstone unavailable (being used by VLBI)
PRSR1 at Madrid is backup
VSR1 at Canberra is backup
No precision mode recordings at DSS-35 on DOY 129

Don’t record
Same fgain throughout (use TLM off fgain)
Re-set fgain when TLM is off at 06:41:55 and don’t change

DSN Open-Loop Receiver Status

Email from Danny on 4/12

Goldstone

RSR1 – Green (X-band power jumps observed on RSR1A)

RSR2 – Green with date rate != num_samples warnings

RSR3 – Green

VSR1A – "Orange" - DP Internal Error Error may occur; try restarting; reliability in question

VSR1B – "Red" - DP Internal Error Error may occur; try restarting; reliability in question

WVSR1 – Green w/ with fgain bug

WVSR2 – Green w/ with fgain bug

No PRSR

Canberra

RSR1 – Green

RSR2 – Green

VSR1 – Green

PRSR1 –Red

WVSR1 – Green w/ with fgain bug

WVSR2 – Green w/ with fgain bug

Madrid

RSR1A – Red but can be used by overriding dig vfy test

RSR1B - Green

RSR2A – Green

RSR2B – Digitizer test fails due to unknown cause. Can be used by overriding dig vfy test

VSR1 – Red

PRSR1 – Green

WVSR1 – Green w/ with fgain bug

WVSR2 - Green w/ with fgain bug

Real-Time Support

RSSG will be in Ops Room at 5:00 am on Sunday, May 21 (141/1205)

- Last post-cal ends at 11:55 am on Monday, May 22 (142/1855)
- 31 hours
- Will send engineering team support schedule soon

NOA support?

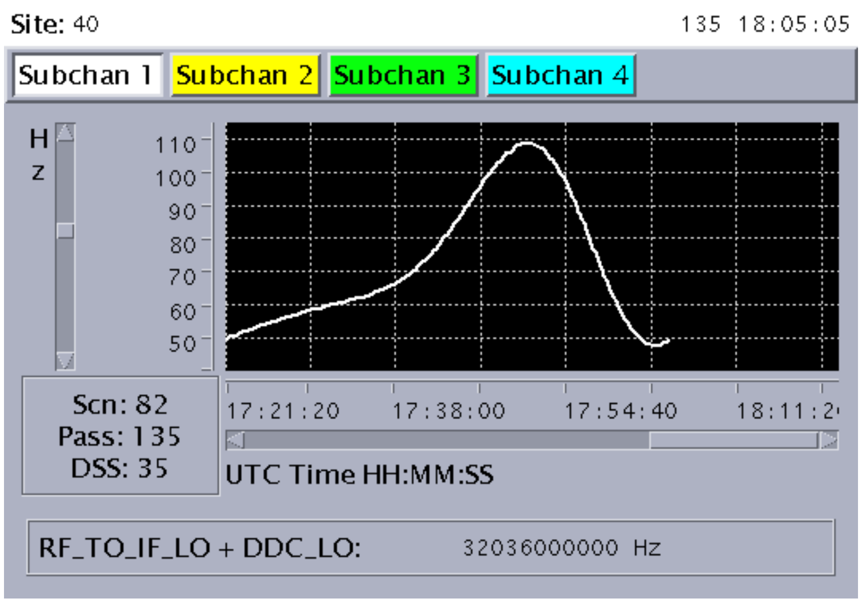
ACE support?

Predicts

- Last NAV OD delivery was on May 9
  - A special delivery is planned on May 19, but too late?!!
  - NAV nominal delivery by 2:30 pm, but said may be able to deliver earlier
  - Elias & Danny – Can you manage?
- RSS will not be modifying the uplink predicts
- Lu: Can you please ask SPS to provide uplink predicts
- Elias and Danny will generate and verify the open-loop downlink predicts
- RSS usually uses three sets of downlink predicts in the open-loop receivers for occultations:
  - #1: Coherent (2-way/3-way)
  - #2: 1-way coherent:1-way predicts offset in real-time to coherent downlink frequency
  - #3: 1-way (no offset): For 1-way baseline and when the DST loses lock (for example, dense ring regions)
- If an additional receiver is available, will record in high precession mode for gravity
  - Like we did during Rev 273 and Rev 274

Post Rev 274 Comments

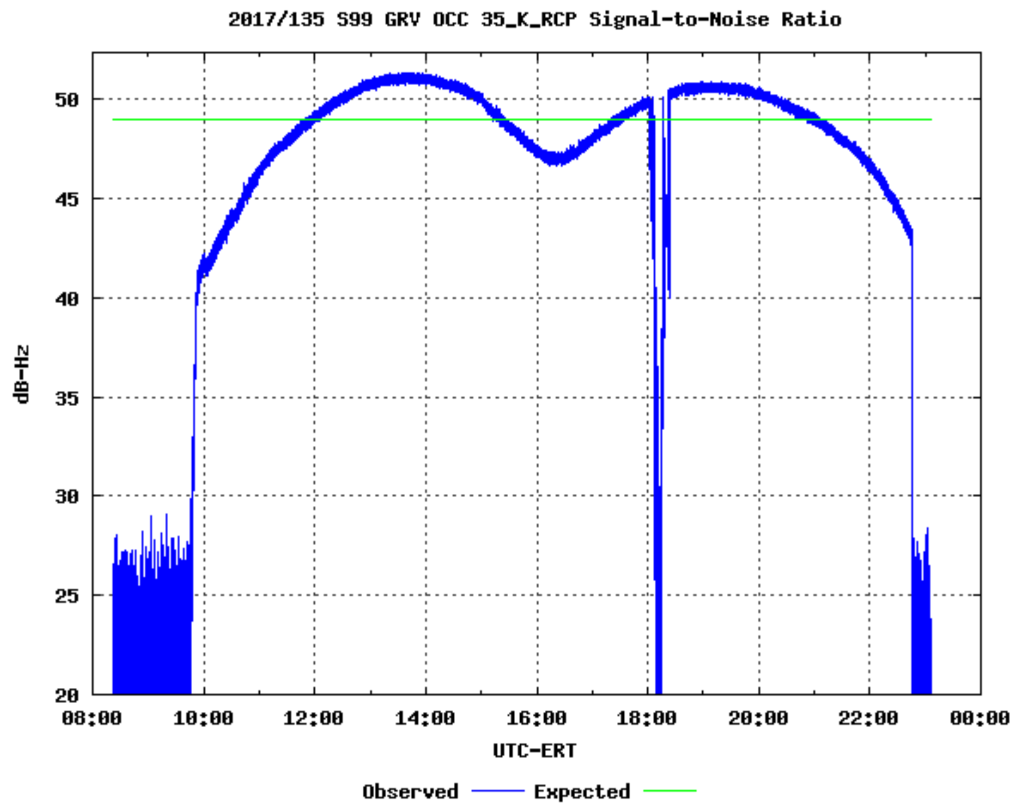
- No High signal dynamics around periapse!
  - All signals remained within the 1 KHz bandwidth
  - Believe Rev 273 large drift in frequency was due to not using coherent predicts with correct uplink ramps
    - DSS-84 was providing the uplink
  - Could also be due to the way ESA generates predicts



DSS-35 Ka-band Residual History Around Periapse (1801)

Post Rev 274 Comments Cont'd

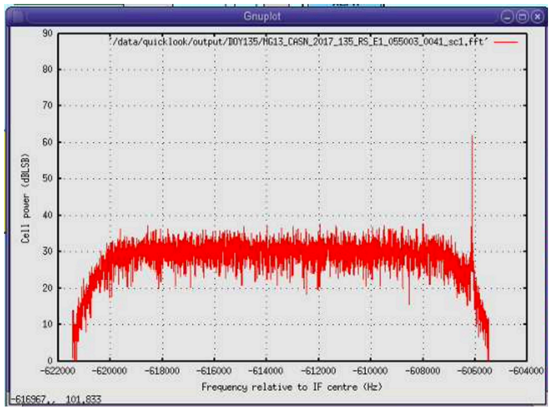
- DSS-35 Subreflector fixed at 45 degrees
  - Worked well
  - Maximum signal power at 45 degrees during rise (~1230) and set (~1930)



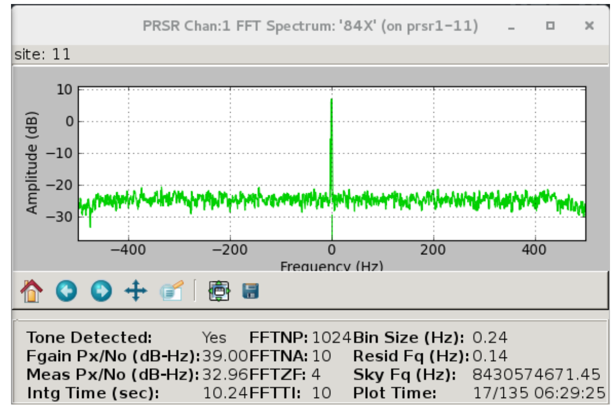
DSS-35 Ka-band Post-Pass Power Plot

Post Rev 274 Comments Cont'd

- ESA's DSS-84 Ka-band recording was at edge of their 16 KHz bandwidth
  - Surprising since our PRSR X-band recording had signal centered in 1 KHz with 0.15 Hz residual

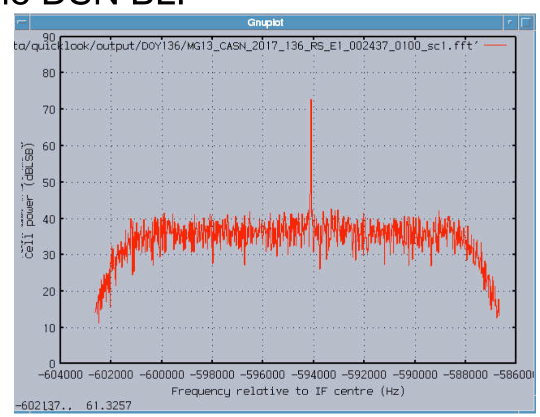


DSS-84 Ka-band Open-Loop on DOY 135



DSS-84 X-band PRSR

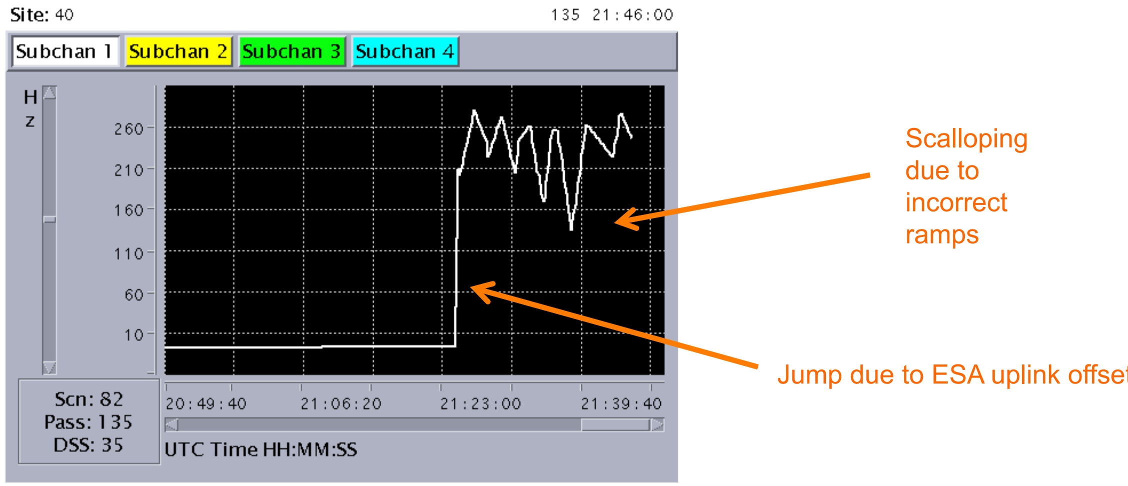
  - ESA tried a different configuration for following DSS-74 track, but encountered some issues that in delaying uplink transfer
  - Tried new configuration again during second DSS-84 track and it worked
    - configured the station with their "altered" BLF for the Uplink and then re-configured the Downlink freq with the DSN BLF



DSS-84 Ka-band Open-Loop on DOY 136

Post Rev 274 Comments Cont'd

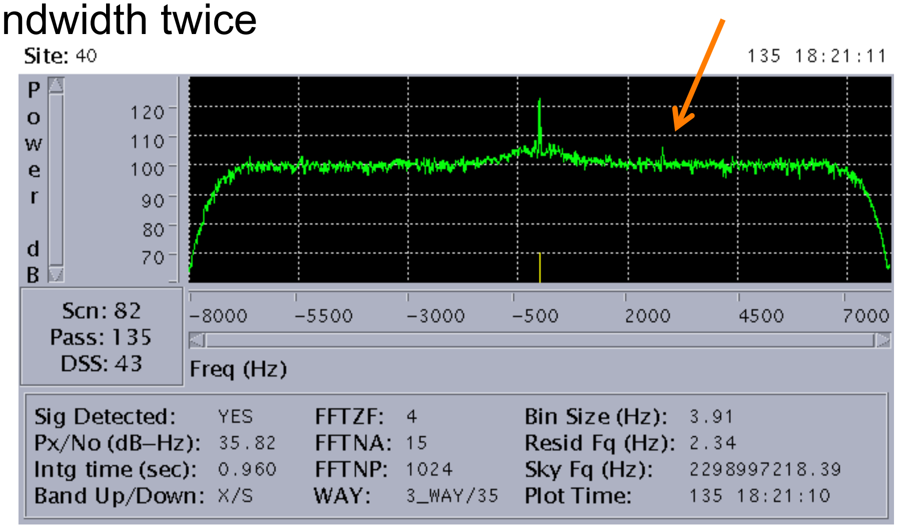
- As usual, observed a jump in residuals (due to ESA using uplink offset) and scalloping (due to incorrect ramps) in DSN open-loop receivers when switched tracking mode to coherent with ESA



DSS-35 Ka-band Frequency Residuals

Actual mode: 3-way/74 Predicts mode: 2-way

- S-band spur at DSS-43 crossed recording bandwidth twice
  - As predicted
  - First drifted left to right, then entered from right and drifted to left
  - Will check Rev 275 predicts



Post Rev 274 Comments Cont'd

- Delay in uplink transfer from DSS-35 to ESA's DSS-74 (New Norica) due to issues getting DSS-74 antenna ready for track
  - No impact to gravity or occultations

- All the 70-m antennas had red equipment!
  - DSS-43: Master Equatorial Servo Interface (MSI) red. Could not use precision pointing
    - Conscan used up until a couple of minutes before start of peri rings occ.
    - Degraded pointing?
  - DSS-63: Master Equatorial Servo Interface (MSI) red. Could not use precision pointing
    - Conscan was used for the first 10 minutes of the track to improve the pointing and a 4 dB jump in X-band power was observed.
    - The Conscan offsets were kept when it was disabled
  - DSS-14: Antenna Servo Drive (ASD) red. Could not support the experiment
    - DSS-24 was obtained instead to support X- and S-band at 6 dB lower SNR

- The 4th order pointing models at all BWGs (DSS-55, DSS-25, DSS-35) appeared to be good. Mostly small or no jumps in Ka-band signal power were observed when Monopulse was enabled
  - Biggest jump was 1 dB at DSS-55 when they re-enabled Monopulse after Ring B out during distant ingress ring occ

Post Rev 274 Comments Cont'd

- DSS-35 enabled Monopulse but accumulated AZ and EL offsets were not updating in our eDMD displays
  - Station had to re-enable
- Kept uplink during distant occultation ingress and egress and DST maintained lock throughout
- DST lost lock for short periods in Ring B during peri occ and distant occs
- Any others?

ORTs

Upcoming

ORT on DOY 139 (May 19) over DSS-35 and DSS-25, X- and Ka-band

17 139 1005 1135 1400 1415 DSS-25 CAS RSS OCCORT MC 7175 N748 1A1
17 139 1005 1135 2040 2055 DSS-35 CAS TP RSS OCCORT MC 7176 N750 1A1

- DSS-35 is prime TP
- Verify Monopulse and acquire pointing data

Uplink Strategy

Uplink Strategy

- DSS-35, 18 kW, ramped, sweep
- DSS-74, 18 kW, ramped, no sweep
  - Uplink transfer from DSS-35
- DSS-55, 18 kW, ramped, no sweep
  - Uplink transfer from DSS-74
- DSS-84, 18 kW, ramped, no sweep
  - Uplink transfer from DSS-55
- DSS-14, 18 kW, ramped, no sweep
  - Uplink transfer from DSS-84
- DSS-43, 18 kW, ramped, no sweep
  - Uplink transfer from DSS-14

Five uplink transfers!!!

Do we need uplink transfer from DSS-35 to DSS-74? Or is 30 minute uplink gap between DSS-35 and DSS-55 acceptable?

DSS-35 transmitter off limit: 141/21:59:52 ERT

DSS-55 transmitter on limit: 141/22:29:20 ERT

If not, we can stop DSS-35 uplink at 21:59:30 and resume uplink over DSS-55 at 22:30:00
RTLT later, uplink gap would end at 142/01:01:52 (C/A – 3hr28m)
Gap was acceptable to gravity during Rev 273, but it was farther away from C/A

Misc

DSS-84 will be prime (2-way) during closest approach period

Subreflectors at DSN and ESA
- Fixed at DSS-84
- Moving otherwise

BLF
- Checked with Telecom prior to Rev 273 if an update is needed, and they said no
- Do we need to check again?

DKF
- Does not have the correct uplink or AOS/LOS times. Use times in RSS timeline
- DKF has playback times

Monopulse
- Per timeline
    - Stations to enable and disable Monopulse only when requested by RSS
- Rising stations - Wait for ~10 degrees elevation to enable Monopulse

4th Order Blind Pointing Models
- Data sent to David
- Graham Baines at Canberra has been checking the DSS-35 pointing model

Misc Cont'd

Timeline
- There will be a v2
- Comments are welcome

Doppler Dynamics
- NOA-s will check accelerations during periapse period
- Need to increase carrier loop bandwidth around periapse?
- Preference is to keep the same bandwidths throughout the support

Rev 275 is shared with CDA
- They picked secondary and offsets

NOPEs
- Any other red/orange equipment?

RSSG

Ops room displays
- Started by first shift, updated as needed by later shifts

Danny
- Please check open-loop receivers status, availability and disk space