Jet Propulsion Laboratory
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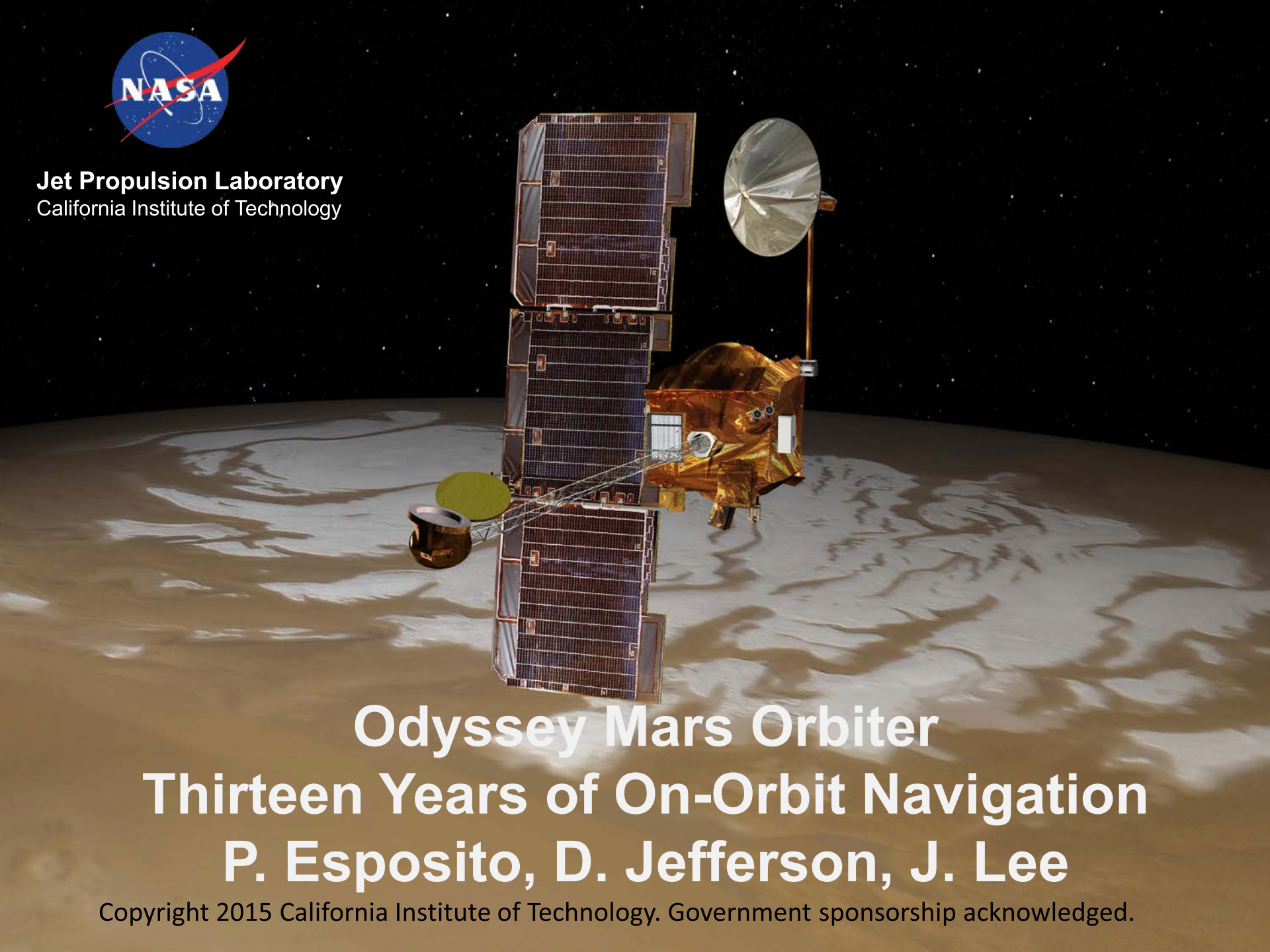

Odyssey Mars Orbiter
Thirteen Years of On-Orbit Navigation

P. Esposito, D. Jefferson, J. Lee

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Overview

- Orbit Characteristics
- Local Mean and True Solar Time: Science and Spacecraft Requirements
- Orbit Trim Maneuvers: Achieving the Requirements
- Phoenix and MSL Entry, Descent and Landing Over-flights
- Entry into Safe Mode – Impact on Trajectory Accuracy
- Trajectory Accuracy and Requirements
- Angular Momentum Desaturations and Resulting ΔV Perturbations
- Comet Siding Spring Mars Flyby, 10/19/2014

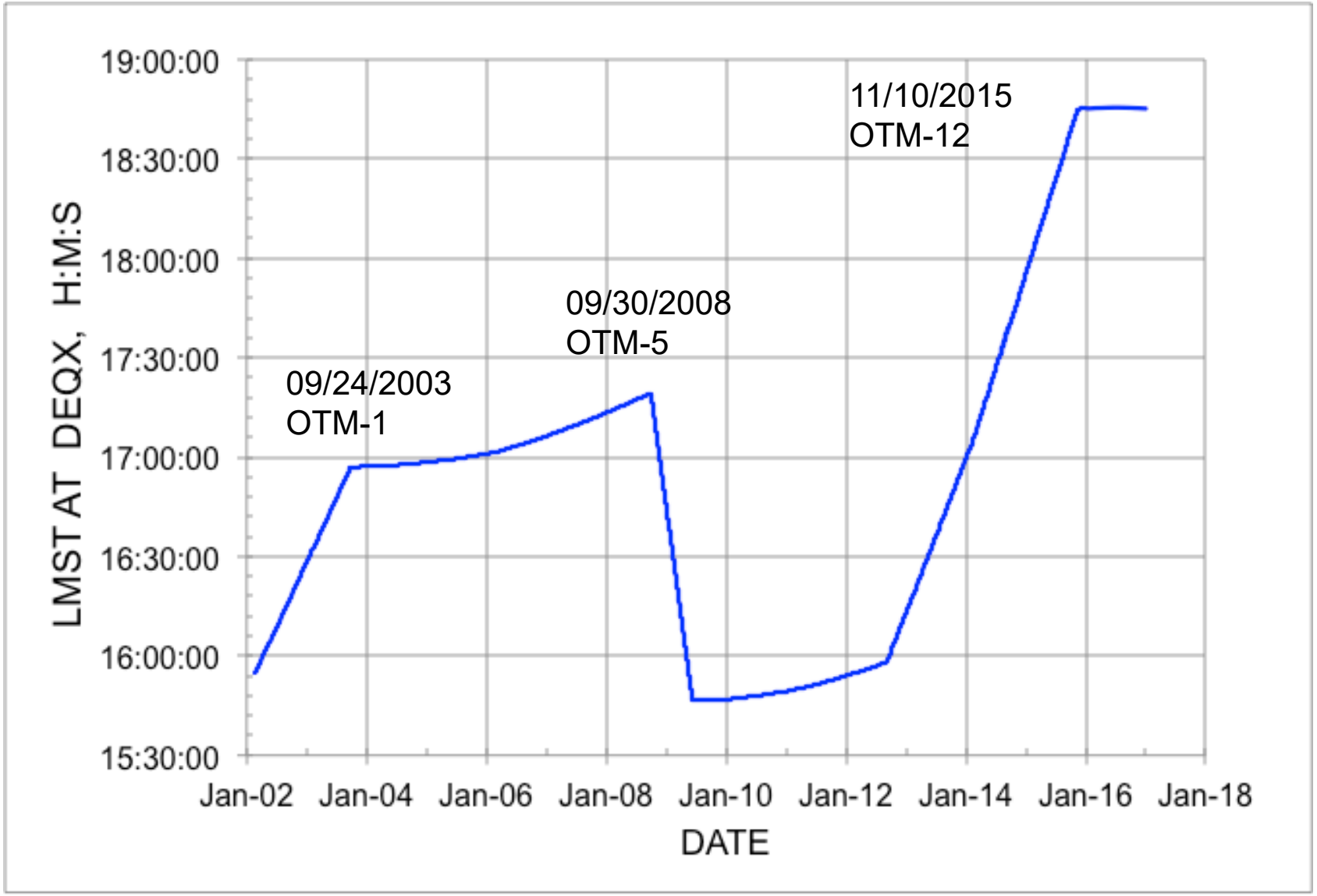
Odyssey Orbit - Osculating

Short Period, Circular, Polar and Sun Synchronous with the LMST Between 3-5 PM and a Frozen Orbit With ω Under Mars' South Pole

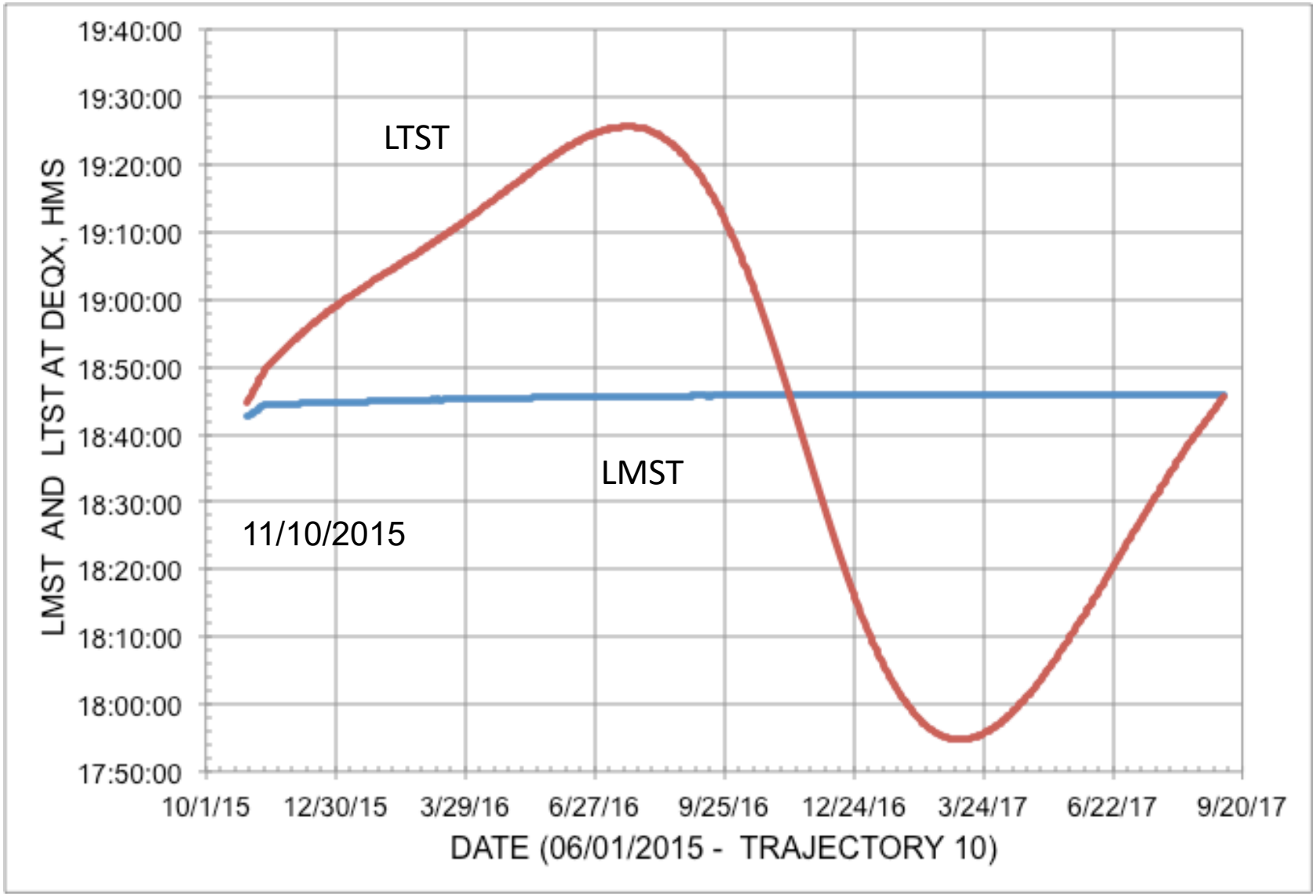
Epoch, ET	10/24/2015, 20:48:27
P, a, e (hour, km)	1.96, 3786.44, 0.0119
I, Ω, ω (deg)	93.24, 200.60, 267.82
Altitude, apoapsis (km)	455.73
Altitude, periapsis (km)	389.69

Mars Centered, Mars Mean Equator and Earth Mean Equator J2000

Local Mean Solar Time Throughout Mapping the Phase



Solar Time Variation After 11/10/2015 Maneuver

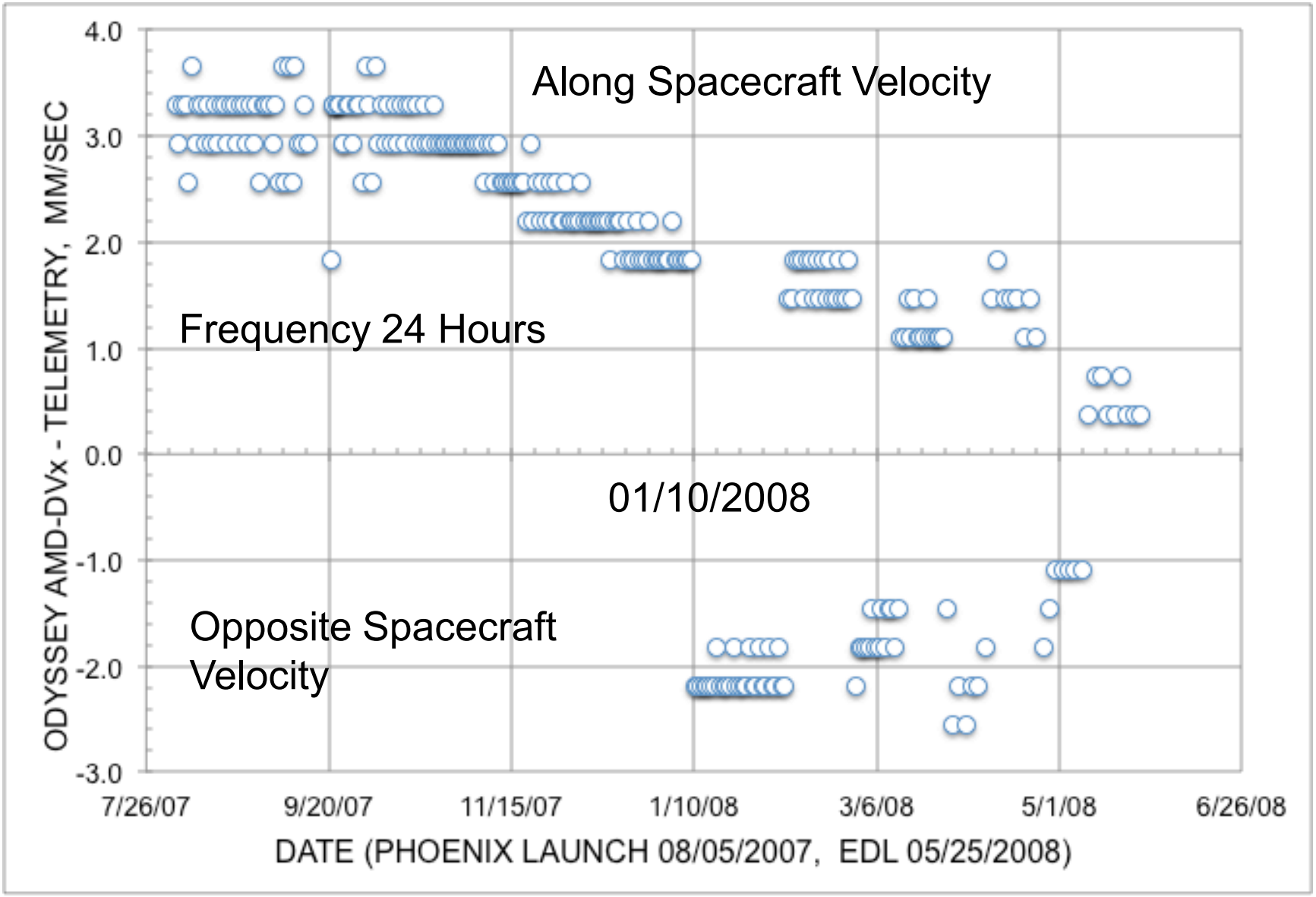


Orbit Trim Maneuvers: LMST and Over-Flight Control

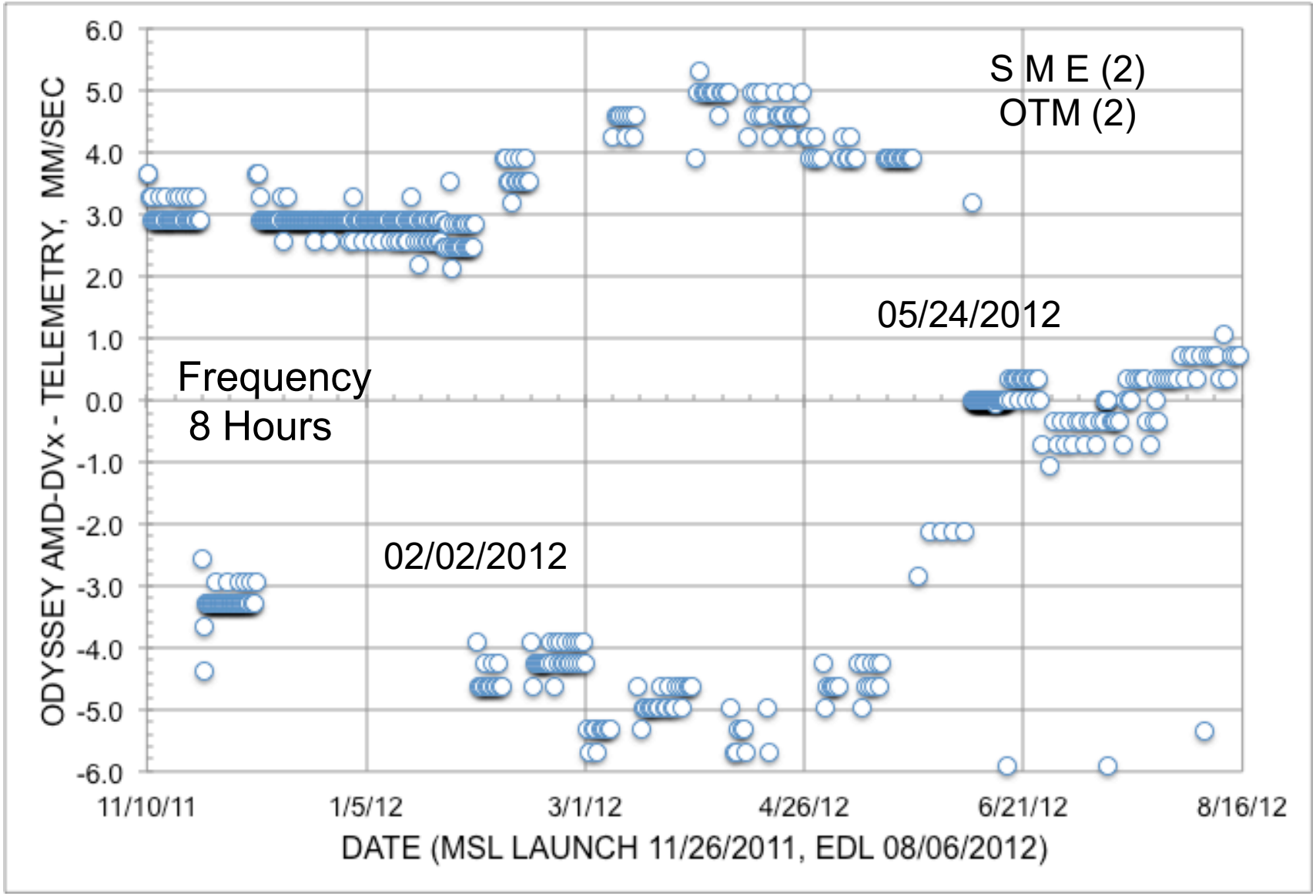
OTM	1	5	6	9	10	12
ΔI, deg	-0.16	-0.56	0.52	0.15	0.043	-0.22
ΔV, m/s	9.3	32.7	30.6	8.7	2.5	12.6
Fuel, kg	1.8	5.8	5.6	1.6	0.5	2.3
Date	9/24 2003	9/30 2008	6/09 2009	9/05 2012	2/11 2014	11/10 2015

OTM	2	7	8	11
ΔP, sec	3.25	0.41	-2.53	2.31
ΔV, m/s	0.50	0.063	0.38	0.36
Fuel, kg	0.17	0.03	0.09	0.09
Date	11/22/03	7/11/12	7/24/12	8/05/14
Over-flight	Spirit	MSL	MSL	CSS

Odyssey Angular Momentum Desaturation ΔVs



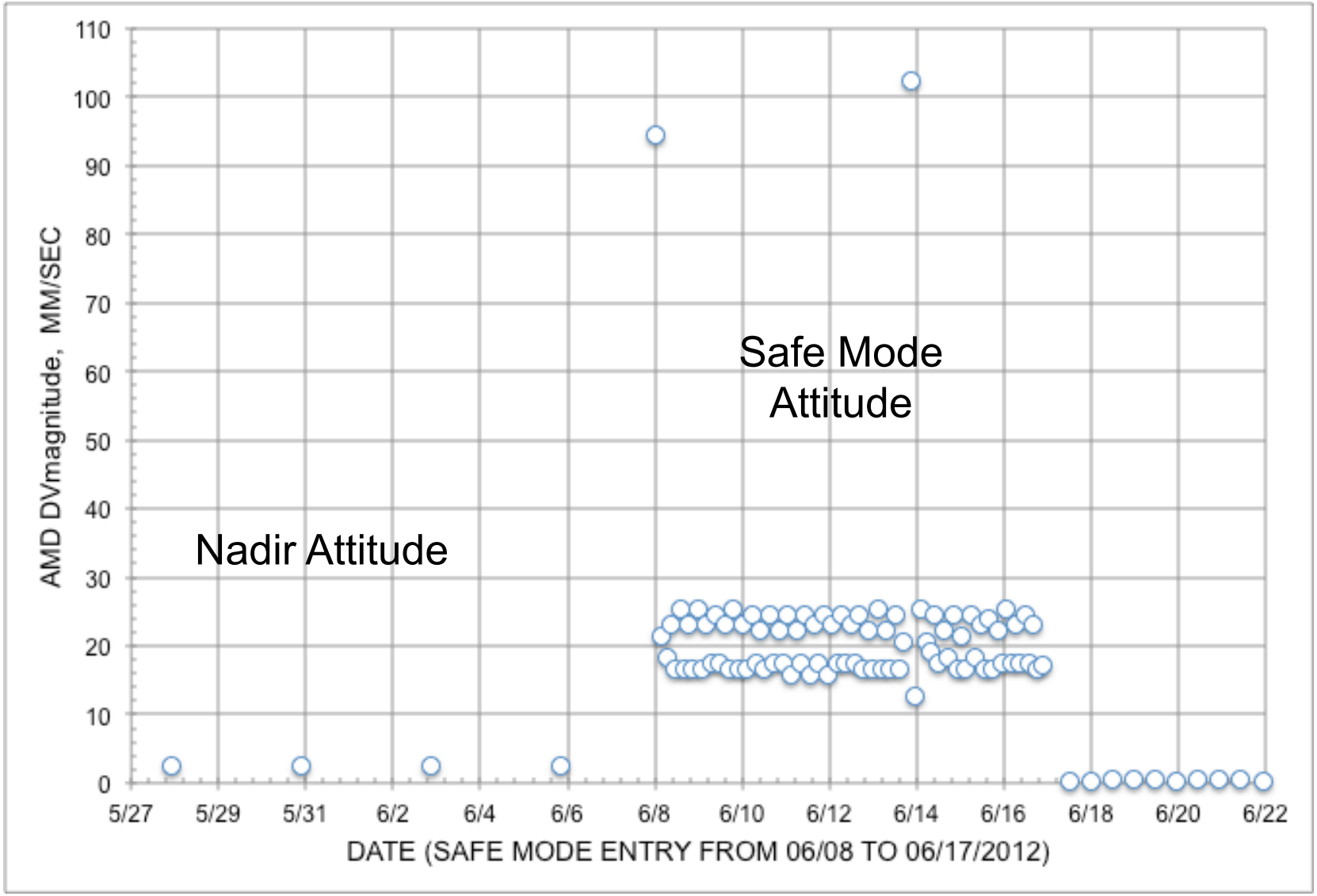
Odyssey Angular Momentum Desaturation ΔVs



Odyssey Safe Mode Entry and Resulting Timing Error

SME Date (duration, days)	Trajectory Date, To (days past To)	Tdeqx Error Rate (sec/day)
2010 July 14 (2)	06/28/2010 (16)	-4.7
2012 June 8 (9)	05/29/2012 (9)	2.7
2012 July 11 (1)	07/02/2012 (9)	-14.1
2012 Nov 5 (2.5)	10/15/2012 (21)	16.3 and 4.0
2013 Dec 8 (2)	12/02/2013 (6)	2.9
2011 and 2014	No SMEs	---

AMD ΔV During Safe Mode

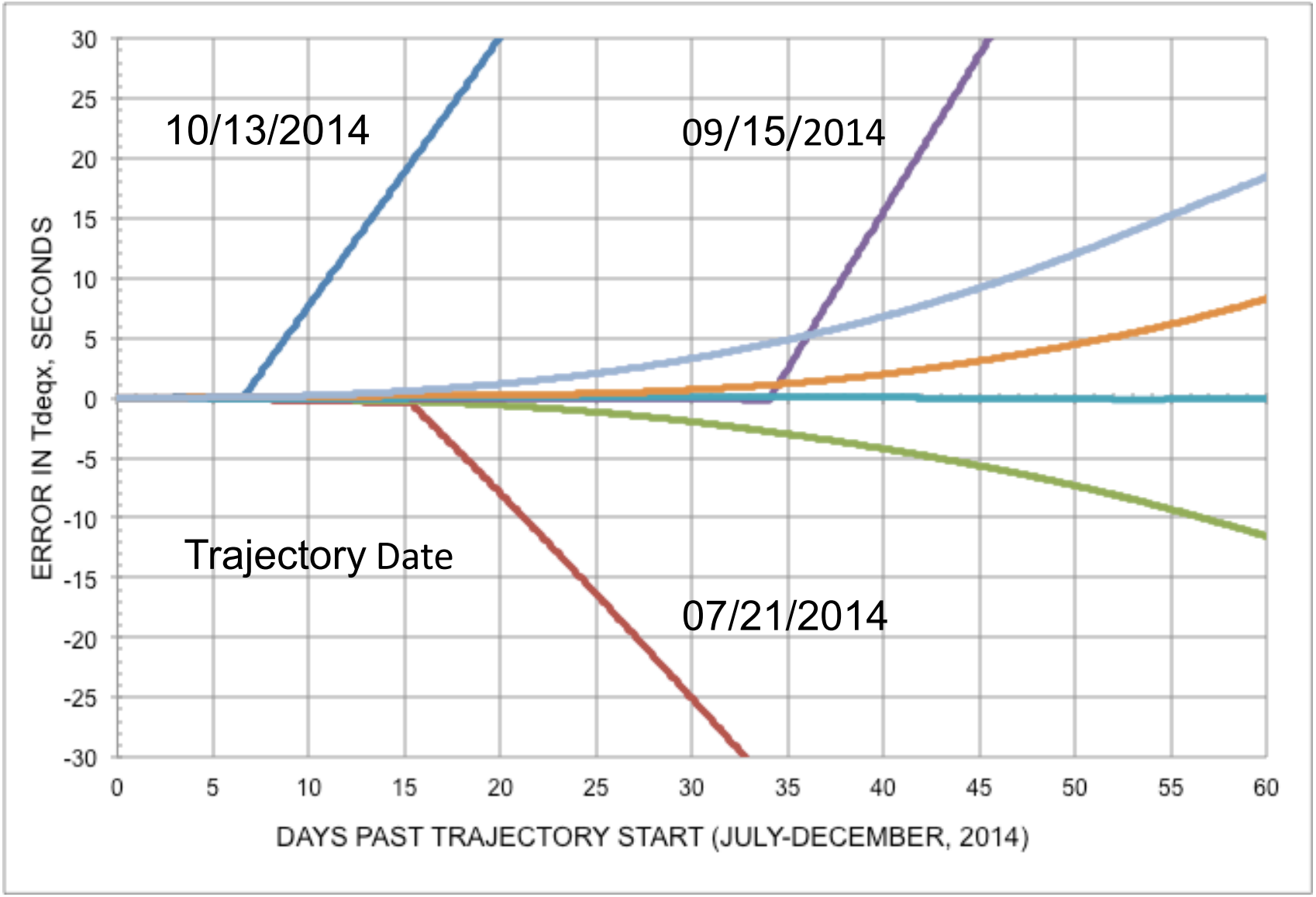


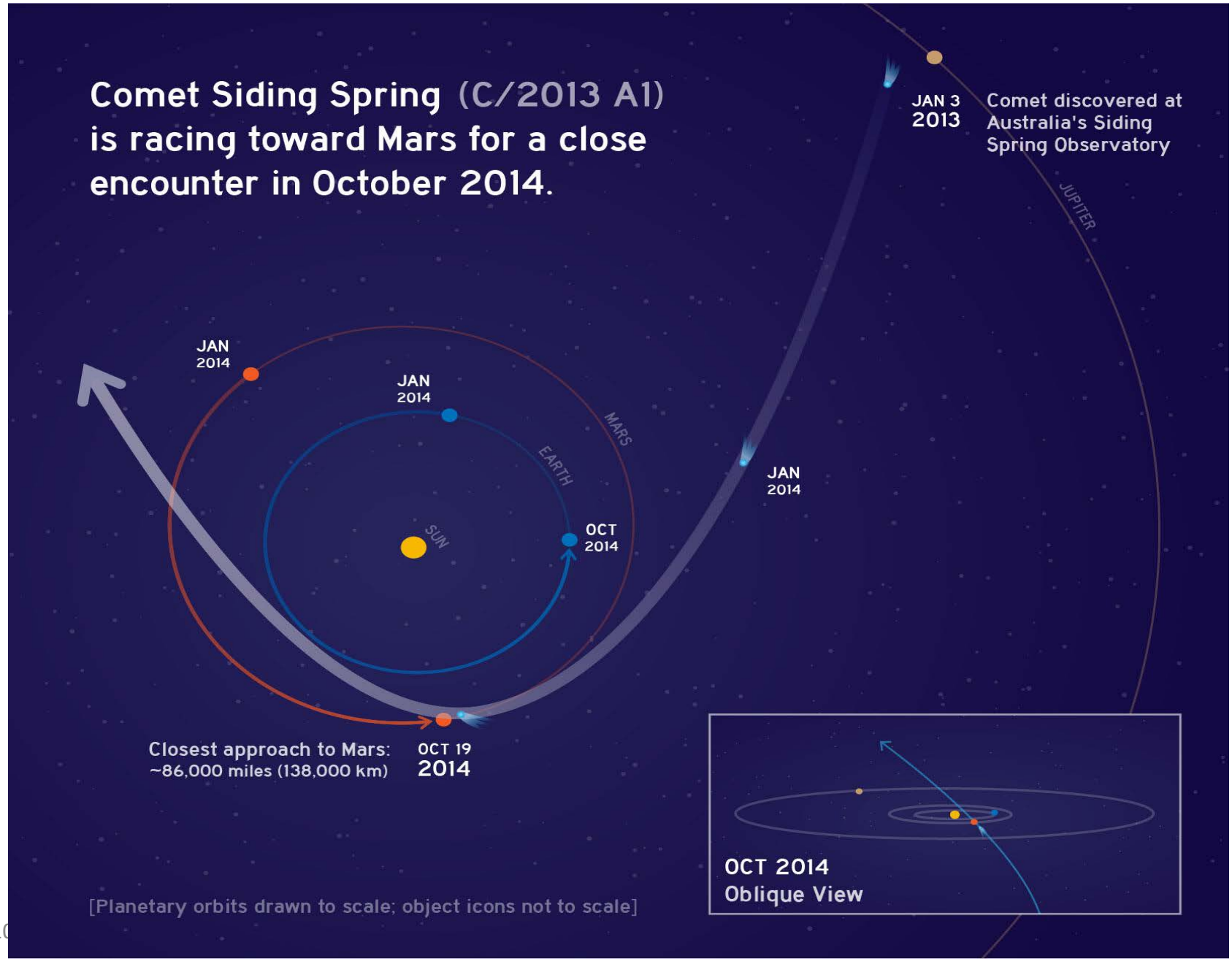
Tdeqx Error Due to Safe Mode Entry

Tdeqx Error (sec) After N Days – 2014

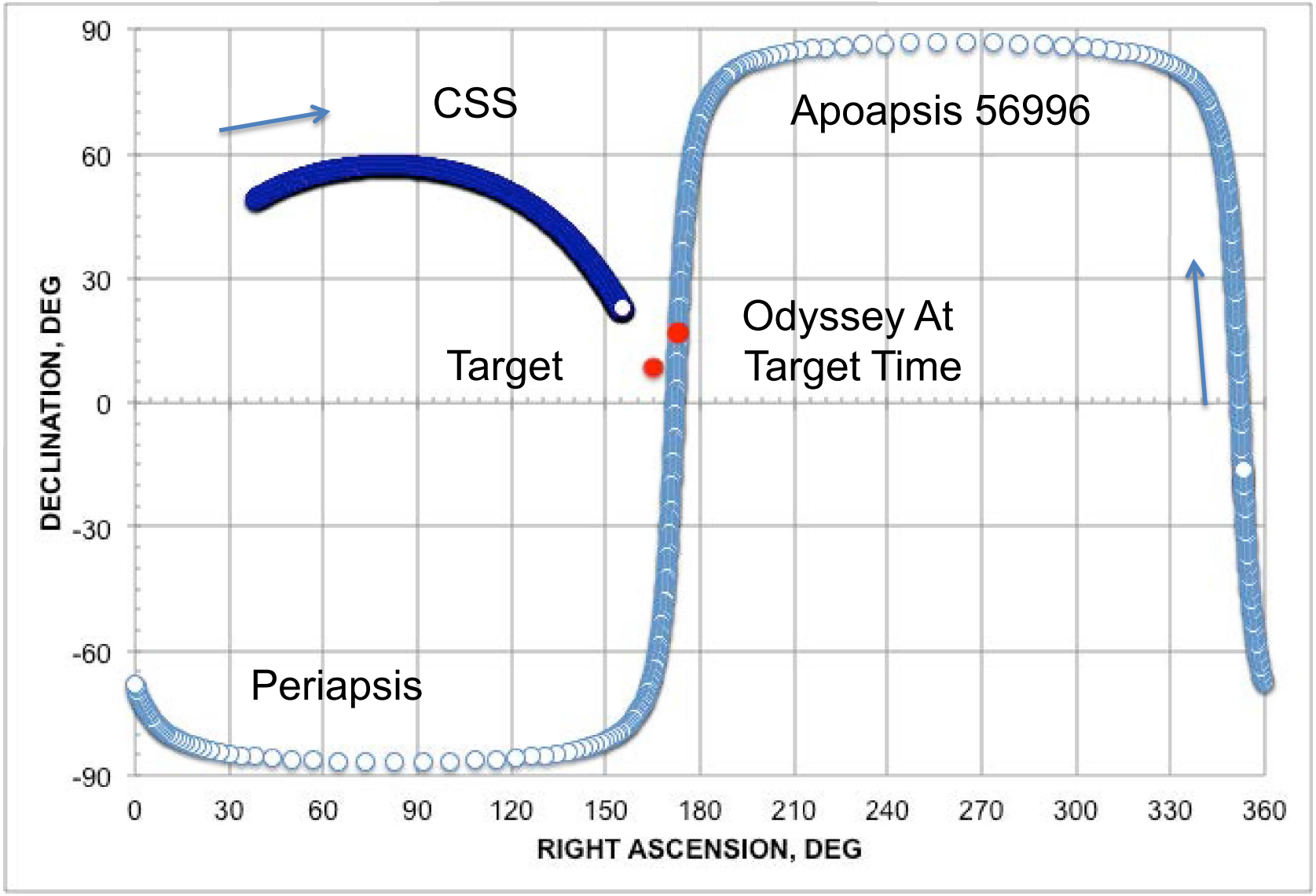
Traj Date	7 day	28 day	56 day	Comment (Days past To)
1/21/14	0.01	-3.96	-21.2	OTM-10 2/11/14 (21)
2/3/14	0.019	-10.5	-19.7	OTM-10 2/11/14 (8)
3/3/14	0.059	1.72	14.9	
3/31/14	0.097	3.14	19.6	
4/28/14	0.11	2.57	14.3	
5/27/14	-0.15	-2.64	-14.9	
6/23/14	0.014	-0.26	-23.4	OTM-11 8/5/14 (43)
7/21/14	-0.104	-21.6	-73.8	OTM-11 8/5/14 (15)
8/18/14	-0.034	-1.62	-9.72	
9/15/14	-0.009	-0.071	58.8	CSS DVs 10/19-21/14 (34)
10/13/14	1	49.3	114.9	CSS DVs 10/19-21/14 (6)
10/27/14	-0.019	0.11	-0.12	Exceptional Accuracy
11/24/14	0.083	0.54	6.55	
12/8/14	0.0743	2.75	15.9	

Tdeqx Error Over Sixty Days of Prediction

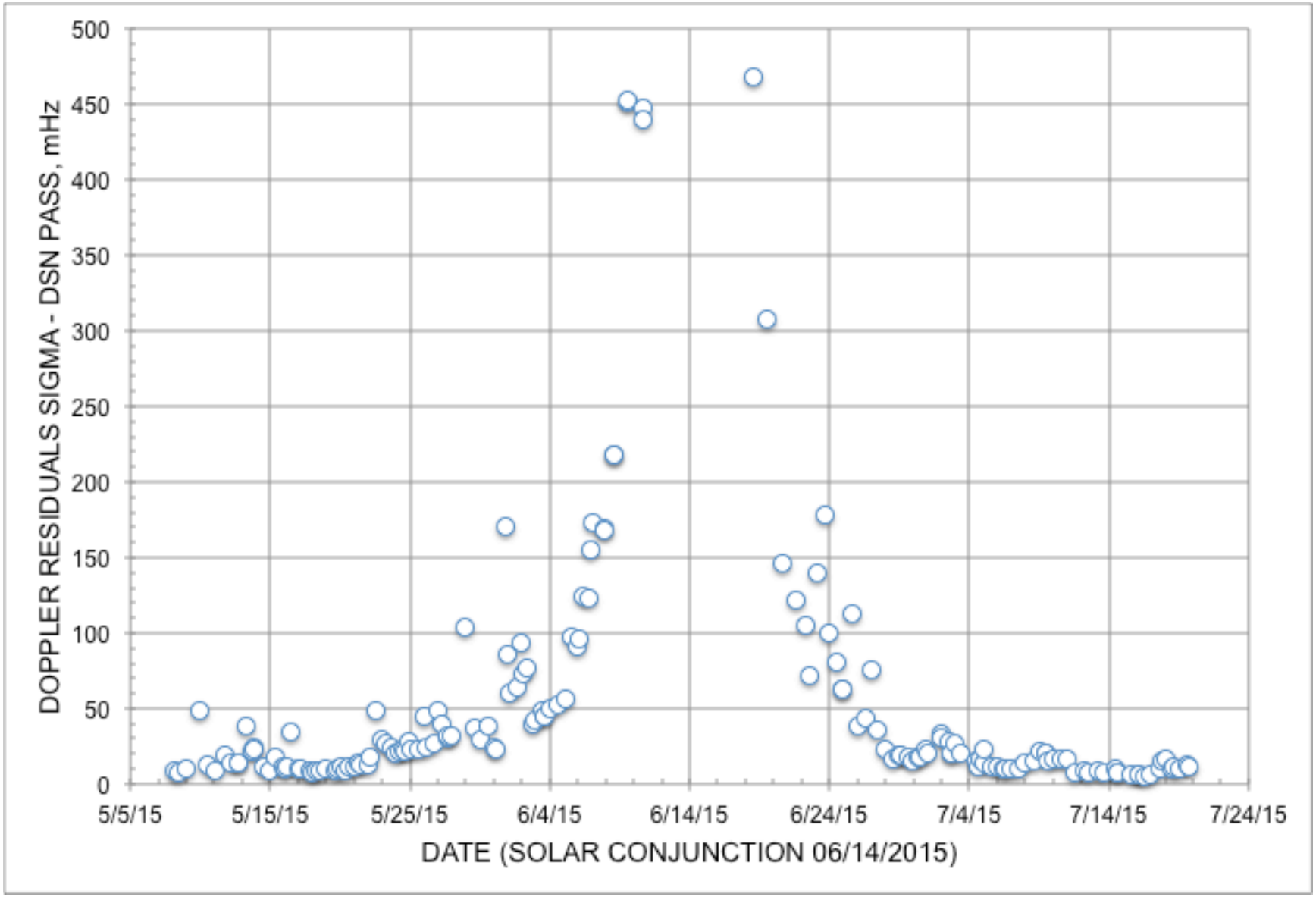



Comet Siding Spring (C/2013 A1) is racing toward Mars for a close encounter in October 2014.
JAN 3 2013
Comet discovered at Australia's Siding Spring Observatory
JUPITER
JAN 2014
JAN 2014
MARS
EARTH
SUN
OCT 2014
JAN 2014
Closest approach to Mars: ~86,000 miles (138,000 km)
OCT 19 2014
OCT 2014
Oblique View
[Planetary orbits drawn to scale; object icons not to scale]

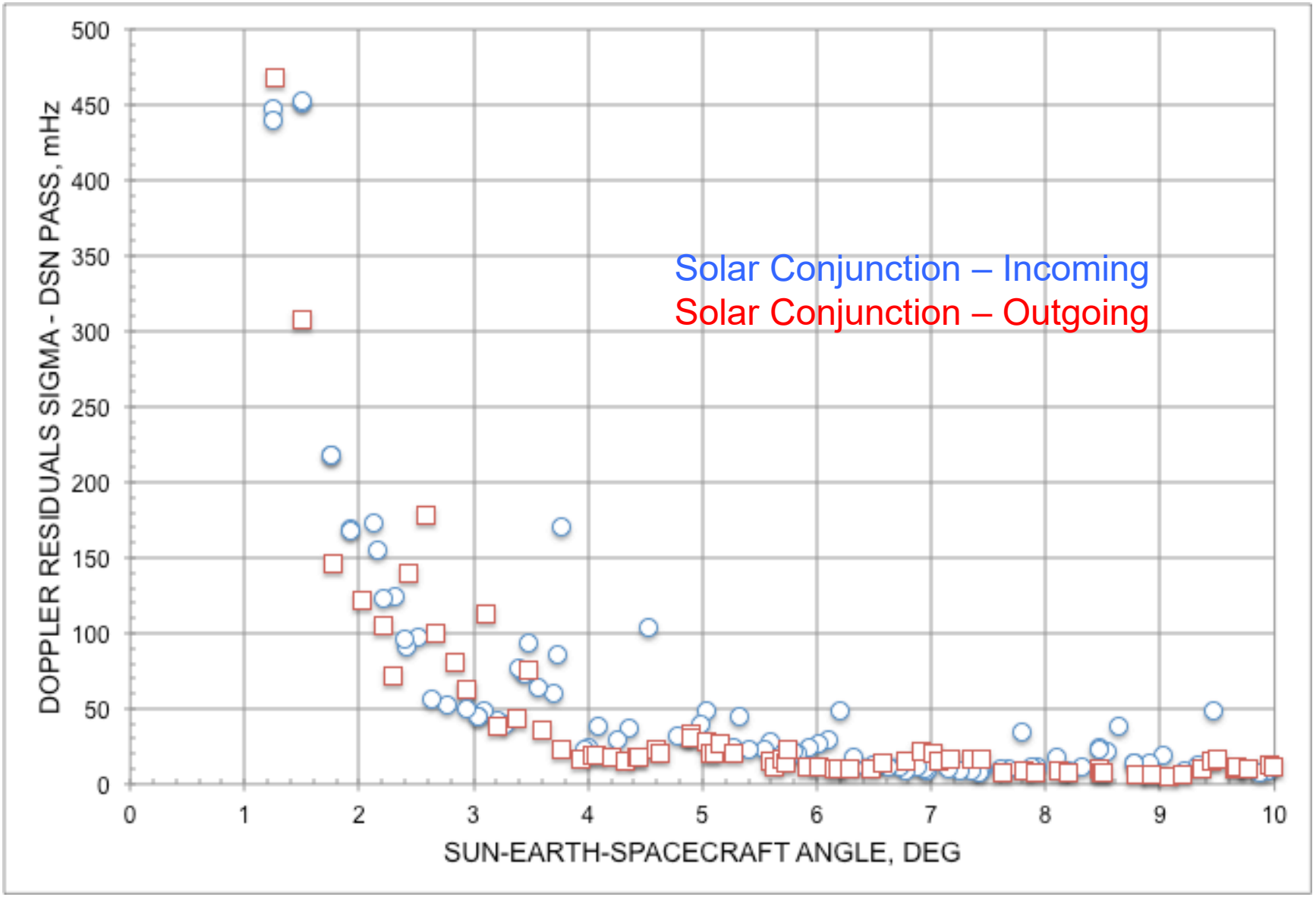
Odyssey Orbit During CSS Mars Flyby



Doppler Data Degradation – Solar Conjunction 2015

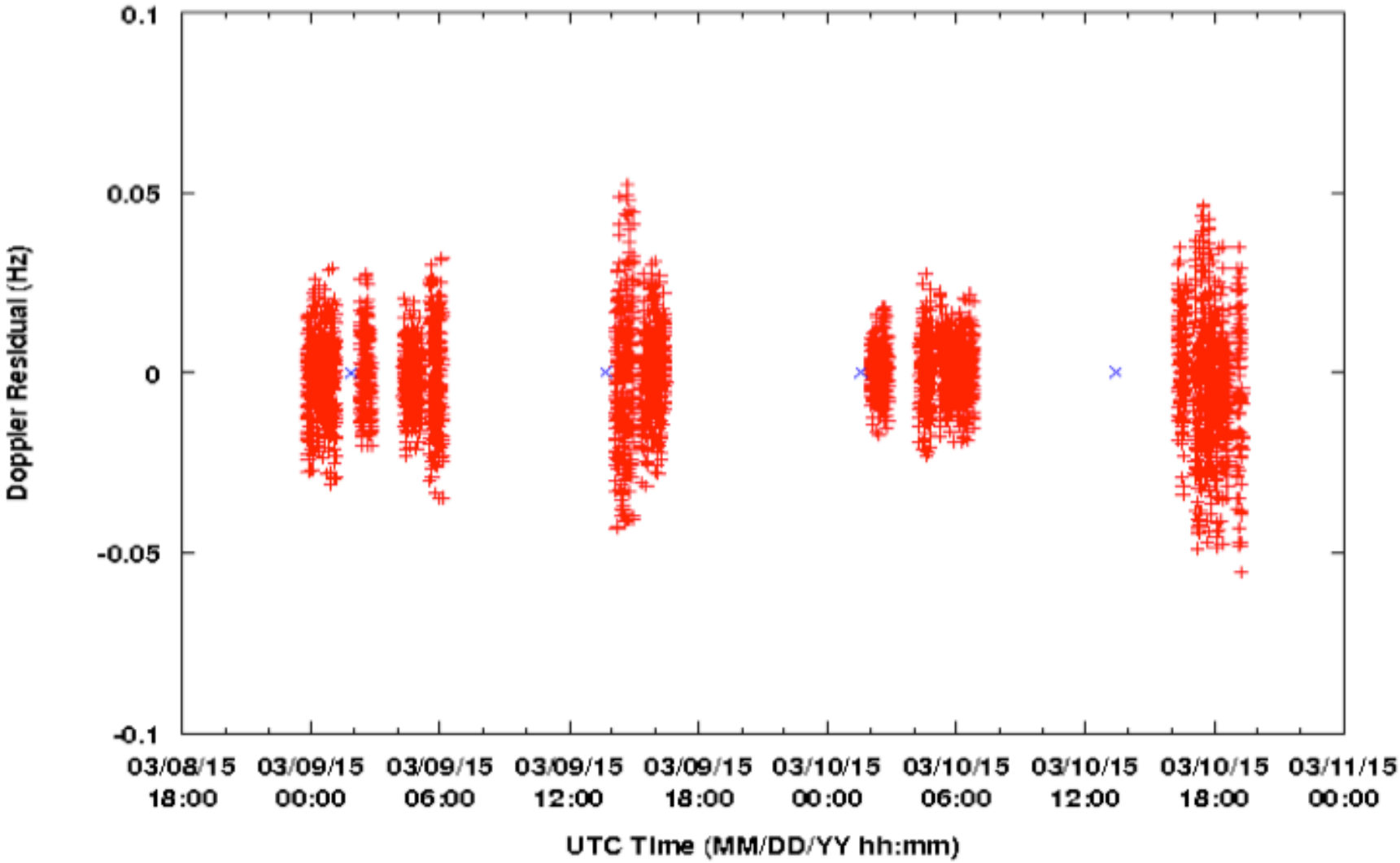


Doppler Data Degradation – Solar Conjunction 2015

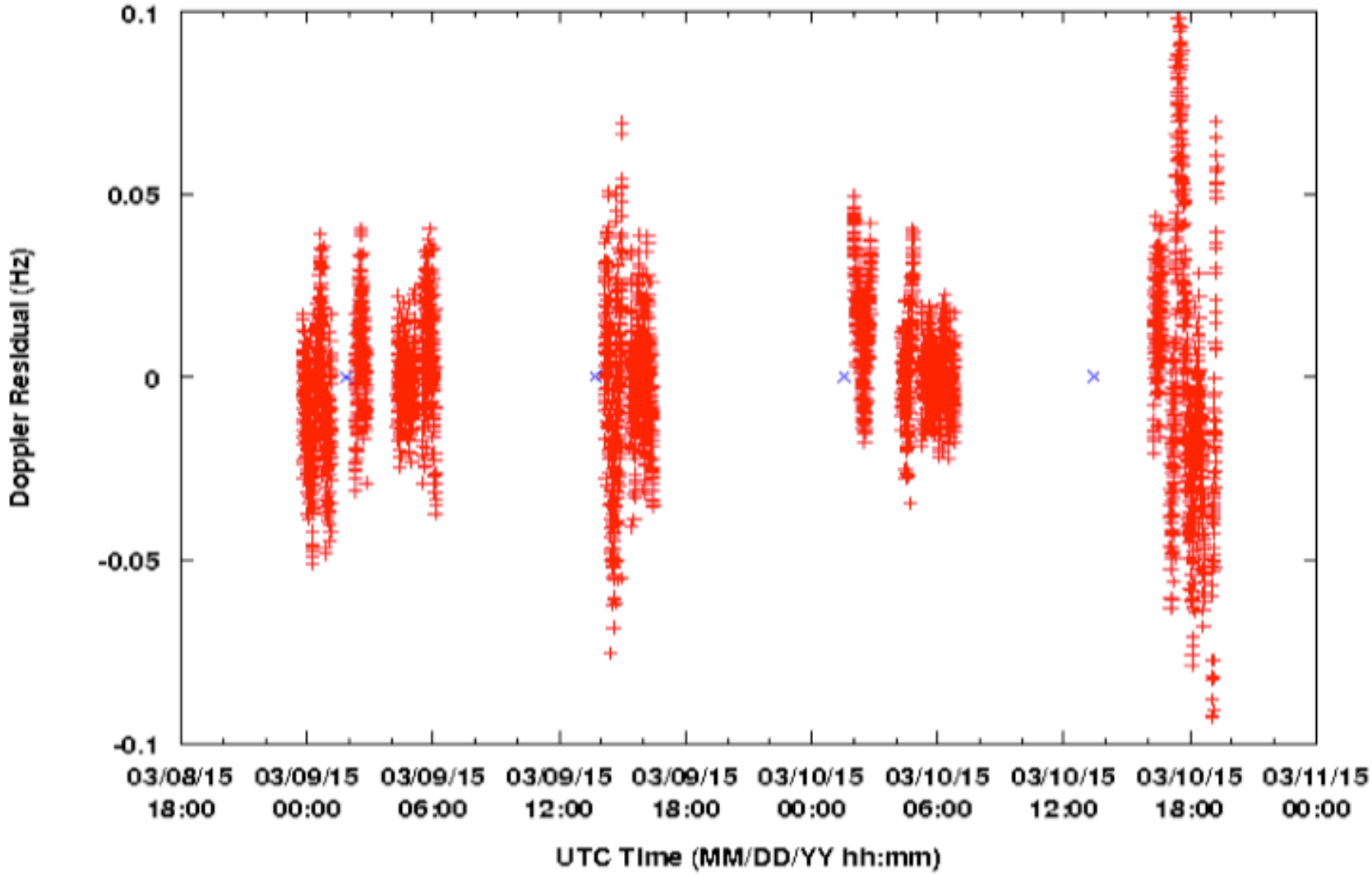


Back-Up Information

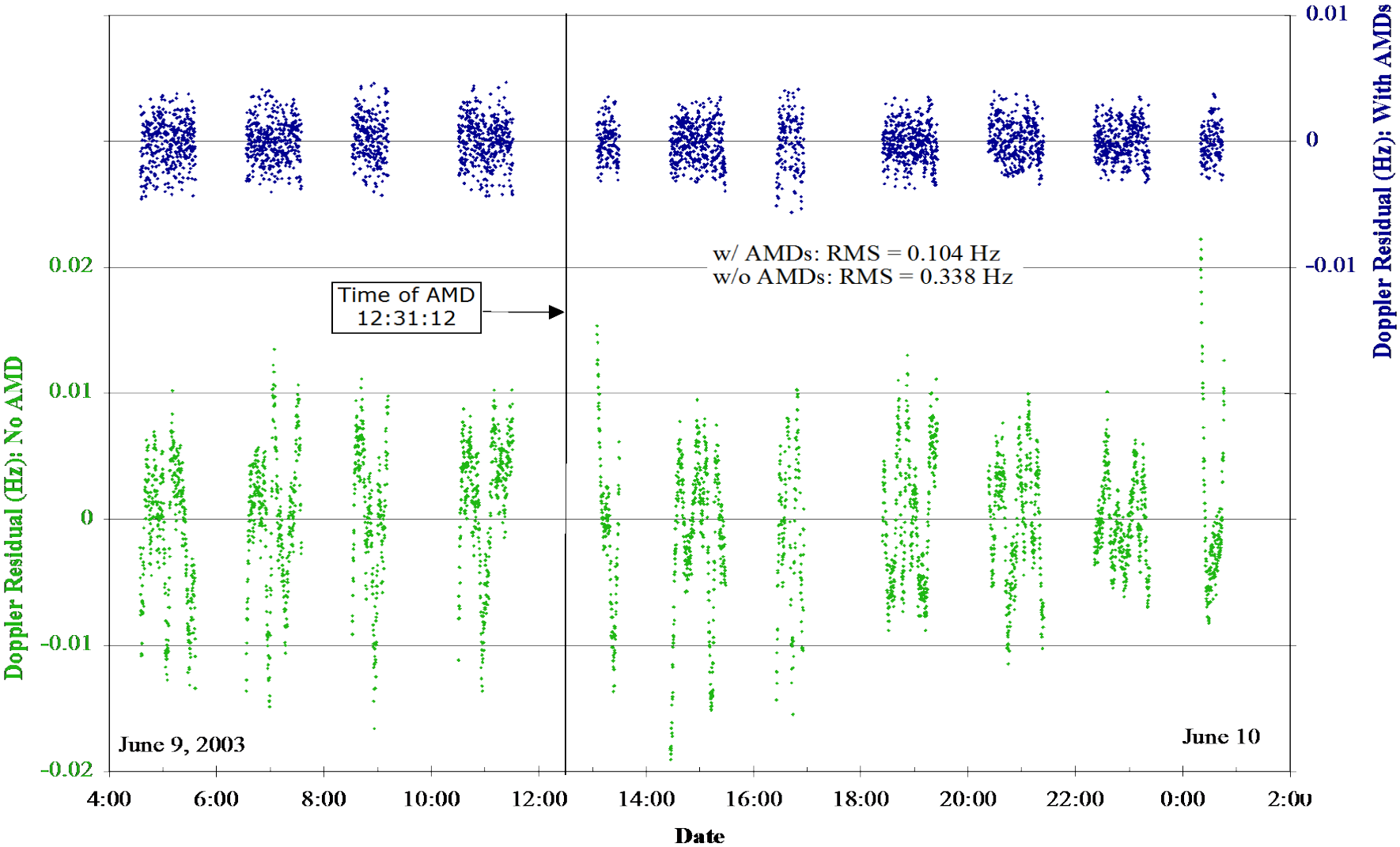
Doppler Residuals – Four AMD ΔVs Estimated

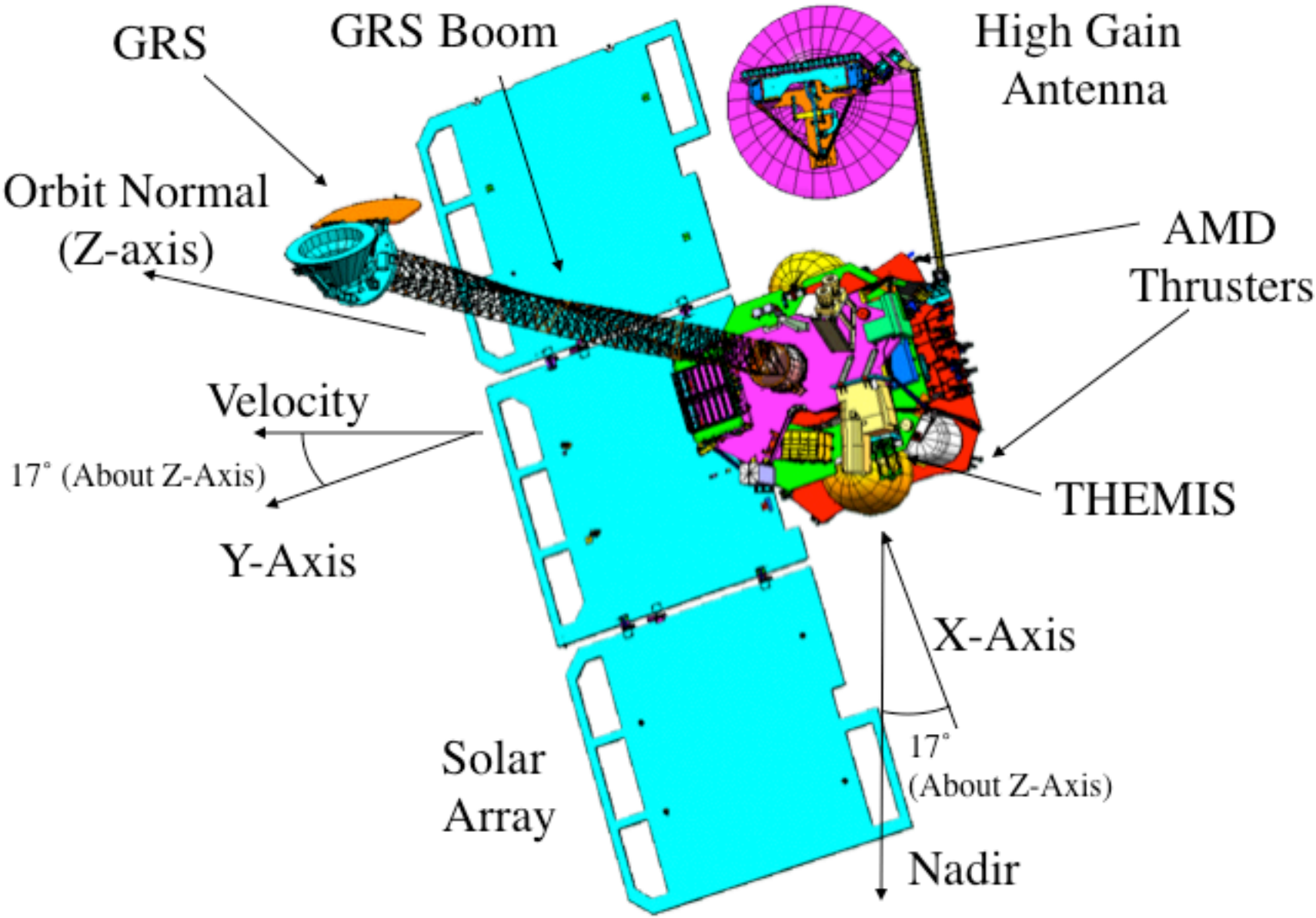


Doppler Residuals – No AMD ΔVs Modeled

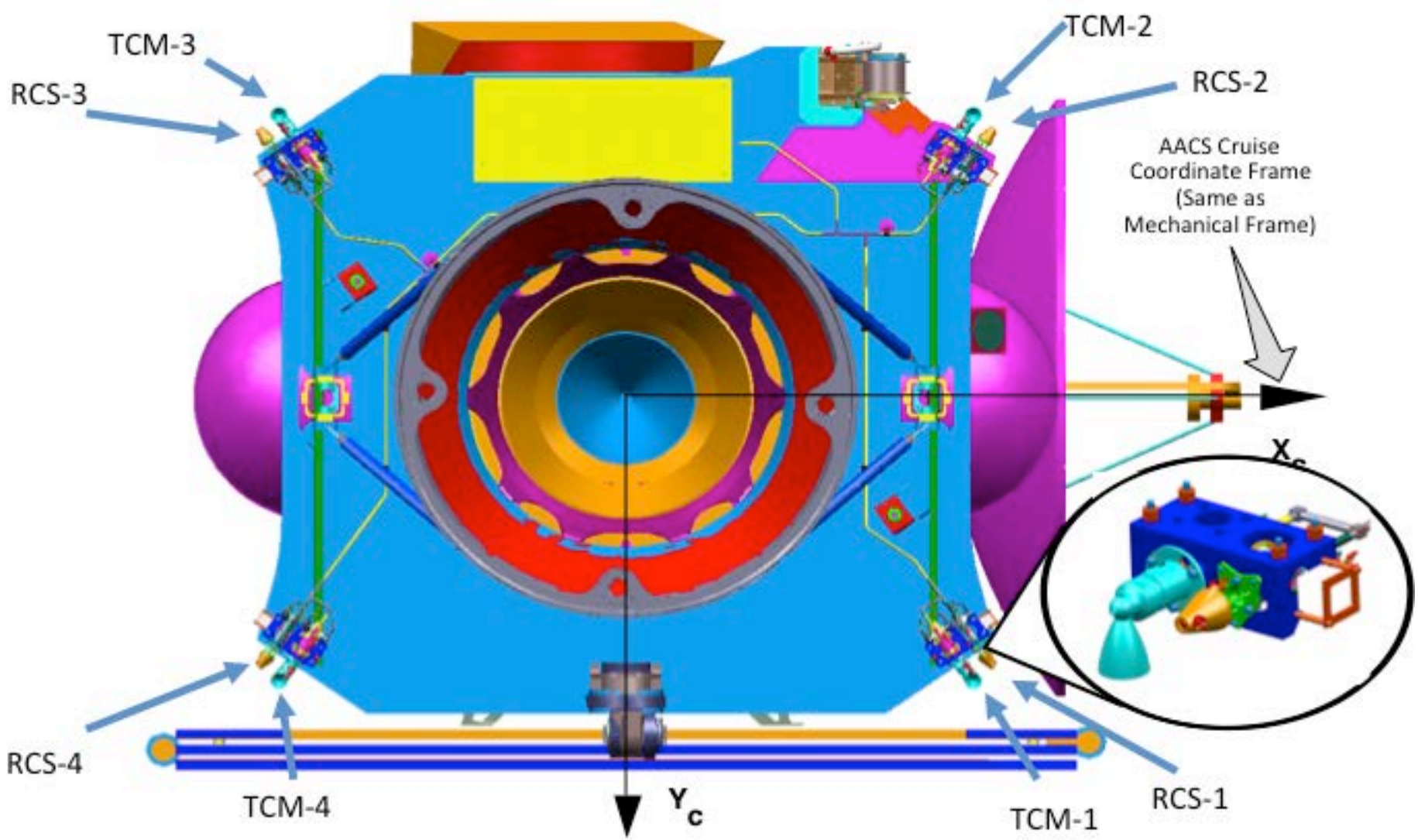


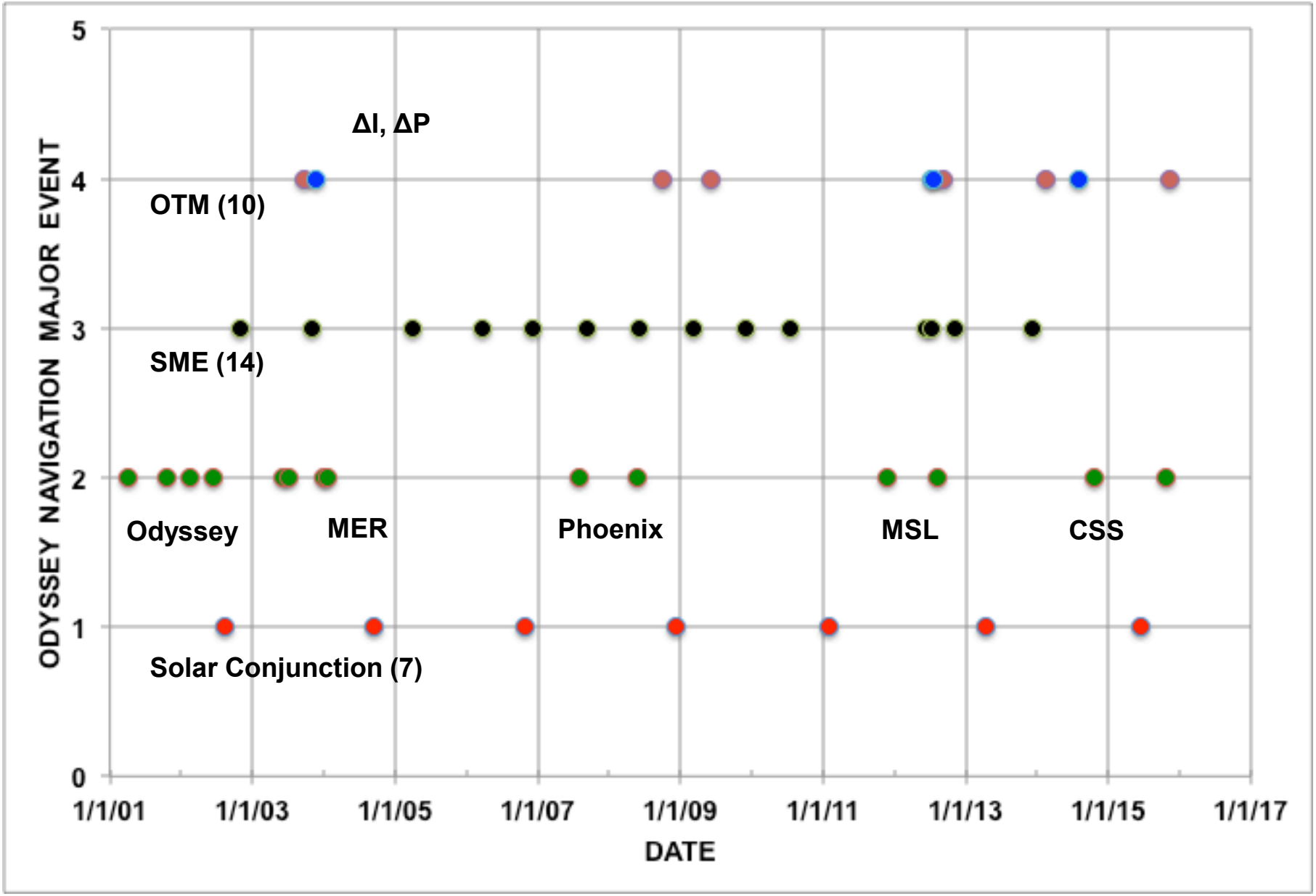
Doppler Analysis - AMD ΔV Estimation – Reconstructed Orbits




GRS
GRS Boom
High Gain
Antenna
Orbit Normal
(Z-axis)
AMD
Thrusters
Velocity
17° (About Z-Axis)
Y-Axis
THEMIS
X-Axis
17°
(About Z-Axis)
Solar
Array
Nadir

Spacecraft Thruster Configuration




ΔI, ΔP
OTM (10)
SME (14)
Odyssey
MER
Phoenix
MSL
CSS
Solar Conjunction (7)
ODYSSEY NAVIGATION MAJOR EVENT
5
4
3
2
1
0
1/1/01
1/1/03
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
DATE

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10/21/2015

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