

Scheduling Experience in Two Gyro Mode

April 20, 2006

Rodger Doxsey

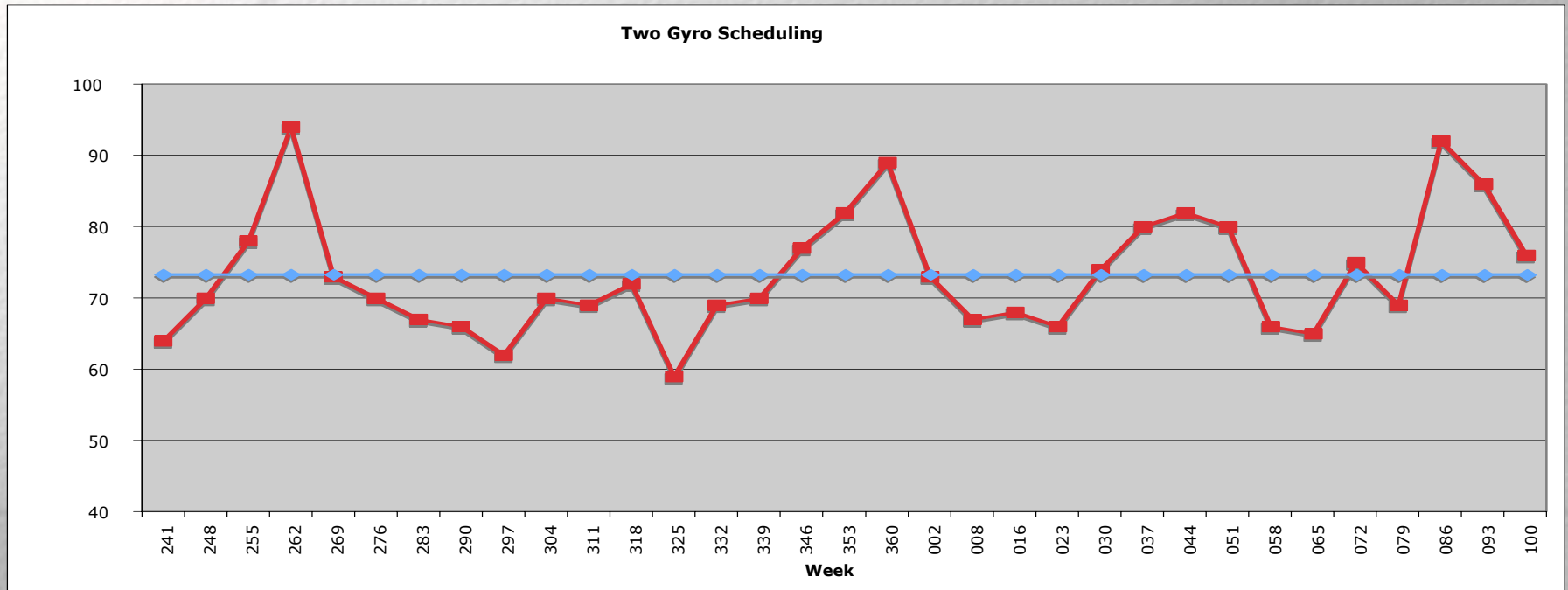
Scheduling Topics

- Reminder of Two Gyro expectations
- Summary of Two Gyro scheduling performance
 - ◆ *Achieved Orbits/week*
 - ◆ *Two Gyro system improvements*
 - ◆ *Cycle 14 Progress*
 - ◆ Large and Treasury Programs
 - ◆ Other C14 programs
 - ◆ Targets of Opportunity
 - ◆ Snapshots
- Scheduling directions in the future

Expectations for Two Gyro Mode

- Criteria for switching to Two Gyro Mode was to gain 2000 orbits relative to staying in Three Gyro Mode
 - ◆ Based on gyro lifetime models, this requires an effective rate of 67 successful orbits/week
 - ◆ Expected 2% failure rate implied we need to schedule 68.5 orbits/week
 - ◆ Three gyro scheduling rate was 80 orbits/week
- To date, we are averaging 73.3 orbits/week
 - ◆ Failure rate has been 3.62%
 - ◆ Effective rate has been 70.6 orbits/week

Scheduling performance - Orbits

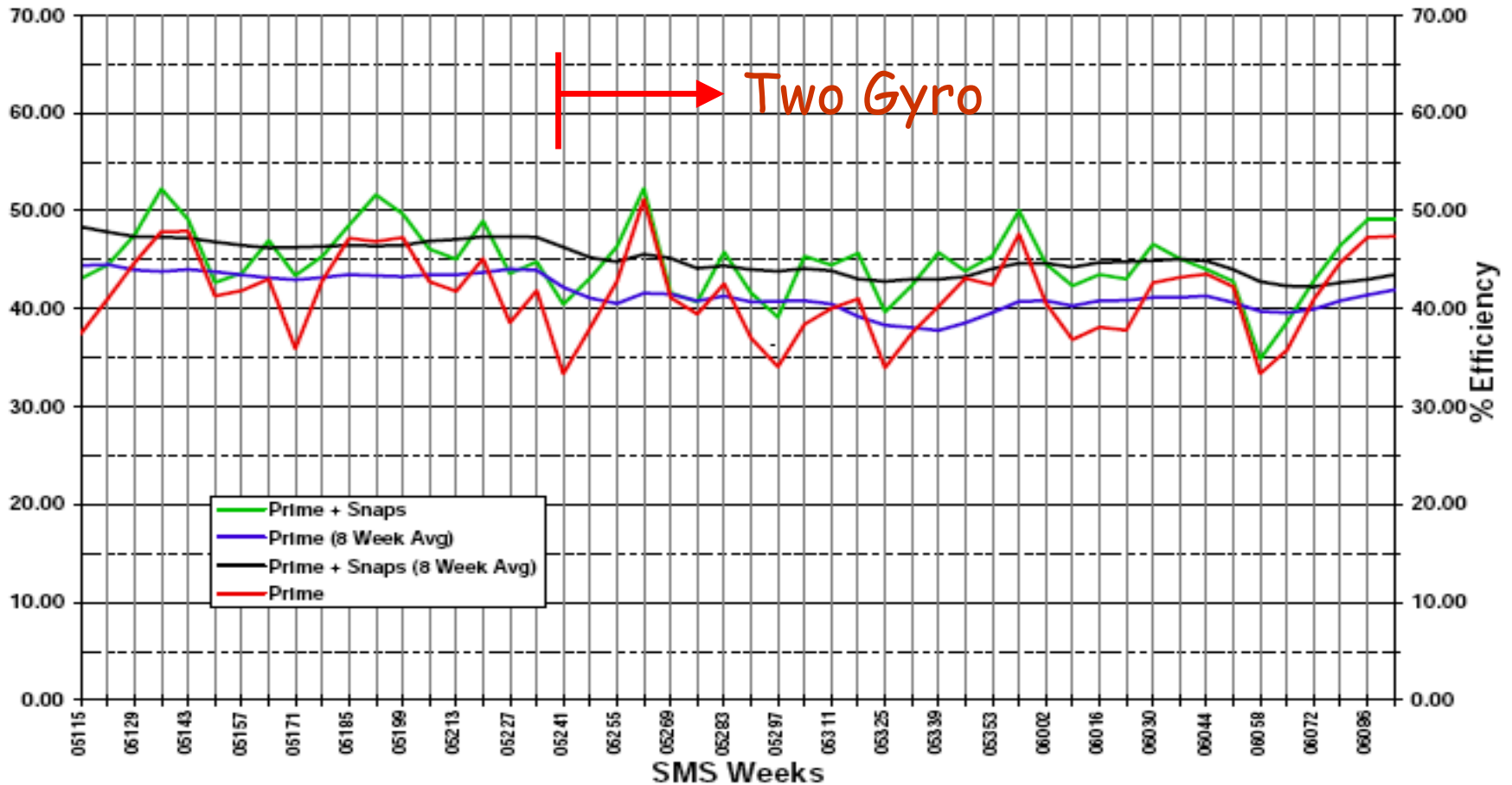


- Through April 10, we have averaged 73.3 orbits per week, scheduled
- Peaks and valleys are due to SAA interactions

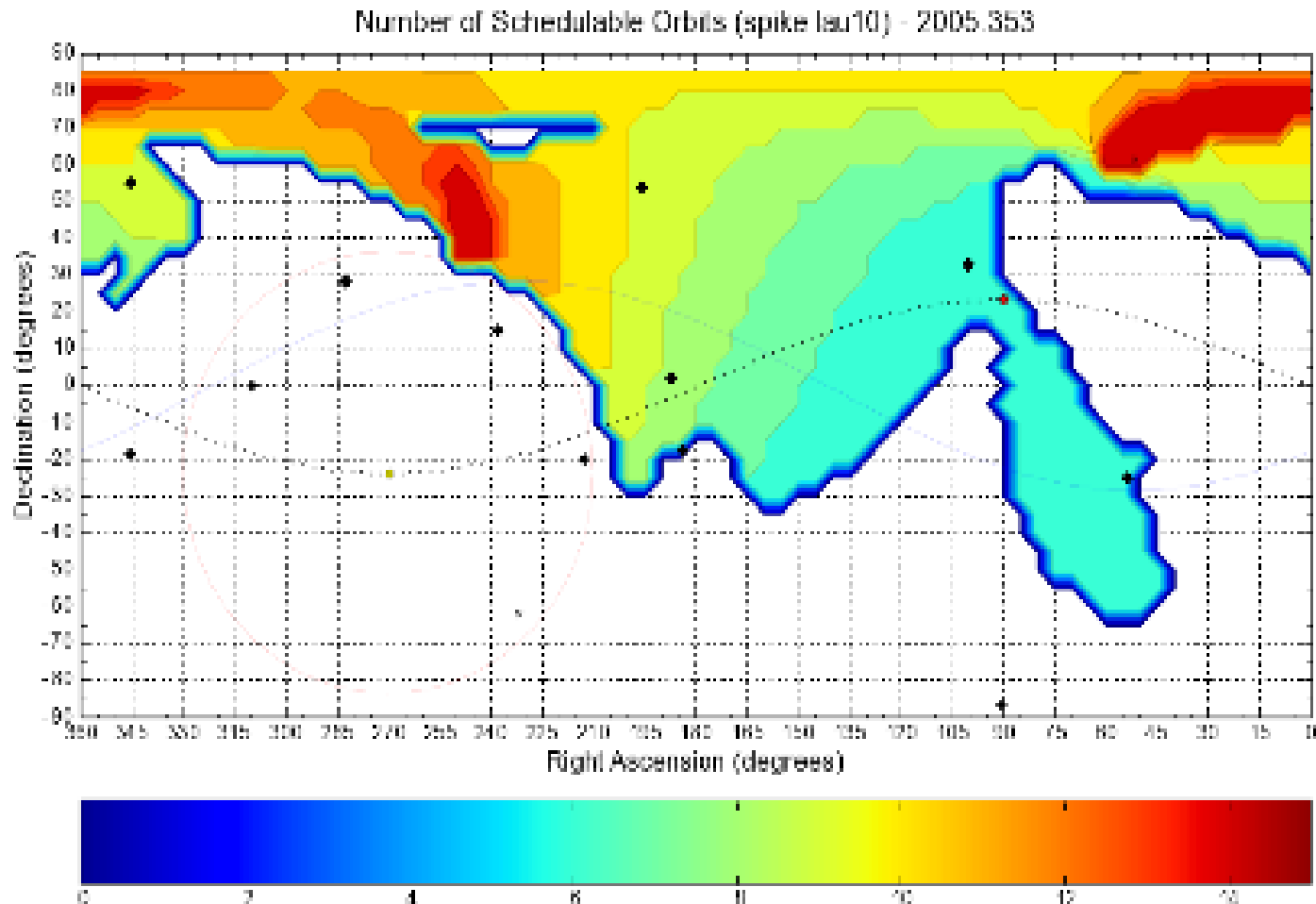
Scheduling Performance - Efficiency

Spacecraft Time Scheduling Efficiency

SMS 05115-06093 (as of 03/29/06)



SAA interacts with Two Gyro mode



Two Gyro Acquisition success rate

- Three Gyro Success rate in 2005: 99.02%
- Two Gyro Success rate: 96.38%
 - ◆ Bad guide star rate is the same (~1%)
 - ◆ Additional failure rate (~2.6%) is due to errors in the FHST portions of acquisitions, prior to Guide Star Acq
- FHSTs are much more critical in Two Gyro mode
 - ◆ Various causes for failures have been identified and are being addressed with FSW changes, Acquisition Logic changes, etc.
 - ◆ Expect failure rate to come down as various failure scenarios are identified and fixed

Two Gyro Improvements

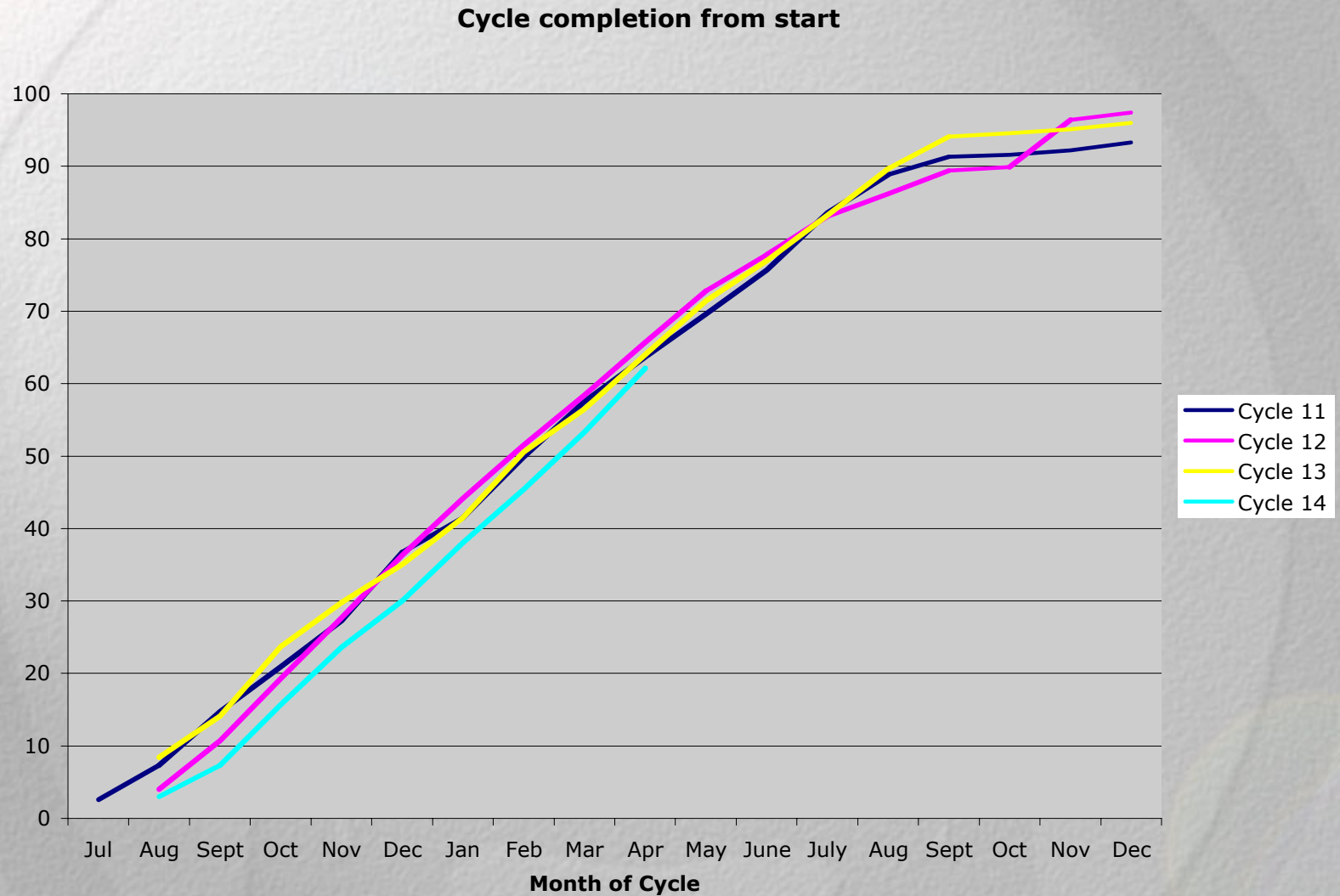
- Timing changes improve schedulability
- Reduced Earth avoidance angle will improve schedulability
- Additional roll flexibility being investigated

Date	IRC	OBAD1	OBAD2	GOB	GSACQ	End-to-End Time	Total FHST Time
Feb 2005 OOT	3.0 ^m	10.25 ^m	8.25 ^m	4.25 ^m	8.15 ^m	29.65 ^m	27.78 ^m
At Time of TGM Entry	3.0 ^m	9.75 ^m	4.42 ^m	4.25 ^m	8.15 ^m	25.32 ^m	23.45 ^m
Nov 1 Update	2.5 ^m	8.25 ^m	4.42 ^m	2.43 ^m	7.68 ^m	22.85 ^m	19.63 ^m
Feb 27 Update	1.6 ^m	7.4 ^m	4.25 ^m	2.43 ^m	7.68 ^m	20.93 ^m	17.71 ^m
April 3 Update	1.6 ^m	7.4 ^m	4.08 ^m	2.58 ^m	8.15 ^m	21.23 ^m	17.53 ^m
Total Diff	-1.4 ^m	-2.85 ^m	-4.17 ^m	-1.67 ^m	0.0 ^m	-8.42 ^m	-10.25 ^m

Progress on Cycle 14

- Execution of Cycle 14 program is proceeding well
 - ◆ Scheduling team has adjusted quickly to two gyro mode
- Recent DDs -
 - ◆ Weaver - *“Confirm the Discovery of Two New Satellites of Pluto”*
 - ◆ Mountain - *“ACS Mosaic of M82”*
 - ◆ Choi - *“Observations of the Active Centaur 60558 2000 EC98”*
 - ◆ de Pater - *“Quit Winking: Jupiter Opens its Other Eye”*
 - ◆ Simon-Miller - *“Rapid Response: Jupiter’s White Oval Turns Red”*

Cycle 14 Orbit Execution Rate



Cycle 14 Treasury/Large Programs

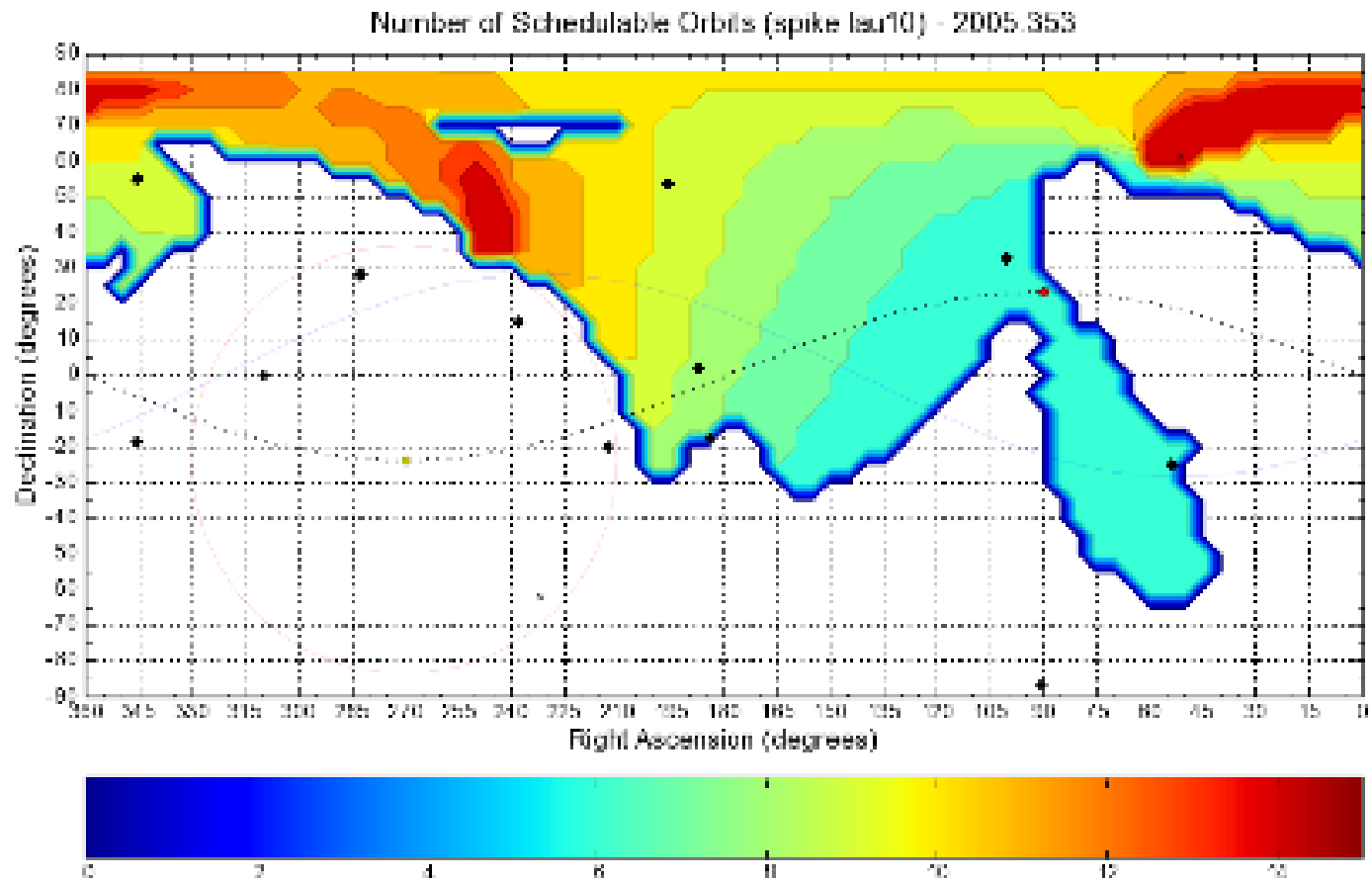
Program	Title	PI	This week	Observed	Allocated	% complete	Timeline
10496	Dark Energy Studies	Perlmutter	1	132	219	60.3%	
10602	Galaxies at z>6.5	Sheth	0	113	204	55.4%	June
10500	BARS	Malhotra	0	200	200	100.0%	
10705	Bubular Cluster	Sarajedini	2	58	134	43.3%	April-J
10504	cosmic Reionization	Edis	0	31	110	28.2%	May-Aug
10506	Neutral Gas Survey	Turnshek	3	73	109	67.0%	
10507	Gamma-ray Bursts	Kulkarni	0	2	100	2.0%	
10509	Star Formation	Gallart	0	14	97	14.4%	April, J
10512	Infrared Galaxies	Evans	2	62	88	70.5%	
10610	Extrasolar Planets	Benedict	0	69	72	95.8%	
10508	Star Formation	Da Costa	0	0	69	0.0%	May/Ju
10497	SN/Hubble Correlat	Ries	0	64	68	94.1%	
	as of Apr 9:	total:	8	818	1470	55.6%	
		%		56%			

Targets of Opportunity

PI	prop_	allocated	completed	scheduled	unplanned	left to
Perlmutter	10496	219	112	72	35	160
Smartt	10498	8	1	0	7	880
Grundy	10508	12	5	3	4	330
Bennett	10544	4	2	0	2	500
Kulkarni	10551	100	2	9	89	890
Berger	10616	24	6	0	18	750
Fox	10624	42	18	0	24	570
Tanvir	10633	22	2	0	20	910
	GRBs	188	28	9	151	800

- Backlog of unexecuted ToOs in Spring is common
- GRBs are *SWIFT* activated

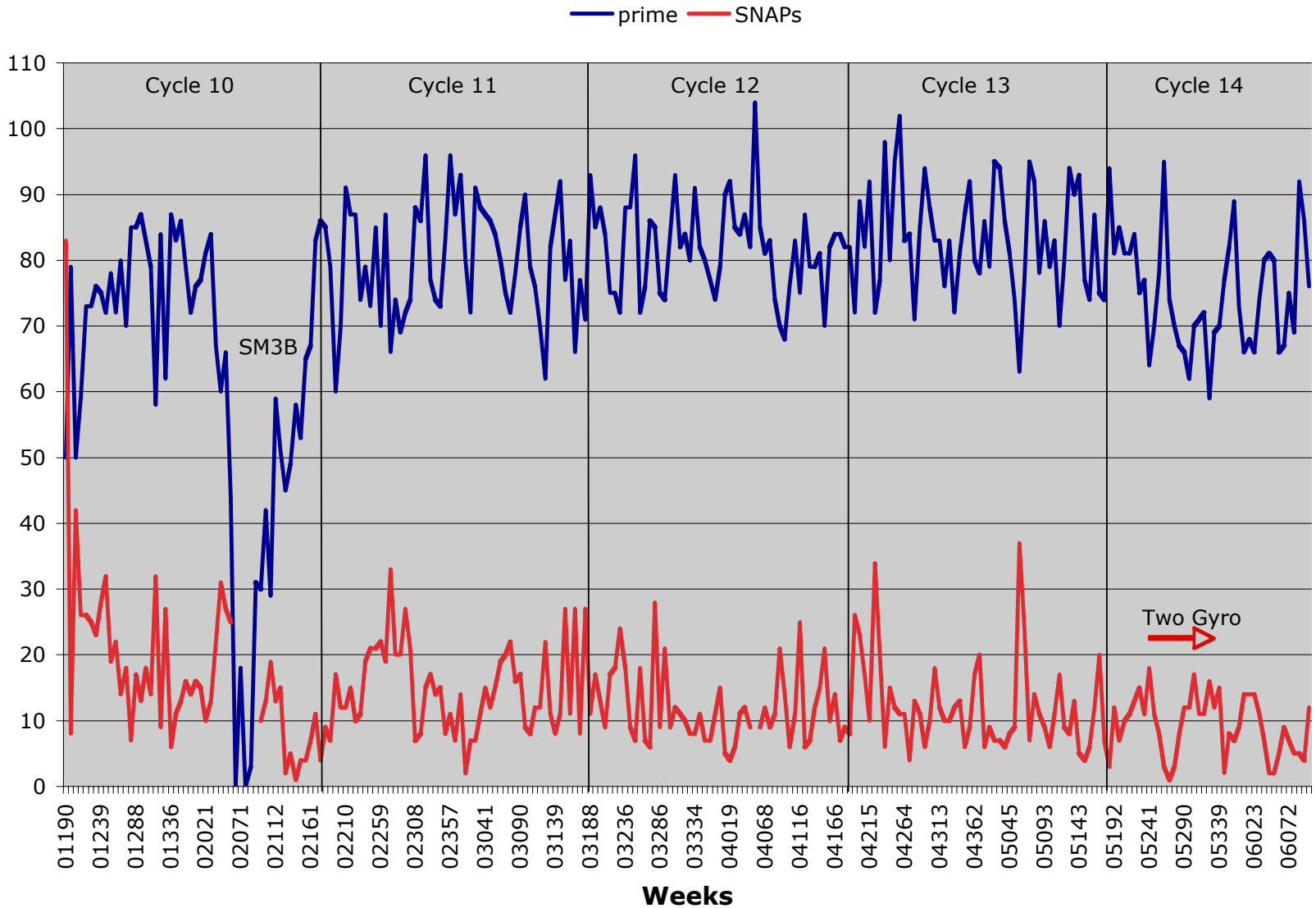
Swift Pointings



Snapshot scheduling

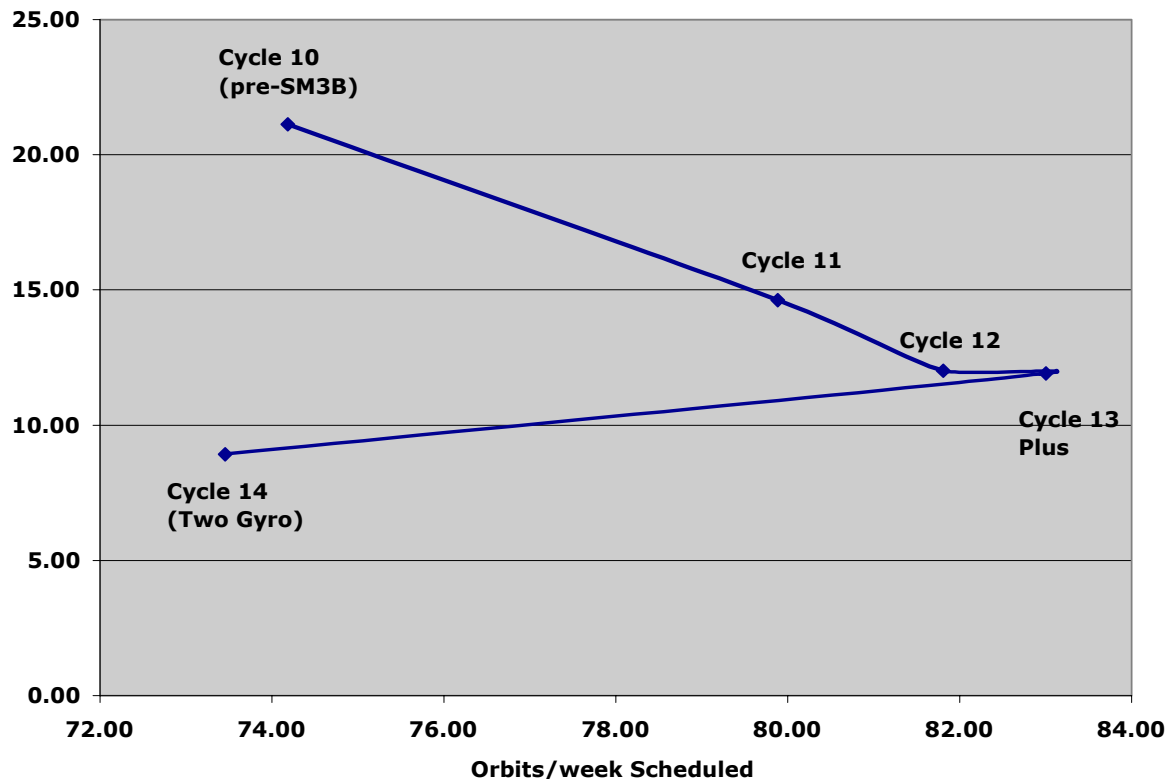
- Snapshots fill gaps that are left after GO programs are scheduled
 - ◆ Scheduled automatically, not manually
 - ◆ Number and size distribution of gaps is determined by the success in scheduling GO programs
- Improvements in scheduling GO programs have reduced gaps available for Snapshots

Scheduling rates for Cycles 10-14



Recent Snapshot History

- Snapshot opportunities have been decreasing over the last several cycles
 - ◆ Full orbit gaps have nearly completely disappeared
 - ◆ Partial orbit gaps are decreasing

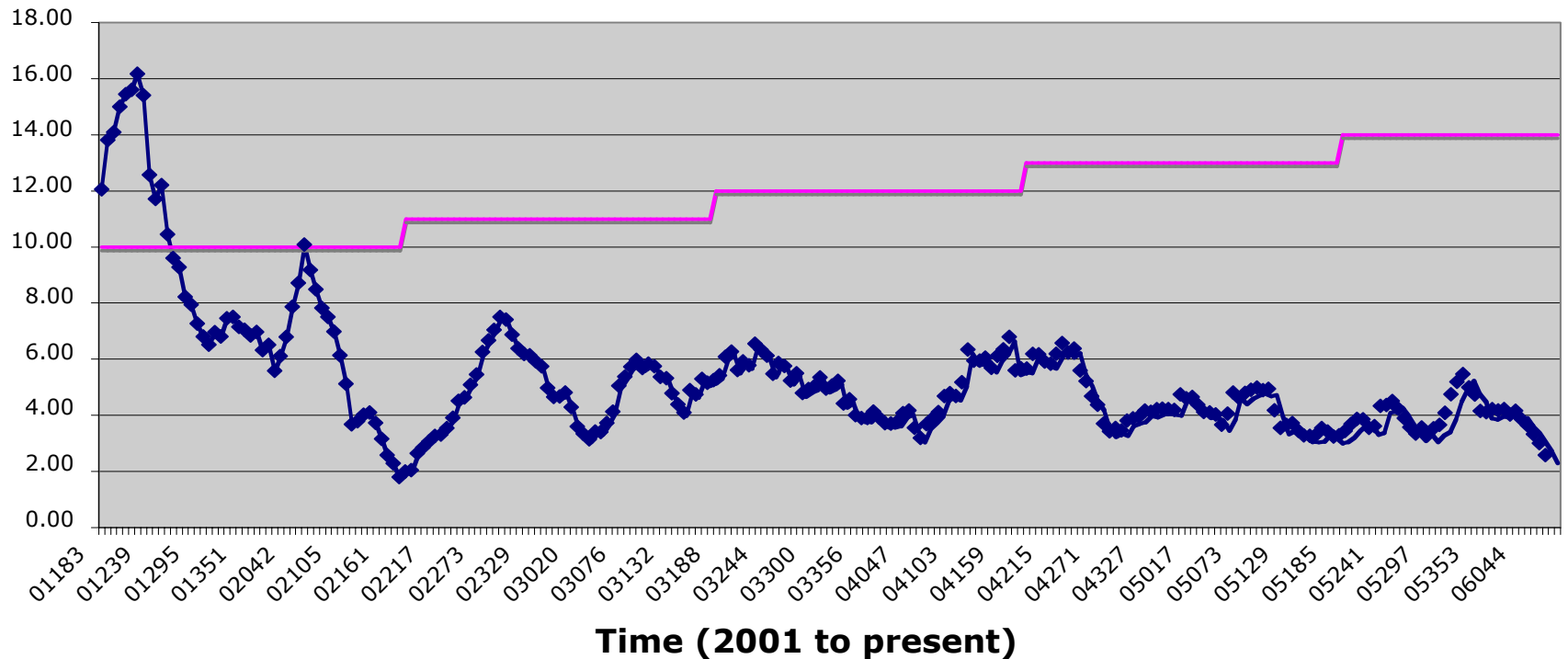


In Three Gyro mode:
GO Orbits + Snaps=95

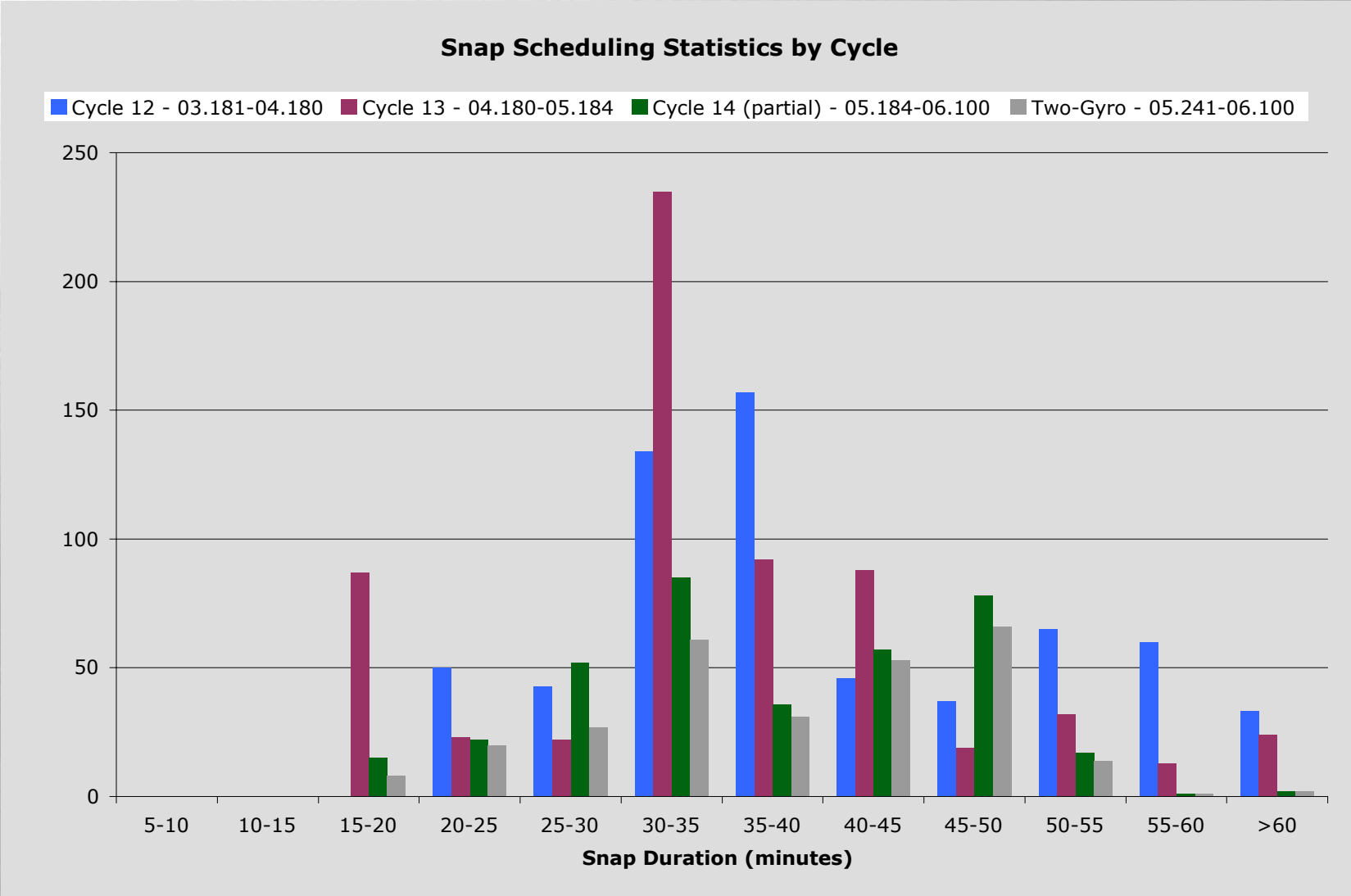
In Two Gyro mode:
GO Orbits + Snaps=82
(so far)

Recent Snapshot History

- Contribution of Snaps to Observing Efficiency has been decreasing
 - ◆ Reflects fewer Snaps scheduled
 - ◆ Shift to shorter Snaps

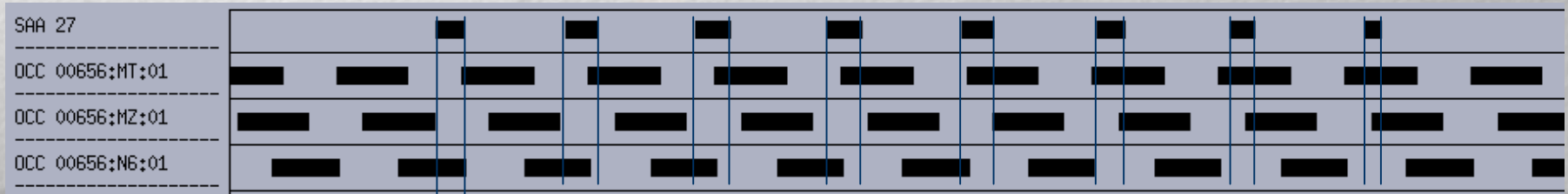


Recent Snapshot Durations



Scheduling and the SAA

- SAA passages are responsible for gaps in the schedule
 - ◆ 7-8 SAA passages per day (of 15 orbits/day)
 - ◆ 1 - 30 minute duration
 - ◆ SAAs are fixed in time by orbit
 - ◆ Location relative to occultation pattern depends on target location

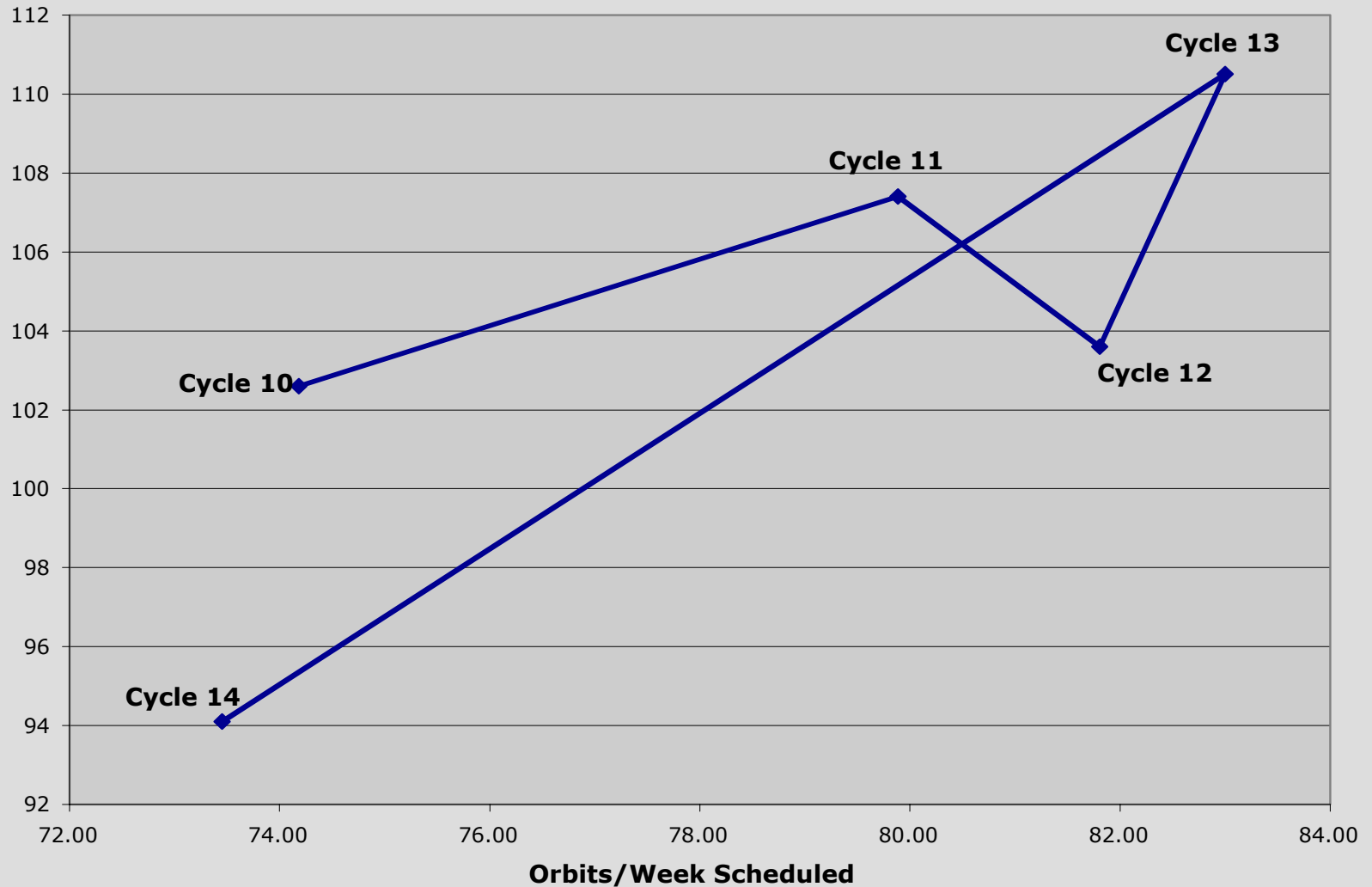


- Tricks for increasing number of orbits scheduled
 - ◆ Find targets that “hide” the SAA
 - ◆ Not always possible
 - ◆ Use 3 SAA-impacted orbits for a nominal 2 orbit visit
 - ◆ Works best for short exposure programs
 - ◆ Schedule nominal orbits in CVZ
 - ◆ “Craft” visits to be shorter than nominal visibility time

How many orbits might we schedule?

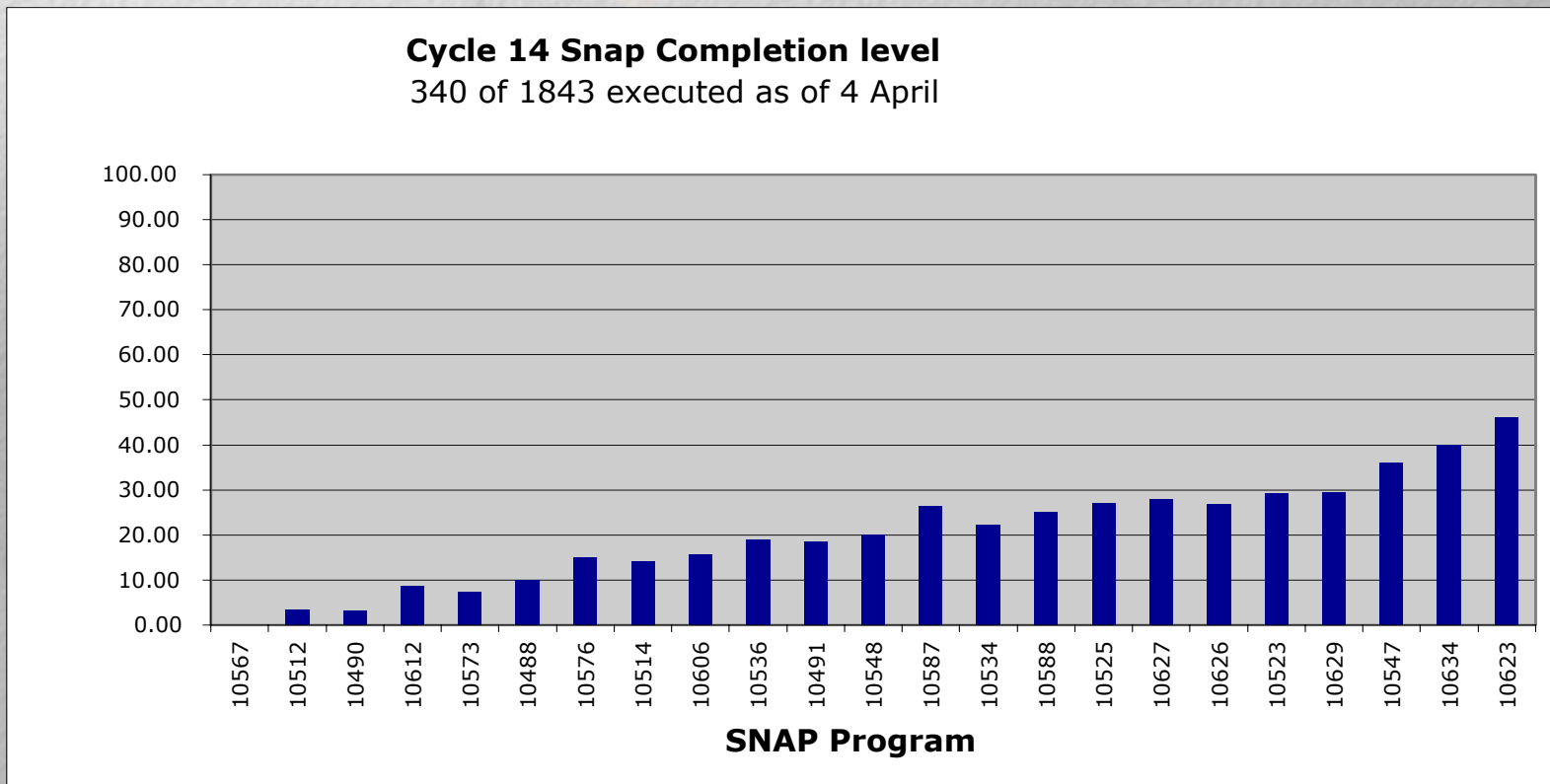
- Physical orbit is the 96 minute period for one trip around the Earth
 - ◆ 105 physical orbits/week
- TAC orbit is the nominal visibility period for one uninterrupted physical orbit
- *IF* there were no SAA, we would schedule ~105 TAC orbits/week
- *IF* we could use *no* SAA orbits, we would schedule ~52 TAC orbits/week
- *IF* all the SAA time were put in one contiguous segment, we would schedule ~90 TAC orbits/week
- *IF* SAA passages never intruded on target visibilities, we would schedule ~105 TAC orbits/week

How do we do at utilizing orbits ?



Cycle 14 Snapshots

- 23 programs with 1843 targets were accepted for Cycle 14
- Overall completion level is low
 - ◆ Project 23% overall completion by July 1



Why is the completion level so low?

- We solicited too many from the TAC (2000 vs. 1500)
 - ◆ At the time, we were concerned that the Long-Range plan might undersubscribe some weeks (seen in early Two Gyro scheduling tests)
 - ◆ Such situations would leave many gaps to be filled
- Two Gyro Snap scheduling rate is lower than Three Gyro (8/week vs. 12/week) when schedule is packed
 - ◆ No estimate was made of Two Gyro Snap scheduling rate (too much work)
 - ◆ Two Gyro Snap scheduling rate was expected to be lower
- Projected completion without these effects:
 - ◆ 28% if we selected 1500 Snaps
 - ◆ 34% if we scheduled current pool at Three Gyro rates
 - ◆ 41% if we scheduled 1500 at Three Gyro rates
 - ◆ Cycle 13 overall Snap completion rate was 40%

Distribution across Snap Programs

- Some programs schedule more frequently than others
 - ◆ This has always been the case (e.g. STIS MAMAs)
 - ◆ Shorter Snaps are more likely to schedule than long ones
 - ◆ Restricted sky availability in Two Gyro mode may increase the dispersion among programs (especially with time)

Cycle 14								
Prop ID	Instrument	Executed	Next Cycle	Requested	Comp_Level_(%)	Date_report	visibility	sky loc.
10567	ACS	0		80	0.00	4-Apr-06	1-3 orbits	NGC1407
10512	ACS	5		150	3.33	4-Apr-06	2200s	J. Trojans
10490	ACS	2		65	3.08	4-Apr-06	3300s	scattered
10612	FGS	6		70	8.57	4-Apr-06	2000-2800s	CYG OB2
10573	ACS	2		27	7.41	4-Apr-06	1700-2500s	Gplane
10488	ACS	4		40	10.00	4-Apr-06	2000s	scattered
10576	ACS	9		60	15.00	4-Apr-06	1500s	scattered
10514	ACS	35		250	14.00	4-Apr-06	1900s	Kuiper B
10606	ACS	13		83	15.66	4-Apr-06	1500s	scattered
10536	ACS	19		100	19.00	4-Apr-06	2500-2900s	scattered
10491	ACS	23		124	18.55	4-Apr-06	2700s	scattered
10548	ACS	10		50	20.00	4-Apr-06	1750s	scattered
10587	ACS	31		118	26.27	4-Apr-06	1000-1500s	scattered
10534	WFPC2/ACS	8		36	22.22	4-Apr-06	1400-1700s	Uran/Nep
10588	ACS	20		80	25.00	4-Apr-06	1450s	scattered
10525	ACS	29		107	27.10	4-Apr-06	900-3000s	scattered
10627	ACS	14		50	28.00	4-Apr-06	1300-1800s	scattered
10626	ACS	40		150	26.67	4-Apr-06	2350s	scattered
10523	ACS	27		92	29.35	4-Apr-06	2500s	scattered
10629	ACS	5		17	29.41	4-Apr-06	1900s	SMC
10547	ACS	18		50	36.00	4-Apr-06	1200-1400s	scattered
10634	ACS	2		5	40.00	4-Apr-06	2700s	scattered
10623	ACS	18		39	46.15	4-Apr-06	1500s	scattered

How Do We Schedule Snapshots?

- Step 1. Develop Snap list for scheduling each week
 - ◆ Randomize all legal visits of C14 programs <50% complete
 - ◆ Tack on randomized visits of C14 programs >50% complete
 - ◆ Tack on randomized visits of C13 programs <50% complete
 - ◆ Tack on randomized visits of C13 programs >50% complete
- Step 2. Take first 200 visits from this list
 - ◆ In practice, only take from the first list (C14 < 50% complete)
- Step 3. Develop scheduling score for each visit of the 200
 - ◆ Uses same scoring/weighting algorithms as prime observations
 - ◆ Factors included:
 - ◆ GO priority assignment
 - ◆ Moving target
 - ◆ Running out of time (last 8 weeks)
 - ◆ Scheduling efficiency
 - ◆ Others not entirely clear (code last fiddled ~10 years ago)

How Do We Schedule Snapshots?

- Step 4. Sort 200 visits by score
- Step 5. Pass through entire list of 200, trying each visit in all remaining places in the schedule
 - ◆ If a visit can schedule, it is put in that place, which is no longer available for other Snaps
- Step 6. Complete other steps of scheduling process (TDRSS, command loads, etc.)
- Step 7. Update database for scheduled visits

Potential Operational Improvements

- Use more than 200 visits each week
 - ◆ Not likely to schedule more Snaps, but doesn't cost much
- Revise scoring scheme
 - ◆ Develop weighting specific for Snap programs
 - ◆ Bias towards efficiency ? (try longest first)
 - ◆ Bias towards flat completion across programs ?
- Reduce 50% bias point in initial selection step
 - ◆ Small effect, drops some programs from list of 200
 - ◆ Could reduce Snap scheduling, since shortest Snaps will be biased against
- Increase potential for C14 scheduling in C15
 - ◆ Put C14 < 50% ahead of C15 > 50%

Scheduling directions for the Future

- Continued small tweaks to Two Gyro mode
 - ◆ FHST induced failures will be reduced to ~1% (my guess)
 - ◆ Additional reductions in timing will provide small increases in sky availability (a few days for typical targets)
 - ◆ Increase roll ranges will provide small increases in sky availability
- Some continued improvements in GO program scheduling
 - ◆ SAA hiding
 - ◆ Handling of Large/Treasury programs
 - ◆ Dispersion of targets in selected C15 programs will have as large an impact on scheduling rate
- Little overall change in snapshot situation
 - ◆ Improvements in Snap processing may add 1 per week
 - ◆ Improvements in GO scheduling may reduce Snap opportunities
 - ◆ Emphasizing very short exposures might open up some new ground
- Some gains achieved in the next two years will apply after going back to 3 Gyro mode (SM4)