Scheduling Experience in Two Gyro Mode

April 20, 2006

Rodger Doxsey

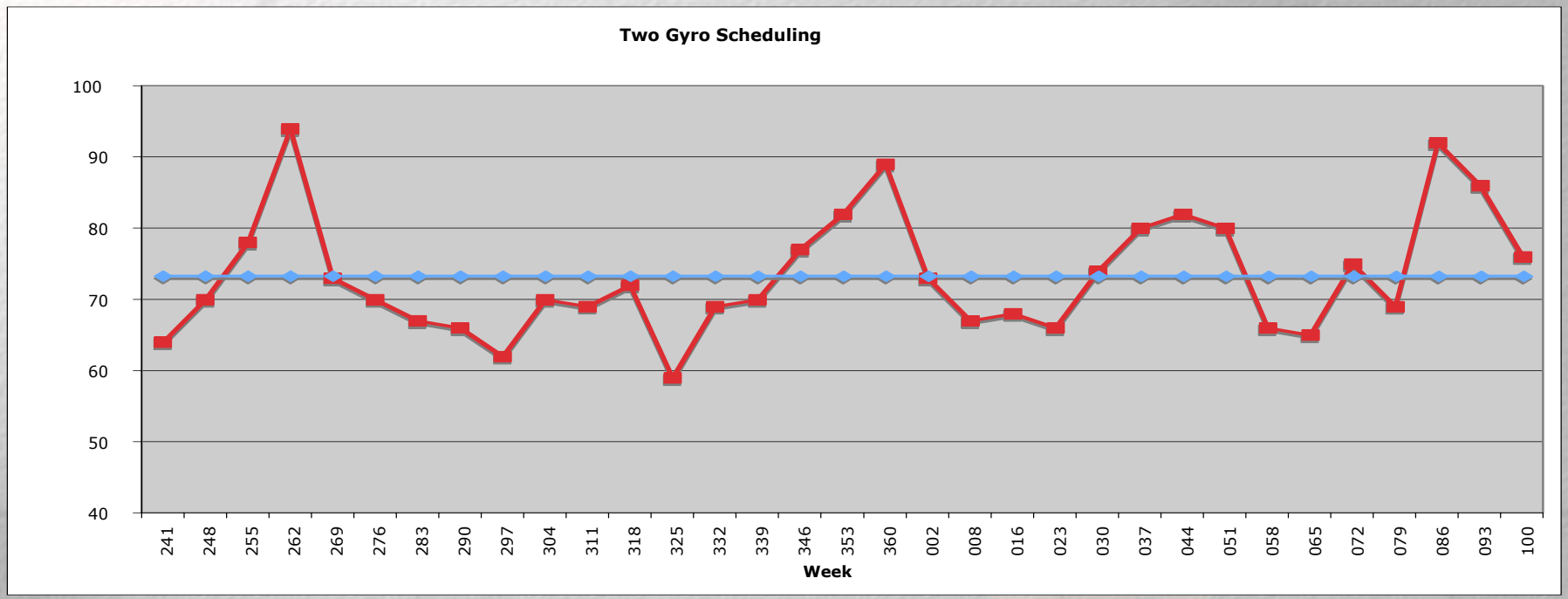
Scheduling Topics

- 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

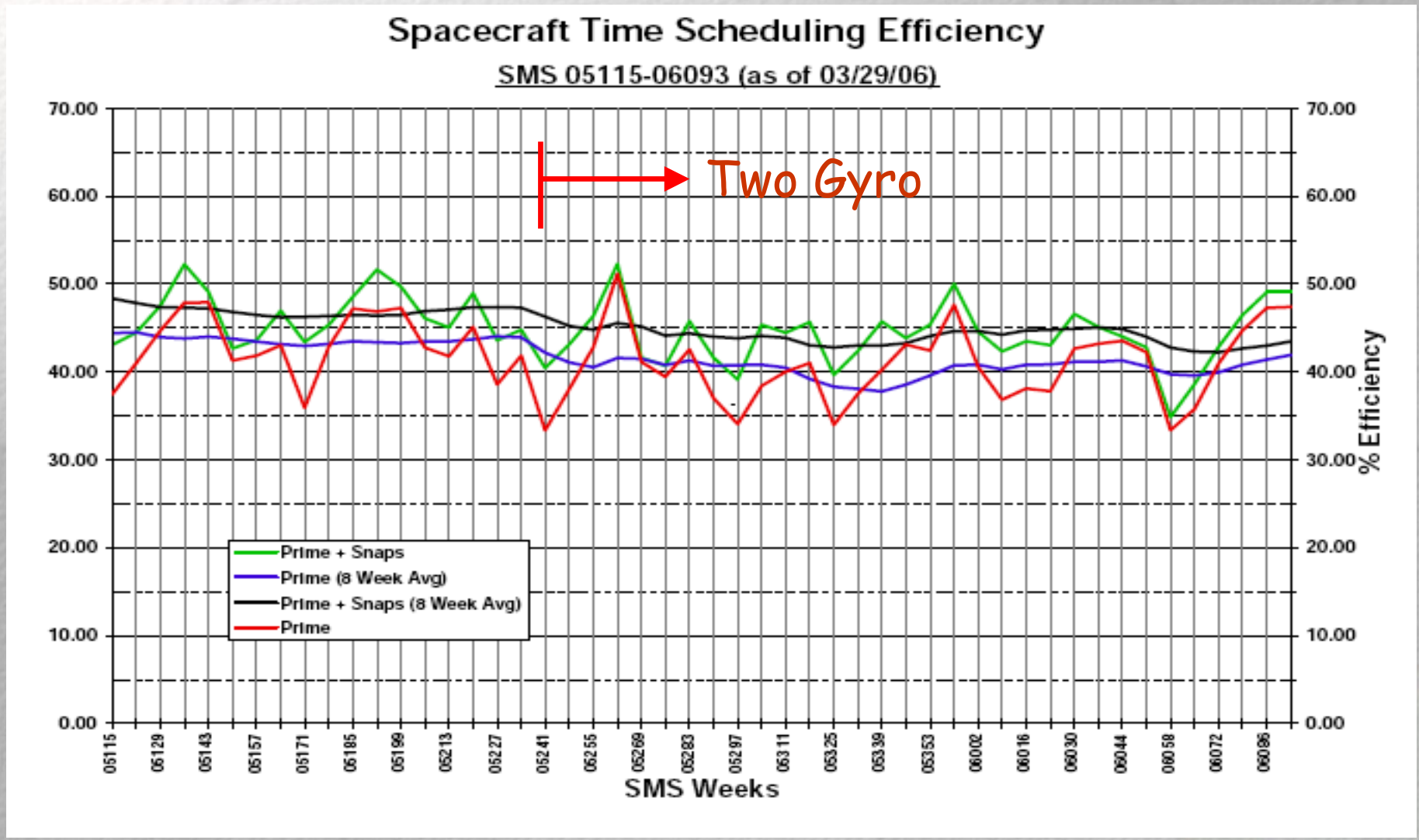
- Criteria for switching to Two Gyro Mode was to gain 2000 orbits relative to staying in Three Gyro Mode
  - Based on gyro lifetime models, this requires an effective rate of 67 successful orbits/week
  - Expected 2% failure rate implied we need to schedule 68.5 orbits/week
  - Three gyro scheduling 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

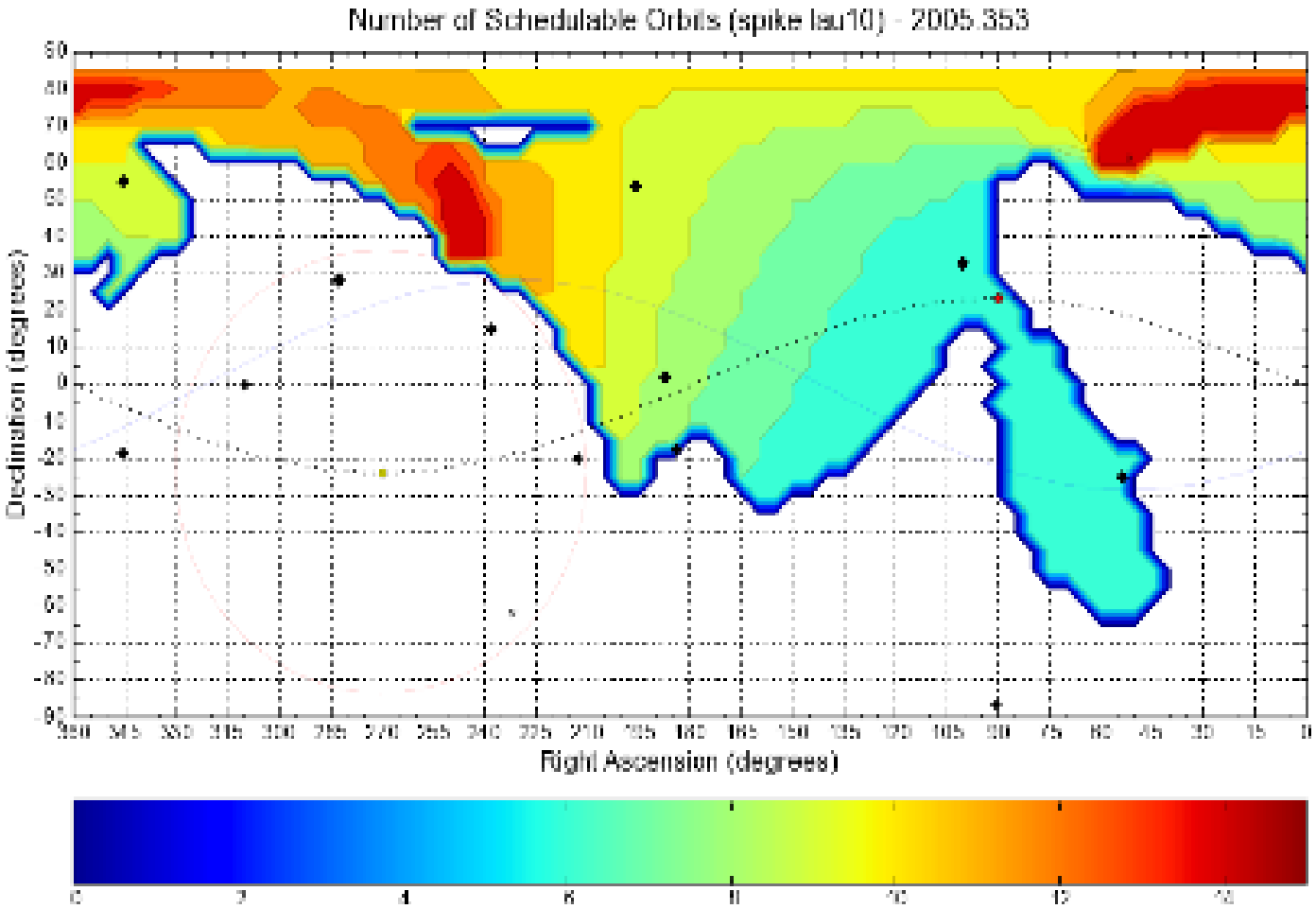


- Through April 10, we have averaged 73.3 orbits per week, scheduled
- Peaks and valleys are due to SAA interactions

Scheduling Performance - Efficiency



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

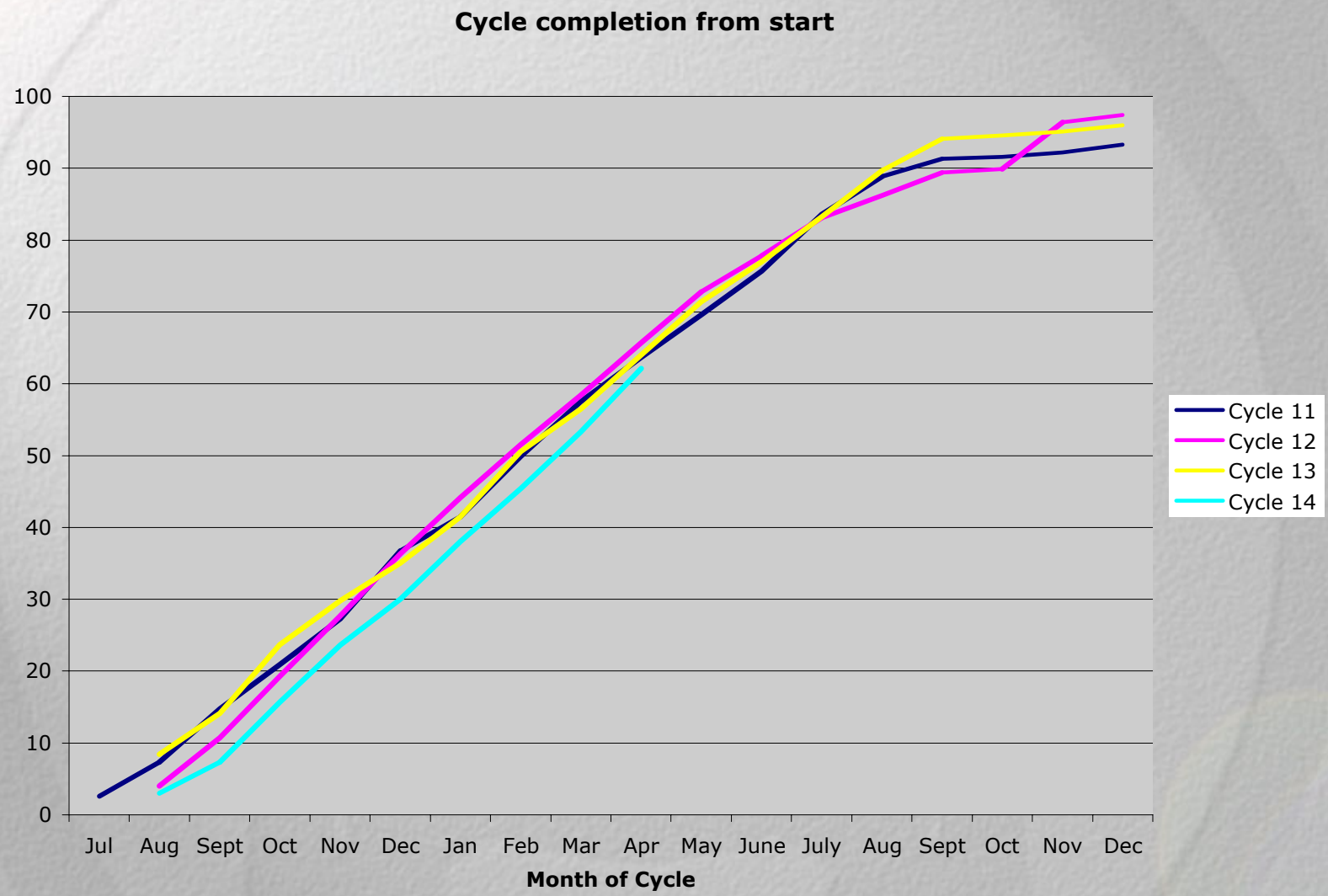
- Timing changes improve schedulability
- Reduced Earth avoidance angle will improve schedulability
- Additional roll flexibility being investigated

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

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

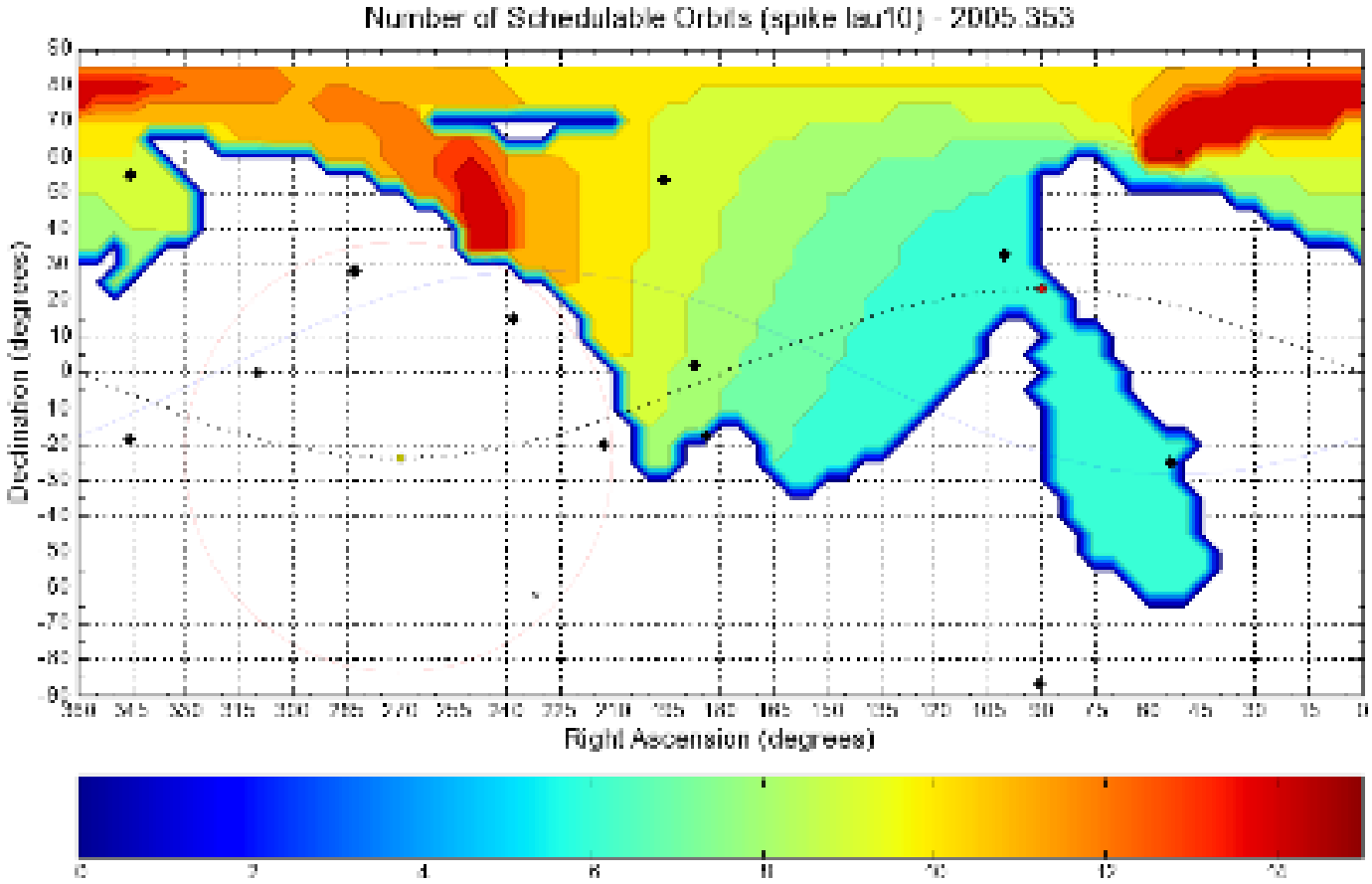
Program	Title	PI	This week	Observed	Allocated	% complete	Time
10496	Dark Energy Studies	Perlmutter	1	132	219	60.3%	
10632	Galaxies at z>6.5 in the UDF	Illingworth	0	113	204	55.4%	Dec
10585	SNAPSHOTS	Malhotra	0	200	200	100.0%	
10775	Globular Cluster Survey	Sarajedini	2	58	134	43.3%	April-J
10504	Cosmic Reionization	Ellis	0	31	110	28.2%	May-Au
10584	Neutral Gas Survey	Tumlinson	3	73	109	67.0%	
10561	Gamma-ray Bursts	Kulkarni	0	2	100	2.0%	
10582	Star Formation	Gallart	0	14	97	14.4%	April, J
10592	Infrared Galaxies	Evans	2	62	88	70.5%	
10607	Extrasolar Planets	Benedict	0	69	72	95.8%	
10583	Star Formation	Da Costa	0	0	69	0.0%	May/Ju
10497	SN/Hubble Constant	Riess	0	64	68	94.1%	
	as of Apr 9:	total:	8	818	1470	55.6%	
		%		56%			

Targets of Opportunity

PI	prop_id	allocated	completed	scheduled	unplanned	left t
Perlmutter	10496	219	112	72	35	16
Smartt	10498	8	1	0	7	88
Grundy	10508	12	5	3	4	33
Bennett	10544	4	2	0	2	50
Kulkarni	10551	100	2	9	89	89
Berger	10616	24	6	0	18	75
Fox	10624	42	18	0	24	57
Tanvir	10633	22	2	0	20	91
	GRBs	188	28	9	151	80

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

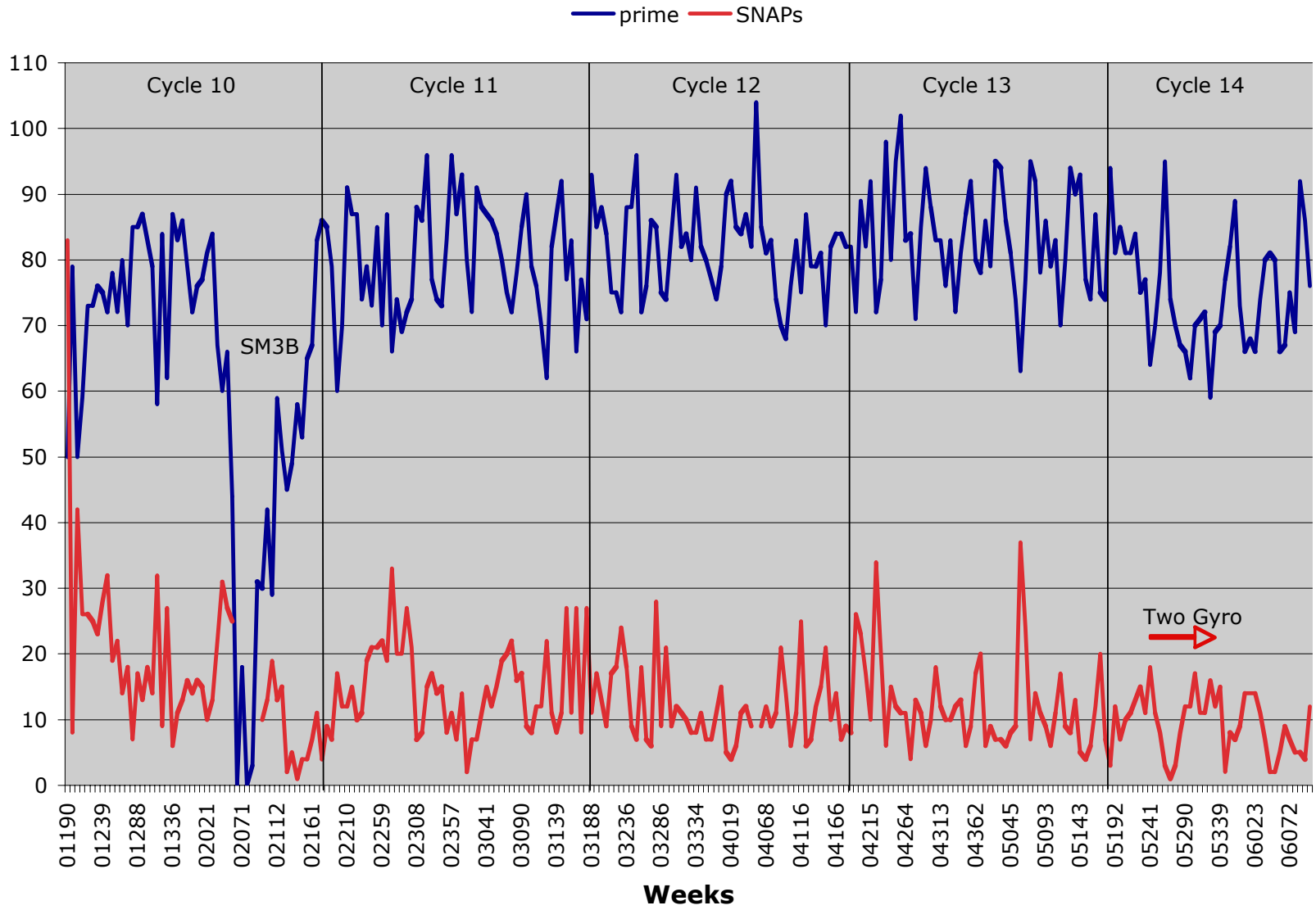
Swift Pointings



Snapshot scheduling

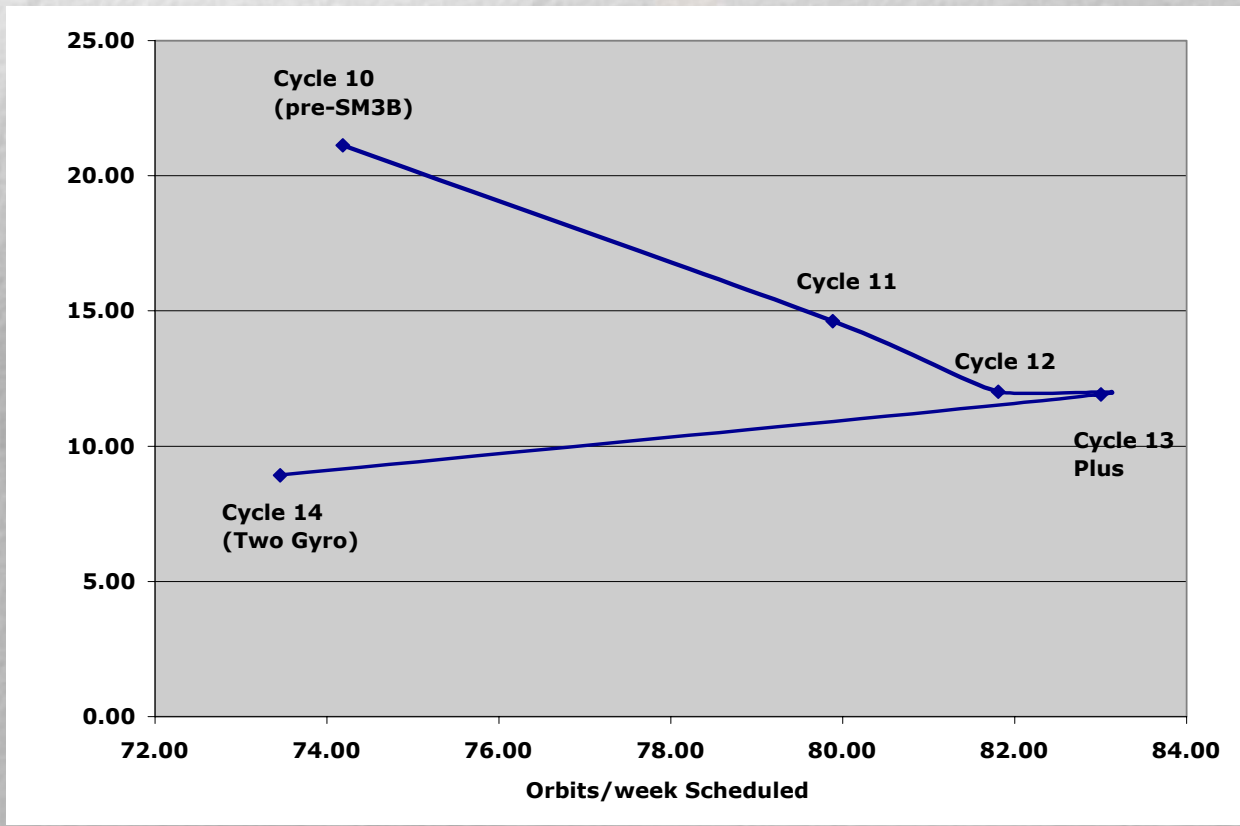
- Snapshots fill gaps that are left after GO programs are scheduled
  - Scheduled automatically, not manually
  - Number and size distribution of gaps is determined by the success in scheduling GO programs
- Improvements in scheduling GO programs have reduced gaps available for Snapshots

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

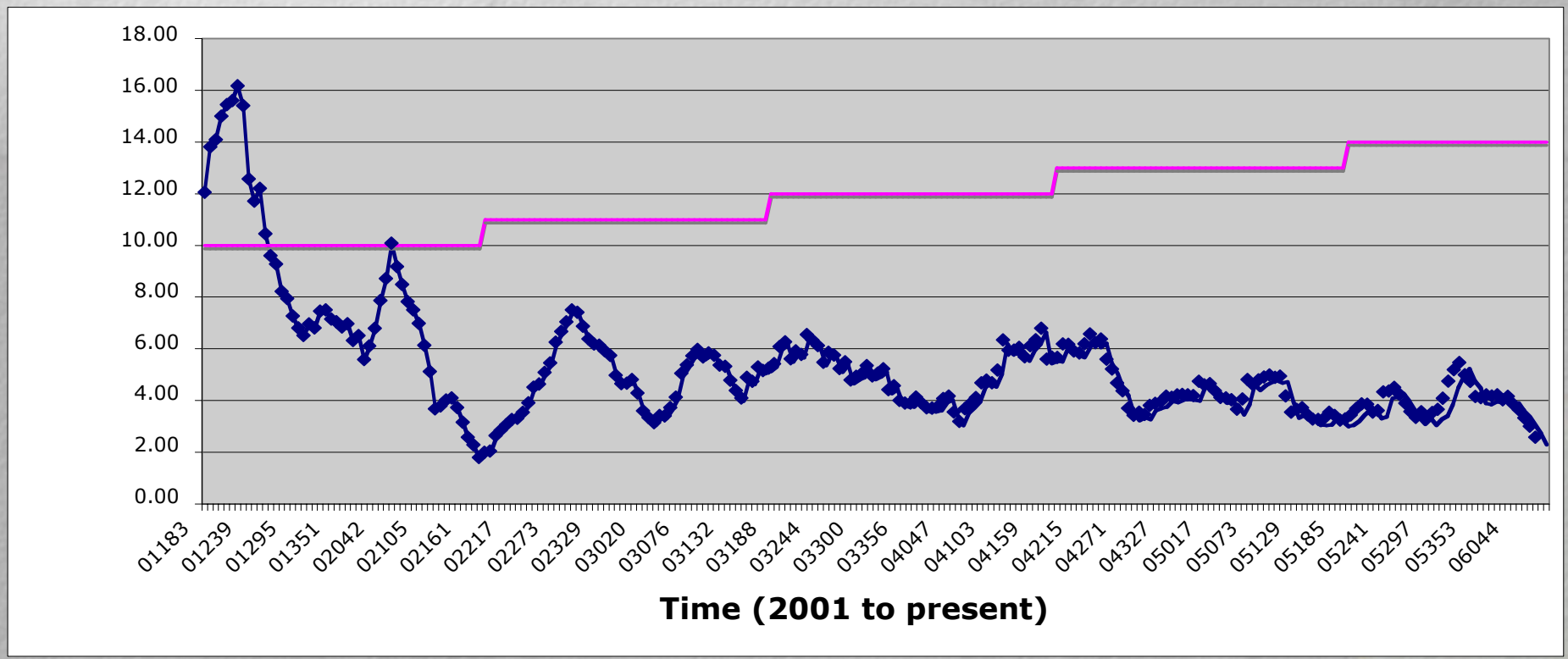


In Three Gyro mode:
GO Orbits + Snaps=95

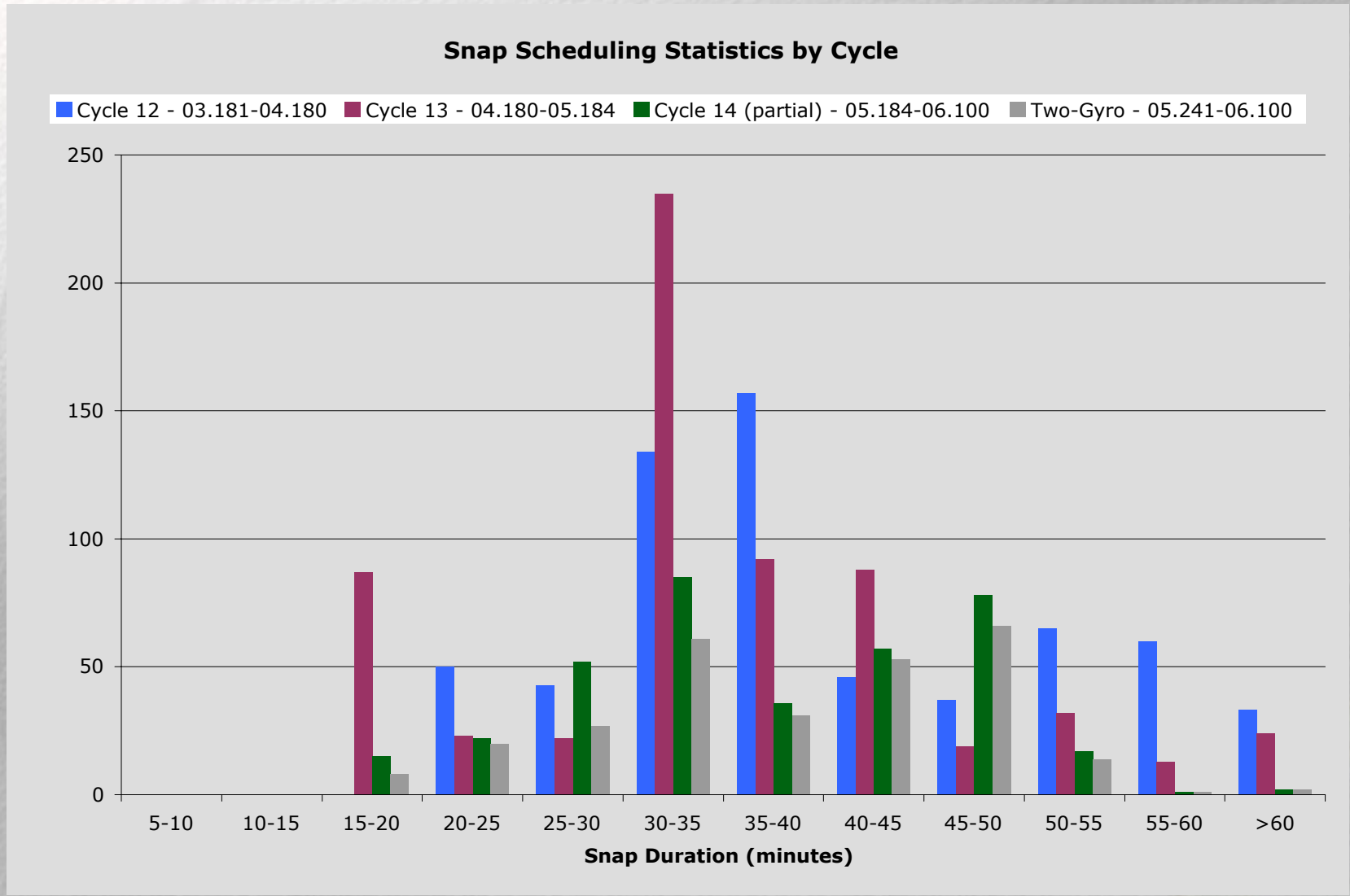
In Two Gyro mode:
GO Orbits + Snaps=82
(so far)

Recent Snapshot History

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

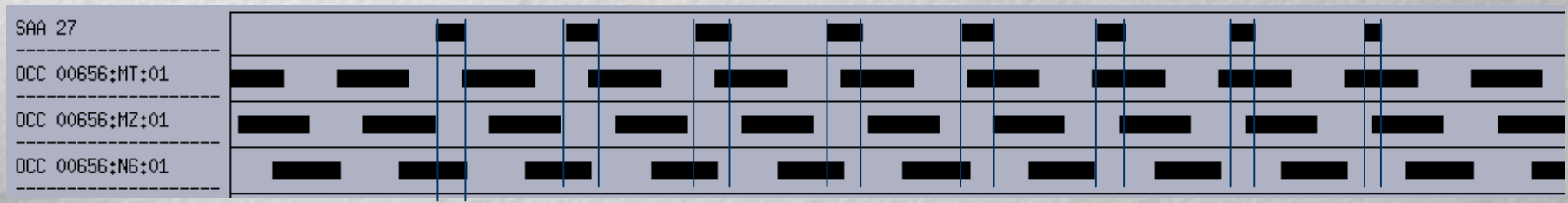


Recent Snapshot Durations



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

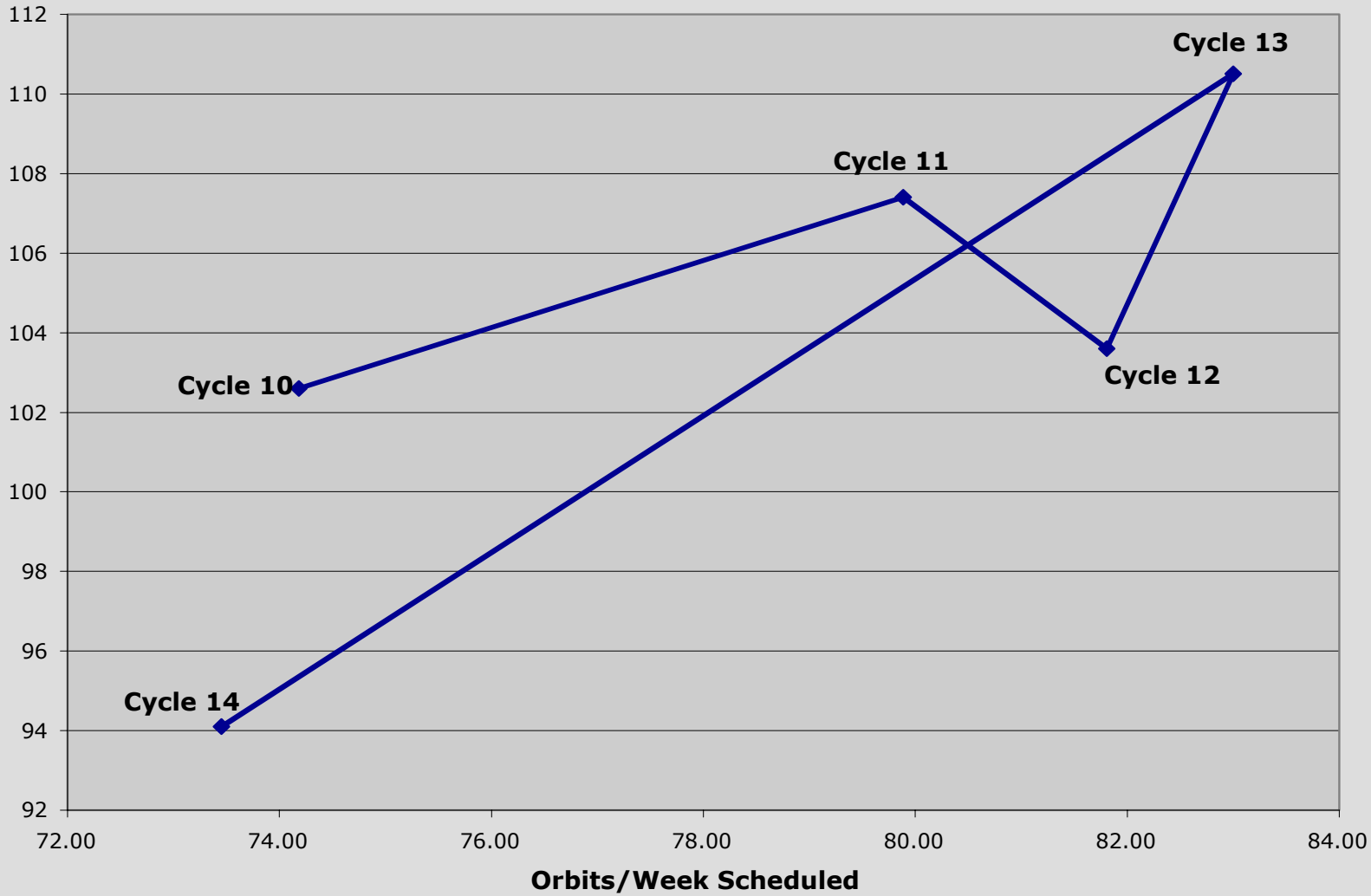


- Tricks for increasing number of orbits scheduled
  - Find targets that "hide" the SAA
    - Not always possible
  - Use 3 SAA-impacted orbits for a nominal 2 orbit visit
    - Works best for short exposure programs
  - Schedule nominal orbits in CVZ
  - "Craft" visits to be shorter than nominal visibility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

How many orbits might we schedule?

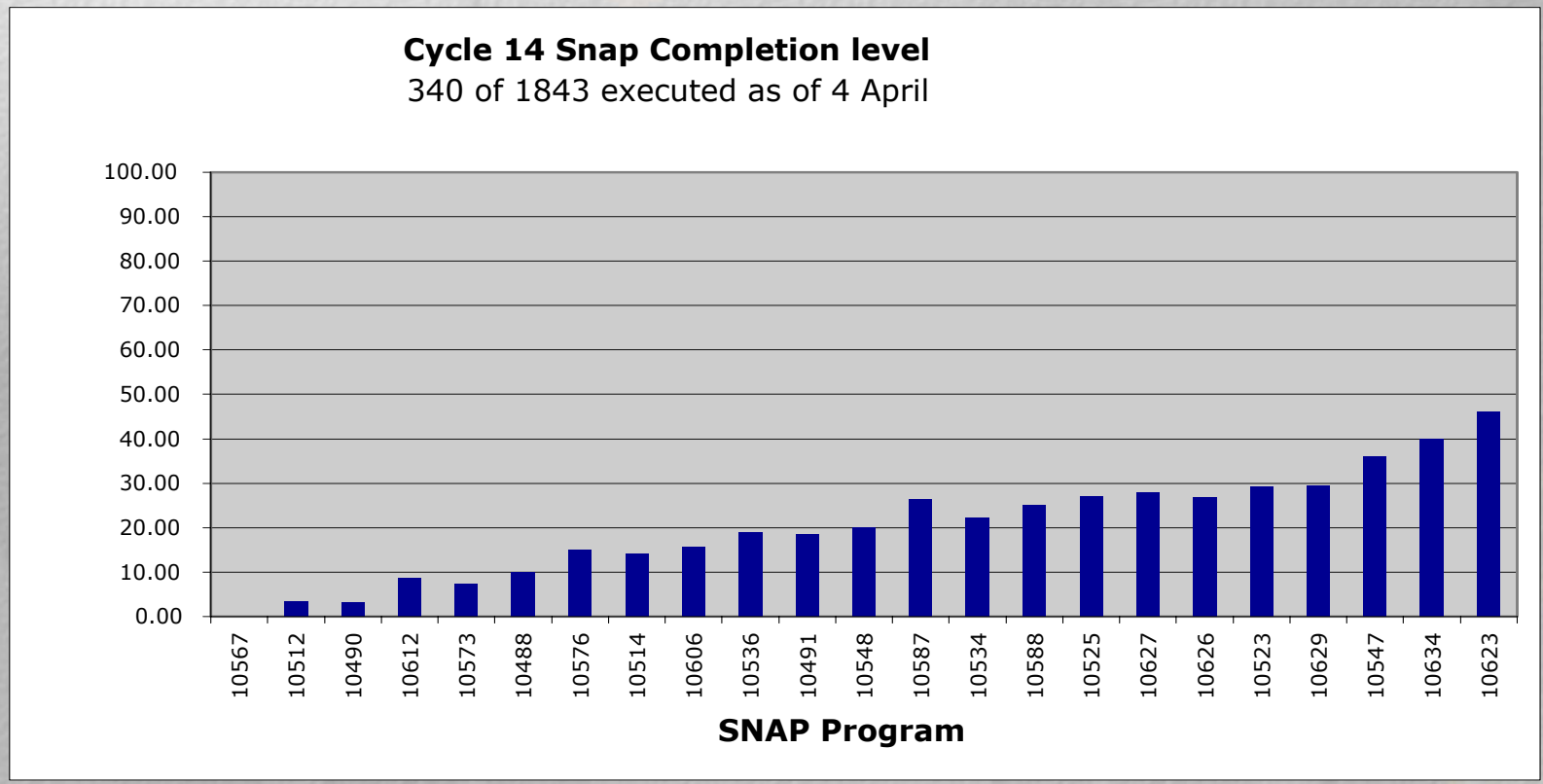
- Physical orbit is the 96 minute period for one trip around the Earth
  - 105 physical orbits/week
- TAC orbit is the nominal visibility period for one uninterrupted physical orbit
- *IF* there were no SAA, we would schedule ~105 TAC orbits/week
- *IF* we could use *no* SAA orbits, we would schedule ~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)