Science in Two Gyro Mode

October 30, 2003

Topics

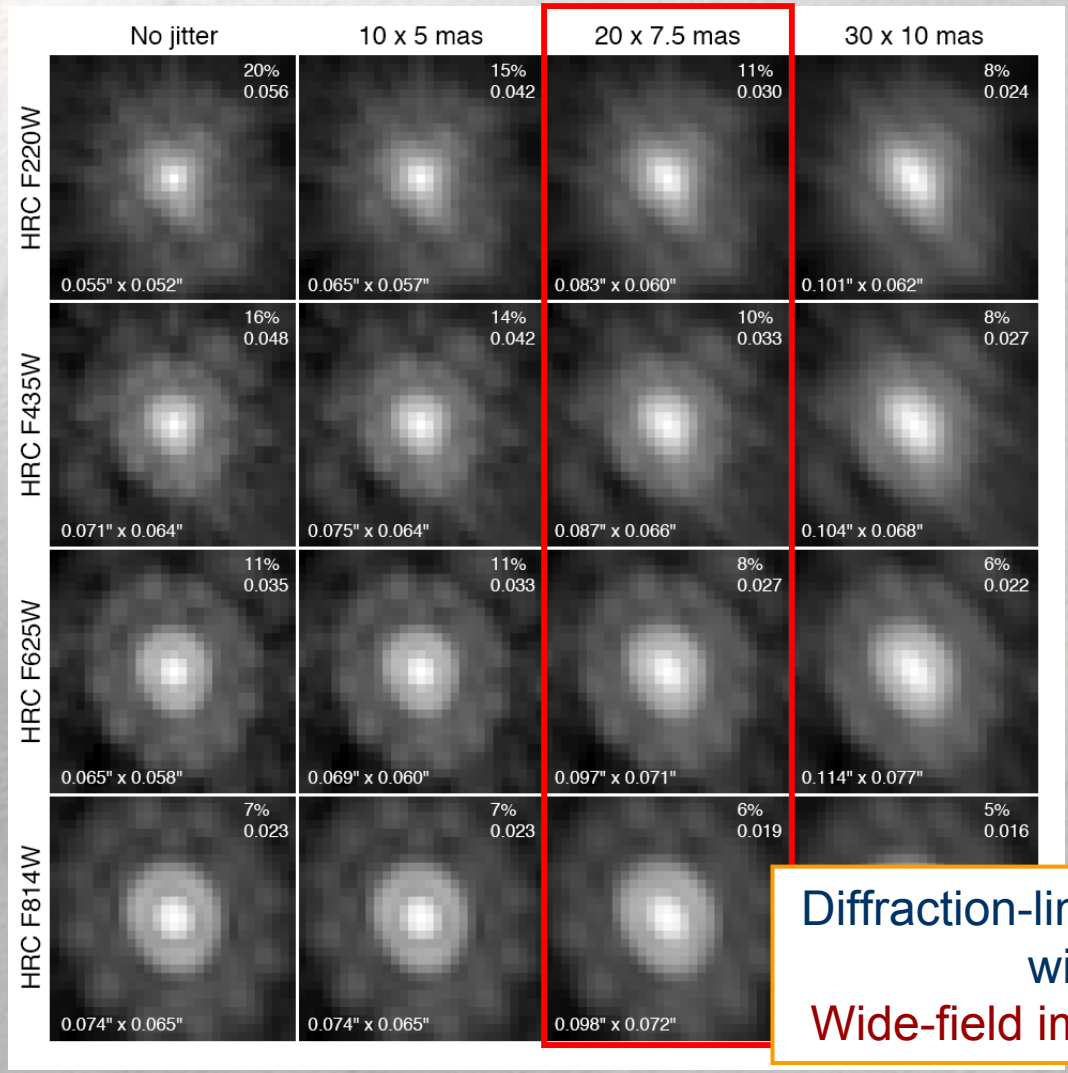
- Impact of Two Gyro operations on the HST Science program
  - Observations
  - Scheduling
- Concept for operational use of Two Gyro mode
- Visibility Studies

Impact of Two Gyro operations on the HST Science program

- Jitter performance in Two Gyro mode may not support all current science programs
  - Smallest aperture, highest spatial resolution programs may be affected (relatively small part of total program)
  - Potential restrictions will be better characterized after hi-fidelity PCS simulations and on-orbit tests
  - Disposition of potentially affected science programs will be made after entry into Two Gyro mode and accumulation of more extensive jitter performance data

Images under 2-gyro control

PSF: $\sigma_{tot}^2 = \sigma_{intrinsic}^2 + \sigma_{jitter}^2$



- Jitter magnitude will depend on which 2 gyros remain alive
- Direction of elongation will also depend on which 2 gyros remain alive
- Expected worst jitter ~15-30 mas
- ACS/HRC degraded
- ACS/WFC suffers small degradation
- Broad slits OK, narrow

Diffraction-limited & high-contrast imaging will be compromised
Wide-field imaging will only suffer slightly

Science Implications – Cycle 12

- $time_{exp} \sim PSF^2$

  Rough exposure time increase vs. jitter

σ_{jitter}:	25	50 mas
HRC scale	2x	7x
WFC scale	1.3x	2x
>WFC	1x	1.3x

- Current HST Science:
  - 91% Large (WFC) scale
  - 9% Small (HRC) scale
  - Instrument split:
    - ACS: 55%
    - NICMOS: 21%
    - STIS: 17%
    - WFPC2: 2%
    - FGS: 5%

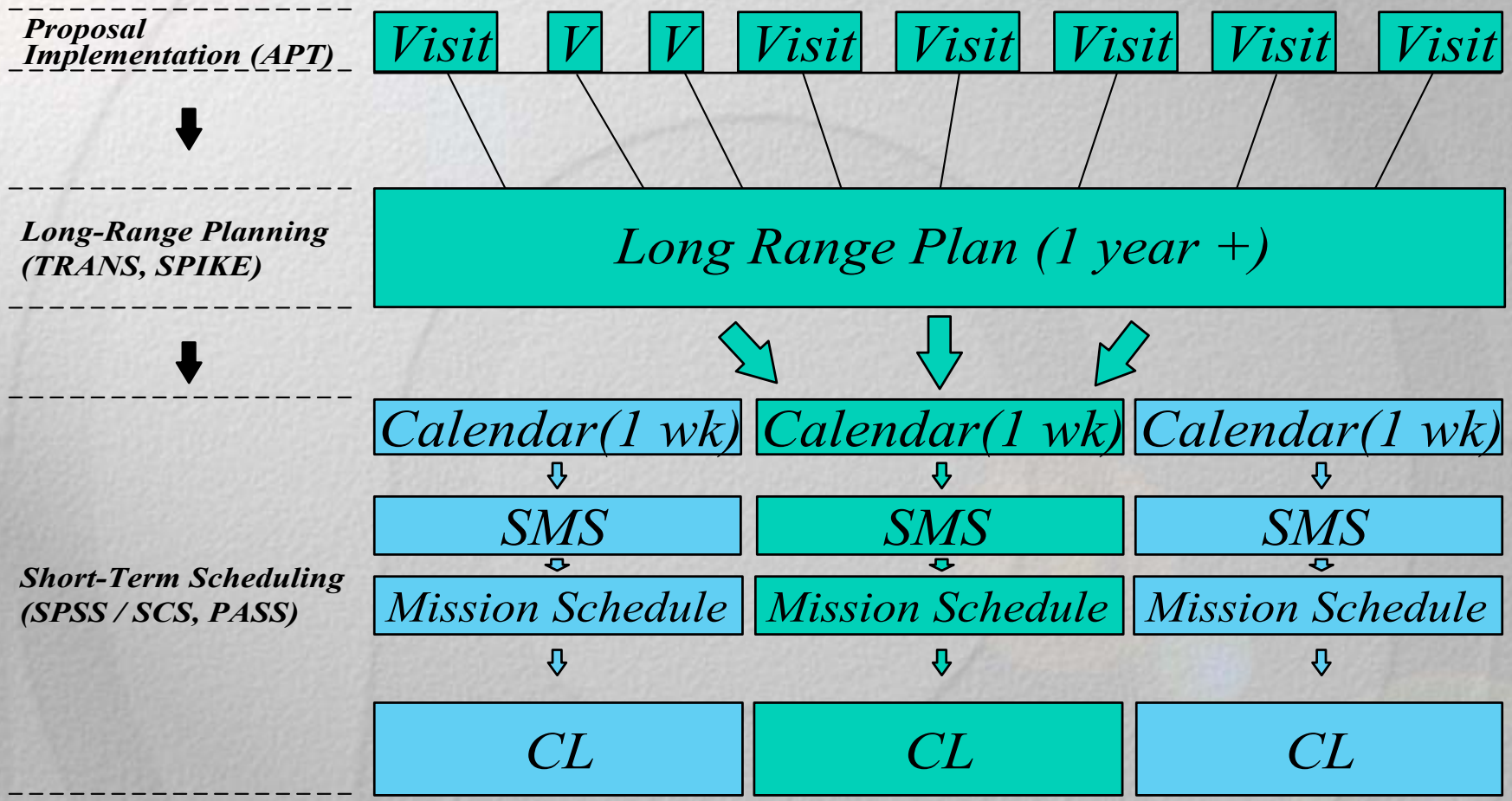
Instrument	Aperture	%Time
ACS	Small	5.1%
	Large	**49.7%**
NICMOS	Small	3.4%
	Large	**17.6%**
STIS	Small	0.4%
	Large	**16.4%**
WFPC2	**Large**	**2.3%**
FGS	Small	5.0%
Total	*Small*	*8.5%*
	Large	***91.5%***

The full science program requires:
1.35x exposure at $\sigma \sim 25$ mas
2.5x exposure at $\sigma \sim 50$ mas

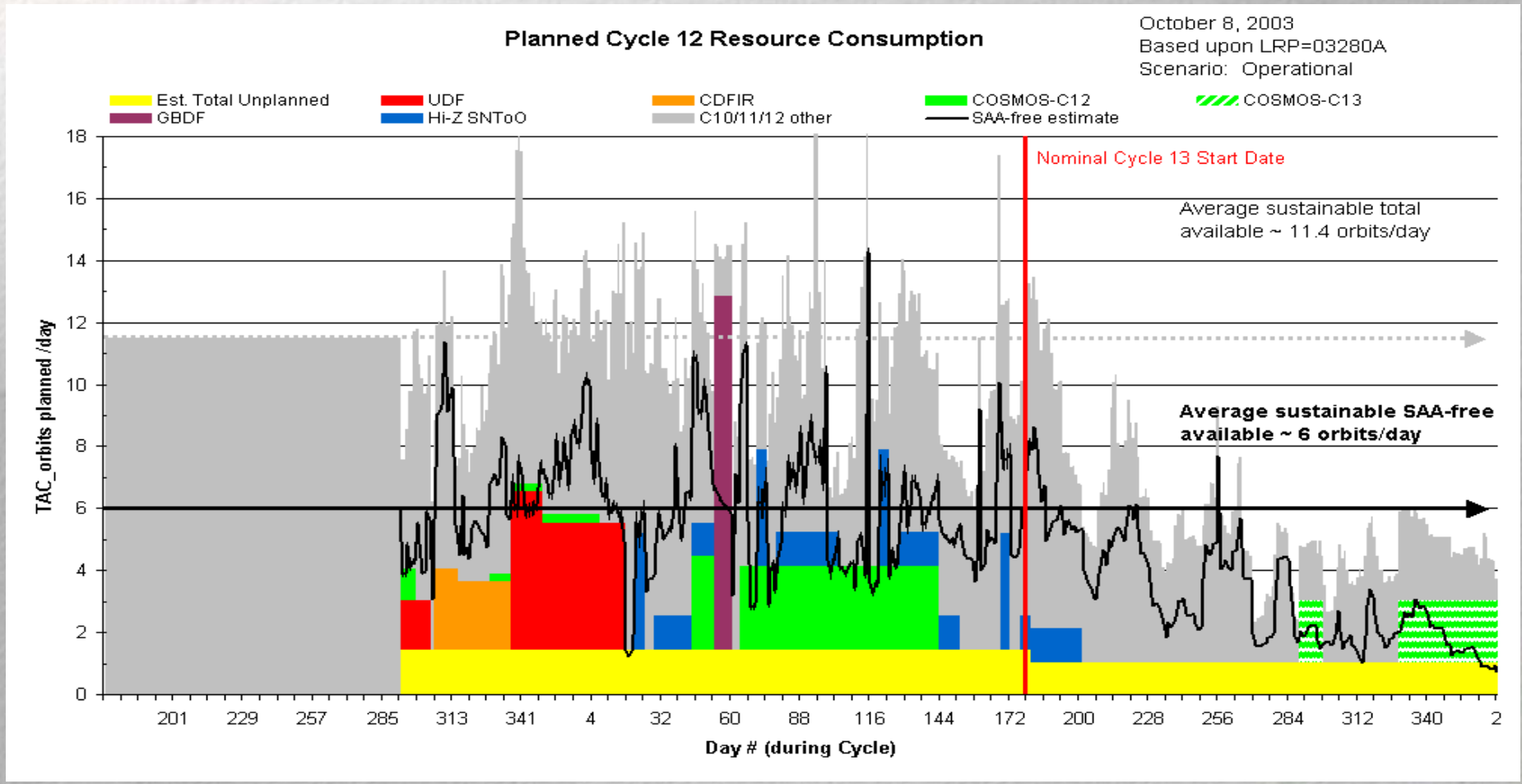
Impact of Two Gyro operations on the HST Science program

- Current cycle Long-Range observing plan will be totally disrupted at entry into Two Gyro mode
- Impacts of two-gyro mode on schedulability of science program
  - Longer Guide Star acquisition times
    - Currently takes ~ 6.1 minutes during V1 visibility period
    - Will take ~ 10 minutes (tbr) in Two Gyro mode
  - No Guide Star re-acquisitions, must do full acquisitions
    - ~ 10 minutes (tbr) vs. 5 minutes
  - Much more difficult FHST scheduling requirements

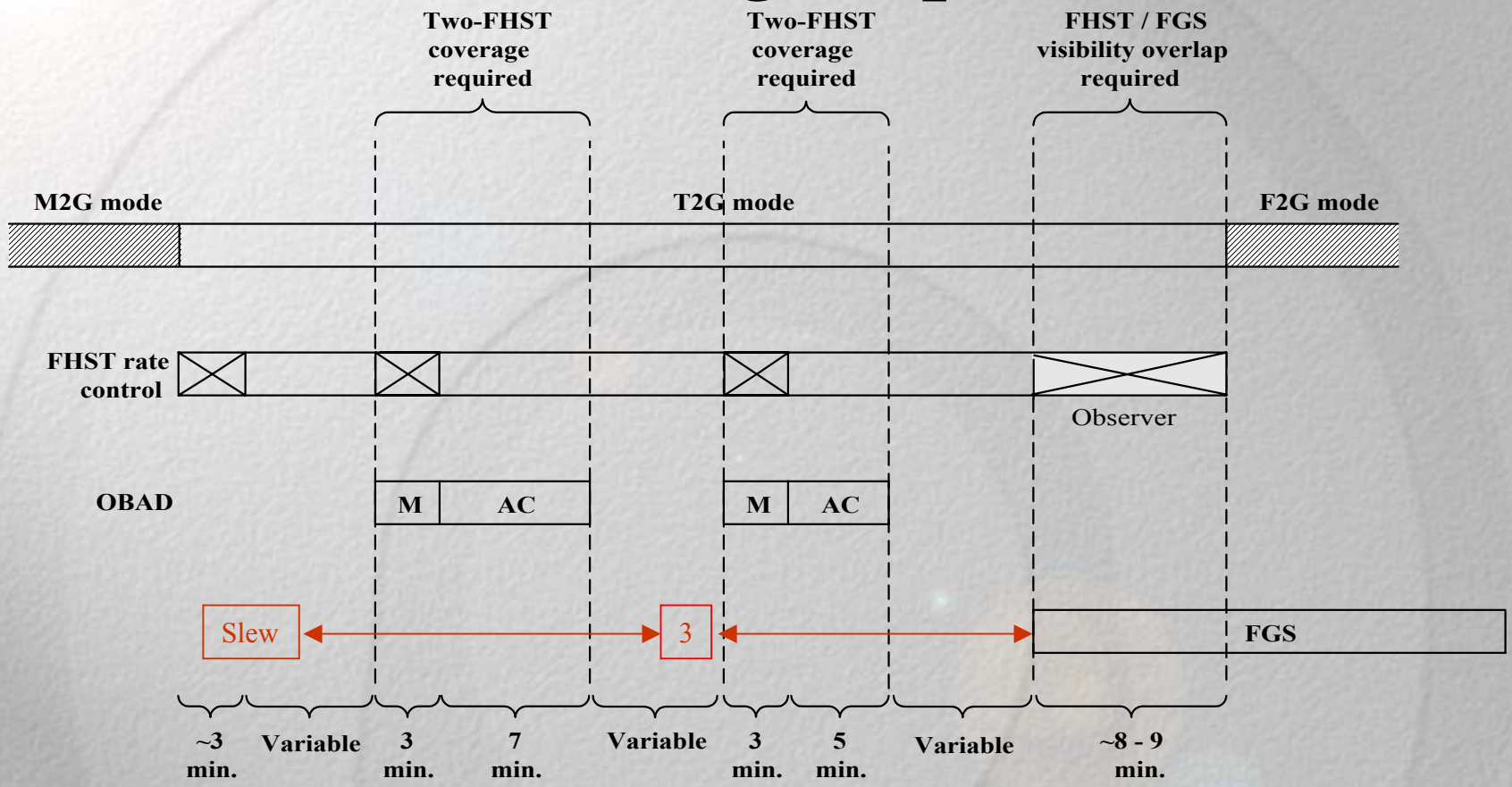
HST Scheduling Process



Current HST Long Range Plan



FHST scheduling requirements



Legend:

- ⨯ = **No rate control handoff allowed**
- **M** = **Map**
- **AC** = **Attitude correction**

3 = 3-axis update, anytime between end of slew and start of GS Acq
Currently, 80% of GS Acqs have 3-axis update prior to GS Acq.

Impact of Two Gyro operations on the HST Science program

- Most current visits will not schedule due to longer Guide Star acquisition times (simple problem)
  - Packed orbits may not accommodate extra duration
  - Would require small tweaks by observers
  - Would require iteration with many observers
- Most current visits will not schedule due to FHST requirements (difficult problem)
  - GO specified scheduling requirements (ORIENT, BETWEEN, etc.) imply a time of year and roll angle restriction for visits
  - These will conflict with FHST visibility requirements
  - Will frequently require substantial redesign of observing strategy by observers

Impact of Two Gyro operations on the HST Science program

- Net result is the current science program at the time of Two Gyro mode entry will be largely unusable in the state it is in
- Developing strategy for transition from normal science program to one supported by Two Gyro mode
  - Keep HST scientifically productive
  - Get back to broad, peer-review program as soon as possible
  - Could happen at any time

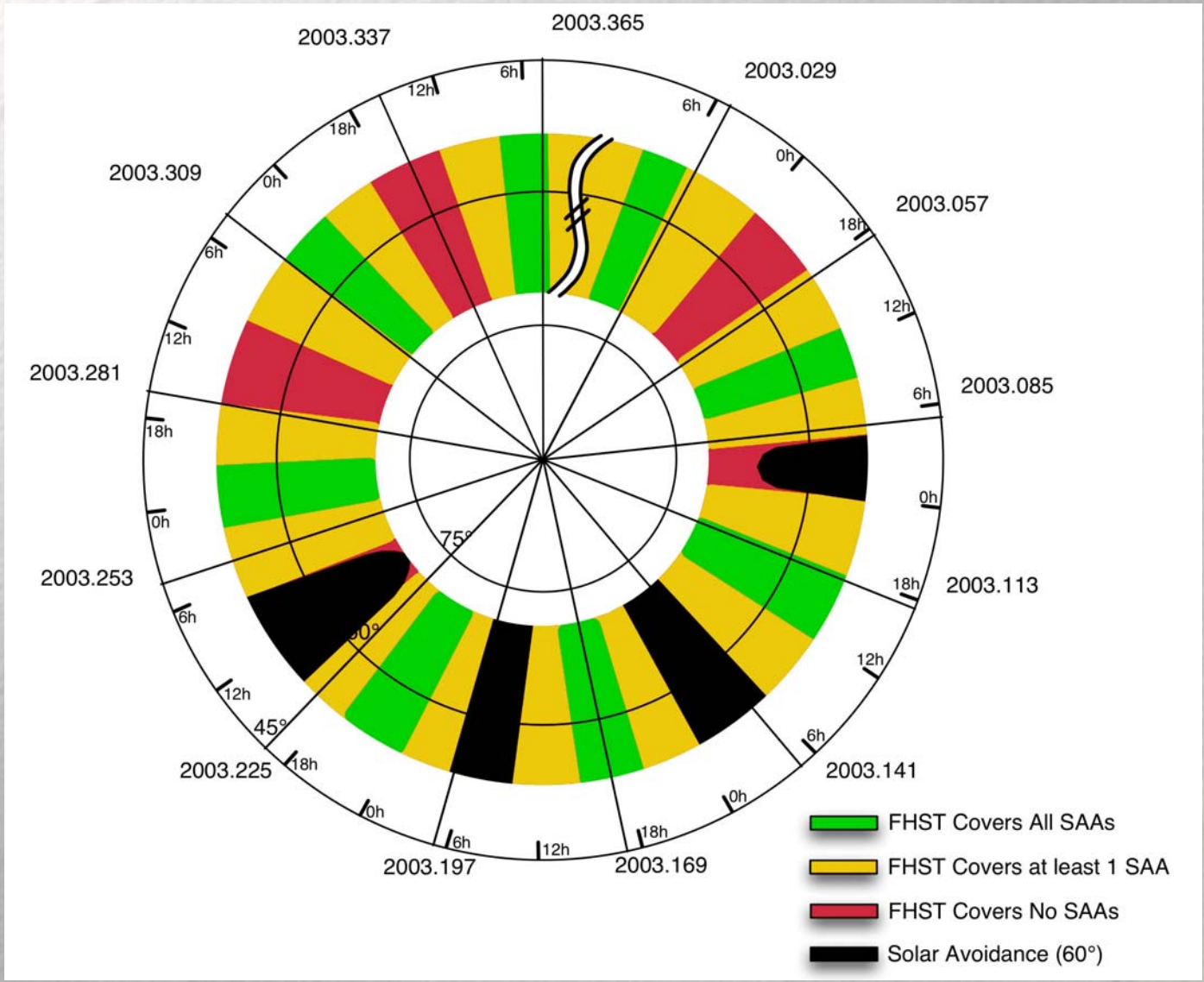
Concept for use of Two Gyro mode

- Initial operations period using CVZ (continuous viewing zone) – several months
- Widen target pool with programs/visits rebuilt by observers – several months
- Full sky availability, but limited by FHST scheduling requirements –
  - Probably at next full GO cycle (requires Phase II implementation)
  - Will depend on timing of cycles relative to two-gyro entry and to SM4

Why use the CVZ ?

- CVZ provides long, continuous observing periods
  - ~ 12 hours between SAA impacted orbits
  - > 1 day if SAAs can be bridged with FHST coverage
- Relatively easy to schedule initial operational tests and science observations
  - FGS is always available, removes one scheduling constraint
  - Test and science programs are not sensitive to acquisition times, we can start with very conservative values
  - Well defined region for target selection, with 56 day repeat cycle
- Can facilitate some performance evaluations
  - Jitter vs. orbital effects
  - Jitter vs. Guide Star magnitude
  - Use of FHSTs to cover SAAs (possibly occultations)

Northern FGS CVZ -Nominal Roll



Science program in CVZ

- Use of CVZ will allow some advance work to be done
  - Target locations restricted
  - Any given target in the CVZ will be viewable within 56 days of entry into Two Gyro mode
- Expect to concentrate on relatively long observations to take advantage of CVZ
- Likely to be non-proprietary observations, similar to HST Treasury Programs
- Policies and processes to be worked with:
  - Space Telescope Users Committee (November 7)
  - Astronomy community
  - HSTP

Widening target pool

- Start with T2G coverage of SAA passages during CVZ observing
- Adjust timing restrictions for FHST coverage based on performance evaluation
- Re-work applicable GO programs to adapt to guide star acquisition times and FHST scheduling requirements
- Begin scheduling non-CVZ visits as they are available and can be scheduled

Visibility Studies

- Current scheduling process is a result of 13 years of experience with HST
- Developing Two-gyro scheduling experience via three studies
  - CVZ scheduling study
  - All-sky target availability study
  - Current cycle scheduling study

CVZ Scheduling Study

- Status: Nearly complete; need to complete analysis of the effect of changing the timings and to write up the final results
- Built upon earlier work done to evaluate the potential of using the CVZ as a way of achieving relatively high observing efficiency
- Evaluated using the north and south CVZs for early operations
  - Evaluated the ability to cover SAA passages with FHST availability
  - Estimated how many orbits are schedulable and how many will be lost due to uncovered SAA passages
    - Number of usable orbits varies from ~7 to 15 orbits per day
    - A scheduling efficiency >~ 50% is implied
  - Evaluated the level of scheduling flexibility available (via off-nominal roll, etc.) to adjust these uncovered periods
- Results of study can be used to evaluate potential early two-gyro science programs

All-Sky Target Availability Study

- Status: In progress; proposals / targets to be used have been written; expect to be completed by the end of the year
- Assess the availability of targets across the entire sky
  - Driven by FHST scheduling restrictions
  - Provide basic information about when and how various portions of the sky are accessible
  - Instantaneously, expect <50% of the sky to be available (predominantly due to FGS / FHST visibility synchronization)
- Perform schedulability sensitivity studies
  - Vary worst case pointing error in M2G / T2G
  - Vary FHST durations and timings for transitions from T2G to F2G
- Utilize SPIKE and other tools to evaluate a grid of targets over the entire sky, comparing the results to nominal operations
- Provides insight into how much of any pre-existing observational program could be supported

Current Cycle Scheduling Study

- Status: Start early next year
- Evaluate what fraction of an entire cycle could be scheduled using a representative pool of observations
- Results will help determine the observing policies that the STScI would put in place to support two-gyro mode
  - If only a few typical cycle observations can be scheduled as originally requested, then it is likely that development of a new observing program would be necessary ASAP (while carrying out an interim CVZ campaign)
  - If a substantial fraction can be scheduled in two-gyro mode, then more time to respond will be available, and potentially a new program could simply be brought in with the next planned observing cycle
- Details are to be defined as previous studies are completed