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NGST Ad Hoc Science Working Group
Minutes of ASWG Meeting #10, 22-23 November, 1999, Belmont Conference Center

22 November 1999

Attendees: Santiago Arribas, Richard Burg, Ewine van Dishoeck, Mike Fall, Harry Ferguson, Bob Fosbury, Jon Gardner, Matt Greenhouse, Don Hall, John Hutchings, Peter Jakobsen, Bob Kirshner, Simon Lilly, Knox Long, John Mather, Pat McCray, Mark McCaughrean, Mike Meyer, Phil Nicholson, Takashi Onaka, Mike Rich, Marcia Rieke, Peter Schneider, Ethan Schreier, Eric Smith, Massimo Stiavelli, Peter Stockman, Guy Stringfellow

1. Status Briefing:

John Mather discusses the timing of the Tripartite (Jan 5-6), the AAS special session (Jan. 12), and NRA II. In March, the Tripartite will meet again. (Ed. Note: these meeting times have slipped almost a month but the April deadline is still a goal). In late March, many members of the NGST team will present papers at the SPIE meeting in Munich. In April, the upper management of the Tripartite will finalize the international contributions

2. Technical Panel Report:

Paul Geithner presents the final report from the Technical Review Panel. The results are similar to those presented at the previous ASWG meeting. There was significantly more information in the areas of MEM devices and cooling. For instance, the panel concluded that active cooling would be better done with coolers rather than cryostats (I&T, launch support and weight.) The risk summaries have been updated and show that all spectrometer concepts except for the IFMOS will require significant development funding. Scott Collins, a Technical Review Panel member, discussed the MEMS issues with us later in the meeting. The technical risk "fever chart" received our attention. One of the changes was a more sober view of the active cooling. None of the coolers is immune from I&T problems or vibration problems. The mass impact was significant for the cryostat (175 kg). Instrument costs were unchanged from the earlier estimates. Paul explained how the parametric analysis worked. Interestingly the FTS was the most extreme variation from previous history and hence had the most uncertain cost.

3. Technical Homework

- Matt Greenhouse presents new information on the QE of infrared arrays in the visible. The measured InSb QE for HYDICE: The overall QE uncoated is about 70% from 0.2-5 microns. The QE of the coated versions is good in the NIR but choppy in the visible. The SIRTF detector shows good QE in the InSb even though it is optimized at 3.5 microns. The HgCdTe uncoated detector shows good QE in the visible (from Don Hall. The MTF for InSb, 7 μm thickness, shows that the MTF is reduced from 50% to 30% from a 30 μm to 20 μm pitch. Several participants note that the MTF of NICMOS got worse in the visible. The MTF is 62% with an 18μm pitch for a HgCdTe at 1.5 μm. The overall recommendation is that the MTF should not be a strong discriminant in the selection of device types.
- Filter Red Leak: Barr Associates will sign up to 10^{-2} with a 90% in band transmission and 10^{-3} with 85% transmission. There is some concern that studying blue stars in a rich field of giants will need 10^{-6} - 10^{-7} blocking.
- Diffraction: Matt shows that calculations of scattering from micromirrors and microshutters should not increase the pupil size significantly. There is some uncertainty about tilted "on" mirrors at the longer wavelengths since they are reflecting a coherent converging wavefront with an Airy disc larger than a single mirror.
- Cost of a 2x2 arc-min NIR Camera: it is estimated to be 53% of the 4 x 4 arcmin camera cost. The yardstick NIR camera was estimated to cost 36-89M by parametric means + contingency + fee. The grass roots estimate is 41M + contingency + fee (but minus the shared support hardware.)
- NGST Visible PSF: Richard Burg discusses model results using various assumptions about the low-mid-high spatial frequencies. The Krist PSF model shows that the visible 80% point is around 0.045 arcsec whereas the 2 μm 80% point is around 0.080 arcsec (no mid-frequency errors). If we assume that we have lambda/40 at 2 microns due to mid-frequency errors, we get a 15% drop in throughput due to scattering. The mid-frequency errors will be dominated by the actuator spacing and accuracy of setting in the mirror or DM
- Pierre Bely recommends the proposed image quality goals.

Encircled Energy Radius at	0.6 microns	2 microns
80%	0.08"	0.1" (measures the quality of the core - low freq. err.)
95%	1.0"	0.6" (measures the amount of scat. light, mid-freq. err.)

(Editorial remark: we are now studying this in reverse-- what is the energy inside 0.06" and 0.2" radii. The former basically is related to the strehl ratio and the latter to the scatter)

- Krist's models show that with the same mid-frequency surface error as HST (in absolute terms) and 1/20 wave RMS of low frequency error at 2 microns the strehl

ratio is 0.05. Here the reduction in strehl at visible wavelengths is due to mostly to low-frequency terms.
- Cost of an additional guider: Richard Burg showed various options for encorporating a separate guider in addition to the NIR science camera. There is signficant advantage at accessing a wider field of view/brighter guide stars to increase the sampling frequency of the guider and reduce vibration feedthrough in the 3-30 Hz regime. The additional cost is approximately 30-80M for any of the methods (e.g. equivalent to a science instrument

4. MEMS Tehnological Readiness

Scott Collins (U.C. Davis) discusses the MEMS technology risks. He showed the details of silicon-based Sandia Labs MEMS mirror. Each mirror is approximately 100x100 microns. The critical factor for all three projects is that they are not very mature. There are probably gaps in the technological developments of each project. The fill factors (efficiency) is 80% for the microshutters and >95% for the mirrors. The tilts may be important for the mirrors (the Sandia MEMS are flat in the on-phase) because of the incoming coherent wavefront.

Designing the development process can take a long time. This harks back to the early days of chip development. Each individual investigator says that there is a high probability that the developments will succeed. Coating on polysilicon can cause stresses on the mirrors. Adding gold and other materials has a risk of turning the mirrors into potato chip. The risk for the GSFC effort is probably one of time not resources. Sandia wants a 6-9 mos. Phase 1 to develop a high fidelity cost estimate. They are comfortable doing 128x128 arrays because of their current manufacturing capability (Editorial note, one mirror of the 3x3 GSFC micromirror array was successfully tested at 28K during the ASWG meeting, thus indicating that the design is workable)

5. ASWG Subcommittee Updates

Visible-NIR Camera subcommittee: The group has created a draft report which will be revised and distributed to the ASWG. They have changed some of the nomenclature of the minimum camera.

NIR Spectrograph subcommittee: The principle debate has been the choice of MOS/IFU for the science in the DRM. The general consensus is a MOS design.

MIR Spectrograph subcommittee: The subcommittee is adding a mid-level capability, between the minimum MIR spectrograph/camera and the most MIR capable system.

6. IFU/MEMS R~1000 spectrograph Pros and Cons:

Marcia Rieke presents the consensus of the committee regarding this issue. The fundamental result is that the committee as a whole favors a MOS solution if that technology can be made ready for NGST. But the choice of "offramp" approaches is more complicated.

The committee downgraded the "ordinary" IFTS because of its lower relative speed for individual objects. For obtaining high-resolution spectra of every pixel, however, the IFTS can be superior to dispersive techniques. However, there are no clear science requirements for that capability.

Both the IFU and IFTS are relatively safe in terms of development risk -- the IFU is safer according to the Technical panel. Dense star cluster surveys favor an IFU whereas galaxy surveys favor the mechanical MOS. The lower technical risks favor the image-slicer IFU.

Simon Lilly presented his take on this trade. He assumes 4K x 4k detector (0.1 arcsec pixels); full octave of spectroscopic coverage 700 pixels. 15" x 15" IFU or 105 arcsec of slit. He recommends the order of MEMS-MOS, MOS-Mechanical Slit, (slits or mechanical slits), FTS + IFS for small fields. Note that the 15" x 15" IFU is smaller than the LeFevre design because of the choice of pixel size and array size.

On the first (paper) vote of the ASWG to order these: 1.1 for MEMS, 2.6 for IFU, 3.1 for Mech.MOS, and 3.3 for FTS. Here the IFU was assumed to be a full octave, 0.2 arcsec pixels, ~25"x25". For this vote, the ASWG were asked not to consider the technology risks that might be involved for the various approaches. It was agreed that for riskier approaches such as the MEMS microshutters and micromirrors a compatible "off ramp" would also need to be pursued in parallel to ensure an acceptable but reduced science capability.

After some discussion of the requirements for an "off-ramp" in which the IFU was thought to be the least risky/most ready of all the spectroscopic designs, the vote was: 1.70 for IFU, 1.78 for Mech. MOS and 2.53 for the IFTS. Again the major sentiment against the IFTS was not one of complexity and cost but rather the long time needed for any single deep spectrum. Simon Lilly has pointed out that the IFTS actually would change the way NGST does science from a HST model to a COBE-like model (long, rich observations).

23 November, 1999

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1. Revisiting the Science Capabilities:

The ASWG devoted an hour to listing the key science observations that could be made with each of the instrumental science capabilities. These were captured on viewgraphs to be used at the AAS and with NASA-HQ.

Following this list, the ASWG voted the priorities of the science capabilities. The rankings were similar to those obtained at the Nov. 5, 1999 meeting.

2. The Instrument Complement

Using the ranked instrument capabilities, the ASWG developed a recommended a three instrument complement to meet the core science requirements for NGST. That complement is

A wide field, ~ 4 x 4 arcmin. NIR camera, Nyquist sampled at 2 μm. The camera should cover the wavelength range 0.6-5 μm and be zodi-noise limited at wavelengths longer than ~ 0.8 μm. The ASWG endorses the addition of a simple coronagraphic option into the camera if it can be done at relatively modest cost (not require the descoping of the three top instruments). The camera and/or the following spectrographic instrument must include a zodi-limited R ~ 100 spectroscopic capability for point sources. Some multi-object capability should be provided with this capability (long-slit or picket fence).

A NIR MOS using an array of selectable mirrors or slits over a large field of view (>~ 10 sq. arcminutes). The spectral range should be 1-5 μm with R~1000 at the center of each spectral octave. Slit/mirror scales ~ 0.1 arcsec. This spectrograph may also include a sensitive R ~100 capability (see above). By vote, the ASWG was evenly split whether the off-ramp should be a 100 element mechanical slit MOS over the same field of view (~10 sq. arcmin) or a ~25" x 25" integral field unit with 0.2 arcsec slits and covering an entire spectral octave at a time, again R~1000 with the R~100 option if not provided by the camera.

A MIR Camera/Spectrograph: This combination instrument would use a 1k x1k Si:As BIB detector (5-28 μm), ideally with useful quantum efficiency at the 28.3 molecular hydrogen line. The field of view would be approximately 2 x 2 arcminutes for the camera and the spectral resolution should be R ~ 1500 or higher.

These three instruments should form the "core" instrument package for NGST. Even this package cannot perform all the top 7 DRM programs. The ASWG considered four options for adding a fourth instrument, if funding were available. The voting for these capabilities were:

High angular resolution, high spectral resolution NIR spectrograph (>~2" x 2", R~3000-5000): 6 votes

High angular resolution, high spectral resolution MIR spectrograph, (>~2" x 2", R~3000-5000): 6 votes

High resolution camera (Nyquist sampled at 1 micron and extended capabilities into the visible): 7 votes

NIR Coronagraphic Camera (optimized at 5 microns): 1 vote

The ASWG agreed that any of the top three instruments would be of approximately equal scientific priority and that the coronagraphic capability would be a highly desirable option for the NIR camera.

4. Project Scientist Remarks:

All three Project Scientists indicated that they felt that the prioritization process had been a success and that they would take the ASWG advice to their top management. John Mather once again reviewed the schedule for the allocation process. The ASWG reviewed Mather's presentation to the AAS and NASA-HQ and recommended that much of the presentation be used as backup charts for the AAS.

5. Science Policies and the Future of the ASWG

Peter Stockman spoke informally about the process of refining science policies for NGST and about the future of the ASWG. Bruce Margon remarked that the best approach may be to make policy decisions only as they are needed, rather than create unnecessary concerns within the community so early in the program. The first science policies that need to be addressed are the roles and makeup of the flight science working group and the science teams created to oversee the development of the science instruments. In this regard, Peter indicated that the future of the ASWG itself was somewhat murky. The ASWG has made a major contribution to the program over the two years since its creation: creating and ranking the DRM, the creation and scientific prioritization of the five science themes, and the study and prioritization of the major scientific instrument capabilities. The next two to three years will be devoted to science advocacy and more interactions with the prime contractors and the NGST system engineering effort. There is also a desire within elements of the Project to accelerate the selection of the flight science team. ESA will likely create its science team within approximately a year. Depending on these selection processes, the current ASWG may be asked to extend their membership for another year or if the US selection is delayed, it may be reconstituted to cover the next two-three year interval. In any case, we expect to hold another meeting of the current ASWG-minus in the late-Feb, early March time frame to discuss the progress in the allocation process and to review feedback from the AAS meeting.

ASWG members are encouraged to help at the NGST display booth in the Jan. AAS meeting in Atlanta. If they are interested, they should contact Harry Ferguson at the STScI (ferguson@stsci.edu). There is also a meeting on the "First Generation of Cosmic Structures" in Harvard on 15-18 May, in which the promise of NGST will be a key ingredient. The web site for the conference is http://cfa-www.harvard.edu/apconf/