Notes on Third Meeting of NGAO Solar System, February 28, 2006

Attendees: Antonin Bouchez (Caltech), Joshua Emery (NASA-Ames), Franck Marchis (UC-Berkeley)
Members who could not attend: Mate Adamkovics (UC-Berkeley), Keith Noll (STSCI)

Summary: The group reviewed the Potential Instrument table, discussed the progress made and problems encountered for the science case project tasks. We also defined what should be ready for the Science Case workshop.
Notes are available below

Next telecon is scheduled on March 15 at 10am PST (I will be in Europe, so hopefully I will find a way to call this 877 number?).

Regards
Franck Marchis, subgroup chair

Potential Instruments
* on Feb 28, we reviewed the XLS file provided by R. Dekany. This is a very interesting table, extremely useful and well constructed.

a few possible corrections:
- NIRC-2 detector is sensitive up to 0.9 microns but this mode was not offered in 2005B (Z band filter not installed).
- NIRC-2: the lowest resolution is 360 (160 mas slit, lowres grism, wide camera, K filter) from R. Campbell's email

Some comments:
* In the NIR & visible, MOAO system will not provide an angular resolution competitive to spacecraft imaging capabilities or even HST. An angular resolution of 0.100-0.150 arcsec on-axis is attainable with a 3m telescope (like Lick-Shane). None of our science cases, require a multiobject spectroscopic capabilities.

* A corrected field of view larger than 45" is unnecessary for all of our selected science cases. MCAO is therefore not a priority for planetary science.

* MIRAO has also a low interest for our science cases. It will not provide an angular resolution good enough to study most of the planetary science objects. For instance, in the case of Io (1" diameter), MIRAO resolution will correspond to 2 element of resolution only. Not much information will be obtained, if compared with integrated photometric observations (available on 3m class telescope). Without estimate of the sensitivy and comparison with Spitzer space telescope, TEXES at IRTF and future SOFIA missions (or JWST), we cannot say much about it. If the TSIS obtained some positive inputs from other committee, such brief study should be made.

We therefore mostly focused on LTAO instruments. Considering our science cases, we sorted them out in order of interest:

1- Visible Camera/IFU
Considering a corrected FOV 5" max, what will be the cost of a 1", 2", 5" IFU FoV?
Low spectral resolution (R~400) is enough to characterize the composition of asteroid/satellite solid surface. We would like to know if such spectroscopic mode could be implemented.
high priority because of the significantly higher angular resolution & sensitivity + Spectroscopic capability in optical

2- Super OSIRIS (comparison with OSIRIS: more lenslets and lower WFE)
Because of the better angular resolution provided by LTAO in Z & J bands, the smaller angular size of the lenslets will be useful for our science cases (characterization of the surface of Titan and Galilean satellites for instance).
Low spectral resolution (R~400) is enough to characterize the composition of asteroid/satellite solid surface. We would like to know if such spectroscopic mode could be implemented.

3- Super NIRC2 (comparisoon with NIRC2: significantly better WFE & polarimeter)
2K x 2K NIR Alladin detector are not available. The FOV should be then twice the one offered by NIRC-2
lowest priority since for most of our science cases we will use small FOV and NIRC-2 already provides a good imaging capabilities.
Low spectral resolution (R~400) is enough to characterize the composition of asteroid/satellite solid surface. We would like to know if such spectroscopic mode could be implemented.

Recommendations:
- Coronagraphic capabilities (what kind of mask structure?) must be offered on Super-NIRC2 and the visible camera imaging instruments.
- What about polarimetry in the visible light? We will investigate if polarimetry will bring some information for the study of Titan and the surface of asteroids, but it should be interesting for the study of circumstellar disks.

The updated text is written in italic.
Science cases

A. --------- Multiple Asteroidal Systems ----------

* A.1 Simulation of 87 Sylvia and its 2 moons (assigned to Franck)
- Characteristic of the asteroidal system
  This is a main-belt asteroid with mv~12, two moons are known and were detected with Keck AO (2001) & VLT-NACO (2005). The primary is resolved (~0.12)
- For this simulation a third faint moon will be added closer to the primary and also a fourth one between the new moons
- detection profile will be calculated (algorithm already developed FM)
- Positions of centroid and relative photometry will be measured. Precision on the estimate of the orbital parameters will be discussed (possibility of detecting very small precessions, and gravitational effects between moons (forced eccentricity)?)
- Comparison with TinyTIM HRC/ACS (HST) & VLT-NACO (KN)
- *polarimetry in visible and NIR range?*

Inputs from Technical team: Simulated short exposure On-Axis PSFs (~2-5s) (x10) at various wavelength (0.5, 0.7, 1.2, 1.6, 2.2 microns) at median seeing conditions for a bright reference (mv=12)
Main Goals: Stability of the PSF (very high SR) and its influence for the orbit determination of multiple systems + gain for observations in visible

Progress:
** On Feb 28, SIMULATION are ready. Images will be degraded by convolution with recently provided PSF. Animation displaying the four moons is available on* http://astron.berkeley.edu/~fmarchis/document/KNGAO/SylviaProject/sylvia_anim.mpg

* A.2 Observations of 2003EL61 and its two moons (assigned to Antonin)
- Characteristic of the asteroidal system
  This is a TNO asteroid with mv~17.4, two moons are known and were detected with Keck LGS AO (2005). Will the primary be resolved in visible?
- detection profile will be calculated (algorithm already developed FM)
- Positions of centroid and relative photometry will be measured.
- Comparison with TinyTIM HRC/ACS (HST) & Keck LGS AO (KN)
- Shall we expect a gain in the case of coronagraphic observations?
- *polarimetry in visible and NIR range?*

Inputs from Technical team: Simulated long exposure On-Axis PSFs (~60s) (x3) at various wavelength (0.5, 0.7, 1.2 microns) in good seeing conditions for a faint reference (mv=17.4)
Main Goals: Quality of the PSF and comparison with HST (quantify), *Check if coronagraphy will be useful (useful in BLIP only?)*

Progress:
** On Feb 28: assigned to Antonin (confirmed).*

* A.3 Size and Shape of Asteroids (assigned to Josh & Keith?)
This work is mostly a statistical study. Tables will be prepared for this project.
- We want to know:
  How many asteroids can be observed with a NGAO with a limit of magnitude of 15,16,17,17.5, 18 in all populations (MB, Trojan, Centaurs, TNOs)
  How many asteroids could be resolved with a NGAO working at 0.5, 0.7, 1.2 microns
- Illustrate the size estimate and variety of shape using resolved images of asteroids from spacecrafts (Itokawa, Ida, Matilde, ...)
- Scientific justification. Why is it important? (formation process, collisions, ...)

Inputs from Technical team: Angular resolution at 0.5, 0.7, 1.2 microns for mv<15 and mv~17.5 at median seeing conditions
Main goals: Gain in angular resolution because of the visible wavelength range

* A.4 Spectroscopy of moonlets (assigned to Josh & Franck)
Because the halo around primary asteroid will be reduced, spectroscopy capability will be enhanced
- Using the image simulations from A.1 and A.2, quantify the S/N gain (comparing with Keck AO NGS/LGS)

- Scientific justification: What kind of absorption features can we expect for asteroid surfaces (C,S, M, V taxonomic types) in the NIR, and in visible. Do we need the short wavelength visible range (<0.7 microns). What is the most adequate spectral resolution?

Inputs from Technical team: inputs about IFU and relation with spectral resolution (do we need this?)
Main goals: Do we really need the short wavelength range in visible? what kind of R for the instrument?

Progress:
** On Feb 28 assigned to Josh & Franck*

B. ---------- Titan and other Giant Planet satellites ----------

B.1. Titan surface and atmosphere (assigned to Mate & Franck)
We will create a fake Titan observations considering also the haze component in visible and NIR and using global map (with R=30-200 km) of Cassini spacecraft. We will focus on atmospheric windows for which the surface can be seen (tools are ready MA & FM). Wavelength not defined yet.
- Deconvolution with AIDA may be included (algorithm 95% ready FM)
- Comparison with Keck NGS AO, VLT AO, and Cassini will be included
- Good temporal coverage from the ground vs spacecraft will be discussed and illustrated by surface changes due to a cryo-volcano (and/or clouds in the troposphere?)
- Spectroscopy to detect N2+ species in the atmosphere (high R) and measure winds in Titan atmosphere at various altitudes (extremely high R).

For wind on Titan
see http://astron.berkeley.edu/~fmarchis/document/KNGAO/Documents/Kostiuk_TitanWind.pdf

Inputs from Technical team: Simulated short exposure On-Axis PSFs (~2-4s) (x10) at various wavelength (NOT YET DEFINED) in good seeing conditions for a bright reference (mv=8.5). Should we expect a degradation due to the angular size of Titan (D=0.8")

Main Goals: Observations of an extended object - imaging and spectroscopy of its atmosphere. Comparison with previous NGS AO systems. Illustration of the variability of solar system phenomena (volcanism, clouds)

Progress:
** Feb .28: Model is ready. Perfect images will be generated soon (from Mate)*

B. 2 Io volcanism (assigned to Franck)
We will create two set of fake Io images with various active eruptive centers using Galileo/Voyager global map (R~35 km). One in sunlit (on axis reference) and the second one in eclipse (off axis reference at 25"). Observations at 0.7, 0.9, 1.2, 1.6, 2.2 microns will be considered not finalized yet)
- Deconvolution with AIDA may be included (algorithm 95% ready FM)
- Comparison with Keck NGS AO & Gemini PlanetFinder will be included
- Photometric precision on the eruptive centers will be estimated

Inputs from technical team:

- Simulated short exposure On-Axis PSFs (~1s) (x10) at various wavelength (0.7, 0.9, 1.2, 1.6, 2.2 microns) under good seeing conditions for a bright reference (mv=5.5).
- Simulated short exposure Off-Axis PSFs (~1s) (x10) at various wavelength (0.7, 0.9, 1.2, 1.6, 2.2 microns) under good seeing conditions for a bright reference (mv=6) located at 25" (or more...).
- possibility to discuss NIR WFS (to close the loop on Io itself in eclipse?)

Main Goals: Observations of an extended object - imaging of its surface. Comparison with previous NGS AO systems. Illustration of the variability of solar system phenomena (volcanism). Comparison with Keck NGS AO anisoplanetic and KPAO (wider-field AO systems such as MCAO & MOAO).

B.3 Observations of smaller Giant Planet satellites (assigned to Josh (& Antonin?))
With this work we expect to be able to tell if a KNGAO system will be useful to study other Giant planet satellites. A table summarizing those which can be observed (on-axis) and the best spatial resolution (in km + number of element on the disk), plus a brief summary of their scientific interest (spectroscopy, activity, work previously done).
Example: For NIR spectroscopy of four of Saturn's satellites (including Enceladus), you can have a look
on http://astron.berkeley.edu/~fmarchis/document/KNGAO/Documents/SaturnSatellites/

Inputs from technical team:
- Problem of halo due to the disk of the Giant planets (how can we quantify/simulate this?)
- Angular resolution at 0.5, 0.7, 1.2 microns for mv<15 and mv~17.5 in median seeing conditions
- Proper motion (non sidereal tracking)

Main Goals: Make sure that this instruments will be useful for various targets in the solar system

C. ---------- Atmosphere of Giant Planets --------- We decided to drop this science case for the moment
A difficult problem. The committee has the feeling that the design of a AO system aiming to observe only Jupiter/Saturn is not appropriate. Low priority science case
* If cross-correlation is chosen. what should be the wavelength of observations (comparing the contrast of features of the atmosphere of Jupiter/Saturn with those on the photosphere of Sun)
* If we want to use the satellites to close the tip-tilt loop. Several problems 1. their intensity vs the glare of the Planet 2. Motion of the satellites 3. anisoplanetic effect must be simulated.
* Spectroscopy? need science inputs
* Atmosphere and environment of Uranus & Neptune
Quality of KPAO PSF on such extended objects?