Science Implications of Build-to-Cost Cost-Savings Ideas

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Item 1. No multiple deployable IFU capability

a. We agree: no multiple capability, for reasons of cost and complexity.

b. Impact: will take longer to accomplish science goals on high-z galaxy assembly and star formation history, physics of giant planet atmospheres, Galactic Center, resolved stellar populations. Probably rules out NGAO use for lensing by galaxy clusters (too much telescope time needed to line up one IFU along lens arcs).

c. To partially recover some of this science, there would be a significant advantage to being able to use both OSIRIS and the new single-headed IFU at the same time. Gives a factor of two multiplexing without building two heads of the new IFU.

- This will require that OSIRIS be operable on-axis and that the new IFU be operable in a deployable mode off-axis (or vice versa)
- Needs a cost-benefit analysis
- Example of a science case that would benefit: high-z galaxies. Use OSIRIS on-axis with one of the brighter high-z galaxies in the field, and use the new higher-throughput IFU off-axis with a fainter galaxy in the field. Doubles the efficiency for survey follow-up work. Needs a more quantitative study, with "real" deep fields.

Figure 1. Hubble Deep Field. Approx. 20x20 arc sec.

d. Do we need a 32x32 MEMS for the IFU or is the 20x20 DM sufficient or could we put it after the 2nd relay MEMS?

- Need to see Rich's spreadsheets to determine if 20x20 will give sufficiently small enclosed energy radius. Requirement for high-z galaxies: 50% EE in 0.07 arc sec.

- If we put the new IFU behind the second relay, could we still use it at the same time as OSIRIS? Probably not, unless we have complex dichroic farm. Also, need to look at which option would have fewer surfaces. (Need high throughput and low emissivity.)

Item 3. Only control 48 subapertures across the pupil in the 2nd relay

Need a quantitative understanding of impact on wavefront error, enclosed energy, and other science-relevant performance metrics.

Science that would/could be impacted: imaging of extrasolar planets, binary asteroids, Galactic Center, black hole mass measurements in nearby AGNs. quasar host galaxies, resolved stellar populations, moons of giant planets

Item 6. Should we implement OSIRIS with the new NGAO system?

Science: AGNs, Galactic Center, gravitationally lensed galaxy kinematics, resolved stellar pops, moons of the Giant Planets, young stellar objects.

a. (same as point c in item 1 above) There would be a significant science advantage to being able to use both OSIRIS and the new single-headed IFU at the same time. Gives a factor of two multiplexing without building two heads of the new IFU.

- This will require that OSIRIS be operable on-axis and that the new IFU be operable in a deployable mode off-axis

- Needs a cost-benefit analysis

b. Strategic planning document highlights the need for a high-angular-resolution IFU as well as a “high-throughput near-IR IFU” as high priorities for extragalactic science. This could be met either in a single instrument with both capabilities, or by using OSIRIS for high angular resolution and a new IFU for higher throughput. Needs quantitative cost-benefit study.

Item 9. Do not implement visible imager.

a. The strategic planning document says there is a need for an “optical IFU and imager (to use NGAO at the I-band)” as a high priority for extragalactic science, and also for planetary science.

b. This could be two stand-alone instruments (but note that the IFU is not on our list and the imager is a candidate to be cut). Alternatively we could fold this capability (down to I band) into the new IR IFU and the new NIR imager.

c. For the imager, consider science that could be done with a stripped-down version with only a few operating modes. Evaluate cost and benefit of such an imager.

Item 12. Fewer devices and controlled degrees of freedom.

a. In general this is a good idea. Science team should come up with the minimum number of different operating modes that can still accomplish the main science goals. Some of the less important science goals can be met with diminished capabilities.

b. If there is sufficient science benefit and a low enough cost to being able to operate both OSIRIS and the new IFU at the same time, some portion of this simplification may not be possible. It's a cost-benefit decision.

Item 14. Fix the central four LGS beacons.

a. Need a quantitative analysis of penalty in wavefront error, for a selection of science cases.

b. If we are going to keep the possibility of using both OSIRIS and the new IFU at the same time, we need to analyze the impact of fixing the central four LGS beacons for the off-axis instrument.

Items from notes at bottom of spreadsheet:

No ADC for tip-tilt sensors and near-IR IFUs. Need a quantitative analysis of penalty in wavefront error for a selection of science cases.

Pulling in the schedule by a year. This has the ancillary science benefit of giving us comparative advantage relative to JWST, TMT, etc.

Other, more radical thoughts: Consider performance hits and science losses if:

1. we only have one fixed constellation of laser guide stars (both for science and TT).

2. we only have one LGS WFS plate scale.

3. we don't have natural guide star mode at all. There are two cases: science proposed for NGS, and backup science with NGS when the laser fails. Both could be met to some extent by current NGS AO system, given sufficient scheduling flexibility.

4. we didn't have a truth wavefront sensor at all.

We need to factor in the desire for having staged development, so that if no more funding is available at a given stage the Keck science community will still benefit. (per Mike Bolte)