IMACS Commissioning

Presentation to Pre-Ship Review

Alan Dressler

May 28, 2003

Present schedule for installation and commissioning of IMACS:

August 6-15 Installation

August 16-20 Continued installation and/or sky tests

September 11-13 Sky tests with ADC/corrector

September 17-21 Continued commissioning

October 15-29 Scheduled observing, commissioning as needed

Re-qualification of mechanical devices – step 1

Validate mechanisms function

During or immediately following assembly process, verify function of

- Mask server
- Principal, Shack-Hartmann, Center Field guiders
- 2 Filter servers
- 2 Shutters
- Disperser Server
- Grating Tilt Mechanisms

Verification to include proper operation of all limit switches and status sensors. Two *Physik Instrument* motion stages also to be rechecked.

Once adjusted to function correctly, set up scripts used in Pasadena to test multiple repetitions – cycle devices equivalent to at least 1 month's use (~100's reps per device, ~20 hours in 5 hr sessions). Tests to be done while rotating the instrument 360 degrees (NIR control?)

Re-qualification of mechanical devices –step 2

Validate mechanism performance

Mask server

- Adjust hard stops for mask insertion. Masks should hold position (flexure while latched) relative to FOS disk to 0.1 arcsec during full rotation (these done with Heidenhain gauges)

- IFU – repeat position not required, flexure < 0.2 arcsec during rotation

Notes: 1) Check all masks for installation and insertion. 2) Fine tune laser cutting

Re-qualification of mechanical devices –step 2

Validate mechanism performance (cont.)

Guiders

- Measure flexure of principal guider relative to inserted mask over a full rotation of the instrument (spec: < 0.1 arcsec)

- Measure flexure of the Shack-Hartman guider relative to inserted mask over a full rotation of the instrument (spec < 0.2 arcsec). Check both modes (direct and SH)

- Measure flexure of centerfield guider relative to inserted mask: spec < 0.2 arcsec over full rotation.

Re-qualification of mechanical devices –step 2

Validate mechanism performance (cont.)

Structure Flexure

Verify performance and implement look-up tables

- Using a test mask, put in imaging mirror and measure flexure of the structure as a function of angle using the f/4 camera.
- Repeat with grating mechanism
- Repeat procedure for f/2 camera (open).
- Repeat with grism
- Re-implement and test open-loop flexure compensation using piezo-stage carrying 8K mosaic. Test closed-loop control.

Mask server and dispersers – associated activities:

- Implement full capabilities of mask cutting system provided by Clardy's mask-making software.
- Tune the laser cutter parameters for best performance and balance this with cutting speed.
- Establish the protocols for mask cutting, specifying the responsibilities of both observers and technical personnel.
- Develop procedure for transporting and installing masks
- Dispersers: Complete/verify tables of central wavelength and range for each grating and grism

Cooling system

- Connect IMACS to Magellan fluid cooling system. Test performance of cooling manifolds (electronic racks, CCD controllers, Piezo-controller, guide cameras…)

- Monitor and analyze thermal data from IMACS internal sensors. Measure response time of structure and of optics. Determine impact of disequilibrium on imaging quality (could require many months of operation to get a handle on this). Time constants can be tuned (changes in insulation) if results suggest a strong reason to do so.

Mosaic CCD Camera

• Connect and test Cryotiger cooling system. Check temperatures of CCD's

• Check for CCD window frosting in Magellan environment. N_2 flush?

• Re-validate performance of camera in Magellan environment. Noise/pickup problems? Measure read noise/QE for different chips (If substantially different, observers might choose one or more chips preferentially for spectroscopy when all are not required.)

• Re-check all software control functions, including re-binning, sub-rasters, pause, abort, etc. Check "wing chip" function.

• Implement and test control for nod & shuffle observing mode

• Check for light leaks in an illuminated dome, testing integrity of IMACS hatch and panel enclosures.

• Establish protocols and procedures for moving the mosaic CCD camera from f/4 to f/2.5 camera and vice versa.

Step 3 – Imaging tests

Re-establish the "internal" optical performance (per Pasadena)

- Using a slit mask with a grid of points, take images of the full field to establish the focus/scale for the f/2 camera. This camera is athermal so the only degree of freedom is the CCD focus mechanism (done in Pasadena).

- With this value of the CCD focus, repeat this procedure for the f/4 camera, using movable f/4 camera element L05 to set the zero for this camera's focus (done in Pasadena).

- Check that the focus holds over the full fields of the respective cameras – this is important in order to check the ADC/corrector when it is ready (this is an internal focus test).

Imaging tests (cont.)

Test IMACS with Magellan optics – on the sky. Small field done first in August, in September with ADC/corrector.

- Starting with f/4 camera, with CCD focus and L05 as determined from the slit mask focus test, image a star field. Repeat with f/2.

- Align elements (IMACS imaging mirror?) to insure that the optical axis falls at the center of the slit mask and on the center of the 8K array. Check (adjust?) position of tertiary mirror (detent on rotator?) to align with IMACS optical axis.

- Focus of the three guiders in imaging mode has been provisionally established with metrology. With telescope focused on the IMACS focal surface, establish the final focus for the three guide by focusing the commercial lenses on the guide cameras.

Imaging tests (cont.)

• Make sure that images in the Center Field Guider slit mask are in focus over its 2-arcminute field – this tests possible error in the tilt of its slit mask. Check that the focus of each guider maintains as these guiders are moved through their full range of motion.

• The Center Field Guider Shack-Hartman sensor is first calibrated with an illuminated pinhole (in Pasadena or in Chile?), as has been done with existing guiders at Magellan. Use CFG Shack-Hartmann test to correct the primary mirror shape (and secondary position?). Test this result (for an on-axis star) by comparing with the Shack-Hartmann sensor on the East platform (LDSS?) -- requires ~10 minutes to cycle, so has to be done several times.

• Test full field with ADC/corrector. Image quality over the field will test the performance of the ADC/corrector, specifically, whether the optical prescriptions of the ADC and IMACS agree.

Imaging tests (cont.)

• Once IMACS CFG Shack-Hartmann wavefront sensor's calibration has been validated, use it to internally calibrate off-axis Shack-Hartmann guider by running both simultaneously. Check this calibration for the full radial and chord motion of this guider.

• Scale and distortions – IMACS optical scale/distortion has been measured through imaging of a precision slit mask – this done with f/2 camera to cover entire field. The scale and distortion of Magellan Baade should be known from the optical precision to high order, but hasn't been checked to the precision required for IMACS slit masks, about 1/100,000. To check and/or determine, of image a astrometric field with IMACS f/2 camera and back out the internal measurements. Resulting parameters are used for laser cutting of masks.

• Measure focus offsets for available filters (first done in Pasadena)

• Measure imaging throughput of IMACS with available filters.

Imaging tests (cont.)

- Check for light leaks and stray light, including LED's

- Test for scattered light: put a 7th magnitude star at various places in the field and look for ghosts in deep exposures, f/4 and f/2 camera

- Check baffling: put a 5th magnitude star outside the fields of the two cameras and take deep exposures (skirt baffle around Magellan secondary?)

- Take a series of very deep exposures with f/4 camera in the best conditions. Include a faint star field (globular or dwarf galaxy) and a faint extended nebulosity

- Take a series of very deep exposure with f/2 camera, as above. Check guiding on very long exposures, including rotation.

- Take some art shots.

Step 4 – spectroscopic tests

First tests

• Verify performance of internal calibration unit (arc lamps and flat field) – take arc spectra for both cameras (done in Pasadena)

• Use Magellan flat field screen and calibration lamps to establish approximate exposure times for arcs and flats for the different gratings/settings.

• Test IMACS flexure of grating tilt mechanism to compare with Pasadena results, including angle/wavelength adjustment. Check and/or adjust rotation of the gratings to produce center-straight spectra (may have been done in Pasadena).

•Test all gratings. Determine throughput for each grating, quantum efficiency as a function of wavelength. If not already done, establish central wavelengths and ranges as a function of grating tilt encoder.

Spectroscopy (cont.)

Single object spectroscopy with direct slit-viewing:

• Starting with CFG and its multi-tier slit, take spectra with 300 l/mm gratings (covering 3400 – 10,000 Angstroms) of standard stars to test resolution, throughput. (Throughput of other gratings can be established by coupling through flat fields.)

• Establish approximate magnitude limits for acquiring objects with the CFG.

• Take a series test exposures, for example, a very faint ERO at low resolution and a relatively bright QSO at R ~ 10,000.

• Place a 7^{th} magnitude star on the slit and measure the point-spread-function of the resulting spectrum along the slit – scattered light! (Compare with a direct image in same conditions.)

Spectroscopy **--** Multi-slit spectroscopy

Establish procedures to set up and execute a multi-slit mask spectroscopic exposure:

- Develop, test IMACS & Magellan software which must
  - Send/receive telescope position, IMACS ⬅➔ TCS
  - Send IMACS ➔ TCS guider (1,2,3) on/off
  - Send guider field angles IMACS ➔ TCS
  - Send/receive ➔ Cursor positions (for precision alignment and tracking corrections such as atmospheric dispersion scale correction – not done in ADC!)
- Acquire guide stars – test Clardy's software to position guiders to known guide star positions.
- Develop and test mask alignment software. Build on Phillips programs for WFCCD and LDSS-2. Interface with Clardy's files from mask making program.

Spectroscopy **--** Multi-slit spectroscopy (cont.)

Take a number of long integration multi-slit mask exposures

- Measure total throughput of f/4 + grating system
- Measure total throughput of f/2 + grism system
- Compare beginning and ending alignments after long exposures!

- Perform first-cut spectral extraction to check data
- Set up and test nod & shuffle multi-slit spectroscopy.
- Test “multi-field mask” application.

Test Integral Field Unit – use calibration lamps, then selected targets such as a galactic nucleus, center of a globular cluster, H II region.

Future: test Echellette mode and Tunable Filter

Documentation

In advance of commissioning, begin to write an operations manual for observers. Amend, correct, and expand during commissioning. Include sample spectra, line lists for calibration, throughput and QE numbers, resolutions as a function of grating and slit width, etc.

Develop a troubleshooting chapter.

After commissioning, polish this document and put it on the web.