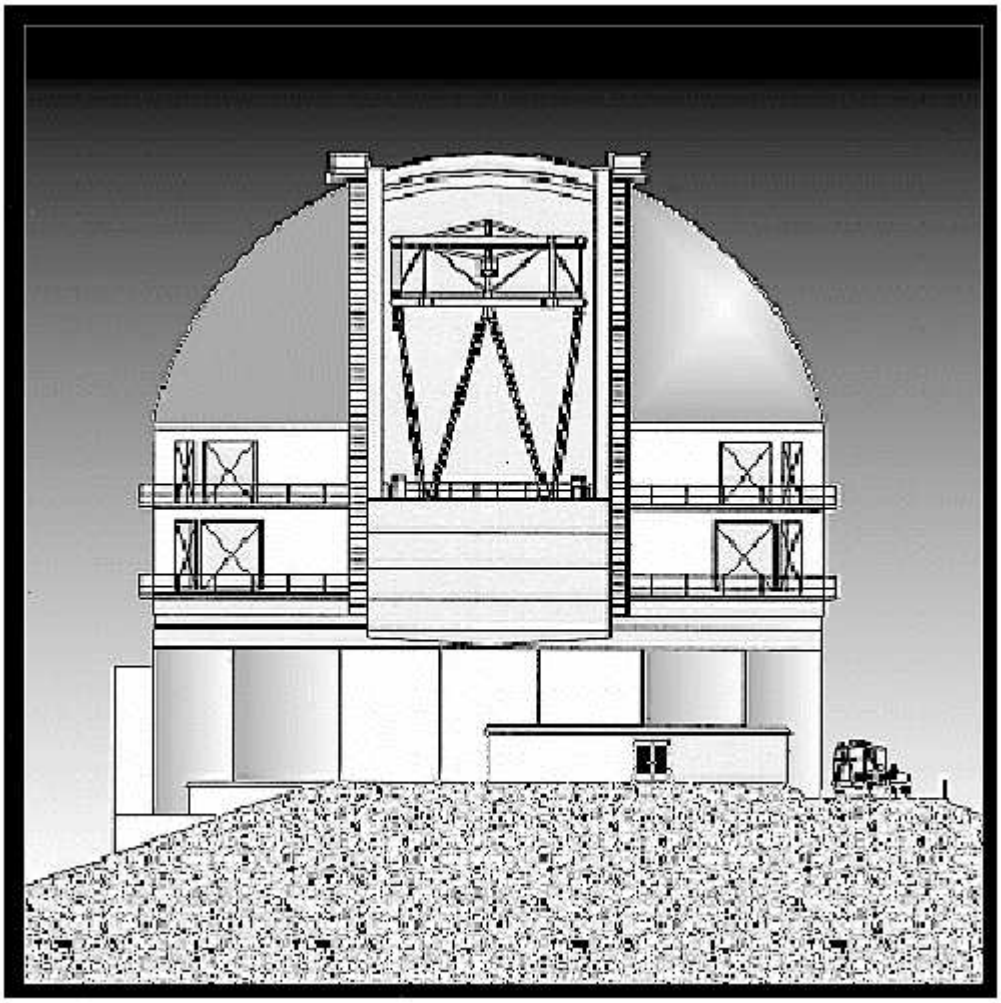
GEMINI
8-M Telescopes
Project

SPE-C-G0061

Gemini 8m Telescopes Instrument Science Requirements



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January 27, 1996

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Change and Approval Sheet

Revision 1.0 (Initial Release)
January 27, 1996

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1. GSC Approved Near Infrared Imager (NIRI) Design Specifications

(a) The 1-5 µm imager will be used for commissioning the Mauna Kea telescope, as well as for scientific observations, and will have the following capabilities:

1) 1-5.5 µm wavelength coverage
2) Array: 1024x1024 InSb array, 27 µm pixels
3) High Throughput
4) Internal Instrument Background:
   (i) <1% telescope emissivity for $\lambda > 2.2$ µm
   (ii) <0.5 e/s/pix at shorter wavelengths
5) Cold focal plane wheel with variety of field stops, slits, etc.
6) Three Plate Scales:

Pixel Size	**Field of View**
0.02”	20”
0.05”	51”
0.12”	123”

7) Filter Requirements: 20-30 slots for filters, grisms, and polarizers
8) Grism capability; R~700, 1-2.5 µm
9) Pupil viewing

(b) Goals:
1) Design for 2048 x 2048 arrays using 27 µm pixels
2) Coronagraphic mode

2. GSC Approved Near Infrared Spectrograph (NIRS) Design Specifications

(a) The 1-5 µm Spectrograph for Mauna Kea is planned to be the second instrument available on the telescope, and its capabilities will be:

1) Wavelength coverage: 0.9-5.5 µm
2) Array: 1024x1024, InSb array, 27 µm pixels
3) High Throughput
4) Spectral Resolution: R ~ 2,000, R ≥ 8,000
5) Pixel Scale: 0."05 / pixel
6) Slit Width**:** 0.”1 to 0.”2
7) Slit Length: ≥ 50 arcsec
8) Polarizing Prism

(b) Desirable Options (in no particular order except the first item):

1) Slit Length of 150 arcsec, pixel scale of 0.15 arcsec/pixel
- Having a coarse (0.15" pixels) camera implies a grating turret (they are coupled), not just the two position system that is required above in the baseline design
2) Cross Dispersion or Simultaneous Wavelength Coverage
3) Multi-Slit
4) Integral Field Mode
   - IFU has been split off as a separate R&D activity
5) Spectral resolutions of 15,000 - 30,000

3. GSC Approved Gemini Multi Object Spectrograph (GMOS) Design Specifications

(a) There will be two Multi-Object Spectrographs (MOS), one for Mauna Kea, optimized for red applications, and one for Cerro Pachon, optimized for blue applications. Their other capabilities will be:

1) Wavelength Coverage: 0.4 - 1.1 µm
2) Arrays: 6144x4096 CCD array composed of 3 2048x4096 buttable CCDs, 15 µm pixels
3) Image Scale: Single plate scale of 0.08 arcsec per pixel
4) Slit Sampling: 2.5 times the image pixel scale
5) Imaging Mode: Supports MOS mask production
6) Spectral Resolution: up to 10,000
7) ADC that is removable though not remotely deployable
8) Integral Field Mode: Sub-apertures with dia. 2.5 times the pixel scale, 8 arcsec FOV

(b) Optional Features (in no particular order except the first 2 items):

1) Extension of wavelength coverage to UV atmospheric cutoff and to 1.8 µm
2) High spatial resolution integral field mode at >0.7 µm

4. GSC Approved Mid Infrared Imager (MIRI) Design Specifications

(a) The 8-30 µm imager will initially be deployed at Mauna Kea and will be available for use at first light on Cerro Pachon. Its capabilities will be:

1) Wavelength Range: 5 to 25 µm
2) Array: ~256x256 Si:As IBC
3) High Throughput
4) Plate Scale: $\leq$ 0.13 arcsec/pixel
5) Instrument Background: < 1% effective emissivity in low emissivity atmospheric windows
6) Filter Requirements: 20-30 cold filters

(b) Desirable Options:

1) Dichroic feed to InSb array for NIR guiding/simultaneous imaging
2) Optical design consistent with x2 upgrade in array size

5. GSC Approved High Resolution Optical Spectrograph(HROS) Design Specifications

(a) The High Resolution Optical Spectrograph (HROS) will be the second optical instrument installed at Cerro Pachon and will include the following capabilities:

1) Array: 4096x4096 CCD, 15mm pixels
2) Throughput is Highest Scientific Priority, particularly in UV
3) Requirement: >10% at R=50,000 and 500nm; goal 15%
4) Resolution: in the range of 30,000 to 80,000, resolution >120,000 is a second priority
5) Stability:
   (i) Cassegrain - Maximum Motion of 2 µm per Hour of Tracking (1/20th of a Resolution Element Per Hour)
   (ii) Fiber Fed - Stability of 30 m/s in the High Stability Lab
6) Slit:
   (i) Width 0.6"@R=50,000, 0.24"@R=120,000
   (ii) Length Up to 1'
7) Sampling: 2.5 Pixels per Resolution Element

6. Cryogenic Optical Bench (COB)

(a) The commissioning instrument for the Cerro Pachon telescope will be a 1-5 µm imager borrowed from CTIO. This instrument is expected to be the Cryogenic Optical Bench detector (COB), currently in use on the KPNO telescopes.

(b) NOAO plans to upgrade the array in COB to 1024x1024 InSb and make it available at CTIO in 1996. When mounted on the Gemini telescope, the expected capability will be:

1) Wavelength range: 1-5.5 µm
2) Array:1024x1024 InSb
3) Pixel size: 0.05"
4) Internal optical/IR dichroic for acquisition/guiding using an external CCD
5) Two filter wheels with 40 filter positions
   (i) Broad bandpass imaging
   (ii) Narrow bandpass imaging
6) Long slit grism spectroscopy; resolution ~500 in the J, H, and K bands
7) Polarimetry
8) Closed cycle cooler operation

7. Scientific Optical Imagers

(a) The Optical Acquisition Cameras listed are not scientific instruments, but provide basic acquisition capabilities and are considered to be part of the Acquisition and Guiding unit.
(b) The only scientific optical imaging capability available will be that provided in the MOS instruments.

8. GSC Approved Gemini Adaptive Optics System (GAOS) Design Specifications

(a) The Mauna Kea telescope will be equipped with a natural guide star adaptive optics (AO) capability as part of the initial facility. The GSC approved requirements and goals for this system are:

1) Requirements:
   (i) Delivered Strehl ratio >0.5 at 1.6 µm in median seeing conditions, with the intent of maximizing image concentration and sky coverage of a natural guide star system for $0.7 < \lambda\,(\mu m) < 5.0$ µm. We recognize that strehls exceeding 0.1 are scientifically valuable. This requirement is expected to deliver Stehls of ~0.2 at 0.7 µm in the best tenth percentile conditions.
   (ii) The AO system should not increase the total emissivity by more than 15% for $2.2 < \lambda\,(\mu m) < 5.0$ µm (i.e., a total telescope emissivity requirement of <19%).
   (iii) The throughput of the AO science path should be maximized in the $0.5 < \lambda\,(\mu m) < 5.0$ band and should not be less that 50% in this band.
   (iv) The performance of the AO system as a function of zenith angle should degrade no faster than $S(Z) \propto S(0)^n$, where n = sec(Z) and Z = zenith angle.
   (v) The stability of the AO system should be sufficient to ensure that the delivered Strehl ratios be limited only by atmospheric effects for up to a one hour integration.

2) Goals:
   (i) The total AO emissivity should be less than 10% without ADCs in the $2.2 < \lambda\,(\mu m) < 5.0$ band.
   (ii) Laser Beacons: The natural guide star AO system should be designed in such a way that it can be upgraded to a laser guide star system with the priority to increase the system's sky coverage at the above performance levels.

9. Royal Observatory Edinburgh's Mid-IR Spectrometer (Michelle)

(a) Based on ~256x256 Si:As IBC Array
(b) Long slit spectroscopy, 8-25 µm range
   1) R~200: 8-13 µm window in a single exposure
   2) R~1000: Optimum detectivity of narrow ionic and molecular emission lines
   3) R~30,000: Velocity resolved observations of narrow emission lines
   4) Pixel scale: 0.18"
   5) Slit width: 0.36"
(c) Diffraction limited imaging
   1) Pixel scale: 0.10"
(d) Background limited sensitivity under all of the above conditions

10. NOAO's High Resolution IR Echelle Spectrometer (Phoenix)

(a) 1024x512 InSb array
(b) 1-5 µm
    1) Resolution: R~100,000 (2 pixel) or 67,000 (3 pixel)
    2) Pixel scale: 0.09 arcsecond
    3) Slit width: 0.17 arcsecond (2 pixel) or 0.26 arcsecond (3 pixel)
    4) Slit length: 14 arcseconds
    5) Spectral format: Single echelle order displayed, band pass = 1500 km/s
(c) Guiding - visible light sent to port for tip/tilt sensor (CCD)
(d) Infrared direct imaging and pupil imaging
(e) Closed cycle cooler operation

11. GSC Approved Optical CCD Design Specifications
[Doug to fill in ???]

12. GSC Approved Optical CCD Controller Design Specifications
[Doug to fill in ???\]

13. GSC Approved Near IR Array Design Specifications
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14. GSC Approved Near IR Array Controller Design Specifications
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15. GSC Approved Acquisiition and Guide Design Specifications
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16. GSC Approved Wave Front Sensor Design Specifications
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17. GSC Approved IR On Instrument Wave Front Sensor Design Specifications
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18. GSC Approved Calibration Unit Design Specifications
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