SCORPIO – A new facility instrument for Gemini South

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Abstract

SCORPIO, the new Gen4#3 facility instrument for the Gemini South telescope, will provide imaging and spectroscopy in eight wavelength bands simultaneously from 0.4 to 2.2 microns. SCORPIO will be extremely versatile in addressing forefront science cases ranging from Solar System studies to extragalactic astrophysics and will play a leading role in Gemini follow-up of time-domain events triggered by large-scale surveys. The instrument is currently in its Assembly, Integration and Verification phase and is expected to be commissioned at Cerro Pachón during semester 2024A and offered to the Gemini user community starting in 2024B. In this poster, we review SCORPIO's history, motivation, and final design, describe the expected performance in the context of its driving science cases, and summarize how it will be integrated in the Gemini TDA projects and operations.

The SCORPIO Story

In 2015 based on the Gemini Instrumentation Feasibility Studies, Gemini assembled an independent Gen 4#3 Steering Committee to help guide the Observatory with the Gen 4#3 project. The committee produced a Science Assessment Report and Technical & Cost Assessment Report.

Gemini considered the Gen 4#3 Steering Committee recommendation report, public community comments and feedback, financial, time, and technical/interface constraints, Board resolutions, and STAC recommendations and released an RFP in May 2016. Evaluation and selection progressed through the fall of 2016 resulting in the awarding of a contract to the Southwest Research Institute.

What is SCORPIO?

SCORPIO is an 8-channel imager and spectrograph that will simultaneously observe the g, r, i, z, Y, J, H, and K_S bands in a square field-of-view of 3'x3'. It will obtain long slit (3' long) spectroscopy with a resolution of R∼4,000, simultaneously covering the range between 0.37-2.35 microns. By using state of the art detectors, SCORPIO will have negligible readout times enabling high time-resolution observations.

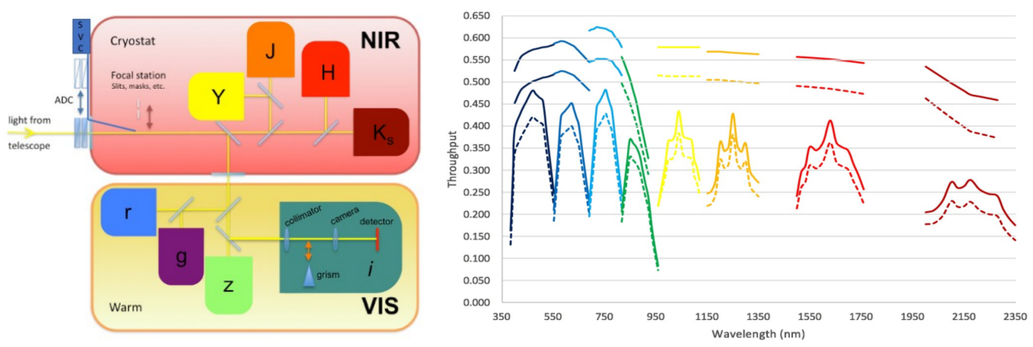

Figure 1: Left panel: SCORPIO schematic layout. Right panel: instrument total throughput in imaging and spectroscopic modes. Solid and dashed lines refer to the case without and with the ADC, respectively. Gemini's telescope throughput is not included.

Science Cases

SCORPIO will deliver groundbreaking scientific output over a very broad range of topics that cover fields as diverse as trans-Neptunian objects and Centaurs in the Solar System, exoplanets, neutron stars, X-ray binaries, active galactic nuclei, supernovae, tidal disruption events, and gamma-ray bursts.

SCORPIO's multi-wavelength spectroscopy (and the possibility for simultaneous multi-band imaging) makes it the optimal machine for the efficient characterization of astronomical transients - similar to those expected to be discovered in the 2020s by LSST, which promises to play a leading role in advancing our understanding of these objects identified through their explosive variability. The availability of high time-resolution, coupled with Gemini's rapid response capability, will also allow researchers to use SCORPIO to catch transient objects in their earliest phases and monitor their rapid evolution.

Observing Modes

- **Imaging:** all 8 channels sample the entire 180"×180" field of view delivered by the SCORPIO optics at a spatial pixel scale of 0.18"/pixel; low-speed detector readout is used to minimize read noise.
- **Spectroscopy:** Slits 180" (1000 pixels) in length and of various widths together with VPH grisms to disperse the spectra over the full width of each detector; low-speed readout is used to minimize read noise.
- **High-cadence Imaging:** a special field stop restricts the illuminated area to 180"×18" (1000×100 pixels); high-speed readout provides high temporal resolution.

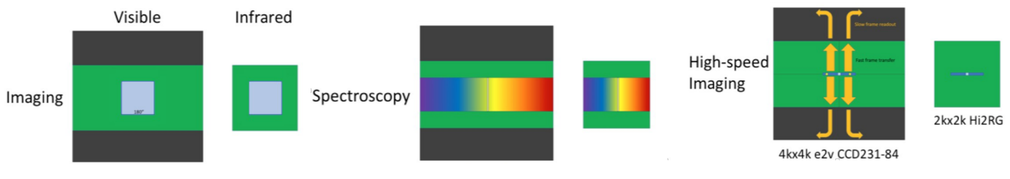

Figure 2: Layout of the imaging and spectroscopy areas on the detectors.

Instrument Design

Each of SCORPIO's eight arms is an imaging spectrograph, based on the use of high-efficiency dichroics to split the light. The light arriving from the telescope first goes through an atmospheric dispersion corrector (ADC) that compensates for atmospheric chromatic aberrations. The light then enters the NIR cryogenic chamber, where it reaches the focal plane unit. After the focal plane, the light is divided by the first dichroic into NIR and Visible (VIS) light. The VIS light then leaves the cryogenic chamber through a second window to the VIS bench which is approximately at the same temperature as the telescope. From there, the light of both beams follow similar paths, where the light is collimated and subsequently split by additional dichroics. The collimated beam of each arm passes through either a filter or grism, depending on the observing mode, and is refocused by a camera onto the detector.

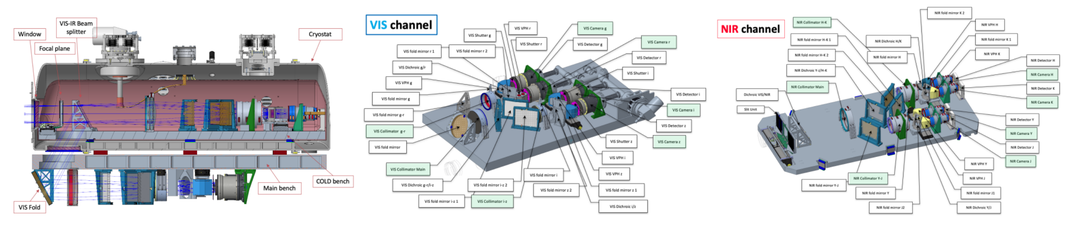

Figure 3: Left panel: 3-D side-view of SCORPIO opto-mechanical layout. Central and right panel: CAD rendering of, respectively, the visible and infrared optical bench.

Optical Layout

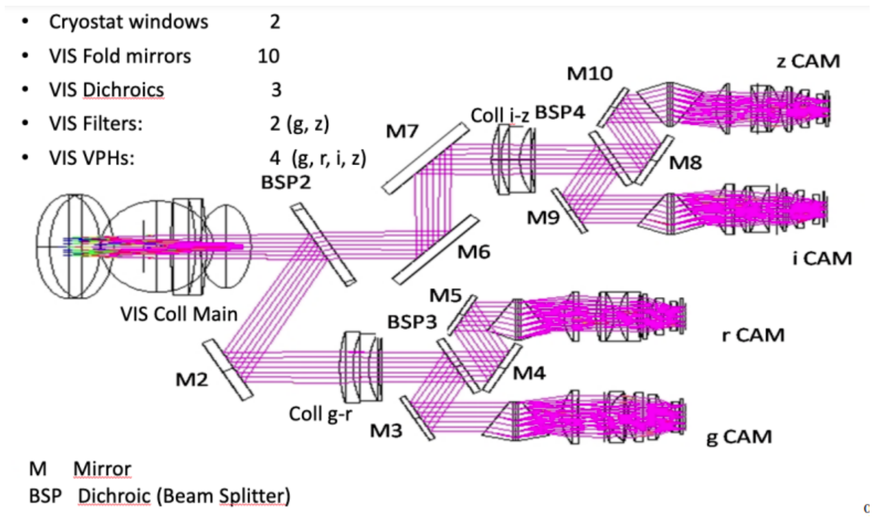

Figure 4: Schematic optical layout of the SCORPIO visible channel. After the beam splitter (and the folding mirror for the VIS channel), both the visible and infrared beams share a similar layout based on the classic imaging-spectrograph design, with a collimator, a pupil and a camera.

Integration into Gemini Science Operations

Observing Monitor Tool (OMT)

An Observing Monitor Tool (OMT) specifically designed for optimizing the effectiveness of SCORPIO science operations is currently under development. It is supposed to provide the night observer with real-time visualization and analysis of incoming data to enable rapid decision making and execution.

SCORPIO & DRAGONS

The SCORPIO data reduction pipeline will use DRAGONS and is being built upon already existing core imaging and longslit algorithms and tools, while also addressing the data's special needs. Users familiar with DRAGONS imaging and longslit reduction will see the similarities.

References

[1] Robberto, M., Roming, P. W. A., van der Horst, A. J., et al. 2020, SPIE, 11447, 1144774. doi:10.1117/12.2568031

[2] SCORPIO Concept of Operations, 2021, SwRI & Gemini Obs., internal document.