Gemini Next Generation Operations Software

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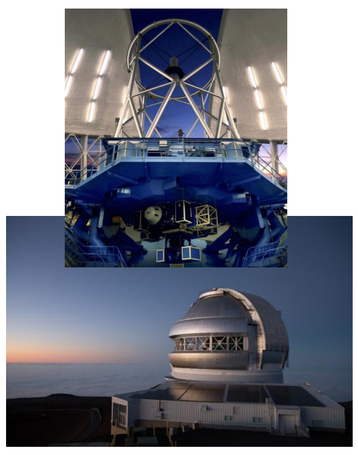
The International Gemini Observatory

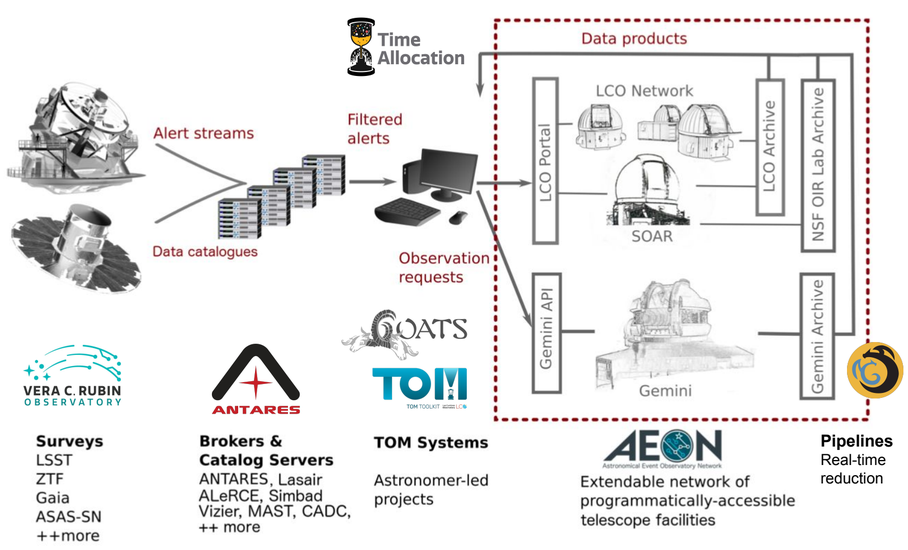
- Twin 8-m telescopes
  - Hawaii and Chile (full sky, 6 hours of longitudinal difference)
  - 5 full international participants (US, CA, BR, KR, AR), 2 hosts (HI, CL), exchange (JP)
- Complementary optical/NIR instrumentation
  - Facility and visitor (3 instruments available at a time)
  - Facility instruments have common interfaces to the observatory system
- Operates mostly in queue, so ToOs on most nights
  - Staff observers
  - Match observation constraints to current conditions



Time Domain Follow-Up

Gemini does a substantial amount of time-domain astronomy due to the flexible queue observing mode. Thus it is an important resource for characterizing new and rare objects found in surveys such as the Zwicky Transient Facility (ZTF) and the Vera C. Rubin Observatory's Legacy Survey of Space and Time (*LSST*).

Gemini works within AEON (Astronomical Event Observatory Network) along with Las Cumbres Observatory, SOAR, and the Blanco 4-m at CTIO. These facilities provide programmatic access to queue observing and data archives. These capabilities are being expanded to other facilities and wavelengths via the AEON+ project (https://aeonplus.github.io).



Time Domain Ecosystem:

- Facilities/Surveys generate events
- Brokers catalog and classify events
- Science teams use Target Observation Managers (TOMs) to prioritize and submit observation requests
- Observatories take and reduce data which are distributed via archives

Gemini Program Platform

Current proposal and observation preparation tools (PIT, OT) are more than 25 years old and have fundamental limitations.

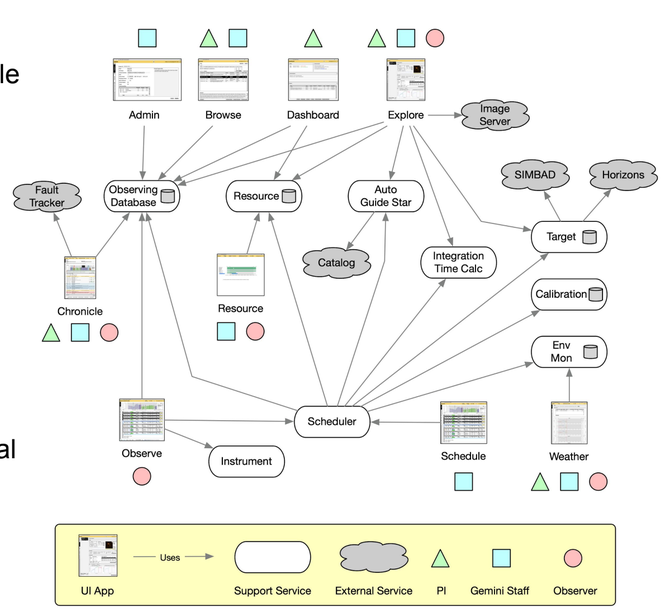
The Gemini Program Platform (GPP) is the core of a new observatory control system with the following goals:

- **Improve usability** - make proposal and Phase 2 preparation much easier
- **Improve efficiency** - improve flexibility and reduce user/staff workload via automation
- **Support Time Domain Astronomy (TDA)** - provide the software framework for the GEMMA scheduler and APIs (e.g. AEON)
- **Support new instruments/systems** - e.g. SCORPIO and GNAO/GIRMOS
- **Avoid obsolescence** - make the code maintainable and scalable

GPP consists of several web applications connecting to a single database and services in the cloud:

- Explore: proposal and observation preparation
- Dashboard: program management
- Browse: basic search
- Chronicle: logging and time accounting
- Weather: current and historical conditions

Most capabilities will also be available programmatically via APIs.



GPP is being developed using the following technologies:

- Postgres database
- Scala programming language for most components. Python is used for some applications.
- GraphQL APIs
- REACT.js and Typescript for the user interfaces

www.gemini.edu

Explore

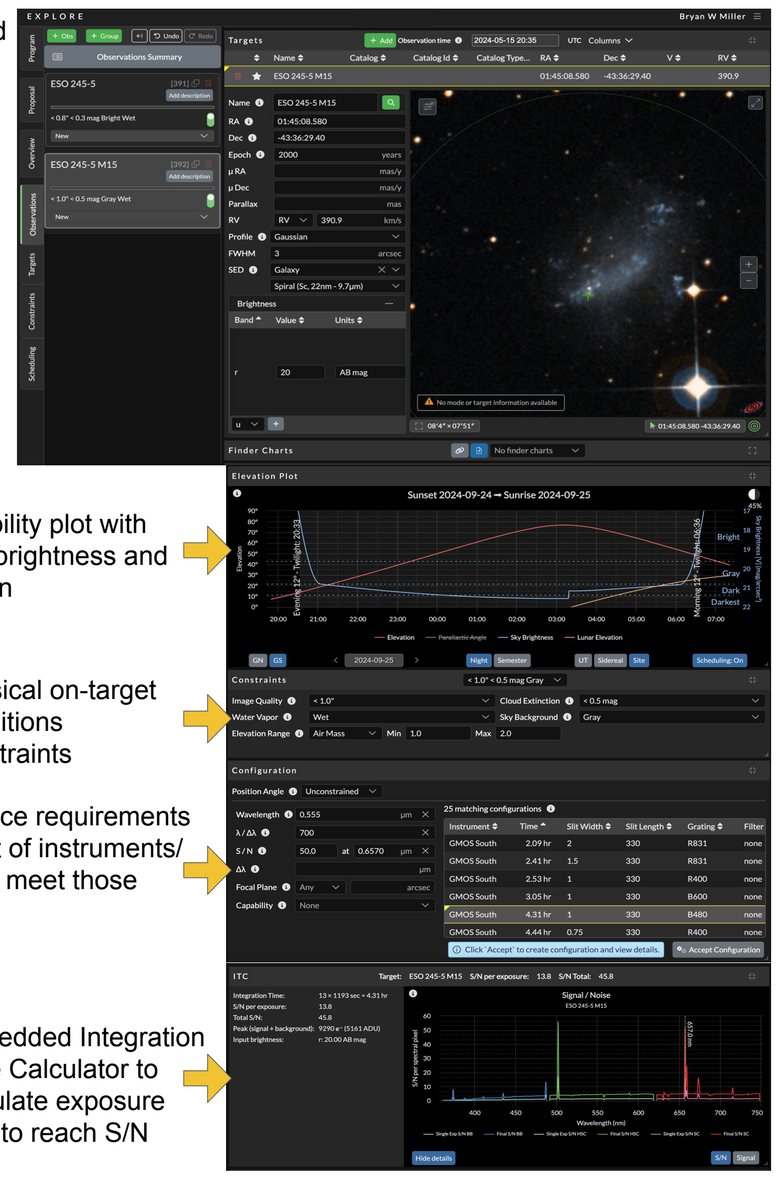
The Explore web application is the new combined Phase 1&2 tool. Observing sequences are generated automatically based on science requirements. If no customization is needed then observations can be executed as soon as they are approved.

In addition to the new features indicated in the figure at the right, Explore will:

- Provide user authentication via ORCID
- Undo/redo of changes
- Allow uploading lists of targets and automatically generate observations that give the desired S/N.
- Allow cadences by providing timing constraints between observations (e.g. observe between 3 and 5 nights after the previous observation.
- Allow logical groupings of observations:
  - AND: observe all together
  - OR: observe n of m
- Generate associated baseline calibrations automatically with the instrument configuration linked to the science observation

GPP night testing and early science use is ongoing and it has been used for demonstrating Rubin follow-up.

GPP is expected to enter operations in 2027.



Visibility plot with sky brightness and moon

Physical on-target conditions constraints

Enter science requirements to see a list of instruments/ modes that meet those constraints

Embedded Integration Time Calculator to calculate exposure time to reach S/N

API Driven ToO Triggering with a TOM

Most actions that can be performed with the Explore UI can be done programmatically via APIs.

Observations can be requested using a Target Observation Manager (TOM; e.g. the TOM Toolkit or SkyPortal) using a GPP python client (https://gpp-client.readthedocs.io). Gemini's GOATS (https://goats.readthedocs.io) is using this client.

Above: GMOS-S observation defined in GOATS, a TOM based on the TOM Toolkit (https://tom-toolkit.readthedocs.io).

GOATS can also be used to download the resulting data and reduce it using the DRAGONS pipeline.

Once an instrument configuration is defined the guide star is chosen and the observing sequence is automatically created.

If no customization is needed, then the observation can be executed without additional human checking.

Dynamic Scheduler

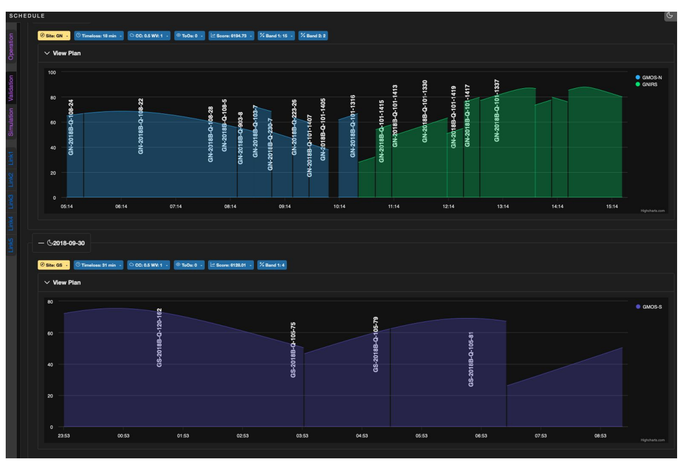
Gemini is implementing real-time scheduling with initial funding from the NSF-funded GEMMA (Gemini in the Era of Multi-Messenger Astronomy) project.

Goals:

- Automatically update observing plans within 1 minute as events occur (e.g. ToOs, weather changes, faults), which will:
  - Reduce the effort of human queue coordinators who currently prepare multiple queue schedules for a range of possible weather conditions.
  - Give real-time advice to the nighttime observer to ensure that we are always executing the best observation for the current conditions.
- Maintain or improve Gemini's program completion statistics

It will create plans for Gemini North and South together as a mini network (see figure at right).

The scheduler is currently in development in parallel with GPP and has been used for scheduling test nights.



Observing plans created together for GN and GS in the Schedule application.