

Gemini Solar System Follow-up in the LSST Era

Bryan Miller

Andy Adamson, Andy Stephens, Arturo Núñez, and the AEON team

Gemini: twin 8-meter telescopes with coverage of both hemispheres



KR: FP
Subaru: EX



HI: host
CFHT: EX
Keck: EX

CA: FP
20%

US: FP
70%

BR: FP
7%



CL: host
AR: FP
3%



FP: Full Participant (NGO)
Host: Access to local site (NGO)
LTC: Limited-term Collaborator
EX: Exchange Partner

We support four facility instruments + AO at each site. Up to three + AO active at a time.

Gemini North

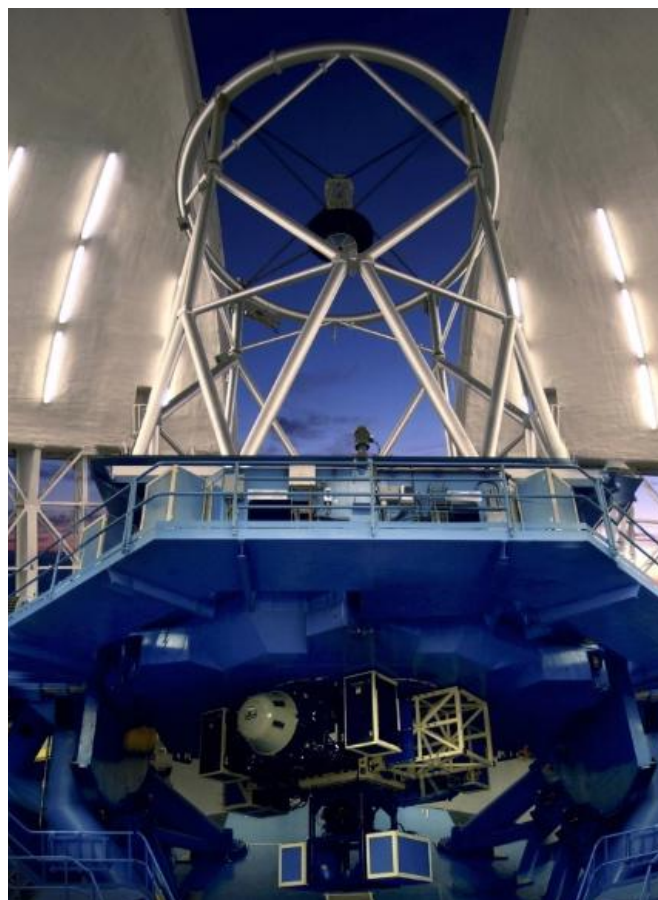
GMOS-N

GNIRS

NIFS

NIRI

**AO: ALTAIR
NGS & LGS**



Gemini South

GMOS-S

FLAMINGOS-2

GPI

GSAOI

**AO: GeMS (MCAO)
LGS (5)**

Optical, Infrared, AO

Proposal idea? We accept all sizes on a variety of timescales.

Director's Time: *any time*

Chief scientist/Director approval

For short, urgent projects

<5%

Poor Weather: *any time*

Head of Science Operations approval

For the worst conditions, bright targets

Fast Turnaround: *once per month*

Peer reviewed, no TAC

For short, immediate, trial, and/or follow-up proposals

(oversubscription: ~3)

10%

Regular Proposals: *once per semester, through the*

National Time Allocation Committees (TAC)

For regular proposals

(oversubscription: ~2)

~70%

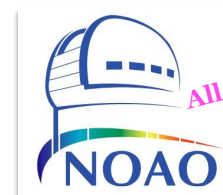
Large & Long Programs: *once per year, through the*

Large Program TAC

For large and/or long **ambitious** proposals (up to 6 sem)

(oversubscription: >5)

20%



“Beyond 2021, Gemini should exploit its geographical location and agile operational model in order to be the premiere facility for the follow-up investigation of targets identified by the Large Synoptic Survey Telescope.” - Beyond 2021: Strategic Vision

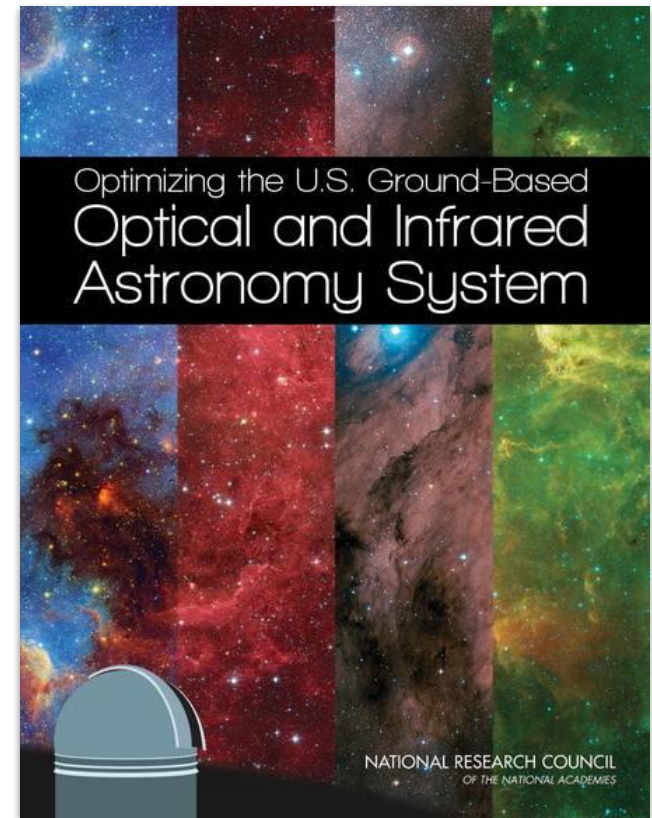
Gemini is following the recommendations of the 2015 “Elmegreen” report:

- Recommendation 4b: high throughput, broad wavelength spectrograph

➡ SCORPIO

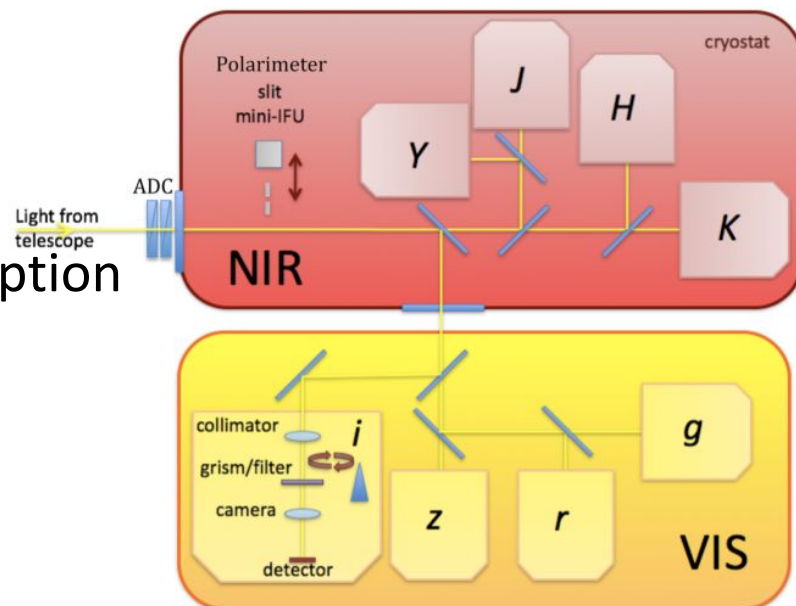
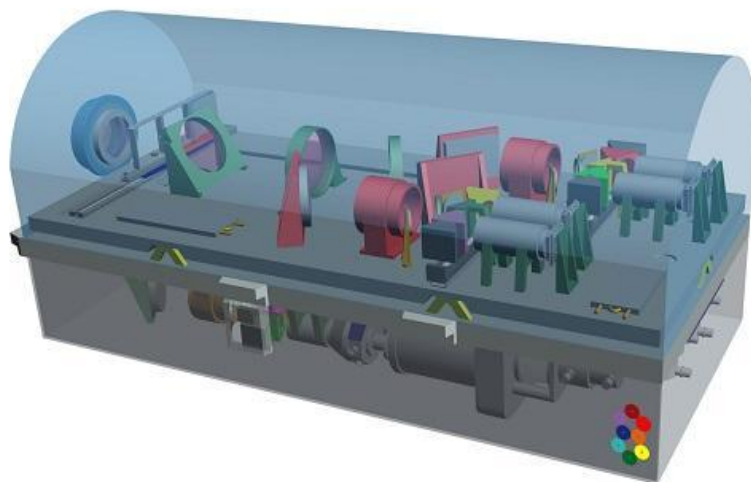
- Recommendation 4d: coordination among NSF facilities, especially in Chile, to optimize LSST follow-up studies

➡ AEON: NOAO/SOAR/Las Cumbres/Gemini collaboration to create a system for performing dynamic queue-scheduled observations and automating follow-up



SCORPIO will be a broad-wavelength LSST follow-up machine.

- $g - K_s$ coverage using 7 dichroics
- Simultaneous 8-band imaging over $3' \times 3'$ field
- Single-object longslit, IFU upgrade option
- $R \sim 4000$
- Must be operational by 2023



Team:

- PI: Massimo Robberto, JHU & STScI
- Project Manager, Co-PI: P. Roming
Southwest Research Institute
- Project Scientist: A. van der Horst
George Washington University

“Beyond 2021, Gemini should exploit its geographical location and agile operational model in order to be the premiere facility for the follow-up investigation of targets identified by the Large Synoptic Survey Telescope.” - Beyond 2021: Strategic Vision

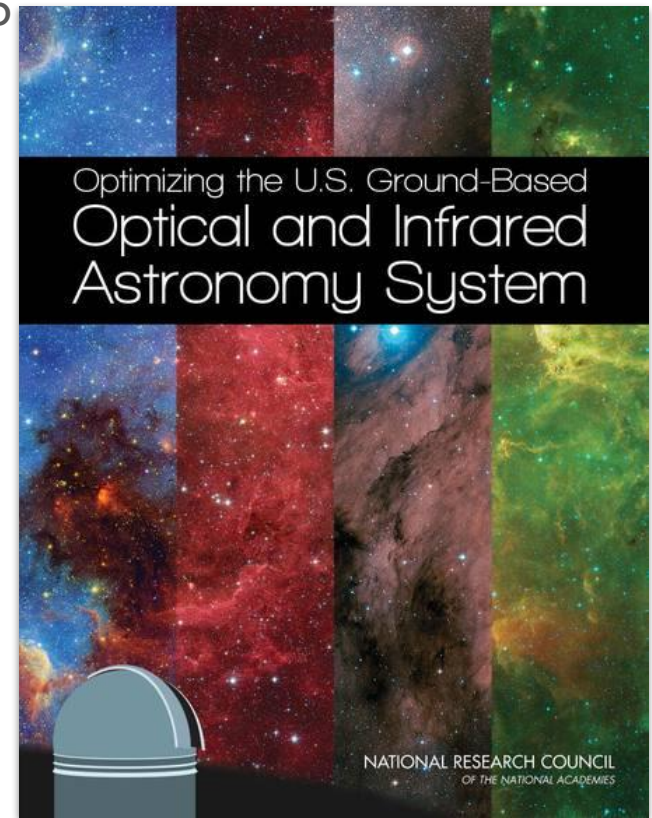
Gemini is following the recommendations of the 2015 “Elmegreen” report:

- Recommendation 4b: high throughput, broad wavelength spectrograph

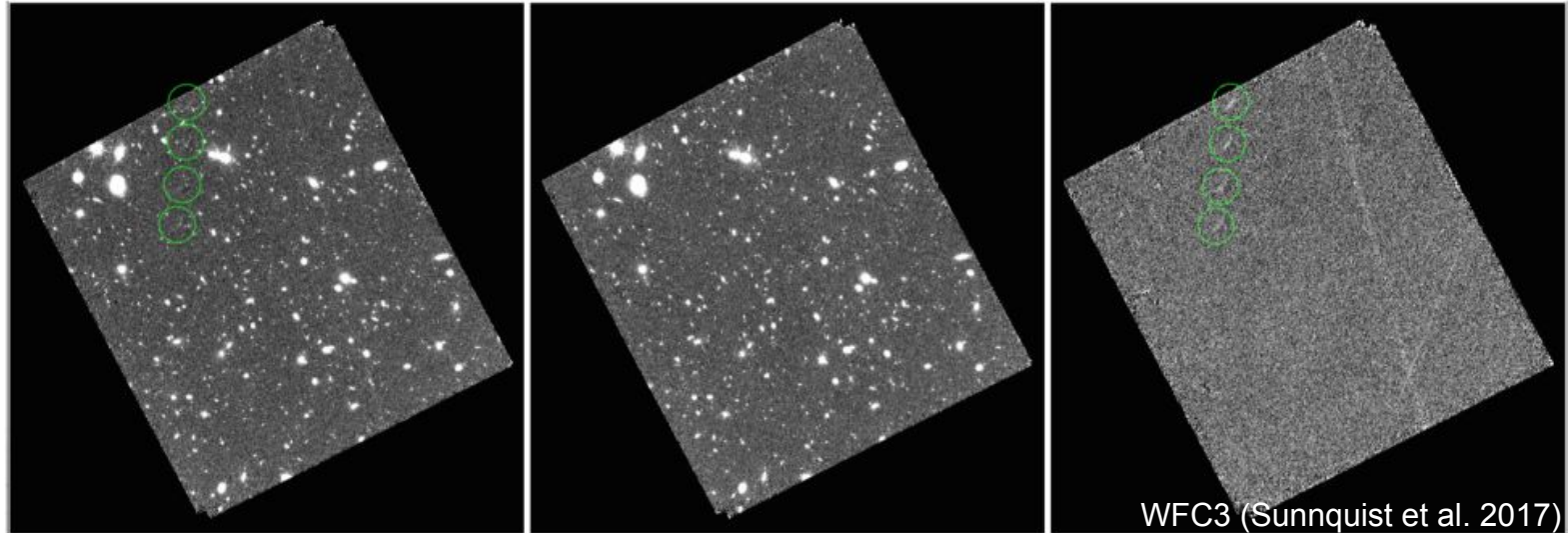
➞ SCORPIO

- Recommendation 4d: coordination among NSF facilities, especially in Chile, to optimize LSST follow-up studies

➞ AEON: NOAO/SOAR/Las Cumbres/Gemini collaboration to create a system for performing dynamic queue-scheduled observations and automating follow-up



Why all the fuss? In operation LSST will generate $\sim 10^7$ transient alerts (~ 1500 new solar system objects) per night!

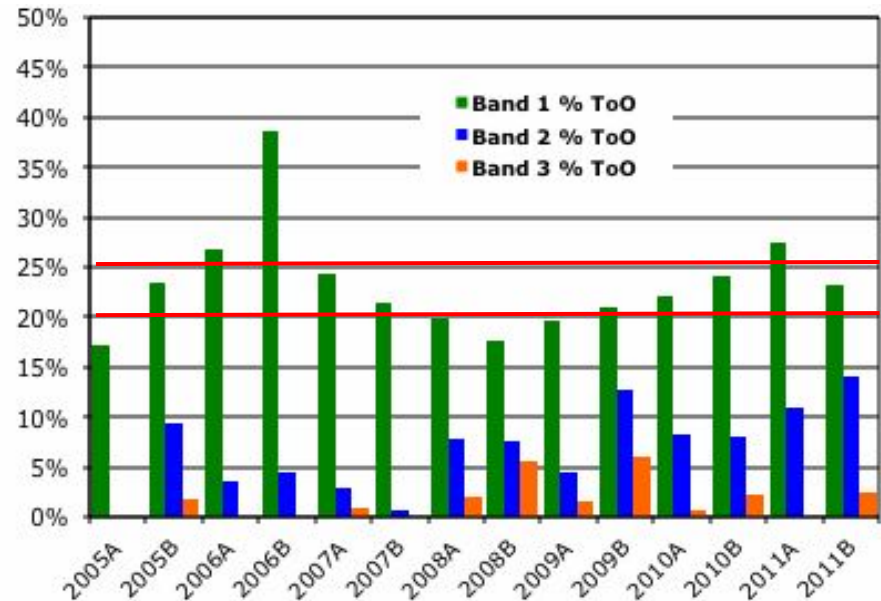


- 2 x 15 sec exposures/visit $\Rightarrow 10^4$ alerts within 60 sec
- Gemini must prepare for *Order(10-100)* triggers/night/tel plus regular queue

Such high event rates will likely swamp current ToO handling procedures

At Gemini, ToOs make up about 20-25% of the time in Band 1

- Max rates are 1-2/night
- Many more will overwhelm the manual scheduling process and observers



At CTIO/SOAR, ToOs interrupt visitor nights

- Many more will be disruptive to standard programs

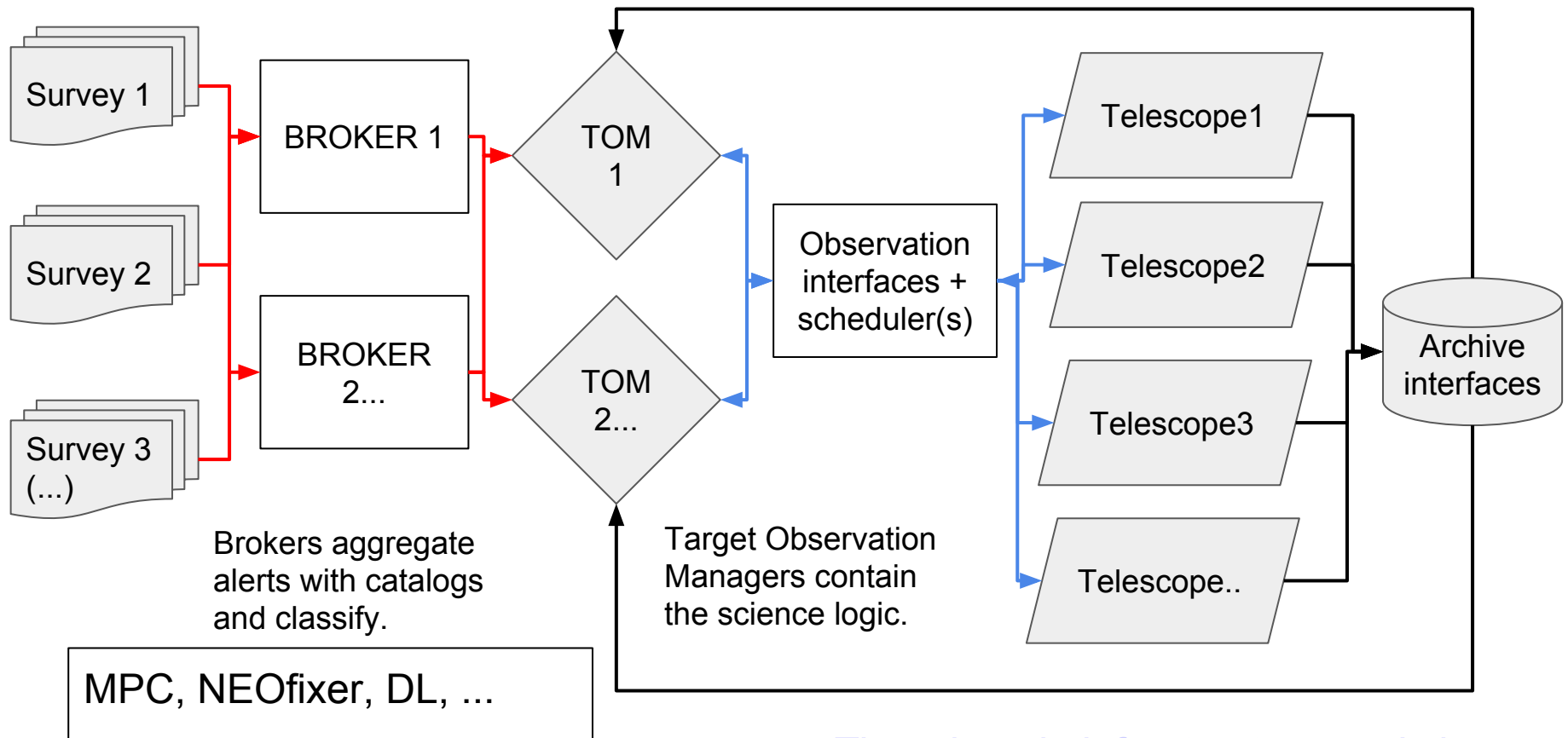
A new solution is needed!

The proposed solution is a follow-up system that dynamically turns alerts into requested data.

"Here is an event"

*"Request everything
matching these criteria"
"Here is what I learned"*

*"Observe X with parameters Y" "Send me data of X"
"Tell me status of X"*



[Time domain infrastructure workshop](#)

(<https://www.noao.edu/meetings/lstt-tds/>)

Target/Observation Managers match targets with telescopes, coordinate observations, and manage data.

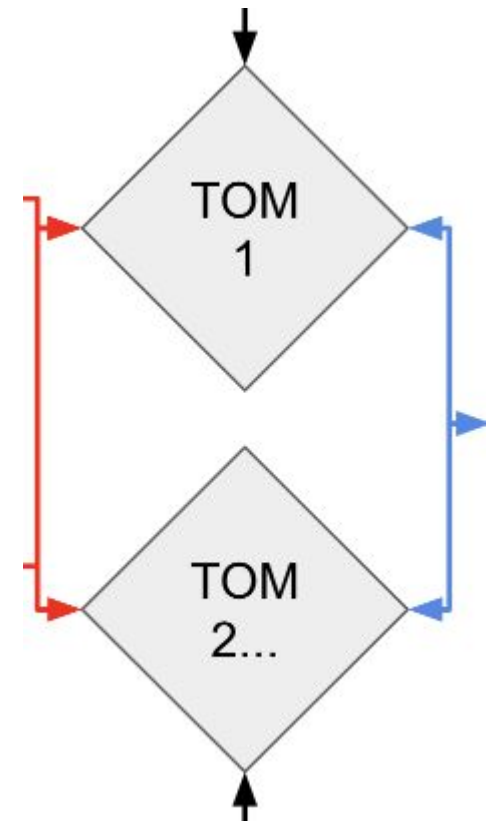
TOMs make up the main science layer:

- Collect and prioritize targets from alert streams (e.g. brokers)
- Are aware of available resources
- Request observations
- Collect and display the returned data
- Manage data access for members
- Share information between interested parties

In use by SNe, exoplanet, NEO, AGN, and microlensing teams.


“Request everything matching these criteria”

“Here is what I learned”







Las Cumbres Observatory is developing a “toolkit” to make these easier to create.

<https://tomtoolkit.github.io>



TOM Toolkit

The Target Observation Management Toolkit is a framework for building software for the next generation of Astronomy.

-  [News](#)
-  [About](#)
-  [Documentation](#)
-  [View On GitHub](#)


Target Observation Manager Toolkit

The TOM Toolkit project was started in early 2018 with the goal of simplifying the development of next generation software for the rapidly evolving field of astronomy. Read more [about TOMs](#) and the [motivation](#) for them.

Are you looking to run a TOM of your own? The [documentation](#) is a good place to get started. The source code for the project is also [available on Github](#).

News

- **23 Aug 18** [MARS Alert Broker Support](#)
- **22 May 18** [TOM Toolkit Development Started](#)



Python + Django. Easy installation and configuration

Now in alpha - under active development
Comments/suggestions welcome

A TOM for Nonsidereal Targets



Latest Comments

No comments yet.

Latest Targets

ID	Created
1896 Beer	2018-10-19

Target/data
access



1896 Beer

[Update Target](#)[Delete Target](#)

Identifier 1896 Beer
Name 1971 UC1
Target Type NON_SIDEREAL
Mean Anomaly 32.91122395550462
Argument Of Perihelion 180.3418847483989
Eccentricity 0.2206090850353469
Longitude Of Ascending Node 182.1441709268328
Inclination To The Ecliptic 2.222453217804944
Mean Daily Motion 0.270435682449235
Semimajor Axis 2.368245496458354
Ephemeris Period 1331.185281245487
Ephemeris Period Error 3.8076e-05
Ephemeris Epoch 2458600.5
Ephemeris Epoch Error 0.0
H 13.8

Observe

[LCO](#)

Plan

Start Time

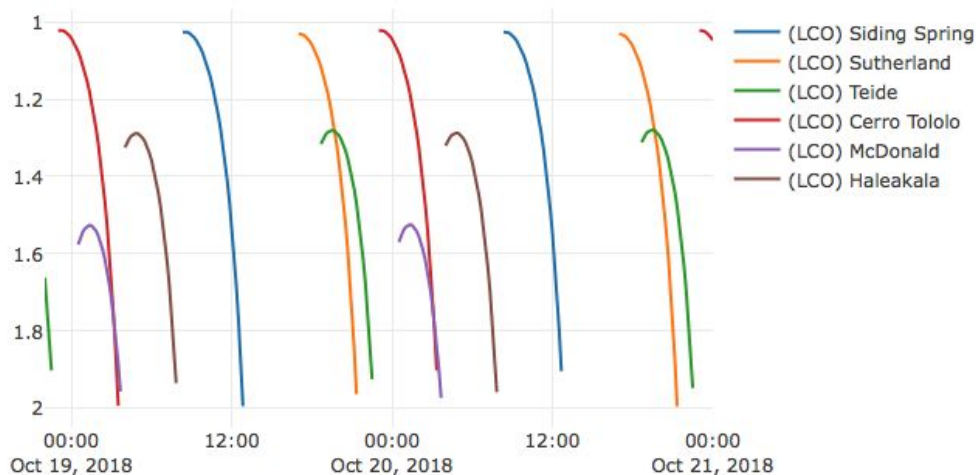
End Time

Maximum Airmass

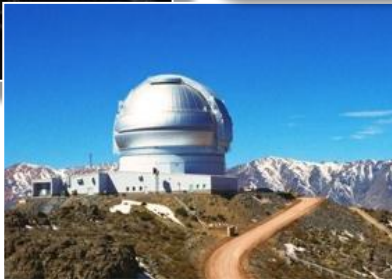
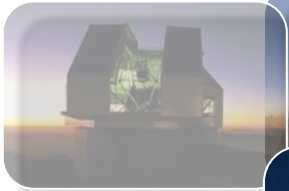
[Plan](#)

Manual or
scripted
observation
requests.

Target visibility



NOAO/SOAR/Las Cumbres/Gemini are working to dynamically schedule requests from TOMs on SOAR, Gemini, Blanco, others...

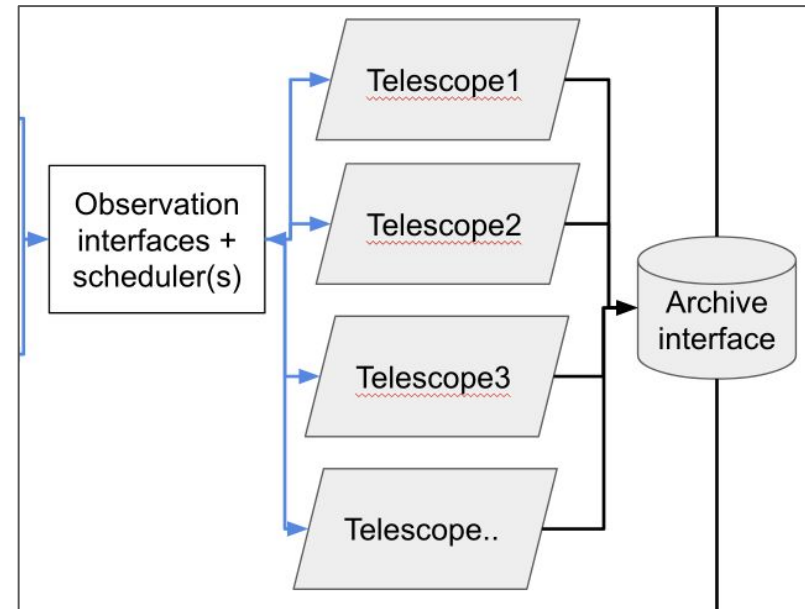


Rachel Street (LCOGT, PS)
Bryan Miller (Gemini, PS)
Stephen Ridgway (NOAO, PS)
Cesar Briceno (NOAO/SOAR)
Andy Adamson (Gemini)
John Blakeslee (Gemini)
Bob Blum (NOAO/NCOA)
Adam Bolton (NOAO)
Todd Boroson (LCOGT)
Jay Elias (SOAR)
Steve Heathcote (NOAO)
Catherine Merrill (NOAO)
Joanna Thomas-Osip (Gemini)



Astronomical Event Observatory Network (AEON):

1. Develop interfaces (APIs)
 - a. TOMs to send requests
 - b. Send schedule
 - c. Receive status
2. Incorporate SOAR into the LCOGT network, execute observations on dedicated nights
3. Coordinate data pipelining and archiving efforts
4. Incorporate Gemini, modify scheduler to handle queue
5. Be ready to incorporate other facilities (Blanco, etc)



Gemini will support AEON observation interfaces and scheduling as part of the ongoing OCS Upgrades Program

Goals:

- Rethink the purpose and UI from first principles
- Make Phase 2 preparation much easier
- Include new features that are not possible in the current code
- Make the code maintainable and scalable



See Oct 2017 Gemini Focus, pg. 20

Phase 1 Application

https://phase1.gemini.edu/ Google

Longslit science: R400 + GG455

Target and SED

Iris luspom: Options ▾

Treux ads las: Options ▾

alum ups silker: ☒ Check

figuration

Iris luspom: ☐ Radio

Treux ads las: ☒ Radio

ditions

Ax: Bx: Cx:

Instrument FoVs

Intermediate Single Exp and Final S/N in aperture

Execution Parameters:

Lorem Ipsum
 Irmas asldk asolio
 Lorem Ipsum
 Irmas asldk asolio
 Lorem Ipsum
 Irmas asldk asolio

Physical conditions on target (FWHM)

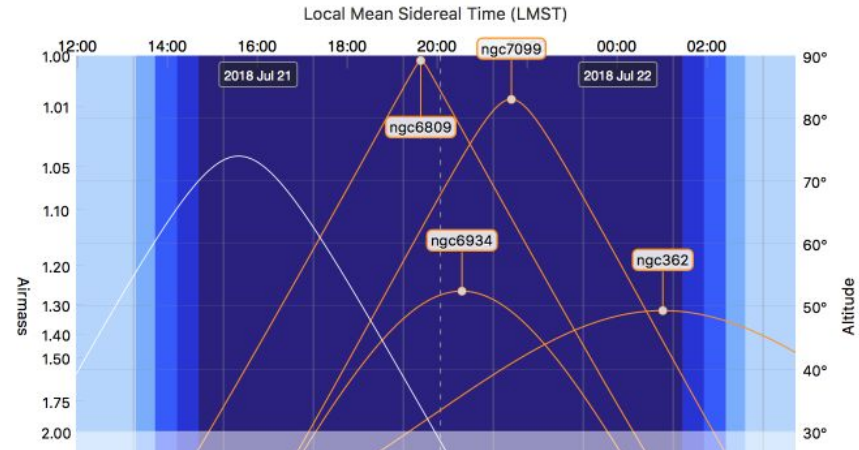
Build around the ITCs

Calculate overheads, execution probability

Calibration steps and observations automatically added, configs linked

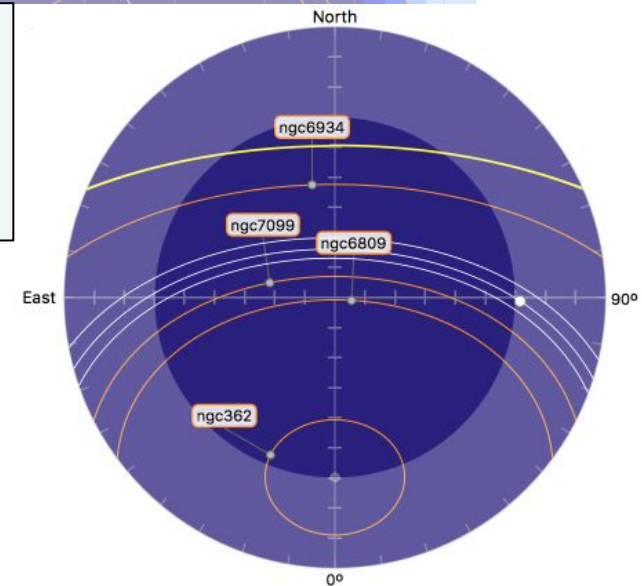
The Phase 2 tool should be easier for new users, more capable for advanced users

Include tool for learning observing techniques (visibilities, planning, etc)



```
{ "target": { "type": "SIDEREAL", "name": "m42", "ra": 83.8220792, "dec": -5.3911111, "proper_motion_ra": 1.67, "proper_motion_dec": -0.3, "parallax": 0.0, "coordinate_system": "ICRS", "equinox": "J2000", "epoch": 2000.0, }, }
```

Programmatic access (eg. APIs for scripts) for search, triggering, feedback, and access to services (ITCs, AGS).



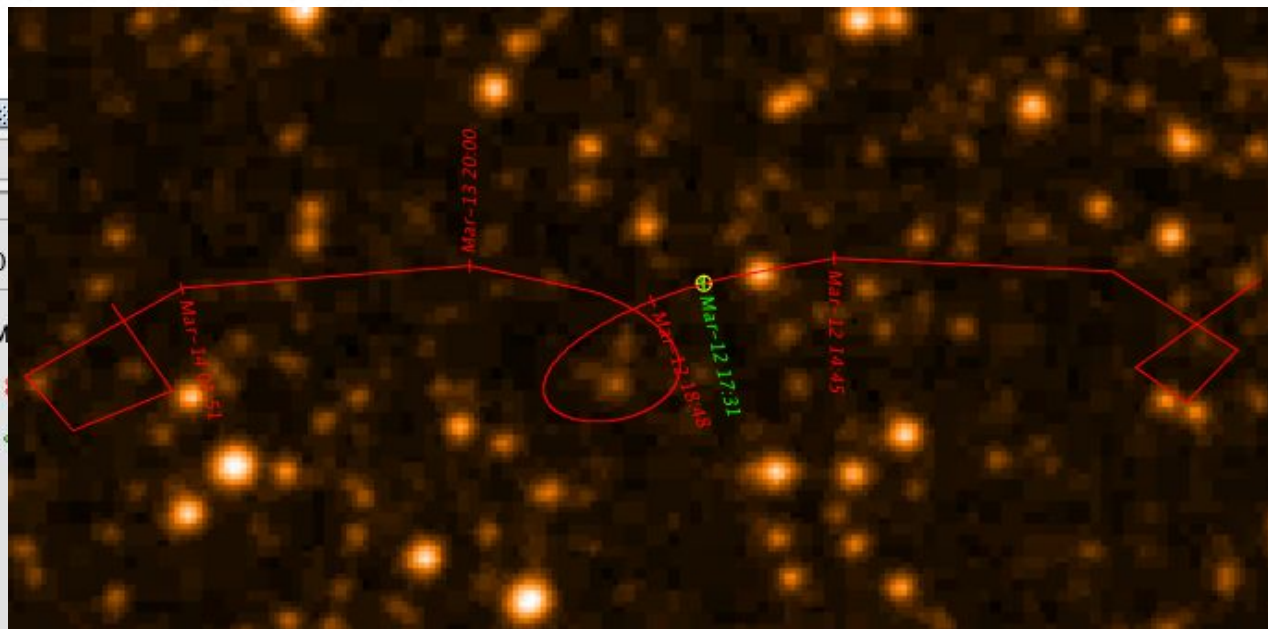
We plan to maintain our current capabilities for nonsidereal targets...

Target Environment

Use this component to enter the base position and wave front sensor targets for this

Type Tag	Name	RA	Dec	Dist	B	
Base	Enceladus	17:00:10.626	-20:59:02.21			
Auto						
● PWFS2 (1)	345-088049	17:00:29.996	-21:04:08.81	6.82	12.564	12.

Automatically-downloaded ephemerides



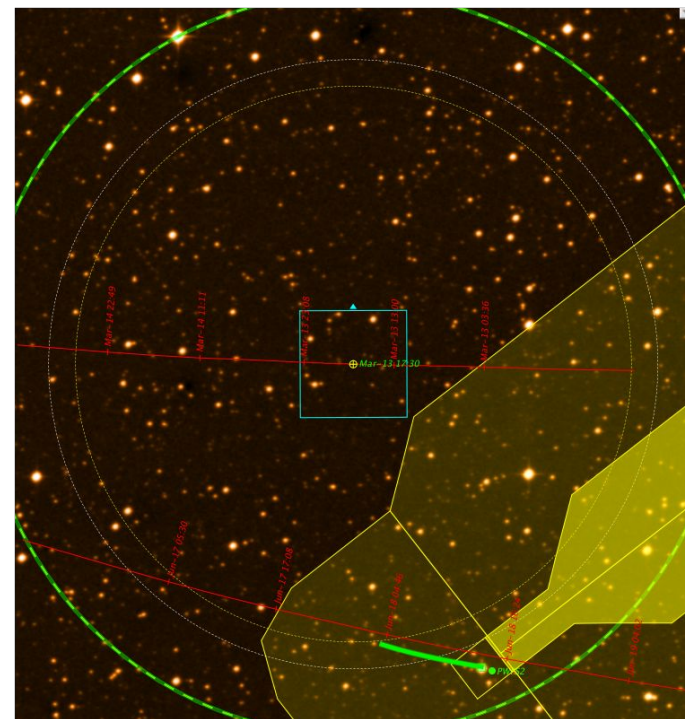
Ephemeris

Elements 1362
Start 2015-12-31 17:00:00 UTC
End 2016-08-31 16:51:00 UTC
Scheduled 2016-03-12 17:30:00 UTC
17:00:10.626 -20:59:02.21
Current --

Visualization of tracks on the sky

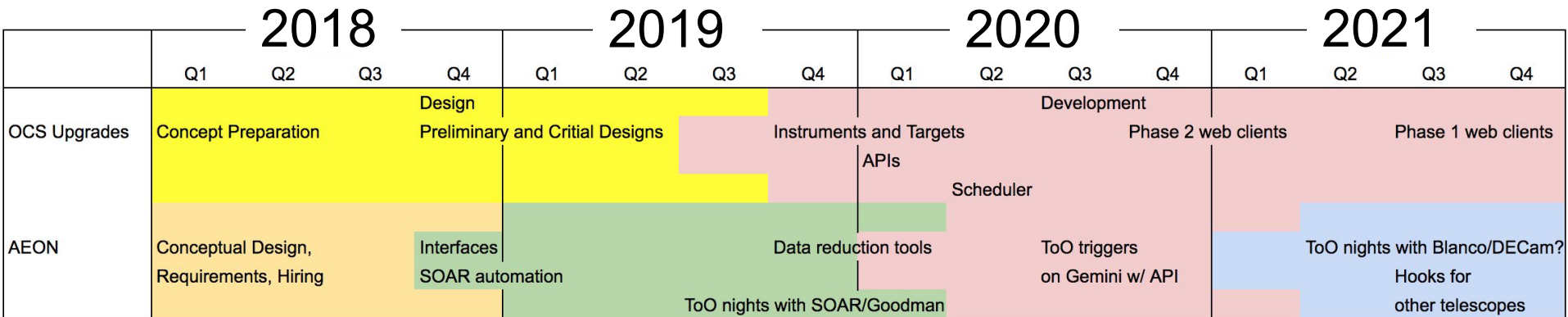
... and improve them

- API support for ToO triggering
- Show track of guide probe and for how long a guide star is usable - use for AGS selection
- Associate manually-uploaded ephemeris with the observation(s) where it is used
- Observe nonsidereal targets at the sidereal rate (pass static coordinate interpolated from the ephemeris)



More suggestions welcome...

OCS Upgrades Program and AEON Timelines



Concepts
& Design

Development

We close the loop by serving data via the Gemini Observatory Archive and providing tools for science quality reduction.



- IRAF to python transition
 - A pure python imaging package release in 2019
 - Work on spectroscopy reduction in python starting in 2018 **in collaboration with SOAR**
- New instruments come with reduction tools that work in our pipeline environment (DRAGONS).
- Automated processing is a goal for the LSST era

Lots of user input and involvement will be needed to make these projects successful

Participate in focus or working groups to discuss specific aspects.

Fill in surveys or questionnaires

Send suggestions to Bryan Miller
(bmiller@gemini.edu)



Testing, testing, testing

The development process will be iterative, so user feedback will be essential.

Summary

Gemini is aiming to be the premier 8-m class member of a follow-up network that will consist of:

- Brokers (alert filters)
- TOMs (target/resource matching)
- Dynamic scheduling and execution
- New instrumentation (SCORPIO)
- Data reduction pipelines

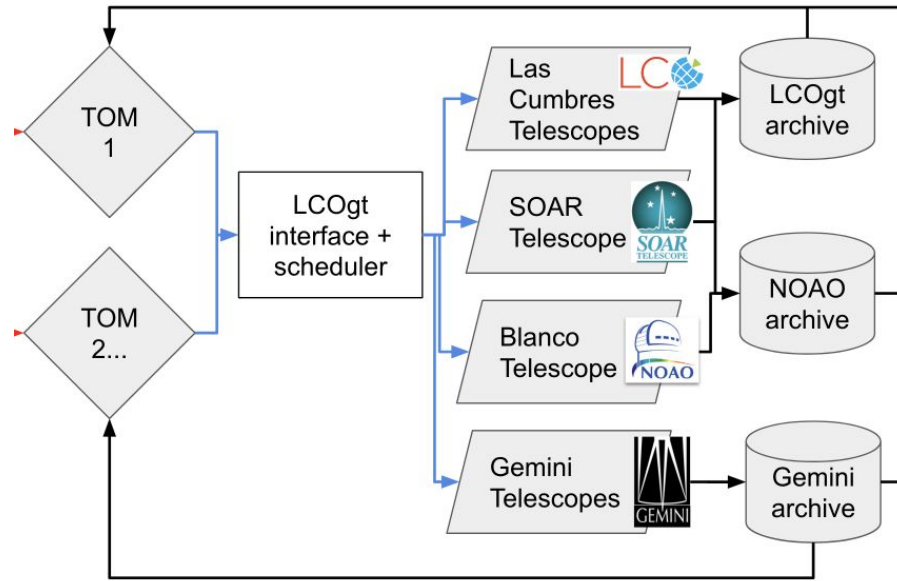
Gemini is re-imagining the observing system to support follow-up and make the process easier for everyone.

Community involvement will be vital.

Get involved now!

1. NOAO/SOAR/Gemini/Las Cumbres are developing a transient follow-up network to enhance the science from LSST
 - a. Broker (alert filter)
 - b. TOM (target/resource matching)
 - c. Scheduling/execution of network nodes
 - d. Data reduction pipelines
2. There are many implications for how we will use or the network and facilities. The discussion needs to start now.
3. Community involvement in the design and testing will be vital. We want your feedback so that we can develop a system that works for everyone and delivers the best science.

Gemini could be incorporated as a node on the global network, like SOAR, or...



Advantages

- Can help avoid duplicate observations
- Might help with coordinating observations

Disadvantages

- Major changes required to the LCOgt scheduler
- Scheduler performance - slower?

How should Gemini participate in AEON?

Dedicated nights on the network for coordinated observation?

“Always on” on queue nights, as now?

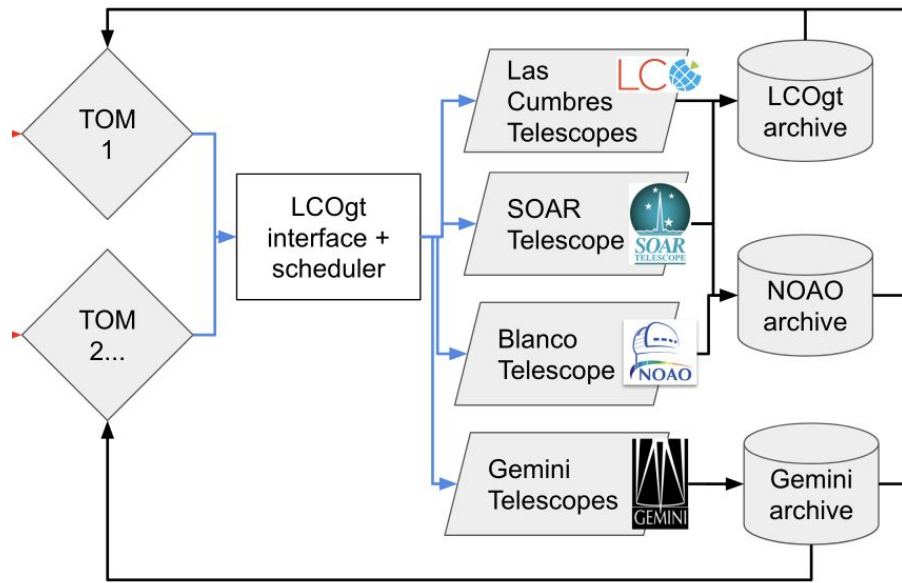
Former seems a step backwards, though useful for testing or in special cases.

∴ We will be working towards the latter.

Implies automated scheduling for all instruments/modes.

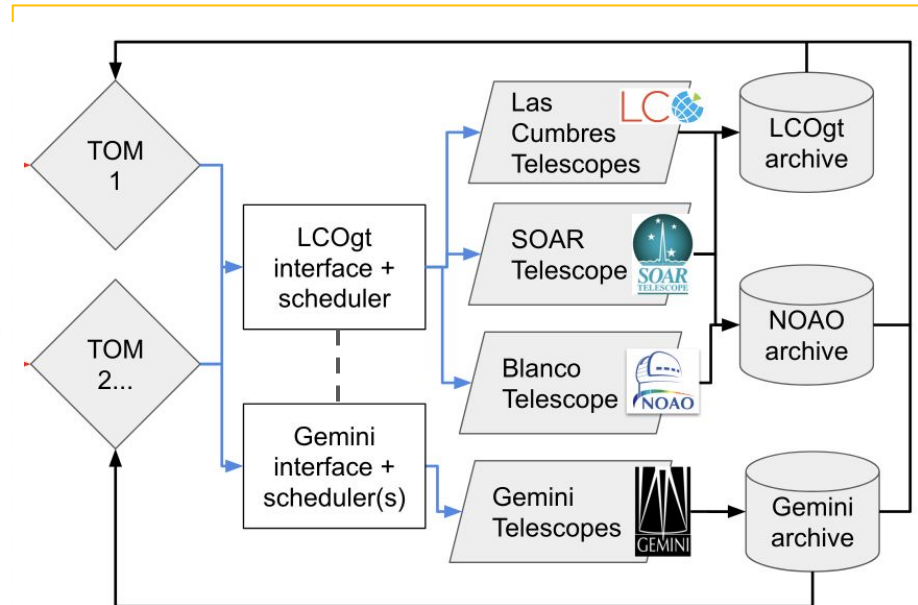
Benefits all programs, increases overall flexibility, reduces busy work for staff.

There are two general architectures for how Gemini could fit into AEON



Node of single scheduler

- Can help avoid duplicate observations
- Might help with coordinating observations

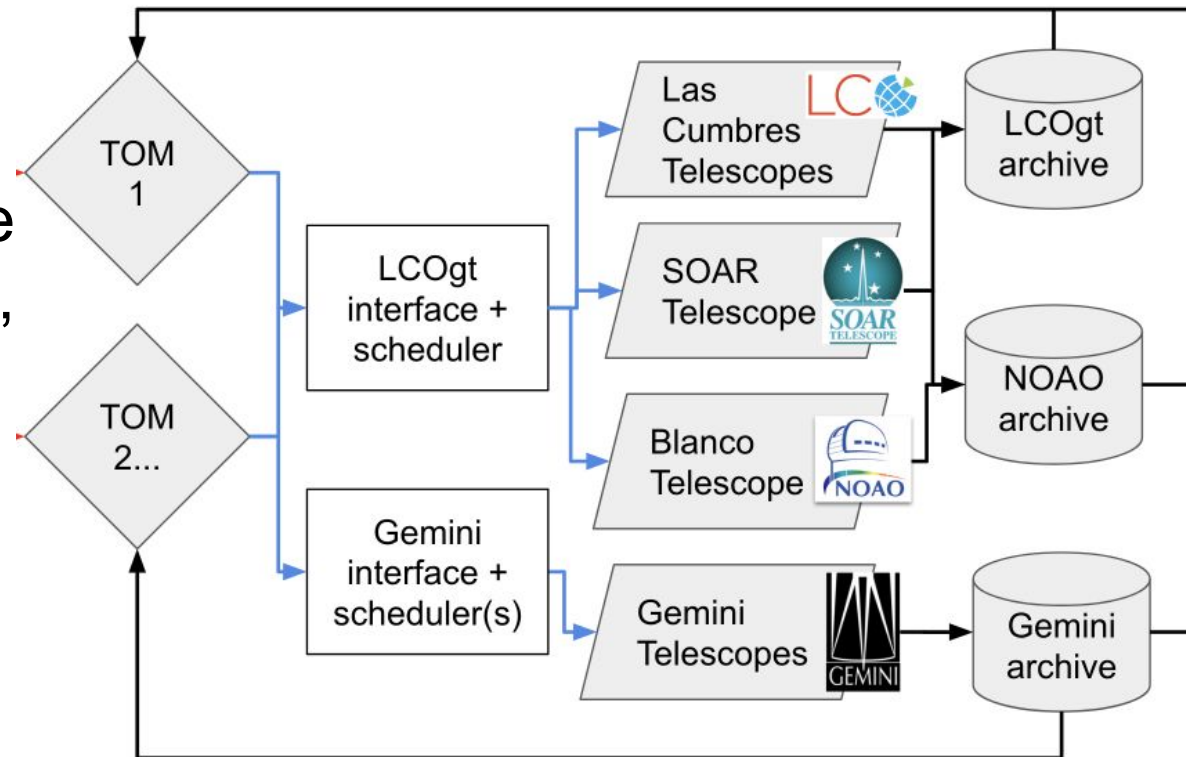


Adapt LCOgt scheduler, run separate copies

- Maybe easier to implement, esp. handling of full queue
- Can run schedulers locally

The current idea is for Gemini to adapt the LCO scheduler and run separate copies.

May be easier to make Gemini-specific needs, handle the rest of the Gemini queue



User-facing observation interfaces (APIs) should be very similar to those for LCOgt
⇒ easier to adapt TOMs

The main goal of current Gemini data reduction efforts is to provide tools for science quality reduction.

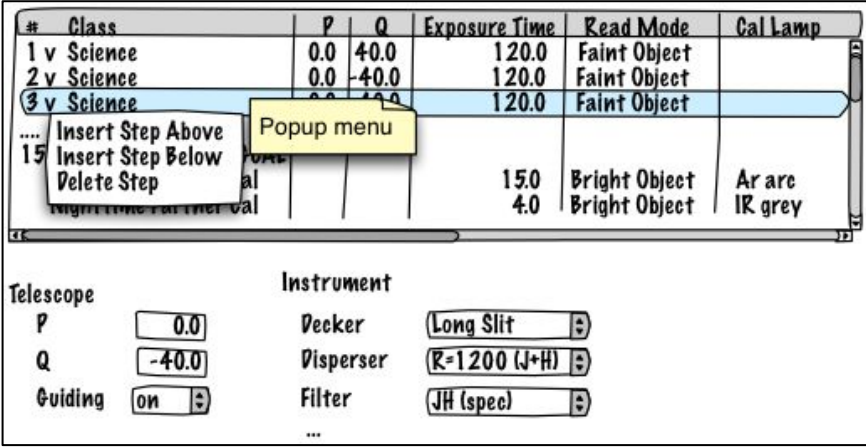


- The Gemini reduction package is transitioning from IRAF to Python.
 - A pure python imaging package will be released in 2018
 - Work on spectroscopy reduction in python to start in 2018 in collaboration with SOAR
- New instruments must come with reduction tools that work within our pipeline environment.
- Automated processing is a goal for the LSST era, not a short-term priority.

Gemini will support AEON observation interfaces and scheduling as part of the ongoing OCS Upgrades Program

Goals

- Rethink the purpose and UI from first principles
- Make Phase 2 preparation much easier for users
- Include new features that are not possible in the current code
- Make the code maintainable and scalable (e.g. use of a relational database)



The mockup displays a table with columns: #, Class, P, Q, Exposure Time, Read Mode, and Cal Lamp. Row 3 is highlighted in blue. A 'Popup menu' is shown over row 3 with options: 'Insert Step Above', 'Insert Step Below', and 'Delete Step'. Below the table, 'Telescope' settings (P: 0.0, Q: -40.0, Guiding: on) and 'Instrument' settings (Decker: Long Slit, Disperser: R=1200 (J+H), Filter: JH (spec)) are shown.

#	Class	P	Q	Exposure Time	Read Mode	Cal Lamp
1	v Science	0.0	40.0	120.0	Faint Object	
2	v Science	0.0	-40.0	120.0	Faint Object	
3	v Science	0.0	40.0	120.0	Faint Object	
...						
15				15.0	Bright Object	
				4.0	Bright Object	Ar arc IR grey

Telescope: P 0.0, Q -40.0, Guiding on

Instrument: Decker Long Slit, Disperser R=1200 (J+H), Filter JH (spec)

UI mockup of new sequence model editor



See Oct 2017 Gemini Focus

Task-specific but consistent UIs \Rightarrow lower learning curve

Longslit science: R400 + GG455

Target and SED

Iris luspom: Options
 Treux ads las: Options
 alum ups silker: ☒ Check

Configuration

Iris luspom: ☐ Radio
 Treux ads las: ☒ Radio

Conditions

Ax: Bx: Cx:

#	Class	P	Q	Exposure Time	Read Mode	Cal Lamp
1 v	Science	0.0	40.0	120.0	Faint Object	
2 v	Science	0.0	-40.0	120.0	Faint Object	
3 v	Science	0.0	-40.0	120.0	Faint Object	
15 v	Night Baseline GCAL					
	Nighttime Partner Cal			15.0	Bright Object	Ar arc
	Nighttime Partner Cal			4.0	Bright Object	IR grey

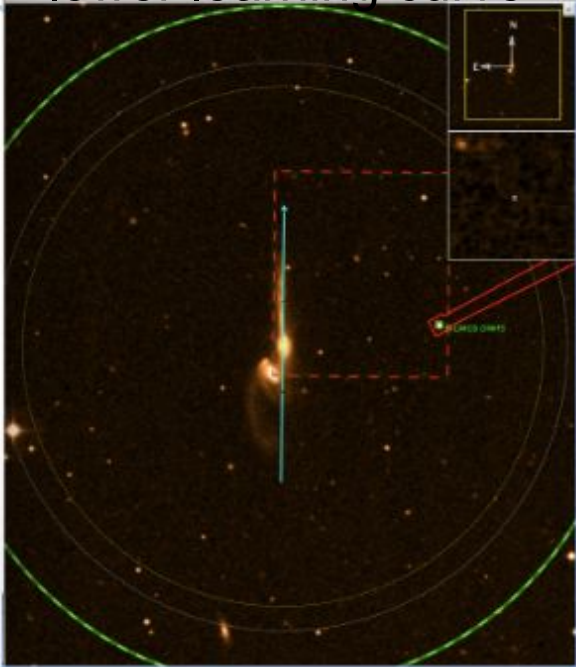
Telescope

P
 Q
 Guiding

Instrument

Decker
 Disperser
 Filter

Execution Parameters:



Calibration steps and observations automatically added, configs linked

The community should consider various issues related to increased follow-up.

Allocation options:

- PI projects through existing TACs (as now)
- Community campaigns?
- Increase the fraction of time in Fast Turnaround?
- Single, system-wide AEON TAC (e.g. LLP)?
 - Allocates time on all network resources
 - Avoids multiple jeopardy from different TACs



Should there be new modes?

- “follow-LSST”?
- Other?

The proposal process should be collaborative and provide assistance with finding the right instrument

Have a Phase “0” tool for discovery of the appropriate instrument/mode for a project

- Near-IR spec, $R \sim 2000$
⇒ F2, GNIRS
- Optical spec, $R > 20000$
⇒ GHOST, GRACES
- Imaging, $\text{FWHM} < 0.1''$
⇒ GSAOI, NIRI

The screenshot displays the Overleaf web editor interface. The left sidebar shows a file explorer with 'fig1.png' and 'GeminiDemo_1...'. The main editor area is split into two panes. The left pane shows LaTeX source code for a proposal, including sections for 'EXPERIMENTAL DESIGN' and 'EXPERIMENTAL DESIGN'. The right pane shows a preview of the proposal, featuring a spectral plot of flux density versus wavelength. The plot shows two spectra: a solid line for NGC5461 and a dashed line for NGC5461. The plot is labeled 'Figure 1: Spectrum of NGC5461 from Puxley et al. (2000)'.

Collaborative editing using templates (e.g. Overleaf, Authorea, Google Drive, Github, ...)