

NEOexchange, AEON and the Time Domain Ecosystem



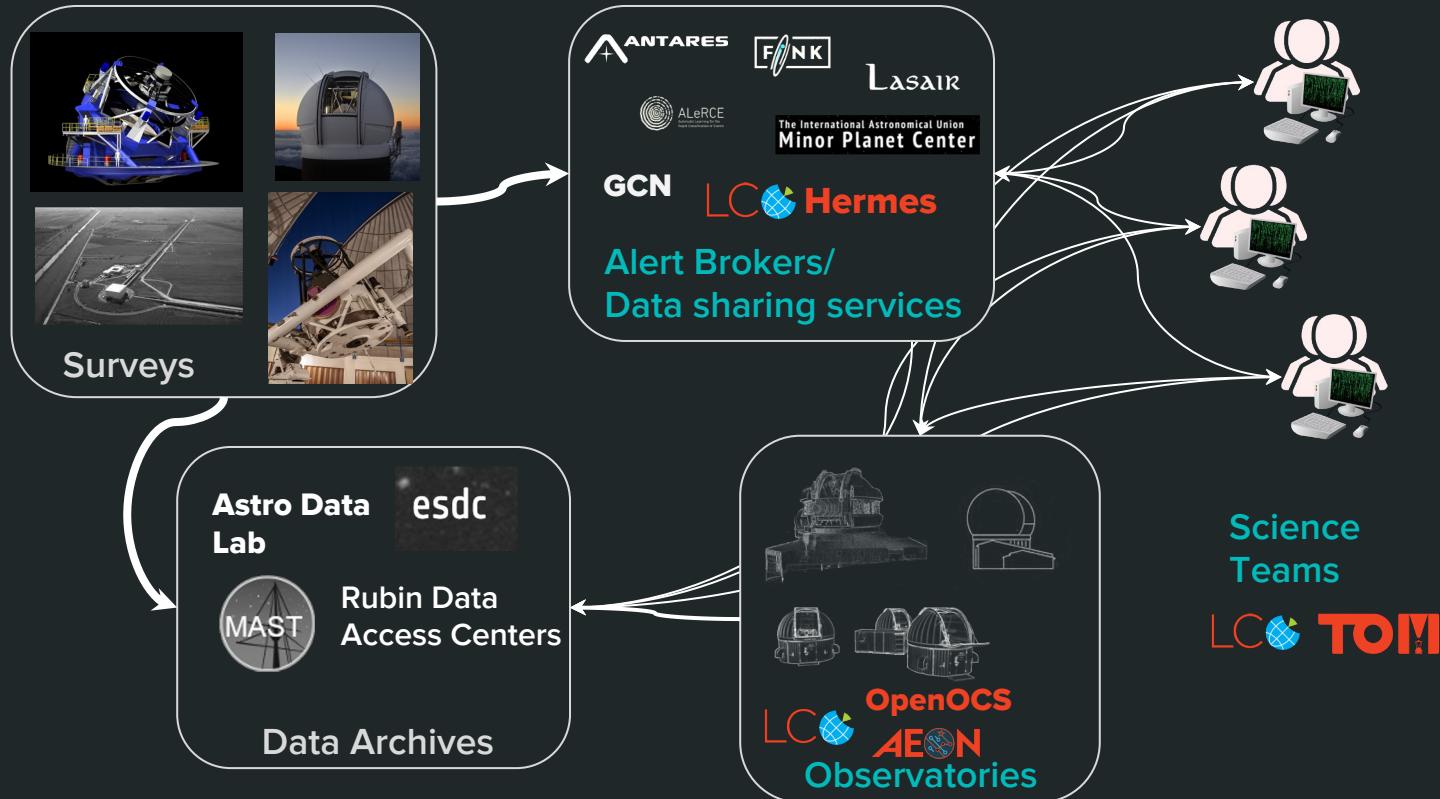
Presenter: Tim Lister (LCO)

TOM, OCS & Hermes Teams: R. Street, W. Lindstrom, J. Chatelain,
J. Nation, C. McCully, A. Howell



(Some of) This material is based upon work supported by the National Science Foundation under Grant No. 2209852

LCO Projects in the Time Domain Ecosystem



SN 2020bio SN I Ib $z=0.008533$

13:55:37.687 +40:28:39.147
208.9070 40.4775

Overview Details Observations Manage Data Observing Runs Photometry Spectroscopy

Known as:

- AT 2020bio
- PS20abu
- SN 2020bio
- ATLAS20etm

Add a new name

Science Interests:

- Classification
- Nearby SNe
- Shock Cooling
- Young SNe

Select Science Tags

Interested Persons:

I'm Interested

Data Used In:

First name of first author

Last name of first author

Brief description of contents of this paper, i.e. "All photometry and spectra"

Submit

Reference Status:

Photometry

Spectroscopy

Latest Comments

- Koichi Itagaki on 2020-01-30
<http://itagaki.jp/images/2020bio.jpg>
- Daichi Hiramatsu on 2020-01-30
5-day limit at 17.5 mag
- Jamie Burke on 2020-01-30
In NGC 5371 (~28 Mpc, DM 32.2). Discovered at 16.7 (-15.5).
- Jamie Burke on 2020-01-30
Swift followup requested.

Show More Comments

Comment

Post

Latest Visibility at LCO

SNEx 2 TOM system [J. Burke, C. Pellagrino, A. Howell, C. McCully]

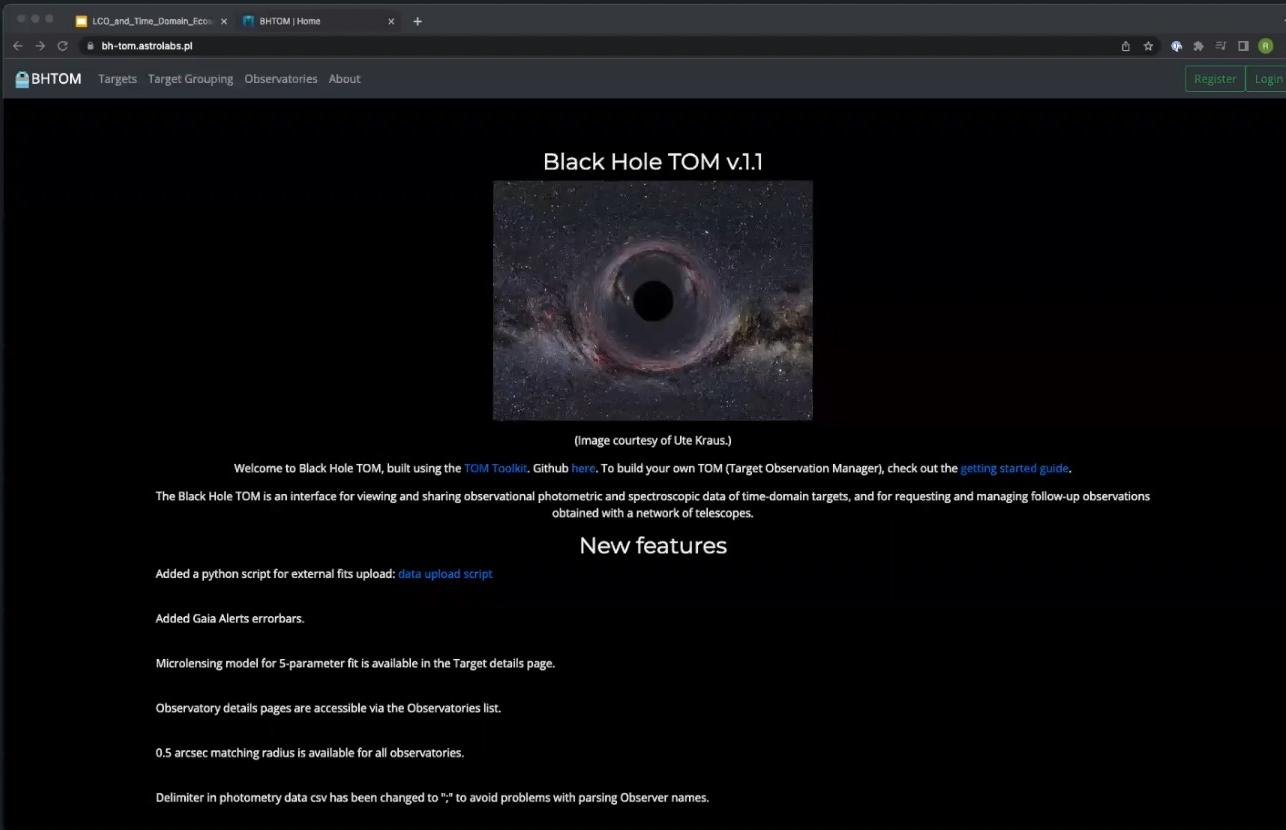
Systems for managing astrophysical projects

Searchable database of astrophysical project information, with observation and data analysis control systems, communication and data visualization tools

Open source, customizable

Black Hole TOM

By Maja Jabłońska, Łukasz Wyrzykowski, Univ. of Warsaw, Poland



The screenshot shows a web browser window for the Black Hole TOM v.1.1 interface. The URL in the address bar is bh-tom.astrolabs.pl. The page title is "BHTOM | Home". The main content area features a large image of a black hole with a bright accretion disk and a central event horizon, with the text "Black Hole TOM v.1.1" above it. Below the image is the credit "(Image courtesy of Ute Kraus.)". A welcome message reads: "Welcome to Black Hole TOM, built using the [TOM Toolkit](#). [Github here](#). To build your own TOM (Target Observation Manager), check out the [getting started guide](#). The Black Hole TOM is an interface for viewing and sharing observational photometric and spectroscopic data of time-domain targets, and for requesting and managing follow-up observations obtained with a network of telescopes." A section titled "New features" lists several recent additions: "Added a python script for external fits upload: [data upload script](#)", "Added Gaia Alerts errorbars.", "Microlensing model for 5-parameter fit is available in the Target details page.", "Observatory details pages are accessible via the Observatories list.", "0.5 arcsec matching radius is available for all observatories.", and "Delimiter in photometry data csv has been changed to ";" to avoid problems with parsing Observer names."

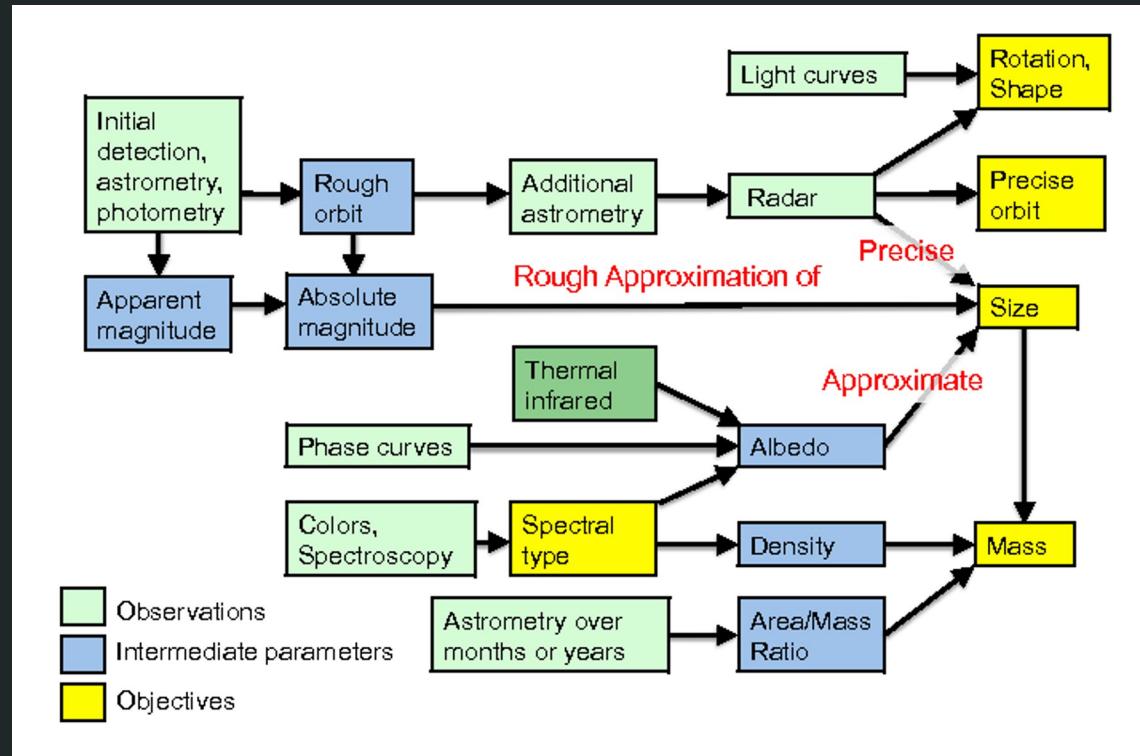
TOM Toolkit Update

- Sept 2019: V1.0 released, TOM Community Workshop
- Sept 2020: V2.0 released
- August 2022: Award of NSF grant:
 - From Cyberinfrastructure for Sustained Scientific Innovation (CSSI) program
 - Grant for \$1.5m over 3 years (October 2022 – September 2025)
 - Focusing on:
 - Multi-messenger Astrophysics,
 - Rubin Observatory (support for alert brokers and follow-up telescopes),
 - User Support & Engagement (including support for Science Collaborations)
- May 2023 V2.14.3
- <https://tom-toolkit.readthedocs.io/>

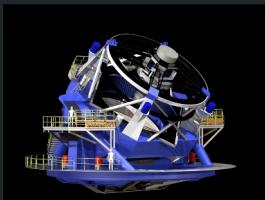


NEOexchange – a small body science-focused TOM system

Overview of NEO Characterization



Follow-up coordinated across a range of facilities



IR imaging/spectra
JWST/IRTF/ESO

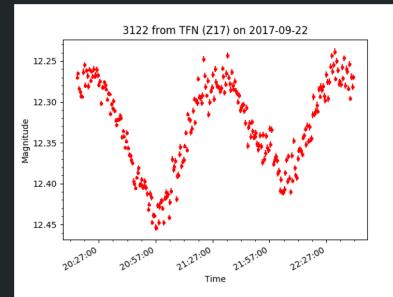
Eliminate non NEOs

NEOfixer

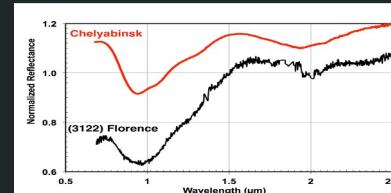
Initial
Followup

Characterization

Photometry/Light curves



Radar imaging
Goldstone/Arecibo (RIP)



Characterization spectra

NEOexchange – Targets

- Targets automatically ingested from:
 - Minor Planet Center
 - Goldstone radar target list
 - NASA small-body-obs mailing list
- User triggerable:
 - Yarkovsky targets
 - Manual addition of LOOK targets
 - Spectrophotometric/flux standards
- Elements, observations & known characterization data ingested

Rank	Target Name	R.A.	Dec.	V Mag.	Rate ("/min)	Required Observations	H Mag.	Origin	SMASS Observations	MANOS Target?	Observation Window (for next 90 days)
1	452334 (2001 LB)	18 04 41.66	-29 42 03.8	16.6	10.18	Spec/LC	21.07	Yarkovsky			Now-06/23
2	467336 (2002 LT3)	18 47 38.35	-17 22 06.6	15.9	5.87	Spec/LC	20.59	Goldstone			Now-07/23
3	2023 HO6	15 33 19.47	+14 31 40.6	17.9	0.56	Spec/LC	20.97	Goldstone			Now-07/23
4	2020 DB5	12 52 12.54	-22 00 36.1	14.0	23.51	Spec/LC	19.29	Goldstone			Now-07/23
5	2019 LH5	18 57 41.66	-15 48 25.1	19.6	0.61	Spec/LC	20.52	Goldstone			06/23-07/23
6	2102 Tantalus (19)	22 18 28.45	-46 16 59.0	17.7	3.22	LC	16.0	Arecibo	Vis		Now-07/23
7	163696 (2003 EB1)	13 13 51.52	-13 49 12.4	16.2	4.10	Spec/LC	16.46	Goldstone	NIR		Now-07/23
8	2018 UY	06 54 46.99	+22 52 06.0	26.1	0.54	Spec/LC	20.88	Goldstone			07/23-08/23
9	136108 Haumea (1)	14 27 37.81	+15 39 47.8	17.5	0.03	Spec/LC	0.37	LCOGT			Now->
10	154244 (2002 KLT)	15 50 21.58	-07 34 17.2	16.0	1.08	Spec/LC	17.72	Goldstone	NIR	Yes	Now->
11	6037 (1988 EG)	21 18 41.33	-08 11 36.5	21.0	0.70	Spec/LC	19.31	Goldstone	NIR		08/23-08/23

Target Name	Target Type	Target Subtype	R.A.	Dec.	V Mag.	Rate ("/min)	Heliocentric Distance (AU)	Observations Scheduled (for next 90 days)
2023 JN16	Asteroid	Main-Belt	13 52 50.53	-14 36 30.9	20.4	0.14	2.9	Inactive since 0...
C/2023 H3	Comet	Jupiter Family	14 11 55.69	-12 37 42.6	20.8	0.09	5.4	Active until 06/30
169P	Comet	Jupiter Family, NEO	11 38 00.24	+05 24 13.4	21.9	0.24	3.5	Nothing scheduled
364P	Comet	Jupiter Family, NEO	01 40 12.90	-05 13 42.6	16.6	1.28	0.9	Inactive since 0...
C/2023 A3	Comet	Dynamically New	14 21 04.37	+03 20 08.9	16.8	0.38	6.3	Active until 06/30
C/2022 T1	Comet	Jupiter Family	09 06 17.88	-04 43 28.2	18.5	0.60	4.1	Active until 06/30
C/2023 C2	Comet	Dynamically New	10 15 54.95	-42 47 41.5	18.4	0.26	5.7	Active until 06/30
C/2022 U3	Comet	Hyperbolic	03 44 47.22	+37 43 04.5	19.2	0.53	5.8	Inactive since 0...
2003 CC22	Centaur	Jupiter Family	10 29 09.89	+14 03 21.3	19.5	0.48	4.2	Inactive since 1...
C/2022 S3	Comet	Hyperbolic	09 45 13.59	+28 00 29.0	23.3	0.80	2.4	Nothing scheduled

NEOexchange – Observations

- Ephemeris calculation
- Spectroscopic SNR feasibility
- Visibility “colorwheels” for LCO sites
- Long-term (1 month) plots for:
 - Sky position
 - Galactic position (MW Bulge/plane avoidance)
 - Helio./geo. distances
 - Mag., elongation, moon separation
 - Positional uncertainty

SCHEDULE OBSERVATIONS SCHEDULE SPECTROSCOPIC OBSERVATIONS

Name X82007 → 2023 HO6

Type NEO [PHA]

Status Actively Following
Characterization Target

Source Goldstone

2023-06-13 Any 1.0m 30.0
UTC date Site Min Altitude
CALCULATE EPHEMERIDES

CHECK SPECTROSCOPIC FEASIBILITY CREATE LC PLOT

Recent Blocks Scheduled
No blocks have been scheduled

Measurements

(2023 KX3) for 2023-06-08 to 2023-07-09
Predicted brightness

(2023 KX3) for 2023-06-08 to 2023-07-09
Galactic position

NEOexchange – Observations (2)

- Scheduling of single visits or repeated cadences (with specified period and “jitter”/flexibility e.g., LOOK DNC 3-day cadence)

Scheduling

HOME TARGETS ▾ BLOCKS DATA

Parameters for: 467336

[SWITCH TO SINGLE OBSERVATION](#)

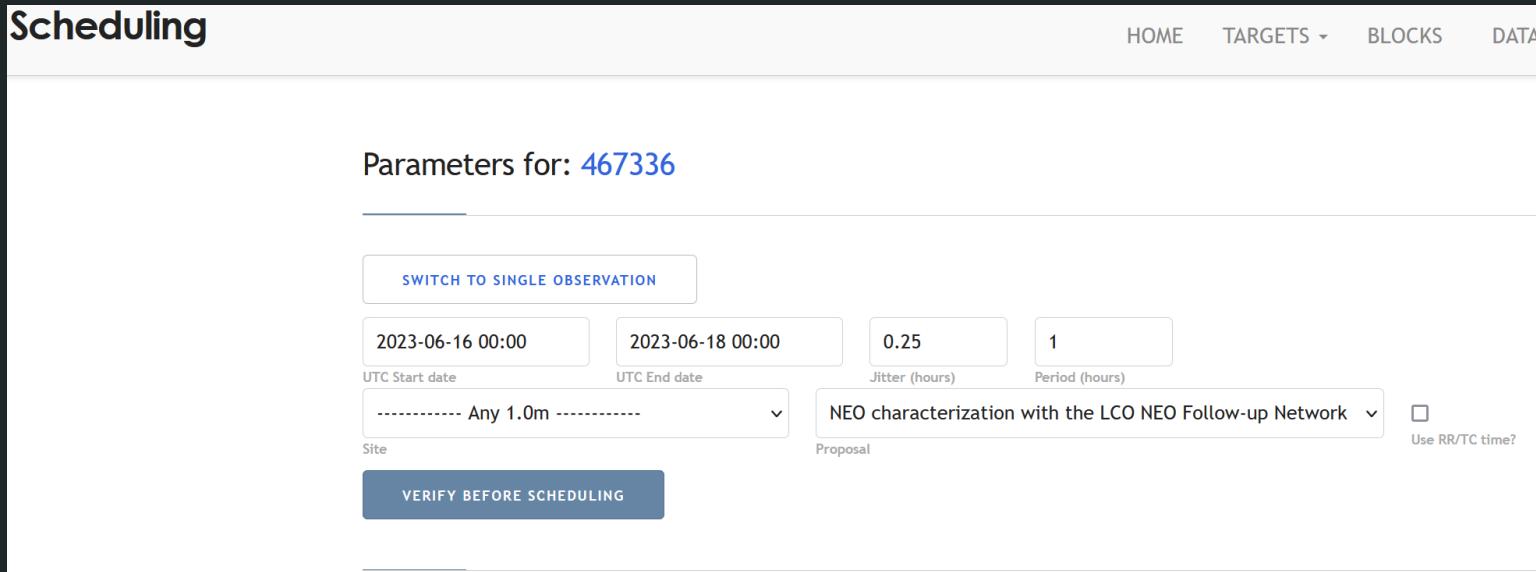
2023-06-16 00:00	2023-06-18 00:00	0.25	1
UTC Start date	UTC End date	Jitter (hours)	Period (hours)

Site: ----- Any 1.0m -----

Proposal: NEO characterization with the LCO NEO Follow-up Network

Use RR/TC time?

[VERIFY BEFORE SCHEDULING](#)



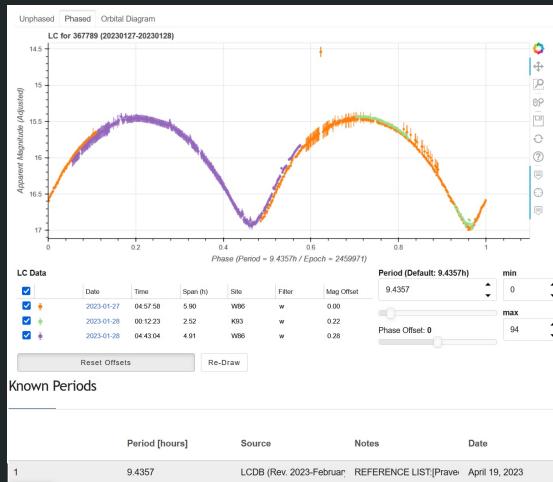
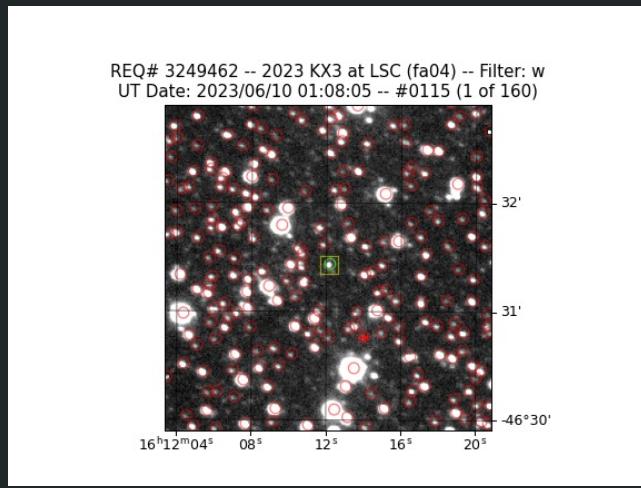
NEOexchange – Observations (3)

- Scheduling confirmation page allows checking of:
 - Position, magnitude
 - Lunar phase and separation
 - Rate (per minute and per exposure)
 - Time usage (important for cadences)
- Can alter (form refreshes):
 - Filter pattern
 - Exposure time
 - Block length
 - Airmass and lunar distance constraint

RIGHT ASCENSION	18 09 15.77
DECLINATION	-10 19 02.9
MAGNITUDE	15.26
LUNAR PHASE / SEPARATION	 154.3°
SPEED / TRAILING	8.76 ''/min → 1.83 ''/exp [Half-Rate]
BINNING	Central 2k, 2x2
FILTER PATTERN	W
SLOT LENGTH	15.0 mins
NO. OF EXPOSURES	23
EXPOSURE LENGTH	25.0 secs
WINDOW (UTC) <input type="checkbox"/> <small>(EDIT)</small>	2023-06-16T00:00:00 -> 2023-06-18T00:00:00
JITTER	0.25 hrs
PERIOD	1.0 hrs
MAX NO. OF REPEATS / TOTAL TIME	48 / 12.00 hrs

NEOexchange – Observations (4)

- Data reduction pipeline:
 - Astrometric fit, ZP calibration, source catalog production
 - Store source catalogs in DB for assignment to object
 - Upload light curves and “guider” movies
- Analysis tools for:
 - Light curves
 - Period determination and phasing
 - Orbit coverage
 - Reflectance spectra and analogs



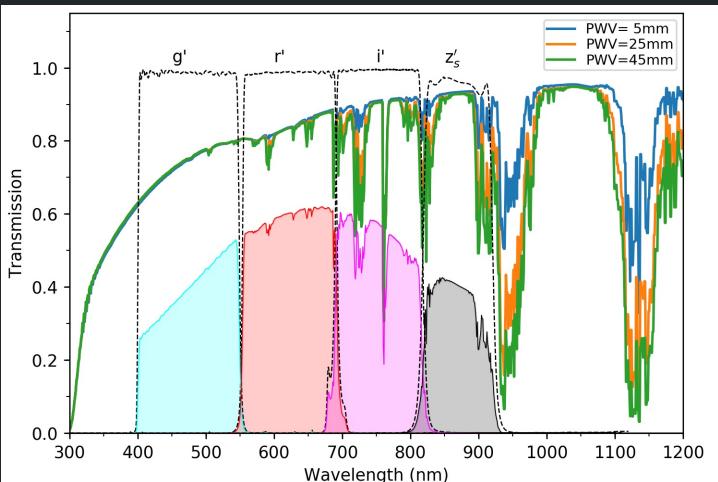
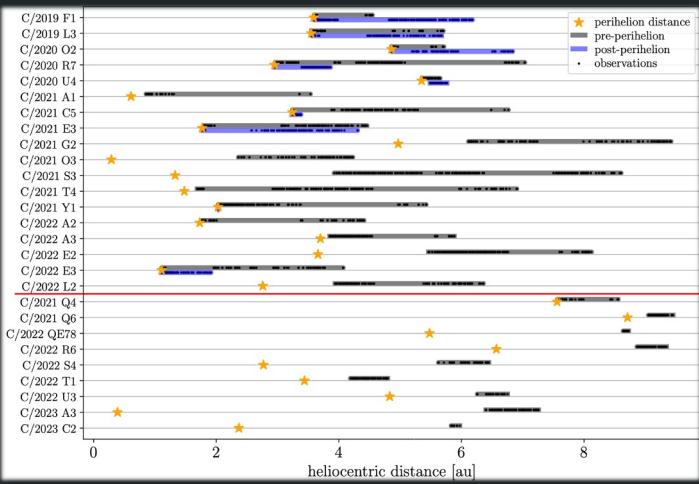
NEOexchange – Management

- Recording in DB of:
 - Overall obs. Requests and individual visits
 - Obtained and reduced Frames
 - Photometric and Astrometric measurements
 - Derived DataProducts: ALCDEF/ “DART format” light curves, spectra, movies, conditions plots, PDS exports
 - Records of exported datasets to e.g. PDS

Data Summary Page						
LCO Light Curves (Spec)						
	Target Name	Period	Quality	Source	Notes	Status
1	413577 (2005 UUL5)	3.459 (h)		LCDB (Rev. 2020-October); V	[Result based on less than fu	No Analysis Done
2	2015 HM10	0.3761 (h)		LCDB (Rev. 2020-October); V	REFERENCE LIST; Thirouin,	No Analysis Done
3	2015 JD1					No Analysis Done
4	537342 (2015 KN120)	46.3 (h)		LCDB (Rev. 2019-January); V	[Result based on less than fu	No Analysis Done
5	2015 KJ19					No Analysis Done

NEOexchange – Future plans

- Better integration of the multi-aperture support developed for DART mission
- Better support for managing long-term programs such as LOOK
- Integration & support for SOAR-AEON using generalized ETC

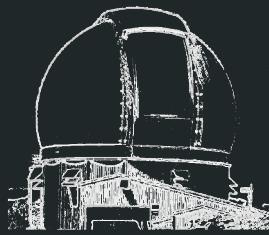


Collaboration of observatories for time-domain astrophysics

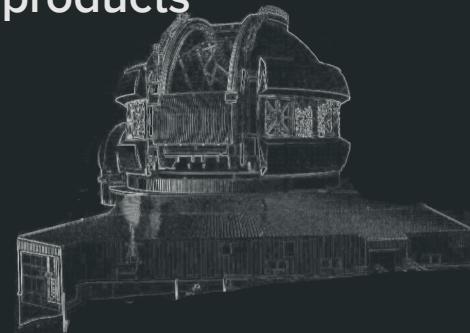
- Observations can be programmatically requested
- Queue-scheduled at least some of the time
 - Manual and robotic operation
- (encouraging) data archives and real-time/rapid pipeline products



Las Cumbres Observatory
Network - 2m, 1m, 0.4m



SOAR - 4m



Gemini N & S - 8m

 Facility Updates

SOAR: Supporting Goodman (optical imaging & spectroscopy) and TripleSpec (NIR spectrograph)

More automated supervised telescope operation

Data pipeline for Goodman spectrograph

Observations routinely requested through LCO scheduling system

Gemini: Developed plugin for TOM Toolkit to enable observation submission

Designing new operating system with AEON in mind

Blanco 4m: Started to work with NOIRLab team on AEON compatibility

Rubin International In-Kind Program

Time on several observatories was offered to the US/Chilean communities in return for LSST data access rights

AEOН-compatibility was strongly encouraged



SALT 10m

Milankovic 1.4m
Telescope, Serbia



Observing Facilities Workshop

Poreć, Croatia in Sept 23-24 2023

Organizing a hands-on workshop to support telescope operators, in collaboration with the Rubin In Kind Program

To be co-located at the LSST@Europe V conference

Extra Slides (Hermes, Open OCS)

Multi-messenger Astrophysics

Established connections with wider MMA community via the SciMMA organization

Prepared for O4 gravitational wave detector run (May 2023 - Dec 2024)

New tools for non-localized events

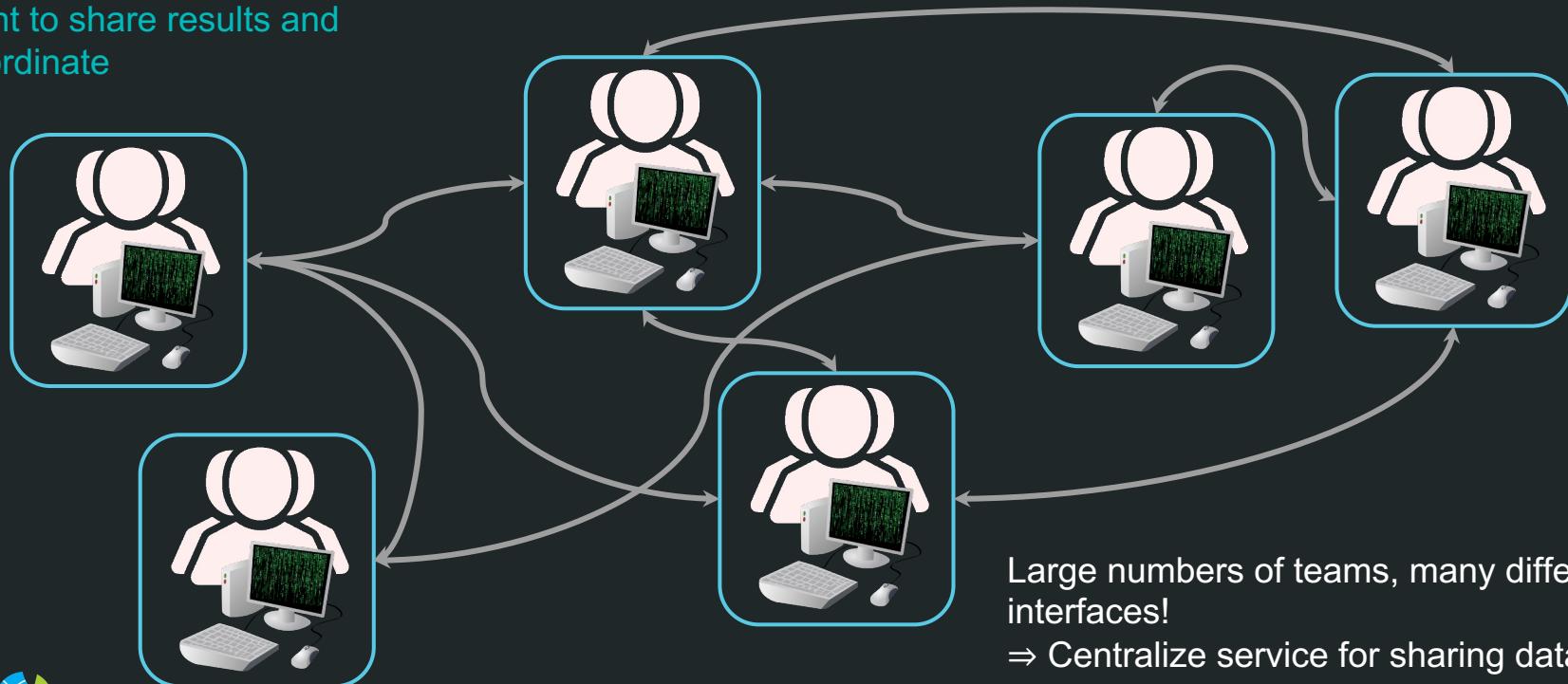
Non-Localized Event Index

Detail Page	GraceDB	Treasure Map	Event Type
1. S190425z Details	S190425z	S190425z	GW
2. S190426c Details	S190426c	S190426c	GW
3. S190718y Details	S190718y	S190718y	GW
4. S200112r Details	S200112r	S200112r	GW
5. S200316bj Details	S200316bj	S200316bj	GW
6. S191110af Details	S191110af	S191110af	GW
7. S191216ap Details	S191216ap	S191216ap	GW



The Messaging Problem

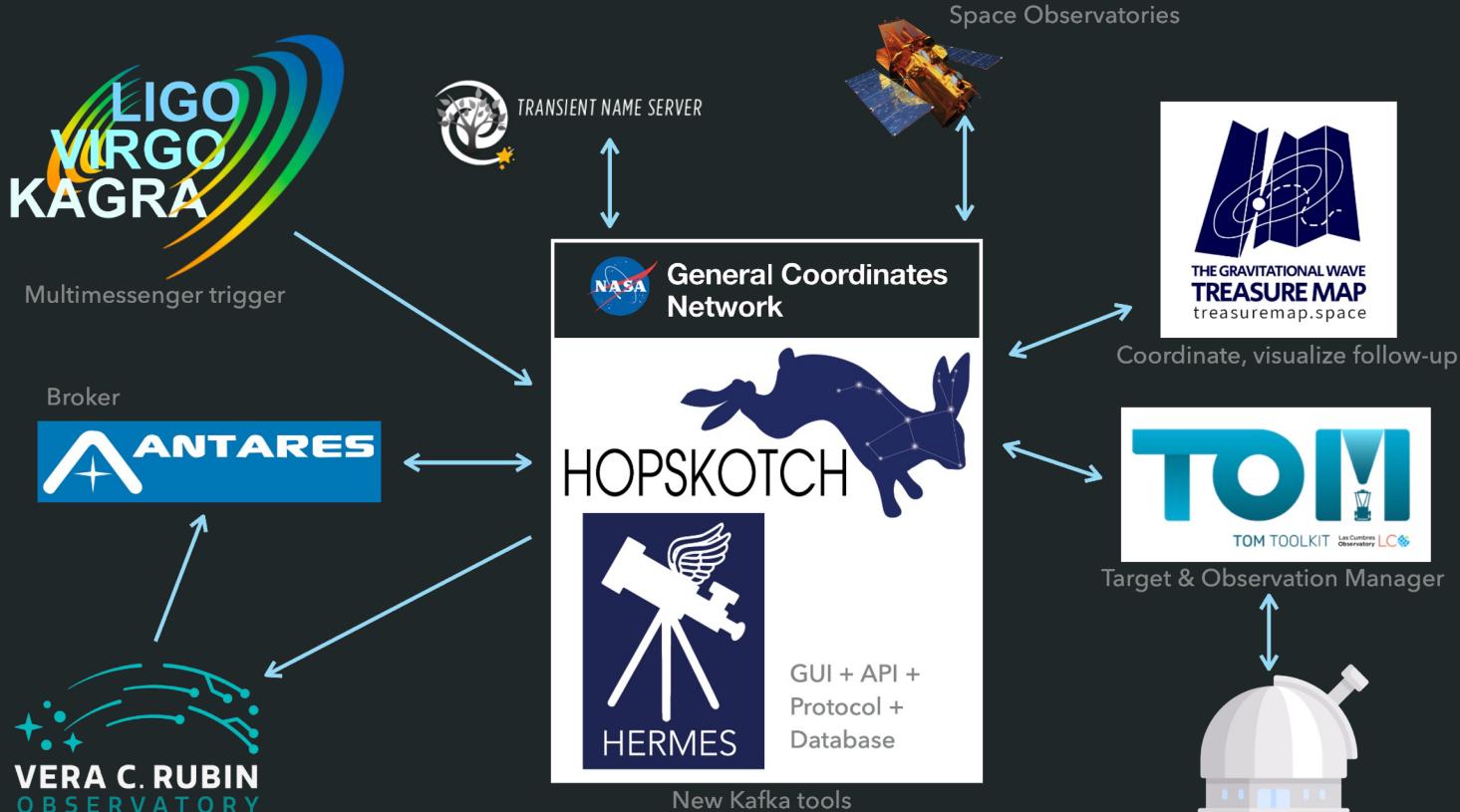
Independent research teams want to share results and coordinate





Hermes

hermes.lco.global



Graphic by A. Howell



Hermes: Hopscotch Enabled Rapid Message Exchange Service

hermes.lco.global

HERMES

Browse Submit Message

Stream Status: green circle About HERMES Guest ▾

Filter by Topic ▾ Search Terms

Timestamp	Topic	Title	Submitter
17 hours ago	gcn.circular	LIGO/Virgo S230531f: Global MASTER-Net observations report	Hop gcn.circular
17 hours ago	gcn.circular	GRB 230525A: CALET Gamma-Ray Burst Monitor detection	Hop gcn.circular
20 hours ago	gcn.circular	LIGO/Virgo/KAGRA S230529ay: Zwicky Transient Facility observations	Hop gcn.circular
20 hours ago	gcn.circular	LIGO/Virgo/KAGRA S230528a: Zwicky Transient Facility observations	Hop gcn.circular
20 hours ago	gcn.circular	LIGO/Virgo/KAGRA S230527ch: Zwicky Transient Facility observations	Hop gcn.circular
a day ago	hermes.message	INTEGRAL follow-up of S230531f	Volodymyr Savchenko
a day ago	gcn.circular	LIGO/Virgo/KAGRA S230529ay: Upper limits from CALET observations.	Hop gcn.circular
a day ago	gcn.circular	LIGO/Virgo/KAGRA S230529ay: AstroSat CZTI non-detection and upper limits	Hop gcn.circular
2 days ago	gcn.circular	LIGO/Virgo S230529ay: Global MASTER-Net observations report	Hop gcn.circular
2 days ago	gcn.circular	LIGO/Virgo/KAGRA S230529ay: upper limits from AGILE/MCAL	Hop gcn.circular

« < 1 2 3 4 ... > » Show: 10 ▾

HERMES is a Message Exchange Service for Multi-Messenger Astronomy applications that allow users to both send and review messages related to a variety of events and targets of interest.

New messaging service supporting nearly any type of astronomical information

Message converted to JSON and published on Kafka-based HOPSKOTCH service

Graphical and programmable user interfaces

Developed in conjunction with SCIMMA.org

TOM sharing data via Hermes

SNeX 2.0 Home Targets ▾ Alerts ▾ Scheduling Data Users TNS Targets Search by name or coord

Curtis McCully Logout

SN 2022wpy

SN Ia $z = 0.0152$ 04:46:28.004 -04:47:23.68
71.6167 -4.7899

Overview Details Observations Manage Data Observing Runs Images Photometry Spectroscopy

Known as:

- AT 2022wpy
- SN 2022wpy
- ATLAS22bhuv

Add a new name

Science Interests:

- Classification
- Ia
- Nearby SNe
- Young SNe

Select Science Tags

Interested Persons:

J. Craig Wheeler
Or Graur

I'm Interested Add to Interesting Targets

Data Used In:

First name of first author

Last name of first author

Brief description of contents of this paper, i.e. "All photometry and"

Latest Comments

Craig Pellegrino on 2022-10-03
In NGC 1659 (64.3 Mpc, dm=34.04), discovered at 19.0 with a 1 day nondetection at 19.6

Add a comment

Latest Visibility at LCO

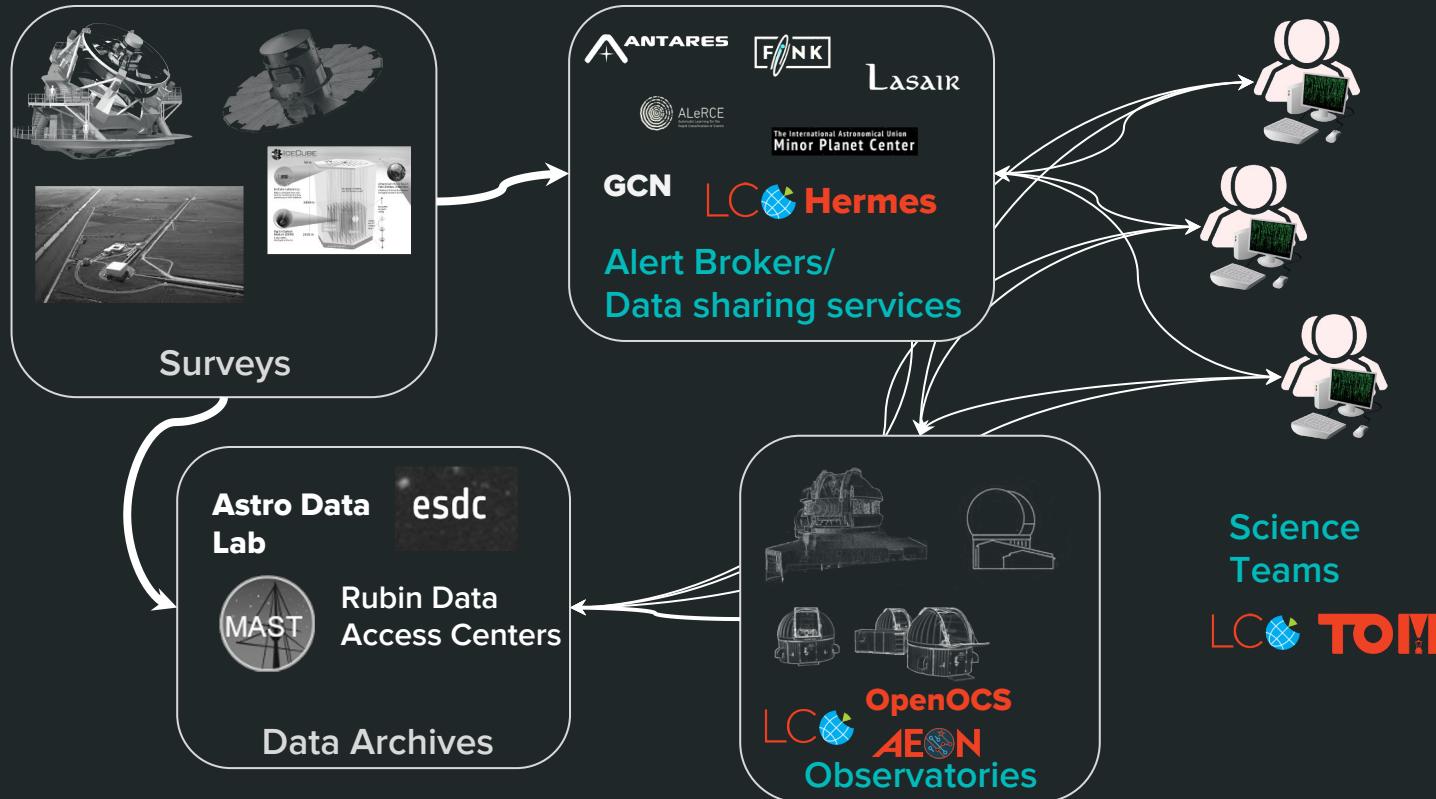
Hours From Now

Aladin Viewer

Recent LCO Images

LCO

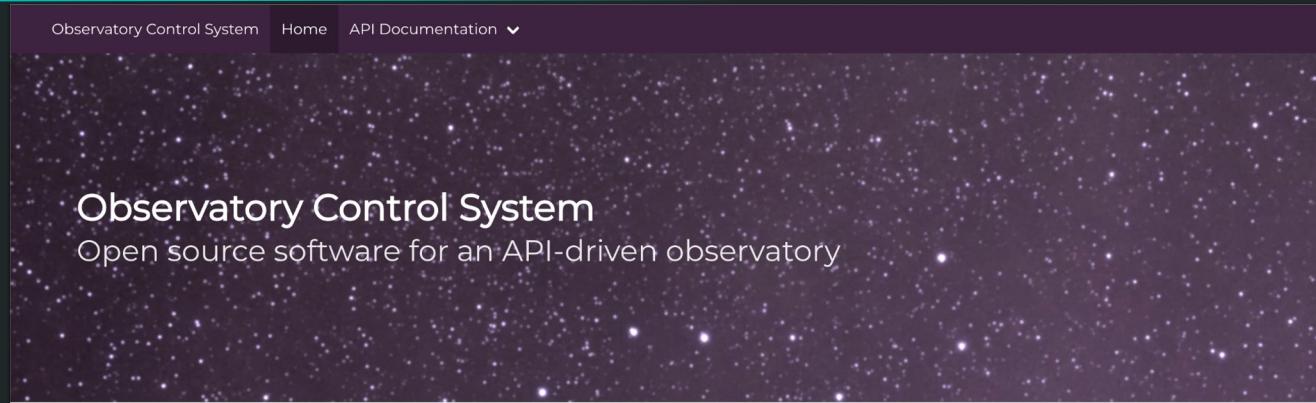
LCO Projects in the Time Domain Ecosystem



Observatory Software

Astrophysics would benefit from more time-domain friendly observing facilities

But most observatories have limited software development budget



The background of the page features a dark, star-filled image of a galaxy or nebula.

Observatory Control System
Open source software for an API-driven observatory

TABLE OF CONTENTS

- Home
- Contributing
 - Code of Conduct
 - Contributor Guidelines
- Components
 - Observation Portal
 - Configuration Database
 - Adaptive Scheduler
 - Science Archive

With the field of astronomy undergoing a revolution in data volume and automation, many observatories around the world are beginning to update their systems to take advantage of modern web technologies. However, producing a fully-featured and maintainable Observatory Control System (OCS) is an expensive undertaking! Las Cumbres Observatory successfully operates a network of 20+ robotic telescopes around the world, driven entirely by APIs. The software that enables this has been bundled up and open-sourced, the goal of which is to increase the rate of adoption of APIs in astronomical observing and to share the knowledge gained in the process of building the software so that the entire community benefits.

What does an API-driven Observatory Control System accomplish?

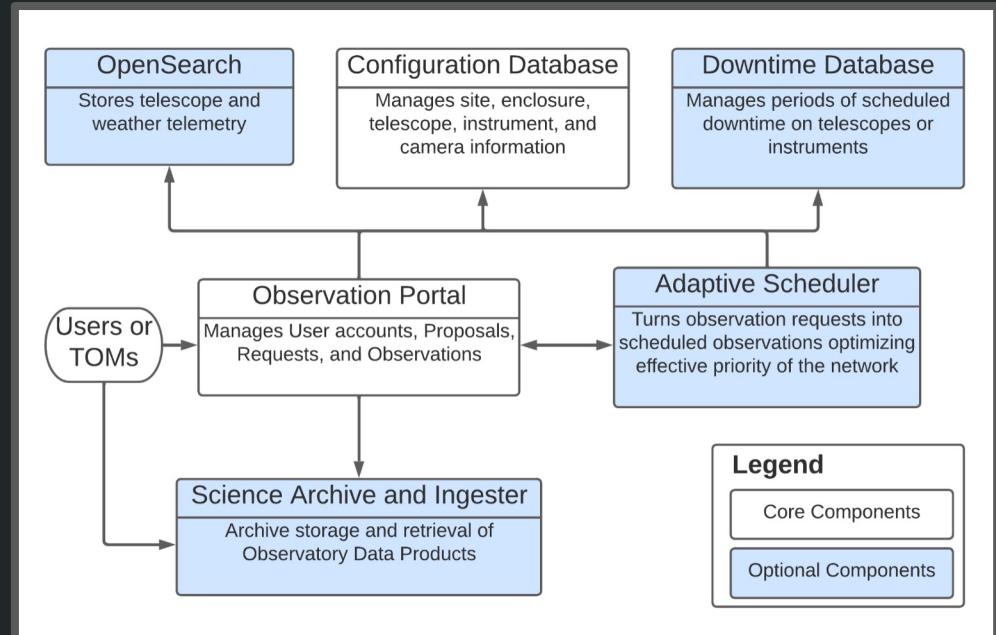
Astronomers can:

- Submit requests to observe a target, track the states of those requests, and cancel requests if their needs have changed
- Be notified once their observation is complete
- Download their science data

Modular suite of APIs to manage key interfaces

- Observation Submission Portal
- Configuration Database
- Adaptive Scheduler for telescope time
- Science Data Archive
- Downtime Database

TOM compatible

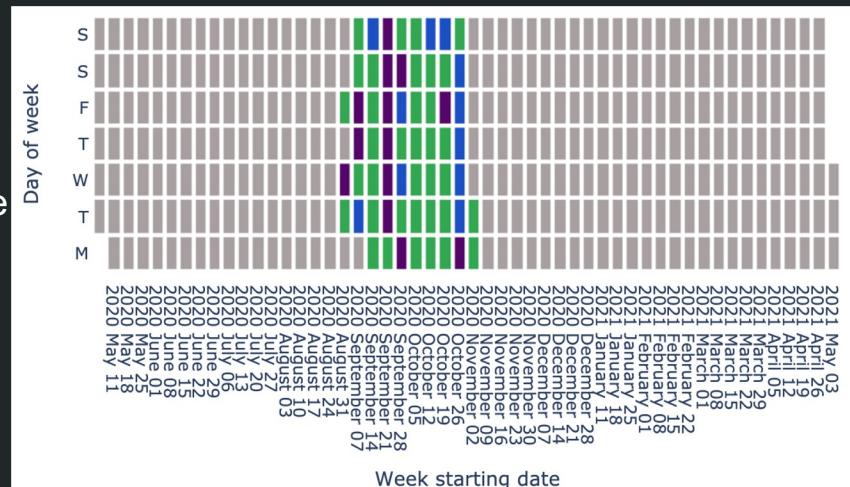


Observatory Control System

observatorycontrolsystem.github.io

Includes Adaptive Scheduler

- Mixed Integer Programming (MIP) solver
- Supports multiple free and commercial solvers
- Supports 3 request types: Rapid Response, Time Critical, and Normal
- Runs when changes are detected



LCO Projects in the Time Domain Ecosystem

