

Time domain astronomy at the Las Cumbres Observatory Global Telescope Network

Stefano Valenti



Private, non-profit organization
founded and run by Wayne Rosing.



Santa Barbara
Headquarters
40+ staff. Others
in Liverpool,
Cardiff, Siding
Spring Australia,
Hawaii

LCOGT.net Headquarters



Santa Barbara, CA

- machine & electrical shops
- optics laboratories
- assembly zones, warehouses
- server rooms, computer labs
- offices & conference rooms
- prototype testing facilities

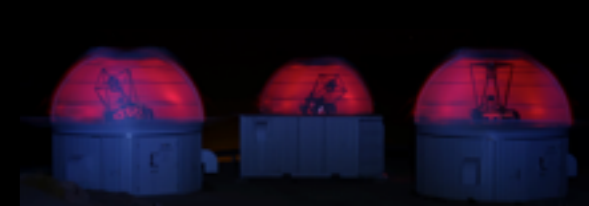
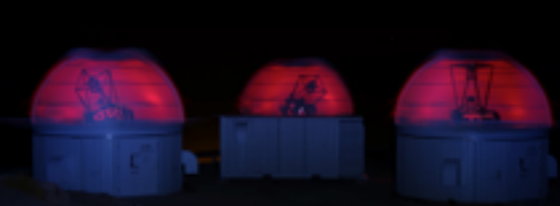


Build and run a global network of robotic telescopes to study time variable objects

Desired network of sites

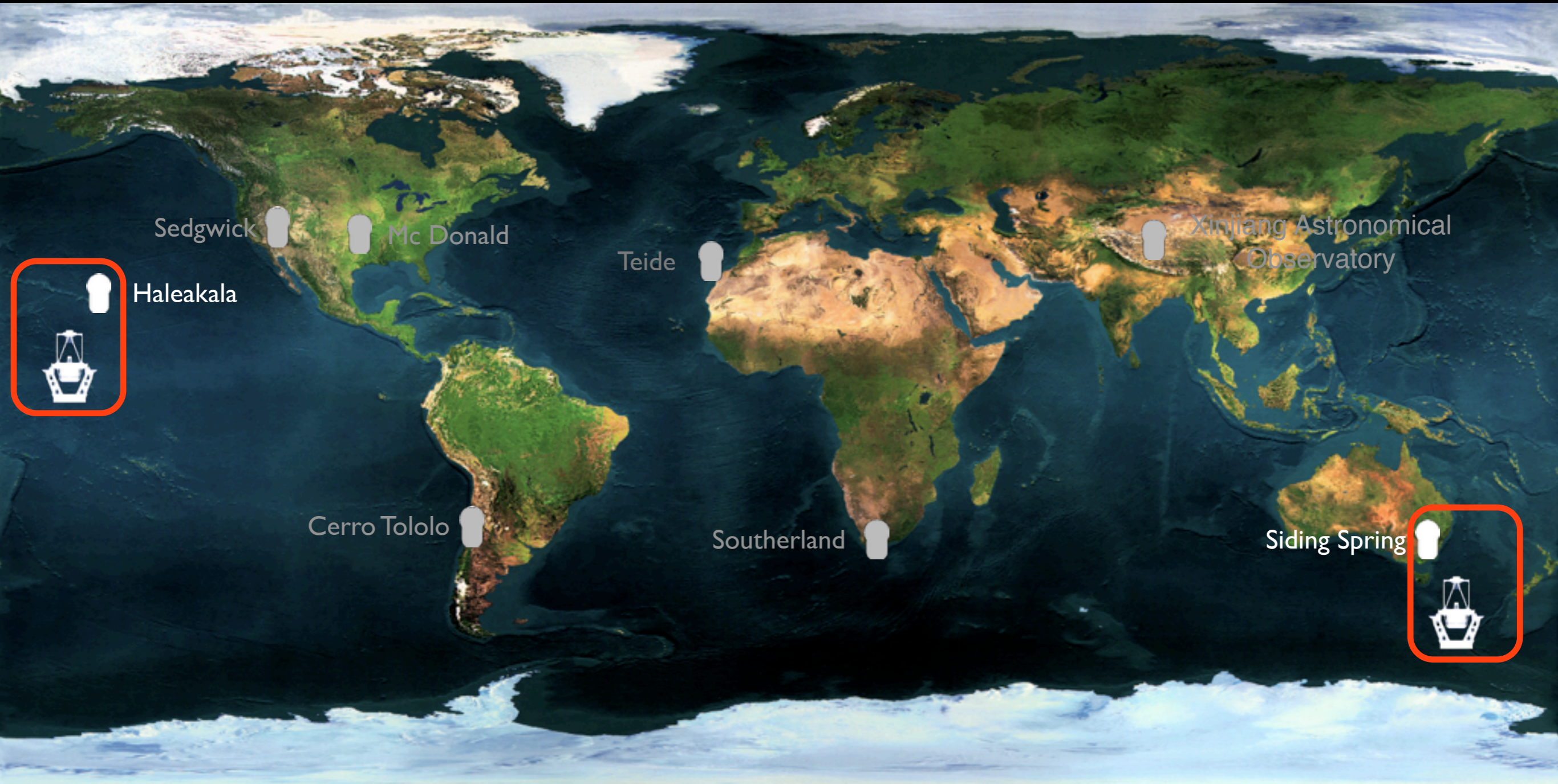


We keep you in the dark !!!!

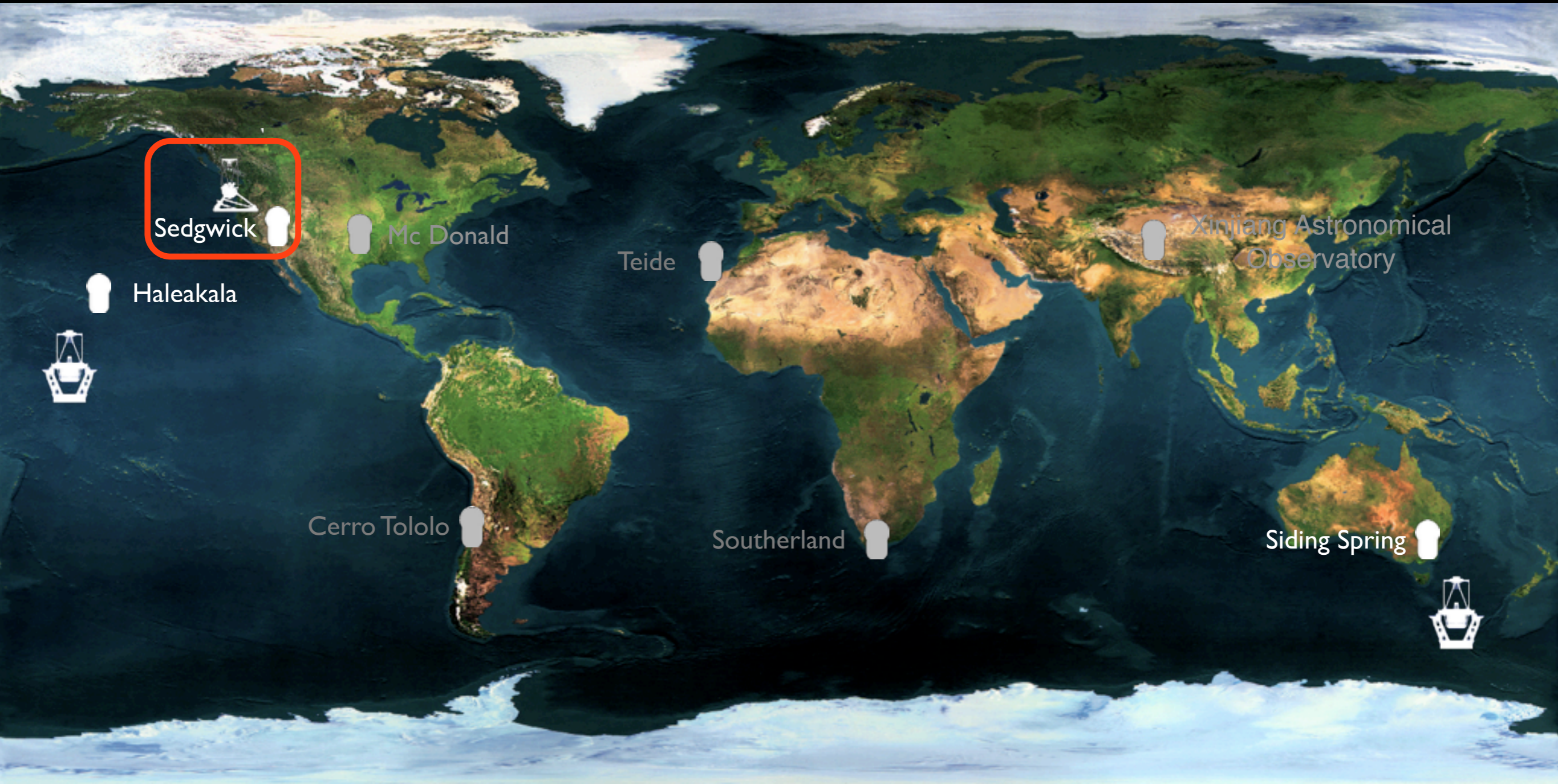


2005

FTS and FTN



2009 april 0.8m testing facility



Sedgwick

Mc Donald

Teide

Xinjiang Astronomical Observatory

Haleakala

Cerro Tololo

Southerland

Siding Spring

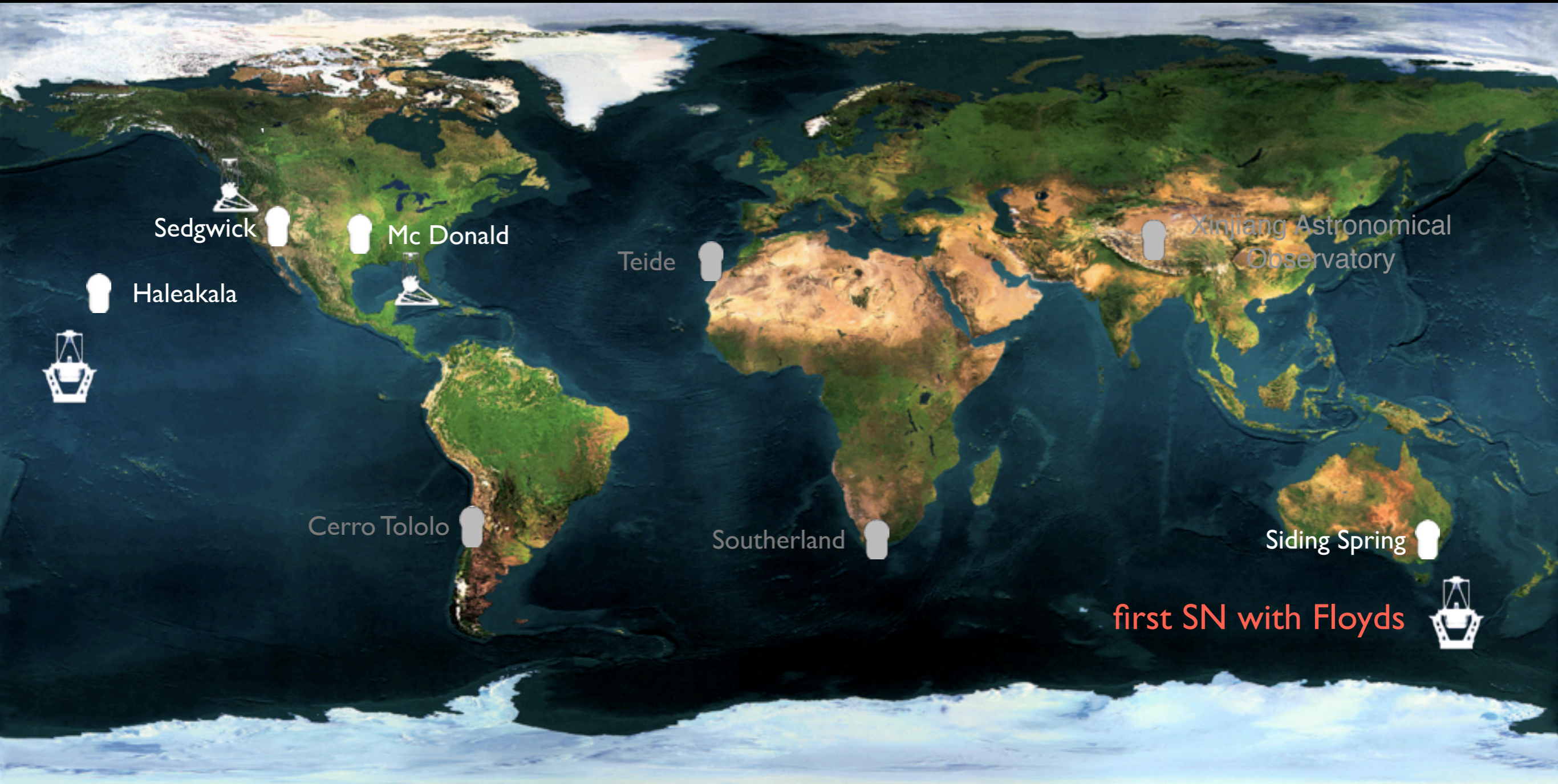
April 2012

Im Texas



June 2012

Floyds @ FTS



Sedgwick

Mc Donald

Teide

Xinjiang Astronomical Observatory

Haleakala

Cerro Tololo

Southerland

Siding Spring

first SN with Floyds

August 2012

Floyds @ FTN



Sedgwick

Mc Donald

Teide

Xinjiang Astronomical Observatory

Haleakala

Floyds @ FTN

Cerro Tololo

Southerland

Siding Spring

October 2012

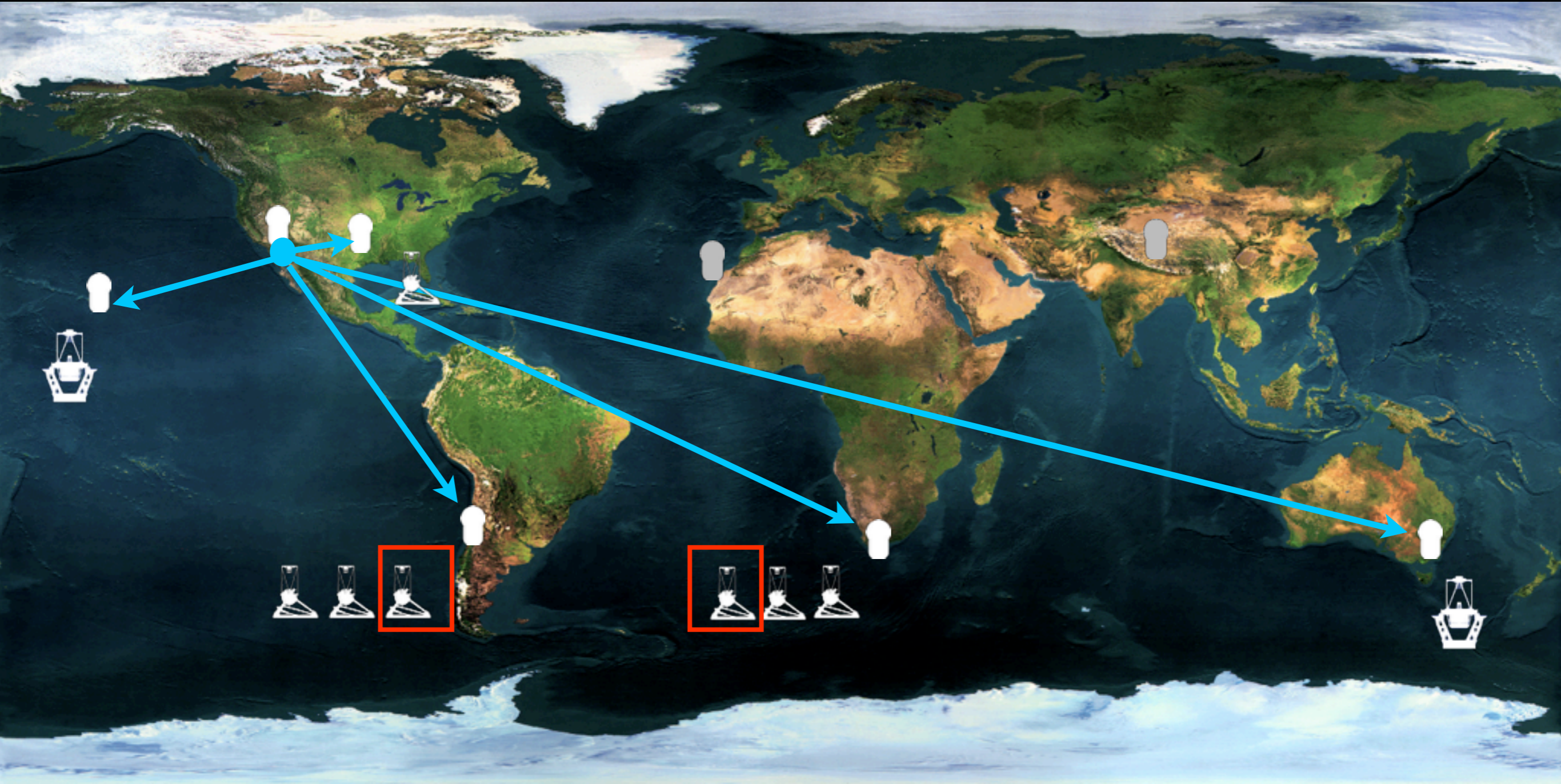
3x1 m in chile



February 2013 3x1m South Africa

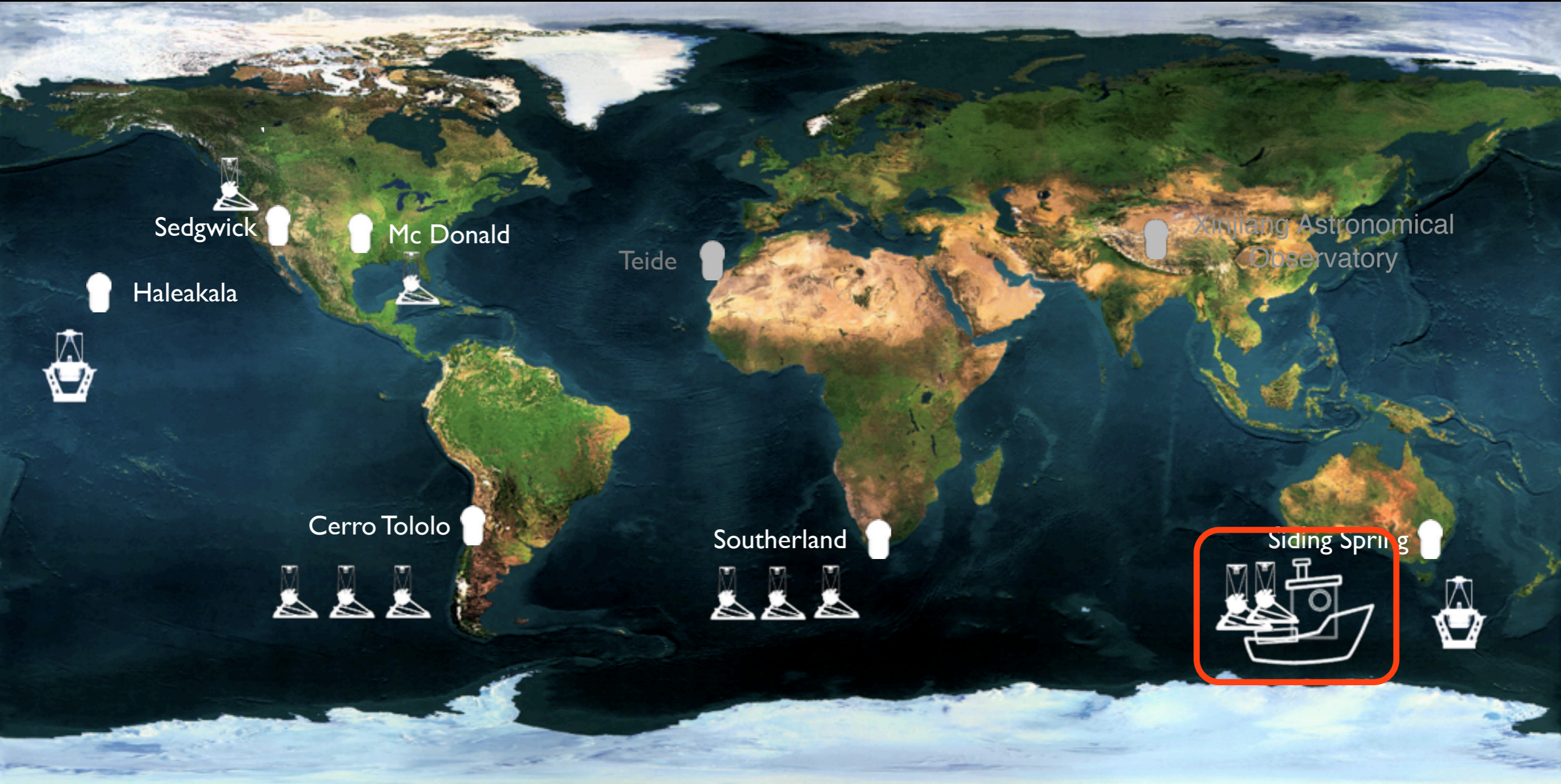


February 2013 (Scheduling)



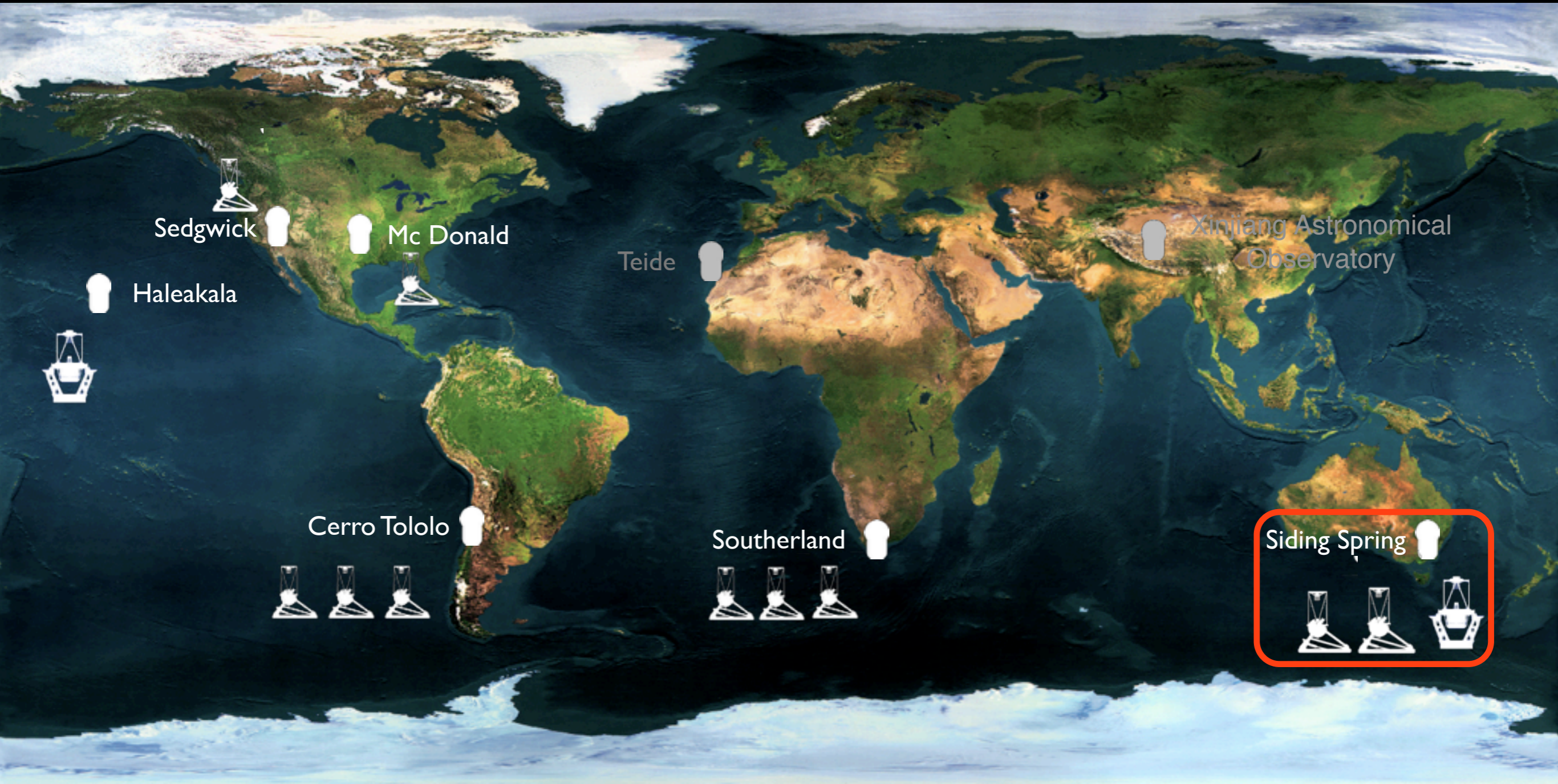
April 2013

2 x 1m ...



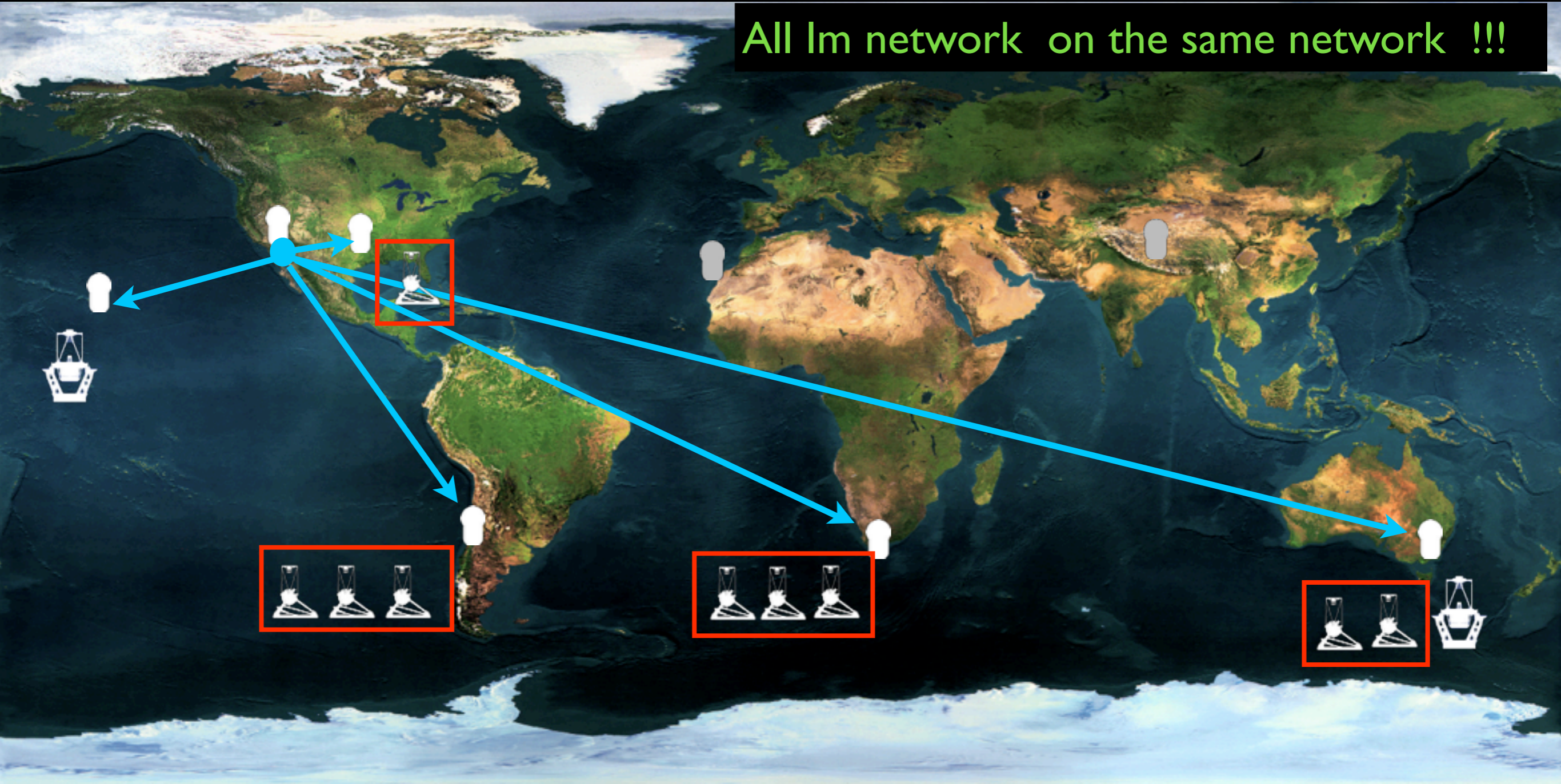
June 2013

2 x 1m operative



July 2013

All Im network on the same network !!!



July 2013

All Im network on the same network !!!



LCOGT Version I



LCOGT Version I

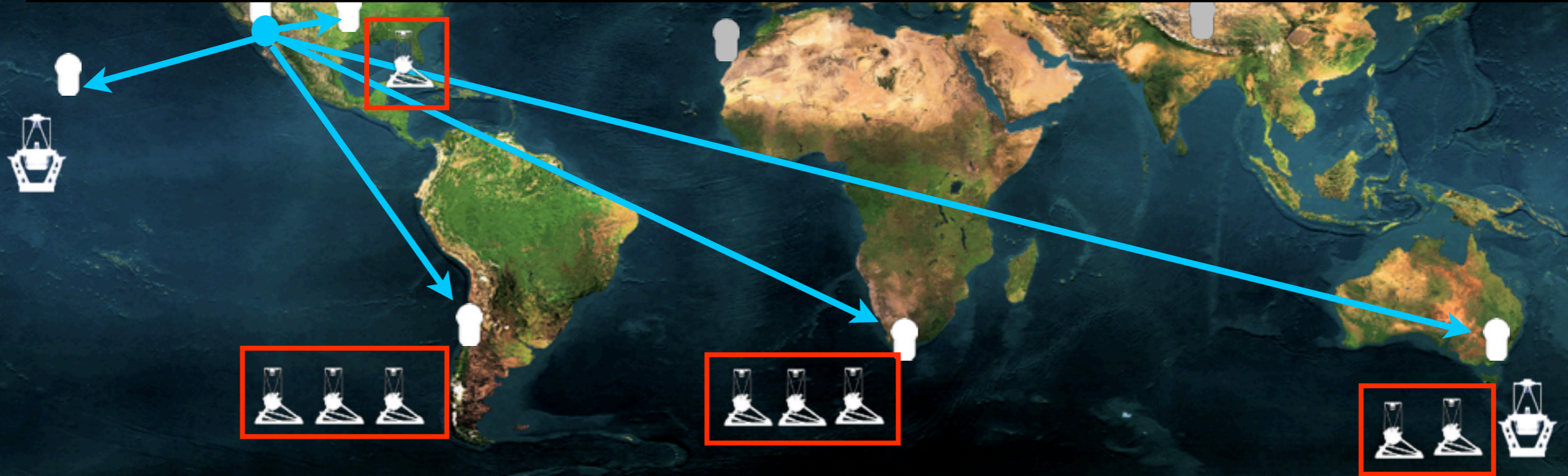
Construction \longrightarrow Operation

V1.0 refers to an initial set of capabilities that allow high-impact science to be done with the LCOGT network, and that we aim to support starting with **semester 2014A, Apr 1 - Sep 30, 2014.**



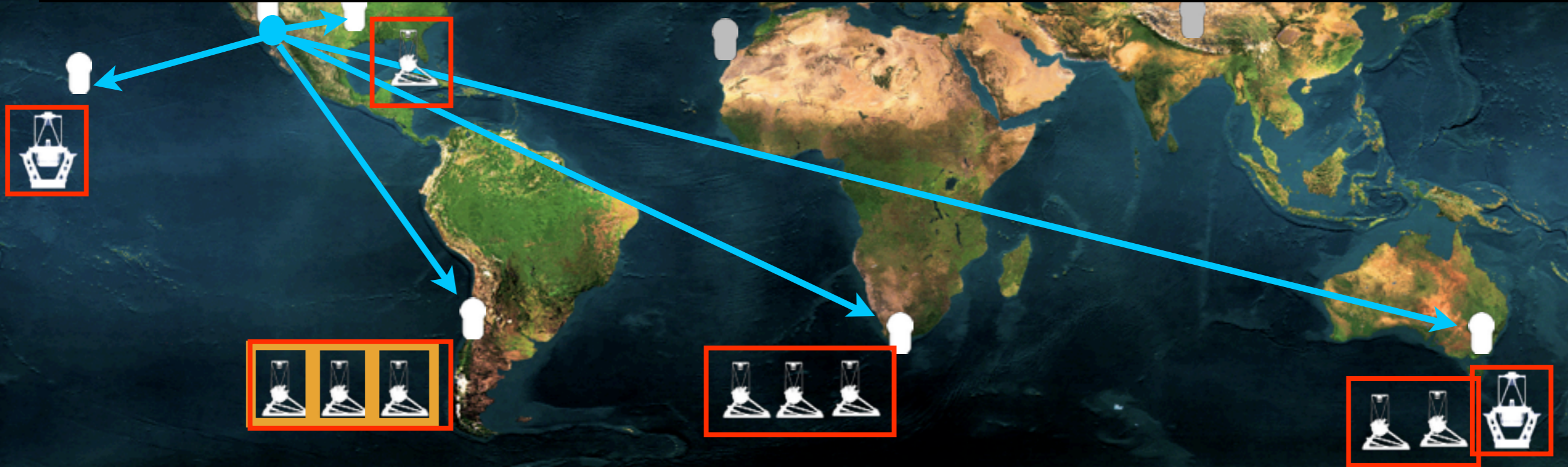
LCOGT Version I

All Im network on the same network
2m Telescopes as part of the network
Deploying optical imagers on Im's
User interface to support proposal process and observation requests



LCOGT Version I (2014 May I)

All Im network on the same network
2m Telescopes as part of the network
Deploying optical imagers on Im's
User interface to support proposal process and observation requests



Telescopes



Fig. 1.— LCOGT's Faulkes North (FTN) 2m telescope at dusk, with the clamshell enclosure open. Faulkes South (FTS) is a twin of FTN, but located at Siding Spring Observatory in Australia.

FTN & FTS (2m)

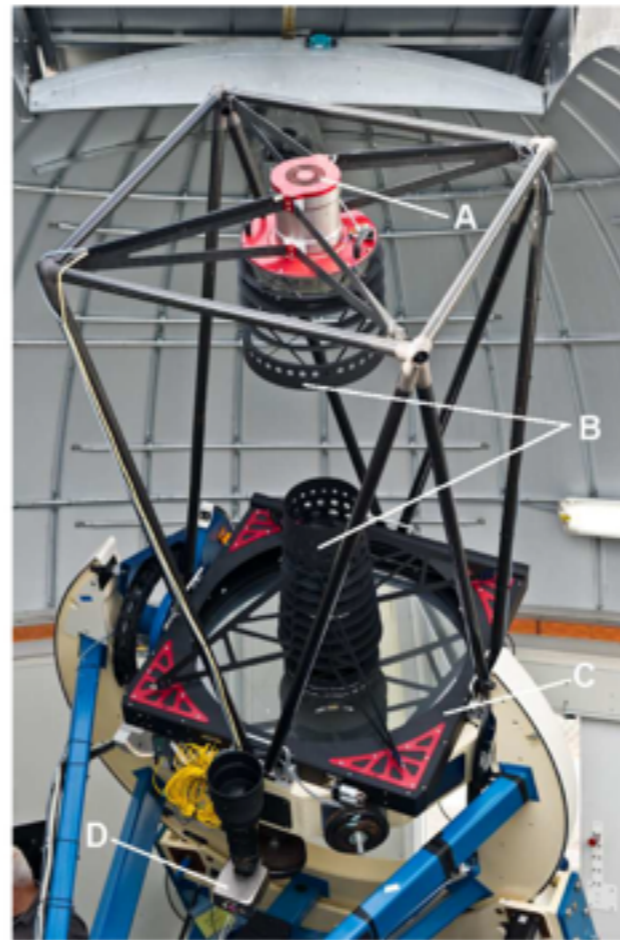


Fig. 2.— 1m telescope, assembled in dome. (A) Secondary mirror tip-tilt-focus mechanism. (B) Lightweight, low-wind-resistance light baffles. (C) Roller-shade primary mirror cover, with integral Hartmann mask. (D) Wide-field Extinction Camera. Photo: Matt Miller, HazardousTaste.com

9 x 1m telescopes

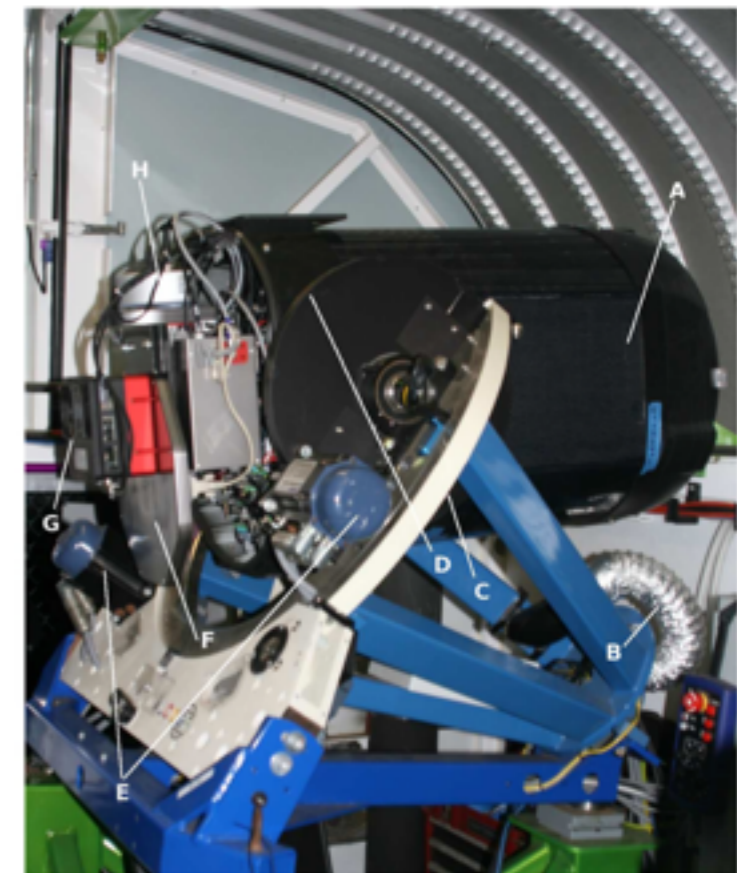


Fig. 3.— 40cm telescope in its Agawan enclosure. (A) Carbon-epoxy telescope tube. (B) Duct for optics tube ventilation. (C) Polar axis bearing, with white fabric dirt guard. (D) Declination axis drive ring. (E) Direct-drive servo motors for RA (left) and Declination (right) axes. (F) 8-position filter wheel for main science camera. (G) SBIG STX-6303 main science CCD camera. (H) Andor Luca R LHSP EMCCD camera.

0.4m telescopes
(2014 ?)



Instruments

- MEROPE

2k x 2k 4.7 FOV 0.13"/pix

- SPECTRAL

4k x 4k 10.5FOV 0.153"/pix

- FLOYDS

low resolution spectrograph

- LIHSP

Lucky Imaging and High Speed Photocom

- SBIG

4k x 4k

16' x 16'

0.232"/pix

u'g'r'i'z', Y, w,

UBVRI (+H α , Jan.)

- SINISTRO (2014)

4k x 4k

26' x 26' FOV

0.389"/pix

- NRES (2015)

Network of Robotic

Echelle Spectrographs

SciCam

1m telescopes

- SCICAM

3k x 2k

29.7' x 19.8' FOV

0.58"/pix

- LIHSP

Lucky Imaging and High Speed Photocom

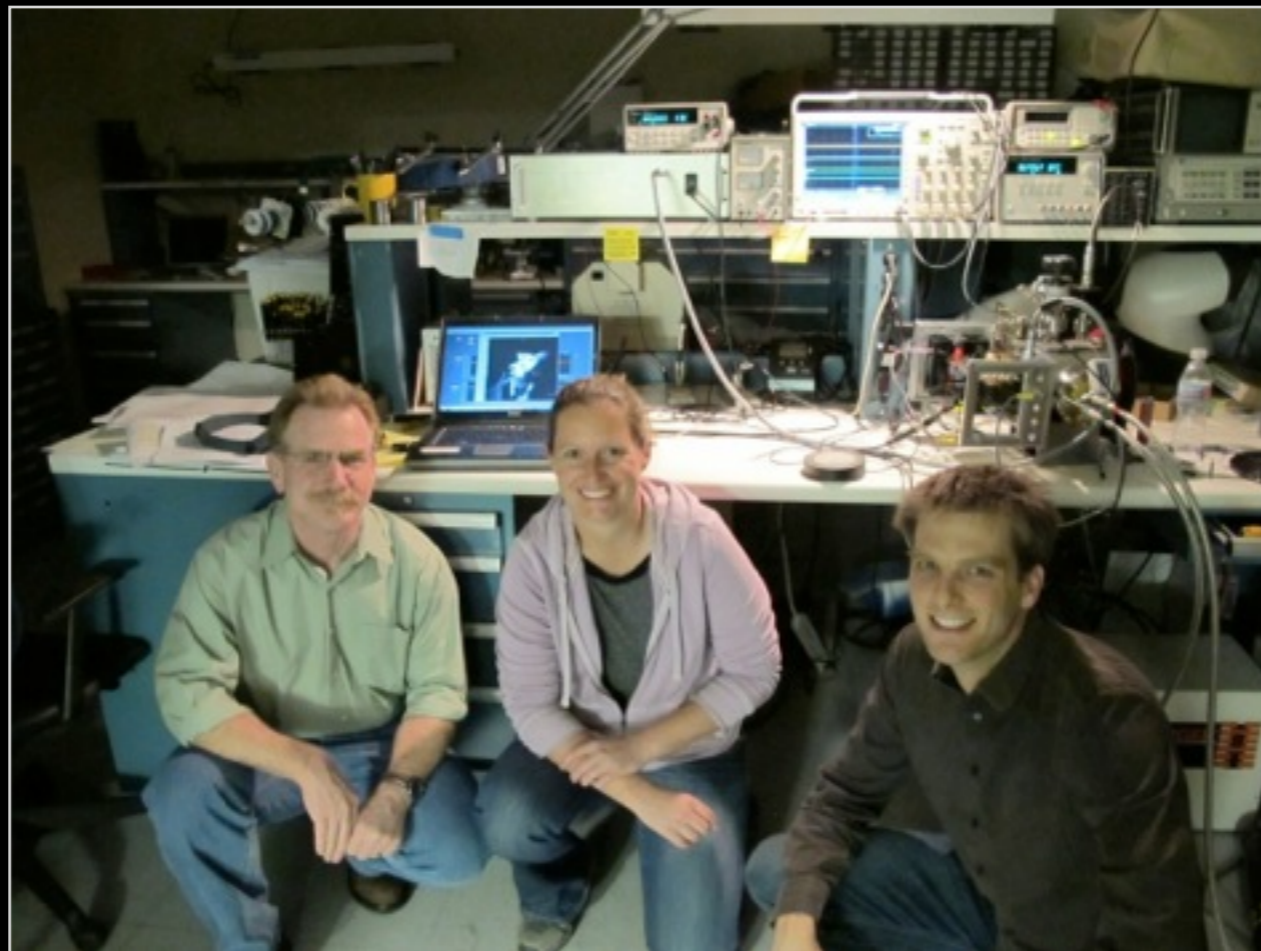
0.4m telescopes

FTN & FTS (2m)



Further Future Instrument for the 1m Telescopes

chip size	4k x 4k
platescale	0.389 arcsec/pixel
field of view	26' x 26'
filters	u'g'r'i'z', Y, w, UBVRI, H α
autoguiding	✓
deployment	Dec. 2013



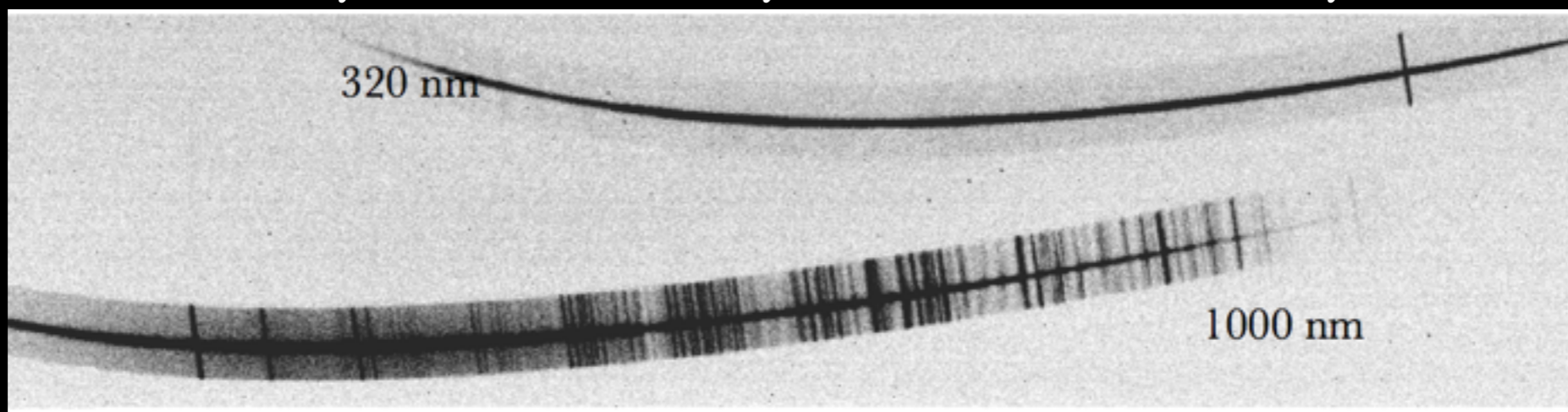
Further Future Instrument for the 1m Telescopes

chip size	4k x 4k
platescale	0.389 arcsec/pixel
field of view	26' x 26'
filters	u'g'r'i'z', Y, w, UBVRI, H α
autoguiding	✓
deployment	Dec. 2013



The Folded Low Order whYte-pupil Double-Dispersed Spectrograph (FLOYDS)

D. Sand, T. Brown, R. Haynes, M. Dubberley, D. Mullins, M. Norbury, E. Hawkins + others



E2V chip; 512 x 2048; 13.5
micron pixels; 1.2x30 arcsec slit

$$R = \lambda / d\lambda$$

R-420 at 350nm (2nd order)

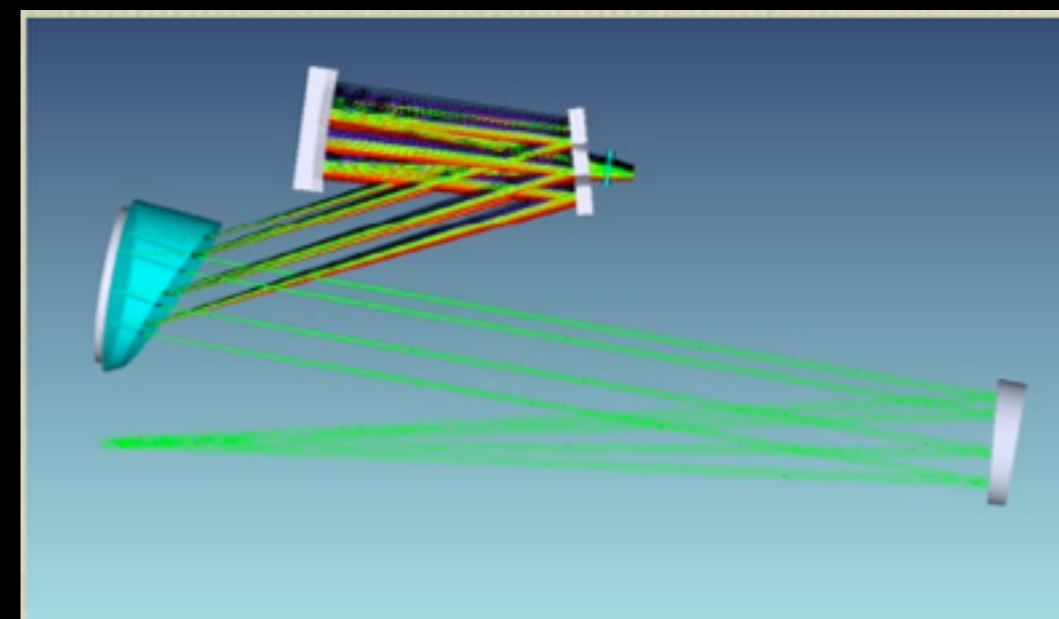
R-690 at 570nm (2nd order)

R-315 at 520 nm (1st order)

R-540 at 900 nm (1st order)

-Slits are site dependent, but 0.9 - 6.0 arcsec

-Calibration unit sits in adjacent room; pneumatic
arm with optics delivers F/10 beam into
spectrograph



Double-pass prism and reflective
grating to get wide range in one shot



FLOYDS robotic low resolution spectrographs

Designed for supernovae

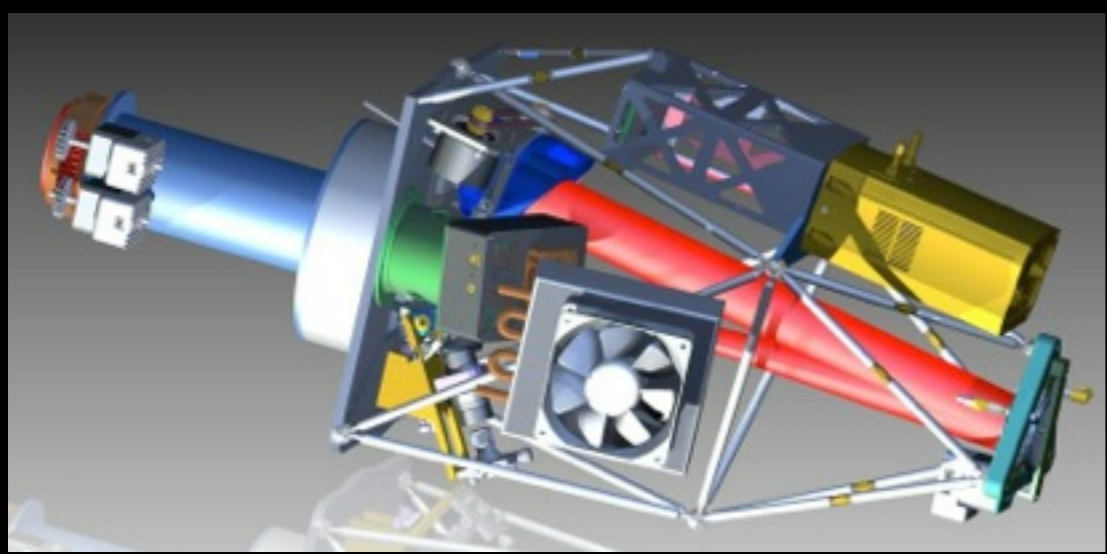
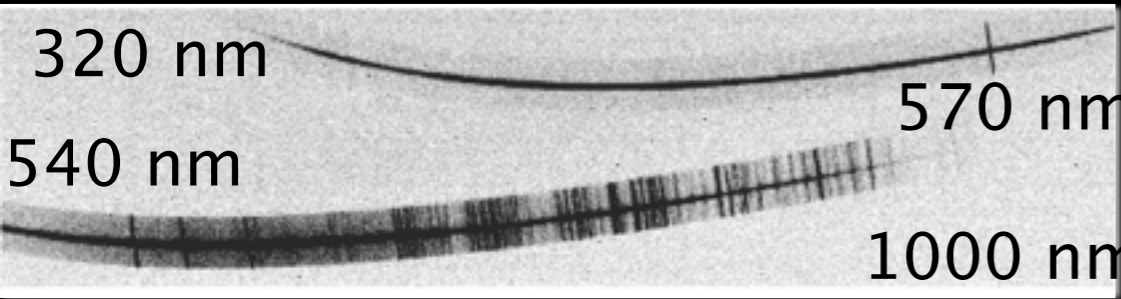
R~400 covering 325nm -- 1000nm in one pointing (cross dispersed).

Can go down to V~20 mag with S/N=10 in 1 hour

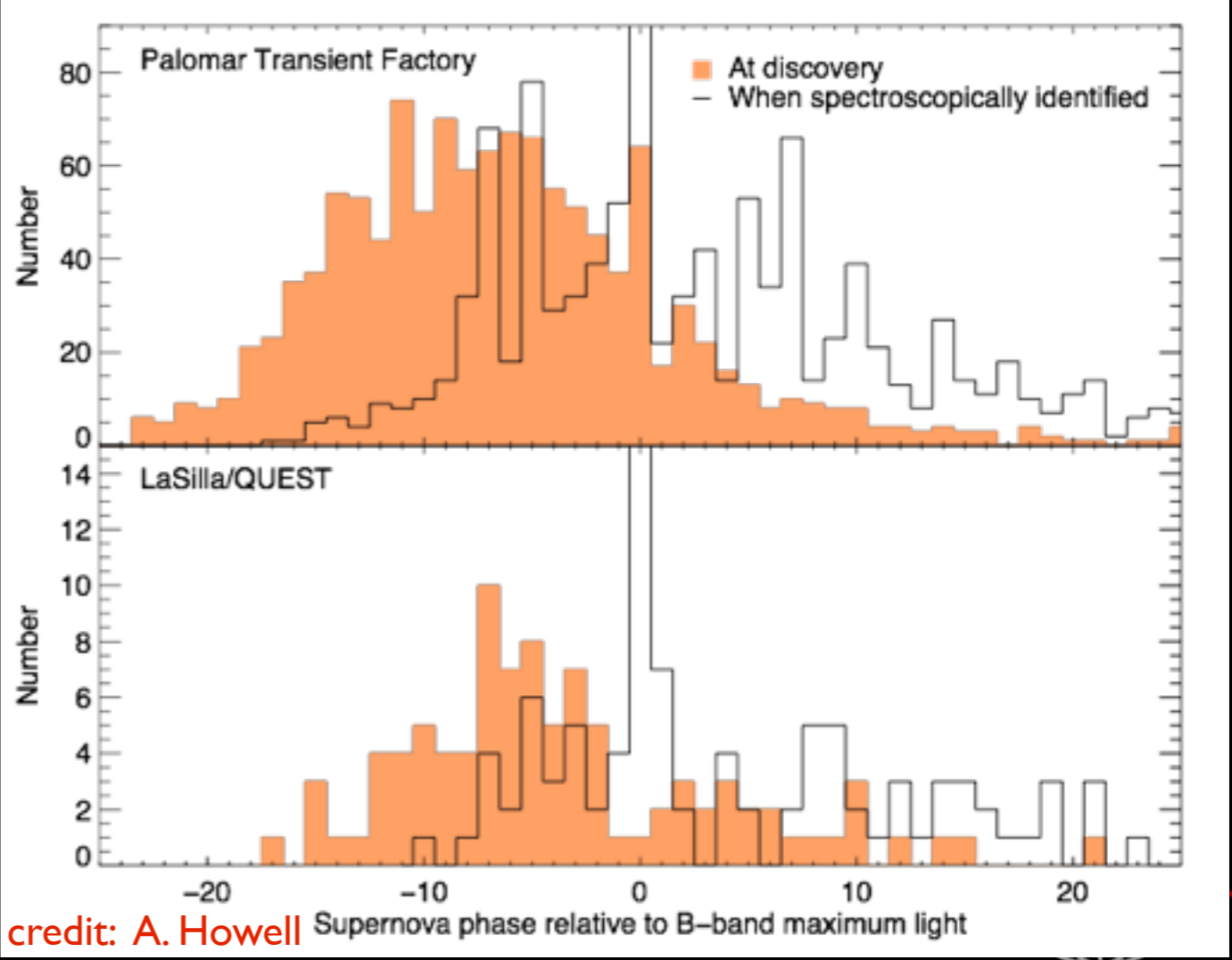


One on each 2m: Faulkes North and South

Spectrographs are in regular nightly operation. Pipeline reduces data, types SN 45s after readout.

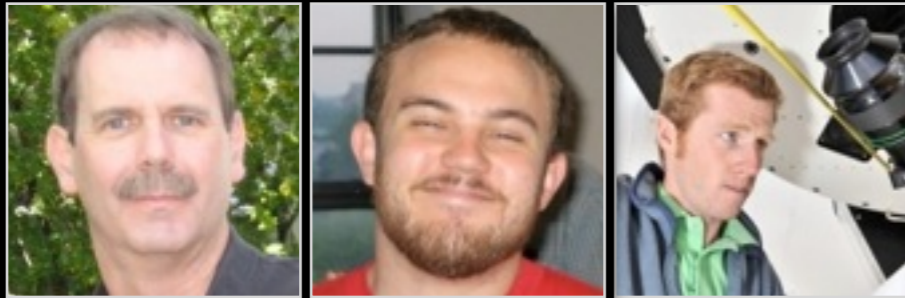


Built by Dave Sand and engineers at LCOGT

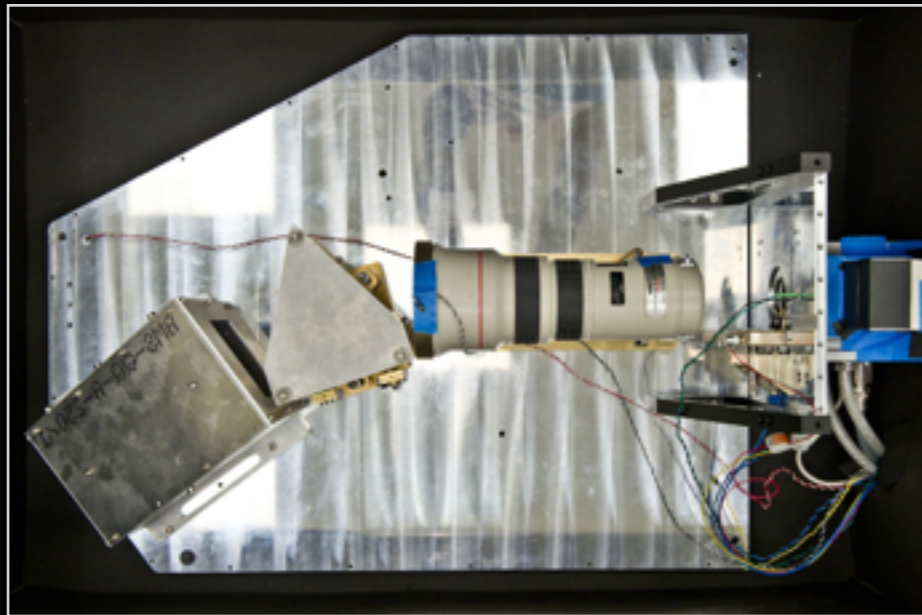


credit: A. Howell Supernova phase relative to B-band maximum light

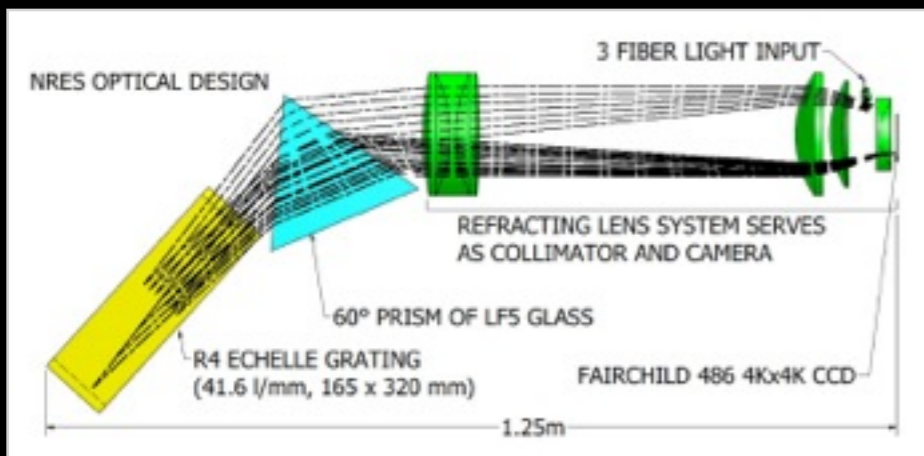
Further Future Instrument for the 1m Telescopes



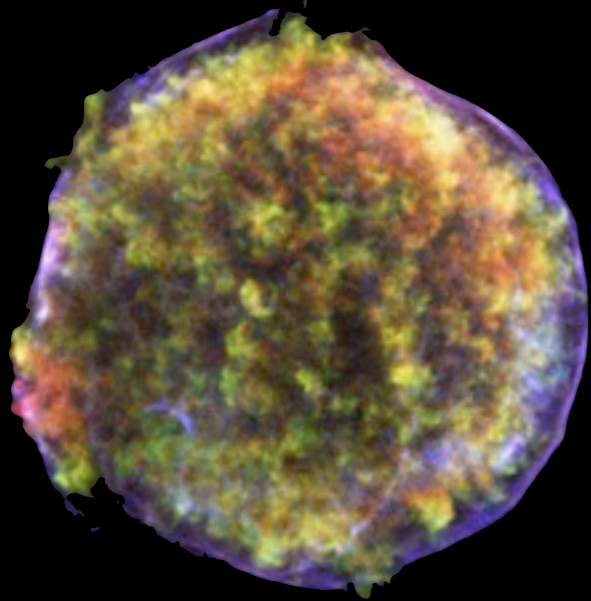
Network of Robotic Echelle Spectrographs (NRES)
Tim Brown, Jason Eastman, John Hygelund
Expect first light in 2014.



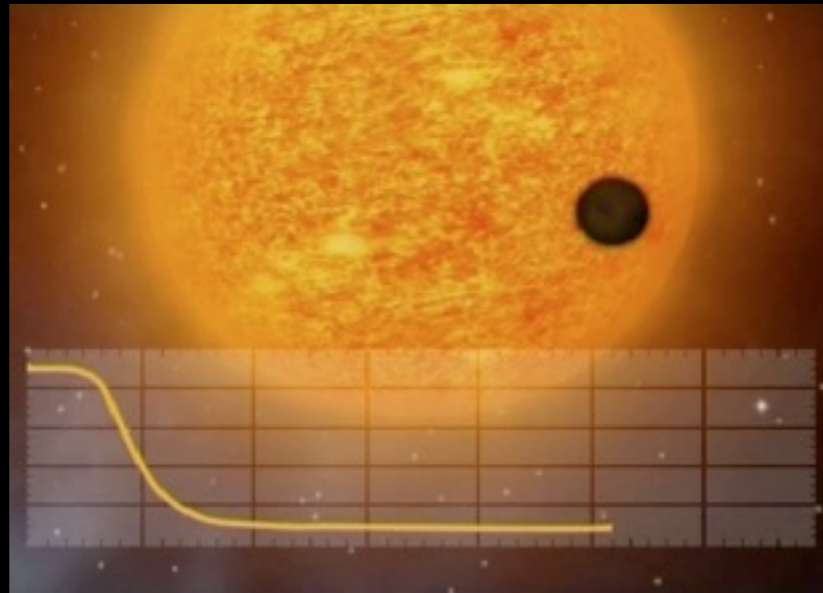
- six identical high-resolution ($R \sim 53,000$), precise (≤ 3 m/s), optical (380-860 nm) echelle spectrographs
- fiber-fed (2.58" per fiber width) simultaneously by two 1 meter telescopes and a ThAr calibration source
- NRES will roughly double the radial velocity planet-vetting capacity nationwide and achieve accuracy better than 3 m/s in reasonable exposure times for stars brighter than $V=12$ (NSF grant of 1 million to develop)
- prototype is being tested at the Sedgwick 0.8m



Science @ LCOGT



Supernovae /
Dark Energy



Extrasolar
planets



Solar system objects

Time variable objects: GRBs,
microlensing, stellar oscillations,
solar system objects, variable stars,
binaries, AGN...



how to use the network ?

- ~ 10 in-house scientists, including postdocs
- 12 collaborating institutions
- buying time
- 2014A semester: 1000 hours usable time per telescope

3 Key projects (3 years)

- The next-generation sample of supernovae (1m = 1030h, 2m = 250h)
- Echo Mapping of AGN Accretion Flows
- Transiting Exoplanet Characterisation (TECH) Key Project

AURA, IFA, ANU, SAAO, U. Texas, St. Andrews U
Colorado University, IPAC, UCSB,
Teide Observatory, Xinjiang Observatory, LCOGT

Site partners

Collaborator

User portal



Observatory

[Home](#) [Requests](#) [Proposals](#) [Feedback](#) [Help](#)

Proposal: The next-generation sample of supernovae

Description: In the study of supernovae, we are leaving the serendipity era, when we had to learn from what nature provided by chance, and entering the database-driven era, when we can ask questions by comparing statistically significant groups of supernovae. This project will obtain light curves and spectra of 100 Type Ia and 100 core-collapse supernovae per year over three years. We will start light curves and spectroscopy within hours of discovery, and focus on those SNe caught soon after explosion. The goals are fivefold: (1) observe supernovae soon after explosion to search for signs of their progenitors, (2) obtain a large homogeneous sample of supernovae for next generation cosmological studies, (3) obtain a large sample of supernovae for statistical studies comparing groups that are split into different populations, (4) obtain some of the first large samples of the recently discovered classes of rare and exotic explosions, (5) obtain the optical light curves and spectroscopy in support of studies at other wavelengths and using other facilities including UV observations, IR imaging and spectroscopy, host galaxy studies, high resolution spectroscopy, and late-time spectroscopy with large telescopes.

1m0 Time Used/Allocated: 133.67 of 1030.00 hrs

2m0 Time Used/Allocated: 42.34 of 250.00 hrs

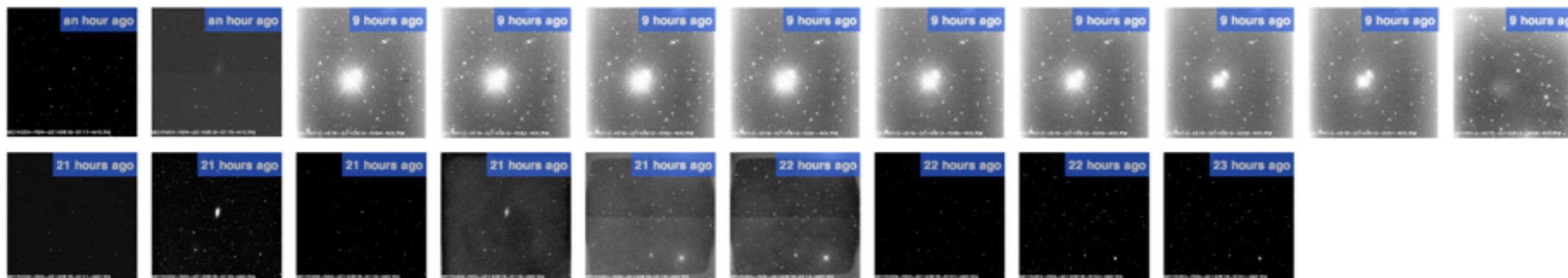
Members: [Andy Howell](#), [Melissa Graham](#), [Charlie Baltay](#), [Emma Walker](#), [David Sand](#), [Stefano Valenti](#), [Abiy Tekola](#), [Iair Arcavi](#), [Eli Kasai](#), [Fang Yuan](#)

Archive Links: [Images](#) | [Photometry](#)

Links

- [Observing Summary](#)
- [Compose Request](#)

Latest observations



Visibility tool

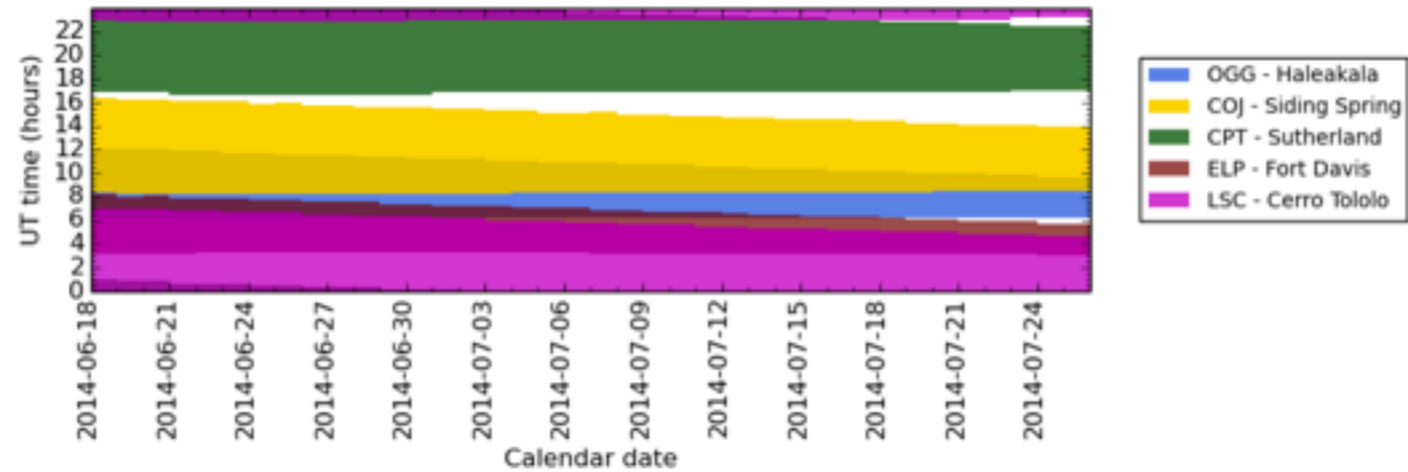
Target coordinates

RA and Dec may be entered as a float value (nn.nnn) or hours, minutes, seconds (hh:mm:ss.ss).

Right ascension Declination Maximum airmass

Seasonal visibility

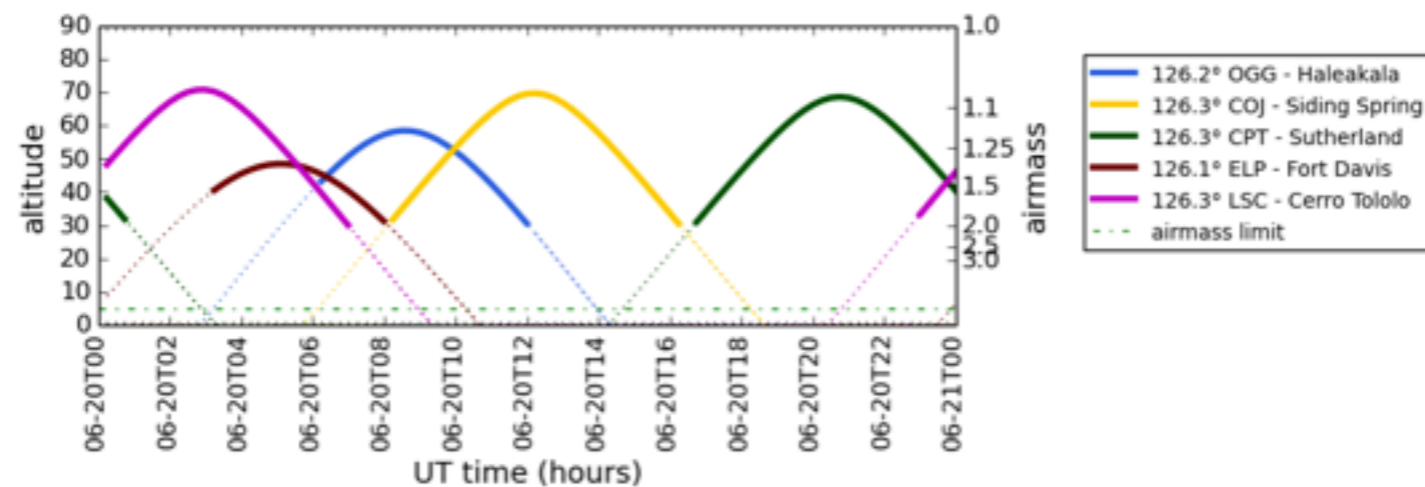
Start date End date



Daily visibility

Target date

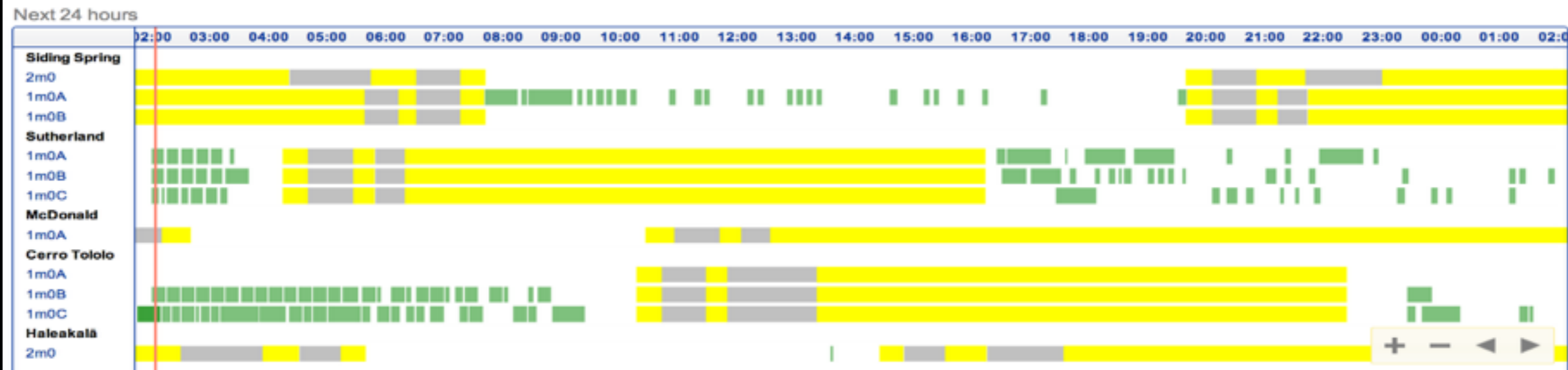
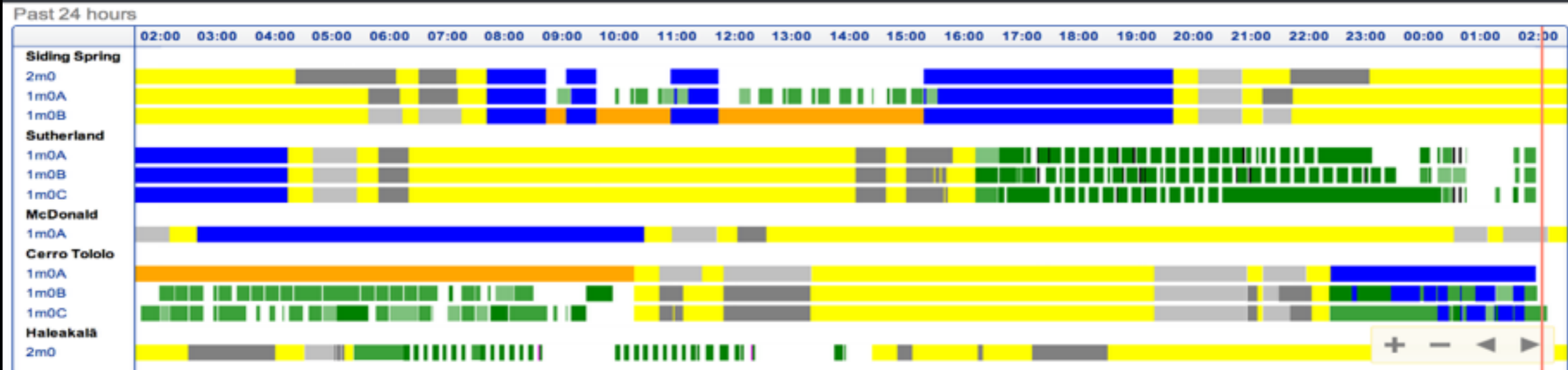
Solid lines represent the visibility window; dotted lines represent daytime or hour angle > 4.6. The angle in the legend is the average moon-target distance during the selected night.



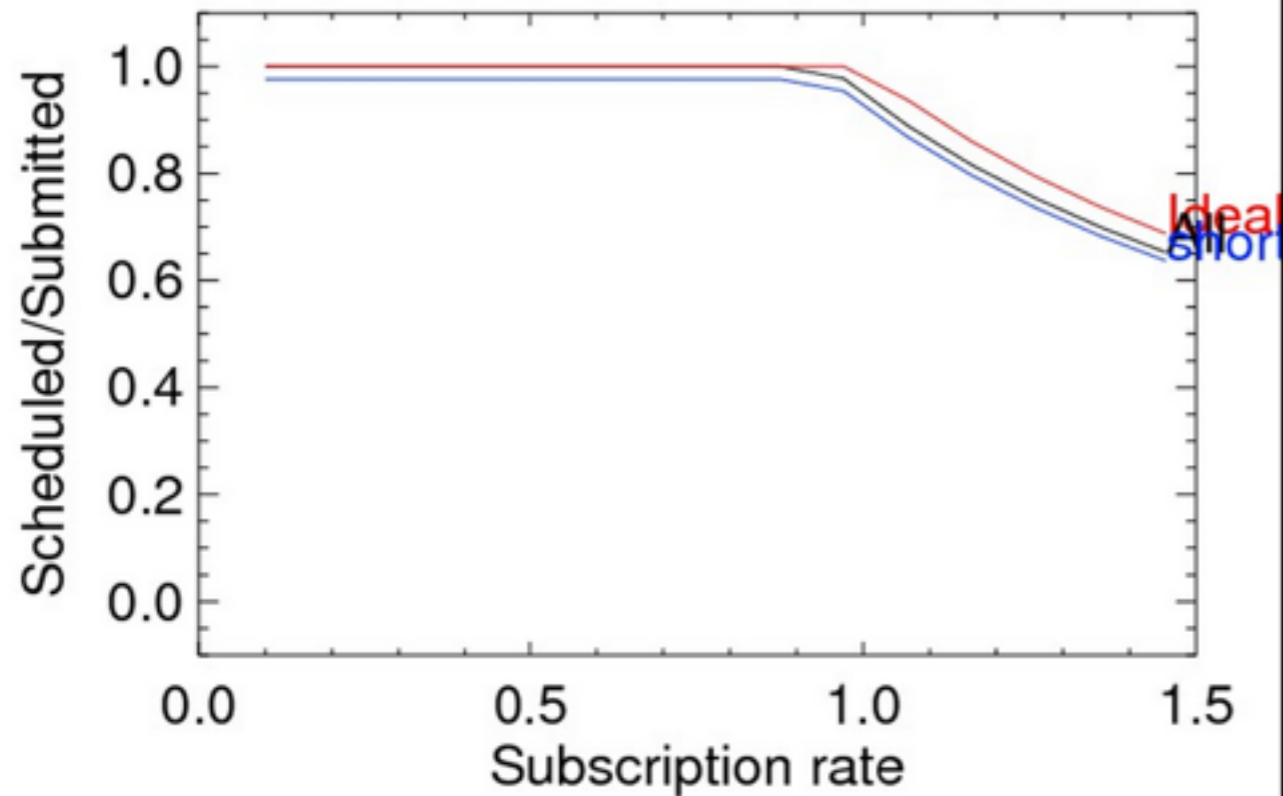
Scheduler

Las Cumbres Observatory Global Telescope Network

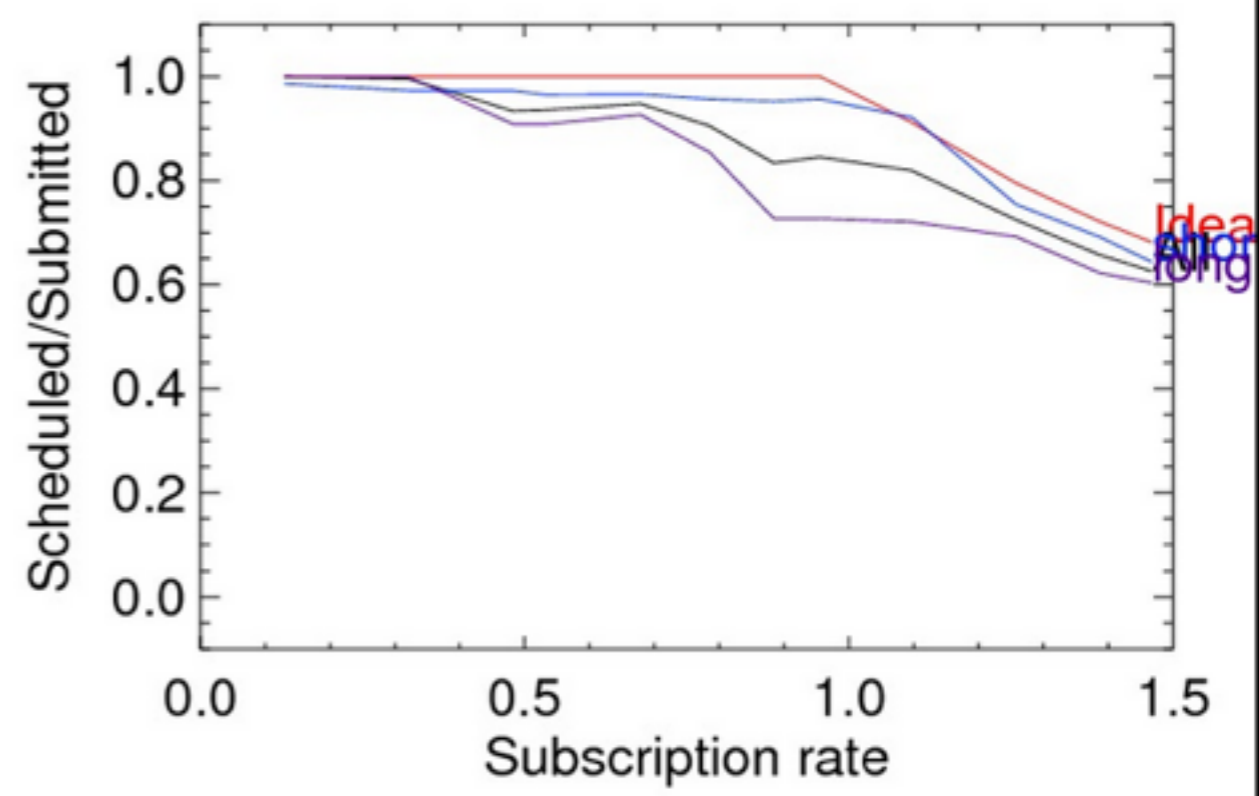
Stefano V | Logout



Scheduler



Blocks that not overlap



Real case



Data

LCOGT | Home | User's Guide | API Interface | Helpdesk

User: anonymous
Log In

Holdings

The archive currently holds 701538 images and 1429236403 extracted source measurements.

LCOGT Links

- Home Page
- Telescope Network
- Science

Archive Links

- Account Management
- My Proposal ID List
- Login Instructions
- User's Guide
- API Interface

Archive Ingest Statistics

Clone this page to your phone:



The LCOGT Archive is the repository for all image and photometric measurements made by the Las Cumbres Observatory Global Telescope Network.

Sky Region

Position
(347.4927 18.3960 | 23h09m58.2s +18d23m45.9s | WASP 21)

Radius
(arcsec)

Facility

Sites
Cerro Tololo (lsc)
Haleakala (ogg)
McDonald (elp)

Telescope

Filter

Date Range

Start

End

Proposal

ID
(W35bTransit WaspTransit)

Photometry Images

Search Archive

<http://lcogtarchive.ipac.caltech.edu/>

Science @ LCOGT

Faculty/Staff
Andy Howell



Postdocs
Stefano Valenti
Iair Arcavi



Students
Griffin Hosseinzadeh



Collaborations

Palomar Transient Factory

Pan-STARRS1

La Silla / Quest

Supernova Legacy Survey

SDSS-II

MENeaCS

Caltech Core Collapse Project

PESSTO

CSP

Padova SN group



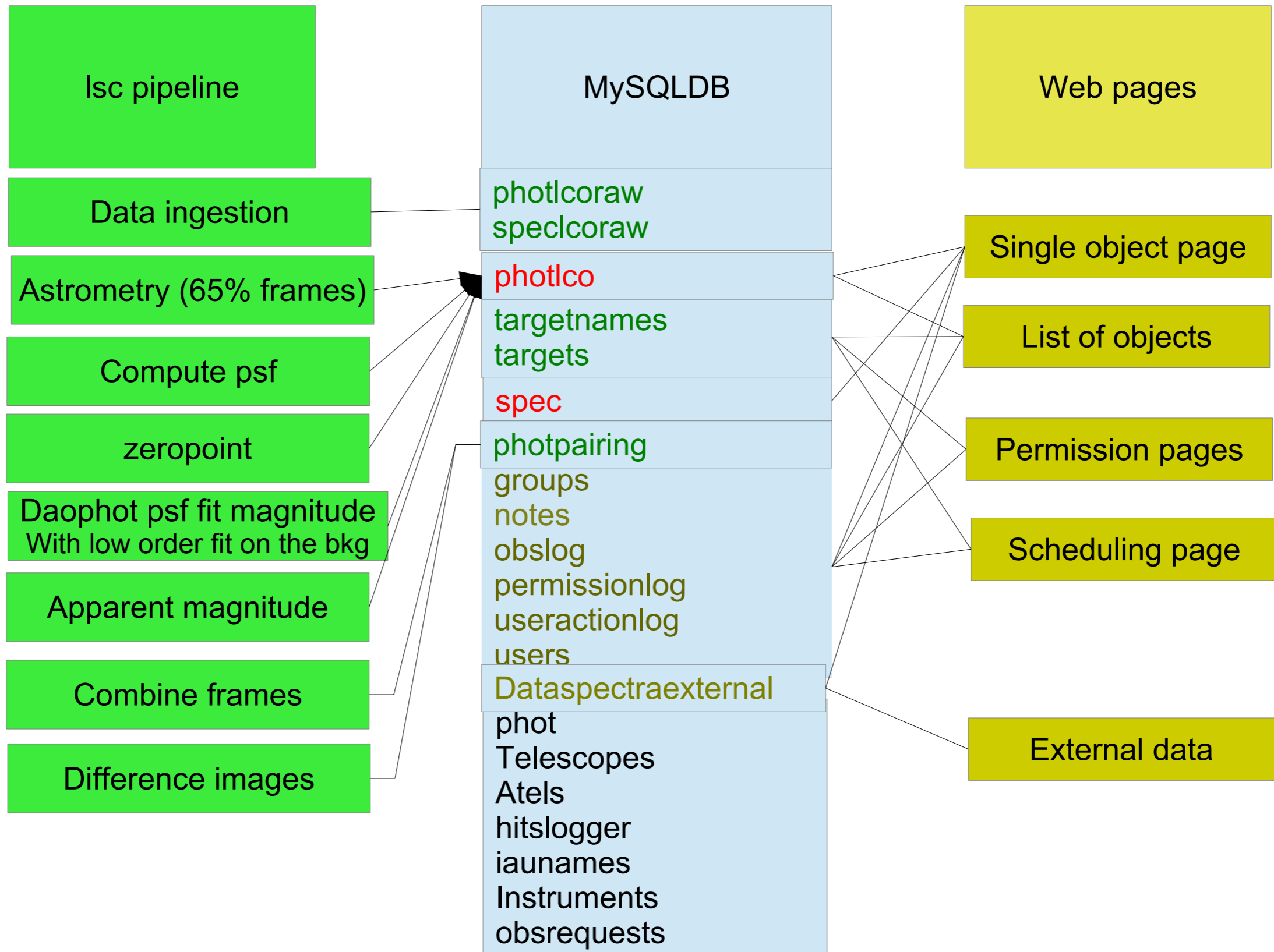
Supernova Key project

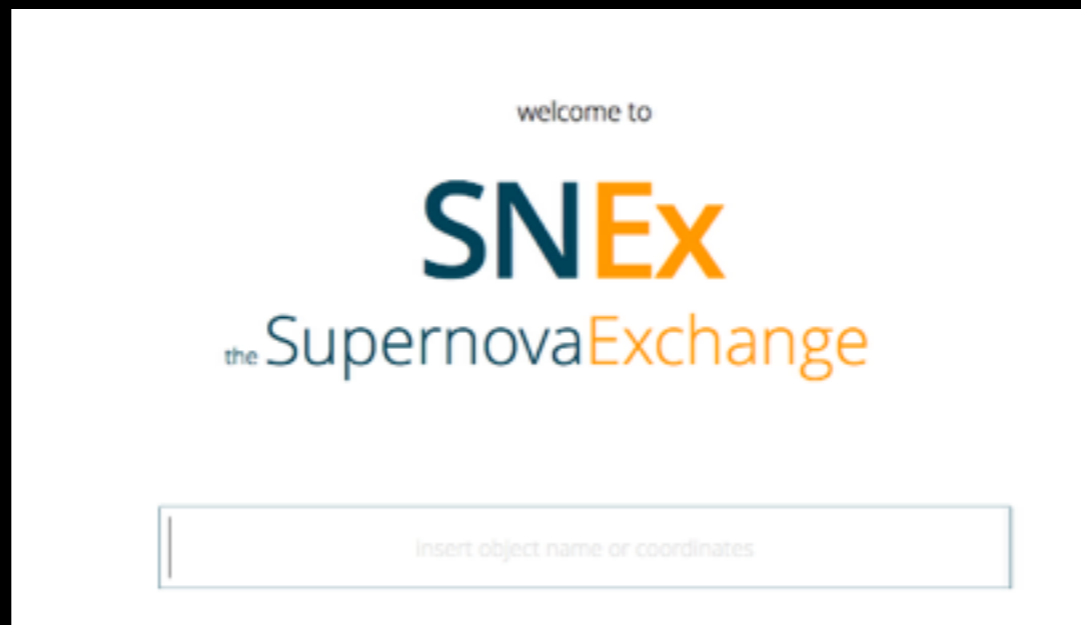
PI: D. Andrew Howell **Co-Is:** Iair Arcavi, Charles Baltay, Bruce Bassett, Yi Cao, Michael Childress, Alexander Conley, Steve Crawford, Nan Ellman, Guojie Feng, Avishay Gal-Yam, Ariel Goobar, Melissa Graham, Eric Hsiao, Eli Kasai, Mansi Kasliwal, Emily Levesque, Roy Maartens, Howie Marion, Ryan McKinnon, Hubiao Niu, Peter Nugent, Eran Ofek, Mark Phillips, Robert Quimby, David Rabinowitz, David Sand, Richard Scalzo, Brian Schmidt, Jeffrey Silverman, Jesper Sollerman, Stephen Smartt, Matthew Smith, Mark Sullivan, Abiy Tekola, Stefano Valenti, Jozsef Vinko, Emma Walker, Lifan Wang, Xiaofeng Wang, J. Craig Wheeler, Fang Yuan

- Demographics:
 - A well-selected sample of core-collapse with good constrain on the explosion
 - Cosmology
- Early SN phase:
 - CC SNe and SNe Ia
- New type of transients:
 - Faint SNe, Super Luminous



Data management





- view objects followup
- trigger observations
- download data
- upload external data



SN2014J SN Ia $z = 0.000677$

09:55:42.14 +69:40:26.0
148.925583 +69.673889



Also known as:
PSN09554214
IPTF14jj

Object Comments

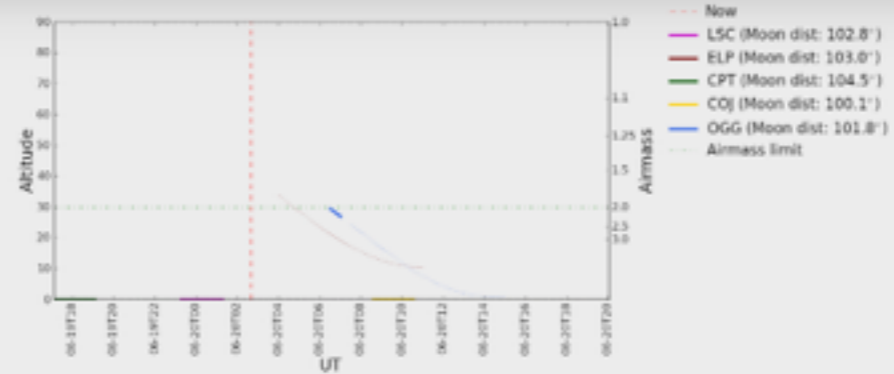
dsand I requested one epoch of imaging (many bands) and one epoch of spectroscopy in the next 6 days.
2014-05-04 00:00:00

Add a comment...

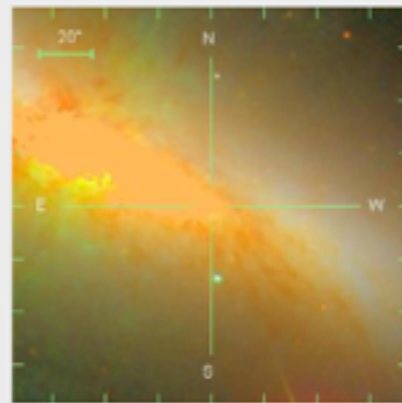
Object visible to:

- ANU
- ASASSN
- CfA
- Chase
- CSP
- ex-LCOGT
- IPTF
- LBNL
- LCOGT
- LSQ
- OKC
- Padova
- PESSTO
- PS1
- PTF
- Public
- QUB
- Skymapper
- UCB
- UT

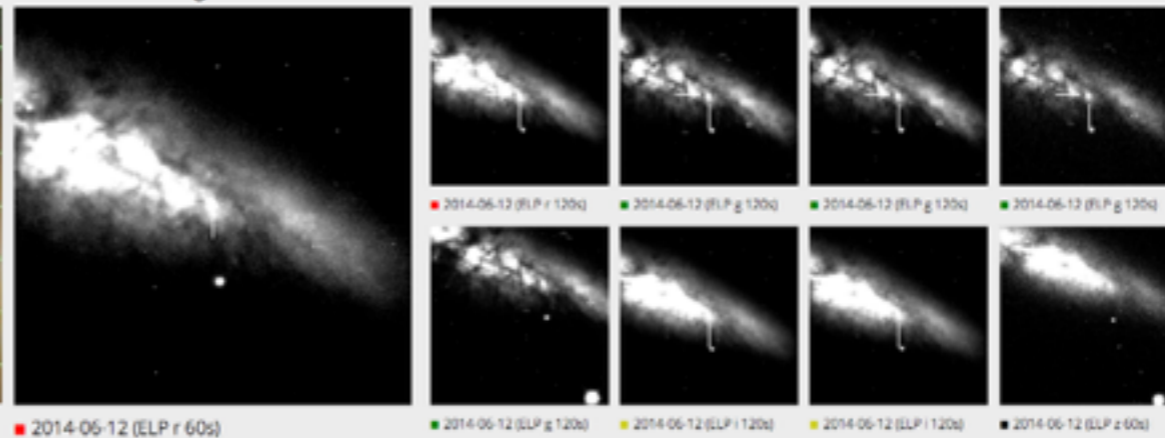
Current Visibility at LCOGT



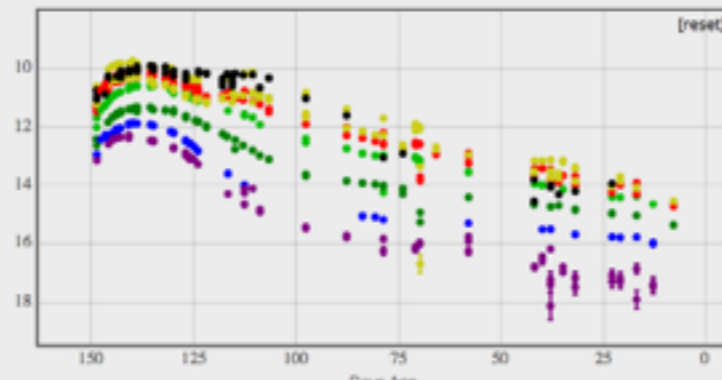
SDSS



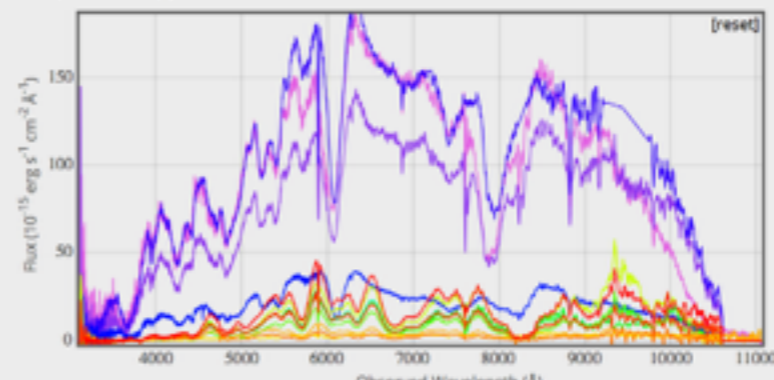
Latest LCOGT Images



Calibrated Photometry Display instrumental photometry



Spectroscopy



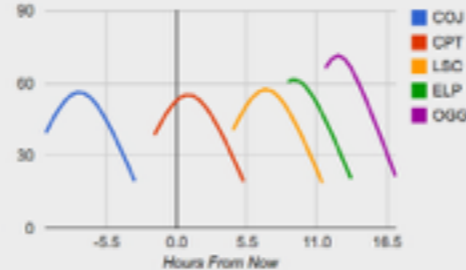
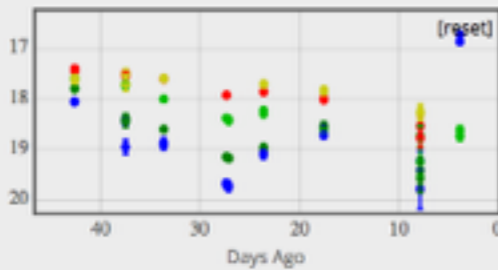
Scheduling

Pending Requests

Target	Type	Cadence	Instrument	Exposures	Start	End	Reminder	Comments
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Expired/Current Reminders

Target	Type	Cadence	Instrument	Exposures	Start	End	Reminder	Comments
IPTF14ans	Phot	3d	Sbig	B 2x300s V 2x200s g 2x300s r 2x200s i 2x200s	2014-05-08 06:43:48 by lair	Ongoing	2014-06-16 00:19:55	

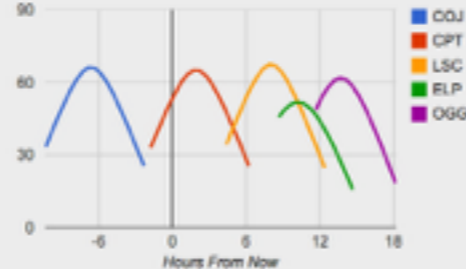
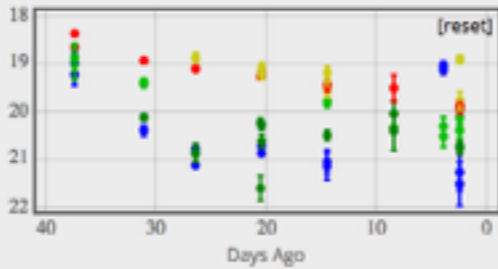


Stop Sequence

Continue Sequence

and display new reminder in days

CSS160715	Phot	3d	Sbig	B 2x300s V 2x200s g 2x300s r 2x200s i 2x200s	2014-05-22 11:37:57 by lair	Ongoing	2014-06-16 00:21:08	lair (2014-05-22 11:37:57): Increasing exposure time
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Stop Sequence

Continue Sequence

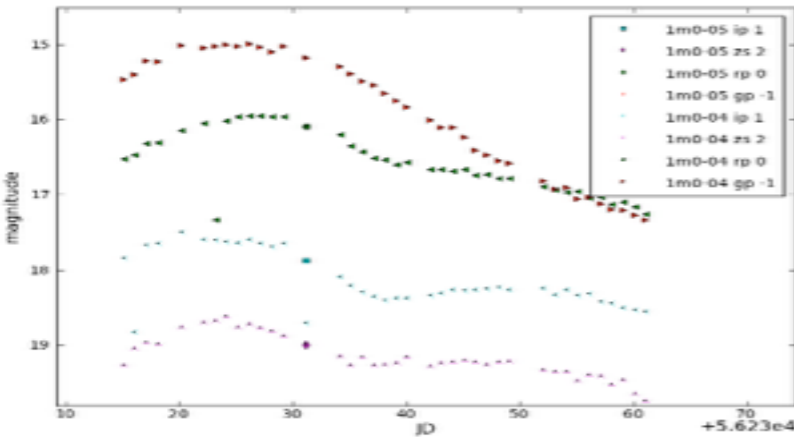
and display new reminder in days

PSN12091154 IPTF14aai	Phot	5d	Sbig	B 2x300s V 2x200s g 2x300s r 2x200s	2014-05-08 06:39:13 by lair	Ongoing	2014-06-16 00:25:58	
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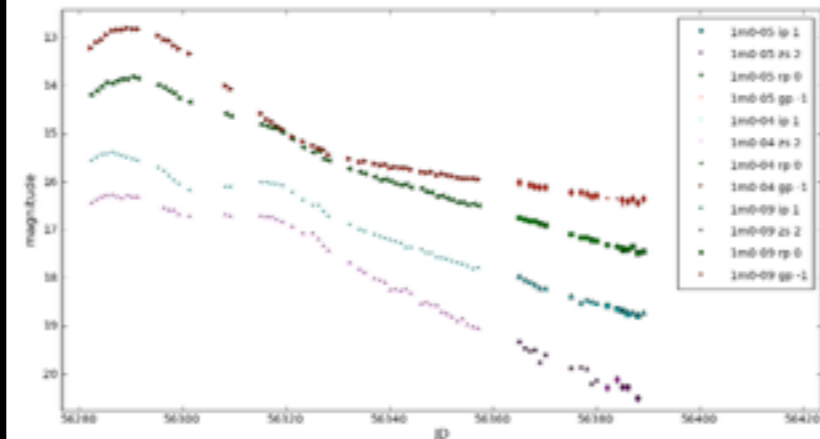


1m telescopes SN data

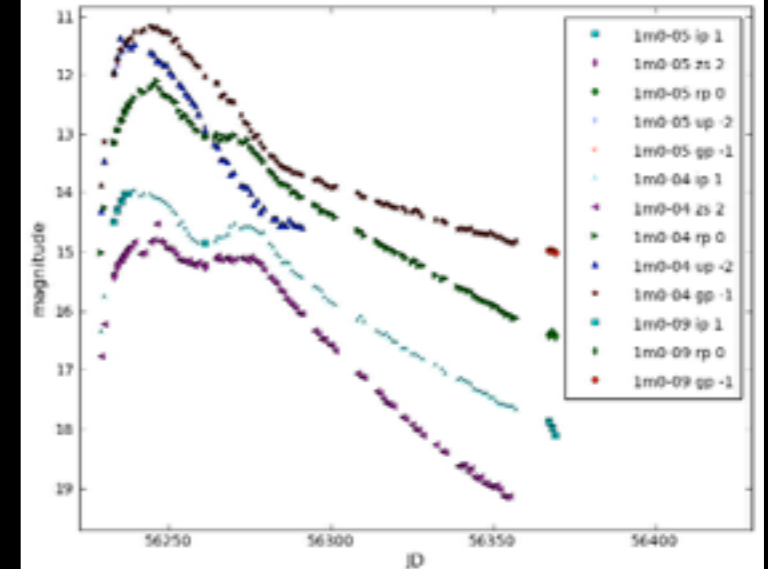
LSQ12gdj



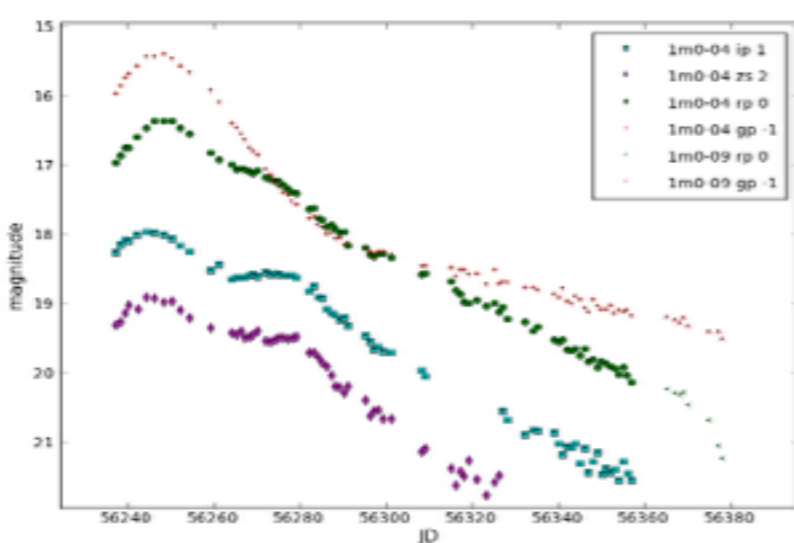
2012hr



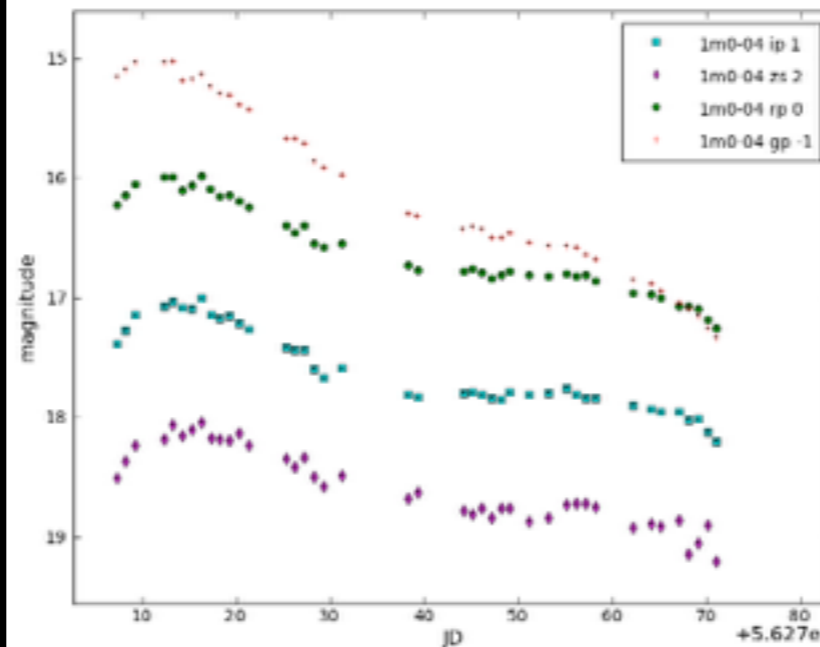
2012fr



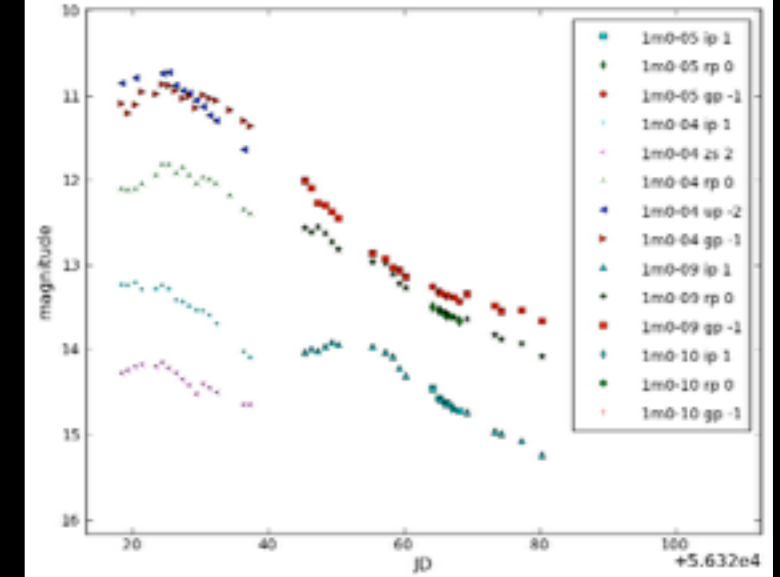
LSQ12fxd



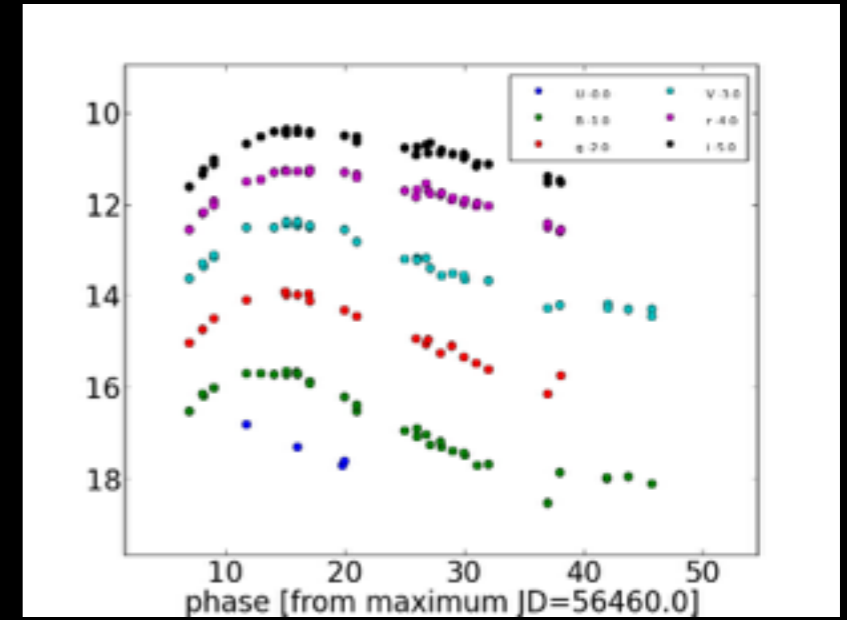
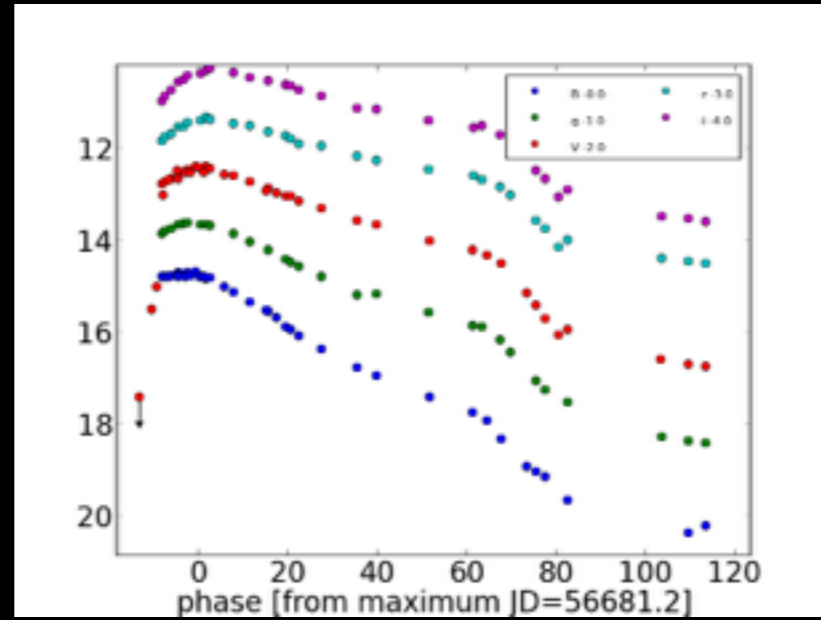
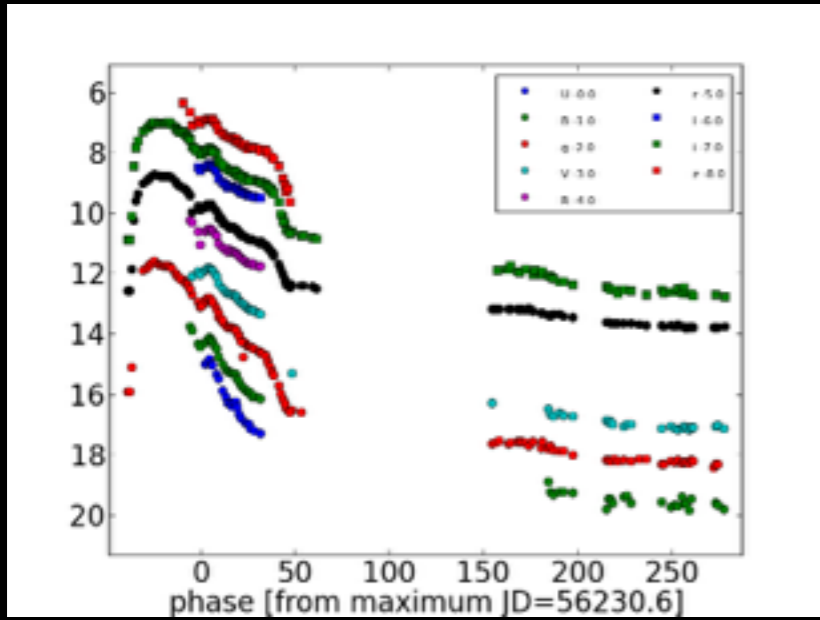
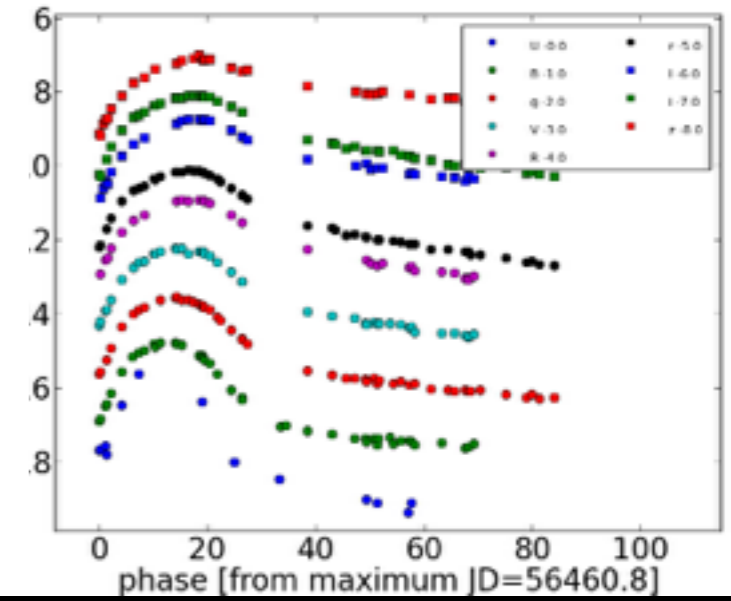
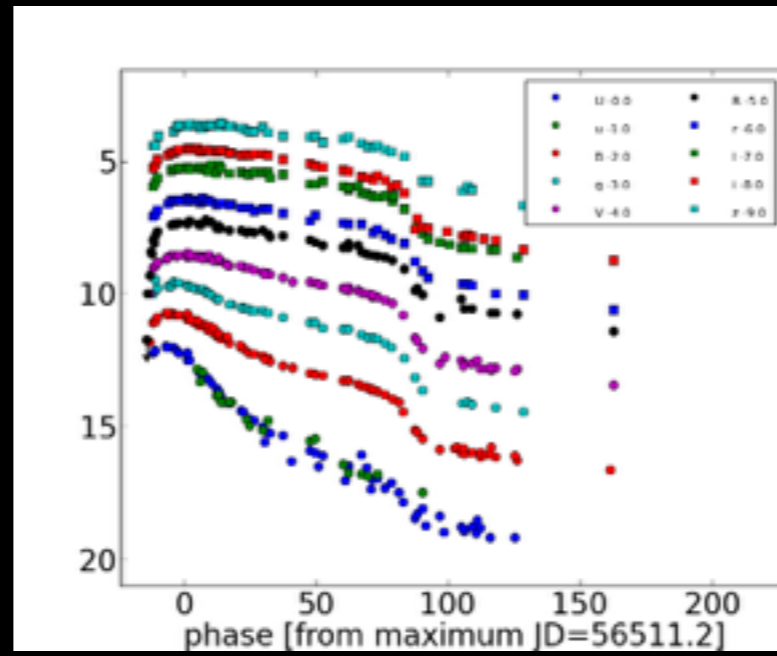
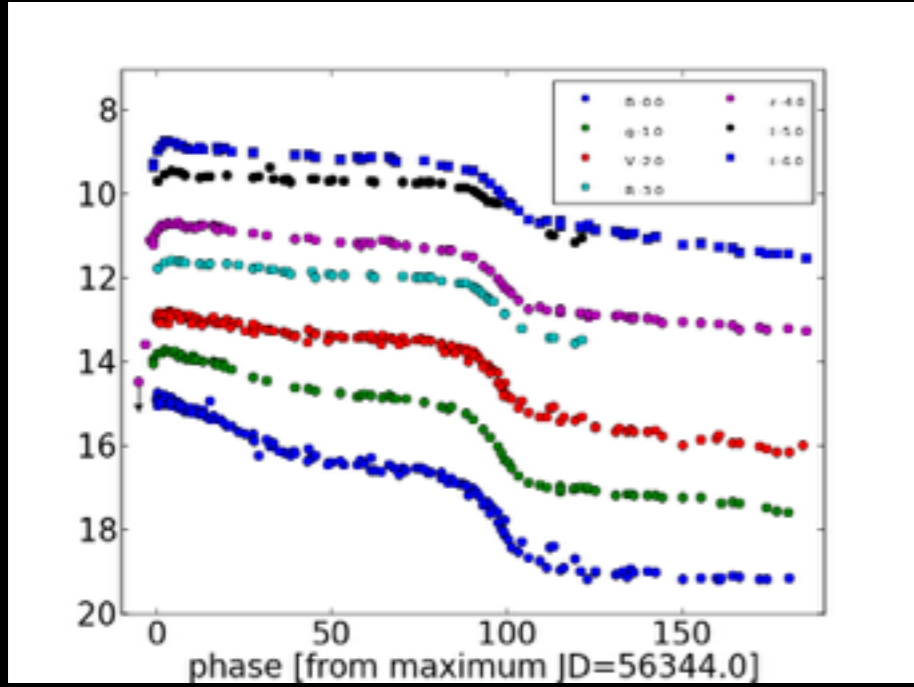
LSQ12hnj



2013aa



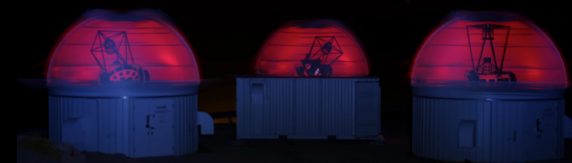
Im telescopes SN data



Ways to use LCOGT

Collaborate with us or a partner institution.

Or buy time: ~25% of the time is for sale.



Calibration

Markov chain Monte Carlo (MCMC) using python package emcee

each frame in BVgri using apass catalog

$$m_{ik} - m_{ck} = a + b * (Ck - Co) + c * (Xk - Xo) + d (Ck - Co)(Xk - Xo)$$

m_{ik} = instrumental mag of star k

m_{ck} = catalog mag of star k

Xk = airmass of star k

Ck = catalog color of star k

Co = average color term (eg 0.6)

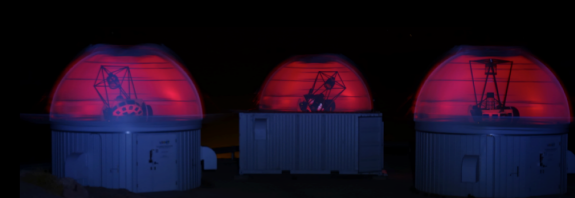
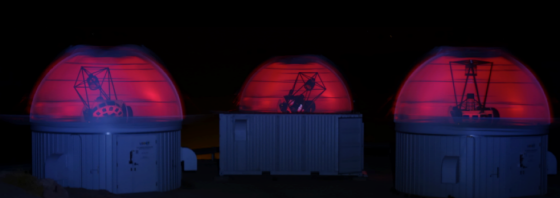
Xo = average airmass (eg 1.3)

a = zeropoint (to be fit)

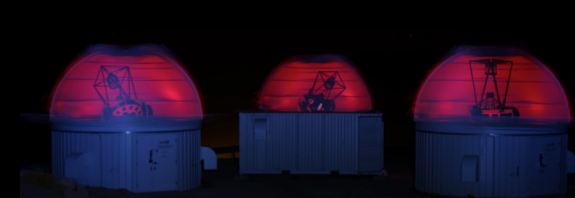
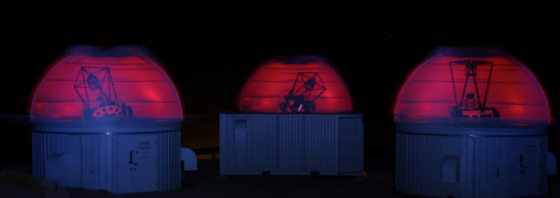
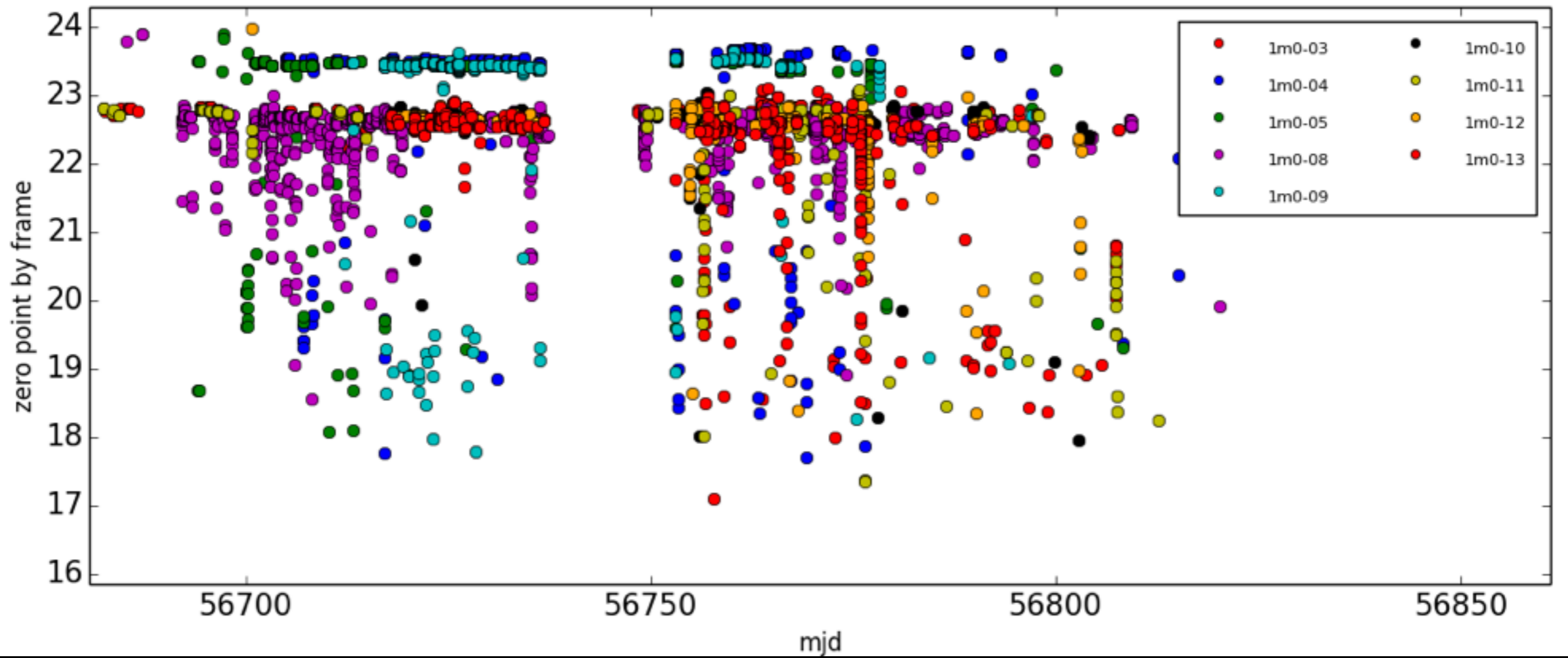
b = color term (to be fit)

c = extinction coeff (to be fit)

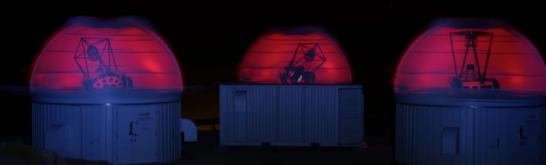
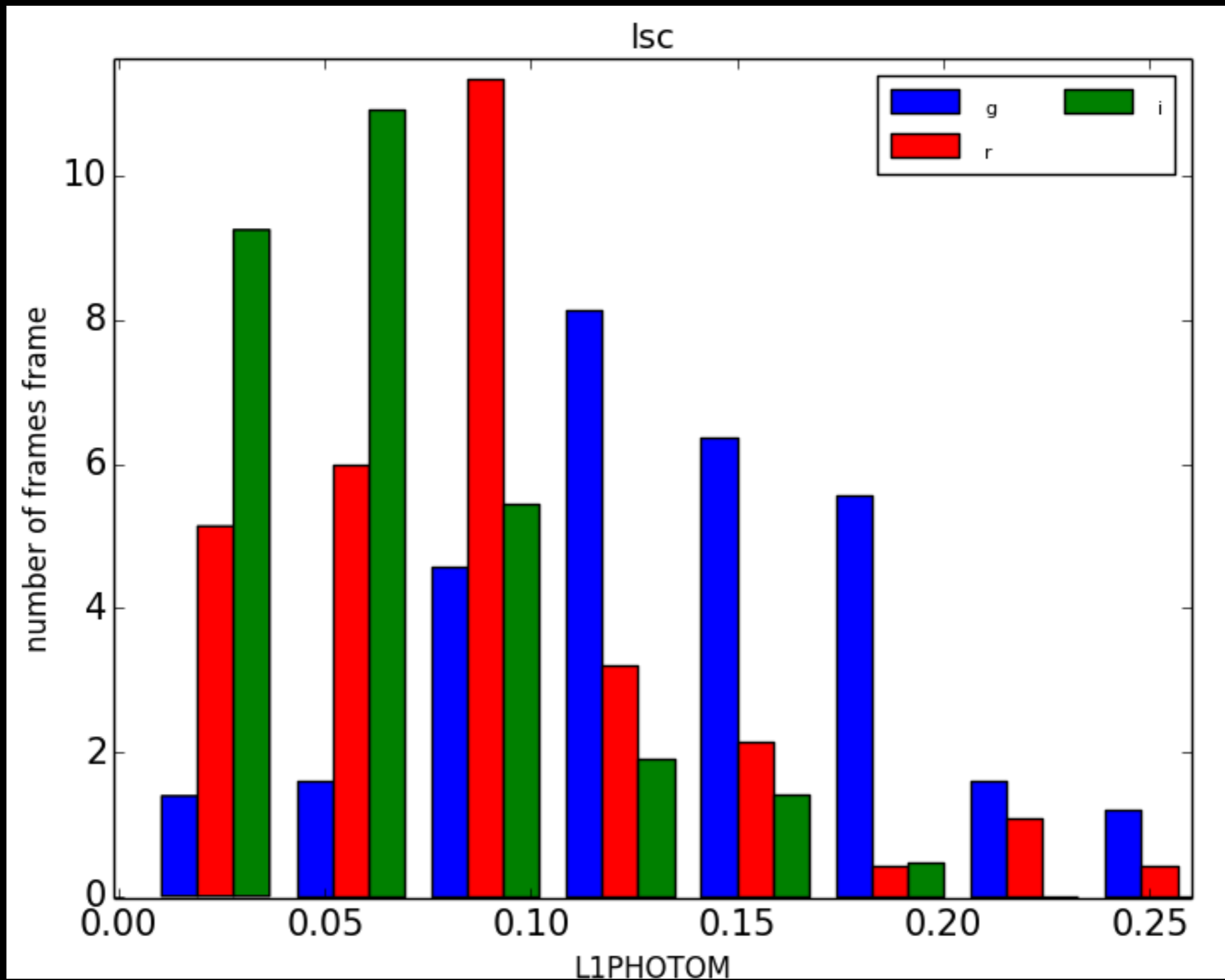
d = coefficient airmass-extinction (to be fit)



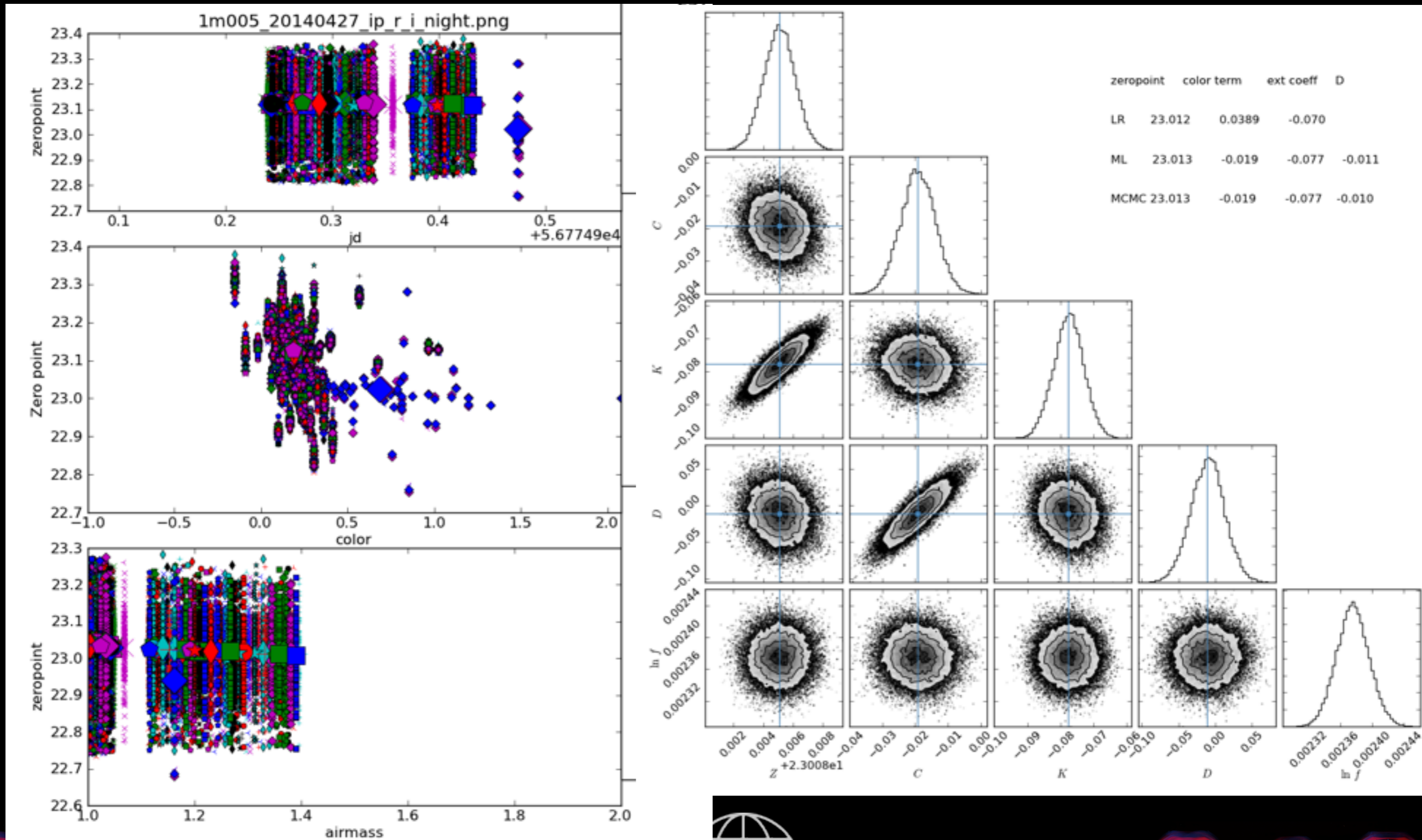
Calibration



Calibration



Calibration

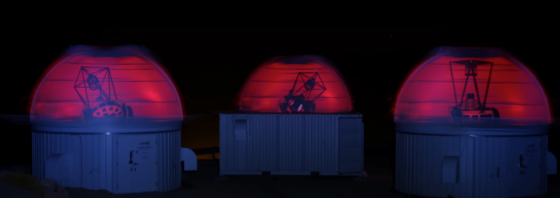
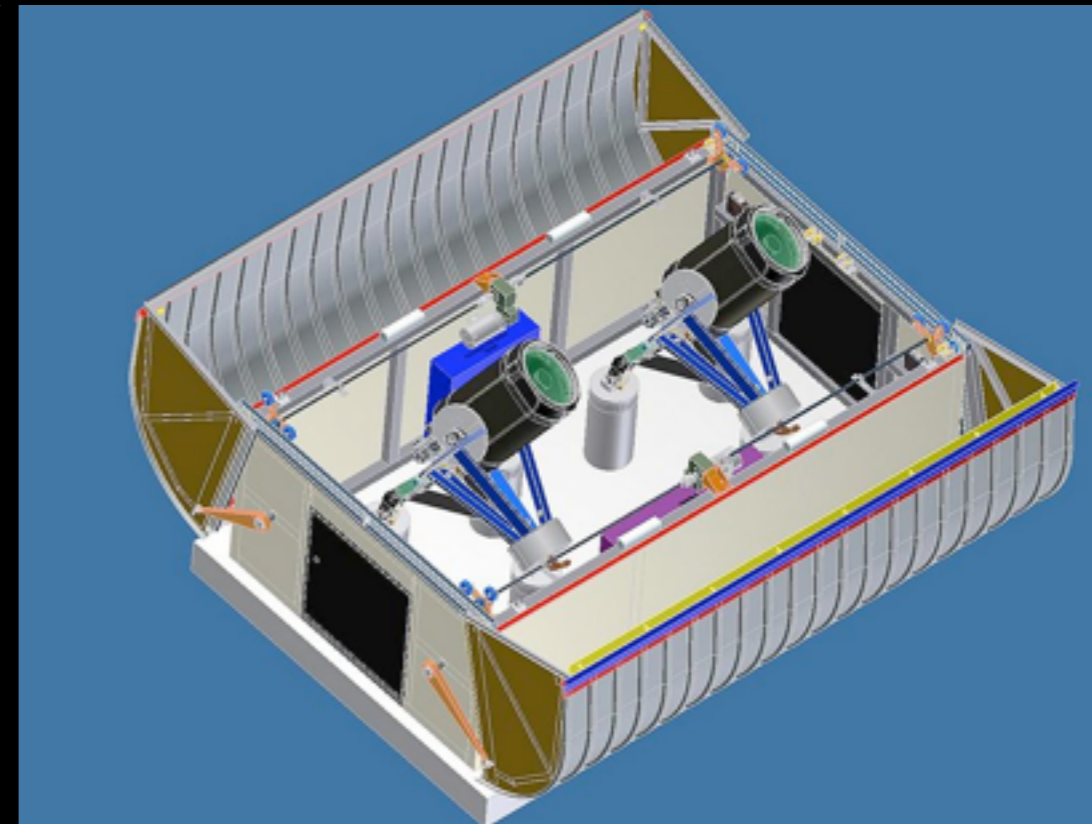


0.4m telescopes

50% science, 50% education

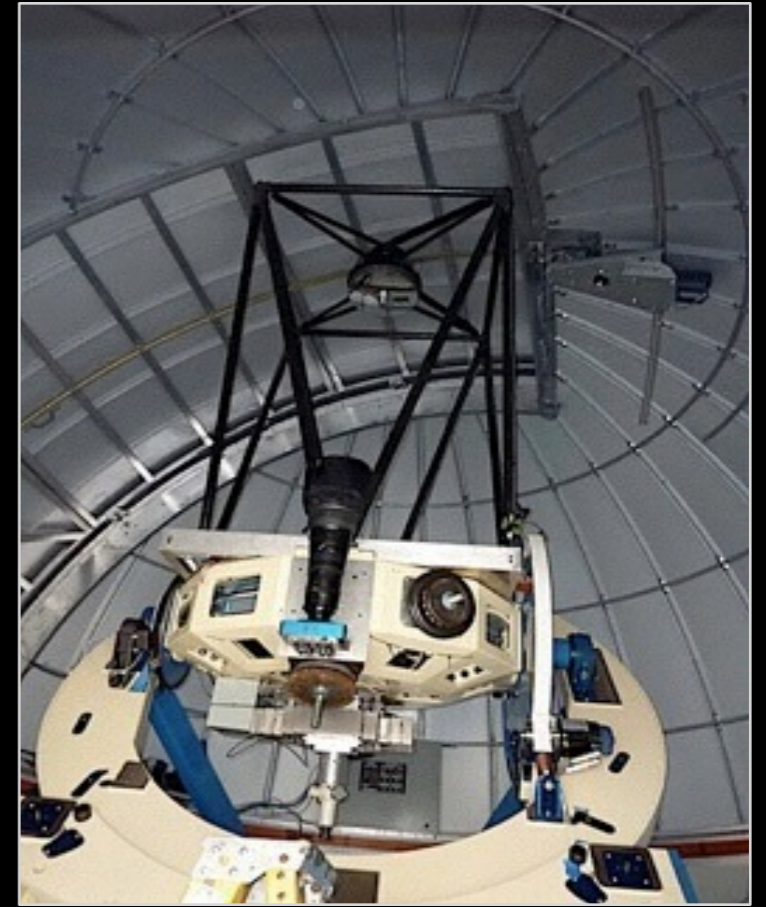
Up to 24 total, deployed in clusters of 2–4 at each site

Hardware built: deployment contingent on funding

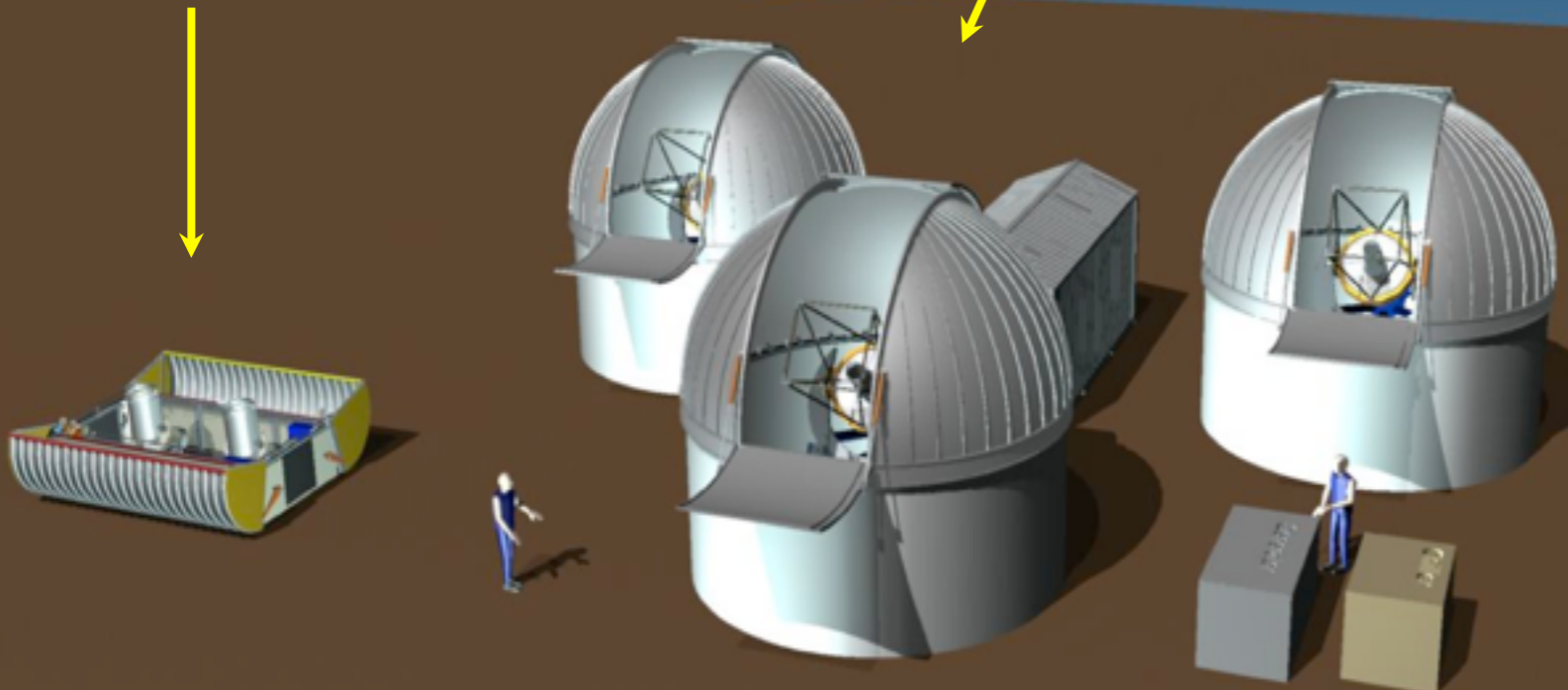


each site

2 - 3
1.0 m telescopes



3 - 4
0.4 m telescopes
Aqawans



“Aqawan” is Chumash for “to be dry”.





*weather
tower*

SSB

*0.4m
Enclosure*

*1.0m
Enclosure*

Storage Container





2 TON MAX

2 TON

DANGER
THIS MACHINE
STARTS AND STOPS
AUTOMATICALLY