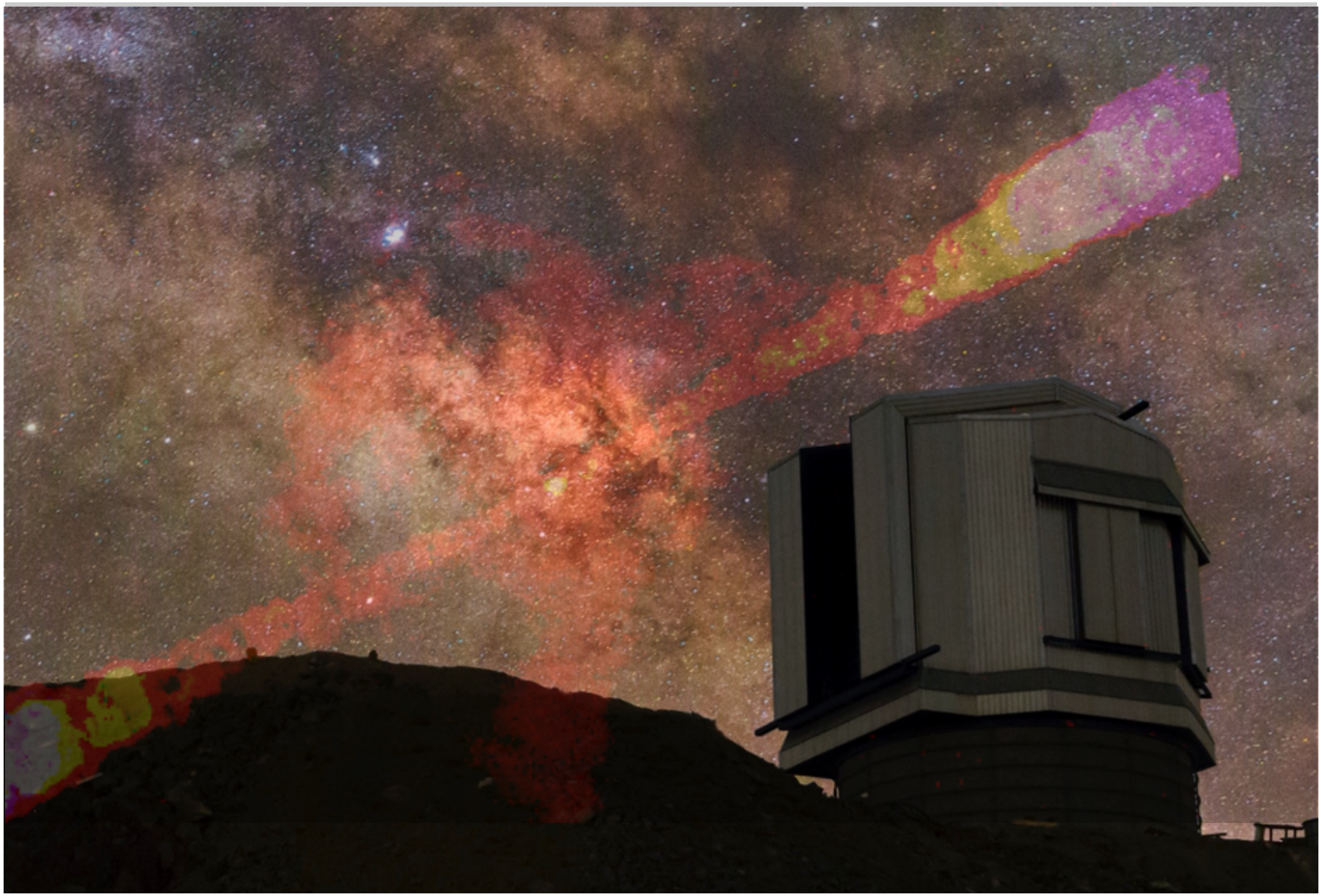
Detectability of GRB Optical Prompt and Afterglow with Iranian National Telescope



Soroush Shakeri

Isfahan University of Technology (IUT)

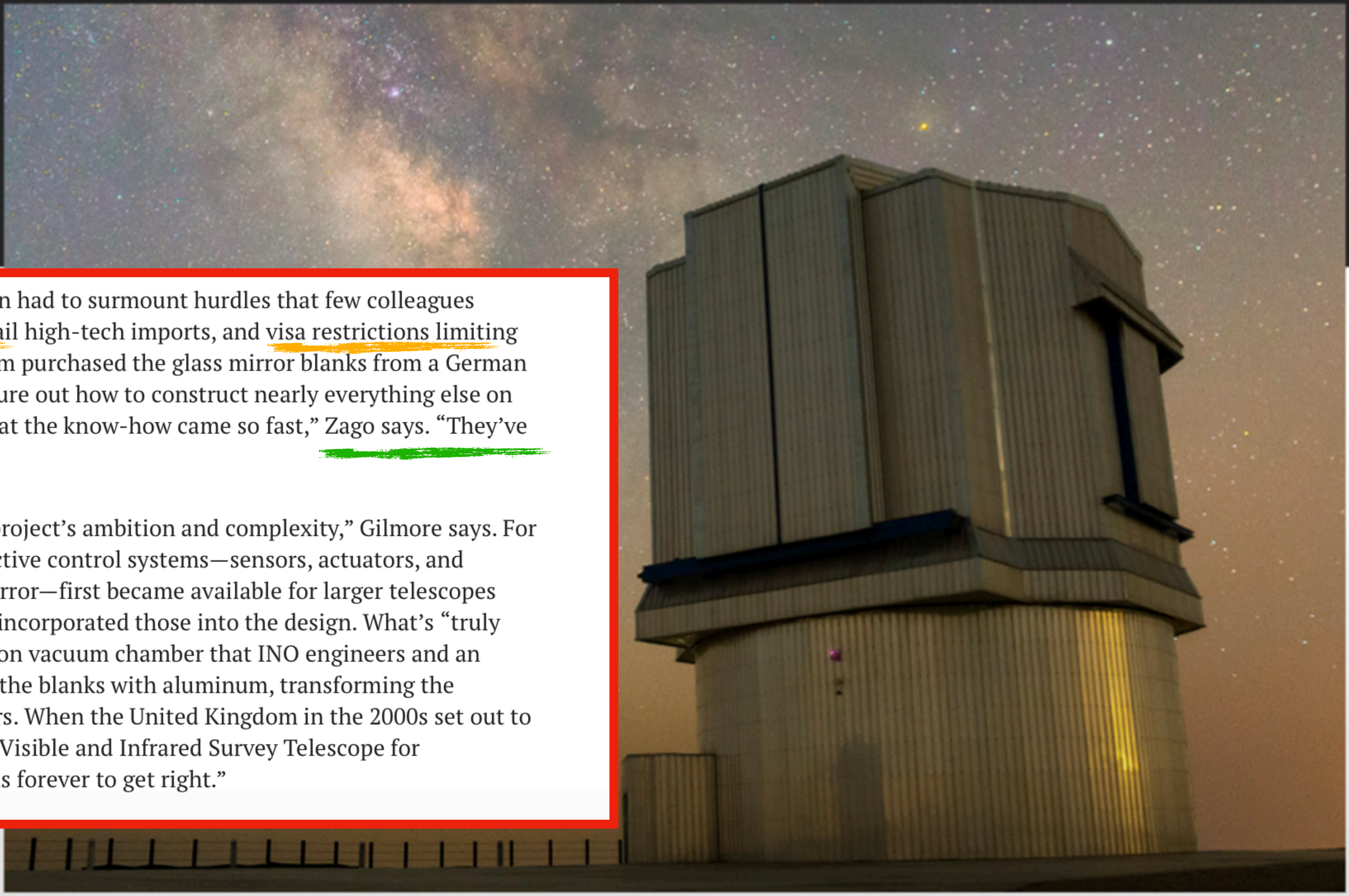
2nd Astro-COLIBRI multi-messenger astrophysics workshop

SCIENCEINSIDER | ASIA/PACIFIC

‘The door is open’: Iranian astronomers seek collaborations for their new, world-class telescope

The 4-meter Iranian National Observatory, which faced long odds, released its first images today

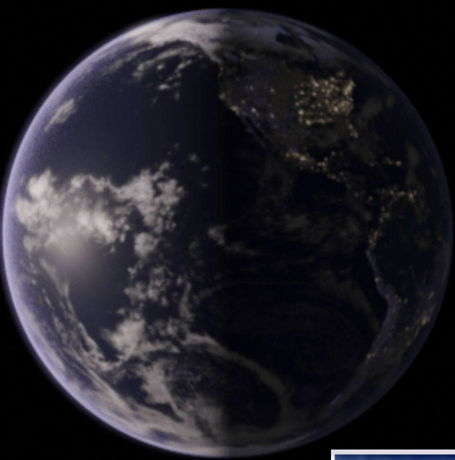
19 OCT 2022 • 4:20 PM • BY RICHARD STONE



Iranian scientists and engineers faced major hurdles building the Iranian National Observatory, including sanctions that curtail high-tech imports and visa restrictions limiting their travel abroad. IRANIAN NATIONAL OBSERVATORY

In building INO, astronomers in Iran had to surmount hurdles that few colleagues elsewhere face: sanctions that curtail high-tech imports, and visa restrictions limiting their travel abroad. The Iranian team purchased the glass mirror blanks from a German firm. INO engineers then had to figure out how to construct nearly everything else on their own. “What surprises me is that the know-how came so fast,” Zago says. “They’ve been working like hell!”

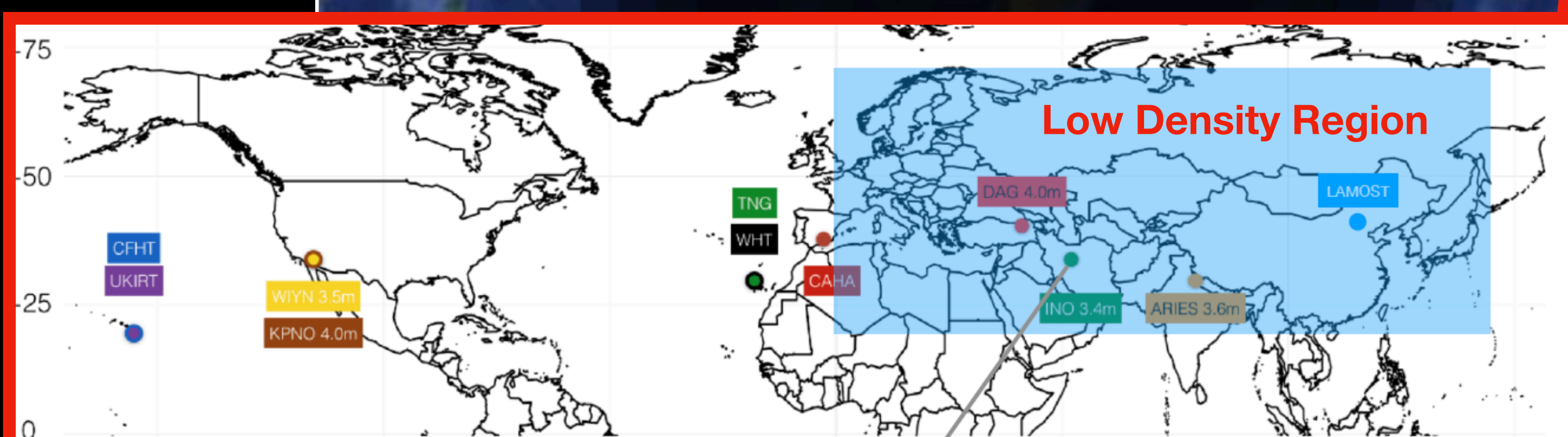
“At every stage they increased the project’s ambition and complexity,” Gilmore says. For example, he says, when so-called active control systems—sensors, actuators, and software that position a primary mirror—first became available for larger telescopes about a decade ago, INO engineers incorporated those into the design. What’s “truly astonishing,” Zago says, is a precision vacuum chamber that INO engineers and an Iranian company fashioned to coat the blanks with aluminum, transforming the polished glass into telescope mirrors. When the United Kingdom in the 2000s set out to build an aluminizing system for its Visible and Infrared Survey Telescope for Astronomy, Gilmore says, “it took us forever to get right.”



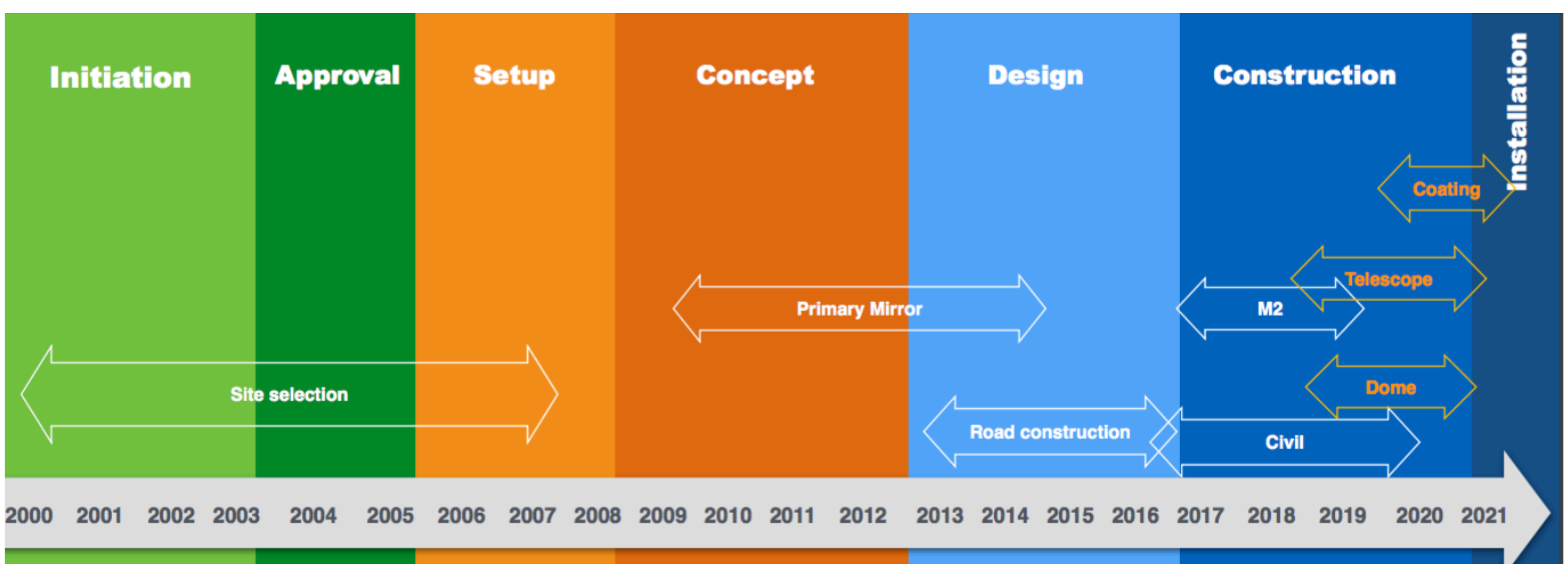
The Distribution of Optical Telescopes All Over the Globe

Science

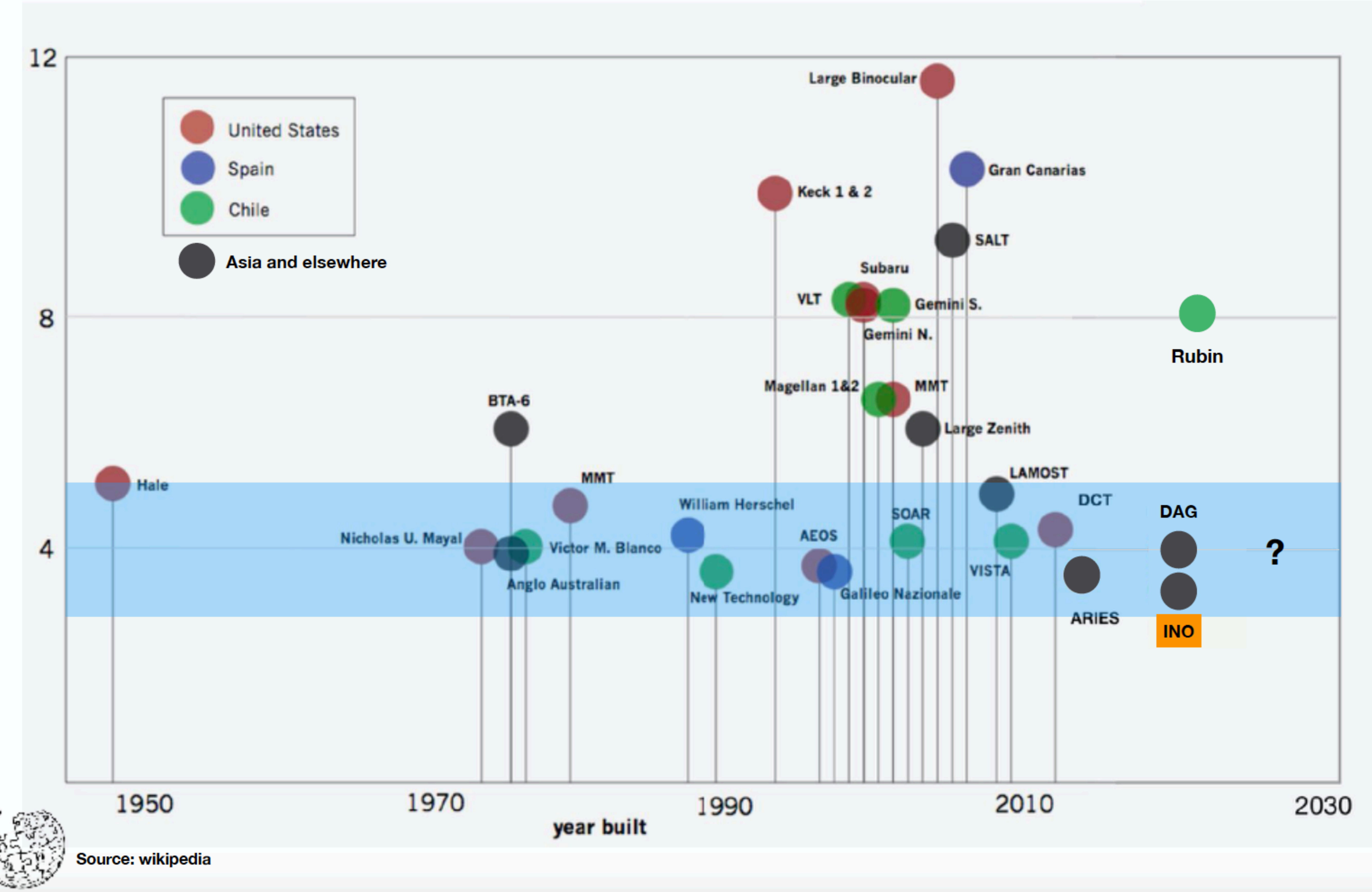
evolution, and hunting for exoplanets. The Iranian observatory and two others in the region—a 4-meter infrared telescope in Turkey nearing completion and a 3.6-meter optical telescope in India—fill a geographic gap in a global network that keys in on fleeting phenomena such as gamma ray bursts to try to pinpoint their locations and unravel their physics. "You need a chain of telescopes all around the world to follow up," Gilmore says.



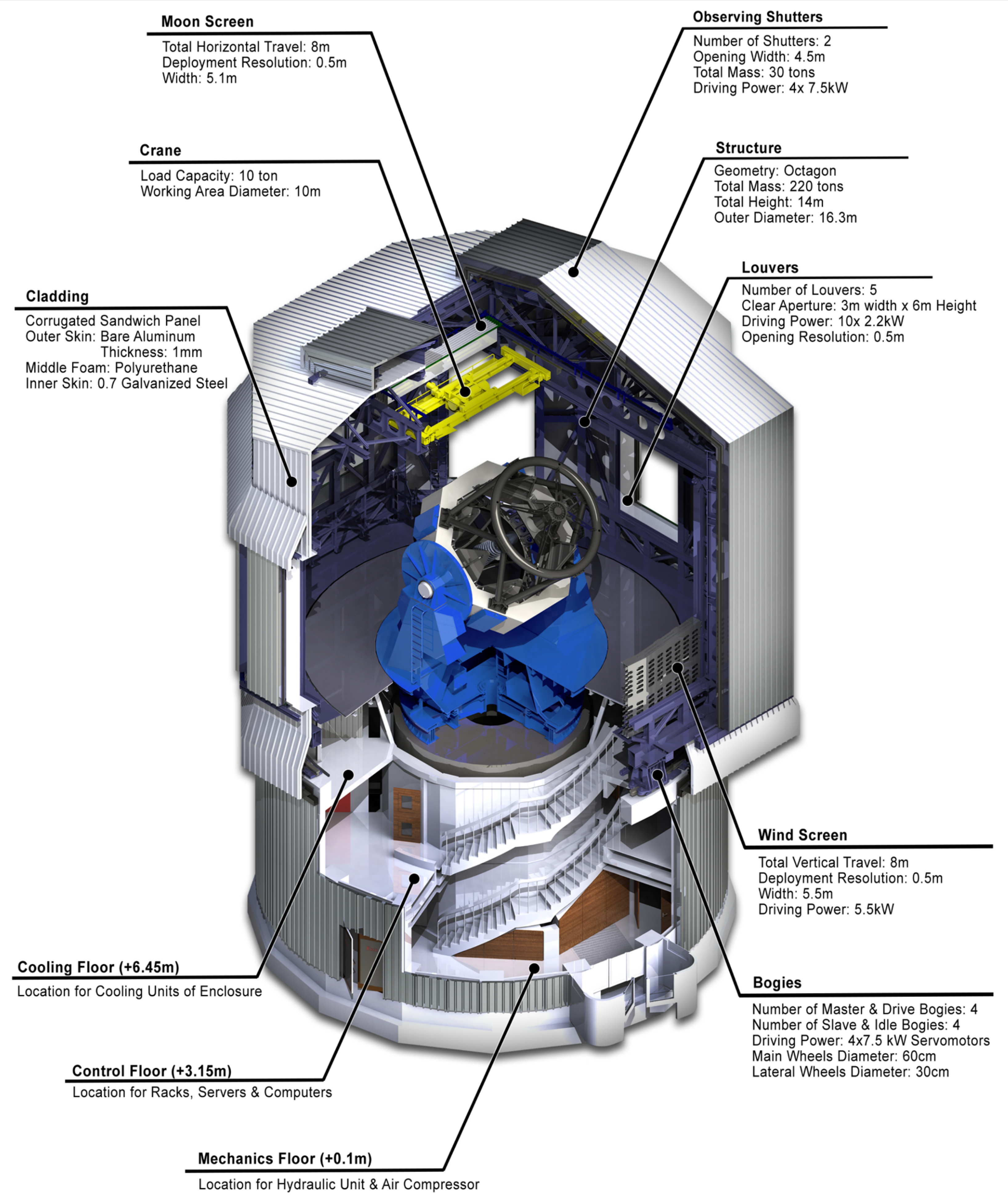
Design - Construction - Installation



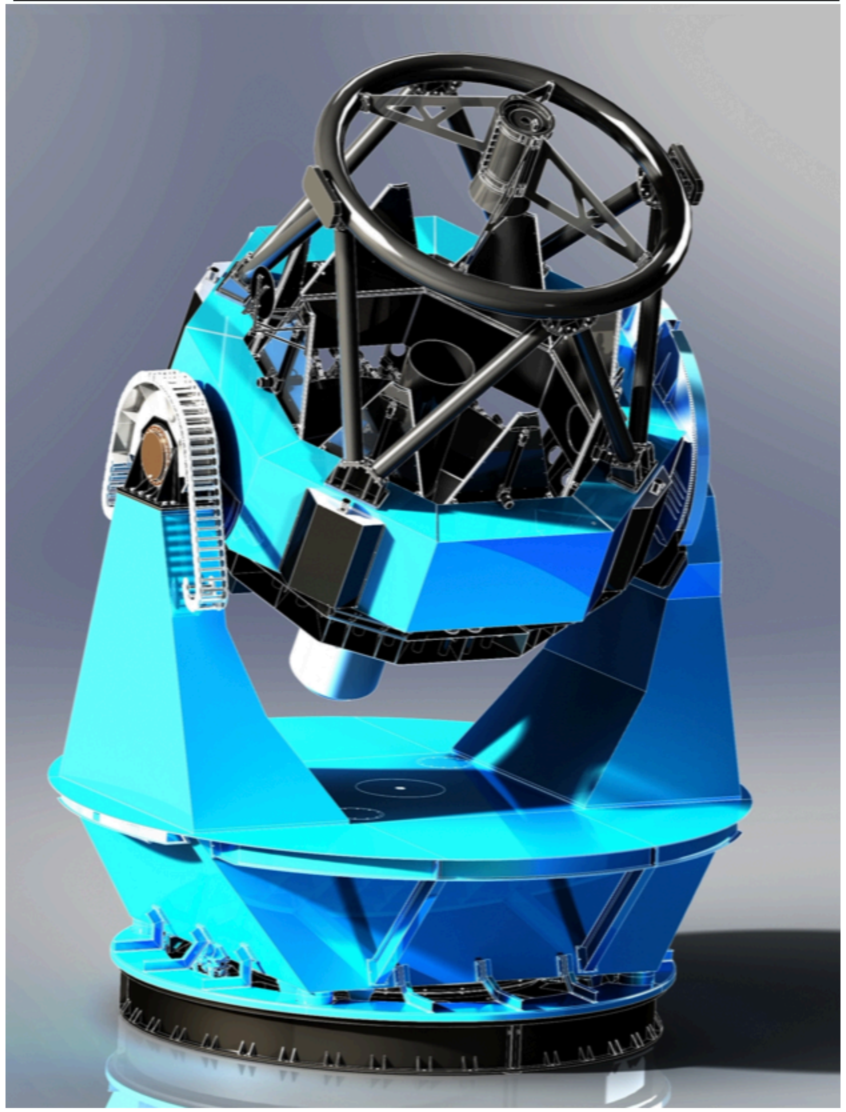
4m Class Telescopes



Source: wikipedia



Optics	Ritchey-Chrétien
Wavelength	325-2500 nm
M1 diameter	3400/700 mm
M1 f-ratio	f/1.5
Telescope f-ratio	f/11.36
Mount	Alt-Az
Guided tracking accuracy	0.2 arcsec
Field of view	8-20 arcmin
Structure weight	90 T

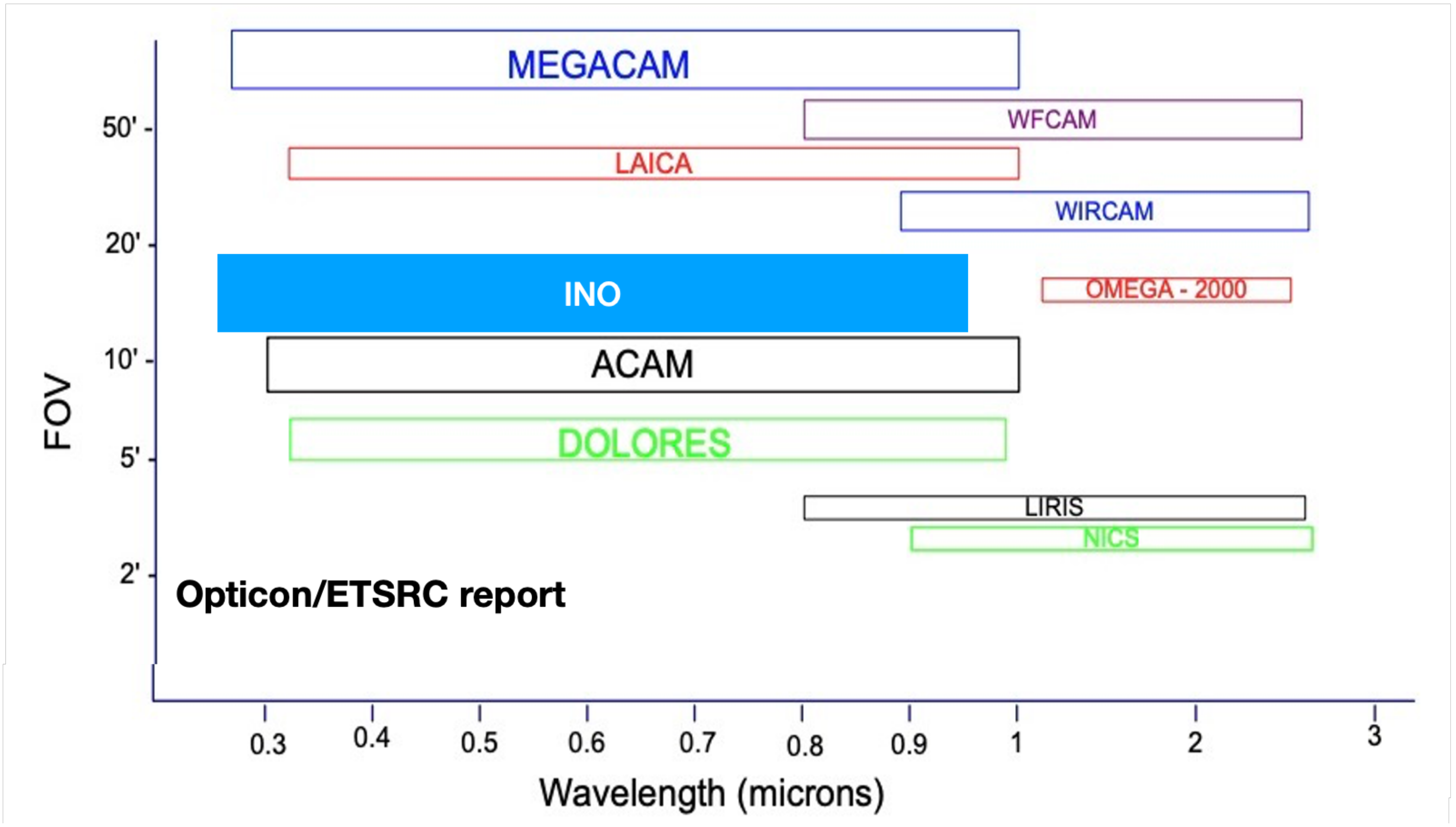


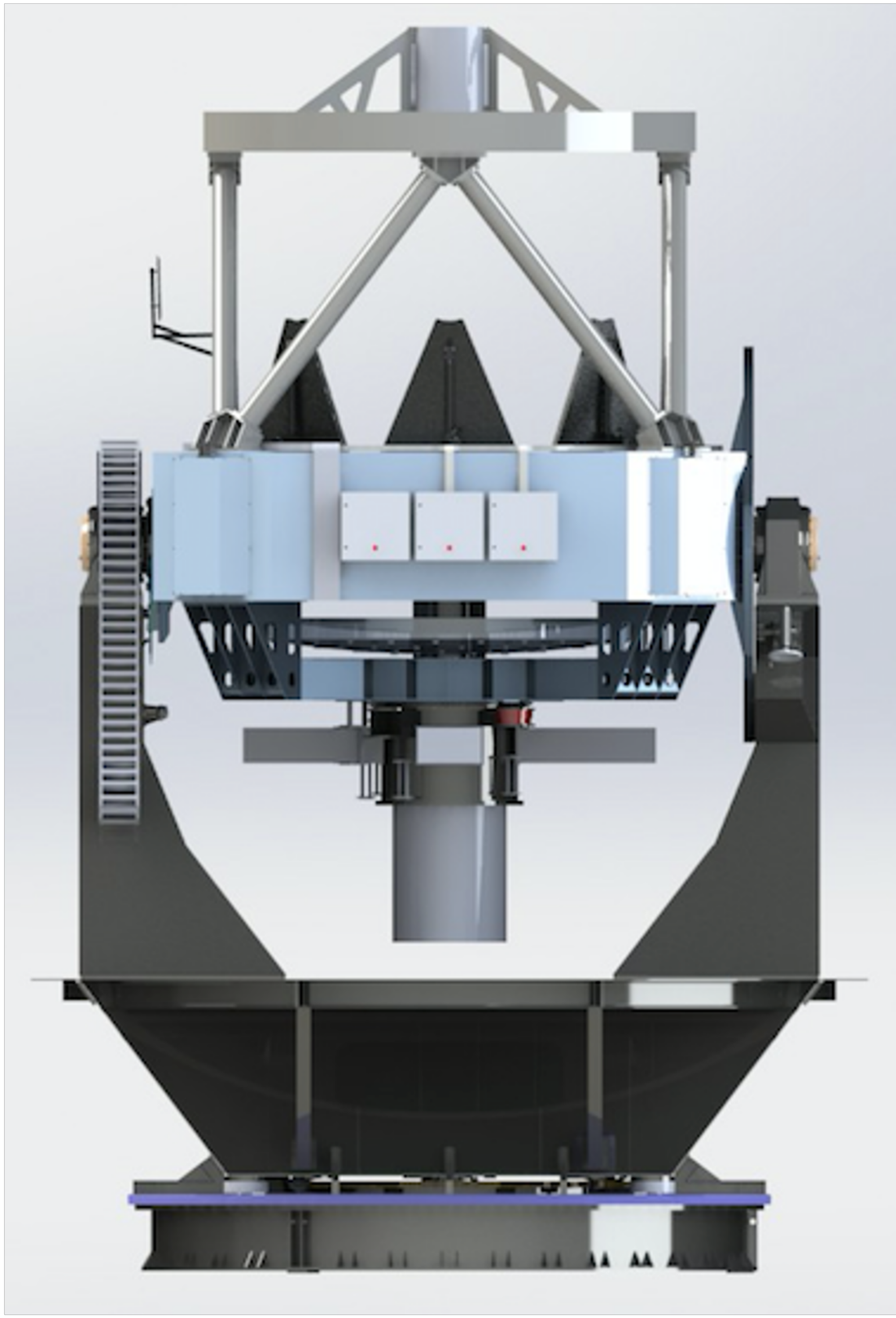
Instrumentation

Phase I:
Commissioning Camera ✓

Phase II:
Imaging camera (FoV 4 arcmin) ✓
Medium/Low resolution Slit Spectrograph [TO BE CONTINUED]

NOT STARTED
Phase III:
Wide field Imaging camera (FoV 20 arcmin)
Multi-object / IFU spectrograph

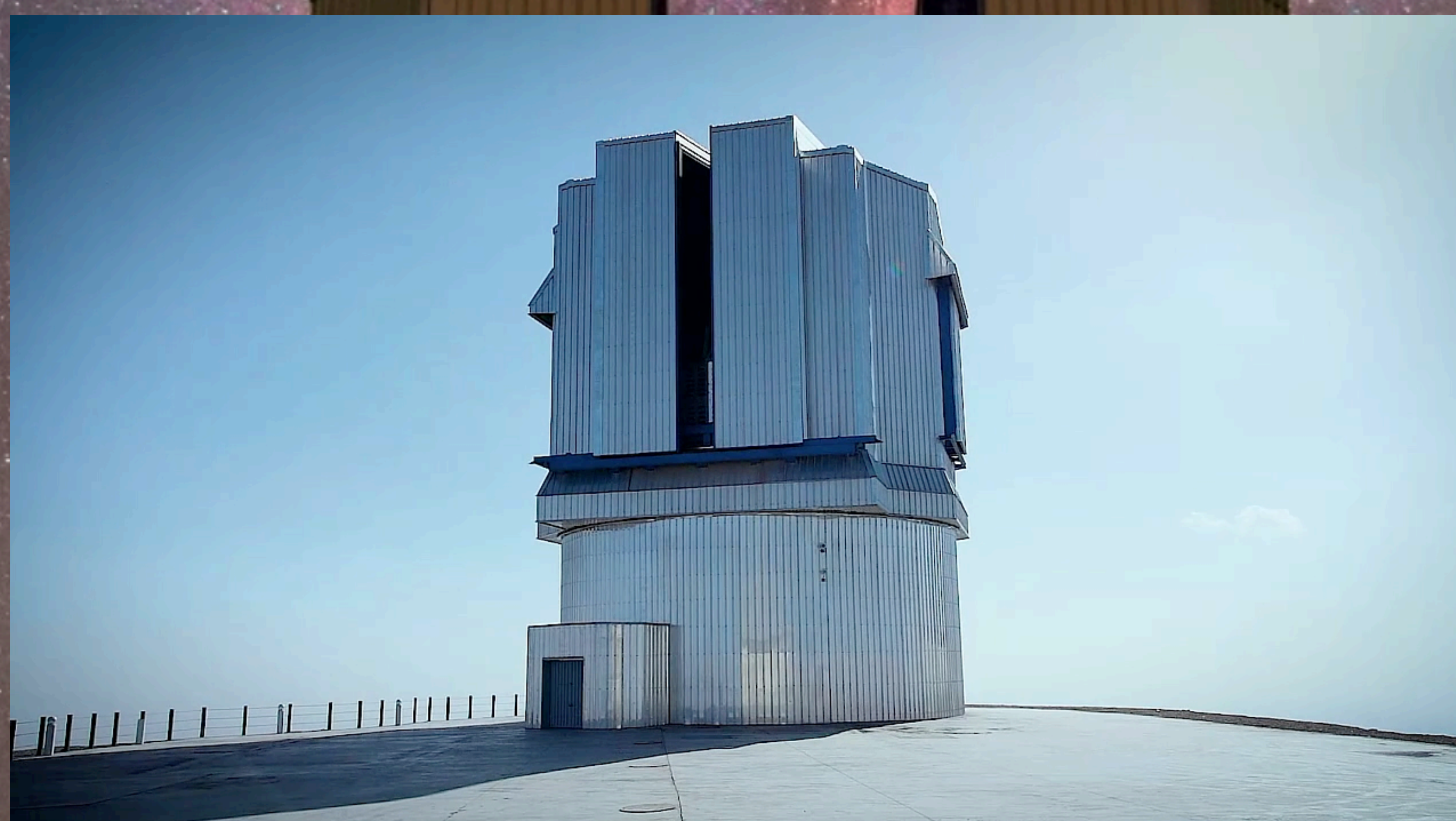




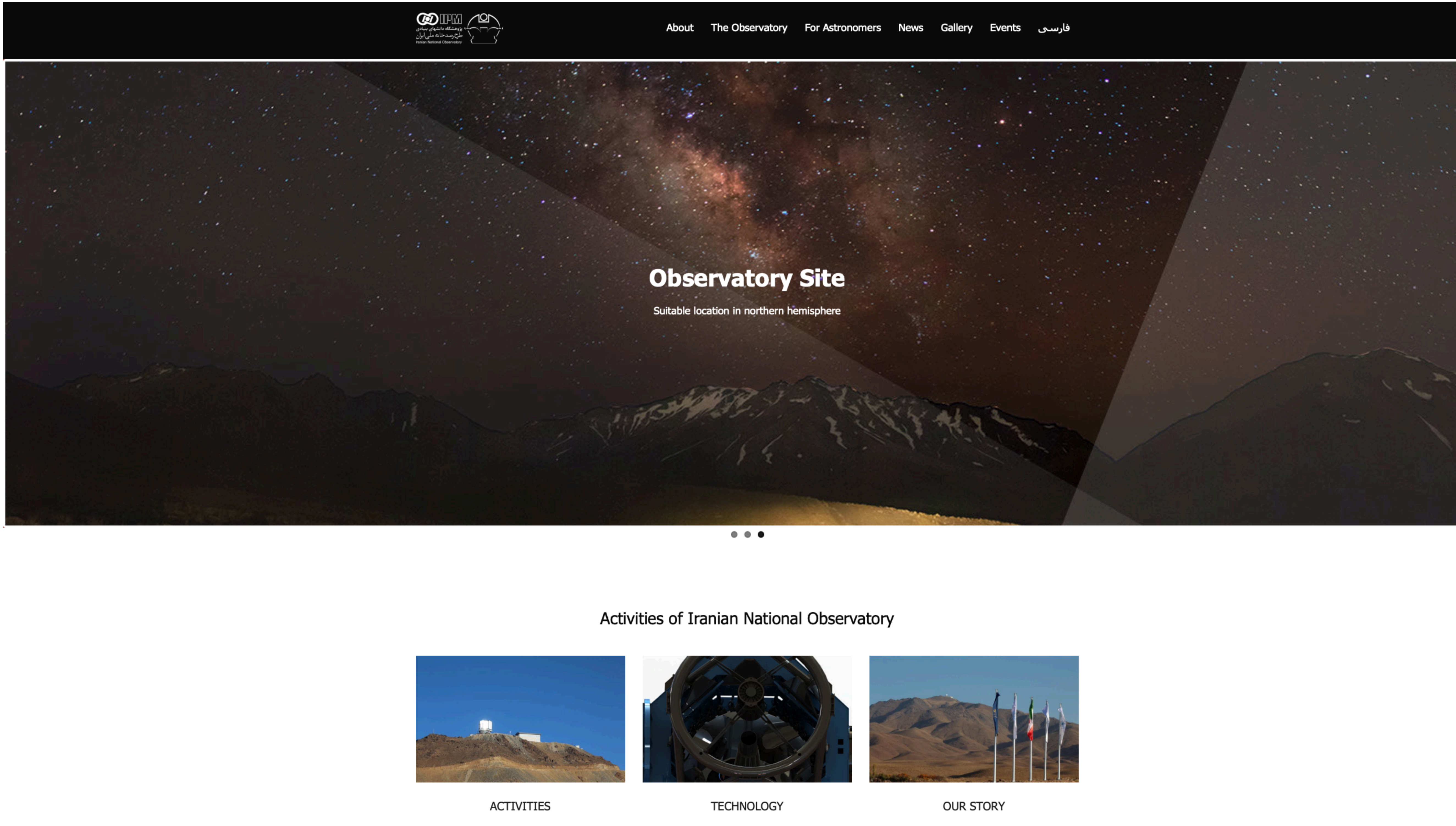
Iranian National Observatory (INO)

رصدخانه ملی ایران

IRANIAN NATIONAL
OBSERVATORY



https://ino.org.ir/en/



First Light in 2021

ARP282 (mag 12.4, 319 Mly)

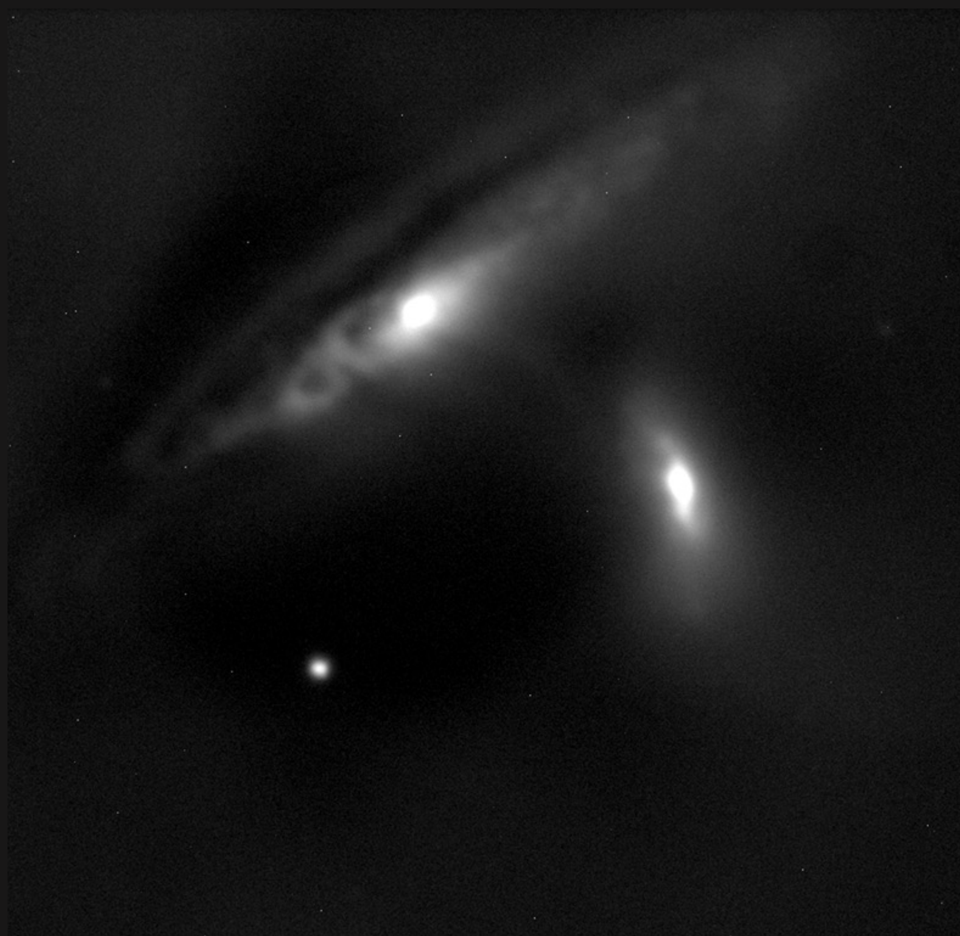
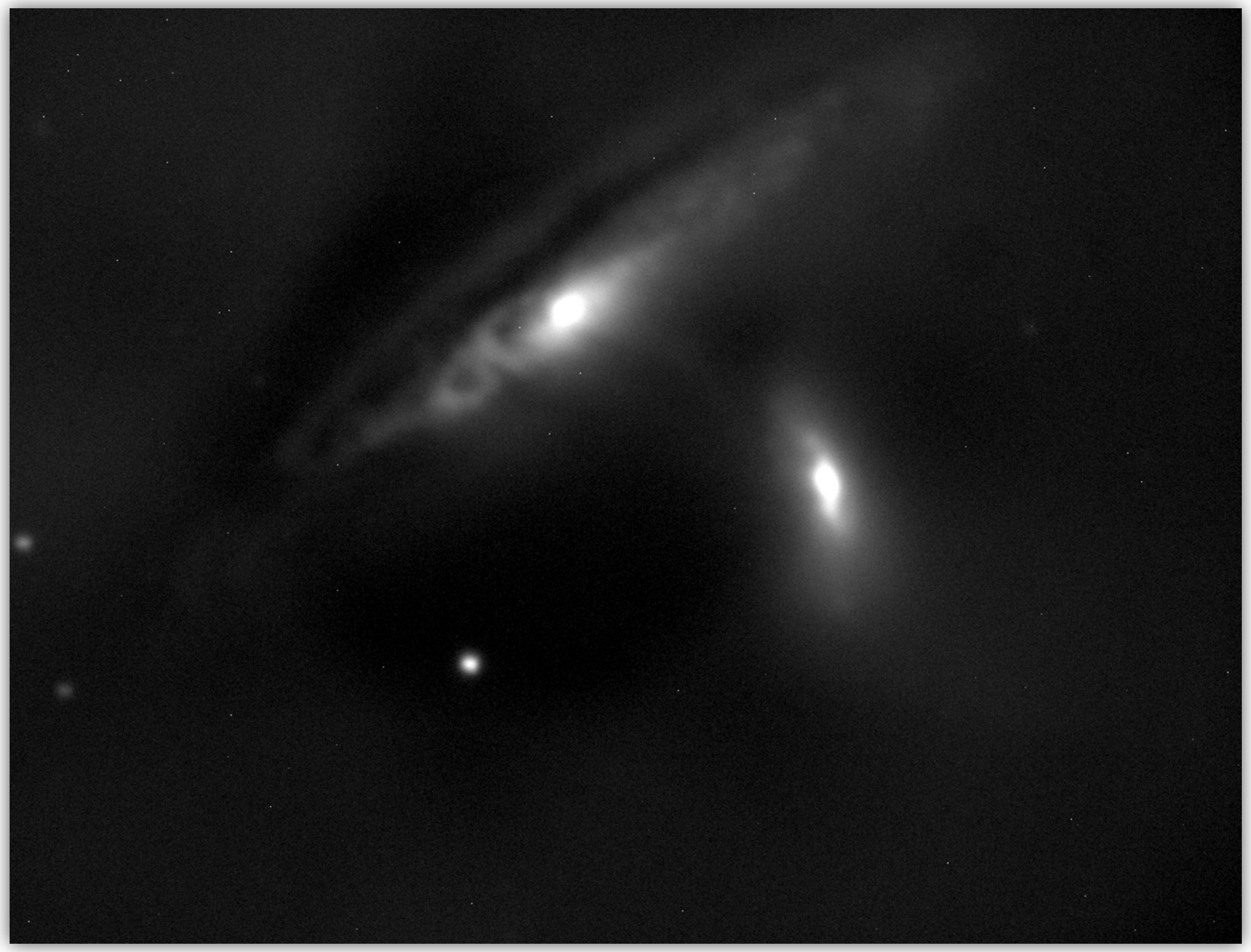
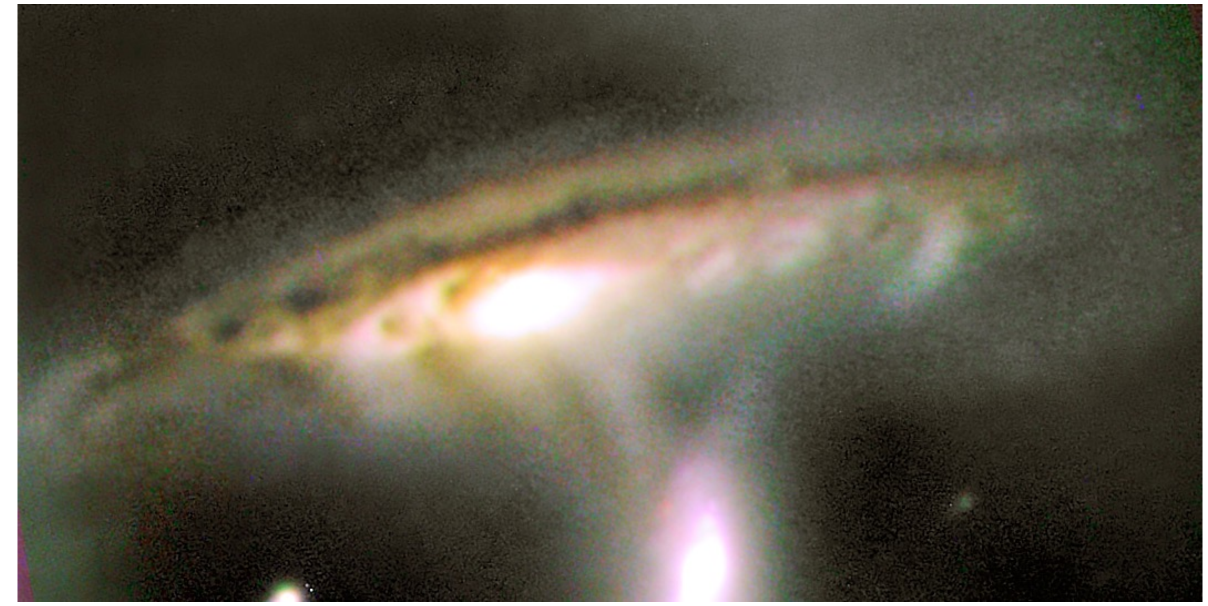


Image Quality: 0.8 arcsec

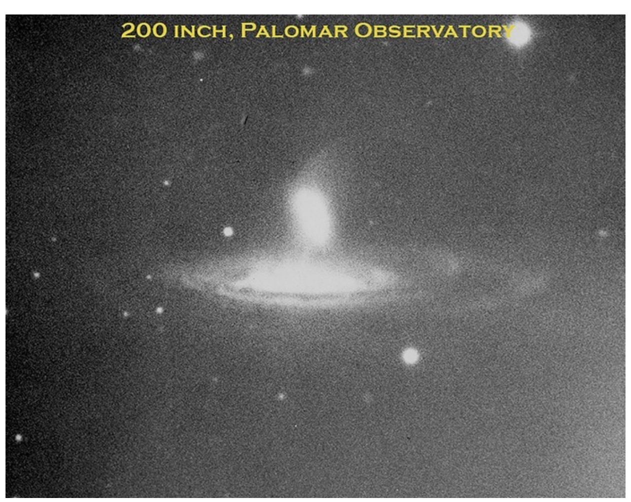
NGC23 (mag 12, 173 Mly)

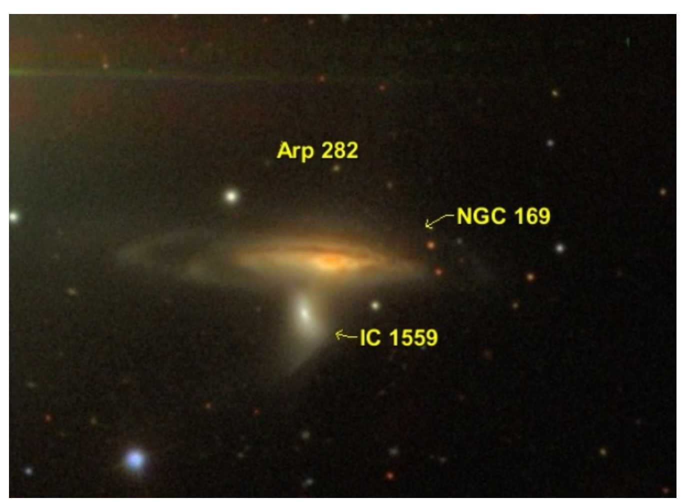
Image Quality: 0.65 arcsec



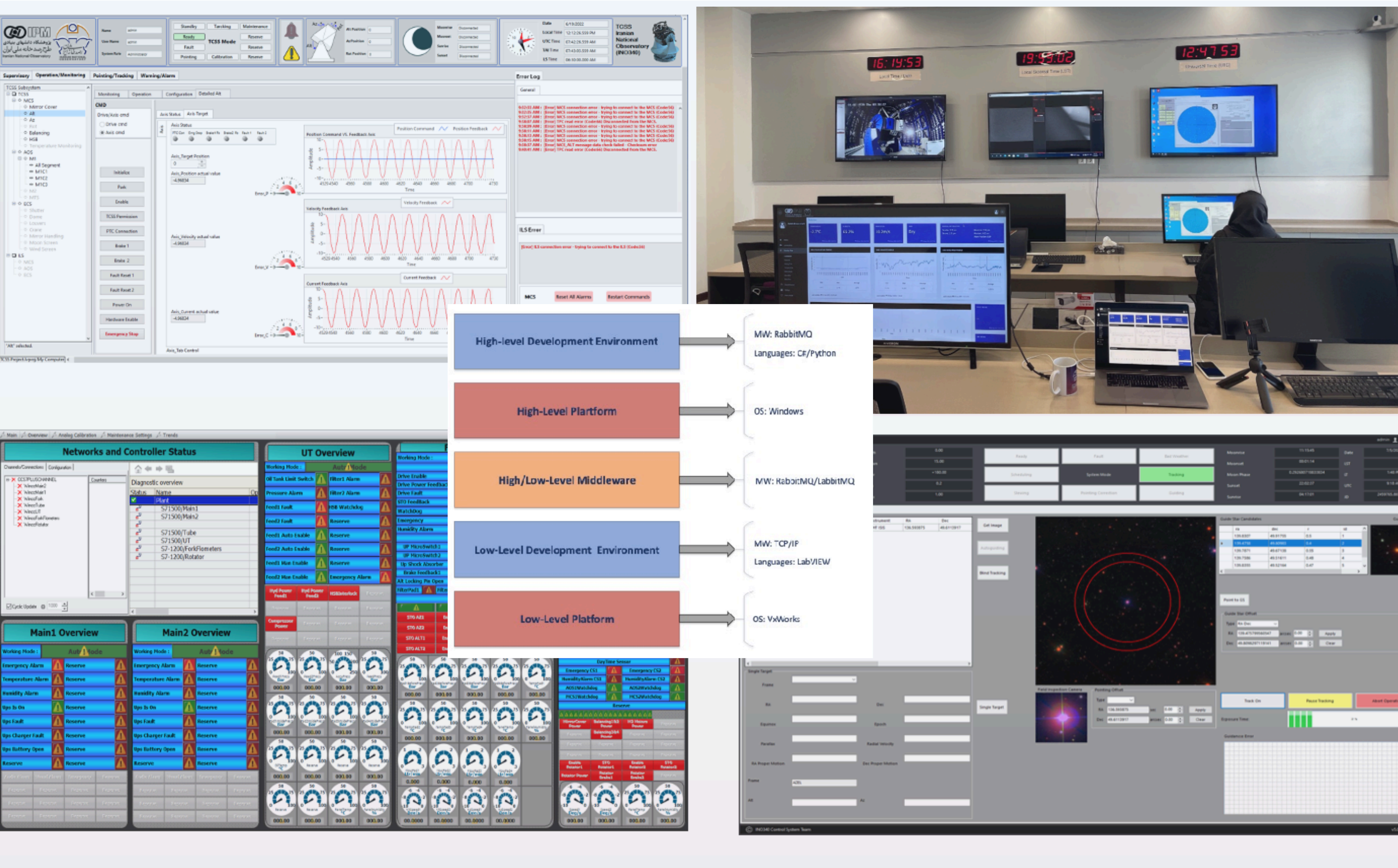


Arp 282, 320 Mly



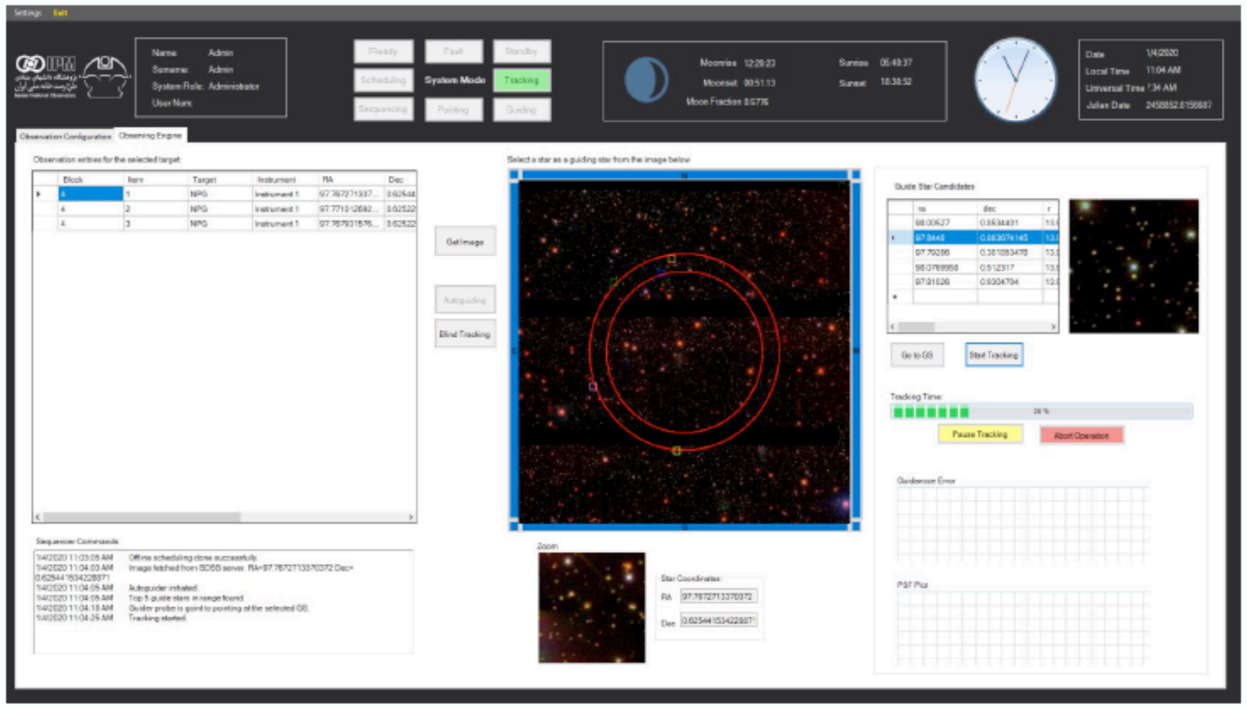


The control system and software development



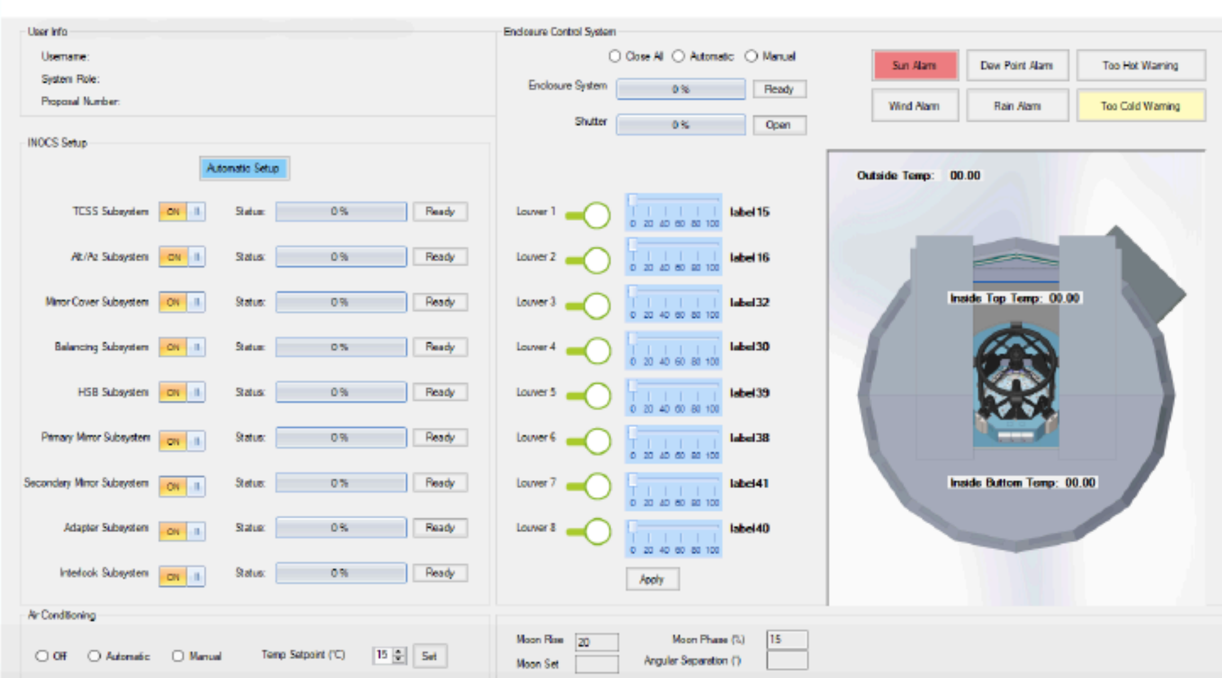
User Interface

Observation Application

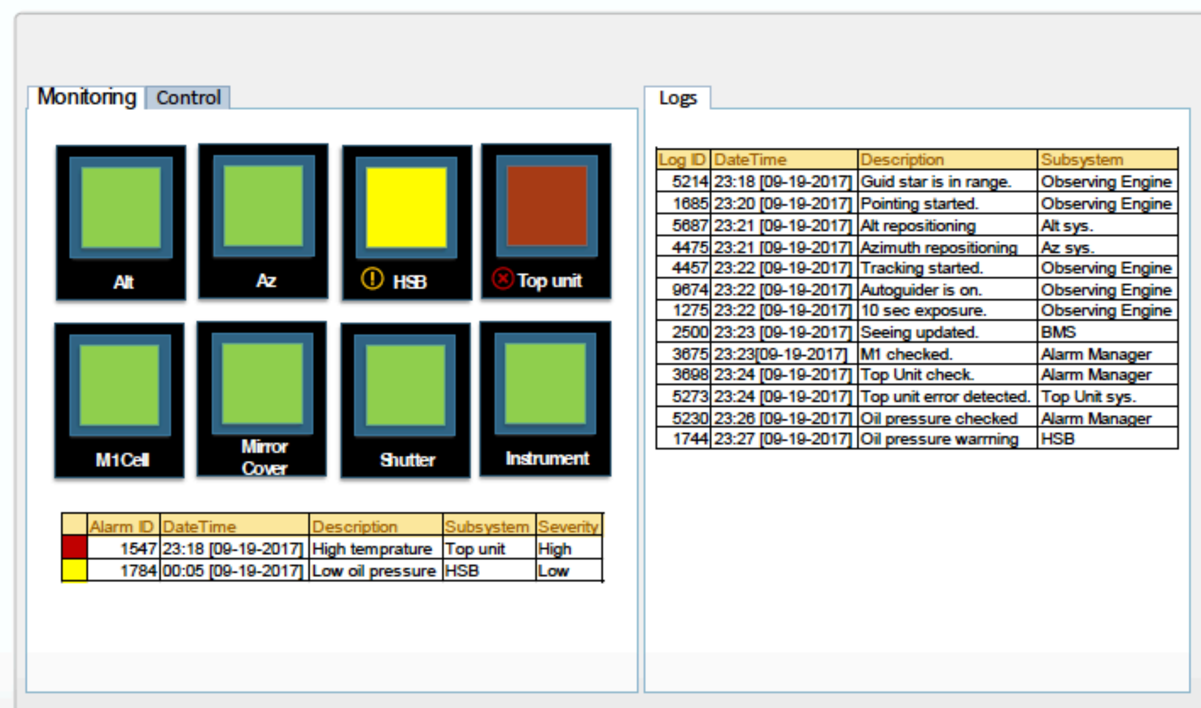


Site Monitoring Application

Telescope Operation Application



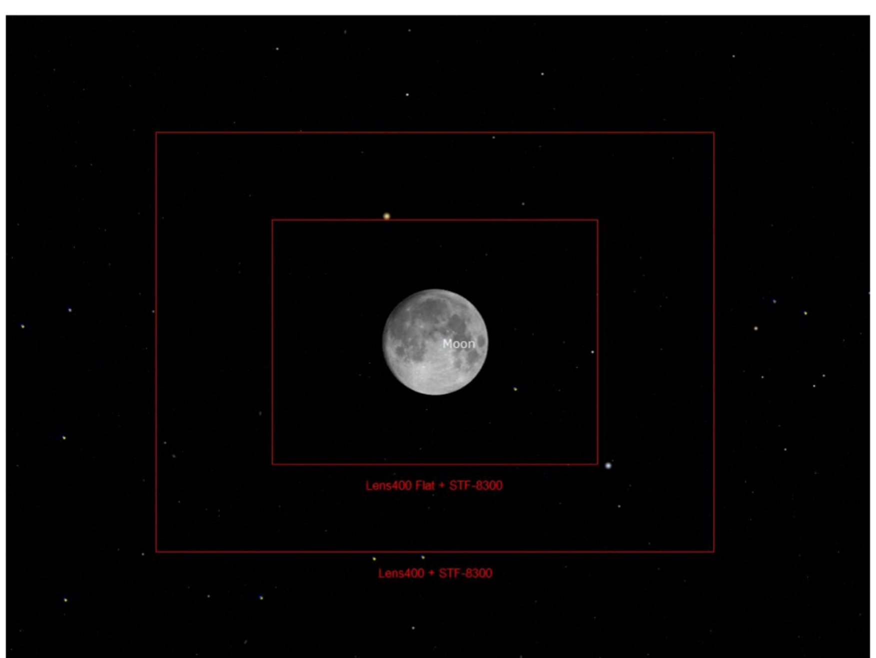
Alarm/Warning Application



INO Lens Array facility

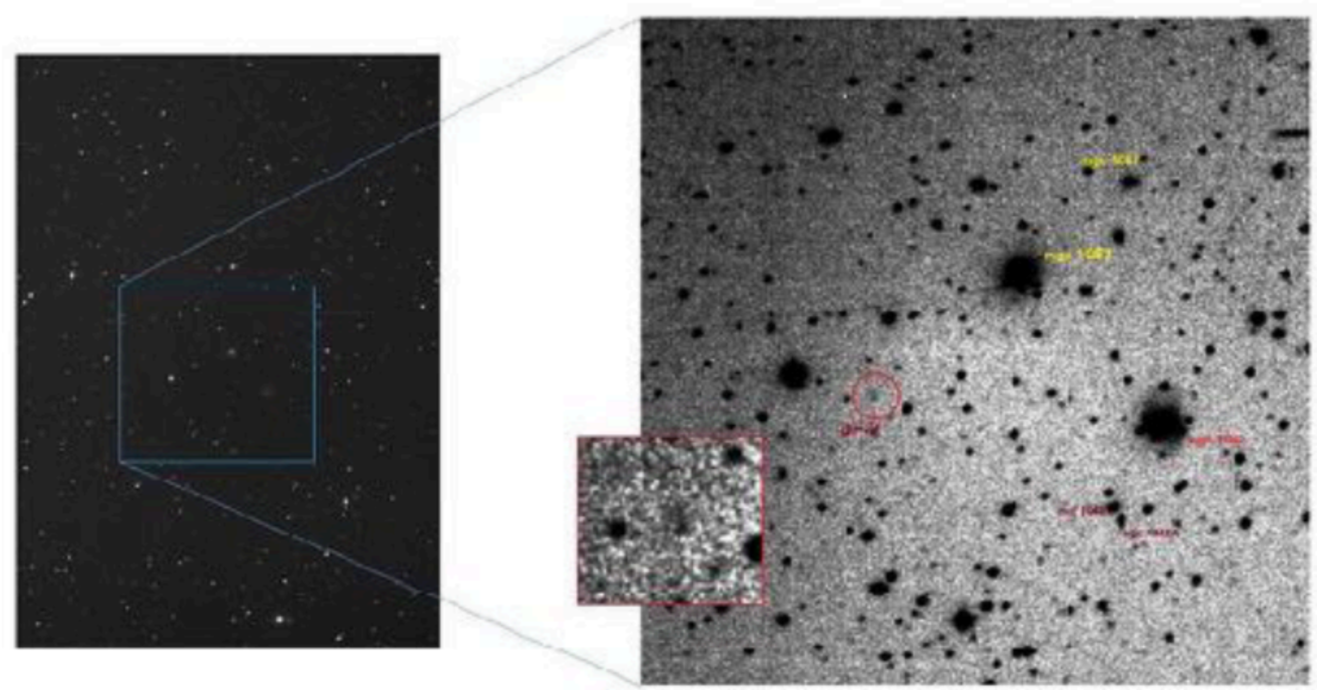
Main Parameters

Focal Length	400 mm
Lens Diameter	140 mm
Focal Ratio	2.8
Lens Construction	16 Elements in 12 Groups
Field of View	154 x 116 arcmin wide field array
CCDs	SBIG STF-8300 Monochrome
Pixel Scale	2.785 arcsec/pix
Filters	B, V, R Photometric Filters
Filter Size	52 mm Drop-In



The field of view of the INOLA compared to the size of the full Moon

Since the time sensitivity of transient events requires prompt response by observers, these targets will have the highest priority in INOLA observations.



Science with 4m telescopes

Galactic

Exoplanets

Microlensing

Stars
Magnetism is WDs
Pre-MS stars
ISM
Metalicity

Solar system
Planetary studies to surveys

Extra-galactic

Galaxy
Dwarfs to giants morphology, star formation, metallicity, Kinematics, Environment, Dark matter, LSBs
Gravitational lensing

AGNs & Quasars
Environments and hosts
AGN varibility

INO operation modes

Regular observing time

Astronomers can apply to this in one of the following modes by submission of Phase I (and Phase II) proposals.

Visiting

The visiting mode will allow training of new observers.

Service

Mostly dedicated to programs requiring short exposures over many nights

Large/Survey programs

These will be set up by the INO in collaboration with the community of astronomers with international presence.

The surveys will be conducted by students assigned to these programs.

Guaranteed time

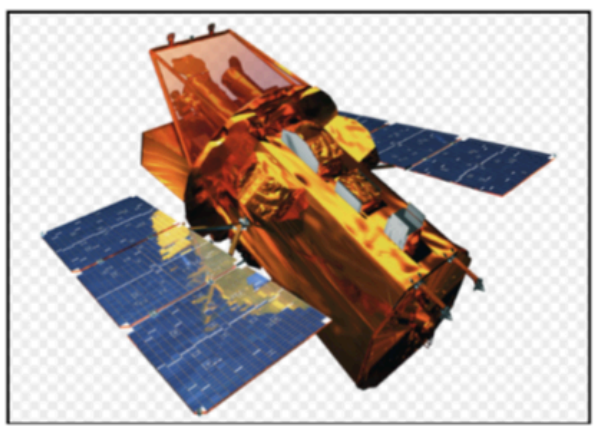
Target of opportunity

INO is likely to adopt a conditional "open sky" policy. A condition that engages the local community.

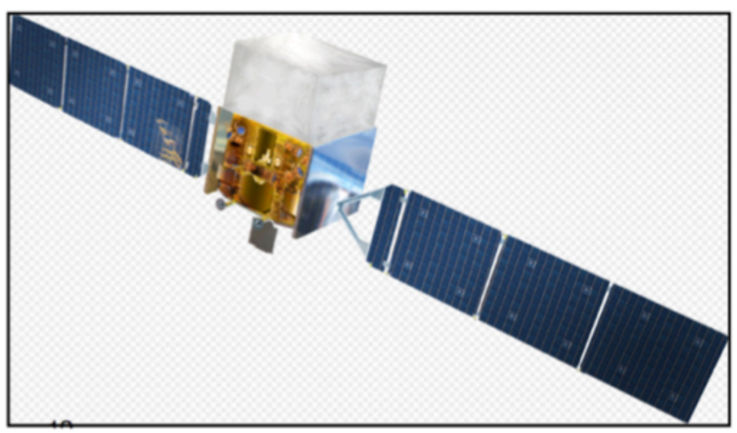
GRB Event Rate

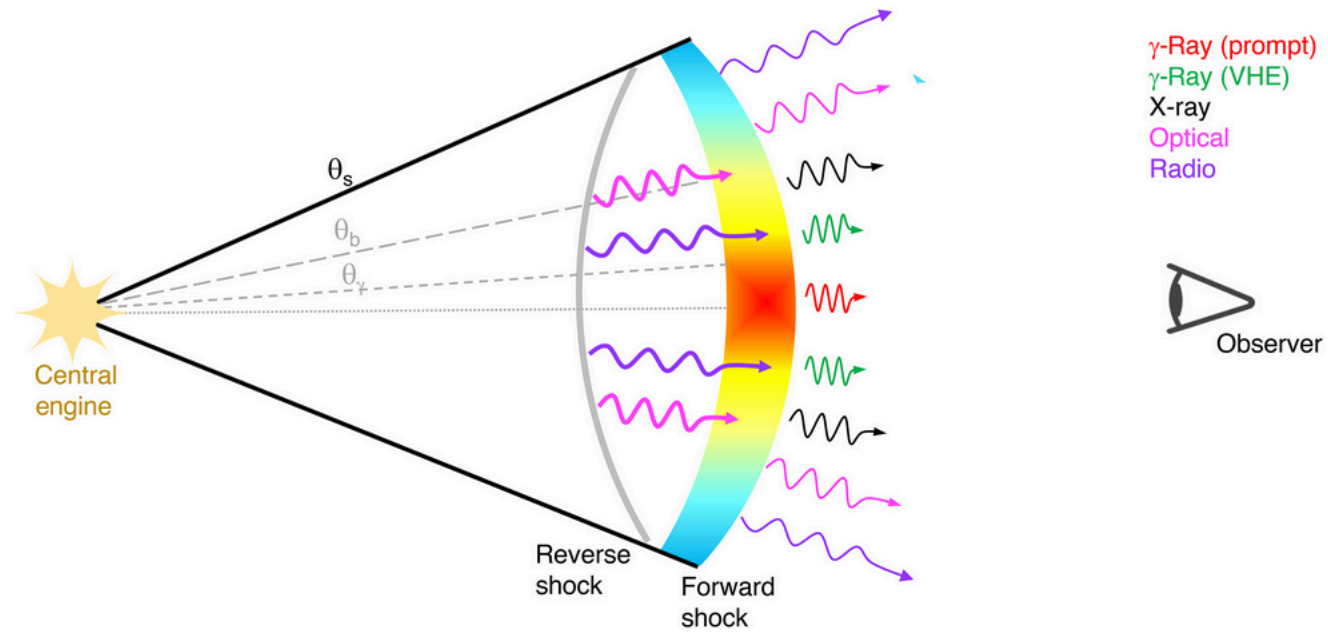
current generation of GRB detectors (e.g. BATSE, *Swift*/BAT, *Fermi*/GBM) have a sensitivity limit of the order of 10^{-8} erg cm^{-2} s^{-1}. With such a threshold, an ideal imaginary 4π all-sky detector on average would detect $\sim$600–1000 GRBs/yr, or $\sim$2–3 GRBs/day. For example, *Swift*/BAT has a field of view of $\sim 1/7$ all sky, and detects 2–3 GRBs per week.

SWIFT 2004-PRESENT



FERMI 2008-PRESENT

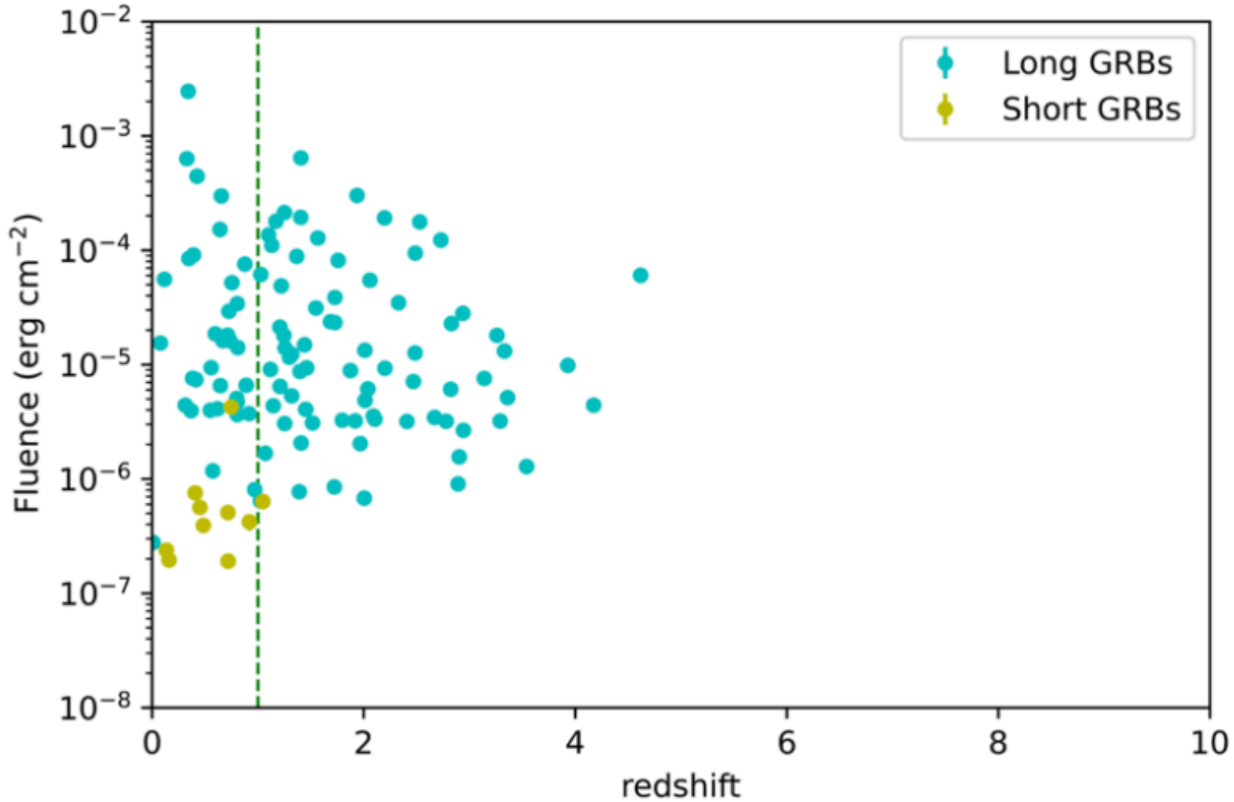




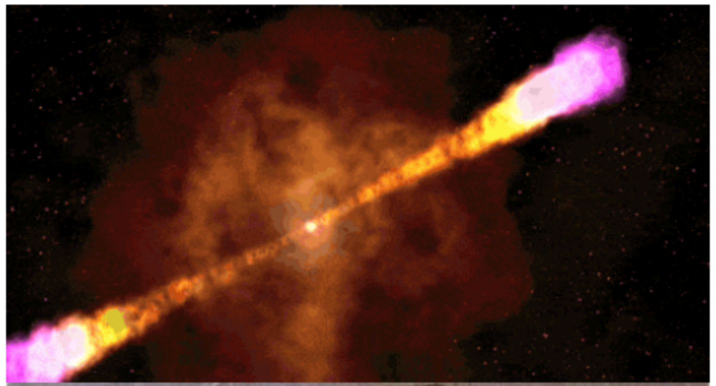
$$\dot{\rho}^{\rm HL}_{0,\rm tot,50} \sim 500\dot{\rho}^{\rm HL}_{0,50} \sim (250 - 500)\ {\rm Gpc}^{-3}\cdot{\rm yr}^{-1} \sim (12.5 - 25)\ {\rm gal}^{-1}\cdot{\rm Myr}^{-1}$$

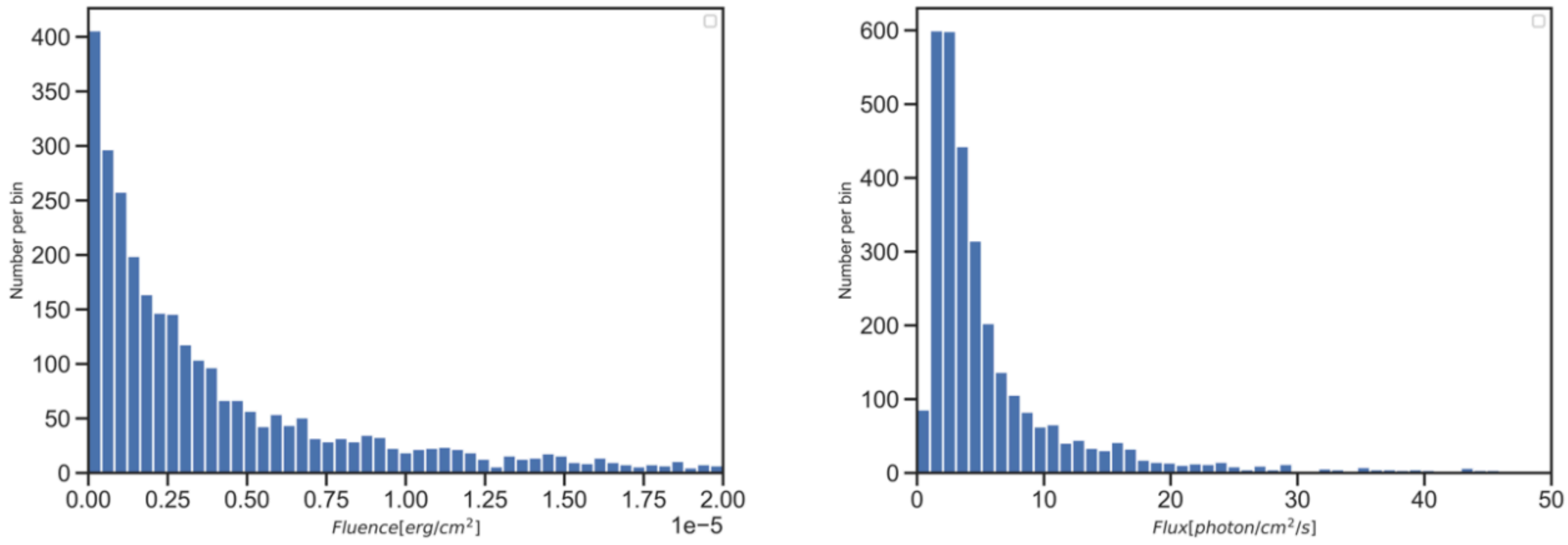
$$\dot{\rho}^{\rm SGRB}_{0,\rm tot,50} \sim (13 - 75)\ {\rm Gpc}^{-3}\cdot{\rm yr}^{-1} \sim (0.6 - 4)\ {\rm gal}^{-1}\cdot{\rm Myr}^{-1}$$

Defining essential criteria for follow-up observations



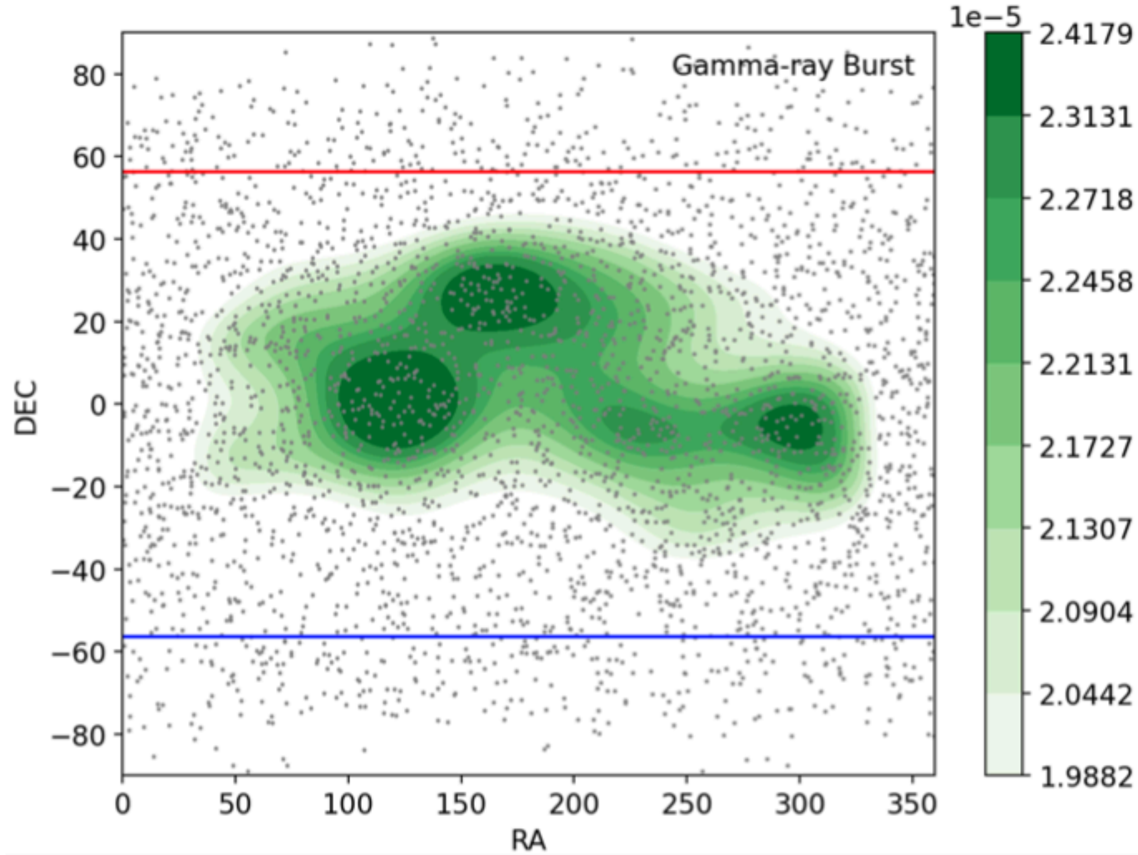
Redshift vs Fluence distribution of 157 GRBs observed by Fermi.

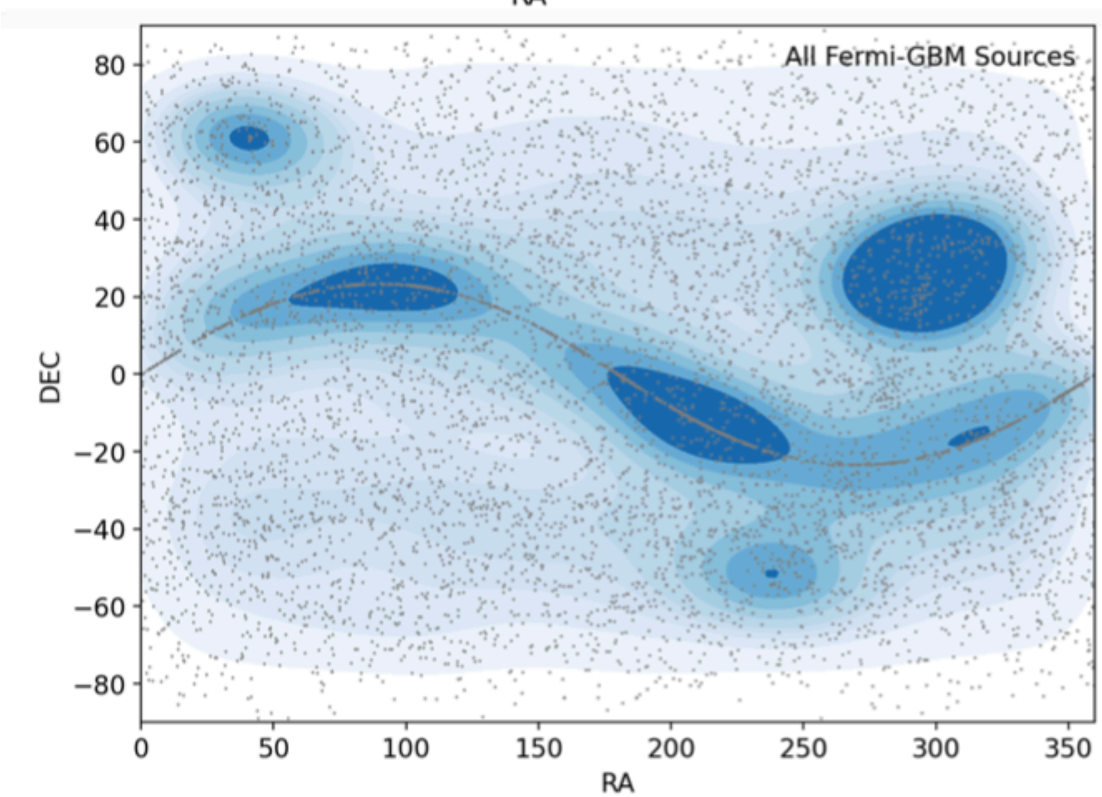


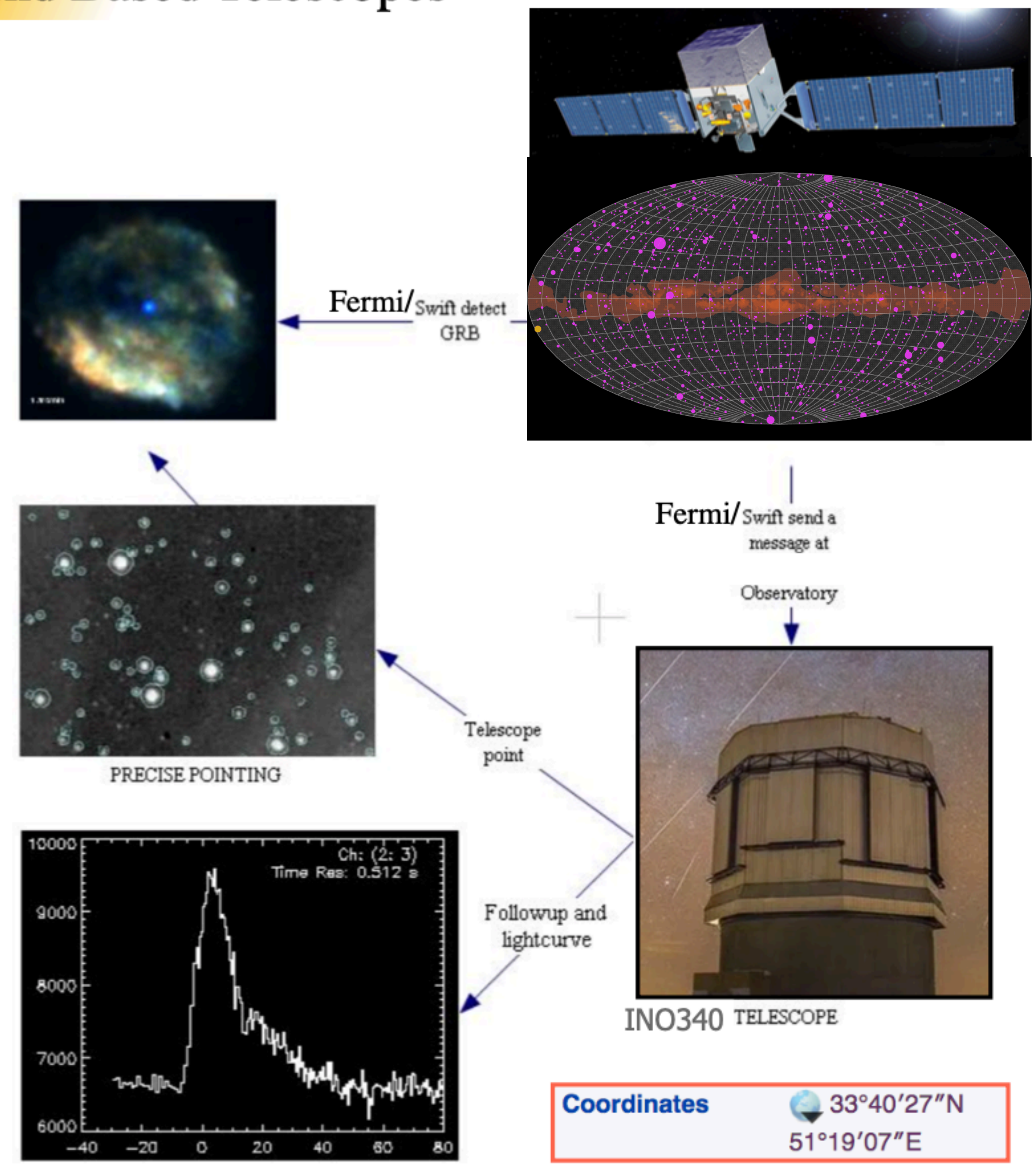


Fluence distribution (left) and Flux distribution (right) of 3225 GRBs observed by Fermi GBM.

Visibility of GRBs for Ground Based Telescopes

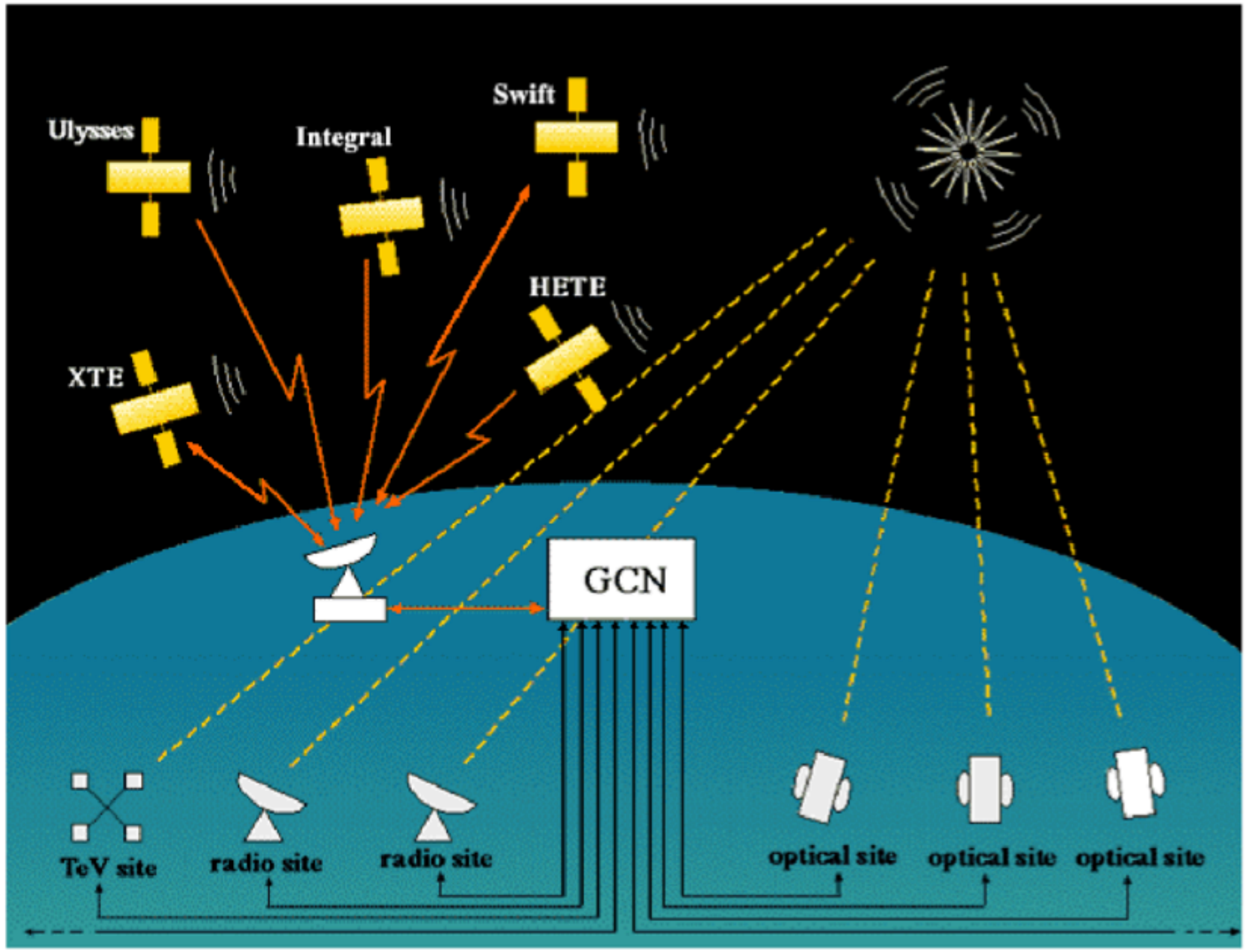


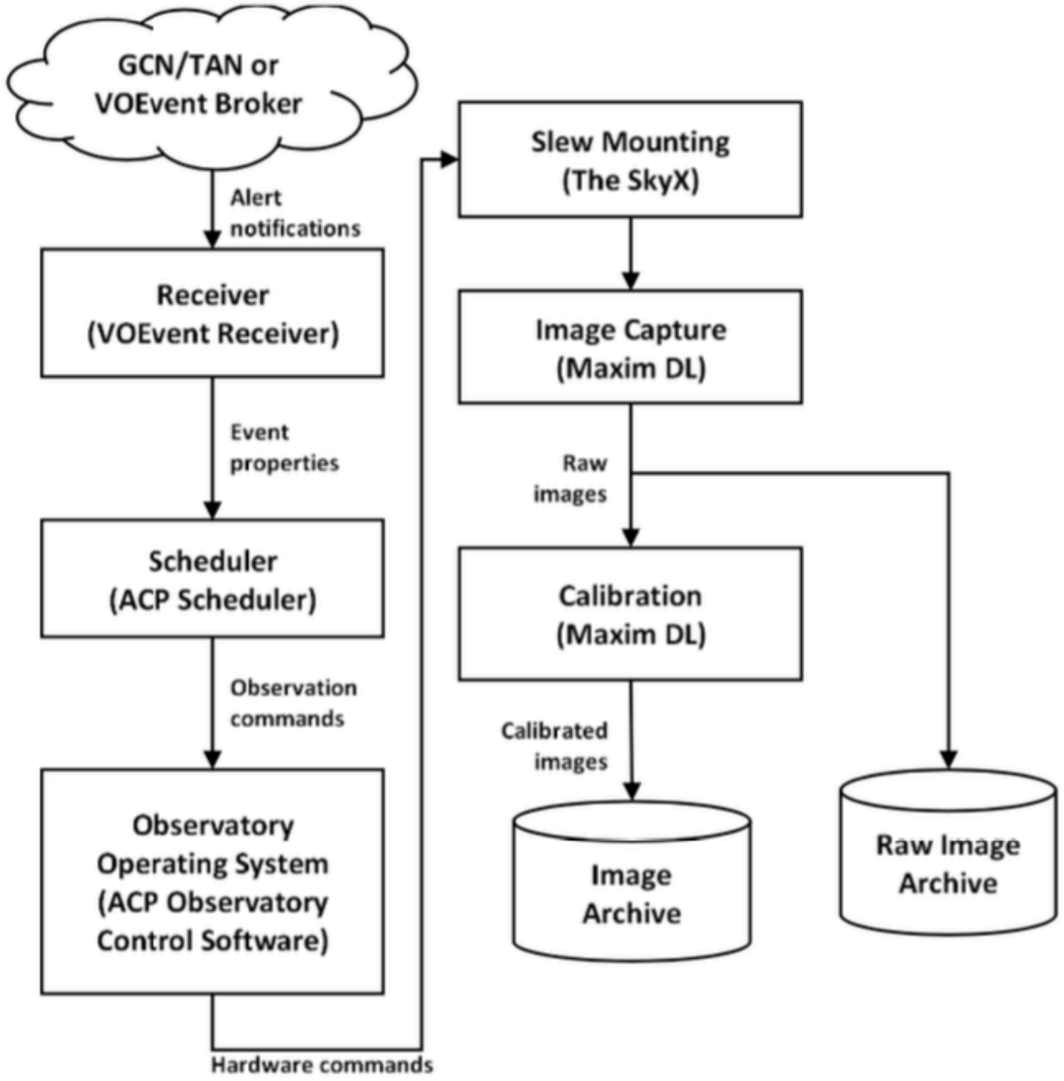




Observatory should continuously monitor GRB alert notifications that NASA sends over the network. When an alert is detected, the computer observatory assess whether the object is sufficiently above the horizon in order to be observed. If the test is successful, the computer stops the ongoing observations, automatically points the GRB and began to photograph it for the rest of the night.

Follow - Up GRB Observations





The Gamma-ray bursts Coordinates Network (GCN)

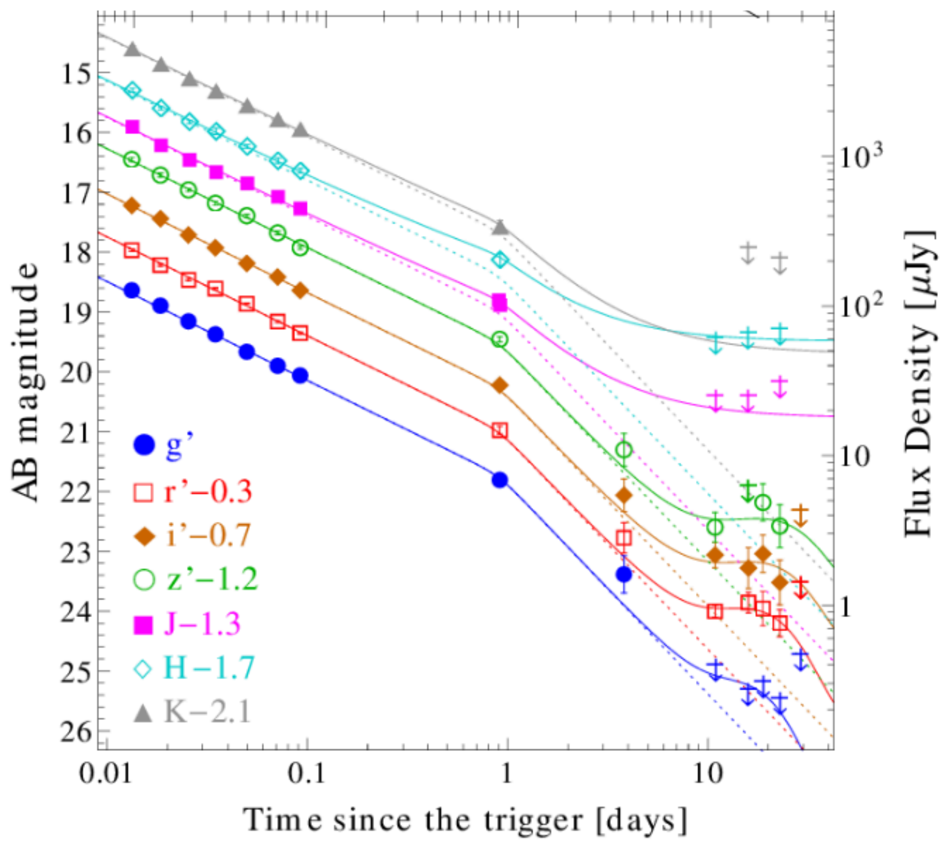
Automatic GRB follow-up Observation

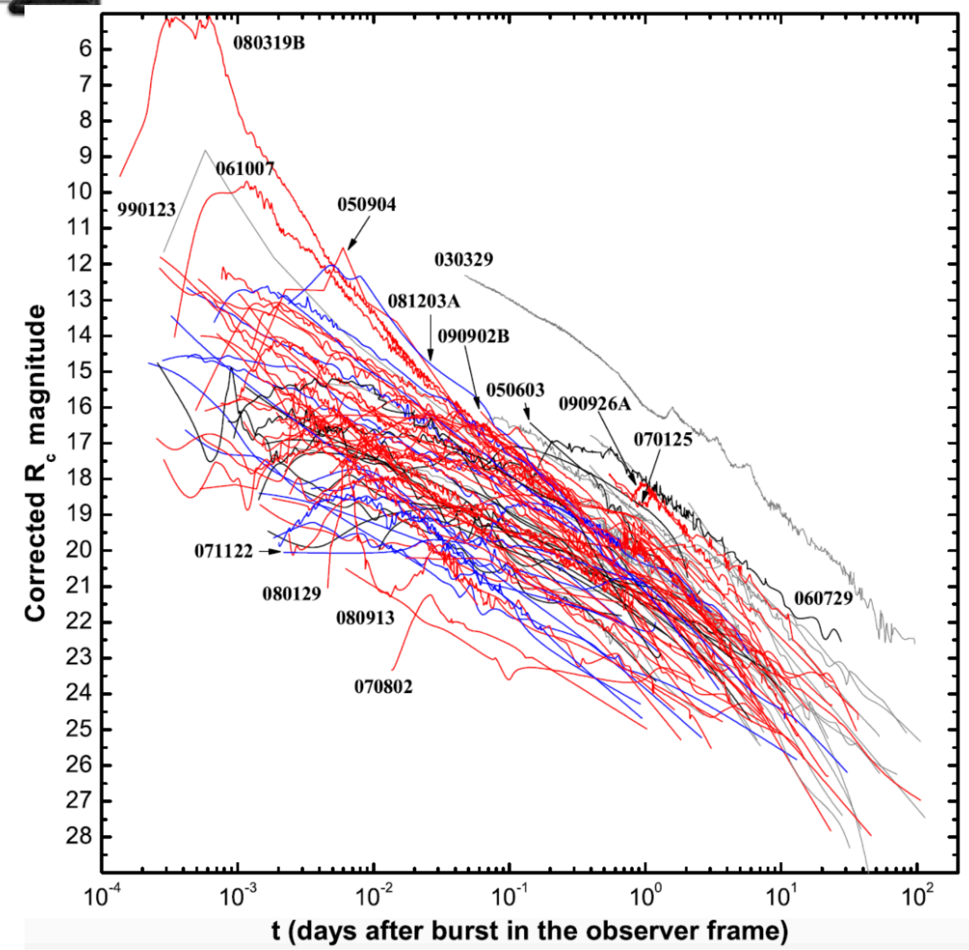
Whenever a satellite reveals a GRB phenomenon, NASA collects and analyzes information quickly and automatically notifies all observers of the network events worthy of being observed.

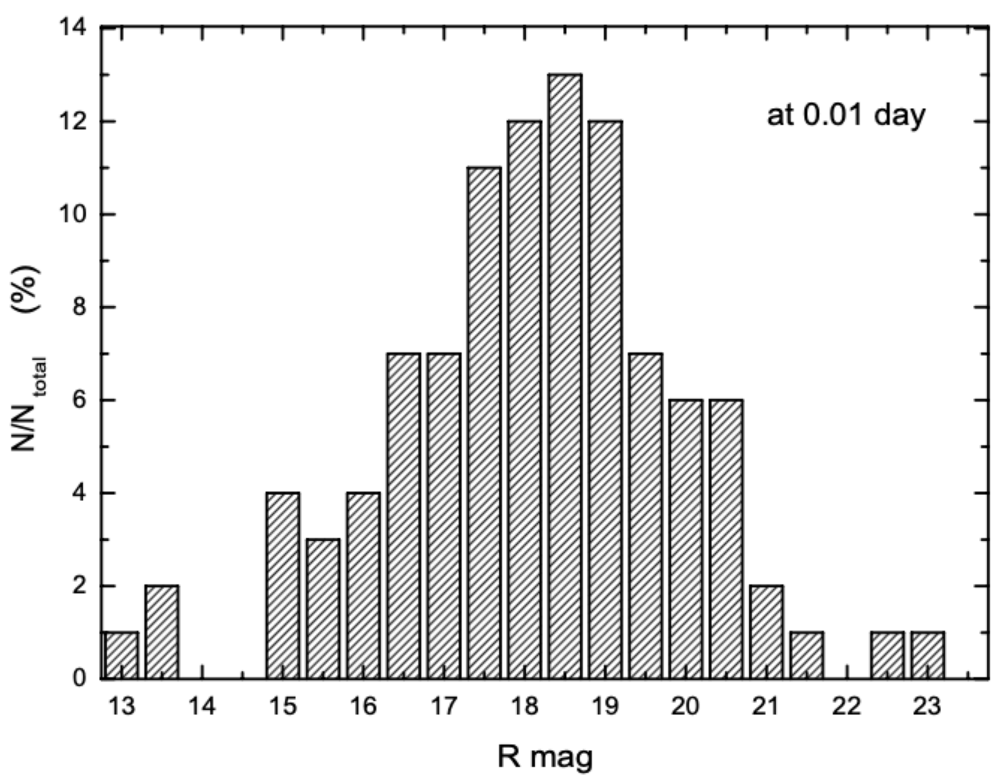
The astronomical observatories which are in condition visibility and operation can be performed follow-up observations

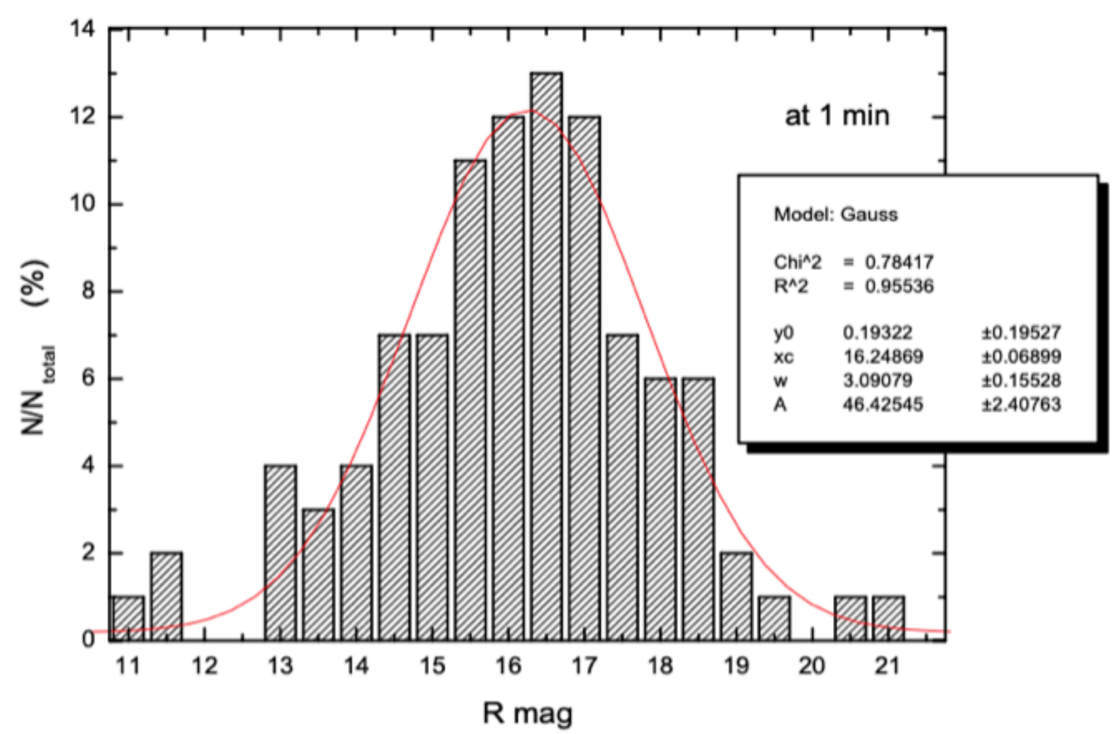
$$m(t_2) = m(t_1) + 2.5\alpha \log\left(\frac{t_2}{t_1}\right)$$

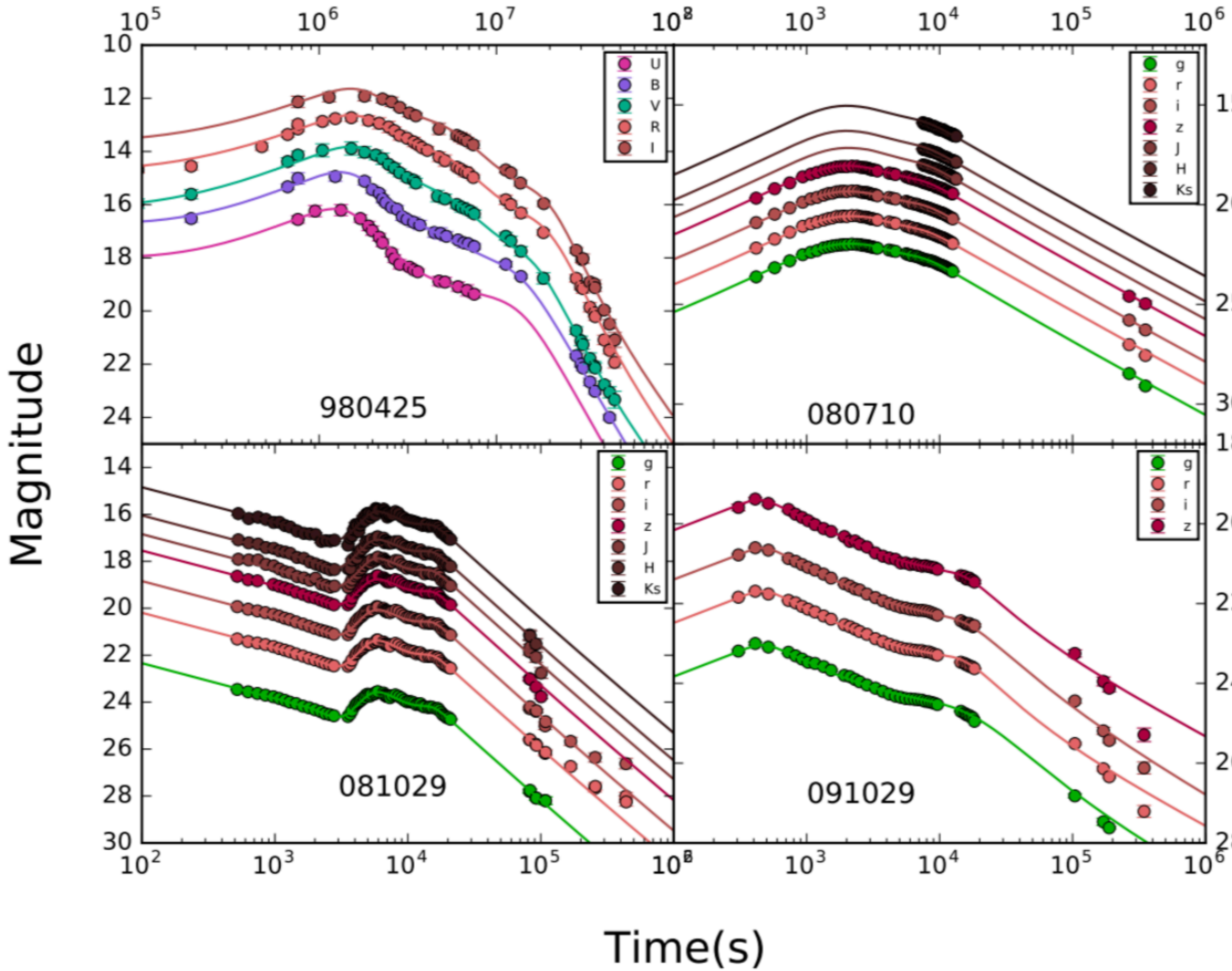
Afterglow Flux $F \propto t^{-\alpha}$ $(0.4 \lesssim \alpha \lesssim 1/4)$









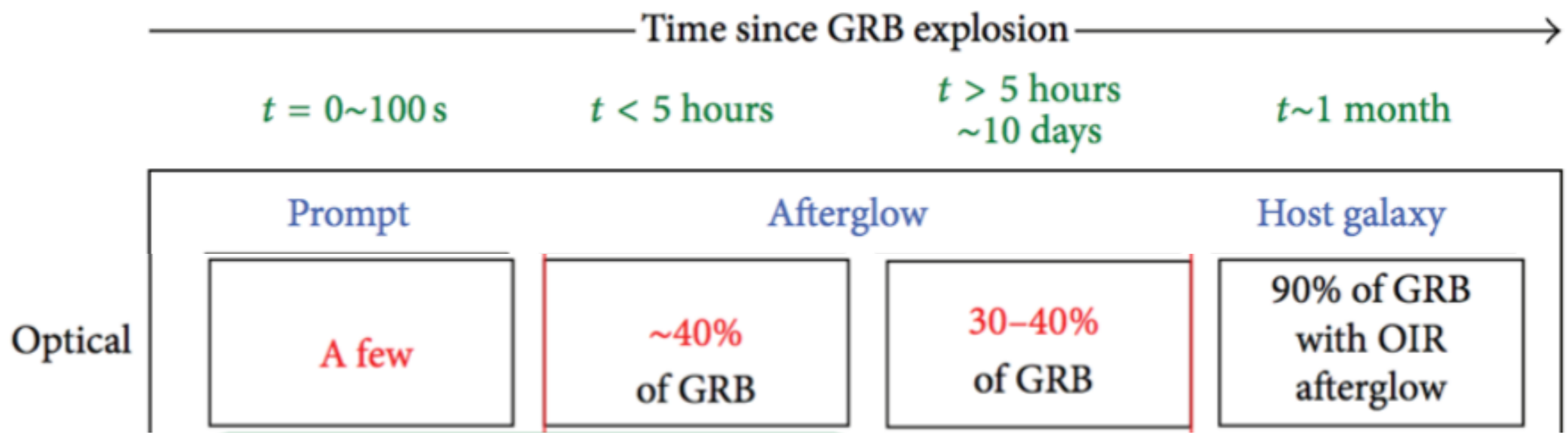

Magnitude
Time(s)
980425
080710
081029
091029
U
B
V
R
I
g
r
i
z
J
H
Ks

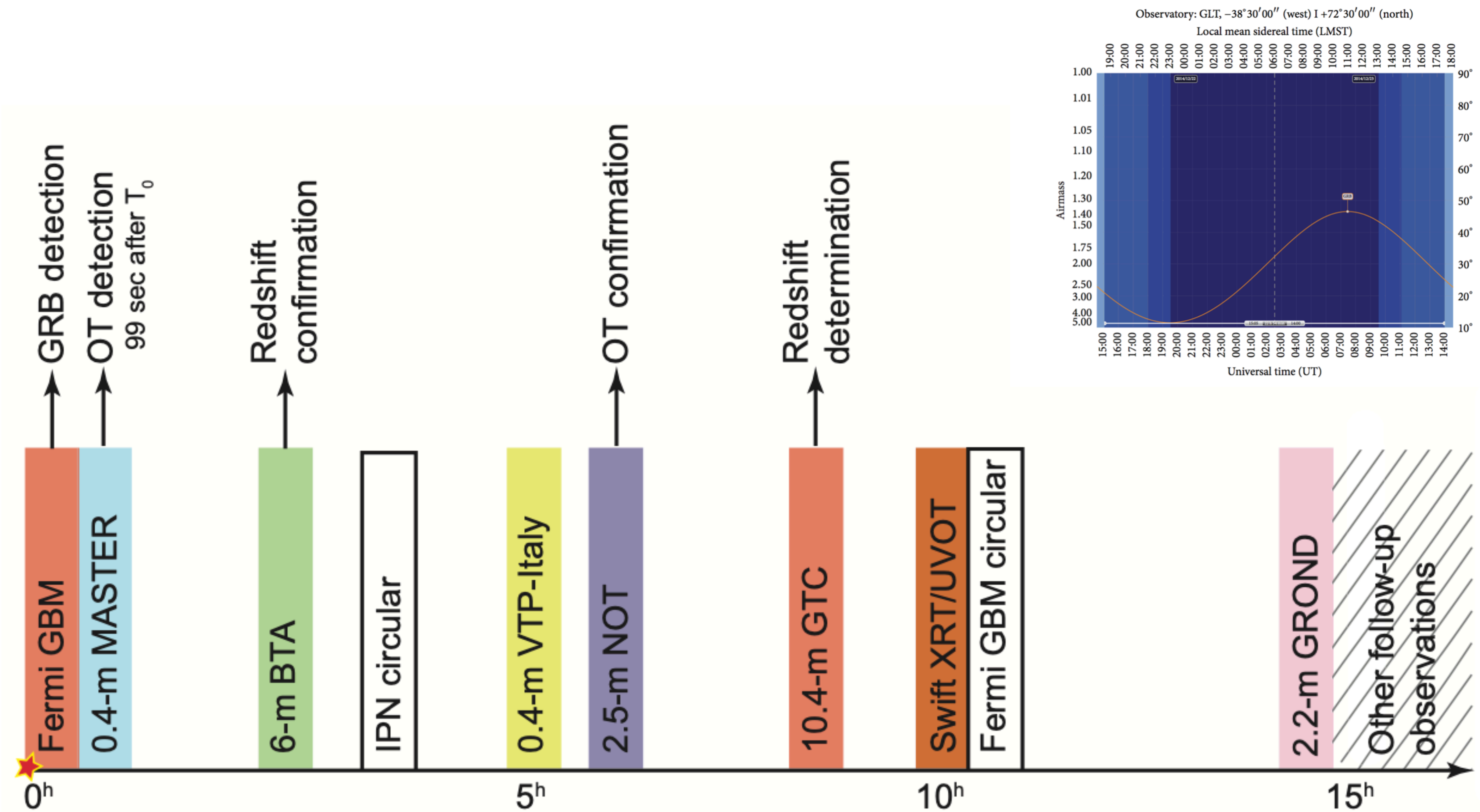
Small Telescopes: AbAO (0.2m), Kitab (0.2m), TAROT (0.25m), Challis Observatory (0.4m), Santel-400AN (0.4m), Hankasalmi Observatory (0.4m), ISON-NM (0.4m), Searchlight Observatory Network (0.4m), iTelescope T21 (0.43m), ISON-NM (0.45m), Monte Agliale Observatory (0.5m), MITSuME (0.5m), VT-50 (0.5m), GRAS 011 (0.51m), SNUO (0.6m), SOAO (0.6m), BOOTES-2 (0.6m), Burke-Gaffney (0.6m), REM (0.6m), Konkoly (0.6m), Mt John University Observatory (0.61m), Lightbuckets (0.61m), Ondrejov (0.65m), Terskol (0.65m), Abastumani Observatory AS-32 (0.7m), GIT (0.7m), HCT (0.7m), KAIT (0.76m), TNT (0.8m), Mondy (0.8m), IAC80 (0.82m), SARA-KP (0.9m).

Medium Telescopes:Nickel (1m), Siding Springs (1m), Lulin (1m), T100 (1.0m), GT-McDonald (1m), Weihai (1m), TUBITAK T100 (1m), Zadko (1m), MLO (1m), DOAO (1m), BAO (1m), Murikabushi (1m), GT (1m), SARA-RM (1.0m), TSHAO (1m), Zeiss-1000 (1m), ARIES Nainital (1.04m), Kiso Observatory (1.05m), Calar Alto (1.23m), CTIO (1.3m), PAIRITEL (1.3m), Devasthal (1.3m), TLS (1.34m), IRSF (1.4m), Kanata Telescope (1.5m), OSN (1.5m), RATIR (1.5m), Maidanak (1.5m), HJT (1.5m), Sierra Nevada (1.5m), Sayan (1.6m), Pan-STARRS 1 (1.8), Asiago Telescope (1.82m), LCO (2m), Nayuta (2m), Liverpool (2m), Tautenburg (2m), Faulks South (2m), HCT (2m), McDonald Observatory (2.1m), Xinglong (2.16m), CAHA (2.2m), MPG (2.2m), GROND (2.2m), Bok (2.3m), GMG (2.4m), NOT (2.5m), FRAM (2.5m), Newton-Sintesz (2.54m), MPG (2.2m), OAJ (2.6m), Lick Shane (3m), WIYN (3.5m), TNG (3.58m), DOT (3.6m), William Herschel (4.2m), Lowell (4.3m), DCT (4.3m).

Large Telescopes:SAO RAS (6m), BTA (6.05m), MMT (6.5m), Magellan (6.5m), Gemini-South (8m), VLT(8.2m), LBT (8.4m), GTC (10.4m).

GRB	redshift	FLUENCE	[Small Telescopes], [Medium Telescopes], [Large Telescopes]
210722A	1.145	4.37E-06	[TAROT, GIT], [RATIR], []
210619B	1.937	3.02E-04	[Konkoly, AbAO, GIT, KAIT], [Deep CAHA, NOT, Xinglong, Liverpool, TNG], [GTC, SAO RAS]
210610B	1.13	1.10E-04	[AbAO, REM, KAIT, MITSuME], [Newton-Sintesz, Liverpool], []
210610A	3.54	1.28E-06	[AbAO, KAIT, MASTER, MITSuME], [Maidanak, CAHA, RATIR, OSN], [SAO RAS]
210204A	0.876	7.57E-05	[Assy and Mondy], [DOT], []
201221D	1.046	6.36E-07	[], [DOT, LCO, Lowell, FRAM, NOT], []
201216C	1.1	1.36E-04	[Terskol, Mondy], [Liverpool, FRAM], [VLT]
201021C	1.07	1.68E-06	[TAROT, MASTER], [], [VLT]
201020B	0.804	3.41E-05	[Mondy, HCT and GIT, Konkoly, MASTER], [Maidanak, DFOT,], [GTC]
201020A	2.903	1.56E-06	[GIT, MASTER, MITSuME], [DFOT], [GTC]
200829A	1.25	2.14E-04	[Konkoly], [Liverpool], [SAO RAS]
200826A	0.7481	4.26E-06	[], [TNG, Lowell], [LBT]
200613A	1.22	4.89E-05	[Mondy, AbAO, MITSuME], [Liverpool], [SAO RAS]
200524A	1.256	1.40E-05	[MITSuME, KAIT], [OAJ, CAHA, DFOT], [SAO RAS]
191011A	1.722	8.52E-07	[MASTER], [RATIR, GROND], [VLT]
190829A	0.0785	1.54E-05	[MASTER], [Liverpool, LCO, TNG], [GTC, MMT]
190719C	2.469	7.12E-06	[], [NOT], [VLT]
190613A	2.78	3.20E-06	[Kitab and AbAO, KAIT, MASTER], [FRAM, SEDM], []
190114C	0.425	4.43E-04	[], [], [GTC]



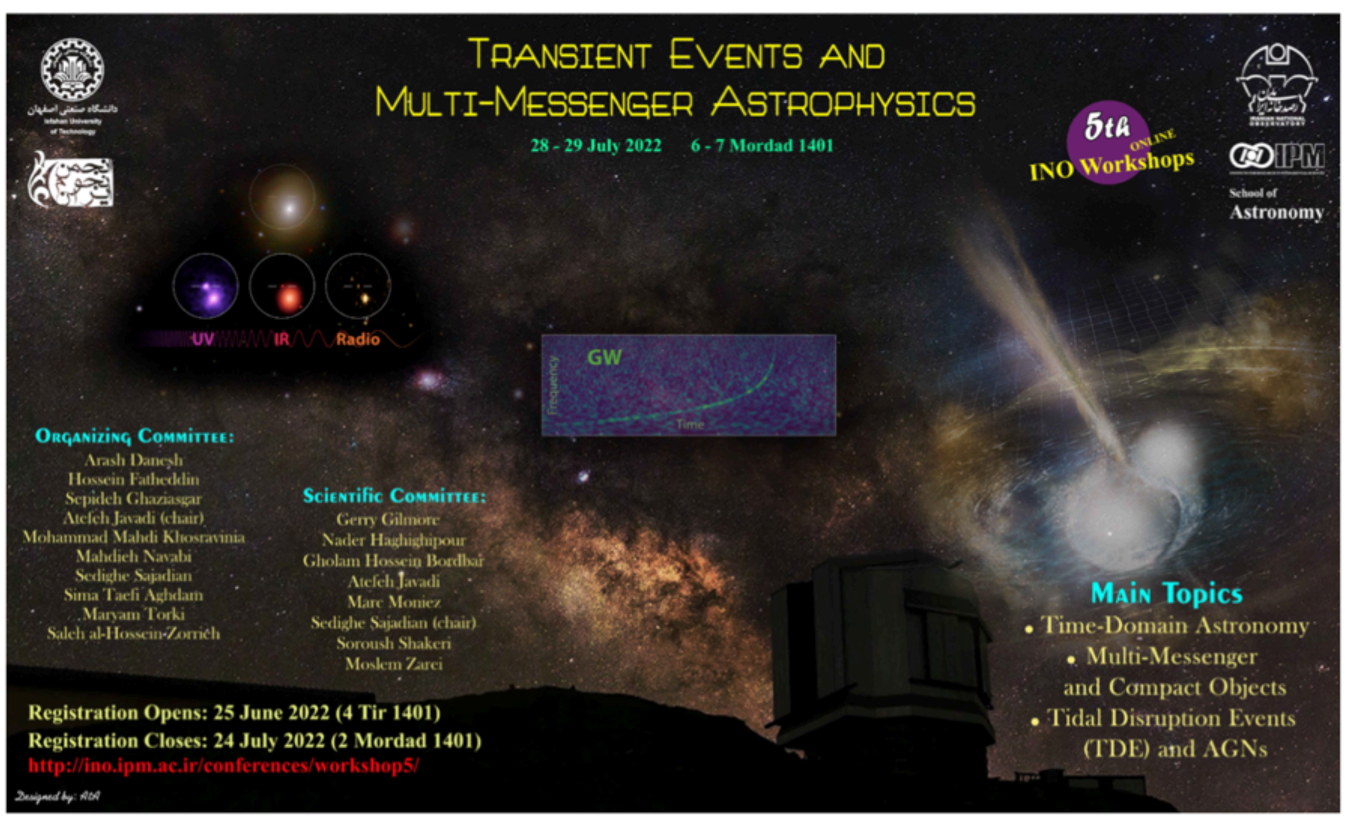


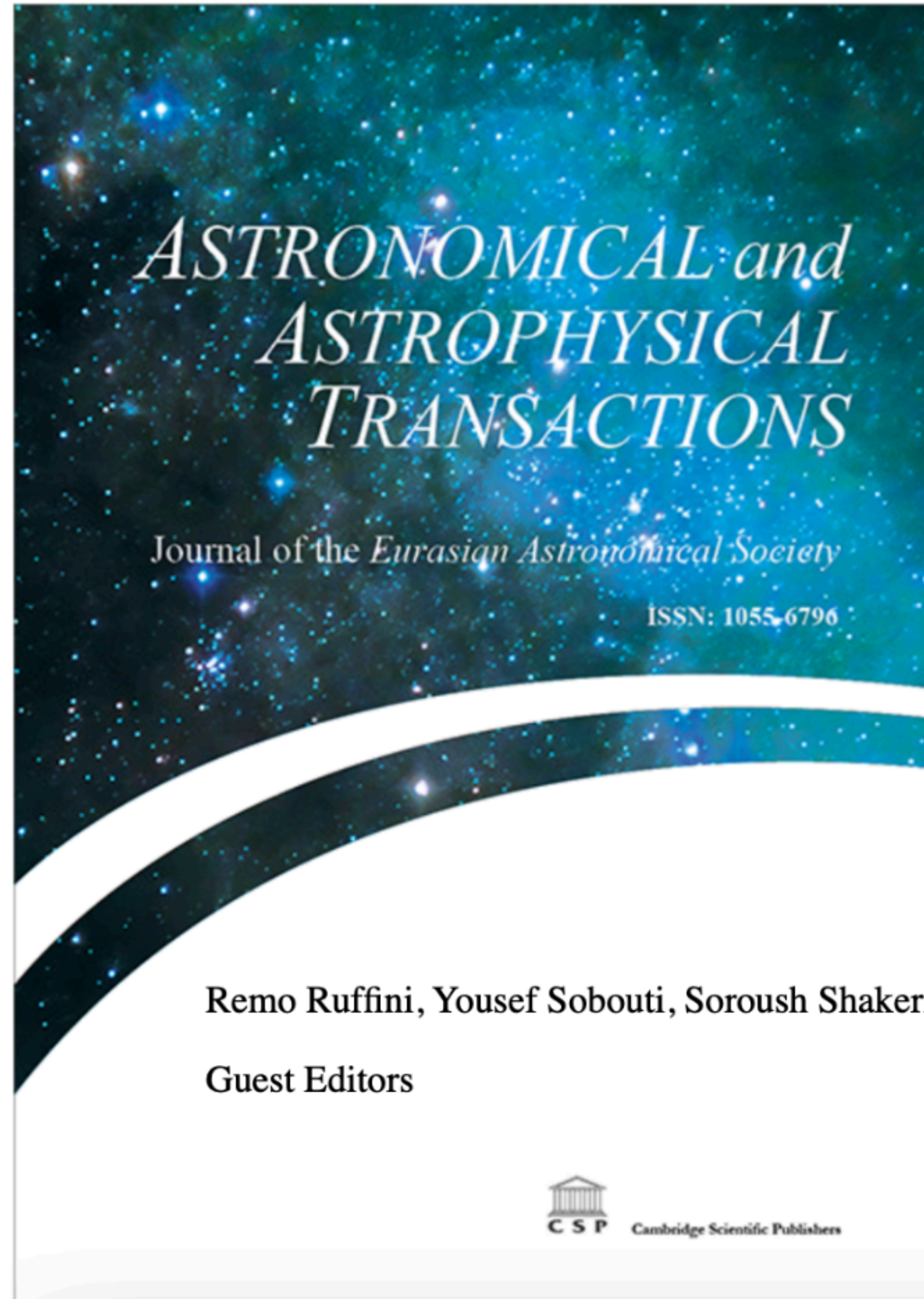
Anastasia Tsvetkova et al, 2022

GRB 140801A observation timeline

ICRANet - Isfahan Astronomy Meeting

Transient Events and Multi-Messenger Astrophysics





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