Iranian National Observatory
INO340
Achievements and Challenges

Habib Khosroshahi

Outline

- Mission and vision
- The site
- The 3.4m telescope
- The enclosure
- Mirror coating
- First Light and commissioning
- Challenges

Thanks to

Project team: M. Bidar, H. Jenab, R. Ravanmehr, M. Saeidifar, M. Mohajer, A. Behnam, H. Z. Azizi, Shalchian, T. Shokapour, A. Mirhaj, R. Mirzaee, H. Altafi, R. Shomali, A. Javadi, F. Ghaderi, A. Danesh, S. Nasiri, S. Fatemi, A. Darudi, A. Molaenezhad

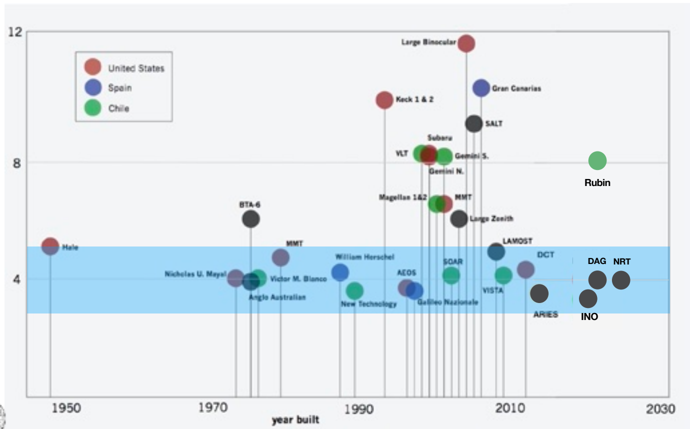
Also

G. Gilmore, L. Zago, P. Alvarez, M. Cullum, P. Salinari, B. Little, R. Ragazzoni, J. Maxwell, A. Ardeberg, D. Buckley, C. Cunnigham, M. Balcells

and

many other organizations and individuals

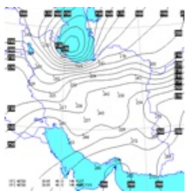
75 years with 4m class telescopes

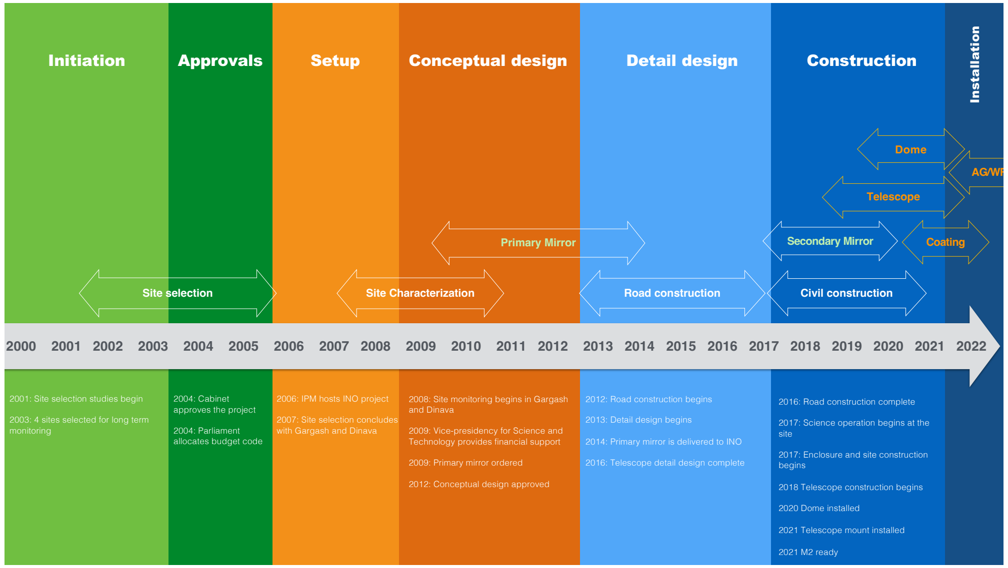


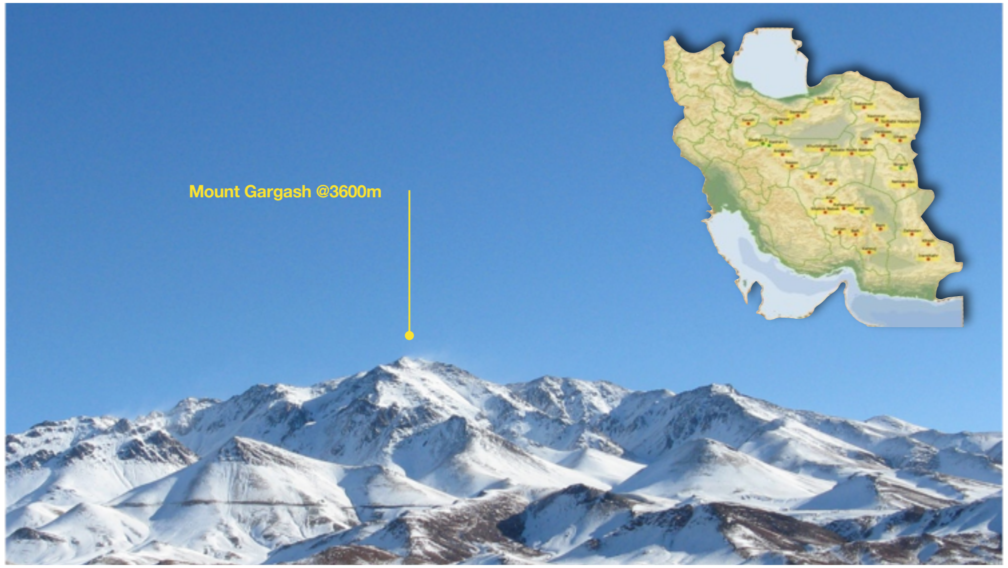
wikipedia

- Time Domain Obs
- Manageable budget
- Training platform
- Versatile
- Technology development
- Advanced Research (e.g. Instrumentation)
- Collaboration

Linking noble past to future challenges

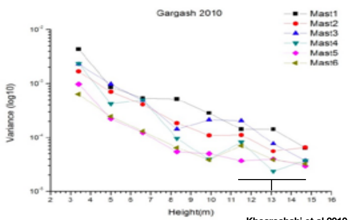




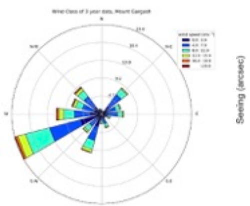


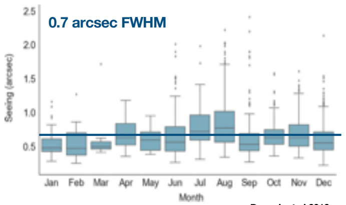
Site properties





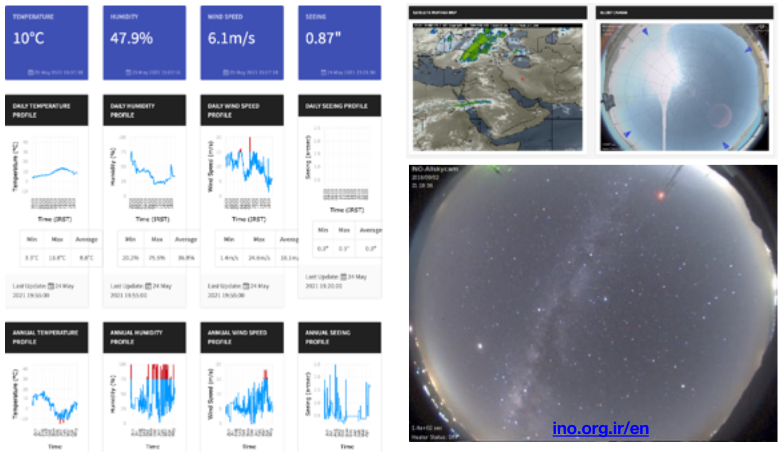
Khosroshahi et al 2010


Nasiri et al (2019)



Danesh et al 2019

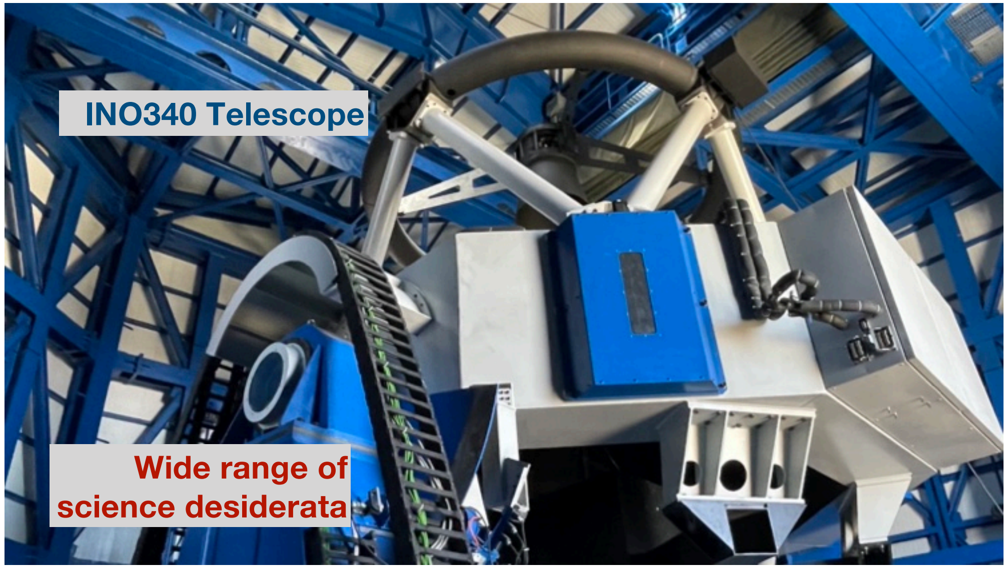
Online site data



Conceptual Design (2009-2012)

A complete observatory suite

Nature Astronomy 2018



Telescope mount specifications

Telescope pointing accuracy (pointing model)

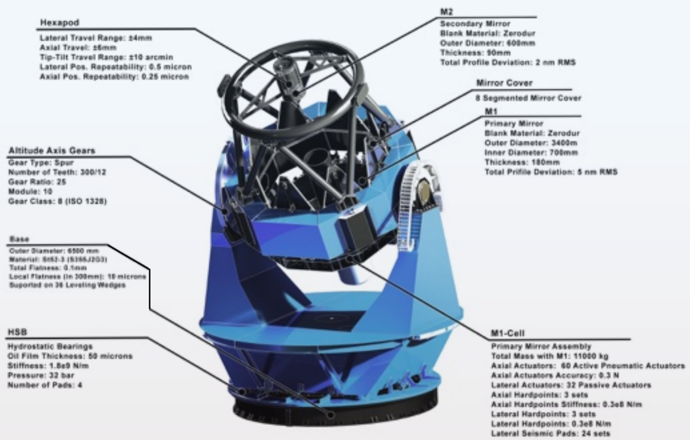
< 3 arcsec rms

Telescope tracking accuracy (unguided)

< 5 arcsec rms

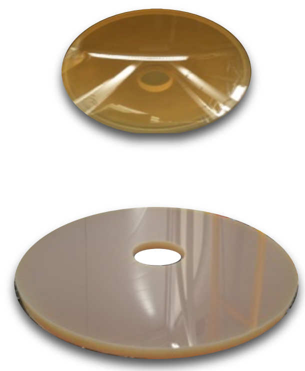
Telescope tracking accuracy (guided)

< 0.2 arcsec rms

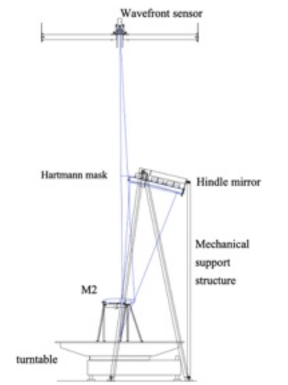


Optical specifications

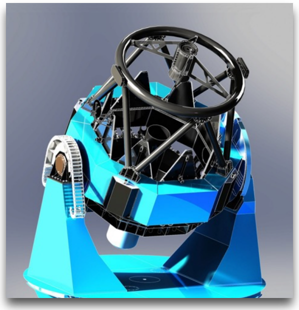
Optical arrangement	Ritchey-Chrétien
Wavelength	325-2500 nm
M1 diameter	3400/700 mm
M2 diameter	587 mm
M1/M2 blank thickness	180 mm / 60 mm
M1 f-ratio	f/1.49
Telescope f-ratio	f/11.25
Field of view	8-20 arcmin
M1/M2 blank material	ZERODUR®
Image quality	0.5 arcsec (80% ECD)
Plate scale	5.4 arcsec per mm
Surface roughness	< 2 nm

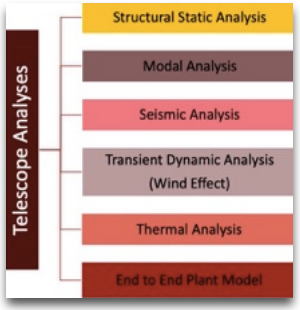


Korhonen, et al 2016



Design and development process





Manufacturing

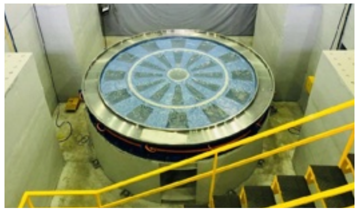

Base machining (2019)

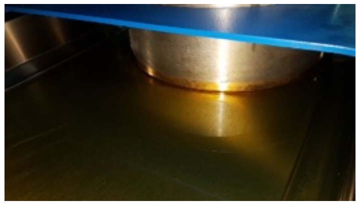

Factory installation setup (2020)


M1 cell machining (2018)

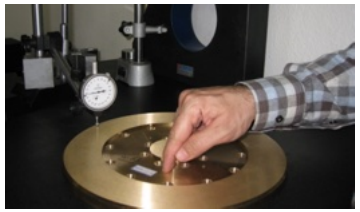
SPIE.

Hydraulic bearing system


Based installation


HSB pads under load


HSB power pack


HSB pad control

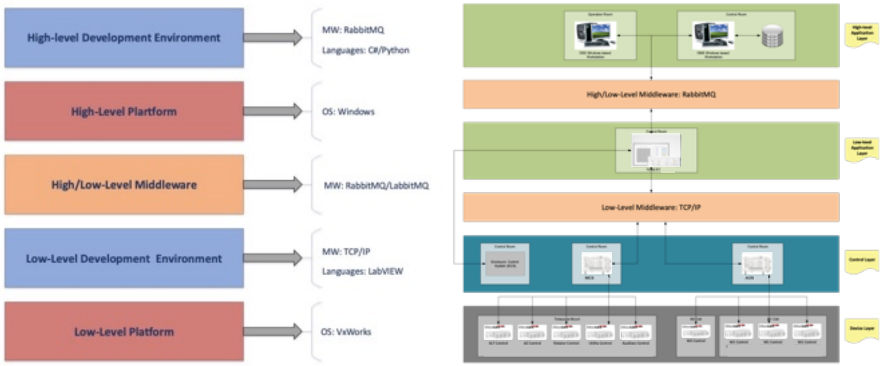
Factory assembly

Factory Assembly

The FAT was limited to mechanical alignment, full mount installation, electrical and piping, M1 cell and axial support, rotator assembly, mirror covers and the two motion test.

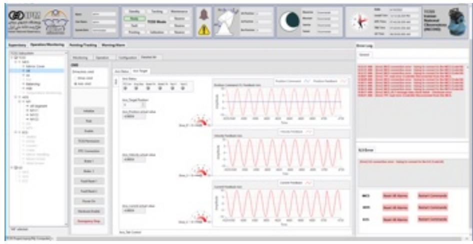
SPIE.

Control System Physical View

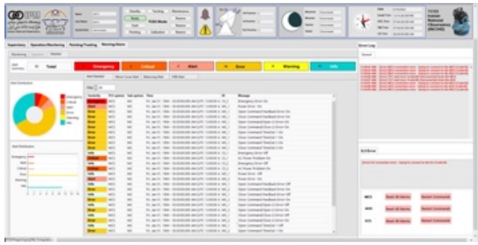


SPIE.

TCSS software



Telescope control system supervisory provides a complete control on the telescope and dome subsystems, such as the MCS, AOS, ECS.

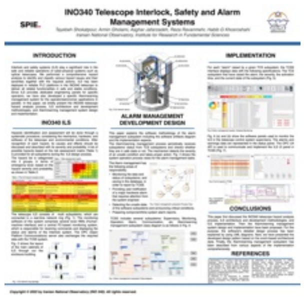


A logging system records and displays the performance of the system.

SPIE.

Interlock system

All subsystems have their own interlock system to prevent damage to personnel and equipments. The interlock system is developed based on PLC.



See poster the presentation for details

Enclosure / dome design drivers

Minimum enclosed air

Ground layer turbulence

Effective air flushing

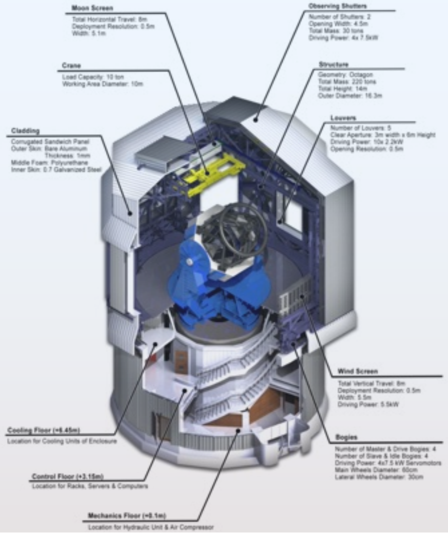
Mirror handling

Temperature/humidity control

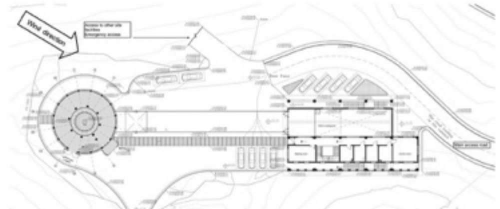
Active cooling

Staff and equipment safety

Installation / Operation

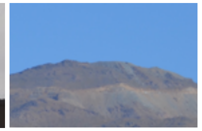


Civil construction



Site plan

Mountain Top Flattening



Geo-technical tests

Road construction

Access road 11.5 km

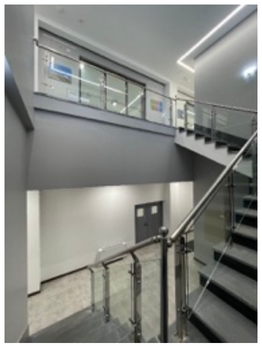
Dome installation

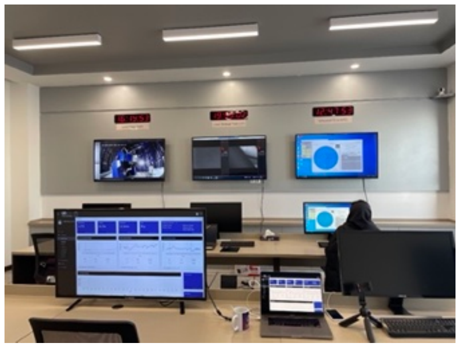
June-August 2020

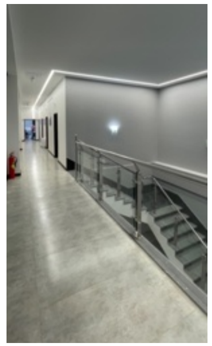
June 2020

June 2021

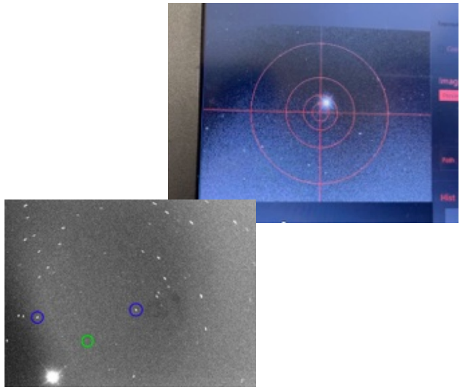
Buildings operational







Pointing and tracking tests

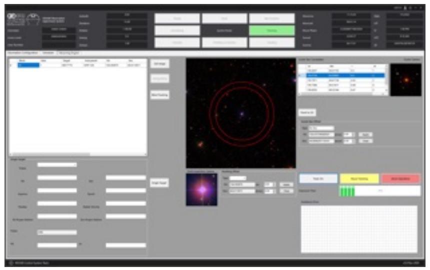


On the sky, the unassisted tracking accuracy is 1.5 arcsec over a duration of 200s.

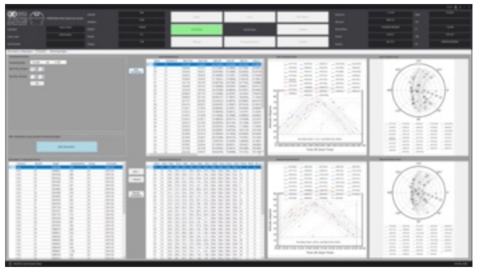
	Command V (″/s)	Ave. V (″/s)	STD V
Test 1	1	1.00005	0.0386
Test 2	15	15.00667	0.159
Test 3	35	35.00096	0.217

Tracking at ~0.1 arcsec RMS on both axes (encoder level)

OSS software



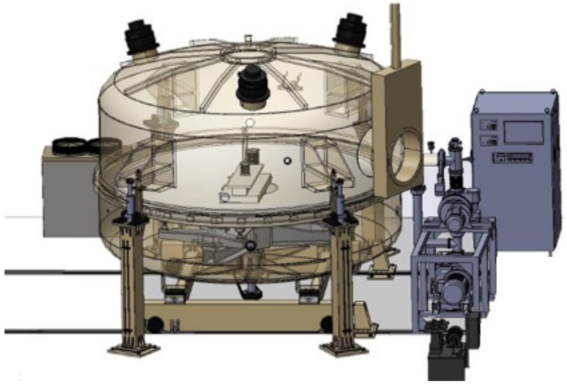
Observers are able to point the telescope manually to their desired target and blocks or upload their target list and scripts.



OSS scheduler will be used to utilise the observations in survey modes. The scheduler can make short and long scheduling by minimising the overhead.

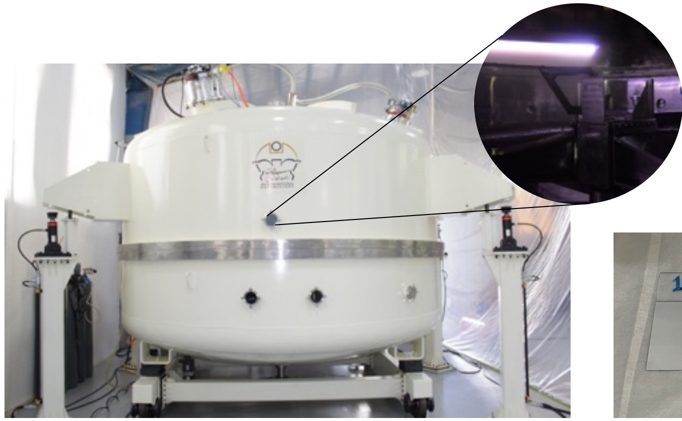
Mirror Aluminizing

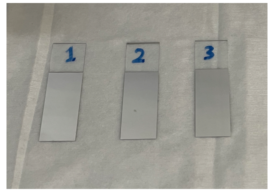
NOT public



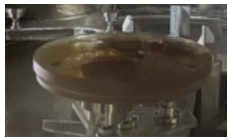
Chamber diameter	390 cm
Chamber height	280 cm
Material	Stainless steel, polished interior
Mirror support	Rotating without wiffletree
Coating type	Sputtering (DC Magnetron)
Target dimmension	170 cm x 20 cm
Vacuum pumps	Dry screw 600 m³/h
	Roots 2000 m³/h
	Turbo 3200 l/s x 3
Coating thickness	~100 nm
Coating uniformity	5%
Vacuum level	2×10^{-6} mbar

Mirror Aluminizing





Mirror Aluminizing



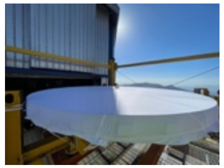
M2 blank inside coating chamber

M2 Aluminized

M1 prepared for coating

M1 Aluminized

Integration of all sub-systems

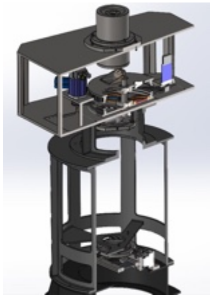


Instrument adapter, A/G & WFS

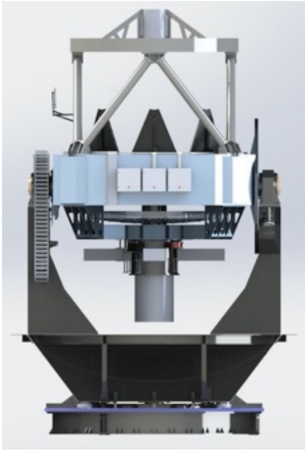
Instrumentation plan

Phase I:
Commissioning Camera

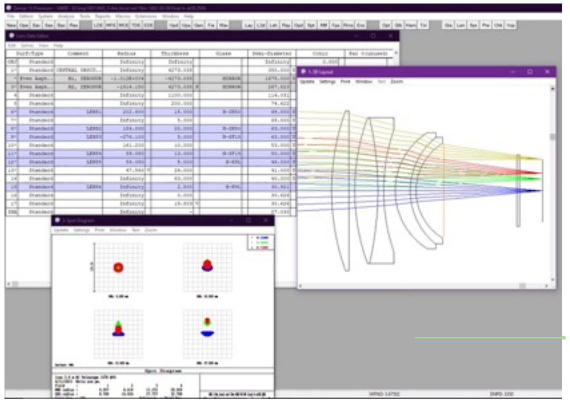
Phase II:
Imaging camera (FoV 4 arcmin)
Medium/Low resolution Slit Spectrograph



Phase III:
Wide field Imaging camera (FoV 20 arcmin)
Multi-object / IFU spectrograph

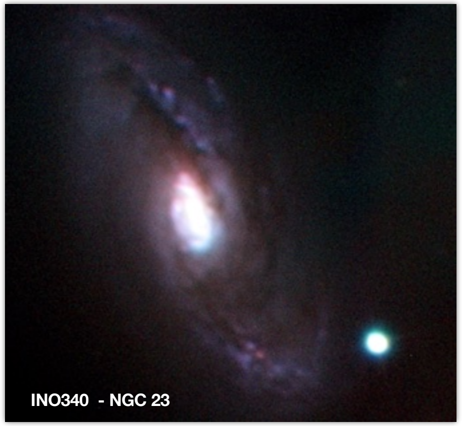


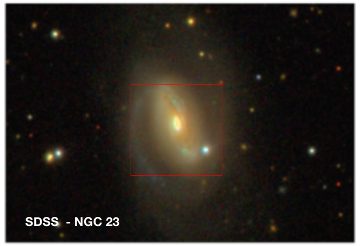
Focal Reducer



NOT public

The first light





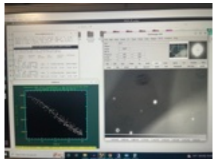


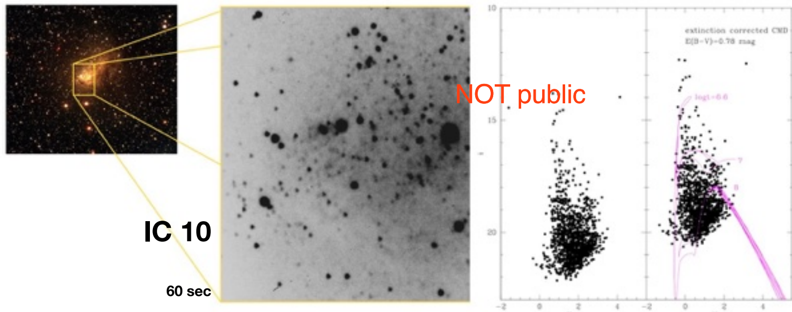
Image FWHM
0.7 arcsec

28 Sept 2022 @20:30

Reference Observations

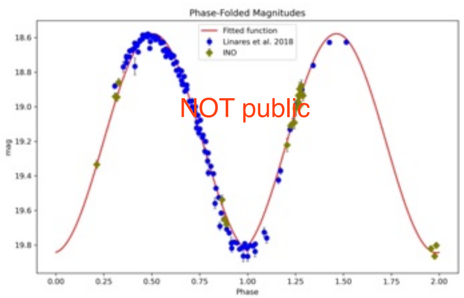
M78 **NGC2342**

Reference Observations



INT 600s INO 300s

Reference Observations



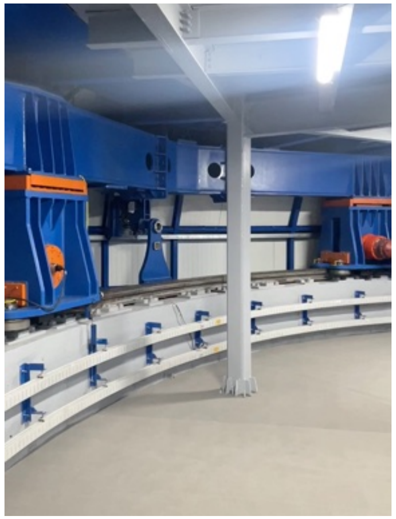
We observed a millisecond pulsar companion (black widow PSR J2215) which is actively absorbing its companion's atmosphere.

The orbital period is 4.1 hours, and during the day and night phases of the companion star, it experiences a brightness variation of approximately 1.2 magnitudes.

This neutron star, with an estimated mass of 2.2 solar masses, is an excellent candidate for studying objects on the brink of collapsing into black holes.

Our observations were conducted in 2023 during commissioning and again in summer 2024, capturing a full orbital phase in the i', r', and g' filters with 100 sec exposure time.

Current plot is showing a few data for quality check, but the full data are more than 300 data points in each filter.



Challenges

Instrumentation: It has been challenging to acquire high grade CCDs for our planned instrumentation.

Competitive science programme: Limited or lack of funding has played a role in slow progress in developing science programme to fully utilise the telescope potentials (also linked to the instrumentation)

We can benefit from joining Observatory/Astronomy Alliances and happy to contribute by making INO340 available.

Learn from Experience: e.g. SAAO

Benefits of joining active Observatory Alliance

• **Time Allocation and Access**: INO to participate and offer observation time.

• **Instrument Sharing/Development**: Hosting visiting instruments from participating observatories. Developing low-cost instruments for the small telescopes.

• **Multi-messenger and Time-Domain Astronomy**: Participation in coordinated, global time-domain observational networks.

• **Remote Observing**: Collaboration on remote observing techniques and dynamic scheduling algorithms.

• **Joint Training**: Participation in training programs to build technical capacity.

• **Coordinated Observations**: Utilising geographic proximity for 24-hour observations and continuous monitoring.

A Trans-Eurasian Alliance?

DOT, INO, DAG + EU / BRICS / GLOBAL Alliances

Coordinated Observations: Due to our geographic distribution, we could collaborate on continuous monitoring of astronomical events, allowing us to observe transient phenomena more effectively.

Shared Expertise: Our telescopes have been optimised for specific but overlapping wavelength regimes. By pooling our knowledge and resources, we can share insights on operational and technical challenges and enhance the efficiency.

Joint Astronomical Research and Education: Through collaboration, we can promote high-impact research in various fields of astronomy. This alliance can also foster educational initiatives, enabling the training of young astronomers.

Future Projects: By working together, we can identify opportunities for the development of future telescopes and astronomical infrastructure, potentially expanding our joint capabilities.

International Forums and Advocacy: A unified effort will allow us to present a stronger voice in international astronomy forums, influencing policy, research directions, and funding opportunities. We can collaborate to advocate for astronomy's development on the global stage.

Technology Development: Our alliance can focus on joint efforts in developing advanced instrumentation, data processing techniques, and technological innovation, benefiting all our observatories and contributing to global astronomical progress.

INO capabilities

Mechanical Design

Control System

Software

Flexible Scheduling

Site monitoring and weather alerts

Machine Learning

***INO340 Project overview*,** Khosroshahi, Habib G.; et al , 2016, SPIE, 9906E, 15K

***INO340 Active Optics System Design and Development* ;** Mahdi Saeidifar, Mohammadreza Rostamian, Tayebeh Shokatpour, Habib G. Khosroshahi, et al , 2022, Proc. SPIE. 12182, Groundbased and Airborne Telescopes IX

INO340 Active Optics Algorithm ; Mahdi Saeidifar, Habib G. Khosroshahi, et al , 2022, Proc. SPIE. 12182, Ground-based and Airborne Telescopes IX

INO340 Telescope Interlock, Safety and Alarm Management Systems Tayebeh Shokatpour, Armin Gholami, Asghar Jafarzadeh, Reza Ravanmehr, Habib G Khosroshahi, 2022, Proc. SPIE. 12189, Software and Cyberinfrastructure for Astronomy VII

Iranian National Observatory; project overview and achievements Habib G. Khosroshahi, et al , 2022, Proc. SPIE. 9906, Ground-based and Airborne Telescopes V

INO340 Telescope end-to-end simulations and performance analysis A. Jafarzadeh, R. Sadeghi-Amin, L. Zago, R. Ravanmehr, H. G. Khosroshahi, M. Rostamian, 2022, Proc. SPIE. 12187, Modelling, Systems Engineering, and Project Management for Astronomy X

Performance analysis of the wavefront sensor in the active correction of the INO340 Telescope R. Shomali, H. Khosroshahi, et al , 2002, Proc. SPIE. 12182, Ground- based and Airborne Telescopes IX