Current and future observational and instrumentation facilities in India



Devendra K. Ojha (ojha@tifr.res.in)
Tata Institute of Fundamental Research
(TIFR), Mumbai, India

Outline

✓ Ground-based Optical/IR facilities in India

✓ National Large Optical Telescope (NLOT) project

✓ Infrared Instrumentation (ground- and balloon-based) at TIFR


HCT
DOT
USO
Sampurnanand Telescope
Mount Abu
GMRT
IGO
Gauribidanur telescope
ORT
Kodaikanal Observatory
VBO
LADAKH
Srinagar
Leh
JAMMU & KASHMIR
Jammu
HIMACHAL PRADESH
PUNJAB
Chandigarh
UTTARAKHAND
HARYANA
DELHI
New Delhi
NEPAL
SIKKIM
BHUTAN
UTTAR PRADESH
Jaipur
RAJASTHAN
Lucknow
BIHAR
Patna
ASSAM
MEGHALAYA
BANGLADESH
MANIPUR
JHARKHAND
WEST BENGAL
TRIPURA
MIZORAM
Ranchi
Kolkata
Agartala
Bhopal
MADHYA PRADESH
GUJARAT
Daman
Silvassa
DADRA & NAGAR HAVELI
MAHARASHTRA
Mumbai
TELANGANA
Hyderabad
ANDHRA PRADESH
Amaravati
Panaji
GOA
KARNATAKA
Bengaluru
Mahe (Puducherry)
Kavaratti
Thiruvananthapuram
INDIAN


INDIA
States and Union Territories
HANLE: 4500-m; 2-meter
Devasthal 2500m;
3.6 meter
Mt. Abu
1.2-meter
2.5-meter
IUCAA
Pune, 1000m
2-meter
IIA, 1000m; 2.3-meter
PAKISTAN
NEPAL
BHUTAN
MYANMAR
BANGLADESH
BAY OF BENGAL
JAMMU & KASHMIR
Srinagar
Shimla
Chandigarh
PUNJAB
UTTARANCHAL
Dehradun
DELHI
HARYANA
RAJASTHAN
Jaipur
UTTAR PRADESH
Lucknow
Gangtok
Itanagar
ASSAM
Dispur
NAGALAND
Kohima
Shillong
Patna
BIHAR
Imphal
MANIPUR
MEGHALAYA
Agartala
TRIPURA
Aizawl
MIZORAM
GUJARAT
Gandhinagar
Bhopal
MADHYA PRADESH
Ranchi
JHARKHAND
WEST BENGAL
Calcutta
CHHATTISGARH
Raipur
ORISSA
Bhubaneshwar
DIU
DAMAN
DADAR & NAGAR HAVELI
MAHARASHTRA
Mumbai (Bombay)
Hyderabad
ANDHRA PRADESH
YANAM (Pondicherry)
KARNATAKA
Bangalore
Chennai (Madras)
PONDICHERRY (Puduchchery)
KARAIKAL (Pondicherry)
TAMILNADU
LAKSHADWEEP
MAHE (Pondicherry)
KERALA
Thiruvananthapuram
Port Blair
ANDAMAN & NICOBAR ISLANDS
N
Map not to Scale
Copyright © Compare Infobase Pvt. Ltd. 2006

Indian Astronomical Observatory

https://www.iiap.res.in/centers/iao/

SITE for the future big Telescopes in India

29 August 2001

IIA, Hanle (Ladakh)
Altitude ~ 4500 meters

HFOSC - Hanle Faint Object Spectrograph Camera
TIRSPEC - TIFR Near Infrared Spectrometer and Imager
HESP - Hanle echelle spectrograph

2m HCT





Median seeing ~ 1.0 arcsec
More than 260 clear nights Precipitable < 2 mm between October and April
Dry site (Annual precipitation of rain & snow< 7 cm)

22 m Imaging Cherenkov Telescope (MACE)

High Altitude Gamma Ray Telescope (HAGAR)

Devasthal Observatory

2016

ARIES, Nainital
Altitude ~ 2540 meters

TANSPEC: TIFR-ARIES Near Infrared Spectrometer
TIRCAM2: TIFR Near Infrared Imaging Camera - II
SPIM: Side-Port Imager
IMAGER
ADFOSC: ARIES Devasthal Faint Object Spectrograph and Camera



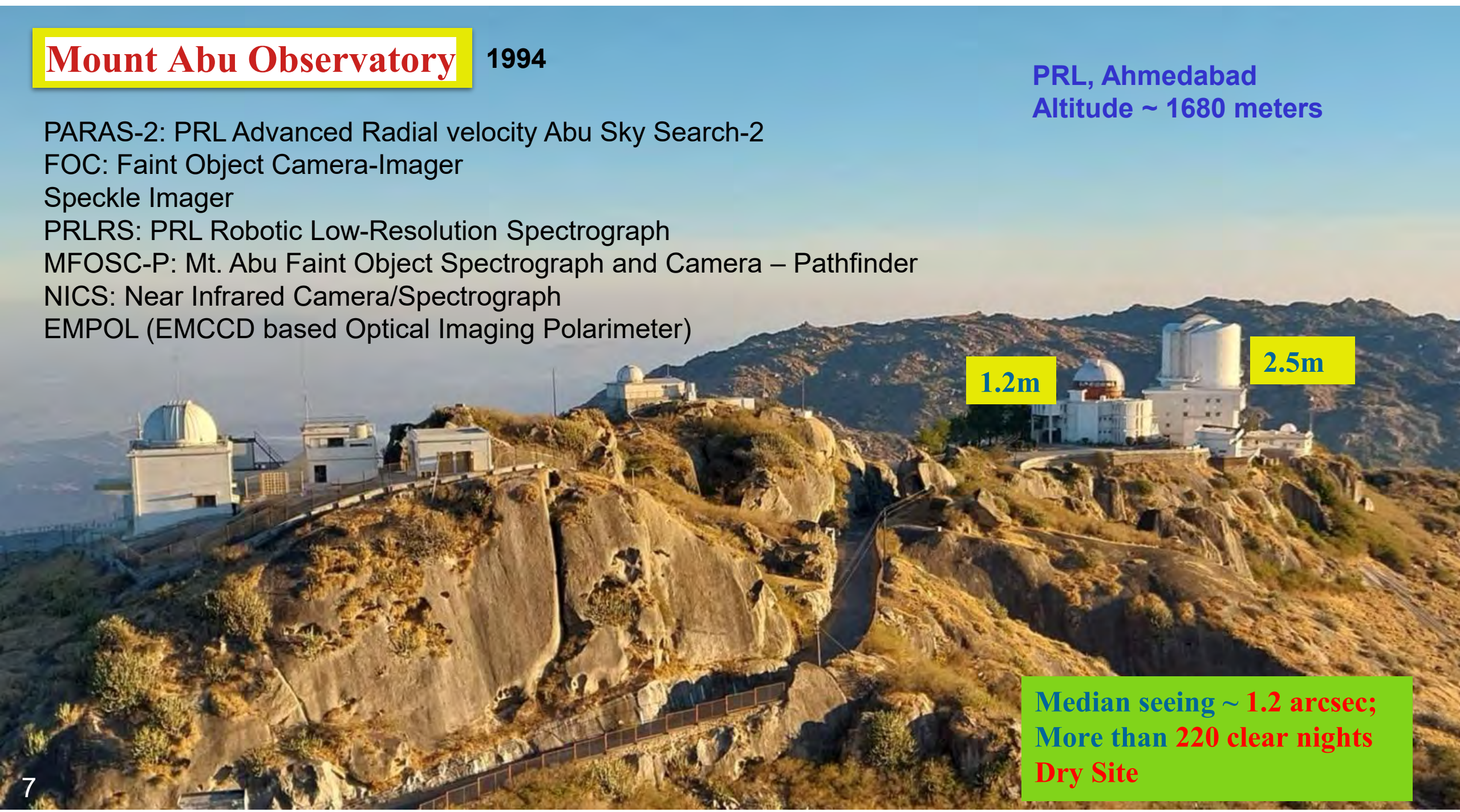
Median seeing ~ 1.1 arcsec; <1 arcsec ~ 40 % of time
Minimum seeing ~ 0.5 arcsec at 11 m height
More than 200 clear nights
< 3 mm of precipitable water vapour for 64 % of the time.
Relative humidity <60% during spectroscopic nights.

Mount Abu Observatory

1994

PRL, Ahmedabad
Altitude ~ 1680 meters

PARAS-2: PRL Advanced Radial velocity Abu Sky Search-2
FOC: Faint Object Camera-Imager
Speckle Imager
PRLRS: PRL Robotic Low-Resolution Spectrograph
MFOSC-P: Mt. Abu Faint Object Spectrograph and Camera – Pathfinder
NICS: Near Infrared Camera/Spectrograph
EMPOL (EMCCD based Optical Imaging Polarimeter)

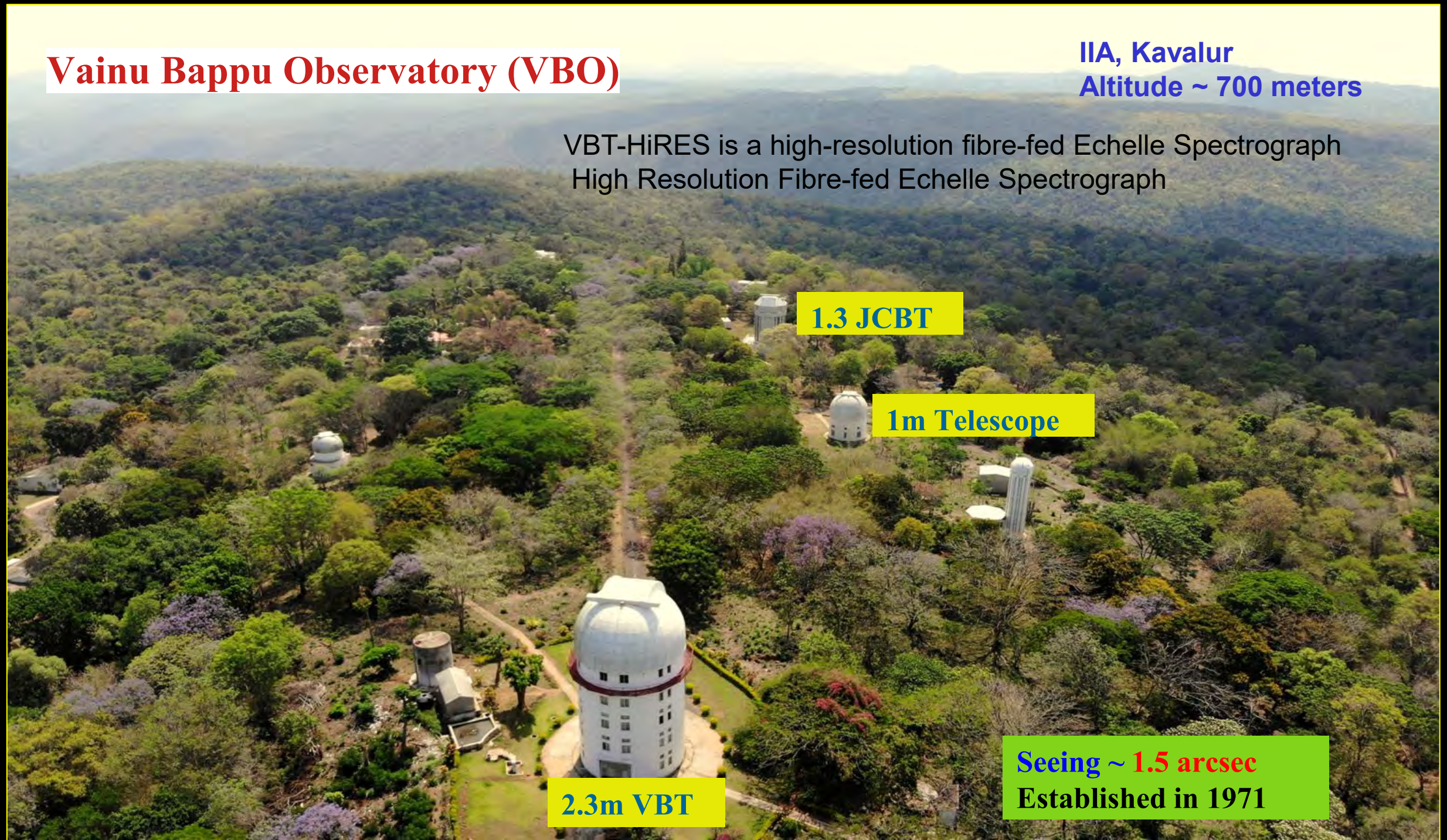


Median seeing ~ 1.2 arcsec;
More than 220 clear nights
Dry Site

Vainu Bappu Observatory (VBO)

IIA, Kavalur
Altitude ~ 700 meters

VBT-HiRES is a high-resolution fibre-fed Echelle Spectrograph
High Resolution Fibre-fed Echelle Spectrograph



Optical/IR telescopes in India and Rest of the World: a chronological summary

India is far behind the rest of the world as far as access to state-of-the-art optical astronomy facilities are concerned.

Period	India	Global
Before 1960	—	1-5m class telescopes (USA and Europe): 1m Yerkes, 2.5m Mount-Wilson, 5.1m Hale Telescope (Palomar)
1960–1980	1m class telescopes: Japal Rangapur Obs. (1.2m:1968), UPSO-ST (1m:1972), VBO (1m:1972)	4-6m facilities: CFHT (3.6m), UKIRT(3.8m IR), 6m Russian telescope, AAT (3.9m) (USA, Europe, Australia, Canada)
1980–1990	1-2m class facilities: VBT (2.34m:1986)	4-6m class telescopes (UK, USA, Australia, Russia, Europe), Hubble Space Telescope (2.4m)
1990–2000	1-2m class facilities	8-10m class facilities: 2 Keck (USA, Canada), 4 VLTs (EU), Gemini South, North (USA, Canada, Chile, Brazil, UK, Argentina, Australia)
2000–2010	1-2m class facilities: HCT (2m:2000), IGO (2m:2005)	More 8-10m telescopes: 8m Subaru (Japan), 10m HET (USA, Germany), 11m SALT (South Africa, USA, Europe, India), 10m GTC (USA, Spain, Mexico, ESO)
2010–2020	2-4m class facilities: HCT, 3.6m Devasthal Optical Telescope (DOT:2014)	8-10m class telescopes, Network of 1m class telescopes dedicated for transient surveys and follow-up, 8m wide-field survey telescope (Vera C.Rubin - LSST)
2020–2040	2-4m class facilities: PRL 2.5m(2022), 4m ILMT (2022)	10m Mauna Kea Spectroscopic Explorer, 25-40m telescope facilities: GMT (25m) (USA, Australia, South Korea), TMT (30m) (USA, Canada, Japan, India, China) and EELT (39m) (14 European countries - ESO).

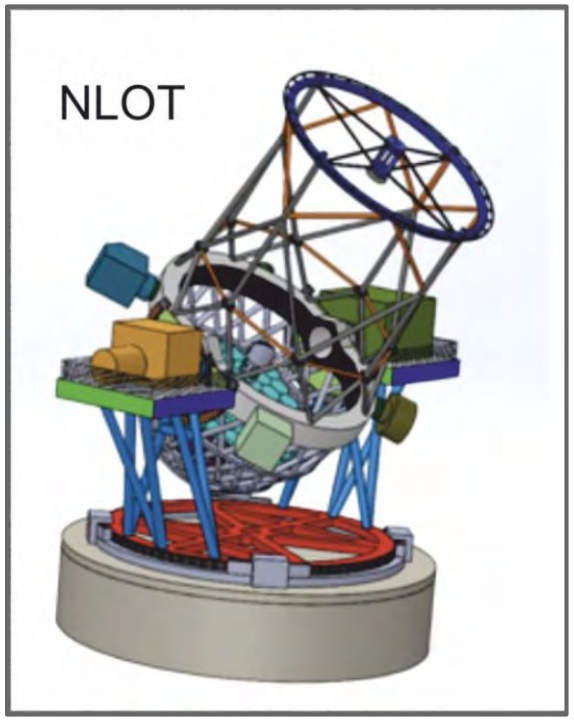
Current Mega Science Involvement (India already a Partner)





National Mega Science Projects: highest priority

National Large Optical/IR Telescope (NLOT)



A 10-12 meter class telescope

A major recommendation of the ASI Vision 2024 document as well

'A 10-12–meter class telescope in India, the National Large Optical-IR Telescope (NLOT), has been identified as the need of the hour for Indian astronomers.....However, there is no 10-meter class telescope in Asia or Australia. A 10-12–meter class telescope in India, at a good site like Hanle, would fill the 'longitudinal gap', and would be crucial for multi-messenger and time-domain science.'

.....ASI Vision Document, 2024

Background & Current Status

Discussion meeting on NLOT during the annual meeting of the Astronomical Society of India (ASI) in 2019 and 2024

Highest priority project in Mega Science Vision 2035 and ASI Vision (2024) documents

A core NLOT team with representatives from all Astronomy Institutes in the country set up on November 2023

Currently working on the DPR

Leveraging the facilities, expertise, industrial partnerships, and established supply chains developed through the Thirty Meter Telescope (TMT) project.

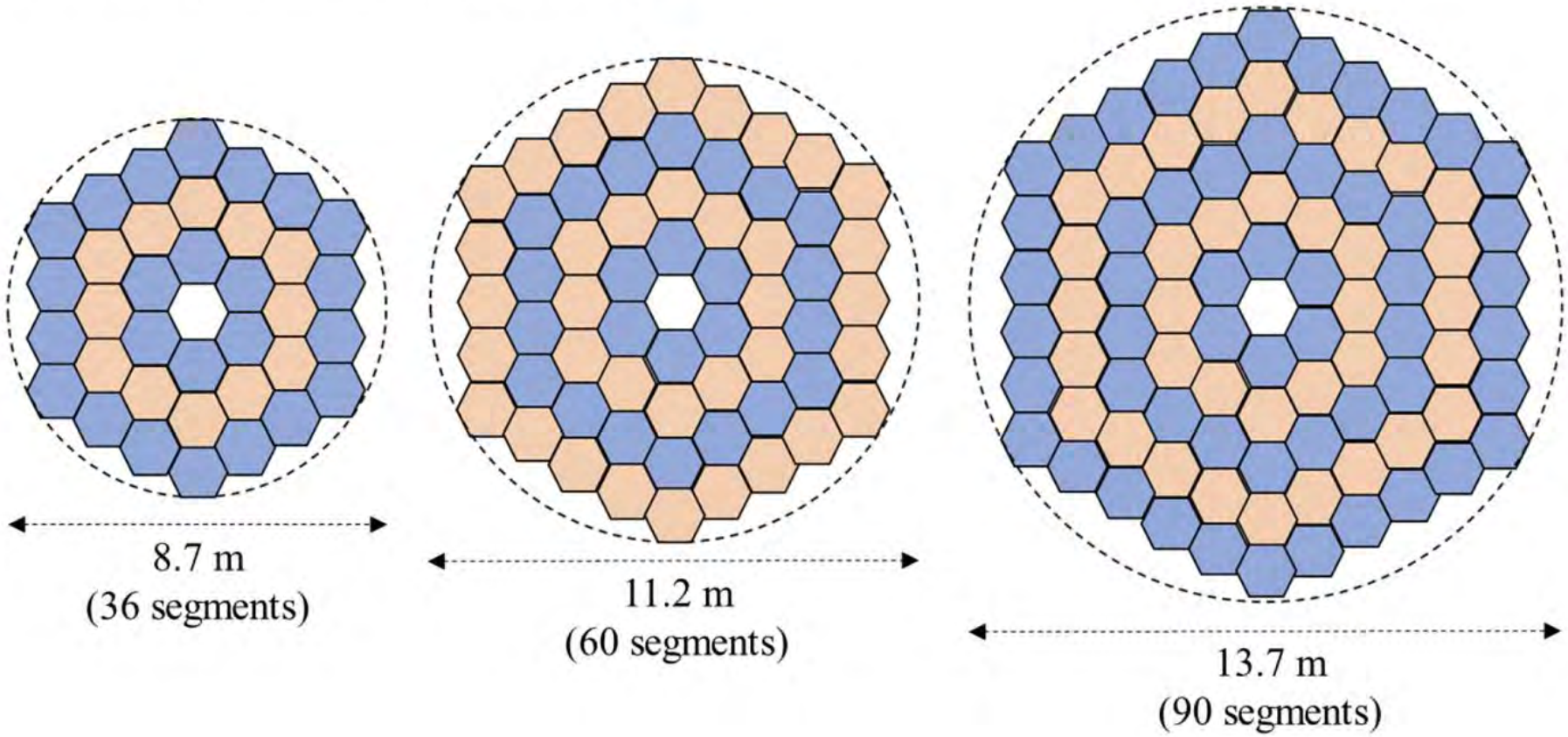
Leveraging TMT heritage

Telescope Aperture	No. of segments	Construction Cost* (Base 2025) (Crores)	Construction Time** (Years)
8.7 m	36 (3 rings)	~980	T0+8
11.2 m	60 (4 rings)	~1250	T0+10
13.7 m	90 (5 rings)	~1650	T0+12

Details of the project costing are given in Appendix C.

***Details of the project timeline are given in Appendix B*

1.44 m mirror segment



NLOT: Salient Features:

The Project Highlight

- First indigenously build big aperture telescope
- First segmented mirror telescope of India
- To be build by Academia-Industry partnership
- >60% project cost to be spent within industry & MSMEs

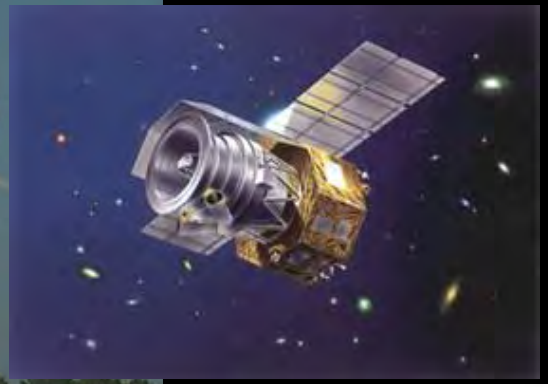
The Site – IAO, Hanle

- Highest telescope site in the world
- Already available Infrastructure
- Wavelength coverage – 300 nm – 25 microns
- Trans-Himalayan Region – less affected by monsoon
- Minimal light pollution: Designated as India's first Dark Sky Reserve
- ~2500 hours of uninterrupted observing hours
- Advantage of longitudinal coverage for transient research
- Latitudinal advantage: Tapping unexplored Northern Hemisphere sky

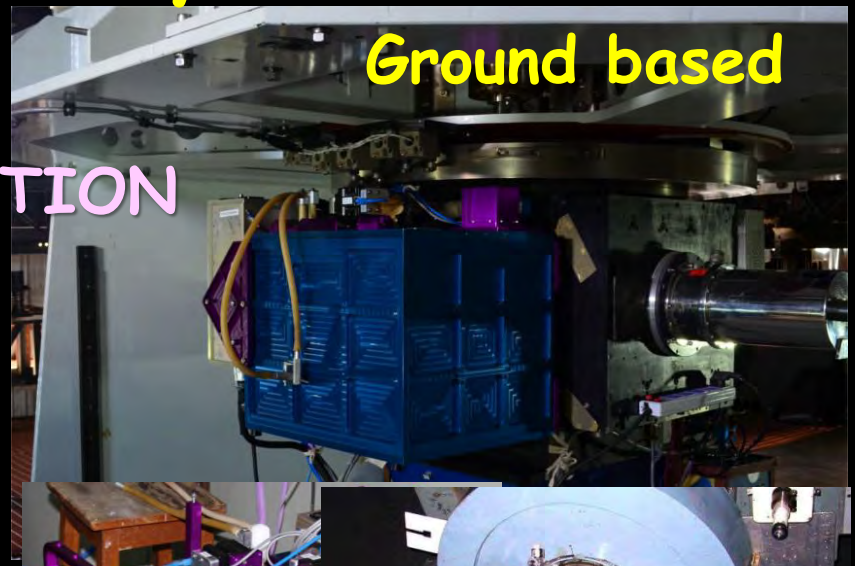
IR Astronomy Activity @ TIFR

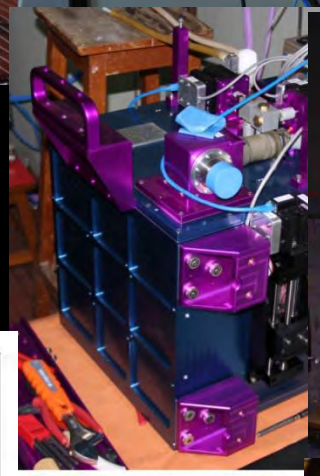
Balloon based

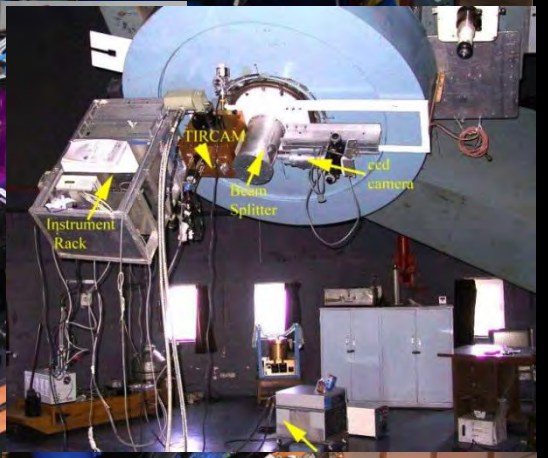
INSTRUMENTATION IN INFRARED ASTRONOMY



Ground based

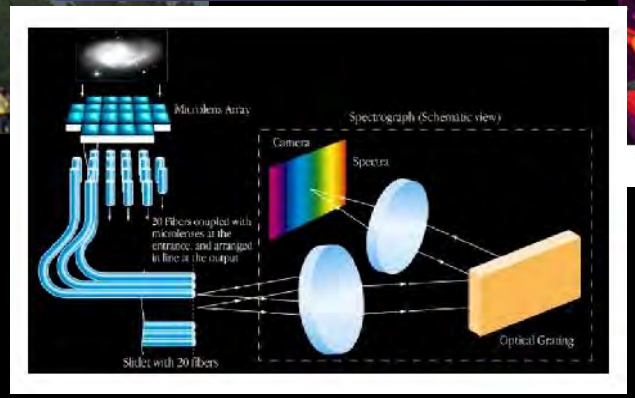




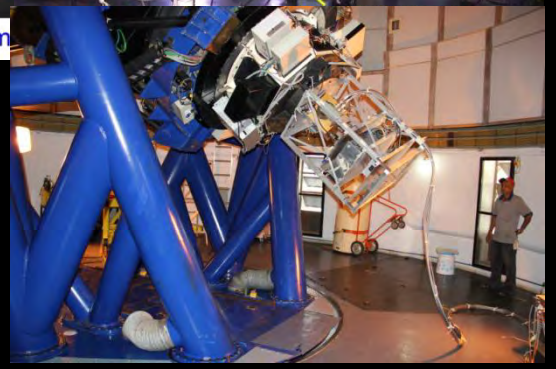


TIFR Spectrometer Cam





Satellite based

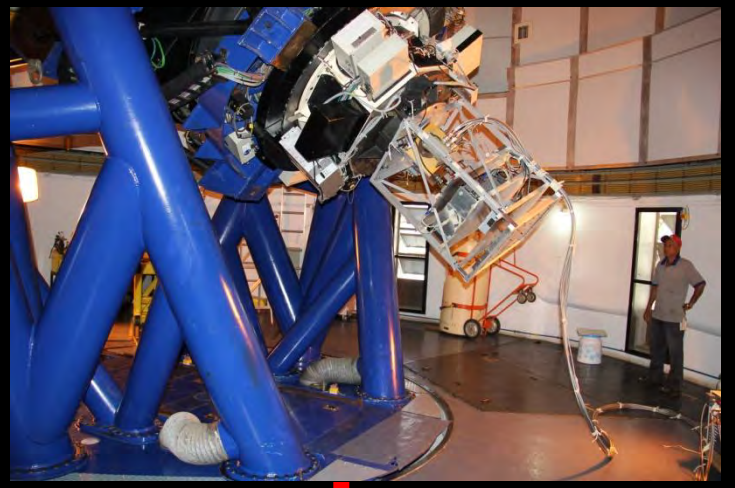


TIFR Ground-based IR Astronomy Program – Progression Plan

TIRCAM (InSb 58 x 62 array)
1.2-meter Mount Abu (PRL) 2001-05



TIRCAM2 (InSb 512 x 512 array) 2005+
2-meter IUCAA telescope (Girawali, Pune)





First light
June
2013

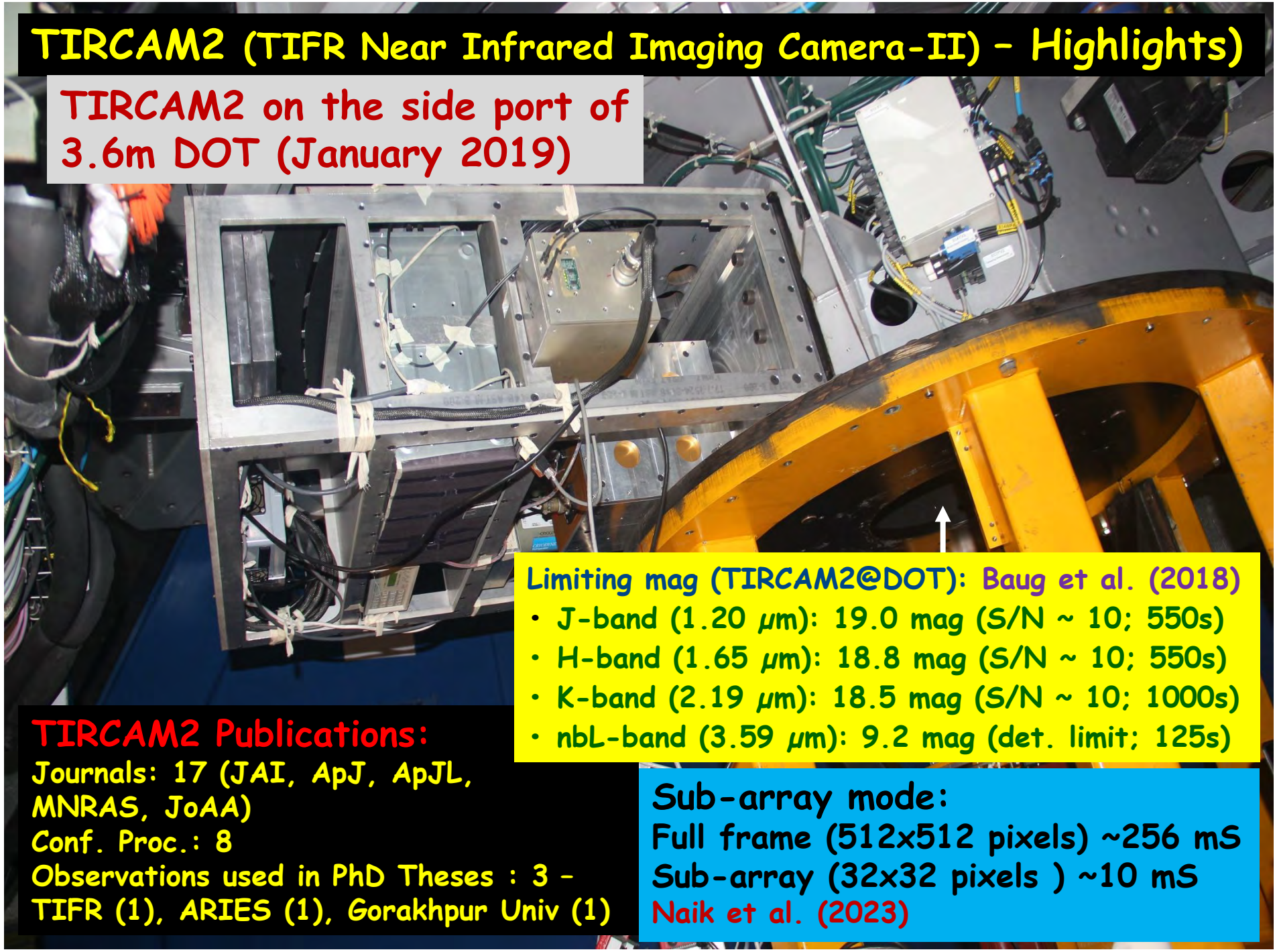
TIRSPEC (1024 x 1024 HAWAII-1 RG)
2-meter Himalayan *Chandra* Telescope (Hanle)

TANSPEC
(2048 x 2048
HAWAII-2 RG)
on
3.6-meter
ARIES
telescope
(Nainital)

2019+



TIRCAM2 (TIFR Near Infrared Imaging Camera-II) – Highlights)



TIRCAM2 on the side port of 3.6m DOT (January 2019)

Limiting mag (TIRCAM2@DOT): Baug et al. (2018)

- J-band (1.20 μm): 19.0 mag (S/N ~ 10; 550s)
- H-band (1.65 μm): 18.8 mag (S/N ~ 10; 550s)
- K-band (2.19 μm): 18.5 mag (S/N ~ 10; 1000s)
- nbL-band (3.59 μm): 9.2 mag (det. limit; 125s)

TIRCAM2 Publications:

Journals: 17 (JAI, ApJ, ApJL, MNRAS, JoAA)
Conf. Proc.: 8
Observations used in PhD Theses : 3 – TIFR (1), ARIES (1), Gorakhpur Univ (1)

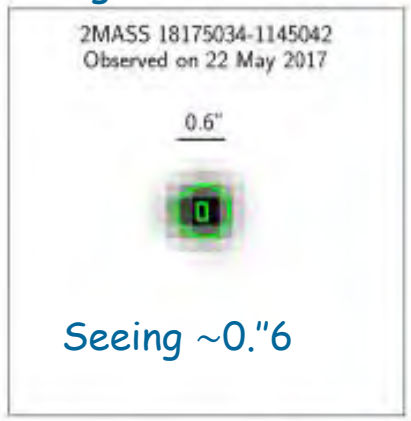
Sub-array mode:
Full frame (512x512 pixels) ~256 mS
Sub-array (32x32 pixels) ~10 mS
Naik et al. (2023)

Devasthal Site Characteristics in NIR using TIRCAM2 @ 3.6m DOT (2017)

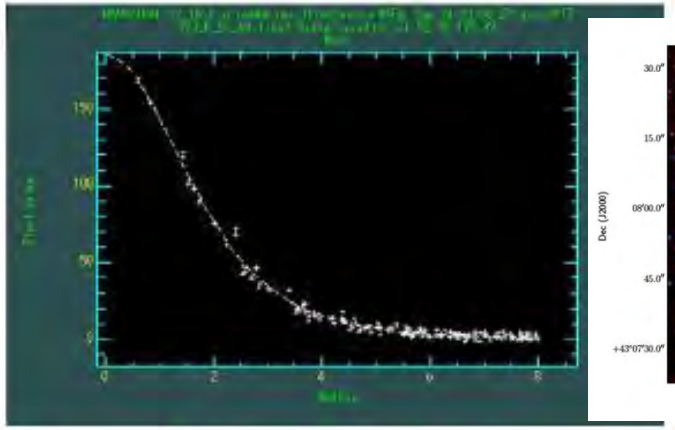
Altitude ~2540 m

Cut-out of a stellar image in K-band

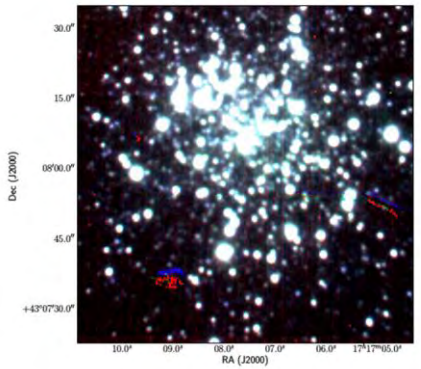
FWHM of the stellar image



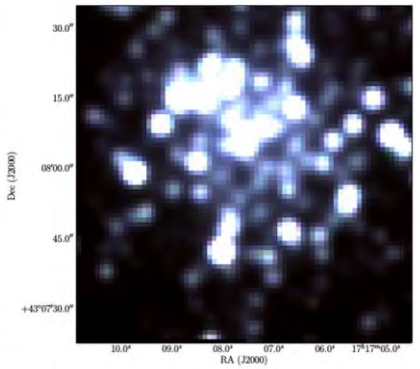
Seeing ~0."6



TIRCAM2

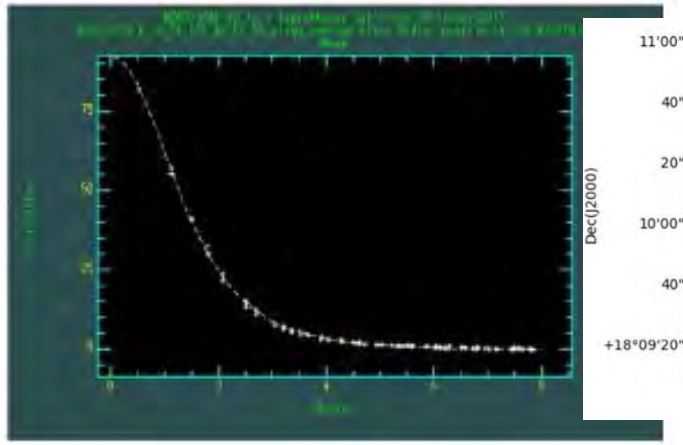


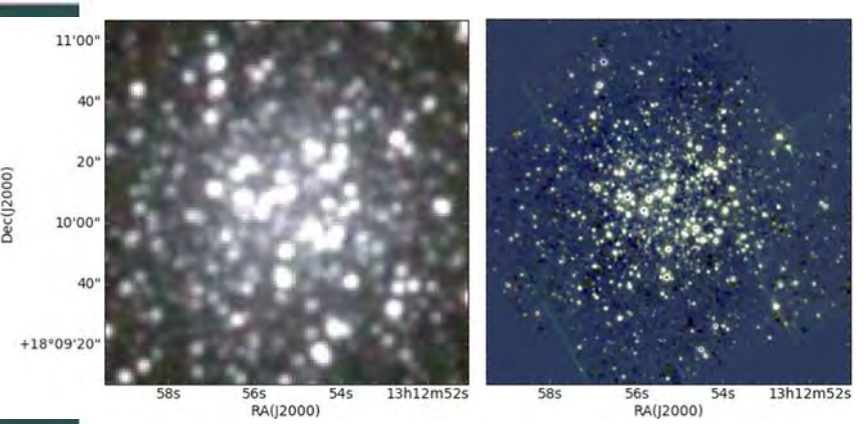
2MASS





Seeing ~0."45





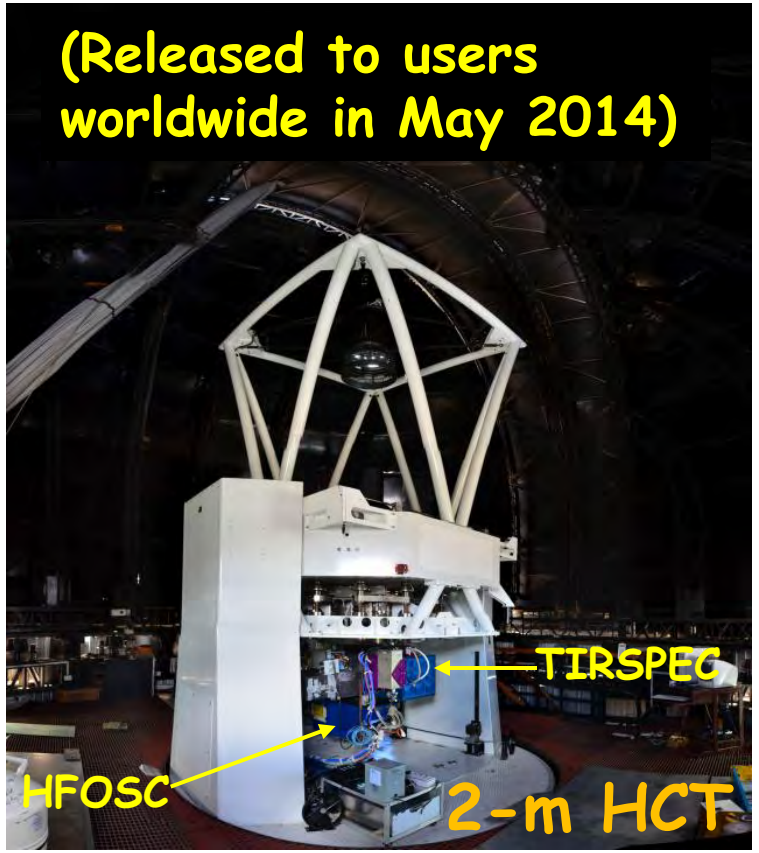
2MASS

TANSPEC

TIRSPEC (TIFR Near Infrared Spectrometer and Imager) – Highlights

On HCT, Hanle, Ladakh (2-meter, 4500 amsl)

- First light: June 2013
- Detector: 1K x 1K Hawaii-1 PACE array (HgCdTe) – 1 – 2.5 microns
- 5' x 5' FoV Imager + Spectrograph (R ~ 1200) - Compact for side port on HCT
- Near simultaneous observations with optical HFOSC
- Heavily used by community (50%)



Photometric mag limits:
(exp time ~170s):

Ks = 17.0 mag (10-σ)
H = 17.5 mag (10-σ)
J = 18.0 mag (10-σ)

Spectral Sensitivity (10-σ):

K ~11.3 mag (~900 sec)

Ninan et at. 2014



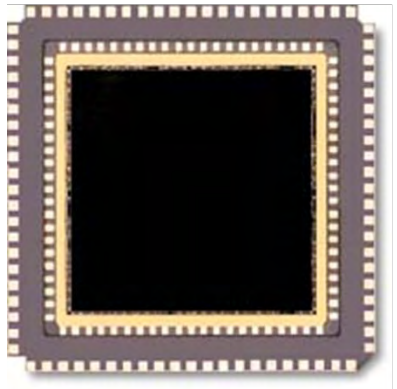
TIFR Spectrometer Camera Instrument

TIRSPEC Publications (01/2024):
Journals: 26 (JAI, ApJ, MNRAS, AJ, JoAA)
Conf. Proc.: 7
Observations used in PhD Theses : 17 - TIFR (3), SNBNCBS (3), IIA (7), ARIES (3), IIST (1)

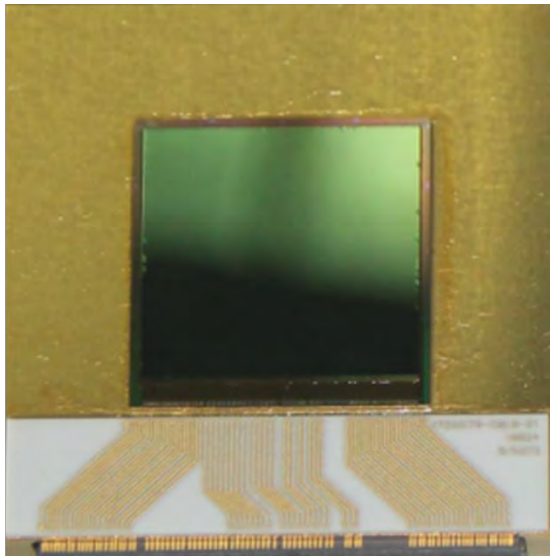
uTIRSPEC - Array Upgrade with Speed Increase

- This spectrometer is completing ~10 years from its installation and commissioning
- Infrared Detector Array (Hawaii-1 PACE) – approaching to end of life - replaced by H1RG (Hawaii-1 RG) array – extend life (10 – 15 years)
- Faster Readout [4 Channels to 16 Channels]
  ~0.9 Sec ➔ 225 mSec

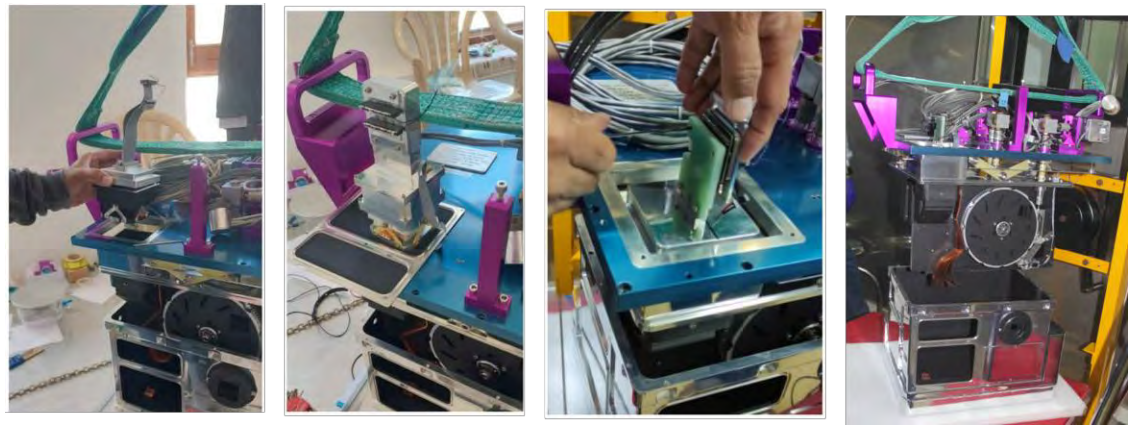
Early 2024



HAWAII 1 PACE FPA

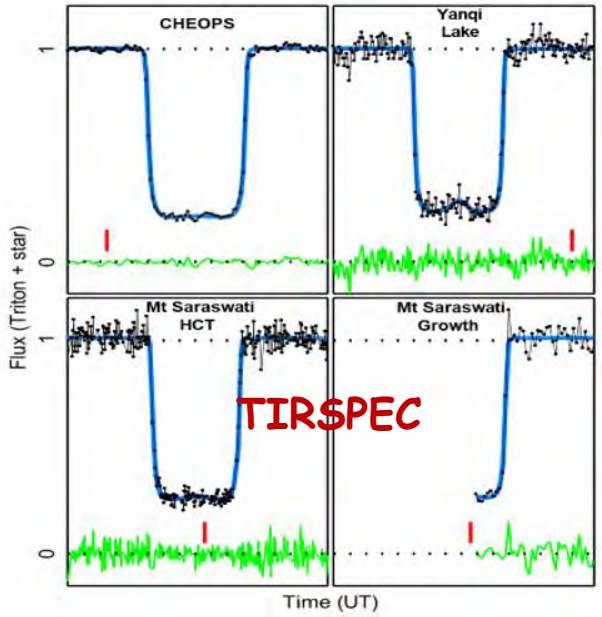


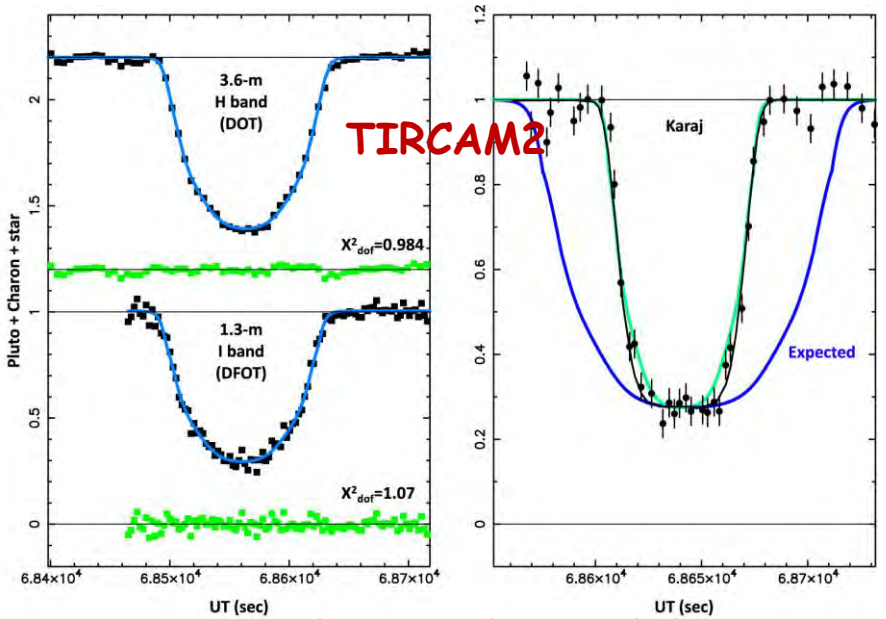
H1RG FPA



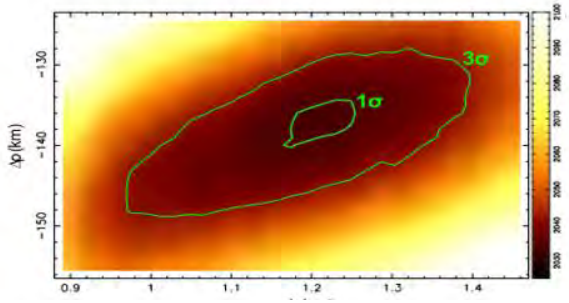
Upgrade operations at TIFR, Mumbai

Fast subarray readout mode of TIRCAM2 and TIRSPEC for millisecond cadence observations of transients

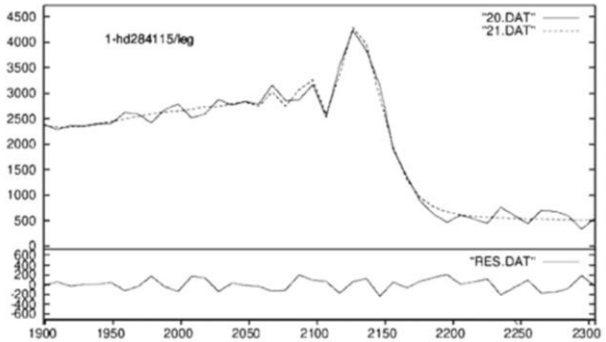




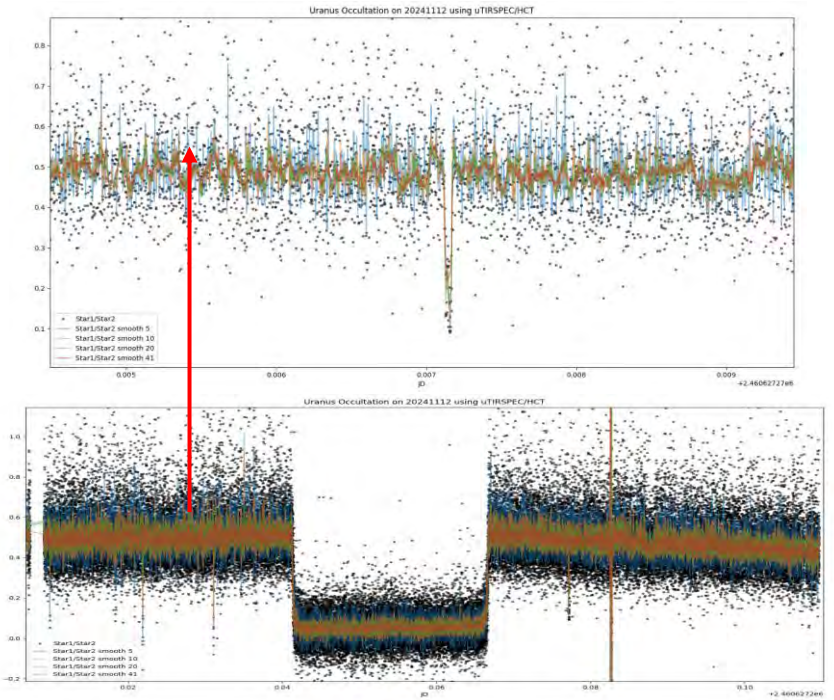
2020 June 6 Pluto occultation light curves (Sicardy et al., 2021, ApJL)



Ground-based stellar occultation observed on 6 October 2022 provides a new measurement of Triton's atmospheric pressure (Sicardy et al. 2024, ApJL, Under Review)



Light curve of a star during occultation by moon obtained with TIRCAM2 subarray (32x32 pixel) mode at DOT (Richichi et al., 2020, MNRAS)



Uranus ring occultation enabled by high-speed capability

TANSPEC (TIFR-ARIES Near Infrared Spectrometer) - Highlights

On DOT, Devasthal (Nainital) (3.6m, 2450 amsl)

- First light: 2019
- Detector: 2K x 2K H2RG (HgCdTe) – 0.55 – 2.5 microns
- 1' x 1' FoV Imager / IR Guider + Spectrograph (R ~ 2750) – Main port instrument
- Simultaneous observations Optical - NIR



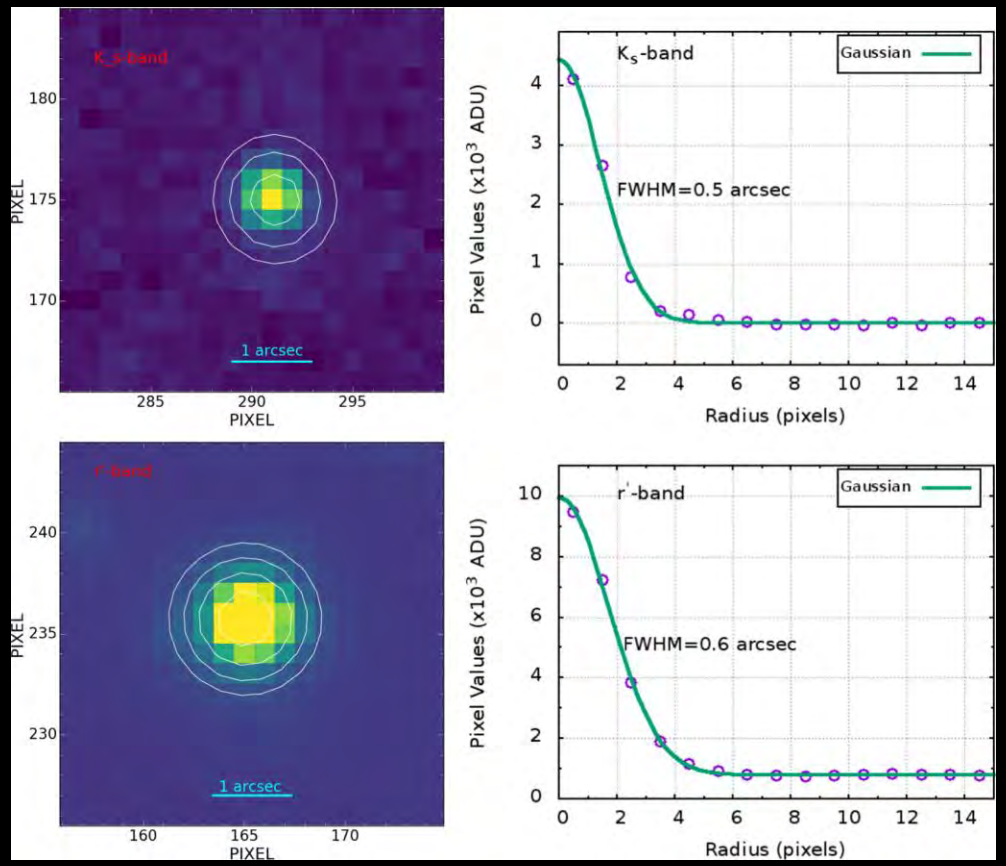
Regular Science observations through TANSPEC on 3.6m DOT:

Cycle_2020-C2: 17-Oct-2020 - 30-Nov-2020
Cycle_2021-C1: 02-Apr-2021 – 31-May-2021
Cycle_2021-C2: 06-Oct-2021 – 06-Dec-2021
01-Jan-2022 – 24-Jan-2022
Cycle_2022-C1: 17-Mar-2022 – 15-May-2022
Cycle_2022-C2: 01-Nov-2022 – 17-Dec-2022
Cycle_2023-C1: 03-Apr-2023 – 31-May-2023
Cycle_2023-C2: 28-Nov-2023 – 31-Jan-2024

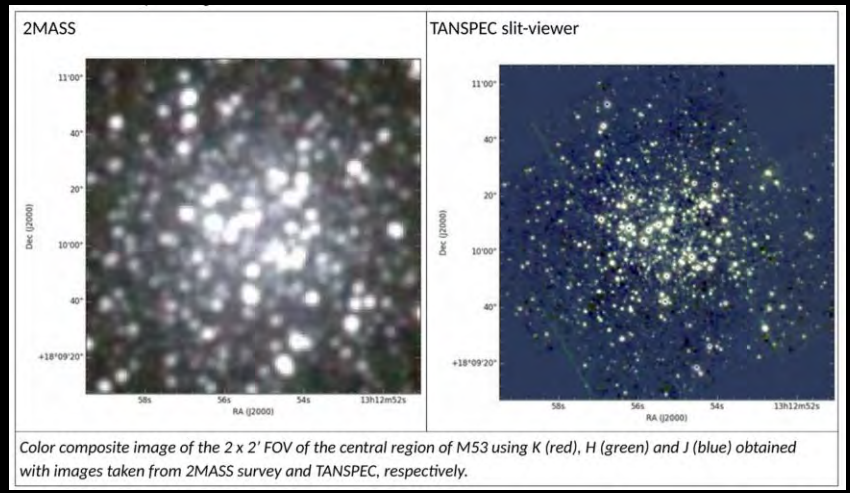
Observed sensitivity (10-σ; one hour): J ~21.5, H ~20.0, K ~19.0 mag, R ~23.0, I ~22.5 mag
Spectral sensitivity (1.0" slit): K ~15.7 (XD) ➡

TANSPEC Publications (01/2024):
Journals: 14 (PASP, ApJ, JoAA)
Conf. Proc.: 4
Observations used in PhD Theses :
3 – TIFR (1), ARIES (2)

Sharma et al. (2022, PASP)



Shape and radial profile of stars in the K_s (upper panels) and r' (lower panels) bands using the slit viewer on the TANSPEC.



Color composite image of the 2 x 2′ FOV of the central region of M53 using K (red), H (green) and J (blue) obtained with images taken from 2MASS survey and TANSPEC, respectively.

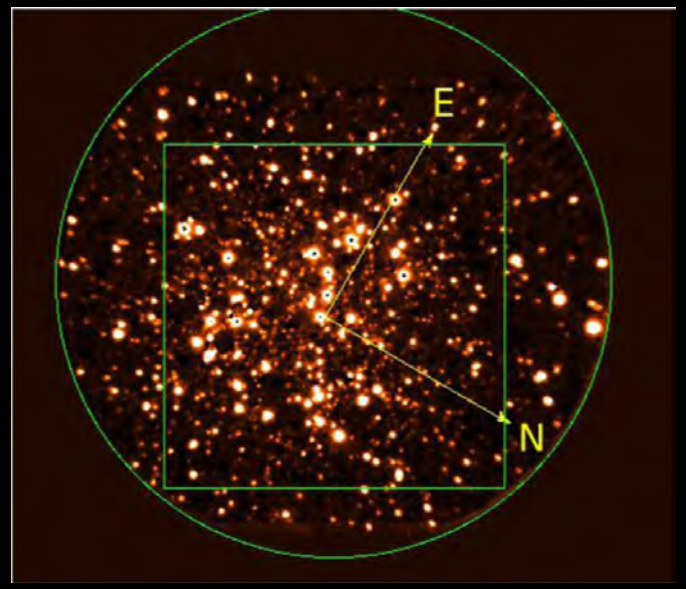
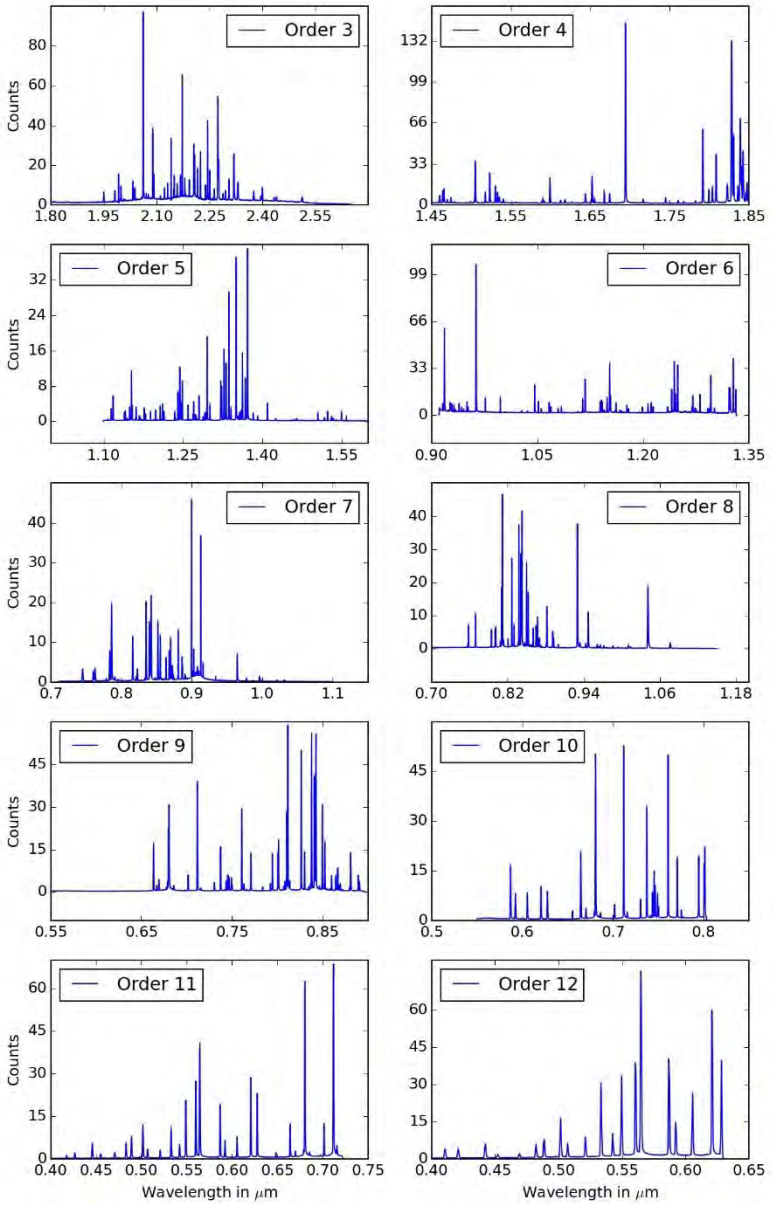


Image of the globular cluster M53 taken in the K_s band using the slit viewer of the TANSPEC on 3.6 m DOT on 2019 April 20.

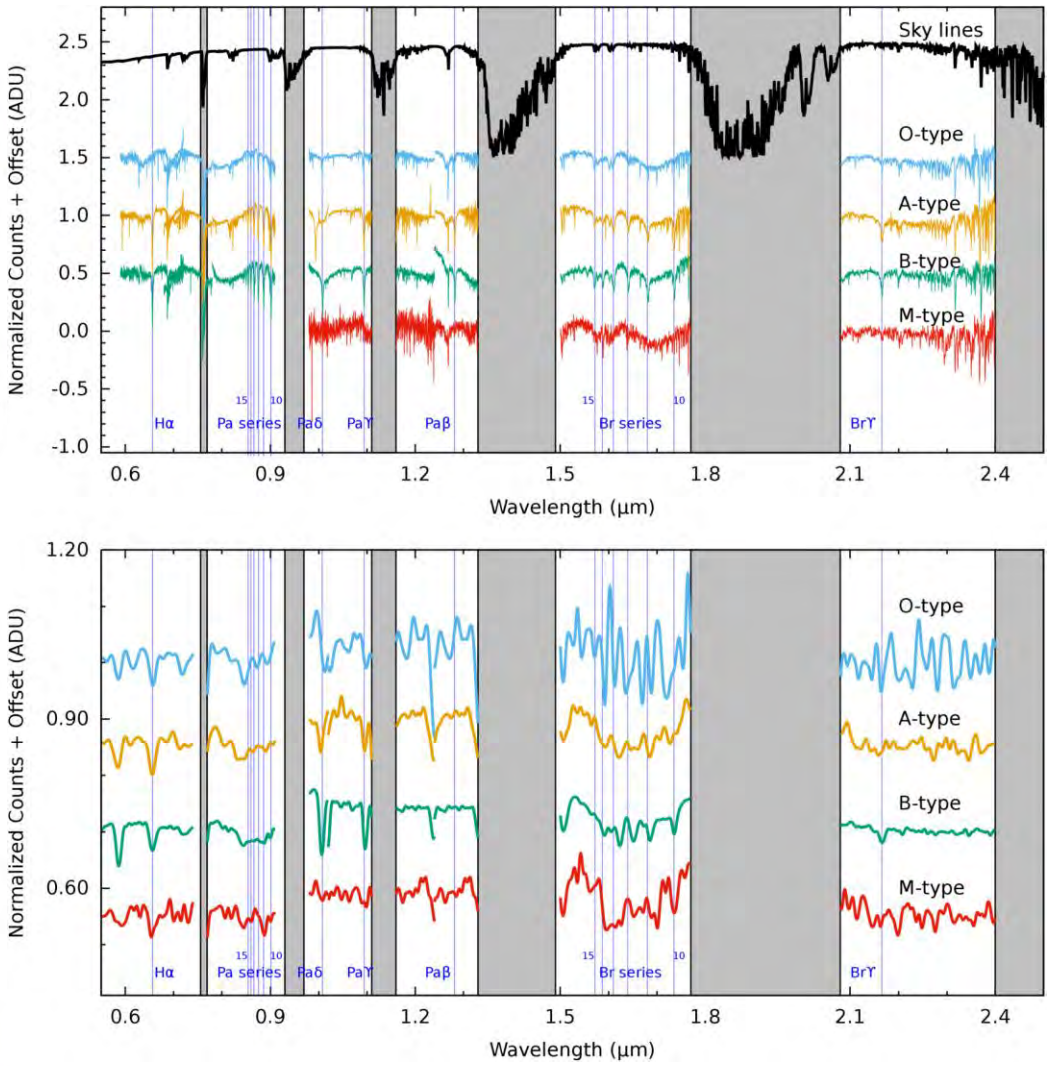
Observed sensitivity (10-sigma; one hour): J ~21.5, H ~20.0, K ~19.0 mag, R ~23.0, I ~22.5 mag

Sharma et al., PASP, 134, 1038 (2022)

TANSPEC Spectral Range: (Expected range: 0.55 – 2.54 micron)



Lamp Spectra: ~0.4 - 2.54 micron



Stellar Spectra: ~0.55 – 2.50 micron

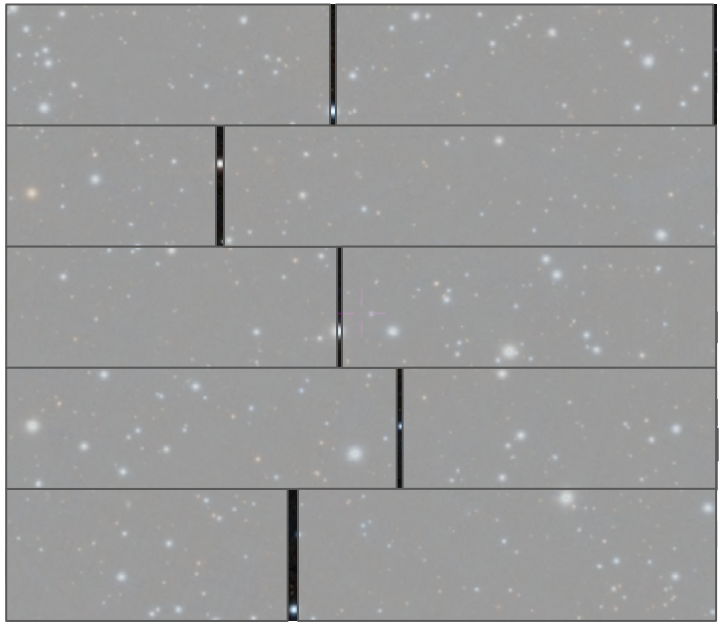
MOIS: Path Finder for NLOT

- Multi-object Infrared Spectrograph (MOIS) 1.0 – 2.5 micron
- 3.6 m Devasthal Optical Telescope (DOT)
- **Configurable Slit Unit Technology**

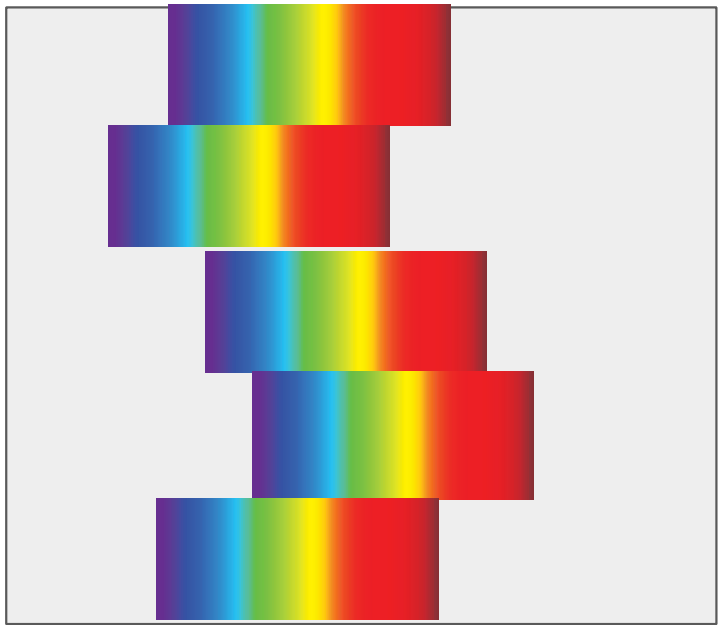
[PI: P. Manoj & B. Mookerjea]



Field in focal plane with CSU bars open



Slits formed by CSU on target objects



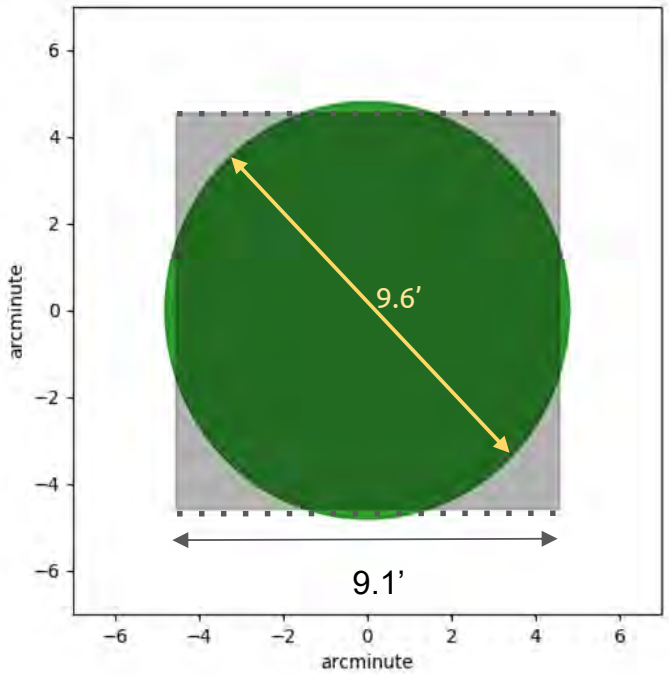
Spectra on Detector

MOIS: Path Finder for NLOT

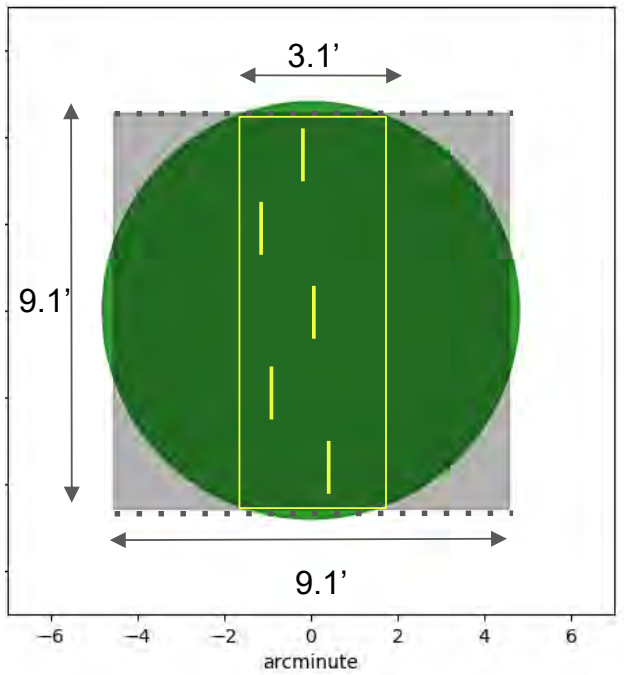
- Multi-object Infrared Spectrograph (MOIS)
- 3.6 m Devasthal Optical Telescope (DOT)
- **Configurable Slit Unit Technology**

Numbers for 3.6 m DOT

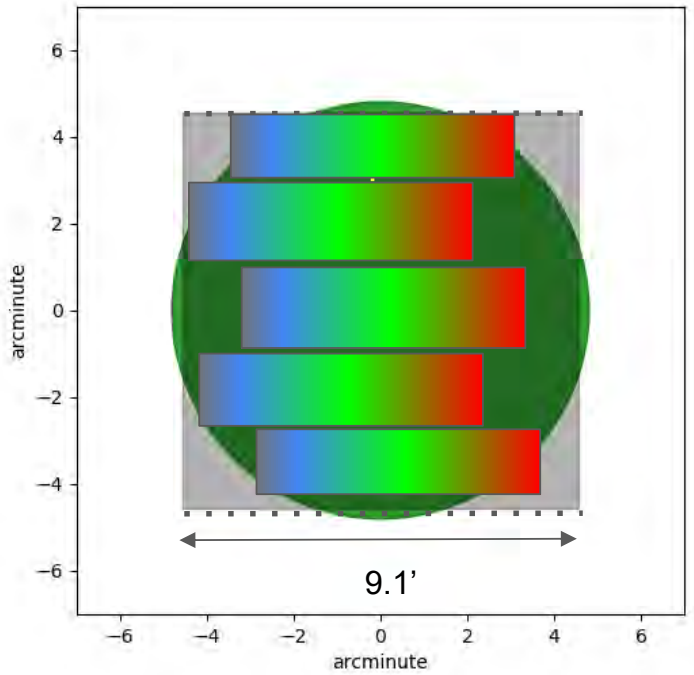
Imaging Field



Example Slit position



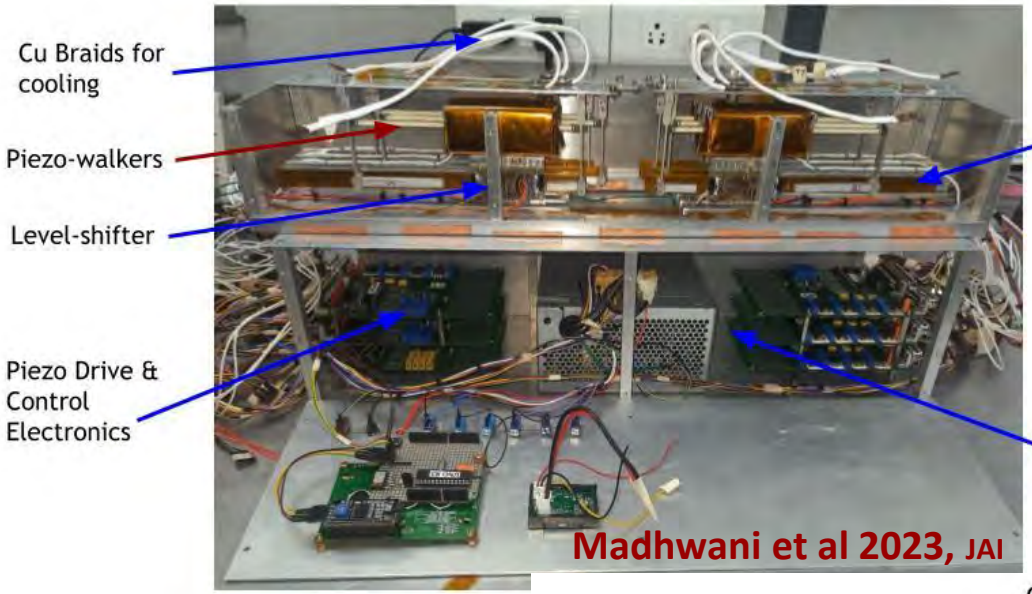
Spectra



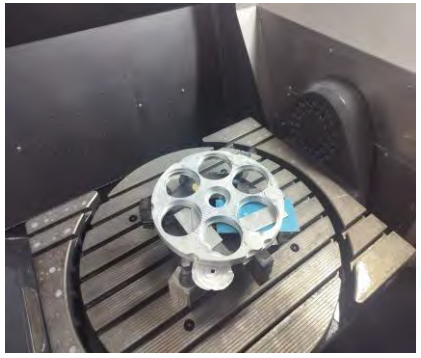
Status

- CSU unit designed, fabricated and tested successfully at cryo.
- Optics Design completed.
- Opto-Mechnical Design advanced Stage.
- Filter Wheels under fabrication

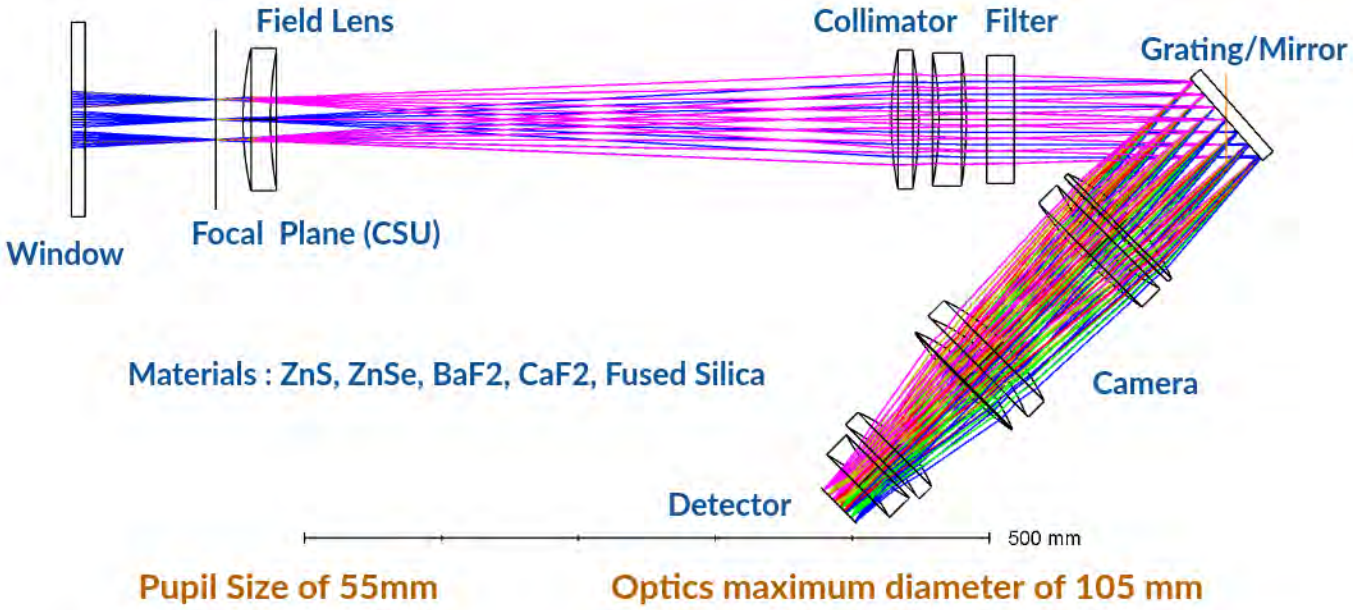
3-Slit Prototype CSU Assembled in TIFR IR Laboratory

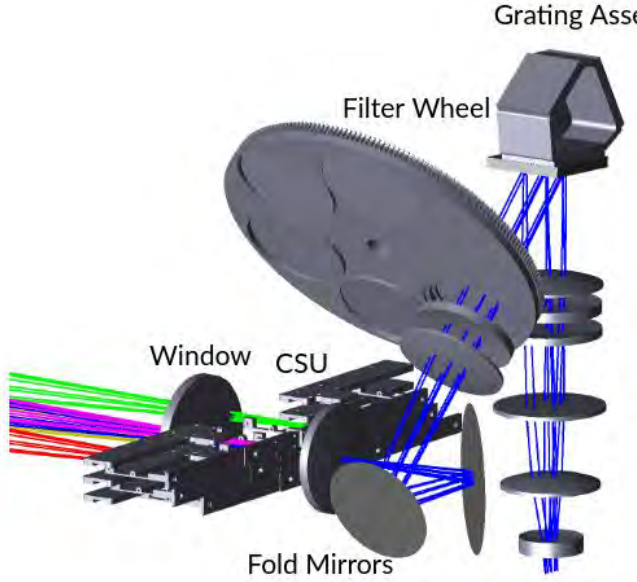


Madhwani et al 2023, JAI







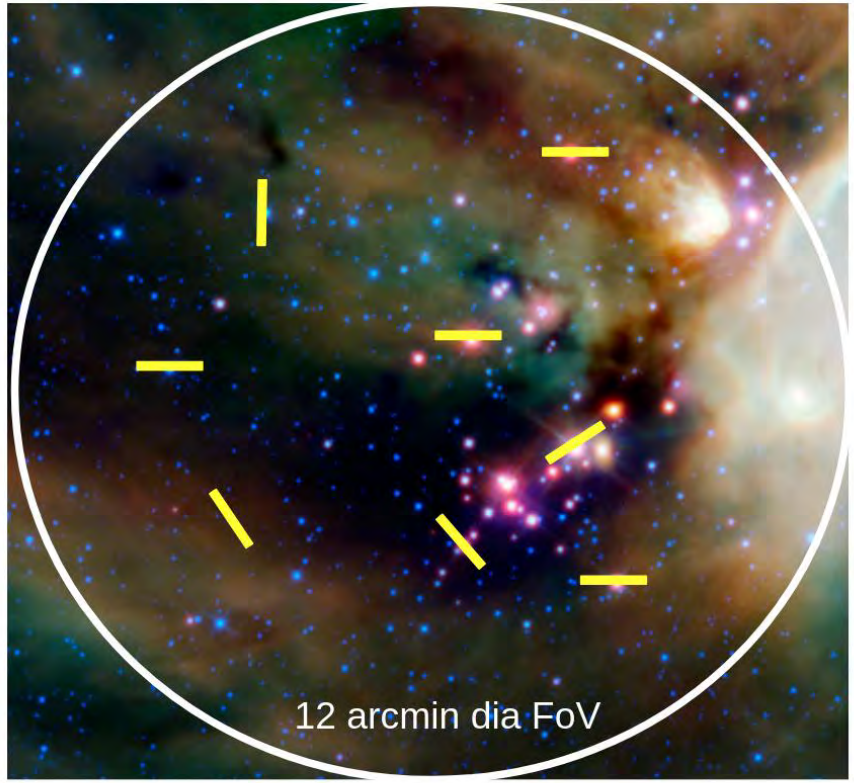


MOIS 3D Model

Surya, A., et. al. 2023, SPIE

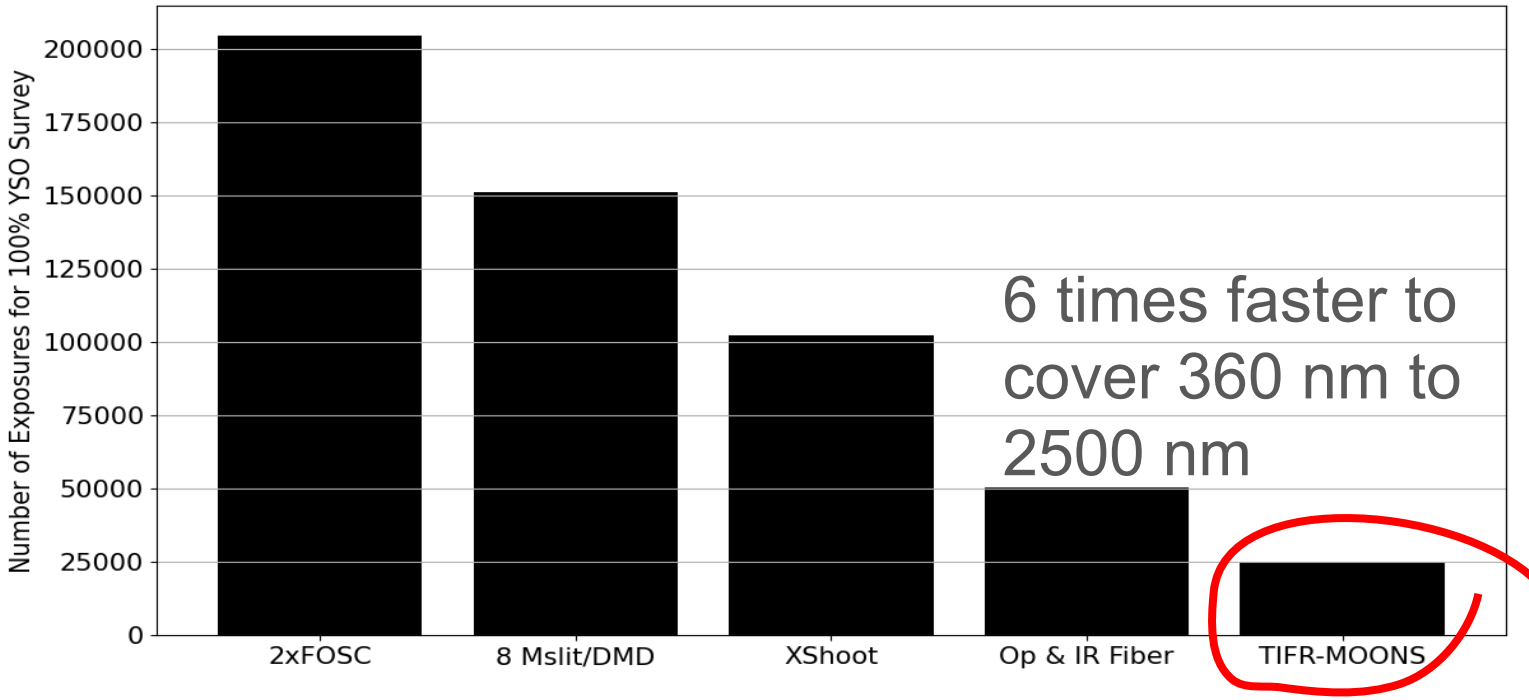
TA-MOONS: Path Finder for NLOT

- Multi-Object Optical to Near-infared Spectrograph (TA-MOONS) [PI: Joe P. Ninan]
- 3.6 m DOT for 0.36 to 2.5 micron spectroscopy survey
- **Deployable Slit Technology**





- DST (ARIES) - DAE (TIFR) (50-50) Partnership.
- Eight 6” slits in 12 arcmin FoV on DOT.
- Simultaneous spatial and wavelength coverage.



Status

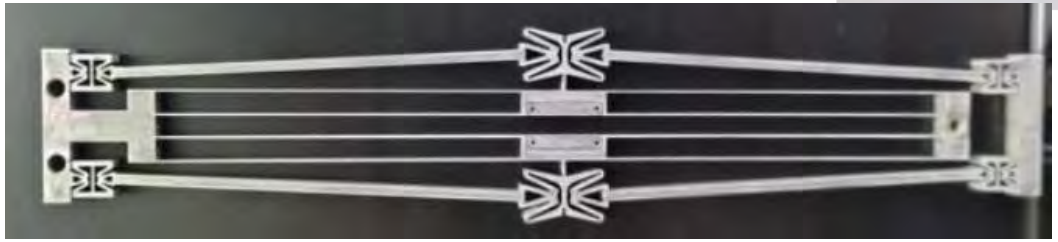
- Front optics design of robotic arms completed.

- Opto-mechanical design in advanced stage
- Cryostat and Electronics design in advanced stage.
- Fabrication of precision stages, prototype arms and slits

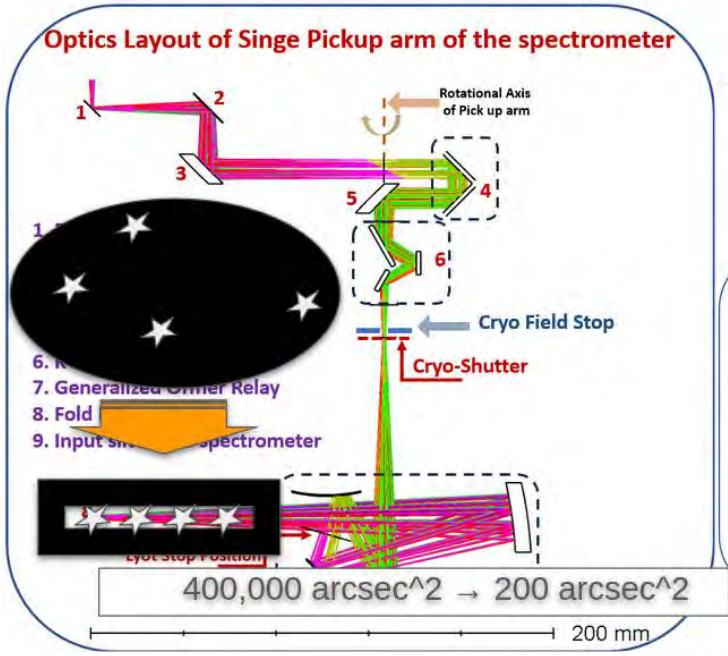


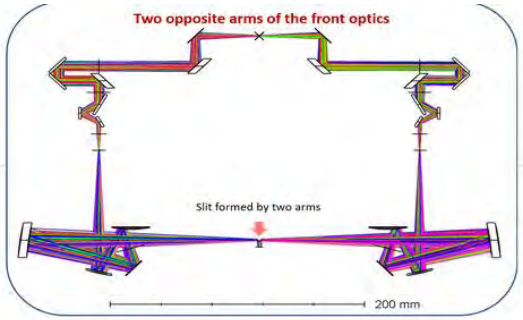


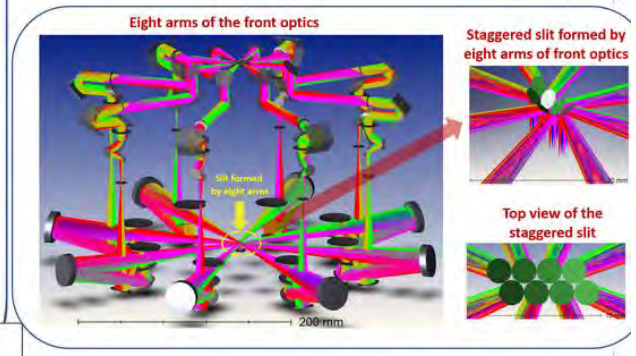




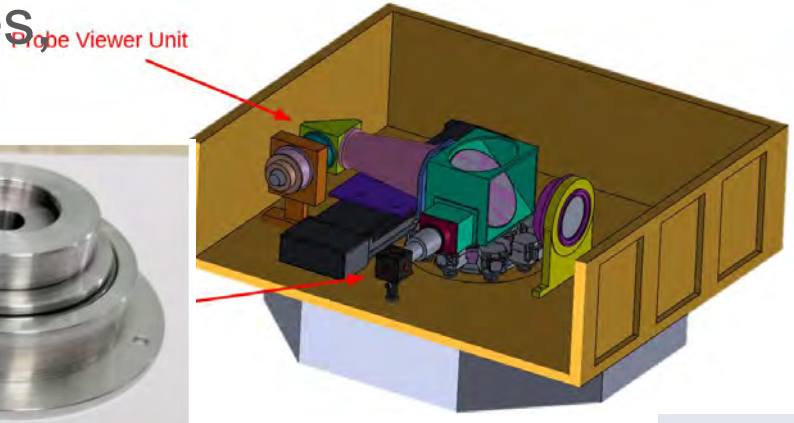
Pickup arm

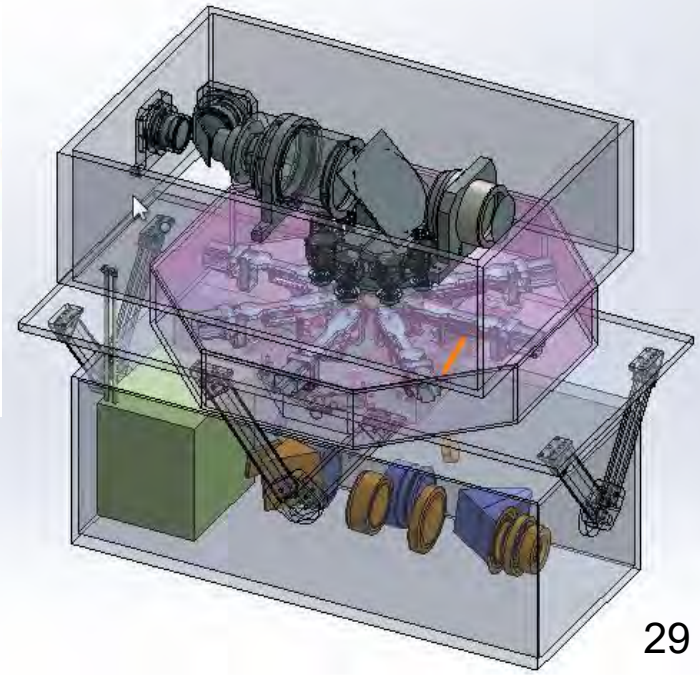






Satheesha + (SPIE 2024)





PDR on 10th December 2025

FIR Astronomy using balloons (TIFR-Japan Joint Collaboration)



"T100" payload on Launch Arm

India-Japan collaborative research based on [C II] balloon-borne experiments using the TIFR telescope & Japanese spectrometer

FIR Spectroscopy 1999+

TIFR 100 cm Balloon Borne Far Infrared Telescope

Primary : 100 cm aluminium;
Mass ~ 850 Kg
No. of launches: 28 (since 1983)

Robust signal processing & image processing scheme

Final map resolution ~ 1.0 arc min (@ 200 μm)

http://web.tifr.res.in/~bf/

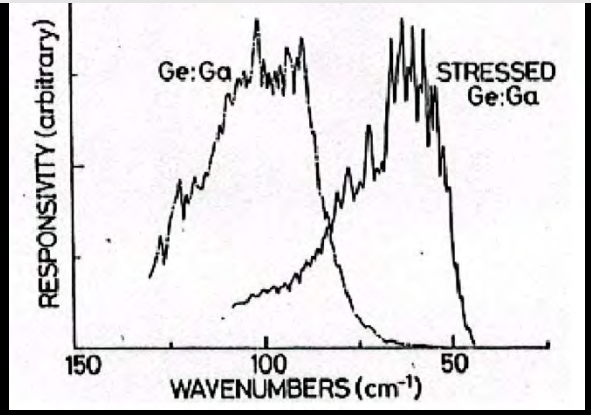


Fabry Perot Spectrometer (FPS)

(Developed at ISAS & Nagoya Univ, Japan & adapted for T100)

Spectral Resolution (R) ~ 1800 (~170 km/s)
Spectral scanning range ~ 63.2 – 63.5 cm^-1
(157.41 μm – 158.57 μm)

Stressed Ge:Ga photoconductor
(Spectral Response)



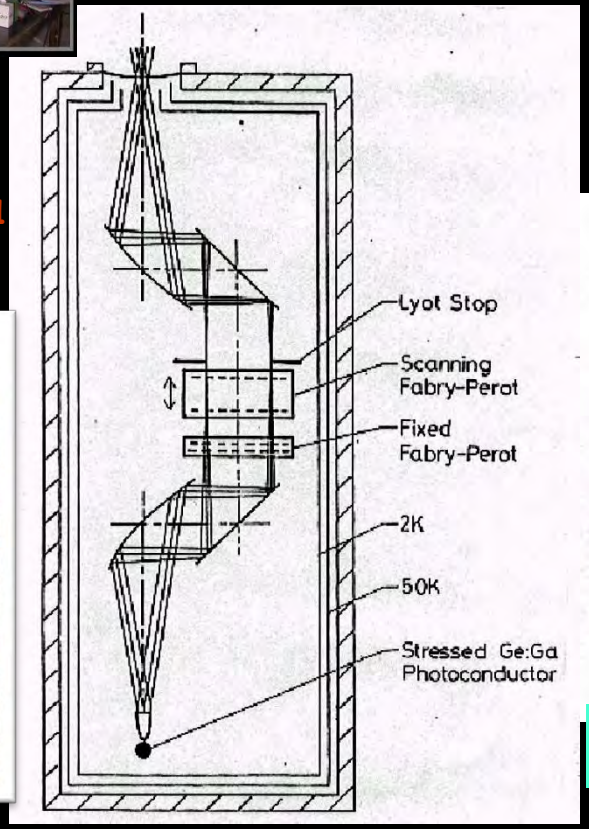
Tuned to [C II] line at 157.7 μm

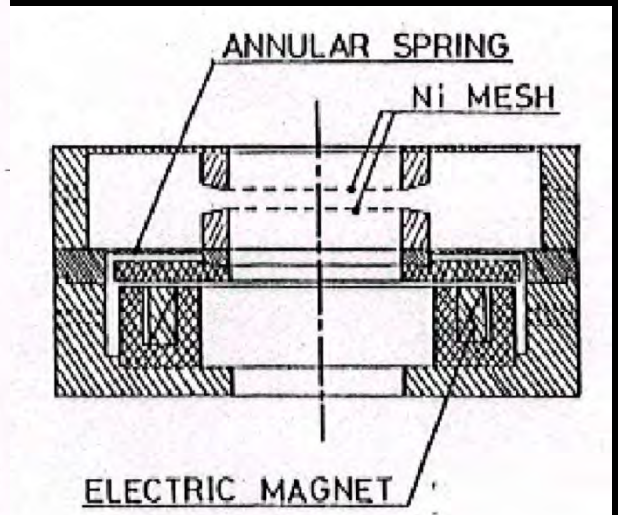
Spatial Resolution - 1.0'

Detection Limit (3-σ) –
~ 1 x 10^{-4} ergs s^{-1} cm^{-2} sr^{-1}



Basic configuration of the FPS





Scanning Fabry Perot

TIFR-BF, Hyderabad



025

TIFR 100-cm + FPS ([C II] 158 μm)
(25-Nov-1999,25-Nov-2001, 30-Mar-2003, 15-Nov-2004, 21-Nov-2006,05-Feb-2009)
Last 7 T100+FPS flights (18-Feb-2017, 30-Nov-2017, 18-Mar-2018, 28-Oct-2018 and 18-Feb-2023, 05-Dec-2024, 29-Mar-2025) - **Next IR balloon Campaign: November 2026**



TIFR 100-cm balloon-borne telescope ➔

T100 payload

Main exp balloon

Fabry-Perot Spectrometer ([C II] 158 μm) ➔

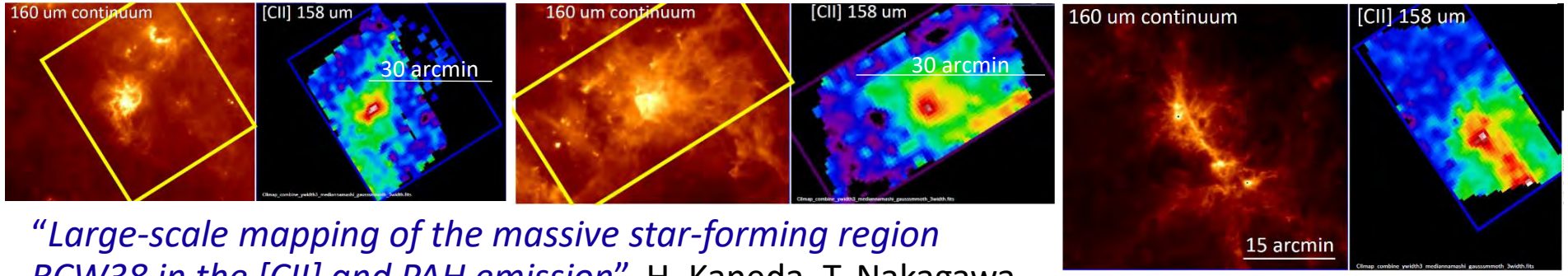


(W3, RCW 36, RCW 38, NGC 2024, Mon-R2, Carina, NGC 6334, NGC 6357, W31, RCW 106, W40, RCW 42, NGC 3603, RCW 116, GM1-24, RCW 40, S255,…..) – 16 star-forming regions

Scientific Outcomes

- **Large-area [C II] maps of Galactic star-forming regions**

W31 | Carina | NGC 6334

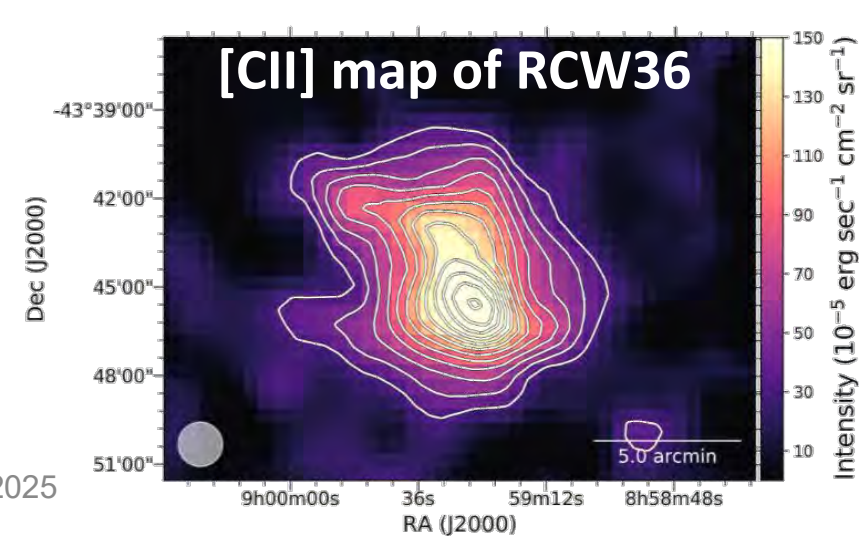


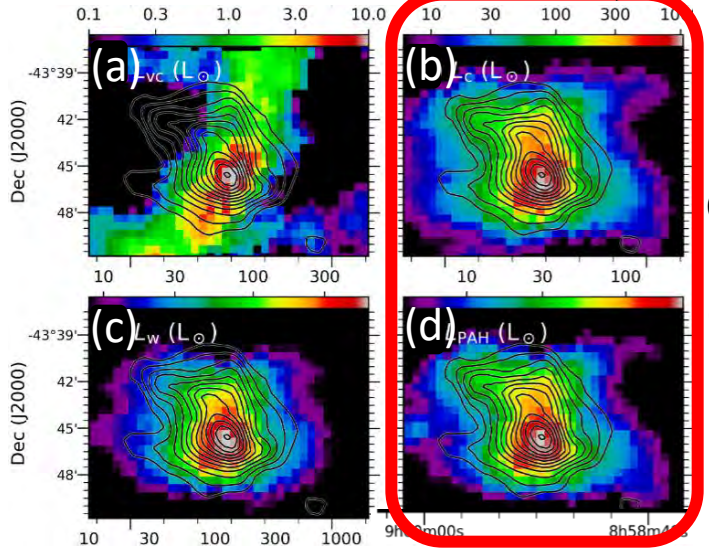
"Large-scale mapping of the massive star-forming region RCW38 in the [CII] and PAH emission", H. Kaneda, T. Nakagawa, S.K. Ghosh, D.K. Ojha, et al., Astronomy & Astrophysics, Volume 556, id.A92, 9 pp (2013)

"[CII] emission properties of the massive star-forming region RCW 36 in a filamentary molecular cloud", T. Suzuki, S. Oyabu, S.K. Ghosh, D.K. Ojha, et al., Astronomy & Astrophysics, Vol. 651, id.A30 (2021).

Ojha et al. (2022), (Cospar)

Good spatial correlations

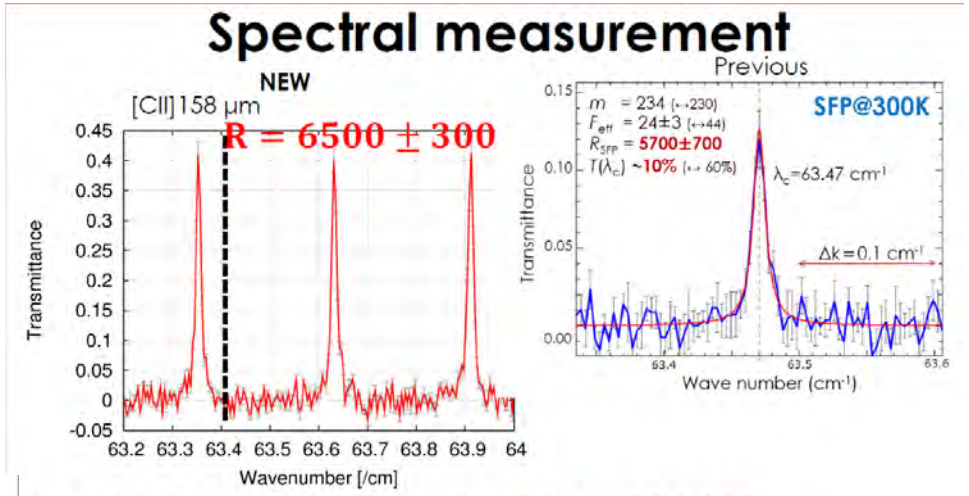




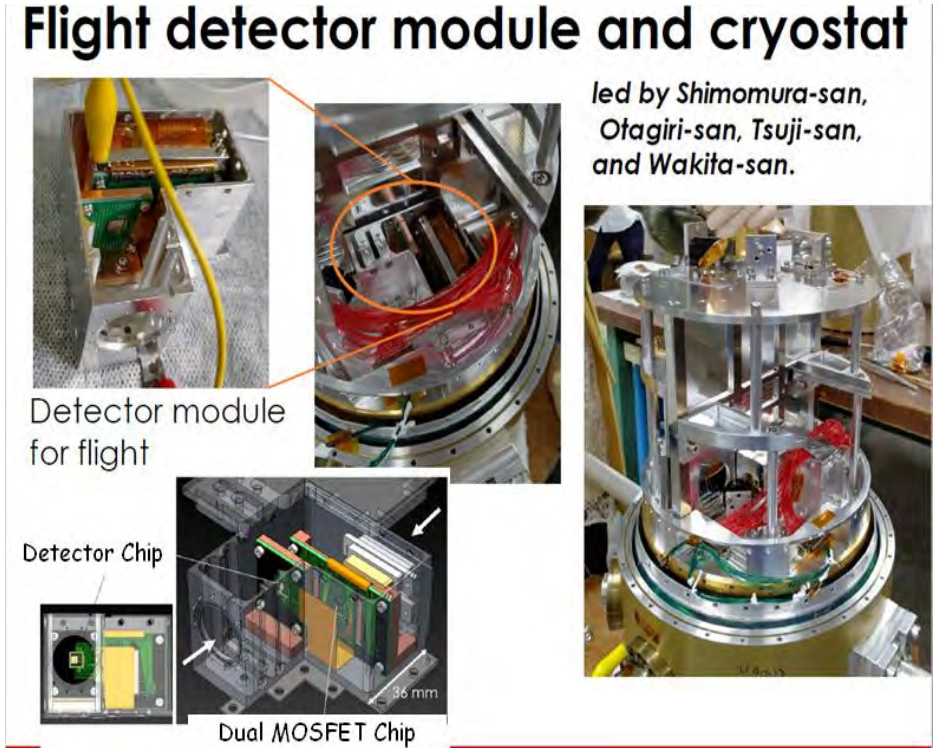
Contours: [CII]
Images: dust emission from
a) Very cold dust,
b) Cold dust,
c) Warm dust,
d) PAHs

Near Future
Upgradation of FPS from single pixel to 5x5 array detector

Best effort Spectral Resolution ~10000

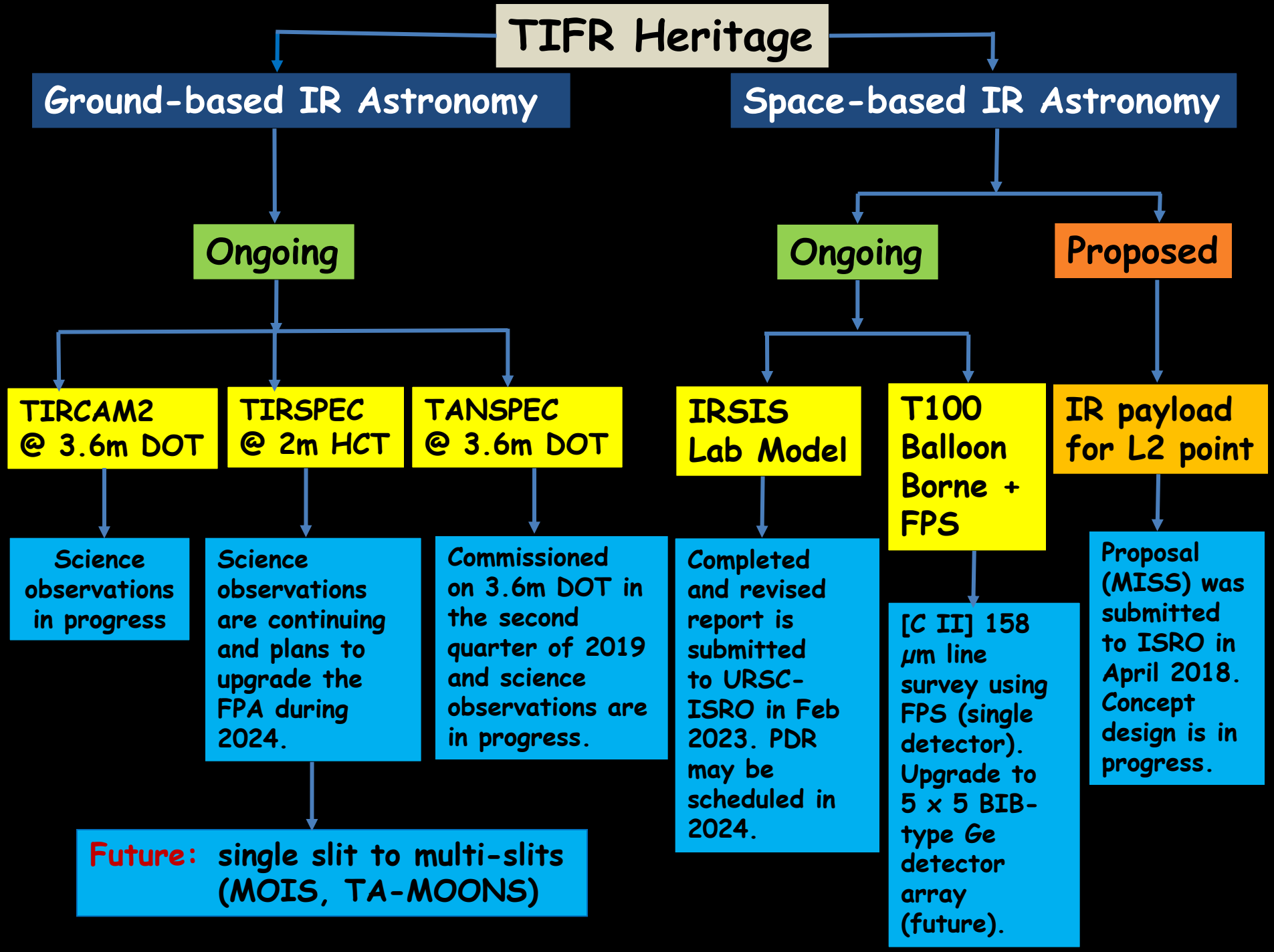


Spectral resolution reached R=6500±300



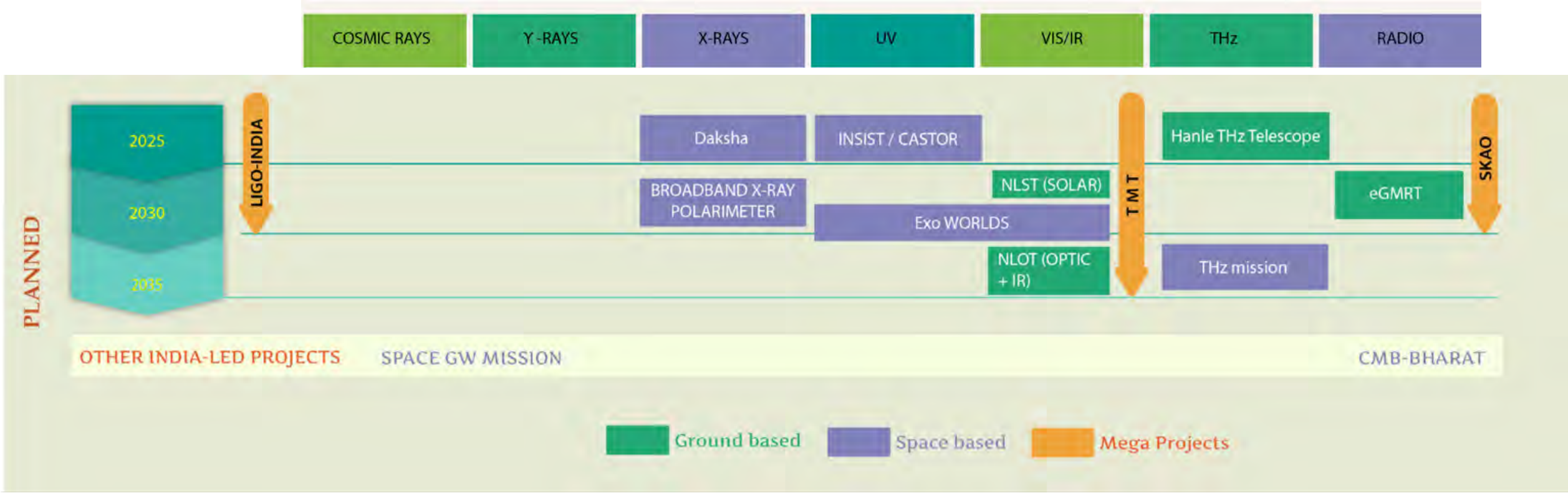
- Design and development for the Telemetry upgradation from existing **~10 kbps to the ~256 kbps** is in progress.
- We plan to use advance **FPGAs** and **Micro-controllers** to implement designs.
- We are planning to interface and test new FPS and T100 electronics in next few months and looking for the test balloon flight during **2025**.

Design and Development of new 5x5 array FPS, its readout electronics etc. is supposed to be completed in few months.


TIFR Heritage
Ground-based IR Astronomy
Space-based IR Astronomy
Ongoing
Ongoing
Proposed
TIRCAM2 @ 3.6m DOT
TIRSPEC @ 2m HCT
TANSPEC @ 3.6m DOT
IRSIS Lab Model
T100 Balloon Borne + FPS
IR payload for L2 point
Science observations in progress
Science observations are continuing and plans to upgrade the FPA during 2024.
Commissioned on 3.6m DOT in the second quarter of 2019 and science observations are in progress.
Completed and revised report is submitted to URSC-ISRO in Feb 2023. PDR may be scheduled in 2024.
[C II] 158 μm line survey using FPS (single detector). Upgrade to 5 x 5 BIB-type Ge detector array (future).
Proposal (MISS) was submitted to ISRO in April 2018. Concept design is in progress.
Future: single slit to multi-slits (MOIS, TA-MOONS)

Summary - Future Proposed Indian Observatories

A major new development in recent times is the participation of India in multiple international megaprojects in astronomy: **LIGO-India** for setting up a gravitational wave detector India, the **Thirty Meter Telescope (TMT)** project for near-infrared and optical astronomy, and the **Square Kilometre Array Observatory (SKAO)** for radio astronomy. These projects provide Indian astronomers access to cutting edge facilities over the coming decades. In addition, several major ground- and space-based projects are in the pipeline **(NLOT, NLST, ExoWorld, INSIST…..).**

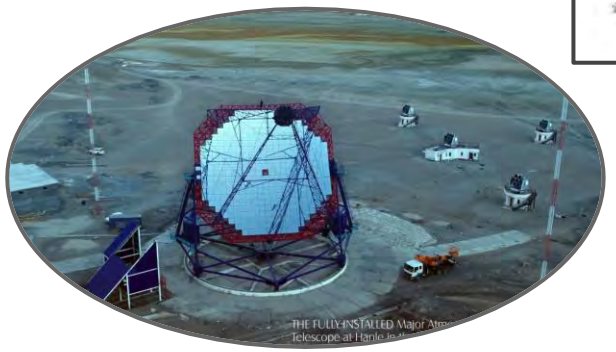


Thank you!



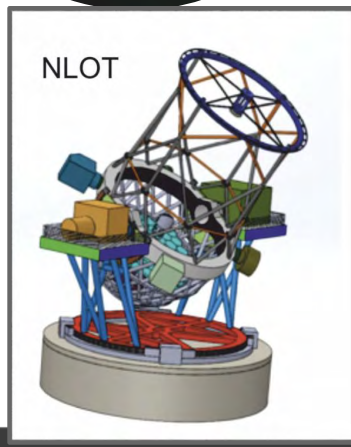

LIGO-INDIA



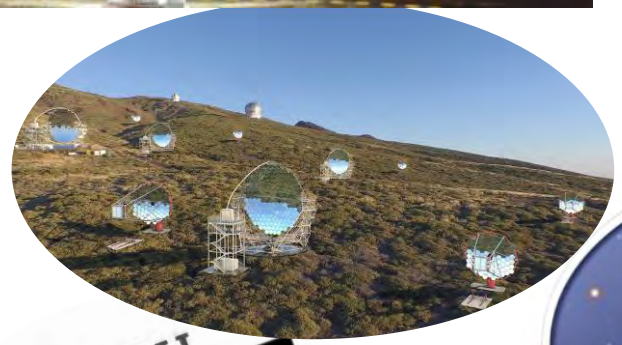



SKA


TMT

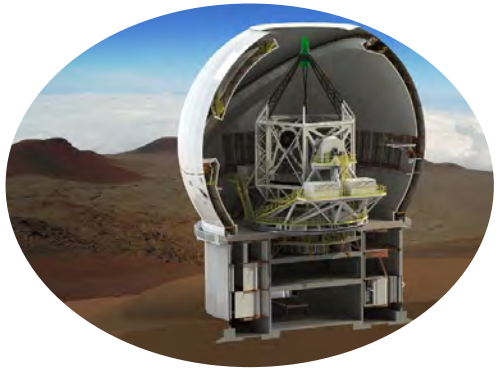

NLOT


EXOWORLDS
An ISRO Exoplanet Mission

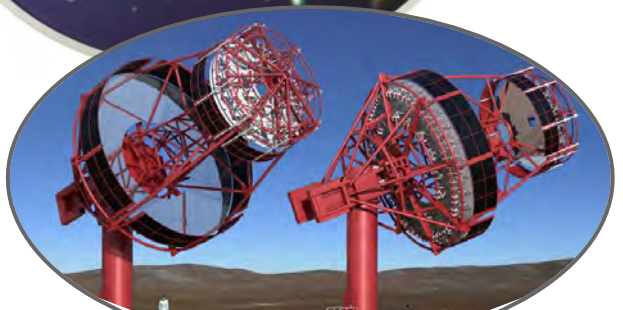



IRSIS


INSIST
A UV spectroscopic missio




PRATUSH




DAKSHA