Advancements in Optics Research at NARIT

Supachai Awiphan

NATIONAL ASTRONOMICAL RESEARCH INSTITUTE OF THAILAND (PUBLIC ORGANIZATION)







- 1. To develop the facilities and human capabilities in optical technologies and related fields in Thailand.
- 2. To develop high-performance and cutting-edge technology optical instruments for astronomy, space, life science, and industry.
- 3. To lead research activities in innovative optical technologies to stimulate the development of high-technology companies.
- 4. To train Thai and/or ASEAN engineers, researchers, and entrepreneurs in optics and photonics.

Center for Optics and Photonics Sites



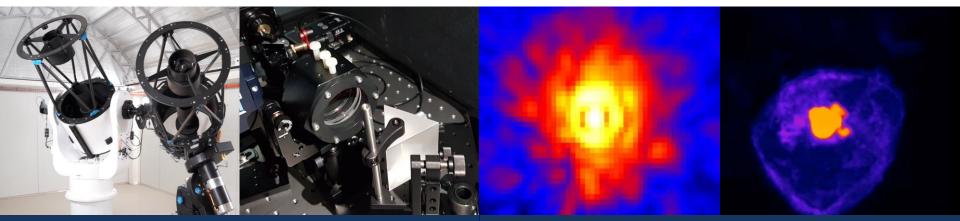
- Clean room optical laboratory (cleanliness class 100,000)
- Optical design room



Regional Observatory for the Public, Songkhla



Current activities



Telescope design

- TNT Prime Focus Camera
- Planetary Imaging Telescope
 project
- 0.6-0.8 m Telescope design
- TNT optical alignment and performance optimization

Spectrograph

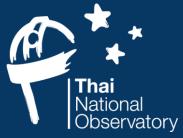
- Low-Resolution Spectrograph
- EXOhSPEC
 - Thai Space Consortium Hyperspectral Imager
 - UV-Visible Spectrometer for Atmospheric Science
 - Fourier Transform Spectrograph

Coronagraph and Adaptive Optics

- Evanescent Wave Coronagraph (EvWaCo)
- Adaptive Optics

Industry/Medical/Atmos. Science applications

- Time-Resolved Raman Spectroscopy system
 - Bench-Top for industry applications
 - Compact system for medical applications
- RAMAN Lidar (Atmospheric Science)
- Two-photon microscope system



1. 2.

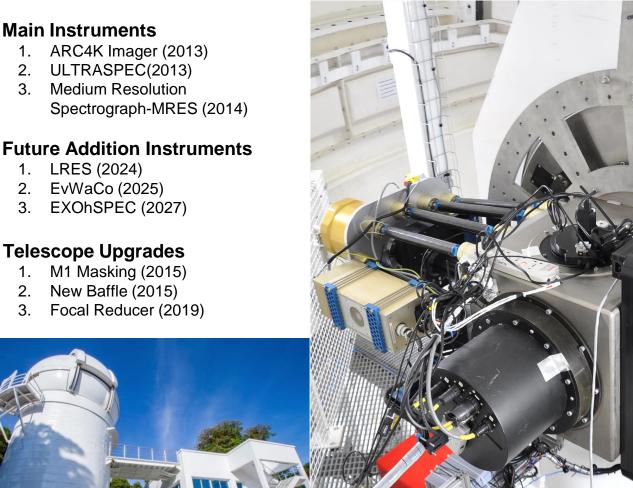
3. Medium Resolution Spectrograph-MRES (2014)

Future Addition Instruments

- LRES (2024) 1.
- 2. EvWaCo (2025)
- 3. EXOhSPEC (2027)

Telescope Upgrades

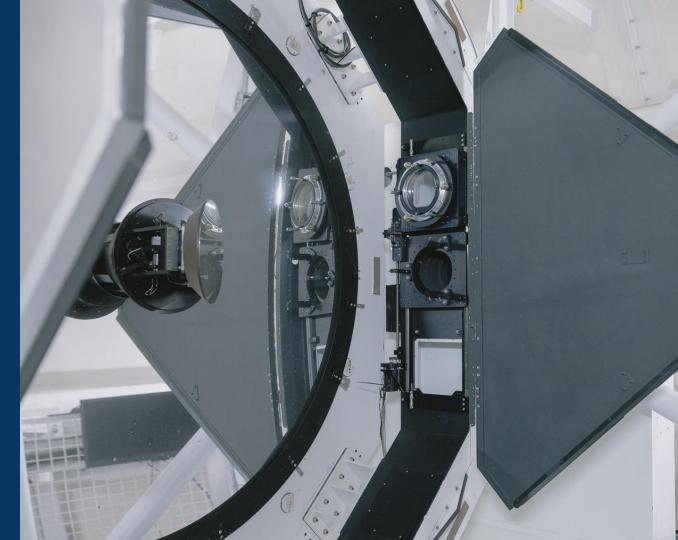
- M1 Masking (2015) 1.
- 2. New Baffle (2015)
- 3. Focal Reducer (2019)



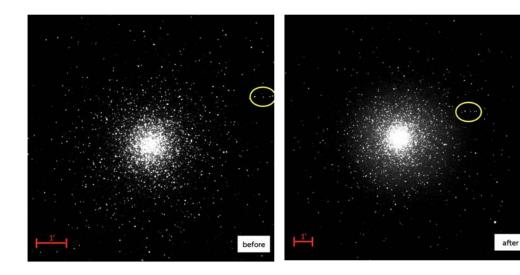
Thai National Telescope Instruments

Focal Reducer

Objective: to enlarge the field of view on the 4k camera and provide image quality close to seeing limit

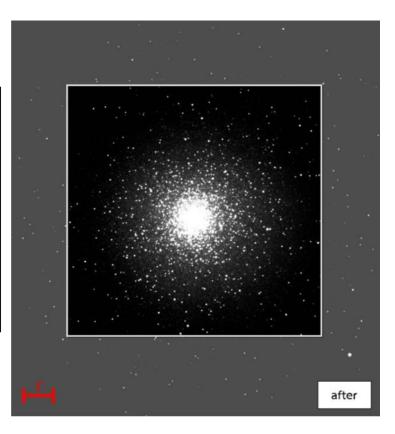


Focal Reducer



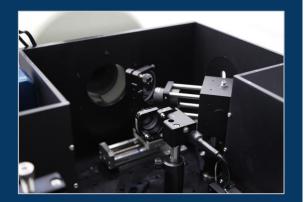
Field of View: 8.8 x 8.8 arcmins

Field of View: 14.6 x 14.6 arcmins

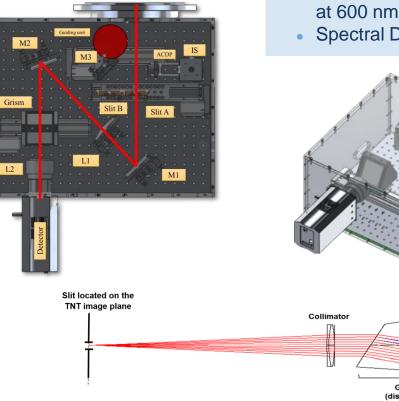


Globular cluster M3

LRS Low Resolution Spectrograph



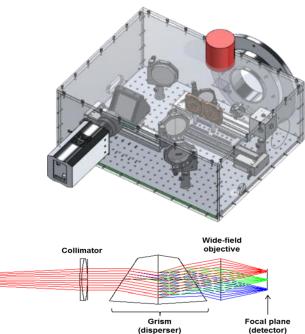
Objective: Development of low-resolution spectrograph for the 2.4 m Thai National Telescope



Schematic of the LRS Mark-III with the optical axis

Specifications

- Slit less/Long slit spectrograph
- Spectral Resolution: R=1000 at 600 nm
- Spectral Domain: 400-800 nm



LRS Low Resolution Spectrograph

Testing LRS at the 2.4-m Thai National Telescope

5000

5500

6000

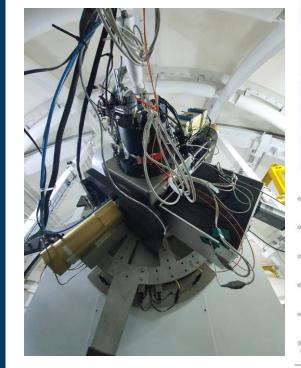
6500

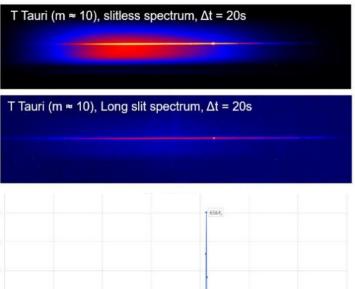
Wavelength in A

7000

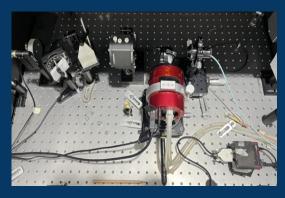
7500

8000



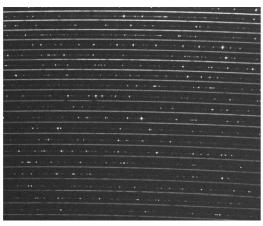


EXOhSPEC Exoplanet High Resolution Spectrograph





Objective: To develop a new kind of compact and cost-effective high-resolution Echelle spectrograph



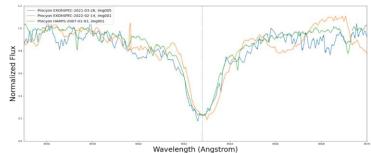
Spectra of Procyon ($V_{mag} = 0.37$) with an exposure time of 180 seconds



Insulation box and temperature control

Specifications

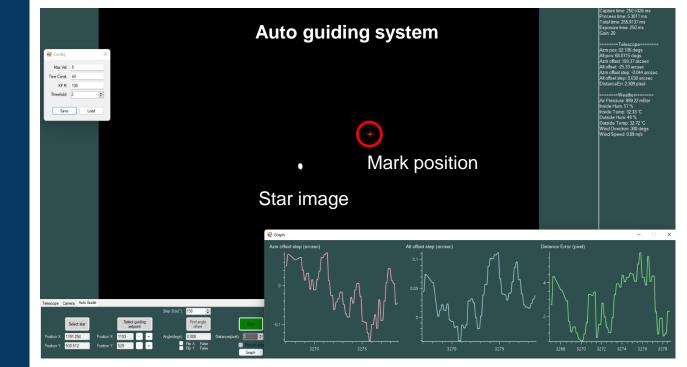
- Fiber-fed Echelle spectrograph
- Spectral Resolution: R>70000
- Spectral Domain: 400-1000 nm



Median sp. resolution R=42,000 (FWHM = 0.01488 nm) determined from 206 ThAr lines



EXOhSPEC Exoplanet High Resolution Spectrograph

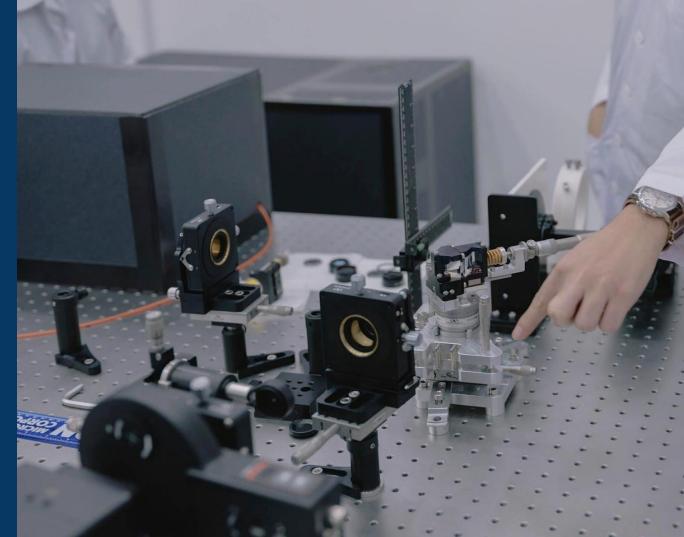


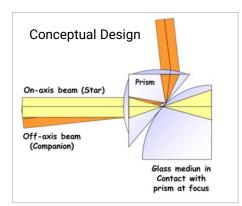


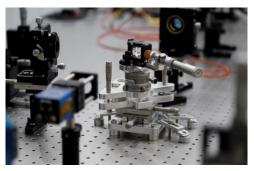


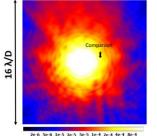


Objective: Development of Evanescent Wave Coronagraph prototype

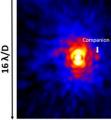








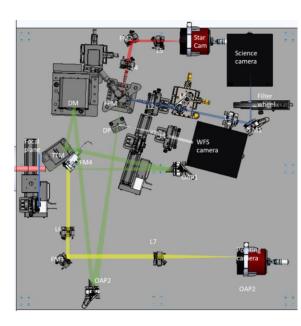
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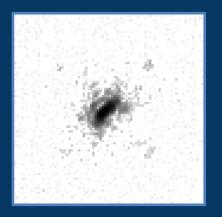


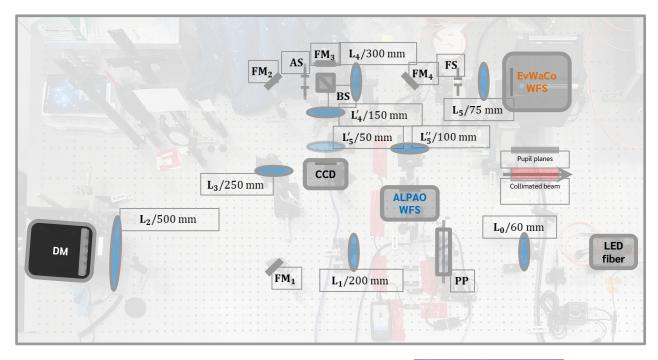
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Specifications

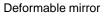
- Evanescent Wave Coronagraph
- Spectral Domain: R- and I-bands
- Raw constrast: <10⁻⁴ at IWA
- Inner Working Angle: 0.5"
- FOV: 10"
- Limiting magnitude: 8

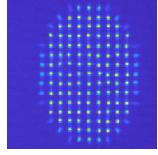






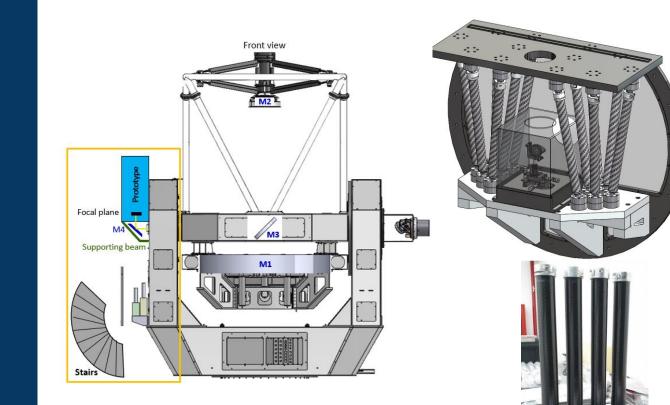






Wavefront sensor Camera

Mechanical design of EvWaCo prototype

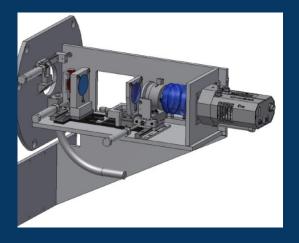


TRT Thai Robotic Telescope Network

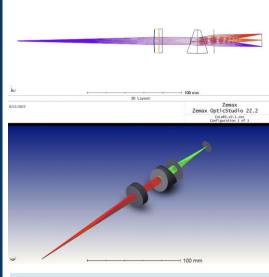


In 2024 - 0.7 m @CTIO

CoLoRS Compact Low Resolution Spectrograph



Objective: To develop a light weight compact spectrograph with robotic capability

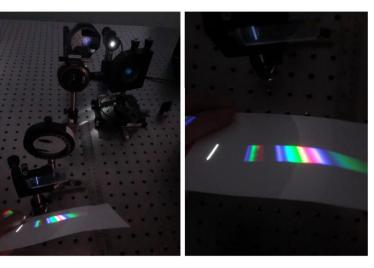


Schematic of the CoLoRS with the optical axis



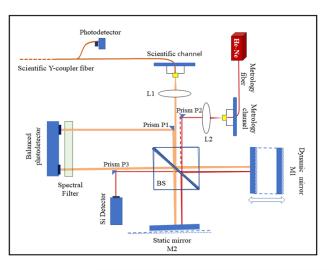
Specifications

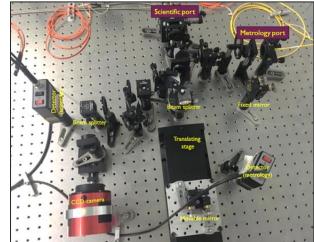
- Slit less/Long slit spectrograph
- Spectral Resolution: R=100-200
- Spectral Domain: 400-800 nm
- Robotic capability

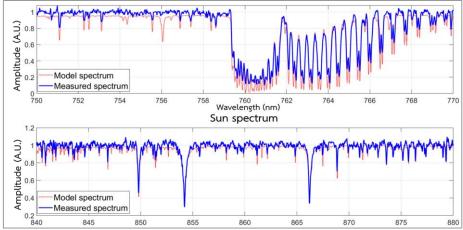


Fourier Transform Spectrograph

Objective: to develop a laboratory prototype of a fiber-fed Fourier Transform Spectrograph

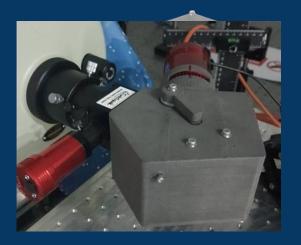






Experiment verification: Observe Sun Spectra

UV to Visible Spectrograph

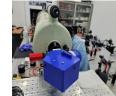


Objective: Development of spectrograph for UV to visible (350-700)

For Astronomy and Atmospheric Science purposes

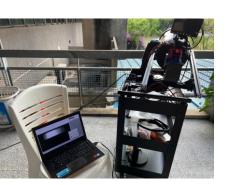


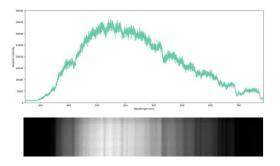




PLA 3D printed prototype

Nylon 3D printed prototype

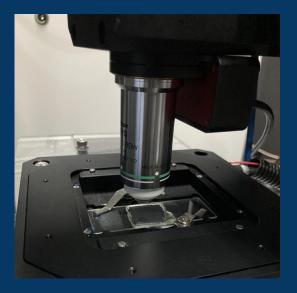




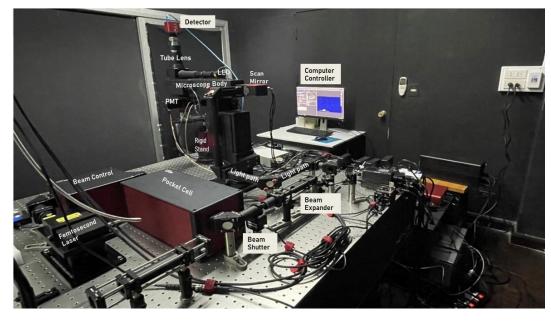
Specifications

- Spectral Resolution: R=500-3500
- Spectral Domain: 350-700 nm
- Czerny-Turner design

Multi-photon Microscope



Objective: to develop in Thailand state-ofthe-art multi-photon and single-molecule fluorescence microscopes.



The first modular two-photon microscope set-up in Thailand

2022:

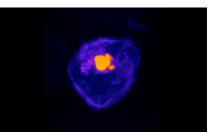
- Upright two-photon fluorescence microscope setup (M1).
- Study Human Embryonic Kidney Cell (HEK) samples 2023:
- M1 upgrade (930 nm femtosecond laser)
- M1 upgrade (two-photon polymerization)
- Study mouse pancreatic tissues for diabetes medication research.
- Study HEK samples for cancer research.
- Imaging chloroplasts (teaching)

2024:

- Single molecule fluorescence microscope (Msm)
- M1 upgrade (EMCCD installation)

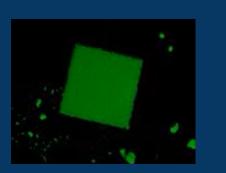
2025:

Inverted two-photon fluorescence microscope for better live cell imaging

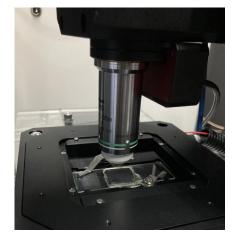


Human Embryonic Kidney Cell (HEK) samples courtesy of Dr. Praopim Limsakul

Multi-photon Microscope



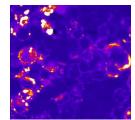


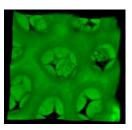


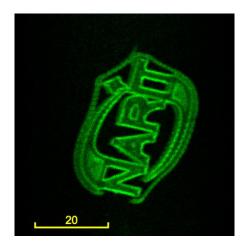
Two-photon polymerization: Micro-scale 3D printing

Potential applications:

- Miniaturized optical bio- and chemical sensors
- Microfluidics
- Lab-on-chip



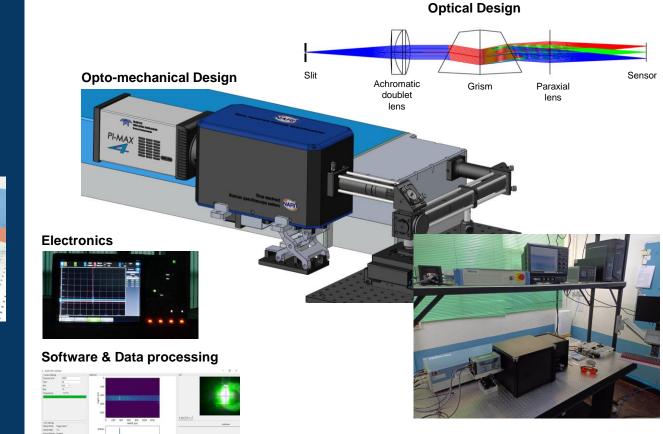




Time-resolved Raman spectroscopy system



Objective: to develop in Thailand state-ofart Raman spectroscopy system

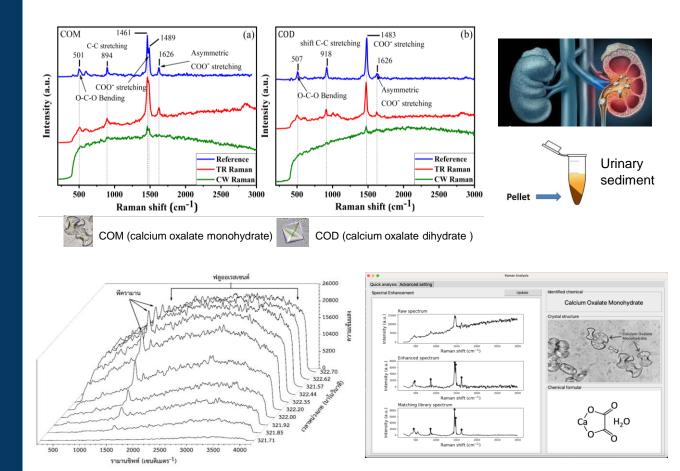


- ✓ Fluorescence background suppression
- ✓ Enhance sensitivity
- ✓ Time-resolved or distance-resolved Raman spectrum acquisition

Time-resolved Raman spectroscopy system

Kidney stone early detection:

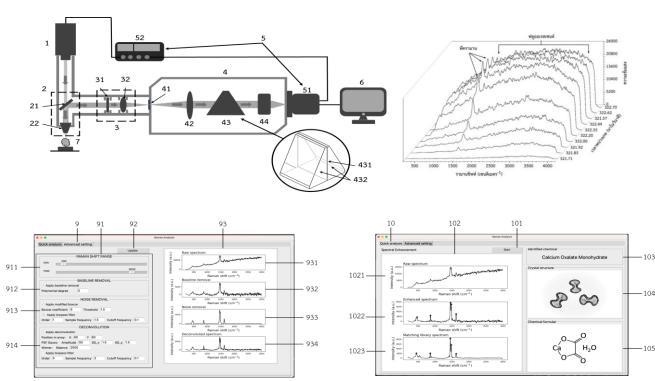
Fluorescence-suppressed Raman spectroscopy enables quick and sensitive detection of urinary stone composition, e.g. COM (a) and COD, directly from urinary sediment



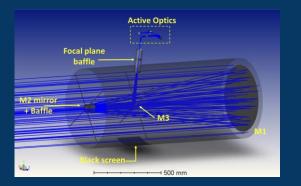
Time-resolved Raman spectroscopy system

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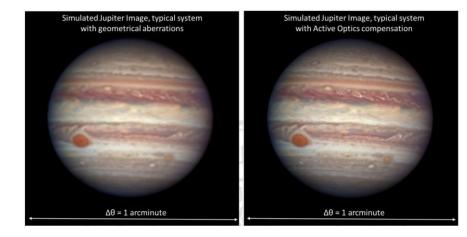


Telescope Development



Objective: To build up NARIT staff capabilities in telescope optical design and mechanical design and to be able to assemble telescopes

0.5 m Planetary Imaging Telescope

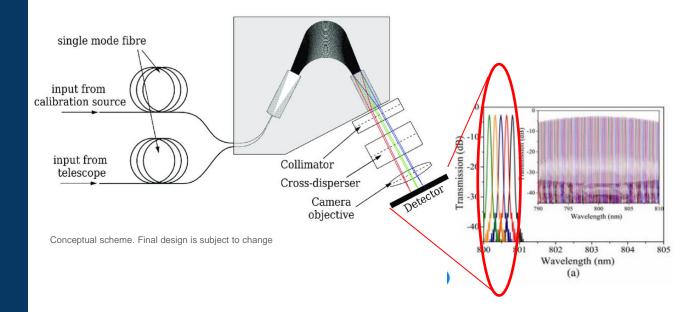


0.8 m Telescope for Regional Observatories



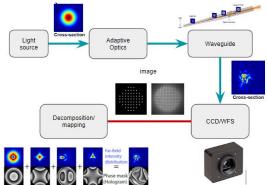
Photonics chip and Fiber optics

Objective: Develop the operation and characterization apparatus for spectroscopy on photonic chip

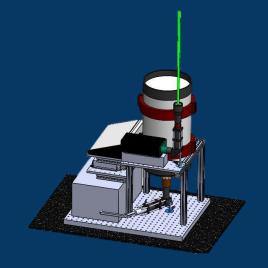


Overall objectives:

- Create optical apparatus for photonic chip and fiber optics operation at NARIT, especially for the spectroscopy application
- Create optical apparatus for characterization of distorted wavefront when photons pass through waveguide
- Create a build-in-house tapered fiber machine and fabrication of taper for research purposes
- Create a proper environment and efficient pipeline for in-house chip design and outsourcing fabrication

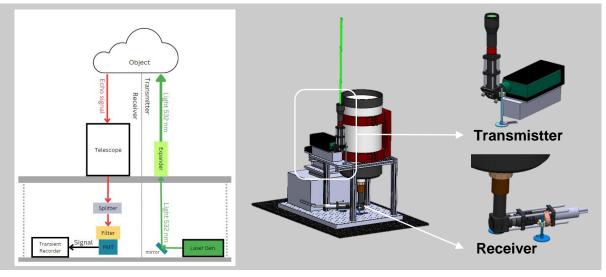


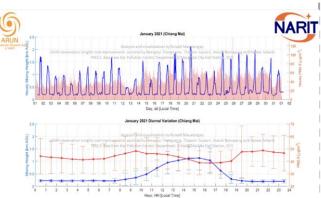
Atmospheric LiDAR



Objective: To investigate and develop a MIE scattering LiDAR system for atmospheric application

Atmospheric LiDAR Design





Expectation output

Phase I (March-September 2023):

- Single wavelength (532 nm)
- Unpolarized
- 10 km (night-time)

Phase II (October 2023-September 2024):

- Prototype development
- 10 km (night-time)/ 5 km (day-time)
- Data processing (Polarization)

Hyperspectral Imager



Objective: To develop the spectrometer prototype for the TSC-1 hyperspectral imager

Satellite TSC-1



Position on slit

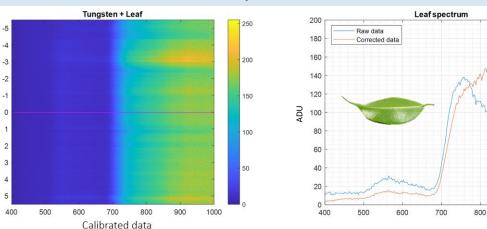
 Main Payload equipment: Hyperspectral Imaging Camera 15 ~30 m GSD



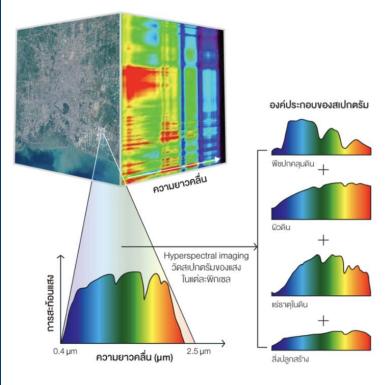
900

1000

Preliminary calibrated data

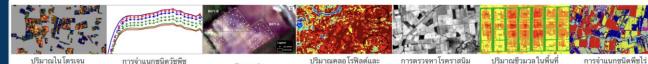


Hyperspectral Imager





Hyperspectral Drone



ปริมาณไนโตรเจน ในไร่อ้อย การจำแนกชนิดวัชพืช โดยอัตโนมัติในไร่ช้าวโพด

ลักษณะดิน

ปริมาณคลอ โรฟิลด์และ ไนโตรเจนในต้นข้าว การตรวจหาโรคราสนิม ปริมาณชีวมวลในพื้นที่ ในไร่อ้อยก่อนลูกลาม เพาะปลูก

การจำแนกขนตพขาร และวัชพืชโดยอัตโนมัติ

Pedagogical project



Objective: To promote optical instrument design education in Thailand

PI: Dr. Chanisa kanjnasakul **Team:** Mr. Weerapot Wanajaroen



Advanced physics laboratory course:

• Introduction to Optics design, Aberrations

• Single lens, Doublet and Telescope design class using CODE V software

• Optical design class 9 hr (on-line) for SUT students

Optical design class 15 hr at CMU

• Total student: 30 students (22 CMU students, 2 SUT students, 5 NARIT engineers, 1 CMU lecturers)

THANK YOU