

Infrared Imaging Spectroscopic Missions: NISS & SPHEREx

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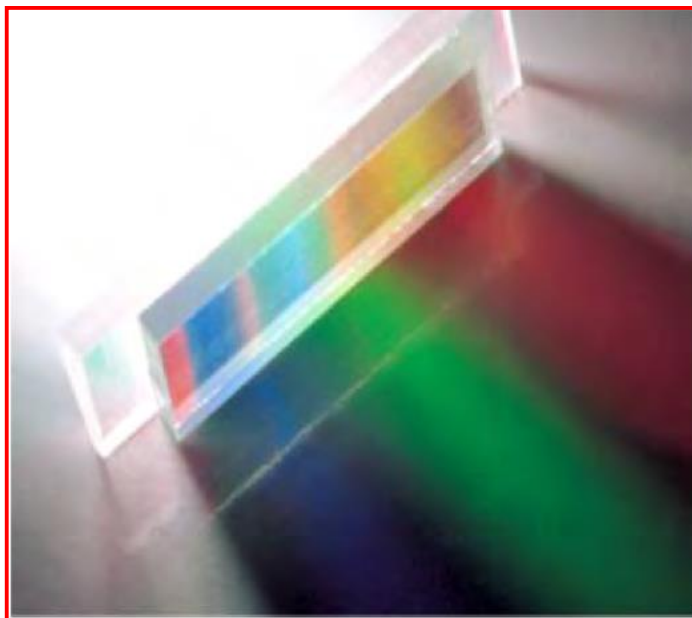
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⁵ Korea Institute for Advanced Study

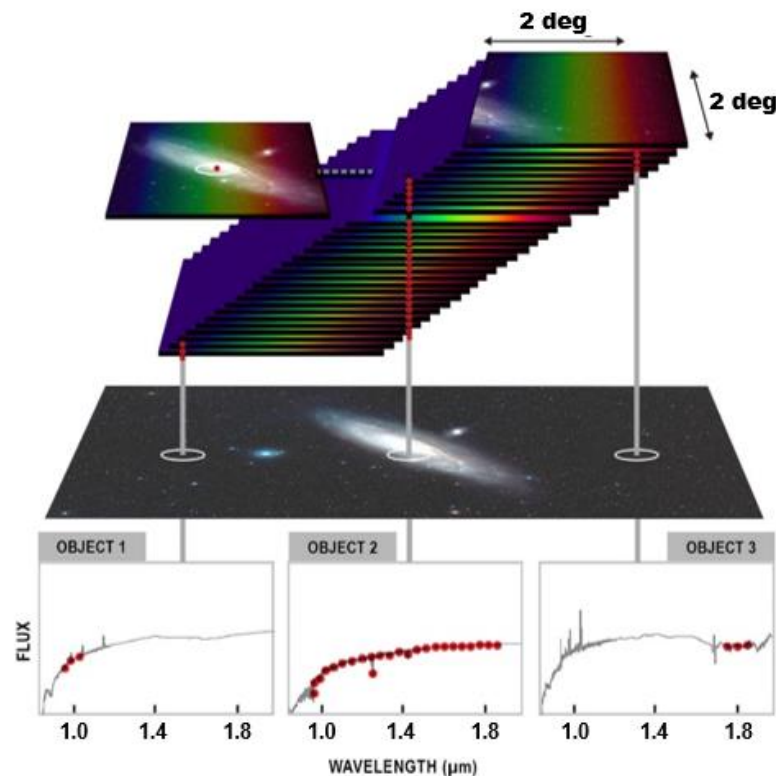


Infrared Spectro-Photometric Survey?

- Wide-field Imaging + Wide- λ Range Spectroscopy
- No moving part: reliable observations
- High throughput & survey efficiency
- Technically demonstrated through NISS mission (2018)

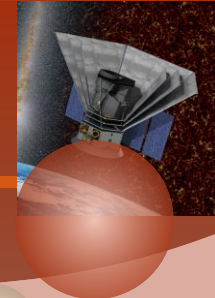


Linear Variable Filter

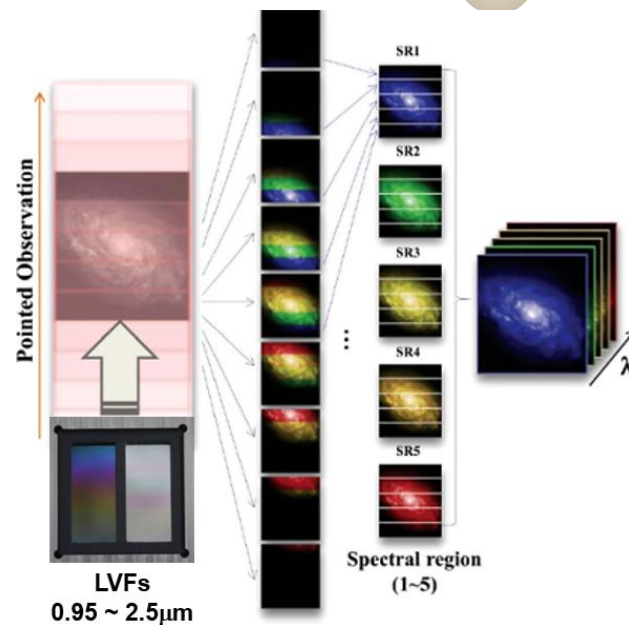
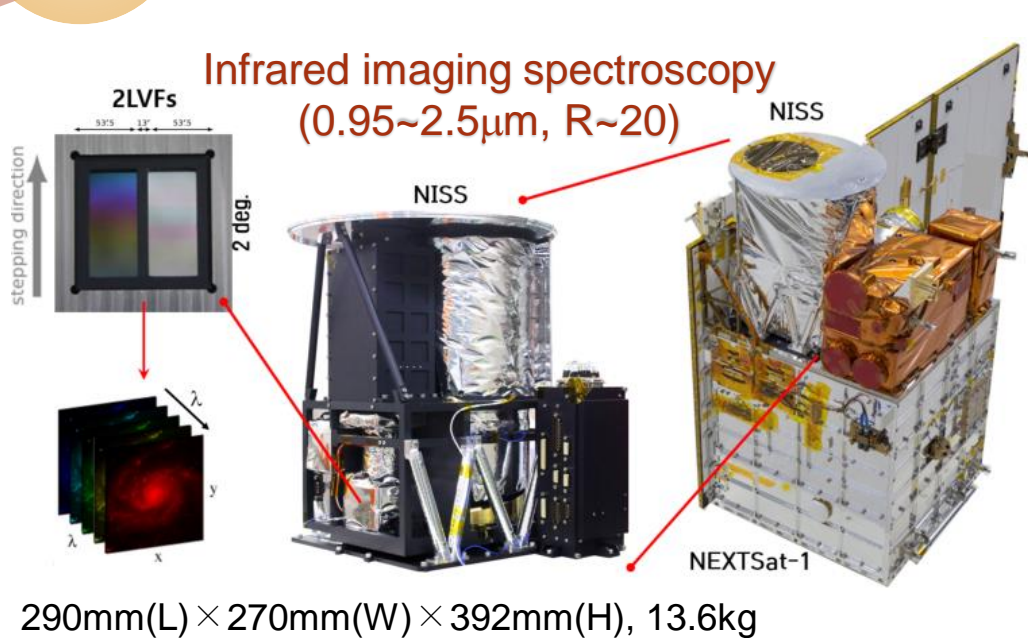




Launch of NISS / Initial Operation



- ❖ Near-Infrared Imaging Spectrometer (NISS) onboard NEXTSat-1
- ❖ Spectro-photometric survey: $\sim 100 \text{ deg}^2$ during 2-yr operation



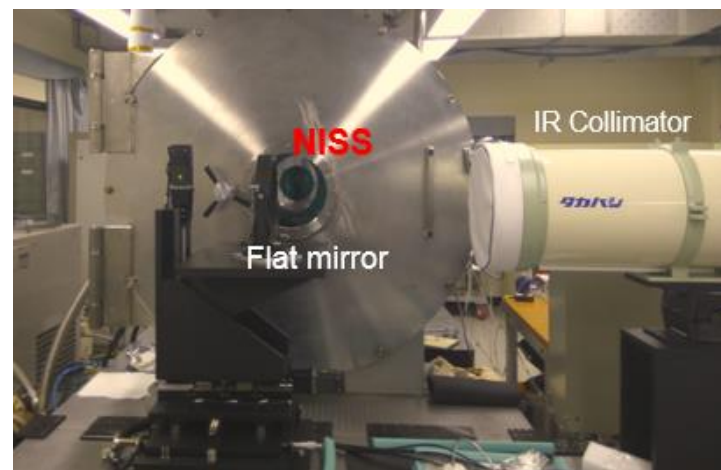
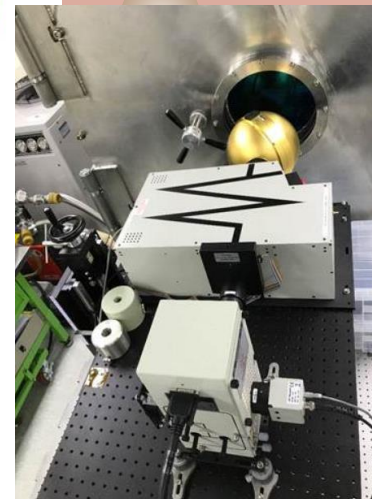
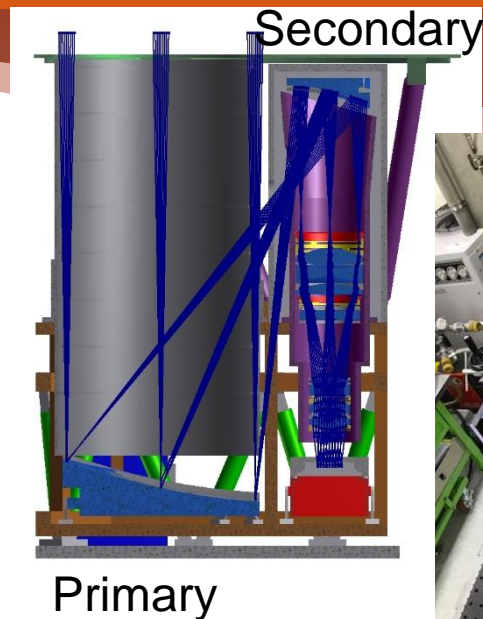
- Operation: ~2 years
 - Initial operation period: 3 months
 - Main observation: 18 months
 - User observation: 3 months





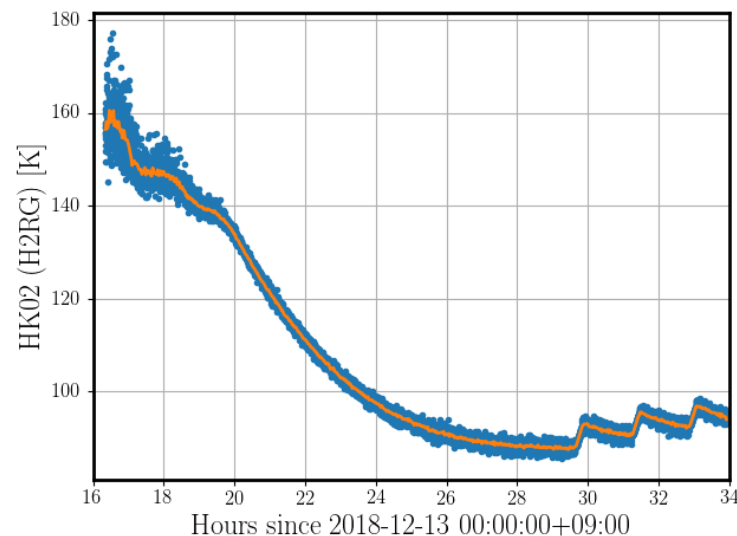
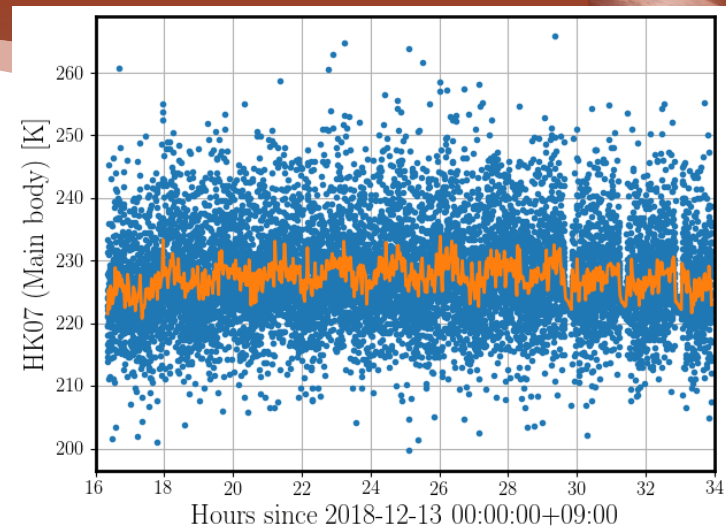
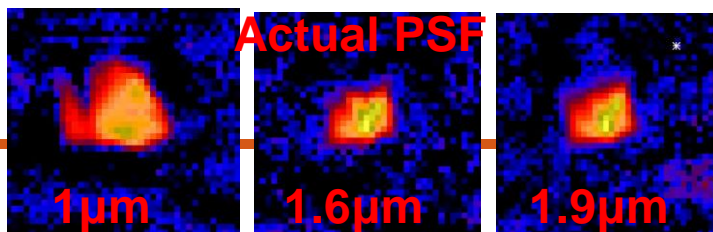
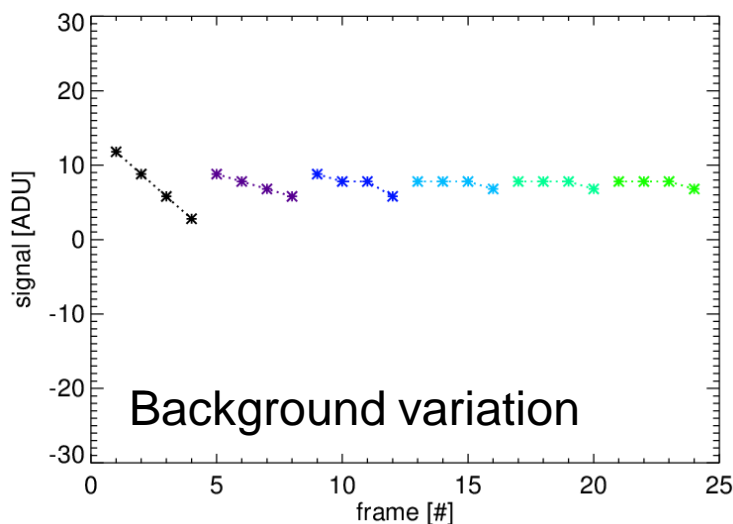
Full Development

- Optics
 - Optical design & analysis
 - Mirrors & lens
- Opto-mechanics, Structure
 - Mechanical design & analysis
 - Barrel, structure
 - Passive & active cooling system
- Electronics
 - Operation of IR sensor
 - Data transfer
- Calibration & Operation
 - Test, Cal., DR
 - Operation



Operations in Space

- Cooling Time (Op-TA)
 - Telescope: ~ 2 day (~ 1 day)
 - IR sensor: ~ 24 hrs (~ 12 hrs)
- Telescope: 220 – 230K
- IR Sensor: 88 – 96K





Images from Initial Operations

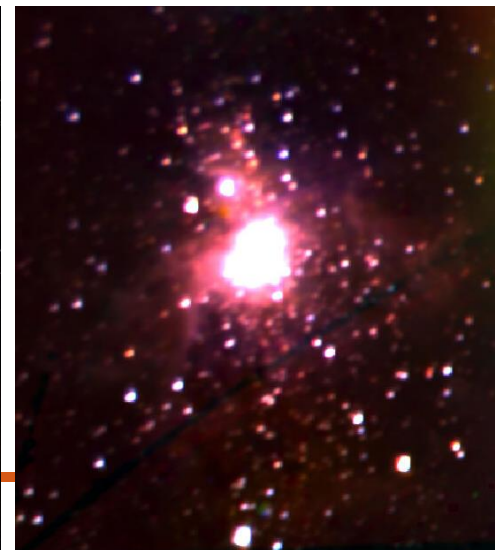
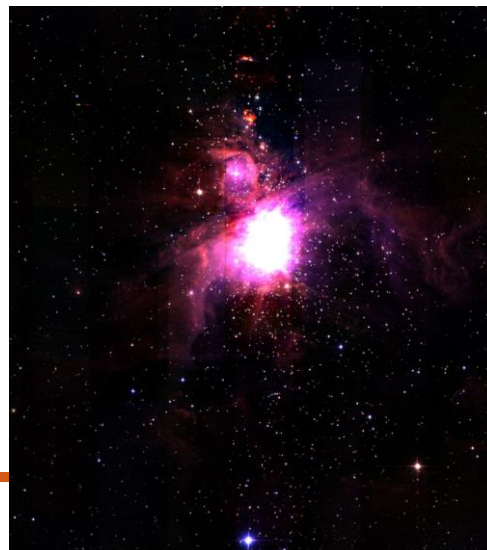


HST vs NISS

M33

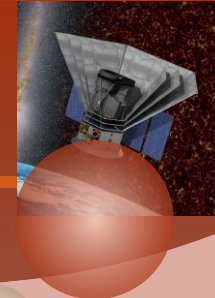
Orion

2MASS vs NISS



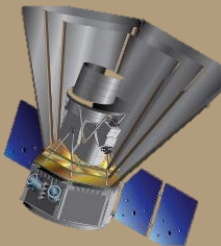




Developments of Space IR Instruments



- Study of diffuse components from MIRIS & NISS
 - ⊙ EBL Study: near Ecliptic poles observed by AKARI
 - ⊙ Star formation & ionized diffuse gas: Galactic plane

Mission Parameter	MIRIS (2014)	NISS (2018)	SPHEREx
			
FoV	3.6×3.6 deg.	2×2 deg.	3.5×11.3 deg.
Aperture of Telescope	8cm	15cm	20cm
Spectral Coverage	1.1 & 1.6 (1.87) μ m	0.95 ~ 2.5 μ m	0.75 ~ 5 μ m
Spectral Resolution	5 (45)	20	40 - 150
Spatial Resolution	51.6"	15"	6"
Coverage (Deep fields)	~3,000 deg ²	150 deg ²	All-sky
Depth	18 AB mag.	17 AB mag.	19 AB mag.

SPHEREx: An All-Sky Spectral Survey

Designed to Explore

- The Origin of the Universe
- The Origin and History of Galaxies
- The Origin of Water in Planetary Systems

The First All-Sky Near-IR Spectral Survey

A Rich Legacy Archive for the Astronomy Community with 100s of Millions of Stars and Galaxies

Low-Risk Implementation

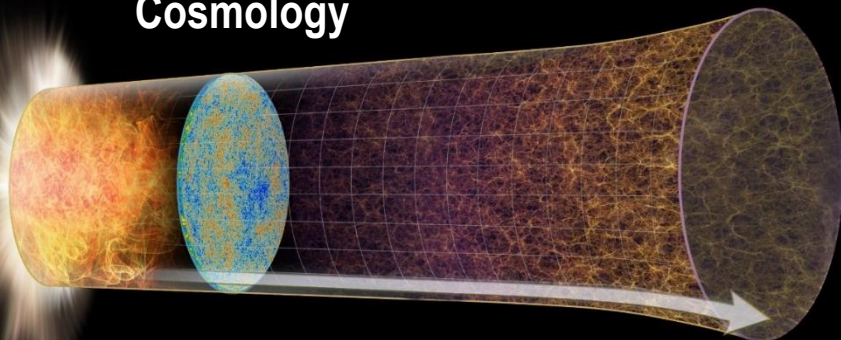
- Single Observing Mode
- No Moving Parts
- Large Technical & Scientific Margins

Finally Selected!



Major Scientific Goals

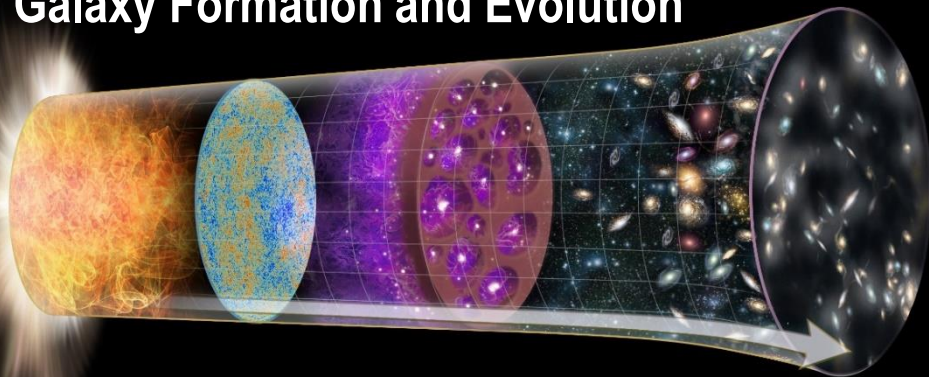
Cosmology



Directly Addressed through an All-sky NIR spectral survey from space

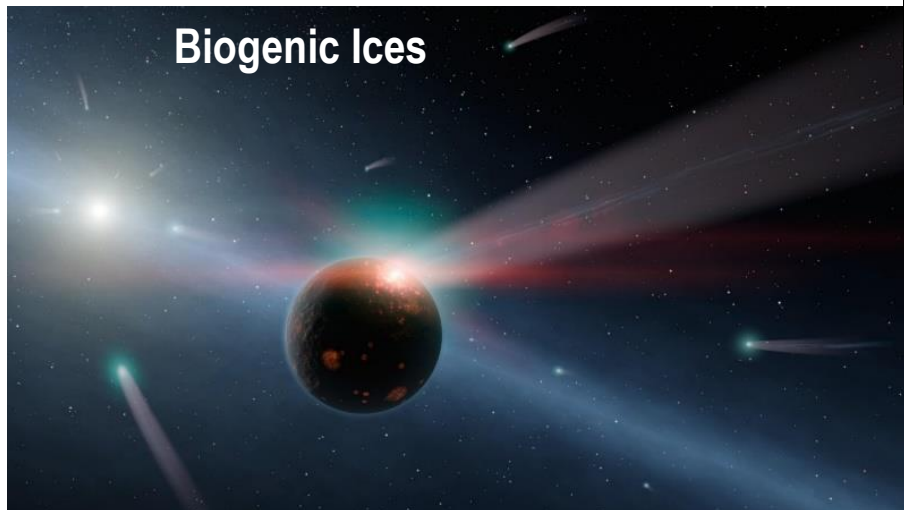
SPHEREx will probe the 3D Large scale structure today to gain insight to the earliest epochs of the universe. Measure σ_{fNL} to high accuracy.

Galaxy Formation and Evolution



SPHEREx extragalactic background light measurements determine the total light emitted by galaxies

Biogenic Ices



SPHEREx will measure the H_2O , CO , CO_2 , CH_3OH ice content in clouds and disks, determining how ices are inherited from parent clouds vs. processed in disks

SPHEREx Creates an All-Sky Legacy Archive

Galaxies

Detected
> 1 billion



Medium-Accuracy Spectra
> 100 million



High-Accuracy Spectra
10 million



Clusters
25,000



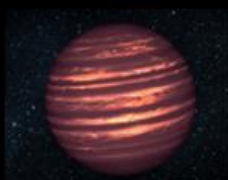
Main Sequence Spectra
> 100 million



Dust-forming
10,000



Brown Dwarfs
> 400



Cataclysms
> 1,000



Stars

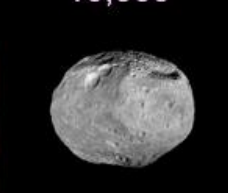
Quasars
> 1.5 million



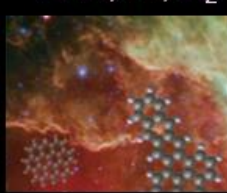
Quasars $z > 7$
1 – 300?



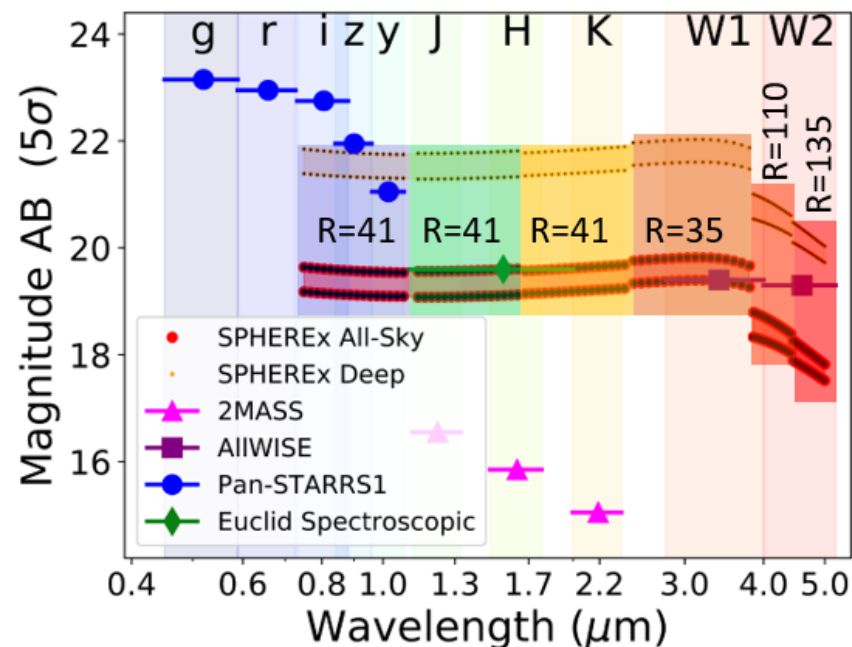
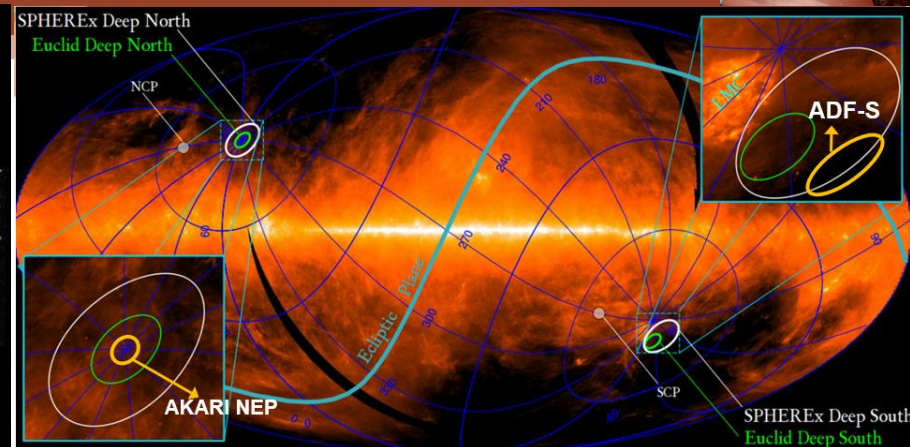
Asteroid & Comet Spectra
10,000



Galactic Line Maps
PAH, HI, H₂

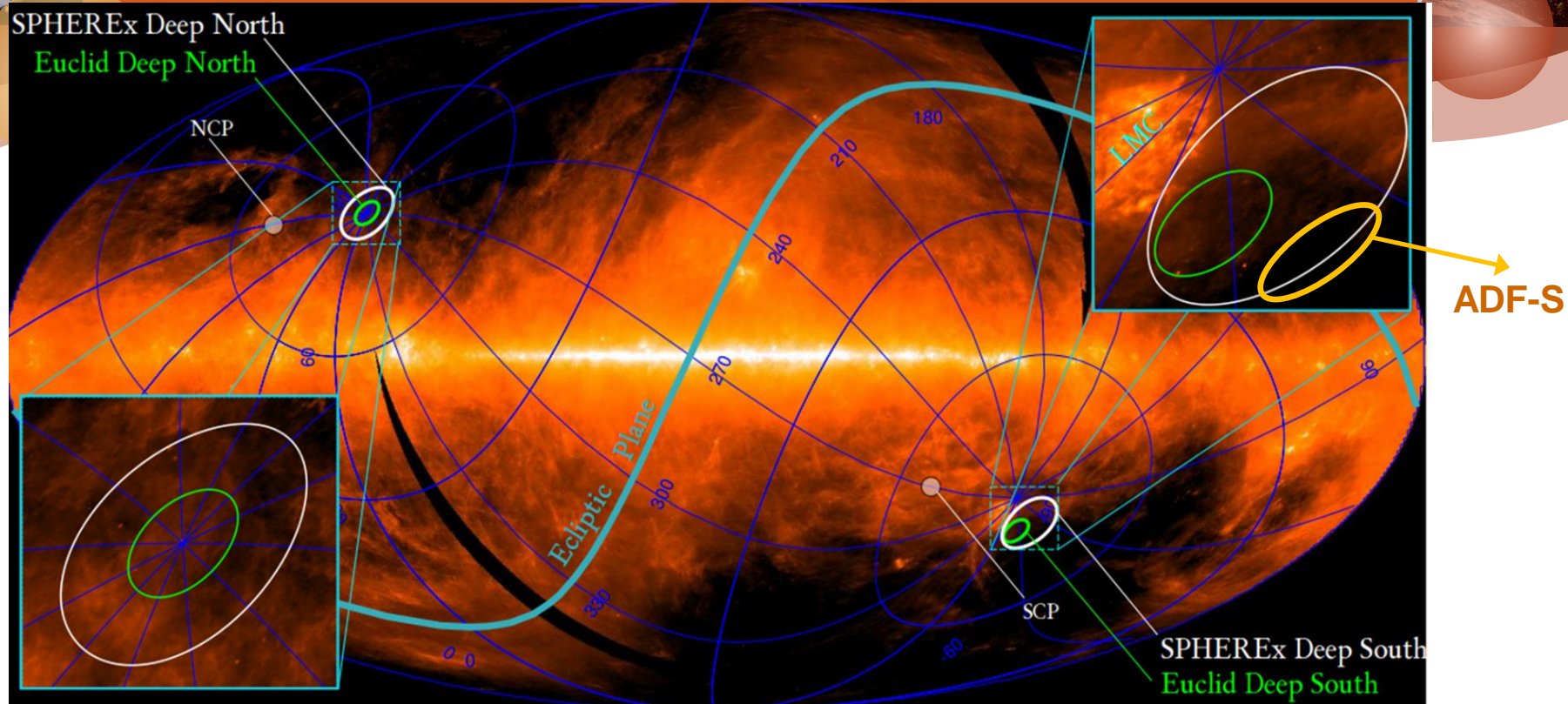


Other



A spectrum for every 6" pixel on the sky

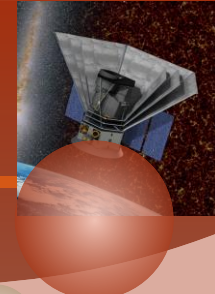
SPHEREx Deep Fields



- NEP/SEP: 100 + 100 sq. deg.
 - AKARI Deep Fields (NEP/SEP)
 - Average 60x deeper than all-sky survey
 - Spatially not uniform, but include Euclid Deep Fields (eROSITA)



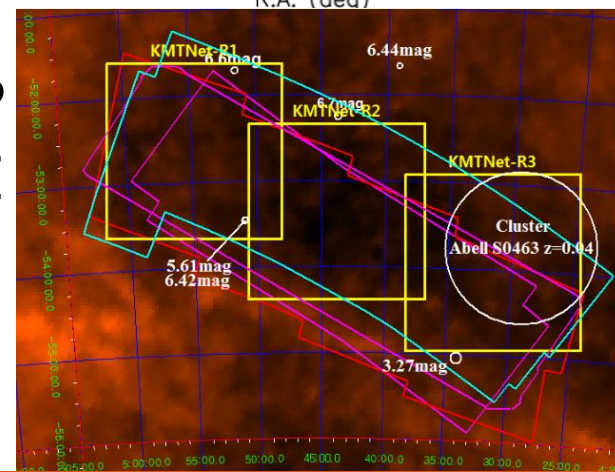
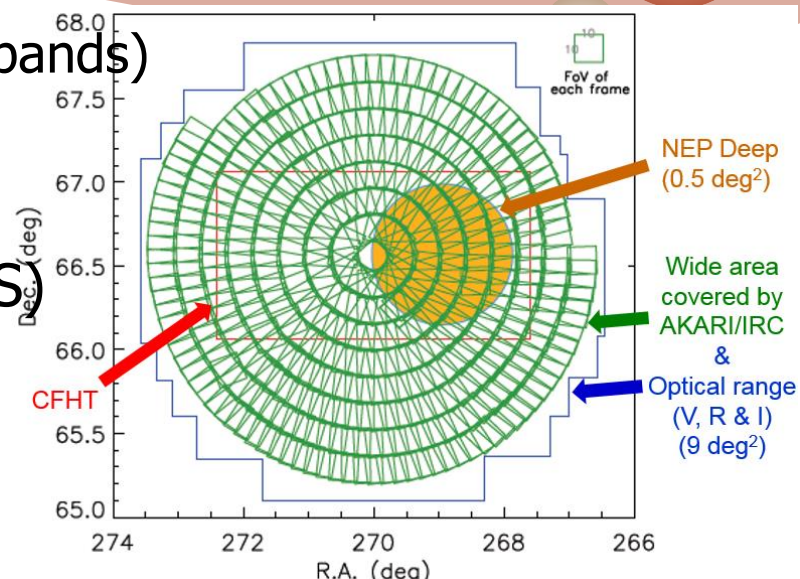
AKARI Deep Surveys @ EP



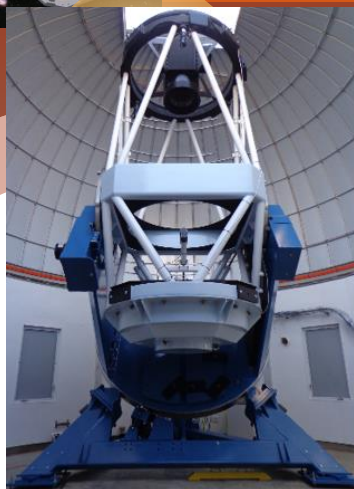
- NEP: 5.4 deg.² by IRC (Near- & Mid-IR 9 bands)
- SEP(ADF-S): 12 deg.² by FIS (FIR 4 bands)

○ Ancillary Data (undergoing)

- Optical data: Subaru(N), KMTNet(S)
- NIR: Kitt Peak FLAMINGOS – NEP
VISTA - SEP
- MIRIS (I & H): up to 10 x 10 deg.
- Spec: MMT/Hectospec
& WYIN/Hydra – NEP, AOMega - SEP
- FIR-Submm: Herschel PACS & SPIRE
- Submm: SCUBA-2, (ALMA)
- mm: AzTEC – SEP, (ALMA)



Expecting Synergy with KASI's Facilities



KMTNet



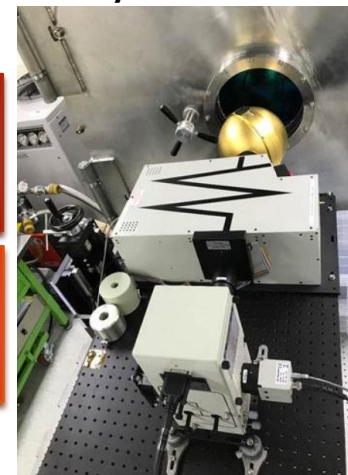
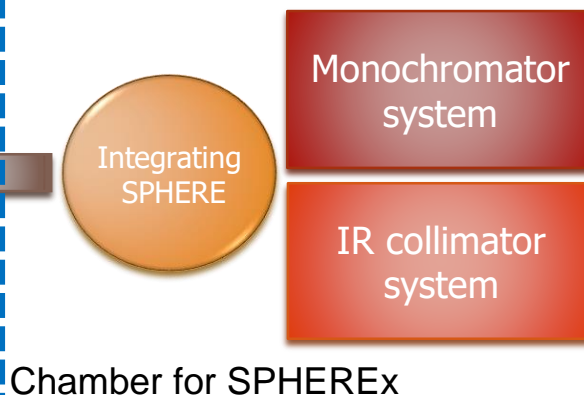
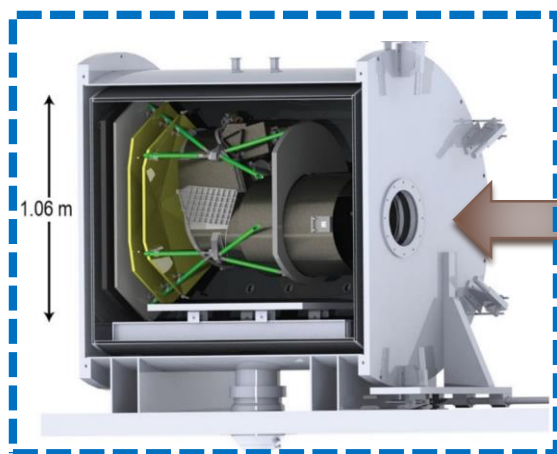
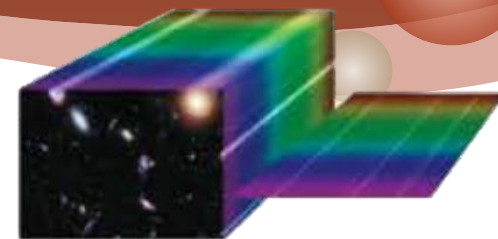
- Korea Microlensing Telescope Network (KMTNet)
- Access to foreign facilities
 - EAOs: JCMT, ALMA, ...
 - Mid-sized optical telescopes: Gemini-S/N, MMT, UKIRT, ...
- GMT, LSST, ...

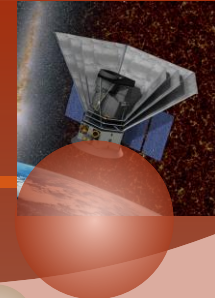




KASI's Contribution

- Data reduction pipeline: experience from NISS
- Science (especially extragalactic science)
 - Pre-studies with NISS: operation from 2018
 - Multi-wavelength surveys for NEP/SEP regions
- Ground support equipment for characterizing the instrument (cryo. Chamber, integrating sphere, ground station electronics)
 - Re-design of cryo. chamber
 - Test items: optics & system





Phase Studies (10 yrs)

- Phase-A (2018): Conceptual design
- **Development Phase (2019 ~ 2022)**
 - Detailed design, Assembly & preparation of DR
 - Preparation of Science Cases
- Operational Phase (2023 ~ 2025)
 - Constructs test calibration facilities & Calibration
 - All-sky survey & evaluation of PV data
- Science Phase (2025 ~ 2028)
 - Research activities with legacy science data
 - Revision of DR for Science Enhancement Options (SEOs)

Collaborations in Science

- Cosmology: 3D large-Scale structure

KIAS

○ Galactic Sciences

- Ice Features from YSOs & IRDCs
- Exploring unshocked SN ejecta in young SNs
- Deep ecliptic patrol of the southern sky: DEEP-South
- Transient objects (stars, SNs, ...)

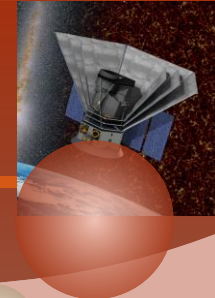


○ Extragalactic Sciences



- SF properties of near-by galaxies
- Near-by and high-z AGNs & AGNs
- Properties of High-z emission line galaxies
- Origin of Cosmic Infrared Background





Summary

- Space instruments developed by KASI
 - Technical demonstration: imaging spectroscopy with LVFs
 - Imaging spectroscopic survey: Nearby galaxies, star-forming regions, low-background regions ...

- SPHEREx
 - KASI's contribution
 - Galactic / Extragalactic Sciences
 - Synergy with other Facilities (KMTNet, GMT, GEMINI, MMT ...)
 - More science cases from Korean community
 - Need more manpowers

- Contributing sources to CIB?
 - Extragalactic Sciences with NEP/SEP Regions