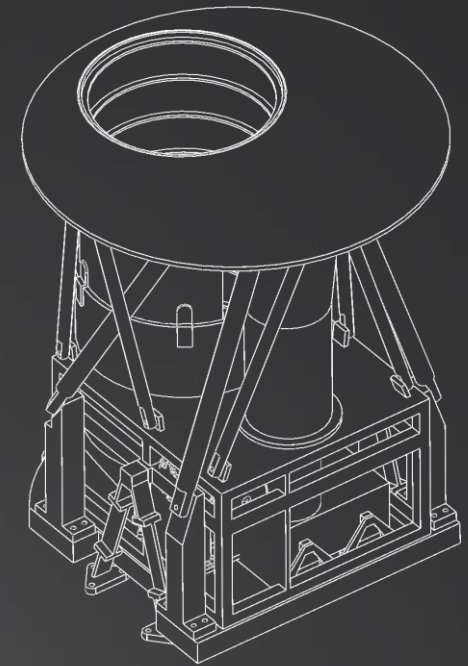

Infrared Spectro–Photometric Survey in Space

– Focusing on NISS & SPHEREx –

Woong–Seob Jeong
Space Astronomy Group, KASI



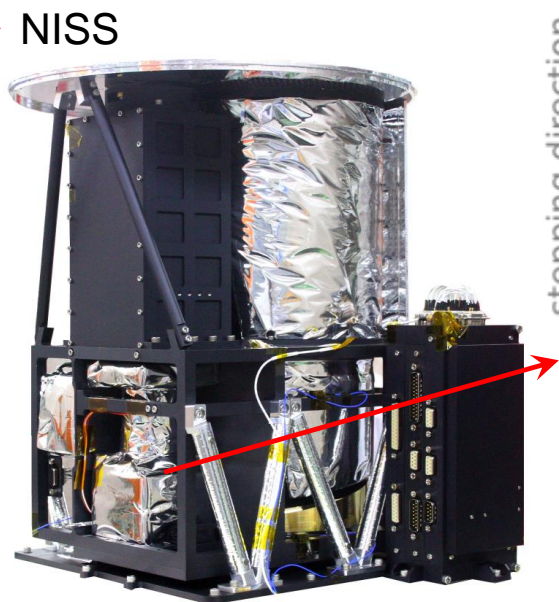


NISS: Near-IR Imaging Spectrometer onboard NEXTSat-1 (2017)

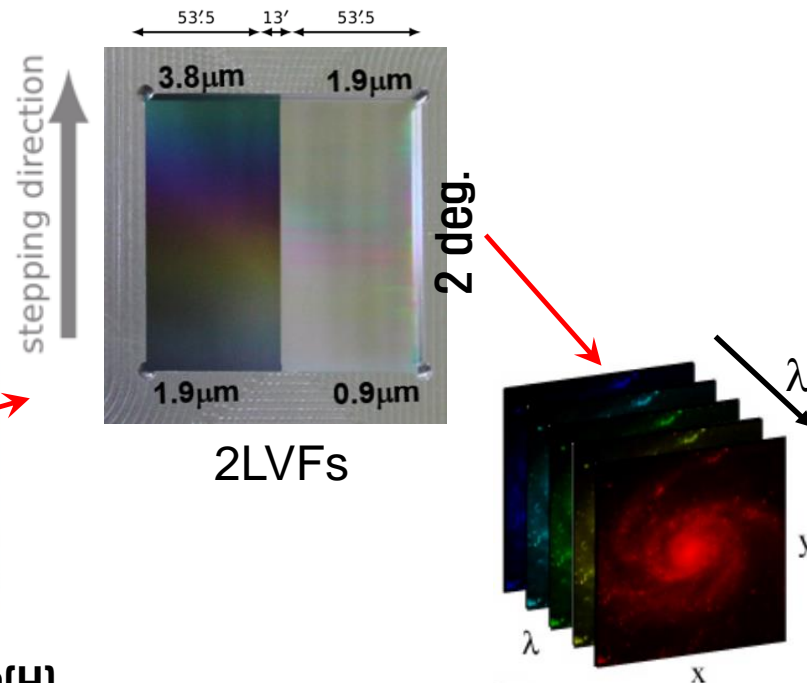
- Wavelength range: 0.9 ~ 3.8 μm → **2.5 μm** (R~20)
- Array format: 1024 x 1024, FoV: ~2 deg. X 2 deg. (15"resol.)
- 15cm aperture, Imaging & Low-Resolution Spectroscopy (R~20), Sensitivity ~17 AB mag. – spectrophotometric survey area ~150 deg²



NEXTSat-1
EQM



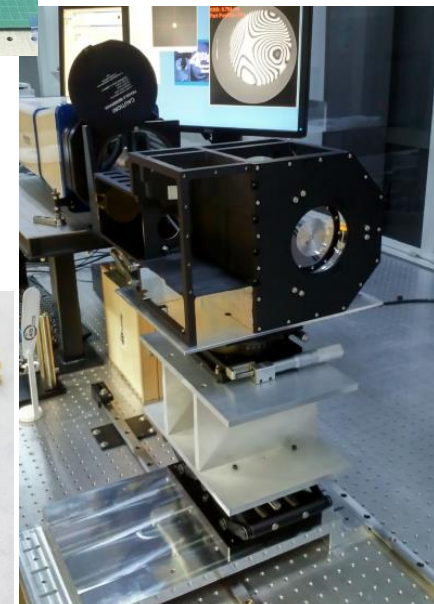
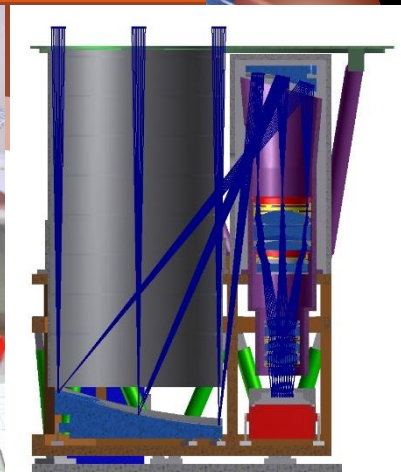
NISS
290mm(L) × 270mm(W) × 400mm(H)
14kg





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: ~2 yrs

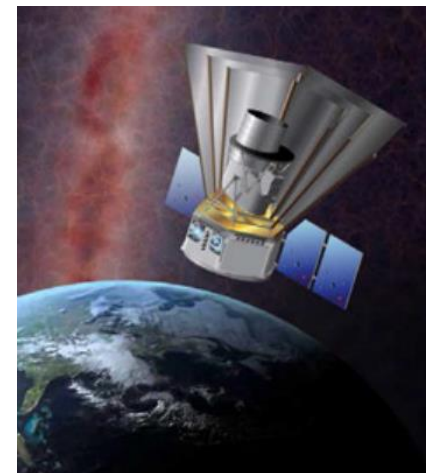


SPHEREx, NASA SMEX Mission (2020)

- Spectro-**P**hotometer for the **E**xtragalactic structure, **R**eionization and ices **E**xplorer: under Phase-A Study
- Spectro-photometric all-sky survey: 1.4B spectral catalog (0.75 ~ 4.8 μ m, R=40 ~150)
- Participating Institutes (PI: Jamie Bock): International Collaboration
 - JPL: management, thermal system, readout electronics, QA
 - Caltech: Instrument Development, I&T, Data Pipeline
 - Ball Aerospace & Technologies Corporation: spacecraft
 - ASU, Caltech, Harvard, IfA, JPL, OSU, UC Irvine: Science
 - **KASI (~10% budget) : H/W, data pipeline, science**

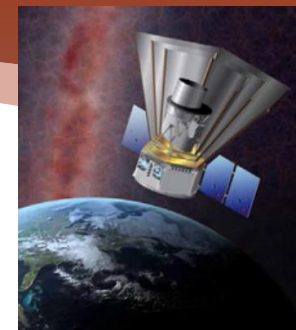
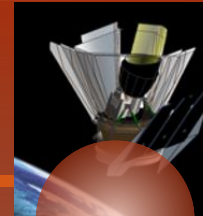


- SPHEREx is the upgraded mission of the NISS



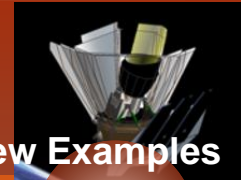


NISS vs. SPHEREx

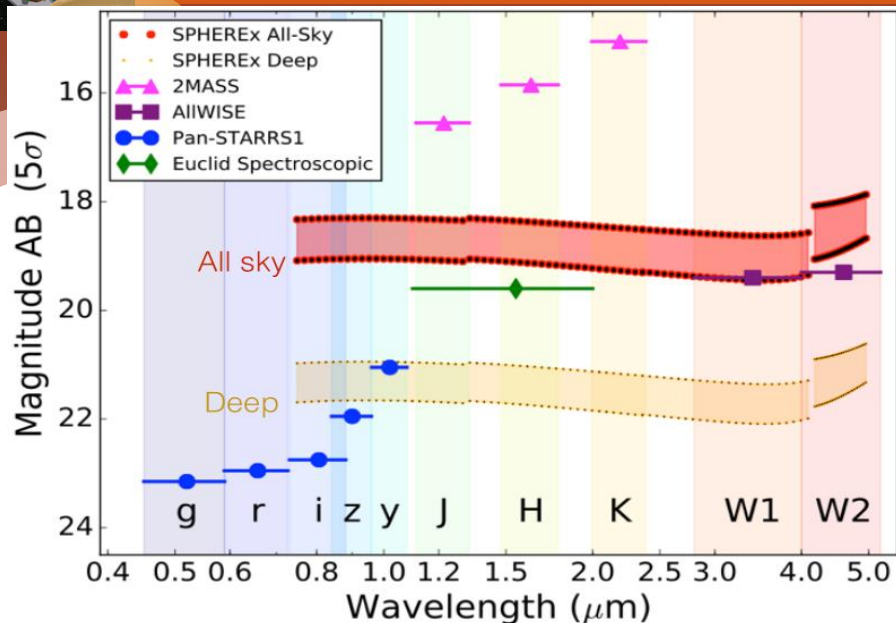


	NISS	SPHEREx
FoV	2x2 deg	3.5x7 deg
Spectral Coverage	0.9-3.8 μ m	0.75-5 μ m
Spectral Resolution	20	40-140
Spatial Resolution	15 arcsec	6 arcsec
Survey Area	~150 sq. deg.	All Sky
Sensitivity	17 AB mag.	19 AB mag. (deep fields: x30)

SPHEREx: All-Sky Legacy Archive



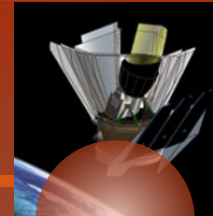
Legacy Science Opportunities: A Few Examples



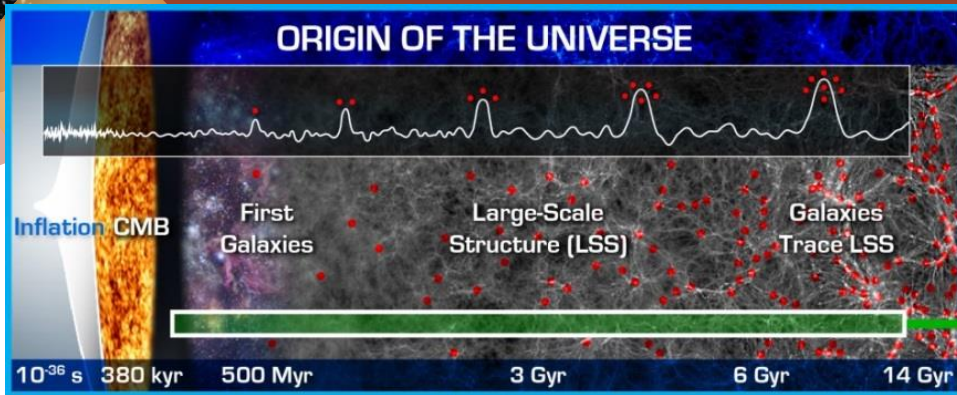
Notable Features of the SPHEREx All-Sky Survey

- High S/N spectrum for every 2MASS source
- Solid detection of faintest WISE sources
- Catalogs ideal for GMT/JWST observations
- Redshifts for other surveys (e.g., eRosita X-Ray survey)
- Photo baselines for wide-field transient survey
- Mapping 3D distribution of Galactic ices
- ...

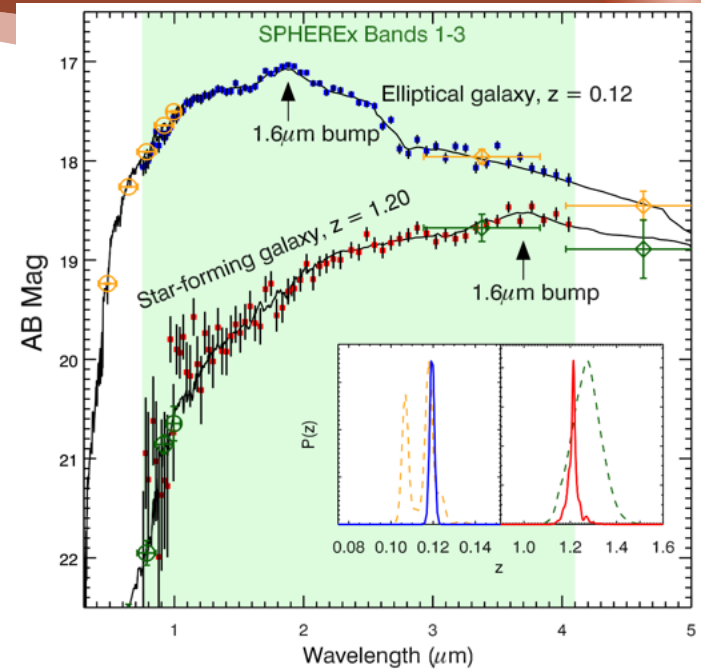
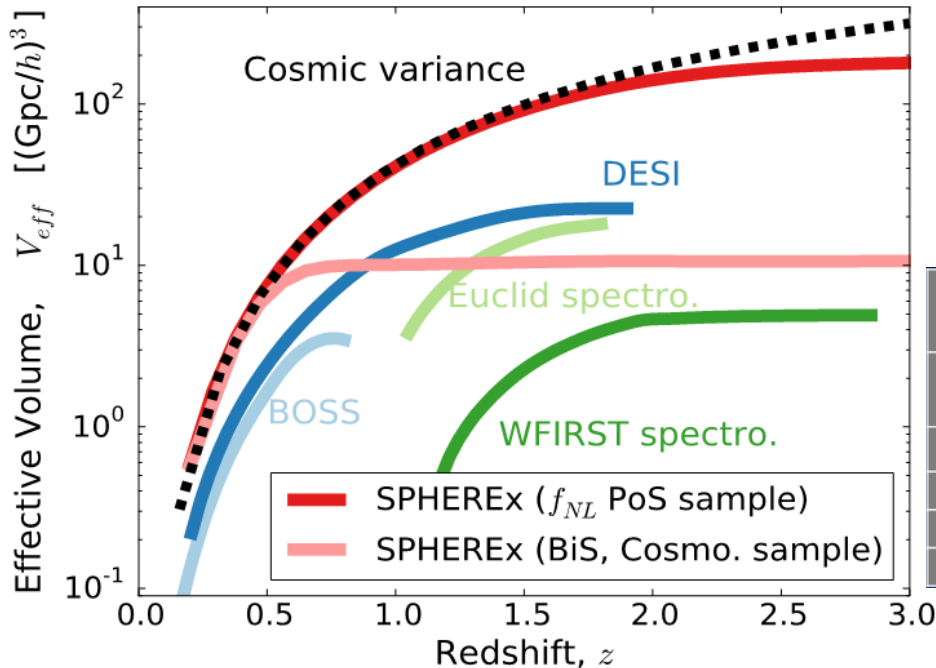
Object	# Sources	Legacy Science	Reference
Detected galaxies	1.4 billion	Properties of distant and heavily obscured galaxies	Simulation based on COSMOS and Pan-STARRS
Galaxies $s(z)/(1+z) < 0.03$	120 million	Study (H, CO, O, S, H ₂ O) line and PAH emission by galaxy type. Explore galaxy and AGN life cycle	
Galaxies $s(z)/(1+z) < 0.003$	9.8 million	Cross check of Euclid photo-z. Measure dynamics of groups and map filaments.	
QSOs	>1.5 million	Understand QSO lifecycle, environment and taxonomy	Ross et al. (2013) plus simulations
QSOs at $z > 7$	0-300	Determine if early QSOs exist. Follow-up spectroscopy probes EOR through Ly α forest	
Clusters with ≥ 5 members	25,000	Redshifts for all eRosita clusters. Viral masses and merger dynamics	Geach et al., 2011, SDSS counts
X-ray source characterization	>100,000	In conjunction with eROSITA, detect X-ray source SEDs (e.g., AGNs) and their spectroscopic redshifts	Workshop White Paper (Doré et al., 2016)
Missing baryon studies	>10,000	In conjunction with CMB experiments, measure the kSZ signal of galaxy groups and clusters	Doré et al. (2016) Ferraro et al. (2016)
Exoplanet characterization	>1000	Determine precise radii for exoplanets from host star studies (§9.1.2)	Doré et al. (2016)
Deuterated PAH search	~100	Probe and possibly map deuterated PAHs; complete inventory of D in local ISM	Doré et al. (2016) Doney et al. (2015)
Lowest metallicity stars	~1000	Identify low-mass stars throughout the Galaxy by their IR signatures; and map their distribution	Doré et al. (2016)
Asteroids and comets	10,000/100	Spectrally classify numerous asteroids; CO/CO ₂ ratio in comets	Doré et al. (2016)
Nearby, resolved galaxies	~100	Spectrally image galaxies to trace stellar populations, star formation, etc.	Doré et al. (2016)



SPHEREx: LSS

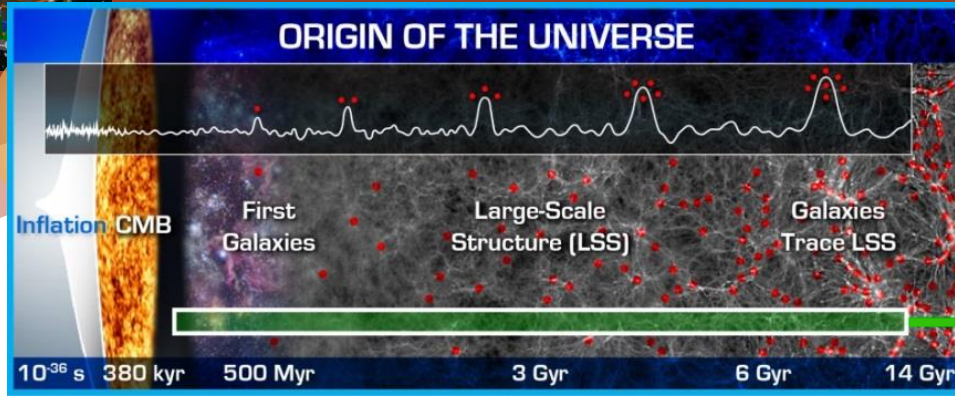


Time Since Big Bang



1 σ errors, statistical (systematics)	SPHEREx (MEV)			Euclid (GC)	Current
	PoS	BiS	PoS+BiS		
f_{NL}	0.86 (0.15)	0.23 (0.05)	0.15 (0.03)	5.59	5.0
Spectral Index n_s ($\times 10^{-3}$)	2.6	1.5	1.4	2.6	4.0
Running α_s ($\times 10^{-3}$)	1.0	1.0	0.49	1.1	7.5
Curvature Ω_k ($\times 10^{-4}$)	7.6	9.5	6.6	7.0	20
Dark Energy FOM	381	NC	NC	309	14

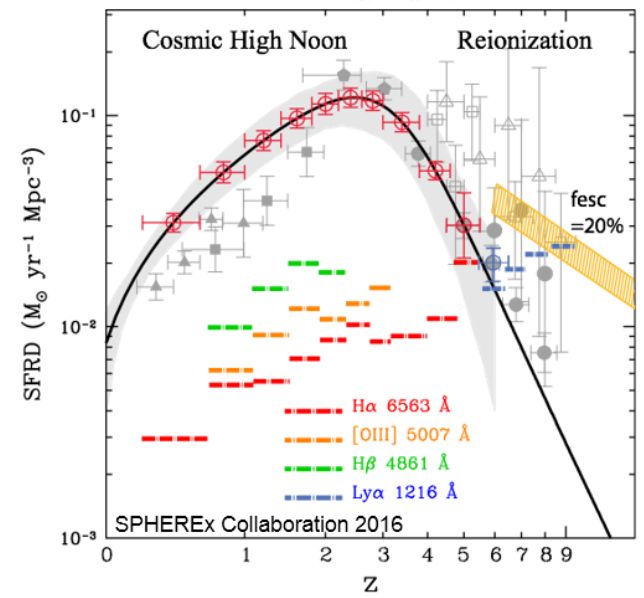
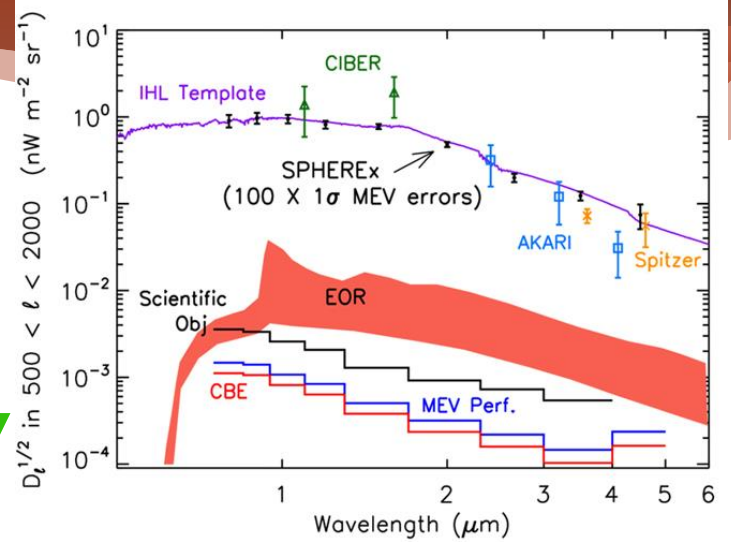
SPHEREx: Galaxy Evolution

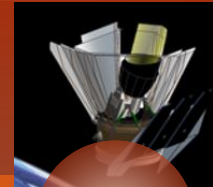
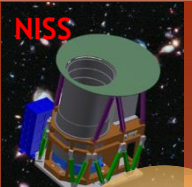


Time Since Big Bang

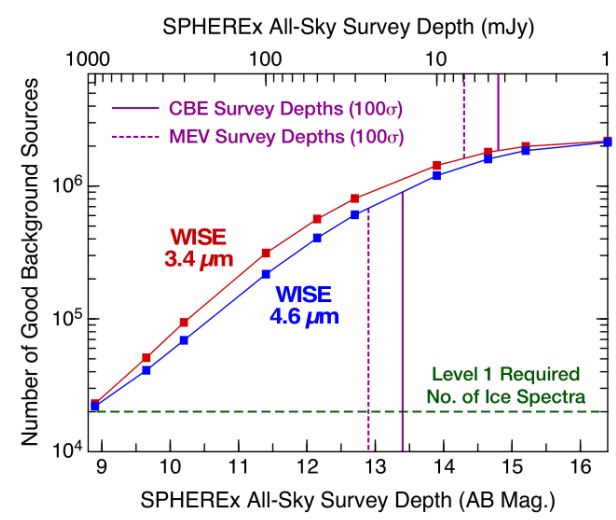
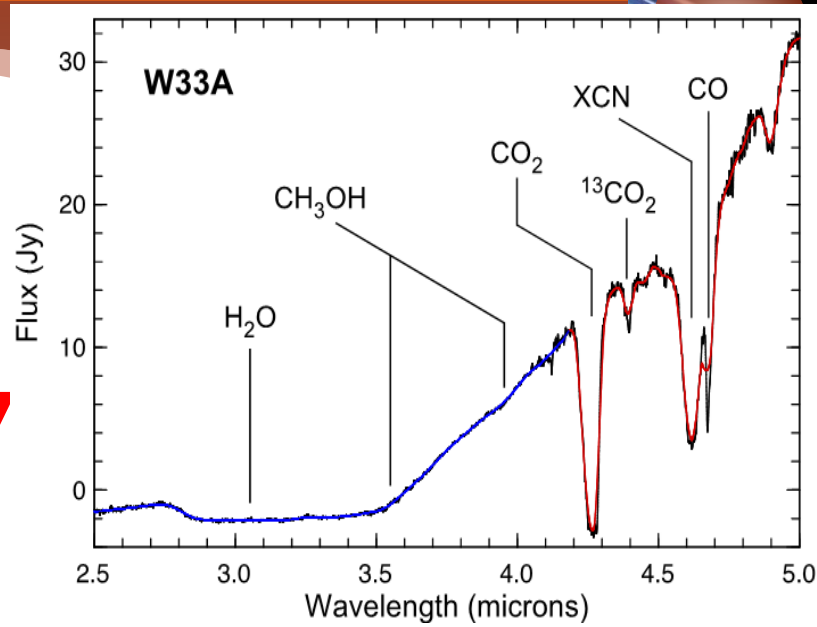
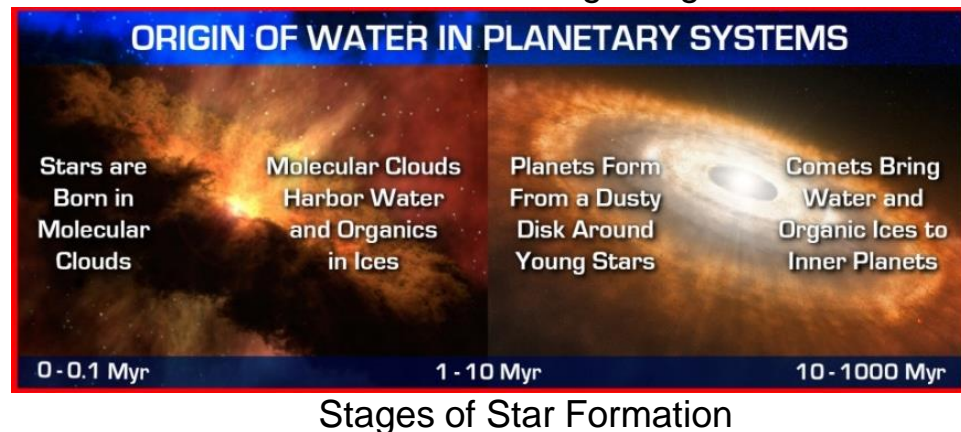
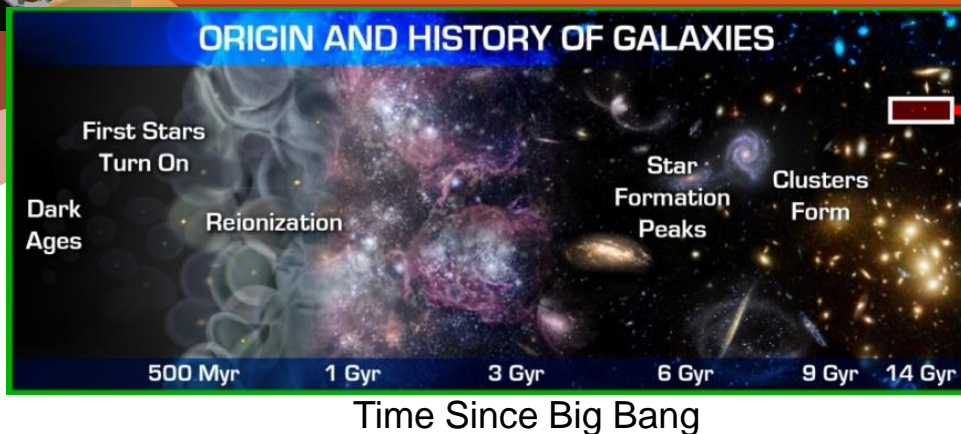


- Expected Lyman EOR features, with SNR >100 on the RMS fluctuations
- Faint EOR signal using distinctive spectral features and cross-correlations.
- Minimum EOR signal
- Line Intensity Mapping: Amplitude of linear clustering in multiple lines





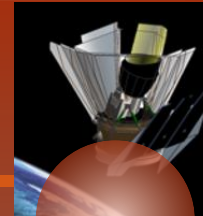
SPHEREx: Ice Survey



Abundance and composition of biogenic ices (H₂O, CO₂, CO, XCN and CH₃OH) in dense molecular clouds and protoplanetary disks

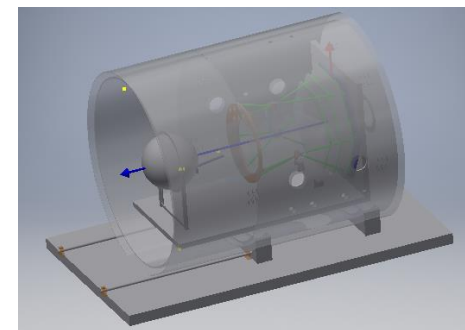
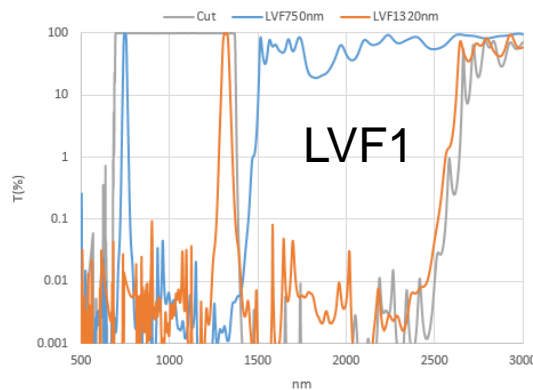


Hardware Contribution



- Hardware for electronics
 - 6 FPAs (H2RG array) + 6 sidecars
 - Test of detectors & screening
- Hardware for optics
 - Baffle tube structure for wide-field telescope

- Optical Filters
 - 4 Linear Variable Filters
 - Dichroic filters

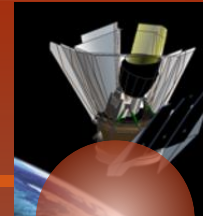


Chamber for SPHEREx

- Ground support equipment for characterizing the instrument (cryo. Chamber, integrating sphere, ground station electronics)



Manpower Contribution



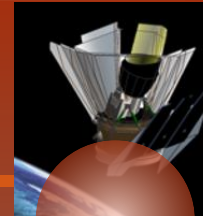
- Contribution of the works
 - Software – Data reduction pipelines
 - Software for analysis tools → to be experienced through NISS

- Science & Operation (launch of NISS – 2017)
 - Synergy with other space missions (e.g., eROSITA, JWST, Euclid)
 - Follow-up targets for Ground telescopes (e.g., GMT, LSST)
 - Collaboration with other Groups at KASI: Instrument group in CfLT, Cosmology group, Galaxy evolution group, ...
 - Collaboration with SNU, KHU, KBNU & KIAS

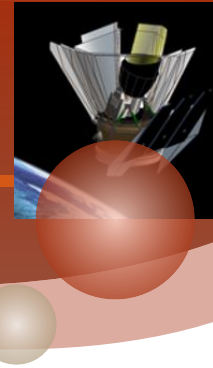




SPHEREx Science Cases (Korea)

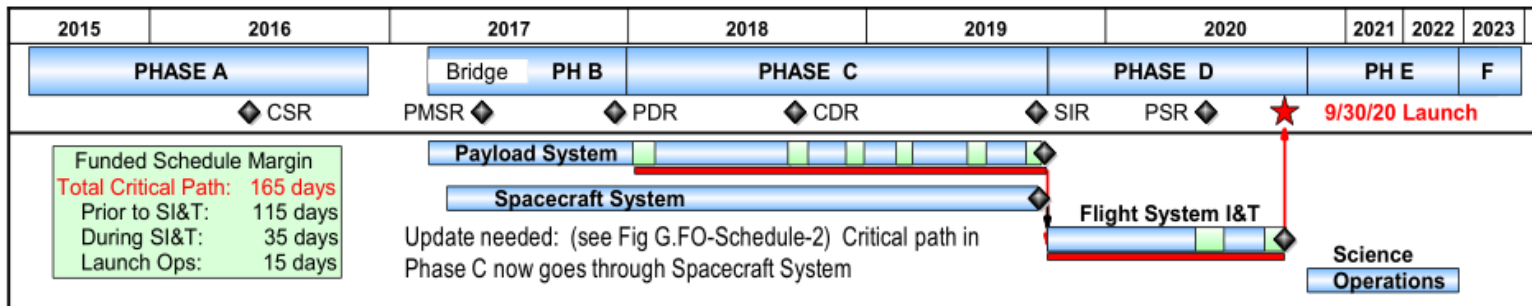


- Cosmology, Extragalactic, Galactic sciences
- Galactic Sciences
 - Ice Features from YSOs & IRDCs
 - SNRs
 - ZL spectra from Near- to Mid-IR
 - Moving objects: DEEP-South
- Extragalactic Sciences
 - SF properties of near-by galaxies (PAH, Pa, Br lines, ...)
 - Near-by and high-z AGNs
 - Properties of High-z emission line galaxies
 - CIRB study in NEP and SEP region (AKARI Deep Fields)
- More science cases from astronomical community



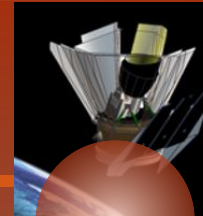
Phase Studies

- Phase-A study (2016): Conceptual design
- Development Phase (2017 ~ 2019)
 - Detailed design, Assembly & preparation of DR
 - Constructs test calibration facilities
- Operational Phase (2020 ~ 2022)
 - Calibration of Instruments & Space Environment Test
 - All-sky survey & evaluation of PV data
- Science Phase (2023 ~ 2024 -2025)
 - Research activities with legacy science data
 - Revision of DR for Science Enhancement Options (SEOs)





Extragalactic Deep Fields

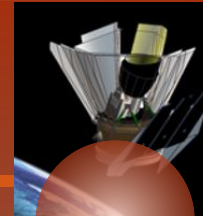


- AKARI Deep Fields → SPHEREx, Euclid
 - NEP ~5.4 sq. deg. (wide)
 - Near- to MIR
 - NEP Deep & Monitoring field
 - NEP Wide
 - ...

 - SEP ~12 sq. deg.
 - FIR
 - ...



Science Subjects @ KASI



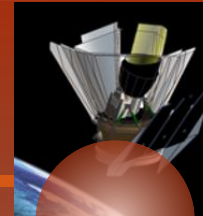
- Local galaxies
 - Barred galaxies (SFGs) – Spitzer S4G
 - Local Dusty SFGs (+ galaxy cluster)

- High-z galaxies: DOGs, ULIRGs, SMGs, AGNs ...
 - Dust-Obscured Galaxies @ $z \sim 1-2$
 - High-z candidates @ $z > 2$

- CIRB (unresolved)
 - NIR & FIR – Submm.



Summary

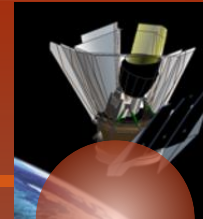


○ NISS (2017)

- Technical demonstration: imaging spectroscopy
- Imaging spectroscopic survey: Nearby galaxies, star-forming regions, low-background regions ...
- Operation from 2017 (2-yr lifetime)

○ SPHEREx (2020)

- Galactic / Extragalactic Sciences
- Synergy with other Facilities (KMTNet, GMT ...)
- More science cases from Korean community



Discussions

- 전천 적외선 영상분광 자료 외부은하 활용
 - SPHEREx 최종 선정 시 과학활용 준비
 - SPHEREx 메인 주제들 이외에 가능한 외부은하 연구들에 대한 논의가 필요