PRESENTATIONS

This page was intentionally left blank

Space Far-IR Interferometry and the Study of Galaxy Evolution

Xiaolei Zhang, Raytheon ITSS / NASA GSFC

Abstract

NASA is currently carrying out studies on the prospect of space-based far-infrared interferometry. Two mission concepts, that of the Space Infrared Interferometric Telescope (SPIRIT), which is a 30 meter baseline, connected structure space interferometer, and the Submillimeter Probe of the Evolution of Cosmic Structure (SPECS), which is a separate spacecraft interferometer with baselines up to one kilometer, have been proposed by the NASA GSFC/NASA JPL consortium. These missions will be used for the study of the formation and evolution of galaxies in the early universe.

Space Far-IR Interferometry and the Study of Galaxy Evolution

Xiaolei Zhang (Raytheon ITSS / NASA GSFC)
and the Far-IR Interferometry Mission Study Working Group

Space Far IR Interferometry Study Team

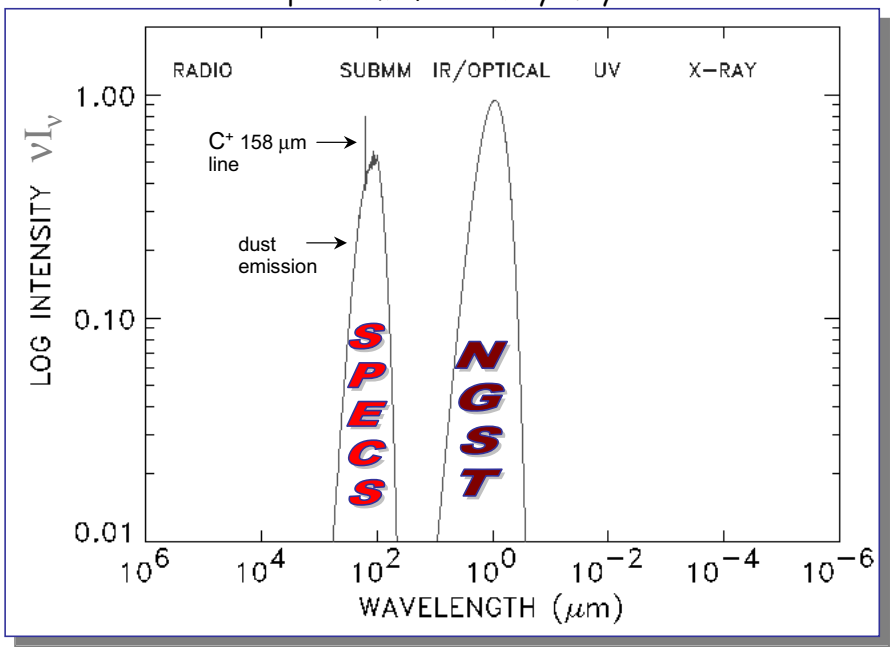
W. Danch(GSFC)	L. Mundy (UMD)
M. Dragovan (JPL)	R. Mushotzky (GSFC)
E. Dwek (GSFC)	D. Neufeld (JHU)
L. Feinberg (GSFC)	J. Pedelty (JSFC)
D. Gezari (GSFC)	M. Shao (JPL)
W. Goss (JPL)	R. Silverberg (GSFC)
M. Harwit	D. Spergel (Princeton)
W. Langer (JPL)	J. Staguhn (Raytheon/GSFC)
C. Lawrence (JPL)	M. Swain (JPL)
D. Leisawitz (GSFC)	E.L. Wright (UCLA)
J. Mather (GSFC)	H.W. Yorke (JPL)
S.H Moseley, Jr. (GSFC)	X. Zhang (Raytheon/GSFC)

"The Submillimeter Probe of the Evolution of Cosmic Structure" (Mather et al. 2000, submitted to RSI)

S P E C S
SUBMILLIMETER PROBE OF THE EVOLUTION OF COSMIC STRUCTURE

Half of the luminosity and 98% of the photons in the post-Big Bang Universe are in the far-infrared and submillimeter

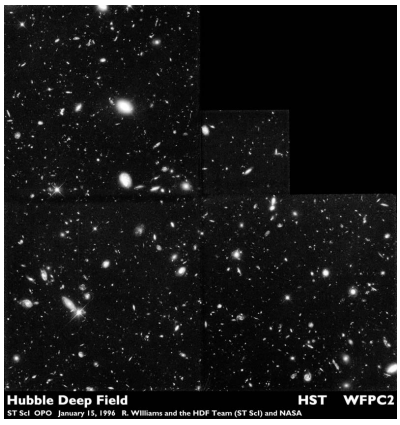
Spectrum of the Milky Way



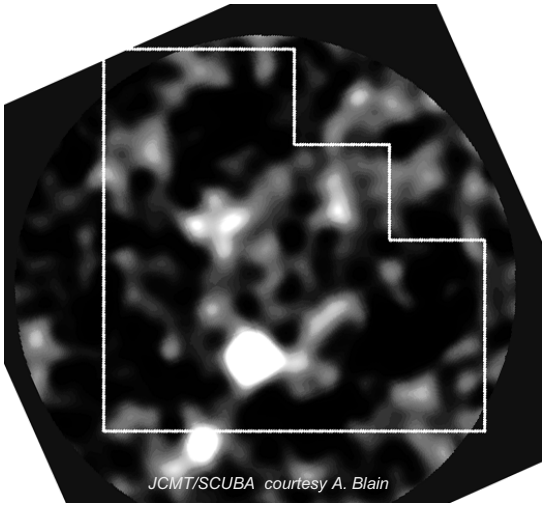
S P E C S
SUBMILLIMETER PROBE OF THE EVOLUTION OF COSMIC STRUCTURE

Our present view of the Universe in the submillimeter, instead of looking

like this,



looks like this



Compelling science

Primary objective: enable studies of cosmic structure development

- Formation of the first stars and galaxies
- Evolution of galaxies over time
- Element production over cosmic history

Also…

- Formation of stars and planetary systems
- Dust-enshrouded Active Galactic Nuclei

The SPECS capabilities are needed to achieve NASA's SEU and Origins theme objectives

Desired Measurement Capabilities

	SPIRIT [a, b]	SPECS [a]
Spectral Range	40 - 500 μm	40 - 500 μm
Angular Resolution, λ / b_{max}	1.8" at 250 μm	0.05" at 250 μm
Spectral Resolution	$\lambda/\Delta\lambda = 1000$	$\lambda/\Delta\lambda = 10{,}000$
Field of View, $N_{pix}\ \lambda / 2D$	14' at 250 μm	14' at 250 μm
Sensitivity	νS_ν 3×10^{8} Jy-Hz, 3×10^{-18} W m^{-2} in 10^5 sec over entire spectral range, 5σ	νS_ν 3×10^{8} Jy-Hz, 3×10^{-18} W m^{-2} in 10^5 sec over entire spectral range, 5σ

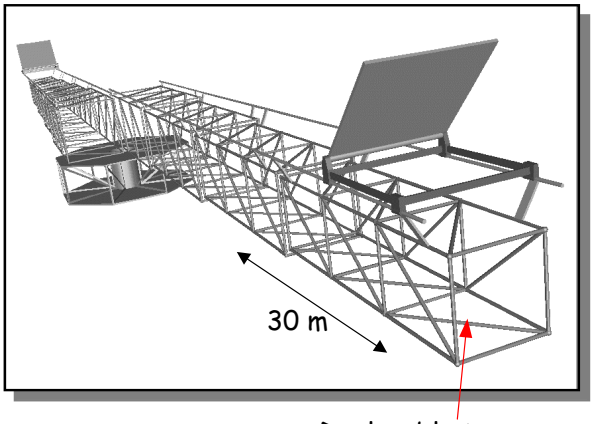
[a] Michelson spatial and spectral interferometer
[b] Technology demonstration, scientific pathfinder mission for SPECS

This can *only* be done in space at cryogenic temperatures with sensitive detector arrays. The required technology is within reach.

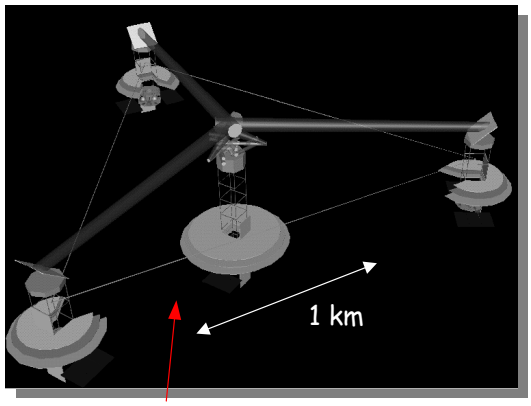
Early Concepts for Far IR Space Interferometry

SPIRIT ~2009
Space IR Interferometry Trailblazer

SPECS ~2015
Submillimeter Probe of the Evolution of Cosmic Structure



Deployable truss

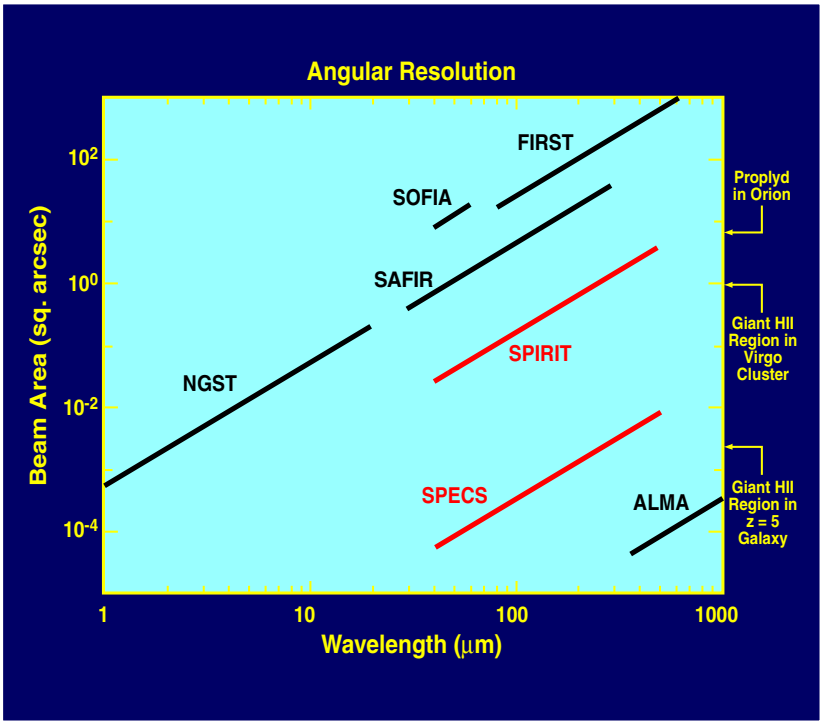


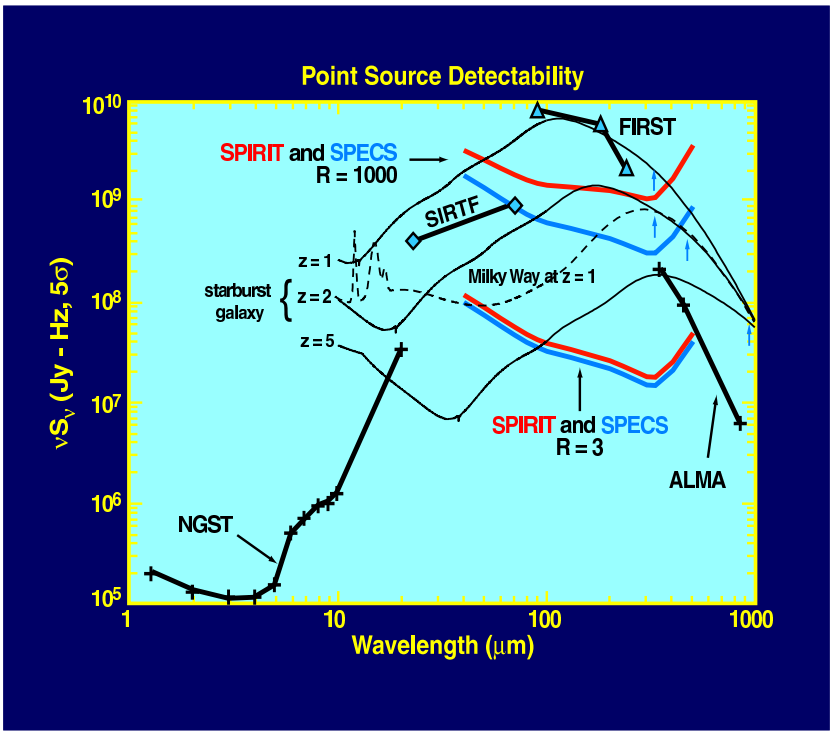
Tethered spacecraft formation

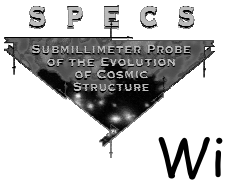
Baseline lengths and orientations are fully adjustable, enabling complete u-v plane coverage, image synthesis

Key technologies

- Large format arrays of photon-counting FIR detectors with low-power readout
- Formation flying with tethers
- Low-mass optics
- Efficient cryogenic cooling systems
- Long-stroke cryogenic delay lines
- Wide-field imaging interferometry


Angular Resolution
Beam Area (sq. arcsec)
10^2
10^0
10^{-2}
10^{-4}
FIRST
SOFIA
SAFIR
SPIRIT
NGST
SPECS
ALMA
Proplyd in Orion
Giant HII Region in Virgo Cluster
Giant HII Region in z = 5 Galaxy
1
10
100
1000
Wavelength (μm)


Point Source Detectability
νS_ν (Jy - Hz, 5σ)
10^{10}
10^9
10^8
10^7
10^6
10^5
SPIRIT and SPECS R = 1000
FIRST
SIRTF
z = 1
z = 2
z = 5
starburst galaxy
Milky Way at z = 1
SPIRIT and SPECS R = 3
ALMA
NGST
1
10
100
1000
Wavelength (μm)



Issues to be Studied by the Wide Field Imaging Interferometry Testbed (WIIT)

- Optics performance. Aberration compensation and modeling.
- Delay line stroke. Michelson spectrometer. Absolute phase reference.
- Image processing, joint deconvolution.
- Addition of short spacing fluxes.
- Data management. Algorithm efficiency.

Summary

- Key Technologies need to be developed within the decade; detectors, support electronics, and wide-field imaging interferometry technique now
- Mission concept studies are essential to optimize scientific capability and define technical requirements
- Critical technologies should be demonstrated in space by 2009. Possibly a 30m FIR interferometer on a deployable boom (SPIRIT)
- Full scale space interferometer (SPECS) when ready; goal 2015

This page was intentionally left blank