

ASTE:

*THE ATACAMA SUBMILLIMETER
TELESCOPE EXPERIMENT*



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The ASTE Project

- Aims of the ASTE project

Science: Explore the southern sky with sub-mm wavelength

Technology: On site evaluation of new methods & technology

Education: Provide opportunity to study observation & instrumentation to young astronomers



- ASTE team
 - National Astronomical Observatory of Japan
(NRO; Nobeyama Radio Observatory)
 - Universidad de Chile
 - The University of Tokyo
 - Nagoya University
 - Osaka-prefecture University
 - Ibaraki University
 - Hokkaido University

What is ASTE?

Diameter: 10m

Surface accuracy: $19\mu\text{m}$

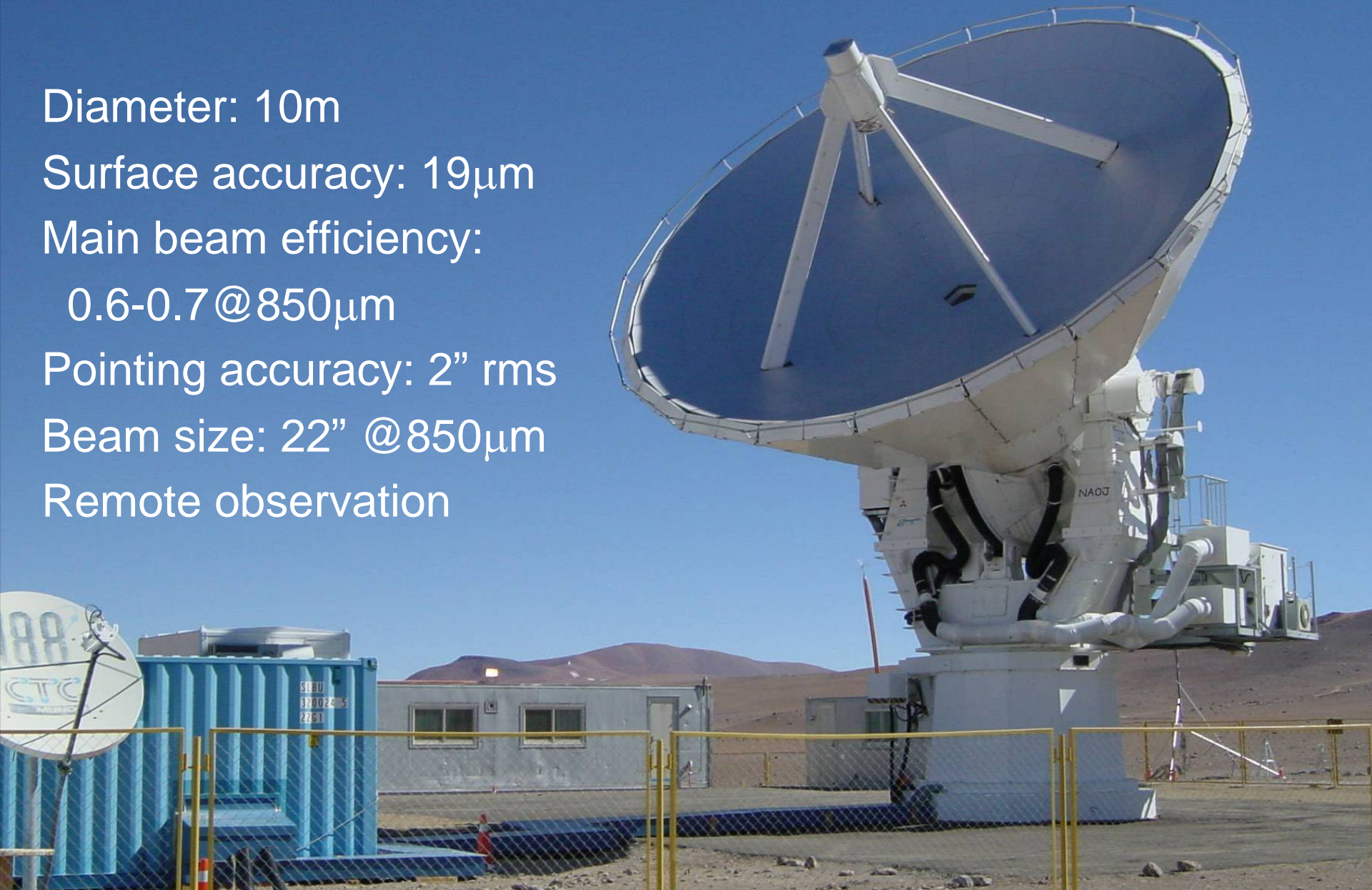
Main beam efficiency:

0.6-0.7 @ $850\mu\text{m}$

Pointing accuracy: 2" rms

Beam size: 22" @ $850\mu\text{m}$

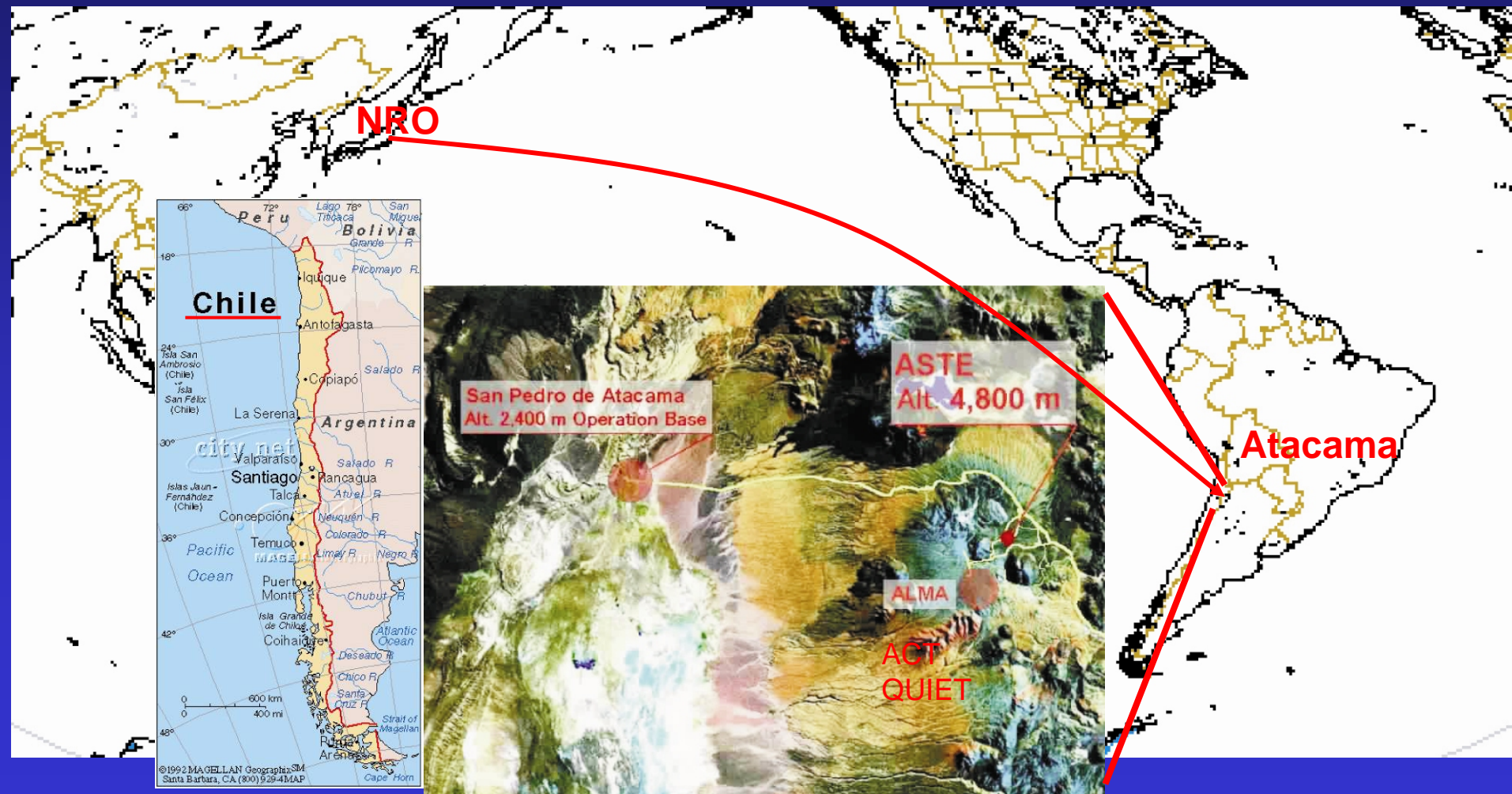
Remote observation



2002 March

Finally at Pampa la Bola

@Atacama desert



Sub-mm?

Digital camera → visible light



Y. Tamura

Sub-mm → thermal emission



Ex) Imagine an IR camera
→ Thermal emission
seen even in dark



Why Atacama?

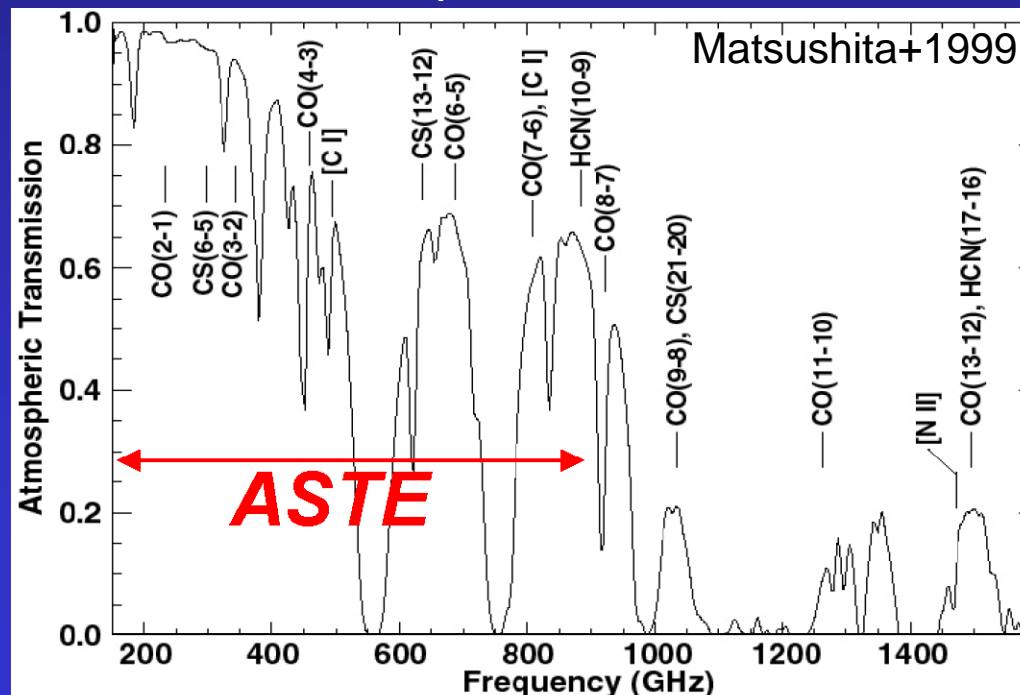
- Absorption by water vapor etc.



SUPER DRY HIGHLAND @ 4800m !!



Atmospheric transmission



ASTE is at the other side of the world,,, but,

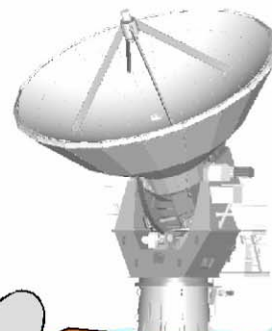
REMOTE OPERATION!!

Santiago
(U. de Chile)



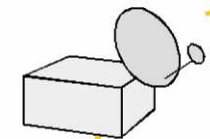
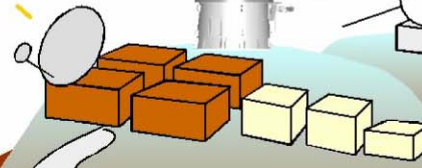
Satellite Link
56~64 kbps

Telescope Site
(Alt. 4800 m)

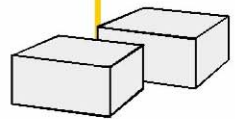


Holography TX

Power Generators



Internet



Japan
(NAOJ and Univ's)



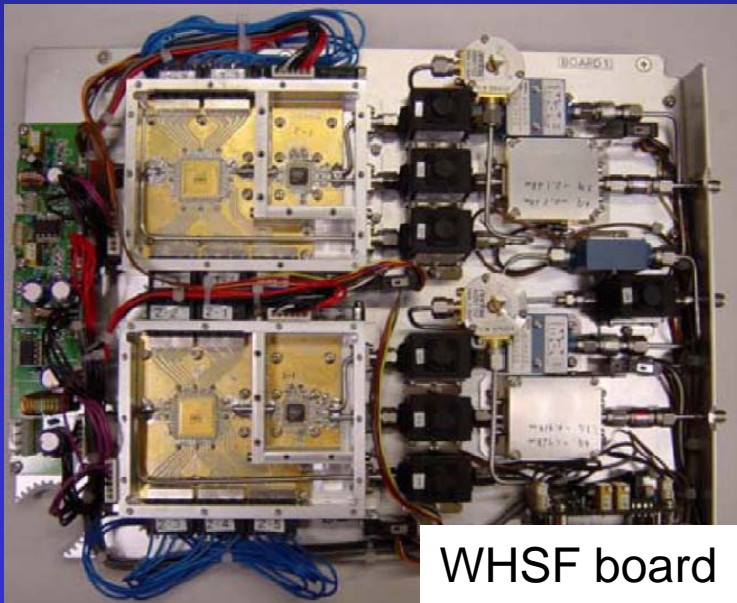
San Pedro de Atacama
(Base Facility, 2400 m)

Recent Achievements

- Spectrometer receiver
- Continuum receiver

CATS345 + WHSF

- Developed by University of Tokyo, NRO/NAOJ
- 2007: First observation
- 2008, 2009: science run



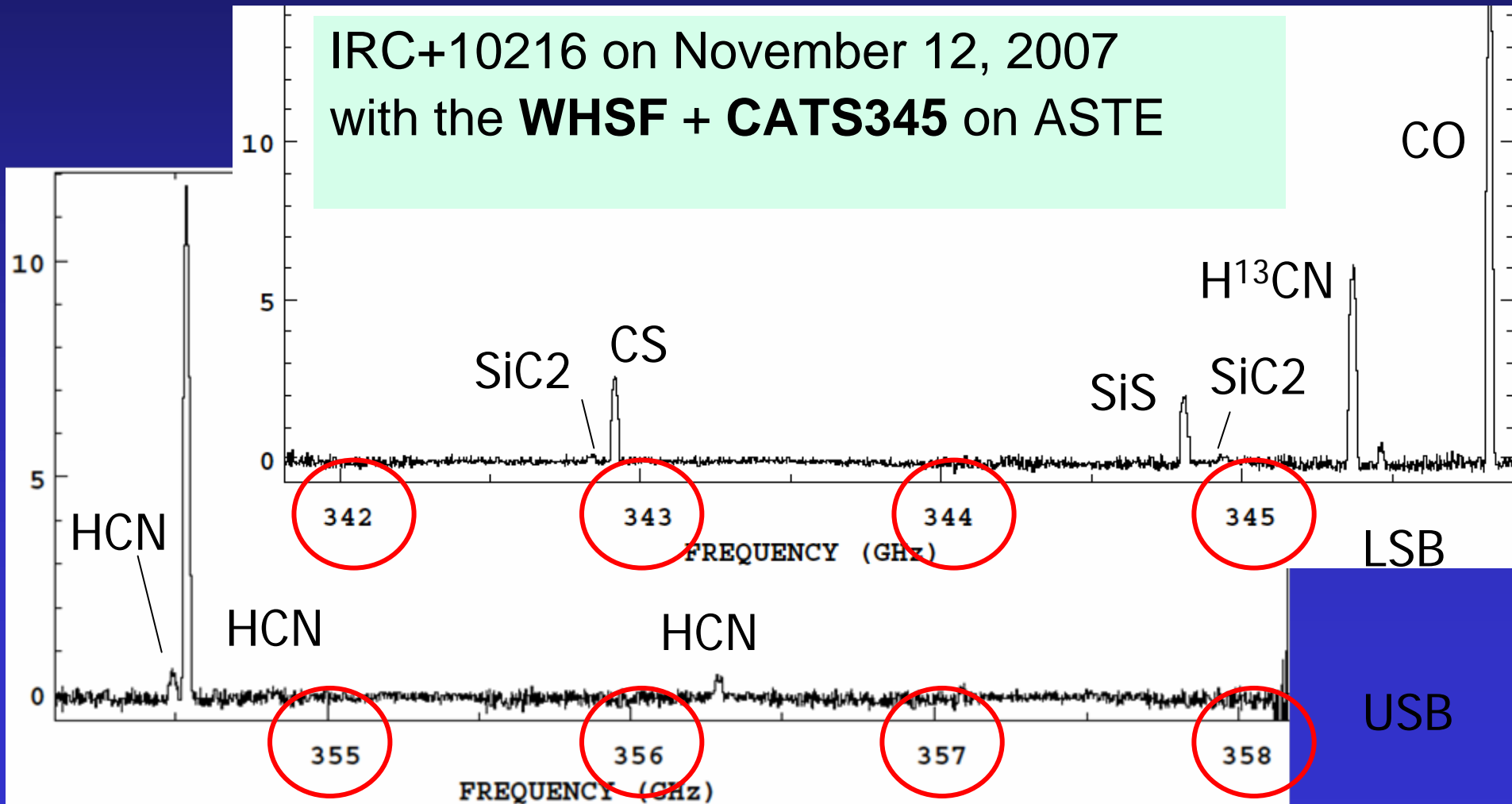
WHSF board
Okuda & Iguchi



CATS345 in the lab. of Univ. of Tokyo
Inoue, Muraoka, Sakai et al.

4096MHz x 2 = 8192MHz !!

- The widest instantaneous spectral coverage at submm
- Very flat baseline



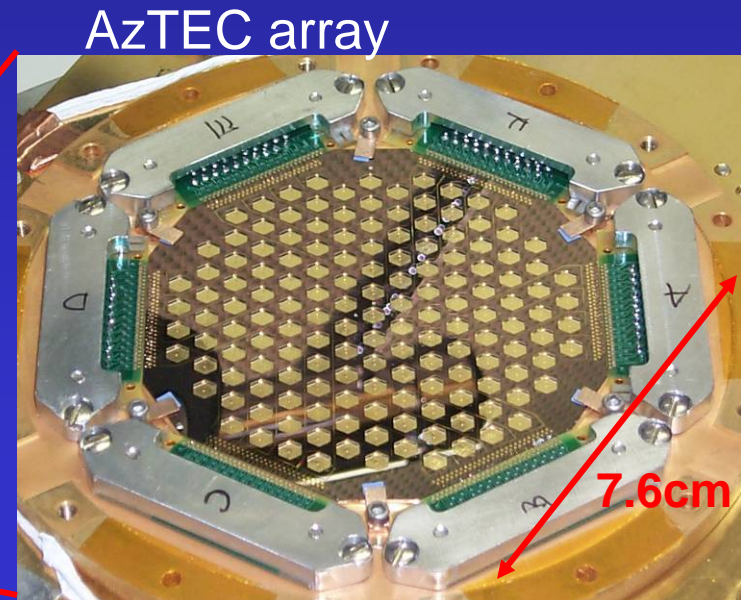
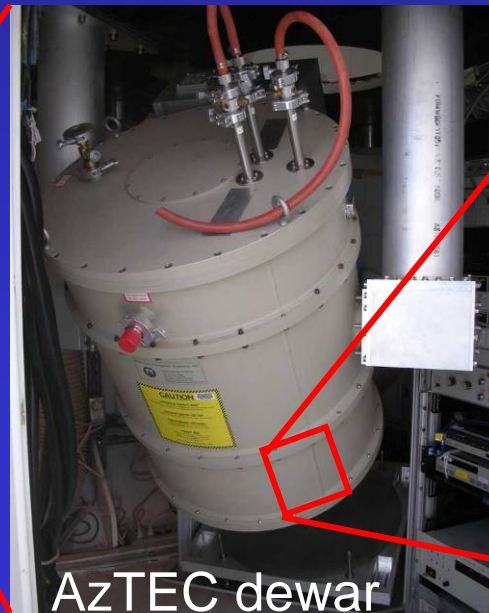
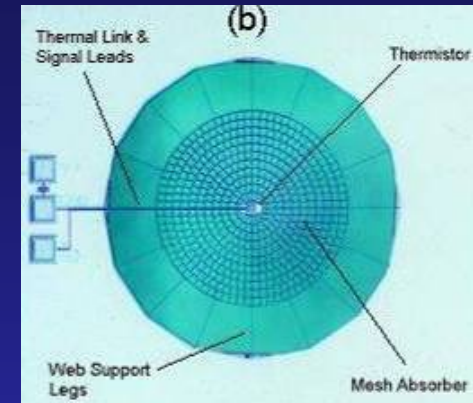
AzTEC on ASTE (2007-2008)

- AzTEC continuum receiver

- 144 bolometer array for 270 GHz
- Developed for LMT

- Collaboration with

- UMass (G. Wilson, M. Yun), INAOE (D. Hughes), et al.

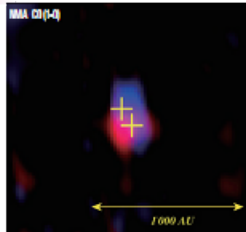
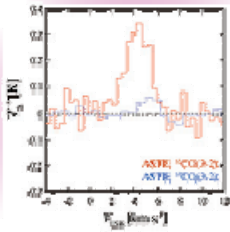
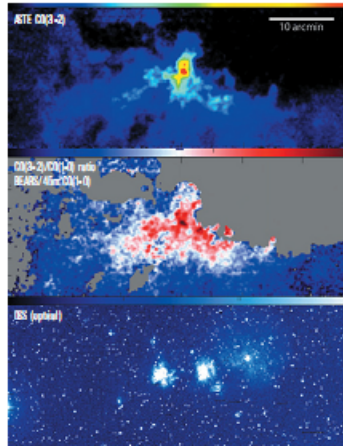


What do we observe?

Probing the Dark Universe with ASTE

Star and Planet Formation

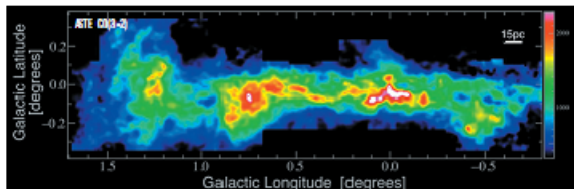
Submillimeter-wave observations are essential for unveiling the dense molecular medium – the cradles of stars. Gemini OB1 molecular cloud complex contains a lot of young massive stars surrounded by glowing gas and plasma called HII regions (bottom panel). New ASTE observations of this region have revealed widespread molecular gas in tremendous details (top panel). By studying the ASTE image together with a millimeter-wave image taken at the NRO 45m telescope, astronomers can now pinpoint exactly where the warmest gas is located (see middle panel, where red is warmer and blue is cooler gas).



Astronomers use ASTE to study young forming planets. With its high spectral resolution, ASTE can probe the detailed motion of gas surrounding young stars that have just formed recently. The figure (left) shows the ASTE spectra of carbon monoxide gas in a proto-planetary system, and figure (right) is an image of the same region taken at the Nobeyama Millimeter Array. Gas velocity is shown in different colors in the image. By calculating the amount of gas and studying its gas motion, astronomers have a better understanding of how planets form, and this may ultimately give clues to how an Earth-like planet was formed.

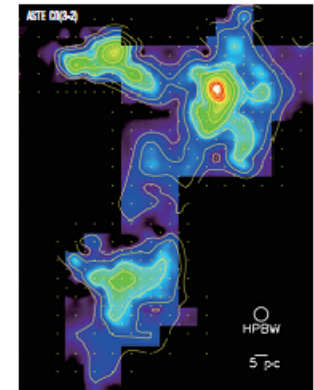
The Center of Milky Way Galaxy

The center of our Milky Way galaxy harbors a massive black hole surrounded by a wealth of molecular gas. ASTE has discovered that the motion of gas in this region is extremely violent and complex (see figure). Astronomers using ASTE are beginning to solve the mysteries surrounding the center of our own galaxy, and will ultimately try to understand how our galaxy was formed.

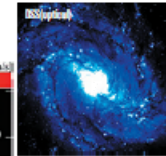
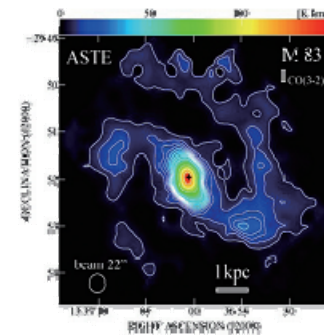


Magellanic Clouds

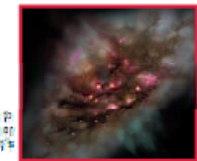
The Magellanic clouds are satellite galaxies to our Milky Way galaxy. Because they are mainly visible from the southern hemisphere, these are excellent target galaxies for ASTE. A region in the Large Magellanic Cloud called N139 is known by astronomers to be producing stars at an extremely high rate. Astronomers using ASTE have successfully produced an image (see figure) of the dense molecular gas, which is the fuel for massive star formation.



Nearby Galaxies



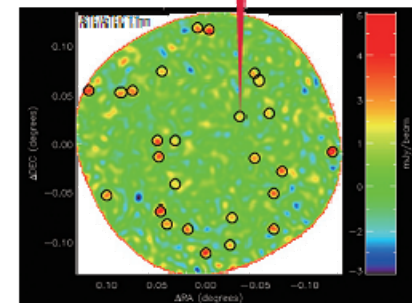
With its tremendous sensitivity to the faintest submillimeter waves, ASTE can probe the star-forming gas in our neighboring galaxies that are millions of light years away. The figure (left) shows the ASTE observation of molecular (carbon monoxide) gas in the central region of a galaxy called M83. The figure (right) shows an image of M83 taken by an optical telescope. The center of the galaxy harbors a huge amount of dense gas, and this is believed to be where new stars are continuously being formed.



Future spaceborne ALMA will be able to study these galaxies with much higher resolving power (see figure for an artist's conception of a distant galaxy).

Distant Universe

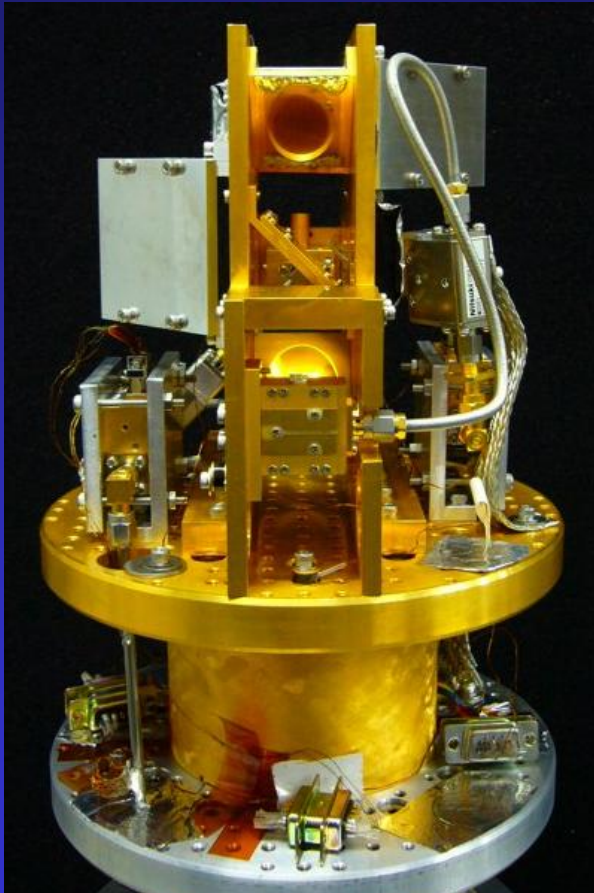
Deep observations of the more distant universe become possible by combining the versatility of ASTE and the sensitivity of ACT/C. Star-forming galaxies residing in the distant universe that are too faint to be visible by optical telescopes become visible in mm/submillimeter wavelengths. The galaxies marked with dark circles were discovered by astronomers using the ACT/C camera onboard ASTE. Astronomers believe that these galaxies reside in an epoch when the universe was less than a few billion years old, and forming stars at an exceedingly high rate.



Future

Future Plans

- Spectroscopy
 - Explore higher frequencies
 - 500GHz, 800GHz



800GHz receiver "AERO"

- Continuum Observations
 - Multi-color bolometer camera development
 - 1.1mm, 850 μ m, 450 μ m
 - Over 400pixels!!



Continuum camera

