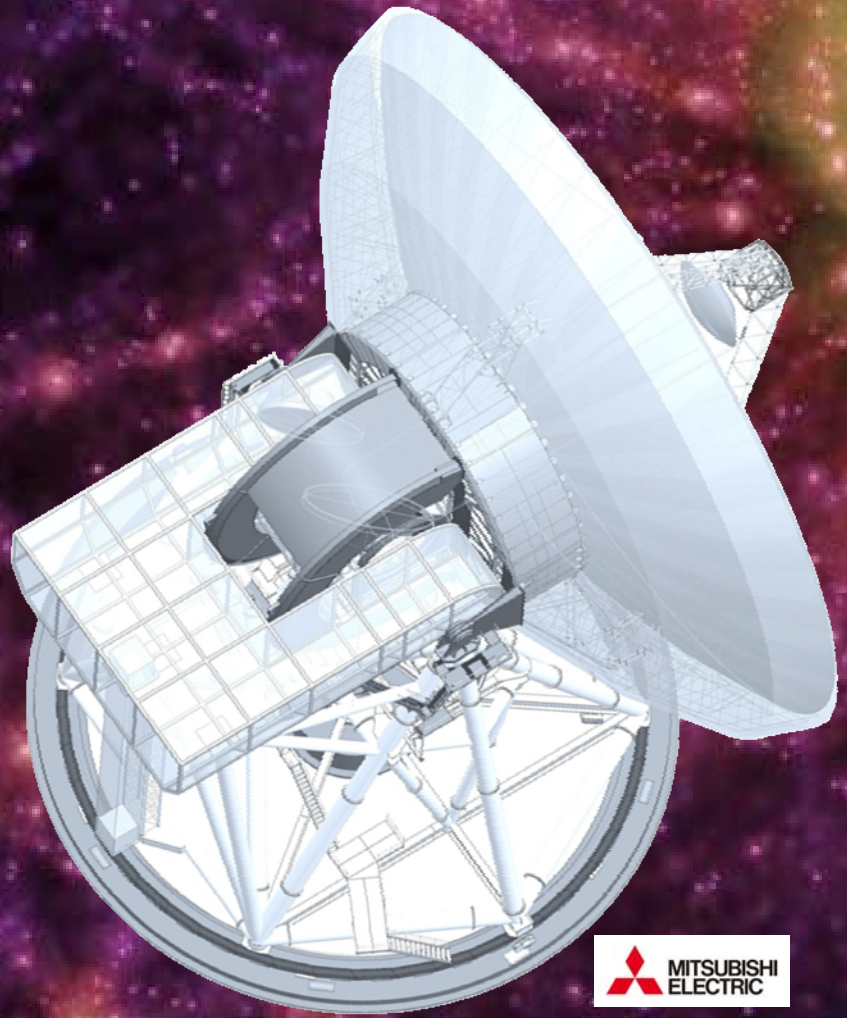
LST

LARGE SUBMILLIMETER TELESCOPE

New 50-m class
single dish telescope

15.6 Mpc/h

# *Large Submillimeter Telescope (LST)*




Ryohei Kawabe, Tai Oshima
Tatsuya Takekoshi, (NAOJ)
Kotaro Kohno, Yoichi Tamura,
Shun Ishii (U. Tokyo) and
LST Working Group


MITSUBISHI ELECTRIC

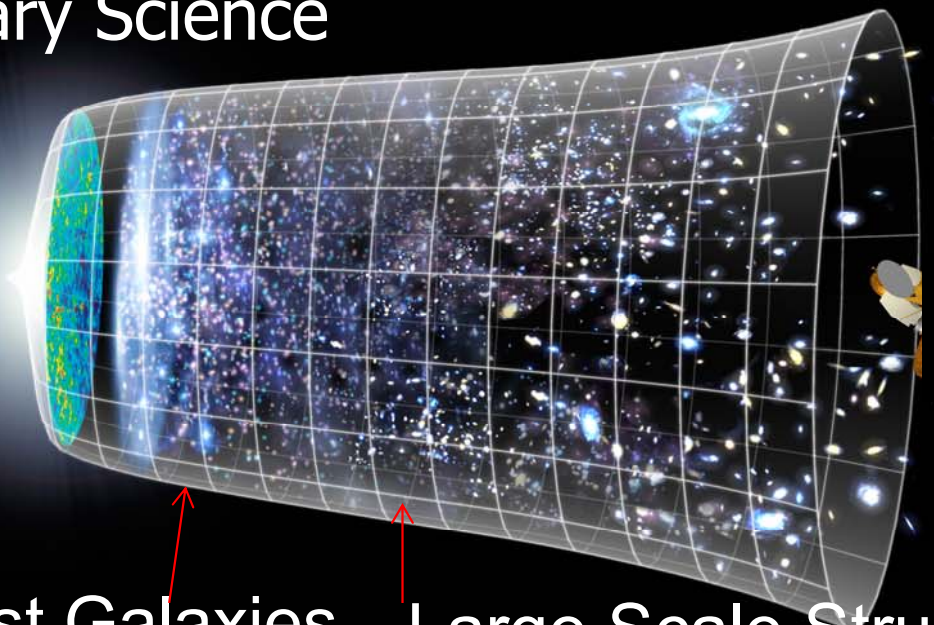
# *Overview*

- The LST is a new telescope optimized for
  - wide-area imaging and spectroscopic surveys in the freq. range of 70-420 GHz allowing exploration of large 3D volume
  - also achieving high-cadence performance for transients
- LST targets observations at higher freq. up to 1THz, using an inner high-precision surface (under-illumination)
- Through exploitation of its synergy with ALMA, the LST will contribute research on a wide range of topics in astronomy and astrophysics, e.g., chemistry, SZ, VLBI,..
- Basic Concept, Specs., Key Sci & Instrument etc. introduced

# *Science Goals in Mm & Submm Astronomy*

- Challenge and resolve basic problems in the expanding, accelerating, and diverse universe

  - e.g., Cosmology, Formation and Evolution of Galaxies/ SMBH, Star Formation, Interstellar Chemistry, Solar system and Planetary Science

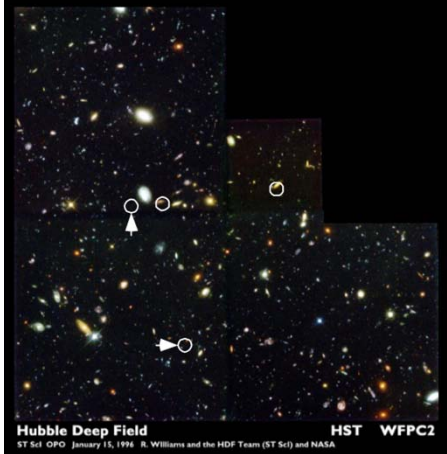


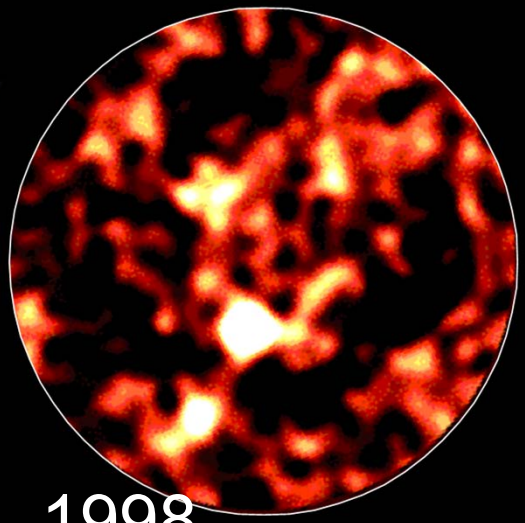
# *ALMA opens new era*

☞ ALMA will contribute to elucidating galaxy formation and planet formation with exploiting extreme performance

- High Angular Resolution, ~ 0.01 arcsec; sharp radio images
- High Sensitivity to reach the early universe (also thanks to very unique characteristic of submillimeter emission in SMG)

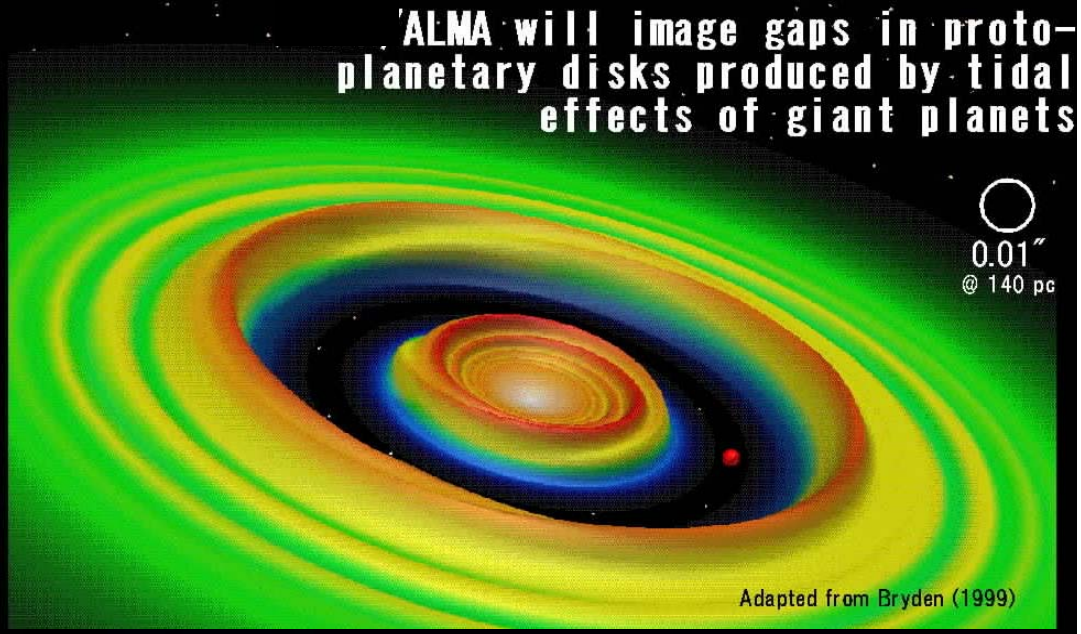
Hubble Deep Field and SCUBA map



Hughes et al. 1998

Gaps in Protoplanetary Disks



# ALMA S

☞ ALMA will contribute to elucid
planet formation with exploitir

Dreams come true images!

.0
ea
f s

Exciting results!

Tsukagoshi+2016

planetary disks produced by tidal
effects of giant planets

0.01″
@ 140 pc

Adapted from Bryden (1999)

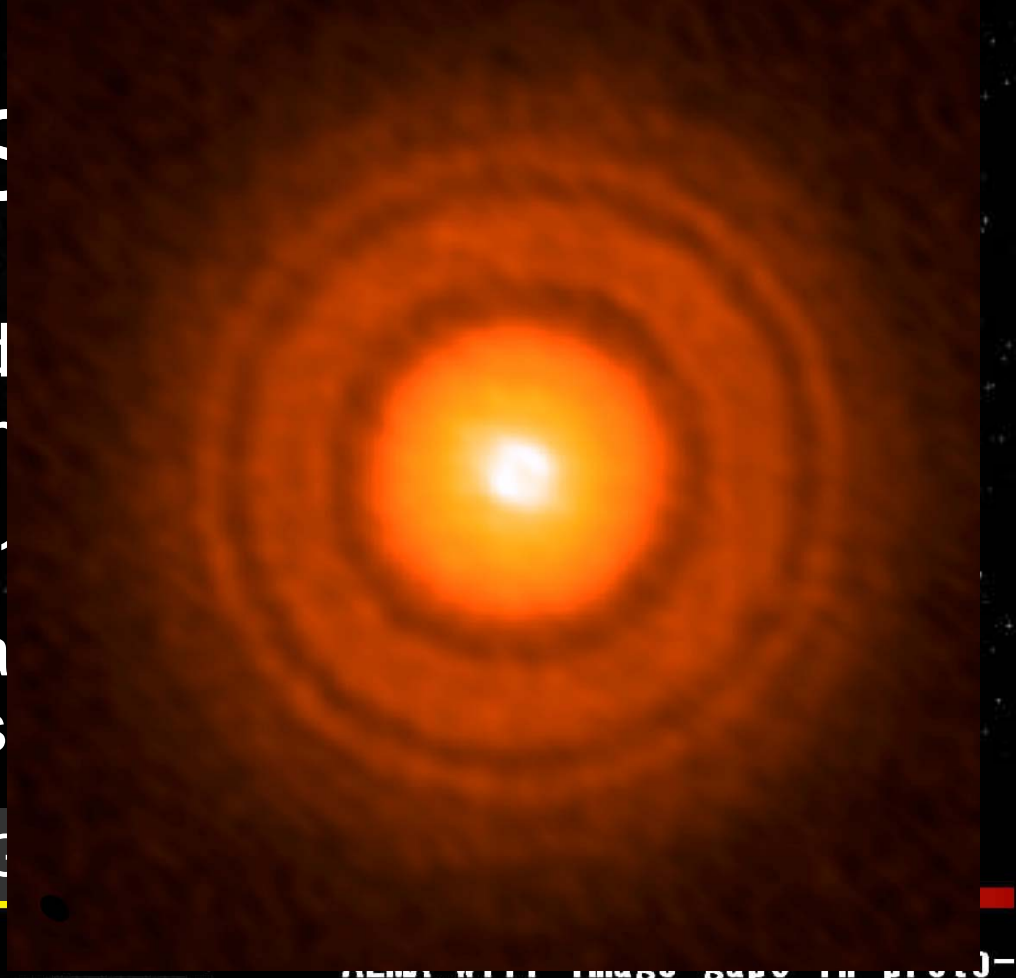
Credit: ALMA (ESO/NAOJ/NRAO)

# ALMA S

☞ ALMA will contribute to elucid
planet formation with exploitir

Dreams come true images!

.0
ea
f s



planetary disks produced by tidal
effects of giant planets

0.01″
@ 140 pc

Adapted from Bryden (1999)

The universe unveiled by ALMA is very limited
in terms of sky and spectroscopic coverage,
in other word, in 3 dimensional volume of the universe.

Credit: ALMA (ESO/NAOJ/NRAO)

# LST

LARGE SUBMILLIMETER TELESCOPE

a new 50 m class mm/sub-mm single dish telescope

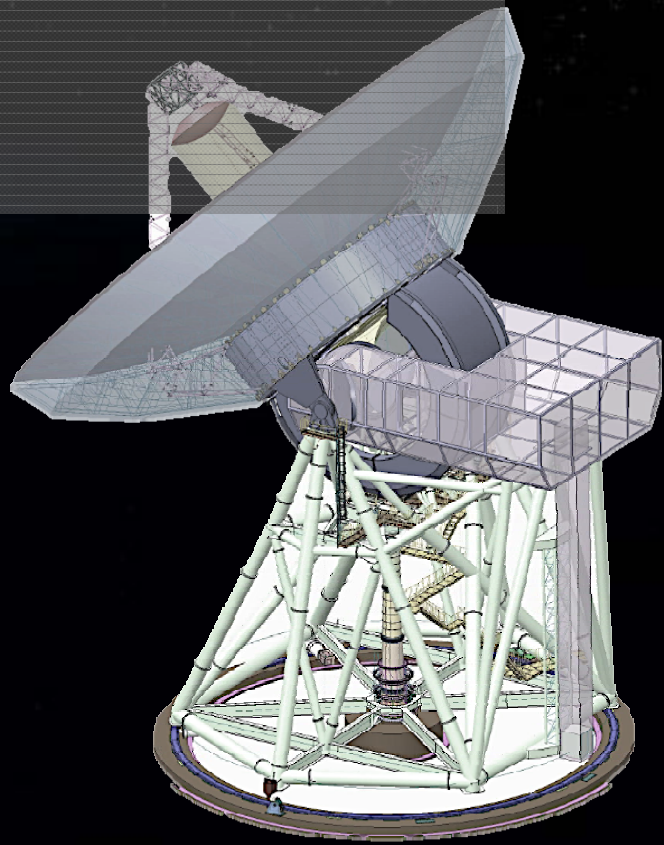
LST will facilitate new discovery space complementary to ALMA

- Ultimate Wide-field Survey (in Cont. & Spectral Lines)
  => exploration of an extremely large 3D volume of the universe
- Time-domain Science
- Incubate New Ideas for Future Science

NRO 45m Telescope

Natural Evolution

ASTE 10 m Telescope In Chie



LARGE SUBMILLIMETER TELESCOPE

# *Chronology of LST*

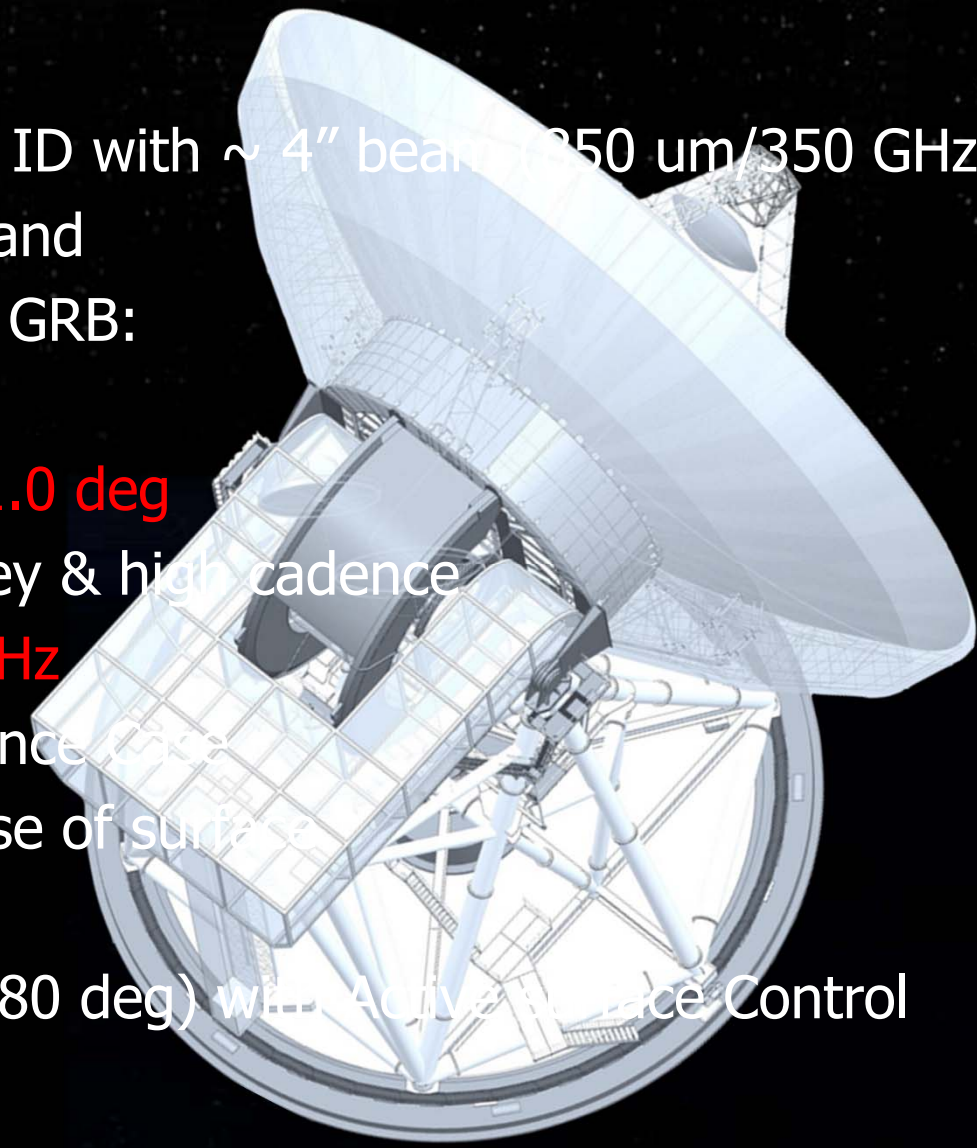
- Started as a future plan of Nobeyama Radio Observatory (45m/ASTE telescopes) in 2008/2009
- Exchanged  basic idea with JP community and outside potential future collaborators in terms of science, telescope specification and instruments
- Science case has been investigated in working group since Jan. in 2010
- Proposed the tentative plan as one of medium-scale plans to Science Council of Japan (SCJ) in 2011
- Concept and Science case been updated in 2014/2015 based on Feedback from SCJ and further discussions
- (will be proposed to SCJ for Master Plan 2020)

LST

LARGE SUBMILLIMETER TELESCOPE

# Basic Concept

## :Tentative Specifications



- Large Aperture: Diameter = ~ 50 m

  less confusion & confident counterpart ID with ~ 4" beam (350 um/350 GHz)

  high sensitivity for line emitter search and

  point-like sources & transients such as GRB:

- Large FOV

  : F.O.V = 30 arcmin. diameter, Goal = 1.0 deg

  cosmological deep and wide-field survey & high cadence

- Main Frequency Range = 70 – 420 GHz

  well fit to Atm windows & "Major" Science Goals

  covers up to ~ THz with the limited use of surface

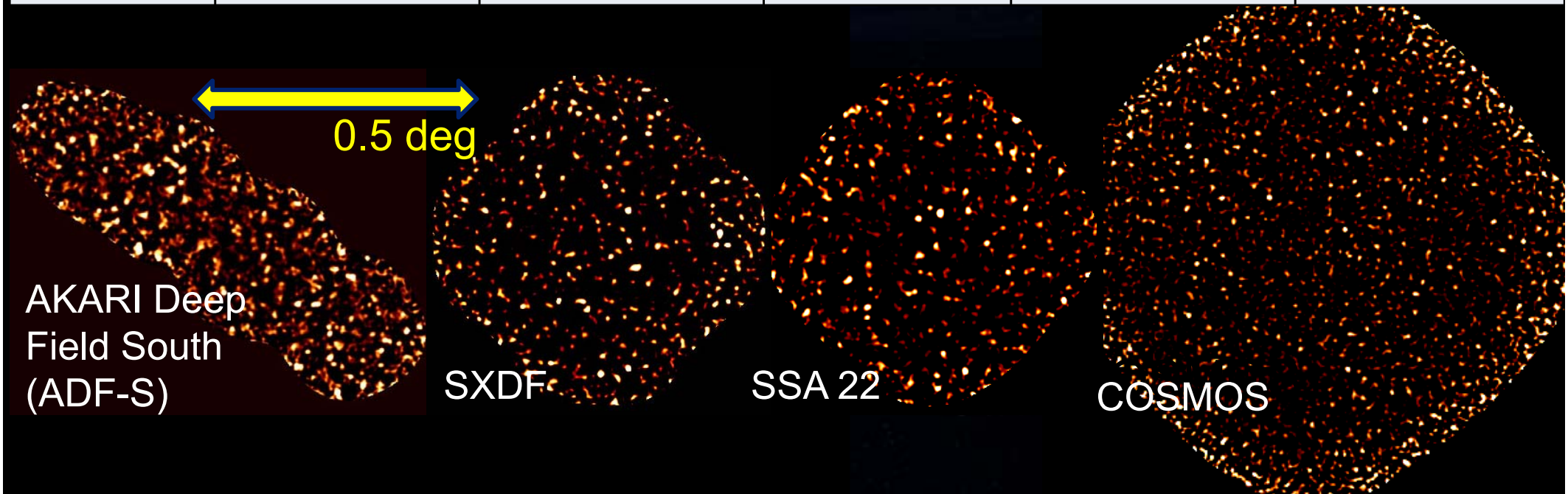
  to maximize synergy with ALMA

- total surface rms ≤45 $\mu$m (El = 30-80 deg) with Active Surface Control

- Possible site; ALMA plateau

# AzTEC/ASTE 1.1mm **confusion limited** deep survey

| Field | ADF-S | SXDF | SSA22 | COSMOS | GOODS-S |
|---|---|---|---|---|---|
| Coverage (arcmin$^2$) | 909 | 954 | 973 | 2967 | 270 |
| Depth (1σ, mJy) | 0.4-0.80 | 0.5-0.9 | 0.7-1.3 | 1.2-2.2 | 0.5-0.7 |
| N sources (>3.5σ) | **233** | **215** | **125** | **205** | **48** |
| references | Hatsukade+ 2011, MNRAS, 411, 102 | Ikarashi+ 2011, MNRAS, 415, 3081 | Tamura+ 2009, Nature, 459, 61 | Aretxaga+ 2011, MNRAS, 415, 3831 | Scott + 2010, MNRAS, 405, 2260 |

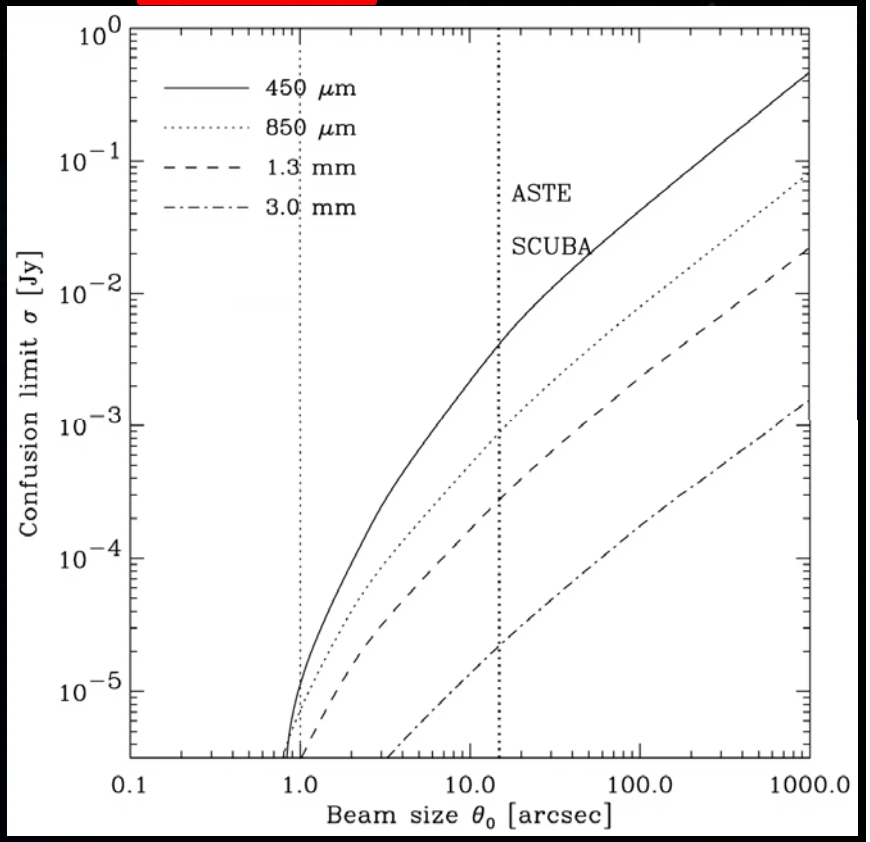


LARGE SUBMILLIMETER TELESCOPE

# Merit of Large Dishes

| | | ASTE | CCAT | 50m | 50m/CCAT |
|---|---|---|---|---|---|
| Source Confusion[a] | $\propto D^{-1.4}$ | 1 | 1/3.6 | 1/10 | (1/2.6) |
| Spatial Resolution | $\propto D^{-1.0}$ | 1 | 1/2.5 | 1/5 | (1/2) |
| Survey Speed[b] | $\propto D^2$ | 1 | 6 | 25 | (4) |
| Speed of pointed obs. (for point-like sources) | $\propto D^4$ | 1 | 36 | 600 | (16) |

LMT in Mexico can also improve source confusion by 10x!




a. See Takeuchi, RK, Kohno+ 2001
b. Evaluated as survey area covered with fixed observing time and depth, e.g., in unit of deg^2/hours

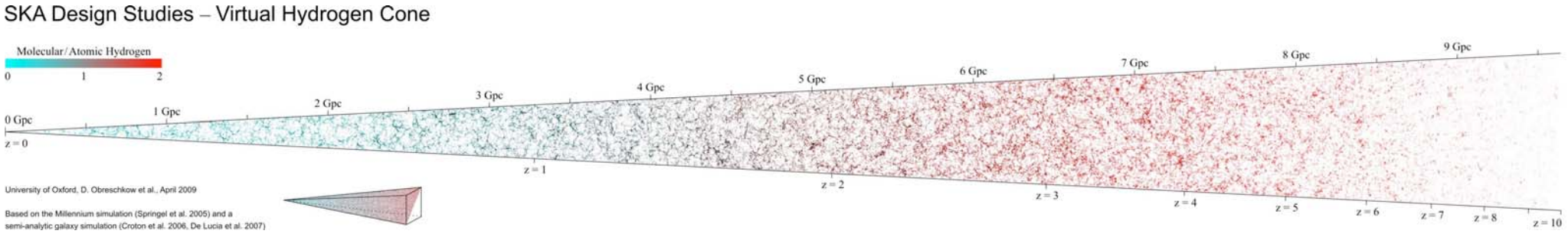
# *Key Science of LST*

☞ Exploration of Cosmic Star Formation History and Large Scale Structures via two kinds of surveys

- Multi-band Deep Continuum Survey over ~$10^3$ deg$^2$
- Blind CO/CII line emitter search (Tomography) up to z~ 7, EoR, using imaging spectrograph not severely affected by source confusion noise

(Blind vs multi-object spectroscopy still needs to be investigated, but blind can provide us with census of "non-biased" line emitters, in which strong-line but continuum-weak emitters will be included)

RK+ 2016 (SPIE proceedings paper)




# CO/[CII] Tomography

+ [OIII] emitter

## EoR Epoch of Reionization

## RSD Redshift Space Distortion

## LSS Cosmic Large-Scale Structure

## CSFH Cosmic Star-formation History

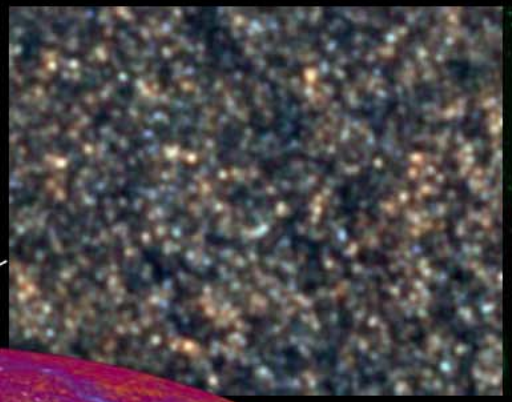
## Evolution of Galaxies

## ... and serendipitous discoveries

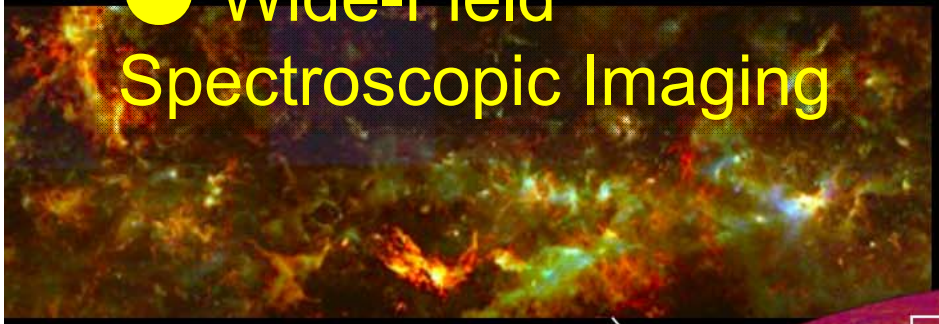
LST
LARGE SUBMILLIMETER TELESCOPE

# *LST covers wide range of Science*

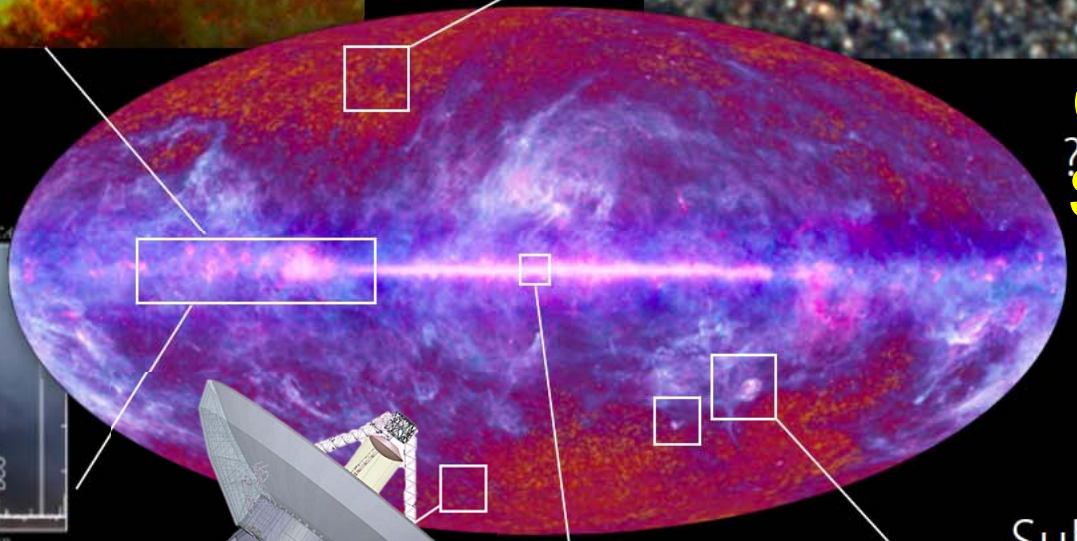
Distant Galaxies and Clusters




● Wide-Field Spectroscopic Imaging

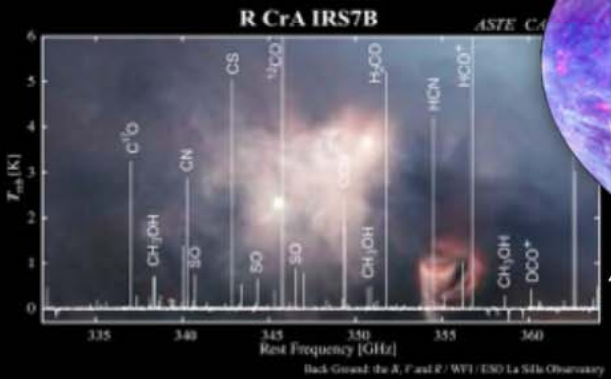


Galactic Plane

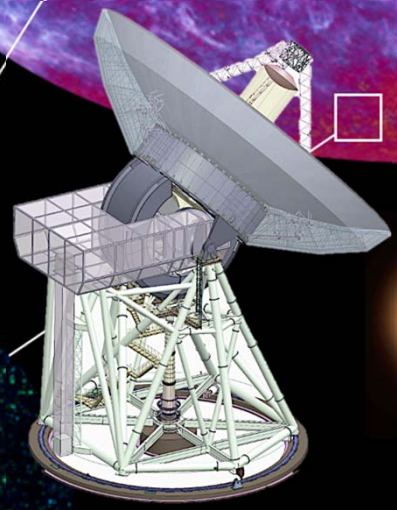


● Time-domain Science

Submm Transients

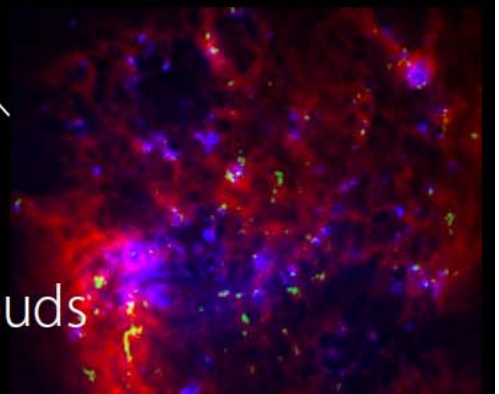



Astrochemistry

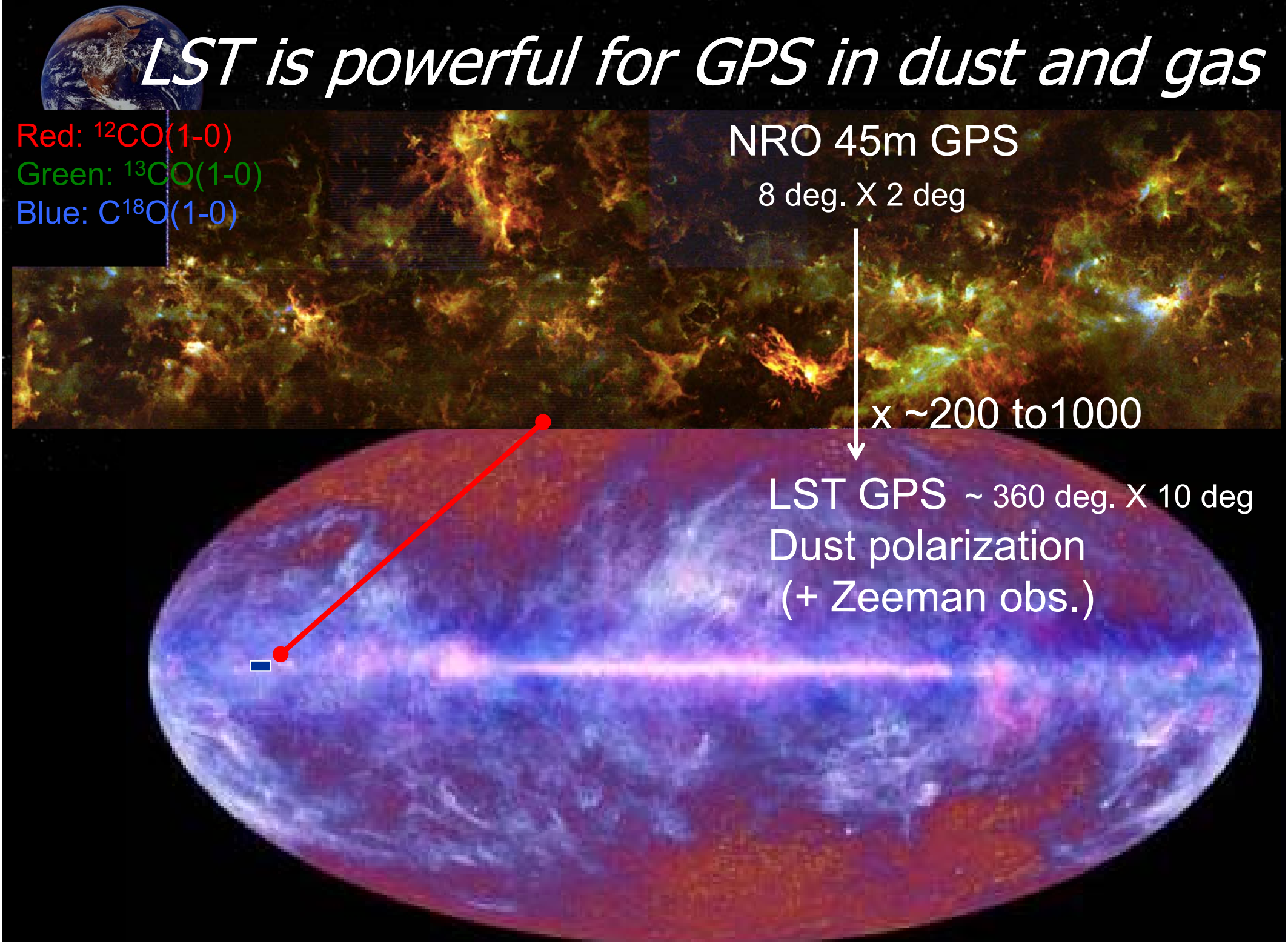


VLBI

Nearby Galaxies



Magellanic Clouds


LST is powerful for GPS in dust and gas
Red: 12CO(1-0)
Green: 13CO(1-0)
Blue: C18O(1-0)
NRO 45m GPS
8 deg. X 2 deg
x ~200 to1000
LST GPS ~ 360 deg. X 10 deg
Dust polarization
(+ Zeeman obs.)

# *Technical Feasibility Study*

- Science Requirement & Technical Specification
- Operation condition & Operation Planning
- Optics Design
- Conceptual Design of Telescope Structure
- Surface Accuracy Budget Analysis
- Developments of Key Instruments
- Millimetric Adaptive Optics (MAO) under discussion: started R&D and plan to demo
- (Very Preliminary) Cost Estimate

LST
LARGE SUBMILLIMETER TELESCOPE

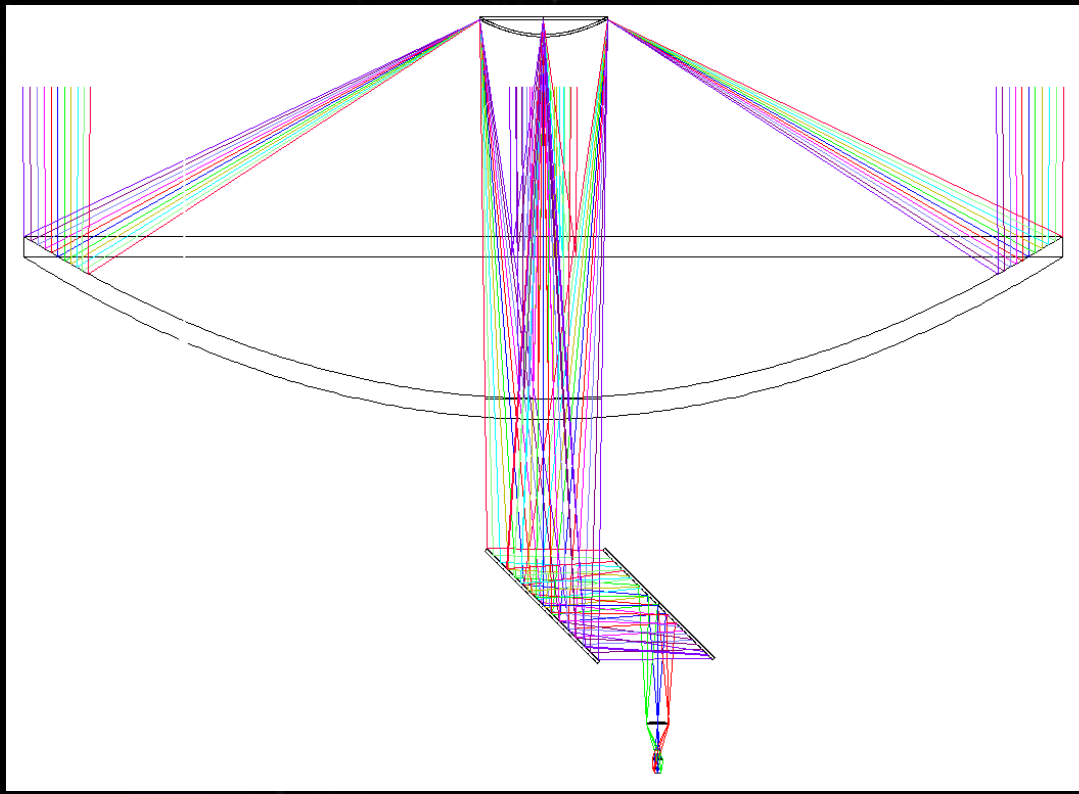
# *Optics Design for wide FOV*

very preliminary

Richey-Chretien Optics for D= 50 m main reflector
Lyot-Stop at Sub-refrector: $D_{effective}$ ~ 46.7 m
FOV ~ 0.7 deg. in diameter at 850 micron achievable

But…

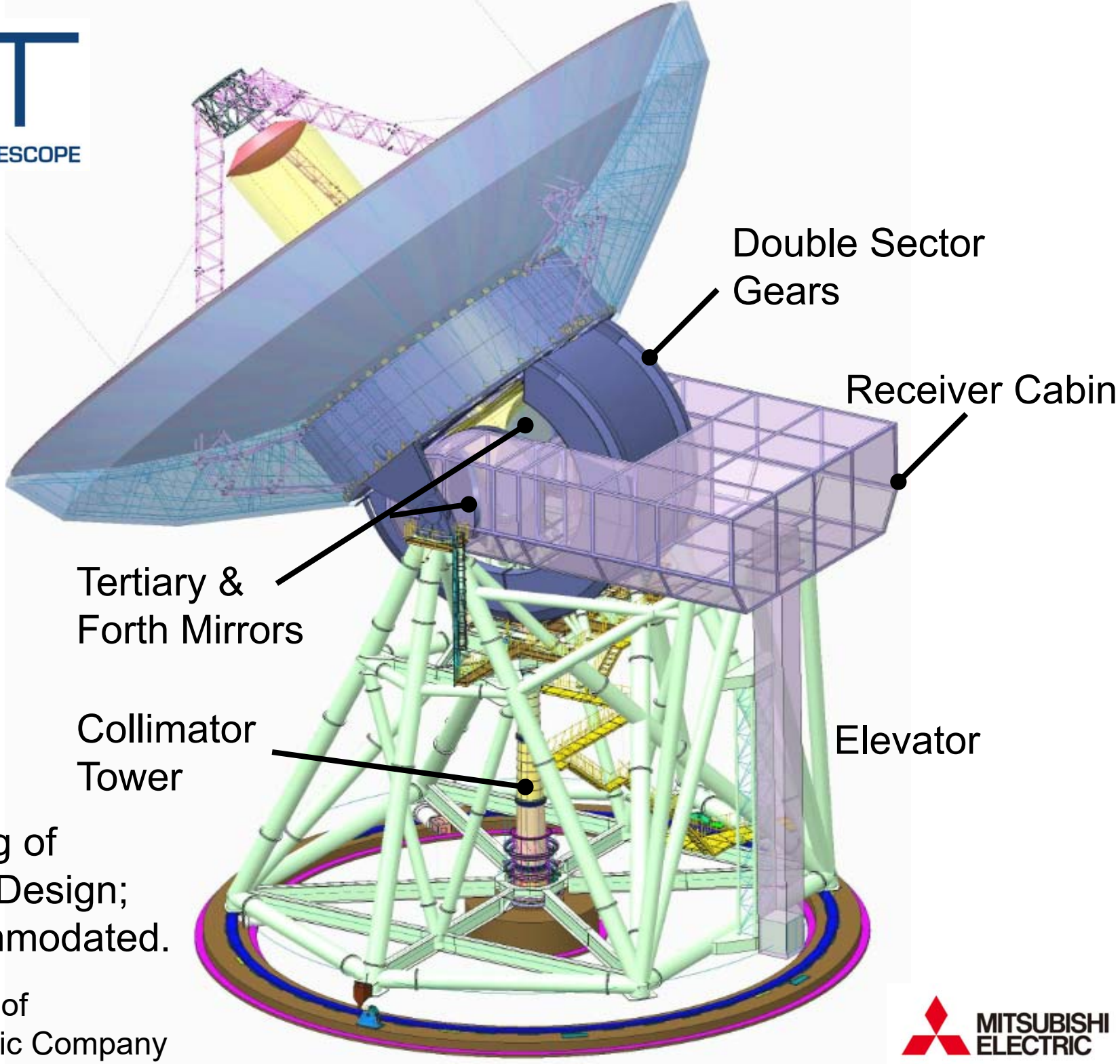
- large mirrors
  $D_{sub\text{-}ref}$ ~ 6.2 m
  #3 mirror ~ 7 m diameter
- huge RX cabin needed
- big impact on telescope mechanical structure?
- being investigating better optics design



Takekoshi, Oshima + in prep.

LST

LARGE SUBMILLIMETER TELESCOPE




The First Drawing of
LST Conceptual Design;
Major req. accommodated.

Image Courtesy of
Mitsubishi Electric Company

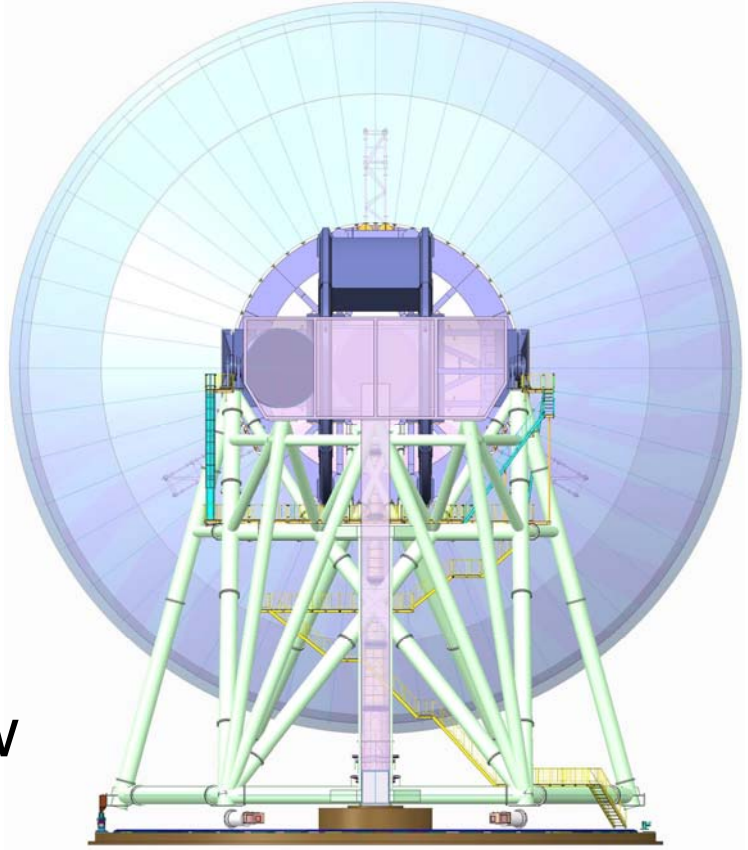
MITSUBISHI ELECTRIC

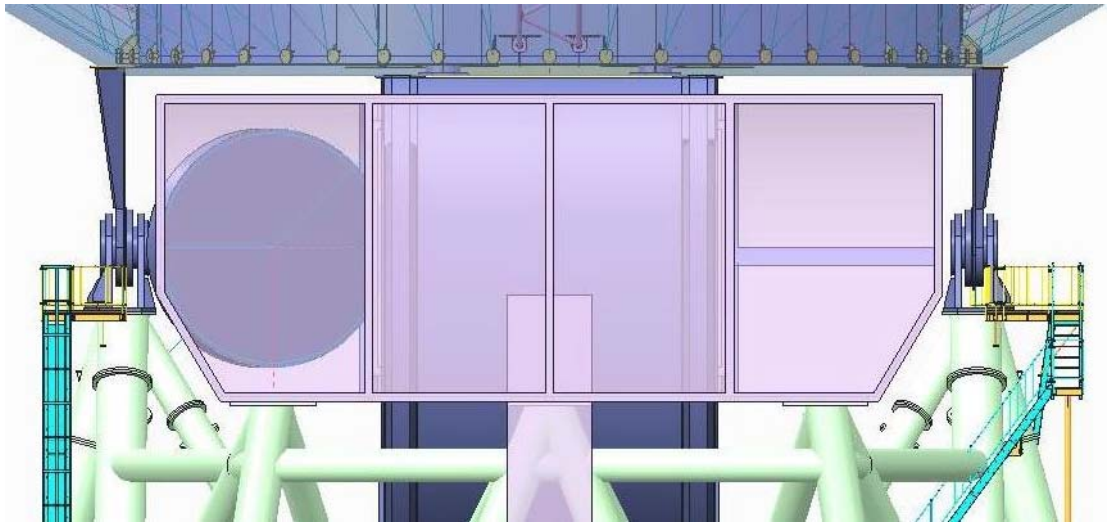
LST

LARGE SUBMILLIMETER TELESCOPE

#3, & #4 mirrors
limit the minimal size of
receiver cabin..

Back View





Top View

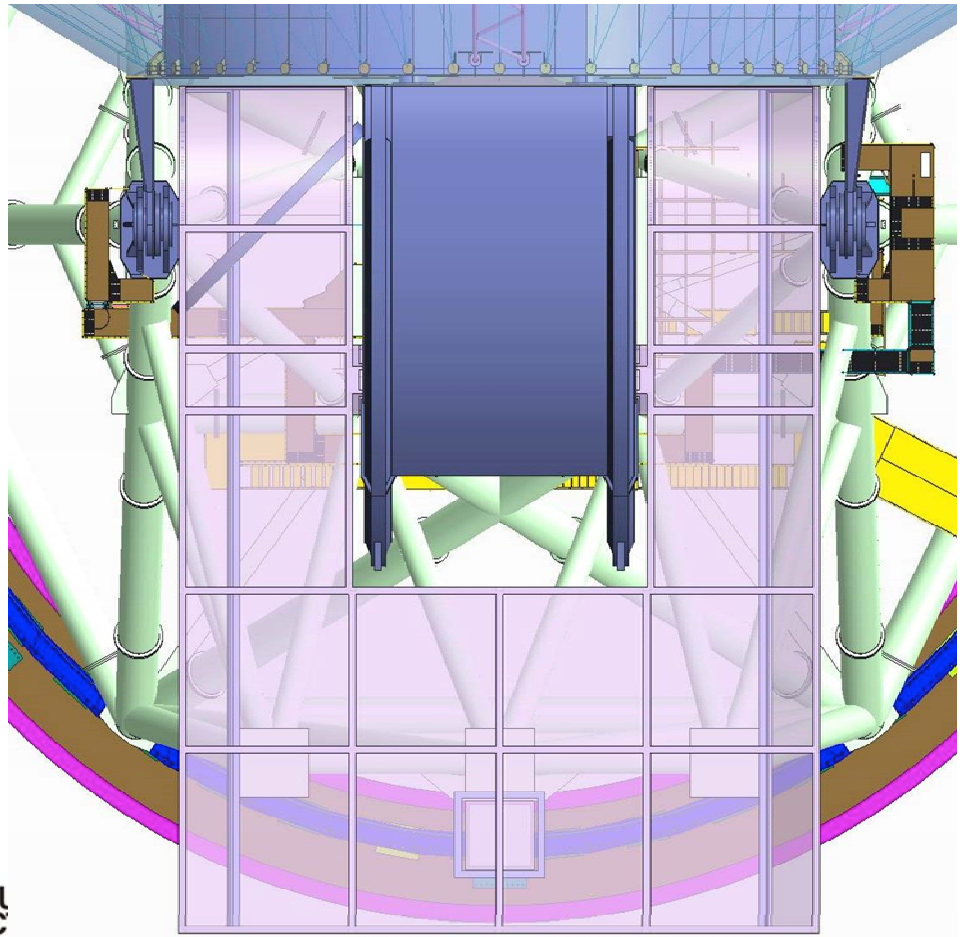


Image Courtesy of
Mitsubishi Electric Company

MITSU
ELEC

# *Active Surface Control Required*