

# The Large Millimeter Telescope in the GLAST era

Alberto Carramiñana<sup>1</sup> & LMT/GTM collaboration<sup>1,2</sup>

Alfonso Serrano (INAOE PI), David Hughes (PS), Luis Carrasco, José Guichard, AC, Itziar Aretxaga, Esperanza Carrasco, William Wall, Miguel Chavez...

Peter Schloerb (PI), William Irvine, Min Yun (PS), Ron Snell, Mark Heyer, Grant Wilson, James Lowenthal, Ronna Erickson, Kamal Souccar, Gopal Narayan, ...



(1) Instituto Nacional de Astrofísica, Óptica y Electrónica, Tonantzintla, Puebla, México

(2) University of Massachusetts, Amherst, Massachusetts, US



LMT/GTM project → science

1<sup>st</sup> GLAST Symposium, Stanford - 6 Feb 2007

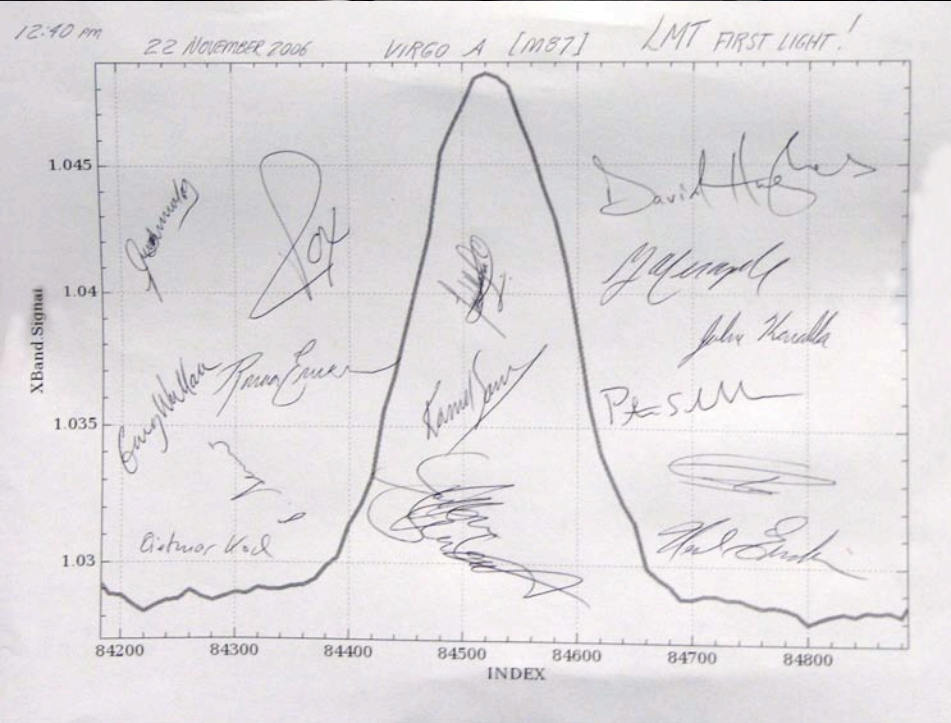
# The Large Millimeter Telescope

## El Gran Telescopio Milimétrico

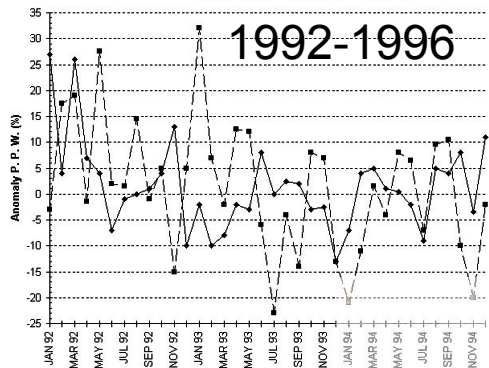
- Bi-national collaboration between INAOE and University of Massachusetts, at Amherst
- The largest single dish mm-telescope
- The largest scientific project in Mexico ever
- Largest US-MX science collaboration
- In construction at volcán Sierra Negra
- Inaugurated on November 22, 2006.



22 November 2006



Behaviour of the Precipitable Water Field 1992-1994  
Sierra Negra and San Pedro Mártir



1996



1997



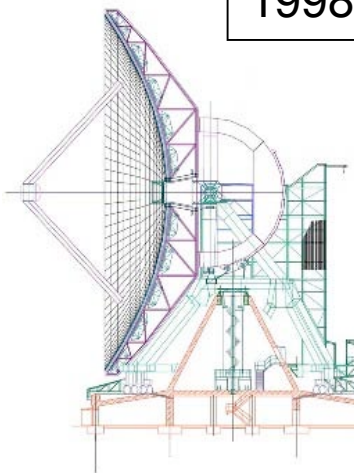
1999



2000



1998



2001



2002



2003



2004



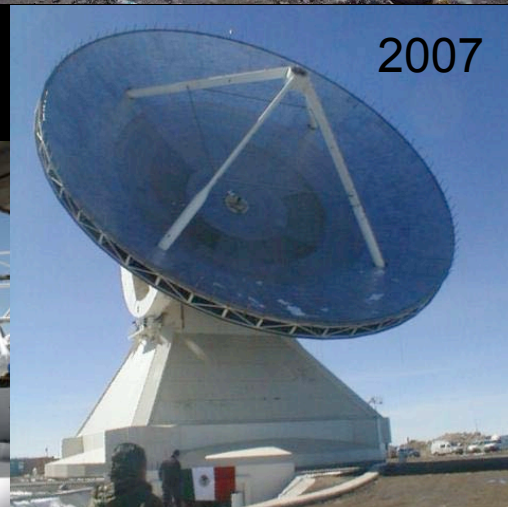
2005



2006



2007



# Antenna specifications

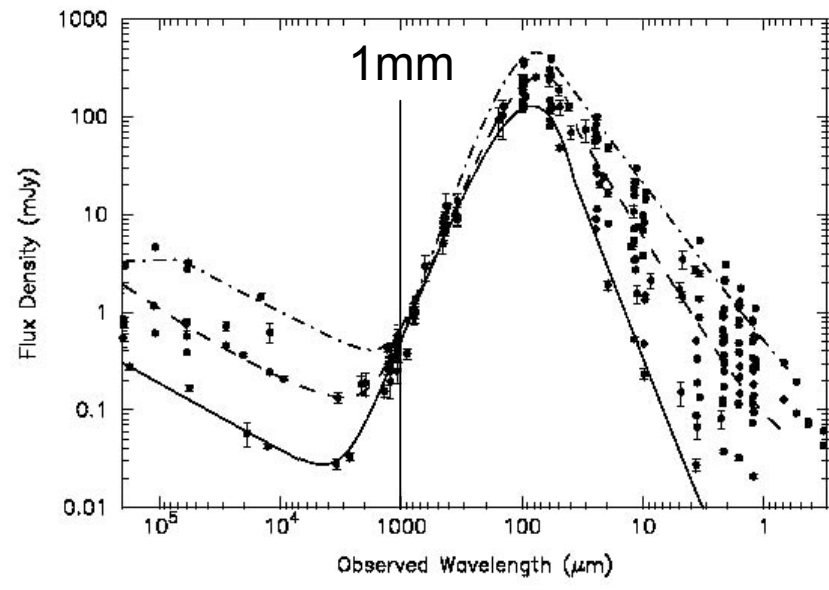
- 50 m diameter aperture (2000 m<sup>2</sup>)
- Range 80 to 350 GHz (→ 0.3 to 1.4 meV)  
→ 70 μm rms active surface (180 panels @ 20 μm)
- 5" (λ/mm) beam → 1" pointing
- FOV = 2'×2'
- 1 deg/s per axis slew
- Spectroscopy – imaging – polarization
- Array cameras

A mapping instrument - OTF

# LMT science

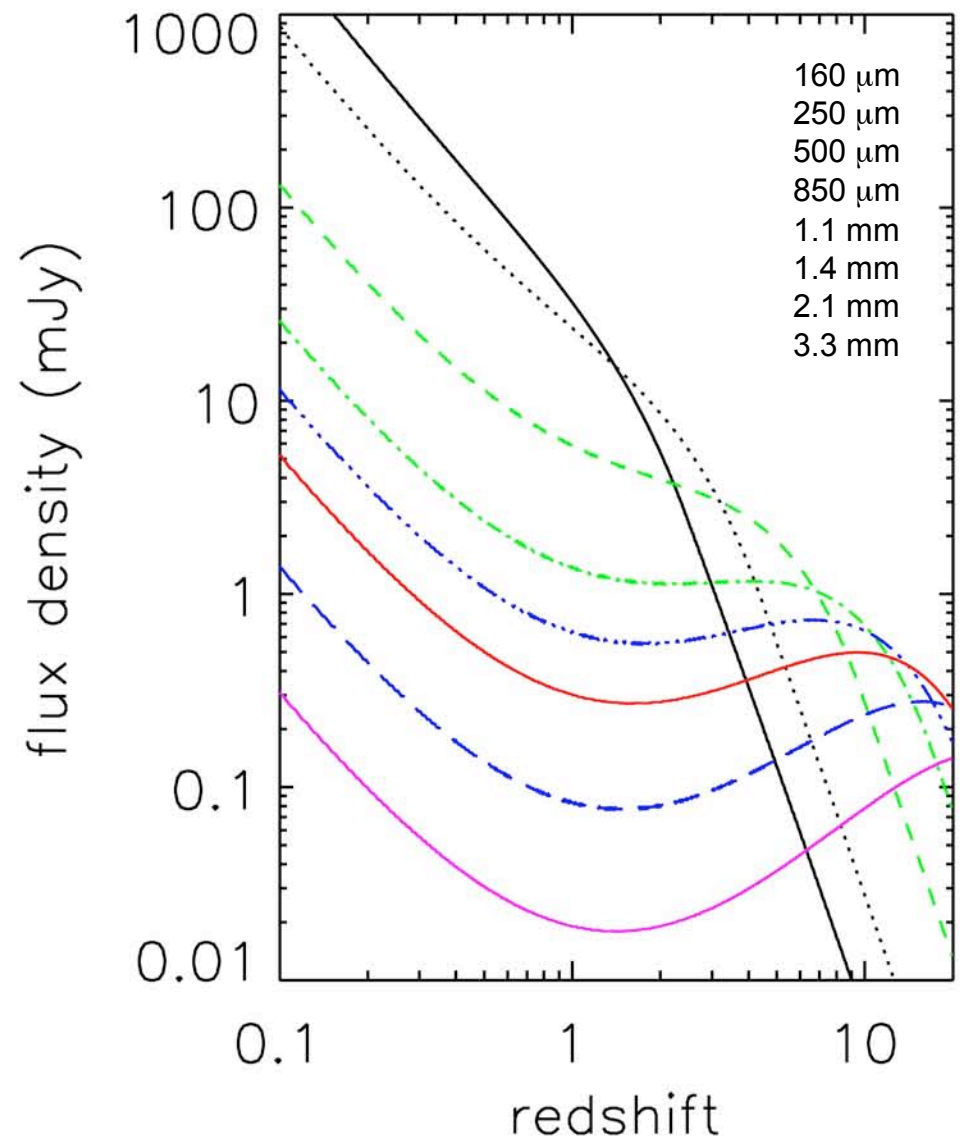
- Universe formation
  - CMB peaks at 1mm
    - CMB structure at small angular scale
    - SZ effect in galaxy clusters
- Galaxy formation
  - negative K correction for 30K dust
    - privileged access to the high redshift Universe
    - surveys to sample & study protogalaxy population
  - direct redshifts from CO ladder
- Star formation
  - maps of molecular species in ULIRs, LIRs and starbursts
  - detailed mapping and studies of molecular clouds in Milky Way and nearby galaxies
- Planet formation
  - detection and imaging of nearby protoplanetary disks
- Solar system formation
  - comets and eKBOs

# Negative K correction



Dusty starburst SED

Dust in RJ:  $F_{\nu} \propto \nu^{2+\beta}$





Spitzer

Massive poststarburst at  $z > 6.5$   
Mobasher et al. 2005

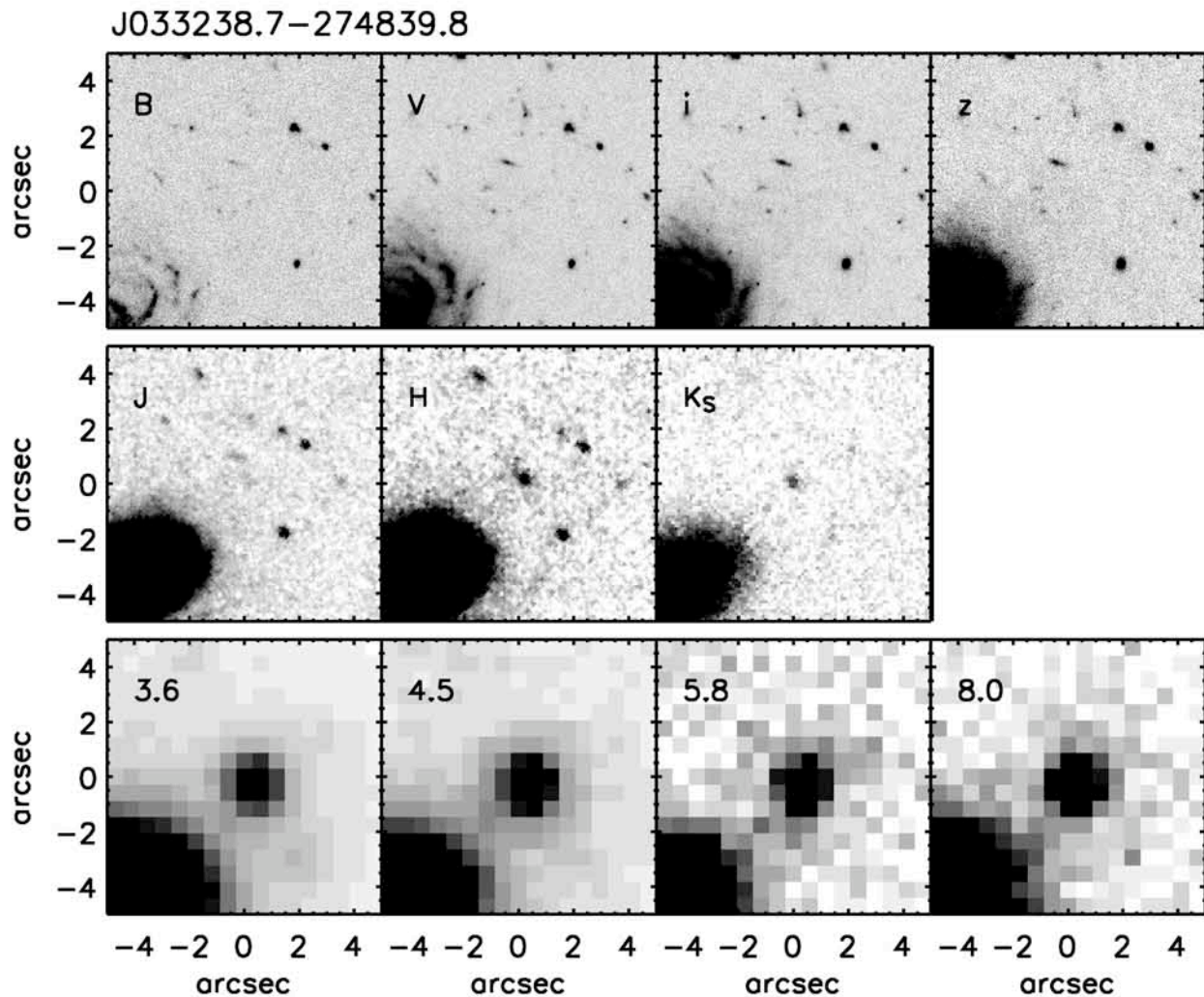
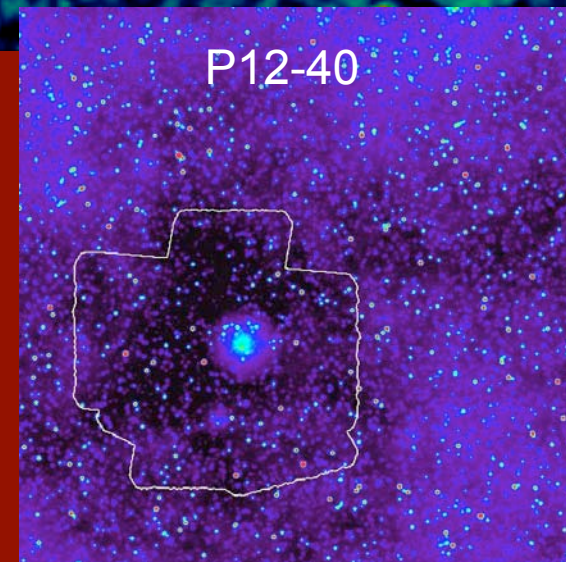
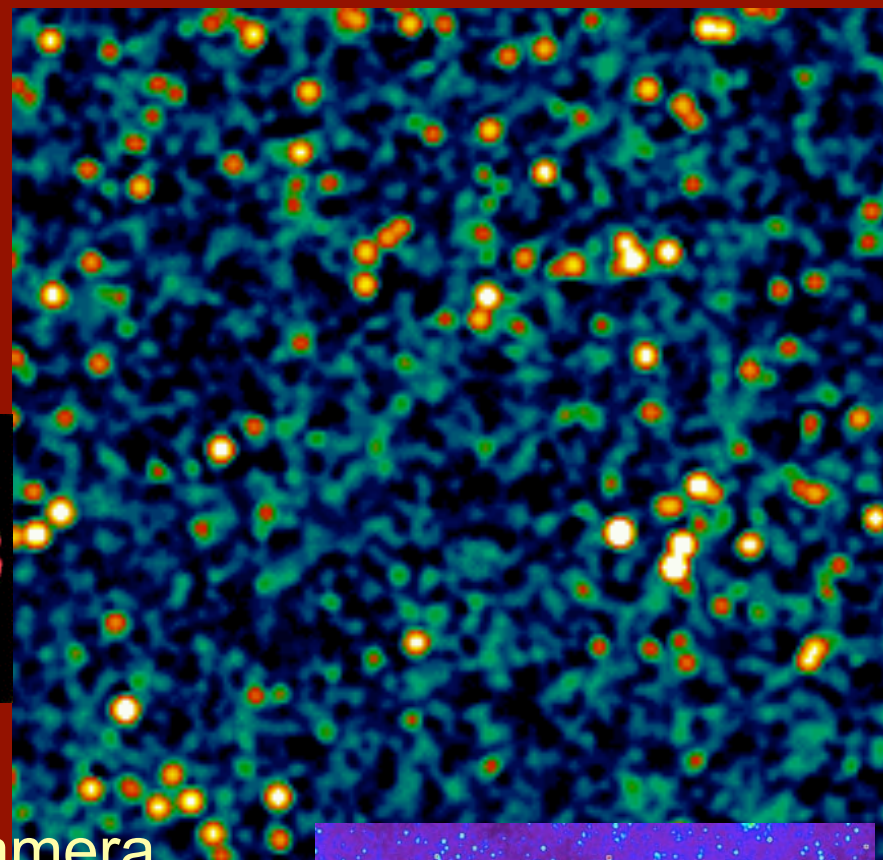
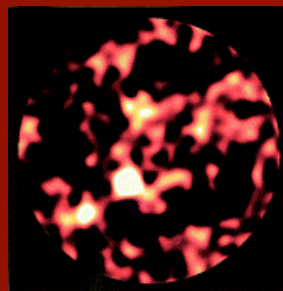
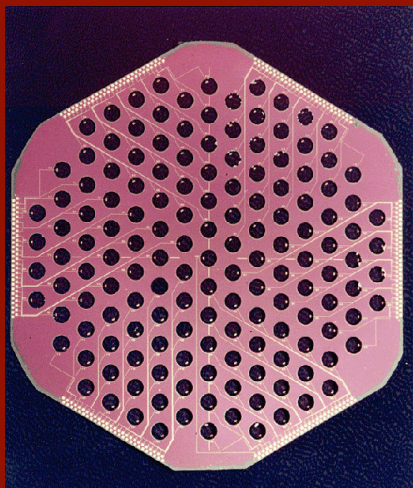


Fig. 1.— Images of the  $J$ -dropout candidate HUDF-JD2 ( $\alpha = 3:32:38.74$ ;  $\delta = -27:48:39.9$  J2000) from HST/ACS ( $B_{435}V_{606}i_{775}z_{850}$ ), HST/NICMOS ( $J_{110}H_{160}$ ), VLT/ISAAC ( $K_s$ ) and Spitzer/IRAC (3.6-8.0  $\mu\text{m}$ ). The  $K_s$  ISAAC image is from deep FIRES observations.

# AzTEC



- 144 element bolometer array camera
- Ideal for large scale continuum mapping
- Successfully run on JCMT – fall 2006

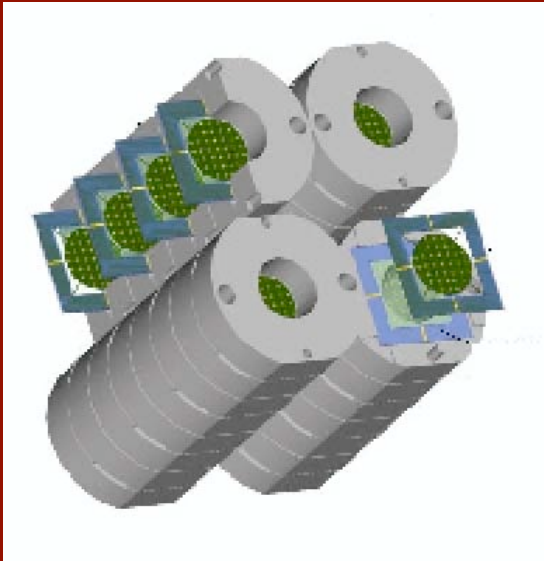
Sample galaxy formation up to  $z > 10$  - in search of the first dust

Add radio: when did AGNs turn on?

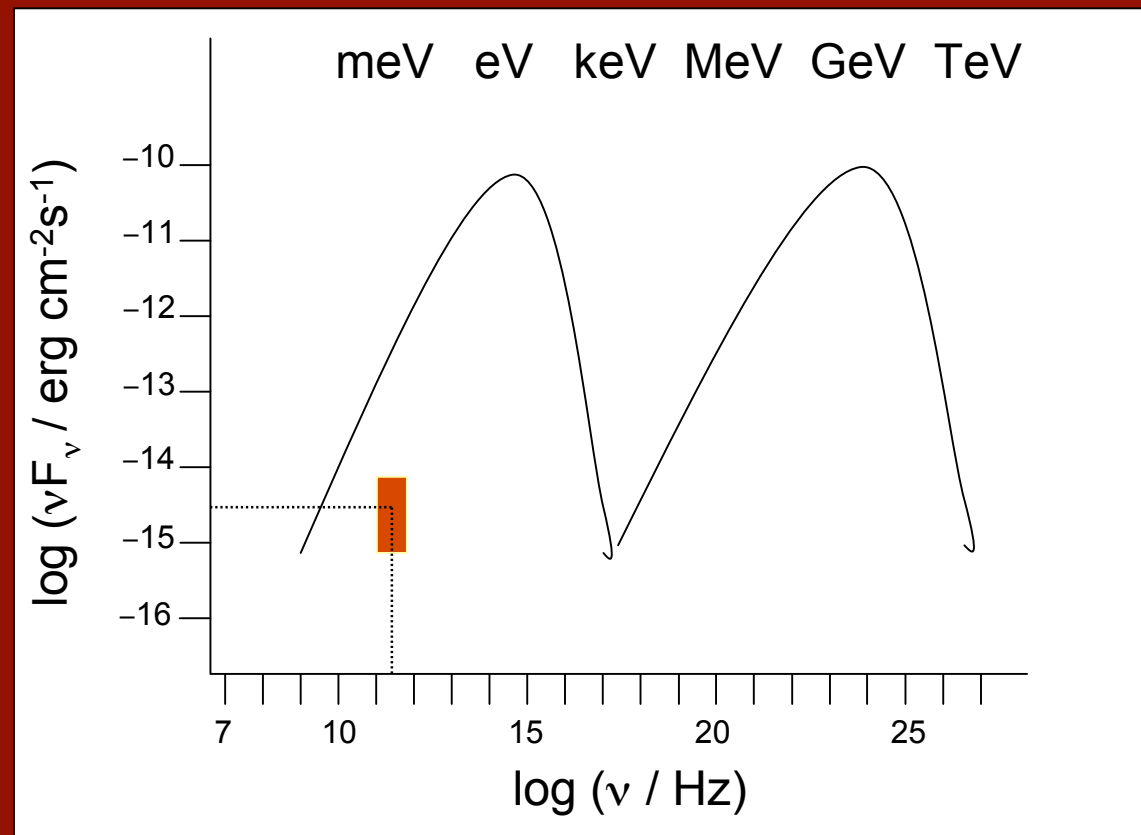
# SPEED

4 pixel freq. selective bolometers for simultaneous 2.1, 1.4, 1.1, 0.8mm

$1\sigma$  @ LMT: 1.3 to 4.9 mJy Hz<sup>1/2</sup>



Wilson et al. 2005



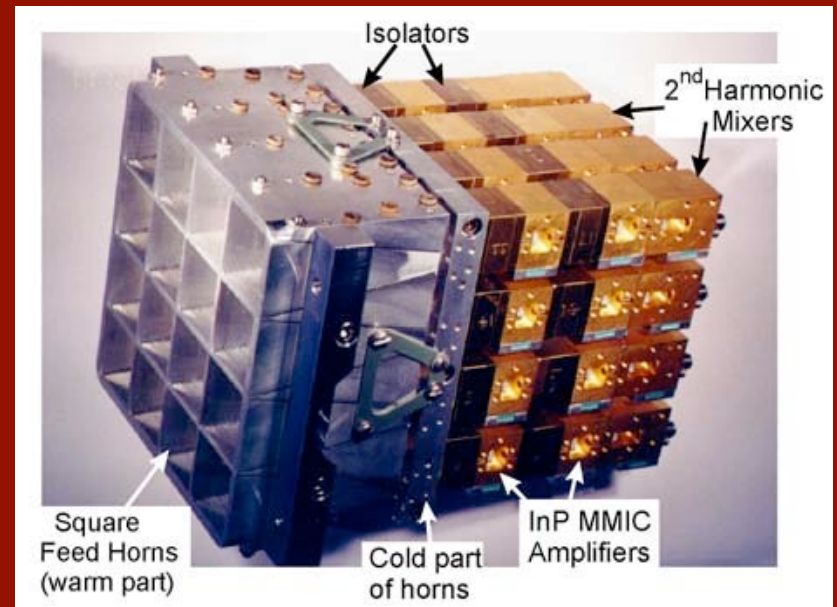
## VARIABILITY

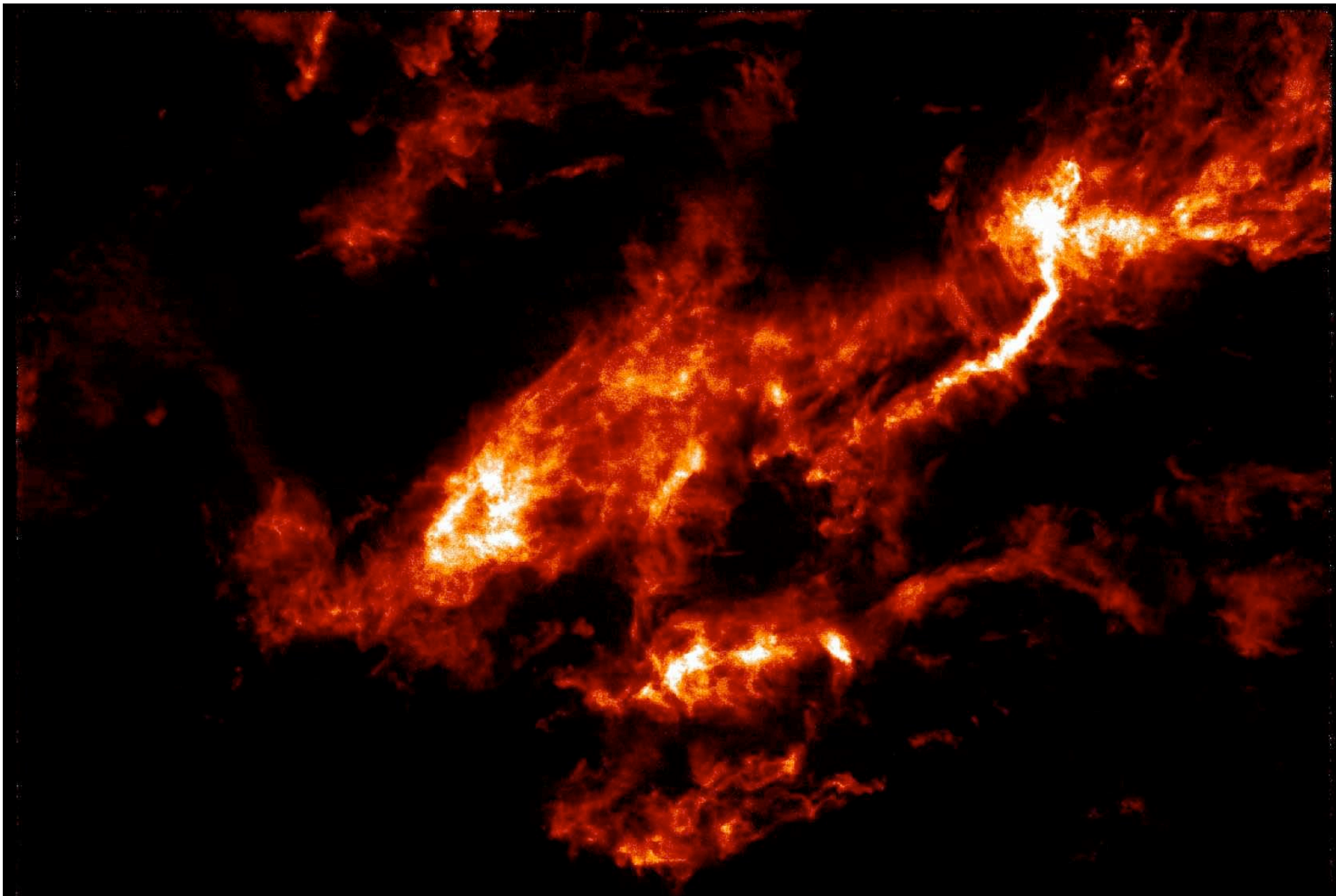
from seconds to years

# The World's Fastest 3mm Array Camera

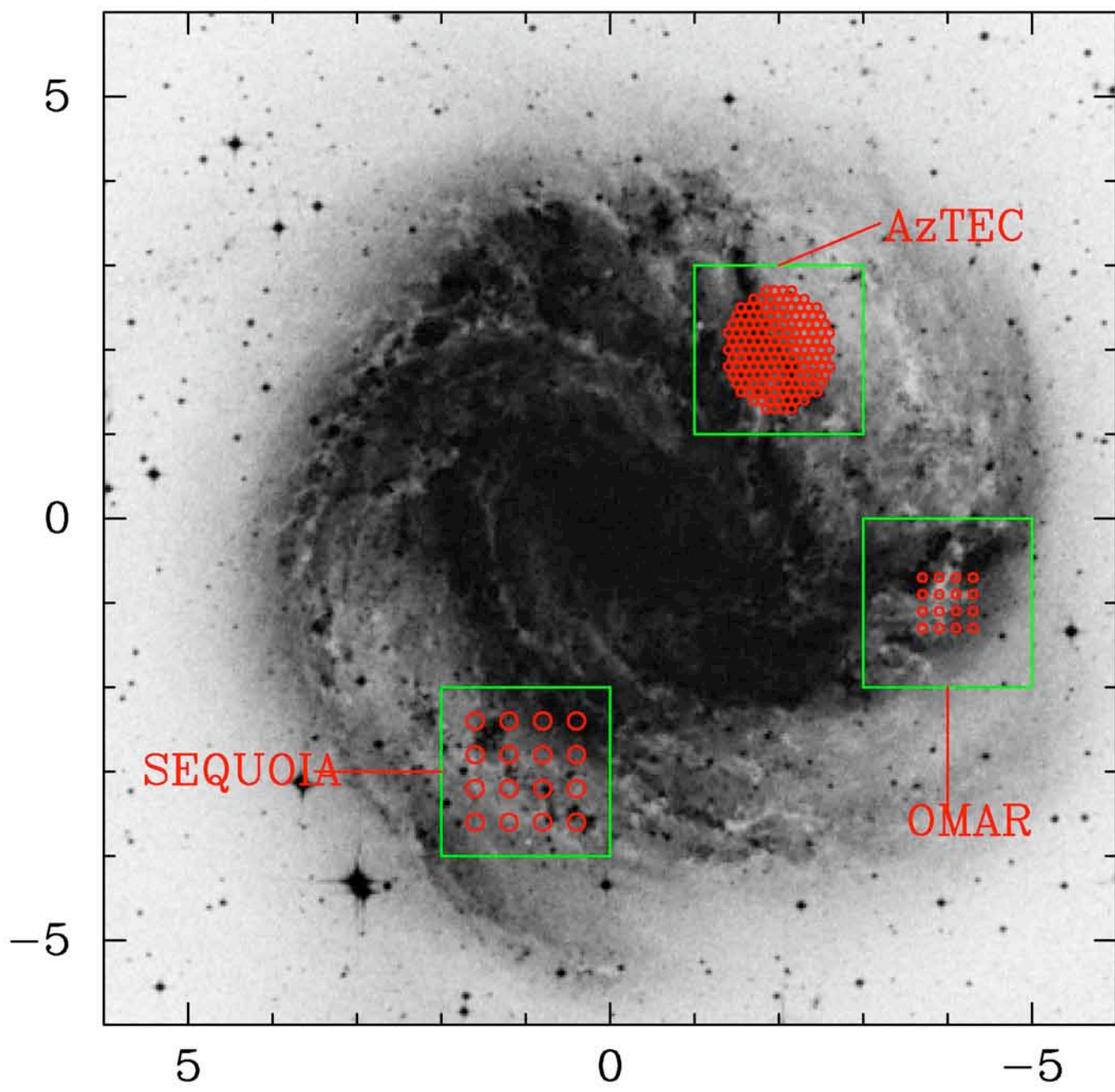
SEQUOIA

32 element heterodyne array  
tunable between 80 and 116 GHz  
high velocity and spatial resolution molecular  
line mapping  
CO (1 $\rightarrow$ 0) mapping with 13" resolution at LMT



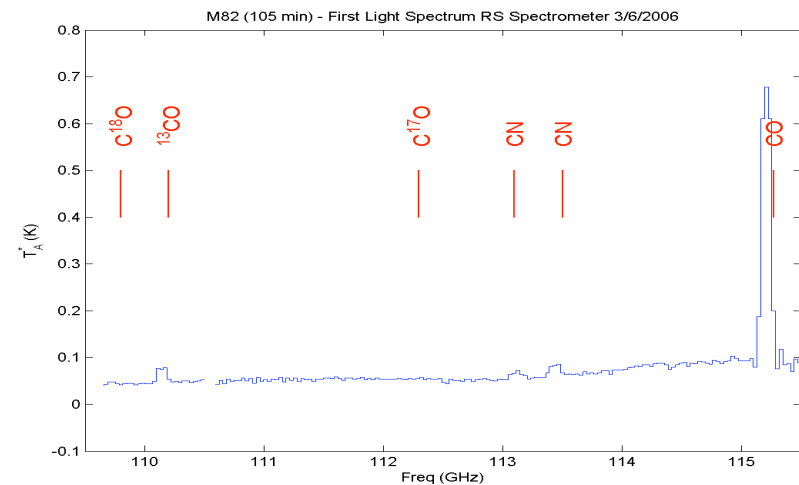
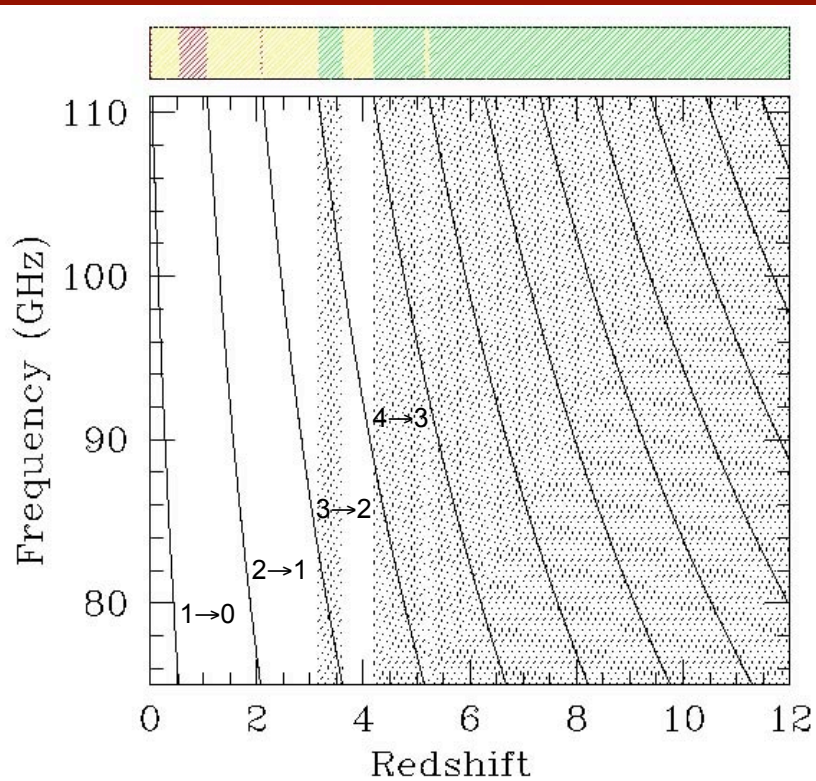
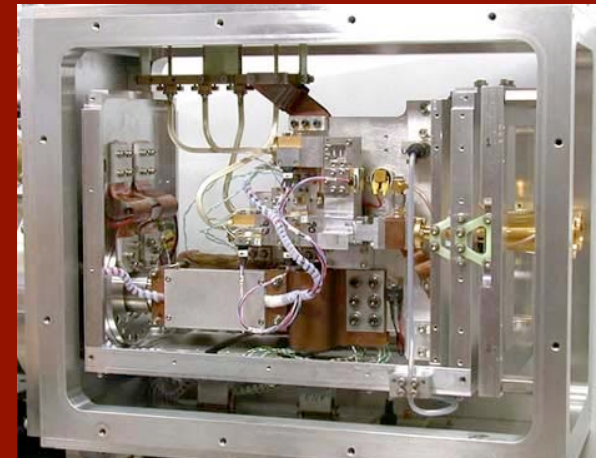


Taurus GMC with SEQUIOA @ FCRAO 14m: 96 sq.deg with 70 m/s resolution  
[www.astro.umass.edu/~heyer/taurus.html](http://www.astro.umass.edu/~heyer/taurus.html)



# Redshift Receiver

- 4 pixel wideband spectrograph
- 75-110 GHz (in one shot)
- Direct LMT redshift determinations



|  | <b>GBT</b>  | <b>CARMA</b> | <b>LMT</b>  | <b>ALMA</b> | <b>ALMA</b> |
|--|-------------|--------------|-------------|-------------|-------------|
| <b>Year of operation</b>                 | <b>2006</b> | <b>2006</b>  | <b>2008</b> | <b>2008</b> | <b>2012</b> |
| <b>Flux sensitivity</b>                  |             |              |             |             |             |
| Line (3mm)                               | 0.6         | 2.5          | 1.0         | 1.1         | 0.3         |
| Continuum (1mm)                          | ×           | 19           | 1.0         | 2.9         | 0.7         |
| <b>Surface brightness sensitivity</b>    |             |              |             |             |             |
| Line (3mm)                               | 2.3         | 3.3          | 1.0         | 3.3         | 2.5         |
| Continuum (1mm)                          | ×           | 25           | 1.0         | 8.8         | 6.6         |
| <b>Mapping speed - point sources</b>     |             |              |             |             |             |
| Line (3mm)                               | 15          | 5.5          | 1.0         | 1.1         | 0.1         |
| Continuum (1mm)                          | ×           | 1100         | 1.0         | 34          | 2.2         |
| <b>Mapping speed - extended emission</b> |             |              |             |             |             |
| Line (3mm)                               | 350         | 7.7          | 1.0         | 10          | 5.8         |
| Continuum (1mm)                          | ×           | 1900         | 1.0         | 320         | 180         |



# Mexican astrophysical facilities

## OAN (San Pedro Mártir)

0.8m, 1.5m, 2.1m  
optical NIR

## OAGH (Cananea)

2.1m optical NIR (0.4m)

+5% GTC

## MEXART (Michoacán)

64×64 dipole array @  
140 MHz

## Consorcio Sierra Negra

LMT: 50m (85-350 GHz)

RT5: 5m (40 GHz) solar

Solar neutron monitor

Cosmic ray array

HAWC @ Mexico?



