EVLA Observations of the Orion Hot Core: a Taste of the Future

Claire Chandler

on behalf of NRAO-NM staff

Atacama Large Millimeter/submillimeter Array
Expanded Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array

NRAO

The EVLA

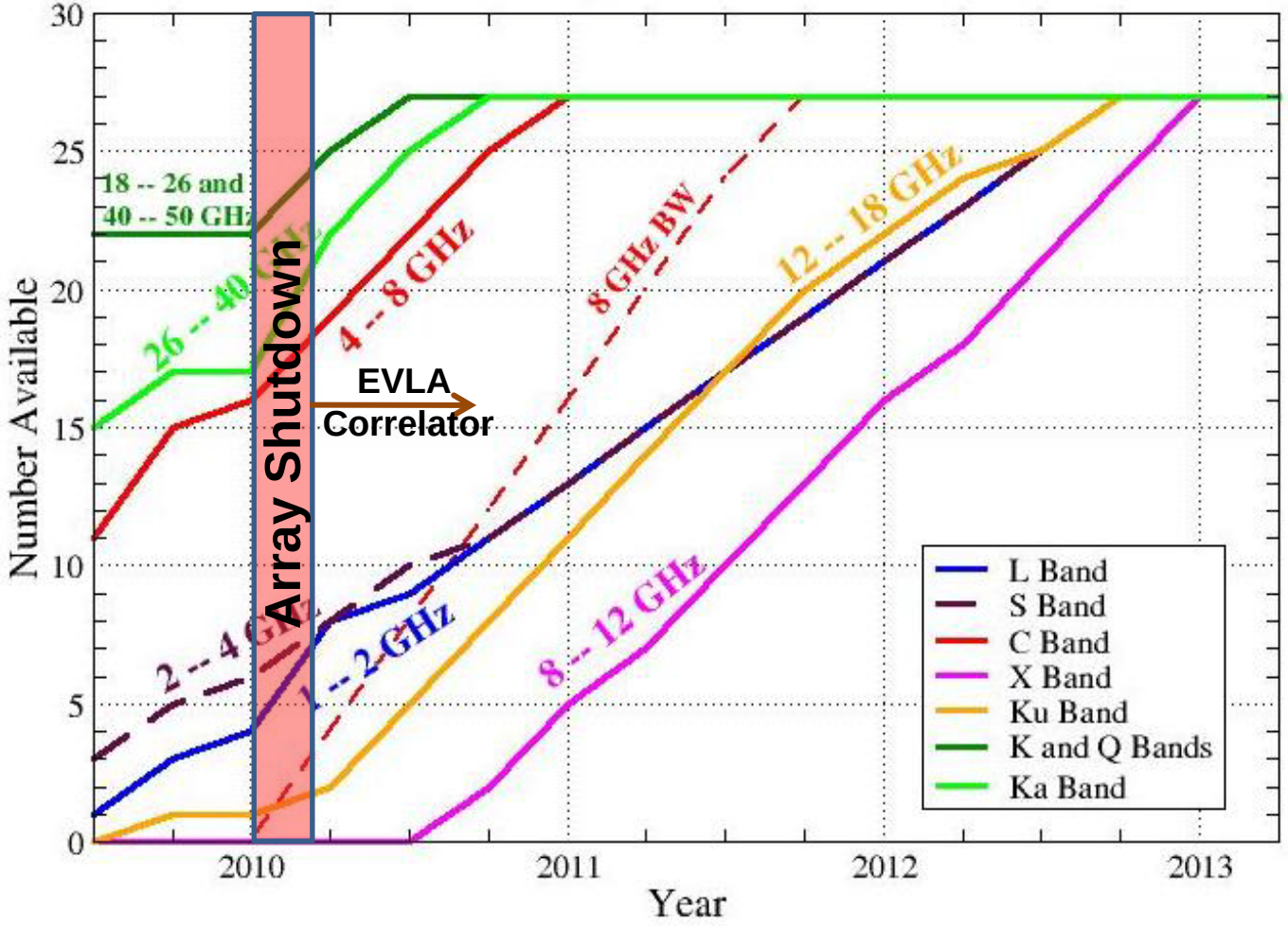
- The Expanded Very Large Array is a $90M upgrade of the Very Large Array; project began in 2001, will be completed in 2012, on time, on spec, on budget
- The EVLA will multiply by orders of magnitude the observational capabilities of the VLA. Key goals are:
  - Full frequency coverage from 1 to 50 GHz.
  - Up to 8 GHz instantaneous bandwidth.
  - New correlator with unprecedented capabilities
  - ~3 μJy (1-σ, 1-hr) point-source continuum sensitivity at most bands.
  - ~1 mJy (1-σ, 1 km/s, 1-hr) line sensitivity at most bands.
- New receivers; new data transmission system; new correlator. See http://science.nrao.edu/evla/publications/meetandpresent.shtml for presentations with more technical detail

Milestones and current status

- 26 of 28 antennas now converted to EVLA standards; antenna conversion complete by July 2010
- VLA correlator was shut down on Jan 11
- New EVLA correlator made by HIA/DRAO, Canada, awakens early February
- EVLA Early Science begins in March 2010
  - OSRO and RSRO programs begin March 2010 and continue through end of 2012
- 2 GHz bandwidth initially, full bandwidth (8 GHz) implemented on all antennas mid-2011
- Receiver implementation completed end of 2012

Availability of EVLA receivers/bandwidth

- VLA or "interim" receivers will continue to be available at L, C, and X-band in addition to those shown below



EVLA correlator capabilities

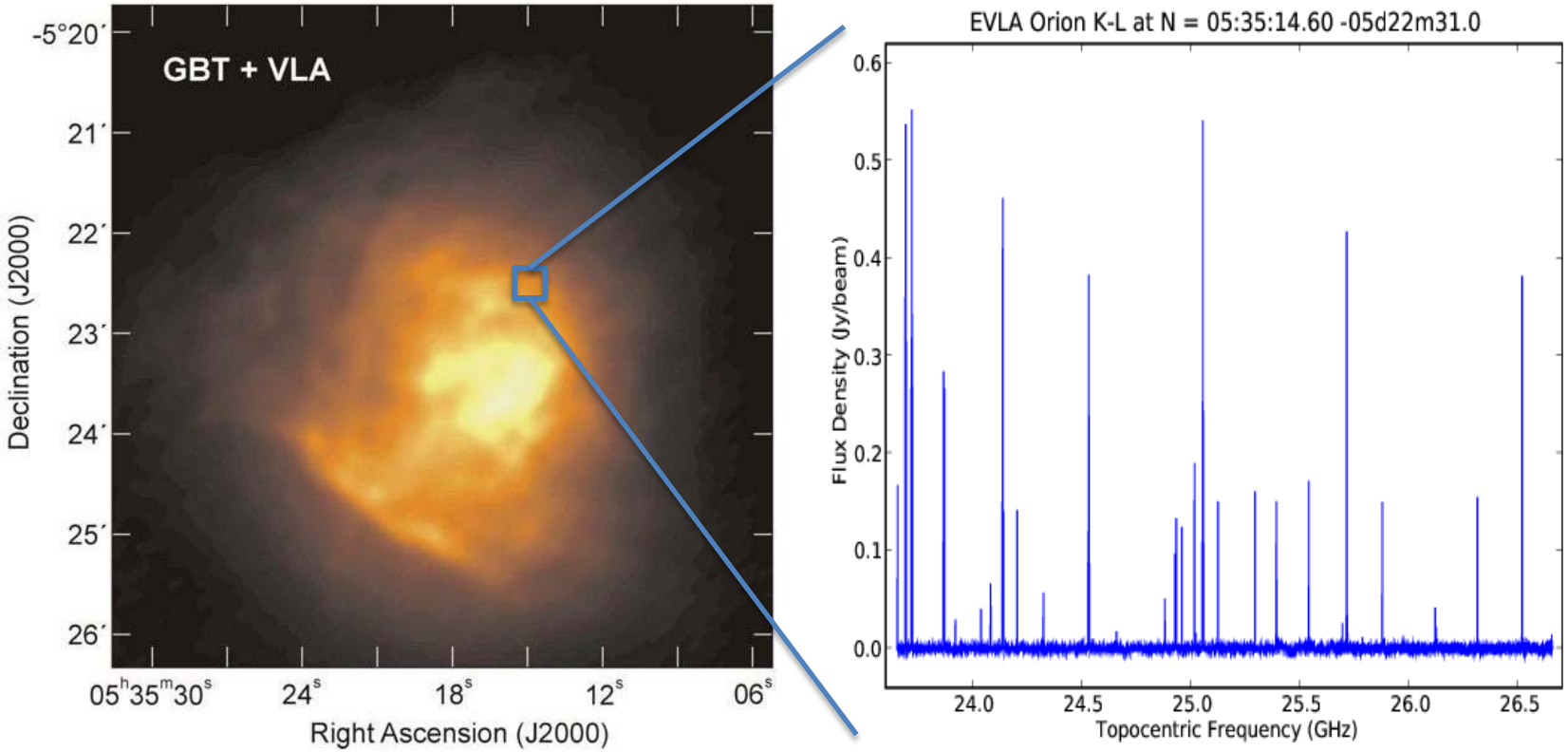
- Major capabilities:
  - 8 GHz maximum instantaneous bandwidth, with full polarization
  - From 16384 (min) to 4.2 million (max) frequency channels
  - 64 independently tunable full polarization sub-bands, each of which is effectively an independent 'sub-correlator'
  - Extensive special modes: pulsar gating/binning, phased array, VLBI, burst modes, and more
- Fundamental capabilities will be developed first, with specialty modes later

Demonstration Science

- A 12-antenna sub-array has been used to test a subset of the final correlator
- The test configuration provides:
  - 8192 channels
  - Full polarization
  - Eight adjacent sub-bands
- To illustrate the capabilities of the correlator we have observed the Orion Hot Core at $\lambda \sim 1.2$ cm:
  - 3 x 1 GHz coverage
  - 24,000 channels with 1.5 km/s spectral resolution
  - $\theta \sim 3$ arcsec

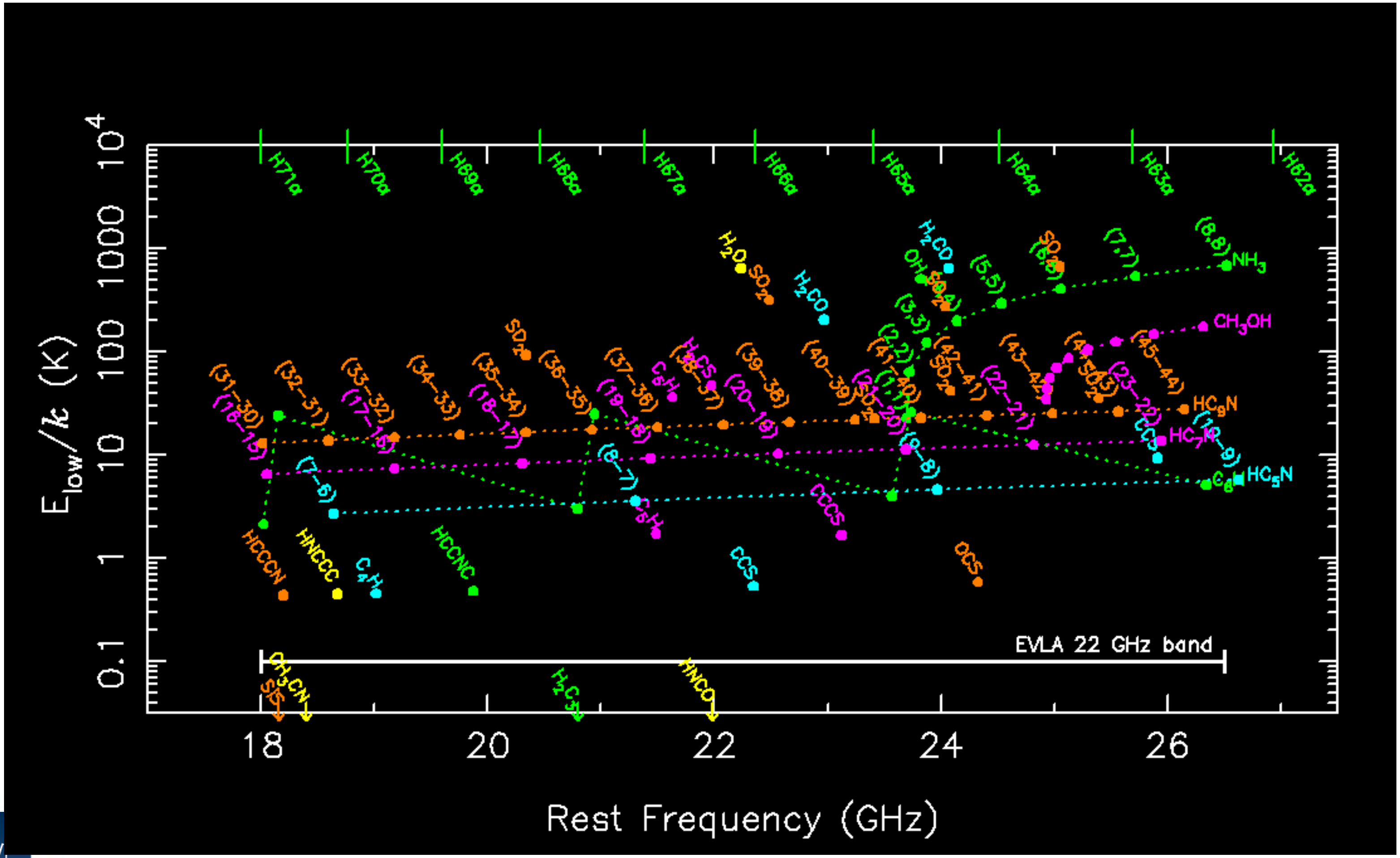
Orion Hot Core

- The hot core lies in the molecular cloud *behind* the nebula
- Hot cores are thought to be signposts of the earliest phase of massive star formation; rich chemistry, high densities and temperatures



8 GHz image from GBT+VLA

Transitions in K-band 18-26.5 GHz window

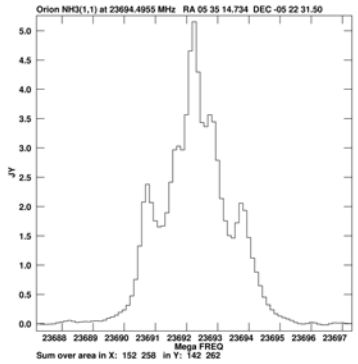


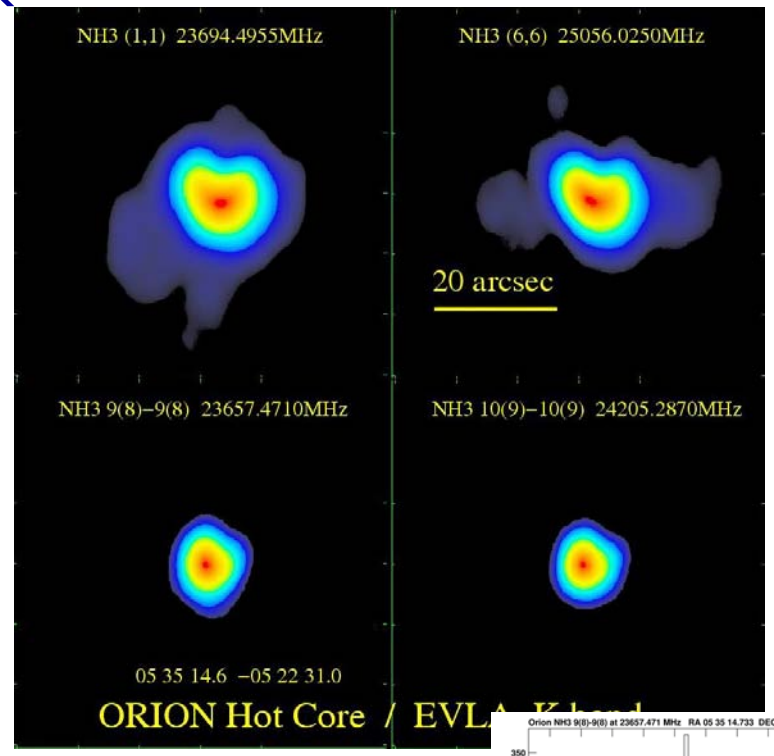
Orion Hot Core line IDs

- Ammonia, NH_3
  - 8 lowest meta-stable inversion transitions (J,K) = (1,1) to (8,8)
  - (6,6) line from $^{15}NH_3$ isotopologue
  - the 4(1,4)-4(0,4) line from NH_2D
  - meta-stable (9,8) & (10,9) lines
- Methyl formate, CH_3CHO
  - two E/A doublets
- Carbonyl sulphide, OCS
  - J=2→1 rotational transition
- Sulphur dioxide, SO_2
  - Three transitions
- Methanol, CH_3OH
  - Ten maser lines from J=2—10 series, E-type
- Various unidentified and weak lines

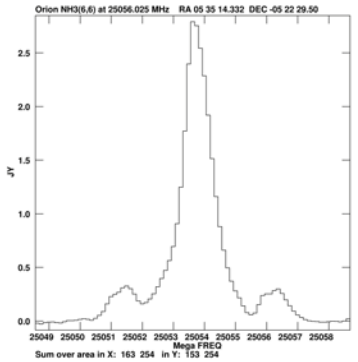
Spatial distribution: NH_3

NH_3 (1,1): E_{low}=23 K



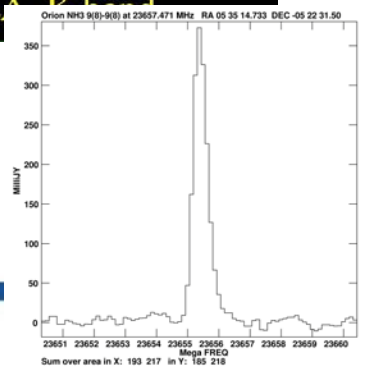


NH_3 (6,6): E_{low}=408 K



Low-energy NH_3 transitions trace cooler, extended molecular gas in the surrounding cloud

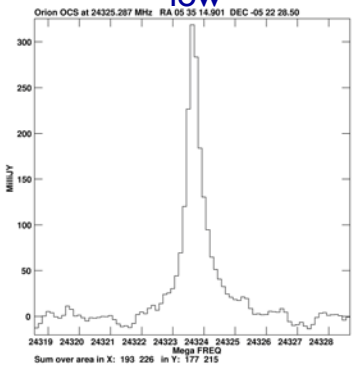
NH_3 9(8)-9(8), 10(9)-10(9): E_{low}~ 940 to 1140 K



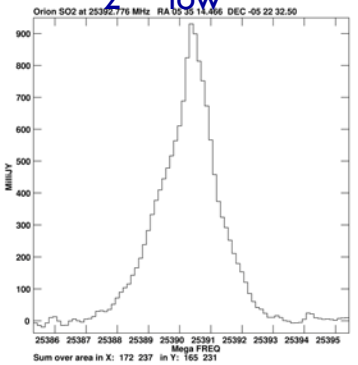
High-energy NH_3 transitions pinpoint location of a central heating source in the hot core

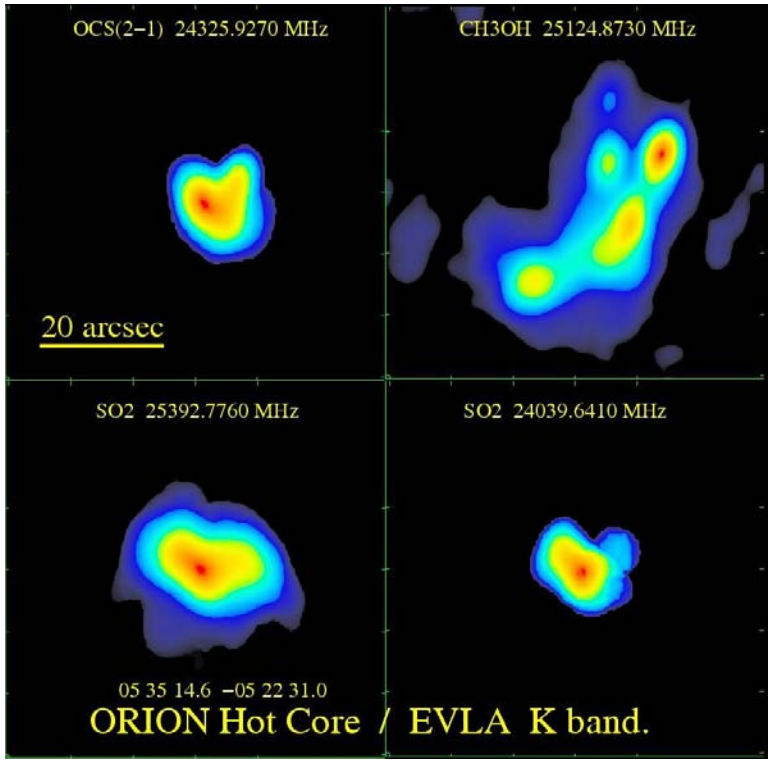
Spatial distribution: S/O-bearing molecules

OCS: E_{low}=0.6 K

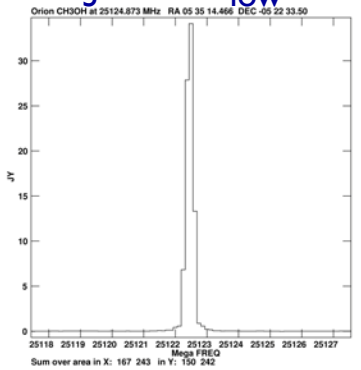


SO_2: E_{low}=36K

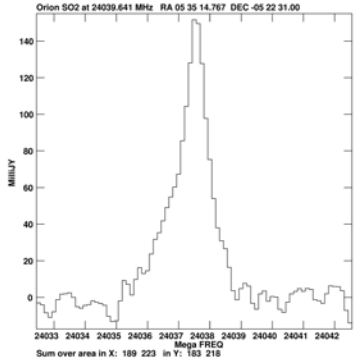




CH_3OH: E_{low}=86K



SO_2: E_{low}=273K

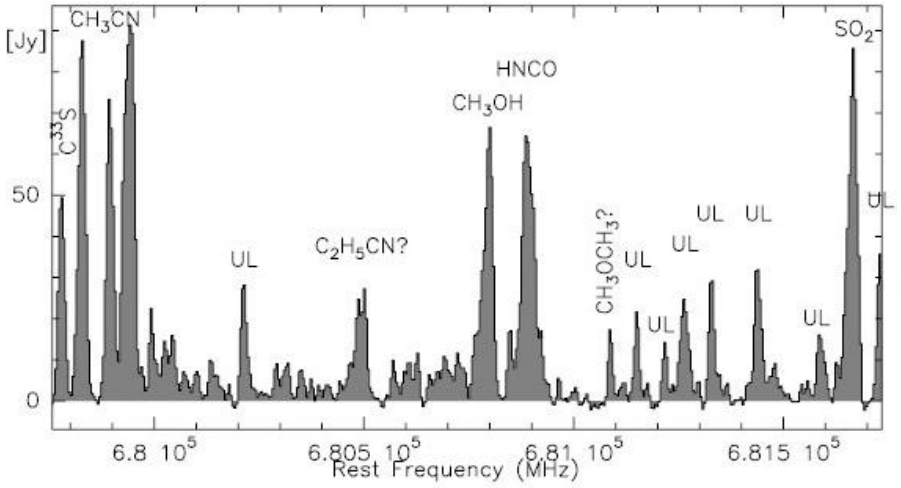


Credits: Eric Greisen, Vivek Dhawan, Steve Myers

See also: full spectrum and images in poster upstairs

Compare with what ALMA can expect:

- 2 GHz of spectrum at 690 GHz from the Submillimeter Array (Beuther et al. 2006):



- No line-free continuum, many line blends!
- Play with the EVLA Demo Science data cube yourself: http://science.nrao.edu/evla/projectstatus/

How you can be part of the EVLA future

- Open Shared Risk Observing (OSRO):
  - Observers will access EVLA in the same way as for the VLA
  - Initial configuration provides 512 spectral channels with one or two sub-bands of 128 MHz (maximum) each, dual or full polarization; see the EVLA Observational Status Summary for full details: http://science.nrao.edu/evla/proposing/obsstatsum.shtml
  - Observing begins March 2010
- Resident Shared Risk Observing (RSRO):
  - Must be resident in Socorro for at least 3 months
  - Participants will assist NRAO staff in expanding capabilities
  - Participants will have access to more extensive observing capabilities
  - Observing time proportional to length of residency
  - 27 proposals received on first call, 13 have been accepted
- For details, see: http://science.nrao.edu/evla/earlyscience/