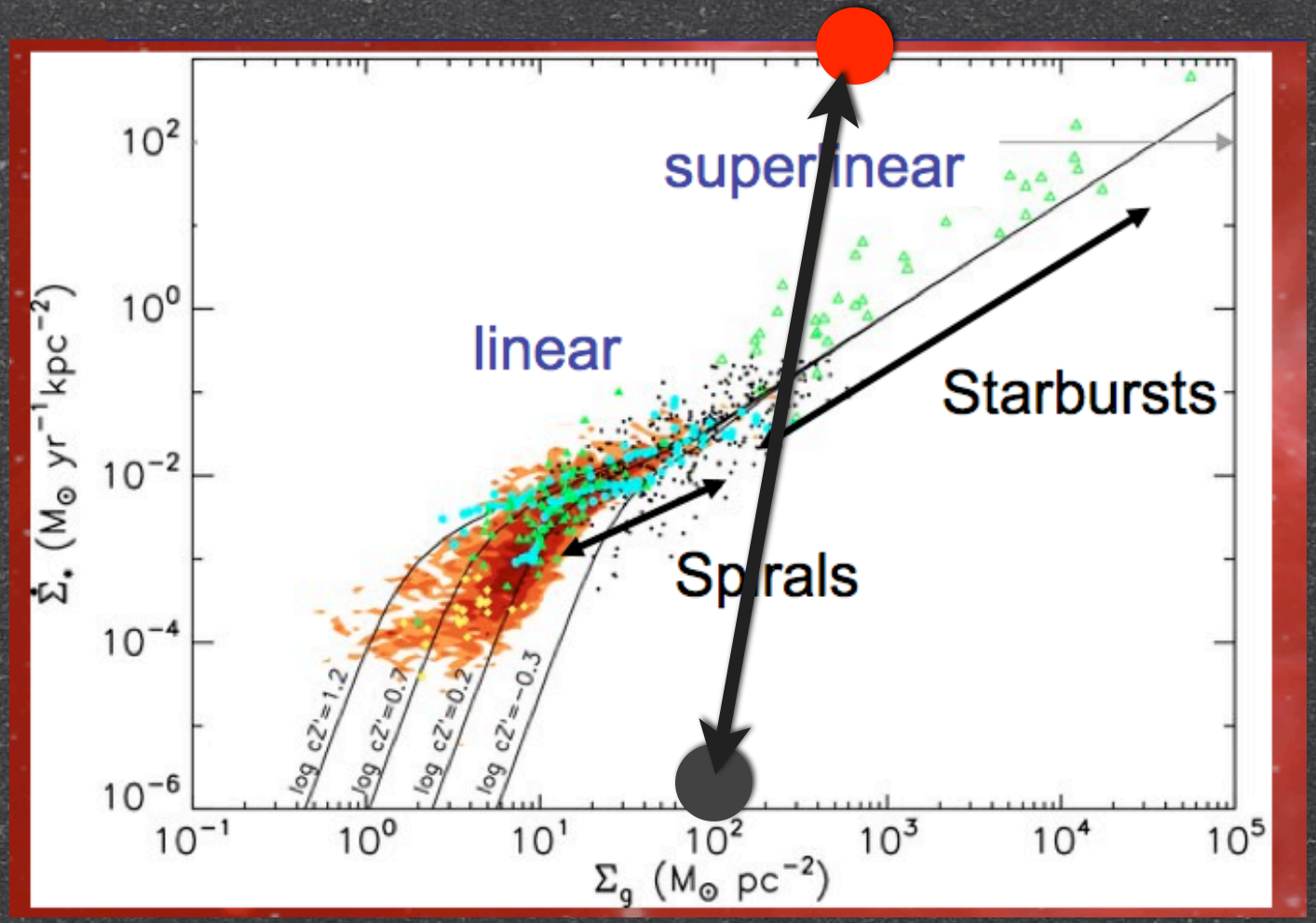
Cosmic Origins

from alcohol to life

1) Star formation in GMCs and Galaxies ...
2) Spectral Complexity versus Physical Reduction
3) The view from the high-z universe
4) Developing the Future of ALMA now

SFR Correlations

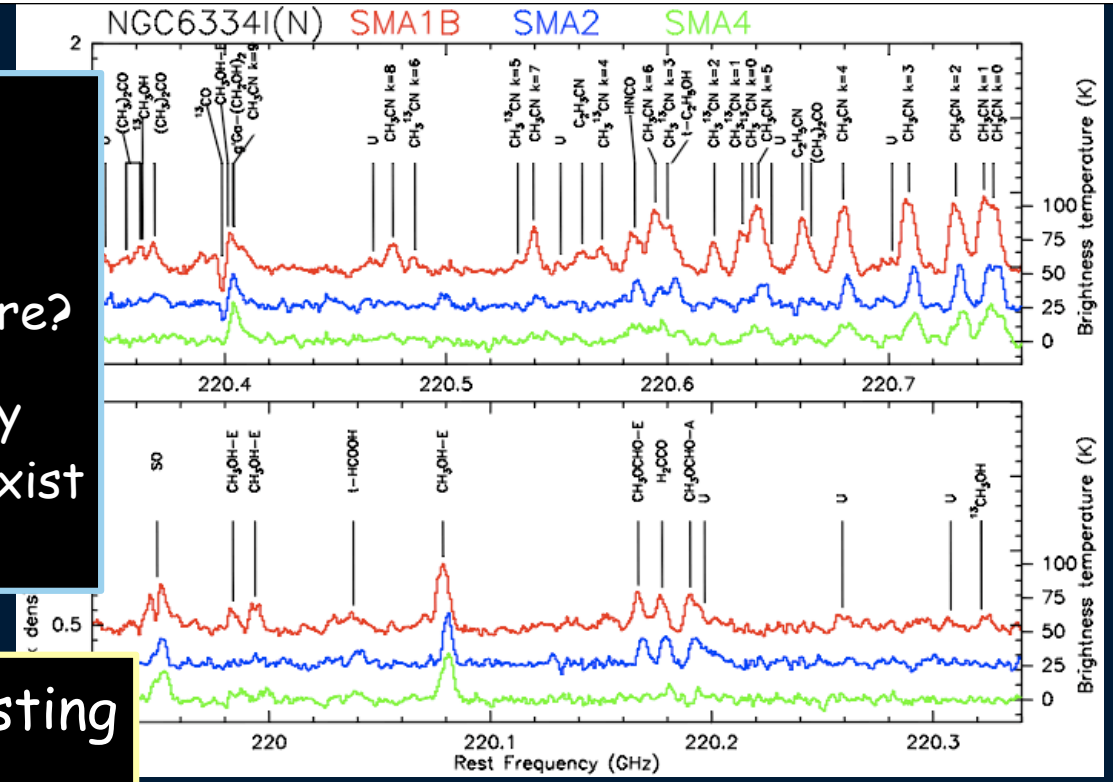


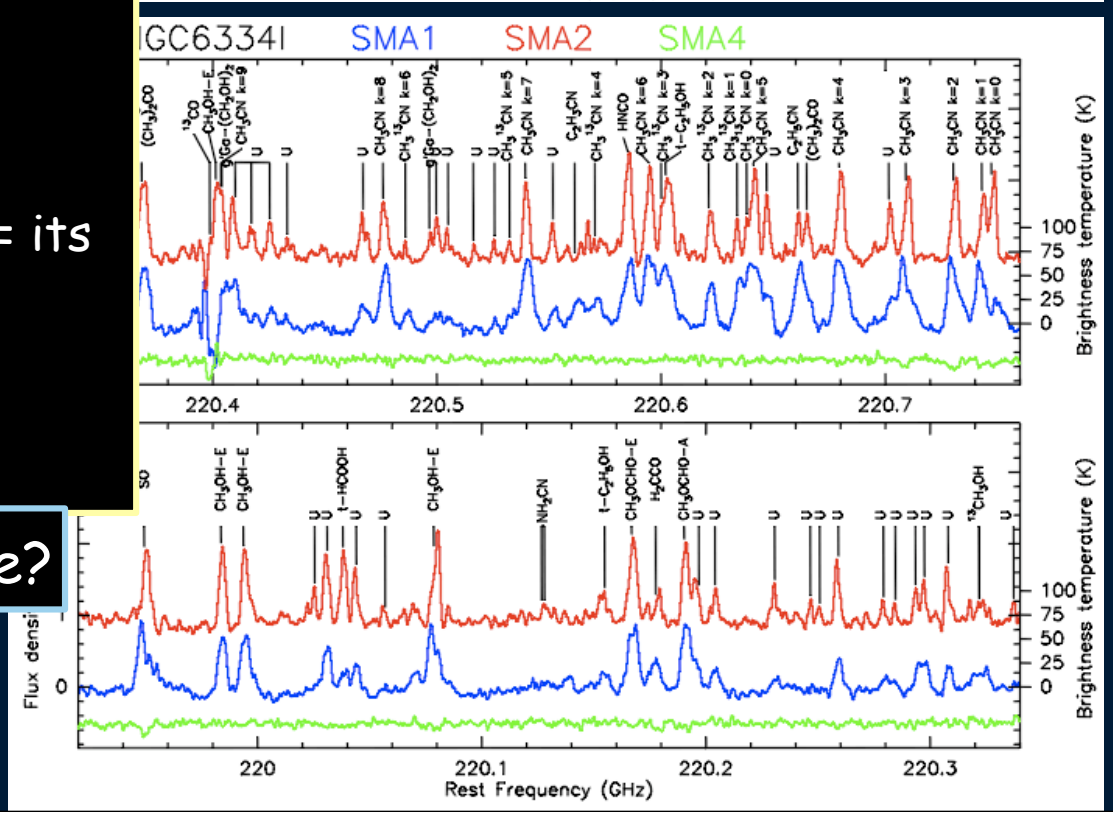
Heiderman's talk (and others)

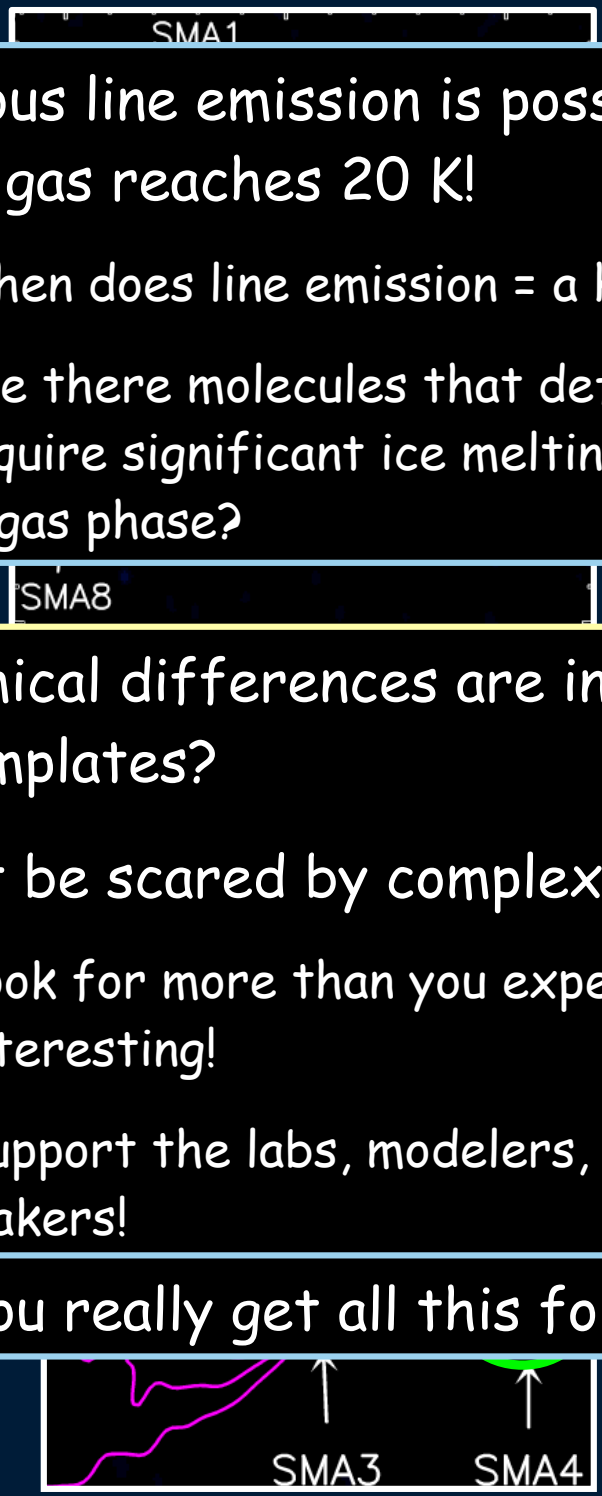
- Copious line emission is possible once gas reaches 20 K!
  - When does line emission = a hot core?
  - Are there molecules that definitely require significant ice melting to exist in gas phase?

- Chemical differences are interesting – Templates?
- Don't be scared by complexity!
  - Look for more than you expected = its interesting!
  - Support the labs, modelers, tool makers!

- Do you really get all this for free?







Sample Correlator Modes for Early Science

Mode	BW per sideband	Channels per sideband	Velocity Res. (km/s) 230 GHz	Min. Integration**
7 (dual)	2 x 2 GHz	2 x 4096	0.64	5 sec
12 (dual)	2 x 62.5 MHz	2 x 4096	0.02	5 sec
13 (cross)	2 x 2 GHz	2 x 2048	1.28	5 sec
18 (cross)	2 x 62.5 MHz	2 x 2048	0.04	5 sec
70 (cross)	2 x 2 GHz	2 x 64	40.8	0.1 sec

*** Estimated minimum integration times for 50 antennas and maximum data rate of 64 MB/sec

Early Science might be a great time for line surveys!

Large Area Surveys - II

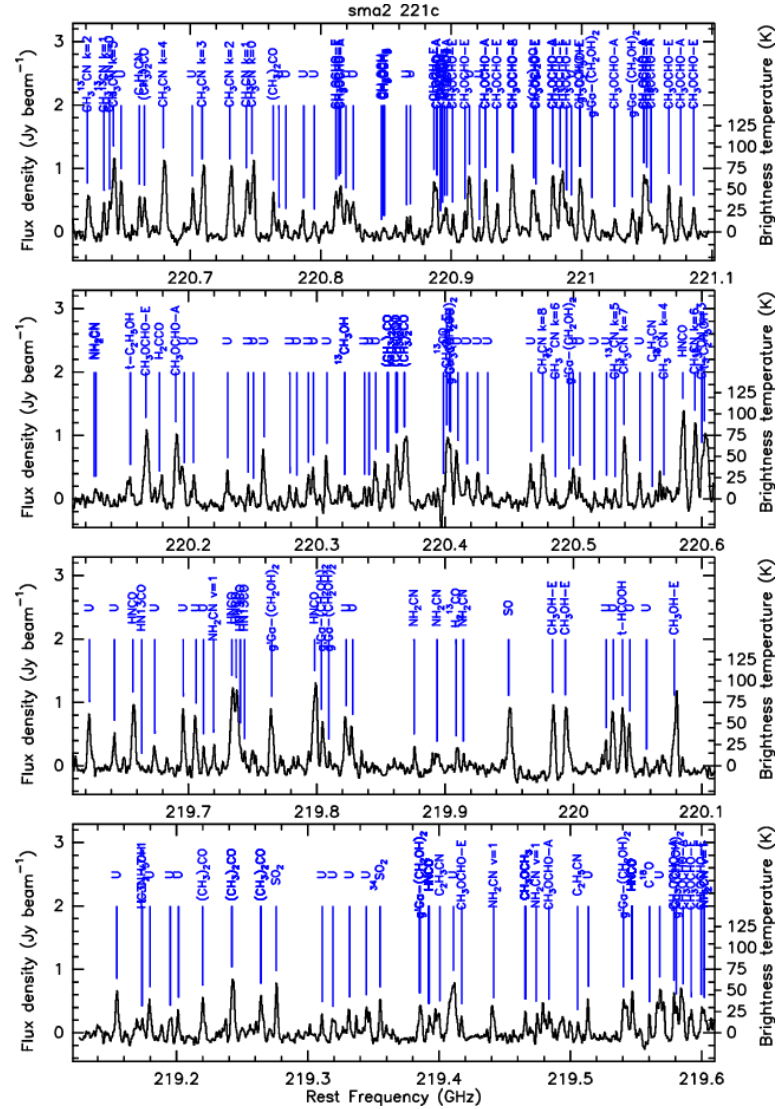
- Requires: Increasing the field of view or increasing the mapping speed (or both)
  - Increasing field of view = Focal Plane Arrays (FPAs):
    - Most radio telescopes only utilize a fraction of the available focal plane. The usable size depends on the exact optics of the telescope.
    - Number of pixels to fill focal plane increases as frequency^2
    - Number of correlations = data rate required scales as the number of pixels x [N*(N-1)]/2 where N is the number of antennas
  - Increasing mapping speed = on-the-fly (OTF) mapping. Requires short integration times = high impact on data rate and compute power

    Examples:
    - ALMA – OTF map of 1 square degree in CO(3-2) in 50 hours would require ~2x the current maximum data rate (64 MB/s). Raw data ~ 20 TB. Image would have 100 Mpixels per channel!
    - GBT – 100 GHz FPA with100 pixels, footprint=4 arcmin. To cover 1 square degree in N_2H+ (93.1 GHz) takes ~10 hours. The data rate would be 0.26 GB/s (32x the current spectrometer) and the cube would be ~10 TB in size. ➔ 1 TB/hour!

- Biggest Challenges: Archiving, Data analysis, and Visualization

Spectral Line Surveys

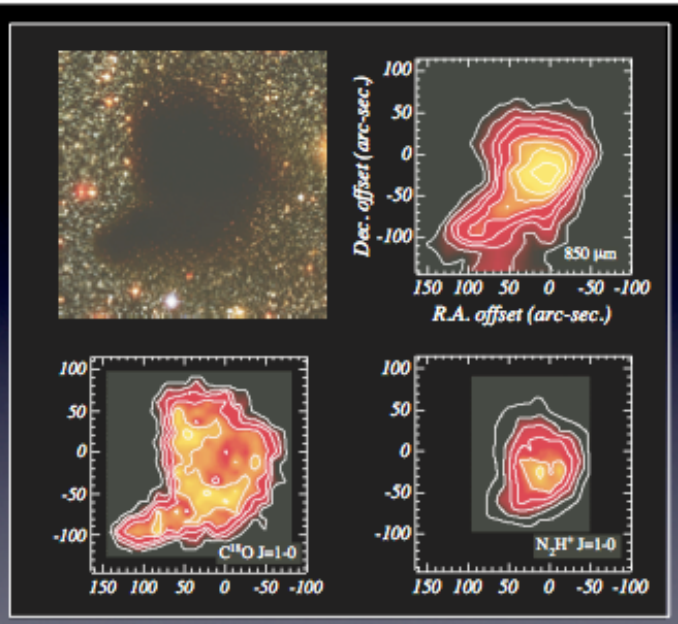
- Spectral lines are critical tools for probing physical conditions, understanding astrochemistry, and discerning the chemical building blocks of life
  - Requires: wide bandwidths plus high spectral and angular resolution. Many diagnostic lines observed simultaneously, removing calibration uncertainties and increasing science throughput.
  - Data rates of ~1 GB/s are required
    - ALMA – Wide bandwidth (8 GHz/pol), but baseline peak data rate (64 MB/s) utilizes ~6% of correlator capability (1 GB/s). Restricted by network hardware, ability to process and archive.
      - ➢ Processing 1 GB/s will require ~1000 CPUs
    - EVLA – Similar baseline data rate, but with capacity for 1 million channels (30x ALMA)
      - ➢ 1 GB/s will require 1000s of CPUs to process. Capable of 32 GB/s!



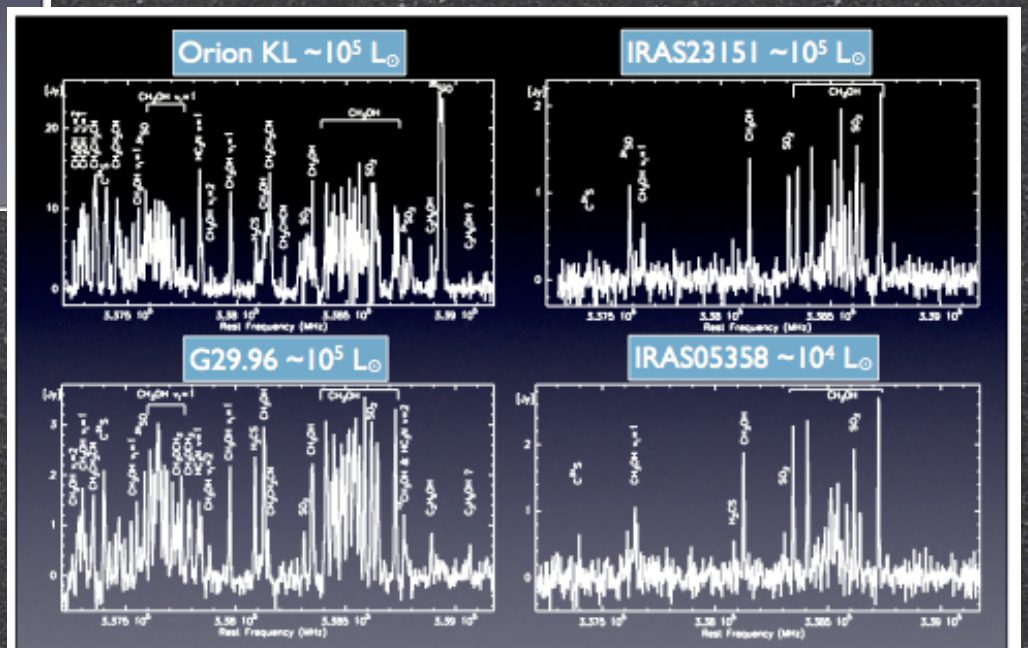
- 2 GHz of bandwidth toward a massive star forming region (Brogan et al. in prep.)

- Biggest Challenges: Data rate, Processing, Analysis and Visualization

Bergin & Tafalla 2007 and references therein

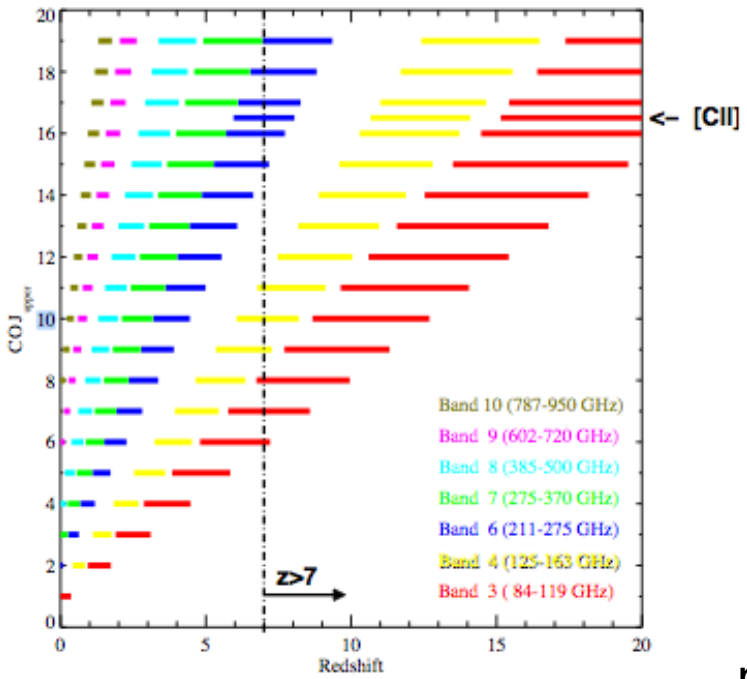


Pre-stellar Low Mass Cores



Beuther et al. 2009

High-redshift CO studies

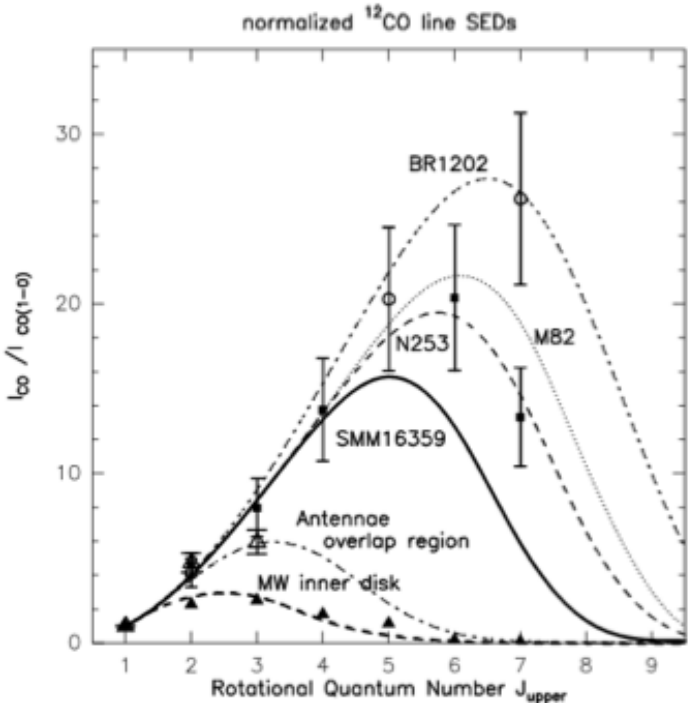


Figures from Walter & Carilli 2007

ALMA will be able to observe several CO J transitions for high-z sources but...
will miss the CO(1-0) transition for all but z<0.4 galaxies!

Peak galaxy formation epoch: 1<z<3

CO(1-0) gives you a measure of the total cold gas reservoir available to fuel star-formation



eVLA can get CO(1-0) for high-z galaxies (but only more northern sources) - is adding Bands 1 & 2 on ALMA a possibility? wanted? a priority?

ALMA Development

- ALMA partners invite Proposals for Studies relevant to the ALMA Development Plan with the aims of
  - Providing opportunities for groups within the regional partnership an opportunity to propose upgrades which may be implemented as part of the ALMA Development Plan
  - To support development of conceptual and detailed designs for upgrades
  - To encourage relevant long-term research and development
- Limited funding available to support groups for the studies, allocated competitively.
- NRAO will issue a Call for Studies soon with the expectation that funding will start this year.
- NRAO will engage the community strongly in ALMA Development, beginning with these Studies. Studies are solicited which
  - Directly enhance scientific capabilities of ALMA by enabling new science
    - Enhanced data throughput (e.g. increasing data rate or pipeline efficiency
    - New Receiver Bands (7mm, 4mm, superTHz, improving or expanding existing bands)
    - Improvement of the System (correlator enhancement, LO improvements, VLBI capability)
  - Indirectly enhance the scientific capabilities of ALMA
    - improving data analysis tools,
    - operations efficiency, or
    - calibration.

Early Science

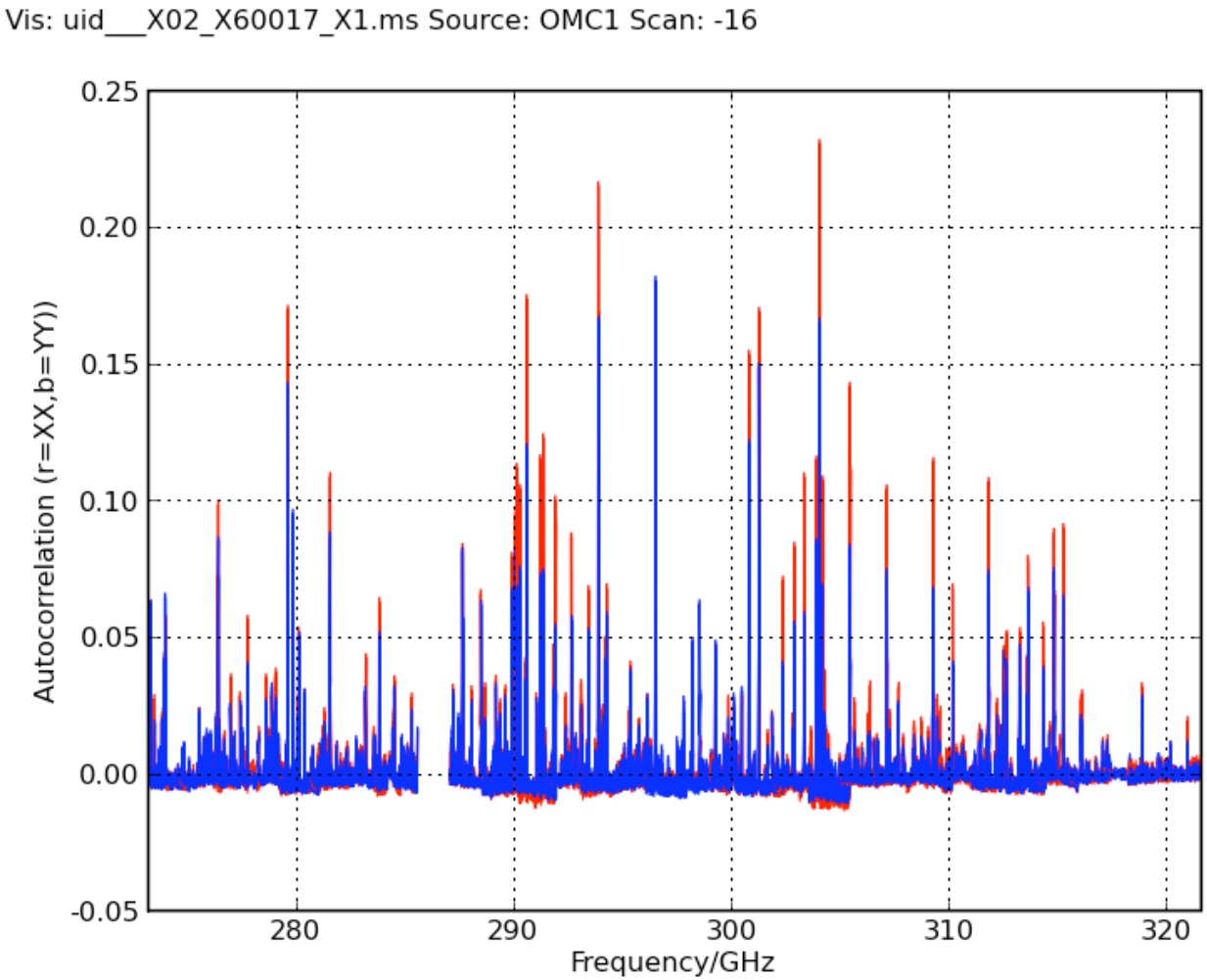
Configurations for ES?

ALMA offers quasi-unique opportunity for

- High frequency imaging of the southern sky
  - At 690 GHz primary beam is ~9”—extended sources different to image
  - Long tracks on short baselines result in shadowing.

- Detection of water emission obscured from less transparent sites

Band 7 (275-373 GHz/1.1-.8mm)



Comparison with IRAM 30m