Science Enabled by Upgrades and Improvements

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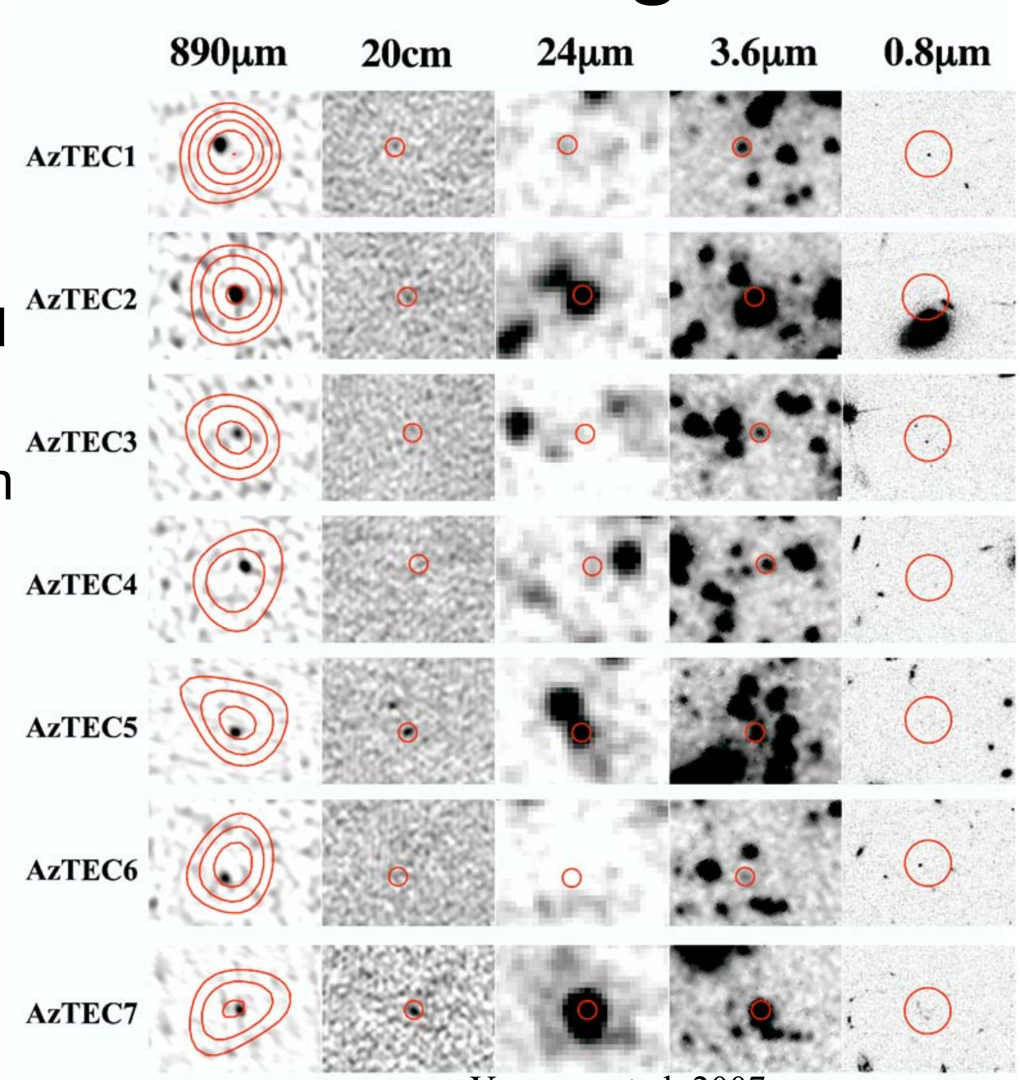
Overview of Improvements

- Better sensitivity, esp. 345 GHz band
  - impacts calibration and **all** SMA science areas
- Higher spatial dynamic range
  - longer baselines: “very extended” configuration
  - shorter baselines: “subcompact” configuration
- Routine polarization observations (waveplates)
- Improved correlator capabilities
  - higher spectral resolution (x4)
  - excellent sideband separation

Extreme Starbursts at High-z

- Half of luminous cosmic energy density from dusty sources
- SMA competitive in this field

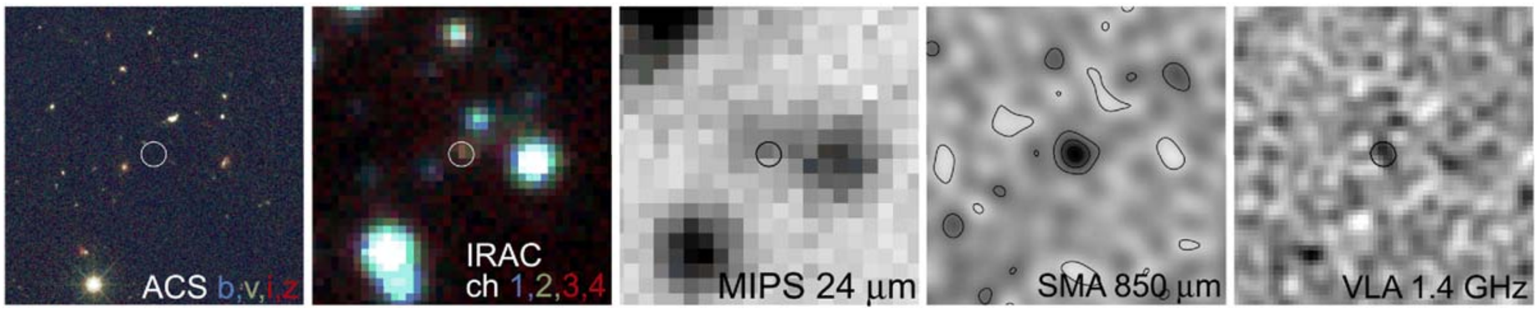
- Flux limited sample of seven "COSMOS" AzTEC sources
  - 0.2" astrometry
  - reliable counterpart identification
- multi-wavelength properties of 5/7 argue for z>3



Younger et al. 2007

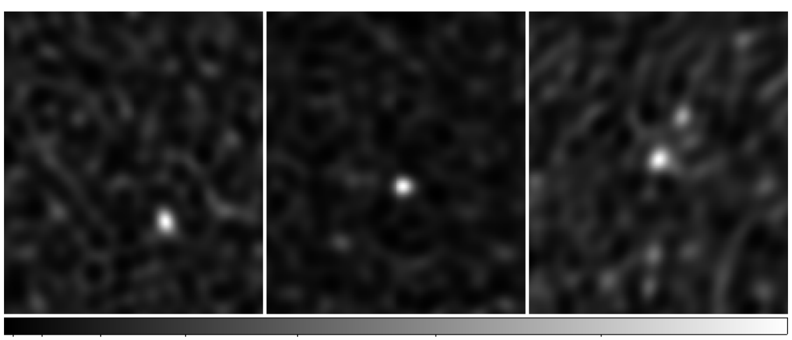
Extreme Starbursts at High-z

- “strong” submm, weak/no radio, no optical, no 24 μm
- L. Cowie: one GOODS-N SCUBA source, likely z>4



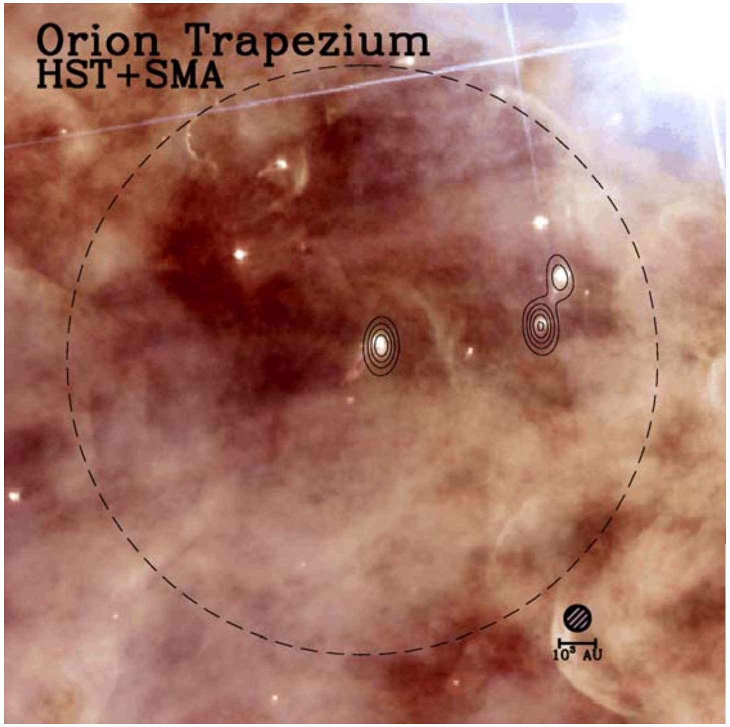
Wang et al., submitted

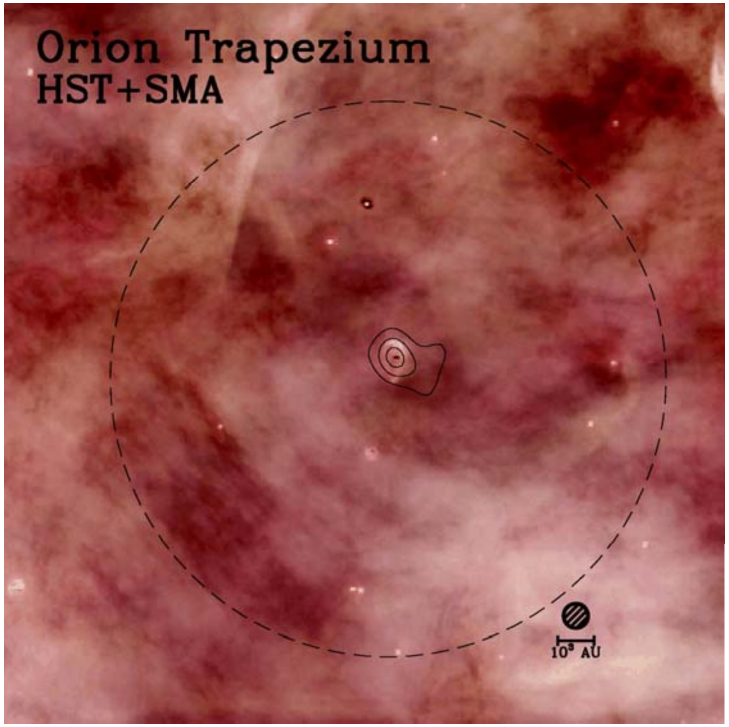
- D. Hughes: galaxy formation in overdense 4C41.17 z=3.8 protocluster, follow-up three AzTEC 1.1 mm sources



n.b. 100% SMA detection rate for AzTEC sources

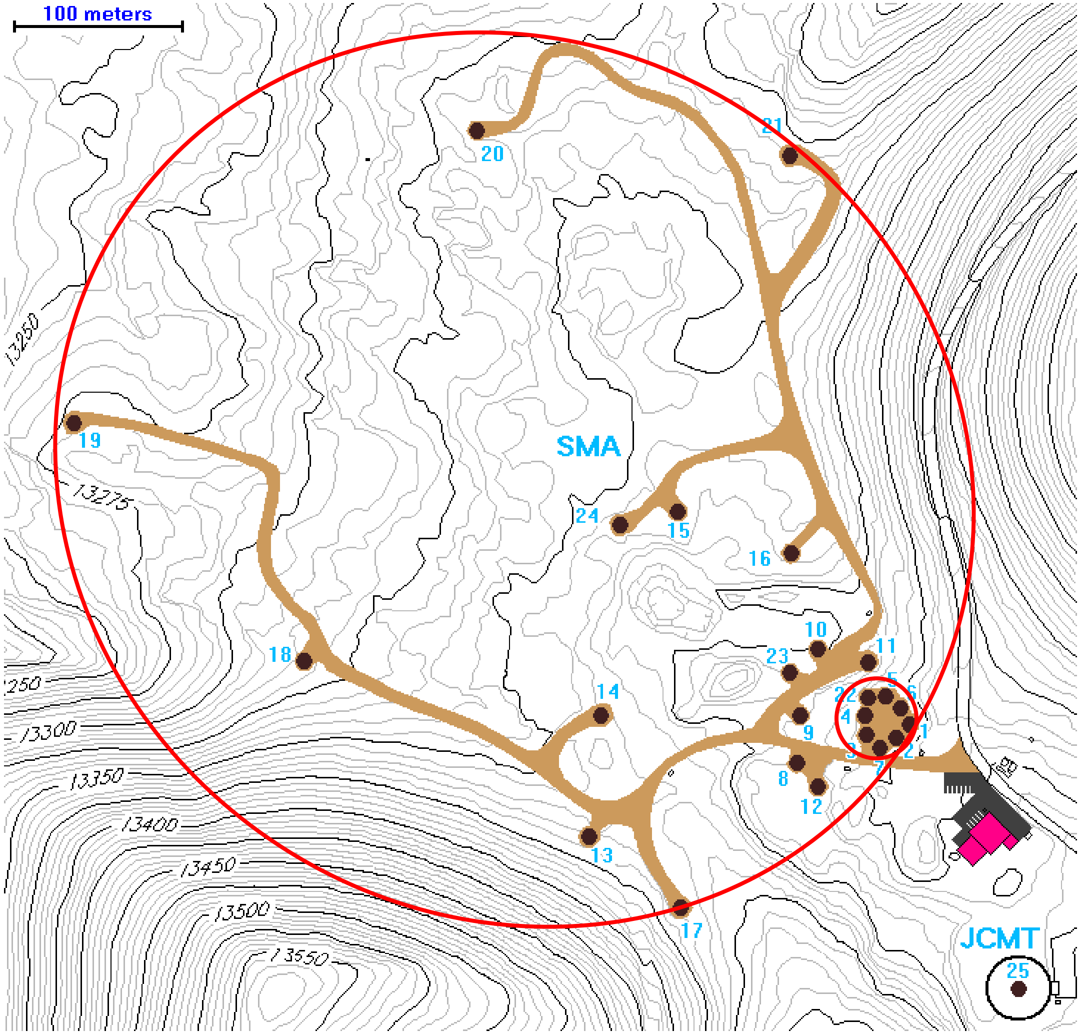
The Orion “Proplyds”





- clusters are the common star and planet formation environment
- disk properties (esp. mass): requires (i) submillimeter, (ii) arcsec resolution, (iii) spatial filtering extended nebula emission
- early SMA detections (Williams, Andrews & Wilner 2005), now greatly expanding sample: Rita Mann, IfA Ph.D. student

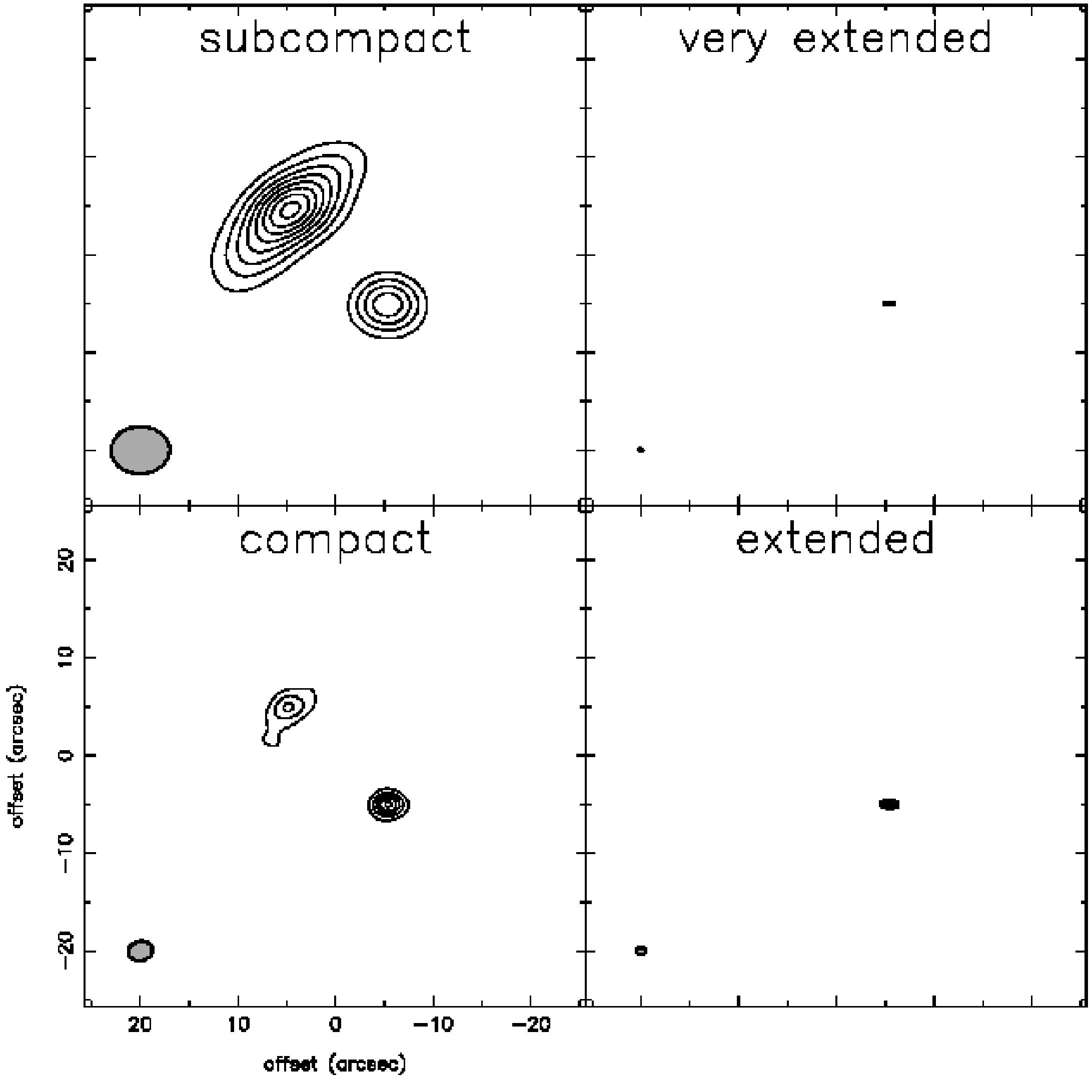
Spatial Dynamic Range



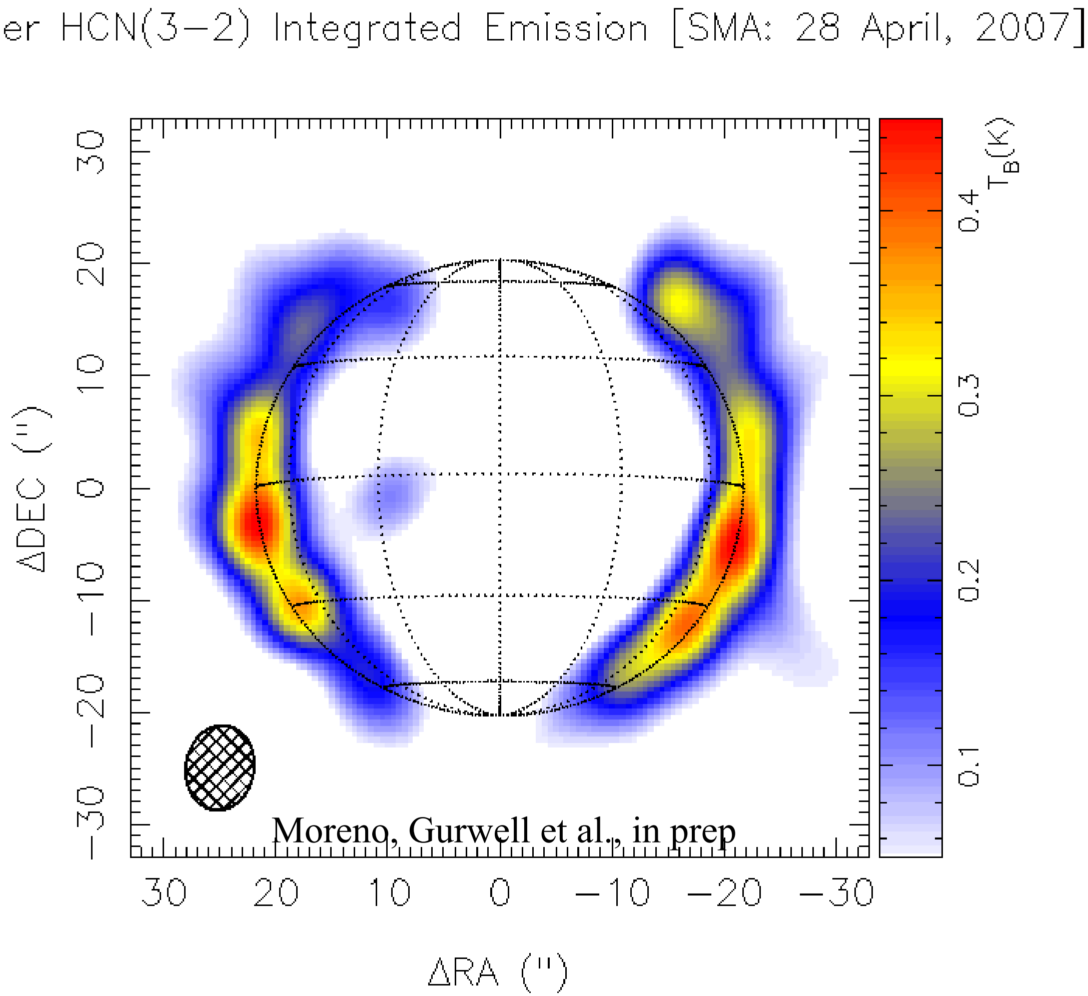
- Very Extended
  - 6 antennas on outer ring, max baseline 508 m (250 mas @345)
- Subcompact
  - 6 antennas on inner ring, 15 baselines 9.5 to 25 m (6” @345)
  - el. > 31.3 deg, coll. avoidance

Subcompact & Very Extended

Spatial Dynamic Range

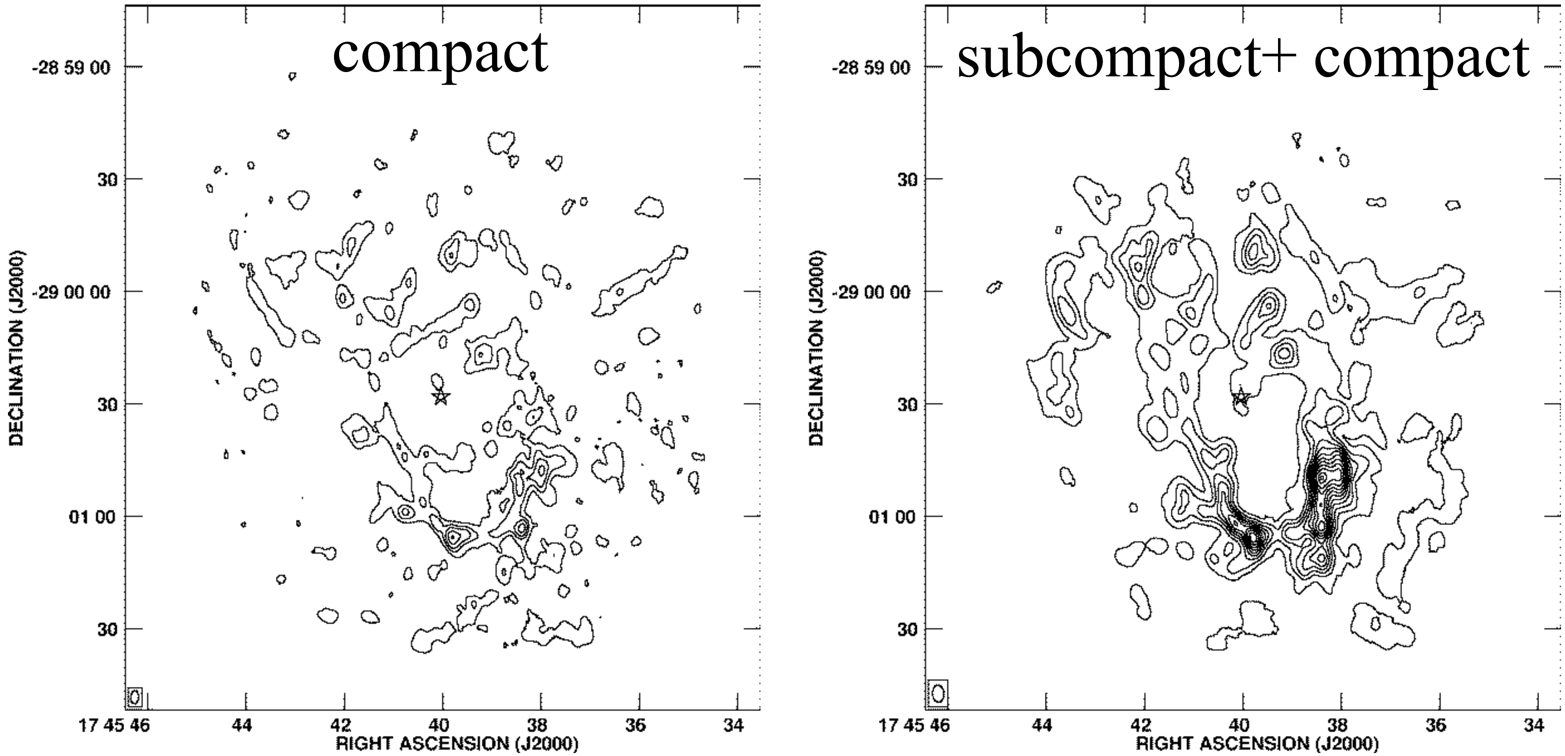


Cometary Debris on Jupiter



- SL-9 impact in 1994 produced molecules, e.g. HCN, CO, CS, in Jovian atmosphere
- SMA imaging clarifies atmospheric evolution
- strong downward transport at poles more important than long term photo-chemical processes

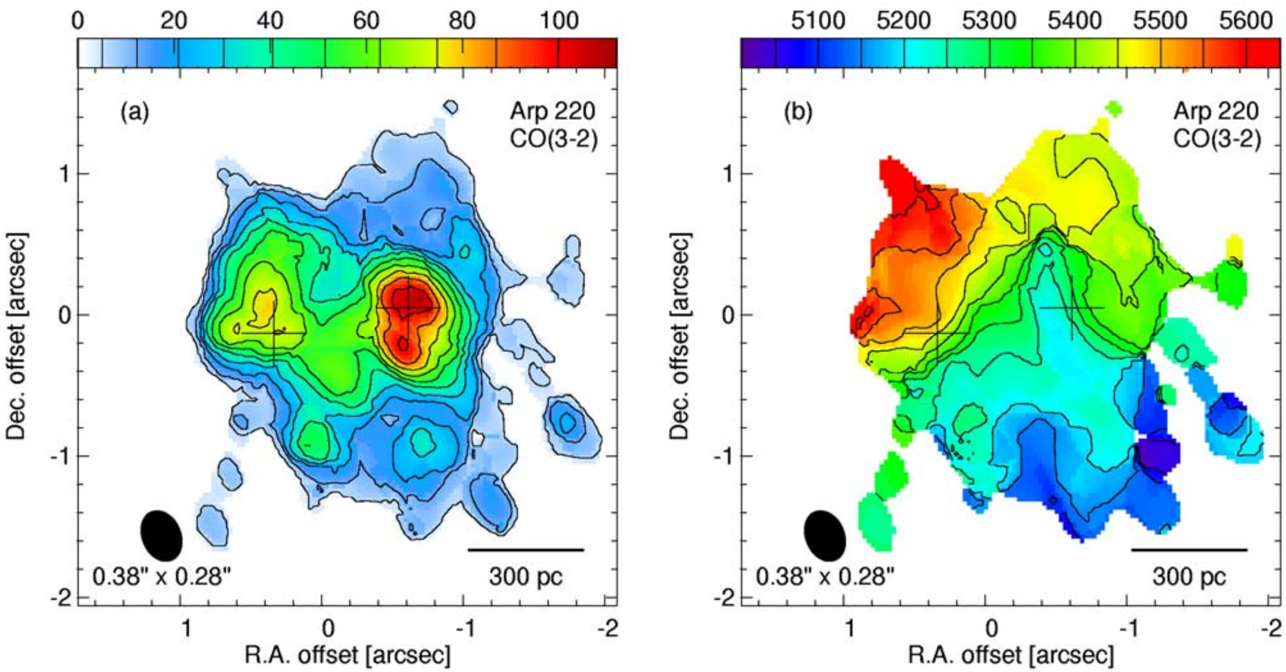
Galactic Center HCN J=4-3

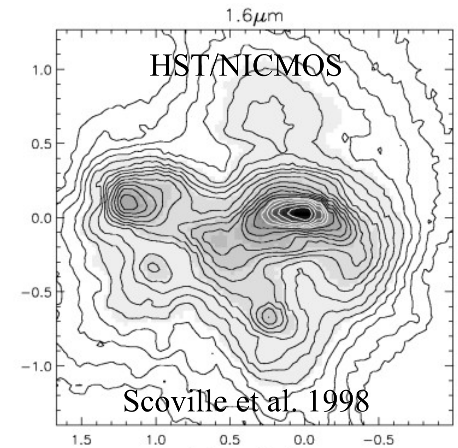


Montero-Castro et al., in prep

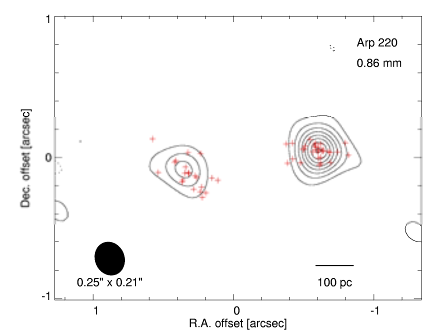
- HCN J=4-3 line traces dense gas, no foreground absorption
- extended emission: 25 field mosaic, subcompact configuration
- asymmetries in physical conditions, complex kinematics

Arp 220 Molecular Gas and Dust



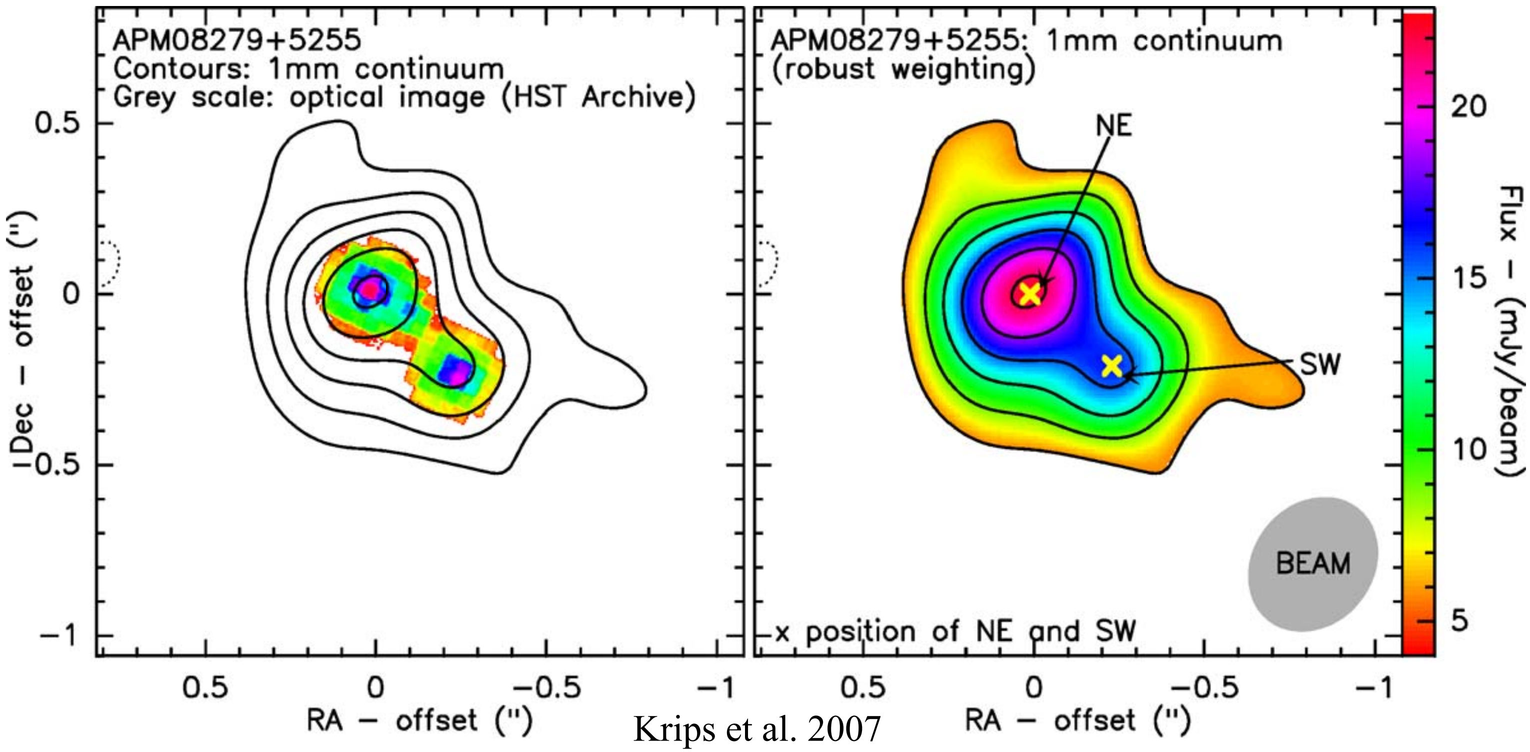


Sakamoto et al., in prep



- Arp 220, nearest ultraluminous galaxy (75 Mpc)
- multiple SMA configurations detail dynamical and physical conditions in advanced merger of two rotating nuclei at size scales < 100 pc
- submm cont. resolved, starburst (E) vs. AGN (W) ?

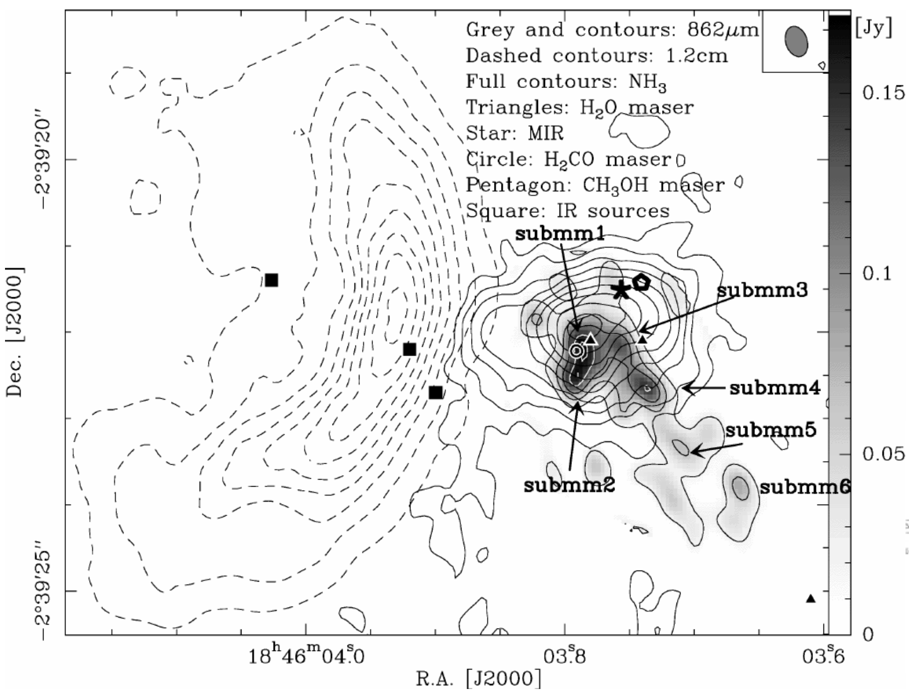
APM08279 Lens at z=3.91

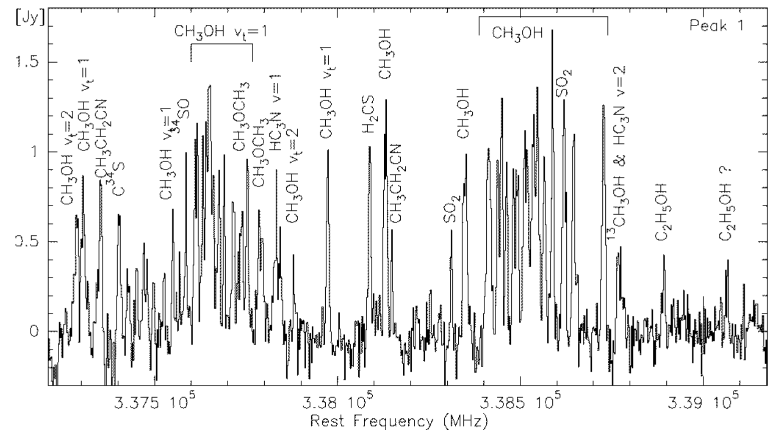


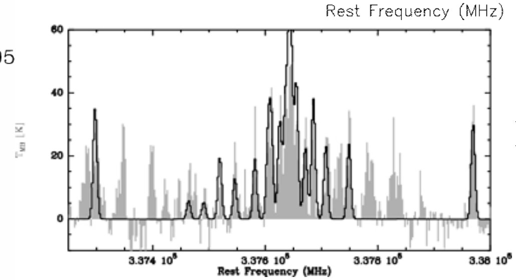
Krips et al. 2007

- subarcsec imaging resolves 1.0 mm (rest frame 200 μm) emission
- gravitational lensing models constrain intrinsic size 80-300 pc, imply offset ~20 pc (3 mas) between optical and millimeter
- suggests cold, extended starburst in addition to quasar heating

Prototypical Hot Core G29.96



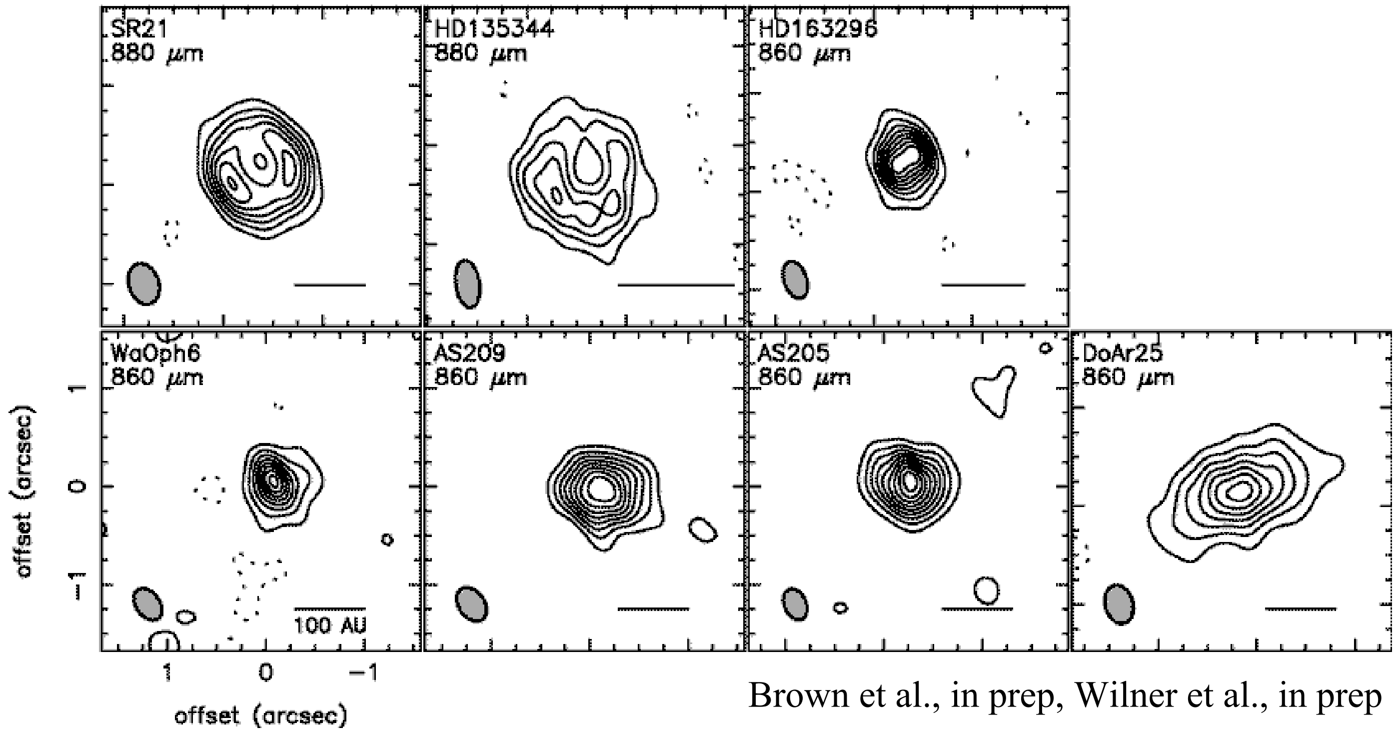




Beuther et al. 2007

- hot core resolved into 6 sources: “proto-Trapezium” (separations ~ 2000 AU)
- plethora of lines in 4 GHz bandpass
  - at least 80 lines from 18 species (including isotopologues, vibrational lines)
  - chemical differentiation, physical conditions, kinematics

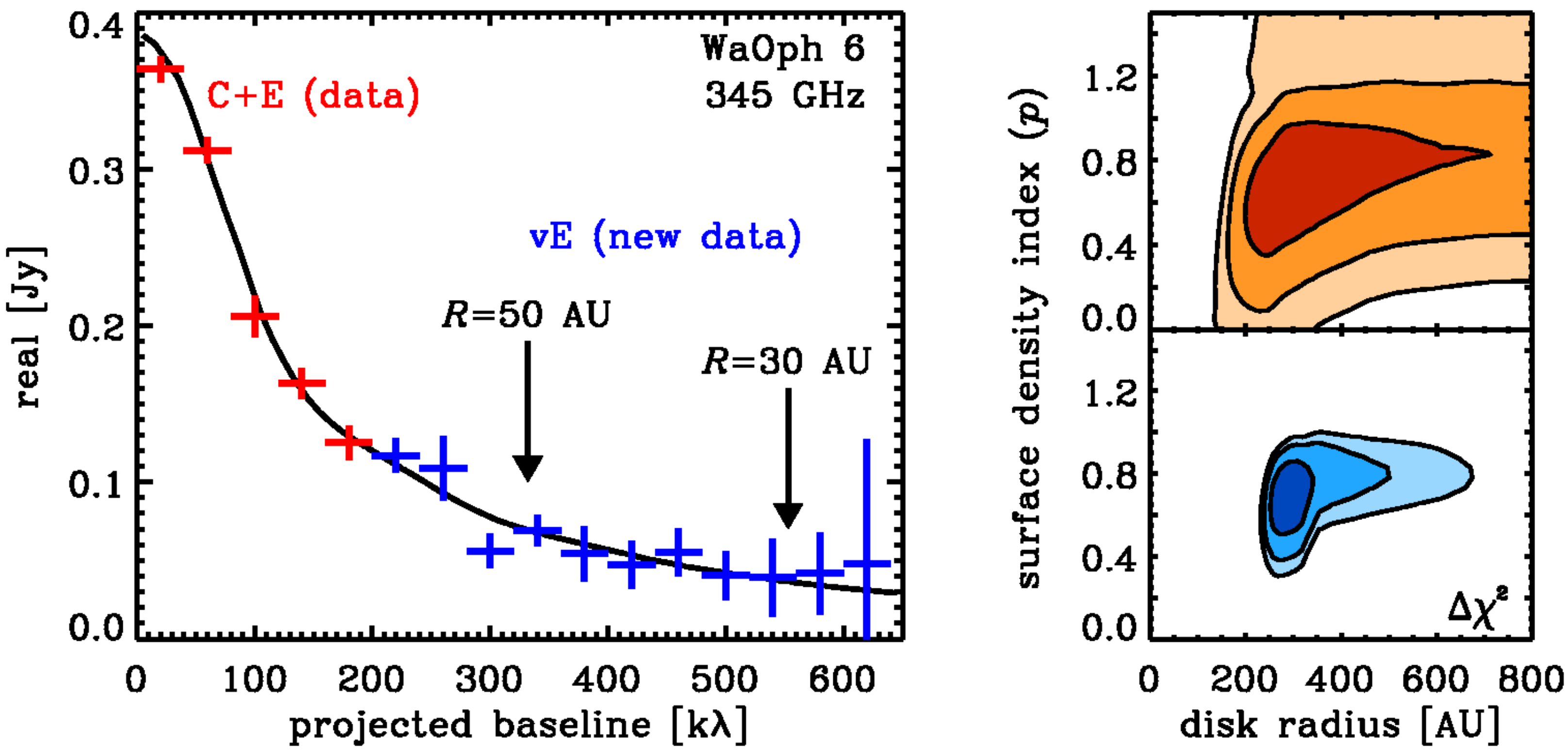
Protoplanetary Disk Structure



Brown et al., in prep, Wilner et al., in prep

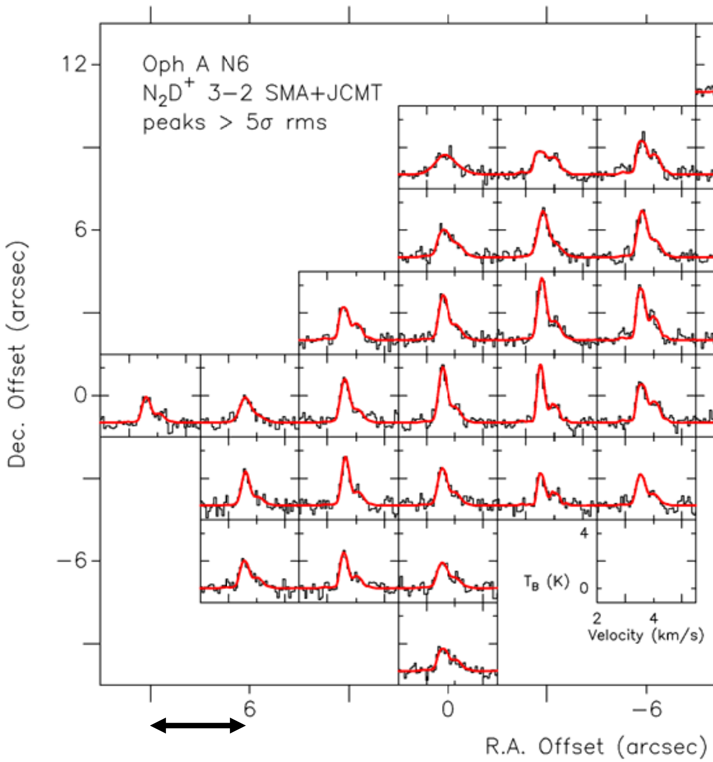
- Disks around young stars are the sites of planet formation
- Sample of (mostly southern) disks resolved at <100 AU scales
- Remarkable variety
- “Cold” transition disks clearly show inner holes, perhaps due to protoplanets

Structure at Higher Resolution

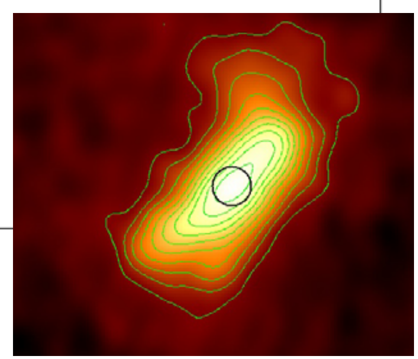


- Dramatically improved constraints with longer baselines

A Small Dense Core in Oph A

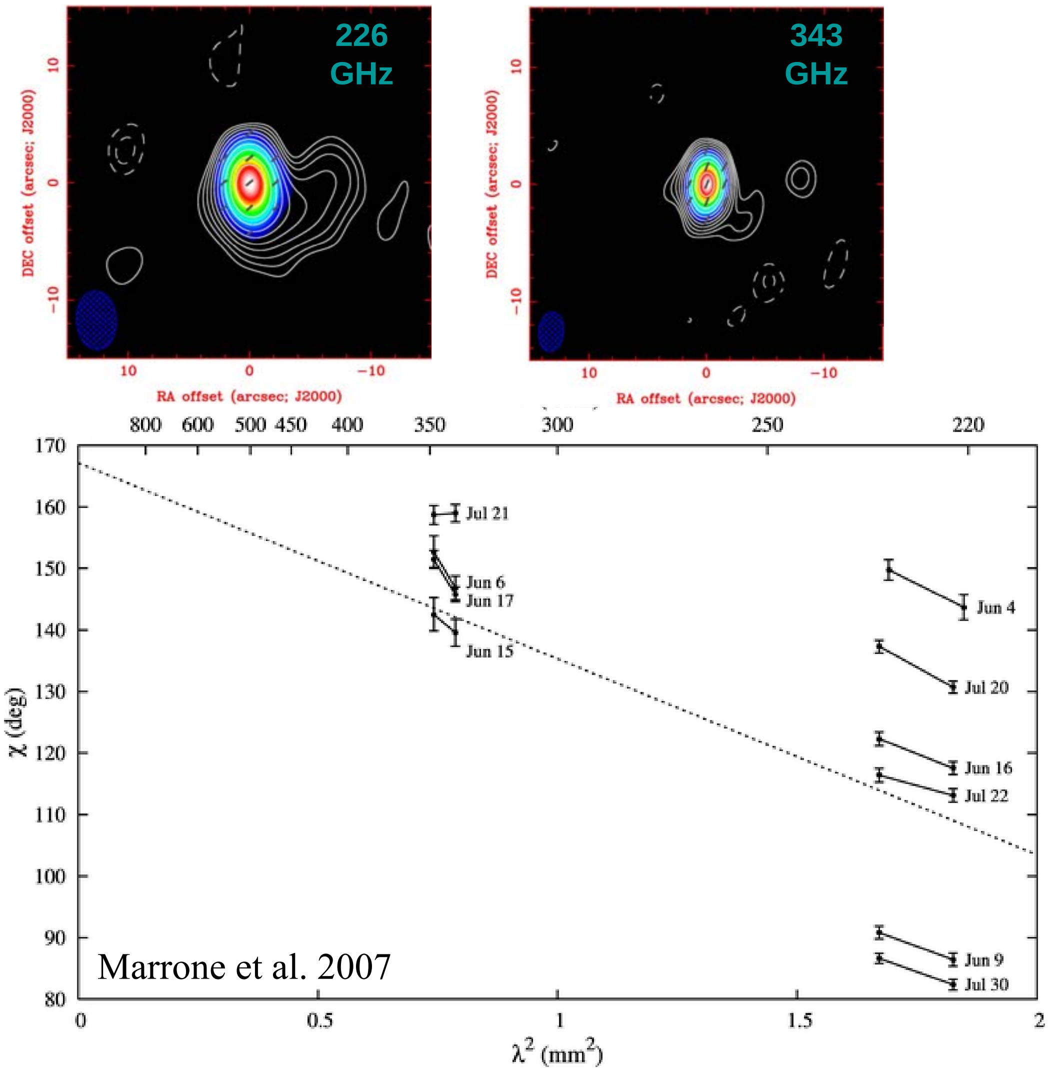


3’’ = 450 AU



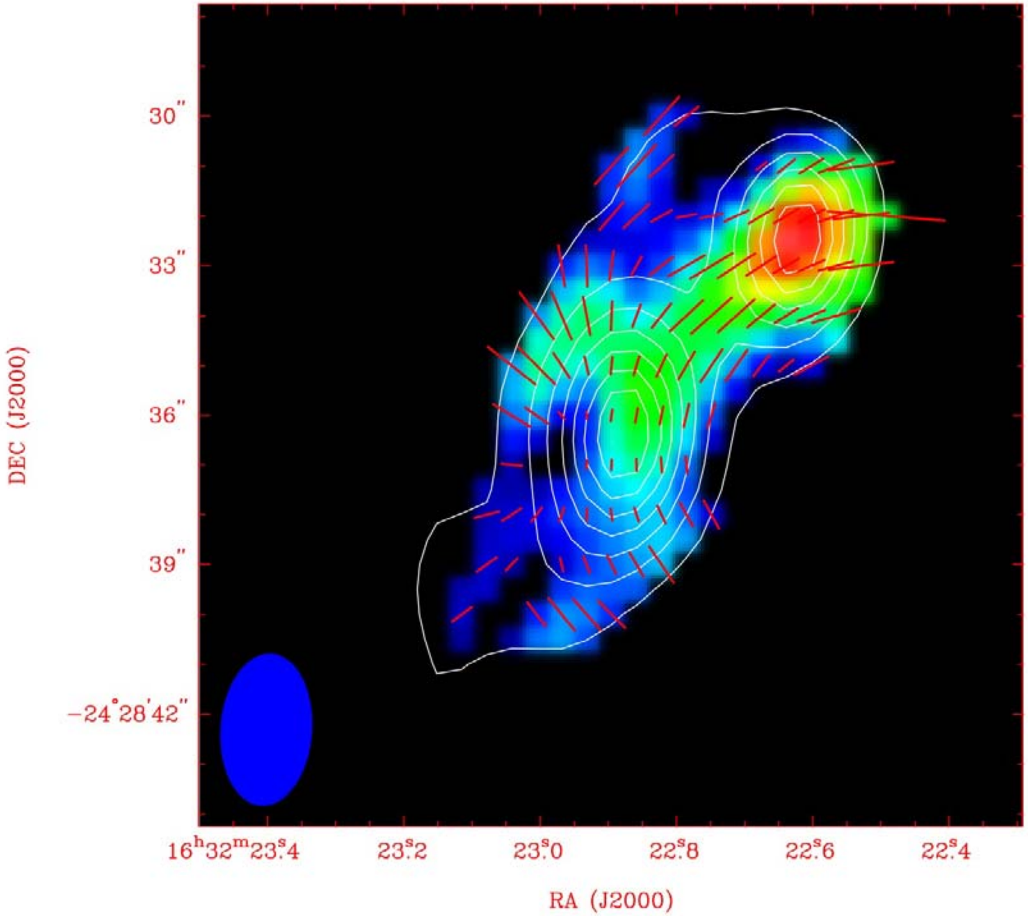
- are cores in cluster regions like isolated cores?
- Oph A N6 SMA observations
  - N_2D+, N_2H+ J=3-2
- number density, column density much higher than isolated cores
- High spectral resolution (50 kHz = 0.065 km/s)
  - comparable thermal and non-thermal motions, “coherent” velocity structure

Sgr A* Rotation Measure



- Sgr A*, closest supermassive black hole, faint: ~10^{-8} L_{edd}
- submm emission probes near R_S
- Faraday rotation (LP change with λ) measures gas conditions in the accretion flow
- RM: 5.6×10^5 rad/m², fluctuations < 25%, Mdot <2×10^{-7} M_{Sun}/yr (model dependent)

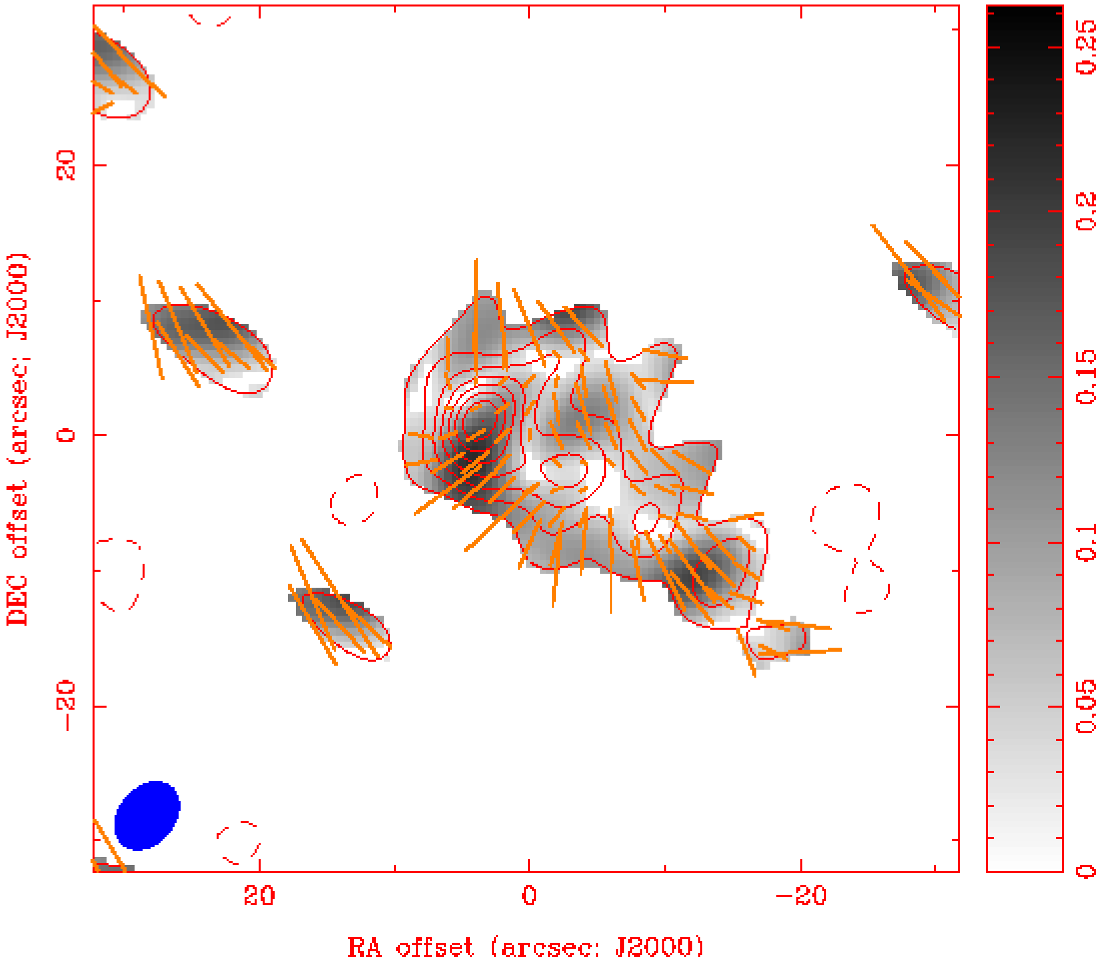
Magnetic Field Morphologies



IRAS1629A/B Rao, Girart et al., in prep

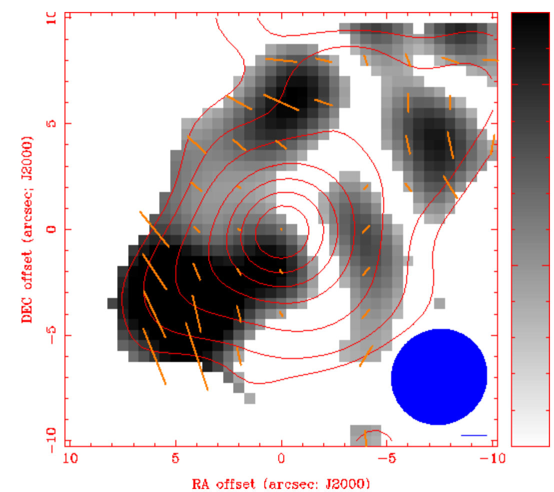
- Importance of magnetic fields in star-formation?
- SMA images polarized emission from grains aligned by magnetic field
- Hourglass shape is long predicted “smoking gun” of magnetic forces resisting gravity

Magnetic Field Morphologies



Sridharan et al., in prep

- First SMA polarization observations of massive star forming regions



Concluding Remarks

- Improvements/upgrades make SMA much more powerful than two years ago
- Pathfinding examples can be drawn from every science area: high-z and nearby galaxies, Galactic Center, evolved stars, low-mass and high-mass star formation, protoplanetary disks, Solar System
  - see upcoming presentations

END