New Horizons for CARMA

Lee Mundy
CARMA Director – on behalf of CARMA

The Combined Array for Research in Millimeter-wave Astronomy

Science

The next generation

Technical Development

28 February 2011

Three major themes exploiting the primary capabilities of CARMA:

- The evolution and physics of galaxy clusters
- Gas and star formation in galaxies
- Physics of star formation

Evolution and physics of galaxy clusters

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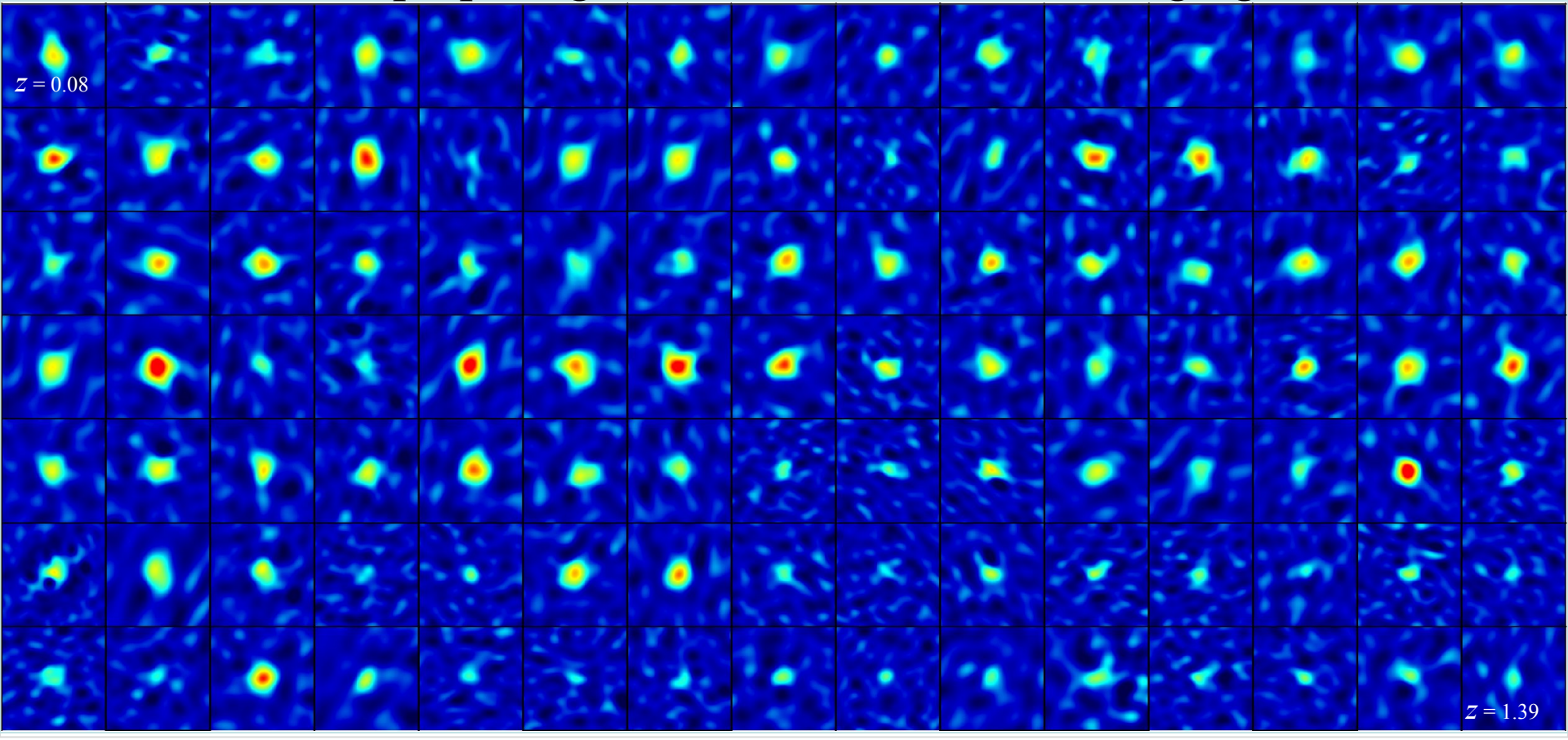
CARMA has a long history of detection of SZE in targeted clusters.

Now CARMA is preparing to move on to detailed imaging.



Evolution and physics of galaxy clusters

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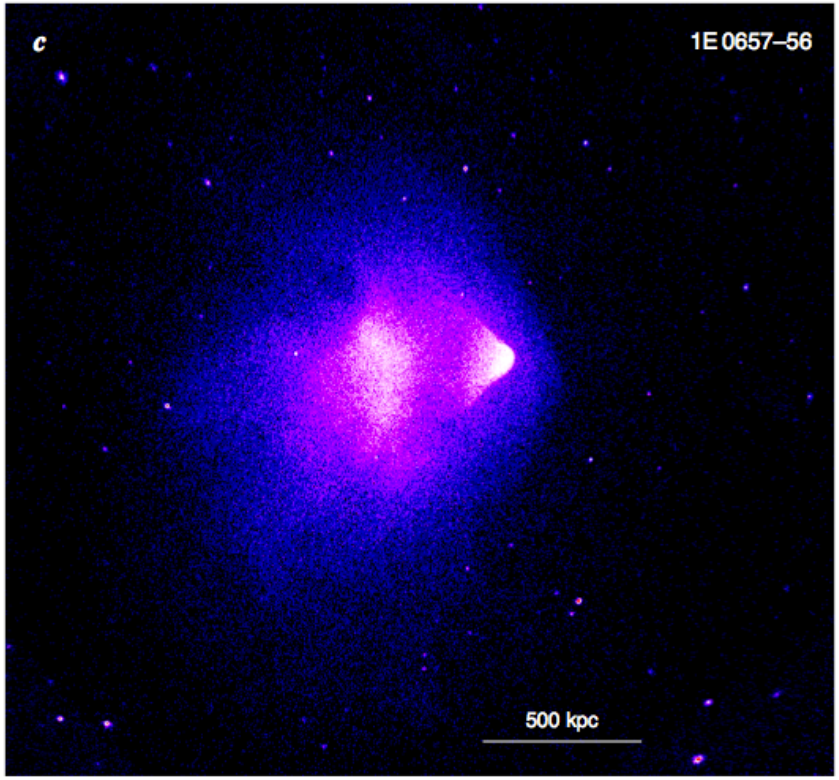
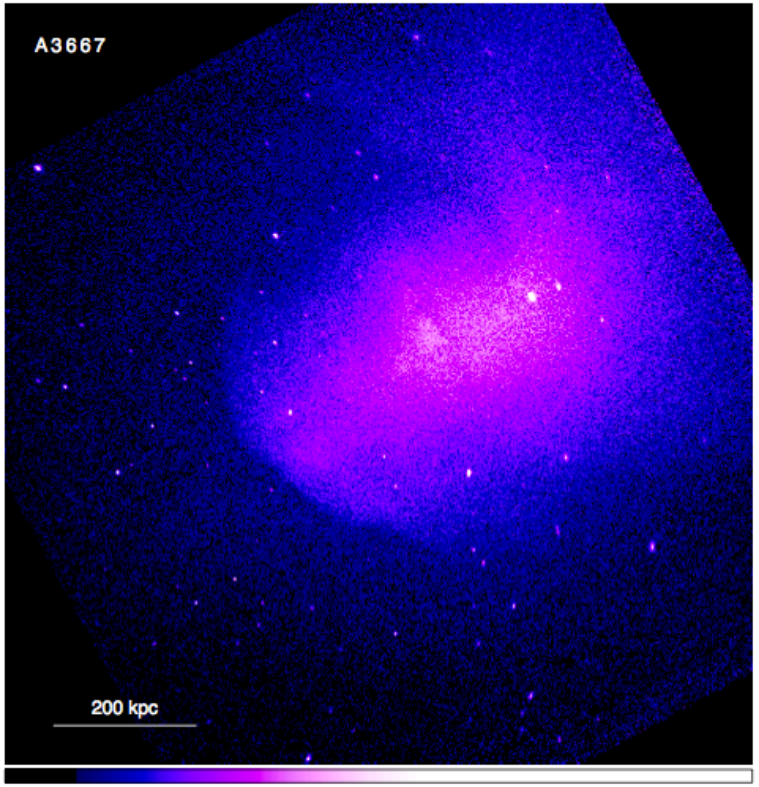
Clusters grow through collisions, accretion. These processes:

- shape final appearance and structure
- cold fronts which are remnants of past mergers
- shock fronts created by merger activity





Evolution and physics of galaxy clusters

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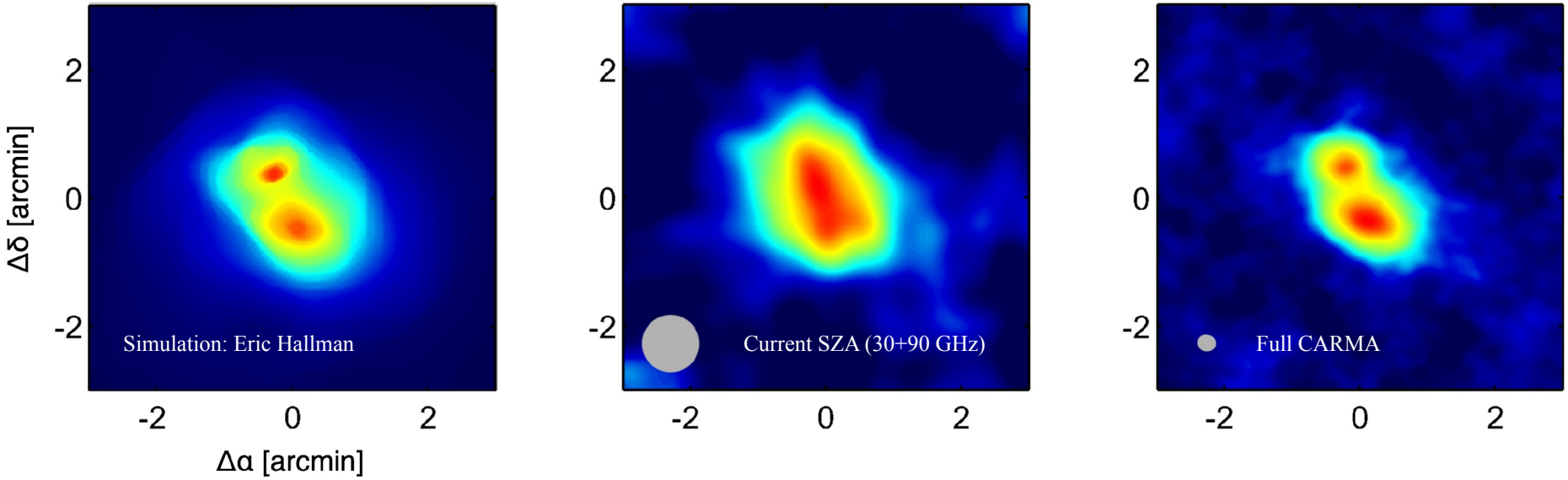
CARMA has just implemented 23-element operations which gives the large field of view of the 3.5-m and the sensitivity of the full array.

Sensitivity, angular resolution, dynamic range all significantly improved

Detailed (<10") cluster SZ imaging is possible with simultaneous arcsecond imaging of radio sources

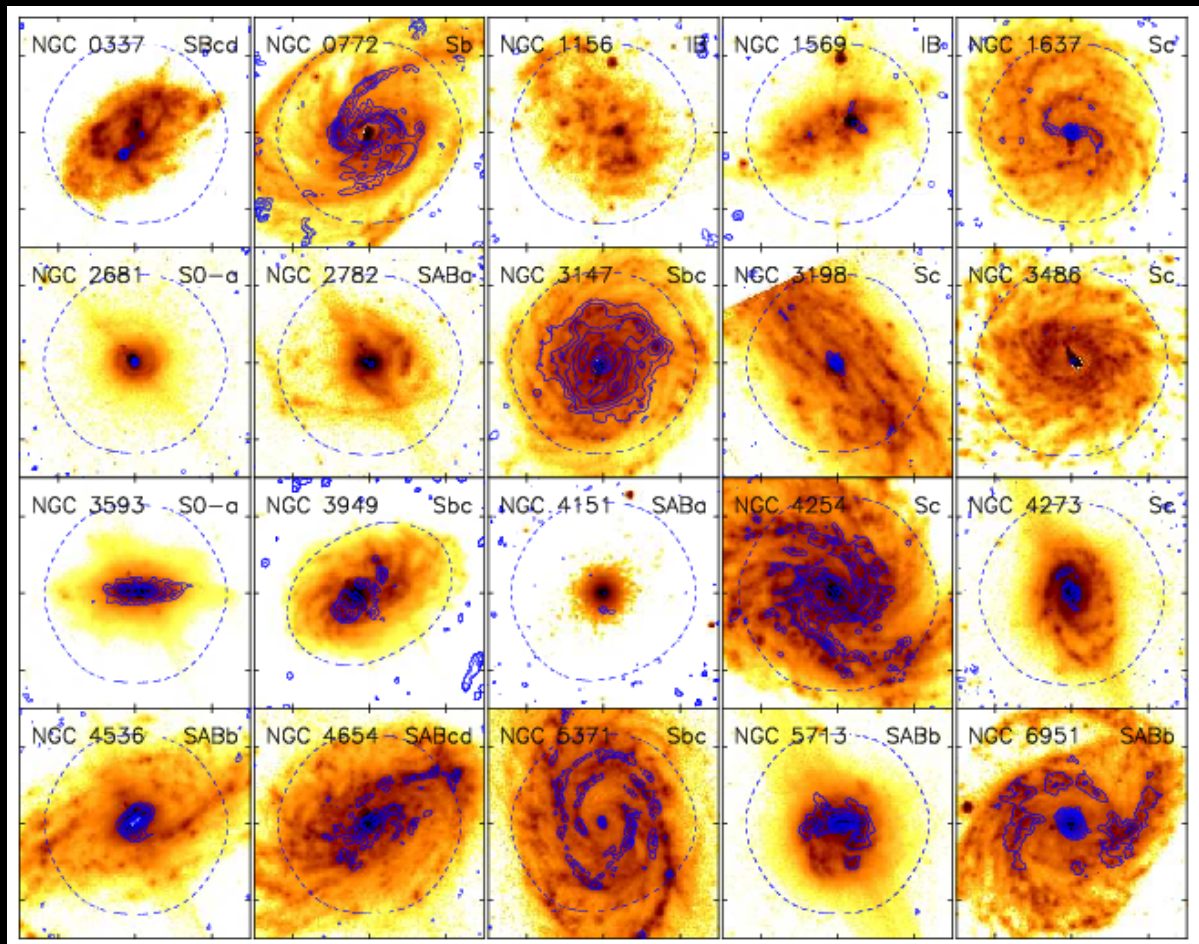


Physics of star formation in galaxies

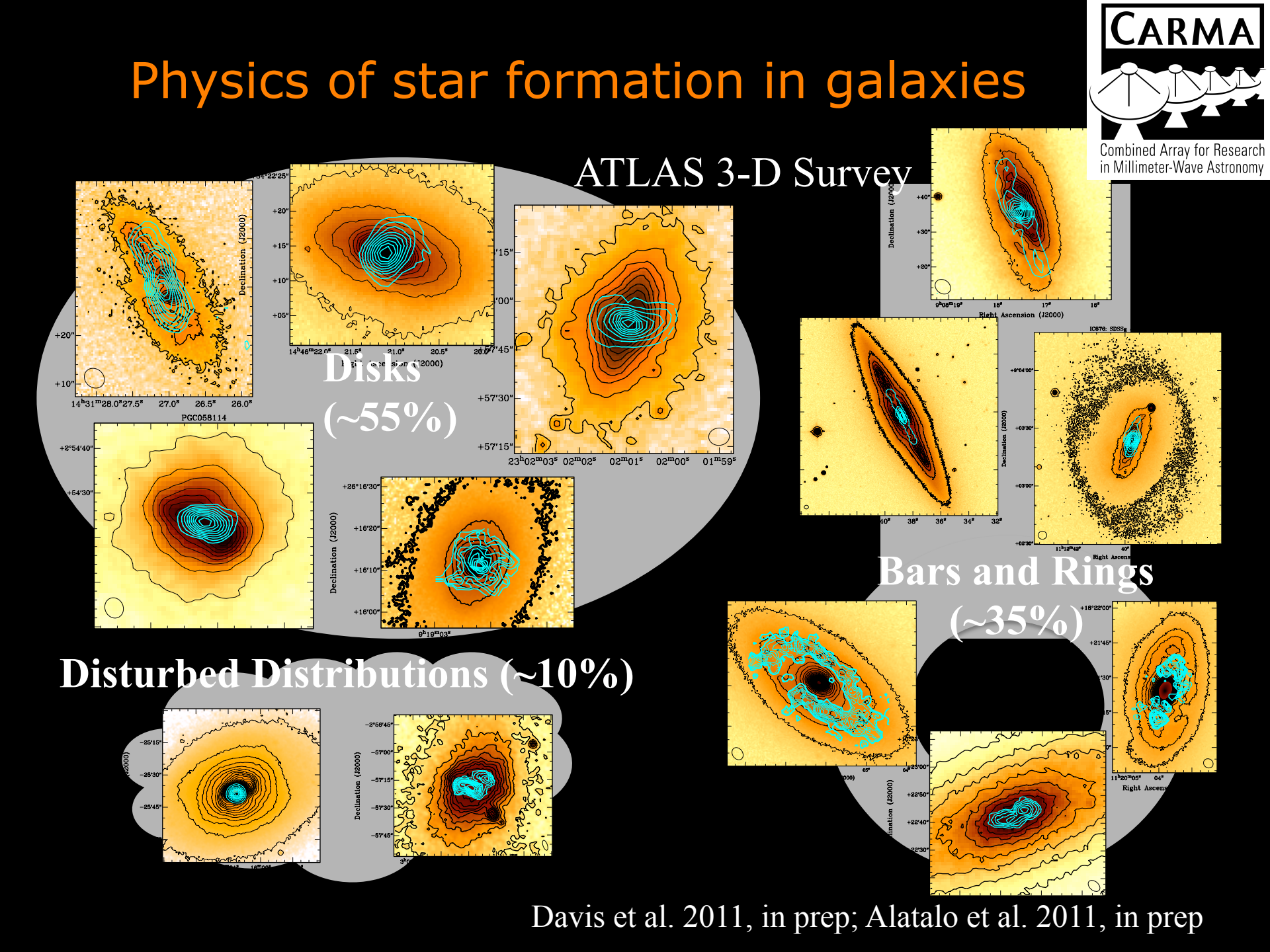
Study: the molecular gas content, structure, and kinematics
the dependence on environment and evolution
the global star formation process in many realizations

CARMA STING:
Characterizing the Spatially Resolved Molecular Gas Star Formation Law in Infrared-bright Nearby Galaxies

Rahman et al. 2011, ApJ in press)



Physics of star formation in galaxies



Davis et al. 2011, in prep; Alatalo et al. 2011, in prep

Physics of star formation in galaxies

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- global relationship between gas and star formation
- star formation efficiency
- gas–star formation relationship
- cycling of matter in the ISM

CARMA mosaic imaging of the full disk for a large sample of nearby galaxies can provide answers.

NGC 4254 (M99)

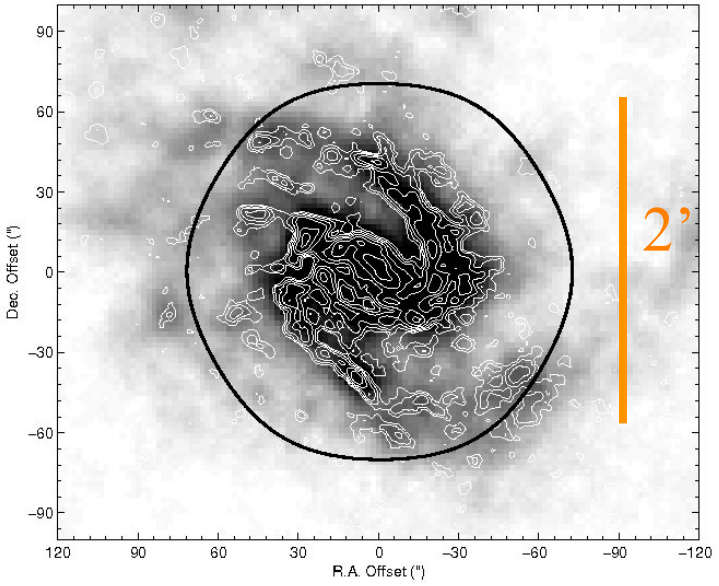
(Rahman et al. 2011, ApJ in press)

Follow-up with deeper, focused, ALMA observations.

CO Emission

Gray scale:
IRAM 30m

Contours:
CARMA 8.5 hrs.



Physics of star formation

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How do molecular clouds transition from inert to star forming?

What is the connection between molecular cores and the star IMF?

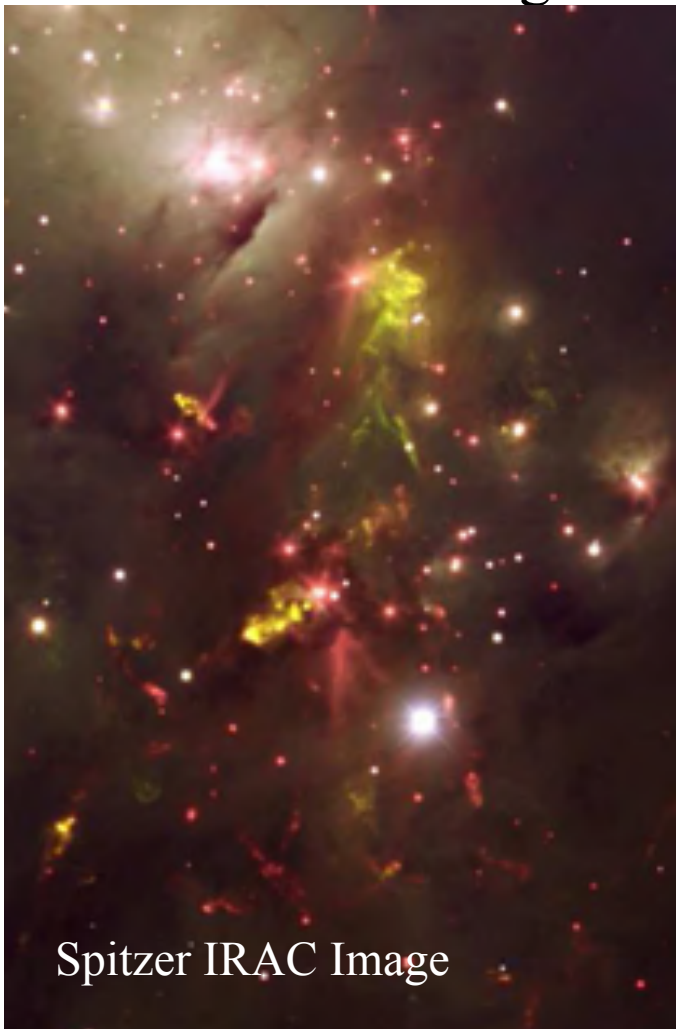
Do turbulence and magnetic fields control cloud structure? Is the answer universal and uniform?

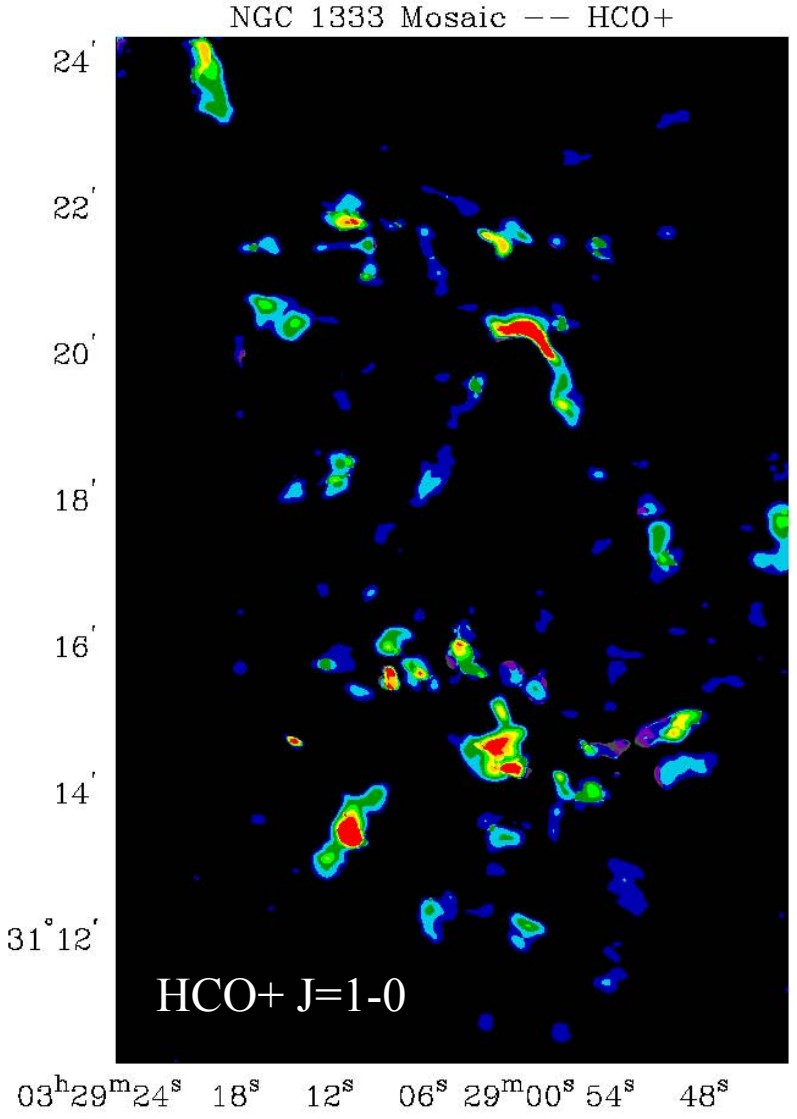
CARMA is effective for wide-field surveys of nearby low-mass and distant massive star forming regions, with 1-5” resolution.

Physics of star formation

First science with 23-element CARMA – 527 pointings towards NGC 1333 SVS 13 Region

Graduate Students
Shaye Storm
Max Rizzo
Katherine Lee
Adele Plunkett

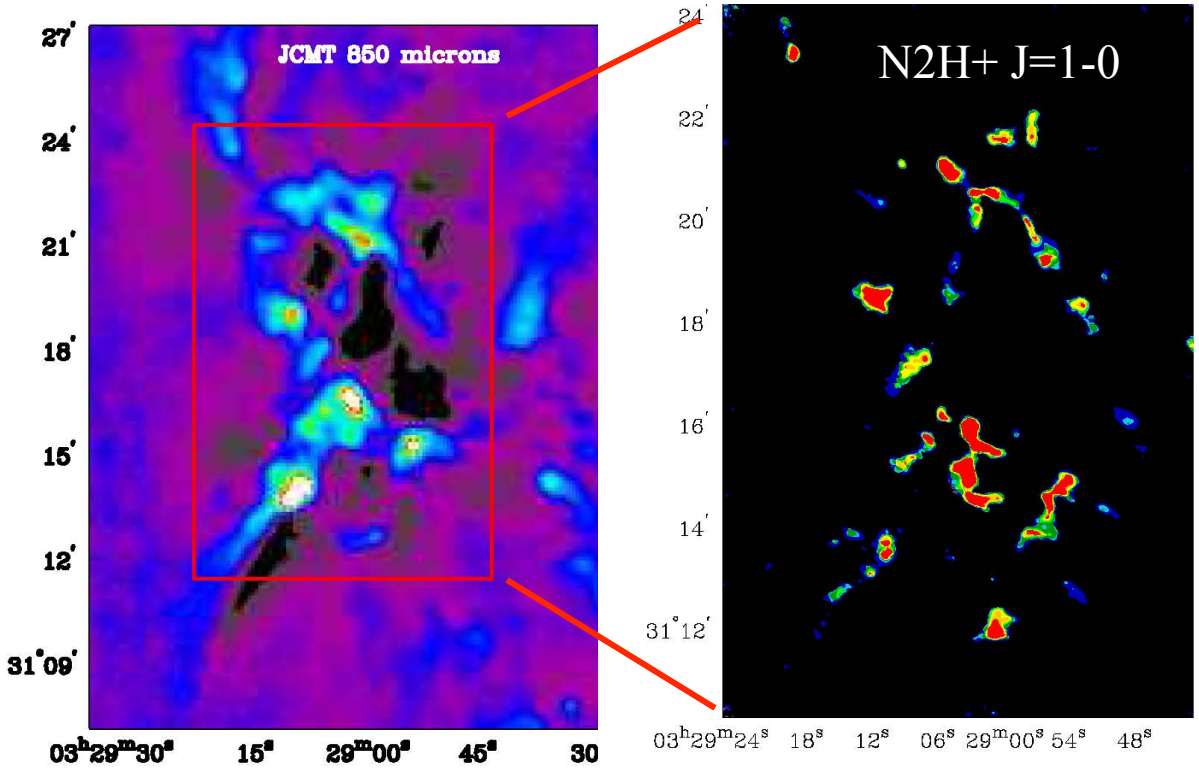


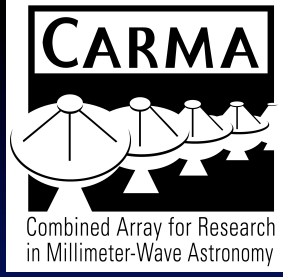


Physics of star formation

Large scale maps with 3-5” resolution of the molecular gas and kinematics, the YSO distribution and dust continuum emission → complete pictures of the cloud structure and star formation for nearby clouds, Infrared Dark Clouds, and regions of massive star formation.

ALMA follow-up can focus on most interesting sources with higher resolution and higher frequencies





Technical Development

Student Involvement

Innovations => Better Science

PACS (Paired Antenna Calibration System) Experiment

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Oct 2009:

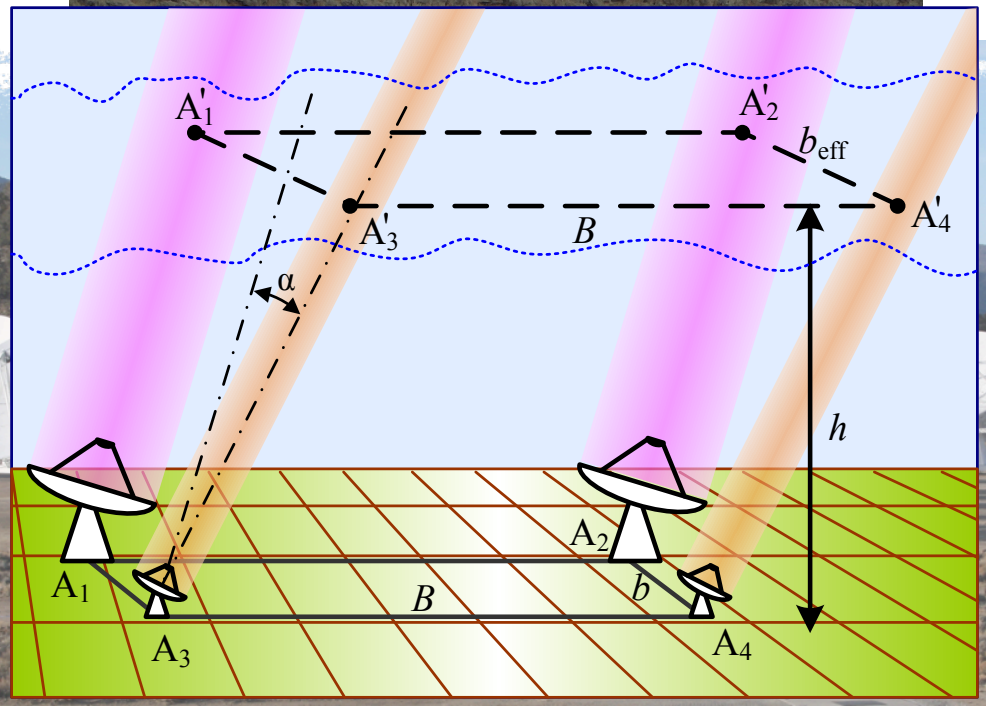
Completed one PACS season for commissioning projects.

March 2011:

Completed third PACS season in January. Last two A,B configurations were for TAC-approved projects.

PhD Thesis work:
Laura Perez (Caltech)
Ashley Zauderer (UMD)

Enables CARMA's 0.15" resolution



"Hybrid" cm Array Experiment

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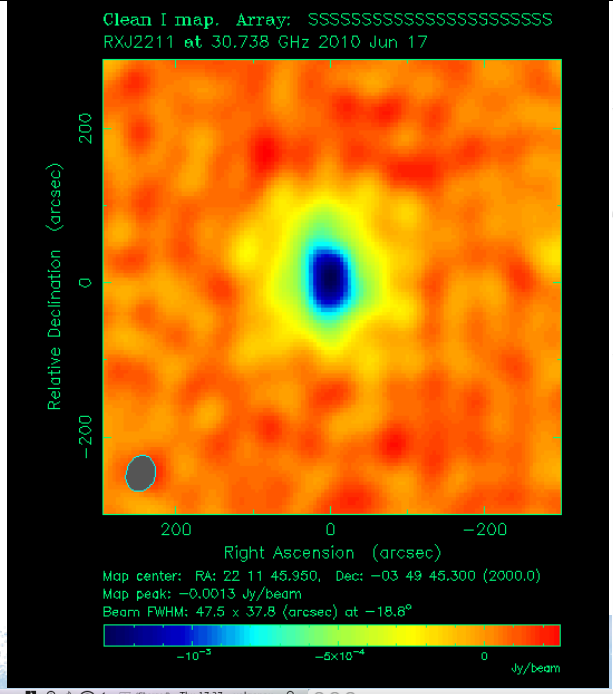
Oct 2009:

First 3.5m + 10m antenna observations in Sep 2009.

Experiment lead by Postdoc Dan Marrone, Tom Plagge and students Alan Zablocki, and Chris Greer

Enables imaging of hot gas in galaxy clusters



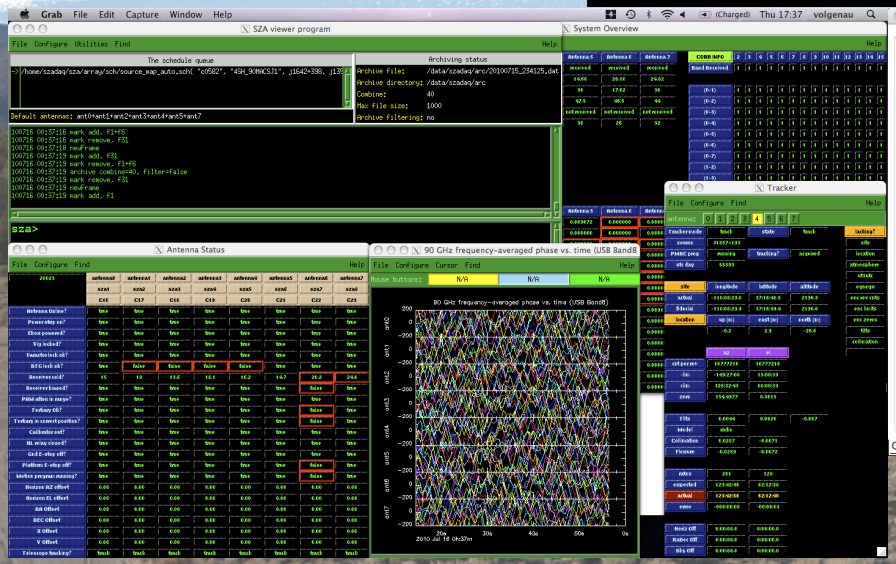
March 2011:

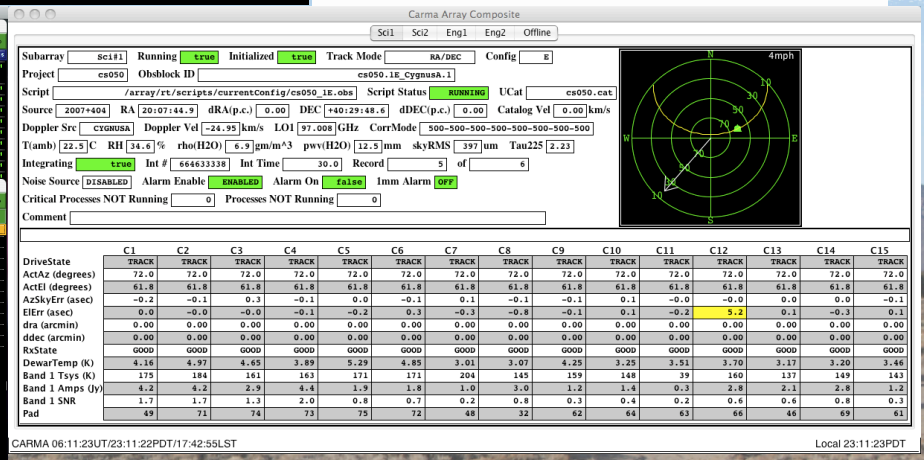
3.5m + 6m + 10m antenna observations in June 2010.

"Live" test of Dual-Science Subarray (DSS) mode.

Switch to DSS observing mode in July 2010.

Full synthesis of control systems in September 2010: common antenna control, monitoring, fault system, data format, PDB.





Dual-polarization 1mm Receivers Development

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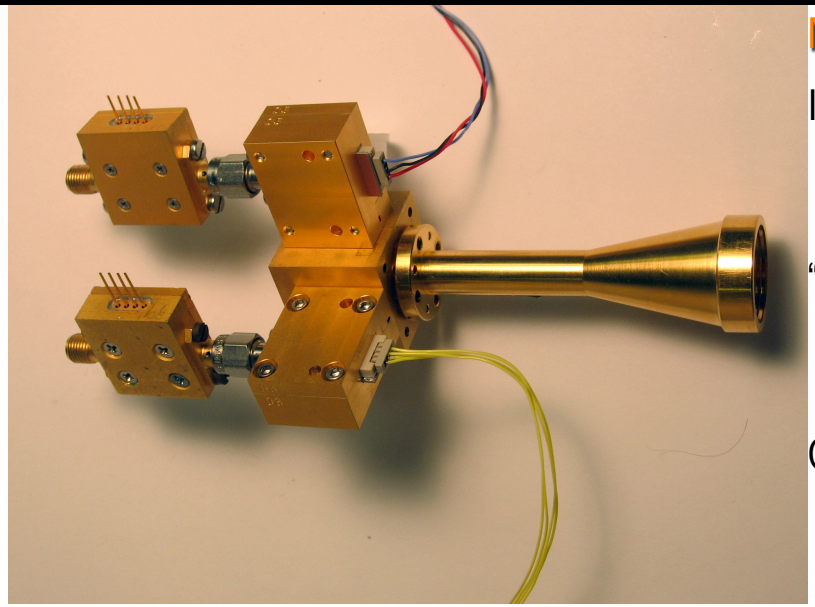
Oct 2009:

Machining, testing, assembly ongoing at Berkeley.

Graduate student Chat Hull (UCB) central to construction, testing and science

Enable magnetic field measurements

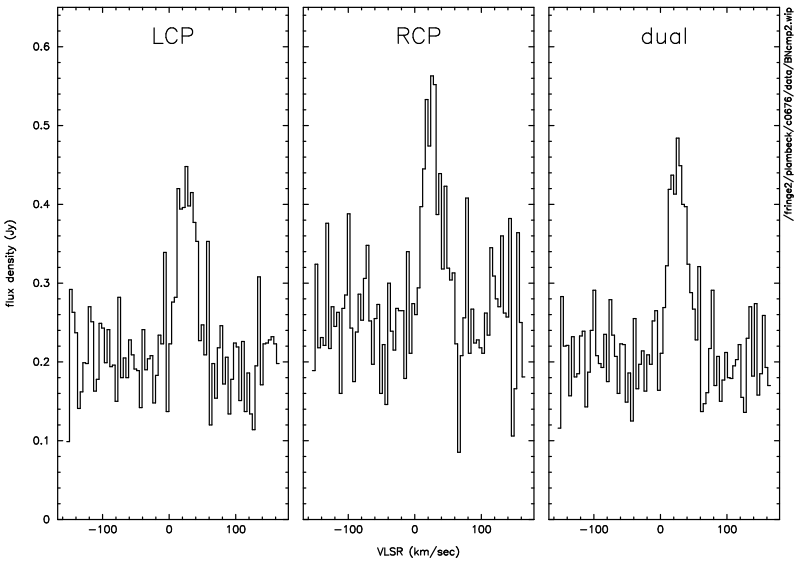


March 2011:

Installation began Sep 2010; RCP mixer on C3 installed Feb 2011.

"Test" observations of Orion BN in LL, RR modes in Jan 2011.

Commissioning of full Stokes observations begin this week.



Data Imaging Pipeline

Automated data reduction/imaging pipeline maintained at UIUC.

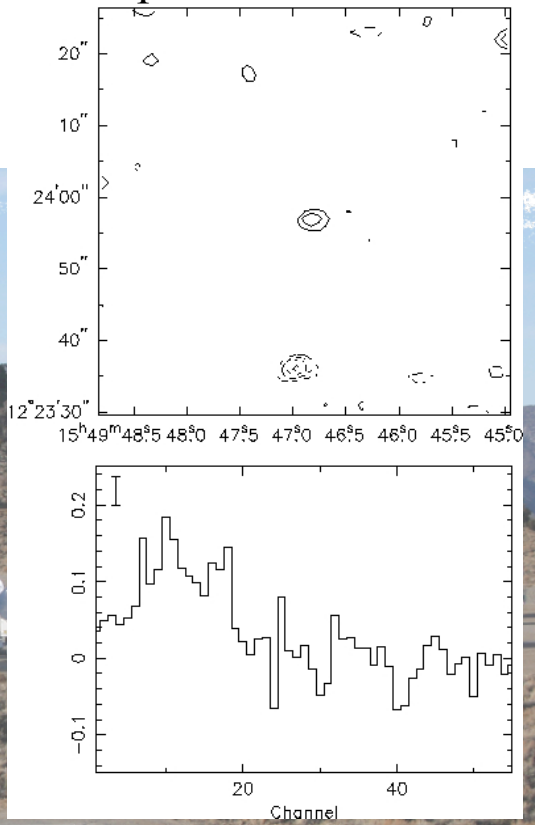
Products:

- Analysis-quality maps.
- Calibrated u,v data.
- Processing script and log.

Beta tests of pipeline completed at CARMA institutions; pipeline results currently available to CARMA members for final testing.

Proposer has access to images of their data; later the data and images are released to the community.

Pipeline Results



CO J=1→0 maps of L1141 from channel 10, contours are ± 3, 4, 5σ. Spectra are from peak emission point

The CARMA MRI project (2010-2013)

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Backend Electronics:

8 GHz bandwidth 23-stations

Direct digitization of entire 1-9 GHz IF output from receivers with commercial ADCs. (Selection process underway.)

"Bandformer" converts IF into 8 tunable sub-bands.

Existing digitizers will be "recycled" as correlators; maximum bandwidth per sub-band 1 GHz.

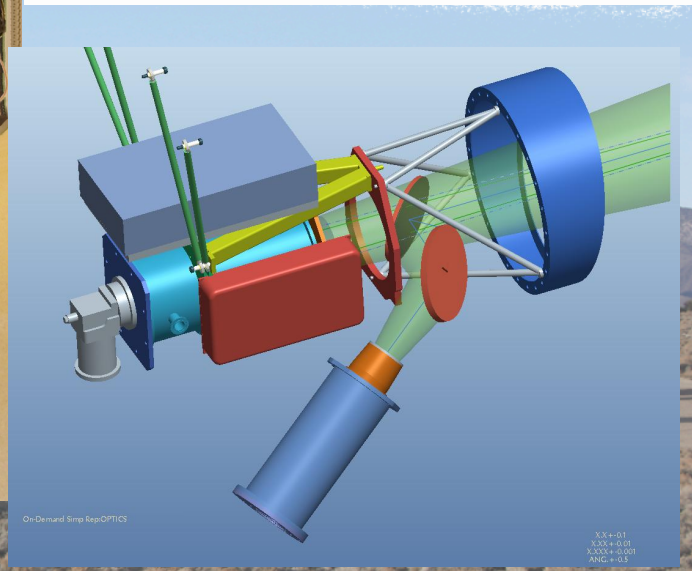
Centimeter receivers:

1cm receivers "recycled" from CBI experiment will be installed on 6m antennas.

Design of dewar support mechanism is underway.

Receiver prototyping under way

Graduate student Zubair Abdulla (U. Chicago)



See poster by Volgenau

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CARMA Call for Proposals announced: Due May 2

Calling for Key projects which can request up to 1000 hours of observing time.

- encouraging new scale of projects
- encouraging production of science data products for distribution to the community

CARMA

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Thanks!

Nikolaus Volgenau

University of California, Berkeley

California Institute of Technology

University of Chicago

University of Illinois at Urbana-Champaign

University of Maryland

National Science Foundation

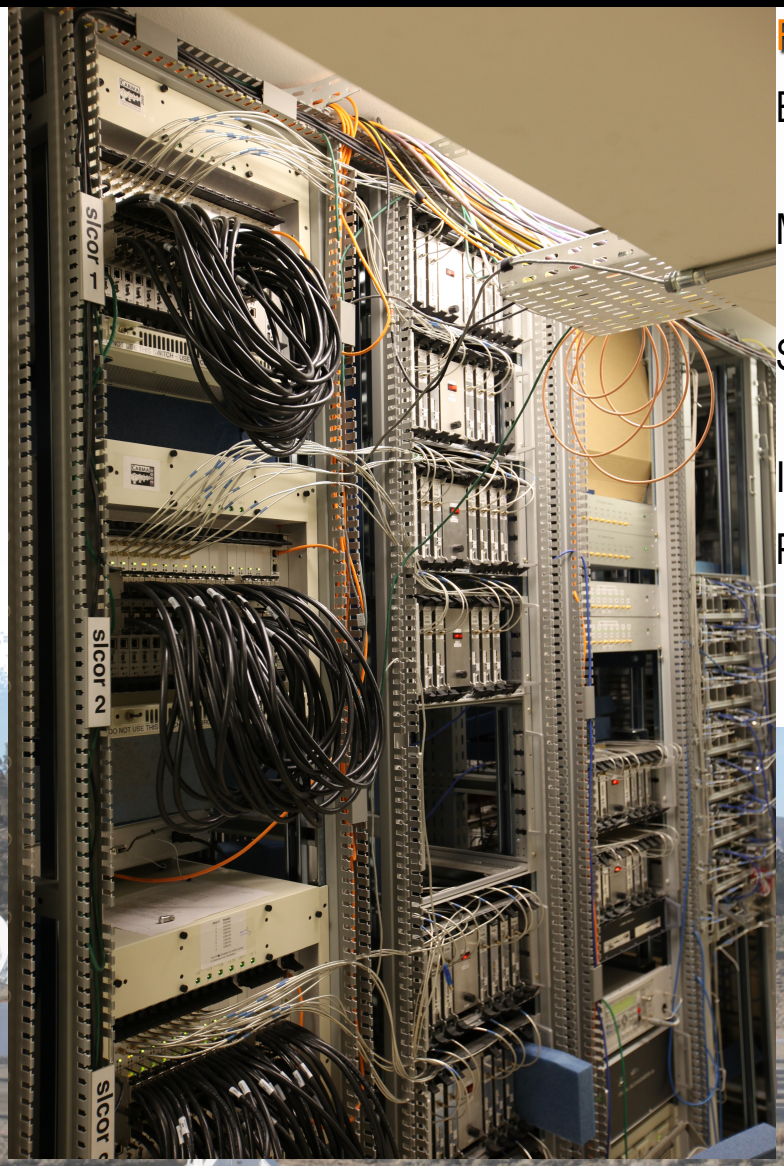
CARMA 8-band SL correlator

Oct 2009:

Three correlator bands.

Maximum bandwidth = 3 x 500 MHz = 1.5 GHz/sideband.

Four narrow band modes: 62, 31, 8,2 MHz.



Feb 2011:

Eight correlator bands, fully operational in July 2010.

Maximum bandwidth = 8 x 500 MHz = 4 GHz/sideband.

Six narrow band modes: 250, 125, 62, 31, 8, 2 MHz.

Increased number of channels.

Potential to cross-correlate 2, 3, and 4-bit samples. (Higher bit-widths increase correlation efficiency.)

The CARMA Switchyard(s)

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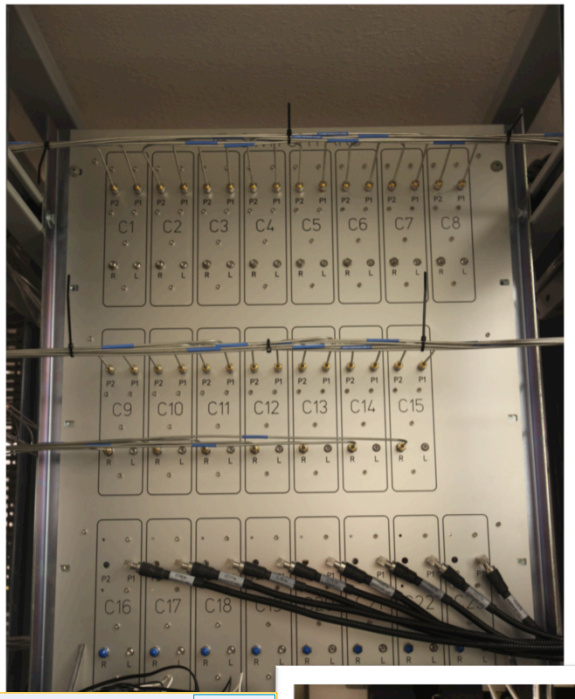
Oct 2009:

Discussions, planning.

Postdocs and graduate students at Caltech and UMD involved in science verification

Enables versatility to mix-and-match antennas with correlators and polarization observations



March 2011:

LO SY sends 1LO to Sci1/Sci2/Eng1 subarrays. Installed and assimilated into RTS Sep 2010.

IF SY: each IF can be split 4 ways; each correlator input switch can select from 4 sources. Installed Oct 2010.

Science observations in “CARMA23” mode happening now!

Commissioning of full Stokes mode in March 2011