

# CASA Status

ASAC Meeting, March 9, 2010 – Mitaka, Japan



**Crystal Brogan (subsystem scientist)**

NRAO/North American ALMA Science Center



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

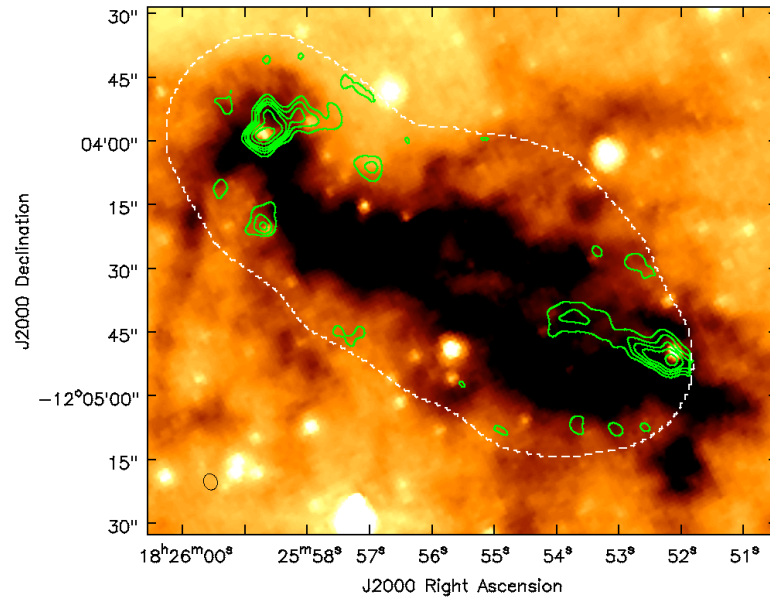


## What is CASA?

- CASA is the post-processing package for ALMA and EVLA
- It is a suite of applications for the reduction and analysis of radio-astronomical data (derived from the former AIPS++ package)
- The algorithms are written in C++; interface in python/ipython/Qt
- It is fully scriptable, with in-line help and scientist-written documentation (notably the user manual/cookbook)
- Telescope data (visibility and single-dish) are stored in a MeasurementSet (MS); a filler converts ALMA/raw data to the MS
- It contains functionality for manipulating/plotting/... core infrastructure data types (e.g., Images, Tables, Measures, ...)
- Extensive interferometric calibration and imaging capabilities implemented via the Hamaker, Bregman, Sault formalism (Measurement Equation)
- It contains image analysis and other mathematical functionality

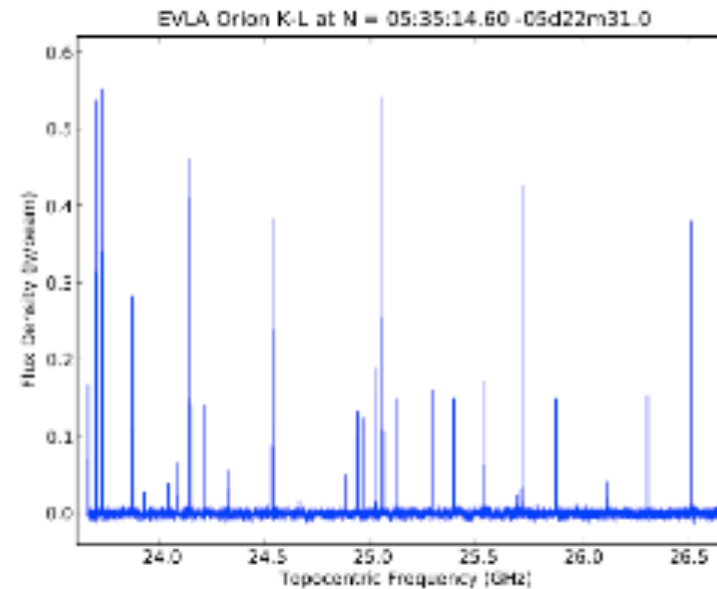
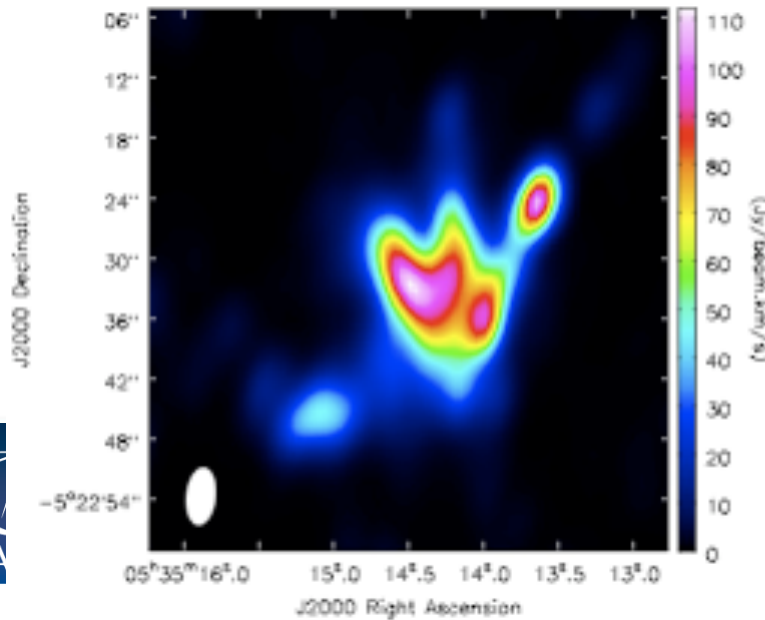
# Production of Scientific Images in CASA

CASA



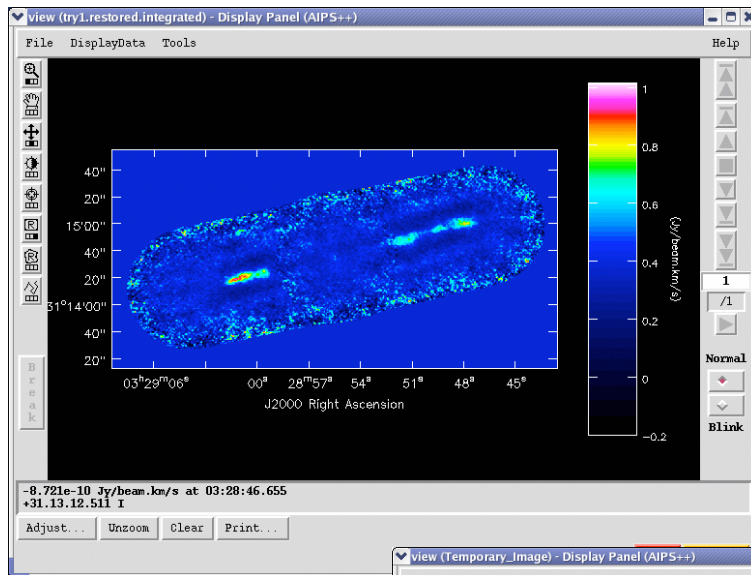
SMA  $^{12}\text{CO}$  (2-1) integrated intensity (green contours) superposed on a GLIMPSE  $8\ \mu\text{m}$  image of the Infrared Dark Cloud (IRDC) G19.3+0.07. Six-pointing SMA mosaic.

EVLA demo science: Orion Hot Core integrated intensity and spectrum: 24k channels!

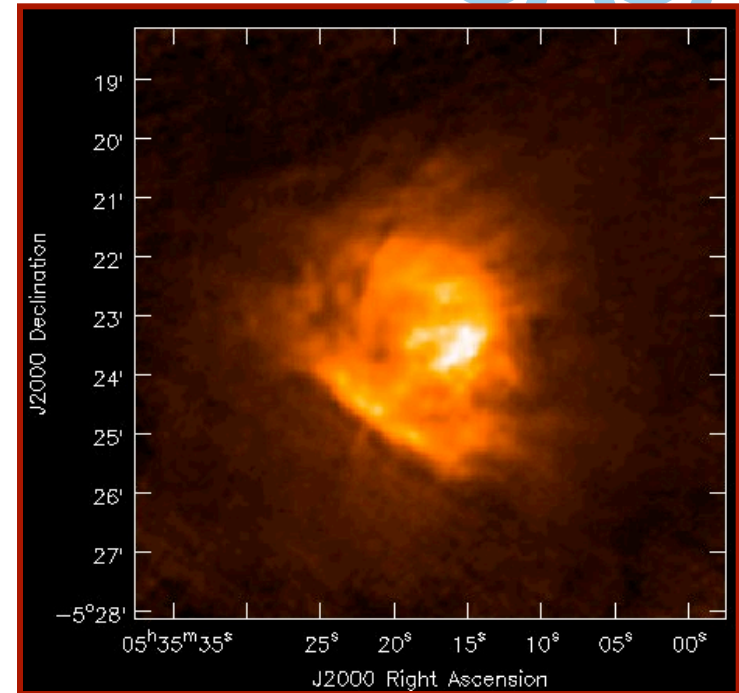


# Single Dish/Interferometer Combination

CASA

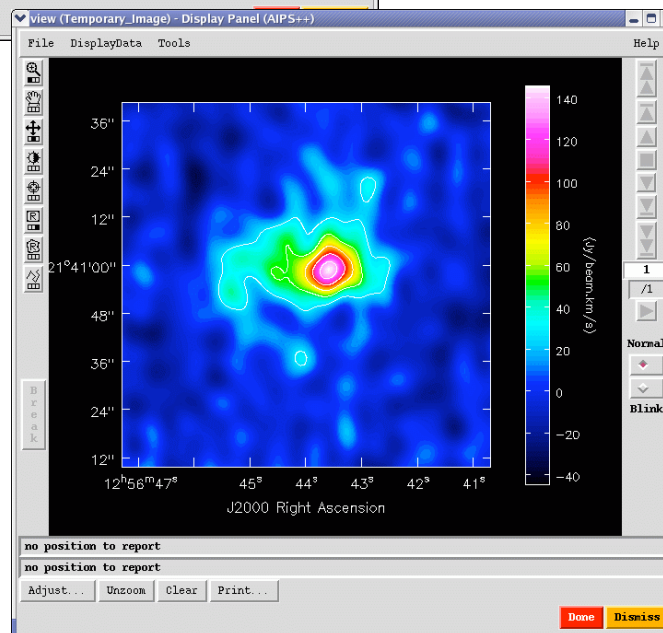


VLA SiO(1-0)  
mosaic,  
CLEAN  
deconvolution



Orion nebula continuum mosaic:  
VLA mosaic + GBT single dish  
on-the-fly image. Combined  
mosaic image produced using  
joint deconvolution, multi-scale  
CLEAN

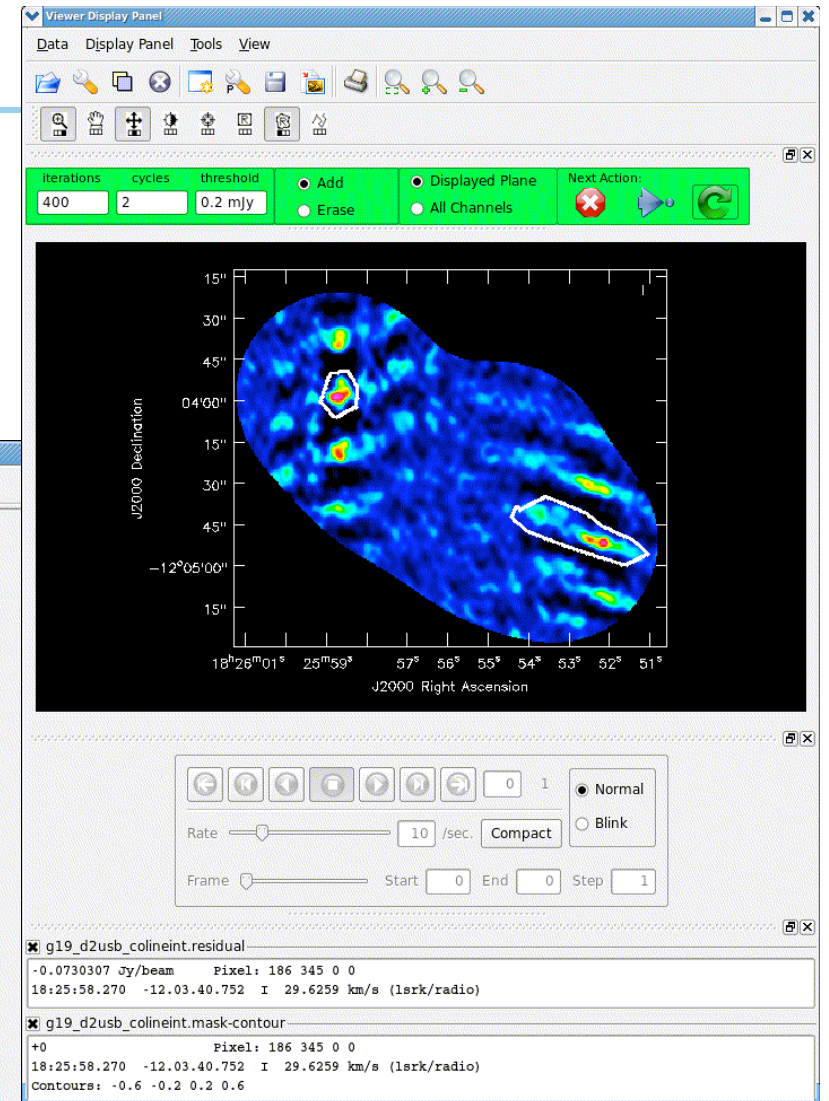
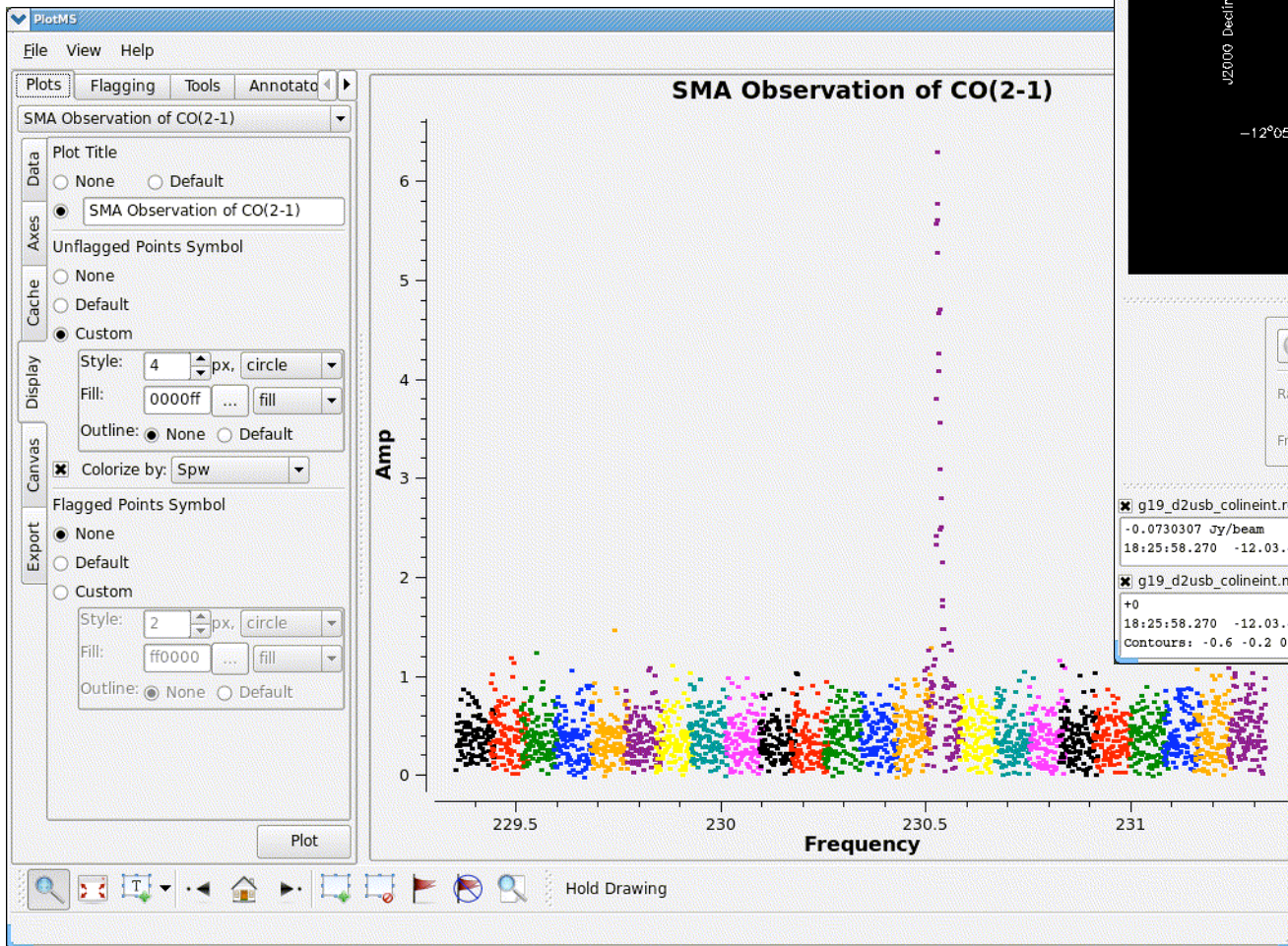
BIMA mosaic +  
12m single dish  
CO(1-0) mosaic,  
This moment 0  
map produced  
from joint  
'feathered' image  
cube





# Interactive cleaning and flagging

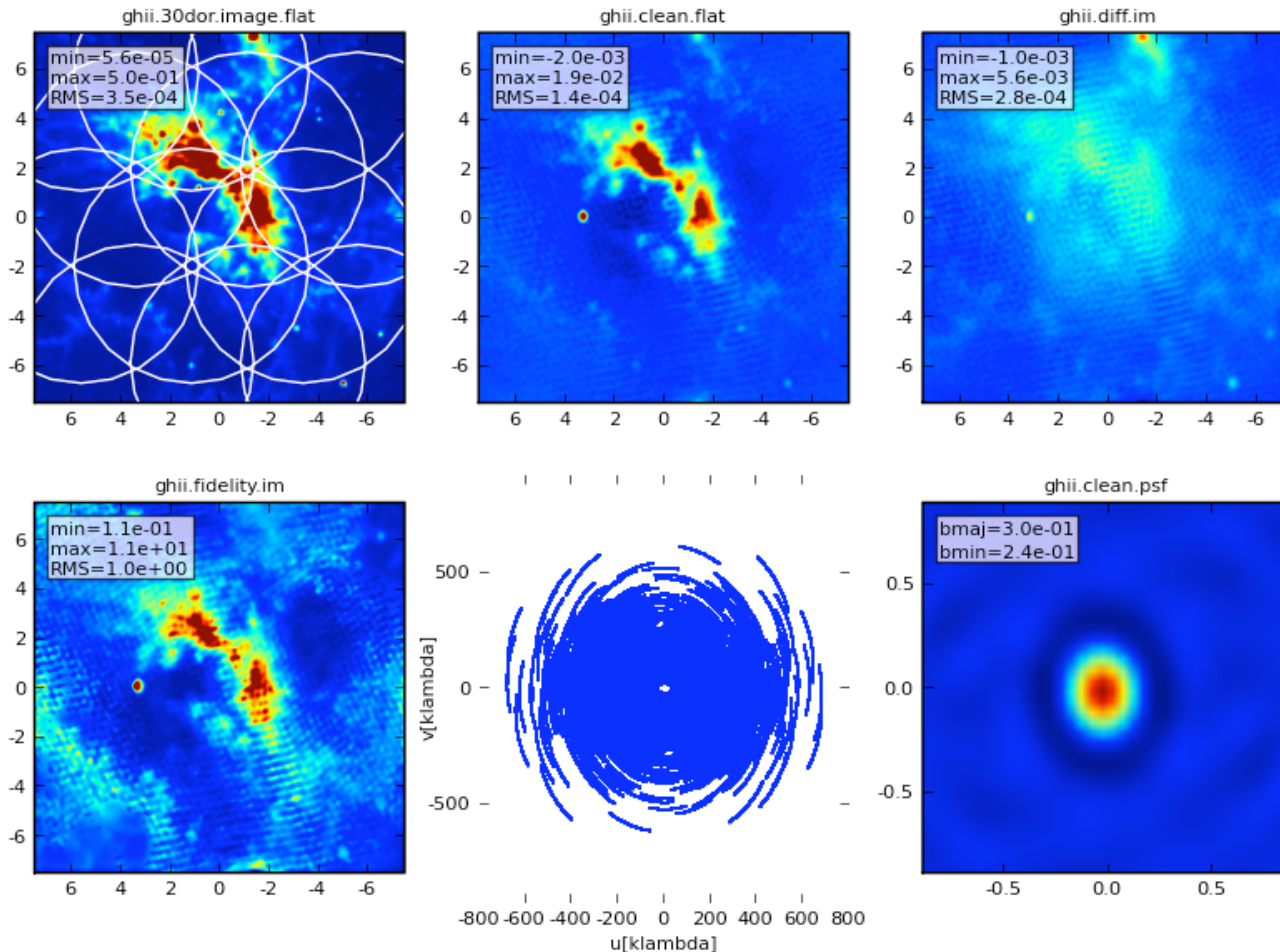
UV-spectrum in plotms, colored by spectral window





# simdata: CASA Simulator

# CASA



- Continuum and simple cubes
- Capability to create dummy header info for model image
- Add thermal noise using same ATM model as Telcal
- All configurations available including preliminary early science configs
- At tool level can add phase screen and cross pol
- Soon single dish simulation will be incorporated

- Infrared image of 30Doradus used as input model
- This figure and the images and uv-data are all outputs of simdata

## CASA Staff

- Group leader hired: Nick Elias (Oct. 2009)
- Development team
  - Currently ~12.5 FTEs with mix of scientific developers and programmers
  - Distribution of people: NRAO: 7.3, NAOJ: 2.7, ESO: 2.5
  - Two vacancies: Application (gui) developer, High performance computing specialist
- Overall Project management: Brian Glendenning (ALMA), Brian Butler (EVLA)
- NRAO Science Oversight
  - Juergen Ott (Project Scientist)
  - Crystal Brogan (ALMA subsystem scientist)
  - Steve Myers (EVLA subsystem scientist)
  - Ed Fomalont (E2E Scientist)
- Creation of ALMA CASA Coordination Group (ACCG)
  - Members from NOAJ – SD effort, NRAO, and JAO for feedback/priorities



## Release Status and Usage

- Have had Beta (patch) releases every ~3-6 months since October 2007
  - Pretty much any recent linux flavor, Mac OSX leopard, snow leopard
  - Available to anyone after registration at <http://my.nrao.edu>
  - > 400 have downloaded so far
- Used every day in Chile for ALMA commissioning
- Being used heavily for EVLA science verification now, and by outside users for start of early science (March 1, 2010)
- Dec. 18, 2009 was first non-beta release (3.0.0) and the next patch (3.0.1) will be @March 15. Another patch (3.0.2) expected before the NRAO synthesis imaging workshop in June.



## Tutorials

- Santiago tutorial for ALMA commissioning staff last year
- Other tutorials this past year: Garching (May 11-13), Hamilton, Canada (June 1-3), Bonn (Oct.), Taiwan (Feb)
- Coming up:
  - April, NAOJ
  - May, Miami AAS special session with talks/demos
  - June, NRAO Synthesis Imaging Workshop – all tutorials in CASA
  - Second Santiago tutorial in Spring or Summer (possibly by videocon)



# CASA Guides

- Uses mediawiki to enable fully annotated scripts
- Additional “guides” continue to be added

The screenshot shows a web browser window displaying the CASA Guides website. The address bar shows the URL <http://casaguides.nrao.edu>. The browser's bookmark bar includes links for 'crystal', 'Todd', 'VLA', 'NRAO Data Archive', and 'Google Calendar'. The page title is 'CASA Guides'. The main content area features a 'Main Page' with a 'Welcome to CASA Guides' section, a 'Featured article' titled 'Calibrating a CARMA Mosaicked Spectral Line Dataset', and a 'Contents' section with sub-sections: 'Getting Started', 'Interactive Tools in CASA', 'Data Reduction Guides', 'Simulations', and 'Indices'. The left sidebar contains a navigation menu, a search box, and a toolbox.

Navigation menu:

- Main Page
- Community portal
- Current events
- Recent changes
- Random page
- Help

Search box:

Toolbox:

- What links here
- Related changes
- Special pages
- Printable version
- Permanent link

Main Page content:

## Welcome to CASA Guides

This wiki provides examples and hints for reducing data in [CASA](#) (Common Astronomy Software Applications).  
56 articles since July 2009.

## Featured article

Calibrating a CARMA Mosaicked Spectral Line Dataset

## Contents

### Getting Started

- [CASA Homepage](#)
- [CASA Primer](#)
- [Full CASA User Manual and Cookbook \(Revision 3.0.0\)](#)
- [Getting Started in CASA](#)
- [AIPS-to-CASA Cheat Sheet](#)
- [Hints, Tips, & Tricks](#)

### Interactive Tools in CASA

- [Data flagging with viewer](#)
- [Data flagging with plotms](#)
- [Averaging data in plotms](#)
- [Axis definitions in plotms](#)

### Data Reduction Guides

- [Extracting scripts from these tutorials](#)
- [VLA Guides](#)
  - [Tutorials](#)
  - [Hints, Tips, & Tricks](#)
- [CARMA Guides](#)
  - [Tutorials](#)
  - [Hints, Tips, & Tricks](#)

### Simulations

- [Simulating Observations in CASA](#)

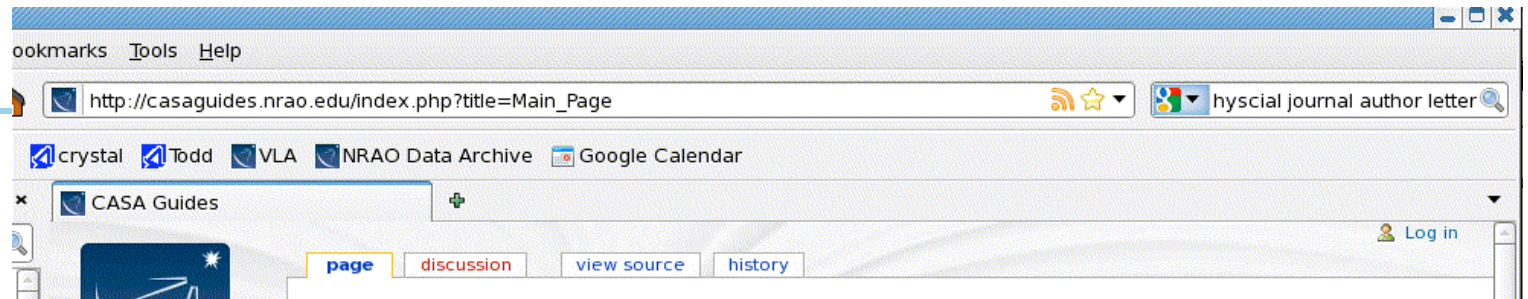
### Indices

- [List of All Articles](#)
- [Index by Category](#)

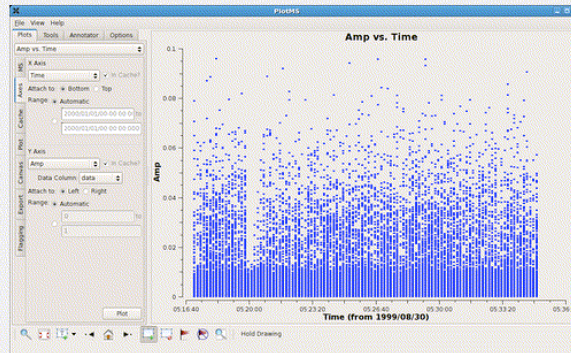




# CASA Guides



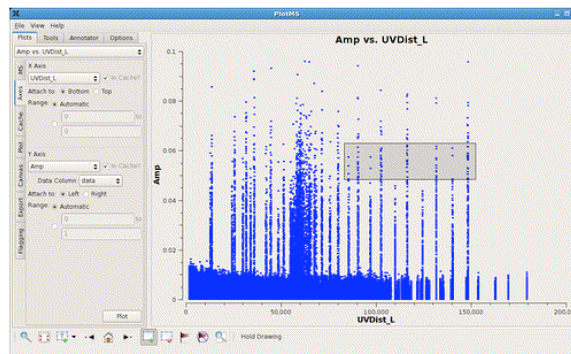
The figure at right shows the unflagged data for the first source (field = 0) after flagging the obviously discrepant points. Things look deceptively OK, but in fact there remain bad data from one antenna. The antenna contributed poor data for the entire observation of this source, and, since the problem is not isolated in time, it is difficult to see it in this projection.



*Click to enlarge*

Here are the same data reprojected onto baseline separations. (Axes) **X Axis = UVDist\_L** (projected baseline separations in units of the observing wavelength). The misbehaving antenna shows up as spikes in these snapshot observations, because each baseline with that antenna spans only a narrow range of baseline separations. (A longer observation would produce broader spikes, because the projected baseline separations would span a greater range as they rotate with the earth under the source.)

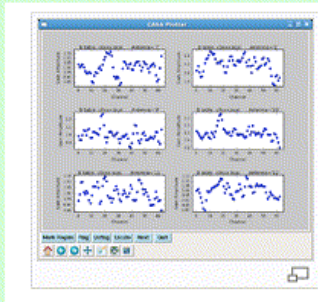
The idea now would be to highlight a subset of the discrepant data as shown in the figure and extend the flags to the common antenna of these baselines. At the time of this writing, this option is not available in the development build of *plotms*, but keep an eye on (Flagging) **Extend flags = Antenna**.



*Click to enlarge*

## Featured article

Calibrating a CARMA Mosaicked Spectral Line Dataset



## Data Reduction Guides

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- [Axis definitions in plotms](#)





# New CASA Helpdesk

- In mid-Feb. NRAO launched Kayako helpdesk at <http://help.nrao.edu>
- Kayako combines the utilities of managing tickets/ user support with a knowledge base
  - Herschel and Spitzer Science Centers
  - top candidate for the ALMA Helpdesk

The screenshot displays the National Radio Astronomy Observatory (NRAO) Kayako Helpdesk interface. The browser address bar shows the URL [https://help.nrao.edu/index.php?\\_m=tickets&\\_a=submit](https://help.nrao.edu/index.php?_m=tickets&_a=submit). The page header includes the NRAO logo, the text "National Radio Astronomy Observatory A facility of the National Science Foundation", and the date "04 Mar 2010". The main content area is titled "Support Center » Submit a Ticket" and contains a "Submit a Ticket" section with the instruction: "If you can't find a solution to your problem in our knowledgebase, you can submit a ticket by selecting the appropriate department below." Below this is a "Select Department" form with radio buttons for: General (selected), Observation Preparation (EVLA), Observation Preparation (VLBA), Archive Access, Data Processing (AIPS), Data Processing (CASA), and ALMA/NAASC. There are "Next »" and "Reset" buttons. A "Back" link is also present. On the right side, there is a "My Account" section showing "Logged In: Crystal Brogan" with a "[Logout]" link, and a "Search" section with a search box, a "Search" button, and a dropdown menu set to "-- Entire Support Site --". Below the search section is a "Live Support" status indicator showing "OFFLINE". The footer of the page includes navigation links: "Home | View Tickets | Submit a Ticket | Knowledgebase", a language dropdown set to "English (U.S.)", and the text "Help Desk Software Helpdesk Software by Kayako SupportSuite v3.60.04". The browser's search bar at the bottom shows "Find: simul" with "Next", "Previous", "Highlight all", and "Match case" options.

## Current CASA Strengths for ALMA/EVLA

- Full data import (e.g., complex correlator setups)
  - ALMA/EVLA raw data formats designed with CASA in mind
- Able to handle large datasets
- Wide-band imaging using Multiscale MFS
- W-projection imaging
- Non-linearized polarization calibration (for high dynamic range), frequency-dependent D terms
- Spline G (gain) and Bandpass solutions
- Data inspection/modification tools; scriptability in general

## Calibration

- Standard gain & bandpass calibration
  - Sampled and Polynomial/Spline solutions available
  - Flux density reference scaling
  - Sampled baseline-based solution available
  - Solution normalization
  - Phase-only, *Amp-only options*
  - Auto-interpolation of flagged channels in bandpass
- Polarization calibration
  - Linearized instrumental polarization (D-terms) solutions available
  - *Channelized option for frequency-dependent instrumental polarization*
  - Optional solution for source polarization
  - Polarization position-angle solution support (for circular basis)



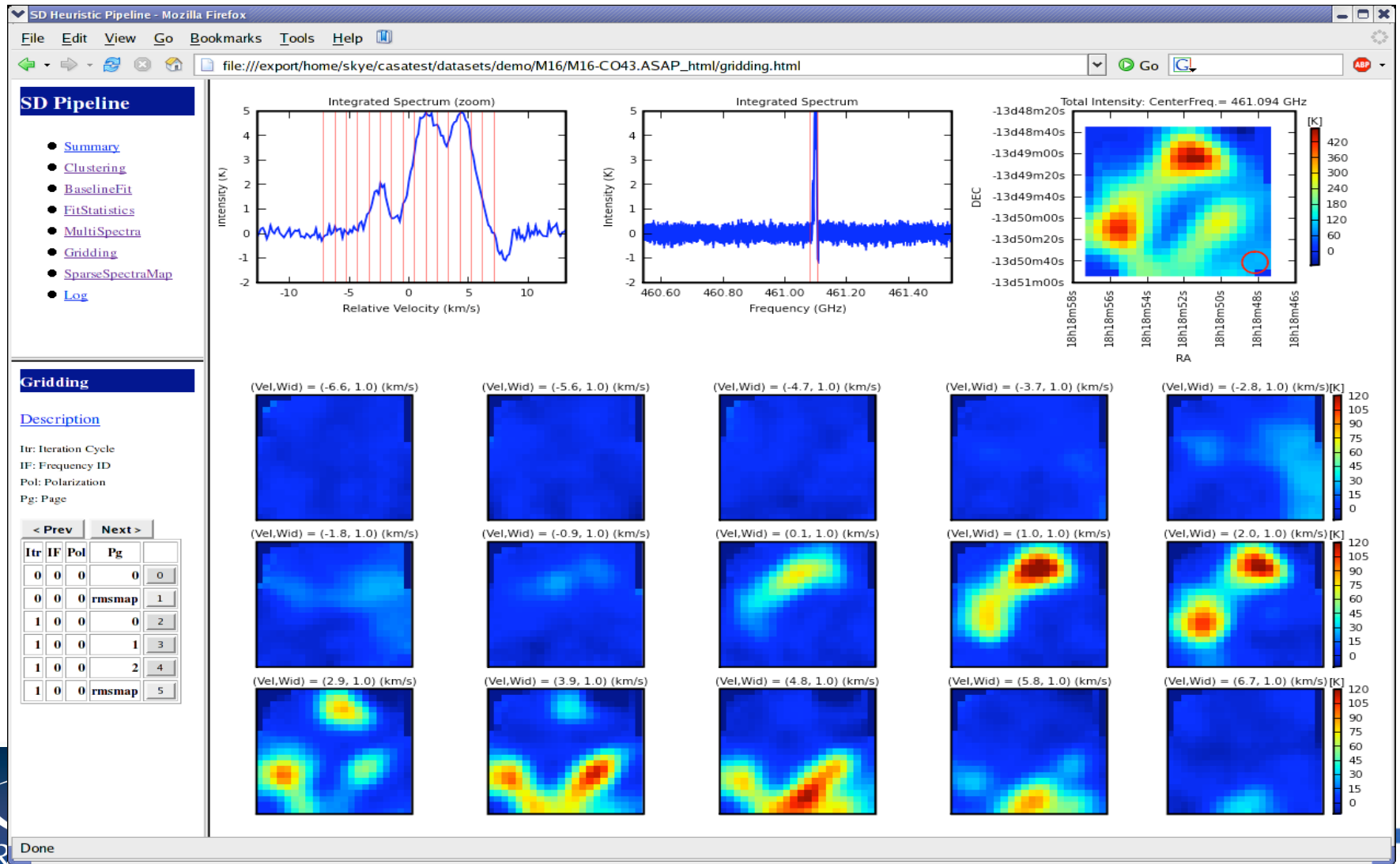
## Imaging & Deconvolution

- Mosaic imaging
  - Joint deconvolution (Miriad style) and by *gridding convolution*
  - Mosaicing with heterogenous arrays (ALMA, CARMA)
- Widefield imaging: *W-projection* and faceting
  - *W-projection* more than 1 order of magnitude faster than faceting
- Multiple algorithms for single dish and interferometry combination
  - Feathering
  - Single Dish as a model for deconvolution
  - *True joint deconvolution using both visibility data and single dish data*
    - Requires data with well-calibrated weights between the single dish and interferometry data (ALMA), and testing
- *Full beam Stokes I, V imaging*
  - Targeted at friendly VLA users on a “shared risk” basis
- *Multiscale clean*
- MEM & NNLS (toolkit level only so-far)

## Single Dish

- Based on ATNF ASAP package
- Calibration and flagging
  - Calibration of position-switching, frequency-switching spectral data
  - Calculate quotient spectra
  - Calibration of total power raster scan data
  - Opacity correction (based on input opacity value)
  - Flagging by channel or row
- Imaging
  - Imaging of total power and spectral line raster scan data, including solar-system objects: Uses interferometric Imager
- Data analysis
  - Baseline fitting and subtraction
  - Plotting and profile fitting
  - Basic vector arithmetic
  - Removal of scanning noise by “Press-out” and FFT filtering

## Pipeline test based on CASA Single Dish Package





## Performance

- For “small” to “intermediate” (1-10 GB) sized datasets  
CASA is comparable to other packages
  - Sometimes faster, sometimes slower; complex parameter space
- CASA’s architecture was designed to allow parallelization to be introduced at several levels
  - Storage manager (I/O) through OpenMP through Python scripting
  - Also I/O is organized to minimize passes through the data
- Started: Terabyte initiative
  - Flag, calibrate, image 1 TB (raw data size) data = 10h of **peak** (~2012) data rate
    - Tests to date concentrating on initial (2010) large data sizes = 100 GB

## Performance (2)

- Cluster (16 nodes, 128 cores) purchased, working on simulating the data and initial timing tests (joint ALMA/EVLA purchase)
- Initial end-to-end (flagging/calibration/observe) testing of the data-parallel (“embarrassingly parallel”) case
  - 100 GB ~ 3H on the cluster
- Collaboration with UVA parallelization group recently started
  - E.g., systematic profiling, CUDA sample implementation of gridding/degridding inner loop)
- Major question: nodes vs. cores (do we have enough FLOPS/IO to support many cores)

*Testing ALMA/EVLA sized data sets is the important exercise!*

## Planned for the coming year...

- Support of ALMA commissioning needs
- Improvements needed for polarization calibration of linear feeds
- Improvements to calibration table plotting (incorporate into plotms)
- Planet models for use as resolved calibrators
- Splatalogue search capabilities and overplotting
- Viewer improvements (especially for spectral line plotting and analysis)
- Improvements to image analysis tasks
- Improvements to “TV” based flagging in the Viewer (on-the-fly spectral and time averaging)
- A CARMA miriad filler (through partnership with Peter Teuben at U. Maryland)
- Expanded and more modularized simulation capabilities, incorporate single dish simulation