An Approach to Wide-band Imaging

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- The problem
- Redefining “image”
- Evaluation of techniques using simulated data
- Further development
- Described in memo on Obit web page
  http://www.cv.nrao.edu/~bcotton/Obit.html

The Problem

- Want wide bandwidths for better sensitivity, uv coverage
- But:
  - Brightness distribution varies across bandpass
  - wide bandwidths→better sensitivity→full field imaging
  - primary beam variations across bandpass
- Brightness per pixel no longer adequate for wideband images

Redefining Image

- Need to describe spectrum per pixel
- Options:
  - Continuum image becomes cube of narrow-band images
  - Pixel becomes a vector parameterizing spectrum
- In following, adopt parameterized spectrum:

$$s_\nu = s_{\nu_0}\, e^{\alpha\, log(\nu/\nu_0) + \beta\, log(\nu/\nu_0)^2 + \ldots}$$

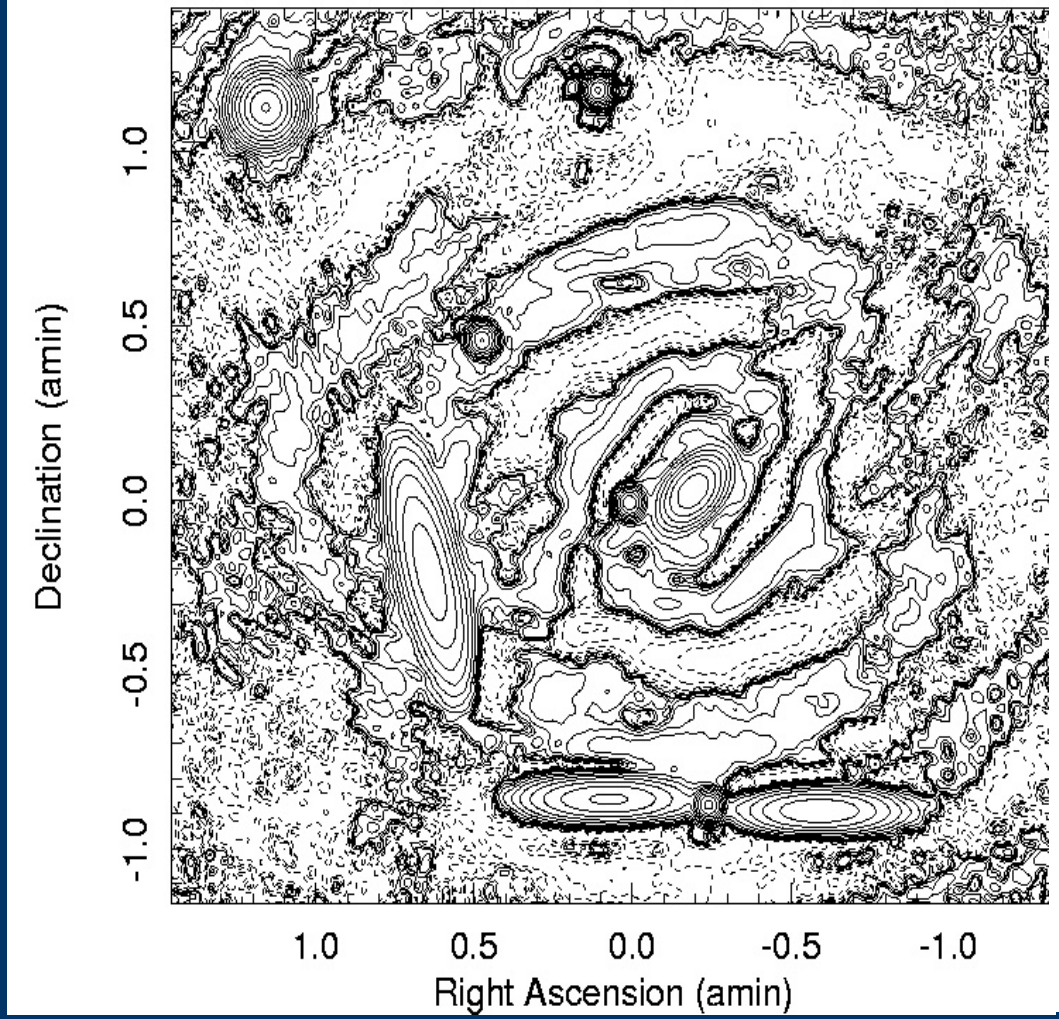
- Where:
  - ν_0 is reference frequency,
  - S, α, β, ... are flux density, spectral terms

Simulated Data

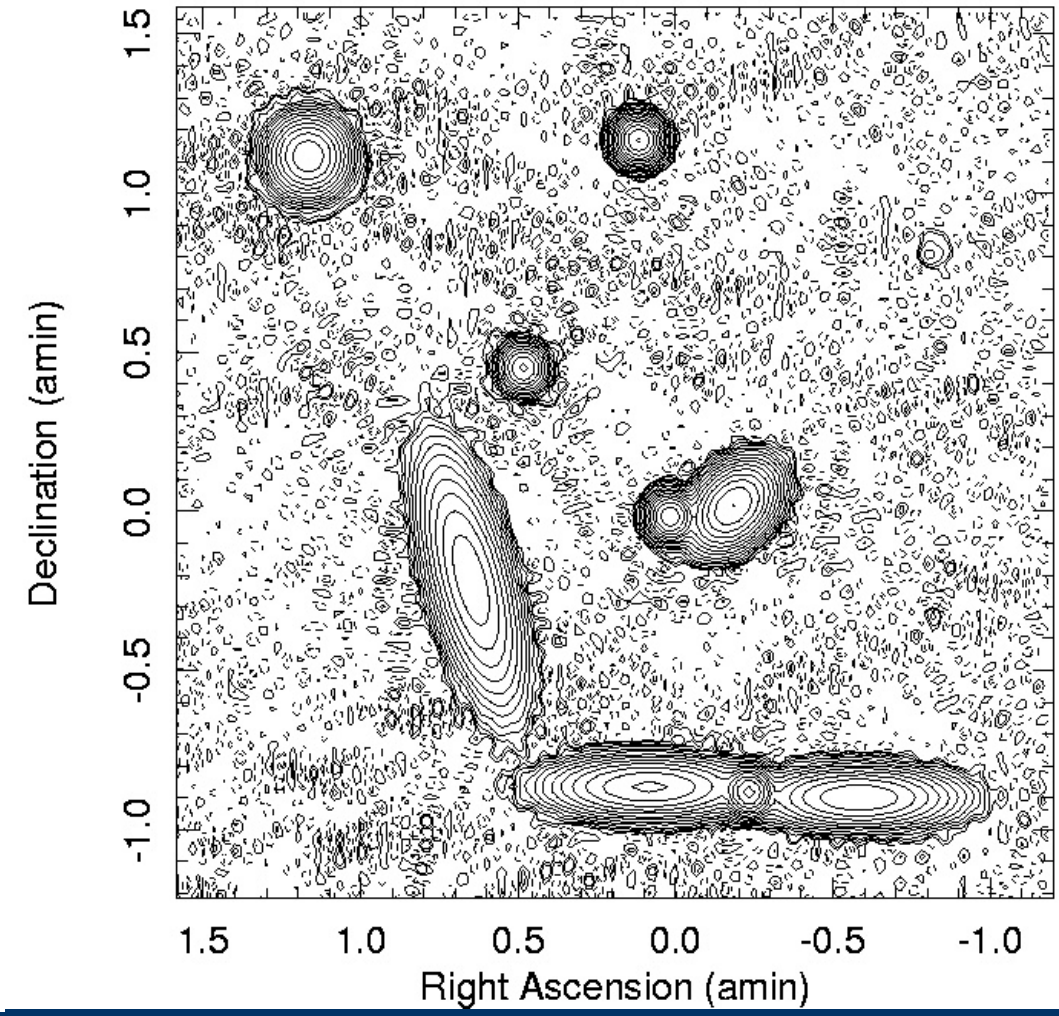
- Modified VLA data set to 10 “IFs” covering 1.4-2.3 GHz with 15x390 kHz channels each
- Replaced data with model with Gaussians of various sizes, shapes and spectra.
- Model extreme but not outrageous
- All testing done in Obit

Traditional Imaging

- Image data ignoring spectral variations:



Image/CLEAN all data



Image/CLEAN single IF

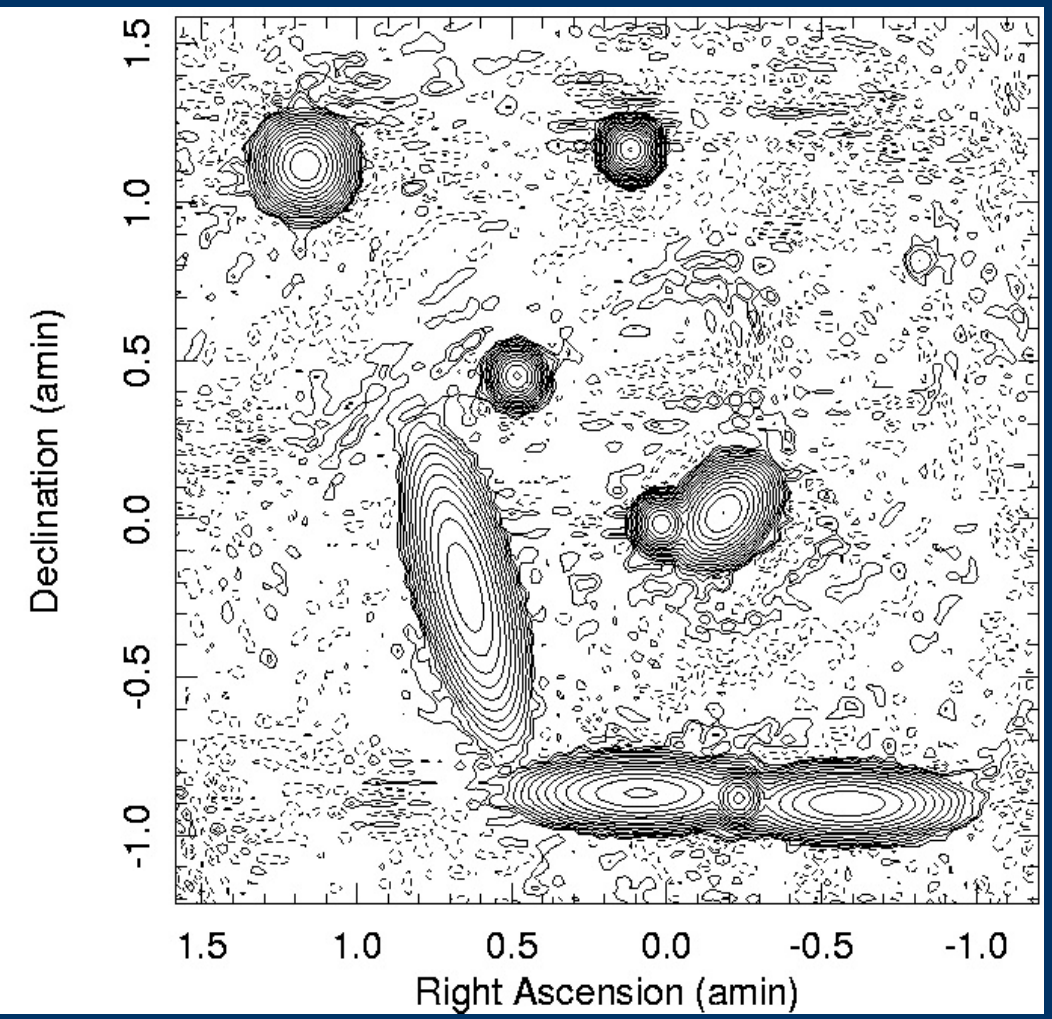
Traditional imaging, cont'd

- Use Dynamic Range (DR) as measure of quality
- All data DR=5,100
- One IF DR=35,400
- Narrow band gives much superior results ☹
- MUST take spectra into account

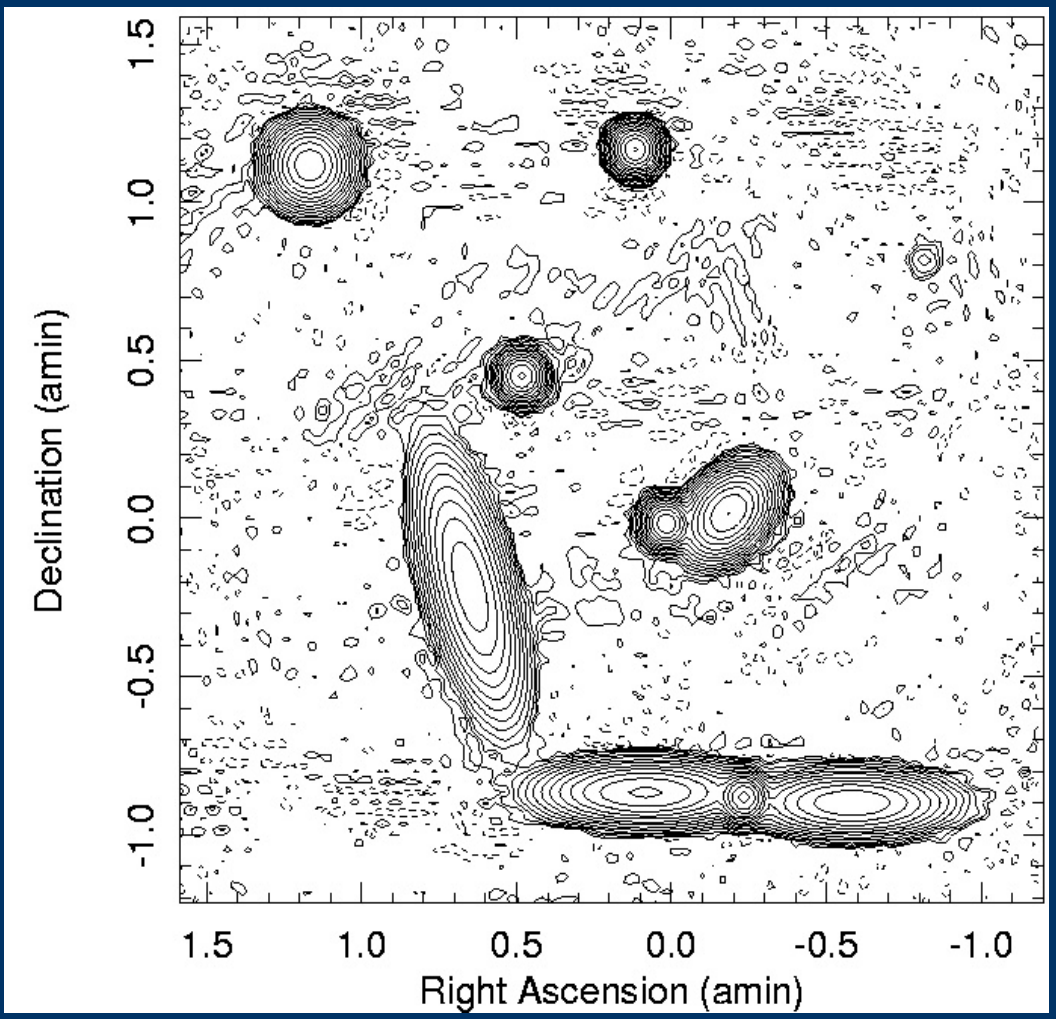
Spectral Imaging

- Want deconvolved spectral image
- Spectral imaging technique:
  - Make narrow band dirty images
  - Taper to match resolution
  - Fit spectra to each pixel
  - Deconvolve using flux density at ν_0
  - CLEAN components generalized to include spectrum
  - Sky model to visibility calculation includes spectra

Spectral Imaging Results



Three term spectrum



Two term spectrum

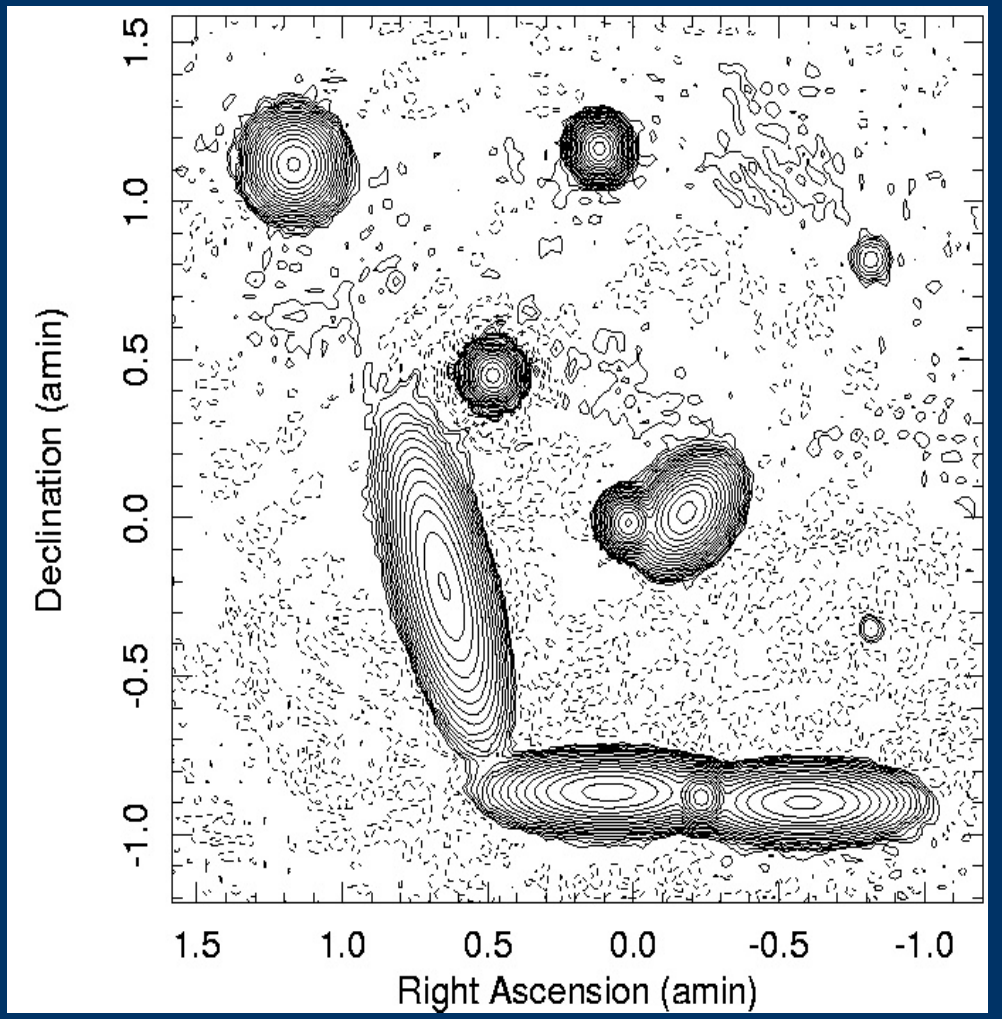
Spectral Imaging Results

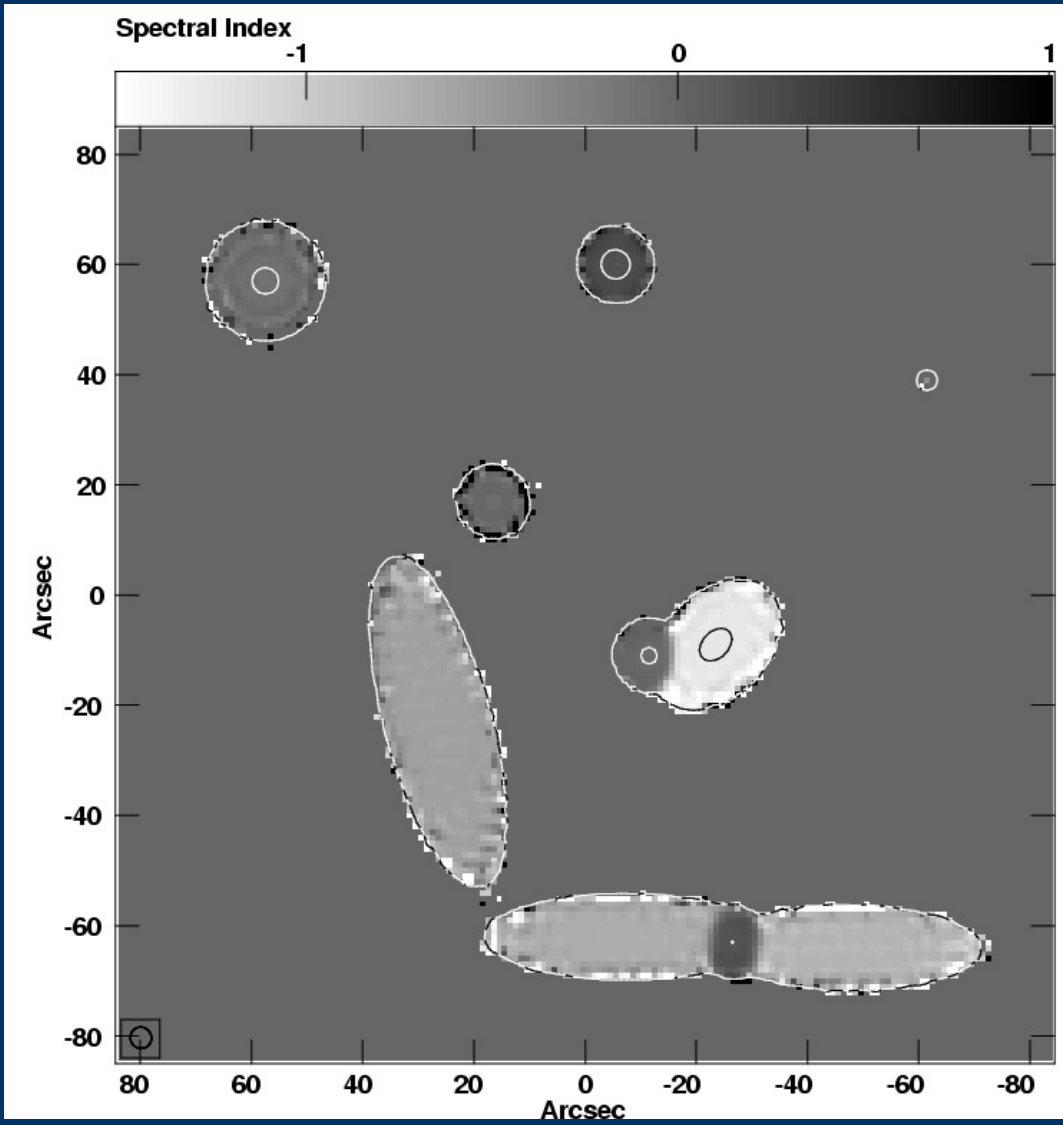
- With three term spectrum DR=37,200
- With two term spectrum DR=50,800
- Does about as well as narrowband case ☹

Spectral Fitting

- Have two nonlinear processes, deconvolution, spectral fitting
- Reverse order, CLEAN narrowband, fit CLEAN images

Spectral Fitting Results





Flux density

Spectral index

Spectral Fitting Results

- DR=283,000 ☺
- Large improvement over narrow band image

Future Development

- Generalizing self-calibration to use spectra
- Include primary beam effects
- Testing on real data