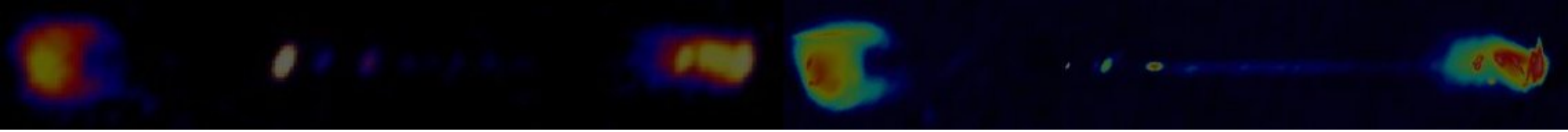

Finding and Analyzing Features in Noisy Cubes

(using multi-frequency smear fitting)

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Smear Fitting

A two step deconvolution method:

1. Fit a set of model components, typically several dozen elliptical gaussians, to the visibilities by minimizing χ^2.

$$\chi^2 = \sum_i \left| \frac{V_i - V_{model}(\vec{u}_i; \vec{p})}{\sigma_i} \right|^2$$

   ($\vec{u}_i$ = the ith baseline and $\vec{p}$ = the parameter set)

2. Bias the model to broaden each component to account for the uncertainty of the intensity distribution. (Let χ^2 go up by approximately the number of degrees of freedom.)

Implemented as a patch to difmap. It is *not* in CASA.

Model Construction

...the harder and more interesting step.

The good Different functional types (Gaussians, uniform disks, optically thin ellipsoids, etc.) can be mixed and matched.

The bad Typically we don't know a priori how many components of each type to use.

The goal* Use as few parameters as necessary.
* Maximum Entropy uses many more parameters (pixels) than measurements, but uses regularization to bring down the effective amount of info being claimed beyond some prior.

Model Construction

Heuristics are necessary (a consequence of incomplete and noisy sampling for any deconvolution method), *but*:

- 

  they can be (and have been) scripted,
  (although some are implemented as new "tools")
- and so far there has been no need to specify clean boxes or scales.

Model Construction

Many of smear fitting's heuristics are mainly aimed at speeding up model construction.

- Don't do global fits when they aren't necessary.
- Don't directly fit to the visibilities when it isn't necessary. (Like minor and major cycles in clean.)

It can blend smoothly with clean.

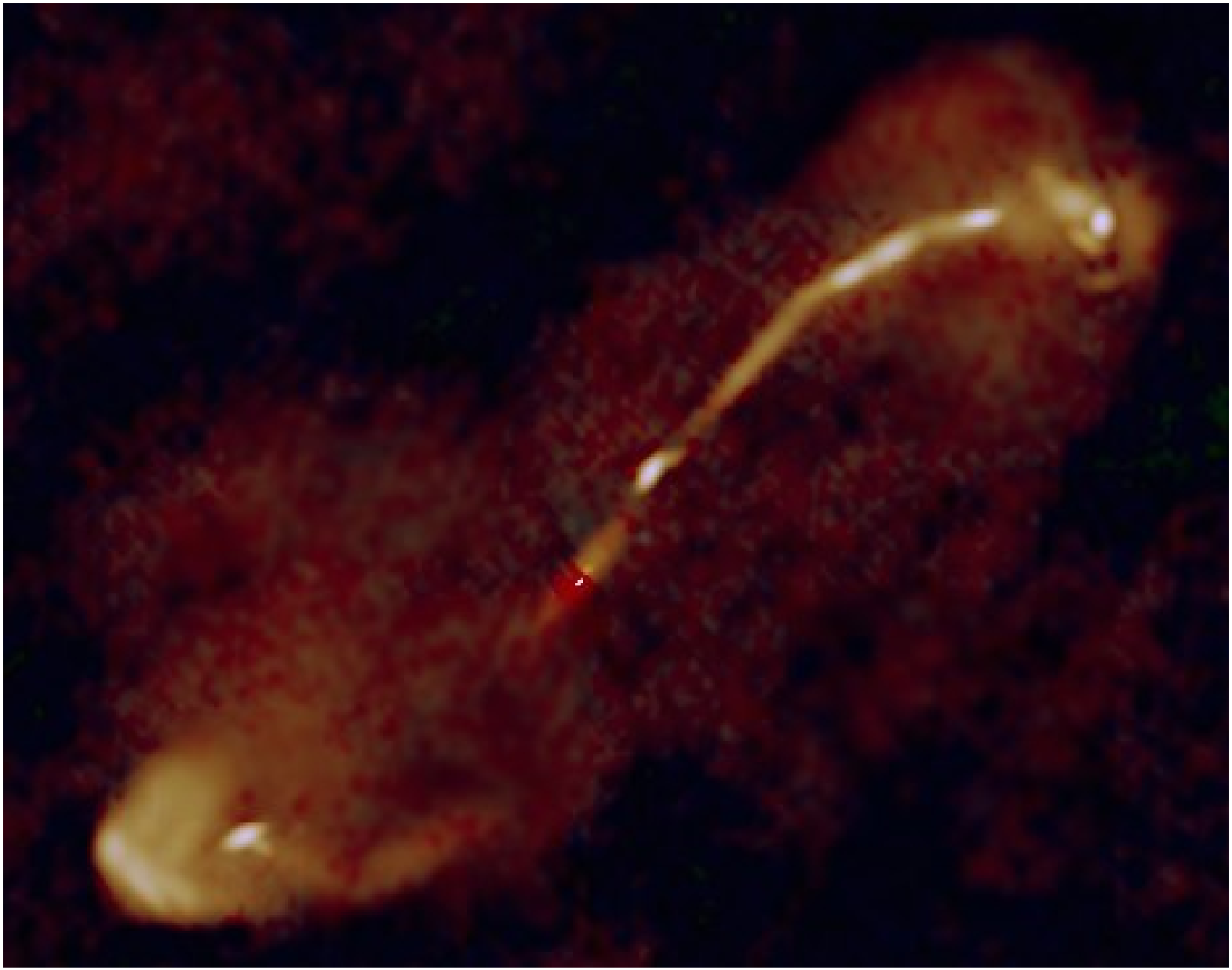
Multifrequency Smear Fitting

$$\chi^2 = \sum_{\nu} \sum_{i} \left| \frac{V_i - V_{model}(\vec{u}, \nu; \vec{p})}{\sigma_i} \right|^2$$

vs.

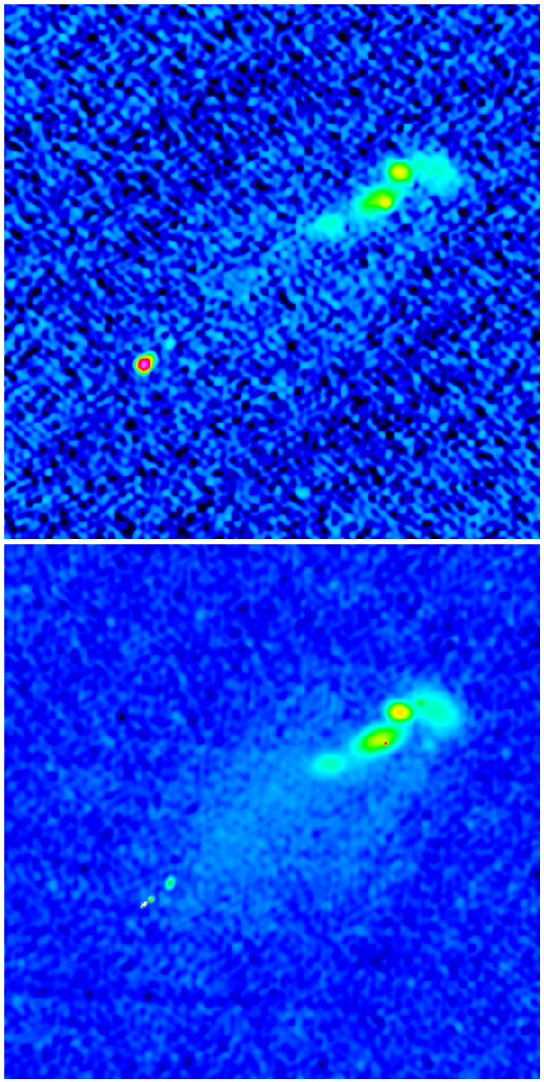
$$= \sum_{\nu} \sum_{i} \left| \frac{V_i - V_{\nu,\mathrm{model}}(\vec{u}; \vec{p})}{\sigma_i} \right|^2$$

A combined 5 and 8 GHz VLA image



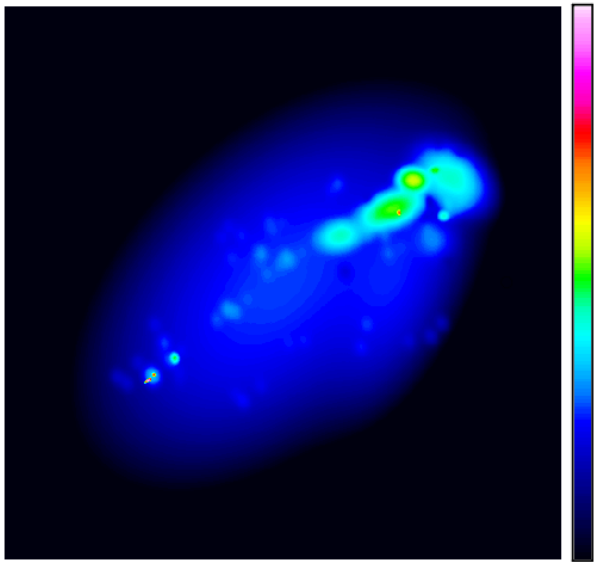
One Size Does Not Fit All

VLA A Array



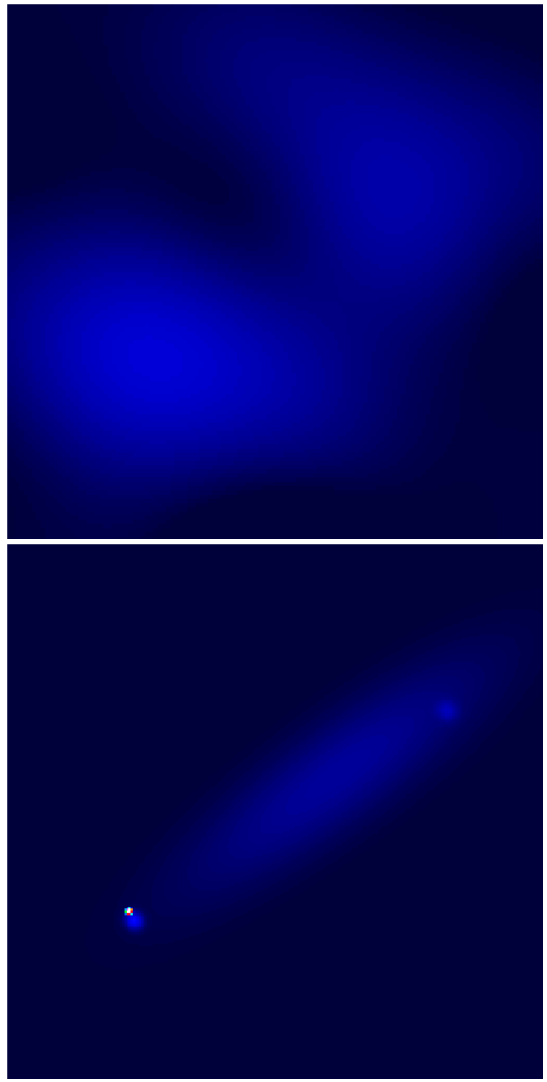
← CLEAN →

True image



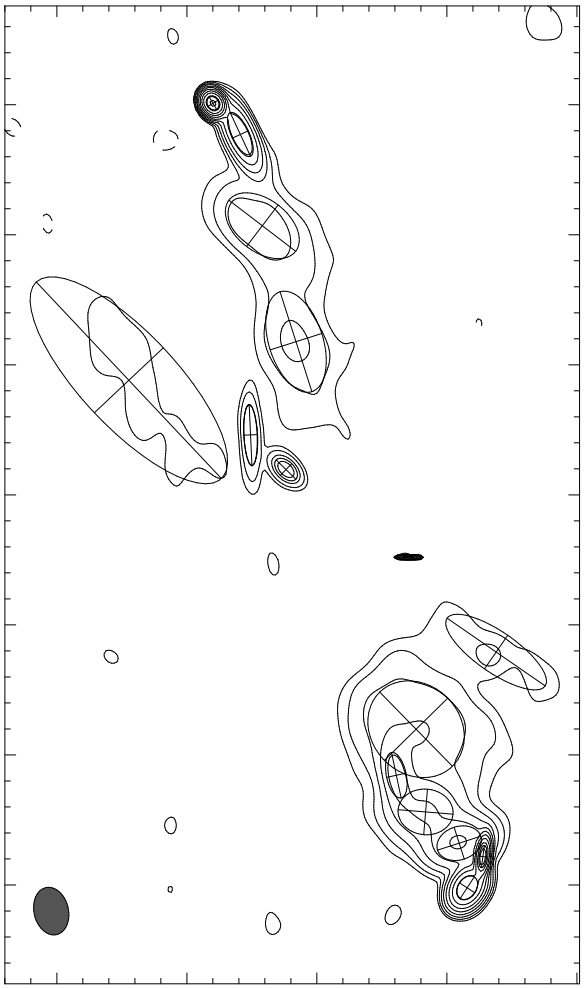
← Smear fitted →

VLA D Array

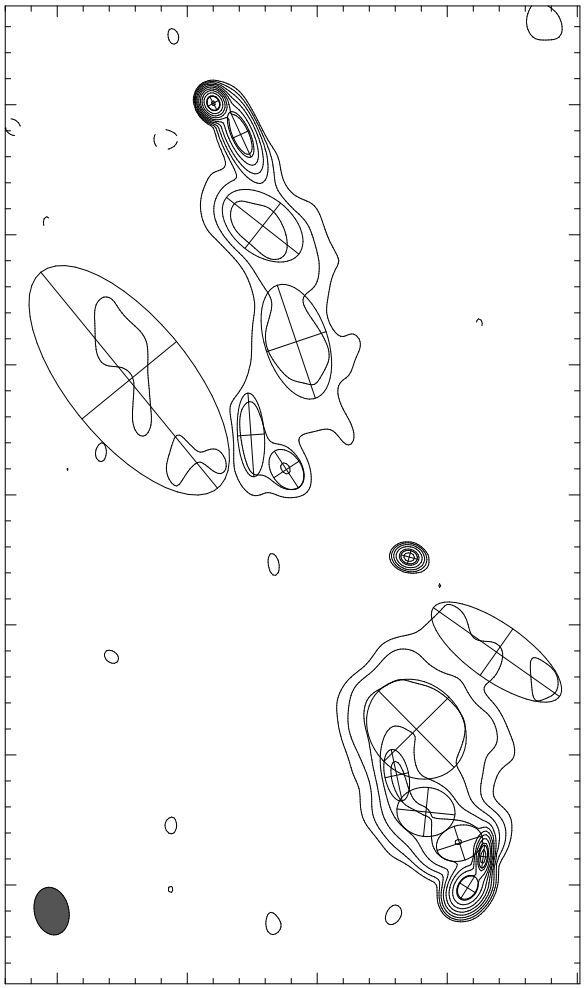


Smear fitting

Unsmeared



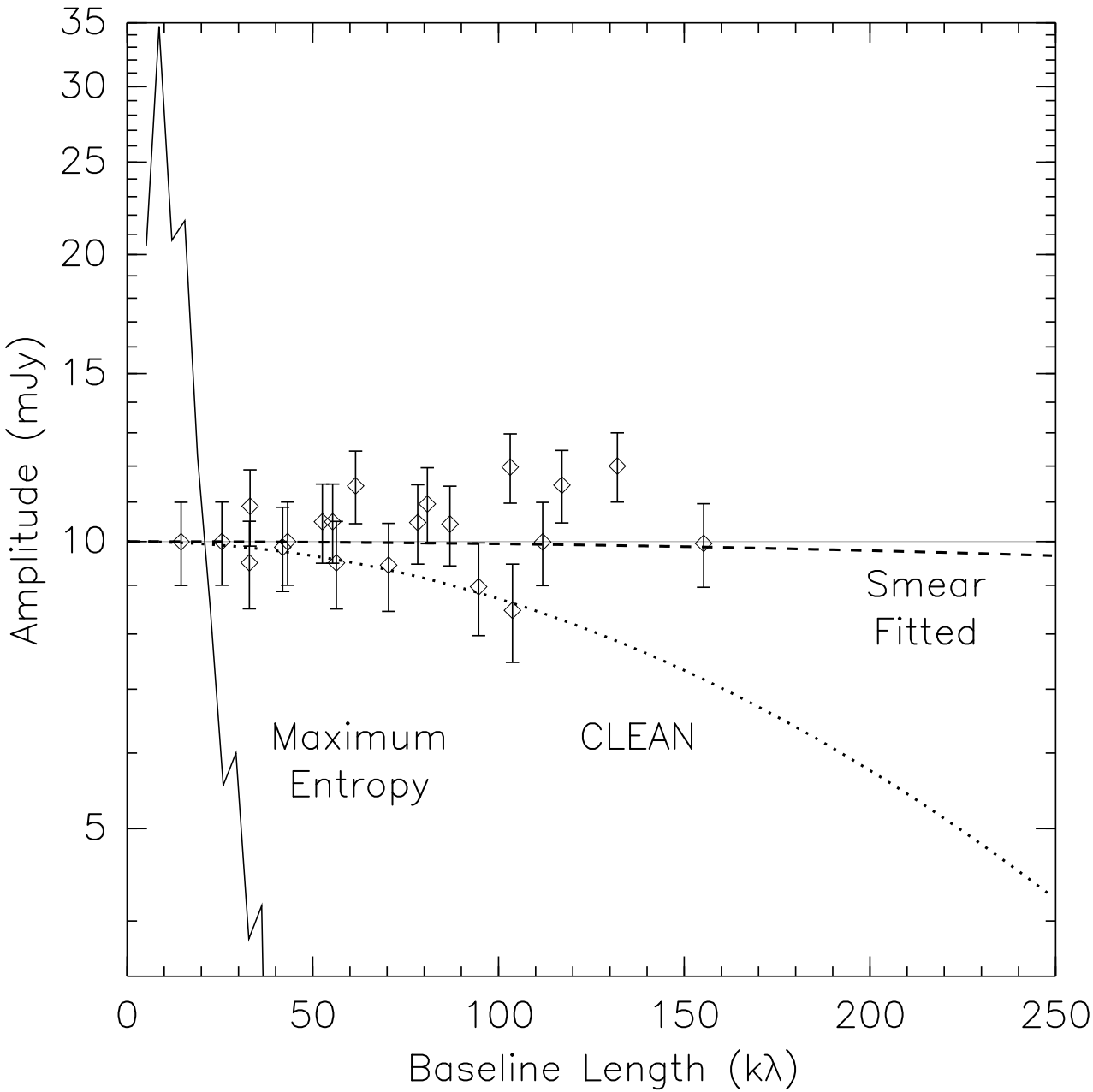
Smeared



A small(er) set of extended components instead of 1000's of δ functions, or 10^6's of pixels.

Custom smoothing instead of one size fits all or total entropy.

A peek at the *uv* plane ...



Aren't pixels more flexible?

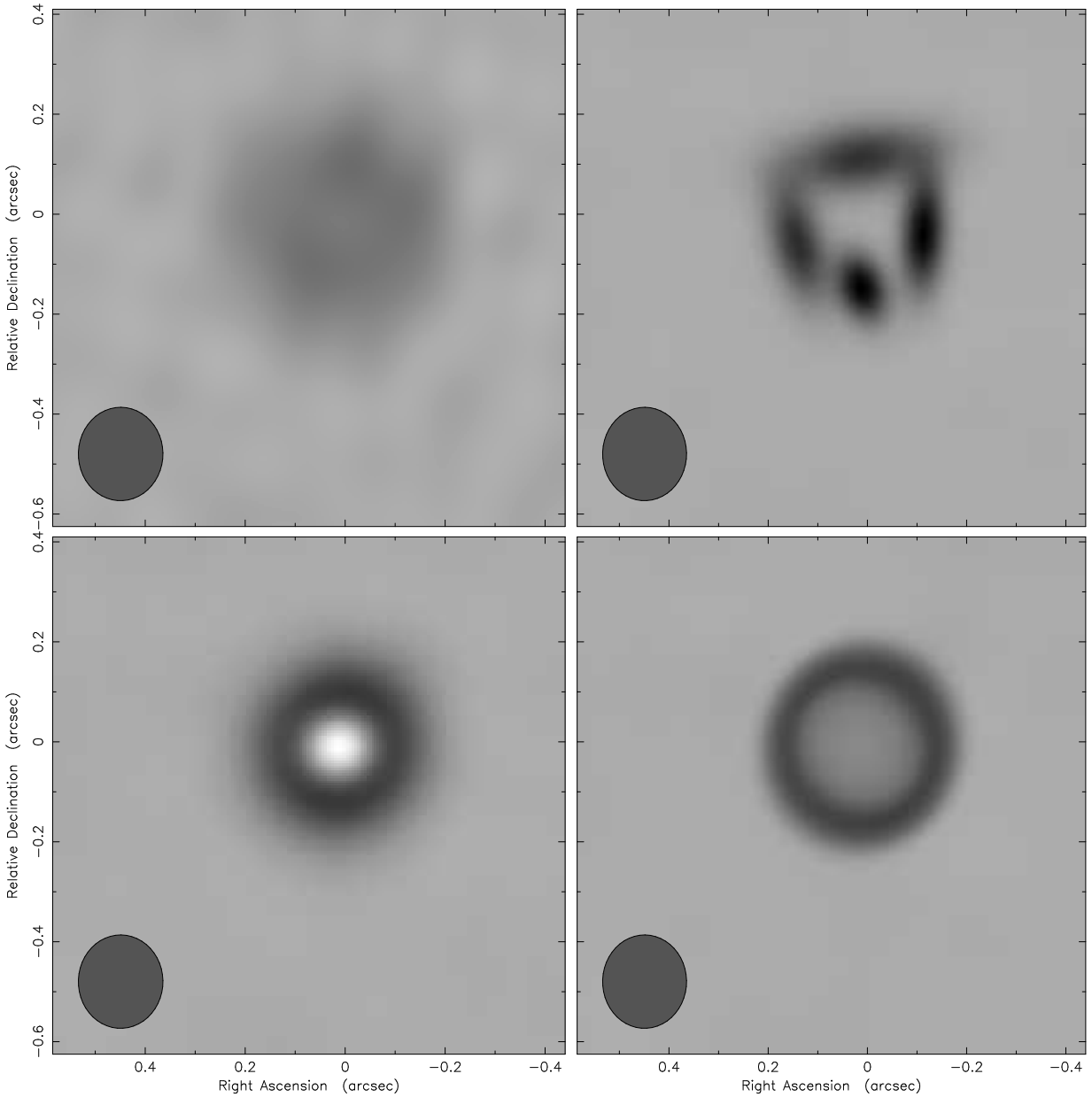
Maximum Entropy, CLEAN, and NNLS already semiautomatically produce models
but

- pixels are rather anonymous,
- one size does not fit all,
- and selfcalibration needs to be worked in, too.

Incorporating Physical Insight

You may have good reason to allow different functions...

Data courtesy of E. Seaquist.



Receiving Physical Insight

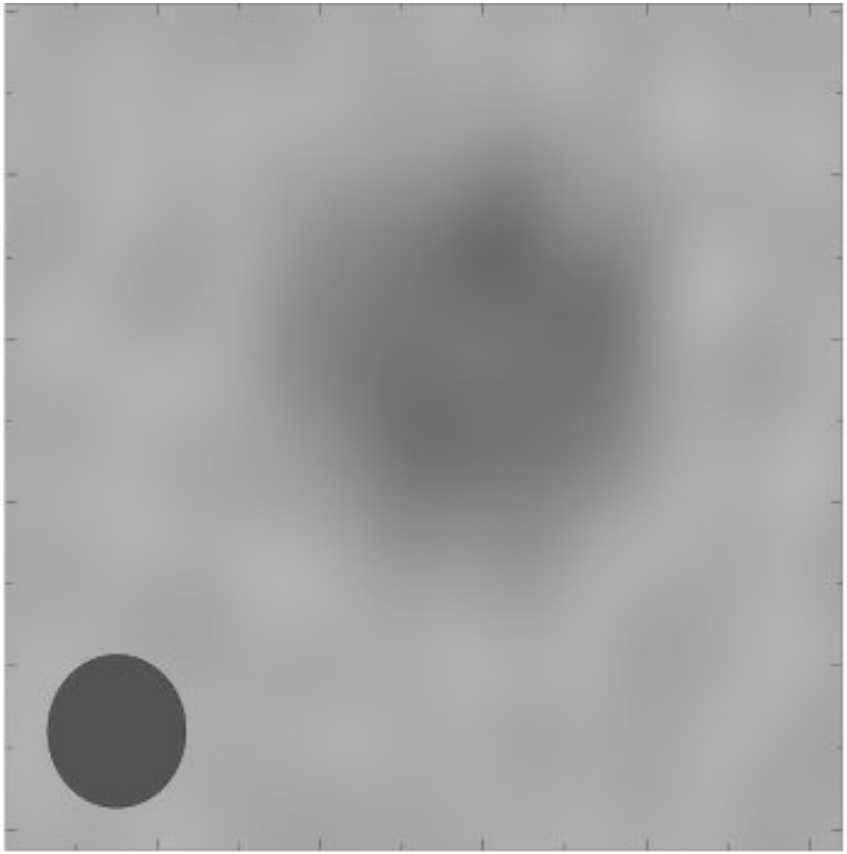
(...or at least publishing a little sooner.)

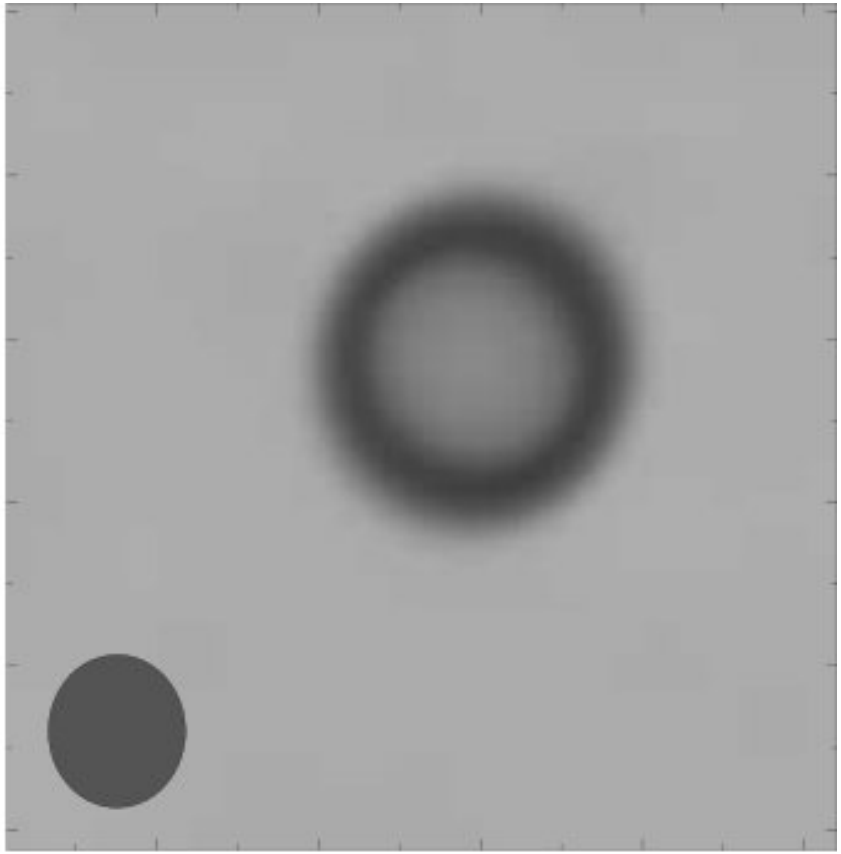
Fitting the model for deconvolution also produces the values (optionally with uncertainties) of potentially interesting parameters.

						Smearing Beam		
Flux (mJy)	Radius (mas)	θ (°)	Major Axis (mas)	Axial Ratio	ϕ (°)	Major Axis (mas)	Axial Ratio	ϕ (°)
49.74	151.44	154.63	178.3	0.3713	54.88	28.0	0.6682	66.87
60.30	135.08	63.04	219.5	0.4656	−29.75	35.4	0.7553	−30.43
43.54	126.11	−131.21	135.8	0.4981	−50.51	25.7	0.7641	−60.96
55.56	119.32	−37.60	132.9	0.8316	81.56	22.6	0.9544	−133.90

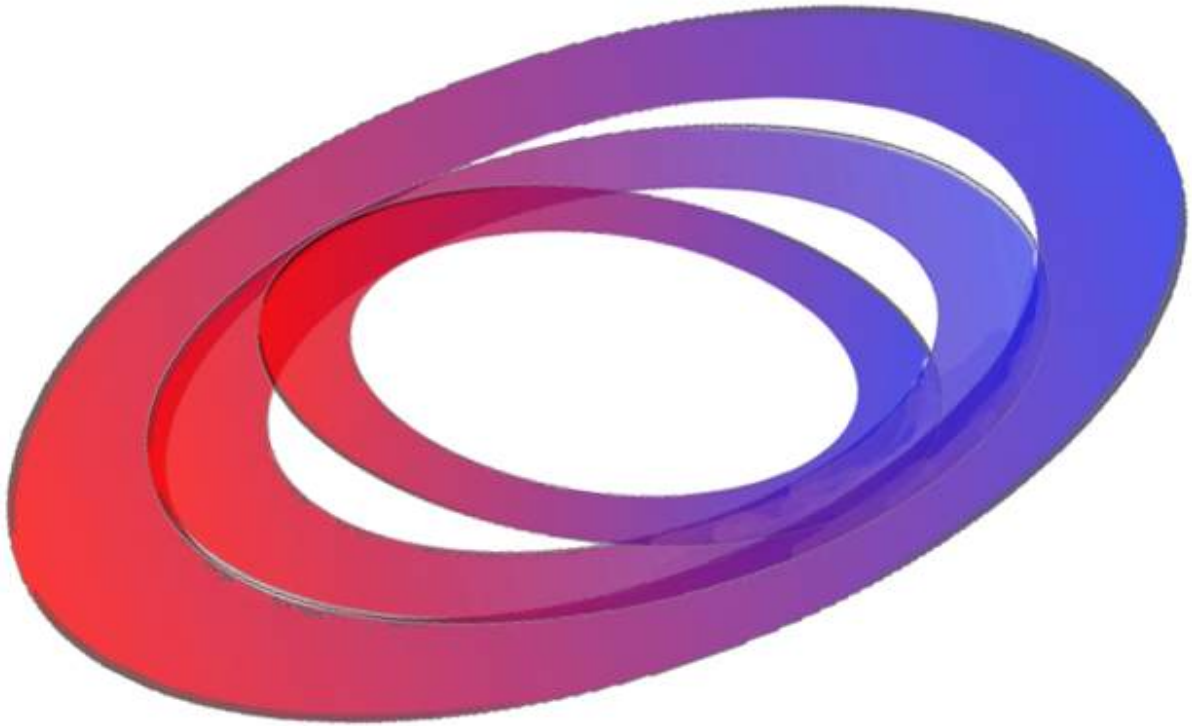
Table 1: Winning lottery numbers

Expanding Shells



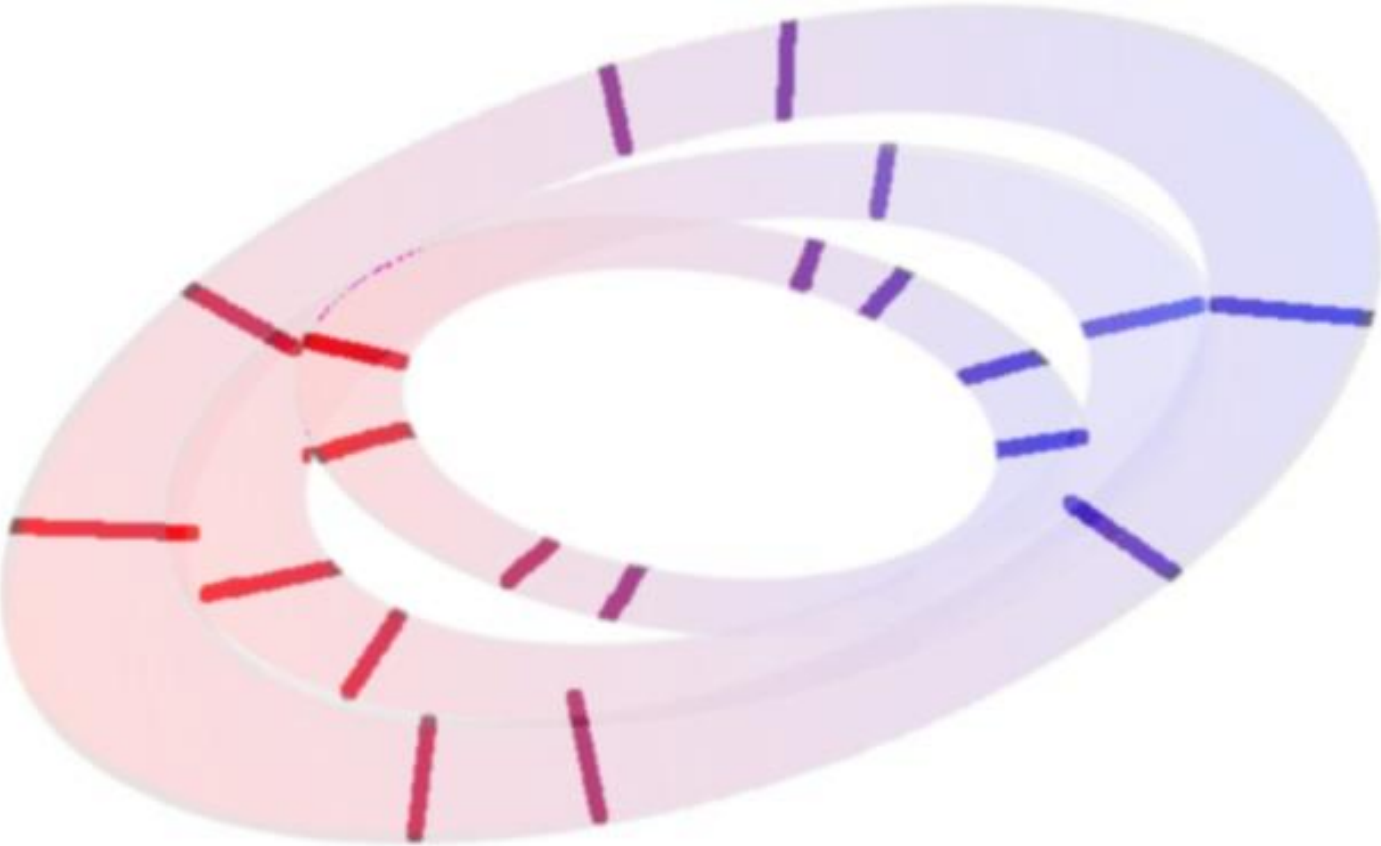


Spiral Galaxies



- There already are tilted ring model fitters,
- TiRiFiC, `http://www.astro.uni-bonn.de/~gjozsa/tirific.html` (G. Jozsa et al)

Spiral Galaxies



- The Fourier transform of a line segment is just a sinc.

Summary

- Model fitting is a particularly powerful way to combine data from multiple frequencies.
- Smear fitting does both deconvolution and model fitting.
- `http://www.cv.nrao.edu/~rreid/smerf/`