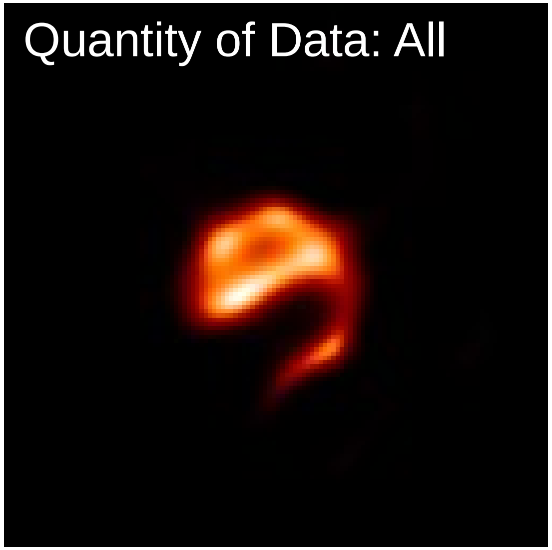
Finding Artifacts in Images

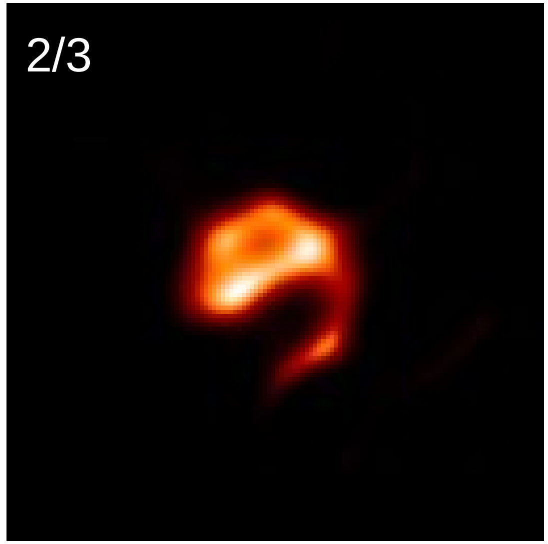
Brian Kloppenborg

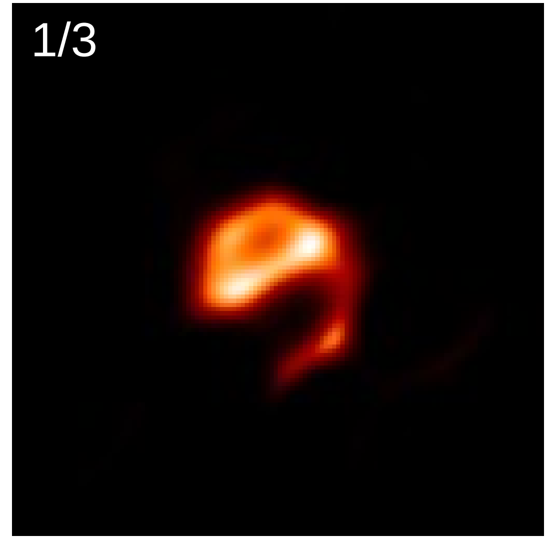
Types of artifacts

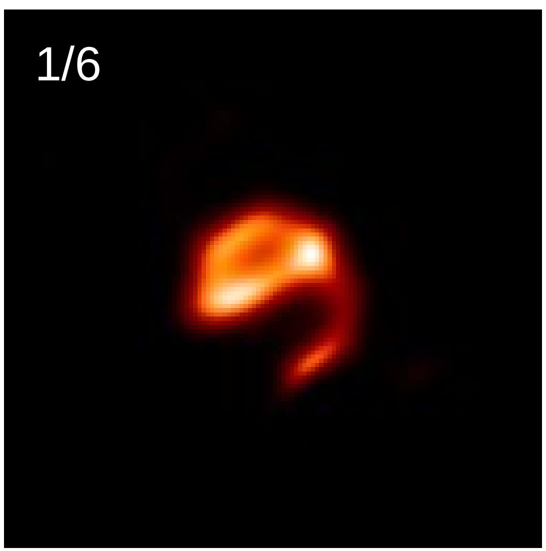
- In the data:
  - UV coverage
  - Calibration
  - T3 bleeds
  - Inflated V^2
  - Errors underestimated
  - Bandwidth smearing
  - Temporal issues
- User-error
  - Choice of regularizer
  - Hyperparameter values
  - Overly restrictive priors
  - Over fitting
- Reconstruction Engine
  - Fourier ringing
  - Flux calibration
  - Global vs. local minima

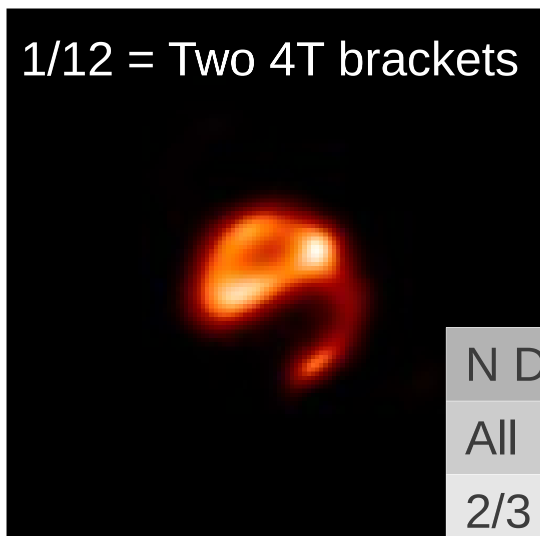
UV Coverage: How does it change the image?







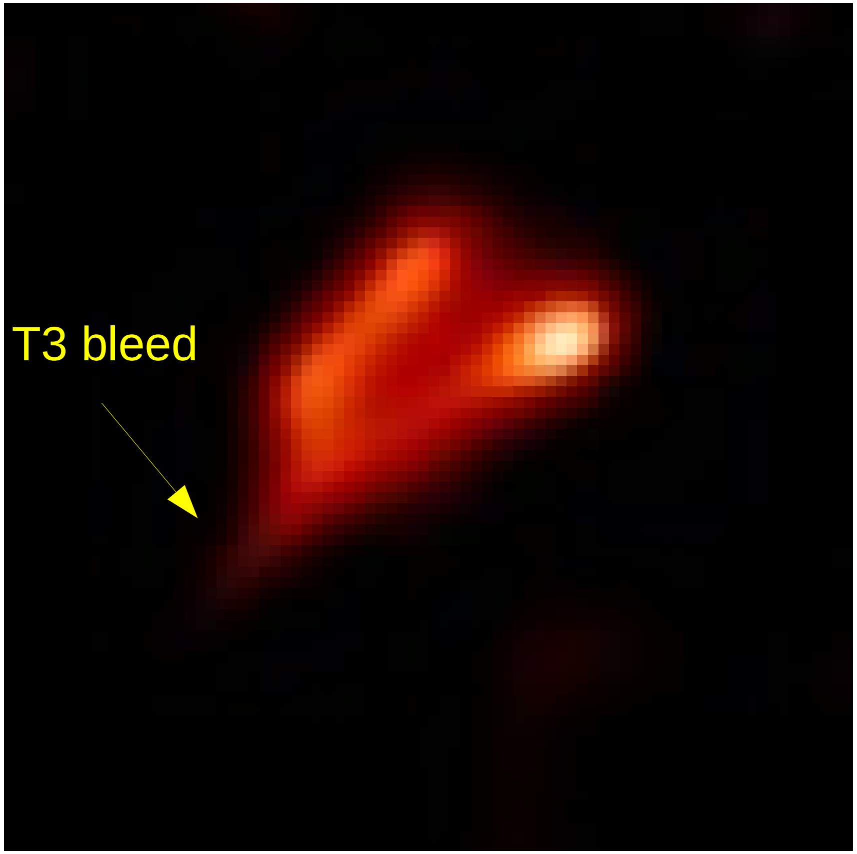




Less data can result in similar images, but beware that “better” chi^2 don't necessarily mean better images.

N Data	Reduced chi2
All	0.87
2/3	0.82
1/3	0.75
1/6	0.51
1/12	0.45

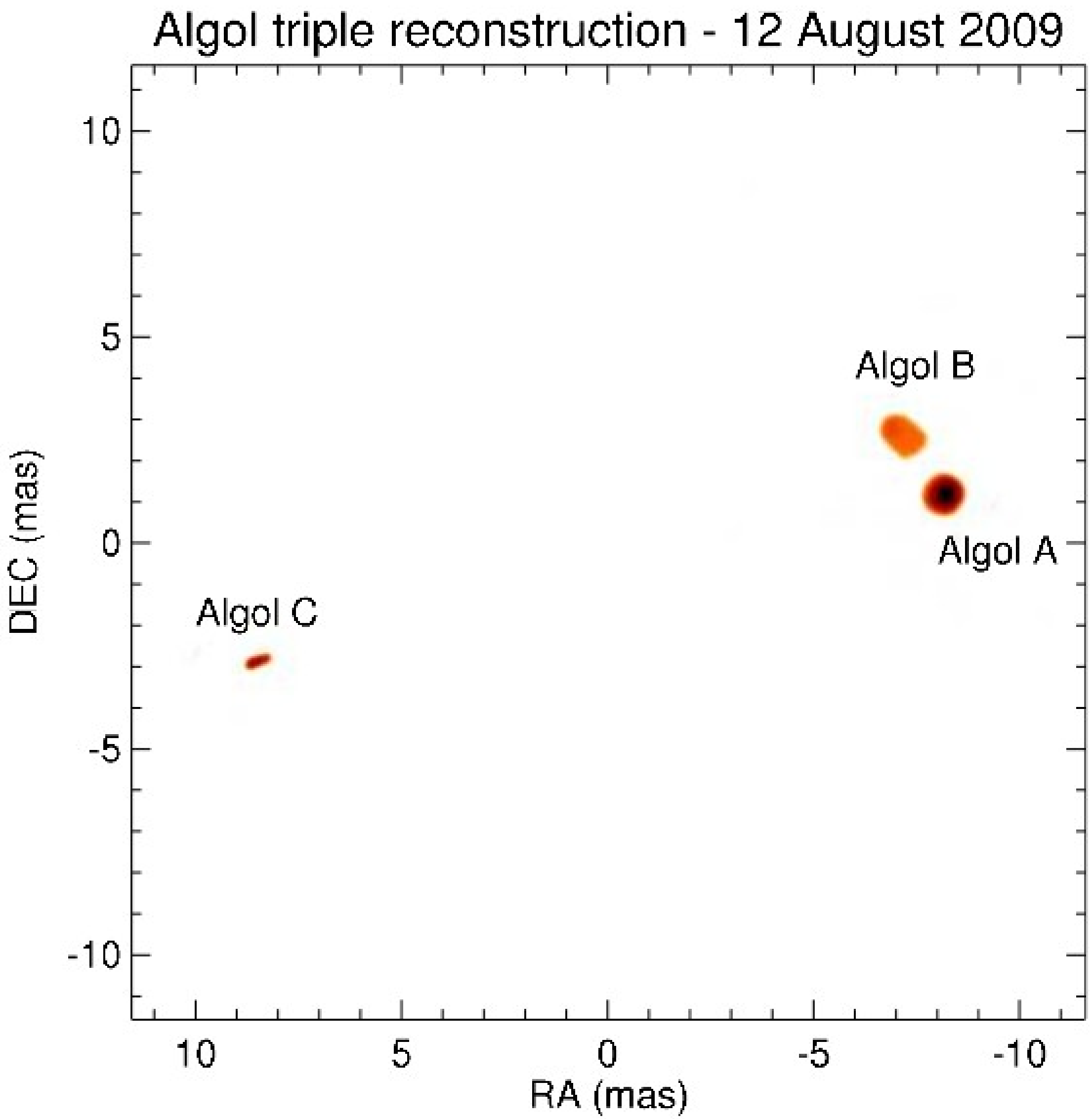
Problems in the data



2010-10

- Artificially high triple amplitudes (a.k.a. T3s) can result in odd artifacts. An example is shown to the left.

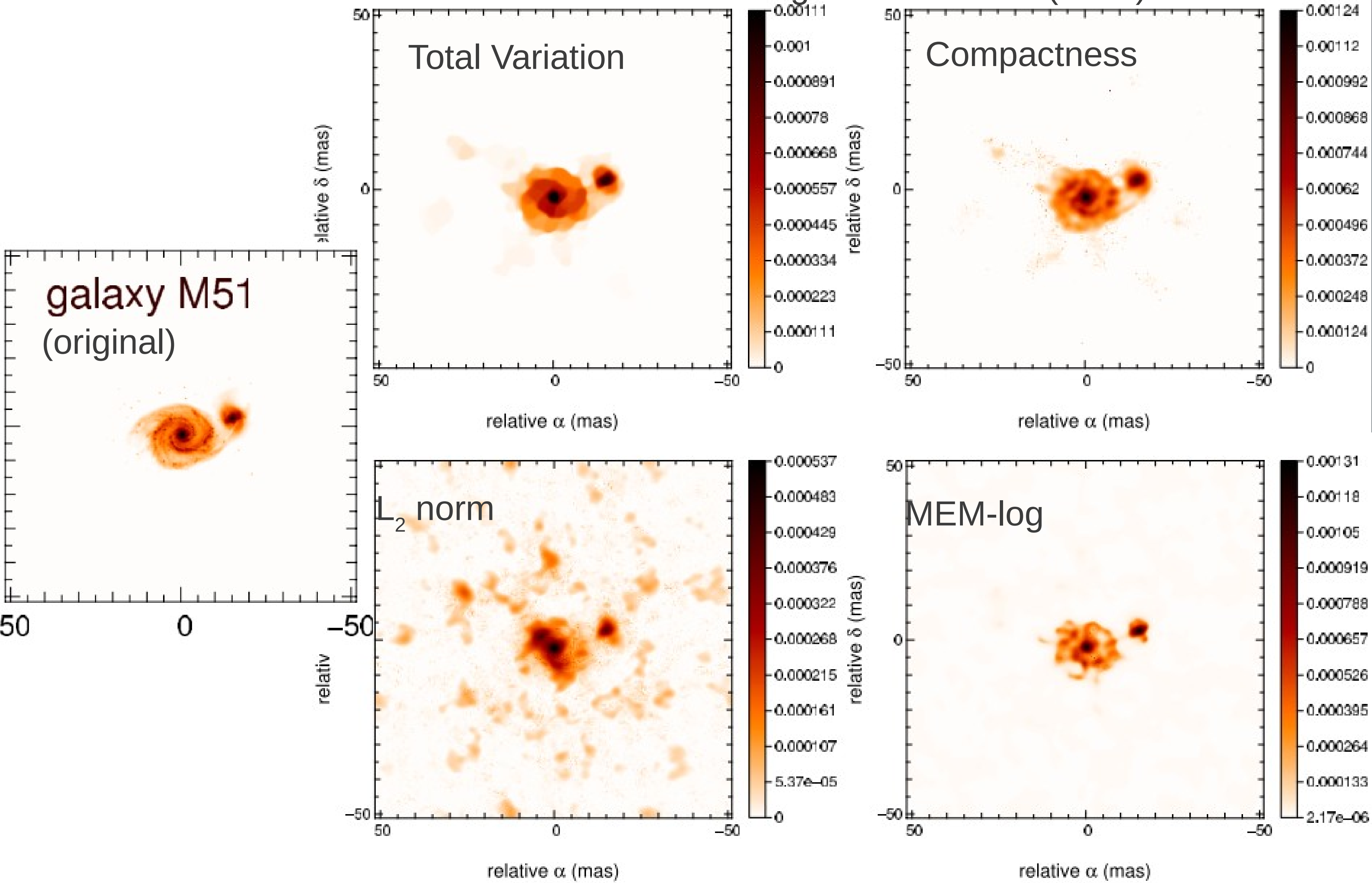
Problems in the data: Bandwidth smearing



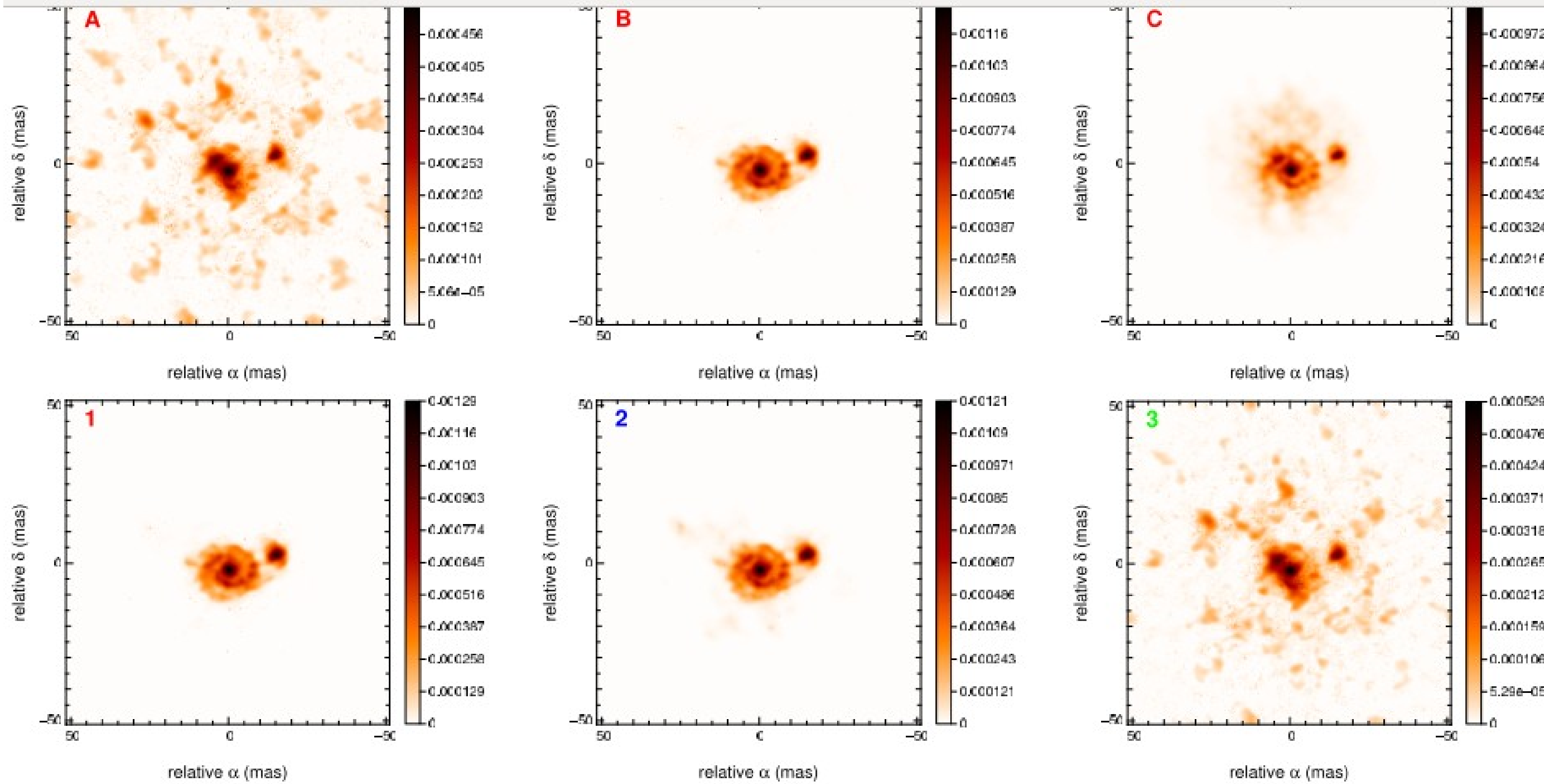
Bandwidth smearing can result in artificially elongated structures in reconstructed images. Algol C in this image from Baron (2012) features this artifact.

User error: Choice of regularizer

Choosing the “wrong” regularization function can result in artifacts and unphysical flux distribution. See discussion and these figures in Renard (2011).



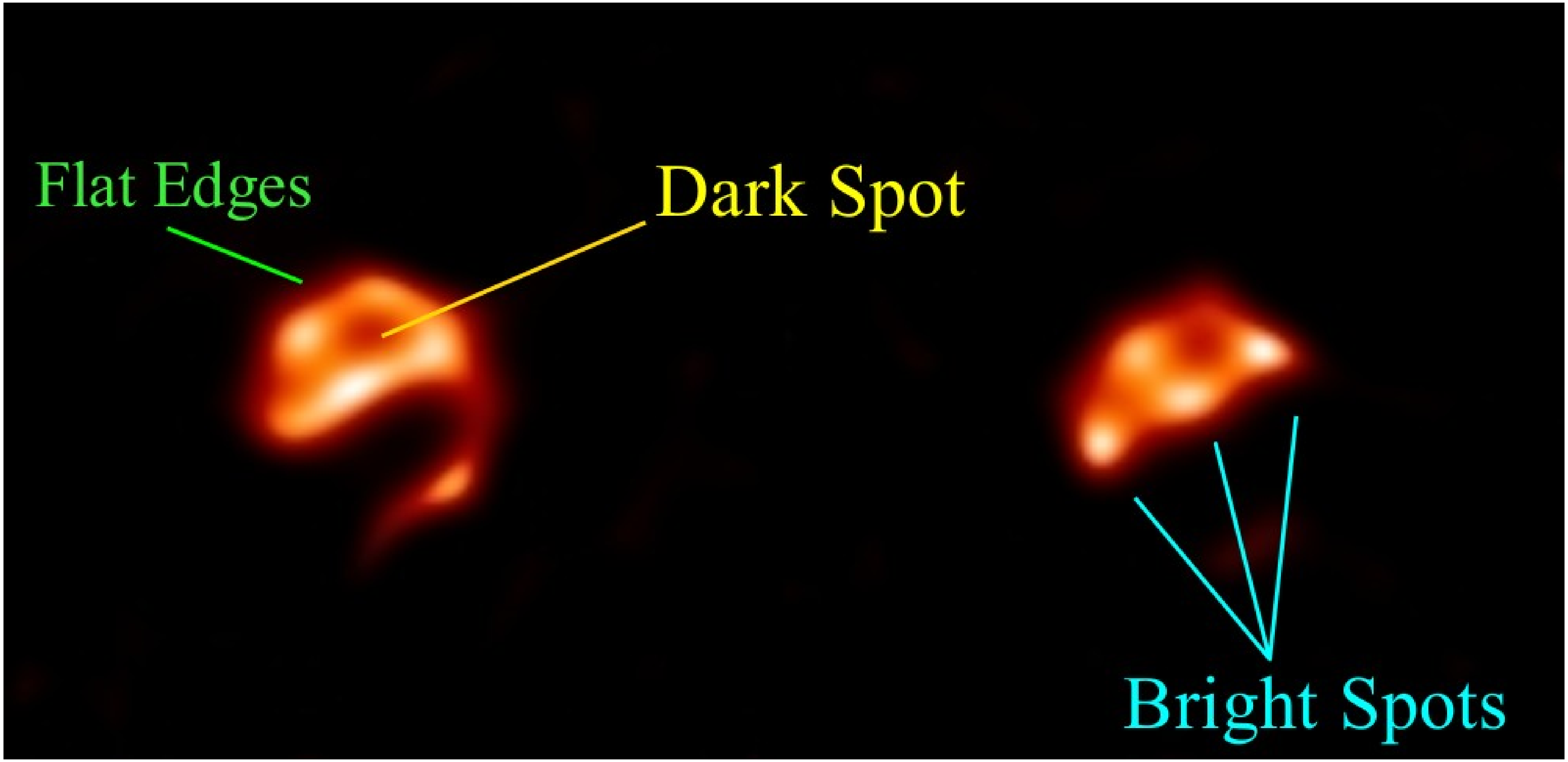
User-induced errors: Regularization weights



Even if the “right” regularization function is picked, the user's choice of the hyperparameter can significantly alter the resulting image.

All reconstructions using MEM regularizer, hyperparameter varies
See Renard (2011 A&A 533) for more information

Examples: My work on epsilon Auriage

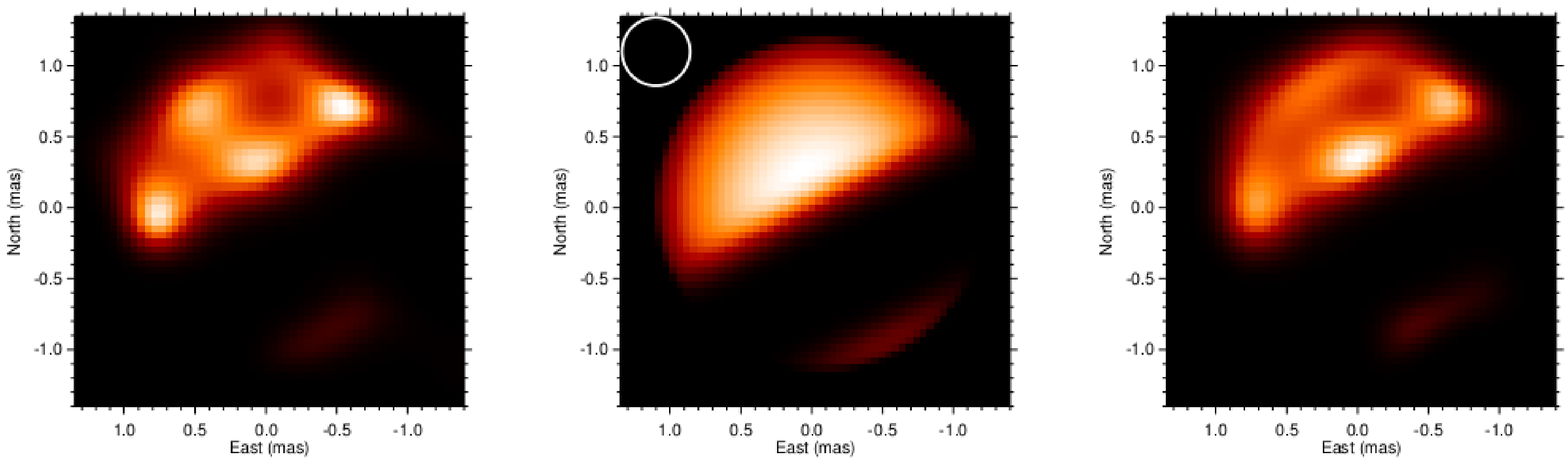


- Edges due to UV sampling?
- Dark spot in northern hemisphere an alias of disk?
- Bright spots real?
- Polar cap trustworthy?

How can you test for artifacts in your images?

- Create (simple) model of object, save FITS image
- Sample model image with same UV coverage as original data
- Redistribute nominal values following Gaussian distribution w/ real (or predicted) data uncertainties
- Export "fake" data to OIFITS format
- Reconstruct model image from fake data
- Compare model, fake, and real images

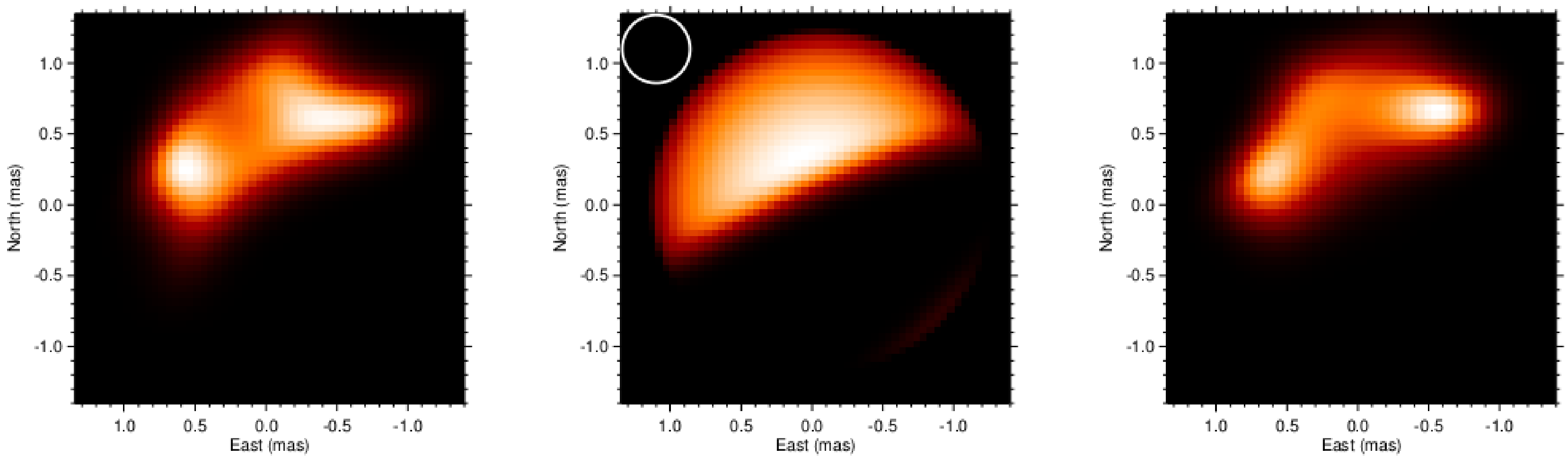
Example of method



(a) Real Image (b) Model (c) Simulated Image

- Spots on equator and dark spot in northern hemisphere not in model → artifacts.
- Southern pole present in model, simulation, and real image → likely real
- Bright spot in northern hemisphere of real image. Not present in model or image. Possibly an additional real feature, but more testing needed.

Example of method

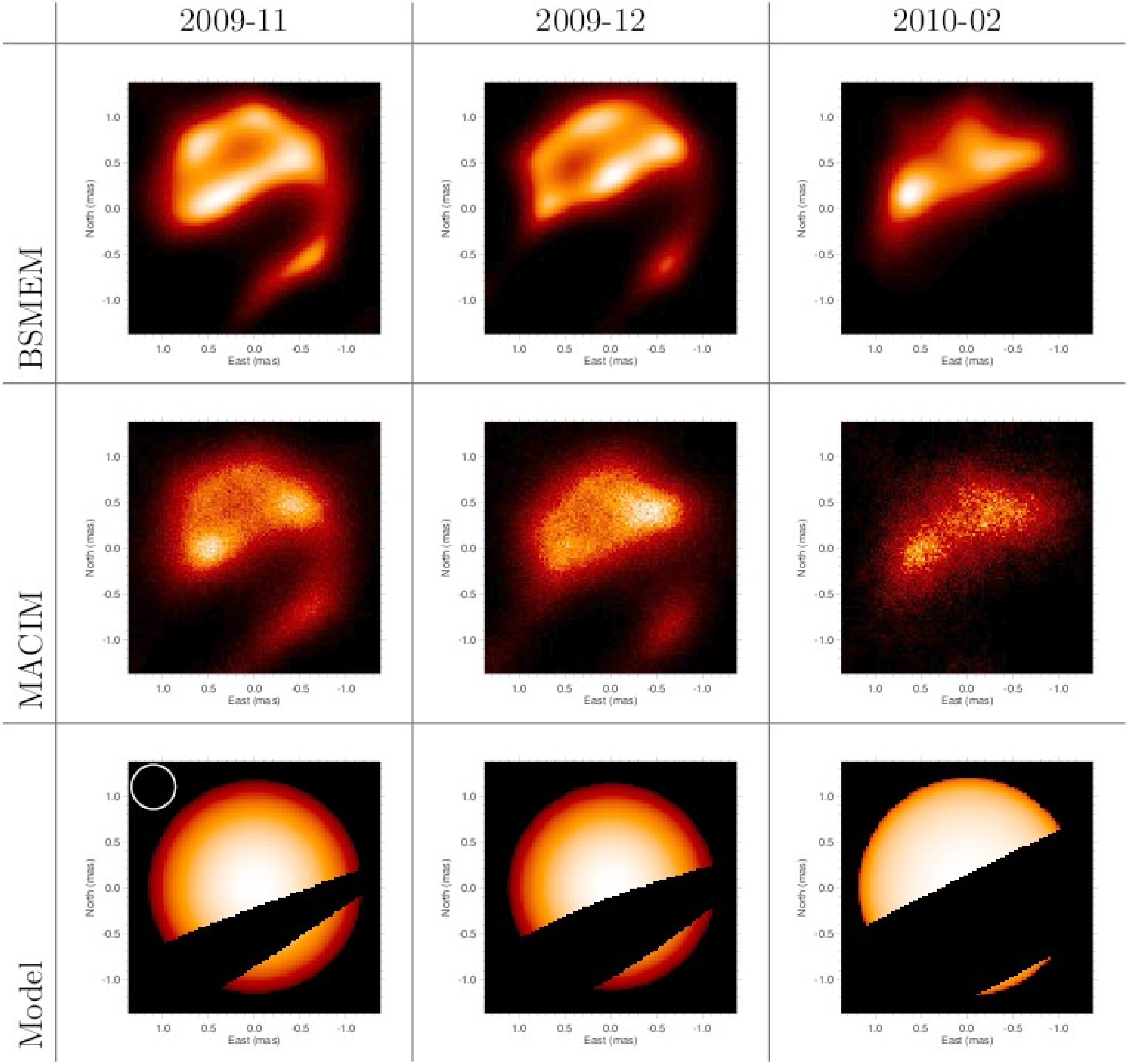


(a) Real Image (b) Model (c) Simulated Image

- Should the absence of the southern pole in the real image be regarded as significant?
  - Shows up in model, but no in simulation

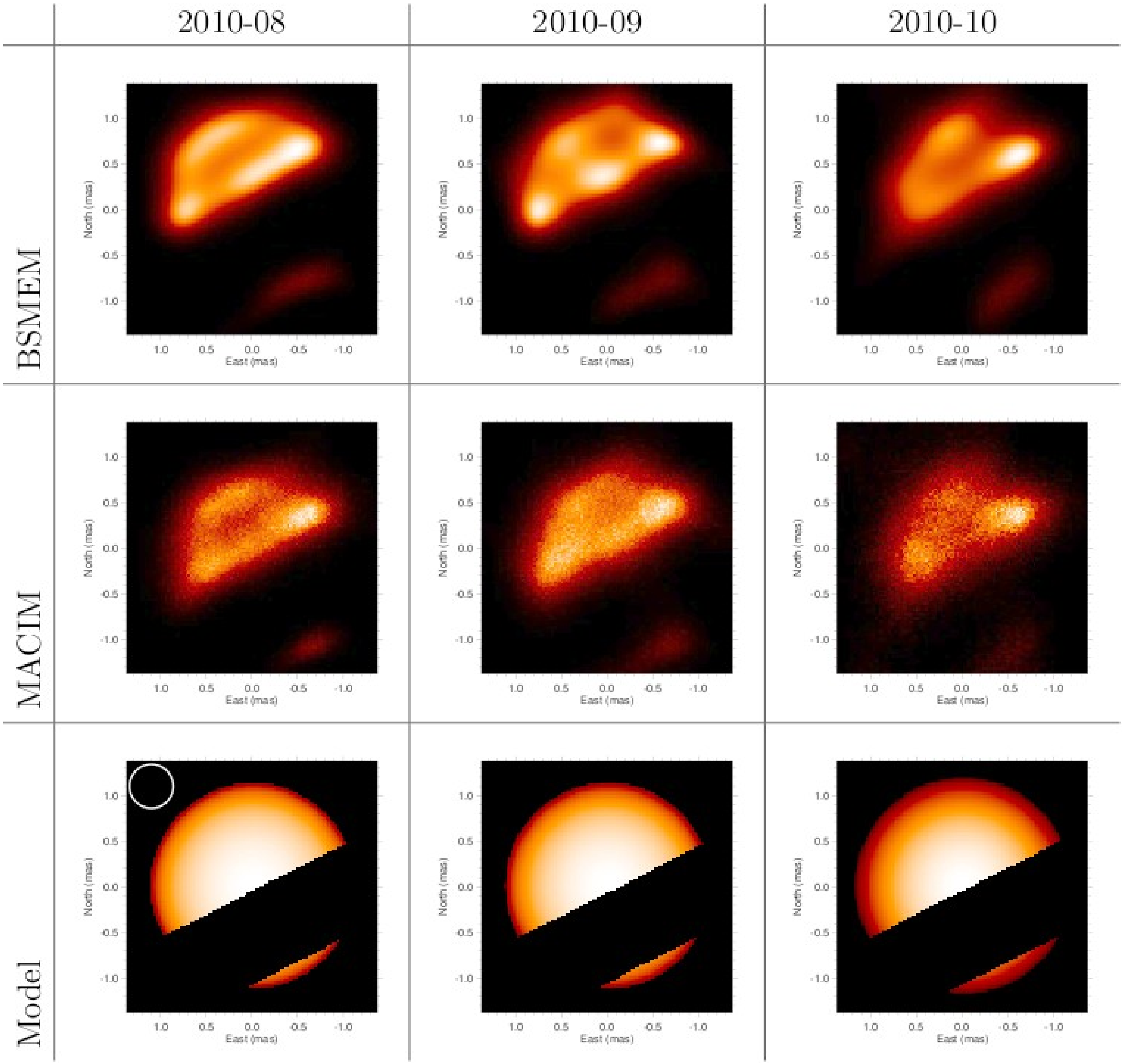
    →probably inadequate sampling to detect it's presence, so the “lack” of this feature shouldn't be given much consideration.

Examples: Spot the artifacts

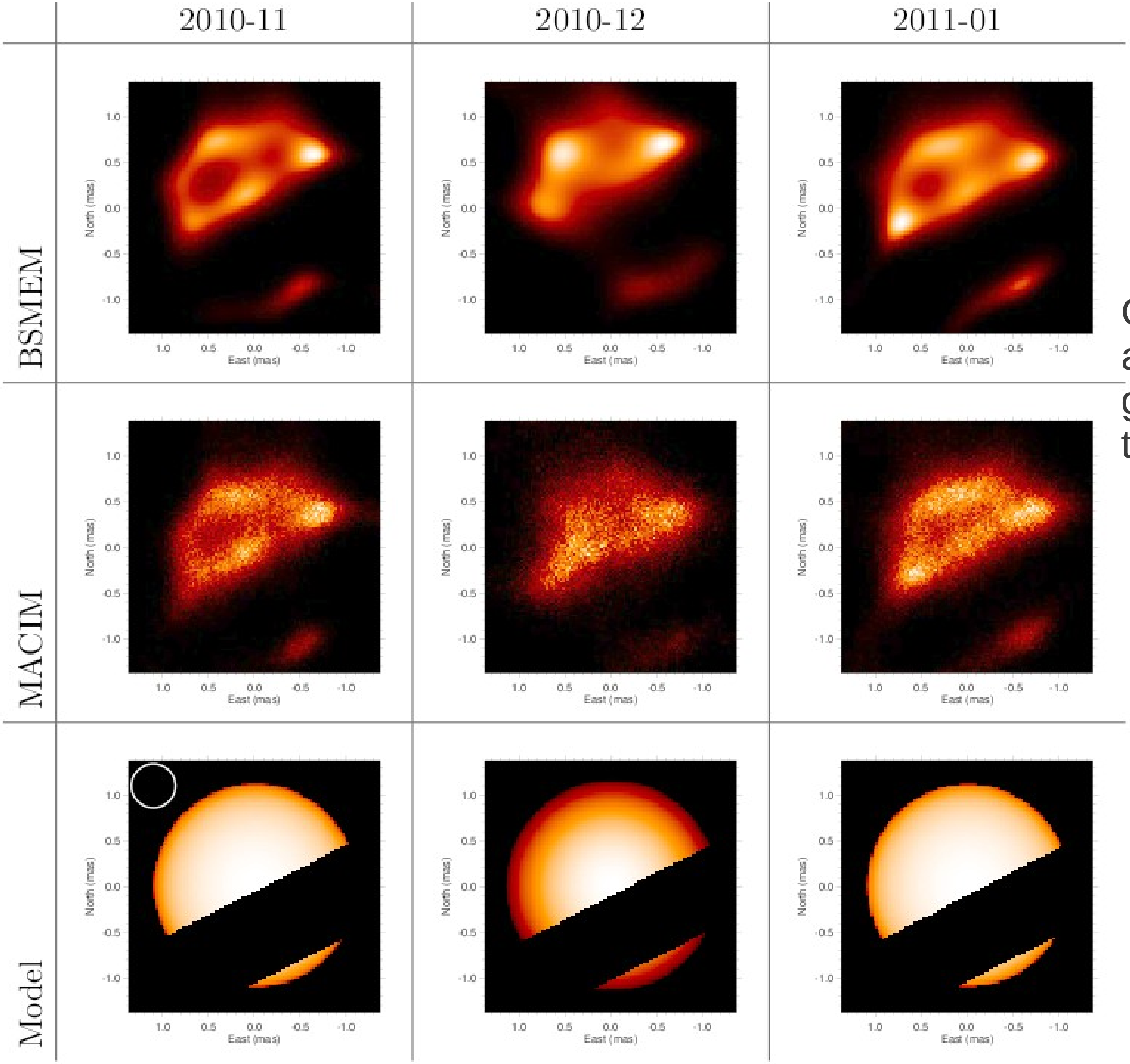


MACIM images have too few elements to produce reliable images

Examples

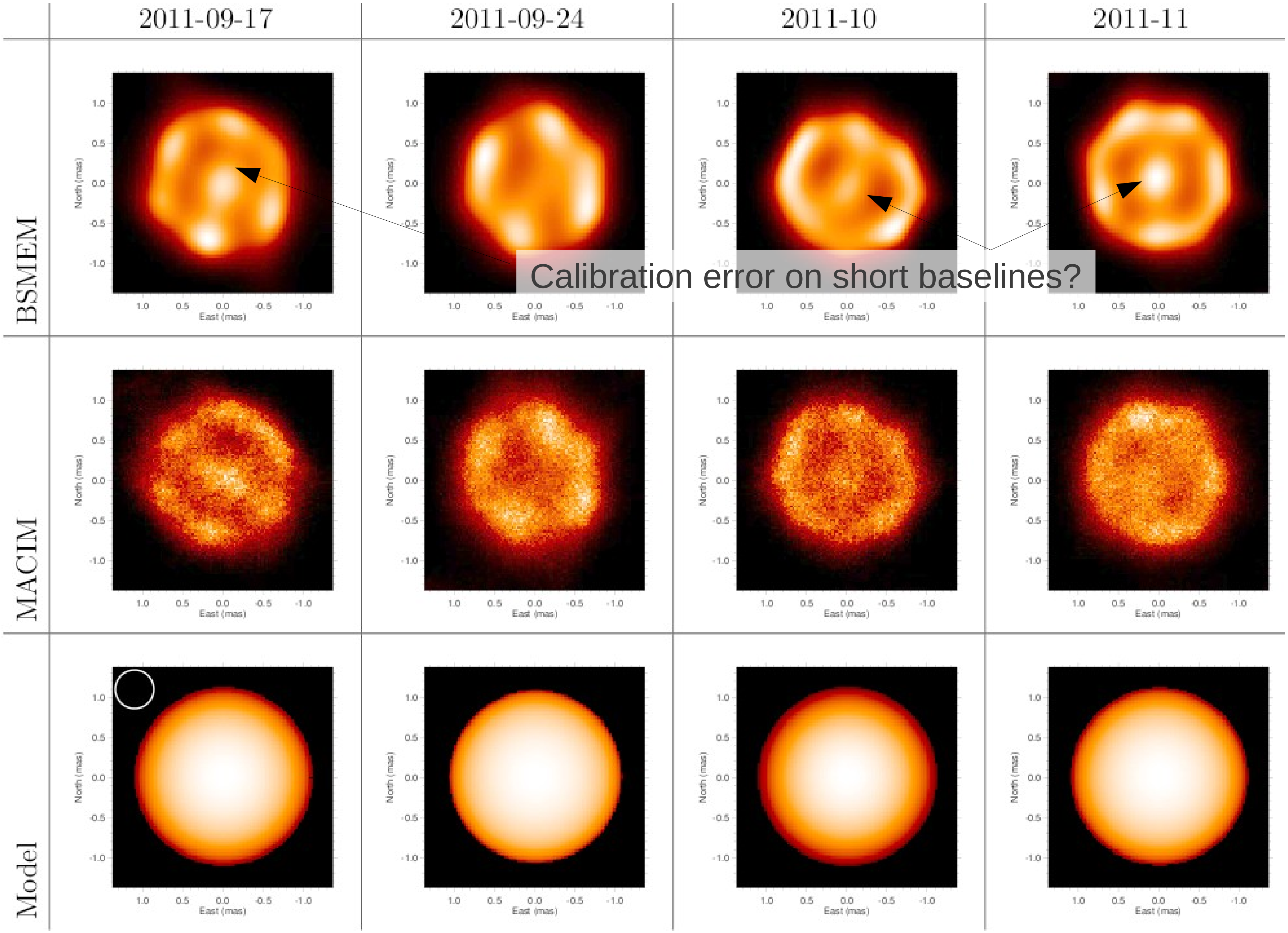


Examples

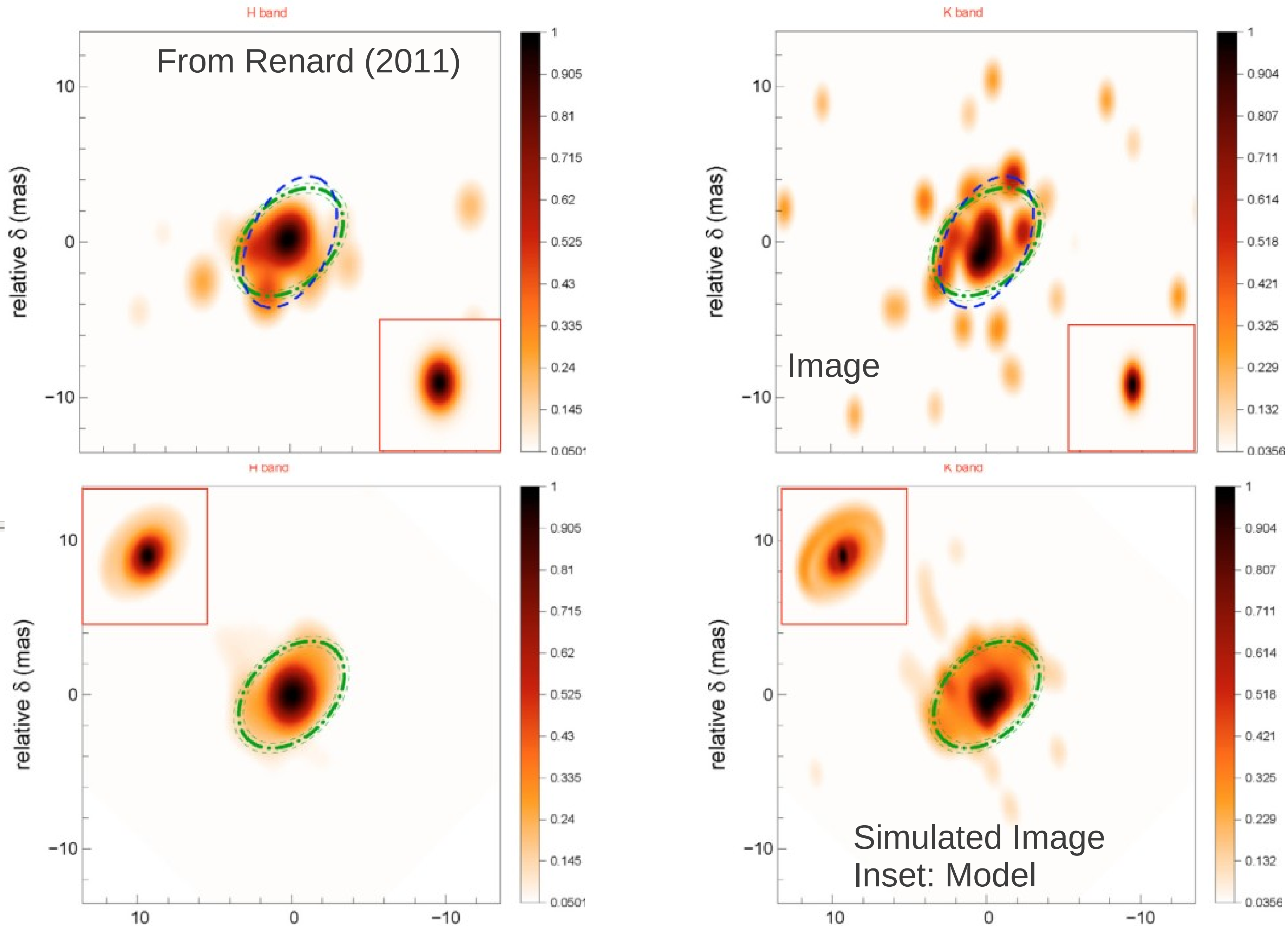


Comparing MACIM and BSMEM images gives some confidence to common features.

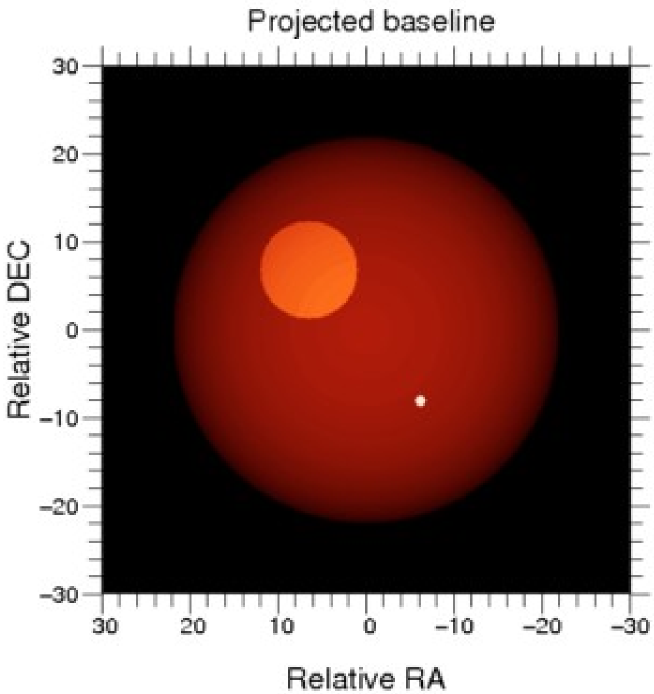
Interferometric Images and Models

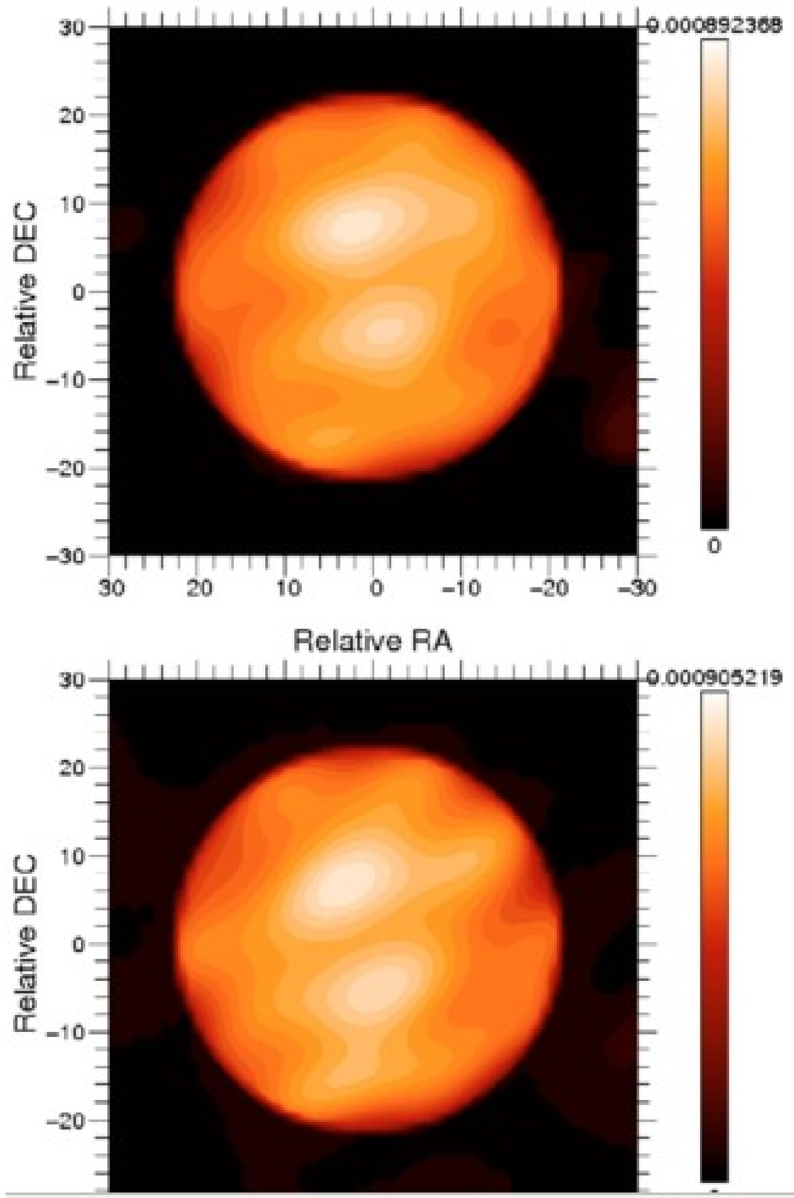


Examples: Stray flux



Examples





Betelgeuse
From Haubois (2009)
Model chi2_r: 15
Image chi2_r: 5.7, 4.7

With such bad fits, are any of these really trustworthy?

Conclusion

- Closely inspect your data, look for bad/odd data points
- Try many different regularizers, hyperparameters.
- Be skeptical of your images!
- Simulate your observations.