An interpolation/extrapolation method for imaging from visibilities in RHESSI

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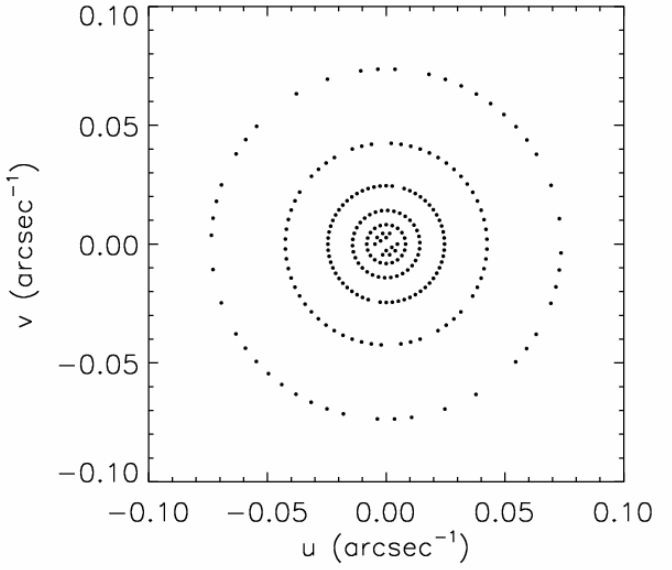
Methods for **I**mage and **D**ata **A**nalysis

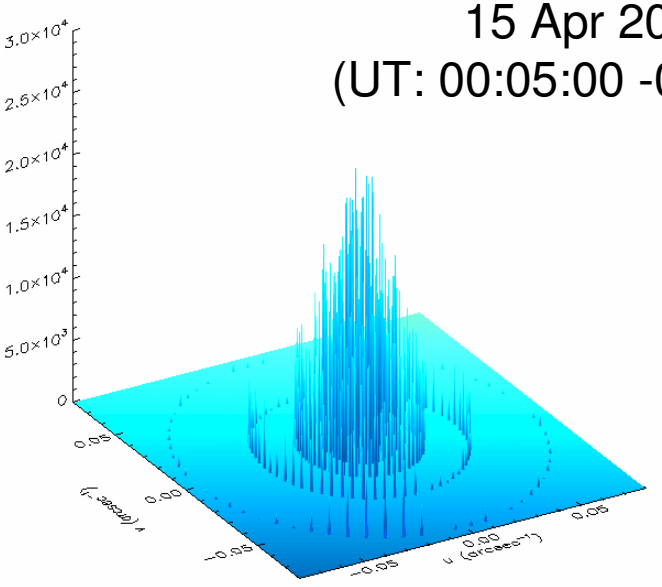
Imaging from visibilities in RHESSI

• **RHESSI** employs a Rotating Modulation Collimator (**RMC**) technique: rapid time variations of the detected counts are induced by the presence of 9 different grids (characterized by specific pitches) in front of 9 different detectors.

• This observed temporal modulation is interpreted in terms of **measurements of specific spatial Fourier components of the radiation emitted**

• These Fourier components, termed **visibilities**, are measured at **spatial frequencies** *(u,v)* corresponding to the angular resolutions of the various RMCs.





15 Apr 2002
(UT: 00:05:00 -00:10:00)

Visibility-based imaging algorithms in RHESSI

$$V(u,v;\varepsilon) = \mathcal{F}(I(x,y;\varepsilon))$$

$$I(x,y;\varepsilon) = \mathcal{F}^{-1}(V(u,v;\varepsilon))$$

Images of the flare can be obtained by performing an inverse Fourier transform on this visibility information

Backprojection

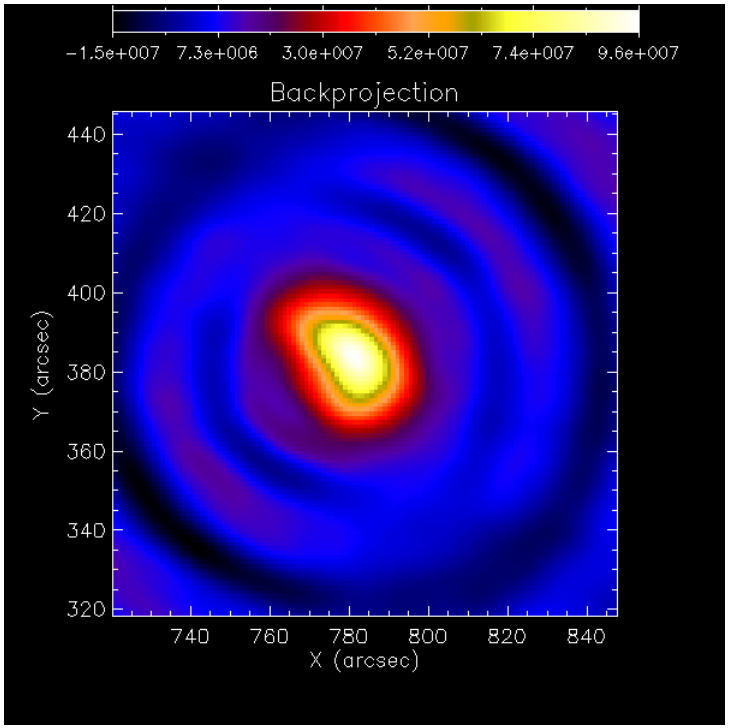


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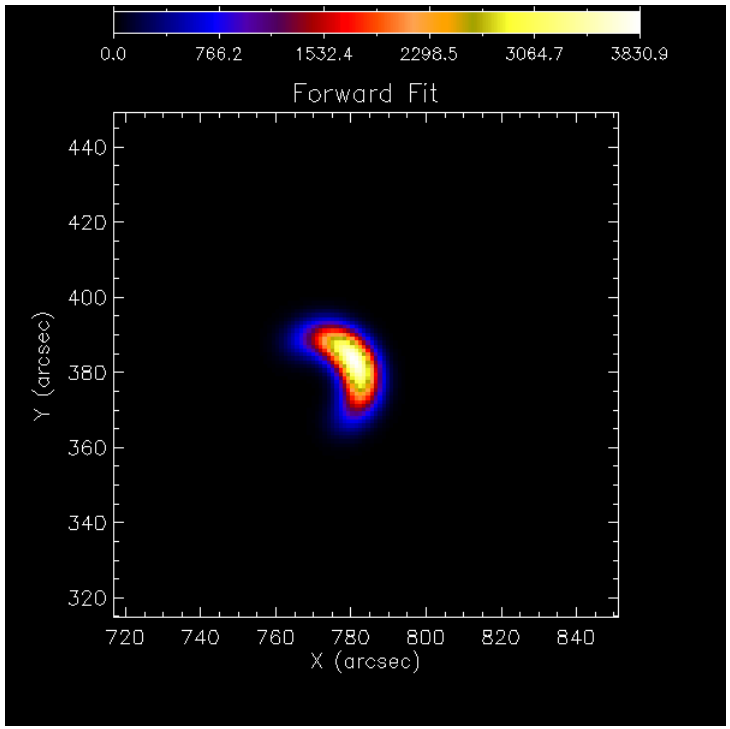
Image quality is compromised by the sparsity of the discrete set of visibility component.

Visibility-based imaging algorithms in RHESSI

FORWARD-FIT



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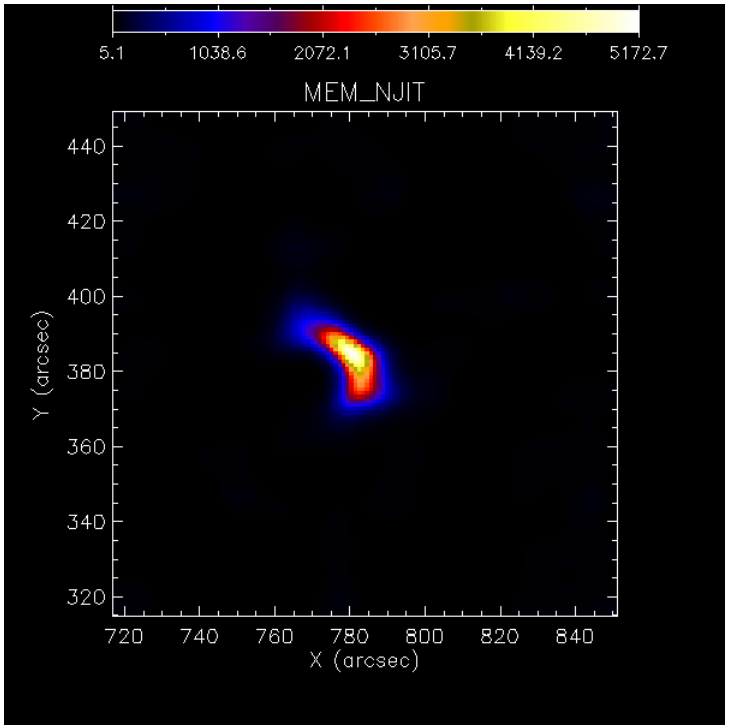
MEM-NJIT



Interpolation algorithm

It is therefore desirable to *generate* visibility information, both **within** and **outside** the disk in (*u,v*) space spanned by the available data.

Information **within** the disk can be obtained by a smoothed **interpolation** procedure.

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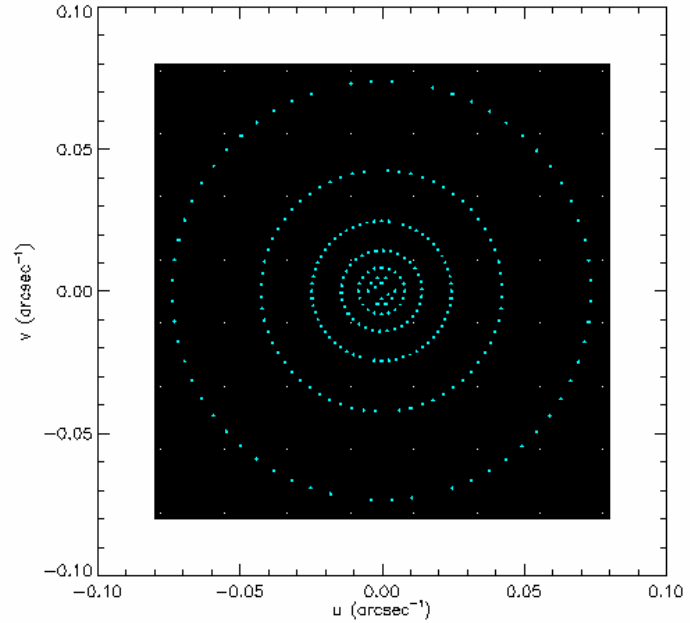

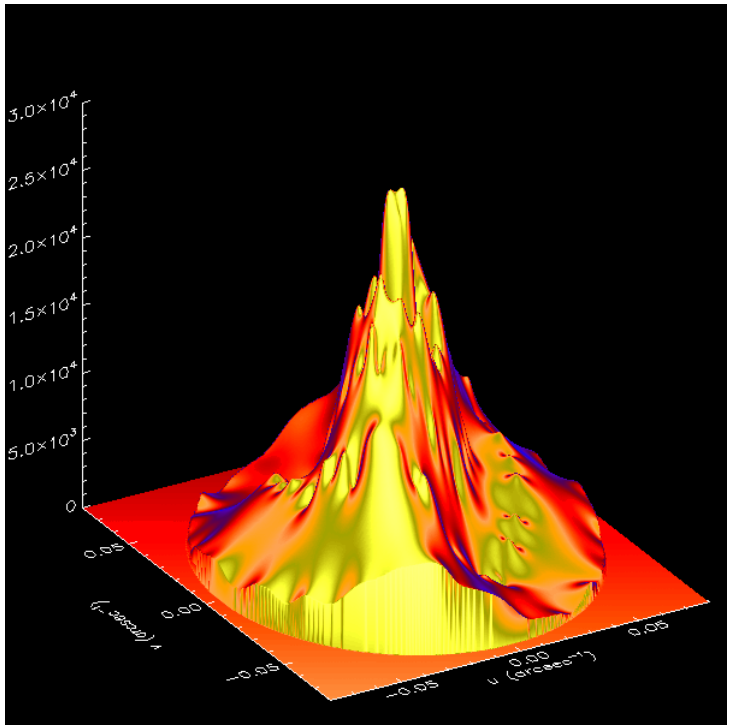

The idea is to use the FFT2D algorithm on the smoothed visibility surface produced by the interpolation algorithm

Interpolation + FFT algorithm

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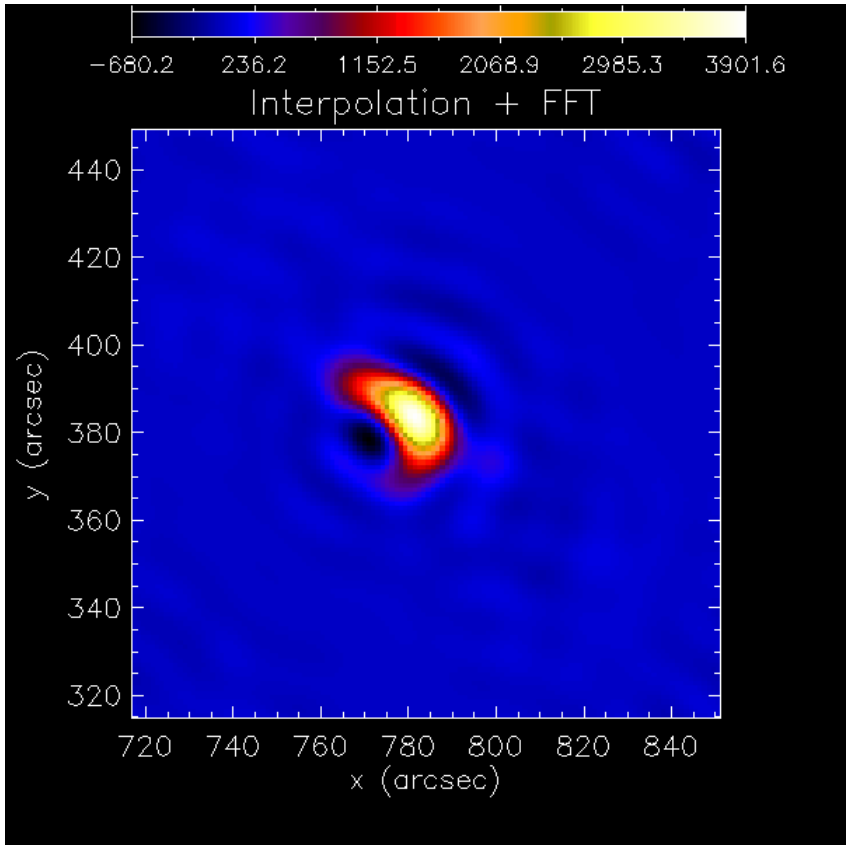

Drawbacks:

- the reconstructed map shows a ringing effects around the source
- the recovered flux assumes unphysical negative values

To remove ringing, some constraint based on a priori information on the solution must be introduced

Example: **projected Landweber method** with positivity constraint.

This method reduces these drawbacks
and
seeks for out-of-band extrapolation

Interpolation + extrapolation algorithm

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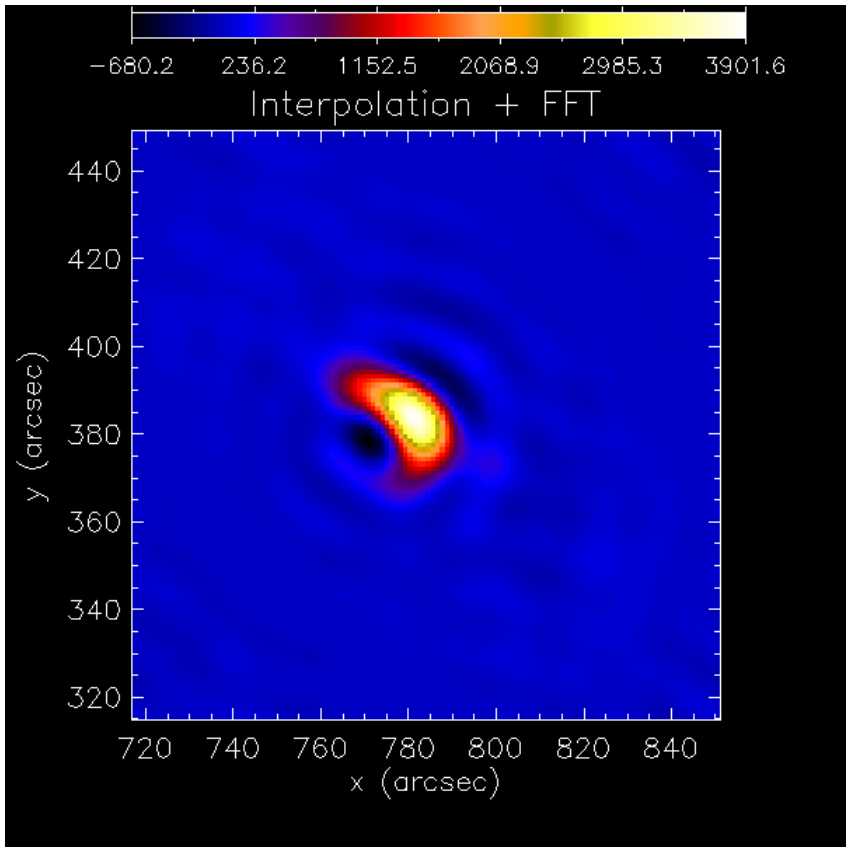

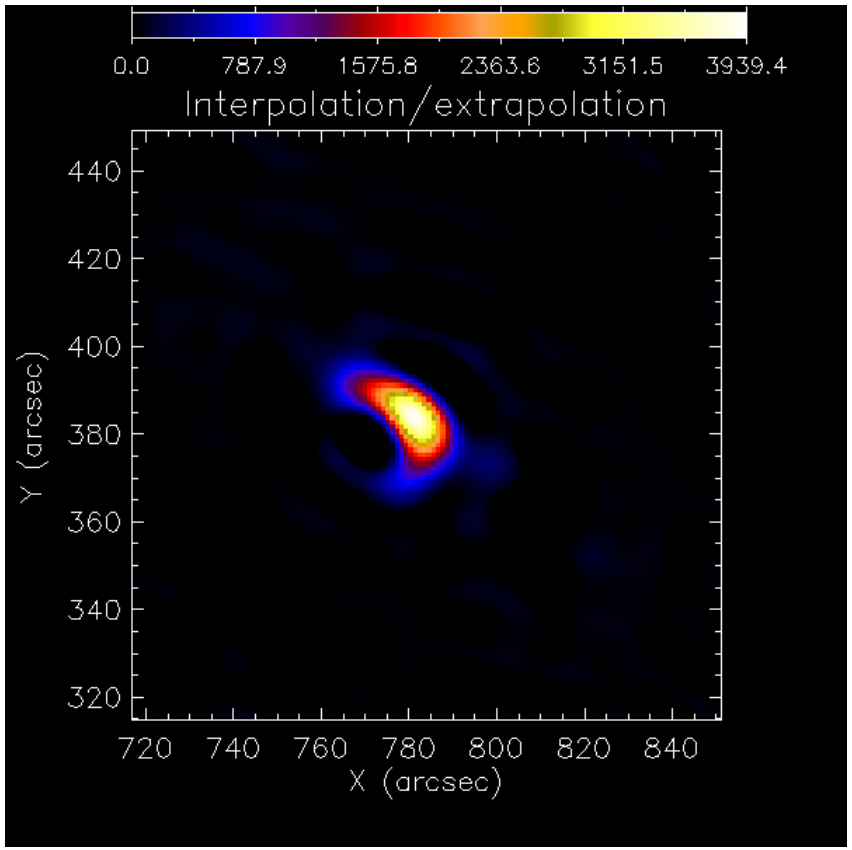

All results at a glance

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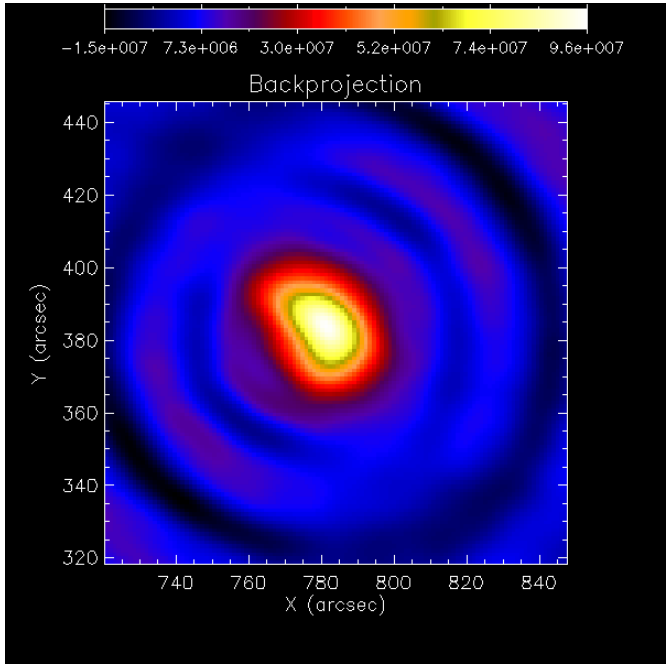
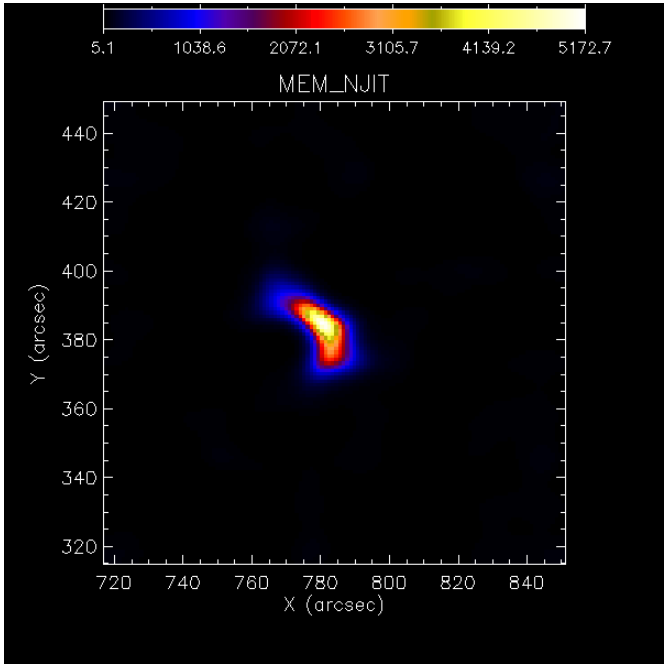
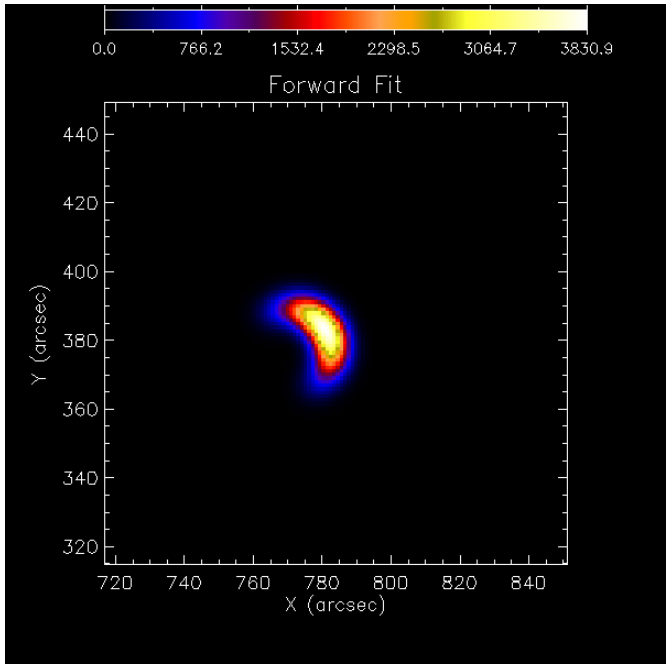
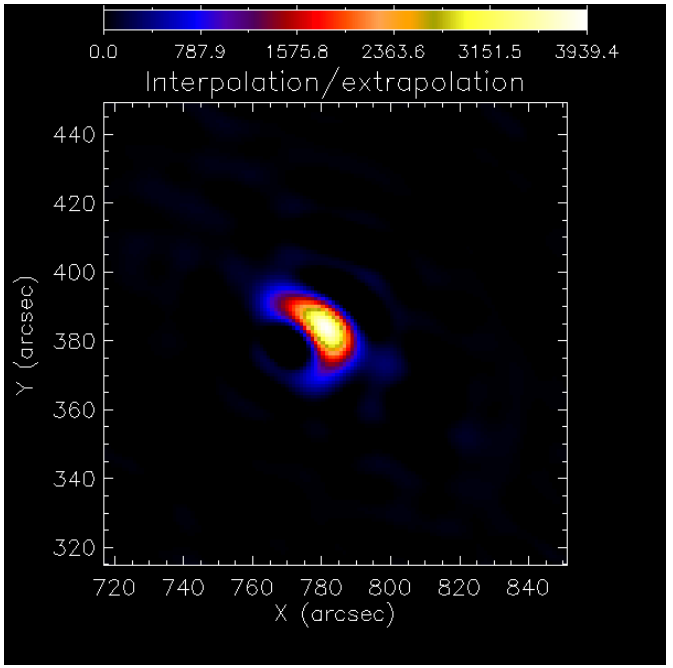








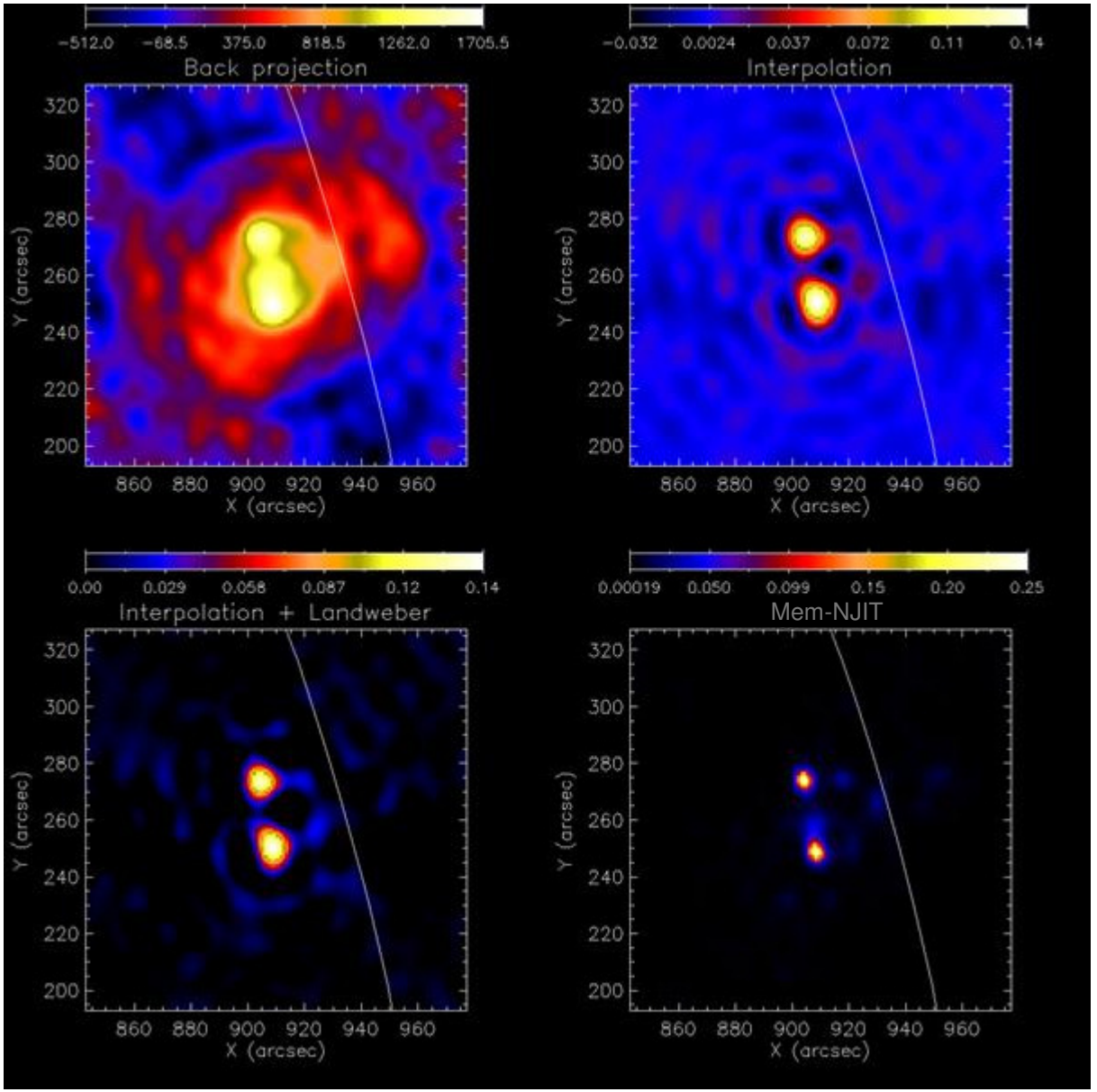
Validation of the interpolation/extrapolation algorithm

Testing the method using simulated data

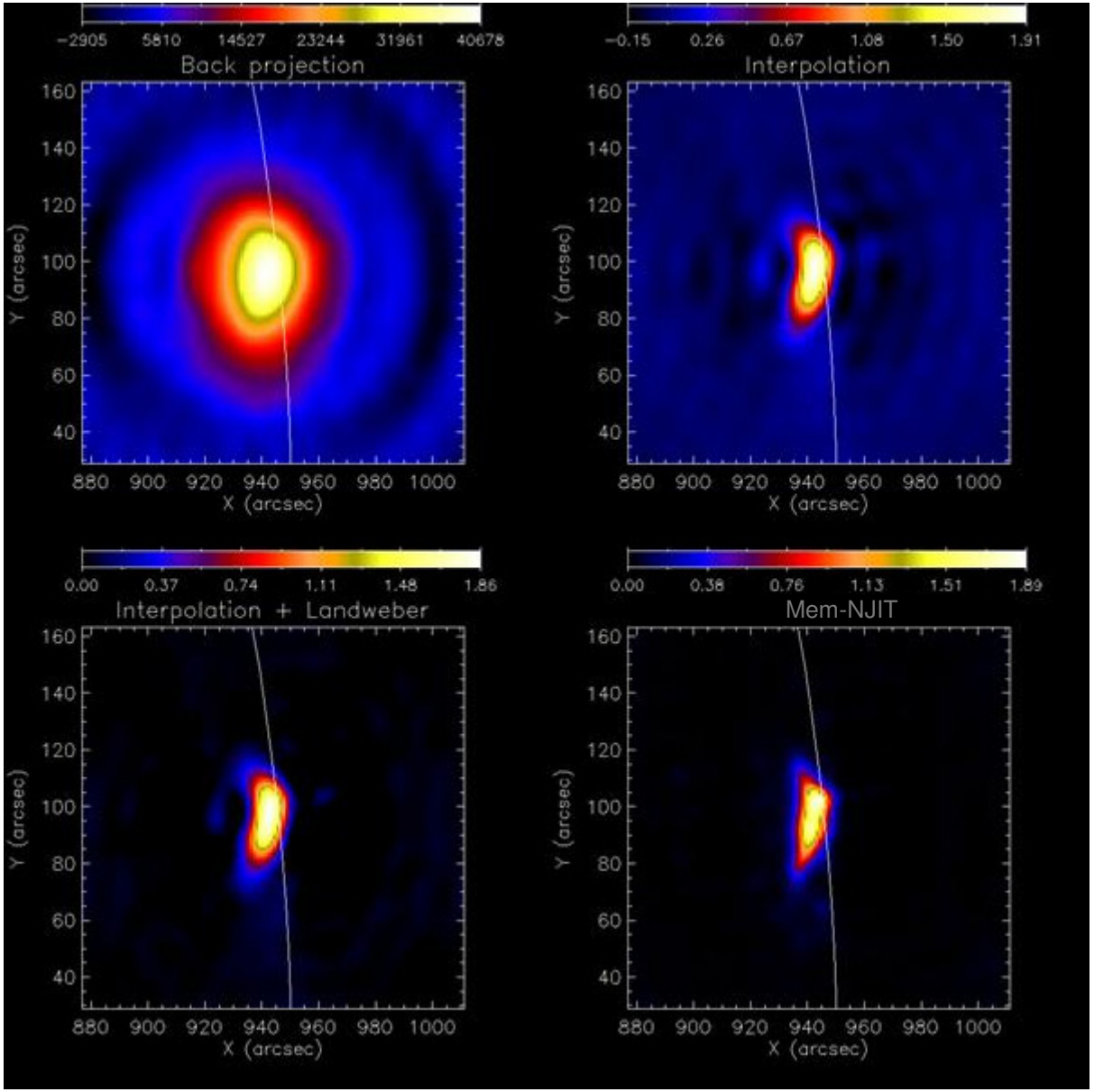
We tested the effectiveness and the resolution power of the interpolation/extrapolation method in the reconstruction of:

- single sources with different size
- double footpoints with increasing brightness ratio
- double footpoints with different size
- double footpoints with decreasing distance
- extended sources

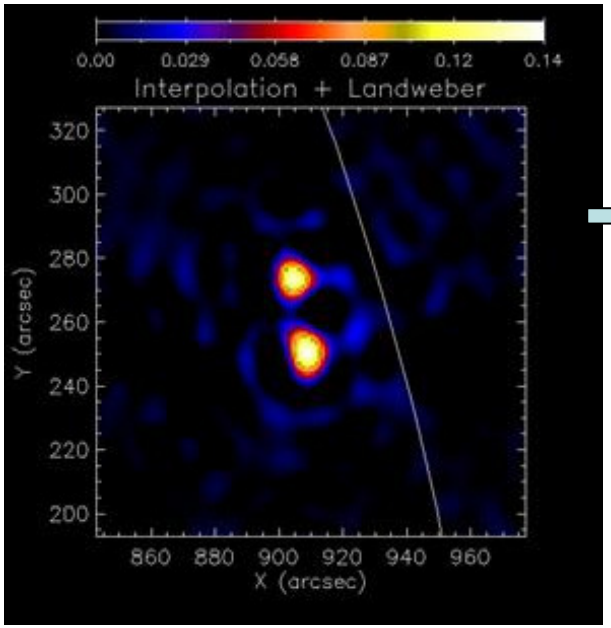
More applications to real data (2002 Feb 20, 11:06:02 – 11:06:34)



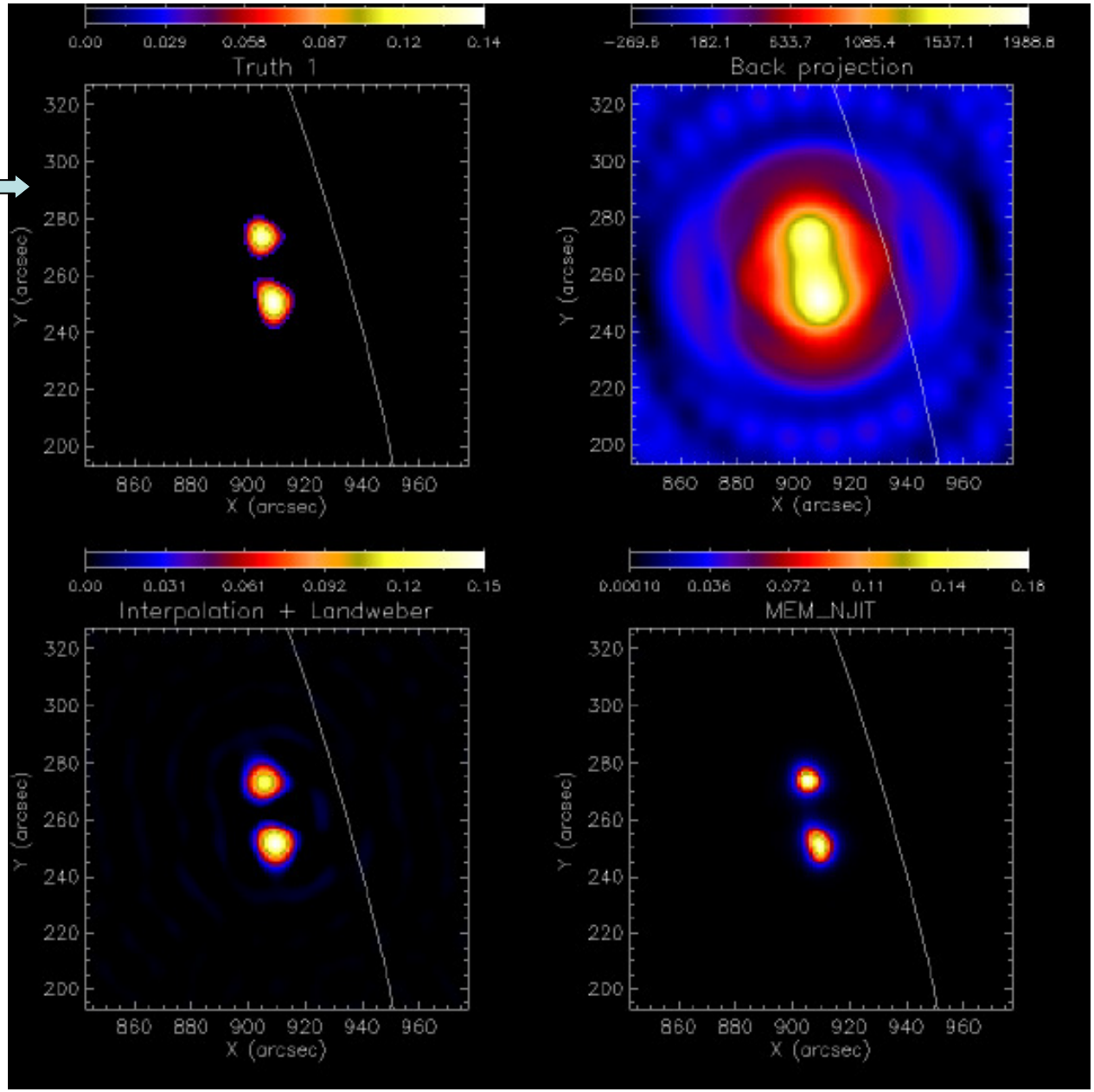
More applications to real data (2004 Aug 31, 05:33:00 – 05:38:00)



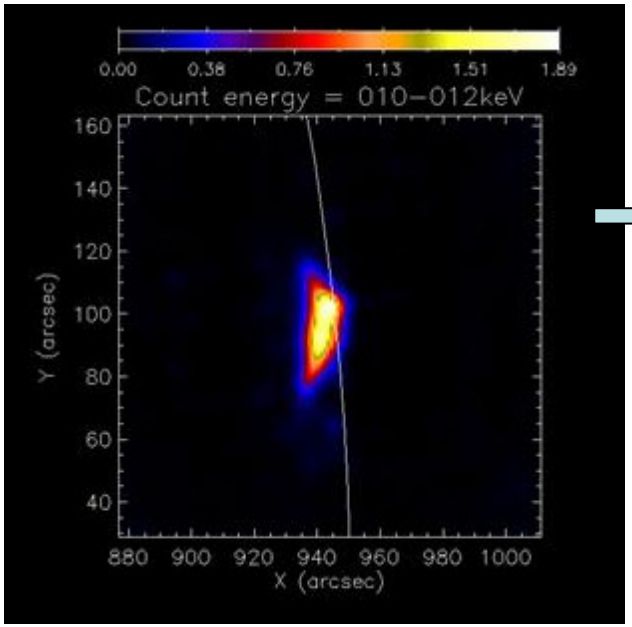
Truth test I (2002 Feb 20, 11:06:02 – 11:06:34)



The truth is the interp/extrap reconstruction thresholded at 20% of the peak value.



Truth test II (2004 Aug 31, 05:33:00 – 05:38:00)



The truth is the MEM_NJIT reconstruction thresholded at 20% of the peak value.