Memo Re: Masking Frequency Bands of Bursts

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This memo investigates the effect of gaussian fitting in the autocorrelation space of FRB burst data under the removal of a band of frequency data.

1 Band Removal ON Burst Centre

In this section we remove a band of frequencies from the centre of a burst. A sample burst (with noise), as well as its banded, squeezed, and autoconvolution processed image (of the squeezed burst) are shown below.

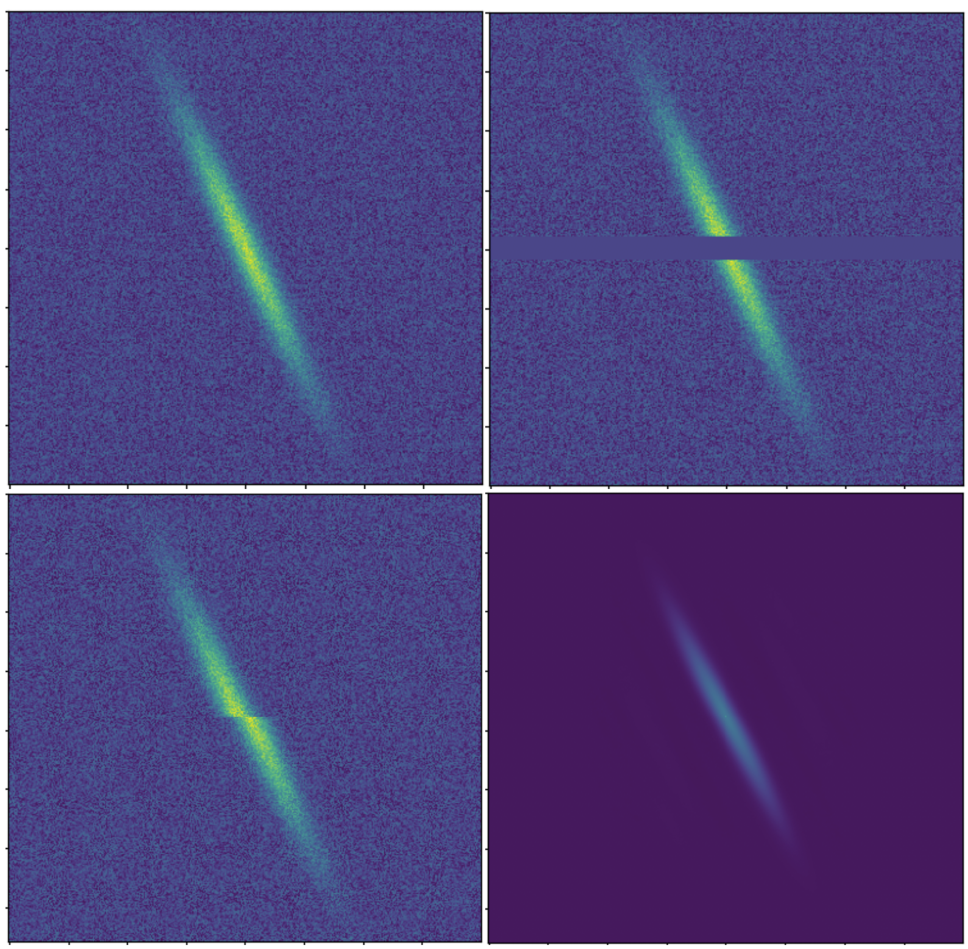

Figure 1: In book-reading order: Original burst, band-masked burst, squeezed burst, and autoconvolution processed image (of the squeezed burst).

1.1 Methodology

We will use three gaussian fitting approaches:

1. **Continuous domain fit on autoconvolution**. In this approach, we squeeze down the data to remove the missing frequency band, we perform an autoconvolution on the result, and we fit a gaussian to the result *under the assumption that the domain is continuous*. This technique differs from the next, in that the fitter assumes that the domain is continuous and isotropic in its x- and y-coordinates.

2. **Discontinuous domain fit on autoconvolution**. In this approach, we also squeeze and autoconvolve, but we fit a gaussian to the result *while providing knowledge to the solver that the y-coordinate possesses a discontinuity of the band width.* That is to say, the solver is aware that the y coordinate "jumps" when passing through the centre of the image, and evaluates its fitting gaussian accordingly.

3. **Discontinuous domain fit on raw (squeezed) data**. In this approach, we squeeze the data but *do not* autoconvolve, and we fit a gaussian to the data while providing knowledge to the solver of the y-discontinuity (similar to #2).

1.2 Results

We first remove a band of 20 pixels. This situation was depicted in the opening figure. The results are tabulated below.

Fitter	σ_x, %err	σ_y, %err	θ, %err
Reference generated pulse	12.38	114.30	24.85°
#1: Continuous domain, AC	12.53, 1.2%	109.32, 4.4%	27.6°, 11.1%
#2: Discontinuous domain, AC	13.03, 5.2%	113.34, 0.8%	24.96°, 0.4%
#3: Discontinuous domain, raw	12.40, 0.2%	115.05, 0.7%	24.82°, 0.1%

Next, we remove a band of 40 pixels. This situation is depicted below.

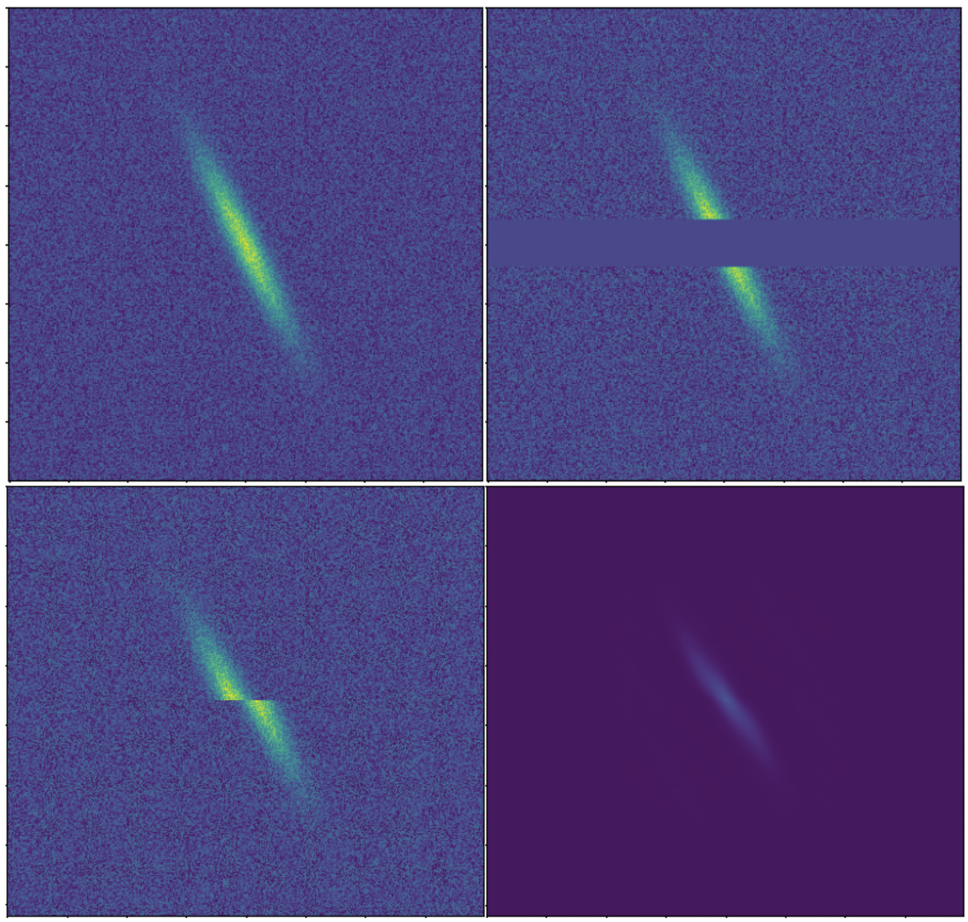

Figure 2: In book-reading order: Original burst, band-masked burst, squeezed burst, and autoconvolution processed image (of the squeezed burst); now with a 40-pixel band removed.

The results are tabulated below.

Fitter	σ_x, %err	σ_y, %err	θ, %err
Reference generated pulse	11.70	76.32	26.19°
#1: Continuous domain, AC	12.66, 8.3%	70.87, 7.1%	35.71°, 36%
#2: Discontinuous domain, AC	15.01, 28%	77.17, 1.1%	26.47°, 1.1%
#3: Discontinuous domain, raw	11.64, 0.5%	77.03, 0.9%	26.24°, 0.2%

Next, we remove a band of 60 pixels. This situation is depicted below.

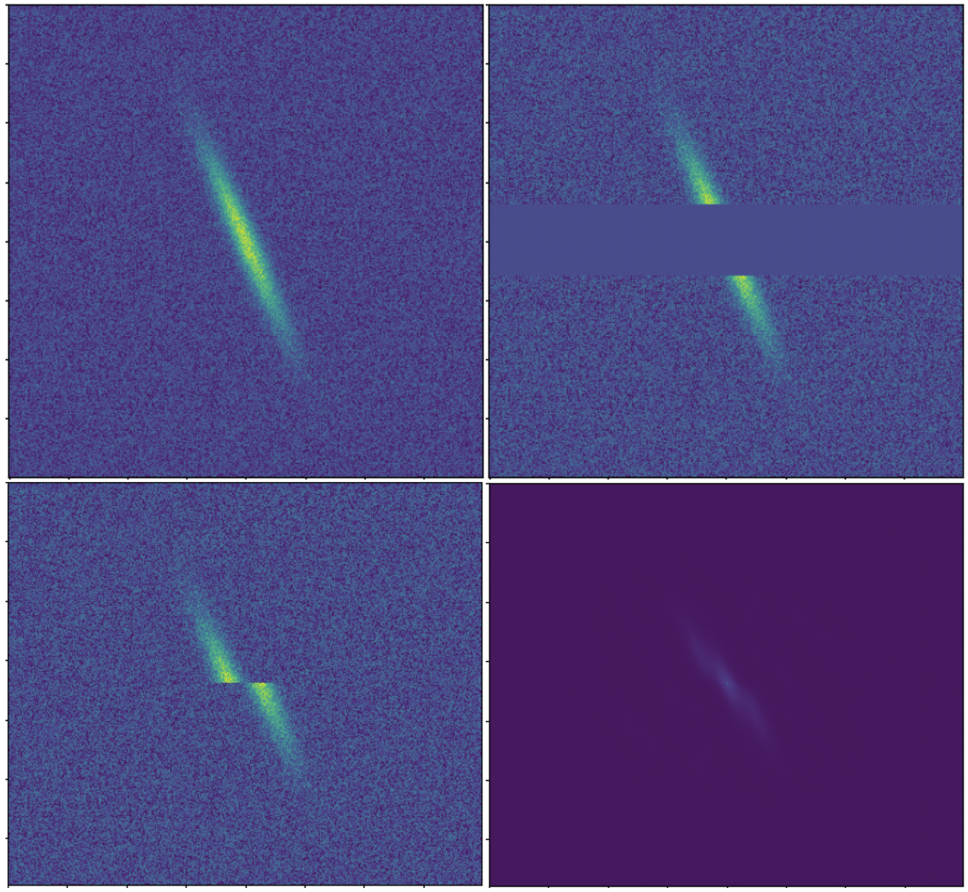

Figure 3: In book-reading order: Original burst, band-masked burst, squeezed burst, and autoconvolution processed image (of the squeezed burst); now with a 60-pixel band removed.

The results are tabulated below.

Fitter	σ_x, %err	σ_y, %err	θ, %err
Reference generated pulse	9.69	76.57	23.33°
#1: Continuous domain, AC	12.64, 30%	65.83, 14%	37.43°, 60%
#2: Discontinuous domain, AC	17.34, 79%	73.77, 3.65%	23.51°, 0.75%
#3: Discontinuous domain, raw	9.81, 1%	76.88, 0.4%	23.23°, 0.4%

Admittedly, the above few tests had very narrow σ_x; let's repeat the previous test with a pulse twice as wide; the situation is depicted below.

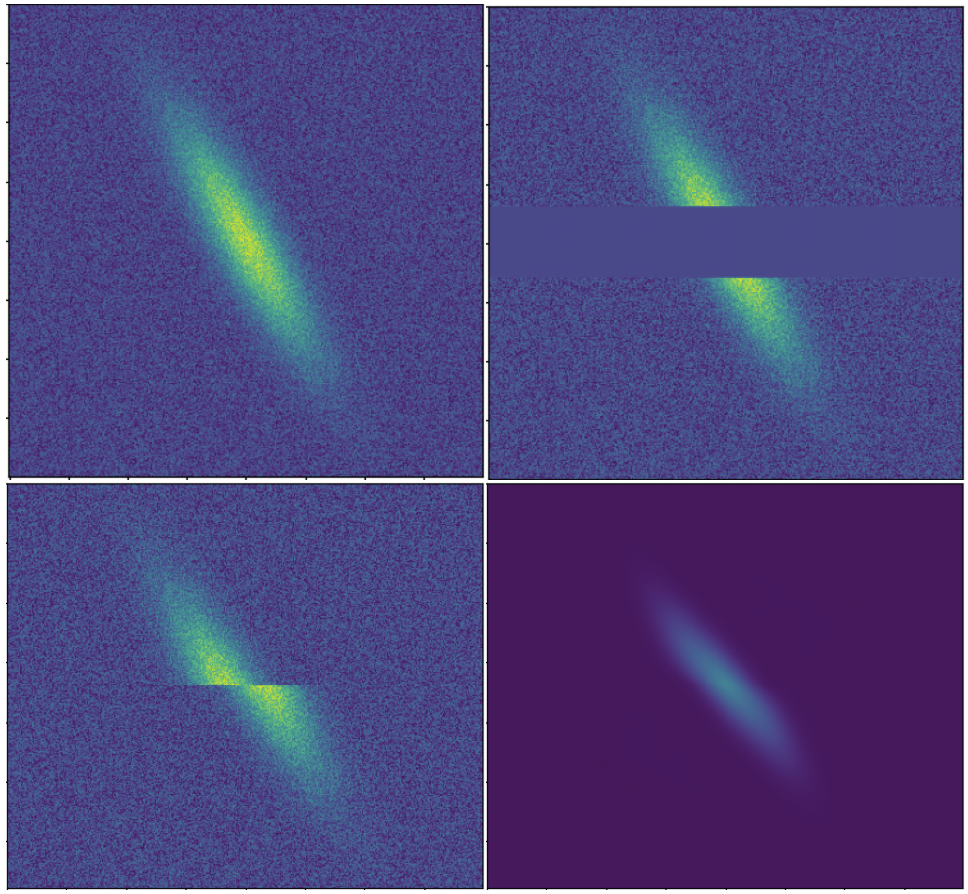

Figure 4: In book-reading order: Original burst, band-masked burst, squeezed burst, and autoconvolution processed image (of the squeezed burst); now with a 60-pixel band removed and a wider σ_x.

The results are tabulated below.

Fitter	σ_x, %err	σ_y, %err	θ, %err
Reference generated pulse	24.35	105.97	29.38°
#1: Continuous domain, AC	23.57, 3%	97.25, 8%	41.55°, 40%
#2: Discontinuous domain, AC	28.21, 16%	103.21, 3%	30.22°, 3%
#3: Discontinuous domain, raw	24.32, 0.1%	105.41, 0.5%	29.47°, 0.3%

1.3 General Observations so Far

So far we have only removed a band from the centre, and a few general trends have emerged:

1. Fitting a gaussian on the raw data while telling the solver about the domain discontinuity gives the best fit; *however, from conversations with Mohammed and Martin this does not seem feasible for real data. We have to perform the autoconvolution (we expect).*

2. Forgetting item #1, performing a fit on the autoconvoluted data while informing the solver of a domain discontinuity gives the best angle, and is fairly robust. It also gives the best σ_y; however, it gives a *worse* σ_x than fitting on the autoconvoluted data *without* informing the solver of the domain discontinuity.

3. σ_x seems to generate the greatest error under the band removal.

2 Band Removal OFF Burst Centre

In this section we repeat all of the above, but we remove a frequency band that is off the burst centre. A sample scenario is depicted below, which is a repeat of the prior sample (60 pixel band removed, wider σ_x), but with the band centre lifted up 60 pixels.

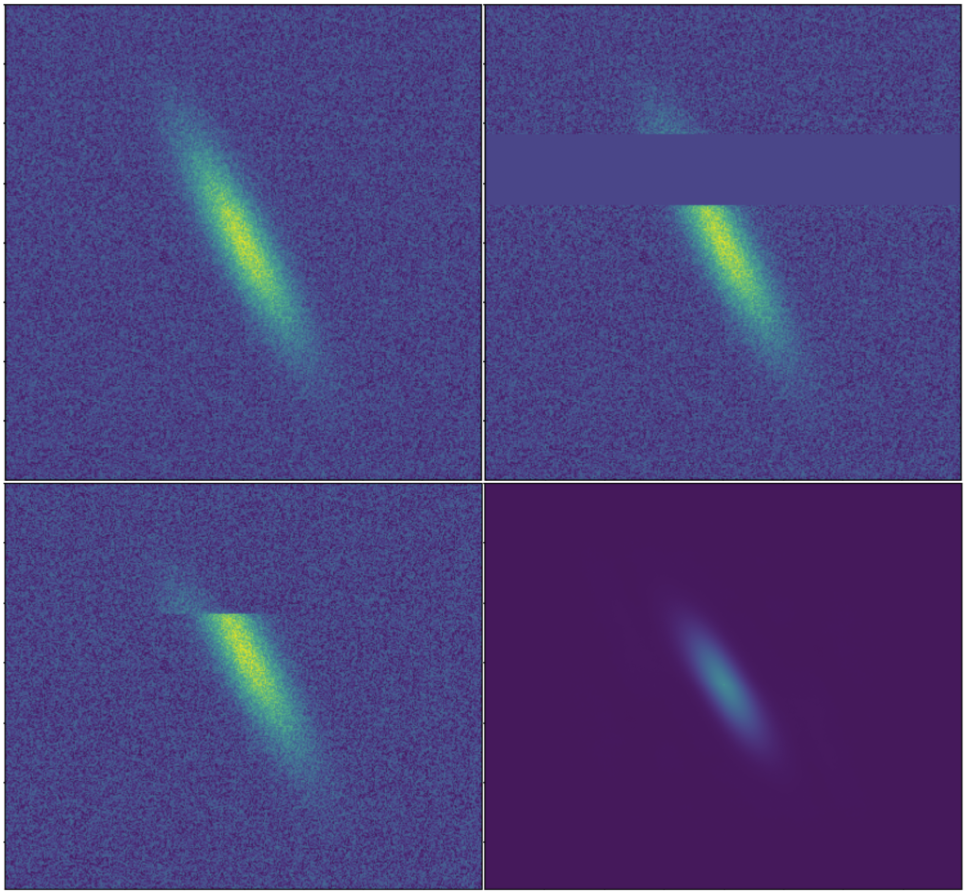

Figure 5: In book-reading order: Original burst, band-masked burst, squeezed burst, and autoconvolution processed image (of the squeezed burst); 60-pixel band removed, wider σ_x, and band centre shifted up 60 pixels.

The results are tabulated below.

Fitter	σ_x, %err	σ_y, %err	θ, %err
Reference generated pulse	20.86	87.48	27.74°
#1: Continuous domain, AC	20.73, 0.7%	66.27, 24%	16.72°, 17%
#2: Discontinuous domain, AC	24.59, 18%	87.11, 0.4%	21.99°, 21%
#3: Discontinuous domain, raw	20.72, 0.7%	87.83, 0.4%	27.84°, 0.3%

Comparing the #2 row to that of the prior (on-burst-centre band) scenario, we have the following differences:

1. σ_x is roughly equally estimated,
2. σ_y is better-estimated, and
3. The angle θ is worse-estimated.