Ground clutter filter

We have chosen a system that uses several sparse matrix-vector multiplications to filter the input I/Q data. The ground clutter model is fixed for solid ground and several filters with different ground-clutter-to-precipitation power ratios are used. The adaptive algorithm then chooses the best results, either the unfiltered signal or one of the filtered signals.
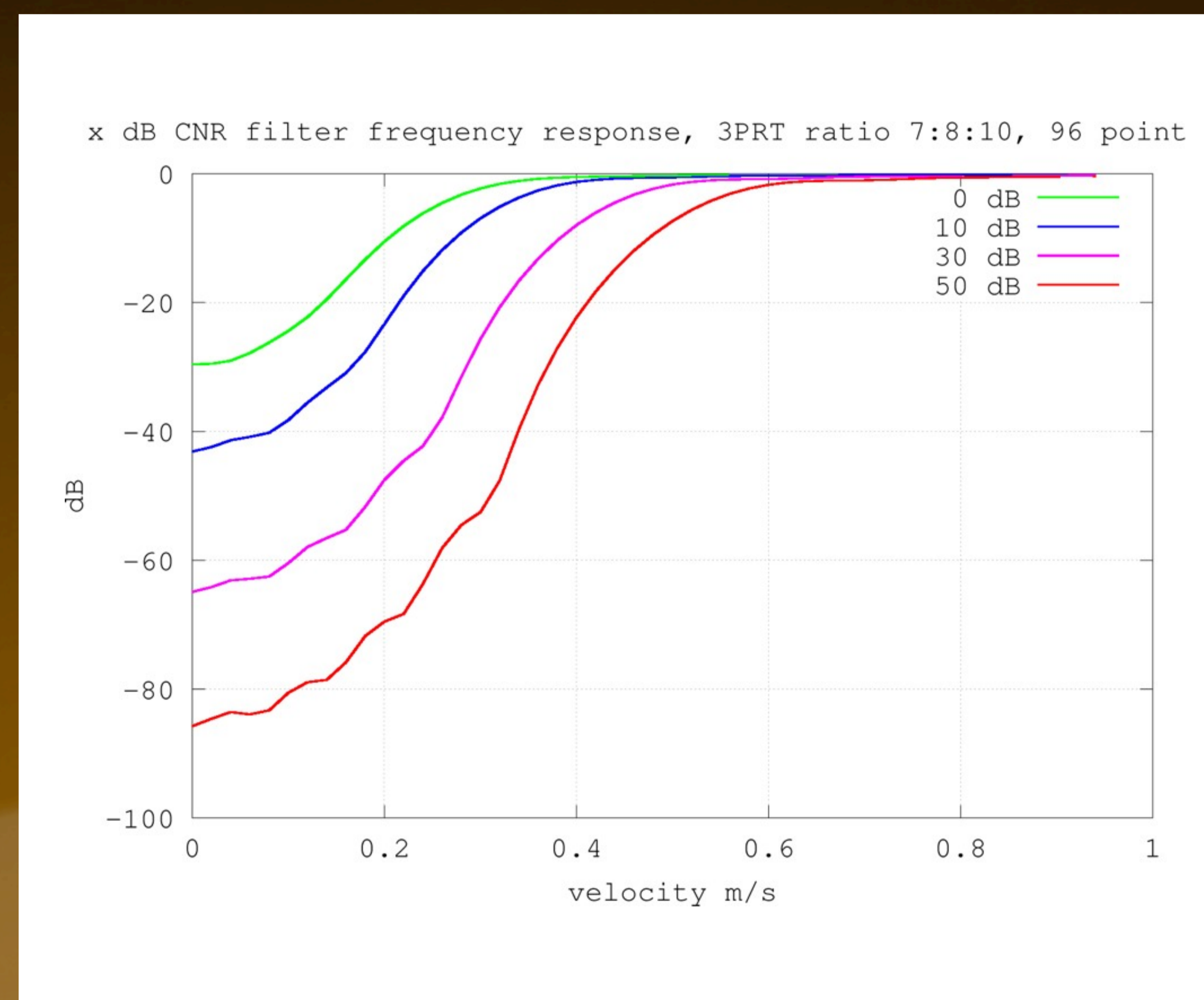
Our system typically processes eight beams of one degree of antenna rotation as one operation. Using a rotational speed of 10 degrees per second this results in a input vector of 384 samples. The vector is multiplied by the filter matrices.

There is no need to use the same ground clutter model for all filters, the system can include filters for non-gaussian ground clutter, for instance from vegetation.

In this example four filters are used, all using the same gaussian model with a width of sigma = 0.1 m/s. The 0 dB filter is designed to filter out ground clutter which has the same power as the rest of the signal.
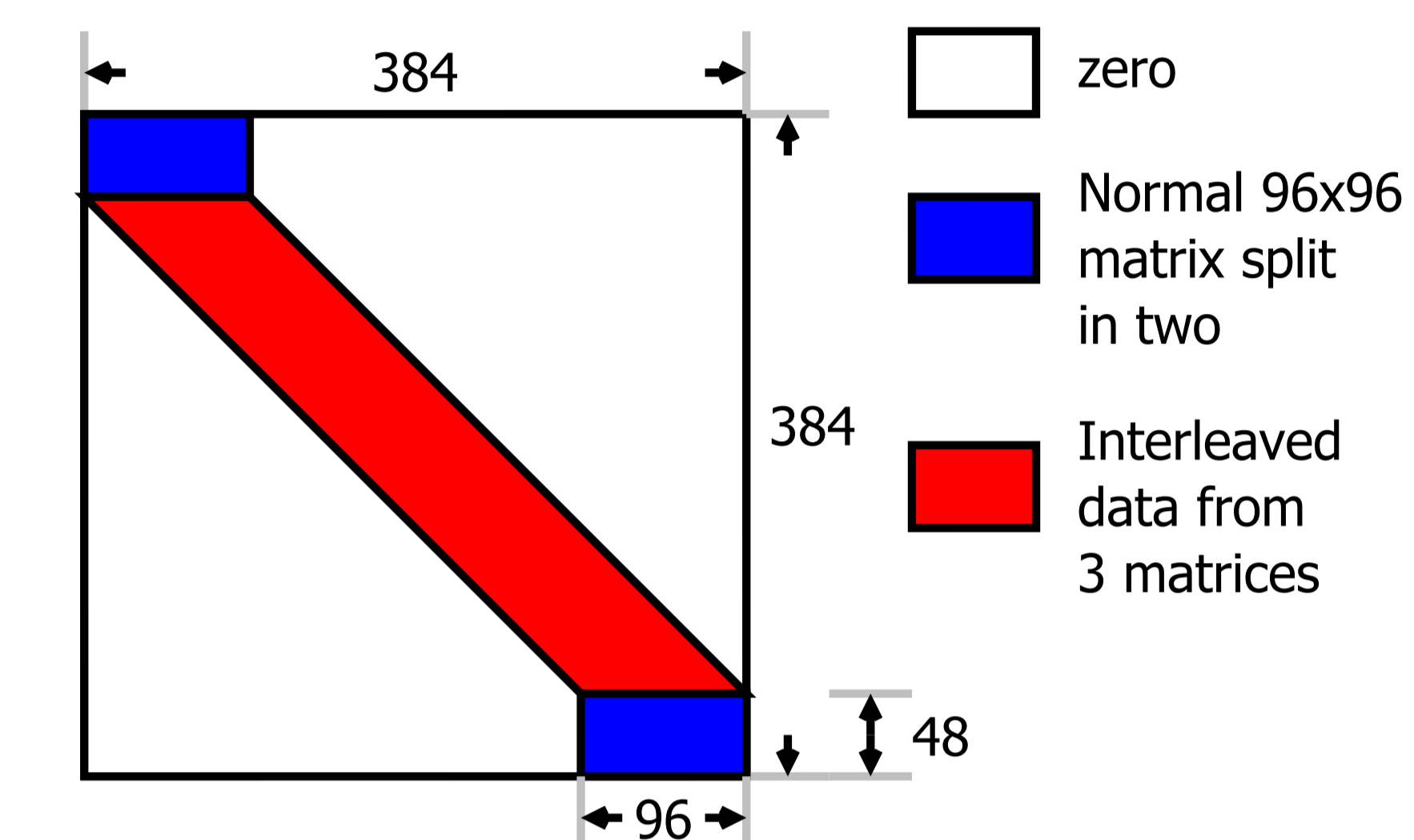
In theory, the four plots should be the same shape, only shifted downwards.

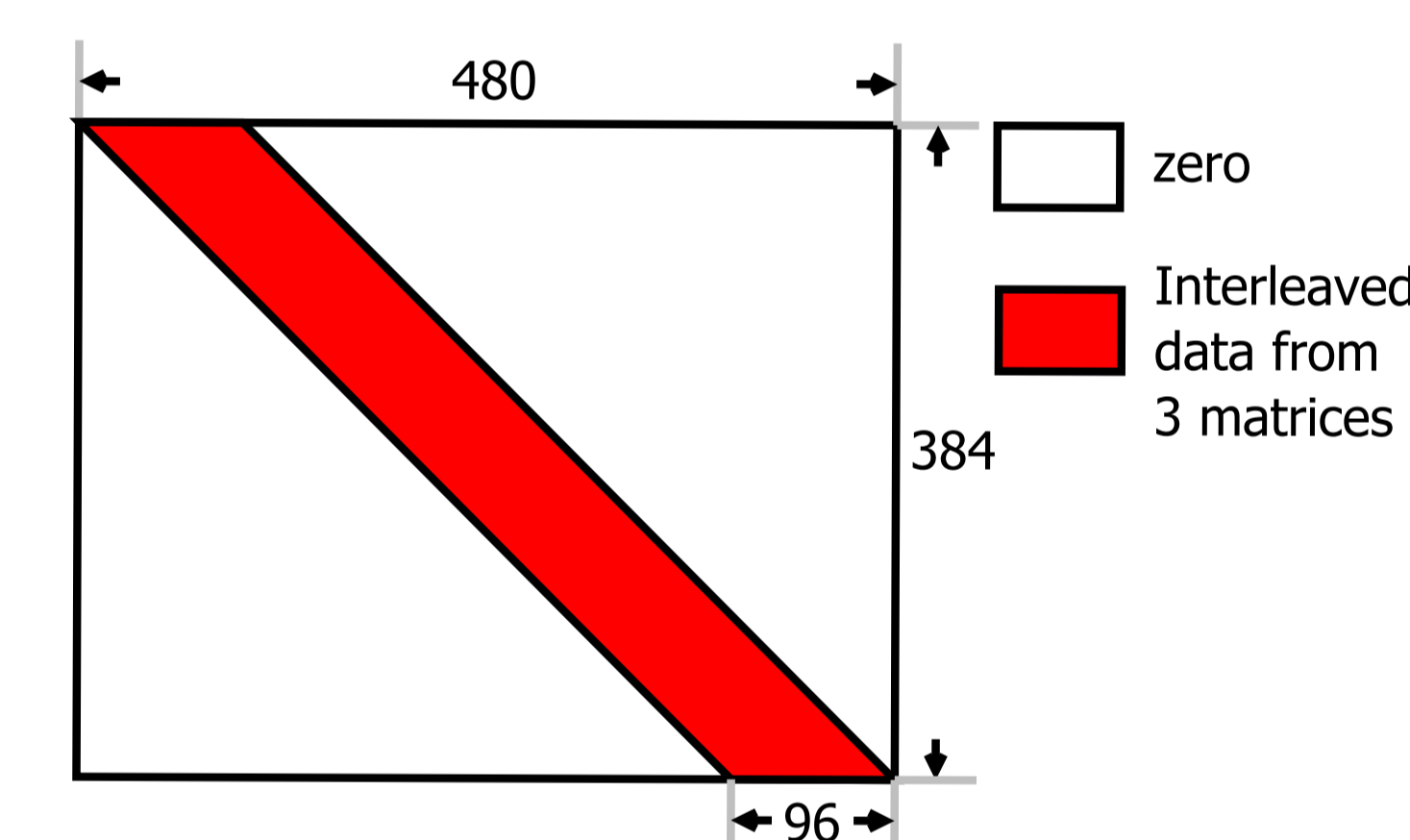A vegetation filter would show as triagular, with much higher width.

x dB CNR filter frequency response, 3PRT ratio 7:8:10, 96 point

0 dB
10 dB
30 dB
50 dB

Structure of the filter matrices

8 degrees in, 8 degrees out

zero

Normal 96x96 matrix split in two

Interleaved data from 3 matrices

10 degrees in, 8 degrees out (FIR)

zero

Interleaved data from 3 matrices

Strict data separation

zero

Normal 48x48 matrix

Jörn Sierwald, Eigenor Corporation
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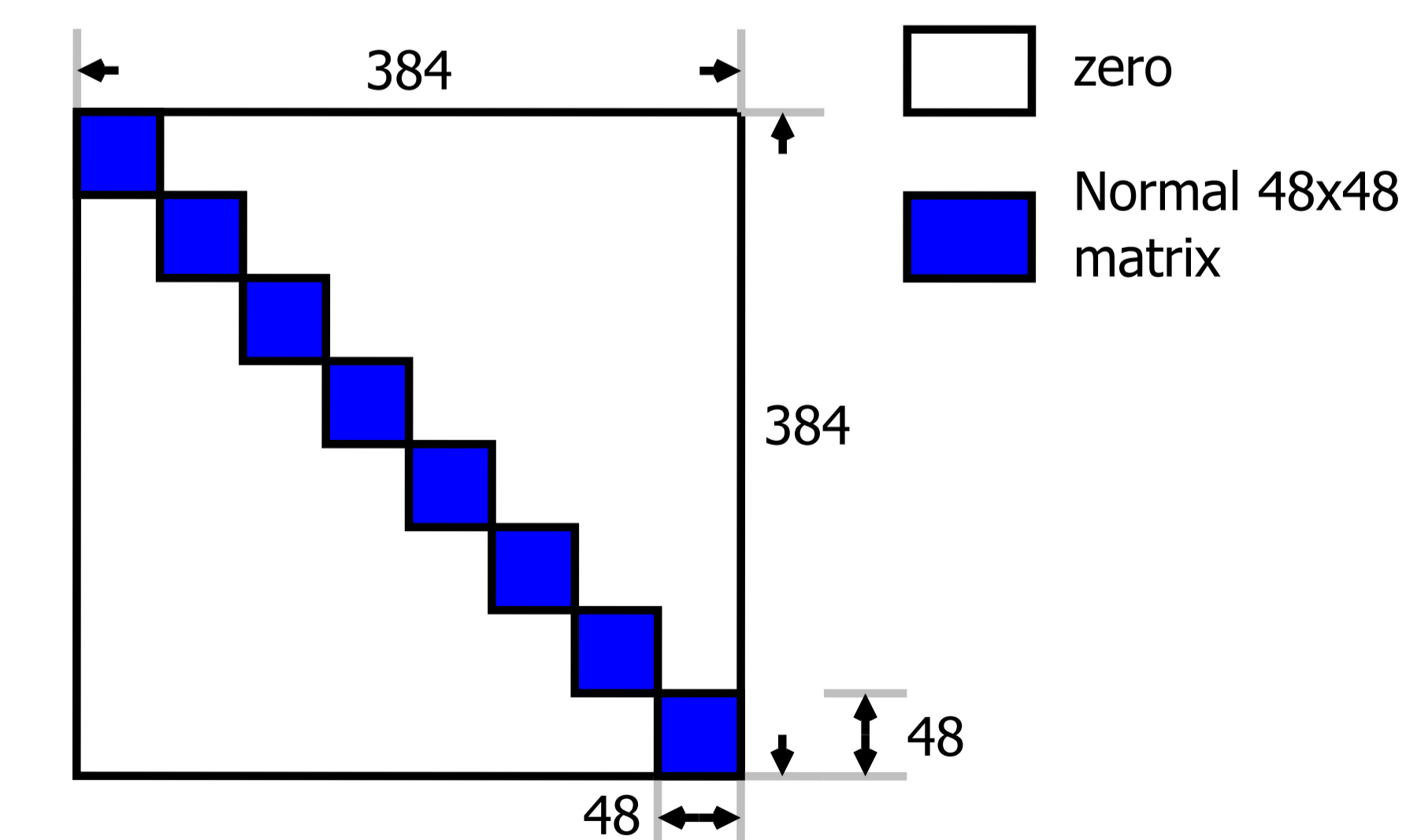
Adaptive filtering

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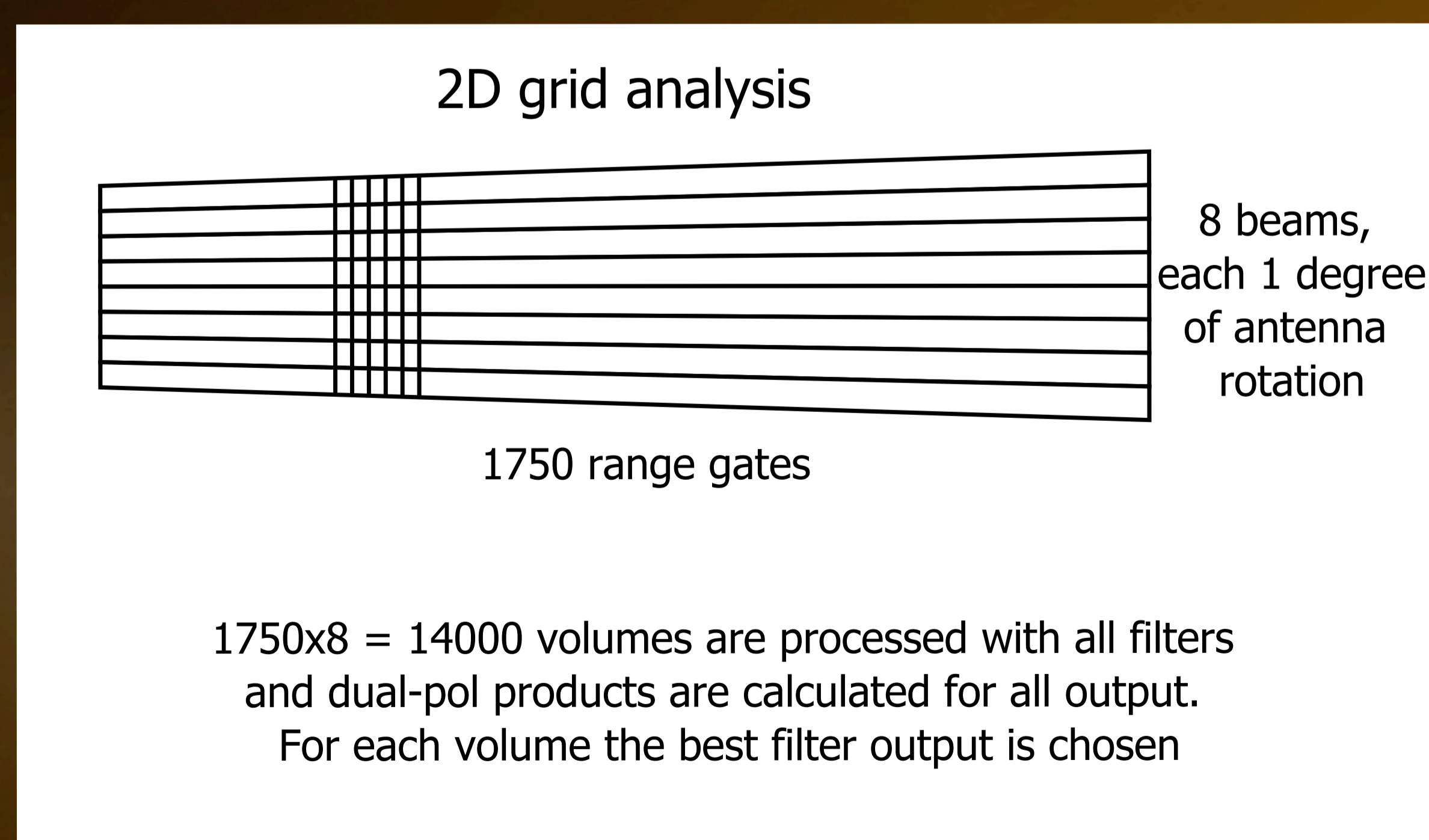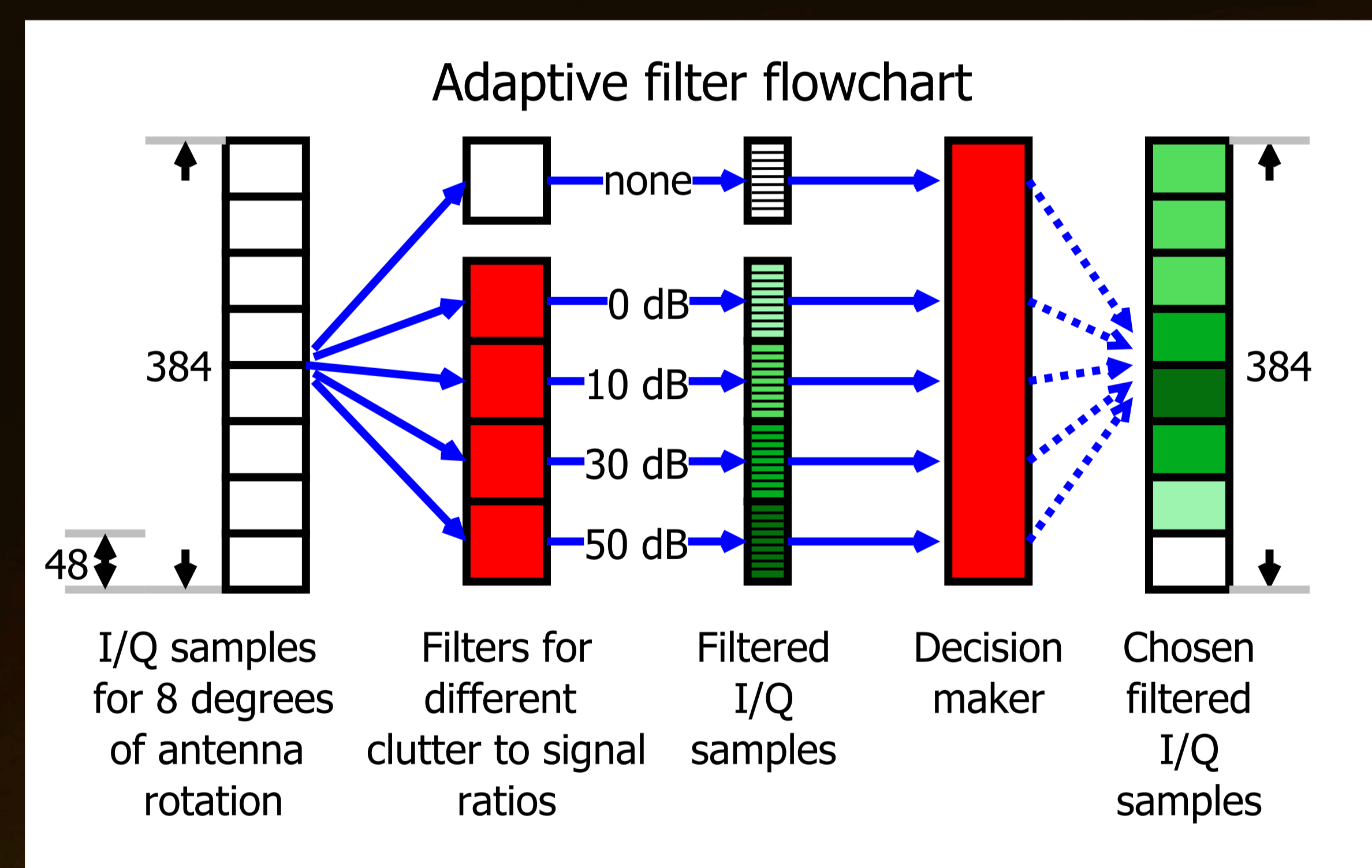The input data is filtered with several filters and dual-polarization parameters are calculated for all of the output. The adaptive algorithm chooses one of the filtered signals.

This is significantly different from other systems which make the decision to filter first and then remove the ground clutter.

These graphs show only three of the indicators used by the adaptive algorithm: power, copolar correlation and differential phase. The last row shows the decision. On the x-axis a number of consecutive range gates are shown, all belonging to the same beam/heading.

The left column shows rain at 0 m/s with a low width. The filtering does only damage and never improves anything. The power drops further with each filter. Rho is highest with no filtering. The differential phase in gates 3 to 6 shows that the signal is destroyed by the 30 dB and 50 dB filters.
The middle column shows a mix of GC and rain at 0 m/s. The algorithm tries to choose a smooth rho and psi curve. Note that the 30 dB and 50 dB filters remove more power than the 10 dB filter, but the removed power is from rain.
The right column shows a mix of GC and rain at 5 m/s. The 0 dB filter handles this case nicely, note that the lines from 0, 10, 30 and 50 dB are exactly the same in most places, which is different from the middle column.

Adaptive filter flowchart

384

48

| I/Q samples for 8 degrees of antenna rotation | Filters for different clutter to signal ratios | Filtered I/Q samples | Decision maker | Chosen filtered I/Q samples |

none, 0 dB, 10 dB, 30 dB, 50 dB

384

2D grid analysis

8 beams, each 1 degree of antenna rotation

1750 range gates

1750x8 = 14000 volumes are processed with all filters and dual-pol products are calculated for all output. For each volume the best filter output is chosen

Rain at 0 m/s   Rain at 0 m/s and GC   Rain at 5 m/s and GC

Power

Copolar correlation

Differential phase

Decision:
0 - no filter
1 - 0 dB
2 - 10 dB
3 - 30 dB
4 - 50 dB

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