Mandatory 3

IN5450

Espen Lønes

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- Pulse compression
- Virtual array
- DAS
- TDMA / CDMA
- Hamming tapering
- Using virtual array positions

Overview

- LFM pulse
- Pulse length 10 ms
- Bandwidth 10 kHz
- Center frequency 10 kHz
- 2 transmitters
- 32 receivers
- $c = 340$ m/s
- TDMA data [Nt, Nrx, Ntx]
- Upchirp for both transmits
- CDMA data [Nt, Nrx]
- Down for left transmit, Up for right.

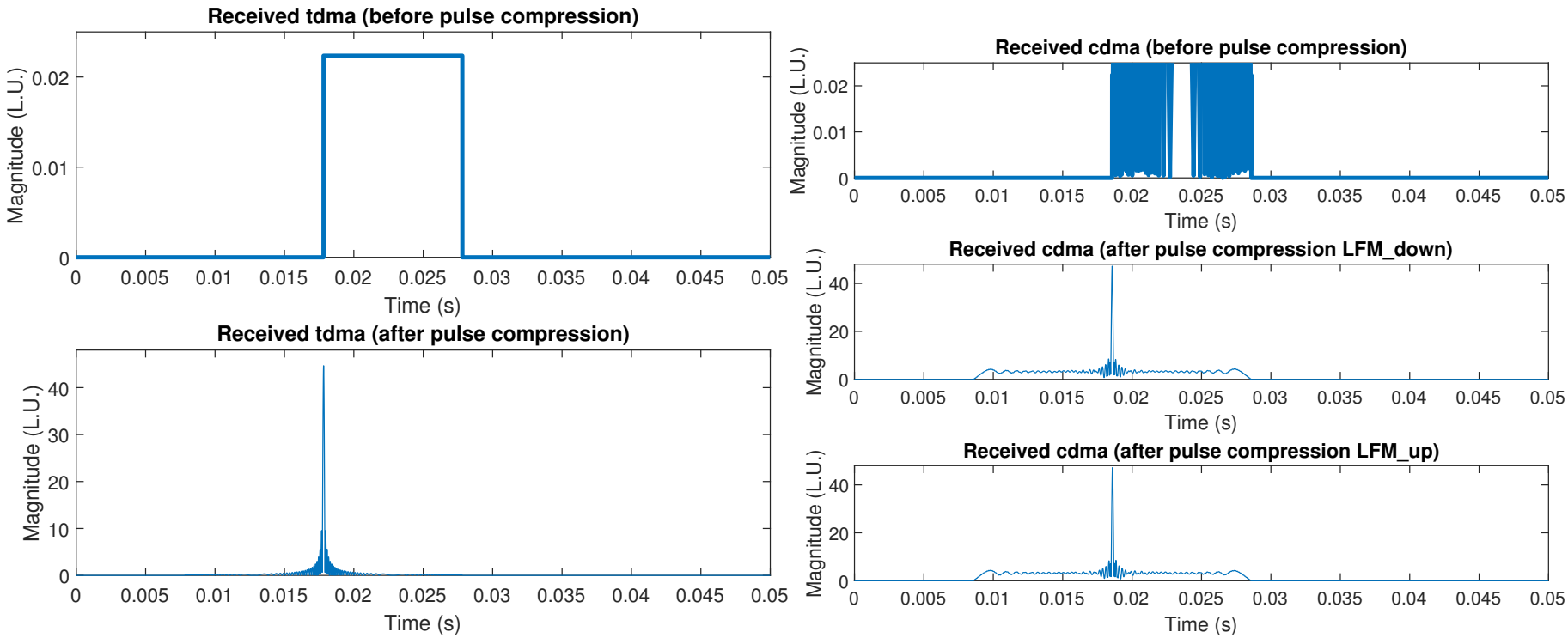
Pulse compression code

```
alpha = B/T_p; % chirp rate
t = [0:(1/fs):T_p]; % time for pulse
tmax = (N_t/fs - 1/fs); % end time for recever
tt =  [0:(1/fs):tmax]; % time for recever
LFM_up = exp(j * 2 * pi * ( (fc - (B/2)) * t + ((alpha * (t.^2))/2) ));
LFM_down = exp(j * 2 * pi * ( (fc + (B/2)) * t - ((alpha * (t.^2))/2) ));

tmp = tdma_data(:,1,1); % single receve, single transmit
[m,lag] = xcorr(tmp, LFM_up);
% only with positive lag
m = m(lag >= 0);
tm = lag(lag >= 0)/fs;
```

Pulse compression images

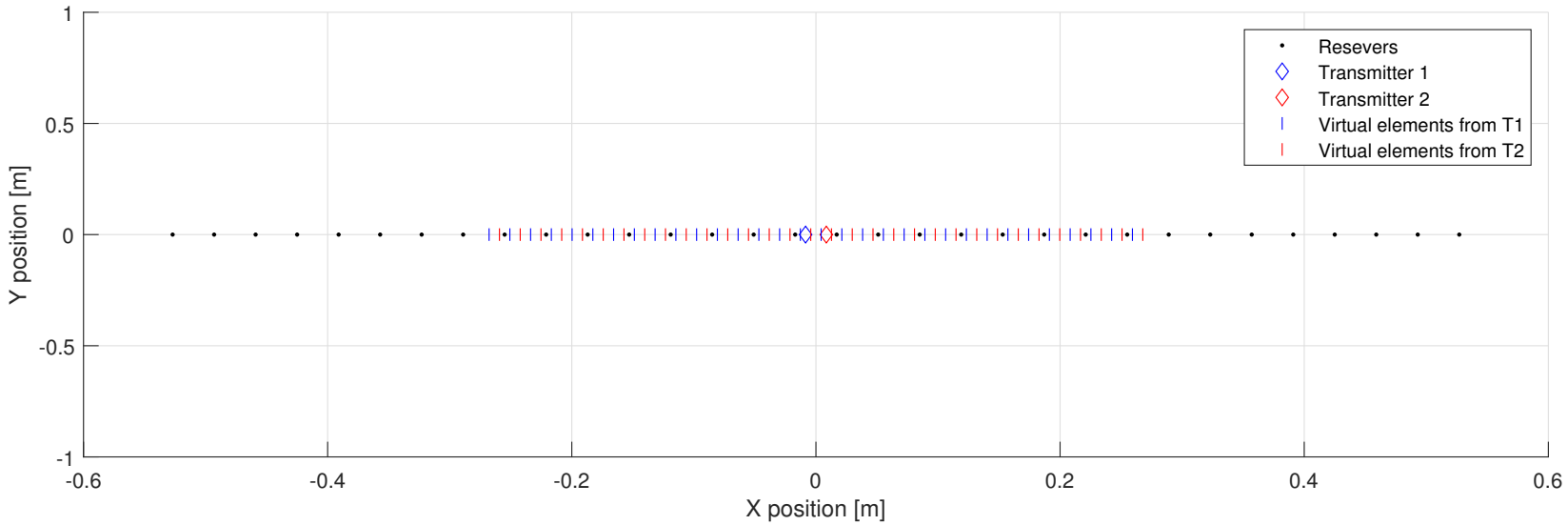
We see one reflector.



Theoretical time resolution = 1 / B = 1.0000e-04 = 0.0001 s.
Measured resolution = 0.01792 - 0.017725 = 1.9500e-04 = 0.000195 s.
Measured $\approx$ 2 * Theoretical

Virtual array

For one transmit sampling is half compared to using two transmits. (Array is also slightly longer for two transmits.)



Theoretical lateral resolution $= \lambda/L = (c/fc)/(2 * 0.26775) = \frac{0.0340}{0.5355}$
$= 0.0635[rad] = 3.638282[deg]$
Approx lateral resolution at 4 m: $R * a = 4 * 0.0635 = 0.254m$
Theoretical axial resolution $= c/(2 * B) = 0.0170m$
At 4 meters $0.254/0.0170 = 14.9$, axial is 15 times better than lateral.

DAS code

```
if load_data == 0
    load('image_tdma_1_transmit.mat');
    load('image_tdma_2_transmit.mat');
elseif load_data == 1
    for transmit = 1:N_tx
        for receiver = 1:N_rx
            m = all_m(:,transmit,receiver);
            for xx = 1:xres
                for yy = 1:yres
                    r_t = sqrt( (tx_pos(transmit)-x(xx))^2 + (y(yy))^2 );
                    r_r = sqrt( (rx_pos(receiver)-x(xx))^2 + (y(yy))^2 );
                    r = r_t + r_r;
                    t_delay = r / c;
                    t_sample = round(t_delay * fs);
                    if t_sample > 0 && t_sample < N_t
                        image_tdma_2_transmit(yy,xx) = image_tdma_2_transmit(yy,xx) + m(t_sample);
                        if transmit == 1
                            image_tdma_1_transmit(yy,xx) = image_tdma_1_transmit(yy,xx) + m(t_sample);
                        end % if
                    end % if
                end % yy
            end % xx
        end % receiver
    end % transmit
    save('image_tdma_1_transmit.mat', 'image_tdma_1_transmit');
    save('image_tdma_2_transmit.mat', 'image_tdma_2_transmit');
end % if/else
```

TDMA two transmits

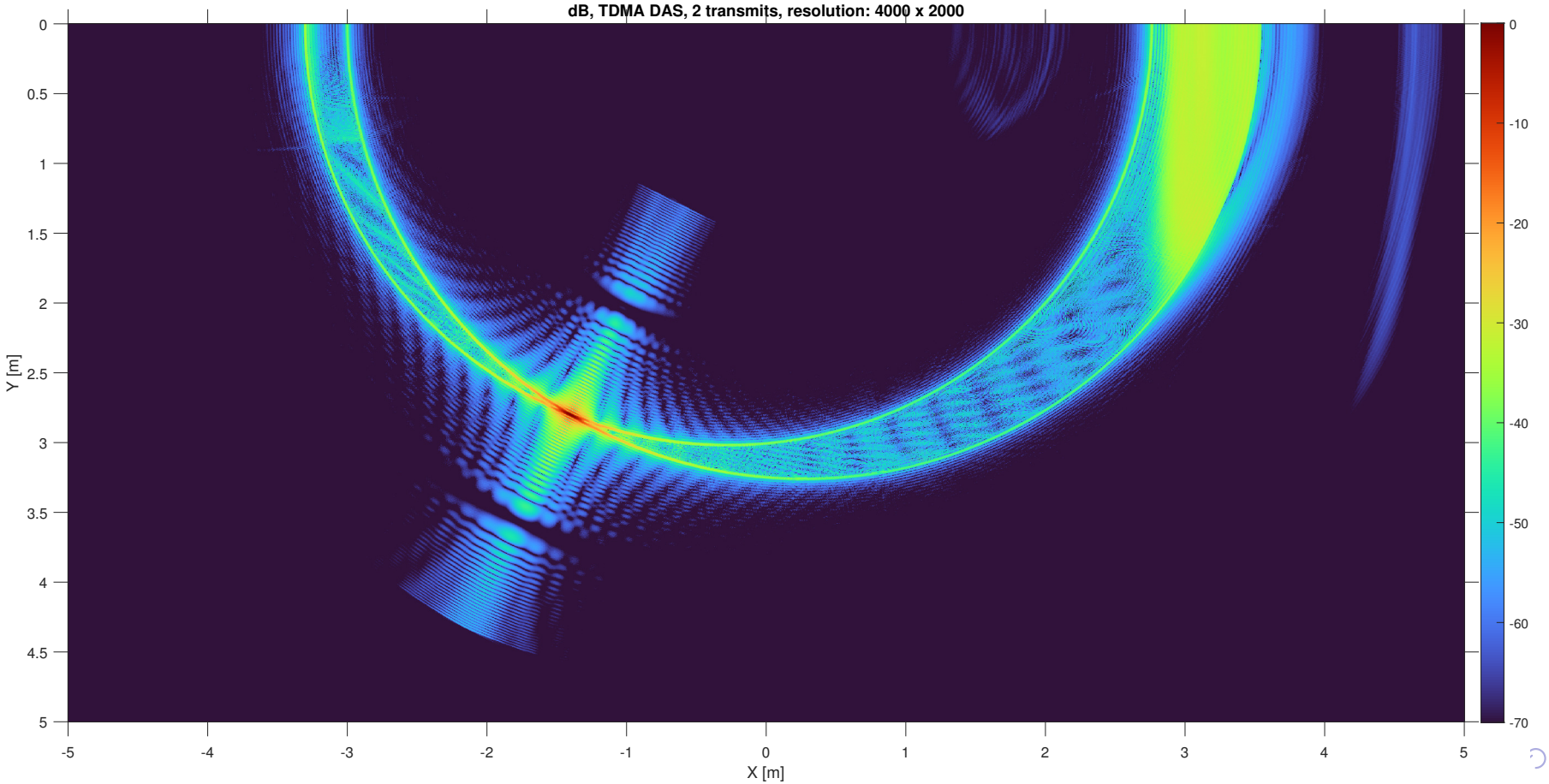
Reflector is at [x,y] = [-1.3975, 2.8025] or [r, θ] = [3.1316, 116.5037]

Single point reflector. Axial pollution spans 2 * width of pulse.

Theoretical lateral res.: $\frac{(c/fc)}{2*0.527} = 0.0323[rad]$. 0.1012[m] at point.

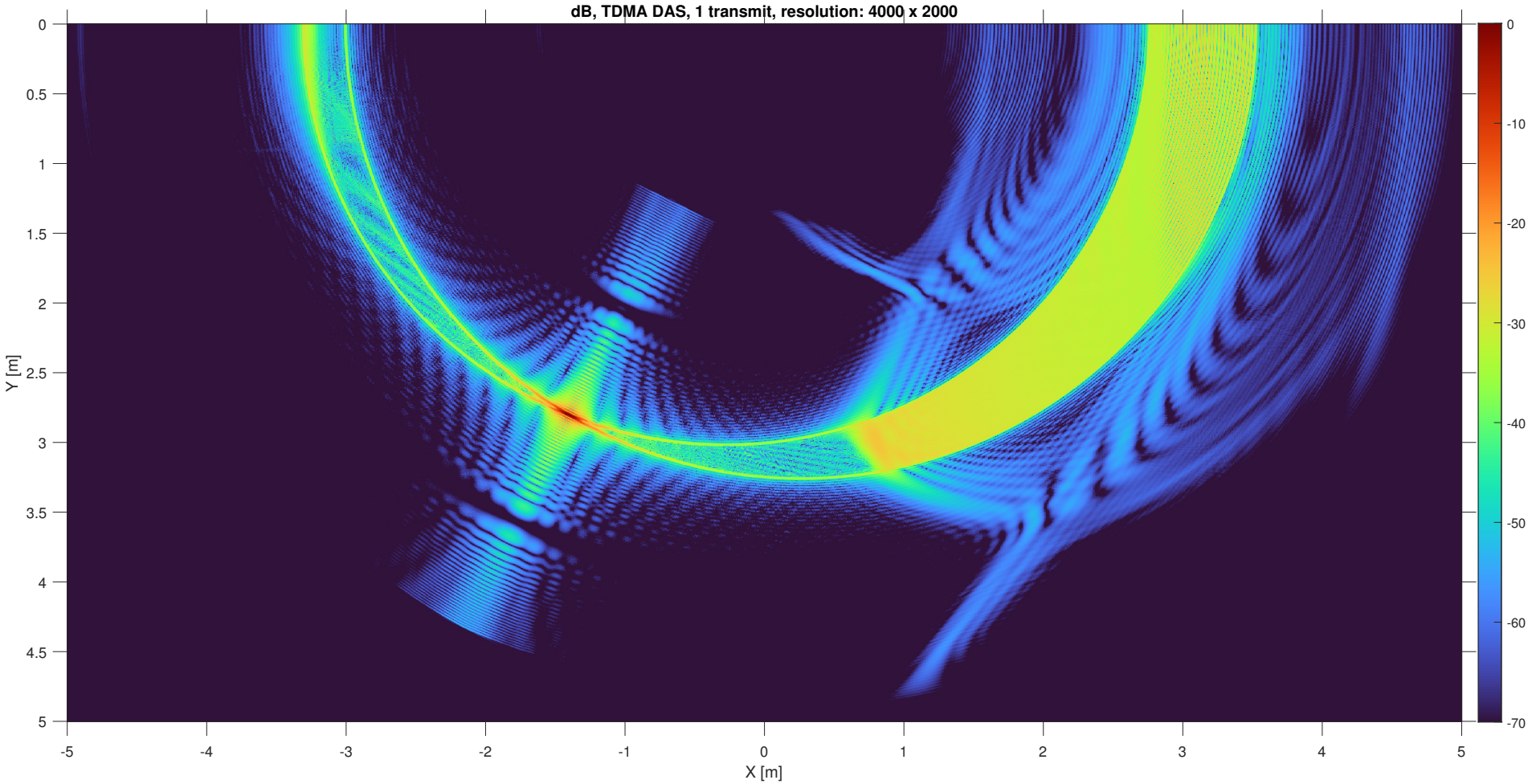
Measured: $0.0951[m]$

Theoretical axial res.: $c/(2*B) = 0.0170[m]$. Measured: $0.0140[m]$



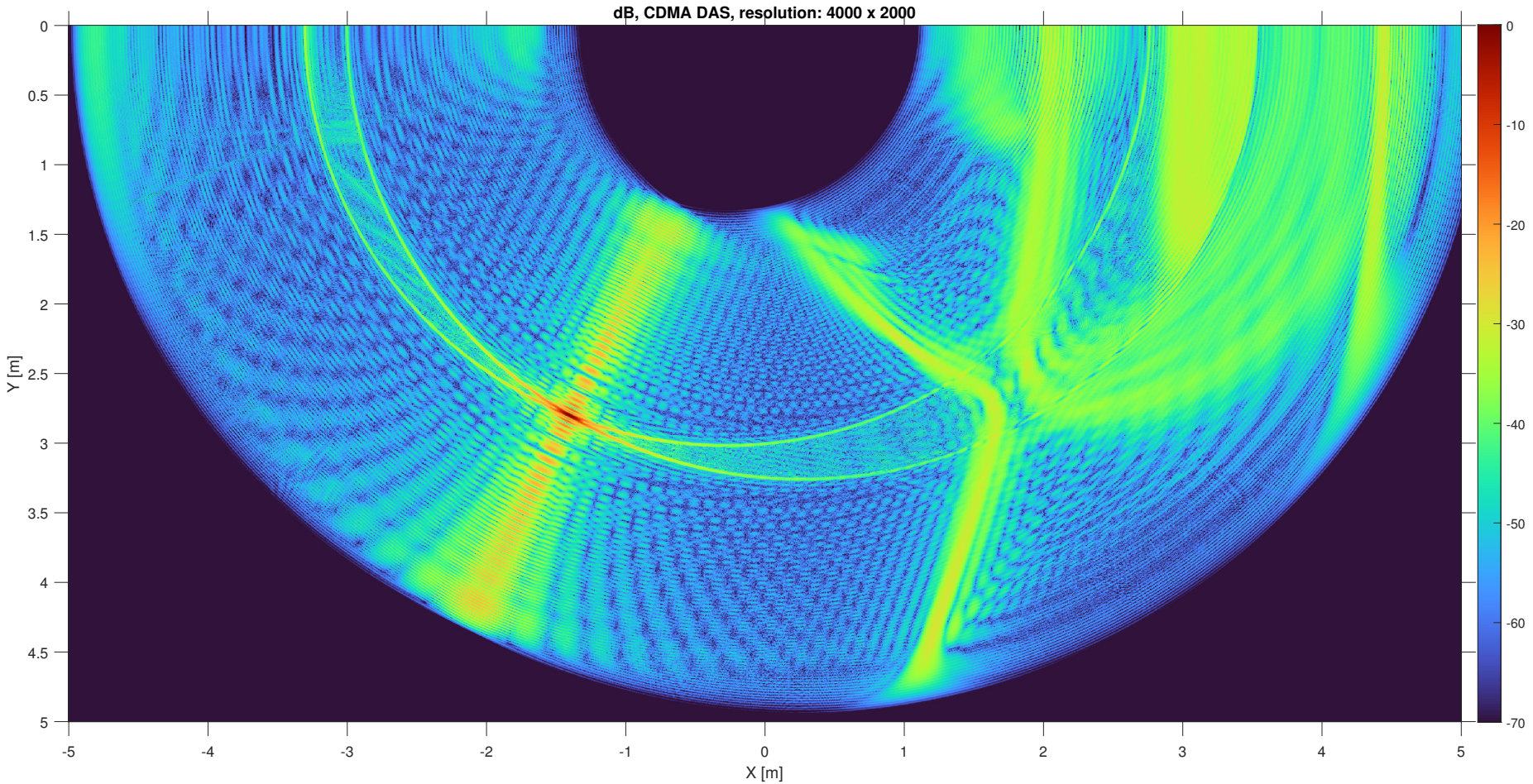
TDMA one transmit

Similar image around point but stronger/larger artefacts to the sides.



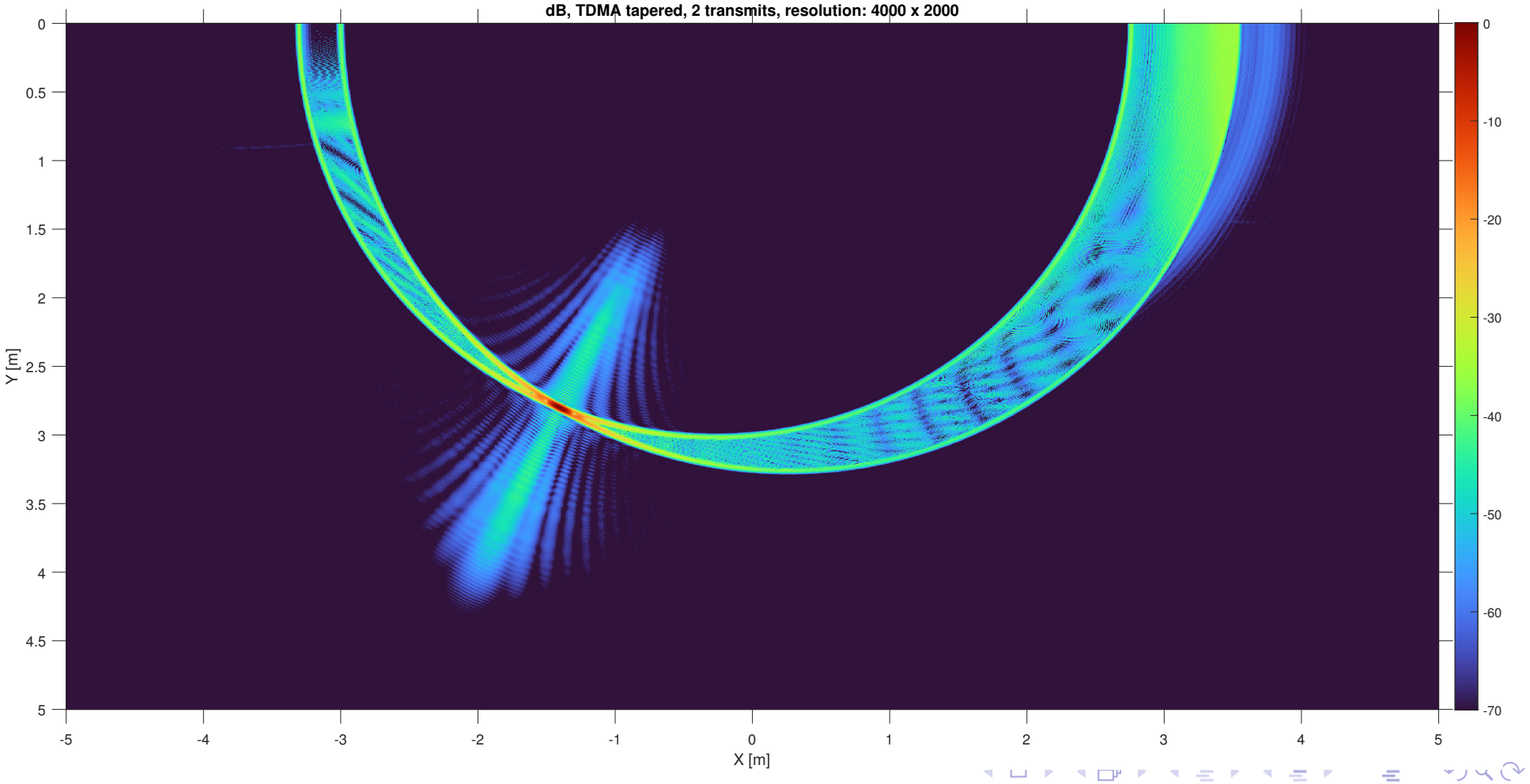
CDMA plot

All over higher level of pollution than TDMA.
(Higher 'baseline' pollution artefacts).
Because the two pulses interfere slightly (provides nose for each other).
Worse quality but half the imaging time.



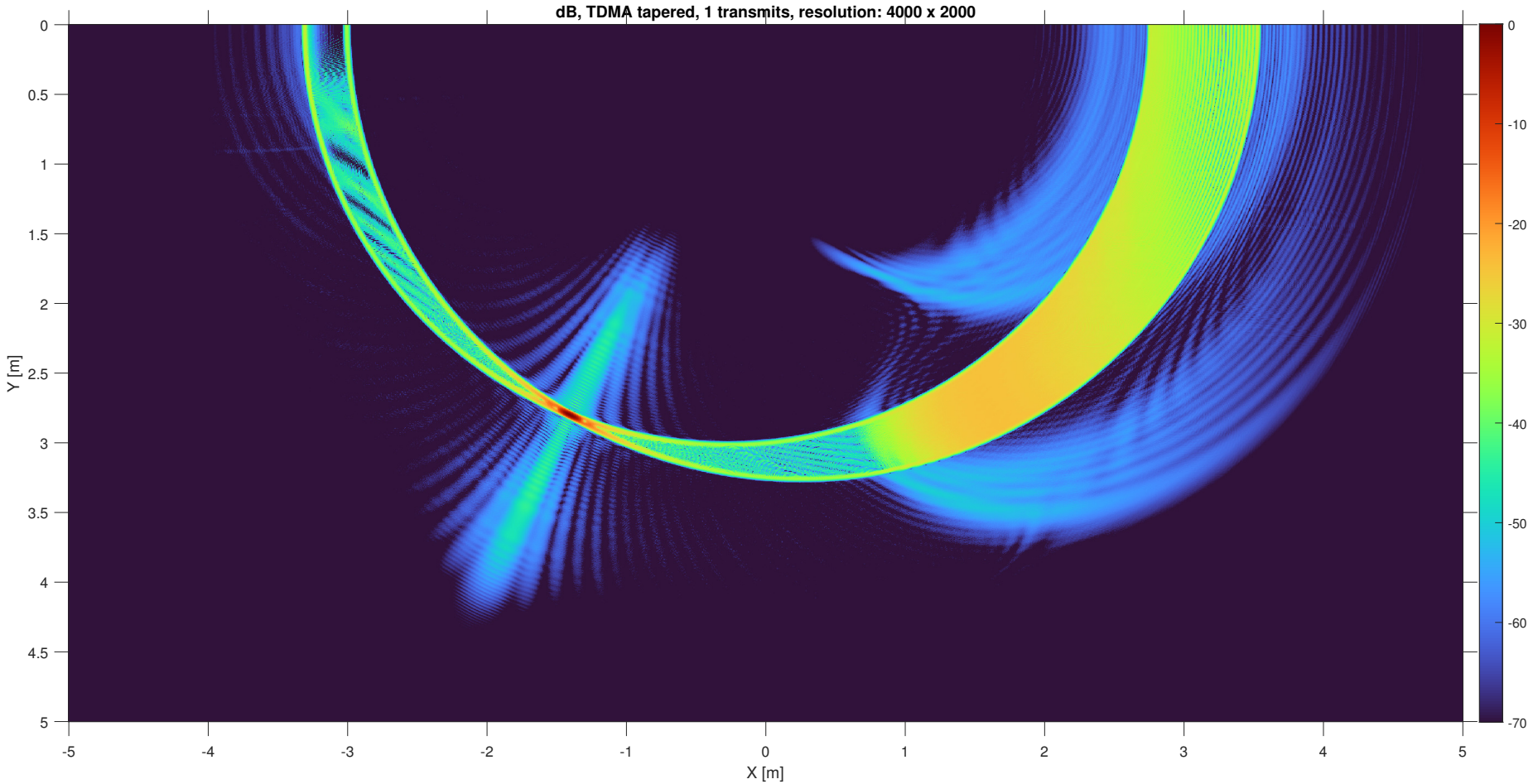
Hamming tapered full TDMA

Hamming tapering was used on receive array and transmit waveform.
Less / smother artefacts, especially far to the sides.
Worse resolution.



Hamming tapered single transmit TDMA

Hamming tapering was used on receive array and transmit waveform.
Again worse resolution.
Partially removes and smooths some of the single transmit artefacts.

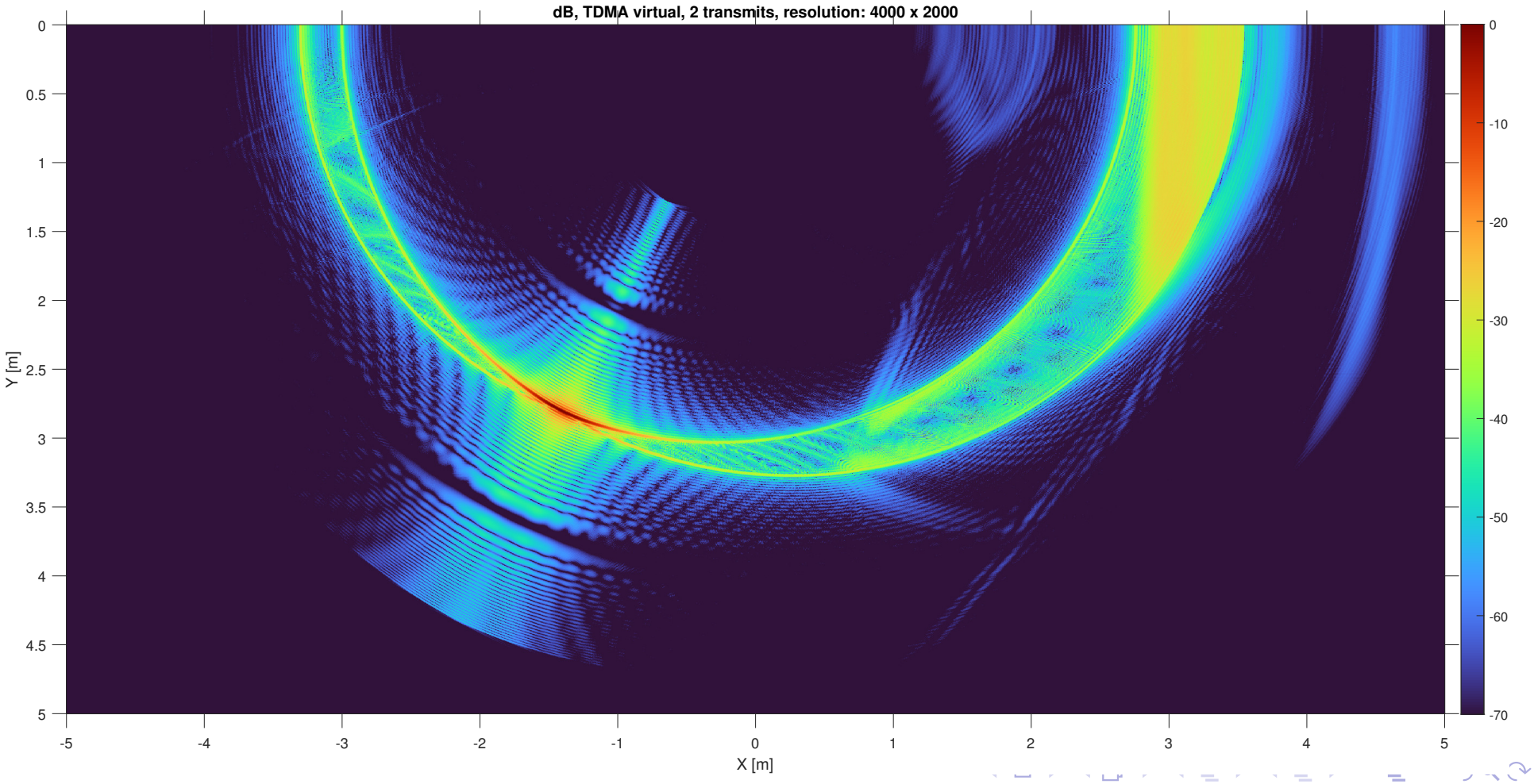


TDMA with virtual array positions

Equal axial resolution. $(\frac{1}{B})$

Worse lateral resolution because of shorter array length. $(\frac{\lambda}{L})$.

0.0323[rad] vs. 0.0635[rad]



References

- https://www-int.uio.no/studier/emner/matnat/ifi/IN5450/v22/undervisningsmateriale/mandatory_three/in5450_mimo_project_2022.pdf
- https://www-int.uio.no/studier/emner/matnat/ifi/IN5450/v22/undervisningsmateriale/in5450_mimo_2022_v1_handout_compressed.pdf
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