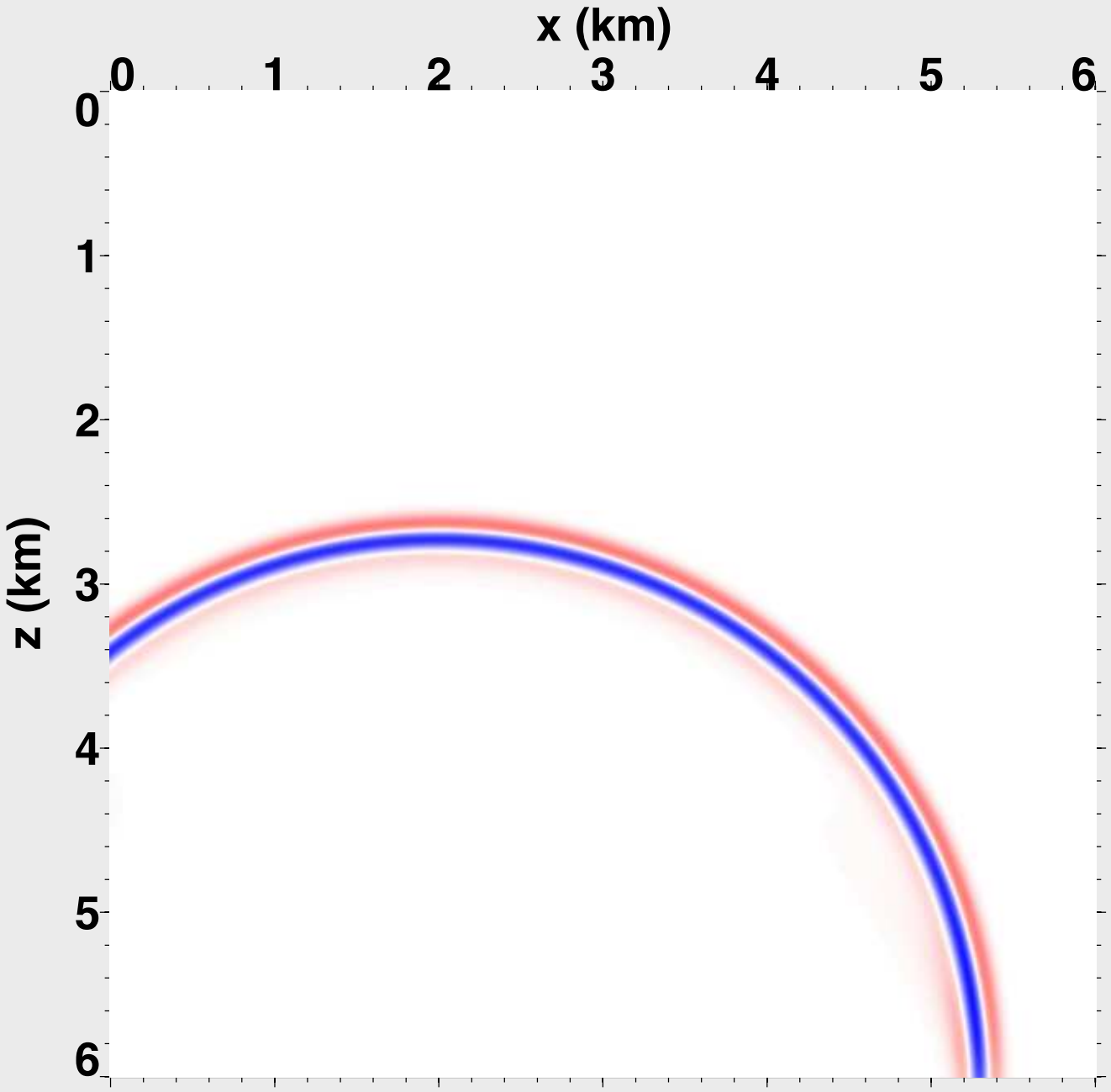
Snell's law
Reflection & Transmission

Nori Nakata

Stanford University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1
2
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4
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z (km)
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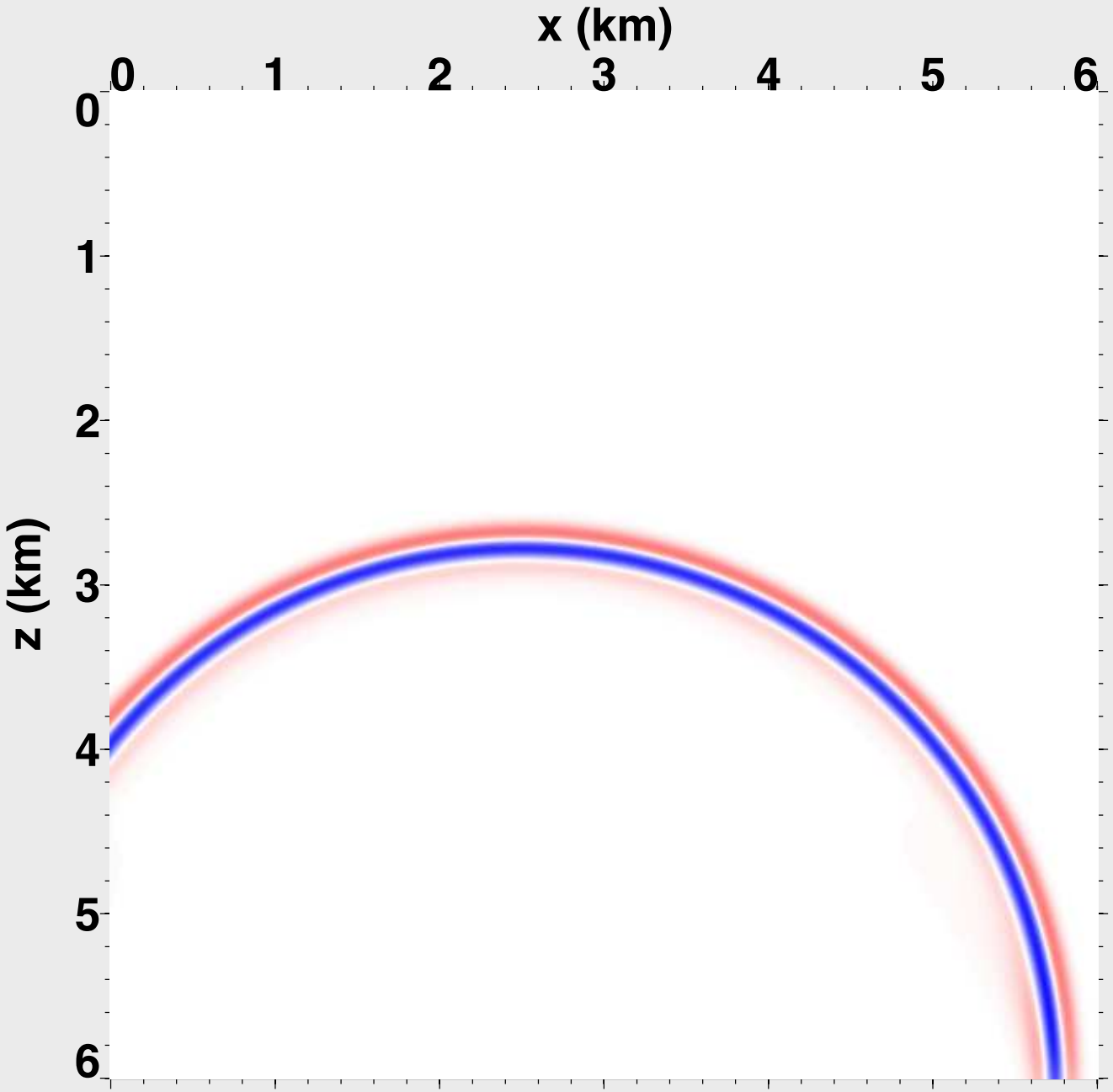
x (km)
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z (km)
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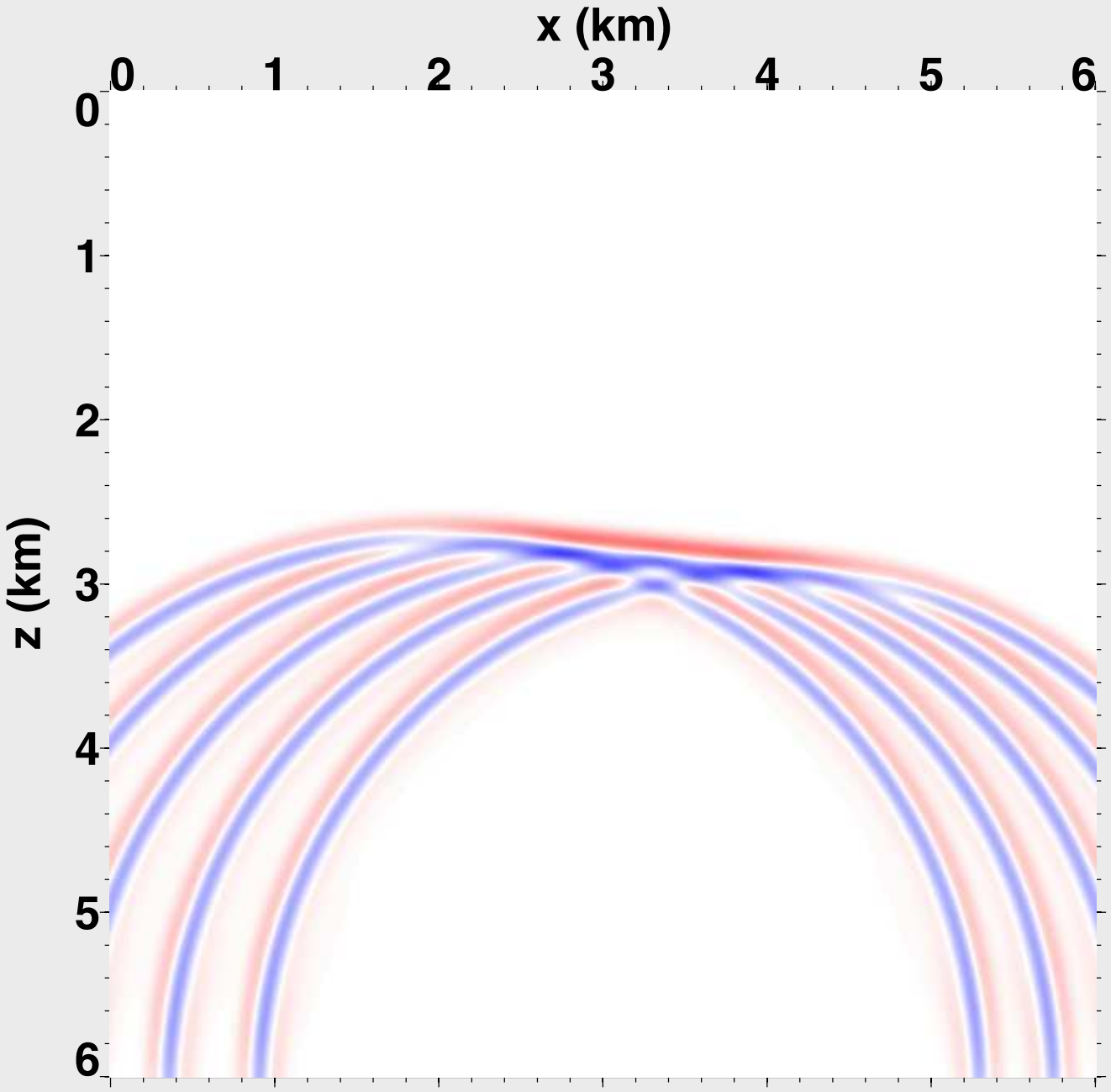
x (km)
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z (km)
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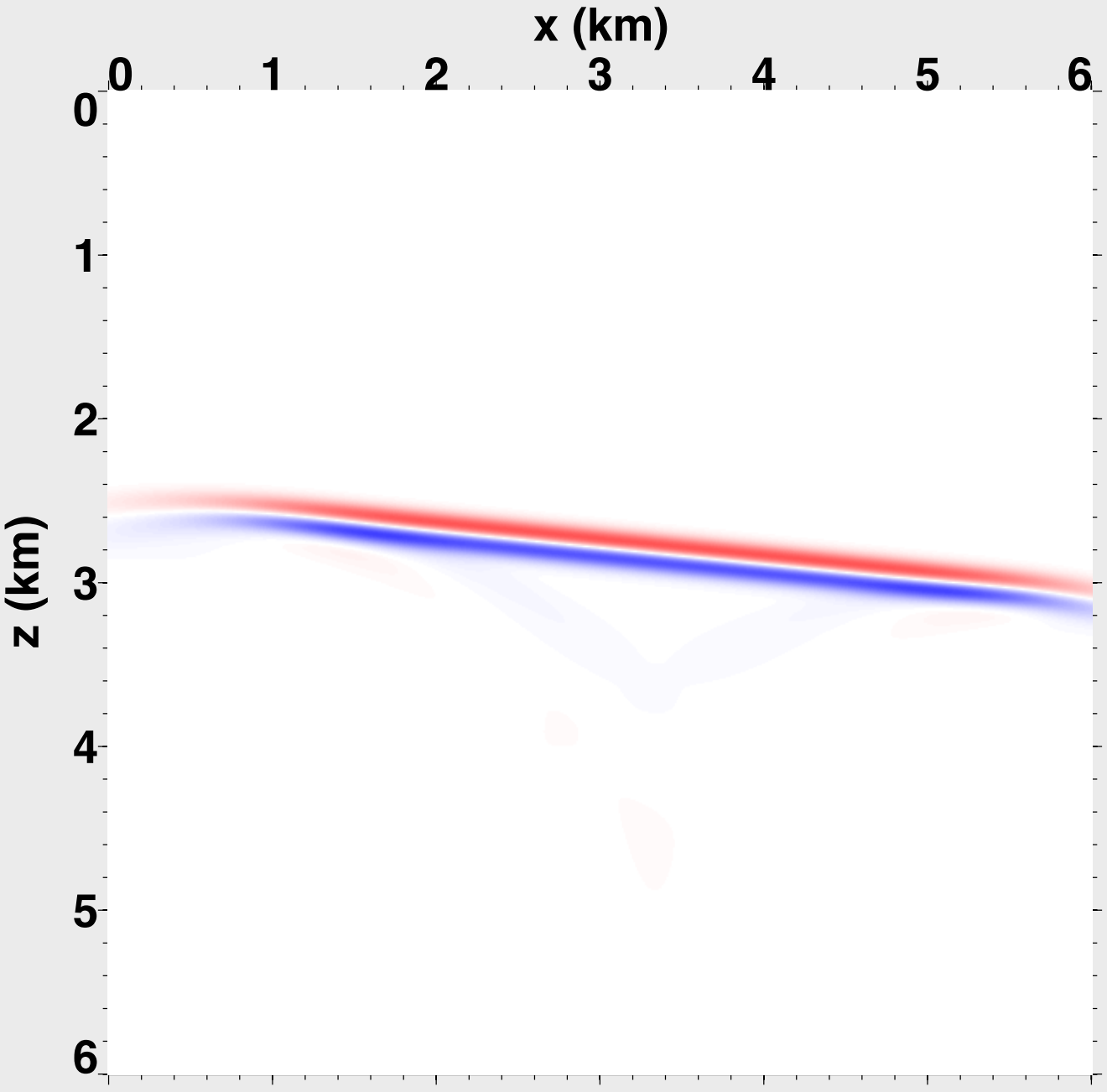
x (km)
0
1
2
3
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5
6
z (km)
0
1
2
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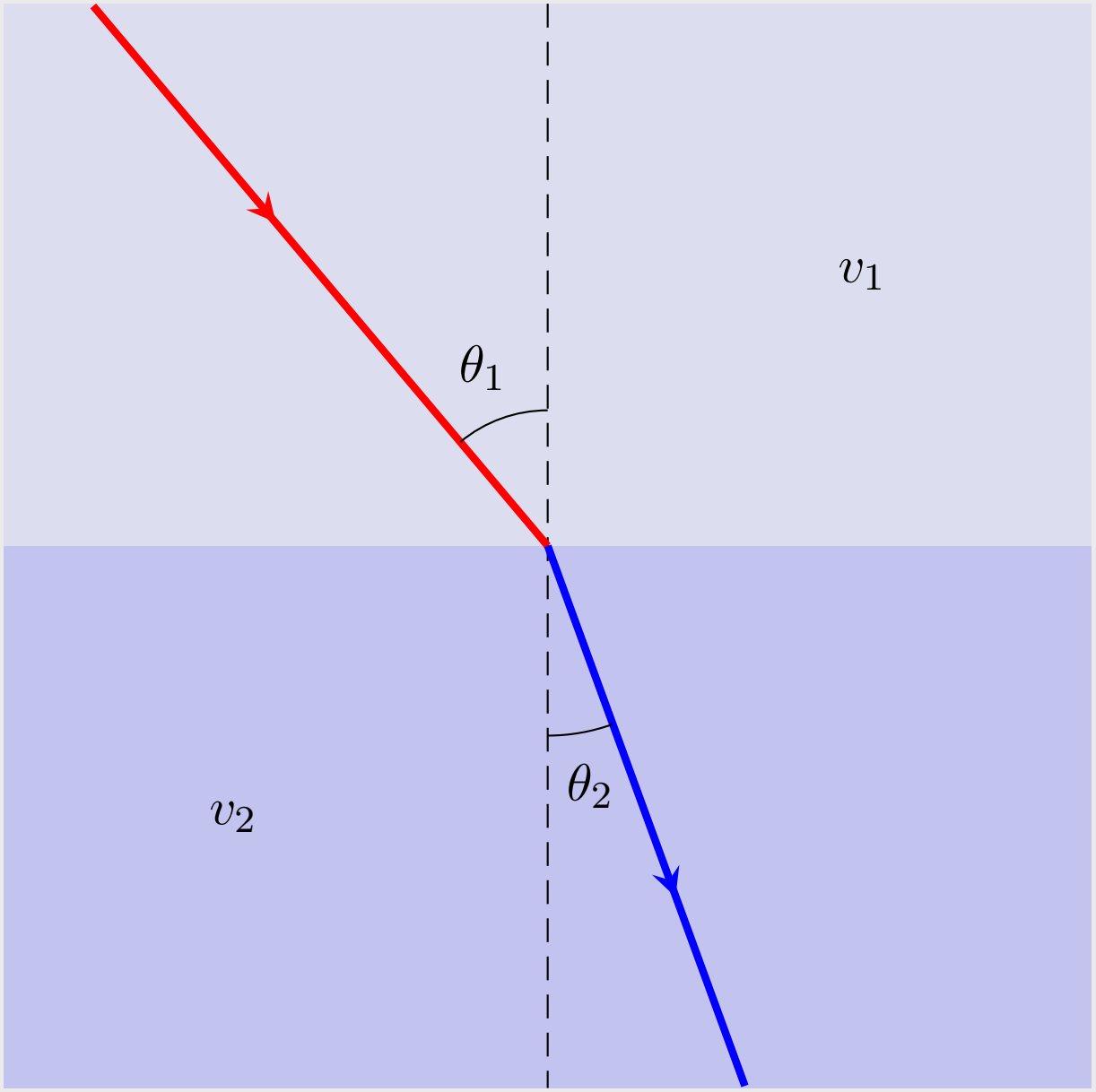
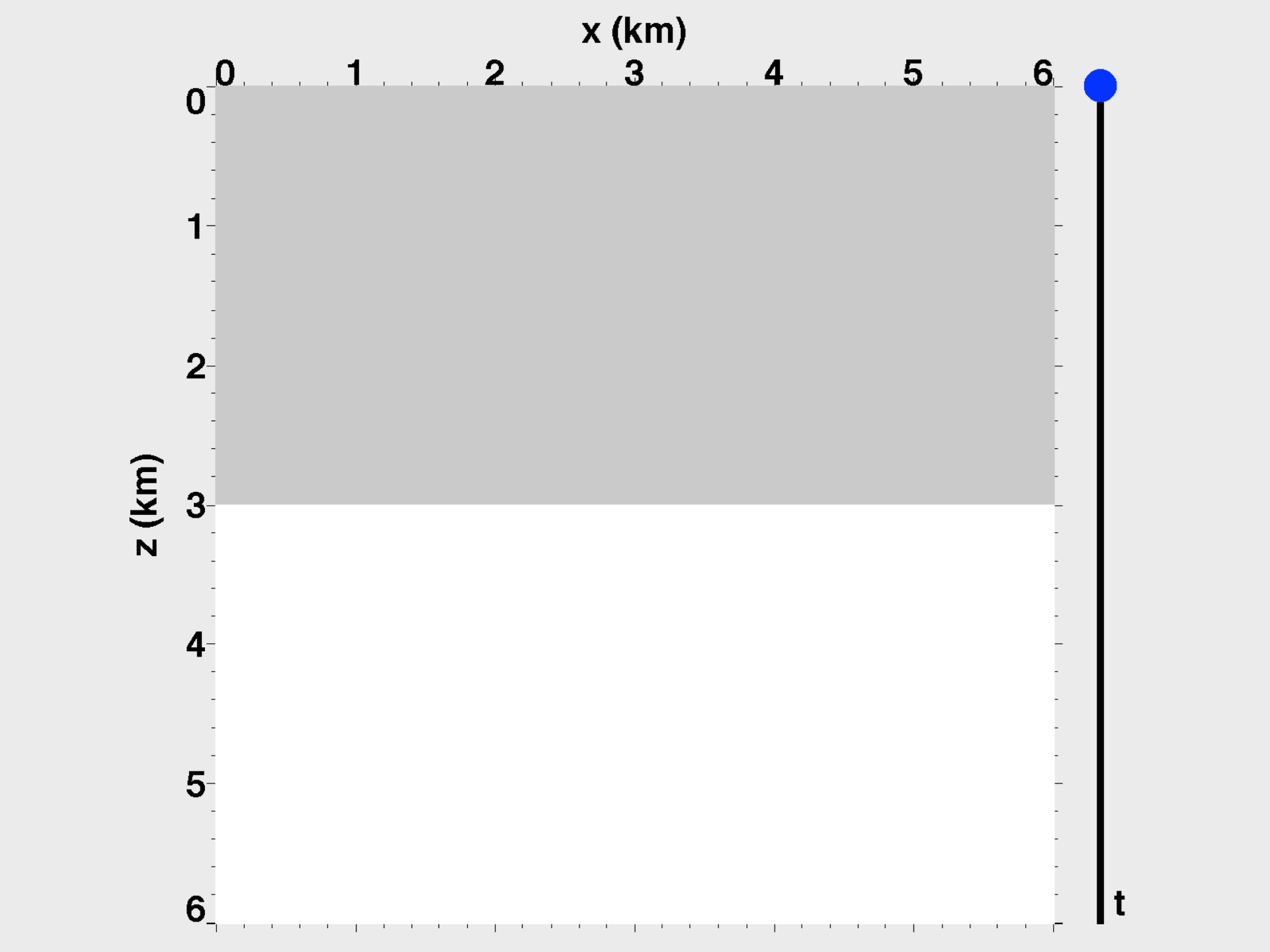
5
6

Snell's law



Change propagating direction


x (km)
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1
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z (km)
0
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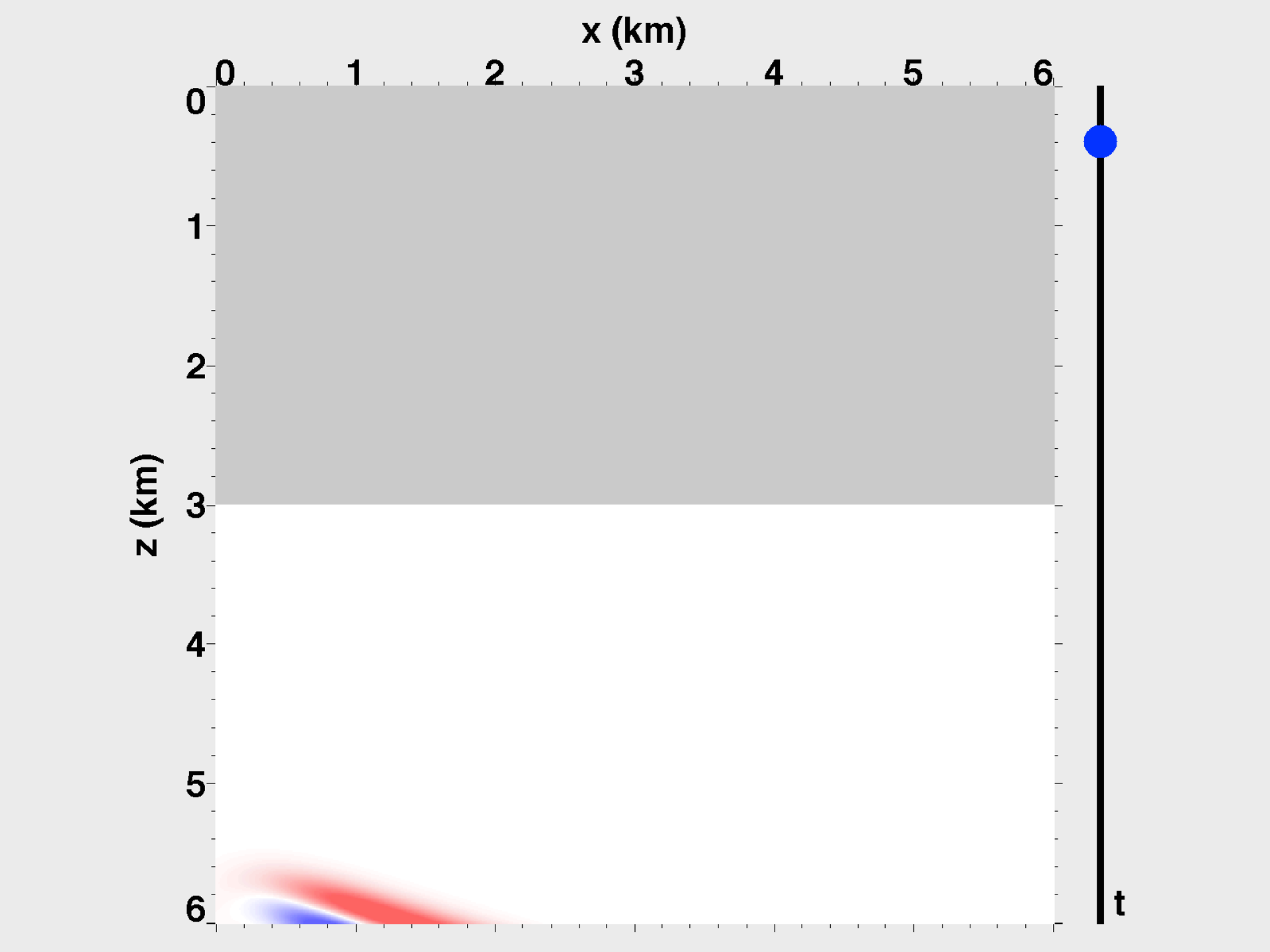
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z (km)
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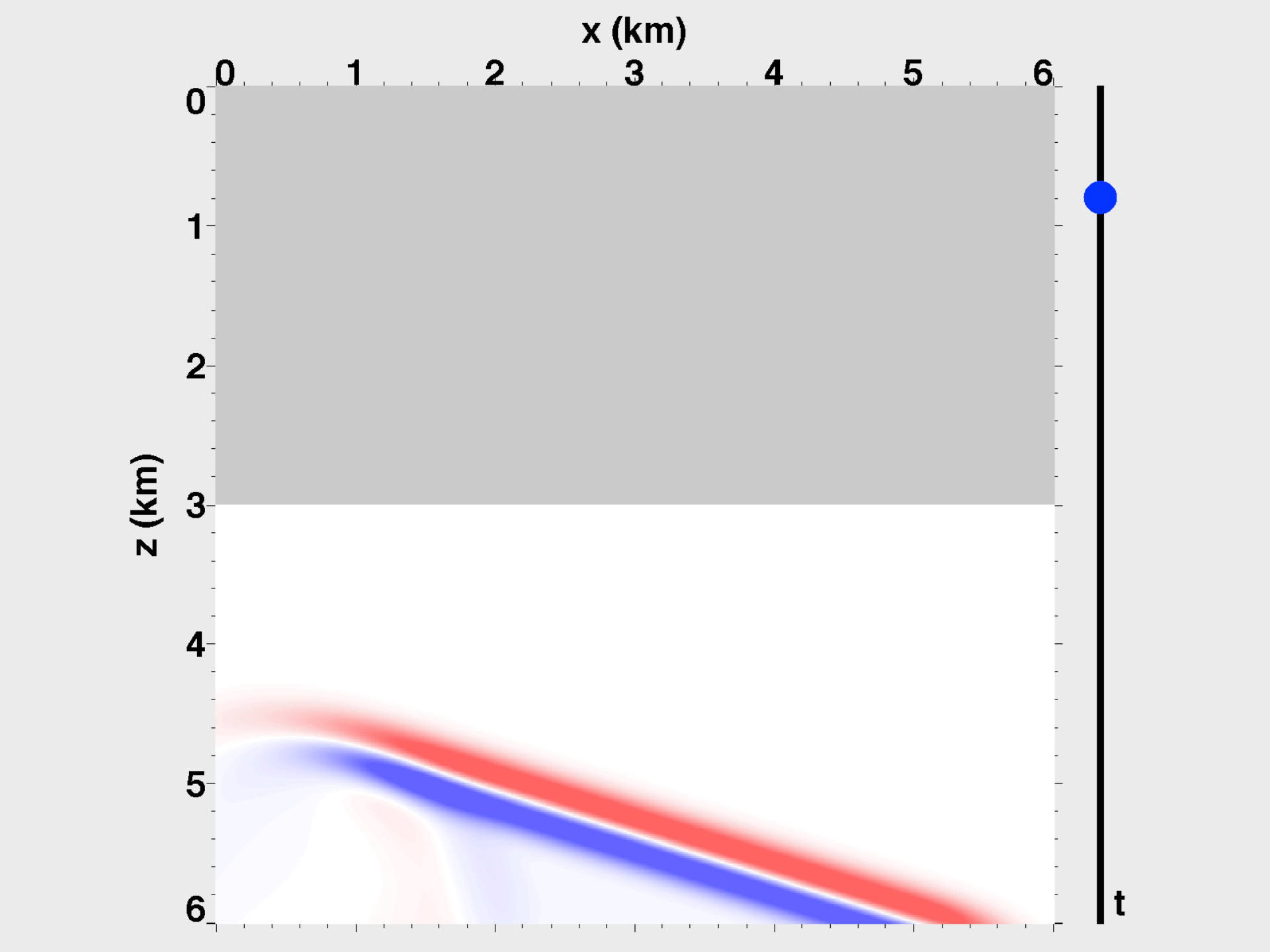
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z (km)
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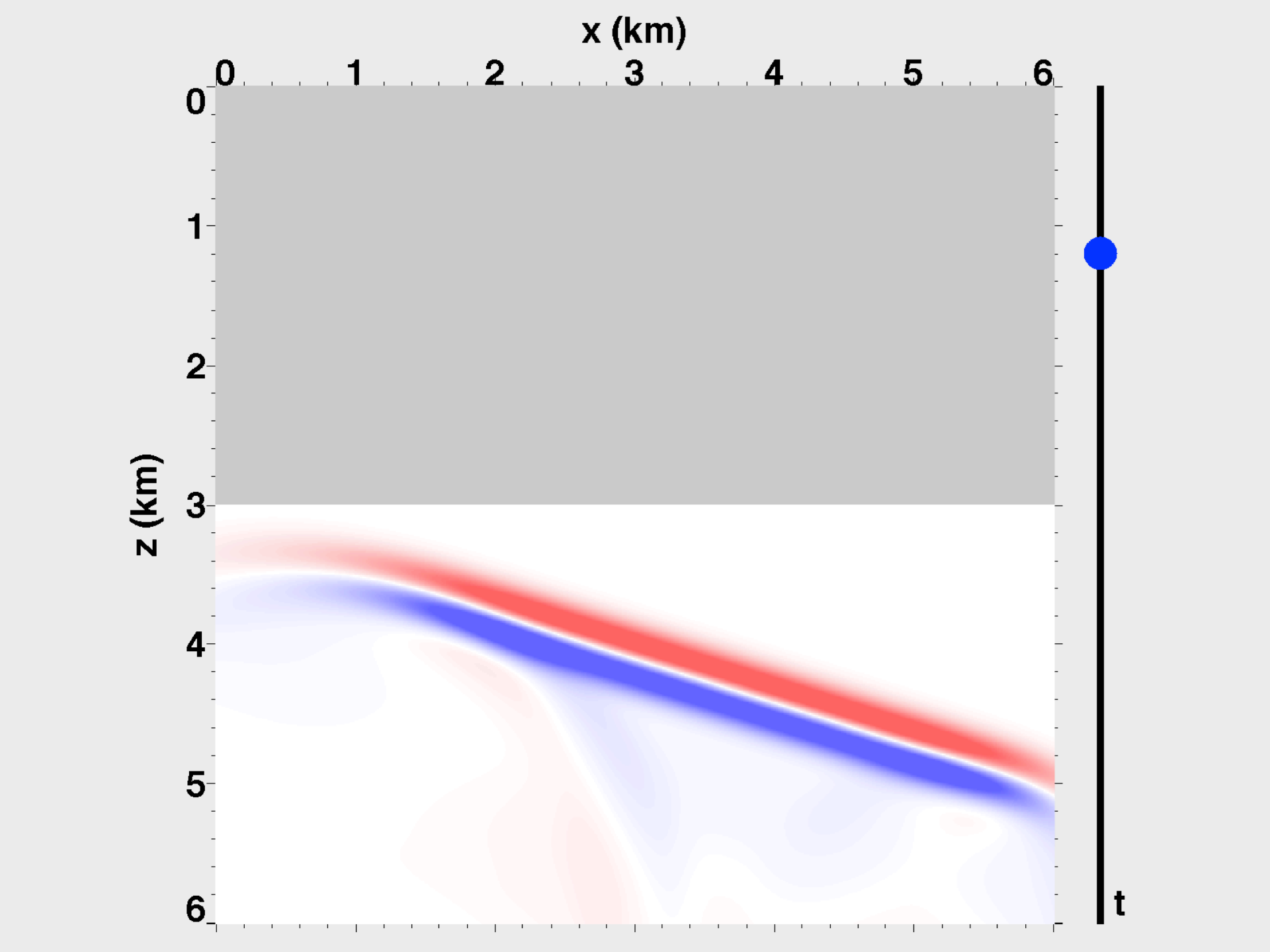
x (km)
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z (km)
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6
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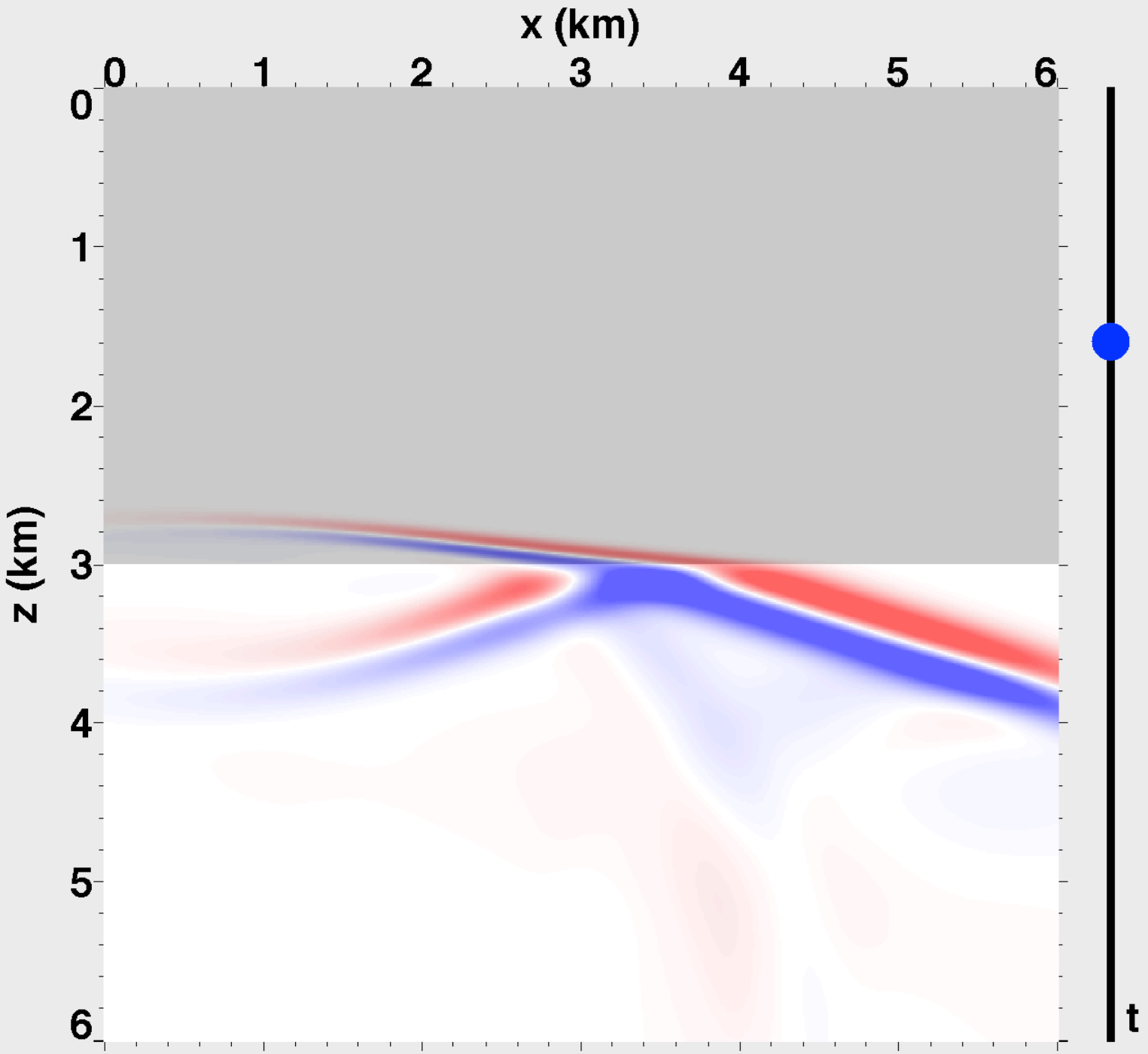
x (km)
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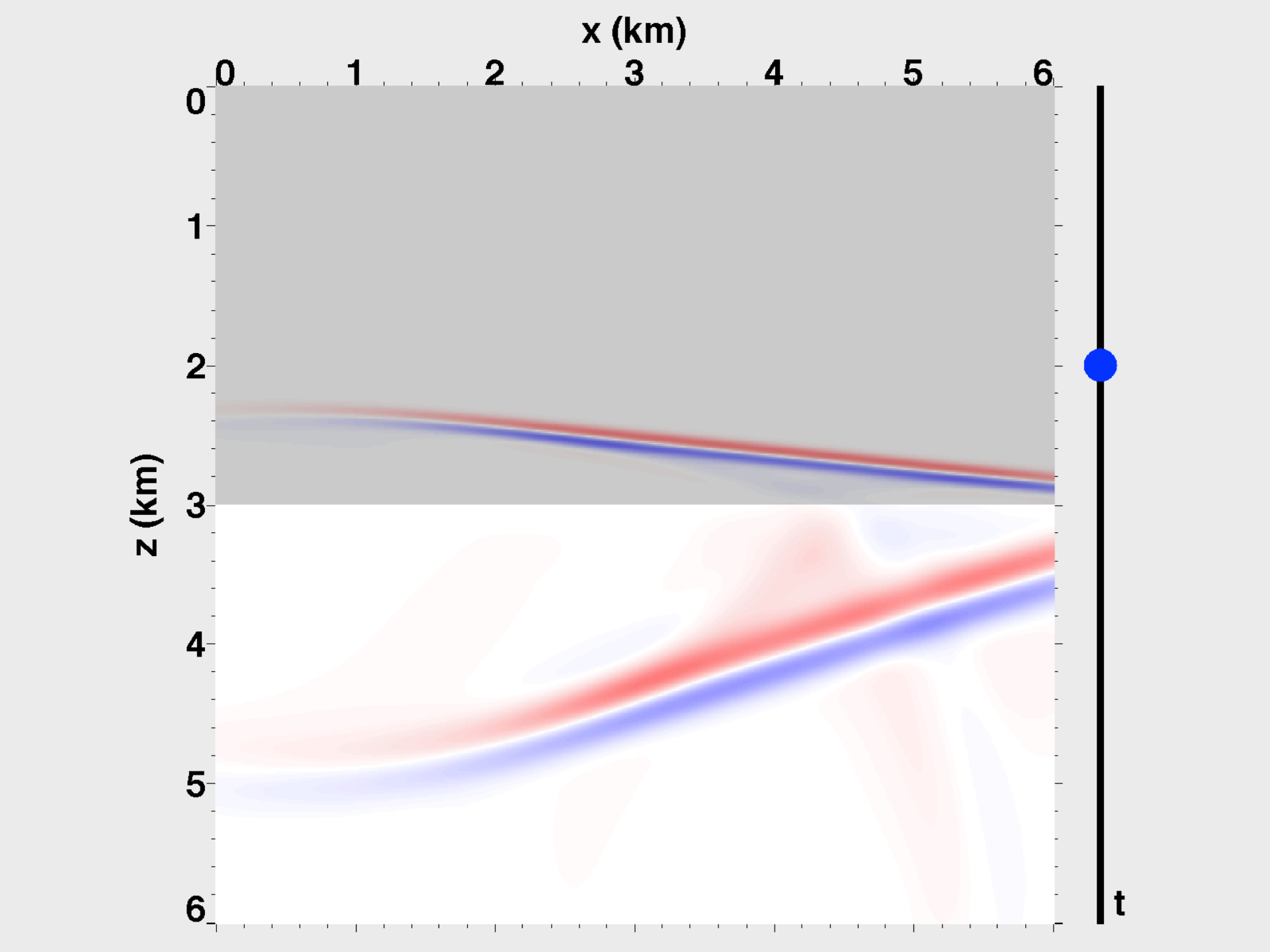
x (km)
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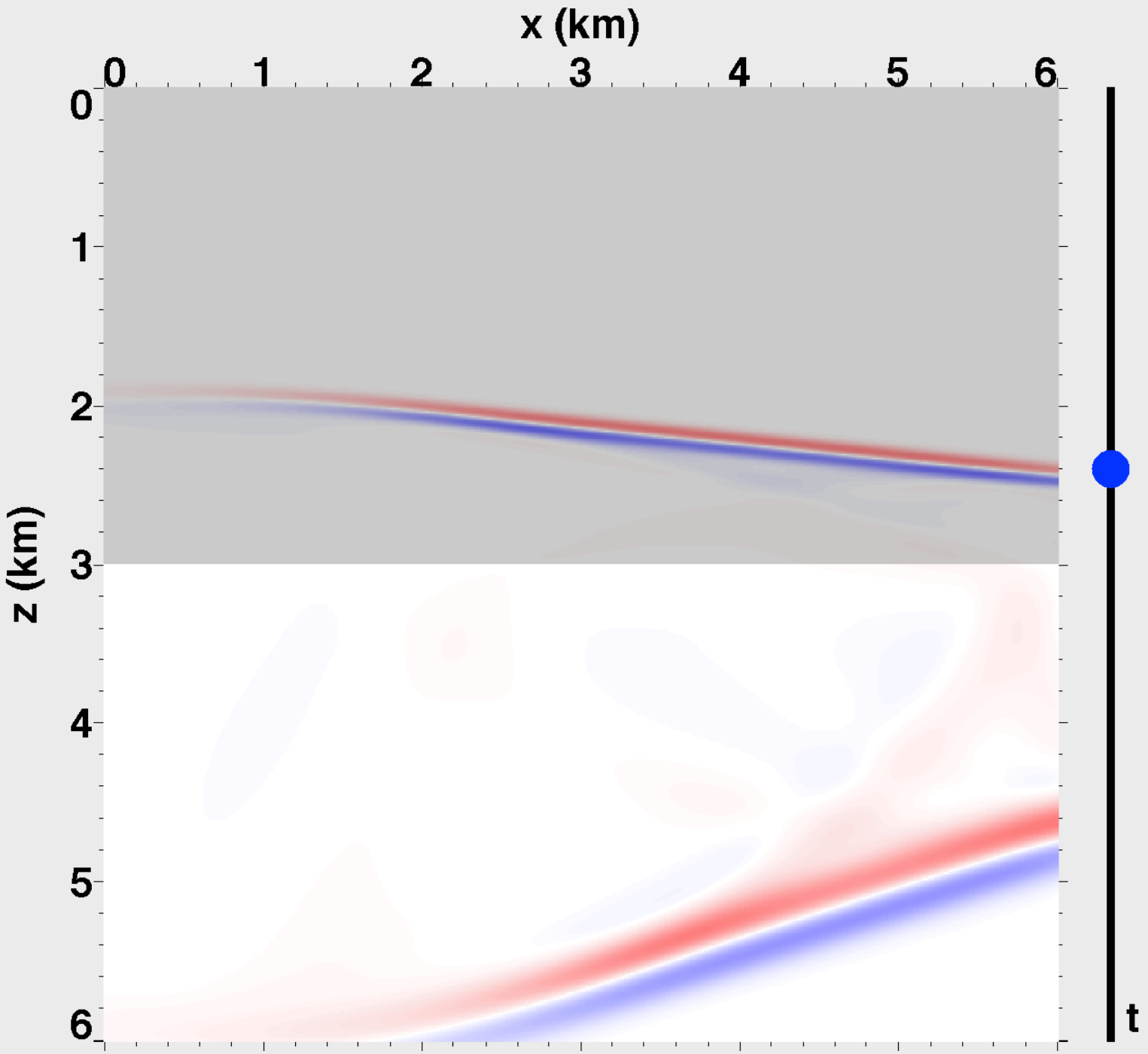
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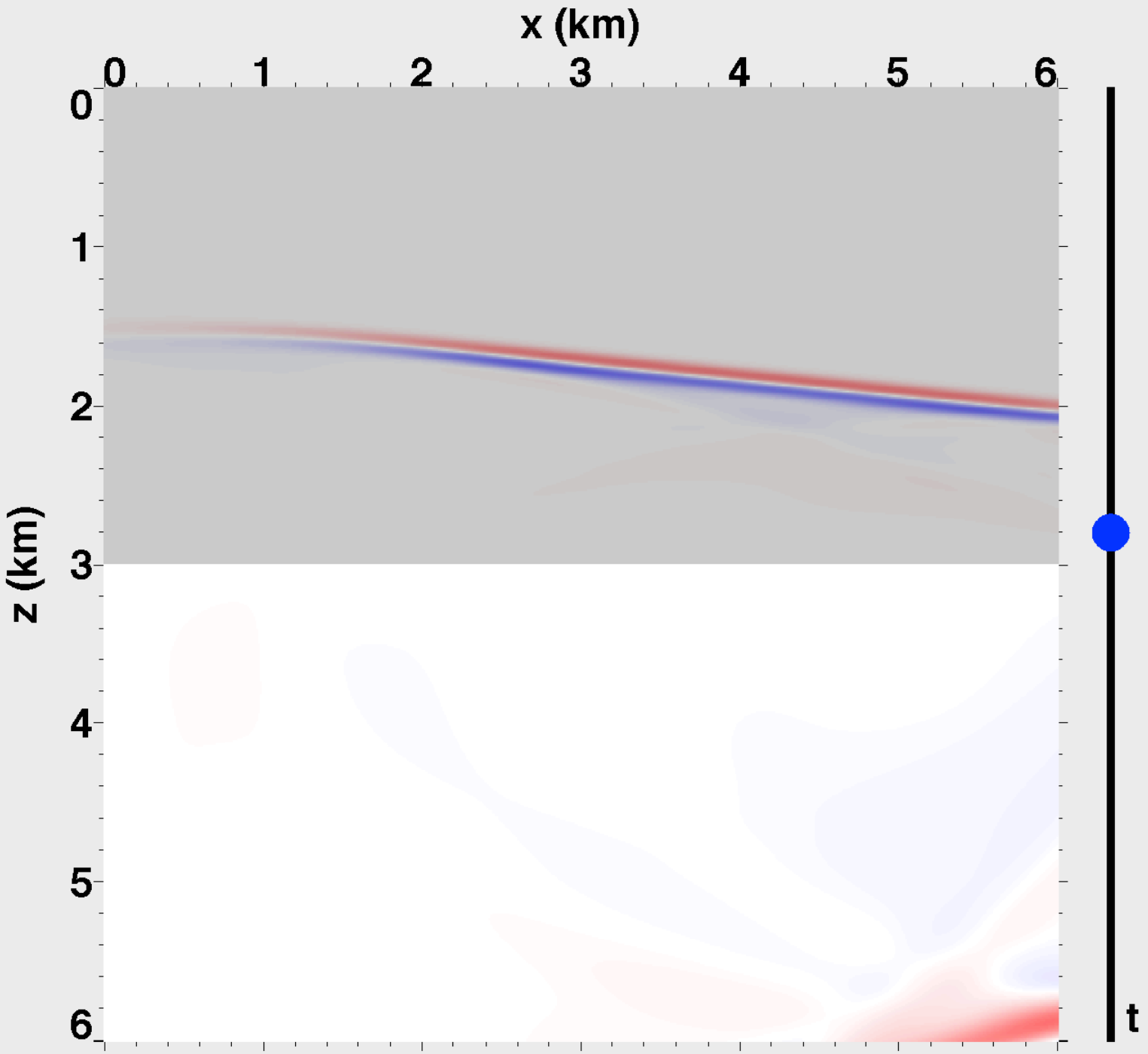
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z (km)
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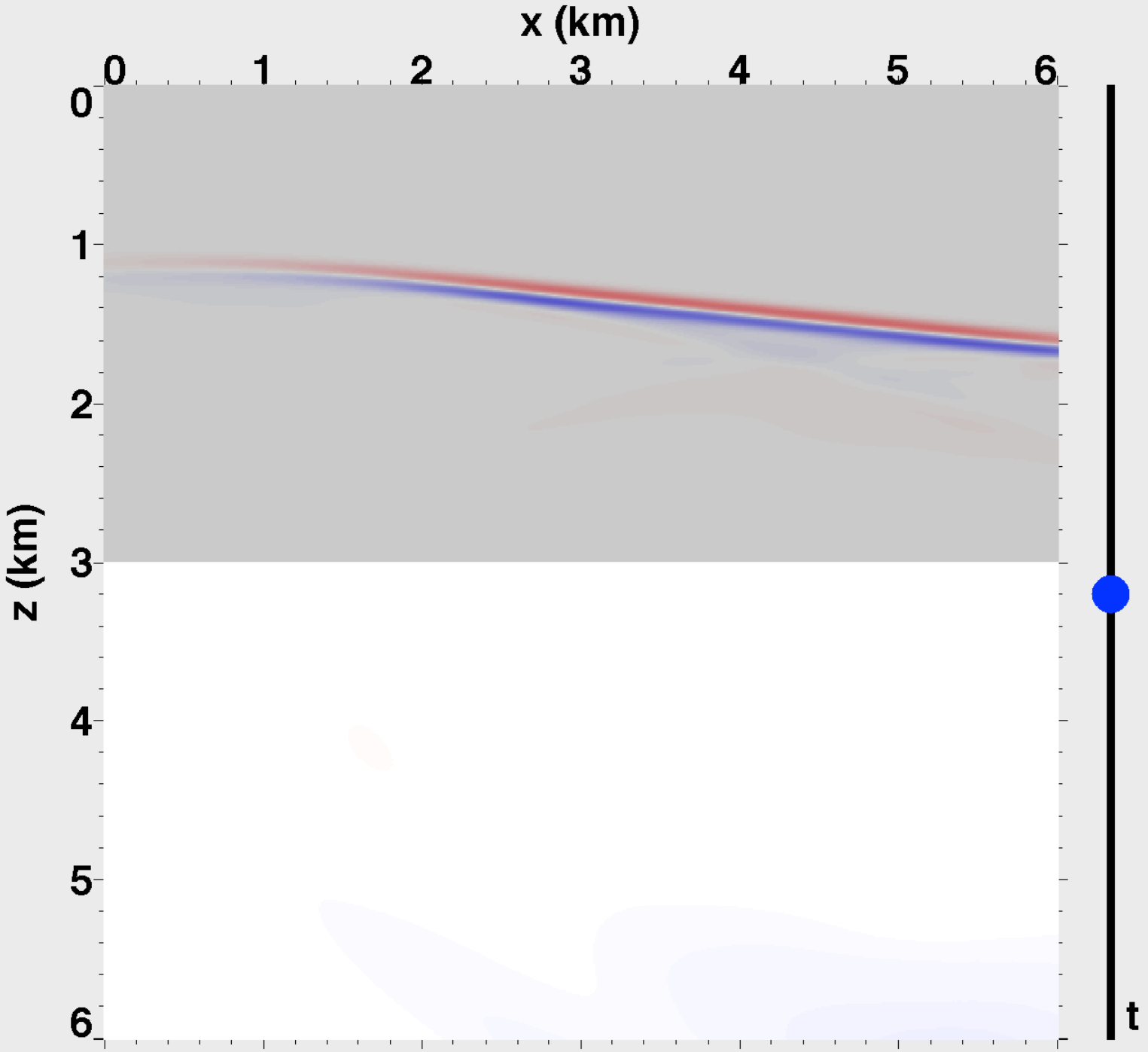
x (km)
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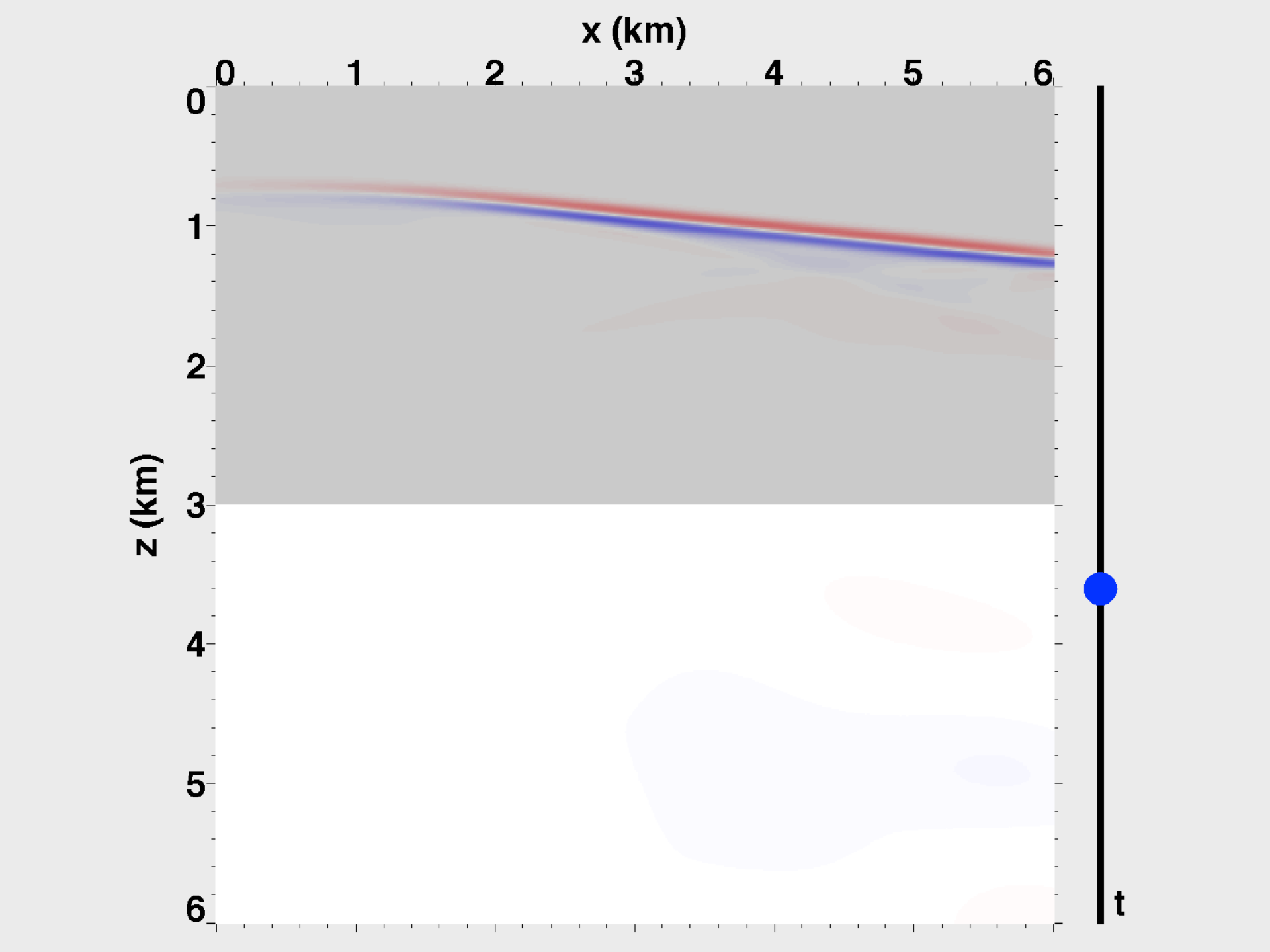
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z (km)
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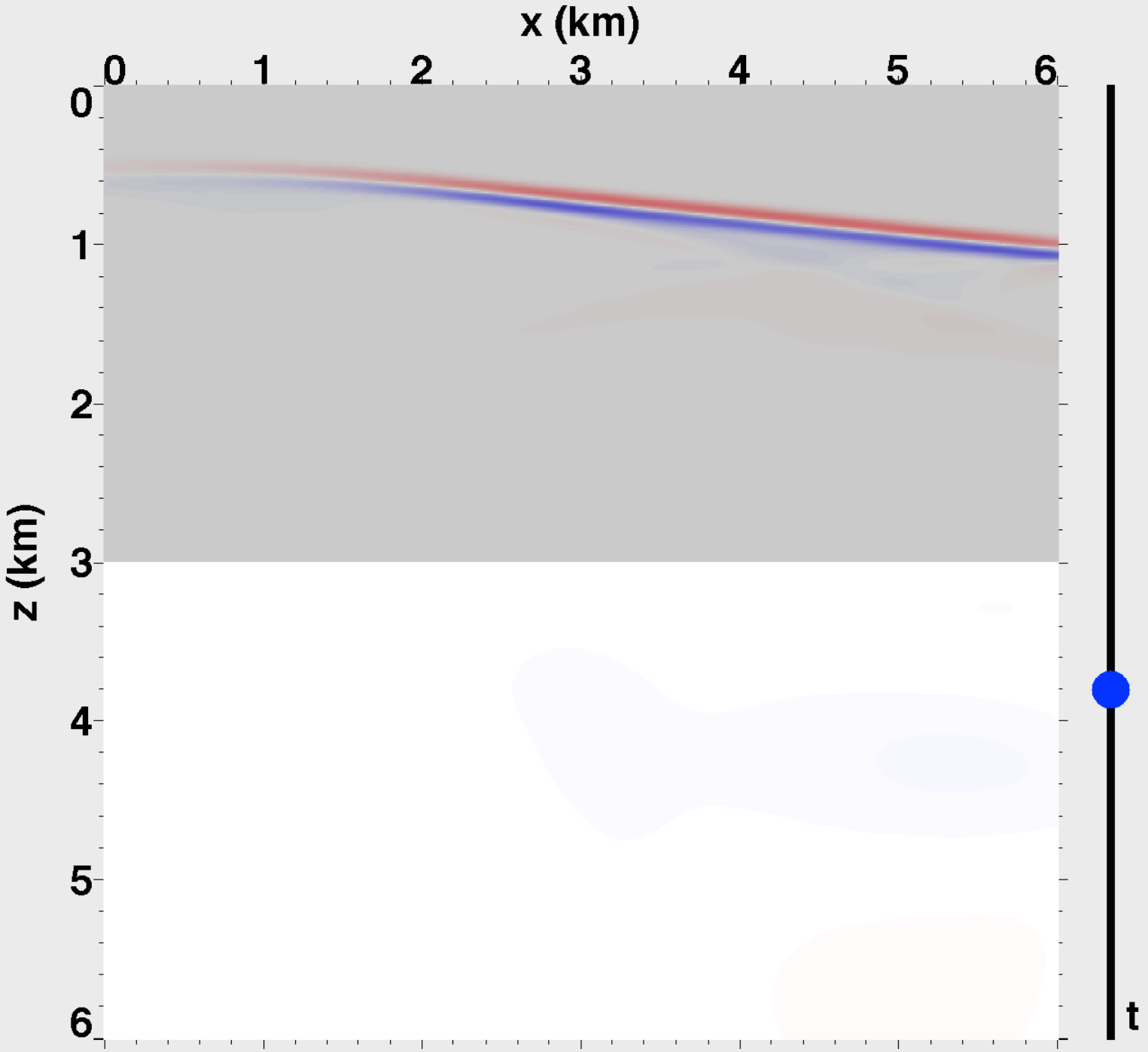
x (km)
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z (km)
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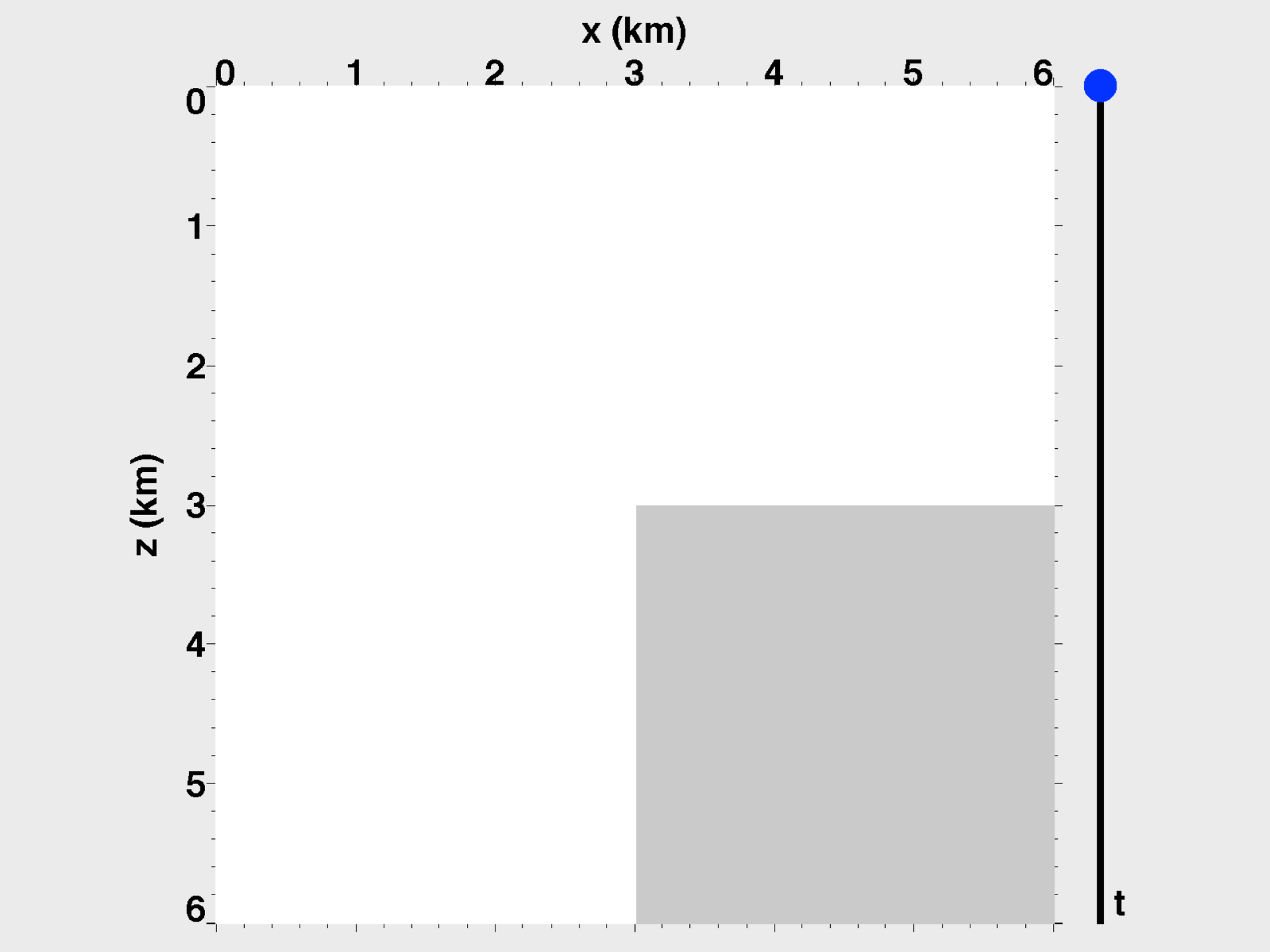
Change propagating direction

another example


x (km)
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z (km)
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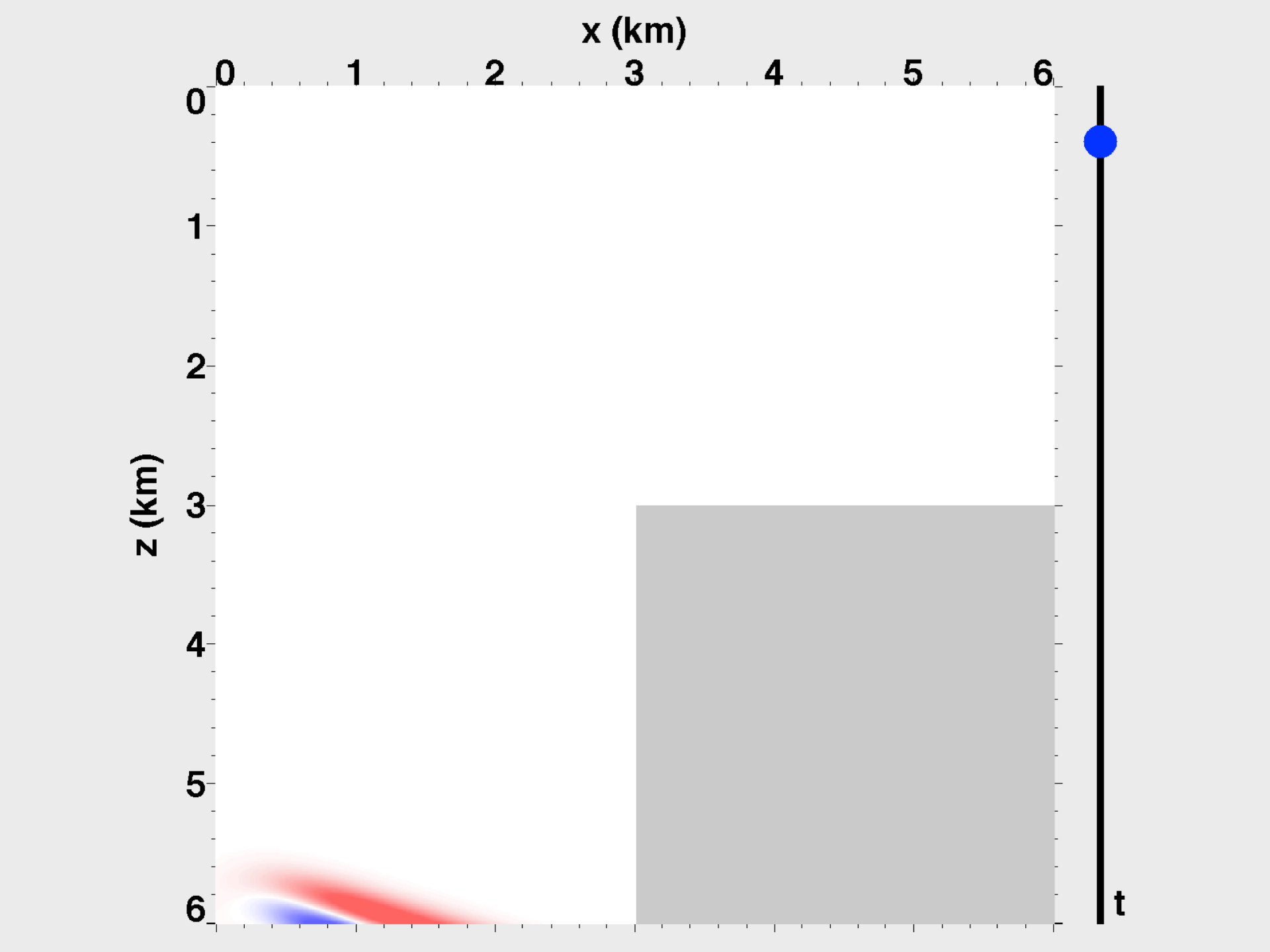
x (km)
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z (km)
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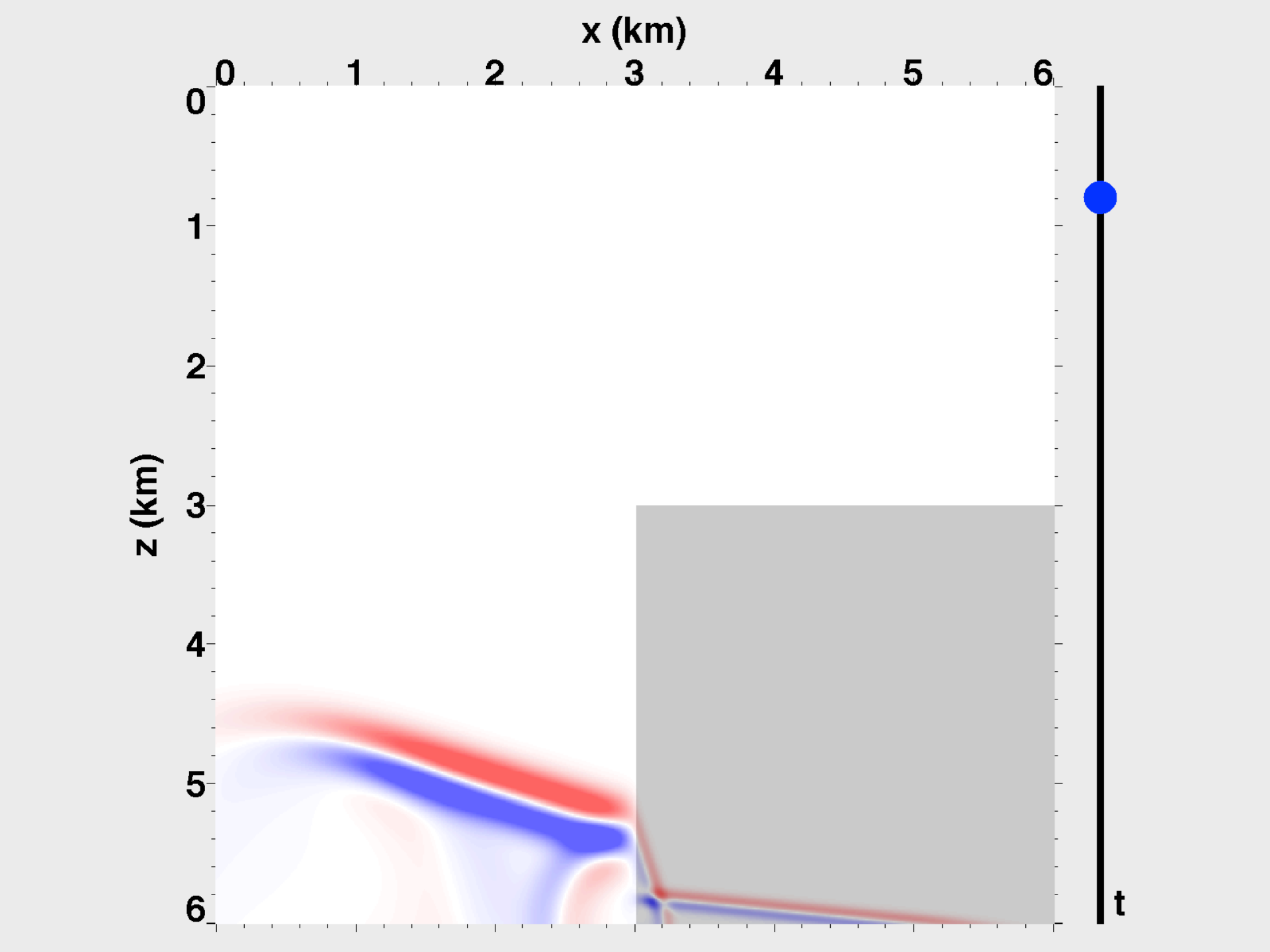
x (km)
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z (km)
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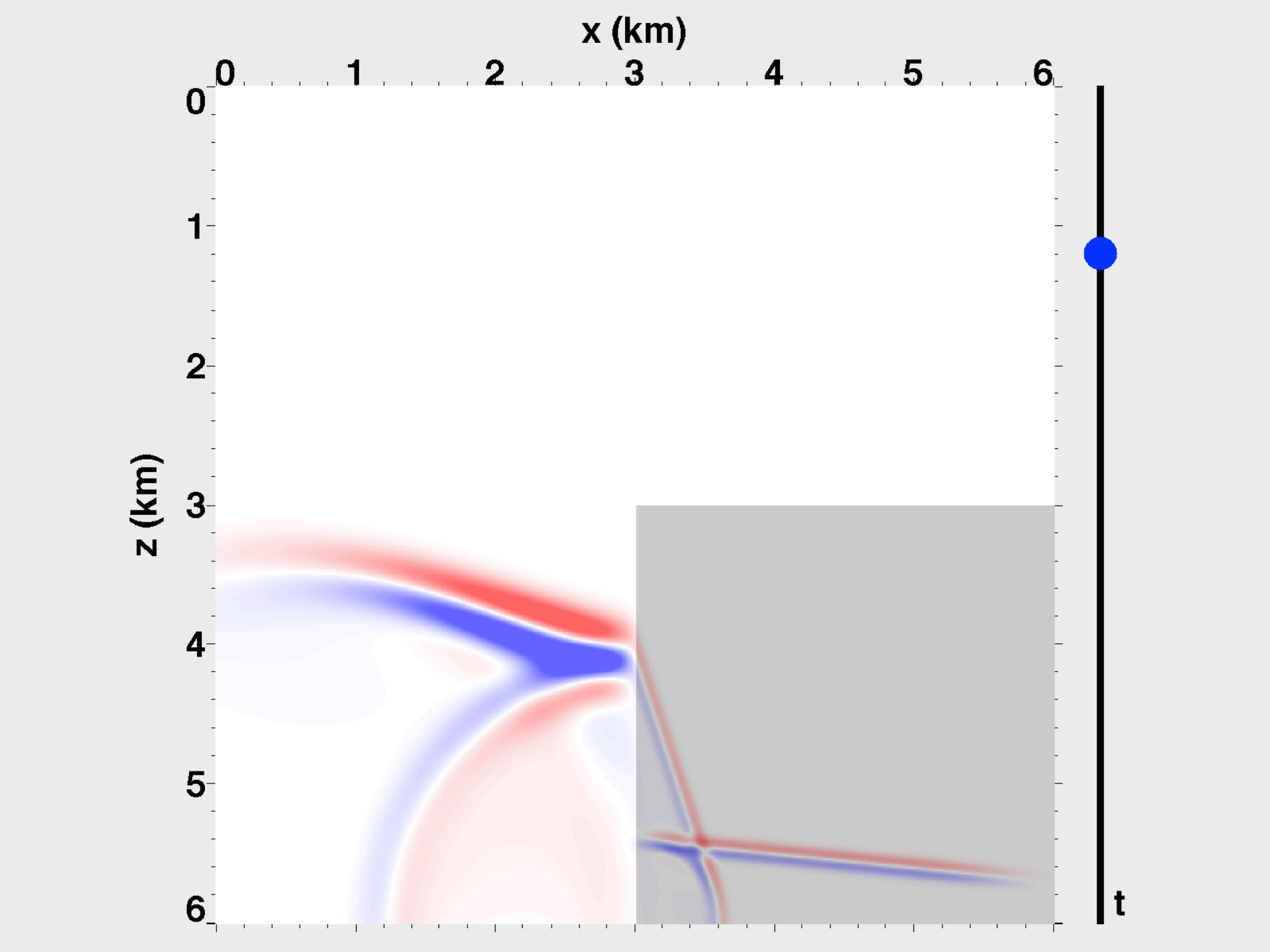
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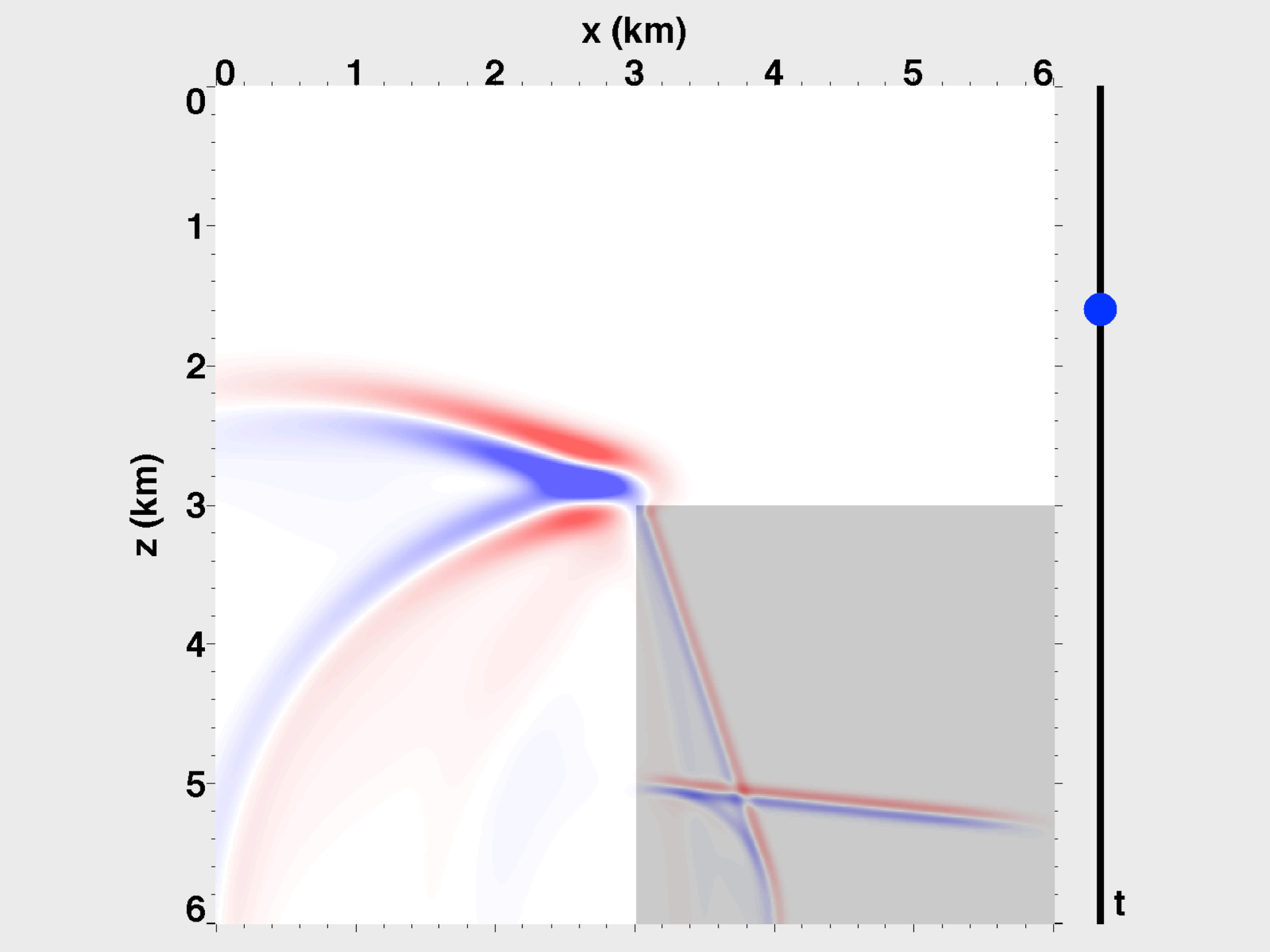
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z (km)
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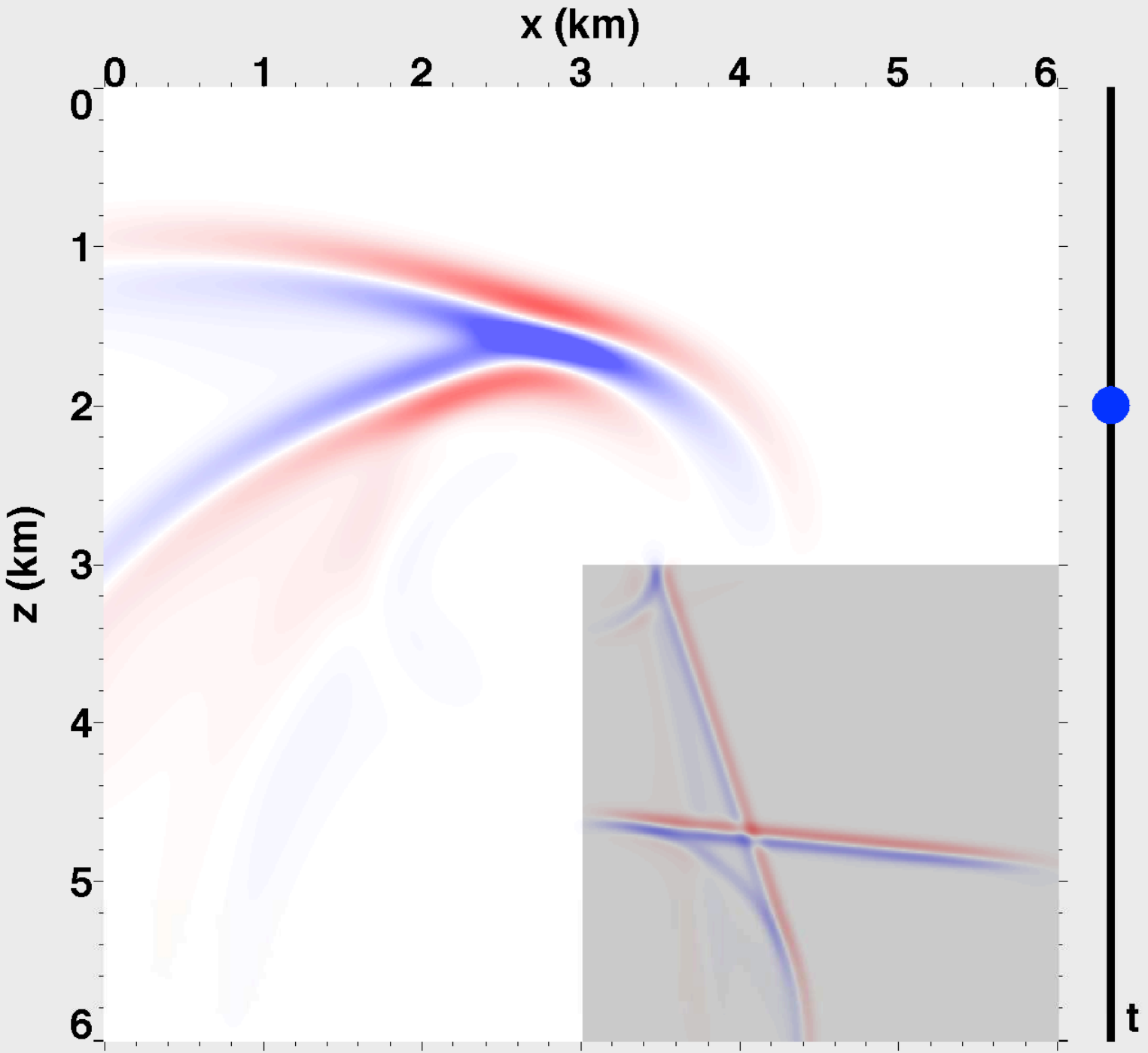
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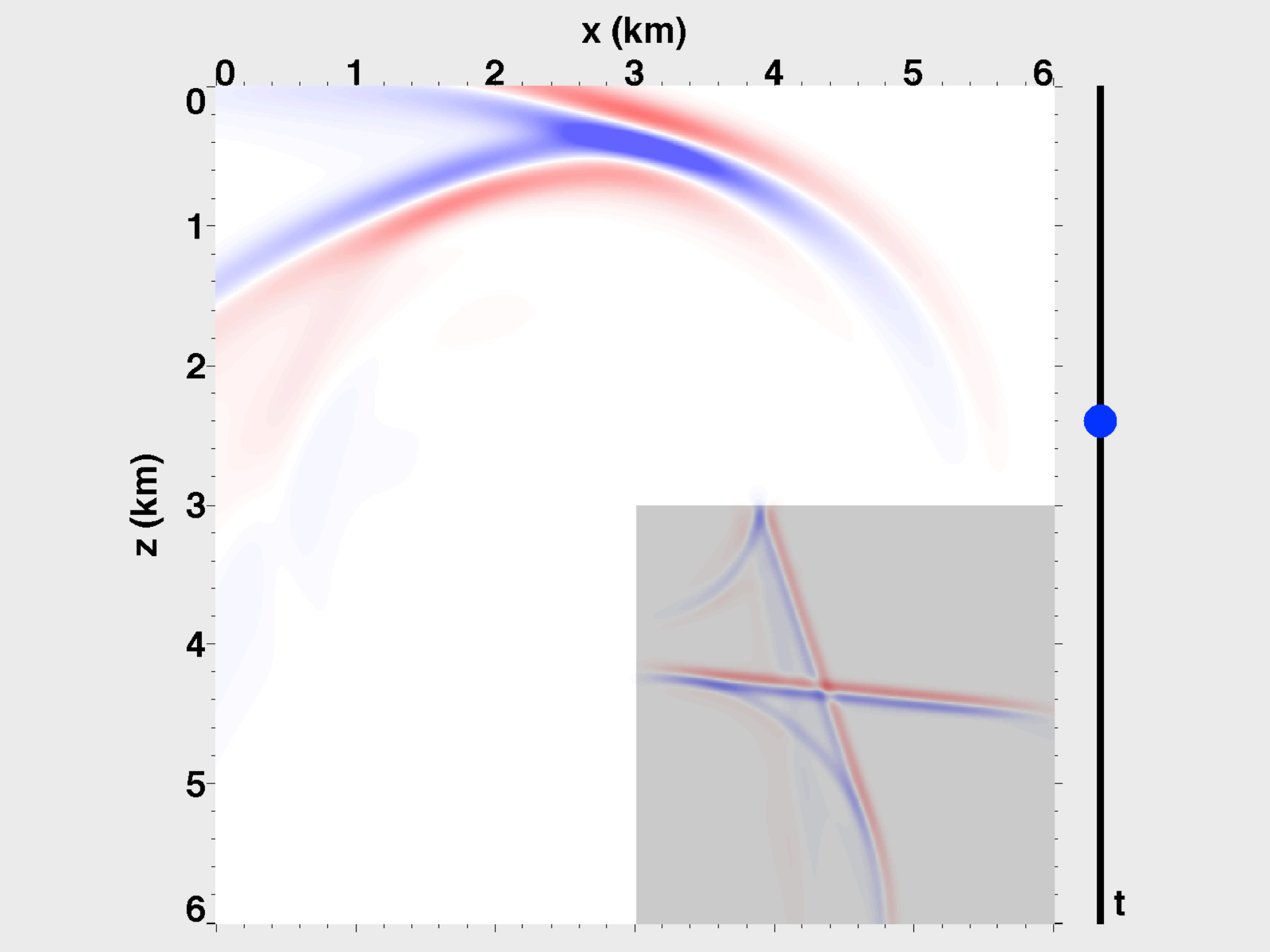
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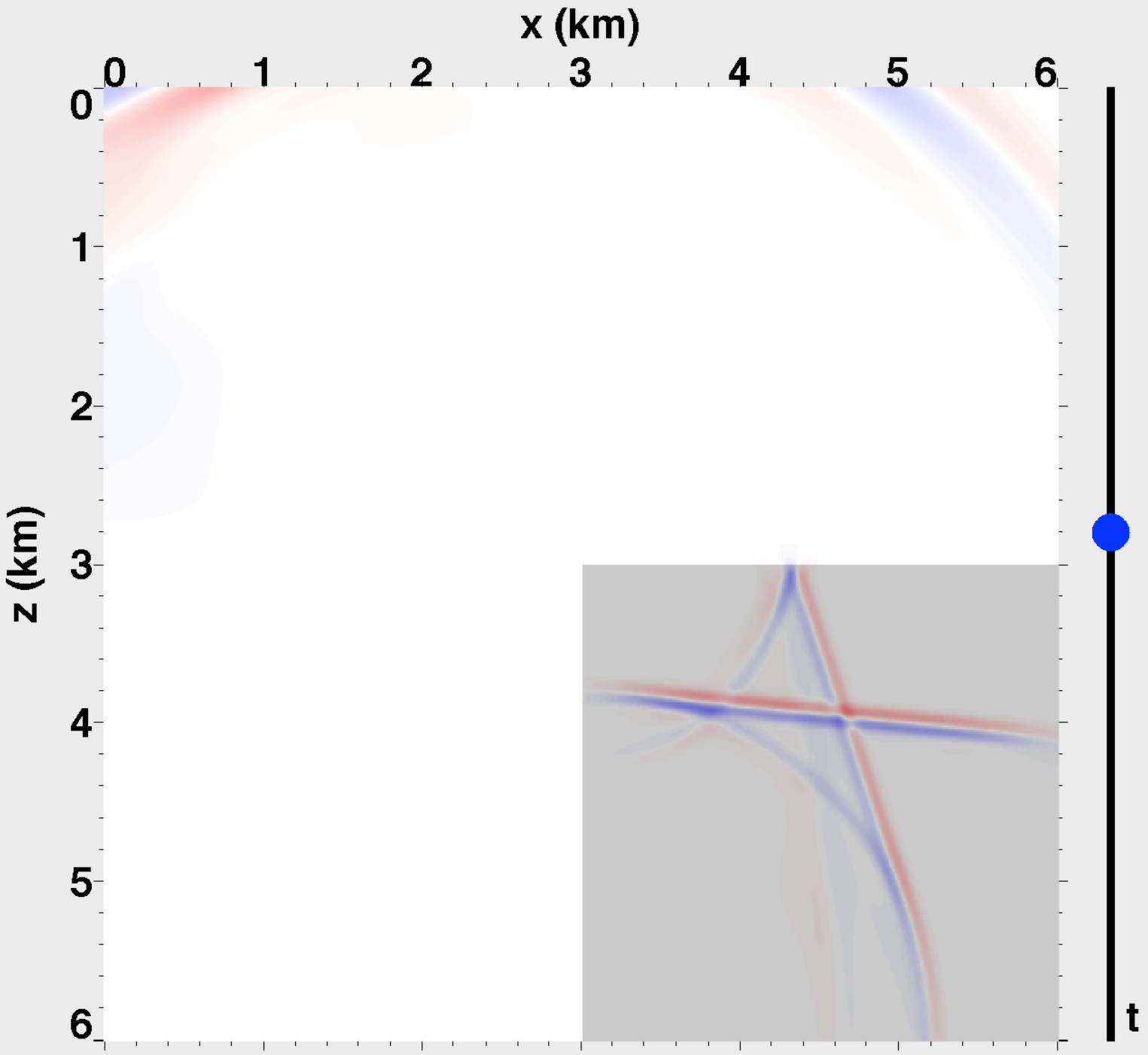
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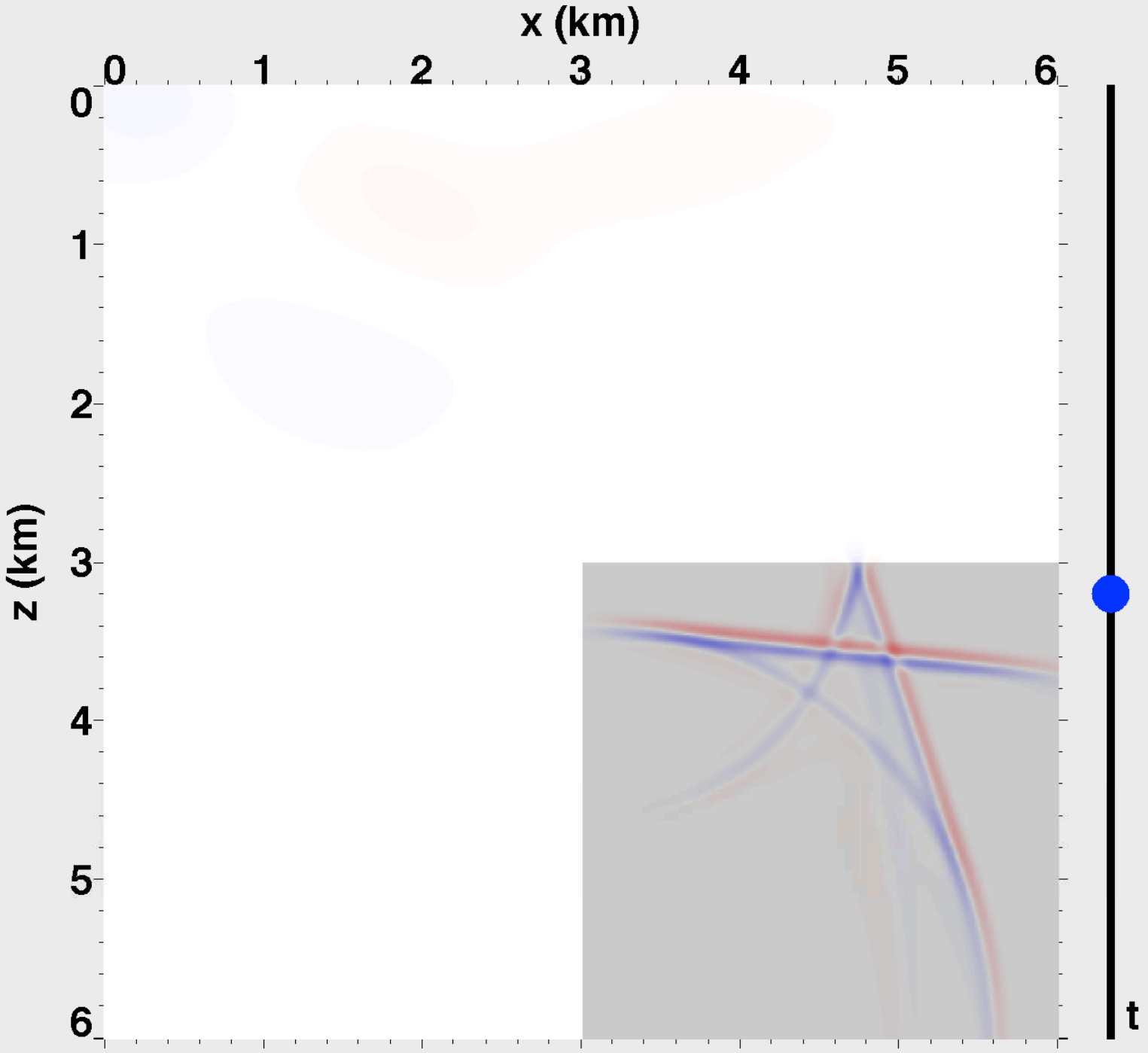
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z (km)
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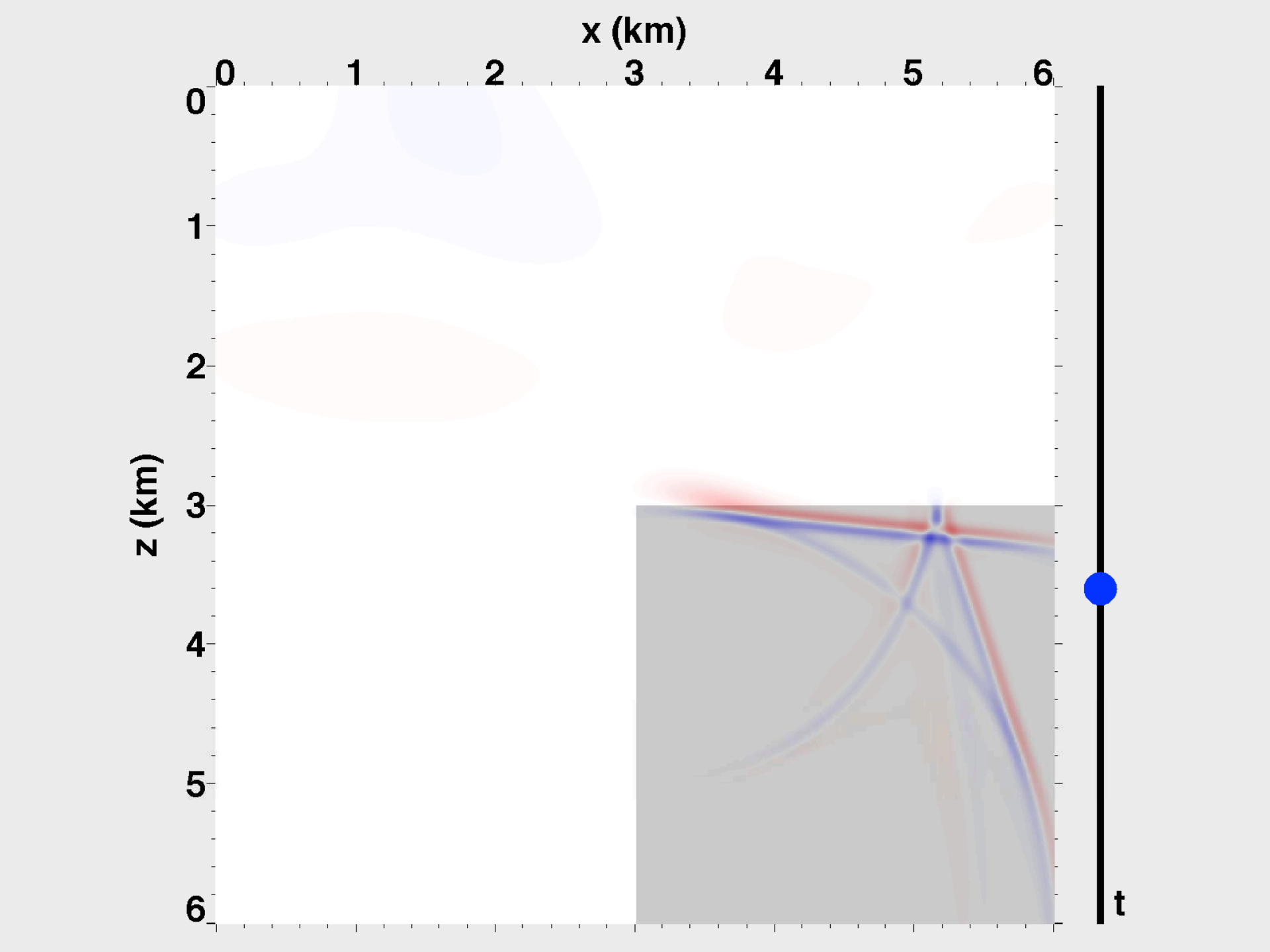
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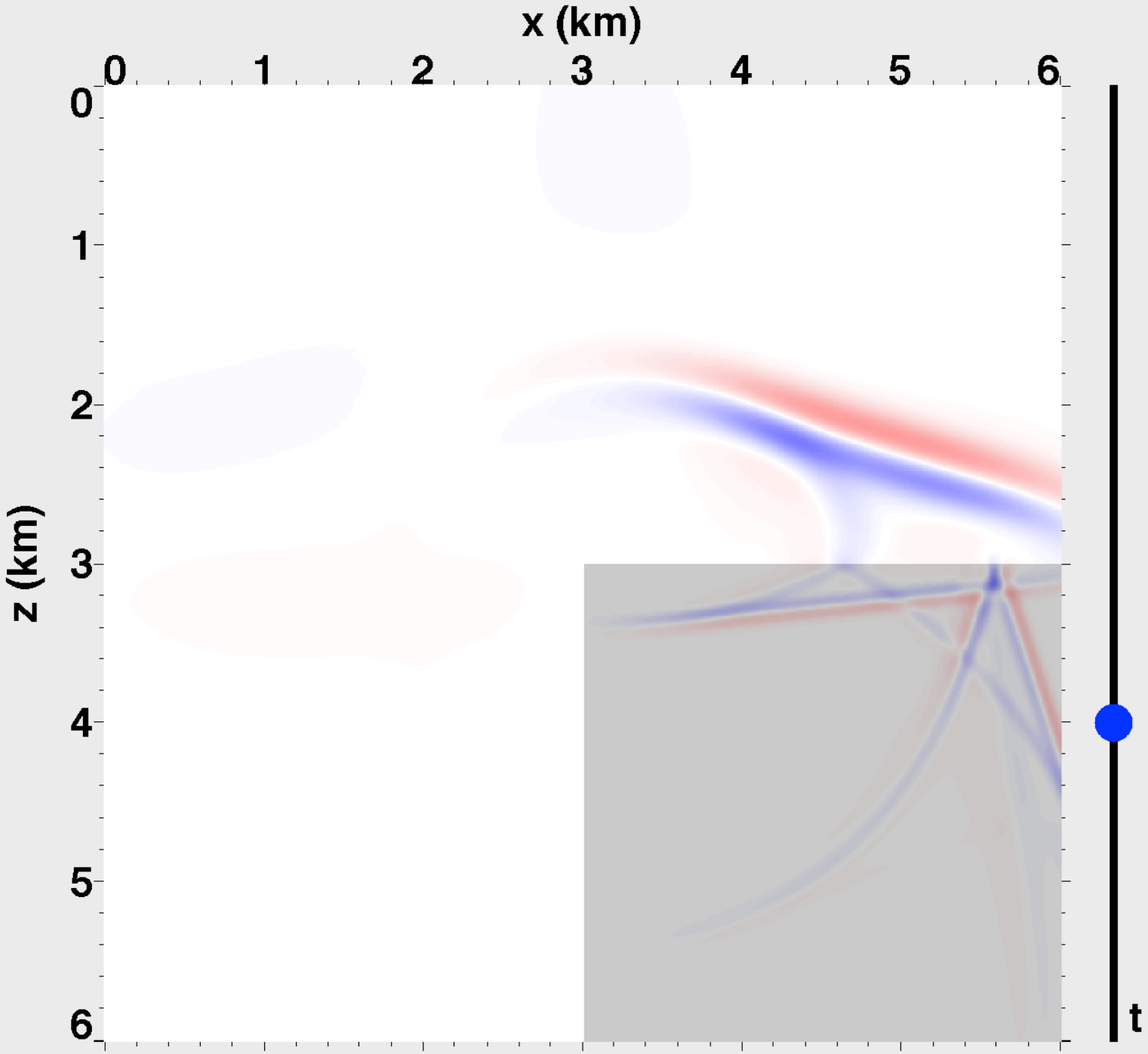
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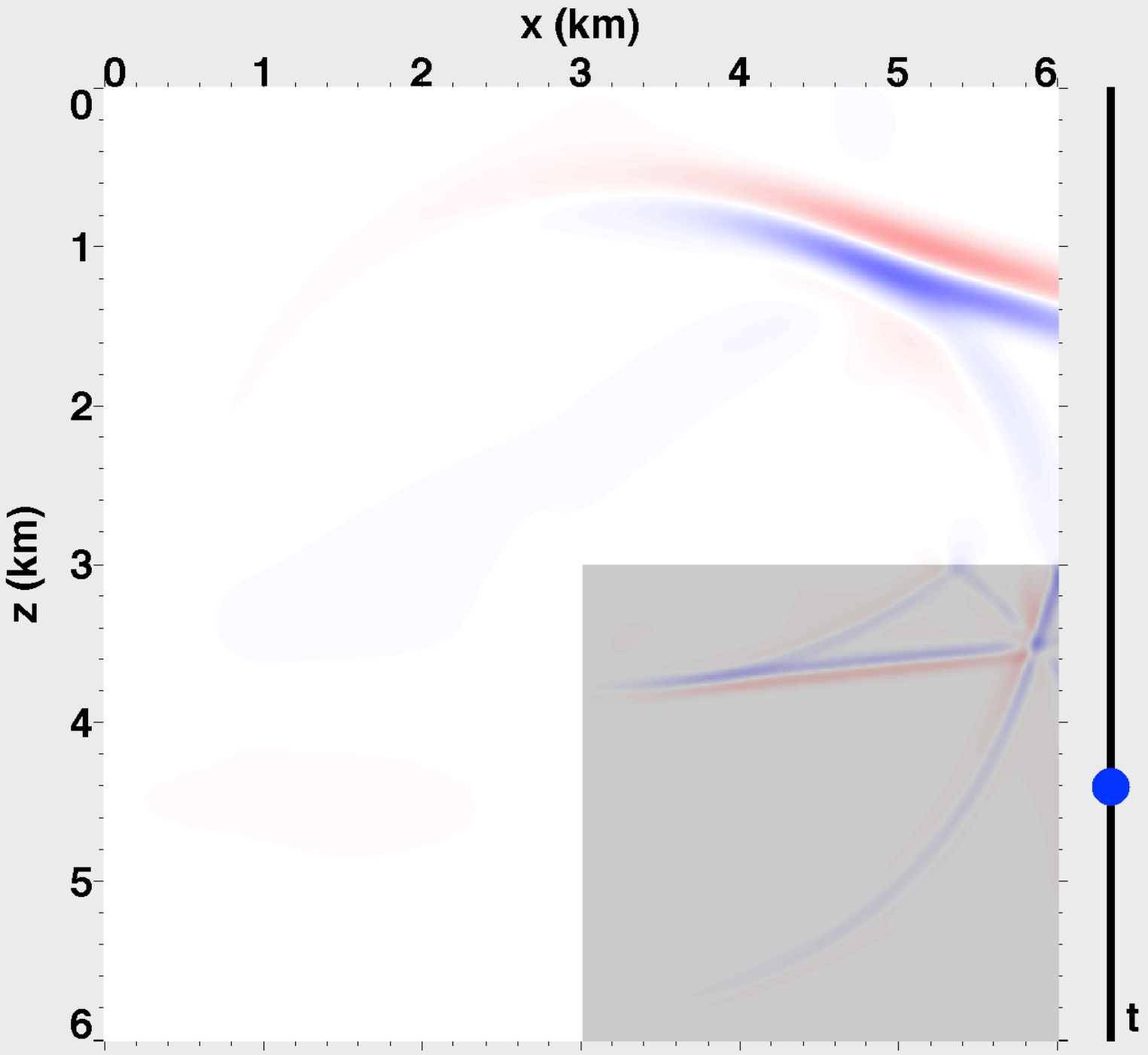
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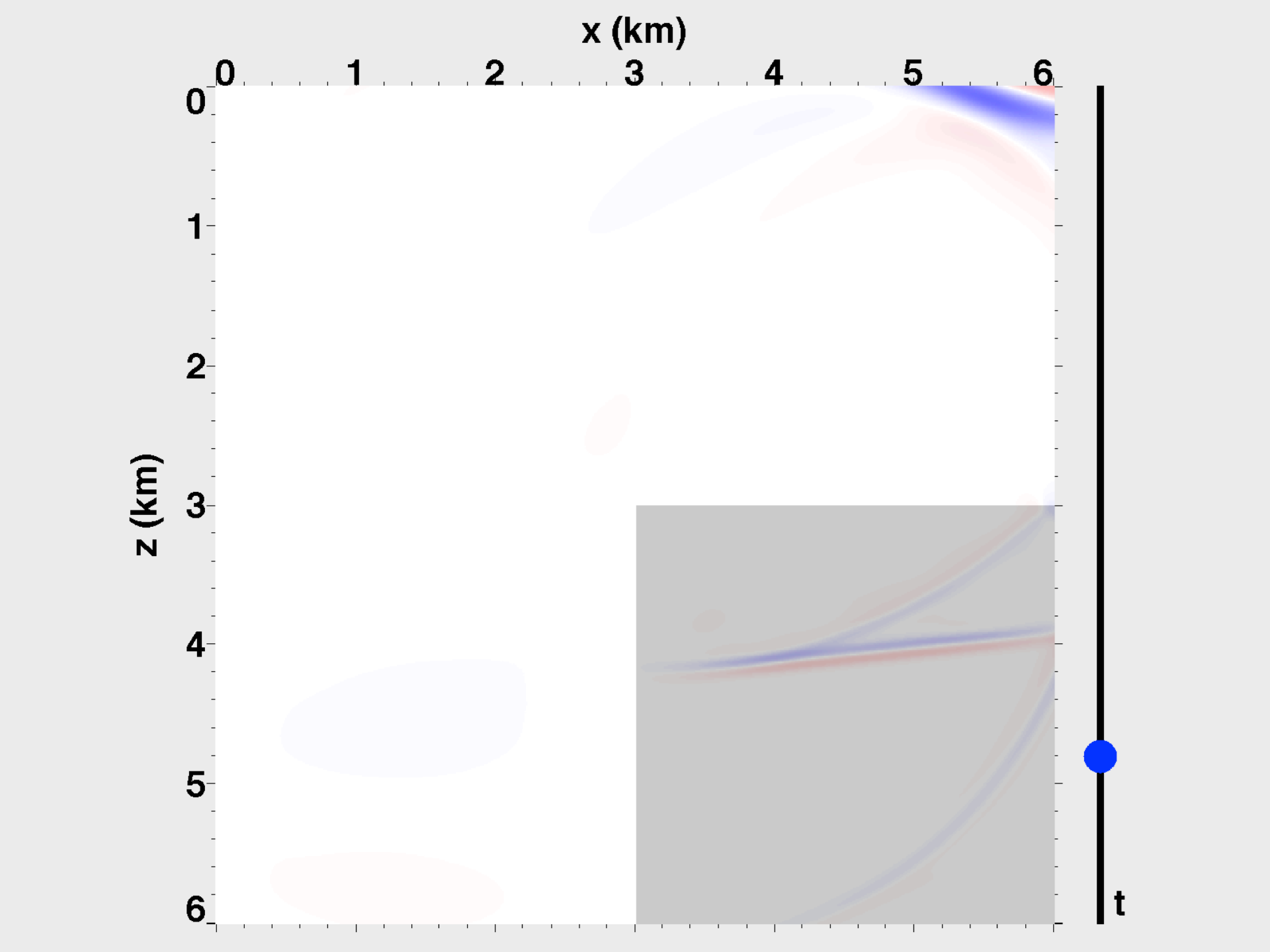
t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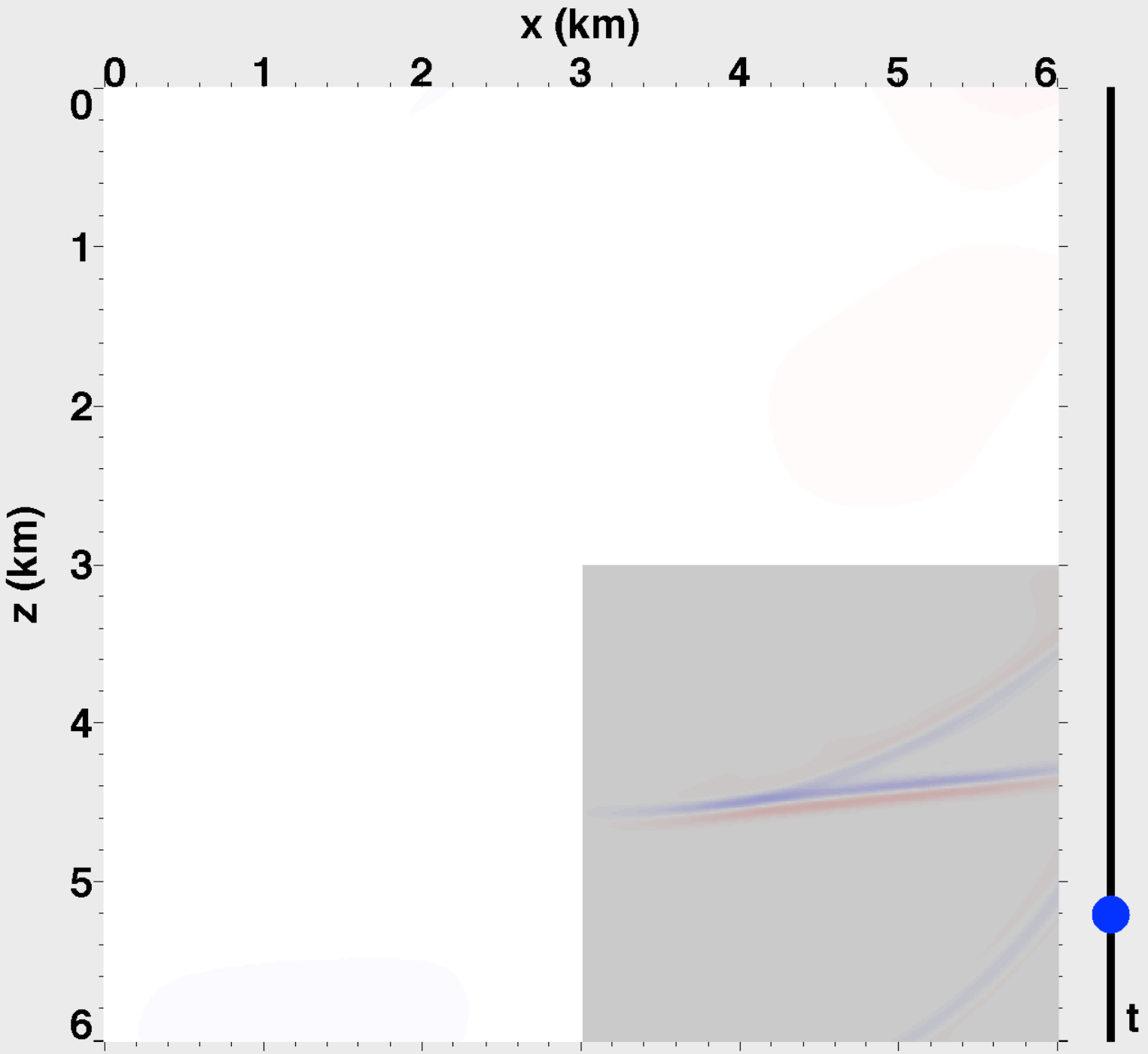
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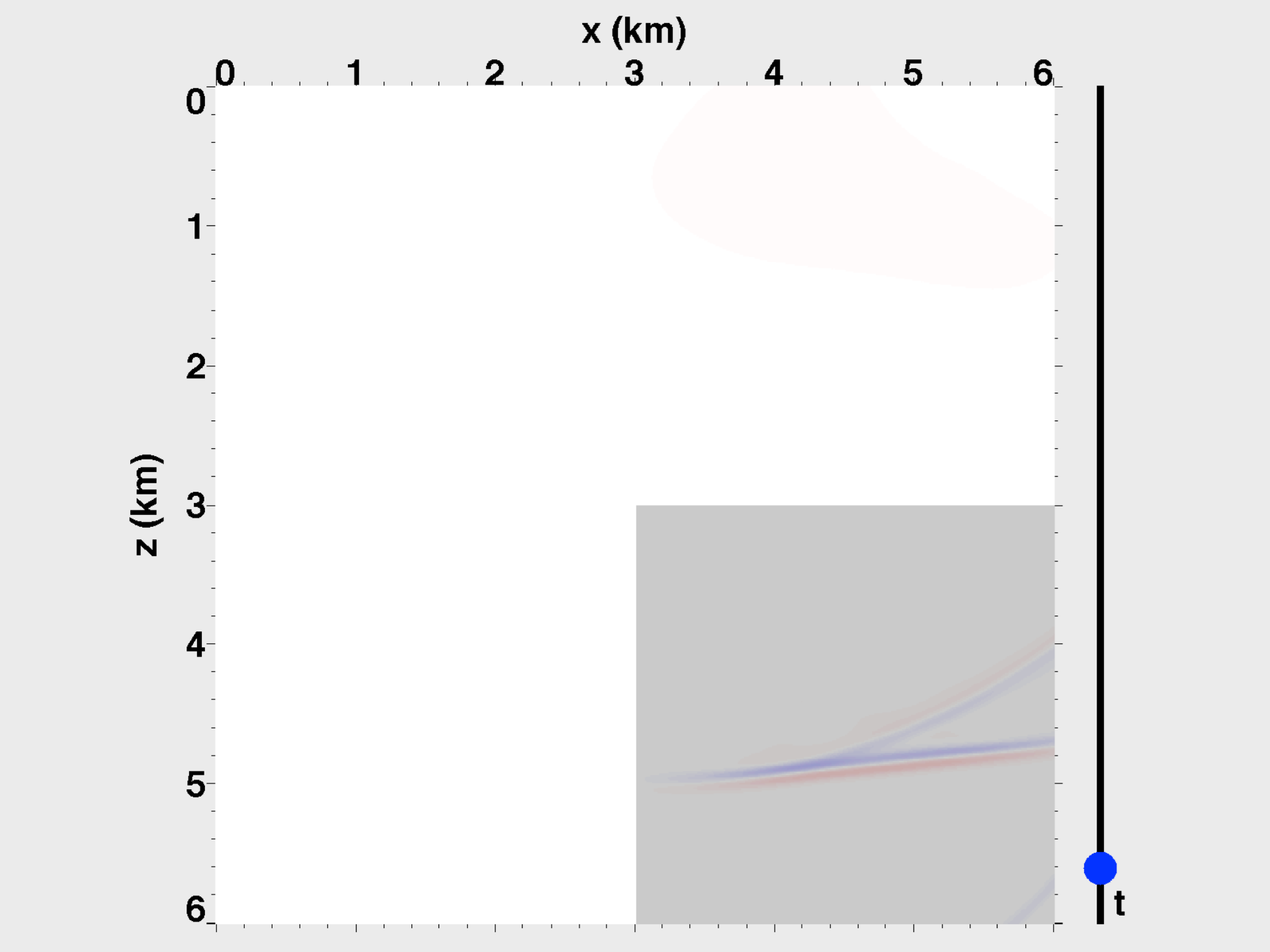

x (km)
0
1
2
3
4
5
6
z (km)
0
1
2
3
4
5
6
t

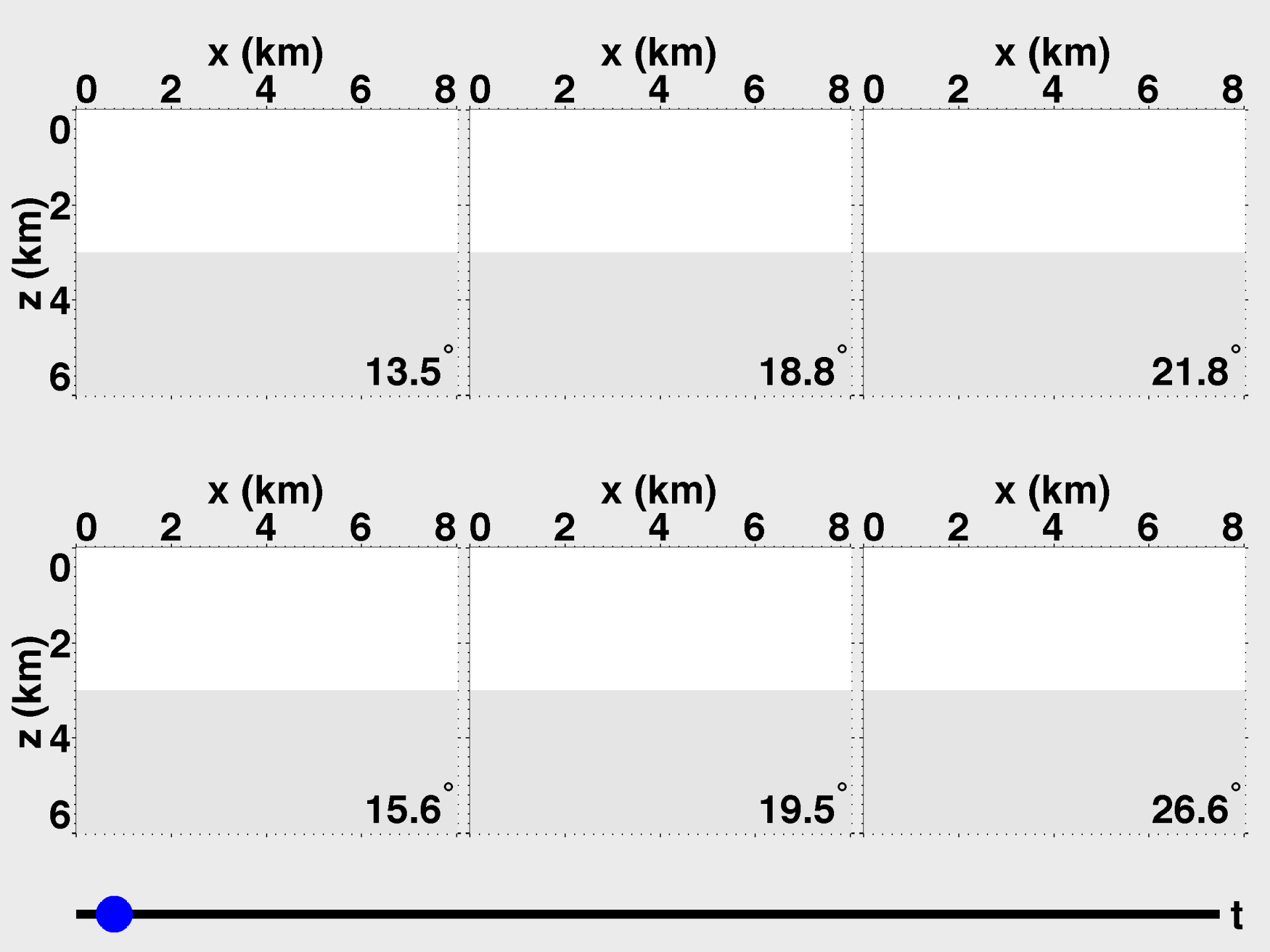
$$\rho \begin{pmatrix} \frac{\partial^2 u_1}{\partial t^2} \\ \frac{\partial^2 u_2}{\partial t^2} \\ \frac{\partial^2 u_3}{\partial t^2} \end{pmatrix} = (\lambda + 2\mu) \begin{pmatrix} \frac{\partial}{\partial x_1} \left(\frac{\partial u_1}{\partial x_1} + \frac{\partial u_2}{\partial x_2} + \frac{\partial u_3}{\partial x_3} \right) \\ \frac{\partial}{\partial x_2} \left(\frac{\partial u_1}{\partial x_1} + \frac{\partial u_2}{\partial x_2} + \frac{\partial u_3}{\partial x_3} \right) \\ \frac{\partial}{\partial x_3} \left(\frac{\partial u_1}{\partial x_1} + \frac{\partial u_2}{\partial x_2} + \frac{\partial u_3}{\partial x_3} \right) \end{pmatrix}$$

$$-\mu \begin{pmatrix} \frac{\partial}{\partial x_2} \left(\frac{\partial u_2}{\partial x_1} - \frac{\partial u_1}{\partial x_2} \right) - \frac{\partial}{\partial x_3} \left(\frac{\partial u_1}{\partial x_3} - \frac{\partial u_3}{\partial x_1} \right) \\ \frac{\partial}{\partial x_3} \left(\frac{\partial u_3}{\partial x_2} - \frac{\partial u_2}{\partial x_3} \right) - \frac{\partial}{\partial x_1} \left(\frac{\partial u_2}{\partial x_1} - \frac{\partial u_1}{\partial x_2} \right) \\ \frac{\partial}{\partial x_1} \left(\frac{\partial u_1}{\partial x_3} - \frac{\partial u_3}{\partial x_1} \right) - \frac{\partial}{\partial x_2} \left(\frac{\partial u_3}{\partial x_2} - \frac{\partial u_2}{\partial x_3} \right) \end{pmatrix}$$

$$\rho \begin{pmatrix} \frac{\partial^2 u_1}{\partial t^2} \\ \frac{\partial^2 u_2}{\partial t^2} \\ \frac{\partial^2 u_3}{\partial t^2} \end{pmatrix} = (\lambda + 2\mu) \begin{pmatrix} \frac{\partial}{\partial x_1} \left(\frac{\partial u_1}{\partial x_1} + \frac{\partial u_3}{\partial x_3} \right) \\ 0 \\ \frac{\partial}{\partial x_3} \left(\frac{\partial u_1}{\partial x_1} + \frac{\partial u_3}{\partial x_3} \right) \end{pmatrix}$$

$$+\mu \begin{pmatrix} \frac{\partial}{\partial x_3} \left(\frac{\partial u_1}{\partial x_3} - \frac{\partial u_3}{\partial x_1} \right) \\ \frac{\partial^2 u_2}{\partial x_3^2} + \frac{\partial^2 u_2}{\partial x_1^2} \\ \frac{\partial}{\partial x_1} \left(\frac{\partial u_1}{\partial x_3} - \frac{\partial u_3}{\partial x_1} \right) \end{pmatrix}$$

Postcritical waves


x (km)
0
2
4
6
8
z (km)
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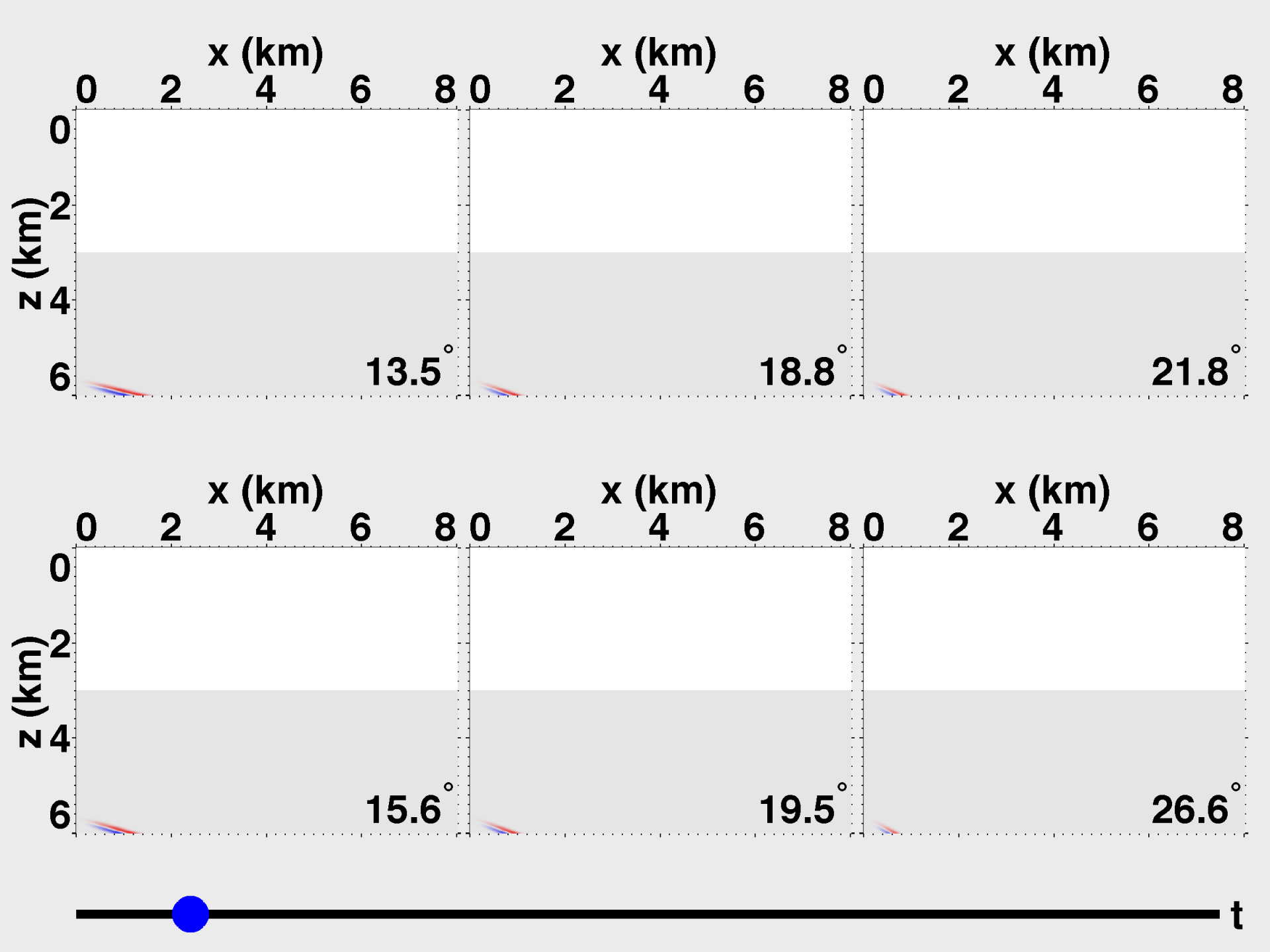
2
4
6
13.5°
18.8°
21.8°
15.6°
19.5°
26.6°
t


x (km)
0
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6
13.5°
18.8°
21.8°
15.6°
19.5°
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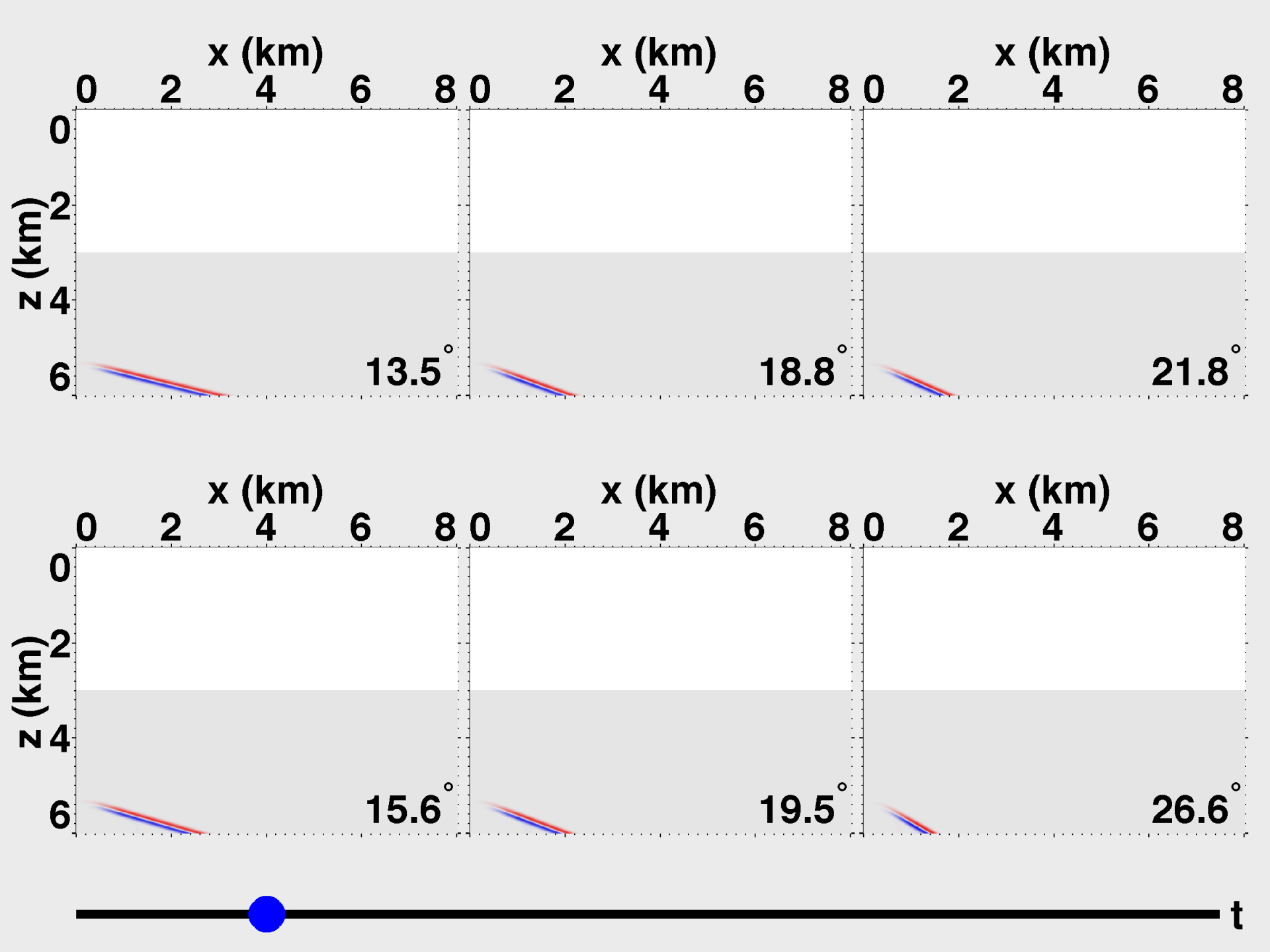
t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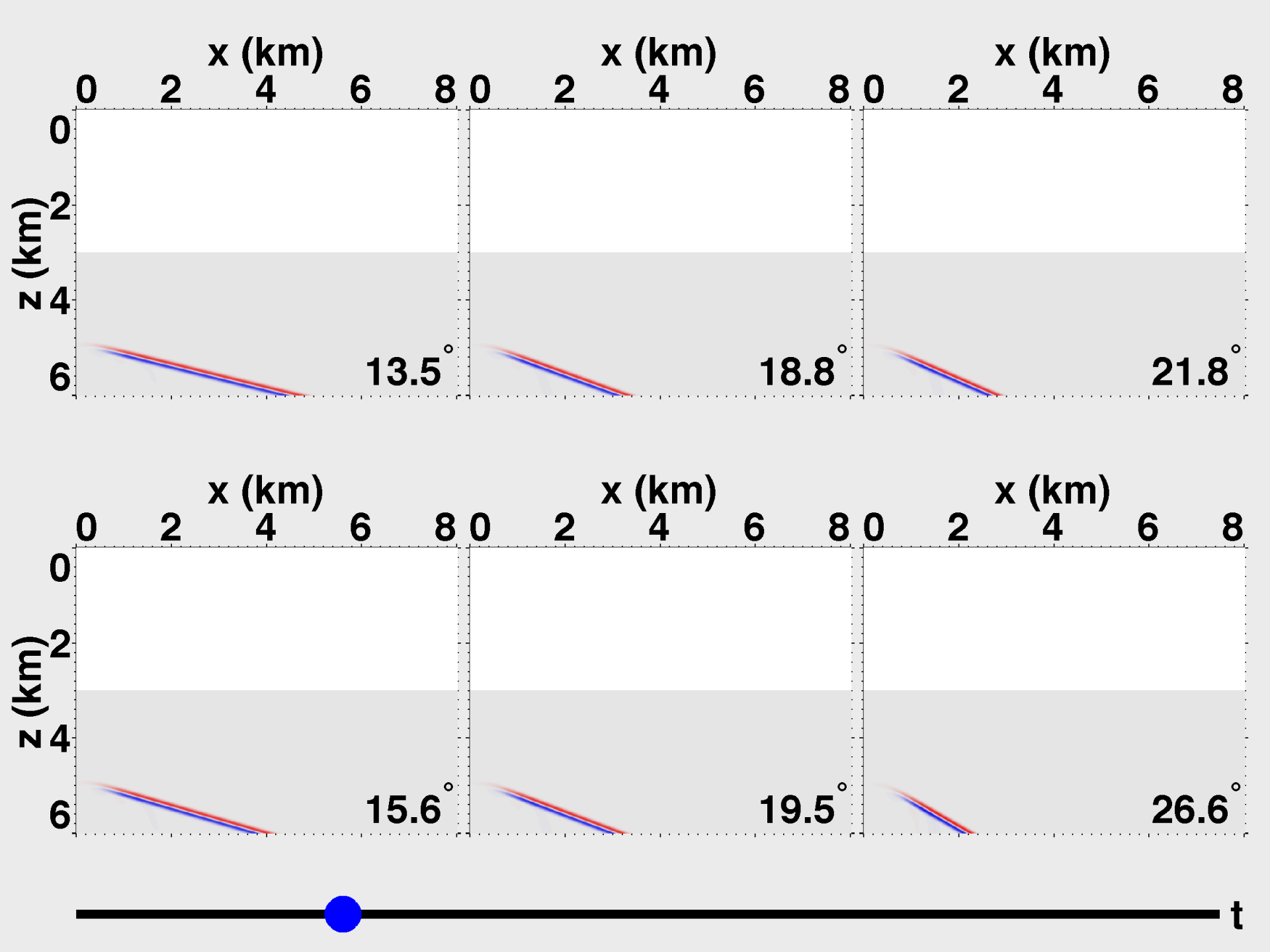
6
13.5°
18.8°
21.8°
15.6°
19.5°
26.6°
t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z (km)
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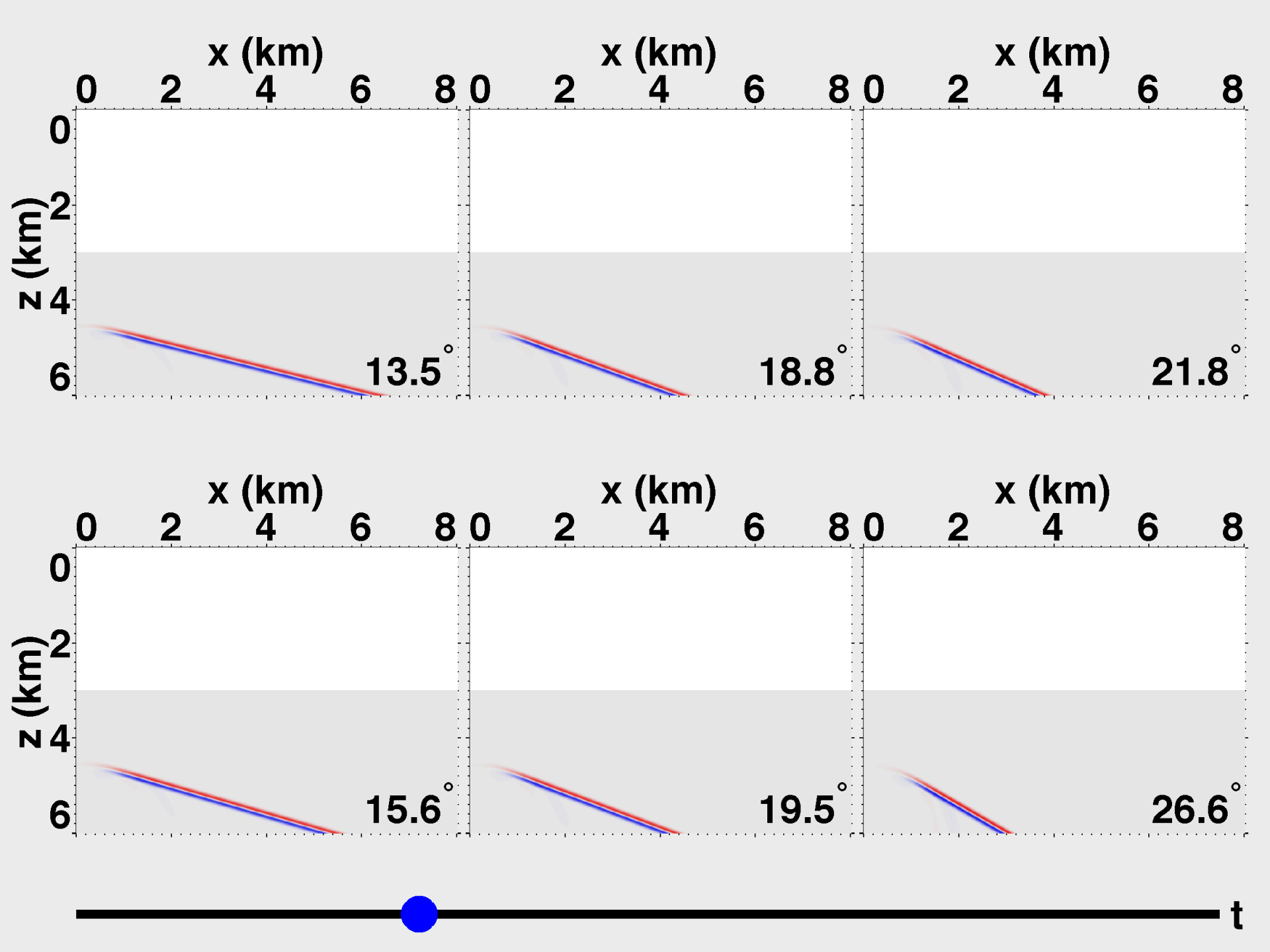
6
13.5°
18.8°
21.8°
15.6°
19.5°
26.6°
t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4
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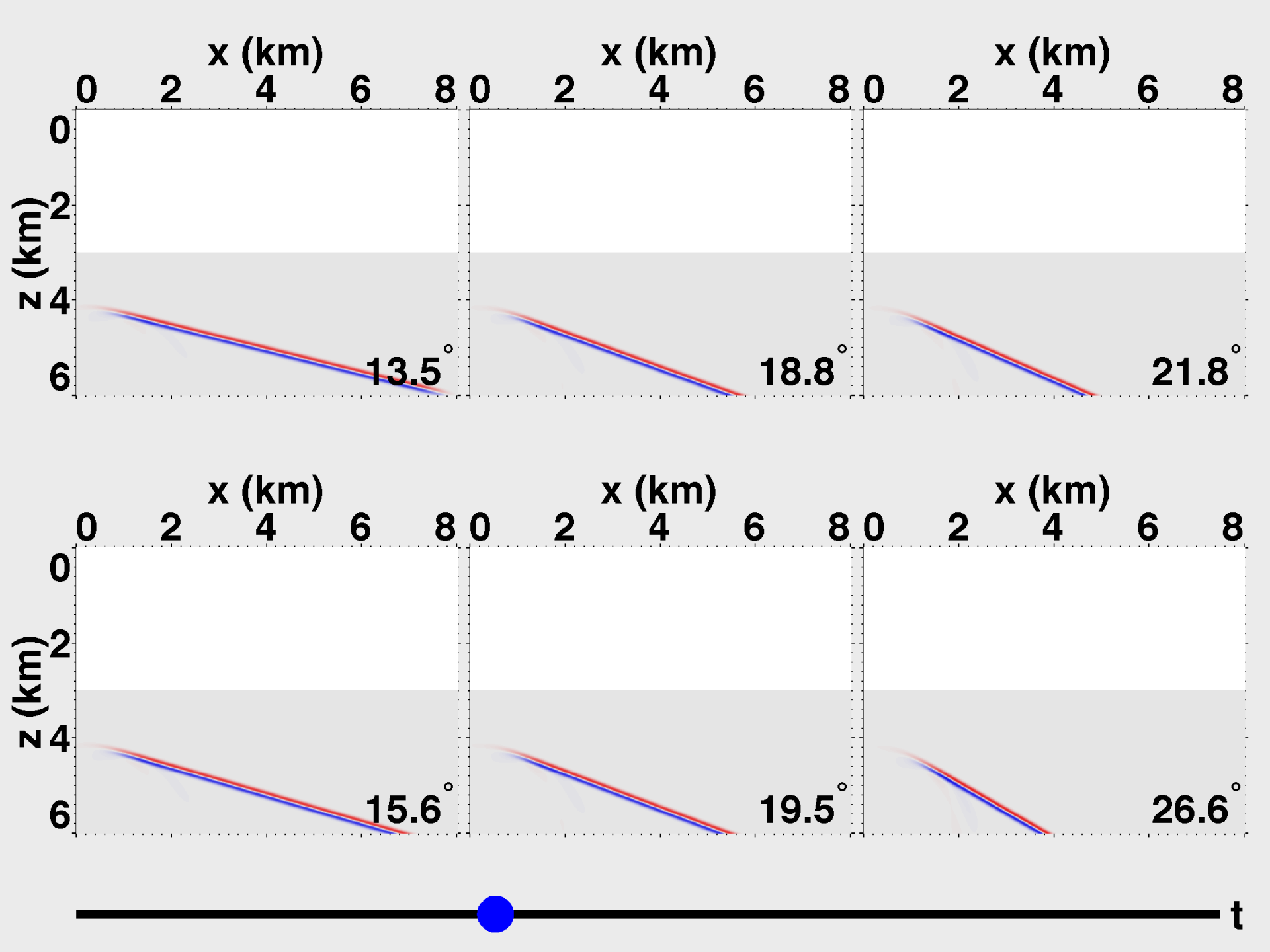
18.8°
21.8°
15.6°
19.5°
26.6°
t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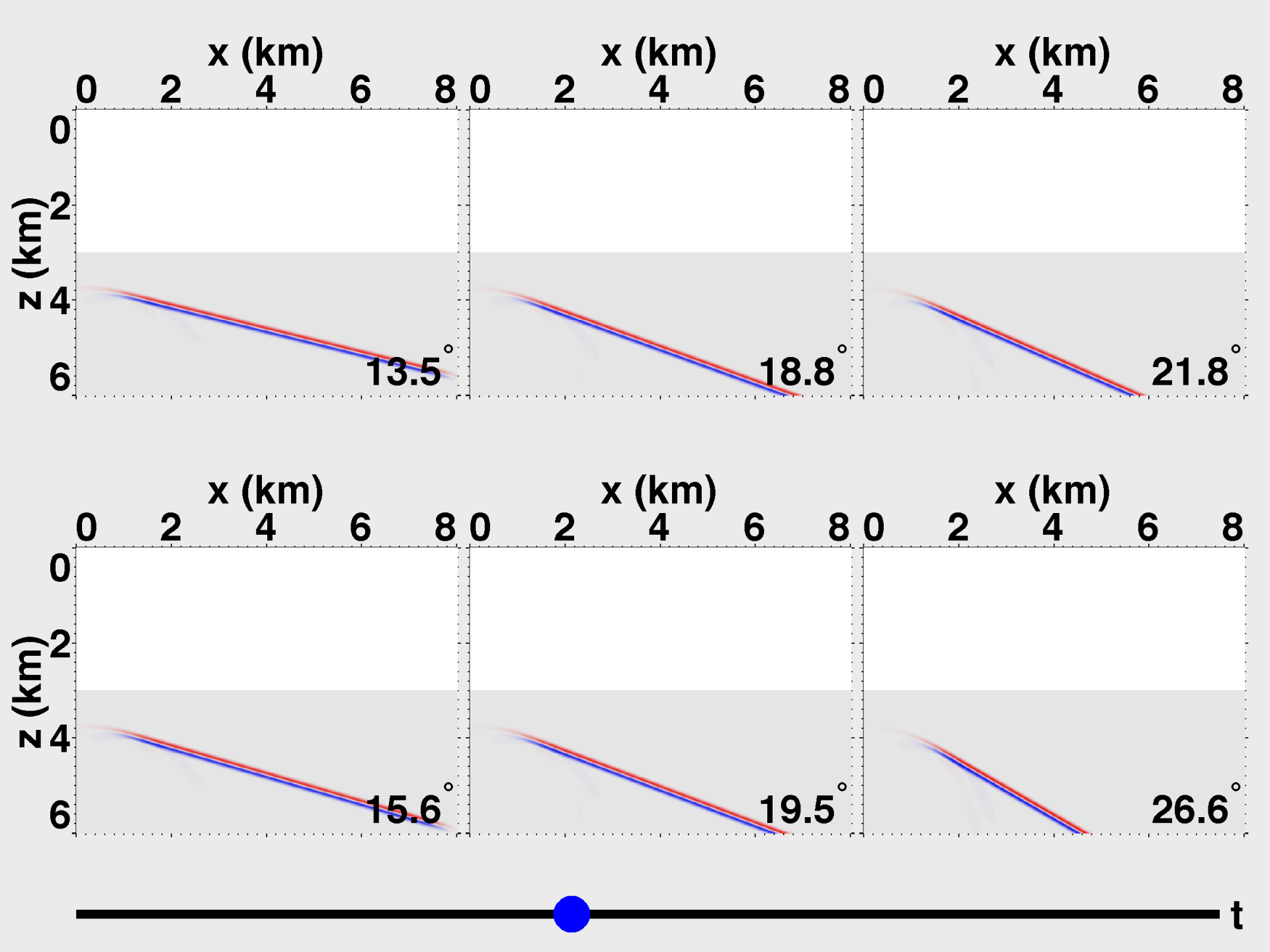
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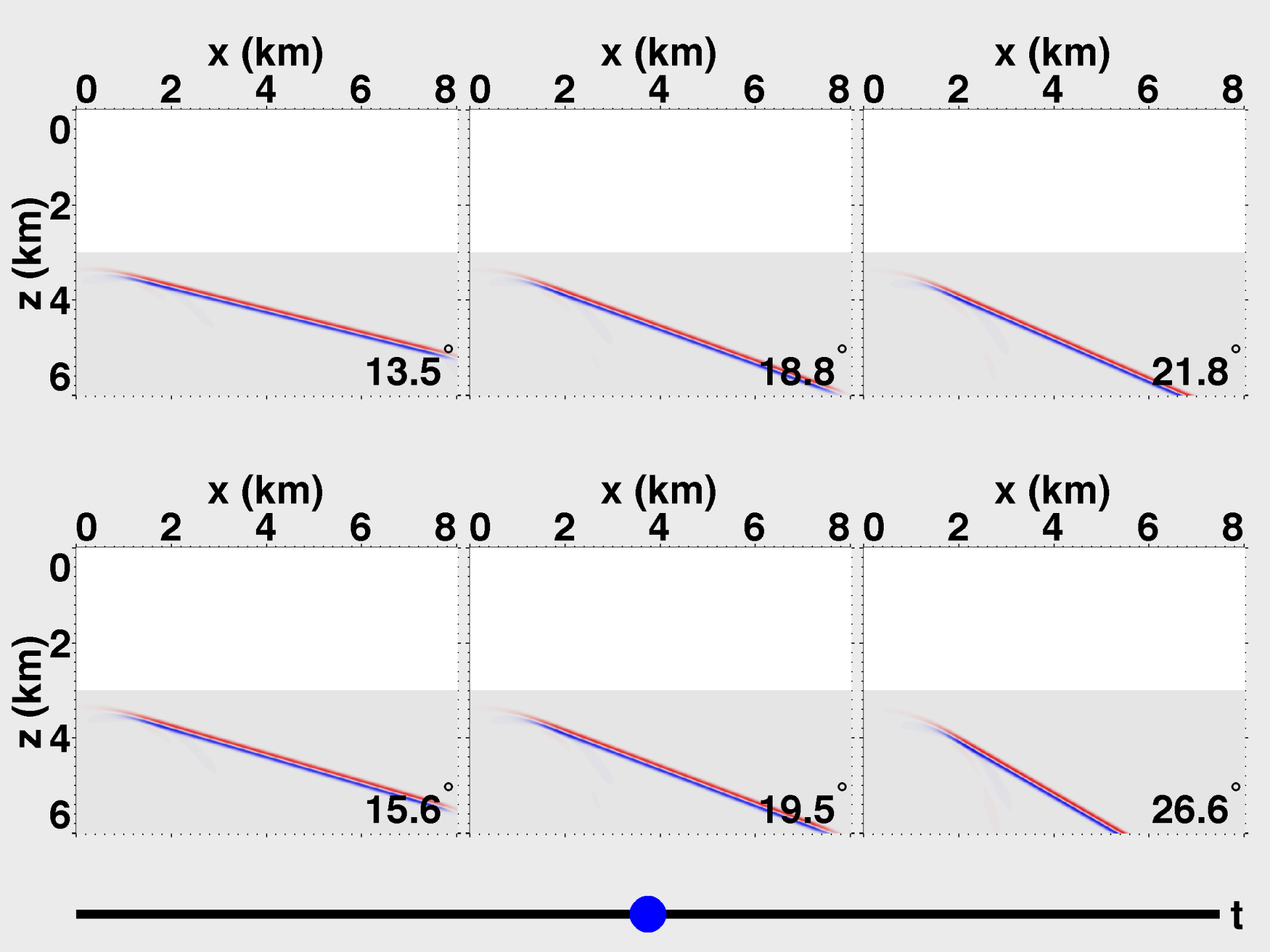
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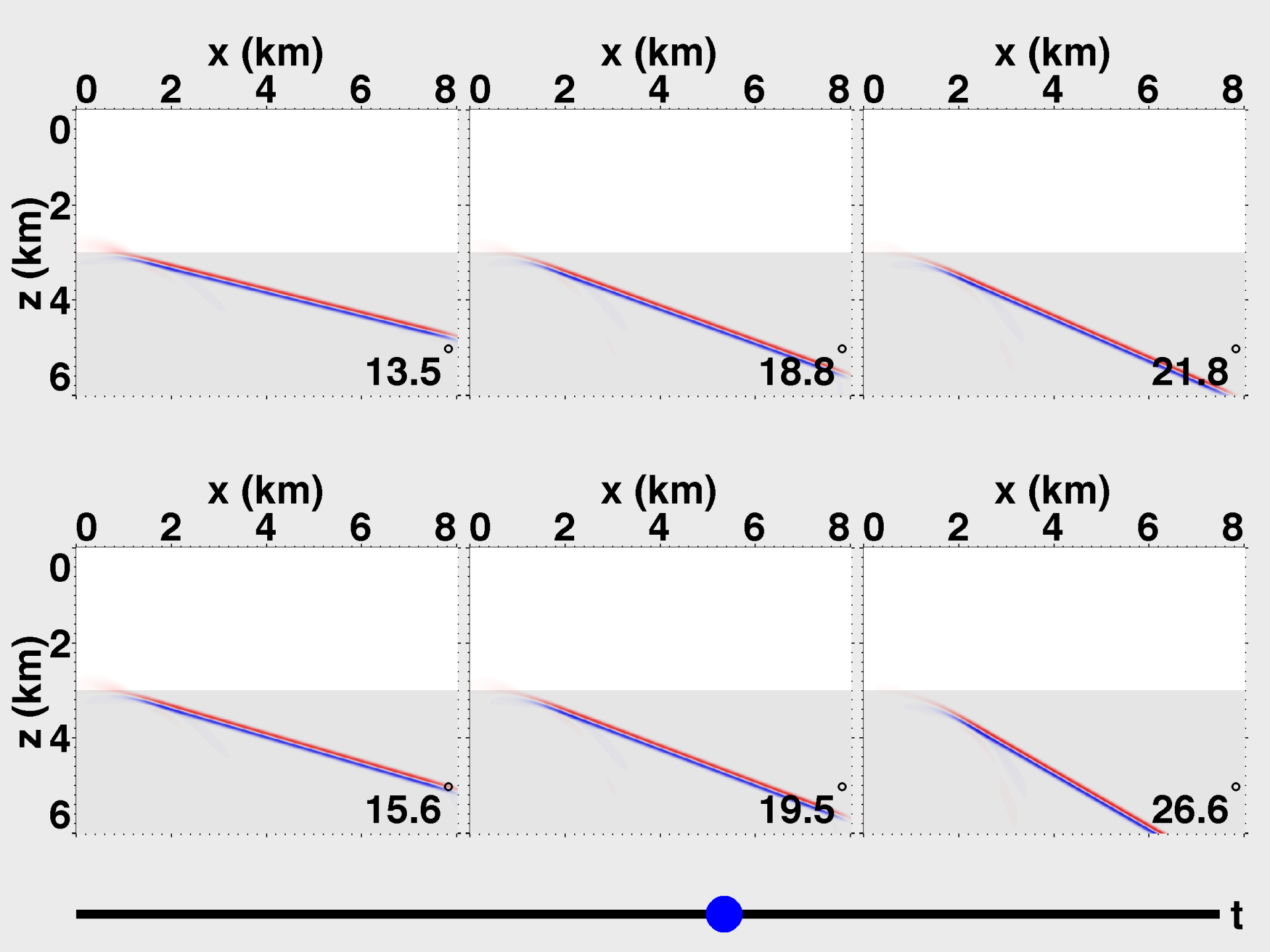
26.6°
t


x (km)
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4
6
8
z (km)
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13.5°
18.8°
21.8°
15.6°
19.5°
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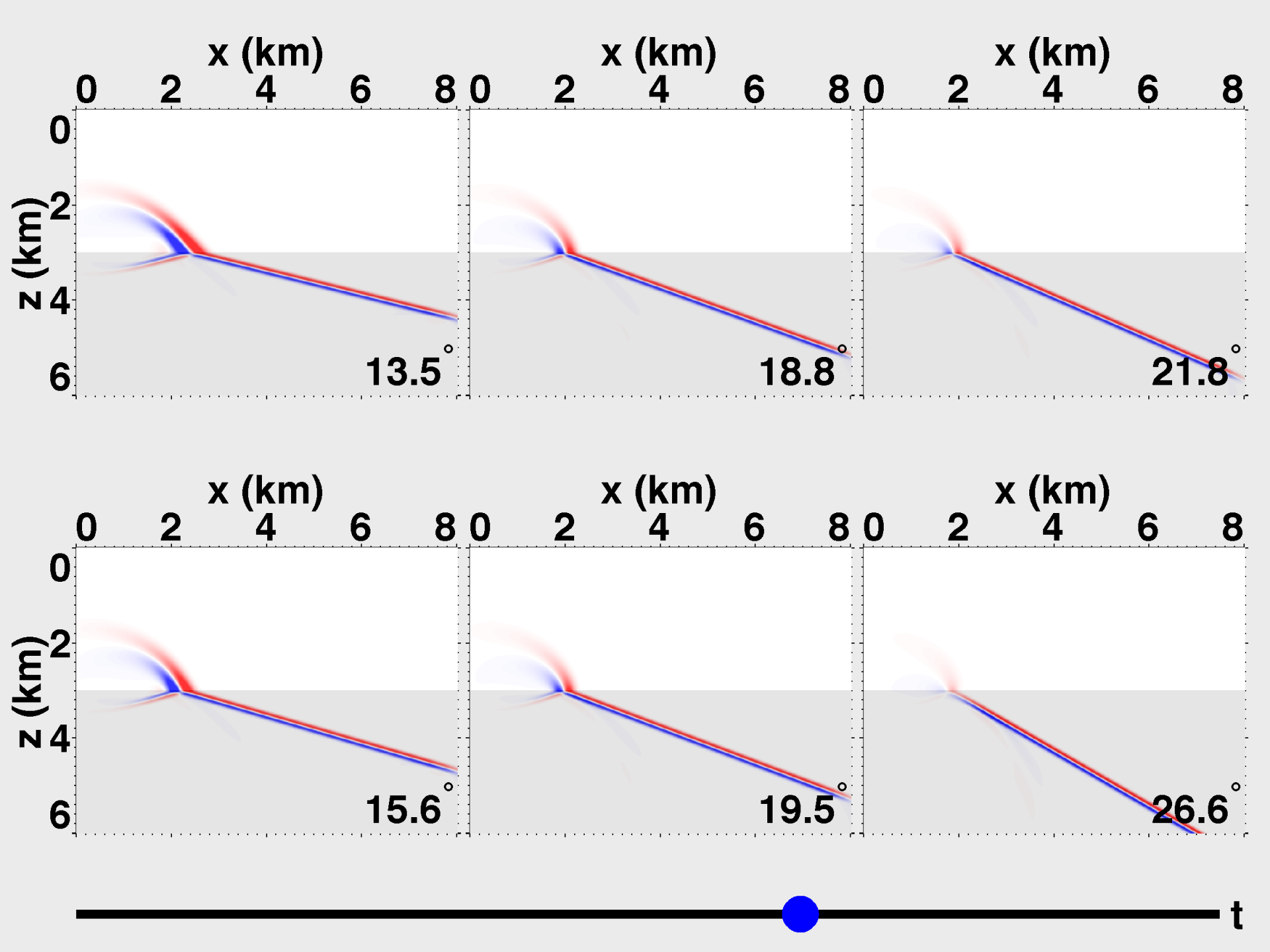
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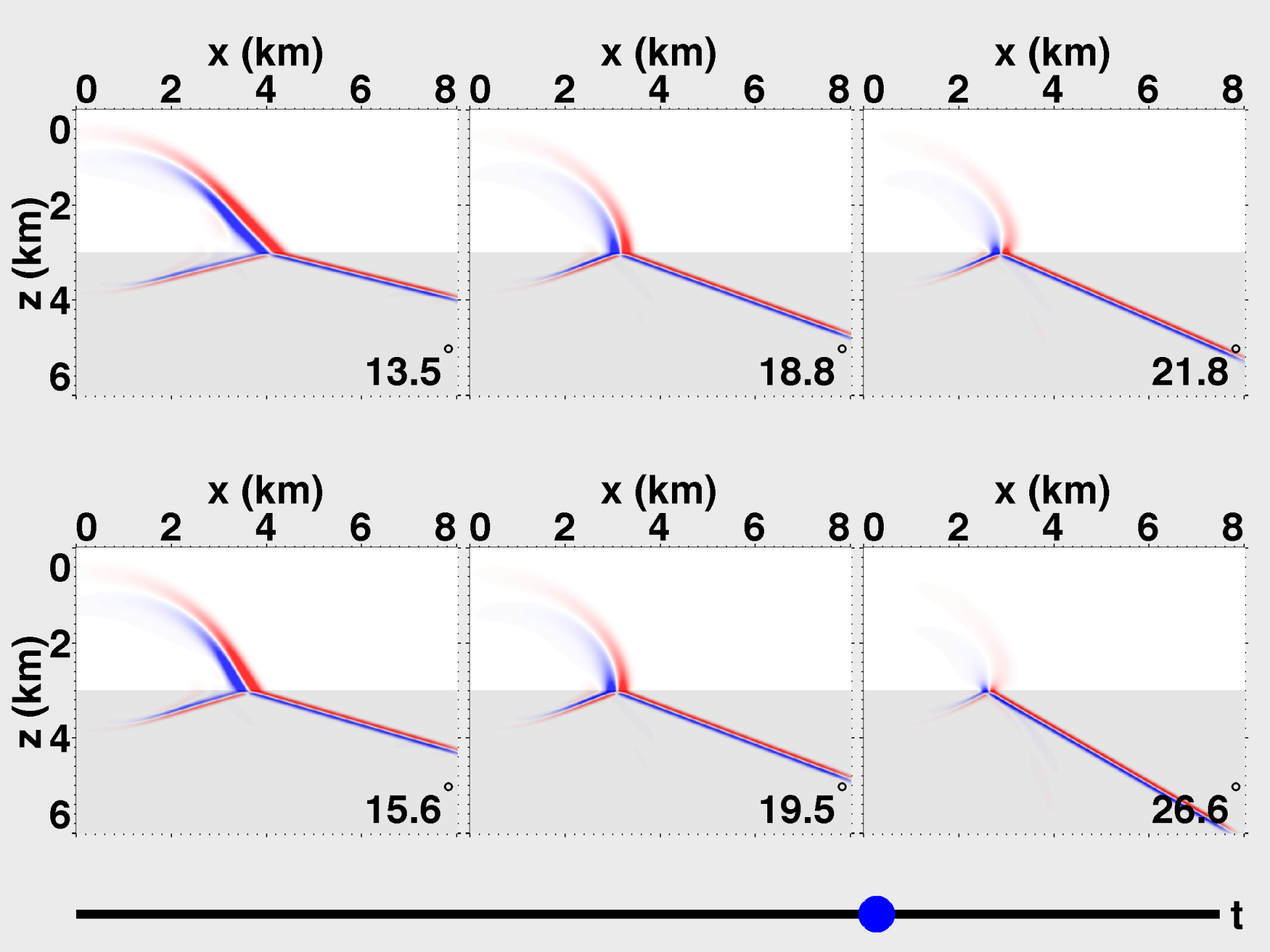
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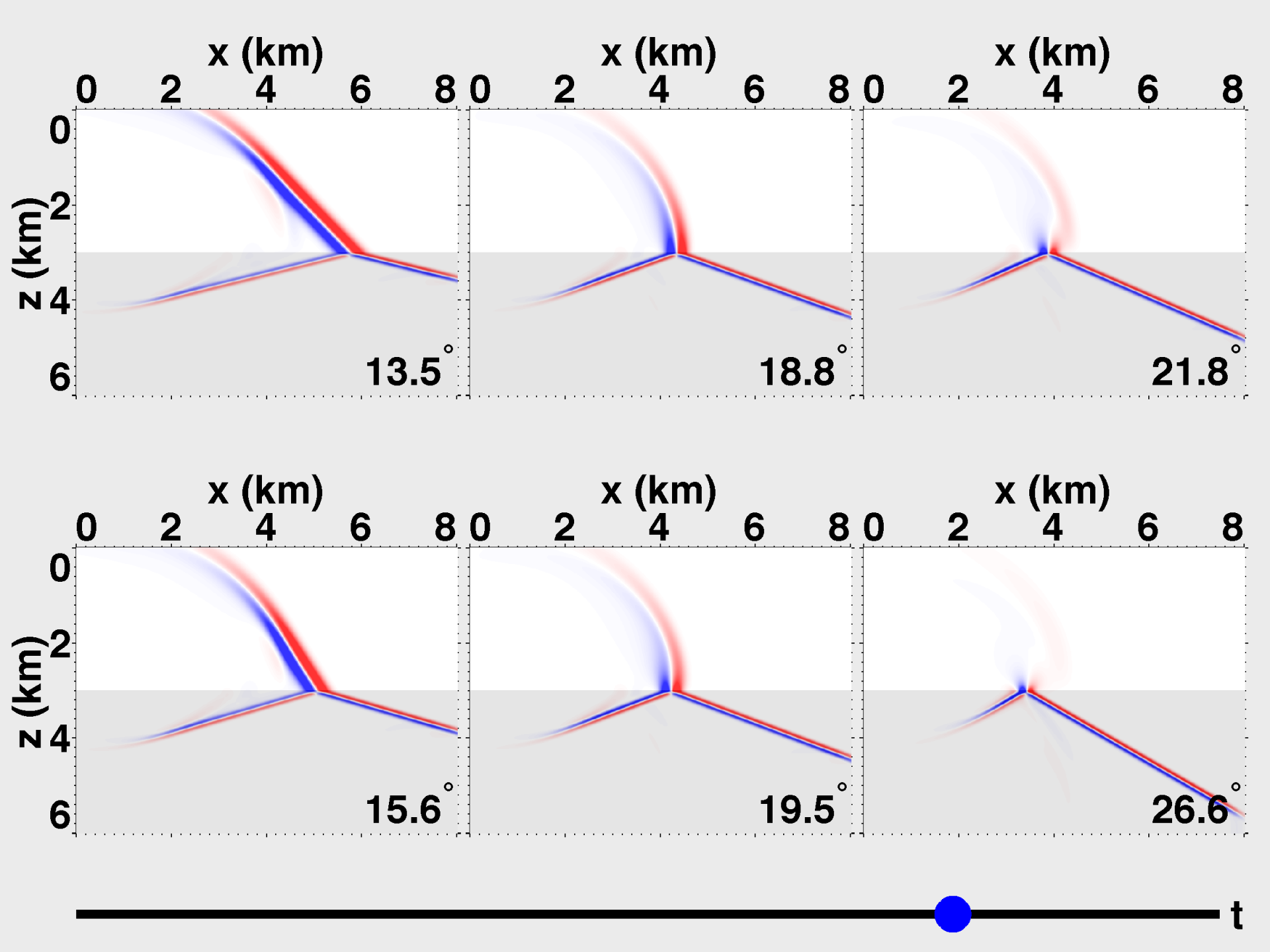
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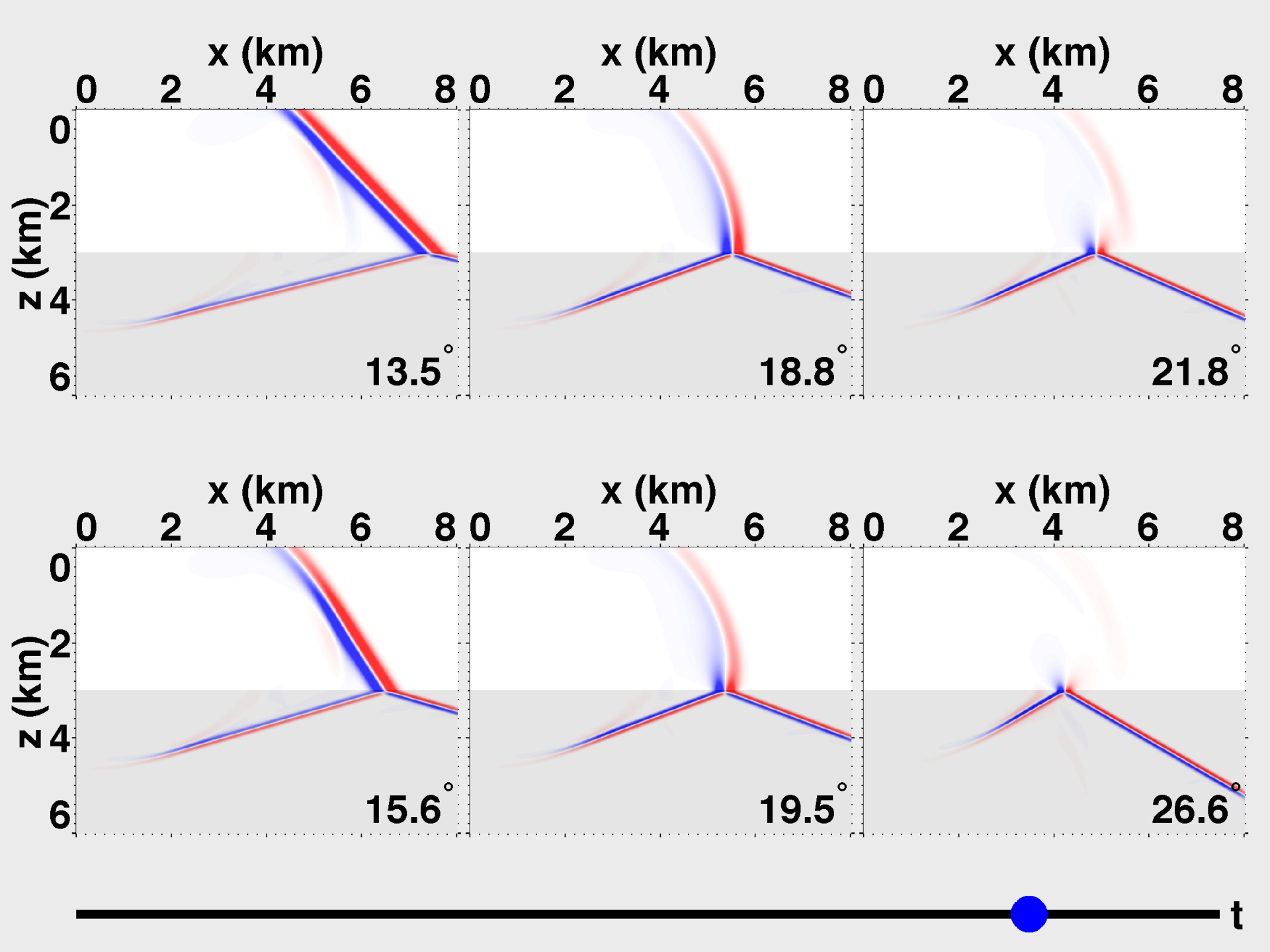
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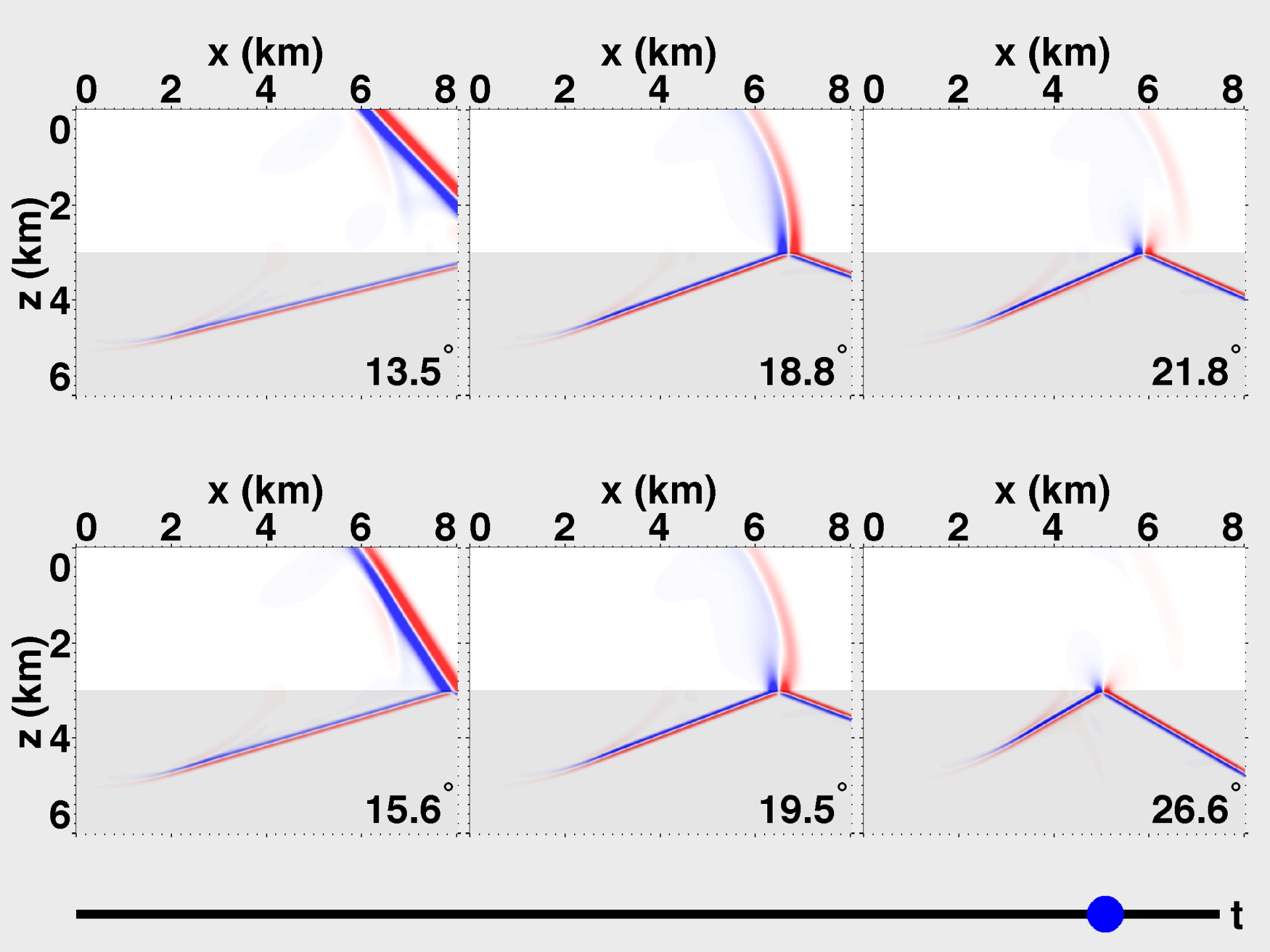
x (km)
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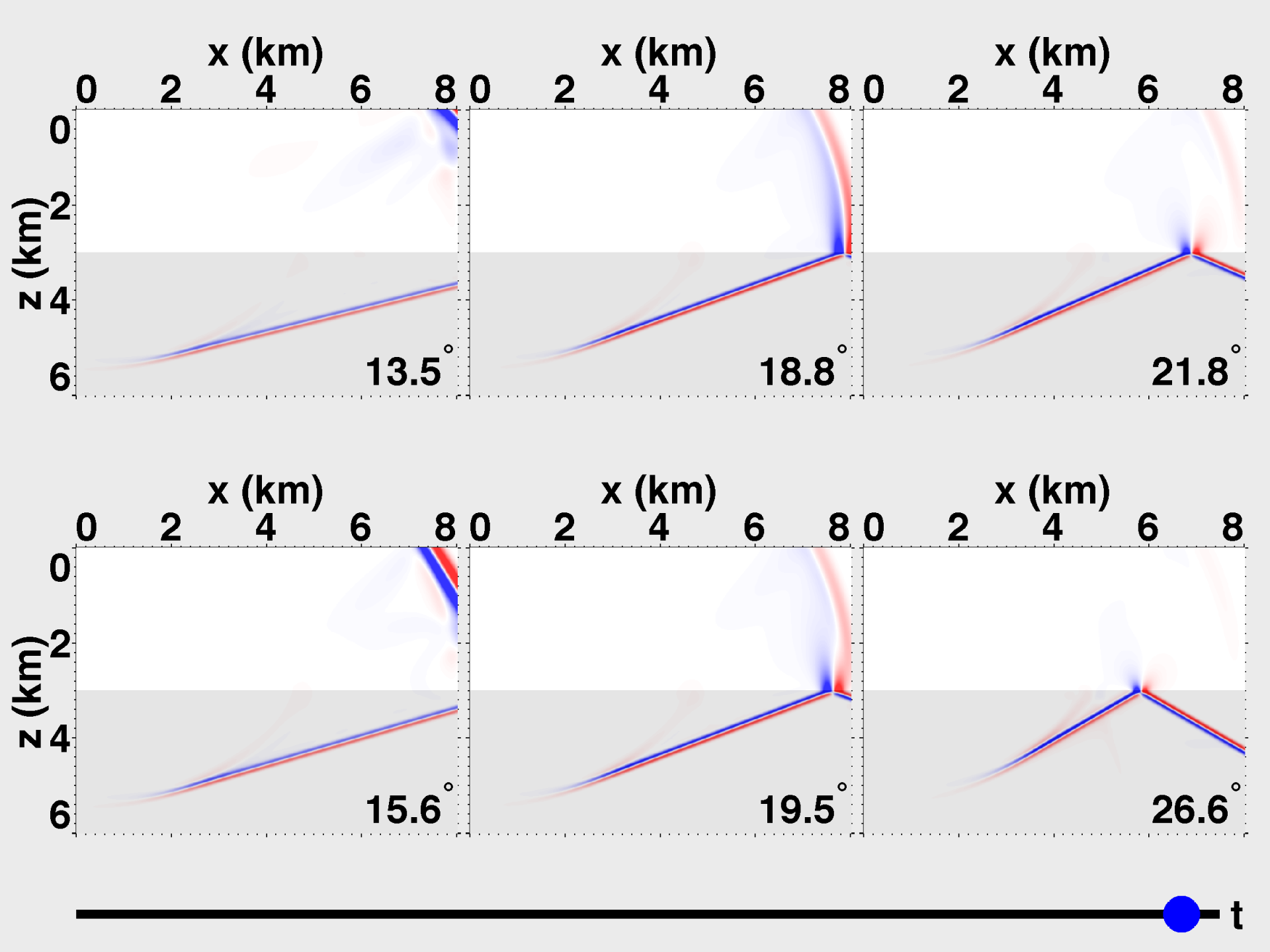
x (km)
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Shot gather