SeiVis: An Interactive Visual Subsurface Modeling Application

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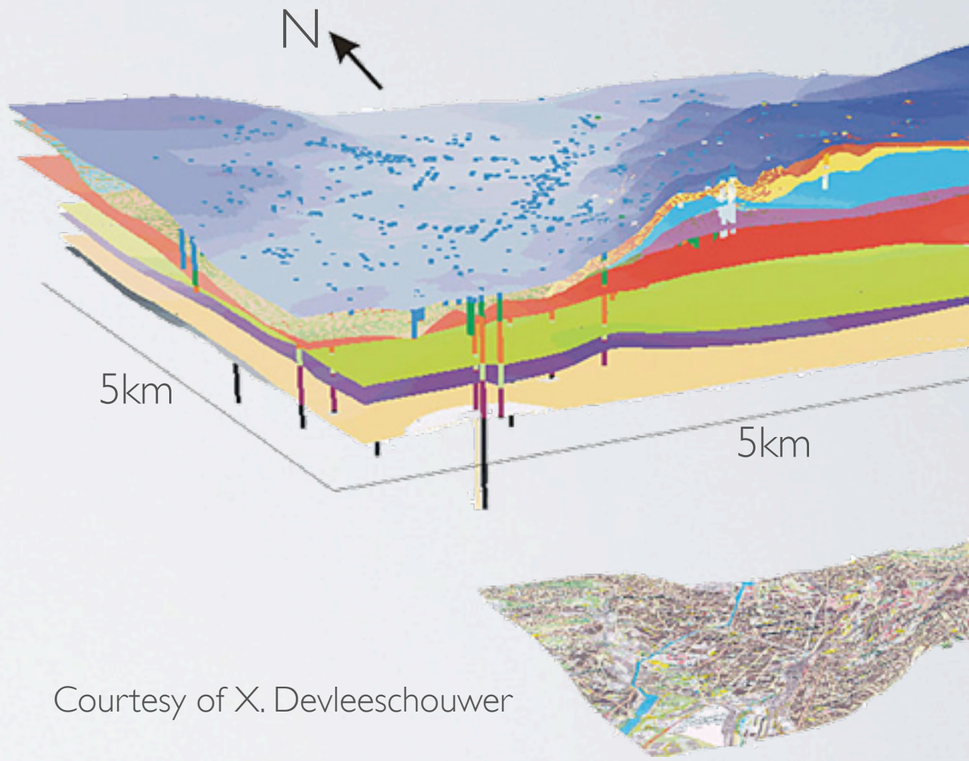
Subsurface Modeling // Overview

- Description of subsurface layers
  - horizons
  - faults
- Created from seismic survey
  - well data + seismic tomography
- Seismic tomography
  - recorded depth dimension is time
  - target depth dimension is lateral depth



Courtesy of X. Devleeschouwer

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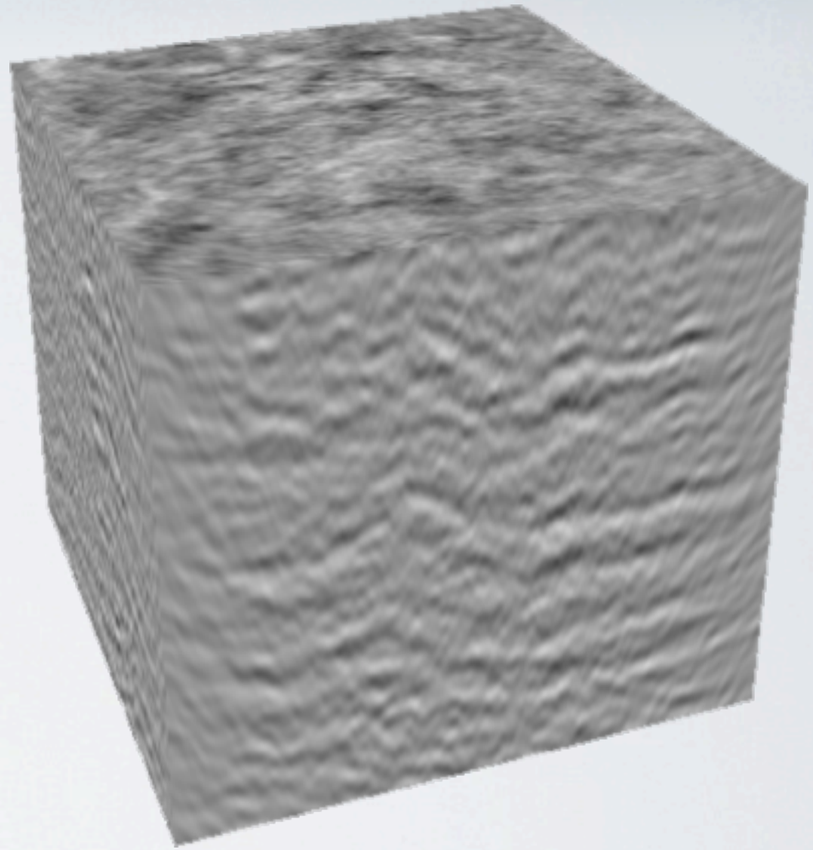
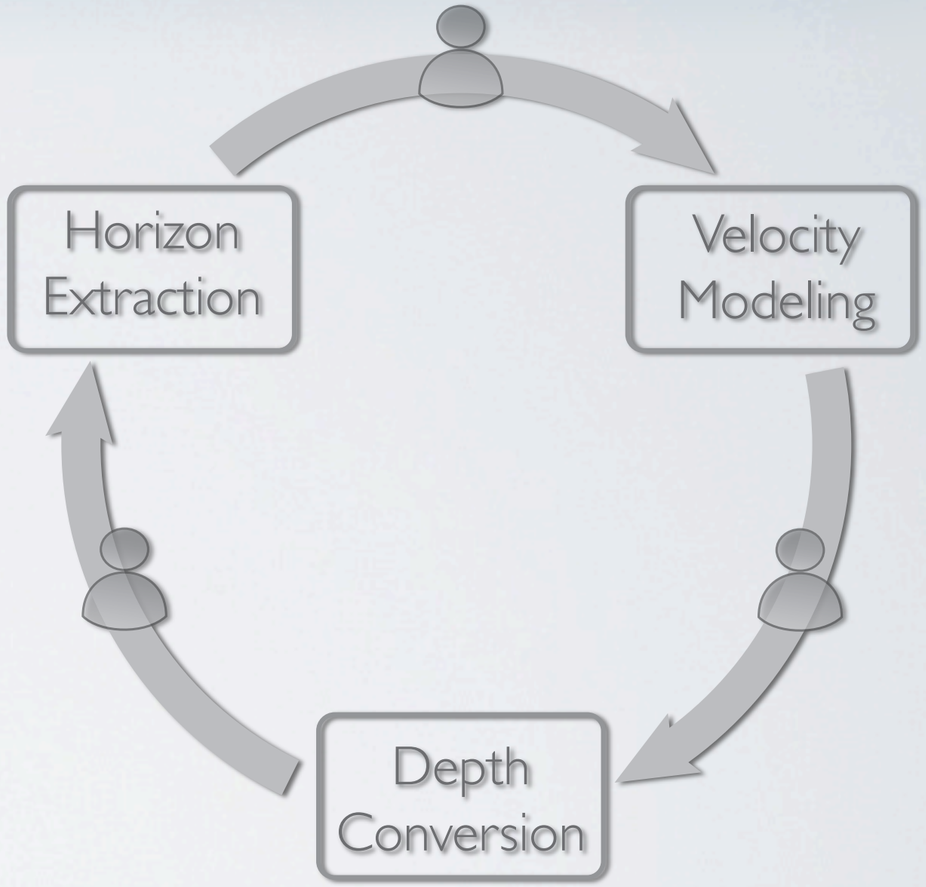


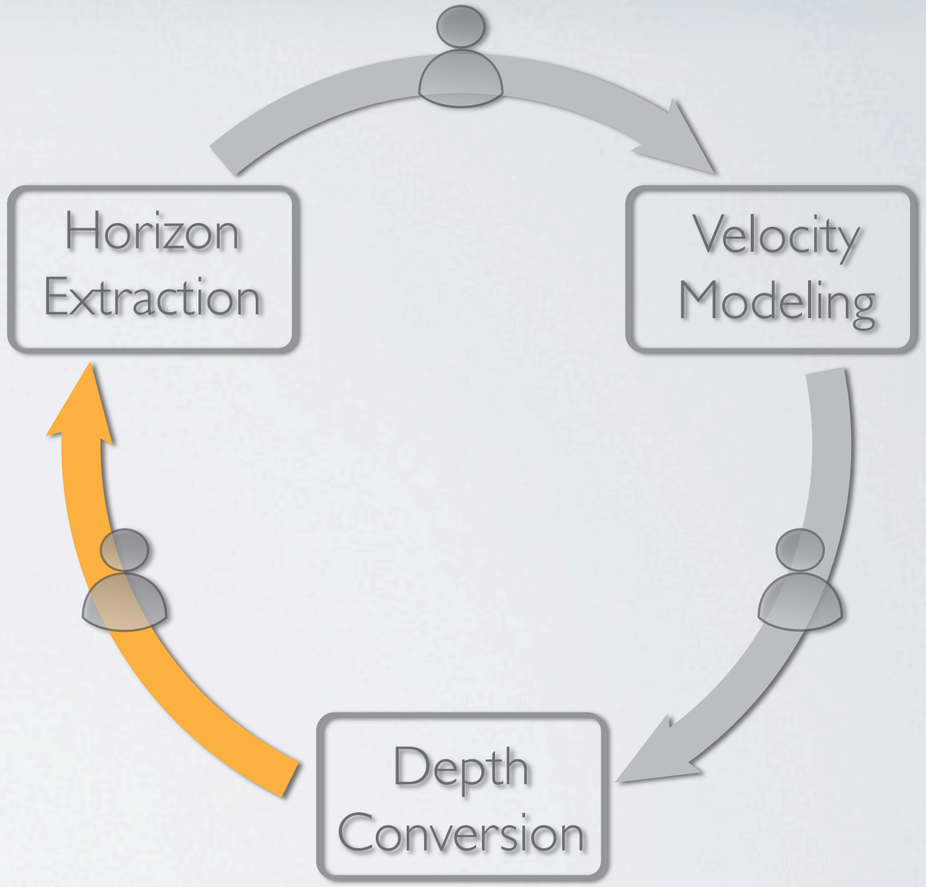
Subsurface Modeling // Workflow

- Feature extraction
  - based on seismic tomography
  - results in model in time domain
- Velocity modeling
  - per layer velocity based on model in time
  - results in velocity model
- Depth Conversion
  - transforms model from time to depth



Subsurface Modeling // Problems

- Additional data only at the end of pipeline
- Errors become visible after depth conversion
  - propagating fixes back into interpretation is time-consuming and hard
  - instead locally hot-fixing velocity model
    - +might fix the layer model
    - – might result in unphysical velocity model



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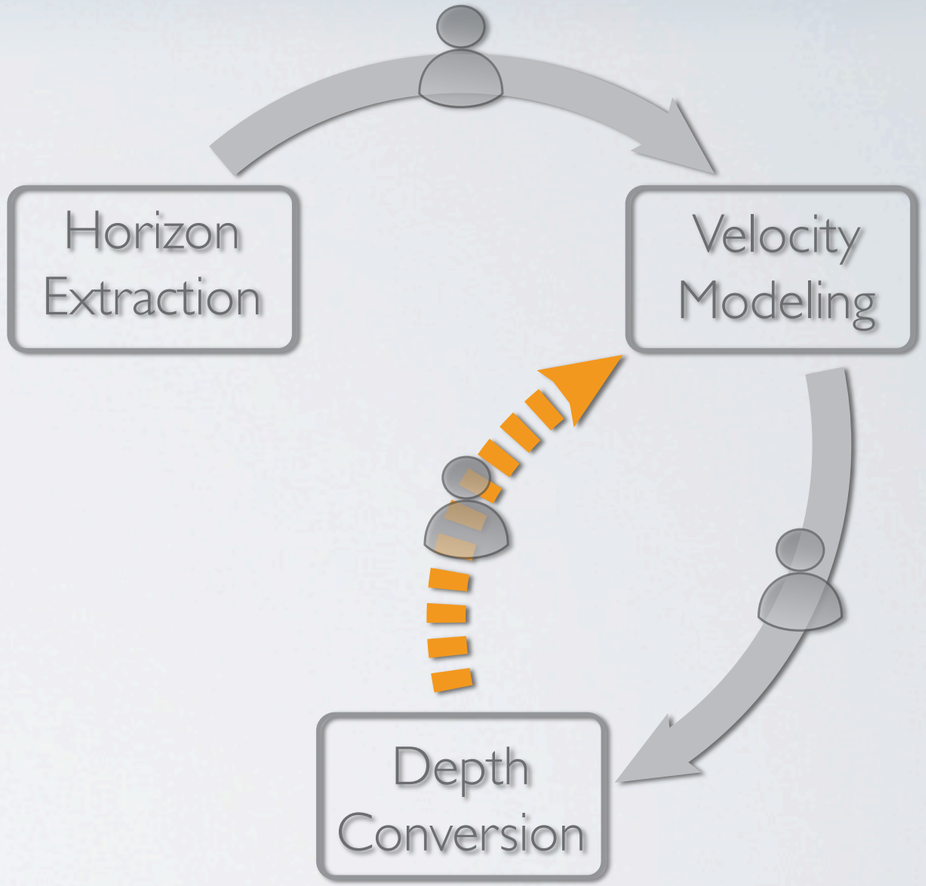
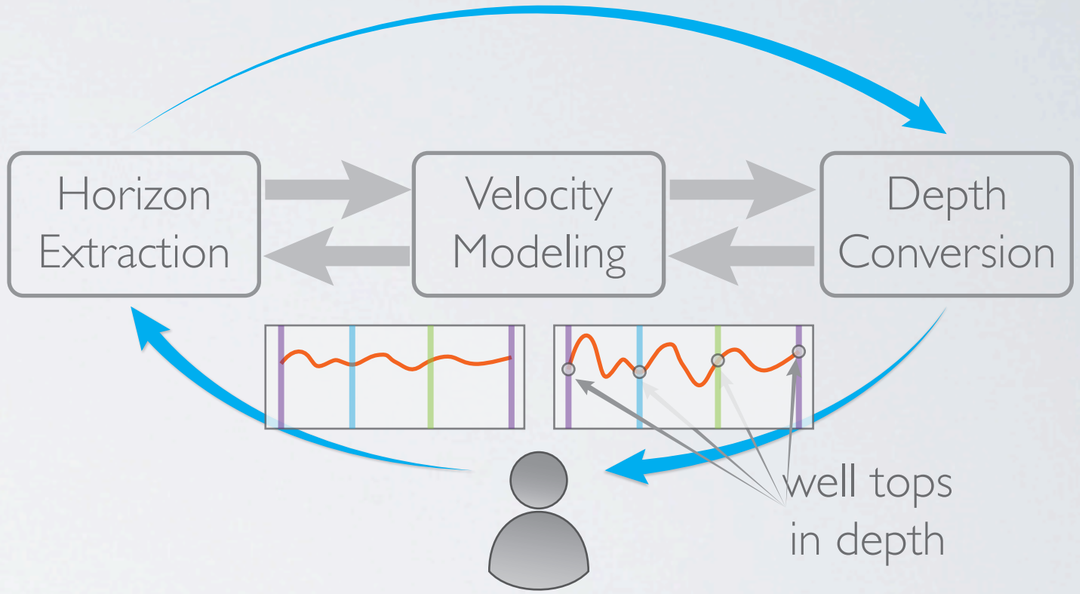
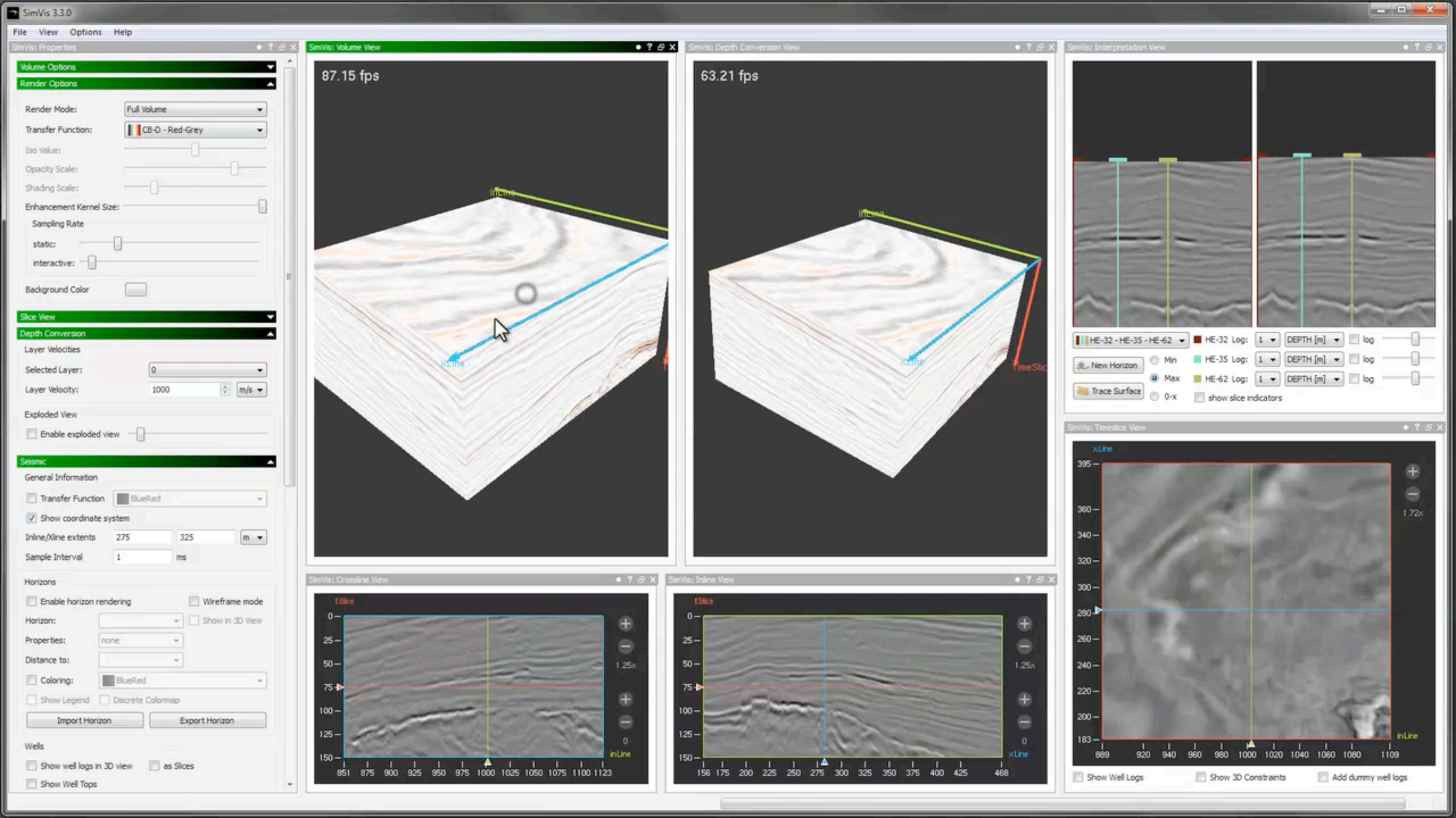


Subsurface Modeling // Integration

- Idea: Integrate all three steps
  - starting new horizon automatically updates layer model
    - ➡ velocity can be assigned immediately
    - ➡ allows computation of depth conversion during interpretation

➡ Joint time/depth domain workflow




SimVis 3.3.0
File
View
Options
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Volume Options
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interactive:
Background Color
Slice View
Depth Conversion
Layer Velocities
Selected Layer:
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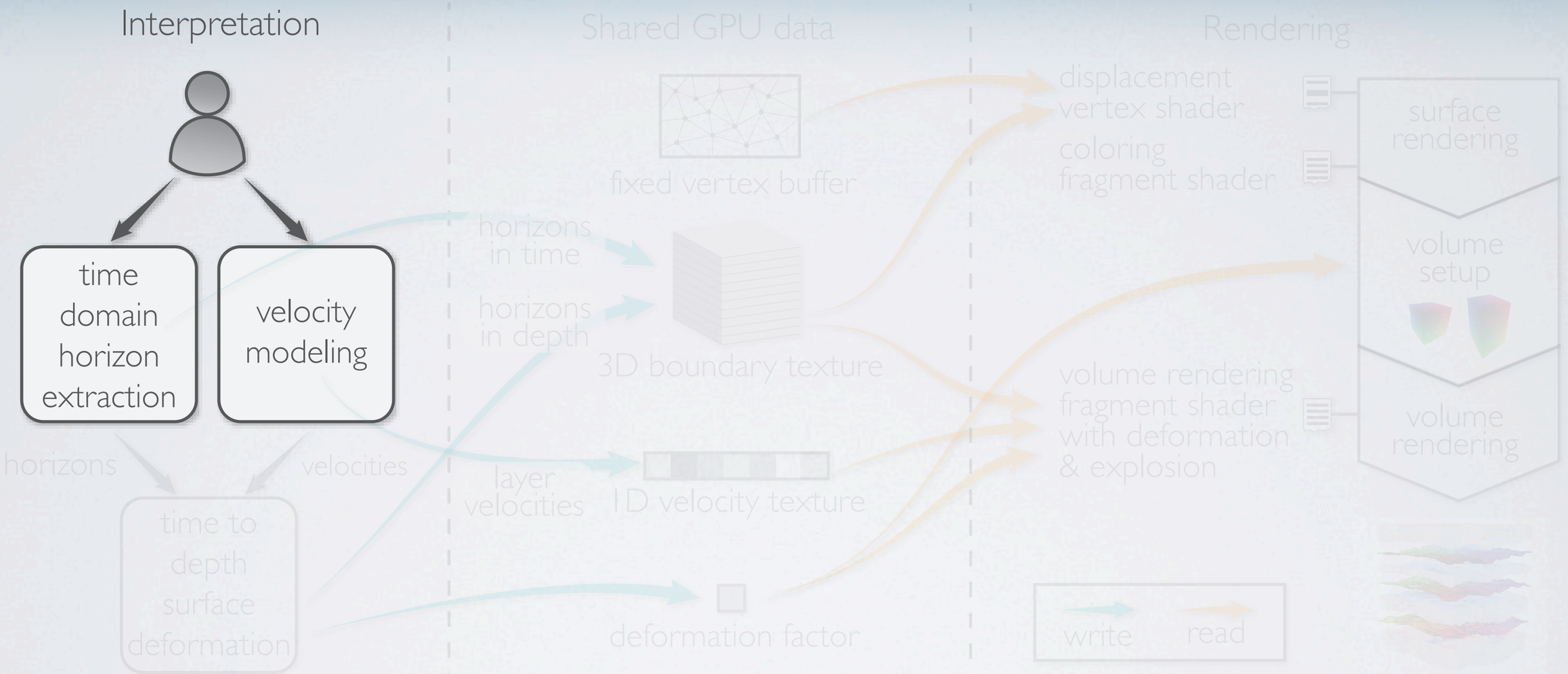
Exploded View
Enable exploded view
Seismic
General Information
Transfer Function
Show coordinate system
Inline/Xline extents
Sample Interval
Horizons
Enable horizon rendering
Wireframe mode
Horizon:
Properties:
Distance to:
Coloring:
Show Legend
Discrete Colormap
Import Horizon
Export Horizon
Wells
Show well logs in 3D view
as Slices
Show Well Tops
SimVis: Volume View
87.15 fps
SimVis: Depth Conversion View
63.21 fps
SimVis: Interpretation View
New Horizon
Trace Surface
Min
Max
show slice indicators
SimVis: Timeslice View
SimVis: Crossline View
SimVis: Inline View
Show Well Logs
Show 3D Constraints
Add dummy well logs

Joint Time/Depth Domain // Pipeline



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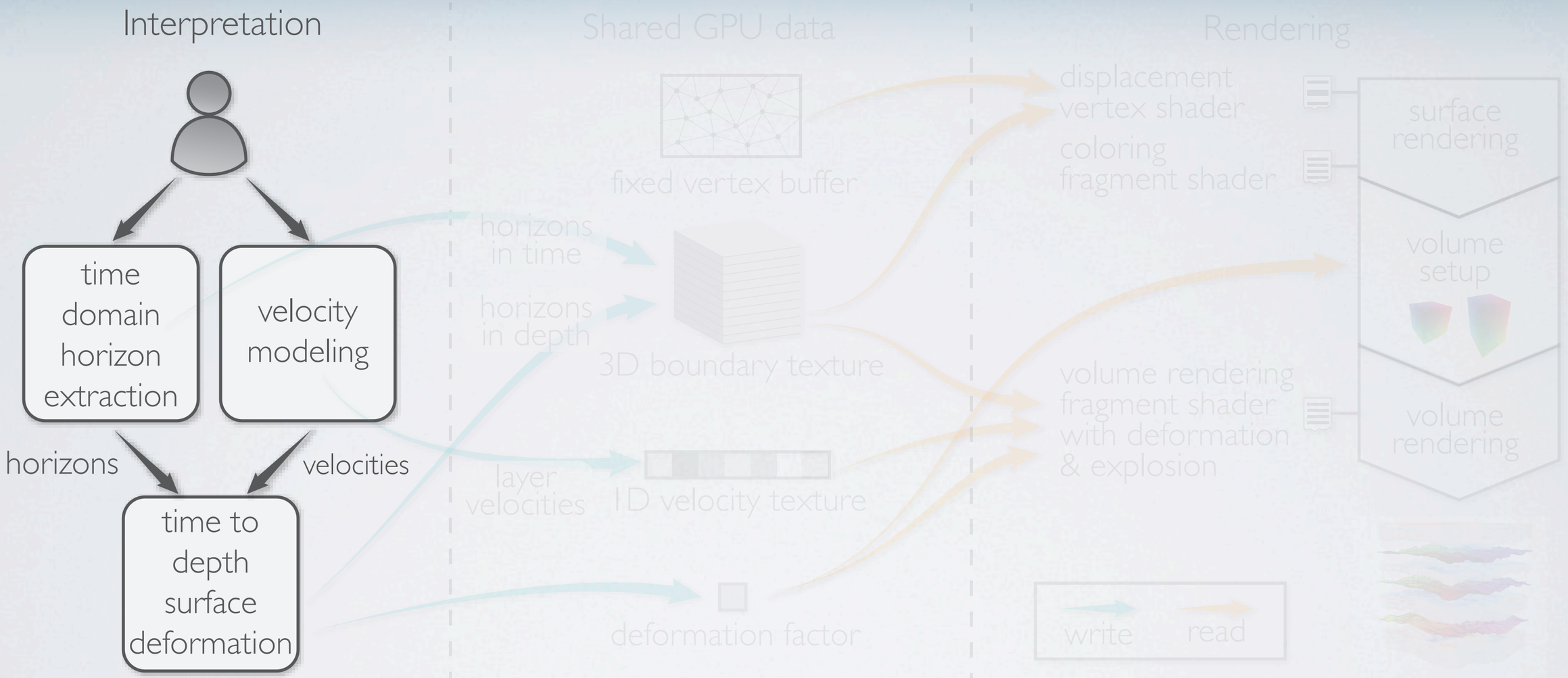
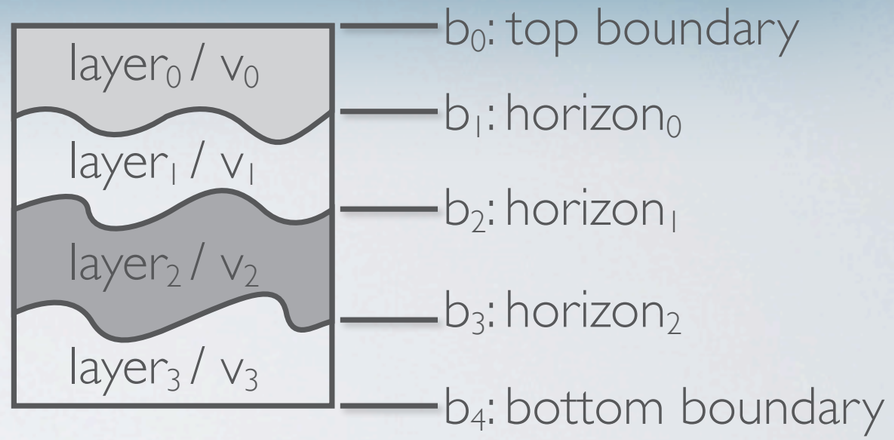


Joint Time/Depth Domain // Deformation

- Horizon deformation
  - iteratively deform boundaries from top to bottom
  - all x,y-coordinates are independent
  - top boundary is equal in time & depth
  - following boundaries are sum of previous deformed boundary and deformed layer



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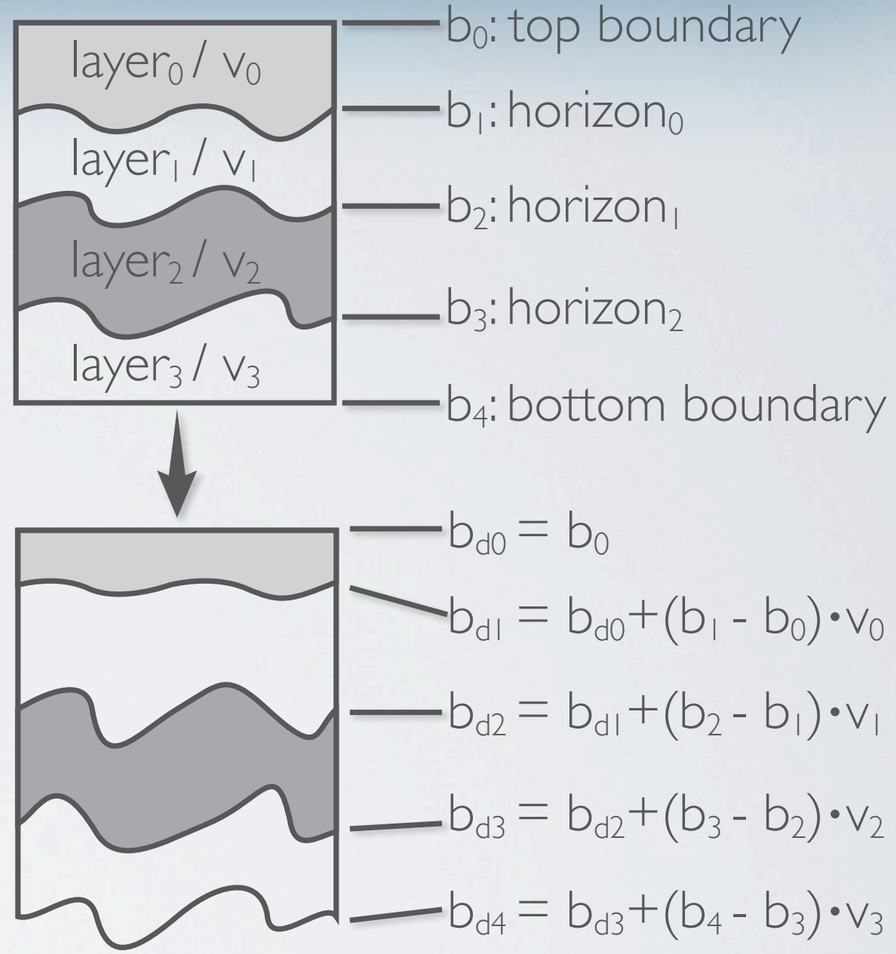

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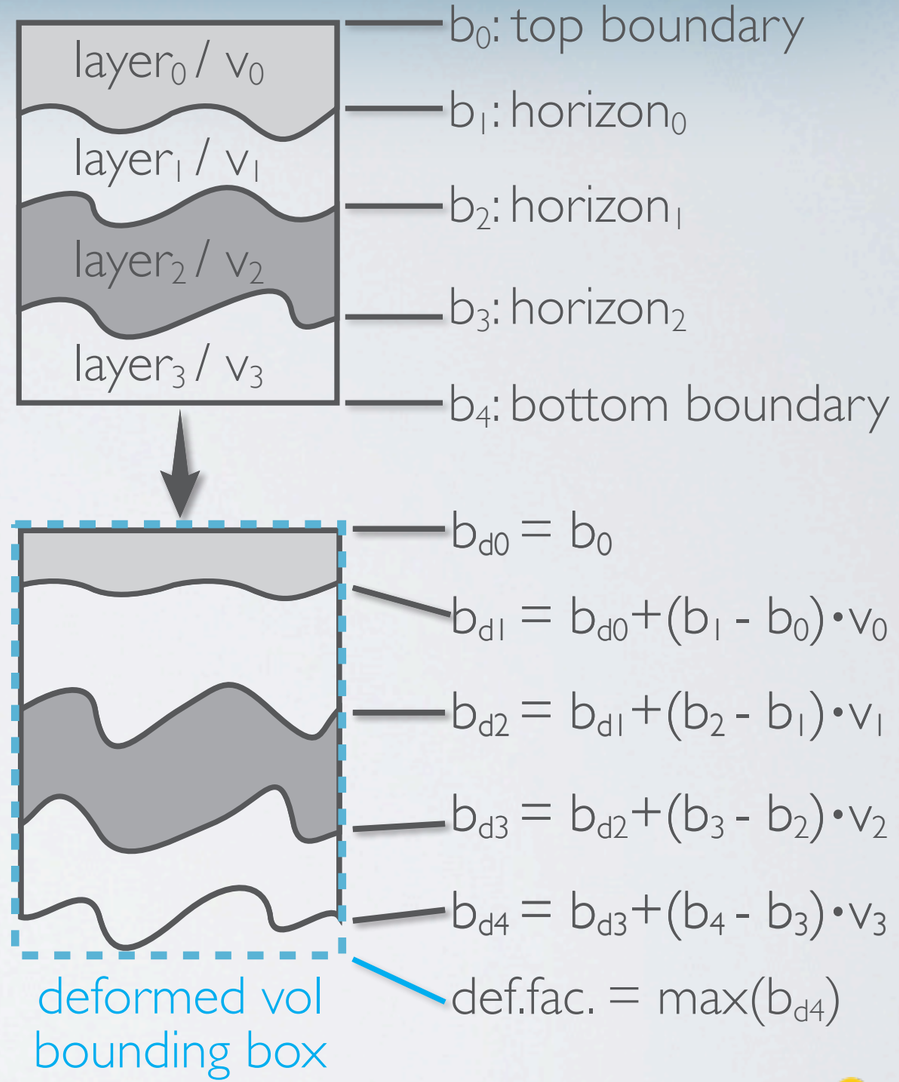

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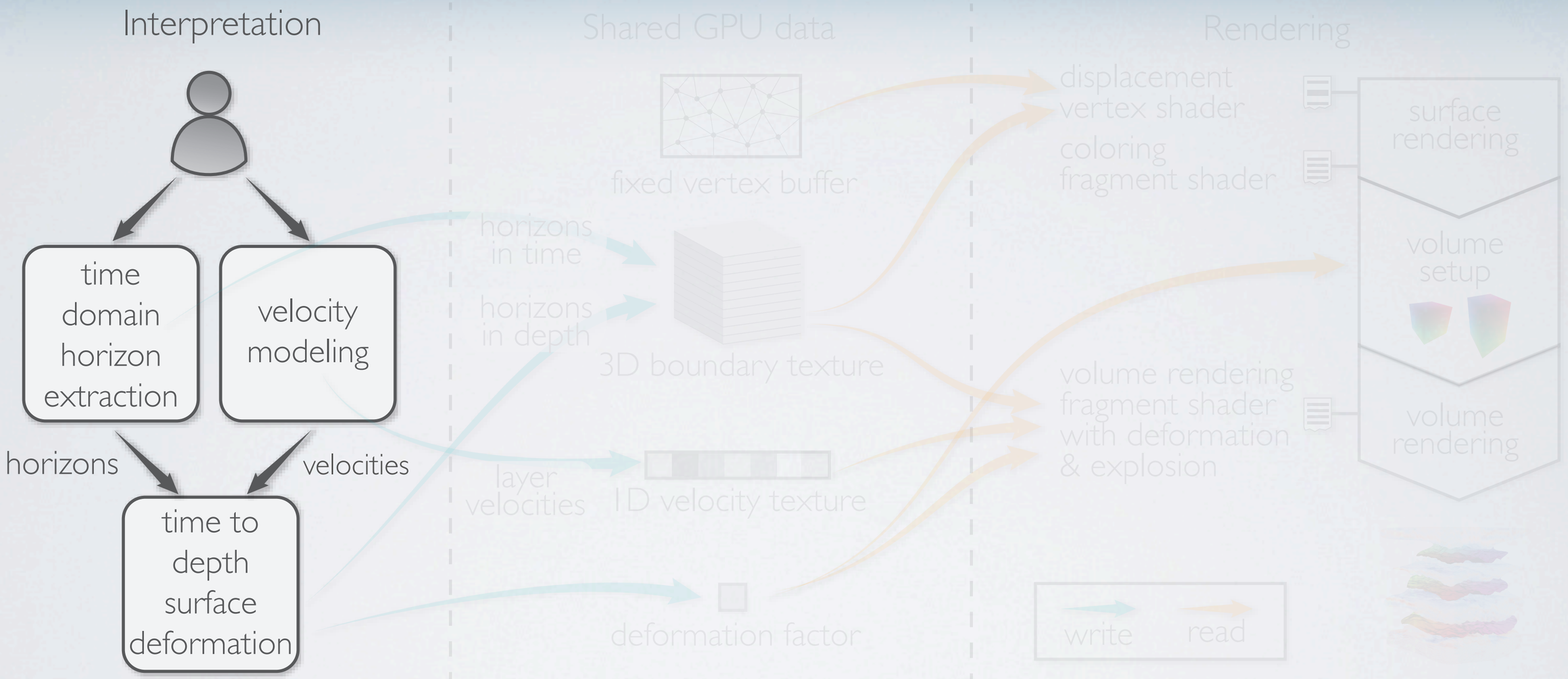

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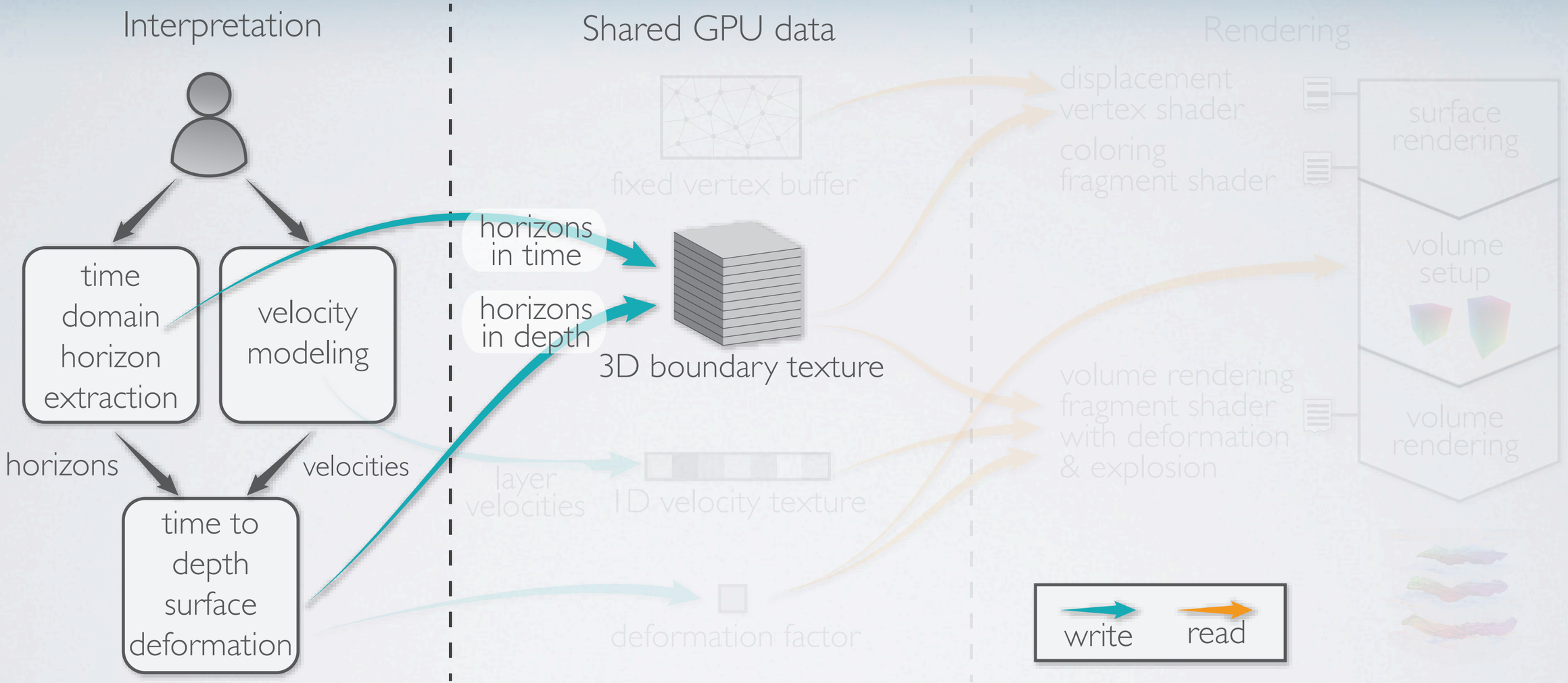

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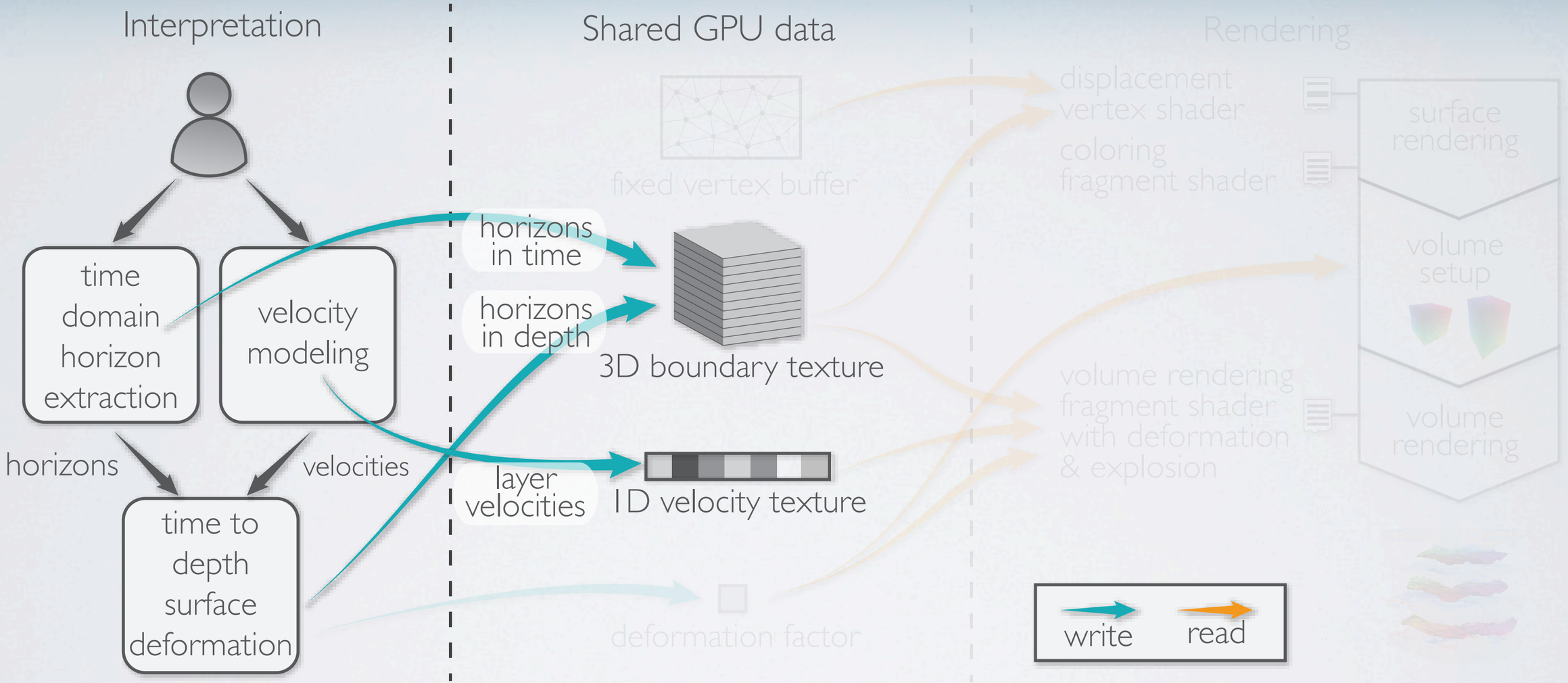

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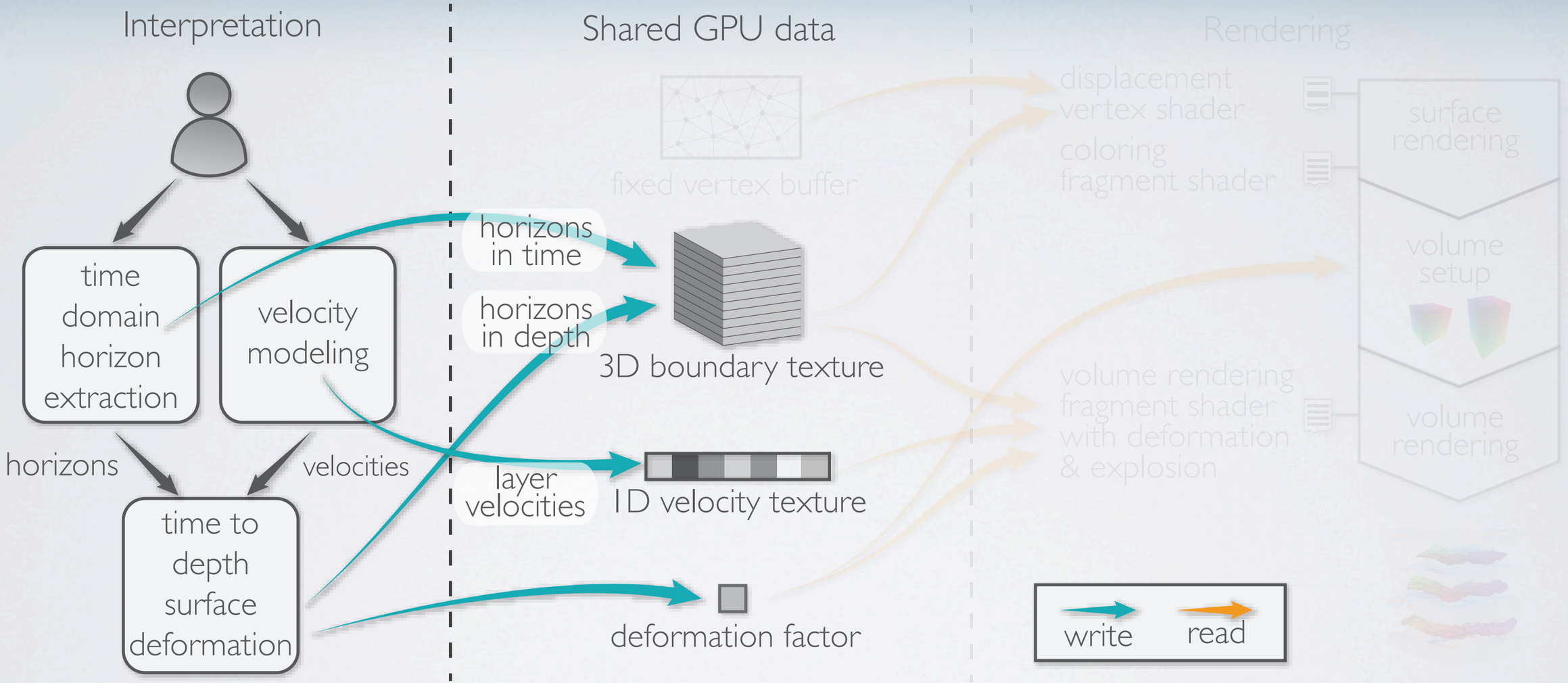

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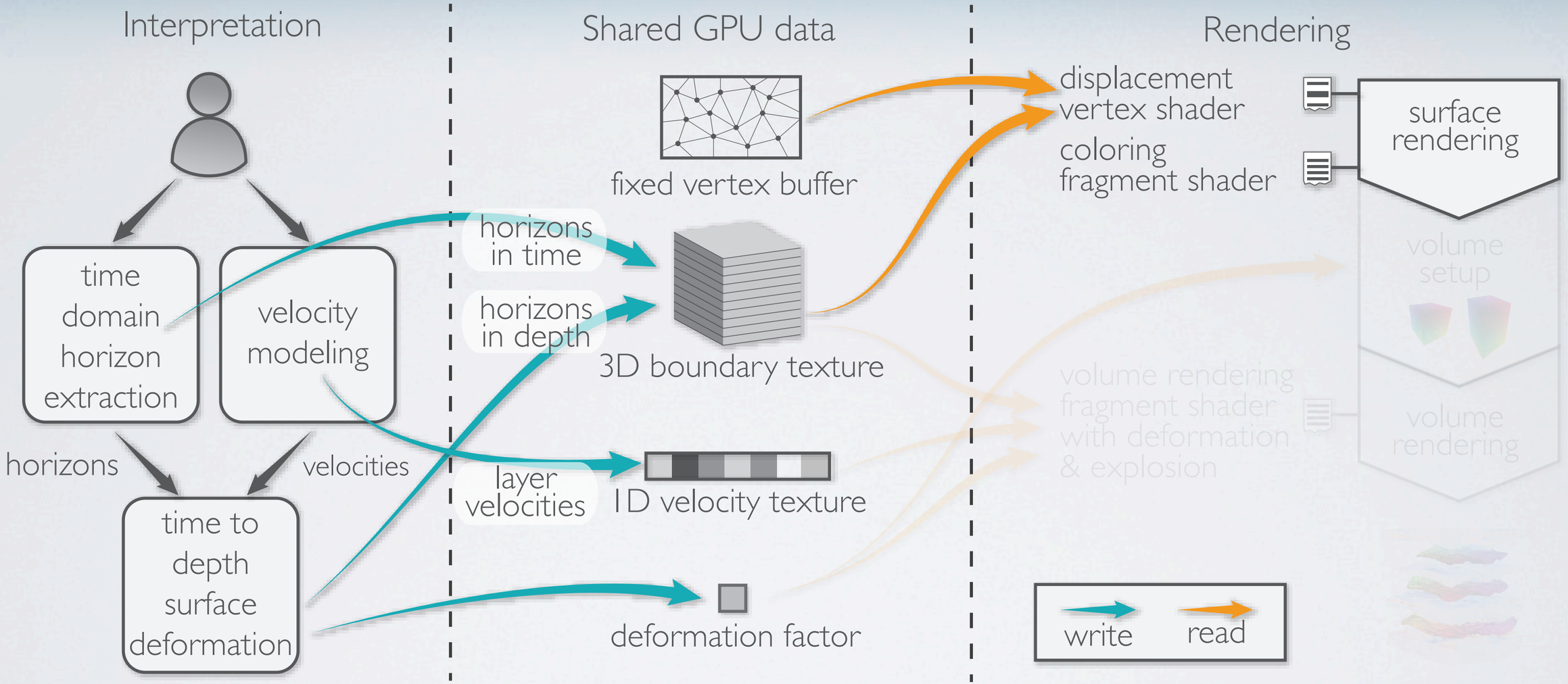

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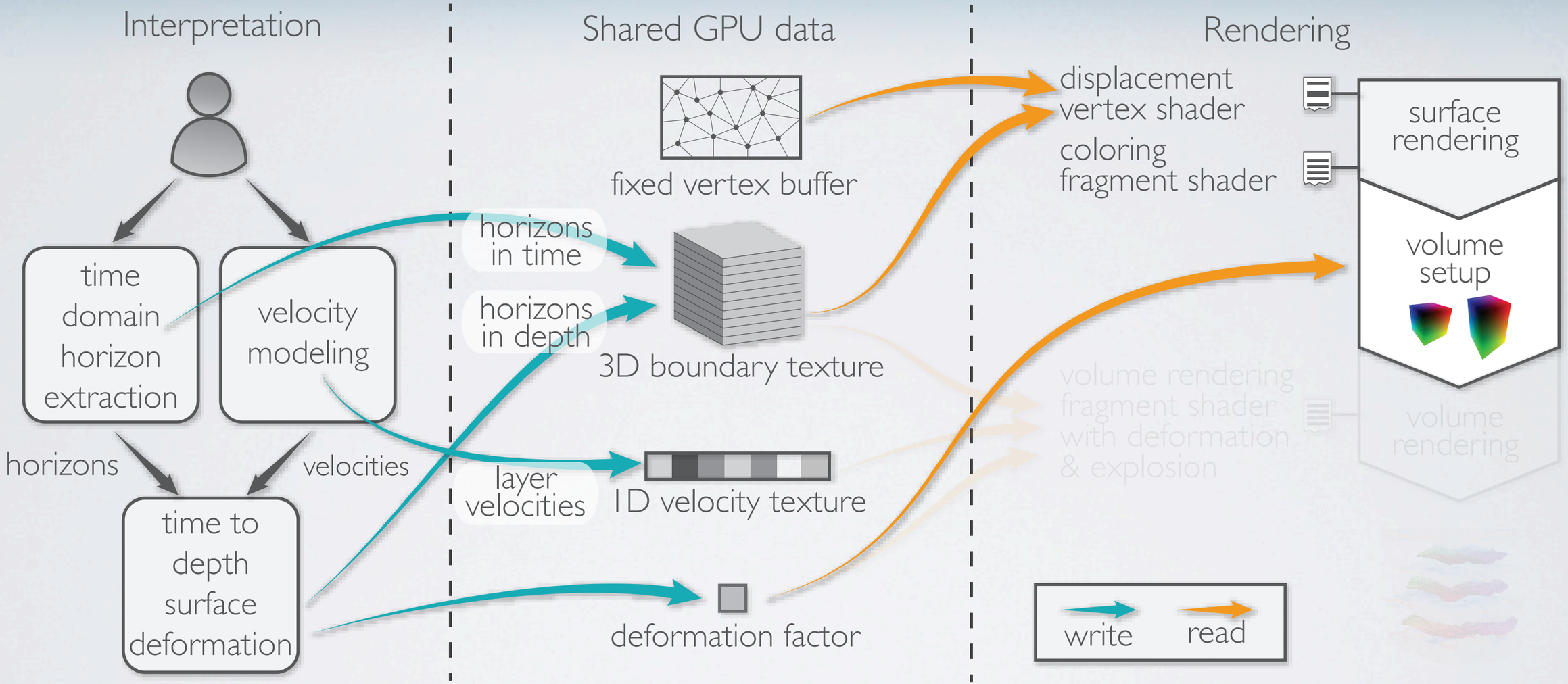

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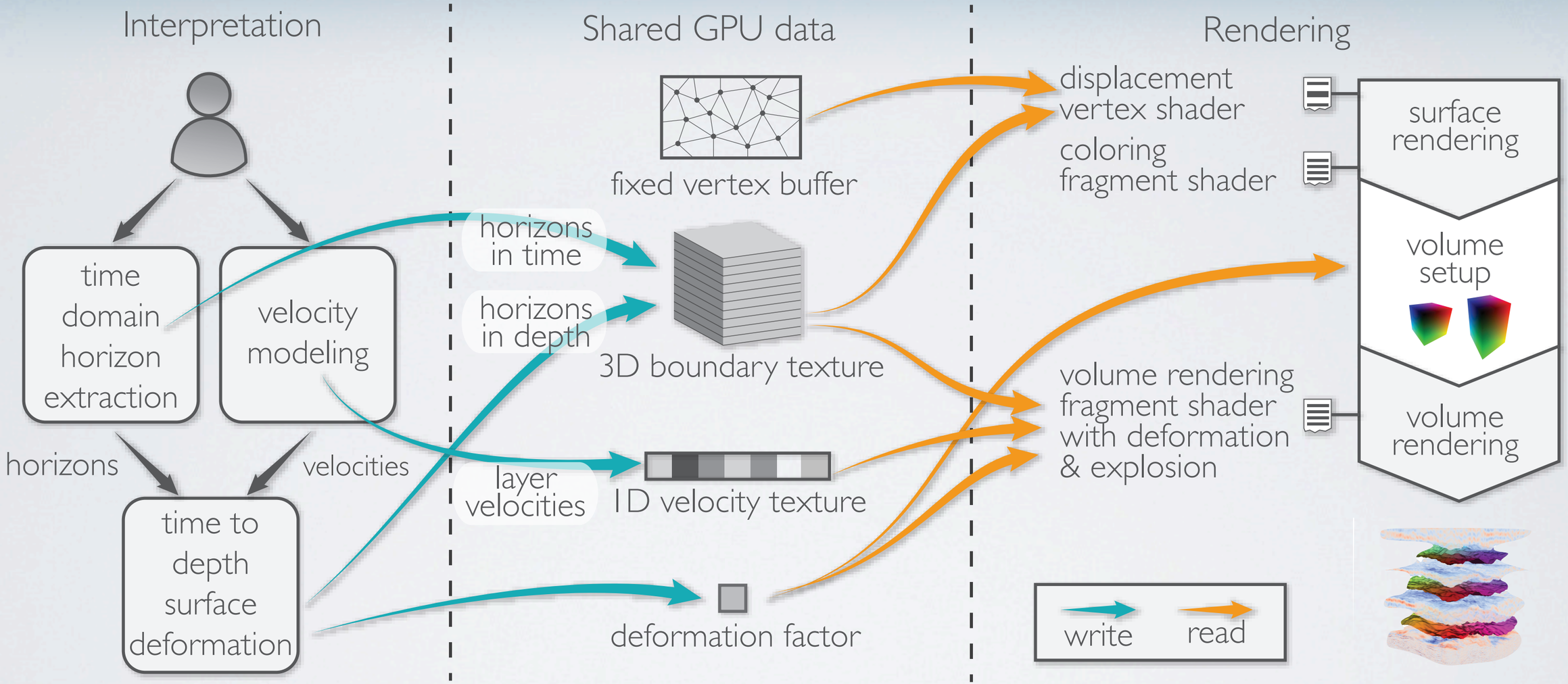

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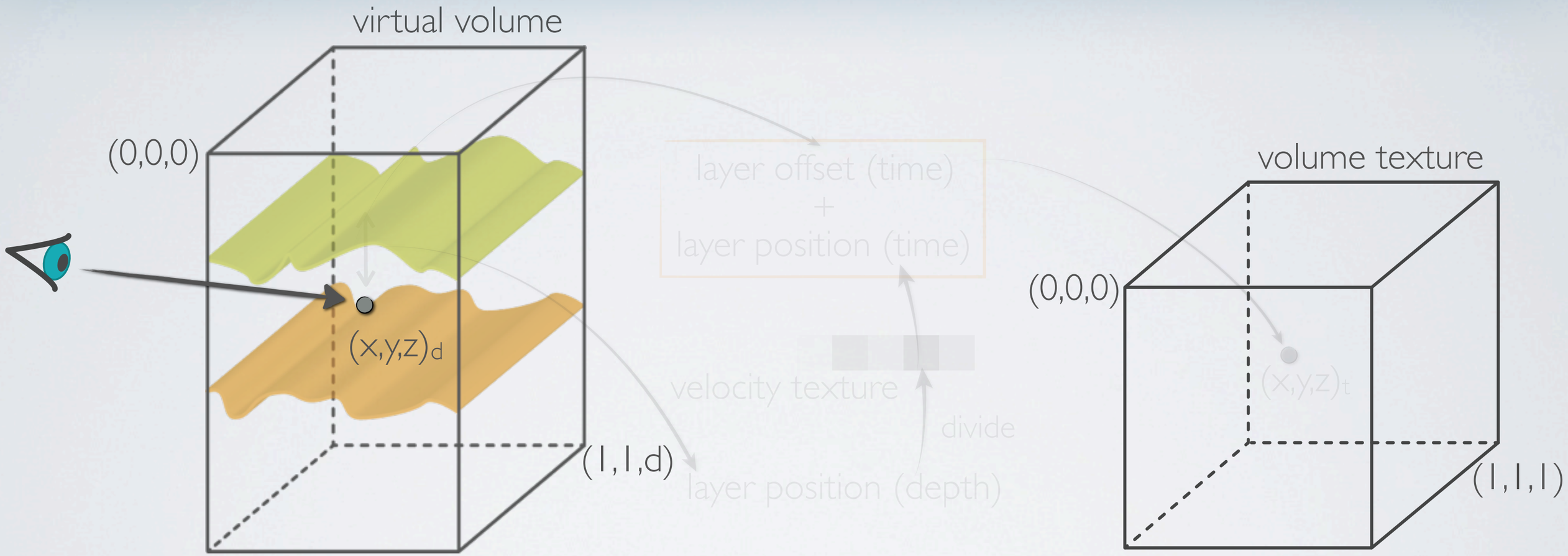

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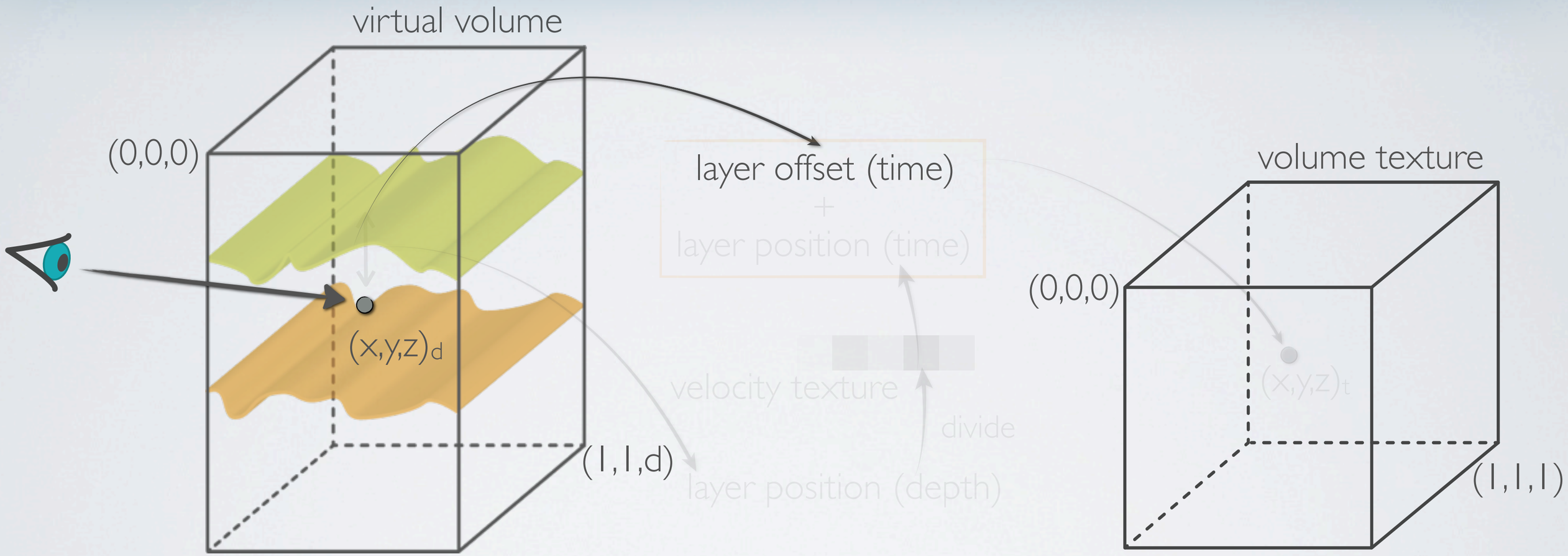

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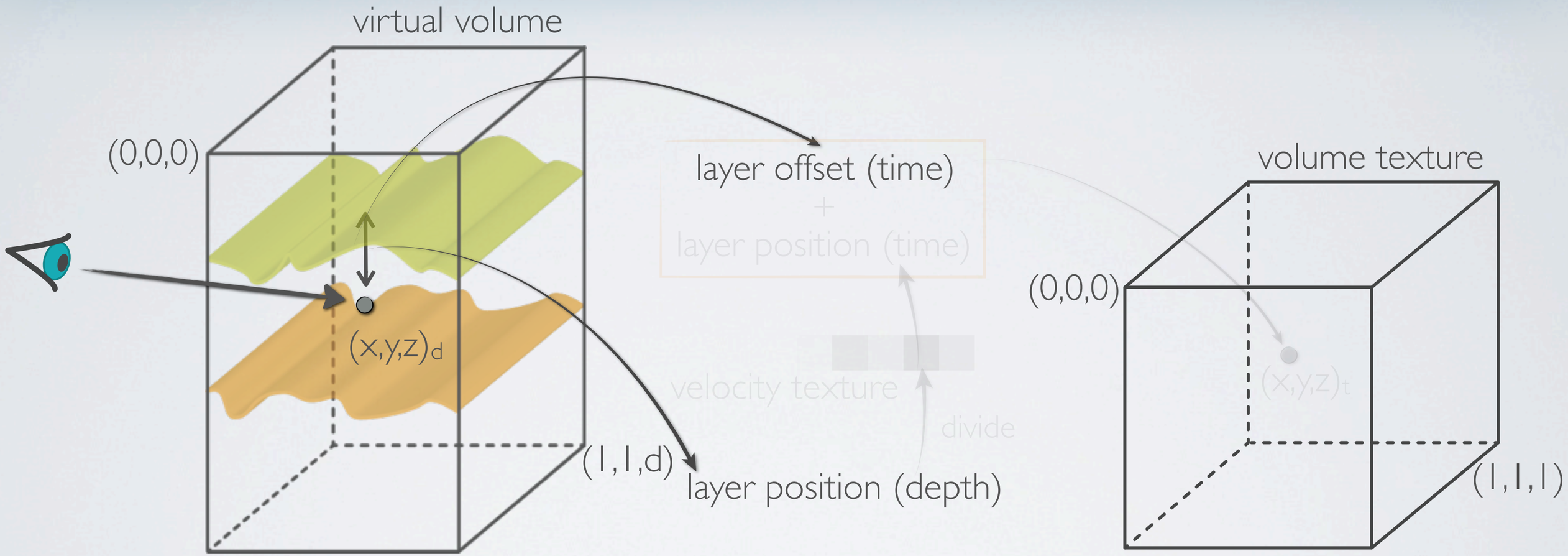

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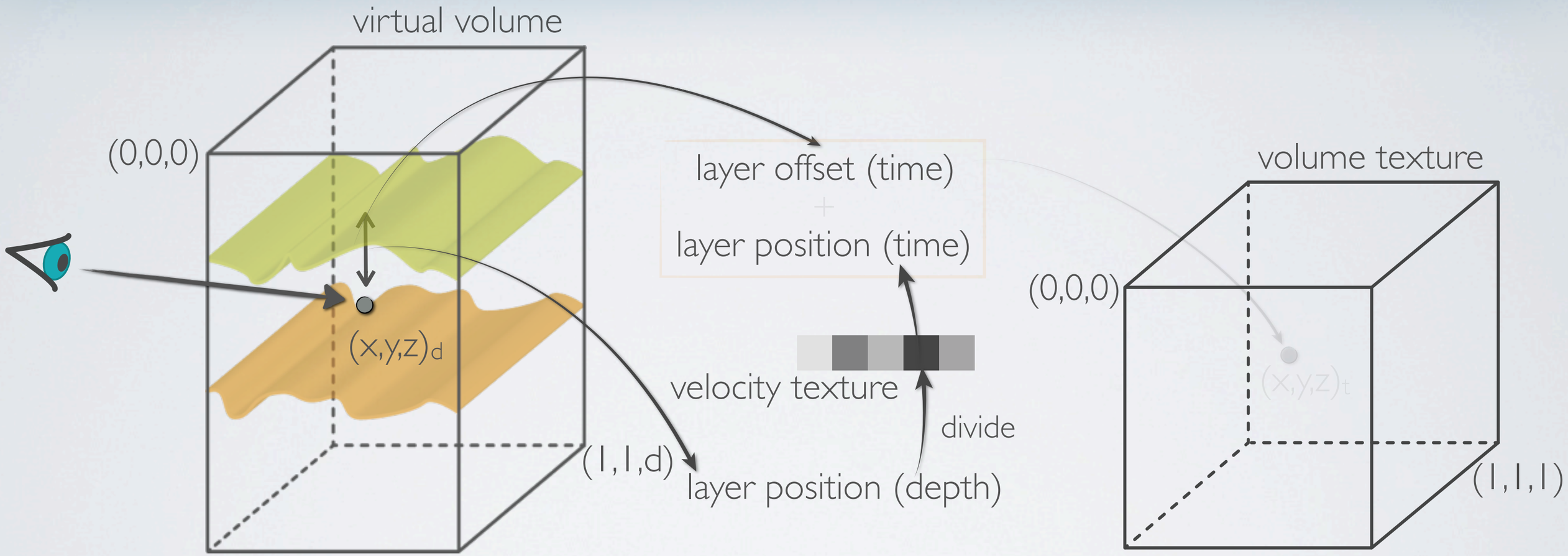

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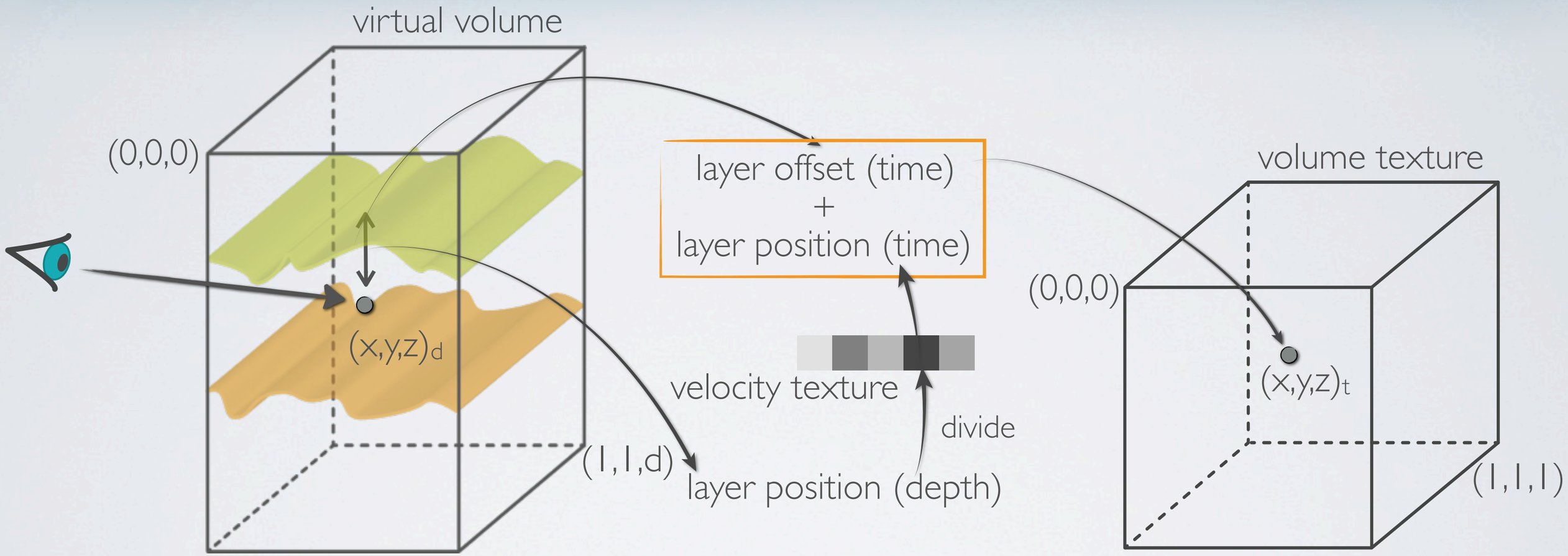
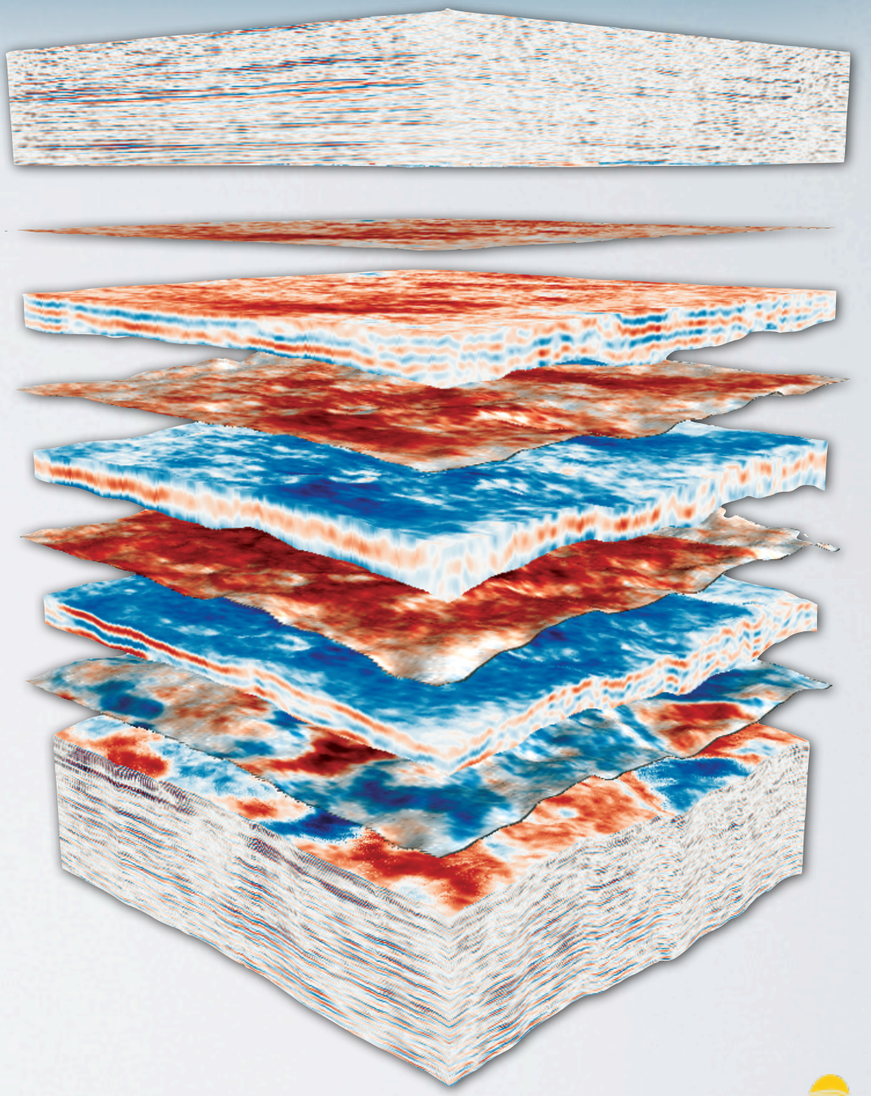


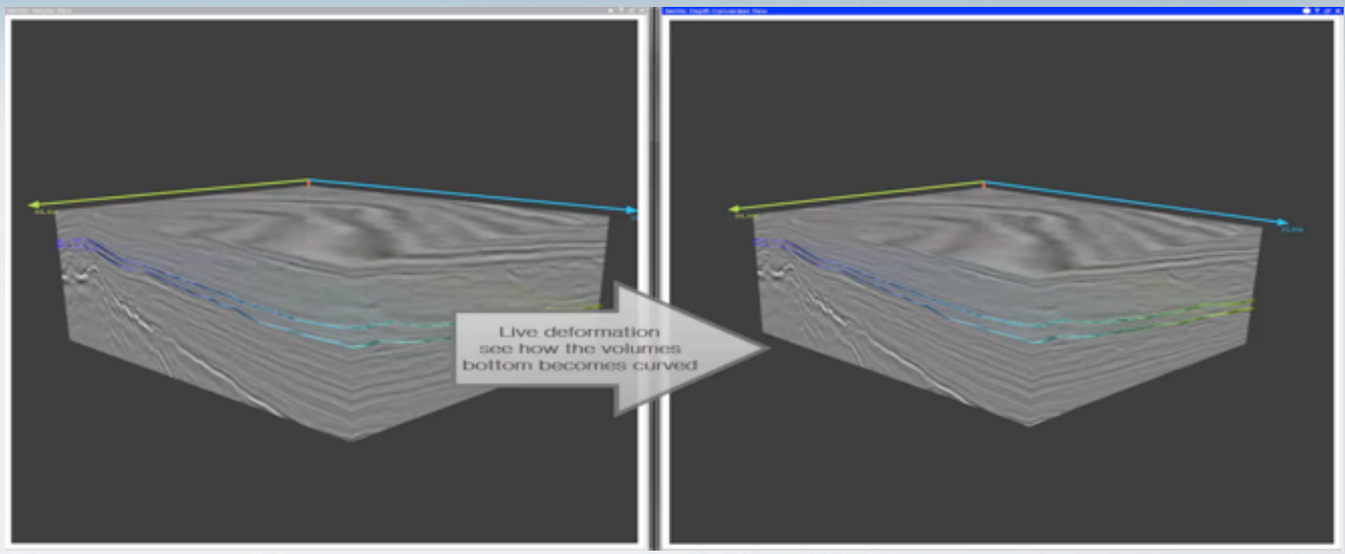
Joint Time/Depth Domain // Exploded Views

- Same principle as deformation
  - add empty space to deformation factor
  - use proximity to boundary to decide whether sample is in explosion spacing
  - render explosion spacing transparently



Results // Performance

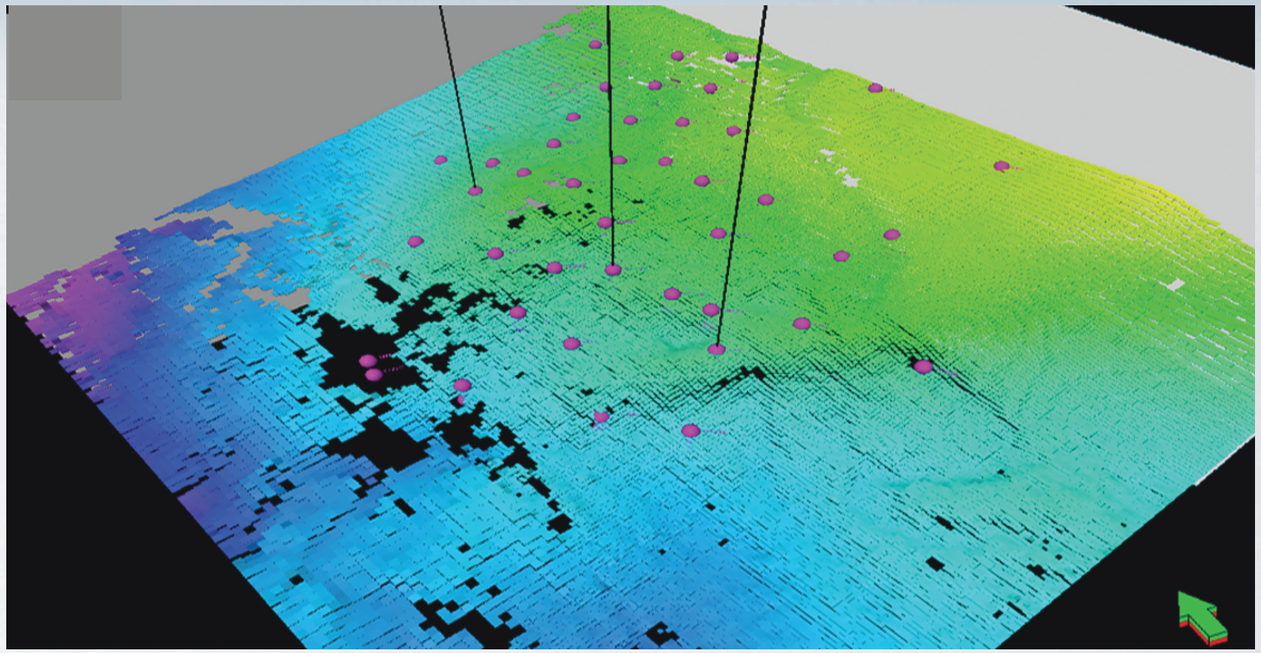
- Layer updates are interactive
- Small performance penalty for live depth conversion



Dataset	Layers		Rendering time / fps		
	number	update / ms	base	+ dc	+ dc, expl.
240x240x1509 165MB	2	9	117	99	68
	4	12	117	87	46
1422x667x1024 1.85GB	2	144	101	81	50
	4	174	101	77	27

Results // Expert Evaluation

- 60 minutes for both apps
  (after introduction to our tool)
- Expert likes prism based workflow
- Live depth conversion is very helpful



App	Initial Interpret.	Velocity computation	Depth conv. computation	Refine	# slices / prisms	Avg. time
Petrel	>60min	21s	29s	n/a	18	200s
SeiVis	~45min	on the fly	on the fly	<10 min	63	43s

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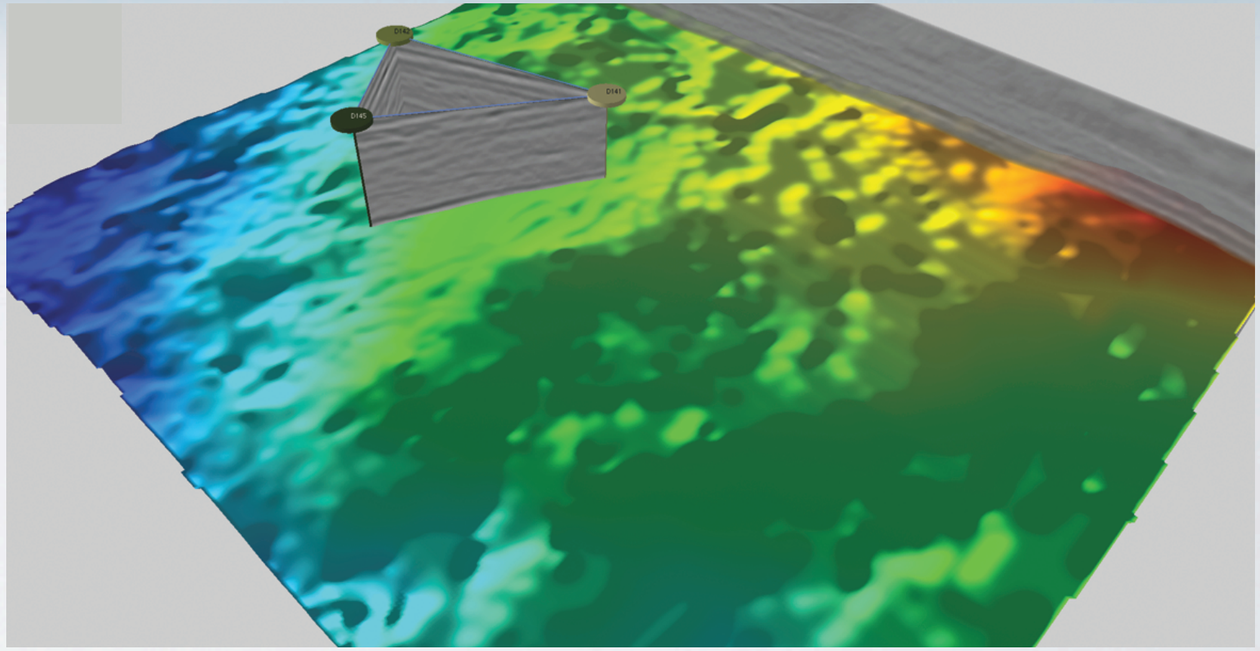

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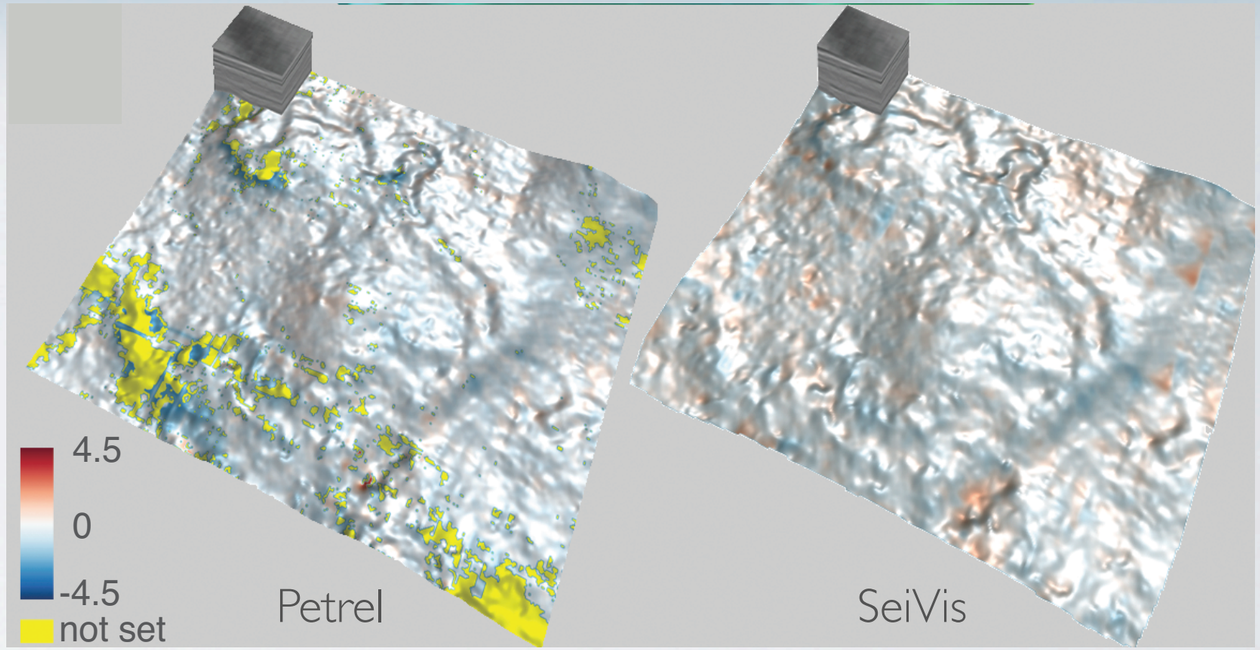

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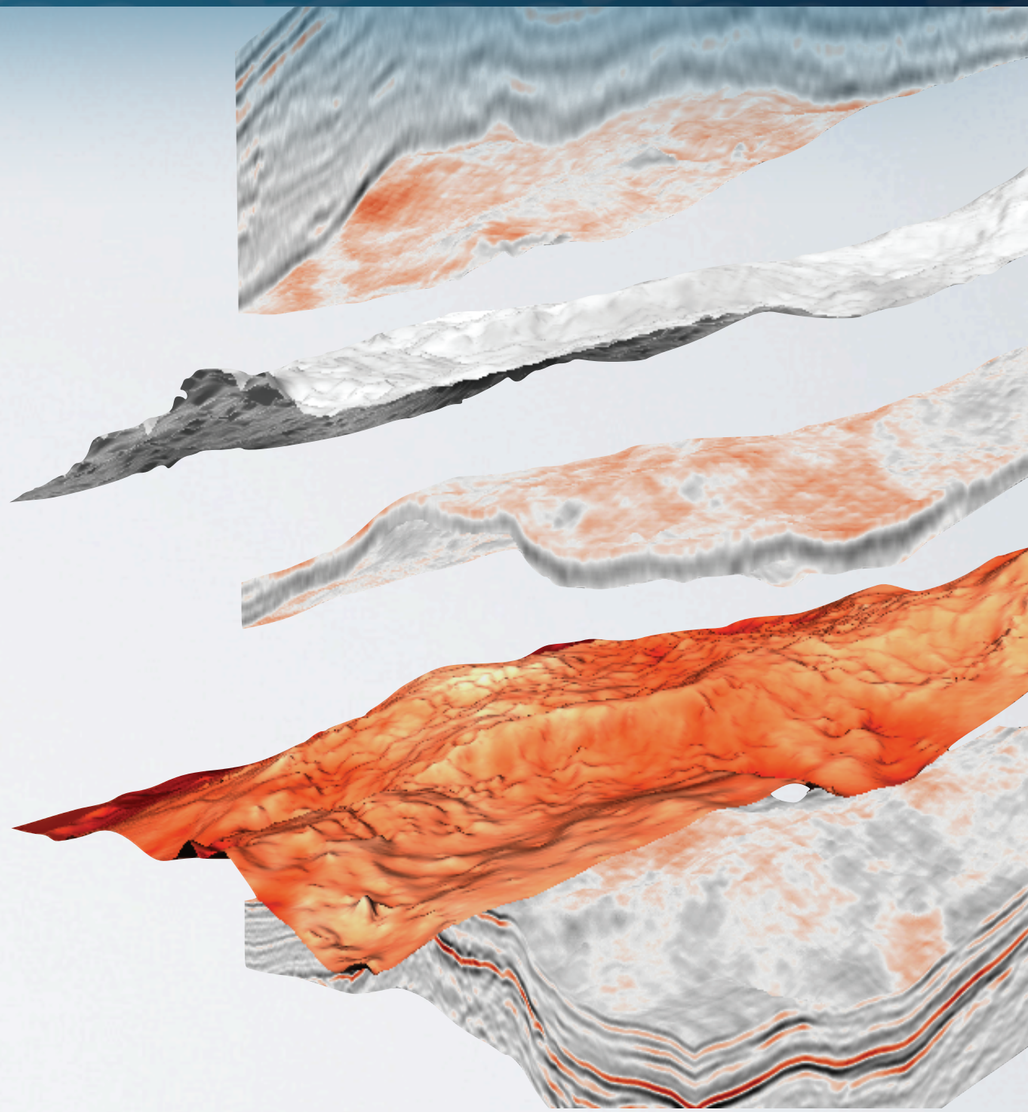
Conclusion

- SeiVis provides a novel, integrated workflow for subsurface modeling
  - new on the fly volume deformation & exploded views
- Expert evaluation shows advantages of new workflow



Questions?

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The datasets are courtesy of Heinemann Oil GmbH.