EuroVis 2015
The EG / VGTC Conference on Visualization
25 - 29 May
Cagliari / Sardinia / Italy

Department of Computer Science
UNIVERSITY OF CALGARY

A Quality-Preserving Cartesian to Body-Centered Cubic Downsampling Transform

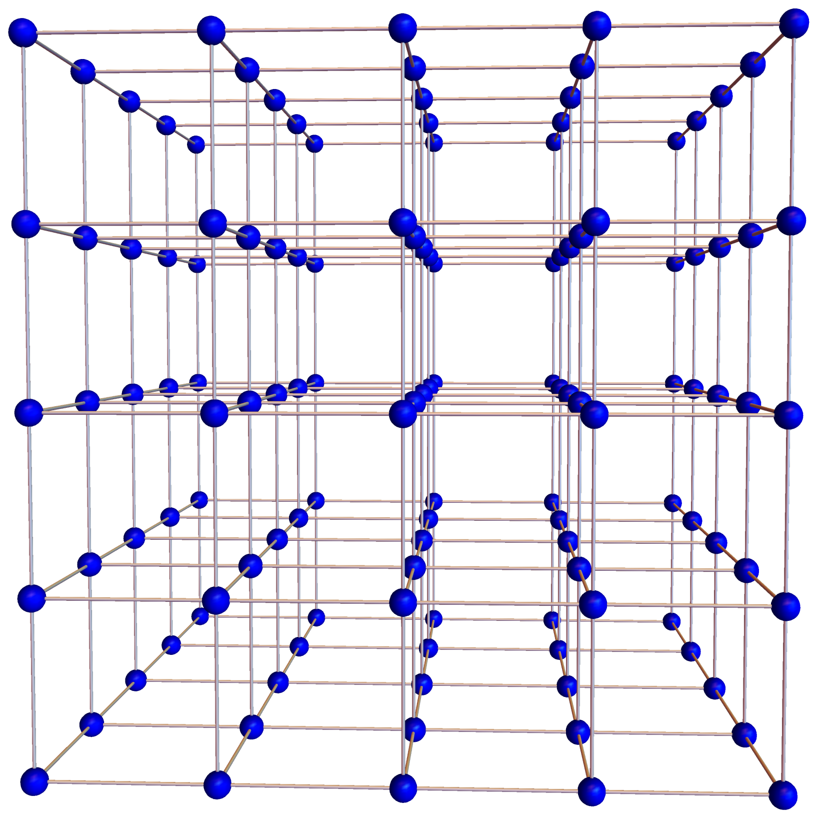
Usman R. Alim

Thiago Valentin de Oliveira
Universidade Federal do Rio de Janeiro

VISAGG
Visualization and Graphics Group

Problem

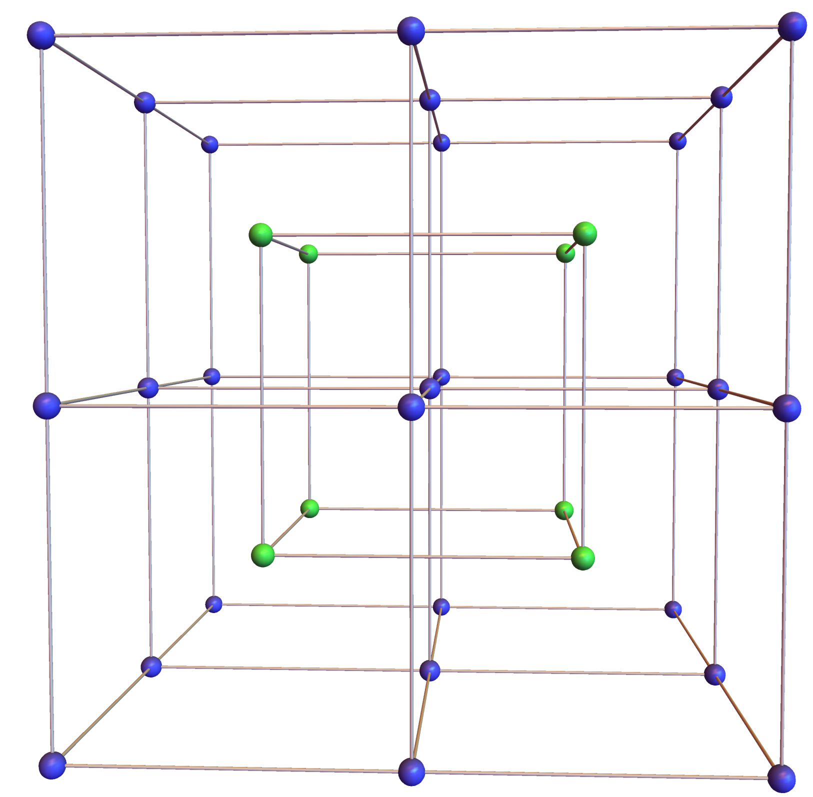
Cartesian



how to downsample?

quality?

BCC



- De Facto standard for volumetric data processing.
- Easy to use but *inefficient* sampling.

- *Efficient* sampling.
- Can we use it for data reduction?

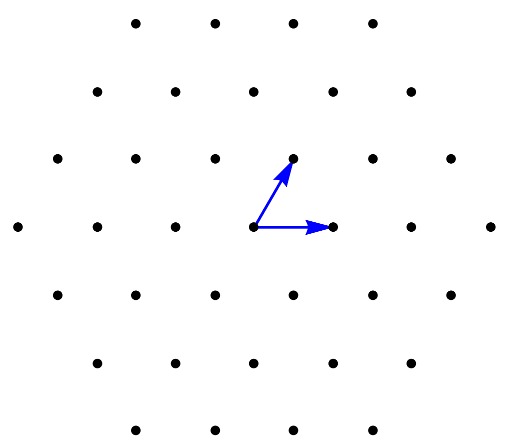
Outline

1. Motivation
2. Error Analysis
3. BCC to CC Downsampling
4. Results

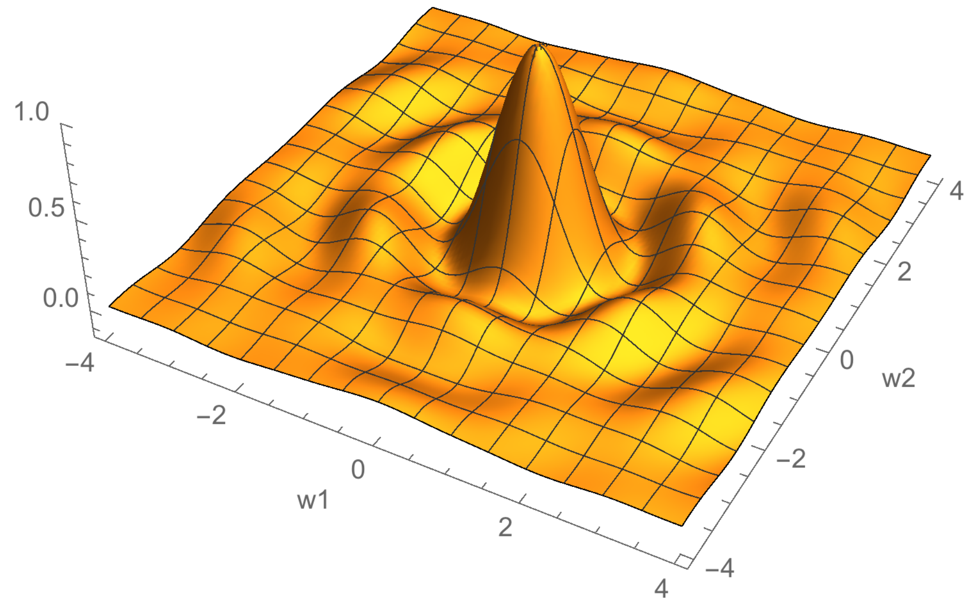
Ideal Recovery

Spatial | Fourier

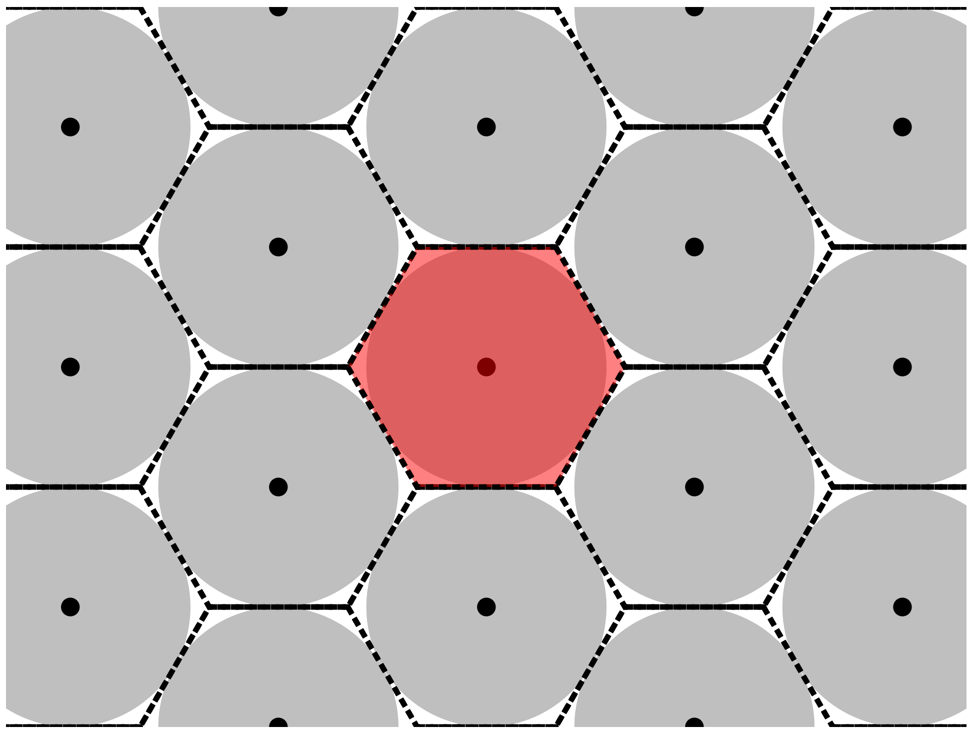
Sampling on a lattice replicates the spectrum on the reciprocal lattice.



lattice samples

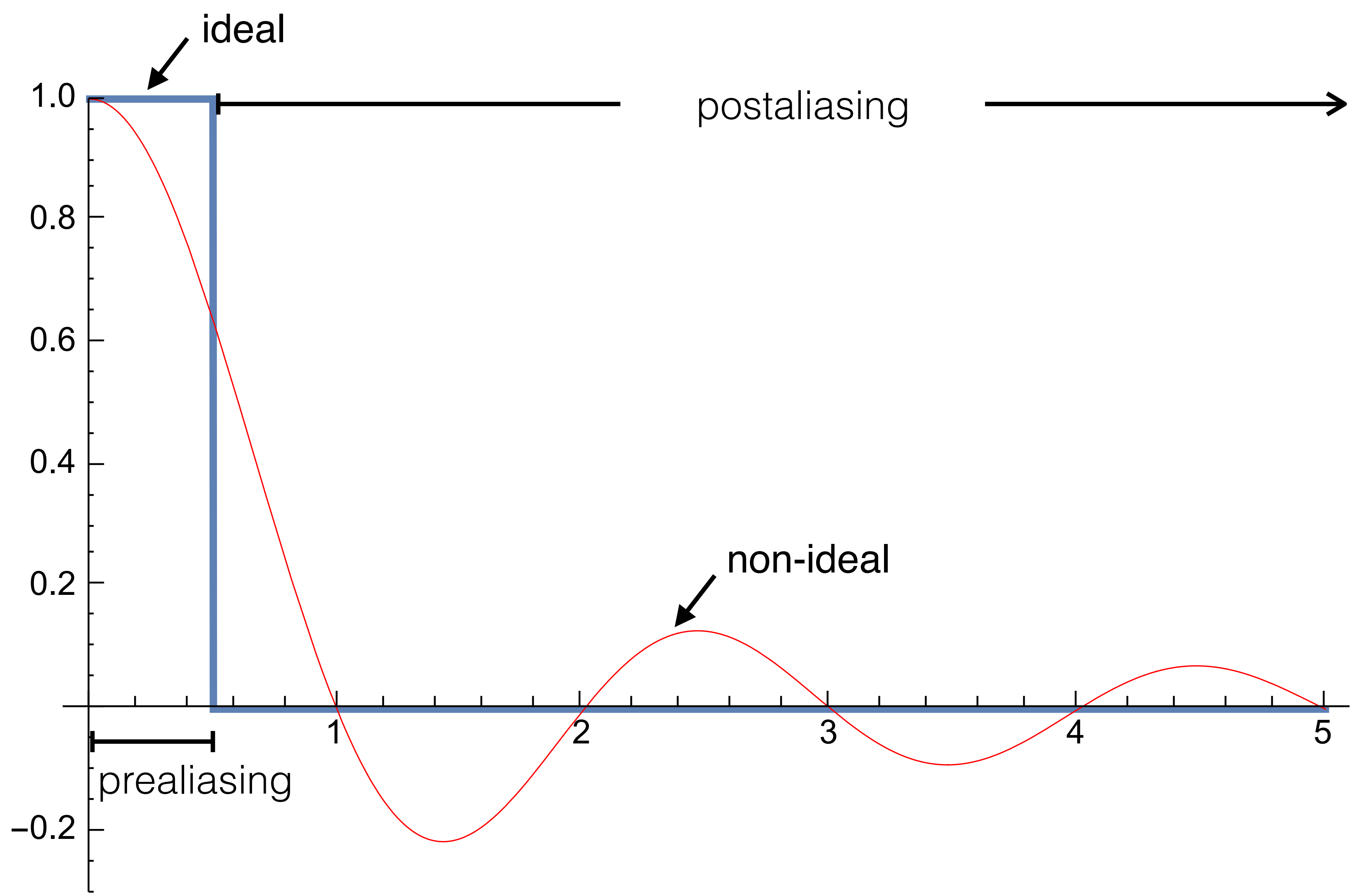


Convolve with sinc kernel for ideal recovery



Multiply with box function to recover the spectrum

Error for Non-Ideal Kernels



- When sampling rate is high, post-aliasing error dominates.
- Error can be characterized by comparing with the ideal.

Post-Aliasing Error Quantification

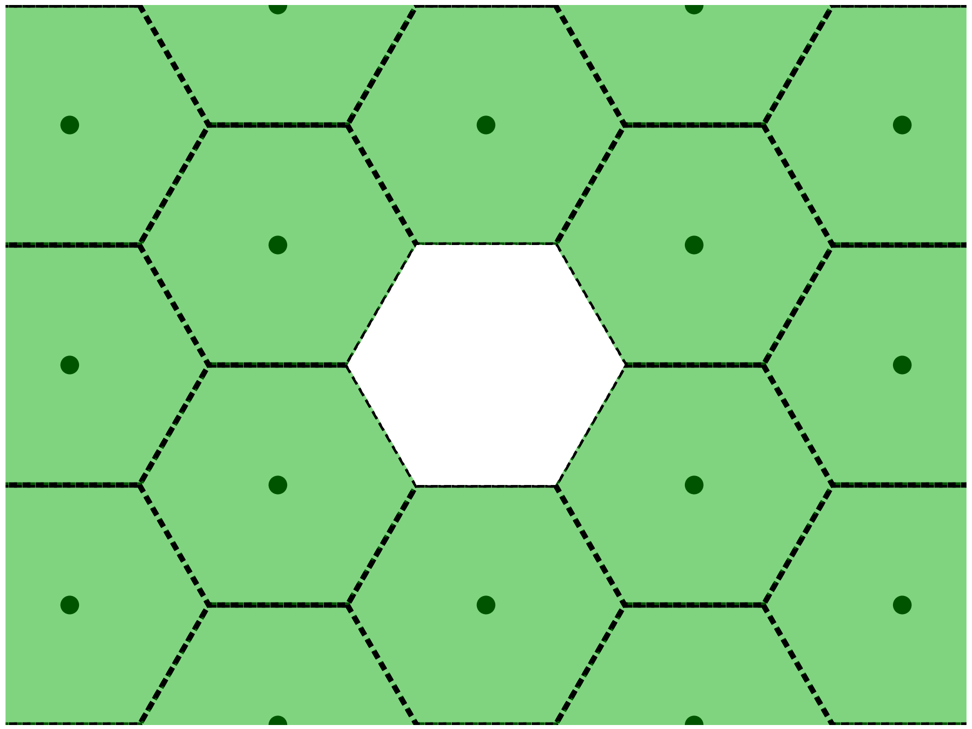
- Kernel: $\varphi(\mathbf{x}) \leftrightarrow \hat{\varphi}(\mathbf{u})$
- Quantify the out-of-band portion of $\hat{\varphi}(\mathbf{u})$:

$$\int_{\mathbb{R}^n \setminus \mathbb{V}_{\mathcal{L}^\circ}} |\hat{\varphi}(\mathbf{u})|^2 d\mathbf{u}$$

DTFT of autocorrelation seq.

$$= \int_{\mathbb{V}_{\mathcal{L}^\circ}} \left(\hat{A}_\varphi(\mathbf{u}) - |\hat{\varphi}(\mathbf{u})|^2 \right) d\mathbf{u}$$

$E(\mathbf{u})$: **post-aliasing error kernel**



out-of-band region: $\mathbb{R}^n \setminus \mathbb{V}_{\mathcal{L}^\circ}$

$E(h\mathbf{u})$: scale error kernel to handle different sampling rates

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3. **BCC to CC Downsampling**
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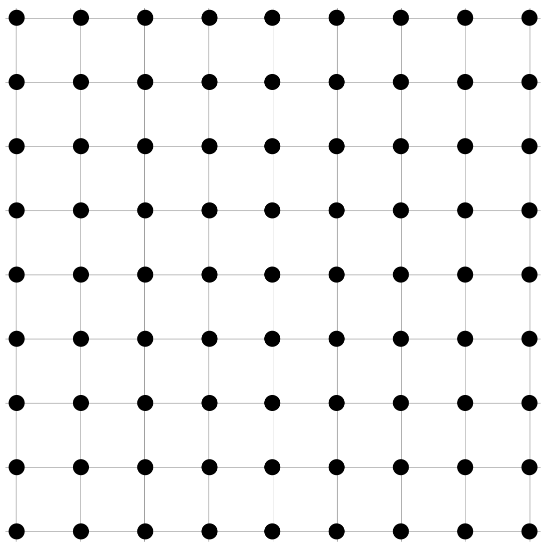
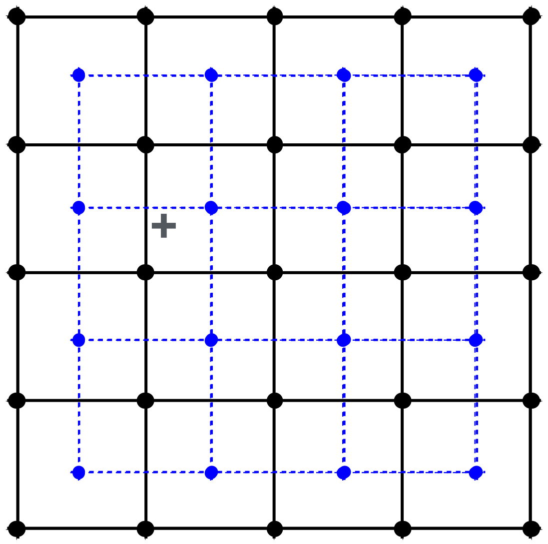
Kernel Choice

Cartesian



- Trilinear B-spline

BCC



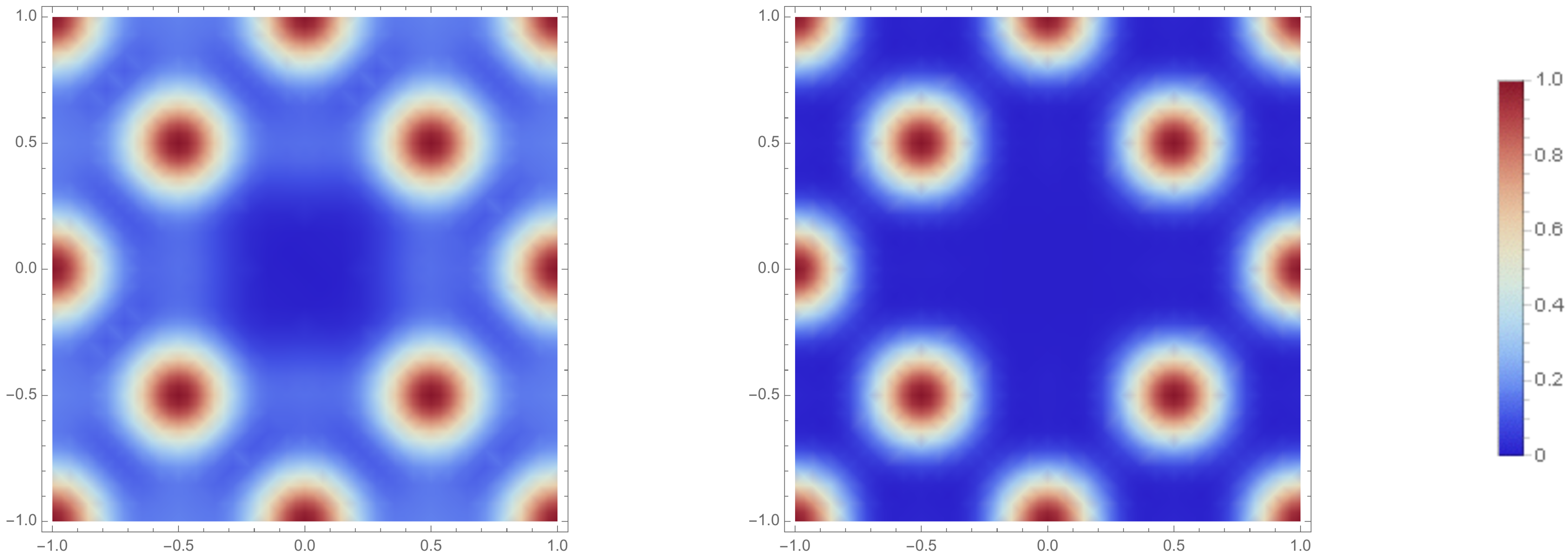
- Cosine-weighted Trilinear B-spline (CWLB) [CSÉBFALVI, TVCG 2013]
- Blends two trilinear fetches according to

$$W_\lambda(x, y, z) := \frac{1}{2} + \frac{\lambda}{6}(\cos \pi x + \cos \pi y + \cos \pi z).$$

λ is a free parameter.

Optimizing the CWLB kernel

- Use the post-aliasing error kernel to:
  - find optimal λ,
  - determine gain in sampling rate.



unoptimized CWLB

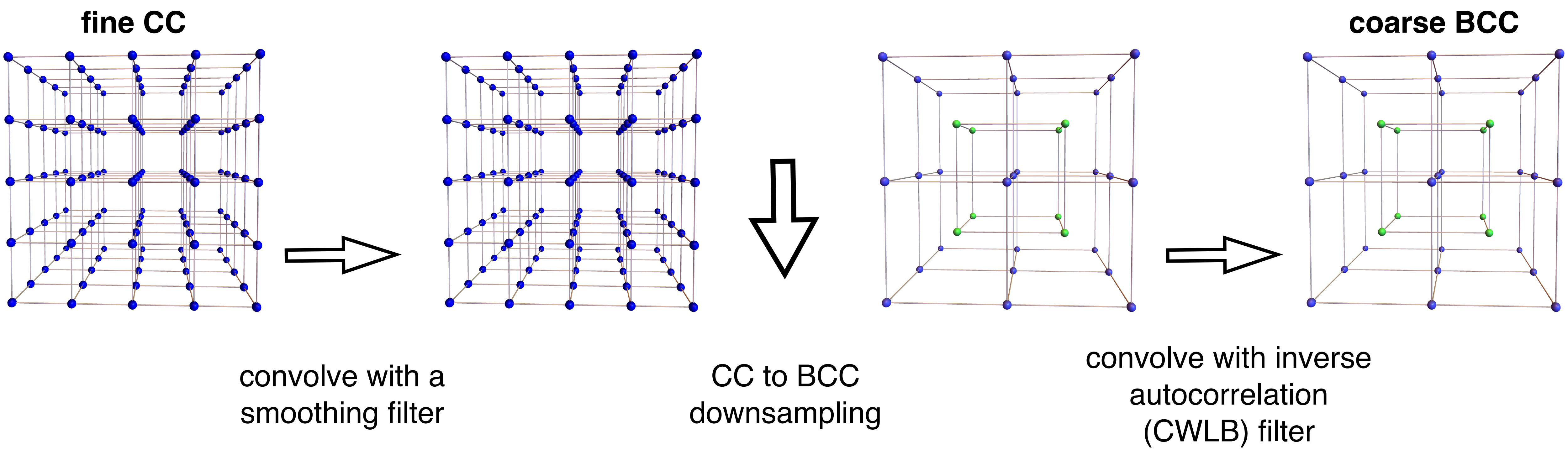
optimized CWLB

same error with a quarter of the samples!

$w = 0$ slices of the error kernel

Downsampling

- Project fine resolution Trilinear CC representation to a coarse CWLB BCC representation [HOSSAIN ET AL., TVCG 2011].



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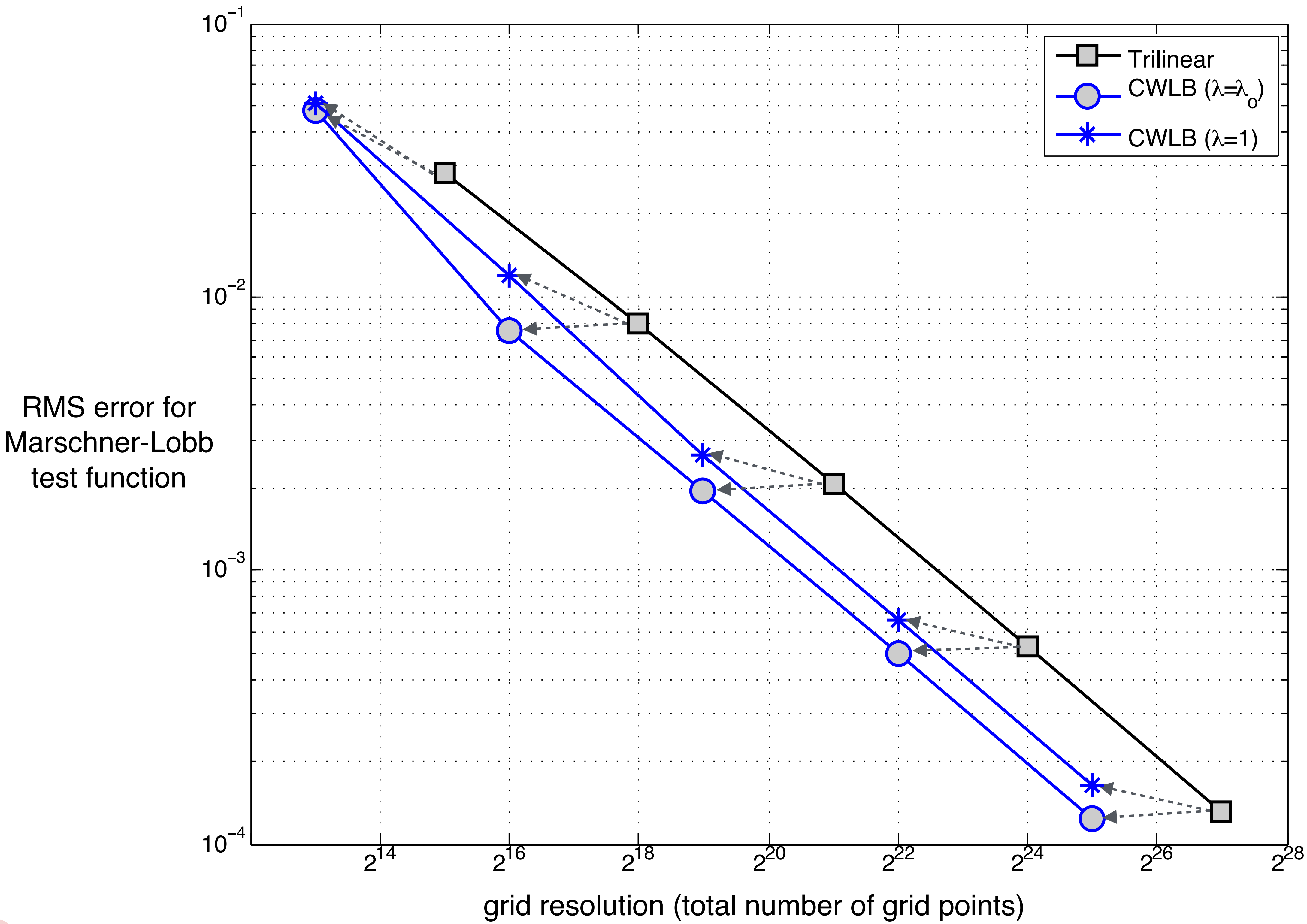
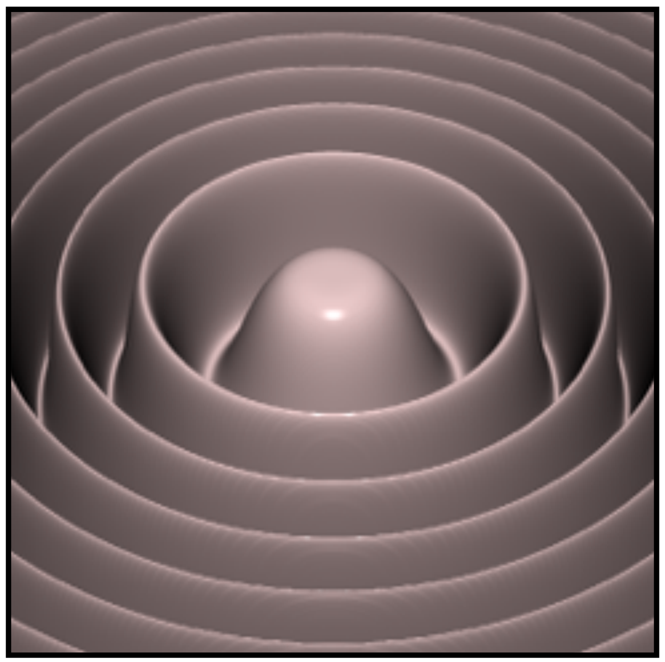
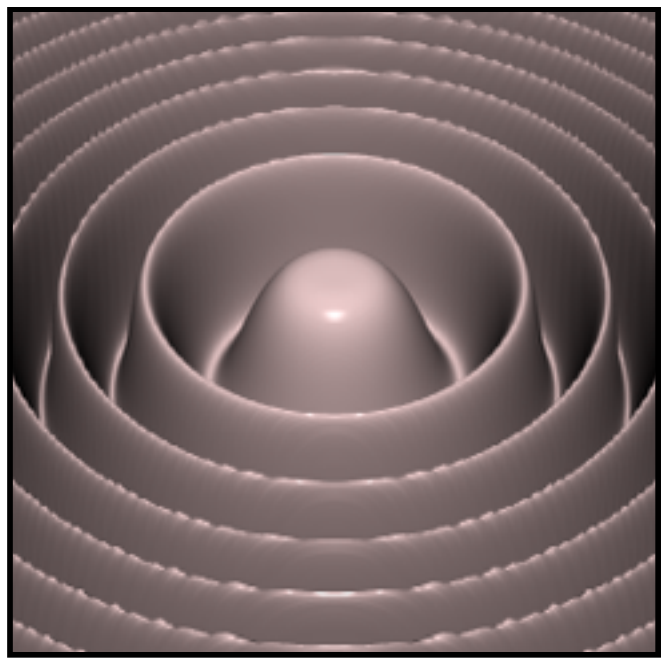
Convergence Test



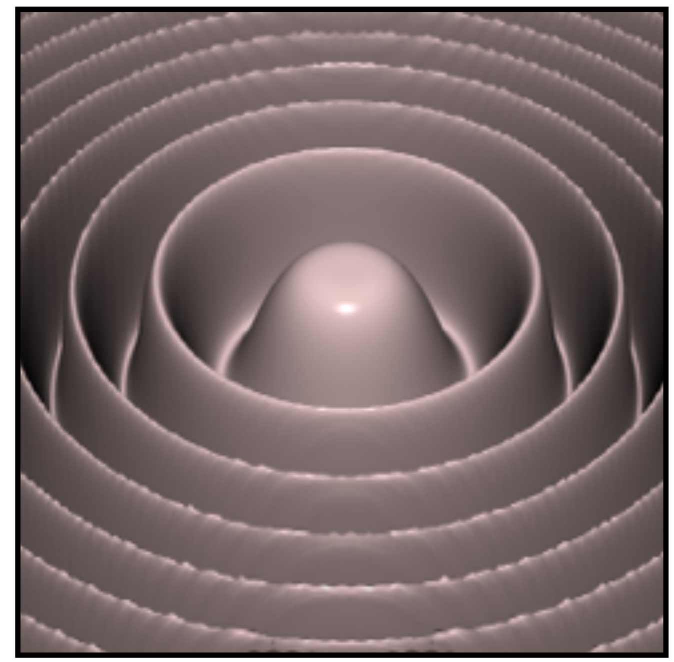
Volume Rendering Tests



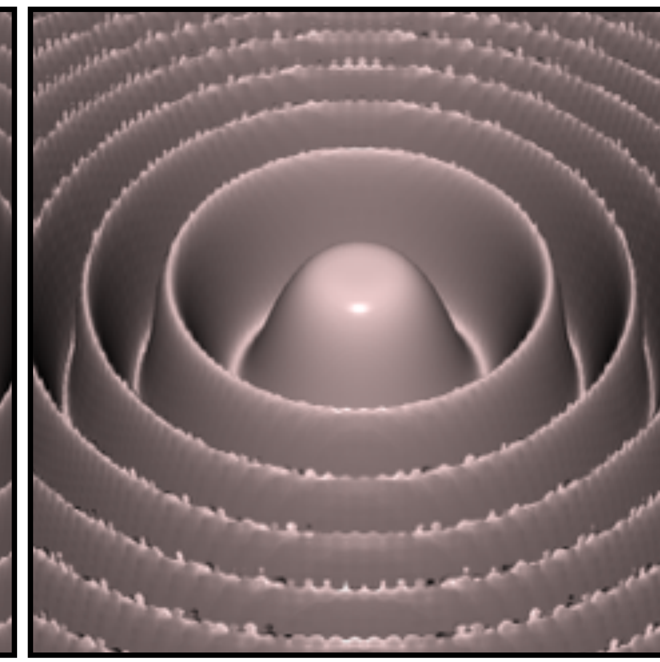
ground truth



128^3 CC
trilinear

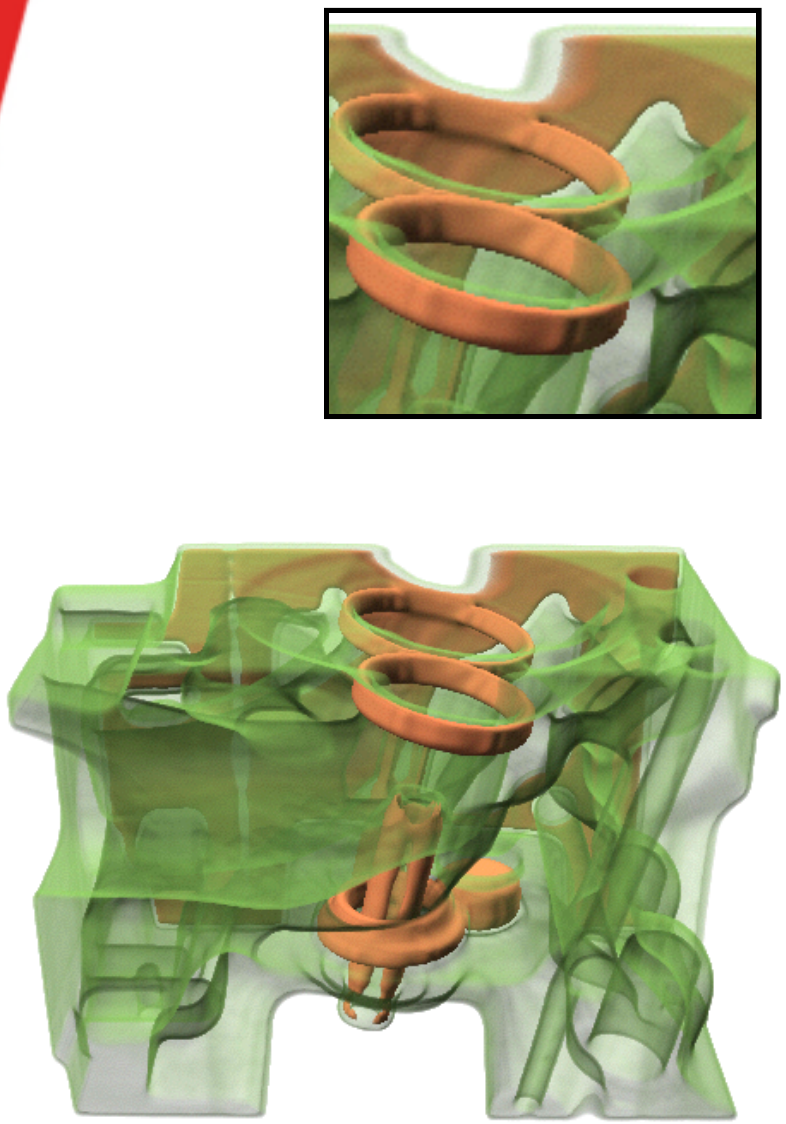


64^3 x 2 BCC
optimized
CWLB

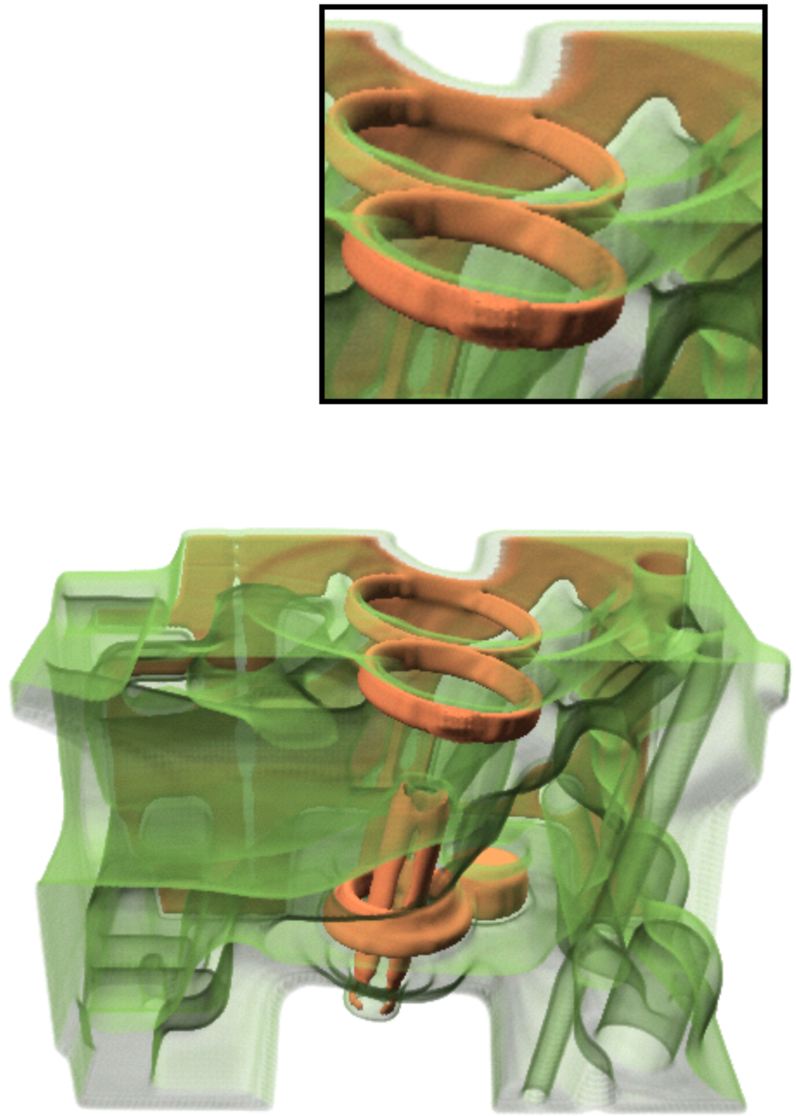


64^3 x 2 BCC
unoptimized
CWLB

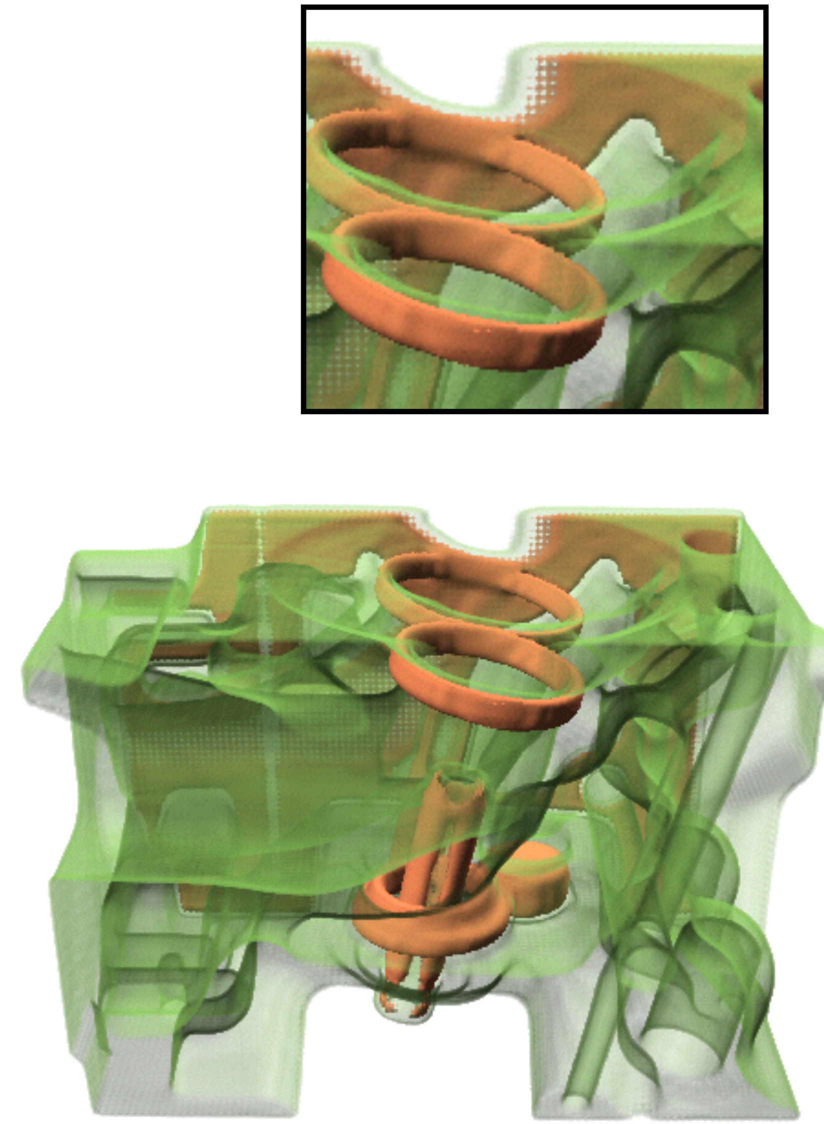
Volume Rendering Tests



256 x 256 x 128 CC
trilinear



128 x 128 x 64 x 2 BCC
optimized CWLB



128 x 128 x 64 x 2 BCC
unoptimized CWLB

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Conclusion

- Error quantification in the Fourier domain.
- Using the optimized CWLB leads to a 75% data reduction with similar quality!

Thank you for your attention!

ualim@ucalgary.ca
http://visagg.cpsc.ucalgary.ca