

# **CS 247 – Scientific Visualization**

## **Lecture 20: Volume Visualization, Pt. 6**

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# Reading Assignment #10 (until Apr 9)



## Read (required):

- Paper:

*Markus Hadwiger, Ali K. Al-Awami, Johanna Beyer, Marco Agus, and Hanspeter Pfister*

*SparseLeap: Efficient Empty Space Skipping for Large-Scale Volume Rendering, IEEE Scientific Visualization 2017,*

[http://vccvisualization.org/publications/2017\\_hadwiger\\_sparseleap.pdf](http://vccvisualization.org/publications/2017_hadwiger_sparseleap.pdf)

[http://vccvisualization.org/publications/2017\\_hadwiger\\_sparseleap.mp4](http://vccvisualization.org/publications/2017_hadwiger_sparseleap.mp4)

## Read (optional):

- Real-Time Volume Graphics, Chapter 6  
(Global Volume Illumination)

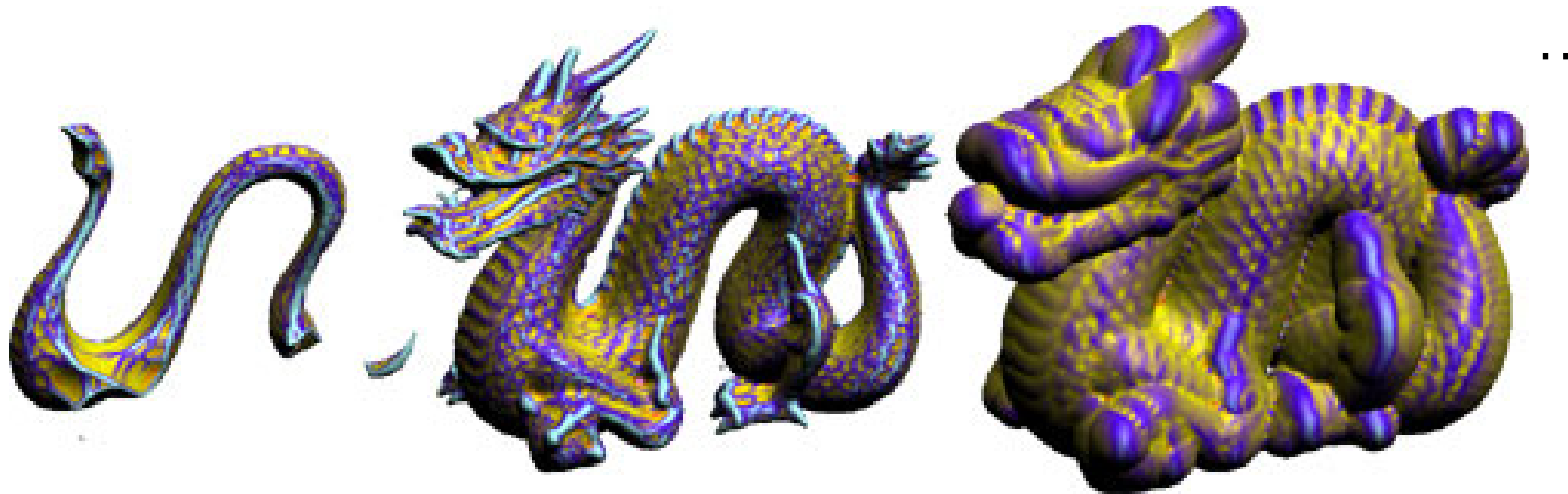
# Isosurface Ray-Casting

# Isosurface Ray-Casting



## Isosurfaces/Level Sets

- Scanned data (fit signed distance function to points, ...)
- Signed distance fields
- CSG (constructive solid geometry) operations

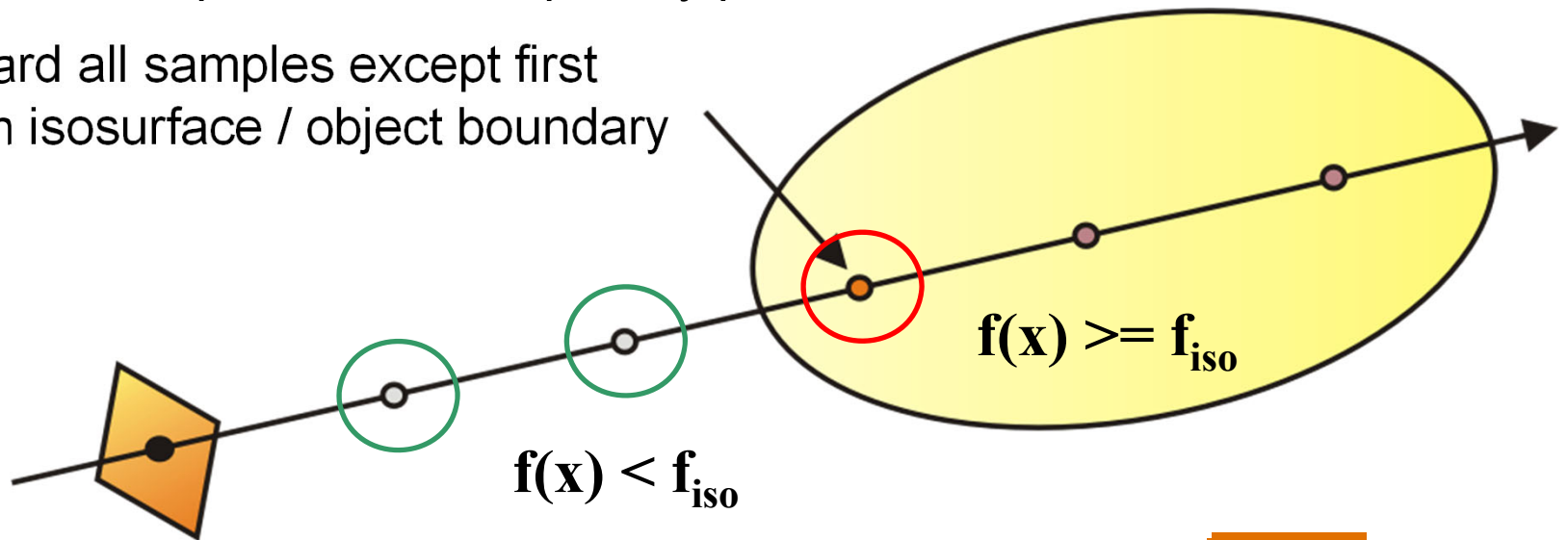


# Isosurface Ray-Casting

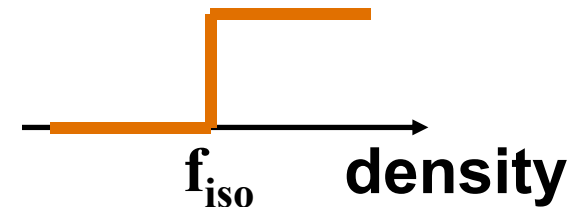


Opaque isosurfaces:  
only one sample contributes per ray/pixel

Discard all samples except first  
hit on isosurface / object boundary



Threshold transfer function / alpha test



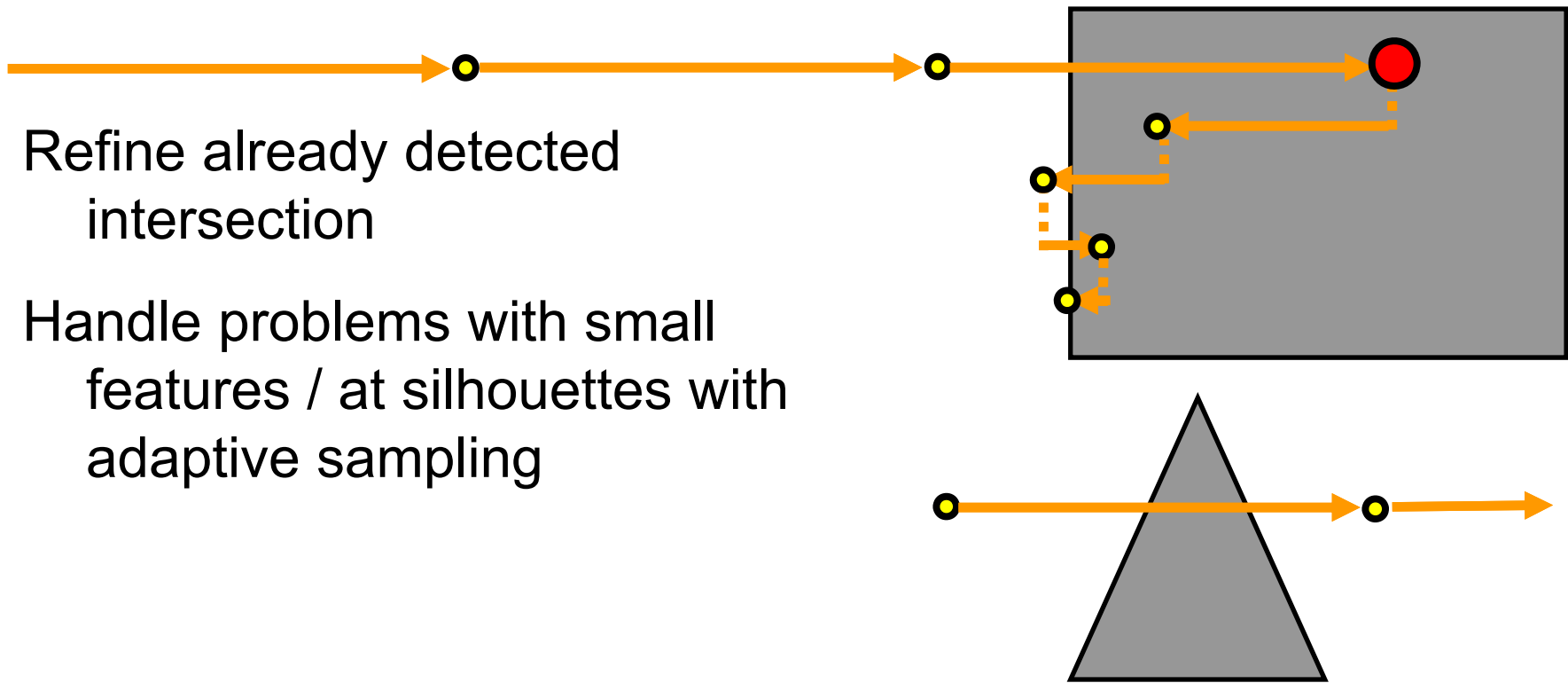
**First hit ray casting**

# Intersection Refinement (1)



Fixed number of bisection / binary search steps

Virtually no impact on performance



Refine already detected intersection

Handle problems with small features / at silhouettes with adaptive sampling

## Intersection Refinement (2)



without refinement



with refinement

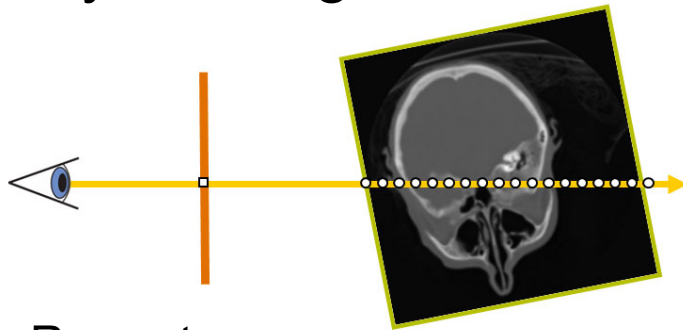


sampling distance 5 voxels (no adaptive sampling)

# Ray-Casting vs. Isosurface Ray-Casting



## Ray-Casting



Ray setup

Loop over ray

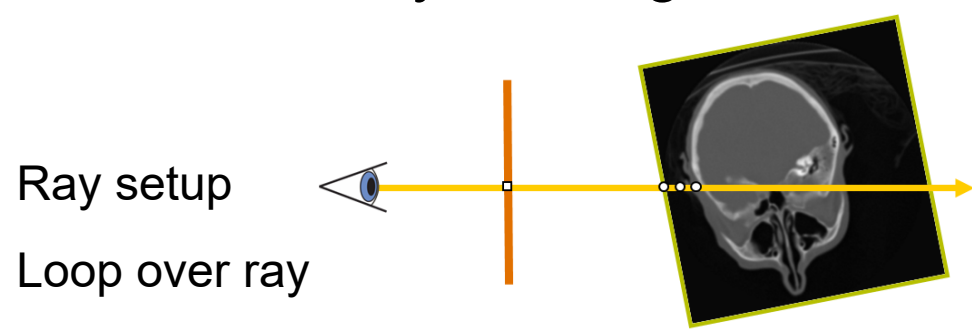
Sample scalar field

Classification

Shading

Compositing

## Isosurface Ray-Casting



Ray setup

Loop over ray

Sample scalar field

if  $\text{value} \geq \text{isoValue}$  (i.e., first hit)

break out of the loop

[Refine first hit location] (optional)

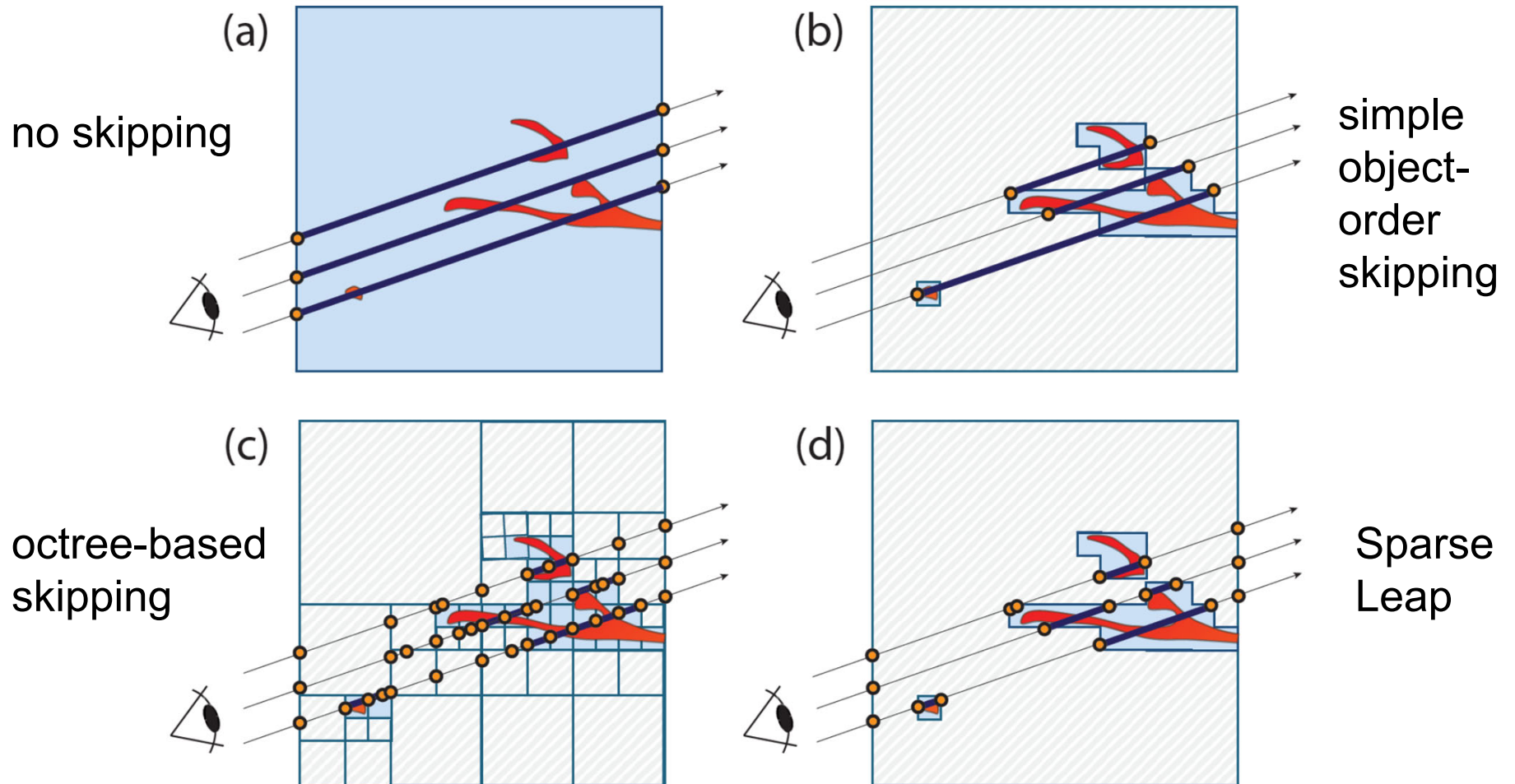
Shading

(Compositing not needed)



# Empty Space Skipping

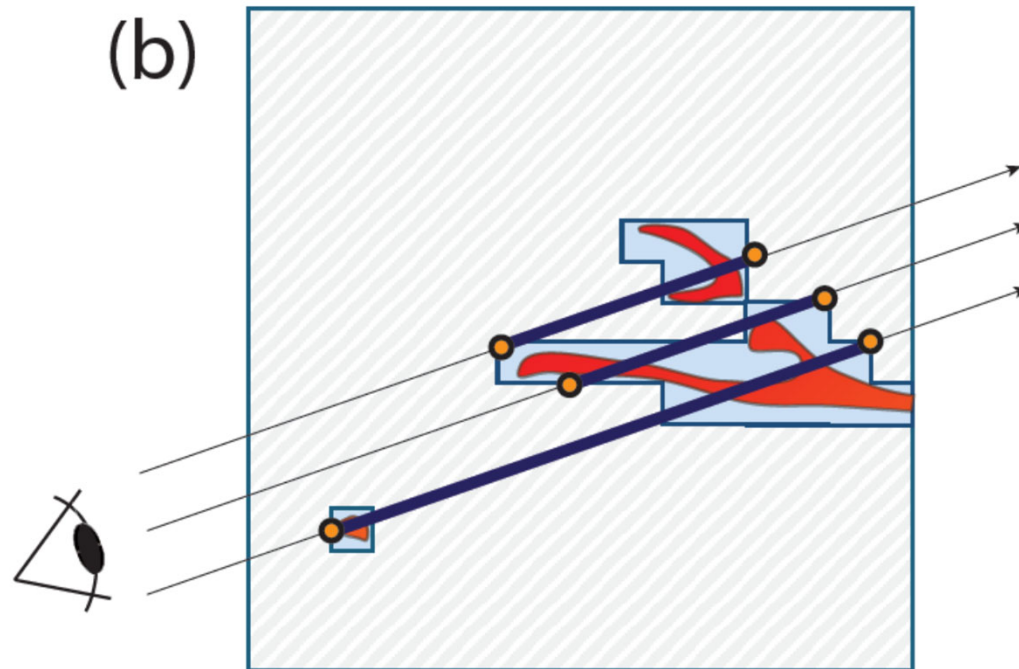
# Different Approaches



# Object-Order Empty Space Skipping



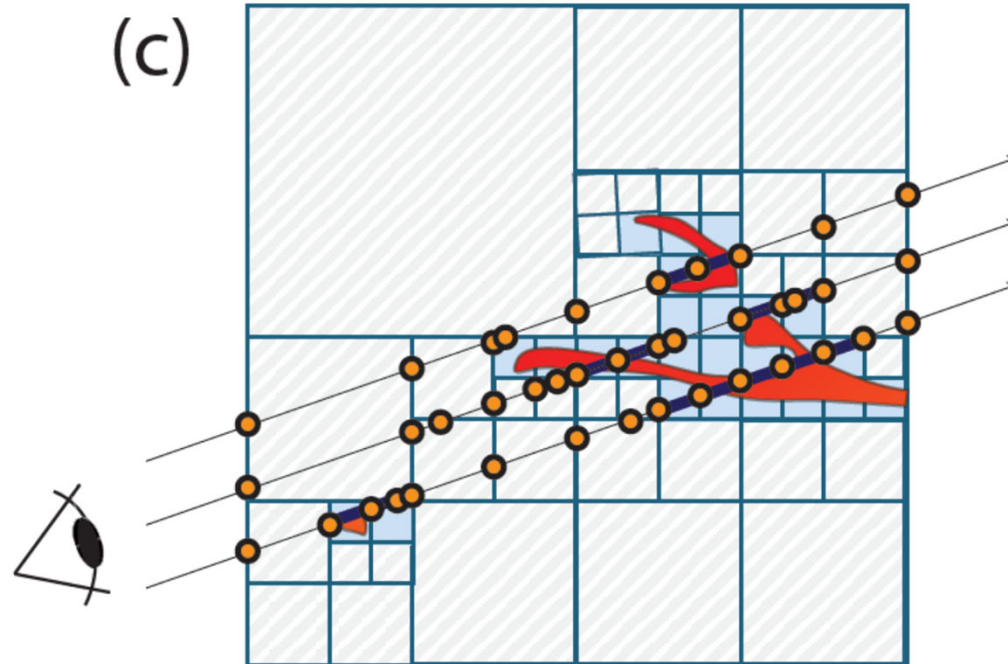
Modify initial rasterization step for ray setup



# Octree-Based Empty Space Skipping



Everything is done during tree traversal along the ray



# More on Transfer Functions

# Classification – Transfer Functions



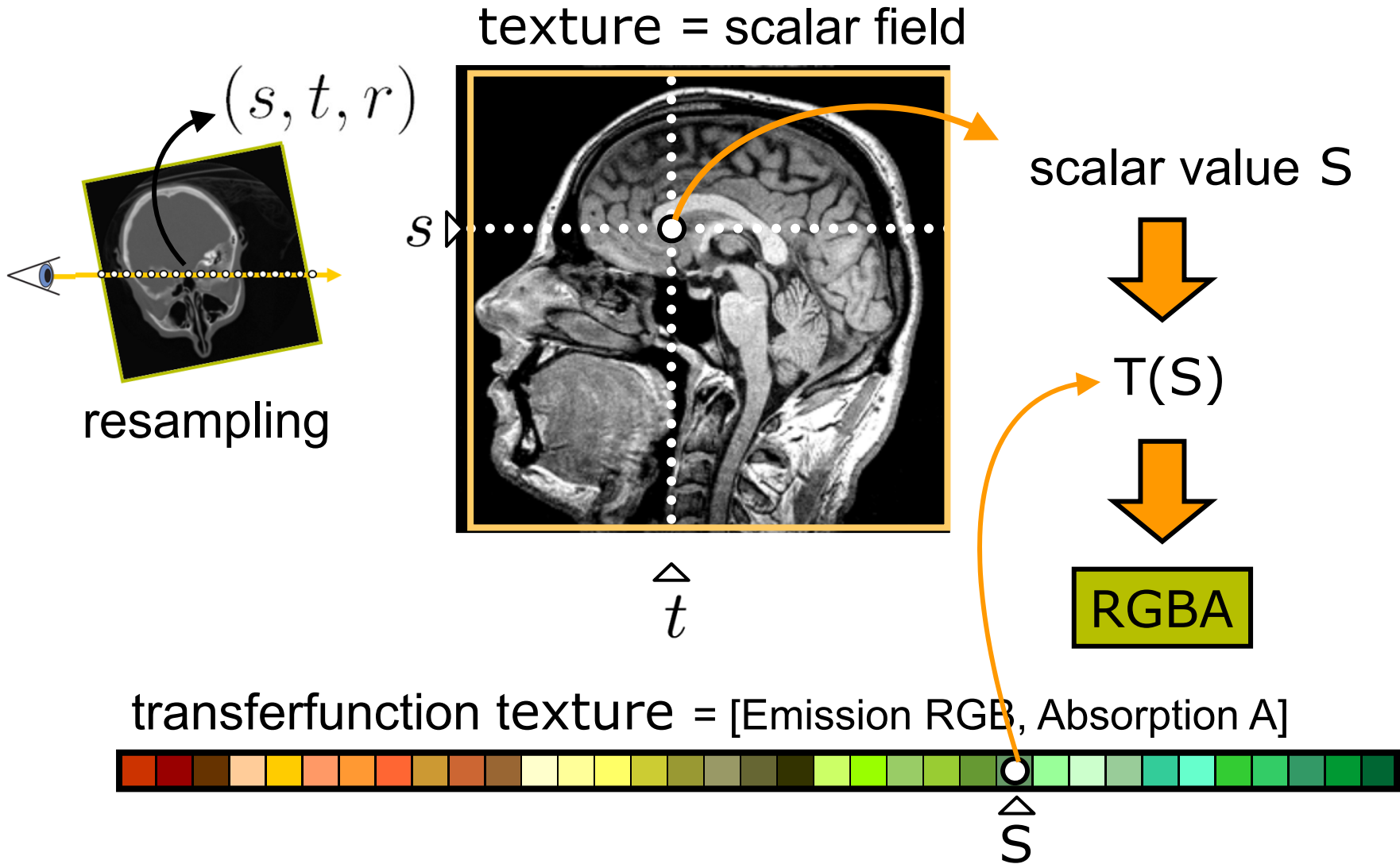
During Classification the user defines the “*look*” of the data.

- Which parts are transparent?
- Which parts have what color?

The user defines a *transfer function*.



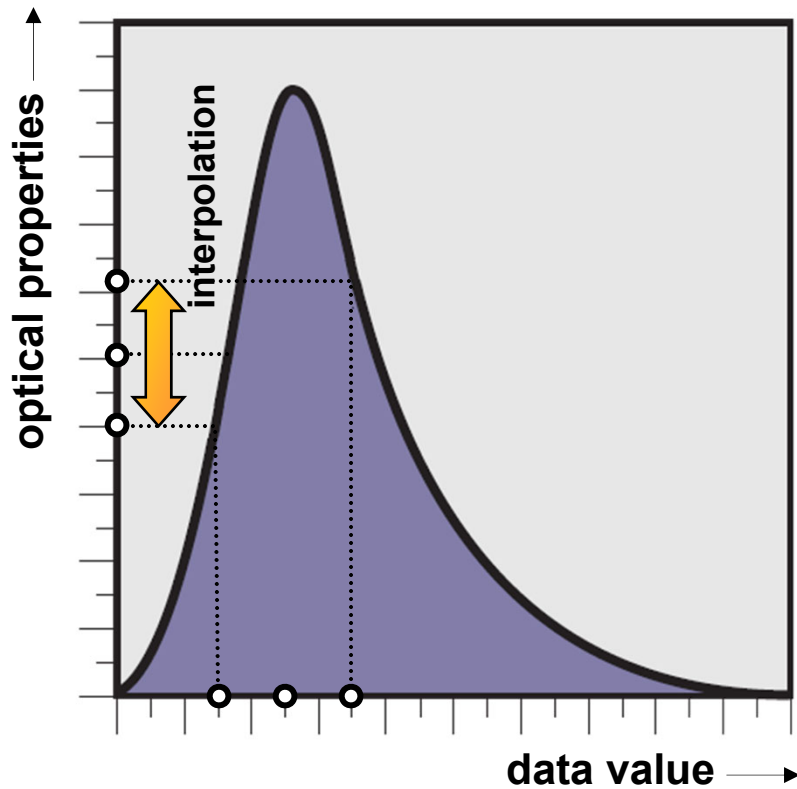
# 1D Transfer Functions



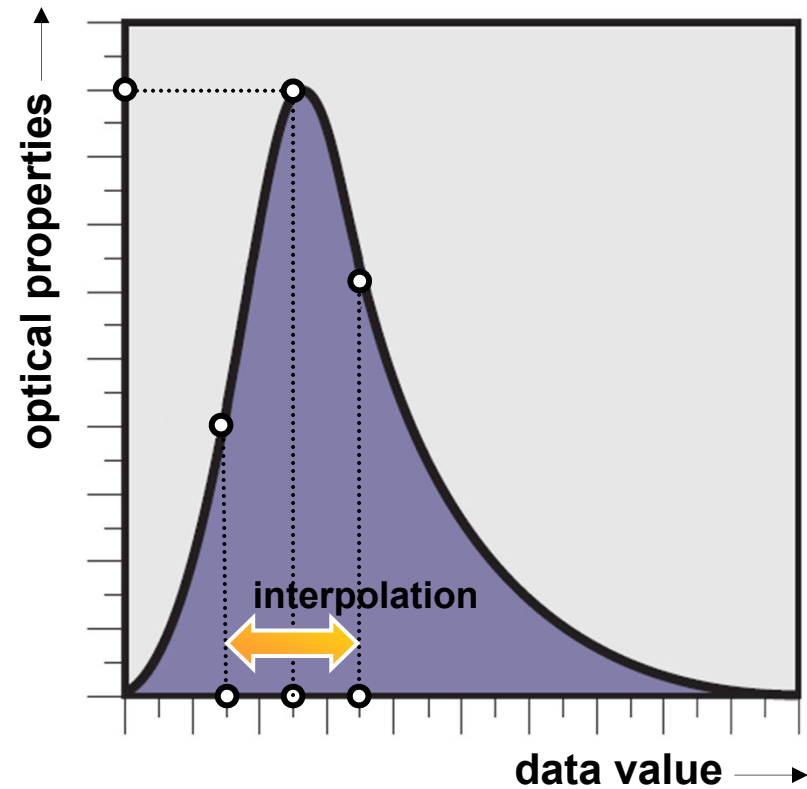
# Pre- vs Post-Interpolative Classification



## PRE-INTERPOLATIVE



## POST-INTERPOLATIVE

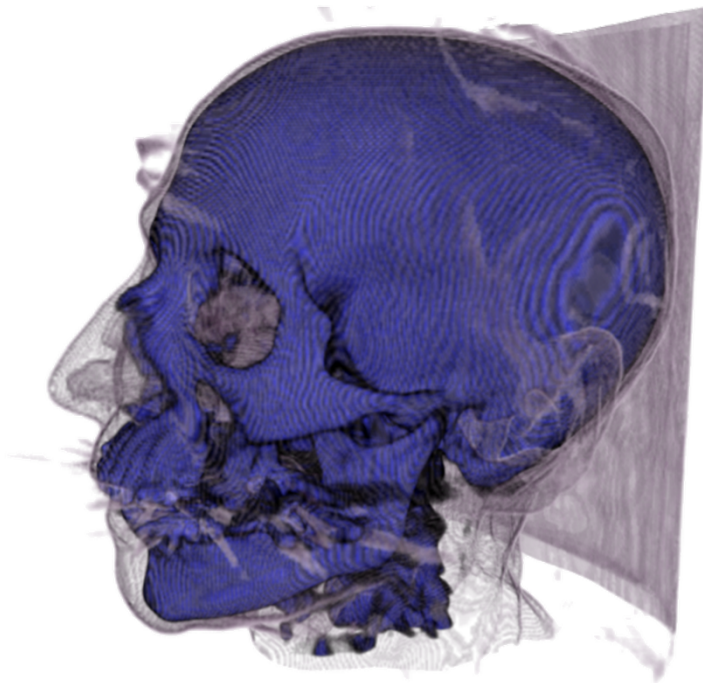




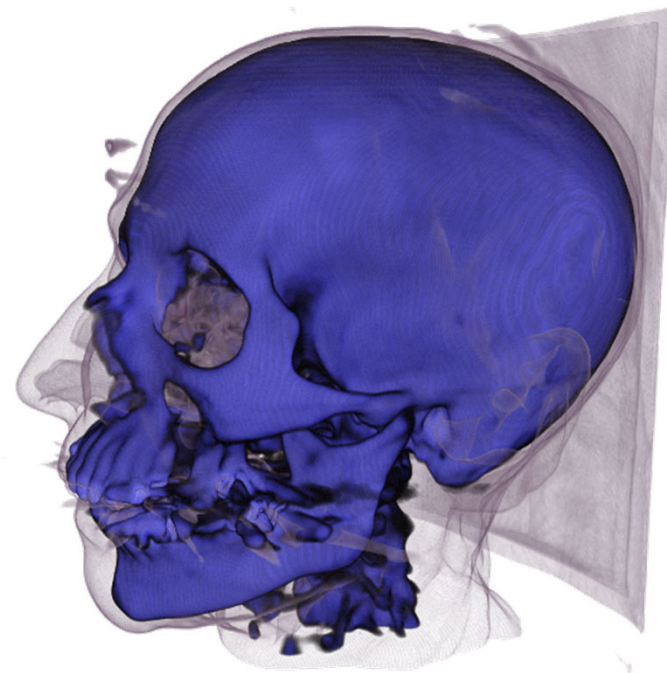
# Quality: Pre- vs. Post-Classification



Comparison of image quality



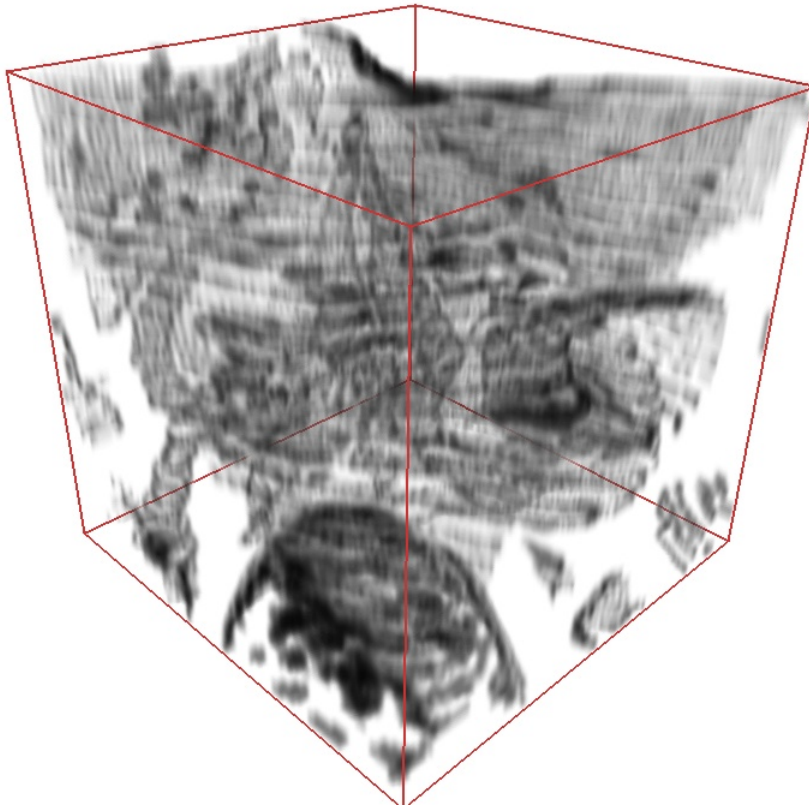
**Pre-Classification**



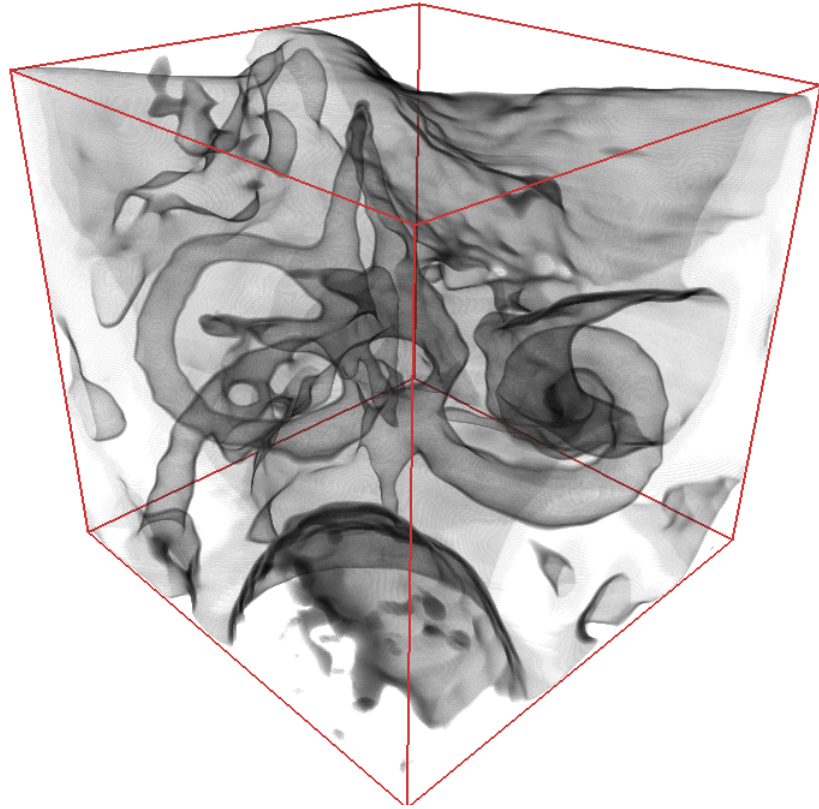
**Post-Classification**

same TF, same resolution, same sampling rate

# Quality: Pre- vs. Post-Classification

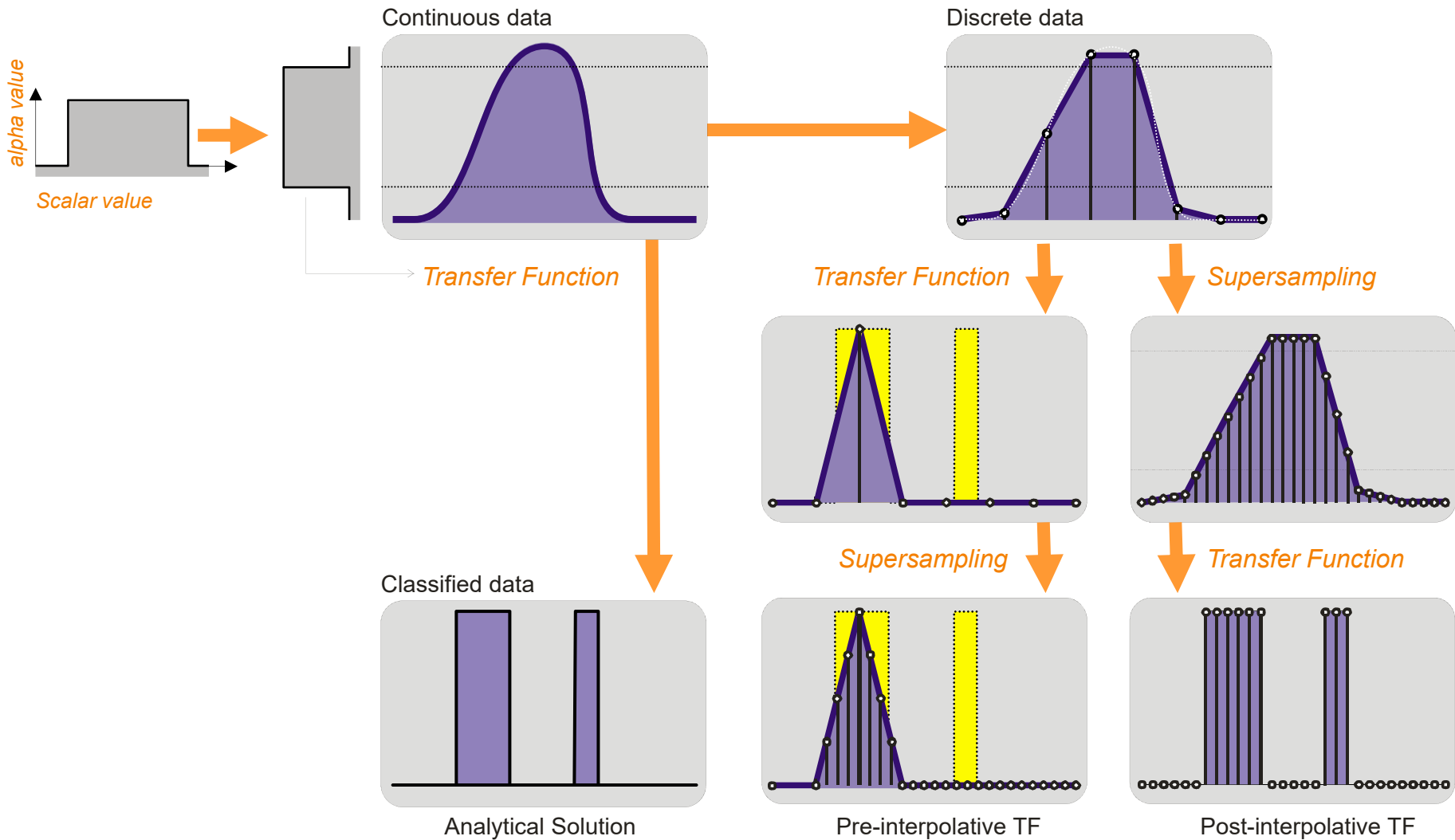


Pre-Classification

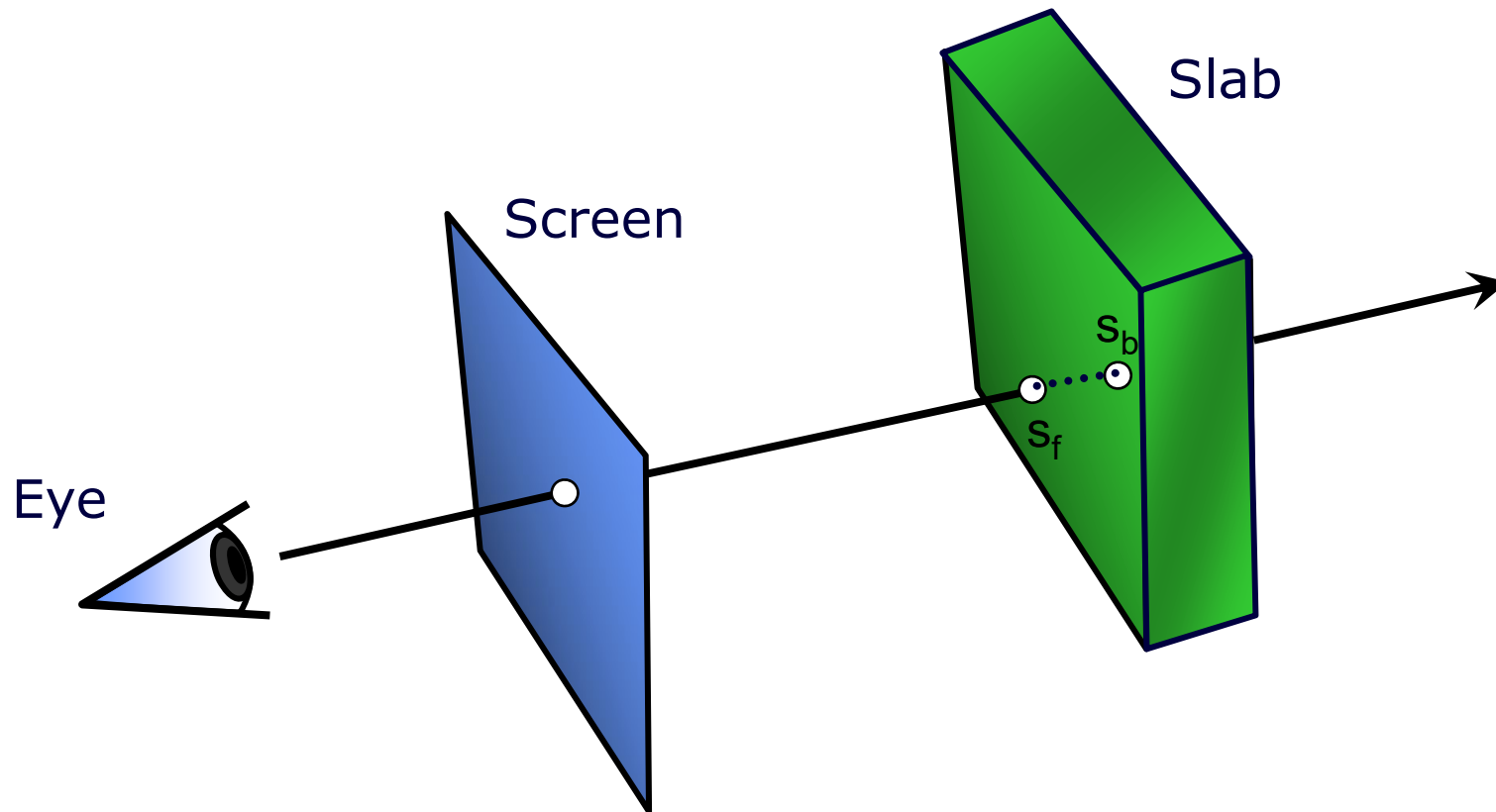


Post-Classification

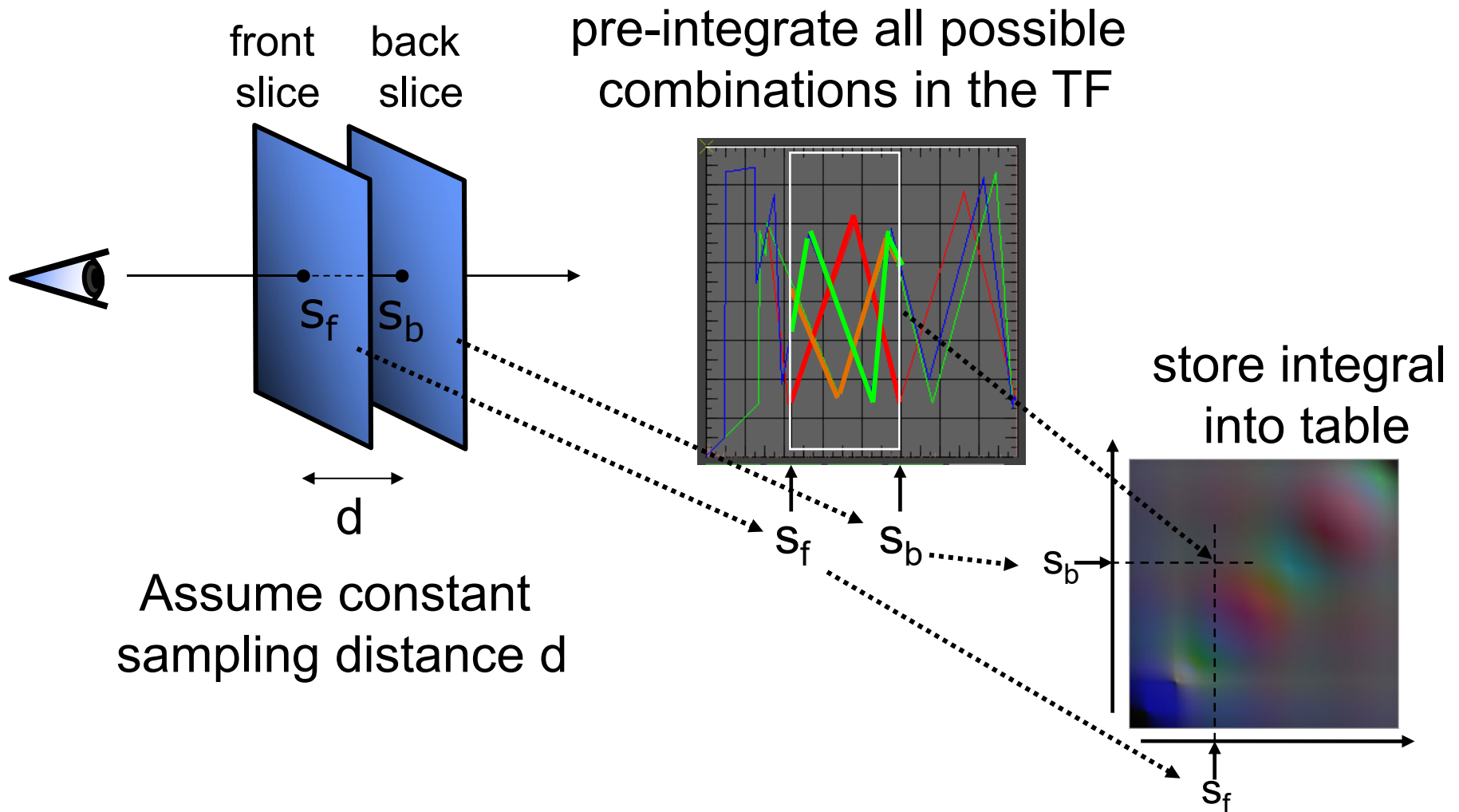
# Pre- vs Post-Classification



# Pre-Integrated Classification



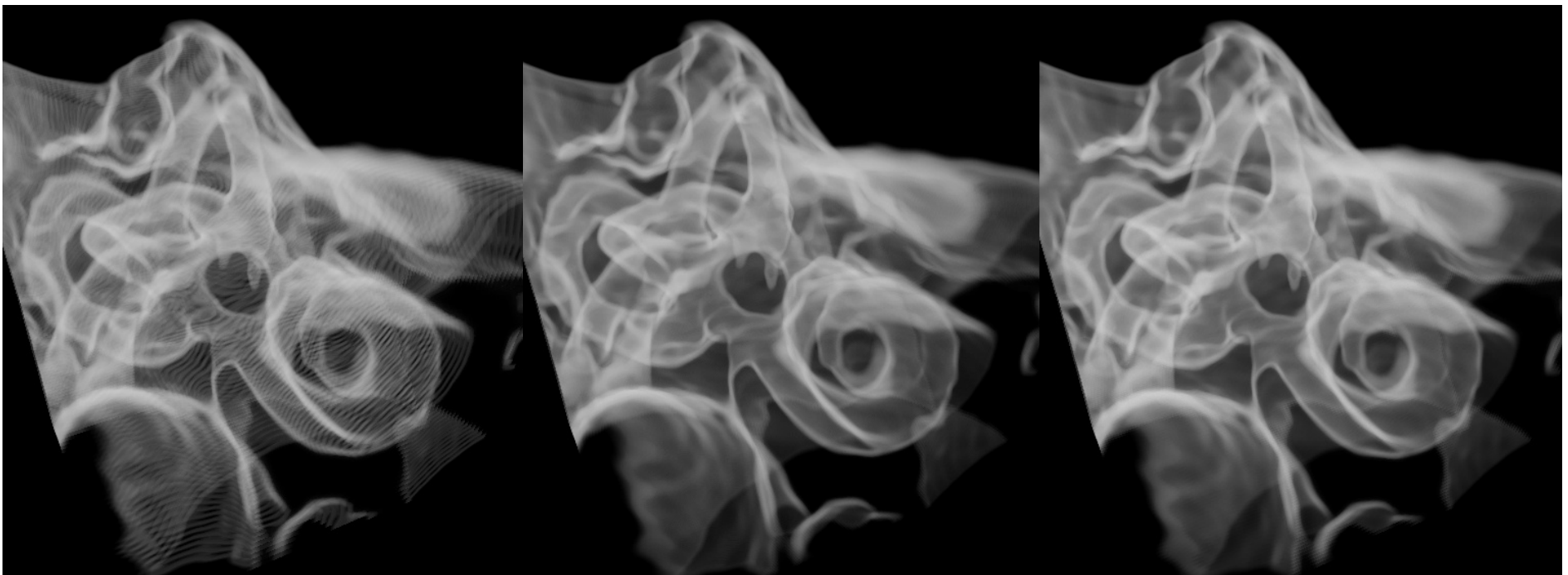
# Pre-Integrated Classification



# Pre-Integrated Classification



Quality comparison



128 Slices

284 Slices

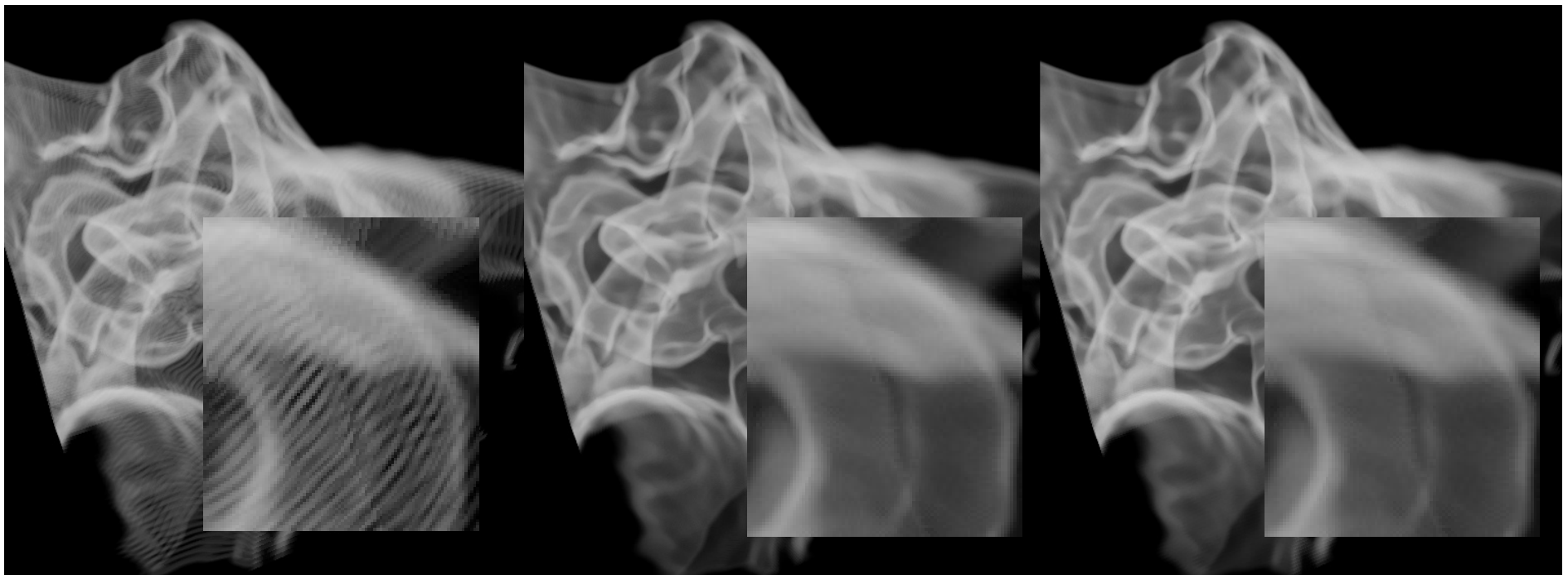
128 Slabs

© Weiskopf/Machiraju/Möller

# Pre-Integrated Classification



## Quality comparison



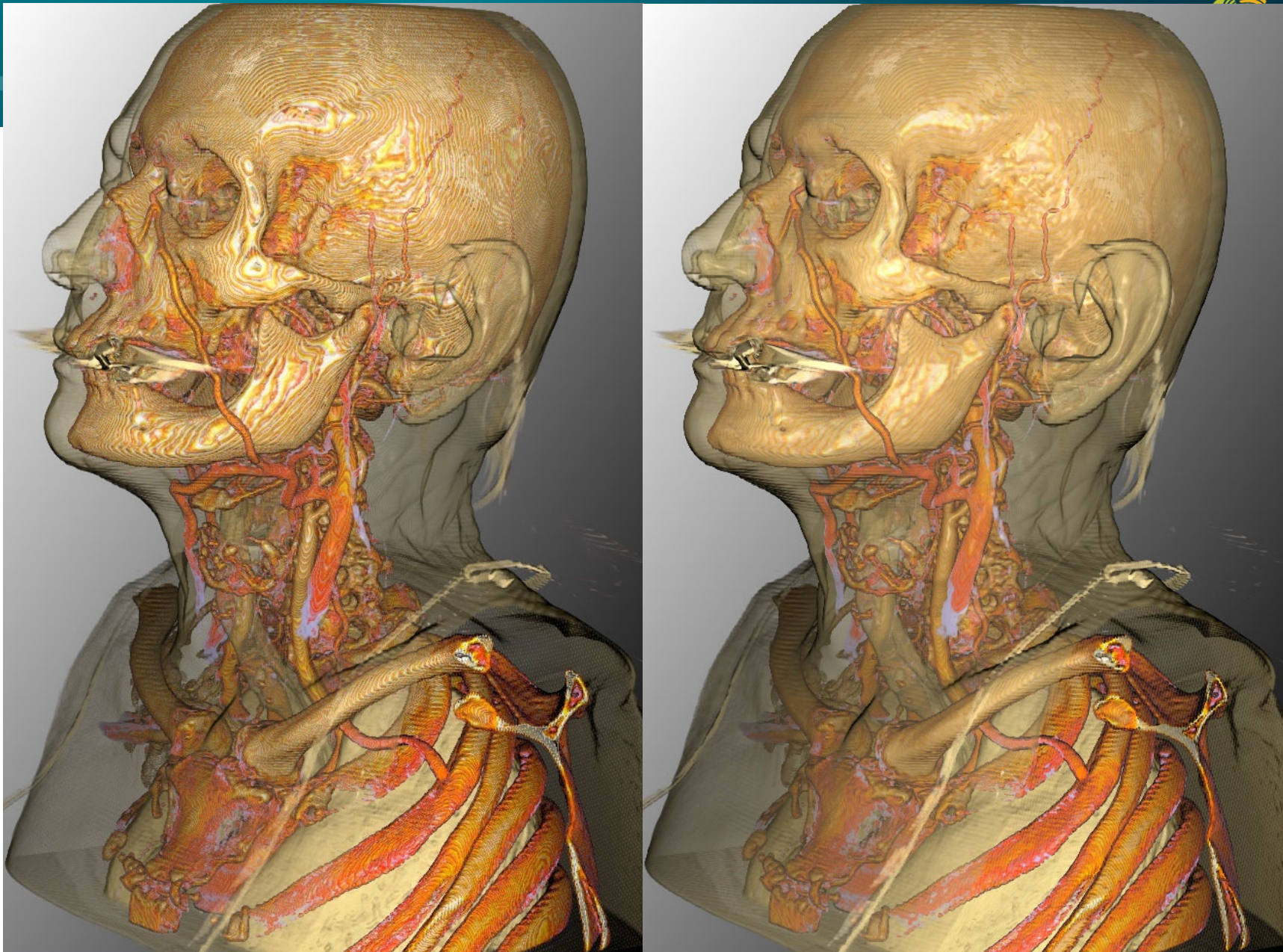
128 Slices

284 Slices

128 Slabs

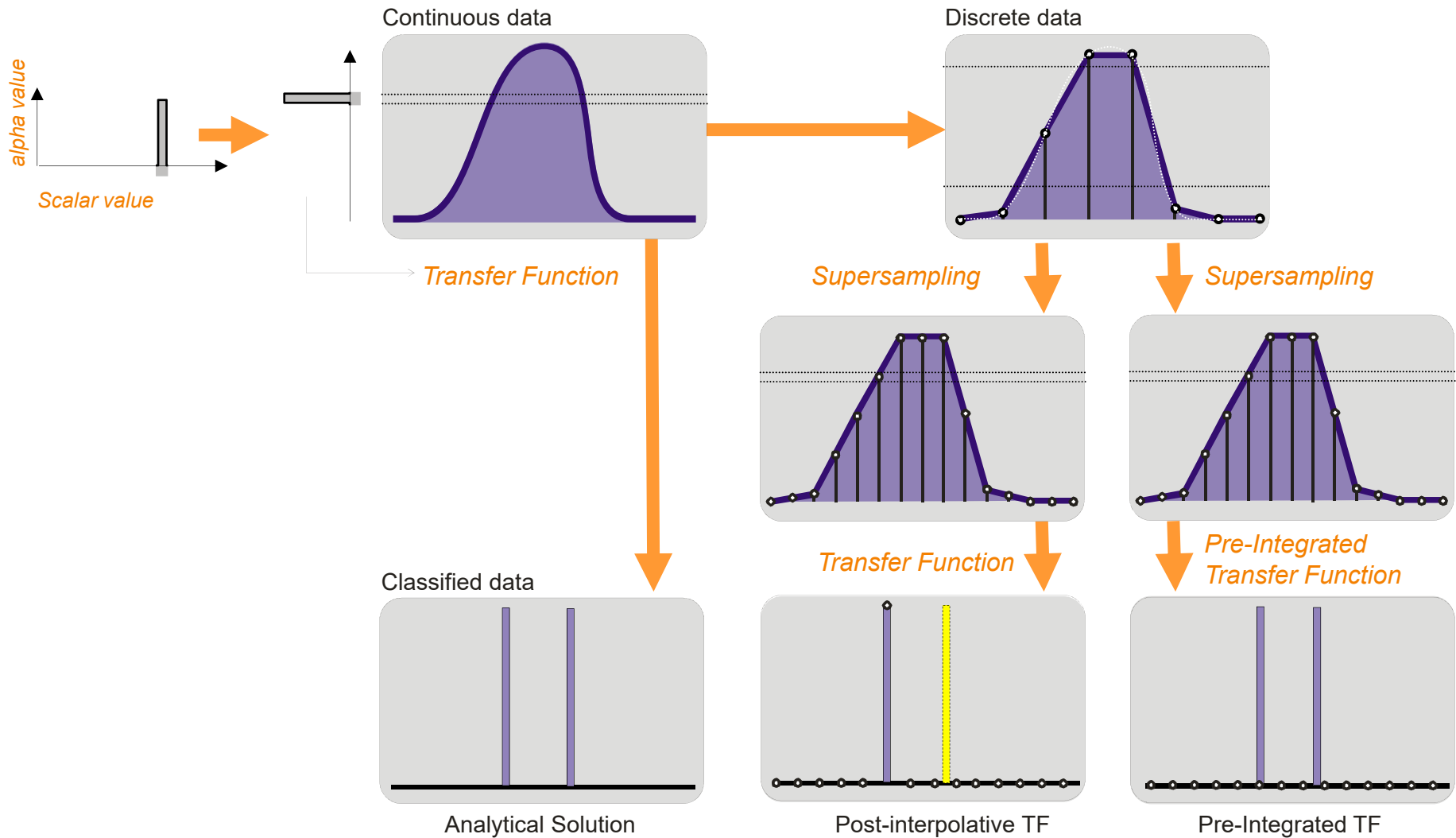
© Weiskopf/Machiraju/Möller

# Pre-Integrated Classification





# Post- vs. Pre-Integrated Classification



# Thank you.

## Thanks for material

- Helwig Hauser
- Eduard Gröller
- Daniel Weiskopf
- Torsten Möller
- Ronny Peikert
- Philipp Muigg
- Christof Rezk-Salama