

# CS 247 – Scientific Visualization

## Lecture 14: Volume Visualization, Pt. 1

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# Reading Assignment #7 (until Mar 19)

Read (required):

- Real-Time Volume Graphics, Chapter 1  
*(Theoretical Background and Basic Approaches)*,  
from beginning to 1.4.4 (inclusive)

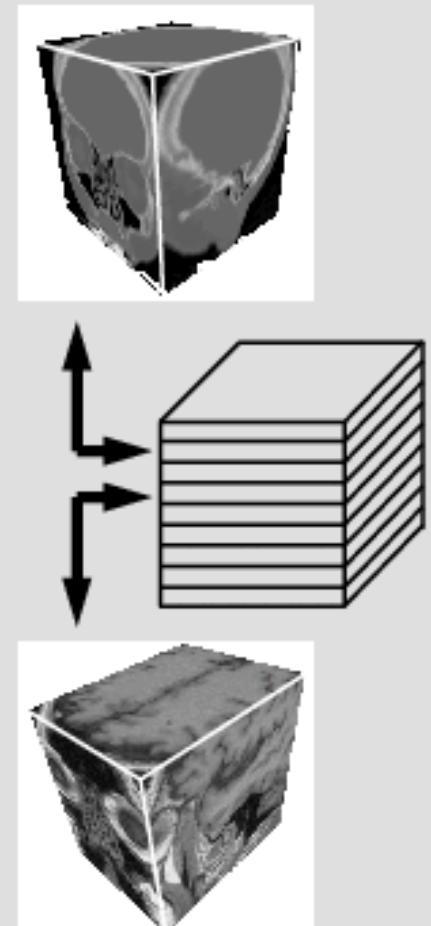
Read (optional):

- Paper:  
*Nelson Max, Optical Models for Direct Volume Rendering,*  
*IEEE Transactions on Visualization and Computer Graphics, 1995*  
<http://dx.doi.org/10.1109/2945.468400>

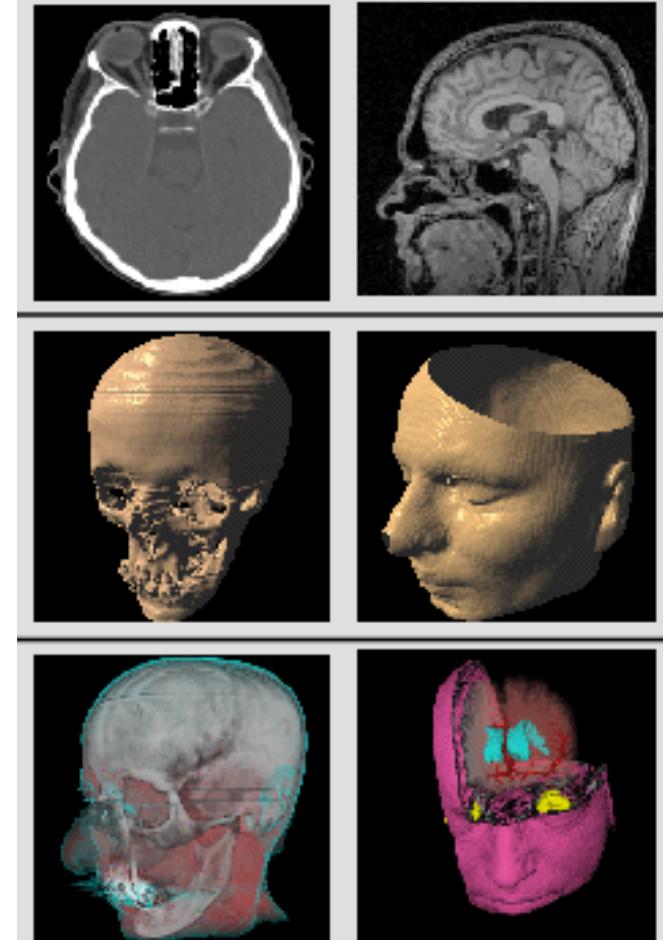
# Volume Rendering

# Theory

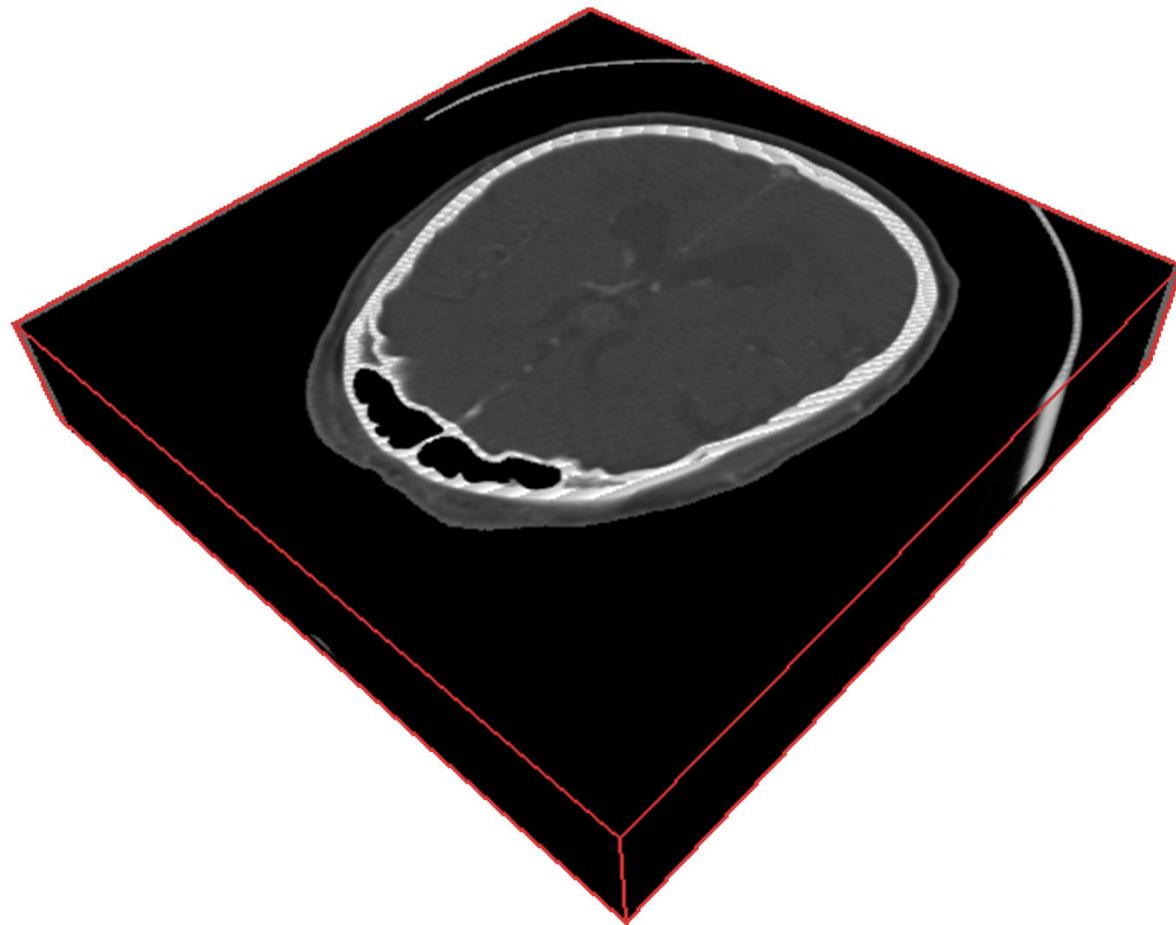
# Volume Visualization



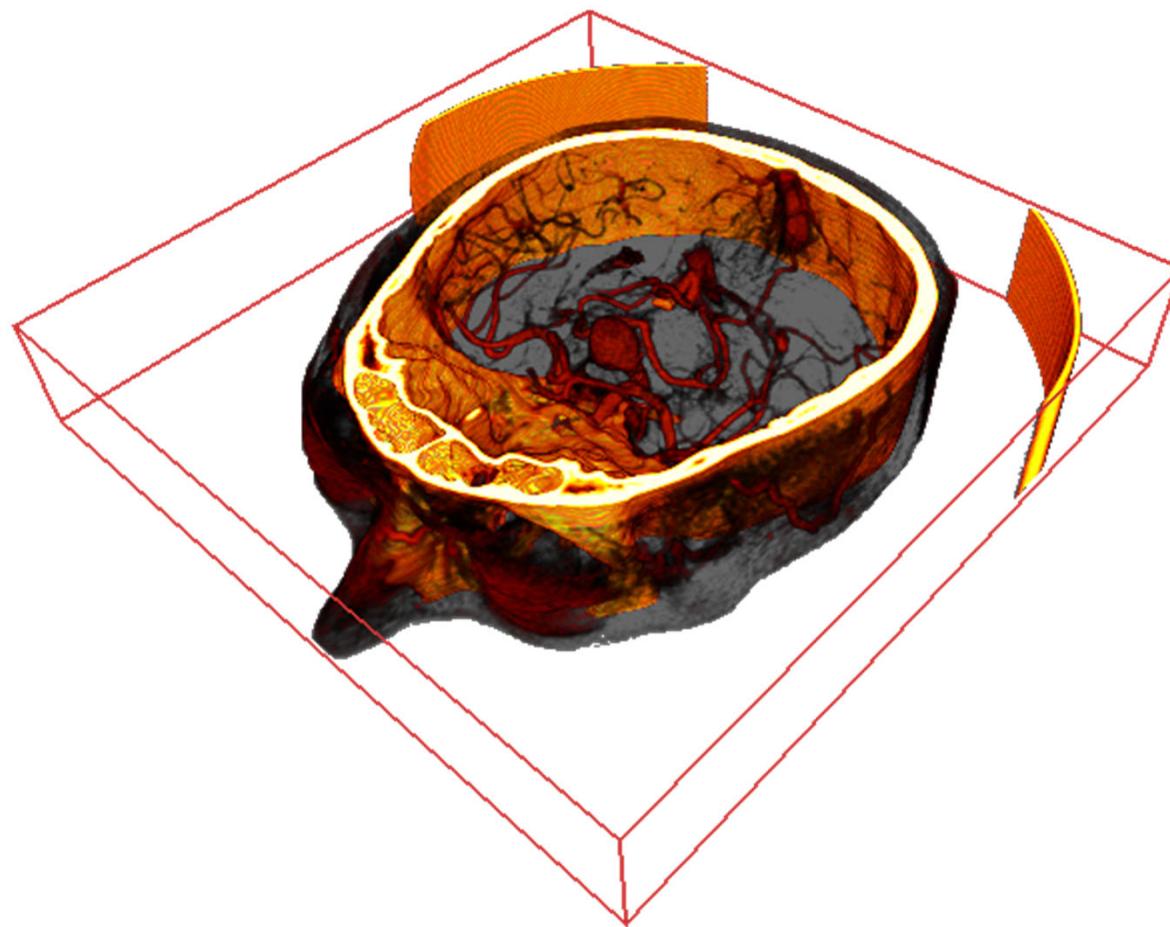
- 2D visualization  
slice images  
(or multi-planar  
reformatting MPR)
- *Indirect*  
3D visualization  
isosurfaces  
(or surface-shaded  
display: SSD)
- *Direct*  
3D visualization  
(direct volume  
rendering: DVR)



# Direct Volume Rendering



# Direct Volume Rendering

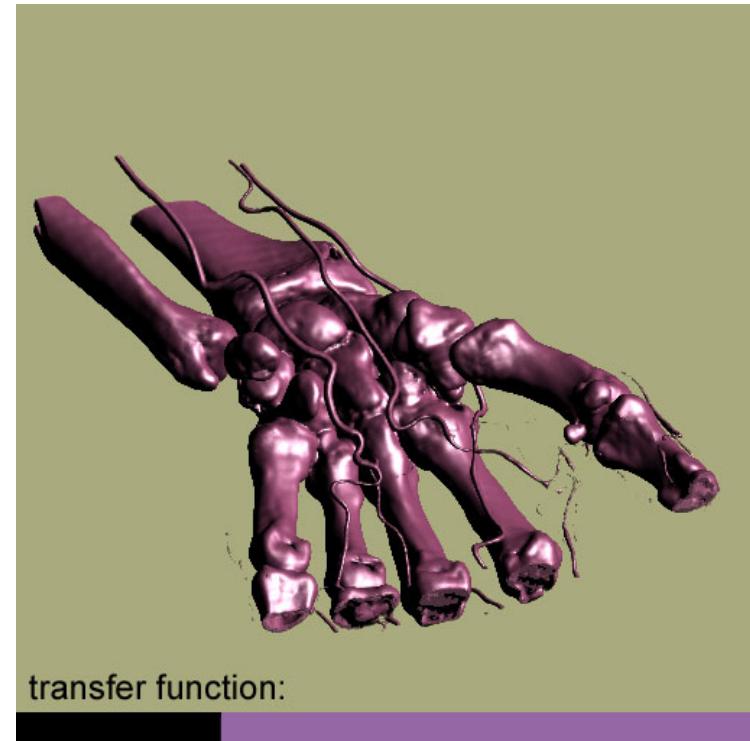
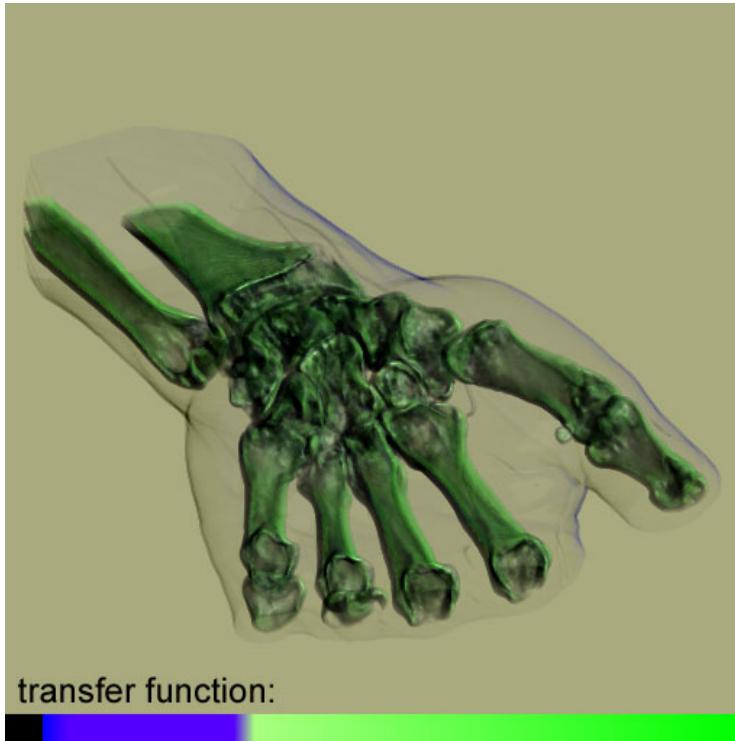


# Transparent Volumes vs. Isosurfaces



The *transfer function* assigns *optical properties* to data

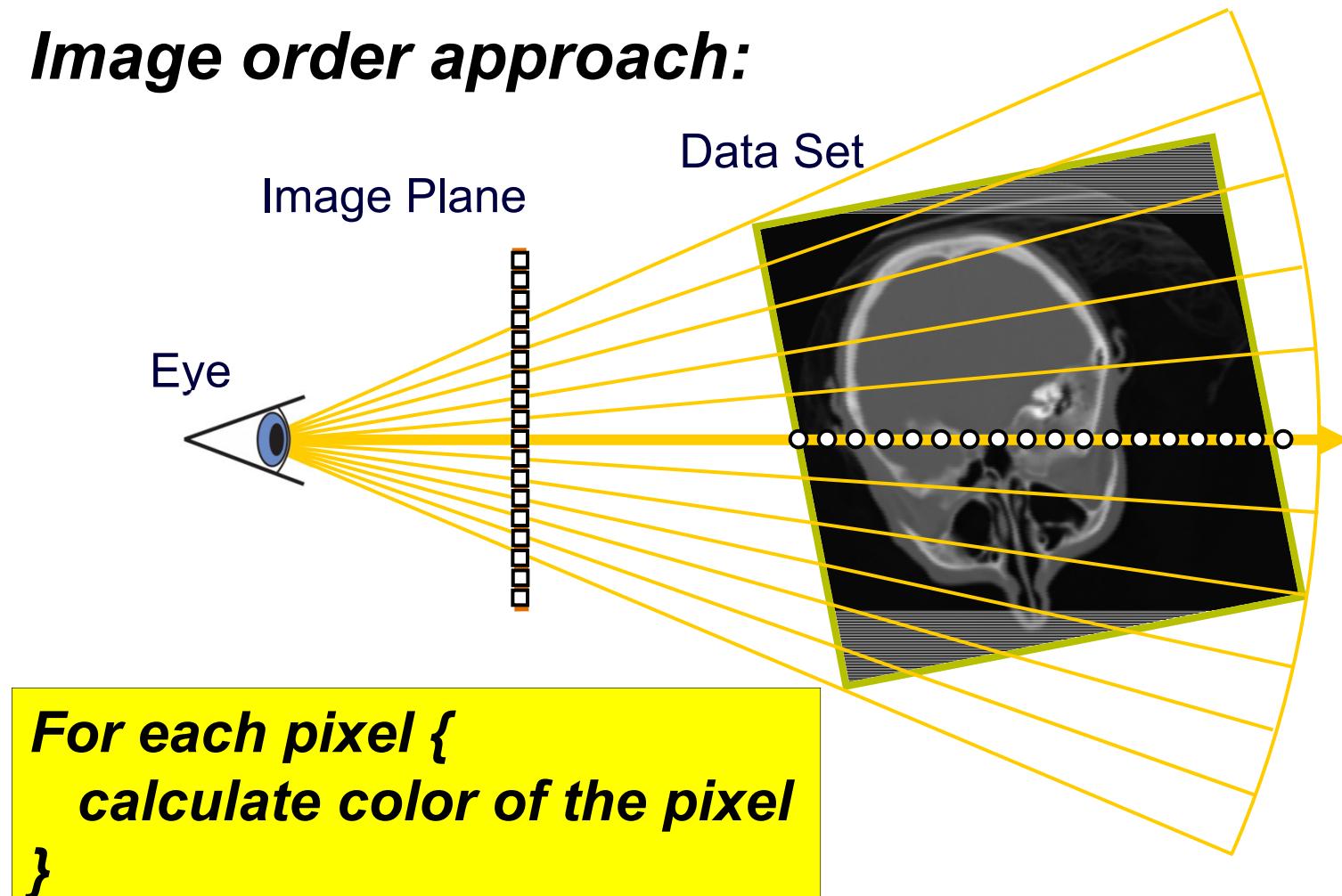
- Translucent volumes
- But also: isosurface rendering using step function as transfer function



# Direct Volume Rendering: Image Order



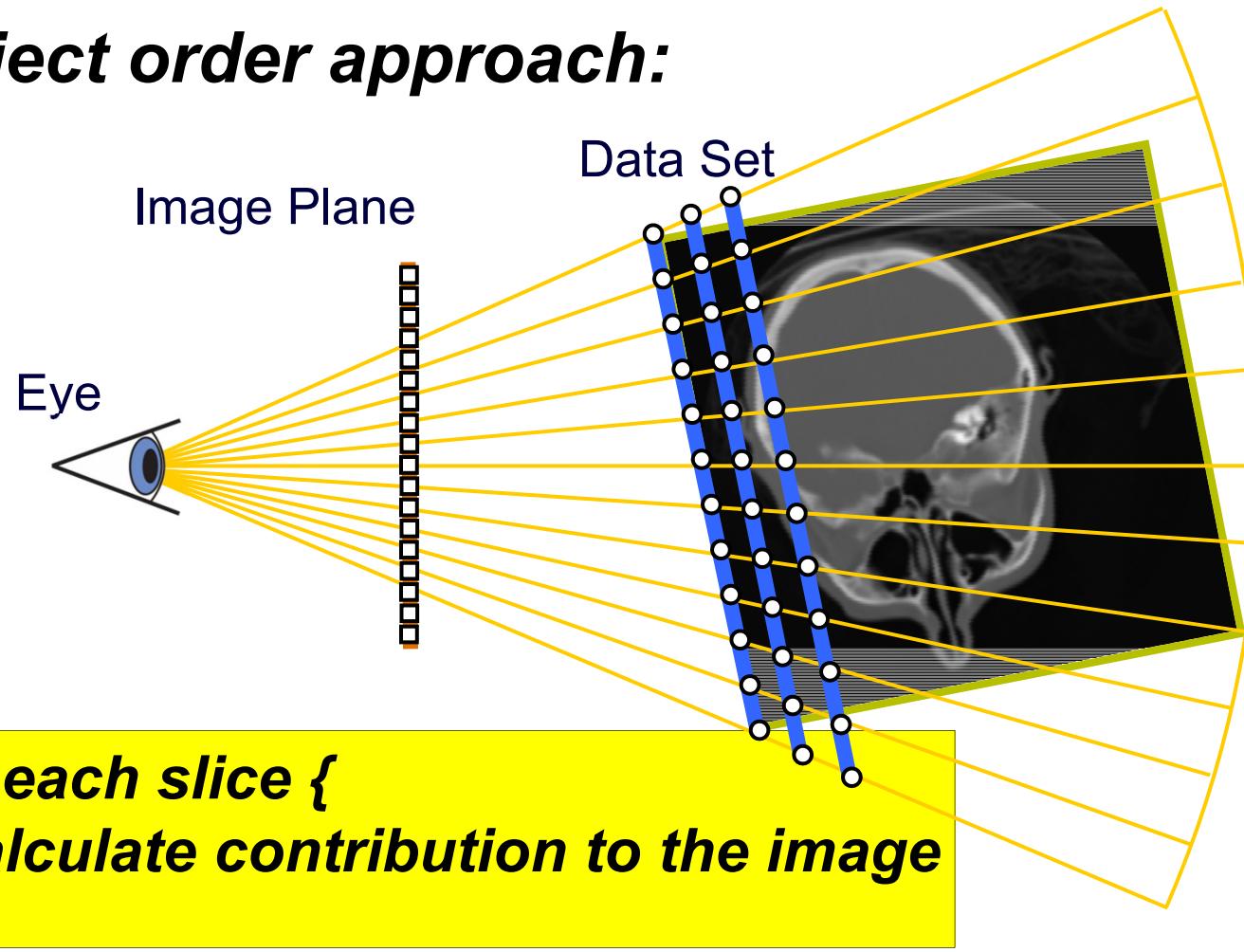
***Image order approach:***



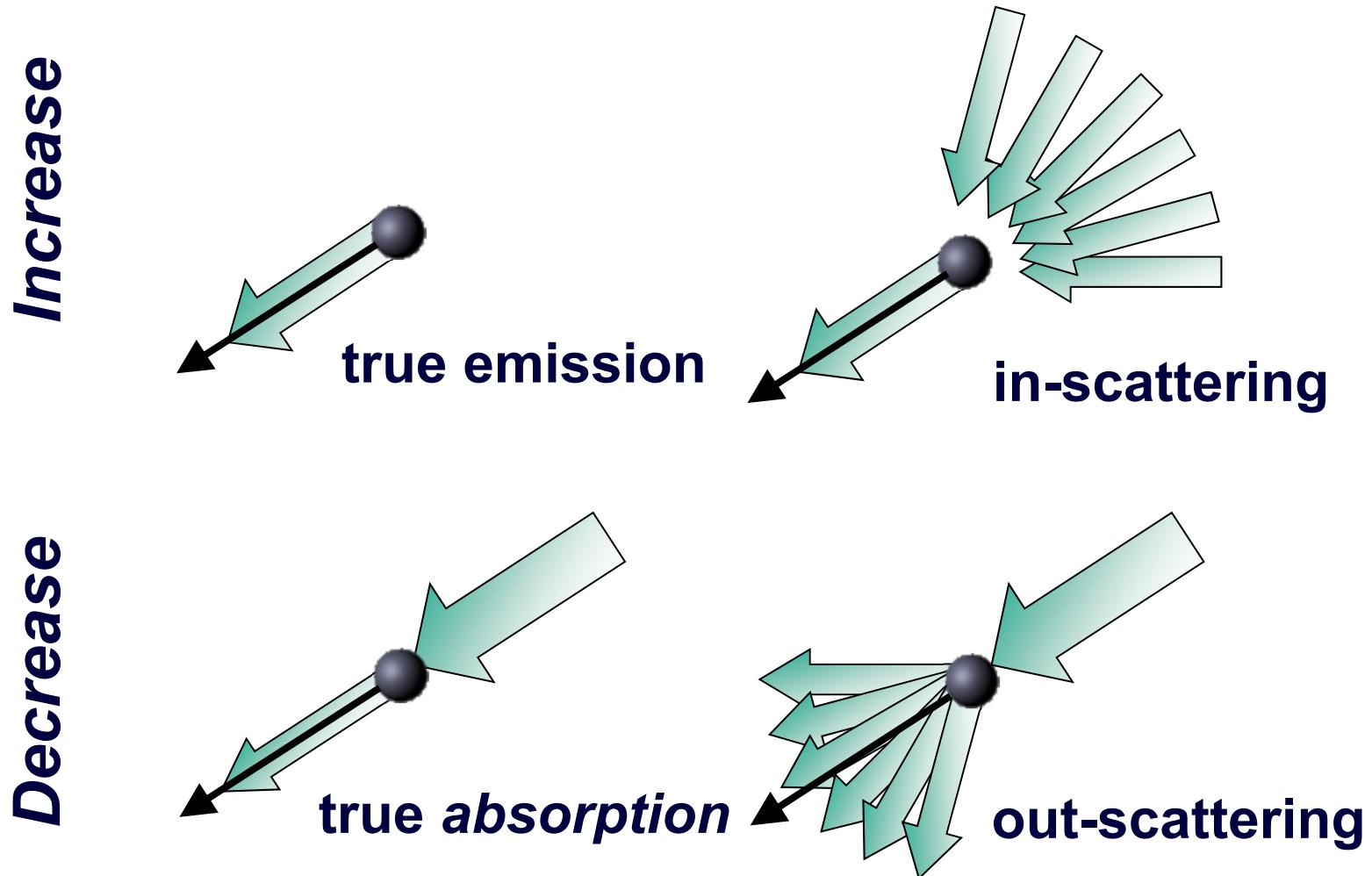
# Direct Volume Rendering: Object Order



***Object order approach:***



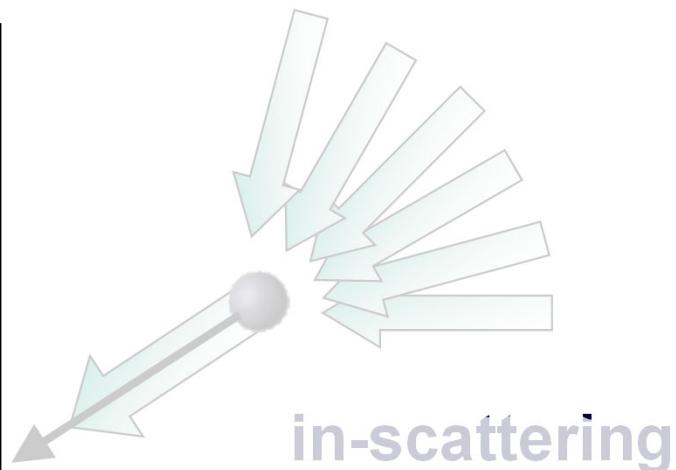
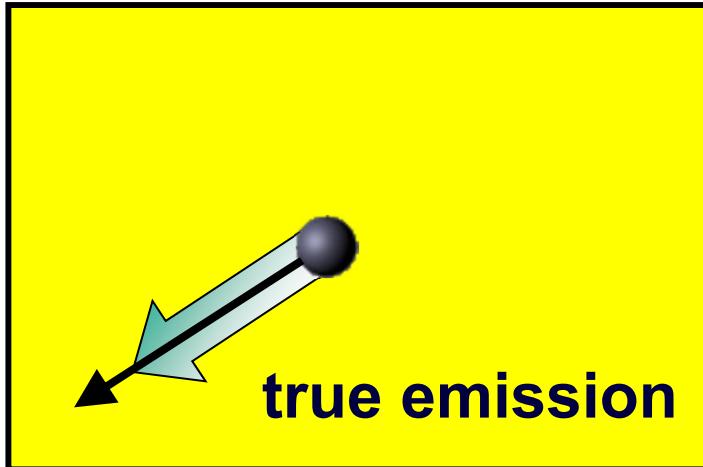
# Physical Model of Radiative Transfer



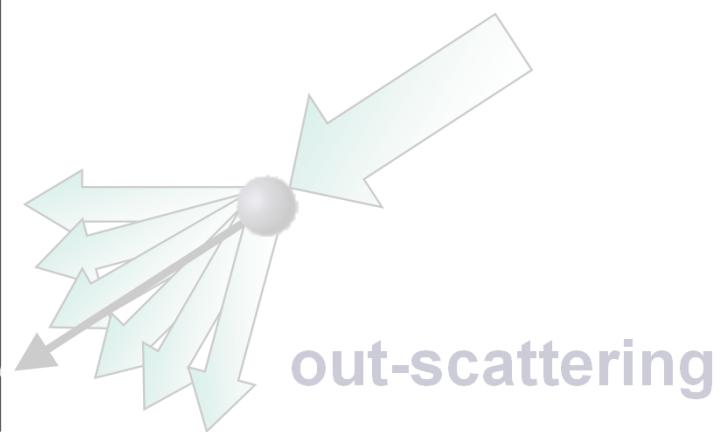
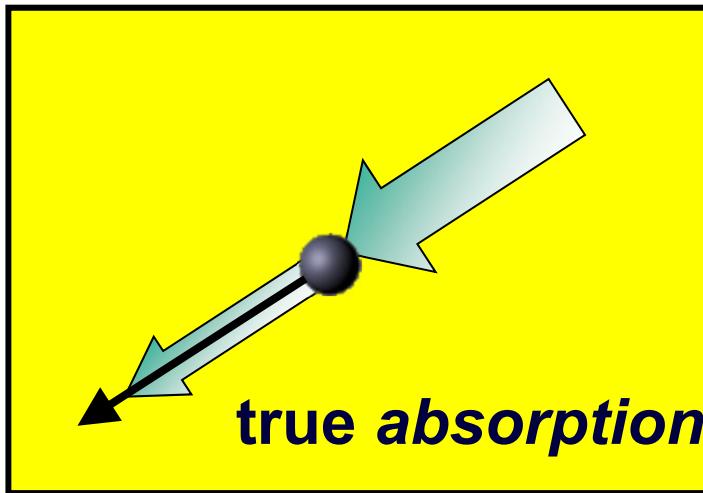
# Physical Model of Radiative Transfer



*Increase*



*Decrease*



# Optical Models: Physical Model gives ODE



Optical Models for Direct Volume Rendering, Nelson Max  
Emission-Absorption optical model

$$\frac{dI}{ds} (s) = q(s) - \kappa(s) I(s)$$

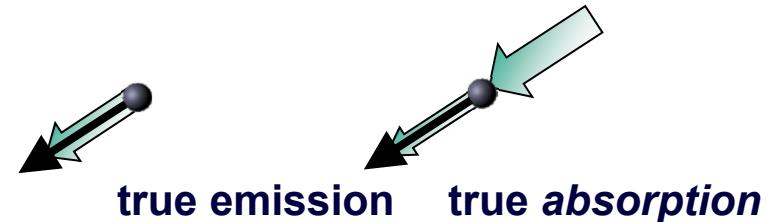


Right-hand side: *Rates of change* (derivatives) of light intensity along ray  
Absorption rate is proportional to light intensity: Solution is exponential

# Volume Rendering Integral



Volume rendering integral  
for *Emission Absorption* model



$$I(s) = I(s_0) e^{-\tau(s_0, s)} + \int_{s_0}^s q(\tilde{s}) e^{-\tau(\tilde{s}, s)} d\tilde{s}$$

Iterative/recursive numerical solutions:

**Back-to-front compositing**

$$C'_i = C_i + (1 - A_i)C'_{i-1}$$

**Front-to-back compositing**

$$C'_i = C'_{i+1} + (1 - A'_{i+1})C_i$$

$$A'_i = A'_{i+1} + (1 - A'_{i+1})A_i$$

here, all colors are associated colors!

# Thank you.

Thanks for material

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