Stochastic Approach for Integrated Rendering of Volumes and Semi-transparent Surfaces

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2. Stochastic Rendering
   - Object-space approach
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   - Integrated Rendering
3. High resolution display system
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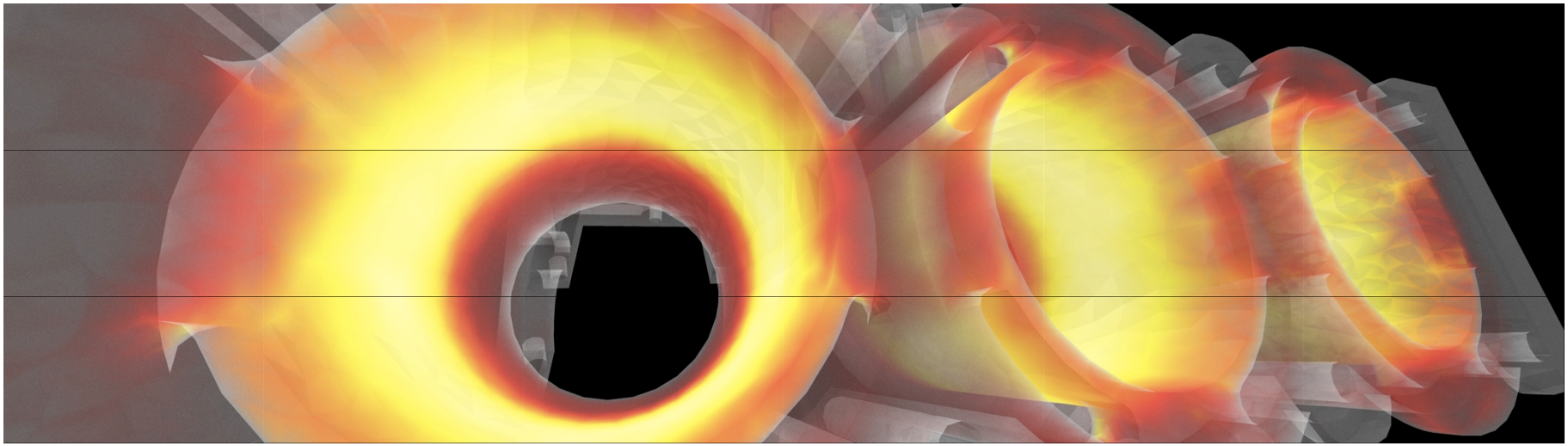
Introduction

- Fused visualization
  - Order-independent technique for regular and irregular volumes and semi-transparent polygons
  - High resolution rendering on tiled-display system



Rendering results of the V6 engine data (282K tets.), Image resolution: 8,190 x 2,304, Frame rate: 1 - 24 fps

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Stochastic Rendering

Object-space approach

- Estimating a density of particles
- Generating a set of particles from objects
- Projecting the particles into an image plane
- Ensemble averaging

Particle-based Volume Rendering (PBVR)

for volume [N.Sakamoto et al., 2007]
for polygon [S.Tanaka et al., 2011]

Image-space approach

- Using a opacity as a probability
- Projecting objects in to an image plane
- Ensemble averaging

Stochastic Projected Tetrahedra (SPT)

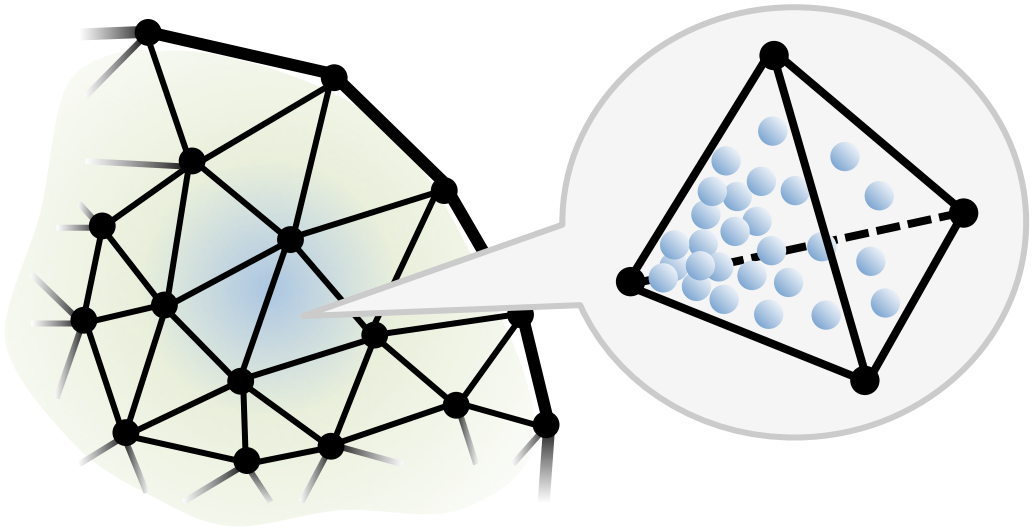
for tet. volume [N.Sakamoto, et al.,2009]

Integrated rendering of volumes and semi-transparent polygons based on SPT

High resolution rendering on tiled display

Object-space approach

- Particle-based Volume Rendering (PBVR)
  - Suitable for large and complex volume datasets
  - Visibility sorting is not required
  - Volume data is represented as particles



Opacity

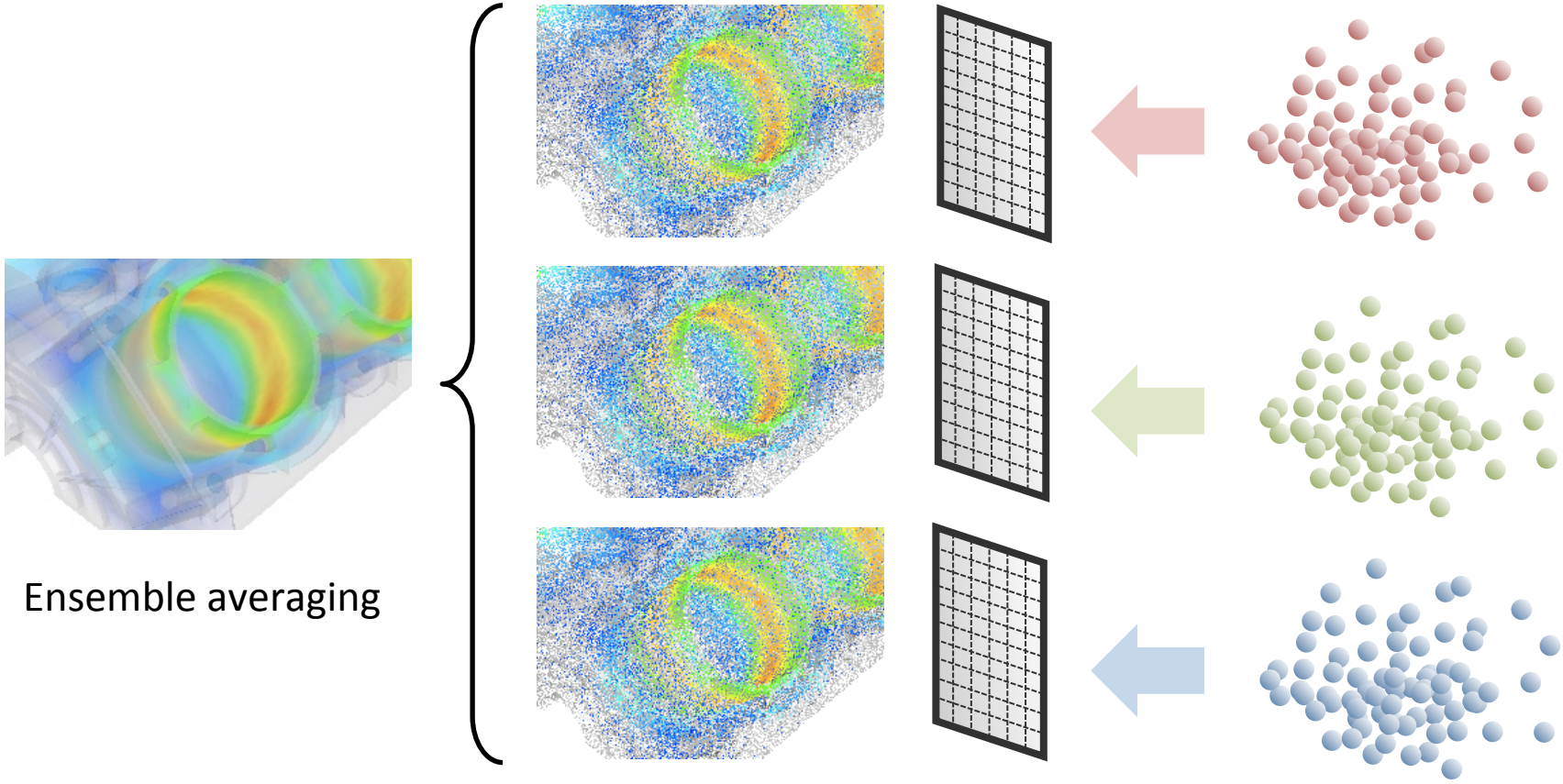
$$\rho = \frac{-\log(1-\alpha)}{\pi r^2 \Delta t}$$

Particle density
(Num. of particles within a unit volume)

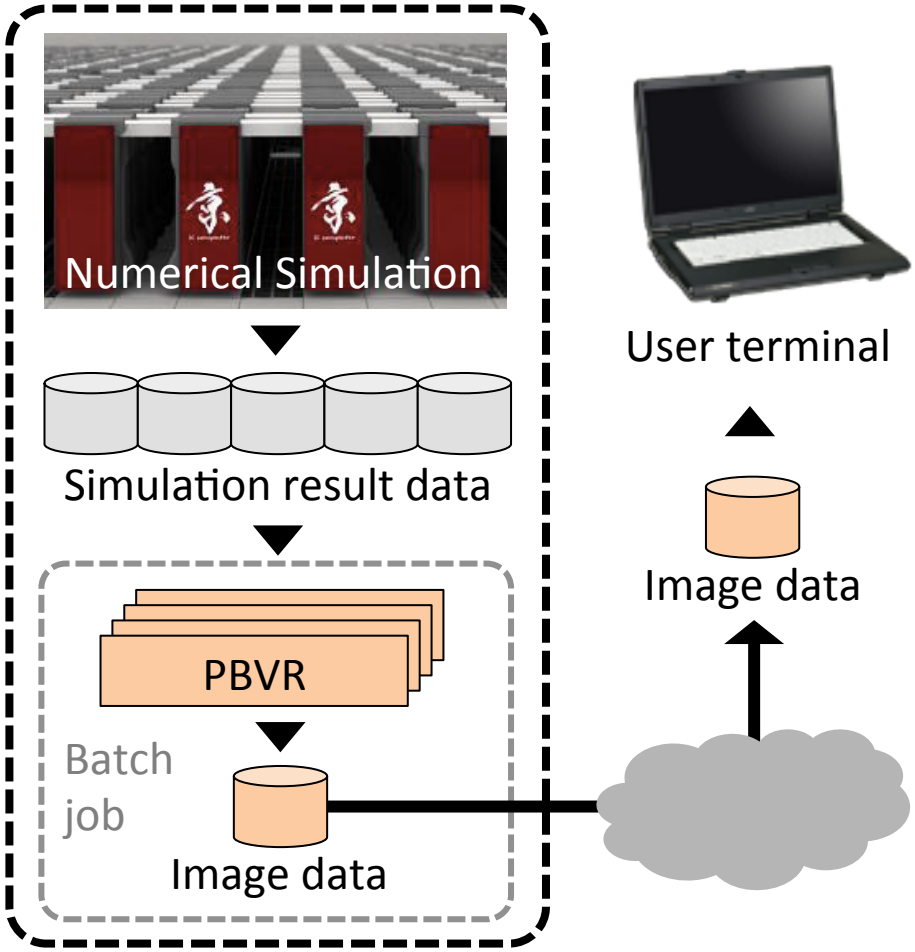
N.Sakamoto, J.Nonaka, K.Koyamada, and S.Tanaka, Particle-based Volume Rendering, In Proc. of Asia- Pacific Symposium on Visualization 2007, pp.141-144, 2007

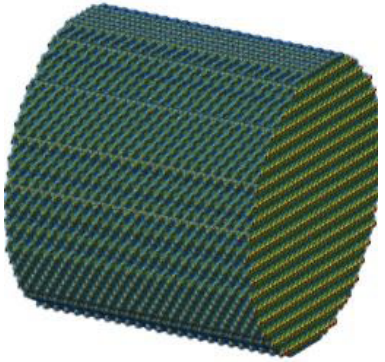
Improvement of image quality

- Ensemble averaging of rendering images

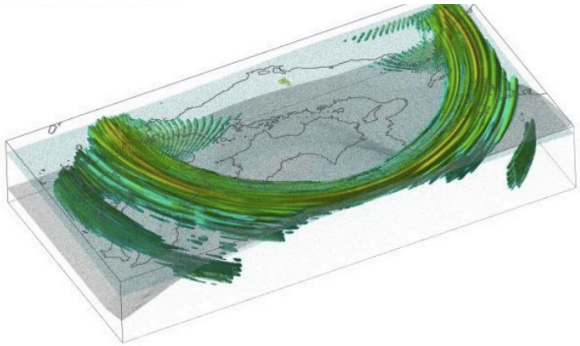


Parallel PBVR on K computer





Visualization result of silicon nanowire (RSDFT)
RIKEN AICS and Univ. of Tokyo

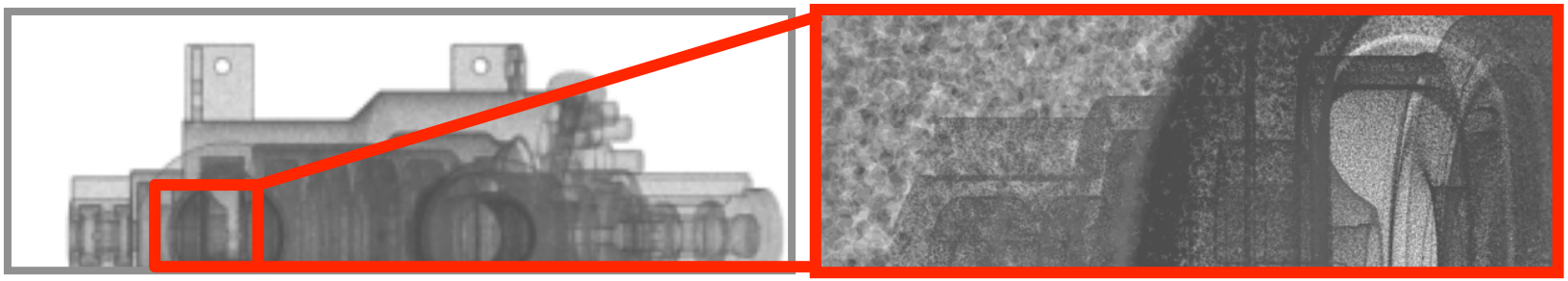


Visualization result of seismic wave
Earthquake Research Institute, Univ. of Tokyo

Ogasa et al., "Visualization technology for the K computer", Fujitsu Scientific & Technical Journal, Vol.48, No.3, 2012.

Drawback of PBVR

- Generation of low-quality images in which particles are visible on the boundary surface polygons when viewed closely.



- It is necessary to generate a large number of particles to obtain a high-resolution image.

Image-space approach

- Brightness equation

$$B_0 = \sum_{i=1}^{n} c_i \times (\alpha_i \prod_{j=1}^{i-1} (1 - \alpha_j))$$

- Sorting-free approach
  - Brightness = Expected value of luminosity

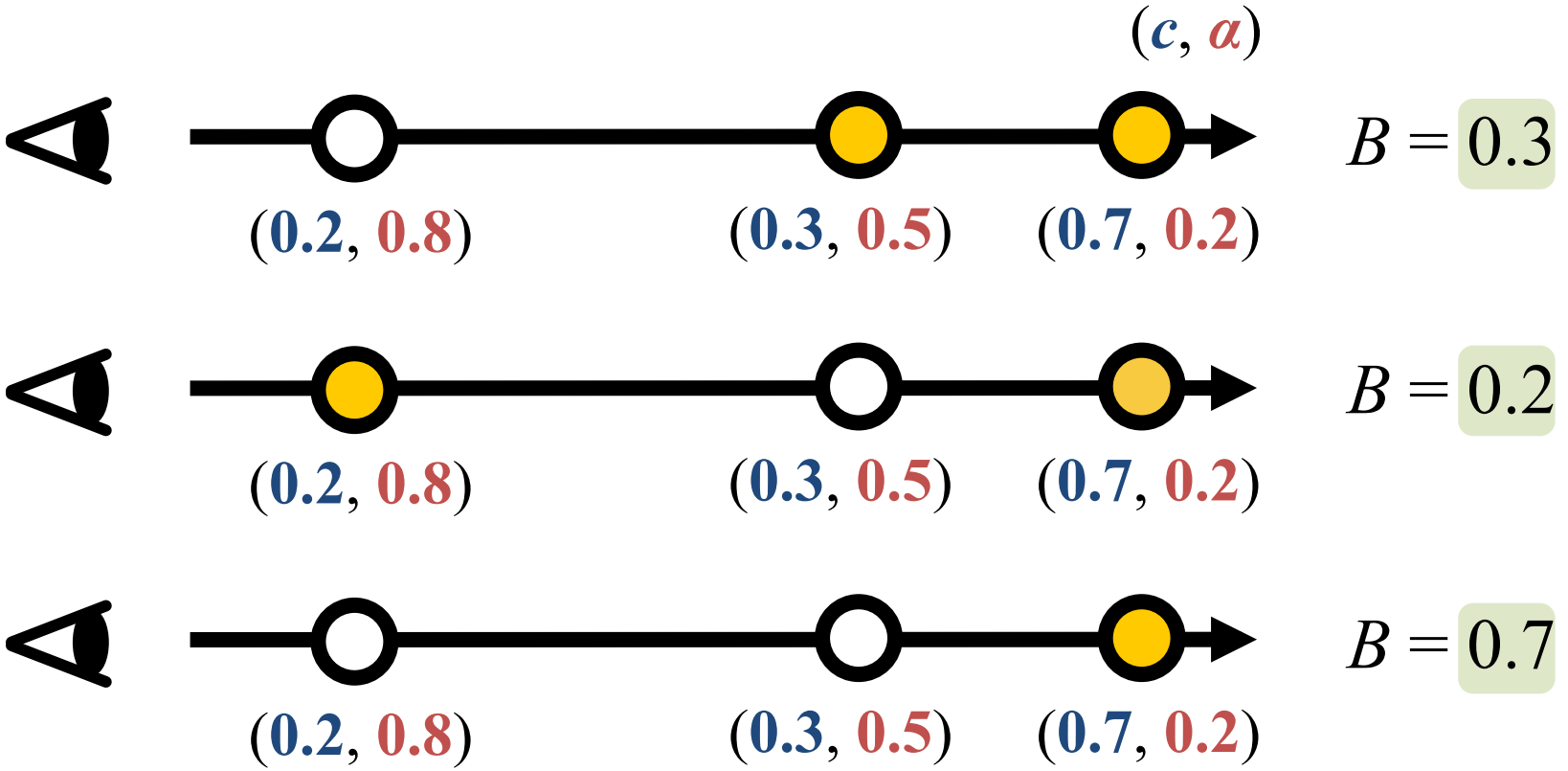
$$B_0 = \sum_{k=1}^{n} c_k P_k$$

$$P_k = \alpha_k \prod_{j=1}^{k-1} (1 - \alpha_j)$$

➡ Probability of "$c_k = B_0$"

Brightness calculation

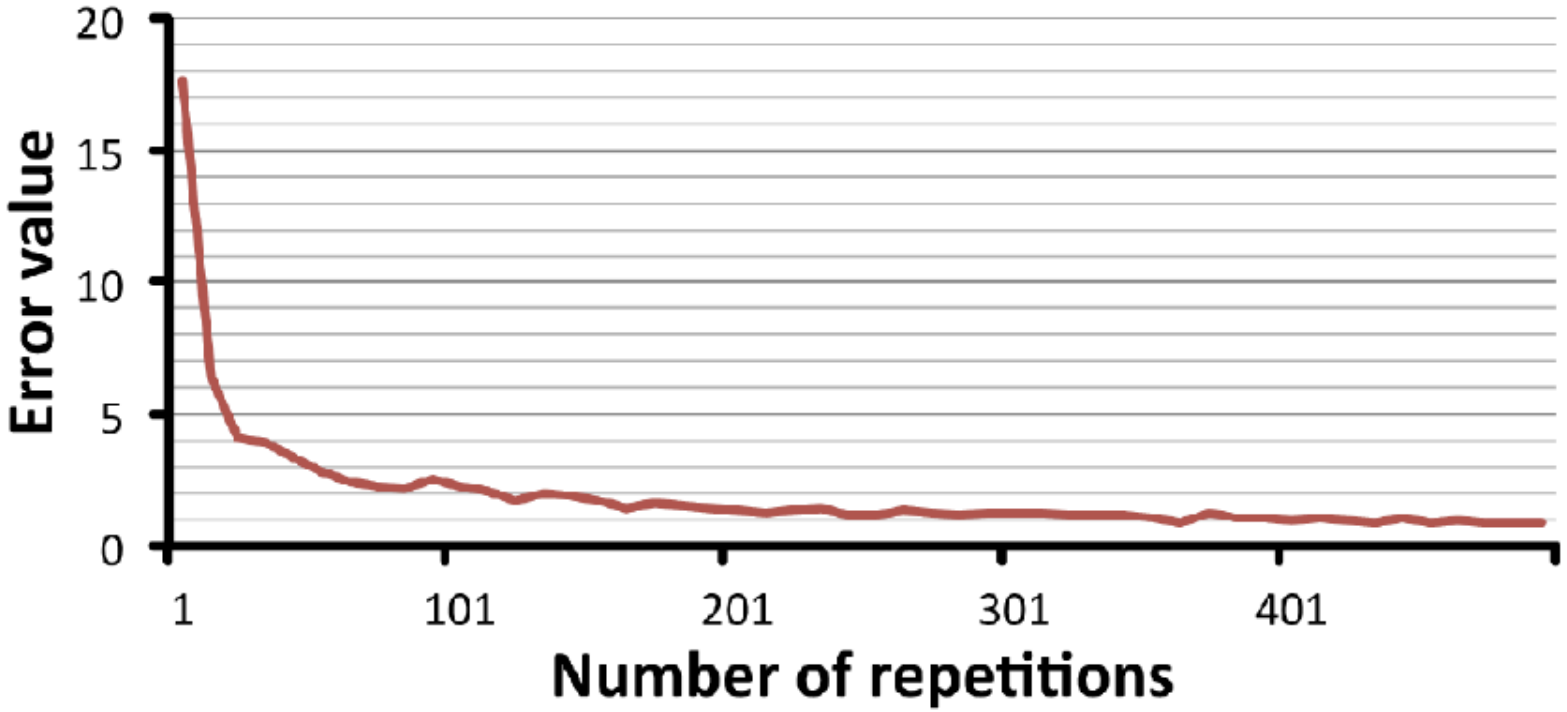
- Expected value of brightness



Final brightness: $B = (0.3 + 0.2 + 0.7) / 3 = 0.4$

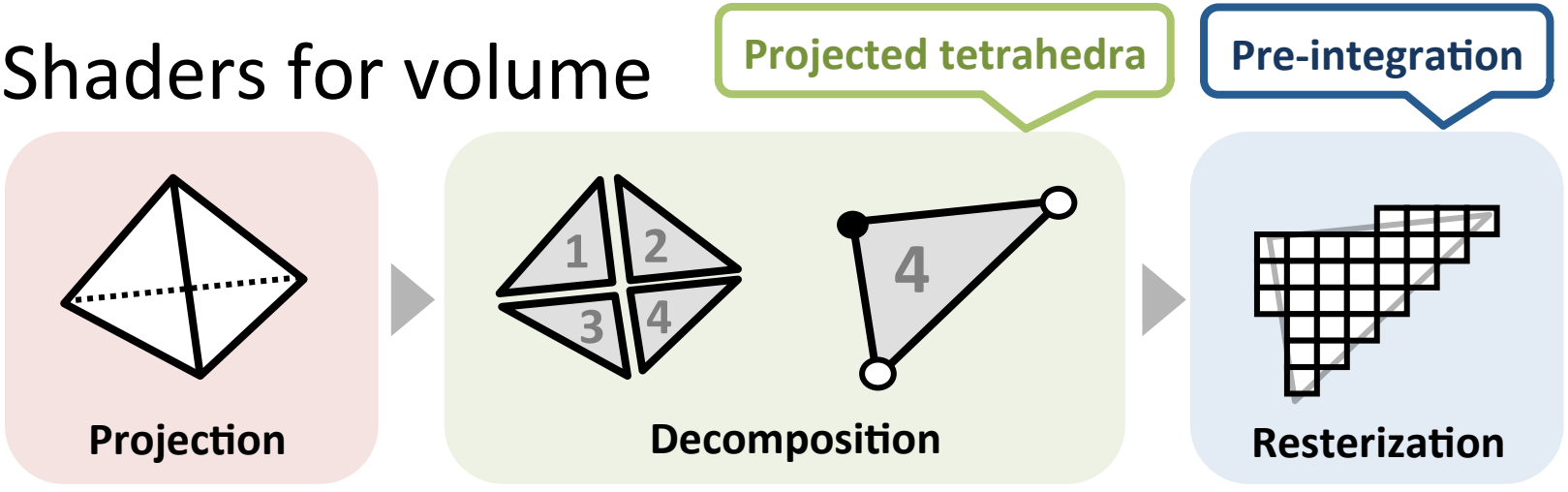
Error evaluation

- Error value is defined as the absolute difference between the true and approximated brightness values.

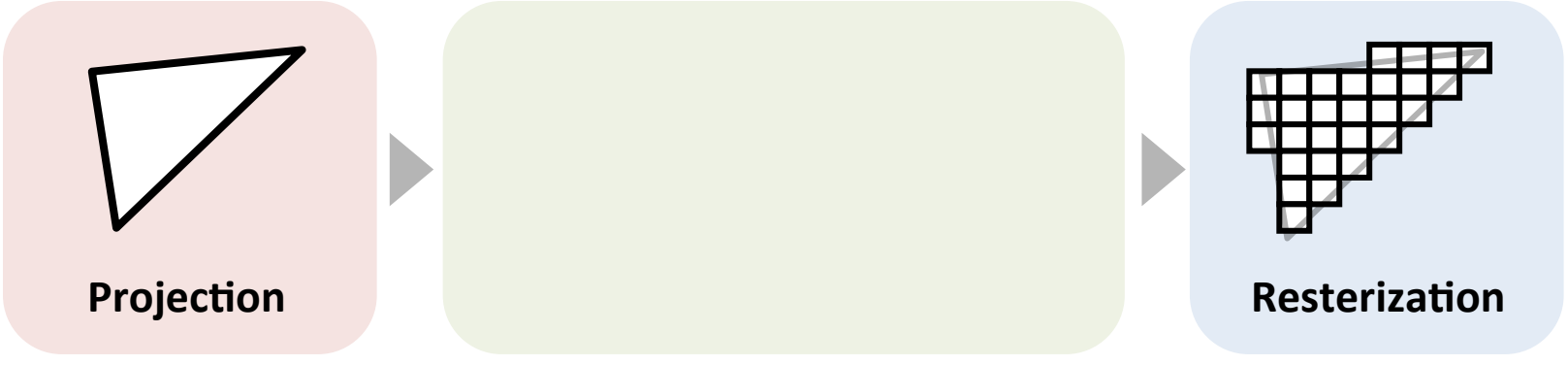


Implementation

- Shaders for volume

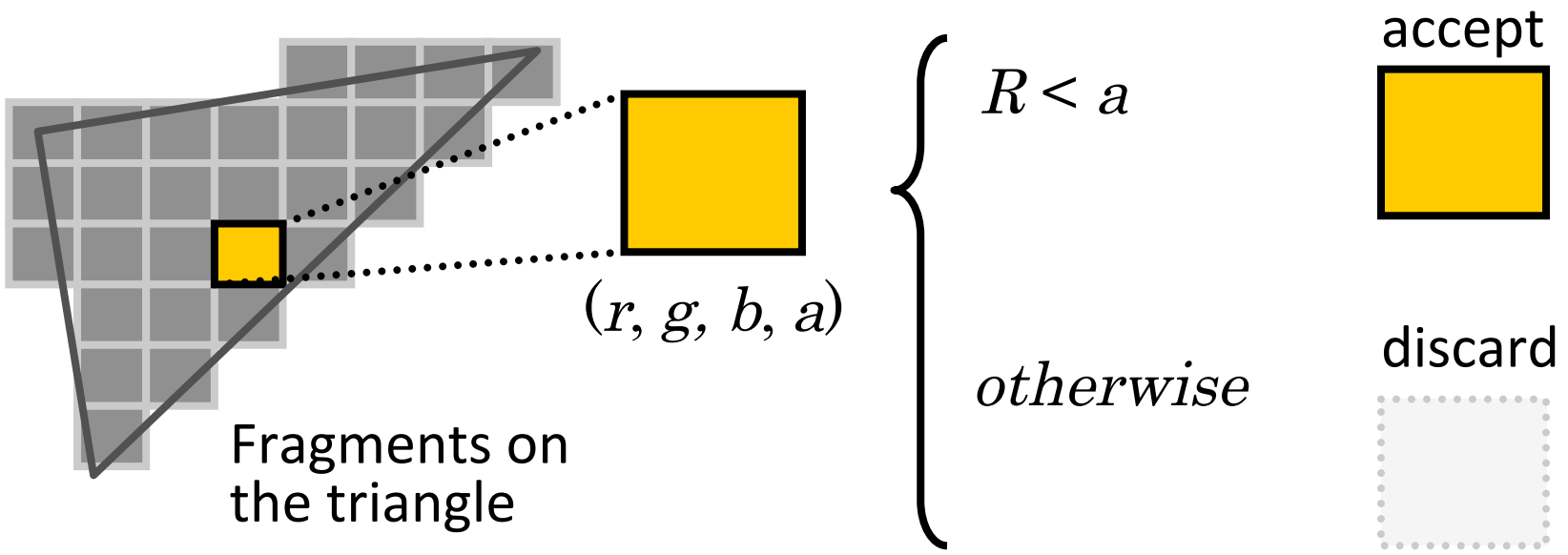


- Shaders for polygon



Color composition

- Performing a stochastic discard



Integration of volumes with polygons

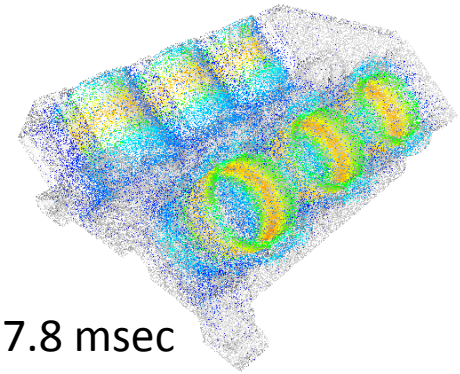
1. Frame buffer *F*
2. Object list *L*
3. **for each** repetition level *Lr* **do**
4. **for each** object *O* in *L* **do**
5. **if** *O* is volume data **then**
6. Rendering *O* with volume shaders
7. **else if** *O* is polygon data **then**
8. Rendering *O* with polygon shaders
9. **end if**
10. **end for**
11. **end for**
12. Average frame buffer *F*

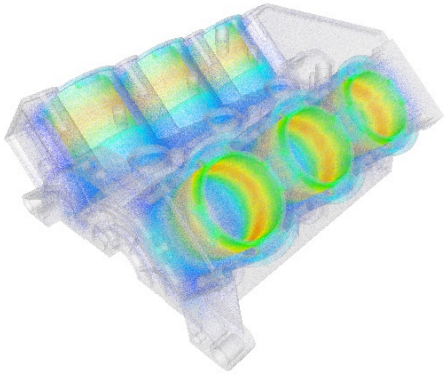
Accum. pixels to *F*

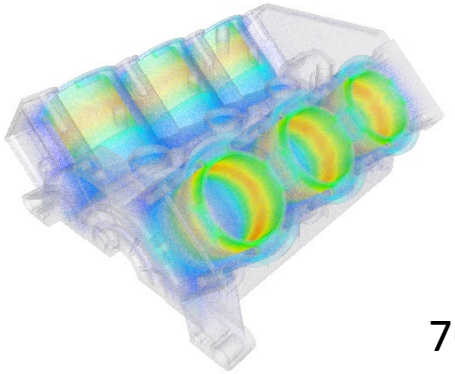
Draw *F*

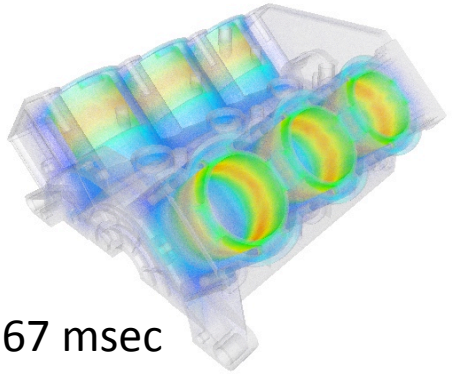
Repetition level changes

- Rendering results of the engine data and the pump data in change of repetition level (L_r).







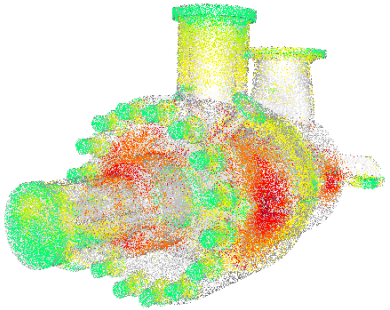


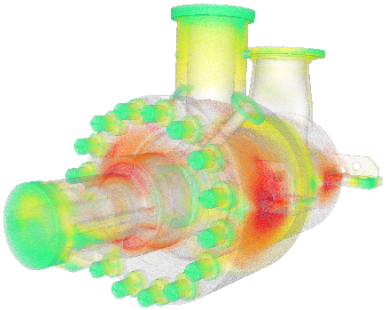
7.8 msec

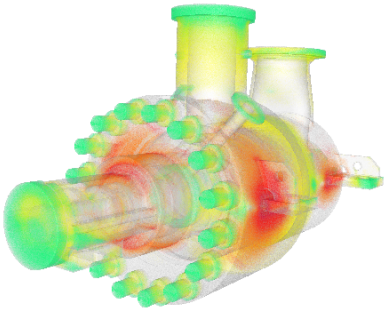
767 msec

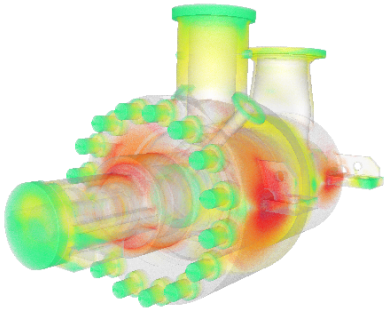
206 msec

20,653 msec









L_r=1

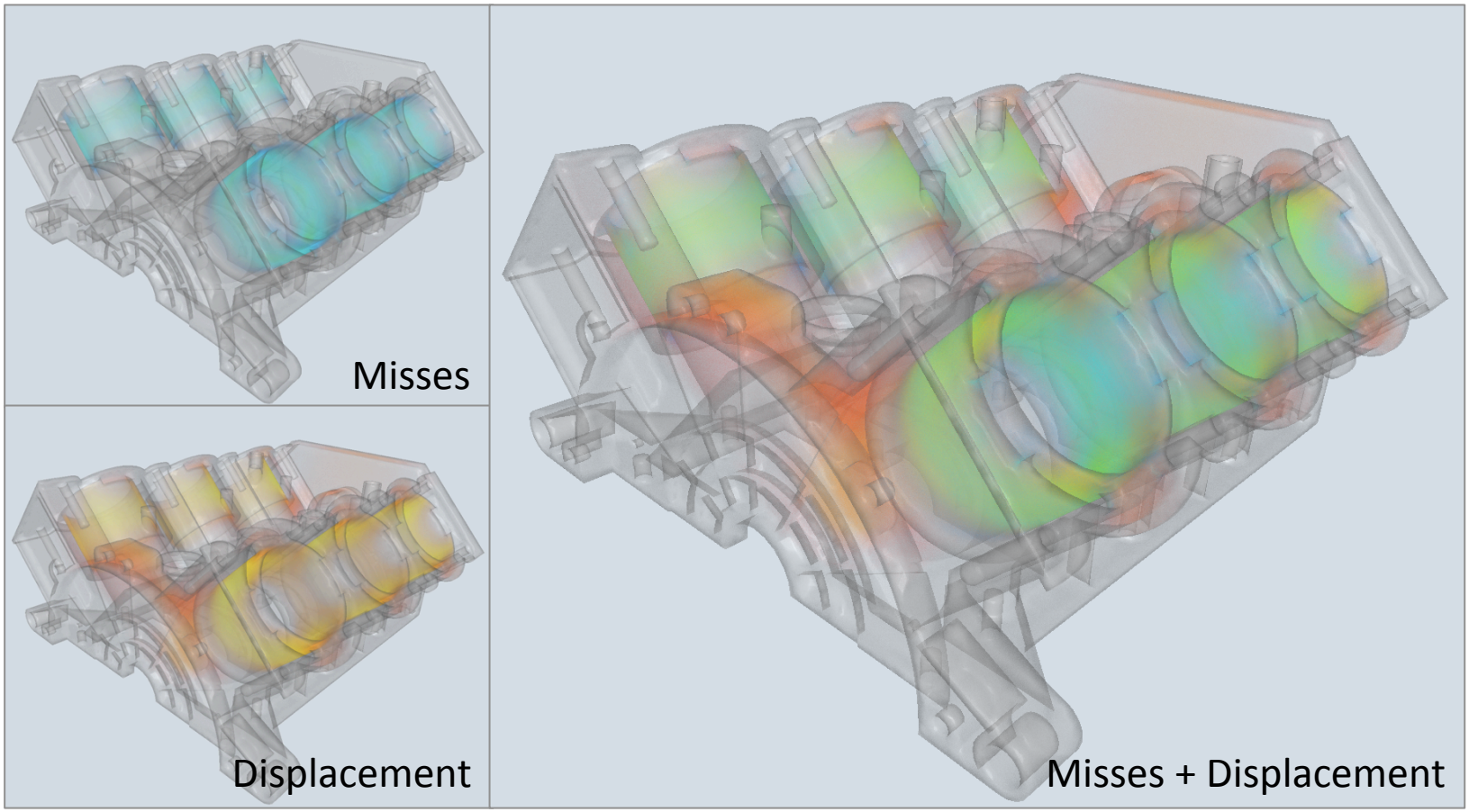
L_r=25

L_r=49

L_r=100

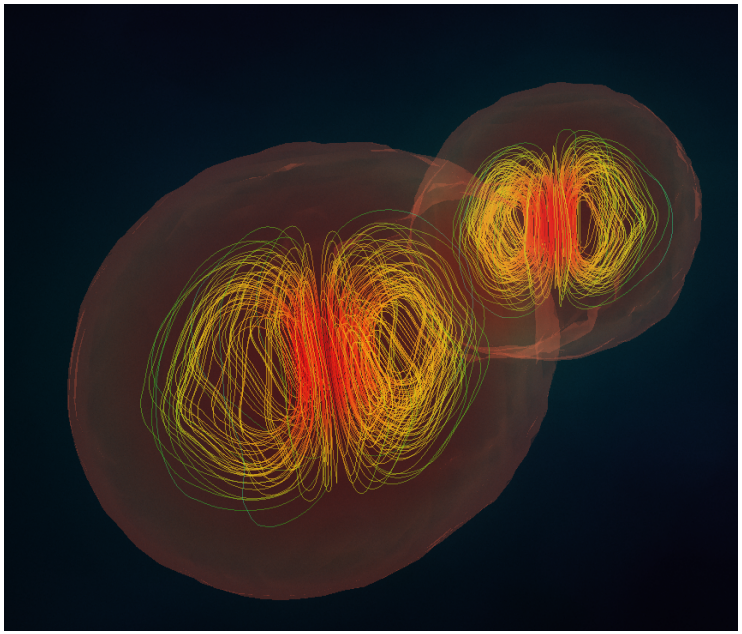
Multivariate volume rendering

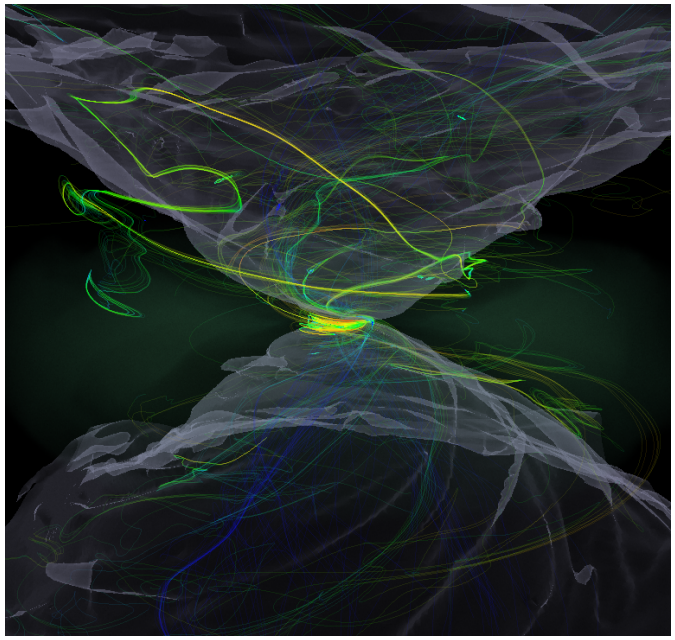
- Misses stress and displacement



Visualization of astrophysics data

- Magnetic field and mass density around a simulated black hole which is generated by a collision of binary neutron star merger.

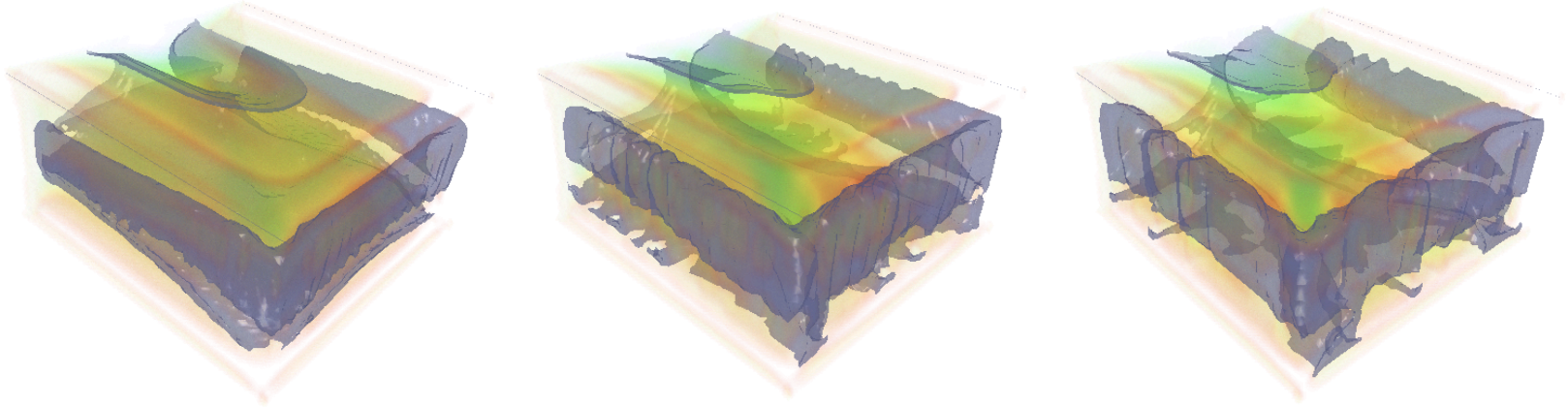




Data courtesy of Prof. Shibata, Dr. Kiuchi, Dr. Sekiguchi, Kyoto Univsersity

Visualization of fluid dynamics data

- Immiscible multi-phase fluid in a tank with vertical moving wall by MICS (Multiphase Incompressible flow solver with Collocated grid System)



Data courtesy of Prof. Ushijima, Mr. Fujioka, Kyoto Univsersity

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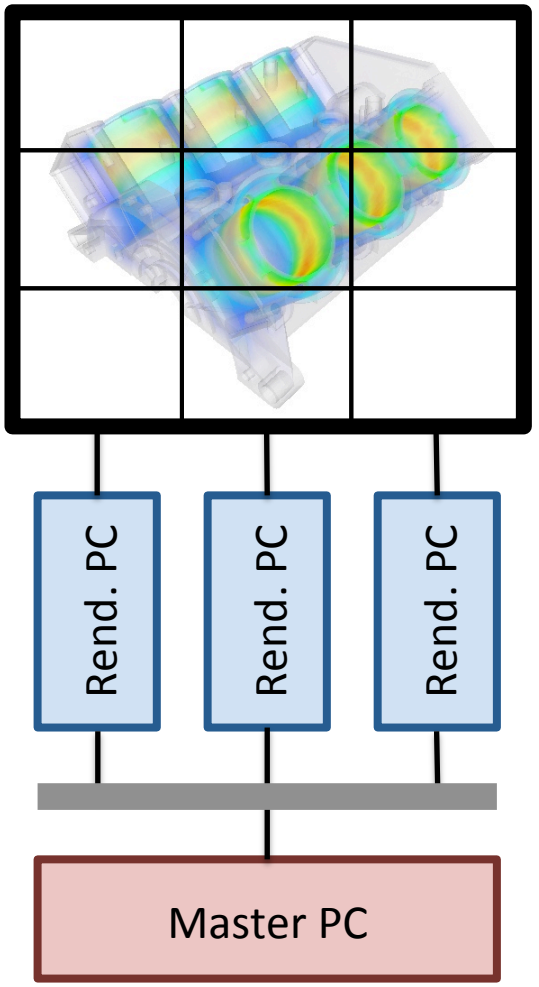
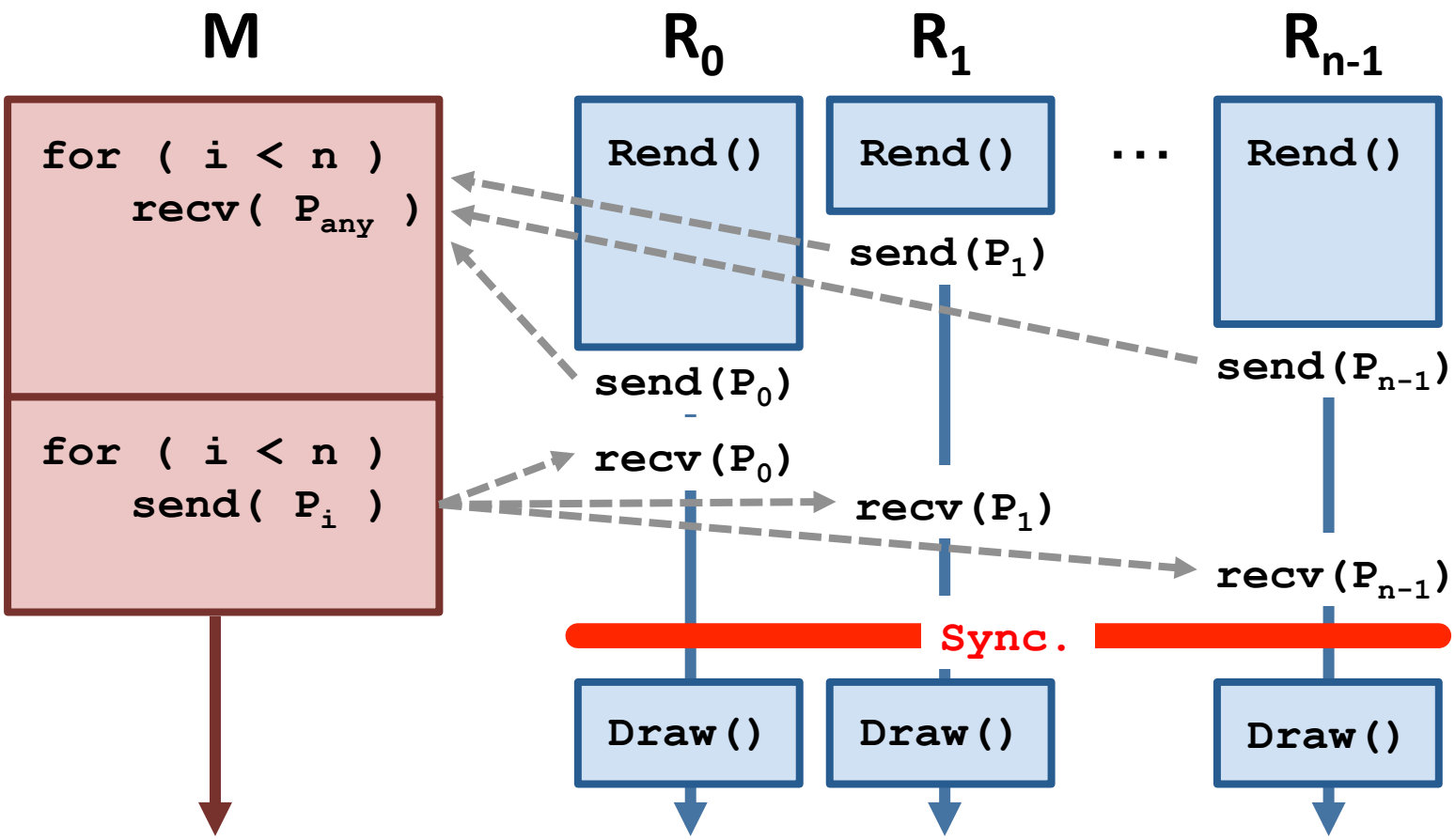
Tiled display system

- Master node
  - Manage the rendering nodes
  - Send events to the rendering nodes
- Rendering node
  - Connect to the displays
  - Receive the events from the master node
  - Generate image according to the viewport in the divided screen space



Frame synchronization

- Ping-pong synchronization mechanism



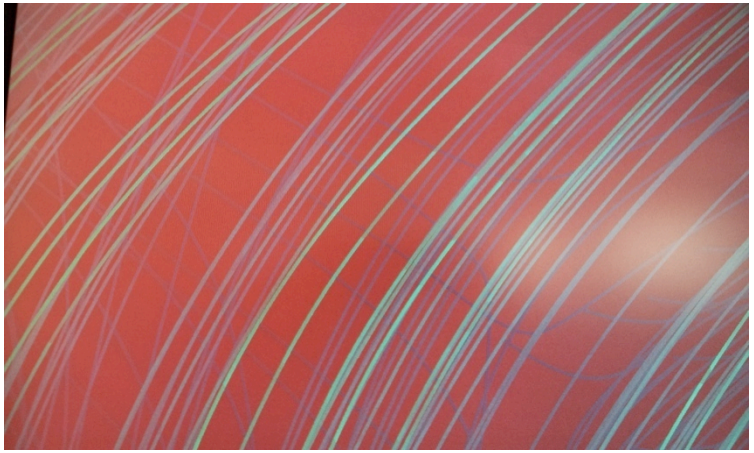
Tiled display system（40LCDs）

- Rendering PC：10
  - Intel Core2Duo 2.6 GHz, 2 GB RAM
  - NVIDIA Quadro 2000 1GB
  - 1GB Ethernet
- LCD：40（8 x 5）
- Resolution
  - LCD: 1,280 x 1,024 pixels
  - Total: 10,240 x 5,120 pixels

Rendering results on 40 LCDs

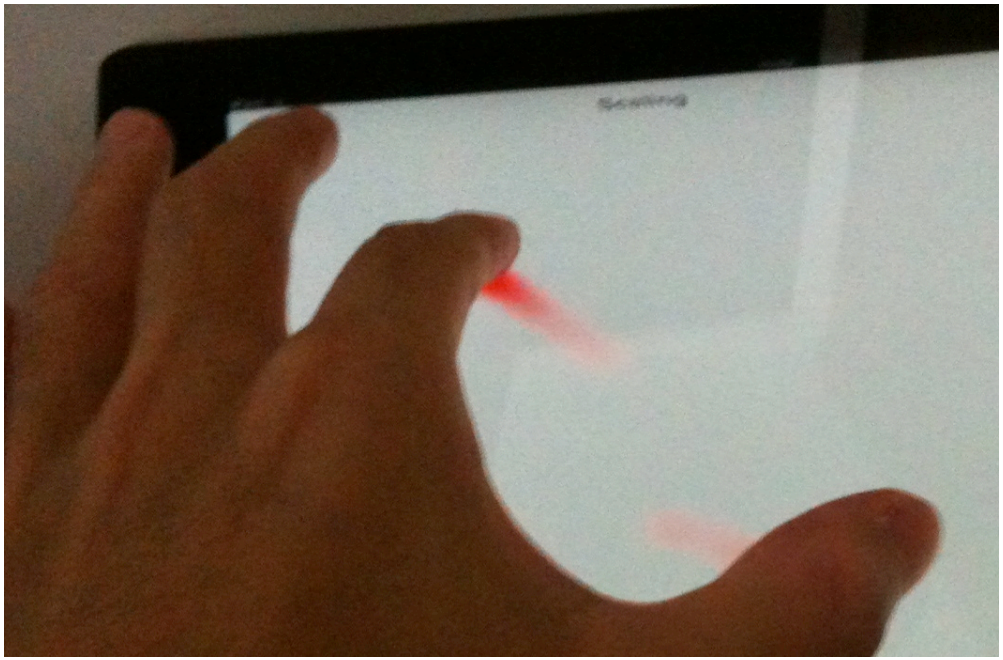
- Volume + boundary surfaces + hyper streamlines



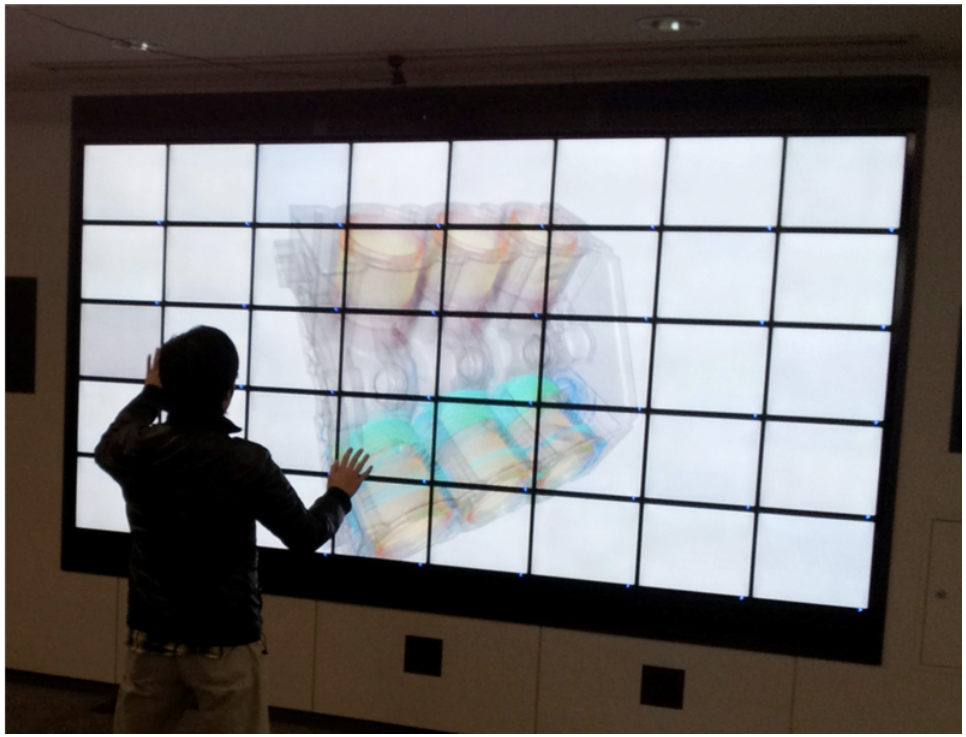
Multi-touch interface

- Using tablet PC
- Multi-touch operation



Gesture interface

- Using stereo camera (Microsoft Kinect)
- Gesture operation



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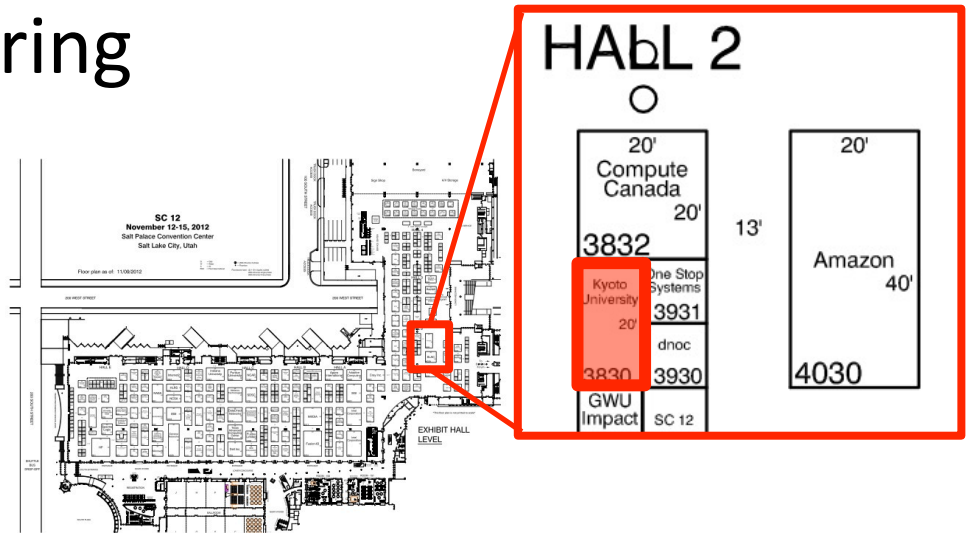
Conclusion

- Stochastic rendering
  - Sorting-free technique
  - Integration rendering volumes with semi-transparent polygons
- High resolution rendering
  - Tiled display system
  - User interface



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