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# Real World Applications on Massively Parallel Environments

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# Contents of Presentation

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- Introduction
- Industry: Electromagnetic field simulator
- Environment: Tsunami simulator
- Healthcare : Heart simulator
- Conclusion

# Introduction

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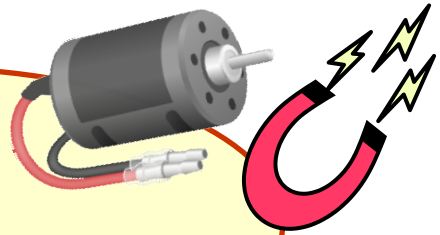
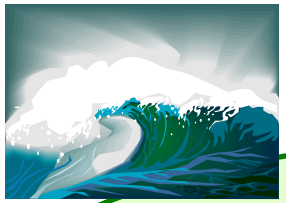
- Aims
  - Effective utilization of HPC
  - Broaden the possibilities of HPC
  - Practical applications

- Application Areas



Industry
- new product
- new material
- energy saving



Environment
- prediction and prevention of disaster
- prepare for and protect against disaster

Health care
- aid diagnosis
- personalized therapy
- efficient drug trial

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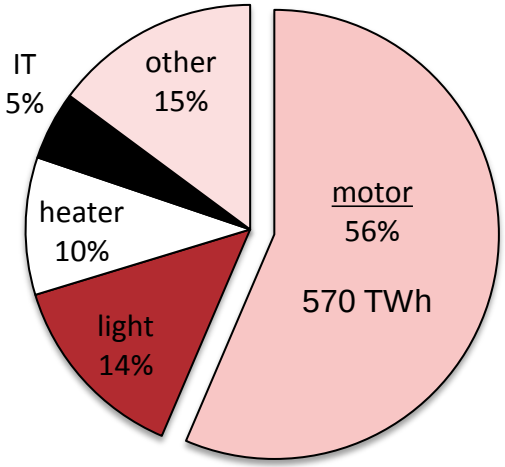
# Industry:
# Electromagnetic field simulator

i. Design of Motor

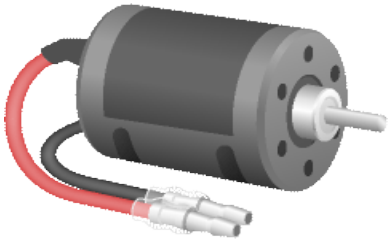
ii. Efficiency Improvement of Magnet

# Energy Saving Design of Motor

- Motors consume almost half of the generated electric power
  - The same tendency is also observed globally




in Japan
(2009, Fuji-Keizai)



1% more efficient

≈

Saving
One thermal plant

# Coupling of Simulation of Two Scales

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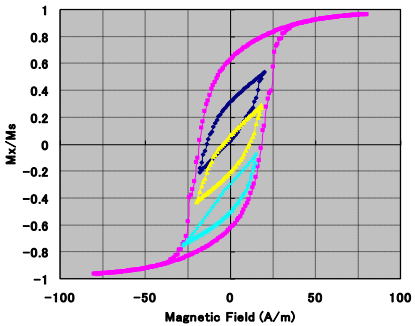
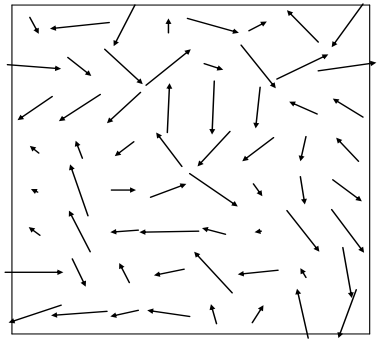
- Highly precise magnetic field analysis for design of products realized

micro-magnetics hysteresis model
(material property)



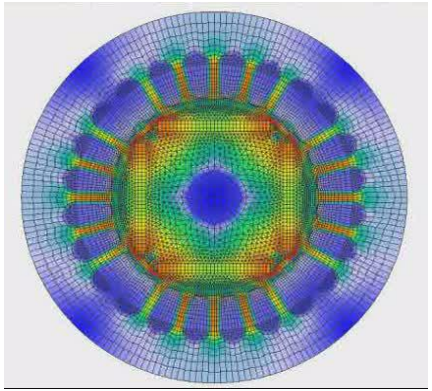

hysteresis loop



magnetization

weakly coupling

EM analysis: FEM
(deformation & current)



FEM analysis result

# Rare Earth Magnet Analysis

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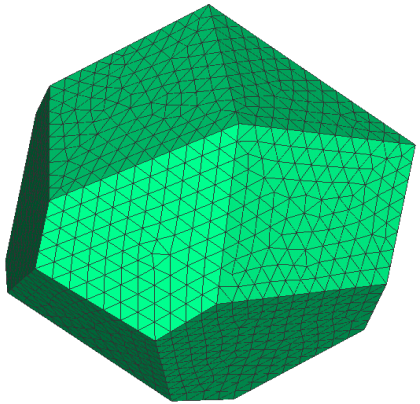
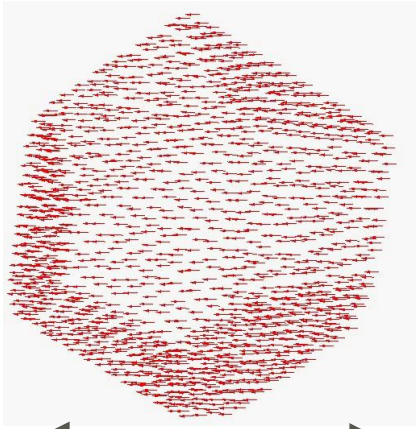
- Magnetic reversal* process of rare earth magnet analyzed with 3-D micromagnetics simulation



mesh size < 1nm



8~10 nm

*magnetic reversal: the phenomenon which direction of magnetization reverses by direction of an external magnetic field.

**BY USING HPC, THE REALISTIC STRUCTURE AND PRECISE PHYSICAL PROCESS OF CRYSTAL GRAINS CAN BE SIMULATED.**

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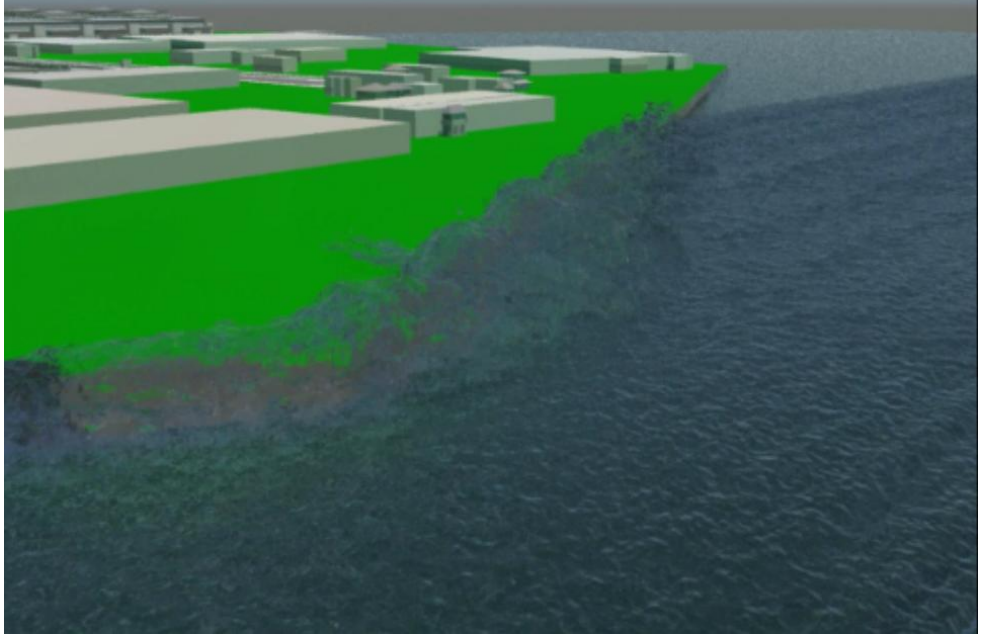
# Environment: Tsunami simulator

- This whole project is a collaboration with Prof. Imamura of IRIDeS, Tohoku University

# Prevention of Tsunami Disaster

- Mar., 11th, 2011
  - M9 earthquake & historic tsunami
  - Over 19,000 victims
- Target
  - Tsunami-proof design of buildings
  - Escape planning
  - Preliminarily enlightening on the danger
  - City planning
  - Tolerability of evacuation cites or public buildings

This movie is for the demonstration of the simulation technique, not for prediction of actual tsunami damage.



The Digital terrain data is provided by GEO Technology Laboratory Co., Ltd.

# For Safety Urban Planning

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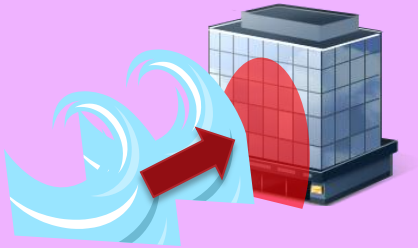
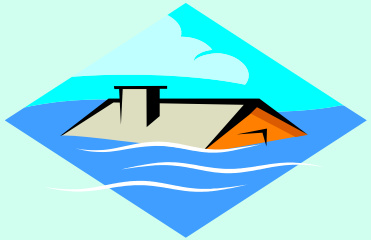
1. Calculation of wave stress
   - Formulation of tsunami-proof intensity standard
   - Tsunami-proof design



2. Inundation analysis w/o overdamping
   - Re-examination of dikes
   - Escape planning
   - Hazard analysis
   - Preliminarily enlightening on the danger
   - Tolerability of evacuation cite or public building



# Breaking Wave on Surface

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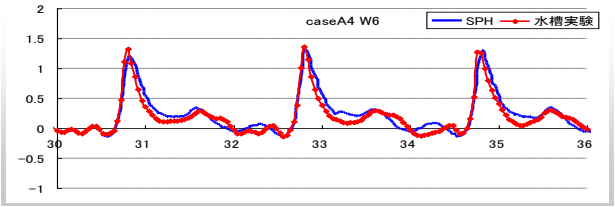
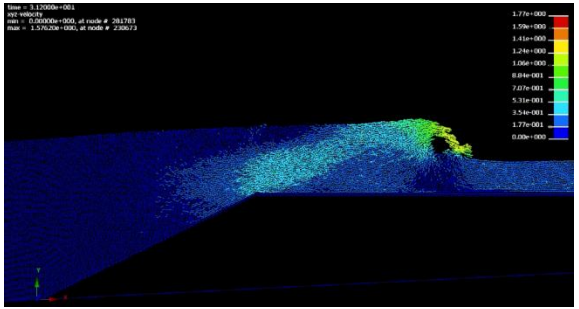
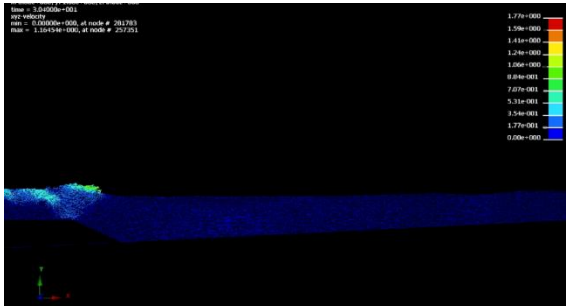
- Surface motion at an artificial reef




The time series of wave height matches the experimental data.
The source of the experimental data is Oki, Murakami, Mase (2002) Proc. Coast. Eng., 49, 41.

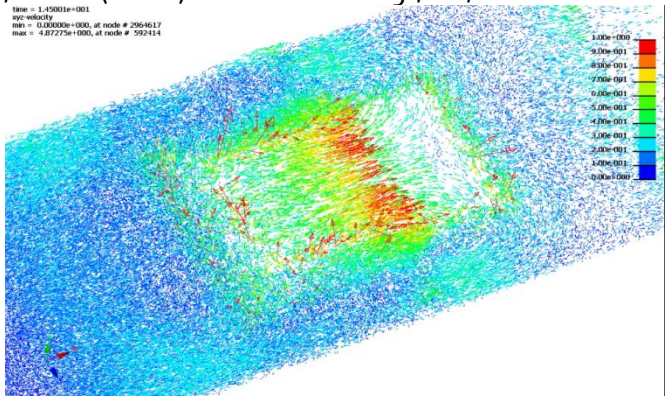


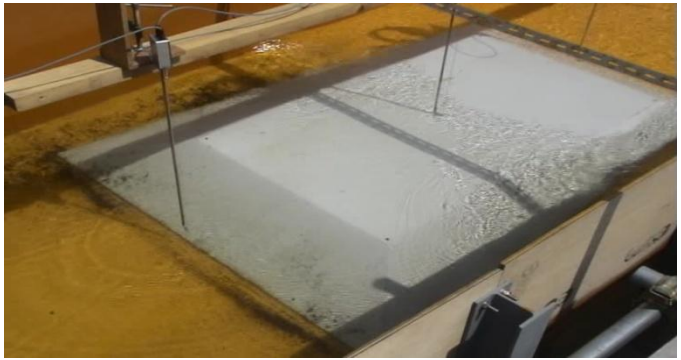
wave breaking



wave reforming

simulation





The hydraulic experiment is performed by Prof. Murakami of Univ. of Miyazaki.

# Combination of 2-D & 3-D Simulations

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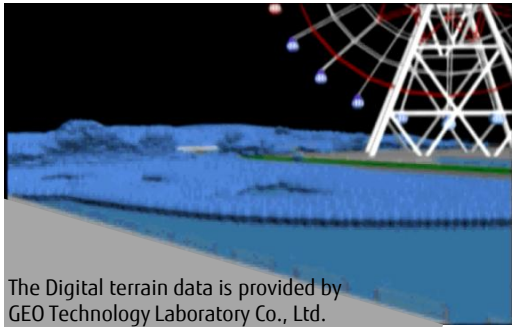
- Seamless 3-D simulation from the epicenter to an urban area

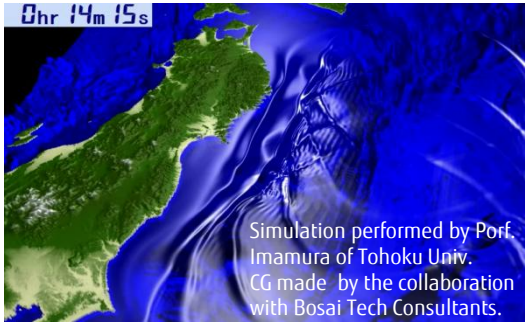
**tsunami simulator**

SPH method (3-D) for small area

combine

Shallow-water model (2-D) for broad area




calculation of wave stress to buildings

inundation in urban areas

tsunami propagation. from epicenter

**10m** **1km** **100km**

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# Healthcare:
# Heart simulator [UT-Heart]

- This work is a collaboration with Prof. Hisada and Prof. Sugiura of the University of Tokyo and Fujitsu Limited

# For Personalized Therapy

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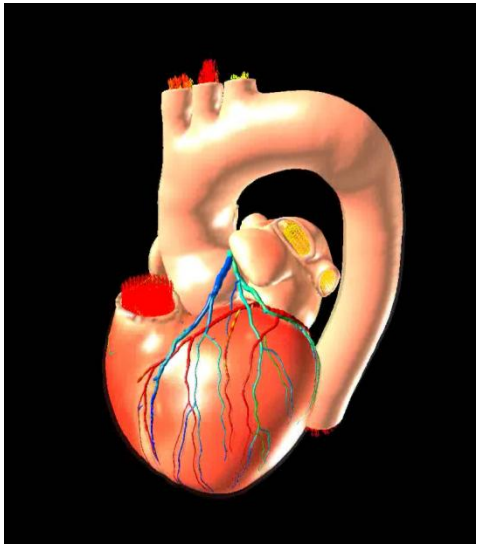
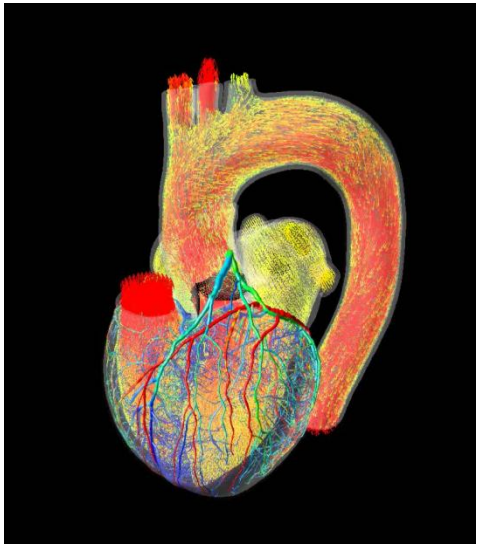
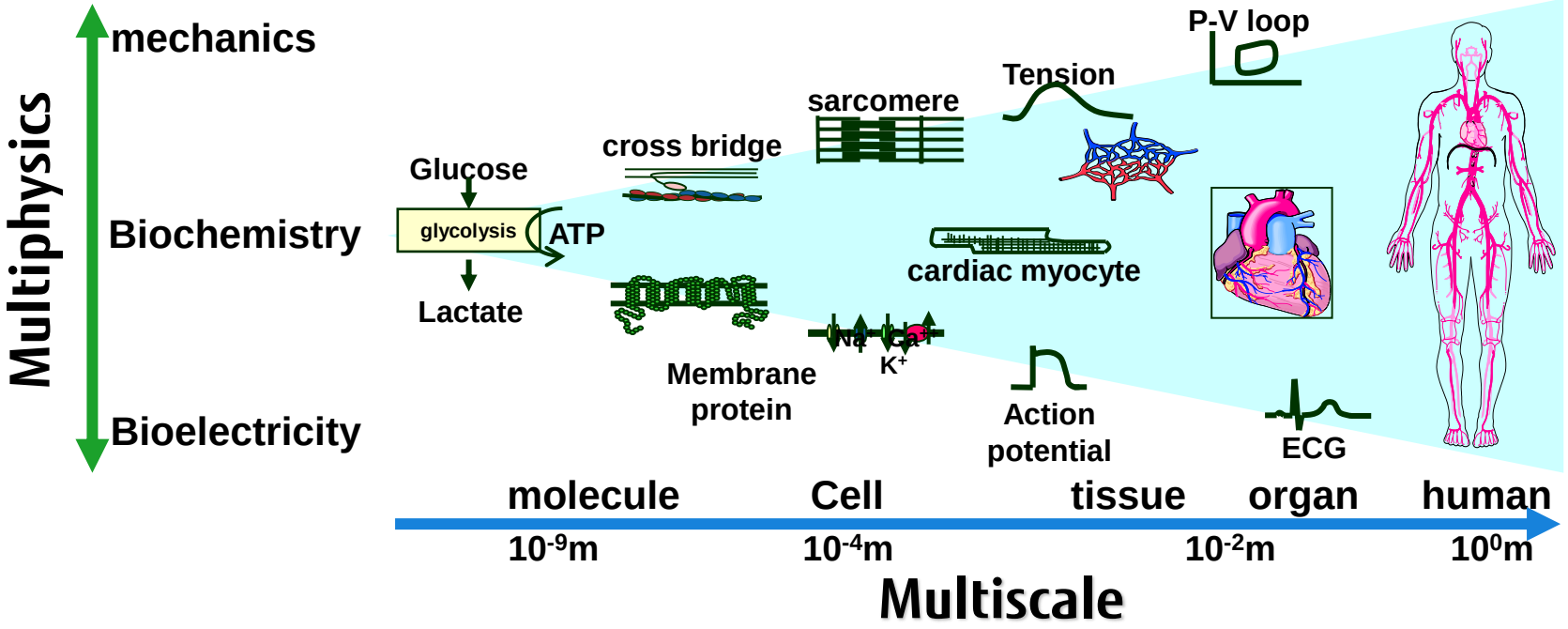
- CVD (cardiovascular disease)
  - One of the leading causes of death





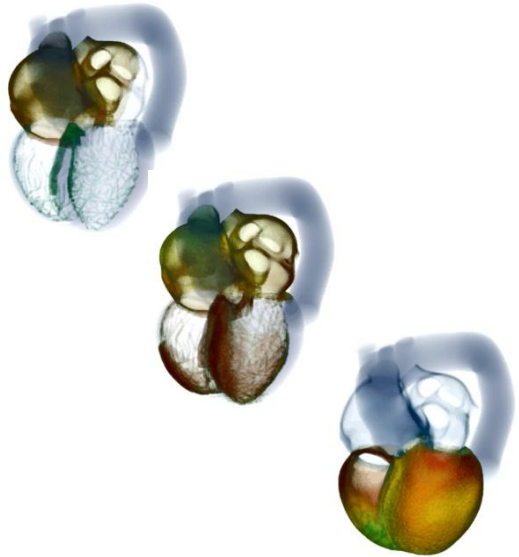
- Computer aided therapy
  - Personalized therapy
  - Efficient drug discovery

# Multiscale & Multiphysics

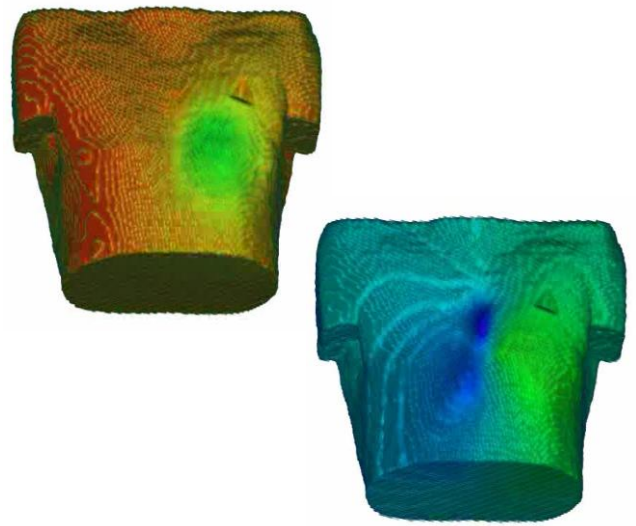


# Electrocardiogram (ECG)

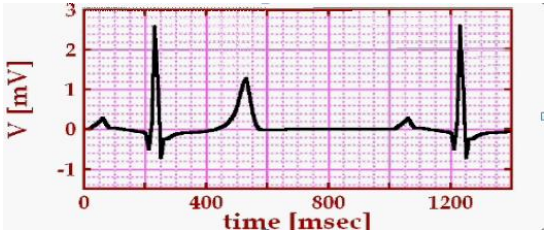
- Comparison of ECG measurement
  - between heart simulator and human heart



Cardiac Excitation



Potential Distribution on torso surface


Lead II ECG

# Ventriculoplasty

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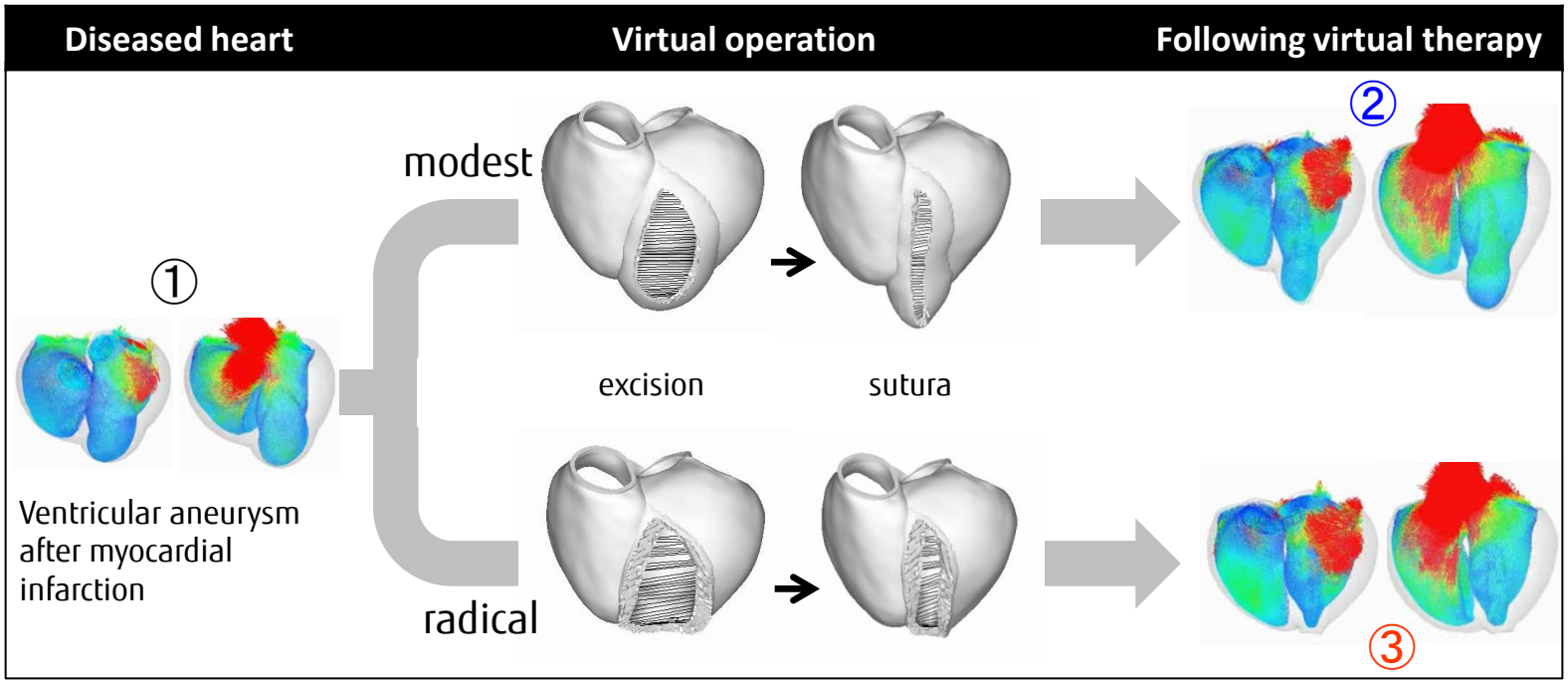
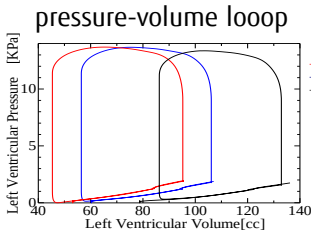
## Virtual surgical treatment



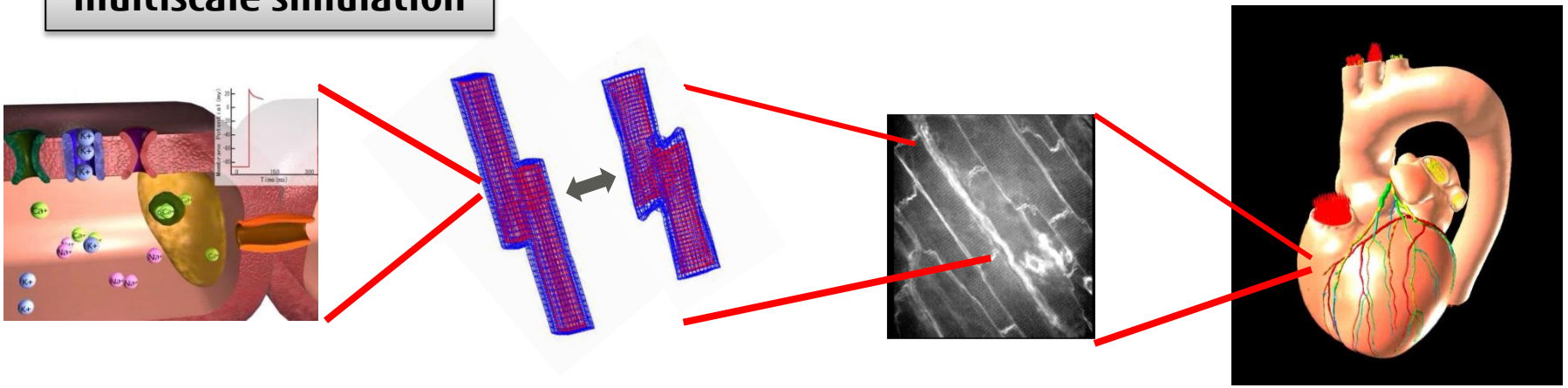

| | EF |
|---|---|
| ① | 34.9 |
| ② | 46.6 |
| ③ | 50.9 |

EF: Ejection Fraction. EF represents the strength of pumping function of heart.
Defined as (end-diastolic volume – end-systolic volume) / (end-diastolic volume).

# Multiscale Analysis

- For the personalized therapy in medical domain
  - As a bridge between molecular biology and clinical application

**multiscale simulation**



micro — macro

molecule — cell — tissue — organ

| | | | |
|---|---|---|---|
| EC-coupling<br>metabolism, sarcomere dynamics | structural dynamics by FEM<br>contraction force | homogenization method | FSI by FEM<br>circulation |

# Scalability and Performance on "K computer"

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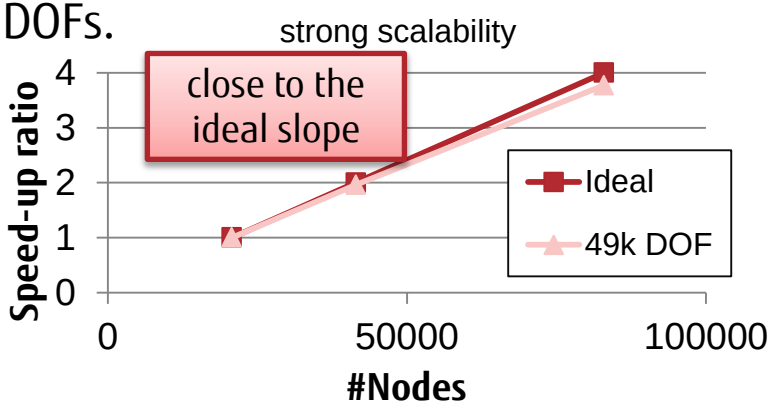
- Succeeded in simulating 1.5 heartbeats lasting about 17 hours and using 602,112 cores.
- Achieved more than 90% of the ideal scaling and 27.7% of the peak performance using 20,736/41,472/82,944 nodes with 659,456 embedded numerical cells of and 49,248 DOFs.




| #Nodes | 20,736 | 41,472 | 82,944 |
|---|---|---|---|
| Pflops | 0.78 | 1.49 | **2.94** |
| % of the peak performance | 29.32 | 28.12 | 27.72 |
| % of the ideal scaling | 100 | 98.0 | 95.3 |

Present results were obtained by early access to the "K computer" at RIKEN AICS as a "grand challenge application" under the "R&D of Next-Generation Integrated Life-Science Simulation Software" program supported by MEXT.

# Conclusion

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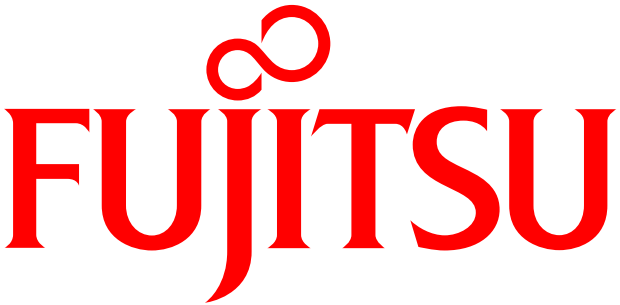
- FUJITSU has been developing the HPC applications for practical use
  - Effective utilization of HPC
  - Broaden the possibilities of HPC
  - Practical applications
- Some of these were introduced.
  - Tsunami simulator based on article method for disaster prevention
    - From the epicenter to the urban area
  - FEM based Electromagnetic field simulator for industry
    - Coupled with micromagnetics simulator
    - Optimization in macroscopic quantities possible, taking into account of the effect of micro magnetics
  - FEM based human heart simulator (UT-Heart) for personalized medical therapy
    - Multiscale & multiphysics heart simulator
    - Possibilities of use to aid diagnosis not only in surgery but also in a medical domain for personalized medical treatment
    - Achieved more than 90% of the ideal scaling and 27.7% of the peak performance on "K computer"

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Thank you for your attention.