

H23年度宇宙科学情報解析シンポジウム

H24 (2012)年2月15日、ISAS/JAXA、新A棟二階会議室

# クラウド環境での磁気圏シミュレーション の3次元多重画像解析

Multiple 3D Visualization of Magnetosphere  
Simulation under Science Clouds

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Nagoya University

# CSI Project (**e-Science Program**) Basic Study for Geospace Virtual Observatory/Virtual Organization

## **NAREGI Grid Middleware Version 1**

### **Functions of NAREGI Grid System**

Information Service

Grid PSE

Grid Workflow Tool

GVS (Grid Visualization System)

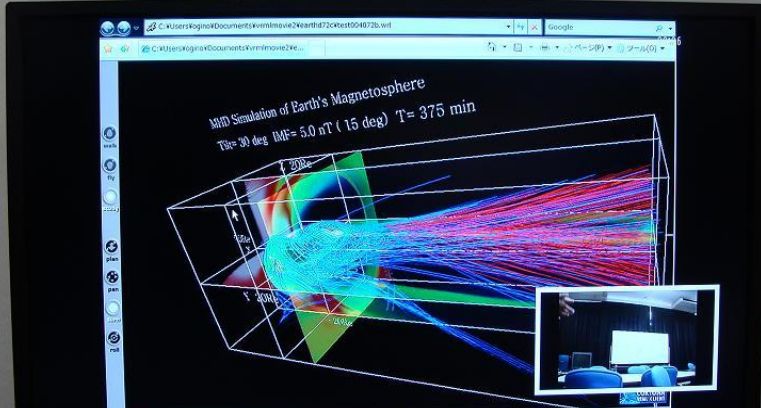
Data Grid

### **VO (Virtual Organization)**

# Basic Study for Geospace Virtual Observatory/Virtual Organization

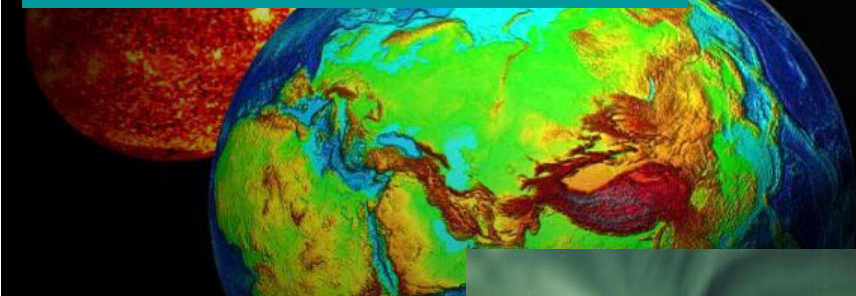
STEL and ITC of Nagoya University

## 1. Visualization Grid and Virtual Reality (VR) Remote 3D movie common usage



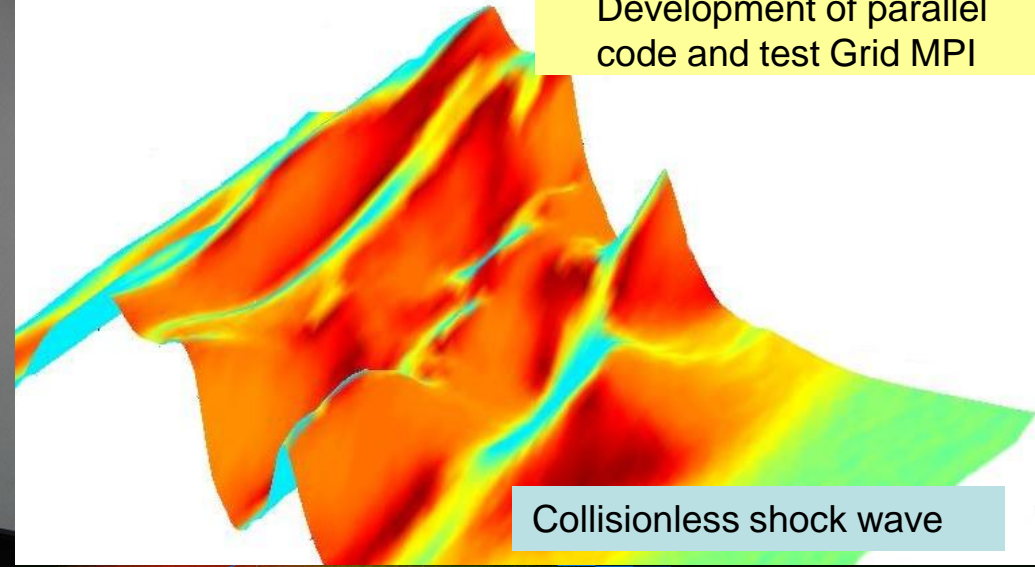
Transfer test of 3D movie (STEL, Nagoya u)

## 3. Data Grid: Construction and usage of data on solar-terrestrial science

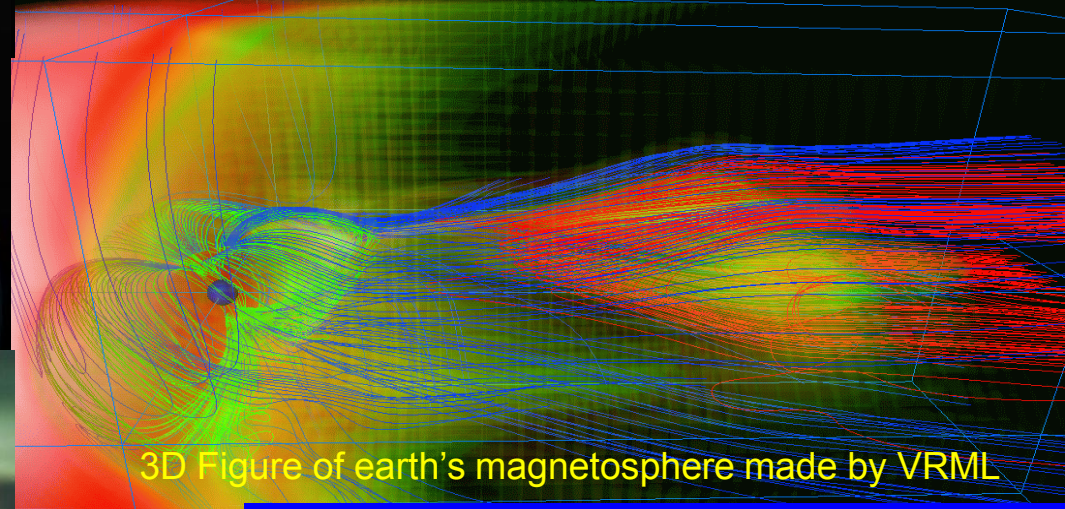


CAWSES and CAWSES-II Database in Japan (2007-2013)

## 2. Grid Supercomputing and geospace simulator: Development of parallel code and test Grid MPI



Collisionless shock wave



3D Figure of earth's magnetosphere made by VRML

## 4. Test of Grid 3 functions and integration by NAREGI Middleware Version 1 of ITC, Nagoya U

This document is provided by JAXA

# Processing and graphics of simulation data with NAREGI Grid Portal

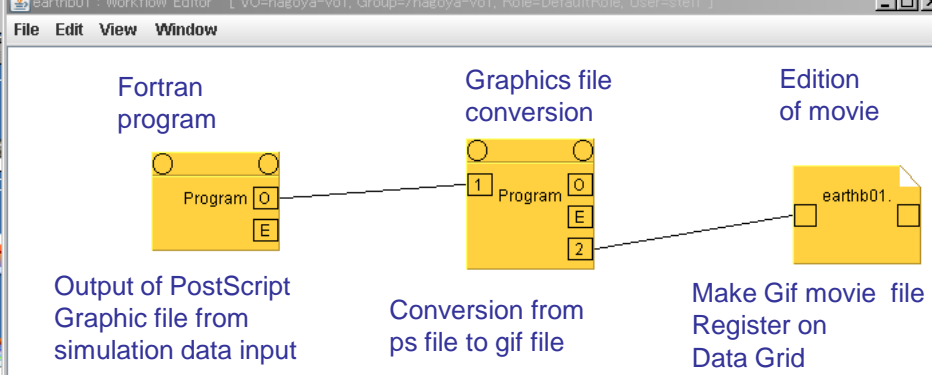
File View

Name	Status	Submit Time	Terminate Time
earthb01	Queued	2009/05/09 20:50:39 JST	
earthb01	Done	2009/05/08 19:07:21 JST	2009/05/08 19:28:59 JST
lorentz01	Done	2009/05/08 15:34:15 JST	2009/05/08 15:36:26 JST

Status of execution

Name	Owner	Size	Date	Metadata
[..]	stel1	0	May 8 2009 16:24:32	
earthb01.gif	stel1	1,006,525	May 8 2009 19:28:46	Comment Location
lorentz01.wrl	stel1	11,632,800	May 8 2009 15:36:04	Comment Location

List of files registered in Data Grid



Movie file displayed On Grid Portal

Input of simulation data

Execution of Fortran program

Display of movie on NAREGI Grid Portal

This document is provided by JAXA.



# Execution with NAREGI Grid Portal and Graphics with Data Grid

## Grid PSE + Workflow Tool + Data Grid → Graphics and 3D Visualization with VRML

### Animation Movie of Earth's Simulation data

Magnetosphere of Hot Jupiter ( $D_{sw}=346.5nPa$   
 $B_g=1.00*B_o$   $B_z=-20.0nT$   $V_{sw}=300km/s$   $t=57m$ )

X 20Re  
Y 20Re  
Z 20Re  
T Z 20Re  
X 20Re  
Y 20Re  
Z 20Re

### Animation Movie of Earth's Simulation data

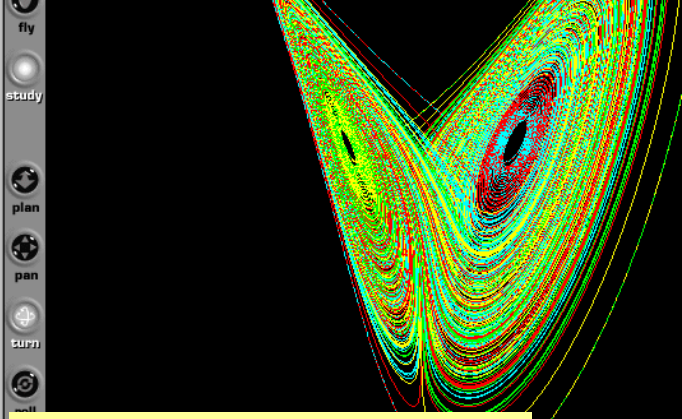
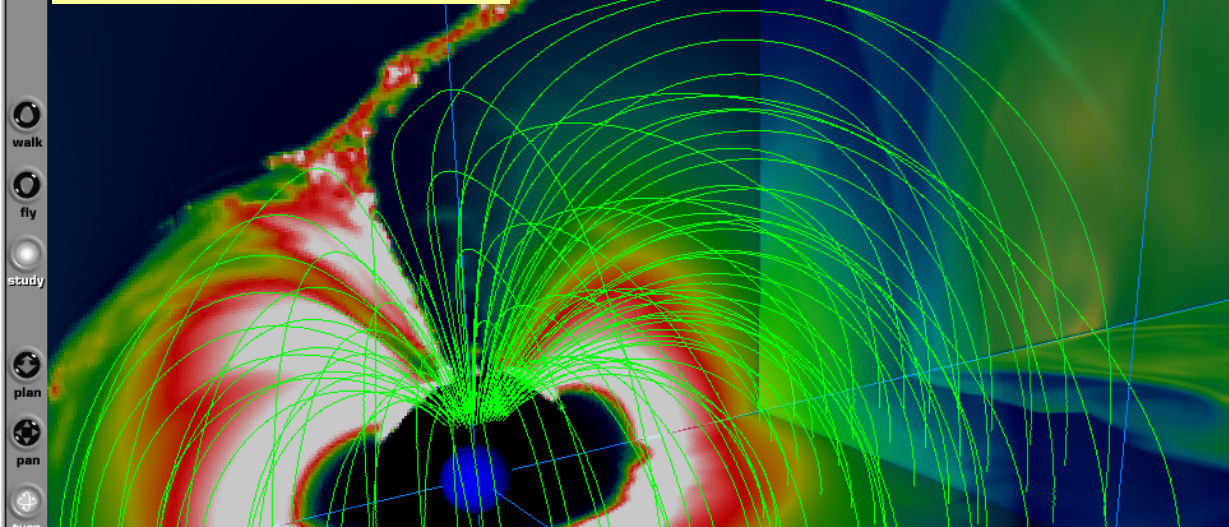
Magnetosphere of Hot Jupiter ( $D_{sw}=346.5nPa$   
 $B_g=1.00*B_o$   $B_z=20.0nT$   $V_{sw}=300km/s$   $t=179m$ )

X 20Re  
Y 20Re  
Z 20Re  
T Z 20Re  
X 20Re  
Y 20Re  
Z 20Re

$l_{cz}=10$   $u=10$   $nxp=200$   $nr=800$

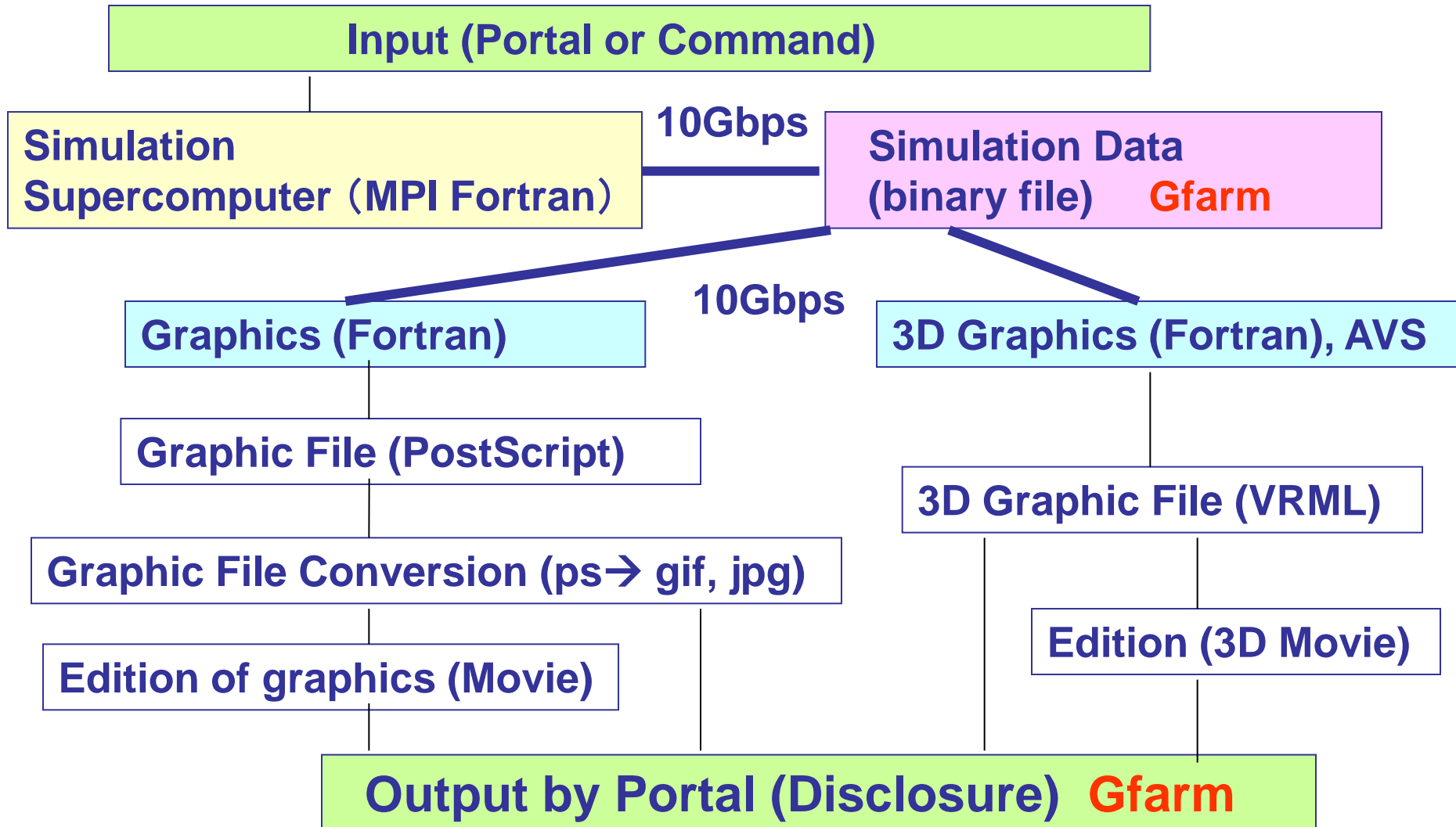
Windows Internet Explorer browser window showing the URL `D:\imports\earthb1\vrml01\wfor5360.wrl`. The address bar and search bar are visible.

3D visualization of earth's magnetosphere with VRML

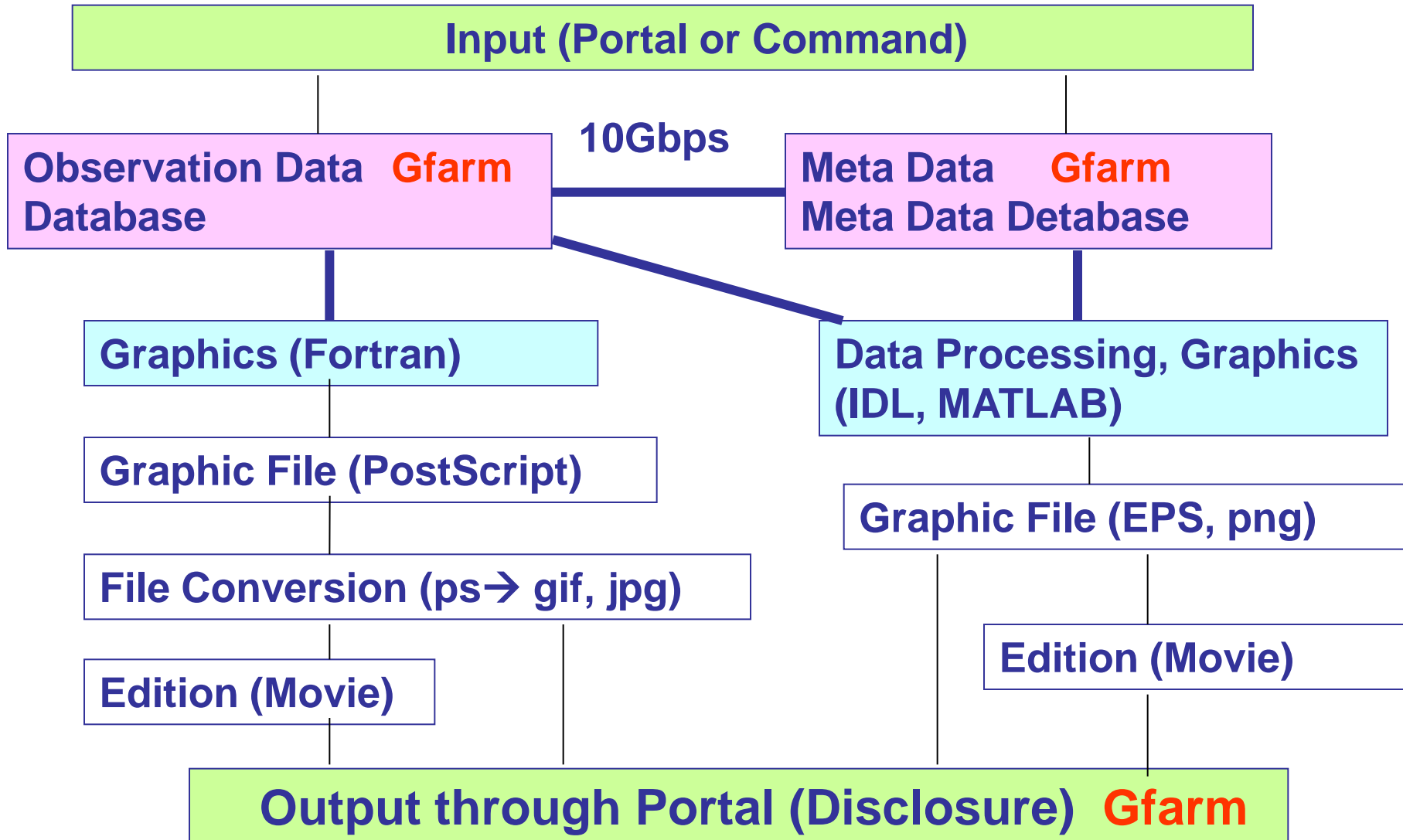


Computation of Lorentz model and 3D visualization with VRML

# Integration of Simulation Workflow (Network)

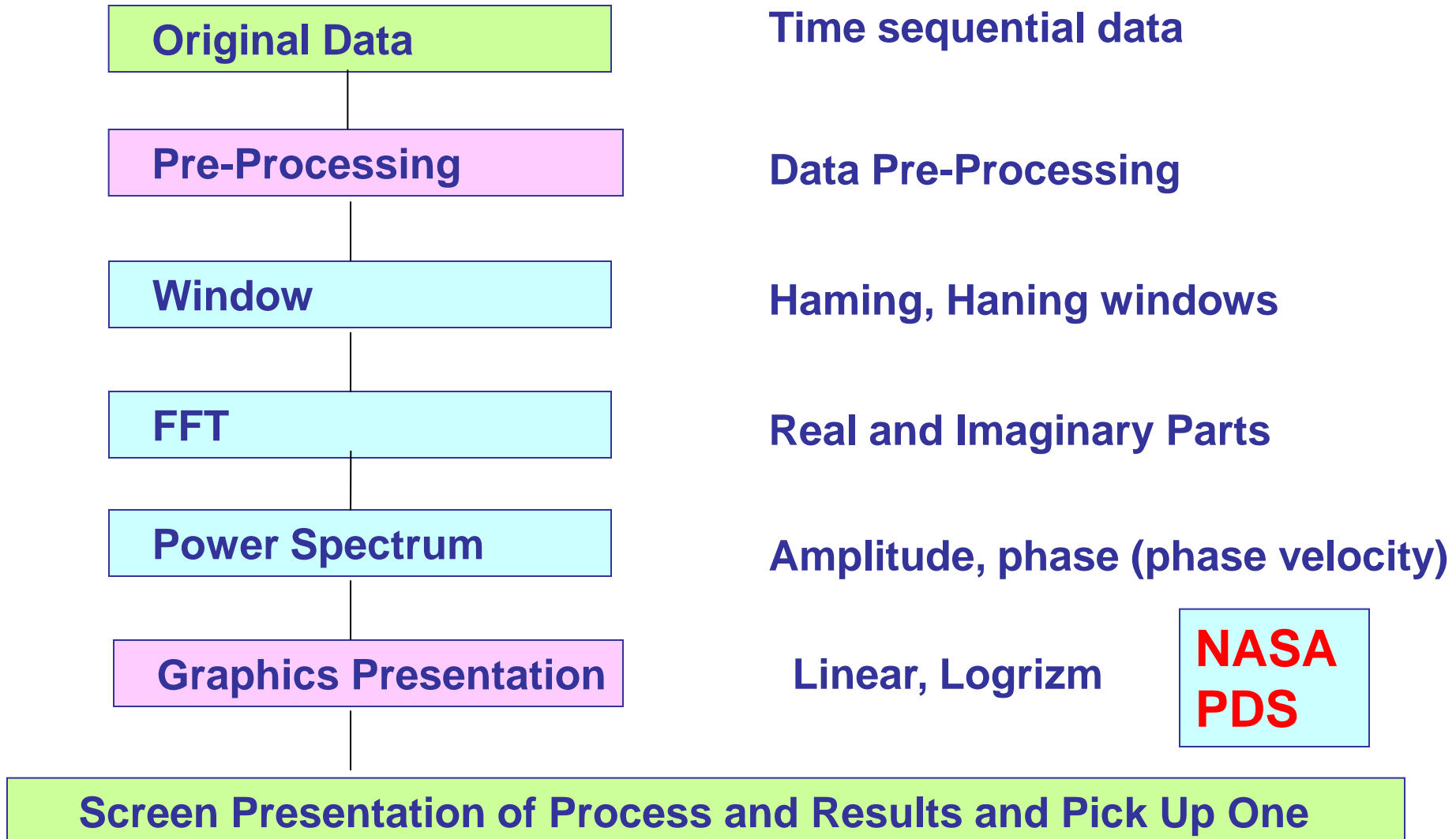


# Observation Data Workflow (Network)



# Data/Graphics Processing

Network: Process and Data on Screen + Pick Up





# New Trends on Advanced IT Usage

**Supurcomputer**  
**Next-age Supercomputer**

**Clouds, Grids**

**High-Speed Network**

SINET3, JGN-X

1 Gbps, 10 Gbps

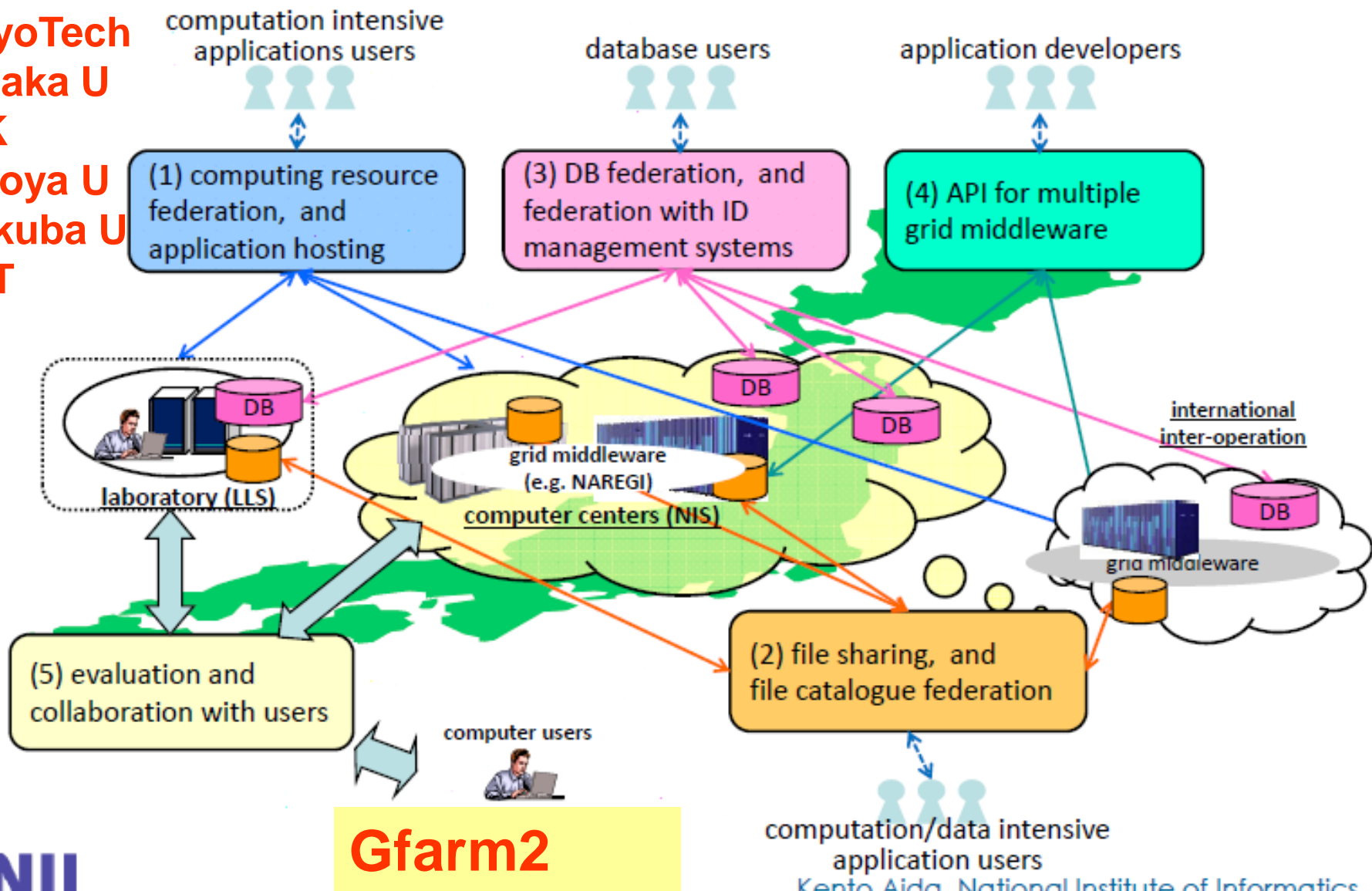
**Wide Area File System**

Gfarm

**How can we use the IT in simulation and data analyses?**

# REsources liNKage for E-science (RENKEI)

NII +  
TokyoTech  
Ohsaka U  
KEK  
Nagoya U  
Tsukuba U  
AIST



NII

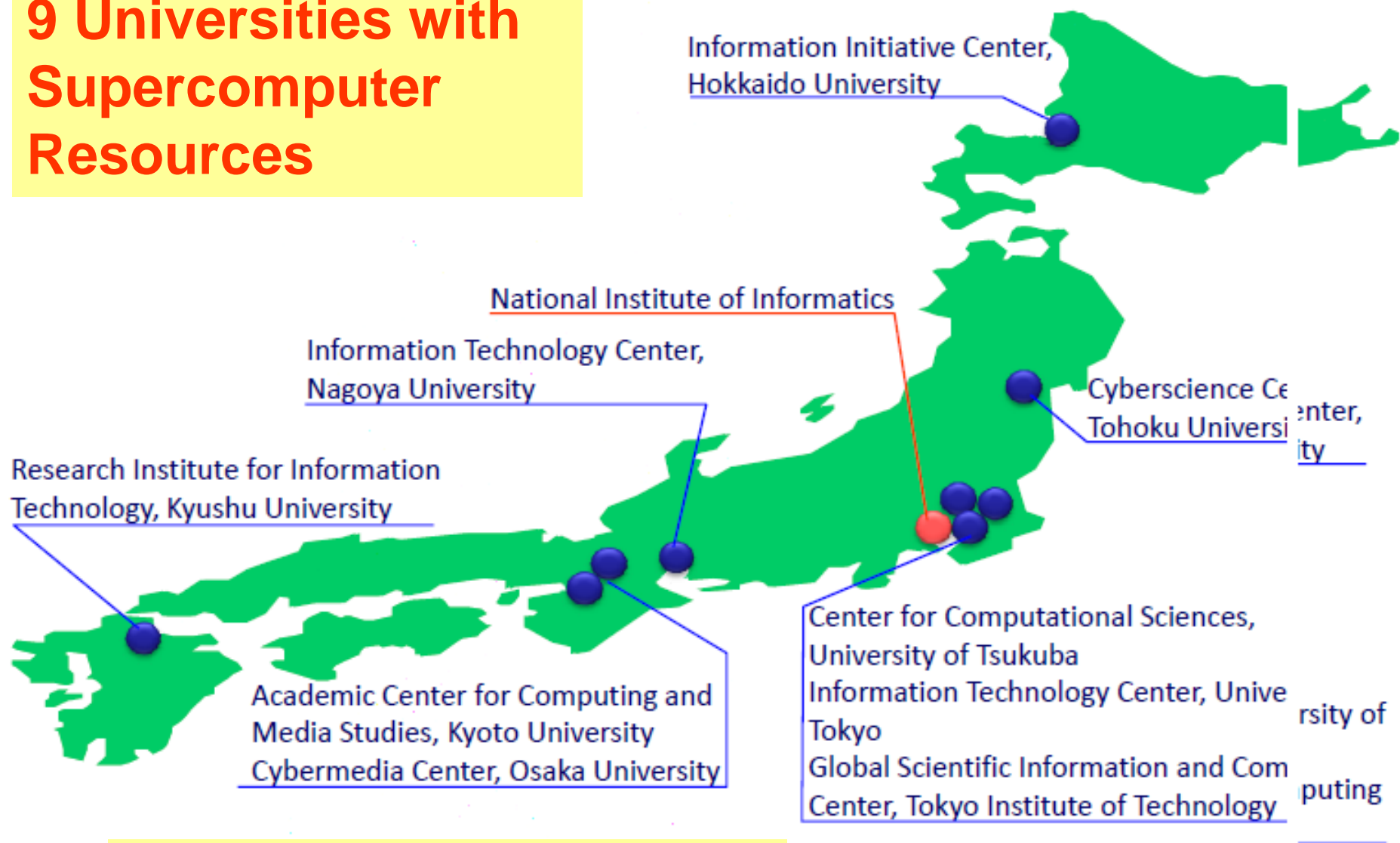
Gfarm2

computation/data intensive application users  
Kento Aida, National Institute of Informatics

# NII + 9 Universities with Supercomputer Resources

## Sites

## CSI GRID



## Gfarm storage system

Kento Aida, National Institute of Informatics

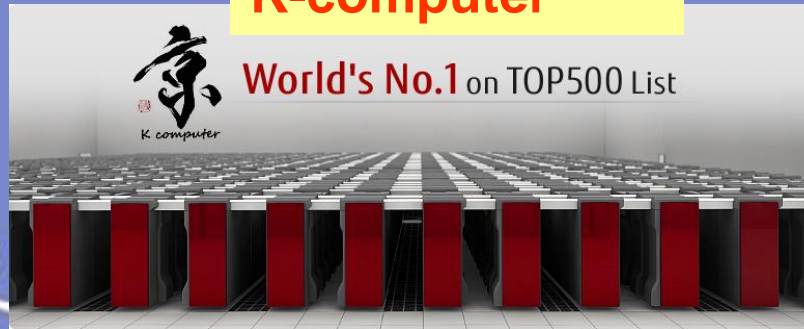
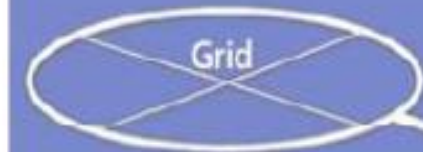
# Computing Systems in CSI → HPCI

**CSI Grids**

**K-computer**

World's No.1 on TOP500 List

**Next Generation Supercomputer (K-computer)**



Grid Interoperability and International Collaboration

- EGEE
- Teragrid

Grid

National Infrastructure System (Institute, University)

Infrastructural middleware (GRID, Infrastructure for certification, etc.)

**Gfarm storage**

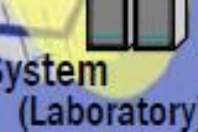
**NII + 9 Universities**

Industry-university joint research VO

University/interuniversity research institutes VO

Project VO

Virtual research environment for various fields



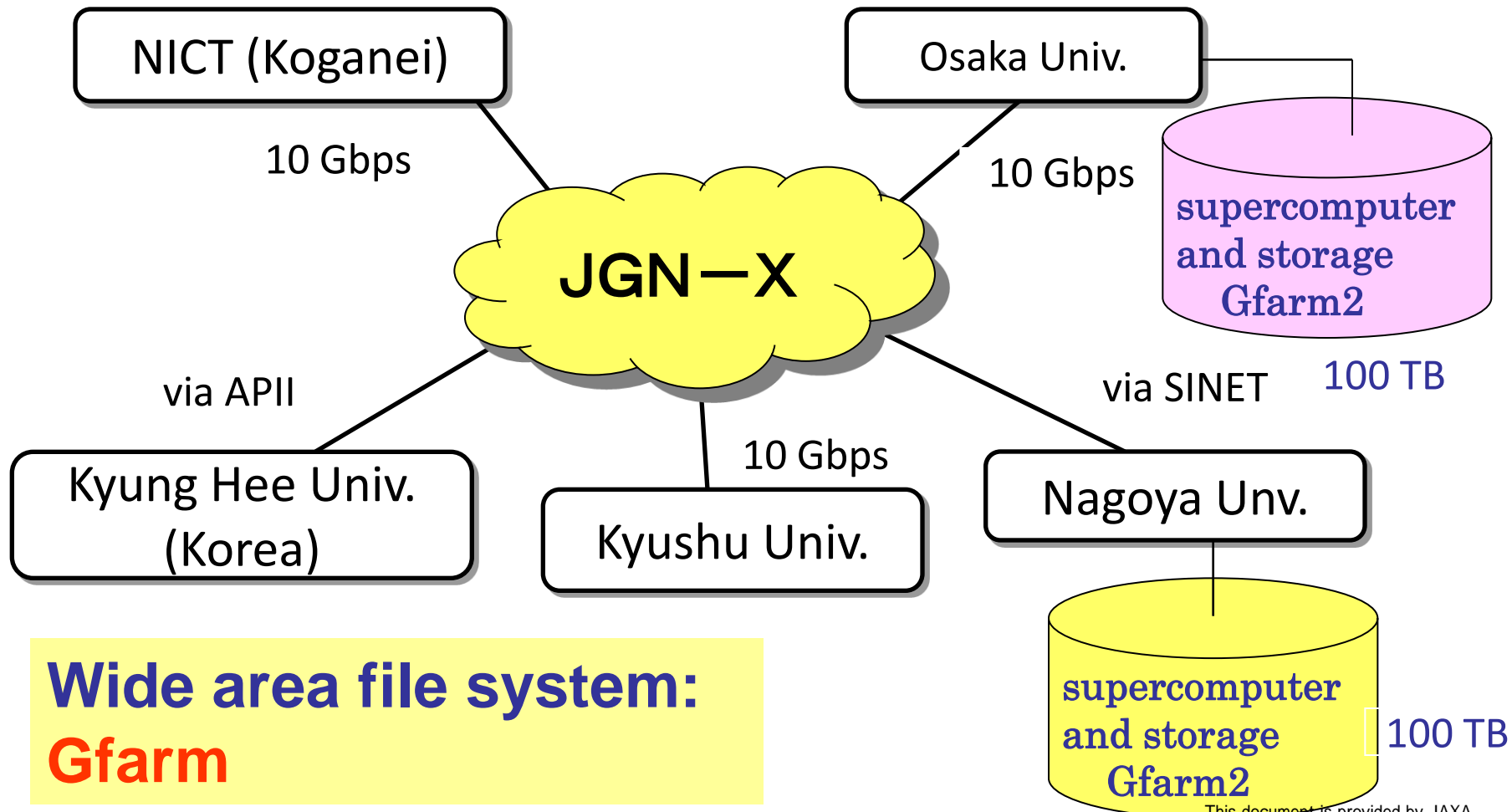
SINET 3

Laboratory Level System (Laboratory)

# Network Topology of JGN-X

NICT OneSpaceNet (10 Gbps)

Construction of  
geospace science clouds





# NICT commodity storage system, Gfarm

1 Server with 8 Desk Boxes (48TB)

1 Desk Box composed by 1.5TB x 4

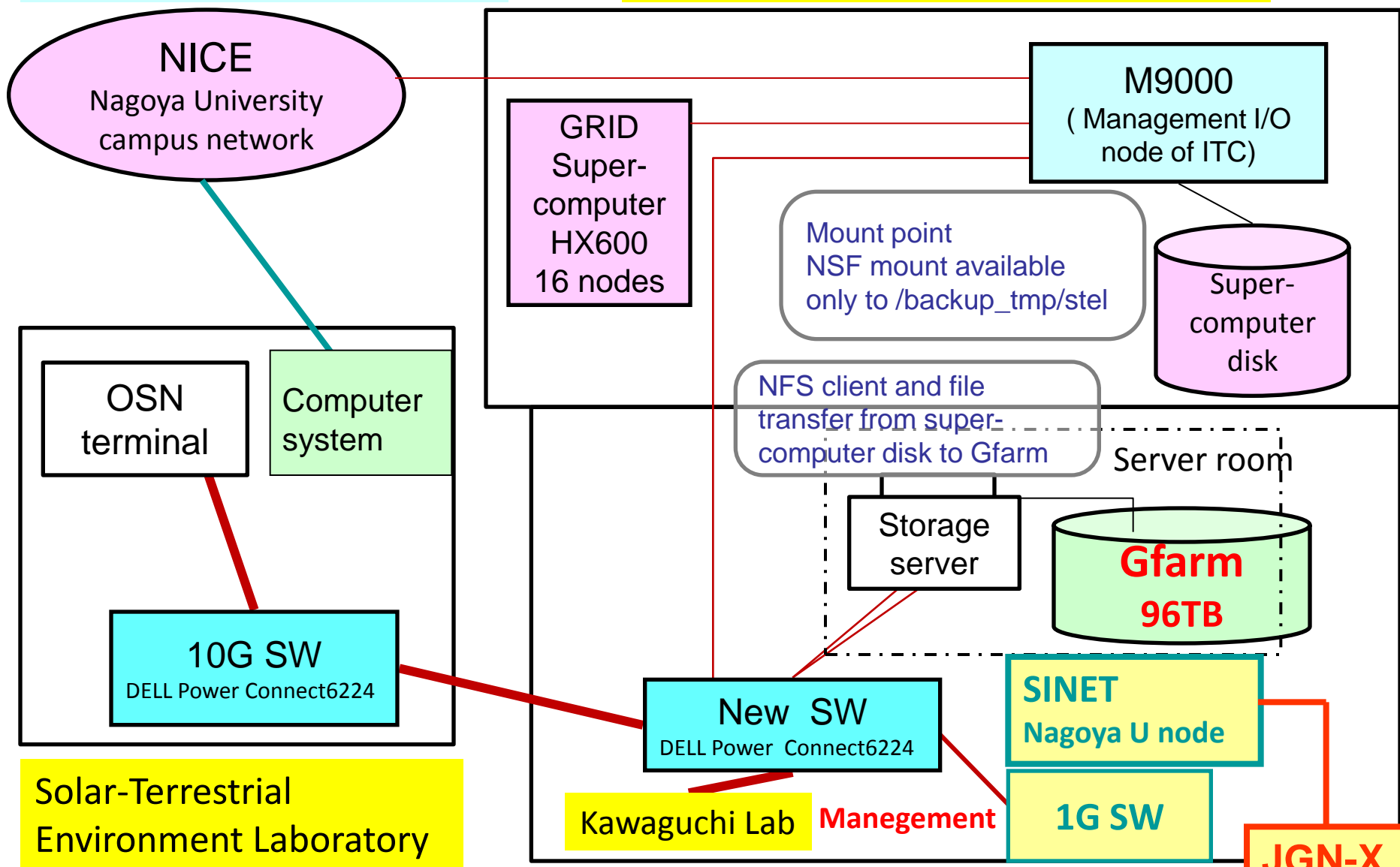
Additional goods for emergency

Battery covered by UPS with 1500 VA for 2 Servers (with desk)

# NICT OneSpaceNet – in Nagoya University (2011/08/26)

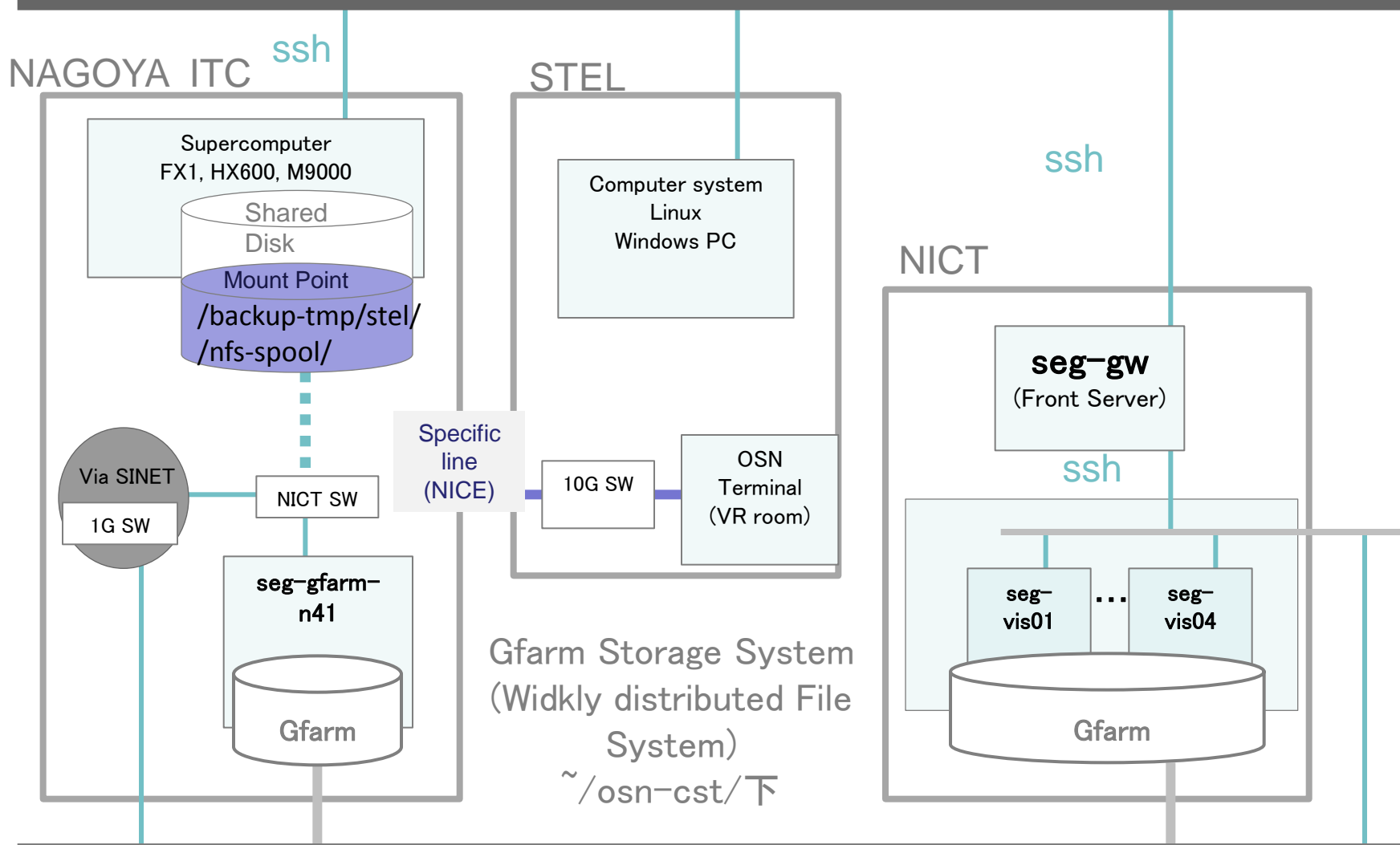
## Science Clouds

## ITC Center of Nagoya University



# NICT OneSpaceNet – Nagoya University Connection (2011/11/08)

## SINET (Nagoya Univ LAN:NICE) - Internet




JGN-X

JGN-X Management

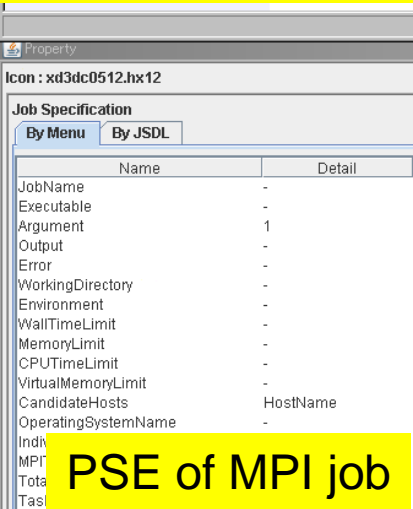
# Use of NAREGI Computation GRID and **RENKEI-PoP**

## Execution of MHD simulation with MPI Fortran

### NAREGI Portal and MPI Fortran job run



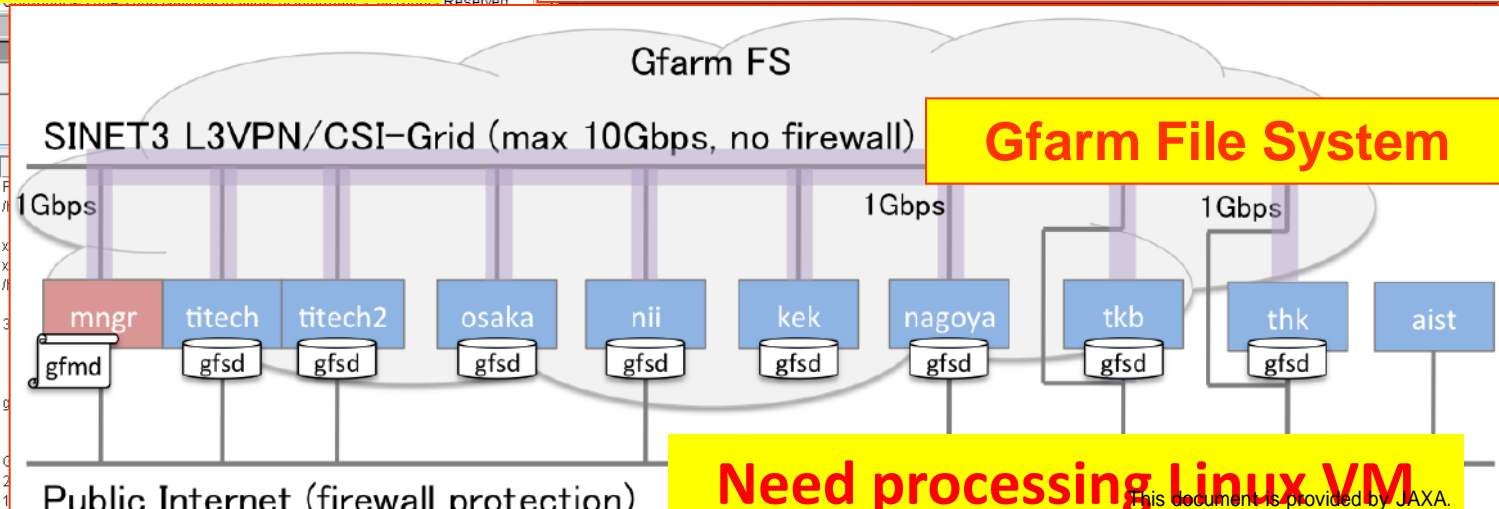
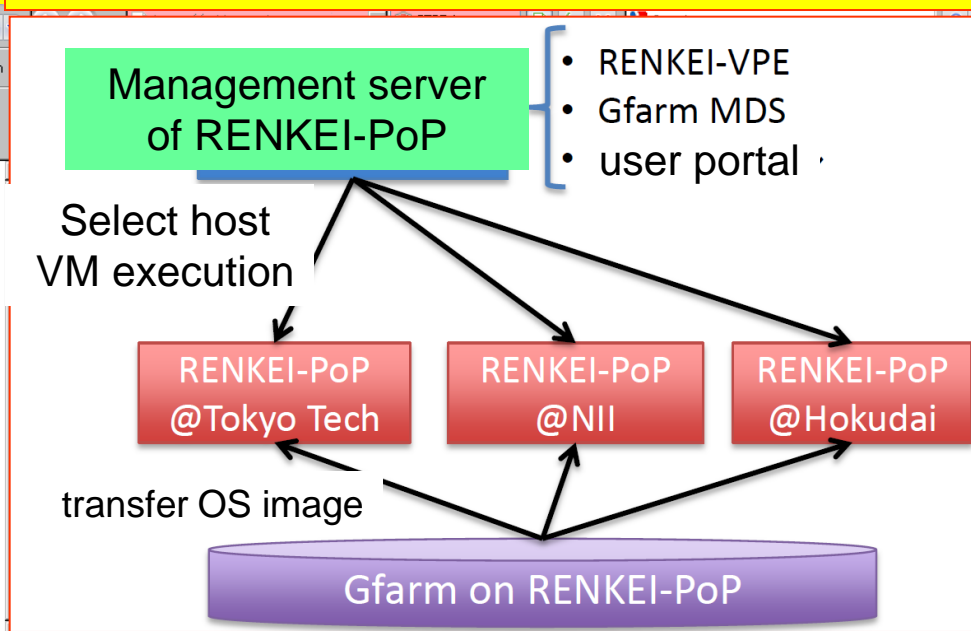
Parallel job by HX600 16node 256 cpu



Name	Detail
JobName	-
Executable	-
Argument	1
Output	-
Error	-
WorkingDirectory	-
Environment	-
WallTimeLimit	-
MemoryLimit	-
CPUTimeLimit	-
VirtualMemoryLimit	-
CandidateHosts	HostName
OperatingSystemName	-

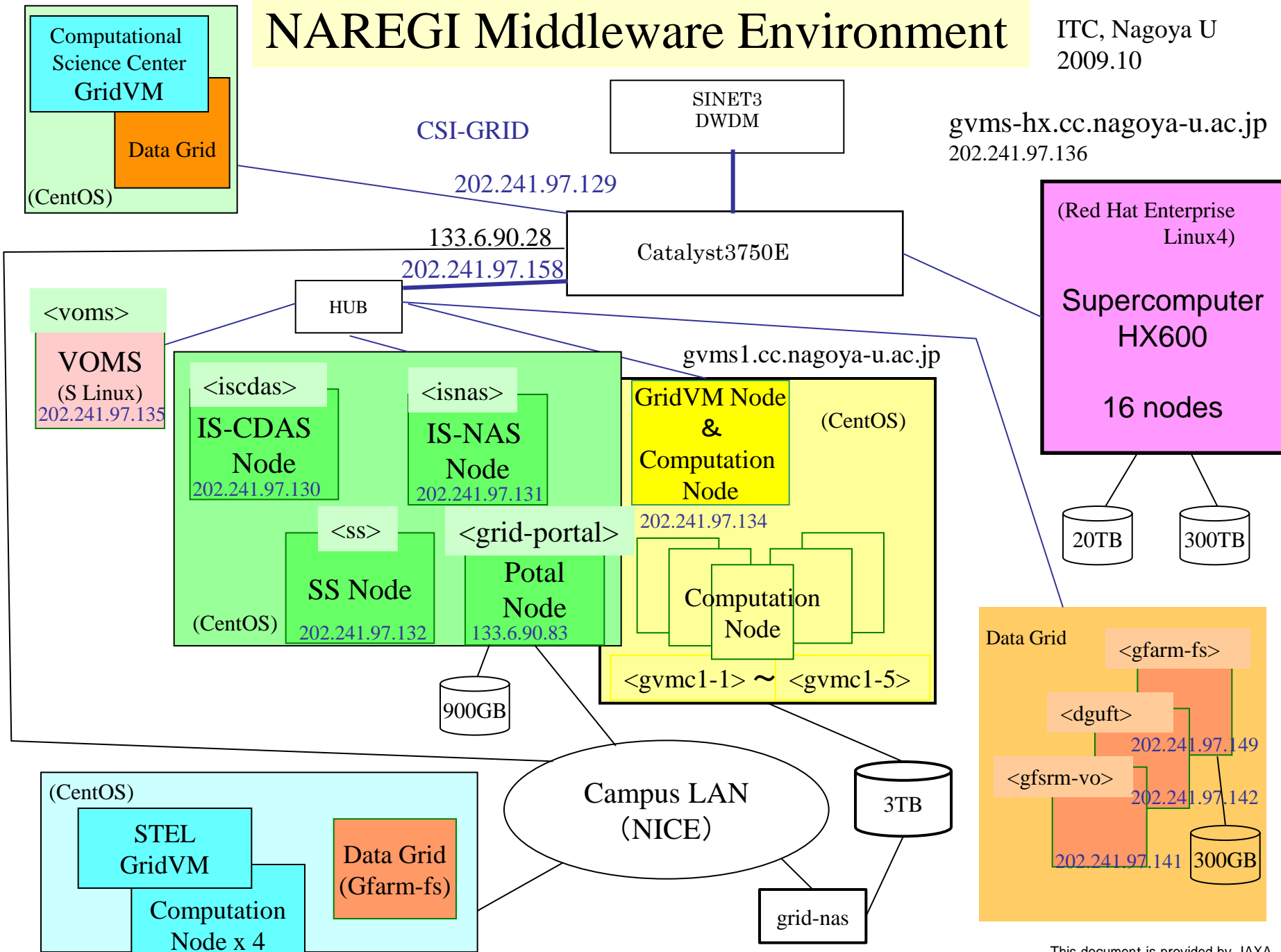
PSE of MPI job

### RENKEI-PoP and wide area file (Gfarm2)



# NAREGI Middleware Environment

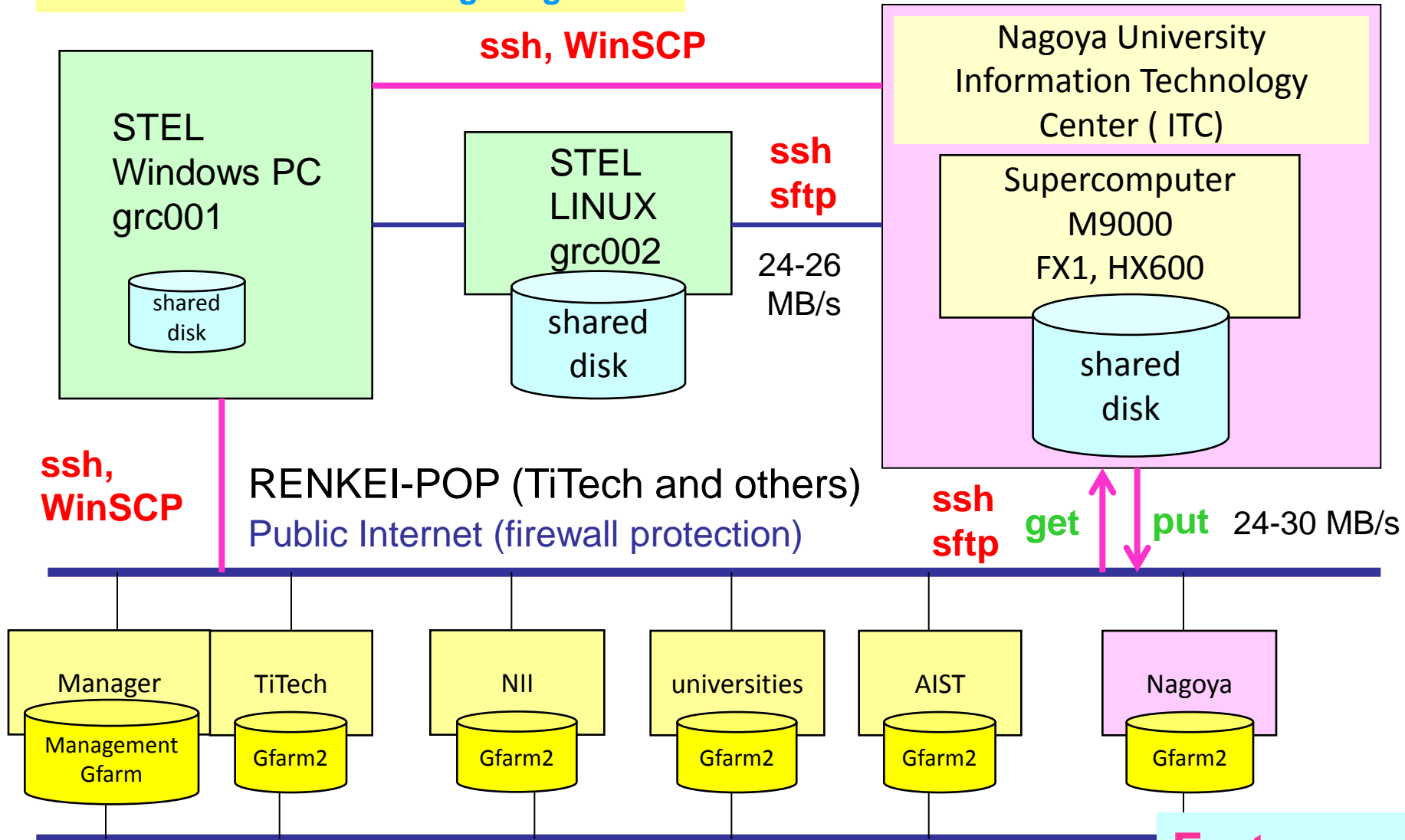
ITC, Nagoya U  
2009.10





# Use of Supercomputer and Gfarm System

## Install of Gfortran and ImageMagick



SINET3 L3VPN/CSI-Grid (no firewall) Gfarm system: 200TB

**Fortran  
compiler**

# RENKEI-PoP (Nagoya)

# Access to Nagoya U supercomputer

## RENKEI-PoP (TiTech)

## Shared disk for supercomputer

```

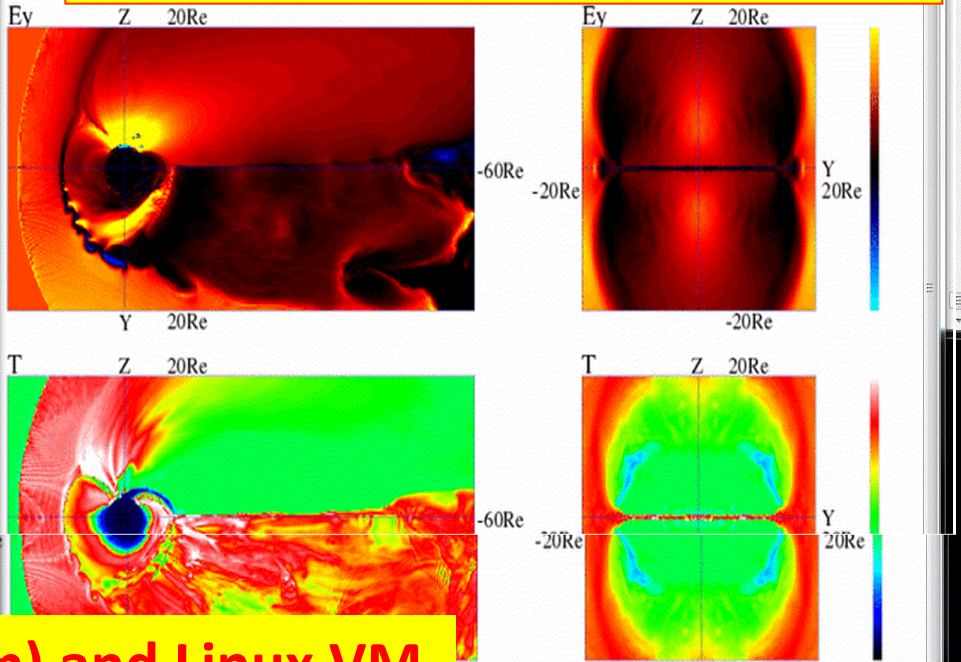
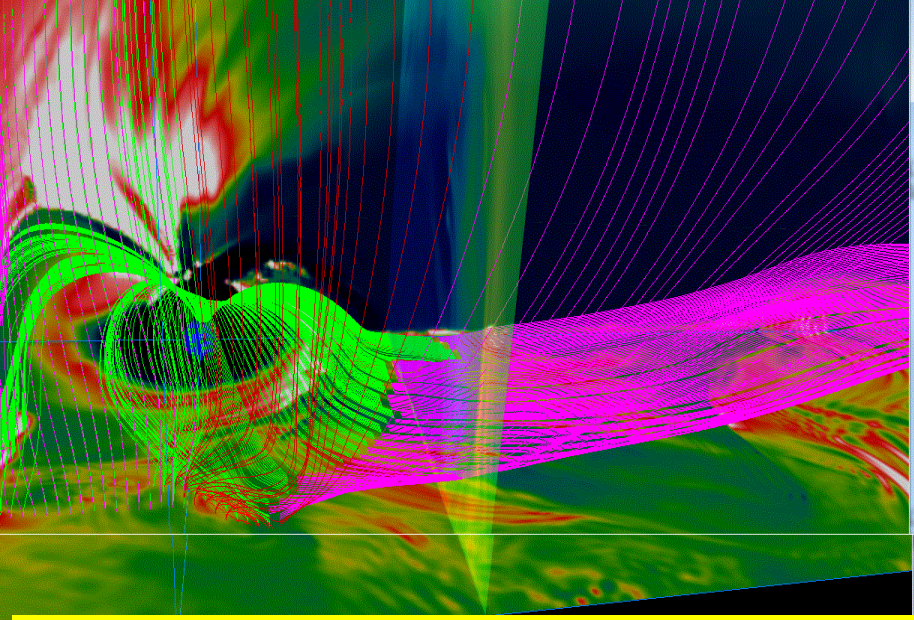
osoino@rpop-nagoya bin$ which gcc
/usr/bin/gcc
osoino@rpop-nagoya bin$ pwd
/usr/bin
osoino@rpop-nagoya bin$ pwd
/usr/bin
osoino@rpop-nagoya bin$ cd /home/osoino/gfarm/home/
osoino@rpop-nagoya eartha$ ls -l
total 48802706
-rw-r--r-- 1 osino root 4147430784 Jun 30 08:51 ed
-rw-r--r-- 1 osino root 4147430784 Jun 30 08:54 ed
-rw-r--r-- 1 osino root 4147430784 Jun 30 08:58 ed
-rw-r--r-- 1 osino root 4147430784 Jun 30 10:01 ed
-rw-r--r-- 1 osino root 4147430784 Jun 30 10:04 ed
-rw-r--r-- 1 osino root 4147430784 Jun 30 10:08 ed
-rw-r--r-- 1 osino root 4147430784 Jun 30 10:11 ed
-rw-r--r-- 1 osino root 4147430784 Jun 30 10:14 ed
-rw-r--r-- 1 osino root 4147430784 Jun 30 10:18 ed
-rw-r--r-- 1 osino root 4147430784 Jun 30 10:21 ed
-rw-r--r-- 1 osino root 4147430784 Jun 30 10:24 ed
osoino@rpop-nagoya eartha$ pwd
/home/osino/gfarm/home/osino/eartha
osoino@rpop-nagoya eartha$ cd ..
osoino@rpop-nagoya osino$ ls
eartha test1
osoino@rpop-nagoya osino$ cd test1

```

The terminal window shows the output of 'ls -l' for various files and directories, including permissions like 'drwxr-xr-x' and 'rwxr-xr-x', and file names like 'zipporce', 'zippsplit', 'zless', 'zmore', 'znew', and 'zsoelin'. The web browser window shows the 'RENKEI-PoP Portal' with a search bar and navigation links.

## 3D visualization by LINUX and graphic display by PC

## Making movie by LINUX and graphic display by PC

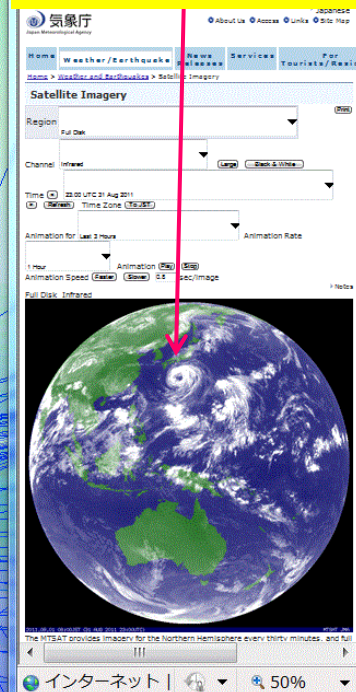


## Need wide area file system (Gfarm) and Linux VM

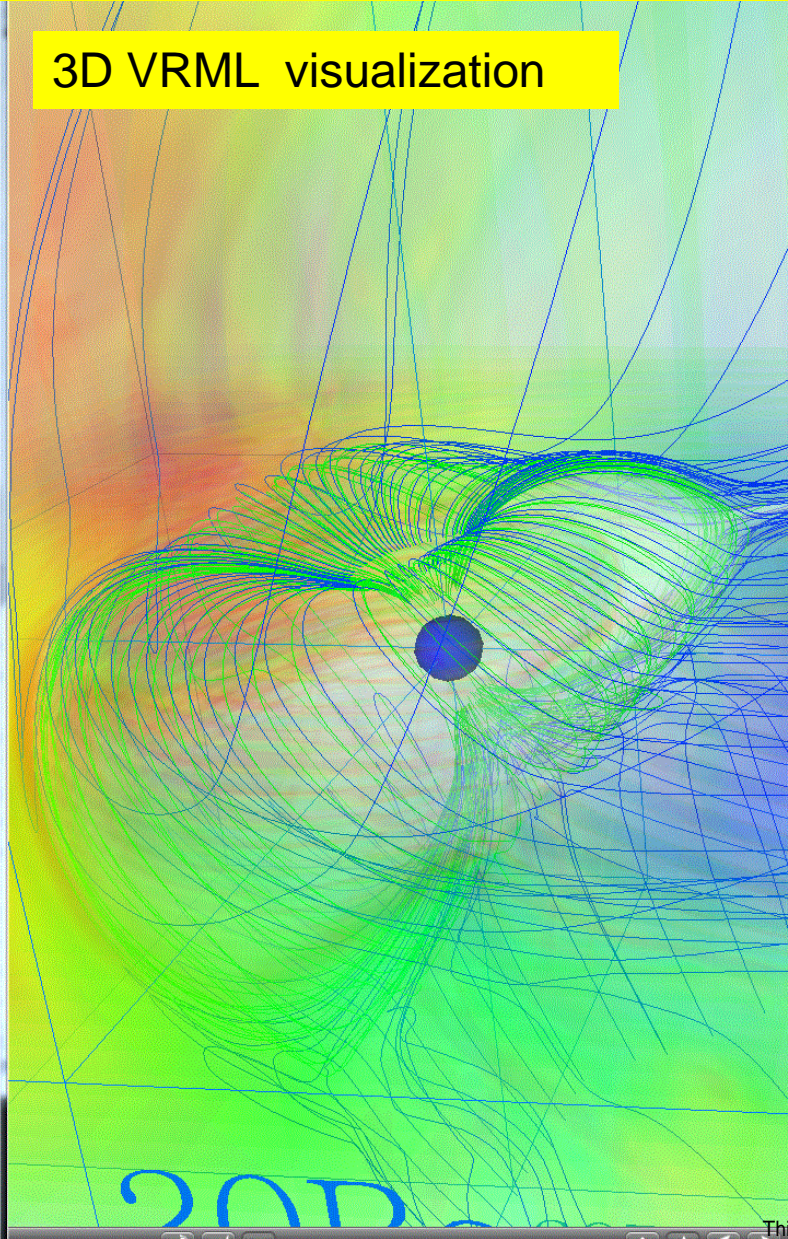


# All processes can be done in RENKEI-PoP Gfarm

## Typhoon 12 Sep. 2, 2011

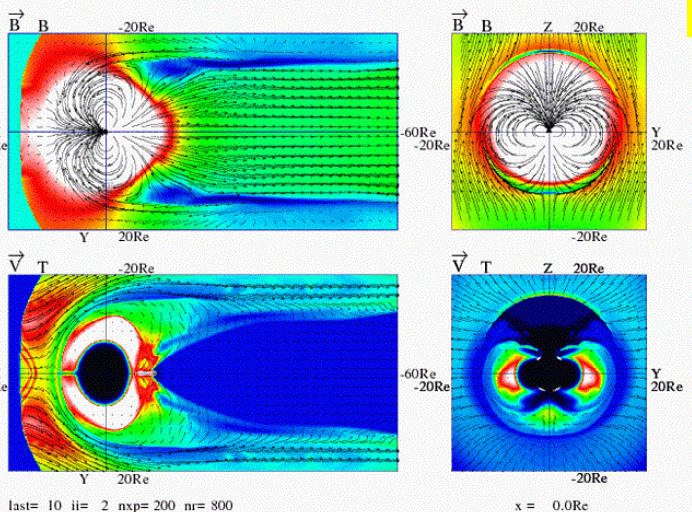


### 3D VRML visualization



### Animation movie of simulation

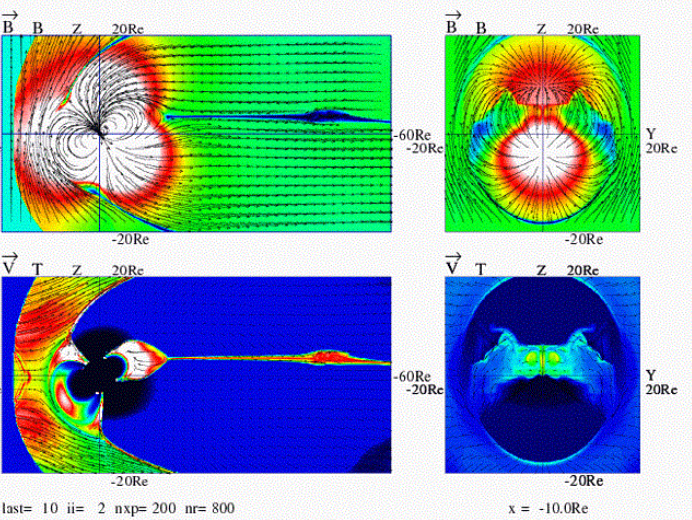
Tilt= 30 deg IMF=10.0 nT (90 deg) T= 202 min



無題 2

### MHD Simulation of Dipole Tilt in Magnetosphere

Tilt= 30 deg IMF=10.0 nT (90 deg) T= 202 min



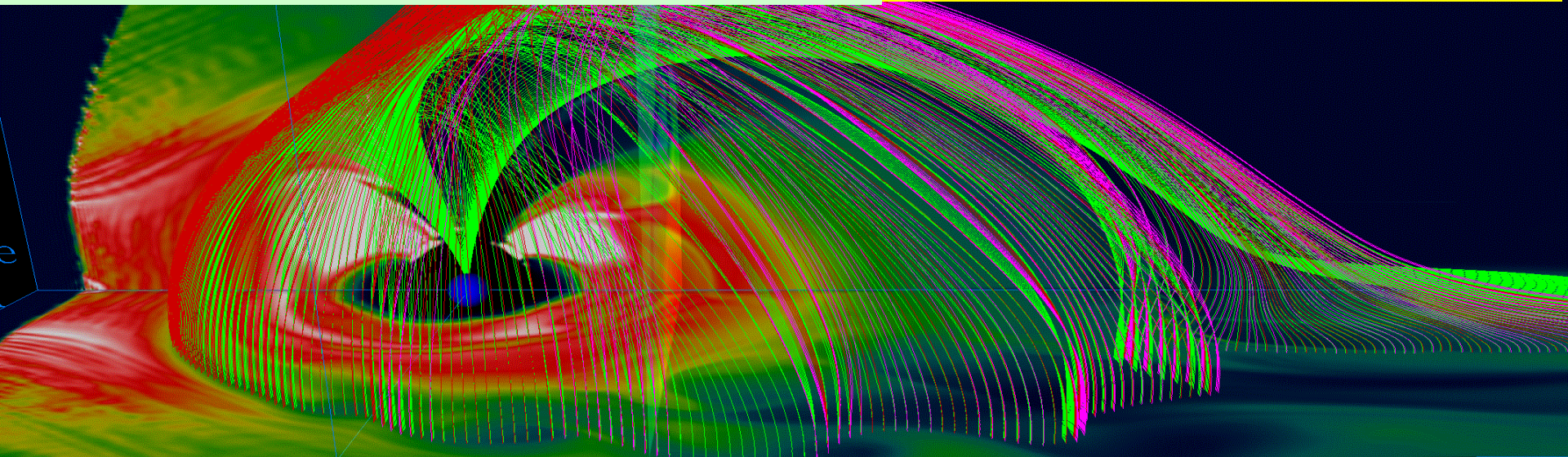
無題 1



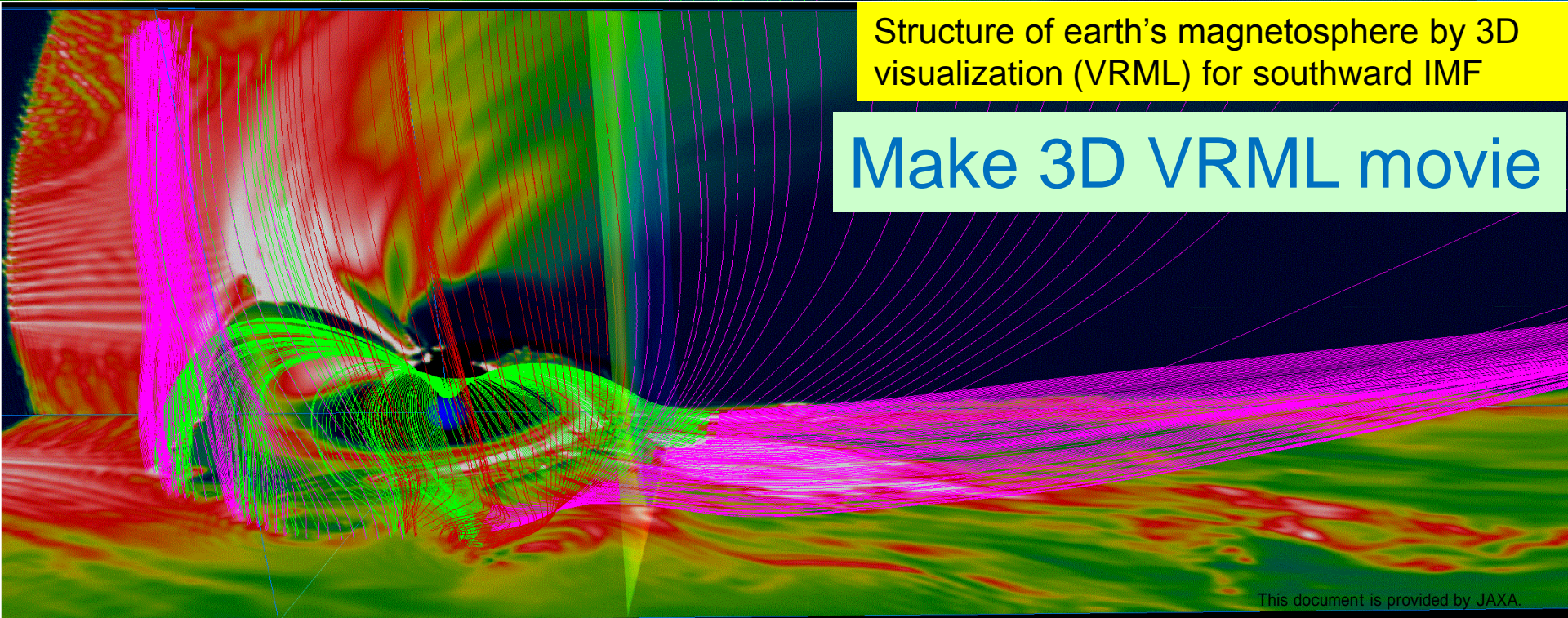


# High Resolution MHD Simulation

Structure of earth's magnetosphere by 3D visualization (VRML) for northward IMF



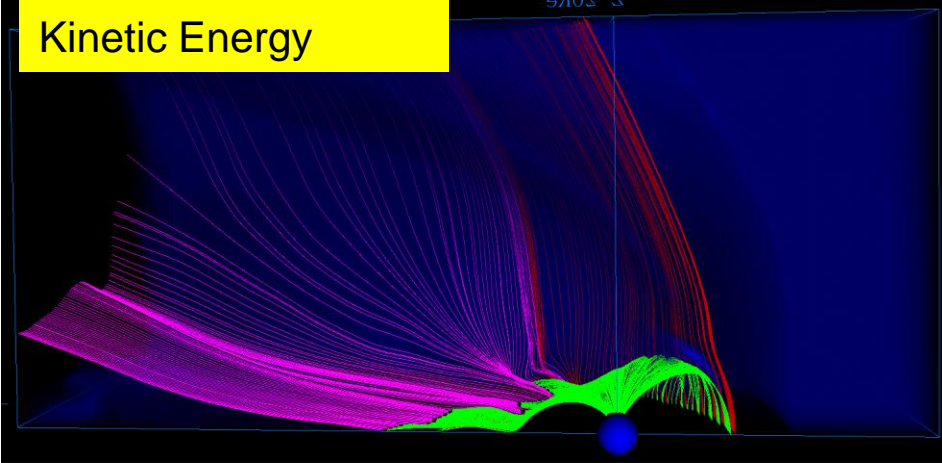
Structure of earth's magnetosphere by 3D visualization (VRML) for southward IMF



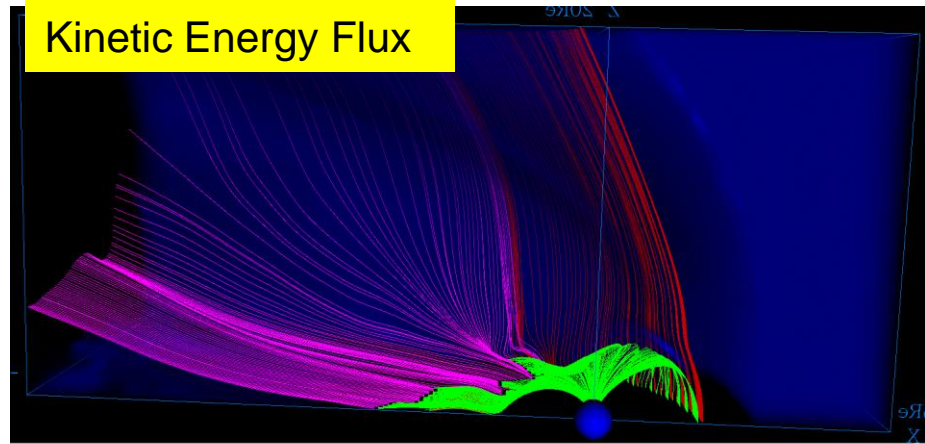
Make 3D VRML movie



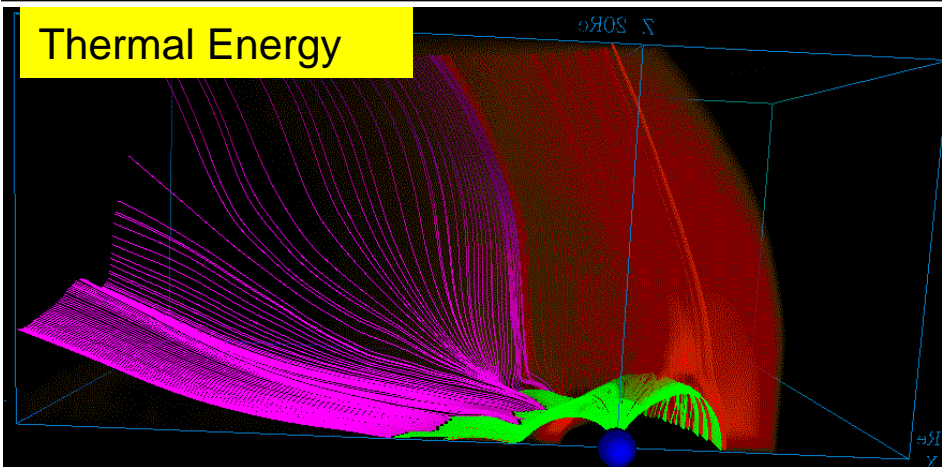
Kinetic Energy



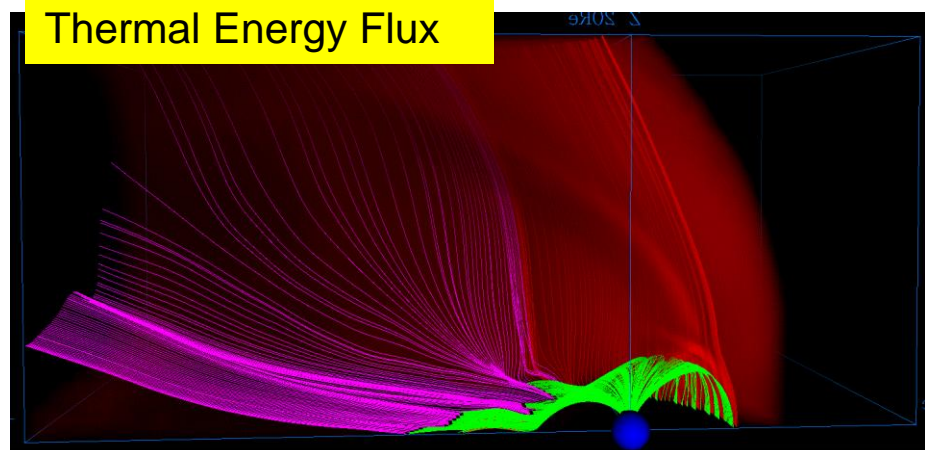
Kinetic Energy Flux



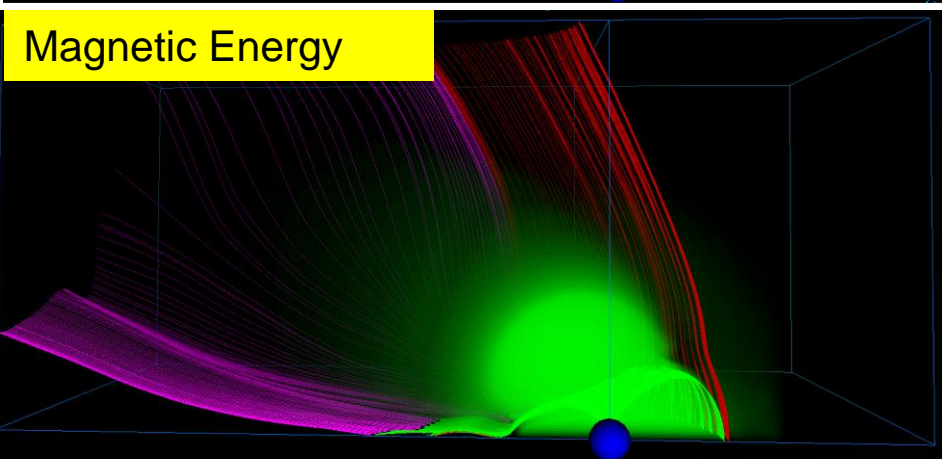
Thermal Energy



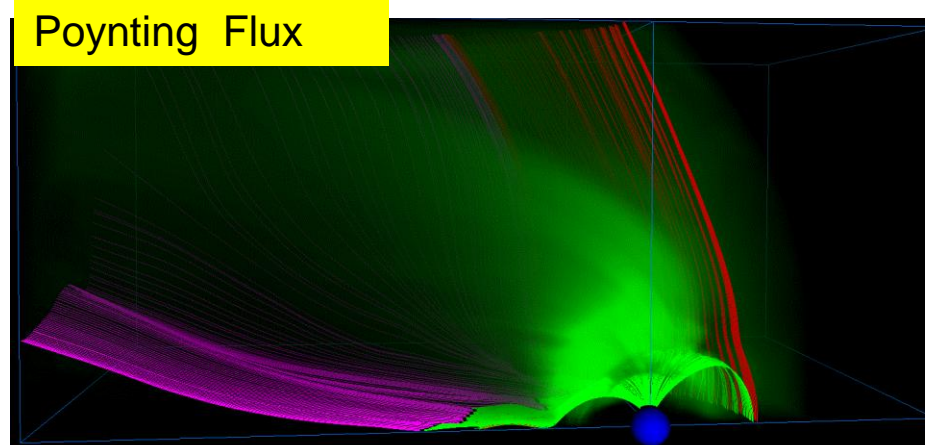
Thermal Energy Flux



Magnetic Energy



Poynting Flux





# Procedure of Simulation and Processing

1. **Execute computer simulation** on earth's magnetosphere by Nagoya supercomputer (FX1, HX600, M9000).
2. **File transfer of simulation data from supercomputer shared disk to RENKEI-PoP Gfarm** (wide area storage system, Gfarm2) with sftp. (use secret/public key system, then carry out file transfer by "put file-name")
3. **Data processing and graphics** (including 3D visualization) by a LINUX machine **in RENKEI-PoP system** with our **own Fortran program**. (make PostScript graphic files and change gif files by gfortran program and ImageMagick, make 3D VRML graphic files by gfortran program)
4. **Get output graphic files from RENKEI-PoP Gfarm** to Windows PC with WinSCP and display on PC.

# Importance of Integration with Software to Use Advanced IT Infrastructure

**Supercomputer**  
**Next-Generation, K-computer**

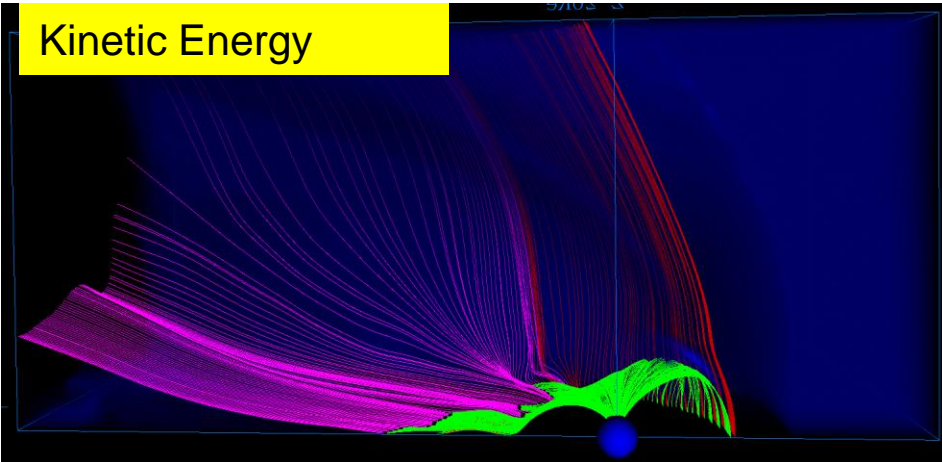
**Geospace Science Clouds**  
**Integration (PSE, Workflow, Network)**

**High Speed Network**  
SINET3, JGN-X  
1 Gbps, 10 Gbps

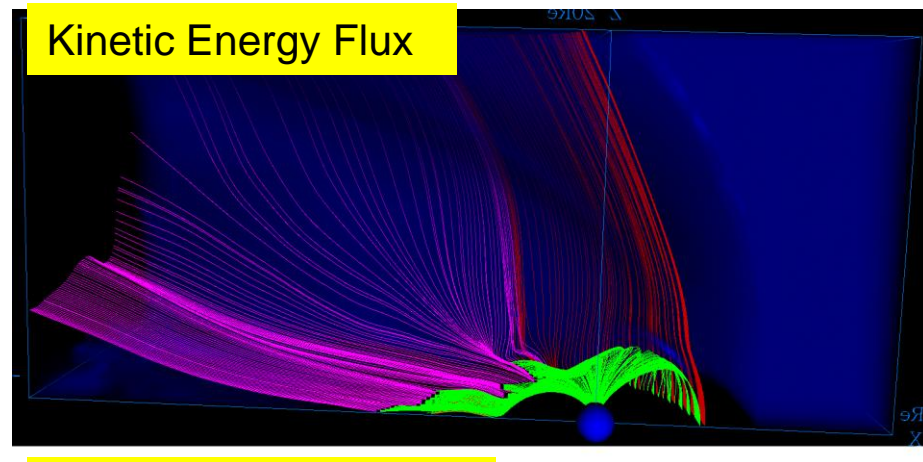
**Wide Area File System**  
Gfarm

**We can use it with Linux with Fortran compiler.**

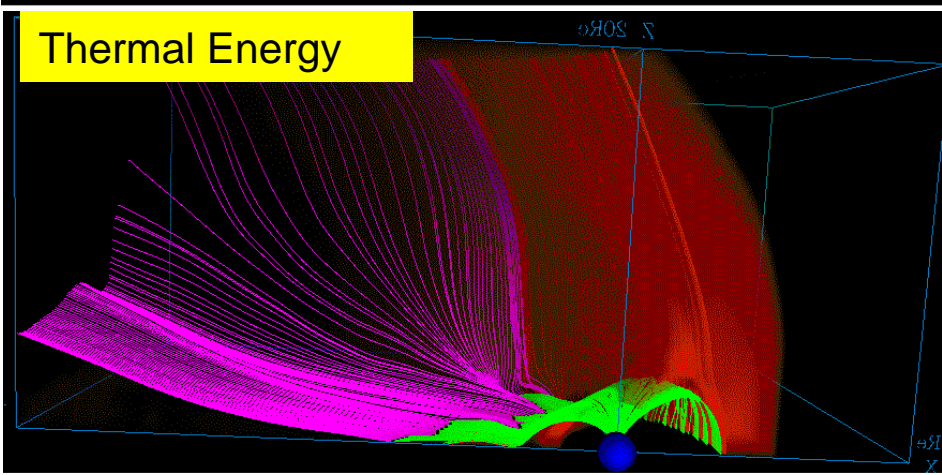
Kinetic Energy



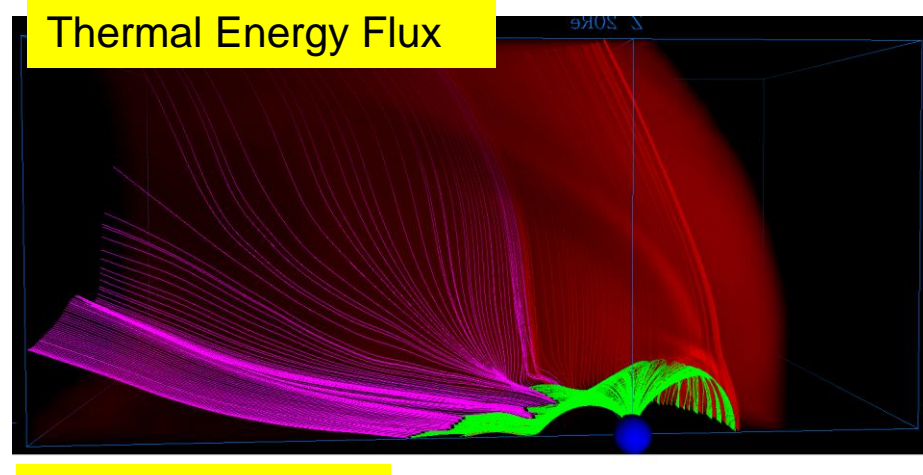
Kinetic Energy Flux



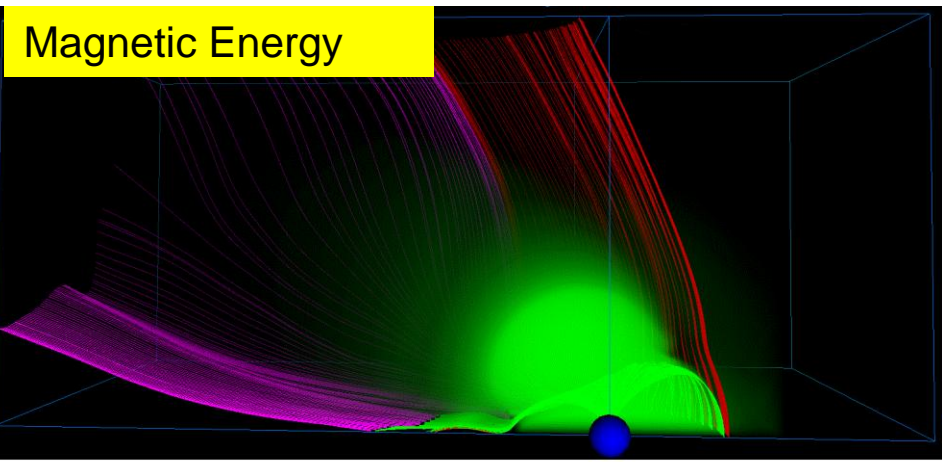
Thermal Energy



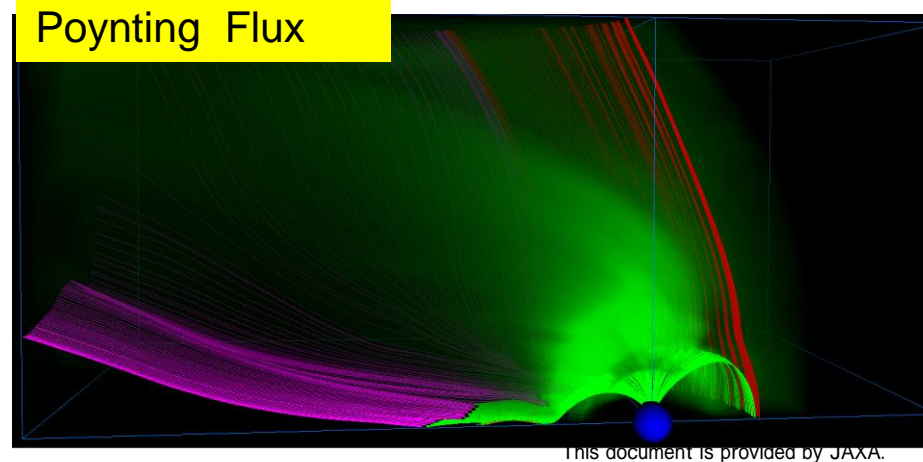
Thermal Energy Flux



Magnetic Energy



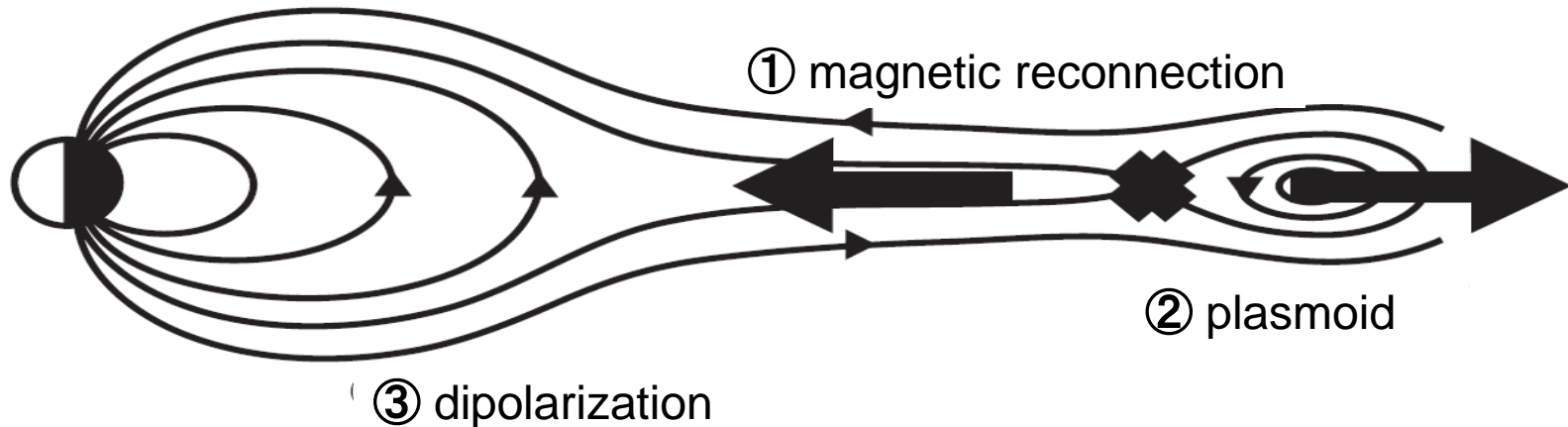
Poynting Flux



# Dynamics in Plasma Sheet

Plasma sheet has high temperature and Mach number  $< 1$ .

Thermal flux (TF) is greater than kinetic flux (KF) in plasma sheet.



- Magnetic flux returns from tail to dayside by Poynting Flux (PF).
- As a position approaches from reconnection point to the earth, KF changes to TF, and then to PF, which carries energy from tail to dayside magnetosphere.

$$\mathbf{KF} + \mathbf{TF} + \mathbf{PF} = \frac{1}{2} v^2 \mathbf{v} \rho + \frac{\gamma}{\gamma - 1} p \mathbf{v} + \mathbf{E} \times \mathbf{B}$$

$$\frac{\partial}{\partial t} \left( \frac{1}{2} v^2 \rho + \frac{1}{\gamma - 1} p + \frac{1}{2} B^2 \right) + \nabla \cdot \left( \frac{1}{2} v^2 \mathbf{v} \rho + \frac{\gamma}{\gamma - 1} p \mathbf{v} + \mathbf{E} \times \mathbf{B} \right) = 0$$