

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

Tatsuki Ogino and Takayuki Umeda
Solar-Terrestrial Environment Laboratory,
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)

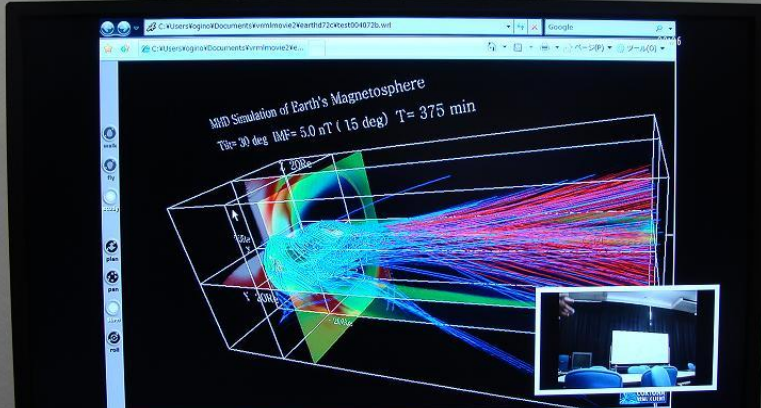
Data Grid

VO (Virtual Organization)

Basic Study for Geospace Virtual Observatory/Virtual Organization

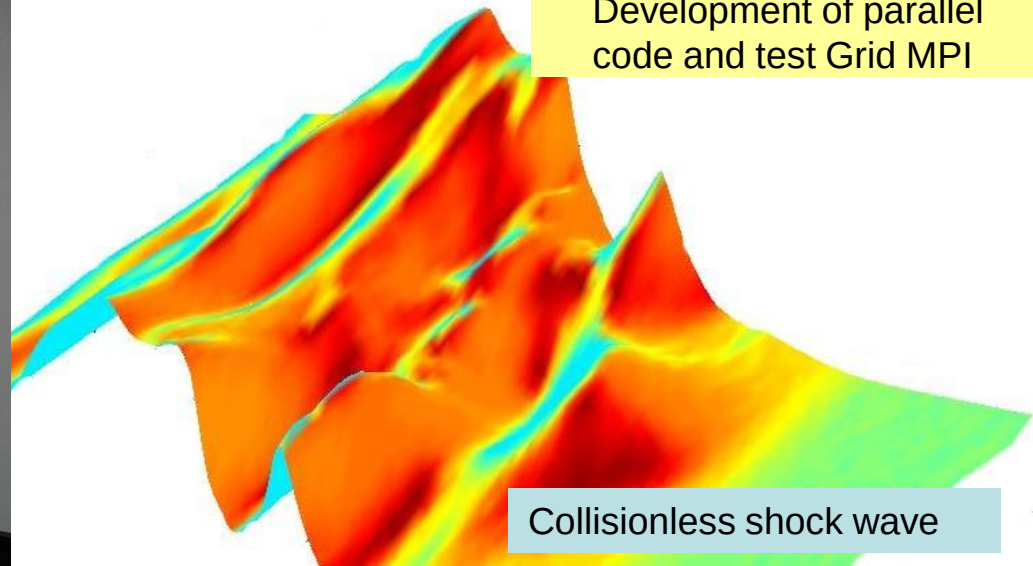
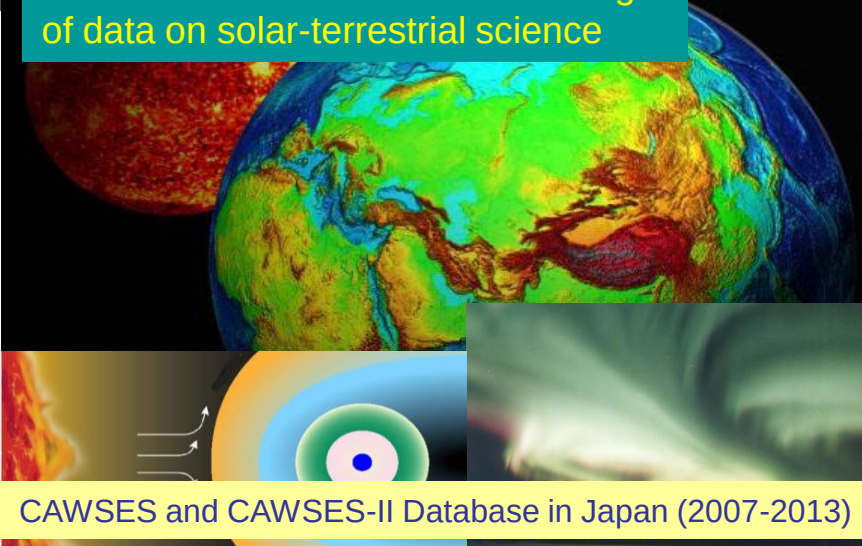
STEL and ITC of Nagoya University

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

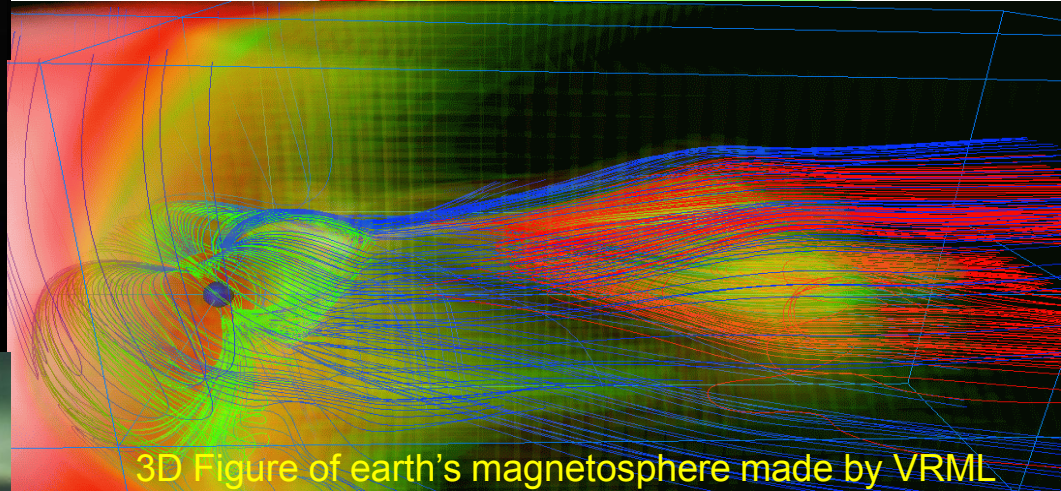


Transfer test of 3D movie (STEL, Nagoya u)

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



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

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

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

Processing and graphics of simulation data with NAREGI Grid Portal

NAREGI
National Research Grid Initiative
Center for GRID Research and Development NII - National Institute of Informatics

NAREGI Grid Portal

Grid Tools

User: stel1
VO: nagoya-vo1, Group: , Role: DefaultRole
Proxy Certificate Expiration: Fri May 15 2009 15:13:14 +0900

Information Service Open
Grid PSE Open
Grid Workflow Tool Open
Grid Visualization System Open
Data Grid Environment Open

Workflow Tool - Windows Internet Explorer

Job List Upload Download

Folder
folder-1
folder-2
ogino-1

Workflow Sequential diagram

lorentz01 earthb01

earthb01 : Workflow Editor [VO=nagoya-vo1, Group=nagoya-vo1, Role=DefaultRole, User=stel1]

File Edit View Window

Fortran program

Output of PostScript Graphic file from simulation data input

Graphics file conversion

Conversion from ps file to gif file

Edition of movie

Make Gif movie file Register on Data Grid

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

Datagrid Access Management System

User: stel1
VO: nagoya-vo1

File Browser
[Add Host View]
[Import Local File]
Transfer Job List
[Select Status]
Gfarm
[Search for Metadata]
[User Information]
[Gfarm Node]
[User List]
Return Menu

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

C:\Documents and Settings\Administrator\Local Settings\Temporary Internet Files\Content.IE5\G9M... - Windows Internet Explorer

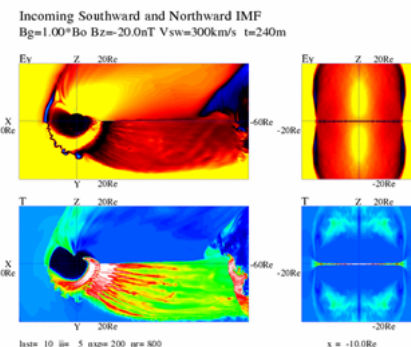
NAREGI Datagri...

Movie file displayed On Grid Portal

Input of simulation data

Execution of Fortran program

Display of movie on NAREGI Grid Portal



Execution with NAREGI Grid Portal and Graphics with Data Grid

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

NAREGI Grid Portal

NAREGI
National Research Grid Initiative
Center for GRID Research and Development NII - National Institute of Informatics

Grid Applications
Grid Middleware
Networking
NAREGI

NAREGI Grid Portal

Sign Out
Grid Tools

User: steli
VO: nagoya-vo1, Group: , Role: DefaultRole
Proxy Certificate Expiration: Fri Apr 17 2009 15:11:32 +0900

UserManagementServer

Login
Proxy Certificate Registration
Certificate Issue / Renewal
Password Change

Information Service Open
Grid PSE Open
Grid Workflow Tool Open
Grid Visualization System Open
Data Grid Environment Open

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D:\imports\earthb1\vrml01\wfor5360.wrl - Windows Internet Explorer

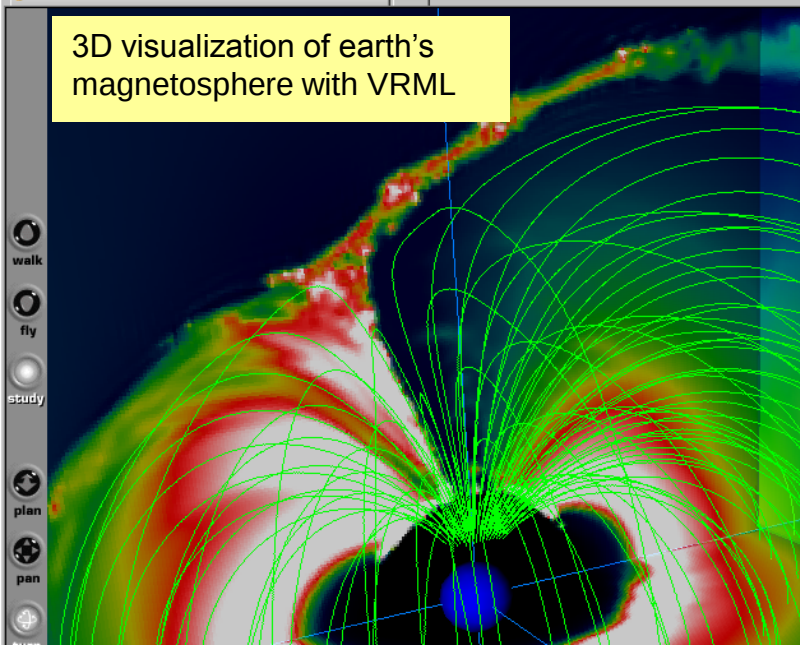
D:\imports\earthb1\vrml01\wfor5360.wrl

ファイル(E) 編集(E) 表示(V) お気に入り(A) ツール(T) ヘルプ(H) x Google g

お気に入り おすすめサイト HotMail の無料サービス Yahoo! JAPAN Web スライス ギャラリー

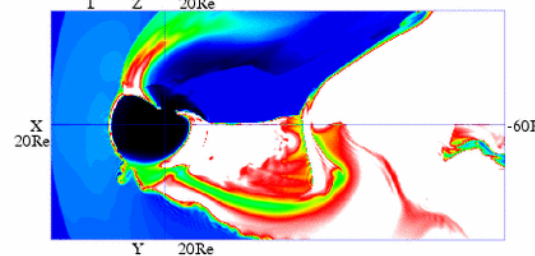
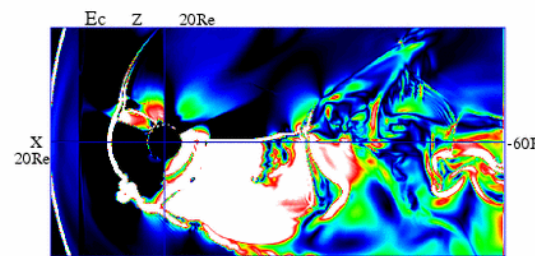
D:\imports\earthb1\vrml01\wfor5360.wrl

3D visualization of earth's magnetosphere with VRML

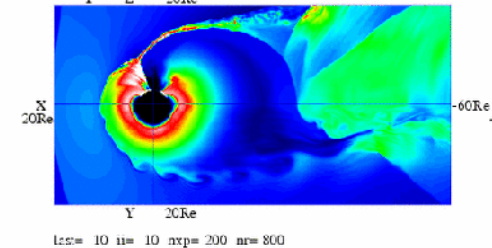
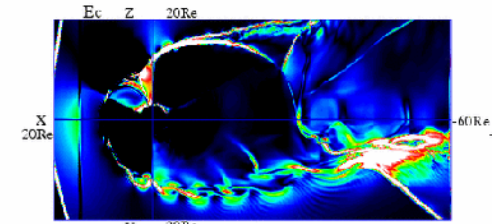


Animation Movie of Earth's Simulation data

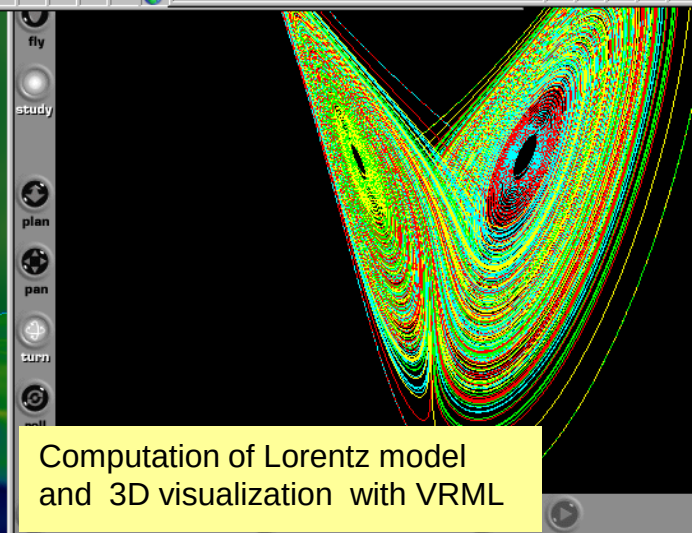
Magnetosphere of Hot Jupiter (Dsw=346.5nPa
Bg=1.00*Bo Bz=-20.0nT Vsw=300km/s t= 57m



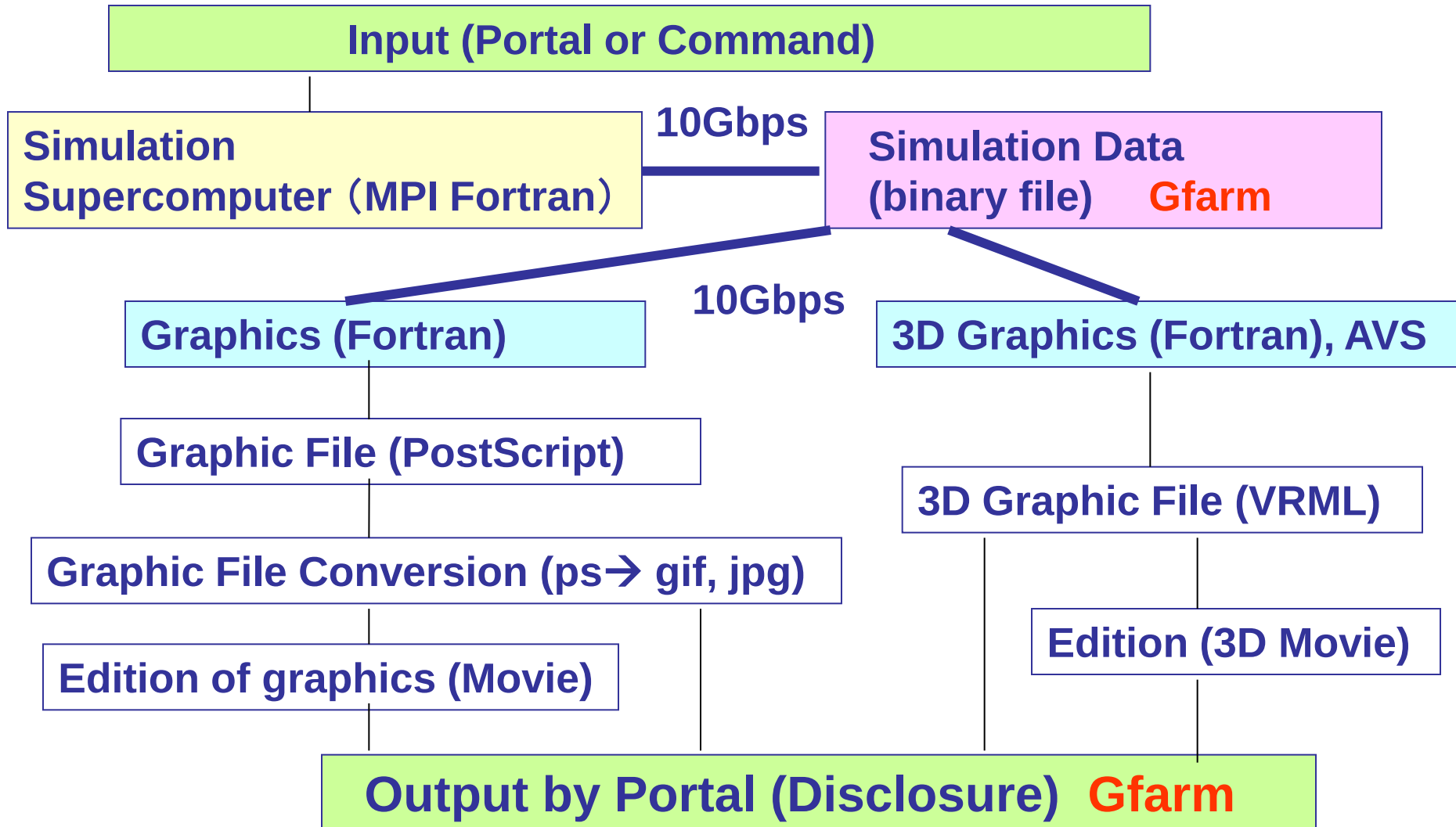
Magnetosphere of Hot Jupiter (Dsw=346.5nPa
Bg=1.00*Bo Bz= 20.0nT Vsw=300km/s t=479m



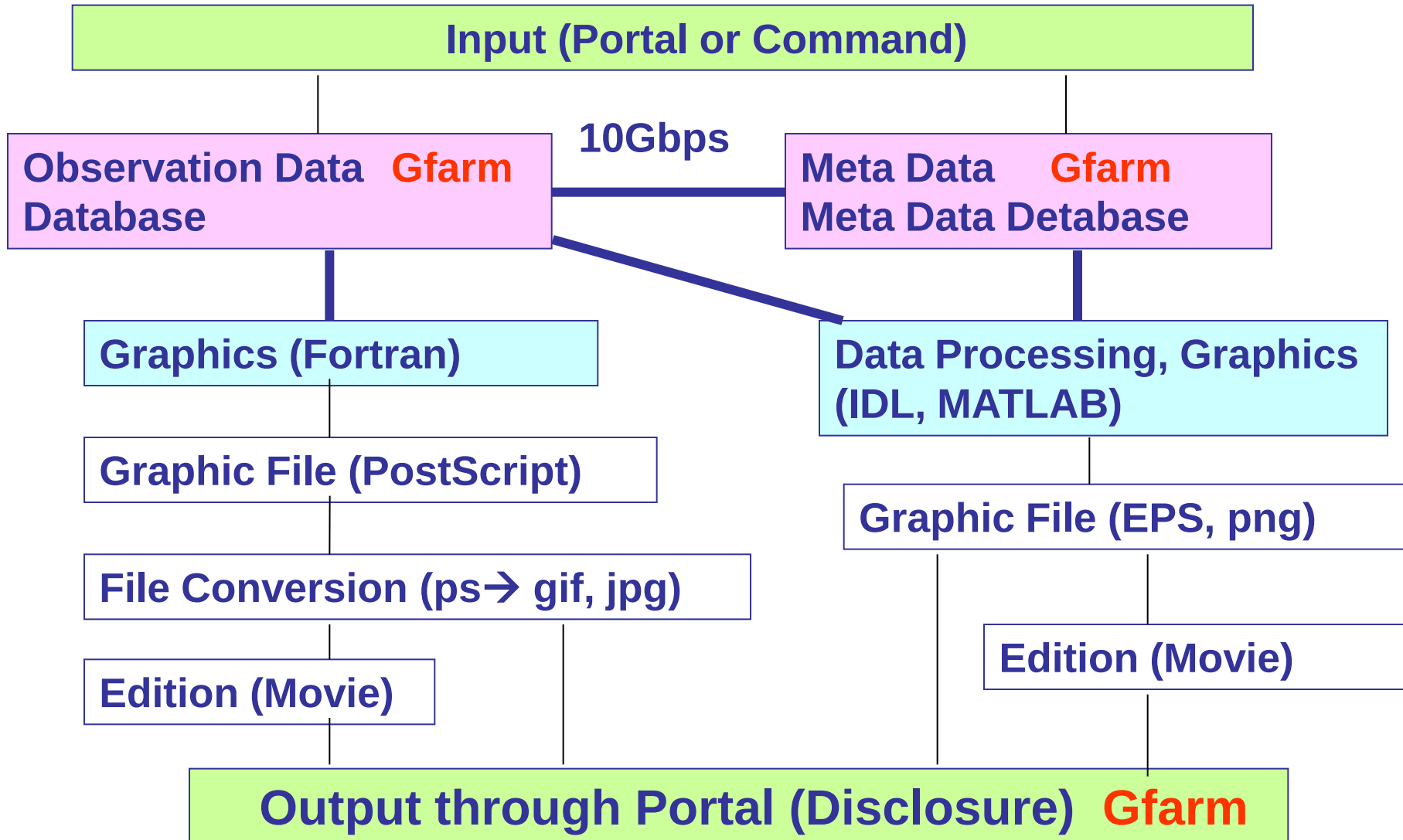
Computation of Lorentz model
and 3D visualization with VRML



Integration of Simulation Workflow (Network)



Observation Data Workflow (Network)



Data/Graphics Processing

Network: Process and Data on Screen + Pick Up

Original Data

Time sequential data

Pre-Processing

Data Pre-Processing

Window

Hanning, Hanning windows

FFT

Real and Imaginary Parts

Power Spectrum

Amplitude, phase (phase velocity)

Graphics Presentation

Linear, Logrizm

NASA
PDS

Screen Presentation of Process and Results and Pick Up One

New Trends on Advanced IT Usage

Supurcomputer
Next-age Supercomputer

Clouds, Grids

High-Speed Network

SINET3, JGN-X

1 Gbps, 10 Gbps

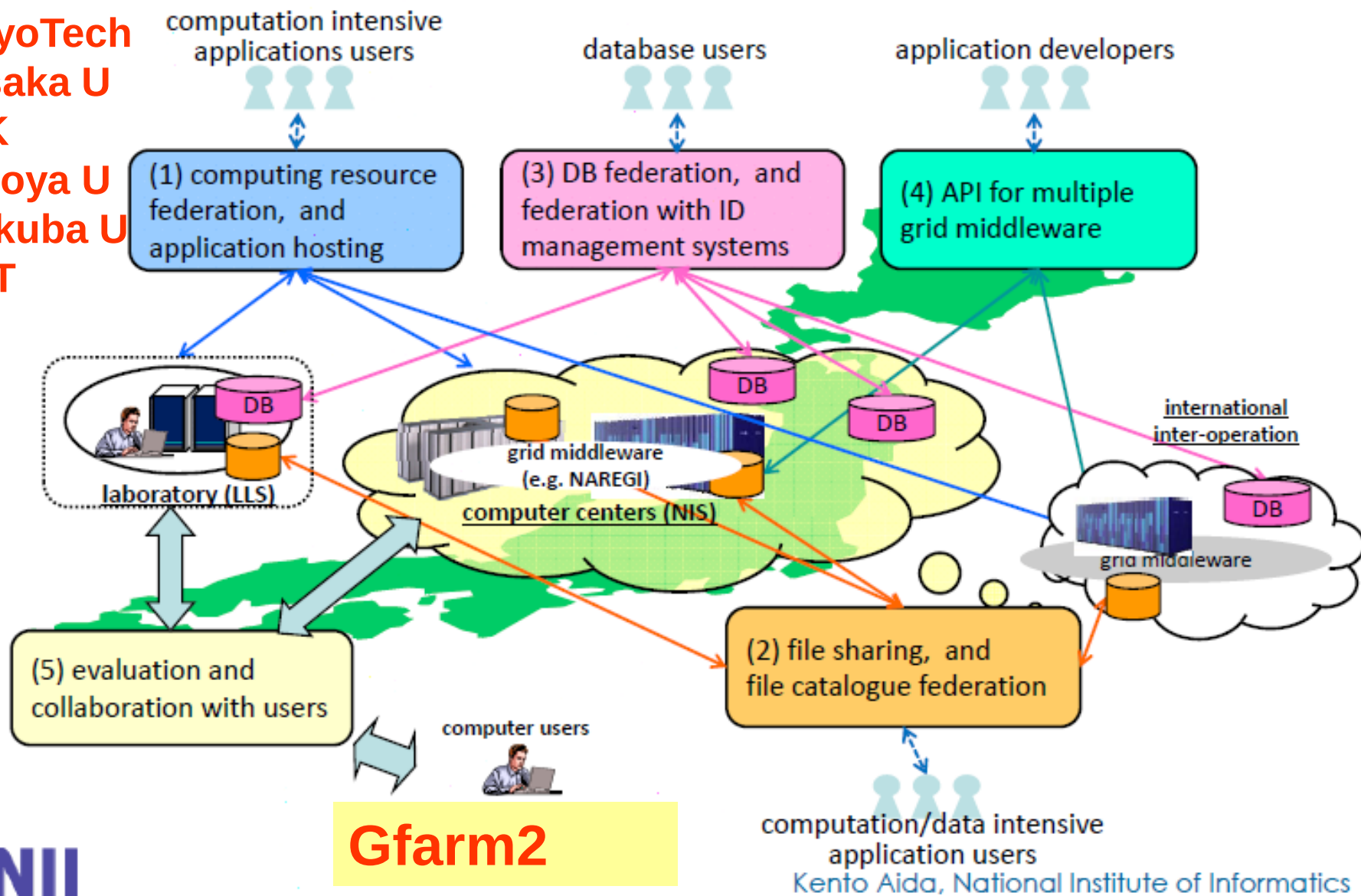
**Wide Area File
System**

Gfarm

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

REsources liNKage for E-science (RENKEI)

NII +
TokyoTech
Osaka U
KEK
Nagoya U
Tsukuba U
AIST

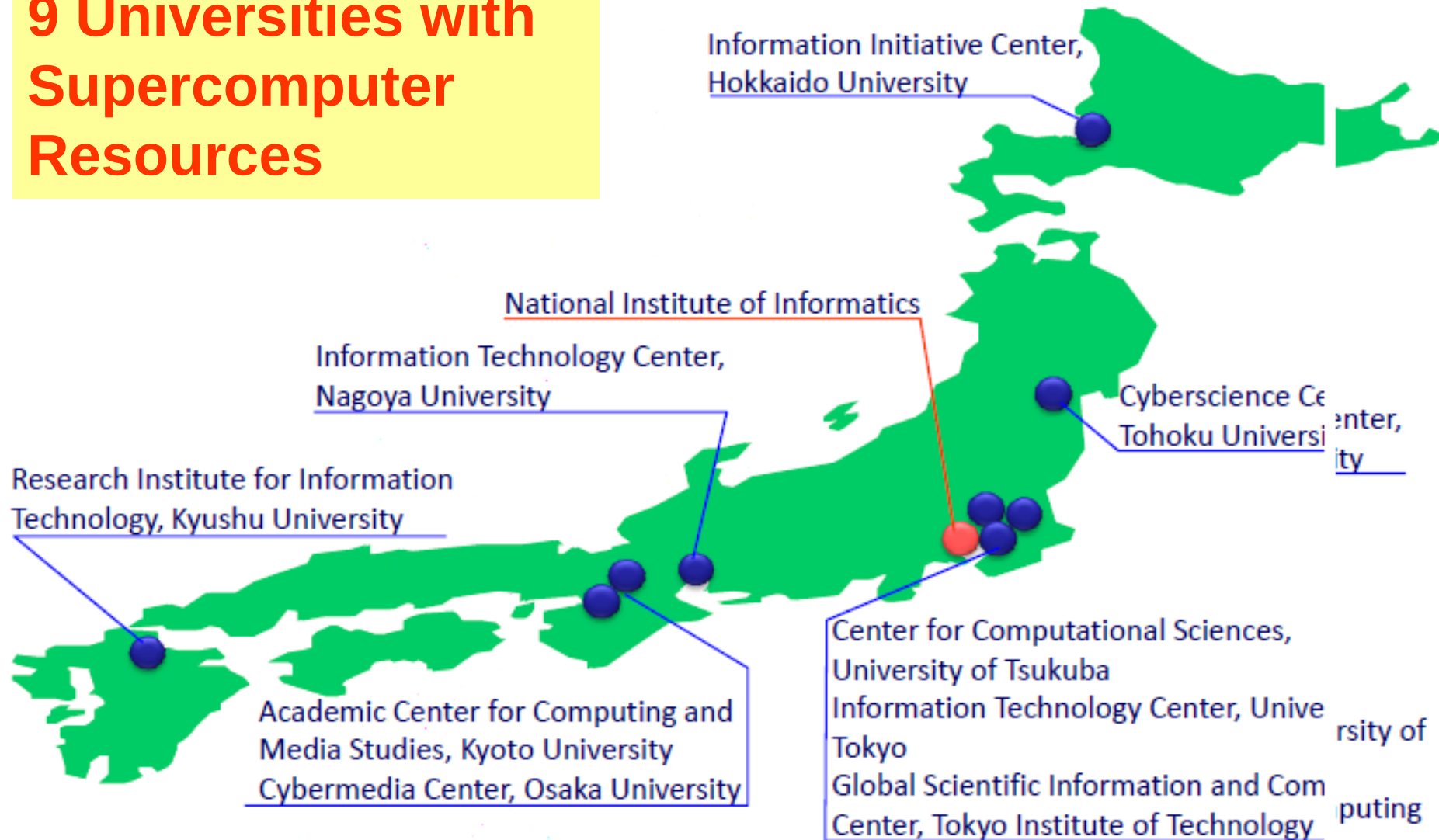


NII + 9 Universities with Supercomputer Resources

Sites

CSI GRID

8



Gfarm storage system

Kento Aida, National Institute of Informatics

Computing Systems in CSI → HPCI

CSI Grids

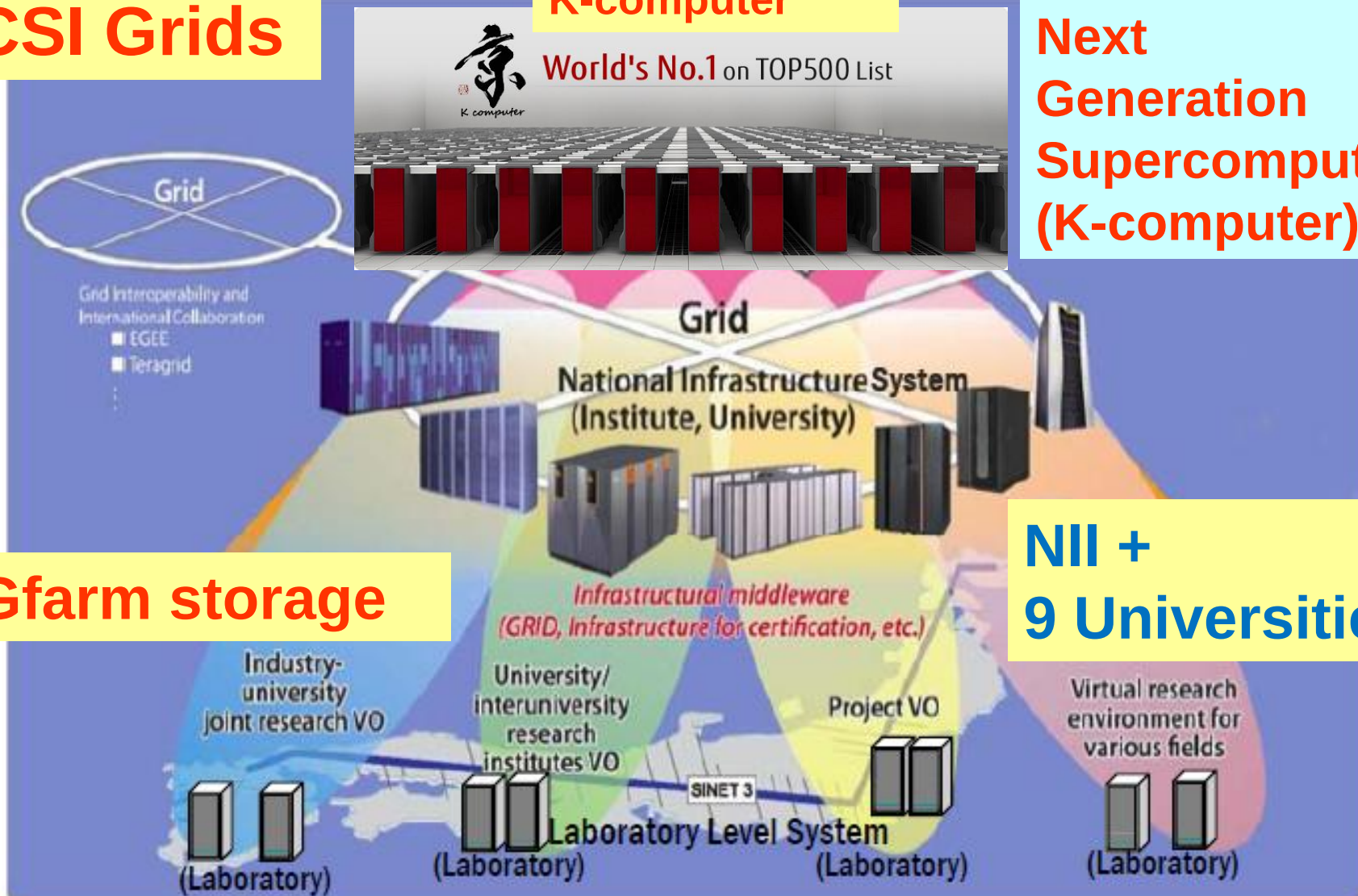
K-computer

World's No.1 on TOP500 List

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

Gfarm storage

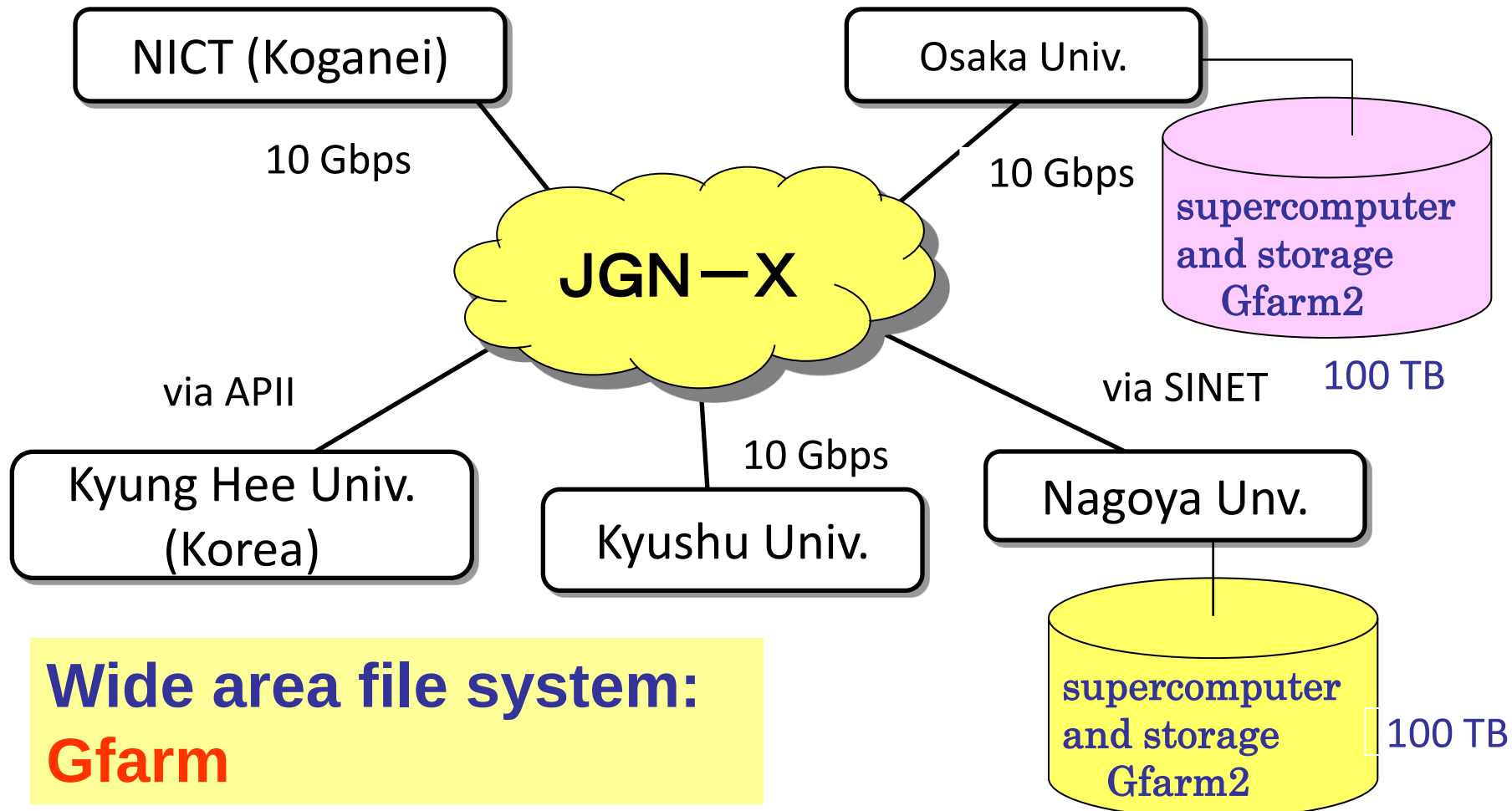
**NII +
9 Universities**



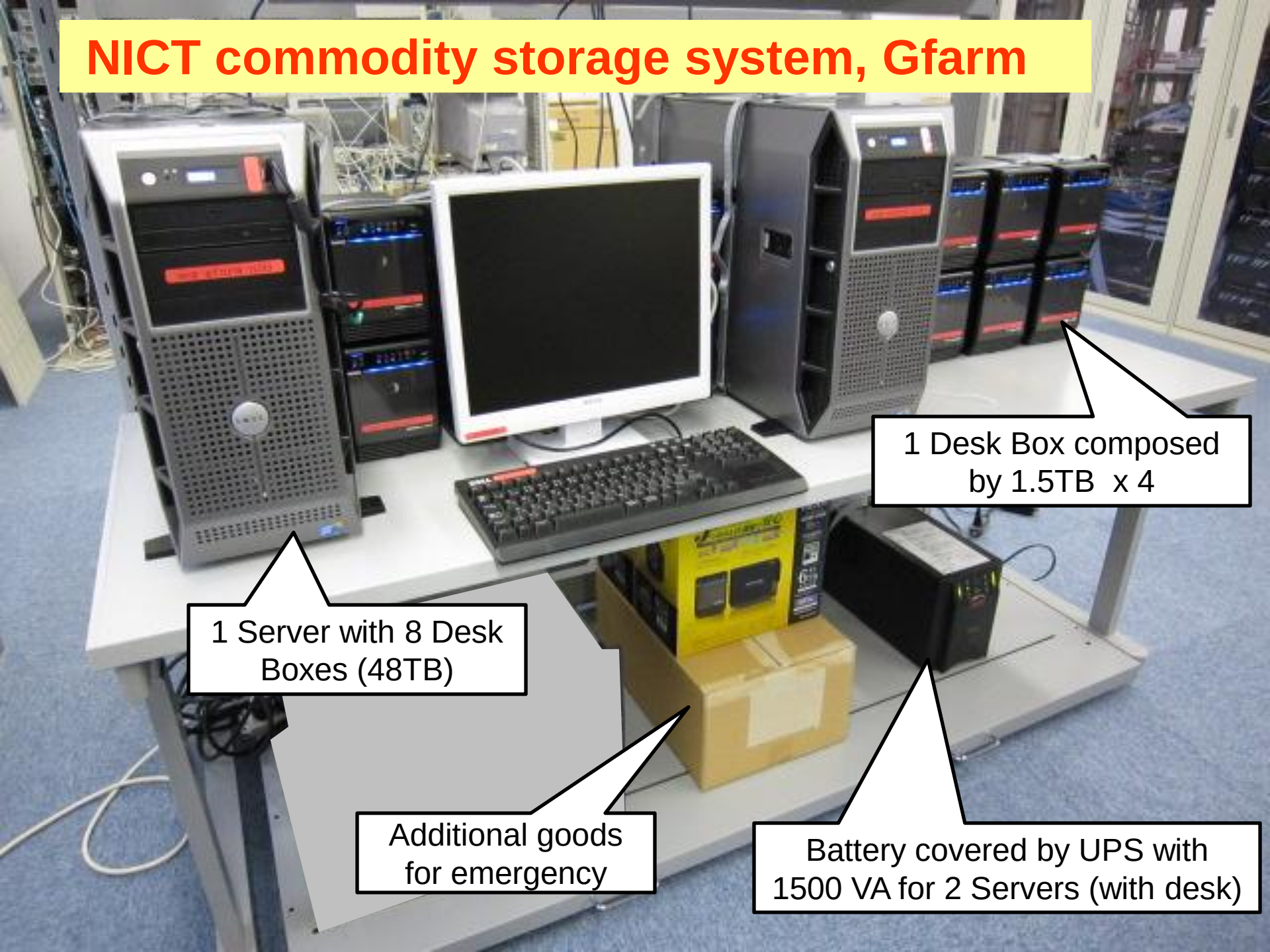
Network Topology of JGN-X

NICT OneSpaceNet (10 Gbps)

Construction of
geospace science clouds



NICT commodity storage system, Gfarm



1 Server with 8 Desk Boxes (48TB)

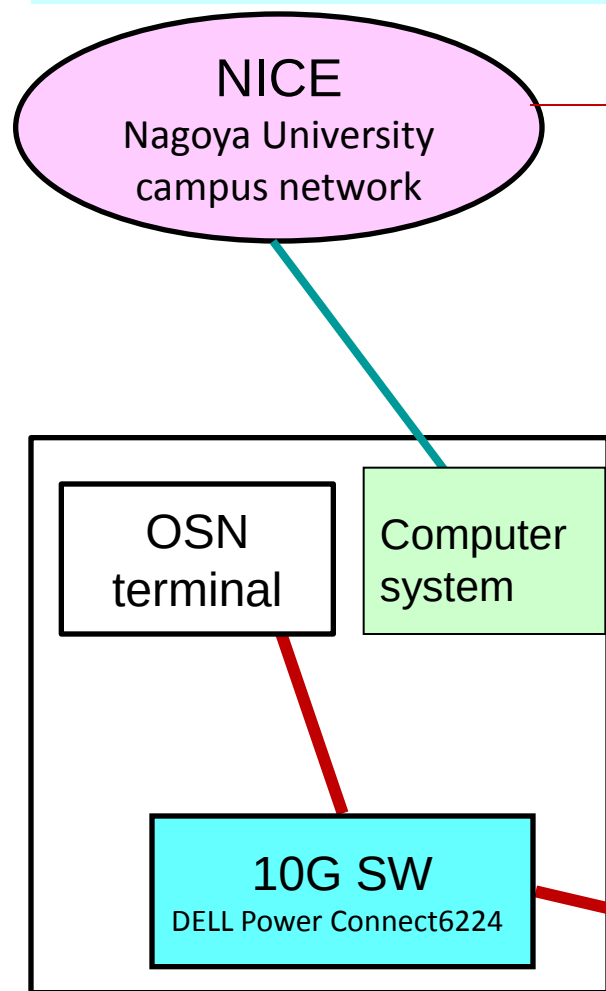
1 Desk Box composed by 1.5TB x 4

Additional goods for emergency

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

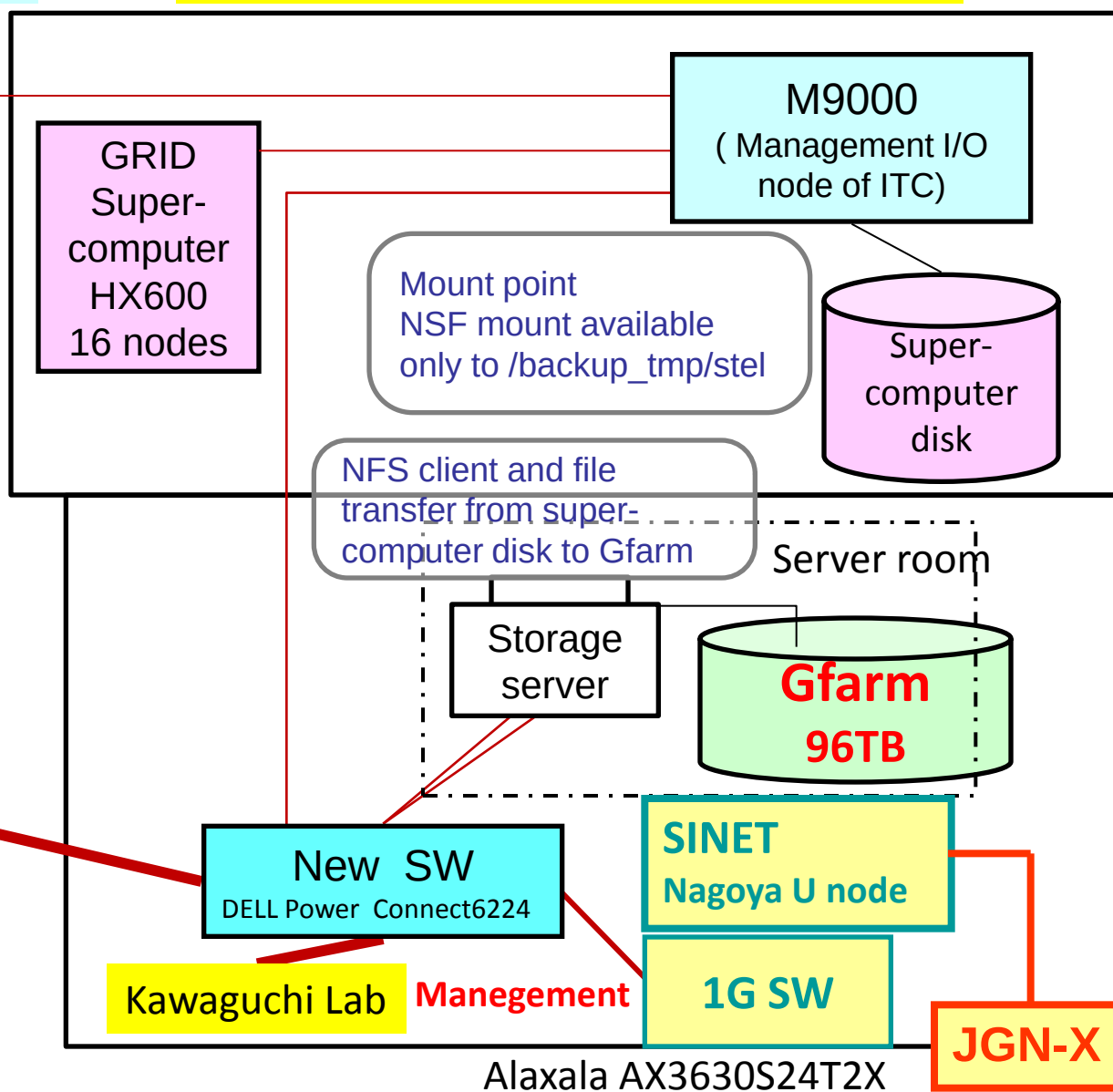
NICT OneSpaceNet – in Nagoya University (2011/08/26)

Science Clouds



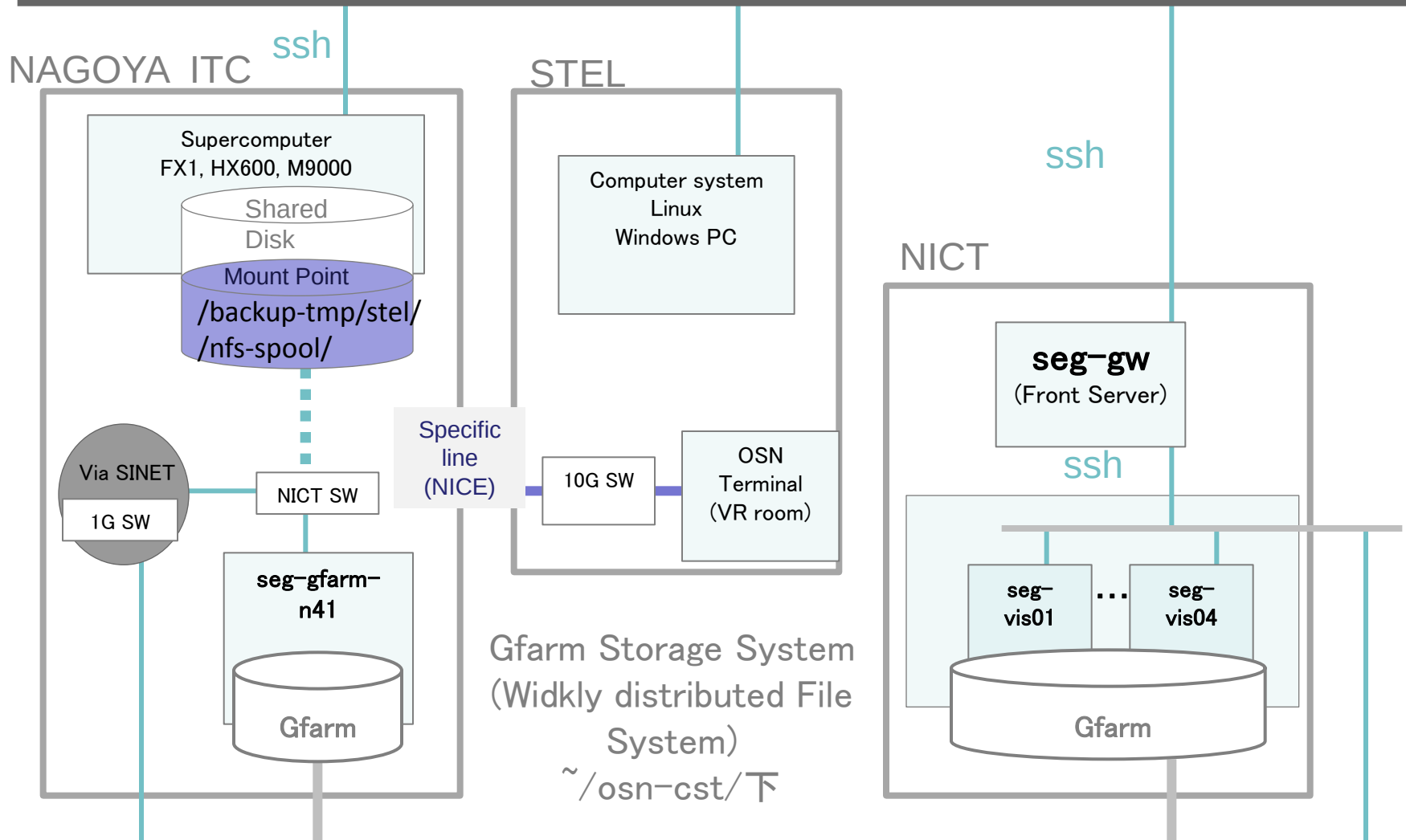
Solar-Terrestrial
Environment Laboratory

ITC Center of Nagoya University



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

SINET (Nagoya Univ LAN:NICE) - Internet



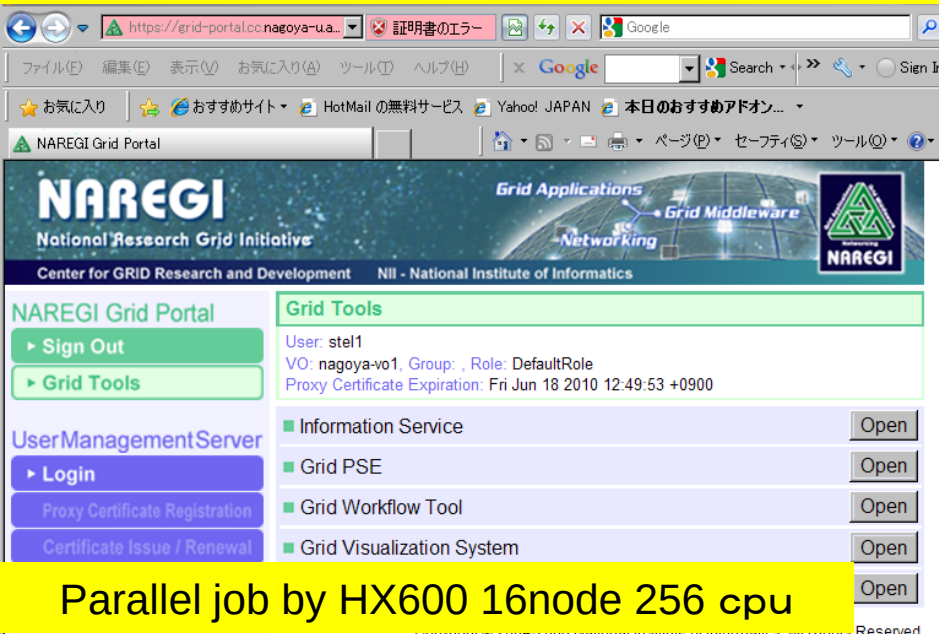
JGN-X

JGN-X Management

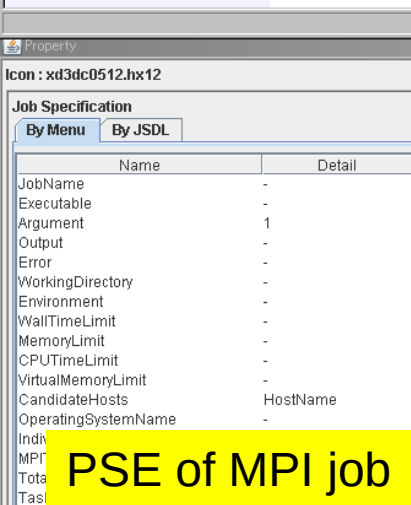
Use of NAREGI Computation GRID and **RENKEI-PoP**

Execution of MHD simulation with MPI Fortran

NAREGI Portal and MPI Fortran job run

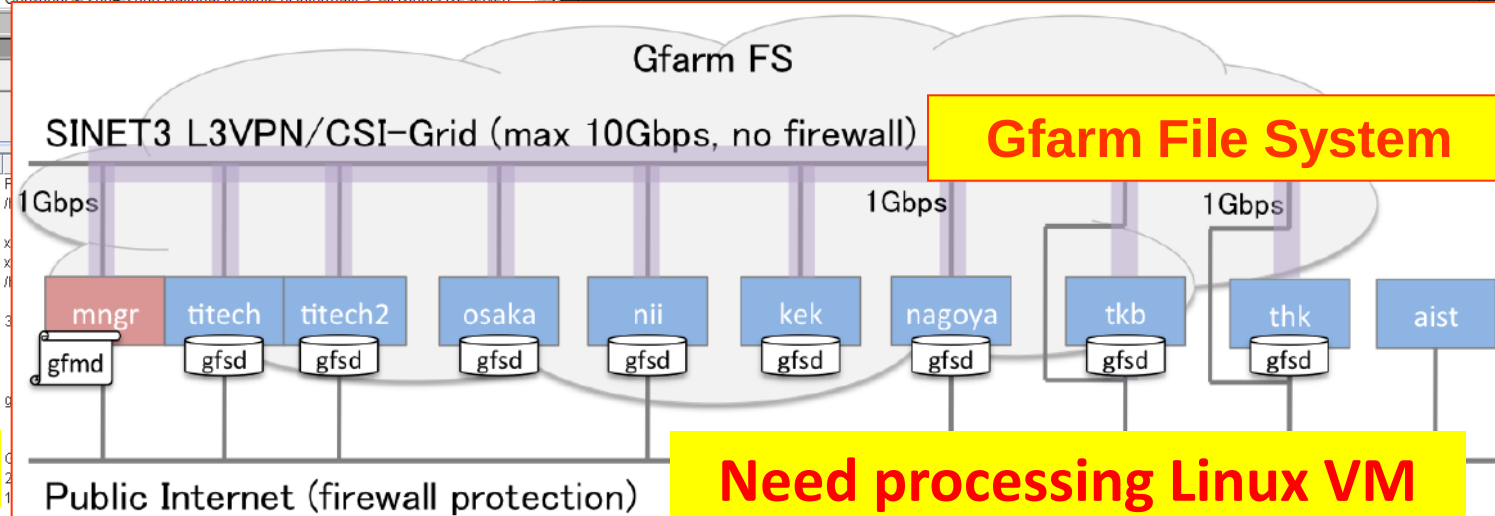
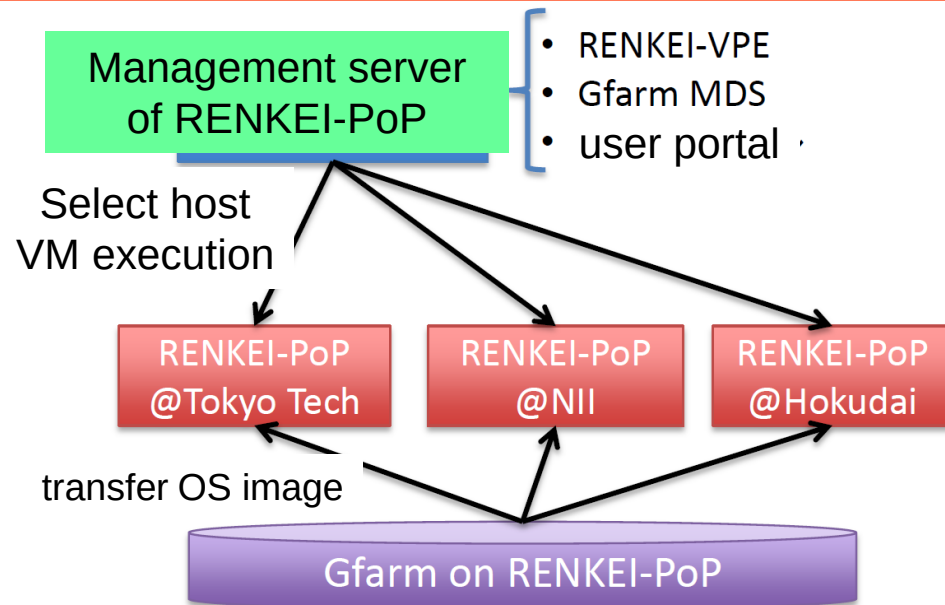


Parallel job by HX600 16node 256 cpu



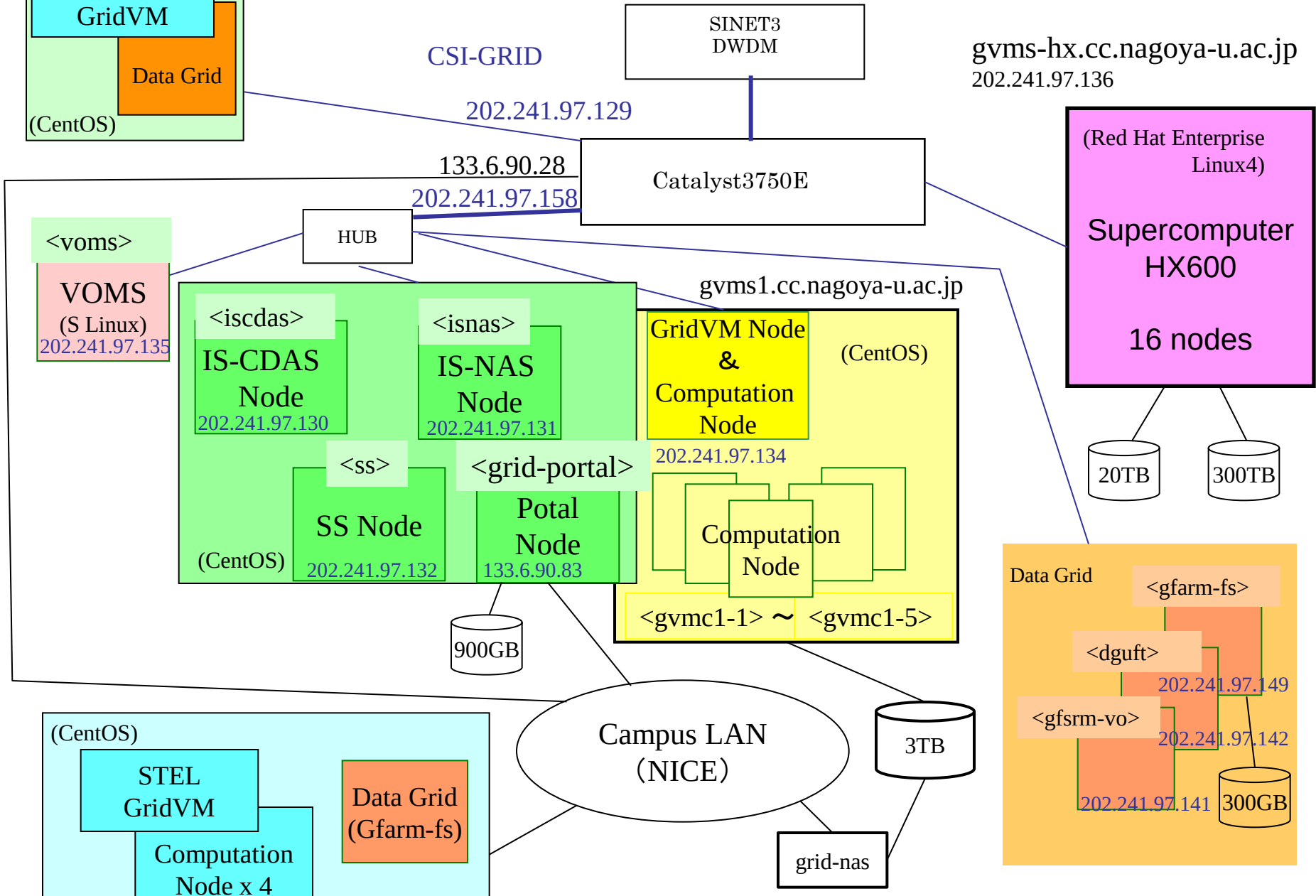
PSE of MPI job

RENKEI-PoP and wide area file (Gfarm2)



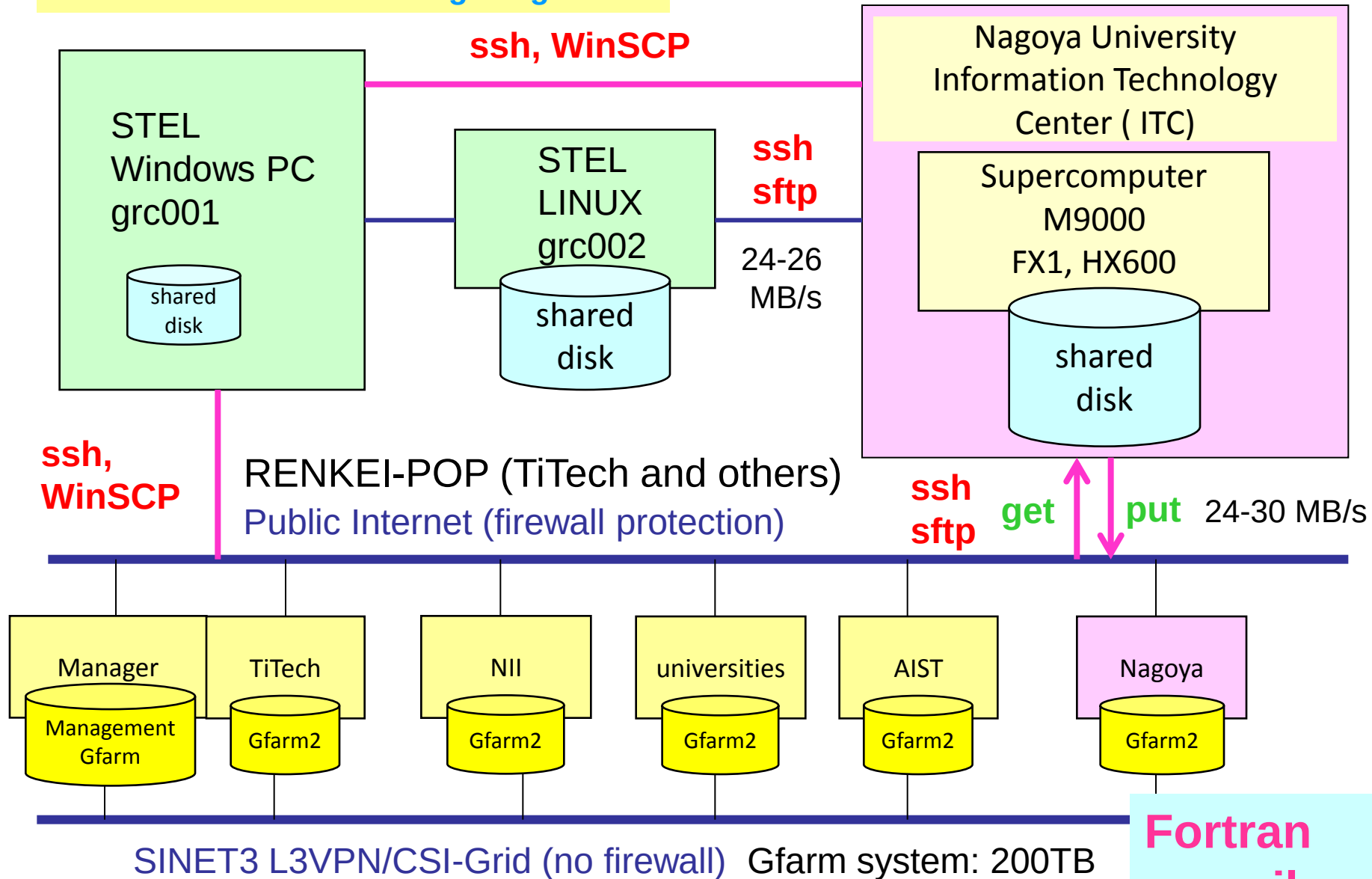
NAREGI Middleware Environment

ITC, Nagoya U
2009.10



Use of Supercomputer and Gfarm System

Install of Gfortran and ImageMagick



RENKEI-PoP (Nagoya)

Access to Nagoya U supercomputer

RENKEI-PoP (TiTech)

Shared disk for supercomputer

```
osino@rpop-nagoya bin$ which gcc
/usr/bin/gcc
osino@rpop-nagoya bin$ pwd
/usr/bin
osino@rpop-nagoya bin$ pwd
/usr/bin
osino@rpop-nagoya bin$ cd /home/osino/gfarm/home
osino@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 08:59 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
osino@rpop-nagoya eartha$ pwd
/home/osino/gfarm/home/osino/earth
osino@rpop-nagoya eartha$ cd ..
osino@rpop-nagoya osino$ ls
eartha test1
osino@rpop-nagoya osino$ cd test1
osino@rpop-nagoya osino$
```

ファイル(F) 編集(E) 設定(S) コントロール(O) ウィンドウ(W) ヘルプ(H)

sp1.cc.nagoya-u.ac.jp:22 - Tera Term VT

ファイル(F) 編集(E) 設定(S) コントロール(O) ウィンドウ(W) ヘルプ(H)

rw-r--r-- 1 a41456a user 37130883188 Jul 7 08:48 ed420059.data

rw-r--r-- 1 a41456a user 37130883188 Jul 7 08:48 ed420060.data

rw-r--r-- 1 a41456a user 37130883188 Jul 8 14:45 ed420061.data

rw-r--r-- 1 a41456a user 37130883188 Jul 8 14:45 ed420062.data

rw-r--r-- 1 a41456a user 37130883188 Jul 8 14:45 ed420063.data

rw-r--r-- 1 a41456a user 37130883188 Jul 8 14:45 ed420064.data

Y\$kgcrdisk2Ydisk1Y\$kgcr30Wimports-20110415Yearhb4WLeaethb3aYzg4.wzmfa6180.gif - Windows Internet Explorer

Y\$kgcrdisk2Ydisk1Y\$kgcr30Wimports-20110415Yearhb4WLeaethb3aYzg4.wzmfa6180.gif

ファイル(F) 編集(E) 表示(V) お気に入り(A) ツール(T) ヘルプ(H)

X 変換 ▼ 開 選択

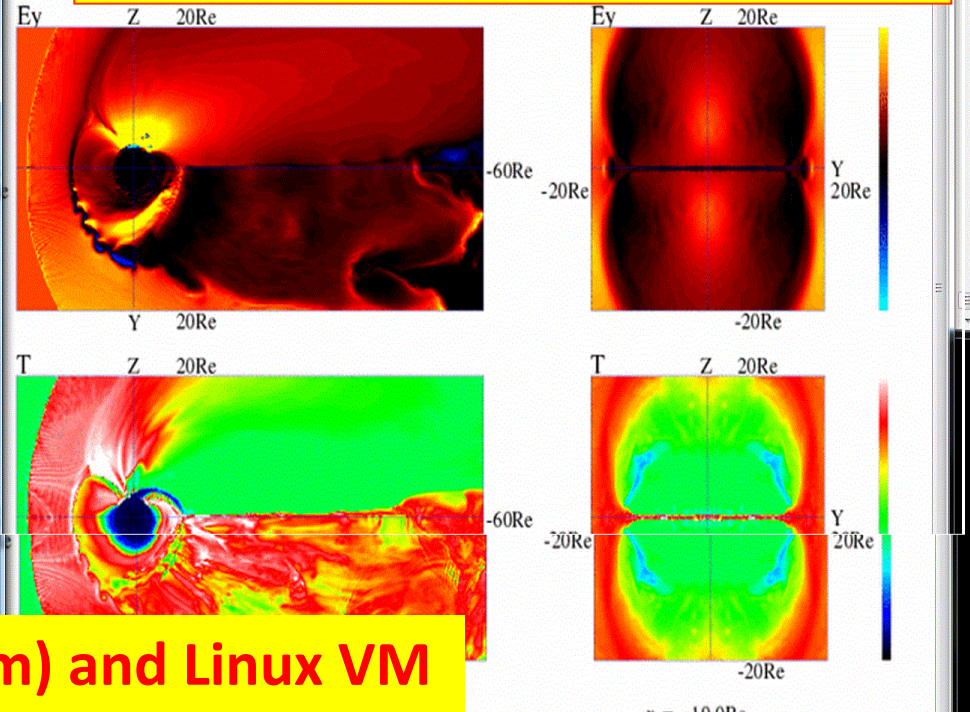
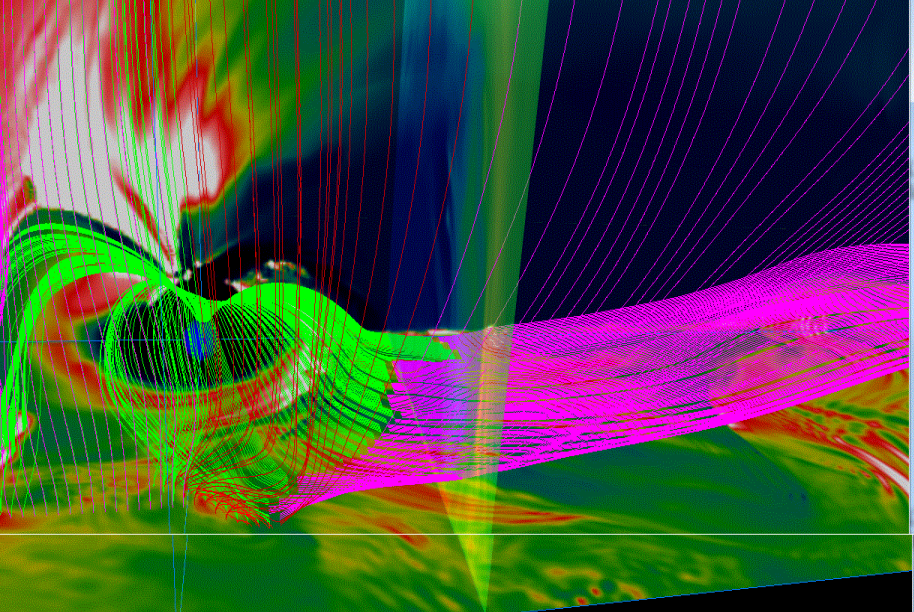
★ お気に入り ★ おすすめサイト ▼ 本日のおすすめアド...

RENKEI-PoP Portal Y\$kgcrdisk2Y... 空白のページ

ページ(P) ▼ セーフティ(S) ツール(O) ?

3D visualization by LINUX and graphic display by PC

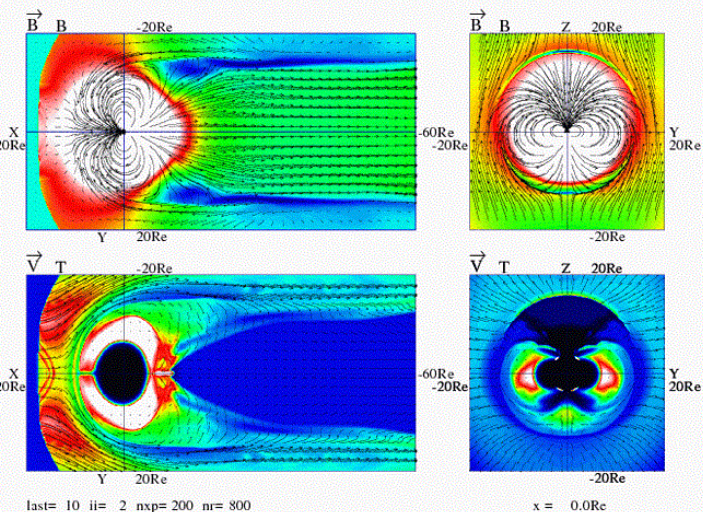
Making movie by LINUX and graphic display by PC



Need wide area file system (Gfarm) and Linux VM

Animation movie of simulation

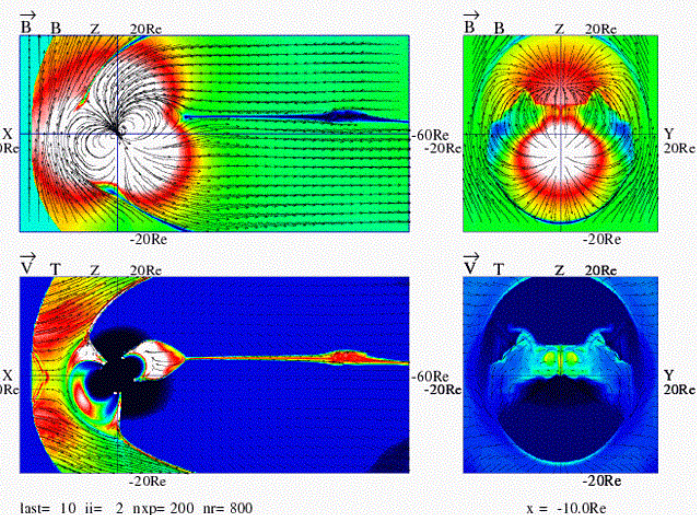
Tilt= 30 deg IMF=10.0 nT (90 deg) T= 202 min



無題 2

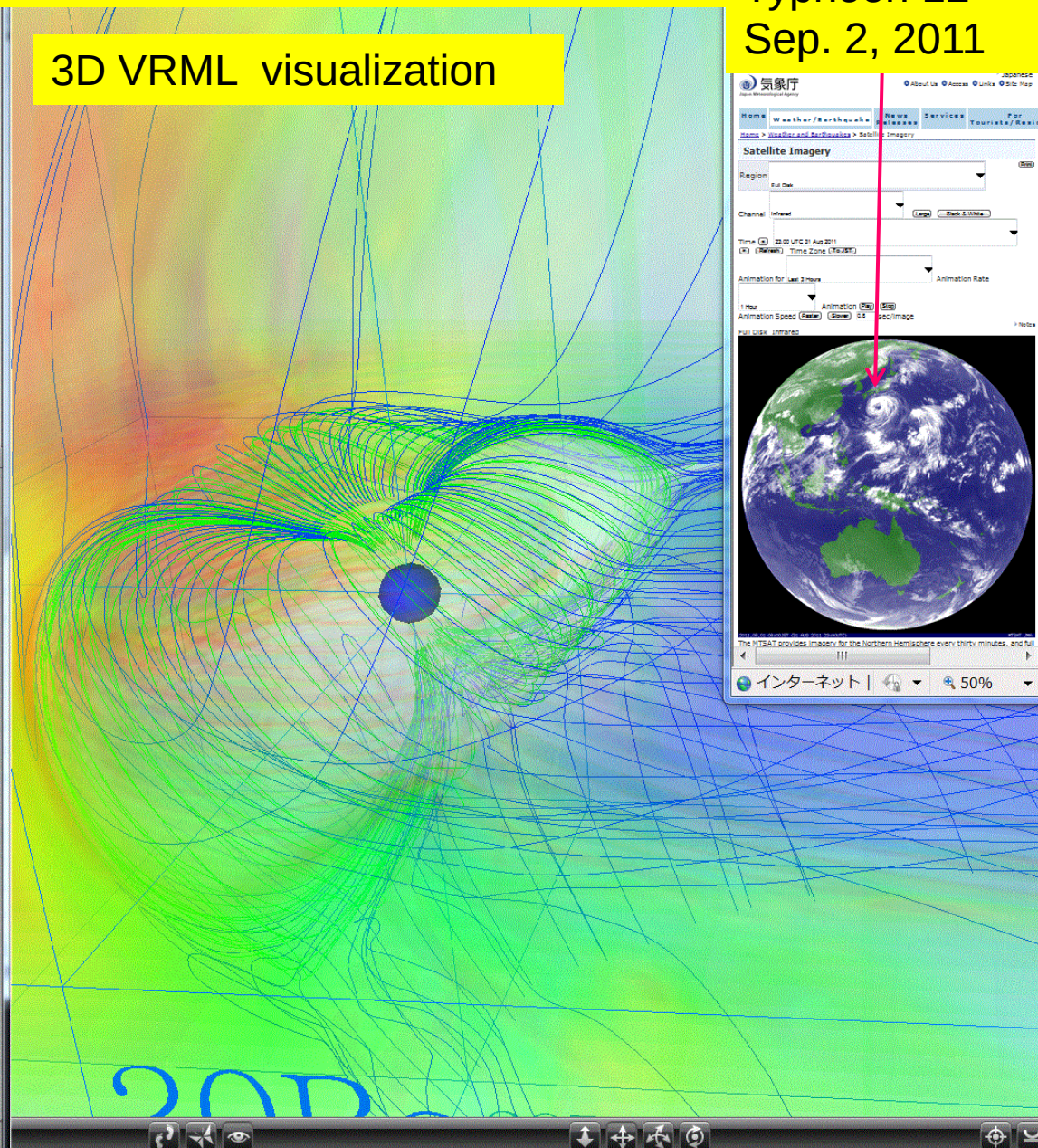
MHD Simulation of Dipole Tilt in Magnetosphere

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

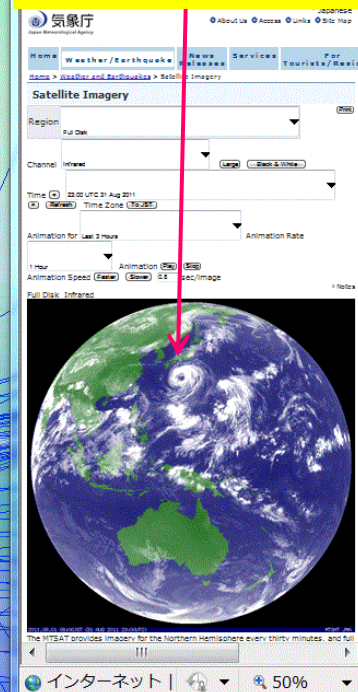


All processes can be done in RENKEI-PoP Gfarm

3D VRML visualization

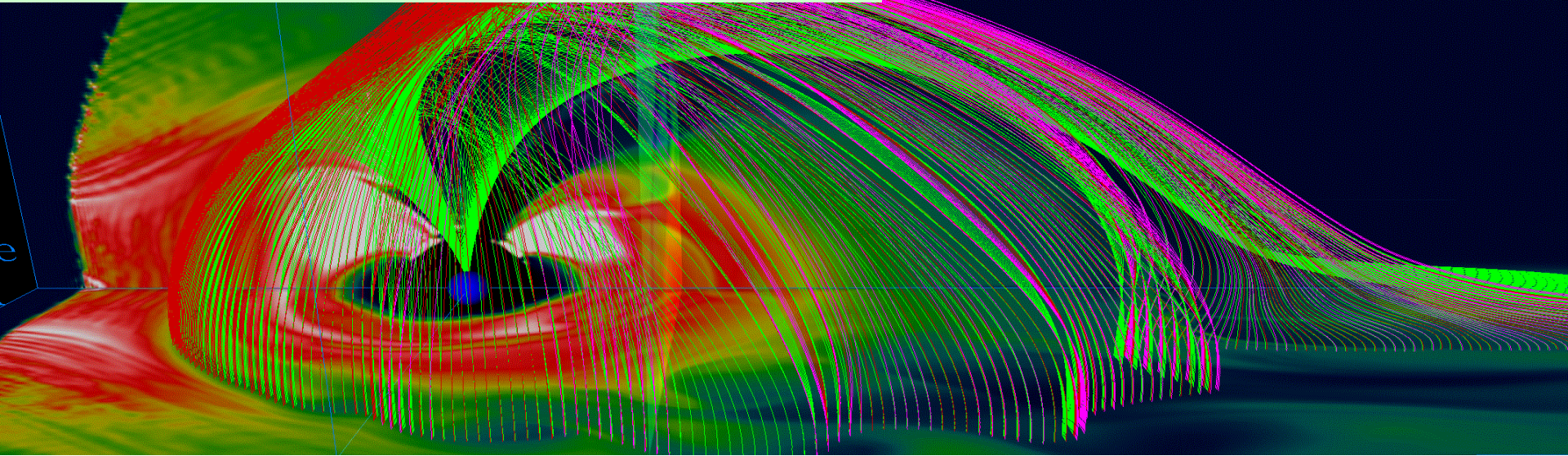


Typhoon 12
Sep. 2, 2011



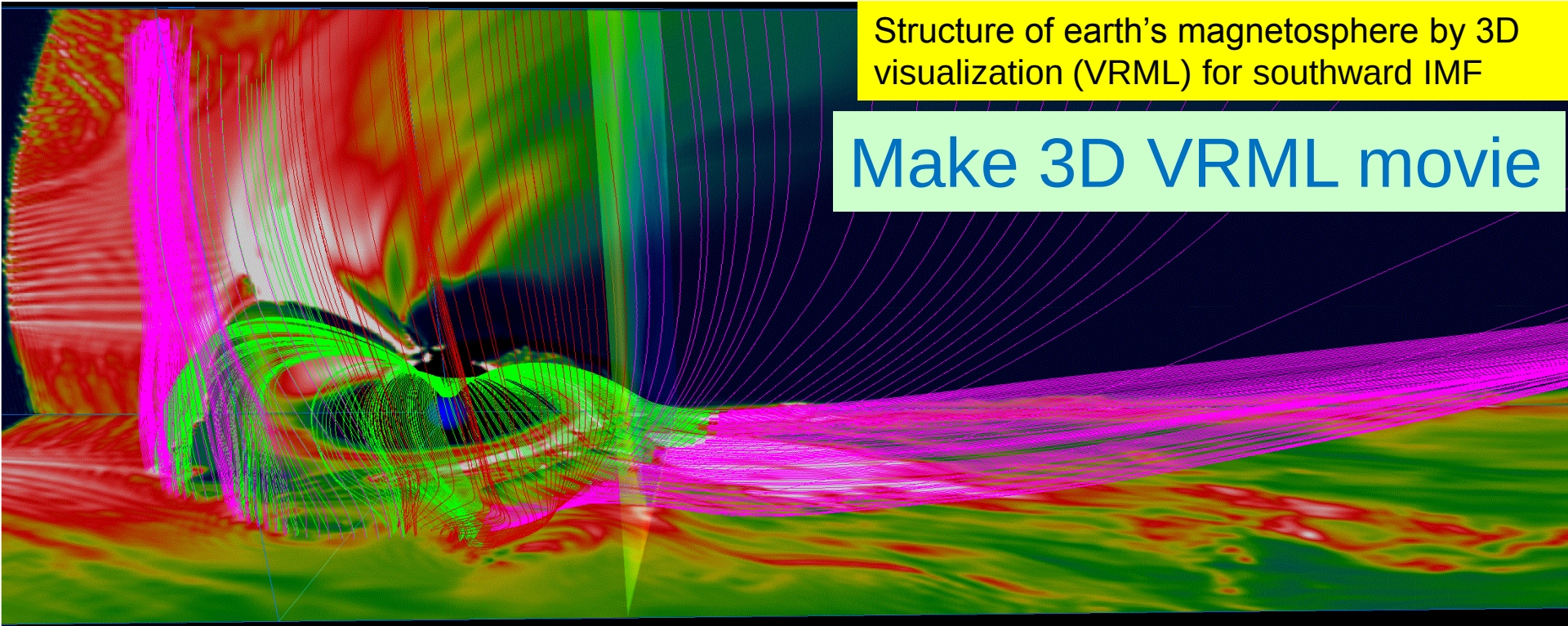
High Resolution MHD Simulation

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

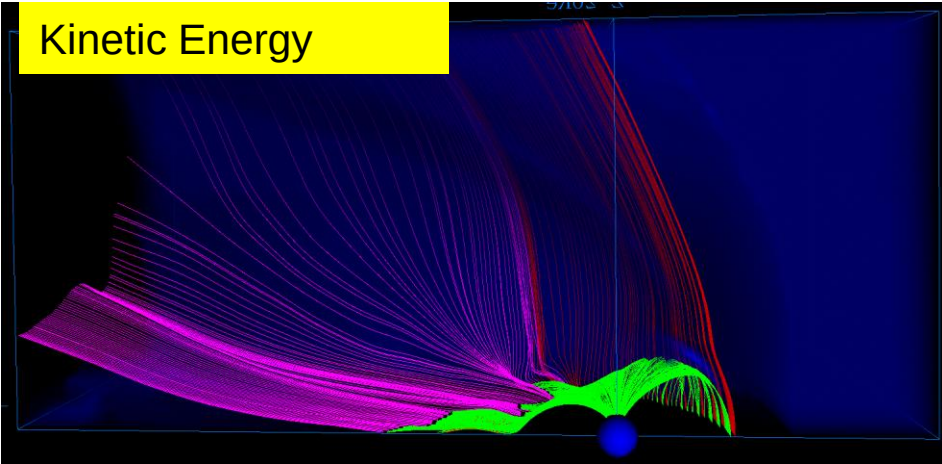


Structure of earth's magnetosphere by 3D visualization (VRML) for southward IMF

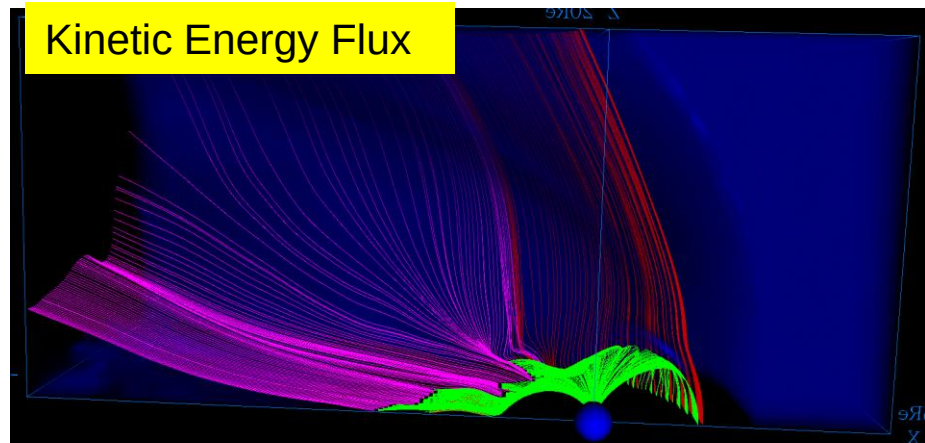
Make 3D VRML movie



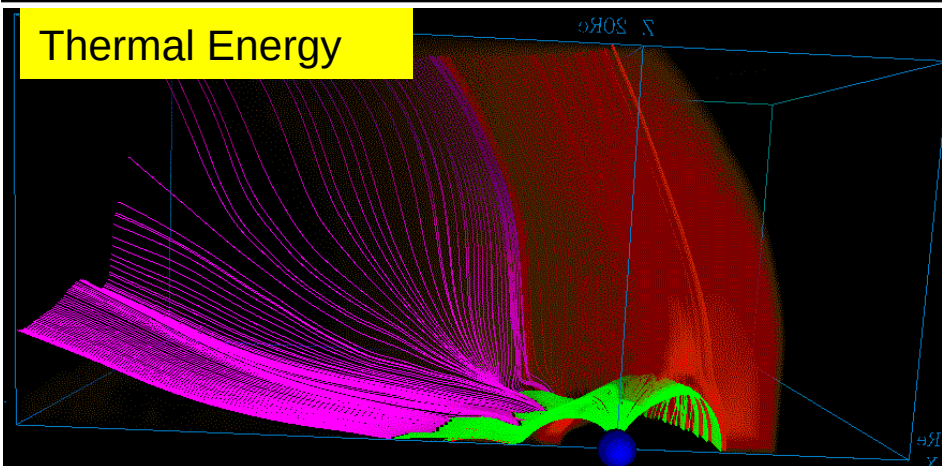
Kinetic Energy



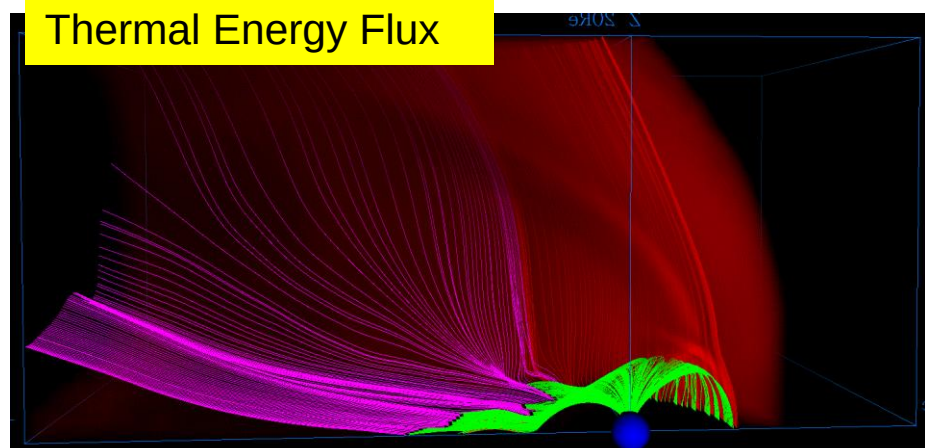
Kinetic Energy Flux



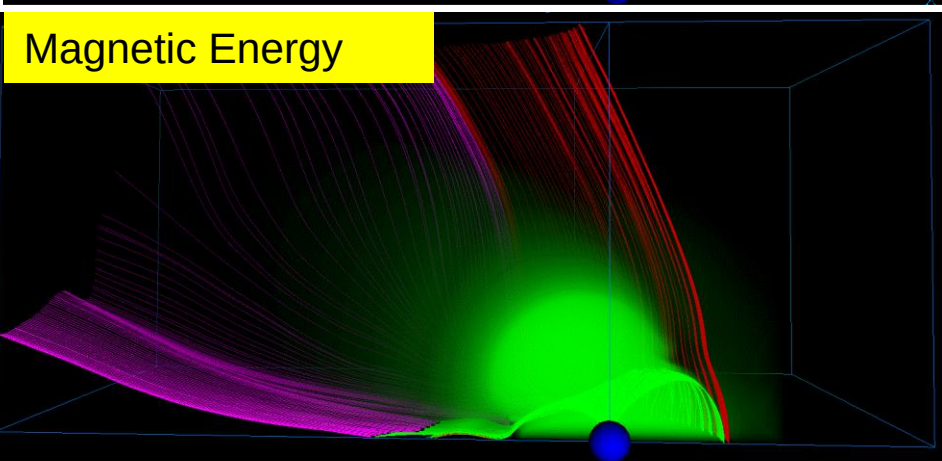
Thermal Energy



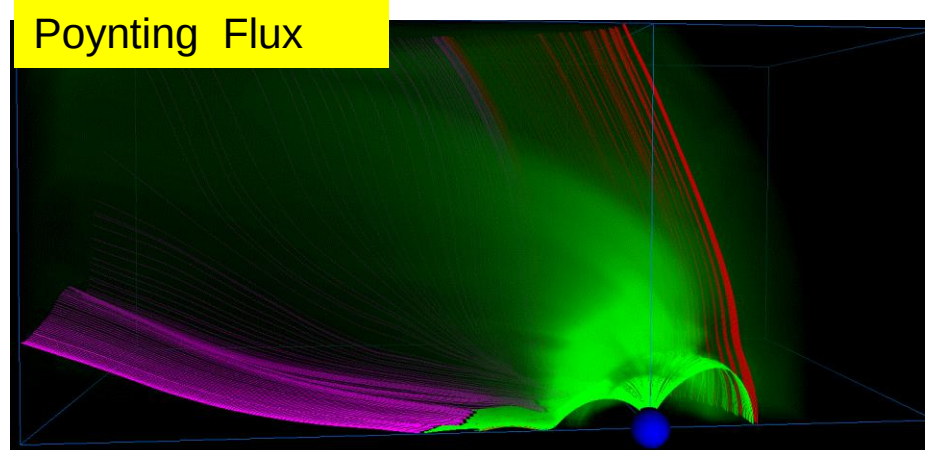
Thermal Energy Flux



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

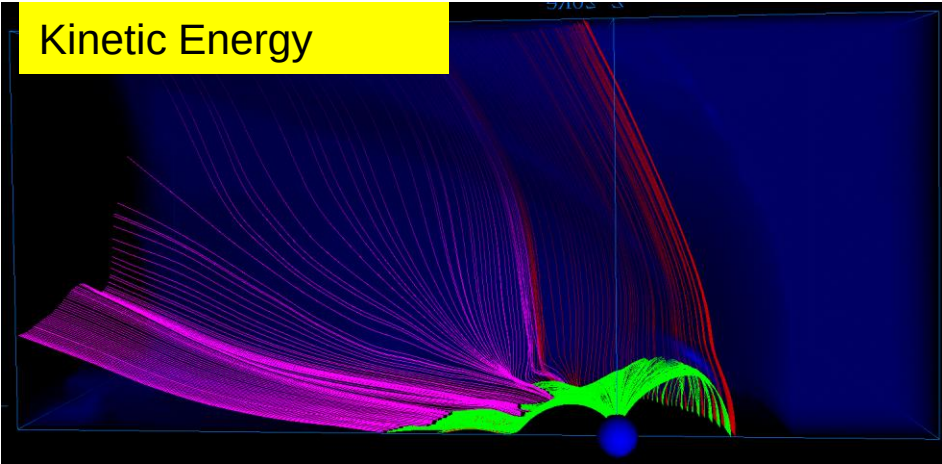
Geospace Science Clouds
Integration (PSE, Workflow, Network)

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

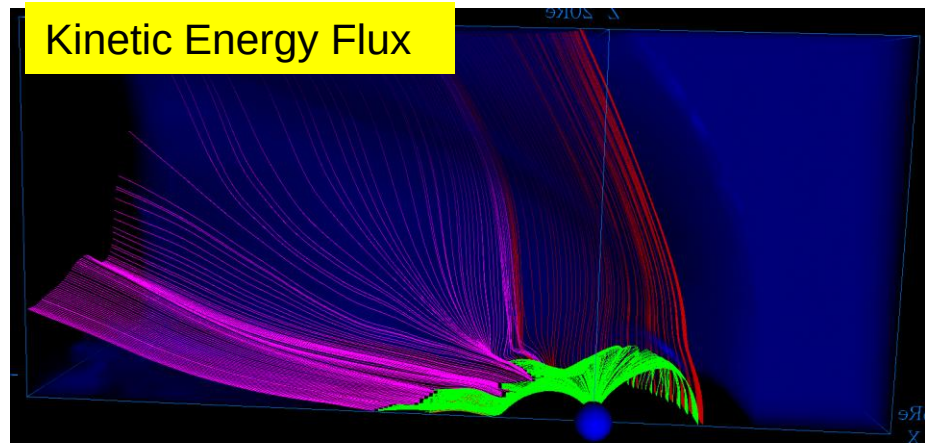
Wide Area File System
Gfarm

We can use it with Linux with Fortran compiler.

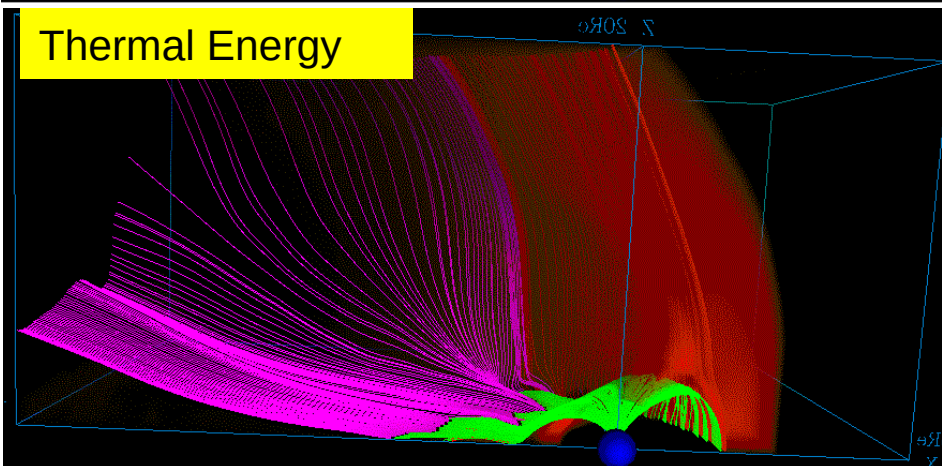
Kinetic Energy



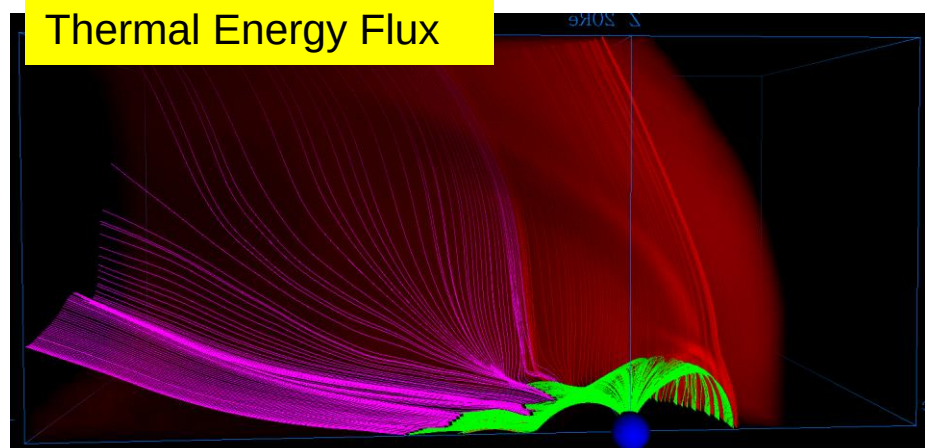
Kinetic Energy Flux



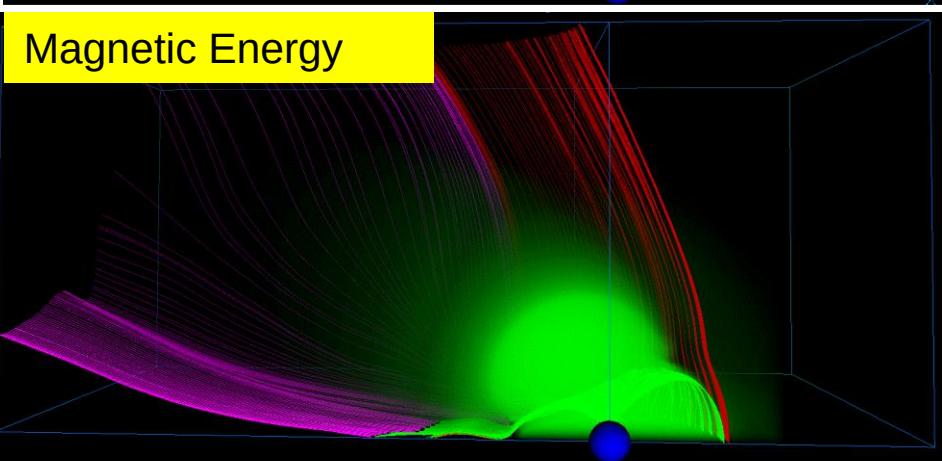
Thermal Energy



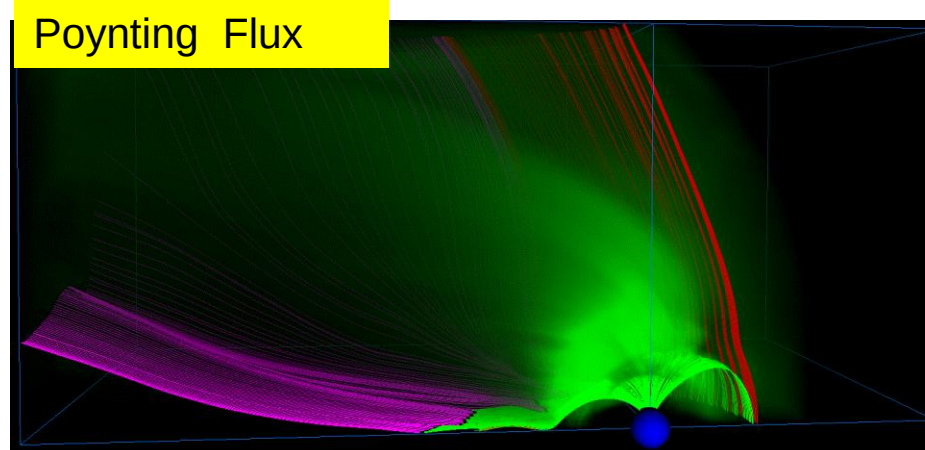
Thermal Energy Flux



Magnetic Energy



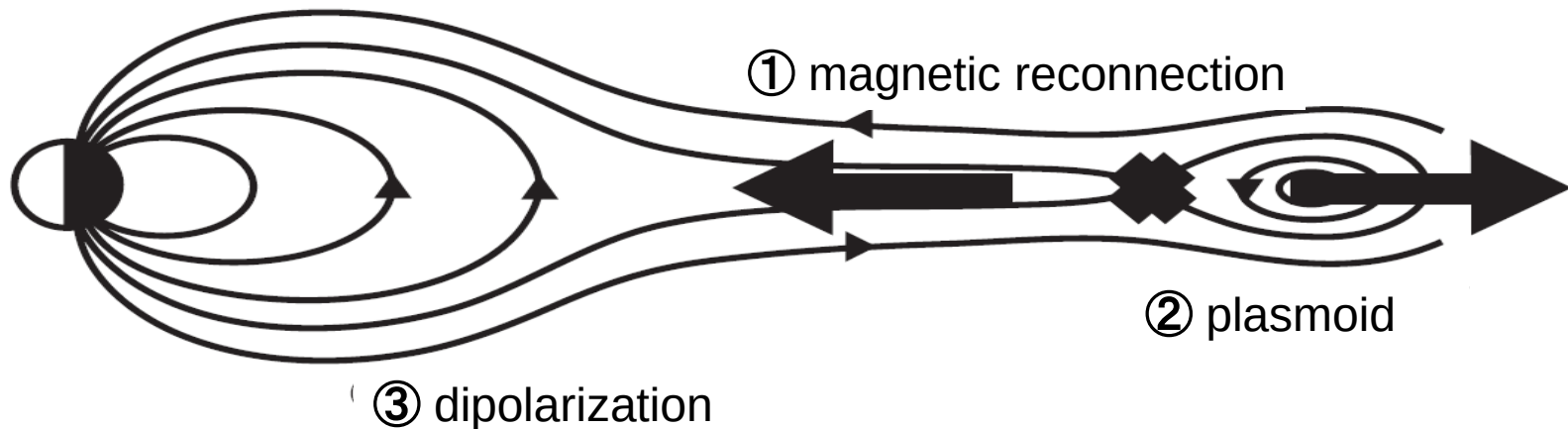
Poynting Flux



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.

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

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