

Particle Therapy Simulation on GRID

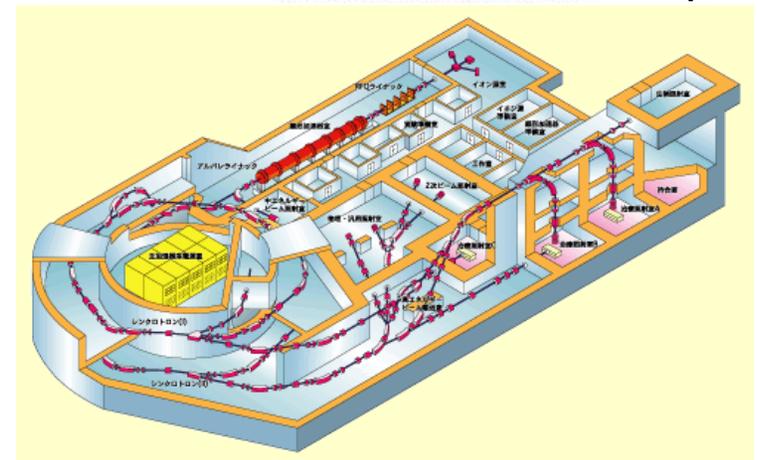
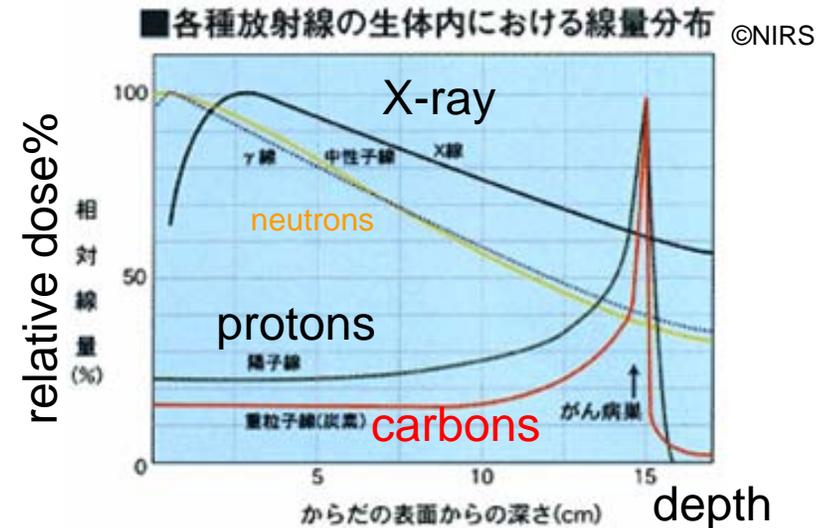
Takashi Sasaki, Go Iwai and Koichi Murakami
KEK Computing Research Center
and
JST/CREST

The project

- Collaboration between Medical Physicists and Geant4 developers in Japan
- Funded by Japan Science and Technology Agency during 2003-2008
- Development on the software suit for particle therapy simulation including
 - Dose calculation engine, visualization, GRID and so on
- Validation on the simulation results
 - Interaction of carbons (nuclear fragmentation) are not well known yet

Particle Therapy

- Mostly using protons or carbons, sometime heavier ions or neutrons for cancer therapy
 - Synchrotrons or cychrotrons are used
- Advantage in quality of life (less collateral side effects)



NIRS-HIMAC

Carbon therapy

- PROS
 - Carbons give narrower Bragg Peak than protons
 - Less side effects
 - Better biological effects than protons
 - Less dose, better efficiency
- CONS
 - More costs on construction for carbons than protons
 - Facility for protons is not cheap, anyway
 - 1B JPY vs 0.7B JPY

Contribution from particle physics

- Many of accelerator laboratories in the world are committing cancer therapy somehow
 - CERN
 - Accelerator developments
 - Research on anti-proton therapy
 - GSI
 - Heavy ion therapy
 - KEK
 - Proton therapy 1983-2000
 - Medical accelerator development

Particle therapy facility in operation

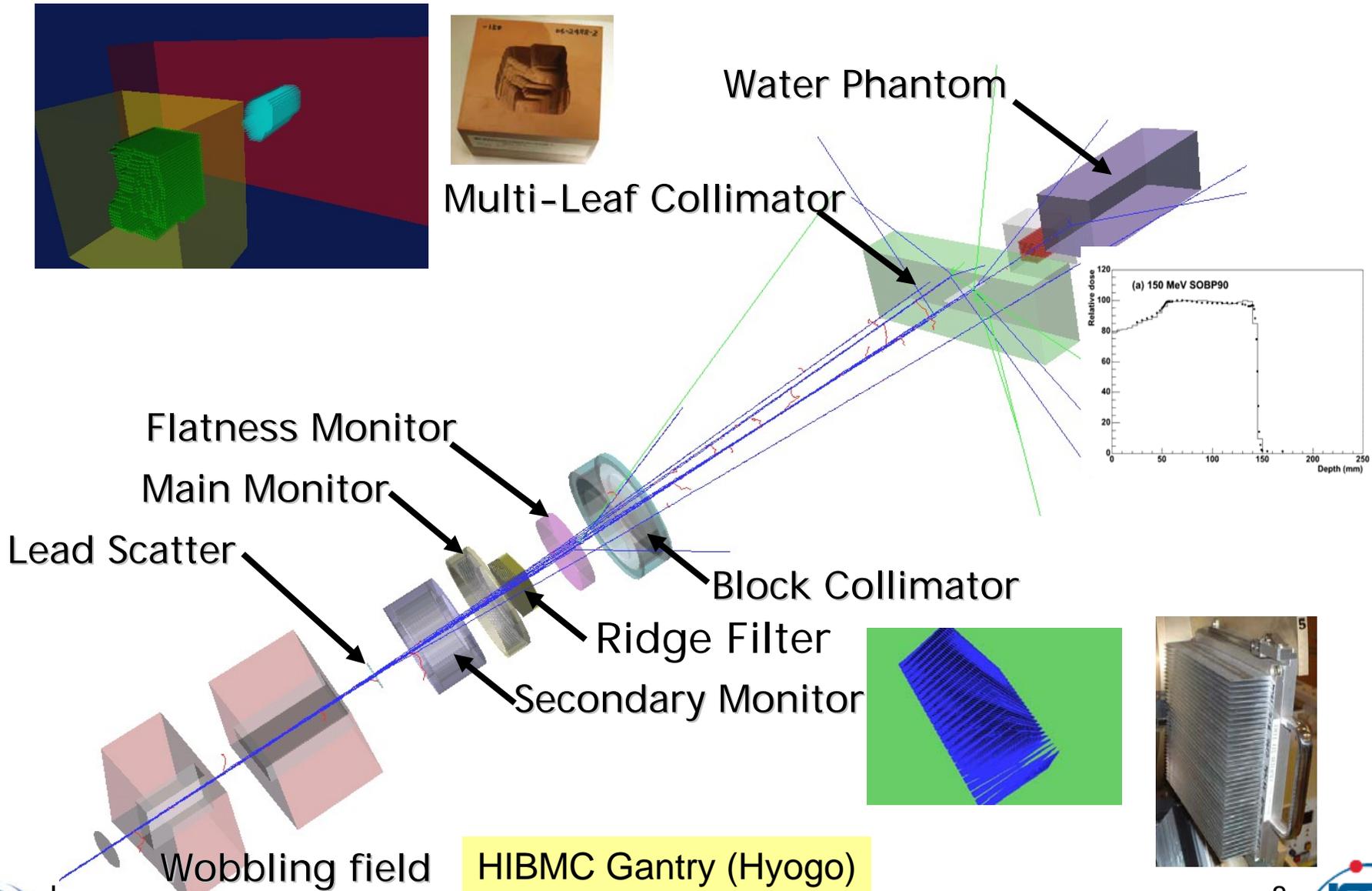
		WHAT	FIRST	TOTAL	DATE OF TOTAL
Canada	Vancouver (TRIUMF)	p	1995	111	Sep-06 eyes only
China	Wanjie (WPTC)	p	2004	270	July-06
England	Clatterbridge	p	1989	1584	Dec-06 eyes only
France	Nice (CAL)	p	1991	3129	Sep-06
France	Orsay (CPO)	p	1991	3126	Dec-06 eyes only
France	Orsay (CPO)	p	1991	640	Dec-06
Germany	Darmstadt (GSI)	C ion	1997	316	July-06
Germany	Berlin (HMI)	p	1998	829	Dec-06
Italy	Catania (INFN-LNS)	p	2002	114	Oct-06 eyes only
Japan	Chiba (HIMAC)	C ion	1994	2867	Aug-06
Japan	Kashiwa (NCC)	p	1998	462	Nov-06
Japan	Hyogo (HIBMC)	p	2001	1099	Sep-06
Japan	Hyogo (HIBMC)	C ion	2002	131	Sep-06
Japan	Tsukuba (PMRC, 2)	p	2001	930	July-06
Japan	WERC	p	2002	33	Aug-06
Japan	Shizuoka	p	2003	410	Nov-06
Russia	Moscow (ITEP)	p	1969	3858	Dec-05
Russia	St. Petersburg	p	1975	1320	Oct-06
Russia	Dubna (JINR, 2)	p	1999	318	July-06
South Africa	iThemba LABS	p	1993	486	Dec-06
Sweden	Uppsala (2)	p	1989	738	Dec-06
Switzerland	Villigen PSI (72 MeV-Optis)	p	1984	4646	Dec-06 eyes only
Switzerland	Villigen PSI (230 MeV)	p	1996	262	Dec-06
CA., USA	UCSF - CNL	p	1994	920	Mar-07
CA., USA	Loma Linda (LLUMC)	p	1990	11414	Nov-06
IN., USA	Bloomington (MPRI, 2)	p	2004	220	Sep-06
MA., USA	Boston (NPTC)	p	2001	2080	Oct-06
TX, USA	Houston (M.D. Anderson)	p	2006	114	Dec-06
FL, USA	Jacksonville (UFPTI)	p	2006	15	Dec-06

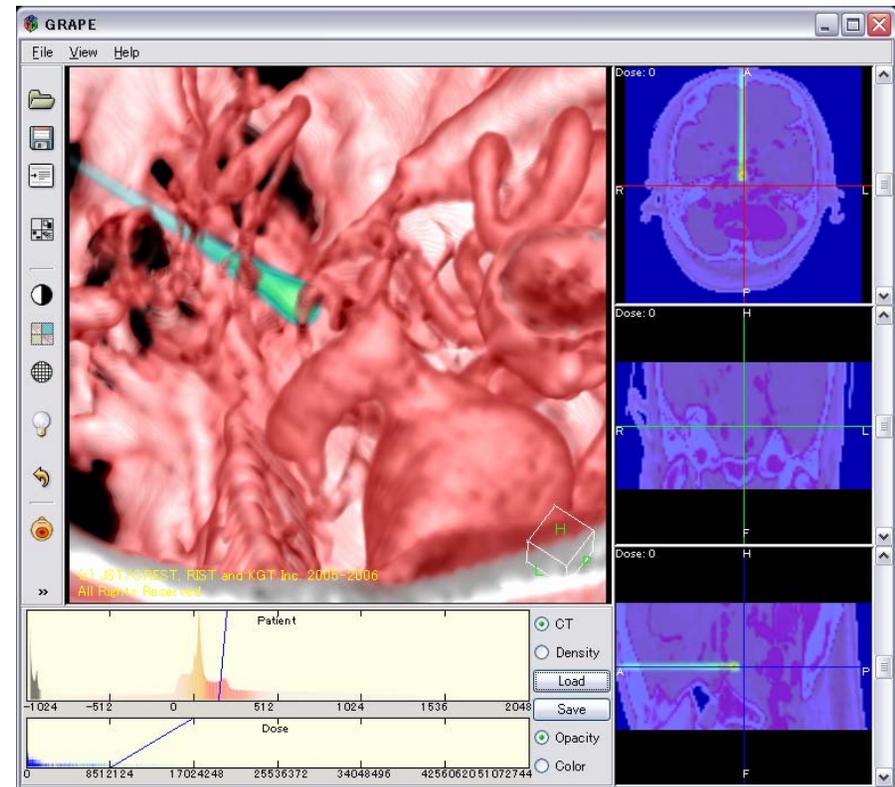
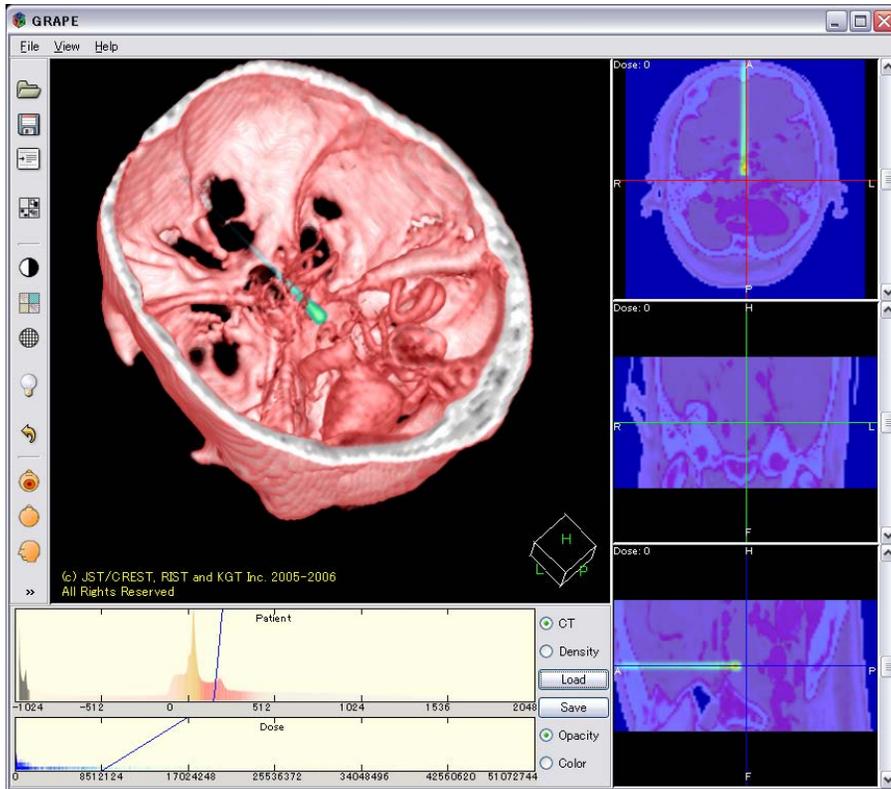


Facility under construction

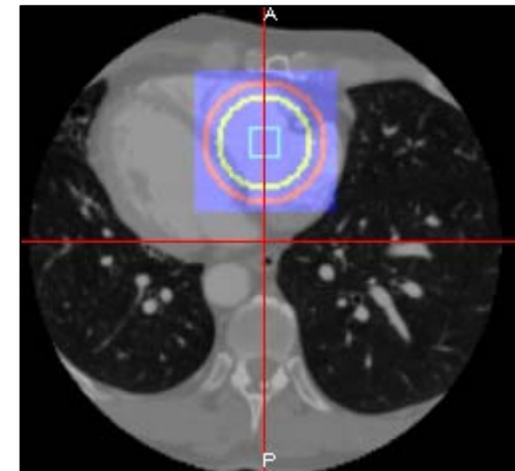
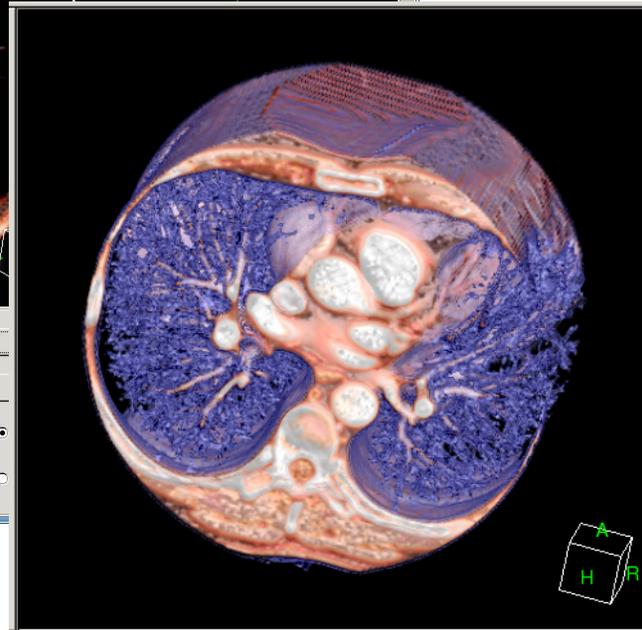
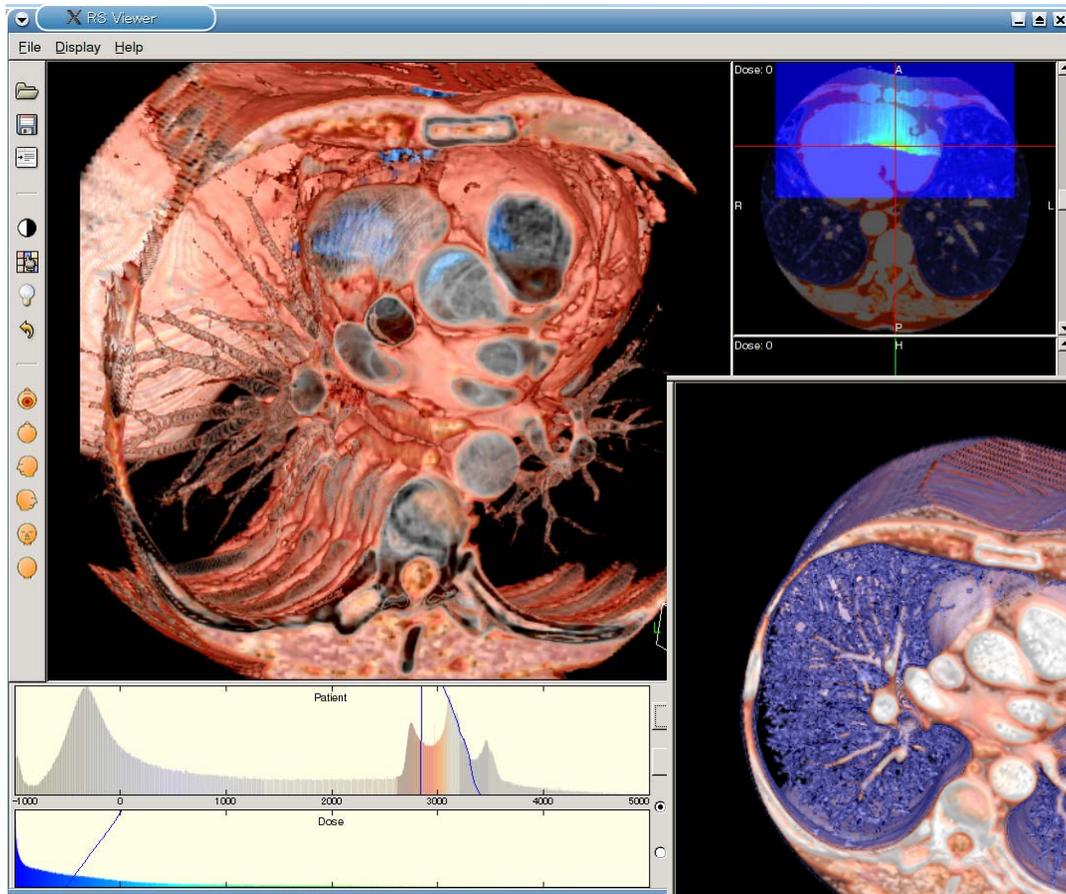
WHO, WHERE	COUNTRY	PARTICLE	MAX. CLINICAL ENERGY (MeV)	BEAM DIRECTION	NO. OF TREATMENT ROOMS	START OF TREATMENT PLANNED
RPTC, Munich*	Germany	p	250 SC cyclotron	4 gantries, with scanning, 1 horiz.	5	2007
PSI, Villigen*	Switzerland	p	250 SC cyclotron	Additional gantry, 2D parallel scanning, 1 horiz.	3	2007/08 (OPTIS2/ Gantry2)
NCC, Seoul*	Korea	p	230 cyclotron	2 gantries 1 horiz.	3	2007
CNAO, Pavia*	Italy	p, ion	430/u synchrotron	1 gantry? 3 horiz. 1 vert	3-4	2009?
Heidelberg/GSI Darmstadt*	Germany	p, ion	430/u synchrotron	1 gantry, raster scanning, 2 fixed beams	3	2007
Gunma Univ. Takasaki, Gunma	Japan	ion	400/u Synchrotron	1 vert+holiz., 1 vert 1 horiz.	3	2009
Fukui Pref. Fukui	Japan	p	synchrotron	?	?	2009?
Minami Tohoku Hospital (priv.) Fukushima	Japan	p	synchrotron	1 vert 2gatry	3	Autumn 2008

Hadron Therapy Simulation





Visualized by gMocren
<http://geant4.kek.jp/gMocren>



Boost Simulation Speed

- Massive computing power is required for precise simulation.
 - typical situation of hadron therapy simulation;
 - 1M events/~3days @ Pentium-4 3.0GHz processor
- Parallelization on local PC cluster
 - Event level parallelism has been implemented using MPI.
 - We can get performance gain almost linear to # processors.
- Distributed analysis on GRID





Hospital

User Model in Medical Application

User model in medical applications is different from HEP

- ✓ limited applications w/ different parameters sets
- ✓ support for non-GRID users
- ✓ closed (secure) network environment

Grid access via HTTP
 ✓ Set parameters
 ✓ Job submission, management, monitoring
 ✓ Return parameter sets

Resource Broker
 ✓ Inquiry resource information
 ✓ Job queuing and logging

Grid Web UI

Resource Broker

Network Server

Task Queue

Match Maker

Information Supermarket

Job Submission

Virtual Organization
 ✓ Based on GSI
 ✓ Across the institutes

Firewall

Site-A

Globus I/F

Site-B

Globus I/F

Site-C

Globus I/F

WMS

WN

WN

WN

File Catalogue

- ✓ Independent of physical location of files
- ✓ Replication and transfer automatically

WMS

WN

WN

WN

WN

WN

WN

SE

WMS

WN

WN

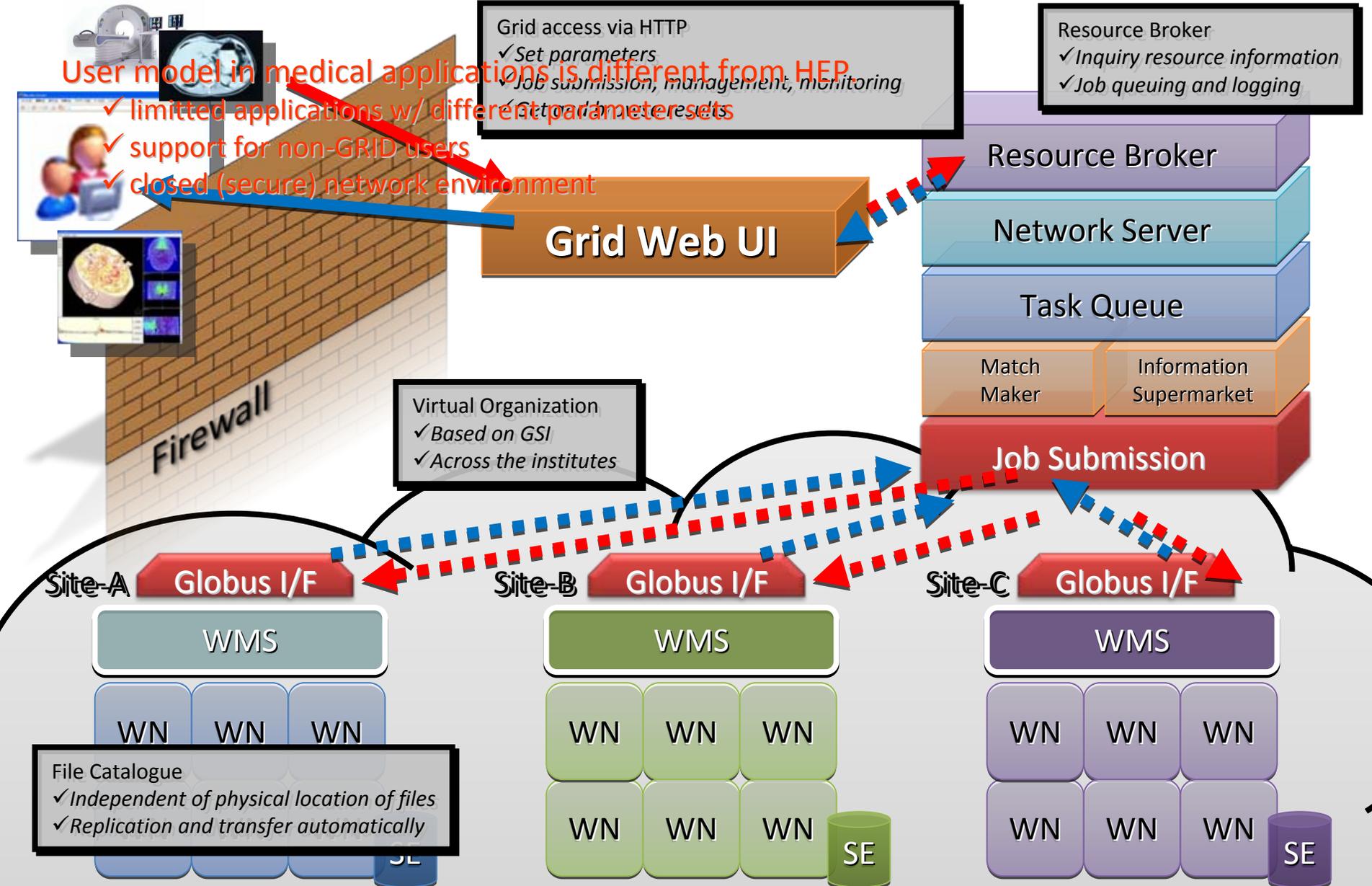
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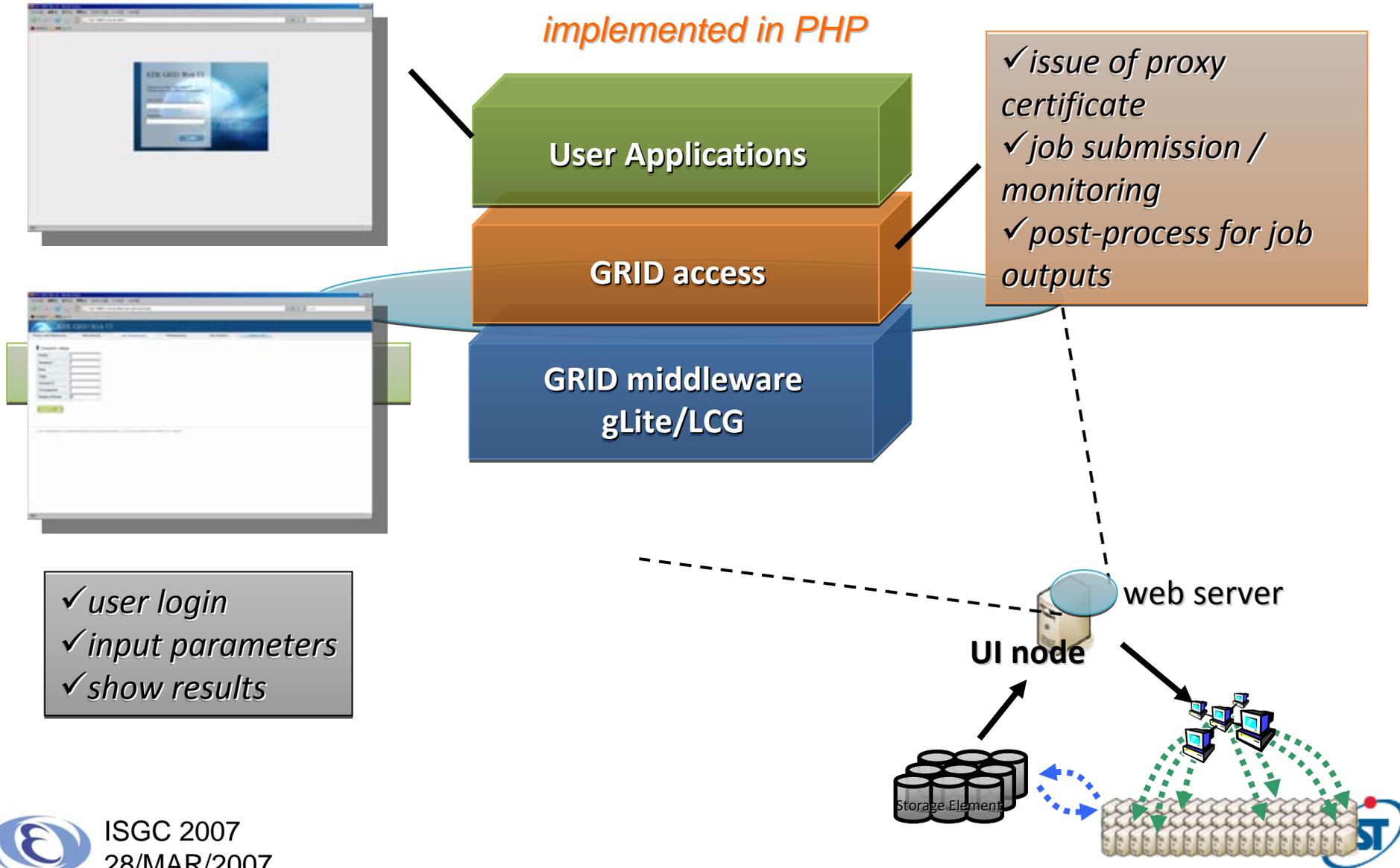
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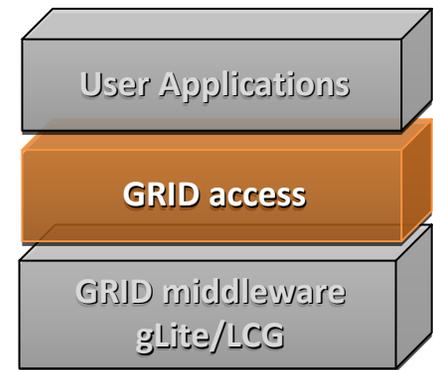
Grid Web Portal for Medical Application

- We will provide web interface as an easy-to-access way to GRID resources.
 - managing GRID jobs across firewalls
 - Intra-networks of universities/hospitals are closed under firewalls in most cases.
 - Users applications are served as Web applications
 - fixed application (hadron therapy simulation) changing different parameter sets
- Note:
 - Potentially, a toolkit for constructing GRID web applications

Structure of GRID Web Interface



GRID Access Layer



- Implemented in *PHP*.
- GRID API/commands are wrapped out:
 - issue of proxy certificates
 - *xxx-proxy-init/info/destroy*
 - job management
 - submission/cancellation
 - *xxx-job-submit/xxx-job-cancel*
 - job monitoring
 - *xxx-job-status*
 - post-process for job outputs
 - merging job outputs (histogram, etc.)
 - collection/replication of results
 - *xxx-job-get-output, lfc-xxx, lcg-cp, lcg-cr, etc.*

GRID Access Layer (Cont.)

- HTML generation
 - showing information of proxy / Grid resources
 - for submitting / monitoring jobs
- Note:
 - Currently, users' certificates are supposed to be uploaded on the UI node (web server).
 - Hopefully, this should be improved, so that users certificates imported in a web browser can be used.

Proxy / Grid Resources Information

The screenshot shows the KEK GRID Web UI interface. At the top, there is a navigation menu with tabs for Proxy and Resource, Monitoring, Job Submission, Preferences, Job History, and Logout. Below the menu, there is a section for the GRID pass phrase with an input field and an Initialize button. The main content area is divided into three sections: Proxy Information, Computing Element, and Storage Element.

Proxy Information

Subject	/C=JP/O=KEK/OU=CRC/CN=Demonstration for Web Service/CN=proxy
Issuer	/C=JP/O=KEK/OU=CRC/CN=Demonstration for Web Service
Identity	/C=JP/O=KEK/OU=CRC/CN=Demonstration for Web Service
Type	full legacy globus proxy
Strength	512 bits
Path	/tmp/ls09up_webui000001
Timeleft	7:51:12

Computing Element

#CPU	Free	Total Jobs	Running	Waiting	ComputingElement
14	12	2	2	0	dg10.cc.kek.jp:2119/jobmanager-icgpbs-g4med
48	44	0	0	0	ris02.cc.kek.jp:2119/jobmanager-icgpbs-g4med

Storage Element

Avail Space(Kb)	Used Space(Kb)	Type	SEs
128000000	130000000	n.a	dg11.cc.kek.jp
869020000	290980000	n.a	ris06.cc.kek.jp

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Job Monitoring

KEK GRID Web UI - Mozilla Firefox

http://dg04.cc.kek.jp/webui/job_detail.php?jid=000079&p=5&o=

KEK GRID Web UI

Proxy and Resource Monitoring Job Submission Preferences Job History Logout

Job Set 000079 in detail

	Job ID	Start / End (UTC)	Status	JDL	Shell	Macro	Log	LFN	CE
<input checked="" type="checkbox"/>	https://dg09.cc.kek.jp:9000/1SAiIzuo0-7HZnDlowQtbA	Start Sat Feb 24 07:40:18 2007 End Sat Feb 24 07:47:31 2007	Done (Success)	0001.jdl	0001.sh	0001.mac	Stdout stdout_log Stderr stderr_log	hist_000079_0001.root	dg10.cc.kek.jp:2119/jobmanager-kgpbe-g4med
<input checked="" type="checkbox"/>	https://dg09.cc.kek.jp:9000/V5MM-Rsl7nz37CusgeBr-g	Start Sat Feb 24 07:40:27 2007 End Sat Feb 24 07:48:40 2007	Done (Success)	0002.jdl	0002.sh	0002.mac	Stdout stdout_log Stderr stderr_log	hist_000079_0002.root	dg10.cc.kek.jp:2119/jobmanager-kgpbe-g4med
<input checked="" type="checkbox"/>	https://dg09.cc.kek.jp:9000/OcoXkof40SzGgDC8l8aCQ	Start Sat Feb 24 07:40:37 2007 End Sat Feb 24 07:46:35 2007	Done (Success)	0003.jdl	0003.sh	0003.mac	Stdout stdout_log Stderr stderr_log	hist_000079_0003.root	dg10.cc.kek.jp:2119/jobmanager-kgpbe-g4med

Back Reload Merge Tarball

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完了

Job Status and History

KEK GRID Web UI - Mozilla Firefox

http://de04.cc.kek.jp/webui/job_history.php?p=1&o=

はじめよう 最新ニュース

KEK GRID Web UI

Proxy and Resource Monitoring Job Submission Preferences Job History Logout

Total 34 Jobsets: 1 2 3 4 5 6 7 Next Last

Jobset ID	Start(UTC)	End(UTC)	Status	
000092	Mon Feb 26 09:05:22 2007		Running	Cancel
000098	Mon Feb 26 09:05:08 2007		Running	Cancel
000097			Submitting...	
000096	Mon Feb 26 08:59:20 2007	Mon Feb 26 09:06:27 2007	Done	
000095	Mon Feb 26 08:59:12 2007	Mon Feb 26 09:05:24 2007	Done	

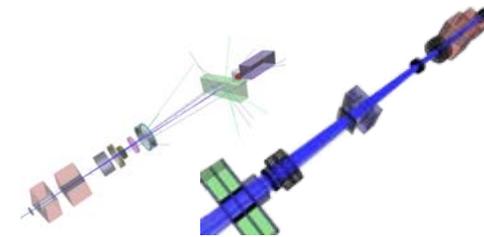
Reload

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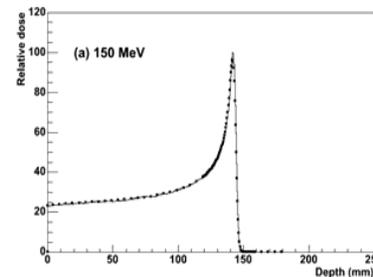
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Web User Application

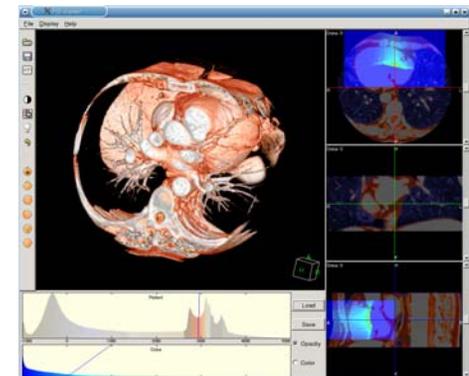
- Input parameters
 - Facility
 - HIBMC/NIRS-IHI/NCC-East/.... (Japanese facilities)
 - Geometry (beamline modules)
 - collimator/wobler magnet/scatterer/range shifter/ridge filter/MLC/...
 - Target
 - water phantom / human body (DICOM)
 - Beam condition
 - beam energy/beam spread
 - Simulation parameters
 - physics lists
 - cut values



- Outputs
 - ROOT file
 - Dose distribution
 - GDD file
 - CT image w/ dose map
 - ...

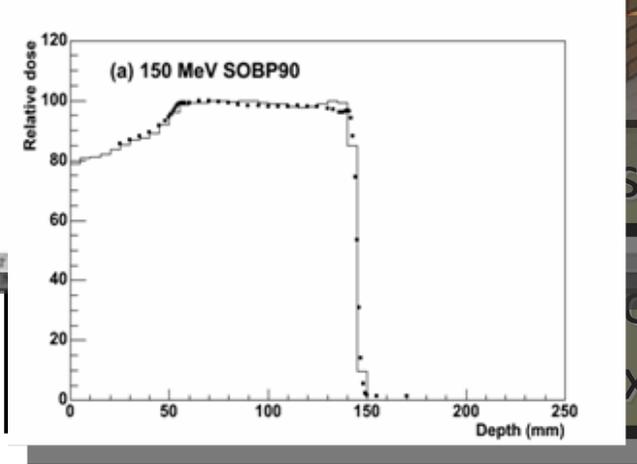
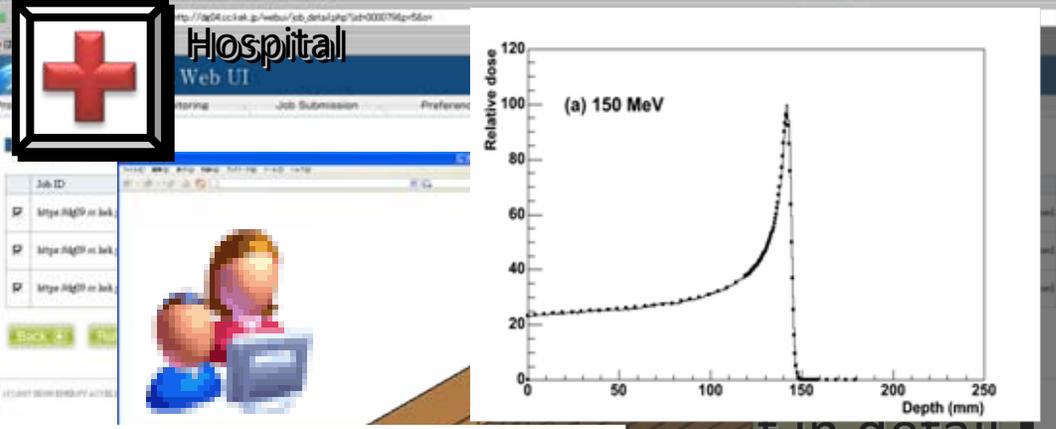


gMocren





Hospital



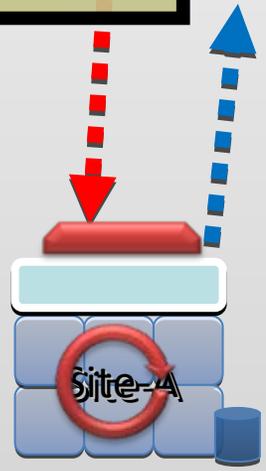
et in detail

sults

source information
xy certificate

Grid Web UI

Broker
Server
Queue
Information Supermarket
Job Submission



Practical Workflow



ISGC 2007
28/MAR/2007

Current Status & Future Prospects

- Medical application of Geant4 and GRID
 - MC-based dose calculation system in radiotherapy requires large amount of computing power.
- Gridification is a solution to boost simulation speed.
 - We are developing an easy-to-use web portal for hadron therapy simulation on a GRID environment,
 - providing a secure and efficient way of distributed analysis in the context of GRID technology.
 - We will improve functionality/usability.
 - migration of user applications
 - DICOM file sharing
 - use user certificates in web browsers (instead of uid/passwd)

Side project

- Education application
 - Course material on radiology and particle physics
 - web based application
 - Not yet GRIDaware

