



Enabling Grids for E-scienceE

Bordeaux, November 3 -10, 2005

GATE FOR BRACHYTHERAPY APPLICATIONS

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www.eu-egee.org



Geant4 2005 10th International Conference

- **GATE (Geant4 Application to Tomographic Émission) is based on Geant4 libraries**
- **In order to adapt GATE for dosimetry applications a dose map calculation module was developed**
- **Dose deposit may be collected in the phantom through the « addDoseOutput » command** (dose deposited in each voxel)
- **Dose calculations obtained with GATE have been compared to other methods** (MC codes, Analytical method)
- **Results for Ocular brachytherapy treatment using $^{106}\text{Ru}/^{106}\text{Rh}$ Applicator with GATE**

Geometry and systems: To facilitate the hierarchical description of a detector

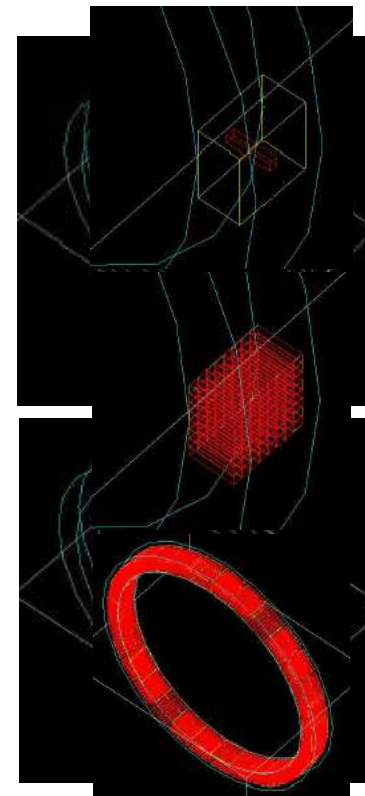
Existing

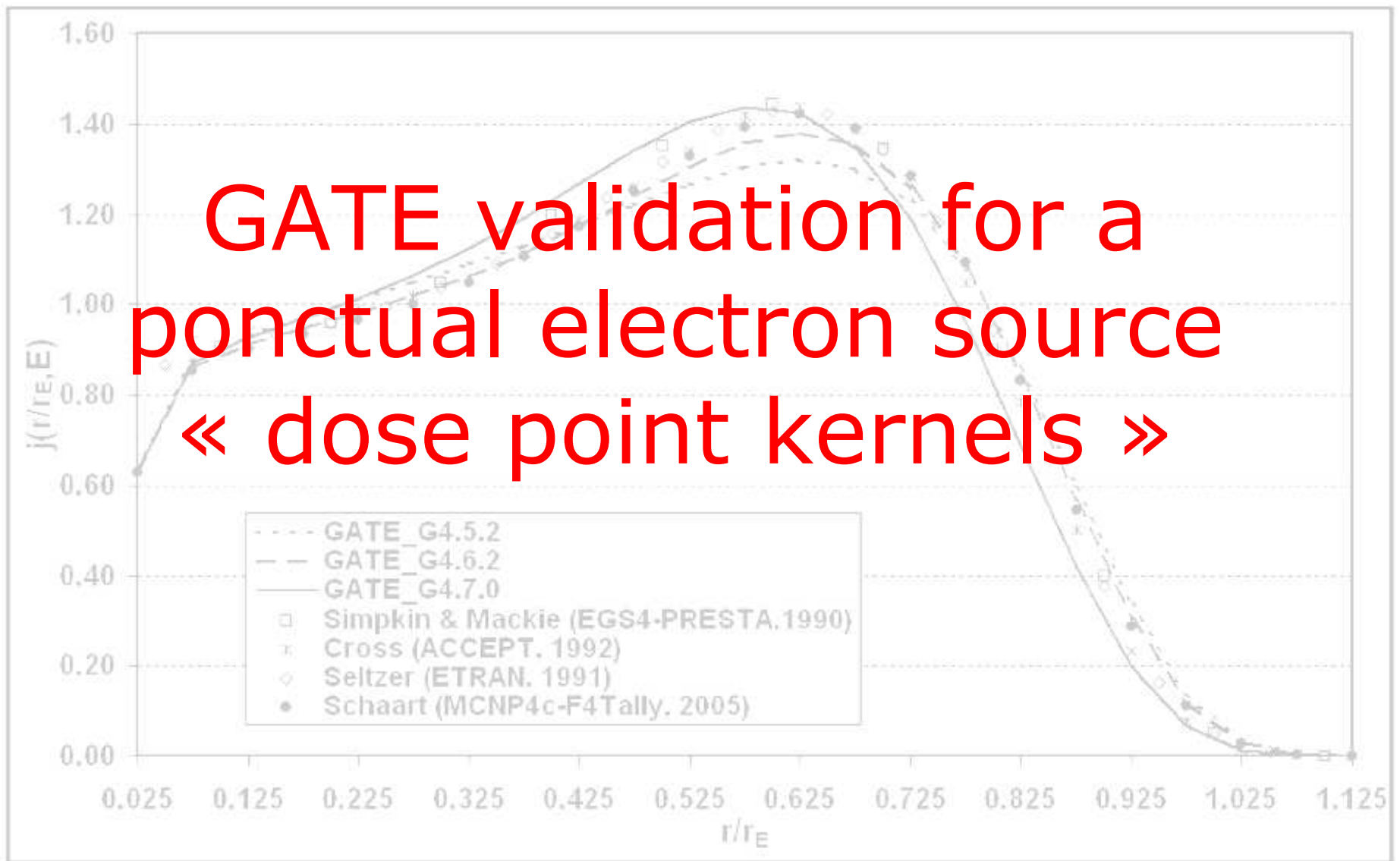
- Systems dedicated for SPECT and TEP
- Global scanner system used for radiotherapy
- Data analysis tool: ROOT

```
# C R Y S T A L
/gate/box1/daughters/name box2
/gate/box1/daughters/insert box
/gate/box2/geometry/setXLength 10. mm
/gate/box2/geometry/setYLength 2. mm
/gate/box2/geometry/setZLength 2. mm
/gate/box2/setMaterial LSO
# R E P E A T C R Y S T A L
/gate/box2/repeaters/insert cubicArray
/gate/box2/cubicArray/setRepeatNumberX 1
/gate/box2/cubicArray/setRepeatNumberY 8
/gate/box2/cubicArray/setRepeatNumberZ 8
/gate/box2/cubicArray/setRepeatVector 0. 2.25 2.25 mm
# A T T A C H V o l u m e s T o a S Y S T E M
/gate/systems/cylindricalPET/rsector/attach box1
/gate/systems/cylindricalPET/module/attach box2
# R E P E A T R S E C T O R
/gate/box1/repeaters/insert ring
/gate/box1/ring/setRepeatNumber 30
# D e f i n e a S E N S I T I V E D e t e c t o r
/gate/box2/attachCrystalSD
```

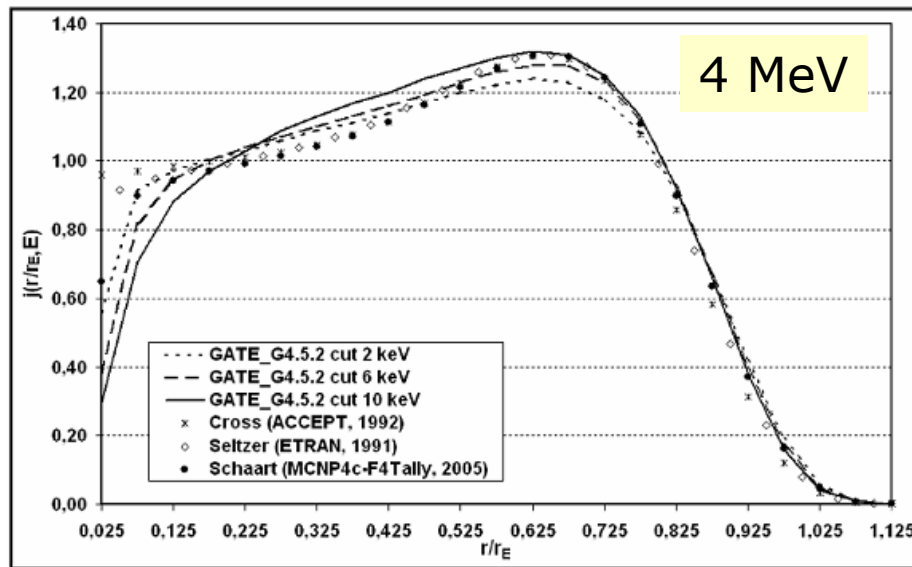
Needs

- Systems for linear accelerators
- Systems for sealed sources
- Data output adapted

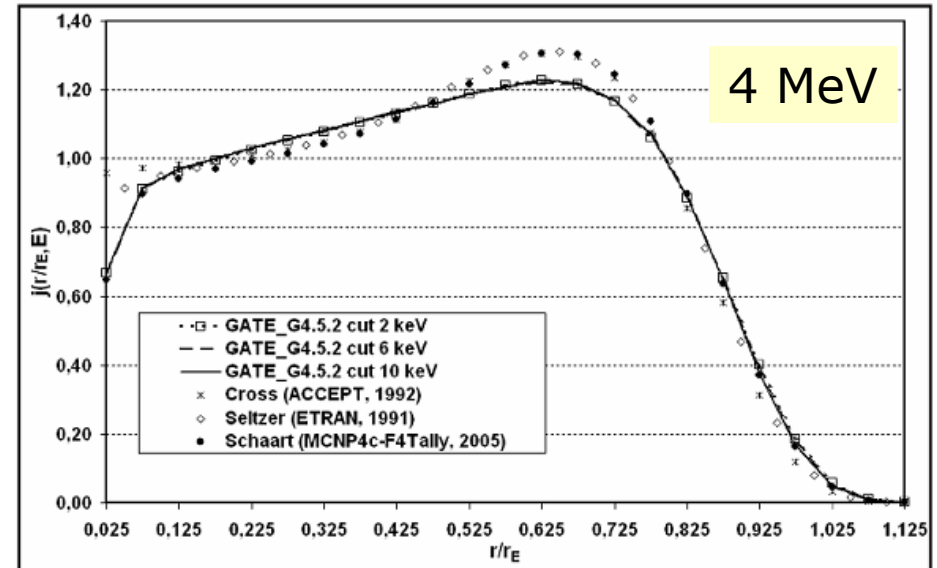




Impact of cuts and detection volume



Large volume

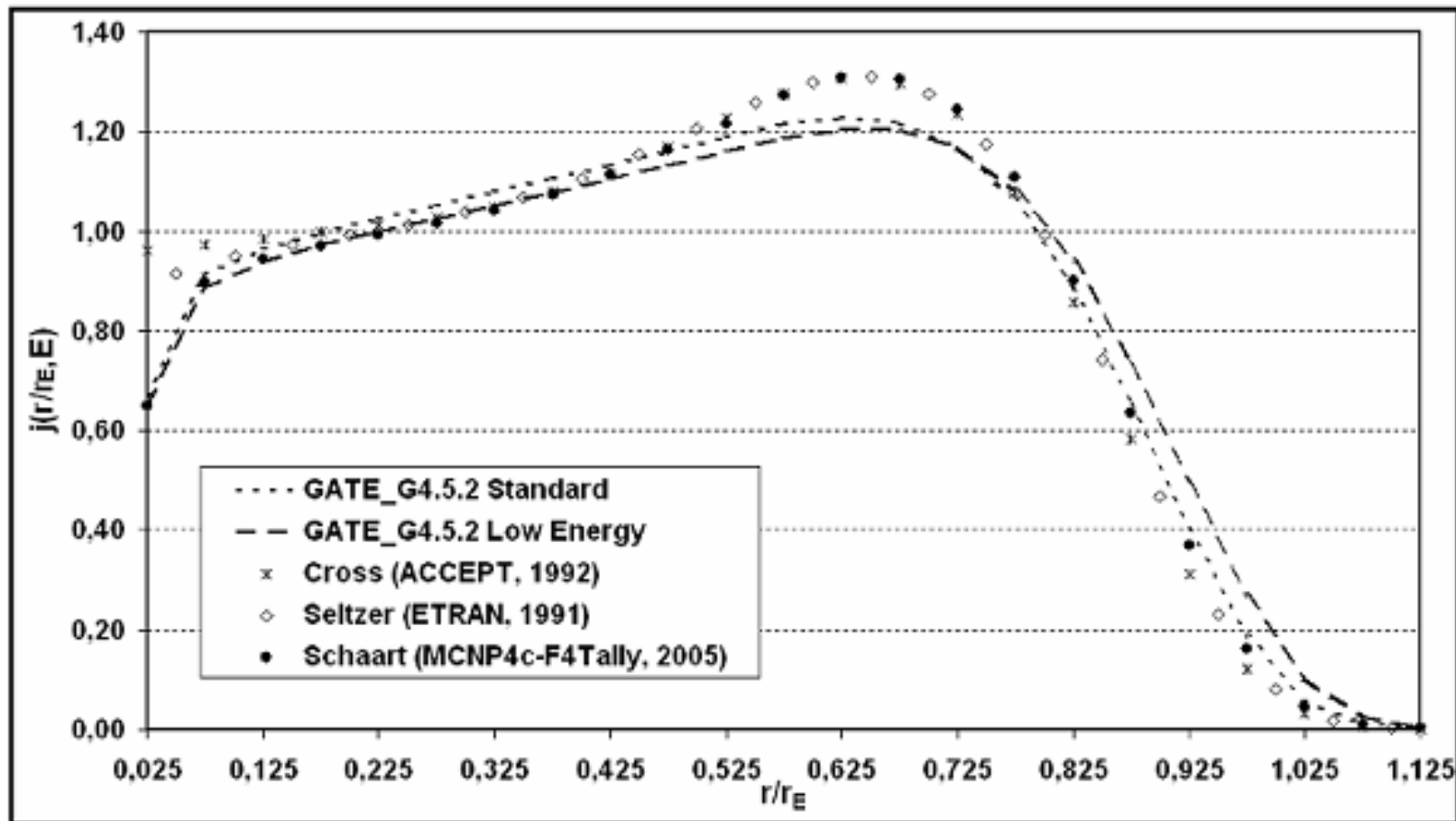


Concentric spheres

➡ Variation of the dose deposit with cut in the homogeneous medium

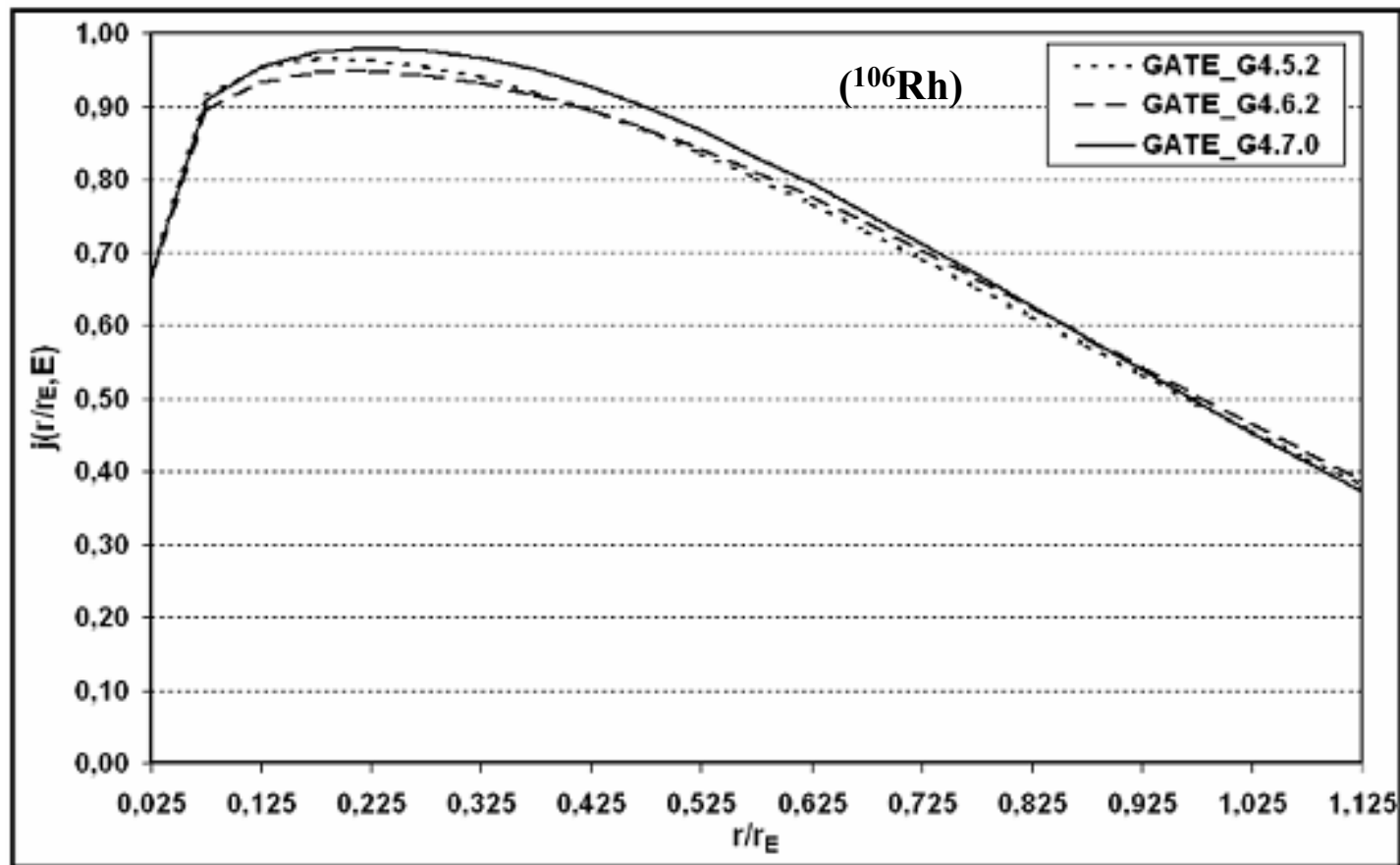
➡ Stability of the results for simulation in the concentric spheres

Impact of physics implemented in geant4



➡ Variations between the packages due to the implementation of ionization process

Impact of physics implemented in geant4



➔ Variations attenuated for different version of Geant4

- **Impact of geometry in GEANT4**

- Results in the volume divided into concentric spheres = Results in homogeneous volume with the smallest cut

- **Impact of ionization**

- Differences between the two packages does not account for the variations observed between the versions of GEANT4
- Differences between the packages due to the implementation of the processes of ionization





↪ Variations observed between Geant4 versions due to the implementation of the multiple scattering process

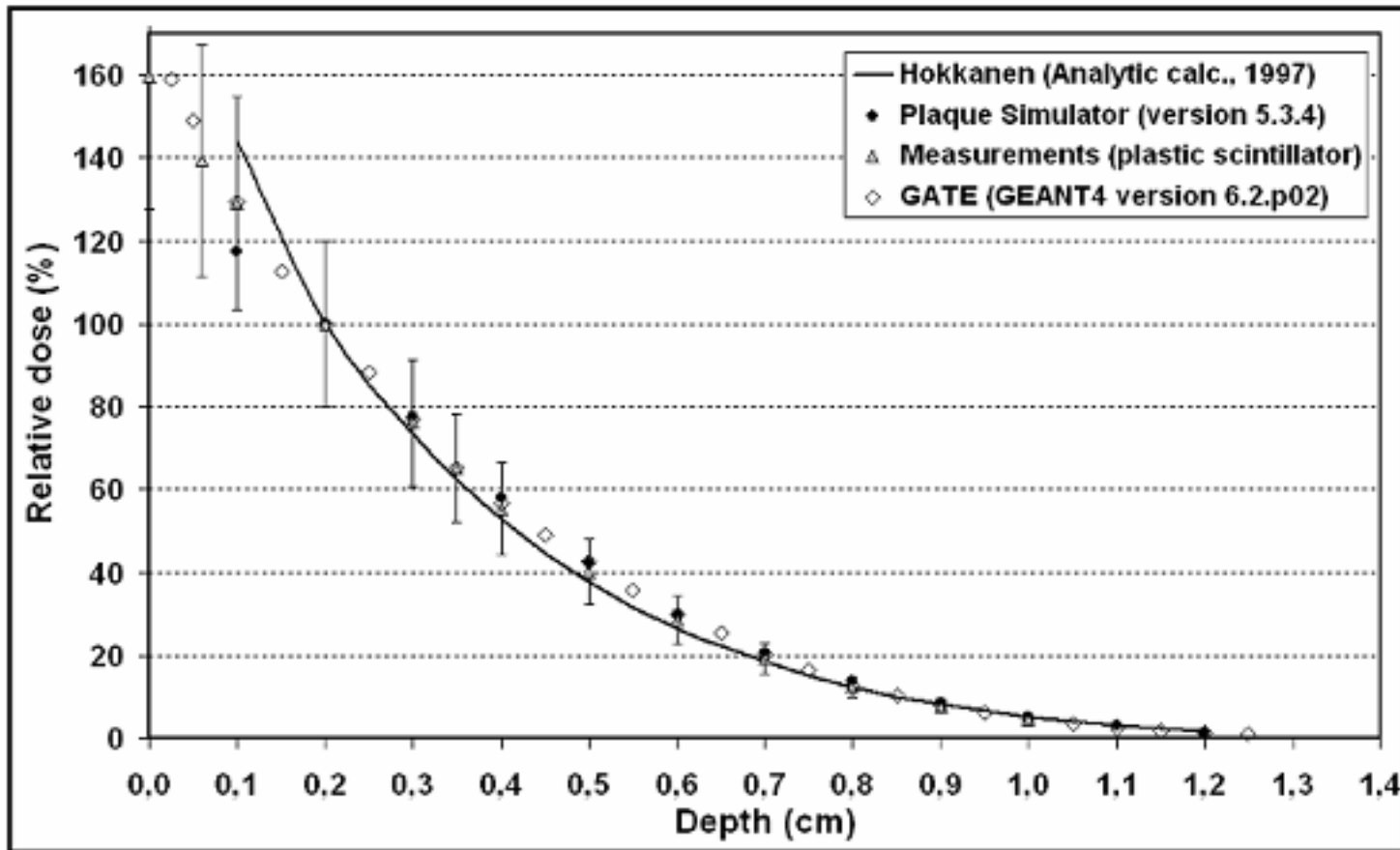
↪ **GEANT4.6.2** version is closest to the other MC codes



Ocular brachytherapy using $^{106}\text{Ru}/^{106}\text{Rh}$ applicator with GATE

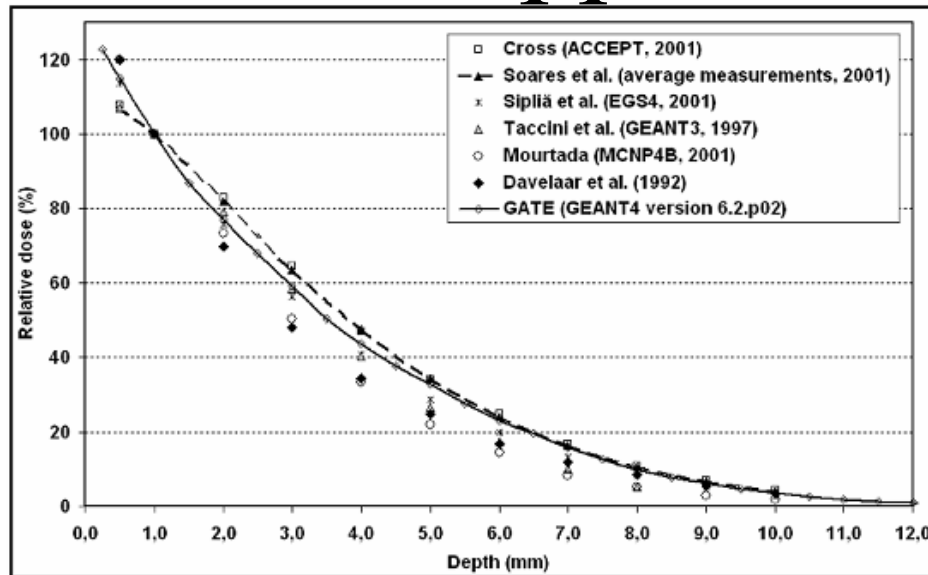
- **GATE results compared with various methods:**
 - Empirical method (Hokkanen) starting from Loevinger function
 - Experimental measurements: plastic scintillator & NIST study
 - Analytical soft: Plaque Simulator
 - Other Monte Carlo code: ACCEPT 3.0, MCNP, EGS4...
- **Ophtalmic applicator description:**

Applicator	Therapy use	Curvature radius	Diameter	height
 CCB	Uvea and choroid melanomes	12 mm	20 mm	5,4 mm
 CCA	Uvea and choroid melanomes	12 mm	15,3 mm	3,3 mm
 CCX	Rétinoblastomes	12 mm	11,6 mm	2,3 mm
 CCZ	Study of rabbit eye	12 mm	11,6 mm	2,3 mm



Comparisons:

- **GATE/Hokkanen:** good correlation without the modeling of silver applicator for analytical calculations (Cross)
- **GATE/measurments:** good agreement in spite errors bars $\pm 20\%$
- **GATE/Plaque Simulator:** very good agreement up to 1 cm



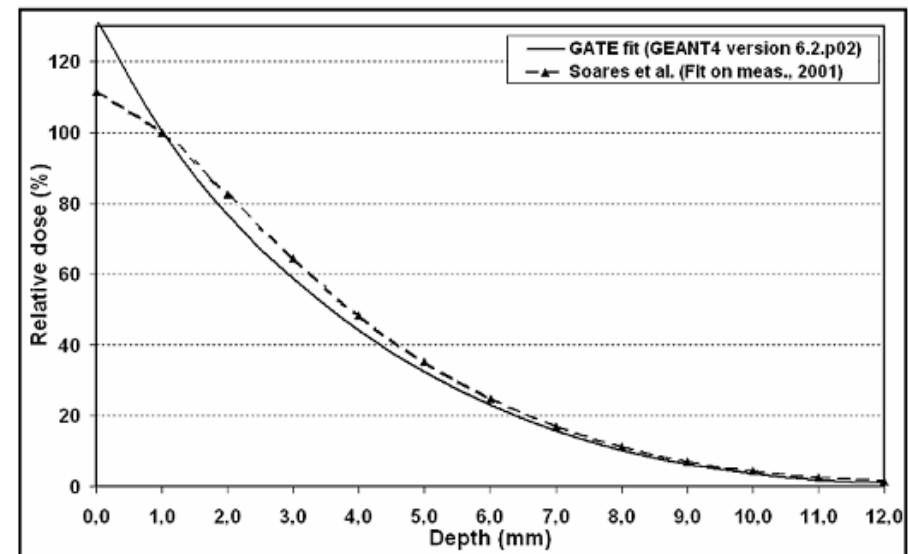
Comparisons with realised measurements taken by NIST (Soares et al.):

$$\left[D(z, r_0) / D(z_0, r_0) \right] = \exp(a_s + b_s z + c_s z^2 + d_s z^3 + e_s z^4 + f_s z^5)$$

- **For 0.0 mm: 20% of variations between dose value**
- **Between 1 & 12mm: variations < 5.7%**

Comparisons with other Monte Carlo code

- **Large various between GATE and ACCEPT-3.0:**
- **Variations < 2% up to 1 cm**
- **High variations at a short distances: 18% at 0.05 cm and 7% at 0.1 cm**



- GATE is already in use for dosimetry applications in both animal and human models.
- Certain challenges still remain in for GATE to become a MC code for dosimetry applications.
- Concerning a brachytherapy application using Iodine 125 sources: a study for kerma/dose calculation with « track length estimator » method is under validation

Future Work

- Optimization of the execution speed, improved flexibility in the dose calculation module
- Validation studies in the use of GATE for internal and external dosimetry applications
- GEANT4 validation for dosimetry related to the electrons (tests of the multiple scattering in the next versions)
- Dosimetry on images patient voxelized (modeling with real patients data)

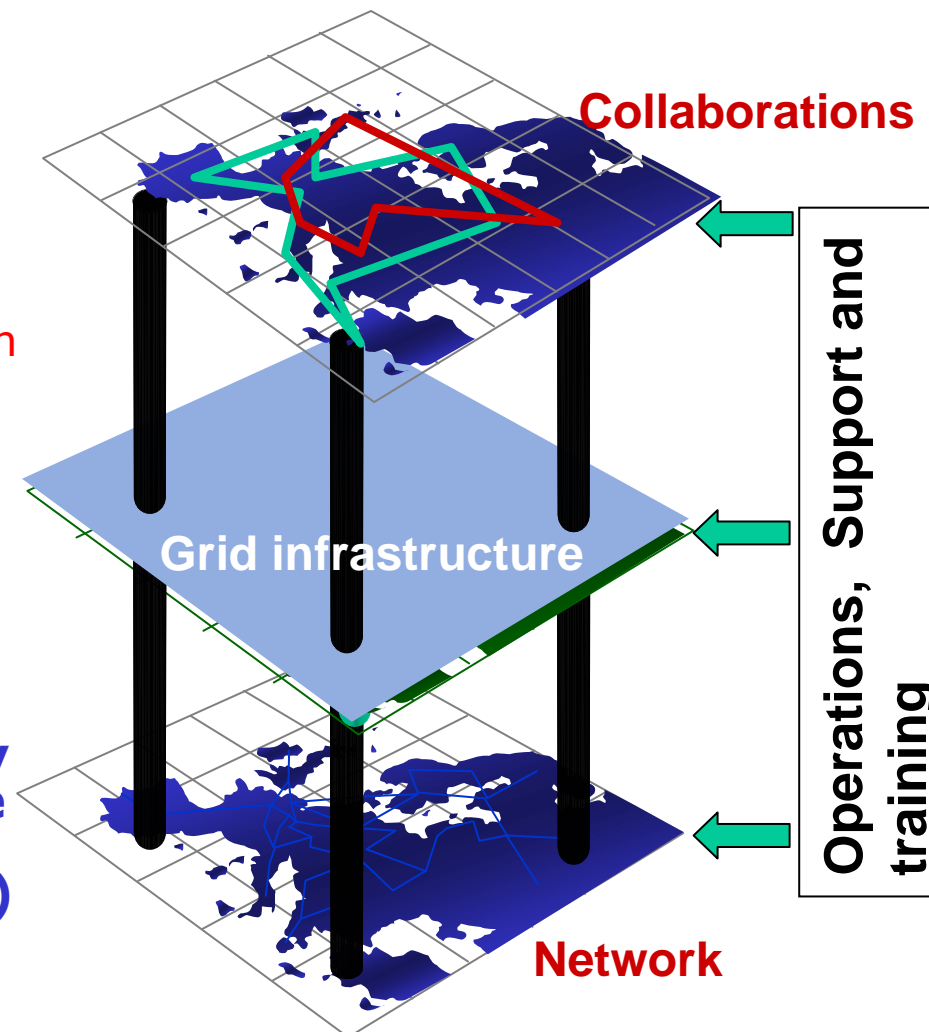
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GATE SIMULATIONS IN A GRID ENVIRONMENT

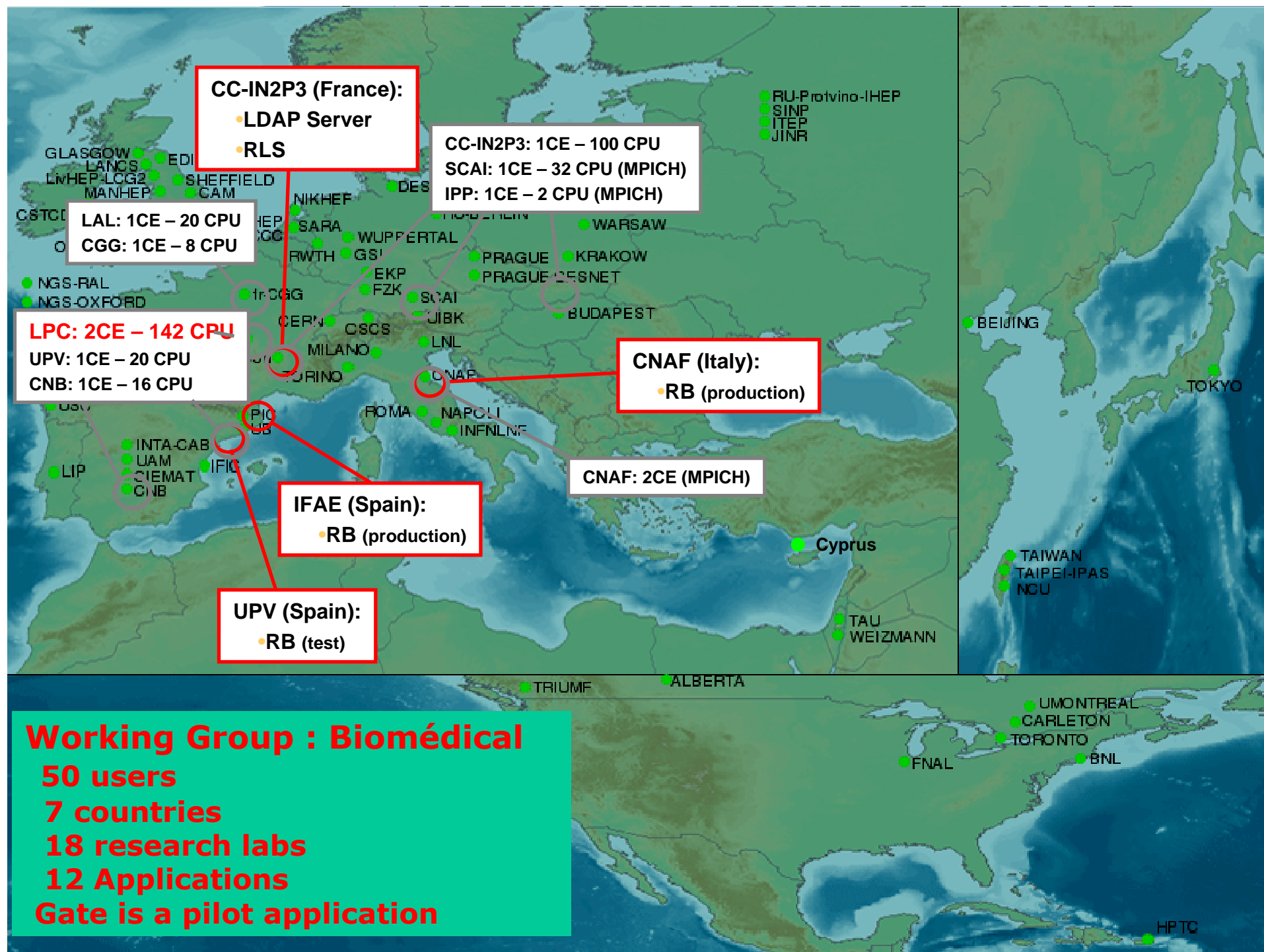


- **GATE, a MC simulation platform for treatment planning in radiotherapy and brachytherapy**
- **To reduce computing time, deployment of GATE applications on a computing grid environment**
- **the method is based on the parallelization of Random Number Generator used of MC**
- **Strategy and results achieved**
- **Convivial access to the grid environment for the medical physicist (Genius portal)**

- **Build a large-scale production grid service to:**
 - Support science and technology worldwide
 - Link with and build on national, regional and international initiatives
 - Foster international cooperation both in the creation and the use of the e-infrastructure
- **71 leading institutions in 27 countries, federated in regional Grids**
- **Aiming for a combined capacity of over 20'000 CPUs (one of the largest international Grid infrastructures ever assembled)**



GATE : Application pilote for biomedical working group





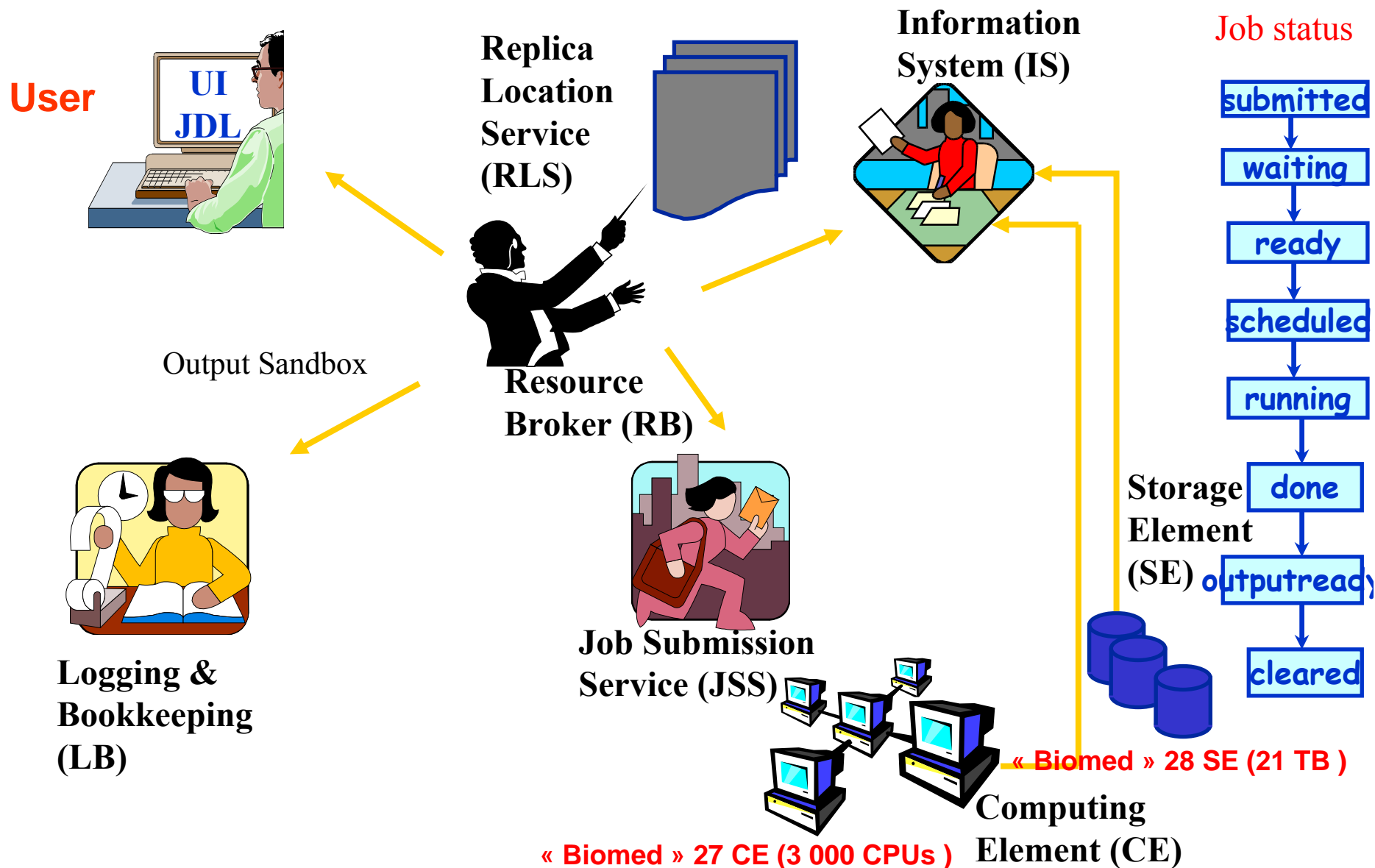
GATE installations

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- **For an easy installation on sites without root privileges, use of RPMs (...)**
- **RPMs G4.5.2.p02**
 - gate_v1.2.0 Redhat 7.3 (current installation)
 - gate_v1.2.0 SL3
- **RPMs G4.6.2.p02**
 - gate_v2.1.0 SL3 (current installation)
 - gate_v2.1.0 SL3
- **RPMs G4.7**
 - gate_v2.2.0 SL3
- **Sites with GATE Application: SL3 system**
 - CCIN2P3 (Lyon)
 - LPC (Clermont-Ferrand)
 - HGRNET (Greece)
 - CNB (Madrid)
 - INFN (Italy)
 - Taiwan

eGEE How to use the grid

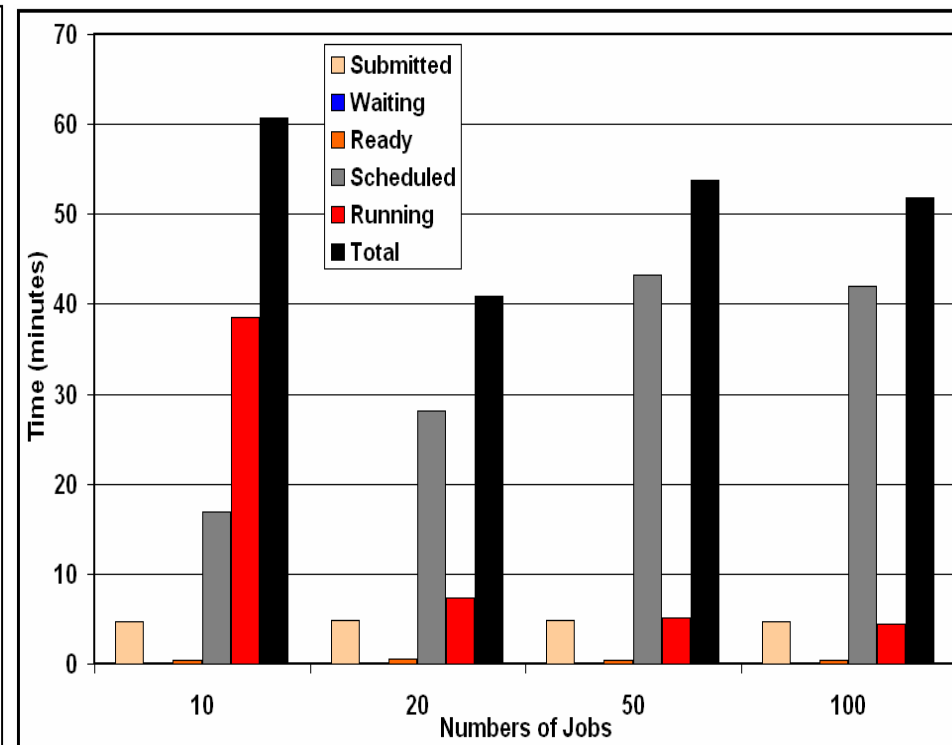
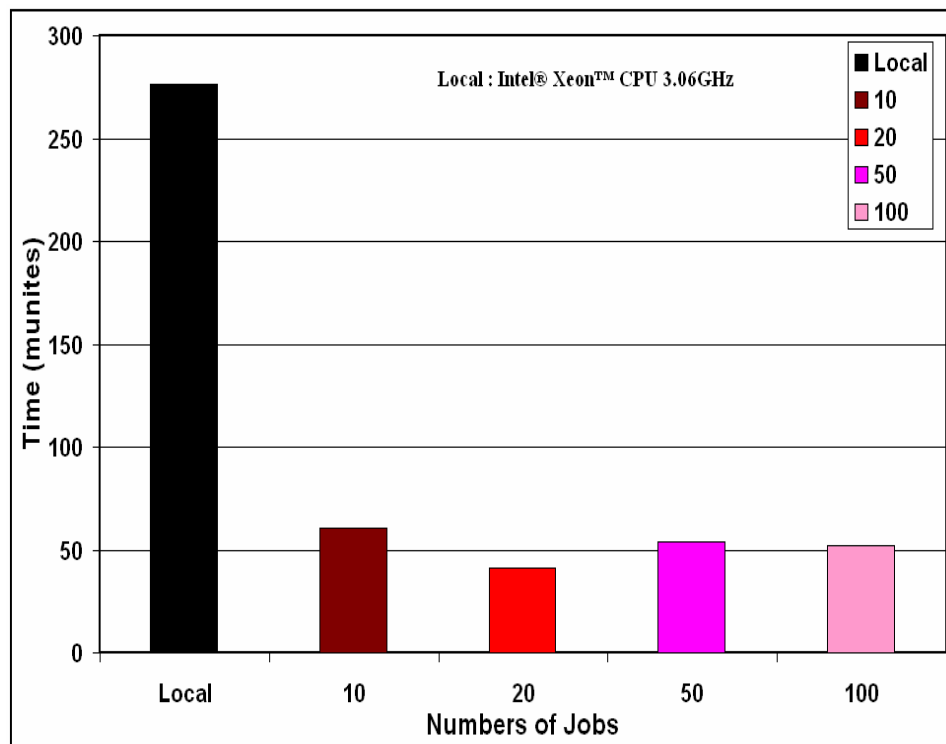
Enabling Grids for E-science



CE : 100 Pentium 3/4

Local : Xeon 3GHz

Maximum Gain = 7 for 20 jobs



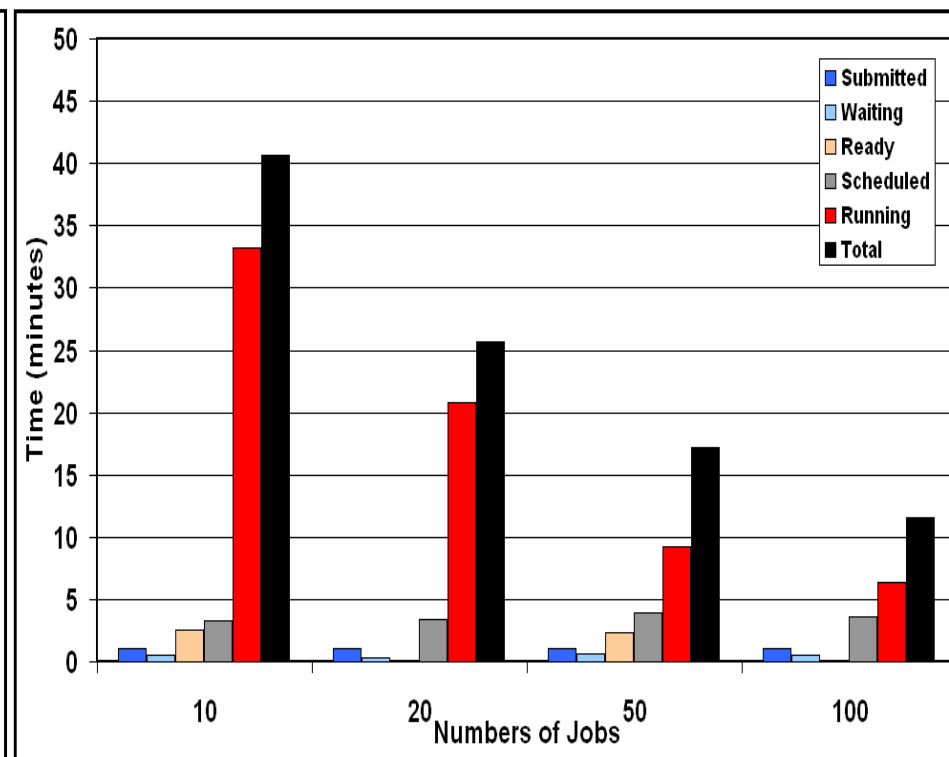
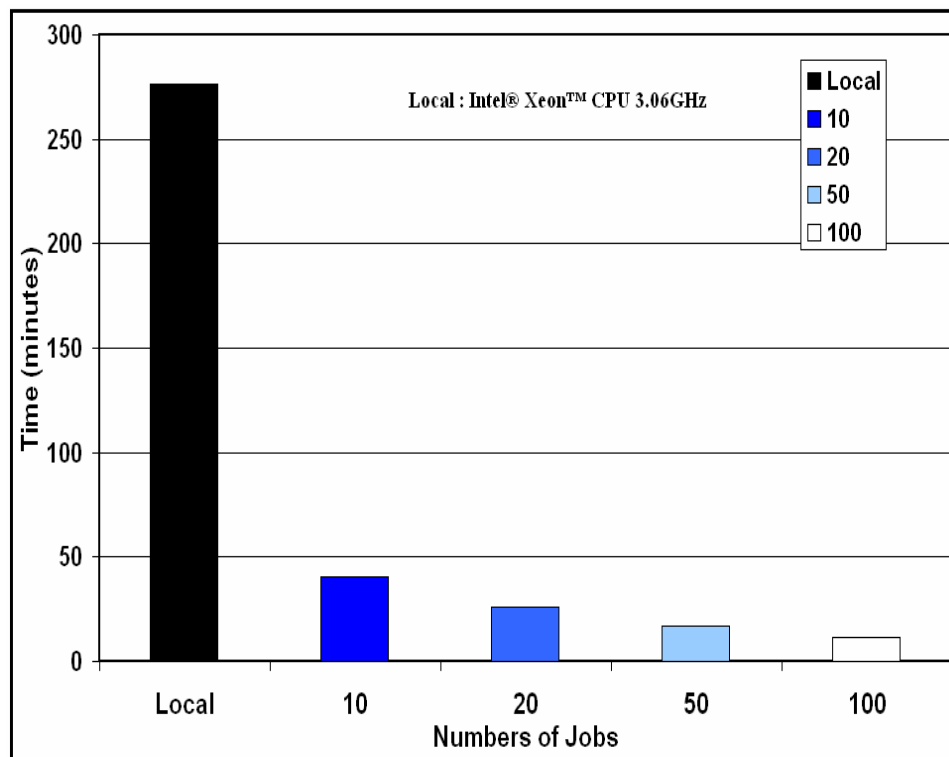
- **Computing time is not proportional to the number of jobs running in parallel**

- the launching time of the jobs, the grid managing of the jobs
- the numbers of machines on the CE, the CE load and performance

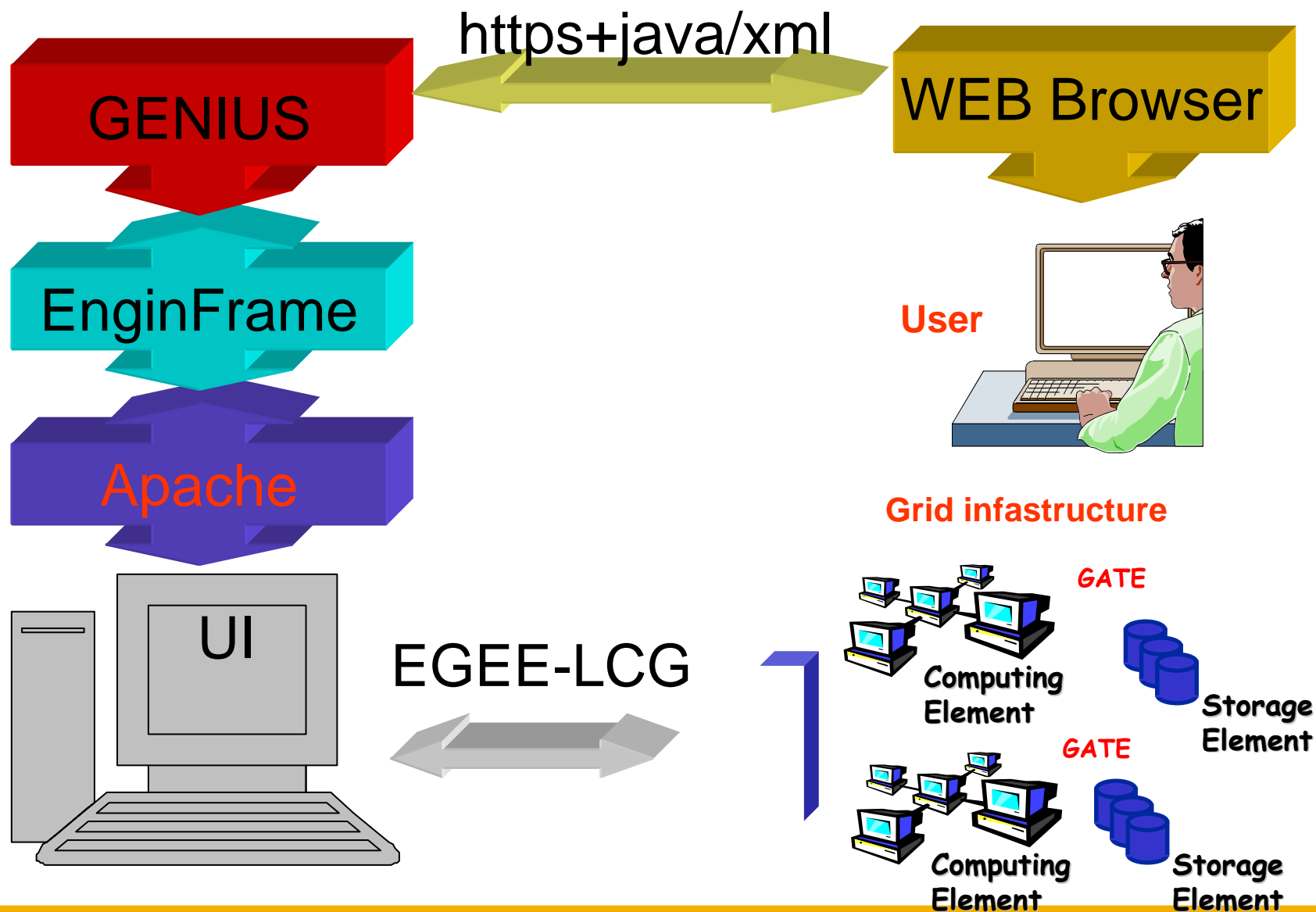
CE : 84 Xeon 3GHz

Local : Xeon 3GHz


Maximum Gain = 24 for 100 jobs



- Gains in computing time are similar when we let the grid (RB) select the best place between LPC and CC-IN2P3
 - 90% of jobs are sent on LPC
 - Gains in computing time is 19




<https://clrglop208.in2p3.fr>




INFN
Istituto Nazionale
di Fisica Nucleare

- File Services
- Security Services
- Job Services
- Data Services
- Info Services
- Monitoring Services
- Interactive Services
 - Grid Settings
 - Set VO
 - Current VO Services
 - Statistics
 - Logout


powered by
EnginFrame 3.2
compliant with
LCG-2
GRID.IT



enginframe



genius



eGEE
Enabling Grids for
E-science in Europe

Grid Enabled web eNvironment for site Independent User job Submission

Welcome to GENIUS 2.9.0

[Important Notice](#)

[GENIUS User's Guide \(pdf\)](#)

[New Grid Authentication with MyProxy](#)

[GENIUS MyProxy Server Installation](#)

[GENIUS CVS Available](#)

[GENIUS Mailing List](#)

[GENIUS Mailing Archive \(Help on Majordomo Commands\)](#)

[GRID MOVIE](#)

[Useful Links](#)

[Credits](#)

This portal is best viewed with Mozilla 1.6.

Netscape (4.79, 4.80, 6 and higher) and Internet

Explorer (5 or higher) can also be used.

The use of any other web browsers could induce some
visualization mismatches and is not currently suggested.

GENIUS is based on Apache 1.3.31 and OpenSSL 0.9.7d.

Last update: **Mon 12 July 2004**


GATE : Jobs Settings : (Creating a GATE simulation)

Welcome to the GENIUS INFN GRID Portal - Microsoft Internet Explorer

Fichier Edition Affichage Favoris Outils ?

Précédente Recherche Favoris




Adresse <https://grid-tutor.ct.infn.it/> OK Liens »



Jobs Settings

- up
- Create GATE files
- Remove GATE files
- Make JDLs

powered by
EnginFrame 3.2
compliant with
LCG-2
GRID.IT

Grid Enabled web eNvironment for site Independent User job Submission

RB: gilda VO: gilda RLS: GILDA Your Data Logout

Create GATE files

With this service it will be created/checked your GATE Repository and Settings. If you choose to perform Root Analysis, please read these few [instruction](#) for your root class files.

Repository Name

Root Analysis ☐ Yes ☐ No

InputSandbox Files (3 files)

InputData lfn:

macro (.mac)

Number of Partitions

Status Files (=Number of Partitions)

Terminé Internet


GATE : Jobs Queue :(job management: job status)

Welcome to the GENIUS INFN GRID Portal - Microsoft Internet Explorer

Fichier Edition Affichage Favoris Outils ?

Précédente Rechercher Favoris



Adresse <https://grid-tutor.ct.infn.it/> OK Liens »




Jobs Services

- up
- Jobs Settings
- Jobs Submission
- Jobs Queue
- GATE job data

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Grid Enabled web eNvironment for site Independent User job Submission



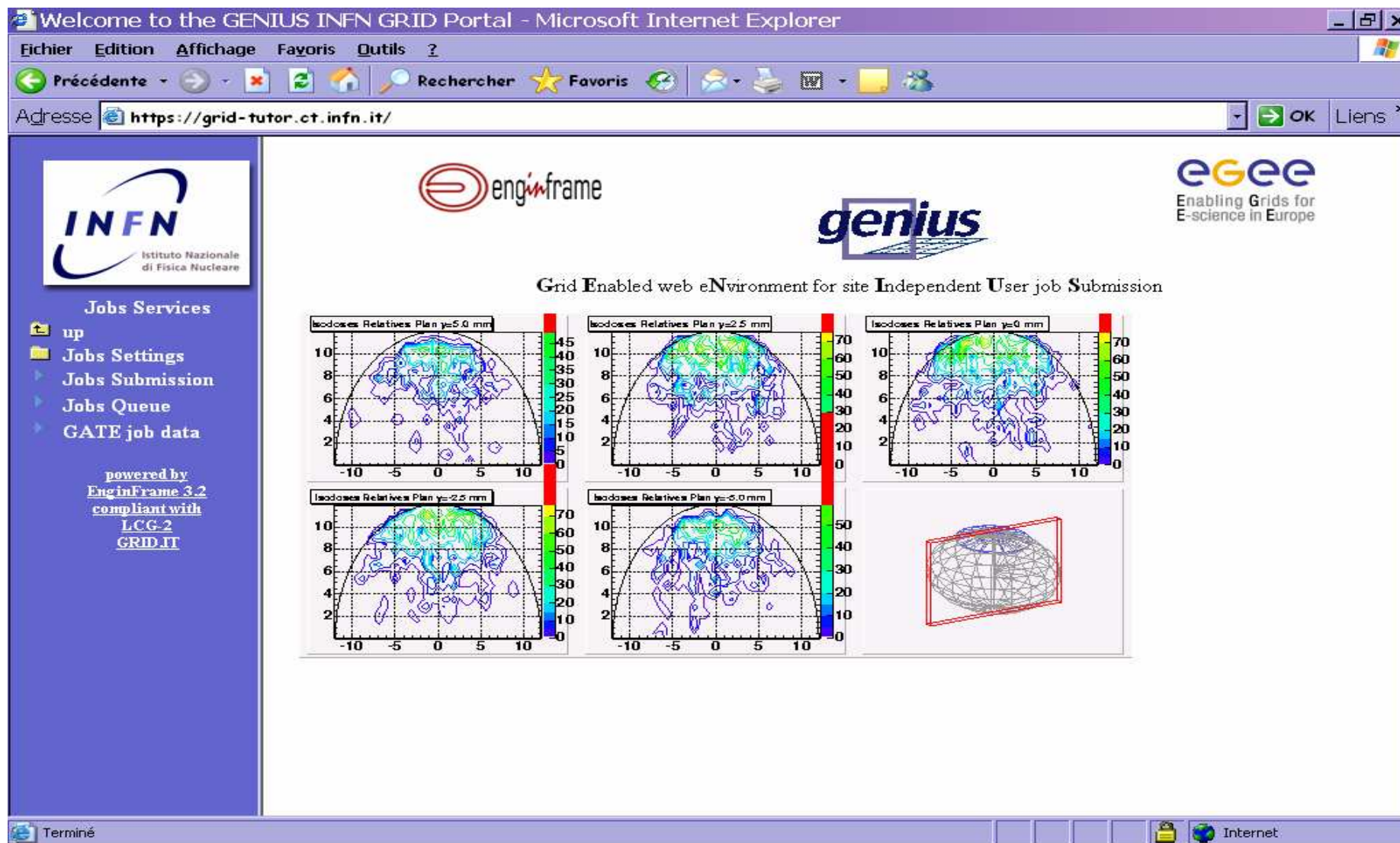
Enabling Grids for
E-science in Europe

RB: gilda		VO: gilda	RLS: GILDA	Your Data	Logout
No	Job ID	Last update	Destination	Status	
4	https://grid004.ct.infn.it:9000/qdCL6HCv4AMG9QFqn645kw	Fri Nov 12 13:38:01 2004	grid010.ct.infn.it:2119/jobmanager-lcgpbs-infinite	Scheduled	
3	https://grid004.ct.infn.it:9000/moI2CgILw9k5Dik4eJ682w	Fri Nov 12 13:40:47 2004	grid010.ct.infn.it:2119/jobmanager-lcgpbs-infinite	Running	
2	https://grid004.ct.infn.it:9000/epYl_-EMrNzeyyFJ7ulEzQ	Fri Nov 12 13:40:48 2004	grid010.ct.infn.it:2119/jobmanager-lcgpbs-infinite	Running	
1	https://grid004.ct.infn.it:9000/DuNF0S0k9m3PonYf-rTizA	Fri Nov 12 13:40:48 2004	grid010.ct.infn.it:2119/jobmanager-lcgpbs-infinite	Running	

Terminé

Internet

GATE : Jobs Services : (Submission, results)



- **The computation time was reduced although not sufficiently for clinical practice: further optimisations are going on**

Remark : Submission and retrieval times are very important using sequential submission (need to use multithreaded submission)

- **A portal has been created to ease the access to this applications for the medical physicists**
- **A large community of users is interested in GATE**
- **Real production is done on grid infrastructure**
- **Inter-connection between web and grid services needs to be validated on production infrastructure**