

A Monte Carlo – GEANT4 web application to support Intra-Operative Electron Radio Therapy technique

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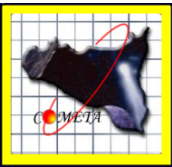
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Workshop GARR – Calcolo e Storage Distribuito
Roma, 9-30 November 2012
Ministero Istruzione Università e Ricerca





Outline

LATO HSR GIGLIO
LABORATORIO DI TECNOLOGIE
ONCOLOGICHE



- **LATO (Laboratorio di Tecnologie Oncologiche) HSR Giglio**
 - Clinical and Research Activities;

- **The Intra-Operative Electron Radio Therapy (IOERT) technique in a nutshell;**



***ior_t_therapy*: a Monte Carlo application based on the GEANT4 toolkit;**

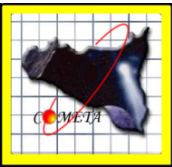
- *ior_t_therapy* & Grid: why and how ?

- **The Consorzio COMETA;**
 - Overview

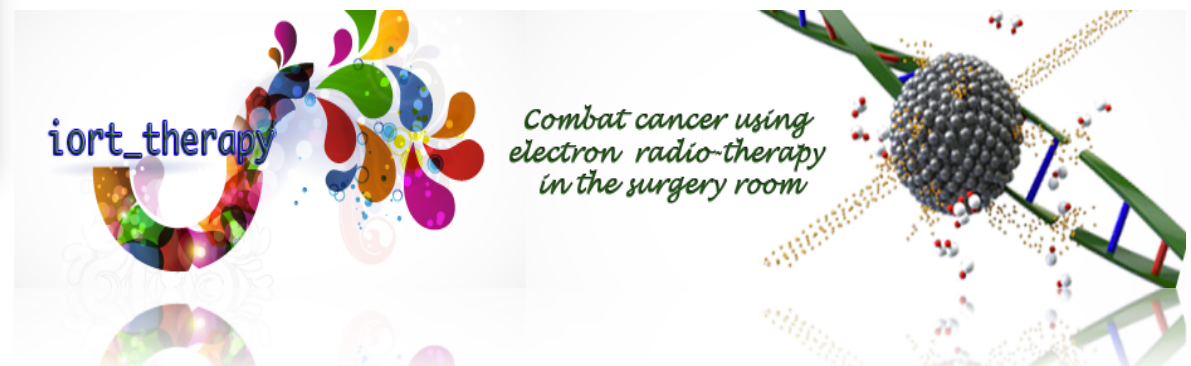


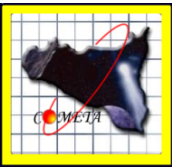
- **The Catania Science Gateway components;**
 - Architecture
 - The *ior_t_therapy* application on the Science Gateway
- **Summary and Conclusions;**
- **References and Contacts.**





- ❑ **LATO** (Laboratorio di Tecnologie Oncologiche) HSR Giglio
 - Clinical and Research Activities
- ❑ The **Intra-Operative Electron Radio-Therapy** (IOERT) technique in a nutshell
- ❑ ***ior_ttherapy***: a Monte Carlo application based on the GEANT4 toolkit
 - ❖ ***ior_ttherapy*** & grid: why and how ?



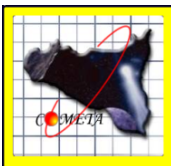


Laboratorio **d**i **T**ecnologie
Oncologiche (**LATO**) @ **HSR**
Giglio – **F**ondazione **I**stituto
San **R**affaele **G.** **G**iglio di
Cefalù, **C**ontrada
Pietrapollastra – **P**isciotta
90015 Cefalù (PA)



Clinical and Research Activities:

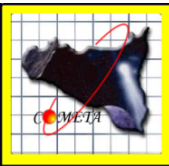
- ✓ **Proteomic and Genomic;**
- ✓ **Morbid Anatomy;**
- ✓ **Intra-Operative Electron Radio-Therapy (IOERT);**
- ✓ **Magnetic Resonance;**
- ✓ **Nuclear Medicine;**
- ✓ **Magnetic Resonance guided Focused Ultrasound Surgery (MRgFUS);**
- ✓ **Clinic Informatics.**



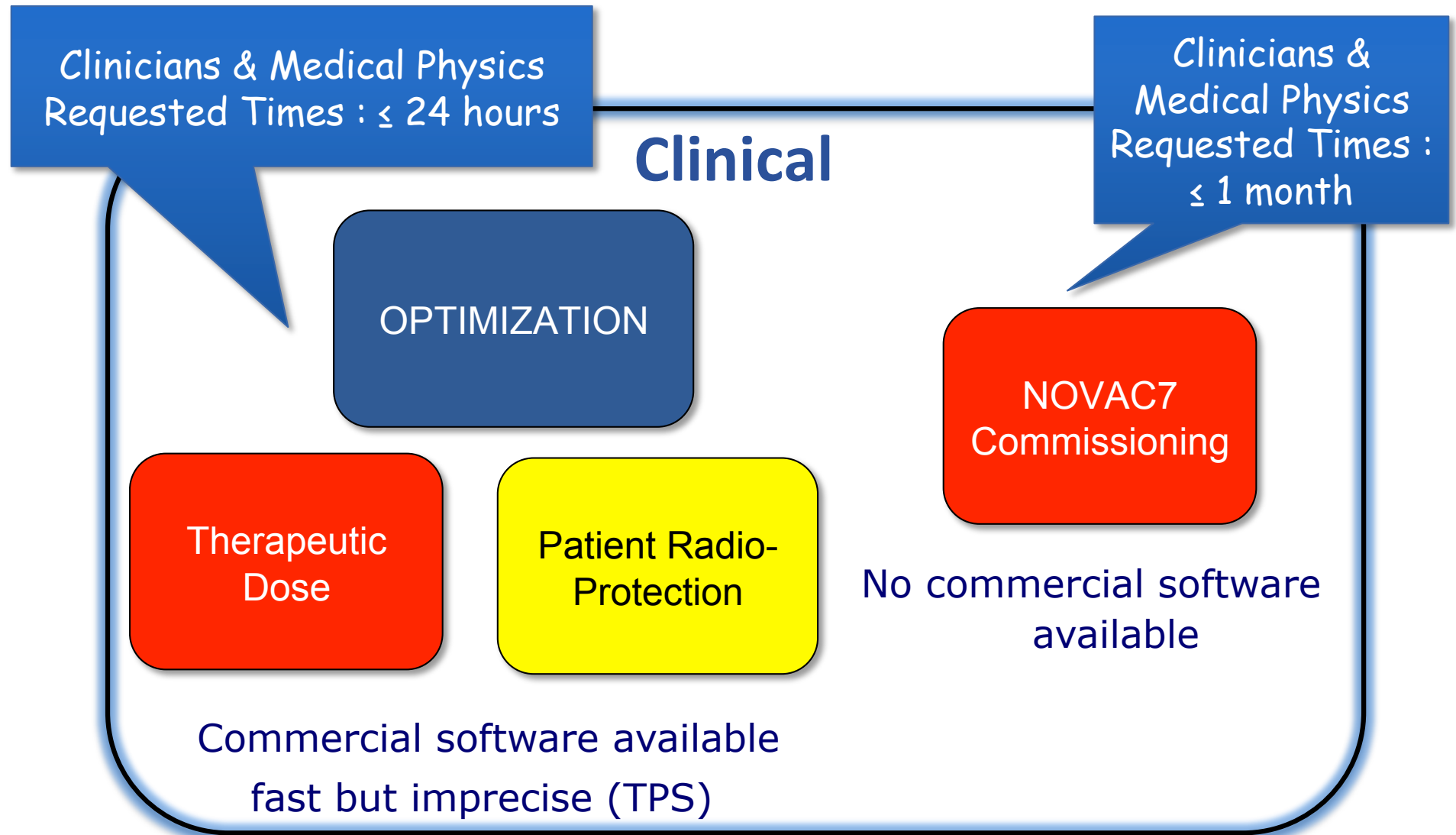
The Intra-Operative Electron Radio-Therapy (IOERT) technique in a nutshell

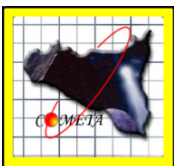
- ❖ **Intra-Operative Electron Radiotherapy (IOERT)** is an advanced radiation therapy technique that allows treatment of tumors after surgery, directly in the surgery room, delivering a high dose to the target (*Veronesi et al 2001*);
- ❖ Treatment for breast, stomach, prostate cancers;
- ❖ The electron beam is produced through dedicated and mobile accelerators, such as **NOVAC7** (NRT, Aprilia, Italy);
 - ✓ Electron beams of 4, 6, 8 e 10 MeV with different diameters (from 3 to 10 cm) and slant angles collimators (0° , 15° , 22.5° , 30° and 45°)





Clinical and Technologic Activities related to IOERT

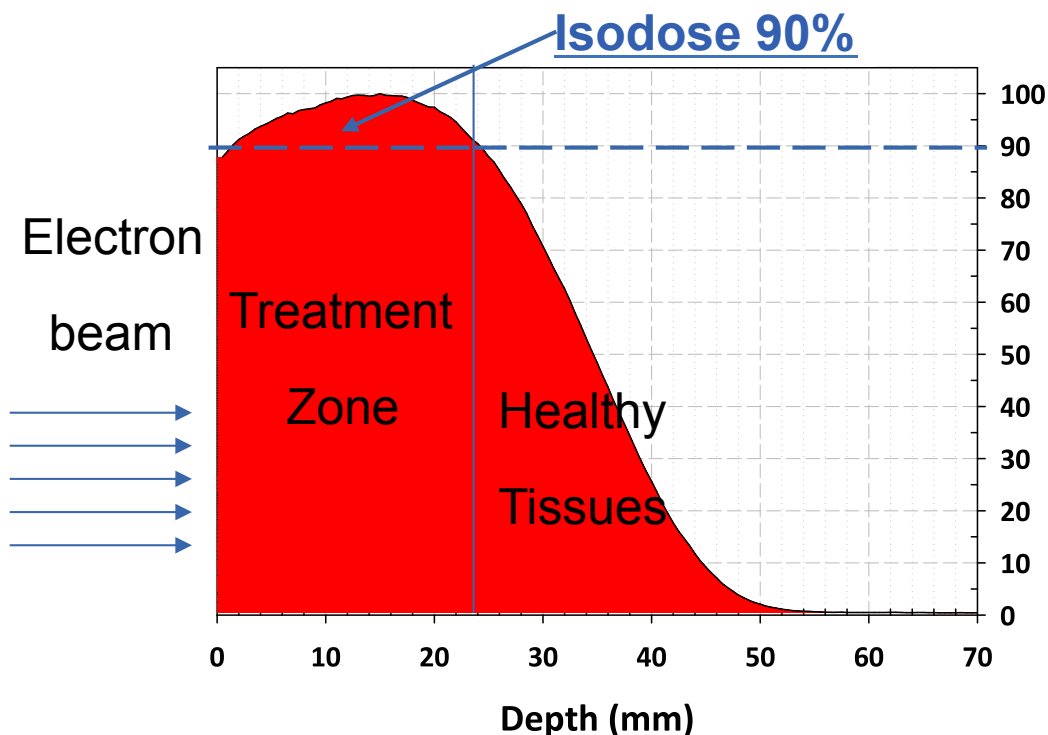




Patient Radio-Protection and Therapeutic Dose optimization

- ❖ One of the most relevant risks in breast intra-operative electron radiotherapy is the **incorrect positioning** or **misalignment** of the **shielding disc** which are mandatory in high-dose IORT.

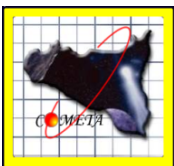
Dose prescription: single dose (21 Gy) to the tumor bed



Normal tissue protection



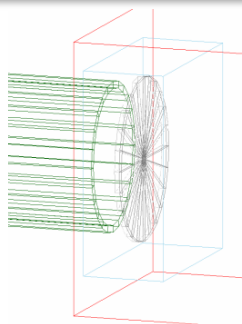
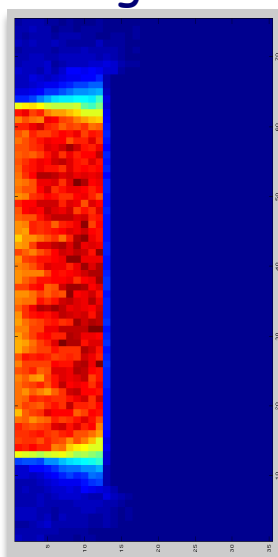
Positioning of a metal disc



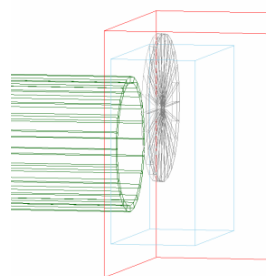
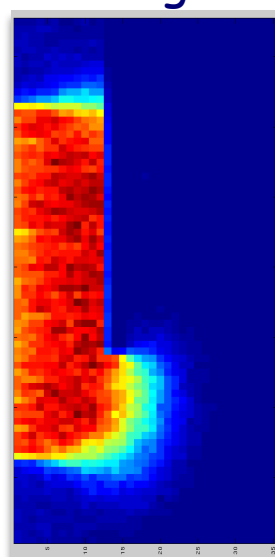
Patient Radio-Protection and Therapeutic Dose optimization

- ❖ If such a setup error occurs, the treatment zone could receive a **non-uniform dose delivery**, or some electron beam could **irradiate** some patient's healthy tissue

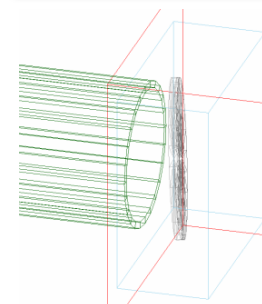
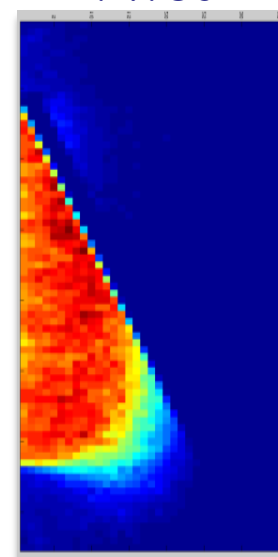
aligned

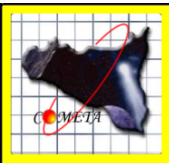


misaligned

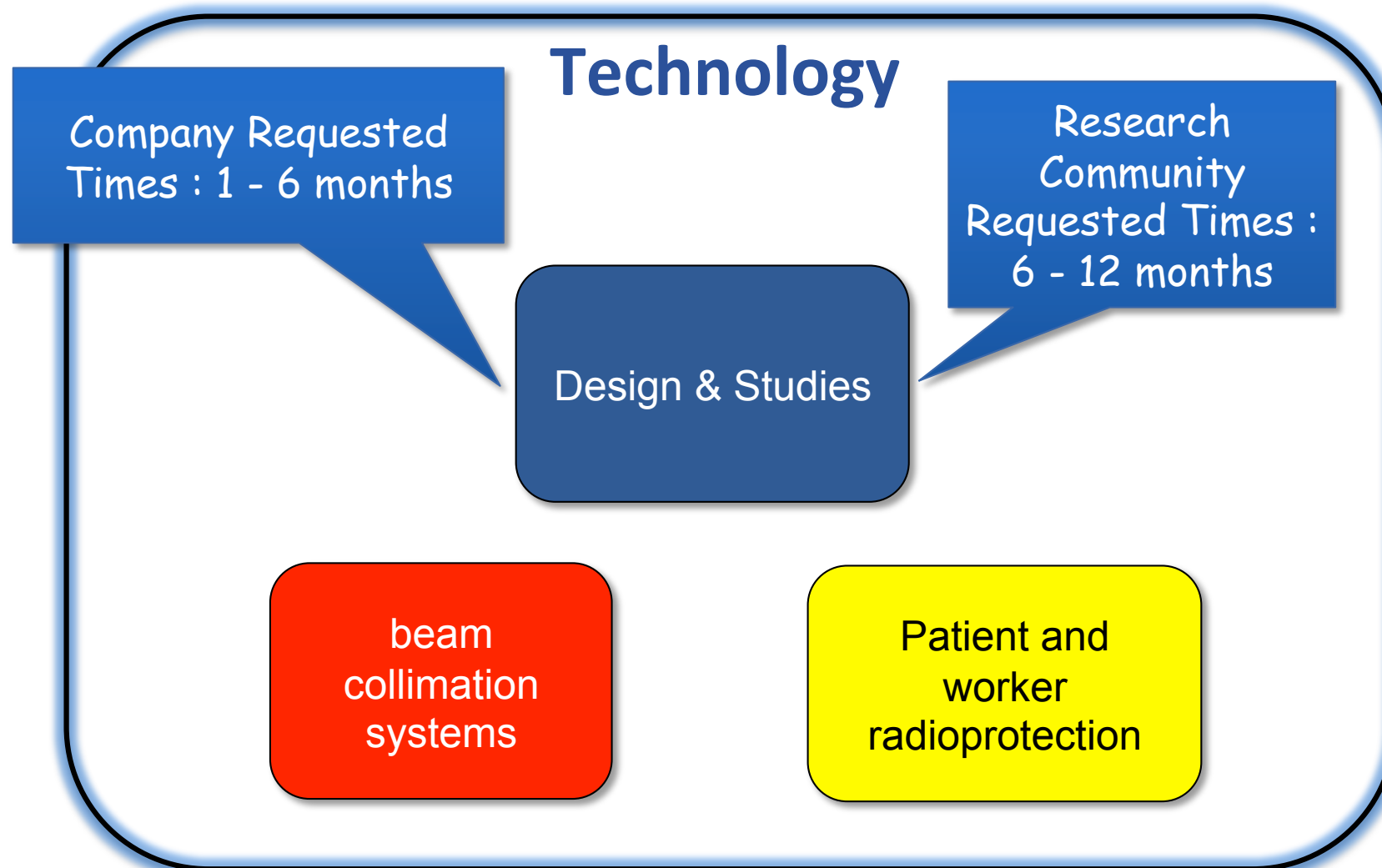


tilted

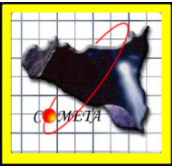




Clinical and Technologic Activities related to IOERT

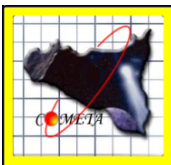


❖ No commercial software available

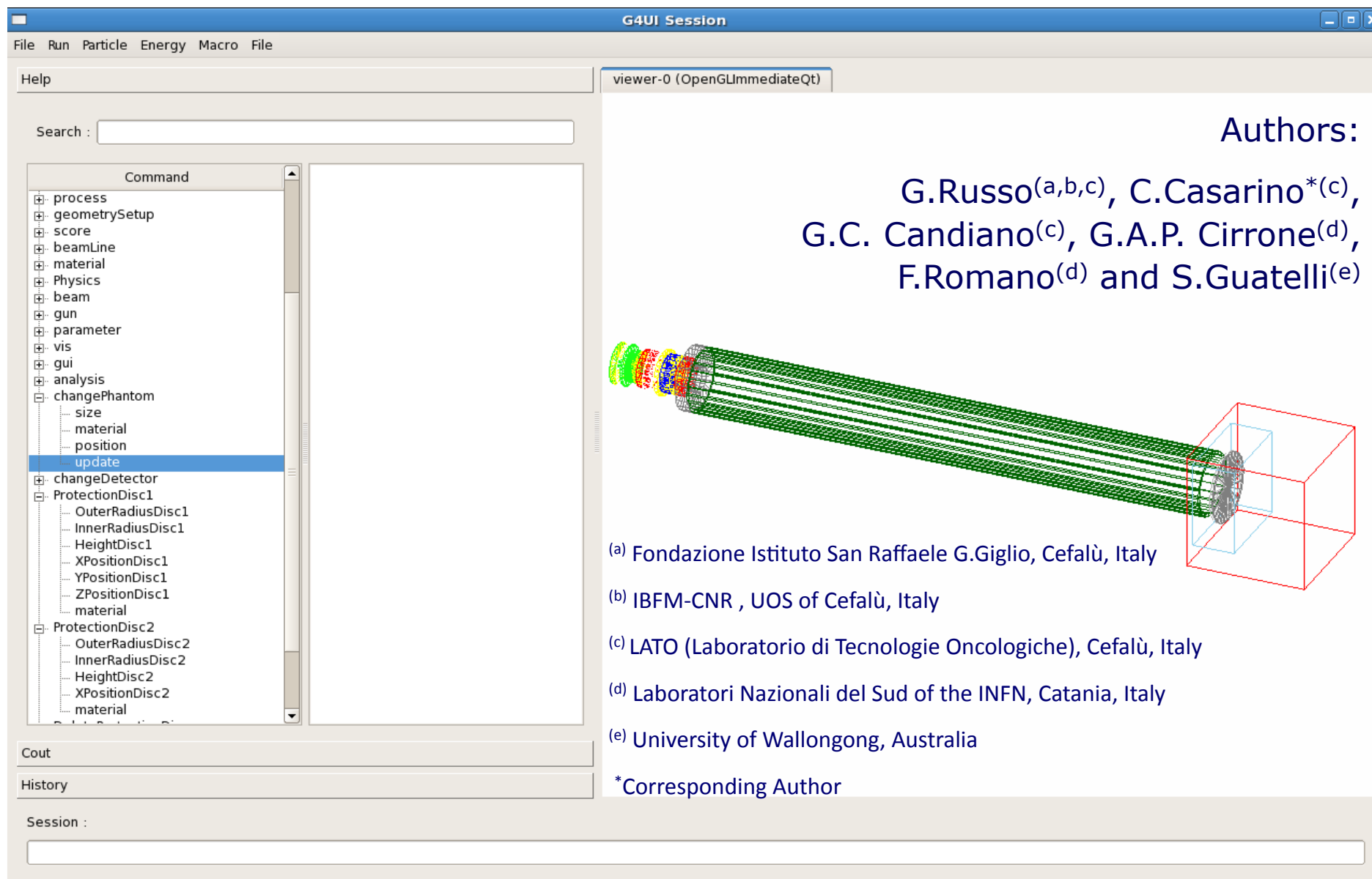


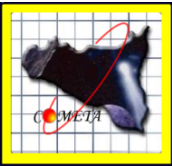
ior_t_therapy: a Monte Carlo application based on the GEANT4 toolkit

- ❖ **The application simulates the electron beam and the collimation system of the NOVAC7 accelerator and addresses several clinical and technical issues related to the IOERT technique such as:**
 - ✓ **the optimization of the therapeutic dose distribution;**
 - ✓ **the study of radio-protection aspects;**
 - ✓ **the development of procedures for the verification of the NOVAC7 specifications (Commissioning);**
 - ✓ **the design and optimization of the collimation system;**
- ❖ **Starting from release 9.5 *ior_t_therapy* application is officially supported by the GEANT4 collaboration (**
<http://geant4.web.cern.ch/geant4/>);



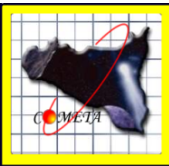
ior_t_therapy graphycal interface





iort_therapy & grid: why and how ?

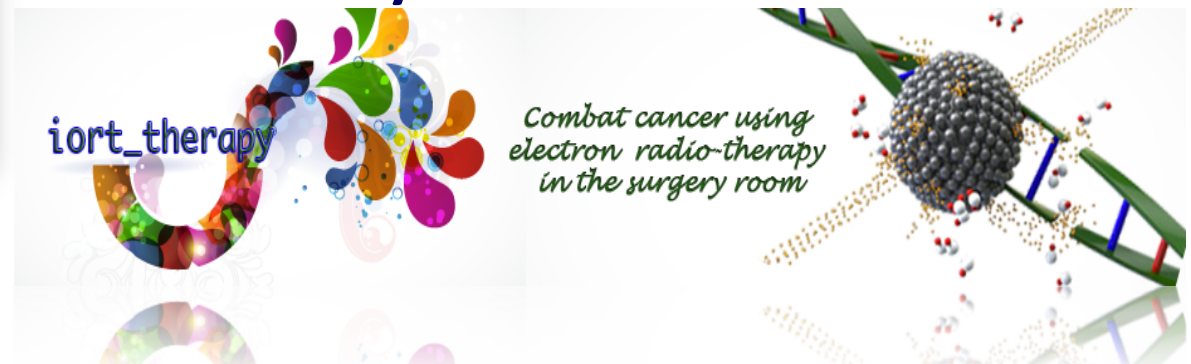
- ❖ The *iort_therapy* application needs a full installation of GEANT4 toolkit and of some additional libraries (2.2 GB);
- ❖ On a single CPU (with 3 GHz core) it would require about **200 days of CPU time** to produce the dose distribution with the required precision;
 - ✓ Targeted and research studies usually demand **tens** of dose distribution;
- ❖ Some **customization** for grid env. was needed to run the application in a self-consistent manner (167 MB);
 - ✓ typical **result**: a dose distribution in a volume of 300 x 300 x 140 voxels;
 - ✓ **size** output files: up to few GB of raw data per day;

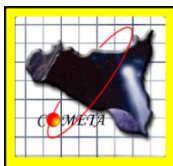


Porting of iort_therapy application to grid



- ❑ The **Consorzio COMETA**
- ❑ The **Catania Science Gateway** components
- ❑ The *iort_therapy* application on the Science Gateway
- ❑ *iort_therapy*'s **results**
- ❑ *iort_therapy*'s post-processing & future plans
- ❑ Summary & Conclusions





The Consorzio COMETA

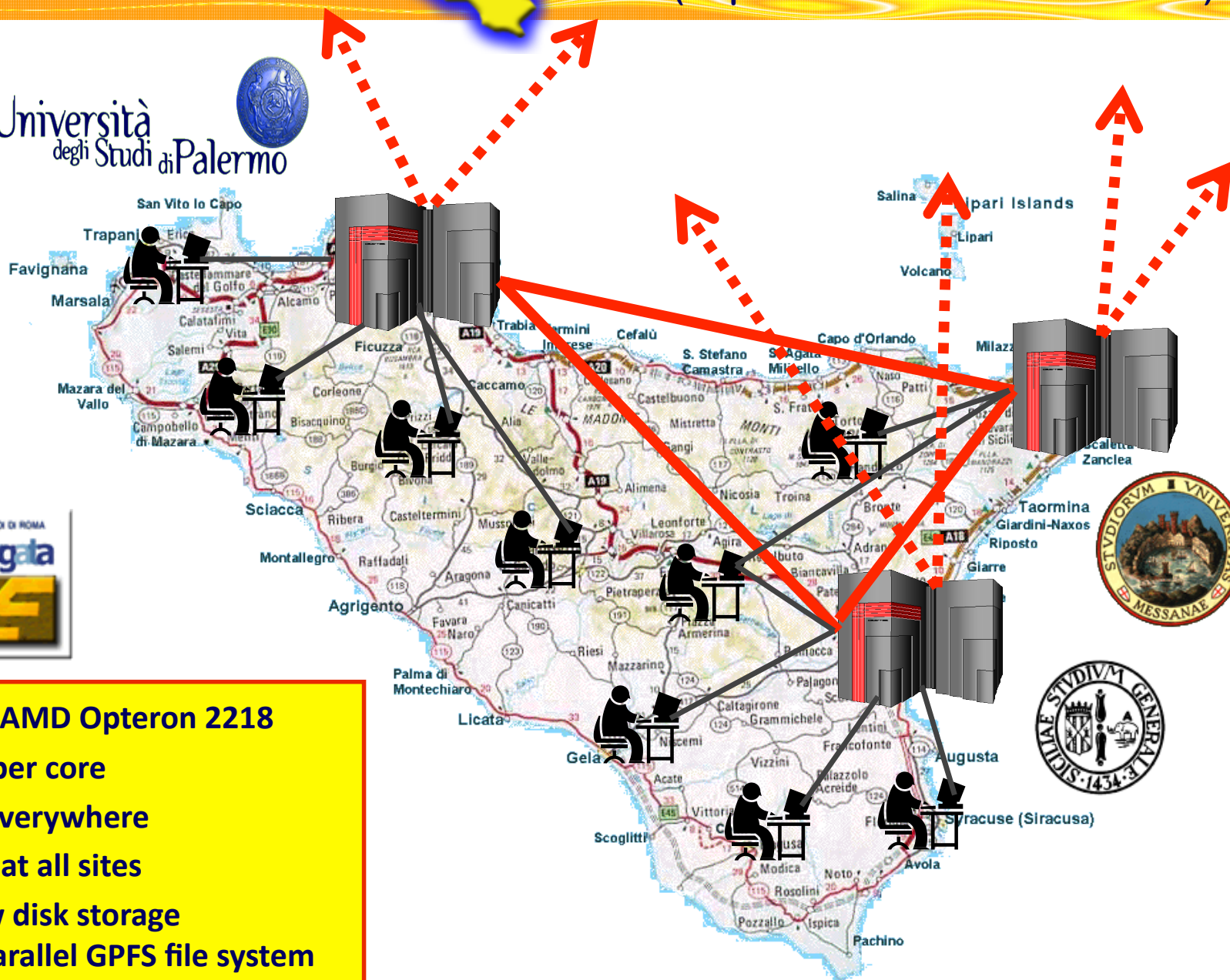
(<http://www.consorzio-cometa.it>)

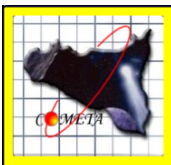


INGV



1. **~2000 cores** AMD Opteron 2218
2. **2 GB of RAM** per core
3. **LSF as LRMS** everywhere
4. **Infiniband-4X** at all sites
5. **200+ TB** of raw disk storage
Distributed/parallel GPFS file system

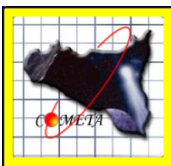




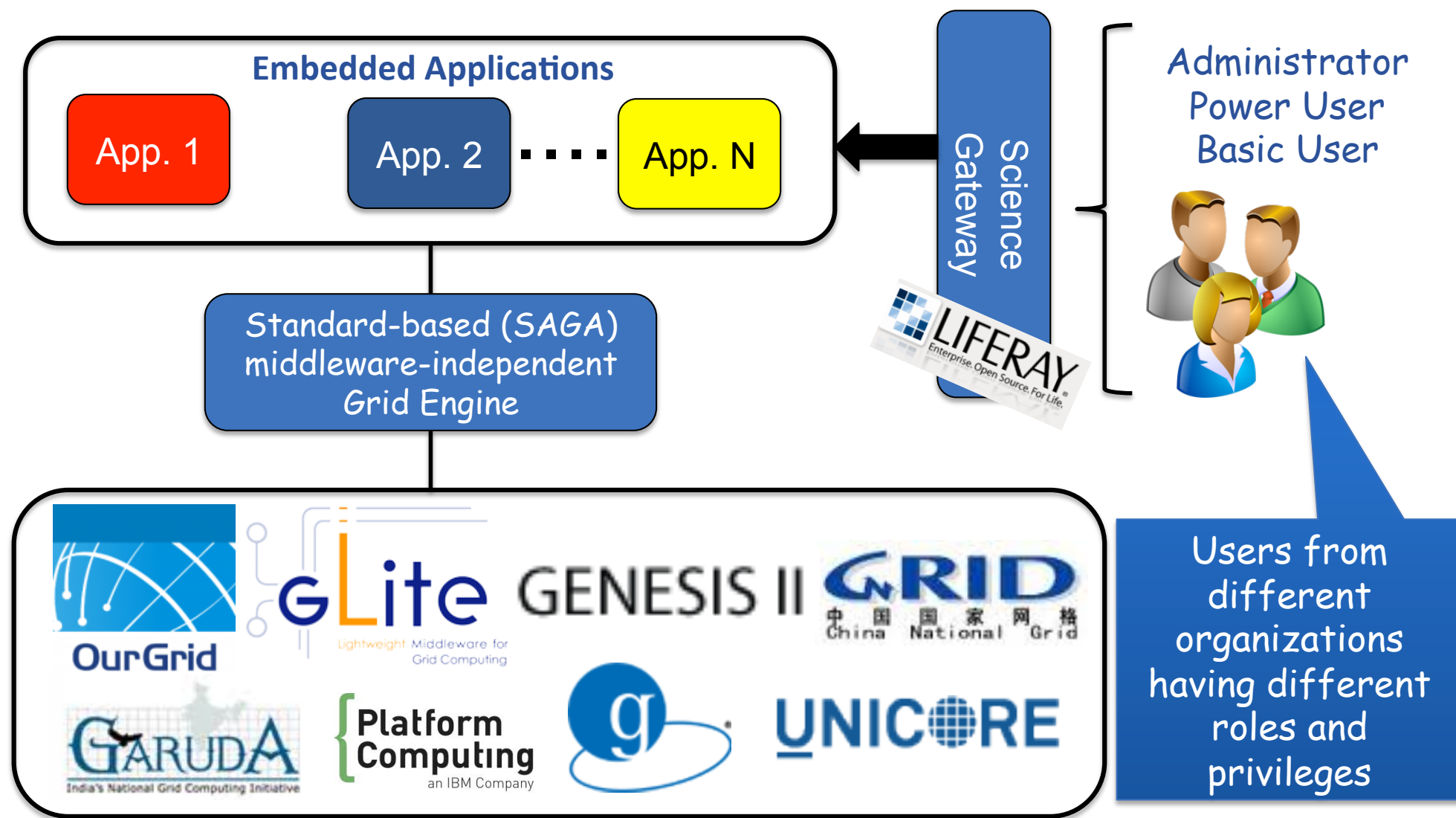
The Catania Science Gateway components

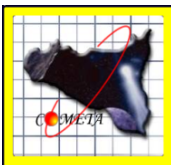
- ❖ The primary requirements that drove us in the design and implementation of the Science Gateway were:
 - ✓ Use of standards;
 - ✓ Simplicity;
 - ✓ Easiness of use;
 - ✓ Re-usability.
- ❖ For the development of the basic elements of the Science Gateway we decided to adopt the **JSR 286** standard and **Liferay** as portlet container;
- ❖ Identity Federations based on the **SAML 2.0** standard and on its implementation based on Shibboleth;
- ❖ To access the computing resources we use **SAGA** and its JSAGA implementation;
- ❖ For all grid transactions we rely on robot X.509 certificates and on the following standards: **JAX-RS** and **PKCS#11**;
- ❖ We comply with the EGI VO Portal Policy and the EGI Grid Security Traceability and Logging Policy !!





The Catania Science Gateway model





The iort_therapy application on the Science Gateway

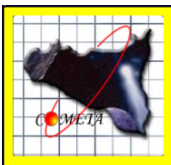


running on <http://gw.ct.infn.it>

The screenshot shows a web browser window at gw.ct.infn.it/run-iort_therapy. The interface includes a breadcrumb trail: Science Gateway to IGI > Applications > Life Sciences > iort_therapy > run_iort_therapy. On the left is a 'My Workspace' sidebar with links to Jobs, JobsMap, Data, and Help. The main content area is titled 'The iort Project' and contains an 'Iort_Therapy Input Form'. This form has three sections: 1. 'Display Settings' (selected), which states the current IORT_THERAPY portlet is configured for 'The COMETA Grid Infrastructure' (indicated by a green checkmark). It also provides instructions for users, input requirements (GEANT4 macro file and number of runs), and output files. 2. 'Worldwide Software Distribution', and 3. 'Specify your Input Settings'. At the bottom, there is a rating section showing 'Your Rating' and 'Average (1 Vote)' with five stars each. The footer indicates 'IORT_THERAPY portlet ver. 1.1.8'.

1

It provides some explanation about the application



The iort_therapy application on the Science Gateway

gw.ct.infn.it/run-iort_therapy

Science Gateway to IGI > Applications > Life Sciences > iort_therapy > run_iort_therapy

Help

2 Worldwide Software Distribution

See with the Google Map API where the software has been successfully installed.

Select the GPS location of the grid resource where you want run your demo OR, BETTER, let the Science Gateway to choose the best one for you!

Legend ☒ Split close sites ☐ Unsplit close sites ☒ Computing resource

Map Mappa Satellite

inf-n-ce-01.ct.pi2s2.it

Vote the resource availability

Rating: ★★★★★
Average: 0.00 (0)

Google

Dati mappa - Termini e condizioni d'uso

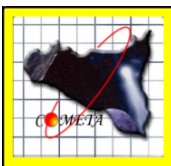


running on <http://gw.ct.infn.it>

2

It shows the computing resources where GEANT4 has been successfully deployed

It is possible to rank the generic computing resource



The iort_therapy application on the Science Gateway



running on <http://gw.ct.infn.it>

Science Gateway to IGI > Applications > Life Sciences > iort_therapy > run_iort_therapy

My Workspace MYWORK

- Jobs
- JobsMap
- Data
- Help

The iort Project

Iort_Therapy Input Form

- 1 Display Settings
- 2 Worldwide Software Distribution
- 3 Specify your Input Settings

Please, paste the macro you want to run in the textarea below, OR upload it in an ASCII file

☒ Upload macro defaultMacro.mac

☐ Insert macro

Description: E=8.9_900keV_coll60_N=2x10^5_GMV_discoPb

☒ Notification

☐ N

Number of GEANT4 jobs to be submitted: 20

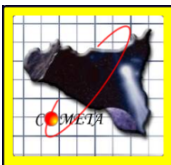
All rights reserved

3 Uploading a GEANT4 macro as ASCII file or use the text-area

Job description

Enable e-mail notification

of Monte Carlo jobs submitted



The iort_therapy application on the Science Gateway

Showing the status of the Monte Carlo simulations using Google Map



running on <http://gw.ct.infn.it>

Asking
support

Automat
output
download

Science Gateway to IGI My JobsMap

My Workspace

- Jobs
- JobsMap
- Data
- Help

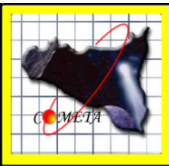
Active Jobs List Done Jobs List

Mappa Satellite

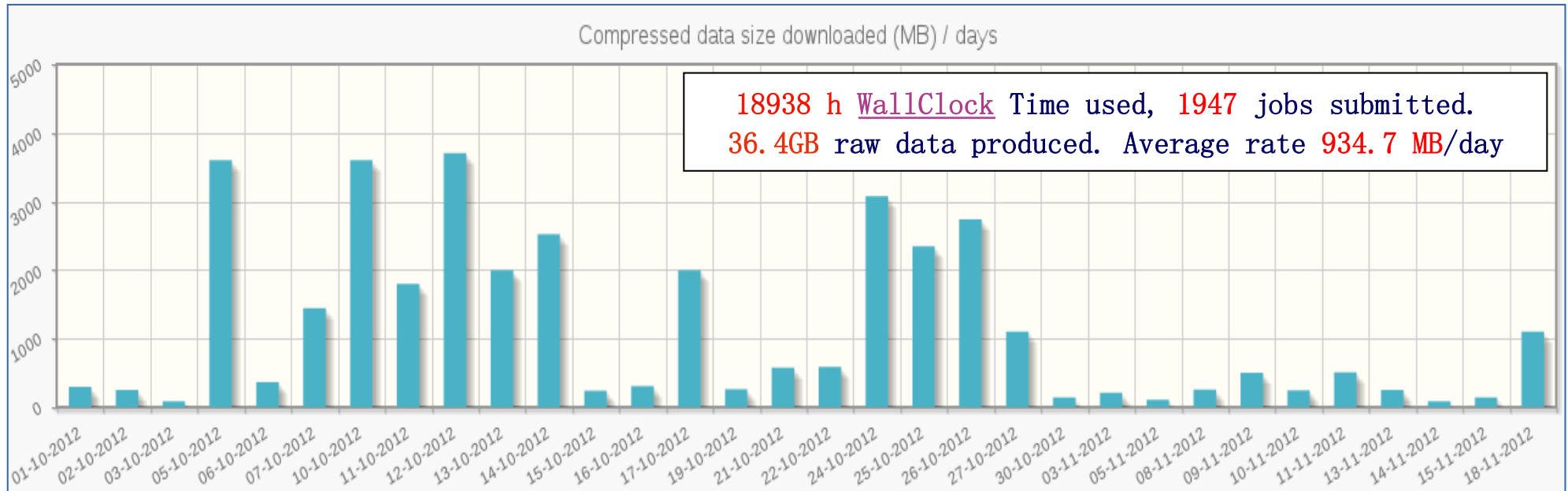
CE:infnIns-ce-01.ct.pi2s2.it
N.Jobs running: 10
N.Jobs done:0
Middleware:EML-gLite

Google

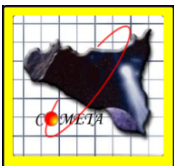
Map data ©2012 Google - Termini e condizioni d'uso



ioert_therapy's results

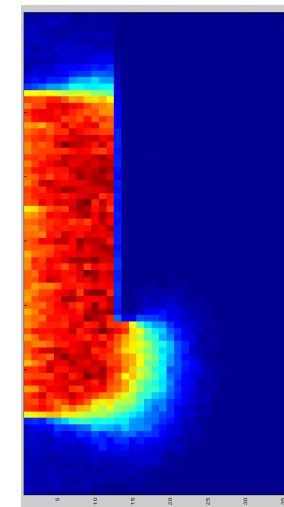
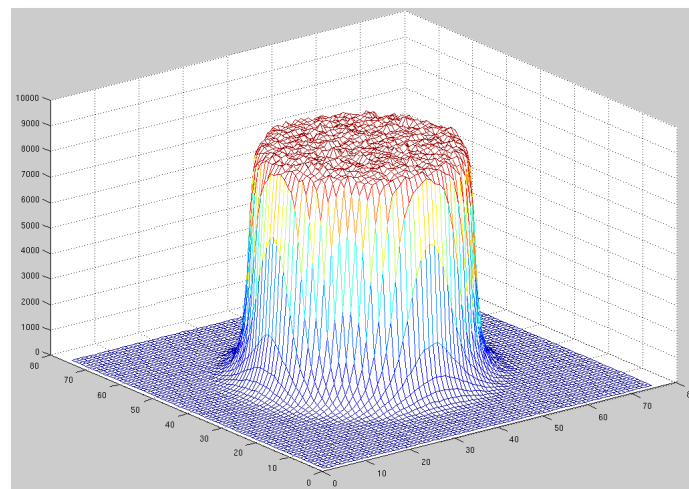
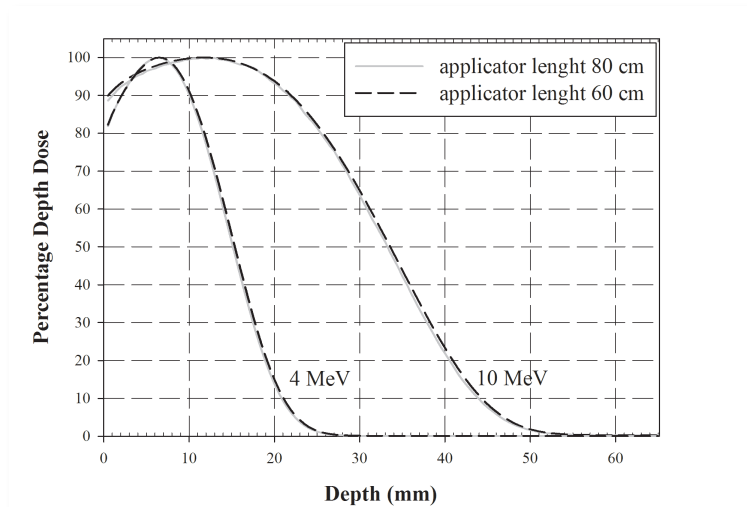


- ❖ The average data rate produced from the grid:
 - ✓ partially address the IOERT **Clinical** requirements
 - The **Commissioning** could be done in 1 week
 - ✓ fully address the IOERT **Technical** requirements
 - The grid infrastructure helps to fulfill Company and Research's requirements

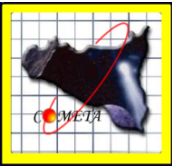


ior_ttherapy's post-processing and future plans

- ❖ **MATLAB** is used to extract dose distributions relative to small region of the 300 x 300 x 140 voxels volume, as **1D-2D dose distributions**;

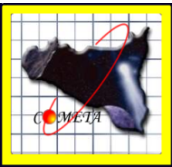


- ❖ **Raw data produced by grid is post-processed offline using MATLAB routines (~ 200 lines of code);**
 - ✓ Investigating the possibility to use other open-source software (i.e. **GNU Octave**) on the grid.



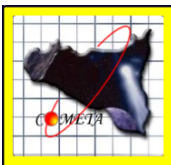
Summary & Conclusions

- ❖ Thanks to the computing capabilities of Consorzio COMETA, the Laboratorio di Tecnologie Oncologiche can then:
 - ✓ **sustain** a research project to validate and improve commercial IOERT Treatment Planning System (TPS);
 - ✓ **collaborate** with New Radiant Technology NRT S.p.a. company to optimize patient radio-protection and the design of the collimation system.



References

- Russo G, CASARINO C, Arnetta G Candiano, A Stefano. F Alongi, G Borasi, C Messa, MC Gilardi (2012). **Dose distribution changes with shielding disc misalignments and wrong orientations in breast IOERT: a Monte Carlo – GEANT4 and experimental study.** J. Appl. Clin. Med. Phys. 5 , 74 - 92
- G Russo, CASARINO C., G Candiano, G Borasi, C Messa, MC Gilardi (2012). **A GEANT4 application for the simulation of the NOVAC7: a support to optimize the clinical setup in IOERT treatment.** In: 3rd European Workshop on Monte Carlo Treatment Planning. Sevilla, Spain, 15-18 May 2012
- I Fazio, G Russo, CASARINO C., G Candiano, G Borasi, C Messa, MC Gilardi (2012). **DOSE DISTRIBUTION CHANGES WITH SHIELDING DISC MISALIGNMENTS AND WRONG ORIENTATIONS IN BREAST IOERT: A MONTE CARLO – GEANT4 STUDY.** In: ISIORT 7th International Conference of the International Society for Intraoperative Radiation Therapy (ISIORT). Baveno, Italy, June 22-24, 2012
- V. Ardizzone, R. Barbera, A. Calanducci, M. Fargetta, E. Ingrà, I. Porro, G. La Rocca, S. Monforte, R. Ricceri, R. Rotondo, D. Scardaci, A. Schenone – 2012, **The DECIDE Science Gateway, Journal of Grid Computing – Special Issue: Science Gateway**, ISSN 1570-7873, 2012



Contacts

THANK
YOU

Any questions, comments or remarks are very welcome.

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