
# The eIMRT Project: Planning and Verification of IMRT treatments on Grid

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**http://eimrt.cesga.es**

# The e-IMRT project

Introduction

- project overview
- basic concepts
- architecture
- services

Monte Carlo treatment verification

- overview
- GRID implementation
- data post-processing

Status, conclussions, future work

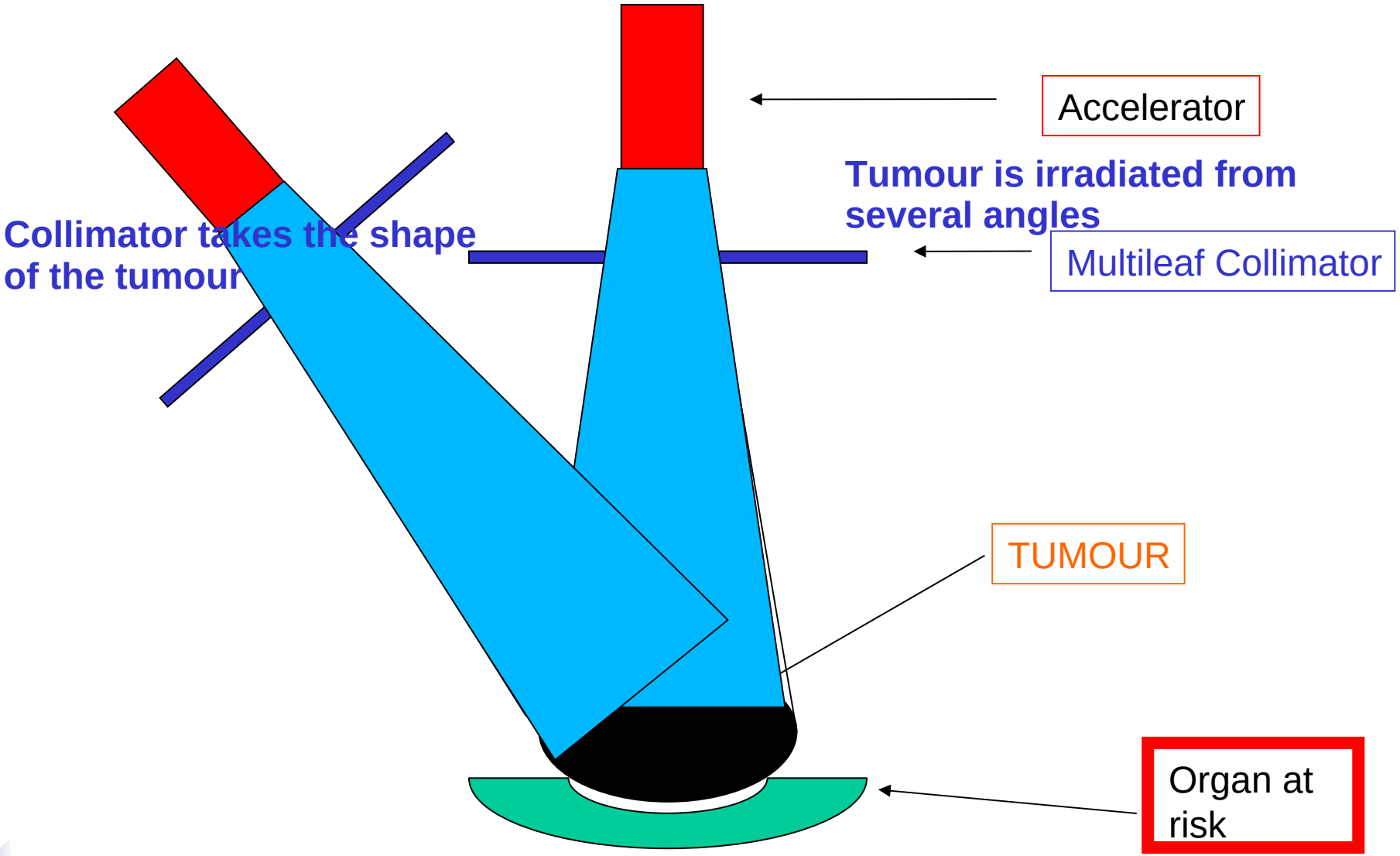
# What is the IMRT project?

eIMRT aims the development of a **remote** computational platform for:

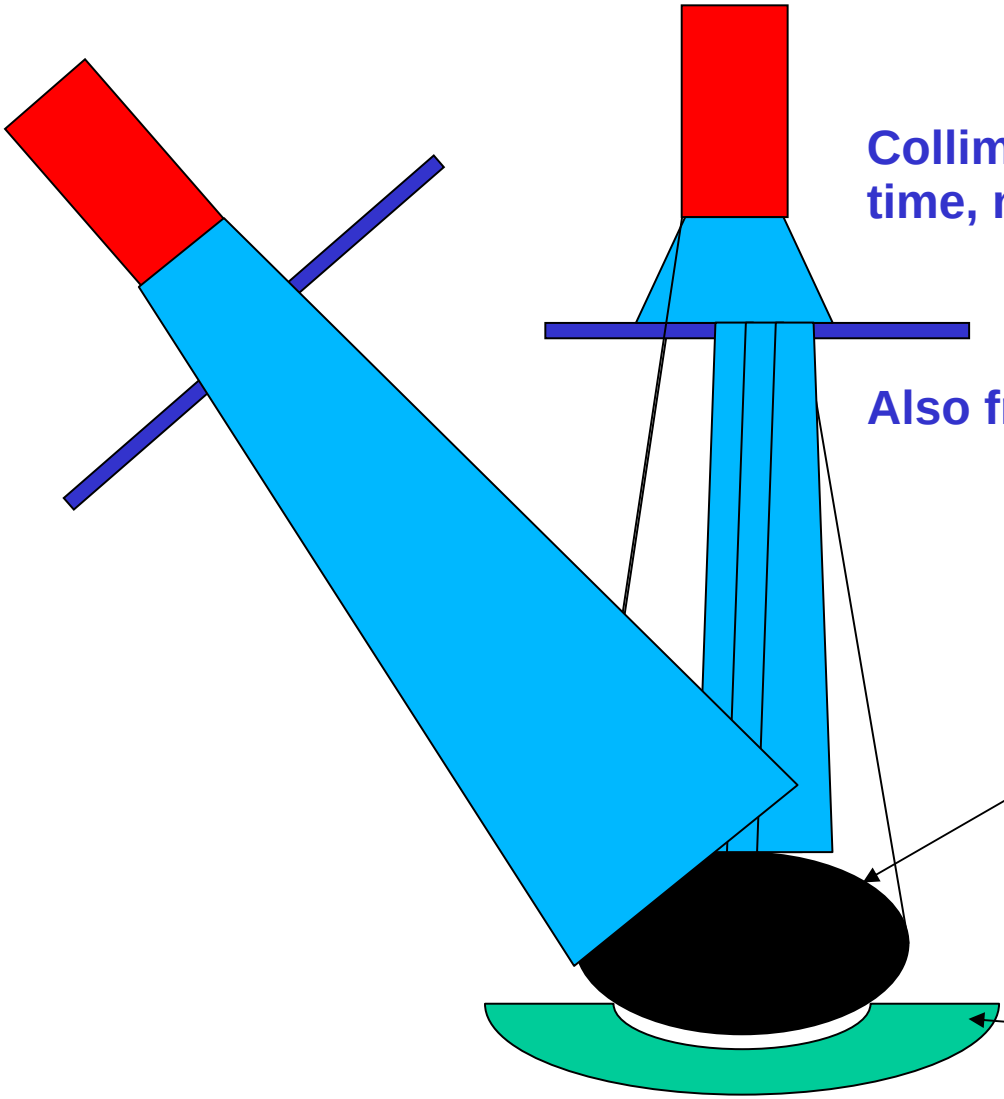
- treatment **VERIFICATION** (using Monte Carlo)
- treatment **OPTIMIZATION** (CRT & IMRT)
- **REPOSITORY** of treatments for radiotherapy research

- **REQUIREMENTS**
  - Simple, user friendly and multi-algorithm
  - Hide complexity of HW infrastructure
  - Flexible and Scalable
  - Lowest possible human intervention
  - Portable to different computing infrastructures (local clusters or GRIDs)
  - Based on standards
  - Complements Treatment Planning Systems (TPS)

# What is CRT (Conformal RadioTherapy)?



# What is IMRT (Intensity Modulated Radiation Therapy)?



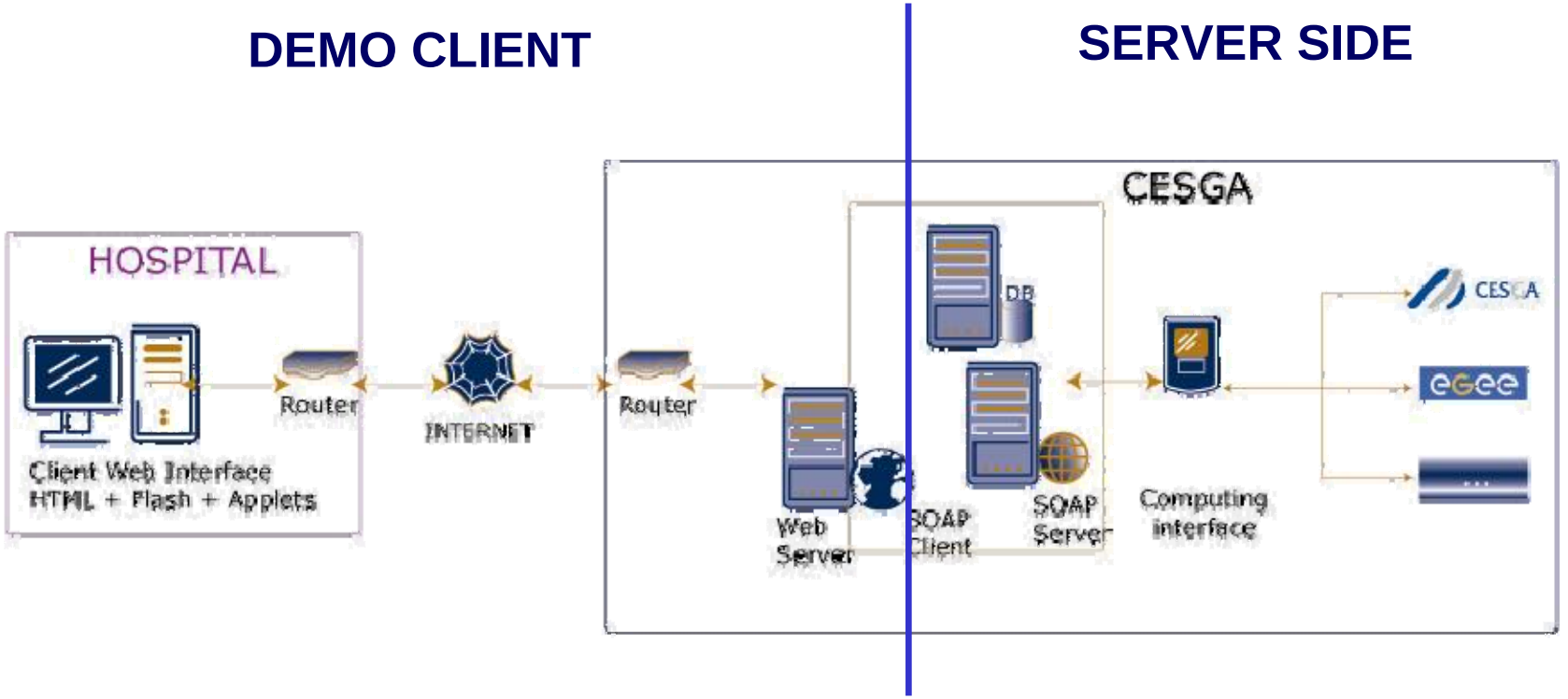
**Collimator moves during beam-time, modulating intensity**

**Also from different angles**

TUMOUR

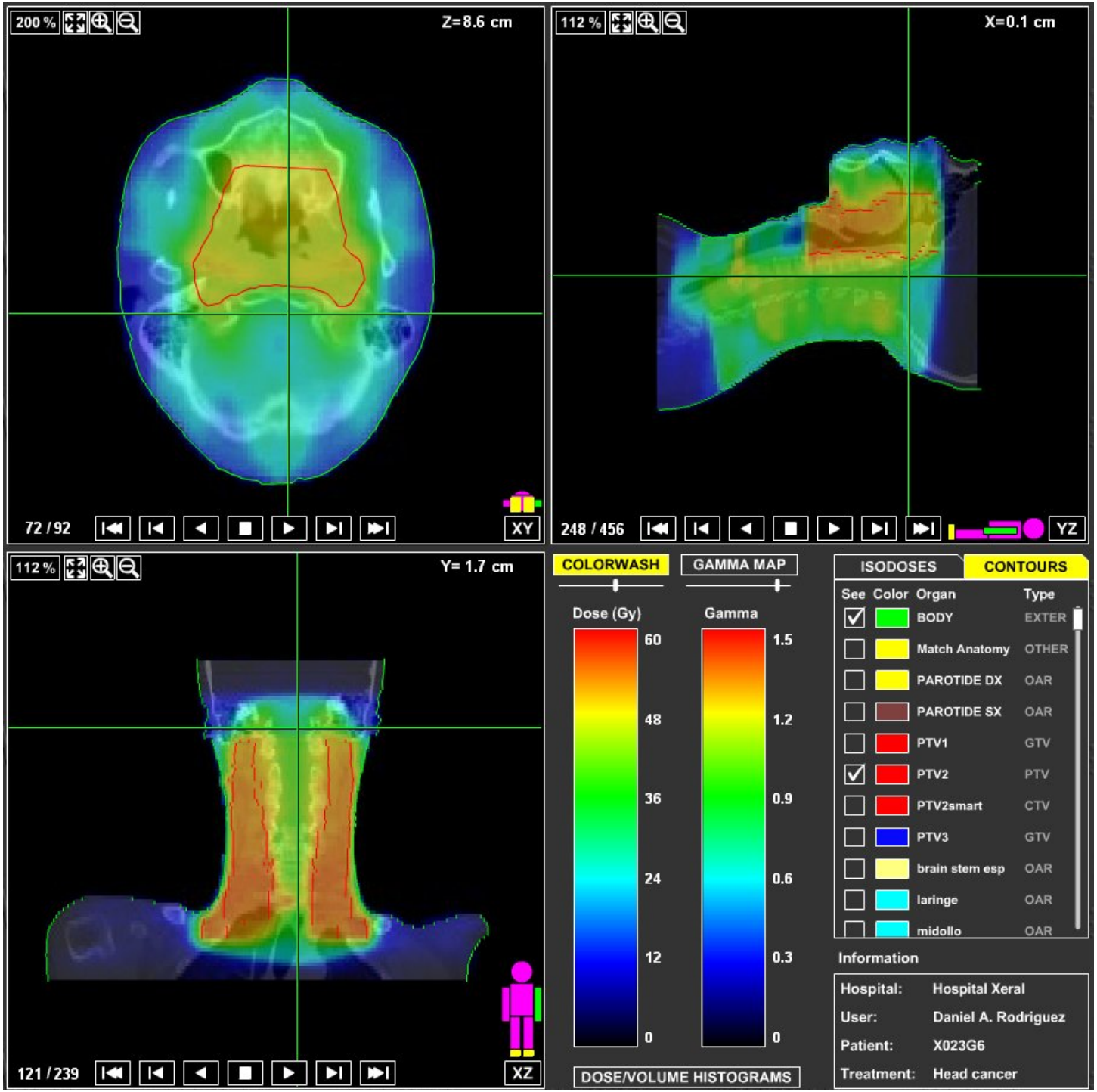
Organ at risk

# e-IMRT Architecture




**SOA Architecture**

**Based on GRID technologies**


200 %
Z=8.6 cm
72 / 92
XY
112 %
X=0.1 cm
248 / 456
YZ
112 %
Y= 1.7 cm
121 / 239
XZ
COLORWASH
GAMMA MAP
Dose (Gy)
60
48
36
24
12
0
Gamma
1.5
1.2
0.9
0.6
0.3
0
DOSE/VOLUME HISTOGRAMS
ISODOSES
CONTOURS
See Color Organ Type
BODY EXTER
Match Anatomy OTHER
PAROTIDE DX OAR
PAROTIDE SX OAR
PTV1 GTV
PTV2 PTV
PTV2smart CTV
PTV3 GTV
brain stem esp OAR
laringe OAR
midollo OAR
Information
Hospital: Hospital Xeral
User: Daniel A. Rodriguez
Patient: X023G6
Treatment: Head cancer

# e-IMRT Architecture: Services

- **UserManagement**, which manages all the information related to user and control sessions.

- **FileManagement**, which makes all the operations for uploading and controlling the files related to the treatments as DICOM CT, DICOM RTPlan, etc.

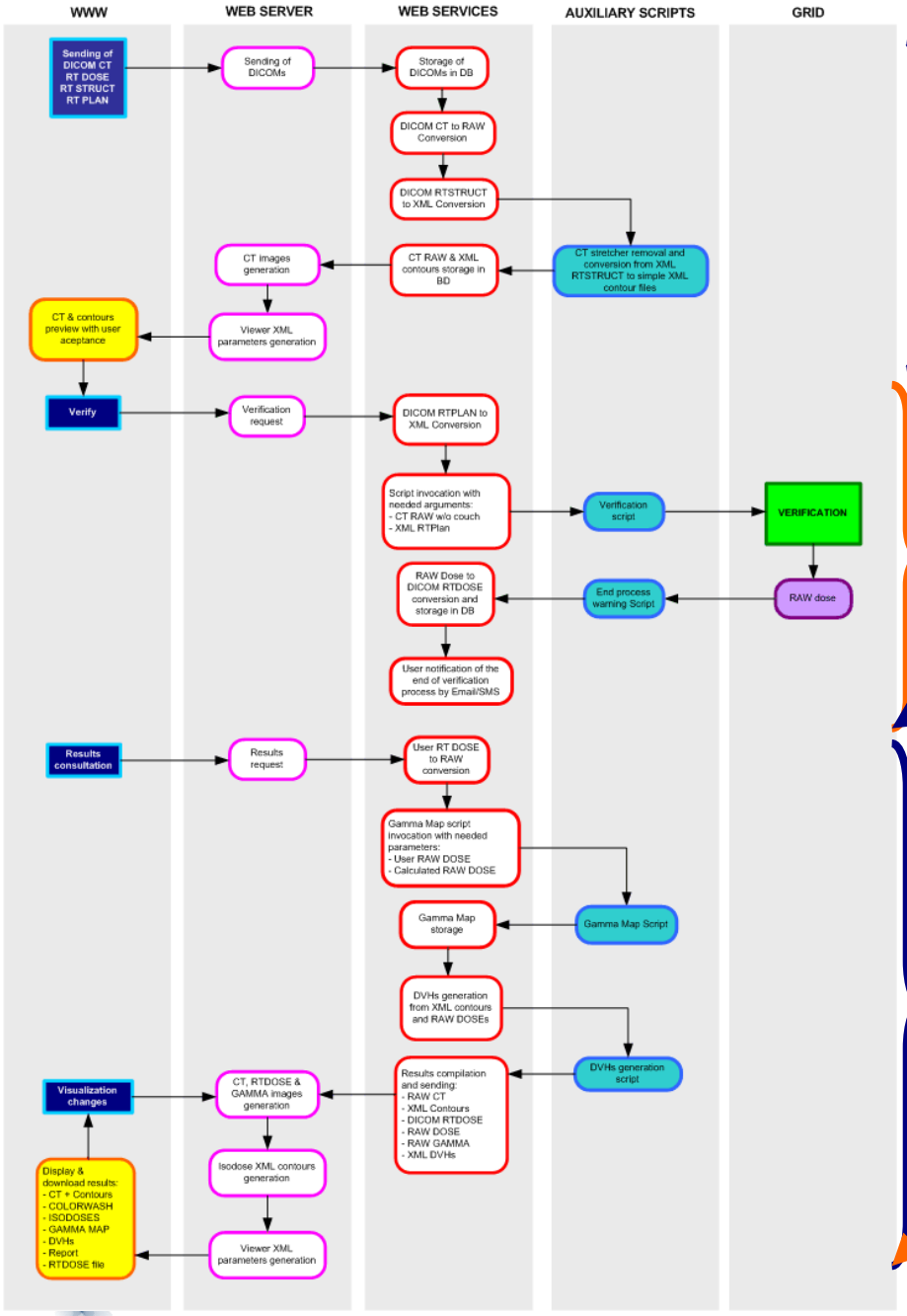
- **TreatmentManagement**, for managing the information and operations related to a treatment.

- **Verification**, which submits and controls the operations related to the verification of a treatment.

- **MapManagement**, for generating different maps to compare two dose distributions.

- **Monitorization**, which allows the monitorization of the status of a computational operation, such as verification, and alerts the final user when it ends.

# Verification Workflow




1. Upload DICOM files

2. RUN SIMULATIONS

3. ANALYZE RESULTS

# Monte Carlo Treatment verification

**Comparison between a TPS-calculated dose distribution and a Monte Carlo-calculated dose distribution for a certain beam arrangement**

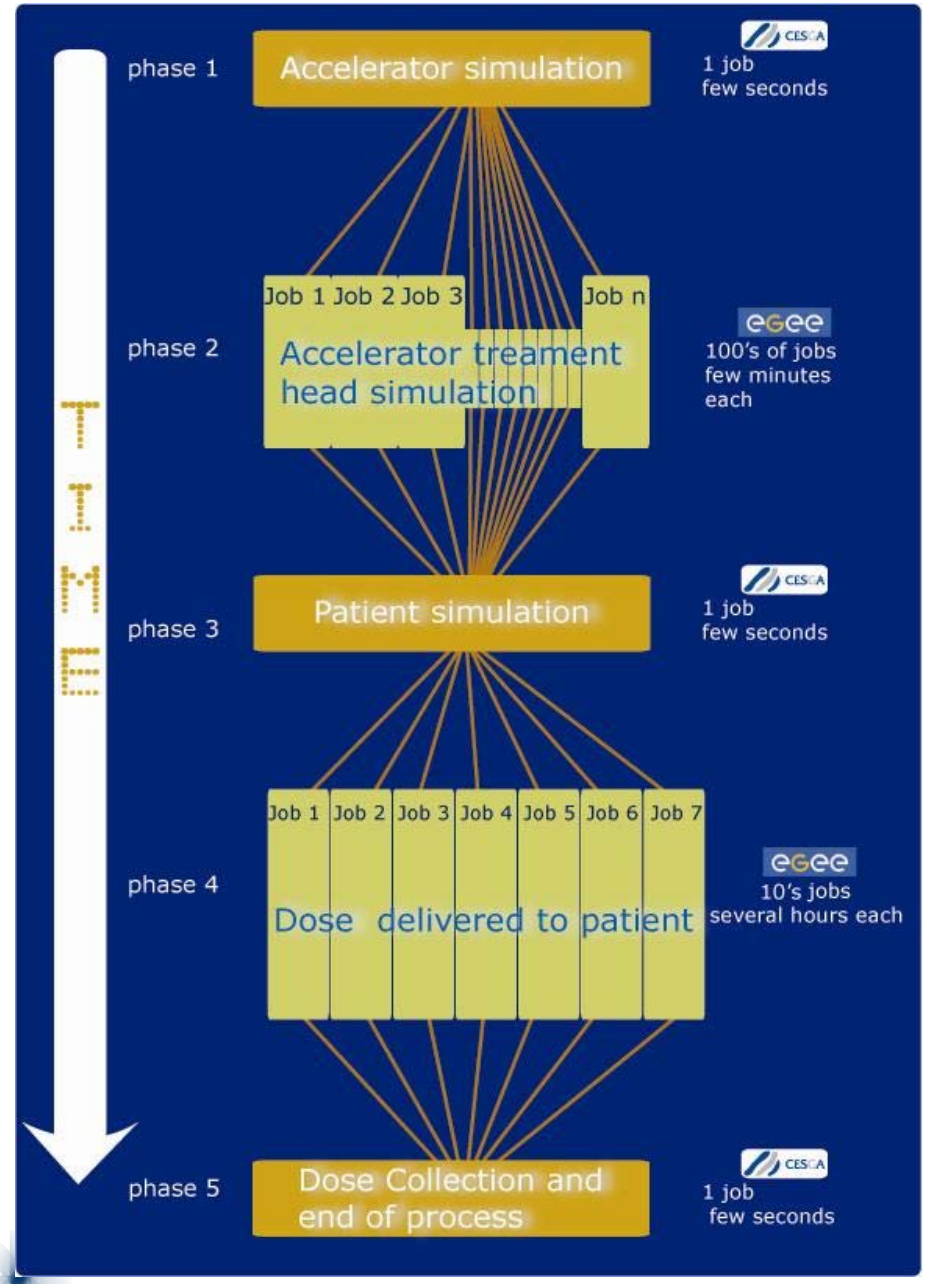
**Features**

- Based on Monte Carlo code: BEAMnrc (accelerator) and DOSXYZnrc (phantom):
- Decoupled the verification process from the accelerator model (inputs are created on-the-fly)
- Decoupled the verification process from the type of treatment (CRT, step-and-shoot IMRT and dynamic IMRT treatments are supported)

# Monte Carlo Treatment verification

- Phase 1: Accelerator simulation.
- Phase 2: Accelerator treatment head simulation
- Phase 3: Patient simulation.
- Phase 4: Dose delivered to the patient.
- Phase 5: Dose collection and end of process.

Radiotherapist manually
compares TPS and e-IMRT Monte Carlo doses
Using different maps




# Monte Carlo Treatment verification.

## GRID execution

-Phase 1: Sequential. Runs locally

-Phase 2: Parallel. Over short 1000's jobs. Runs on GRID

-Phase 3: Sequential. Runs locally

-Phase 4: Parallel. Over long 10 jobs. Runs on GRID

-Phase 5: Sequential. Runs locally

# Phase 2 latency challenge

- GRID high latency for sending one job (seconds)

- Phase 2 jobs very short (few minutes)

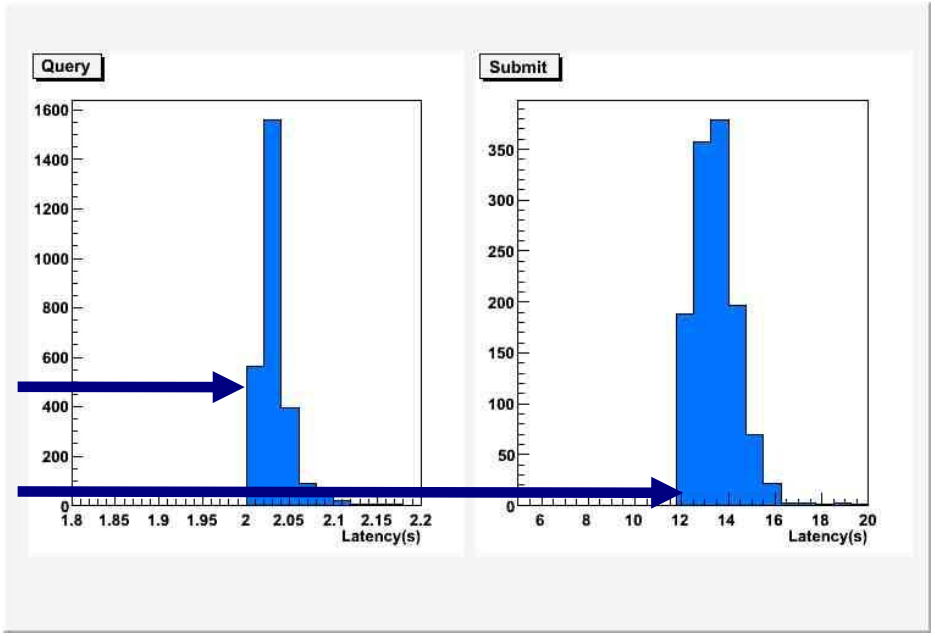
- Need monitoring

SOLUTION:

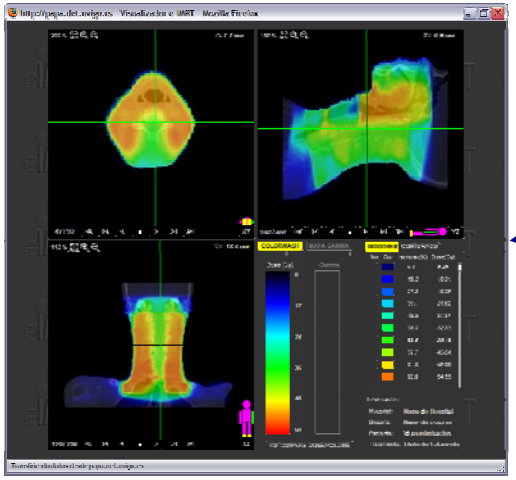
- grouping of inputs

2 seconds for query

20 seconds for submit

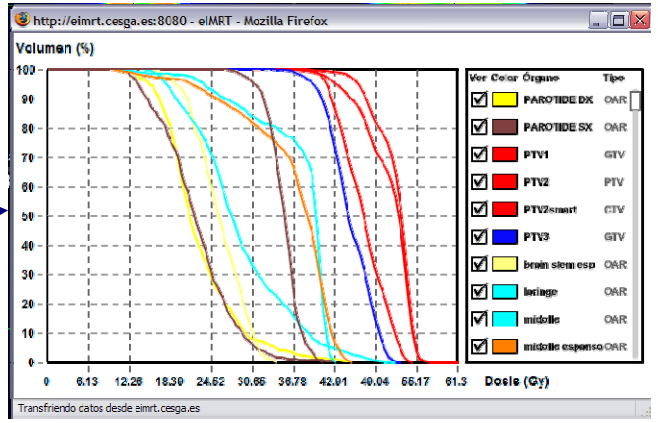


# Verification://visualization



Dose colorwash, isodoses and contours

Dose-Volume Histograms




Gamma and Other comparative Maps

# Status of platform

- Developed version 1.0
  - Handling of user, user accelerators and CTs databases
  - CT characterization
  - Treatment submission (EGEE, int.eu.grid, local cluster), status control and results review
  - Visualization tools: isodoses, DVHs, dose colorwash and gamma maps
- Developed commissioning software and databases for SIEMENS PRIMUS 6MV and VARIAN 2100CD 6MV
- Developed treatment verification core tools
- Tested 2 IMRT treatments: 1 step-and-shoot (Siemens PRIMUS) and 1 dynamic MLC (Varian 2100 CD)

# Conclussions

- The decoupled eIMRT architecture is a cost-effective solution to speed-up the CPU intensive processes in advanced radiotherapy planning:
  - accelerator characterization,
  - treatment validation
  - treatment optimization
- There are no similar distributed environments for verification and optimization of radiotherapy treatments
- Problems with submission and monitoring due to the high latencies on GRID
- Good best-case for an interactive GRID

# Future Work

- Optimization of treatments
- Characterization of any accelerator (now only two models supported)
- End-to-end authorization based on certificates
- Repository

# Thank you for your attention!!!

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**This work makes use of results produced by the Enabling Grids for E-sciencE project, a project co-funded by the European Commission (under contract number INFSO-RI-031688) through the Sixth Framework Programme. EGEE brings together 91 partners in 32 countries to provide a seamless GRID infrastructure available to the European research community 24 hours a day. Full information is available at http://www.eu-egee.org.**



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Financed through Xunta de Galicia project PGIDT05SIN00101CT
and partially by the *European Social Fund*