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High Performance Computing for Monte Carlo Radiotherapy Calculations

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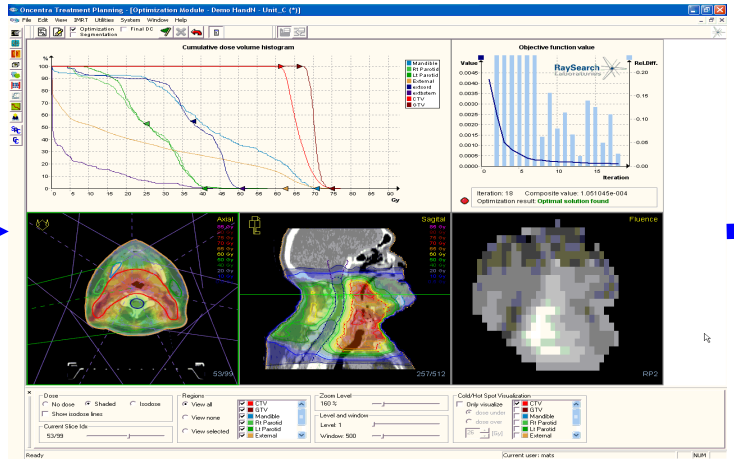
Overview

- Radiotherapy treatment.
- Traditional dose calculation.
- Why Monte Carlo simulations?
- What is the RTGrid portal?
- How does RTGrid work?
- Experimental results.

Radiotherapy Treatment

1. Scan the patient

2. Identify tumour regions



3. Calculate the dosage

Computation intensive

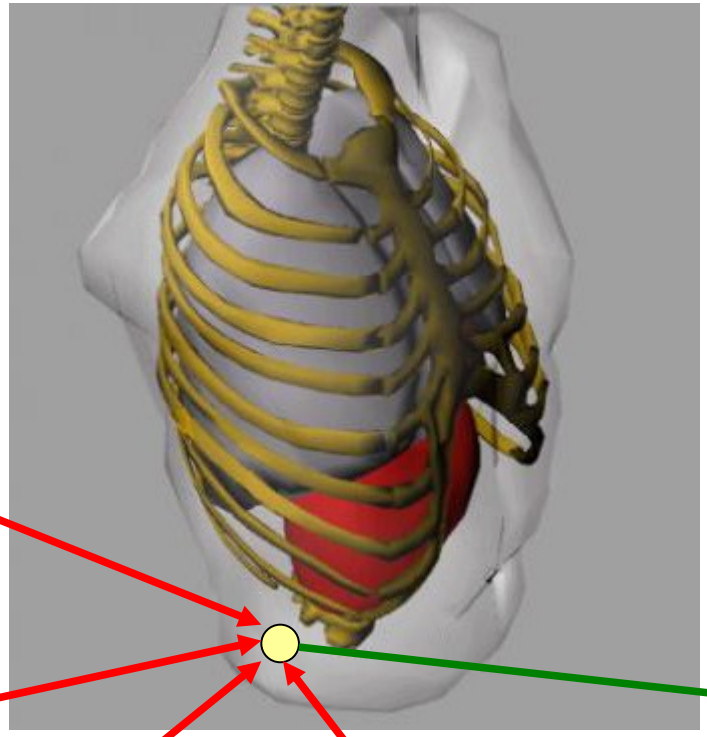
The area which the RTGrid project aims to address

4. Administer the radiation

Traditional dose calculation

- Typically performed on PCs and Workstations.
- Lacks computational power.
- Less accurate dosage.
- Higher chance of destroying healthy tissues.

Monte Carlo simulation



(Large n means accurate dosage)

Why Monte Carlo simulations?

Advantages:

- Accurate dosage.
- Low risk of destroying healthy tissues.

Drawbacks:

- Takes a long time to simulate (several days).
- Thus, not clinically deployable.

What is the RTGrid portal?

- A distributed simulation framework.
- Provides necessary computational power.
- Supports template-based simulation experiments.
- Making Monte Carlo dose calculations feasible.

RTGrid provisions

- Web portal interface:

  For remote simulation management.

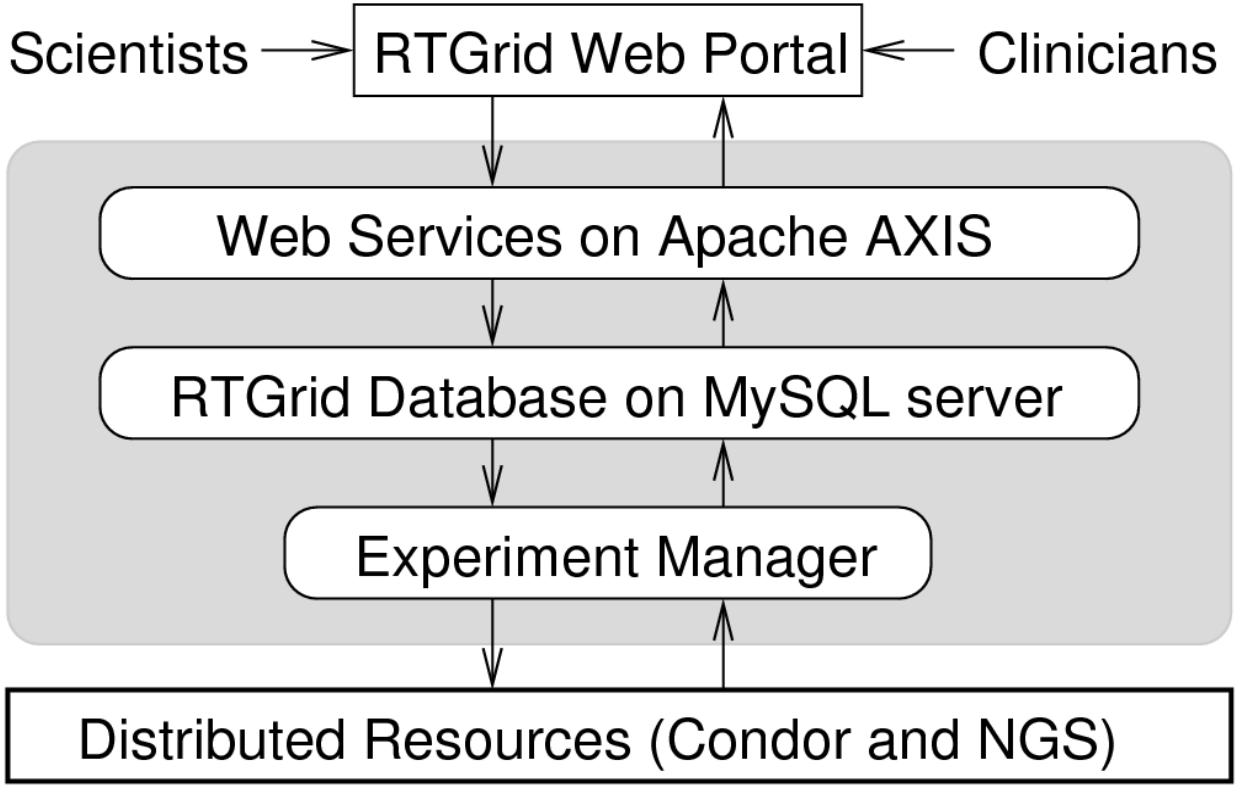
- Pluggable resource modules:

  For accessing distributed computational resources.

- Profiles:

  A reliable way to create Monte Carlo simulations from well-tested simulation templates.

The System Architecture

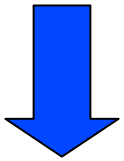


The implementation

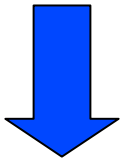
- Web server – Apache Tomcat, Ver. 5.0.28
- Web portal – Gridsphere, Ver. 2.2.9
- GSI credentials – Gridportlets, Ver. 1.4
- Web services – Apache Axis (SOAP), Ver. 1.4
- Database – MySQL, Ver. 5.0.22
- Experiment manager – Python, Ver. 2.4.3

Using the RTGrid portal

Research Scientists create a simulation template



Clinical scientists use an existing template



Manage existing simulations

Creating a simulation template

Menu

- Create profile
- List owned
- List accessible

- Set preferences
- Help
- Log out scmgy
- Refresh

Create profile << Back to profile list

Name:

Description:

Access permissions:

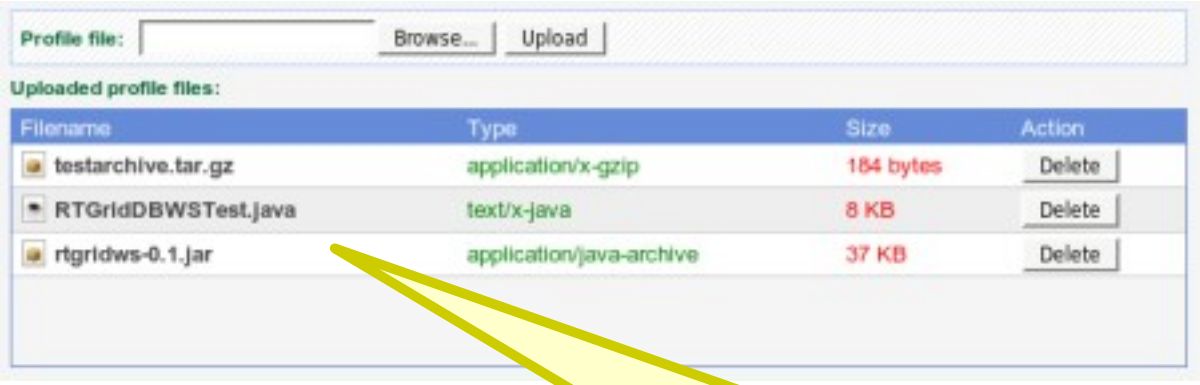
Read	Edit	Use	Group	Description
☐	☐	☐	resource	This user group allows users to share tasks that are related to the management
☐	☐	☐	users	This user group allows users to share tasks that are in general allowed to
☐	☐	☐	admin	This user group allows users to share access to administration related tasks.

Profile file: Browse... Upload

Profile extension XML: Browse... Upload

Create Cancel

Creating a simulation template

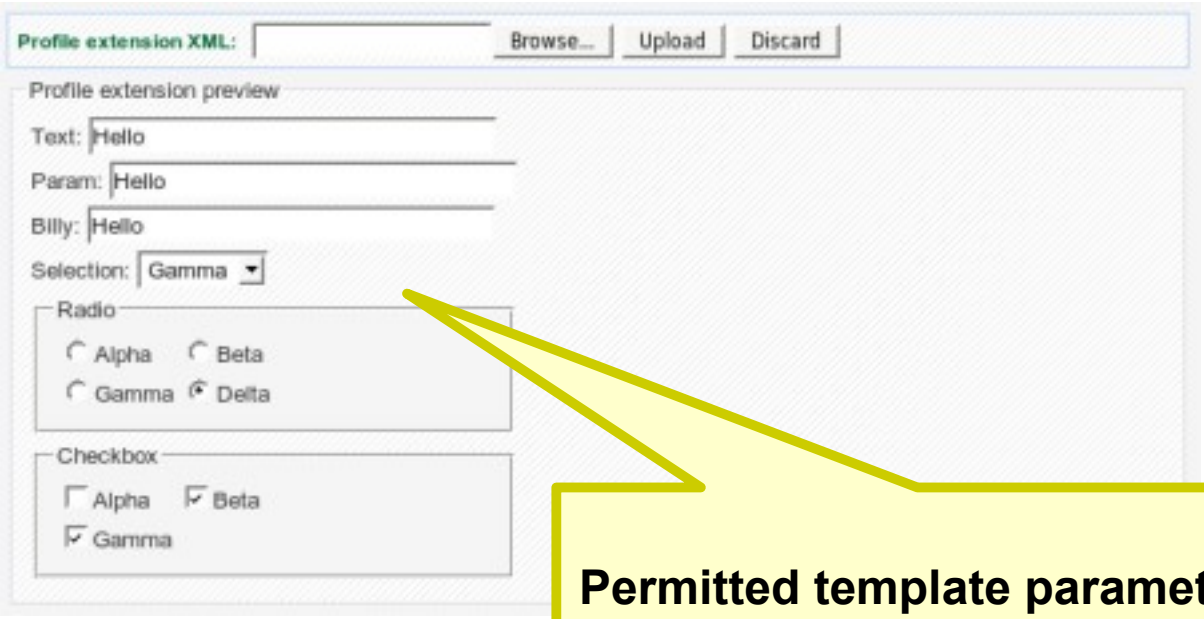


Simulation template data files

Executable code and configuration scripts.

Supports standard archive formats (.jar, .tar, .tar.gz, .tar.bz2, .zip) for uploading large file sets or directories. Archive files will be extracted automatically.

Creating a simulation template

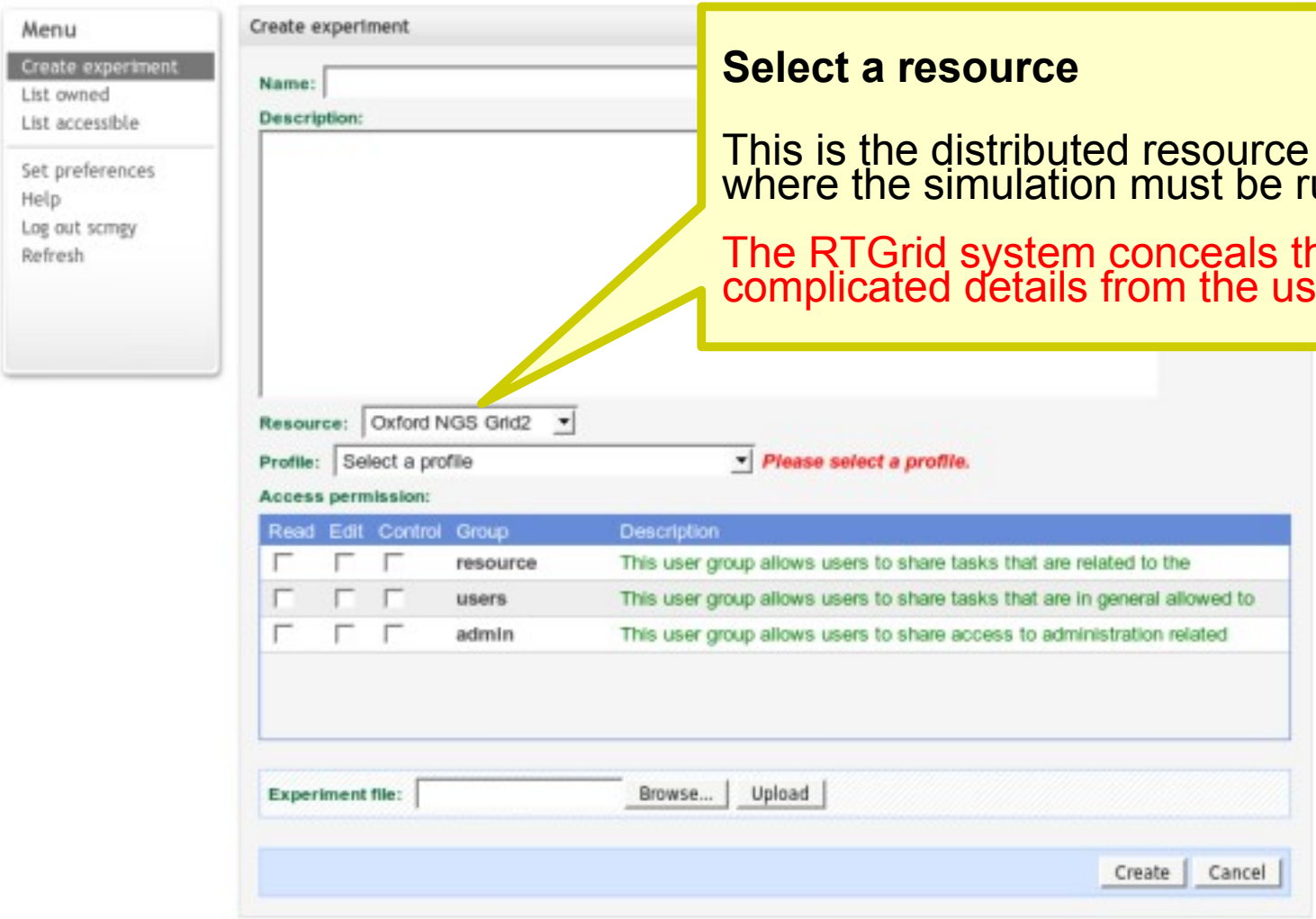


Permitted template parameters

These values are specified by the user when a new simulation experiment is derived from this template.

What is being displayed here is a preview of what the template user will see when this template is selected.

Creating a simulation experiment

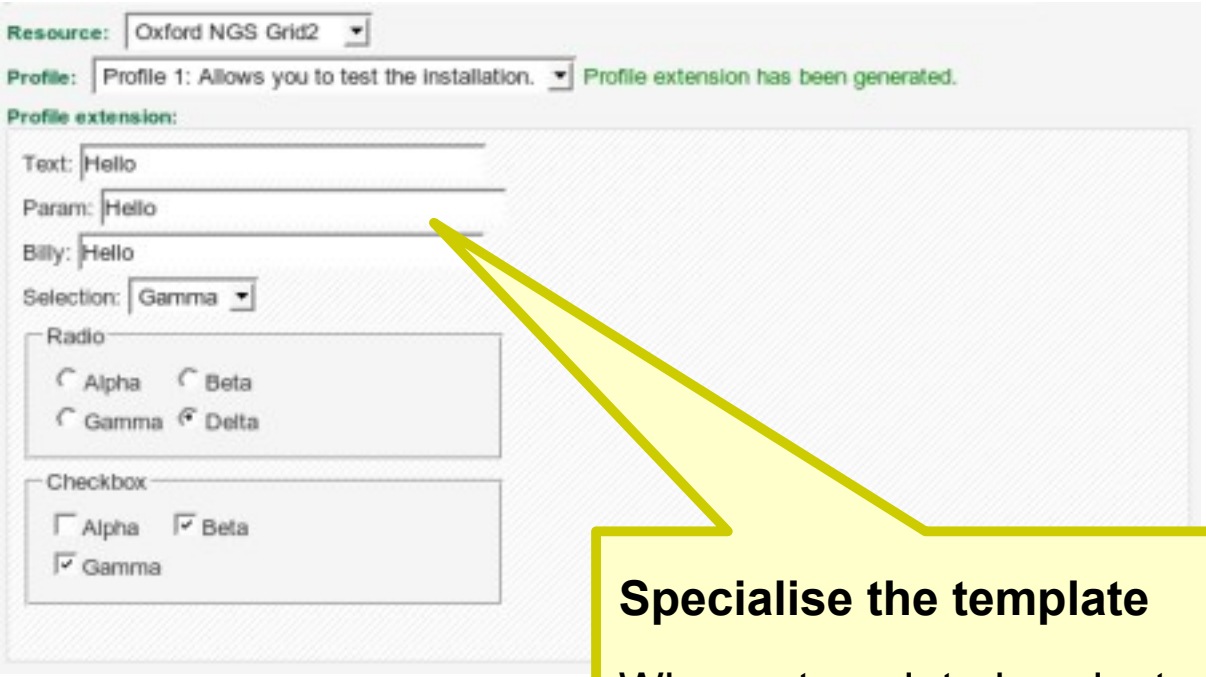


Select a resource

This is the distributed resource where the simulation must be run.

The RTGrid system conceals the complicated details from the user.

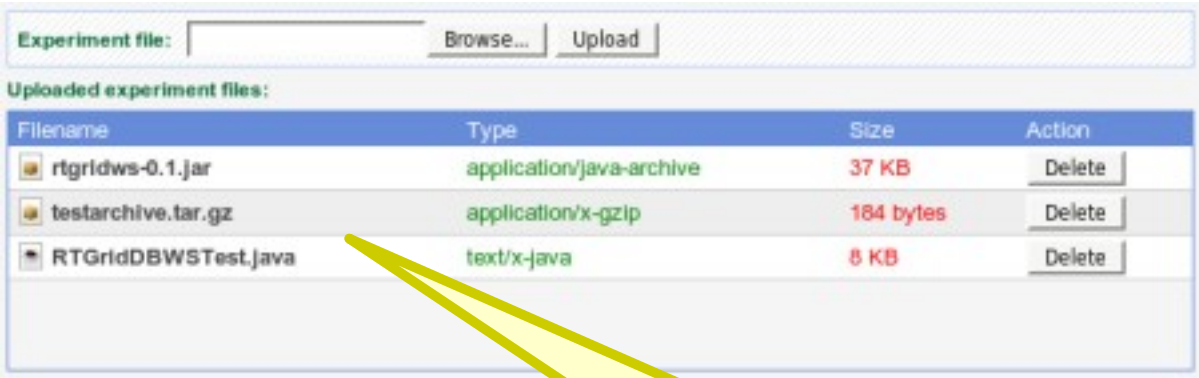
Creating a simulation experiment



Specialise the template

When a template is selected, the user is displayed with the associated template extension and default parameters. The user can supply new parameters.

Creating a simulation experiment



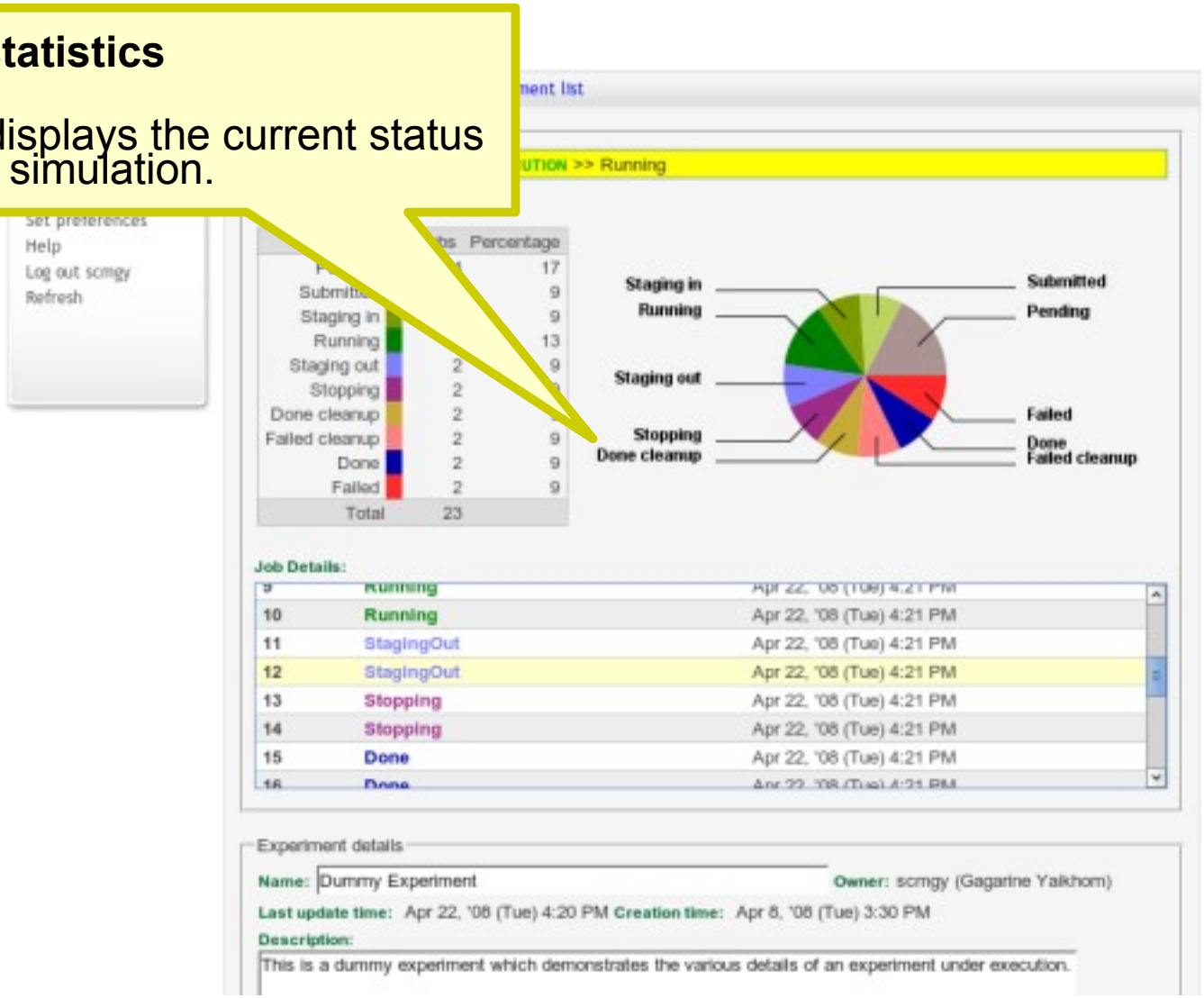
Upload experiment files

Some experiments might require special files that are not available with the chosen template.

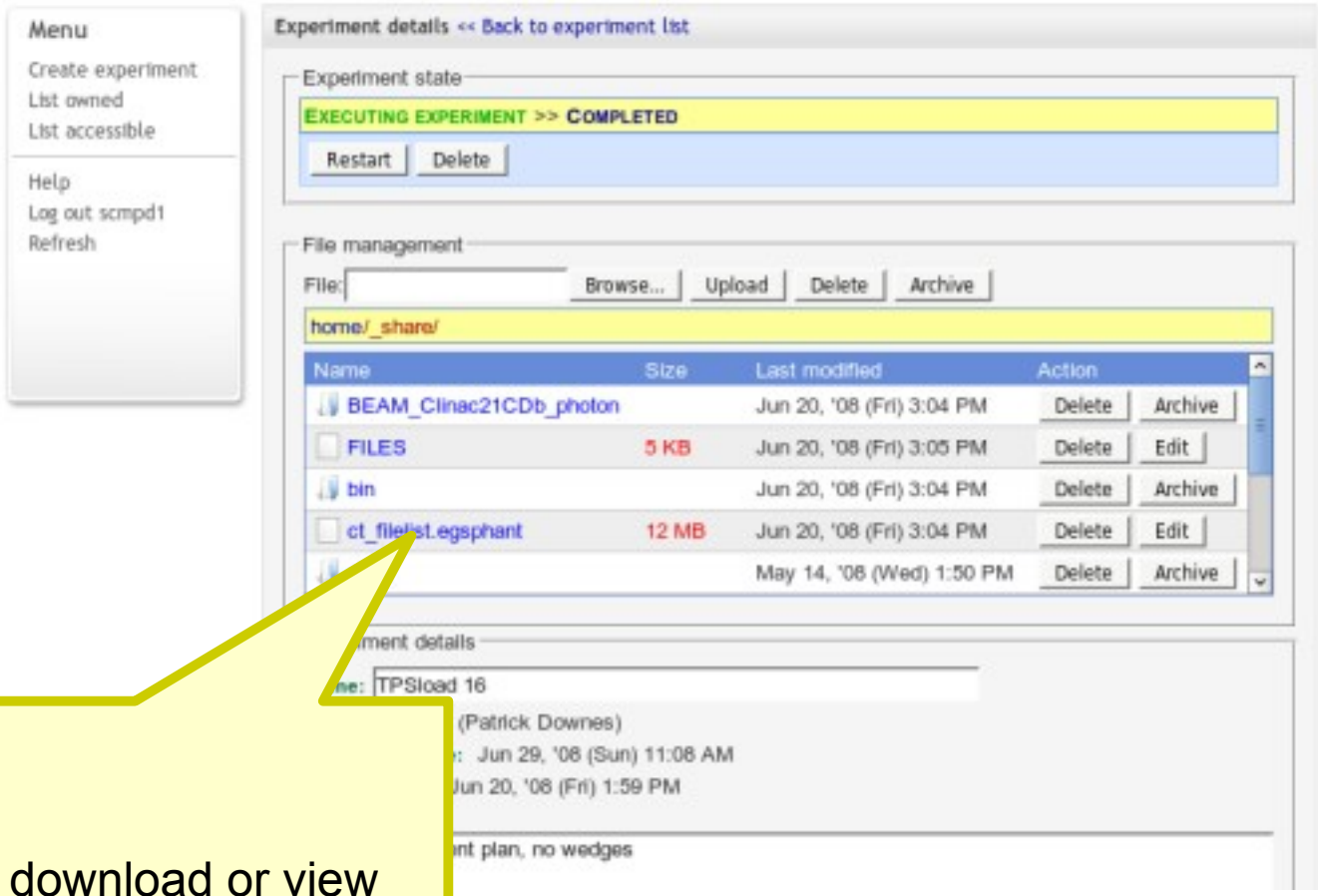
Managing a simulation experiment

Job statistics

This displays the current status of the simulation.



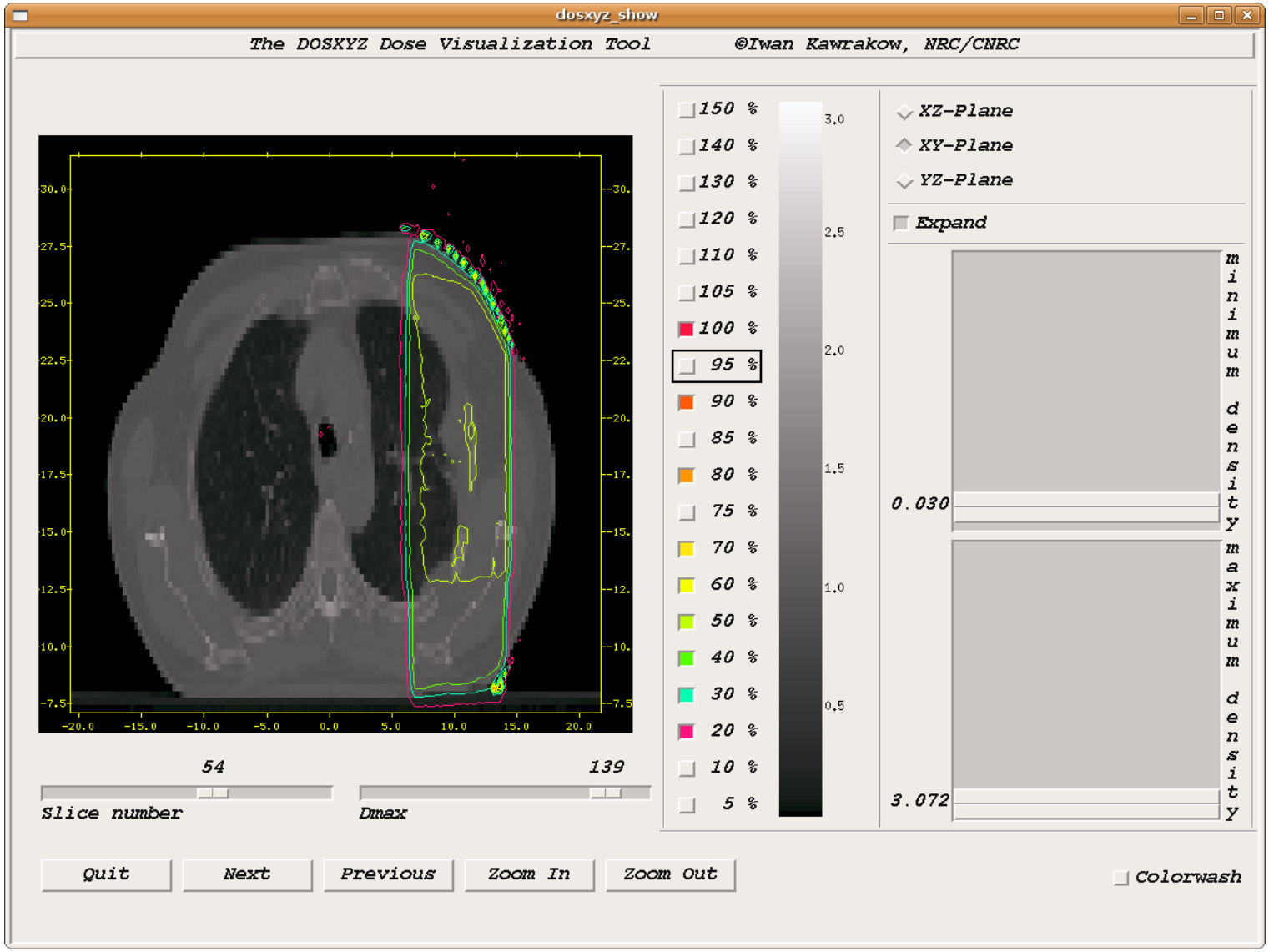
Managing a simulation experiment



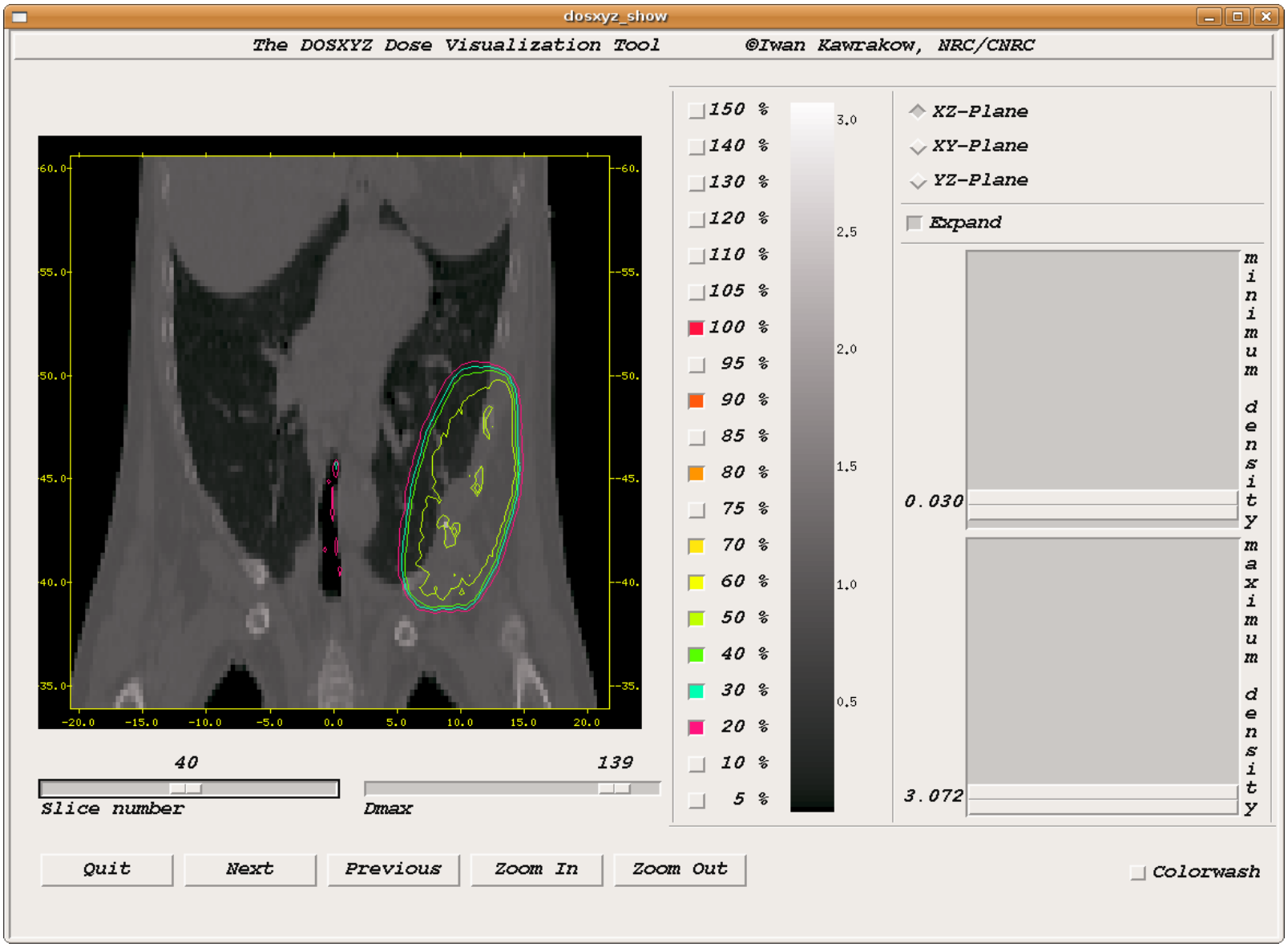
File browser

The user can download or view output and experiment-specific data files from this file browser.

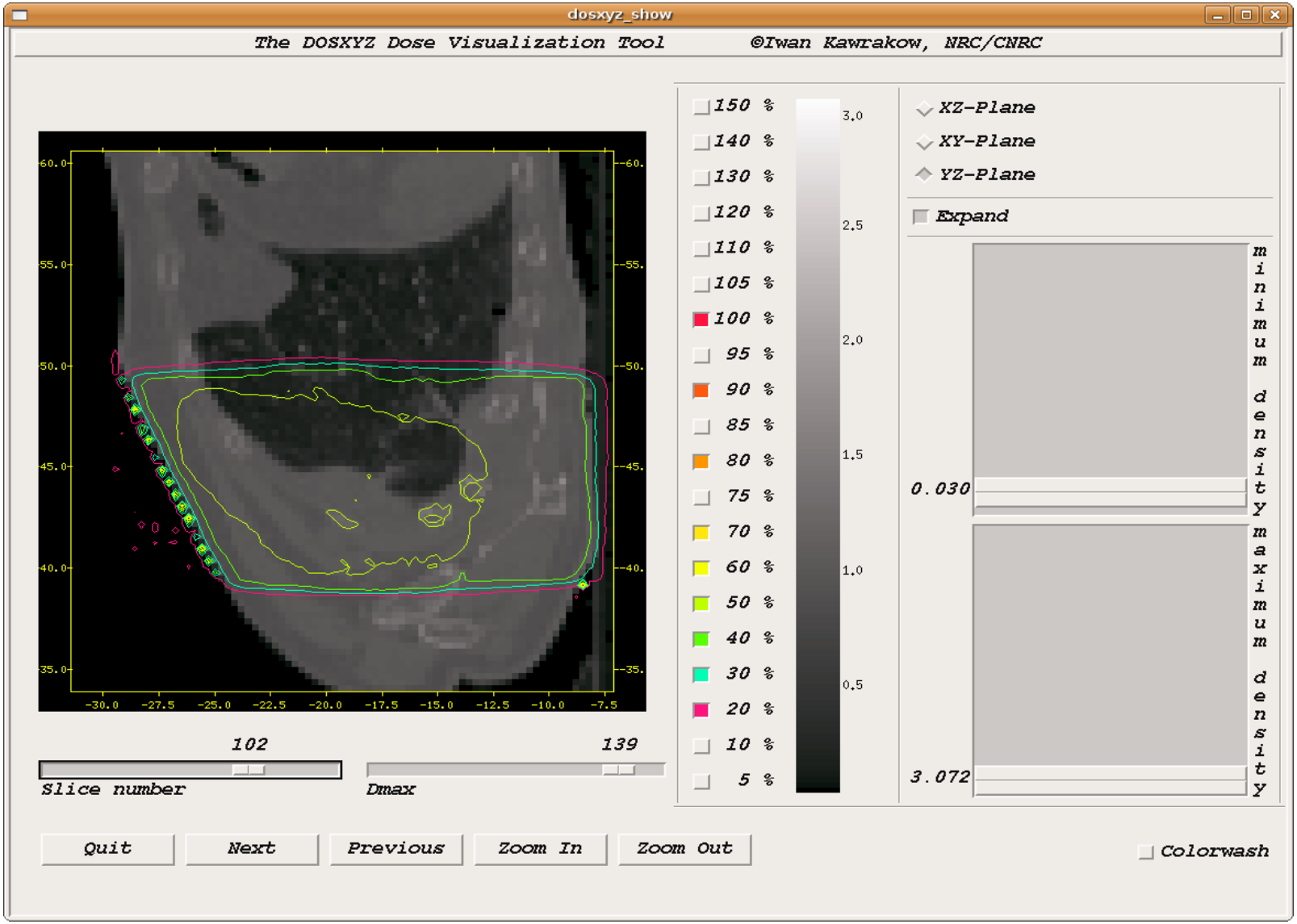
The Radiotherapy dose



The Radiotherapy dose



The Radiotherapy dose



Experimental Results (Condor)

Breakdown of the execution times for each of the experiments which ran on the Cardiff Condor Pool.

Jobs	Pre(%)	Run(%)	Post(%)	Speedup	Efficiency
20	15 seconds (0.06)	7.15 hours (99.79)	38 seconds (0.15)	11.48	0.57
40	30 seconds (0.21)	3.92 hours (99.30)	70 seconds (0.49)	20.55	0.51
80	50 seconds (0.37)	3.75 hours (98.62)	139 seconds (1.01)	21.35	0.27
120	71 seconds (0.60)	3.17 hours (97.25)	252 seconds (2.15)	24.89	0.21
160	108 seconds (1.94)	1.38 hours (89.09)	500 seconds (8.97)	52.22	0.33

The percentage of the execution time of each phase against the total execution time is given in parentheses.

Experimental Results (NGS)

Breakdown of the execution times for each of the experiments which ran on the National Grid Service.

Jobs	Pre(%)	Run(%)	Post(%)	Speedup	Efficiency
20	14 seconds (0.10)	3.83 hours (99.83)	10 seconds (0.07)	21.07	1.05
40	28 seconds (0.38)	2.03 hours (99.25)	27 seconds (0.37)	39.49	0.99
80	42 seconds (0.40)	2.88 hours (99.23)	39 seconds (0.37)	26.39	0.33
120	163 seconds (1.68)	2.63 hours (97.81)	51 seconds (0.51)	30.21	0.25
160	106 seconds (1.16)	2.47 hours (98.09)	68 seconds (0.75)	32.09	0.2

The percentage of the execution time of each phase against the total execution time is given in parentheses.

The highlighted experiments were affected by an unpredictable file transfer problem which degraded the performance.

Conclusions

- Significant speedup achievable.
- Some of the main issues:
  - Condor: pre-emption, suspension, and eviction.
  - NGS: unpredictable file transfer problem.

Future Work

- Investigate approaches for splitting into jobs.
- Investigate physical factors in MC models.
- Further experimentation with treatment plans.

Email: rtgrid@cs.cf.ac.uk

Demonstration:
Booth 13 Appleton Tower,
Wednesday 15:10 – 18:10

Thank you for your kind attention.