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de Protección y Seguridad Radiológica

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"Radioprotección: Nuevos Desafíos para un Mundo en Evolución"

GRUPO DE DOSIMETRIA NUMÉRICA / CNPq

UNIVERSIDADE FEDERAL DE PERNAMBUCO

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VOXELIZATION OF MESH PHANTOMS FOR COUPLING TO THE EGSnrc

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Buenos Aires, 16 de Abril de 2015



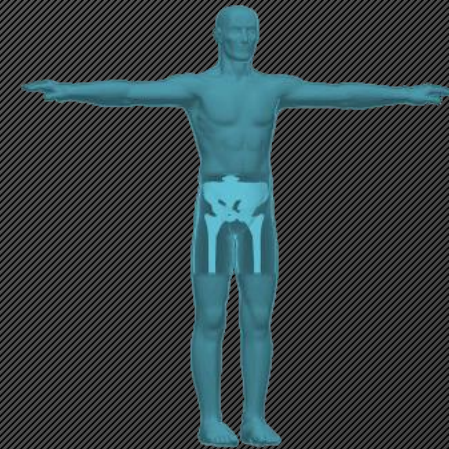
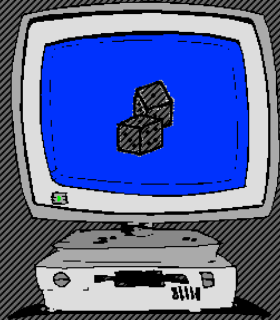
Objective of this work

EXPOSURE COMPUTATIONAL MODEL

MONTE CARLO CODE

ALGORITHM OF THE RADIOACTIVE SOURCE

ANTHROPOMORPHIC PHANTOM



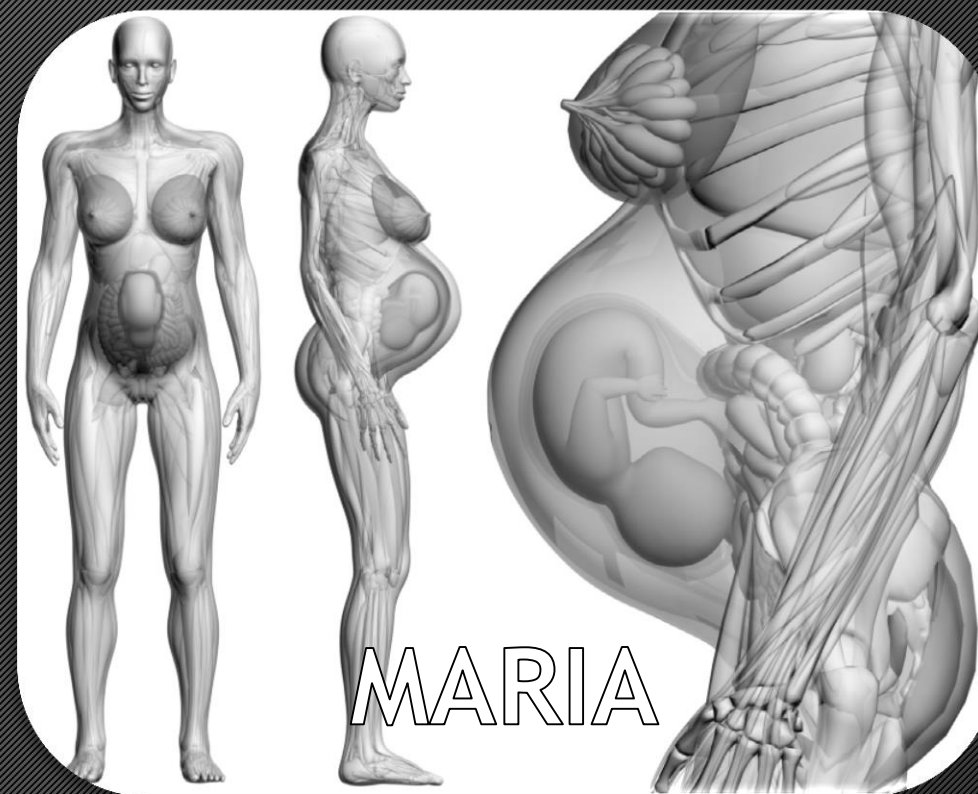
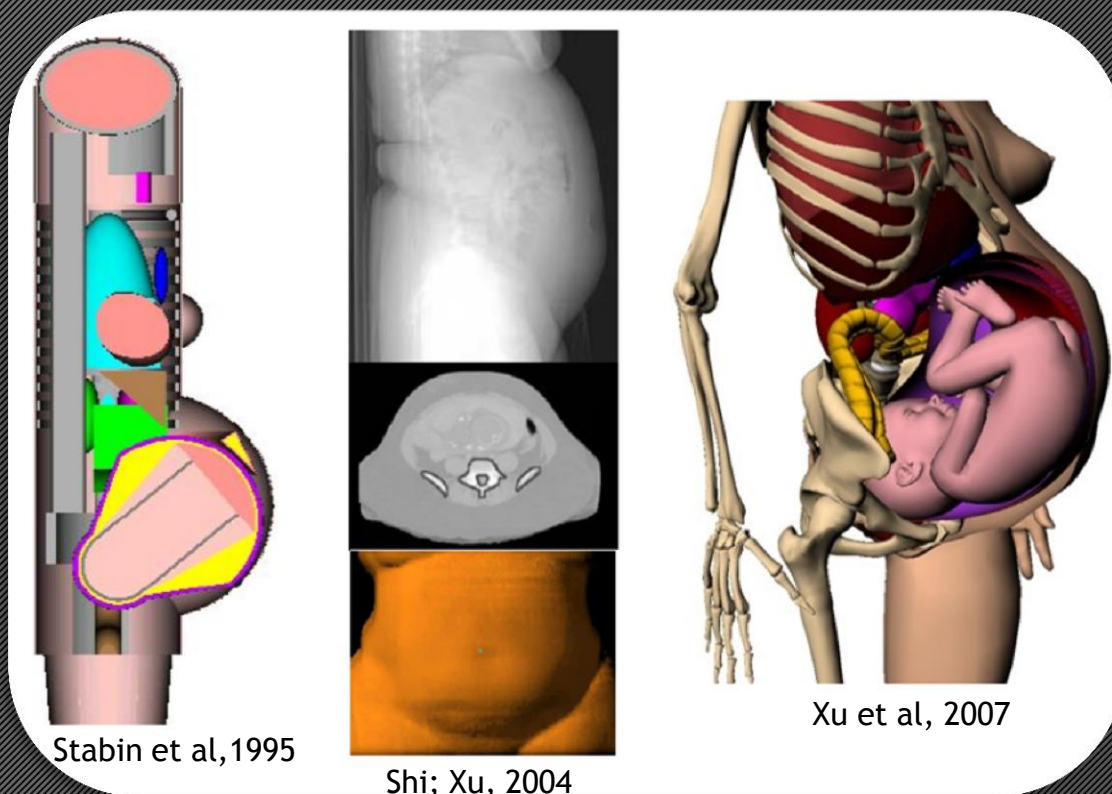
To perform dosimetric evaluations it is necessary to have a voxelized phantom coupled to a MC code.

HOW CAN WE DO THIS IF THE PHANTOM IS MESH TYPE?



1. Evolution of Computational Anthropomorphic Phantoms

1.1 Pregnant Phantoms



Mathematical, Tomographic (voxels), Hybrid and **Mesh** phantoms

Modelo Antropomórfico para dosimetria das Radiações Ionizantes em Adultas



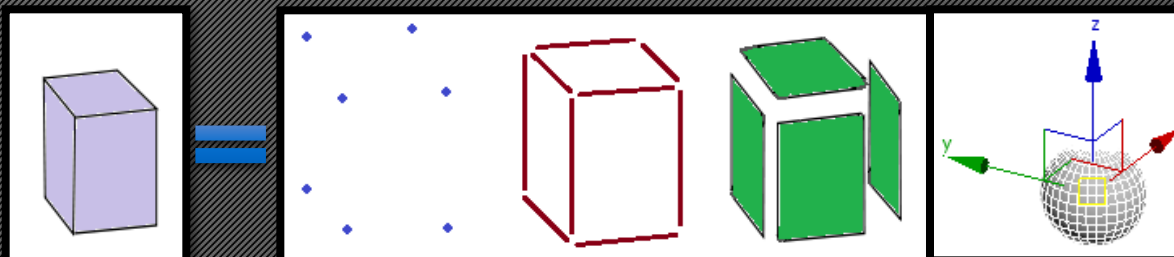
2. Voxelization of Mesh Phantoms

2.1 File type conversion

- Converting binary files (*.max) into text files (*.obj), containing 3D structures;
- Converting text files (*.obj) into data files 8-bit (*.raw), containing voxels structures.

```
MARIA.max  Form1.cs
00000000 D0 CF 11 E0 A1 B1 1A E1 00 00 00 00 00 00 00 .....
00000010 00 00 00 00 00 00 00 00 3E 00 04 00 FE FF 0C 00 .....
00000020 06 00 00 00 00 00 00 00 01 00 00 00 0C 00 00 00 .....
00000030 01 00 00 00 00 00 00 00 00 10 00 00 00 02 00 00 00 .....
00000040 01 00 00 00 FE FF FF FF 00 00 00 00 00 00 00 00 .....
00000050 65 02 00 00 89 07 00 00 10 0A 00 00 09 0F 00 00 e.....
00000060 A5 13 00 00 5C 16 00 00 55 1B 00 00 D2 1D 00 00 ....\..
00000070 32 23 00 00 3A 26 00 00 B2 2B 00 00 FF FF FF FF 2#...:&.
00000080 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF .....
```

```
7 mllib FemaleHumanAnatomy.mtl
8 # object Model::Female_Body_L_Eye
9 g Model_Female_Body_L_Eye
10 v -196.64017 166.92300 -2.69032
11 v -196.73257 166.85500 -2.70534
12 v -196.91536 167.04100 -2.72251
378 v -196.53981 167.17999 -0.41203
379 v -196.42622 167.00800 -0.42974
380 # 370 vertices
381 vt 0.24378 0.93690
382 vt 0.24579 0.93540
383 vt 0.24978 0.93938
384 vt 0.24414 0.93938
385 vt 0.24058 0.93557
767 # 386 texture vertices
768 vn 0.13530 0.04553 -0.98976
769 vn 0.13530 0.04553 -0.98976
1793 vn 0.07389 -0.05361 0.99582
1794 vn 0.07389 -0.05361 0.99582
1795 # 1027 normals
2161 f 370/386/1015 306/322/1016 265/281/1017 357/373/1018
2162 f 256/272/1019 370/386/1019 357/373/1020 41/44/1021
```



Box-Modeling: Vertices Edges Polygon Normals

2. Voxelization of Mesh Phantoms

2.2 Binvox Tool

STEP 1



Binvox (<http://www.cs.princeton.edu/~min/binvox/binvox.html>)

- Program executed through command prompt, that converts individual 3D objects (surfaces) into voxels. The output file can be adjusted with additional software.

```
Usage: binvox [-d <voxel dimension>] [-t <voxel file type>] [-c] [-v] <model file
espec>
  -d: specify voxel grid size (default 128, max 1024)
  -t: specify voxel file type (default binvox, also supported: hips, mira, vtk,
raw)
  -c: z-buffer based carving method only
  -v: z-buffer based parity voting method only (default is both -c and -v)
Additional parameters:
  -bb <minx> <miny> <minz> <maxx> <maxy> <maxz>: force a different bounding box
Supported 3D model file formats:
  VRML V2.0: almost fully supported
  UG, OBJ, OFF, DXF, XGL, POV, BREP, PLY, JOT: only polygons supported
Example:
binvox -c -d 200 -t mira plane.wrl
```

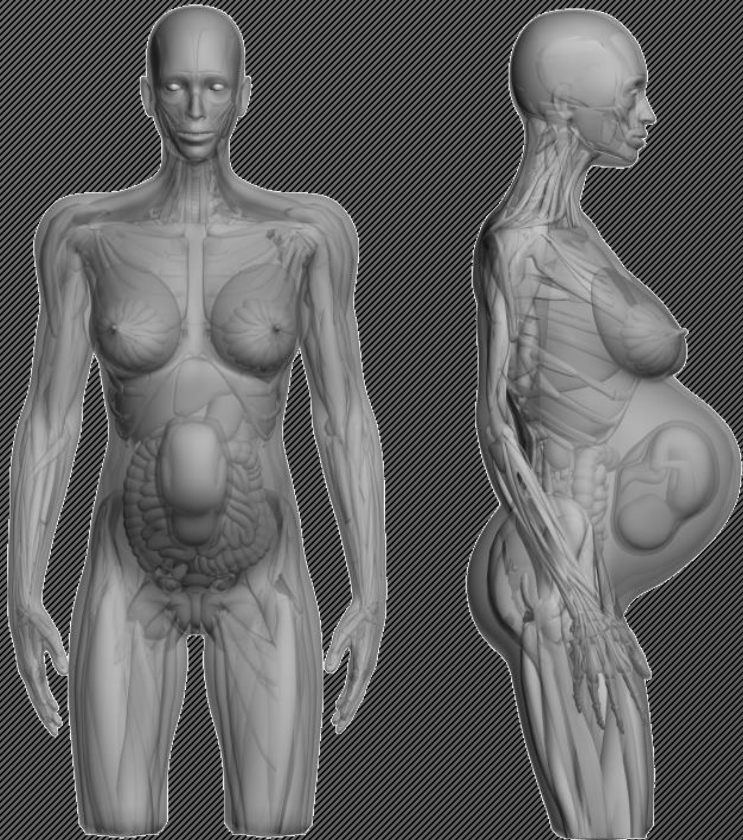
2. Voxelization of Mesh Phantoms

2.2 Binvox Tool

STEP 1



Definition of 3D object to be voxelized - Check the file types accepted by Binvox

Four orthographic views of a 3D model of a human torso. The top-left view is the front view, the top-right is the right side view, and the bottom-left is the top view. Each view shows the model against a light blue background with a coordinate system (x, y, z) and a 'FRONT', 'RIGHT', or 'TOP' label. A yellow arrow points from the bottom-left view towards the left side of the slide.

Is it possible to voxelize a whole-body phantom in order to achieve voxel resolution equal to 1,2 mm³?

2. Voxelization of Mesh Phantoms

2.2 Binvox Tool

STEP 2



Defining information: N° of voxels, Type of output files...

```
C:\Users\gdn>cd\Binvox
```

```
C:\Binvox>binvox.exe
```

```
cmd Prompt de Comando
```

```
Usage: binvox [-d <voxel dimension>] [-t <voxel file type>] [-c] [-v] <model file
espec>
  -d: specify voxel grid size (default 128, max 1024)
  -t: specify voxel file type (default binvox, also supported: hips, mira, utk,
raw)
  -c: z-buffer based carving method only
  -v: z-buffer based parity voting method only (default is both -c and -v)
Additional parameters:
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Supported 3D model file formats:
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Example:
binvox -c -d 200 -t mira plane.wrl

C:\Binvox>binvox -v -d 830 -t raw FETO.obj ←
```

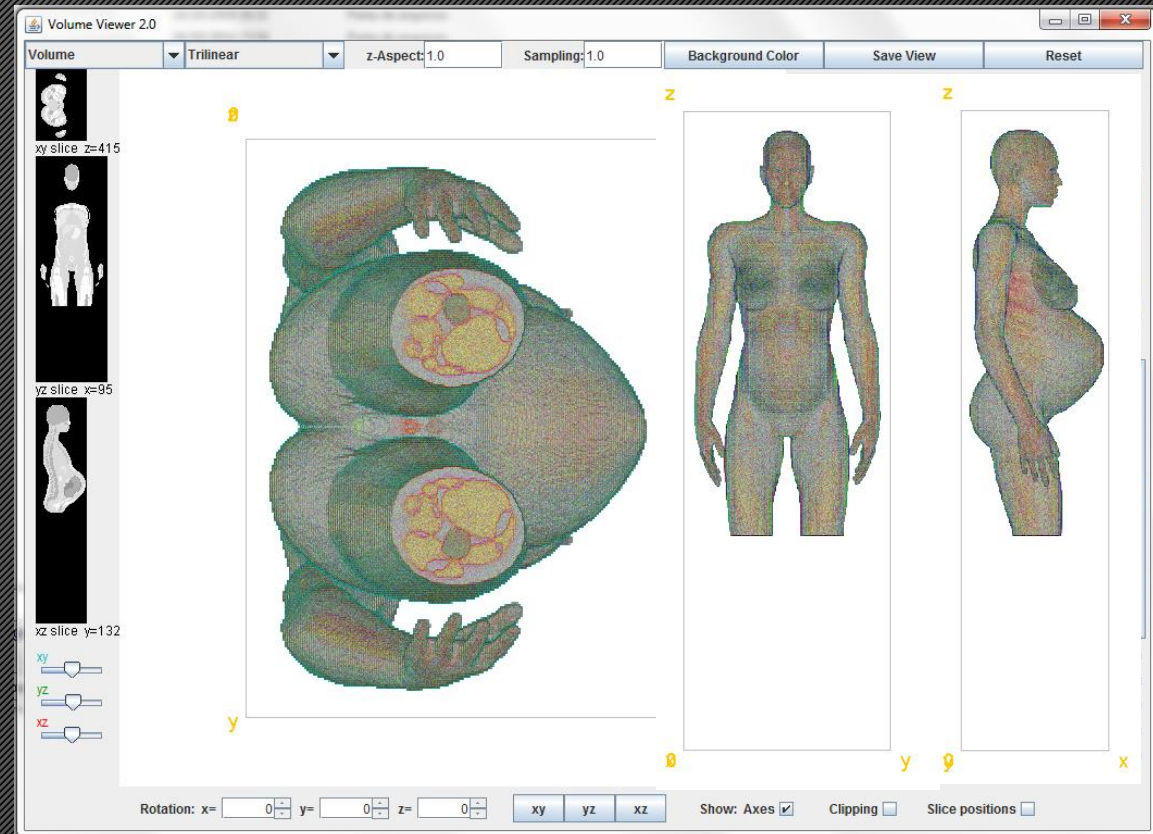
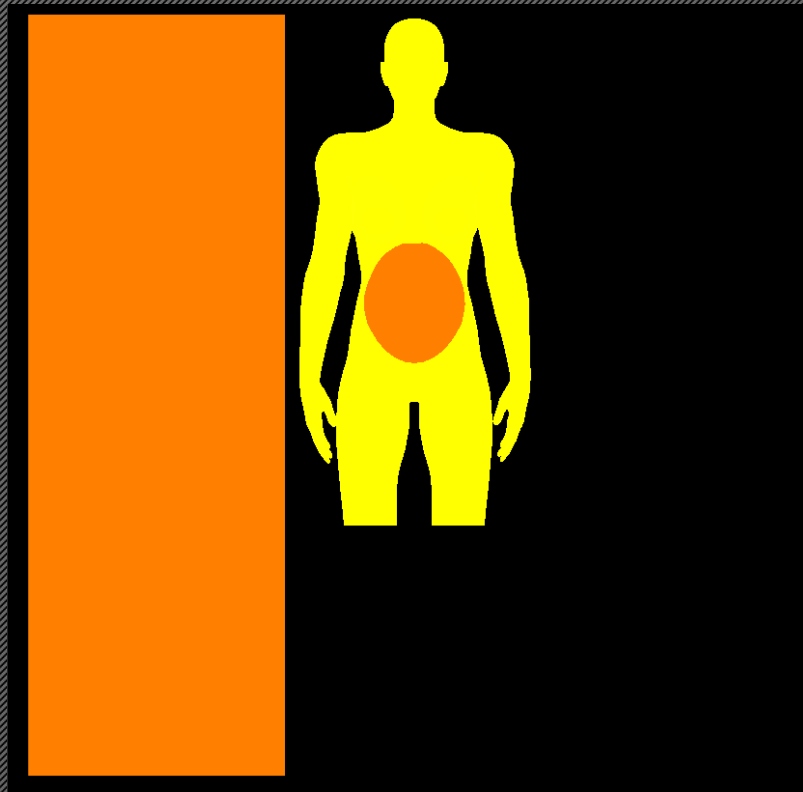
2. Voxelization of Mesh Phantoms

2.2 Binvox Tool

STEP 3



Visualization of voxelized structures for adjustments if necessary.

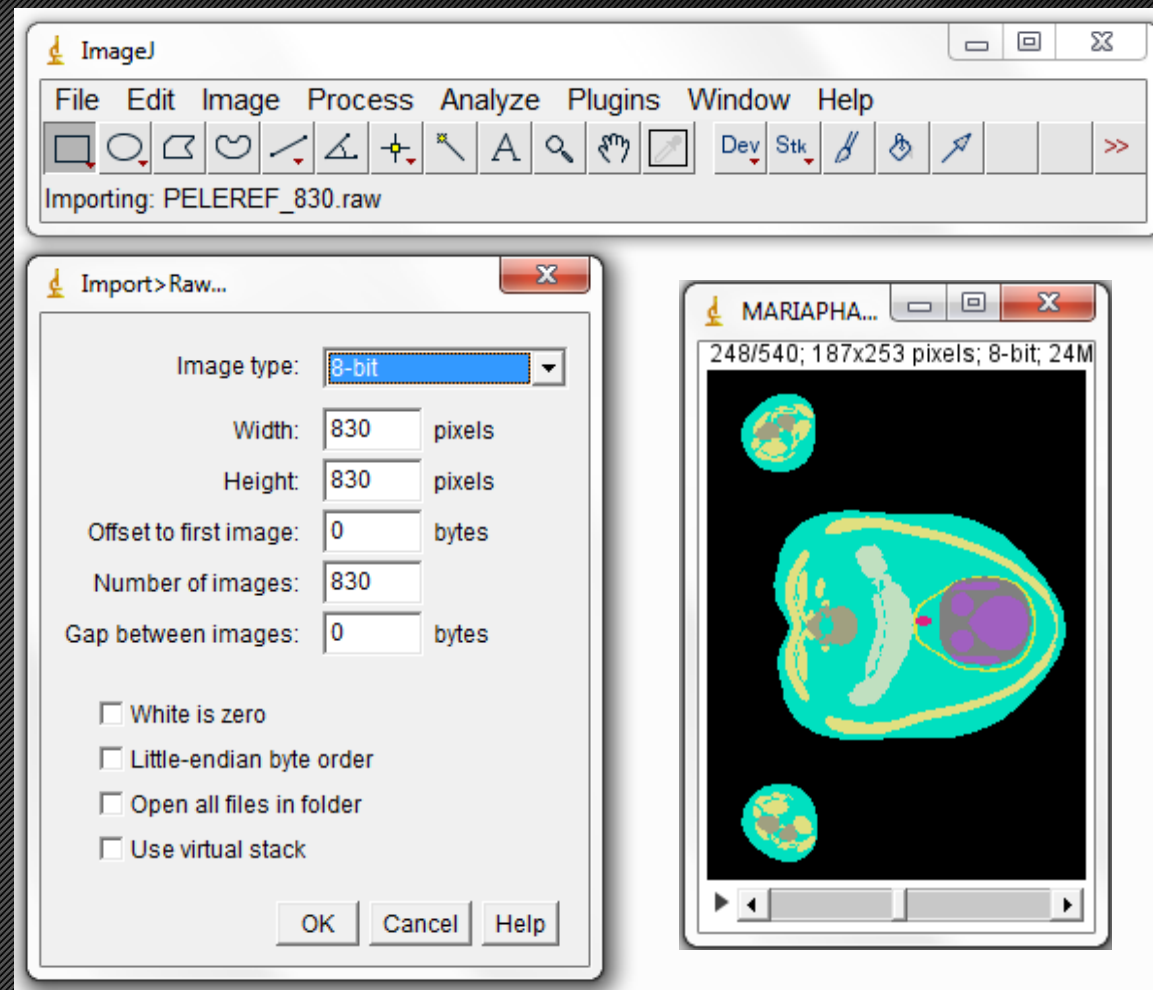
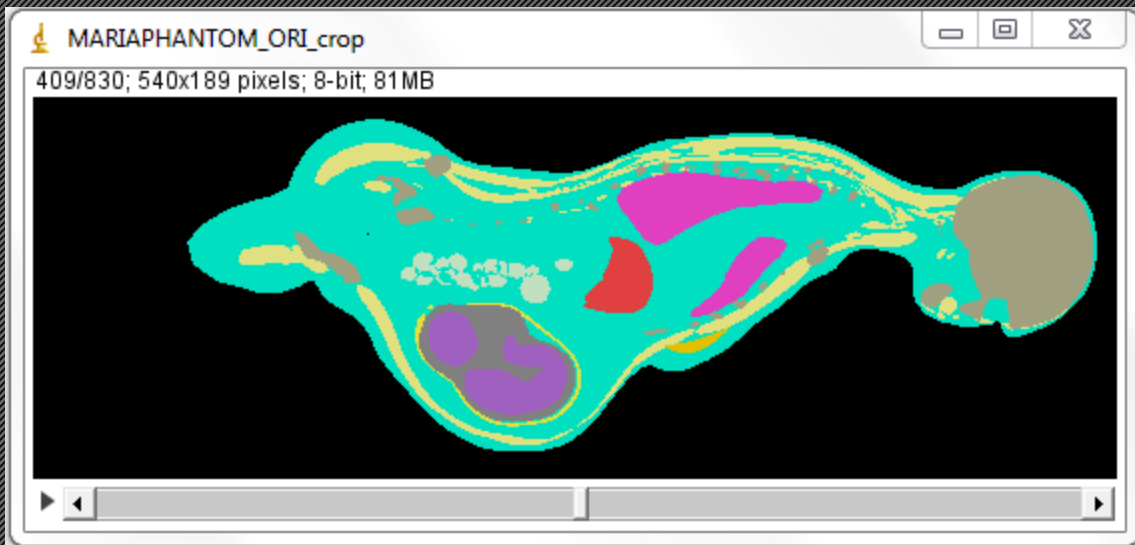


3. Adjustments of voxelized phantom

FIJI/
ImageJ

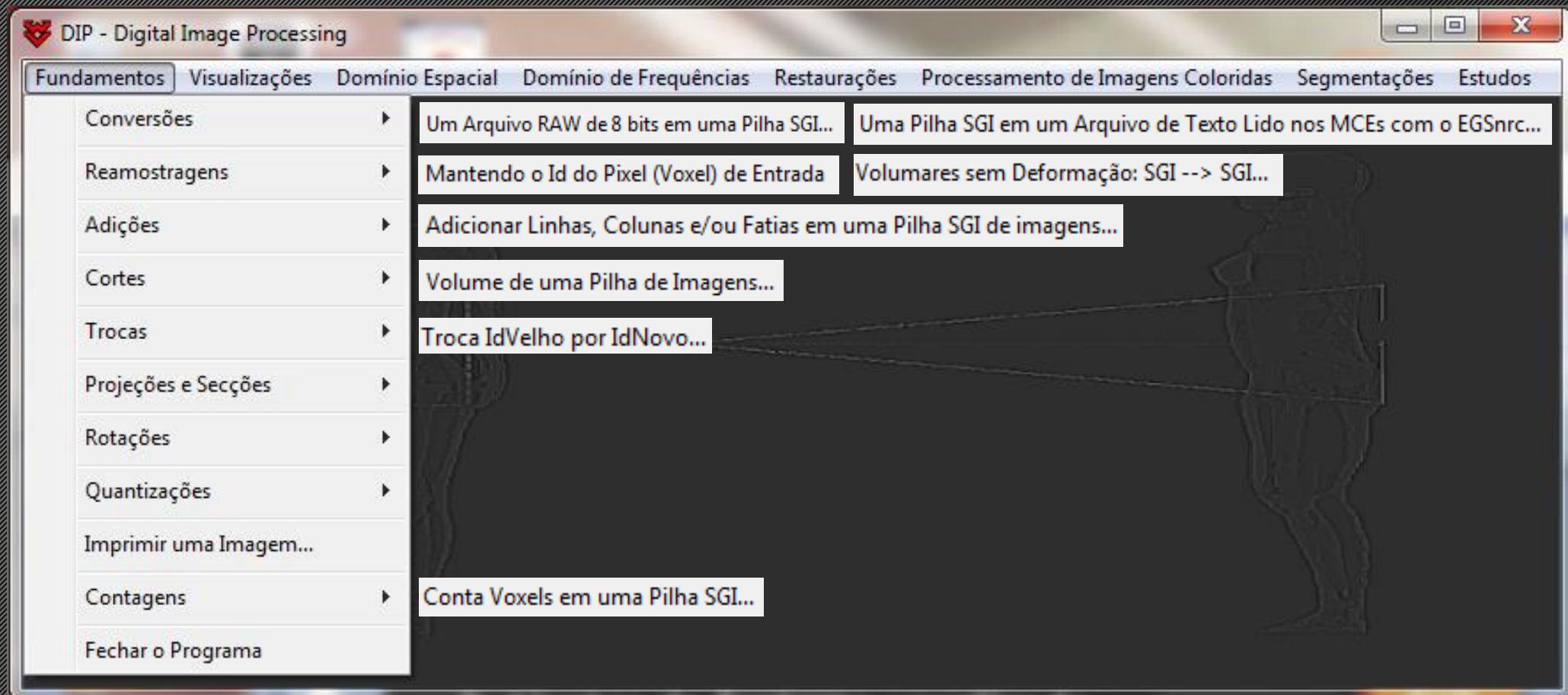


- ID assignment and color (RGB) for each structures
- Union of structures
- Cuts
- Rotations



3. Adjustments of voxelized phantom

DIP



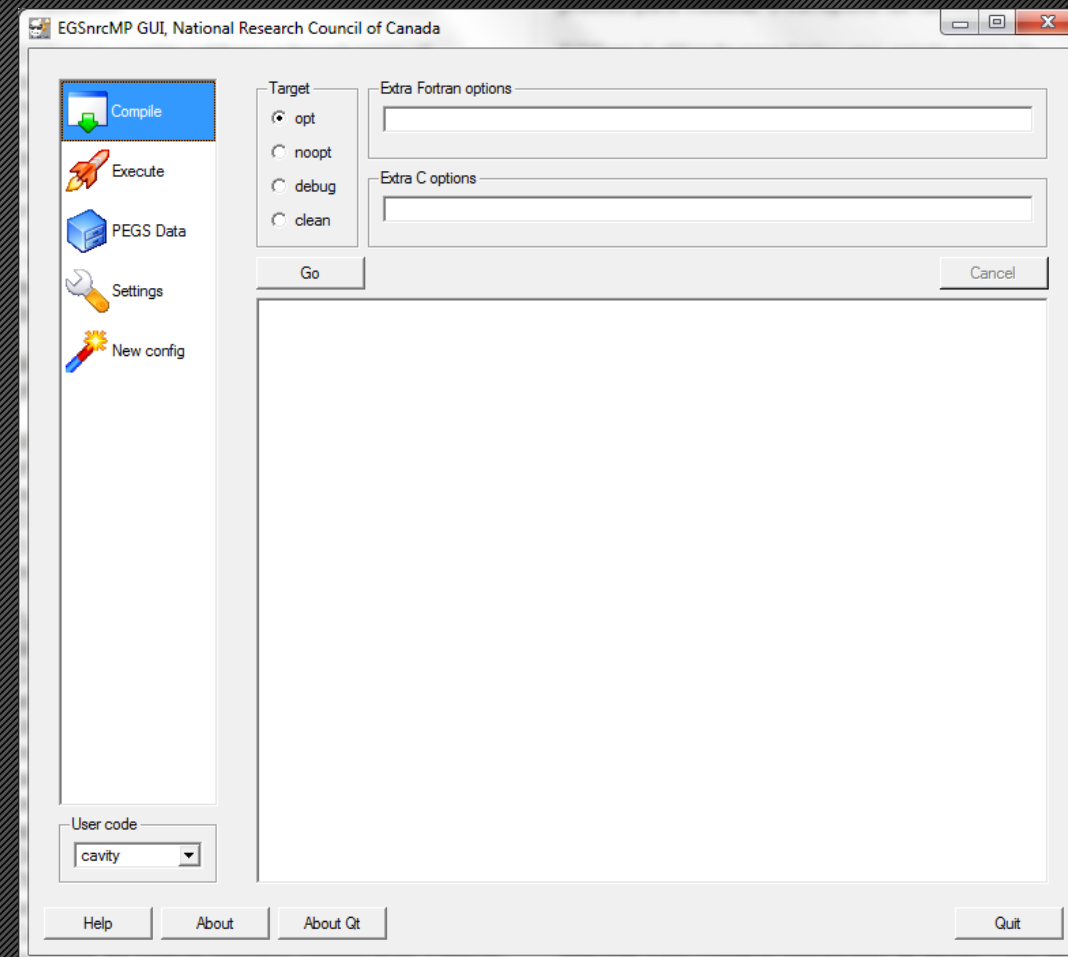
4. Coupling MARIA to MC code EGSnrc

EGSnrc



EGSnrc

- EGSnrc is trusted by researchers worldwide for simulation accuracy and speed. It is widely regarded as the most accurate computer program for electron and photon transport simulation.
- Allowing the user to choose the geometry for coupling and to define parameters used during the simulation.

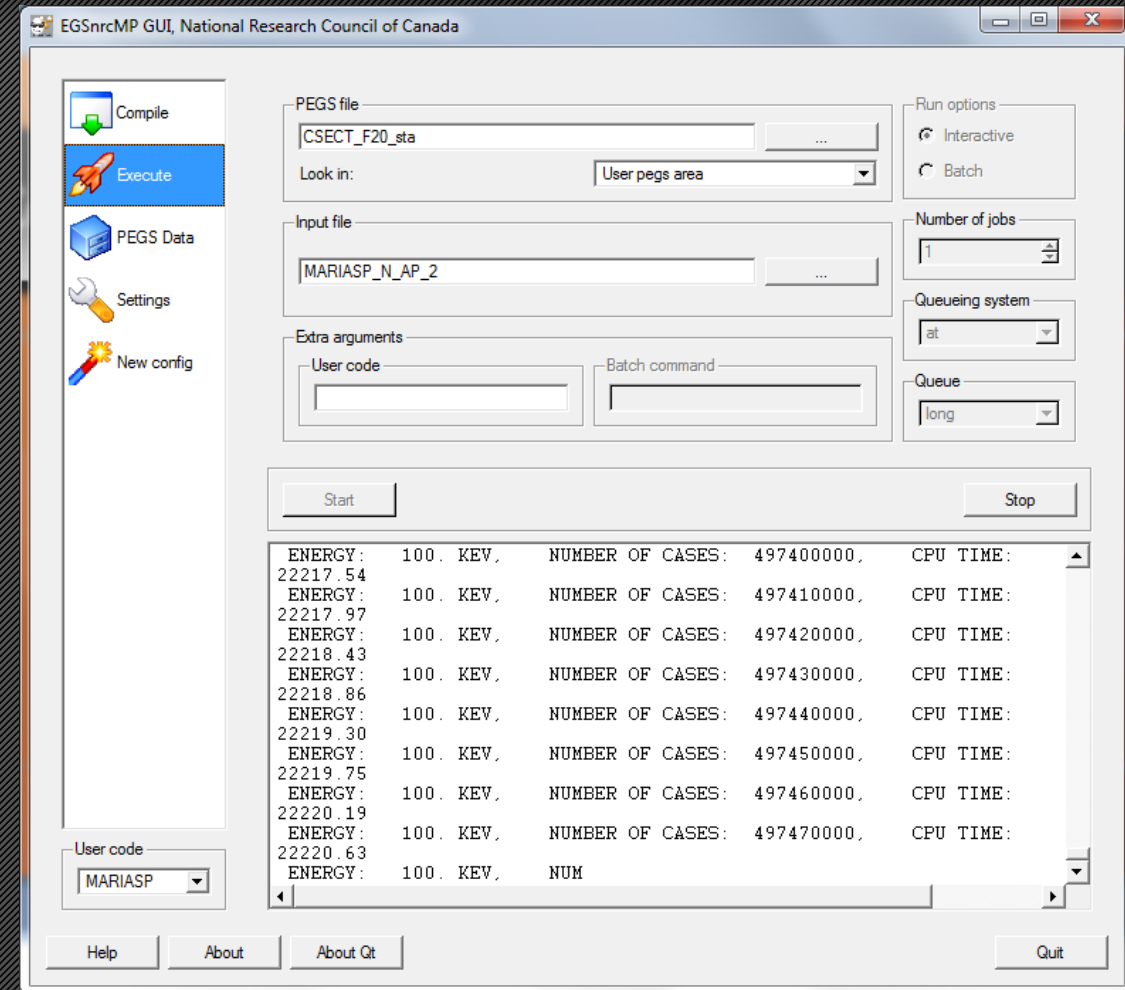


5. Dosimetric Evaluations



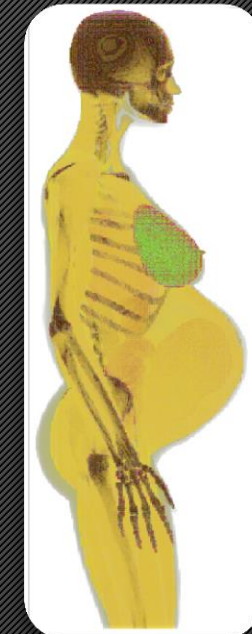
MARIA/EGSnrc

1. Geometry definition: Primary data and additional information were saved as a file text that can be read inside of the MC code and assigned to the phantom through organs/tissues'ID;
2. Definition of the radioactive source;
3. Internal modification of the main code and the other files read during the compilation/simulation



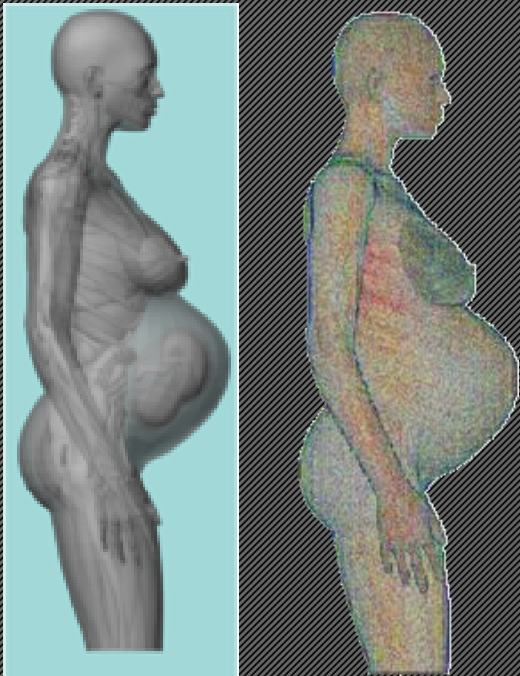
Results

MARIA phantom - Voxelized version			
ID	Organ	N° of voxels	Density (g/cm ³)
1	Amniotic Sac	280224	1,0300
2	Placenta	2912	1,0300
4	Brain	563645	1,0500
5	Fetus	318675	1,0300
8	Intestines	377895	1,0400
9	Liver	202976	1,0500
10	Lungs	2012665	0,2600
11	Muscle	6246648	1,0500
13	Ovaries	1096	1,0400
17	Skin	942251	1,0900
19	Stomach	89085	1,0400
24	Uterus	124780	1,0300
25	Adipose Tissue	15626751	0,9500
29	Skeleton Average	1970706	1,3700
30	Cortical Bone, Whole Body	1970706	1,9200
114	Whole Body Average	28760309	0,9630





Conclusions



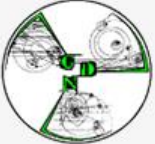
- In this work, the phantom MARIA was voxelized using the Binvox program.
- This version has a reduced number of organs and tissues coupled to the EGSnrc MC code.
- Simulations using algorithms of external radioactive sources, developed by GDN, were already performed in order to verify graphically and numerically the dosimetric results in the existent organs/tissues and to validate the coupling.
- A new menu for voxelize whole-body phantoms without loose voxel resolution was implemented into DIP software, developed by GDN.
- The new voxelized version of MARIA, including all the radiosensitive organs and tissues, will be available soon in the GDN website.

Grupo de Dosimetria Numérica - GDN/CNPq




Dosimetria Numérica | Gr. x

dosimetrianumerica.org

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3D visualization of a radiation beam passing through a series of rectangular blocks, with red lines representing the beam's path and a blue line representing the central axis.

Obrigada! ¡Gracias! Thank you!



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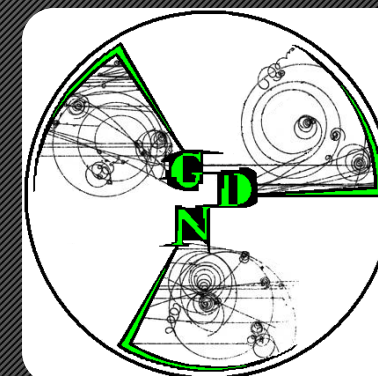
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