

# MaxLLG User Guide

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# Summary

This document provides guidance on how to use the MaxLLG GUI and Solver.

To run the Solver on an object, a matrix file is required. This file is a collection of values that describe the three-dimensional structure of the object.

To create the matrix file there are two different approaches to using the GUI:

1. Using two-dimensional .png images created in photo editing software (E.g. Photoshop or [Gimp](#))  
This approach is suitable for objects which have a linear third axis, such as cables.
2. Using .step files created in a CAD software application from three-dimensional objects (E.g. AutoCAD or [FreeCAD](#))  
This method is suited for more complicated geometrical parts.

The Solver also relies on a host of other parameters which are passed to the solver in a separate file. These parameters can be amended on the Meta Script screen.

Once the matrix file has been created and the meta script values set, the Solver can be run. During its run the Solver creates 'out\_' files that can be viewed as heatmaps in the output section.

The GUI uses locally stored stylesheets and jquery files. It also creates a sqlite database to store user information.

# Installation

Prior to installation, please ensure that you have the following installed:

- Python 3
- Freecad & Python2
- Pip (E.g. apt install python3-pip)
- Venv (E.g. apt install python3.9-venv)

If you are intending to use the 3D CAD approach to creating matrix files, then the FreeCAD application must be installed. Get it from [www.freecadweb.org](http://www.freecadweb.org).

FreeCAD requires Python version 2. This also needs to be installed.

## Running setup.sh

Once the prerequisite packages have been installed, run the setup script to ready your system:

```
./setup.sh
```

Once run, the script will begin to setup the app on your system.

## Specifying the Port number

The app requires a port to run locally and defaults to 5000. However, if this port is already in use, an alternative port number can be specified as an argument. E.g.:

```
./setup.sh 5001
```

## User Input

As the setup script runs, there will be three requests for user input.

### User Input 1

The first, almost immediately, is simply to 'Press any key to continue'

## Python

The setup script then attempts to determine the most up to date python version, and the accompanying command.

## User Input 2

The user is then asked for the python version for use with the FreeCad package. This is usually **python2**.

## Virtual Environment

The setup file then creates a virtual environment within which to run the app. The required packages are then installed into this environment.

## FreeCAD

### User Input 3

Once the python commands have been identified, setup will ask for the location of the freecad lib directory. Please supply this.

E.g. /usr/lib64/freecad/lib

## Troubleshooting

If the port is already in use, the setup will fail at the very end. If this happens, simply use the *start.sh* script to restart the app as detailed in the 'Restarting the GUI' section below.

## Restarting the GUI

Once the setup file has been run, there is no need to run it again. Instead, if the Flask server needs to be restarted, use the *start* script:

```
./start.sh
```

Again, the port can be specified as an argument:

```
./start.sh python 5001
```

NB. The main python command must also be sent as an argument (to start the GUI process). E.g. python or python3

# The Home Page

The first page loaded by the app gives obvious links to the start the solving process:

The screenshot shows the MaxLLG Solver home page. At the top, there is a dark navigation bar with the following links: MaxLLG, 2D Image Files, 3D CAD Files, Matrix Files, Output Folders, User Doc, and Login. Below the navigation bar, the main content area has a white background. The first section, titled "Welcome to the MaxLLG Solver", contains the text "This web app will help you to work through the solver process". Below this, there are three blue rectangular boxes, each containing a title and a link. The first box is titled "Use 2D images to run the solver" and has the link "Start the procedure for running the MaxLLG Solver using 2D images". The second box is titled "Use 3D CAD to run the solver" and has the link "Start the procedure for running the MaxLLG Solver using 3D CAD". The third box is titled "View the User Documentation" and has the link "Clear guidelines on how to use the MaxLLG GUI".

MaxLLG   2D Image Files   3D CAD Files   Matrix Files   Output Folders   User Doc   Login

## Welcome to the MaxLLG Solver

This web app will help you to work through the solver process

**Use 2D images to run the solver**

[Start the procedure for running the MaxLLG Solver using 2D images](#)

**Use 3D CAD to run the solver**

[Start the procedure for running the MaxLLG Solver using 3D CAD](#)

**View the User Documentation**

[Clear guidelines on how to use the MaxLLG GUI](#)

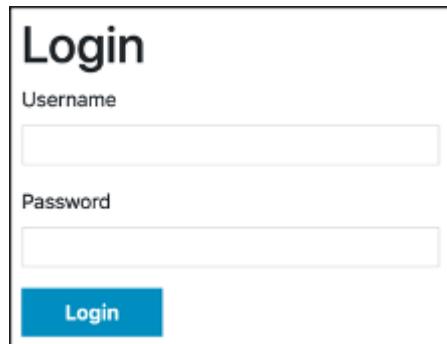
Figure 1: Home page

# Logging in

When clicking on any other page of the GUI you will need to login. A user is automatically created during setup and can be used to proceed:

Username: admin

Password: \*\*\*Please ask\*\*\*



The image shows a simple login interface. It features a title 'Login' at the top. Below it are two input fields: 'Username' and 'Password', each with a corresponding text input box. At the bottom is a blue rectangular button with the word 'Login' in white text.

*Figure 2: Logging in*

Once logged in you will see 'Logged in as <<username>>' in the top navigation bar:



*Figure 3: The nav bar showing the logged in user*

## Adding more users

To add further users, run the `add_user.py` file with the new username and password as parameters:

```
python add_user.py <<username>> <<password>>
```

# Creating the matrix file

## Using 2D images

### Create an Image

Create an image that resembles the cross section of your part. The image below uses a coaxial cable as an example:

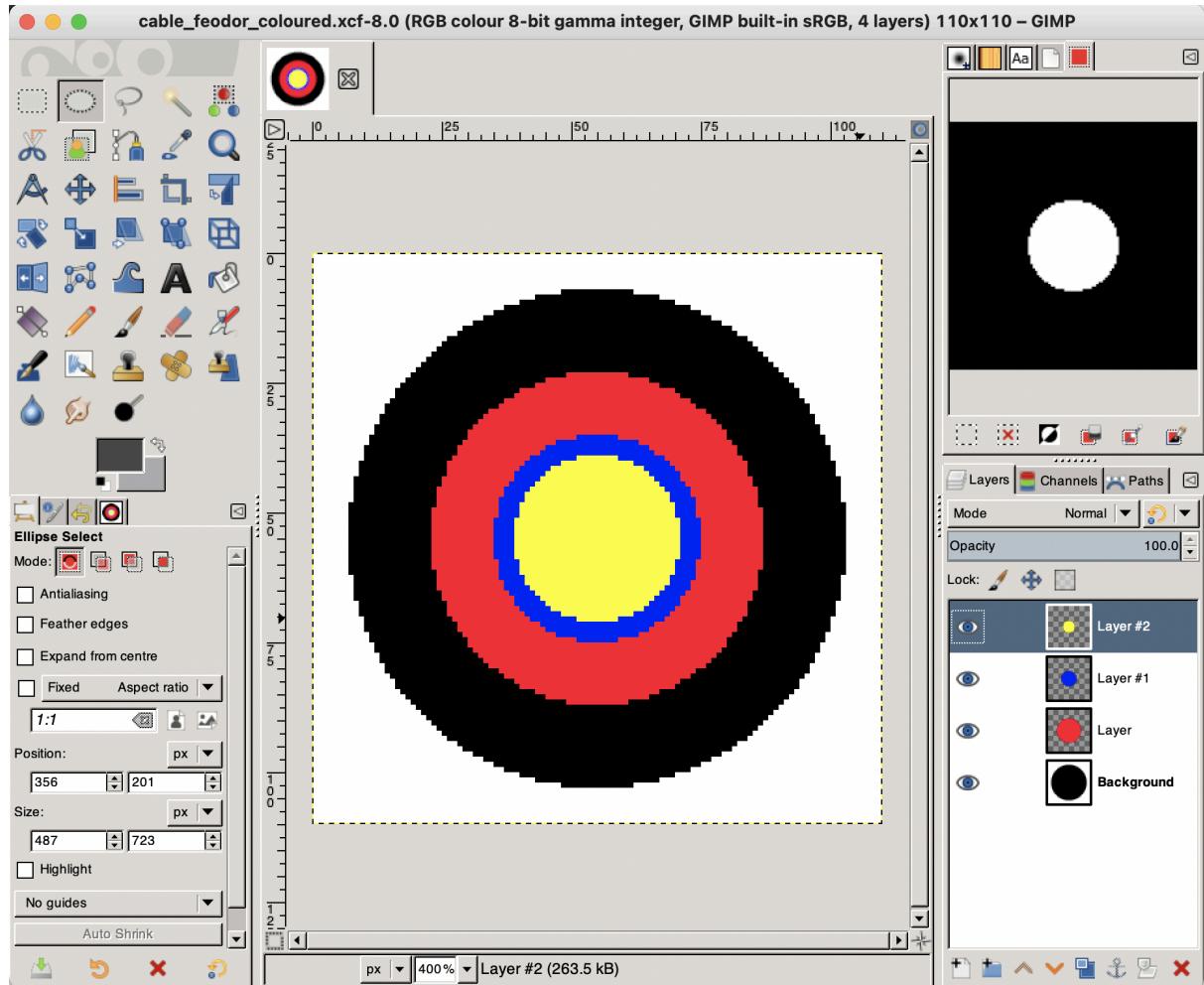


Figure 4: Creating a 2D image in GIMP

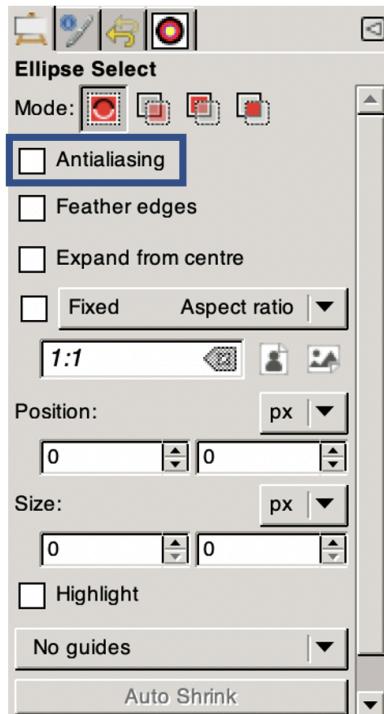


Figure 5: Untick the 'Antialiasing' checkbox in the 'Tool Options' menu

NB. Importantly, ensure the following:

- **Antialiasing is TURNED OFF** so the colours do not merge into one another.
- The area around the part is coloured white. This is so a 3D image can be rendered later.

The drawing above uses a canvas of 110x110 pixels.

On the '2D Image Files' page, load the image into the GUI by clicking on the 'Browse' button.

## 2D Image Files

Upload and view your 2D images. Once uploaded, click 'Add Constants' to create a matrix file for use with the solver.

### Upload

[Browse...](#)   **No file selected.** [Upload](#)

Must be a gif, jpg, jpeg or png file

### List of files uploaded

**Important:** The images below have been flipped along the x (horizontal) axis to show the 0,0 point at the bottom left corner. This is because 3D representations are also built with point 0,0,0 at the bottom left corner.

Show **10** entries

Search:

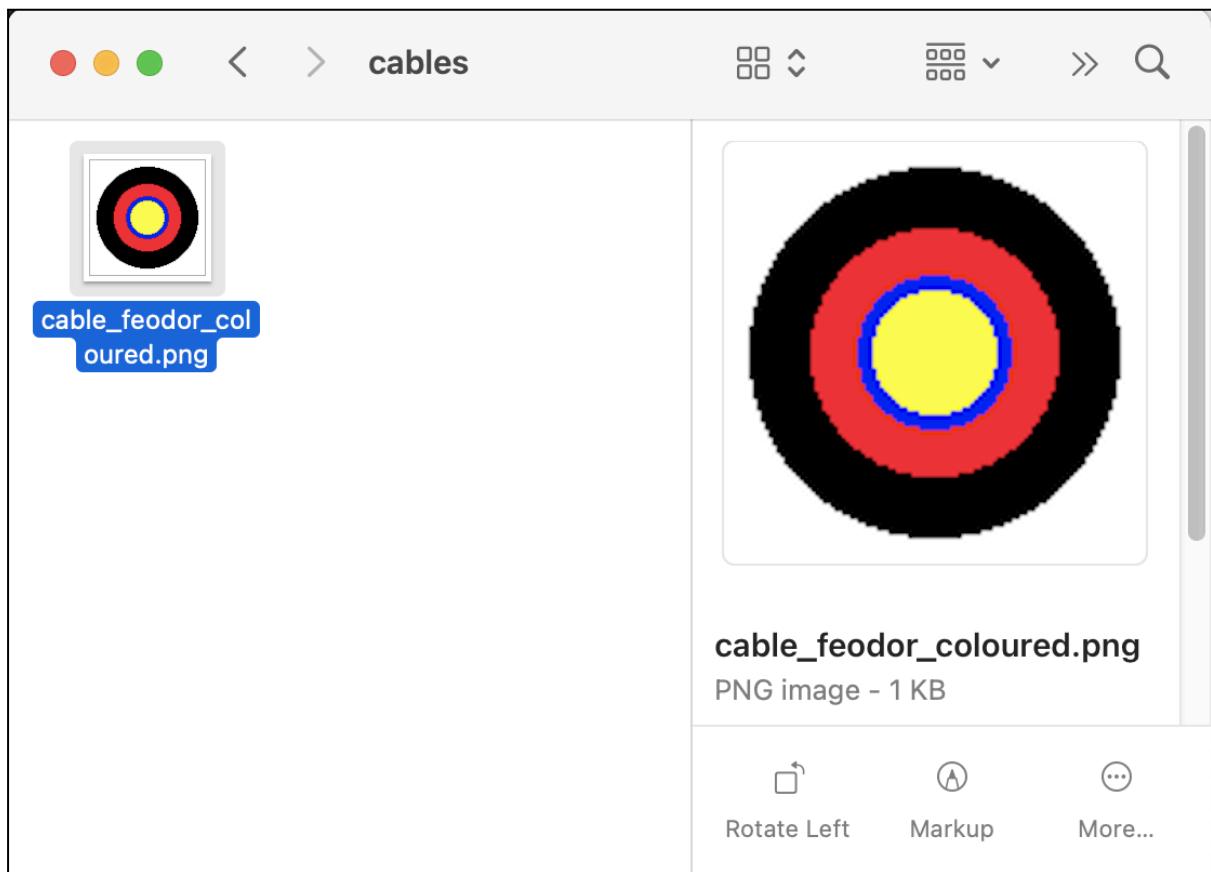
File name	File size	Date uploaded	Actions
No data available in table			

Showing 0 to 0 of 0 entries

[Previous](#) [Next](#)

*Figure 6: The empty '2D Image Files' screen*

Navigate to your image and click 'Open'.



*Figure 7: The 'File Upload' dialog box*

On the original '2D Image Files' screen, the path to your file will now show next to the 'Browse'.

## 2D Image Files

Upload and view your 2D images. Once uploaded, click 'Add Constants' to create a matrix file for use with the solver.

### Upload

[Browse...](#) **cable\_feodor\_coloured.png** [Upload](#)

Must be a gif, jpg, jpeg or png file

*Figure 8: Upload message*

Click the 'Upload' button. This will load your image into the GUI:

## List of files uploaded

**Important:** The images below have been flipped along the x (horizontal) axis to show the 0,0 point at the bottom left corner. This is because 3D representations are also built with point 0,0 at the bottom left corner.

Show 10 entries

Search:

File name	File size	Date uploaded		
 <a href="#">cable_feodor_coloured.png</a>	1.5 kB	2022-02-18 12:34:46	<a href="#">Add Constants</a>	<a href="#">Remove</a>

Showing 1 to 1 of 1 entries

Previous 1 Next

*Figure 9: Uploaded 2D image file*

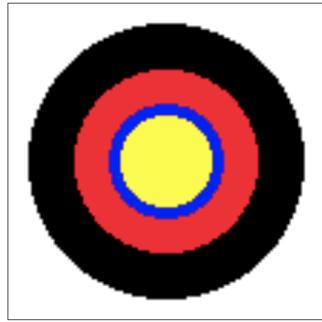
## Add Parameters

To create your matrix file, click the 'Add Constants' link:

## Enter Constants

Add values for each constant of the materials used in the object to create the matrix file.

Color	Magnetisation	Conductivity	Dielectric
<input type="color" value="#ffffff"/> #ffffff	0.0	1.0	1.0
<input type="color" value="#000000"/> #000000	0.0	2.0	1.0
<input type="color" value="#ff002b"/> #ff002b	0.0	3.0	1.0
<input type="color" value="#fcfe01"/> #fcfe01	0.0	4.0	1.0
<input type="color" value="#1908fb"/> #1908fb	0.0	5.0	1.0
Length Dimension	100		
Matrix file name	cable_feodor_coloured.png		
<b>Create Matrix File</b>			



**Important:** The image above has been flipped along the x (horizontal) axis to show the 0,0 point at the bottom left corner. This is because 3D representations are also built with point 0,0,0 at the bottom left corner.

Figure 10: Add parameters

Choose values for Magnetisation, Conductivity and Dielectric.

The screen will remember any values entered previously *for this image*.

### Length Dimension

The 'Length Dimension' is the depth of the part. For a cable, this would be the length of the cable.

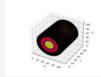
This value essentially gives the 2D drawing a third dimension and allows the GUI to create a 3D representation of the object.

### Matrix file name

The name of the matrix file that will be created can also be set here. It can be different than the actual image filename.

When ready, click the 'Create Matrix File' button.

This will combine the data in the image and the parameters to create the matrix file for the Solver. The browser will be redirected to the 'Matrix Files' page. This should only take a few seconds.

Matrix Files							
List of files created/uploaded							
Show 10 entries		Search: <input type="text"/>					
File name	Percent complete	File size	Object size	Date created	Join First	Join Last	
	cable_feodor_coloured--001 100%	15.7 MB	x=110 y=100 z=110 1210000 cells	2022-02-18 12:41:14	<input type="radio"/>	<input type="radio"/>	<a href="#">Add Parameters</a> <a href="#">Remove</a>

Showing 1 to 1 of 1 entries Previous [1](#) Next

Figure 11: The 'Matrix Files' page

## Naming Convention

Since the same png can be used to create multiple matrix files, a three-digit number is appended to the end of the filename:

E.g. cable\_feodor\_coloured--001 (see above)

## Dimensions

The dimensions of each matrix file are shown to give the user a clear indication of the size of the object.

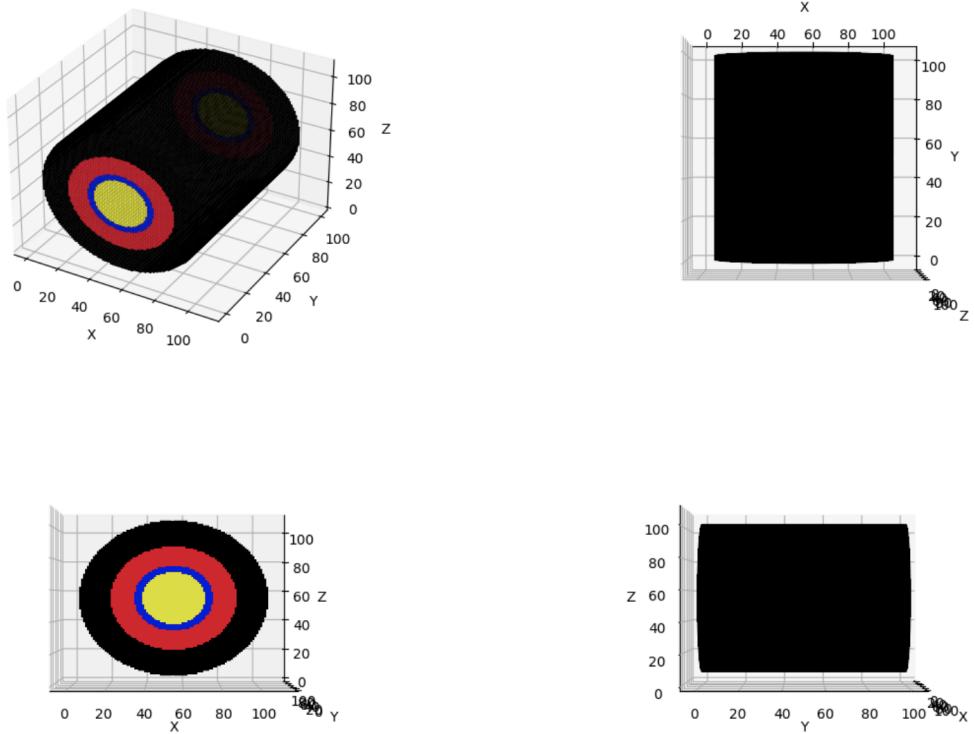
## 3D representation of png files

Once the matrix file has been created, the GUI will display the thumbnail of the original png image. However, the GUI will also begin to construct a graphical 3D representation of the part using the x and y dimensions of the png and the length dimension supplied on the 'Add parameters' page. This may take a few minutes depending on the size of the matrix file. When finished, the GUI will display the 3D version instead of the 2D png (as in the Figure above).

The thumbnail can be clicked on to open a new window showing a larger version of the 3D image and 2D views from each different axis:

## cable\_feodor\_coloured--001

[Close Window](#)



*Figure 12: 3D representation of the 2D png file*

NB. These images are created in sequence so there may be a small time lag between each displaying.

To create the image, the GUI uses the values for Magnetivity, Conductivity and Dielectric and assigns the same colour to each unique set, based on the colours used in the original png image.

NB. In the image above, some of the layers of the coaxial cable were assigned the same parameters so share the same colour.

**2D matrix file creation is now complete.**

## Using 3D CAD files

The MaxLLG GUI uses the power of the [FreeCAD](#) application to convert 3D CAD images into input\_files for use by the Solver.

License information for FreeCAD can be found [here](#).

### Create the 3D CAD image

To create the 3D image (also known as a 'part') in FreeCAD, or another CAD application. Any application can be used but the part must be exported as a .step file.

Also, if the part is made up of multiple sub-parts, then each part must be exported as a separate .step file.

The figure below shows a spherical part in FreeCAD with a radius of 50mm.

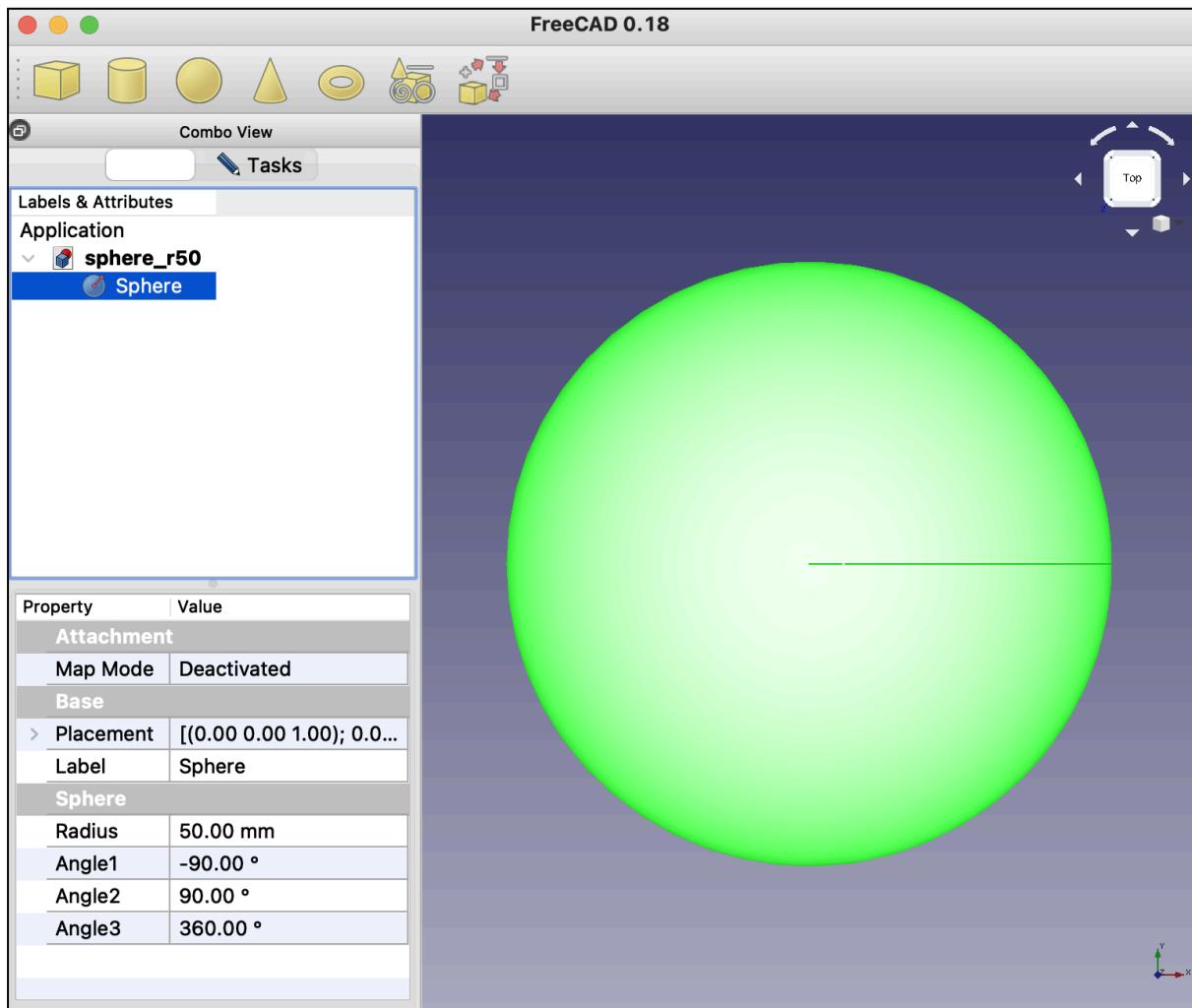


Figure 13: Creating a sphere in FreeCAD

This spherical part can be created in FreeCAD in the following way:

- I. In the 'View' menu, open the 'Workbench' section and choose the 'part' workbench
- II. Also in the 'View' menu, choose the 'Toolbars' section and open the 'Solids' toolbar.
- III. This will display the different shapes that can be easily created in FreeCAD (see the top left section of the Figure above).
- IV. Click on the sphere icon.
- V. Draw a sphere on the main canvas area of the FreeCAD app (where the sphere is in the Figure above).
- VI. Once drawn, many parameters for the part can be set by clicking of the word 'sphere' in the left-hand section and choosing 'Data' in the lower 'Property View' section. In particular, the radius for the sphere can be set here.
- VII. Once any parameters have been set, the part can be exported in the 'File > Export' menu:

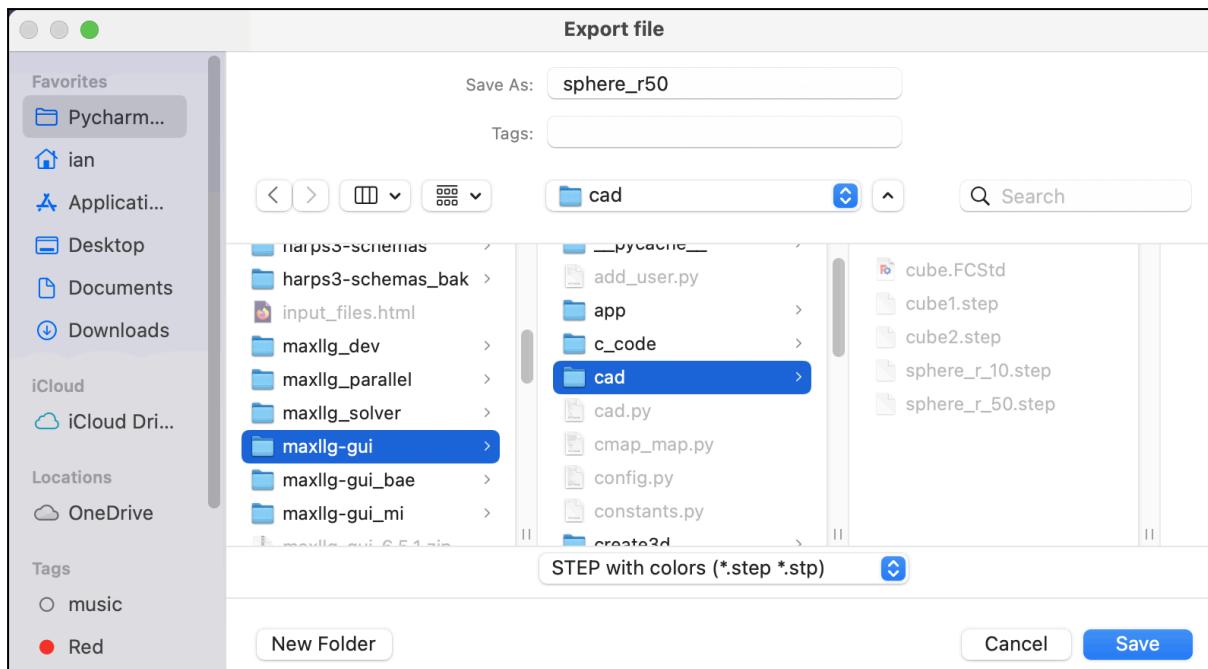


Figure 14: FreeCAD dialog box to save part as .step file

For a part made up of multiple sub parts (or different materials), select each part in turn in the left-hand menu and use the 'File > Export' option.

## The 3D CAD File

The GUI needs to know the location of the step files and the values for Magnetivity, Conductivity and Dielectric (as in the 2D process).

Once all parts have been exported, open the GUI and click on the '3D CAD Files' menu option:

## 3D CAD Files

Create and view data files for your 3D CAD images. Once created, click 'Create Matrix File' to build a matrix file for use with the solver.

### Create new CAD file

[Create New](#)

### List of CAD files

Show  entries

Search:

File name	File size (bytes)	Date created				
No data available in table						

Showing 0 to 0 of 0 entries

[Previous](#) [Next](#)

*Figure 15: The '3D CAD files' page showing the list of data files*

Create a new data file by clicking the 'Create new' button beneath the header.

The dialog box opens as below:

## Matrix File

Enter the name of the matrix file which will be created from the step files.

**Matrix file name:**

input\_sphere\_50r

NB. If editing the file name, changing the name will create a new CAD file

**Fast method?**

Tick this box if your CAD image has been split into separate step files.

This will make the matrix file generation run faster.

Untick this box if you have created a single step file containing multiple objects.  
This approach requires further calculations to create an accurate matrix file.

## Step Files and Constants

### Step File 1 Details

Enter the location of the first step file and the constants.

**Filename:**

**Clear**

Choose new: **Browse...** **sphere\_r\_50.step** **Clear**

**NB. File extension must be .step**

**Magnetisation:**

0.0

**Conductivity:**

5000000.0

**Dielectric:**

0.0

### Default Constants

These constants are for the area around the part(s).

E.g. trunking or just air.

**Magnetisation:**

**Conductivity:**

**Dielectric:**

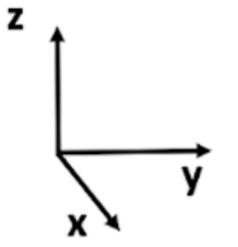
## Increase dimensions

Increase the size of the x, y and z dimensions of the CAD structure.

The dimensions will be increased each side.

E.g. Increasing the x dimension by 2 below, will add 2 to the start AND the end of the x dimension, increasing the total length by 4.

Use the following image as a guide:



**X dimension (horizontal):**

**Y dimension  
(length/depth):**

**Z dimension (vertical):**

Figure 16: The Create/edit 3D CAD file dialog box

Complete the required parameters:

### Matrix file name (shown above)

Choose a suitable name for your matrix file. This will also be the name of the output directory that the files created by the solver will be stored in.

### Fast method? (shown above):

Ticking this box (which is ticked by default) greatly increases the speed of the matrix file creation.

If a single object is being used (E.g. a sphere) or multiple objects that have been split into separate step files (E.g. three spheres saved as separate step files) then keep this box ticked.

If multiple step files are saved as a single step file then this needs further computation so untick this box.

### Step file 1 details (shown above):

#### Filename:

Click 'Browse' and navigate to your step file.

#### Magnetisation:

Enter the value of magnetisation of the object in Tesla (e.g. 0.1 will correspond to 0.1 Tesla or 1KG)

#### Conductivity

Value of the conductivity in [siemens/m] (e.g. ~1e7 for Iron).

*Dielectric:*

Relative dielectric constant (1 for vacuum). **NOTE** this should not be zero, unless the conductivity is high.

**Default constants (shown above):**

Constants for any section of the CAD image which does not have any material.

E.g. the area outside of the sphere. A default (vacuum) setting would be 0.0 0.0 1.0.

**Increase Dimensions (shown above):**

The size of the 3D structure can be increased along the x, y and z axis separately. Each dimension will be extended at both ends.

E.g. Entering 2 in the X axis box will increase the x dimension by 2 cells at each end, making a total extension of 4. When PML or PBC boundary conditions are used, this extension should at least be of the same or larger size.

**Step file 2/3/4/5 details (not shown above):**

For 3D parts with multiple sub parts. These boxes should be completed as the step file 1 boxes.

Once all of the parameters have been entered, click 'Save'

**Create the matrix file**

Your new data file will appear at the top of the list on the '3D Image Files' page.

List of CAD files				
File name		File size (bytes)	Date created	
input_sphere_50r	100	2023-01-30 11:52:10	<a href="#">Edit</a>	<a href="#">Create Matrix File</a>
Showing 1 to 1 of 1 entries				
			<a href="#">Previous</a>	<a href="#">1</a> <a href="#">Next</a>

*Figure 17: Showing the new file data has been created*

To create the matrix file, click the 'Make matrix file' link.

**Matrix file creation and progress**

The GUI will be redirected to the 'MatrixFiles' page where a message will inform you that the matrix file creation has begun:

# Matrix Files

- Input file creation started - refresh the screen to see updates in the list below.

Figure 18: Message on the Matrix Files' screen once an matrix file creation has begun

The new input\_file will begin to be created. The progress can be seen in the file list:

Matrix Files							
List of files created/uploaded							
Show 10 entries							
File name	Percent complete	File size	Object size	Date created	Join First	Join Last	
input_sphere_50r-001	19%			2023-01-30 12:26:28			<button>Stop</button>
 input_sphere_10r-001	100%	121.0 kB	x=20 y=20 z=20 8000 cells	2023-01-30 12:15:31	<input type="radio"/>	<input type="radio"/>	<button>Add Parameters</button> <button>Remove</button>
Showing 1 to 2 of 2 entries				Previous	1	Next	

Figure 19: The Matrix File list shows the progress of the new matrix file creation. Here it is currently at 19%

Creating a matrix file from a large step file (E.g. a grid size of 100x100x100 pixels will take several minutes. During this time it is possible to stop the process using the red 'Stop' button.

Once created, the completed matrix file will show at the top of the list:

List of files created/uploaded							
Show 10 entries							
File name	Percent complete	File size	Object size	Date created	Join First	Join Last	
Image being created <a href="#">Stop</a>	100%	15.1 MB	x=100 y=100 z=100 1000000 cells	2023-01-30 12:41:05	<input type="radio"/>	<input type="radio"/>	<button>Add Parameters</button> <button>Remove</button>
 input_sphere_10r-001	100%	121.0 kB	x=20 y=20 z=20 8000 cells	2023-01-30 12:15:31	<input type="radio"/>	<input type="radio"/>	<button>Add Parameters</button> <button>Remove</button>
Showing 1 to 2 of 2 entries				Previous	1	Next	

Figure 20: The completed matrix file is shown

Once the matrix file has been created, the GUI will build a 3D representation. For large files, this can take several minutes but can be stopped by clicking on the 'Stop' link.

Once the 3D representation has been built, it will display as a thumbnail next to the matrix file:

List of files created/uploaded								
File name	Percent complete	File size	Object size	Date created	Join First	Join Last		
 input_sphere_50r--001	100%	15.1 MB	x=100 y=100 z=100 1000000 cells	2023-01-30 12:41:05	<input type="radio"/>	<input type="radio"/>	<a href="#">Add Parameters</a>	<a href="#">Remove</a>
 input_sphere_10r--001	100%	121.0 kB	x=20 y=20 z=20 8000 cells	2023-01-30 12:15:31	<input type="radio"/>	<input type="radio"/>	<a href="#">Add Parameters</a>	<a href="#">Remove</a>
Showing 1 to 2 of 2 entries								
				Previous	1	Next		

Figure 21: The completed matrix file is shown, along with the 3D representation

Click on the thumbnail image to view the 3D representation of the matrix file:

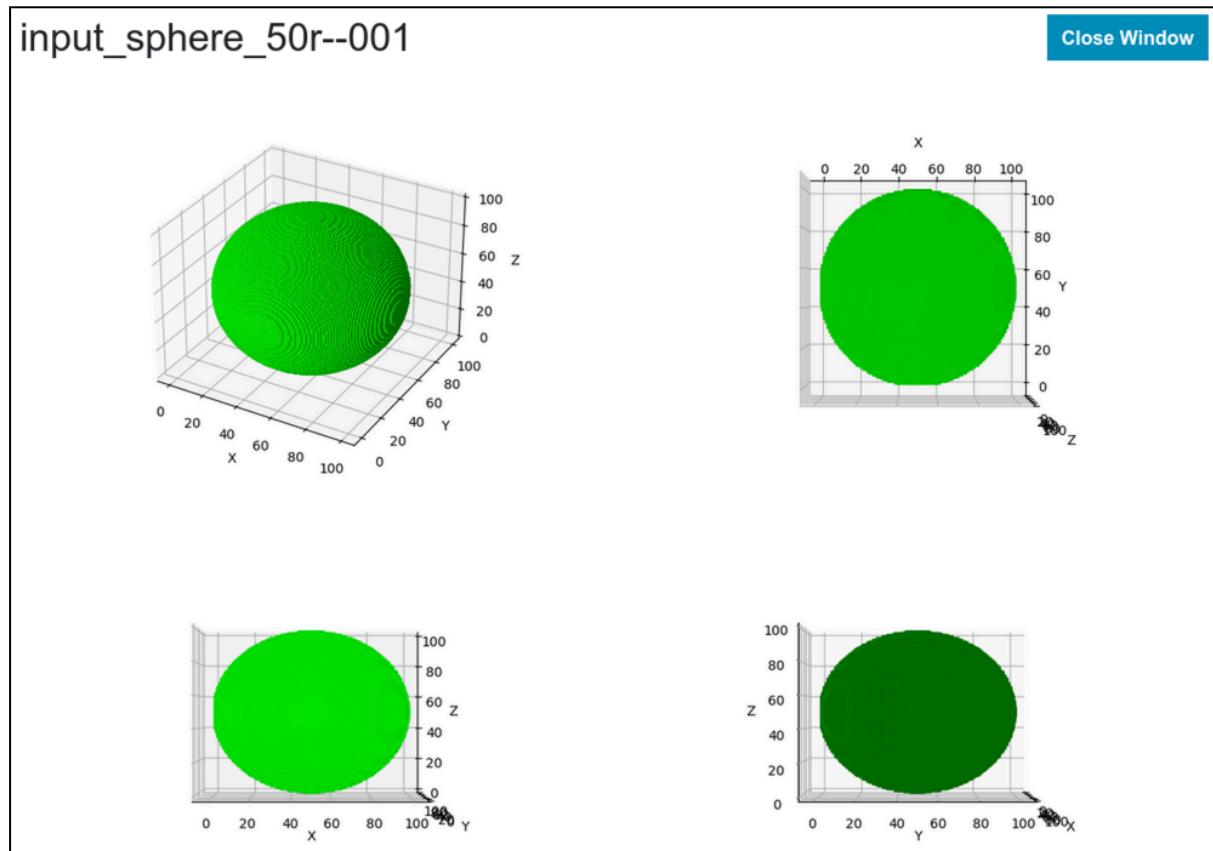


Figure 22: 3D representation of the .step file

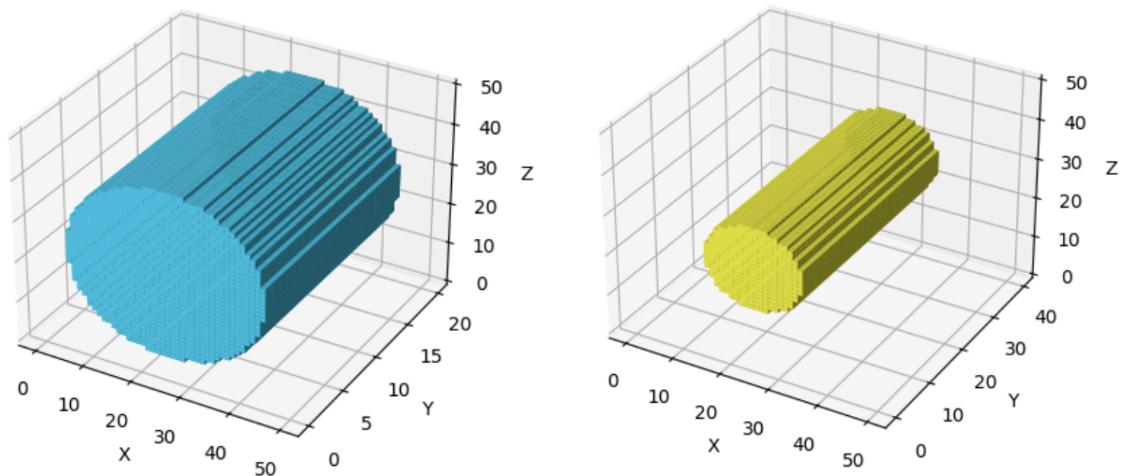
**3D Matrix file creation is now complete.**

## Joining matrix files

Any two matrix files can be joined to create a larger file, essentially increasing the size of the 3D part it is based upon. This is particularly useful when using 2D images as they can be joined together to create a non-linear 3D structure.

To join two matrix files, the files must have the same length x and z axis. For example, an image of 50x40x50 has the same x and z axis as a second image of size 50x20x50. The y axis can be any length as it represents the depth of the 3D image which is the axis that the two images are joined on.

E.g.:



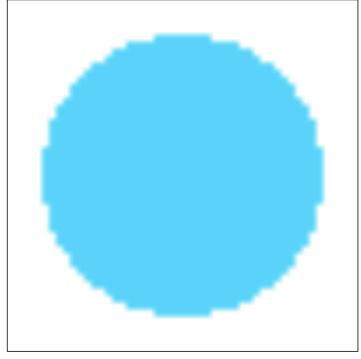
*Figure 23: 3D representations of two matrix files with the same length x and z axis that can be joined.*

NB. In each image, the area surrounding the part must have the same parameters.  
E.g. When creating the matrix files for the two parts above, the white area surrounding the actual part is given the same parameters in each:

## Enter Constants

Add values for each constant of the materials used in the object to create the matrix file.

Color	Magnetisation	Conductivity	Dielectric
<input checked="" type="checkbox"/> #00d8ff	0.0	20	1.0
<input type="checkbox"/> #ffffff	0.0	1.0	1.0
Length Dimension	20		
Matrix file name	join1.png		
<b>Create Matrix File</b>			



## Enter Constants

Add values for each constant of the materials used in the object to create the matrix file.

Color	Magnetisation	Conductivity	Dielectric
<input type="checkbox"/> #ffffff	0.0	1.0	1.0
<input checked="" type="checkbox"/> #fcfe01	0.0	3.0	1.0
Length Dimension	40		
Matrix file name	join2.png		
<b>Create Matrix File</b>			

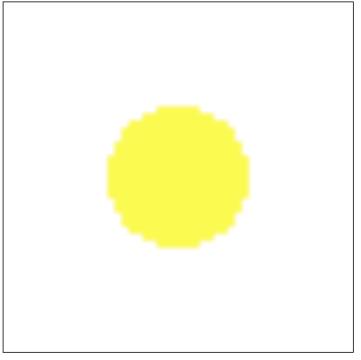


Figure 24: Set the same parameters for the white surround before joining

To join two images, select the ‘Join First’ and ‘Join Second’ radio buttons next to the desired images on the ‘Matrix Files’ page:

### List of files created/uploaded

Show 10 entries

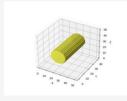
	File name	Percent complete	File size	Object size	Date created	Join First	Join Last
	join2--001	100%	1.3 MB	x=50 y=40 z=50 100000 cells	2023-01-30 12:47:35	<input checked="" type="radio"/>	<input type="radio"/>
	join1--001	100%	650.0 KB	x=50 y=20 z=50 50000 cells	2023-01-30 12:46:51	<input type="radio"/>	<input checked="" type="radio"/>

Figure 25: Selecting the matrix files to join using the ‘Join First’ and ‘Join Second’ radio buttons

Finally, click the 'Join Files' button at the bottom of the page:

NB. A name for the new file must be chosen.

## Join files

Join two files by choosing a file to go first and one to go last in the table above.

Then enter a name for the new file and click the 'Join' button below:

New filename:

*NB. Do not append the name with a number (such as '--002') as this will be done automatically.*

**Join**

Figure 26: The 'Join files' section

A new matrix file named 'joined—001' will be created (subsequent joined files will increment E.g. joined—002, joined—003, etc):

## List of files created/uploaded

Show  entries

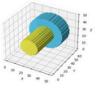
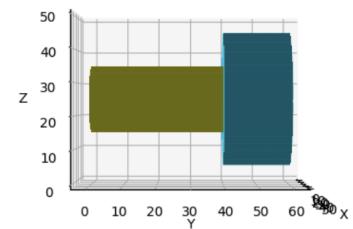
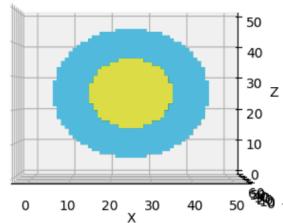
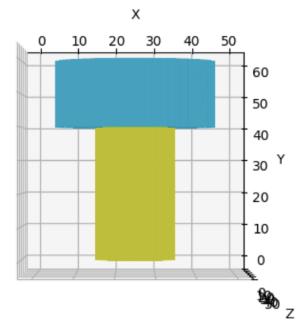
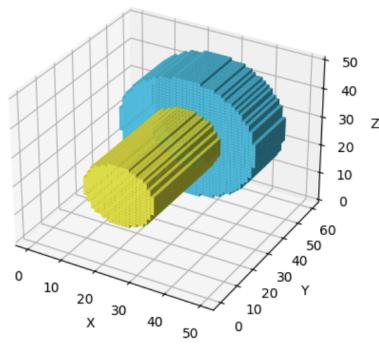
File name	Percent complete	File size	Object size	Date created
 joined--001	100%	1.9 MB	x=50 y=60 z=50 150000 cells	2023-01-30 12:57:25

Figure 27: The new joined object on the 'Matrix Files' page

## joined--001

[Close Window](#)



*Figure 28: A 3D representation of the new joined object*

As with other 3D representations, this image may take a few seconds/minutes to build. It will appear on the matrix files page when finished (the page will need to be refreshed).

## Setting the metascript parameters

The Solver also requires a number of extra parameters in order to run. These parameters are stored in a file (also referred to as the 'metascript' file) and passed to the Solver with the matrix file.

The GUI is packaged with the metascript parameters already set to default values. However, they can be changed on the 'Parameters' page:

# Parameters

## For file: cable\_feodor\_coloured--001

### Upload Parameters File

This will overwrite any current parameters file for this image.

[Browse...](#)
No file selected.
[Upload](#)

**NB. Allowed file extensions are .txt or no extension**

Parameters variables are split into different groups.

Please remember to **click the 'Update Parameters' button** at the bottom of the screen once you have finished editing.

Input	Constants	Output	Boundary Conditions	Magnetic Parameters	Statistical Distributions
<b>Signal:</b>	Uniform <input checked="" type="radio"/>				
	Radial <input type="radio"/>				
<b>Source:</b>	Soft <input checked="" type="radio"/>				
	Hard <input type="radio"/>				
	Voltage <input checked="" type="radio"/>				
	Field <input type="radio"/>				
	Load <input type="radio"/>	1			
	Amplitude <input type="radio"/>	1			
<b>Uniform:</b>	E <input checked="" type="radio"/>	Ex 0 Ey 0 Ez 1	x <sub>1</sub> 46 y <sub>1</sub> 50 z <sub>1</sub> 81	x <sub>2</sub> 54 y <sub>2</sub> 50 z <sub>2</sub> 85	
	H <input type="radio"/>				
	H <sub>p</sub> <input type="radio"/>				
<a href="#">View signal position</a>					

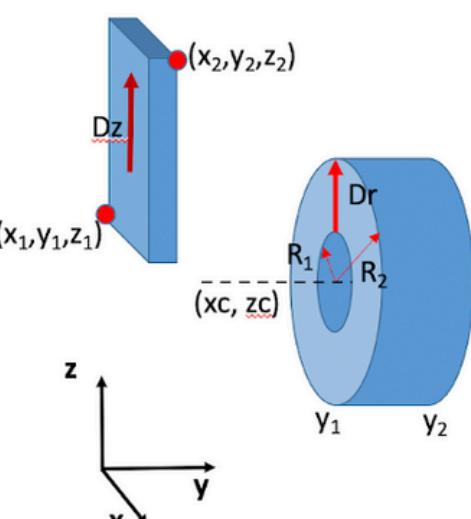


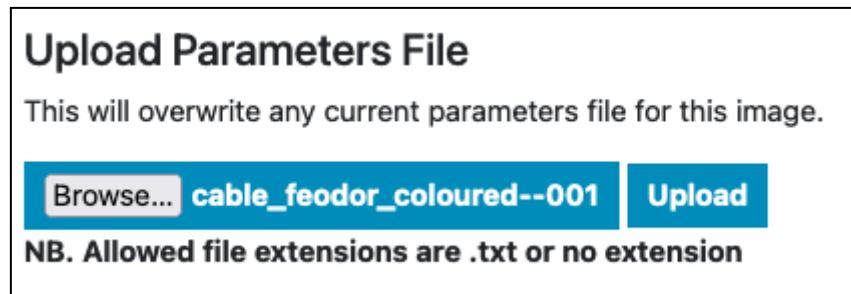
Figure 29: The ‘Parameters’ page showing the ‘Uniform Signal’ section.

NB. The parameters file must be created for a matrix file before the solver is run. The 'Solve' link on the matrix files page will only be displayed once the parameters file has been created for the matrix file.

Each matrix file has its own parameters file.

## Uploading a parameters file

A pre-existing parameters file, perhaps that has been created before for another matrix file, can be uploaded using the section at the top of the page:



*Figure 30: Uploading a parameters file*

The parameters page is split into several separate tabs:

- Input
- Constants
- Output
- Boundary Conditions
- Magnetic Parameters
- Statistical Distributions

### **IMPORTANT!**

**The variables in the final ‘Statistical Distributions’ pane are not currently used by the solver.**

However, they are described below to be made ready for implementation in a later versions.

## Input

The input page is dynamic and offers different options based on the signal selection and signal shape selection. The image on the right of the page gives some guidance to these parameters.

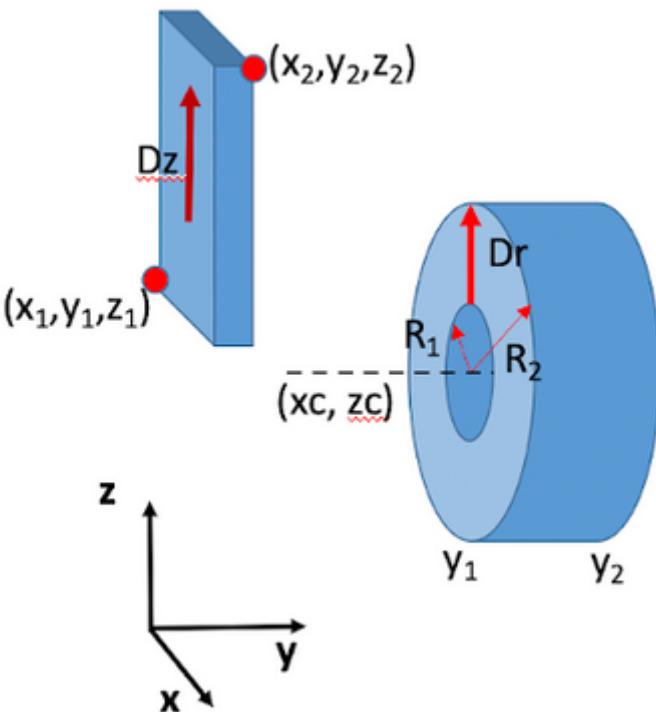


Figure 31: The Input pane: Visual explanation of the Uniform and Radial Signal

They are also detailed below, including their effect on the Solver:

## Signal

Signal input can be chosen as either a uniform or radial (as shown in the Figure above).

<b>Signal:</b>	<b>Uniform</b> <input checked="" type="radio"/>	<b>Radial</b> <input type="radio"/>		
<b>Source:</b>	Soft <input checked="" type="radio"/>	Hard <input type="radio"/>		
	Voltage <input checked="" type="radio"/>	Field <input type="radio"/>		
	Load <input type="text" value="1"/>			
	Amplitude <input type="text" value="1"/>			
<b>Uniform:</b>	<b>E</b> <input checked="" type="radio"/>	Ex <input type="text" value="0"/>	<b>x<sub>1</sub></b> <input type="text" value="46"/>	<b>x<sub>2</sub></b> <input type="text" value="54"/>
	<b>H</b> <input type="radio"/>	Ey <input type="text" value="0"/>	<b>y<sub>1</sub></b> <input type="text" value="10"/>	<b>y<sub>2</sub></b> <input type="text" value="10"/>
	<b>H<sub>p</sub></b> <input type="radio"/>	Ez <input type="text" value="1"/>	<b>z<sub>1</sub></b> <input type="text" value="81"/>	<b>z<sub>2</sub></b> <input type="text" value="85"/>
<b>View signal position</b>				

Figure 32: The Input pane: Uniform section

### Uniform

Uniform signal with the same values of the chosen field (E,H or Hp) across the cuboid defined between the diagonal coordinates (x<sub>1</sub>,y<sub>1</sub>,z<sub>1</sub> and x<sub>2</sub>,y<sub>2</sub>,z<sub>2</sub>).

### Soft/Hard

Hard source imposes the signal by overwriting the present number with that in the signal. Soft source adds the value in the source to that currently present in the cell. NOTE! If hard source is chosen, the source cells will be hard reflectors for any waves propagating towards the source.

### Voltage/Field

Choose Field for sourcing the fields (E,H,Hp) within the source volume. The units are respectively, V/m and A/m. The Voltage selection implies the use of electric field, but with a particular difference of potentials. This option is normally used for transmission lines or antennas, where voltage is supplied to metallic conductors.

### Load

Is used with the Voltage source, providing the resistance of the internal voltage source (e.g. 50 Ohm).

### Amplitude

Numerical value of the sourcing field (or voltage). The units will be used according to the chosen field.

### E, H & Hp (radio buttons)

Choice of the fields

### Ex, Ey & Ez

Directional cosines of the field E (e.g. Ex=cos(θ), where θ is the angle between the vector E and x-axis. The magnitude of the vector is defined by the value in the **Amplitude**.  $Ex^2 + Ey^2 + Ez^2 = 1$  )

### Hx, Hy & Hz

Directional cosines of the field H

### Hpx, Hpy & Hpz

Directional cosines of the field Hp

### View Signal Position button

To view the positioning of the signal set by the x, y and z parameters, click this button:

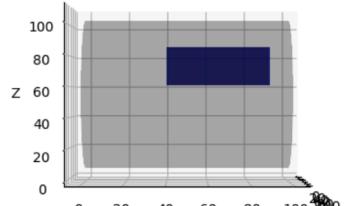
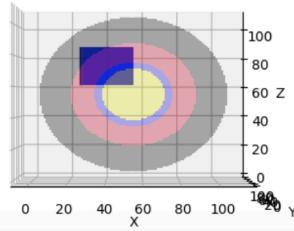
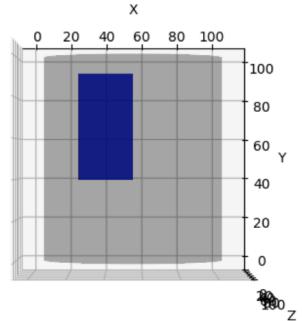
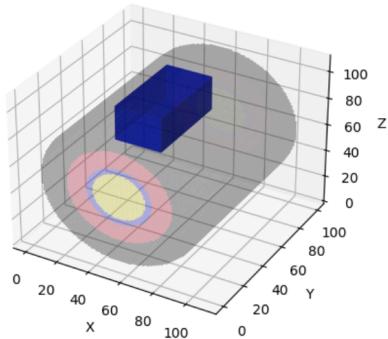
# Metascript Signal

[Close Window](#)

cable\_feodor\_coloured--001

Move the slider below to switch view between the object and the signal:

Object  Signal



*Figure 33: The positioning of the Uniform signal*

The slider changes the opacity of each image so it is possible to see more clearly the position of the signal against the object.

<b>Signal:</b>	<b>Uniform</b> <input checked="" type="radio"/>	<b>Radial</b> <input type="radio"/>
<b>Source:</b>	Soft <input checked="" type="radio"/>	Hard <input type="radio"/>
	Voltage <input checked="" type="radio"/>	Field <input type="radio"/>
Load	1 <input style="width: 20px" type="button" value="^"/> <input style="width: 20px" type="button" value="v"/>	
Amplitude	1 <input style="width: 20px" type="button" value="^"/> <input style="width: 20px" type="button" value="v"/>	
<b>Radial:</b>	Centre (xc, zc) <input type="text" value="50"/> <input style="width: 20px" type="button" value="^"/> <input style="width: 20px" type="button" value="v"/> <input type="text" value="50"/> <input style="width: 20px" type="button" value="^"/> <input style="width: 20px" type="button" value="v"/>	
	R <sub>1</sub> <input type="text" value="16"/> <input style="width: 20px" type="button" value="^"/> <input style="width: 20px" type="button" value="v"/>	y <sub>1</sub> <input type="text" value="10"/> <input style="width: 20px" type="button" value="^"/> <input style="width: 20px" type="button" value="v"/>
	R <sub>2</sub> <input type="text" value="40"/> <input style="width: 20px" type="button" value="^"/> <input style="width: 20px" type="button" value="v"/>	y <sub>2</sub> <input type="text" value="12"/> <input style="width: 20px" type="button" value="^"/> <input style="width: 20px" type="button" value="v"/>
<b>View signal position</b>		

Figure 34: The Input pane: Radial section

### Radial

Input signal for a radial input pulse.

NB. The Radial input also contains several fields visible in the 'Uniform' section.

#### Dr

Amplitude of radial pulse.

#### Centre (xc, zc)

Central position for radial pulse in xz plane.

#### R<sub>1</sub>

Value of inner pulse radius.

#### y<sub>1</sub>

Pulse position range along the y direction beginning with y1.

#### R<sub>2</sub>

Value of outer pulse radius.

#### y<sub>2</sub>

Pulse position range along the y direction ending with y2.

#### View Signal Position button

To view the positioning of the signal set by the x, y and z parameters, click this button:

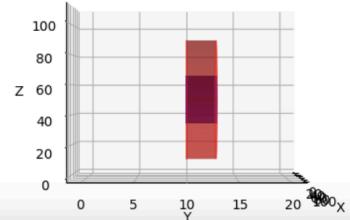
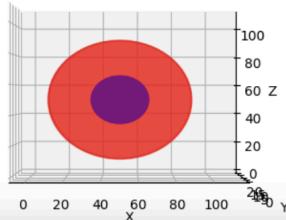
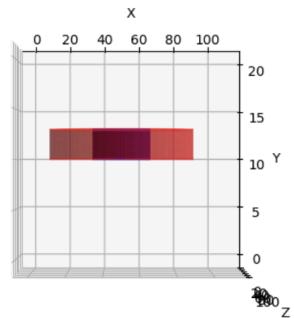
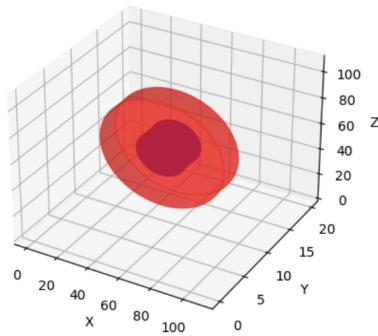
## Metascript Signal - Radial

[Close Window](#)

cable\_feodor\_coloured--004

Move the slider below to switch view between the object and the signal:

Object  Signal



*Figure 35: The positioning of the Radial signal*

### Signal Shape:

Signal shape can be either Pulsed or Continuous

#### Pulsed

Select dropdown menu for pulse excitation.

Choose between a Gaussian “Top Hat” and Sinc for the pulse excitation.

#### Gaussian

Selects Gaussian function as input pulse.

<b>Signal shape:</b>	<b>Pulsed</b> <input checked="" type="radio"/>	<b>Continuous</b> <input type="radio"/>
<b>Parameters:</b>	Gaussian	<input checked="" type="radio"/>
	Top Hat	<input type="radio"/>
	Sinc	<input type="radio"/>
Spread	100 <input style="width: 20px; height: 20px; border: 1px solid black; margin-left: 10px;" type="button" value="^"/> 0.0000183333 seconds	
Delay	500 <input style="width: 20px; height: 20px; border: 1px solid black; margin-left: 10px;" type="button" value="^"/> 0.0000916667 seconds	

Figure 36: Pulsed Gaussian parameters

### Spread

Spread of Gaussian function. Shows conversion to seconds.

### Delay

Delay of Gaussian function. Shows conversion to seconds.

### Top Hat

Selects “Top Hat” function as input pulse.

<b>Signal shape:</b>	<b>Pulsed</b> <input checked="" type="radio"/>	<b>Continuous</b> <input type="radio"/>
<b>Parameters:</b>	Gaussian	<input type="radio"/>
	Top Hat	<input checked="" type="radio"/>
	Sinc	<input type="radio"/>
Pulse Length (steps)	2000 <input style="width: 20px; height: 20px; border: 1px solid black; margin-left: 10px;" type="button" value="^"/>	
Delay	500 <input style="width: 20px; height: 20px; border: 1px solid black; margin-left: 10px;" type="button" value="^"/>	
Fall	100 <input style="width: 20px; height: 20px; border: 1px solid black; margin-left: 10px;" type="button" value="^"/>	
Rise	100 <input style="width: 20px; height: 20px; border: 1px solid black; margin-left: 10px;" type="button" value="^"/>	
Number of pulses	1 <input style="width: 20px; height: 20px; border: 1px solid black; margin-left: 10px;" type="button" value="^"/>	

Figure 37: Pulsed “Top Hat” parameters

### Pulse length (steps)

Number of steps that pulse excitation remains active.

### Delay

Sets the delay before the start of the pulse

### Fall

Number of steps in pulse fall.

### Rise

Number of steps in pulse rise.

### Number of pulses

Number of pulses that are applied in the simulation.

### Sinc

Selects Sinc function as input pulse.

<b>Signal shape:</b>	<b>Pulsed</b> <input checked="" type="radio"/>
	<b>Continuous</b> <input type="radio"/>
<b>Parameters:</b>	Pulsed Gaussian <input type="radio"/>
	Pulsed Top Hat <input type="radio"/>
	Pulsed Sinc <input checked="" type="radio"/>
Base frequency (Hz)	<input type="text"/>
Delay (steps)	<input type="text"/>
Width $\Delta W$ (Hz)	<input type="text"/>
Wave num. K (1/px)	<input type="text"/>
$\Delta K$ (1/px)	<input type="text"/>

Figure 38: Pulsed Sinc parameters

#### Base frequency (Hz)

The centre frequency within the gaussian envelope.

#### Delay (steps)

Delay in time steps before the pulse starts.

#### Width $\Delta W$ (Hz)

The width of the gaussian envelope (in frequency).

#### Wave num. K (1/px)

The central wave number. Dimension is in  $2\pi/\lambda$  where lambda is in pixels.

#### $\Delta K$ (1/px)

The width of the wave number region. The width is defined around the centre wave number.

### Continuous Signal shape

Continuous excitation with a single frequency.

#### Frequency

Choose frequency for continuous excitation.

<b>Signal shape:</b>	Pulsed	<input type="radio"/>
	Continuous	<input checked="" type="radio"/>
Continuous Parameters:	Frequency	10000000000 <input type="button" value="▼"/>

Figure 39: Continuous signal shape parameters

## Initial Fields

Parameters can be loaded from previous output. Select 'Load from file' and choose the output directory and Frame number.

<b>Initial Fields:</b>	Zero	<input type="radio"/>
	Load from file	<input checked="" type="radio"/>
File parameters:	Directory	Please Choose <input type="button" value="▼"/>
	Frame number	Please Choose <input type="button" value="▼"/>

Figure 40: The 'Input' section showing the 'Radial Signal' and 'Continuous Signal Shape' sections

## Constants

The options in the constants section are static:

Input	Constants	Output	Boundary Conditions	Magnetic Parameters	Statistical Distributions												
<b>Constants:</b> <table border="1"> <tr> <td>Time Steps:</td> <td>10000 <input type="button" value="▼"/></td> <td>0.0018333333 seconds</td> </tr> <tr> <td>Cell Size z (m):</td> <td>0.00025 <input type="button" value="▼"/></td> <td>Full grid size on z axis = 0.0275 m</td> </tr> <tr> <td>Cell Size x (m):</td> <td>0.00025 <input type="button" value="▼"/></td> <td>Full grid size on x axis = 0.0275 m</td> </tr> <tr> <td>Cell Size y (m):</td> <td>0.0005 <input type="button" value="▼"/></td> <td>Full grid size on y axis = 0.01 m</td> </tr> </table>						Time Steps:	10000 <input type="button" value="▼"/>	0.0018333333 seconds	Cell Size z (m):	0.00025 <input type="button" value="▼"/>	Full grid size on z axis = 0.0275 m	Cell Size x (m):	0.00025 <input type="button" value="▼"/>	Full grid size on x axis = 0.0275 m	Cell Size y (m):	0.0005 <input type="button" value="▼"/>	Full grid size on y axis = 0.01 m
Time Steps:	10000 <input type="button" value="▼"/>	0.0018333333 seconds															
Cell Size z (m):	0.00025 <input type="button" value="▼"/>	Full grid size on z axis = 0.0275 m															
Cell Size x (m):	0.00025 <input type="button" value="▼"/>	Full grid size on x axis = 0.0275 m															
Cell Size y (m):	0.0005 <input type="button" value="▼"/>	Full grid size on y axis = 0.01 m															

Figure 41: The 'Constants' pane

### Time\_steps

Total number of timesteps for the simulation. The conversion to seconds is displayed.

### Cell sizes

Cell size of simulation in metres. Once entered, the actual grid size for each axis is calculated and displayed.

## Output

Input	Constants	Output	Boundary Conditions	Magnetic Parameters	Statistical Distributions
<b>Output:</b>					
<b>Output Fields</b>		<input checked="" type="checkbox"/> Mx <input type="checkbox"/> My <input type="checkbox"/> Mz	<input type="checkbox"/> Ex <input checked="" type="checkbox"/> Ey <input type="checkbox"/> Ez	<input type="checkbox"/> Hx <input type="checkbox"/> Hy <input checked="" type="checkbox"/> Hz	
<b>2D planes</b>		<input checked="" type="checkbox"/> yz <input checked="" type="checkbox"/> xz <input checked="" type="checkbox"/> xy	at pixel:	x <input type="text" value="50"/> y <input type="text" value="50"/> z <input type="text" value="83"/>	
<b>Every Nth frame:</b>		<input type="text" value="100"/>			
<b>Single detectors</b>		On/Off <input type="checkbox"/>			
<b>Output Fields</b>		<input checked="" type="radio"/> E <input type="radio"/> H <input type="radio"/> M			
Port 1		<input type="checkbox"/>	at pixel:	x <input type="text"/> y <input type="text"/> z <input type="text"/>	
Port 2		<input type="checkbox"/>		x <input type="text"/> y <input type="text"/> z <input type="text"/>	
<b>Save final fields</b>		On/Off <input type="checkbox"/>			

Figure 42: The 'Output' pane

The options in the Output section are also static:

### Output Fields

Select which data fields to output using the interface.

### 2D planes xy, yz & xz

Output plane for vector data.

### At pixel x, y & z

Pixel position for each output plane.

### Every Nth frame

Output data at every Nth timesteps

### Save final fields

Select whether to output the electromagnetic fields and magnetisation at the final state of the simulation.

### **Single Detectors**

The single detector feature can be used to record the electric field at two selected positions in the 3D simulation space.

#### **On/Off**

Choosing 'On' will save files aTime1.dat and aTime2.dat recording the specified fields at the position of the two ports.

#### **Output Fields - E, H & M**

Two positions can be selected using each port to record transmission and reflection data.

#### **Port 1 & 2**

Two positions can be selected using each port to record transmission and reflection data.

#### **at pixel**

Choose the specific grid location using the x, y and z pixels.

### **Save final fields**

Description required

## **Boundary Conditions**

The solver contains several different options for boundary conditions, including perfectly matched layer (PML), perfect electric conductor (PEC) and periodic boundary conditions (PBC).

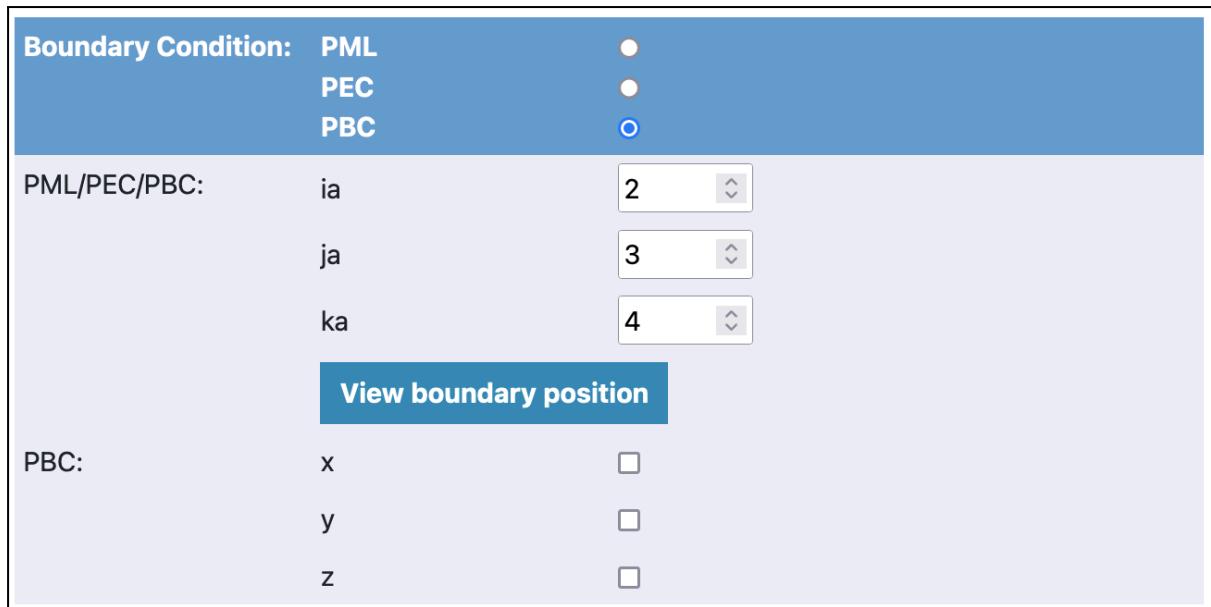


Figure 43: The ‘Boundary Conditions’ pane showing PBC options

### Specifying boundary conditions

Each boundary condition can be selected by choosing one of the “PML”, “PEC” or “PBC” options in the dropdown menu. The planes terminating the simulation space are assigned , and directions which can be enabled or disabled by ticking the neighbouring option box (see Fig. 31).

### Controlling depth of PML layer

Electromagnetic wave absorption at the ends of the simulation space can be controlled by increasing or decreasing the number of cells in the PML layer. Increasing the number of PML cells will generally improve the degree of electromagnetic wave absorption at the cost of a longer computation time, due to the increased number of simulation cells. The number of cells in the PML layer can be chosen using the dropdown options “ia”, “ja” and “ka” in the PML panel, which are integers corresponding to the x, y and z-axes, respectively. The PEC and PBC boundary conditions are also defined to begin at the points “ia”, “ja” and “ka” and can be controlled using the same PML parameters.

### View Boundary Position button

To view the positioning of the signal set by the x, y and z parameters, click this button:

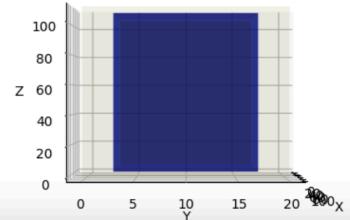
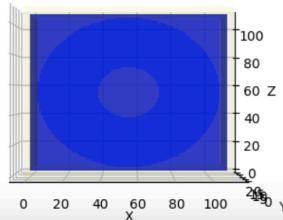
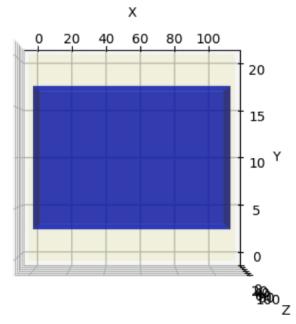
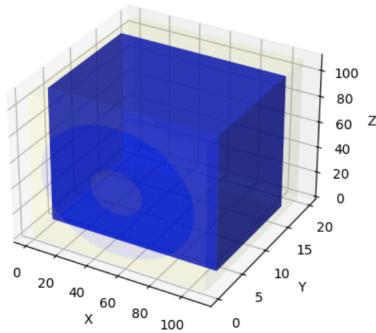
## Metascript Boundary

[Close Window](#)

cable\_feodor\_coloured--004

Move the slider below to switch view between the object and the boundary:

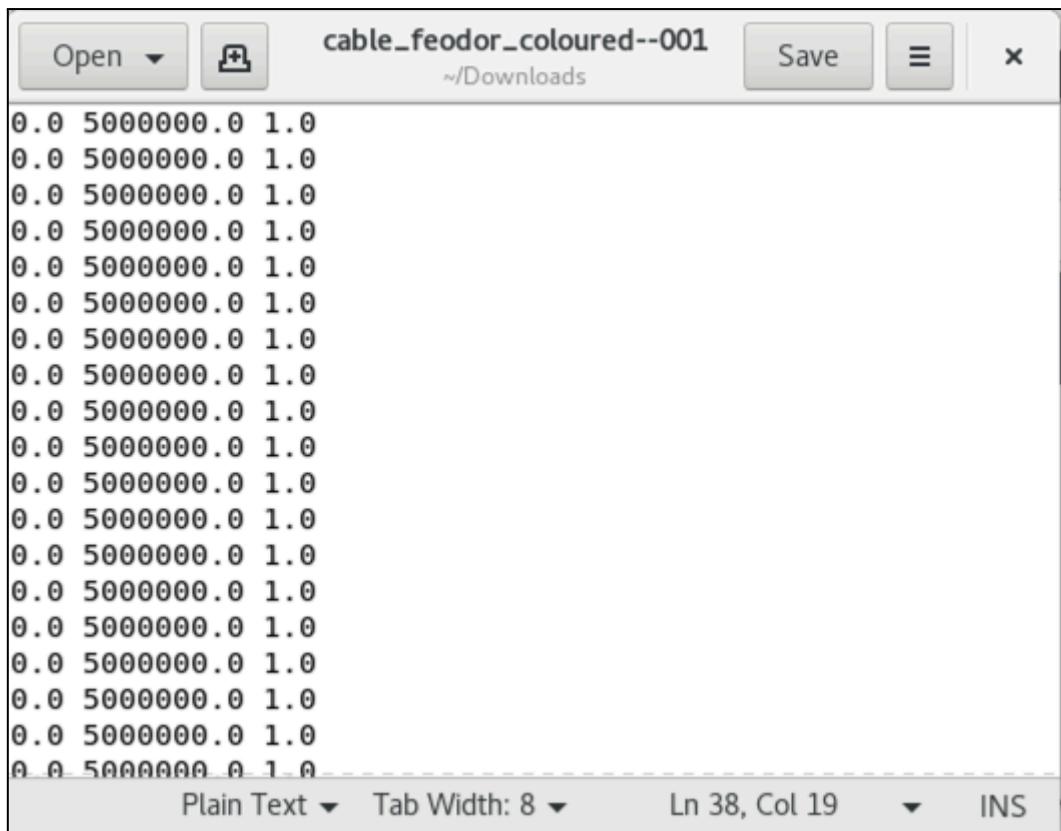
Object  Boundary



*Figure 44: Displaying the Boundary position*

### Manual input of material parameters

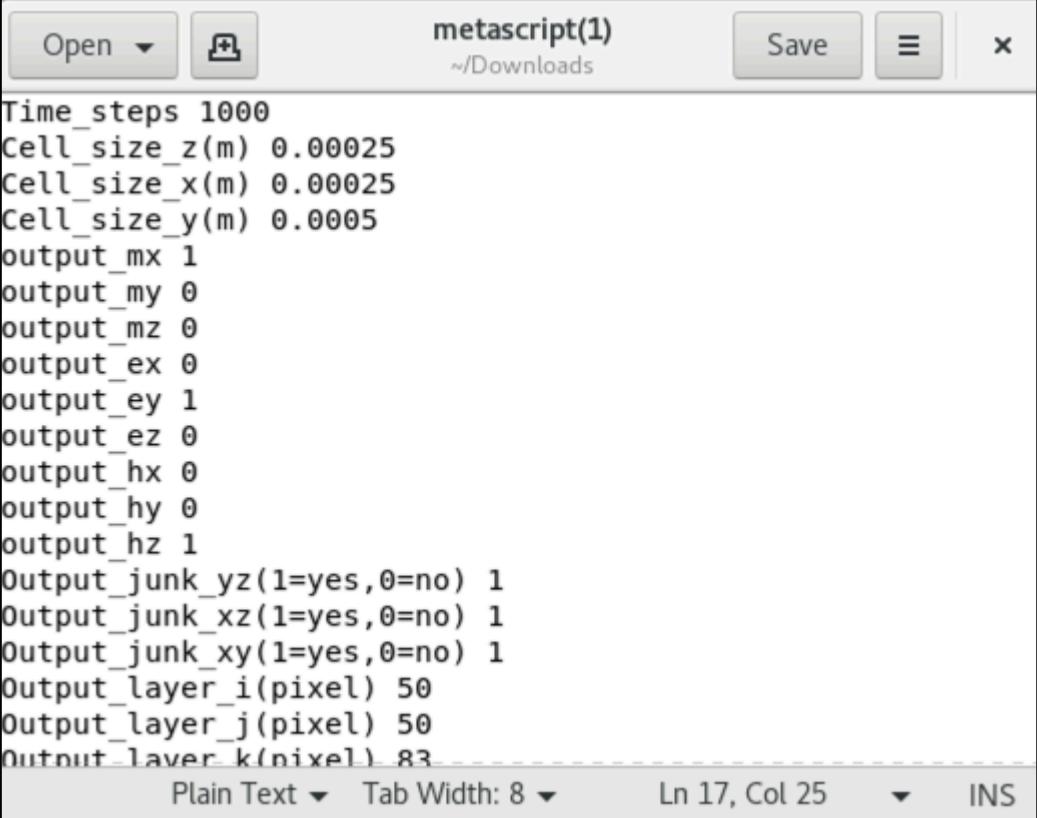
As an alternative to GUI input, material properties can be imported manually using text file formats found in the “metascript” and “matrix file” folders.



```
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
0.0 5000000.0 1.0
```

Figure 45: 'material\_input' file

In the above text file example, each row represents one cell in the grid which are populated sequentially according to a triple "for" loop. In this loop process, the x-axis represents the outer loop, and the z-axis represents the inner loop, with the y-axis in the middle. The value of conductivity, magnetisation and dielectric constant correspond to the first, second and third columns, respectively. The total number of rows equals the total number of cells in the simulation grid.



The screenshot shows a text editor window with the following interface elements:

- Top bar: "Open" with a dropdown arrow, a file icon, "metascript(1)" (highlighted in blue), " ~/Downloads", "Save", a menu icon, and a close button "x".
- Text area: A configuration file with the following content:

```
Time_steps 1000
Cell_size_z(m) 0.00025
Cell_size_x(m) 0.00025
Cell_size_y(m) 0.0005
output_mx 1
output_my 0
output_mz 0
output_ex 0
output_ey 1
output_ez 0
output_hx 0
output_hy 0
output_hz 1
Output_junk_yz(1=yes,0=no) 1
Output_junk_xz(1=yes,0=no) 1
Output_junk_xy(1=yes,0=no) 1
Output_layer_i(pixel) 50
Output_layer_j(pixel) 50
Output_layer_k(pixel) 83
```
- Bottom bar: "Plain Text" dropdown, "Tab Width: 8" dropdown, "Ln 17, Col 25" text, a dropdown arrow, and "INS" button.

Figure 46: 'metascript' file

In the metascript folder, user-defined simulation parameters can be controlled by modifying the output text file following the creation of a metascript. Each row corresponds to a different physical parameter which can be controlled by varying its associated numerical value.

## Magnetic Parameters

**Magnetic Parameters:**

**Applied Field:**  $\mu_0 H$  (T) 0.04 x  y  z

**Magnetisation:** On/Off

**Saturated State:** On/Off

**Magnetisation Components:** mx  my  mz

**Anisotropy Constant:**  $\mu_0 H_k$  (T) 0 x  y  z

**Damping Constant:**  $\alpha$  0.001

**Exchange:** On/Off

**Mboost:** Mb 0

Figure 47: The 'Magnetic Parameters' pane

The options in the Magnetic Parameters section are static:

### Applied Field $\mu_0 H$ (T)

Absolute value of the applied magnetic field in Tesla.

### Applied Field x, y & z

Directional cosines describing the orientation of the applied field.

### Magnetisation (A/m)

Controls whether to enable or disable the magnetisation.

### Saturated State

Control parameter to begin the simulation from an ideally saturated state or relaxed magnetic state.

### Saturation Magnetisation $\mu_0 M_s$ (T)

Absolute value of the saturation magnetisation in Tesla.

### **Magnetisation x, y & z**

Directional cosines describing the orientation of the magnetisation vector.

### **Anisotropy constant $\mu_0 M_s$ (J/m<sup>3</sup>)**

Absolute value of the uniaxial anisotropy with second ( $K_1$ ) order terms. In the easy axis case ( $K_1 > 0$ ) the energy density  $E$  is computed by

$$E = K_1 |\mathbf{u} \times \mathbf{m}|^2,$$

where  $\mathbf{m}$  is the reduced (unit) magnetization and  $\mathbf{u}$  is the easy axis. Here the energy is zero if the magnetization is aligned with the easy axis. In the hard axis case ( $K_1 < 0$ ) the energy is offset so that the zero point occurs when the magnetization lies in the easy plane (i.e., orthogonal to the hard axis). In this case the energy density is given by

$$E = -K_1 (\mathbf{u} \cdot \mathbf{m})^2.$$

### **Applied Field x, y & z**

Absolute value of the applied magnetic field in Tesla.

### **Damping Constant a**

Value for the damping parameter of the Landau-Lifshitz-Gilbert equation.

### **Exchange**

Control parameter to enable or disable the exchange energy.

### **Exchange constant $A_{ij}$ (J/m)**

Absolute value of the exchange constant for a standard 6-neighbor exchange energy with an exchange energy density contribution from cell  $i$  given by

$$E_i = \sum_{j \in N_i} A_{ij} \frac{\mathbf{m}_i \cdot (\mathbf{m}_i - \mathbf{m}_j)}{\Delta_{ij}^2}$$

where  $N_i$  is the set consisting of the 6 cells nearest to cell  $i$ ,  $A_{ij}$  is the exchange coefficient between cells  $i$  and  $j$  in J/m, and  $\Delta_{ij}$  is the discretization step size between cell  $i$  and cell  $j$  in meters.

### **Mboost**

Multiples the time step used by the Landau-Lifshitz-Gilbert equation by the constant value Mboost.

## **Statistical Distributions**

(Not currently available in the current version of the Solver)

Input	Constants	Output	Boundary Conditions	Magnetic Parameters	Statistical Distributions
<b>Statistical Distributions:</b> <b>Volume Fraction:</b> <input type="text"/> <b>Offset along y-axis:</b> <input type="text"/> <b>Radius:</b> <input type="text"/> <b>Conductivity:</b> <input type="text"/> <b>Dielectric constant:</b> <input type="text"/> <b>Grid size:</b> <input type="text"/> <input type="text"/> <input type="text"/> <b>Geometry:</b> <input type="checkbox"/> Sphere <input type="checkbox"/> Use matrix file <b>Distribution:</b> On/Off <input type="checkbox"/> <b>Uniform:</b> <input type="checkbox"/> upper limit: <input type="text"/> lower limit <input type="text"/> <b>Gaussian:</b> <input type="checkbox"/> standard deviation <input type="text"/> mean <input type="text"/>					

Figure 48: The 'Statistical Distributions' pane

### Volume Fraction

Percentage of volume occupied by spherical inclusions.

### Offset along y-axis

Description required

### Radius

Description required

### Dielectric constant

Description required

### Grid size

Description required

### Geometry – 'Sphere' or 'Use matrix file'

Populate the grid analytically with spherical particles or use standard matrix files.

### Distribution – 'On' or 'Off'

Turn on or off the statistical randomization of chosen input particle.

### Uniform

Statistically distribute material/geometric properties using a uniform probability density.

Uniform upper limit, lower limit & standard deviation

Upper and lower bounds on the uniform variation of material/geometric properties. For example, a range of 0.8 (lower) to 1.2 (upper) uniformly distributes properties between 80% and 120% of initial input.

### **Gaussian**

Statistically distribute material/geometric properties using a Gaussian probability density.

#### **Gaussian standard deviation & mean**

User inputs for standard deviation and mean.

### **Exponentially Modified Gaussian**

Statistically distribute material/geometric properties using an exponentially modified Gaussian probability density.

#### **Exponentially Modified Gaussian standard deviation, mean & exponential mean**

User inputs for standard deviation, Gaussian mean and exponential mean.

## Saving the Metascript File

When finished, click the ‘Update Parameters’ button at the bottom of the page to store the changes to the meta script parameters. This can be done from any pane.

There is also a link to ignore any updates and reload the original data.

**Update Parameters** or [click here to reload the original data in the form](#)

*Figure 49: The ‘Matrix Files’ page showing the ‘Solve’ link*

# Running the Solver and analysing the results

To run the Solver, simply click the ‘Solve’ button next to the desired matrix file on the Matrix Files’ page:

List of files created/uploaded								
Show 10 entries		Search: <input type="text"/>						
File name	Percent complete	File size	Object size	Date created	Join First	Join Last		
 cable_feodor_coloured--001	100%	15.7 MB	x=110 y=100 z=110 1210000 cells	2022-02-18 12:41:14	<input type="radio"/>	<input type="radio"/>	<a href="#">Edit Parameters</a>	<a href="#">Solve</a>
Showing 1 to 1 of 1 entries								

Figure 50: The ‘Matrix Files’ page showing the ‘Solve’ link

The browser will redirect to the ‘Output’ tab, in a new directory solely for the output of this run. The progress will update automatically every 10 seconds (this can be halted by clicking the link at the top of the page - see the Figure below).

## Job Queued

The output page will show a status of ‘Job Queued’ until the solver starts.

Files Created for <i>cable_feodor_coloured--001_020</i>		
Showing OUTPUT files		<a href="#">Stop Solver</a>
<b>JOB QUEUED</b>		<a href="#">Show CONFIG files</a>
This page will <b>refresh every 10 seconds</b> until the solver has finished. Click <a href="#">here</a> to turn this refresh off.		<a href="#">Create Zipfile of all files</a>
<b>0% complete</b> (based on 'out' file creation)		
Displaying <b>0 - 0</b> records in total <b>0</b>		
File name	File size	Date created
No data available in table		

Figure 51: The Solver begins to run at 0% progress

## Solver Running

The solver begins by calculating the number of files it needs to output and uses this to calculate the percentage complete metric.

As the solver runs, output is produced in the form of 'out\_' files. These can be clicked on and viewed before the solver is finished.

The percentage completed metric will increase along with the number of files produced (see the Figure below).

**Files Created for *cable\_feodor\_coloured--014\_002***

Showing OUTPUT files

**SOLVER RUNNING**

This page will **refresh every 10 seconds** until the solver has finished. Click [here](#) to turn this refresh off.

**30% complete** (based on 'out' file creation)

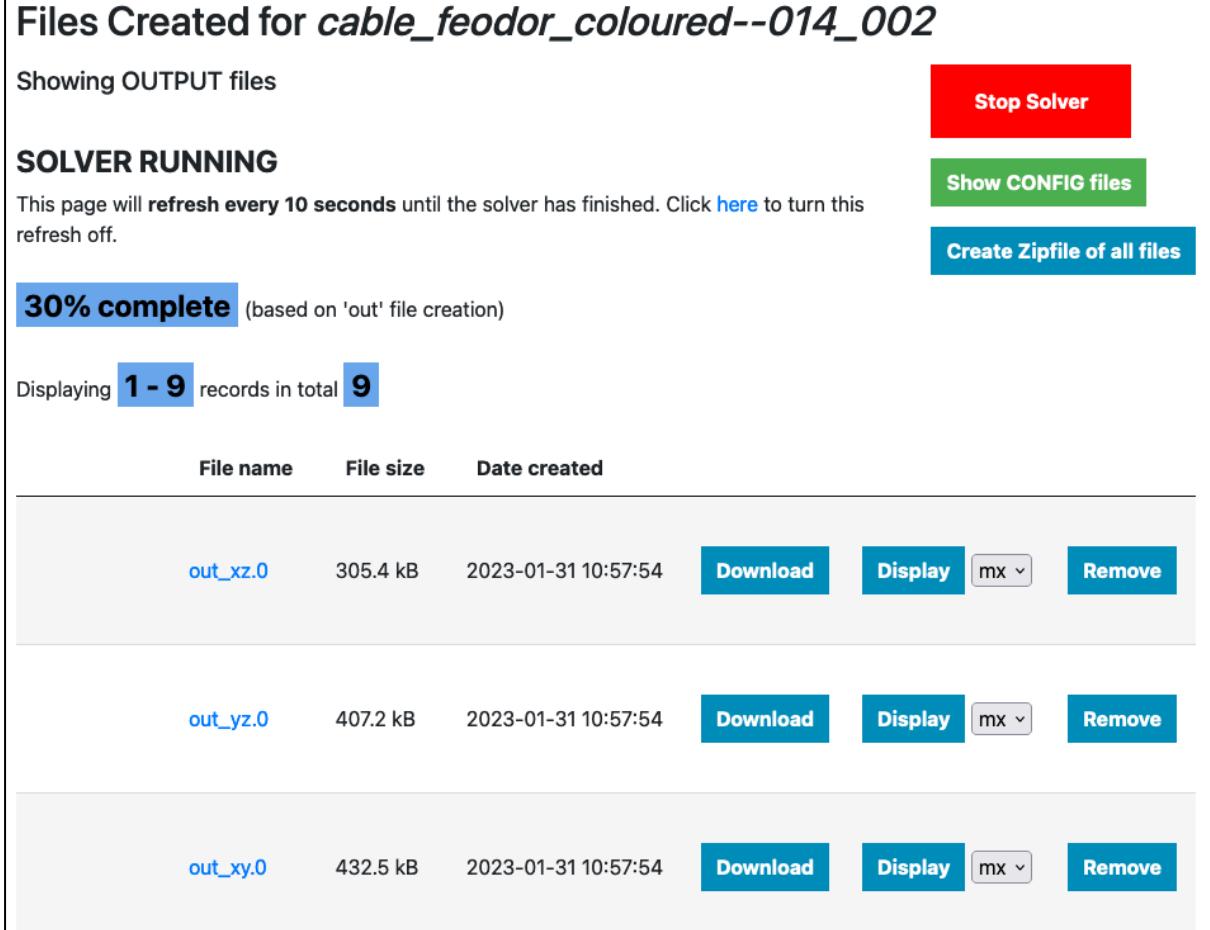
Displaying **1 - 9** records in total **9**

File name	File size	Date created	Download	Display	mx ▾	Remove
<a href="#">out_xz.0</a>	305.4 kB	2023-01-31 10:57:54	<a href="#">Download</a>	<a href="#">Display</a>	mx ▾	<a href="#">Remove</a>
<a href="#">out_yz.0</a>	407.2 kB	2023-01-31 10:57:54	<a href="#">Download</a>	<a href="#">Display</a>	mx ▾	<a href="#">Remove</a>
<a href="#">out_xy.0</a>	432.5 kB	2023-01-31 10:57:54	<a href="#">Download</a>	<a href="#">Display</a>	mx ▾	<a href="#">Remove</a>

**Stop Solver**

**Show CONFIG files**

**Create Zipfile of all files**



The screenshot shows a web-based solver interface. At the top, it says 'Files Created for cable\_feodor\_coloured--014\_002'. Below that, it says 'Showing OUTPUT files'. A large red button on the right says 'Stop Solver'. Below that are three green buttons: 'Show CONFIG files', 'Create Zipfile of all files', and another 'Stop Solver' button. The main area is titled 'SOLVER RUNNING' and says 'This page will refresh every 10 seconds until the solver has finished. Click here to turn this refresh off.' It shows '30% complete' (based on 'out' file creation). It displays 9 records in total, with records 1-9 shown. Each record has a file name (out\_xz.0, out\_yz.0, out\_xy.0), file size (305.4 kB, 407.2 kB, 432.5 kB), date created (2023-01-31 10:57:54), and buttons for Download, Display, and Remove. There are also 'mx ▾' dropdowns next to the Display and Remove buttons.

Figure 52: The page reloads automatically to show the new progress. This time at 30%

## Manually Stopping the Solver

At any time it is possible to stop the solver by clicking the red 'Stop Solver' button.

Files Created for *cable\_feodor\_coloured--001\_007*

• Solver stopped

Showing OUTPUT files

[Show CONFIG files](#)

**SOLVER STOPPED BEFORE COMPLETION**

Output is shown below

**70% complete** (based on 'out' file creation)

Displaying **1 - 10** records in total **21**

« [1](#) [2](#) [3](#) »

File name	File size	Date created	Actions
<a href="#">out_xy.0</a>	1.1 MB	2023-02-01 12:07:59	<a href="#">Download</a> <a href="#">Display</a> <a href="#">mx</a> <a href="#">Remove</a>

Figure 53: Stopping the solver before completion

## Not a Number

After each refresh, the GUI checks the latest output file for the presence of 'nan' - Not a Number.

If 'nan' is found in the output file, this signifies an error and the Solver is stopped.

## Files Created for *cable\_feodor\_coloured--005\_004*

- Found "Not a Number" (nan) in *junkMxz.11*
- Solver stopped

Showing OUTPUT files

Show CONFIG files

### SOLVER STOPPED - Output Contains 'Not a Number'

Full output is shown below

Create Zipfile of all files

**6% complete** (based on 'out' file creation)

Displaying **1 - 10** records in total **13**

« 1 2 »

File name	File size	Date created
<a href="#">junkMxz.0</a>	521.0 kB	2023-04-24 15:17:43

[Download](#)

[Display](#)

mx ▾

[Remove](#)

Figure 54: Checking for 'nan' - Not a number

## Segmentation Fault

If an error occurs in the running of the solver causing it to stop (usually in the form of a segmentation fault), this is noted on the output screen.

## Files Created for *test4--001\_001*

Showing OUTPUT files

Show CONFIG files

### SOLVER STOPPED - Segmentation Fault

Create Zipfile of all files

See the log file in the 'Config' section for more details or contact the administrator

**0% complete** (based on 'out' file creation)

Displaying **0 - 0** records in total **0**

File name	File size	Date created
No data available in table		

Figure 55: Segmentation Fault

## Solver Finished

Once the Solver reaches 100%, all output files have been created.

## Files Created for *cable\_feodor\_coloured--014\_002*

Showing OUTPUT files

Show CONFIG files

### SOLVER FINISHED

Create Zipfile of all files

Full output is shown below

**100% complete** (based on 'out' file creation)

Displaying **1 - 10** records in total **30**

« **1** **2** **3** »

File name	File size	Date created	
-----------	-----------	--------------	--

<a href="#">out_xz.0</a>	305.4 kB	2023-01-31 10:57:54	<a href="#">Download</a>	<a href="#">Display</a>	<a href="#">mx</a> ▾	<a href="#">Remove</a>
--------------------------	----------	---------------------	--------------------------	-------------------------	----------------------	------------------------

<a href="#">out_yz.0</a>	407.2 kB	2023-01-31 10:57:54	<a href="#">Download</a>	<a href="#">Display</a>	<a href="#">mx</a> ▾	<a href="#">Remove</a>
--------------------------	----------	---------------------	--------------------------	-------------------------	----------------------	------------------------

Figure 56: The Solver has finished and all output files are displayed for analysis

## Creating a Zipfile

All output can be easily zipped into an archive file for download. Simply click the 'Create Zipfile of all files' button:

## Files Created for *cable\_feodor\_coloured--001\_017*

- Zip file created: [cable\\_feodor\\_coloured--001\\_017.zip](#) and added to the CONFIG section
- Check the end of the file list below

Showing OUTPUT files

Show CONFIG files

### SOLVER FINISHED

Create Zipfile of all files

Full output is shown below

Figure 57: Clicking the 'Create Zipfile' button

Files Created for <i>cable_feodor_coloured--001_017</i>					
Showing CONFIG files		Show OUTPUT files			
SOLVER FINISHED		Create Zipfile of all files			
Full output is shown below					
<b>100% complete</b> (based on 'out' file creation)					
File name	File size	Date created			
<a href="#">metascript</a>	1.9 kB	2023-01-31 18:17:18	<a href="#">Download</a> <a href="#">Remove</a>		
<a href="#">cable_feodor_coloured--001_017.log</a>	365 Bytes	2023-01-31 18:17:45	<a href="#">Download</a> <a href="#">Remove</a>		
<a href="#">cable_feodor_coloured--001_017.zip</a>	188.5 kB	2023-02-01 09:44:27	<a href="#">Download</a> <a href="#">Remove</a>		

Figure 58: The created zipfile

## Config Files

The main screen shows only the 'out\_' files but several other files are also created by the solver, providing valuable configuration data. These are displayed on the Config screen, accessible by clicking on the 'Show Config Files' button:

Files Created for <i>cable_feodor_coloured--014_002</i>					
Showing CONFIG files		Show OUTPUT files			
SOLVER FINISHED		Create Zipfile of all files			
Full output is shown below					
<b>100% complete</b> (based on 'out' file creation)					
Displaying <b>1 - 6</b> records in total <b>6</b>					
File name		File size	Date created		
metascript		1.9 kB	2023-01-31 10:57:20		
<a href="#">Download</a>		<a href="#">Remove</a>			
stdout.txt		2.9 kB	2023-01-31 10:59:59		
<a href="#">Download</a>		<a href="#">Remove</a>			
stderr.txt		326 Bytes	2023-01-31 10:59:59		
<a href="#">Download</a>		<a href="#">Remove</a>			

Figure 59: The Config files

Explanation of the config files:

### Metascript

This is a copy of the meta script file passed with the matrix file to the solver

### out.dat

Contains a list of the parameters, as read by the solver. (with no errors this should be the same information as in the Metascript file)

### pid2

Description required (4051?)

### aTimeM1(2).dat

Data outputs from ports 1 and 2. (Saved in single column format, each point a value of the chosen field per each step)

### \*\*input\_file\*\*.log

This file contains a log of all output from the command line of running the Solver. It is named the same as the matrix file.

## Analysing the results

All output files can be downloaded for analysis.

### Out Files

The main output files are the 'out\_' files.

The number and type of files outputted are controlled by the 'Constants' and 'Output' panes of the metascript parameters page.

### Number of files

The number of 'out' files is calculated by the following equation:

**Time Steps / Every Nth frame**

**E.g.  $1000/100 = 10$  output files**

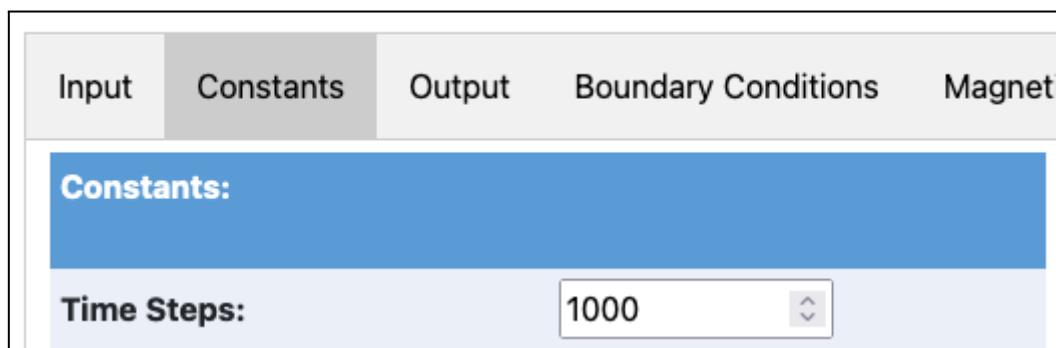


Figure 60: Showing the 'Time Steps' value on the meta script 'Constants' pane

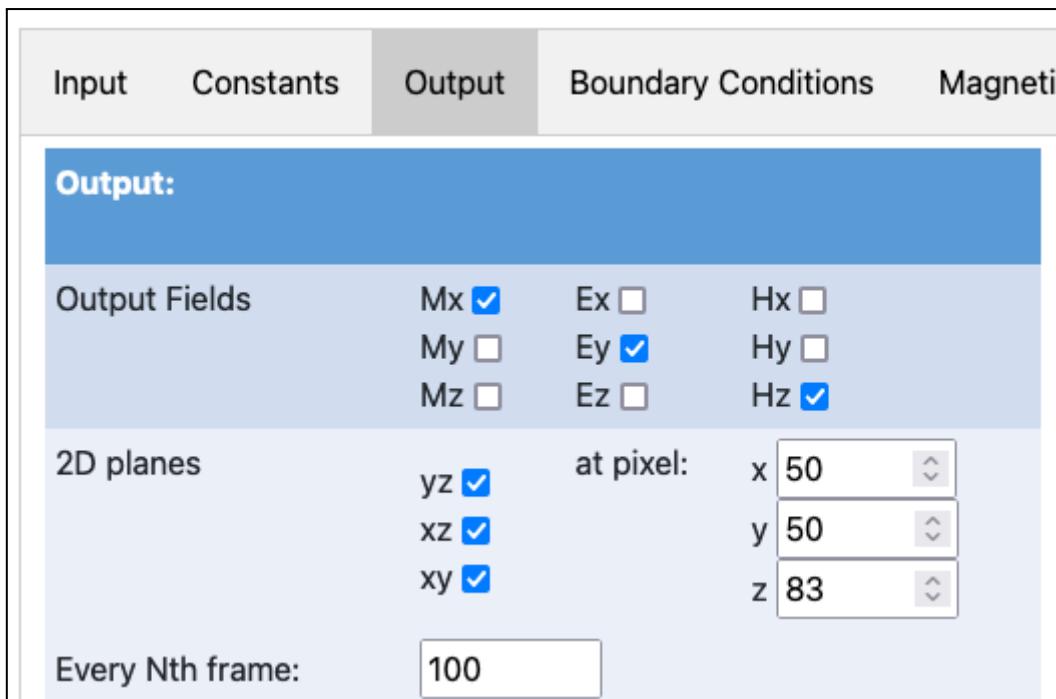


Figure 61: Showing the 'Every Nth frame' value on the meta script 'Output' pane

## Type of output

Each output file can be split into a maximum of three files, based on the desired 2D planes chosen in the meta script 'Output' pane (see the Figure above).

- yz
- xz
- xy

## Displaying output as Heatmaps

Each outputted file can be displayed as a heatmap.

The 'Output Field' must be specified when displaying the heatmap. The 'Output Fields' are selected on the meta script 'Output' pane (see the Figure above) before running the solver.

<a href="#">out_xy.9</a>	602.4 kB	2023-01-31 10:59:59	<a href="#">Download</a>	<a href="#">Display</a>	<input checked="" type="checkbox"/> mx <input checked="" type="checkbox"/> ey <input type="checkbox"/> hz	<a href="#">Remove</a>
<a href="#">out_yz.9</a>	596.6 kB	2023-01-31 10:59:59	<a href="#">Download</a>	<a href="#">Display</a>	<input checked="" type="checkbox"/> ey	<a href="#">Remove</a>
<a href="#">out_xz.9</a>	327.8 kB	2023-01-31 11:00:00	<a href="#">Download</a>	<a href="#">Display</a>	<input checked="" type="checkbox"/> ey	<a href="#">Remove</a>

Figure 62: The 'Display' button and 'Output Field' select box

## Output planes

### out\_xy

These contain data along the xy plane.

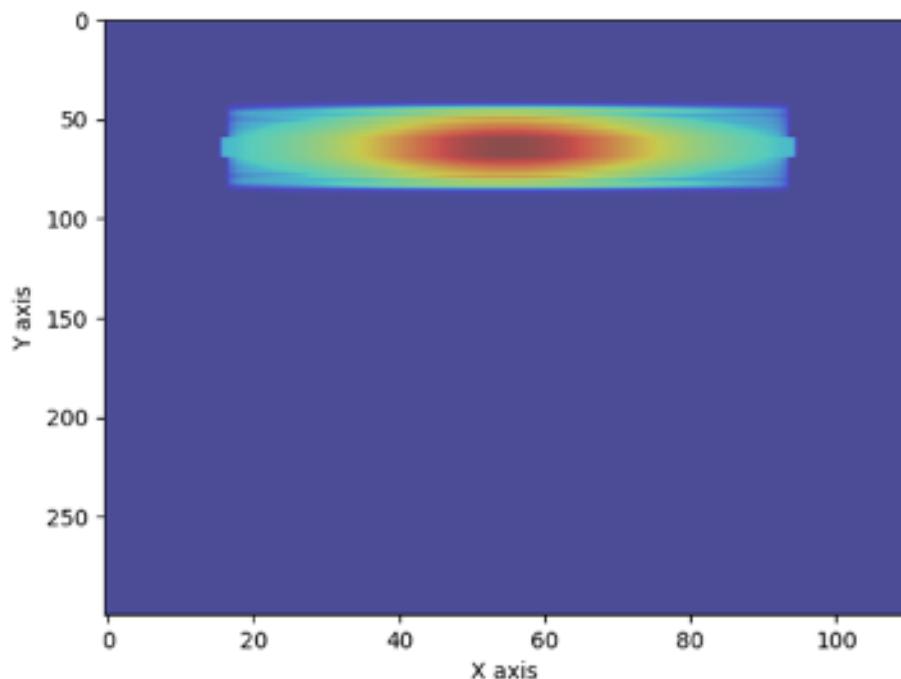


Figure 63: Heatmap of an 'out\_xy' file create on the xy plane for a coaxial cable

### out\_yz

These contain data along the yz plane.

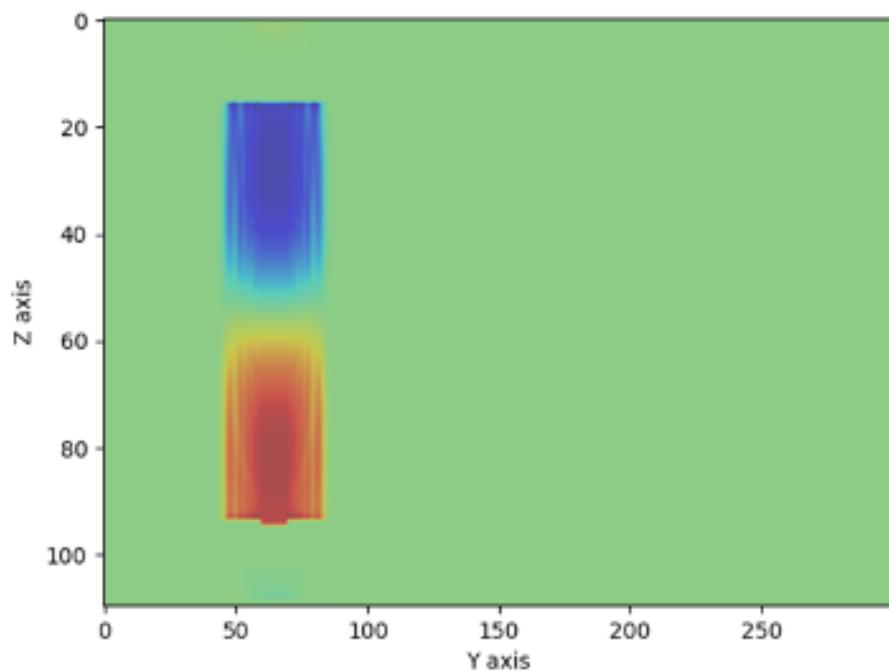


Figure 64 Heatmap of an 'out\_yz' file create on the yz plane for a coaxial cable

#### **out\_xz**

These contain data along the xz plane.

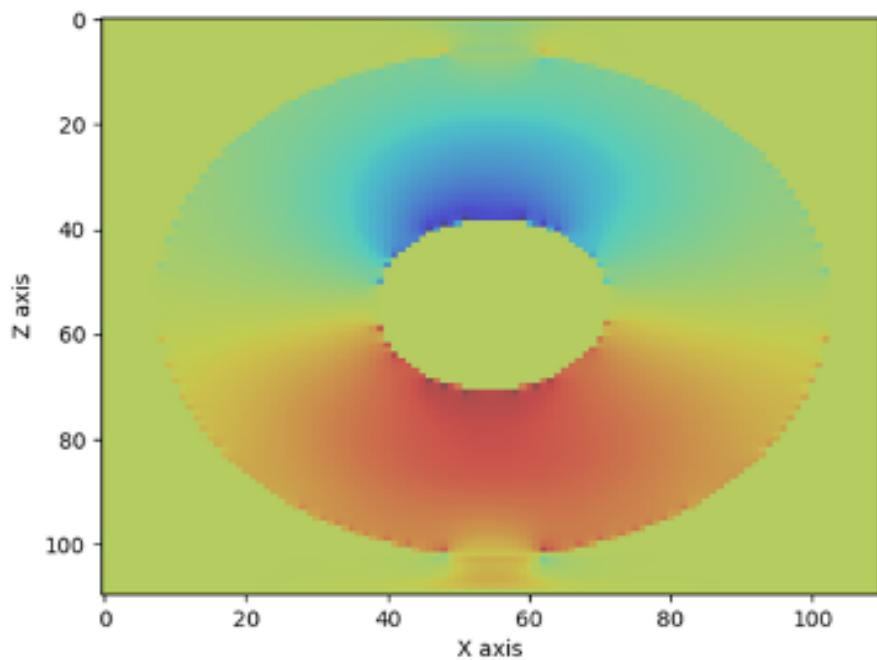


Figure 65: Heatmap of an 'out\_xz' file create on the xz plane for a coaxial cable

## The Output Directory List

The Output section can be revisited by clicking on the 'Output' tab in the top menu:

Output Folders		
Show 10 entries	Search:	
Directory	Date created	
<a href="#">cable_feodor_coloured--001_002</a>	2022-06-15 10:45:37	<button>Remove</button>
<a href="#">cable_feodor_coloured--001_003</a>	2022-07-19 13:38:43	<button>Remove</button>
<a href="#">ferrmet1--001_001</a>	2022-11-15 10:31:50	<button>Remove</button>
<a href="#">ferrmet1--001_002</a>	2022-11-15 11:01:04	<button>Remove</button>

Figure 66: The list of output directories

# Running the Solver from the Command Line

The solver can be run directly from the command line. The following files are required from the GUI which are located in the following directories:

**Matrix File:**

/input\_files/<<user id>>/

**Metascript parameters File:**

/metascript/<<user id>>/

NB. The user id can be obtained from the User table in the database. The ID of the 'admin' user is 1.

To run the solver via the command line, use the following command from the project root directory (inside maxllg-gui):

```
c_code/solver_icc /path/to/metascript/file /path/to/input/file /path/to/output/directory/  
x_dimension z_dimension y_dimension
```

For Windows and Macs, use the solver\_gcc compilation. Paths can be full or relative to the current location.

E.g.

```
c_code/solver_icc metascript/cable_feodor_coloured--001  
input_files/cable_feodor_coloured--001 output/cable_feodor_coloured--001_002/ 110 300  
110
```

# Appendix

## Creating the same matrix file in 2D and 3D

### 2D (using GIMP)

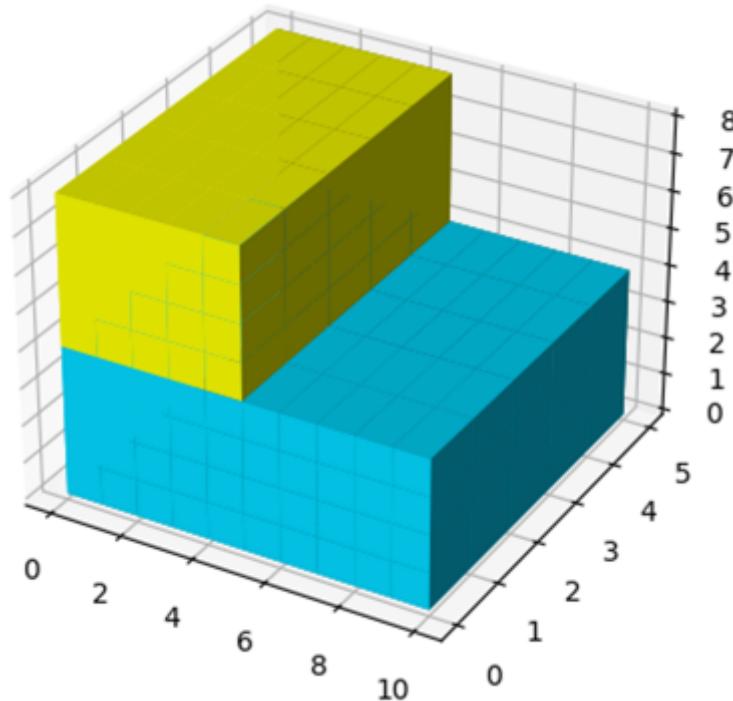


The X axis is horizontal

The Z axis is vertical

The Y axis (not seen in a 2D image) is the depth

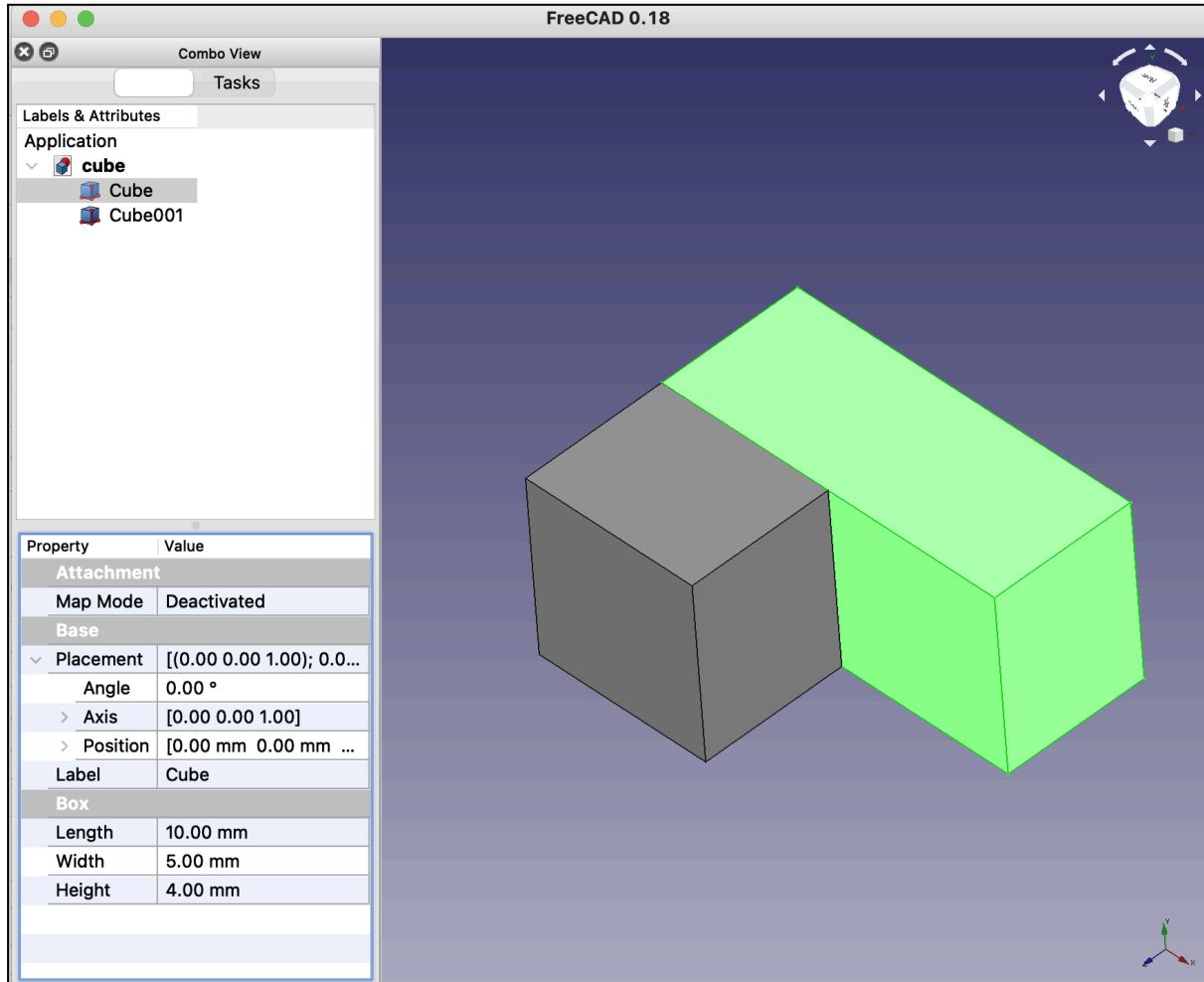
For an image of  $x=10$ ,  $z=8$  and  $y=5$  this creates the following 3D matrix file rendered image:



NB. The 3D image above appears to be 'flipped' along the x axis. This is because image editing software such as GIMP has its 0,0 pixel at the top left of the image. Matplotlib, the python library that renders the matrix file in 3D, sets the 0,0,0 point in the bottom left. This means that, although the images are the same, they appear to be a mirror image of each other.

## 3D (using FreeCAD)

- The X axis is the 'length'
- The Z axis is the 'height'
- The Y axis is the 'width'



These axis can also be seen in the bottom right corner of the FreeCAD window:



(The obscured blue axis label is showing 'z')

The 'cube' FreeCAD and step files are included in the download for testing purposes.

This creates the following 3D matrix file rendered image:

