A first ONELAB-LASER session

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This document gets you started with the ONELAB-LASER simulation tool by leading you through the successive steps of a first session. Completing the whole tutorial should take about one hour.

1 Install and start the ONELAB virtual machine

- To install `VirtualBox` and the virtual machine on your computer, follow the instructions

  `http://onelab.info/wiki/ONELAB_virtual_machine`

- Elmer and Gmsh are preinstalled on the virtual machine. To install the `LASER` model, follow the instructions

  `http://onelab.info/wiki/Elmer`

2 Solve the reference model

- Log in into the virtual machine (username: olvm, passwd: olvm).
- Open a terminal by clicking on the `Terminal` icon in the left menu bar of the virtual machine.
- A the prompt, enter the command ‘‘`gmsh`’’ (without quotes) and strike the return key.
- In the upper bar of the Gmsh window, click on `File > Open`
- Browse to `ELMERMODELS/laser.py`, and click on `Ok`

- You now see the model's geometry in the right panel of the Gmsh window, and the parameters in the left panel. Parameters can be edited, but before doing that, we shall solve and archive the reference solution, i.e. the model with default parameter values.
- Enter a tag, for instance `reference` or `default`, in the `Metamodel > Tag` parameter box in the left panel of the Gmsh window, and validate by striking the return key (important !). This tag is optional. It is used by ONELAB to labelize some automatically generated files.
- Click on `Run`
- During the calculation, click on the (light grey) lower bar of the Gmsh window to open the message console of Gmsh. Reorganize also the opened windows (sizes and positions), so as to see simultaneously the Gmsh window completely, and the last few lines of the terminal. You can this way check the advancement of the Elmer simulation. Note that, during the simulation, the `Run` button of the Gmsh window is modified into a `Stop` button. Click on this button to interrupt the simulation, and wait a few seconds. Refrain from clicking on the `Kill` button as this might generate zombie processes.
- When the simulation is done, the `Stop` button is switched back into a `Run` button.
- Click on the letter "O" in the lower bar of the Gmsh window and then click on `Toggle mesh display` option to dismiss the finite elements in the displayed temperature plot.
- Click on the tape recorder "Play" icon in the lower bar of the Gmsh window to visualize the time evolution of the temperature field. Use the mouse to zoom, rotate and pan the view. See `Help > Keyboard and Mouse usage` for further details.

3 Post-process the model

- Click on the `Document viewer` icon in the left menu bar of the virtual machine.
- From the menu bar **of the virtual machine** (Pay attention not to mix up the menu bar of Gmsh, which is light grey, and that of the virtual machine, which is dark grey-brown), click on `File > Open`

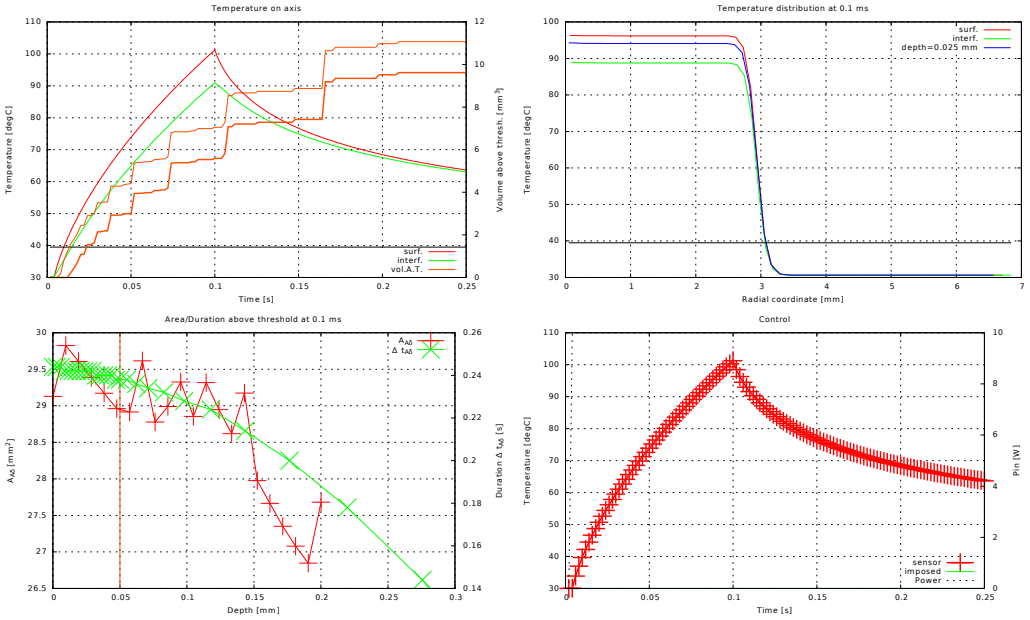

Figure 1: Output file of the reference model (model with default parameter values).

- Select `olvm/ELMERMODELS/laser/plot.pdf` and click on `Open`
- This **output file**, Fig. 1, is automatically generated at each model run. It gathers in a single `pdf` file the main results of the simulation, in a form directly interpretable by the user.
- If the `Archive output files automatically` box is checked in the `Gear` menu-button of Gmsh window (which is not the case by default), then the output file is archived automatically after each model run, i.e. it is copied into the subdirectory called `archive/` under the name `laser_stamp_tag.pdf`. The automatically appended `stamp` consists of a to the second accurate timestamp `yyyy-mm-dd_hh-mm-ss` concatenated with the user-defined ONELAB string parameter `Metamodel > Tag`, which you can edit in the left panel of the Gmsh window. The purpose of the additional tag is to give the user a way to identify the output files corresponding to a same group of simulations.
- The ONELAB parameters whose value is highlighted in coral color in the left panel of the Gmsh window are computed numerical values of interest, here the maximum values of some of the displayed curves.
- When done with the analysis of the output file, don't close the `Document`

`viewer`. Just minimize the window, or leave it in the background. It is automatically updated with the new results at the end of each model run.

- The ONELAB parameters highlighted in light-blue in the left panel of the Gmsh window are the postprocessing parameters. They determine some of the curves represented in the output file `plot.pdf` :
  - The `Thermal threshold fiber [C]` is the threshold above which nociceptive cells are assumed to be activated. This threshold is represented by a horizontal line in the upper plots of the figure.
  - The `Probe time [s]` is the time at which Temperature vs. radius plot (upper right plot) is generated. ONELAB proposes a default value, which corresponds to the end-stimulation time, whenever known.
  - The`Probe depth [m]` is depth from skin surface at which the blue curve in the upper right plot is evaluated. The default depth is 25 microns below the skin surface.

  As long as only post-processing parameters are modified, the computed thermal field remains up to date, and running the model by clicking on the `Run` button does not entail a complete finite element recomputation of the model. The user can thus generate the output file `plot.pdf` for several probe times and probe depths, without recomputing the finite element problem. Only the post-processing is redone.

- One can, for instance, re-analyze the simulation results with a `Thermal threshold` of 41°C instead of the default value 39.5°C. Modify for this the value of the `Thermal threshold fiber [C]`, validate the edited value by striking the return key, check that the other two post-processing parameters have the value you want, and click on the `Run` button.

- Check the updated curves by clicking on the `Document viewer` icon.

- Proceed by modifying other post-processing parameters, and re-running the model. . .

4 Archive the reference model

Before modifying the model parameters, you might want to archive the model we have just solved, so that further post-processing can be done later without needing to recompute the finite element problem. For this

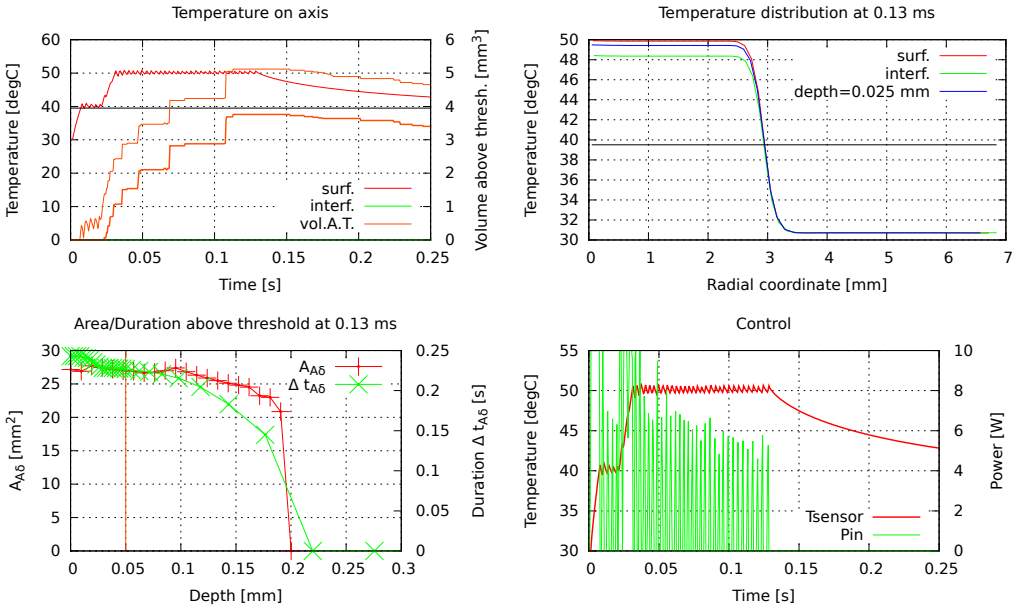

Figure 2: Output file of the modified model (model with closed-loop simulation and 20ms conditioning).

- Click on `Gear menu > Save database`
- It is recommended to save the databases in the working directory. So, browse to the `/home/olvm/ELMERMODELS/laser` directory.
- Complete, by hand, the database name `/home/olvm/ELMERMODELS/laser/onelab_reference.db` in the `filename` box.
- Click on `OK`
- It is important to know that archiving a model renames the solution files on disk, which are thus no longer available for further post-processing actions. If you wan to work on on the same model after having archived it, you have to reload it by clicking on `Gear menu > Load database`
- Take a look in the the working directory `/olvm/ELMERMODELS/laser` and in its subdirectory `archive` to identify which files have been created by saving the database. Use for this the `Home Folder` application (See section **Hints**, below).

5 Modify the model

We now make a more computer-intensive simulation, with the closed-loop stimulator and a 20ms conditioning at $40°C$. For this

- Enter a new tag in the `Metamodel > Tag` parameter box, for instance `case1` or `closed_loop`.
- Modify the parameters as follows
  - `Elmer > Time step = 0.5`
  - `Elmer > Simulation end time = 0.25`
  - `Laser > Laser type = Controlled temperature`
  - `Laser > Conditioning time = 0.02`
  - `Laser > Conditioning temperature = 40`
  - `Postpro > Probe time = 0.13`
- Click on the `Run` button.
- When the simulation is done, click on the `Document viewer` icon and see the new curves, Fig. 2.
- This simulation is archived exactly the same way. Click on `Gear menu > Save database`
- Browse to the `/home/olvm/ELMERMODELS/laser` directory, complete the database name `/home/olvm/ELMERMODELS/laser/onelab_case1.db` in the `filename` box, and click on `OK`

6 Ending a session

- Close the `Document viewer` window.
- Close the `Gmsh` window.
- Click on `Shut Down` under the `Gear` icon of the upper menu bar of the virtual machine window.
- Then, when the virtual machine is closed, you can close VirtualBox on your computer.

7 Sharing data between host and olvm

It is useful to have your host computer and the virtual machine share a directory. For this

- Create on your computer the directory to be shared. Name it `OLVM`.
- Shut down the virtual machine if it is running.
- Select the virtual machine in the left panel of VirtualBox, and click on `Settings > Shared Folders` or `Configuration > Dossiers partagés`.
- Click on the green "+"
- In `Folder Path` (`Chemin du dossier`), click on `Other...` (`Autre...`) and select the path to the directory to be shared on your computer.
- Write `OLVM` in the box `Folder name` (`Nom du dossier`).
- Check `Auto-mount` (`Montage automatique`).
- Run the virtual machine and login. A link to the shared directory is placed on the desktop, with name `SHARED`.
- To export files from the virtual machine to your computer (for further treatment with matlab, reporting, ...), copy them into the `SHARED` directory, with e.g. the `Home Folder` application (See section **Hints**, below), and they become available in the `OLVM` directory on your computer.

8 Hints

- Use the `Home Folder` application, whose icon is in the left menu bar of the virtual machine window, to manage files on the virtual machine, copy, move and delete files, check sizes, etc...
- Use the `Show Layout Keyboard` application, under the keyboard icon in the upper menu bar of the virtual machine window, to find available special characters that are not indicated on the keys of your keyboard. Open the utility and strike the keys on your keyboard to find out the correspondence.
- Always keep an eye on the message console of Gmsh and the Terminal.

- Always validate the edition of a ONELAB parameter by striking the return key.
- When starting a new session, always open the `laser.py` file before loading a database.
- Do not check/uncheck the `Use restored solution` checkbox yourself, except when you have just loaded a database and wants to force recomputation the finite element problem. This parameter is indicative.
- Avoid clicking on the button `Kill`, except is case of crash, as this might generate corrupted files or zombie processes.
- In case of trouble, quit and restart `Gmsh`.
- If the virtual machines becomes very slow, exit Gmsh and enter the command ‘‘`ps u`’’ (without quotes) in the terminal. If one or several processes “python” or “ElmerSolver” (column COMMAND) are still running and consuming CPU time (zombie process), kill them with `killall python` or `killall ElmerSolver`. Alternatively, shut down and restart the virtual machine.
- For any question, or if something does not work as expected, send an email to
  `francois.henrotte@uclouvain.be`.