The OMFIT COGENT Module

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1 Introduction

This tutorial describes the use of the COGENT module in OMFIT [1]. The basic workflow is to convert experimental tokamak magnetic geometry information into two files that are read by COGENT. The first file contains data used to construct a mapping from physical coordinates to the logical coordinates used in the COGENT discretization of the gyrokinetic system. The second file contains data used to reconstruct a smooth magnetic flux. After the two files are created by the workflow described herein, their path names are added to the COGENT input file. More details on the discretization and grid generation algorithms used in COGENT can be found in [3].

To accommodate strong anisotropy along magnetic field lines, COGENT coordinate mappings are flux-surface-aligned except in a neighborhood of the X point. To obtain a discrete representation of a mapping, a flux-surface-aligned grid (called a *mapping grid*) is constructed, stored in a file (called a *mapping file*) and read by COGENT. COGENT then utilizes high-order B-spline interpolation to obtain a smooth mapping. Since the mapping must be smooth up to and some distance beyond the block boundaries defining the magnetic geometry, the underlying mapping grid must be constructed with proper dealignment near the X point and smooth ghost cells such that the resulting B-spline interpolant is indeed smooth. Since this process is difficult to fully automate and often requires some amount of iteration, a goal of this OMFIT module is to provide an interactive tool facilitating this task.

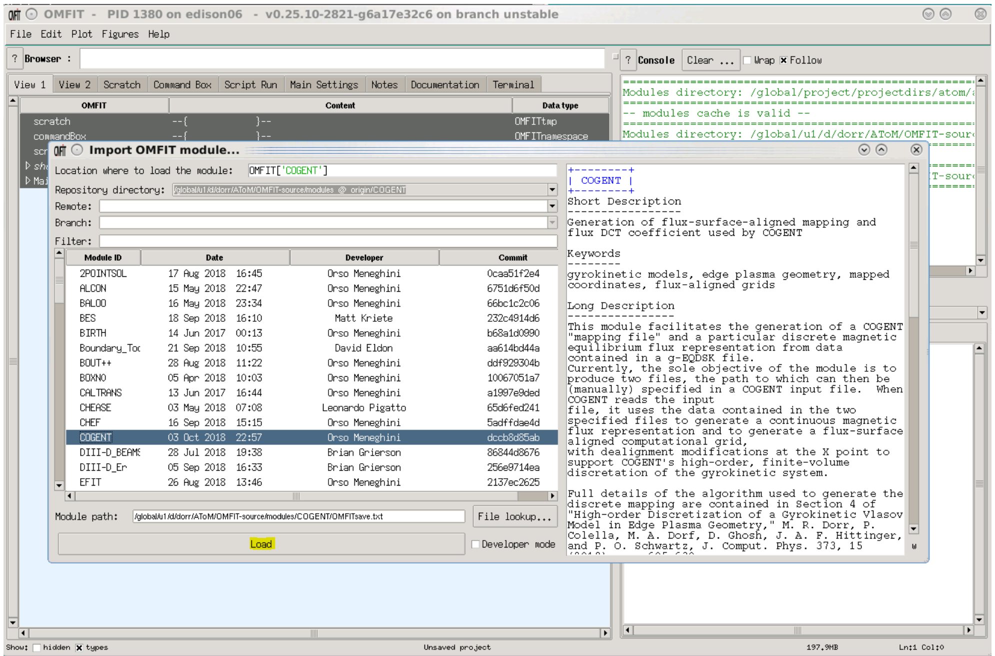
The process of constructing a mapping grid begins with the specification of the magnetic flux. Motivated by the approach used in the Hypnotoad code [2], in which the flux is represented as a discrete cosine transform (DCT) expansion, COGENT similarly reconstructs the magnetic flux from DCT coefficients read from a text file. Since Hypnotoad produces a DCT flux representation from pointwise flux measurements in a G-EQDSK file, the COGENT module includes the ability to use Hypnotoad for that purpose. Although running Hypnotoad generates a grid, it is only the DCT flux coefficients that are of interest in this workflow. A future version of the module will provide a tool to generate the DCT flux file directly from a G-EQDSK, including a smoothing option.

This document assumes that the reader is already familiar with the basics of OMFIT and the operation of its GUI, from which screenshots have been taken for the following tutorial. In addition to access to an OMFIT git repository, the following workflow description assumes that a copy of COGENT and (if desired) Hypnotoad has been installed somewhere.

2 Workflow

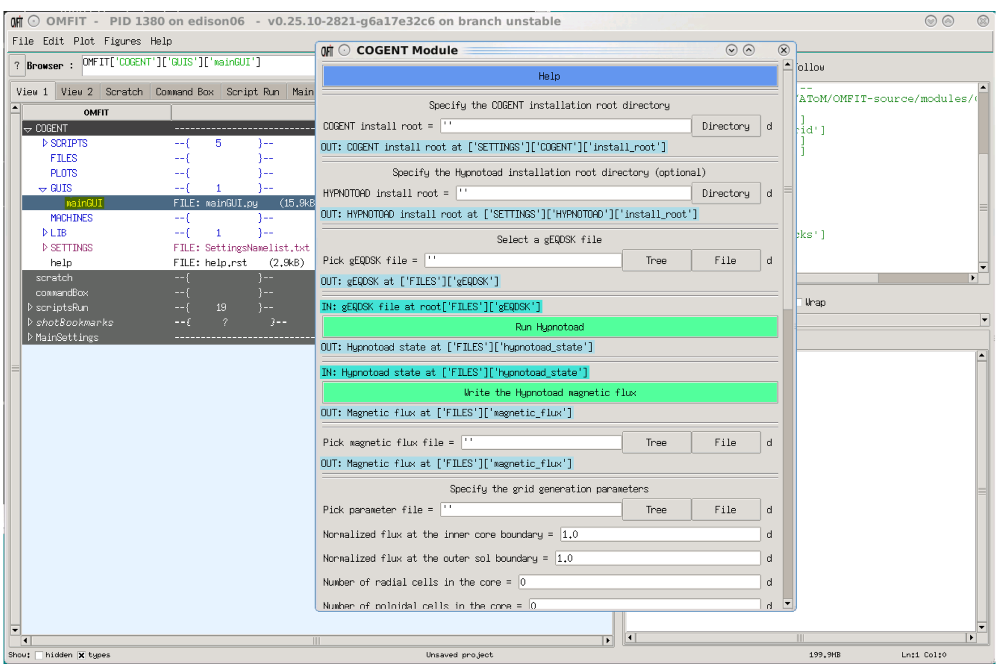
Step 1: Import the COGENT module

Select a local or remote OMFIT repo, select the COGENT module and click "Load":



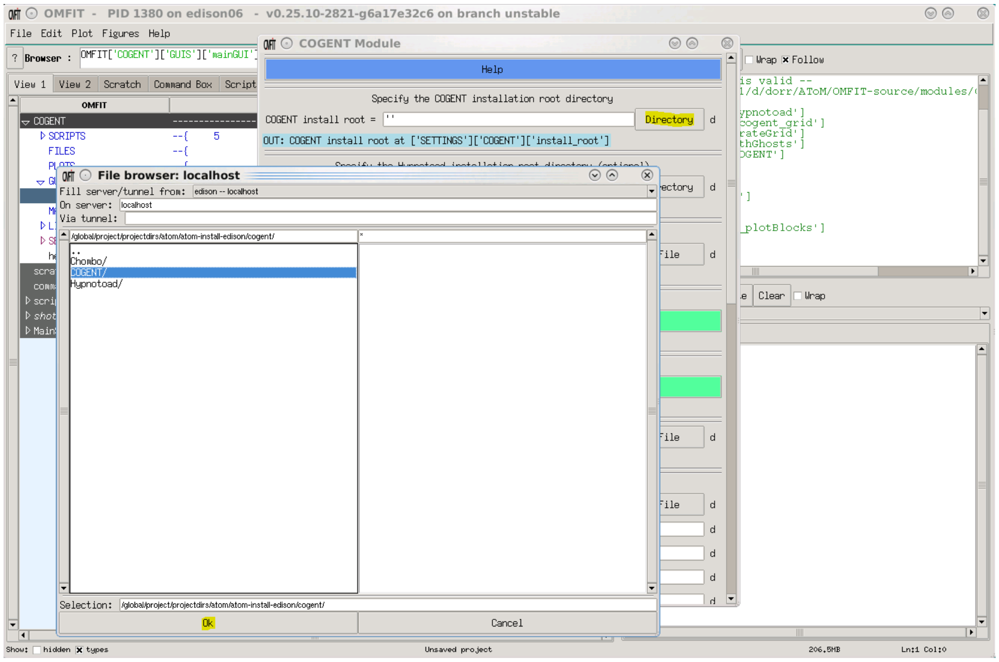
Step 2: Launch the module GUI

Double-click ['COGENT']['GUIS']['mainGUI']:



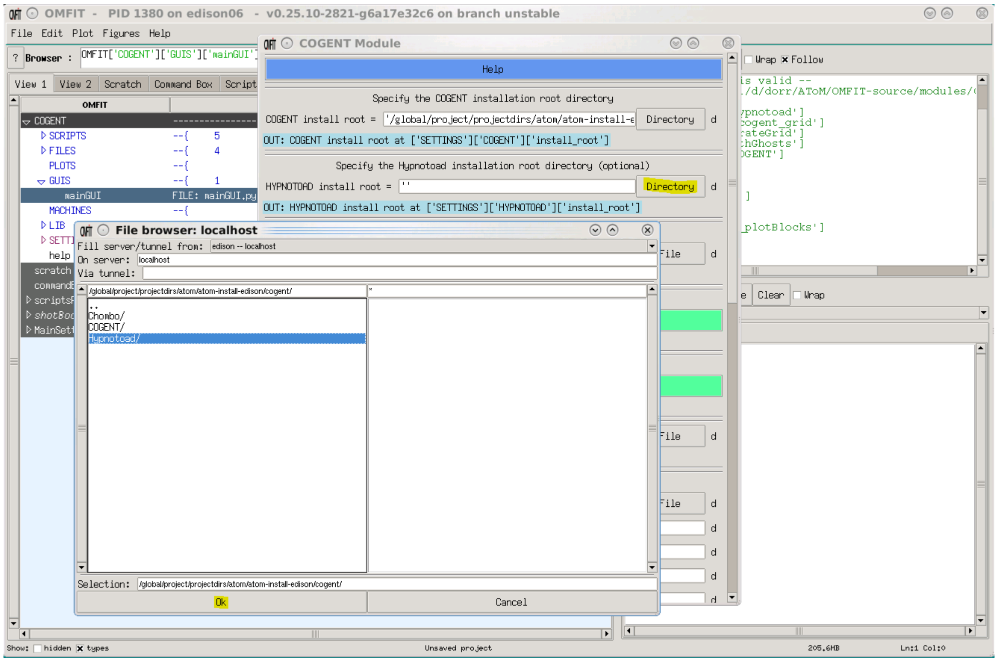
Step 3: Set the COGENT root directory

Set the COGENT installation root directory path in the “COGENT install root” window or by clicking “Directory” to open a file picker:



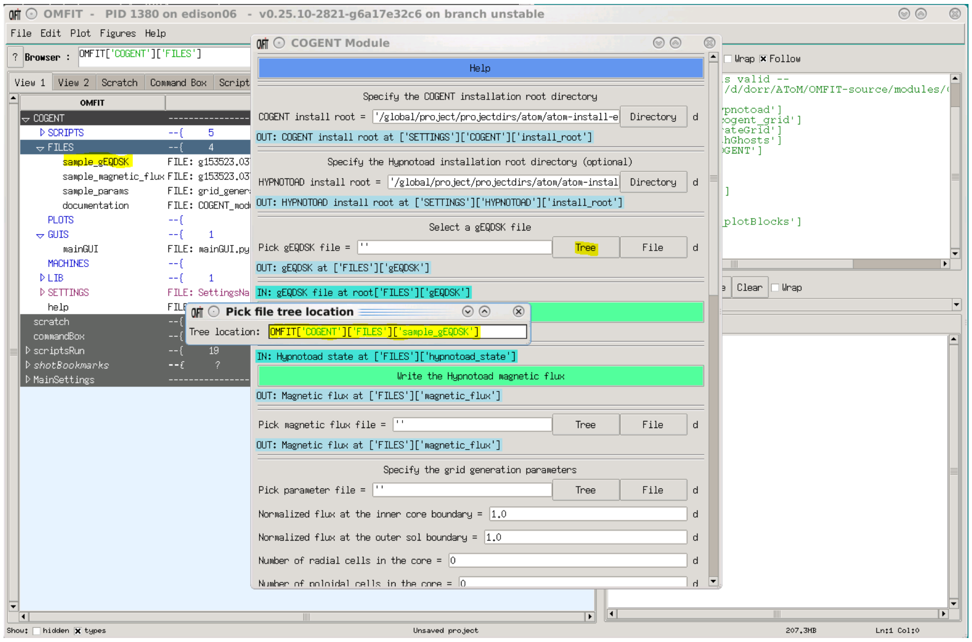
Step 4: If Hypnotoad will be used to generate the magnetic flux, then set its directory path; otherwise skip down to Step 8

As in setting the COGENT path, enter the Hynotoad path manually or use the file picker:



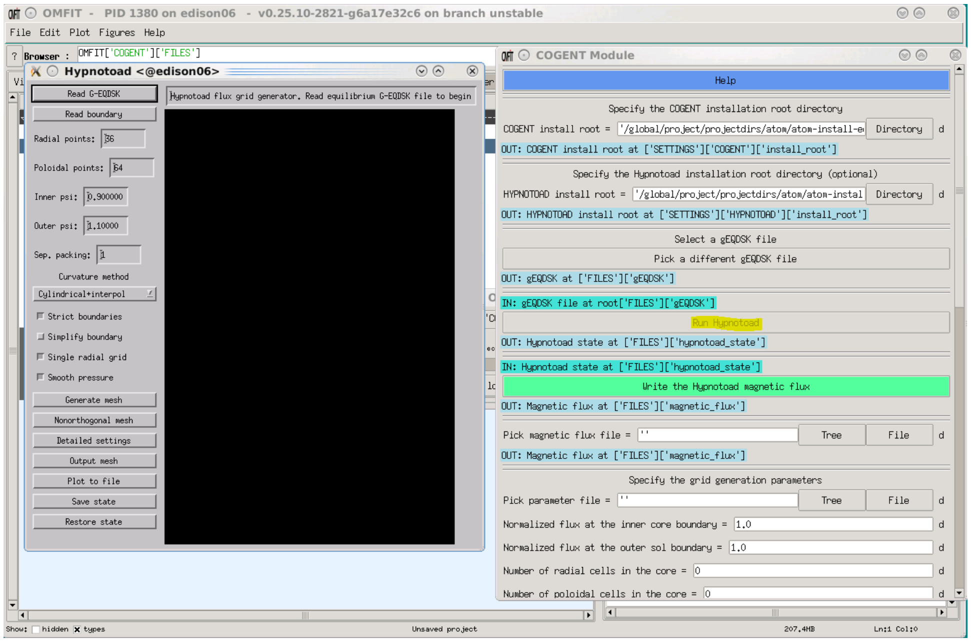
Step 5: Select a G-EQDSK file

In the next GUI element down, select a G-EQDSK file by entering its path, using the file picker launched by the "File" buttton, or by selecting a tree object using the "Tree" button. The setting of the COGENT path in Step 3 will have placed a sample file at the `['COGENT']['FILES']['sample_gEQDSK']` node for use in this tutorial:

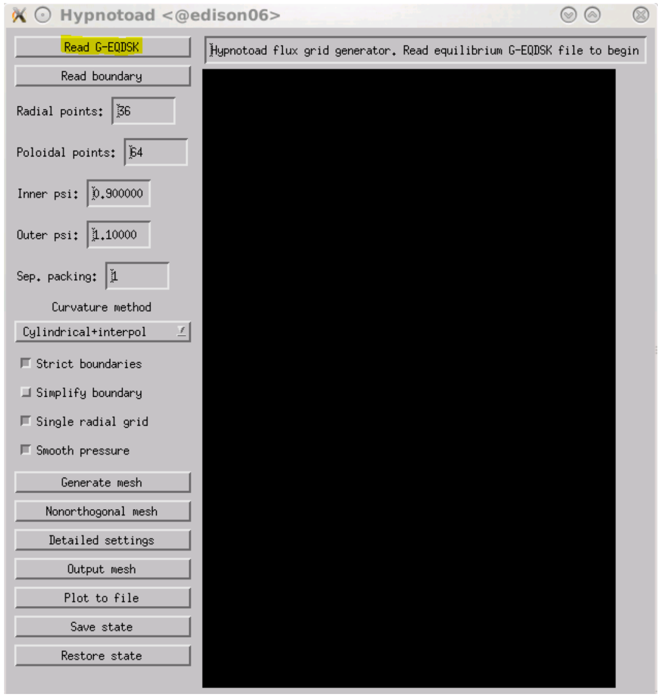


Step 6: Running Hypnotoad to generate the magnetic flux

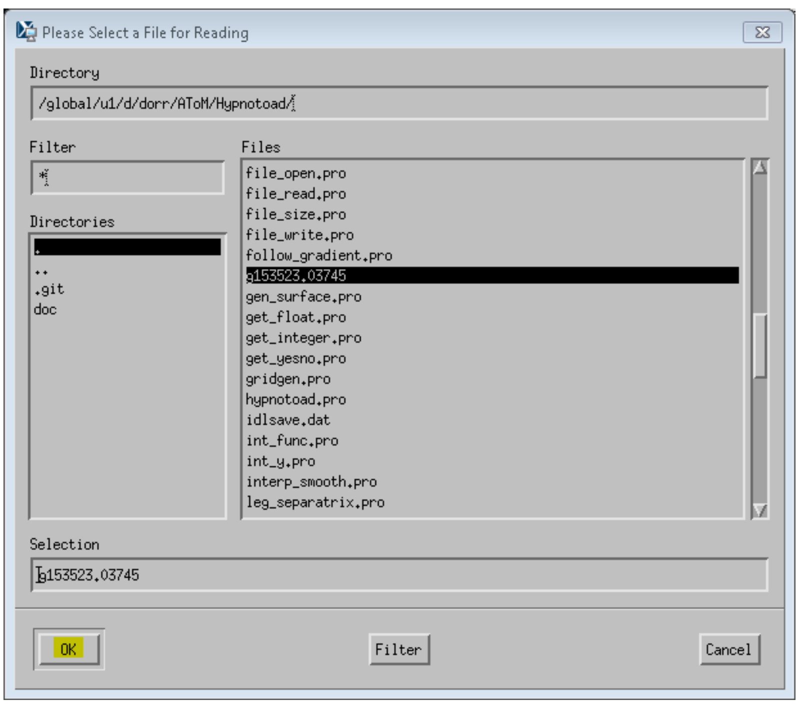
Click "Run Hypnotoad" to open the Hypnotoad window:



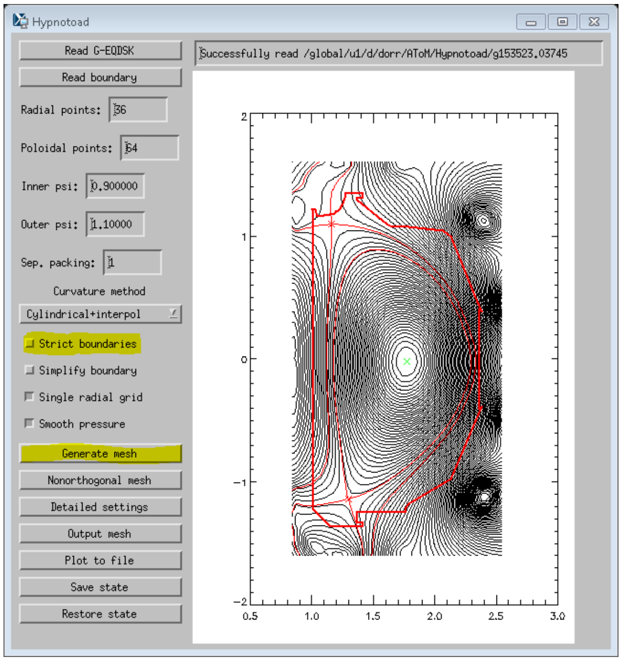
Click “Read G-EQDSK”:



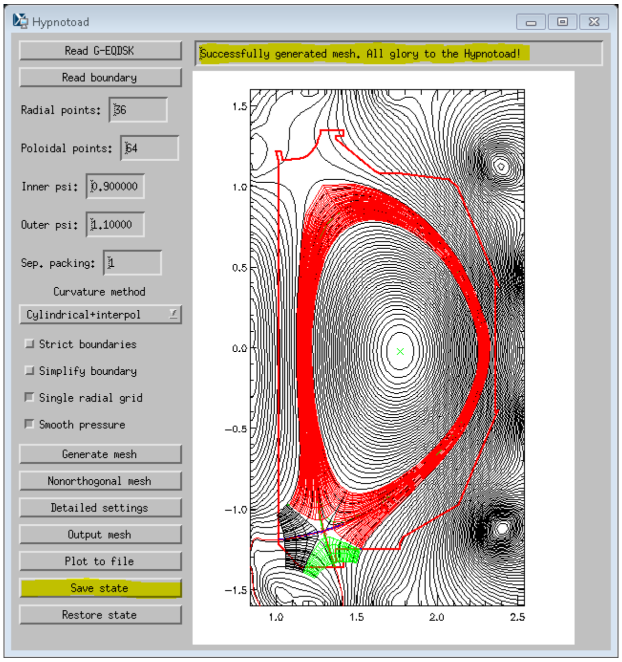
The G-EQDSK file selected in Step 5 will appear in the file picker that opens. Select it (again) and click “OK”:



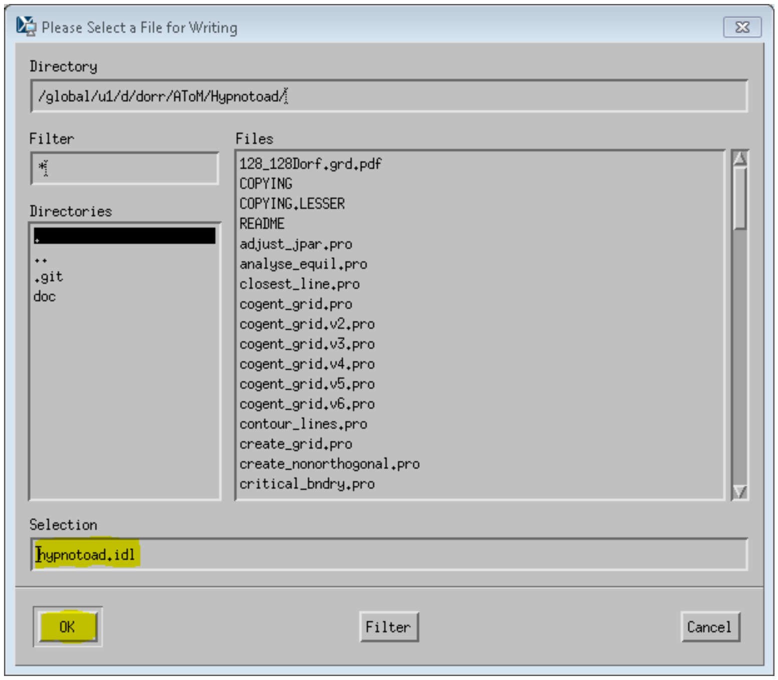
De-select "Strict boundaries" and click "Generate mesh":



When the mesh has been generated, the message "Successfully generated mesh. All glory to the Hypnotoad!" will appear in the upper right-hand box. If any changes are desired, they can be made at this point and the mesh re-generated. When satisfied, click "Save state":



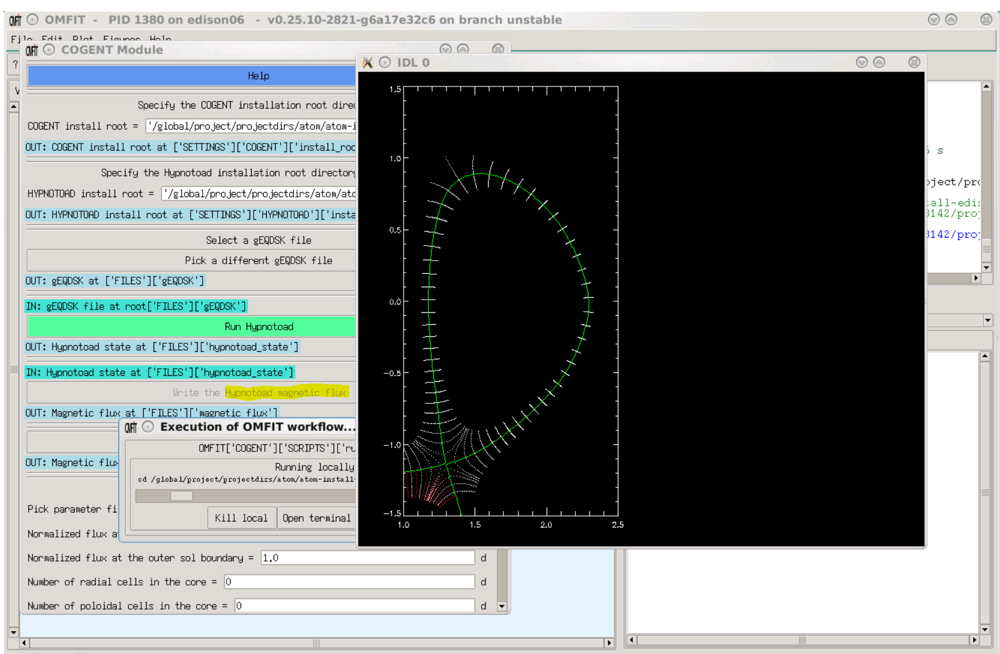
Click "OK", making no other changes:



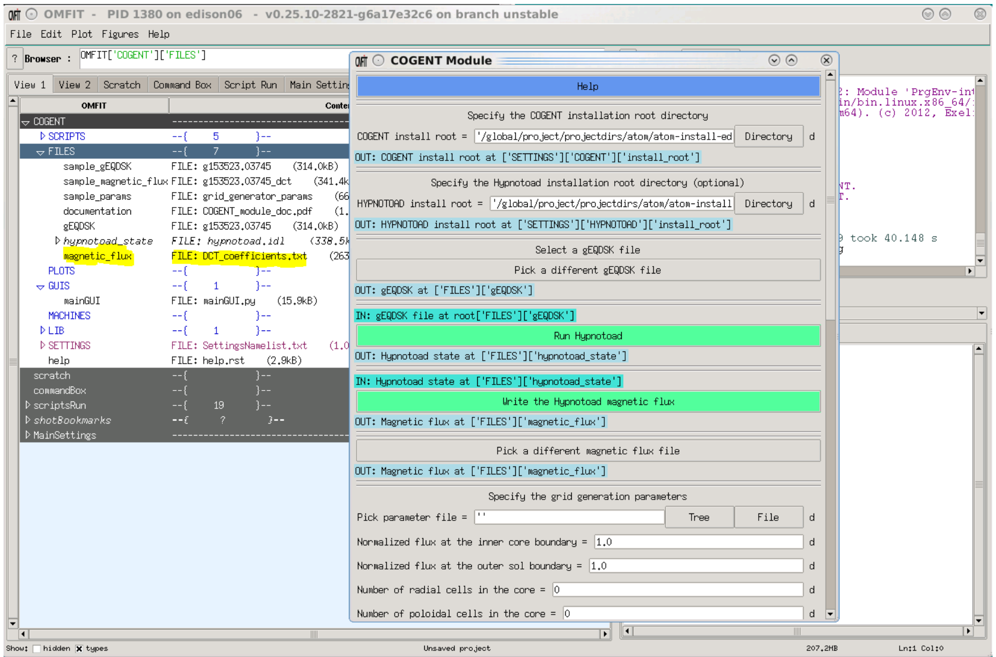
Exit Hypnotoad. The saved state file now appears at `['COGENT']['FILES']['hypnotoad_state']` and can be inspected by clicking the adjacent arrow. *Important*: If Hypnotoad is not shutdown, the state file will not be added to the tree.

Step 7: Write the Hypnotoad magnetic flux

Click "Write Hypnotoad magnetic flux". A new IDL window will appear:

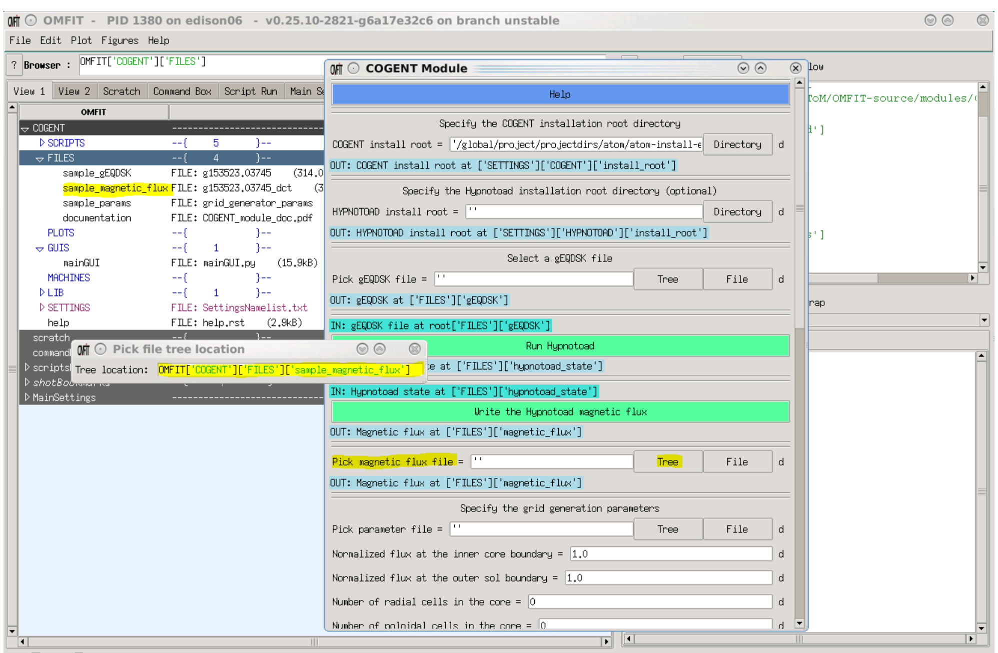


After the magnetic flux is computed, the window closes and a new file containing the flux DCT coefficients now appears at ['COGENT']['FILES']['magnetic_flux']:



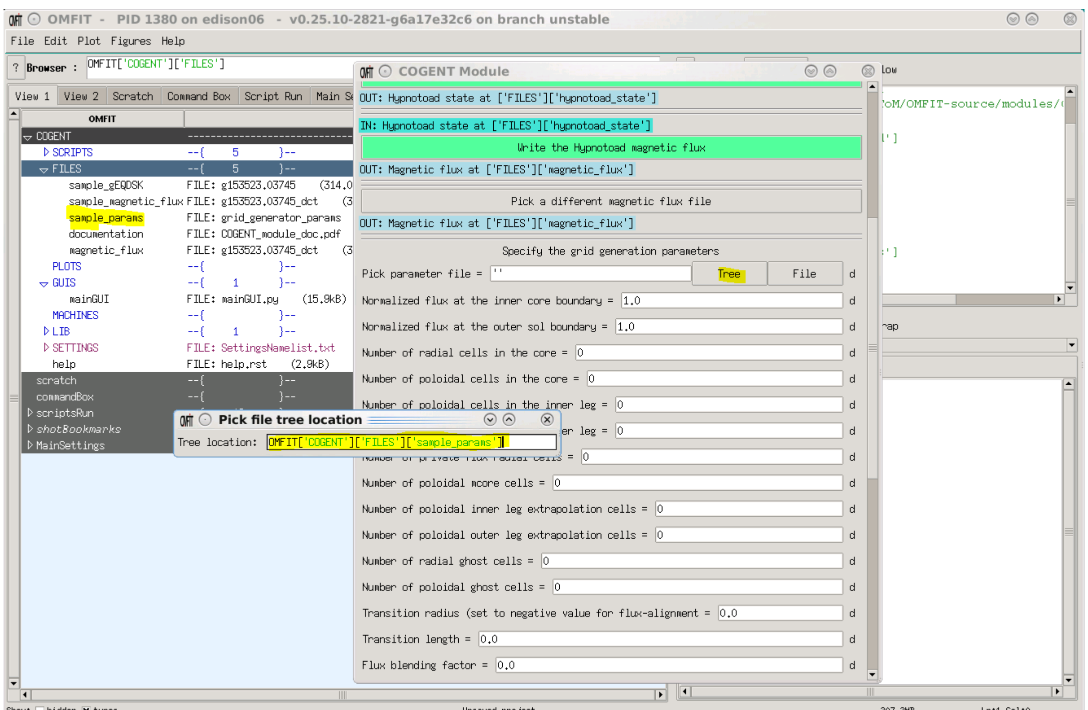
Step 8: Generate a mapping file from the magnetic flux coefficients

The generation of a mapping file requires a couple of utilities from the installed version of COGENT specified in Step 3 and assumes that magnetic flux data has been stored at the node ['COGENT']['FILES']['magnetic_flux']. If Hypnotoad was used as described above

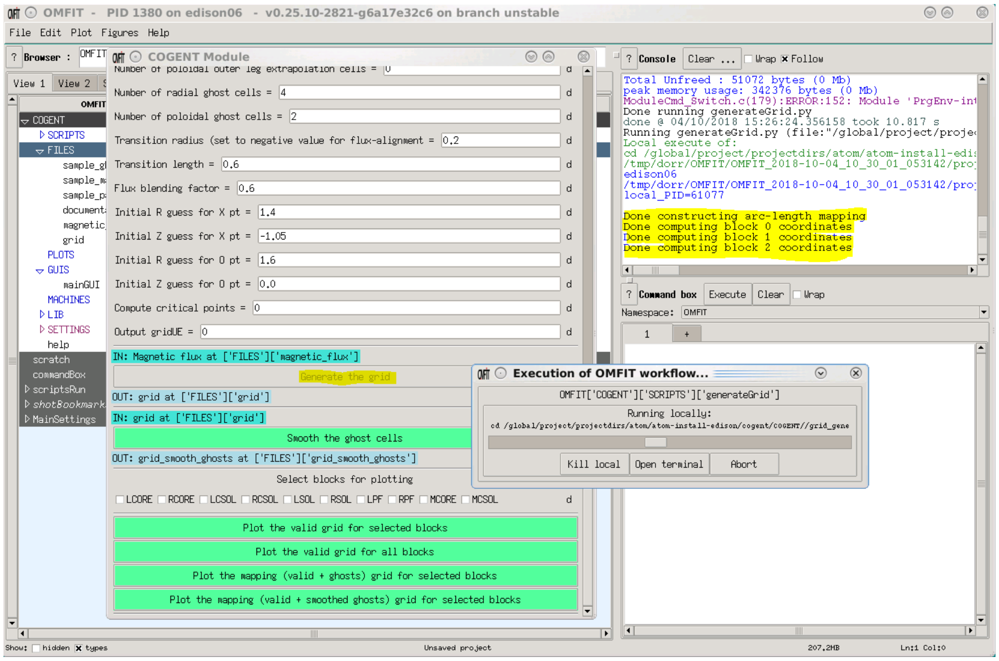


the corresponding flux data will already exist there (Step 7). Otherwise, as we will now assume, the flux data must be loaded either by either (*i*) typing its file path into the "Pick magnetic flux file" box (between the single quotes) and hitting return, (*ii*) clicking on the "File" button on the right to open a file picker, or (*iii*) using the "Tree" button to select a file on the tree. The setting of the COGENT path in Step 3 will have placed a sample file at the `['COGENT']['FILES']['sample_magnetic_flux']` node that we will select in continuing this tutorial. The selected file (using any of the three methods) will then be stored at `['COGENT']['FILES']['magnetic_flux']`.

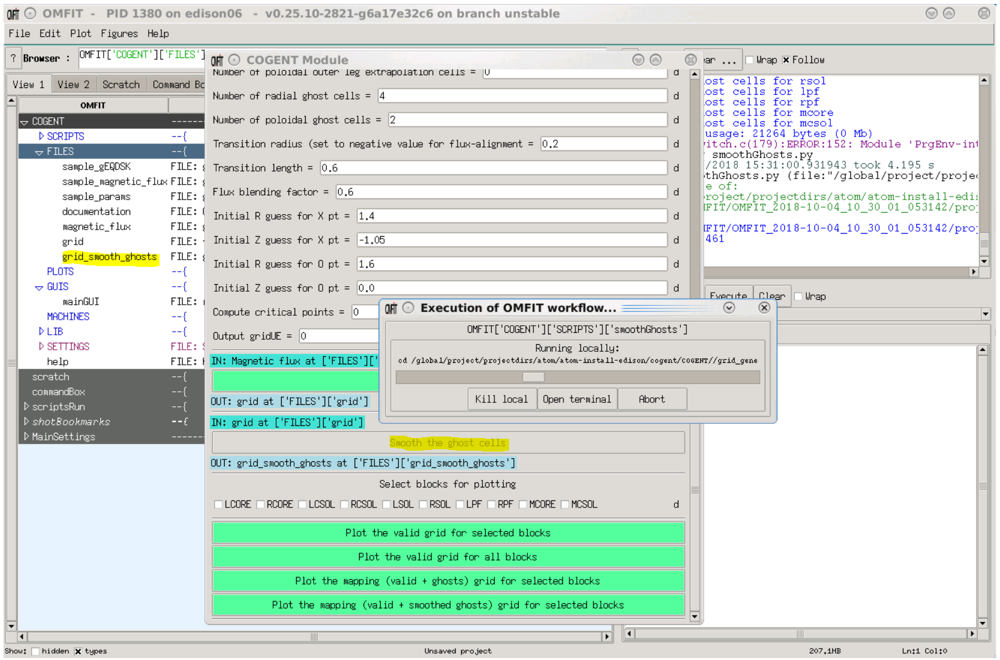
The next step is to set a collection of grid generation parameters in the "Specify the grid generation parameters" section. The meaning of the various parameters is described in the COGENT source file COGENT/grid_generation/scripts/pyRun.py. The parameters can be set by (*i*) setting them one-by-one manually using the COGENT module GUI, (*ii*) reading them from a text file specified either by typing the file path in the "Pick parameters file" box and hitting return or by clicking on the "File" button on the right to open a file picker, or (*iii*) using the "Tree" button to select a text file on the tree. The setting of the COGENT path in Step 3 will have placed a sample file at the `['COGENT']['FILES']['sample_params']` node that we will select in continuing this tutorial. As can be seen by opening the sample file in an editor, the format of the parameter file is a single line of text containing the space-delimited parameter list. Regardless of how the parameters are initially set, individual values can be manually modified simply by editing the value and hitting return.



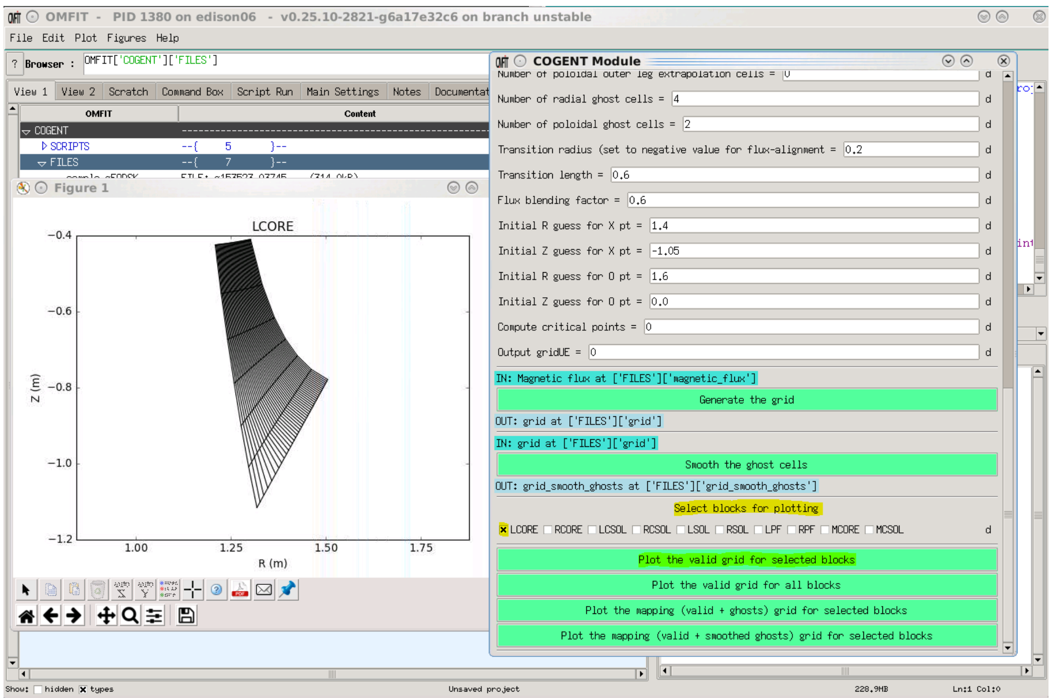
Next, click on the "Generate grid" button. A new window will launch indicating that the mesh generator is running:



After the grid generation is complete and the window closes, the file containing the generated grid will appear at `['COGENT']['FILES']['grid']`. The last step is to click on the "Smooth ghost cells" button, which will run a post-processor, placing the resulting grid at `['COGENT']['FILES']['grid_smooth_ghosts']`:

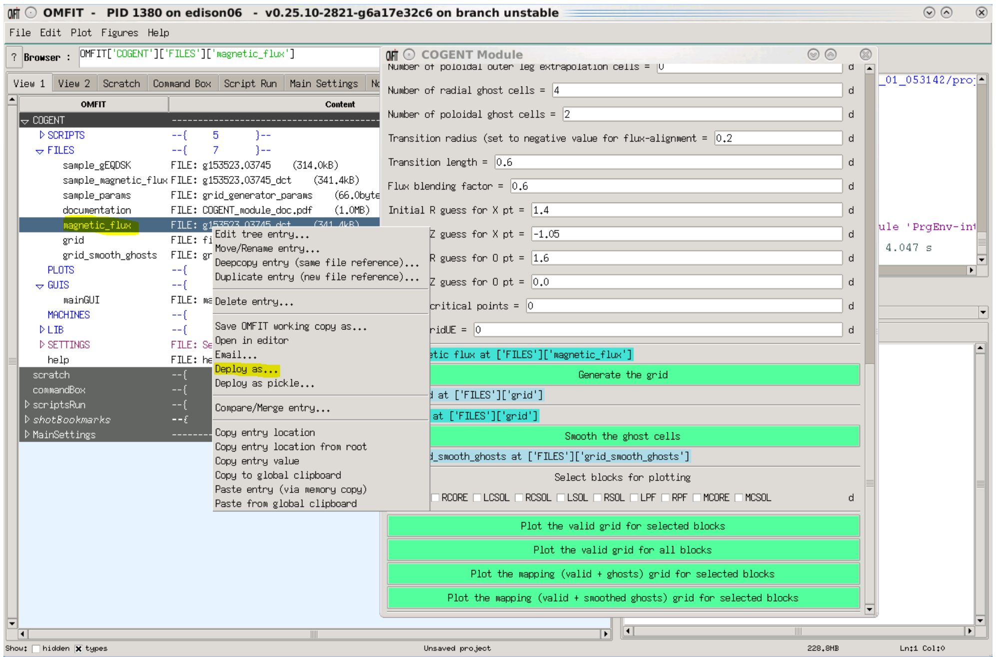


The "Select blocks for plotting" section enables plotting of the grids now generated on one or more blocks. The valid grids (*i.e.*, no ghost cells) can be plotted for all or selected blocks. Grids including ghost cells before ghost cell smoothing can be plotted by clicking the "Plot mapping (valid + ghosts) grid for selected blocks" button. Grids including ghost cells after ghost cell smoothing can be plotted by clicking the "Plot mapping (valid + smoothed ghosts) grid for selected blocks" button:

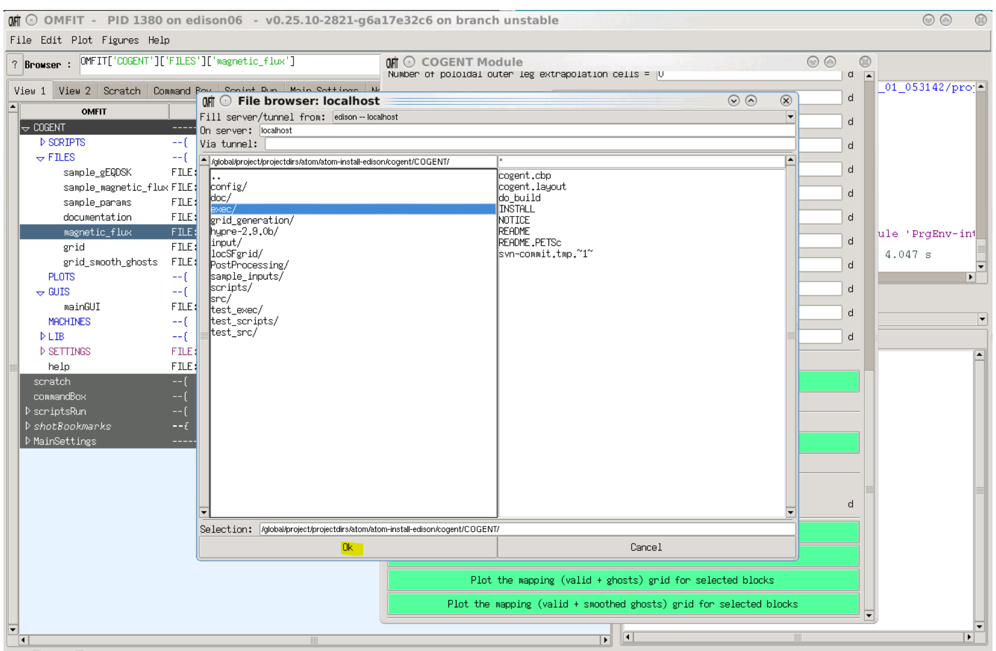


The intended workflow is one in which the user first sets the grid parameters, generates the valid grid, then plots the result. The grid parameters are then modified as desired, for example, to increase the number of poloidal grid cells in the core region or the size of the dealignment region at the X point. Once a satisfactory valid grid is obtained, smooth ghost cells are then generated. By plotting the result, one can then decide if further modifications are needed, for example, additional ghost cells to extend the mapping to a larger region.

Step 9: Write the magnetic flux and mapping file to the COGENT run directory
Right click the `['COGENT']['FILES']['magnetic_flux']` node to open a contex menu containing a "Deploy as" option:



Clicking the option opens a dialog box. Browse to the COGENT run directory, name the DCT coefficient file and hit OK:



Repeat the above to save the the mapping file at `['COGENT']['FILES']['grid_smooth_ghosts']`.

Step 10: Add the mapping grid and flux coefficient file paths to the COGENT input file

Having placed the mapping grid and flux coefficient files in the COGENT run directory, the last step is simply to edit the COGENT input file to point to them, *e.g.*, assuming the files are named `DIIID_mapping` and `DCT_coefficients`, respectively:

```
gksystem.magnetic_geometry_mapping.singlenull.geometry_file = "DIIID_mapping"
gksystem.magnetic_geometry_mapping.singlenull.field_coefficients_file
                                                          = "DCT_coefficients"
```

References

[1] O. Meneghini, `http://gafusion.github.io/OMFIT-source/index.html`.

[2] B. Dudson, `http://github.com/bendudson/Hypnotoad/`.

[3] M. R. Dorr, P. Colella, M. A. Dorf, D. Ghosh, J. A. F. Hittinger, P. O. Schwartz, "High-order Discretization of a Gyrokinetic Vlasov Model in Edge Plasma Geometry,", J. Comp. Phys. 373, No. 15, (2018), pp. 605-630. `doi.org/10.1016/j.jcp.2018.07.008`.