Photonics Simulation Workflow in VSim

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SIMULATIONS EMPOWERING YOUR INNOVATIONS

TWSS 2021

Overview

- Photonics
- Setup based
  - Geometries (CSG, GDS2)
  - Materials
  - Sources
  - Run parameters
  - Monitors
- Calculate modes
- Run
- Visualization
- S parameters calculation

Photonics devices

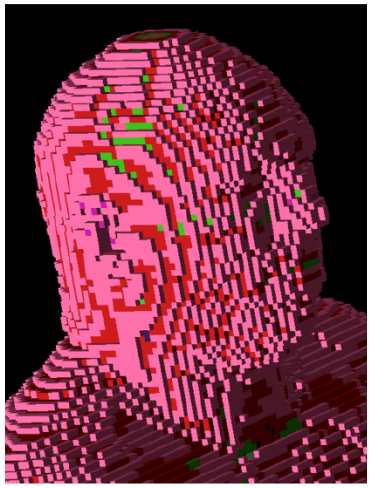
- Photonics: creating, manipulating and detecting light
- Si Photonics several dielectric materials as optical media:
  - Silicon: devices can be made using existing semiconductor fabrication techniques, and because silicon is already used as the substrate for most integrated circuits, it is possible to create hybrid devices in which the optical and electronic components are integrated onto a single microchip
  - Other materials: Si3N4
- In VSim: EM with dielectric materials and vacuum wavelengths around 1.55 micron (telecommunication wavelength)
- Applications: 5G, HPC, telecommunications, data centers, LIDAR
  - Long distance low loss signal transmission
  - High density data (multiples wavelengths), with multiplexing-demultiplexing

Structure of setup

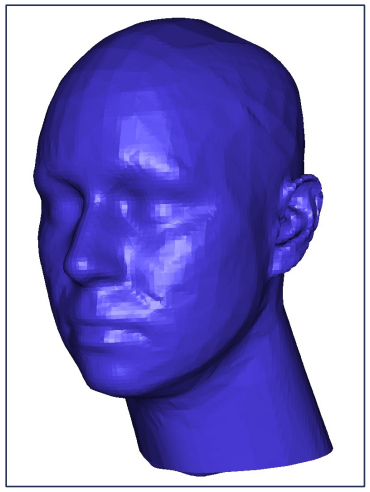
- Basic settings
- Geometry
- Materials
- Source
- Monitors (diagnostics)

Basic settings to pay attention to

- Dimensionality
  - Typically 3
  - You can do 2 for very large systems, but need to make sure that the system is symmetric
- VSim calculates time step (DT) for users, but to see it, you need to go the run panel
- Dielectric solver
  - Permittivity averaging (more memory, more accurate)
  - Point permittivity (less memory, less accurate)
- Background permittivity (can be in vacuum or SiO2, for example)



Point



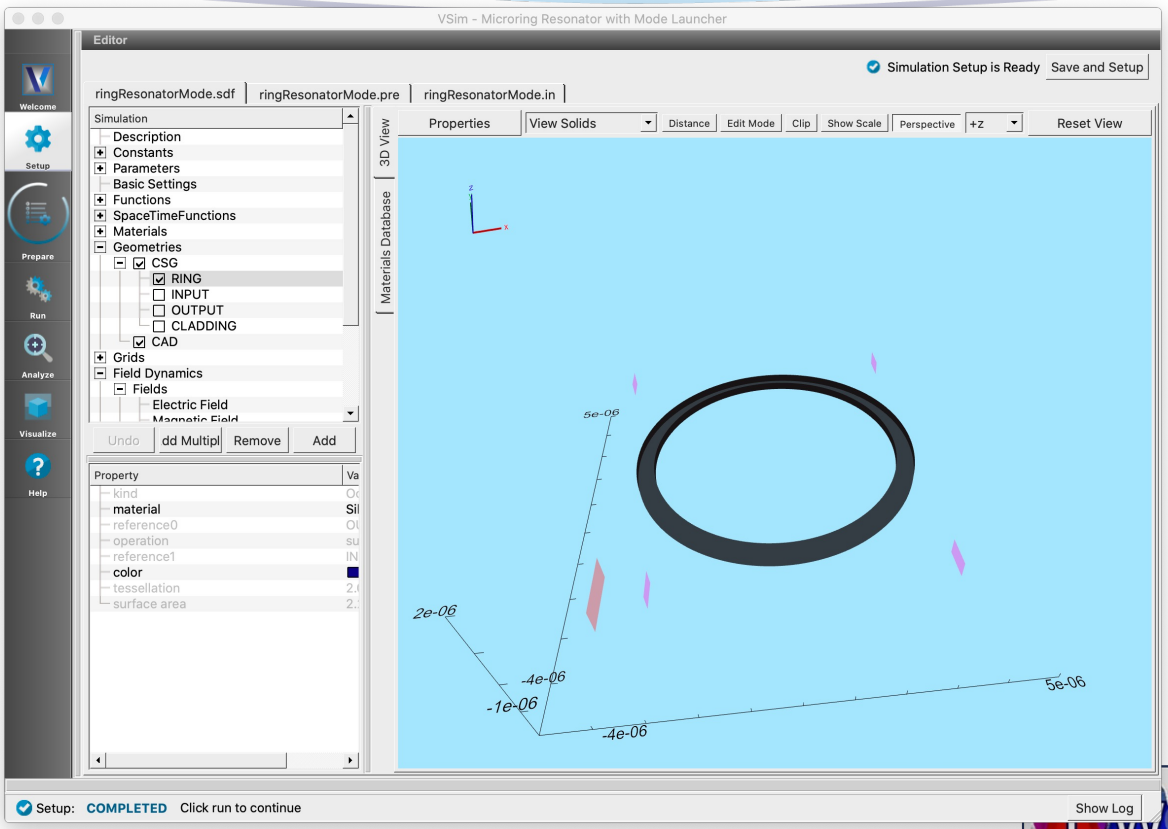
Averaged

Geometry can be created manually or imported

- Manual creating: using primitives, arrays and boolean operations
- Import CAD:
  - STL, commonly used in digital printing
  - GDS2 file format typically used for specifying integrated circuits

Example of CSG geometry

Ring: subtraction of two cylinders
Shapes used in Boolean operations do not have materials and can be hidden from the tree and the visualization



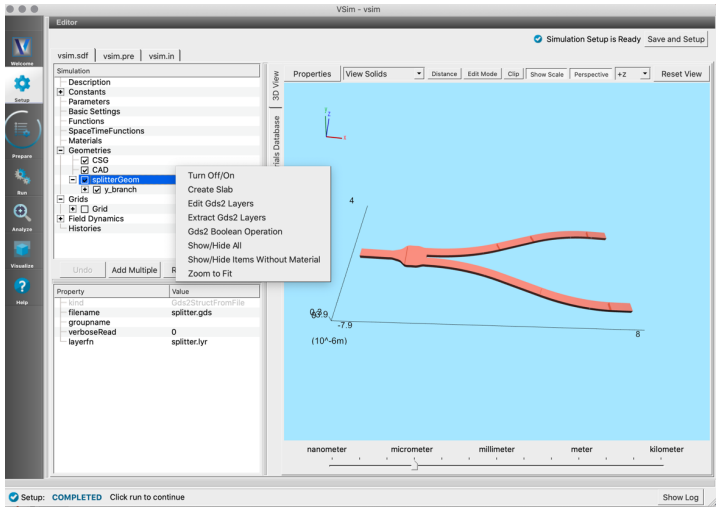
GDS2 import and editing

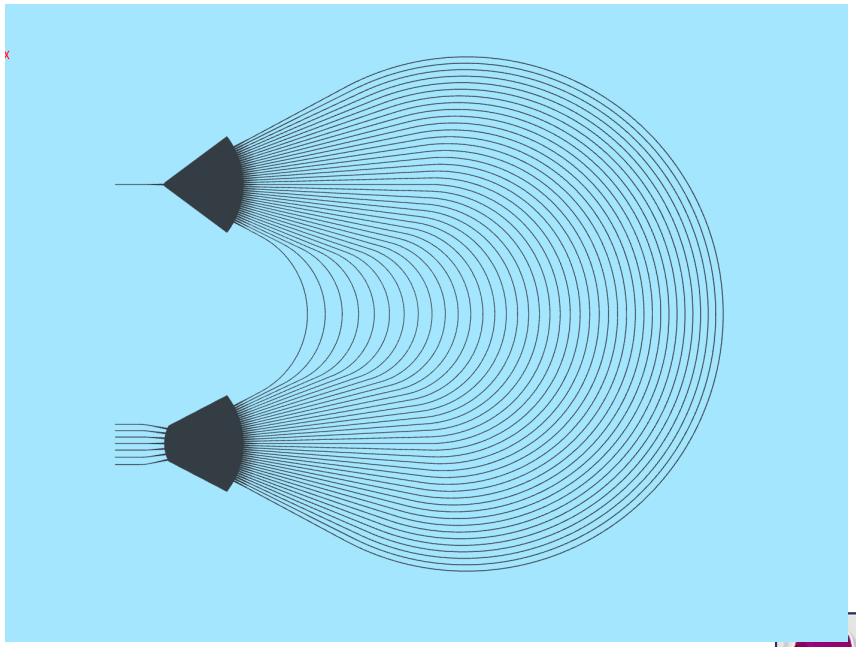
- GDS2 is 2D. There are specialized GDS2 tools: Klayout, gdspy, LayoutEditor
  - It is useful to play with your GDS2 file using these tools
  - GSD2 file consists of layers and does not contain information on z location and z size of the layer
- In VSim one can:
  - Import GDS2 file
  - Extract layers
  - Edit layers z information (thickness and location)
  - Perform Boolean operations on layers

Example of GDS2 geometry

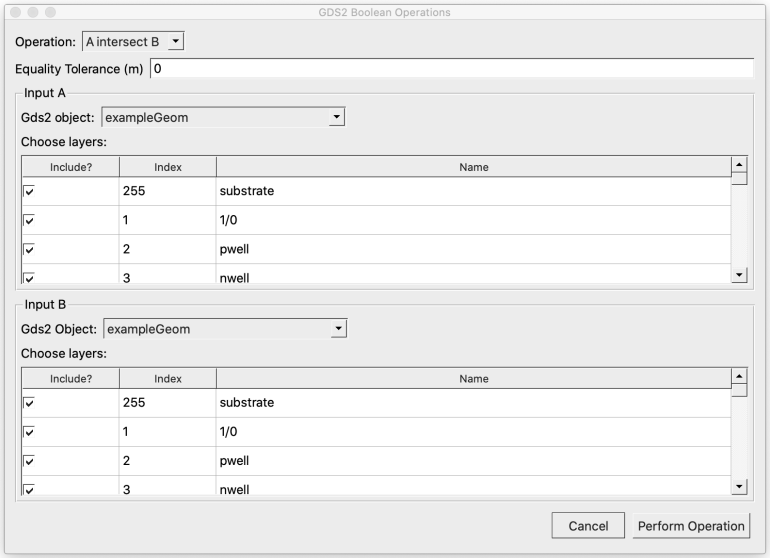
Arrayed Waveguide Grating: mixed signal comes in and gets s
separate frequencies at the output

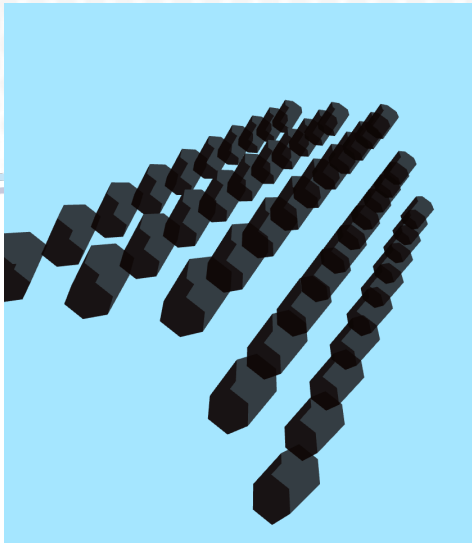
Y-splitter



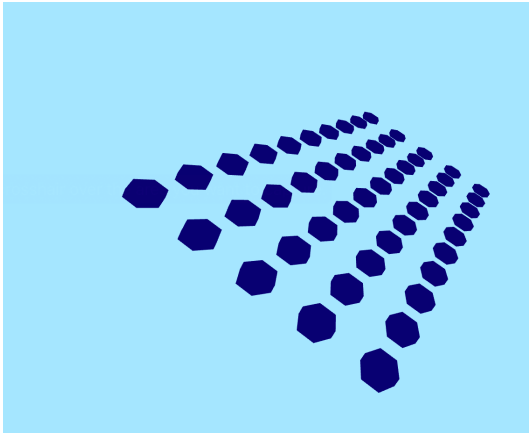


Boolean operations on layers





Original

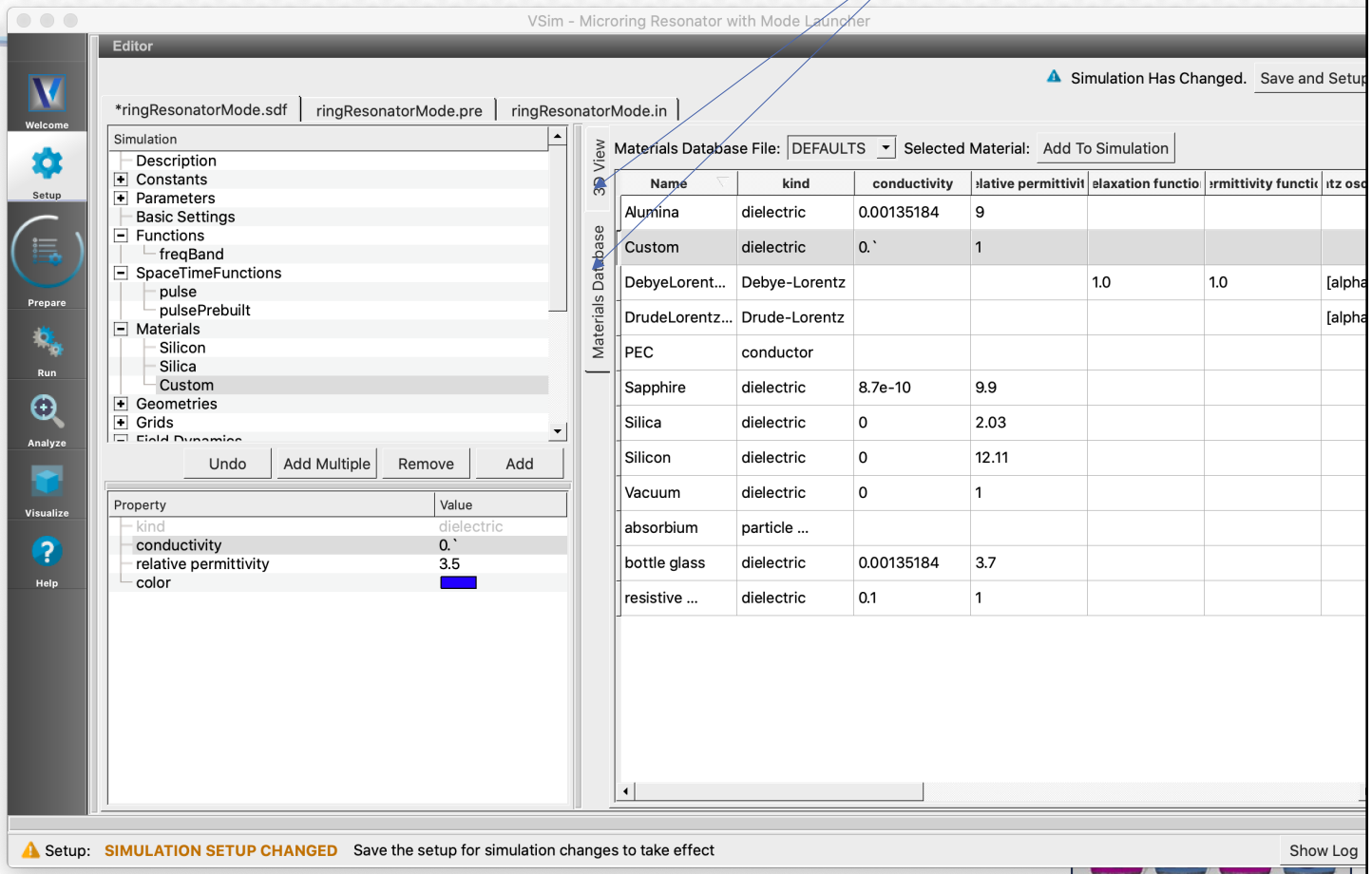


Union of all layers

One can create intersections, subtractions, unions of layers in 2D and assign them different z paramaters

Materials

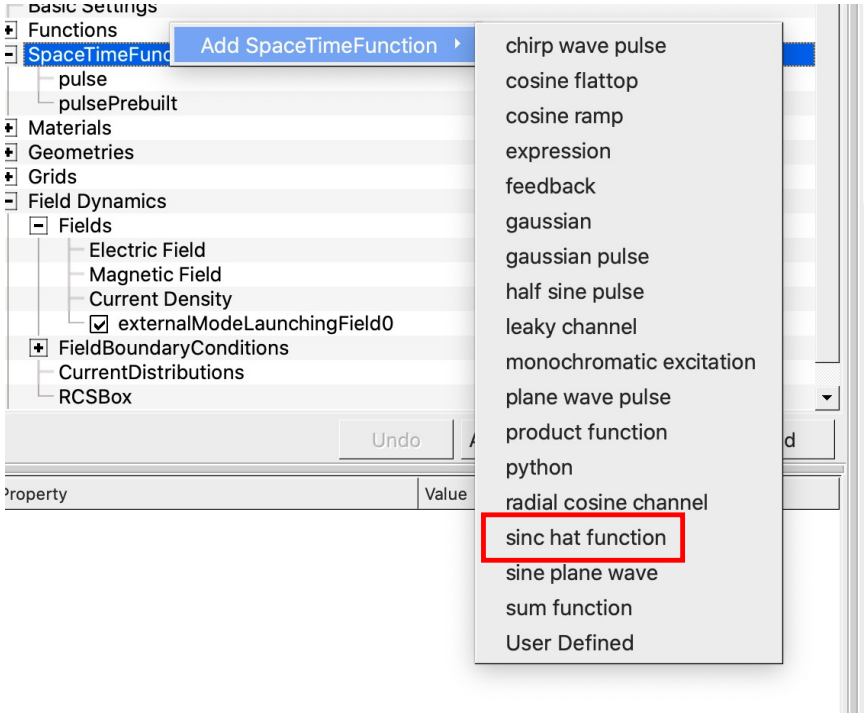
- Background permittivity is set in Basic settings
- Material database contains commonly used Si and SiO2
- Add to simulation
- Edit shapes to choose material
- If you need another material: use Custom material and set it properties



Light source are created by using functions or by using external fields

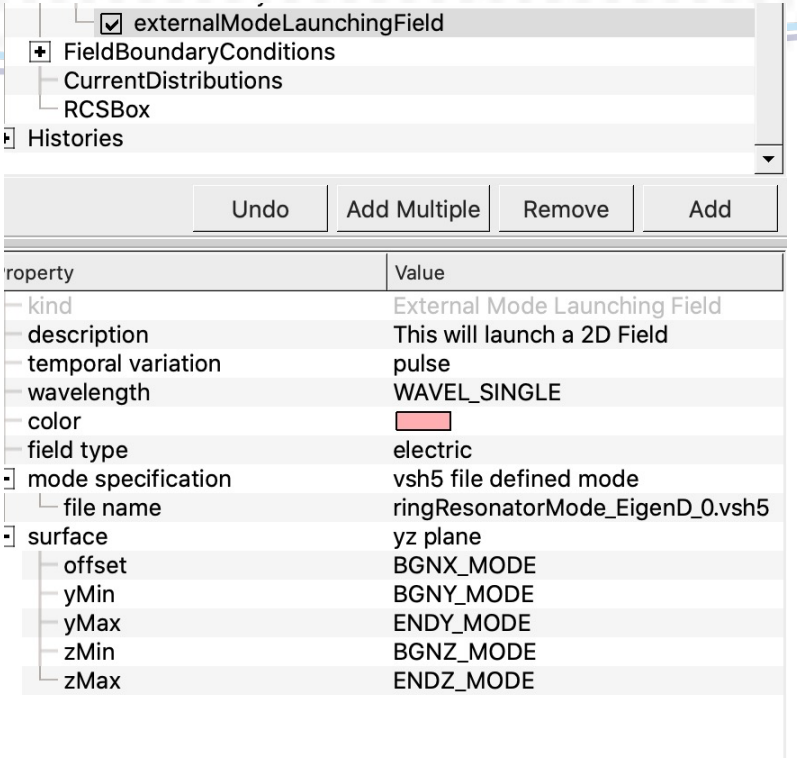
- Can be added as current or field
- Consists of the time function and space distribution
- Time dependency: use prebuilt functions
- Space function: use function (often we use Gaussian) or a use field profile from a 2D hdf5 file
  - External mode launcher using D field found by VSim
  - Mode propagating in x has invariant profile D(y,z)

One can use multiple prebuilt functions to construct time profile

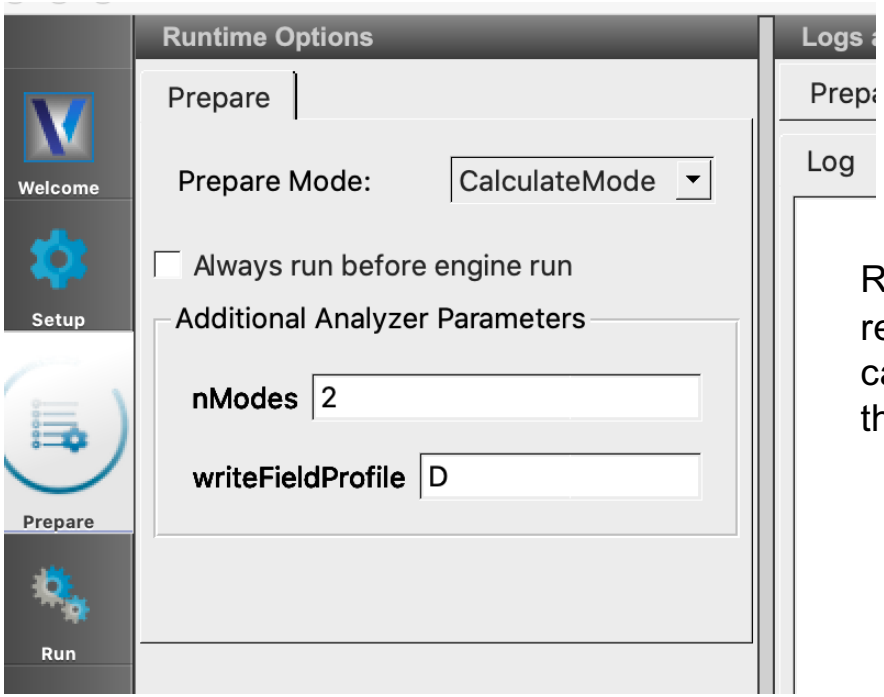


For photonics we will use syncHat function:
Uses min and max wavelengths and creates a flat signal limited by these values.

External mode refers to a file and time signal

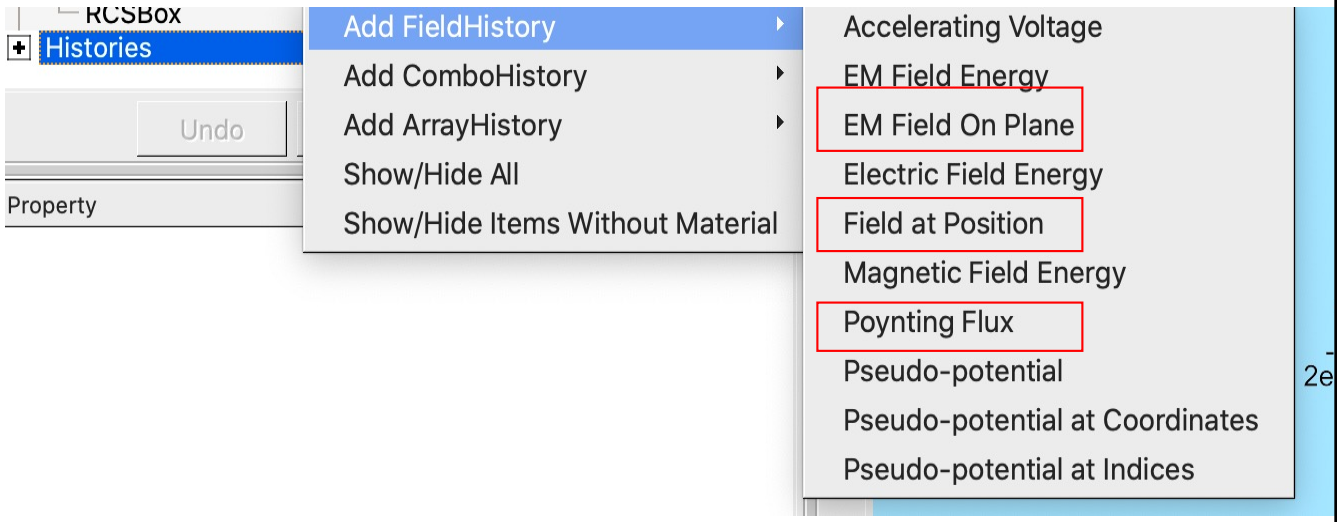


Find modes using Prepare tab



Runs simulation for 1 step, finds invEps,
reads parameters of the external launcher and
calculates modes. One can edit the name of
the field file in the launcher upon inspecting modes in viz panel

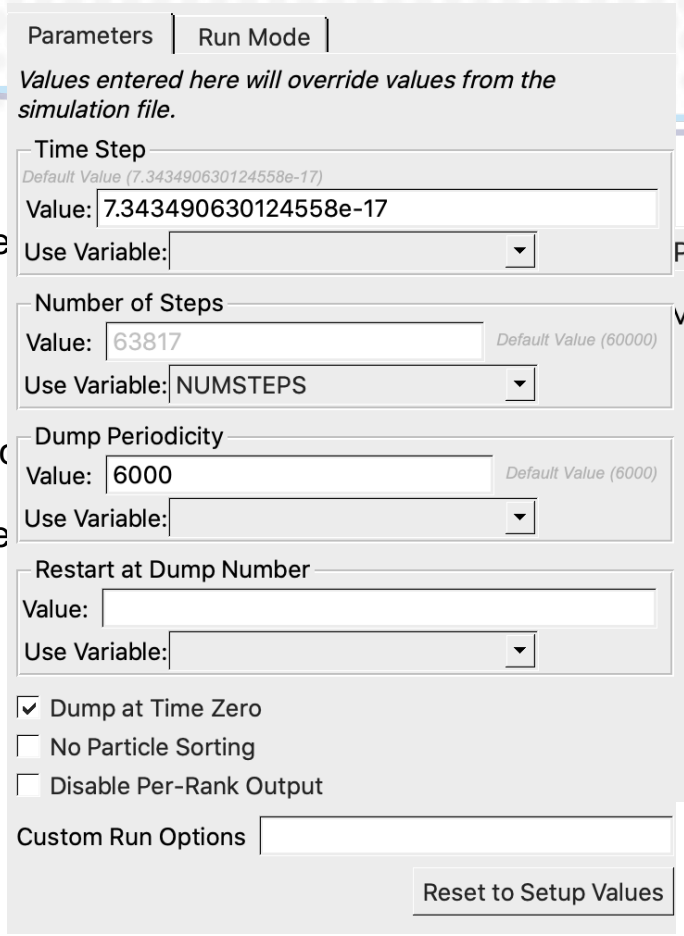
Diagnostics useful for photonics simulations

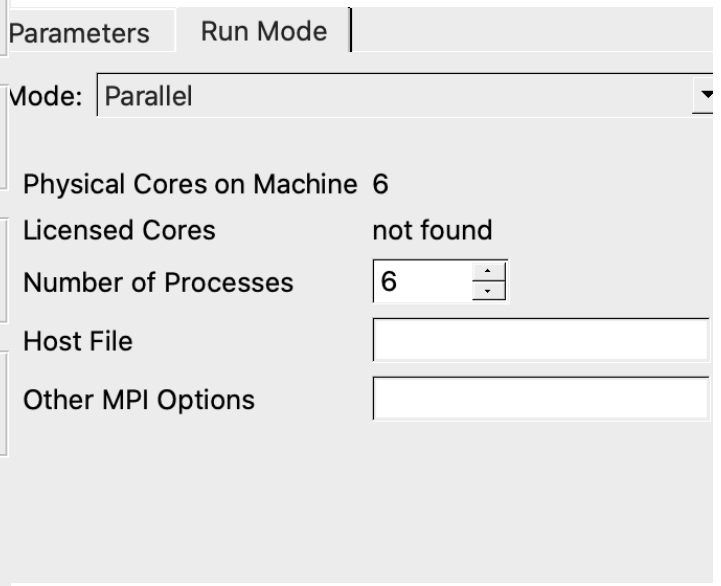


- History: a diagnostic collecting data at each time step
- EM Field on Plane: needed for S parameters calculation

Run panel

- Number of steps so that the signal goes several times across the syste to be able to get frequency domain data
- Dt is default (calculated by VSim)
- Look at the size of the dump file and plan the dumping periodicity accordingly (monitors/histories colle data at each step)

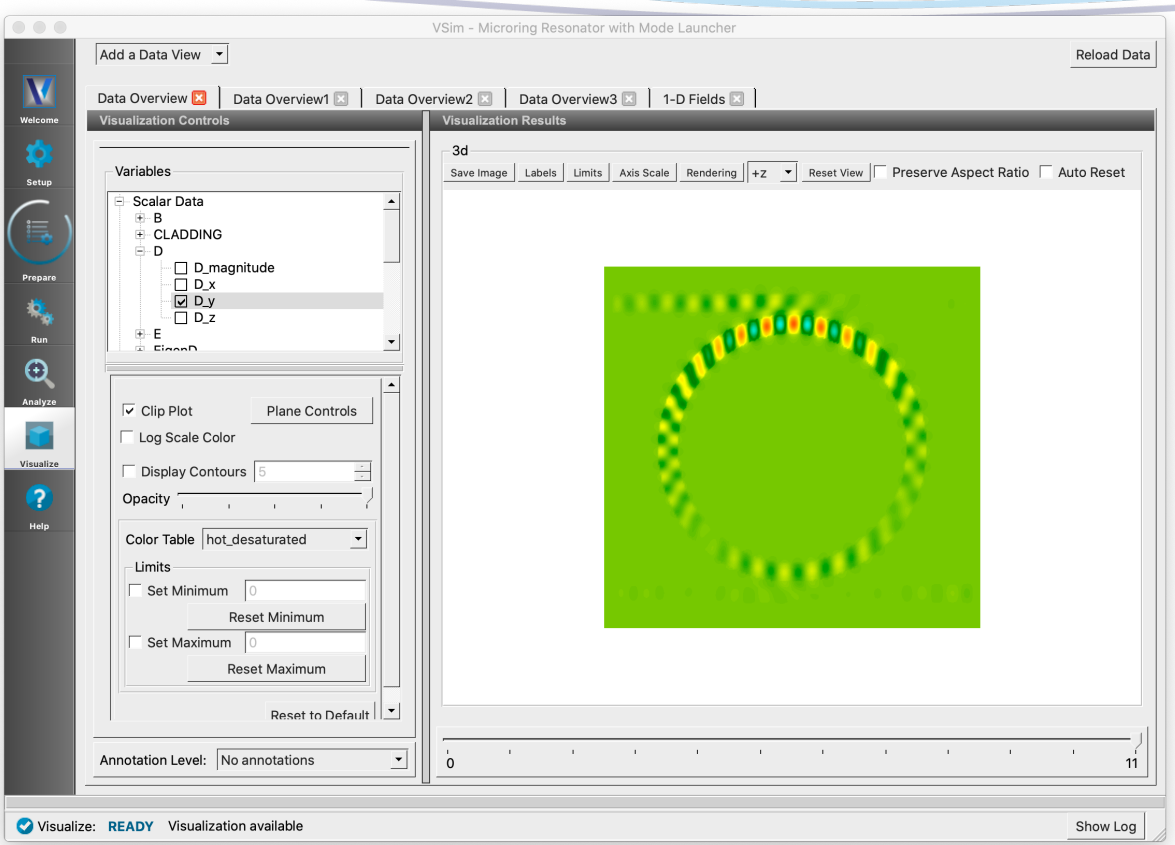




Visualization

- Can add multiple windows: use different windows for different dimensions (1D fields, one data overview for 2D fields, another data overview for 3D fields)
- Cuts
- Isosurfaces
- Color schemes
- Individual controls of each plot

See the field moving



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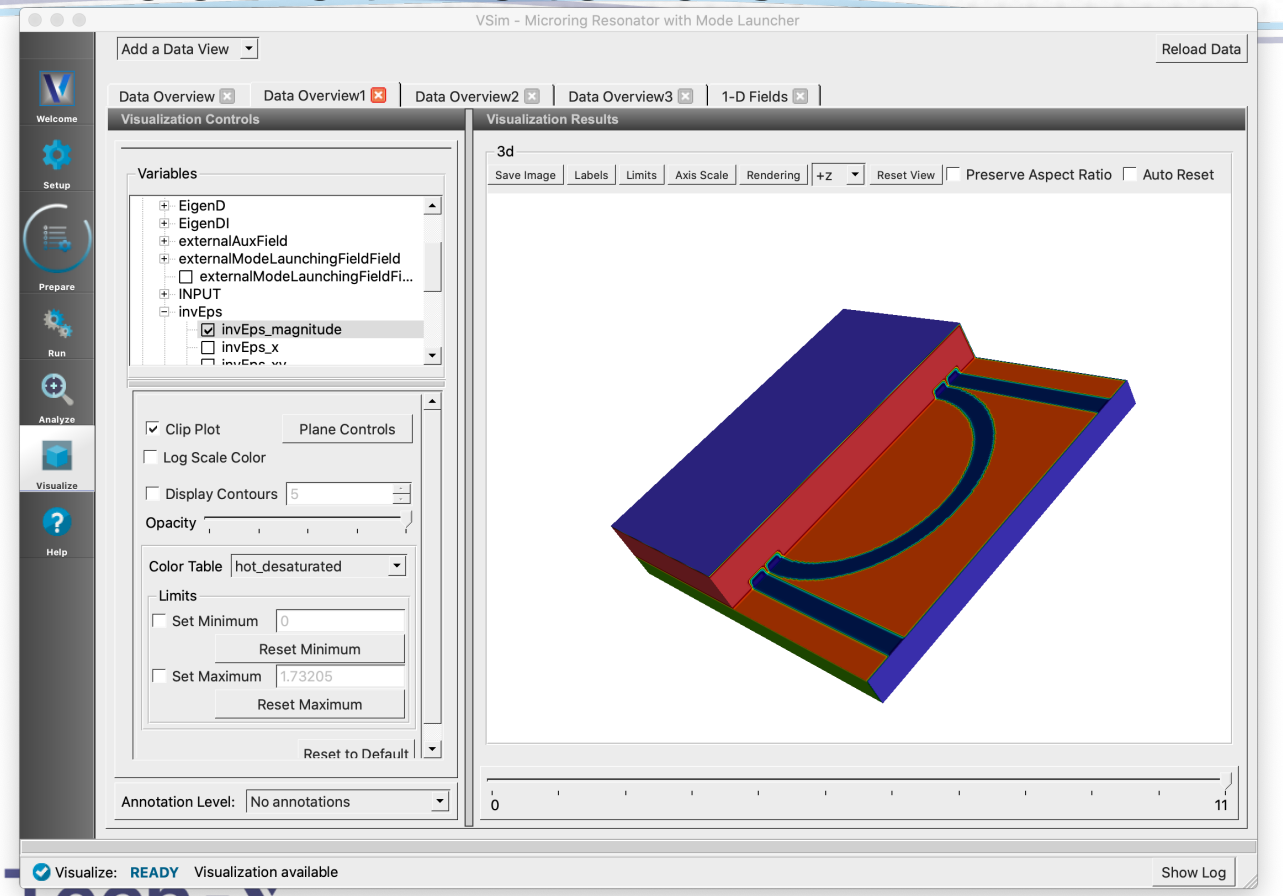
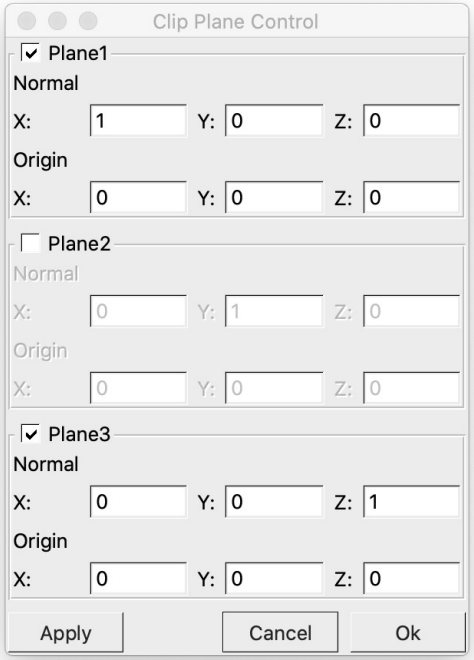
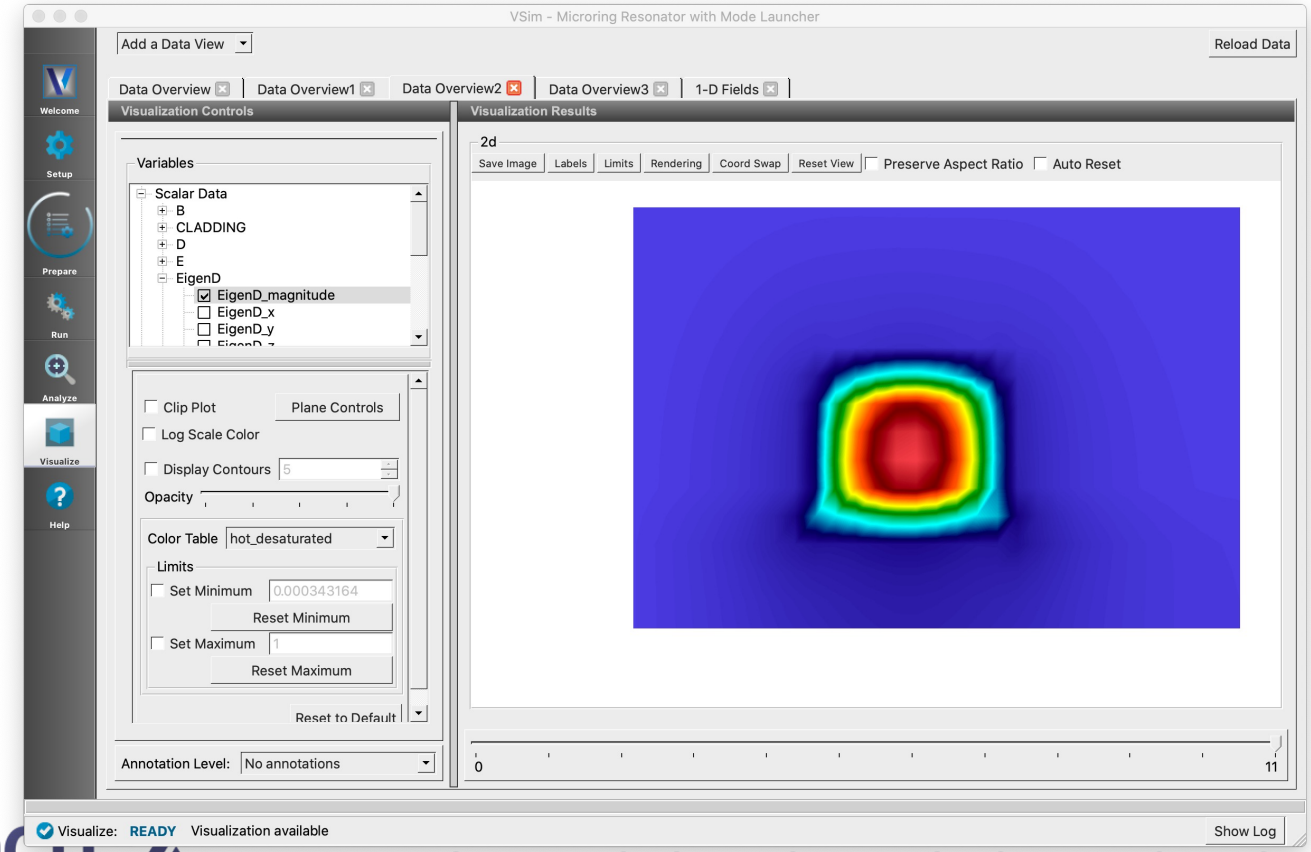
Look at materials

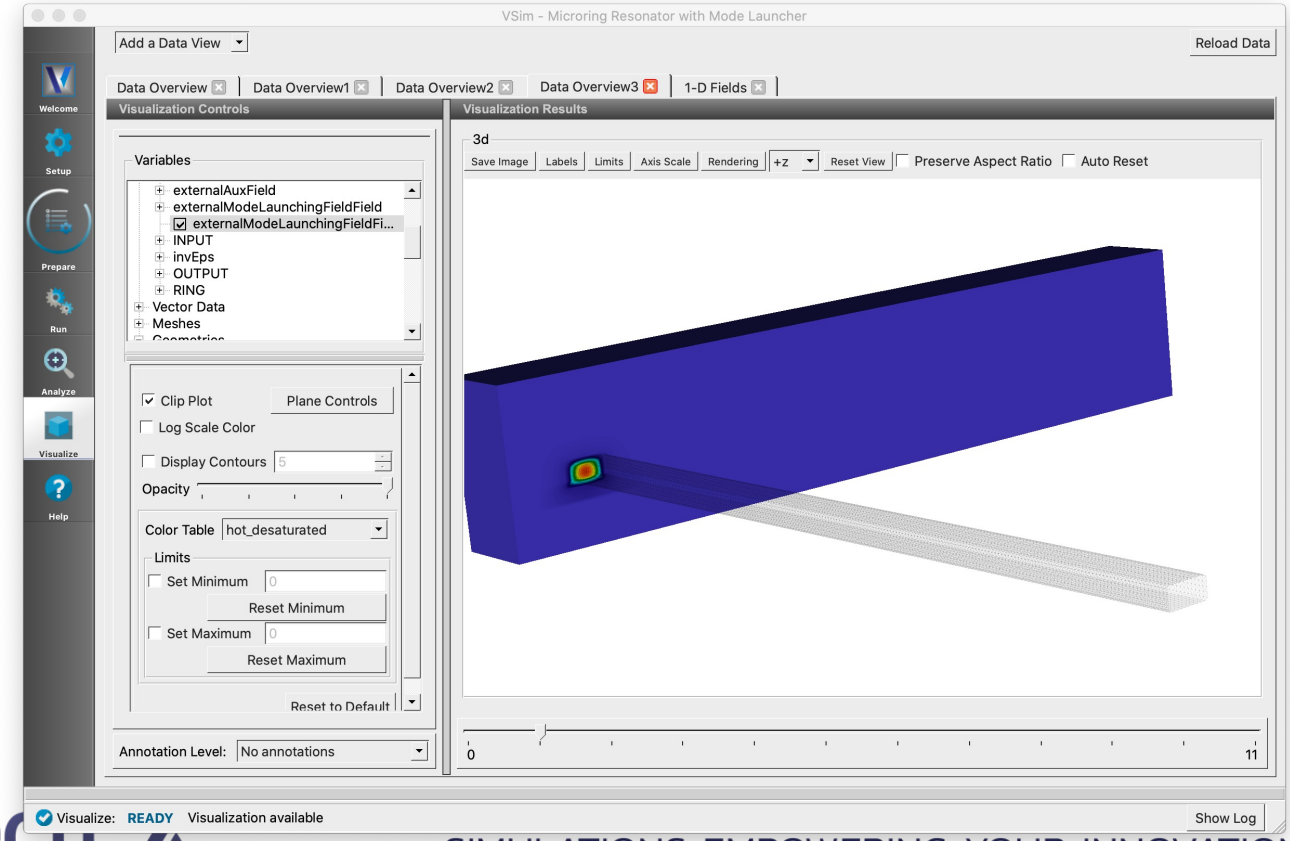




Look at modes

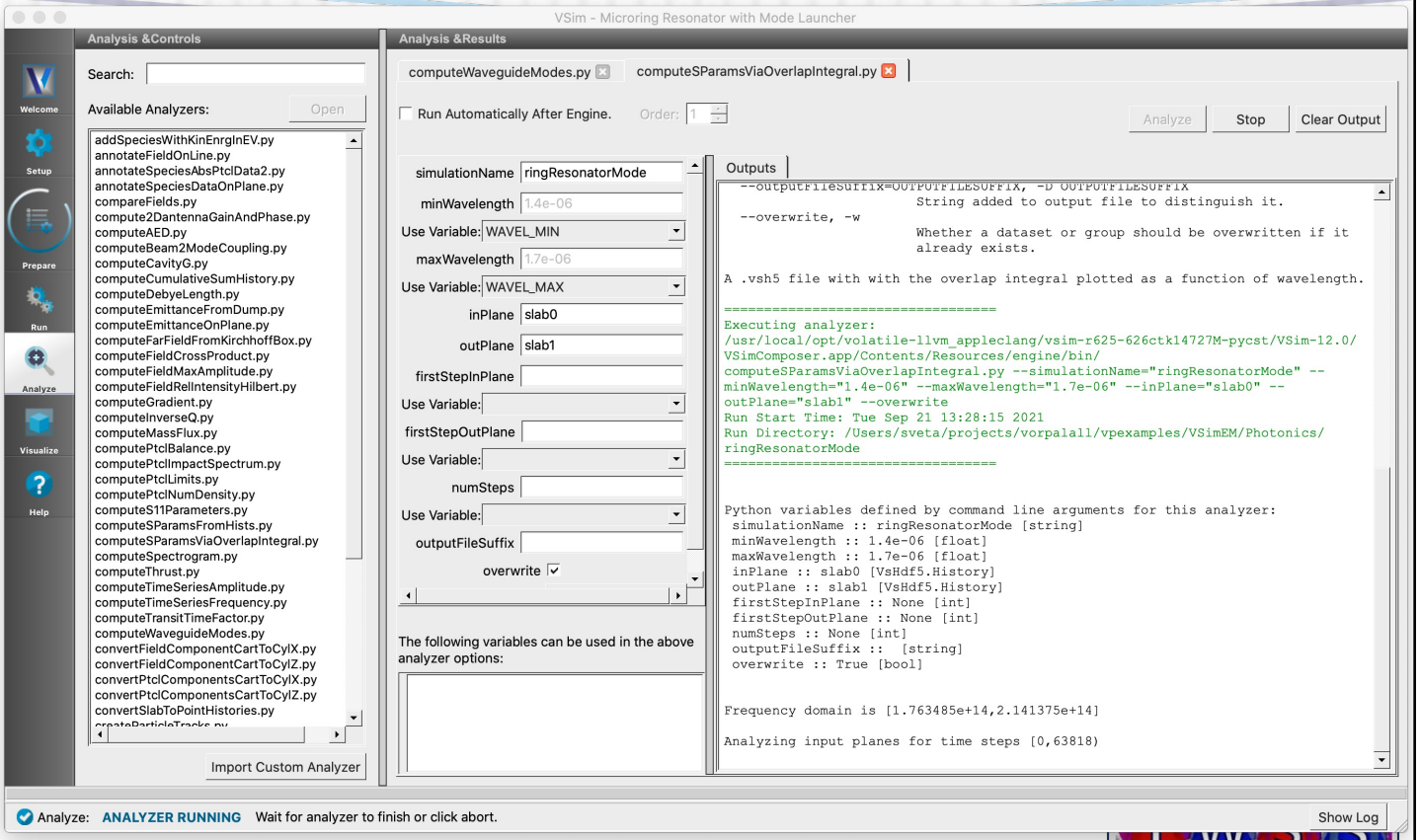


Source in the input



Calculating S parameters

- S parameter is ratio of the integrated power flux going though output and input as a function of vacuum wavelength



Visualize S parameters

- Go to Viz panel
- Reload data
- Add 1D visualization of available data