



# INTRODUCTION TO VSIM: VSIM COMPOSER & VORPAL

Setup, Parameters, Functions, Materials, Geometries,  
Fields, Boundary Conditions, Particles, & Histories

# Outline

- Simulation Requirements
- Useful Simulation Concepts
- Introduction to VSim
- Walkthrough of VSimComposer
- Basic Implementation of
- Conclusions

# Approaching Simulations

- Can the simulation be done?
  - What are the smallest and largest length scales involved?
  - What about time scales? Are you looking to resolve both ion and electron movement?
  - What is the plasma frequency? That affects the size of your time step
  - What do those requirements mean for the number of cells, number of time steps and time step length, needed to simulate and accurately capture?

- In our case of a Hall Thruster:

- Smallest characteristic length scale is typically a Debye length ( $L_D \sim (KT/nq^{**2})$  <-

TODO:LATEX

- In the high electron density locations, this can be of order a few tenths of microns ( $10^{**}-7$  m)

- Longest characteristic length is typically the size of the device – say a few centimeters ( $10^{**}-2$  m)

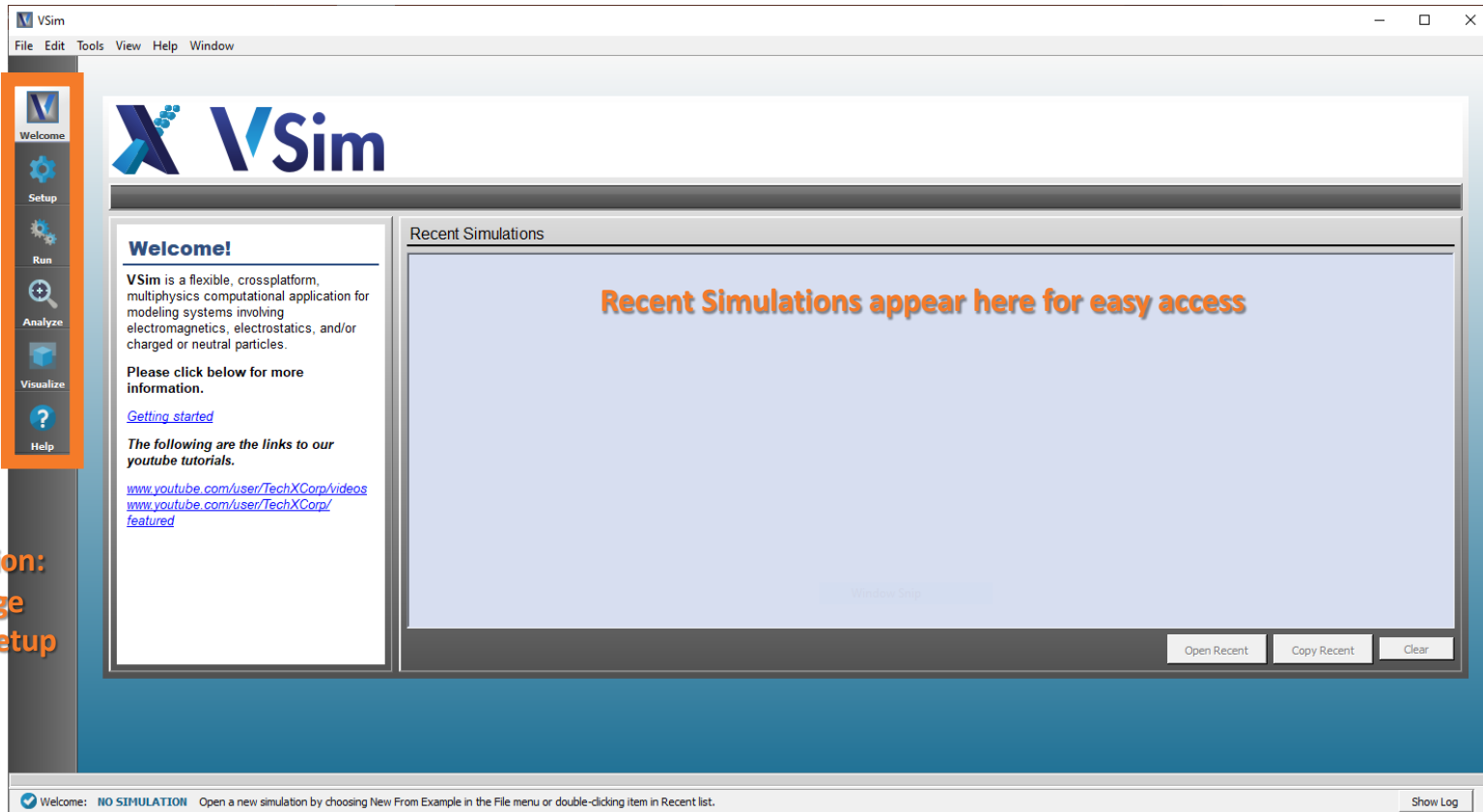
- Plasma frequency is of a few GHz ( $10^{**}9$  Hz),

- Time step is a few picoseconds ( $10^{**}-12$  s)

- What is the core physics looking to be explored?
  - Is it field related, particle-particle collisions, Temperature, Thermal velocity?
  - If collisions are important:
    - Compute the collision frequency using the background magnetic field.
    - If the collision frequency is " $f_c$ ", then make sure time step (DT) is such that  $DT < 1/f_c$
- What is the bare minimum required to obtain a physical result?
  - Increase complexity from there

# Welcome Screen

Welcome Tab



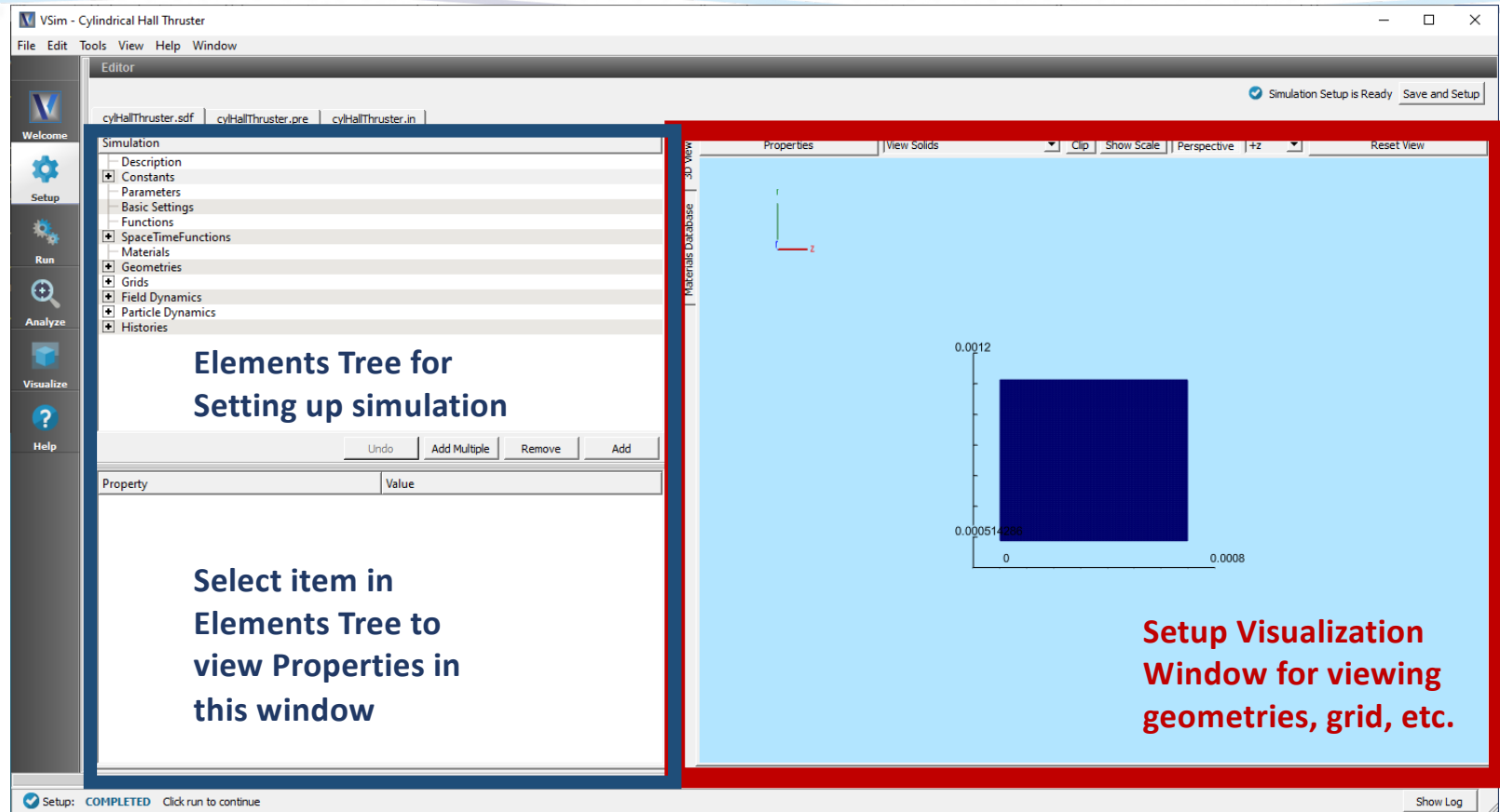
Tabs for navigation:

- Welcome Page
- Simulation Setup
- Running
- Analysis
- Visualization
- Help



SIMULATIONS EMPOWERING YOUR INNOVATIONS

# Default Setup View



# Materials Setup View

VSIm - Cylindrical Hall Thruster

File Edit Tools View Help Window

Editor

Simulation Setup Ready Save and Setup

Materials Database File: DEFAULTS Selected Material: Add To Simulation

3D View

Materials Database

Name	kind	conductivity	relative permittivity	relaxation function	armittivity function	ntz oscillator strer	lorentz frequen
Alumina	dielectric	0.00135184	9				
Custom	dielectric	0	1				
DebyeLorentzM...	Debye-Lorentz			1.0	1.0	[alphaFunction...	[frequencyFun
DrudeLorentzM...	Drude-Lorentz					[alphaFunction...	[frequencyFun
PEC	conductor						
Sapphire	dielectric	8.7e-10	9.9				
Silica	dielectric	0	2.03				
Silicon	dielectric	0	12.11				
Vacuum	dielectric	0	1				
absorbium	particle absorber						
bottle glass	dielectric	0.00135184	3.7				
resistive damper	dielectric	0.1	1				

Elements Tree for Setting up simulation

Select item in Elements Tree to view Properties in this window

Materials Table Window for viewing materials' kind, conductivity, etc.

Setup: COMPLETED Click run to continue

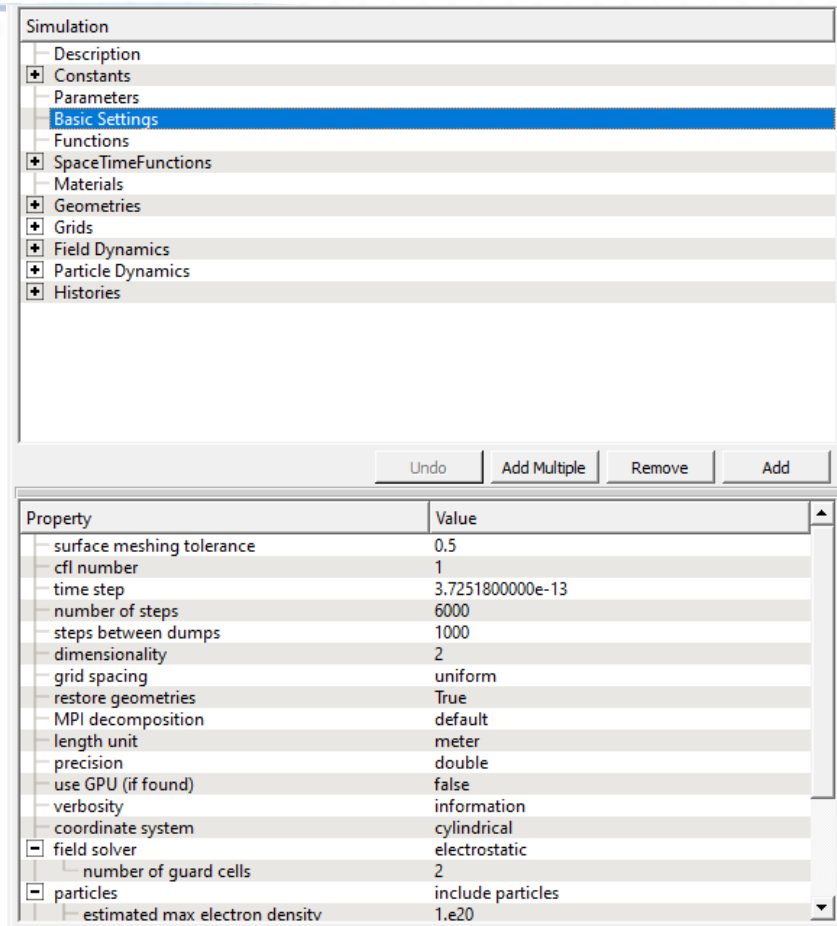
Show Log



# Basic Settings

Elements Tree for  
Setting up simulation

Properties of  
Selected Element  
(*Basic Settings*)



The screenshot shows a software interface for setting up a simulation. On the left, an 'Elements Tree' lists various simulation components: Simulation, Description, Constants, Parameters, **Basic Settings** (highlighted in blue), Functions, SpaceTimeFunctions, Materials, Geometries, Grids, Field Dynamics, Particle Dynamics, and Histories. On the right, a table displays the properties for the selected 'Basic Settings' element. The table has two columns: 'Property' and 'Value'. Below the table are buttons for 'Undo', 'Add Multiple', 'Remove', and 'Add'.

Property	Value
surface meshing tolerance	0.5
cfl number	1
time step	3.7251800000e-13
number of steps	6000
steps between dumps	1000
dimensionality	2
grid spacing	uniform
restore geometries	True
MPI decomposition	default
length unit	meter
precision	double
use GPU (if found)	false
verbosity	information
coordinate system	cylindrical
field solver	electrostatic
number of guard cells	2
particles	include particles
estimated max electron density	1.e20

Click on *Basic Settings* element in  
Tree to edit properties here

# Basic Settings

## Surface Meshing Tolerance

- Determines the relative size at which small cells from a meshed geometry surface are dropped.
- Set to 1.0 for simulations not containing any geometries.

Property	Value
surface meshing tolerance	0.5
cfl number	1
time step	3.7251800000e-13
number of steps	6000
steps between dumps	1000
dimensionality	2
grid spacing	uniform
restore geometries	True
MPI decomposition	default
length unit	meter
precision	double
use GPU (if found)	false
verbosity	information
coordinate system	cylindrical
<input type="checkbox"/> field solver	electrostatic
number of guard cells	2
<input type="checkbox"/> particles	include particles
estimated max electron density	1.e20
estimated max electron temperature (eV)	1.0
dump nodal fields	True
collisions framework	reduced
moving window	no moving window
periodic directions	no periodicity

# Basic Settings

## CFL Number

- If time step is set to zero, the time step is automatically calculated.
- For EM simulations, the time step is reduced proportionately with the CFL number.
- The CFL number is the ratio of time step to Courant limit.

Property	Value
surface meshing tolerance	0.5
cfl number	1
time step	3.7251800000e-13
number of steps	6000
steps between dumps	1000
dimensionality	2
grid spacing	uniform
restore geometries	True
MPI decomposition	default
length unit	meter
precision	double
use GPU (if found)	false
verbosity	information
coordinate system	cylindrical
<input checked="" type="checkbox"/> field solver	electrostatic
number of guard cells	2
<input checked="" type="checkbox"/> particles	include particles
estimated max electron density	1.e20
estimated max electron temperature (eV)	1.0
dump nodal fields	True
collisions framework	reduced
moving window	no moving window
periodic directions	no periodicity

# Basic Settings

## Time Step

- If set to a value that is non-zero, this will be used as the simulation time step.
- If set to zero, the time step is calculated for you based on a number of factors.

Property	Value
surface meshing tolerance	0.5
cfl number	1
time step	3.7251800000e-13
number of steps	6000
steps between dumps	1000
dimensionality	2
grid spacing	uniform
restore geometries	True
MPI decomposition	default
length unit	meter
precision	double
use GPU (if found)	false
verbosity	information
coordinate system	cylindrical
<input checked="" type="checkbox"/> field solver	electrostatic
number of guard cells	2
<input checked="" type="checkbox"/> particles	include particles
estimated max electron density	1.e20
estimated max electron temperature (eV)	1.0
dump nodal fields	True
collisions framework	reduced
moving window	no moving window
periodic directions	no periodicity

# Basic Settings

## Number of Steps

- The number of time steps to run the simulation.

Property	Value
surface meshing tolerance	0.5
cfl number	1
time step	3.7251800000e-13
number of steps	6000
steps between dumps	1000
dimensionality	2
grid spacing	uniform
restore geometries	True
MPI decomposition	default
length unit	meter
precision	double
use GPU (if found)	false
verbosity	information
coordinate system	cylindrical
<input type="checkbox"/> field solver	electrostatic
number of guard cells	2
<input type="checkbox"/> particles	include particles
estimated max electron density	1.e20
estimated max electron temperature (eV)	1.0
dump nodal fields	True
collisions framework	reduced
moving window	no moving window
periodic directions	no periodicity

# Basic Settings

## Steps Between Dumps

- The number of time steps between sequential dumps of data to hdf5 format files.

Property	Value
surface meshing tolerance	0.5
cfl number	1
time step	3.7251800000e-13
number of steps	6000
steps between dumps	1000
dimensionality	2
grid spacing	uniform
restore geometries	True
MPI decomposition	default
length unit	meter
precision	double
use GPU (if found)	false
verbosity	information
coordinate system	cylindrical
<input checked="" type="checkbox"/> field solver	electrostatic
number of guard cells	2
<input checked="" type="checkbox"/> particles	include particles
estimated max electron density	1.e20
estimated max electron temperature (eV)	1.0
dump nodal fields	True
collisions framework	reduced
moving window	no moving window
periodic directions	no periodicity

# Basic Settings

## Dimensionality

- Set to 1, 2, or 3 to indicate how many dimensions to run the simulation in.

Property	Value
surface meshing tolerance	0.5
cfl number	1
time step	3.7251800000e-13
number of steps	6000
steps between dumps	1000
dimensionality	2
grid spacing	uniform
restore geometries	True
MPI decomposition	default
length unit	meter
precision	double
use GPU (if found)	false
verbosity	information
coordinate system	cylindrical
<input checked="" type="checkbox"/> field solver	electrostatic
number of guard cells	2
<input checked="" type="checkbox"/> particles	include particles
estimated max electron density	1.e20
estimated max electron temperature (eV)	1.0
dump nodal fields	True
collisions framework	reduced
moving window	no moving window
periodic directions	no periodicity

# Basic Settings

## Coordinate System

- The type of coordinate system to work in.
  - cartesian
  - cylindrical
- For cylindrical coordinates, only 2 dimensional electrostatic simulations are currently available in visual setup.

Property	Value
surface meshing tolerance	0.5
cfl number	1
time step	3.7251800000e-13
number of steps	6000
steps between dumps	1000
dimensionality	2
grid spacing	uniform
restore geometries	True
MPI decomposition	default
length unit	meter
precision	double
use GPU (if found)	false
verbosity	information
coordinate system	cylindrical
<input type="checkbox"/> field solver	electrostatic
number of guard cells	2
<input type="checkbox"/> particles	include particles
estimated max electron density	1.e20
estimated max electron temperature (eV)	1.0
dump nodal fields	True
collisions framework	reduced
moving window	no moving window
periodic directions	no periodicity



# Basic Settings

## Field Solver

- The field solver determines which equations will be used to calculate the fields:
1. Electrostatic
    - number of guard cells
  2. Electromagnetic
    - Cerenkov Filter
    - Electromagnetic problems allow for the selection of a numerical Cerenkov noise filter.

Property	Value
surface meshing tolerance	0.5
cfl number	1
time step	3.7251800000e-13
number of steps	6000
steps between dumps	1000
dimensionality	2
grid spacing	uniform
restore geometries	True
MPI decomposition	default
length unit	meter
precision	double
use GPU (if found)	false
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coordinate system	cylindrical
<input checked="" type="checkbox"/> field solver	electrostatic
number of guard cells	2
<input checked="" type="checkbox"/> particles	include particles
estimated max electron density	1.e20
estimated max electron temperature (eV)	1.0
dump nodal fields	True
collisions framework	reduced
moving window	no moving window
periodic directions	no periodicity

# Basic Settings

## Particles

- Whether or not to include particles in the simulation.
  1. no particles
  2. include particles
- If particles are included in the simulation, the following 2 properties are used to help calculate the time step.
  - estimated max electron density
  - estimated min electron temperature (eV)

Property	Value
surface meshing tolerance	0.5
cfl number	1
time step	3.7251800000e-13
number of steps	6000
steps between dumps	1000
dimensionality	2
grid spacing	uniform
restore geometries	True
MPI decomposition	default
length unit	meter
precision	double
use GPU (if found)	false
verbosity	information
coordinate system	cylindrical
<input type="checkbox"/> field solver	electrostatic
number of guard cells	2
<input type="checkbox"/> particles	include particles
estimated max electron density	1.e20
estimated max electron temperature (eV)	1.0
dump nodal fields	True
collisions framework	reduced
moving window	no moving window
periodic directions	no periodicity

# Basic Settings

## Collisions Framework

- Whether or not to include particles in the simulation.
  1. no particles
  2. include particles
- If particles are included in the simulation, the following 2 properties are used to help calculate the time step.
  - estimated max electron density
  - estimated min electron temperature (eV)

Property	Value
surface meshing tolerance	0.5
cfl number	1
time step	3.7251800000e-13
number of steps	6000
steps between dumps	1000
dimensionality	2
grid spacing	uniform
restore geometries	True
MPI decomposition	default
length unit	meter
precision	double
use GPU (if found)	false
verbosity	information
coordinate system	cylindrical
<input checked="" type="checkbox"/> field solver	electrostatic
number of guard cells	2
<input checked="" type="checkbox"/> particles	include particles
estimated max electron density	1.e20
estimated max electron temperature (eV)	1.0
dump nodal fields	True
collisions framework	reduced
moving window	no moving window
periodic directions	no periodicity

# Basic Settings

## Moving Window

- Whether or not to use a moving window which allows the simulation window to move at the speed of light in the chosen direction.
- Useful for simulations such as laser pulse or particle beam moving at a velocity close to the speed of light.

Property	Value
surface meshing tolerance	0.5
cfl number	1
time step	3.7251800000e-13
number of steps	6000
steps between dumps	1000
dimensionality	2
grid spacing	uniform
restore geometries	True
MPI decomposition	default
length unit	meter
precision	double
use GPU (if found)	false
verbosity	information
coordinate system	cylindrical
<input type="checkbox"/> field solver	electrostatic
number of guard cells	2
<input type="checkbox"/> particles	include particles
estimated max electron density	1.e20
estimated max electron temperature (eV)	1.0
dump nodal fields	True
collisions framework	reduced
<b>moving window</b>	no moving window
periodic directions	no periodicity

# Basic Settings

## Periodic Directions

- The directions of the simulation which should be modelled as periodic, if any.

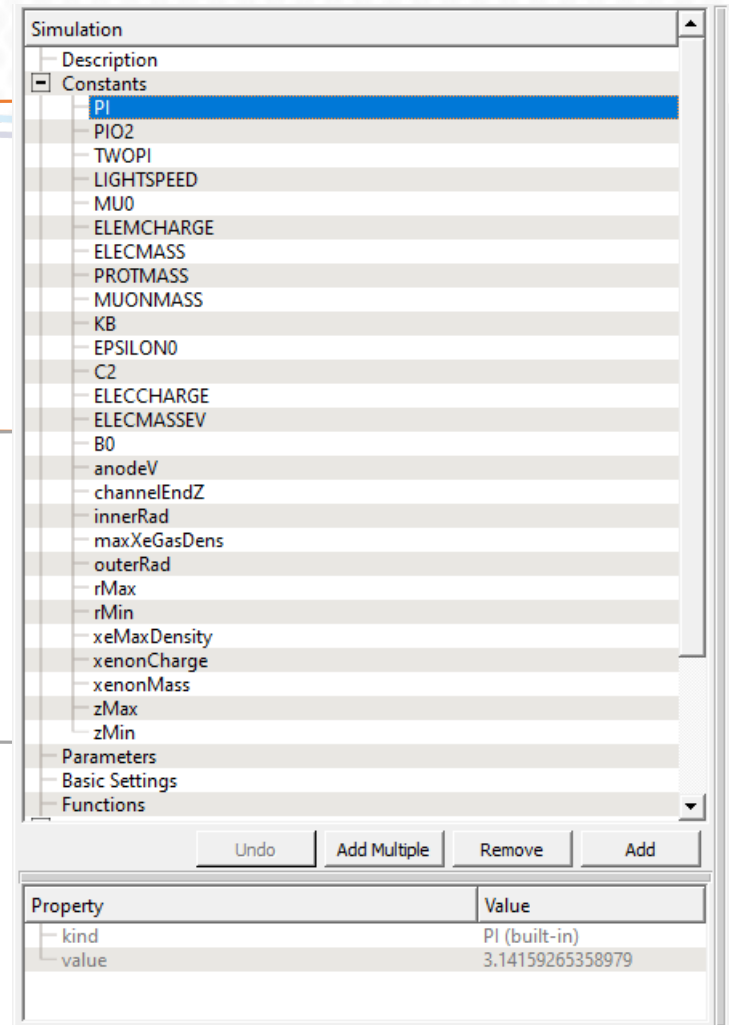
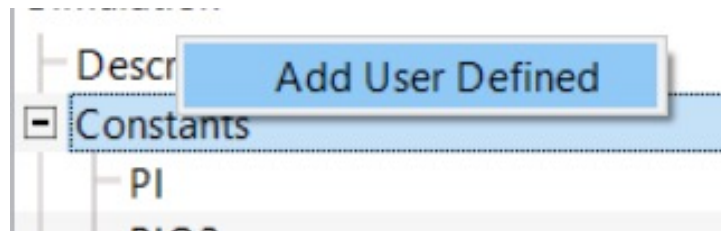
Property	Value
surface meshing tolerance	0.5
cfl number	1
time step	3.7251800000e-13
number of steps	6000
steps between dumps	1000
dimensionality	2
grid spacing	uniform
restore geometries	True
MPI decomposition	default
length unit	meter
precision	double
use GPU (if found)	false
verbosity	information
coordinate system	cylindrical
<input checked="" type="checkbox"/> field solver	electrostatic
number of guard cells	2
<input checked="" type="checkbox"/> particles	include particles
estimated max electron density	1.e20
estimated max electron temperature (eV)	1.0
dump nodal fields	True
collisions framework	reduced
moving window	no moving window
<input checked="" type="checkbox"/> periodic directions	no periodicity

# Constants

**Built-in universal constants:**  
 $\pi$ ,  $2\pi$ ,  $c$ ,  $m_e$ ,  $e^-$ ,  $m_p$ , etc.

**User-defined constants:**  
lengths, frequencies, etc.

**Right-click on element  
in tree**



# Derived Parameters

Parameter Name



Parameter Expression



phasedArrayAntenna.sdf | phasedArrayAntenna.pre | phasedArrayAntenna.in

Simulation

- Description
- Constants
- Parameters
  - THETA**
  - WAVELENGTH
  - LENGTH\_ANTENNA
  - RADIUS\_ANTENNA
  - T\_OFF
  - NTSTEPS
  - OMEGA
  - AMP\_GAUSS
  - SPACING
  - CVL0\_XY
- Basic Settings
- Functions
- SpaceTimeFunctions
- Materials
- Geometries

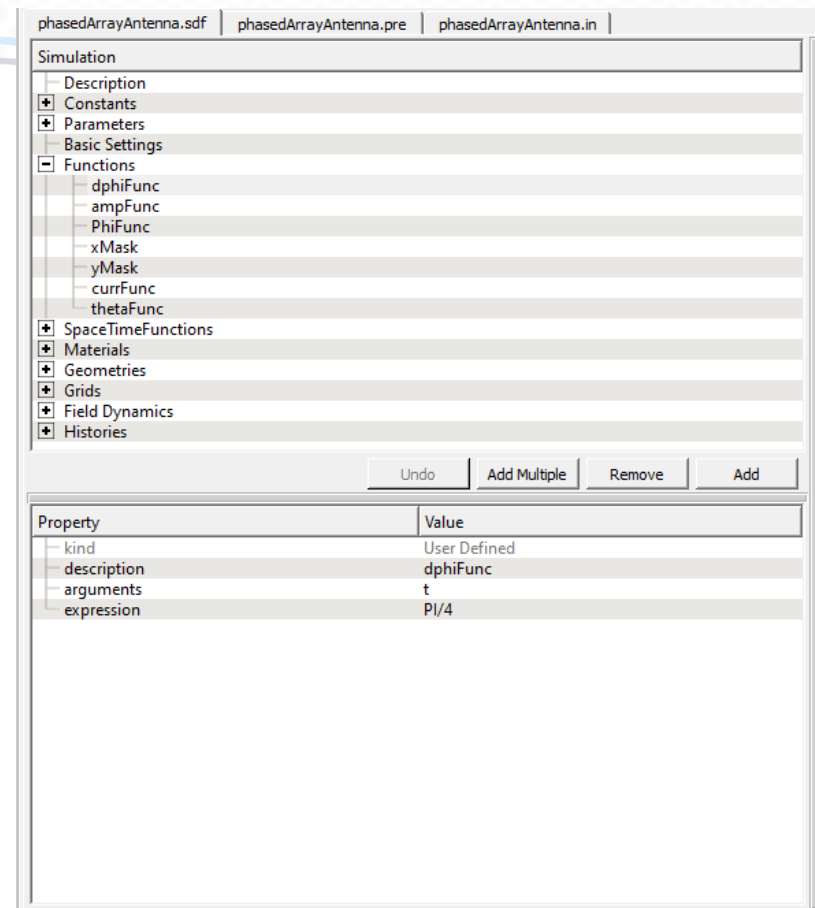
Undo Add Multiple Remove Add

Property	Value
kind	User Defined
description	
expression	$\pi/4$
value	0.785398163397448

VSIm calculates the parameter value from the provided expression

# Functions

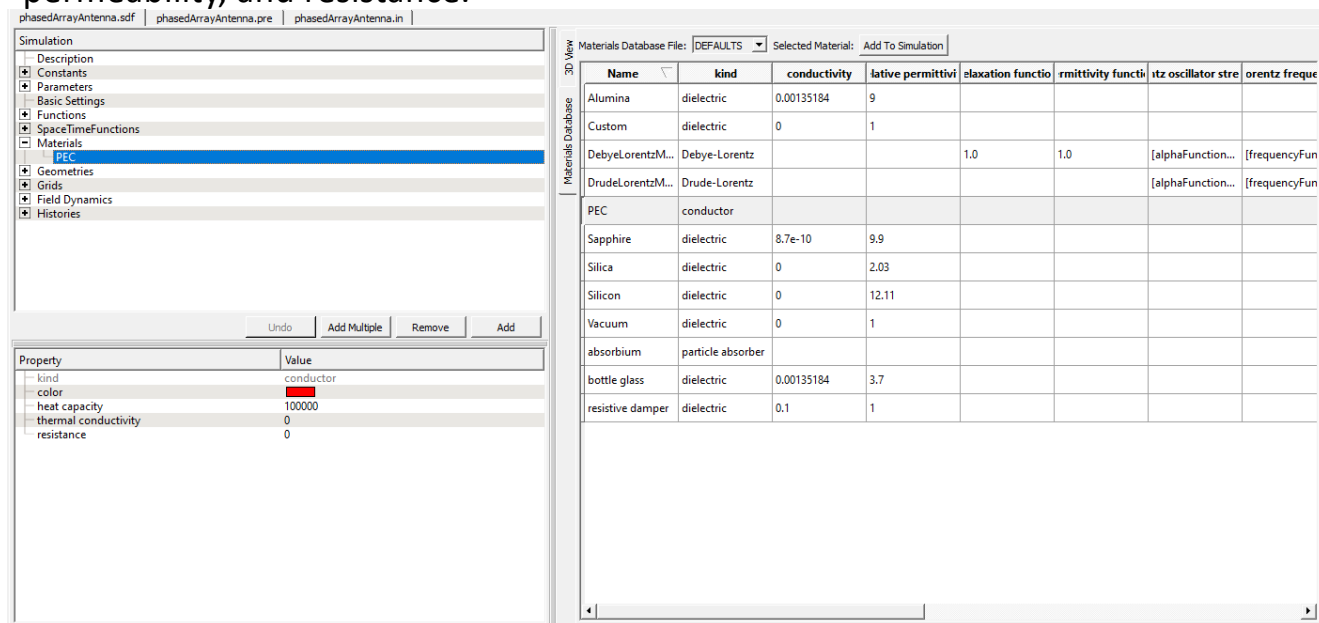
1. Create your own function.
  2. Built-in turn on function.
- The function can contain any number of arbitrary arguments and is not limited to the default values of x,y.
  - The user-supplied expression is a function of the arguments given in the argument property.
  - The expression can include any pre-defined Constants, Parameters, or Functions, as well as real numbers and python operator.





# Materials

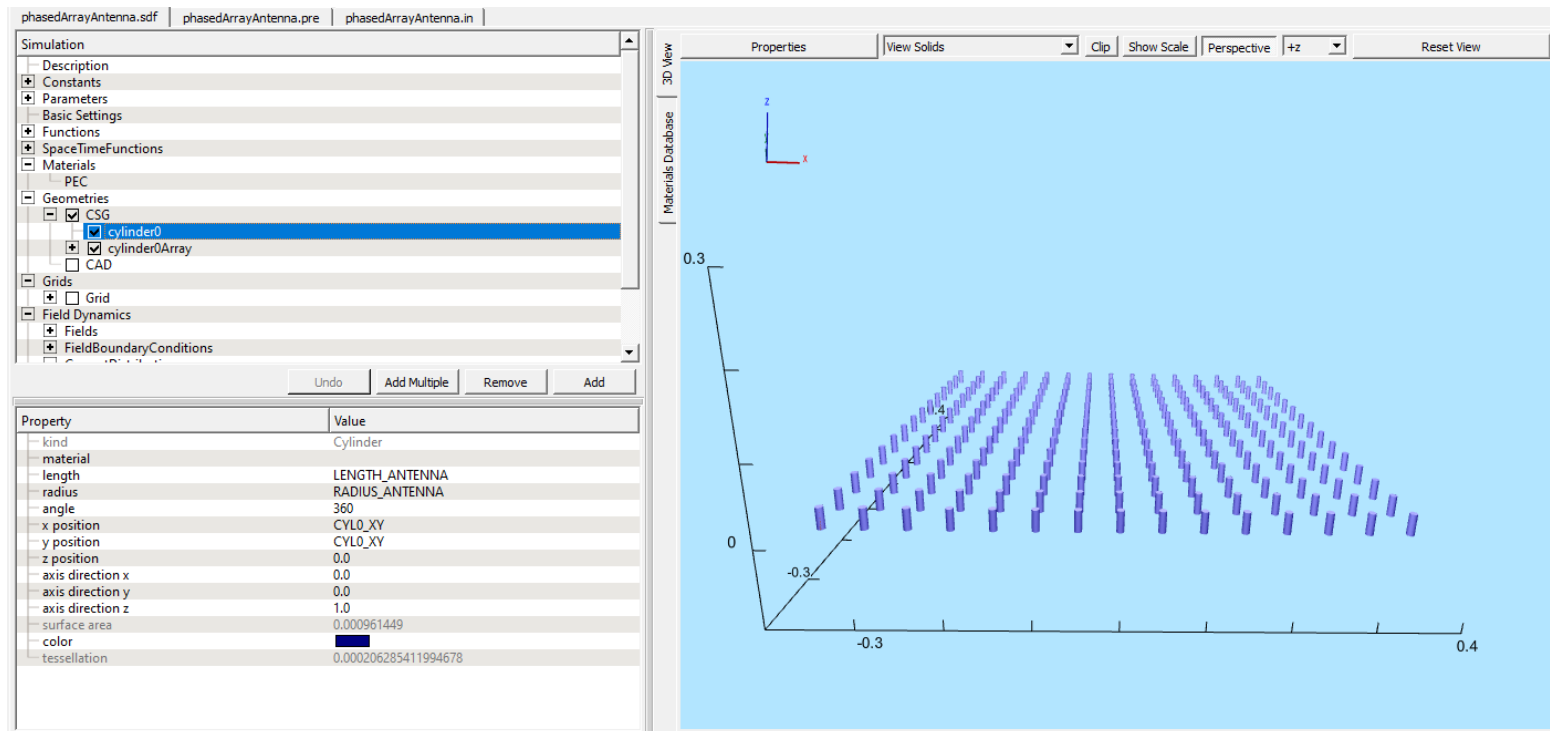
Material Properties: heat capacity, conductivity, permittivity, thermal conductivity, permeability, and resistance.



- See pre-defined materials: switch from *3D View* to *Database*.
- See a wider selection of materials: load the *emthermal.vmat* file by right-clicking on the **Materials** element and selecting *Import Materials*.
- You can also import your own customized material.

# Geometries

- Import Files:
  - .stl, .ply, .vtk, .stp, .step, or .p12
- Build complex devices with Constructive Solid Geometries (CSG):
  - sphere, box, cylinder, cone, torus, pipe, wedge, truncated cone



# Geometries

- CSG Primitives can be combined:

## 1. Subtract

- This will subtract the second selected primitive from the first selected primitive.

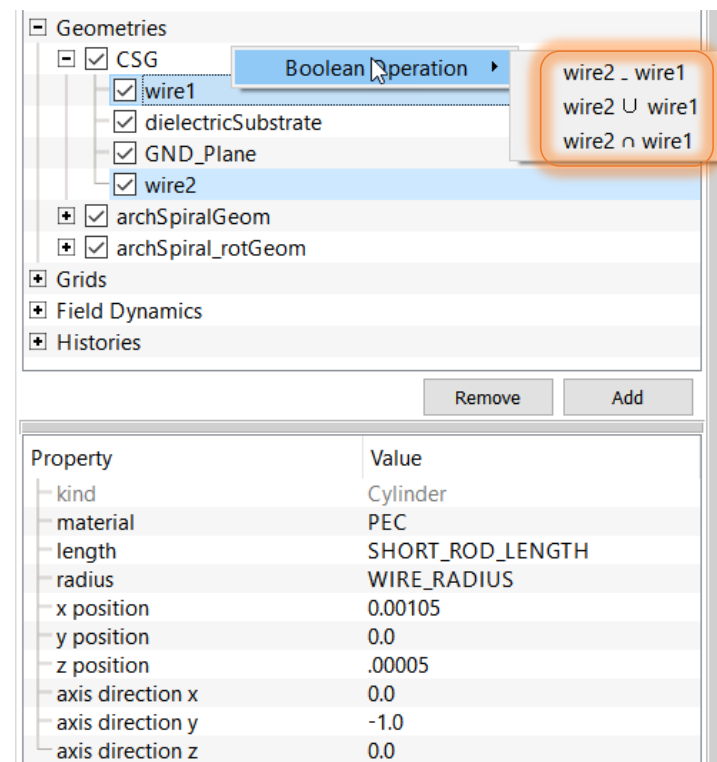
## 2. Union

- This will combine the two primitives into a single object. For use if the combined object is set to be a particle sink.

## 3. Intersect

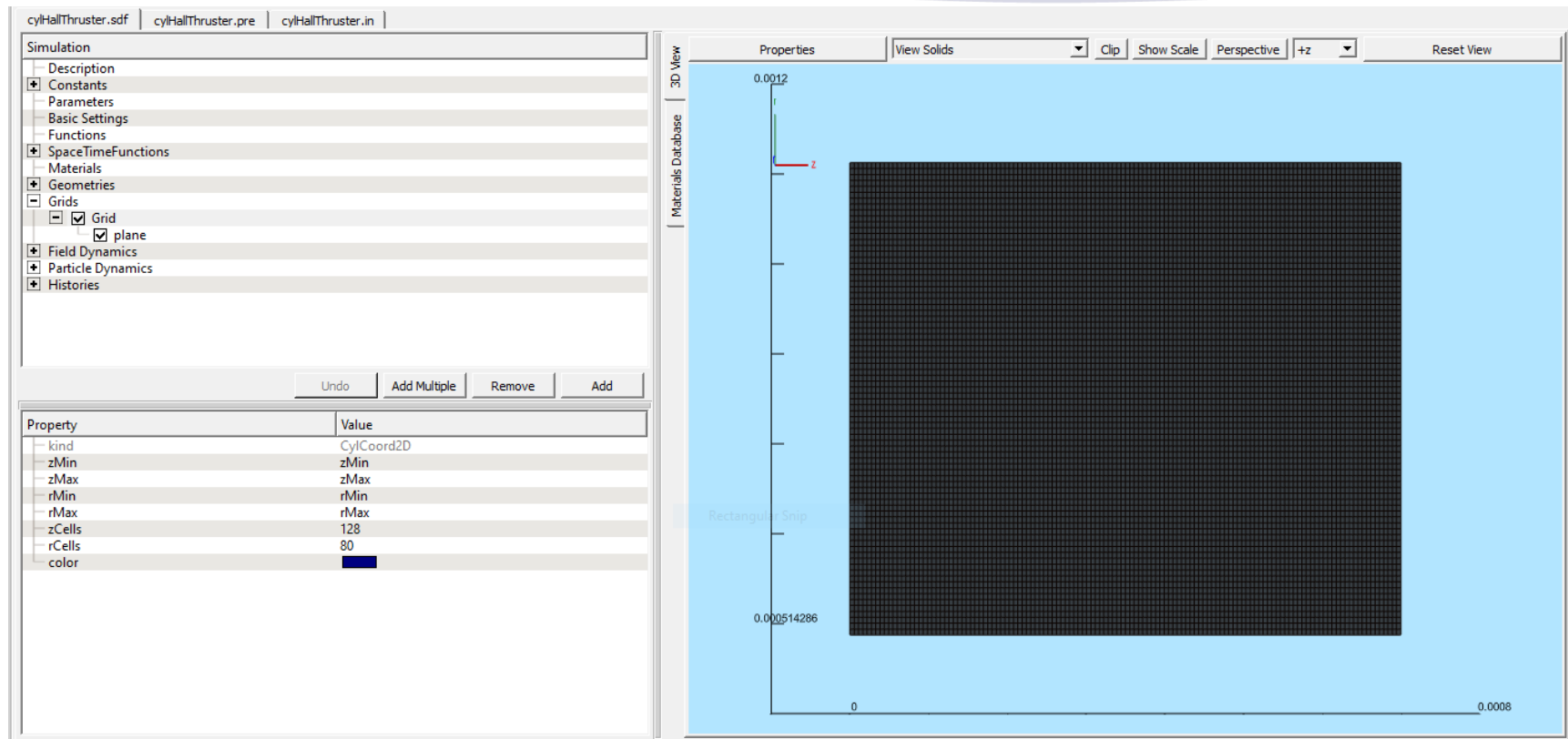
- This will leave only the volume of the two primitives that intersect as an object.

- Boolean operations may be nested.
- For use in the simulation, a Geometries part **MUST** have a material assigned to it, otherwise it is ignored (treated as vacuum).



# Grid

Determines the simulation size and relationship of physical coordinate to cell indices



# Field Dynamics

## 1. Fields

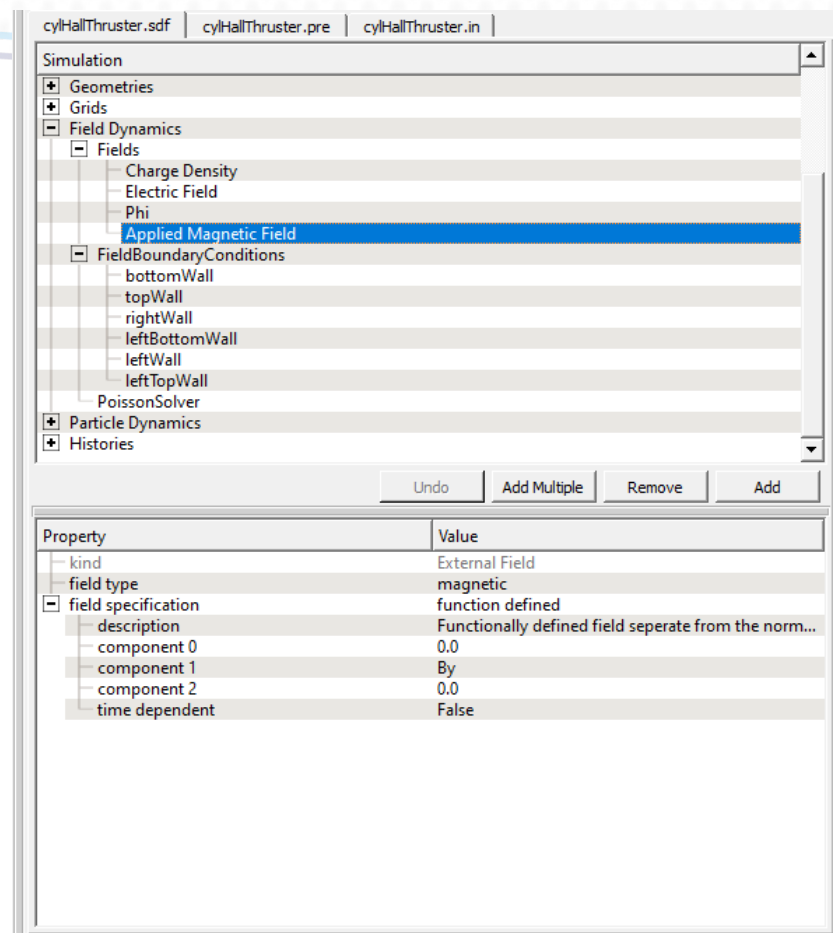
- Initial conditions can be set.
- External fields can be added.

## 2. Field Boundary Conditions

- The field solver determines which Boundary Condition are available to add to your simulation.

## 3. Current Distributions

- Dipole
- Distributed



# Field Boundary Conditions

Field Dynamics

- Fields
  - FieldBoundaryConditions
  - CurrentDistributions
  - RCSBox
- Particle Dynamics
- Histories

Add FieldBoundaryCondition

- Boundary Launcher
- Coaxial Waveguide
- Matched Absorbing Layer
- Open
- Perfect Electric Conductor
- Perfect Magnetic Conductor
- Perfectly Matched Layer
- Port
- Port Launcher
- Rectangular Waveguide

Property	Value
kind	Field Boundary Condition Group

Upper X      Lower Y      Upper Y      Lower X

Field Dynamics

- Fields
  - FieldBoundaryConditions
    - pec0
  - CurrentDistributions
  - RCSBox
- Particle Dynamics
- Histories

Property	Value
kind	Perfect Electric Conductor
surface	upper x

Field Dynamics

- Fields
  - FieldBoundaryConditions
    - pec0
    - pec1
  - CurrentDistributions
  - RCSBox
- Particle Dynamics
- Histories

Property	Value
kind	Perfect Electric Conductor
surface	lower y

Field Dynamics

- Fields
  - FieldBoundaryConditions
    - pec0
    - pec1
    - pec2
  - CurrentDistributions
  - RCSBox
- Particle Dynamics
- Histories

Property	Value
kind	Perfect Electric Conductor
surface	upper y

Field Dynamics

- Fields
  - FieldBoundaryConditions
  - CurrentDistributions
  - RCSBox
- Particle Dynamics
- Histories

Property	Value
kind	Boundary Launcher
field	Electric Field
applied fields	transverse-F lower x
Fy(x, y, z, t)	0.0
Fz(x, y, z, t)	laserPulse

# Particles

## 1. Types

- Regular: electrons, ions (or other charged particles), and neutral particles.
- Test: field-scaled electrons

## 2. Loaders & Emitters

- Load within a volume
- Emit from a surface of boundary
- Emission: primary or secondary

## 3. Boundary Conditions

The screenshot shows the 'Particle Dynamics' menu with 'Add ParticleBoundaryCondition' selected. A list of boundary conditions is displayed in a pop-up window:

- Absorbing
- Boundary Absorb and Save
- Boundary Accumulate
- Boundary Diffuse Reflector
- Cut-Cell Absorb and Save
- Cut-Cell Accumulate
- Interior Absorb and Save
- Interior Accumulate
- Interior Diffuse Reflector
- Interior Partial Transmitter
- Specular Reflecting

Below the menu, the 'Property' table is visible:

Property	Value
kind	Electrons
nominal density	NOM_DEN_E
particle weights	variable weights
particle dynamics	relativistic
weight setting	computed weights
macroparticles per cell	4.0

The screenshot shows the 'Particle Dynamics' menu with 'Add ElectronEmitter' selected. A list of emitter types is displayed in a pop-up window:

- Secondary Emitter
- Shape Settable Flux
- Slab Settable Flux

Below the menu, the 'Property' table is visible:

Property	Value
kind	Electrons
nominal density	NOM_DEN_E
particle weights	variable weights
particle dynamics	relativistic
weight setting	computed weights
macroparticles per cell	4.0



# Particles

## Loading

Particle Dynamics

- KineticParticles
  - electrons0
    - settableFluxShapeElectronEmitterVW
    - ☒ particleLoader

Undo Add Multiple Remove

Property	Value
kind	Particle Loader
description	
load density	relative density
relative density	1.0
particle load placement	bit-reversed
load duration	repeat loading
start time	0.0
stop time	3.40282e+038
load after initialization	true
load upon shift	true
velocity distribution	functional velocity
u0	0.0
u1	0.0
u2	0.0
volume	cartesian 3d slab
xMin	-0.5
xMax	0.5
yMin	-0.5
yMax	0.5
zMin	-0.5
zMax	0.5

## Emitting

Particle Dynamics

- KineticParticles
  - electrons0
    - settableFluxShapeElectronEmitterVW
    - ☒ particleLoader

Undo Add Multiple Remove

Property	Value
kind	Shape Settable Flux
description	
start time	0.0
stop time	1.0
emission specification	emission current density
emission current density	1.0
velocity coordinate system	global
mean velocity 0	0.0
mean velocity 1	0.0
mean velocity 2	0.0
thermal velocity 0	0.0
thermal velocity 1	0.0
thermal velocity 2	0.0
emission surface	shape emitter
emission offset	0.1
object name	please select
macroparticle emission	macroparticle rate
macroparticle rate	1.0
macroparticle emission profile	1.0



Particle Dynamics

KineticPart

Fluids

ReducedCollisions

Histories

Add ParticleSpecies

Add TestParticleSpecies

Charged Particles

Electrons

Neutral Particles

Particle Dynamics

KineticParticles

Fluids

ReducedCollisions

Histories

electrons0

Property	Value
kind	Electrons
nominal density	NOM_DEN_E
particle weights	variable weights
particle dynamics	relativistic
weight setting	computed weights
macroparticles per ...	4.0

Particle Dynamics

KineticPart

Fluids

ReducedCol

Histories

Add ElectronEmitter

Add ParticleBoundaryCondition

Add ParticleLoader

Turn Off/On

Particle Loader

Particle Loader from File

Particle Dynamics

KineticParticles

Fluids

ReducedCollisions

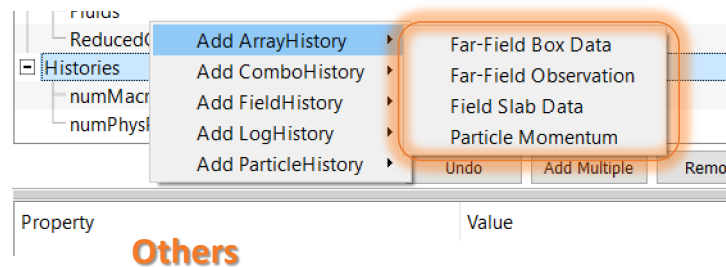
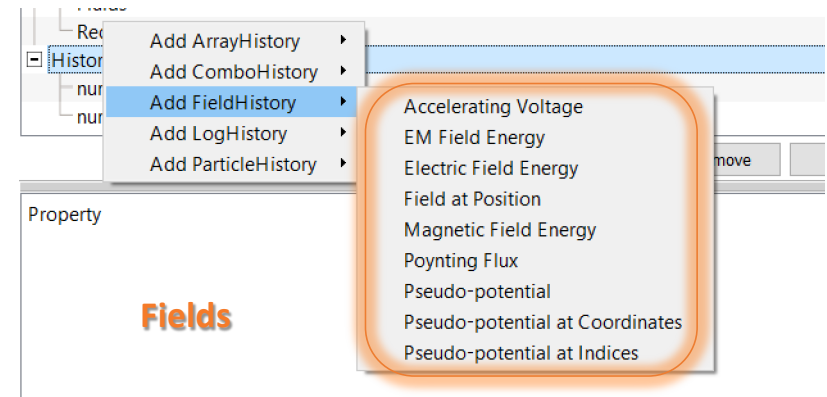
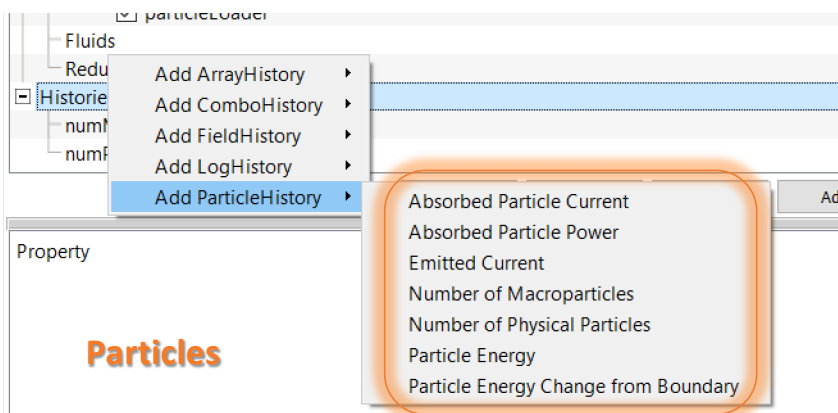
Histories

electrons0

particleLoader

Property	Value
kind	Particle Loader
load density	relative density
relative density	rampUpRelDensity
particle load placement	bit-reversed
load duration	repeat loading
start time	0.0
stop time	3.40282e+038
load after initializat...	false
load upon shift	true
velocity distribution	functional velocity
u0	0.0
u1	0.0
u2	0.0
volume	cartesian 3d slab
xMin	0.0
xMax	ENDX_LOADER
yMin	BGNY
yMax	ENDY
zMin	0.0
zMax	0.0

# Histories



# Histories

The screenshot displays the 'Histories' menu in the Tech-X software. The menu is open, showing options to add various history types. The 'Add ParticleHistory' option is selected, which has opened a sub-menu. In this sub-menu, 'Number of Macroparticles' and 'Number of Physical Particles' are highlighted with blue bars. Two orange arrows originate from these items: one points to the 'Number of Macroparticles' entry in the top history table, and the other points to the 'Number of Physical Particles' entry in the bottom history table.

**Top History Table:**

Property	Value
kind	Number of Macroparticles
particles	electrons0

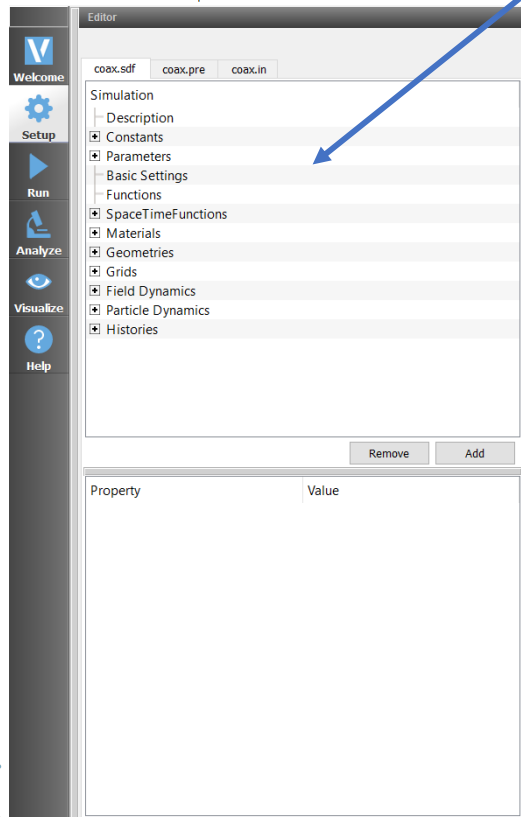
**Bottom History Table:**

Property	Value
kind	Number of Physical Particles
particles	electrons0

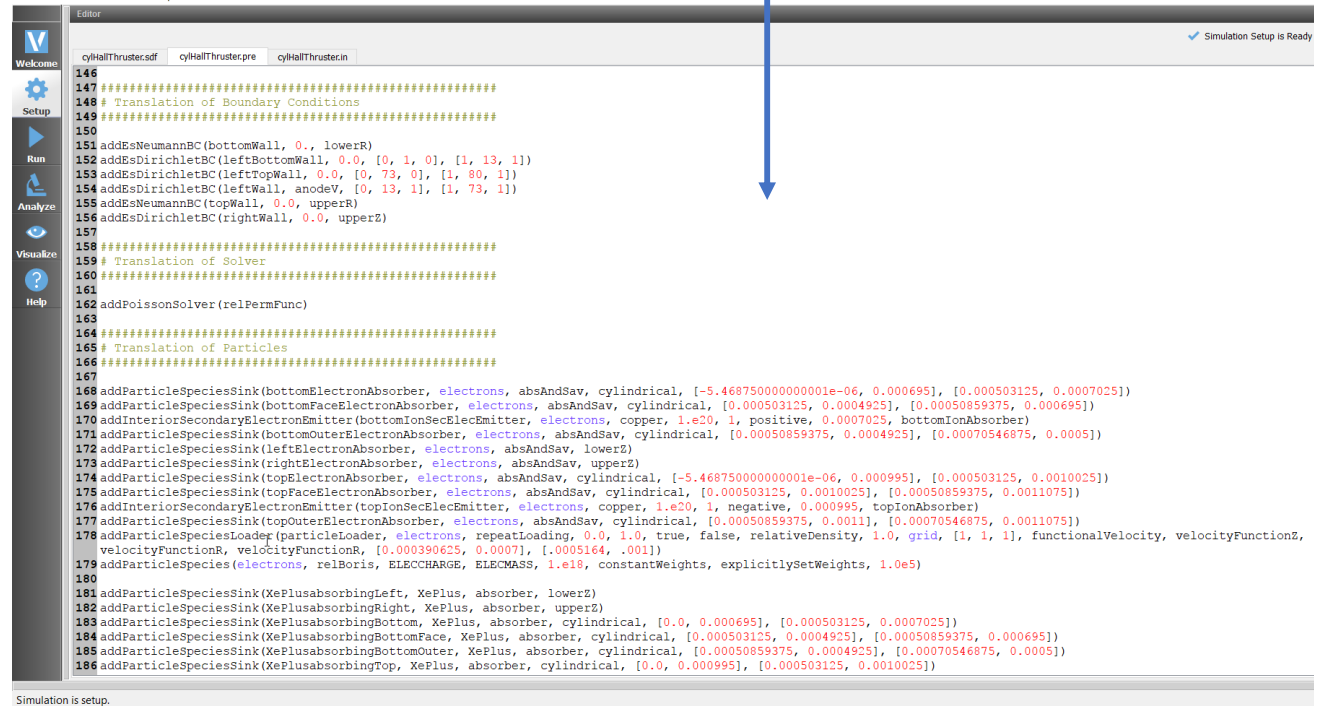
# Visual to Text-Based Comparison

# File Formats: .sdf and macro-ized .pre

VSim8 - Coaxial Cylinder  
File Edit Tools View Help



VSim8 - Cylindrical Hall Thruster  
File Edit Tools View Help



SIMULATIONS EMPOWERING YOUR INNOVATIONS

# Text-Based and Visual Side-by-Side

Editor

coax.sdf coax.pre coax.in

Simulation

- Description
- Constants
- Parameters
- Basic Settings
- Functions
- SpaceTimeFunctions
- Materials
- Geometries
- Grids
- Field Dynamics
  - Fields
  - FieldBoundaryConditions
    - lowerXwaveLauncher
    - CurrentDistributions
- Particle Dynamics
  - KineticParticles
    - electrons
    - BackgroundGases
    - Collisions
- Histories

Property Value

use GPU (if found)	false
verbosity	information
dimensionality	3
grid spacing	uniform
reuse geometry files on restart	true
coordinate system	cartesian
field solver	electromagnetic
Cerenkov filter	none
periodic directions	no periodicity
particles	include particles
estimated max electron den	NOMINAL DENSITY

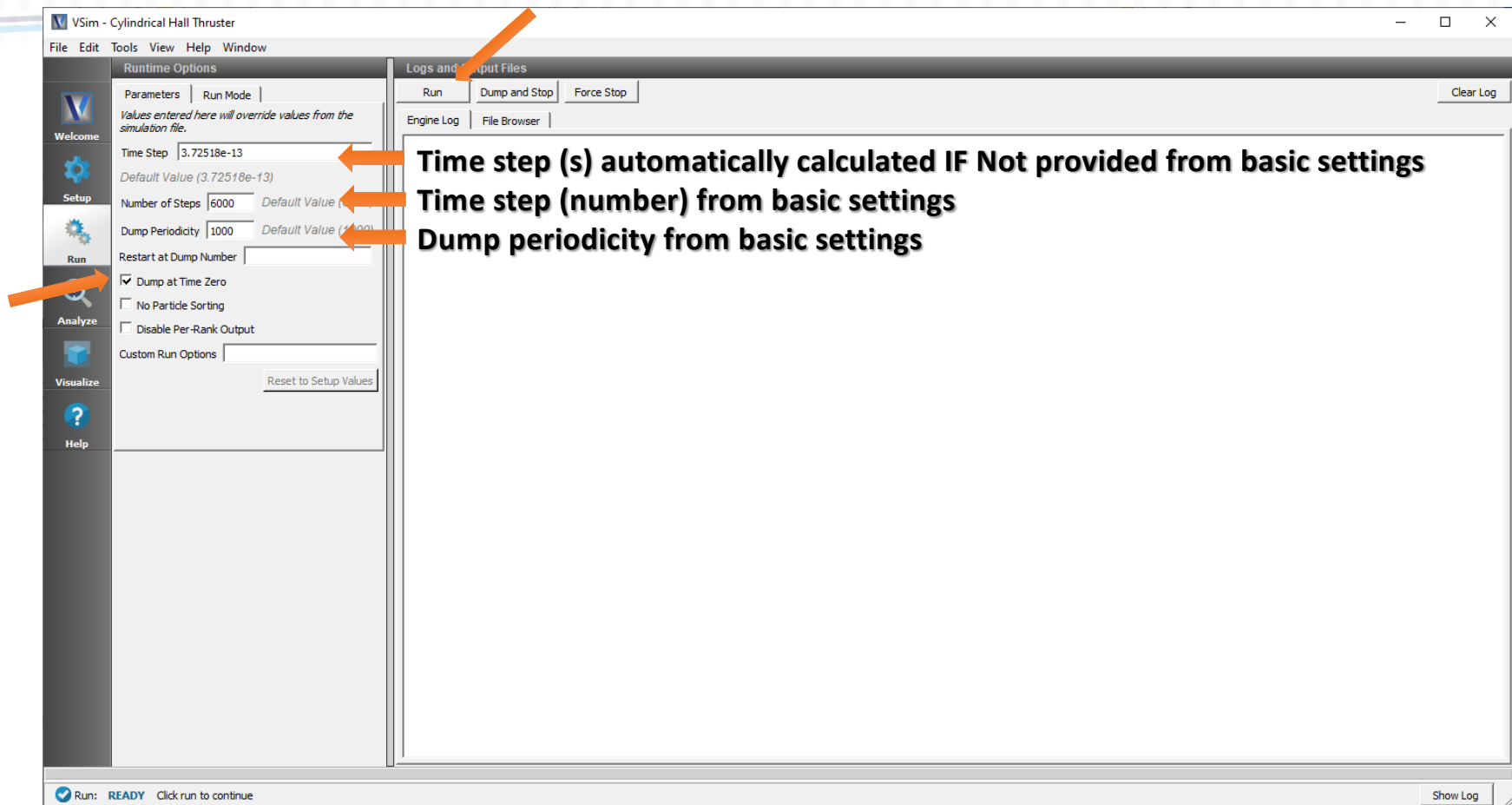
Remove Add

```

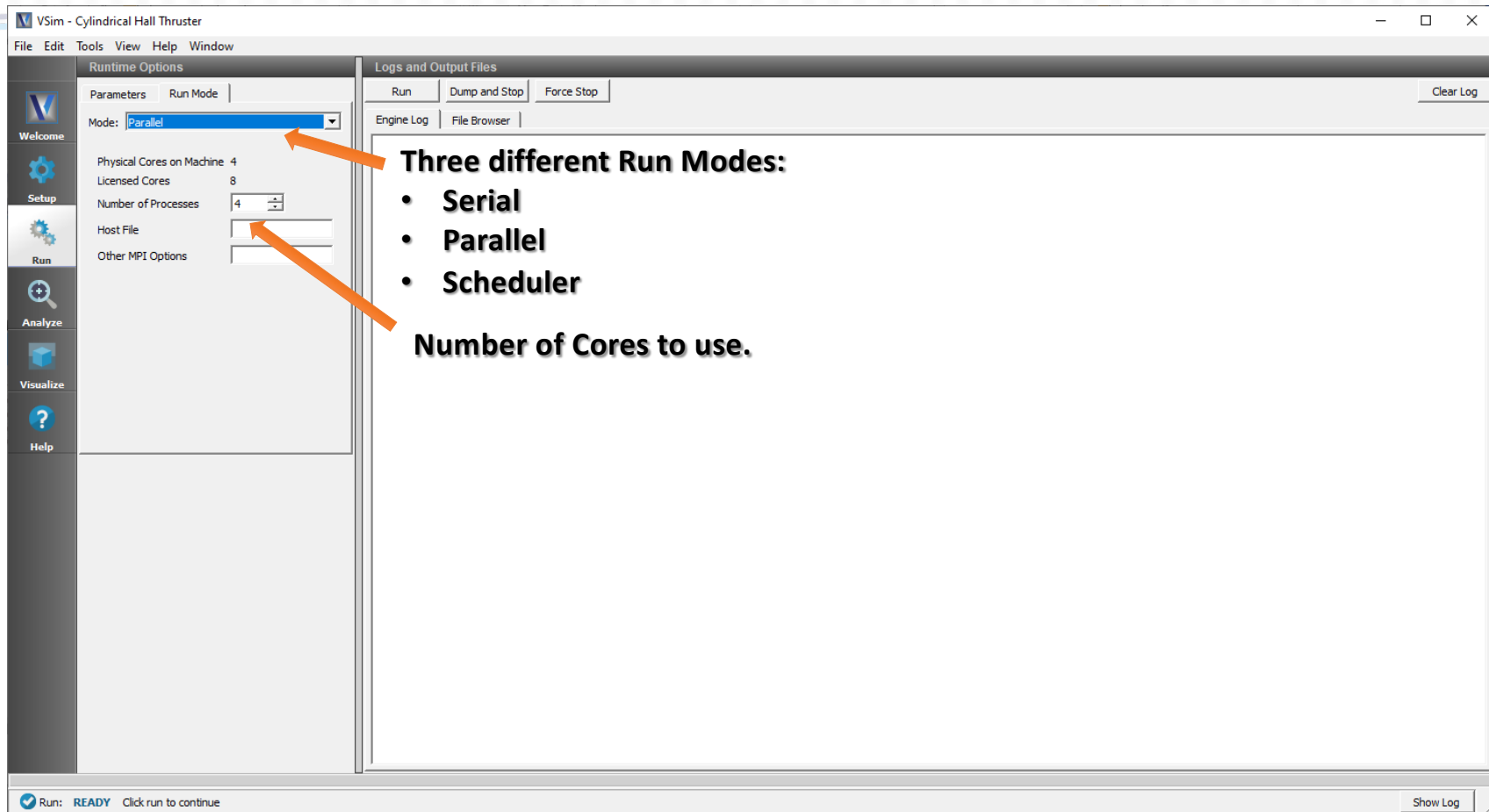
3 <XSim Block>
4   -basic description of simulation
5
6 <XVars Block>
7   -sets the knobs you can turn w/out making big changes to simulation
8
9 $ Constants & $ Variables
10  -built-in (mathphys)
11  -Simulation variables: dump periodicity, NPIM, particle depositors
12  -Grid: beginning, end, number of cells
13  -physics: debye length estimate, cyclotron frequency, thermal velocity...
14
15 $ imports
16  -macros, verbosity...
17
18 <Grid Block>
19  - cylindrical/cartesian
20  - variable/uniform
21
22 <Decomp Block>
23  -usually boring, but lets you manually assign MPI distribution of grid to CPUs
24
25 <Multifield>
26  -Sets up fields and how they are updated (includes setting up the solver)
27  -E, B, rho, phi
28  -Boundary Conditions
29  -Types of Fields: Edge, Nodal (used to push particles), Face
30  -This is generally the 'work-horse/heavy-lifting/beefiest' block
31
32 <Species> & <Fluid>
33  -Adds particle species or fluid background gas to simulation
34  -either explicitly modeled kinetically, or implicitly modeled as background fluid
35  -Sets up sources and sinks
36  -Also can be a hefty block
37
38 <Monte Carlo Interactions>
39  -sets up particle interactions
40  -can set cross-sections from external data files (Hayashi, feedl, and others)
41
42 <Histories>
43  -Data to be recorded at every time step
44  -Currents into/out of surface, number of particles, field at a point
45  -lots of options
    
```

WELCOME SIMULATIONS EMPOWERING YOUR INNOVATIONS

# Running the Simulation



# Running the Simulation



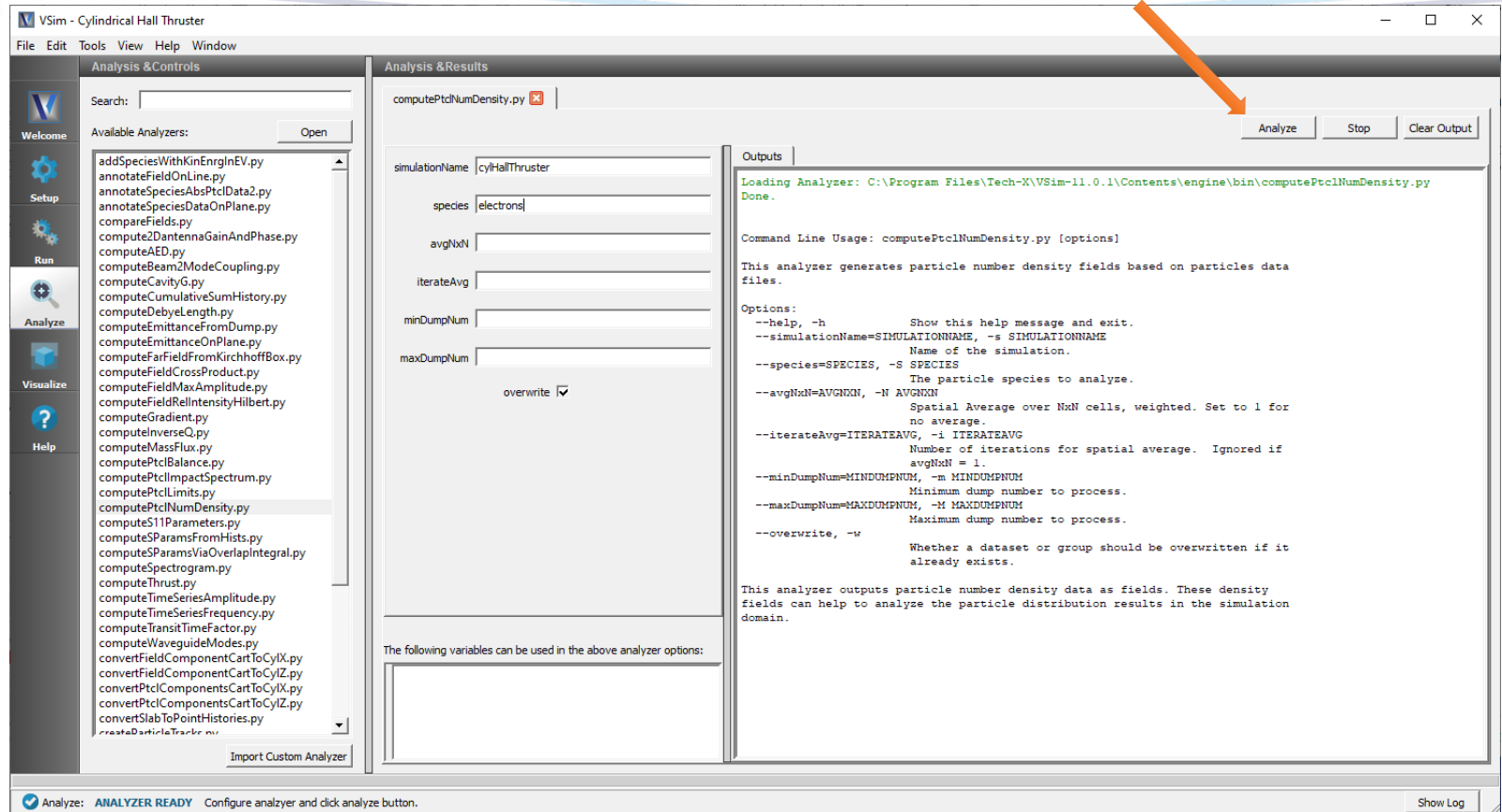


# Analyzing Results

Analyzers, written in python may be used to calculate a variety of items. Custom scripts may be imported for easy use and access.

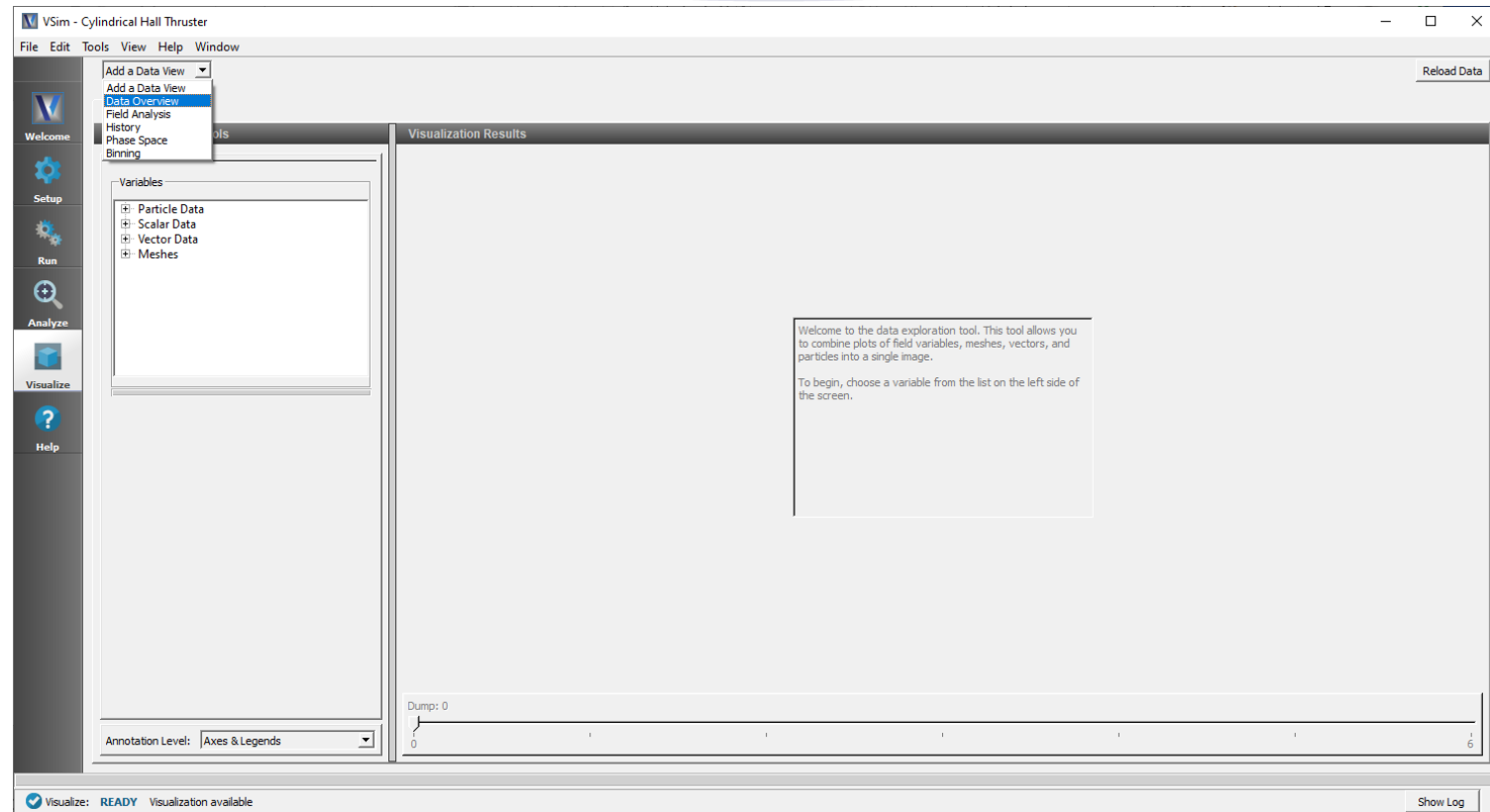
In this case, `computePtcNumDensi`  
`ty.py` is being used to calculate the density of the electrons (or ions). To calculate the density of the electrons, set the `speciesName` to "electrons".

Click Analyze button at the top right

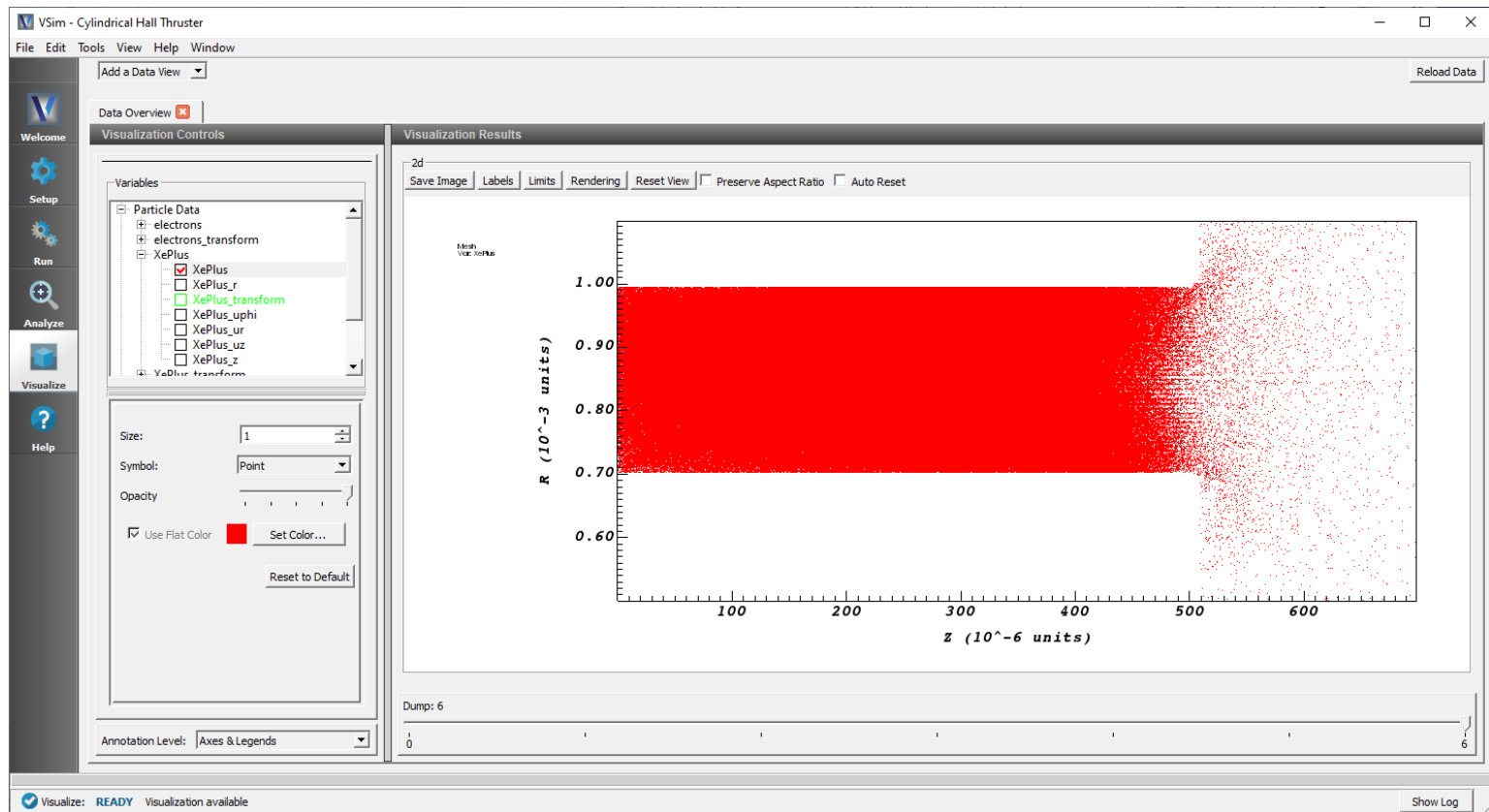


# Visualizing Results

1. Data Overview
2. Field Analysis
3. History
4. Phase Space
5. Binning



# Data Overview



# Field Analysis

