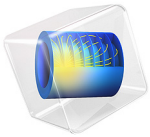

Benchmark Model of a Capacitively Coupled Plasma

Introduction

The underlying physics of a capacitively coupled plasma is rather complicated, even for rather simple geometric configurations and plasma chemistries. This model benchmarks the Plasma, Time Periodic interface against many different codes, the results of which are taken from Ref. 1.

Model Definition

The model geometry consists of a 1D gap of 0.067 m. A plasma forms in the gap provided the driving voltage and fill pressure are high enough. The driving frequency in this model is 13.56 MHz. Helium chemistry is used, as was the case in Ref. 1.

The electron density and mean electron energy are computed by solving a pair of drift-diffusion equations for the electron density and mean electron energy. For detailed information on electron transport, see *Theory for the Drift Diffusion Interface* in the *Plasma Module User's Guide*.

$$\frac{\partial}{\partial t}(n_e) + \nabla \cdot [-n_e(\mu_e \bullet \mathbf{E}) - \mathbf{D}_e \bullet \nabla n_e] = R_e$$

$$\frac{\partial}{\partial t}(n_\varepsilon) + \nabla \cdot [-n_\varepsilon(\mu_\varepsilon \bullet \mathbf{E}) - \mathbf{D}_\varepsilon \bullet \nabla n_\varepsilon] + \mathbf{E} \cdot \Gamma_e = R_\varepsilon$$

The electron source R_e and the energy loss due to inelastic collisions R_ε are defined later. The electron diffusivity, energy mobility, and energy diffusivity are computed from the electron mobility using:

$$\mathbf{D}_e = \mu_e T_e, \mu_\varepsilon = \left(\frac{5}{3}\right)\mu_e, \mathbf{D}_\varepsilon = \mu_\varepsilon T_e$$

The source coefficients in the above equations are determined by the plasma chemistry using rate coefficients. In the case of rate coefficients, the electron source term is given by:

$$R_e = \sum_{j=1}^{M} x_j k_j N_n n_e$$

where x_j is the mole fraction of the target species for reaction j, k_j is the rate coefficient for reaction j (SI unit: m^3/s), and N_n is the total neutral number density (SI unit: $1/\mathrm{m}^3$). The electron energy loss is obtained by summing the collisional energy loss over all reactions:

$$R_\varepsilon = \sum_{j=1}^{P} x_j k_j N_n n_e \Delta\varepsilon_j$$

where $\Delta\varepsilon_j$ is the energy loss from reaction j (SI unit: V). The rate coefficients can be computed from cross section data by the following integral:

$$k_k = \gamma \int_0^\infty \varepsilon \sigma_k(\varepsilon) f(\varepsilon) d\varepsilon$$

where $\gamma = (2q/m_e)^{1/2}$ (SI unit: $C^{1/2}/kg^{1/2}$), m_e is the electron mass (SI unit: kg), ε is energy (SI unit: V), σ_k is the collision cross section (SI unit: m^2), and f is the electron energy distribution function.

For nonelectron species, the following equation is solved for the mass fraction of each species. For detailed information on the transport of the nonelectron species, see *Theory for the Heavy Species Transport Interface* in the *Plasma Module User's Guide*.

$$\rho \frac{\partial}{\partial t}(w_k) + \rho(\mathbf{u} \cdot \nabla) w_k = \nabla \cdot \mathbf{j}_k + R_k$$

The electrostatic field is computed using the following equation:

$$-\nabla \cdot \varepsilon_0 \varepsilon_r \nabla V = \rho$$

The space charge density ρ is automatically computed based on the plasma chemistry specified in the model using the formula:

$$\rho = q\left(\sum_{k=1}^{N} Z_k n_k - n_e\right)$$

For detailed information about electrostatics see *Theory for the Electrostatics Interface* in the *Plasma Module User's Guide*.

In Ref. 1 the ion diffusivity is defined as:

$$D = 0.10901(a\lambda^3)^{\frac{1}{2}}$$

and the mobility, μ as:

$$\mu E = 0.79788(a\lambda)^{\frac{1}{2}}$$

where $a = qE/m$ and λ is the charge exchange mean free path. The same ion mobility and diffusivity models can be set in COMSOL. With that objective, choose **Specify mobility, compute diffusivity** and **Use local field approximation** in the section **Mobility and Diffusivity Expressions** on the ion species node. After that, go to the **Mobility Specification** and choose the **High field** ion mobility model with a **Cross section** σ equal to 3.10^{-19} m^2 to reproduce the same ion mobility and diffusivity as in Ref. 1.

BOUNDARY CONDITIONS

Electrons are lost to the wall due to random motion within a few mean free paths of the wall and gained due to secondary emission effects, resulting in the following boundary condition for the electron flux

$$\mathbf{n} \cdot \Gamma_e = \left(\frac{1-r}{1+r}\right)\left(\frac{1}{2}\nu_{e,\,\mathrm{th}} n_e\right) \tag{1}$$

and the electron energy flux

$$\mathbf{n} \cdot \Gamma_\varepsilon = \left(\frac{1-r}{1+r}\right)\left(\frac{5}{6}\nu_{e,\,\mathrm{th}} n_\varepsilon\right) \tag{2}$$

In order to make the COMSOL Multiphysics implementation of the electron losses to the wall consistent with the reference, the value of r must be set to $5/11$. The second term on the right-hand side of Equation 1 is the gain of electrons due to secondary emission effects, γ_p being the secondary emission coefficient. The second term in Equation 2 is the secondary emission energy flux, ε_p being the mean energy of the secondary electrons. For the helium ions are lost to the wall due to surface reactions and the fact that the electric field is directed toward the wall:

$$\mathbf{n} \cdot \mathbf{j}_k = M_w c_k Z \mu_k (\mathbf{E} \cdot \mathbf{n})[Z_k \mu_k (\mathbf{E} \cdot \mathbf{n}) > 0]$$

PLASMA CHEMISTRY

The reference paper suggests a simplistic plasma chemistry for helium consisting of only 3 reactions and 4 species (electron impact cross sections are obtained from Ref. 2):

TABLE 1: TABLE OF COLLISIONS AND REACTIONS MODELED.

REACTION	FORMULA	TYPE	$\Delta\varepsilon$(eV)
1	e+He=>e+He	Elastic	0
2	e+He=>e+Hes	Excitation	19.5
3	e+Hes=>e+He+	Ionization	24.5

In addition to volumetric reactions, the following surface reactions are implemented:

TABLE 2: TABLE OF SURFACE REACTIONS.

REACTION	FORMULA	STICKING COEFFICIENT
1	Hes=>He	1
2	He+=>He	0

When a metastable helium atom makes contact with the wall, it reverts to the ground state helium atom with some probability (the sticking coefficient).

Results and Discussion

The time averaged ion current density is plotted in Figure 1. The peak ion current density occurs on the electrodes, at a value of around 0.2 A/m^2. At lower pressures the ion current density profile is more smooth across the gap. At 300 mtorr there is a pronounced flattening off of the ion current density in the plasma sheath. These results agree well with those presented in Figure 9 of Ref. 1.

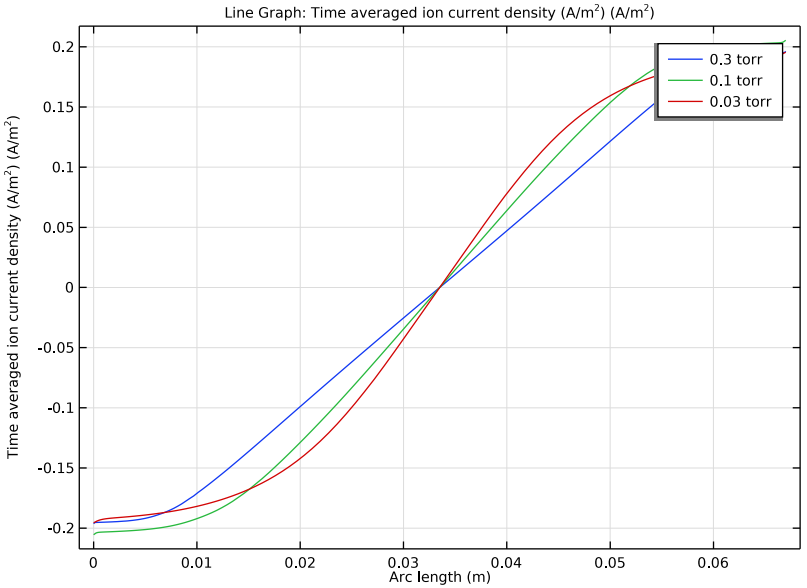

Figure 1: Plot of the period averaged ion current as a function of the distance from the left electrode.

The period averaged excitation and ionization rates are plotted in Figure 2 and Figure 3.

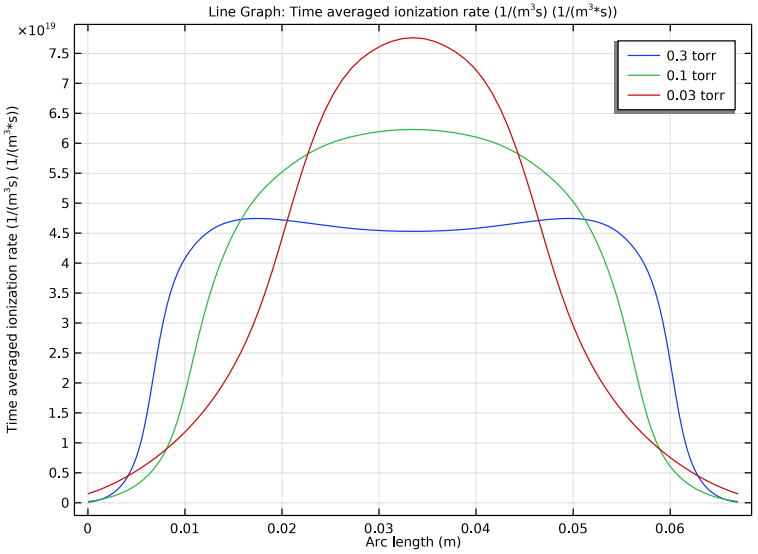

Figure 2: Plot of the period averaged ionization rate as a function of the distance from the left electrode.

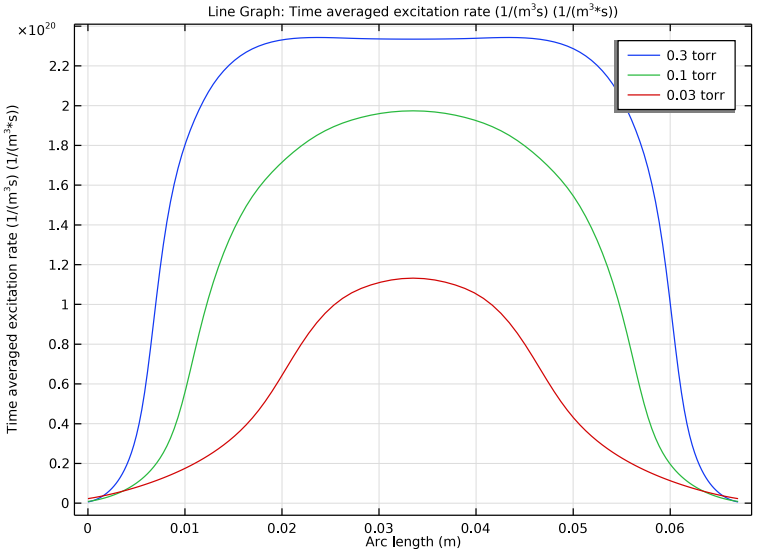

Figure 3: Plot of the period averaged excitation rate as a function of the distance from the left electrode.

The results for the ionization and excitation rates agree well with Ref. 1 in both absolute value and spatial distribution. The period averaged electron power deposition is plotted in Figure 4. The COMSOL results are again, in good agreement with the reference paper.

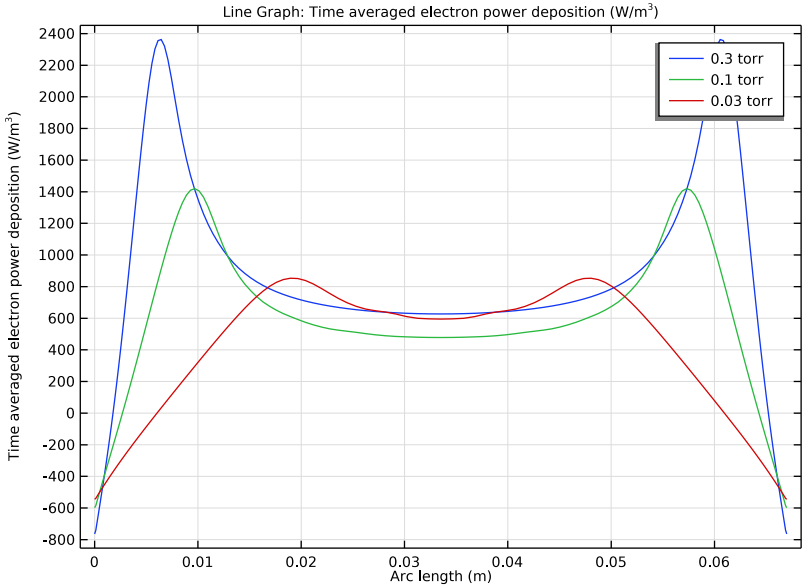

Figure 4: Plot of the period averaged electron power deposition as a function of the distance from the left electrode.

Figure 5 and Figure 6 plot the period averaged electron and ion density at different operating pressures. The electron and ion density is the same in the plasma bulk but the ion density is higher in the plasma sheath. This creates a net positive space charge density in the plasma sheath which tends to hold electrons in the plasma and accelerate ions toward the wall via the plasma potential.

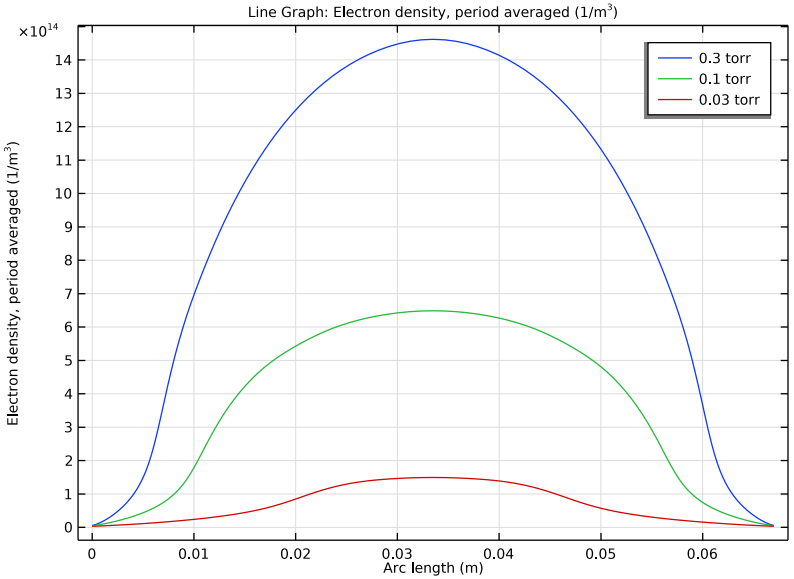

Figure 5: Plot of the period averaged electron density at different operating pressures.

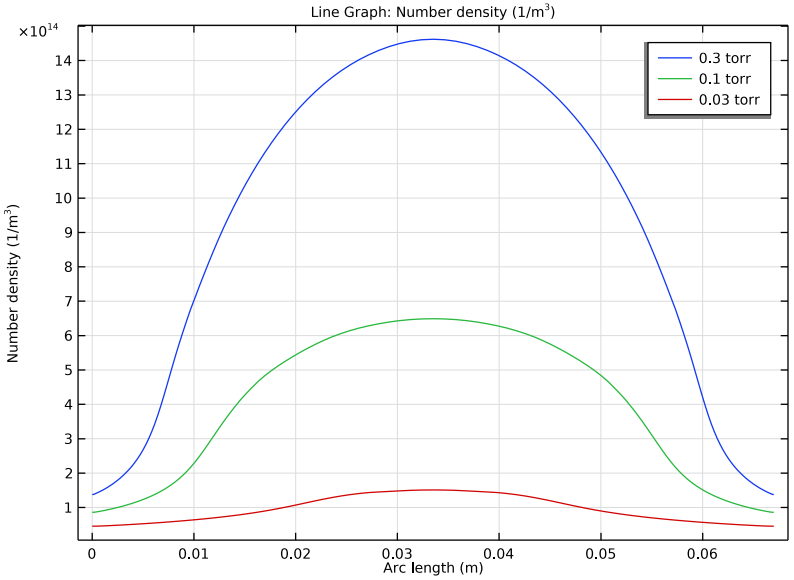

Figure 6: Plot of the period averaged ion density for different operating pressures.

Ref. 1 tabulates a wide range of lumped parameters for the discharge. These same parameters for the COMSOL model are shown in Table 3. There is good agreement between the COMSOL model and the values quoted in Ref. 1.

TABLE 3: RESULTS FROM THE DISCHARGE MODEL.

P (MTORR)	$V_{rf}(V)$	$n_e(\mathrm{cm}^{-3})$	$\bar{\varepsilon}(\mathrm{eV})$	$P_{tot}(\mathrm{mWcm}^{2})$	$j_{pos}(\mathrm{mAcm}^{-2})$	$I_{rf}(\mathrm{mAcm}^{-2})$
30	364.8	1.50×10^{8}	13.5	2.96	0.0196	0.97
100	196.9	6.57×10^{8}	7.05	4.17	0.0205	0.99
300	128.8	1.47×10^{9}	5.08	6.02	0.0196	0.99

References

1. M. Surendra, "Radiofrequency discharge benchmark model comparison," *Plasma Sources Sci. Technol.*, vol. 4, pp 56–73, 1995.

2. Phelps database, www.lxcat.net, retrieved 2017.

Application Library path: `Plasma_Module/Capacitively_Coupled_Plasmas/ccp_benchmark`

Modeling Instructions

From the **File** menu, choose **New**.

NEW

In the **New** window, click **Model Wizard**.

MODEL WIZARD

1 In the **Model Wizard** window, click **1D**.

2 In the **Select Physics** tree, select **Plasma>Plasma, Time Periodic (ptp)**.

3 Click **Add**.

4 Click **Study**.

5 In the **Select Study** tree, select **Preset Studies for Selected Physics Interfaces> Time Periodic**.

6 Click **Done**.

Start by drawing the geometry, which is simply a line of length 0.067m.

GEOMETRY 1

Interval 1 (i1)

1 In the **Model Builder** window, under **Component 1 (comp1)** right-click **Geometry 1** and choose **Interval**.

2 In the **Settings** window for **Interval**, locate the **Interval** section.

3 In the table, enter the following settings:

Coordinates (m)
0
0.067

Define a parameter for the pressure, which will be used when sweeping over pressure in the study.

4 Click **Build All Objects**.

GLOBAL DEFINITIONS

Parameters 1

1 In the **Model Builder** window, under **Global Definitions** click **Parameters 1**.

2 In the **Settings** window for **Parameters**, locate the **Parameters** section.

3 In the table, enter the following settings:

Name	Expression	Value	Description
p0	0.3[torr]	39.997 Pa	Pressure

Define an expression for the input power. The expression is designed to obtain the same current density of 1 mA/cm^2 for each value of pressure.

DEFINITIONS (COMP1)

Variables 1

1 In the **Model Builder** window, under **Component 1 (comp1)** right-click **Definitions** and choose **Variables**.

2 In the **Settings** window for **Variables**, locate the **Variables** section.

3 In the table, enter the following settings:

Name	Expression	Unit	Description
Pin	if(p0==0.03[torr],11.6,9.4)		Input power

Turn off the source stabilization, since it is not needed in this example. Use the Fick's law diffusion model to be consistent with the reference.

PLASMA, TIME PERIODIC (PTP)

1 In the **Model Builder** window, under **Component 1 (comp1)** click **Plasma, Time Periodic (ptp)**.

2 In the **Settings** window for **Plasma, Time Periodic**, locate the **Cross-Section Area** section.

3 In the A text field, type `0.1[m^2]`.

4 Locate the **Electron Energy Distribution Function Settings** section. From the **Electron energy distribution function** list, choose **Maxwellian**.

5 Locate the **Diffusion Model** section. From the **Diffusion model** list, choose **Fick's law**.

Cross Section Import 1

1 In the **Physics** toolbar, click **Global** and choose **Cross Section Import**.

2 In the **Settings** window for **Cross Section Import**, locate the **Cross Section Import** section.

3 Click **Browse**.

4 Browse to the model's Application Libraries folder and double-click the file `He_xsecs.txt`.

5 Click **Import**.

Species: He

1 In the **Model Builder** window, click **Species: He**.

2 In the **Settings** window for **Species**, locate the **Species Formula** section.

3 Select the **From mass constraint** check box.

4 Locate the **General Parameters** section. From the **Preset species data** list, choose **He**.

Species: Hes

1 In the **Model Builder** window, click **Species: Hes**.

2 In the **Settings** window for **Species**, locate the **General Parameters** section.

3 From the **Preset species data** list, choose **He**.

4 In the D_f text field, type `0.8[m^2/s]`.

Load in a table for the helium reduced ion mobility as a function of the reduced electric field. This table corresponds to the high field limit described in the reference.

Species: He+

1 In the **Model Builder** window, click **Species: He+**.

2 In the **Settings** window for **Species**, locate the **Species Formula** section.

3 Select the **Initial value from electroneutrality constraint** check box.

4 Locate the **General Parameters** section. From the **Preset species data** list, choose **He**.

5 Locate the **Mobility and Diffusivity Expressions** section. From the **Specification** list, choose **Specify mobility, compute diffusivity**.

6 From the **Ion temperature** list, choose **Use local field approximation**.

7 Locate the **Mobility Specification** section. From the **Specify using** list, choose **Lookup table**.

8 From the **Mobility a function of** list, choose **Reduced electric field**.

9 Find the **Reduced ion mobility** subsection. Click **Load from File**.

10 Browse to the model's Application Libraries folder and double-click the file `ccp_benchmark_He_mobility.txt`.

Surface Reaction 1

1 In the **Physics** toolbar, click **Boundaries** and choose **Surface Reaction**.

2 In the **Settings** window for **Surface Reaction**, locate the **Reaction Formula** section.

3 In the **Formula** text field, type `He+=>He`.

4 Locate the **Boundary Selection** section. From the **Selection** list, choose **All boundaries**.

5 Locate the **Reaction Parameters** section. In the γ_f text field, type `0`.

6 Locate the **Secondary Emission Parameters** section. In the γ_i text field, type `0`.

7 In the ε_i text field, type `0`.

2: He+=>He

1 Right-click **1: He+=>He** and choose **Duplicate**.

2 In the **Settings** window for **Surface Reaction**, locate the **Reaction Formula** section.

3 In the **Formula** text field, type `Hes=>He`.

4 Locate the **Reaction Parameters** section. In the γ_f text field, type `1`.

Plasma Model 1

1 In the **Model Builder** window, click **Plasma Model 1**.

2 In the **Settings** window for **Plasma Model**, locate the **Model Inputs** section.

3 In the T text field, type `300[K]`.

4 In the p_A text field, type `p0`.

5 Locate the **Electron Density and Energy** section. From the **Electron transport properties** list, choose **Specify mobility only**.

6 In the μ_e text field, type `3.33e24[1/(V*m*s)]/ptp.Nn`.

Wall 1

1 In the **Physics** toolbar, click **Boundaries** and choose **Wall**.

2 In the **Settings** window for **Wall**, locate the **Boundary Selection** section.

3 From the **Selection** list, choose **All boundaries**.

4 Locate the **General Wall Settings** section. In the r_e text field, type `5/11`.

Ground 1

1 In the **Physics** toolbar, click **Boundaries** and choose **Ground**.

2 Select Boundary 1 only.

Metal Contact 1

1 In the **Physics** toolbar, click **Boundaries** and choose **Metal Contact**.

2 In the **Settings** window for **Metal Contact**, locate the **Terminal** section.

3 From the **Source** list, choose **RF**.

4 Select Boundary 2 only.

5 Locate the **RF Source** section. In the P_{rf} text field, type `Pin`.

MESH 1

Edge 1

In the **Mesh** toolbar, click **Edge**.

Distribution 1

1 Right-click **Edge 1** and choose **Distribution**.

2 In the **Settings** window for **Distribution**, locate the **Distribution** section.

3 From the **Distribution type** list, choose **Predefined**.

4 In the **Number of elements** text field, type `150`.

5 In the **Element ratio** text field, type `10`.

6 From the **Growth rate** list, choose **Exponential**.

7 Select the **Symmetric distribution** check box.

8 Click **Build All**.

STUDY 1

Step 1: Time Periodic

1 In the **Model Builder** window, under **Study 1** click **Step 1: Time Periodic**.

2 In the **Settings** window for **Time Periodic**, click to expand the **Study Extensions** section.

3 Select the **Auxiliary sweep** check box.

4 Click + **Add**.

5 In the table, enter the following settings:

Parameter name	Parameter value list	Parameter unit
p0 (Pressure)	`0.3 0.1 0.03`	`torr`

6 In the **Model Builder** window, click **Study 1**.

7 In the **Settings** window for **Study**, locate the **Study Settings** section.

8 Clear the **Generate convergence plots** check box.

9 Clear the **Generate default plots** check box.

10 In the **Home** toolbar, click = **Compute**.

RESULTS

Create some plots to compare with the reference.

1D Plot Group 1

In the **Home** toolbar, click **Add Plot Group** and choose **1D Plot Group**.

We need to use a built in operator to average over the extra dimension. This allows us to plot period averaged quantities for any variable.

Line Graph 1

1 Right-click **1D Plot Group 1** and choose **Line Graph**.

2 In the **Settings** window for **Line Graph**, locate the **Selection** section.

3 From the **Selection** list, choose **All domains**.

4 Locate the **y-Axis Data** section. In the **Expression** text field, type `ptp.xdintop_ptp1(ptp.Jix_wHe_1p/ptp.xdim)`.

5 Click to expand the **Quality** section. From the **Resolution** list, choose **No refinement**.

6 Locate the **y-Axis Data** section.

7 Select the **Description** check box. In the associated text field, type `Time averaged ion current density (A/m<sup>2</sup>)`.

8 Click to expand the **Legends** section. Select the **Show legends** check box.

9 In the **1D Plot Group 1** toolbar, click **Plot**.

Time Averaged Ion Current Density

1 In the **Model Builder** window, under **Results** click **1D Plot Group 1**.

2 In the **Settings** window for **1D Plot Group**, type `Time Averaged Ion Current Density` in the **Label** text field.

3 In the **Time Averaged Ion Current Density** toolbar, click **Plot**.

4 Click the **Zoom Extents** button in the **Graphics** toolbar.

Time Averaged Ionization Rate

1 Right-click **Time Averaged Ion Current Density** and choose **Duplicate**.

2 In the **Settings** window for **1D Plot Group**, type `Time Averaged Ionization Rate` in the **Label** text field.

Line Graph 1

1 In the **Model Builder** window, expand the **Time Averaged Ionization Rate** node, then click **Line Graph 1**.

2 In the **Settings** window for **Line Graph**, locate the **y-Axis Data** section.

3 In the **Expression** text field, type `ptp.Re_av`.

4 In the **Description** text field, type `Time averaged ionization rate (1/(m<sup>3</sup>s)`.

5 In the **Time Averaged Ionization Rate** toolbar, click **Plot**.

6 Click the **Zoom Extents** button in the **Graphics** toolbar.

Time Averaged Excitation Rate

1 In the **Model Builder** window, right-click **Time Averaged Ionization Rate** and choose **Duplicate**.

2 In the **Settings** window for **1D Plot Group**, type `Time Averaged Excitation Rate` in the **Label** text field.

Line Graph 1

1 In the **Model Builder** window, expand the **Time Averaged Excitation Rate** node, then click **Line Graph 1**.

2 In the **Settings** window for **Line Graph**, locate the **y-Axis Data** section.

3 In the **Expression** text field, type `ptp.xdintop_ptp1(ptp.R_wHes*N_A_const/ptp.xdim)`.

4 In the **Description** text field, type `Time averaged excitation rate (1/(m<sup>3</sup>s)`.

5 In the **Time Averaged Excitation Rate** toolbar, click **Plot**.

6 Click the  **Zoom Extents** button in the **Graphics** toolbar.

Time Averaged Electron Power Deposition

1 In the **Model Builder** window, right-click **Time Averaged Excitation Rate** and choose **Duplicate**.

2 In the **Settings** window for **1D Plot Group**, type `Time Averaged Electron Power Deposition` in the **Label** text field.

Line Graph 1

1 In the **Model Builder** window, expand the **Time Averaged Electron Power Deposition** node, then click **Line Graph 1**.

2 In the **Settings** window for **Line Graph**, locate the **y-Axis Data** section.

3 In the **Expression** text field, type `ptp.Pcap_ele_ions_av-ptp.Pcap_ions_av`.

4 In the **Description** text field, type `Time averaged electron power deposition`.

5 In the **Time Averaged Electron Power Deposition** toolbar, click  **Plot**.

6 Click the  **Zoom Extents** button in the **Graphics** toolbar.

7 In the **Time Averaged Electron Power Deposition** toolbar, click  **Plot**.

Time Averaged Electron Density

1 In the **Model Builder** window, right-click **Time Averaged Electron Power Deposition** and choose **Duplicate**.

2 In the **Settings** window for **1D Plot Group**, type `Time Averaged Electron Density` in the **Label** text field.

Line Graph 1

1 In the **Model Builder** window, expand the **Time Averaged Electron Density** node, then click **Line Graph 1**.

2 In the **Settings** window for **Line Graph**, click **Replace Expression** in the upper-right corner of the **y-Axis Data** section. From the menu, choose **Component 1 (comp1)>Plasma, Time Periodic>Electron density>ptp.neav - Electron density, period averaged - 1/m³**.

3 Locate the **y-Axis Data** section. Clear the **Description** check box.

4 In the **Time Averaged Electron Density** toolbar, click  **Plot**.

5 Click the  **Zoom Extents** button in the **Graphics** toolbar.

Time Averaged Ion Density

1 In the **Model Builder** window, right-click **Time Averaged Electron Density** and choose **Duplicate**.

2 In the **Settings** window for **1D Plot Group**, type `Time Averaged Ion Density` in the **Label** text field.

Line Graph 1

1 In the **Model Builder** window, expand the **Time Averaged Ion Density** node, then click **Line Graph 1**.

2 In the **Settings** window for **Line Graph**, click **Replace Expression** in the upper-right corner of the **y-Axis Data** section. From the menu, choose **Component 1 (comp1)>Plasma, Time Periodic>Number densities>ptp.n_wHe_1p_av - Number density - 1/m³**.

3 In the **Time Averaged Ion Density** toolbar, click **Plot**.

4 Click the **Zoom Extents** button in the **Graphics** toolbar.

Study 1/Solution 1 (2) (sol1)

1 In the **Model Builder** window, expand the **Results>Datasets** node.

2 Right-click **Results>Datasets>Study 1/Solution 1 (sol1)** and choose **Duplicate**.

3 In the **Settings** window for **Solution**, locate the **Solution** section.

4 From the **Component** list, choose **Extra Dimension from Plasma, Time Periodic (ptp_xdim)**.

Electric Potential

1 In the **Home** toolbar, click **Add Plot Group** and choose **1D Plot Group**.

2 In the **Settings** window for **1D Plot Group**, locate the **Data** section.

3 From the **Dataset** list, choose **Study 1/Solution 1 (2) (sol1)**.

4 In the **Label** text field, type `Electric Potential`.

Line Graph 1

1 Right-click **Electric Potential** and choose **Line Graph**.

2 In the **Settings** window for **Line Graph**, locate the **Selection** section.

3 From the **Selection** list, choose **All domains**.

4 Click **Replace Expression** in the upper-right corner of the **y-Axis Data** section. From the menu, choose **Component 1 (comp1)>Plasma, Time Periodic>Metal Contact 1> ptp.mct1.V - Electric potential - V**.

5 Locate the **Legends** section. Select the **Show legends** check box.

6 In the **Electric Potential** toolbar, click **Plot**.

7 Click the **Zoom Extents** button in the **Graphics** toolbar.

Cut Point 1D 1

1 In the **Results** toolbar, click **More Datasets** and choose **Cut Point 1D**.

2 In the **Settings** window for **Cut Point 1D**, locate the **Point Data** section.

3 In the **X** text field, type `0.067/2`.

Point Evaluation 1

1 In the **Model Builder** window, under **Results** right-click **Derived Values** and choose **Point Evaluation**.

2 In the **Settings** window for **Point Evaluation**, locate the **Data** section.

3 From the **Dataset** list, choose **Cut Point 1D 1**.

4 Click **Replace Expression** in the upper-right corner of the **Expressions** section. From the menu, choose **Component 1 (comp1)>Plasma, Time Periodic>Electron density>ptp.neav - Electron density, period averaged - 1/m³**.

5 Locate the **Expressions** section. In the table, enter the following settings:

Expression	Unit	Description
`ptp.neav`	`1/m^3`	`Electron density, period averaged`
`(3/2)*ptp.Teav`	`V`	`Mean electron energy, period averaged`

6 Click **Evaluate**.

Line Average 1

1 In the **Results** toolbar, click **More Derived Values** and choose **Average>Line Average**.

2 In the **Settings** window for **Line Average**, locate the **Data** section.

3 From the **Dataset** list, choose **Study 1/Solution 1 (2) (sol1)**.

4 Locate the **Selection** section. From the **Selection** list, choose **All domains**.

5 Locate the **Expressions** section. In the table, enter the following settings:

Expression	Unit	Description
`atxd0(0.067,ptp.nJt)`	`mA/cm^2`	`Period averaged ion current density`

6 Click next to **Evaluate**, then choose **Table 1 - Point Evaluation 1**.