TE-VSC-SCC training Using Molflow for sputtering simulations

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1. Molflow cheatsheet



Mouse controls:

Selection: left button

Rectangle selection: hold left button

Add/Remove from selection: hold SHIFT to add, CTRL to remove

Rotation: right button (slow rotation: hold SHIFT)

Pan: hold middle button

Zoom: mouse wheel (slow / fast zoom: hold SHIFT / CTRL)

2. Guided work: Sputtering in an ellipse-shaped chamber

- We'll use Molflow's built-in tools to draw ellipse chambers
- We'll add cathodes
- We'll sputter and see which configuration is the best
- a) Clear the field

You can start a new geometry from scratch with the File/New command:



You can turn on the "Rules" view option (upper right) to display the coordinate system:



b) Draw an ellipse

We'll first create the end cap of our chamber.

Select Facet/Create shape:



Then we'll draw an ellipse with the following parameters (see image below):

Type: circle/ellipse Center: 0,0,0 (default) Axis1 direction : 1,0,0 (default) Normal direction : 0,0,1 (default)

Axis 1 length : 2 cm Axis 2 length : 1 cm Steps in arc: 100





c) Extrude to a chamber

Choose Facet/Extrude:



Then extrude 10cm towards the facet's normal:

Extrude Facet	C
Towards / against winnal	1
Towards normal Against normal	
extrusion length: 10 cm	
Along straight path	٦
Direction vector:	
dX:cm dY:cm dZ:cm	
Get Base Vertex Get Dir. Vertex	



And the chamber is ready.

d) Add the cathode

Our cathode will be represented by a long, thin rectangle.

There are several ways to create such a long, narrow facet, we could use the "create shape" again. We'll create the shape by coordinates.

Select Vertex/Add new...

2	20) []								
Vertex View Test Time About									
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	Se	lect cop	ated ve	rtex (v	ISIDIE ON	screen)			
T.									

Type -.05 (units are cm) to the X coordinate and click "Add vertex":

Add new vertex			
X: (.05	Y: 0	Z: 0	
Facet center	Facet ū	Facet ⊽	Facet N
	Add	vertex	

Repeat the same with -.05:

Add new vertex			× 🗆 –
X:05	Y: 0	Z: ()
Facet center	Facet ជី	Facet ⊽	Facet N
	Add	vertex	

Now we have two vertices at one cap, we would like to copy them to the other:



Choose Vertex/Mirror-Project:

t	Ve	rtex	View	Test	Time	About	
		Cre Cle Re Ve Mo Sc	eate Fac ear isolat move se rtex coo ove ale	et from ed elected rdinate:	ı Selecti s	ed	•
	Mirror / Project Rotate Add new						
		Sel Un Sel Sel	lect all v iselect a lect cop lect isola	vertex II verte: Ianar v ated ve	k ertex (v rtex	isible on screer	λ

Select the opposite end cap and in the dialog choose "Plane of selected facet":

Mirror/Project selected vertices 📃 🔲 🗙
Plane definiton mode
C XY plane
☐ YZ plane
⊂ XZ plane
✓ Plane of selected facet
Plane equation: <-Get from 3 sel. vertex
0 ×X + 0 ×Y + 0 ×Z + 0 = 0
Mirror vertex Copy mirror vertex
Project vertex Copy project vertex Undo projection
4

Then click **Copy project vertex**. That will make a copy of the two vertices to the opposite cap:



Now we are ready to create the cathode from the four corners.

Choose Vertex / Create facet from selected / Convex Hull:



This will create the actual cathode facet:



(TAB-click anywhere to deselect the yellow vertices)

It is recommended that you save the file now.

e) Setting up the simulation

For any Molflow simulation, we need a gas source and a sink (usually a pump). We will set them up now.

With the cathode facet selected, give it a "uniform" outgassing on the right side. Uniform refers to the directional distribution -> we will have the same sputtering flux in every direction around the cathode.

Also, set the facet to 2-sided, so it sends particles both upwards and downwards:

- Selected Facet (#8587)								
Particle:	s in							
Resorption	Uniform 💽 🦳							
Outgassing (mbar*l/s):								
🗍 Outg/ar	Outg/area(mbar*l/s/cm²): 0.00658;							
I								
Sides:	2 Sided							
Onacity	Opecitur 1 Sided							
opdony.	2 Sided							
Temperatur	Temperature (*K): 293.15							

Now you must select the side walls and set them **sticking**.

The easiest way to select side walls is to select the cathode (if not already selected), then invert the selection (Selection / Invert or CTRL+I):

Molf	Molflow+ 2.8.3 (Sep 21 2020) []									
e Sel	ection	Tools	Facet	Vertex	View	Test				
	Smart Select facets Alt+S									
	Select All Facets Ctrl+A									
	Select	t by Fac	et Numb	er	Alte	N				
	Select	t Stickin	g							
	Select	t Transp	arent							
	Select	t 2 sideo	1							
	Selec	t Texture thu Tou	B hwo hung							
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	Calaal		0							
	Select Abs > U									
	Select large with no hits									
	Select by facet result									
	Select link facets									
	Select telenort facets									
	Select	t non pla	anar face	ets						
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	Invert selection Ctrl+I									
	Memo	rize sele	ection 😽	5		•				
	Select	t memori	ized							
	Clear memorized									
	Select Desorption									
	Select Outgassing Map									
	Select	t Reflect	tive							
	Selec	t volatile	facets							

Now, with the walls selected, set the sticking factor to 1 (100% absorption probability):

Particles out Sticking factor:	1
Pumping Speed (I/s):	606.883

f) Launch the simulation

That's it! Click the Begin button to start simulating:

Simulation							
Reset							
Update							

Your simulation is now running.

If you click the Front view (lower left) and turn on "Line" display, you can see the particle trajectories:



Note: if your particles are only flying in one direction (left), you have to set the desorbing cathode to 2-sided (right).

g) Post-processing: Setting up textures

Our goal is to set up color maps that show us the sputtering thickness. In Molflow, it is achieved through measuring the impingement rate (particle flux).

First, select the wall facets, including the end caps. (For example, by selecting the cathode and inverting selection), then open the **Advanced facet parameters** panel (<<Adv button):



Since we are recording textures on sticking walls, we must choose the **count absorption** option.

The texture resolution should be 10 cells/cm (see above). Click apply on the right side to mesh the facets. Then, launching the simulation again, you will see the first colors:



Finally, to show the impingement rate, open Tools/Texture scaling and set the textures to Impingement Rate display:

Too	ols Facet Vertex \	/iew Test	Tim				
\sqrt{x}	Formula editor	Alt+F					
	Texture Plotter Profile Plotter Histogram Plotter	Alt+T Alt+P					
đ	Texture scaling	Ctrl+D					
0	Particle logger Global Settings						
	Take screenshot	Ctrl+R					
	Moving parts						
Text	ure Scaling					– Curre	X = _
Min		utoscale		Use co	plors	Min:	1.851E+21
Max	1 Set to current	Apply	flow	Swap (thmic scale 204KB	Max:	3.638E+22
2.18	adient 1715e+22 5e+21 1e	+22 1.5e+		2e+22	2.5e+22	3e+22	3.5e+22
	Show: Impingement rate [1/sec/m² -						

The **Volume** view option, combined with Texture, shows the clearest image:

3D Viewer settings							
🗍 Rules	Normals	(
🗍 Lines	🗍 Leaks	🦳 Hits					
✓ Volume	 Texture 	🗍 FacetIDs					
< View	🔲 Indices	C VertexIDs					



h) Post-processing: plotting thickness profile

While color codes are useful for qualitative analysis, plotting the profile along the wall allows to compare different configurations.

We will simply select all wall facets and export the hit count.

Use Selection / Smart Select:



Click analyze – it will check which facet is the neighbor of others (only to do once):



Then with this window open, you can select the wall of the ellipse with one click (you should have 101 facets selected):



Click facet Details button:



Scroll to the Impingement rate column and right-click it, select Copy:

I	Facet	s details								_ 0	×
	rity	Profile	Imping.rate	D 2 D	U 01	N N N I	B]	Pressure	[mbar]	Av.mol.spe	
)00	None	3.56116e+2	Copy o	olumr	n Imping.rate		0.00074	6045	469.;	h
)00	None	3.54166e+21	1.0457e	+19	4.87993e-I	07	0.00073	3548	469.0	
)00	None	3.50994e+21	1.0533e	+19	4.91542e-0	07	0.0007	1694	469.0	
)00	None	3.46119e+21	1.06342	e+19	4.96261e-0	07	0.00069	91144	469.	
)00	None	3.42071e+21	1.080396	e+19	5.04181e-0)7	0.00066	5064	468	
)00	None	3.37923e+21	1.09854	e+19	5.12653e-0	07	0.00063	8569	469.0	
)00	None	3.3518e+21	1.12219e	+19	5.23687e-I	07	0.00061	5622	469.	
4)00	None	3.34531e+21	1.15103e	+19	5.37149e-0	07	0.00059	8497	469.0	
2)00	None	3.35754e+21	1.183886	e+19	5.52478e-I	-07 0.0005		7073	469.	
2)00	None	3.38948e+21	1.22028	e+19	5.69463e-07 5.90744e-07 6.1348e-07		0.00058	31087	469.	
)00	None	3.4599e+21	1.26588	e+19			0.00058	4657	469.0	1
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	💌 De	es. 💌 E	quivAbs.								
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Paste the copied column in an empty Excel sheet, select the pasted Hit column and plot it by Insert/Line plot:





This is your baseline, single-cathode thickness profile, which will be compared with optimized configuration.

In the next steps we will optimize the cathode configuration to compare results.

i) Optimizing configuration

We can simulate several configurations at the same time, so one way to optimize the cathode configuration is to make copies of the geometry to be coated, and run the simulation with different setups, at the same time:



In this exercise, we'll try 3 different cathode setups, and compare the thickness.

Select all facets to make a copy:

Molflow+ 2.8.3 (Sep 21 2020) [one_ellipse_solved.:

Selection		Tools	Tools Facet		View	Т	est
	Smart	Alte	۰S				
	Selec	t All Fac	ets		Ctrl+	A	
	Selec	t by Fac	Alt+	N	⊡ ι		
	Selec			-			

Select Facet / Move:



Move the facets to the right, then to the left by +5 and -5 cm X offsets, clicking **Copy facets**:

Move facet										
Absolute offset C Direction and distance										
dX	5	cm								
đ۲	0	cm								
ďZ	0	cm								
_ In dire	ection									
Distanc	e:	cm								
	Facet normal									
Selec Fac	et center Facet	on base first J Vertex center								
Mov	ve facets Copy	facets								

Between the two copies, you'll have to select the middle structure again (as copy source):



After the copy, the target is selected by default, so in case of error, you can delete it (CTRL+DEL).

Now you can select the cathodes on the left and right, and using the Move / Copy commands, you can achieve custom configurations (up to you):



Example cathode configuration with +0.2 and -0.2cm offsets from center position.

Important: set the outgassing to be the same in total for all configuration, so that results are comparable.

For example, a 2-cathode configuration should outgas 0.5mbar*l/s each, so the total outgassing is 2*0.5=1, comparable with the original single-cathode setup:



Add textures to the copied structures (textures are not copied for performance reasons):

	Lines Leaks Hits
Advanced facet parameters	⊂ Volume 🔽 Texture 🗌 FacetiDs
Texture properties	View Indices VertexIDs
Enable texture Use square cells Force remesn	Selected Facet (102 selected) =
Resolution: 10 cells/cm 0.1 cm/cell	Particles in
Number of cells:x	Desorption None 💌 🥅
Count desorption Count reflection	🕑 Outgassing (mbar*l/s):
Count absorption Count transparent pass	Outg/area(mbar*l/s/cm²):
Angular coefficient Record direction vectors	- Particles out
Texture cell / memory	Sticking factor:
Memory: 2.44MB Cells: 20880	Pumping Speed (I/s):
Additional parameters	Sides: 1 Sided
Reflection: 1 part diffuse, 0 part specular,	
0 part cosine [^] 0	
Accomodation coefficient: 1	Temperature ("K): 293.15
Teleport to facet: 0	Sum Area (cm²): 51.57379904
Structure: 1 Link to: no	Profile: None 💌
Moving part	Adv Details Coord. Apply
Wall sojourn time	Shortcuts
Attempt freq: 1e+13 Hz Binding E: 100 J/mole	- Simulation
View settings	<pre> Sim Besume Beset </pre>
🐨 Draw Texture 🛛 🐨 Draw Volume <- Change draw	✓ Auto update scene Update
Dynamic desorption	Hits 50.80 Mhit (6.1 Mhit/s)
Incident angle distribution	Des. 50.80 Mdes (6.1 Mdes/s)
	Leaks None

Launch the simulation to compare, and extract the plots to finish, repeating the column copy steps:





3. Individual work

In this second exercise you'll work with a real-life geometry, which is harder because facets are randomly oriented.

a) Input files

You'll have the ...

- CAD model (rfcavity.stl)
- The Excel sheet for post-processing (impingement_template.xlsx)

b) Exercise

You have to build a simulation to show thickness along the RF cavity, from a cathode in the center.

Once you solve the uniform case, you'll optimize the sputtering to achieve a more uniform thickness by a "moving cathode" sputtering: you'll desorb different gas quantities along the length – trying to achieve a more uniform thickness.



Moving sputtering/diagnostics instrument. Source: <u>http://cds.cern.ch/record/256049/</u>

("An instrument for internal surface analysis of LEP 200 superconducting radiofrequency cavities")



Possible solution with original (blue) and optimized (orange) thickness.

c) Steps

One way to solve the exercise is by the following steps, like the previous case:

- 1. Import geometry by opening STL file and collapsing
- 2. Create cathode facet
- 3. Add outgassing to cathode
- 4. Add sticking to walls
- 5. Launch the simulation for a quick test
- 6. Add textures to walls
- 7. Export textures and paste them in Excel template to plot thickness profile
- 8. Make a copy of the geometry (second, optimized version)
- 9. Break up the cathode to smaller parts
- 10. Vary outgassing on smaller parts to achieve more uniform thickness
- 11. Compare two (uniform vs non-uniform) thickness profiles

d) Hints / instructions for each step

1. Opening and collapsing file

• When you open rfcavity.stl, Molflow will ask the units of the file: they are centimeters:



• A "Collapse" window pops up, leave the default values and click Collapse (to merge triangles into facets):



triangulated vs collapsed geometry, main differences on the sides

2. Creating cathode

There is an easy and an "elegant" way to create the long, rectangular cathode facet.

Easy way by manually entering the coordinates: Choose Vertex/Add New, and create four vertices at these XYZ coordinates:

- 0.25, 0, 121.9
- -0.25, 0, 121.9
- 0.25, 0, 30
- -0.25, 0, 30

Then select Vertex / Create Facet from Selected / Convex Hull to create the rectangle

Elegant way: you don't need to know the end cap coordinates, since Molflow can automatically project the vertices on the facets.

Create two vertices at (0.25,0,0) and (-0.25,0,0).

Use the Vertex / Mirror-Project command to project these vertices to the end caps (with the plane of selected facet option):

Mirror/Project selected vertices
Plane definiton mode
☐ YZ plane
🗍 XZ plane
✓ Plane of selected facet
Plane equation: <-Get from 3 sel. vertex
0 *X + 0 *Y + 0 *Z + 0 = 0
Mirror vertex Copy mirror vertex
Project vertex Copy project vertex Undo projection

3. Add outgassing to cathode

Set it to two-sided, and add an arbitrary value of "Uniform" outgassing

4. Add sticking to walls

To select walls, either select the cathode and invert selection, or use Selection / Smart select and click on the wall. Don't forget the end caps. Set sticking to 1.

5. Launch simulation

Just click the Begin button on the right. Turn on "Lines" and "Leaks" display, you should have lines but no leaks:



6. Add textures to walls

Select the walls (as in point 4), open the advanced parameters panel (<<Adv) button on right, use the "Count absorption" option with 1cm/cell resolution and click Apply.

7. Export textures to Excel and plot them

Select textures (Selection / Select Textured), the choose File/Export selected textures/By X,Y,Z coordinates/Impingement rate



Save it to a text file (for example export.txt), open the file, select all the data in it and copy to clipboard.

Then open **impingement_template.xlsx**, and paste the (four) columns into the A2 cell (case 1):

	A B	с	D	E			А	В	С	D	E
1 Case 1						1					
2						2	X_coord_c				
	Chart Area					3	moment 0				
	Chart Area					4	-10.2963	-0.02066	-7.45632	5.48E+18	
5						5	-10.3	-0.01696	-6.50447	6.57E+18	
6						6	-10.3	-0.01696	-5.50447	9.86E+18	
7						7	-10.2955	-0.02151	-4.63548	8.96E+18	
8						8	-10.2963	1.03691	-7.90817	1.10E+19	
9						9	-10.2945	0.28128	-7.91	1.64E+19	
10						10	-10.2963	1.48876	-4.71919	5.48E+18	
11						11	-10.3	1.48506	-5.67104	4.93E+18	
12						12	-10.3	1.48506	-6.67104	4.93E+18	
13						13	-10.2955	1.4896	-7.54003	2.02E+19	
14						14	-10.3016	0.859916	-4.27267	4.10E+18	
15						15	-10.276	0.121676	-4.247	1.19E+19	
16						16	-6.59097	1.12897	-4.17105	1.09E+19	
17						17	-7.57033	1.19014	-4.17105	9.35E+18	
18						18	-8.56741	1.25758	-4.17105	4.23E+18	
19						19	-9.56293	1.32491	-4.17105	3.56E+18	
20						20	-6.73021	0.271144	-4.17105	1.16E+19	
21						21	-7.71316	0.340935	-4.17105	1.41E+19	
22						22	-8.697	0.437204	-4.17105	5.58E+18	
23						23	-9.68255	0.575277	-4.17105	2.82E+18	
24						24	-9.78593	-0.01781	-4.17105	2.61E+18	

This will automatically plot the thickness along axis Z:



Explanation:

The texture cells are exported as (X,Y,Z,impingement_rate) value quartets.

Excel averages all cells that lie within a select range of Z coordinates:

-13.5	6.26906E+19
-13	9.30367E+18
-12.5	9.37919E+18
-12	3.35686E+19
-11.5	3.08035E+19
-11	2.67478E+19
-10.5	3.59753E+19

=AVERAGEIFS([0\$2:D\$100001,C\$2:C\$1	.0000	01,">"&N37,C\$2:C\$100001,"<"&N3										
Function Arguments			? ×										
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Average_range	D\$2:D\$100001	Î	= {"Value";0;547617000000000000;65 ^										
Criteria_range1	C\$2:C\$100001	Ť	= {"Z_coord_cm";0;-7.45632;-6.50447;										
Criteria1	">"&N37	Ť	= ">-12.5"										
Criteria_range2	C\$2:C\$100001	Ť	= {"Z_coord_cm";0;-7.45632;-6.50447;										
Criteria2	"<"&N38	Ť	= "<-12" v										
= 9.37919E+18 Finds average(arithmetic mean) for the cells specified by a given set of conditions or criteria. Average_range: are the actual cells to be used to find the average.													
Formula result = 9.379	19E+18												
Help on this function OK Cancel													

This is called conditional averaging (AVERAGEIFS function): if the Z coordinate in the C column is within two values (defined in the N column), then the cell will count towards the average.

8. Make a copy of the geometry

Select all facets, and using the Facet/Move command make a copy by applying an 50cm X or Y offset.



Finally, add textures to the copied RF cavity (textures are not copied).

9. Break up the cathode to smaller parts

- On one of the two cathodes, add a texture (any option, for example "count absorption") with 1cm/cell resolution
- Choose Facet / Explode



• Set the same outgassing (for example 1) on all 152 small cells:



• Select the other (not exploded) cathode and set 152 as outgassing, so that total outgassing is the same



• Test the simulation and the resulting textures, the colors should be the same:



10. Vary outgassing to achieve uniform thickness

Where the impingement is too high or too low (for example, ends), adjust the outgassing by selecting smaller parts of the cathode. This corresponds to the sputtering time at that position in real life. After every change, rerun the simulation and check the result:



When you have a good (enough) uniformity, adjust the total outgassing on the other cathode for comparison.



Original, uniform outgassing (TOP) and equalized outgassing (BOTTOM). Note the differences on the edges.

11. Compare thickness profiles

Select one of the RF bodies, and repeat point 7: export textures to a file and paste to Excel. If you use the template, it will be plotted.

Repeat the process for the other RF cavity and paste the values in "Case 2" in the template sheet.

This will plot the two thickness profiles against each other:

A A	8	C D E	F	G H I J K	I L I M	N I	0	P	Q R	s	т	υI	v I	w	x I	v I	z	AA	AB	AC	AD	AE .	AF	AG	AH	AI	N
1		Case 1		Case 2		Z pos [cm] a	werage imp rate (case 1)	average imp rate (case 2)	factor																		
2 X coord	Y coord c	Z coord c Value		X coord cY coord cZ coord cValue		-30	1.7675E+19	8.68889E+18	47							Ave	erage im	pingeme	nt rate	(1/sec/	m2)						
3 moment	(Constant	Flow){		moment 0 (Constant Flow)(-29.5	1.80619E+19	9.19806E+18		65+10																	
4 -10.2917	-0.02529	-7.70863 8.07E+18		-1.03E+01 -0.02529 -4.46688 9.21E+19		-29	1.85306E+19	9.75966E+18		01115																	
5 -10.3	-0.01696	-7.25447 7.77E+18		-1.03E+01 -0.01696 -4.92104 9.47E+19		-28.5	1.81664E+19	1.01149E+19																			
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11 -10.2857	-0.03124	-4.38061 7.27E+18		-1.03E+01 -0.03124 -7.7949 1.10E+20		-25.5	9.36089E+18	7.12208E+18				./	× Mu	1										VIM.	M		
12 -10.2917	1.28922	-7.9128 9.72E+18		-1.03E+01 0.178872 -7.9128 1.32E+20		-25	2.72441E+19	1.50421E+19		3E+19			MIM											VI VI			
13 -10.3	0.835057	-7.90447 7.77E+18		-1.03E+01 0.633039 -7.90447 1.35E+20		-24.5	3.19689E+19	1.74315E+19				111															
14 -10.3	0.335057	-7.90447 8.43E+18		-1.03E+01 1.13304 -7.90447 1.33E+20		-24	2.58817E+19	1.27277E+19		35.10			111														
15 -10.2673	0.017711	-7.93714 4.83E+18		-1.03E+01 1.45038 -7.93714 1.27E+20		-23.5	3.11496E+19	1.28942E+19		26+19	2			V I													
16 -10.2917	1.49339	-4.46688 7.39E+18		-1.03E+01 1.49339 -7.70863 1.20E+20		-23	3.29827E+19	1.73149E+19				INV	MI	- I I	14		41	44	1	14	AL.	41			MIN I		
17 -10.3	1.48506	-4.92104 8.65E+18		-1.03E+01 1.48506 -7.25447 1.33E+20		-22.5	3.47707E+19	2.00972E+19		1E+19		1.1	1.1	100	h	N U	NL	d los	R ha	1 h	Nh	al la	and I				
18 -10.3	1.48506	-5.42104 7.88E+18		-1.03E+01 1.48506 -6.75447 1.40E+20		-22	1.29075E+19	6.89485E+18			1		1 1~	V									V	111	(U')		
19 -10.3	1.48506	-5.92104 7.77E+18		-1.03E+01 1.48506 -6.25447 1.41E+20		-21.5	1.34868E+19	9.70882E+18						*										N N	· V		
20 -10.3	1.48506	-6.42105 7.77E+18		-1.03E+01 1.48506 -5.75446 1.03E+20		-21	1.58479E+19	1.00254E+19		0																	
21 -10.3	1.48506	-6.92105 5.91E+18		-1.03E+01 1.48506 -5.25446 1.13E+20		-20.5	1.78157E+19	1.02964E+19		-4	01	-20		0		20		40		60		80		100	120		140
22 -10.3	1.48506	-7.42105 6.24E+18		-1.03E+01 1.48506 -4.75446 1.06E+20		-20	1.93023E+19	1.05073E+19										7 nos	ition (cr	4							
28 -10.2857	1.49934	-7.7949 9.15E+18		-1.03E+01 1.49934 -4.38061 1.05E+20		-19.5	2.06425E+19	1.08517E+19										r box	icion (en	-1							
-10.3804	0.851076	-4.35145 1.27E+19		-1.03E+01 0.240014 -4.25904 1.22E+20		-19	2.03547E+19	1.22656E+19																			
25 -10.3171	0.496089	-4.28815 7.33E+18		-1.02E+01 0.608146 -4.19923 1.10E+20		-18.5	1.9499E+19	1.21613E+19																			
-10.276	0.121676	-4.247 7.70E+18		-1.04E+01 0.541479 -4.33256 1.15E+20		-18	1.79772E+19	1.17856E+19																			
27 -10.2998	1.17983	-4.27081 8.56E+18		-1.03E+01 0.925384 -4.27686 1.11E+20		-17.5	1.59584E+19	1.13855E+19																			
28 -10.2471	0.784409	-4.21811 8.78E+18		-1.03E+01 1.33058 -4.2279 1.27E+20		-17	9.82953E+18	7.04039E+18																			
-10.2189	1.50952	-4.18993 6.82E+18		-1.04E+01 1.26659 -4.36075 1.07E+20		-16.5	3.29408E+19	1.73134E+19																			
30 -6.3058	1.35882	-4.17105 1.36E+19		-1.03E+01 1.39809 -4.30929 1.44E+20		-16	3.1551E+19	1.53251E+19																			
31 -6.79364	1.3876	-4.17105 1.05E+19		-9.95E+00 1.33506 -4.17105 4.08E+19		-15.5	2.9668E+19	1.39359E+19																			
32 -7.29217	1.42132	-4.17105 1.01E+19		-9.95E+00 0.835057 -4.17105 4.32E+19		-15	2.76551E+19	1.24689E+19																			
33 -7.78994	1.45498	-4.17105 9.25E+18		-9.95E+00 0.335057 -4.17105 4.64E+19		-14.5	2.40736E+19	1.48316E+19																			
.8 7861	1 48854	.4 17105 8 51F+18		.9 95F+00 .0 01595 .4 17105 4 33F+19		.14	3 35641F+19	1 83587F+19																			

Solution: Pasted data from Case 1 and Case 2, plotted against each other.

Well done!

4. More info and tutorials

On the website (Molflow documentation, mainly for vacuum simulations):

