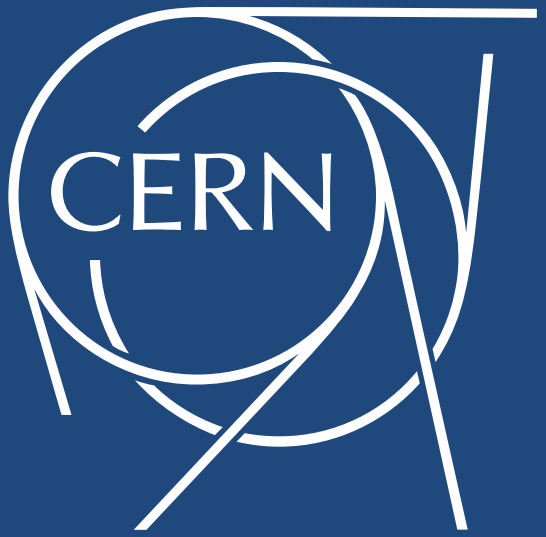
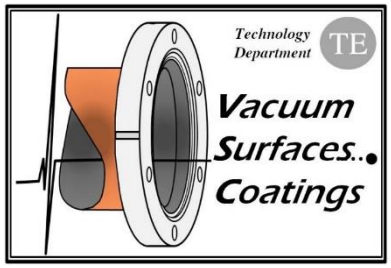
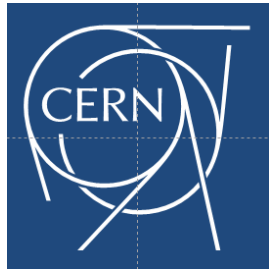

CERN





Molecular-Flow Simulations with Molflow+

R. Kersevan, M. Ady, CERN-TE-VSC-VSM

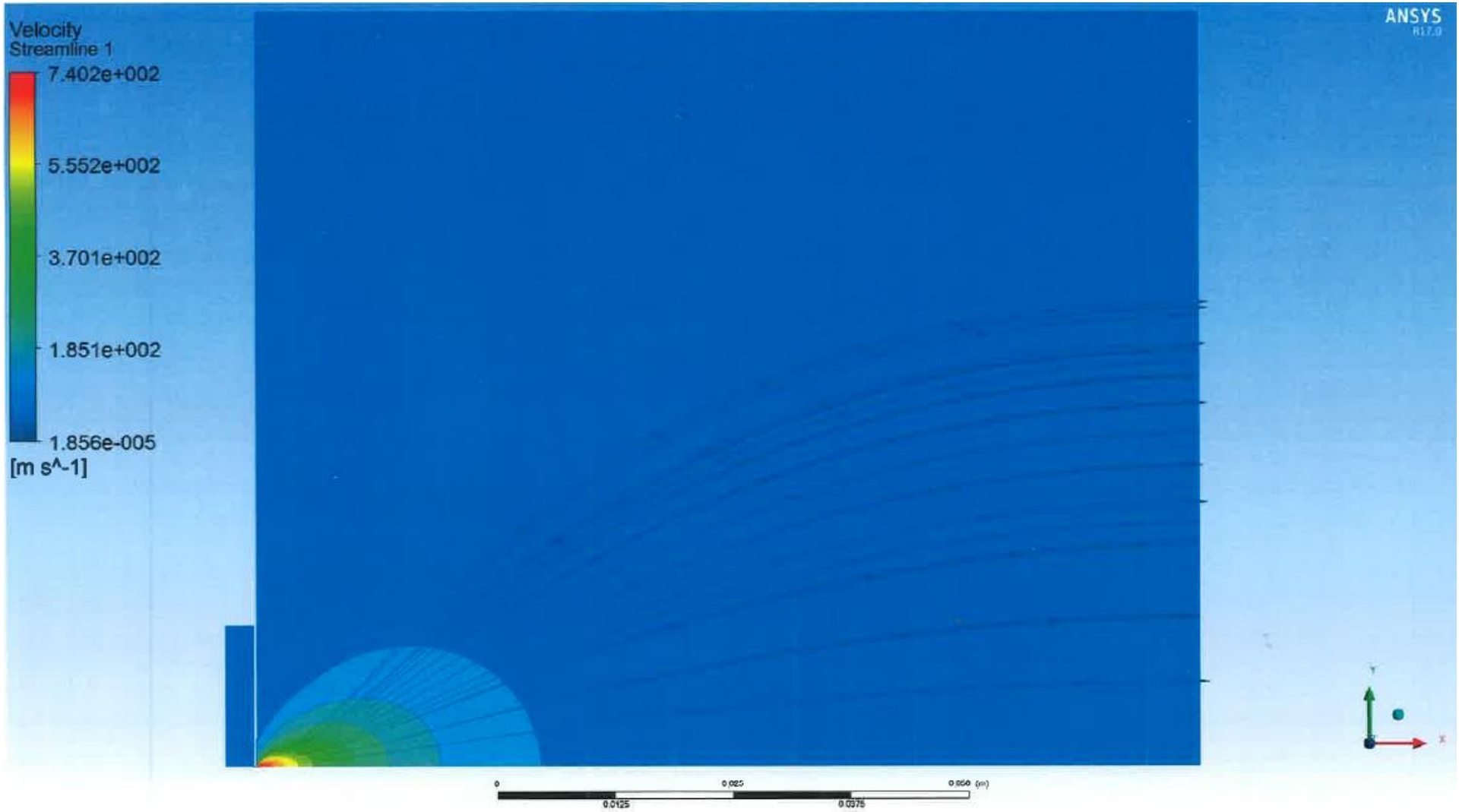
Beam Gas Curtain Project Review
11-12/10/2016 866-2/D-05 CERN

Introduction:

1. The Test-Particle Monte Carlo (TPMC) code Molflow+ has been applied to check the feasibility of ray-tracing optimization of the beam-gas curtain detector (BGCD) geometry;
2. Viscous-flow regime calculations made with ANSYS have been used as an input for the effusion from the high-pressure side and into the 1st skimmer (P. Magagnin);
3. A CAD model, in STL format, has been used as input (courtesy of Elena Barrios Diaz), and then edited within Molflow+ to apply all vacuum parameters (sticking and desorption coefficients);

Input parameters:

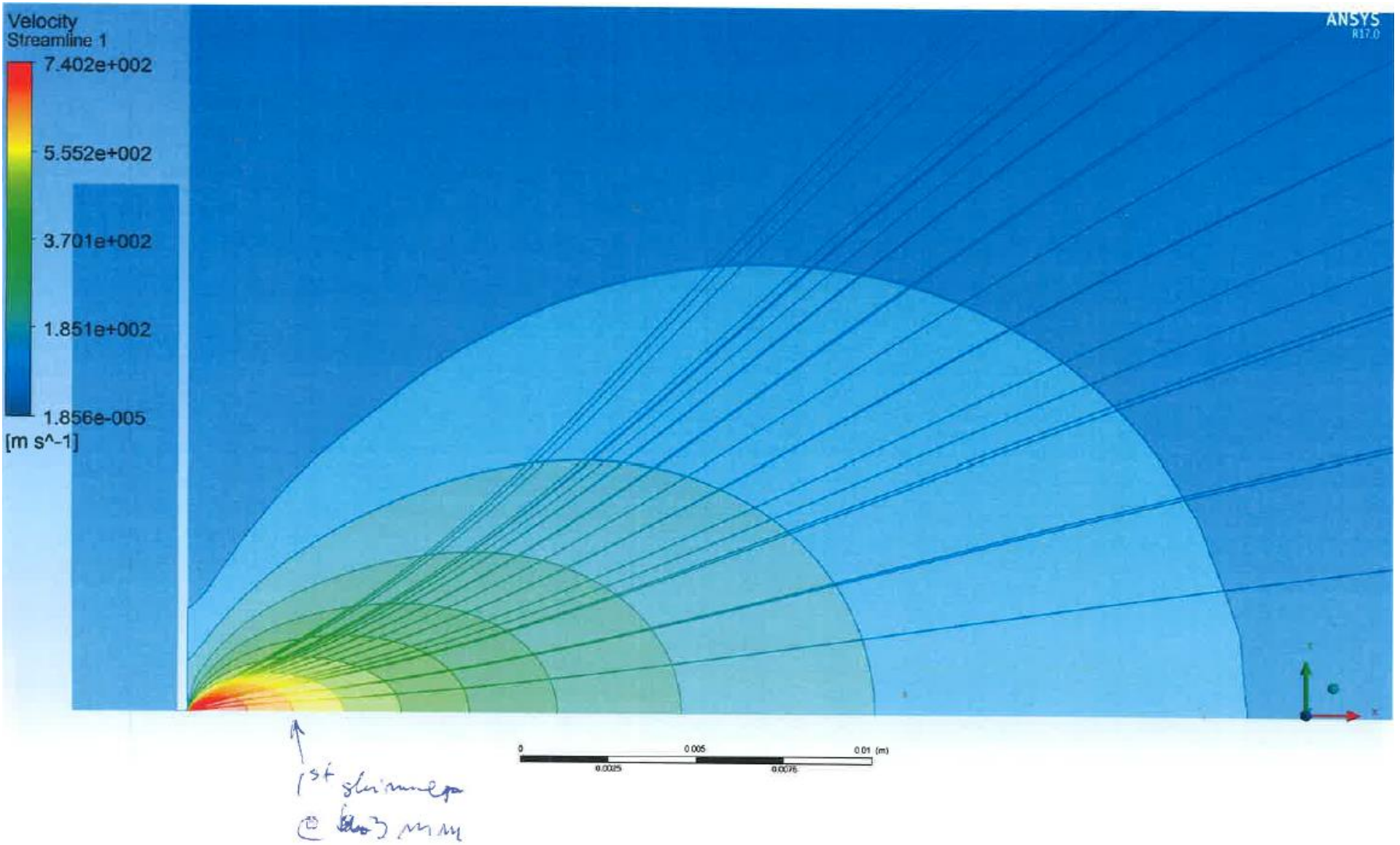
2. Viscous-flow regime input (P. Magagnin, personal communication, July 2016);



Horz. Scale: 50 mm

Input parameters:

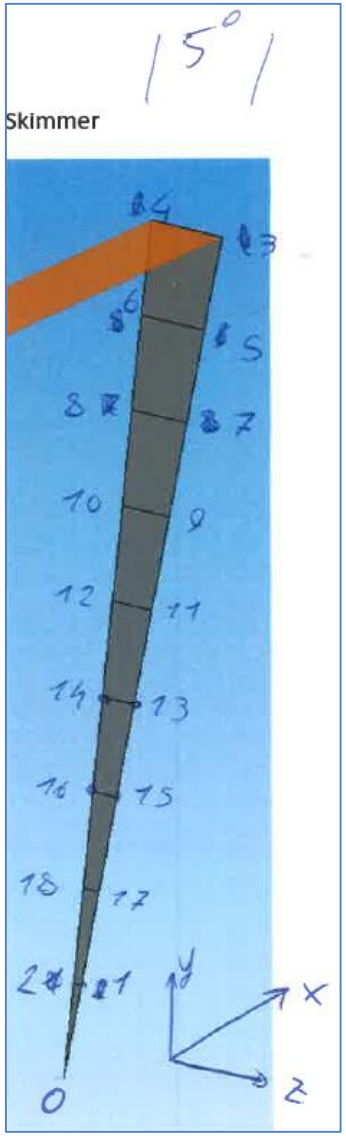
2. Viscous-flow regime input;



Horz. Scale: 10 mm

Input parameters:

2. Viscous-flow regime input;

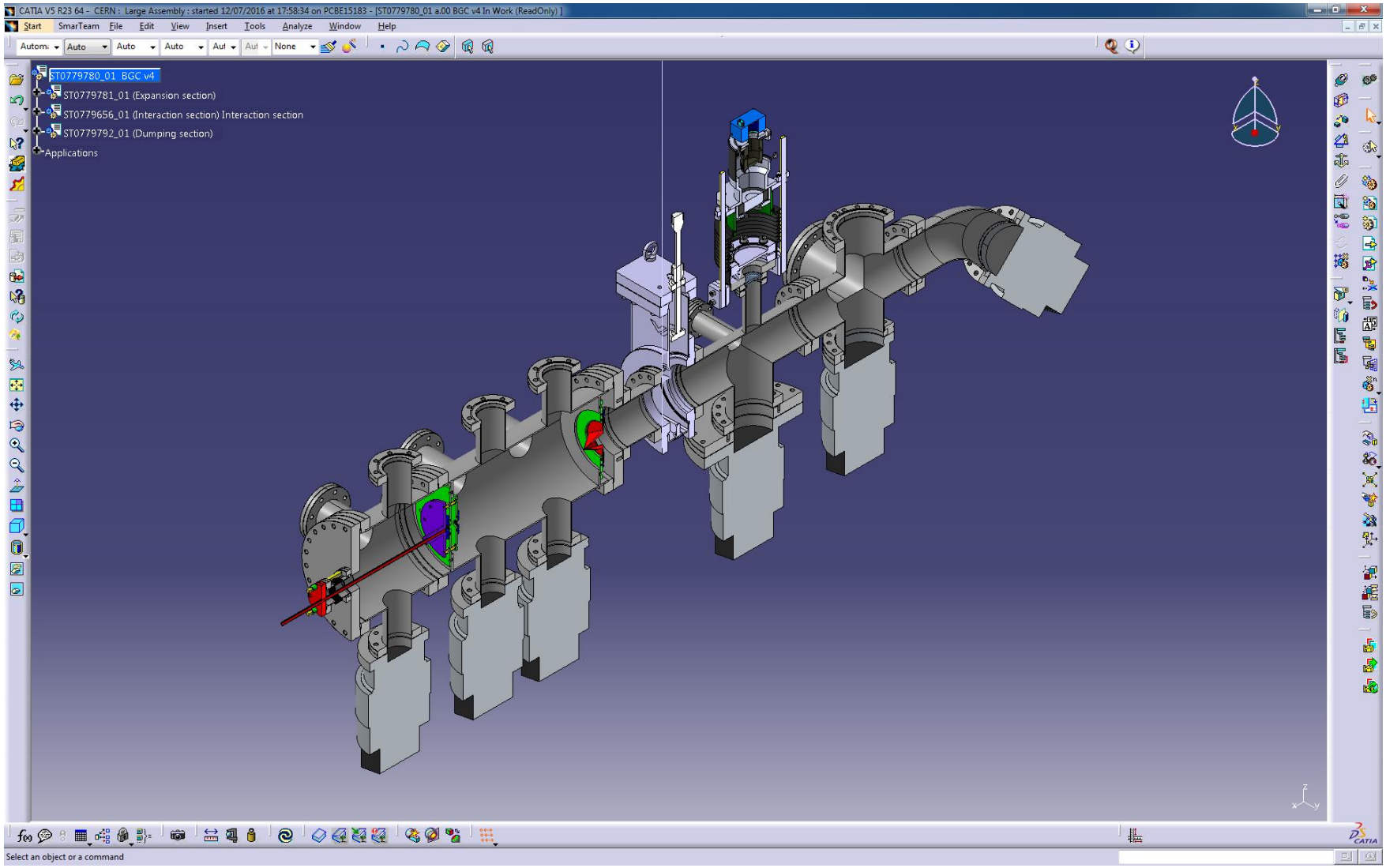


	A	B	C	D	E	F	G	H	I	J	K
1		X[m]	Y[m]	Z[m]	vel	vel u	vel v	vel w	angle	diffRAD	diffDEG
2	0	2.99E-03	0.00E+00	0.00E+00	5.9094E+02	5.9094E+02	0.00E+00	0.00E+00	0		
3	2	2.99E-03	1.00E-05	0.00E+00	5.9088E+02	5.9088E+02	1.53E+00	0.00E+00	0.002586	0.002586	0.148174
4	17	2.99E-03	2.00E-05	0.00E+00	5.9086E+02	5.9085E+02	2.93E+00	0.00E+00	0.004966	0.00238	0.136355
5	16	2.99E-03	3.00E-05	0.00E+00	5.9084E+02	5.9082E+02	4.45E+00	0.00E+00	0.007534	0.002568	0.14713
6	14	2.99E-03	4.00E-05	0.00E+00	5.9080E+02	5.9077E+02	6.00E+00	0.00E+00	0.01016	0.002626	0.150453
7	11	2.99E-03	5.00E-05	0.00E+00	5.9074E+02	5.9069E+02	7.56E+00	0.00E+00	0.0128	0.00264	0.15128
8	9	2.99E-03	6.00E-05	0.00E+00	5.9066E+02	5.9059E+02	9.12E+00	0.00E+00	0.015447	0.002647	0.151646
9	8	2.99E-03	7.00E-05	0.00E+00	5.9057E+02	5.9048E+02	1.07E+01	0.00E+00	0.0181	0.002653	0.152016
10	5	2.99E-03	8.00E-05	0.00E+00	5.9047E+02	5.9034E+02	1.23E+01	0.00E+00	0.02077	0.00267	0.152995
11	4	2.99E-03	9.00E-05	0.00E+00	5.9034E+02	5.9018E+02	1.39E+01	0.00E+00	0.023483	0.002713	0.155452

- One 5-deg slice of the circular orifice on the high-pressure side;
- The deviation angle of the velocity of the gas from the straight axis of the opening has been obtained combining the components of the velocity vector on each of the 9 sub-slices (computed by **M. Ady**);
- The actual speed of the molecules is **not important in steady-state conditions**, other than to determine the amount of gas flowing into the 1st skimmer;
- The orientation of the velocity vector is what matters in terms of **probability of collision with the walls of the system** (conical skimmers and pyramidal nozzle); After few wall collisions the quasi-monochromatic injected molecular beam quickly thermalizes and gets a Maxwell-Boltzmann distribution;

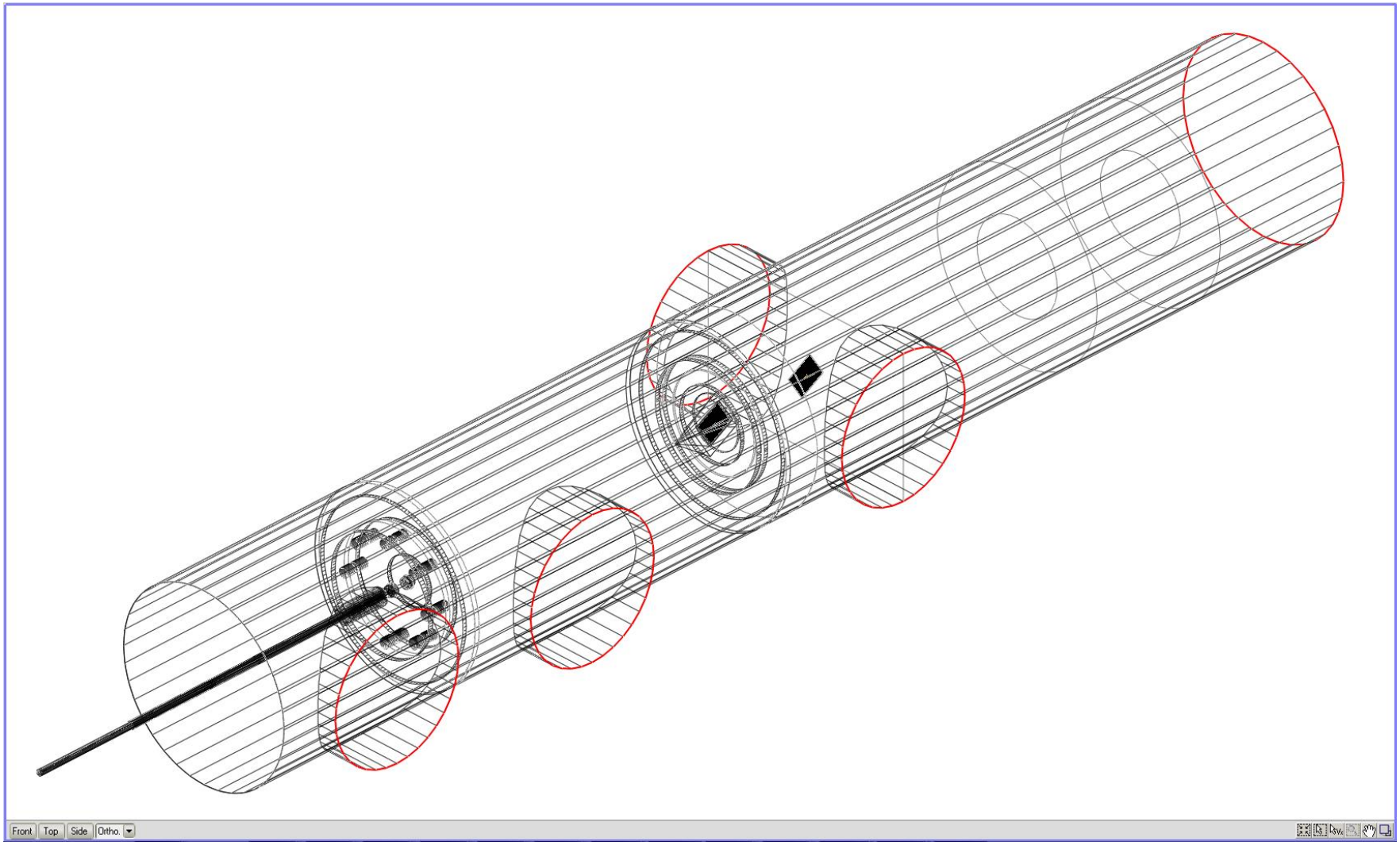
3D Model:

3. CAD model (Elena Barrios Diaz, personal communication, July 2016);



Molflow+ Model:

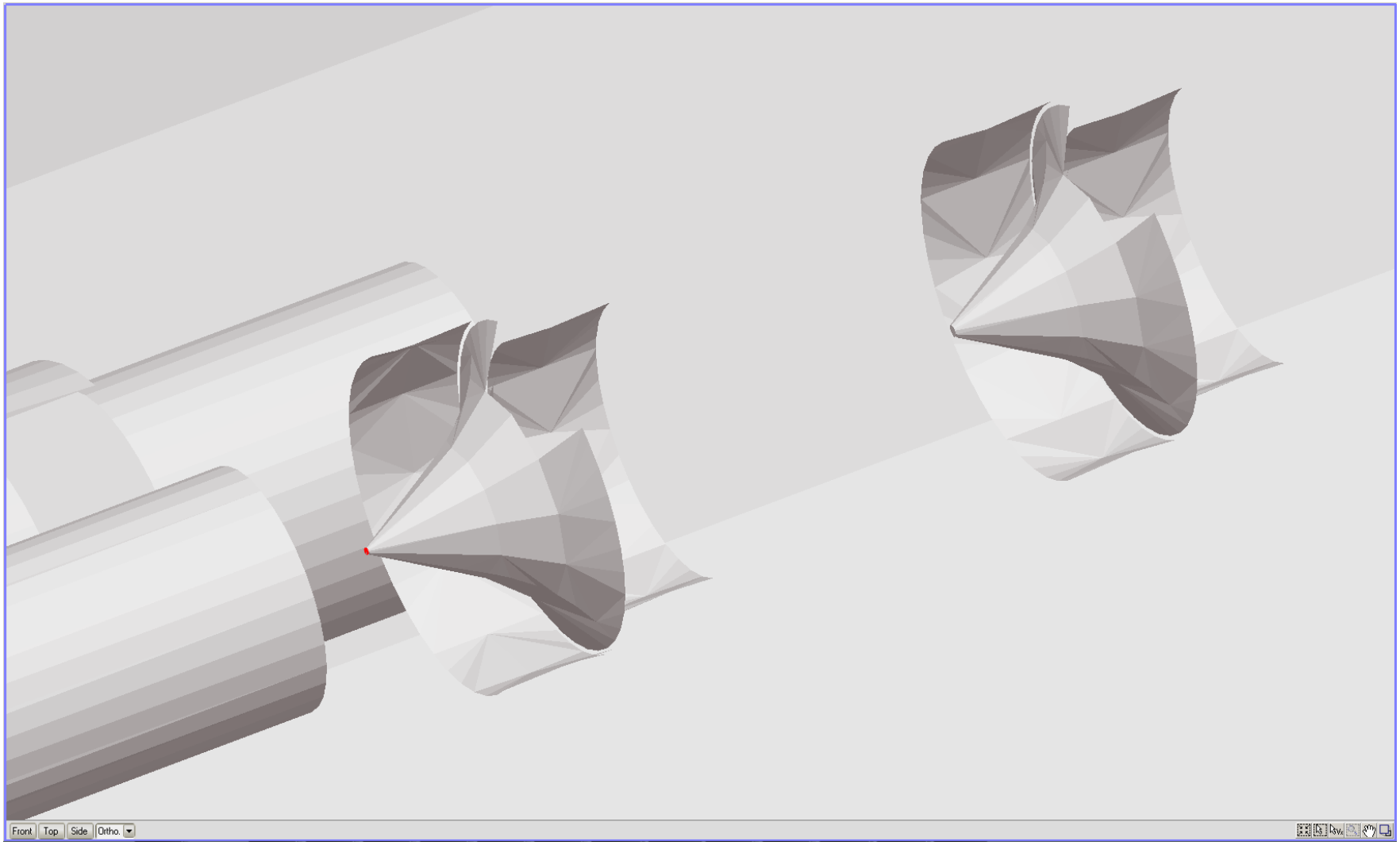
3. Molflow+ model (simplified);



- Red circles: inlet flange to 277 l/s pump;
- Dark rectangles: transparent, virtual facets, with textures to visualise and record hits;

Molflow+ Model:

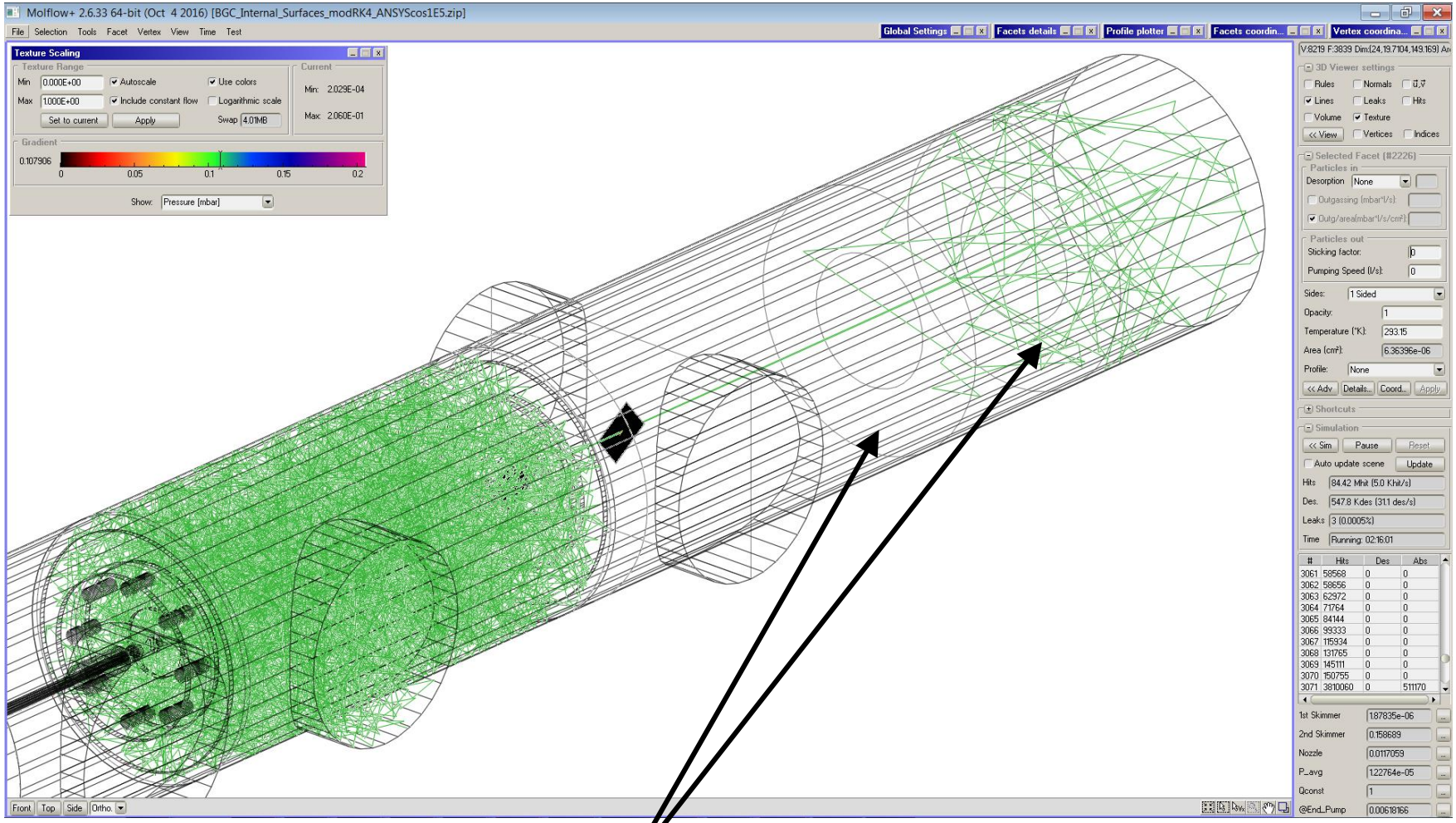
3. Molflow+ model (simplified);



Closer view into the first skimmer area; the little red dot is the inlet surface simulating the viscous-flow distribution as calculated by P. Magagnin;

Molflow+ Model:

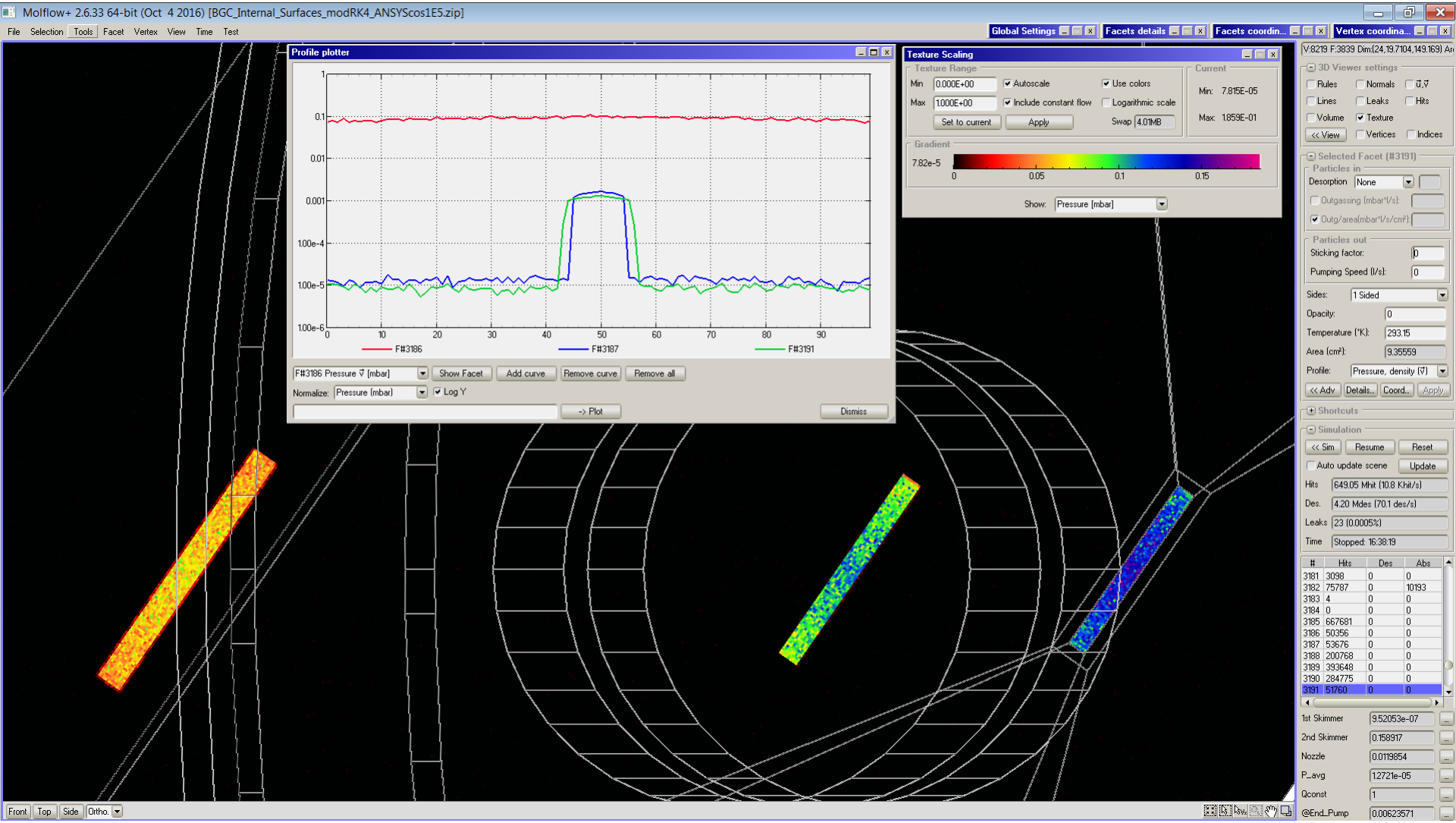
3. Molflow+ model (simplified);



Ray-tracing with Molflow: **<u>two baffles</u>** have been placed in front of the “dump” area turbo pump, to reduce backscattering from it;

Molflow+ Model:

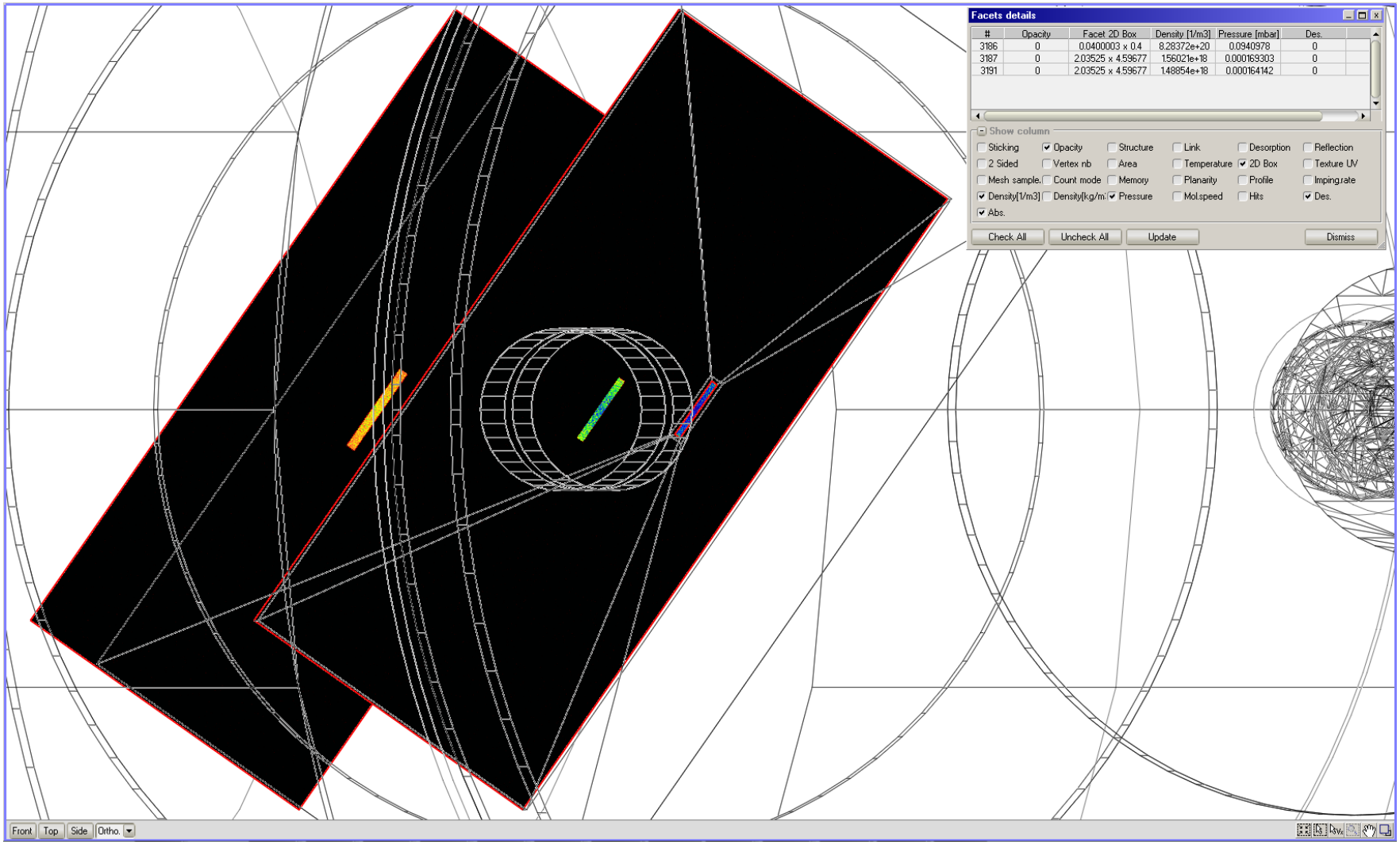
3. Molflow+ model (simplified);



- Close-up view of the textured surfaces;
- Right-to-Left: entrance to nozzle (red profile on inset), base of nozzle (blue), and interaction region (green); The horizontal axis on inset plots is longest side of textured rectangles;
- Red: 4x0.4 mm^2 nozzle inlet; Blue and Green: 20.4 x 46.0 mm^2;

Molflow+ Model:

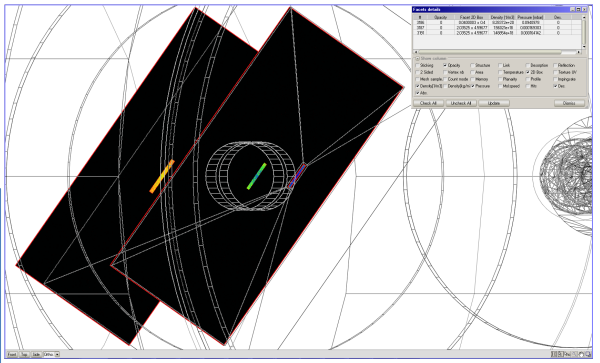
3. Molflow+ model (simplified);

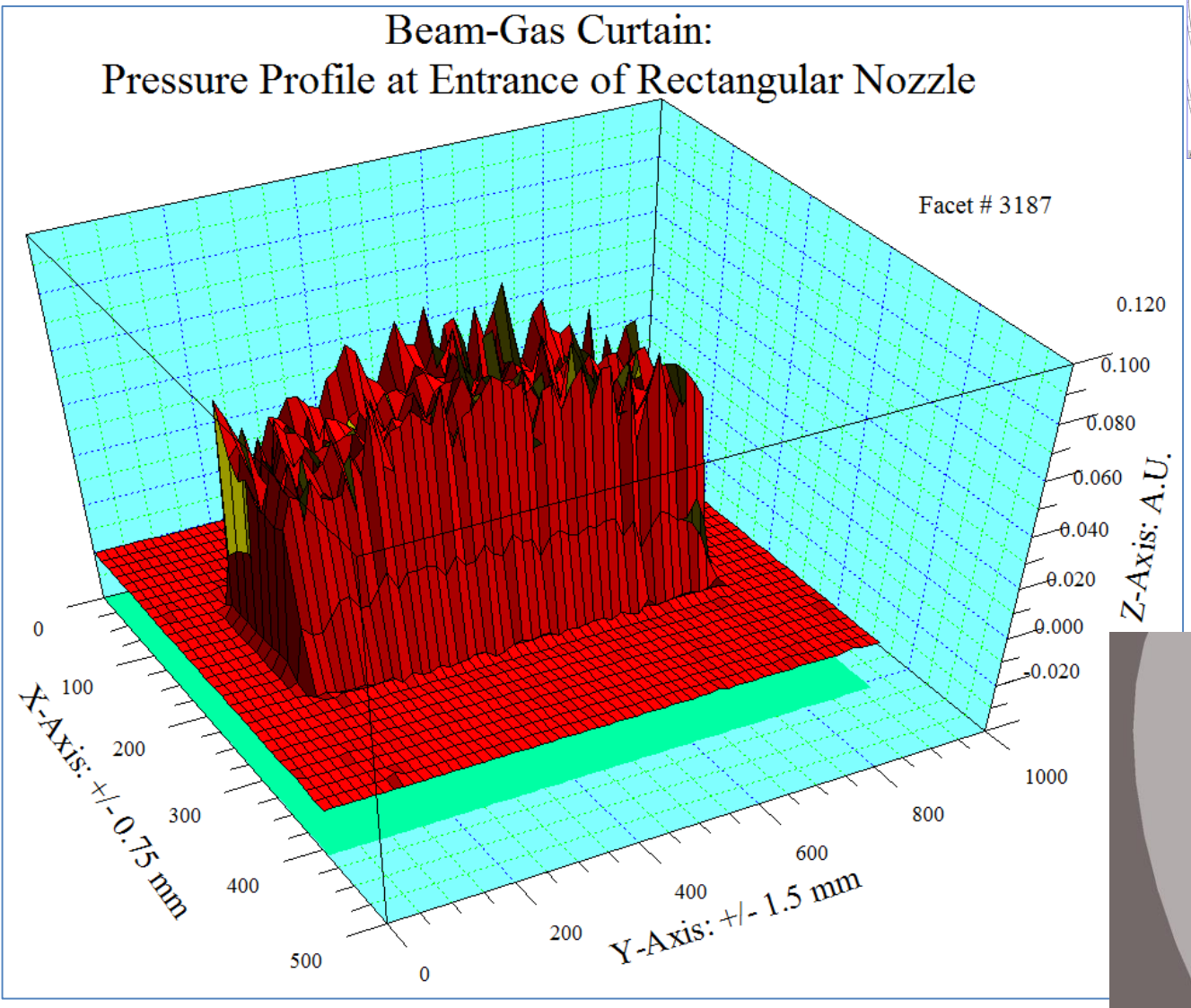


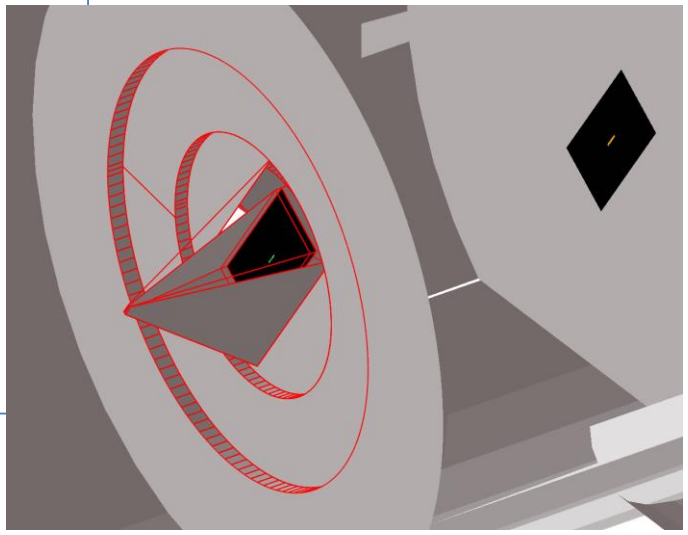
- Red: 4x0.4 mm^2 nozzle inlet; Blue and Green: 20.4 x 46.0 mm^2;

Molecular Distributions

3. Molflow+ model (simplified);



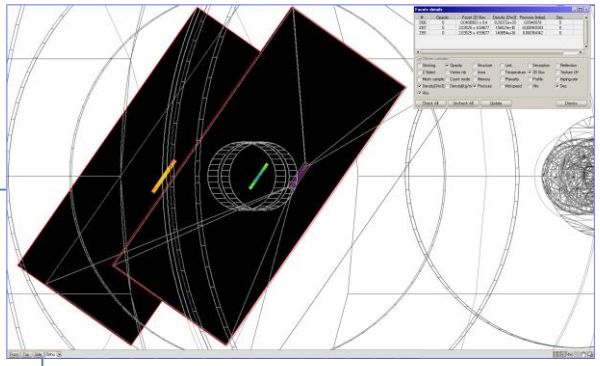


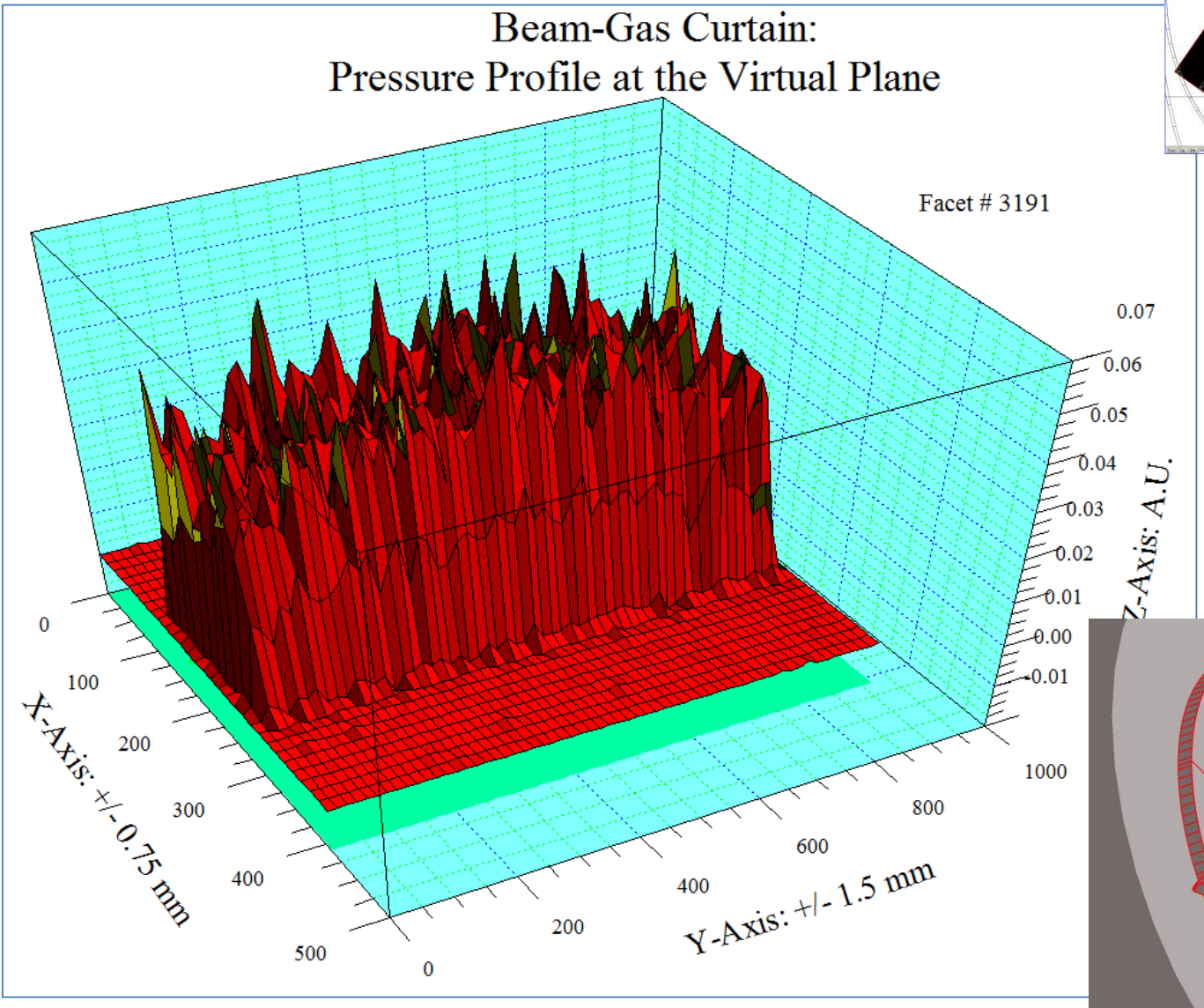


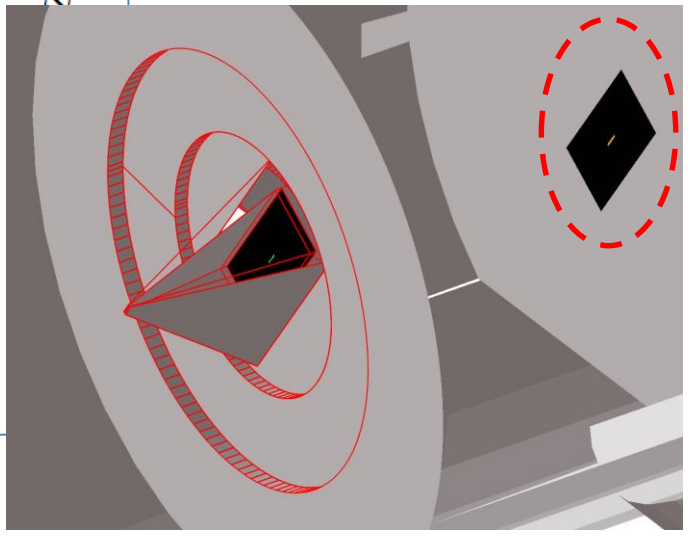
- Facet # 3187: base of pyramidal nozzle;

Molecular Distributions

3. Molflow+ model (simplified);



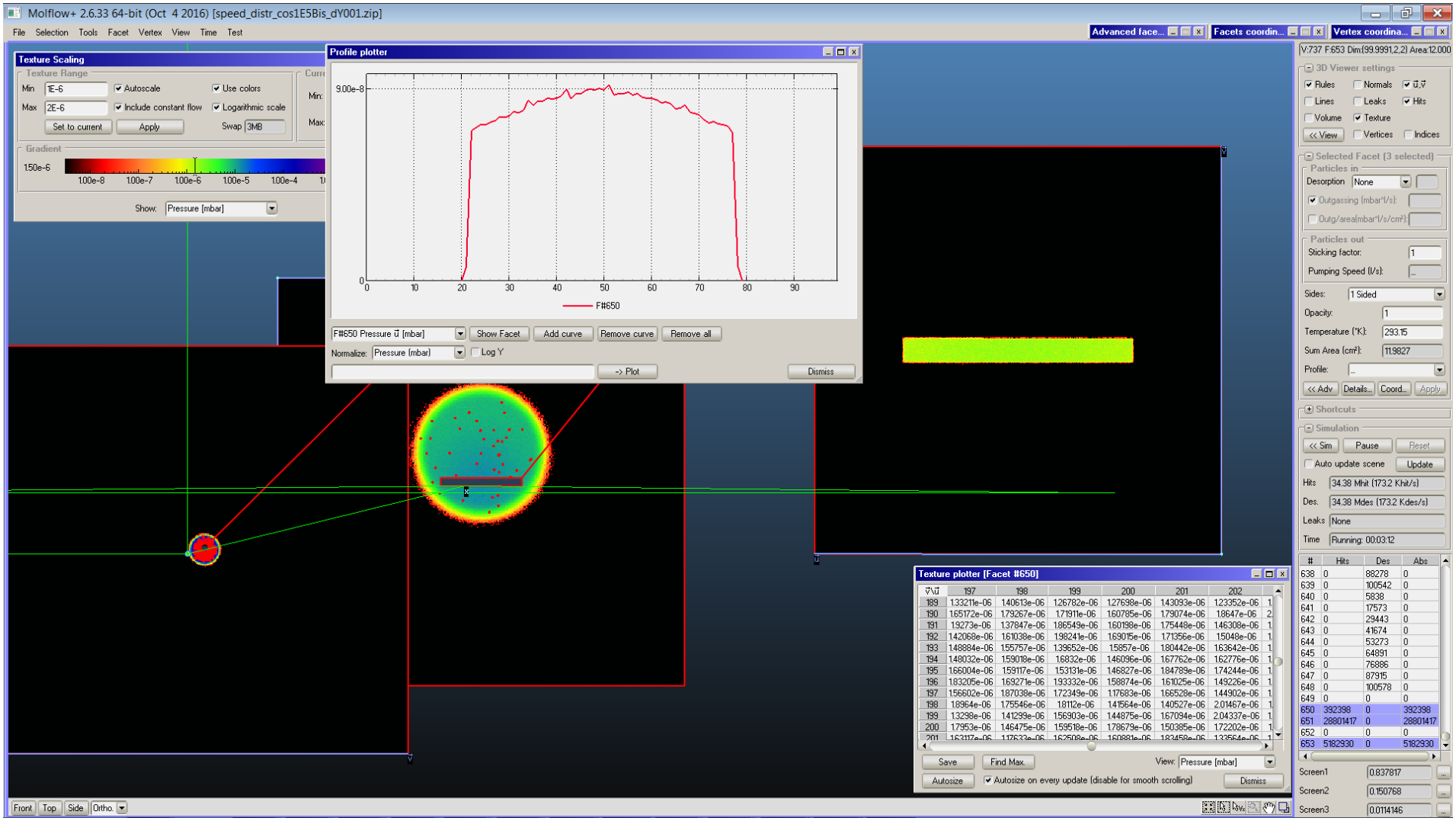




- Facet # 3191: rectangle on virtual facet →

Alignment Tolerances:

Very simplified model (vertical screens with **apertures only**, sticking=1 everywhere):

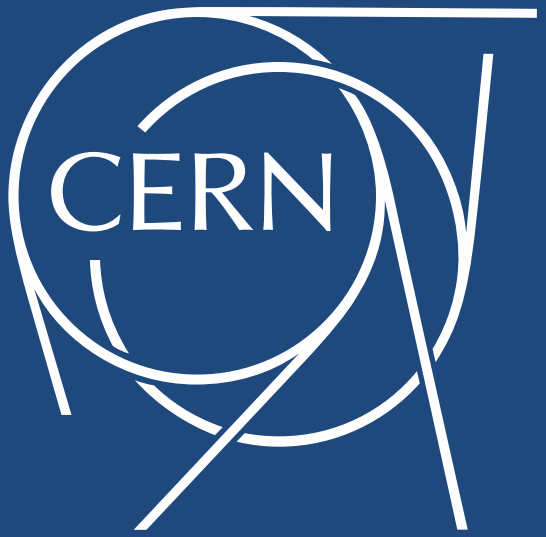


In this case the computational speed is much higher, due to a very much reduced number of facets (737 vs 8219). The plot on the inset shows the horizontal distribution on the virtual facet

Conclusions:

- A first preliminary run of TPMC ray-tracing simulations have been run, on geometries which do not fully represent the real hardware presently under study (as per today's presentation by G. Schneider);
- It has been shown that provided that a viscous-flow input file is given, the molecular flow regime calculations are rather straightforward, and allow the optimization of the design;
- In particular, the TPMC simulations can be used to check the sensitivity of the gas curtain shape and density on the relative alignment of the various skimmers and nozzles; See in particular the "screen only" models;

- **Future work** will implement the real/new geometry and re-run the simulations, possibly validating them with dedicated lab measurements?


CERN