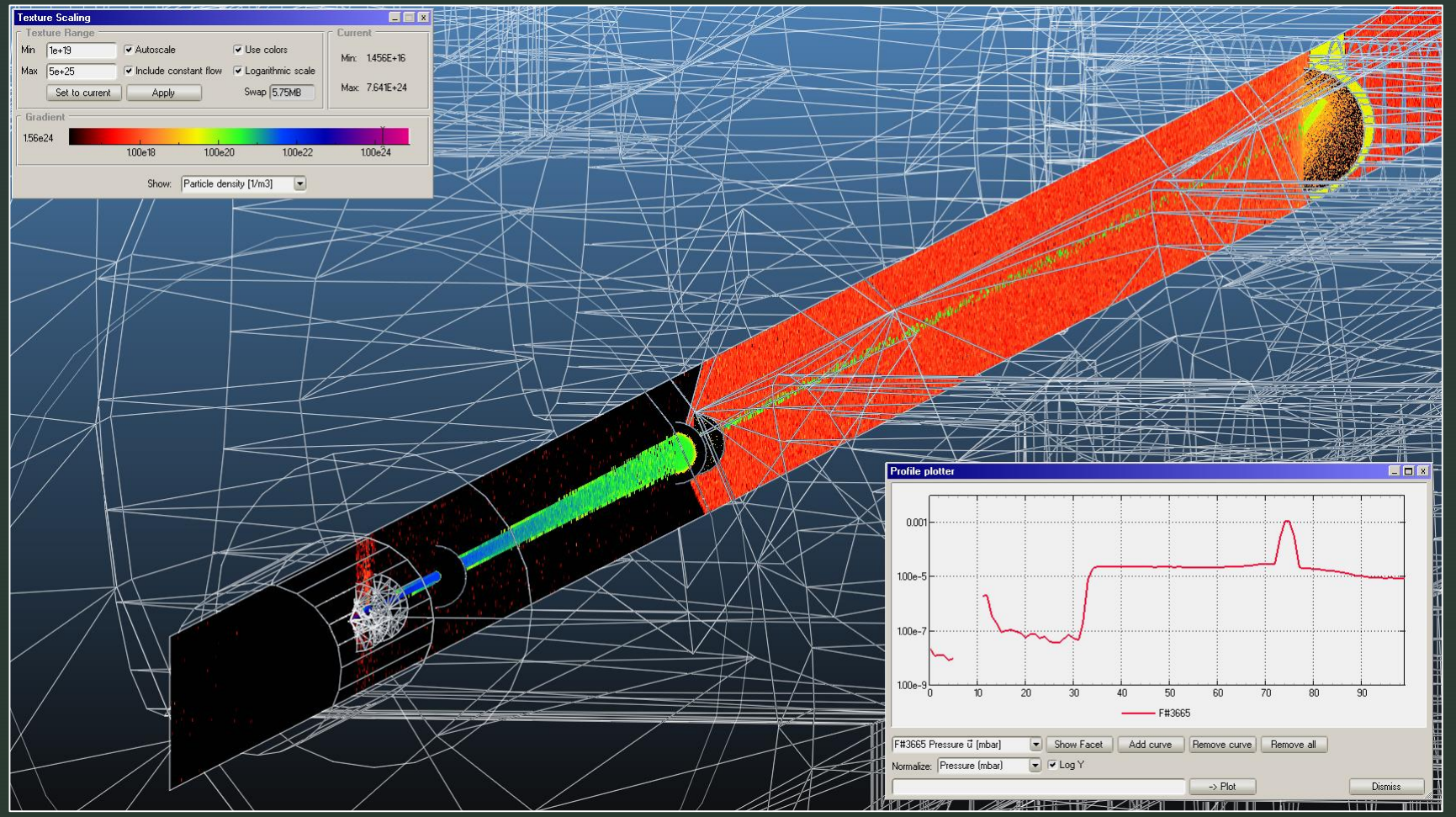
Low pressure simulations update



Marton ADY

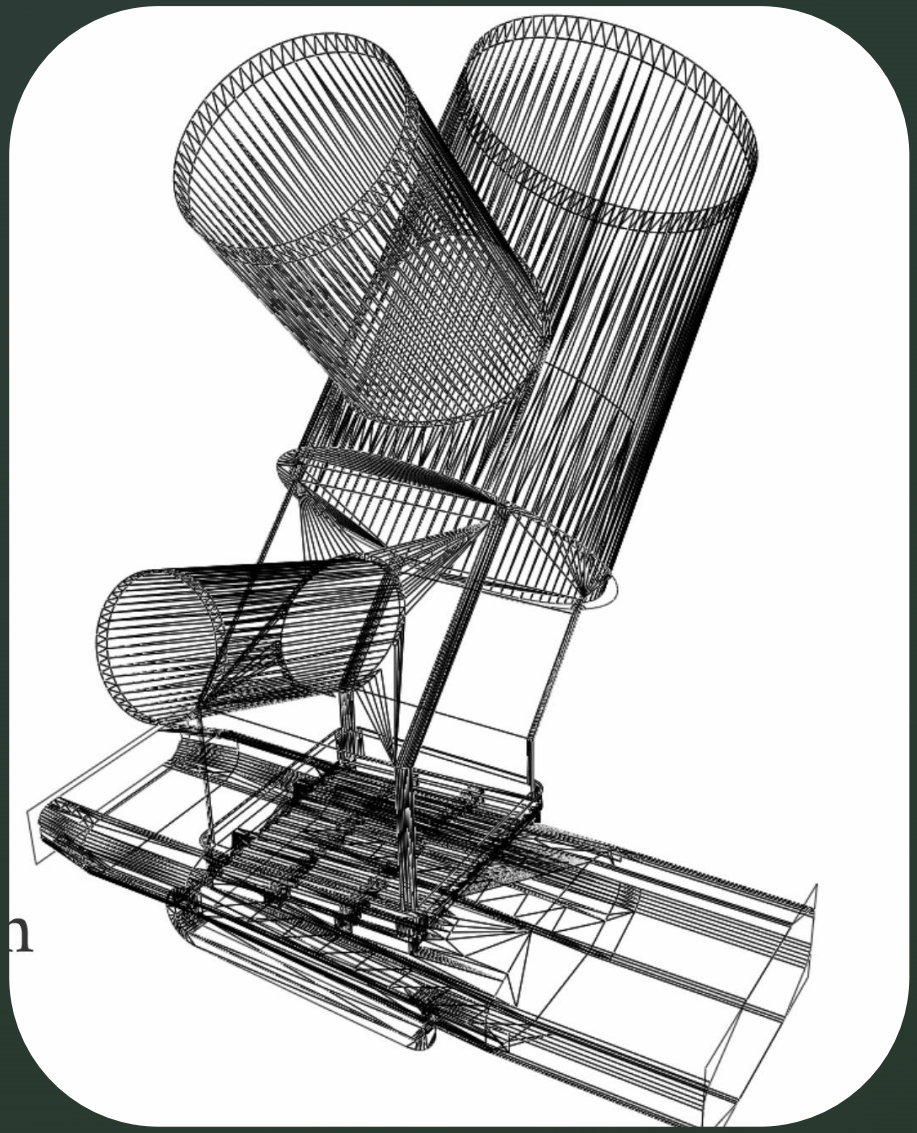
GSI, 19/03/2018

Outline

- Quick reminder of Monte Carlo methods
- Setup 1 (past)
- Setup 2 (present)
- Setup 3 (future)

Monte Carlo simulations

Geometry: polygons



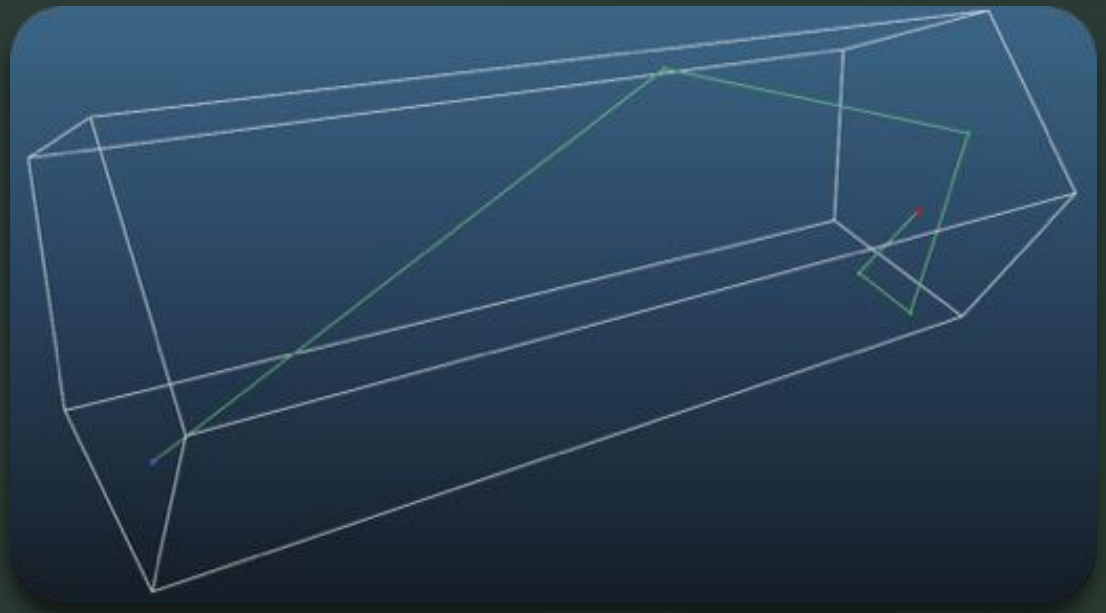
Gas input:

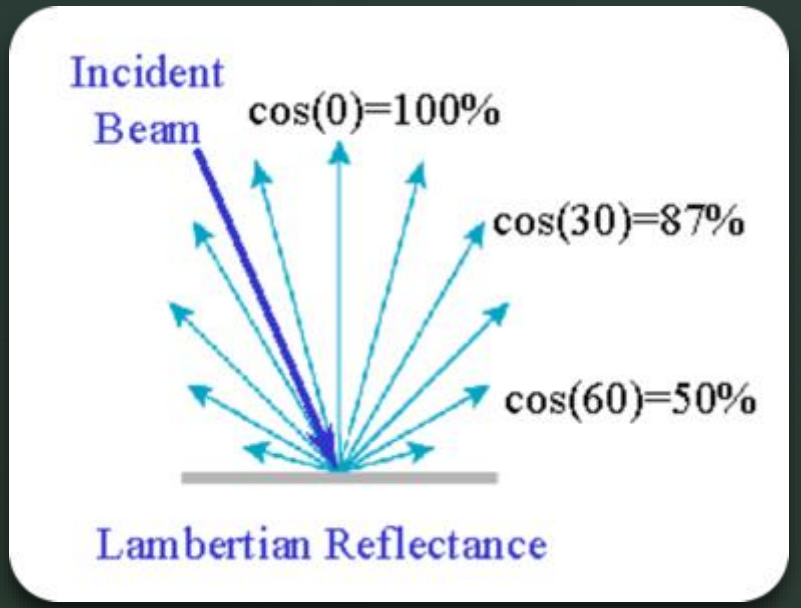
$pV=NkT$

1 $Pa*m^3/s = 2.4*10^{20}$ molecules/s

Virtual / Physical particle ratio

Reflection

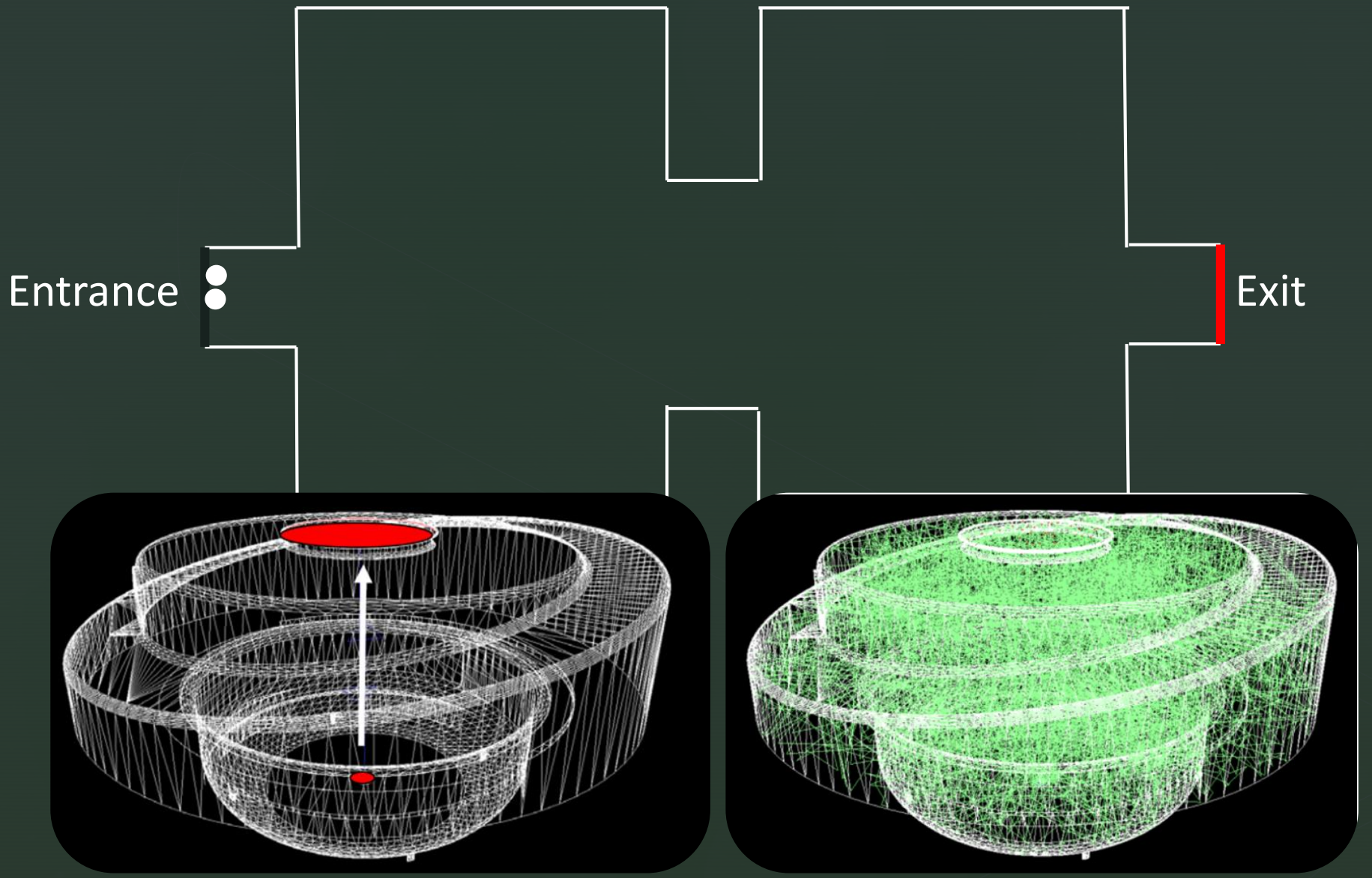


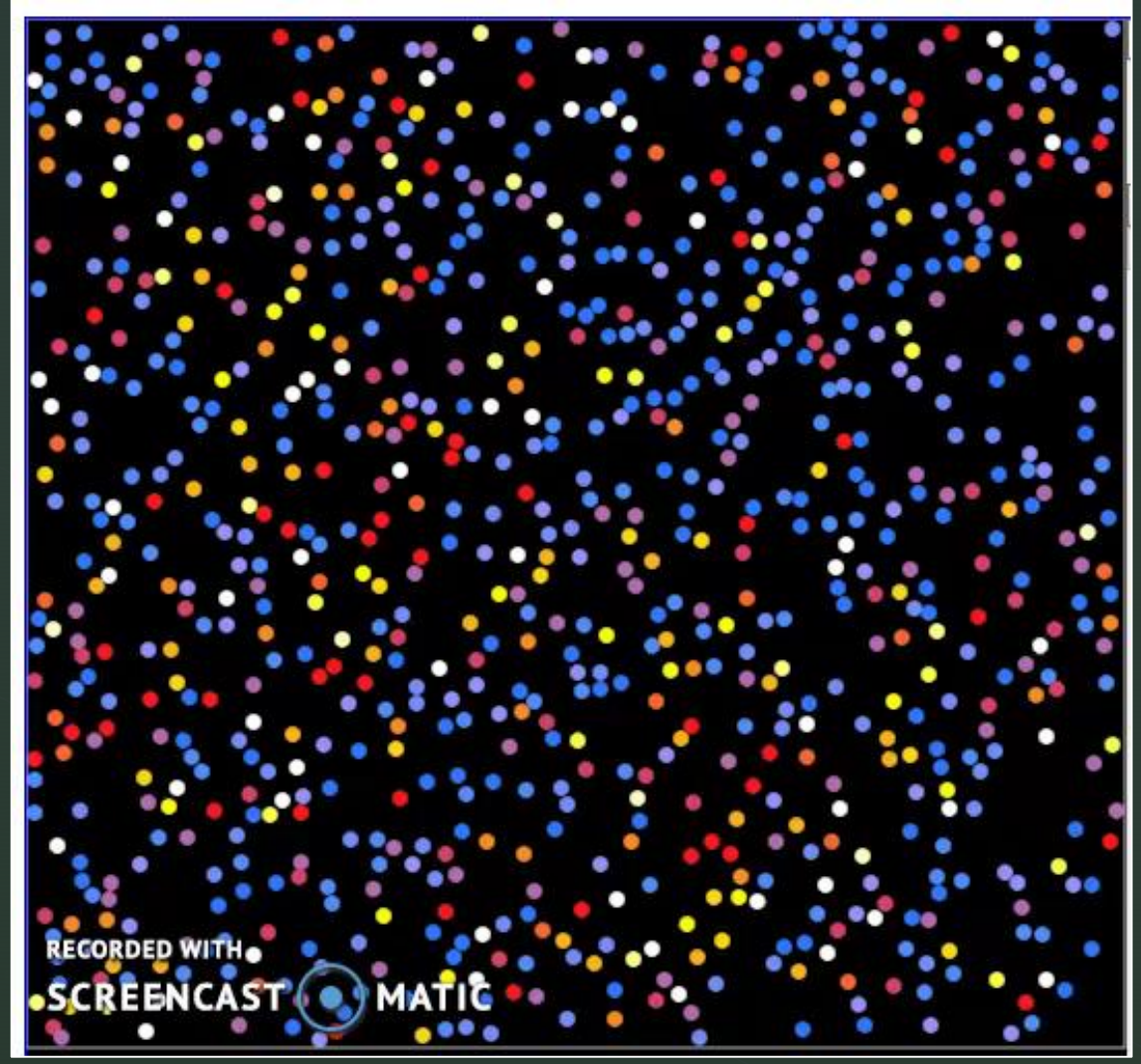


Pumping / absorption

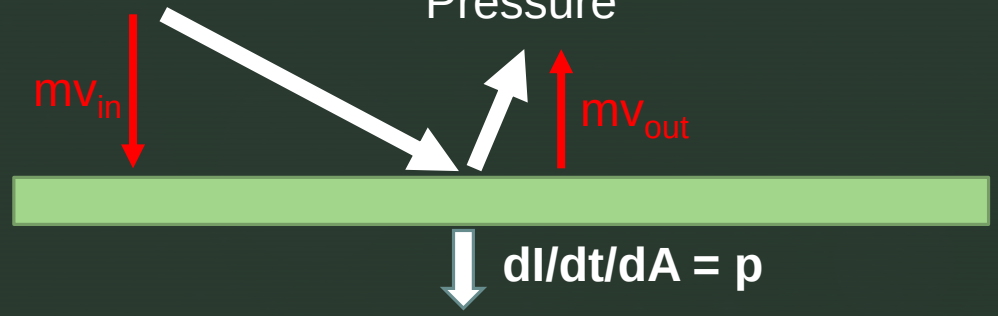
$$S\ [m^3/s] = \text{sticking}\ [0..1] * 1/4 * A\ [m^2] * v_{avg}\ [m/s]$$

Monte Carlo

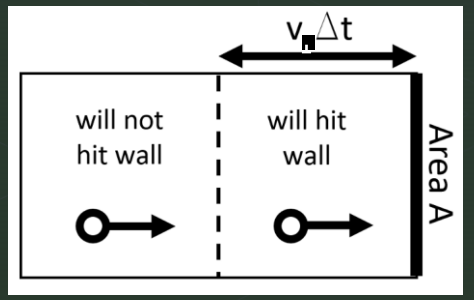




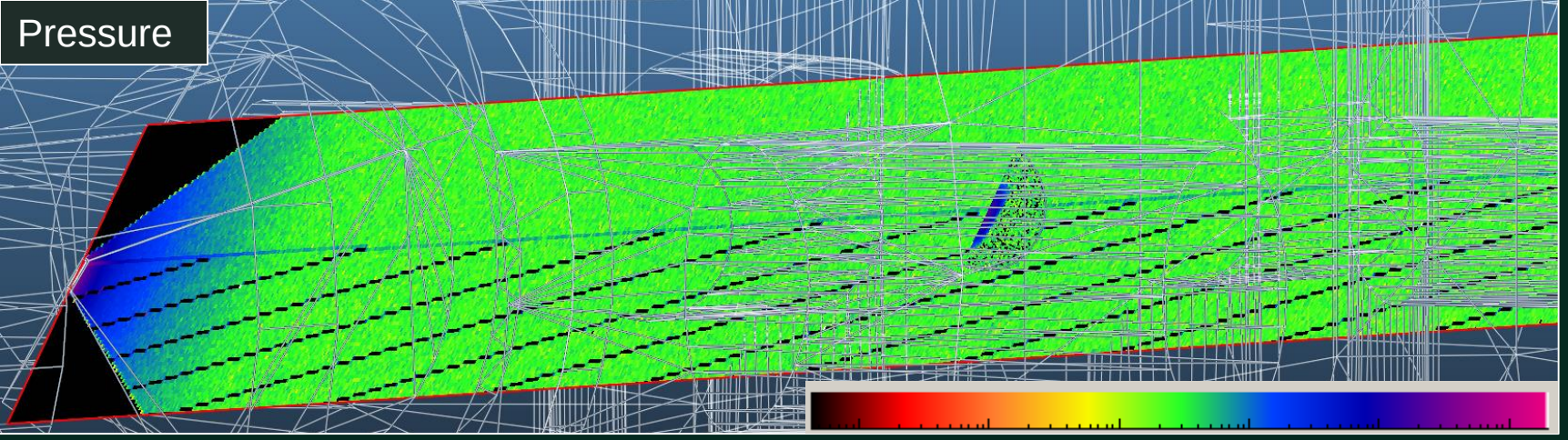
Pressure

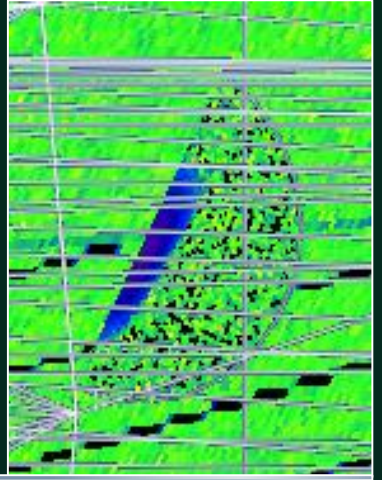


Density

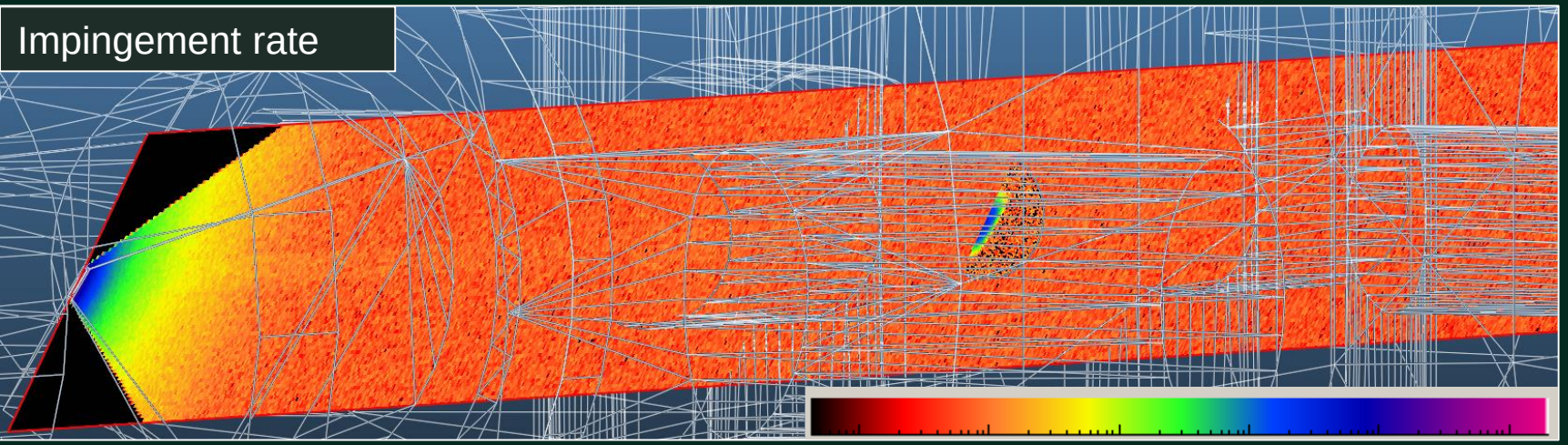


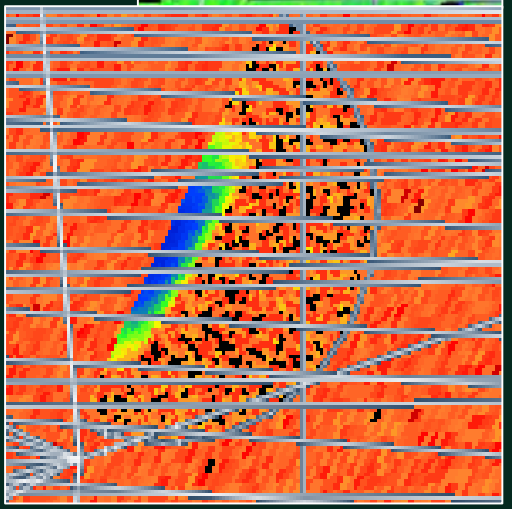
Pressure



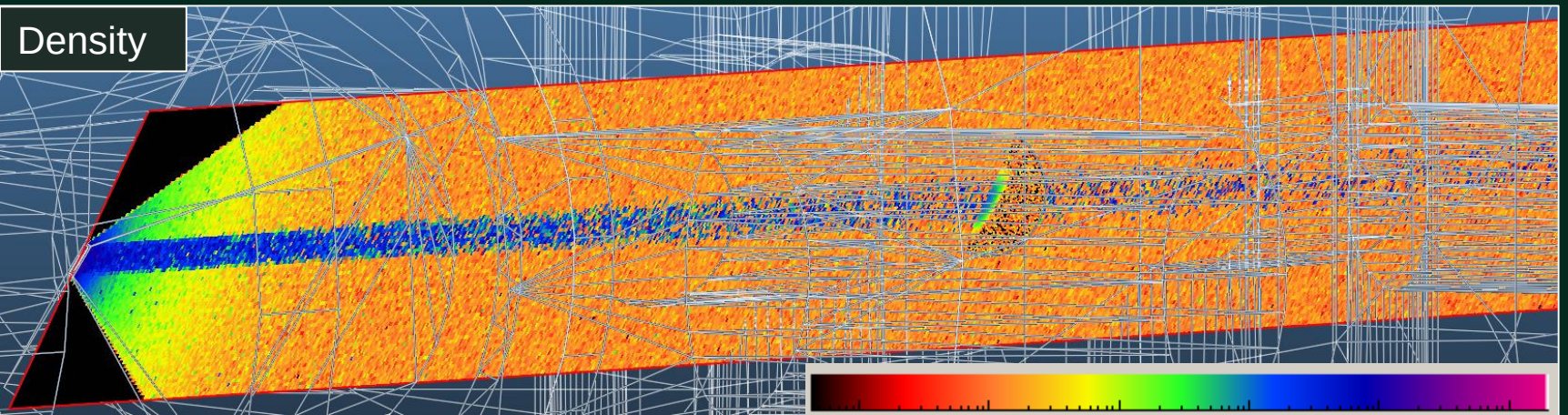


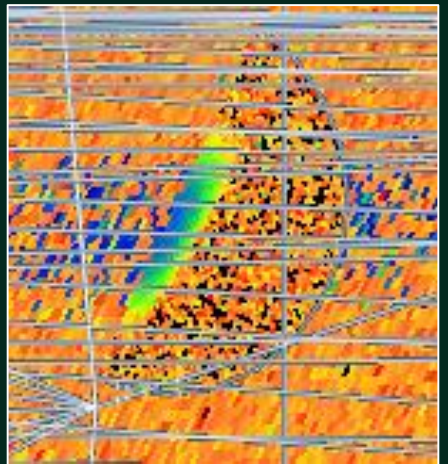
Impingement rate



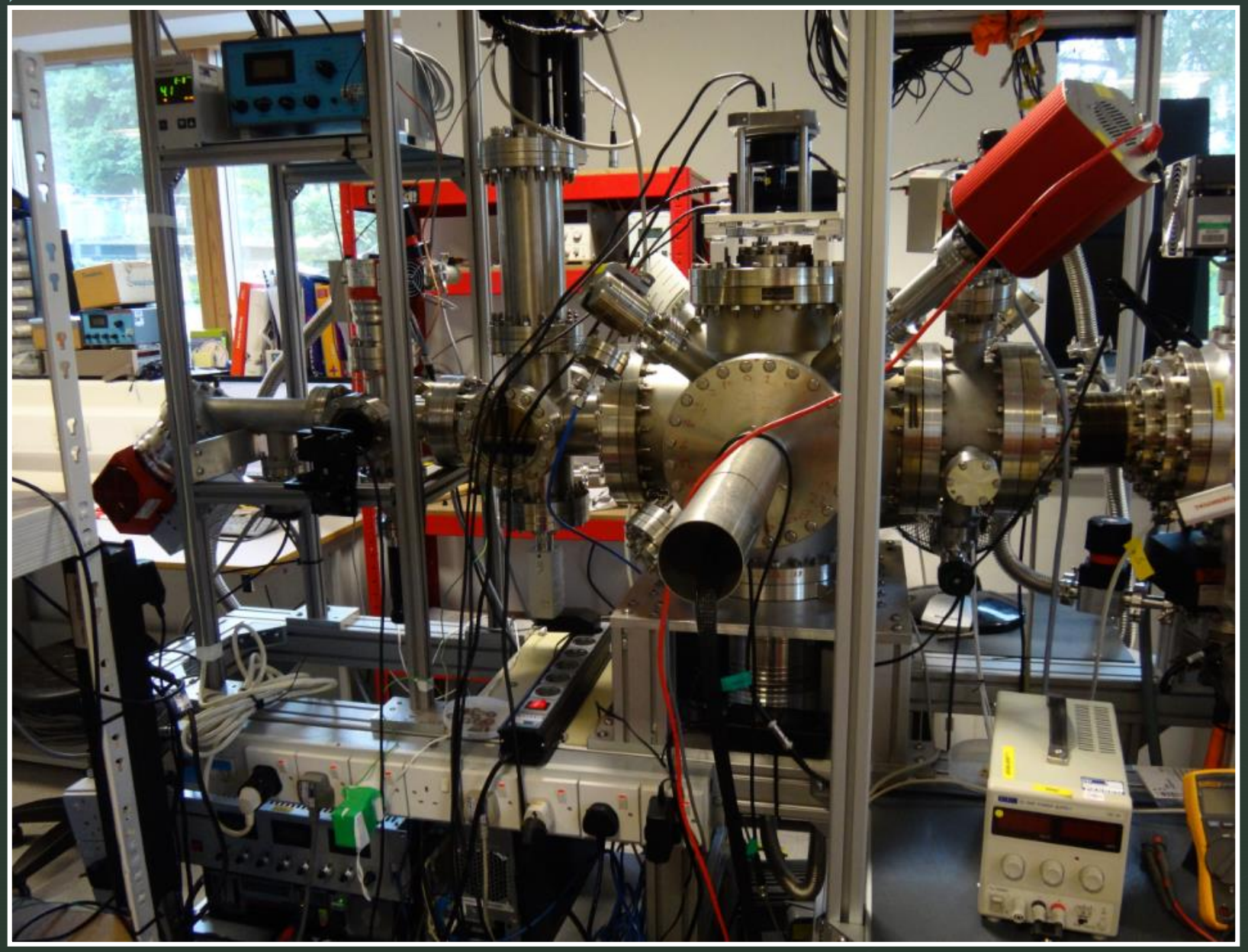


Density

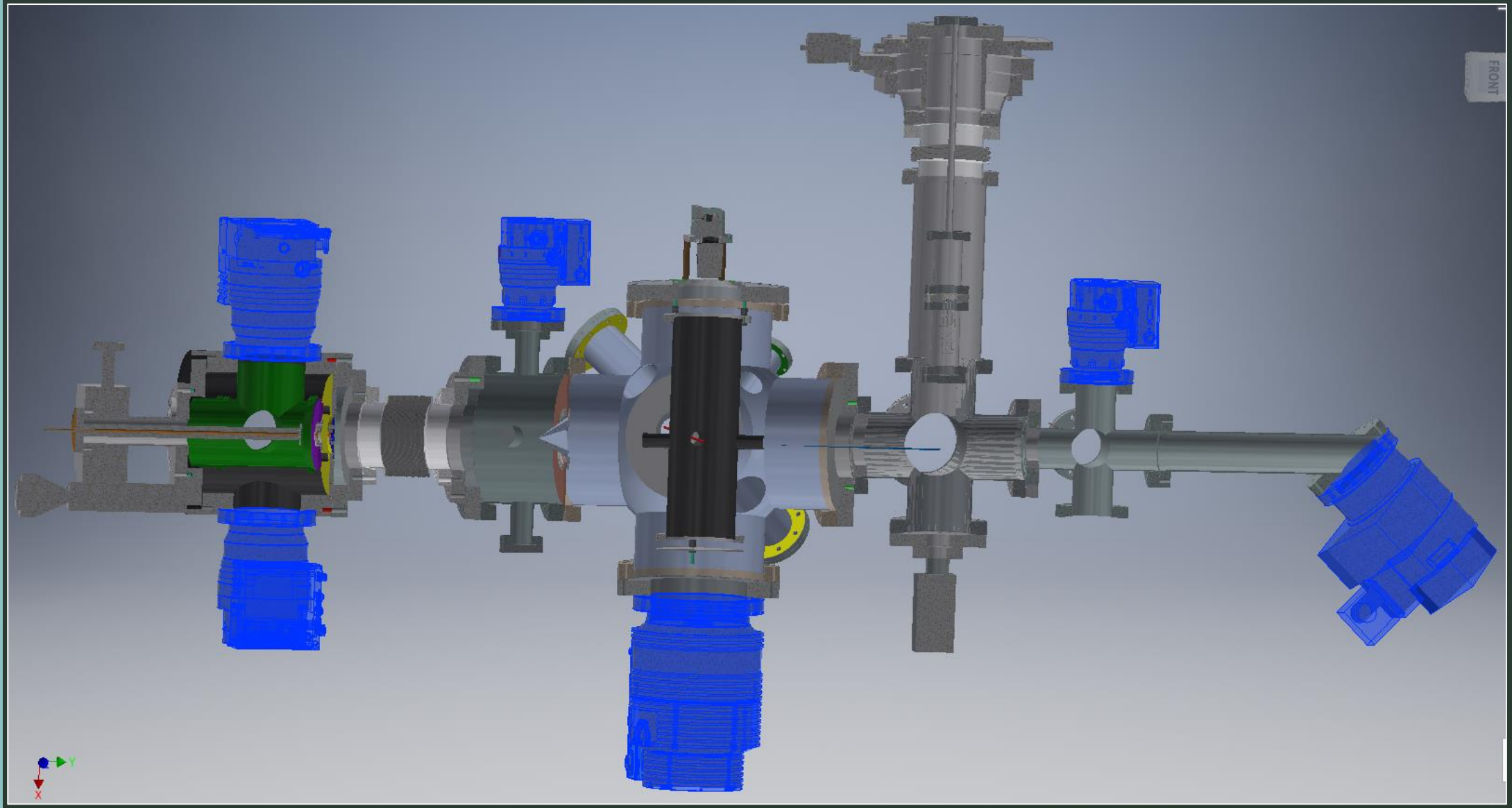




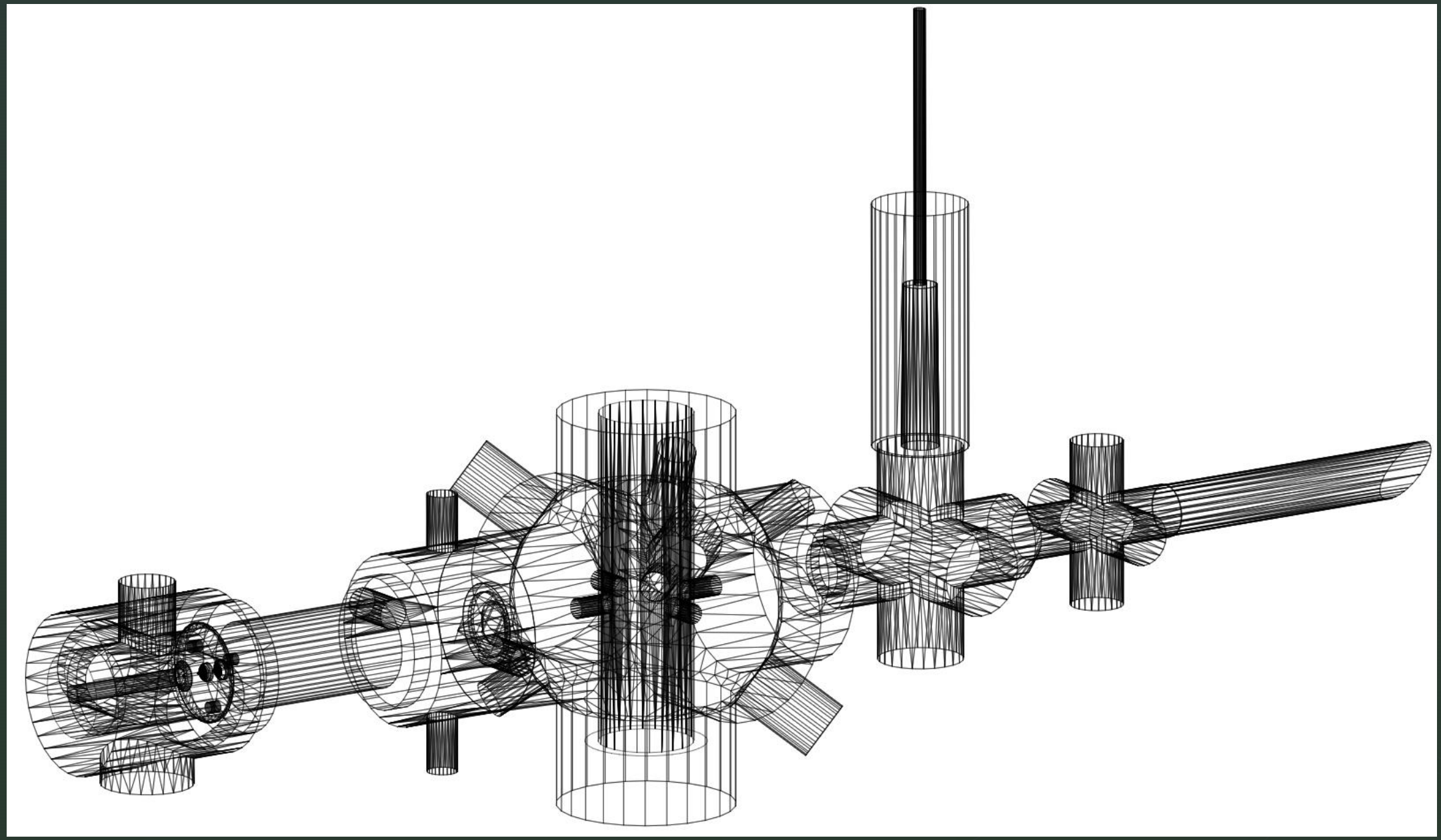
First setup (past)



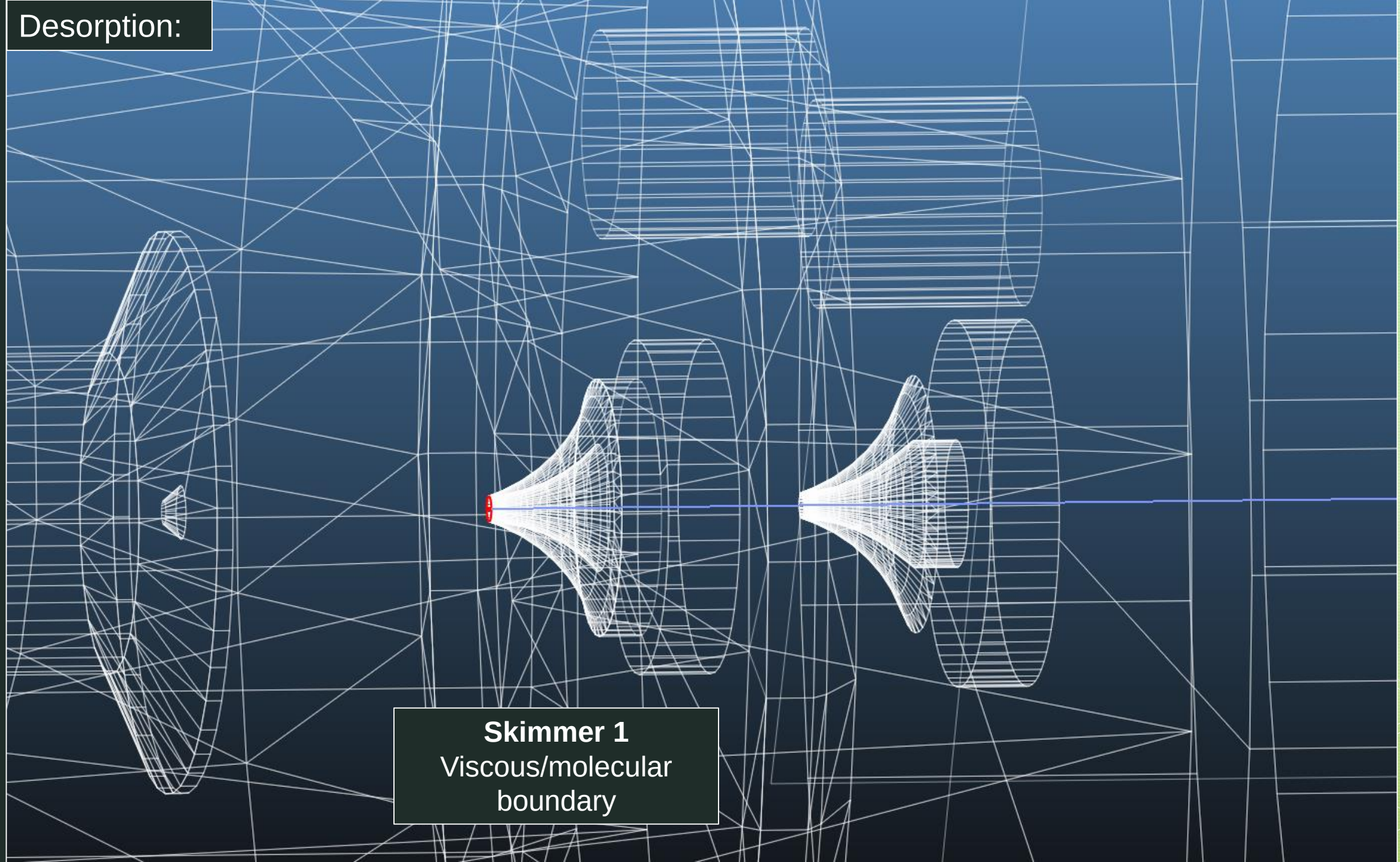
Existing setup



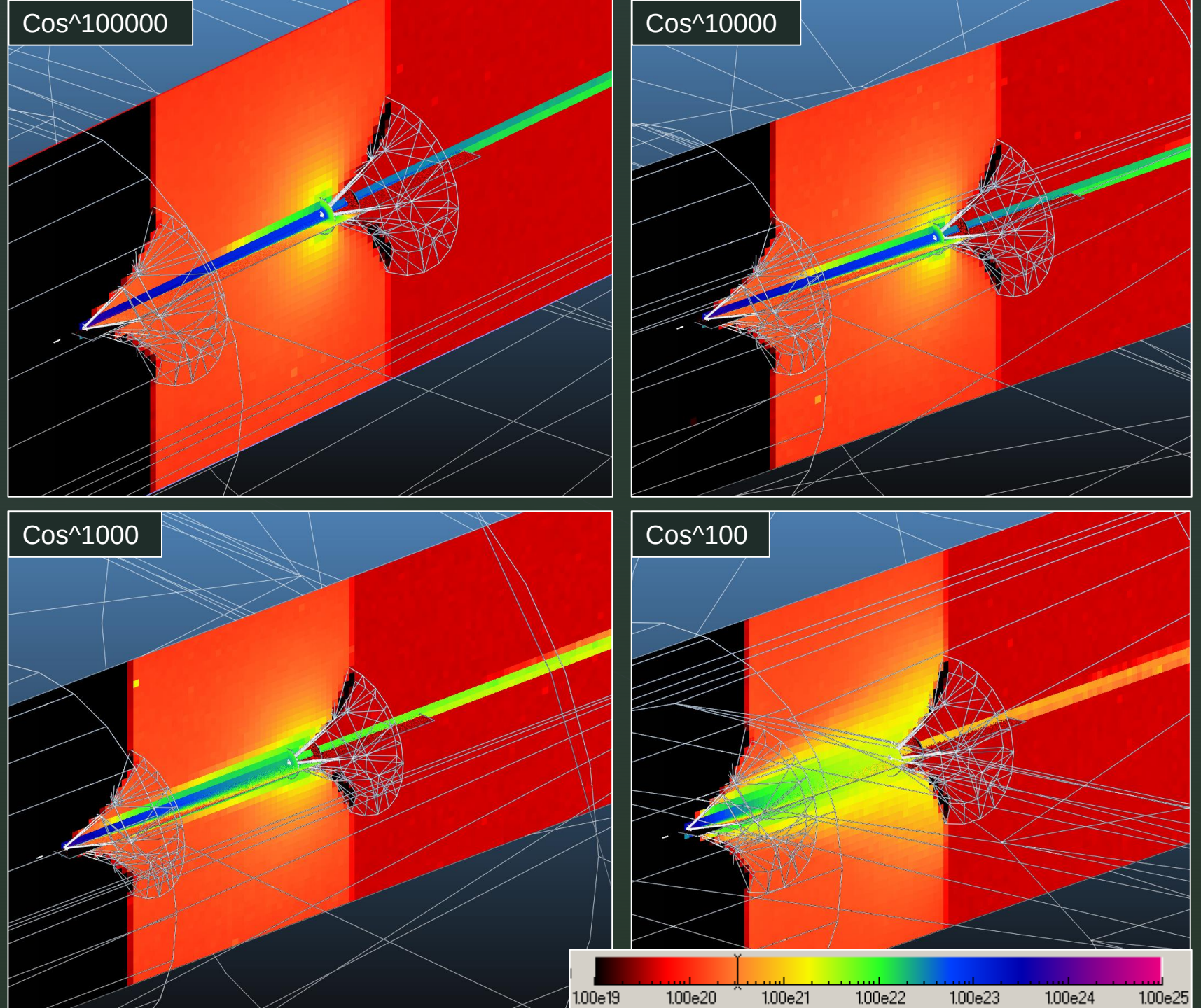
Molflow model (7000 polygons)



Desorption:

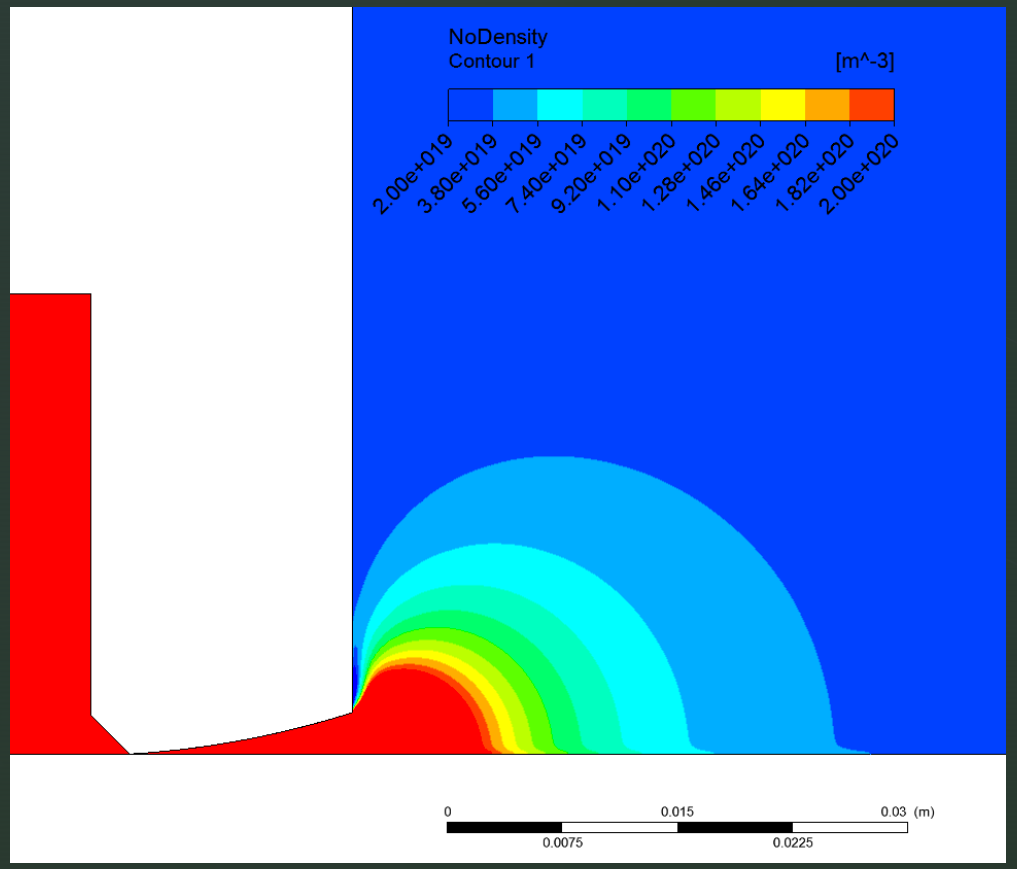


Skimmer 1
Viscous/molecular boundary

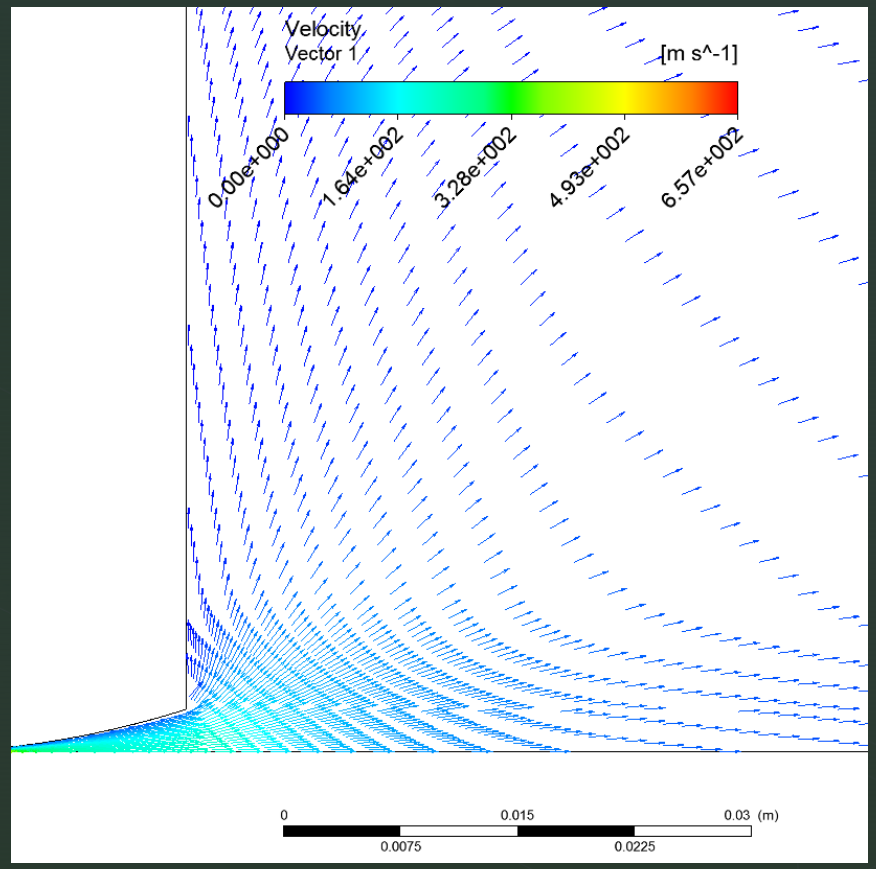

Cos^100000
Cos^10000
Cos^1000
Cos^100
1.00e19
1.00e20
1.00e21
1.00e22
1.00e23
1.00e24
1.00e25

High pressure – low pressure interface data

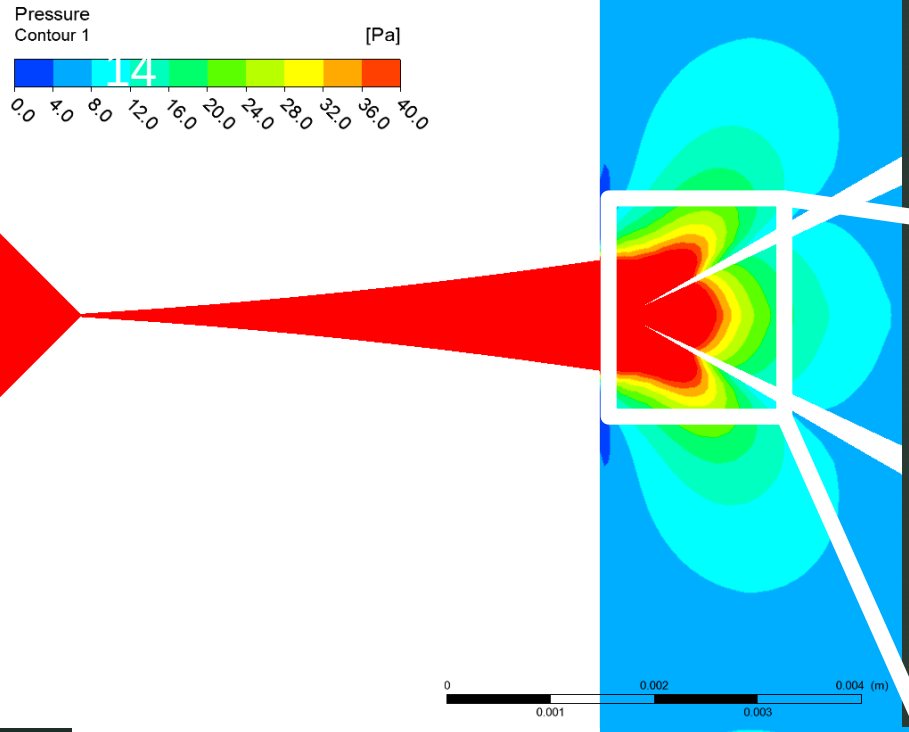
Number density variable



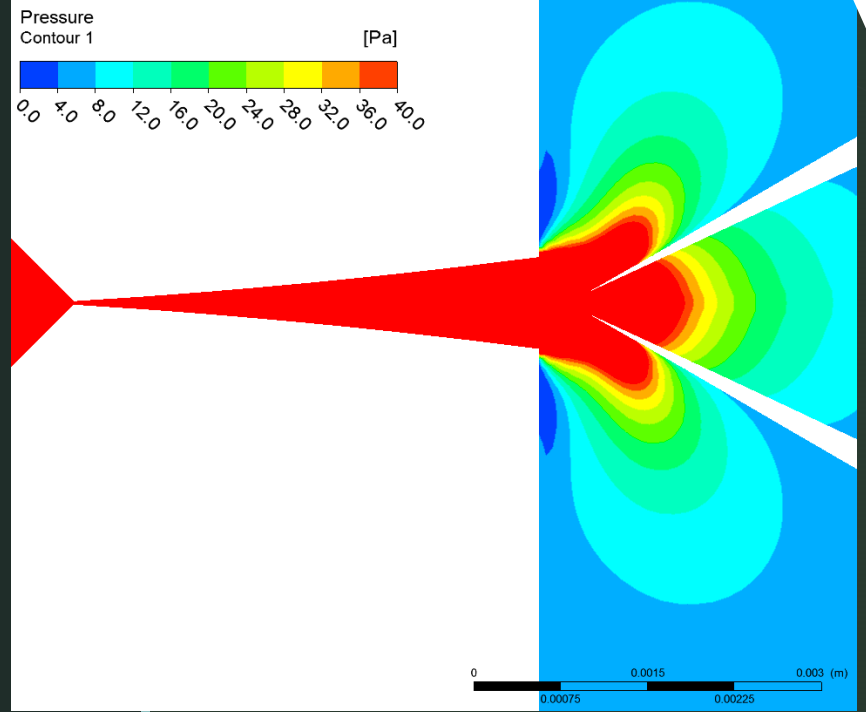
Vectors/streamline direction



Results: Przemysław Smakulski

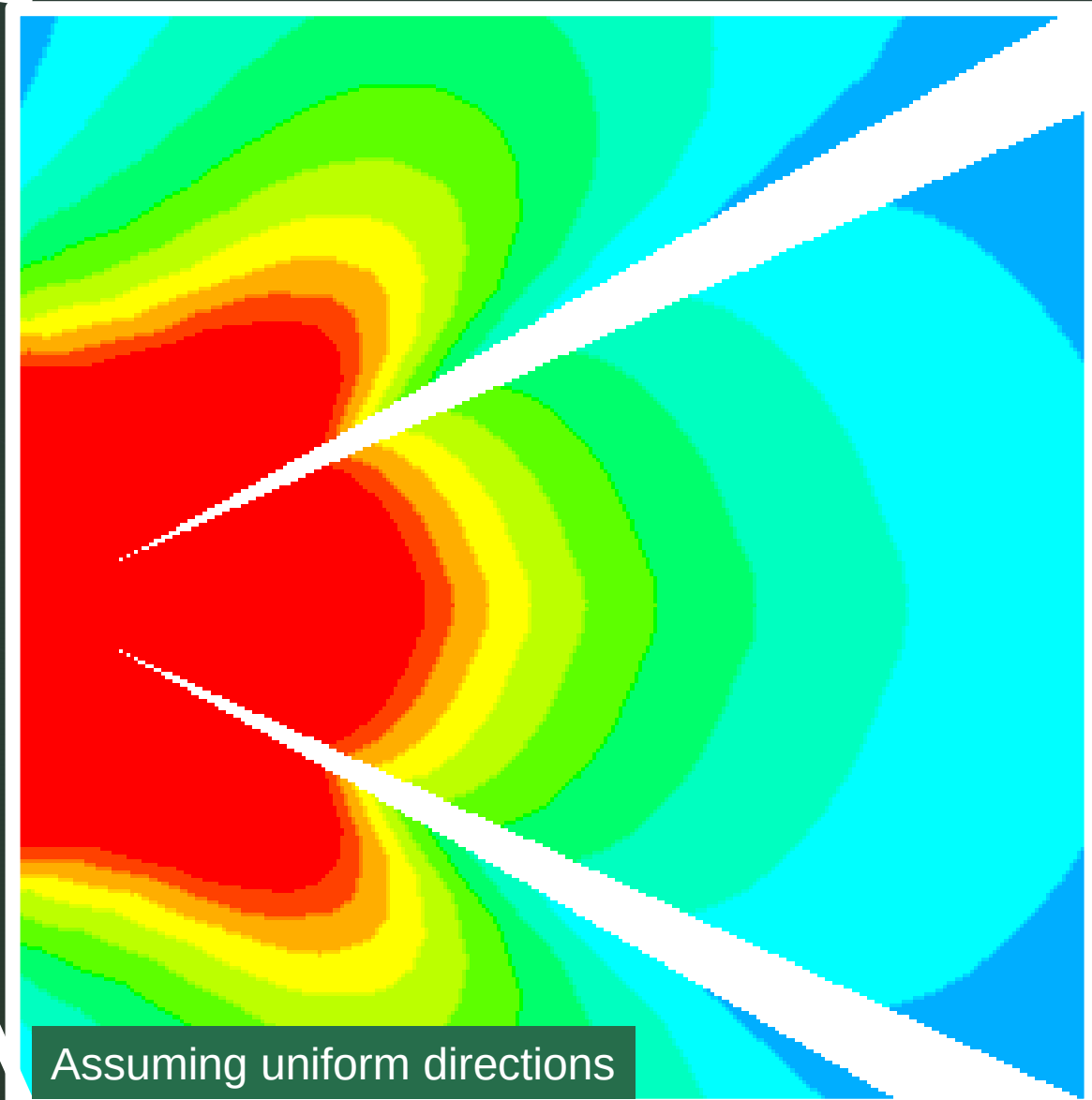


Mod1
L = 5mm

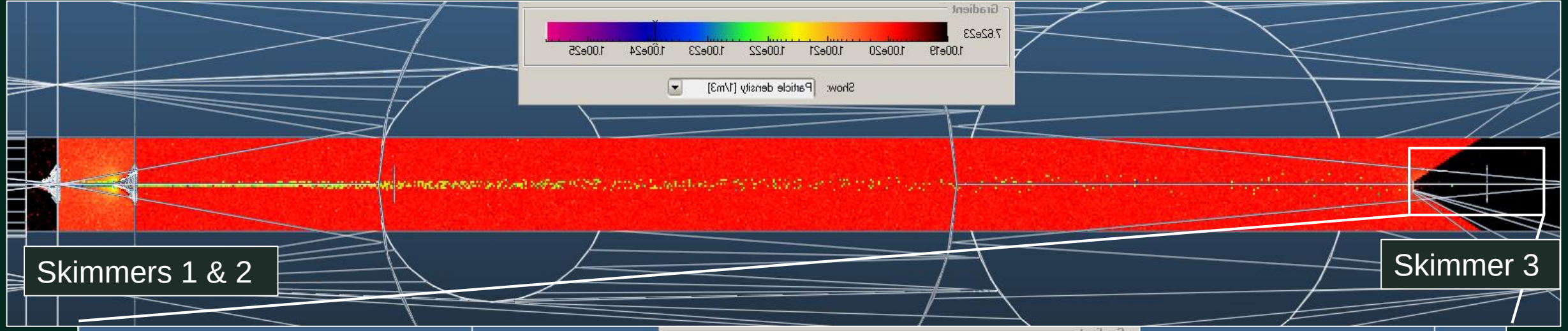


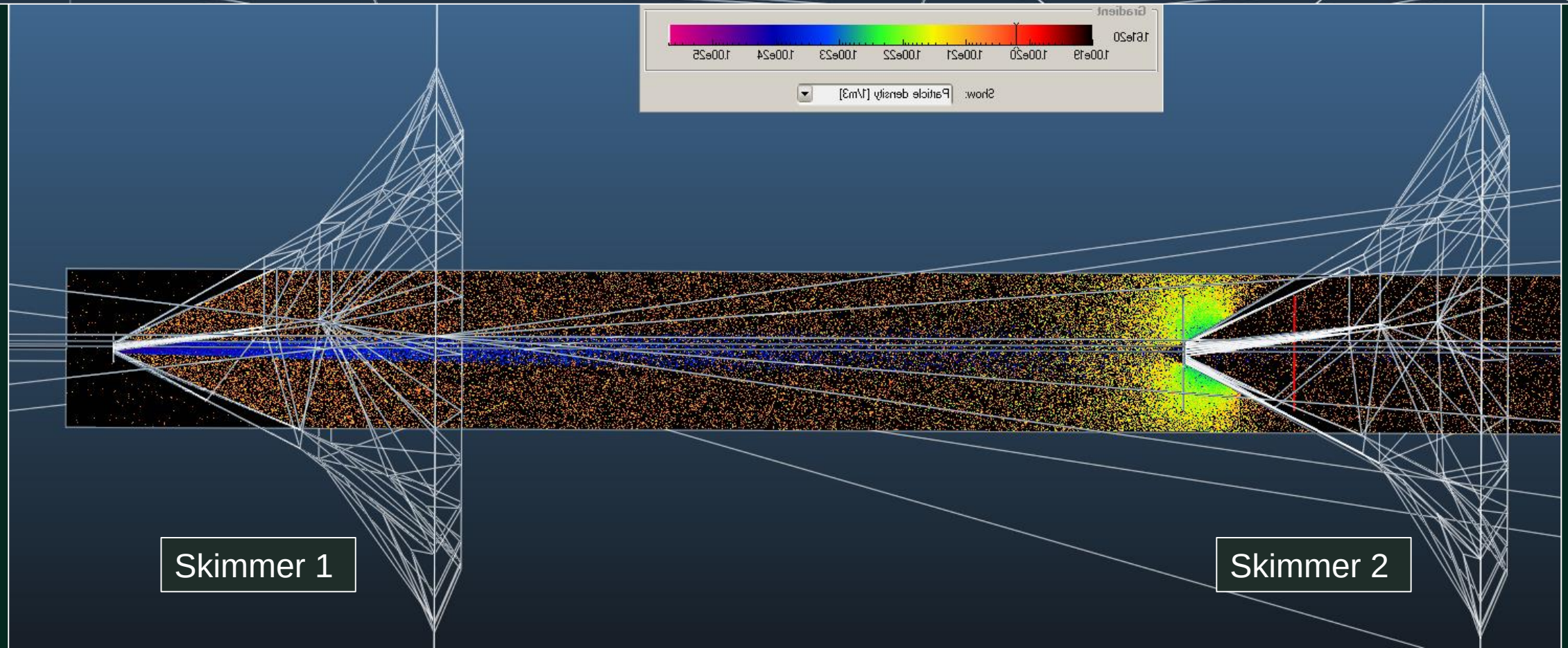
Mod2
L = 4mm

Results: Przemyslaw Smakulski

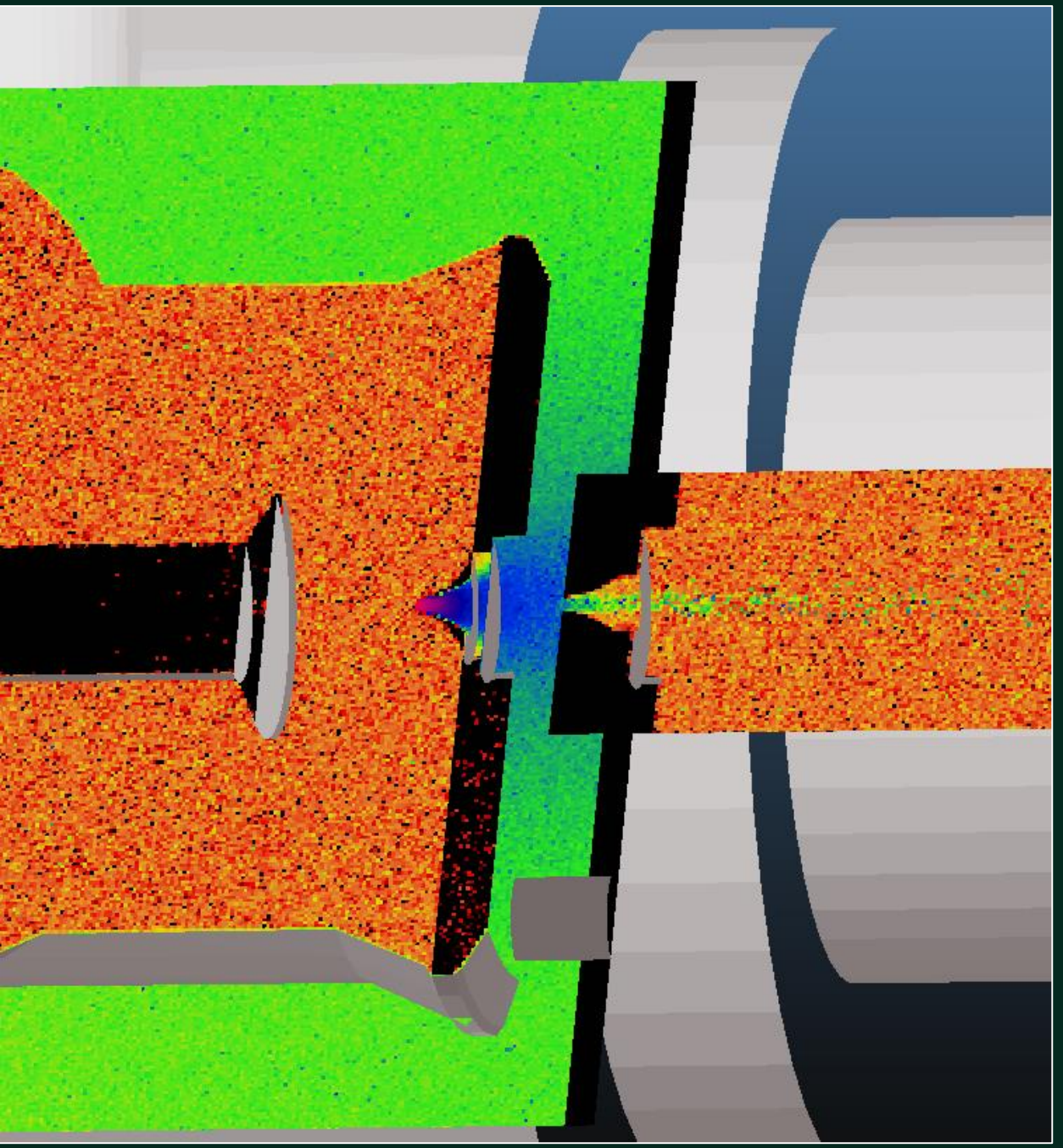


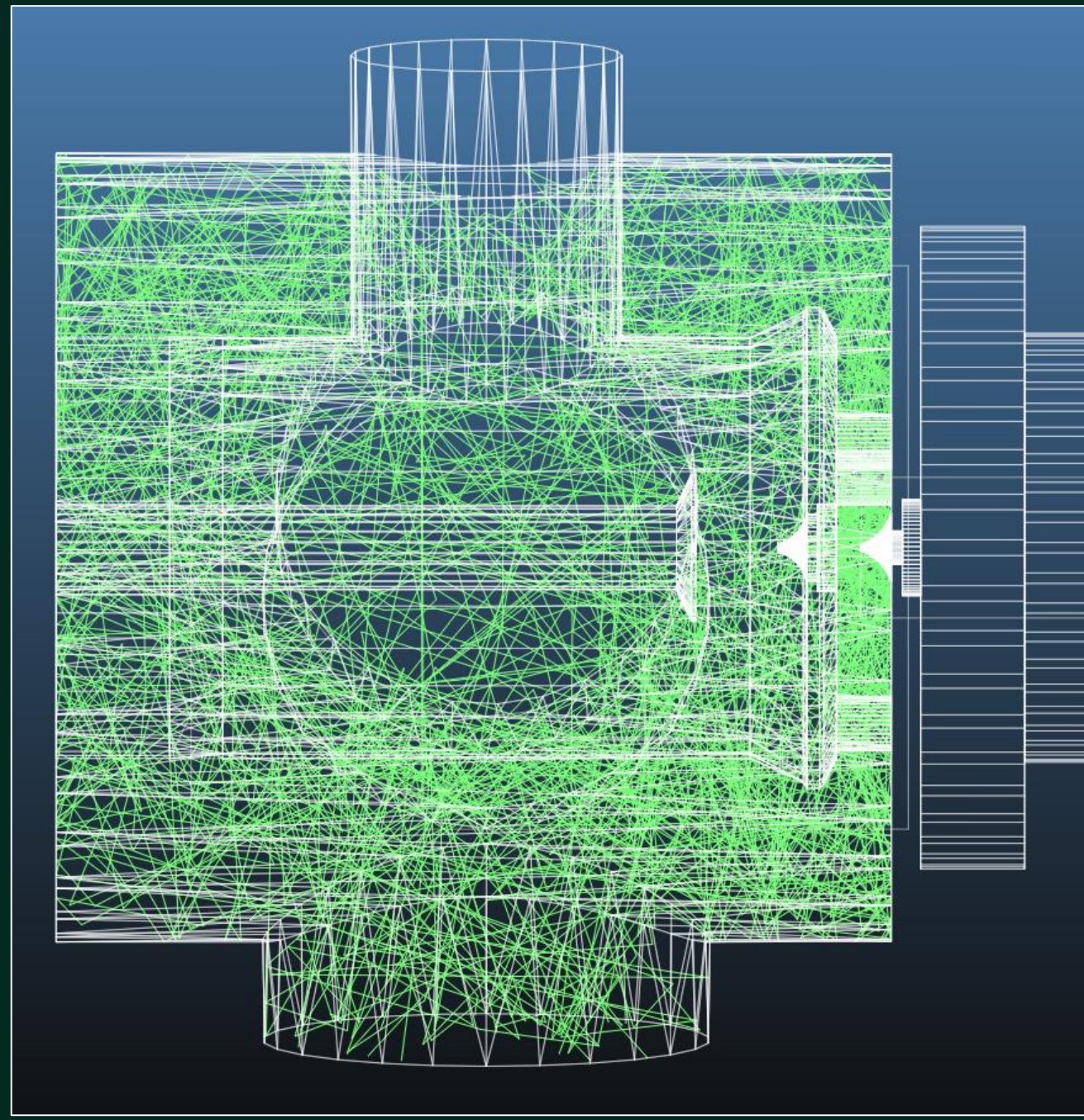
Assuming uniform directions


Skimmers 1 & 2
Skimmer 3


Skimmer 1
Skimmer 2

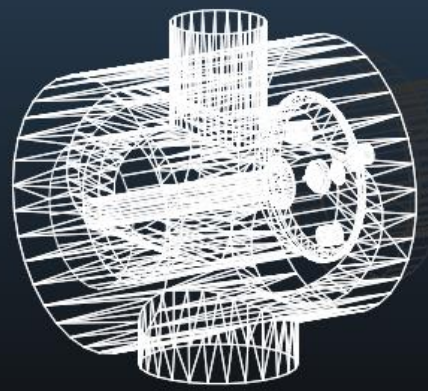
Large density differences: Monte Carlo weakness



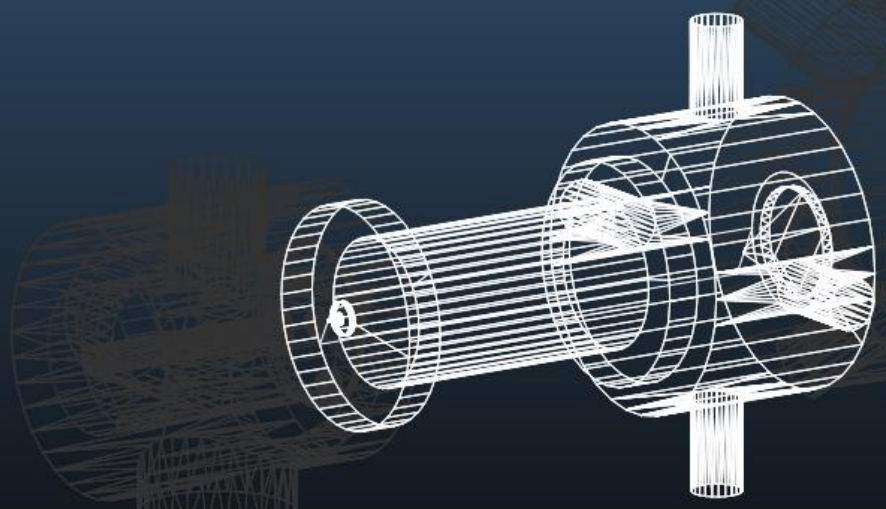


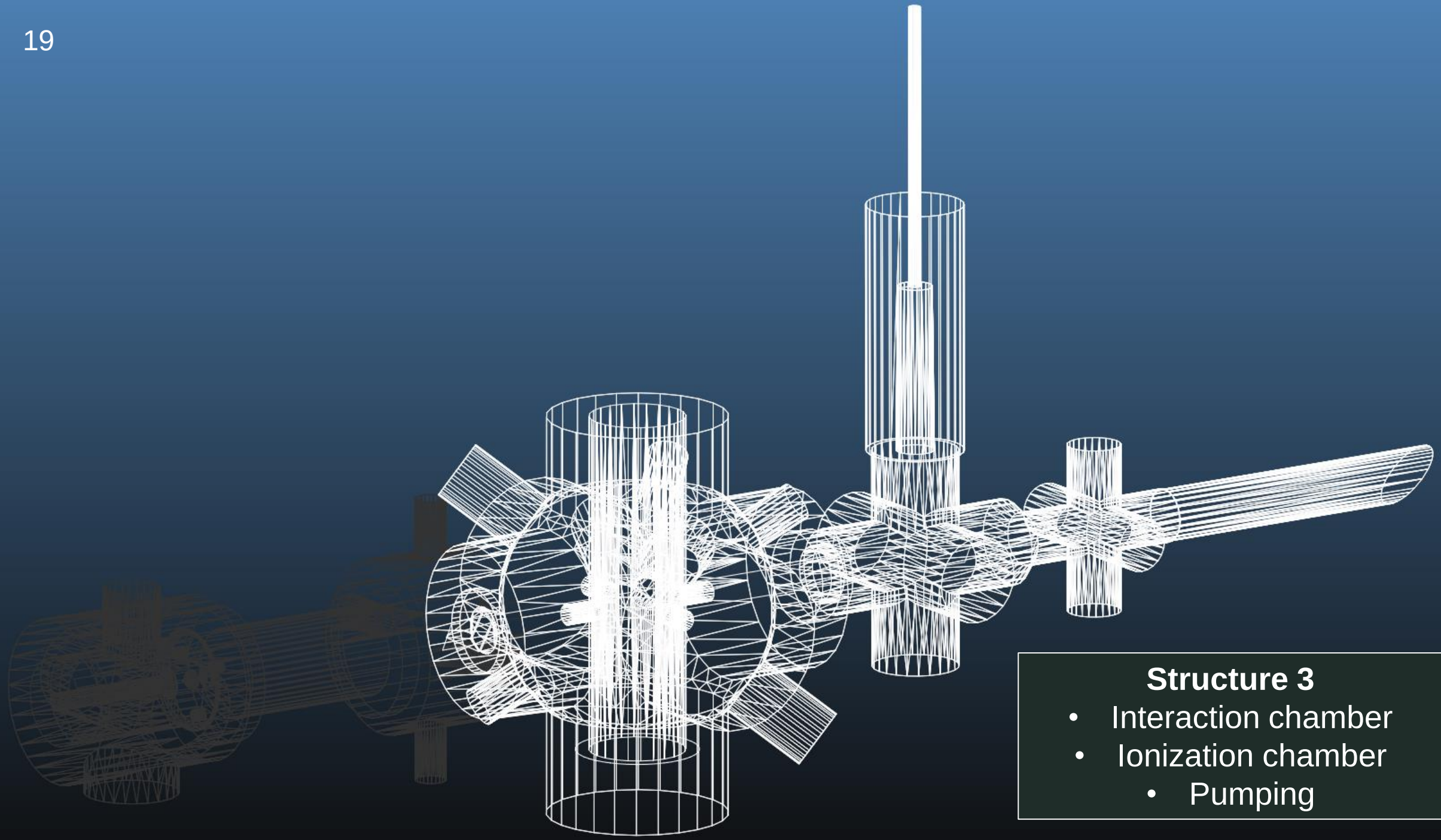
Structure 1

- High pressure nozzle
- Skimmer 1 & 2



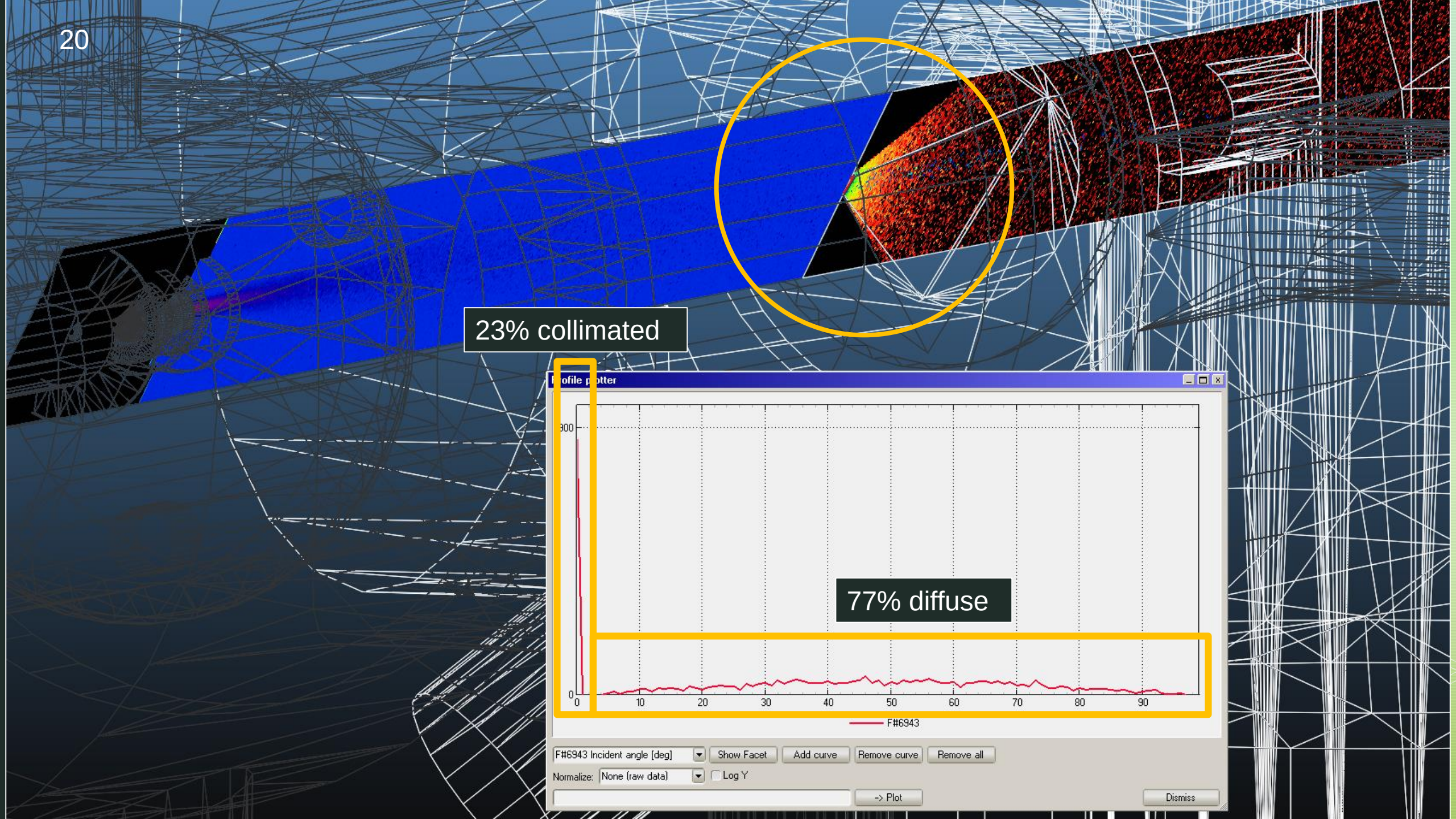
Structure 2
Between skimmers 2 and 3



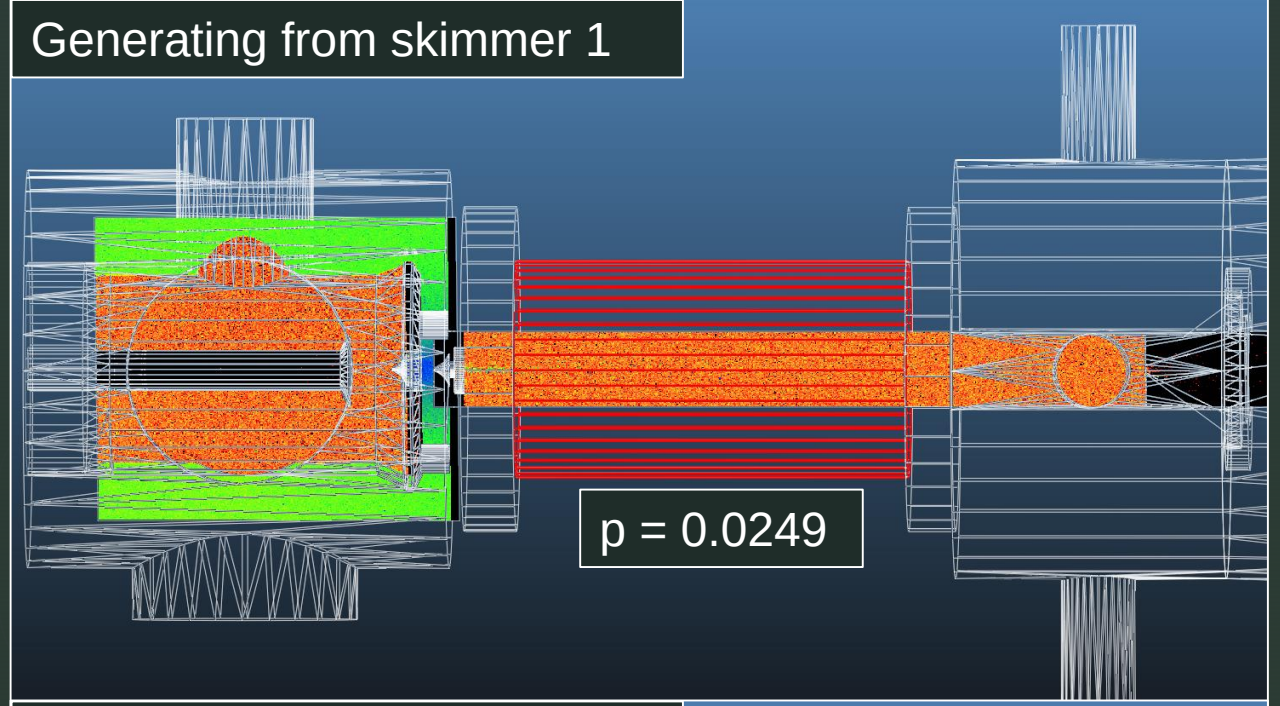


Structure 3

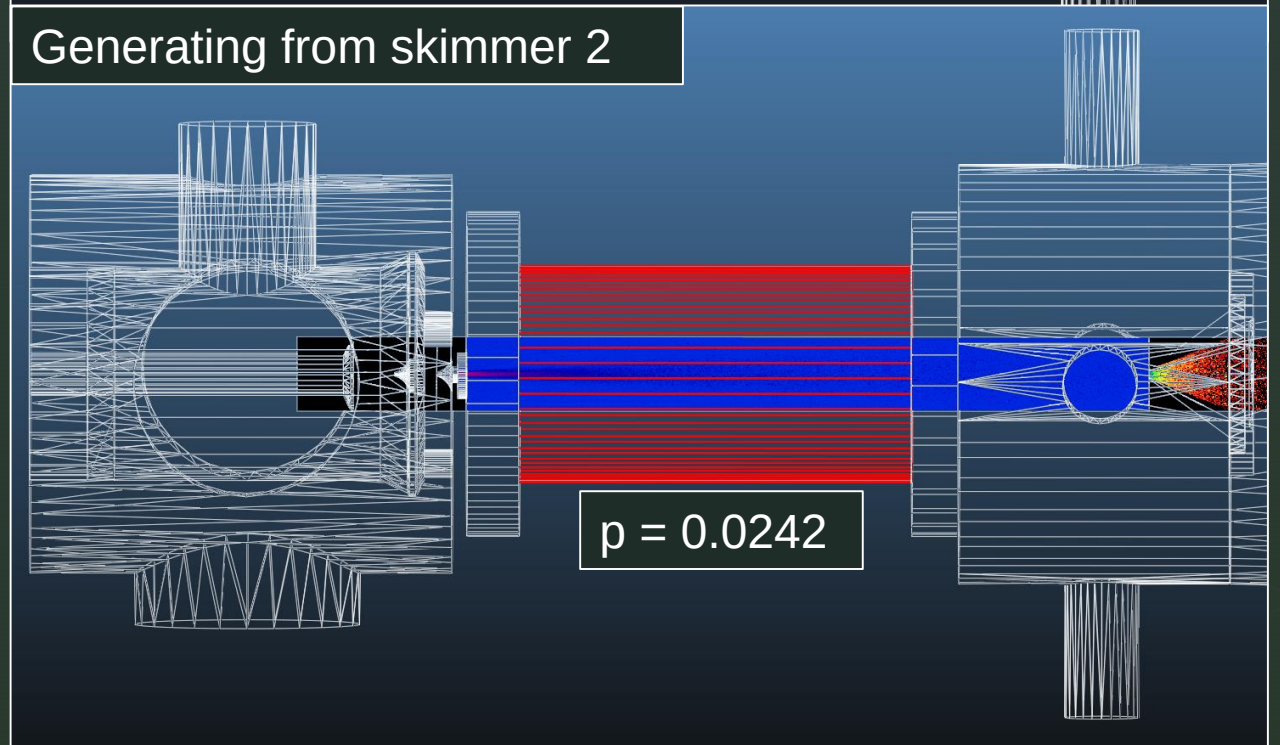
- Interaction chamber
- Ionization chamber
- Pumping


23% collimated
77% diffuse
Profile plotter
300
0
0
10
20
30
40
50
60
70
80
90
F#6943
F#6943 Incident angle [deg]
Show Facet
Add curve
Remove curve
Remove all
Normalize:
None (raw data)
Log Y
-> Plot
Dismiss

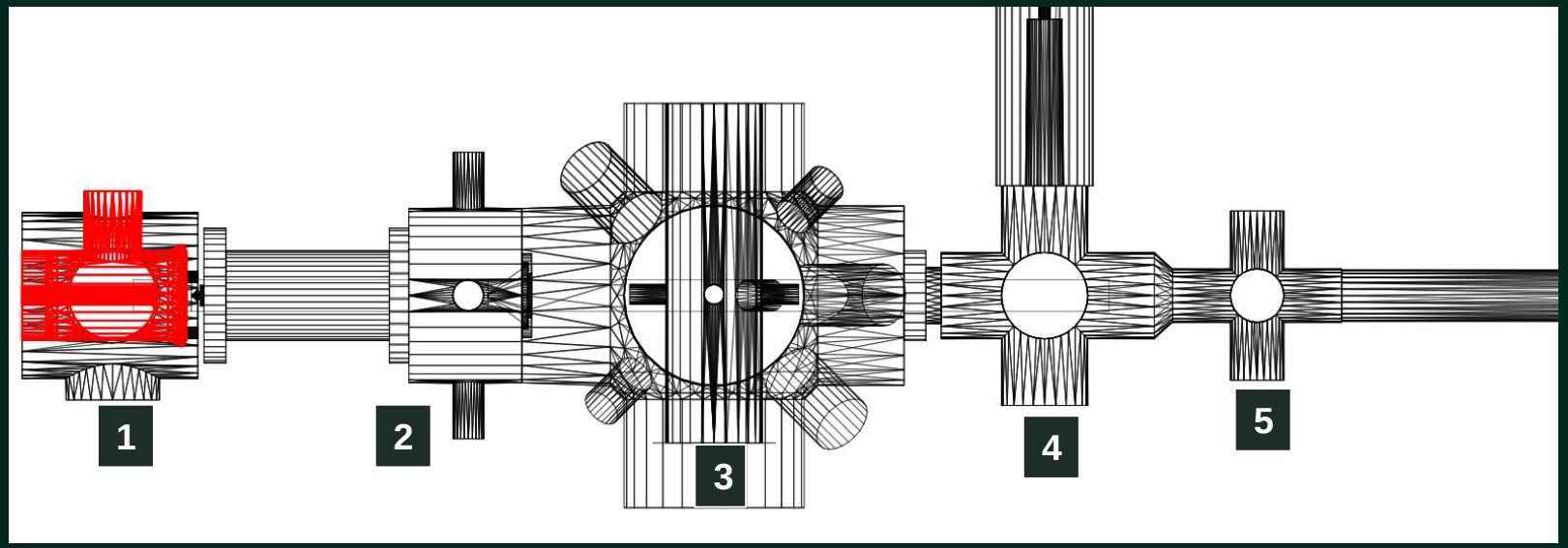
Generating from skimmer 1



Generating from skimmer 2

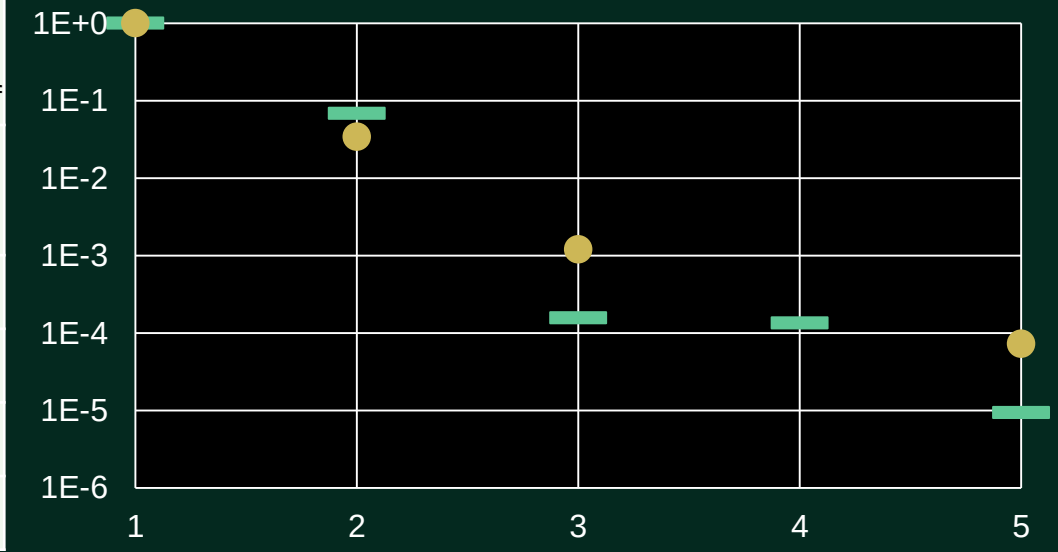


Comparison with experiments

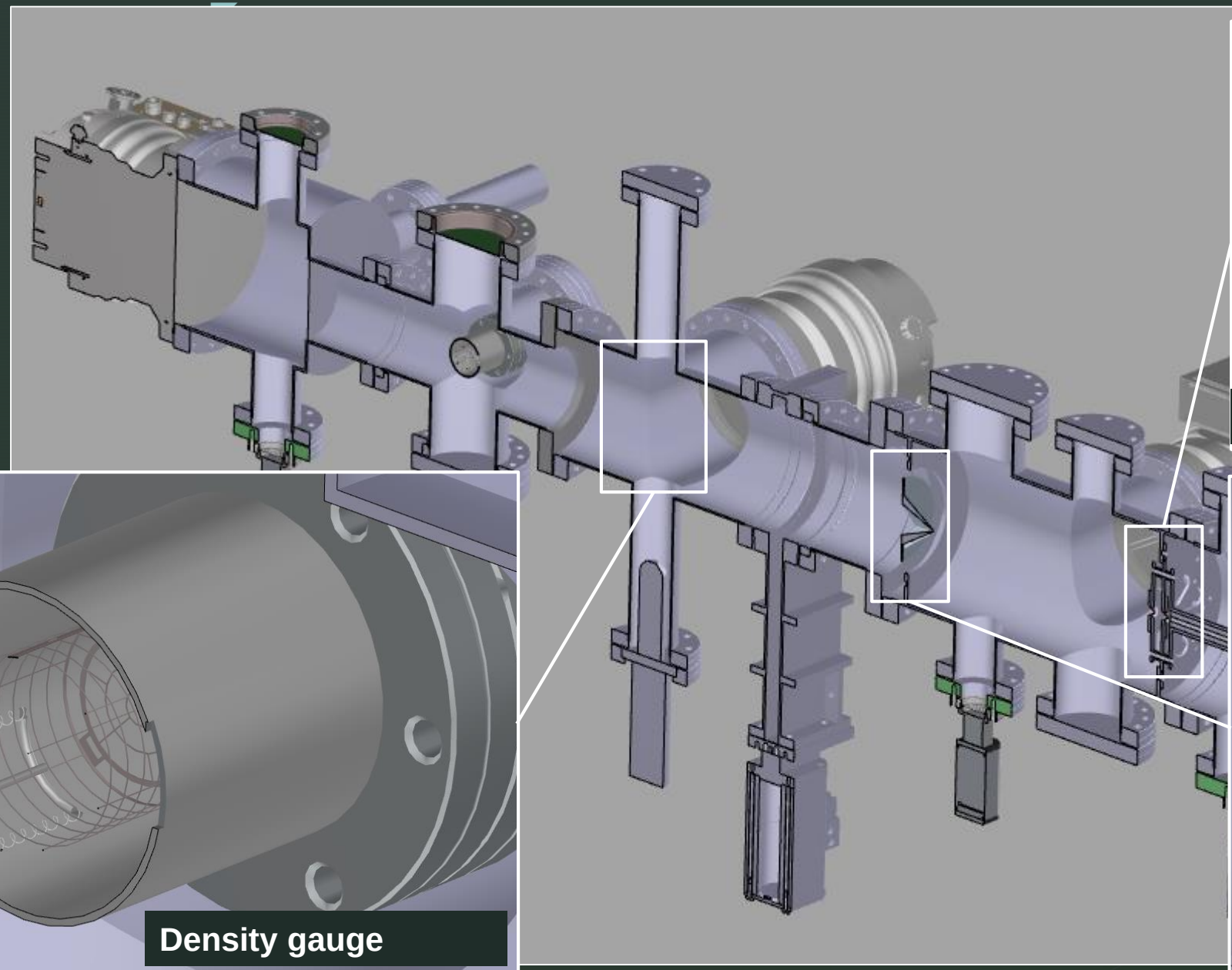


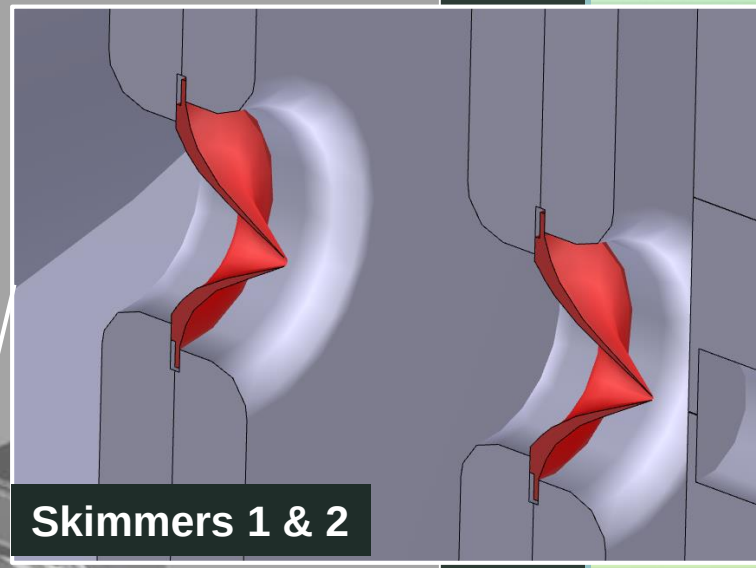
		Norm.density and pressure	Pressure	On	Off	Diff	Norm diff
1	Between skimmers 1 - 2	**1.0E+00**	**3.2E-03**	**6.5E-06**	**1.5E-06**	**5.0E-06**	**1.0E+00**
2	Between skimmers 2 - 3	**6.9E-02**	**2.2E-04**	**2.1E-07**	**4.0E-08**	**1.7E-07**	**3.4E-02**
3	Interaction chamber	**1.6E-04**	**5.0E-07**	**2.8E-08**	**2.2E-08**	**6.0E-09**	**1.2E-03**
4	Ionization chamber	**1.3E-04**	**4.3E-07**				
5	Last pump	**9.4E-06**	**3.0E-08**	**1.3E-09**	**9.4E-10**	**3.6E-10**	**7.2E-05**

Normalized pressures

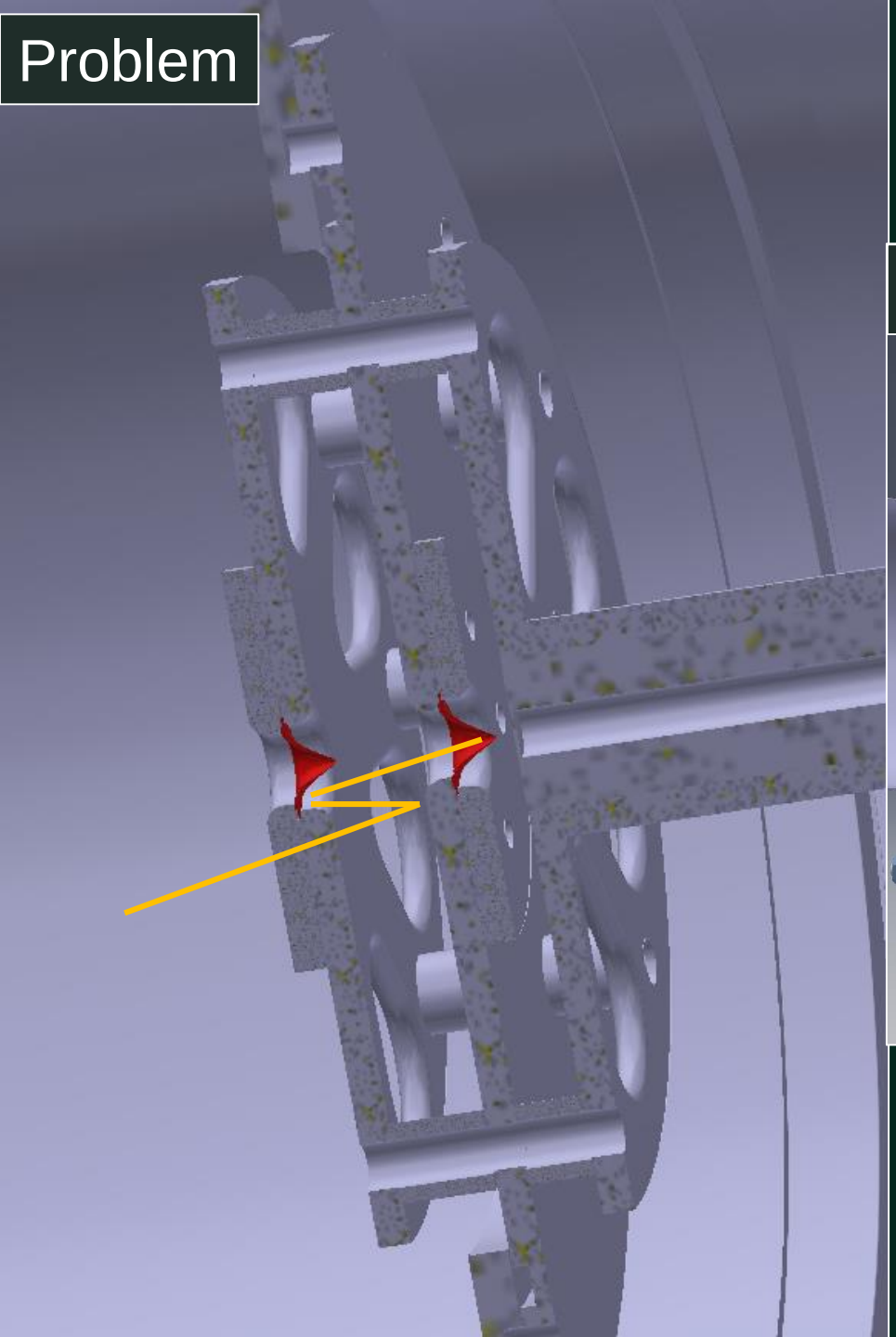


Improved setup (present)

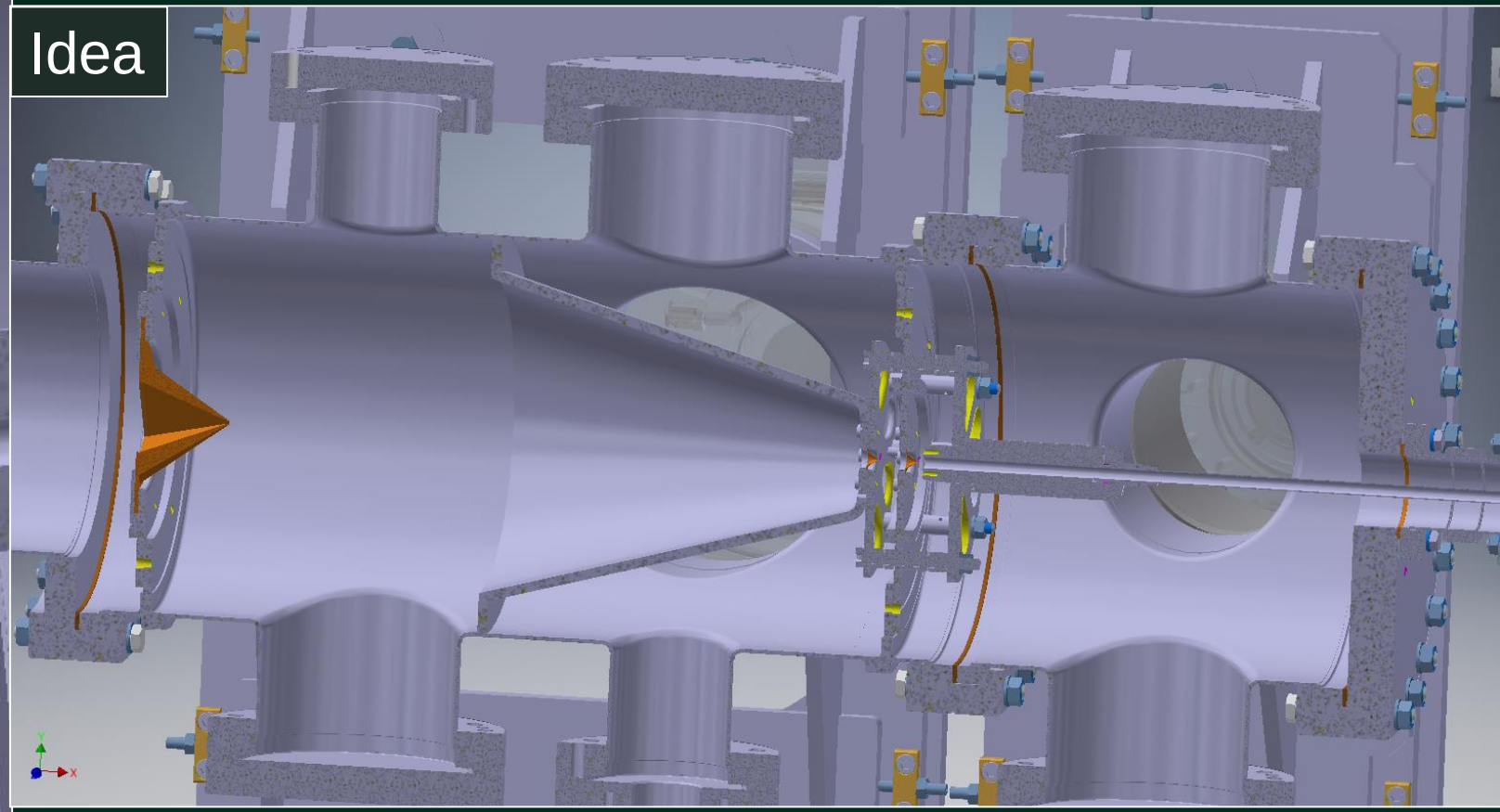




Problem



Idea

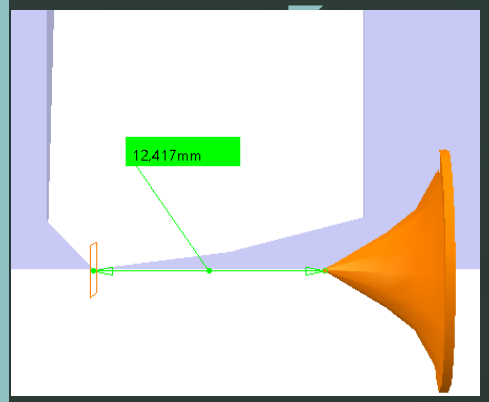


In search of the final setup

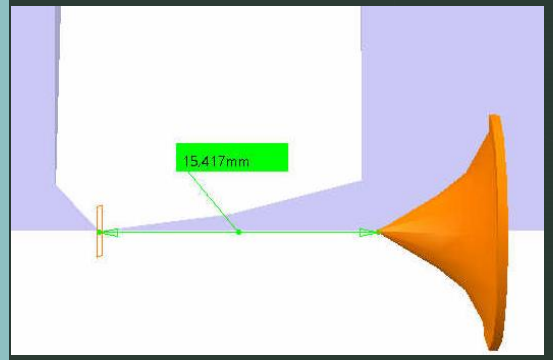
Free parameters, high pressure part

Images: Przemyslaw Smakulski

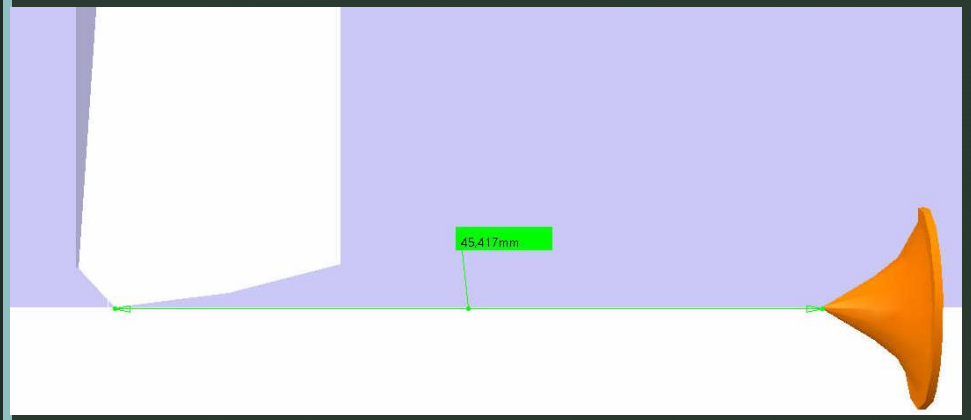
A

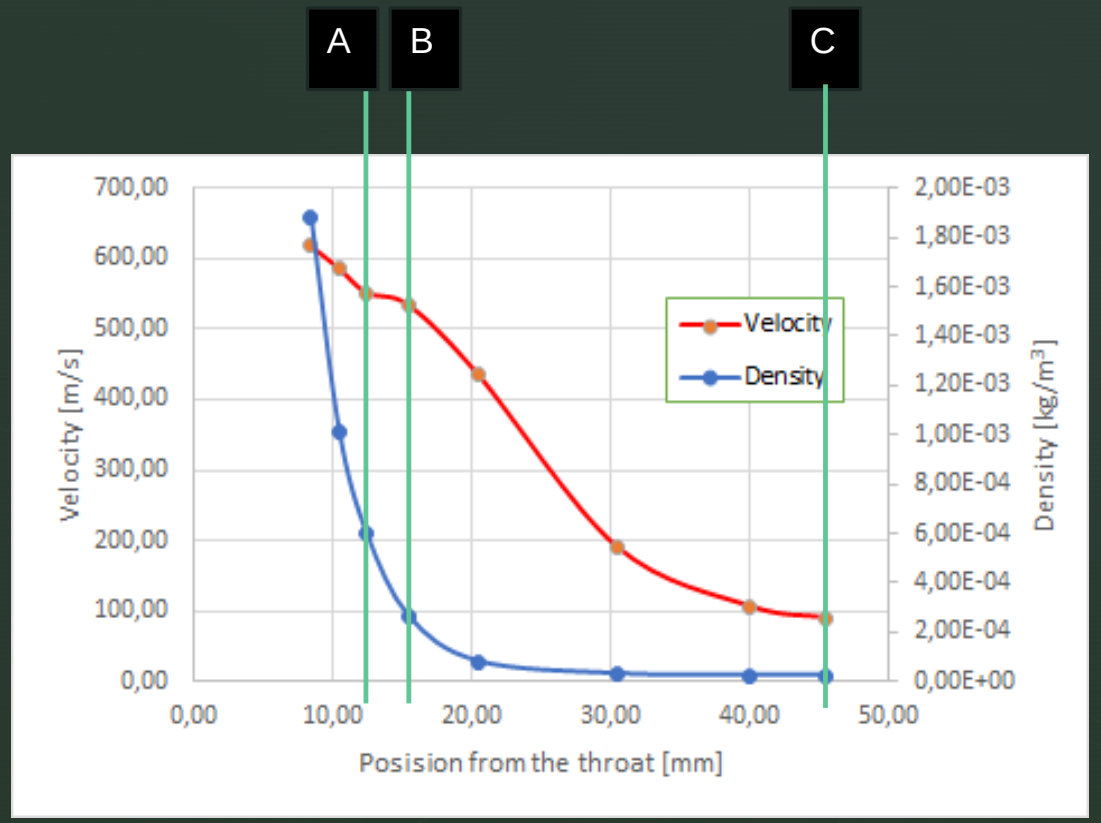


B

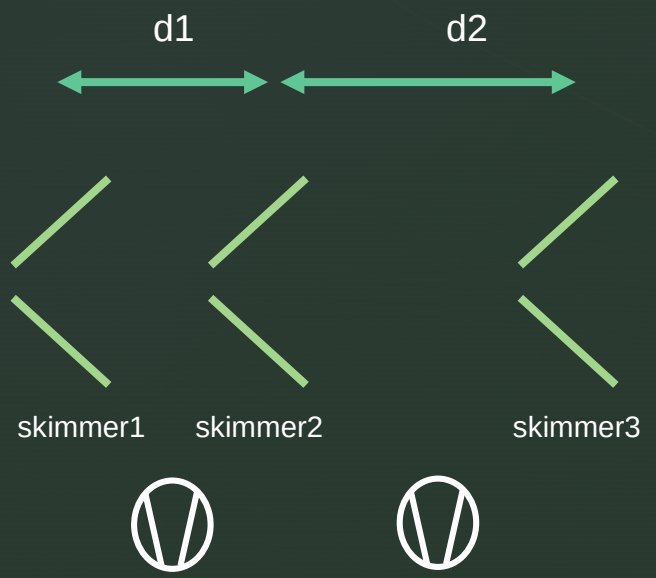


C

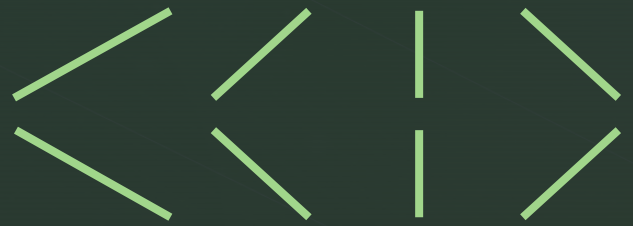




Free parameters, low pressure part



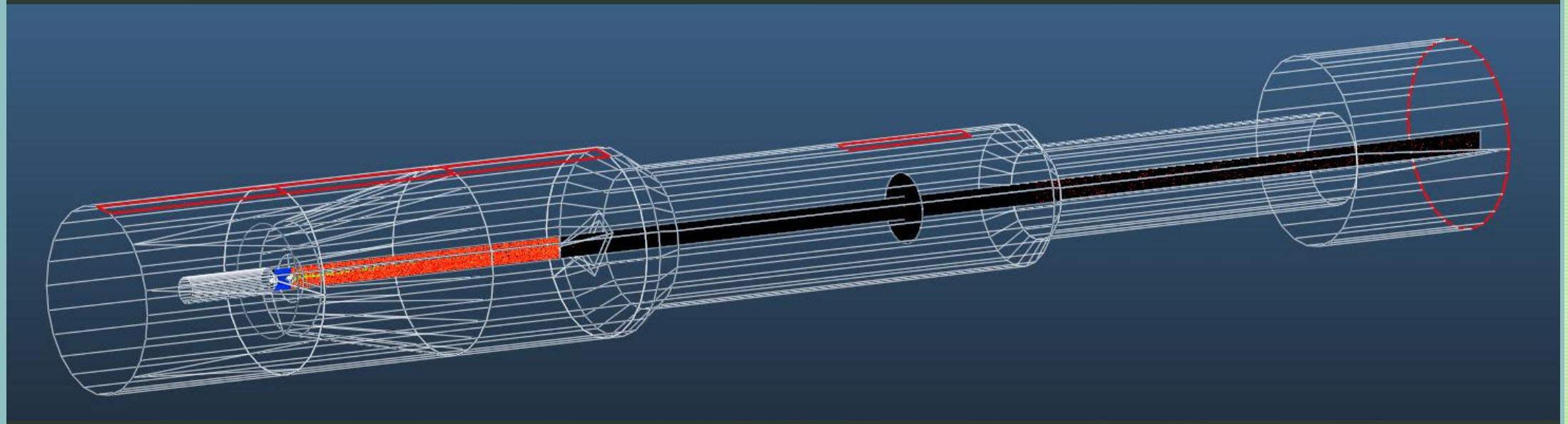
Distance between skimmers



Skimmer shape

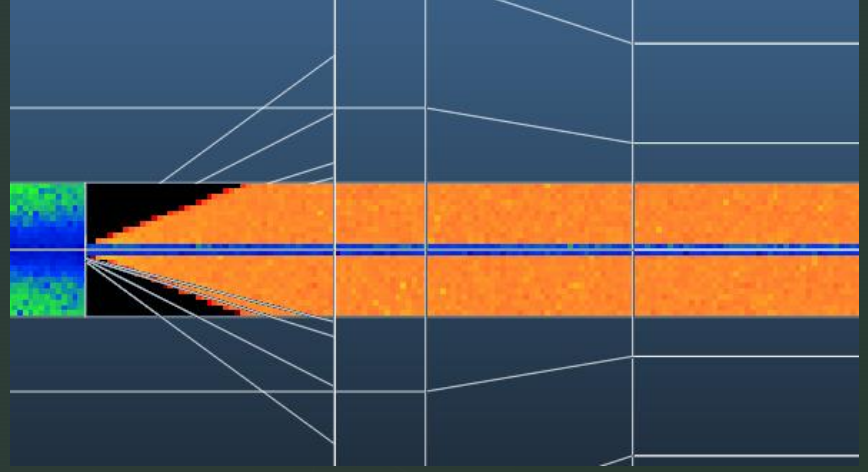
Number of skimmers

Simplified geometry

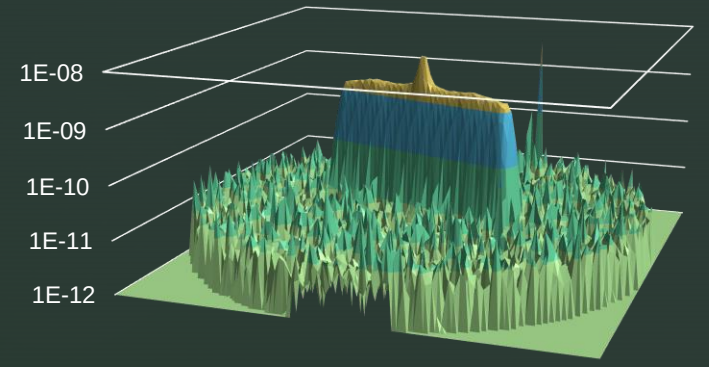


red facets: pumping surfaces

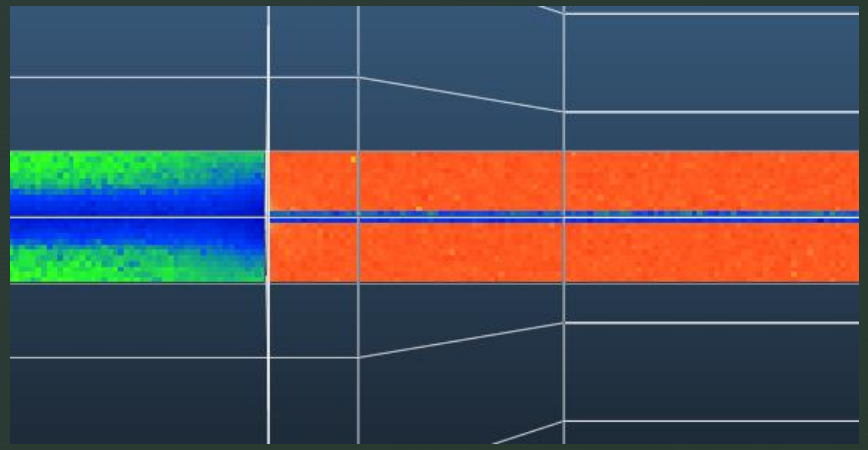
JET



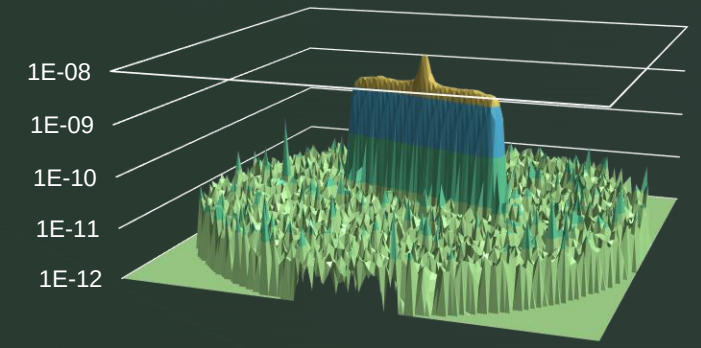
normal skimmer 3



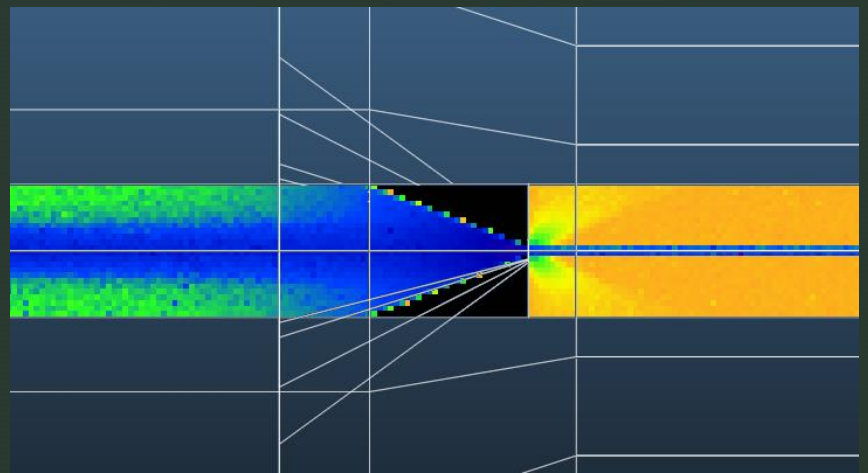
JET



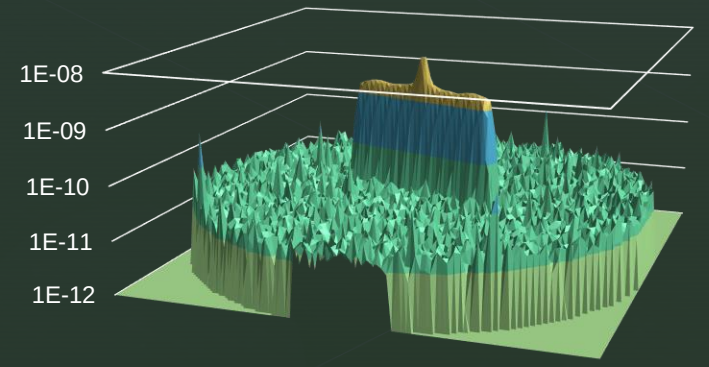
flat skimmer 3



JET



inverse skimmer 3

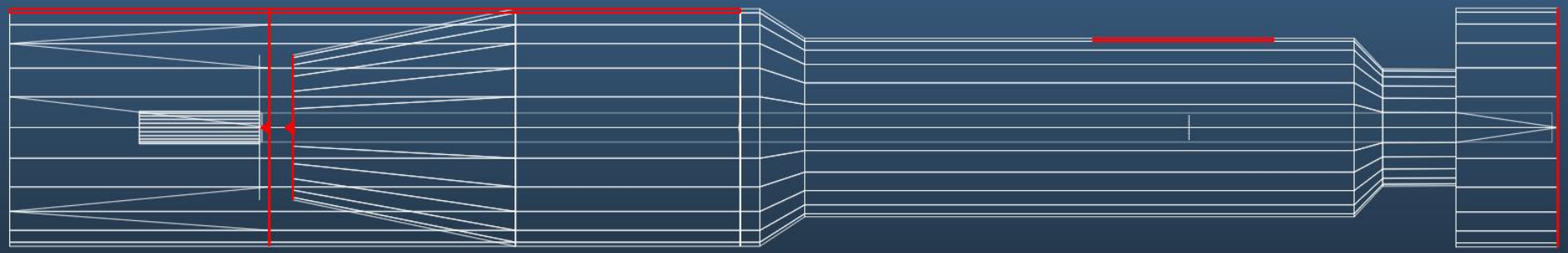


Original

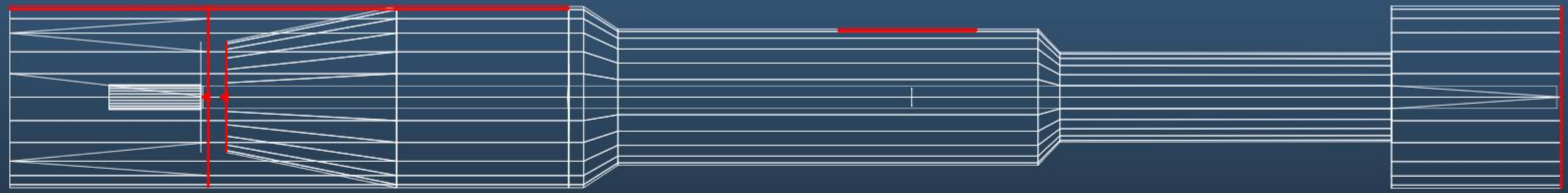
Half space skim2-3

Original

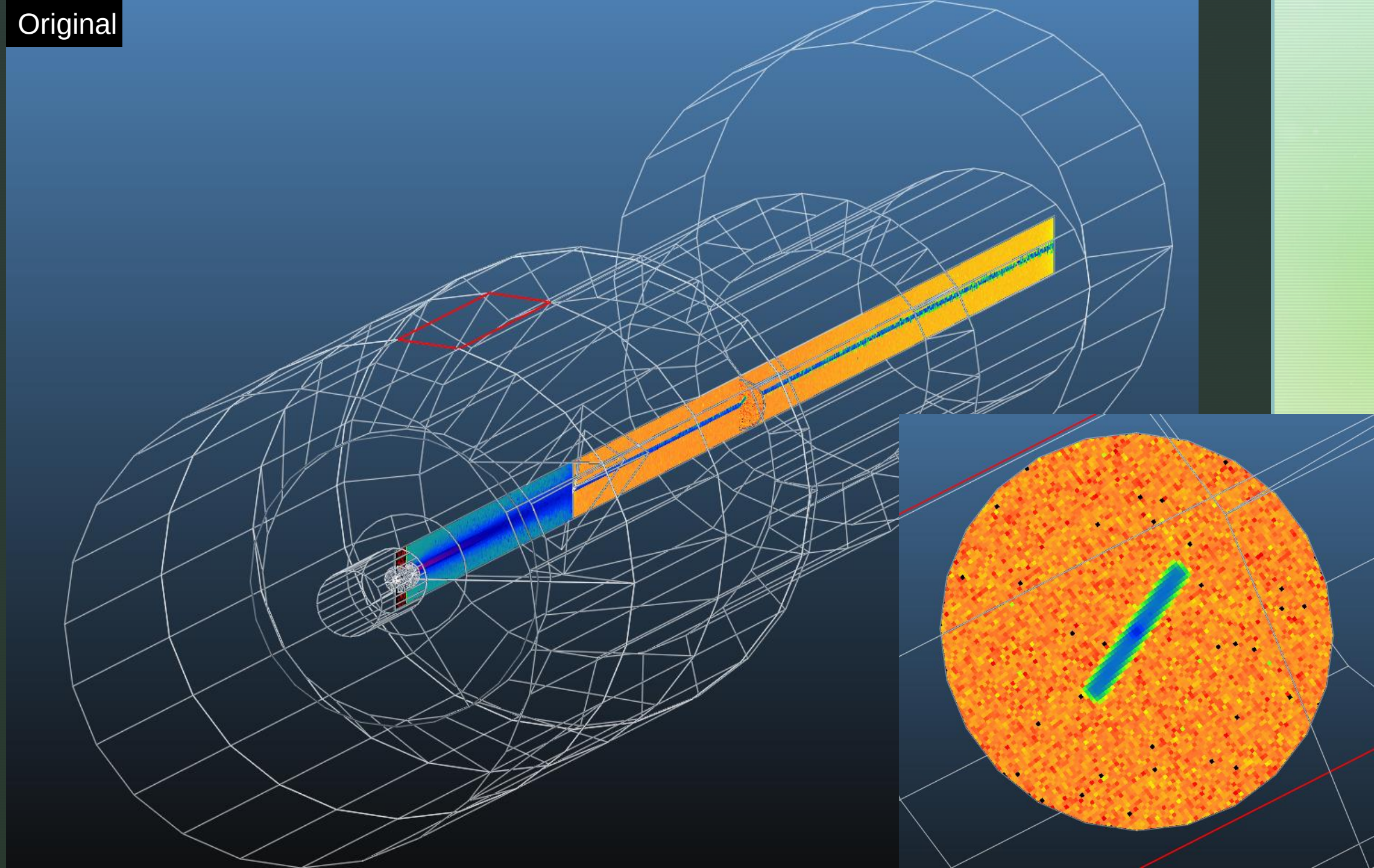
Closer end

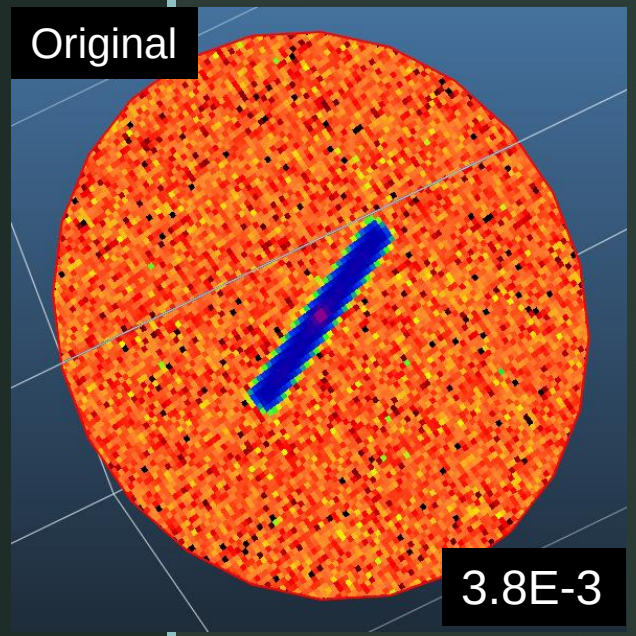


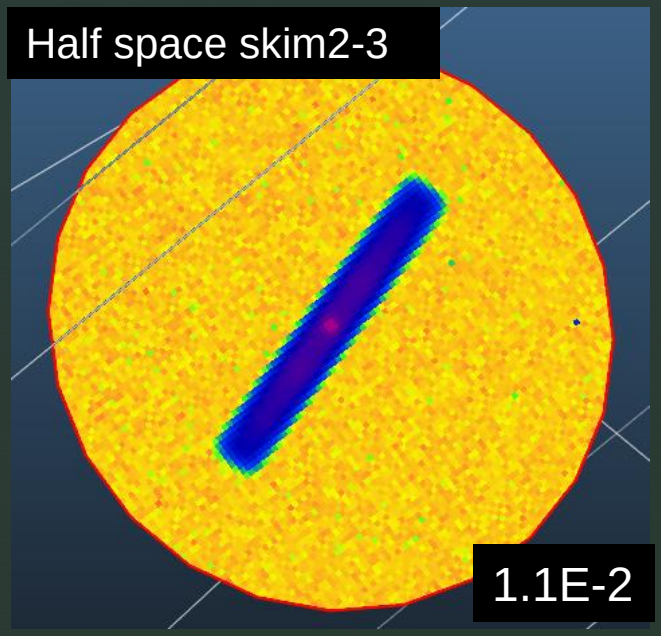
Original

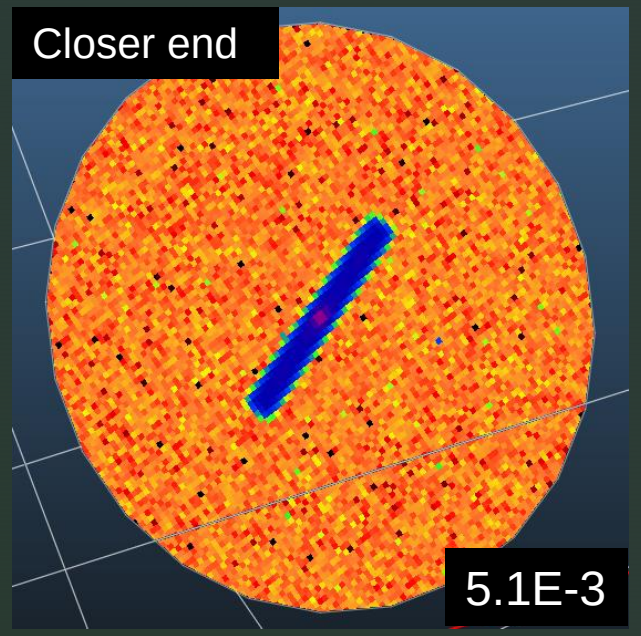


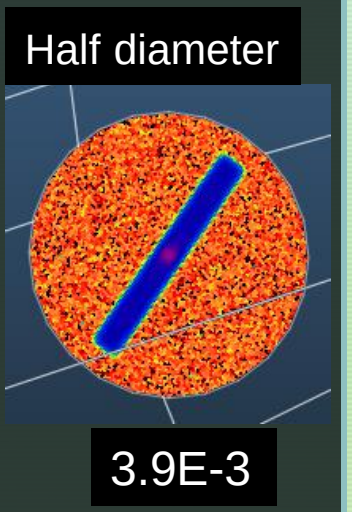
Half diameter

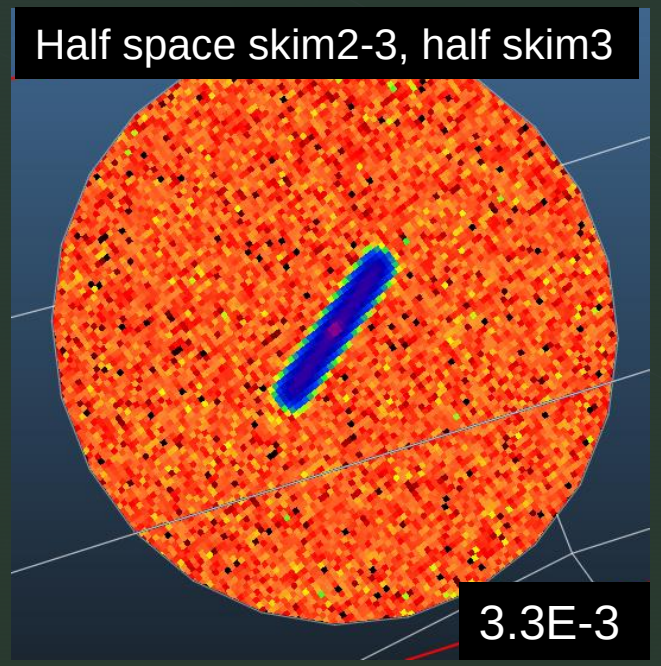

Original

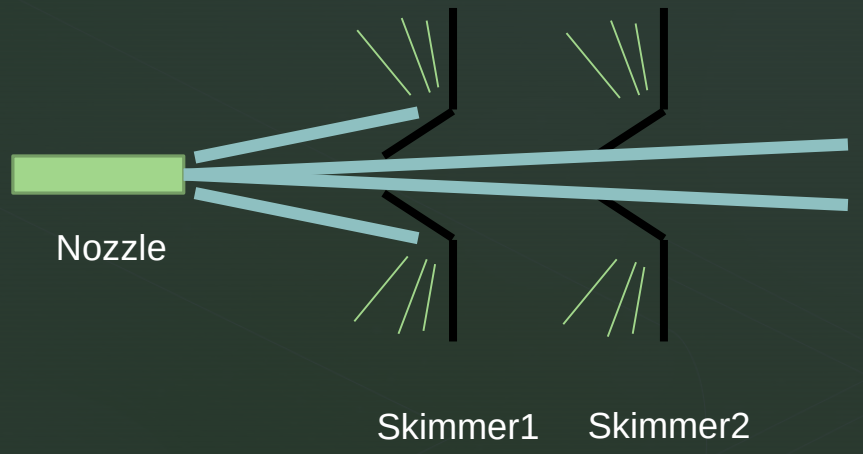

Original
3.8E-3


Half space skim2-3
1.1E-2

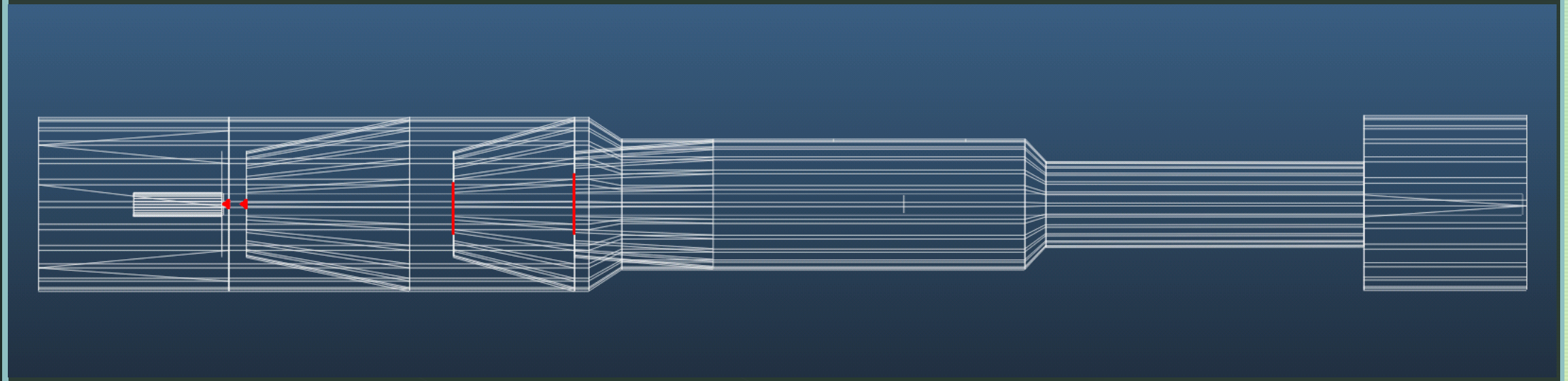

Closer end
5.1E-3

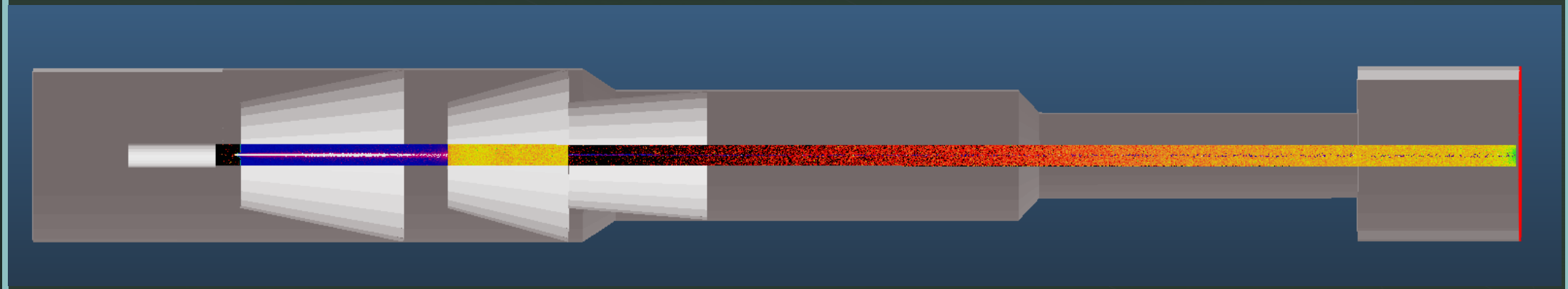

Half diameter
3.9E-3

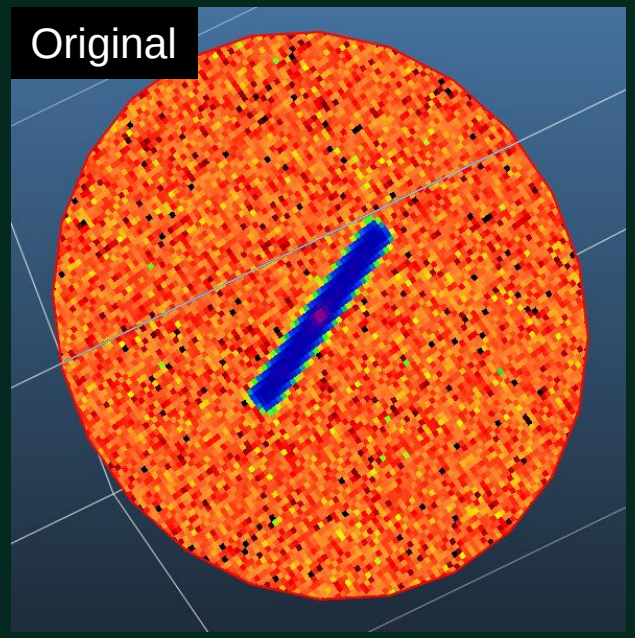

Half space skim2-3, half skim3
3.3E-3


Nozzle
Skimmer1
Skimmer2

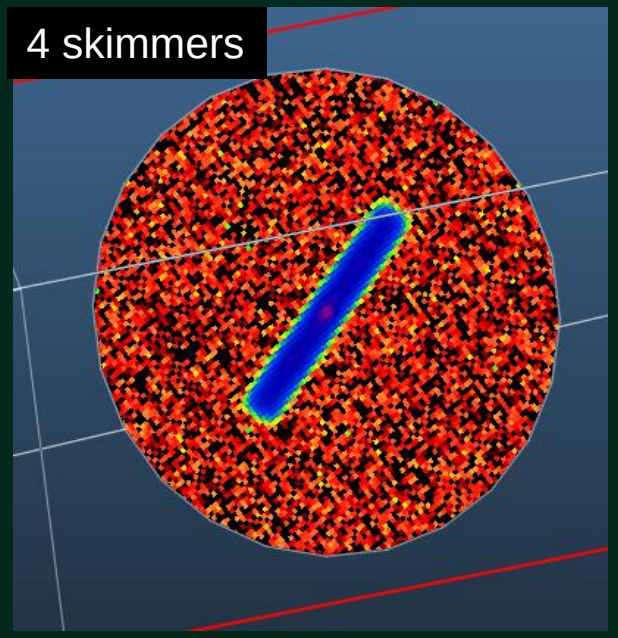
Adding a fourth skimmer



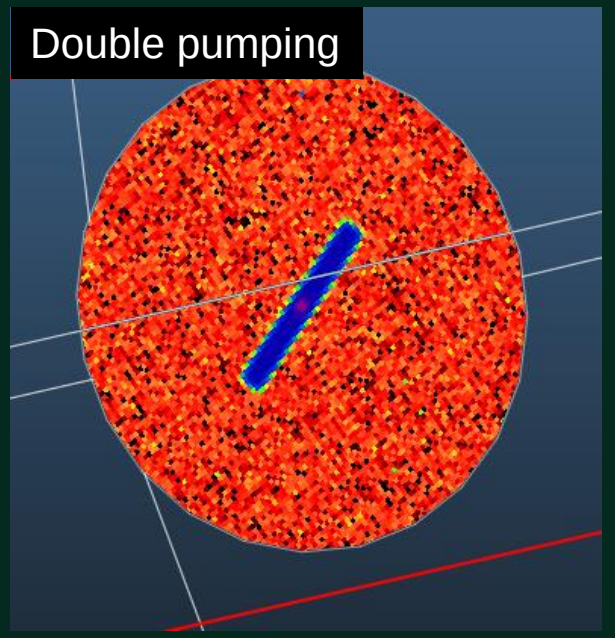




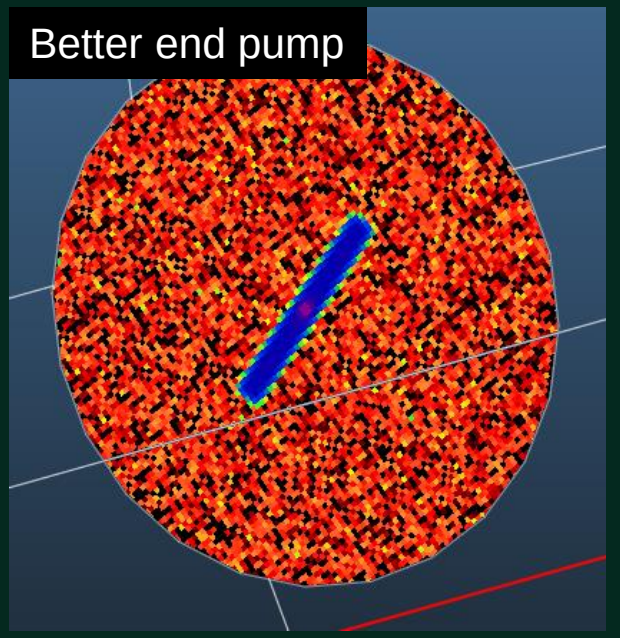
3.8E-3



1.5E-3

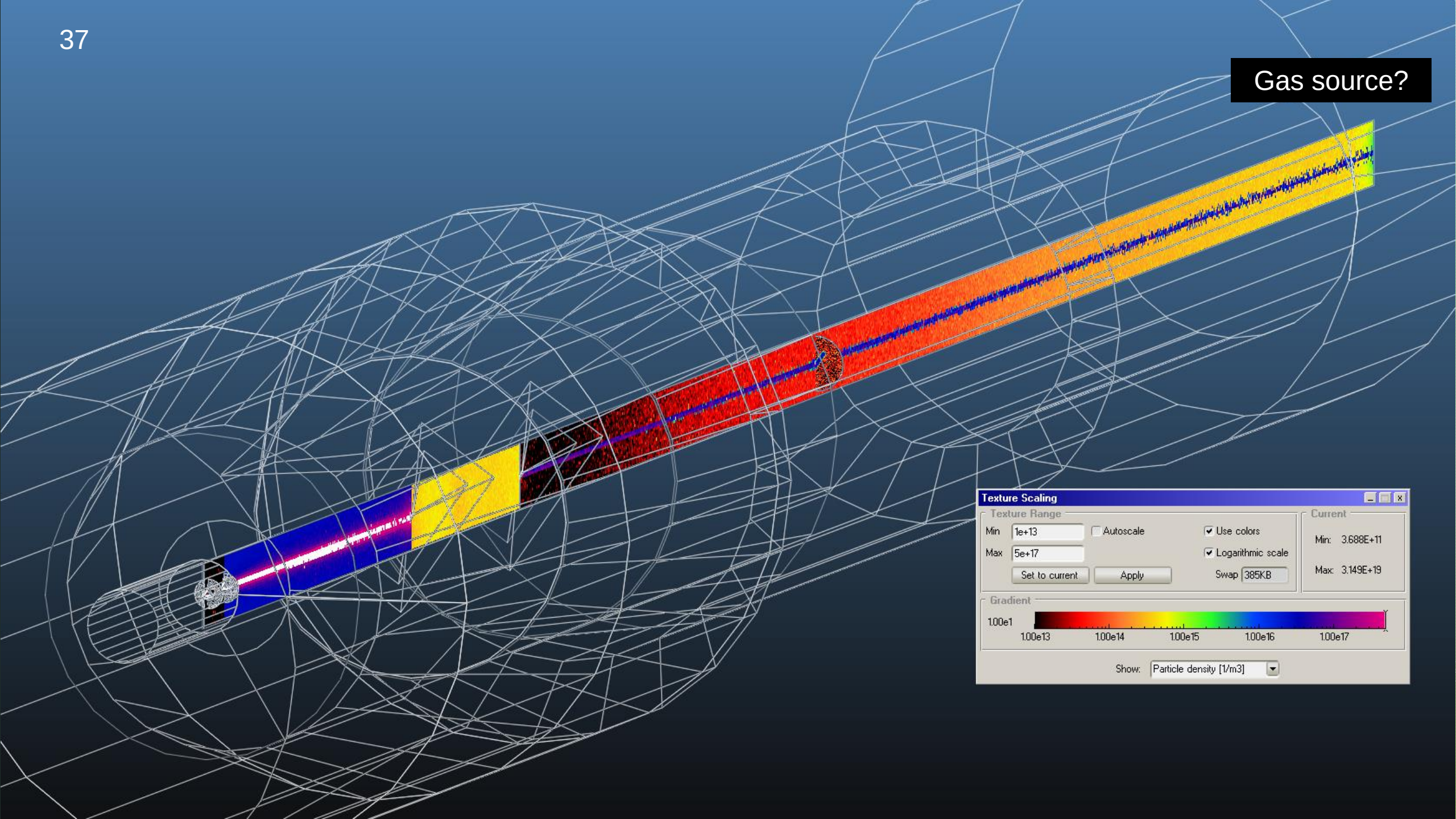


2.2E-3

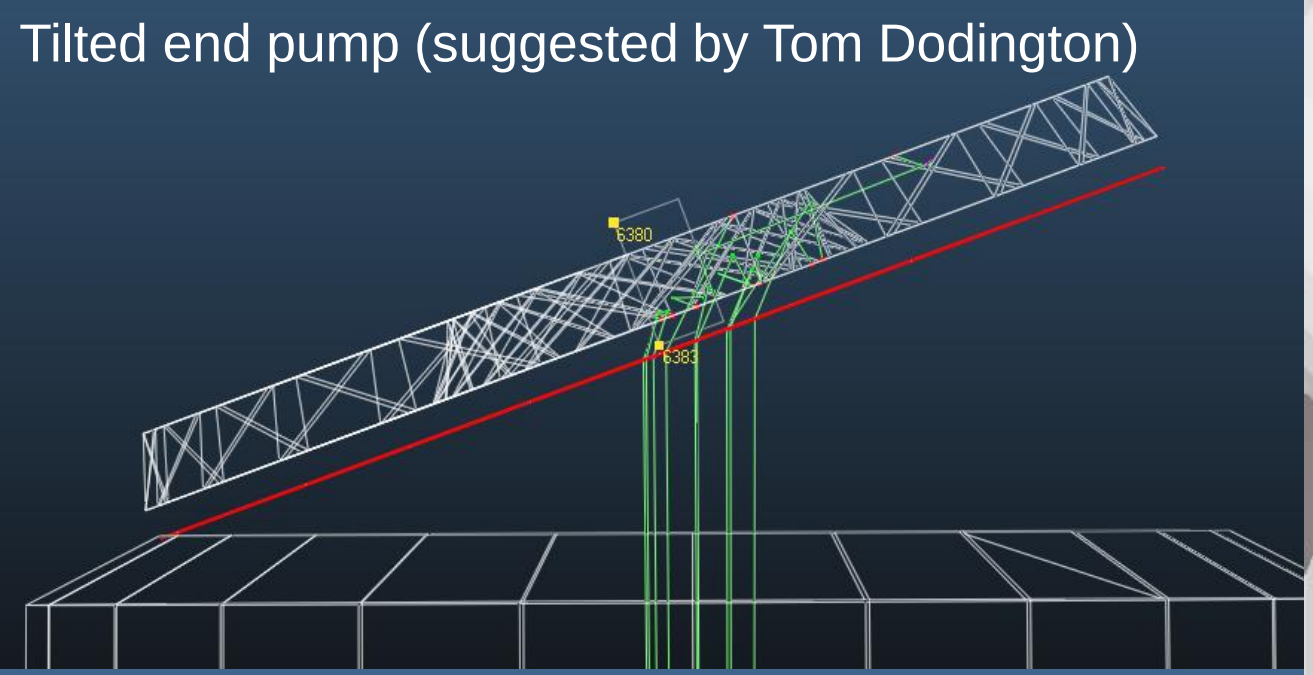


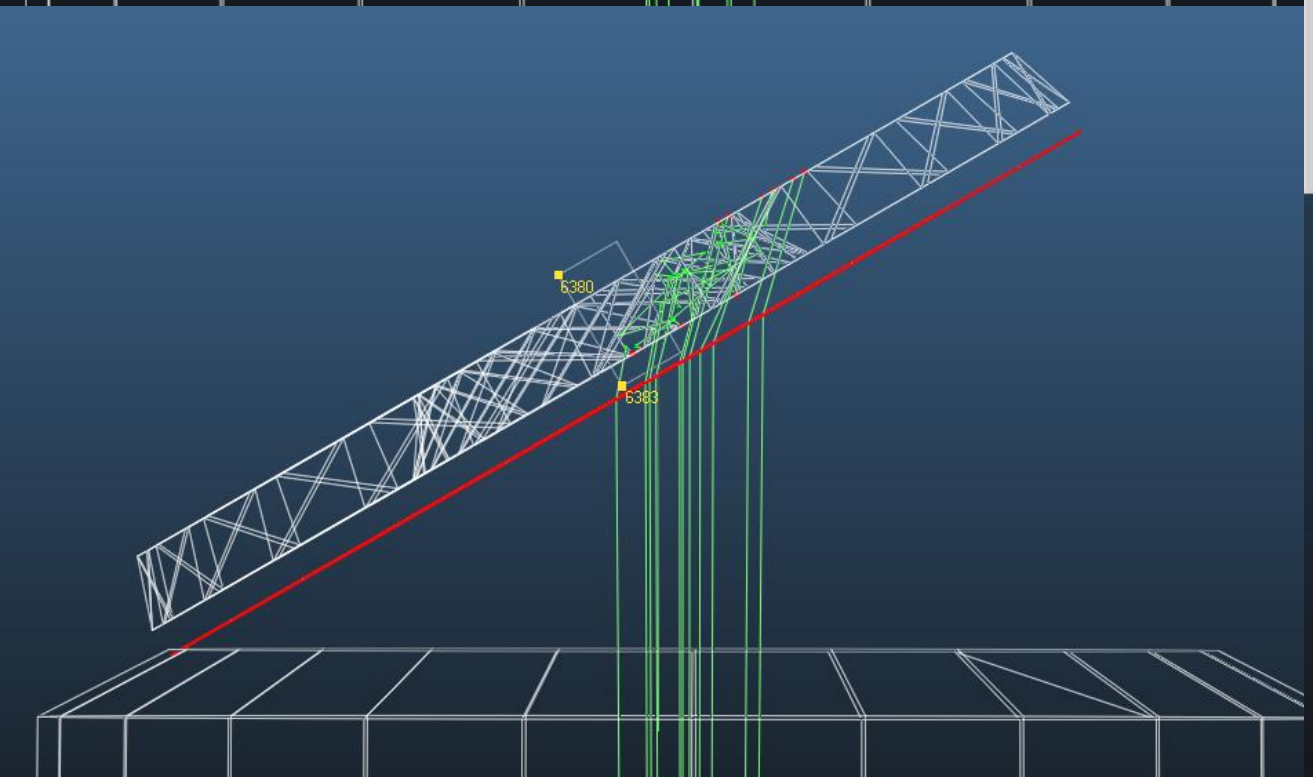
2.0E-3

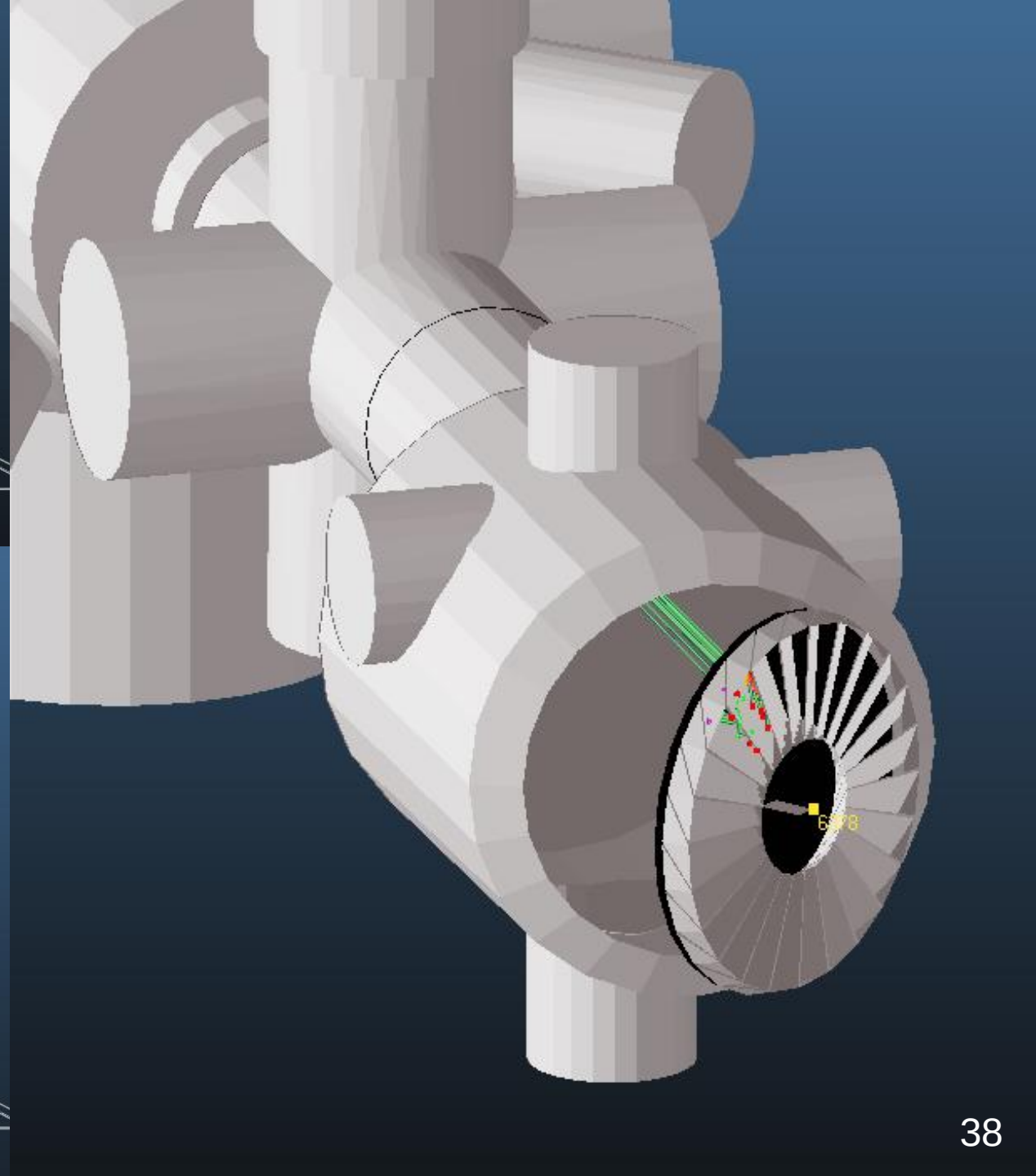
Gas source?

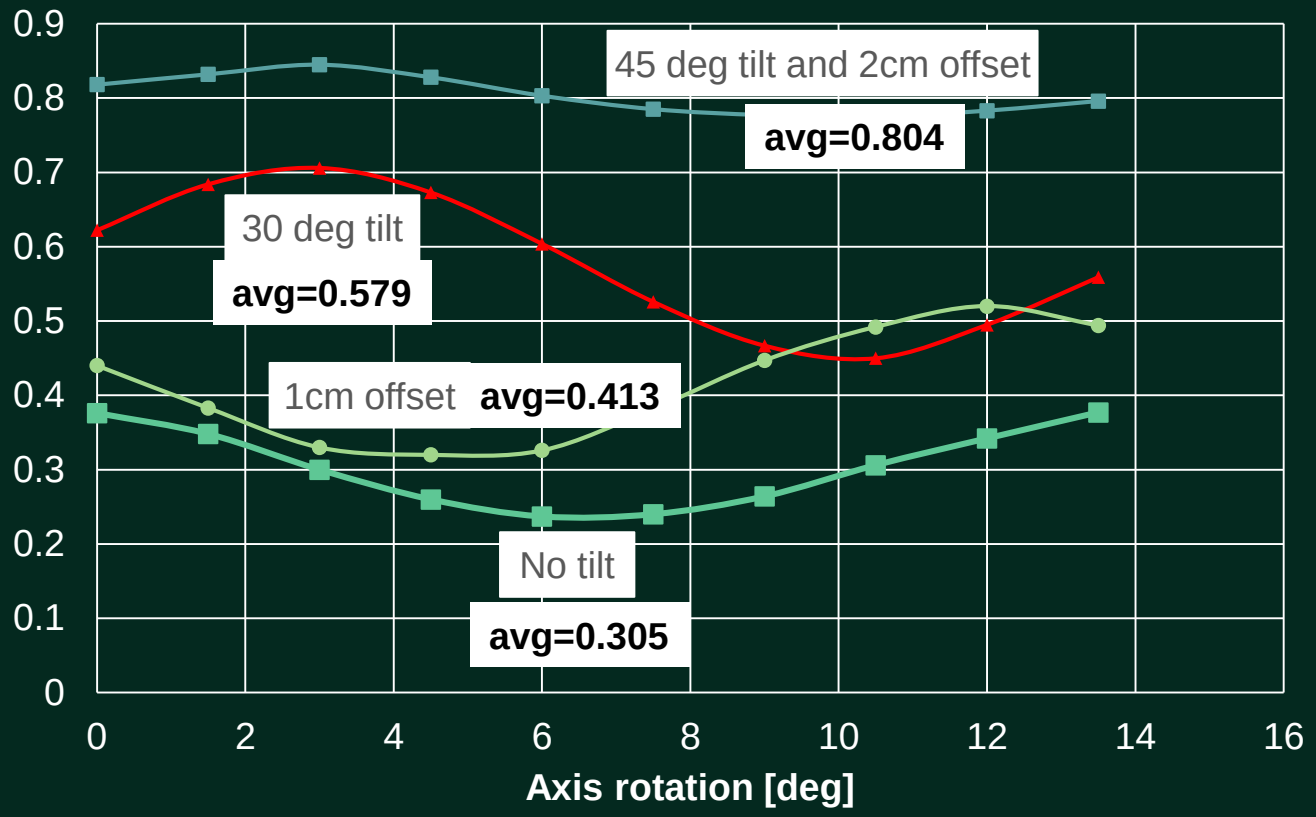

Texture Scaling
Texture Range
Min
1e+13
Autoscale
Use colors
Max
5e+17
Logarithmic scale
Set to current
Apply
Swap
385KB
Current
Min: 3.688E+11
Max: 3.149E+19
Gradient
1.00e1
1.00e13
1.00e14
1.00e15
1.00e16
1.00e17
Show:
Particle density [1/m3]

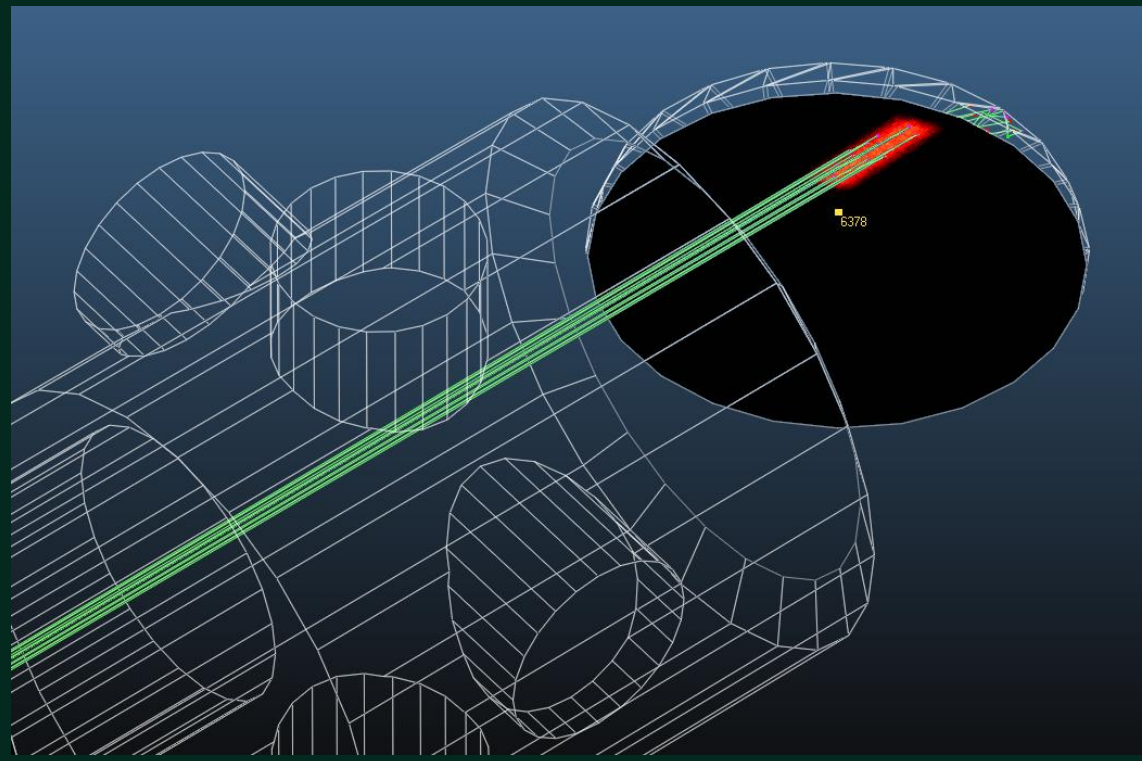
Tilted end pump (suggested by Tom Dodington)



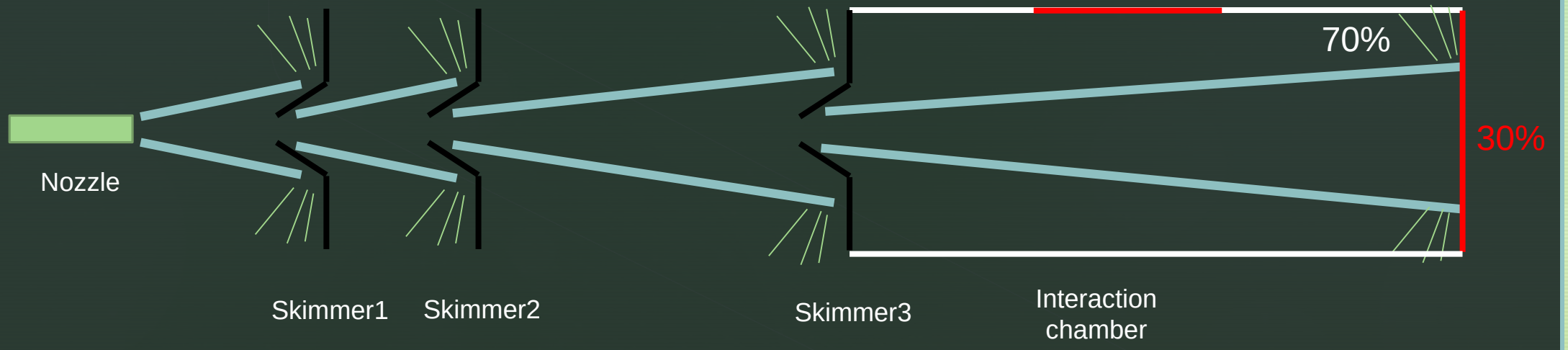




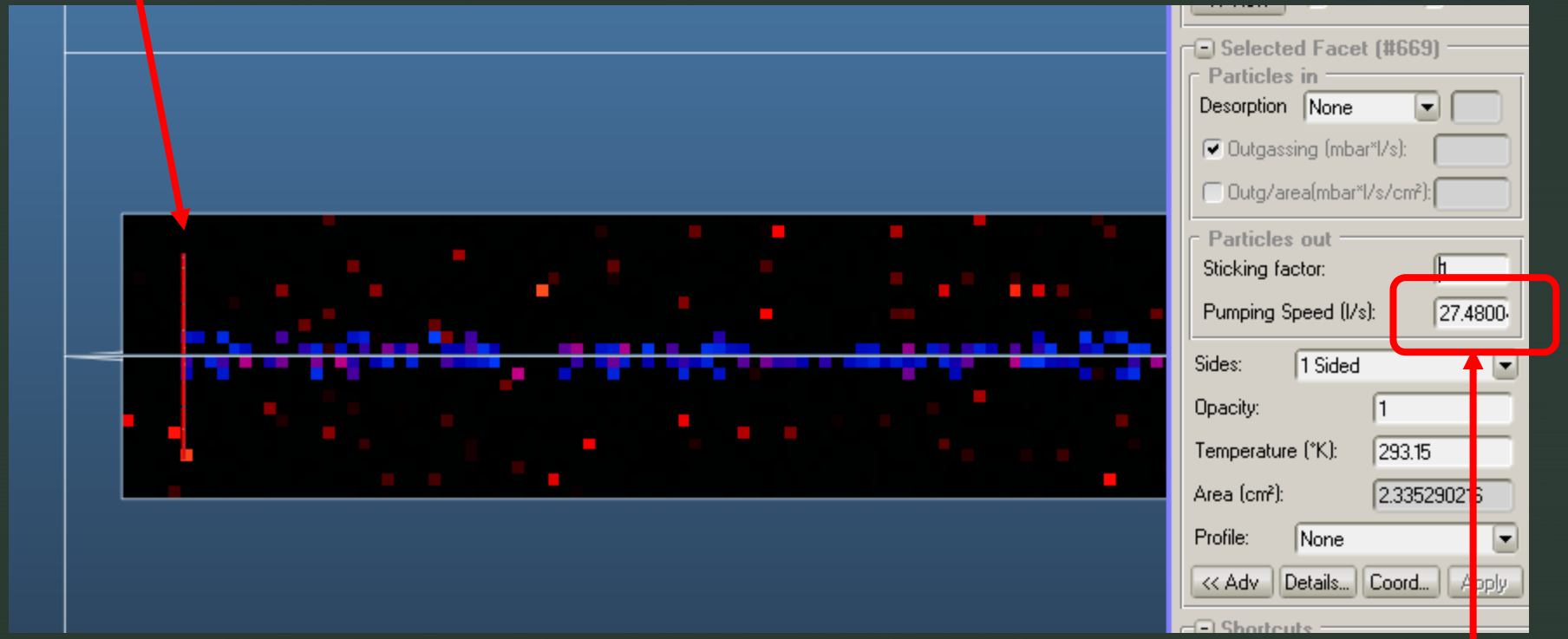

0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
14
16
Axis rotation [deg]
45 deg tilt and 2cm offset
avg=0.804
30 deg tilt
avg=0.579
1cm offset
avg=0.413
No tilt
avg=0.305


6378

Linear system: Iterative simulation

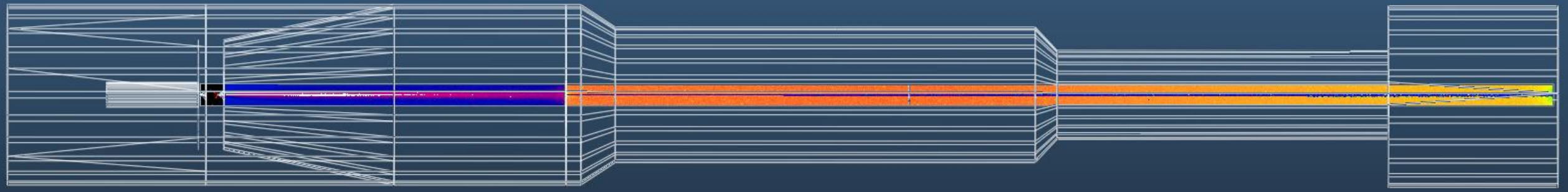


Theoretical surface with perfect sticking

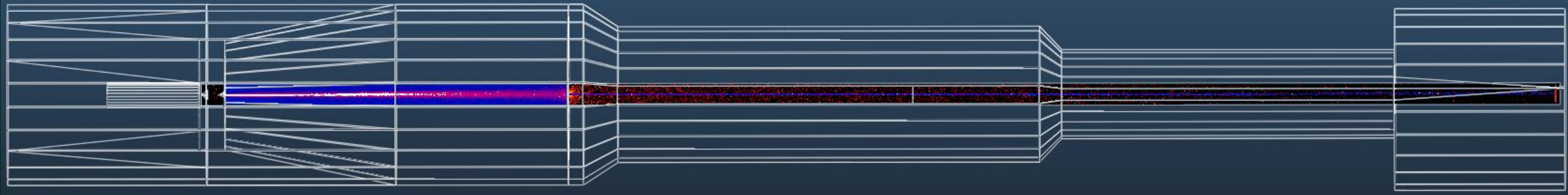


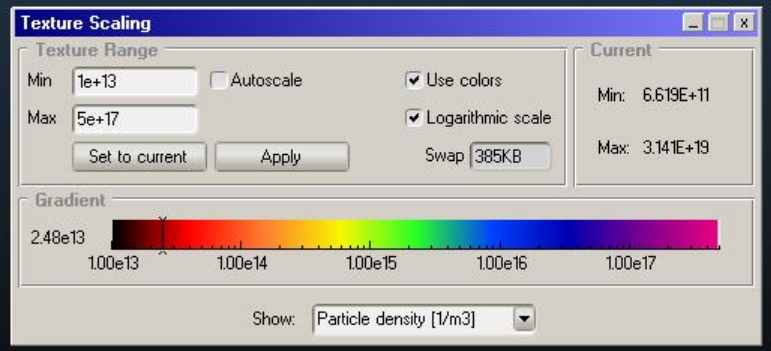
Small pumping

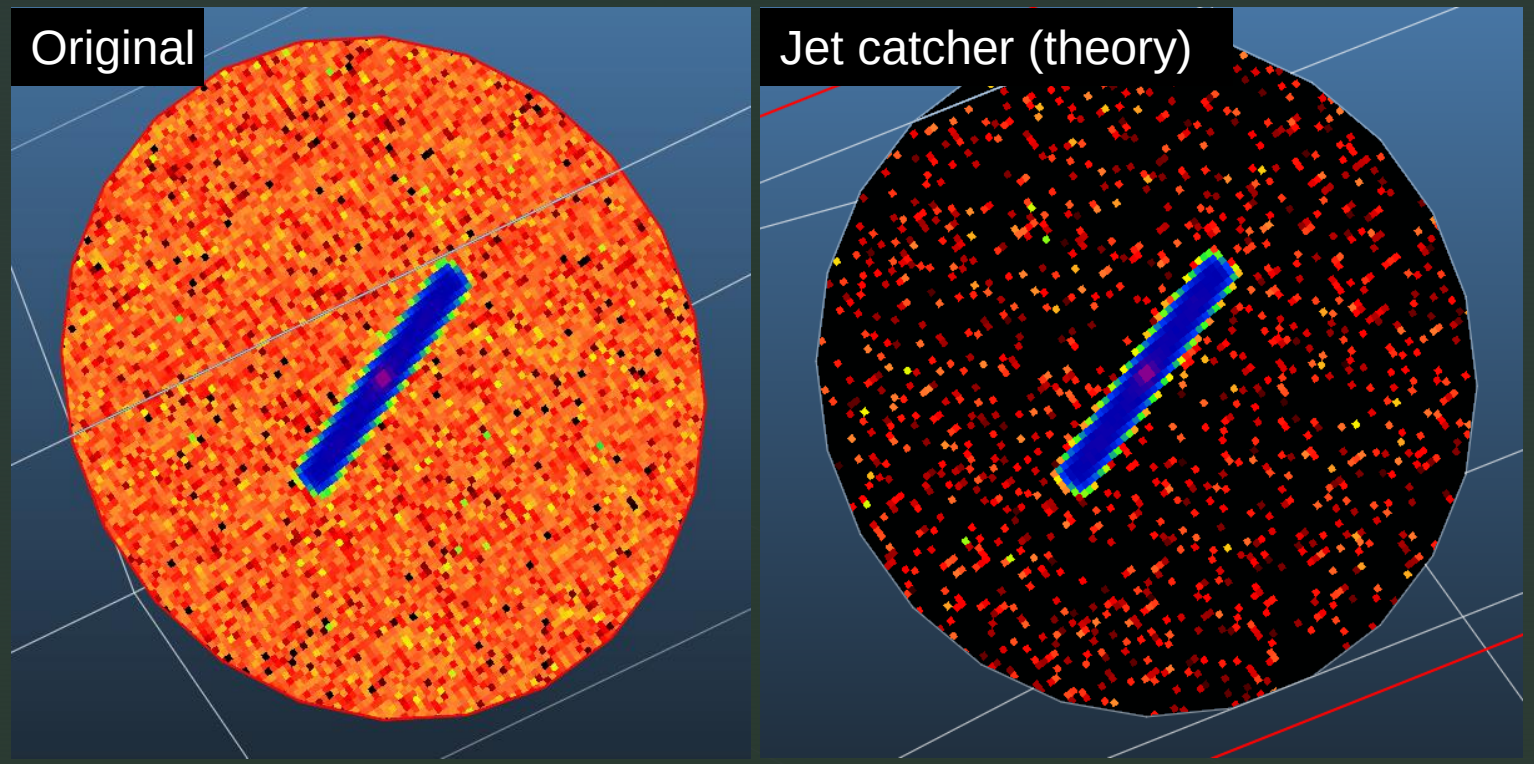
Original



“Jet catcher”



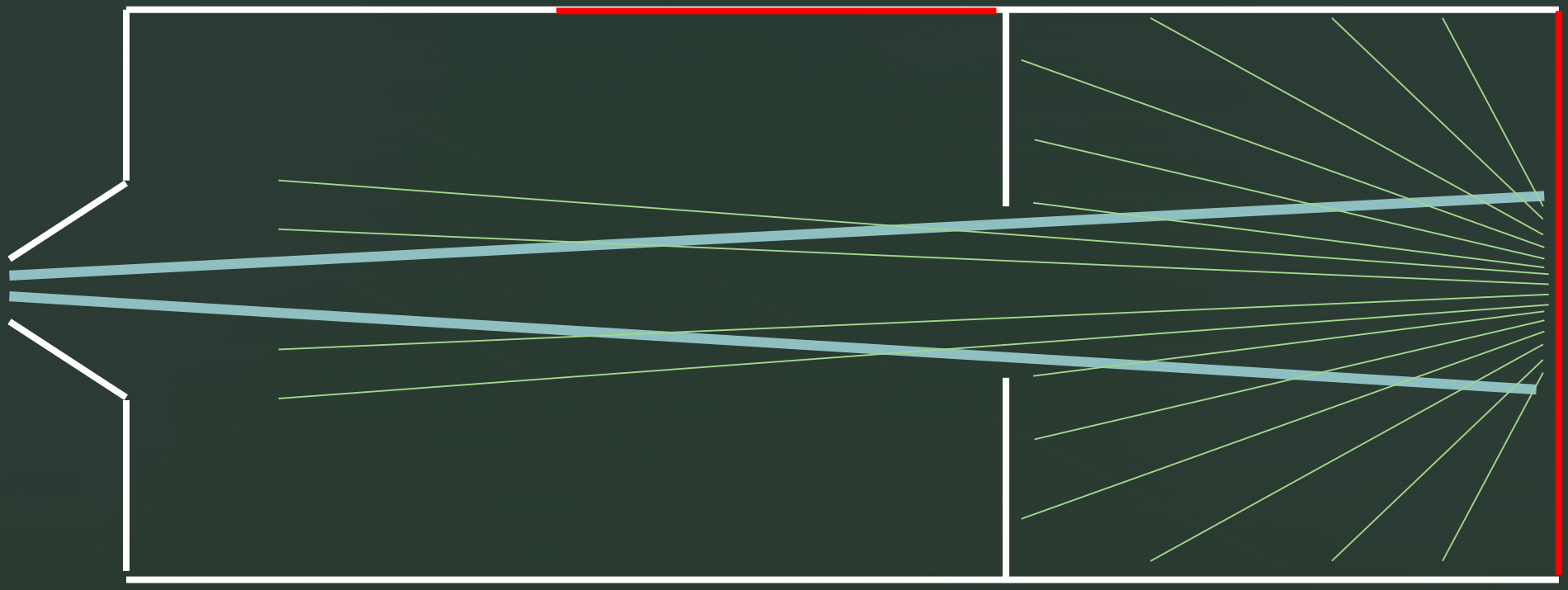




3.8E-3

2.3E-4

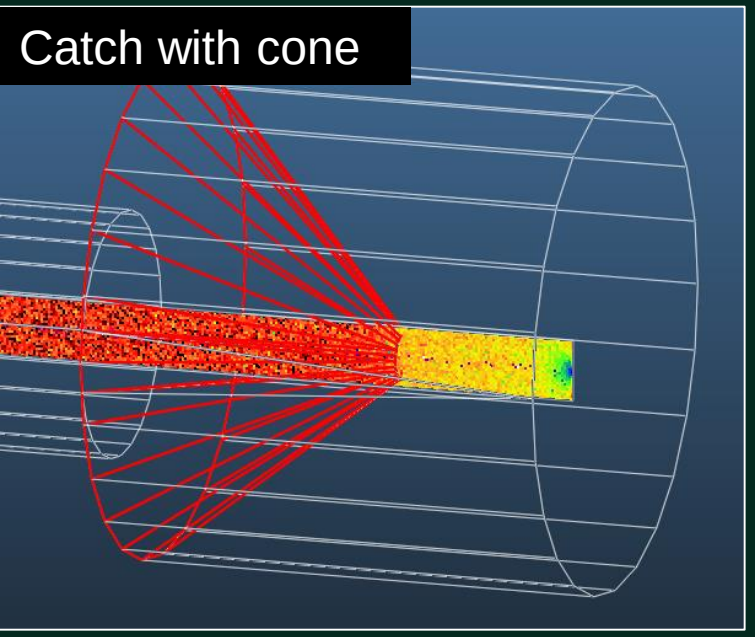
Linear system: Iterative simulation



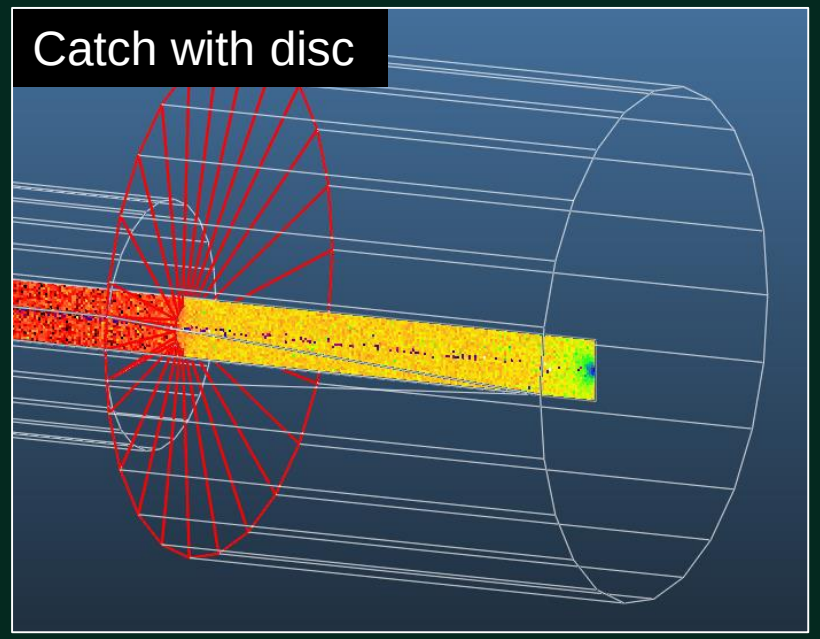
Skimmer3

Interaction chamber

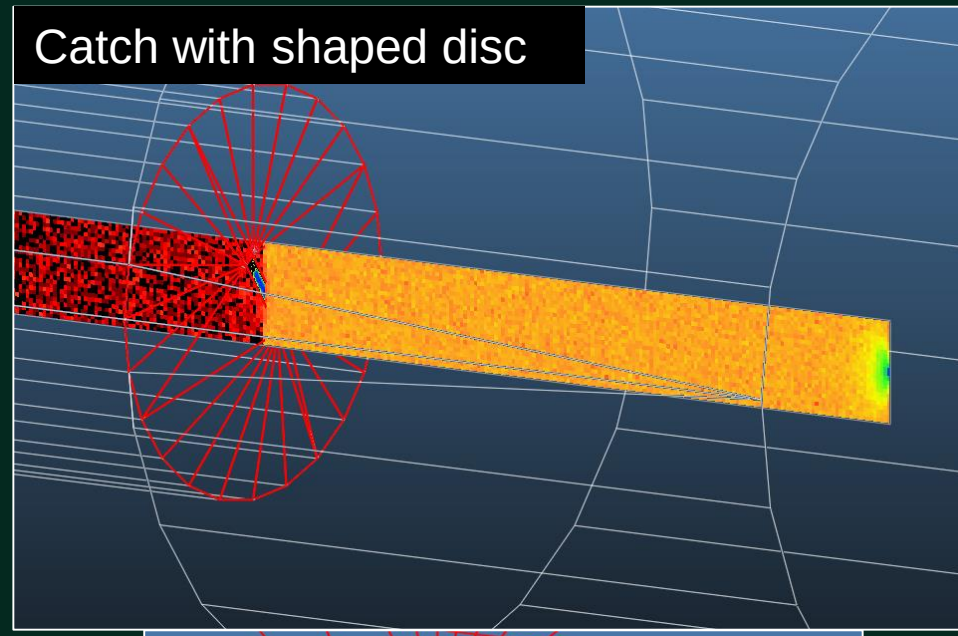
Catch with cone

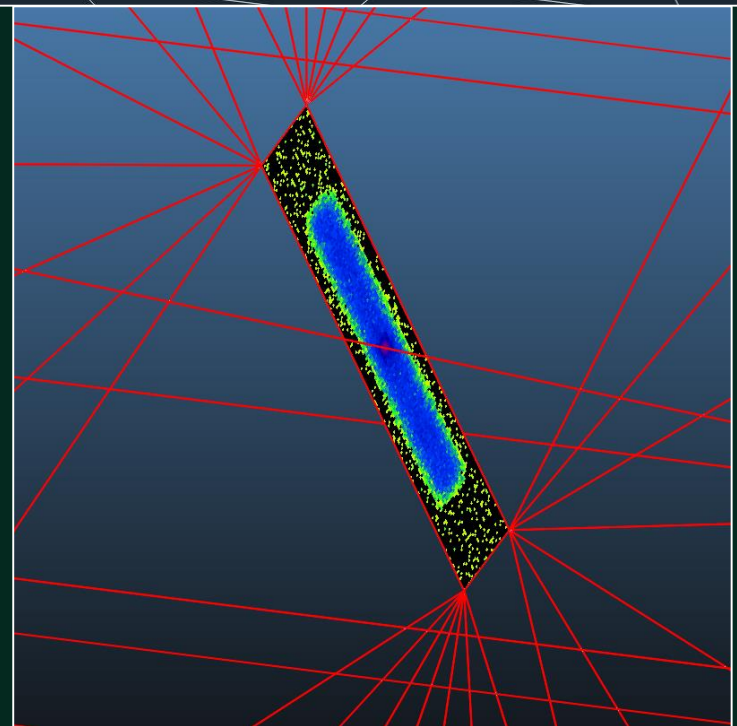


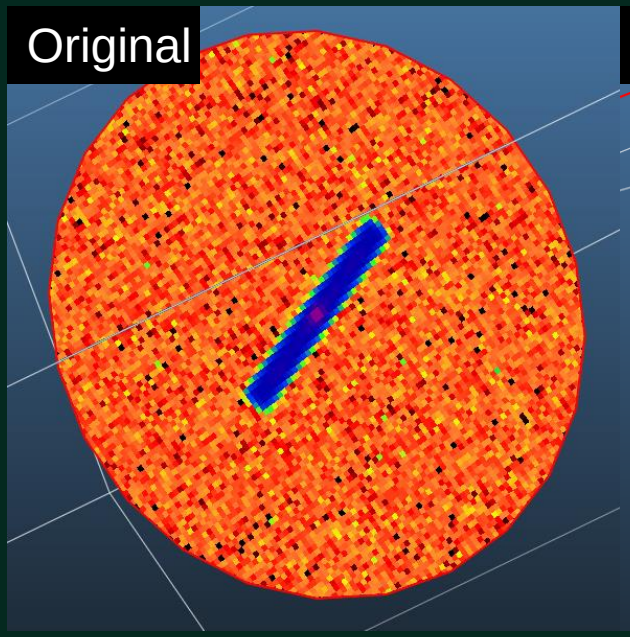
Catch with disc



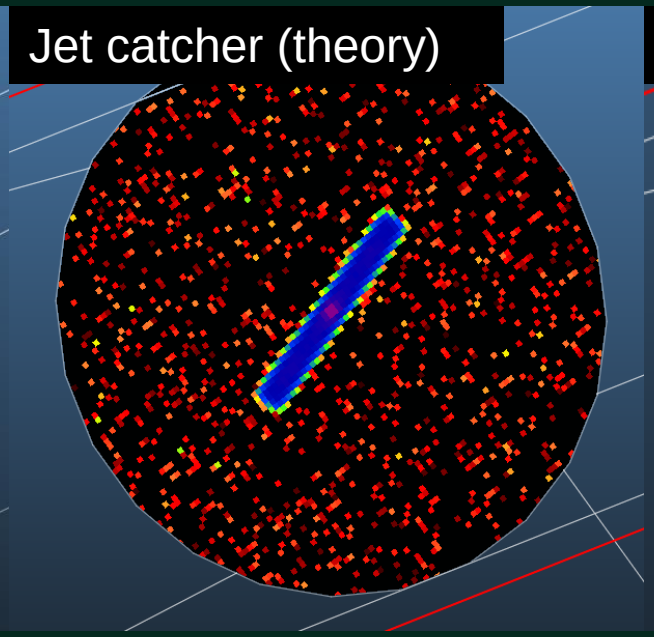
Catch with shaped disc



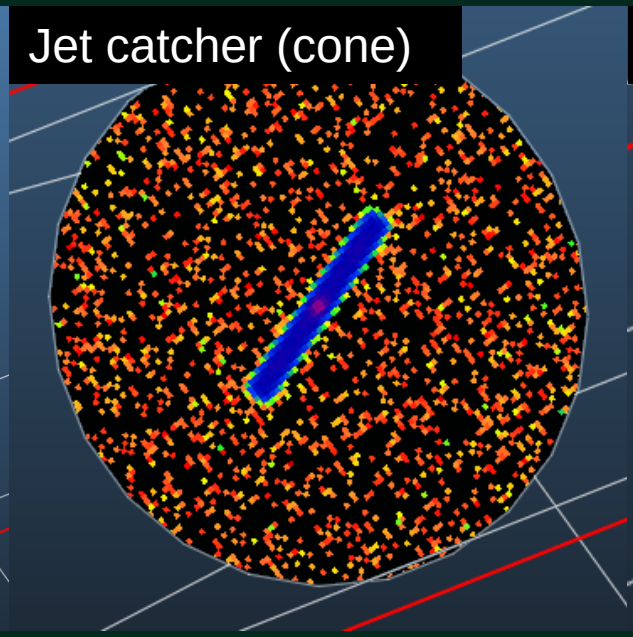




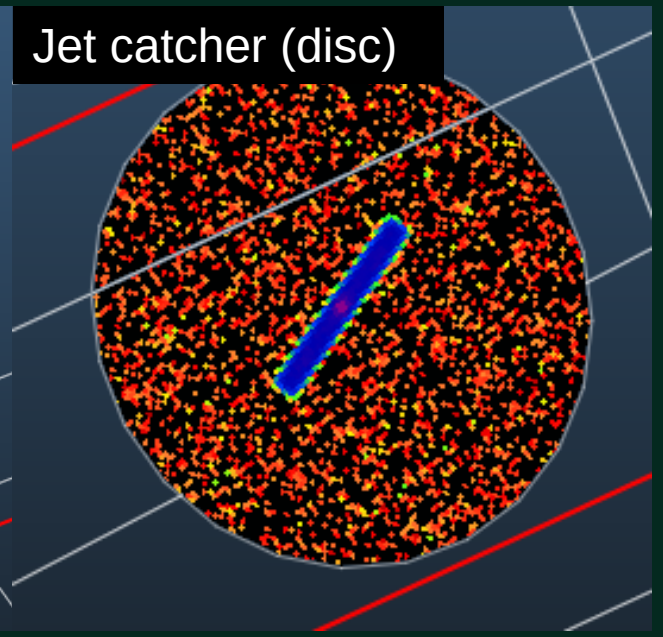
3.8E-3



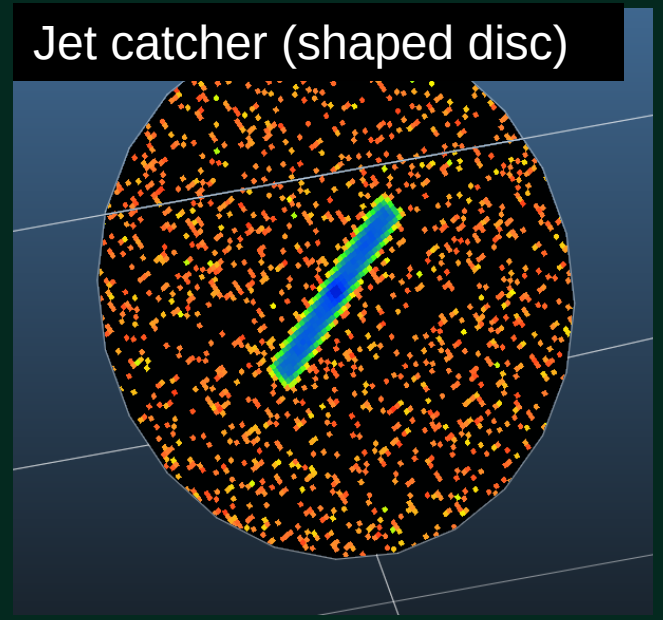
2.3E-4



1.1E-3



1.2E-3



6.3E-4

Conclusion

- A simplified geometry allows to quickly test different geometries (mechanical considerations aside)
- Skimmer shapes, extra skimmers and distances don’t change much
- Extra pumping always reduces background (P=Q/S)
- Jet backscattering is a significant background source
- It can be mitigated by a disc acting as a “particle trap”