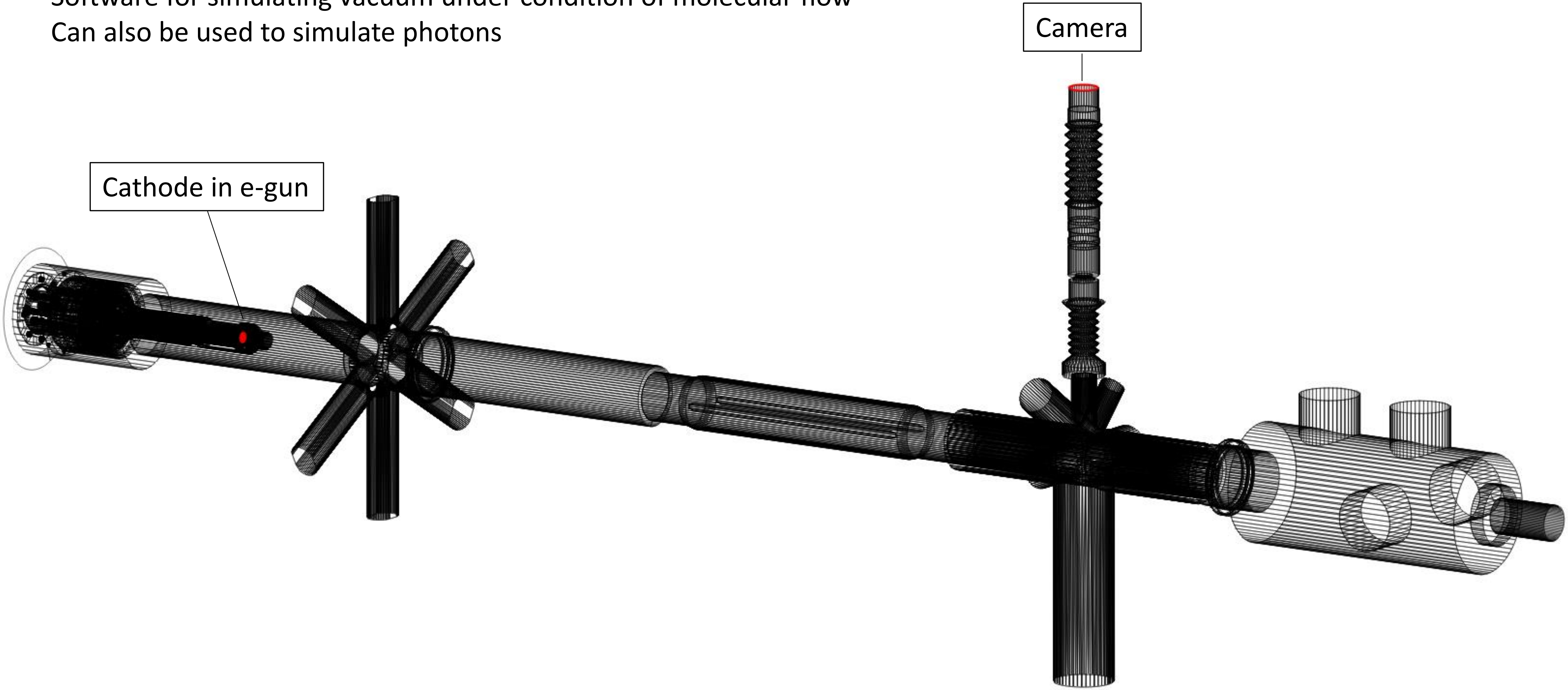
Illumination of test stand BGC camera due to cathode radiation

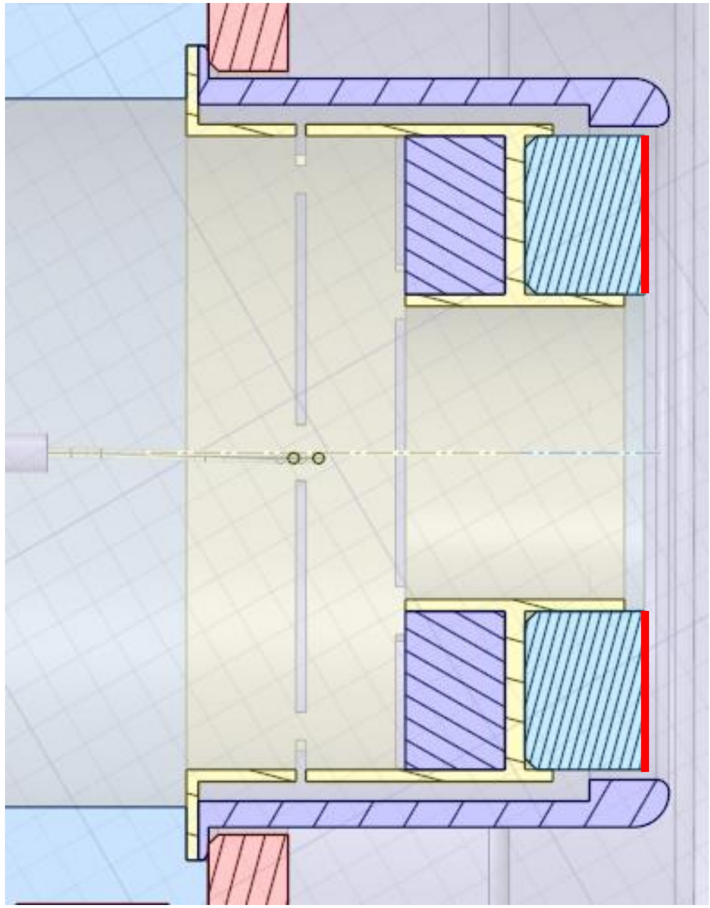
Noah Jens – 10.12.2020

HEL test stand model in MolFlow

Software for simulating vacuum under condition of molecular flow
Can also be used to simulate photons



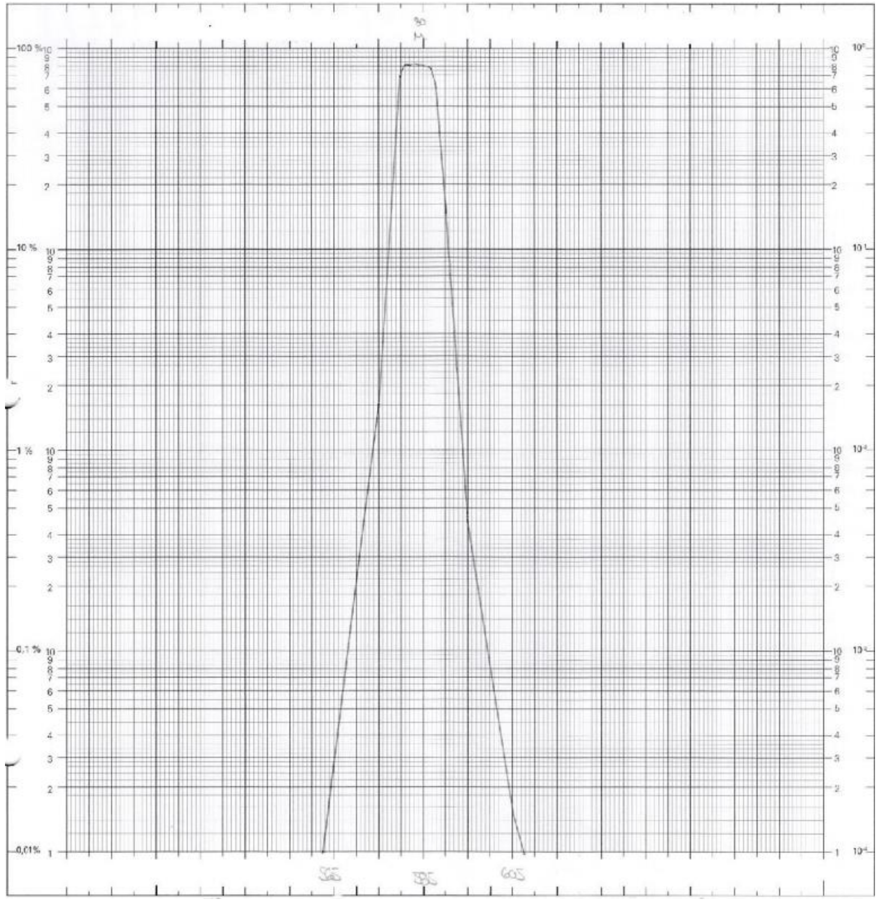
Cathode



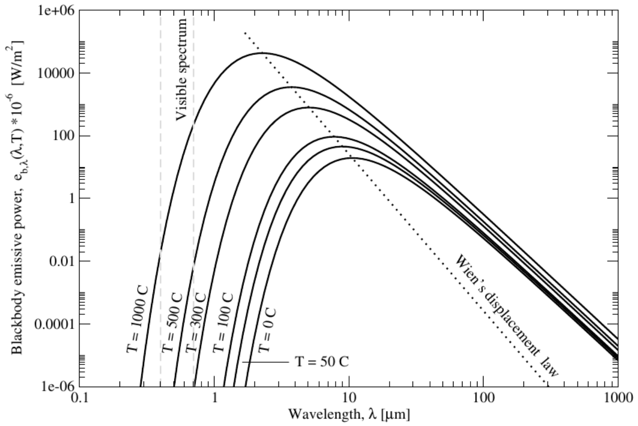
Radiating surface of the cathode

Emitted photon rate in camera filter bandwidth

Data sheet of filter (585nm ± 10nm):



Power of radiation:
(Planck's law)



$$\Delta P = \frac{2\pi h c^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda \mathrm{kT}}} - 1} A\, \varepsilon\, \Delta\lambda$$

Photon rate:

$$\frac{N}{t} = \frac{P}{E_{Ph}} = \frac{P\,\lambda}{\mathrm{h\,c}}$$

$$\frac{N}{t} \approx 1.3E13 \frac{1}{s}$$

N: Number of photons
E_Ph: Photon energy at 585nm

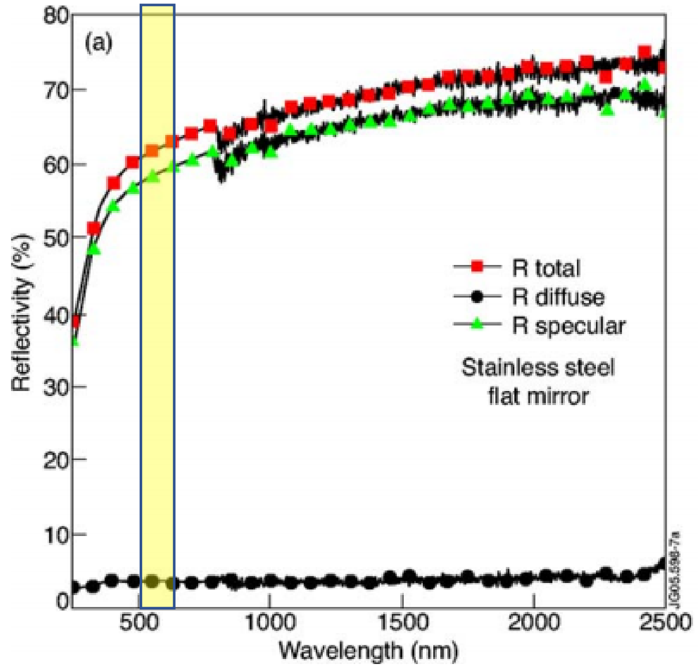
Reflective properties of stainless steel:

Reflectivity:

Wavelength, μm	Spectral reflectance											
	Aluminum	Copper	Gold	Molybdenum	Nickel	Platinum	Silver	Stainless steel 304	Tantalum	Tin	Titanium	Vanadium
0.330	0.808	0.206	0.309	0.416	0.340	0.541	0.274	0.453	0.386	0.569	0.135	0.397
.354	.823	.220	.312	.417	.355	.563	.623	.475	.406	.602	.145	.417
.377	.835	.229	.325	.420	.411	.581	.688	.500	.407	.648	.150	.427
.398	.840	.261	.337	.434	.435	.611	.748	.523	.420	.701	.167	.449
.415	.848	.290	.338	.450	.463	.626	.782	.536	.410	.716	.168	.455
.430	.851	.317	.336	.466	.476	.636	.803	.546	.410	.749	.177	.464
.444	.855	.334	.340	.480	.498	.645	.835	.563	.408	.761	.186	.462
.457	.864	.348	.338	.488	.508	.651	.831	.568	.403	.783	.192	.468
.470	.863	.383	.344	.500	.520	.663	.843	.583	.407	.791	.199	.475
.483	.869	.396	.353	.507	.530	.667	.856	.583	.398	.809	.208	.474
.497	.863	.410	.447	.506	.539	.688	.883	.586	.403	.812	.212	.473
.511	.865	.448	.585	.510	.554	.711	.893	.594	.397	.817	.218	.472
.525	.865	.455	.680	.505	.556	.710	.903	.598	.386	.821	.214	.468
.540	.863	.463	.749	.511	.566	.724	.888	.602	.387	.818	.213	.472
.554	.870	.494	.794	.506	.571	.720	.913	.616	.387	.824	.236	.470
.569	.871	.580	.824	.507	.583	.719	.906	.616	.384	.843	.240	.476
.584	.871	.701	.852	.508	.591	.720	.936	.625	.384	.832	.244	.477
.599	.877	.757	.873	.504	.601	.730	[a].934	.627	.391	.830	.246	.471

https://strives-uploads-prod.s3.us-gov-west-1.amazonaws.com/19690022517/19690022517.pdf?AWSAccessKeyId=AKIASEVSKC45ZTTM42XZ&Expires=1603800472&Signature=aYPAkxUhCaC%2B3ZWCz0kN79sz7Sw%3D

Diffuse and specular reflection:



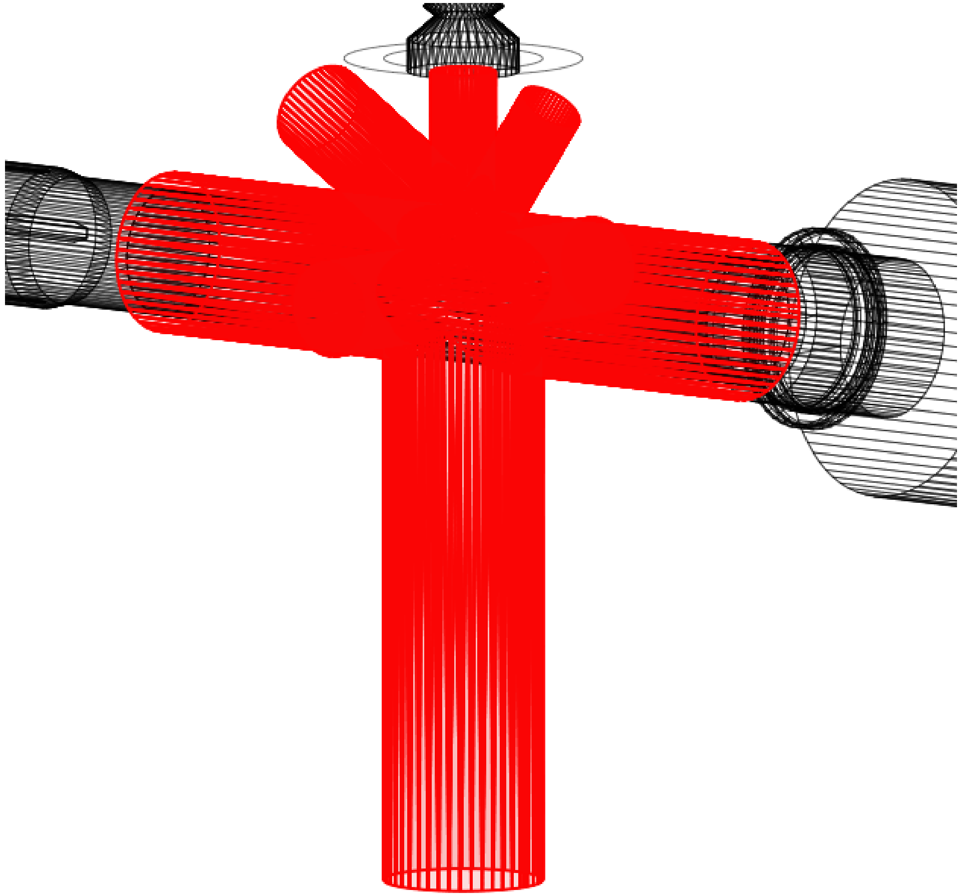
https://www.researchgate.net/publication/37459596_Mirror_test_for_International_Thermonuclear_Experimental_Reactor_at_the_JET_tokamak_An_overview_of_the_program

R=0.625 with **92.8% specular**- and **7.2% diffuse** reflection

All other materials were estimated with 80% specular- and 20% diffuse reflection

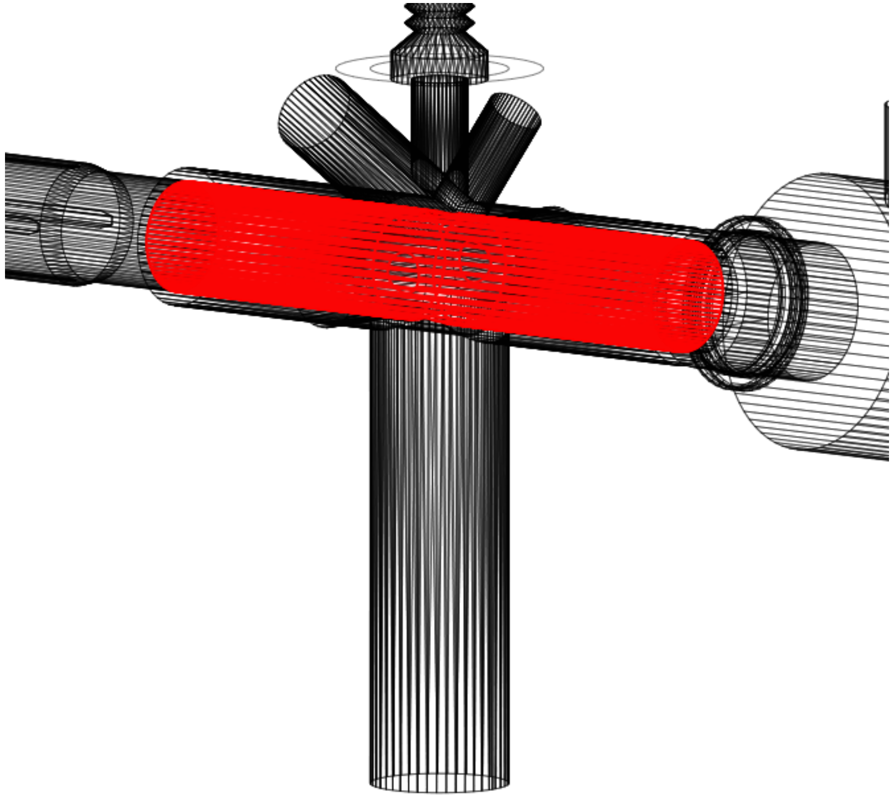
Reflective properties BGC chamber and liner

AC-coating:
R=0.135



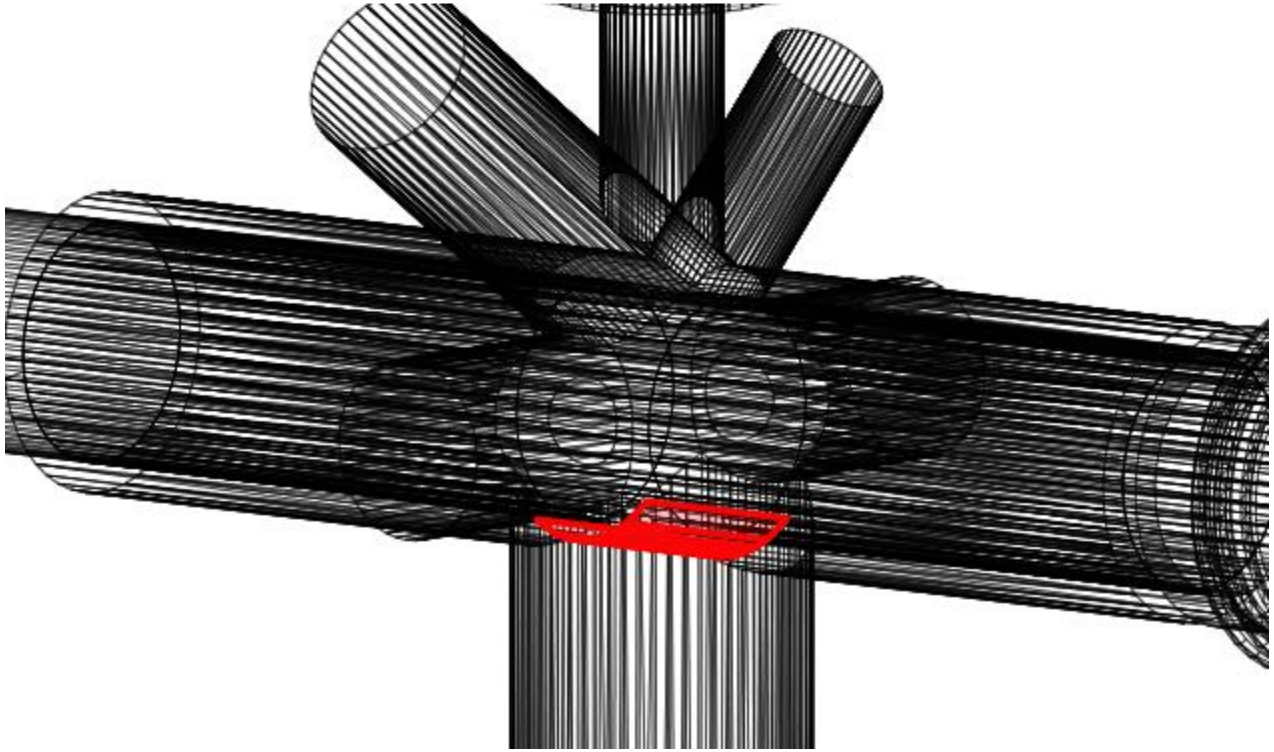
AC-coating inside:
R=0.135

Copper outside:
R=0.61

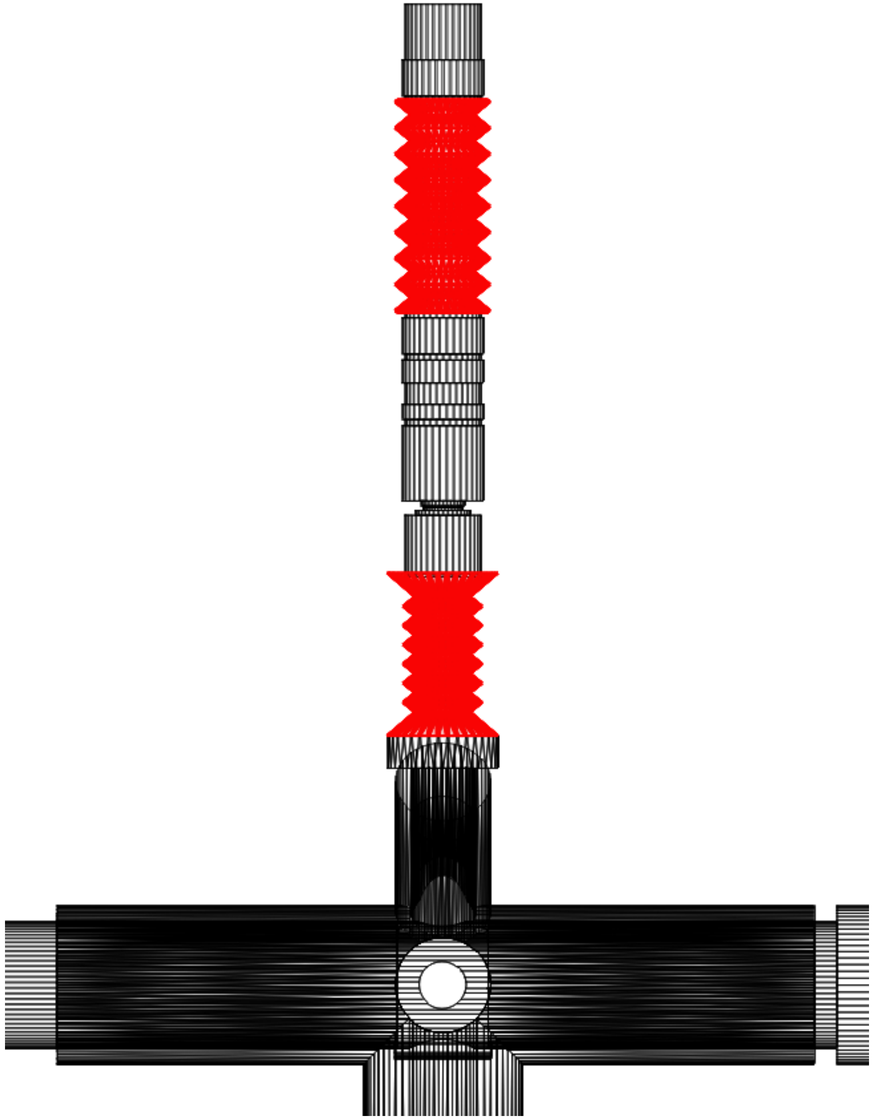


Reflective properties shield, opposing camera

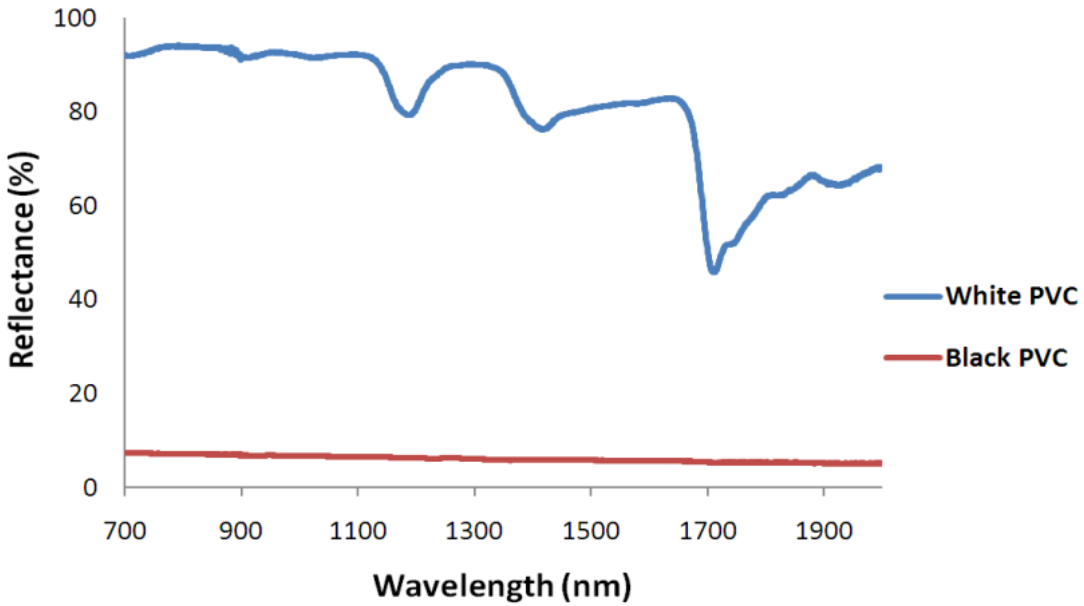
AC-coating:
R=0.002



Reflective properties PVC bellows

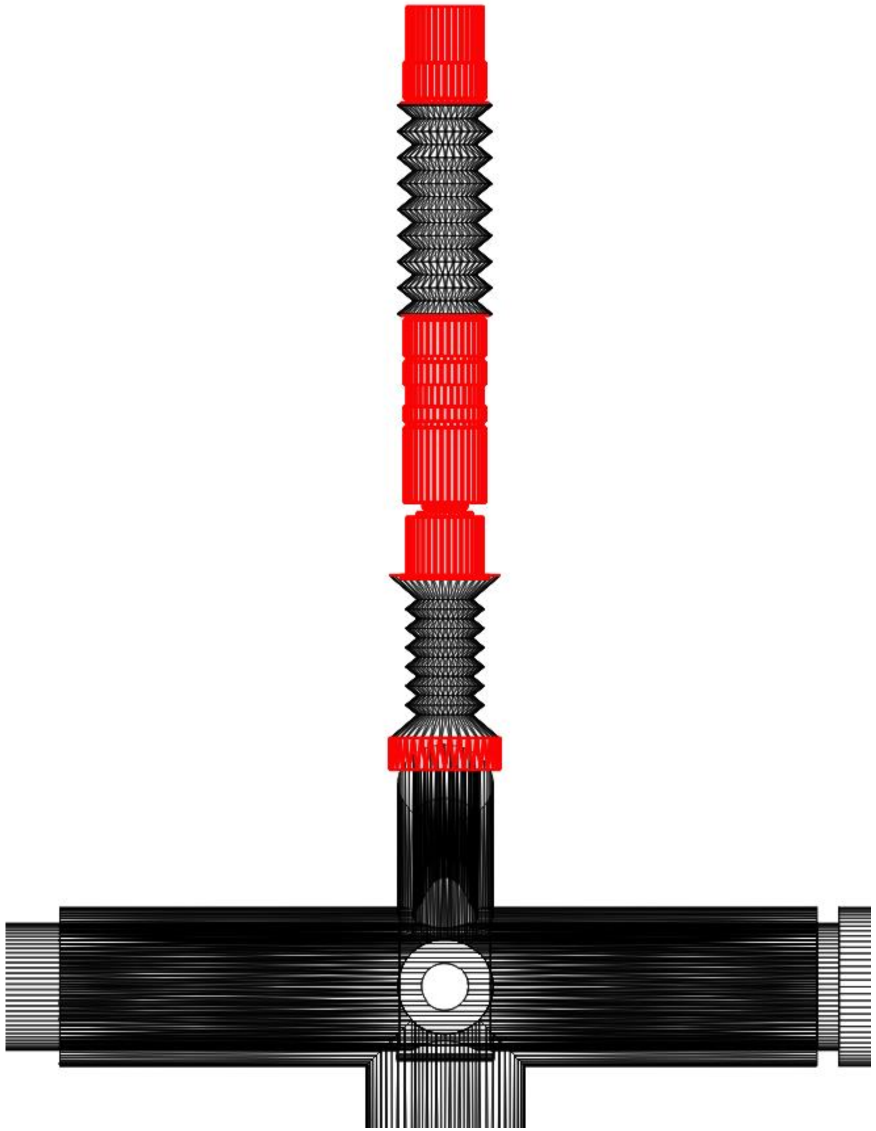


Bellows (Black PVC):
R=0.1

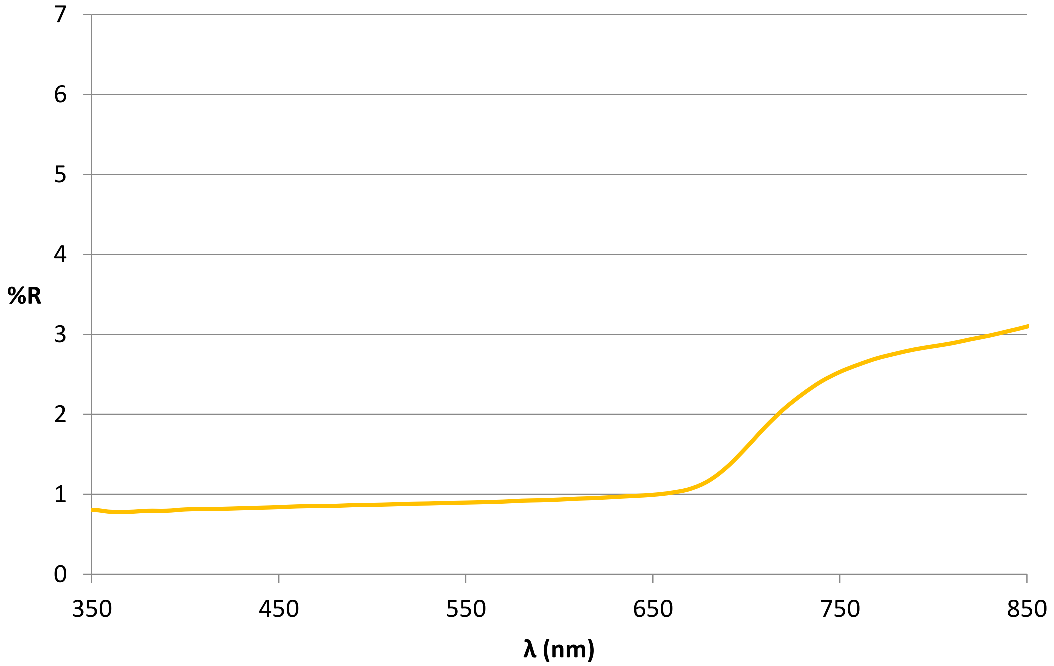


www.researchgate.net/figure/The-NIR-reflectance-spectrum-of-Black-and-white-PVC_fig3_285330830

Reflective properties lens tubes



Lens tubes (Black anodized Aluminum):
R=0.01

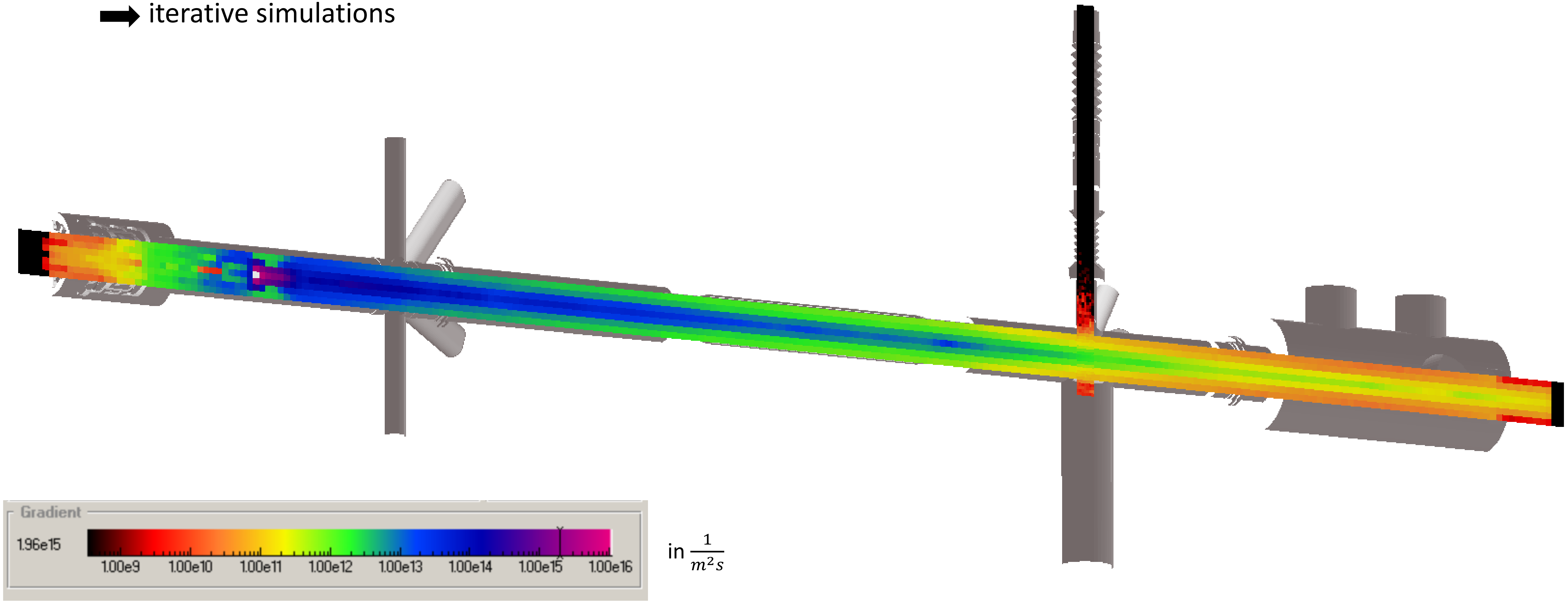


Impingement rate

Cutoff at intersection between liner and camera arm

Difference in impingement rate between cathode and camera facet ≈12 orders of magnitude

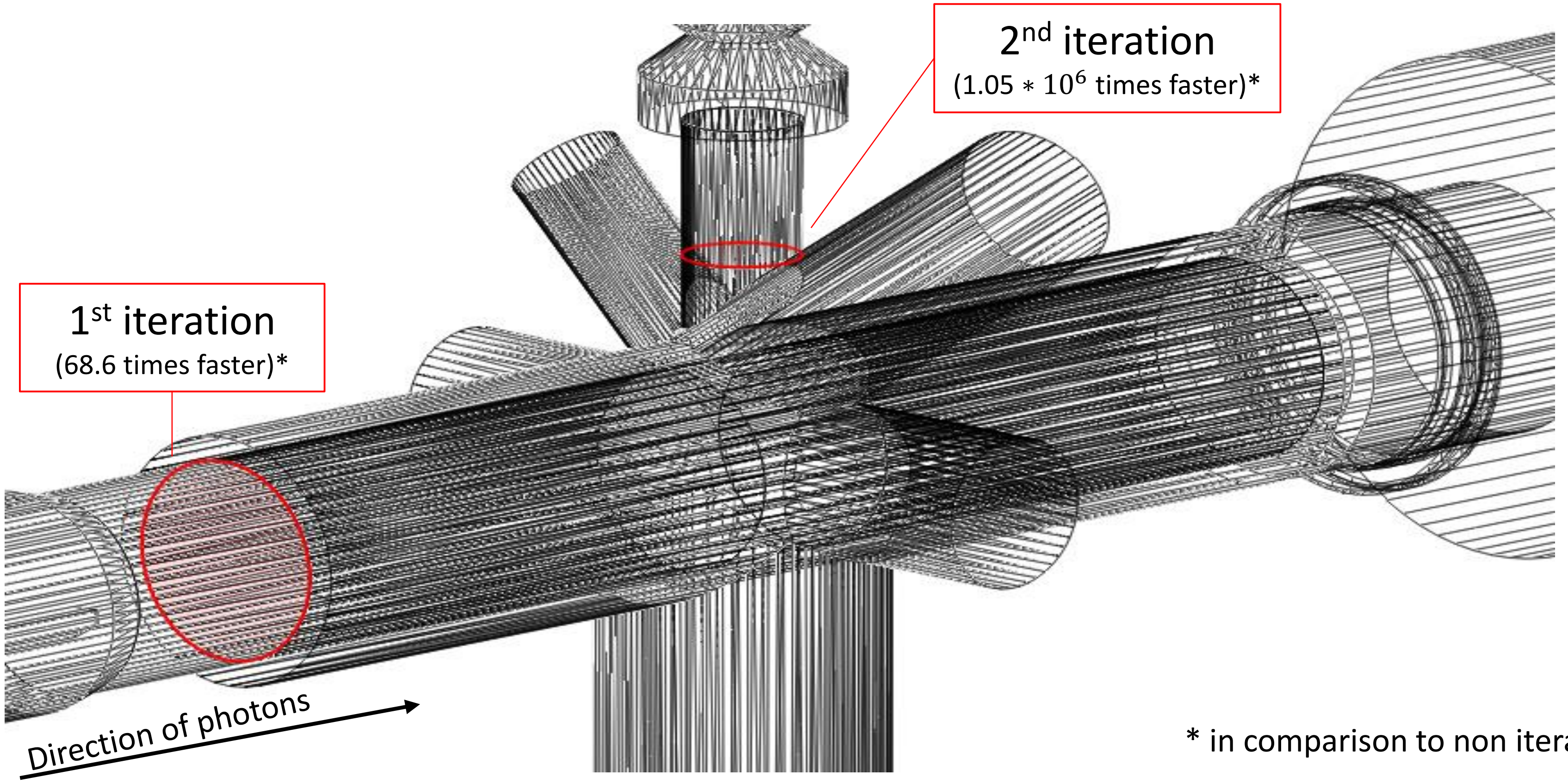
➡ iterative simulations



Iterative simulations

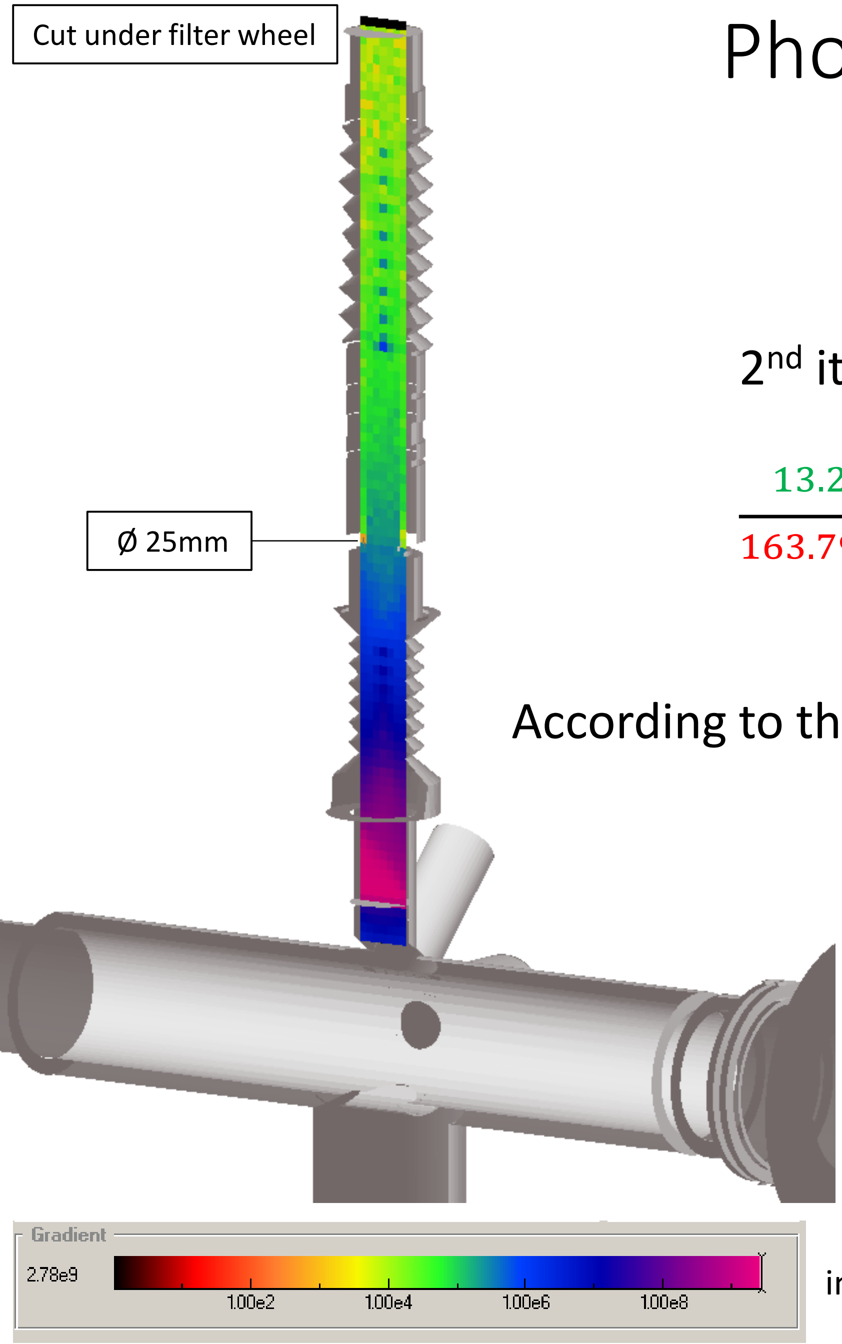
Cut the geometry and simulate a smaller part to gather more data on areas with low impingement rate

- Recording angle map which stores information about the incident angle of incoming photons
- Calculating desorption rate for iterative simulation
- Desorbing from new facet according to angle map and scaled desorption rate



* in comparison to non iterative simulation

Photons hitting the camera facet



in $\frac{1}{m^2 s}$

2nd iteration:

$$\frac{13.2\frac{Mdes}{s}}{163.79\ Mdes} * 22121 \approx \mathbf{1783}\,\frac{\mathbf{1}}{\boldsymbol{s}}$$

Desorption rate
Number of desorptions
Hits on camera facet

According to the simulations the camera will be exposed to about 1783 photons per second