

# Studies of the Calibration Light Source for nEXO's Outer Detector

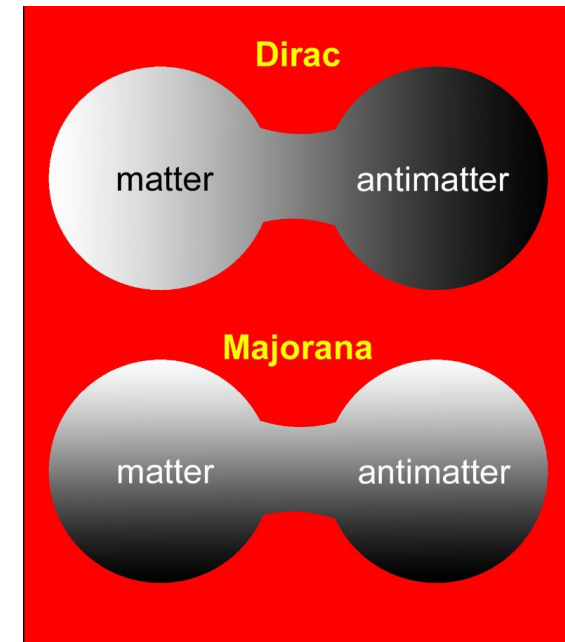
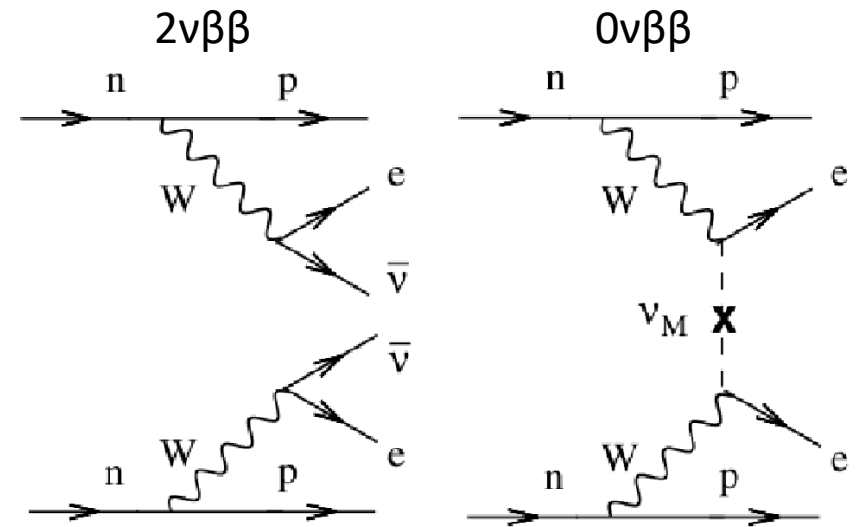
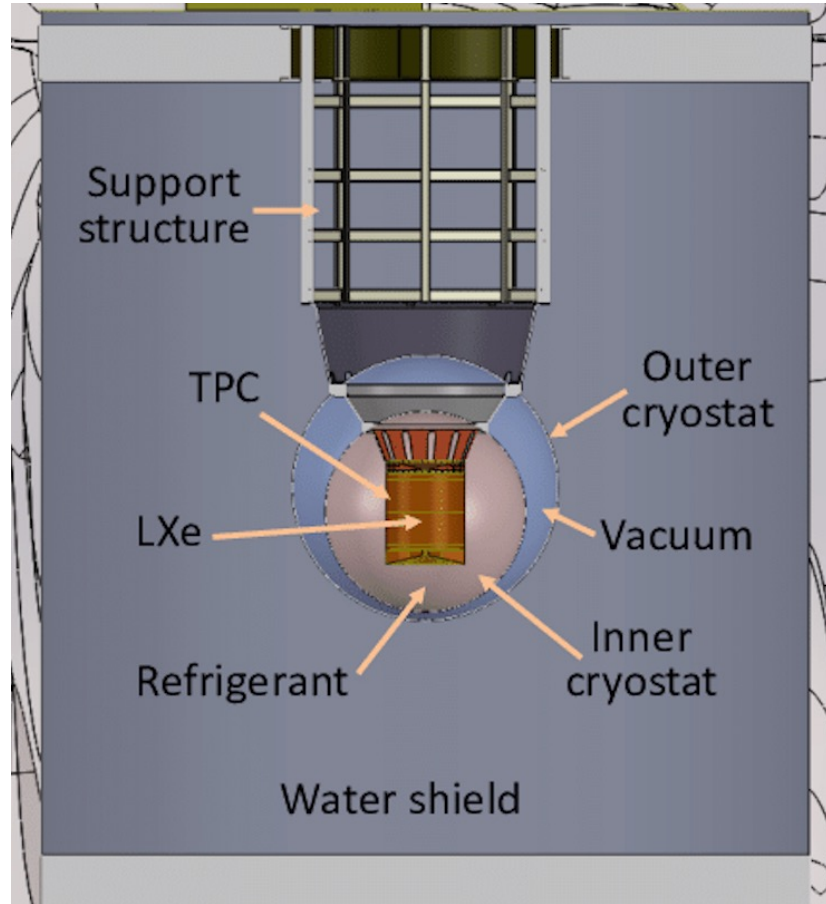
Irina Nitu

Supervised by Professor Thomas Brunner and Samin Majidi

CASST 2024



# nEXO Experiment

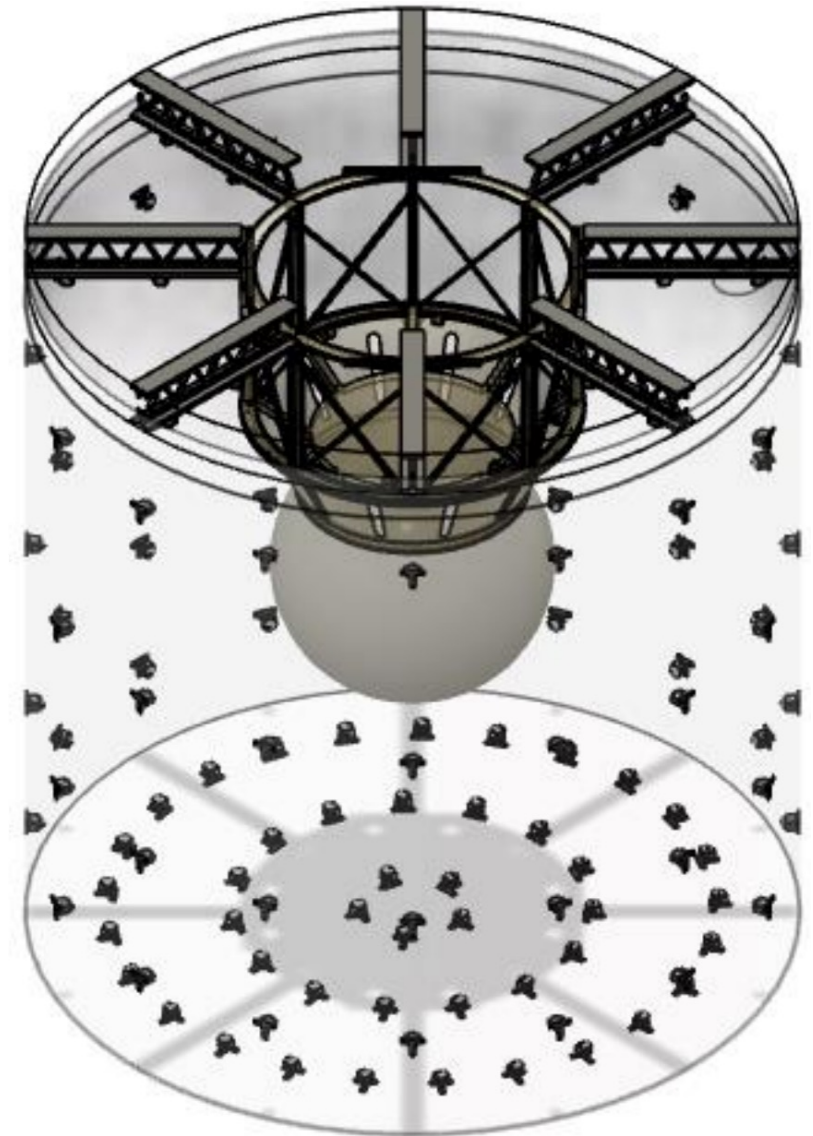


# nEXO Outer Detector

- 12.8 m x 12.3 m tank of ultrapure water
- Neutron moderation
- Shielding from gamma radiation
- Muon veto



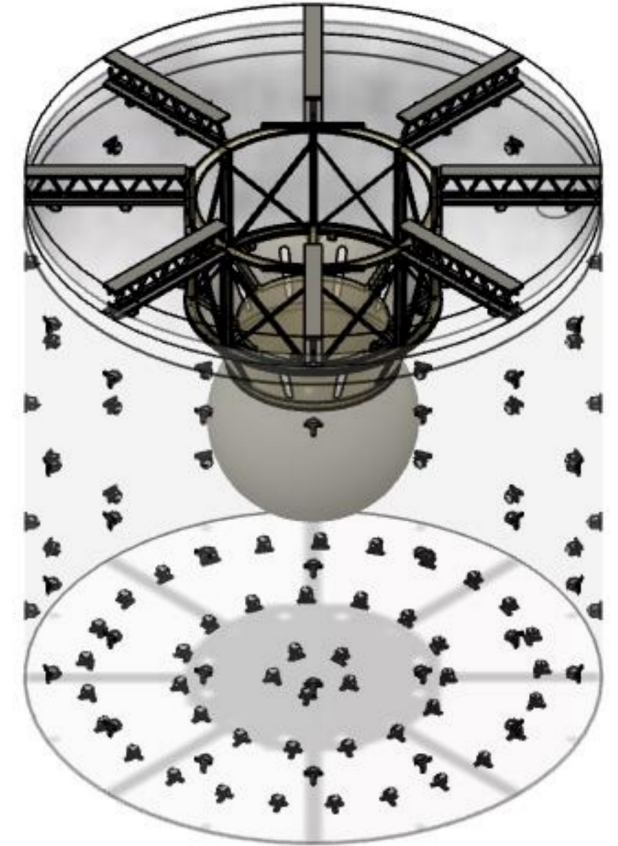
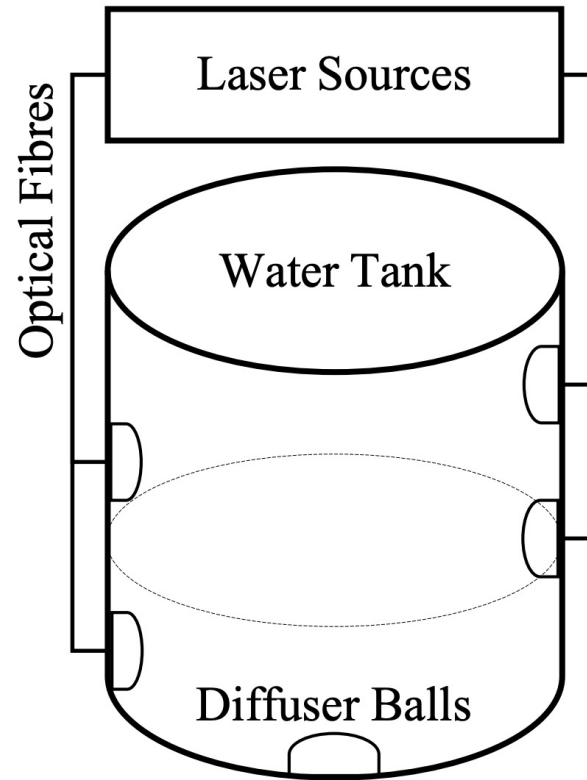
PMT assembly  
(nEXO Pre-  
Conceptual Design  
Report)



Fusion360 model of nEXO outer detector  
(Samin Majidi)

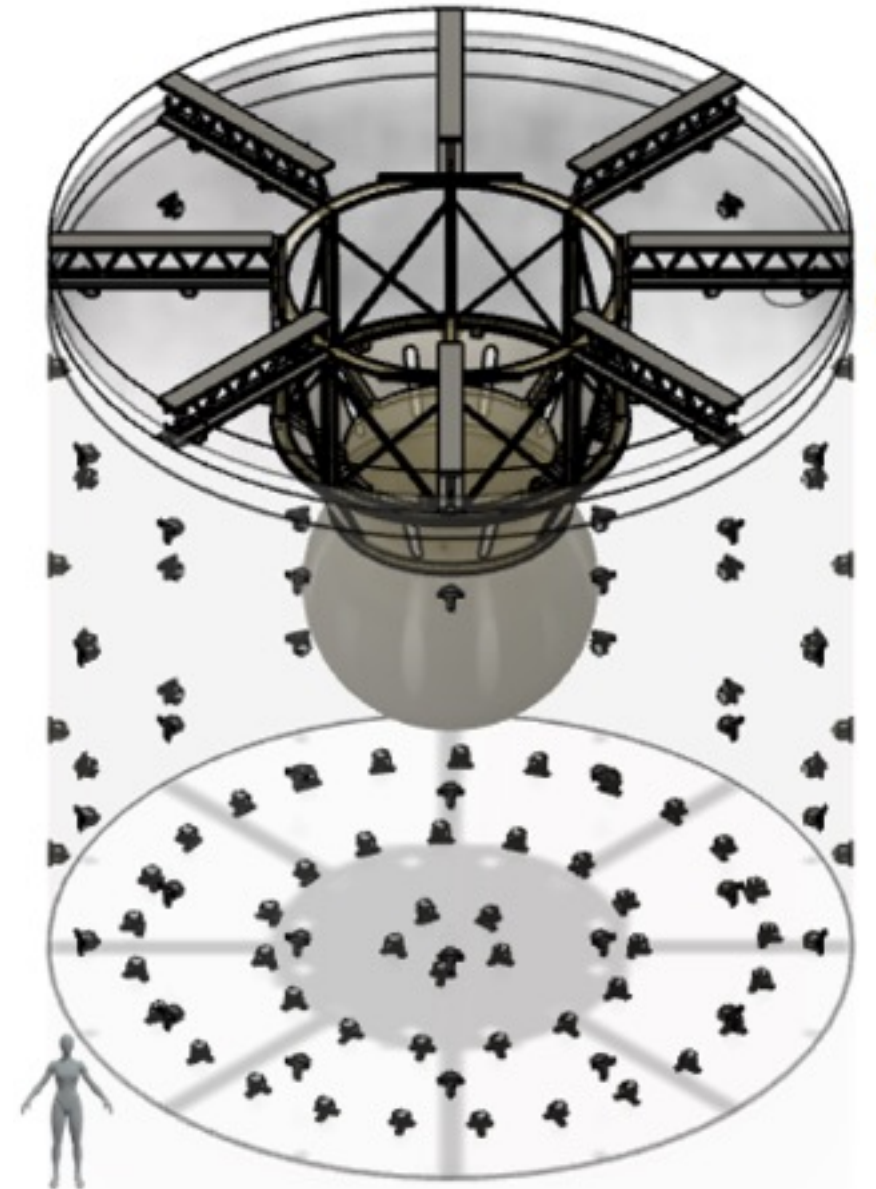
# nEXO Outer Detector Calibration

- Ensure proper PMTs function over time
- Monitor water properties



# Calibration Configuration

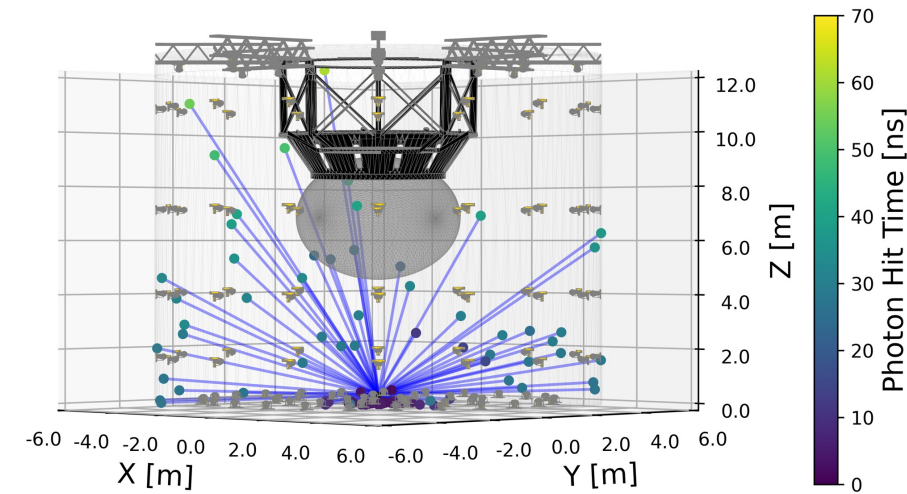
- 4-5 diffuser balls
- Intensity of 2 million photons
- Wavelength of 390 nm
- Each PMT must receive at least 10 photons for calibration



Outer Detector Model  
(Samin Majidi)

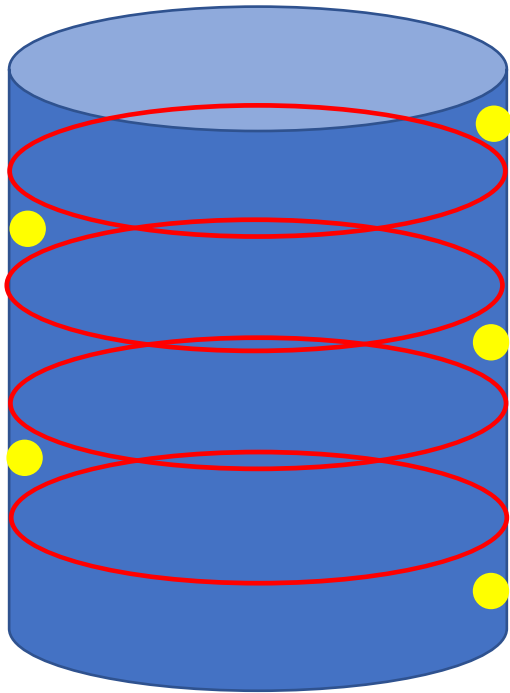
# Chroma

- GPU-based Monte Carlo ray-tracing package
- Specify component materials and material's optical properties
- Photon bomb light generator

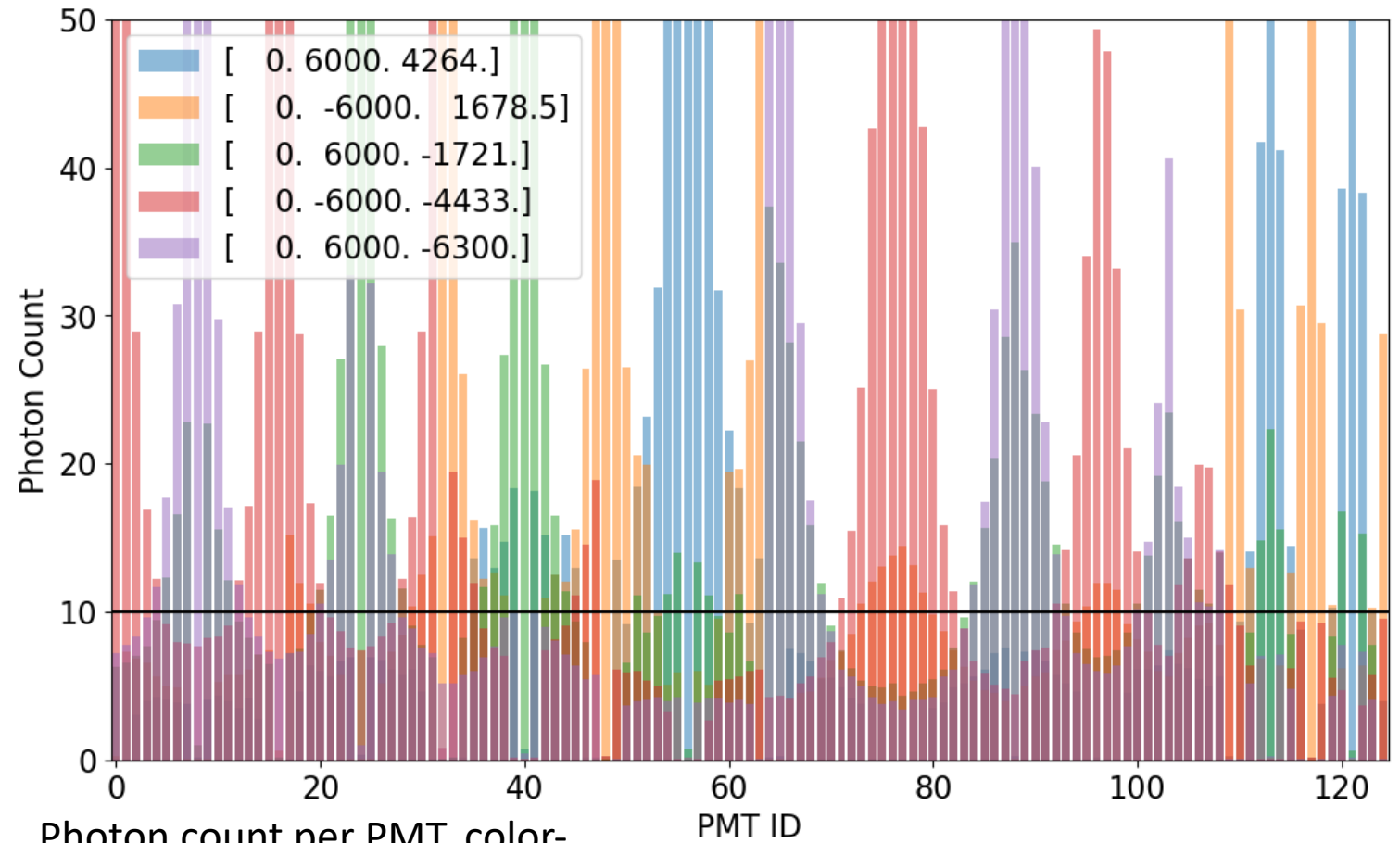


Chroma outer detector light simulation  
(Samin Majidi)

# Light Distribution

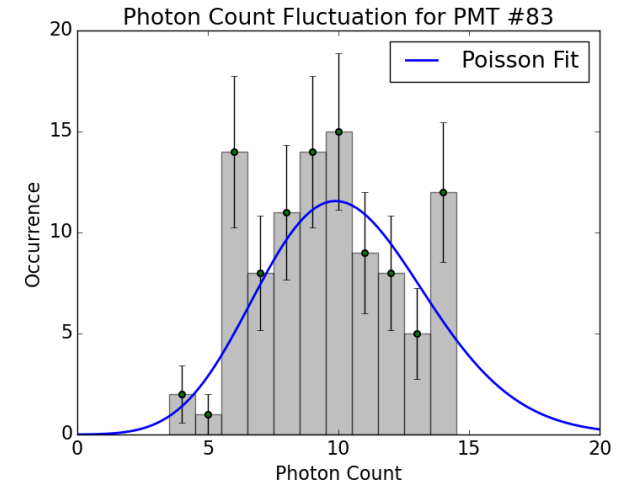
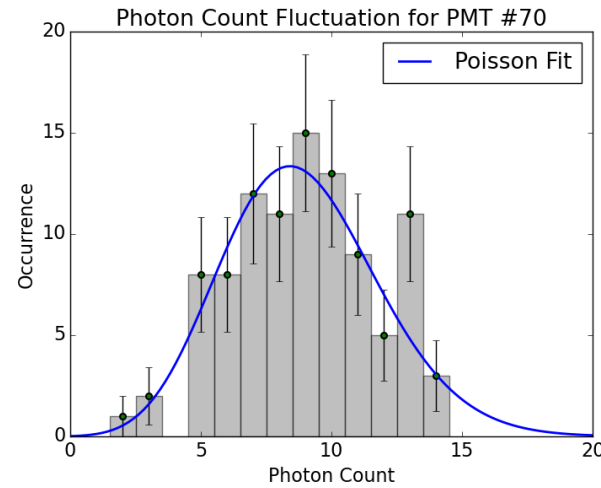
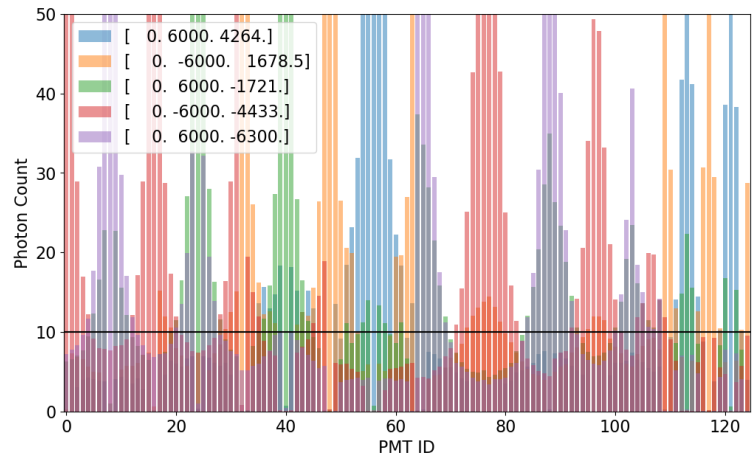


Outer detector diagram



Photon count per PMT, color-coded by source

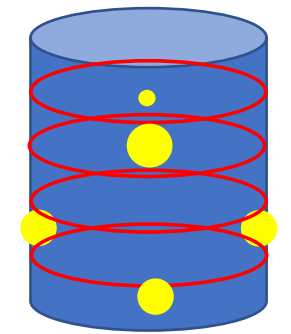
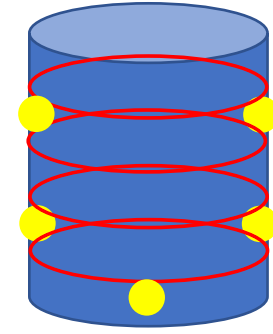
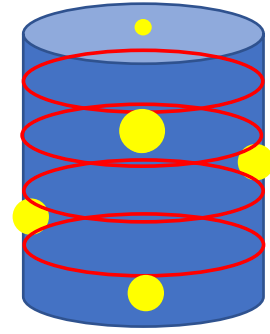
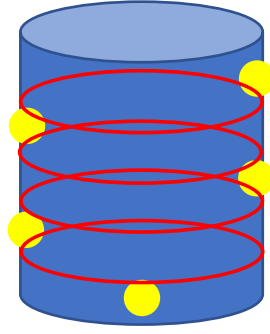
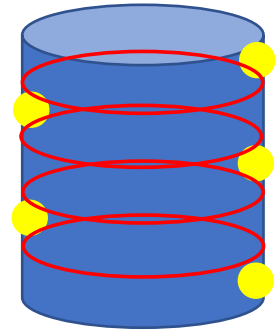
# Photon Count Fluctuations



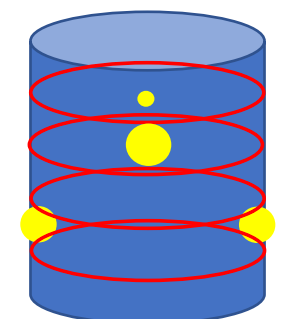
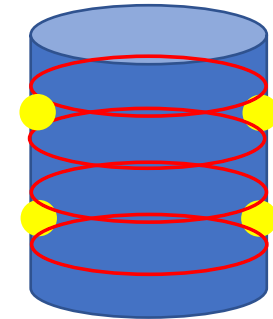
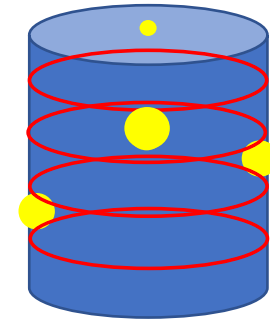
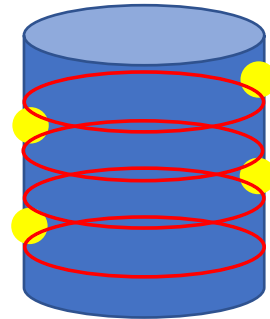
	PMT #70 Photon Count	PMT #83 Photon Count
$\mu$	$8.73 \pm 0.38$	$9.75 \pm 0.35$



# Diffuser Ball Configurations Analysis



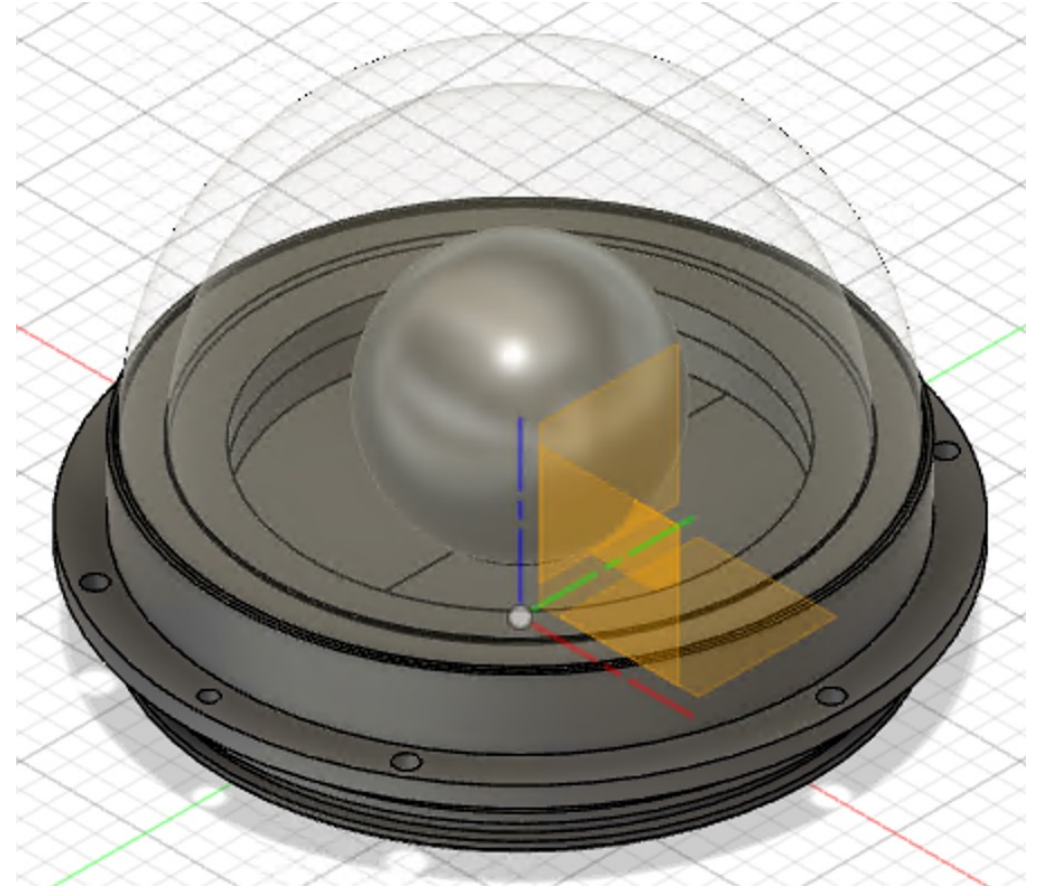
Configuration ID	5.0	5.1	5.2	5.3	5.4
Uncalibrated PMT IDs	#70 ( $8.91 \pm 0.38$ )	-	-	-	-



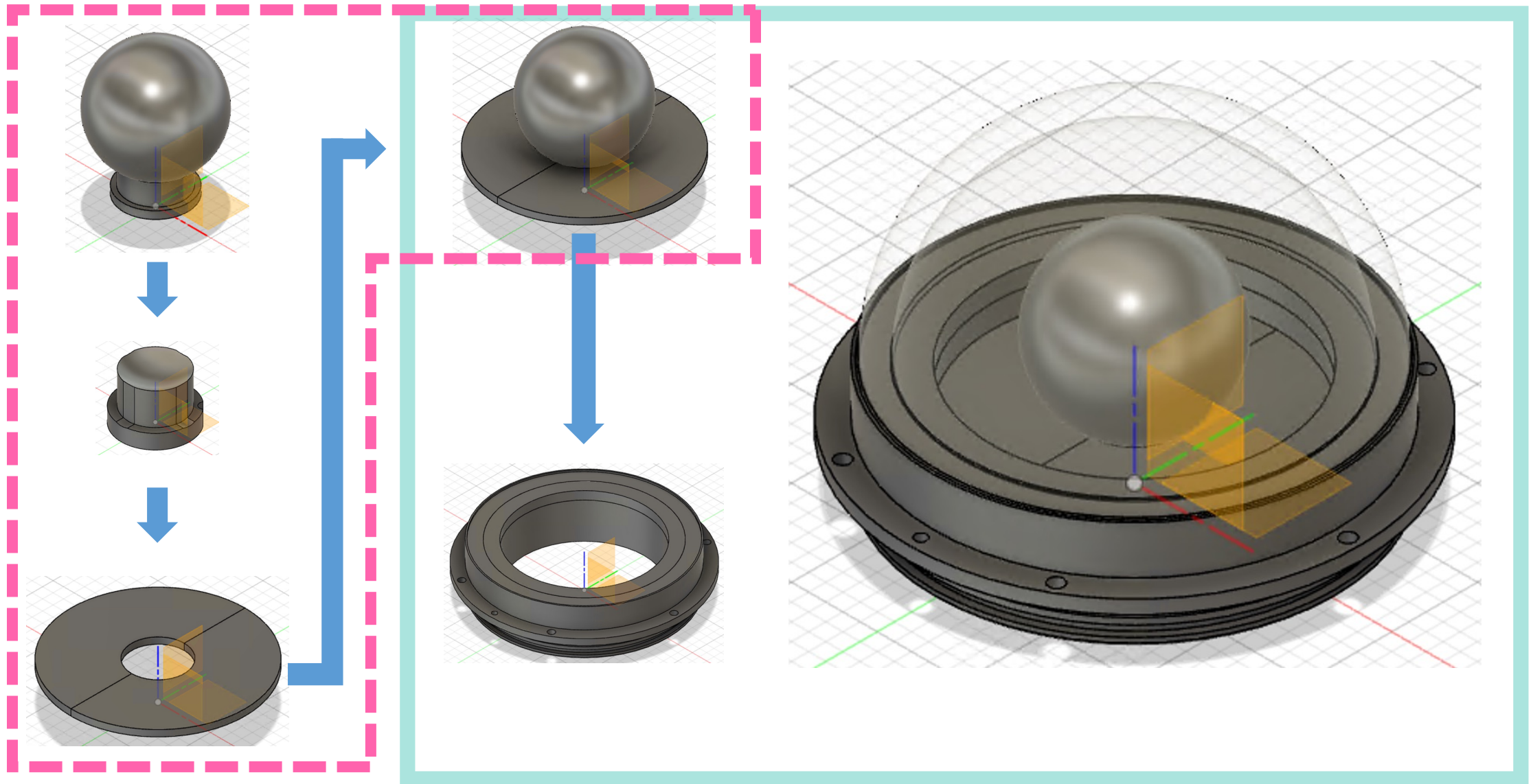
Configuration ID	4.1	4.2	4.3	4.4
Uncalibrated PMT IDs	#8 ( $7.61 \pm 0.33$ ) #70 ( $8.91 \pm 0.38$ ) #83 ( $10.39 \pm 0.43$ )	#8 ( $7.61 \pm 0.33$ ) #70 ( $8.91 \pm 0.38$ )	#70 ( $9.76 \pm 0.33$ ) #83 ( $9.33 \pm 0.33$ )	-

# Diffuser Ball Isotropy

- Goal: verify the isotropy of the device
- Put together light simulations
  - Model device geometry
  - Input in Chroma

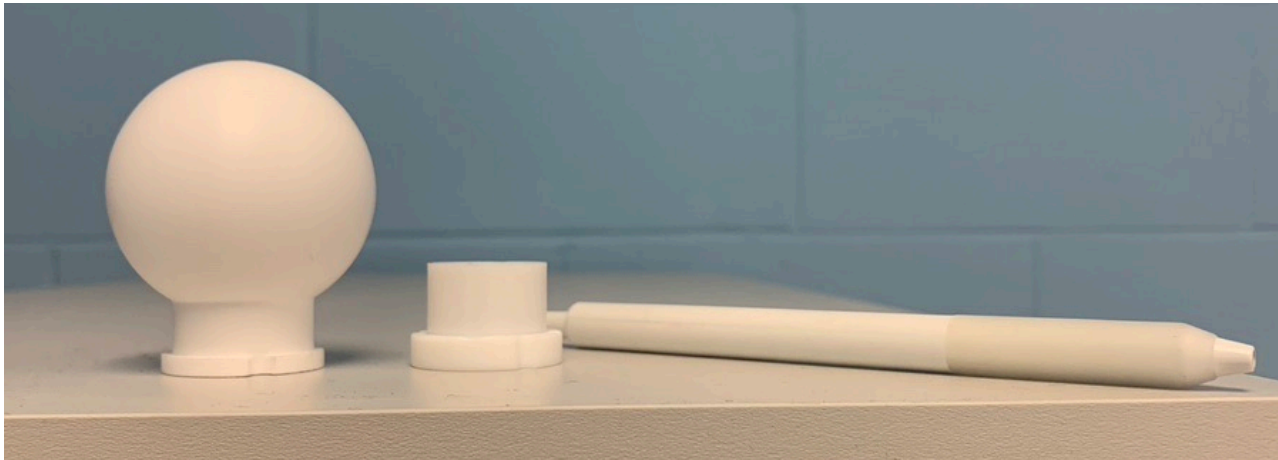


# Diffuser Ball Design

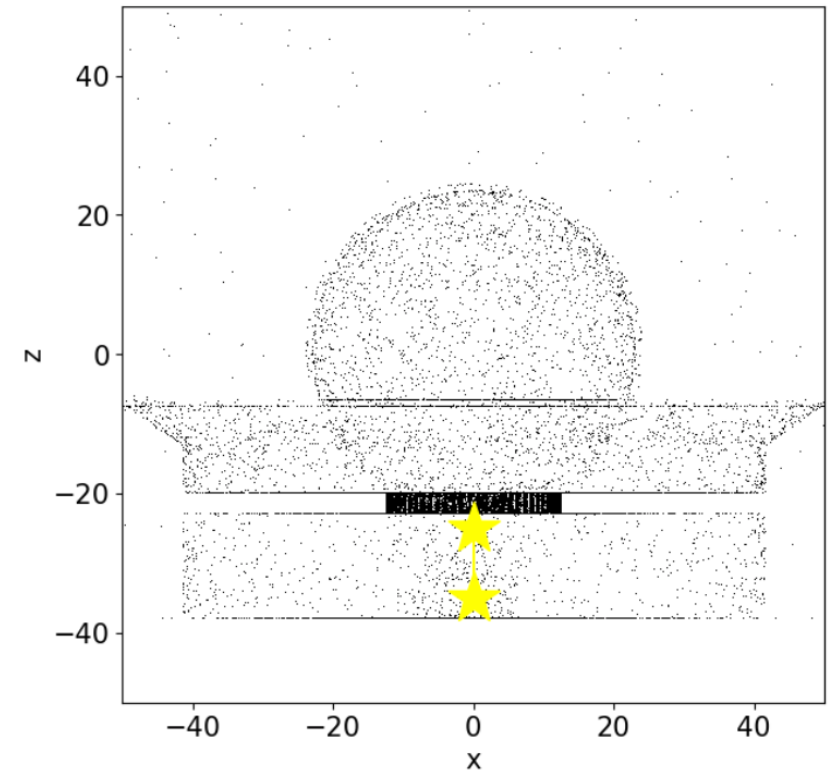


# Diffuser Ball Chroma Simulation

- Specify component materials and material optical properties
- Laser beam light generator



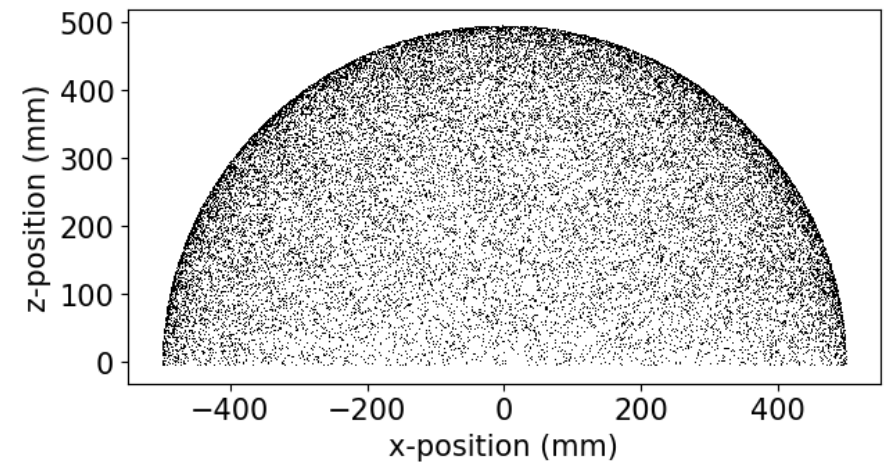
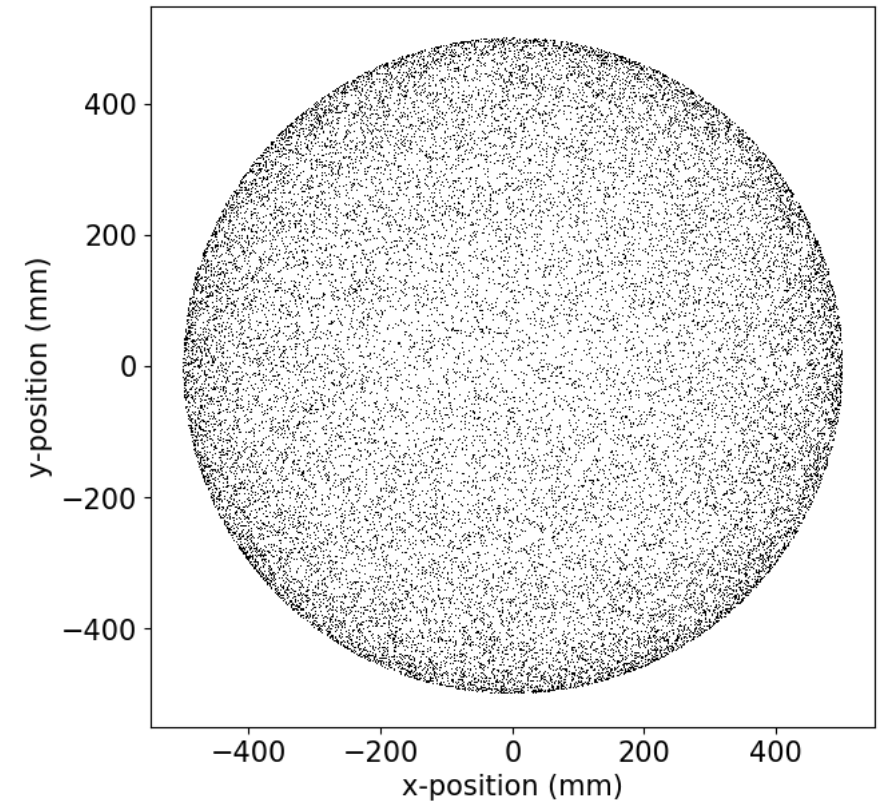
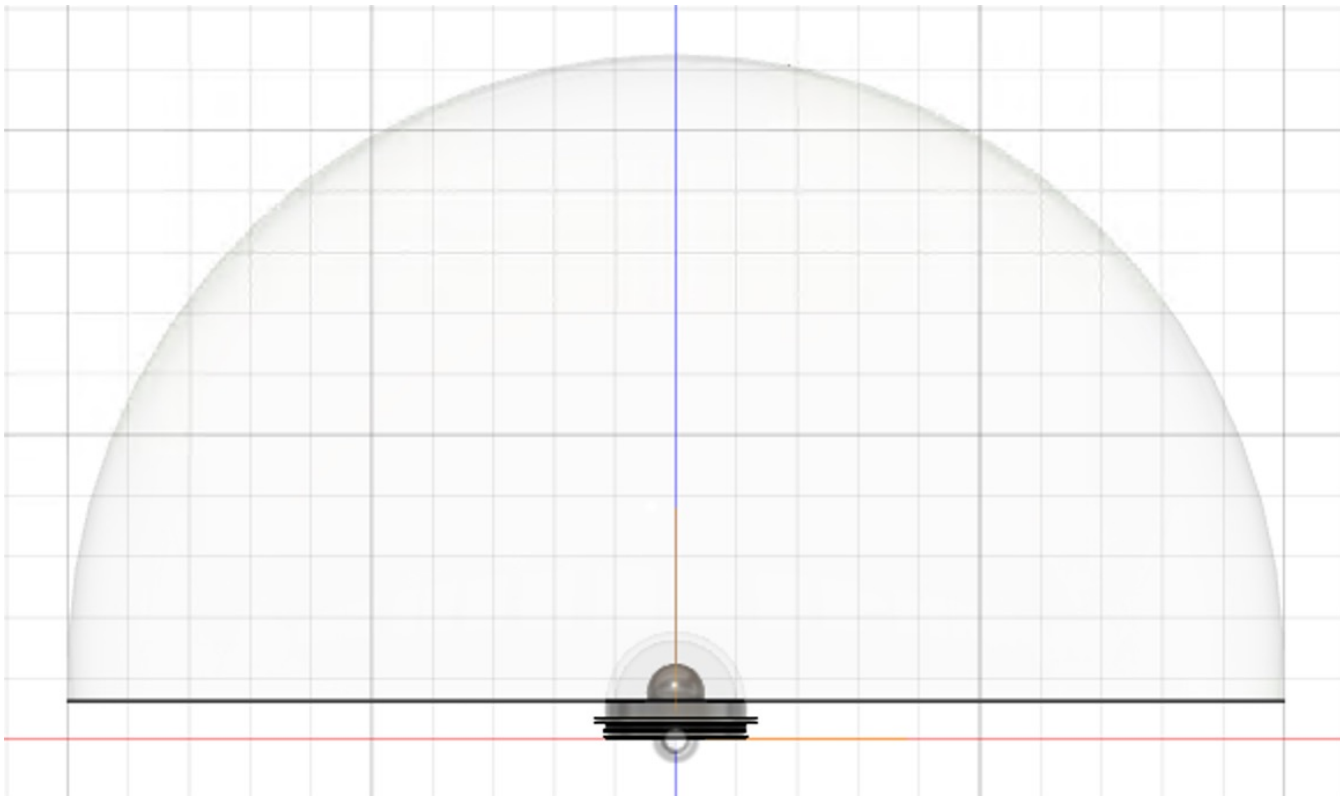
Integrating Sphere and Plug



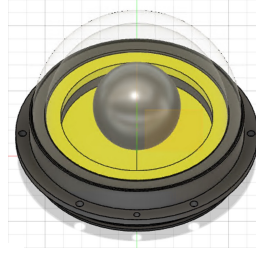
Simulated light source placement

# Simulation Geometry

- Detecting surface: hemisphere shell



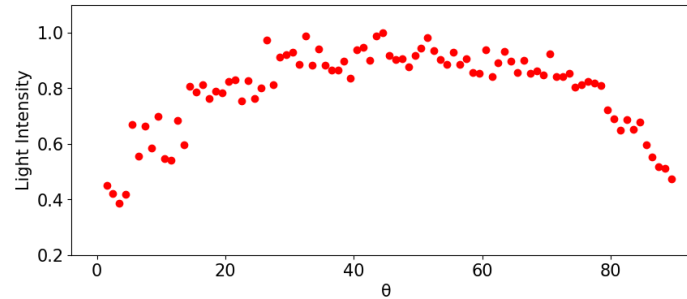
# Isotropy Analysis



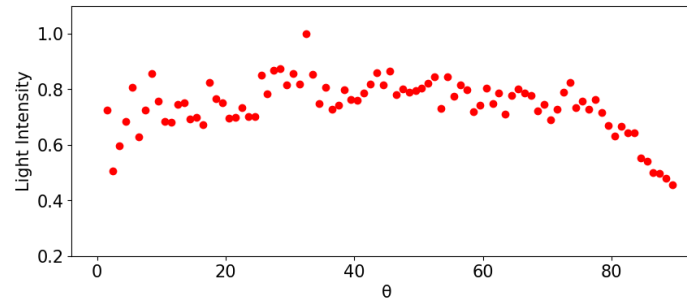
Light intensity maps

Light intensity per solid angle as a function zenith angle

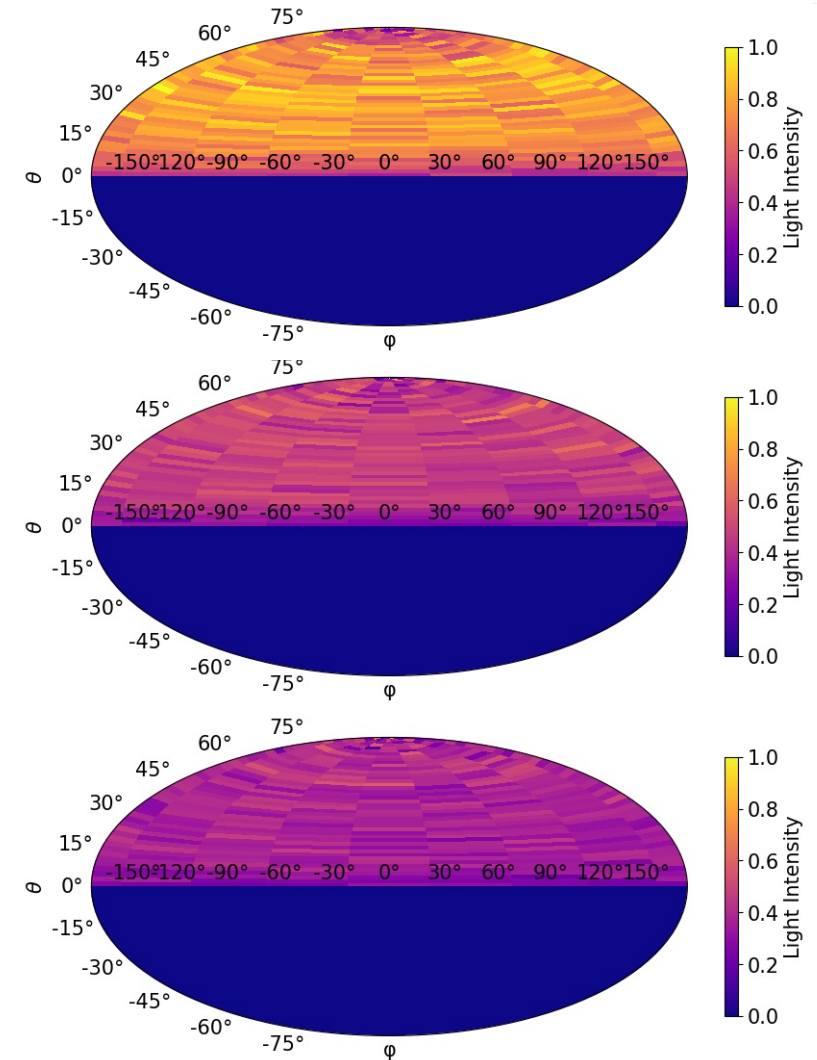
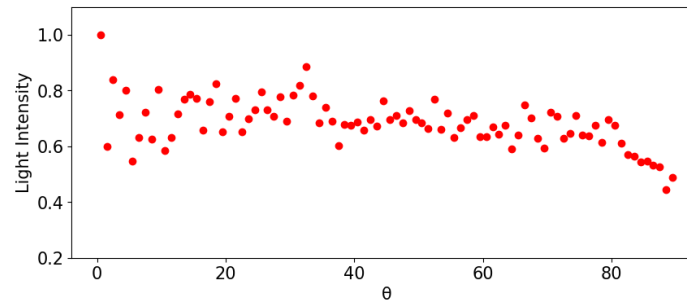
80% reflectivity



50% reflectivity

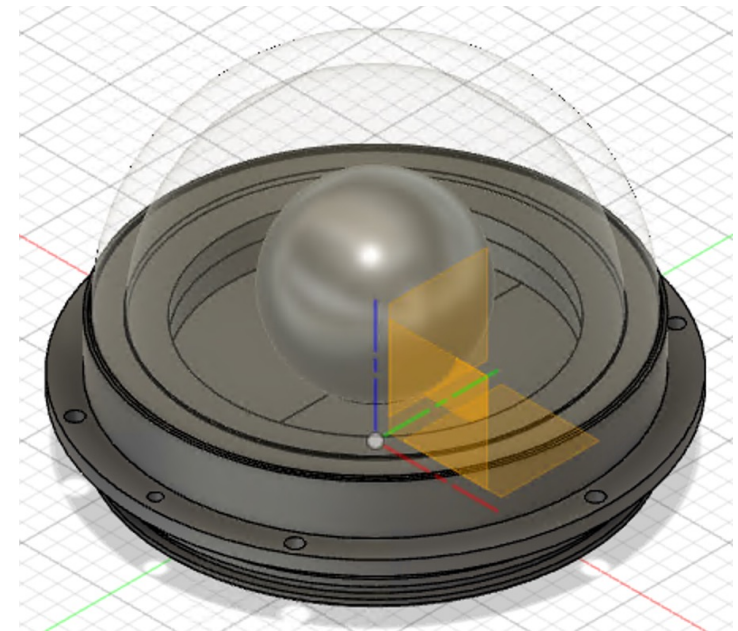
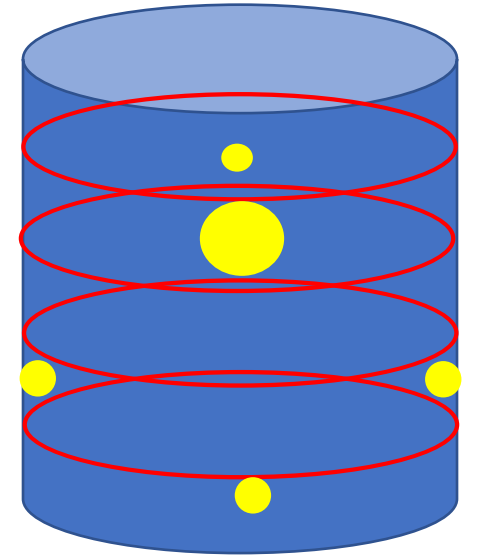
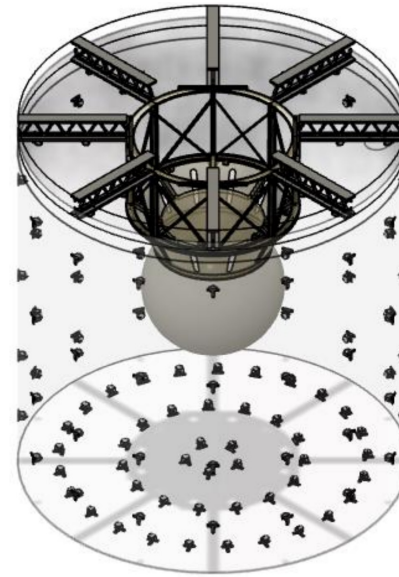


0% reflectivity



# Conclusion

- Future work on diffuser ball configuration will involve analyzing robustness of selected configuration
- Reflectivity of inner metal diffuser ball components has significant impact on the isotropy of the diffuser ball
- Absorptive coating is required to ensure device isotropy
- Further diffuser ball simulations can be used to quantify attenuation through device for estimates of light intensity requirements



# Thank you!

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