mPMT Model Optimization for Water Čerenkov Detectors

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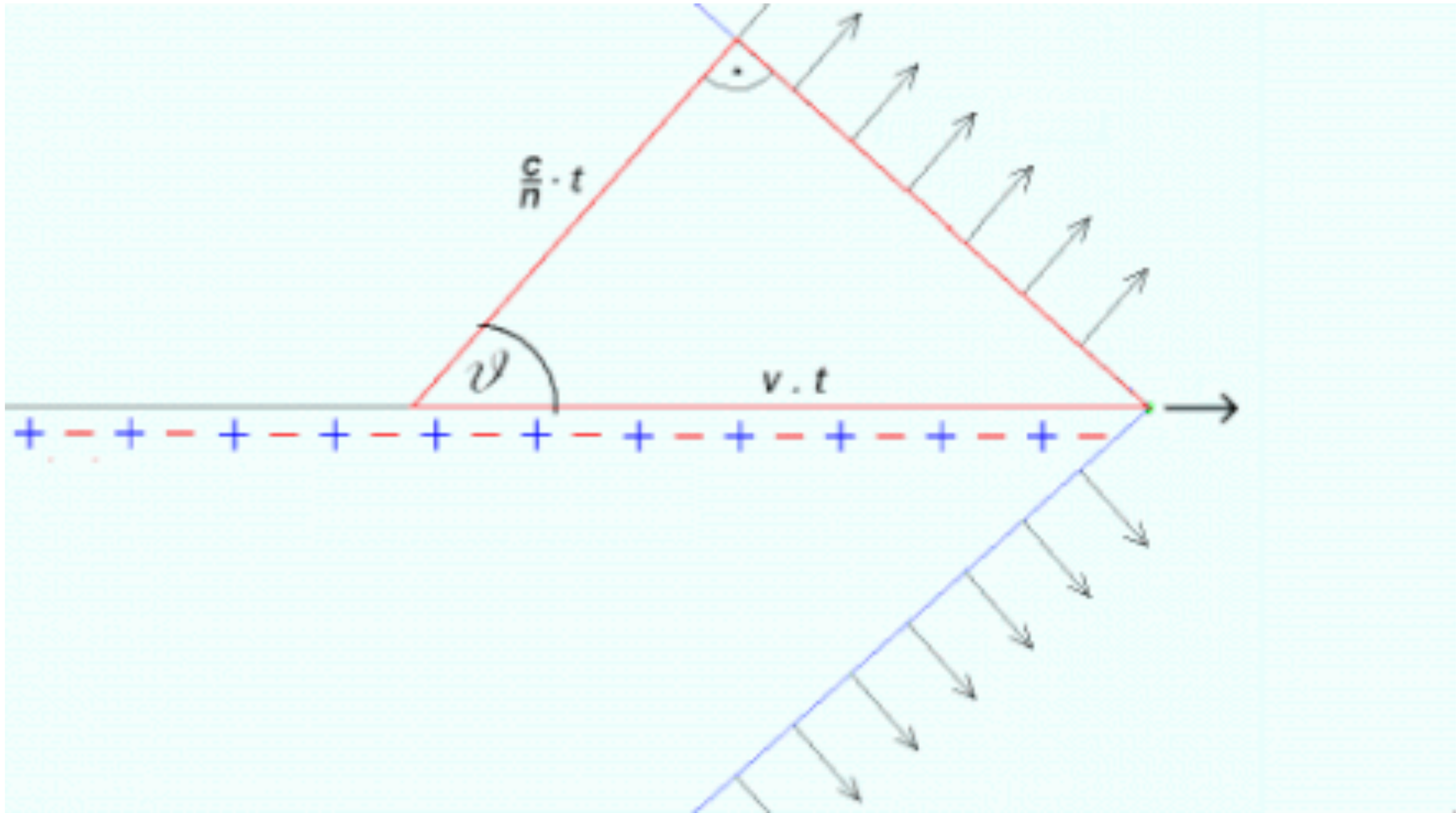
Outline

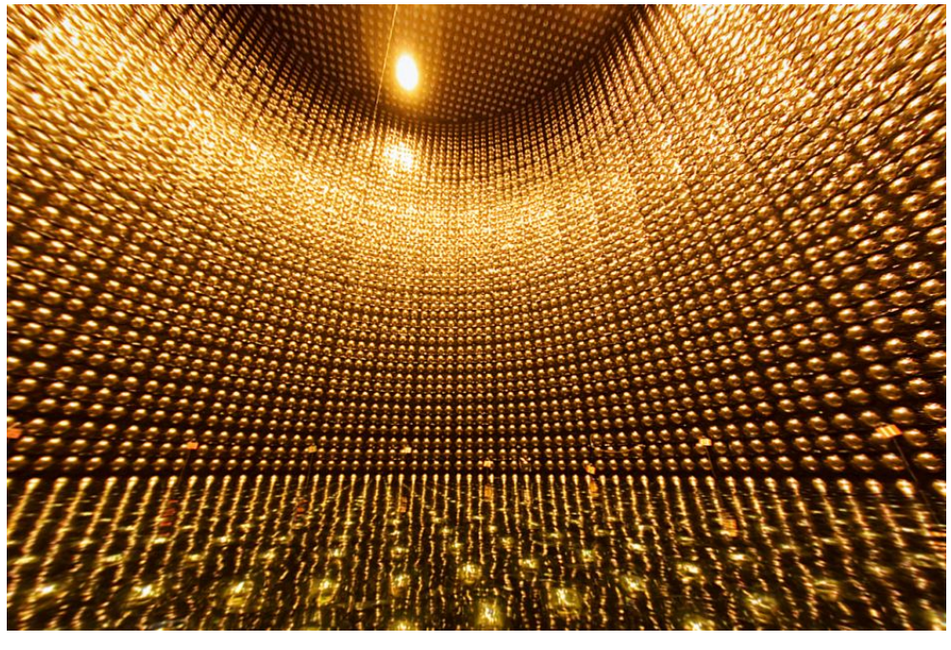
- Summary on Čerenkov radiation and water Čerenkov detectors
- Simulation softwares and codes description
- mPMT optimization results

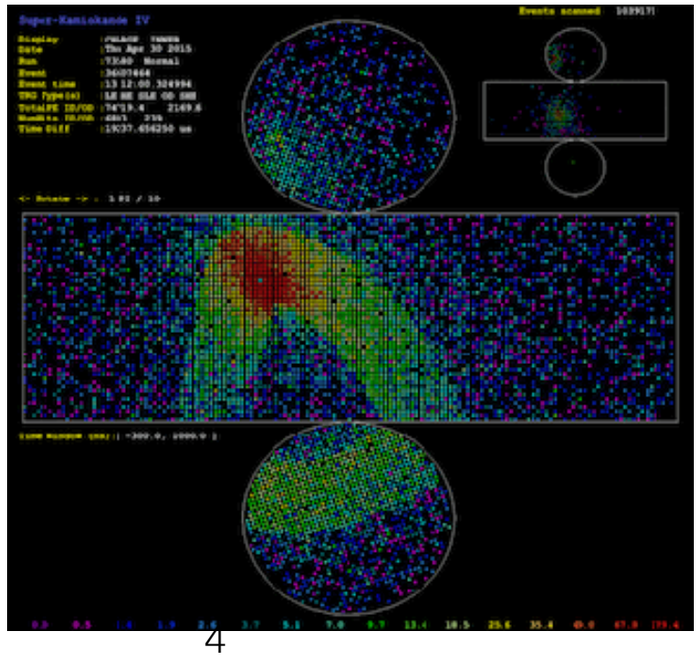
Čerenkov Radiation



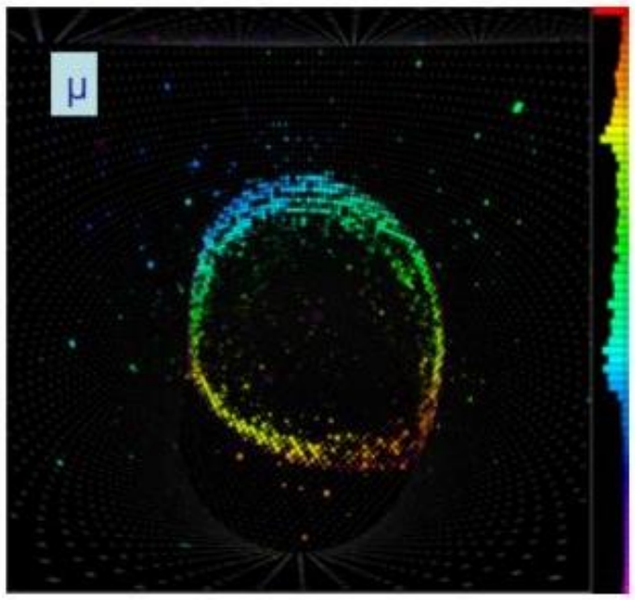
Water Čerenkov Detectors

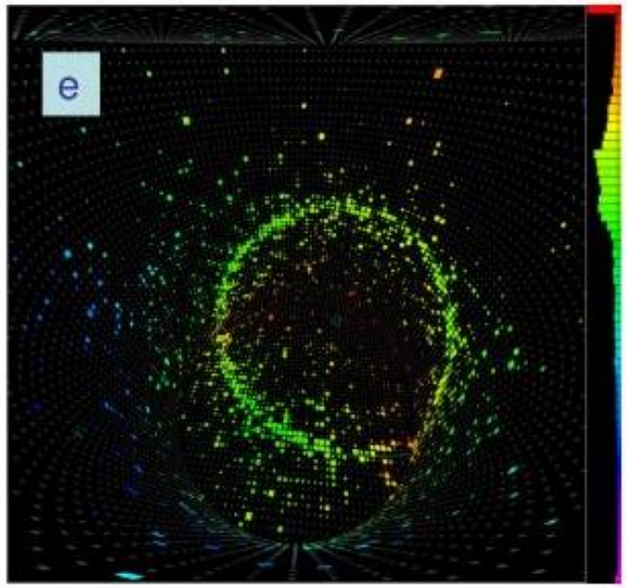
- Čerenkov radiation is detected.
- The resulting data allows for the reconstruction of the cone of emission which gives information of the original particle.
- The Čerenkov spectrum in water is in between 200 nm and 800 nm (simulations done for 400 nm)

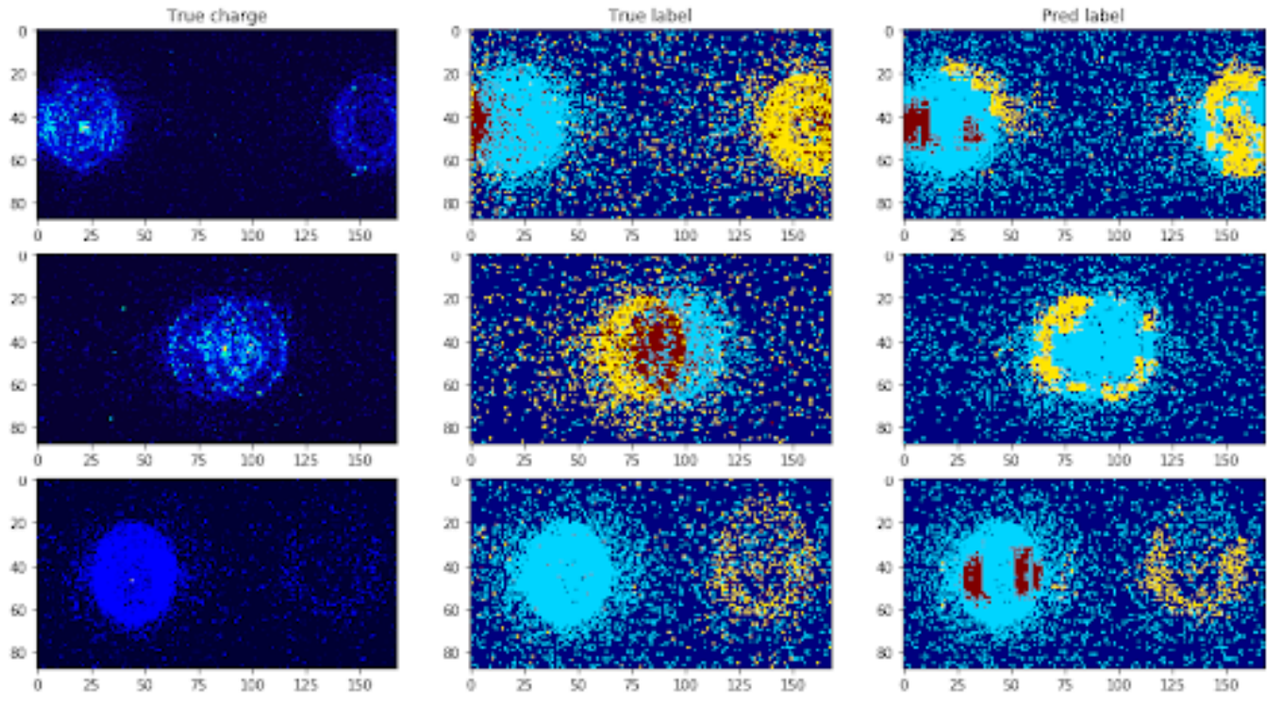




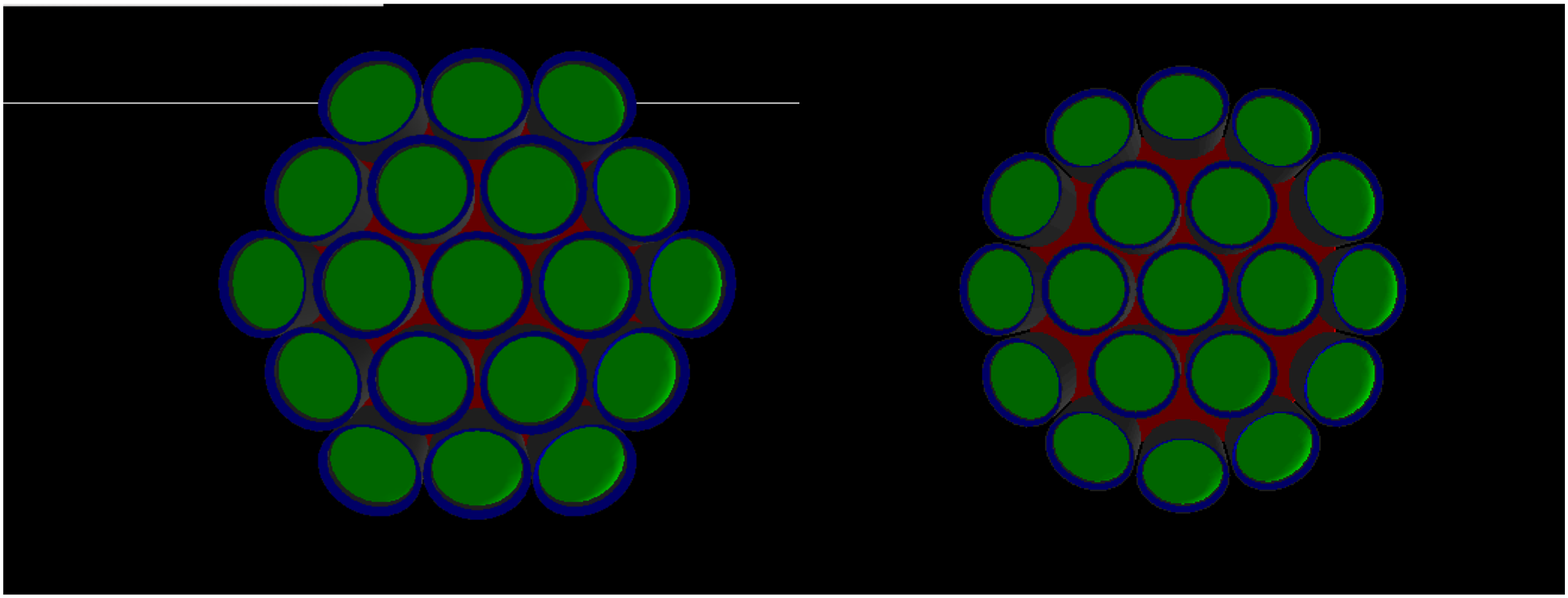
Čerenkov Rings



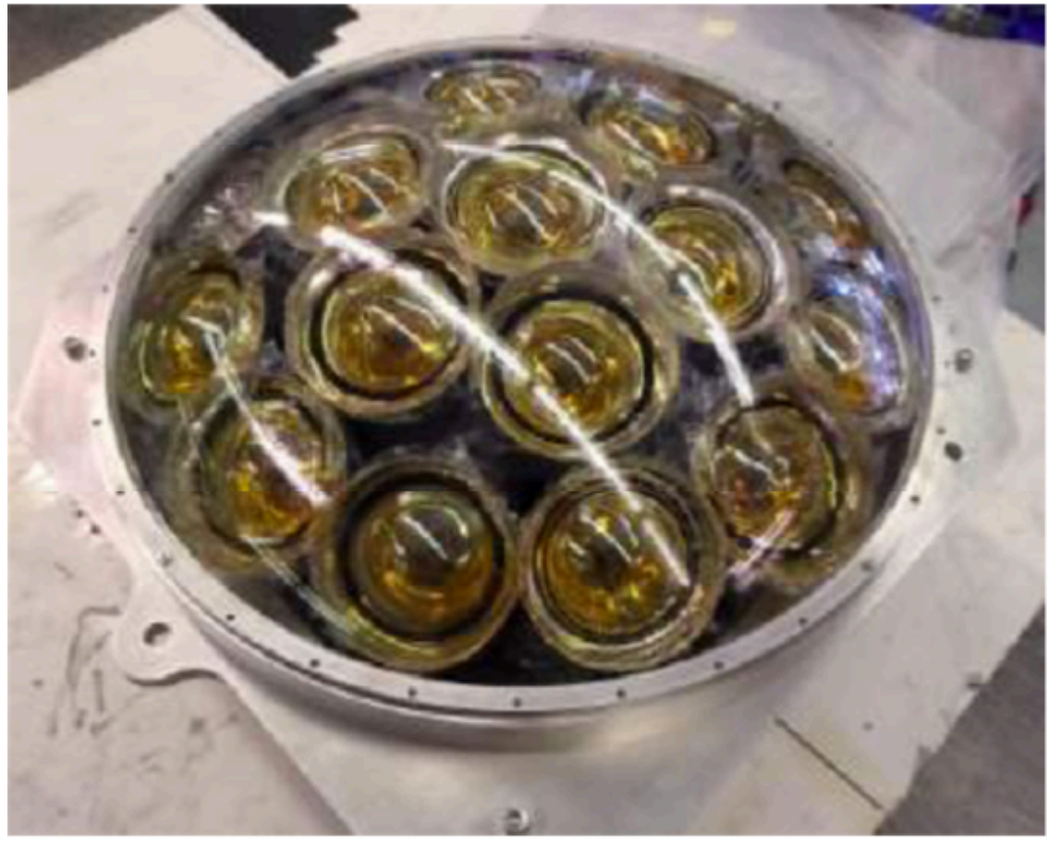




mPMT Models

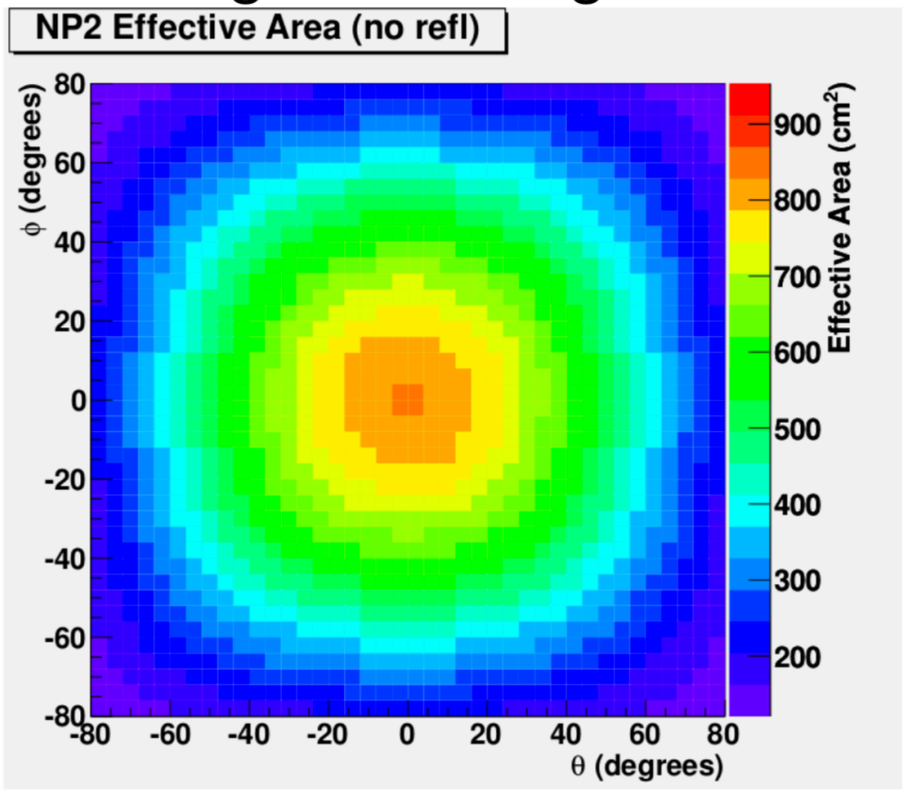


mPMT Models

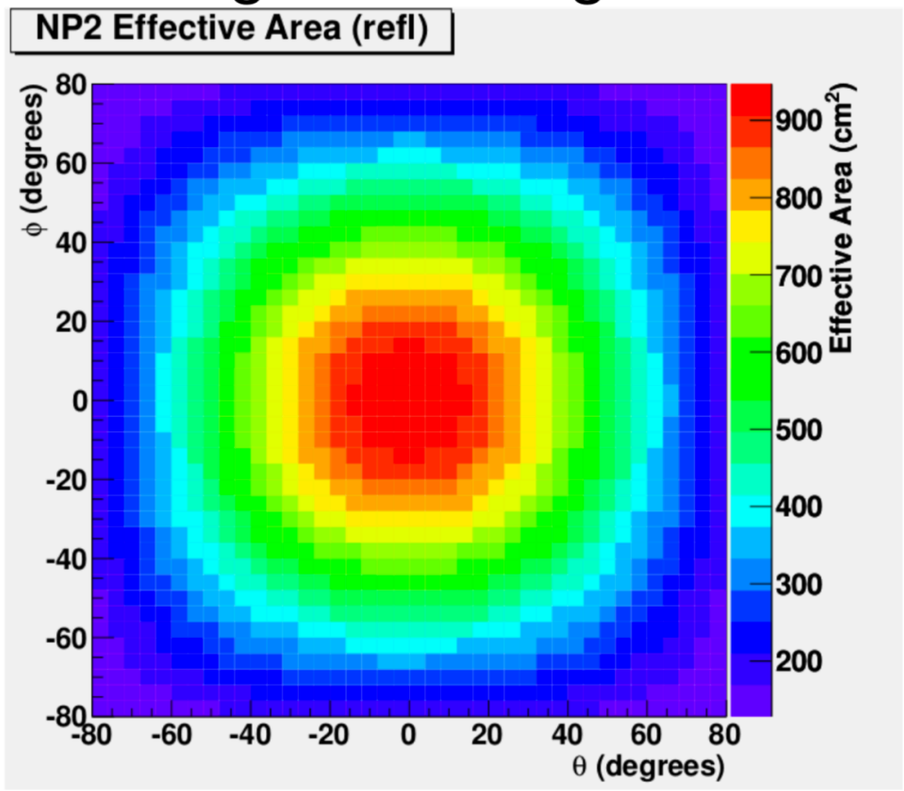


mPMT Optimization

hexagonal configuration



hexagonal configuration

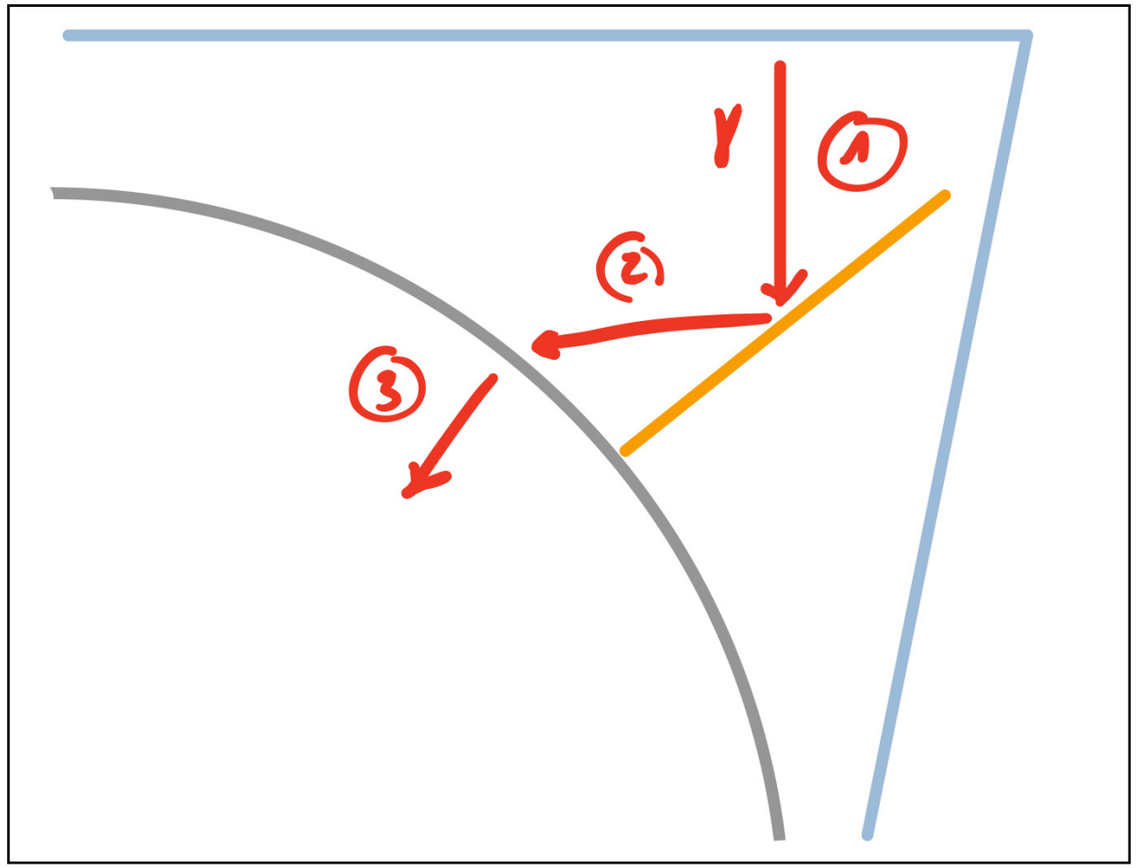


Matlab Simulations

- Model the path of a photon through the gel-reflector-PMT circuit using the Fresnel equations and Snell's law.

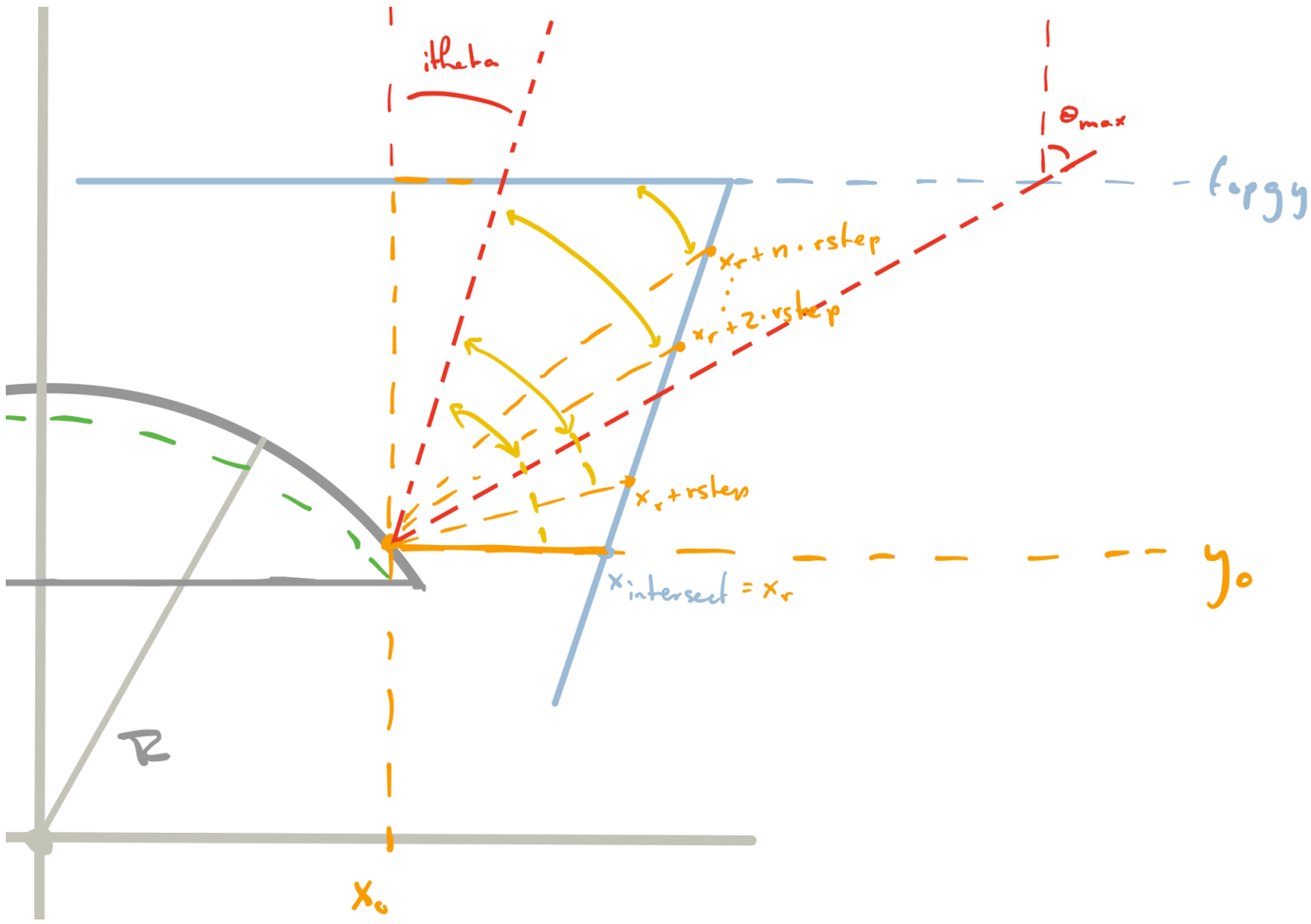
- Find an expression for quantum efficiency in terms of incident angle of photon in PMT.

- Using a proper combination of these equations one can find the total collection efficiency of a PMT configuration.



Matlab Simulations

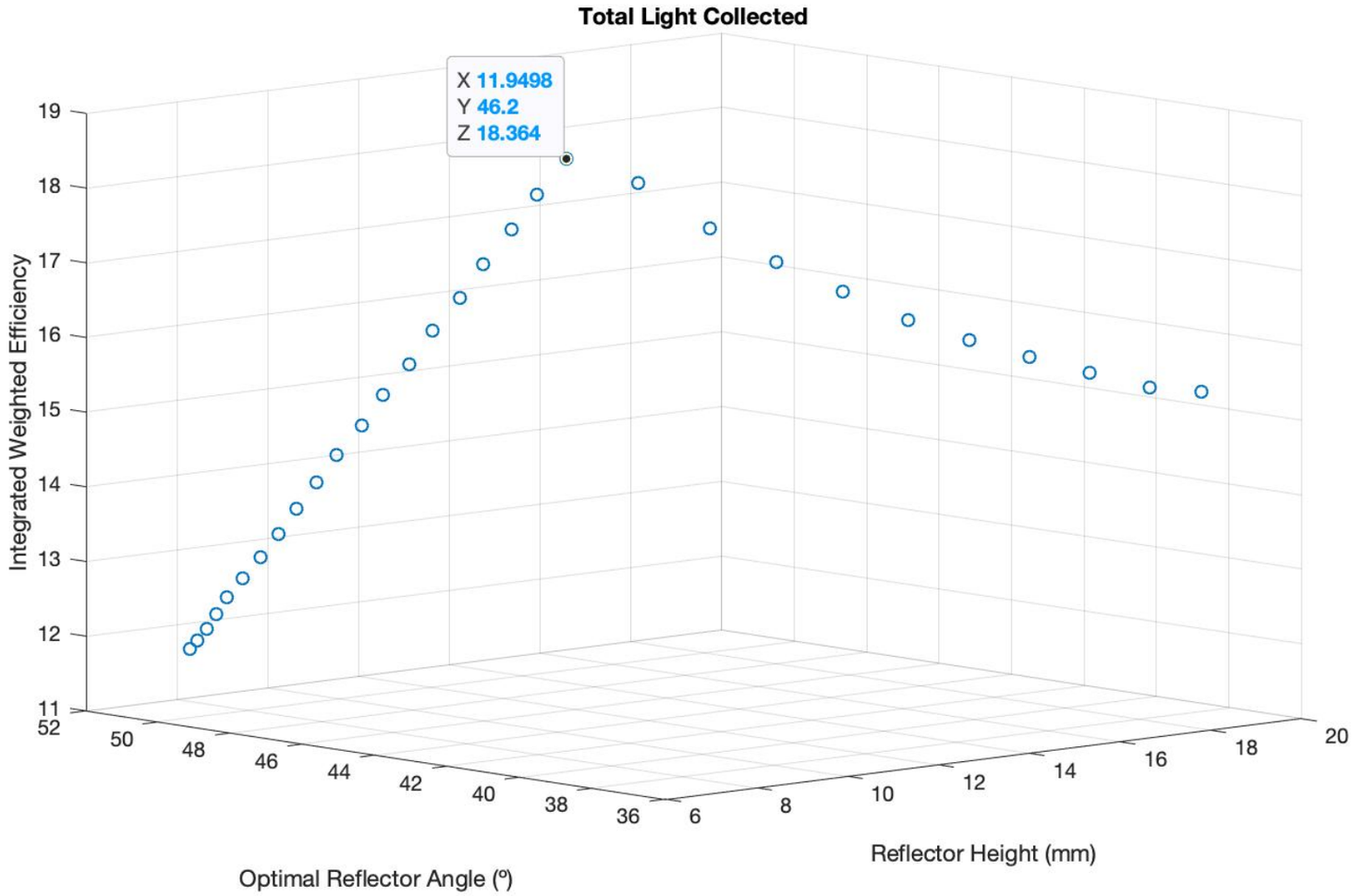
- Model PMT (grey) and gel (blue) for angle and length constraints. Reflector is represented in orange.



- Iterate over reflector lengths.
- Restrict angle depending on the length of the reflector.
- Iterate over possible angles to find the optimal one.

Results

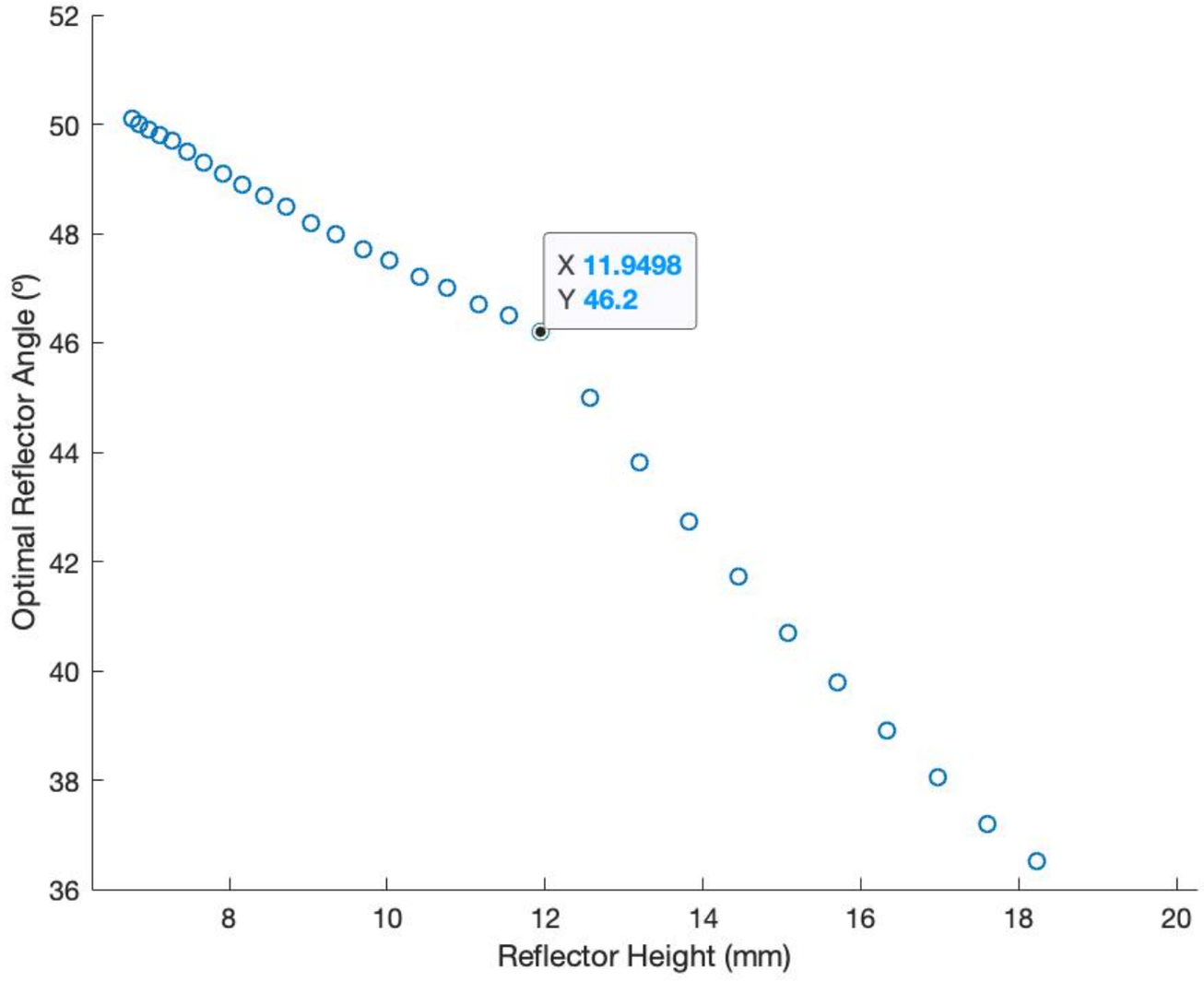
- Angles between 20º and 80º were considered.
- Steps of 0.1 mm and 0.1º respectively.
- Optimal angles lie around 35º and 50º.



Results

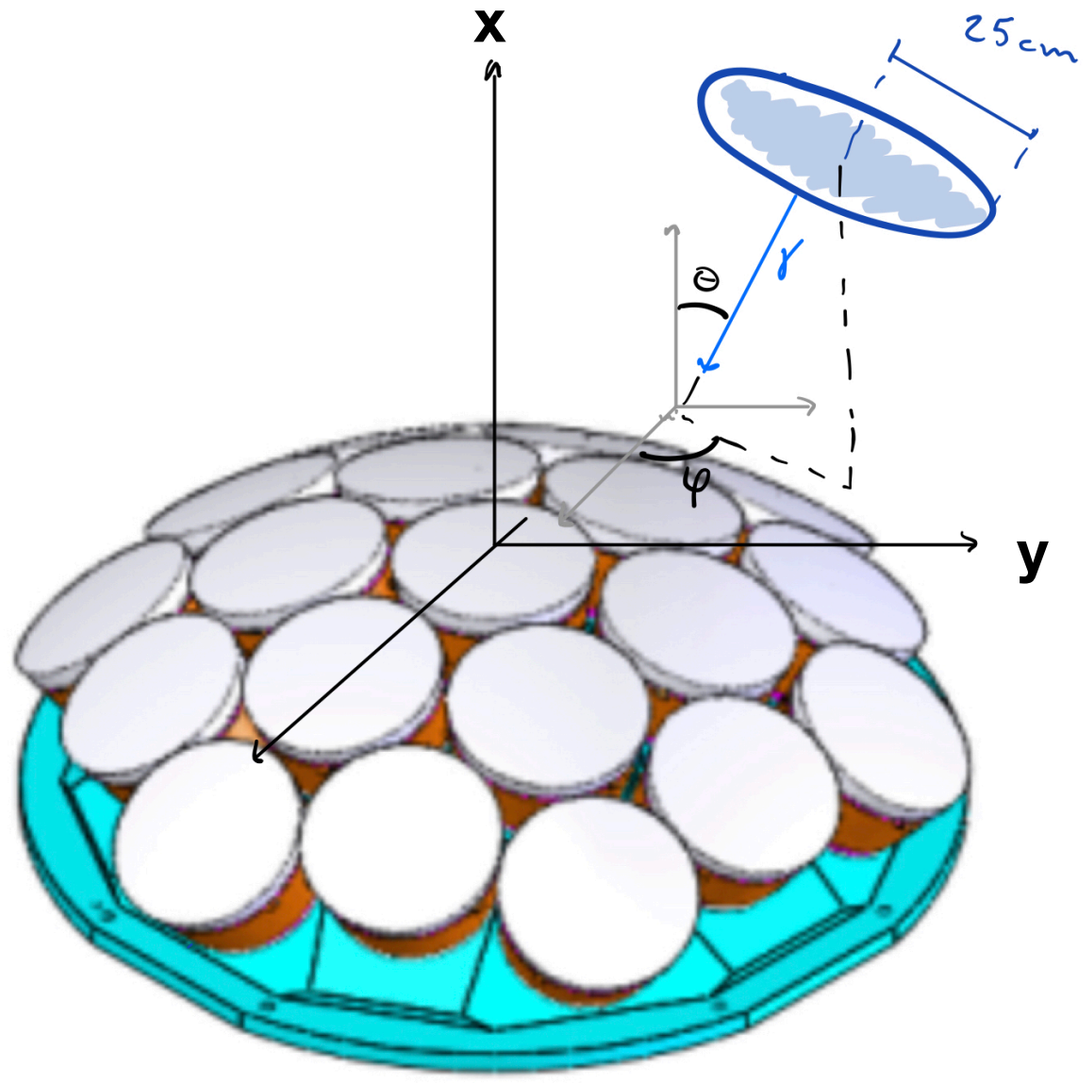
- Comparison of how optimal angle changes as reflector height changes.

- As the height increases, the optimal reflector angle decreases.



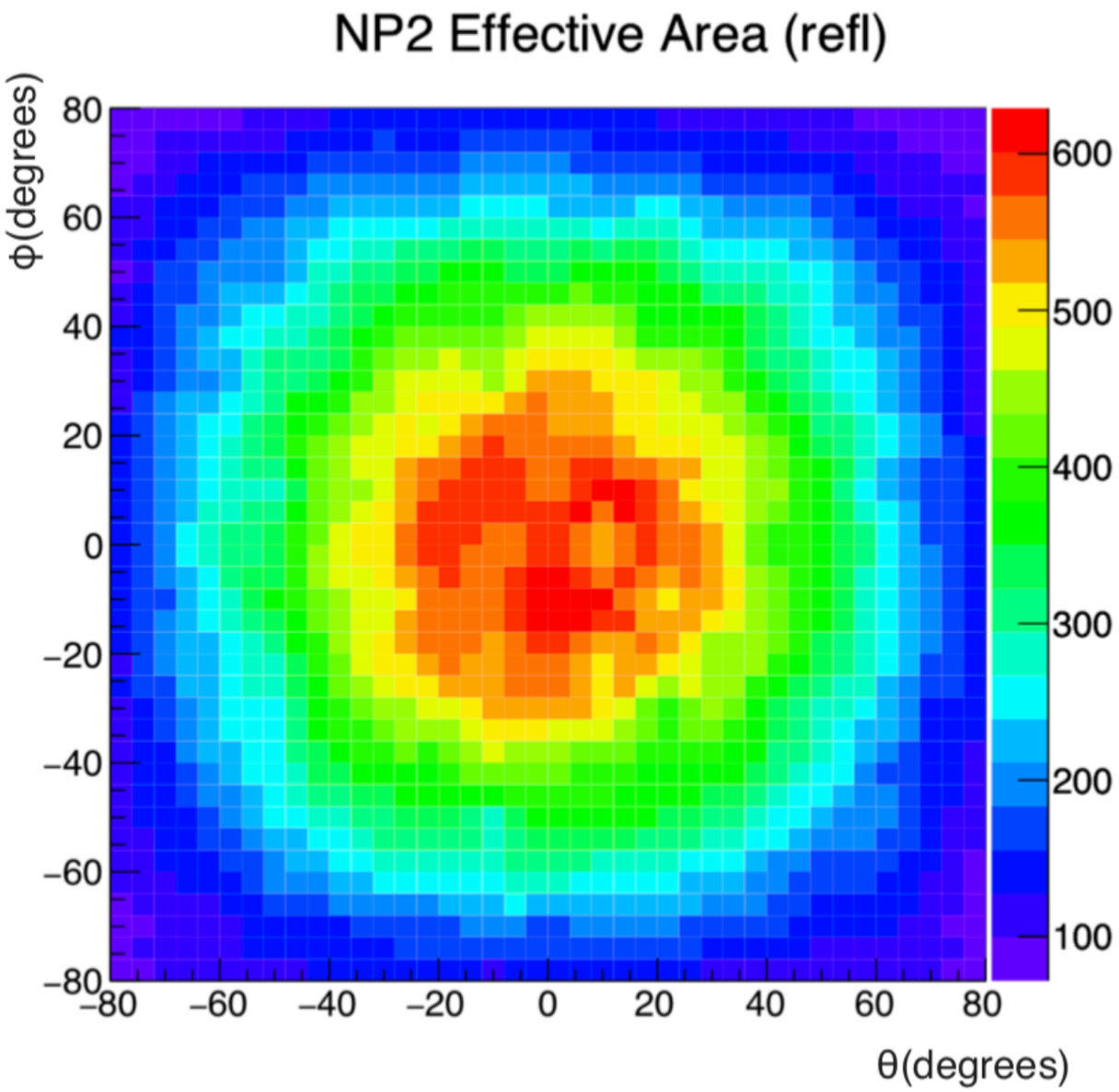
WCSim Simulations

- Simulations were done for $-80^\circ \leq \theta \leq 80^\circ$, $-80^\circ \leq \phi \leq 80^\circ$ with a 25 cm circular photon source

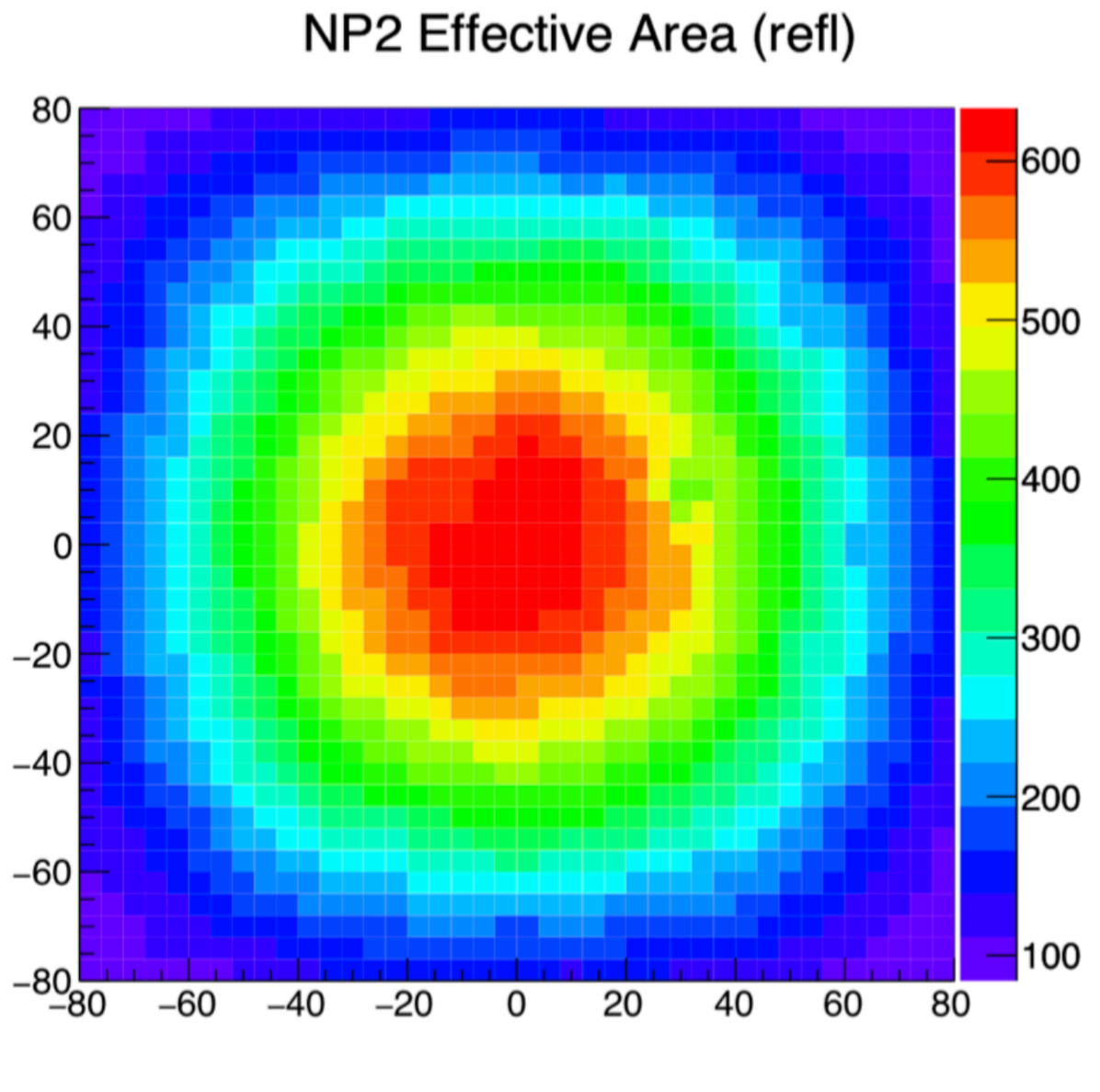


$$\text{Effective Area} = \frac{\text{NHits}}{\text{NEvent}} \cdot \pi r^2$$

Results



Previous Model



First optimization

Further Improvements

- Reduce dead-space between PMTs
- Look into other shapes for reflectors
- Extend simulations to more general scenario
- Obtain a continuous function instead of a scatter plot for optimal reflector angle

Learning Outcomes

- Improve coding skills (C++, Geant4, ROOT, bash, Matlab)
- Use of computer clusters (Cedar and Neut)
- Communication skills
- A new perspective on researching in physics