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Performance test for next-generation optical module "mEgg" in the IceCube Gen2

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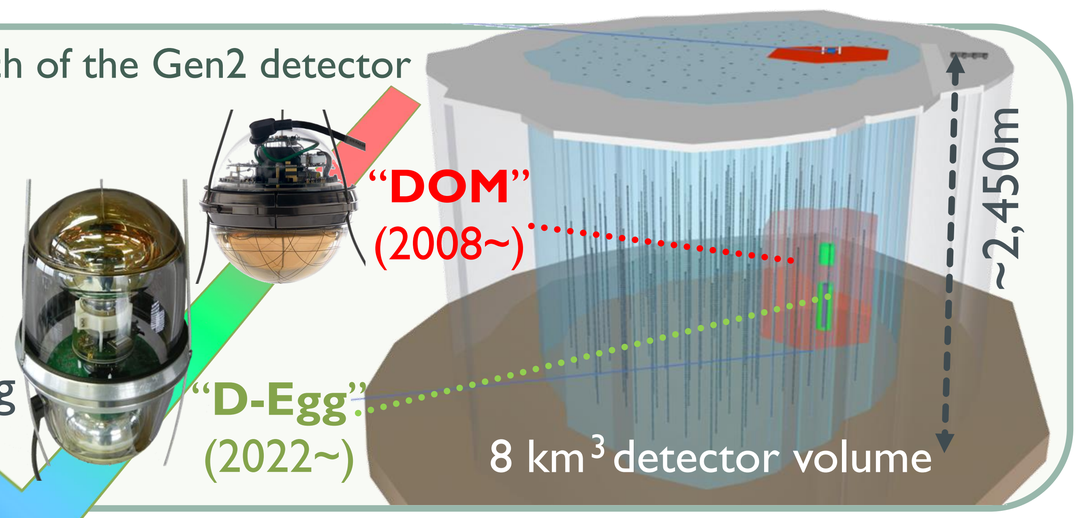
Credit: Sven Lidstrom, National Science Foundation

IceCube-Gen2

- The IceCube experiment detects high energy neutrinos through Cherenkov photons produced in the south pole ice.
- These photons are detected by 5,160 optical modules (DOMs) deployed between 1,450 - 2,450 m below the ice surface. [1]
- IceCube-Gen2 will deploy up to 10,000 more modules expanding the detector volume 8 times larger by 2030. [2]

Fig1: Sketch of the Gen2 detector



Optical module "mEgg"

- ICEHAP's involvement in the first steps for Gen2 are design of "D-Eggs" - modules with 2 large PMTs.
- From this design comes the new "mEgg", using 14 smaller PMTs to gain at least 1.5 times greater sensitivity.

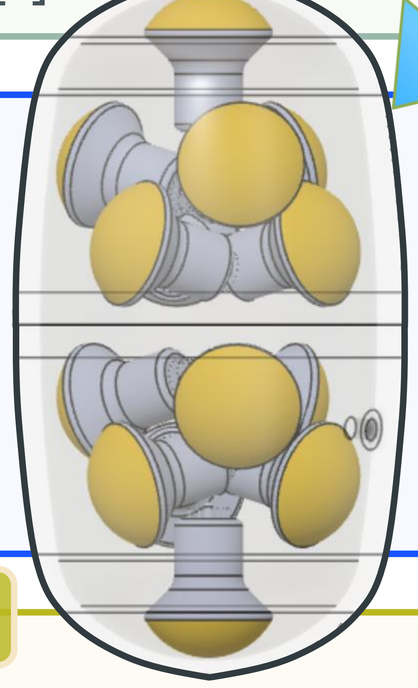


Fig2: Current mEgg design by V.Basu

- The mEgg plans to use a pressure and temperature resistant glass shell, required to survive the harsh South Pole conditions.
- Studies are ongoing to research this new design of PMT.

Simulation study

- Investigated mEgg performance by injecting known photon sources (θ=0deg ~ θ=180deg).
- Simulation considers both normal quantum efficiency (QE) used for DOMs and high QE PMTs for D-Eggs.
- To improve focusing of photons into the PMTs, optical gel is filled entirely inside the glass.
- The increase in efficiency by using optical gel boosts mEgg sensitivity to 1.90 times that of the D-Egg.

Fig3: Photon propagations from the top

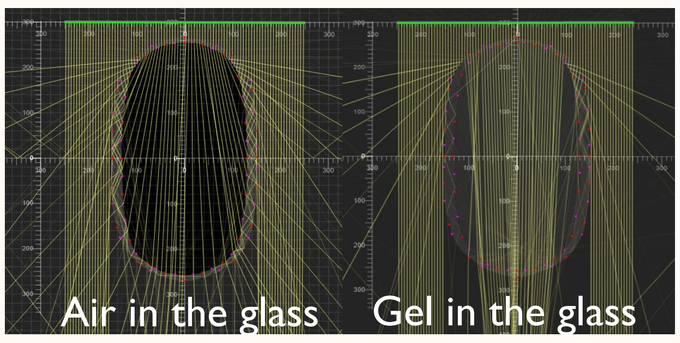
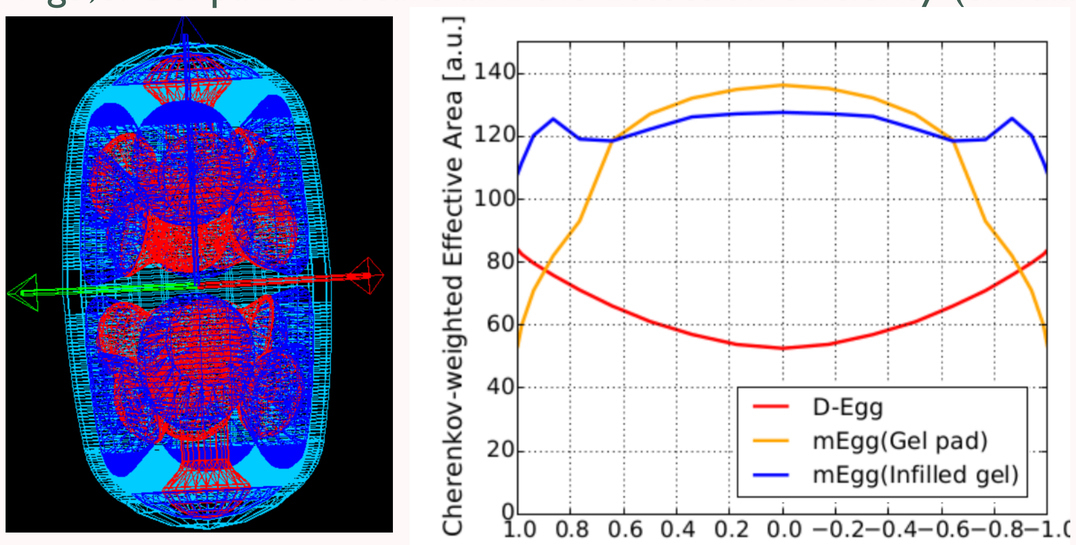


Fig4: Expected detection efficiency (Simulation)

Gel pad installation

Fig5,6: Gel pad structure and the detection efficiency (Simulation)



- We're investigating use of individual "gel pads" installed between the PMT and the glass.
- More realistic option than a fully infilled module.
- Gel pad simulation shows on average 1.74 times larger performance compared to the D-Egg.

Fig7: Gel pad prototype

Summary and Outlook

To detect neutrino events with even greater precision, the next-generation optical module "mEgg" is in development for the IceCube Gen2. mEgg has 14 4" PMTs in the glass vessel, which uses the same shape as the D-Egg. Gel pad is being optimized to increase the efficiency. With the gel pads installed, mEgg performance is projected to be maximum1.74 times over the D-Egg.
In lab measurements will allow us to get the correct photon efficiency with or without the gel pad and compare it with the simulation.

[1] Jakob van Santen. Neutrino Interactions in IceCube above 1 TeV. *PhD thesis, University of Wisconsin Madison,* 2014.
[2] IceCube-Gen2. The Window to the Extreme Universe. *arXiv:2008.04323*, 2020.