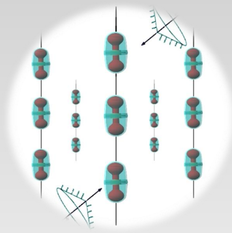
A dual-PMT optical module (D-Egg) for IceCube-Gen2



Hiroto Ijiri[1], Aya Ishihara[1], Lu Lu*[1] and Shigeru Yoshida[1] for the IceCube-Gen2 Collaboration[2]

1. Department of Physics, Chiba University, Japan. 2. http://icecube.wisc.edu/collaboration/authors/icrc15_gen2

**contact email: lu.lu@icecube.wisc.edu*

1. What is D-Egg?

The high-energy extension of the IceCube experiment aims at improving the sensitivity for the detection of neutrinos with few hundreds of TeVs and energies beyond. A design for a larger detection volume is underway [1]. We propose a new type of optical sensor which has improved angular acceptance and higher efficiency for detecting Cherenkov photons. D-Egg stands for :

Dual optical sensor in an **E**llipsoid **G**lass for **G**en2.

2. UV-transparent glass

The D-Egg glass contains less iron and is more UV-transparent (Fig 1) . The thickness of the glass at the pole is reduced by 0.27 cm compared to IceCube DOM.

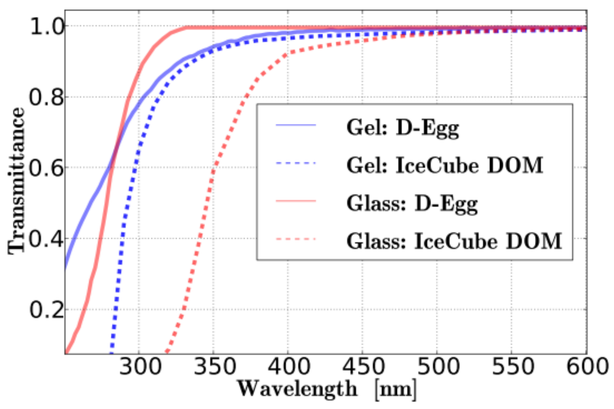


Figure 1: Transmittance of glass and gel for the current IceCube DOM and D-Egg.

3. High quantum efficiency

The D-Egg carries two 8″ PMTs (Hamamatsu R5912-100). The quantum efficiency (QE) for UV range is largely improved. Lab measurements were set up in a freezer in Chiba and shown in Fig 2.

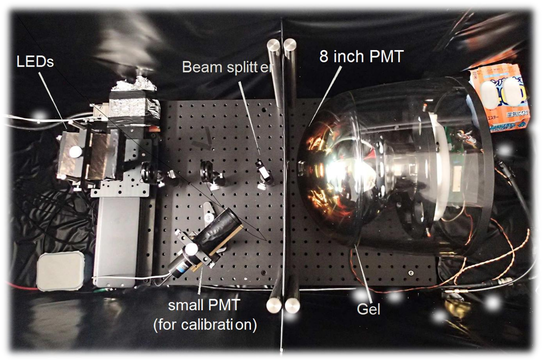


Figure 2: Lab setup for measuring QE of D-Egg (with glass & gel) in the freezer. There are five LED sources (340, 365, 470, 520 and 572 nm) contained in the box on the left.

The geometry of D-Egg and optical properties of glass and gel are implemented in GEANT4. Simulations are compared with data (Fig 3).

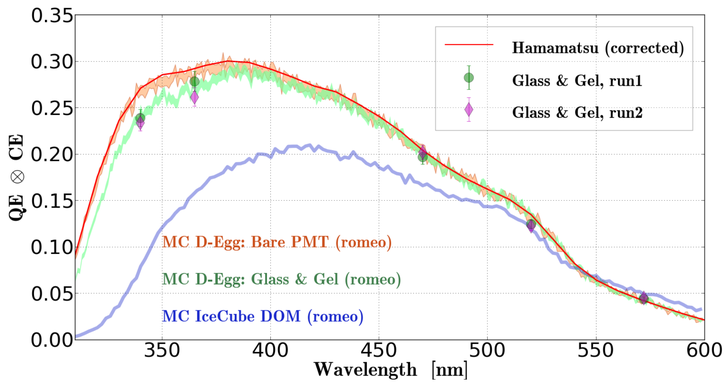


Figure 3: Comparison of simulated and measured QE of D-Egg (with glass & gel). The blue line is the QE of IceCube DOM (with glass & gel).

4. Better angular sensitivity

To simulate the effective area (Fig 4) of D-Egg for isotropically injected photons, we took into account:

- ✓ the shape of glass
- ✓ optical properties of glass and gel
- ✓ quantum efficiency, collection efficiency and charge response of the 8″ PMT

Figure 4. Effective area of IceCube DOM (left) and D-Egg (right) when photons hit isotropically.

5. Mechanical test

Pressure tests at 70 MPa were carried out in Nippon Marine Enterprises and neither glass nor PMT were damaged.

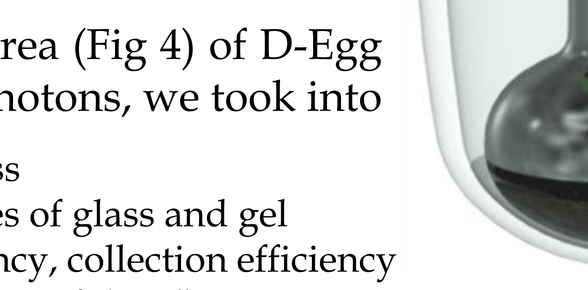


Figure 5. Before the test: D-Egg was inside the blue container which then went down to the pressure vessel (left). D-Egg after the pressure test (right).

6. Example of a down-going muon

Down-going muons are often tricky backgrounds for neutrino studies. The example muon has energy of 4 TeV and a zenith angle 50°. An energy loss of 540 GeV occurred close to DOM 60 on string 41 via bremsstrahlung.

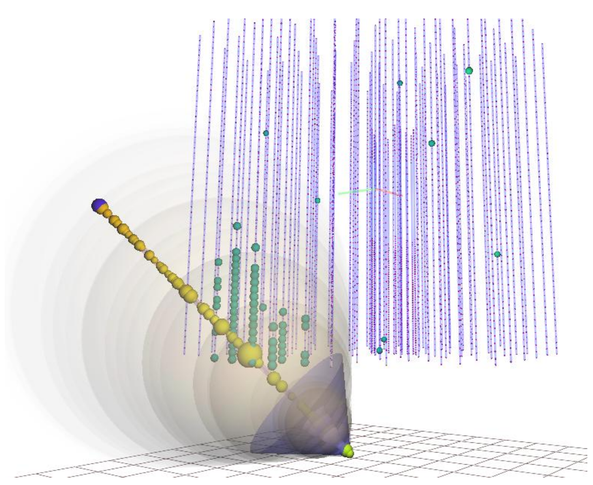


Figure 6. Example of a down-going muon. The largest yellow blob indicates the position of the bremsstrahlung.

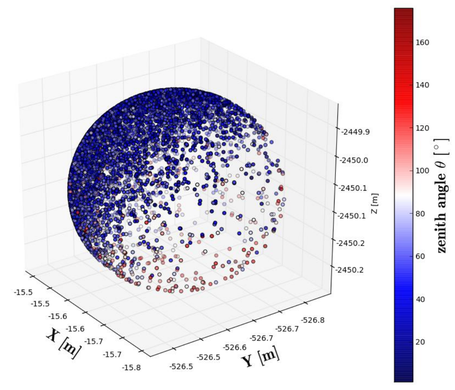


Figure 7. Distribution of photons arriving on the surface of IceCube DOM 60, which is at the bottom of string 41. The distance between DOM 60 and the energy loss position is ~20 m.

The number of scatterings for photons arriving on DOM 60 is ~5. Photons travel in the forward-direction and reach the DOM from the top. There are 21 photoelectrons generated by the IceCube DOM but 336 photoelectrons in case of using D-Egg. With D-Egg it is possible to improve the muon-veto and event reconstruction.

[1] M. G. Aartsen et al. (IceCube-Gen2 Collaboration), IceCube-Gen2: A Vision for the Future of Neutrino Astronomy in Antarctica, (2014)