A novel microstructure-based model to explain the IceCube ice anisotropy

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What is this contribution about?

- Calibration of ice optical properties is fundamental to simulation & reconstruction of Cherenkov signals from muons and neutrinos as recorded by the IceCube Neutrino Observatory
- IceCube observes an anisotropic attenuation, which is aligned with the local flow of the ice ($\sim 10\,\mathrm{m/year}$). At 125 m for an isotropic emitter around twice as much light is recorded compared to the orthogonal direction.
- Previous empirical models introducing directional modifications to Mie scattering and/or absorption fail to simultaneously fit timing and light intensity observables.
- We present a model which incorporates a newly discovered optical effect where light diffusion through the birefringent, polycrystalline micro-structure of the ice yields an effective photon deflection towards the flow axis.

Why is it relevant / interesting?

- Incorrect ice modeling leads to biased event reconstructions. Affecting energy & directions (as relevant for neutrino astronomy and neutrino oscillation analyses) as well as particle identification (e.g. tau neutrino double cascades).
- The deduced ice properties are also of interest in glaciology and climate science as they relate to the ice viscosity.

What has been done?

- Building on earlier work, we simulate the light diffusion expected from large number of possible crystal realizations.
- These diffusion simulations are parametrized, so they can be applied in large scale photon propagation.
- The parametrized model is fitted to LED flasher data.

What is the result?

- The model yields a near perfect data-MC agreement in timing & intensity and will improve event reconstructions.
- In the fitting process, the average crystal size in the detector and its correlation to impurity concentrations, as relevant in glaciology, is deduced.
- The fitted absorption contribution is so far unmotivated.
  Understanding its origin or extending the birefringence to absorb the full effect will be the focus of future studies.

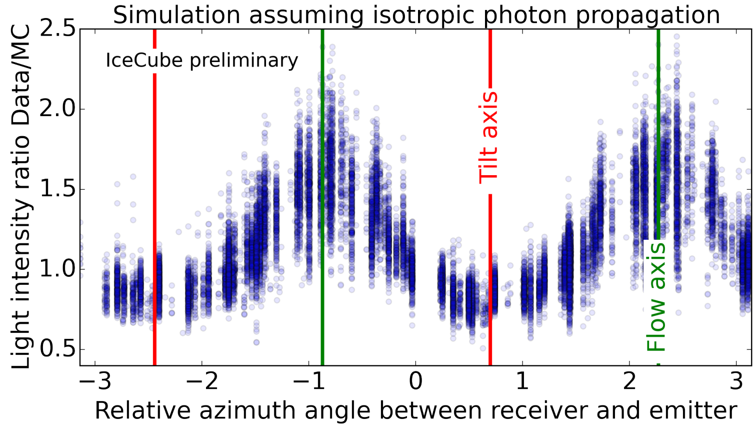

Figure 1: Optical ice anisotropy seen as azimuth dependent intensity excess.

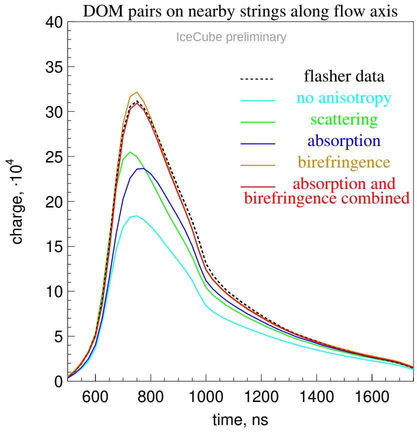

Figure 2: Fit quality achieved with different models of anisotropy.