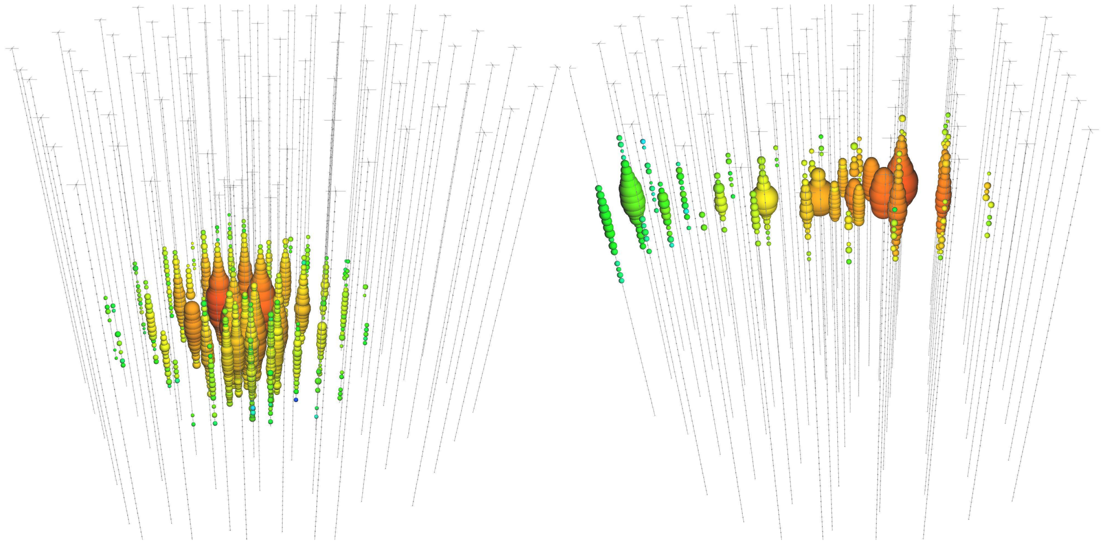

(a) Event classified as cascade   *(b)* Event classified as track

Fig. 0.1: The two event types distinguished in the IceCube detector.

0.1 Neutrino detection

We always observe neutrinos indirectly through their associated charged lepton. Regardless of the type of interaction (charged current via the W boson, or neutral current via the Z), a charged lepton exits with altered properties. The lepton is then detected, and the properties of the neutrino involved in the interaction is then deduced. This deduction is obviously imperfect, and this introduces complexities that we will handle in Ch. **??**.

In this work, we only study the detectors handeled by the IceCube collaboration. They are of Cherenkov type, which means that they detect the secondary charged lepton by its emitted Cherenkov light, produced from its travel through the Antarctic ice.

If the charged leptons interact heavily with the ice, they will travel a short distance and emit a localized flash of Cherenkov light. This event is referred to as a cascade. The neutral current interactions involves quarks, which recoils and procudes showers of hadrons. Also, charged current ν_e interactions also produce cascades. A cascade event is shown in Fig. 0.1a.

If the charged leptons don't interact as much in the ice, they penetrate a larger part of it, emitting light and tertiary particles as they go. This event is referred to as a track, and are often due to muon charged current interactions. A track event is shown in Fig. 0.1b.

To detect the Cherenkov light, 60 Digital Optical Modules (DOMs) are placed on a long string up to 17 m apart. 86 of these strings are then lowered into 2.5 km deep boreholes in the ice. The holes are then sealed by refreezing the ice, resulting in a total of 5160 DOMs in a volume of approximately 1 km^3 [1].

The strings and DOMs are not spaced evenly, making some parts of the detector more sensitive to certain energy ranges than other. 8 strings packed more tightly than the other 78, making that part of the detector sensitive to neutrino energies down to single digit GeV. Due to this part being situated deep within the ice, it is referred to DeepCore. DeepCore will be treated as a separate and independent detector from the rest, which retains the name IceCube. A view of the current setup can be seen in Fig. **??**. In this work, we consider DeepCore data between 5.6 GeV to 56 GeV and IceCube data in the range 0.5 TeV to 10 TeV.

In 2017, the PINGU Letter of Intent was published [2]. The "Precision IceCube Next Generation Upgrade" is an upgrade that will supplement DeepCore, i.e. boosing the capabilites of neutrino detection at the GeV scale. As the PINGU upgrade is not yet financed nor built, we are not able to use any data from it. However, the collaboration has released preliminary simulations which we will use to see how the upgrade might improve IceCube and DeepCore bounds. The PINGU simulations have the same structure as the DeepCore data, so any analysis referring to DeepCore will also apply to PINGU except where noted. However, we treat the PINGU detector as independent of the DeepCore experiment.

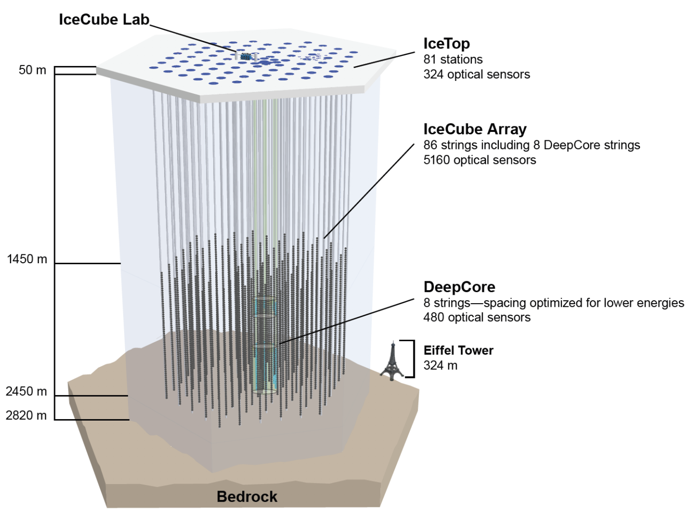

Fig. 0.2: View of the full IceCube array

BIBLIOGRAPHY

[1] Weaver, C. , 149.

[2] Collaboration, T. I.-P.