



Multiperspective neutrino studies

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Abstract

The central theme of my doctoral thesis, carried out at the University of Oviedo, is the study of the characteristics of neutrinos from different points of view.

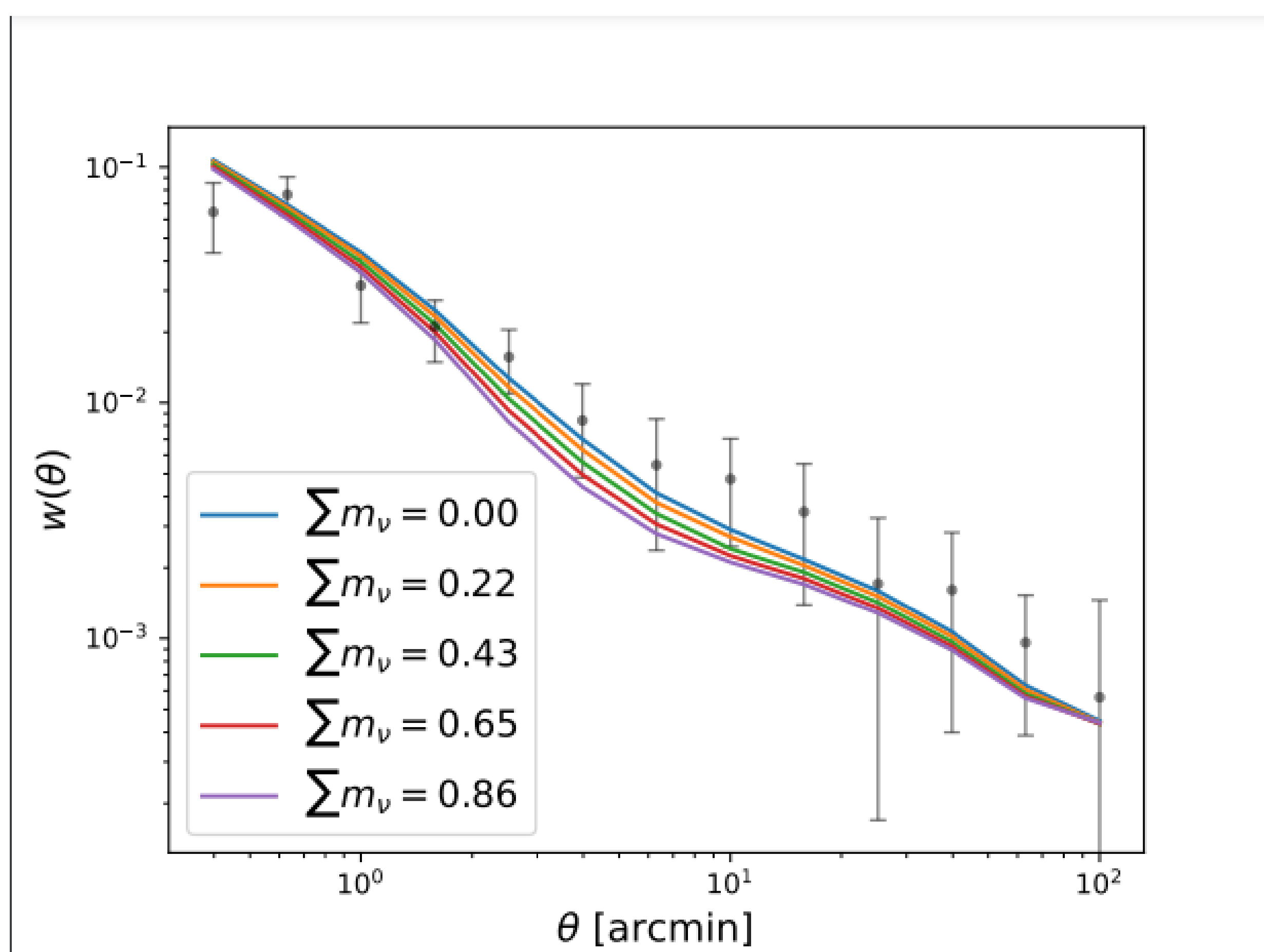
On the one hand, the possible usefulness of cosmological effects, such as weak lensing, in estimating limits on the value of the sum of the neutrino masses is being studied. Simultaneously, work is starting on the development of artificial intelligence algorithms to improve the identification of tau neutrino events in detectors by developing neural networks and a reasonable choice of input variables to distinguish tau-like events from the background.

In addition, a very complete study has been carried out on the compensation of the geomagnetic field by means of coil systems in Cherenkov type detectors, in which the effect of different associated parameters, such as the size or the distance between spires, is studied, and a basic compensation system is proposed which offers optimum results. These results are currently being applied in the design of the compensation system of the Hyper-Kamiokande neutrino detector.

Neutrino masses and weak lensing

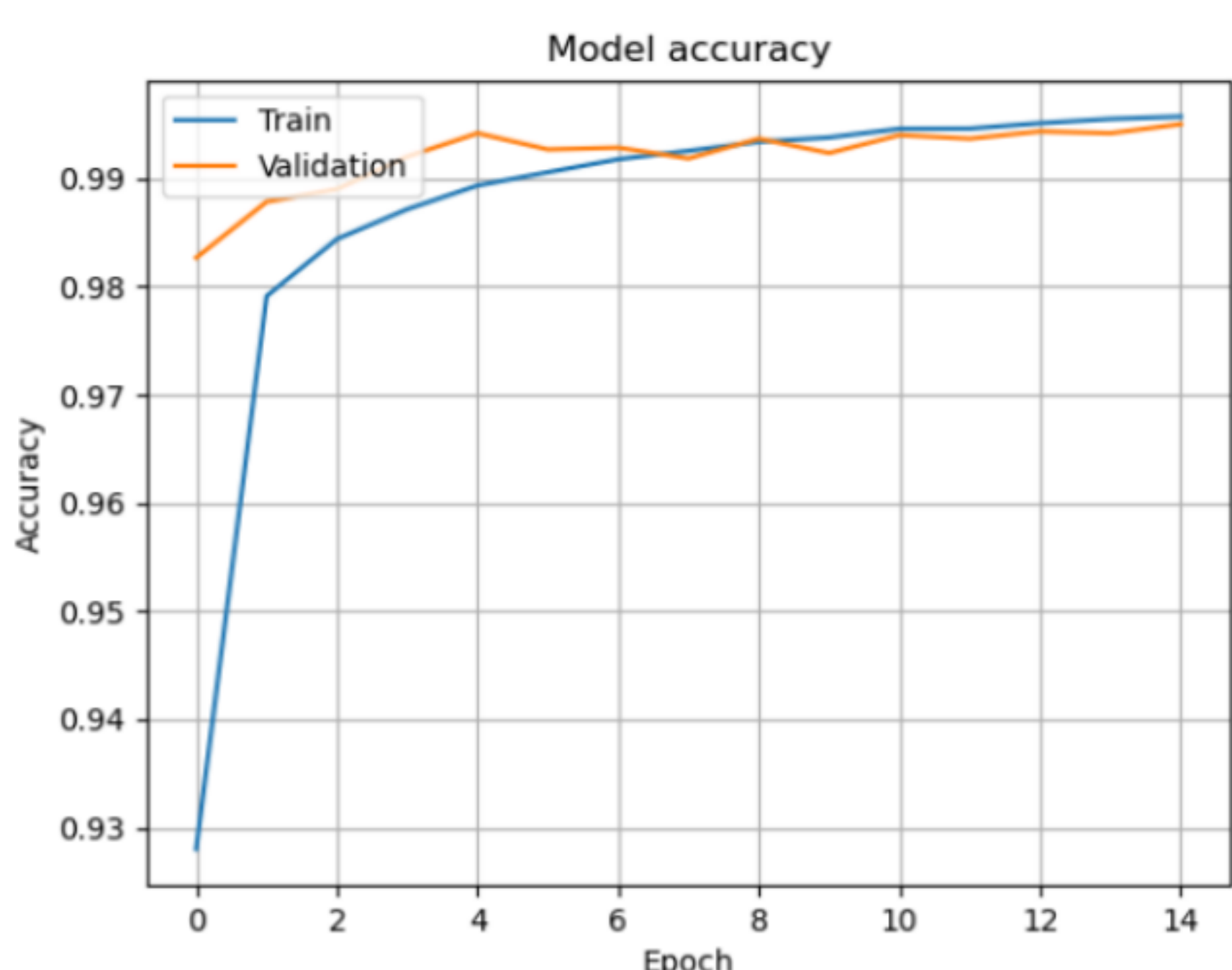
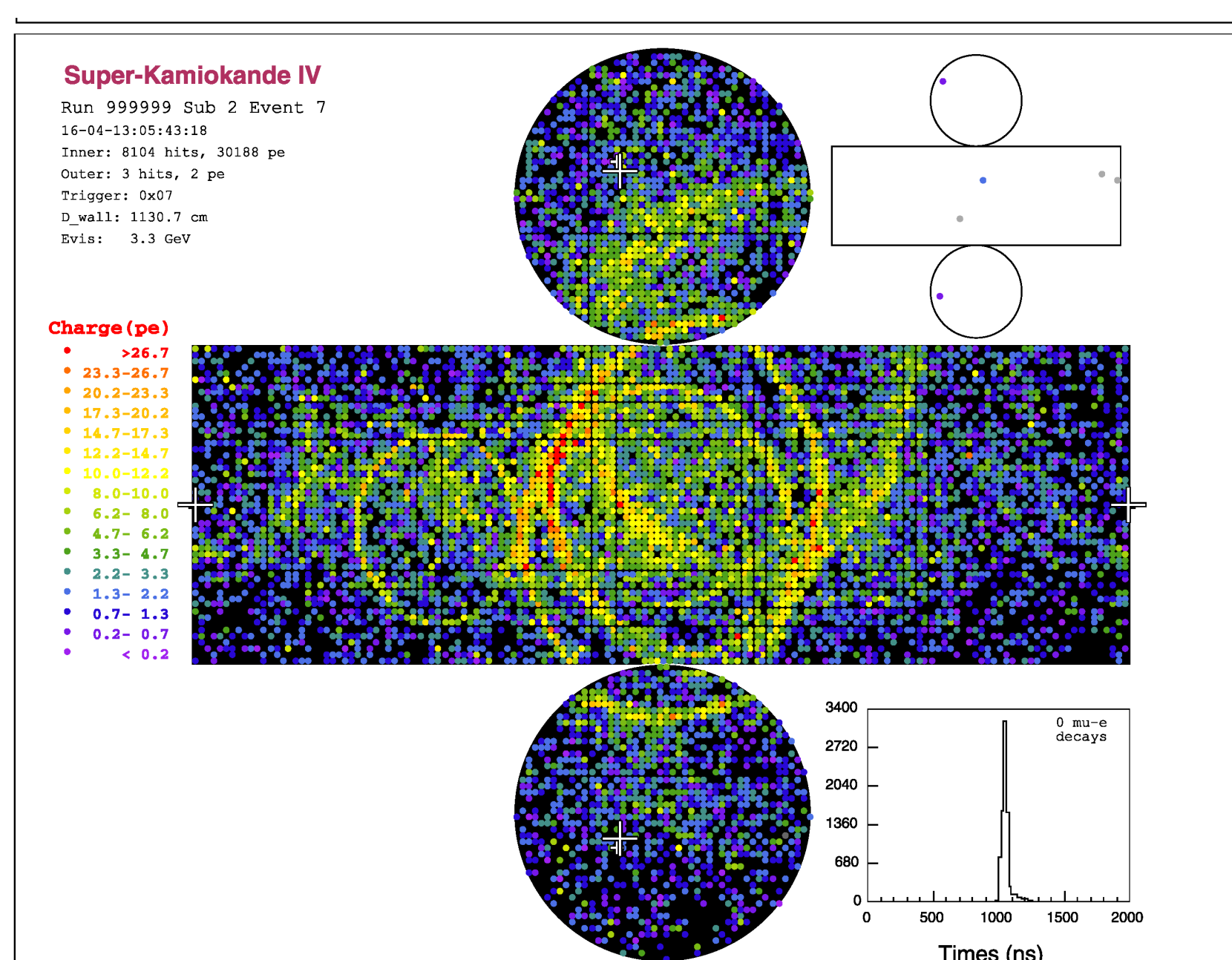
We are currently working on setting limits to the neutrino mass sum through cosmological effects such as weak lensing. The non-zero cross-correlation between background SMGs and lensing, resulting from magnification bias, depends on cosmology as well as neutrino mass and is therefore sensitive to it.

$$w_{fb}(\theta) = 2(\beta - 1) \int_0^\infty \frac{dz}{\chi^2(z)} n_f(z) W^{\text{lens}}(z) \int_0^\infty dl \frac{l}{2\pi} P_{g-dm}(l/\chi(z), z) J_0(l\theta),$$



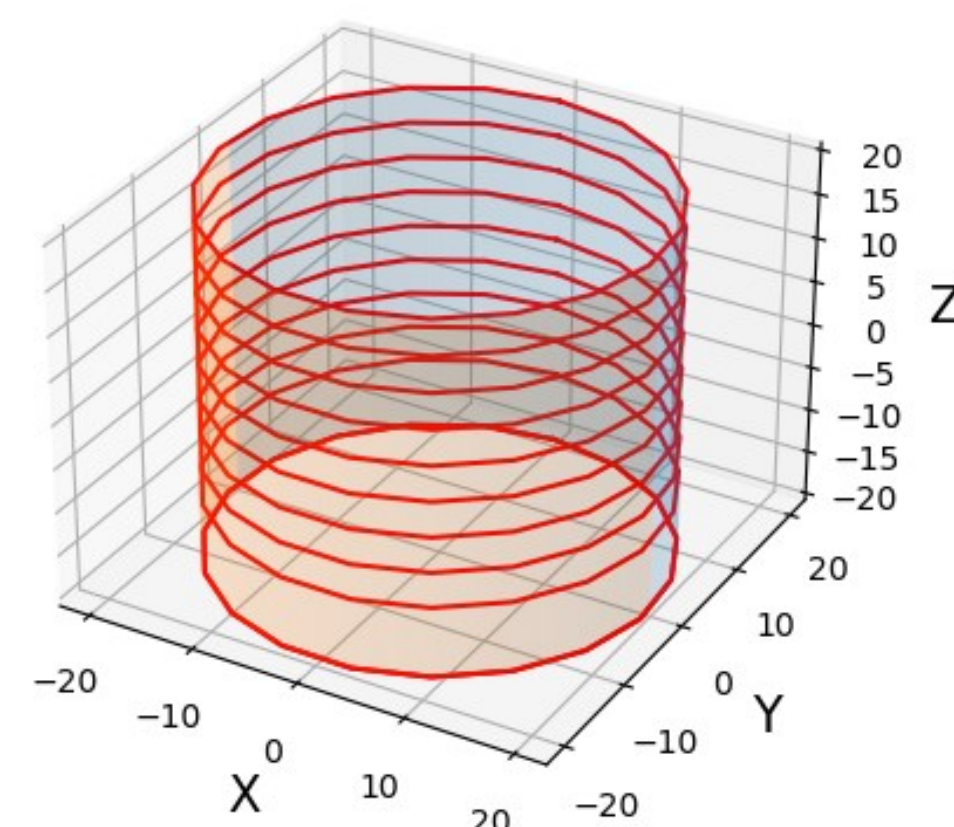
Tau neutrino identification

We are currently starting to work on the development of artificial intelligence algorithms for the identification of tau neutrinos. These events are very complex to identify with respect to the background through the leptonic channel, so they are mainly identified through the hadronic channel, which is characterised by multi-ring generation.

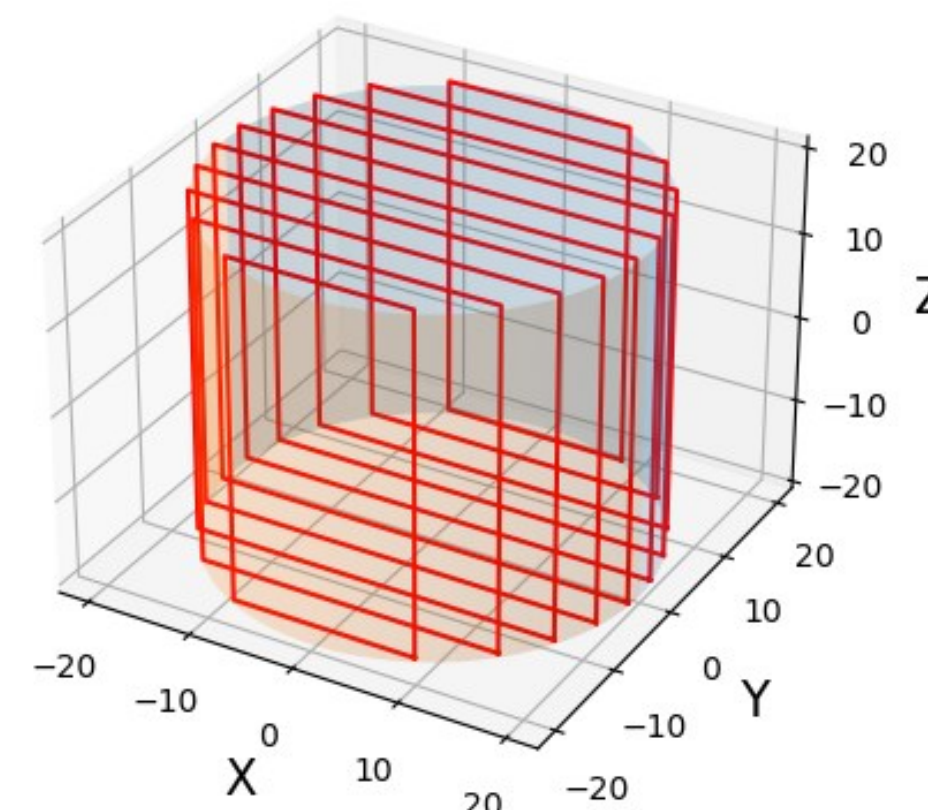


The key is a good selection of physical input variables of the neural network capable of robustly characterising the event, such as the number of electrons generated, the number of ring fragments or the sphericity. Once the identification efficiency of the network has been maximised, the goal is to perform a thorough analysis of the results and to infer relevant related physical parameters, as, for example, the cross-section.

Geomagnetic field compensation system for detectors

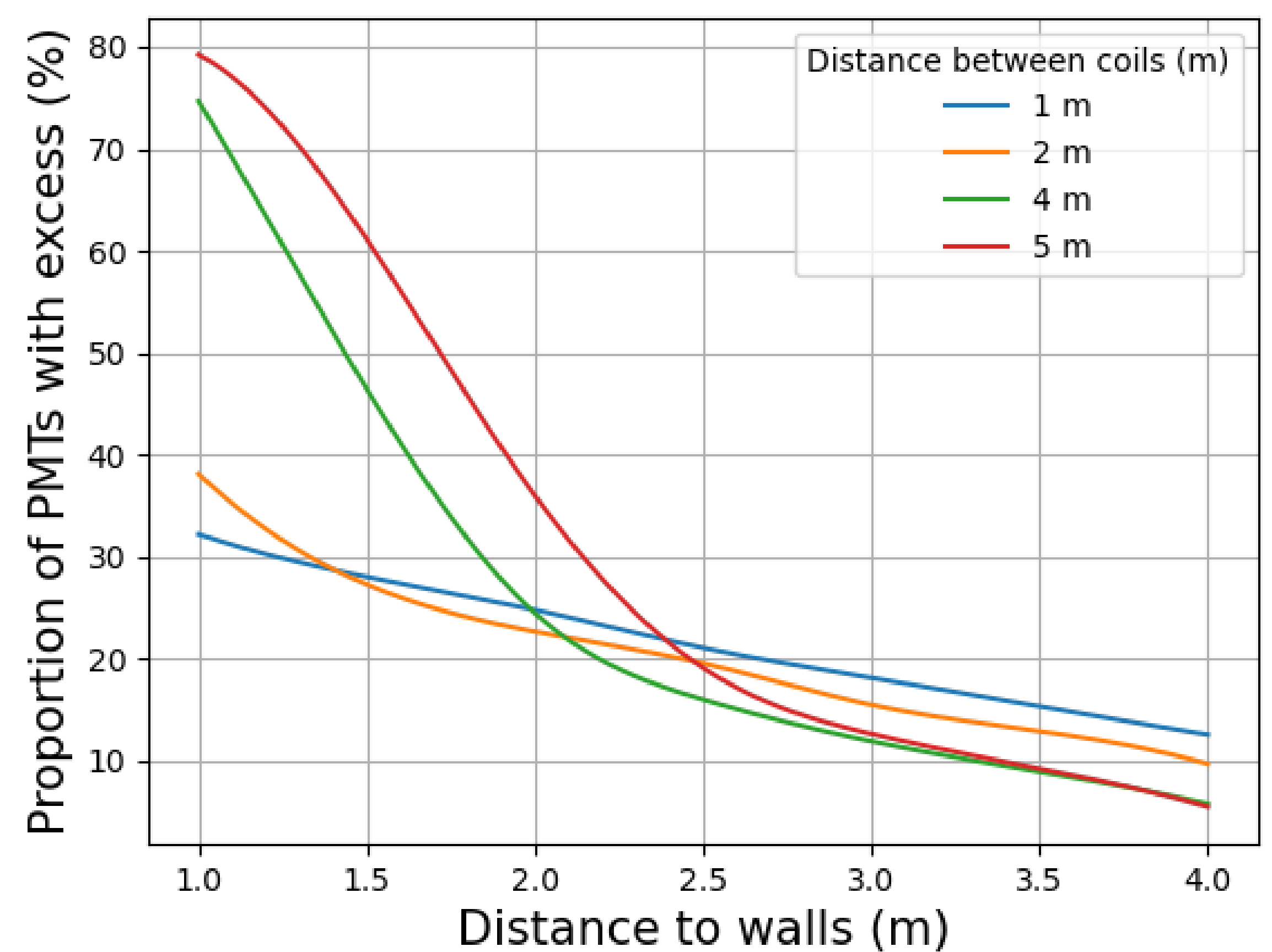


The proper operation of Cherenkov-type neutrino detectors usually involves a spin-based geomagnetic field compensation system to ensure maximum efficiency of the PMTs.

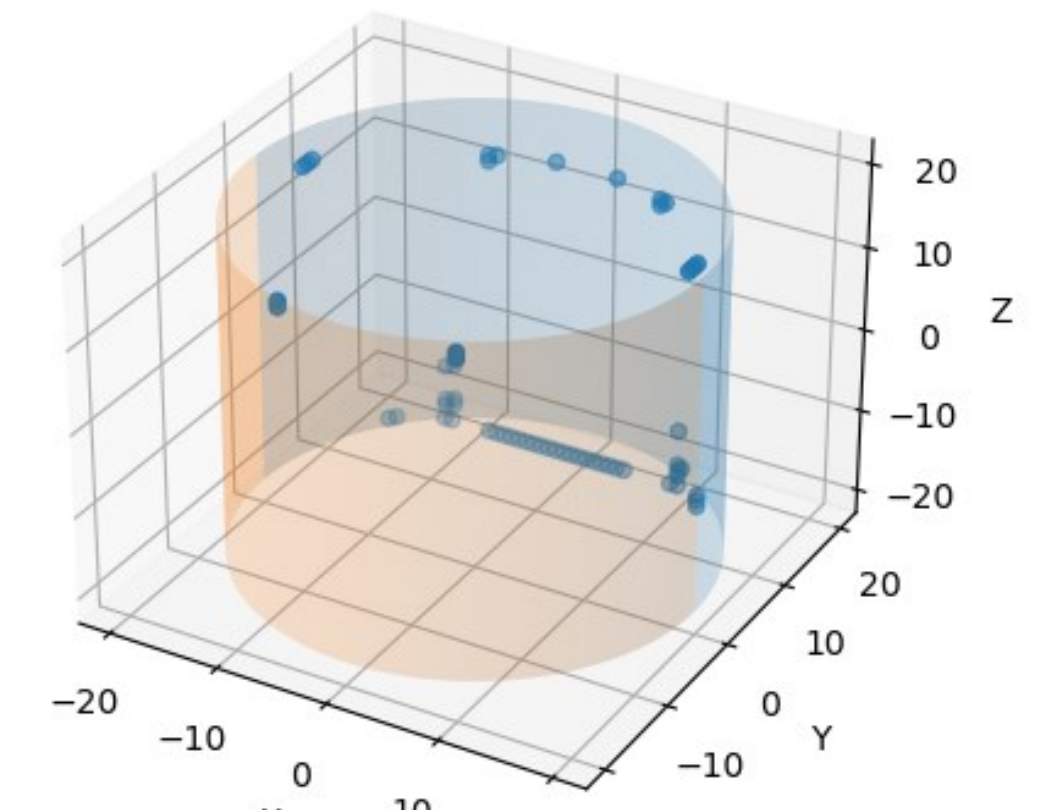
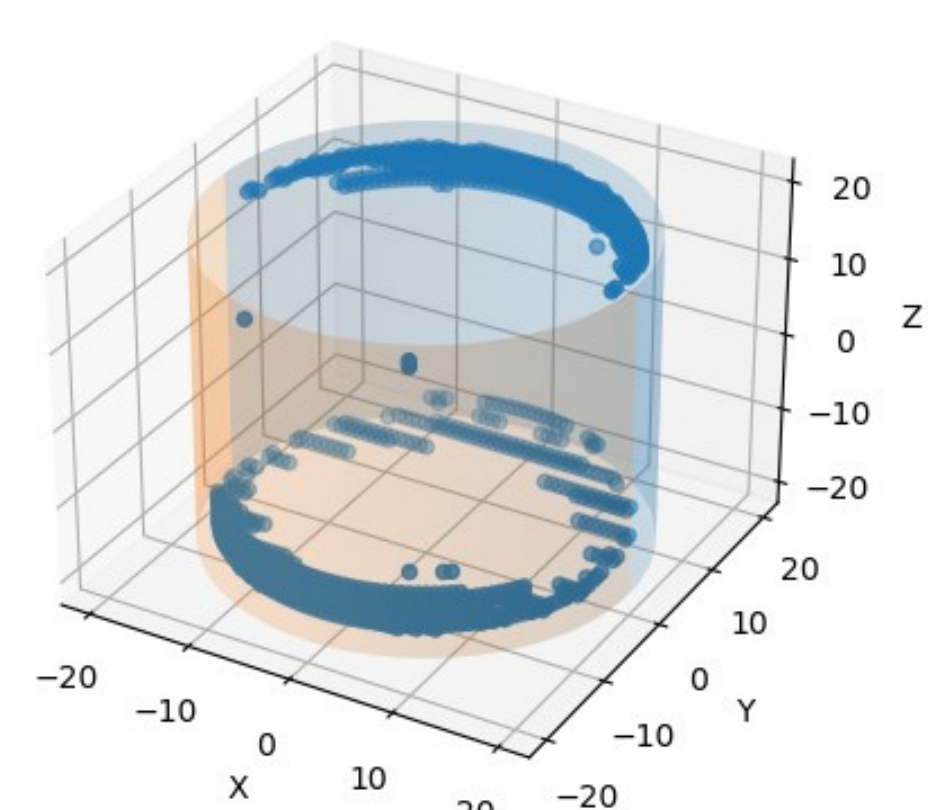


As part of the design work of the Hyper-Kamiokande detector compensation system, an exhaustive study has been carried out on the influence of different parameters involved, such as the size of the detector or the distance between PMTs and coils on the compensation efficiency, based on a basic design consisting of one set of circular coils and one set of rectangular coils.

One of the most important conclusions is how establishing an appropriate PMTs distance between PMTs and coils can greatly facilitate, both in terms of construction and economics, the installation of the compensation system.



In addition, once the basic configuration of loops has been established, certain modifications are proposed to compensate for the geomagnetic field in the most problematic areas of the detector, the top and bottom edges of the walls. Increasing the number of turns at the ends and adding elliptical coils to the bases we have designed reduces the proportion of PMTs with excess magnetic field to almost zero.



References

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2. Bonavera, L., et al. Astronomy & Astrophysics 639, A128
3. Z. Li et al. (Super-Kamiokande Collaboration) Phys. Rev. D 98, 052006