

1 Summer Research Project

For the Physics Research Placement programme I chose to work with Dr Elisabeth Falk as part of the Sudbury Neutrino Observatory (SNO+). SNO+ is a world leading experiment in neutrino detection, based in South-East Canada. My involvement was targeted towards characterising the dispersion of polymer and silica optical fibres, and also the light distribution with these fibres coupled with state-of-the-art lenses and diffusers.

2 Neutrinos

Matter is postulated to consist of two types of particles; Quarks and Leptons. Current experiments are trying to look beyond these but the Standard Model is known to comprise of three 'generations' of Quarks and Leptons:

	Quarks	Leptons
Generation 1	Up	Electron
	Down	Electron-Neutrino
Generation 2	Strange	Muon
	Charm	Muon-Neutrino
Generation 3	Top	Tau
	Bottom	Tau-Neutrino

Generation 1 are the most commonly found and stable particles. Up and Down Quarks combine to form protons and neutrons, electrons then combine with these to form atoms. Electron-Neutrinos are produced in the Sun.

There are many experiments worldwide interested in detecting neutrinos.



Fig. 1: The SNO in Canada [1]



Fig. 2: Double Chooz in France [2]

4 My Project

The calibration requires knowledge of how the light spreads when it leaves an optical fibre.

My project was to automate an experiment that uses state of the art equipment using LabVIEW – a program used worldwide in many hi-tech facilities.

Previously experiments had been undertaken that profiled the the dispersion of two types of fibres – plastic and glass, with diffusers aiming to spread the light.

This had been carried out manually so computerising the experiment will be increase the efficiency of these measurements.

In addition, I was given the task of researching into ball lenses, and designing an apparatus to be able to hold the lens so the output can be profiled.

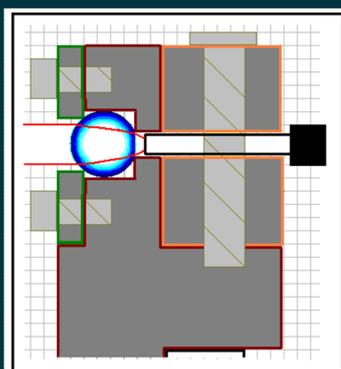


Fig 4: Design for Ball Lens Holder

3 Double Chooz

Did you know there are millions of neutrinos passing through your finger every second? Neutrinos are tiny particles that rarely interact with normal matter – which makes neutrino detection a very difficult and precise science.

The SNO+ experiment is a giant sphere, 12 metres in diameter - filled with a scintillator fluid that will emit a photon when a neutrino interacts with it.

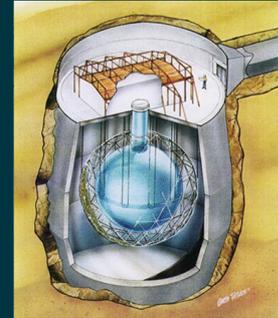


Fig. 3: The detector [3]

The detector lies 2 km underground in Sudbury, Canada.

The detector is surrounded by around 10,000 Photo-Multiplier Tubes (PMTs). Each of these are capable of detecting a single photon.

The University of Sussex's inclusion to this worldwide experiment is to create a calibration system that can check the performances of the PMTs. Light Emitting Diodes (LEDs) will be focused into optical fibres and these fibres will lead into the detector. The fibres will be at fixed points in the chamber and will be arranged so all the PMTs can be covered.

Whats the point of detecting neutrinos?

This experiment aims to progress the knowledge of Physics; the Standard Model of particles can be better understood, and a few questions from the Big Bang can be answered.

5 Results

The program was a quick success, and after spending some time perfecting it, profiles of the plastic and glass fibres with and without diffusers were attained.

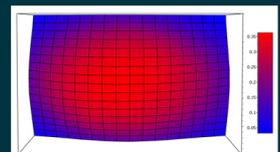


Fig 5: 2D profile of a PMMA fibre

The ball lens holder was created and some preliminary results were taken.

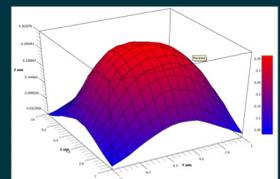


Fig 6: 3D profile of a PMMA fibre

I determined the alignment accuracy effects of the ball lens, as can be seen in Figure 7.

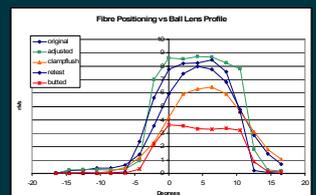


Fig 7

The data is encouraging for use in future experiments, but further profiling of the ball lens is necessary if this type of lens is to be implemented into the experiment.

Acknowledgements

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References

- [1], [3] - <http://snoplus.phy.queensu.ca/> [2] - <http://doublechooz.in2p3.fr>
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