Muon Tomography for Surveying Queen Maeve's Cairn

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Abstract

This poster details the development of our muon tomography detector in attempt to survey Queen Maeve's Cairn, a burial structure in Ireland. Muon tomography is the process of receiving cosmic muons through detection devices in order to determine internal structure. Muons get absorbed less by materials than other particles, which allows them to probe deeper into materials. The structure of the detector is two layers consisting each of a pair of orthogonal scintillators at a distance away from each other. As a muon passes through both layers, we can determine the position and angle of the muon through the detector. The signal from the detector is processed through a DAQ system for data analysis and image reconstruction. The data is then further compared to our Monte Carlo simulations and fed into a machine learning algorithm to improve its resolution and depth reconstruction.

DAQ setup

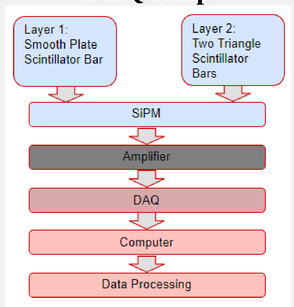
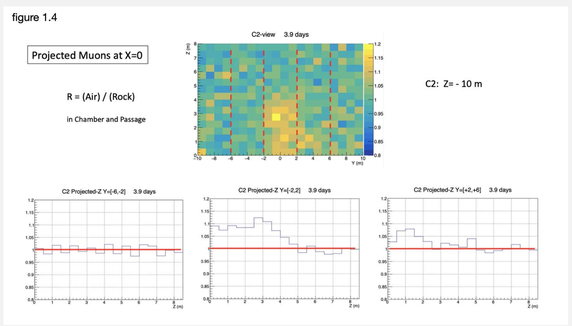


Diagram of current data processing system

Monte Carlo

We use Monte-Carlo simulations to create baseline data by simulating the geometry of the cairn and cosmic muon showers. One of the main goals of the Monte Carlo simulations is to find the ideal position of the detector.



Monte-Carlo Simulation of the cairn, indicating that we could detect it with our current resolution

Cairn specifications

Queen Maeve's cairn is a Neolithic monument in Ireland, that is one of the largest unexcavated of its kind in Europe. Lately, it has suffered drastic and rapid erosion due to visitors climbing on the monument, so it is urgent and an important discovery to have its internal structure mapped noninvasively.

Cairn estimated passage size

Estimated Passage dimensions=2x2x25 m Estimated inner Chamber dimensions=4x4x4 m

Dimensions of Cairn and surrounding hill

Previous Prototypes

-**Prototype 1A**- Our first prototype was a portable unit, consisting of 2 sets of orthogonally placed scintillator bars into PMTs. Data processing was handled by arduinos and a system of delay cables (giving us both ADC and TDC data)

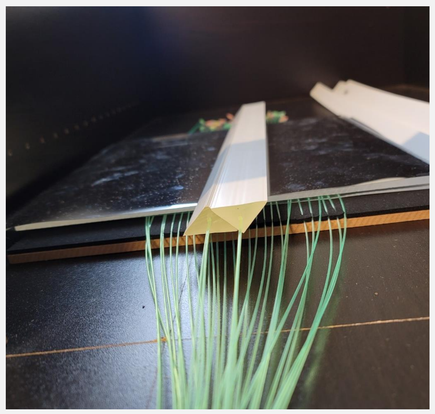
Prototype 1A

-**Prototype 1B**- Using the scintillator/PMT setup from prototype 1A, we spaced the layers further apart. This made it a fixed telescope, with which we collect resolution data in controlled environments. This detector is what the Monte-Carlo simulations use.

Prototype 1B

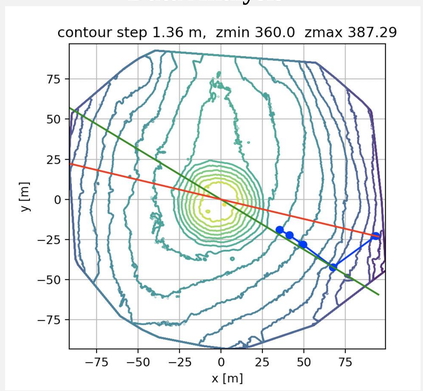
Current Prototype

-**Prototype 2A**- It comes with a unique set of parameters to map an underground large, outdoor archeological site. We have switched to a SiPM instead of PMTs, added optical fibers to the setup and have been experimenting with various scintillator setups.

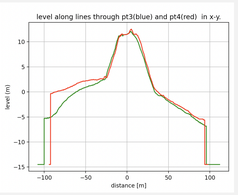


Prototype 2A

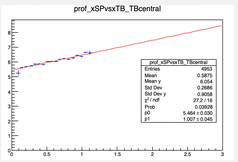
Data Analysis



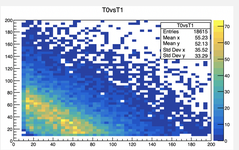
Contour map of Cairn



Plot based on the contour map of the different elevations that the detector will have to "see" through



Plot of position on triangle scintillator bars versus position on smooth plate scintillator bar



Plot of energy deposited in either triangle bar plotted with each other

Acknowledgement

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References

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