A Particle Trajectory Detector for Cosmic-ray Muons

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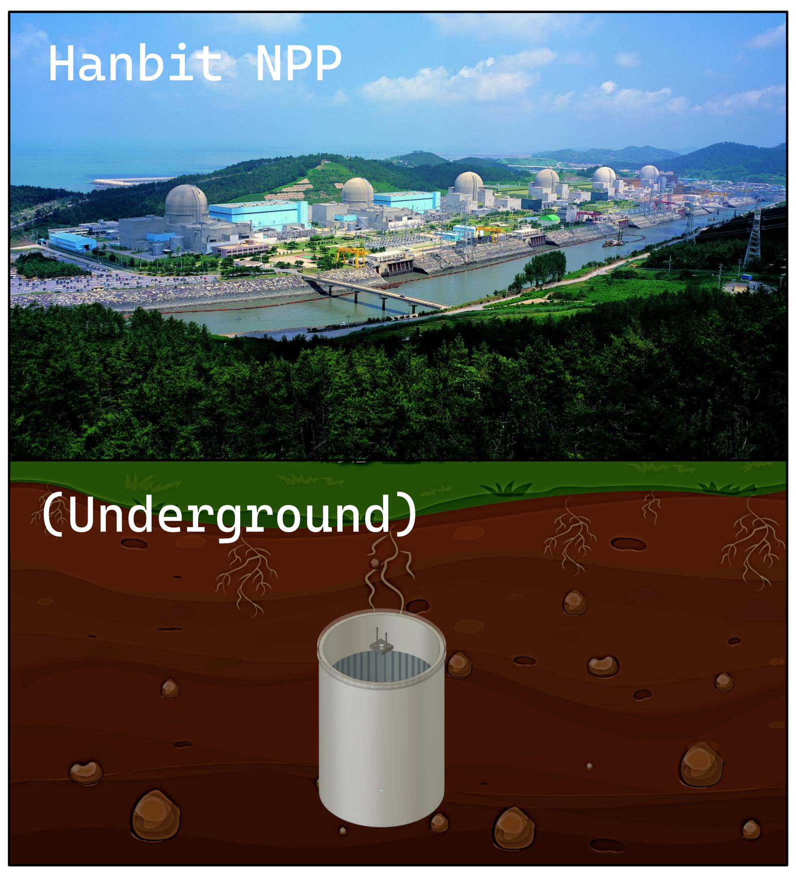
Abstract

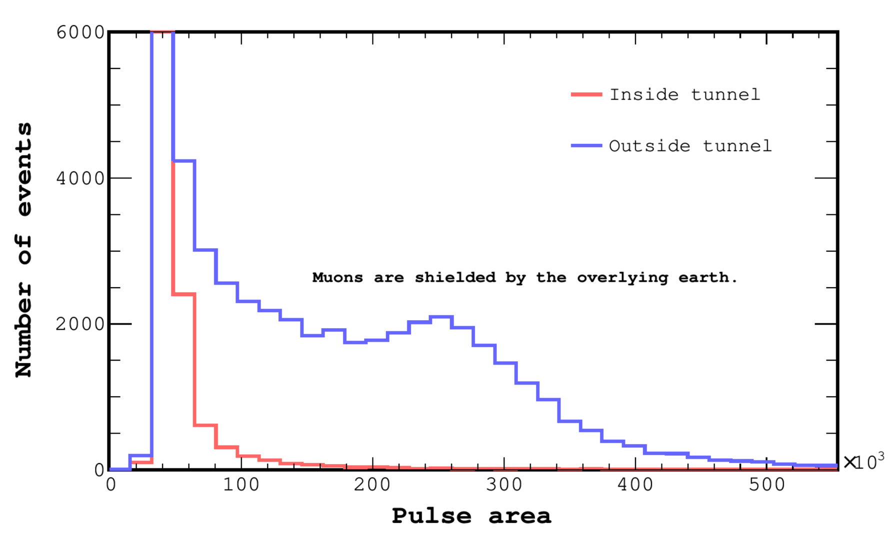
One of the basic requirements of experimental particle physics is the determination of *particle trajectories*. We have developed a muon-trajectory detector constructed of arrays of independent *Liquid Scintillator* (LS)-based detector modules; each mounted with a *Silicon Photodiode* (SiPM). Information can be extracted by connecting each detector to its own separate electronics, where ionisation events (or pulses) from the SiPM are processed and filtered to reject non-muon signals.

Introduction

An independent particle detector prototype "module" *(right)*. We used the S13360 series by Hamamatsu as the photon counting device and liquid scintillator as the photon emitting material. We can visualise the track info of incident cosmic muons by stacking these independent modules into an array.

The Muon Peak

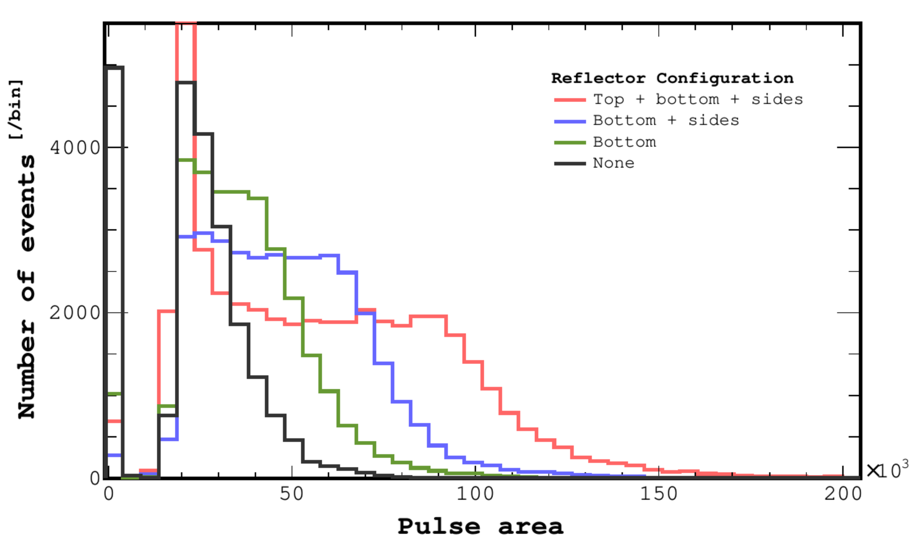


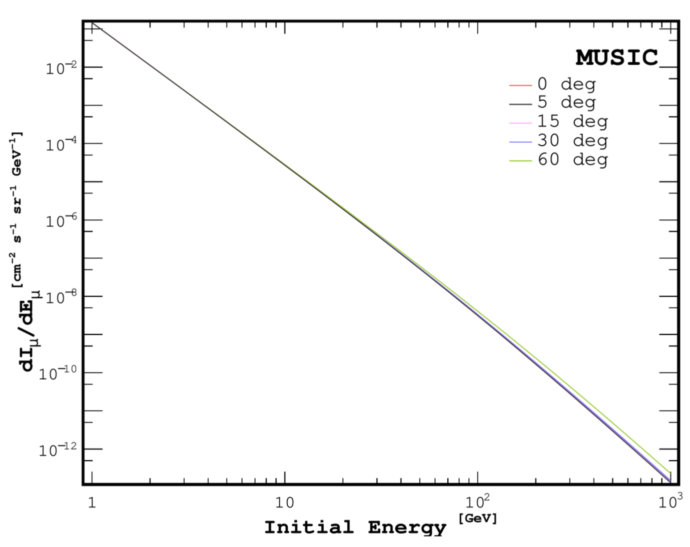


The muon peak identified *(above)*. All muons are shielded by the overlying earth located underground at Hanbit NPP.

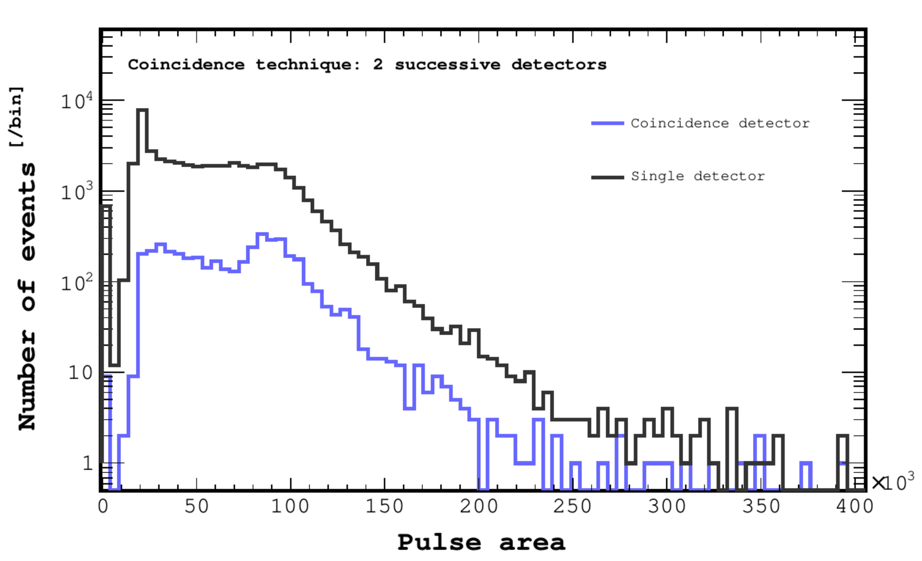
Preliminary Experiment

A typical example of a signal pulse *(above)*, which is liberated from the detector then digitised by the CAEN DT5730 digitiser.



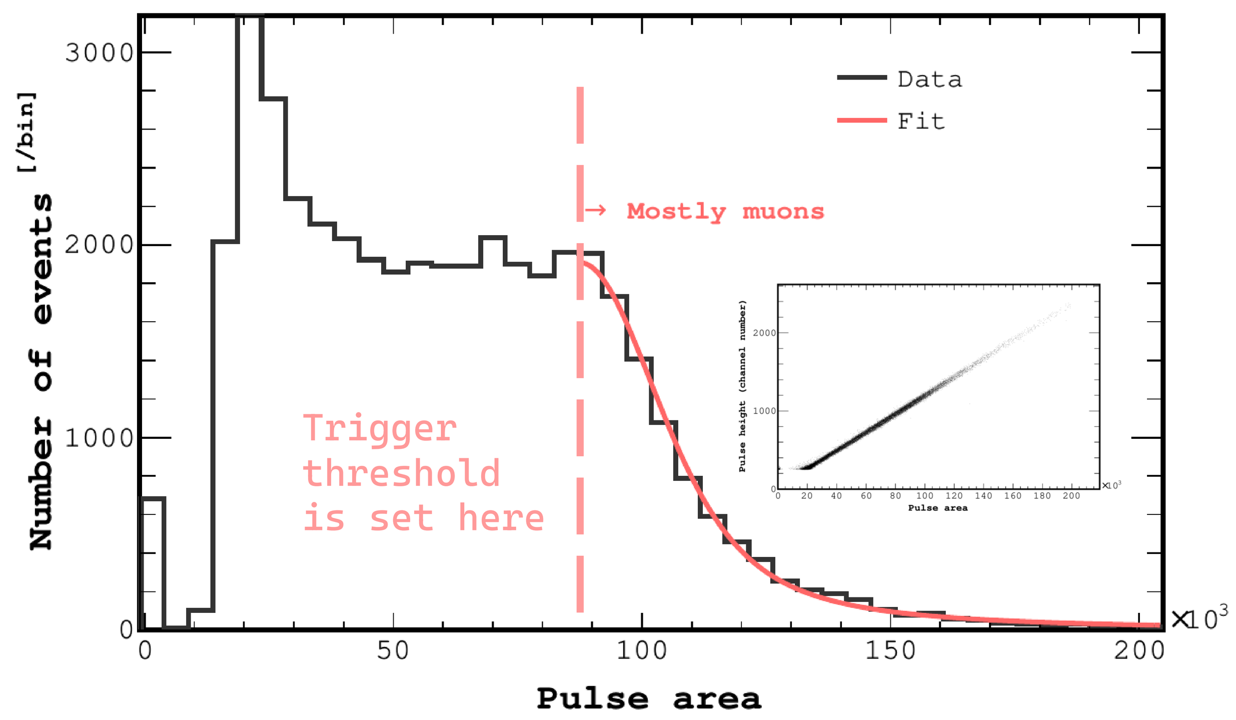


Detector light collection efficiency tests showed clear muon peaks *(top left)*. MC simulation of muon flux reproduced muon event rates *(top right)*.

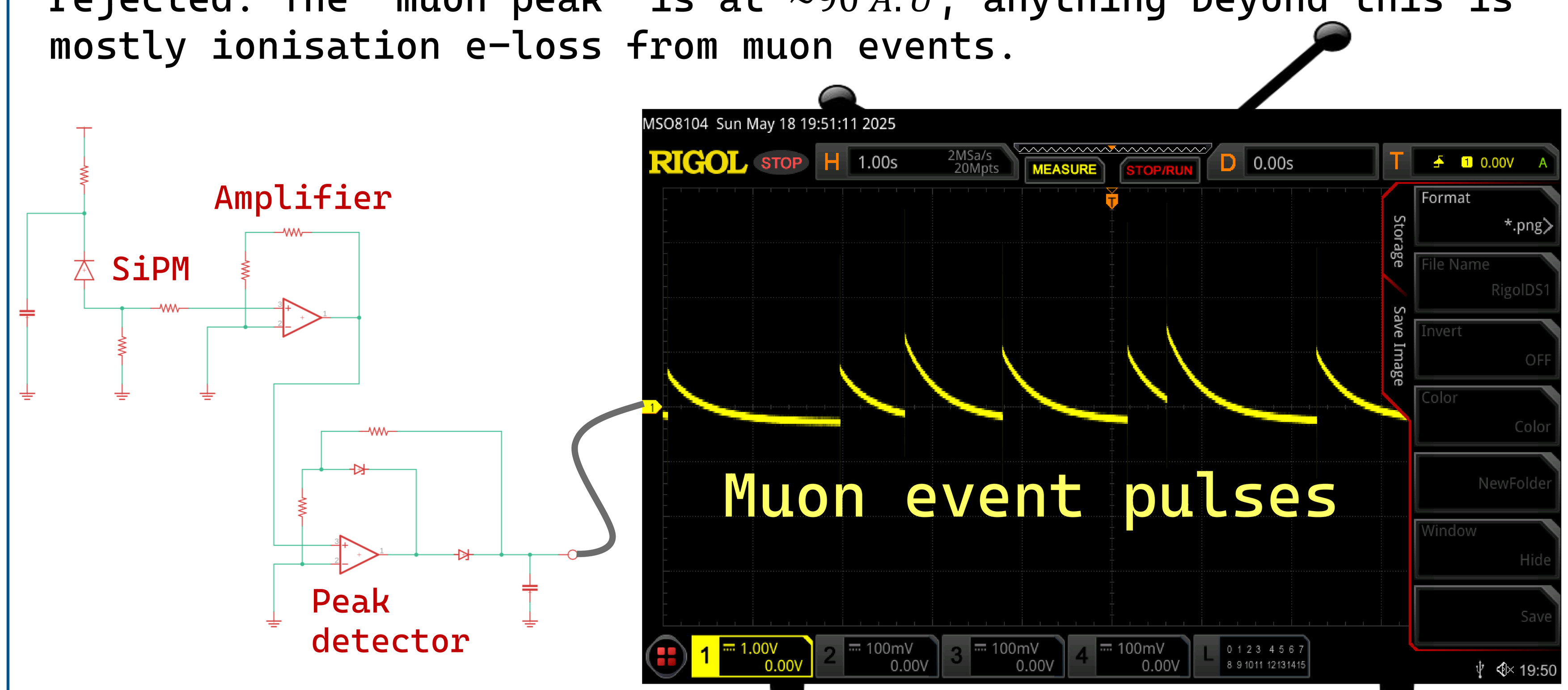


Using two stacked detectors in coincidence, we confirmed the peaks originate from cosmic muon scintillation events *(bottom left)*.

Signal Processing

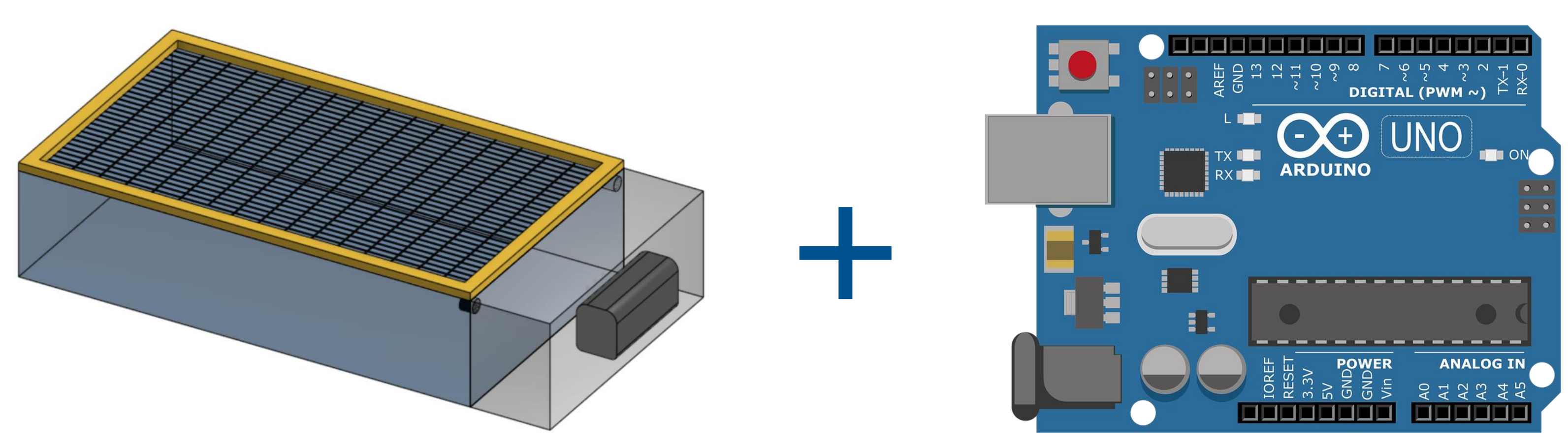


We verify the threshold on the electronics by identifying the most probable value of muon energy loss from the pulse area spectrum and is set low enough such that all valid signals are accepted but high enough so that noise and background events are rejected. The "muon peak" is at $\sim 90\,A.U$, anything beyond this is mostly ionisation e-loss from muon events.

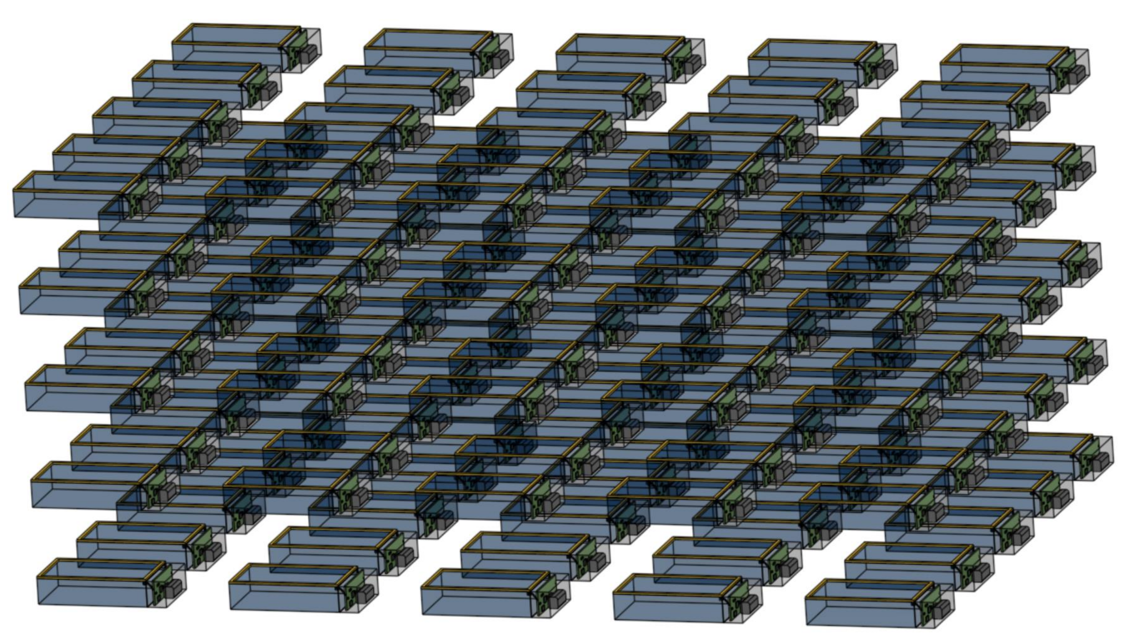


We have amplified and stretched the voltage pulse of muon events for further processing along the DAQ chain (Bottom right).

Future



Each detector is connected to its own separate electronics *(above)*, where ionisation events (or pulses) from the SiPM are processed and filtered to reject non-muon signals.



By stacking these detectors to form an $X-Y-Z$ array *(left)* and using the coincidence between these detectors as a trigger, we obtain the 3D event rate and track info of cosmic muons.

Conclusion

Up to now, we can read the positions through an LED attached to each detector which allows a reconstruction of the track.