Expected Performance of Cosmic Muon Veto Detector at IICHEP, Madurai, India.

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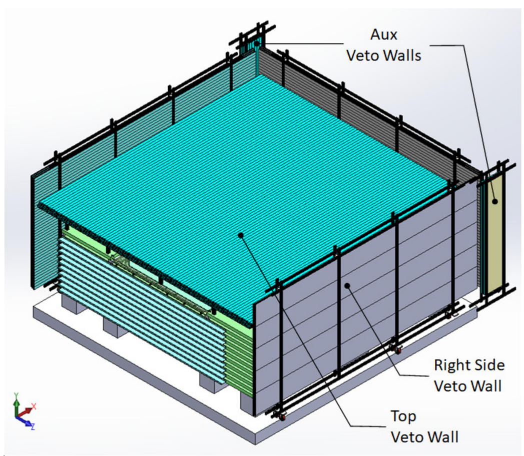
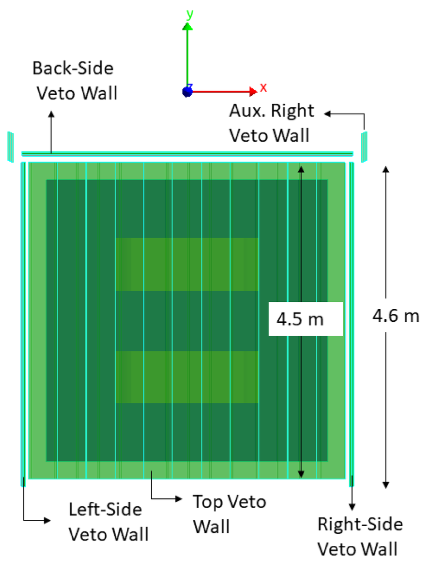
Objective

- Explore feasibilty of building a large scale neutrino detectors at shallow depths.
- Achieve muon veto efficiency of over 99.99 % simultaneously mainintaing fake rate of less than 10^{-5}.

Cosmic Muon Veto Detector





- Active Detector: Extruded Plastic Scintillator (EPS)
- Light Collection: Two 1.4 mm dia double clad WLS
- Readout: 2mm × 2mm Hamamatsu SiPM's
- ≈ 750 EPS and 3000 SiPM's

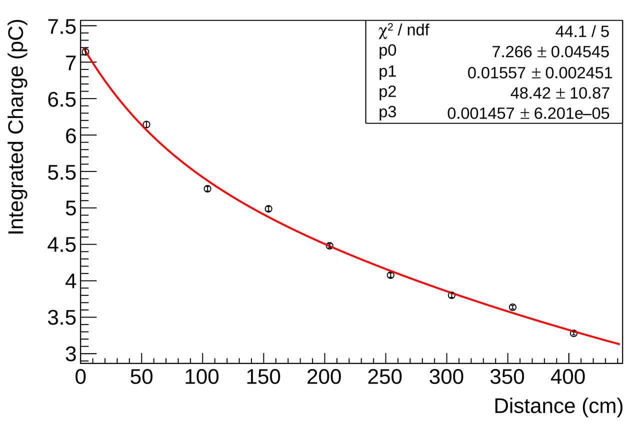
Veto Wall	# of Layers	Layer staggering	# of EPS	EPS dimensions
Top	4	12.5 mm	88/Layer	$4.5\,m \times 5\,cm \times 1-2\,cm$
Right Side	3	15 mm	40/Layer	$4.6\,m \times 5\,cm \times 1\,cm$
Left Side	3	15 mm	40/Layer	$4.6\,m \times 5\,cm \times 1\,cm$
Back Side	3	15 mm	40/Layer	$4.7\,m \times 5\,cm \times 1\,cm$
Auxiliary	3	15 mm	1/Layer	$2.1\,m \times 5\,cm \times 2\,cm$

Charge Measurement

- **Birk's Scaling:** Light yield scales with energy deposition:

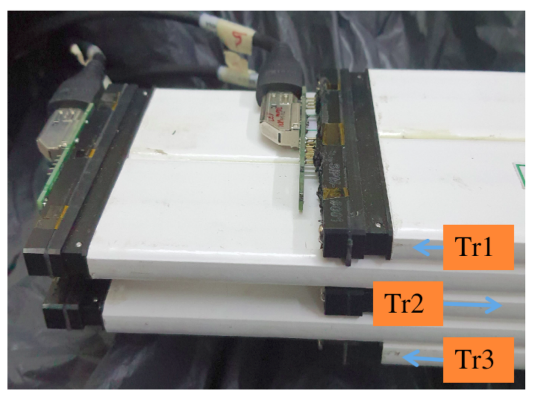
$$\frac{dL}{dx} = \frac{\frac{dE}{dx}}{1 + kB \times \frac{dE}{dx}}$$

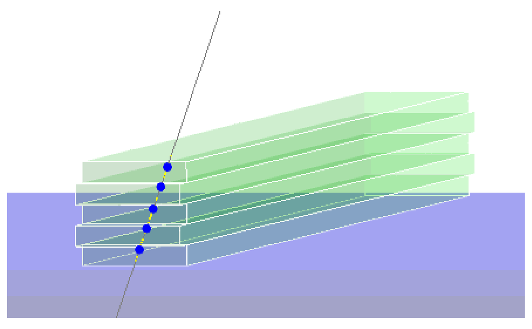
- **Photon Production:** Follows Poisson distribution with mean $Y \times E_{\text{dep}}$.
- **Photon Detection:** $N_{\text{SiPM}} = N_{\text{prod}} \frac{p_1 e^{-p_1 x} + p_2 p_3 e^{-p_3 x}}{p_1 + p_2 p_3}$
- **Observed Charge (Q):** Gaussian with mean $G_{\text{SiPM}} \times N_{\text{SiPM}}$ and variance $\sigma^2_{\text{ped}} + N_{\text{SiPM}}\sigma^2_{\text{sig}}$.

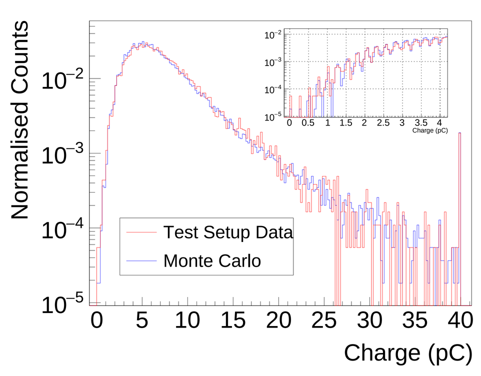


kB	0.126 mm/MeV
Y	0.016 p.e./keV
G_{SiPM}	0.257 pC
σ_{ped}	0.004 pC
σ_{sig}	0.022 pC

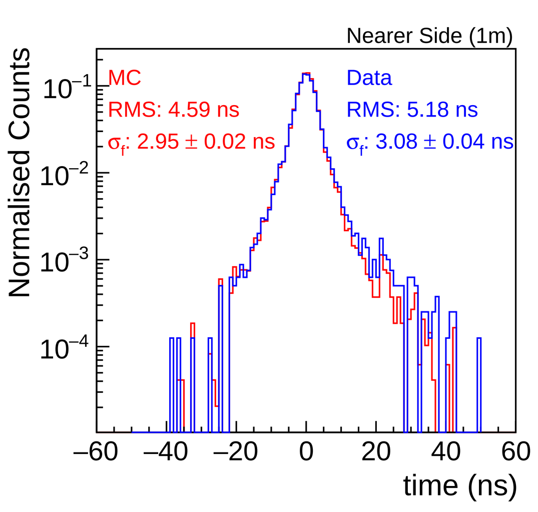
Model Validation

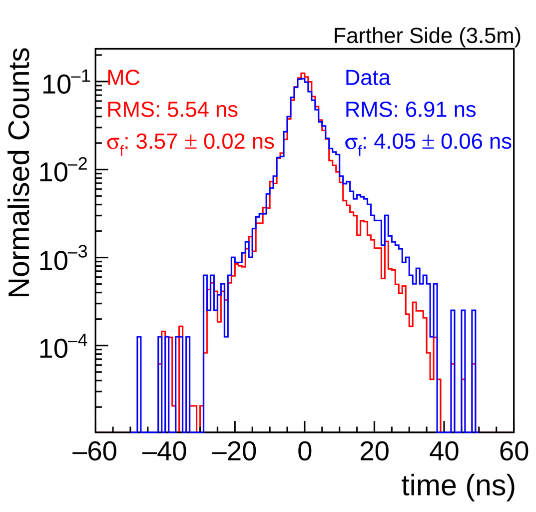






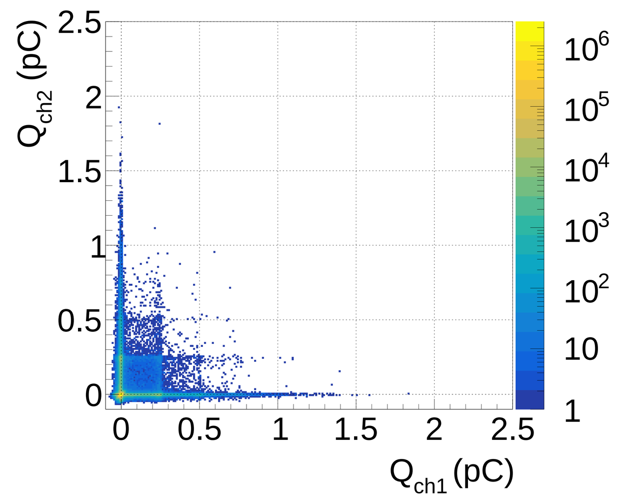
Timing Performance

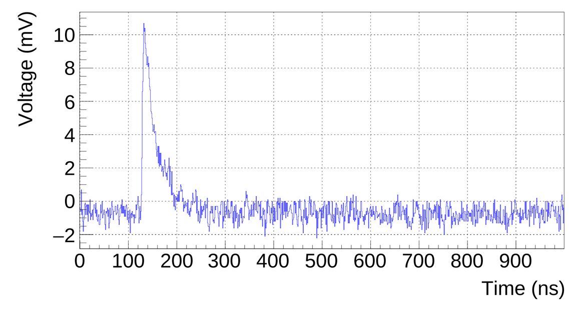




- Time resolution is mainly affected by the Y-11 WLS fiber's 7ns time constant.
- Position uncertainty: $36.76 \pm 1.13\ cm$.
- Larger position uncertainties for low charge signals over longer distances.

Integrated Dark Noise





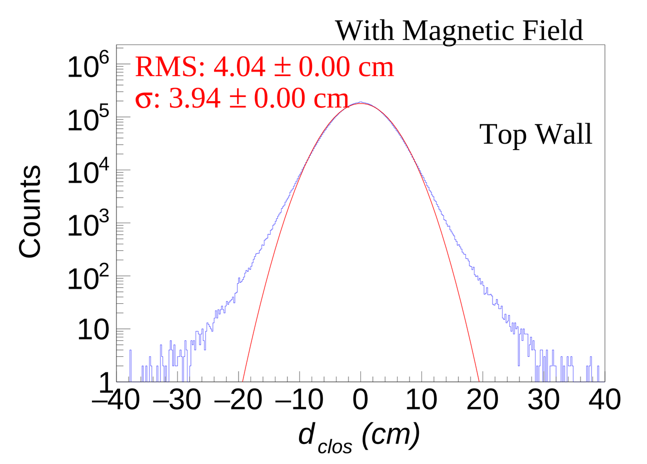
- Integrated ($100\,ns$) dark noise added in all ∼ 3000 SiPM.
- Noise event Tagging.

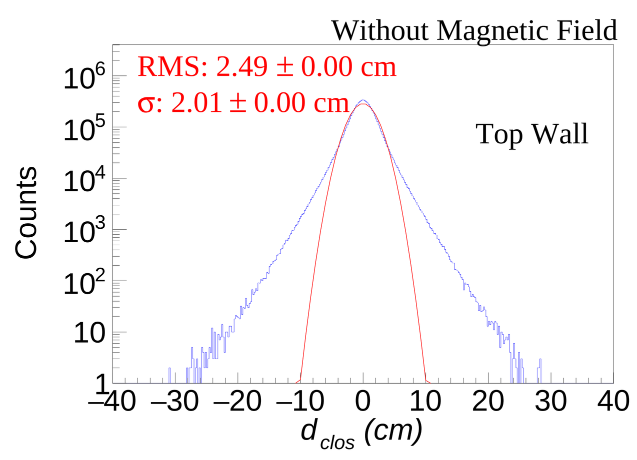
Clustering Scheme

- Hit formation 2 or SiPM's have signal > 2.5 p.e.
- Nearby related hits in a layer are combined into "Clusters".
- Clusters are combine to form doublets, then triplets if related.
- SuperCluster: In the top wall, triplets and doublets combine to form quartets.

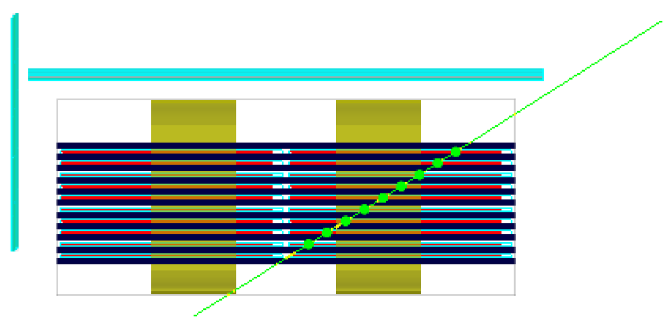
Track Reconstruction and Extrapolation

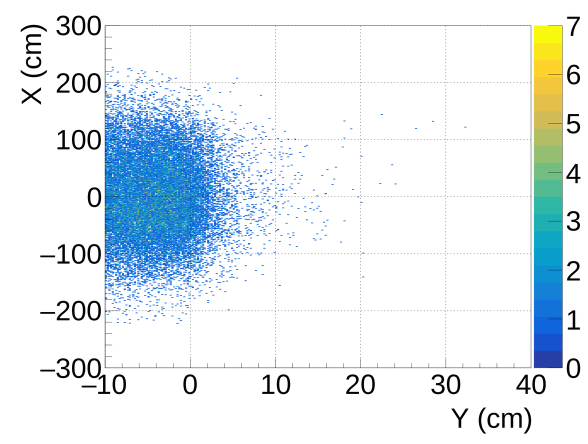
- With Magnetic Field: Kalman Filter based algorithm.
- Without Magnetic Field: Least Square Method.
- Extrapolation: Evaluate closest distance, d_{clos} between track and EPS.



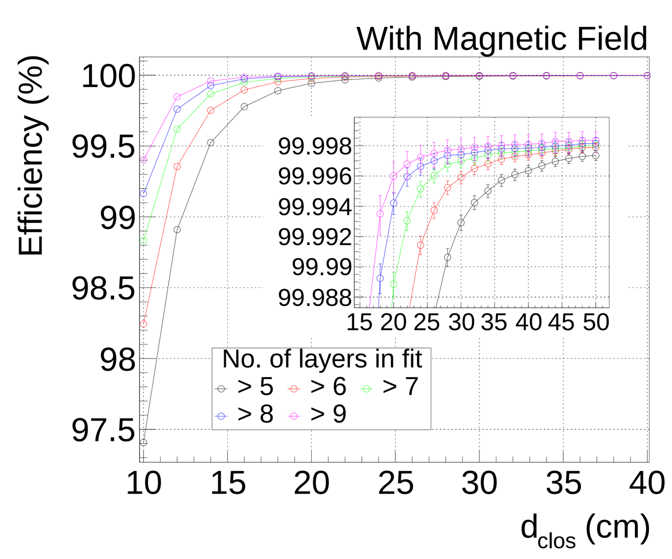


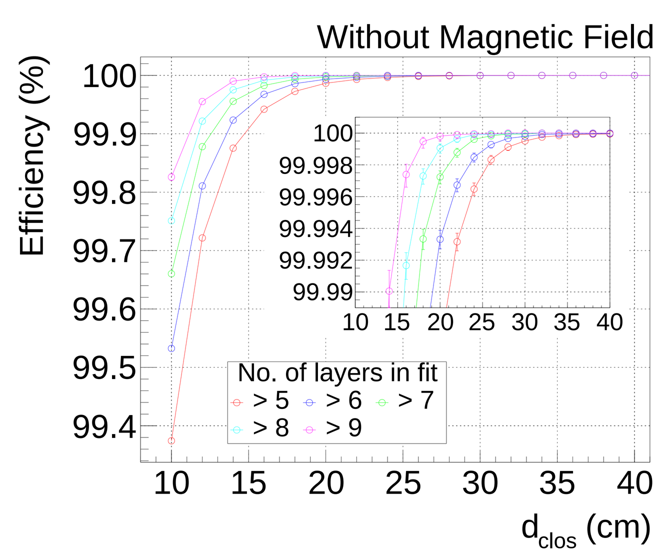
Effective Area of Veto Walls

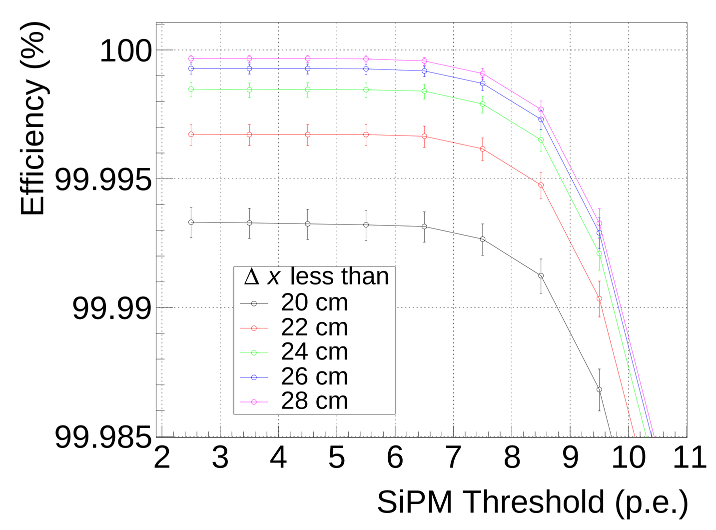


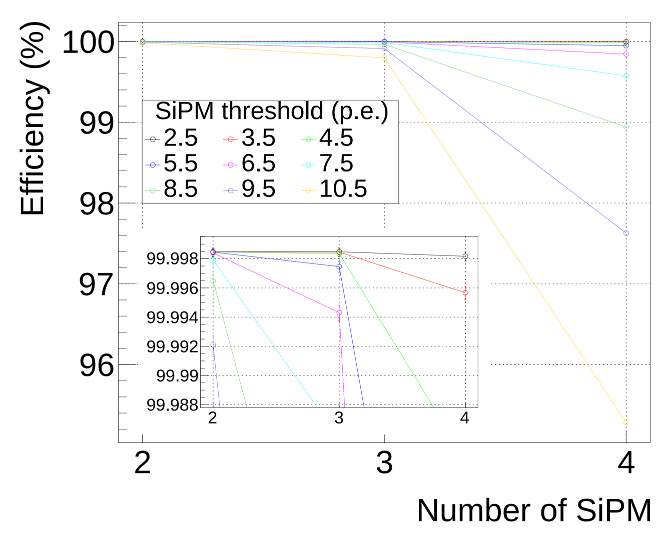


Expected Performance









Summary

Software is developed based on inputs from experimental data to evaluate the performance of CMVD around miniICAL. Using extrapolated muon tracks from the miniICAL, veto criteria is established to achive efficiency > 99.99 %. Observed efficiency is $99.9929\% \pm 0.0005\%$ for d_{clos} up to 30 cm with magnetic field. Additionaly the purity of the simulated sample ($\sim 8.5M$) is observed to be 100.