SBS GRINCH Gas Cherenkov Detector

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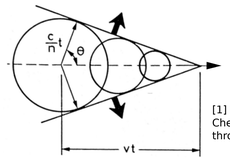
Abstract

The **G**as **R**ing **I**magi**N**g **CH**ernkov (**GRINCH**) is a heavy gas cherenkov threshold detector in the BigBite Calorimeter in Hall A at Jefferson Lab. As a component of the Super BigBite (SBS) spectrometer, it's purpose is to distinguish pions from electrons in scattering experiments. The GRINCH was installed in Hall A in Spring 2021. It was filled with heavy gas and began taking experimental data during the GMn experimental run in January 2022. This poster gives an overview of the commissioning during the run and the preliminary performance results of the GRINCH.

Cherenkov Light

When a particle travels through a medium at a velocity greater than the speed of light in that medium, it creates a cherenkov light cone. The light propagates through the medium and can be detected by photomultiplier tubes (PMTs) as a ring in a chereknov detector.



[1] Propagation of Cherenkov light through a medium.

Electrons will have a greater velocity than a pion at the same momentum due to their smaller mass. A medium with a certain index of refraction can be chosen so that electrons will cherenkov and pions will not, up to certain momentum threshold. This momentum is often called the Pion Threshold.

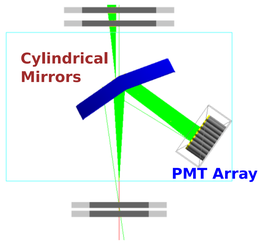
GRINCH Design

510 29-mm Photomultipler Tubes (PMTs) in a Honeycomb array

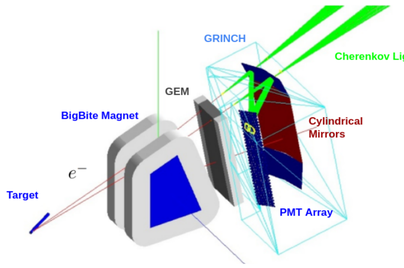
4 highly reflective cylindrical mirrors

C_4F_8O Heavy Gas

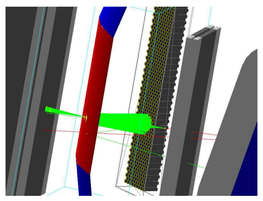
2.7 GeV/c Pion Threshold



Top View



[2] GRINCH GEANT4 Simulations



Side View

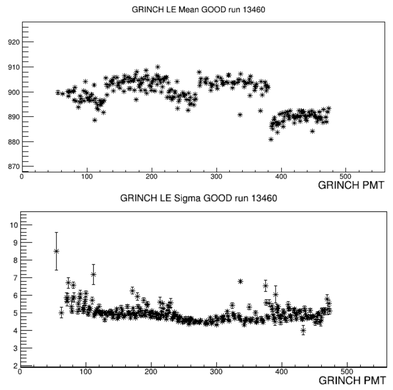
GMn Data

Background Rate = [hits/bin] / ([bin size] * [trigger events processed])

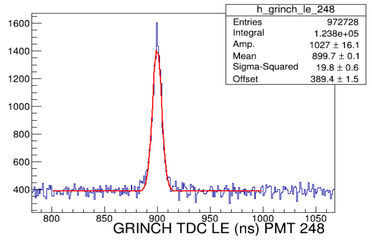
Background rate ~250 KHz for each PMT

Timing Resolution ~5 ns (Sigma on gaussian fit)

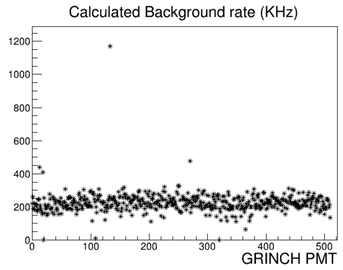
0.25% Occupancy on each PMT for a 10 ns window



Mean (top) and sigma (bottom) values from gaussian fit for GRINCH Leading Edge (LE), run 13460.



Leading Edge (LE) histogram for PMT 248, run 13460.



Calculated background rate for each PMT, run 13460.

Cluster Finding

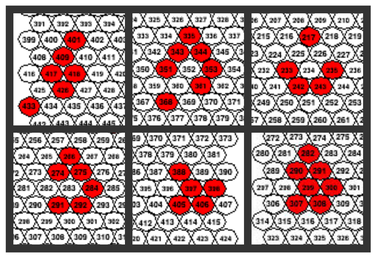
Requires hits on 3 or more neighboring PMTs in the array.

Large timing cut of 40ns in this example.

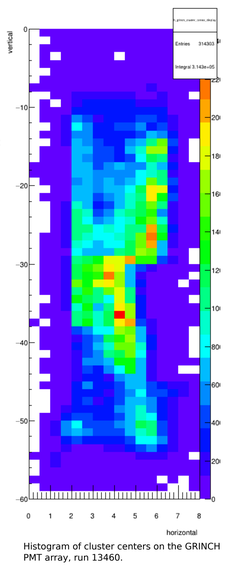
Heat Map of cluster centers shows how the mirrors focus the light onto the PMT array.

87% Preliminary efficiency results using cluster finding.

[3] GRINCH PMT array as seen from inside the detector.



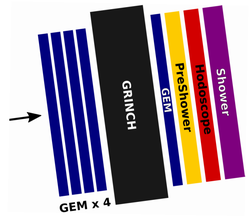
Examples of clusters from electron events, run 13460.

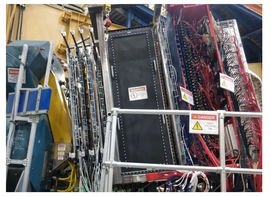


Histogram of cluster centers on the GRINCH PMT array, run 13460.

GRINCH in BigBite

An electron event is detected in GRINCH by looking for the ring created by the cherenkov light cone in the PMT array. When put in series with the other detectors in the BBCal detector package, the GRINCH allows for distinction between pions and electrons of the same momentum.



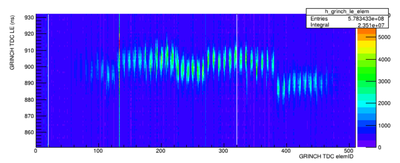


BigBite Magnet and BigBite Calorimeter installed in Hall A.

Next Steps

Leading Edge (LE) timing needs to be calibrated for each channel in order to make a tighter cut.

Trigger timing corrections from the Timing Hodoscope need to be accounted for.



2D histogram of the LE for all the GRINCH PMTs, run 13460.

Incorporate Particle Tracking from the GEMs to investigate behavior of the mirrors.

Calculate the running efficiency of the GRINCH after implementing the above improved analysis.

Conclusions

The GRINCH is a gas cherenkov detector designed and built for the SBS spectrometer in Hall A. Its purpose is to distinguish between pions and electrons in scattering experiments. The GRINCH began taking data for electron events in January 2022 during the GMn experimental run. Data analysis tools such as a cluster finding algorithm have been developed implemented and are in the preliminary stages of producing calibration and performance statistics.

References

[1] *Techniques for Nuclear and Particle Physics Experiments*, W.R. Leo

[2] *GRINCH Detector Technical Document v.11*, Averett, Yao, Wojtskhowski, 2012

[3] Carlos Ayerbe Gayoso, 2018

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