

Cherenkov Detector for High Energy Cosmic Ray Observation



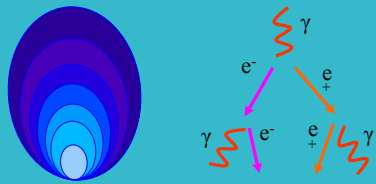
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What is Cherenkov Radiation?

Cherenkov radiation is emitted due to a charged particle going faster than the speed of light. This can be achieved when the particle passes from one medium with a low index of refraction to one with a high index of refraction. By traveling into the new material, the maximum speed of light lowers; the particle travels faster than light could. As the particle goes by atoms, the electrons in the atoms become excited by the change in the electric field, and are given extra energy. To return back to the preferred ground state, these electrons must emit the energy given to them through high energy photons. These photons undergo pair production, which in turn creates more interacting particles.



The primary particle (light colored) arrives sooner than the other particles created in the shower

Cherenkov Radiation Feynman diagram. The chain reaction occurs until a set energy

What is the Role of the Cherenkov Detector?

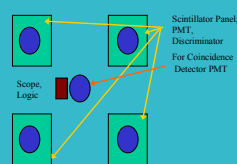
The Cherenkov detector will be used in reconstructing both the energy and direction of high energy particles as the photons created by the atmospheric interactions strike the detectors. The detector itself will be placed on many of the currently planned stations, to help with reconstruction of the shower. The large number of stations will also serve as a check on the timing information necessary to reconstruct the angle of the cosmic ray.

Incorporation of the Cherenkov detectors at each of these stations will allow for less dependence on expensive fluorescence detectors, currently used at Auger South. The cost per Cherenkov detector compared to a fluorescence detector is less than 1:1000 is materials alone.

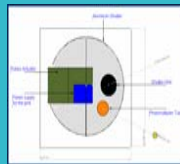
Design

The main detector unit is made up of three major components; the photomultiplier tube (PMT), the actuator, and the housing itself (picture above).

- PMT chosen to be sensitive to UV and blue light, the energies commonly associated with Cherenkov radiation.
- Actuator controls a shutter which shields the light sensitive PMT in case of a loss of power.
- Housing unit is made of aluminum to reduce scattering of photons that may enter the housing unit



When electrons pass through the scintillator, it emits light, which is detected by the PMT on top of the panel. This detection is converted into a negative square pulse by a discriminator and inverter. This output is sent to a central logic unit. Upon coincidence a computer records the data from the main PMT.



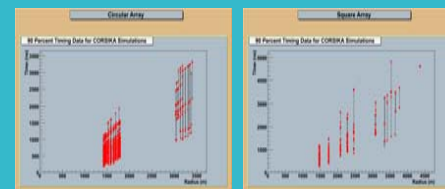
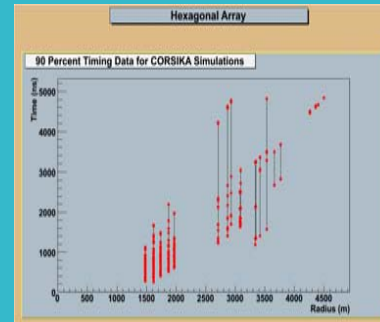
Cherenkov Detector Schematic diagram. The photomultiplier tube incorporated is responsible for detecting photons.

Current Progress

- Main detector built
- Scintillator panels ready; power supplies built
- Coincidence Circuitry; Discriminators built and work; inverter design done, 1/4 done
- Actuator power measured

Simulations

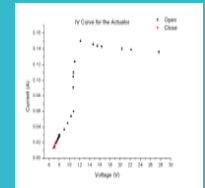
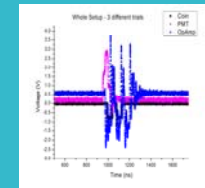
Simulation work was done to find a viable, efficient array geometry for the Auger North array. CORSIKA was used as the workhorse of simulating shower data, while analysis and array creation was coded. By binning the shower particles into 10m bands where detectors are located and taking only the middle 90% of these particles, the robustness of the thinning parameter was investigated. Three arrays were designed to test various geometries: square, circular, and hexagonal.



Results of array simulations. The results show less thinning is required. The advantage of the hexagonal array over the circular array is the breadth of distance data points. The advantage over the square array is a more uniform spacing of data points as well as more data at large distances.

Summary

- Low cost Cherenkov design is a feasible supplement to the fluorescence detectors according to lab tests
- Power consumed by components is low enough to be feasible for a battery recharged daily by solar panels
- Hexagonal array yields the greatest variation in distance from a shower's center; unique data points
- Field testing of the detector to be performed within the month



Results from testing the coincidence circuitry in the lab. The next step is to take observational data.

Power curve for the actuator. It is important to get a low power actuator, as to keep energy efficiency as high as possible.

Future Study

- A redesign of the shutter system on the main detector. Removing the last moving component is equivalent to removing the last piece of the detector which can be expected to break. By experimenting with photovoltaic glass, one may be able to further reduce the power consumed by the station during operation.
- Work on solar panels to increase both efficiency of placement of detectors on the actual Colorado cite and power stored by the solar powered batteries.
- Simulating additional shower data in CORSIKA using less thinning. Now that a tool to measure the quality of thinning has been created, optimization runs, with respect to computing time, of data simulation can occur.

Acknowledgements

Corbin Covault - Case HEA group leader and PI
 Don Driscoll - Initial help with coding strategies
 Erin Vanderpan - CORSIKA output file
 Ross Burton - Aiding with PMT related issues as well as networking issues
 Bob Sobin - Circuit design and help with coincidence electronics
 Edgar Wilson - PMT help and machining wisdom
 Melissa DeLucchi - Coding help and computer issues
 AUGER Project Team
 SOURCE - Funding for summer of 2005