

FIRST LINE OF TITLE
SECOND LINE OF TITLE

by

Author

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Semester Year

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Author

Approved: _____

Xxxx Xxxx, Highest Degree
Chair of the Department of Xxxx

Approved: _____

Xxxx Xxxx, Highest Degree
Dean of the College of Xxxx

Approved: _____

Louis F. Rossi, Ph.D.
Vice Provost for Graduate and Professional Education and
Dean of the Graduate College

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ABSTRACT

Chapter 1

COSMIC RAYS ASTROPHYSICS

For centuries, physicists and the like have studied radiation, charges, and similar phenomena. However, radiation was always assumed to be from the ground. Until XXXX when SOME GUY proposed the idea that radiation could come from space.

The first instrument used to study these processes was the electroscope, a simple device used to detect the presence of charge.

designed to detect the presence of charge was the electroscope.

Studies were conducted using electroscopes, the first instrument designed to detect the presence of charge, to prove various properties of radiation and radioactive materials. Marie and Pierre Curie Yet, over 100 years ago, some physcisits had the idea that

The Universe is beaming with astrophysical processes occurring at various energy scales. At each energy scale, the physical processes occurring at these astrophysical objects produce charged particles, referred to as cosmic rays. Yet,

Cosmic rays span over ten orders of magnitude in energy, with the highest energy cosmic rays exceeding the center of mass energy of the Large Hadron Collider (LHC) collisions by several orders of magnitude.

1.1 Title of Section

This is the information for the first section of the first chapter.

Chapter 2

FUTURE PROSPECTS: SKALA RADIO ANTENNAS AT AUGER

The Pierre Auger Observatory hosts several prototype detectors and pathfinder air-shower arrays in addition to the detectors discussed in chapter 1. This location greatly benefits prototyping new detectors because of the existing structure of the Auger observatory, allowing ease of access for detector maintenance and assistance from the local observatory staff when feasible. Since 2022, 21 total SKALA (Square Kilometer Array Log-periodic Antenna) radio antennas have been deployed at Auger in the 433 m spaced array of SD tanks. These SKALA antennas are Log-Periodic Dipole Antennas (LPDAs), similar to the AERA LPDA antennas, and were originally designed for the Square Kilometer Array’s low frequency telescope in Western Australia. However, certain future cosmic-ray observatories with a surface radio component, such as IceCube-Gen2 and the Radio Neutrino Observatory Greenland (RNO-G), use SKALA antennas to reconstruct and/or veto cosmic ray air showers. This chapter discusses deployment, hardware specifications, and preliminary analysis from SKALA antennas deployed at the Pierre Auger Observatory.

2.1 An IceCube-Gen2 Prototype Station at the Pierre Auger Observatory

IceCube-Gen2 is a future upgrade of the existing IceCube Neutrino Observatory at the South Pole. The upgrade plans to increase the volume of the current in-ice optical array from 1 km^3 to approximately 8 km^3 , in addition to deploying an in-ice radio array for neutrino detection and a surface array of scintillator panels and radio antennas for cosmic ray air shower detection. The planned surface array will span nearly 6 km^2 to cover the full optical array extension, serving both as a veto to the optical array and to reconstruct cosmic-ray air showers and their properties. Each station of the surface

array consists of eight scintillator panels, three SKALA radio antennas, and a central fieldhub hosting the local DAQ of the station. A schematic of the surface station layout at the South Pole is shown in INSERTFIGURE. A first prototype surface station was deployed at the South Pole in January 2020, with two more deployed in January 2025. All South Pole prototypes have been mostly stable in their operations and data taking since deployment. See INSERTREFERENCES for specifics regarding these stations.

In August 2022, a prototype surface station was deployed at the Pierre Auger Observatory. The Auger prototype station has roughly the same design as the South Pole prototype stations, yet slightly different geometry and spacing due to the topology of the location (see INSERTDRONEPICTURE). Other differences include the need for fencing around each detector position to prevent damage from roaming animals, and the lack of height adjustable stands, unnecessary in Argentina as constant snow accumulation is not an issue like at the South Pole. The prototype station is co-located in both the AERA footprint and the densest part of the SD array to serve the main science goal of coincident air-shower measurements with Auger detectors.

2.1.1 Station Layout and Design

Each arm of the Auger prototype station spans about 70 m in length, with a pair of scintillator panels at the ends of each arm. Another pair of scintillator panels lies at the station center, along with the station's local DAQ labeled as TAXI in INSERTLAYOUTSCHEMATIC. Halfway between the station center and the end of each arm is a SKALAv2 type radio antenna. The SKALA antennas have two perpendicular polarizations, each with their own Low Noise Amplifier (LNA) housed in the top most part of the antenna, the trumpet; however, not all antennas in this prototype station have the same orientation (see INSERTLAYOUTWITHSCHEMATIC). The LNAs connect to a type-N coaxial cable that is buried and connected to the TAXI DAQ while each scintillator panel is also connected to TAXI via buried coaxial cables. Power and communications for the DAQ comes from the Central Radio Station (CRS).

Air showers are measured by a coincidence requirement between scintillator triggers.

REFERENCES

Lastname, Firstname “Title.” *Journal*, Year.

Lastname, Firstname, and Firstname Lastname. *Title of Book*. Publisher, Year.

Appendix A

TITLE OF APPENDIX

This is the information for the first appendix, Appendix A. Copy the base file, appA.tex, for each additional appendix needed such as appB.tex, appC.tex, etc. Modify the main base file to include each additional appendix file.

If there is only one appendix, then modify the main file to only use app.tex instead of appA.tex.