THE EXTREME UNIVERSE

OBSERVATIONS OF THE HIGHEST ENERGY PHENOMENA WITH VERITAS

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VERITAS

Smithsonian Astrophysical Observatory
Purdue University  Iowa State University  Washington University in St. Louis
University of Chicago  University of Utah  University of California, Los Angeles
McGill University  University College Dublin
University of Leeds  Adler Planetarium  Argonne National Lab
Barnard College  DePauw University
Grinnell College  University of California, Santa Cruz
University of Iowa  University of Massachusetts
Cork Institute of Technology  Galway-Mayo Institute of Technology
National University of Ireland, Galway  University of Delaware/Bartol Research Institute
Very Energetic Radiation Imaging Telescope Array System
VERY ENERGETIC RADIATION IMAGING TELESCOPE ARRAY SYSTEM
Origin of Very Energetic Radiation

CLOSE TO HOME: WITHIN OUR GALAXY

CRAB NEBULA
SUPERNOVA REMNANTS
PULSARS AND BINARIES
Origin of Very Energetic Radiation

CLOSE TO HOME: WITHIN OUR GALAXY

CRAB NEBULA
SUPERNOVA REMNANTS
PULSARS AND BINARIES

CREDIT: NASA'S CHANDRA XRAY IMAGING OBSERVATORY

CREDIT: NASA'S HUBBLE SPACE TELESCOPE IMAGE

CREDIT: ARTIST IMPRESSION: HTTP://WWW.AST.LEEDS.AC.UK/RESEARCH/TEV.HTML
Origin of Very Energetic Radiation

FAR FROM HOME: EXTRAGALACTIC
ACTIVE GALACTIC NUCLEI
STARBURST GALAXIES
GAMMA RAY BURSTS

CREDIT: Aurore Simonnet, Sonoma State University
CREDIT: NASA HUBBLE SPACE TELESCOPE
Origin of Very Energetic Radiation

FAR FROM HOME: EXTRAGALACTIC
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VERY ENERGETIC RADIATION IMAGING TELESCOPE ARRAY SYSTEM
Imaging Atmospheric Cherenkov Technique

**VERY HIGH ENERGY SOURCE**

**GAMMA RAY**

**PHOTON**

**DECREASING ALTITUDE**

**ATMOSPHERE**
Imaging Atmospheric Cherenkov Technique

**Imaging Atmospheric Cherenkov Technique**

**CHERENKOV RADIATION:**

\[ V > C_{\text{medium}} \]

**Top of the atmosphere**

- Very High Energy Gamma-ray
- Interaction (pair production)
- Secondary particles
- Cerenkov light
- Photons
- Optical reflector
- Mountain

**Diagram:**

- \( \frac{c}{n} t \)
- \( \beta ct \)
- \( \theta \)
Images of Air Showers
Photomultiplier Tubes

- focus ring electrode
- incoming photon
- photocathode
- photoelectron trajectory
- first dynode
- second dynode
- tertiary electron trajectories
- third dynode
- secondary electron trajectories
Camera Images of Gamma Ray Air Showers
VERY ENERGETIC RADIATION IMAGING TELESCOPE ARRAY SYSTEM
Four Telescopes

Four View Points
Four View Points

Four Telescopes
Everyday...

SOURCE PHENOMENOLOGY
EXPERIMENTAL METHOD
OBSERVATION SHIFTS
SOURCE DATA ANALYSIS
SOFTWARE DEVELOPMENT
HARDWARE MAINTENANCE
HARDWARE DEVELOPMENT
MULTI-WAVELENGTH RESOURCES
MULTI-WAVELENGTH ANALYSIS
PROPOSALS
PUBLICATIONS

...a little closer.
A few things to remember....

APPRECIATE THE IGNORANT STATE

ENJOY THE SEARCH NOT THE ANSWER

USE YOUR PEERS AS A RESOURCE

LEARN TO PROGRAM!