VERITAS is a Gamma-Ray Observatory.

(Very Energtic Radiation Imaging Telescope Array System)

Veritas grew out of the Whipple group and Whipple telescope which was based at the Fred Lawrence Whipple Observatory in Southern Arizona.

Whipple pioneered the imaging Atmospheric Cherenkov Technique for detection of very high energy gamma rays. Their emphasis was on the search and study of celestial sources of gamma rays in the energy range of 100 Gev to 1 TeV.

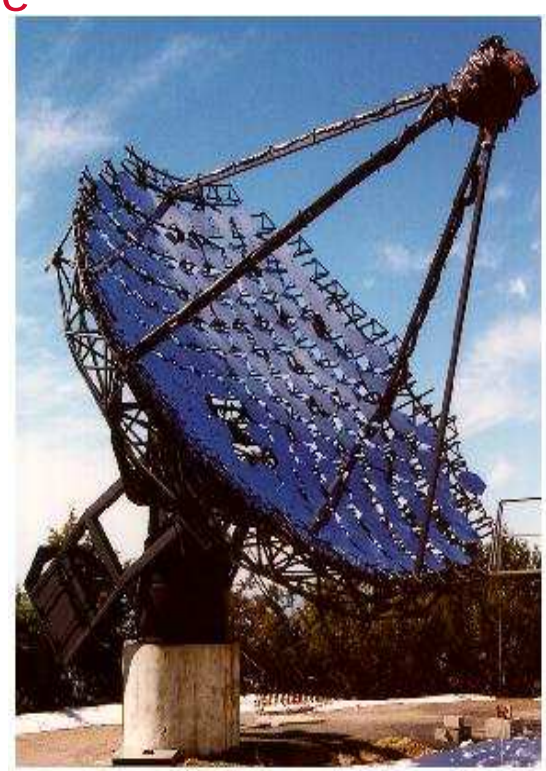


Figure 1: The Whipple Observatory 10 m reflector: the prototype for telescopes in VERITAS.

Collaborators

United States

Smithsonian Astrophysical Observatory
Purdue University
Iowa State University
Washington University, St. Louis
University of Chicago
University of Utah
University of California, Los Angeles
Associate Collaboration Members

Canada

McGill University, Montreal

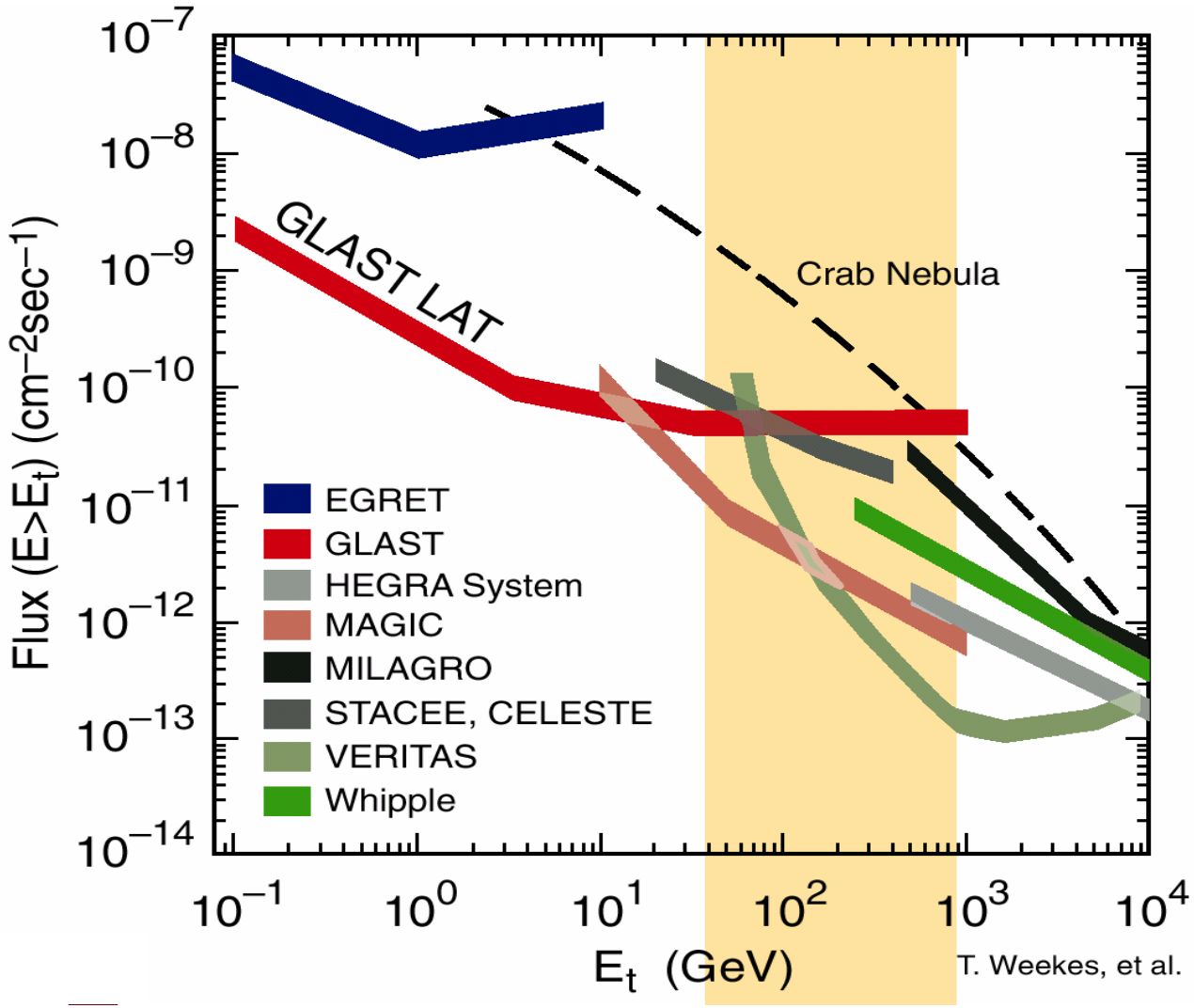
Ireland

National University of Ireland, Dublin
Galway-Mayo Institute of Technology
Cork Institute of Technology
Associate Collaboration Members

United Kingdom

University of Leeds
Associate Collaboration Member

Sensitivity of VERITAS:



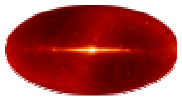
WHY VERITAS?

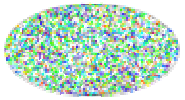
INTEREST, TIMING AND LUCK.

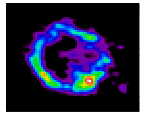
1. There is overlap between astro-physics and accelerator physics in detector technology and physics topics.
2. Experiments are smaller in scope and member size.
3. Allows for more diversity of programs within the division in the age of few future accelerator HEP experiments.
4. University of Chicago wants us (or our EE groups abilities) and the group is easy going, likeable, and pleasant.
5. We want to do it. – Karen, Bob W., Bob S., Rich T., Gary, John (other HEP members have expressed interest, but are presently committed to other projects – Hal, Steve K., Dave R., Larry N.)
6. Bob Rosner (the science advisor to our lab director) is an astrophysicist and is very excited about Argonne becoming involved with astro-physics.
7. Bob has an office in the same building as our U.of C. colleagues and often has lunch with them.

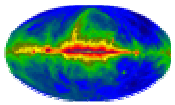
Overview of VERITAS Science

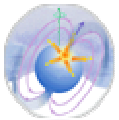
Active Galactic Nuclei

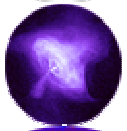

Extragalactic Background Light

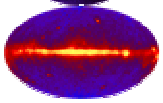

Gamma Ray Bursts

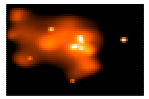

Shell-type Supernova Remnants


Galactic Diffuse Emission

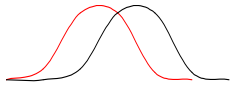

Gamma-ray Pulsars


Plerions

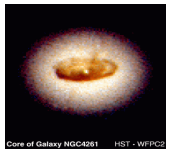

Unidentified EGRET/TeV Sources


Dark Matter (Neutralino Annihilation) *

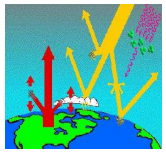
Cosmic Ray Origin *


Lorentz symmetry violation

Overview of VERITAS Science



Primordial Black Holes *



Background Infrared Radiation *

Quantum Gravity *

Neutralino annihilation in the Galactic Center

If neutralinos are the primary component of cold dark matter, they could be concentrated near the galactic center where particle - antiparticle annihilation would produce monoenergetic gamma rays with mean energy equal to the neutralino mass (see figure).

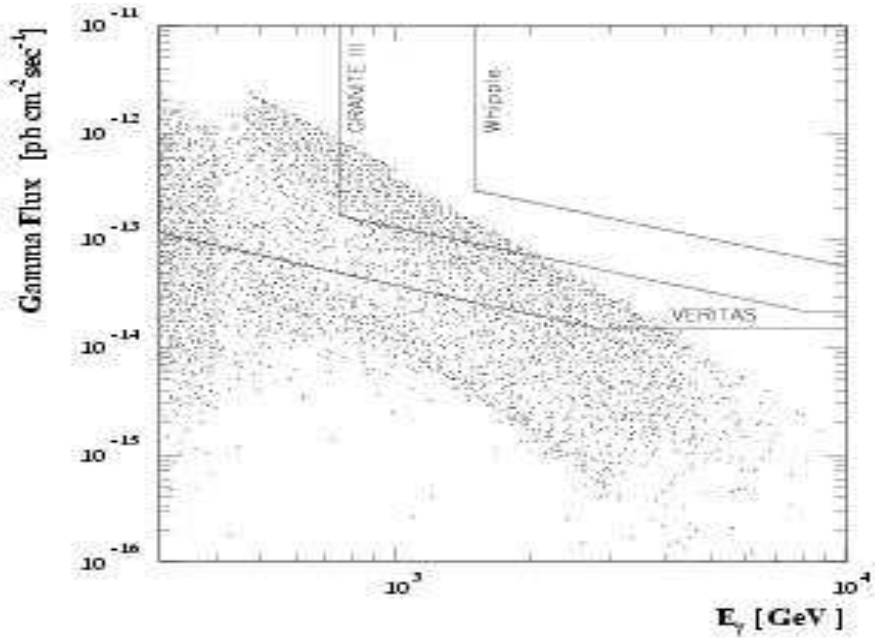


Figure 9: Neutralino annihilation rate from the Galactic center. Shown are the sensitivity curves for Whipple, the Granite III upgrade of the Whipple telescope, and VERITAS. Each point represents a particular choice of supersymmetry model parameters in the experimentally allowed range. Figure from Bergström et al. (1998).

Background Infrared Radiation

Measurements of the VHE spectra from extragalactic sources permit indirect investigation into the nature of the IR background field. Exotic mechanisms, such as Very Massive Objects or the decay of massive neutrinos, may also contribute to the IR background (see figure).

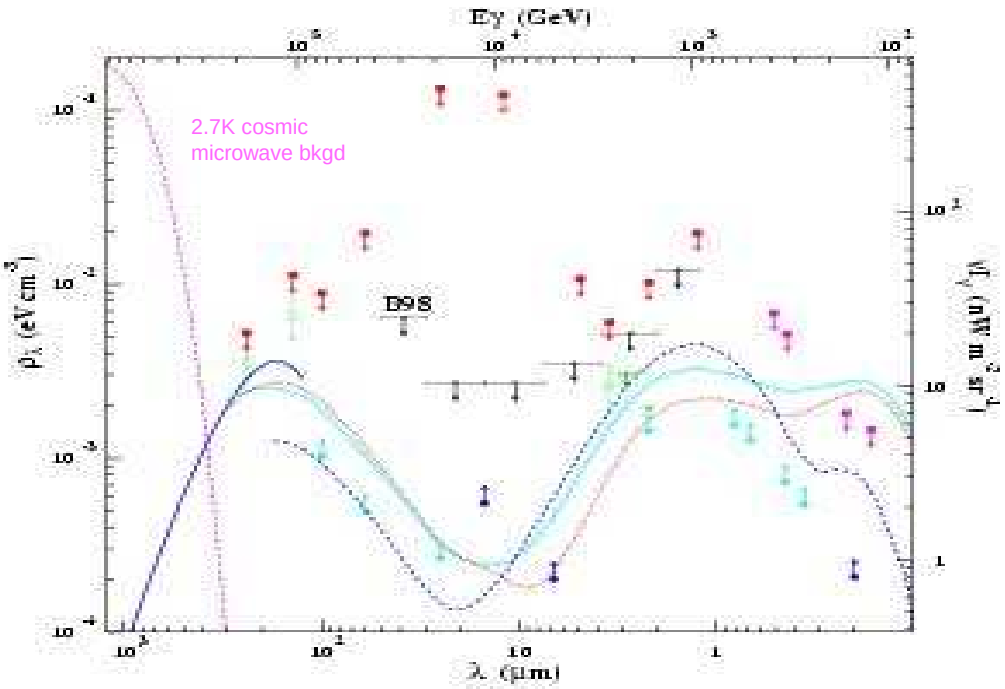


Figure 8: The diffuse intergalactic infrared background. E_γ is the energy at which the pair-production cross-section peaks for head on collisions with photons of wavelength λ. Upper limits derived from γ-ray spectra are shown as horizontal bars with arrows, marked as B98 (Biller et al. 1998). The points and the solid curve represent experimental limits or detections. The dashed line on the left is the 2.7 K cosmic microwave background and the three dashed curves are models of the IR background. Figure from Vassiliev (1999).

Physics Potential – as related to particle physics

Quantum gravity: TeV observations of variable emission from astrophysical objects provide a means of searching for the effects of quantum gravity. VERITAS would be sensitive to quantum gravity effects within a factor of 3 of the Planck mass.

Primordial black hole evaporation: Low mass black holes, if they exist, should emit a burst of radiation in the final stages of evaporation. The Standard Model predicts this last burst of radiation should release about 10**30 erg in 1sec with the energy distribution peaked near 1TeV. In two years of operation, VERITAS would be able to place a limit on this type of decay.

Cosmic Ray Composition: High resolution measurements of charged cosmic ray composition and searches for heavy nuclei and unusual charged states such as quark matter and relativistic magnetic monopoles in the cosmic ray flux.

Direct Cerenkov detection: Detection of DC from primaries offers model independent determination of nuclear composition of the composition of the spectrum at high energies. This light yeild goes as Z**2. DC detection of primaries could also reveal a strange quark matter component of the incoming radiation. SMU claims to have seen evidence for such particles causing seismic activity in a couple of 1993 events.

Current Funding Status

Funded through NSF and DOE. Smithsonian Astrophysics Observatory (ASO) provides and manages site and buildings in Mt Hopkins. Telescope will be located on Horseshoe Canyon on Kitt Peak in Southern Arizona.

In last review (Dec 2002), it was divided into 2 phases. The initial phase is to build 4 telescopes. $20M.

April 2003: Begin building and Installatiion of VERITAS prototype telescope

October 2005: Completion of Phase I: 4 telescope array

October 2007: Completion of Phase II: 7 telescope array

VERITAS-4/VERITAS-7: Concept

VERITAS Philosophy:

- Improve Flux Sensitivity
- Reduce Epeak
- Array of "12 m" telescopes
- Imaging Cameras
- Improved Optics
- Improved Camera
- Flexible Operation using Subarrays
- Efficient Operation (well developed location)
- New Technology where appropriate.

VERITAS-4/VERITAS-7: Concept

Current Status

499 Pixels in focal plane assembly. Prototype uses Hamamatsu R1398 tubes. These are recycled from previous experiments. The field of view (FOV) is ~3.5 deg).

PMT info:

HV supplied by C.A.E.N. unit. Monitor anode current. Need to lower PMT HV for individual tube if it images a bright star. Have star tracker map that is used to predetermine which tube to deaden and when. Will also lower based on observed high anode current.

Cerenkov light:

Intrinsic pulse width is 20ns. Night sky bkgd. (NSB) is wider (~40ns). Now limited by bkgd. If could go to 20ns gate, would allow improved DAQ. Need 1ns timing which is provided by constant fraction discriminators fed by split signal from anode.

Trigger and readout:

500MHz FADC. 19 regions for camera array. Trigger on contiguous tubes in a region (3-4). Can then program how to combine triggers in any of the 19 regions. 5kW/rack in trailer electronics. Air cooled with water chilled radiators. Preamps, charge injection locally on focal plane array.

Existing WBS. Tasks spelled out. Little room for collaboration on initial telescope.

Future and how we can contribute

Better Focal plane assemble:

Are at the limit of what's achievable with cylindrical PMTs. Want more pixels with same or better Q.E. (~15%). 10k pixels is targeted as opposed to current 500. Ultimate, want a resolution of 2-3mm but a goal of 3-5mm is targeted for the next step.

10k pixels is required to get .05deg angular size which matches what is necessary for direct Cerenkov radiation detection of primary cosmic ray. The light yield goes as Z**2.

A first step would be to observe direct Cerenkov detection, then we would be in position to use a similar array for VERITAS focal plane replacement.

Electronics:

Replace FADC. These are not feasible for 10k array. Narrow gate would allow simple measurement of timing and pulse area.

Need better triggering. Uses pattern/topological trigger.

Our 500 Channel Telescope

Our goal is to construct a small high angular resolution triggerable imaging telescope which will be located on-site at Argonne and be capable of observing for the first time the Direct Cerenkov (DC) radiation from cosmic rays as they enter the Earth's atmosphere as well as provide possible improvements in ground based gamma ray telescope sensitivity.

Our 500 Channel Telescope

The DC light from primary cosmics rays must be distinguished against the constant flux of photons from NSB as well as from the Cerenkov light from secondaries in the EAS produced by the primary.

Secondly, DC light has a simple correspondence between emission height and emission angle.

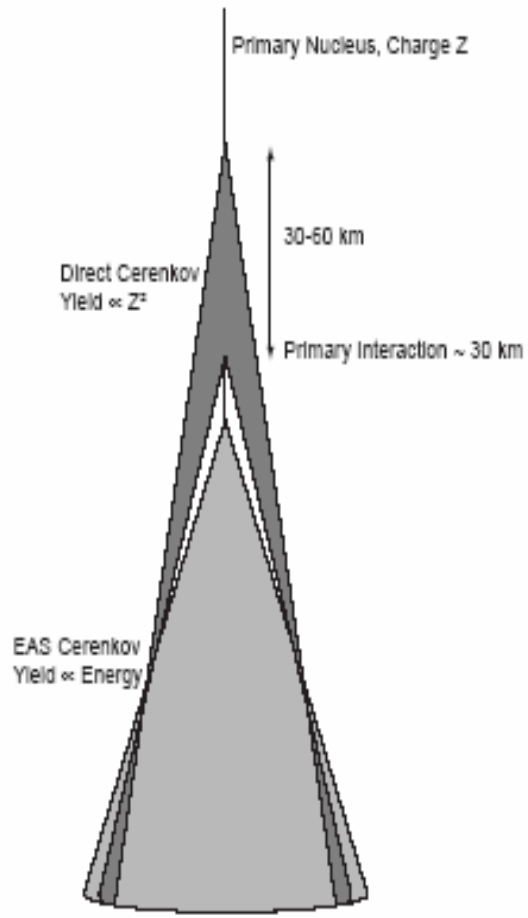


Fig. 1. Schematic Representation of the Čerenkov emission from a cosmic ray primary.

Our 500 Channel Telescope

Milestones for 2004 (as per our proposal):

1. Design of the front end readout matched to the time resolution and dynamic range required for direct Cerenkov detection.
2. Development of a first level trigger.
3. Incorporation of multianode phototubes and front end electronics into the direct Cerenkov telescope.

Milestones for 2005 (as per our proposal):

4. Testing of the telescope on-site at Argonne.
5. First tests of a pattern recognition trigger based on signals digitized after detection of a first level threshold trigger.

Budget

Funding Profile ($k)	Total	FY2004	FY2005
Staff/STA Effort (ANL)	150	100	50
M & S			
Electronics (ANL)	170	50	120
Phototubes (U/C)	15	15	
Mirror (U/C)	50		50
M & S Totals	235	65	170
Operating Total	385	165	220

Tasks for 2004

1. Mostly, just getting started.
2. Bob S, Karen and Gary – setting up a Veritas teststand using MINOS pre-production modules to study timing and signal specifications of DC on 64 channel MPTs.
3. Bob S., Rich and Scott W. – code for teststand.
3. Bob W will work on simulations using CORSIKA MC
4. Bob W and Karen will study night sky bkgd effects on PMTs.

Conclusions

Build a 500 channel telescope and complete our grant

Offers possible future $$ for building electronics

Get us collaborating as partners with Simon Swordy's group

Offers new science challenges to our theory group