VERITAS: THE VERY ENERGETIC RADIATION IMAGING TELESCOPE ARRAY SYSTEM

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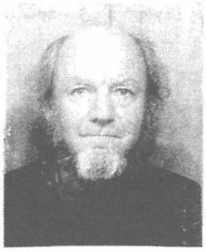

A next generation atmospheric Cherenkov telescope (ACT) is described based on the Whipple Observatory γ-ray telescope. A total of nine such imaging telescopes will be deployed in an array that will permit the maximum versatility and give high sensitivity in the 50 GeV - 50 TeV band (with maximum sensitivity from 100 GeV to 10 TeV).

1 Introduction

Recent successes in Very High Energy γ-ray astronomy using the atmospheric Cherenkov technique have triggered a spate of projects aimed at extending and improving the detection technique. Although these projects (at various stages of conceptual design, detailed planning or actual construction) have radically different experimental approaches, they have important features in common: (i) all are based on the belief that the scientific benefits gained by an increase in sensitivity justify a major effort; (ii) all are agreed that major improvements in sensitivity are physically possible and technically straightforward; (iii) by the standards normally used in this field all the projects are expensive (in the $3M to $15M range).

State-of-the-art imaging ACTs are best represented by the Whipple Collaboration telescope in southern Arizona[11]; the French CAT telescope in the French Pyrenees[9], the Armenian-German-Spanish HEGRA telescope array in the Canary Islands[8], the Durham telescope in Narrabri, Australia[1], the Australian- Japanese telescopes at Woomera, Australia[13], the Russian SHALON-ALATOO project at Tien-Shan[12], the Crimean Astrophysical Observatory telescopes[16] and the Japanese Telescope Array in Utah, USA[3].

The Whipple Observatory γ-ray telescope consists of a 10m diameter optical reflector focussed onto an array of 109 PMTs. The energy threshold is ~300 GeV and the telescope obtains a 5σ excess from the Crab Nebula in one-half hour of on-source observations. In 1998 it is planned to replace the 109 pixel camera with a 541 pixel camera[5]. Although the 10m reflector

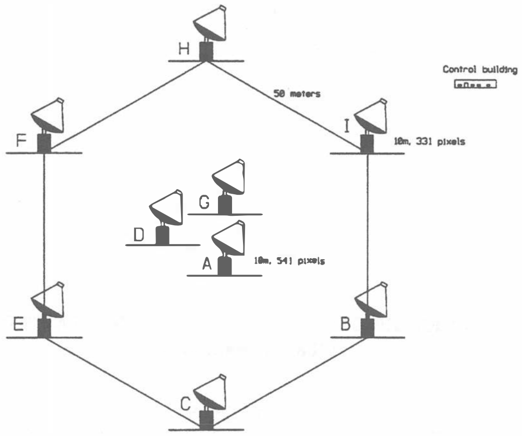

Figure 1: Layout of telescopes in VERITAS.

was built in 1968 and the first imaging camera installed in 1983, this is still the prototype device for atmospheric Cherenkov imaging systems.

The features of VHE ACTs that can be improved include: (a) energy threshold; (b) flux sensitivity; (c) energy resolution; (d) angular resolution; (e) field of view. Of these energy threshold is the easiest to achieve since energy threshold scales as (mirror area)$^{-1}$. The proposed detector, VERITAS, would make improvements in all these parameters.

2 VERITAS

The philosophy underlying VERITAS comes from 30 years of development of ACTs at the Whipple Observatory[14]; the objective is to build a VHE γ-ray observatory which will have a useful lifetime well into the next century. The initial aim is to have the maximum sensitivity in the 100GeV-10TeV range but to have significant sensitivity down to 50 GeV (and lower as new technology photo-detectors become available) and as high as 50TeV (using the low elevation technique[4]). The detection technique will be the so-called "imaging" atmospheric Cherenkov technique which was originally demonstrated at the Whipple Observatory but is now under considerable development at a number of centers. The basic telescopes will be modelled on the Whipple 10m telescopes with wide field cameras of 331 to 541 pixels. The array will consist of nine such telescopes, all capable of independent or coincident operation. The telescope layout will be as shown in Figure 1. A somewhat similar array has been proposed by the Heidelberg group (F.Aharonian, private communication); it would have 16 telescopes with wider separations than envisaged here and would probably be located in Spain.

The proposed location of VERITAS is a flat area at the Whipple Observatory Basecamp (elevation 1.3km) where there is ample space for development as well as easy access to roads, power, etc. Southern Arizona has been shown to be an excellent site for these kinds of astronomical investigation with an impressive record of clear nights. The dark site is not environmentally sensitive nor is there the potential for conflict with other astronomical activities.

The parameters of the array are chosen to give the optimum flux sensitivity in the 100GeV-10TeV range which has proven to be rich in scientific returns. The predicted flux sensitivity is shown in Figure 2; it is seen to be a factor of ten better than any other detector in this range. In these two decades of energy the major background comes from hadron-initiated air showers for which successful identification methods have been developed. At the lower end single muons

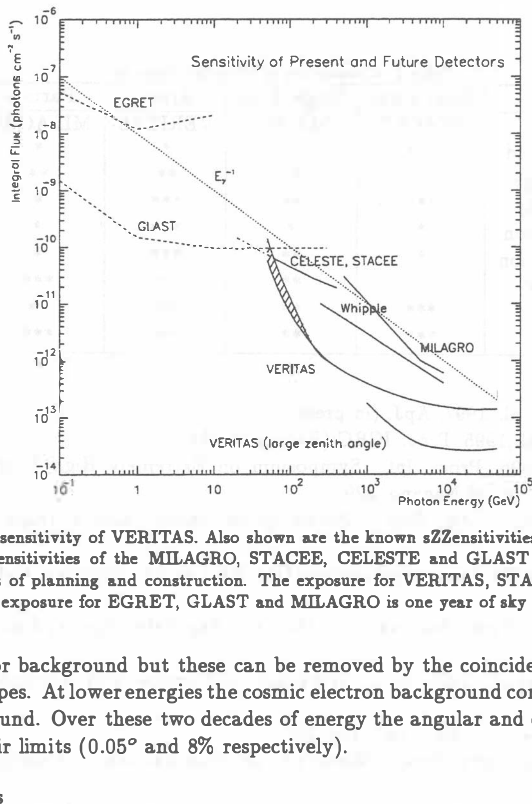

Figure 2: Predicted sensitivity of VERITAS. Also shown are the known sZZensitivities of EGRET and Whipple and the predicted sensitivities of the MILAGRO, STACEE, CELESTE and GLAST experiments, all of which are at various stages of planning and construction. The exposure for VERITAS, STACEE and CELESTE is 50 hours. The exposure for EGRET, GLAST and MILAGRO is one year of sky survey operation.

become the major background but these can be removed by the coincident requirement in the separated telescopes. At lower energies the cosmic electron background constitutes an irreducible isotropic background. Over these two decades of energy the angular and energy resolutions will be pushed to their limits (0.05^o and 8% respectively).

3 Conclusions

There are a number of alternative projects designed to increase the sensitivity of telescopes in the 10GeV-10TeV range. These include the solar farm projects (STACEE in the USA[7] and CELESTE in France[10]), the single dish approach (MAGIC in Germany[6]), the large water Cherenkov air shower detector (MILAGRO in New Mexico, USA[15]), the next generation space telescope (GLAST which will not be launched before 2004[2]). All of these have merit in particular areas; the relative merits of these projects are compared with VERITAS for different experimental parameters in Table 1. In this table the ranking system is *** = excellent; ** = very good: * = good and blank = not good. Since both the choice of parameters and the ranking are assigned by the author it is not surprising that VERITAS compares favorably with all the other projects.

Acknowledgments

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Table 1: *Comparison of Proposed Projects*

Concept	Solar Farm	Single Dish	Array	Particle	Space
Project	STACEE	MAGIC	VERITAS	MILAGRO	GLAST
Energy Threshold	***	**	*	*	***
Dynamic Range	*	**	**	**	***
Flux Sensitivity	*	**	***	*	***
Energy Resolution	*	*	***	*	**
Angular Resolution	*	**	***	*	**
Field of View		**	***	***	***
Cost	***	**	**	**	*
Timeliness	***	**	**	***	*

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ROSSI'S ENDORSEMENT, AT LAST, FOR GAMMA-RAY ASTRONOMER T.C. WEEKES

When Trevor told me this Sunday that he has been awarded the Bruno Rossi prize I was happy... and amused. There is quite an irony behind this award.

In the early sixties Bruno Rossi opened the field of X-ray Astronomy, pretty much against the general beliefs. Well-bred astronomers would have bet not much more than a dime on it.

A few years later (in the late sixties) Trevor, after a PhD in Dublin, was invited to join a team of the Smithonian Institution engaged in a project exploiting a 10 m telescope to study air showers through their Cerenkov light, the 10 m still in operation to-day.

But success had to wait for many years... much longer than for Bruno Rossi's X-ray detections:

- from visible to X-ray there is a factor 1000 in energy;
- from X-ray to TeV photon it's a 1000 million.

Several years after, doubts had arisen (not in the mind of Trevor). The funding agency, the DOE, after a pessimistic audit by Bruno Rossi, withdrew its financial support.

Trevor had to join some other project; he managed to move a hundred yards away so that he could keep an eye on the 10 m.

There the 60" optical telescope was in operation. Trevor developed one of the first CCD cameras. This was the chance which triggered Trevor's inventiveness.

Soon, he was back on his 10m telescope, constructing, with the help of his Irish friends, Niel Porter and Dave Fegan, a 19-PMT and then a 37-PMT camera.

By 1989 (I let you count the years) the founding paper of TeV Astronomy was published, with the evidence of the emission from the Crab and since then Trevor has kept in the lead.

I am sure that Bruno Rossi would be delighted if he had known about this award, and so are we.

Patrick Fleury