Workshop on a wide field-of-view Southern Hemisphere TeV gamma ray observatory

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Hotel NH

Book of Abstracts

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Future Detectors / **0**

A low-cost wide field-of-view Cherenkov Telescope

Author: Thomas Bretz[1]

[1] *RWTH Aachen University*

The FAMOUS telescope is a quarter square meter Fluorescence telescope utilizing a Fresnel lens, silicon-based photo sensors (SiPMs) and a state-of-the-art readout system. Due to its compact design, the system is encapsulated in a carbon fiber reinforces plastic tube. This allows the application also in harsh environments. A prototype system (IceACT) is currently installed at South pole and operated successfully as Air-Cherenkov Telescope proving coincident detection with IceTop. Due to its low costs (<10,000 USD), it is ideally suited to cover large areas on the sky or large surface areas or both. Therefore, it might be worth to investigate a possible advantage combining this system with a HAWC type array to improve, for example, energy resolution.

Hardware / **1**

A muon detector using silicon based photo sensors (SiPMs)

Author: Thomas Bretz[1]

[1] *RWTH Aachen University*

The Pierre Auger observatory currently undergoes a major upgrade (AugerPrime) installing scintillator detectors on top of each tank. With the complement information of the scintillator detector and the water-Cherenkov detector, the muonic component and the electromagnetic component of air-showers can be disentangled. The obvious disadvantage is that both detectors see both components although at different mixture. To resolve this, a scintillator detector has been developed which can be buried under the water tanks using the water as a shielding for the electromagnetic component such that the scintillator detector will only measure the muonic component. In this way, the muonic component can be measure with less bias and both signals can be disentangled more easily. A similar low-cost system could be utilized under a HAWC type array as a veto for hadron induced air-showers showers.

Site / **2**

The development of HAWC at Sierra Negra

Author: Alberto Carramiñana[1]

[1] *Instituto Nacional de Astrofisica, Optica y Electronica (INAOE)*

The High Altitude Water Cherenkov (HAWC) gamma-ray observatory is a currently in full operations, surveying the high energy sky on a quasi-permanent basis. Located at an altitude of 4100m, and covering a declination range reaching down to the Galactic Center, HAWC is now able to detect the Crab nebula within a single transit, allowing unprecedented studies of both variable and extended TeV gamma-ray sources. The development of HAWC was made possible by the experience of the Milagro collaboration and the presence of a scientific community in Mexico able to potentiate the favorable Sierra Negra site, including the infrastructure already present. I will recount the development of HAWC in Mexico, from the 2006 proposal of the Milagro collaboration to the installation of the gamma-ray observatory, marked by its formal inauguration on the 2015 equinox day, and the current on-site operations.

Results from Current Experiments / **3**

Recent results from H.E.S.S.

Author: Fabian Schüssler[1]

[1] *CEA/Irfu*

The High Energy Stereoscopic System (H.E.S.S.) is an array of Imaging Atmospheric Cherenkov Telescopes (IACTs) located in the Khomas Highland of Namibia. The array initially consisted of four 12m telescopes and provided a vast array of discoveries which now form the heritage of the very-high-energy (VHE) gamma-ray astronomy (e.g. the H.E.S.S. Galactic Plane Survey). In 2012, a fifth 28m telescope was added to the array to extend the energy range down to ~ 30 GeV and allow for rapid reaction to alerts and ToOs. The cameras of the 12m telescopes are currently being upgraded to improve the data taking efficiency and optimize the array performance at low energies.

In this contribution we will present the current status of H.E.S.S. and review recent results including the H.E.S.S.-II observations of the Vela pulsar and several AGNs, as well as the discovery of the Galactic Centre "Pevatron". We will also discuss the H.E.S.S. multi-messenger program and searches for transient events like GRBs.

Hardware / **4**

Antares Modules In a Gamma-ray Observatory (AMIGO)

Author: Fabian Schüssler[1]

[1] *CEA/Irfu*

After 10 years of successful operation the ANTARES neutrino telescope will be de-commissioned during 2017. Recently we prepared a proposal which has been submitted to the ANTARES Collaboration in 09/2016: Antares Modules In a Gamma-ray Observatory (AMIGO). We therein propose to recover the optical modules (17inch glass spheres housing each a 10inch PMT) during the de-commission operation and dedicate them to a next generation, wide-field of view gamma-ray observatory in the Southern Hemisphere.
In this contribution we outline the driving ideas behind the AMIGO proposal, discuss its status and upcoming work.

Future Detectors / **5**

ALPACA Project : 100 TeV Gamma-ray Observation in the Southern Sky

Author: Kazumasa KAWATA[1]

[1] *ICRR, University of Tokyo*

We are now proposing a new project to observe 10-1000 TeV gamma rays with very low background noise and wide field of view in the southern hemisphere. We call the ALPACA (Andes Large area PArticle Detector for Cosmic ray physics and Astronomy) project. The observatory will consist of 83,000 m^2 air shower array and 5,400 m^2 underground water-Cherenkov-type muon detector array constructed at 4,740 m a.s.l. (mountainside of Mt. Chacaltaya), near La Paz in Bolivia. The gamma-ray induced air shower has much less muons compared with a cosmic-ray induced one. Therefore, the cosmic-ray backgrounds will be significantly discriminated from the gamma-ray signals by means of counting the number of muons in an air shower. With the ALPACA project, we

expect to detect gamma rays between 10 and a few hundred TeV from the Galactic Center if cosmic rays are accelerated up to PeV energies at the supermassive black hole as suggested from the recent H.E.S.S. observation. In this talk, we will introduce the present status and the future plans of our project.

Motivation for a Wide-FOV Observatory / **6**

Fundamental drivers for the design of a ground-particle based gamma ray observatory

Author: Harm Schoorlemmer[1]

Co-authors: Armelle Jardin-Blicq [2]; Jim Hinton [3]; Pooja Surajbali [2]; Rubén López-Coto [3]; Vikas Joshi [2]

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Air shower detectors at high altitude sites are suitable for gamma ray observation of the sky in the TeV energy range. The efficiency and accuracy with which these observations can be made depend on several key design parameters for such an observatory. By using CORSIKA simulations, we studied the performance of such an observatory as a function of few key design parameters, like altitude, instrumented area, fill factor, and detector unit properties. The results from this study can be used in the decision making and design a next generation wide field-of-view gamma ray observatory.

Motivation for a Wide-FOV Observatory / **7**

Astrophysical motivations for the construction of a wide FoV gamma-ray observatory in the southern hemisphere

Author: Ruben Lopez-Coto[1]

Co-authors: Aion Viana [2]; Armelle Jardin-Blicq [2]; Harm Schoorlemmer [3]; Jim Hinton [2]; Pooja Surajbali [2]; Vikas Joshi [2]

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[2] *MPIK*

[3] *Max-Planck-Institute für Kerphysik*

After the successful performance of ground-based wide FoV gamma-ray observatories in the northern hemisphere, the construction of a similar observatory to observe the southern sky has become a must. The design of a such an observatory will be driven by the physics cases accessible to it. In this contribution we will discuss the physics cases that can only be accessed by this kind of detector. We will also compare the sensitivity of a preliminary design array with the emission expected from this kind of sources.

Future Detectors / **9**

The Cherenkov Telescope Array: Status and Plans

Author: David Williams[1]

[1] *UC Santa Cruz*

The Cherenkov Telescope Array (CTA) will be a new observatory for the study of very-high-energy gamma-ray sources, designed to achieve in the ~30 GeV to ~100 TeV energy band an order of magnitude improvement in sensitivity compared to currently operating instruments: VERITAS, MAGIC, and H.E.S.S. CTA will probe known sources with unprecedented sensitivity, angular resolution, and spectral coverage, while also detecting hundreds of new sources. Operating as an open observatory, CTA will provide access to data to members of the wider astronomical community for the first time in this energy band. The CTA Consortium will also conduct a number of Key Science Projects, including a Galactic Plane survey and a survey of one quarter of the extragalactic sky, creating legacy data sets that will also be available to the public. This presentation will discuss the current status and future plans for the development of CTA and highlight synergies between CTA and a southern wide field-of-view TeV observatory.

Future Detectors / **10**

LATTES: a next generation gamma-ray detector concept

Author: Ruben Conceição[1]

[1] *LIP - Laboratório de Instrumentação e Física Experimental de Partículas*

The detection of Very High Energy gamma-rays to study astrophysical sources relies on the measurement of Extensive Air Showers (EAS) either using Cherenkov detectors or EAS arrays. While the former technique presents a better energy and angular resolution, and has a lower energy threshold, the latter gains significantly in duty cycle and survey area. We present, in this talk, the Large Array Telescope for Tracking Energetic Sources (LATTES), a novel concept for a hybrid EAS array detector, with an improved sensitivity at lower energies (~ 100 GeV). A description of its main features and capabilities, as well as the preliminary results on its expected performance, and sensitivity, will be discussed. Such a wide field of view experiment, which is planned to be installed at high altitude in South America, would be a complementary project to the planned Cherenkov Telescope Array. Its characteristics makes it a powerful tool to trigger observations of variable sources and to detect transient phenomena.

Motivation for a Wide-FOV Observatory / **11**

Semi-Analytic Simulation for a ”HAWC-like” Detector

Author: Andrew Smith[1]

[1] *University of Maryland, College Park*

A semi-analytical model for computing the sensitivity of a large class of wide-field surfaces arrays has been developed. This phenomenological model approximates the exact response as simulated by CORSIKA and GEANT and provides a very simple interface to approximate effective area and background rates as a function of various particle and detector design parameters, such as gamma-ray energy and zenith angle, detector size, trigger threshold, and detector geometry. The hope is that this tool can serve to inform designers of the next generation of TeV-scale wide-field gamma-ray detectors.

Wide FOV Gamma Ray Science / **12**

Beyond the Standard Model with Wide-field Observatories

Author: J. Patrick Harding[1]

[1] *Los Alamos National Laboratory*

Multi-TeV, wide field-of-view (fov) gamma-ray observatories are uniquely suited to search for beyond-the-Standard-Model (BSM) physics using astrophysical objects. These include searches for dark matter, primordial black holes, axions, and tests of Lorentz invariance. Some of the most promising dark matter sources in the sky are several degrees across, so searches with smaller fov instruments are difficult. Also, stacked analyses of many dark matter sources can be used to improve an experiment's dark matter sensitivity, and large field of view instruments survey several dark matter targets. The signatures of primordial black holes could appear anywhere on the sky without warning, so large fov searches are needed to be able to find them. Lorentz invariance violation can best be probed by prompt observations of gamma-ray bursts and long-time studies of pulsars, both of which require long-uptime, large fov studies. Axion-like-particle searches can be done through high-energy observations of distant sources, which requires a large selection of objects to study. Wide fov instruments can search for evidence of several novel physical processes, from quantum gravity to supersymmetry to the nature of dark matter.

Future Detectors / **13**

Simulation study for the proposed wide field-of-view gamma-ray detector array ALTO

Author: Satyendra Thoudam[1]

Co-authors: Michael Punch [2]; Yvonne Becherini [3]

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[2] *LnU & APC/CNRS-IN2P3*

[3] *Linnaeus University*

ALTO is an all-sky field-of-view detector array for high-energy gamma-ray astronomy, proposed to be installed in the Southern Hemisphere at an altitude of ~ 5.1 km above sea level. The array will use water Cherenkov detectors, as in the HAWC observatory, to detect air showers induced by high-energy gamma rays and cosmic rays in the atmosphere, but it will be designed to attain a lower energy threshold, better energy and angular resolutions, and better sensitivity than HAWC. The array will consist of ~1250 smaller-sized detector units each of ~3.6 m wide distributed over a circular area of ~200 m in diameter. In addition to the water Cherenkov detector, each detector unit will consist of a liquid scintillation detector which will serve as a muon detector, facilitating the background rejection, and thereby improving the sensitivity. The background rejection will be further enhanced by the close-packed arrangement and the small size of the detectors which will allow a fine sampling of air shower footprints at the ground. The electronics for ALTO will make use of newly-developed ASIC Analogue Memories for low-power, GHz sampling signal read-out, and the White Rabbit technology for the signal time distribution and time tagging at sub-ns accuracy to achieve a better angular resolution.

In this contribution, I will describe the Monte-Carlo simulation of the experiment, and present the expected performance of the array in terms of reconstruction accuracies of the shower core, arrival direction and energy of the primary particle as well as preliminary estimates of the energy threshold and sensitivity for a point-like gamma-ray source.

Site / **14**

Candidate sites in Argentina for air-shower particle detectors at high altitudes

Author: Adrian C. Rovero[1]

[1] *Instituto de Astronomía y Física del Espacio (IAFE, CONICET-UBA)*

High altitude regions in Argentina are available for water Cherenkov gamma-ray astronomy. In the Northwest of the country areas of ~1 km2 have been identified and studied for astronomical purposes at altitudes greater than 3500 masl. Particularly, a site nearby San Antonio de los Cobres (Salta) is being developed for LLAMA, a project in cooperation with Brasil (50/50). LLAMA is a single dish radiotelescope planed to perform interferometry with ALMA; access roads, power, connectivity and housing is being provided by Argentina in its location at 4850 masl.
In this talk I will describe the site for LLAMA and few others suitable for water Cherenkov gamma-ray astronomy, with good access and availability of water. As done for LLAMA, local support at National and Provincial levels are a plus in Argentina, where several groups have expressed their interest to participate in the development and operation of the new Southern water Cherenkov gamma-ray observatory.

Future Detectors / **15**

ALTO concept and design choices

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[3] *Linnaeus University*

ALTO is a concept/project in the exploratory phase since ~2013, named by the Astroparticle Group at Linnaeus University (LnU) for a project to build a wide-field Very-High-Energy (VHE) gamma-ray observatory at very high altitude in the Southern hemisphere. This will explore the sky in the central region of our Galaxy at very-high-energies, with also the possibility to act as a trigger or source monitor for the smaller-field CTA (Cherenkov Telescope Array) Imaging Atmospheric Cherenkov Telescopes (IACT).

To go beyond the performance of HAWC, we consider several key possible improvements. These concern the following points. (1) Increasing the altitude, to allow a lower threshold especially for following variable Extragalactic sources, such as AGNs but including GRB, Gravitational Wave, or Neutrino alerts. (2) Finer grain of the array, using smaller Water Cherenkov Detector (WCD) tanks, for better characterization of the particle distribution on the ground, but also greater simplicity of operation.(4) Addition of a muon-detector component below each water-Cherenkov tank consisting of liquid scintillator tanks (the scintillator layer detector, SLD), to provide a better rejection criterion against the Cosmic-ray showers. (3) Advanced electronics, using analogue memories (such as NECTAR) to measure the waveform of the detector pulses and White Rabbit timing for propagating a precise clock to the Front End detectors, which can then be placed close to clusters of tanks, avoiding degradation of the signal which happens with transmission over long cables, which might also be vulnerable to noise and lightning.

Here, the current design choices will be described, along with their evolution in discussion with our partners in LANL, CPPM, and IRFU/CEA, and the implementation possibilities. The following talk will describe the results for Monte Carlo simulations for this ALTO detector.

Results from Current Experiments / **16**

Interactions between FACT and HAWC

Author: Daniela Dorner[1]

[1] *Universität Würzburg*

Both FACT and HAWC are monitoring at TeV energies. While HAWC is covering two thirds of the sky every day, FACT is monitoring a small sample of sources in pointed-mode with a better sensitivity.

Thanks to its camera with solid-state photosensors, FACT features an excellent detector performance and stability, which is ideal for monitoring. As the sensors do not degrade when exposed to bright light, observations during strong moonlight are possible, increasing the duty cycle compared to other imaging air Cherenkov telescopes and minimizing the gaps in the light curves around full moon.

This presentation will summarize the five years of FACT monitoring with a special focus on the first joint study of blazar light curves from HAWC and FACT. Benefiting from the 5.3 hour offset between the two sites, light curves with up to 12 hours of continuous coverage are obtained. In a short outlook towards 24/7 monitoring, the plans of the projects M@TE and DWARF will be discussed.

Results from Current Experiments / **17**

Performance of HAWC in First Data

Author: John Pretz[1]

[1] *Penn State*

HAWC is performing well, achieving unprecedented all-sky sensitivity above 1 TeV. The HAWC sensitivity is driven by the best photon/hadron discrimination and angular resolution ever achieved for a wide-field ground array. I will discuss the HAWC performance, focusing on the HAWC observations of the Crab Nebula, highlighting opportunities for improvement in a future Southern observatory.

Site / **18**

Yachay Tech and Gamma Ray Astronomy

Author: Hisakazu Minakata[1]

[1] *Yachay Tech*

In Yachay Tech, a new research oriented university in Ecuador, we are constructing astroparticle physics activities in a wide sense. Obviously, we are interested in the topics of the Puebla meeting, in particular, in the question of how Gamma Ray Astronomy will evolve in South America.

The purpose of my talk is to attract the participants' interests in the newly born university Yachay Tech, which might be able to have astroparticle physics in Physics Department. If any of you have some interests in our Yachay endeavour, please think about coming to Yachay Tech to initiate Gamma Ray Astronomy in Ecuador. We also want to hear your thoughts on how to develop astroparticle physics from scratch in Ecuador.

Motivation for a Wide-FOV Observatory / **19**

Extreme Altitude All-Sky Observatories

Author: Gus Sinnis[1]

[1] *Los Alamos National Laboratory*

This talk will be an overview of the physics and techniques that underlay the performance of all-sky ground-based gamma-ray observatories. An important aspect of the discussion will be on establishing the scientific case for building such an instrument. I will end with some generic simulation results that demonstrate the effect of altitude on the response of such arrays and some potential locations for such an array.

Wide FOV Gamma Ray Science / **20**

Recent HAWC results

Author: Colas Rivière[1]

[1] *Department of Physics, University of Maryland, College Park, MD, USA*

With its large field of view and high duty cycle, HAWC has been observing a large fraction of the sky for than a year. We will present the recent analysis and results, in particular on Galactic sources.

Wide FOV Gamma Ray Science / **21**

Binary Source Opportunities for a Southern Gamma-ray Observatory

Author: Chad Brisbois[1]

[1] *Michigan Tech*

The recent discovery of a sixth gamma ray binary in the Large Magellanic Cloud by the Fermi Large Area Telescope opens up new possibilities for TeV binary searches in the near extragalactic region. Located in the Southern hemisphere, its high luminosity and position in the Large Magellanic Cloud makes this system a unique discovery target for a southern gamma-ray survey observatory. This object, and others like it yet to be detected at TeV and GeV energies may help provide insight into the nature of the emission mechanisms of these sources. This talk will review some known and candidate TeV binary sources in the field of view of a southern gamma-ray observatory

Wide FOV Gamma Ray Science / **22**

The Southern Fermi Bubble and Other Very Extended Emission Structures with the Southern Gamma-Ray Survey Observatory

Author: Hugo Ayala[1]

[1] *Michigan Technological University*

A very high energy gamma-ray survey observatory in the southern hemisphere delivering a large field-of-view and high-duty cycle will complete the picture of our galaxy, in particular in regards to extended and large scale structures. It will provide unprecedented access to the southern Fermi bubble region, to molecular clouds, and diffuse emission in the southern hemisphere at energies >GeV. I will discuss possible detection scenarios, required sensitivities, and physics constraints that could be gained from a large area emission analysis.

Hardware / **23**

Southern observatory costing and logistics

Author: Michael DuVernois[1]

[1] *University of Wisconsin–Madison*

Some comments on the logistics of a Southern Hemisphere TeV All-Sky detector.

Results from Current Experiments / **24**

Interaction between HAWC and VERITAS

Author: Udara Abeysekara[1]

[1] *University of Utah*

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Modern Timing Concepts for Astroparticle Physics

Author: Ralf Wischnewski[1]

[1] *DESY*

Wide FOV Gamma Ray Science / **26**

The TAIGA-HiSCORE array for Gamma Astronomy beyond 10 TeV

Author: Ralf Wischnewski[1]

[1] *DESY*

The Multi-TeV instrument TAIGA-HiSCORE, an AirCherenkov Instrument based on timing .

Welcome and Introductions / **27**

Welcome to Puebla and HAWC

Author: Segev BenZvi[1]

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Some basic information about your visit.

Welcome and Introductions / **28**

Goals of the Workshop

Author: Miguel Mostafa[1]

[1] *Penn State*

Hardware / **29**

Using Non-Imaging Concentrators to Reduce the Cost of WCDs

Author: Segev BenZvi[1]

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Site / **30**

Brief Outline of HAWC DAQ

Author: John Pretz[1]

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