An International Partnership for the future of Ground-based Gamma-ray Astronomy:

Development of a Schwarzschild-Couder Telescope

Key Personnel:

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(+ not all confirmed at this stage)

The approximate proposal budget will be <u>$6M for 5 years</u>

Project Summary

In recent years, very-high-energy (VHE) gamma-ray astronomy has attracted the attention across the scientific community with a number of stunning astrophysical discoveries made by small arrays of imaging atmospheric Cherenkov telescopes (IACTs). The rapid progress in this exciting field of astronomy and astrophysics is expected to continue, boosted by the results from the newly-launched Fermi Gamma-ray Space Telescope (FGST) and further observations by IACTs. Significant scientific results are being obtained in the areas of VHE phenomena in the vicinity of accreting black holes, particle acceleration in the variety of astrophysical environments, indirect detection of dark matter, study of cosmological background radiation fields, and particle physics beyond the standard model.

The growing demands of the scientific community for more sensitive observations of point sources, follow-up examinations of FGST sources, a survey of the full sky, and observations of VHE transient phenomena already exceed the capabilities of present-day ground-based gamma-ray observatories and will require a new generation of instruments to be constructed during the next decade each with a cost of ~$200M. There are already collaborations formed both in the US and Europe to pursue the design and construction of the next generation of these telescope arrays. (Within the US this is called the AGIS collaboration http://www.agis-observatory.org, within Europe this is called CTA http://www.cta-observatory.org). Because the next generation observatory will be costly and technically challenging, these groups have been actively exchanging information on computer simulations and other technical ideas aimed at building these observatories. Until now there has not been a major prototyping effort to bring this international community together. Chicago has played a significant role in the present generation of ground based gamma-ray astronomy telescopes, we plan to help lead the next generation through this proposal. We believe that a major impact can be made on this research field by the support of a PIRE proposal to provide a focus for interchange of people and ideas between these international groups as described below.

Intellectual Merit: Together with our international partners in Germany, Italy, Mexico, and Canada we (UC, ANL, UCLA, Stanford/SLAC) propose to develop and construct a new Schwarzschild-Couder (S-C) telescope, which has an optical design which will provide considerably enhanced performance, improved reliability, and reduced camera cost compared with traditional atmospheric Cherenkov telescopes (ACTs), thereby significantly increasing the scientific discovery potential of future ground based gamma-ray observatories, such as the Advanced Gamma-ray Imaging System (AGIS) or the Cherenkov Telescope Array (CTA). The development and construction of this new telescope is the logical next step to overcome the fundamental methodological limitations of current prime-focus ACTs, namely low angular resolution, small field of view, incompatibility with robust remote operation, and the large cost inherent in high resolution cameras based on large numbers of individual photo multiplier tubes (PMTs). We propose to build and operate this telescope on a site in western Mexico and collect sufficient data to verify the scientific return from this new design for the basis of a large telescope array. We will demonstrate the quality of imaging achievable by the wide-field S-C telescope design and the capabilities of revolutionary approach to highly integrated design of camera electronics compatible with the small plate scale of S-C telescope. Through interaction with the wide range of international and US partners in industry and unique expertise developed at the national laboratories (ANL and SLAC) the execution of this proposal will evaluate and select between emerging technologies for the mass production of relatively inexpensive, light, aspheric mirror segments, such as those based on replication, will test integrated solutions for electronics, such as those based on switched capacitors arrays, and will provide firm cost estimates for future trade off studies and planning of the next generation of major ground-based gamma-ray observatories.

Broader Impact: Further, we will demonstrate unique science capabilities which novel S-C telescope can deliver, if used in the future AGIS and CTA observatories: 1) significant increase of the collecting area at energies larger than 30 TeV which will enable the study of the spectra of galactic sources at the highest energies, 2) wide field of view of S-C telescope, unprecedented for ground based gamma-ray astronomy, will make possible high-resolution imaging of the most extended galactic TeV sources, detection of super-symmetric dark matter annihilation signals originated in the substructures of the Milky Way halo, survey of the full sky, and systematic search with the highest sensitivity for VHE transient phenomena in the Universe at energies above 40 GeV, 3) significant improvement of the angular resolution to achieve unmatched sensitivity of the future IACT arrays in the 40 GeV to 1 TeV energy range to detect cosmic rays in extragalactic systems, such as star burst galaxies and galaxy clusters, as well as to study VHE processes in the vicinity of the black holes in the centers of active galaxies and cosmological magnetic and photon fields (far infrared trough UV). The S-C telescope, which we propose to develop and construct, will become a pilot instrument to survey one of the most favored sites for a next generation ground-based gamma-ray observatory, the San Pedro Martir observatory in Baja Mexico. For the first time, and with critical involvement of our Mexican partners, we plan to demonstrate the feasibility and potential of a remotely operated ground-based gamma-ray telescope. This project will provide a unique opportunity for integrated scientific instrumentation development, research, and education for a number of young scientists involved in it from US, Italy, Germany, Mexico, and Canada. The vanguard industrial development of optics and electronics in these countries will be shared and will provide the key elements for the implementation of the S-C telescope. The design work and technology development to be undertaken in this effort will advance ground-based gamma-ray astronomy to the threshold of the next generation of IACTs experiment, which has exceptional scientific prospects. The development of new mirror technologies, highly-integrated electronics and readout systems, fast triggers, and a high-throughput data acquisition system are also beneficial to the development of particle physics detectors in general. The novel wide-field SC telescope has significant potential for application in visible and infrared astronomy, especially if diffraction-limited optics of this design can be built. In addition, the activities suggested in this proposal will stimulate regular contributions to existing local outreach efforts, which will include lectures, and articles in popular science magazines. The US and international collaborators are also strongly committed to involving undergraduate students in the efforts of this proposal, and to the enhancement of diversity in the physical sciences through the direct support of female and minority scientists. A display highlighting the novel S-C telescope concept will be a significant part of an exhibit on the history of telescopes being developed by the Adler Planetarium, who is also expected to become a collaborator on this proposal.