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SYMBIOSIS FOUNDATION

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Dear ERGO Participant,

Symbiosis Foundation, Inc., is a 501(c)(3) private charity incorporated in Florida. The foundation was established in 1993 by the four founders of Symbiosis Corporation to support educational programs in science, technology, engineering, and mathematics. The foundation has sponsored science fairs, contests in robotics and rocketry, museum projects, and educational programs to encourage and reward young men and women who are solving real-world problems by applying science and technology. The foundation is presently run by Tom Bales, President, and Kevin Smith, Chairman.

Symbiosis Foundation is proud to have sponsored: elementary, middle-, and high-school teams in the FIRST Robotics and Lego League competitions; BotsIQ robot combat teams; curricular and extra-curricular elementary science programs; and, museum exhibits such as the Babbage Engine projects at the London Science Museum. We are pleased to have sponsored the Lego League program in Haiti, working with Citadelle Robotics Team from Cap-Hatien.

Our goal is to make Earth a better place by helping youth discover the excitement and fun of applying science and technology to the problems faced by people the world over. With the ERGO Energetic Ray Global Observatory, we hope to foster worldwide collaboration among students to engage in original scientific research and experience the thrill of discovery.

The Foundation would like to acknowledge the help and participation of the following individuals and groups:

- Richard McCorkle, electrical instrumentation engineer, Fairbanks, Alaska, developed the PICTIC+ event-recording circuitry incorporated into the Timestamp Generator.
- Michael Joyce has helped to develop the design, fabrication, and testing of the resistive-plate detectors to be used in advanced versions of the Muon Detector.
- Alan Schimmel built the first ten “beta” Timestamp Generators and Detector circuits during a summer internship in 2010.
- Jorge Piños and Jeff Landrum designed and produced the panels for the Timestamp Generators, RPC Muon Detectors, and G-M Muon Detectors.
- Herb Meeker solved all the problems necessary to install a GPS antenna distribution system at Syntheon, where much of the development work was done.
- Jorge Miranda has taken responsibility for writing the firmware for the embedded TCP/IP server and the SQL code for the central internet data-collection server at www.ergotelescope.org.
- Nola Garcia and StarBot, Inc., have coordinated the organization and communications for the **ERGO** project – and have lent lots of enthusiasm and their famous “Can Do!” attitude.
- The **305 Robotics Consortium**, a group of local middle and high schools involved in robotics and other student science and engineering activities, are the first schools to work with the beta-test “pixels” to begin to work out the unavoidable bugs and operational kinks.
- My partners at Syntheon, who have graciously allowed me to use Syntheon’s facilities for lab work, machine work, and hosting **ERGO** internships and project meetings.

euclid laboratories

Euclid laboratories started as a garage laboratory in 1960 by Tom Bales, Steve Loomis, and Peter Timbe. These seventh- and eighth-graders thought euclid laboratories seemed like an auspicious name for a lab that happened to be located on Euclid Avenue, at Steve's house. It's been a long time since the three boys worked together on perpetual-motion machines and rocket engines, but Tom has continued the lab's tradition of working on things "not well understood." The lab was incorporated in the State of Florida in 1995. euclid's staff consists of Gregory, Maxwell, and William Bales, Connie Ryan, and Tom Bales.

The development of the technology and physical instrumentation for the ERGO Energetic Ray Global Observatory is being done for Symbiosis Foundation by euclid laboratories on a *pro-bono* basis.

Sect. 3, How ERGO Got Started

In 2009, at the TED Conference in Long Beach, CA, Jill Tarter made a wish and challenged the conference attendees:

"I wish that you would empower Earthlings everywhere to become active participants in the ultimate search for cosmic company."

Sitting in that audience, I was captivated by Dr. Tarter's talk — she is the real-life astrophysicist upon whom Carl Sagan's book, "Contact" is based. Having read the book and seen the movie, starring Jodie Foster, I knew a little about Jill's story. What I didn't know was her passion for education and involving children in scientific exploration and the search for extraterrestrial intelligence, SETI. Like many in the audience, I wondered how I might contribute to this great challenge.

It happened that I had been working on a couple of amateur projects: working with atomic clocks and detecting cosmic rays (perhaps an odd combination). I had been thinking to combine these two interests to engage in a quixotic search for "signals" embedded in the cosmic rays that reach Earth. Amateur scientists aren't restricted to working on projects that can secure research funding or which will produce publications, so we can pursue any old thing that interests us. As the history of science and technology shows, many important, but unexpected, discoveries were made by amateurs "tinkering" with subjects outside their own vocation. It's fun to learn new stuff.

My first approach to looking for signals in cosmic rays was to set up an experiment to record the time of arrival

of cosmic passing through my laboratory, and then try to find a pattern in the data. I figured that after a few years of collecting data (and after learning how to analyze that mountain of data) I might be able to find a needle in that haystack of data. At least, it would be fun to look — and it didn't seem that anyone else was looking in that direction. Everybody knows there *aren't* any such signals embedded in cosmic rays.

Listening to Jill's TED Wish talk, I wondered how my hobby project might be expanded to engage children "*...everywhere to become active participants in the ultimate search for cosmic company.*" Well, all we have to do is build a bunch of experimental systems and put them in classrooms around the world.

But, it turned out there were some big challenges, both technical and organizational. The introduction of the ERGO Energetic Ray Global Observatory represents a first step in achieving that goal, and, maybe, helping to fulfill to Jill's wish.

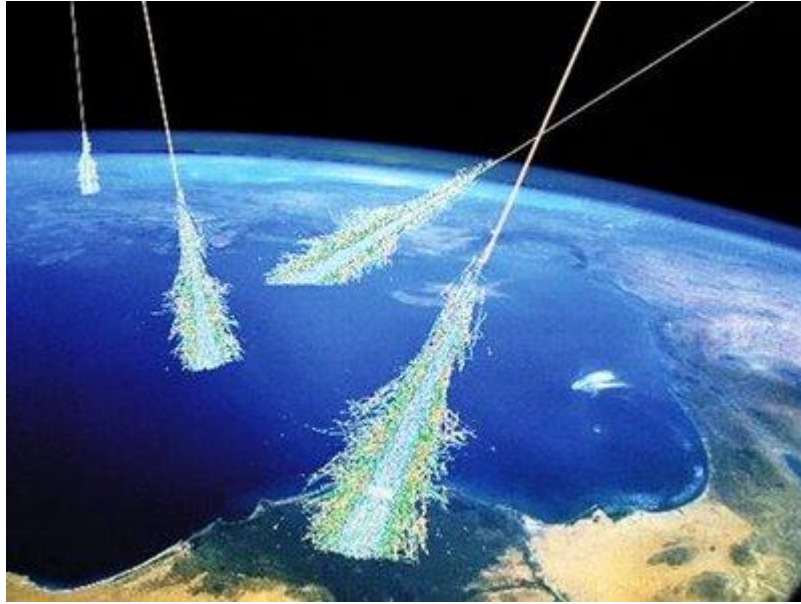
--Tom Bales

Sect. 4, The Cosmic Ray Background

HISTORY

For over a hundred years it has been known that energetic charged particles arrive at Earth from space. We call them “cosmic rays.” In the twentieth century it was found that some of these rays are extremely high energy protons traveling at nearly the speed of light. But, the source of the highest-energy protons--up to hundreds of billion-billion electron volts (exa-electron volts, EeV)--is not known. Since these particles are of much higher energy than any we can create with our technology, it is generally thought that they must be produced by processes related to high-energy magnetic fields, shock waves, or some other such phenomena on a galactic or intergalactic scale. These protons arrive more or less uniformly from all directions in space, but the lack of a specific direction of origin could be either due to a large number of sources or due to their paths being bent by interactions with magnetic fields or particles as they travel through space. Researchers have found variations in the numbers of cosmic rays arriving at Earth over time, and some of these variations have been traced to known causes such as solar wind and Earth’s magnetic field.

Cosmic Ray Showers



ATMOSPHERIC AIR SHOWERS

It is easy to detect these extremely-high-energy protons. When a high-energy proton hits the upper atmosphere it induces a shower of high-energy “daughter” particles that in turn generate more particles. A short while later, a very large number of energetic particles arrives at Earth’s surface, spread over a relatively large area – up to a kilometer in radius. Detectors for such high-energy particles are fairly easy to build, though the rate of particle detection is low for particles with the highest energies.

SCIENTIFIC SPECULATION

Because these particles are of unknown origin, perhaps it isn't unreasonable to suspect that one of their sources might be an intelligent technological civilization somewhere else in our universe. Recognizing that these extraordinarily energetic particles are easy to detect and are able to cross cosmic distances at nearly the speed of light, we might speculate they might have been chosen as a simple means of communication, or to be a beacon signaling the existence of a civilization.

So, we have the stage set for a scientific study to detect natural variations in the arrival rate of cosmic rays, and we also have the *possibility* of detecting an intelligent signal among these events.

MODULATIONS AND SIGNALS

Scientists studying cosmic rays have determined these rays arrive nearly uniformly from all directions (though the most recent studies suggest a bias in some directions). Over time the rate of cosmic-ray events varies slightly, and some of these variations have been related to the annual changes in distance from the sun, solar wind intensity, and in the local magnetic fields near earth. It appears, for example, that increasing numbers of particles emitted by the sun (the "solar wind") causes fewer cosmic rays to be detected--probably because of a shielding effect from the the solar wind. As earth nears the sun, increasing solar wind causes a similar reduction occurs in the most energetic cosmic rays (the ones from outside our

solar system). Thus, the sun causes both regular and irregular variations in the number of particles we detect.

Data gathered by the ERGO distributed telescope system will allow students to see and study patterns of cosmic-ray events in time and space, and to observe daily, annual, and solar-activity-related patterns. In other words, there are lots of real scientific observations and experiments, ranging from simple to complex, which can be done by students participating in the project.

What about the chance of an intelligent "signal" among all these seemingly-random cosmic-ray events? It happens that on earth we will soon be able to create proton beams up to nearly ten tera-electron-volts with the Large Hadron Collider (LHC) at CERN in Switzerland and France. Will we ever be able to accelerate particles to the extremely high energies observed in cosmic rays?

The first proton beams created on Earth in the nineteen-thirties had energies up to a million electron volts or so. We have increased the energy of proton beams by ten million times since then. So, how long will it take us to gain another ten-million-fold energy increase? Some physicists say another ten-million-fold increase may never be possible, because of the physical limits of magnetic fields, energy density, and so forth. What if someone were to work on that problem for another hundred years, or thousand years? What would a physicist living on Earth a million years from now know about generating high-energy beams? There might be a physicist living somewhere else, a million years or longer after his own society discovered nuclear physics. Is it out of the question that somewhere else in our galaxy, or in another galaxy, there have been experiments conducted that resulted in 100 EeV protons being shot off into space?

If we imagine such experiments, is it reasonable to expect that these protons beams would be created in a regular pattern in time--perhaps a pattern with exquisitely precise timing? Now, dear reader, take a leap of imagination: imagine you're that physicist. Would you consider the opportunity to generate these timed pulses in some sort of discernable *pattern* in time? Would you be able to resist doing so? What sort of pattern would you place upon the timing of your cosmic pulses? Would you use regular intervals or changing intervals? Would the time intervals between pulses of your cosmic rays be steadily changing, or would you use some sort of modulation scheme to impart information to the series of pulses – say, prime numbers or the Fibonacci series?

Enough speculation. Let's think about what we might detect and how we might detect it.

Sect. 5, ERGO System Operation

The ERGO Energetic Ray Global Observatory consists of five major components. The first three pieces combine to form a “pixel” of the ERGO system placed at each participating organization:

1. A Muon Detector
2. A Timestamp Generator
3. An Internet Connection

Once each pixel has gathered data packets and uploaded them to the internet, the final pieces of the system allow users to access and visualize the combined data which have been collected by detector systems all over the world.

4. The SQL Database Server: An internet server, hosted by a commercial IP service, provides a repository for event timestamps generated by all the detector systems around the world. Using a Microsoft SQL (“system query language”) database, the combined data are available to users for analysis.
5. User Interfaces: Large mountains of raw data are neither interesting nor exciting to most people. So, we will need to develop more user-friendly ways for students to get at the data and look for patterns. There will be provision to draw from the relational SQL database according to time and location, and some form of visual interface will be developed to give younger students an informative and interesting way to see data being collected in real time as well as historical data from the central database.

Sect. 6, The World's Largest Telescope

Why do we call this system a “telescope,” and what will make it as big as any possible Earth-based telescope? Galileo was the first experimenter to use telescopes to look at the heavens. Of course the telescopes that he used, and most of the ones used by astronomers and amateurs since that time, allow observation of the heavens by the visible light emitted by stars.

Visible light is only one way to observe, though, and many other kinds of radiation have been used to observe the skies. Observations have been made using radio waves, microwaves, gamma rays, infrared light, ultraviolet light, and even neutrinos, x-rays, and gravitational waves emitted and reflected by astronomical objects. Scientists have built very elaborate systems to detect cosmic rays, too.

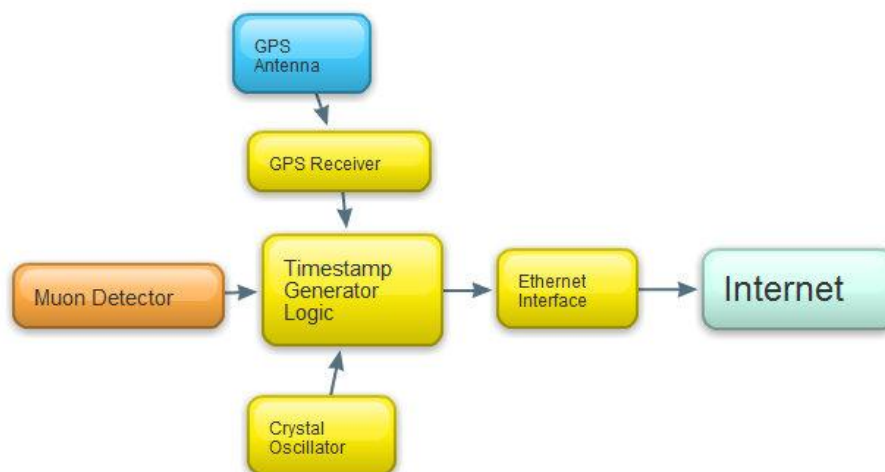
All of these observational systems are called telescopes because each of them allows scientists (and amateurs) to “see far” in different ways. “Seeing far” is what any telescope does, no matter what kind of radiation it is sensitive to. So, it is fair to call the entire ERGO Energetic Ray Global Observatory a “telescope.” ERGO will be formed by sensitive detectors placed in classrooms spread all over the planet. When all the data are assembled and coordinated, a kind of real-time image of the cosmic-ray sky will result. As Earth revolves and orbits the sun, the telescope will scan every direction in the sky. Such an imaging system has never been done on such a far-ranging scale.

Sect. 7, Construction of ERGO's Pixels

Any electronic imaging systems consists of a collection of individual image detecting units, usually called “pixels.” Signals from all the pixels are combined to generate an image. Working like a common digital camera, ERGO consists of an array of individual sensitive elements, or pixels. Each “pixel” consists of a Muon Detector, a Timestamp Generator, and an embedded Ethernet server that provides the internet connection.

Even though the pixels will be spread unevenly over Earth's surface, we will be able to synthesize an image by using the geographic location information reported in each timestamp. In fact, even if one of the pixels is moving, we can include its observations into the overall database by allowing for its changing position. We can imagine “moving pixels” in aircraft, on ships, and with explorers in hard-to-reach areas of Earth. Since most of Earth isn't covered by land, the use of temporary and moving locations will be essential to provide coverage of the full extent of the planet.

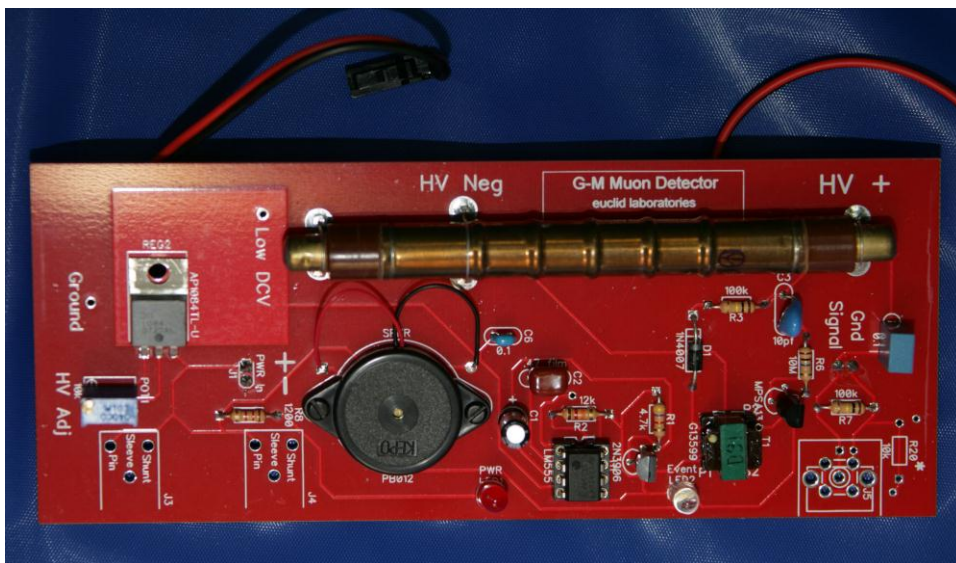
The ERGO “Pixel”



Each pixel of the ERGO imaging array consists of these elements:

1. Muon Detectors: When cosmic ray particles (usually protons) hit the upper atmosphere, a large shower of particles travels down to Earth's surface at nearly the speed of light. The majority of particles that reach the surface are muons, high-energy charged particles that are easy to detect. The simplest muon detector is a Geiger counter, and the Beta detector units are based upon simple Geiger-Müller (G-M) detector tubes excited by several hundred volts of electrical charge. When a charged particle, such as a cosmic-ray-generated muon, passes through the G-M tube, a small spark occurs, generating an electrical signal that goes to the Timestamp Generator.

Geiger-Müller Muon Detector



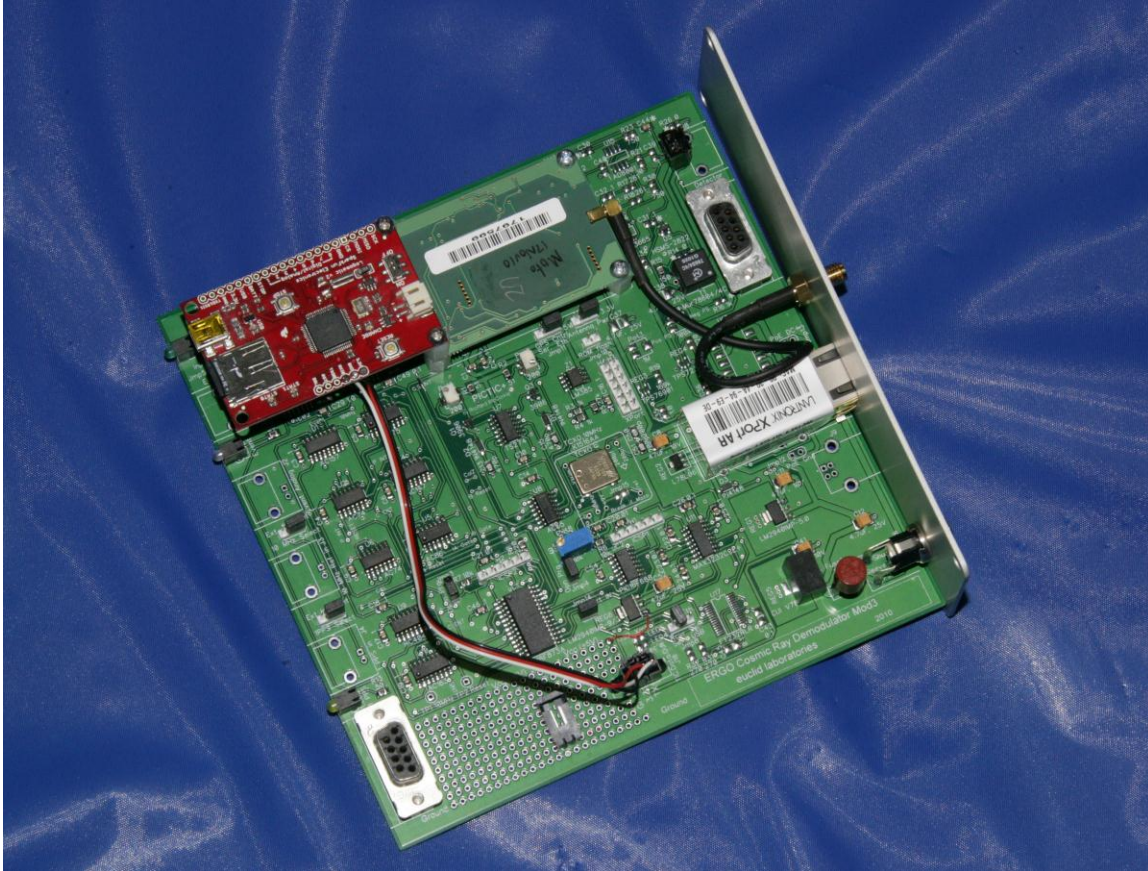
Also being developed for ERGO are glass “resistive plate chamber” (RPC) detectors, which are larger and sensitive only to high-energy particles. RPC detectors operate at much higher voltage and are not commercially available, so the ERGO project is hoping to develop a suitable detector for its use. These

detectors will detect fewer counts of Earth-based background radiation (such as those resulting from radon in the air) and their larger area will increase the likelihood of detecting the cosmic-ray muons of interest.

2. **Timestamp Generators:** The essence of a distributed telescope system is coordinating the observations of many observation sites. Cosmic ray events are detected at each site, and a data packet containing the location and precise time of the event is uploaded to the central database server. These data packets are called “timestamps.”
3. **GPS Receiver:** In order to provide high resolution in position and time, each Timestamp Generator contains a GPS receiver that determines the unit’s location and provides a very precise time reference from the GPS satellite system.
4. **Timestamp Generator Logic:** In order to produce a timestamp data packet, including the local latitude, longitude, altitude, date, time, and fractions of second when the event was detected, a circuit consisting of logic circuits and microprocessors manipulates the signals and data to produce the data packet. By using a crystal oscillator to divide seconds into a billion parts (nanoseconds), the logic produces timestamps precise to within a few meters of position and to within a few tenths of a microsecond of true “GPS time.”
5. **Internet Connection:** Once an event is detected and a timestamp generated, a miniature Ethernet server within the Timestamp Generator uploads the timestamp to the central database server by way of a cable connected to the LAN at the site where the system is located. The only outside resources that the

participating organizations need to supply are power and a LAN connection with internet connectivity.

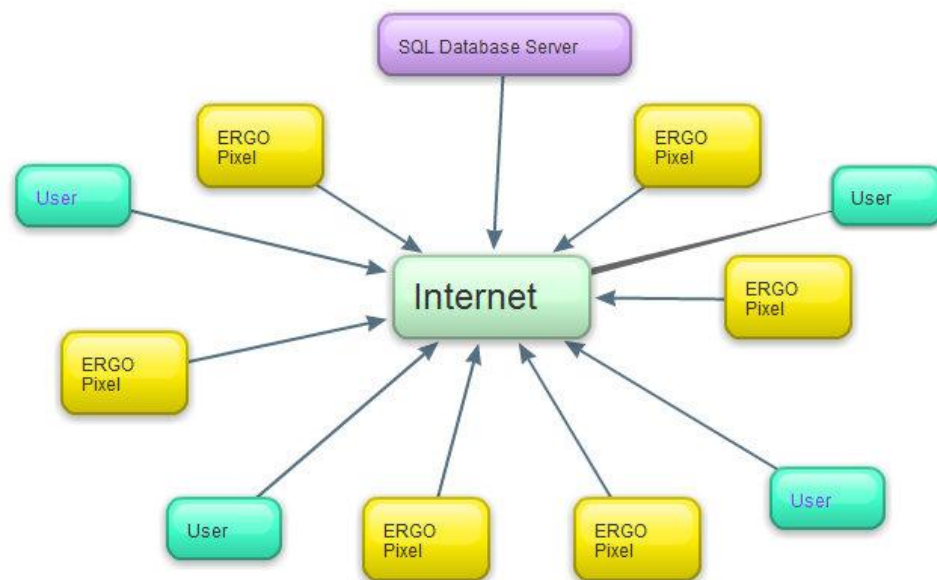
ERGO Timestamp Generator



Sect. 8, Internet Connectivity

Once a timestamp has been generated by one of the ERGO pixels, it is uploaded by the miniature server inside the Timestamp Generator, over the local LAN network, to a central SQL database server. Once the data have been aggregated by the server, they are available to all users for analysis and presentation.

The ERGO Network



Sect. 9, Opportunities for Data Analysis

Users may use the collected data to do retrospective analyses, look at regularities and patterns in the rate of cosmic rays and see how detection rates vary over Earth, how they change throughout the year, and how they are affected by such things as magnetic storms and solar activity cycles. The involvement of a classroom can range from simple counting and averaging of their own data, to comparing their data with those of another location on earth—or to much more complex geometrical and mathematical analyses.

Users may also choose to monitor data in real time as collected to look for global or large-area events that caused by extremely high-energy rays or by clusters of rays. One possible type of analysis, relating to the search for extraterrestrial signals, would be the determination by spherical triangulation of of origin of ensembles of rays. If there *are* any such ensembles, or pulses, of multiple cosmic-ray particles arriving at Earth, they would blanket Earth in about twenty milliseconds, given their relativistic velocities.

Other ways to present the ERGO data, such as visual representations, Google Earth maps, and other graphical means can be developed by participants in the ERGO network.

Sect. 10, Installation at Your School

WHAT'S INCLUDED IN THE SYSTEM

Each Beta-3 ERGO system delivered to an organization consists of all the pieces needed to assemble a “pixel” of the ERGO Energetic Ray Global Observatory. Each participating organization will receive the following pieces:

1. The ERGO detector/timestamp generator instrument, housed in an aluminum extruded cabinet approximately 6.5” X 6.5” X 2” and including the G-M Detector, GPS receiver, logic circuits, oscillator, datalogger, and Ethernet server interface.
2. AC Power Adapter to supply 12 Volts DC to the Detector/Timestamp Generator.
3. The GPS Antenna with 20’ of cable and an SMA connector (hex-type gold-plated fitting) permanently attached to the antenna.

ASSEMBLY OF THE LOCAL “PIXEL”

Connect the components of the Beta-3 ERGO pixel as shown in the following photo:



Plug the AC Power Adapter into a local AC (mains) outlet and connect its output plug to the .

Attach the GPS Antenna by screwing the hexagonal nut on the end of the GPS Antenna cable onto the “GPS Antenna” connection on the rear panel.

The “Ethernet” jack on the Timestamp Generator must be connected to the organization’s local-area network (LAN). The Timestamp Generator will automatically connect to the local router and request an IP address. In most cases, nothing will be required other than plugging in a CAT-5 cable to join the system to a hub or switch on the LAN. If communication is prevented by a local firewall, or if the LAN does not accept the request for IP assignment (DHCP), contact euclid laboratories for assistance.

Once the system is connected, place the GPS antenna in a window sill so that it has a clear view of the sky. If no window is available near where the ERGO unit will be installed, the GPS antenna may be placed in a remote location by means of an SMA extension cable (if needed, contact Euclid Laboratories); long cables can significantly reduce the GPS signal strength, so try to work with the

cable supplied. The antenna is weather-resistant, so it may be placed outdoors, with the cable routed through the building wall by some means. Outside placement will give the greatest reliability and most precise timing. The most important factor is for the antenna to be able to “see” a significant portion of the sky.

Once the connections are completed, the antenna placed, and power connected, wait to see if the blue “Event” light occasionally blinks. If it is blinking (perhaps a few times per minute), then the “physics” part of the system is working. Next, it will be necessary to verify that the system (your local ERGO “pixel”) is uploading information to the central SQL database server. Euclid laboratories will assist you in verifying that everything is working properly, and your data packets are being correctly received.

PARTICIPATING ORGANIZATIONS IN THE ERGO PROJECT

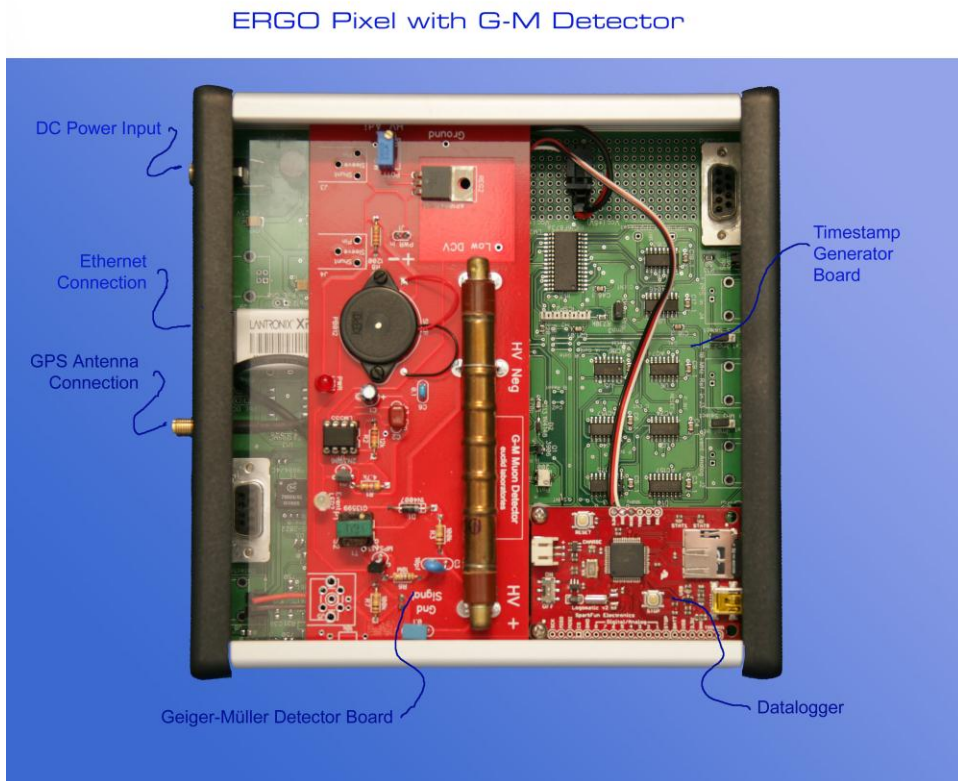
“Beta Roll-out”:

- St. Thomas Episcopal Parish School
- Carrollton School of the Sacred Heart
- Belen Jesuit Preparatory School
- Christopher Columbus High School
- Miami Lakes Technical Educational Center
- Gulliver Preparatory School
- Ransom Everglades School
- Miami Northwestern Senior High School
- StarBot, Inc.
- Syntheon, llc
- Richard McCorkle, Fairbanks, AK
- Museum of Science, Boston

Sect. 11, Technical Details, Drawings, and Schematics

Various technical drawings, photos, and specifications follow to help the users understand the construction of the system's components.

Detector/Timestamp Generator Assembly, with Internal Data Logger



Front and Rear Panels

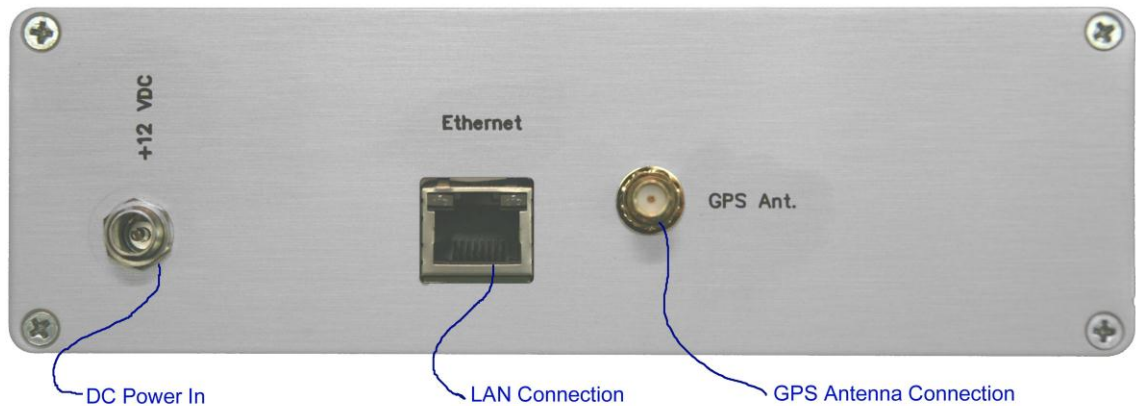
ERGO "Pixel" Front and Rear Panels

Datalogger
USB Jack Micro-SD Card

Front Panel



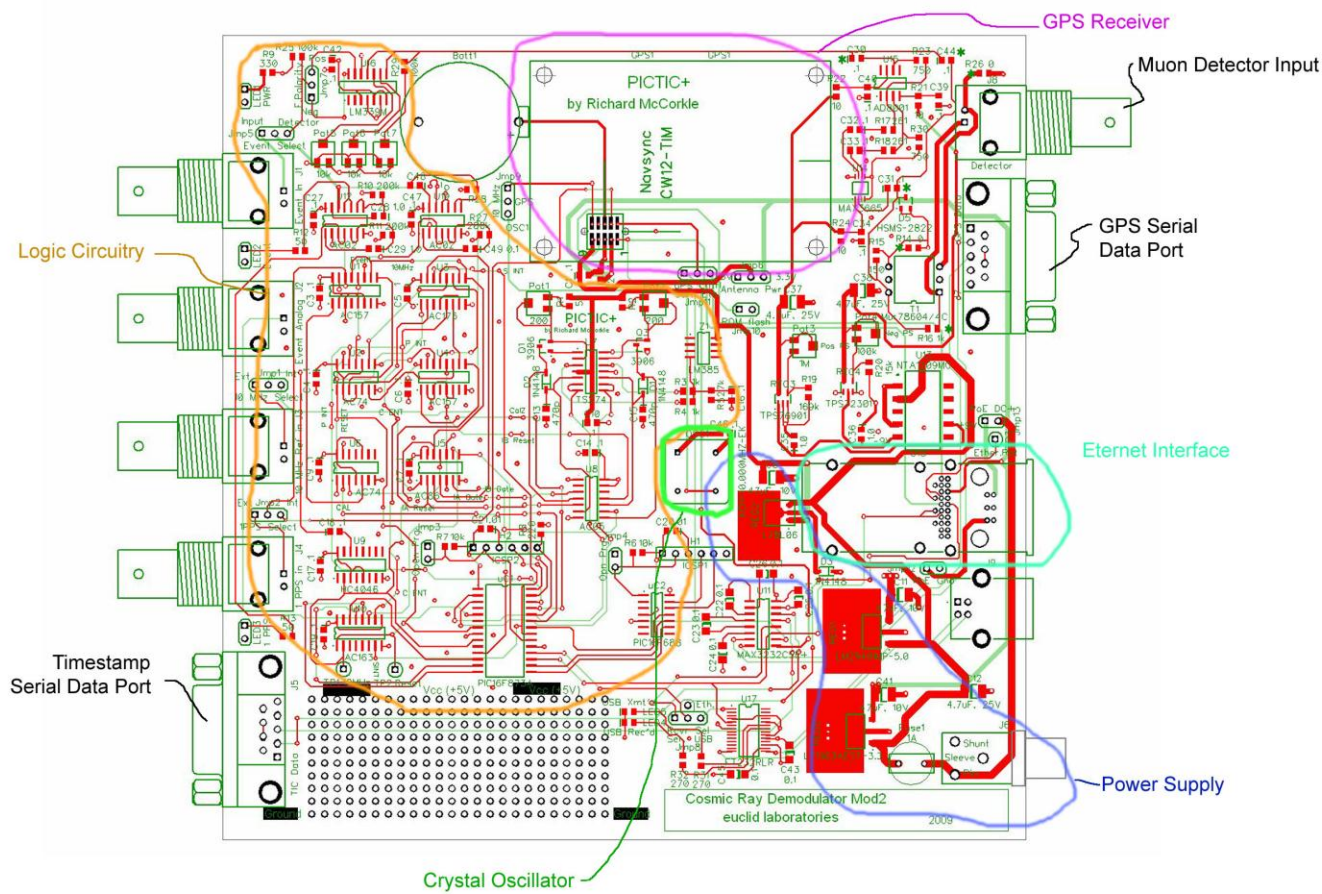
Rear Panel



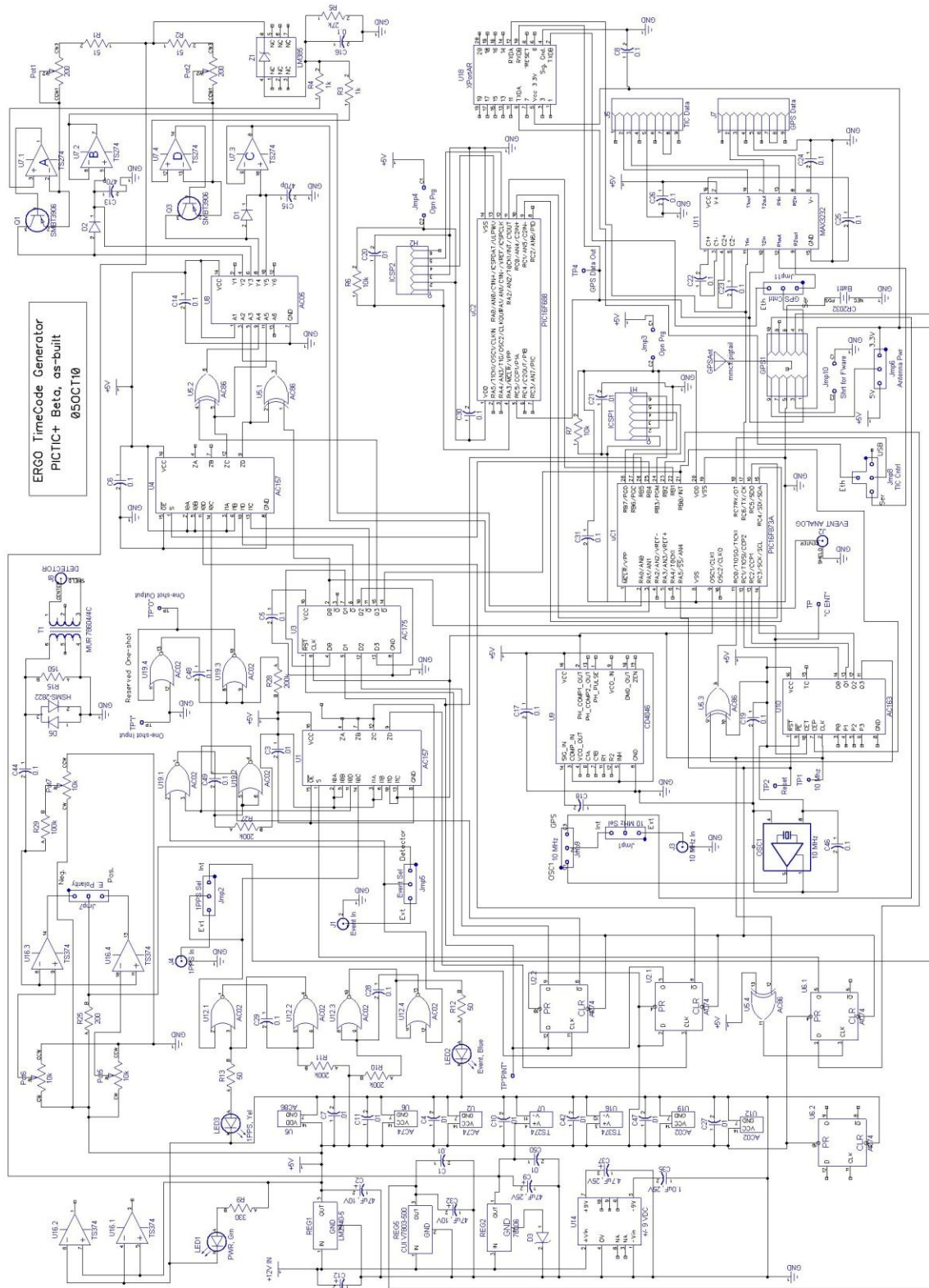
ERGO Timestamp Generator

Sub-systems

ERGO Timestamp Generator



ERGO Timestamp Gen. Schematic



ERGO Beta-3 Timestamp Generator Set-up and Calibration

(performed by euclid laboratories)

1. Adjust low-voltage regulator in G-M Muon Detector to 5.50 volts
2. Connect G-M Muon Detector to Timestamp Generator board (signal and power leads)
3. Connect GPS Antenna to Timestamp Generator
4. Verify that the polarity jumper (Jmp7) is on "Negative"
5. Adjust threshold (Pot6) to one-quarter turn clockwise from the setting where the blue "Event" LED goes from constantly-on to intermittent. If events are not being detected, a setting between one-eighth and one-half turn CW is acceptable
6. Verify that events are being randomly detected, a few seconds apart.
7. Connect the LAN cable and verify data are being sent by the Timestamp Generator.

ERGO Database Manager Local Installation

For Microsoft SQL Management Studio Express

Installing Microsoft SQL 2008 Server Management Studio with Advanced Features

- Download the package software from Microsoft. The version to use for XP and other 32-bit Microsoft operating systems (XP Pro and Windows 7 32-bit) is SQLEXPADV_x86_ENU.exe. You can find it with Google.
- Run installation package: SQLEXPADV_x86_ENU.exe
- Select “Installation” from left-hand list.
- Select first option: New SQL Server stand-alone installation or add features to an existing installation
- When “Setup Support Rules” comes up, fix any issues, such as installing Microsoft Power Shell or re-starting the computer. If no errors are reported, click “Close”
- When “Setup Support Files” comes up, click “Install”
- If no issues, click “Next”
- Click “Next” again to install the free version
- Click the box “I accept the license terms” and click “Next”
- Click “Select All” and then “Next”
- In “Instance Configuration” box, the Named instance should be dotted and indicate “SQLEXPRESS”; the Instance ID should be “SQLEXPRESS”; the Instance root directory should be “C:\Program Files\Microsoft SQL Server\”. Click “Next”
- The next box “Disk Space Requirements” indicates how much space is required and how much is available. Click “Next”
- The next box, “Server Configuration” needs the Account Name and password to be entered:
SQL Server Database Engine: in “Account Name” select NT AUTHORITY\NETWORKING...
Password: blank
Sql Server Reporting sServices: in “Account Name” select NT AUTHORITY\NETWORKING...
Click Next
- The next box, “Database Engine Configuration,” under the “Account Provisioning” tab, select Mixed Mode (SQL Server authentication and Windows authentication); enter the Windows

user's sign-on password (4159), and click "Add Current User"; then click "Next"

- The next box, "Reporting Services Configuration," should have the "Install the native mode default configuration" circle dotted.; click "Next"
- The next box, "Error and Usage Reporting" doesn't need anything checked; click "Next"
- The next box, "Installation Rules" should report no errors. Click "Next"
- The next box, "Ready to Install" gives a lot of information. Click "Install"
- It takes a lot of time, and a whole lot of stuff happens while the progress bar progresses.
- When completed, a message will appear that says you need to restart the computer. Click "Next"
- The next box, "Complete," says the installation completed successfully, and a pop-up box says "You must restart the computer to complete SQL Server Setup"; Click "OK" in that box and the big box will close.

Setting Up Management Studio for ERGO Telescope Data

- Run Microsoft SQL Server Management Studio
- When the "Connect to Server" box pops up, select Server type as "Database Engine"; Server name: s03.winhost.com; Authentication "SQL Server Authentication"; Login: DB_13669_cosmic_user; Password: edc123ijn; "Remember Password"; click "Connect"
- Click on Databases in the left-hand tree menu to open it. Click on DB_13669_cosmic; Tables; System Tables; dbo.eventraw; columns; rawdata; double-click to bring up "Column Properties" box; click "Close"
- Click "New Query" in upper left-hand toolbar (just below "File" tab).
- In upper window, under "SQLQuery1.sql" tab, type : `select *
from eventraw`
- Click "Execute" button
- Data will be listed in lower window.