**NWX-NASA-JPL-AUDIO-CORE**

**Night Sky Network Telecon:**
**The ERGO Project**

**February 24, 2015**
**8:00 pm CT**

Coordinator: Welcome and thank you for standing by. All participant lines will be in listen-only mode until the question and answer session of today's call. At that time you may ask a question by pressing star 1. Today's conference is being recorded. If you have any objections, please disconnect at this time. I would now like to turn the call over to David Prosper. Thank you. You may begin.

David Prosper: Hi, everyone. This is Dave Prosper from the NASA Night Sky Network here at the Astronomical Society of the Pacific in San Francisco, California. And I'm really excited to present this teleconference with our guest speaker, Tom Bales from the ERGO citizen science project to detect cosmic rays.

One of the most exciting parts of this project, aside from the science, is the ease in which an ergo unit can be set up and used by people of all ages. And it's a great way to introduce kids into not just the next level of physics but to the instruments they can use with that physics as well.

So before we get started, I just want to make sure that you can all view the presentation slides. So if you don't have the slides up in front of you yet, you can download them at BIT.LY/NSNERGO. And that's in all capital letters, by the way. Just BIT.LY/NSNERGO.

And if you have any other problems along the way, feel free to email us at nightskyinfo@astrosociety.org. I just updated my computer to Windows 10. And I should hopefully get those emails no problem, though my Outlook has been acting up a little bit today, of course.

Now for a brief minute, I would like to hear from the folks joining us tonight. So I'd like to open up the lines for a minute, (Jared). And if the folks out there could just give us your name and tell us where you're calling in from and what club you're with, we'll have an idea of who's out there listening in.

Coordinator: Absolutely. All lines are now open.

Stewart Myers: Okay. I'm Stewart Myers from Amateur Astronomers, Inc. in New Jersey.

(West): And (unintelligible) (West) from Amateur Astronomers, Inc. in New Jersey.

David Prosper: Awesome.

Linda Prince: This is Linda Prince from the Amateur Observers Society of New York. Hello, Dave.

David Prosper: Awesome. Hi Linda.

Robert Lyons: Robert Lyons, Everett Astronomical Society from Washington State.

David Prosper: Excellent.

Michael Singer: Hi. Michael Singer from the Los Angeles Astronomical Society of southern California.

David Prosper: Awesome. Welcome.

Harry Treece: Harry Treece from the Astronomical Association of Southern Illinois in Carbondale, Illinois.

David Prosper: Very cool. Thank you for joining us. Okay. And we'll just wrap that up for now. And it's really good to hear from everyone. And so if this is your first or fiftieth teleconference with us, welcome. Just follow along with the slides. And there'll be time for a brief Q&A at the end of the talk.

Now just for a minute, we have a brief overview of the latest NSN news for our members. We had temporarily resolved the bounce back issue in sending emails to domains hosted by AT&T.net.

But that was a brief respite, because the bounce backs are back again, unfortunately. So somehow we got blacklisted again. So we have several cases open with AT&T to get the NSN mail server off their blacklist. So hopefully this will be permanently resolved soon. So you have our apologies for this.

In the meantime, you can manually email your roster using your BCC option by using a file of your members downloaded from the club's inter-center roster page. It's kind of an ugly work around. But we're hoping to get us on the good list again shortly.

We have also a brief backlog on emails. But we're hoping to catch up with most of you all by tomorrow. There's been a lot going on behind the scenes. So hopefully there'll be a lot of good news shortly.

And speaking of other busy news, we just finished shipping pins to everyone last week. And so if you've not yet received your pins, please send us a note. Because you should have them at this point.

And we have a few left. So if your club would like to order more outreach award pins or you'd missed the cutoff date, you can still order them from us. We have a few left.

And you can go to BIT.LY/NSNPAYPAL to order them and send us an email at nightskyinfo@astrosociety.org to let us know your preferred shipping address. Or you can just email us and we can figure stuff out. So yes.

Anyway, it's my great pleasure now to introduce our speaker, Tom Bales, from the ERGO Project. Tom is going to talk about ERGO, a global citizen science project developed by high school and college students over the past five years.

The Energetic Ray Global Observatory is made up of cosmic ray detectors around the world, primarily in schools, museums, and laboratories. All of these detectors are connected by the internet so that a precision, location, and timestamp is reported for each detected cosmic ray event.

The goal is to engage kids in science by building a unique network that can search for time and position related correlations from cosmic ray detection around the world.

Tom Bales graduated from MIT in 1970 with a bachelor's degree in mechanical engineering. His career has been primarily in the field of medical device development with occasional work in the field of rocket propulsion.

And for the past several years, he has devoted much of his time to working with stem students involved in robotics, cosmic rays, and other experimental science projects. Mr. Bales is a registered professional engineer in the state of Florida, and the holder of 140 issued U.S. patents. So Tom, if you'd like to begin.

Tom Bales: Hi, David. Yes. Well it's a great pleasure to be able to speak to all of you. And I hope you'll find the ERGO Project interesting. I thought I'd start by telling you how it all got started. If you're looking at the slides, you'll see the lead slide - it's a little zany. It's what if kids ran the world's biggest telescope. Well it's actually - what if kids built and ran the world's biggest telescope.

The idea came out of some things that I was tinkering with and a talk that I heard at a TED conference in 2009 by Jill Tarter. Some of you may know Jill. She has been in charge of the SETI Institute for a while and is the actual person who is the basis of the character Ellie Arroway in the Sagan movie Contact.

So she really was one of the pioneers of radio astronomy. And she's been leading the charge lately to try to get kids interested in science and technology.

And I heard this talk. And I said - wow. That's maybe something I could do. I have been tinkering around with a number of things, because I'm kind of a tinkerer. I have this book on cosmic rays, because for some reason I just got interested in cosmic rays.

And as I'm sure all of us do, the first step is to buy a big, thick book and see how much of it you can read. In this case, it wasn't very much. In fact, some of the graphs I couldn't even interpret. So I started carrying it around hoping that somebody would say - hey, Tom, wow. That's a cool looking book you've got. I'm interested in that too. Well that never really happened.

But I was at a conference in England. It was the 150th anniversary of the British Urological Association, which is kind of an oddball group to be at. And there I met a bunch of Americans that are in a user group called the Time Nuts. So I've always been interested in clocks. And they were talking a lot about atomic clocks and super precise time measurement, especially using the GPS satellite system.

And at the same time, the Large Hadron Collider was being turned on. So it was an exciting time. And I thought - how do these things all fit together? Well one way they fit together was, it was a good excuse for me to buy some Geiger counters and some atomic clocks and some things like that - some instruments - just because it looked like an interesting field to play around in.

I was working with those things on a project of my own in the hopes of getting some students - in particular my own kids - interested in pursuing this. Because I figured - well, it would look good on a college application anyways, if nothing else, that we've been studying cosmic rays.

As I'm sure you know, any time you mention cosmic rays people think you're really smart. Mostly because it's something that not many people know about. But it's pretty simple stuff, really, to the extent that it's understood.

So what's a cosmic ray? Cosmic rays are hitting the earth all the time. They're very high energy, typically. Most of them are protons - about 80% of them. And the remainder of them are helium nuclei alpha particles and some heavier nuclei, at least up to iron in nuclear size.

Somehow they get accelerated in some cases to fast energies, energies in the range of tens of electron volts - or 10 to the 21st electron volts. Now, to give you an idea of what that means, the Large Hadron Collider can only accelerate protons up to around 10 teravolts or 10 to the 13th electron volts. So there's another 10 million or so fold increase in energy before you get to the realm of some of these highest energy cosmic rays.

David Prosper: Tom, one second. Can I just ask what slide we're on right now?

Tom Bales: Sure. Just starting to talk about slide four.

David Prosper: Four. Cool. Thank you. Just so we know - for people who are following along at home.

Tom Bales: I'll try to give you a hint of when to switch slides.

David Prosper: Cool. Thank you.

Tom Bales: So these rays are coming from all over. In fact, many of the ones that we can detect in earth are from extragalactic origin. In some cases, as much as three billion light-years away. Which means they've been sailing through space a long, long time before getting here. They're such high energy that they're basically going at the speed of light or very nearly so within a tiny fraction of the speed of light.

So let's go to slide number five. So what's a cosmic ray? Again, 80% of them are protons. And what happens, of course, is it becomes ionized at high temperature - let's say in a star or in a interstellar cloud - and so you have a loose proton.

Next slide is sometimes the proton gets wildly accelerated. Well somehow - doesn't seem very scientific - but it's not at all clear how all of these particles are accelerated to such high energy levels.

Some of them are fairly well known - magnetic fields even around stars, black holes, jets of particles from black holes, from collapsing stars, the neutron stars count for some of them. But according to the research that's been done by cosmic ray scientists, those processes are not energetic enough to create the particles that we see in the highest energy ranges.

Now cosmic rays have one really neat characteristic, especially for the amateur. They're easy to detect. Now they're easy to detect because we live on the earth. And the earth is surrounded by an atmosphere. And the atmosphere kind of works like an antenna, if you think about the way a radio amateur would look at it.

Each time one of these particles hits the upper atmosphere, it creates a cascade of particles. Usually first a pair of pions and then the pions hit other nuclei and the air molecules, and all sorts of particles - gamma rays, neutrinos, and muons are finally generated.

The muons - again, they're going (relativistically) at speed. And although a muon only has a half-life of around one millisecond, the atmosphere looks really thin if you're going at the speed of light.

So they all impact the earth. And this giant shower ends up being a pancake of highly energetic particles hitting the earth. And that pancake may be hundreds of meters or maybe even a thousand meters in diameter.

So for each proton, you can detect this event over quite a range. Which means simple means suffice to detect these cosmic rays events. Geiger counters work just fine. They're probably the cheapest way to do it.

Scientists who are involved in doing more sophisticated work like to use scintillation counters. And in particular they'll use a pair of them to make sure that it's not just some terrestrial radiation that's being detected. Basically you stack two detectors. And if you get a simultaneous or nearly simultaneous event from both of them, then it's probably a muon from outer space.

So what's the ERGO Project? Next slide, number nine. The ERGO Project or Energetic Ray Global Observatory is a project to get kids interested in science. Notice that I didn't say it's a project to discover great things about cosmic rays. We hope to do that. And we're certainly set up to be able to do some studies which none of the other cosmic ray research operations could possibly do.

But the primary goal - which I'll come back to at the end - is to get kids interested. You know, we've all had the experience of being in chemistry class or science class in elementary or middle or high school, where you stick some nails in a lemon and you try to measure the voltage. Or you watch some nails rust in a bag with some lemon juice in it. Or these sorts of corny experiments rubbing peanuts onto brown paper.

And it seems to me that those experiments aren't really illuminating, and they aren't really exciting. It's hard to imagine that anybody ever got excited about a lemon with a copper and a zinc nail stuck into it. So I thought - let's try to do some real science. Something that at least involves some real instrumentation and some real measurements and a possibility of discovering something new.

So let's go down to slide number 10. Our idea is to create a global observatory. Well, we say that it's the world's largest telescope. And we say that because the aperture of our telescope objective is about 8,000 miles in diameter.

In other words, it's the earth itself. It happens that we're equipped with this nice, rotating planet that goes around once every 24 hours or so. So a sensor placed somewhere on the earth will scan around most of the sky as it turns and as the earth revolves around the sun over the year. So we have a scanning array.

We would love to cover the whole earth, of course, with pixels or sensors. But that's probably a little beyond our ability to do right now. But we're at least working on hundreds of them. We've got over a hundred now out in the field.

And what each sensor is, is a radiation counter and a system for measuring time and location very precisely. And it's our goal to get as many as perhaps a thousand over the next two or three years, so that we'll have quite a large array.

We've been collecting data now for four years or so. And we have hundreds of gigabytes of data recorded on our server. And that accounts for several hundred million events that we've detected with the sensors that we have spread around the earth.

If you want to see what our network is doing at any given time, you can go to www.ergotelescope.org. And there's a map there that you can click on and see what's happening live. And it'll show you either on a round Google Earth sphere or on a flat map where the instruments are reporting around the earth. Of course there are a lot here in the United States. But we're starting to get more and more of them around the outside of the planet.

So let's go down to the next slide. Slide number 11. What makes up an ERGO detector? Well you have to have some kind of a muon detector - some kind of a radiation detector. We're using Geiger-Müller tubes - actually surplus ones from Russia. They're readily available. And they don't cost very much. But they still are one of the more expensive components of our systems.

It'd be nice to have multiples of them so we could do coincidence detection. It'd be even nicer if we had a big planer detector of some sort. But to do that generally involves using photo multiplier tubes, more expensive electronics, and it's just a more elaborate thing.

Part of our goal is to be able to make hundreds of thousands of these instruments. So they can't cost $5,000 or $10,000 each. They need to cost in the hundreds of dollars range at the most. But in one of our instruments is a Geiger counter detector, some sort of a location and time sensor - in other words, a GPS satellite receiver.

It turns out the GPS is the most precise way of measuring time, unless you're really, really, really hardcore and you have your atomic clock that you're willing to go to Fort Collins, Colorado to calibrate every now and then. GPS is pretty good. You can get down to at least a few tens of nanoseconds of actual, official, coordinated time.

So inside our instrument, we have those things. And some electronics is required so that when an event is detected, we create a timestamp. One second. We create a timestamp which says the latitude, longitude, altitude, and the time down to nanoseconds.

Our original instruments - which you see in that picture on slide 11 - were about six inches square and about two inches high. And they cost us around $600 or $700 in parts to build. They were all built by students, by the way - mostly high school students. Most of the project has been done by high school and college students, and a couple of elementary school students.

Slide 12 shows you what's inside. There's a GPS antenna which goes in a windowsill, typically. The GPS receiver is built into the system. The muon detector - in this case, a Geiger counter.

Some electronics to do the timestamp generation. A crystal oscillator as a local time base. An Ethernet interface. And the internet. So we have our server on the internet. And it collects data from all of these instruments, which - just like ET - call home whenever an event happens.

Slide number 13. So we have this giant telescope. And as you all know, telescope doesn't mean necessarily looking with your eyeballs, but some means of seeing far.

So the internet connects a bunch of these pixels shown in yellow. And some users shown in green, who can dial into or log into the database to do data analysis. And the pink thing at the top is our SQL database server.

We're actually using a database software called MySQL right now. And it's almost in the public domain. There's public domain software you can get to deal with it. And maybe we'll talk about that a little later.

In slide number 14 you'll see what the inside of those old boxes use. And these are what we have in place around the world right now. You can see that red board on the top, the big one with the Geiger tube on it.

The green board underneath is a whole bunch of analog logic chips and a couple of microprocessors. The small red board on the lower right hand corner, you can see, is a data logger. And just to the left of it - left and down from it - is a small green board you might be able to make out. And that's the precision GPS time receiver.

But now we've got a new version. We've been working on trying to improve this system so that we can make more of them. The primary goal is to make them cheaper, but try to make them better as well. And we did a lot of experimenting with Arduinos, different flavors.

And what we found was that an Arduino with SD card storage and an Ethernet interface and enough memory to run our software ended up being a rather expensive affair, over $100 just for the Arduino board or an Arduino and some add-on shields.

So about that time, the Raspberry Pi computer came out. And now for $35 you can buy basically a little, tiny, desktop computer. On the right hand picture on slide number 15, you see at the bottom that green board - that's a Raspberry Pi. Well, up to a week ago that was the latest version. There's now a new latest version. But they're all compatible.

It runs Linux. And it's actually, as I said, a desktop computer. On the bottom of it, you can see with the little bit of brown tape on it, an HDMI connecter. So you can connect by USB a keyboard and a mouse. And you connect a monitor by that HDMI cord. And you have an actual, fully operational Linux computer.

And that has great advantages to us. Because although we might not need that user interface most of the time, it sure is handy when you're trying to set an instrument up and connect it into a local area network.

Many of our instruments are at school and colleges. And if you've ever had any experience trying to connect something to the internet at a college or a high school, it's a challenge. Because they go to a lot of trouble to keep people from connecting to their internet, to their LAN.

So having a real desktop environment lets us go and sign in by Wi-Fi or by wired Ethernet and enter passwords and do all the things that you need to be able to connect a computer into the local area network.

On top of that green board is the red board. And that's all the rest of an ERGO pixel. At the top you can see an outline of a Geiger counter tube. It's actually knotted underneath the board. Below that are some connectors that interface with the Raspberry Pi.

Just a few tips. There's a high voltage power supply to run the Geiger counter. It needs around 400-V dc or so. In the lower right hand corner of the red board, you see kind of a gold-colored rectangular module. That's the GPS chip. In fact, it has its own antenna built in.

And for about $20 you can buy these - this is a u-blox GPS receiver. And it can detect the time within about 20 or 30 nanoseconds and the location within, let's say, 30 to 100 feet - depending upon satellite reception. To the right of that, you see a small RS connector, which is what the antenna connects to.

So if you plug these two boards together, now you have a complete ERGO receiver - a pixel is what we like to call them. And that goes inside an aluminum box as you see on the left. And all you have to do is to connect an Ethernet either by wire or by Wi-Fi. And connect a power supply and the antenna - and you're ready to rock and roll. It puts itself online and starts sending data in.

So we've been experimenting with the Raspberry Pi. The software has been written by some students. Our goal is to put all of this in the public domain. Anybody who wants access to it, we will give you. We just haven't gone through the formality of putting it in the public domain so that everybody can get at it.

Our hope is that either we manufacture that red add-on board or we get somebody like Adafruit or Sparkfun - if you know those companies - to manufacture and sell it for us. So that anybody could buy one of those and put a Geiger counter tube on it, buy a Raspberry Pi, download the software from our Web site onto an SD card, and they're ready to go. Plug in and you become part of the network.

If we go down to slide 16, I thought I'd talk to you a little bit about - what do we need now? Doing this project has been a real educational experience for me. Of course I like to work on hardware. I like machining boxes. And I like suturing things and putting together the Geiger counters and doing all of that stuff.

But I'm not so (fast) with the software. But fortunately we've had some students and some adults who have taken up the challenge there and have provided the software that we need. But that gets the pixels built.

And there's still some remaining problems that are a bit tricky to manage. And I thought maybe I'd get some help from you guys and ladies to overcome some of those obstacles. One is - how do you place these things?

You need to find a place either in a school or a library or a museum - or even in a laboratory or a teacher's house - where somebody's interested in participating in the project and who will make sure the thing stays plugged in and respond to us by email now and then.

But most of our connections - even the ones in Indonesia and the Middle East and Australia and the Galapagos and the Canary Islands, Alaska - have all been first, second, or third generation person-to-person contacts. We haven't figured out a way to advertise to get the right sort of people with the right level of motivation to be able to join in and take part in the fun and help us develop the project.

So it's been going by word of mouth, really. And if any of you are interested in participating then you should contact me. You can send a note in to tom@ergotelescope.org and I'd be happy to talk to you.

We're starting to build 100 more of these Raspberry Pi based pixels. So we're looking for people who are willing to participate, host one of these pixels, and participate in the project - help us figure out how to get kids excited and interested in it.

So this summer, I plan to have about a dozen students - that's what we've had for the last three or four years - working in my laboratory building ERGO pixels. We've got 100 of those red boards that were factory built. So assembly is going to be much less laborious now.

But they're going to learn about machining the holes in those aluminum boxes and laser-engraving the end caps and doing all those things - putting together assembly manuals and installation manuals and that sort of thing.

We need somebody to analyze data - to look for patterns in time and location. Well, why would we want to do that? It turns out that's the thing that we have a unique ability to do. Nobody else has a worldwide or global array of radiation detectors. Never mind cosmic ray detectors.

So if there are any global scale patterns in space or in time or location, we're the ones to look for it and try to identify it. What that means, of course, is number crunching. And downloading information from the database, constructing queries in the mySQL database, trying to look for patterns and temporal consistencies in the events.

We need help in making contacts with school and colleges to host these things. If you're interested in writing code, our Web site is rather rudimentary. And we'd love to have data up, analysis applications on the Web site, so that you could download data directly. They'd be in comma-separated files or some other sort of usable numerical data

Also, since it's a Raspberry Pi and there are a lot of people working with Raspberry Pi's, we figure there are a lot of opportunities for enhancing the resident software, including applications that could run under Linux for the local management of the pixels or doing local experiments, so forth.

We're looking for teachers who are interested in some real tough science project for them to do with their students. It's hard to get into classrooms, because teachers are so burdened with curriculum, all that nasty stuff that they're required to teach. Some of it's not that exciting.

But it's hard to find time to do citizen science projects like this. So we're looking for - as somebody might say - a few good teachers who have the ability and the interest in pushing the envelope here with kids from elementary school to college age.

Because there are things that you can do, some of which are very simple, some of which are much more elaborate, and everything in between in terms of math and physics, engineering, and even manufacturing these devices. Since with the new system, the Raspberry Pi based, a classroom could build a few of them and place them in homes or in partner's schools.

So what's next? Well, we're building these 100 Raspberry Pi things. And those are the task you see that we have to do in the spring and the summer to meet our goal by August of having 100 units - hopefully many of them placed, but at least all of them packaged up and ready to ship.

We're going to be looking for hosts for the new pixels. That's where some of you might be able to help us. And we're going to be starting to work in earnest on analyzing the data of all the events that we've recorded so far.

We want to explore ways to make it easy to get an ERGO. And that will probably mean either we manufacture them and sell them or donate them or do something like that, or we get an enterprise like Sparkfun or Adafruit or Seed Labs or the Maker Shed to manufacture them or at least to distribute them - so as to take that load away from us and really open up the project to a lot of other people.

And the real goal is to keep kids excited about doing real science. Our interns have done a lot of things besides just building the hardware and doing coding. We've done a rocket launch. We did a balloon launch last summer. We've done field experiments. People have taken ERGO pixels to the tops of mountains.

I'm hoping to get someone to take one down in a mine. There aren't a lot of mines in Florida, by the way, which is where we're centered. But there are mines that you can get quite deep up in the Midwest and the northern parts of the United States. There's a Sudbury mine and I guess it's the Home State Laboratory where they actually have tours.

So it's possible for somebody to go and take one of these things thousands of feet into the earth. The highest energy cosmic rays will penetrate hundreds or maybe even a thousand feet of earth. But when you get down that deep, we should be pretty much not seeing any cosmic radiation, only seeing terrestrial background.

So that's what we're trying to accomplish. And if any of you are interested, you might be able to help us with that. Now I thought I'd give you a little bit of speculation. Part of the reason for doing this is because this is one of the things which gets the kids interested. And it may seem crazy. And I'll preface it by saying this may sound completely nuts. But it's not entirely incredible.

So go to the next slide. Let's see, 18 shows you about how many we have on now. If you check our Web site you'll see typically about 40 instruments are on today. And our goal is 1,000 pixels.

Now the fun stuff. Well where do they come from? This is slide 22 and 23. We know that at least some of them come from black holes and active galactic nuclei, but maybe not all of them. There are speculation that some of them are accelerated by intergalactic magnetic fields, and in particular, places where magnetic fields separate and reconnect. There can be very high accelerating gradients in the magnetic fields.

And here's our what-if, on slide number 24. Let's go back to 1935. In 1935, a couple of guys in England named Cockcroft and Walton built the first serious particle accelerator. They figured out a way to make a dc power supply that could generate a million volts. And that was pretty high tech then. In fact, it was the highest tech thing there was.

And they could accelerate protons, then, to a million electron volts of energy. And they did a lot of work. And it was the only way to do high energy physics other than cosmic ray research. So a million electron volts.

Now, next slide. Slide number 25. We now have the Large Hadron Collider. And it's up around 10 trillion volts - 10 trillion electron volts of energy. And that took us about 70 years. Let's see - yes, 75 years.

So the next slide - and you'll see the energy of a cosmic ray air shower or the particle that generates the air shower is a whole bunch of electron volts. It's around as much as 10 to the 21st to ten to the 22nd. One particle has been detected at 10 to the 22nd electron volts.

So we don't know where they come from. They could be coming from these natural processes, but maybe not. Maybe they're coming from little green men. Now I had the opportunity to ask a scientist who works at CERN. I said, in 1935 they could make a million electron volts. And now you can make 10 trillion electron volts in energy. How long will it be before you can do 10 to 100 times electron volts?

And he laughed. And he thought that was an amusing question. And he had an answer for me. He thought about it, I guess. And his name is Brian Cox. Some of you may have seen him on TV shows.

And he said - well that's simply not going to happen, because you would have to have materials that can generate magnetic fields higher than any that we know how to generate. The radius of the accelerator would have to be larger than the radius of the earth. So it's just not going to happen.

But I'm just a mechanical engineer. And I don't have to figure out how things could happen. But I will observe that in 75 years we went from a million electron volts - which Cockcroft and Walton thought was pretty much the limit - to 10 trillion electron volts at the Large Hadron Collider.

And so I asked Brian - well, how long would it take to do another 10 million fold increase in energy to get up to the level of these high energy cosmic rays? And that's where he said - well, it's just not going to happen. There's no way to do that on earth.

So I thought - oh, okay, maybe it'll take more than 75 years. Maybe it'll take 7,500 years. Maybe it'll take 75,000 years. Maybe it'll take a million years. Well, if there are extraterrestrial civilizations and intelligent beings, there's a good chance that some of them are much older than we are, and that they have much more mature technology in the realm of nuclear physics.

So it's not entirely out of the question - don't throw any tomatoes - not entirely crazy to say that there might be physics experiments going on out in the universe where they can generate particles of those kinds of energies.

Now imagine you're this little green man cosmic physicist. And you've got your accelerator. And you can generate particles of this energy level. What would you do with them? Well, I say you'd be doing some interesting experiments.

But you'd have to be very careful where you point them. You couldn't point them into the ground as we do with the Large Hadron Collider, because there'd just be too much back spray of radiation. It'd be dangerous. And you couldn't shoot it at your neighbors. Well that wouldn't be very good. In fact, the only safe direction to shoot it would be up.

But you couldn't shoot it through the atmosphere, because there'd be enough interaction with the molecules in the atmosphere that again you'd have a lot of back scatter radiation. It wouldn't be safe for life. So you'd have to build a chimney. You'd have to build a chimney that would go up through most of your atmosphere. And it would have to be evacuated.

Now we've got an engineering problem. So I can speculate about that. In order to build a hollow tower, a chimney, that's got a pretty high quality vacuum in it, that would be an economically difficult thing to do.

You'd want to make it as skinny as possible just to save money, to make it more practical to build. And that means that you'd have to make sure that your beam was very tightly focused or else it would run into the walls of the chimney and you'd have the same problem as before.

Another thing that we've seen in all of our physics experiments to date is that particles are generated in pulses. So imagine you're this little green man with a lab coat on, and you're generating very high energy pulses of protons. And you're shooting them out of your atmosphere in a very tightly focused beam. And you're doing this in pulses.

Well, the pulses would probably be separated in time by fixed increments. They'd be regularly timed. And if you were doing that - take my speculation a little bit farther - wouldn't you take the opportunity to encode some kind of data on that?

If you remember the movie Contact and Carl Sagan's book on which it was based, they found what appeared to be noise at first. And then on more careful inspection, it was modulated signals. And the modulated signals were modulated. And there were several layers of modulation in it.

So if I've got a factory that's sending out high energy particles that would be detectable at vast intergalactic distances, I just might be tempted to impart some kind of a modulation on those pulse trains.

Well, who would look for that? Not any real scientist, obviously. An amateur might look for it. But how would you detect it? Now imagine you had a big, rotating antenna like the earth. And you had a bunch of pixels or cosmic ray sensors spread all around the earth. And you had them all linked together.

Well if one of these pulses encountered earth, you would be able to detect that if more than a few particles were detected by our pixels. We'd be able to see the timing as that pancake of particles, that pulse of particles wraps around one hemisphere of the earth.

And so embedded in our data would be the signature of any kinds of pulses like this. Now, embedded in our data might also be - or should also be - the signature of natural events, any kind of periodic galactic events or intergalactic things. Even pulses of solar wind particles, which are really low energy cosmic rays.

So nobody's got an antenna or an array of pixels or detectors that could detect that sort of thing except the ERGO Project. We have hundreds of gigabytes of data. And it's there waiting for people to look through, to see if there are hidden signals in it. Maybe something to discover. Maybe not.

But that's what science is about. It's about the search. And it also always - or almost always - involves finding something interesting when you were looking for something else. So anybody got any questions?

David Prosper: Yes. Operator, if you could let everyone know how they can dial in to ask a question for Tom?

Coordinator: Thank you. If you do have a question or a comment, please press star 1 and record your name slowly and clearly when prompted. Once again, press star 1 to ask a question. Press star 2 to withdraw your question. One moment, please, for questions to come in.

David Prosper: I actually have a question while we wait for some questions. When mounting the ERGO, what's the equivalent of - say, like, for telescopes we have to worry about light pollution. Is there any kind of equivalent? Like, say, if you're in an area with a lot of radon or anything like that, possibly, that you need to be aware of when mounting it?

Tom Bales: Well you don't have much control over that. But certainly in different areas around the world, there are some places that have natural background radiation a thousand times as high as in other places.

Installations that we've had at high altitudes like in Bogota, Colombia and in Chili have higher background radiations, because we're detecting all kinds of charge particles with a simple Geiger-Müller type detector.

So the hope is that while our signal to noise ratio might not be very great, the signal's still there, embedded. And the noise should be fairly random. So we think that we'll be able to pick out any signals that are actually attributable to cosmic events in doing that.

But looking at terrestrial radiation could be an interesting thing as well. When we were first starting the project, the disaster at the Fukushima reactor in Japan happened. And people were starting to be interested in where that plume of radiation might be going. Well, we had only one sensor on the West Coast. And it was south of where the radiation actually traveled.

So we didn't have the ability to actually chart that. But imagine we had a thousand sensors around the earth. And somewhere, some nuclear event happens or atomic event happens. We could trace that. It would be a practically useful thing to do.

David Prosper: Cool.

(Susie): This is (Susie). I had a quick question about the distribution of your detectors. On your picture, you have it kind of centered on Africa. So it looks like there's a lot in Africa and Europe. Is that a real distribution of where you have the detectors? Do you also have many in North America?

Tom Bales: Well, the picture's a little bit of wishful thinking. That's where we'd like to have things distributed when we have an array of, let's say, a thousand pixels out there. It's been particularly difficult to get into Africa.

It's also been fairly difficult to get into parts of the Middle East, and impossible to get into China - although I do have a couple of Chinese exchange students staying with me this week. So maybe I have a possible in to do that.

North America is the easiest place, of course. South Florida is where we have a concentration. But we have some on the West Coast. We have one up in Alaska, which I think is not online today but is usually online. You know, the earth is only covered partially by land. A lot of the places you'd like to put pixels are covered with water. So we have to deal with that as well.

Although someone speculated that perhaps we could get cruise ships, which now have internet connection, to host an ERGO pixel. And it would travel around. After all, we'll know in the timestamp signal where they are, the exact location as well as the time. So it's not out of the question to have some roving sensors even on the oceans. If you know anybody in Africa, please let me know.

(Susie): Okay.

David Prosper: I actually had a couple of (unintelligible) friends just come back from their tour in Africa. I had another practical question about mounting the ERGO. Some GPS devices are pretty sensitive to anything blocking their signal. Can it be mounted in the, like, inside of buildings? Or should it be primarily like outside or next to a window or something like that? For the best GPS?

Tom Bales: We found the best results by having an antenna in a windowsill. It's usually not easy to get one mounted really outside. Although, of course, that's ideal. These receivers are set into an operating mode so that once they've achieved a position lock, they can report time even if they can only see one satellite at a time.

And between that, they do what's called freewheeling. They have a holdover clock that works in between those times. It's not quite as precise, but it keeps things cooking along between when satellites are visible.

The detector, of course, can be anywhere in a building. It could be in a basement, as long as there's a window somewhere that you can get the GPS antenna to. It doesn't matter really whether it's on the roof of a building or in the basement, in terms of receiving cosmic rays, because they go through buildings quite handily. They're not intimidated at all by a few feet of concrete.

To give you an idea, the continuation of cosmic rays by the atmosphere is only about 10% to 20%. And we were doing an experiment with the kids once of - okay, let's shield these things from cosmic rays and see how much background radiation there is. So we figured - well, we'll get some heavy plates of steel and do that. And we tried some two inch thick steel plates. It didn't make any difference at all.

So then we went back to the numbers and figured out - why is this not shielding? You'd think a couple of inches of steel and iron would be a pretty effective shield. But the atmosphere weighs about 15 pounds per square inch of surface area.

That's why we say the atmospheric pressure is 14.7 pounds per square inch. And what that means is above every square inch of the surface is about 15 pounds of air. Well, 15 pounds of steel over a square inch is about four feet thick.

So, needless to say, a few inches of concrete and steel really don't make any different at all. So placement of the ERGO pixels is pretty easy and straightforward except for being able to see in the sky for the GPS antenna.

David Prosper: I think we have a question?

Coordinator: Yes. There is a question from the phone lines. Stewart Myers, your line is open.

Stewart Myers: Hello. Thanks for the presentation. I was wondering - I think you may have been touching on it while I was doing the star 1 bit - but how do you differentiate between cosmic rays and radioactive particles from earth?

Tom Bales: Well, we can't at the moment - not with these simple detectors that we have. It's a dream. And we've worked experimentally on trying to construct inexpensive muon-specific detectors. We haven't found a way to do that.

People who have done similar kinds of projects on smaller scales have used scintillators, usually plastic scintillators, and photo multiplier tubes. And have used them in pairs with some shielding in between them so that they really can discriminate the super-high-energy muons that represent cosmic rays.

The way we built the ERGO pixels to make them affordable at all, we use just a simple radiation chare particle detector. And that means that the background terrestrial radiation is visible as well. It's pretty random.

We don't yet know if there are any diurnal or annual variations in background radiation, although from other research that I've read of, there's some hint that there might be. That's another bit of research that we could do.

But if you know anybody who wants to try to engineer and build and inexpensive muon-specific detector, I'd love to work with them. That would be a real serious improvement in the ERGO network.

Stewart Myers: And another thing. How can you decipher directional information from a cosmic ray detected the conventional way? Because a cosmic ray when it's zipping through space - if it's a charged particle - wouldn't it be affected by the galactic magnetic field? The solar system magnetic field - which is actually the sun's magnetic field? And then finally our magnetic field? So you figure the directional information would be somewhat scrambled.

Tom Bales: Yes. In fact, it is. Cosmic ray scientists talk about rigidity in particles. And it's really a function of their energy. A more energetic particle is more rigid when faced with intergalactic magnetic fields.

But it turns out that - except for the very, very highest energy particles - they're pretty well homogenized before they get to earth by magnetic fields within the galaxy and between galaxies. So it makes it not quite so straightforward to determine direction.

Some experiments that have been going on in Chili and a couple of other detectors where they have very sophisticated instruments that can detect the actual direction of arrival of the muon showers by looking at scintillation in the atmosphere and things like that - have actually started to report that there are preponderances coming from some directions. And those are probably directions within our galaxy. And again, that's at the higher energy particles.

So there might be something that we could detect with cosmic rays that are not so homogenized, because they come from our own galaxy. But the reason for looking for these pulses of particles is that a pulse would still be probably pretty much a flat wave front.

If a pulse is generated or somehow created by some natural or non-natural process a long way away, even though the entire pulse will be scrambled and sent in all kinds of directions on its way to the earth, those particles are traveling pretty close to the speed of light. So they should all arrive at about the same time.

And although the direction that we would impute from looking at the timing as the detections wrap around the earth wouldn't necessarily be the direction to the source, it would be an indication that there was a global-sized pulse. And that would be interesting.

David Prosper: Cool. Do we have any more questions?

Coordinator: I am showing no further questions at this time.

David Prosper: Okay. We're actually - it's almost seven o'clock, so I guess we'll have to wrap up tonight. Thank you all so much. And if anyone has any further questions about ERGO or about how to get a detector or get involved or help spread the word, the email address again, Tom, is tom@ergotelescope.org. Correct?

Tom Bales: That's right.

David Prosper: Excellent. Cool. So that's all the time we have for this evening. So thank you NSN network members for joining us. And thank you to Tom, so much, for giving us so much of your time in our presentation.

Tom Bales: It's always nice to be able to be able to blabber on and on about something that you're excited about.

David Prosper: Well this is fantastic. I'm really hoping the next version of ERGO is a huge success.

Tom Bales: Thank you.

David Prosper: Yes. And I'm all about helping to mine that data. That would be fun.

Tom Bales: Yes. You never know what's embedded in there waiting to be discovered.

David Prosper: Yes. Cool. Keep us posted. Well that is all for tonight. You can find this telecon along with many other on the Night Sky Network under astronomy activities. Just search for telecon. And tonight's presentation with the full audio and written transcript will be posted by the end of this week - hopefully in the next couple days. So good night, everyone. And keep looking up.

Tom Bales: Good night.

David Prosper: Good night.

Coordinator: That does conclude today's conference. Thank you for participating. You may disconnect your lines at this time.

END