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The Pierre Auger Project - *A Model for International Science*

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Abstract

The need for more international collaborations in big science projects has been recognized for many years. Only within the last two decades, however, has the increased scale of these projects together with increased government funding flexibility provided the motivation and means to enable such collaborations. The Auger Project, although modest compared with many projects in space science, high energy physics and astronomy, may serve as a useful model.

Introduction

The Pierre Auger Project to build the world's largest cosmic ray observatory is approaching completion on a vast plain in western Argentina. A unique feature of Auger is its broad, truly international character in that the project is not dominated by any country, region or institution. This sort of partnership has been rare in big international science projects and has presented some special challenges. Auger collaborators have come together from 17 countries with backgrounds in experiments (large and small) in cosmic ray physics, high energy physics, nuclear physics and astronomy - an eclectic mixture of national and scientific cultures. This diversity was an important element in the success of this project. A review of the experience of organizing and building the Auger Observatory may be of value to those planning international science projects in the future.

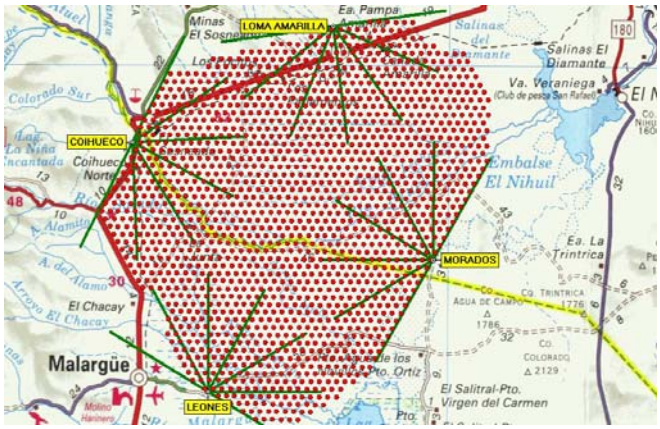
The Pierre Auger Collaboration

Background

The Auger Project was conceived in the hallway during the International Cosmic Ray Conference in Dublin in 1991 by Jim Cronin of the University of Chicago and Alan Watson of the University of Leeds. It had become clear to them that only the construction of a very large air shower array in both the Northern and Southern hemispheres would yield the statistical power and complete sky coverage necessary to probe the origin of the most energetic particles in nature.

A design workshop was held at Fermilab between February and July of 1995. During this time visitors to Fermilab, organized into detector specific subgroups, planned the project. This effort was supported by a series of seminars by experts on a verity of related topics. The Fermilab workshop produced a design report with a discussion of the science, a conceptual design and cost estimate. The Design Report became the basis for funding proposals by the collaborating Auger countries to their funding agencies.

The Auger design calls for an array of 1600 water Cherenkov surface detectors spread over 3000 km^2 and arranged on a triangular grid, with the sides of the triangles being 1.5 km. The surface array will be overlooked from four sites by fluorescence detector stations, each containing six fixed telescopes, designed to detect air-fluorescence light. The surface detector stations measure the density distribution of the air shower cascade at it strikes the surface while the fluorescence telescopes measure the light produced by atmospheric nitrogen excited by the cascading shower. Beyond its large aperture, the most powerful feature of the design is the ability to record showers simultaneously with these two complementary techniques.



The Auger Observatory. Each dot corresponds to one of the 1600 surface detector stations. The four fluorescence detector enclosures are shown, each with the field of view of its six telescopes.

A surface detector station

A fluorescence telescope enclosures

The site search got underway almost immediately using funds from a private grant. With the site requirements developed during the design workshop in hand, a team evaluated numerous prospective sites in both hemispheres. The site selection was based primarily on these requirements and the quality of the scientific support in the host country. An important, but secondary, consideration was the value of incentives that potential host countries offered. Selecting the site early and within the collaboration was a deliberate strategy to avoid the painful process such as that witnessed in the Superconducting Supercollider (SSC) project. In 1995 and 1996 preferred sites were selected by the collaboration in the Southern and Northern hemispheres respectively. In the selection process each Auger country had one vote.

After a period of research and development, the Engineering Array, consisting of 32 active prototype surface array detectors and two prototype fluorescence telescopes, was built to validate the design. A strong push to complete the Engineering Array on schedule was essential to persuade the funding agencies (and ourselves) that the Auger collaboration could deliver on performance promises made in the proposal. Before the end of the scheduled two years, the Engineering Array was able to record and reconstruct air shower events with both detectors and simultaneously by the surface array and the fluorescence detectors. We were able to demonstrate the viability of our deployment methodology as well as the performance of all of our detectors, communications equipment and data systems. Indeed, we found that the detectors performed better even better than expected, substantially increasing our physics reach.

Installation of production detectors was started in 2002. As of this writing the detectors are more than 75% completed. While the Engineering Array was assembled and deployed almost completely by Auger collaborators, production deployment has been transferred to

trained Observatory staff. The scientists now oversee the quality of the work and carry out the commissioning the completed detectors.

The Observatory started collecting data in January 2004. The first physics results were presented during the 2005 summer conference season. There are now two physics papers in publication and several others in preparation.

Organization

The collaboration that emerged during and after the Fermilab Design Workshop now consists of about 69 institutions in 17 countries spread over Europe, North and South America and Australia. No country dominates with the maximum contribution of any one country to construction being less than 25%. Another feature is that the project is not anchored to some strong institution that could provide financial stability as are big collider detectors. A suitable model for such a collaboration did not exist.

The first step in forming the collaboration was to draw up an organization headed by two oversight bodies - Collaboration Board and Finance Board. The Collaboration Board, consisting of representatives from all of the Auger member institutions, is the governing body of the collaboration that deals with such issues as science policy, admission of new members and publications.

The Finance Board, on the CERN model, consists of representatives of each of the funding agencies - often more than one per country. The Finance Board provides financial and management oversight. The meetings of this body provide a forum for funding agencies of the partner countries to resolve funding related problems. The Finance Board has been particularly important to the success of Auger because of the nature of the partnership. It has been in our interest and as it surely would be to all international projects to have such a body with full representation and the confidence of the partners.

The next organizational step was to develop an international agreement that would be acceptable to the collaborating countries. A draft agreement was developed that was a synthesis of governance schemes from collider experiments and large astronomy projects. The Finance Board met at UNESCO in Paris in the November of 1998 and went line by line through the draft. They were able to hammer out a consensus document under the highly skillful leadership of the acting chair of the Auger Finance Board, Herwig Schopper - former Director General of CERN. The resulting document was, in fact, much shorter than the

original draft. Basically the Auger International Agreement is a simple statement of support for the project together with concise statements on financing, membership, withdrawal, ownership and related governance issues. Struggles followed when the agreement was circulated among the funding bureaucracies of the various member countries. Lawyers insisted on many changes in spite of a clear statement at the beginning that the agreement was not a legally binding document. Although it was uncertain if the ratification process would ever converge, it eventually did so with the first signatures affixed at a meeting in Mendoza, Argentina on March 15, 1999.

Below the Finance Board and Collaboration Board in Auger organization chart is the spokesperson and the project office. The project management structure is fairly typical. The project management office staff consists of the project manager, deputy project manager, the project engineer, a cost and schedule officer and part time help with quality assurance and safety. Task Leaders (level two managers) head task groups for the detector subsystems, site activities, data acquisition, data processing, communications and data analysis.

The Auger Observatory in Argentina has a staff of about 15 headed by the Site Manager. It was necessary to form an independent foundation (Fundación Observatorio Pierre Auger Argentina) to act as legal agent for the Auger Project in Argentina. The Auger Foundation enables hiring of staff, holding contracts and handling operating funds for the Observatory within Argentina.

Auger employs the tools of management that we have learned over recent years from industry and large science projects like those at Fermilab, CERN and the ill-fated SSC. These include cost and schedule tracking, elements of systems engineering and quality assurance and ES&H (environment, safety and health) programs. These tools were adapted to the particular needs of Auger, an international project based on an equal partnership. For example, imposing elaborate cost and schedule tracking systems on a group of countries that contribute mostly in-kind and that have different accounting methods and whose accounting records are inaccessible is impractical. We converted the value of all of the contributions to a standard Auger currency (nominally US dollars) corrected for the cost accounting system of each country. Progress was tracked bimonthly and in semi-annual reporting sessions with the Task Leaders.

We have adopted the most effective features of systems engineering and quality assurance while avoiding the rigorous application of these methods often advocated by their proponents with almost religious fervor. Many groups, particularly small ones used to small experiments

with a few people suffer culture shock when exposed to the management discipline required in large projects. At first we found that the frequent technical reviews, change control actions and requests for cost and schedule information were often considered bureaucratic harassment. Once the essential role of these tools to our success was understood, the Auger collaborators accepted and even promoted them. The frequent technical reviews served more than just to ensure the quality of the design, construction and operation of the systems. Builders of the disparate systems were made part of each others review panels thereby extending their sense of ownership and responsibility for the performance of the project as a whole.

Bob Wilson, the builder of Fermilab, taught us that science projects are best managed by scientists. That remains advice worth heeding. In its formative years, Auger often found itself under pressure to install "professional managers" of one kind or another. Although scientists managing science projects may not always rigorously follow management orthodoxy, they have been successful because they are driven by a passionate commitment to the science goals. Managers and engineers lend essential discipline to the project while the day by day decisions at the highest levels need to be made by scientists with a clear understanding of the science objectives always in mind. The good news for those in governments and funding agencies concerned about sound management of projects large and small is that the world scientific community is growing an experienced cadre of scientist-managers as the result of the growing scale of the science projects over the past few decades.

Funding

Once the Auger Project was organized, a list of the anticipated contributions by each country was drawn up. By the terms of the International Agreement the contribution of each country was to consist of 80% in-kind deliverables and 20% cash, the latter contributed to a common fund held by CERN. The common fund for big collider experiments is typically for costly components such as big solenoid magnets, an expense that needs to be shared. In Auger the Common Fund was nominally for the procurement of photomultiplier tubes that, for Auger, is one of the biggest single expenses. Some countries preferred to buy the phototubes directly from the vendor rather than contribute to the Common Fund thus expanding its currency to both cash and phototubes. At the same time the Common Fund account served as a convenient neutral collection point for construction and operating funds.

The distribution of construction tasks produced relatively few conflicts. One exception was the reticence of some countries to fund civil construction beyond their borders. At the same time the host country did not want to fund all of the bricks and mortar. In fact as time went on the funding agencies became more flexible as the practical requirements for the success of such large and diverse international project became apparent.

In the beginning there was a strong feeling on the part of many countries that they had to have a specific, complete piece of hardware on which they could paint their flag. Although this was a headache at first such demands soon faded away as the collaboration began to work closely together. At this point it is hard to find a piece of Auger equipment that does not contain components from several countries.

The past three decades of large high energy physics experiments that depended on moral commitment and good will of the participants have been remarkably successful. In fact, participants typically contribute more than they originally promise. The Auger Project has been a beneficiary of this tradition of good will. Nevertheless to make international science projects work, countries must assume some risk that one or more of the partners may not meet their commitment for reasons beyond their control. In the ten years or more from the proposal through construction large projects, economic conditions in some of the collaborating countries may change. In the case of Auger Project the drastic devaluation of the currencies in Argentina and Brazil in 2001 made it impossible for them to continue their original anticipated contributions in a timely way. The other Auger countries generously responded to requests to take up the slack.

Another funding related issue is the importation of equipment into the host country. If much of the equipment is to be in-kind, a smooth importation scheme must be found at the outset. In the beginning Auger was facing many millions of dollars in customs charges. Eventually our Argentine colleagues were able to work out an arrangement in which the embassy of each participating country would apply for a customs waiver to the Argentine foreign ministry for each shipment of equipment. The embassies have been enormously helpful to us in this regard. The importation now works quite smoothly and we are comfortable when the customs agents appear unannounced to make sure that the equipment is indeed used in the project.

As is now common practice, operating costs for the Observatory including salaries, utilities and maintenance are apportioned by the number of scientists that sign scientific papers. Major changes or

upgrades are not included in the operating budget. The annual operating cost is currently less than three percent of the capital cost.

Outreach

The Auger Observatory is located in Malargüe, a rather remote city of 20,000 people at the base of the Andes Mountains. From the beginning the people of Malargüe have welcomed us and have make our visits to Observatory consistently pleasant. In return we have tried to reach out to the community in a number of ways. Our visitor center receives nearly 6,000 visitors a year. Spanish speaking collaborators have visited many area schools to talk about science and goals of the Observatory. A science fair organized by Auger for Malargüe and the surrounding communities was a great success. Most recently Jim Cronin obtained a grant from the Grainger Foundation of Chicago to build a new secondary school for the city. Indeed we have become part of the culture of the city. Each year, for example, we participate in the annual Malargüe Day celebration and parade. (It is a rare day when scientists march in a parade applauded like rock stars!) All this interaction has led to the point where the community has a sense of ownership for the Observatory. This relationship has been vitally important to our success.

Auger collaborators marching in the Malargüe Day parade

Summary

The Auger Observatory, originated from an idea in 1991 to probe the mysteries of the highest energy cosmic rays, is now approaching completion in Argentina. The first physics results are in publication with the promise of more exciting science to come. Planning for Auger North has begun. Along the way we have gained experience in organizing and building a truly international science project.