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The Canada-Wide Network of Large Area Cosmic Ray Time Coincidence Array Telescopes

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Abstract. The Canada-Wide Network of Large Area Cosmic Ray Time Coincidence Array Telescopes (CANLACT) collaboration is the Canadian part of the North American Large-Area Time Coincidence Array (NALTA) project (NALTA website). Starting as ALTA (Alberta LTA) at the University of Alberta in 1996, the collaboration now includes seven Canadian institutions. The idea is to build a very large, if somewhat sparse, cosmic ray air-shower array using semi-autonomous detector modules placed in high schools, linked by the internet and GPS timing. It will provide the opportunity to search for time-correlated cosmic ray events over 100's or 1000's of km. This article gives an overview of the project from the technical and educational points of view, and we report the results of a long-baseline test of modules in Edmonton and Vancouver.

1 Introduction

Interest in cosmic ray physics is now focussing on very high energy events and long-distance correlations between events. New projects aim at obtaining detailed pictures of very large air showers (Auger, OWL project websites). Ground-based detectors like Auger now use distributed computing and commercial communications technology to instrument large areas - 1000s of km^2 of the earth's surface. The dual idea behind CANLACT/NALTA is to base semi-autonomous detectors at high school sites in order to (a) use available power and communications links and (b) to exploit the educational opportunities of having a research instrument placed within reach of school students and teachers. Aspects of building large air-shower arrays - cabling, timing, data acquisition etc. - which were once major technical challenges, are now solvable relatively cheaply using commercial computing, networking and GPS systems. While certain irreducible costs like photomultiplier tubes (PMTs), scintillators and fast electronics mean the cost of modules is not trivial, about C$30,000, it is still possible to consider building a sparse array based at high school locations. The spacing of high schools in urban areas (about 4 km in Vancouver) is somewhat larger than ideal for a competitive air-shower array (Auger's spacing is 1.5 km). However, the possibility of operating modules separated by 1000s of km, makes it possible to search for speculative long-range correlations like the GZ effect (Tanco and Watson, 1999).

The opportunities which open up when rubbing shoulders with the high school community are many and not fully worked out yet. Possibly the biggest is that it will draw teachers and students into the ambit of a research effort, and help maintain the interest in physics of the brightest of them (teachers included) in the face of official curricula which terminate in the 19th century.

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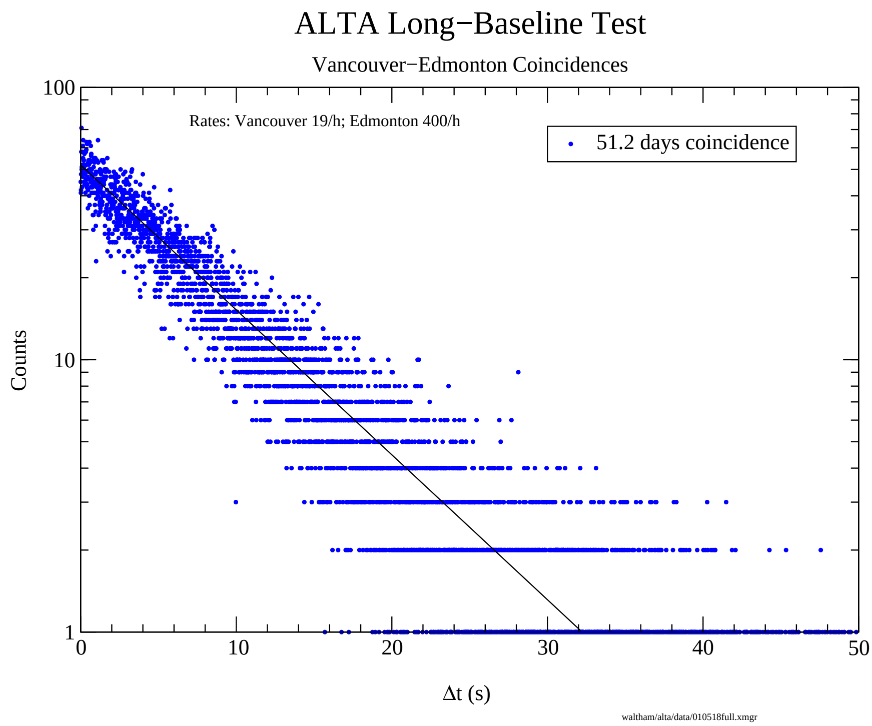
2 Technical Description

The individual modules consist of three 1 cm thick scintillators each of area 0.5 m^2. They are placed on a high school roof in three water-proof boxes arranged in an equilateral triangle of about 10 m on a side. In this way each module can be triggered in coincidence to reduce the overall data rate. The trigger threshold on each PMT is set so that a single minimum ionizing muon can be detected at high efficiency. Cosmic ray air showers of $\sim 10^{12}$ eV can cause a triple coincidence for this geometry. Also on the roof is the GPS antenna which provides the timing for the system.

The signals are passed along long cables to the purpose-built data acquisition crate housed inside the school. The crate also contains HV sources for the PMTs and the GPS receiver. This crate is read out by a Pentium computer which stores timing and pulse-height information for each event.

Each individual data acquisition crate can be controlled locally or via a web browser from a distant site. Any computer in the network can, in principle, download data from all the others and analyze the data for coincidences and reconstruct air shower parameters.



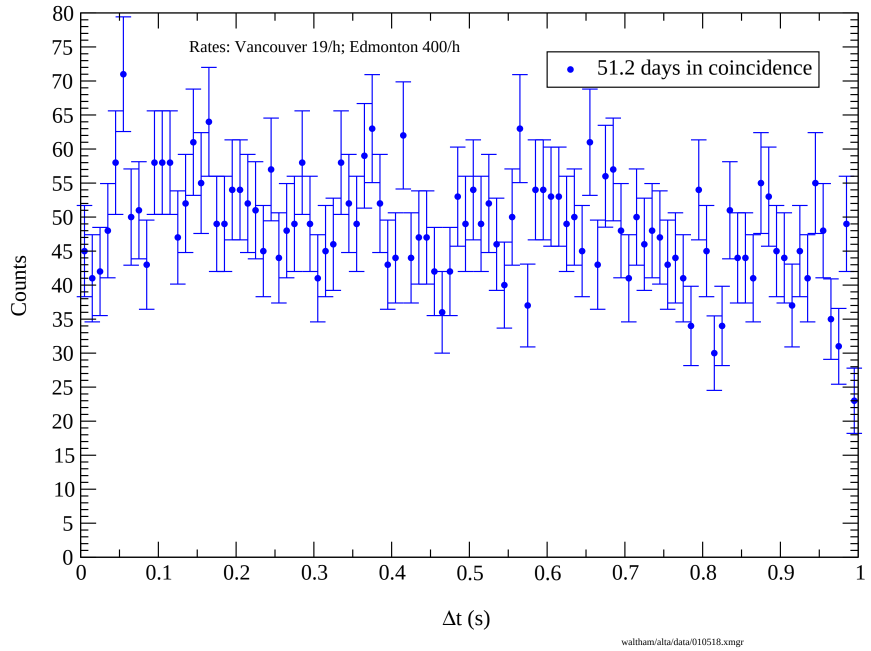


Fig. 1. Histogram of coincidence times Δt in recent long-baseline test. The line drawn in the upper plot is $2\lambda_1\lambda_2 e^{-(\lambda_1+\lambda_2)\Delta t}$, where Δt is the 10 ms bin of the histograms.

3 Long-Baseline Test

Two modules in Edmonton (53° 31'N, 113° 31'W 690 m a.s.l.) and Vancouver (49° 16'N,123° 15'W, 100 m a.s.l.) have been running independently since January 2001. The two sites are 825 km (2.75 light ms) apart. The Edmonton module consists of three horizontal scintillators 1 m^2 in area, 25 mm thick, placed on a equilateral triangle, 15 m on a side. The Vancouver module is similar except that the scintillators are 0.2 m^2 in area, 6 mm thick, 10 m apart.

By May 2001 the total elapsed time when both modules were live amounted to 51.2 days. Data from both modules have been analyzed for coincidences. For each event in one module, the nearest event in the other module was found, and time difference between the two, Δt was evaluated. For purely random coindences, the distribution of Δt is expected to have the form:

$$\frac{dR}{d\Delta t} = 2\lambda_1\lambda_2 e^{-(\lambda_1+\lambda_2)\Delta t} \quad (1)$$

The rate of coincidences per second per bin in Δt is $dR/d\Delta t$ in units of s^{-2} and λ_1 and λ_2 are the event rates per second in the two modules. In this case $\lambda_1 \approx 19$/h (Vancouver) and $\lambda_2 \approx 400$/h (Edmonton) owing to differences in altitude and detector geometry. A histogram of Δt is shown in Fig. 1. The results are consistent with random coincidences. There are 16 coincidences within 3 ms; 15 random coincidences were expected.

The timing resolution of individual PMT/scintillator combinations was about 10ns. The timing precision due to the GPS system was expected to be within 50 ns.

A similar experiment was carried out in Switzerland (Carrel and Martin, 1994) with four detectors enclosing 5000 km^2 and a maximum baseline of 186 km (0.62 light ms). The authors reported a small excess of quadruple coincidences above expected random rates within a 0.62 ms window.

4 Educational Opportunities

The integration of a cosmic ray research project into high school activities is not an easy task when teacher and student time is highly focussed on standard examinations. In addition, many provincial ministries of education mandate Physics 11 and 12 curricula which contain little or no "modern" (i.e. post-1850) physics. Hence we expect that a lot of effort in high schools will be extra-curricula and driven by a very small number of committed students and teachers. An alternative, exploited in Alberta and BC is to use time set aside for general personal improvement ("Career and Personal Planning" in BC, "Career and Technology Studies" in AB).

In addition we have identified the following points of contact between cosmic ray experiments and BC grade 11 and 12 courses:

– Subatomic Physics (Physics 11)

– Astronomy and Atmospheric Physics(Earth Science 11)

– Opto-electronics (Physics 12)

– Data acquisition and scientific networking (InfoTech 12)

– Computer modelling and simulation (InfoTech 12)

– Data analysis and data representation (Math 11 and 12)

– Applications of GPS (Geology 12)

Detectors are now operating at the following high schools in greater Edmonton: Archbishop O'Leary, Archbishop MacDonald, Holy Trinity, Austin O'Brien and Drayton Valley. Trial programs educational programs with small groups of interested grade 12 students have been mounted at these high schools in Edmonton and also Sir Winston Churchill Secondary School in Vancouver. Model lesson plans are available on the original ALTA website.

5 Present and Future

At the time of writing (May 2001), there are 5 modules operational in Edmonton and one in Vancouver. Few technical difficulties remain in the deployment and control of single modules. Funds are constantly being sought to increase the number of modules and to expand the collaboration across Canada.

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