

CRAnE: A JAS-based Data Acquisition System for Cosmic Rays^{*}

Jennifer Docktor, Manuel Reyes,
Tom Glanzman, Willy Langeveld

*Stanford Linear Accelerator Center
Stanford University
Stanford, CA*

ABSTRACT

Cosmic Ray Analysis Environment (CRAnE) is a software tool designed to collect and plot data from a cosmic ray telescope (CRT) connected to a computer serial port. As a plugin to Java Analysis Studio (JAS), CRAnE provides visual displays of incoming cosmic ray rates as they are detected. In an effort to make the program user-friendly, it operates through a graphical user interface. This paper describes the features of CRAnE and includes installation and operation instructions in the appended user's manual.

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1. Introduction

1.1 HISTORY

In the 1990's efforts were started to design and build a simple and inexpensive cosmic ray detector apparatus for use by high school physics teachers. The first such devices were manufactured from materials commonly available at accelerator laboratories, and they were simple and safe enough to be used in the classroom setting.

One program that became involved in building cosmic ray detectors is QuarkNet, which is based at Fermi National Accelerator Laboratory (Fermilab) [1]. The QuarkNet project is an endeavor supported by the National Science Foundation and the U.S. Department of Energy to educate high school students and teachers about high-energy physics and involve them in research [2].

The Stanford Linear Accelerator Center (SLAC) hosted a QuarkNet workshop from June 19 to July 3, 2003, during which high school science teachers met with the goal of integrating the experience they received at SLAC into their science courses. Throughout one week of the workshop the QuarkNet participants helped to build ten cosmic ray telescopes (CRTs) that will be used to conduct experiments in their classrooms. A photograph of a completed CRT is shown in Figure 1.

1.2 COSMIC RAYS

The CRT devices are capable of detecting secondary subatomic particles such as muons, the charged decay products of pions which are produced when high-energy protons from outer space collide with air molecules in the Earth's upper atmosphere and create an air shower [3]. The origin of these high-energy primary cosmic ray protons is not fully understood, but the prevailing theory suggests they are accelerated in the magnetic fields surrounding supernova remnants [4]. Muons in particular reach the Earth's surface because they can penetrate large amounts of matter without interacting, and have a sufficiently long lifetime.

2. Cosmic Ray Telescope (CRT)

In the present design the SLAC QuarkNet CRTs are constructed from scintillators, photomultiplier tubes (PMTs), high voltage converters, and a QuarkNet coincidence logic board [5]. The scintillator plastic produces a small flash of light when a charged particle passes through it. Each scintillator panel is connected to a photomultiplier tube by a polished Lucite "light guide" bonded at each end with optical glue, and this segment of the CRT is wrapped in several layers of opaque materials for light shielding [6]. The PMTs convert light pulses into amplified electrical pulses, which are transmitted to the logic board. Attached to each PMT is a base, which converts low voltage (5VDC) from the logic board to high voltage for the PMT.

The logic board has four input channels to receive electrical signals from the PMT base circuit. These signals are processed and sent to a serial port for communication with a computer.

The logic board has the ability to either interpret single pulses from each individual PMT as triggering events or to interpret a coincidence between multiple incoming signals as a triggering event. It also has built-in temperature and pressure sensors that can send readings to the serial port upon request. In addition, the logic board has the ability to receive absolute time information from a GPS unit.

Each CRT consists of two scintillator-PMT-base “paddles” held some fixed distance apart on a rotatable arm of ABS plastic affixed to a plastic post supported by a wooden base, as shown in Figure 1. The paddles are aligned to generate coincident triggering events when a cosmic ray passes through them. A principal classroom experiment with a CRT involves measuring the angular distribution of the cosmic ray flux through the paddles.

3. Cosmic Ray Analysis Environment (CRAnE)

3.1 INTRODUCTION

For the purposes of using these CRTs in the classroom, it is necessary for the data received from the detectors to be translated into a more manageable and accessible format. To this specific end, we designed a computer program called Cosmic Ray Analysis Environment (CRAnE) that acts as a plug-in to Java Analysis Studio (JAS) [7], a data analysis package developed within the high-energy physics community. CRAnE reads the serial port output of the detectors, collects relevant information, and saves it as a computer file. The program also maintains a plot of incoming cosmic ray rates in real-time.

3.2 FEATURES

CRAnE provides a simple method of configuring and running an experiment with the CRT (see Figure 2). It allows the user to start and stop data collection upon request, specify a location for the stored data file, specify a serial port, select the logic board channels in use, and set the time interval over which to bin data. Once the data acquisition process has begun, CRAnE reads the data stream from the serial port, selects the data corresponding to cosmic ray events, and displays the data in graphical form.

In version 1.0 the program creates two graphs in real-time that analyze the data received from the detector. The first graph displays the observed cosmic ray rate vs. time. The second graph is a histogram of time intervals between consecutive cosmic ray events (see Figure 3). In the interest of preserving data for future analysis, CRAnE saves the raw information received from the logic board to a file along with the computer clock time in milliseconds from the start of the data acquisition period.

4. VERSION 1.0 NOTES

In version 1.0 of CRAnE, the time processed for a cosmic ray event is the internal clock time of the computer. Future versions of CRAnE could acquire a more precise time of data acquisition from the GPS unit in conjunction with the internal clock time of the board. In addition, version 1.0 is compatible with logic board firmware dated 6/27/03. Firmware output formats are subject to change with each new version.

CRAnE software will be distributed on CDs and packaged with the CRTs, and it will also be available on the Internet for download. The CRTs will be distributed to various involved schools and travel between classrooms in the near future, on their quest educate students and teachers about cosmic rays and delve deeper into understanding the mysteries of the cosmos.

5. Acknowledgments

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- [7] T. Johnson, “Java Analysis Studio”, Oct. 29, 2001 <http://jas.freehep.org>

FIGURES:



Figure 1: Photograph of a CRT setup

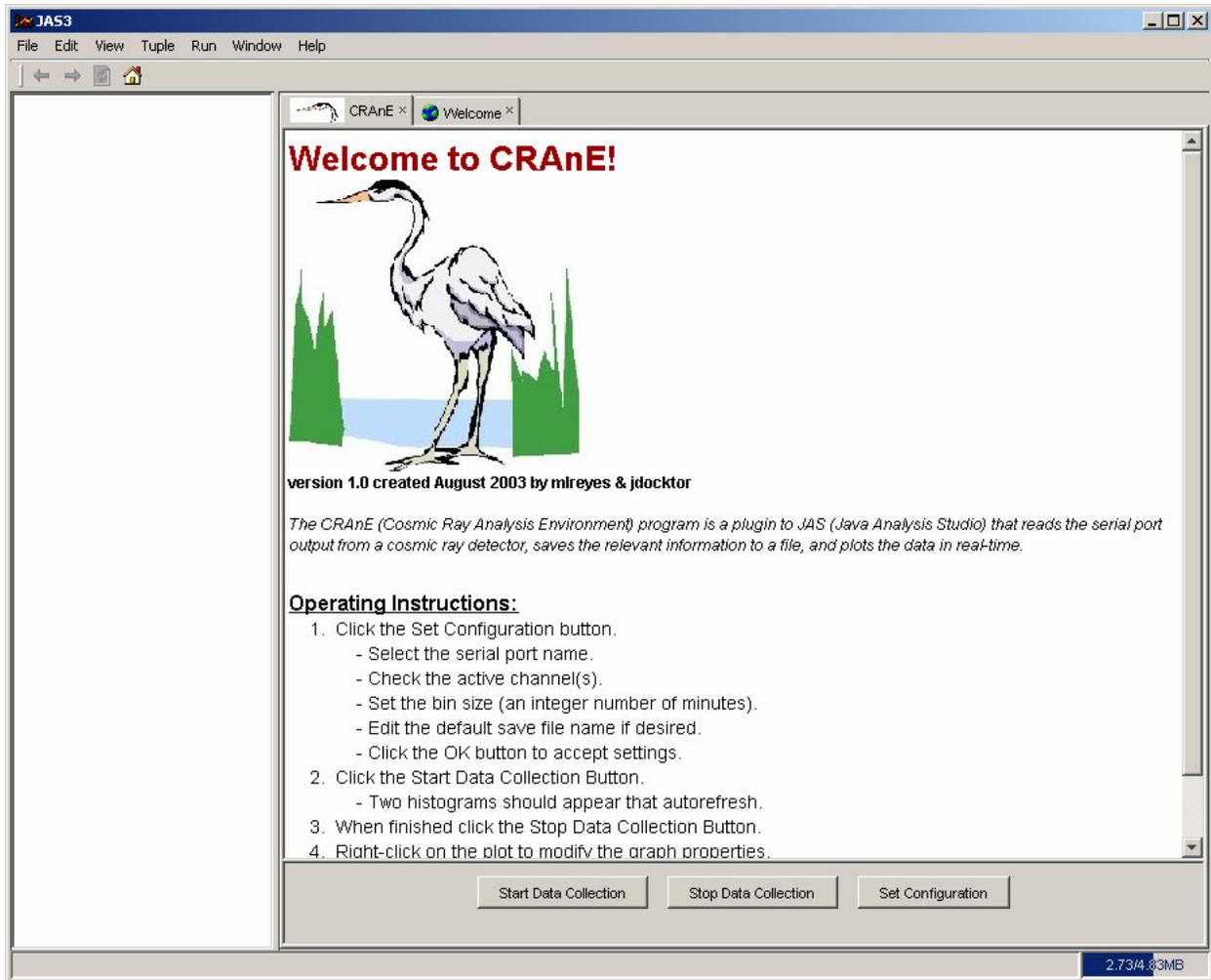


Figure 2: Screen shot of CRANe

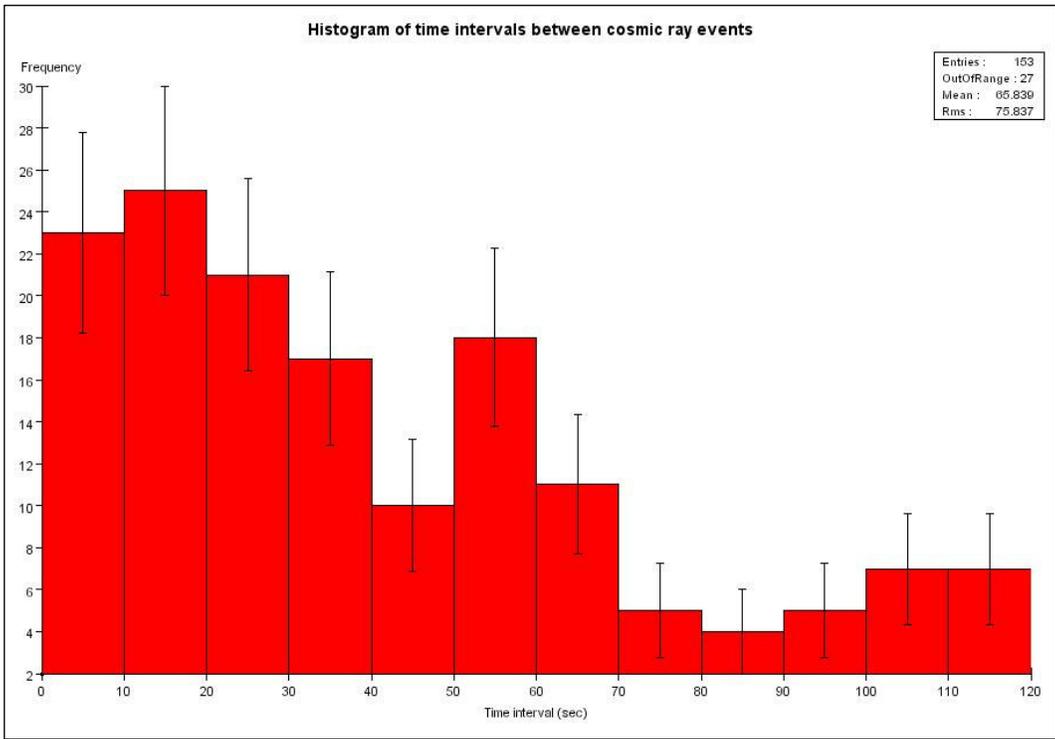
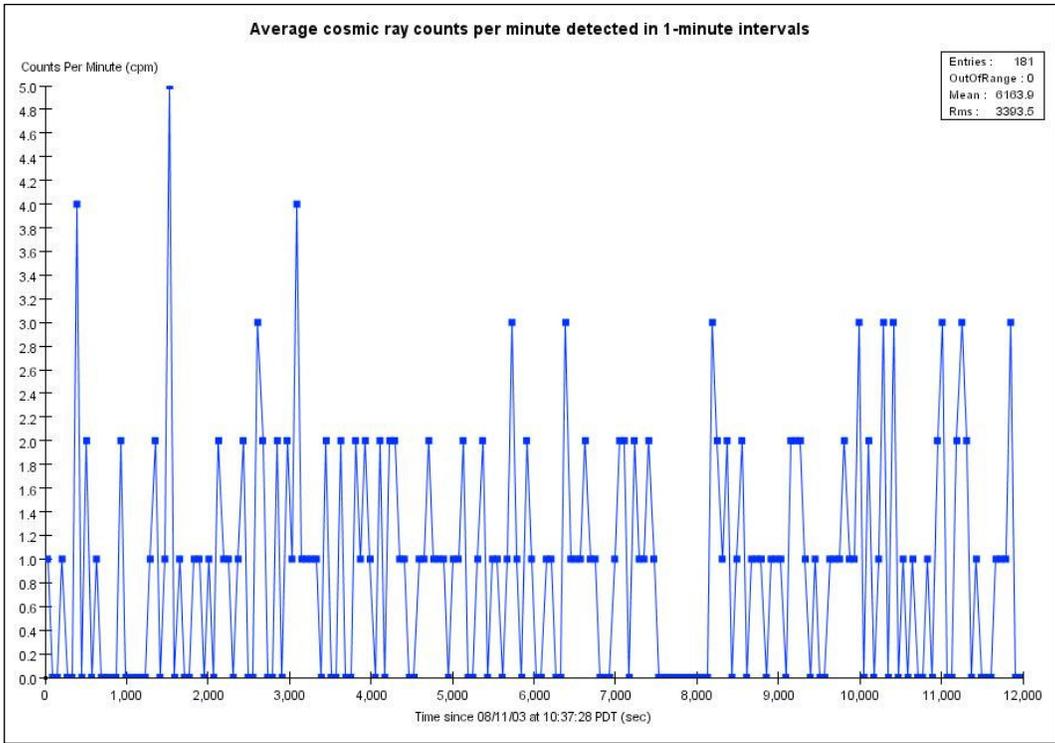
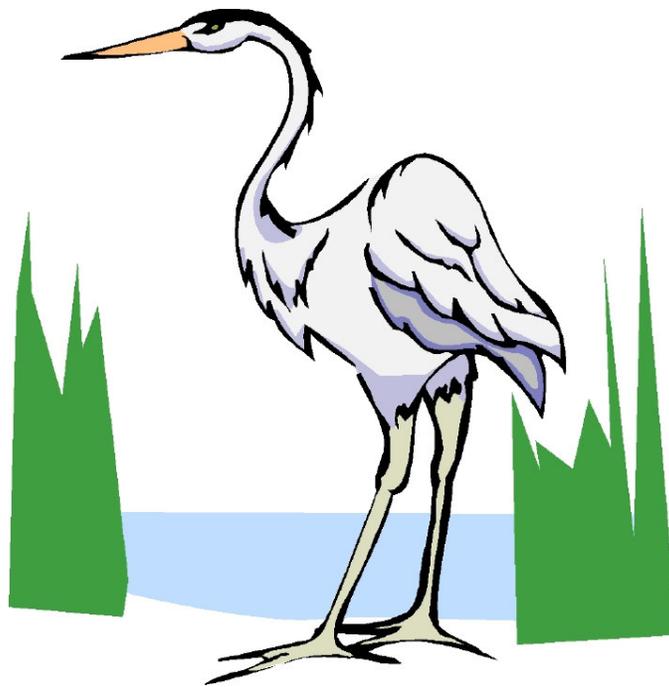


Figure 3: Examples of the graphs produced by CRANe

CRAAnE User's Manual



Written by Manuel Reyes and Jennifer Dockett
under the direction of Tom Glanzman and Willy Langeveld.
Stanford Linear Accelerator Center, Stanford University
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I. Introduction

Welcome to the Cosmic Ray Analysis Environment (CRAnE) User's Manual!

CRAnE is a software tool developed for use with the cosmic ray telescope (CRT). It is a plug-in to Java Analysis Studio (JAS), a data analysis system developed at SLAC for use in high energy physics. This plugin extends the operation of JAS to include cosmic ray data acquisition.

This manual provides detailed information on the installation and operation of CRAnE. Installation examples are specific to the Windows environment.

II. Installation

A. Installing Java and JAS3

Step 1:

- Go to the website <http://java.sun.com> and click on the J2SE link.
- Click on the J2SE Downloads tab.
- Click on the J2SE 1.4.1 link.
- Download the J2SE v 1.4.1_0x JRE for your computer's operating system.
- Follow the instructions to install the Java run-time environment.

Step 2:

- Go back to the website <http://java.sun.com> and click on the Downloads link.
- Under the J2SE heading browse the drop-down list for Java Communications API (JCA) 2.0 and click to select it. Press Go.
- Follow the instructions to download.
- Unzip the file to some location on your computer.
- Copy the file `win32com.dll` from the `commapi` folder to the JRE `bin` directory (this is probably found in a location such as `C:\Program Files\Java\j2re1.4.1_0x\bin`).
- Copy the file `comm.jar` from the `commapi` folder to the JRE `lib` directory.
- Copy the `javax.comm.properties` file to the JRE `lib` directory.

Step 3:

- Go to the website <http://jas.freehep.org/> and click the JAS3 link.
- Click the Download link.
- Follow instructions to download JAS3.

Step 4:

- Find the `jas.ini` ("Configuration Settings") file in the JAS3 folder (this is probably found in a location such as `C:\Program Files\JAS3\jas.ini`).
- Open the file. After the last line of text in the file, enter a new line starting with the capital letter "C" followed by the file path of the `comm.jar` file copied in Step 2 (i.e.,

enter a new line that says `Cc:\Program Files\Java\j2re1.4.1_0x\lib\comm.jar` if `comm.jar` is located at `c:\Program Files\Java\j2re1.4.1_0x\lib\comm.jar`). Save the changes made to the file.

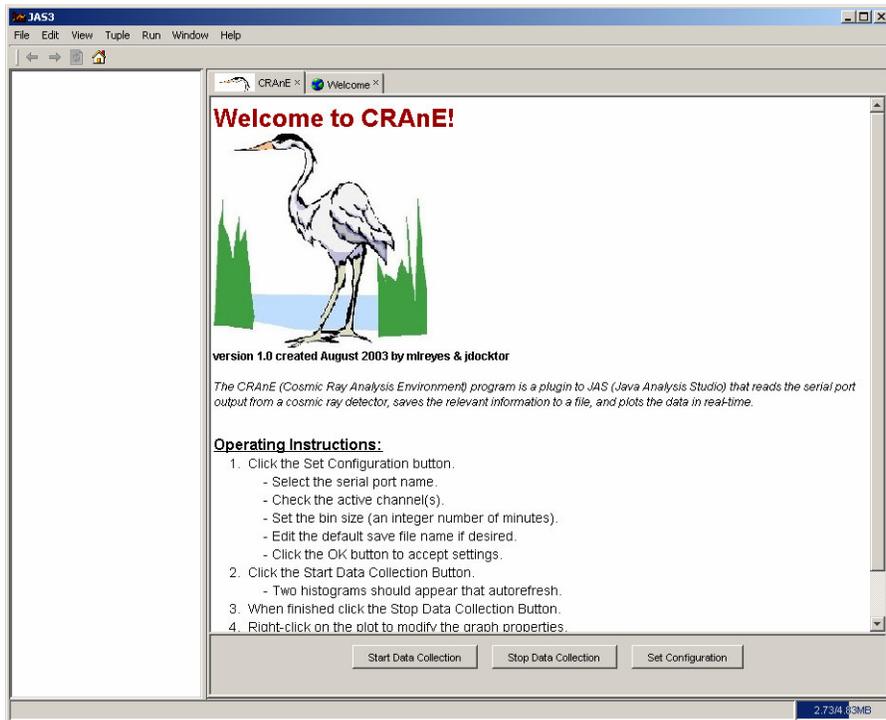
B. Installing CRANe

- Go to the CRANe website <http://www.slac.stanford.edu/quarknet/crane> and follow the downloading instructions or insert the CRANe CD.
- Move the `crane.jar` file to the `extensions` folder for JAS3 (this is probably found in a location such as `C:\Program Files\JAS3\extensions`).

III. Operation

A. Configuration Settings

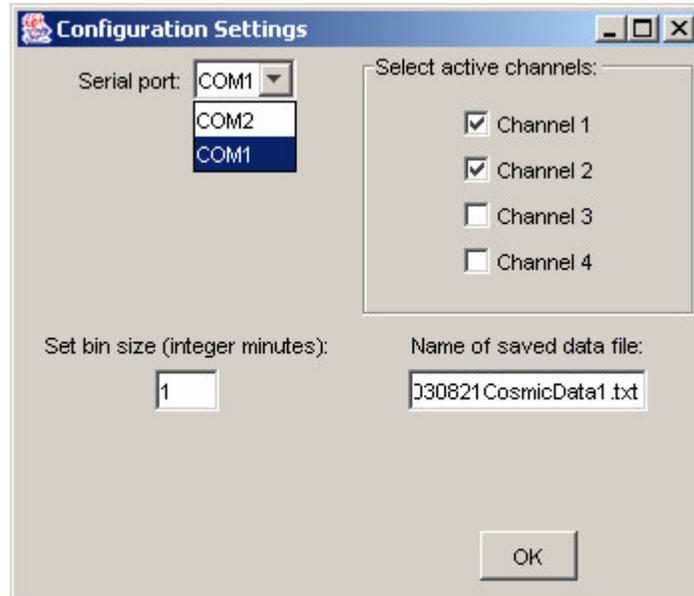
To begin using CRANe, open JAS and click on the CRANe tab to activate the CRANe main window.



Double check the following in your set-up:

- The photomultiplier tube bases are switched on (check the yellow LED lights)
- The RS-232 serial port connector ribbon cable is plugged in to the logic board and a serial port of the computer.
- All other cables are correctly connected.

- The GPS must remain connected to the logic board at all times.
- Click the “Set Configuration” button on the CRAnE main window to begin. The following window will pop up:



i. Serial Port

The first item on the configuration settings popup window is a drop-down box to select the serial port name. The selected item displayed in the text field should correspond to the place that the RS-232 serial port connector ribbon cable is affixed to the computer. Choices are determined by the serial ports available on the computer itself, and may vary from machine to machine. Some examples include COM1, COM2, etc. The default setting for this feature is the first item from the list.

ii. Channel Selection

The next item on the configuration settings popup window is a set of checkboxes to select the active channels. The selected item(s) should correspond to the channel(s) connected to the logic board. The channels are numbered 1-4 such that when the channels are closest to you, channel 1 is on the left and channel 4 is on the right. Selecting any number of channels will require that all those channels fire in coincidence in order to trigger an event. Any deselected channels will be disabled. The present model of the CRT only has two paddles, so selecting more than two channels at a time will not produce any data. The default setting for this feature is channels 1 and 2 selected.

iii. Bin size

Another item on the configuration settings popup window is a text field for the bin size in integer minutes. This sets the time interval in minutes over which to collect data for the plot of counts-per-minute detected over time. For example, a bin size of 5 minutes will

collect data for 5 minutes and compute and plot the average number of events per minute during this time interval. A new data point or bar is added to the count plot after a bin size time interval passes. The default setting for this text field is 1 minute, meaning that the graph refreshes with the newly added counts every minute.

iv. File Name

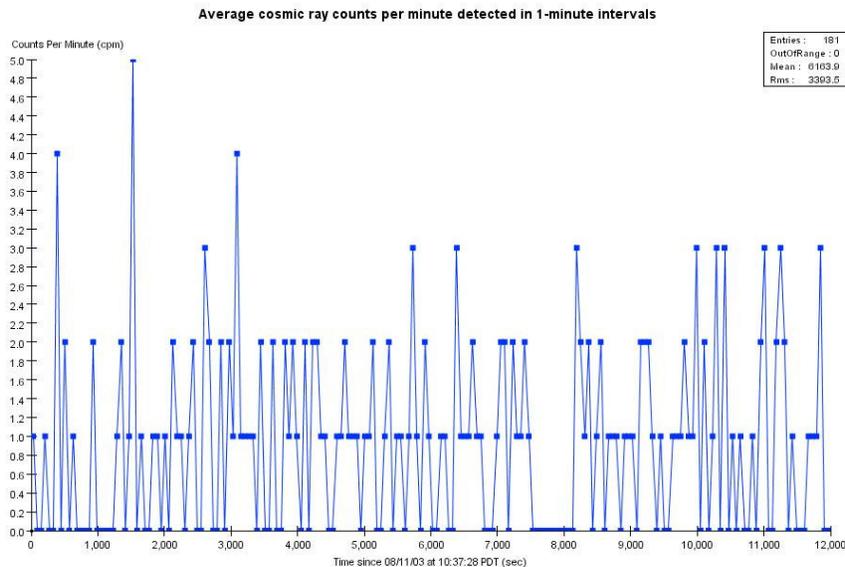
The final item on the configuration settings popup window is a text field for the file name. This represents the location to which the data processed by the program is saved for future reference. CRAnE will only function properly if there is a valid entry in this text field; a file by the given name must not already exist and the directory in which the file is to be created must already exist. The default setting is a file located in the user's home directory named with the current date followed by "Cosmic Data", an index, and the suffix ".txt". For more information refer to section D: File Saving.

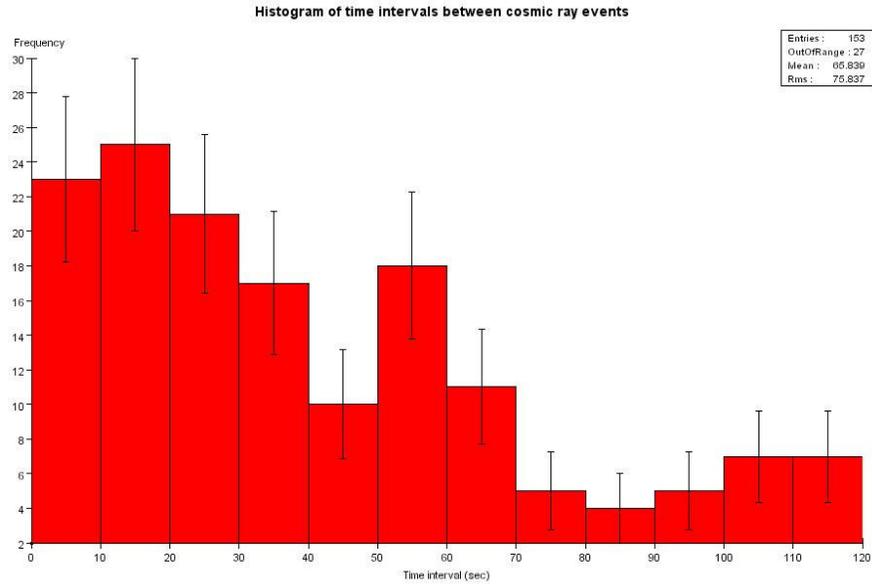
B. Collecting Data

Start/Stop Data Collection

Once the configurations have been set, press the "OK" button in the Configuration Settings window. Do not close the window by clicking the "X" in the upper corner; doing so will not enable the "Start Data Collection" button.

Press the "Start Data Collection" button. Two graphs should open which will update as the logic board receives signals:



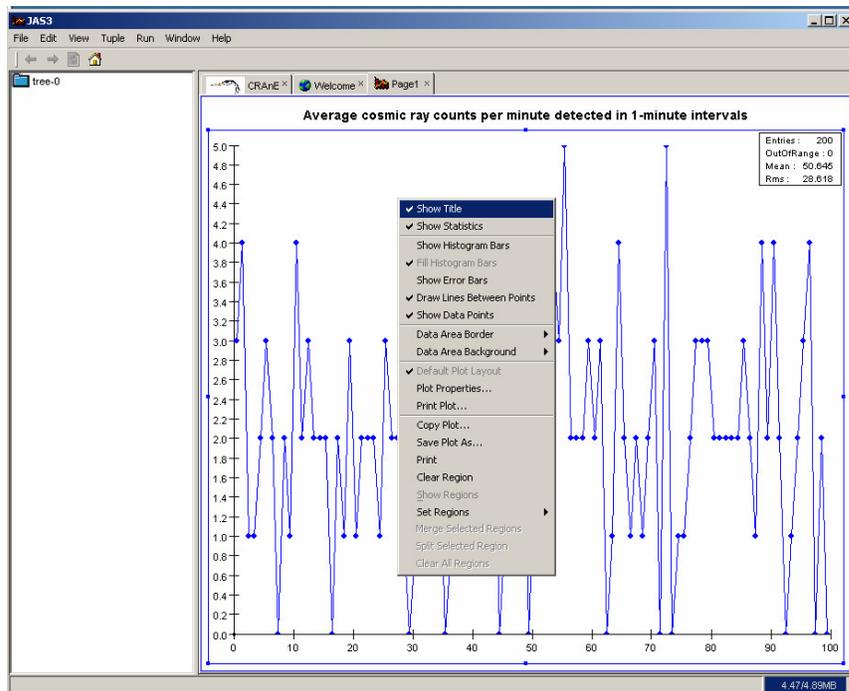


Upon completion of data collection, press the “Stop Data Collection” button.

C. Graph Options

i. Plot Display Options

Once data collection has ceased, the plot display can be edited from options in JAS. Right click on the plot area for a list of available options, as shown in the following illustration:



For example, you could deselect the histogram bars and show the data as points and/or lines, toggle the error bars, display statistics, modify the axes, disable the suppression of zeros, change the color scheme, print, etc. Right click on the title area for a list of options for the title space.

The “Print” function of the options list is identical to the “Print” option from the File menu. To view and/or change the printer settings click File on the menu bar and select “Print Setup”.

The “Copy plot” item on the options list allows you to copy the graph image and paste it as a picture into another environment, such as Microsoft Word.

ii. Saving a plot image

The “Save Plot As” selection on the options list produces a window requesting the file save location for the plot. The default format is `.cmg` (Computer Graphics Metafile) but this can be changed to more familiar formats such as `.gif` or `.jpg` from the drop-down list.

D. File Saving

For each cosmic ray event observed, CRAnE writes two pieces of information to the save file. The main component is the raw data from the logic board preserved in its original format. The other component is the time in milliseconds from the beginning of data collection that a cosmic ray event was processed by CRAnE. This time is annexed to the logic board data line of the corresponding event.