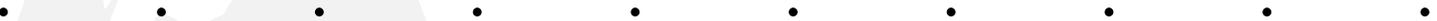




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Bartol Research Institute

BRI - UTas - AAD Neutron Monitor Latitude Survey



*Equipment Description and Operating
Procedures for the 2004-2005 Voyage of
the USCGC Polar Star (WAGB-10)*





Bartol Research Institute - University of Tasmania - Australian Antarctic Division Neutron Monitor Latitude Survey

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Investigation Overview

Cosmic rays are energetic particles (including electrons, protons, and heavier elements) produced in the galaxy by processes that are not fully understood. The propagation of these particles is influenced by magnetic fields in the solar wind and in the magnetosphere of the Earth. By recording variations and fluctuations in the cosmic ray intensity, we are able to investigate changes in these magnetic fields.

Neutron monitors measure the “debris” left after the primary cosmic rays enter the atmosphere of the earth. Much of the information regarding the composition of the cosmic rays is lost in this process, but the large size of the neutron monitor permits an extremely accurate determination of the intensity of cosmic rays striking the atmosphere directly above the detector. The paths taken by these cosmic rays are influenced by the magnetic field of the earth, so that the monitor is “looking” toward a particular direction in space. This direction is in general very much removed from the local vertical. Our network of neutron monitors measures the anisotropy of cosmic rays.

Near the equator, the magnetic field of the earth is more effective in keeping cosmic rays from reaching the atmosphere than it is near the poles; so only higher energy particles are admitted. A parameter called the “Effective Cutoff Rigidity” can be calculated to summarize this process. (Rigidity, or momentum per unit charge, is closely related to the particle energy but is more useful in the actual calculations.)

In a latitude survey, a neutron monitor is transported through a range of cutoff rigidities as rapidly as possible. (Speed is important because the cosmic ray intensity changes with time.) The variation in counting rate of the neutron monitor as a function of effective cutoff rigidity permits a measurement of the cosmic ray spectrum (integrated over particle type) at energies where direct spacecraft measurement is difficult or impossible due to the large detector sizes required. Observed deviations from perfect ordering of the data by the calculated cutoff rigidity may be used to produce refined models of the magnetic field of the earth.

Further information about cosmic rays and the neutron monitor program of which this investigation is a part, may be found on our web site: www.bartol.udel.edu/~neutronm/

Project Collaboration

The University of Delaware Bartol Research Institute, the University of Tasmania, and the Australian Antarctic Division are collaborating on annual latitude surveys through and beyond the solar minimum expected in 2007-2008. Primarily, the Australian contribution is equipment, while the Bartol (with NSF and USCG support) contribution is operation and logistics. Both groups participate in scientific evaluation of the data. Key personnel are:

John Bieber, Professor, University of Delaware, is principal investigator of NSF project S-120. His primary research interest is calculation of particle propagation in magnetic fields. (john@bartol.udel.edu)

Paul Evenson, Professor, University of Delaware, is a co-investigator on project S-120. He is the primary science contact for the annual latitude survey. His primary research interest is measurement of cosmic ray energy spectra using high altitude balloons and spacecraft. (penguin@bartol.udel.edu)

Leonard Shulman, Electronics Engineer, University of Delaware Bartol Research Institute, is responsible for technical development and maintenance of the Bartol network of neutron monitors (Thule, Inuvik, McMurdo, Goose Bay, Ft. Smith, Peawanuck, Nain, South Pole, Newark, and the installation on the Polar Star or Polar Sea). (shulman@bartol.udel.edu)

John Humble is with the University of Tasmania School of Mathematics and Physics. John.Humble@utas.edu.au

Marc Duldig is Program Leader for Space and Atmospheric Sciences, Australian Antarctic Division. marc.duldig@aad.gov.au

Equipment Overview

The TasVan. All equipment is housed in a standard, insulated shipping container often referred to as the “TasVan”, which conforms to all applicable standards and may be handled in any standard way. When moving with a fork lift, note that the load is unbalanced. For operation, the TasVan requires both 110 and 220 volt electric power and a supply of seawater for internal cooling.



3NM64. The scientific instrument is a neutron monitor, technically known as 3NM64. The NM64 is the basic design; the “3” refers to the fact that there are three units installed in the TasVan. The NM64 is constructed mainly from lead and polyethylene, with the neutron detectors inserted from the side. The detectors are cylinders filled with boron trifluoride gas (enriched in the isotope boron-10). The boron nuclei react with neutrons and undergo nuclear fission. The resulting bursts of energy ionize the gas and eventually produce electrical pulses on a wire maintained at a potential of (typically) -2800 volts. These electrical pulses are counted by the electronics inside the TasVan.



Electronics. Racks inside the TasVan record all data automatically, along with ship’s position (derived from GPS receivers) and barometric pressure. Accurate position and pressure information is vital to the success of the experiment. The ship’s log serves as a backup data source in case of failure of the automatic units.

Climate Control. Automatic heating and cooling systems are installed in the TasVan to maintain proper operating conditions for the equipment. Different systems are used during different parts of the voyage. The transfer of systems is typically made during port calls in Australia or New Zealand, both when entering and leaving Antarctic waters.

Equipment Description

In this section, we give a brief but specific description of the construction and operation of individual pieces of equipment. Further information may be found in the blue ring binder furnished to the Science Officer. Questions should be sent to penguin@bartol.udel.edu and /or shulman@bartol.udel.edu. (If urgent, send to both as we are often out of town.)

Electric Service. Both 220 volt and 110-volt power enter the TasVan. The 220-volt service powers two resistance heaters and a heat pump that uses seawater as a heat source or sink. The 110-volt service powers the electronic equipment. Circuit breakers for both are found inside the TasVan on the forward bulkhead.



Resistance Heaters. Located on both sides of the TasVan. Power is controlled by the circuit breaker for the 220-volt service. Turning this breaker “off” disconnects power to the unit. The resistance heaters are used only in Antarctic waters. They are secured during the passage from Seattle to Sydney and on the return passage from Adelaide to Seattle. Thermostatic controls for these heaters are located on the heaters.

Seawater Heat Pump. Located near the forward bulkhead on the port side. Power is supplied by a breaker for the 220-volt service. This unit provides both heating and cooling for the TasVan. The control is located on the port wall, near the unit. When operating, this unit must be supplied with flowing water, and left in automatic mode with a set point of 70 degrees. The heat pump cannot be used in Antarctic waters because the water temperature is too low for proper extraction of heat. It is secured southbound at Sydney and reactivated northbound at Adelaide. When secured, the seawater supply must be disconnected and the circuit breaker turned off.



Electronics Rack. Most of the electronics are located in the rack adjacent to the onboard computer. The documentation “Blue Book” should be kept available for reference.

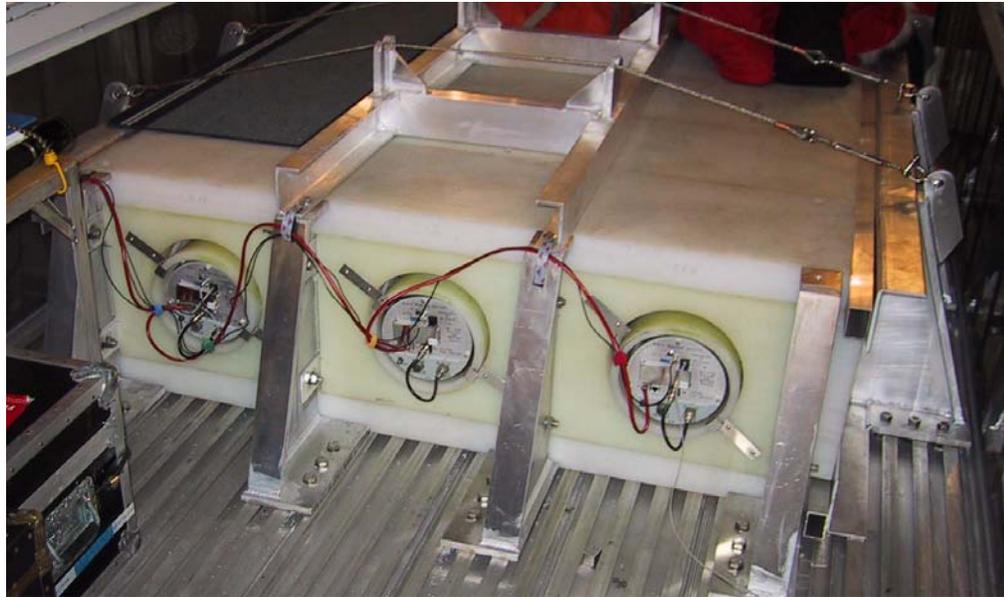


Uninterruptible Power Supply (UPS). Located in the electronics rack. Power is controlled by a breaker in the 110 volt service. The on-off switch is located on the rear of the unit. The UPS conditions all of the power to the electronics. It provides approximately 30 minutes operation of the electronics in case of brief interruption in ship’s power. If a longer interruption is expected, the unit should be secured by turning the switch on the back “off”. To restart, turn the switch on the back “on” and push the “on” indicator on the front panel. Normal operating mode is the green “online” indicator on.

University of Tasmania Data Logger. Located in the electronics rack, the data logger records data from the detectors and one barometer in a solid-state memory. The Logger has its own DC power supply. Data summaries from the Logger appear on the computer display for diagnostic purposes. The one-second light should flash once per second in normal operation, with occasional longer flashes. If this light is not flashing, or if there is no recent transmission displayed on the screen of the computer, the “Reset” button should be pushed. If no lights flash when the reset button is pushed, check that power is reaching the unit from the power supply. No other field service is possible.

Footlockers and Storage Cases. Footlockers and storage cases, secured with bungee cords, contain spare parts and documentation intended for use by the investigators during servicing visits to the ship. Entry by ship’s crew is authorized only by specific invitation or in connection with official ship’s business.

BP-28 Neutron Detectors. BP-28 (Chalk River) neutron detectors are mounted in the NM-64. They are self contained and should not be serviced by ship’s personnel. Input is low voltage power to the electronics, with an internal supply generating -2800 volts (nominal) to the detector. Outputs are logic pulses, each of which corresponds to the detection of a single neutron. The units operate independently, so it is possible to disconnect an individual unit if a failure causes interference. Since the units are daisy-chained, such removal may require re-configuration of the wiring. The logic pulses are counted by independent and redundant data acquisition systems (the Logger and the Bartol Electronics).



Low Voltage Power Supply. Located in the electronics rack. Powered from the 110 volt UPS. Provides low voltage power to the Bartol Electronics (and through this to the Remote Units). Normal state is “power on”. Fluctuations in current at a one second rate are normal and are due to the operation of the readout electronics. Cycling “power off” / “power on” resets the electronics.

Bartol Electronics. Card cage located in the electronics rack. Several printed circuit boards perform different functions, to produce a consolidated data stream for analysis by the computer. They are powered from the Low Voltage Supply. To reset, cycle the power.

Master Unit. One of the boards in the Bartol Electronics, the Master provides power to the remote units and collects data from these units. Normally the Master has nothing visible ex-

cept the flashing LEDs (green heartbeat 2 or 3 times per second, and red busy once per second). However, if any Remotes do not respond, the Master will display the number of units that had an error during the last readout. To reset, cycle the power.

Remote Units. Located on the neutron detectors, and powered from the Master, the Remote Units operate the detectors and count pulses from them. To reset, cycle the power to the Bartol Electronics.

Digiquartz Barometer(s). Mounted on boards in the Bartol Electronics. One or two units may be installed. The output consists of two square-wave signals, with frequencies related to the barometric pressure and operating temperature by a complex formula. The outputs are sent redundantly to the Logger and the Bartol Electronics.

AIR Barometer. Located in the electronics rack. Output is a digitally coded signal giving barometric pressure. Powered and read by the Bartol Electronics.

Analog Tiltmeters. Redundant sensors are located on a board in the Bartol Electronics. Output of each sensor is three analog signals giving inclination on two axes and unit temperature. The values shown on the display are uncalibrated engineering units.

PotchMon. Mounted near the access door, the Potchefstroom University (South Africa) calibration monitor is a miniature version of the neutron monitor installed in the Tasvan. It is being carried to test and calibrate it against the standard monitor. This unit operates automatically, with backup data transferred to the computer via an Ethernet link. If there is an error message displayed on the LCD, the unit must be reset. To reset, power it down according to the instructions on the LCD, then remove the white cap on the power button and press the button.



Lights. Lights in the TasVan should be kept off when not needed. Heat from the bulbs can influence thermal control.

Computer. Located near the electronics rack. Powered from the 110 volt UPS. This is a standard PC, operating under Windows XP which accumulates and records data using programs written in Visual Basic Version 6.0. The hard drive contains the operating system and is used to record the daily log files for transmission to the experimenters via e-mail along with the full time resolution dataset. An identical, spare PC is normally kept in one of the crates in the Tasvan. If it is necessary to reboot the computer, power to the electronics rack MUST be switched off prior to and during the reboot. If instrument data are presented to the computer during reboot, it often detects this as a “pointing device” and causes the mouse pointer to jump around on the screen. If this happens, power off the electronics to stop the mouse pointer from jumping, and shut down the computer normally. Then reboot with power to the electronics still off.

CD Burner. Installed in the PC. Used for backup of data and software during visits by the investigators.

“Floppy” Drive (3.5 inch). Installed in the PC. Used during the voyage to copy daily log files for transmission to the investigators via e-mail. A special program is provided to automate this operation. Details are given in the section on the daily station check

Rocket Port. Installed in the PC, the Rocket Port adds serial ports COM3 through COM6. COM3 is used for general communication with the Bartol Electronics. COM4 is used to communicate with the Logger. The latest message from the Logger is always displayed on the PC screen. COM5 is currently unused. COM6 is used as required for a calibration barometer. There is a parameter file on the computer that allows straightforward reconfiguration of these ports.

GPS Receivers. Two units are mounted in the rack to furnish data to the consolidated data stream. The most recent record read from each is always displayed on the PC screen. The last valid position from each is displayed in a separate location on the PC screen. There is also a GPS receiver in the calibration monitor. Antennae for all three receivers are mounted on the forward bulkhead of the Tasvan, as shown in the photograph. The antennae are all identical, and may be interchanged if necessary for troubleshooting.



Operation Overview

Operation of the neutron monitor in the TasVan is fully automatic. All data are recorded either on hard disks or in solid-state memory. Periodic visits by the investigators are made to download the data and to maintain and upgrade the hardware and software.

Activities requested of the ship’s crew are designed to diagnose and correct minor problems that might develop in the instrumentation and to alert the investigators to major problems that might require special repair visits to the ship. The most important part of the process is the daily transmission of a diagnostic log file to the investigators via e-mail. Daily entry (weather permitting) into the TasVan is requested to obtain this log file and to perform a series of inspections. The investigators will examine the transmitted log files, and may request further diagnostic and/or repair activity from the crew.

A checklist and log form is provided, covering one week of daily checks. These forms should be retained on the ship for reference by the investigators during the servicing visits. If anomalies are noted, the relevant forms may be sent via **Fax (302) 831-1843**, attention of Len Shulman, or the observations may be summarized in an e-mail message sent to **shulman@bartol.udel.edu** with a copy sent to **penguin@bartol.udel.edu**.

An immediate response to anomaly reports should be expected. The crew may take reasonable corrective action before receiving a reply from the investigators, but all such actions and the results of them should be reported to the investigators via e-mail or Fax.

Daily Station Check

The following operations and checks should be performed on a daily basis. Each item should be checked off on the checklist, or a reading entered, as appropriate. The light in the TasVan should be kept off when not in use, and the door kept closed as much as possible to ease the strain on the climate control system.

In transmitting the log files, **please do not** transmit the file for the **current day** unless explicitly requested. The file is updated from time to time during the day, and is only complete when the day ends. Copying the file during an update may cause a system crash. Note that the computer is always kept on Universal time. The current day can always be found from the updating time on the computer screen. The date is part of the file name.

Monitor Summary. Observe the operation of the system as summarized by the screen display on the PC. All remote units should be responding. If the display is frozen, first try to close the program with the (X) box. If that does not work, use CTRL-ALT-DEL and try to get Windows to terminate the program. If either of these works, restart the program by double clicking on the “Earth” icon. If all else fails, reboot Windows. Be certain that the “DA Power” is **OFF** before rebooting Windows. The program should load automatically. When it has loaded, the “DA Power” should be turned back on.

PotchMon. Observe the operation of the Potchefstroom Calibration Monitor as indicated on the LCD screen attached to the unit. Reset if necessary. To reset, shut down the monitor following instructions on the LCD display. Then remove the white cap on the power switch, and press the power button.

GPS. Messages from both units should appear once per second, and most should contain valid positions. The separate display of the “last valid” position should be recent and reasonable. Interchange the antennae as a diagnostic if one unit is not responding. There is a spare antenna in the footlocker.

Barometers. Entries for all barometers on the screen display should be consistent and update at least once per minute.

Tiltmeters: Display on the computer screen should update once per second, and should agree with the observed motion of the ship.

Logger. The message on the Monitor screen should be no more than one hour old, and the one-second light on the logger itself should be flashing. No other lights should be on. Push the Logger reset if this is not the case.

Temperature. Record the temperature from the display near the electronics rack.

Humidity. Record the humidity from the display near the electronics rack.

UPS. Check that the green “online” light is on.

Bartol Electronics. Check that the lights are flashing in their normal patterns

Thermal Control. When the heat pump is being used, check that the control is set to auto mode. The temperature set point should be 70 degrees. Check the seawater connections for leaks, and check that the condensate drain is open. If the heat pump is secured, verify proper operation of the resistance heaters. The heat pump and the resistance heaters should not be used at the same time.

Log File. Place a DOS formatted floppy disk in the drive, and bring the log copy window to the front by clicking on the taskbar. Click the “Copy File” button, and select the file to be copied with the dialog box. (This will usually be near the end of the list; I have not found a way to get Windows to make the end of the list the default location) Clicking the “OK” button will copy the selected file to the disk. E-mail the file to **penguin@bartol.udel.edu** as soon as possible. The file contains only printing ASCII, so it may be edited into a message or sent as an attachment. To restart the Log Copy program, double click the floppy disk icon on the screen. The program also restarts when Windows is re-booted.