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Title: Revised SNAP III Training Manual

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1 INTRODUCTION

The Shielded Neutron Assay Probe (SNAP) technique was developed to determine the leakage neutron source strength of a radioactive object. The original system consisted of an Eberline™ Mini-scaler and discrete neutron detector. The system was operated by obtaining the count rate with the Eberline™ instrument, determining the absolute efficiency from a graph, and calculating the neutron source strength by hand.

In 2003 the SNAP III, shown in Figure 1, was designed and built. It required the operator to position the SNAP, and then measure the source-to-detector and detector-to-reflector distances. Next the operator entered the distance measurements and started the data acquisition. The SNAP acquired the required count rate and then calculated and displayed the leakage neutron source strength (NSS). The original design of the SNAP III is described in SNAP III Training Manual (ER-TRN-PLN-0258, Rev. 0, January 2004, prepared by William Baird)

This report describes some changes that have been made to the SNAP III. One important change is the addition of a LEMO connector to provide neutron detection output pulses for input to the MC-15. This feature is useful in active interrogation with a neutron generator because the MC-15 has the capability to only record data when it is not gated off by a pulse from the neutron generator. This avoids recording of a lot of data during the generator pulses that are not useful. Another change was the replacement of the infrared RS-232 serial communication output by a similar output via a 4-pin LEMO connector. The current document includes a more complete explanation of how to estimate the amount of moderation around a neutron-emitting source.

Figure 1 SNAP III.

1.1 Purpose

This purpose of this document is to aid users of the Shielded Neutron Assay Probe (SNAP) achieve a better understanding of the capabilities and limitations this instrument.

1.2 Scope

This document is written to provide information and guidance to the users of the SNAP.

1.3 Precautions and Limitations

1.3.1 Electrical Safety

None of the procedures described in this manual require disassembly of the SNAP III. However, in the interest of safety, a description of the hazards inside the unit and their extent is included. Each unit contains a high-voltage power supply capable of 2 kV and 7 μA of current. There is 0.002 μF of capacitance, which if charged to 2 kV, would store 0.004 J. Los Alamos National Laboratory classifies this in the Electrical Safety Program

P101-13 Rev. 3 as Class 2.1 R&D electronic work, which requires de-energized electrical safety training. The internal lithium-ion battery has an integral protection circuit that protects the battery from over voltage (>4.35 V), short circuit (>3 A), and high temperatures (>100°C).

1.3.2 Precautions

The SNAP III weighs 24.25 pounds. Care is required in lifting. This unit contains a Reuter-Stokes ^{3}He proportional gas tubes 1 inch in diameter by 8 inches long. Each tube is pressurized to 10 atm and has a hazard class/division rating of 2.2 by the U.S. Department of Transportation. The SNAP detectors require special hazard documentation for shipment.

2 DEPLOYMENT

2.1 Configuration

The SNAP III is used in the same manner as the older SNAP units. The flat surface of the SNAP should be placed toward the source. You should be able to read the display and see the source on the opposite side of the SNAP in the correct orientation as illustrated in Figure 2, which shows the SNAP III and the neutron multiplicity detector positioned in an ideal data collection configuration.

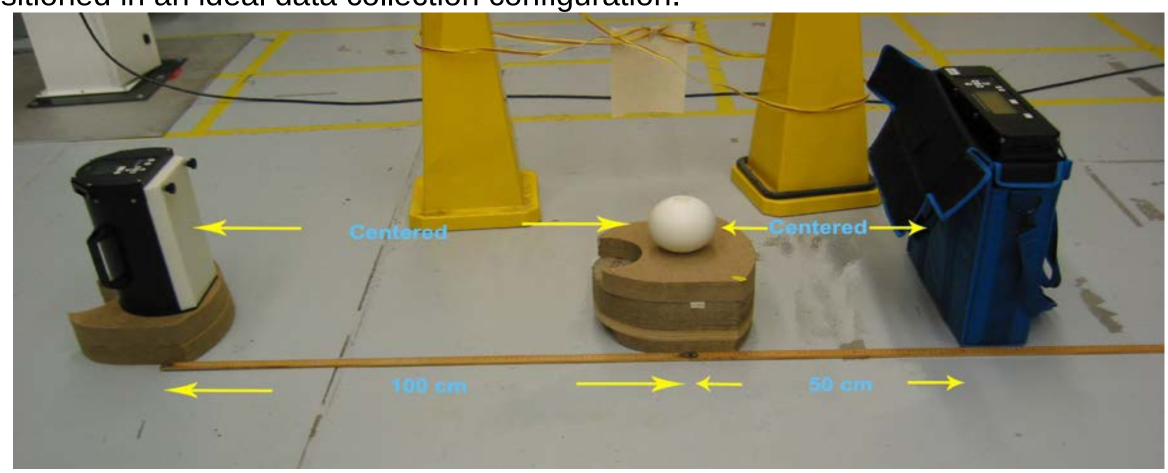


Figure 2 A typical data collection configuration.

The source in Figure 2 is a ^{252}**Cf** fission neutron source located inside a sphere of polyethylene to moderate the neutron energy. The distances shown represent an ideal situation. These may need to be changed for a specific collection scenario depending on the size of the source and the location of the source in the environment. An alternative configuration might have the two detectors at a right angle to the source. The distances would be similar. Note the source is at the centerline for the two detectors.

2.2 Positioning

Locate the neutron "hot spot" by hand scanning the object of interest. Position the SNAP as close as possible to the same height as the neutron hot spot on a stable vibration free mount. Position the SNAP to keep the source-to-detector distance within the range of 75 to 125 cm. If the object of interest is larger than 1.25 meters, position the SNAP close to the surface. Figure 3 shows an operator measuring the source-to-detector distance.

Figure 3 The SNAP source-to-detector measurement.

The SNAP source-to-detector distance is measured from the center of the source to the center of the detector tube, or 4.7 cm behind the front of the bare SNAP. The SNAP reflector-to-detector distance is measured from the center of the detector to the floor. These values are critical; if the distance measurements are only estimates, then the minimums and the maximums should be noted. This allows a range of possible neutron source strength values to be calculated after the count rate is determined. If the floor is thin metal and a concrete wall is located nearby, then the reflector to detector distance is measured to the wall. When both the floor and wall are good reflectors then the distance to the second reflector needs to be known as well. When more reflectors are nearby, photos and distances are needed to document the configuration for calculations.

3 MEASUREMENT PRECAUTIONS

3.1 SNAP Technique

The SNAP technique calculates neutron source strength by experimentally determining the effect that the distance between the source and the detector and the distance between the detector and a reflector (e.g. the floor) have on the total number of neutrons detected for a specified time. Therefore, any change in the geometry or location of the neutronic reflectors will affect the results. For this technique to work properly, the neutron source, or “hot spot”, must be located as accurately as possible. In addition, the distance between the source and the detector should be optimized to be between 75 and 125 cm. Minimizing the source-to-detector distance can reduce errors caused by reflecting surfaces, which become more significant as the distance increases. However, the error caused by an incorrectly located “hot spot” may be greater than the error associated with reflecting surfaces. Because precise measurements may be impossible to obtain, you should record a range of tolerances for your distance measurements. This will allow the analysis program to calculate the possible range for the source strength values. Note that the ^{3}He tubes are sensitive to microphonics (vibrations). External vibrations may affect the neutron count rate and subsequently the neutron source strength calculation. The SNAP detector efficiency is calibrated for reflections from a single nearby reflector as shown in Figure 4. These curves are stored in the memory of the SNAP unit and two dimensional table lookup using bilateral linear interpolation is used to determine the efficiency for a specific geometry. Figure 4 shows the efficiency of the detector when changing the source-to-detector distance but keeping the detector-to-reflector distance constant.

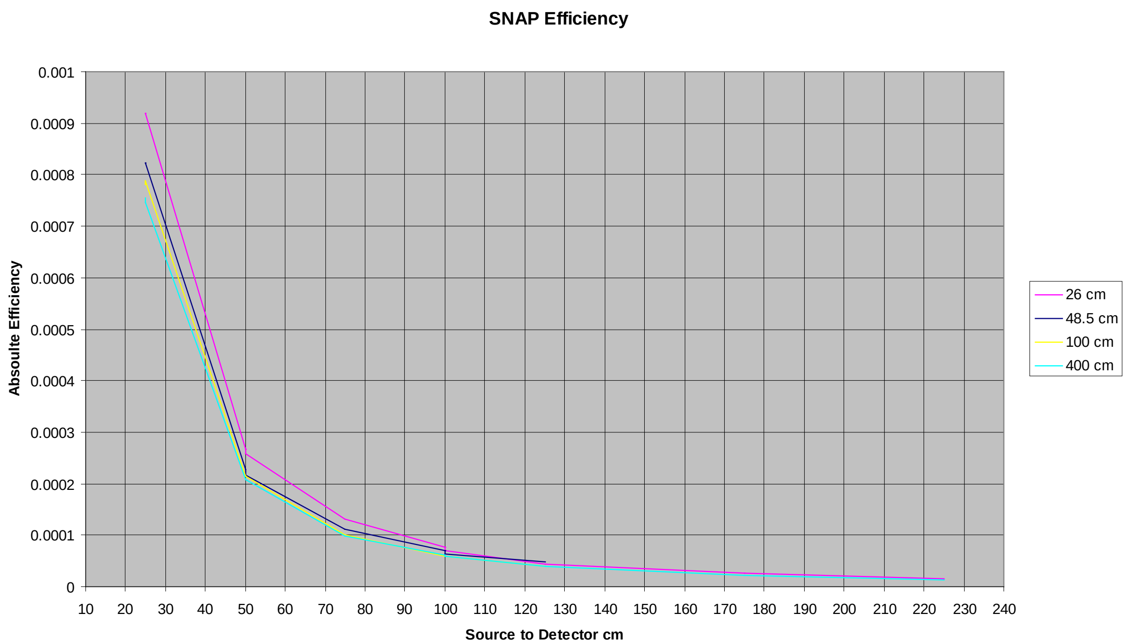


Figure 4 SNAP detector efficiency for a single reflection surface. The source-to-reflector distances are shown in the legend.

3.2 Effects of Moderators

One of the main corrections we make to the calibrated efficiency for the SNAP is the determination of moderation and absorption due to the presence of hydrogenous layers that may be present in a source. Moderation by hydrogen is very efficient because a single collision can result in the transfer of 100% of the energy from the neutron to the hydrogen nucleus through elastic scattering. Moderation of the neutron energy is an important effect because the cross section for neutron detection in ^{3}He is only 3 barns at the average fission energy, but it is 3000 barns at for thermal energy neutrons. There is a cost incurred for neutron detection due to losses of neutrons through inelastic scattering with hydrogen.

The effects of moderation are summarized in three families of curves in Figure 5. The top curve is the transmission ψ, which is the ratio of the number of neutrons that are emitted from the surface of the SNM to the number of neutrons that are detected by the n-pod III.

$$\psi = \frac{\#\, of\ neutrons\ emitted\ from\ the\ surface\ of\ SNM}{\#\, of\ neutrons\ detected\ in\ the\ n - pod}$$

Because the denominator of the ratio is the number of neutrons that are detected, this implies that there is an energy dependence of the transmission ratio, and hence, there is a slight increase in the transmission ratio as a moderator is placed around the material. In essence, the transmission ratio is a first-order approximation of how much effect a moderator has on the neutron flux that is surrounding an SNM object.
The second family of curves shows the ratio of two SNAP-3 measurements. One measurement is without the 1" polyethylene shield in front of the SNAP-3, and the other measurement is with the 1" polyethylene shield in front of the SNAP-3. This ratio, called the rho ratio, gives an estimate of how much moderator is in the system that is being measured.

$$rho\ ratio = \frac{NSS\ reported\ by\ the\ SNAP\ without\ the\ 1"\ poly\ shield}{NSS\ reported\ by\ the\ SNAP\ with\ the\ 1"\ poly\ shield}$$

The third family of curves shows similar rho ratios measured by the n-pod.

$$rho\ ratio = \frac{NSS\ reported\ by\ the\ n - pod\ without\ the\ 1"\ poly\ shield}{NSS\ reported\ by\ the\ n - pod\ with\ the\ 1"\ poly\ shield}$$

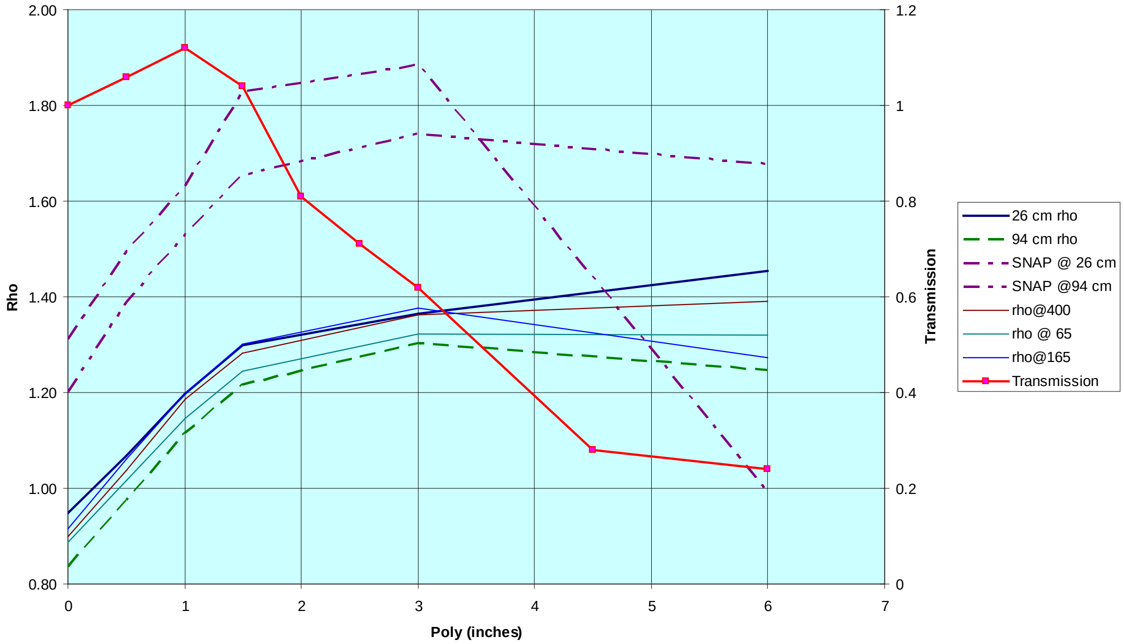


Figure 5 Moderation effects as functions of thickness of polyethylene spheres.

III

Table 1 Description of curves in Figure 5.

Curve	Description
SNAP @ 26 cm	The rho ratio for SNAP-3 detector when it is 26 cm away (usually above) the nearest reflector.
SNAP @ 94 cm	The rho ratio for SNAP-3 detector when it is 94 cm away (usually above) the nearest reflector.
pod @ 26 cm	The rho ratio for n-pod III detector when it is 26 cm away (usually above) the nearest reflector.
pod @ 65 cm	The rho ratio for n-pod III detector when it is 65 cm away (usually above) the nearest reflector.
pod @ 84 cm	The rho ratio for n-pod III detector when it is 84 cm away (usually above) the nearest reflector.
pod @165 cm	The rho ratio for n-pod III detector when it is 165 cm away (usually above) the nearest reflector.
pod @ 400 cm	The rho ratio for n-pod III detector when it is 400 cm away (usually above) the nearest reflector.
Transmission	An initial transmission estimate. This is the only curve on the graph that is read on the right axis.

The SNAP data were taken at 100 cm source-to-detector distances, and the pod data were taken at 50 cm source-to-detector distances. The indicated distances in the legends for the curves were the reflector-to-detector distances measured from the center of the source to the nearest concrete surface (floor). Other possible reflectors were several meters removed from the source and detectors.

The measured rho ratio, from either the SNAP or the n-pod, can be used with Figure 5 to determine the polyethylene moderator thickness. Then this thickness can be used with the transmission curve in Figure 5 to determine the transmission, which is needed in the code Momentum for the analysis of n-pod or MC-15 data.

3.3 Effects of Reflectors

The SNAP detector efficiency is well characterized for the usual geometry with one nearby reflector. Additional reflectors greatly complicate the determination of the efficiency. For instance, measurements in an underground utilities hall will have multiple reflective surfaces in the form of the concrete walls, floor, and ceiling. Figure 6 shows the indicated neutron source strength for a tunnel as determined by the single reflector model in the SNAP detector. The actual source strength was 1.6E6 neutrons per second. The tunnel was 6 feet wide, 8 feet tall, and the source was 1 meter from the end of a branch tunnel. The measurements over-estimate the true neutron source strength by a factor of ~3.6 at 3 meters.

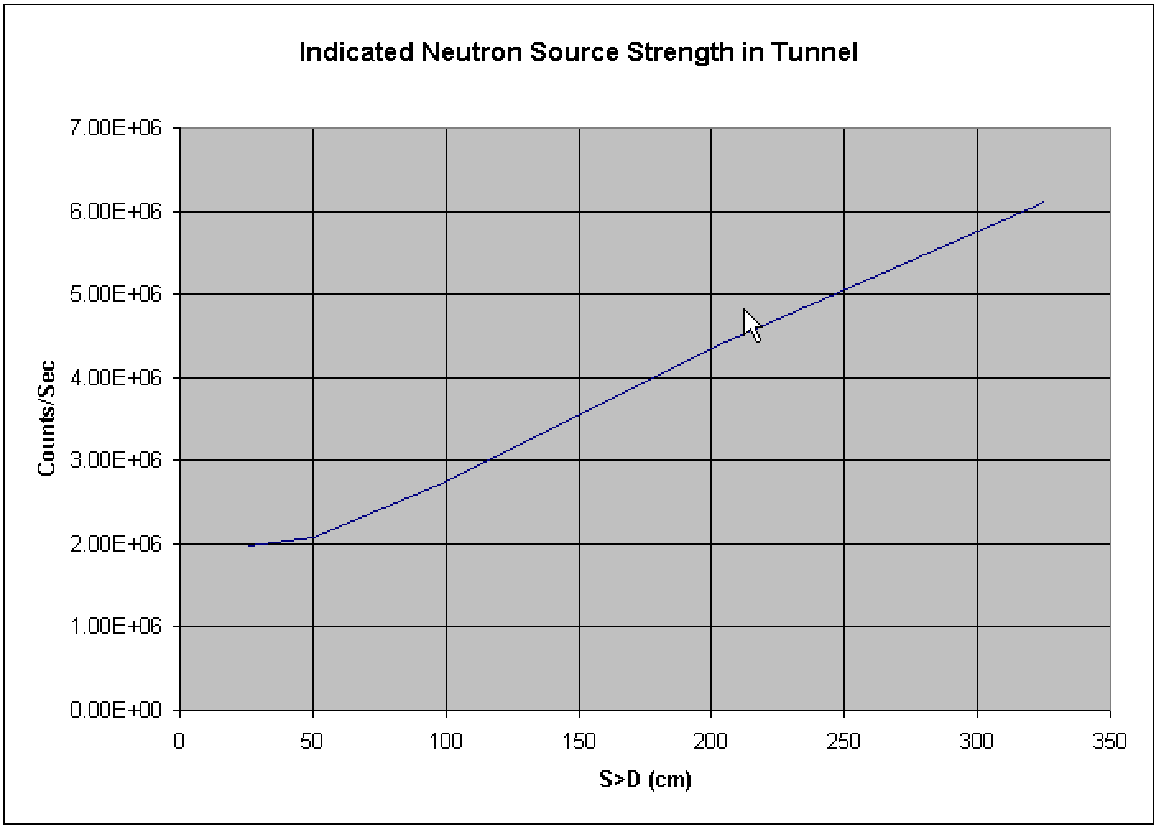


Figure 6 NSS in a tunnel.

The proper model to use includes 5 neutron reflector surfaces corresponding with the back wall, side walls, ceiling, and floor of the tunnel. Figure 7 shows the SNAP detector efficiency and the efficiency modeling results for the same set of measurements with these reflectors included. The values are almost indistinguishable in the plot.
The largest error is a few percent instead of the factor of ~3.6 found with the simpler model. Clearly we need to account for these extra reflectors, and thus we need to take additional measurements of the geometry when extra reflectors are present.

The extra information needed for the modeling consists of the number of extra reflectors, and the distance from the center-line of the SNAP detector to these reflectors. If a reflector is greater than 4 meters from the centerline, then we can usually ignore this reflector. Most measurement geometries will have fewer than 5 reflectors. Reflection from a wall located behind the SNAP detector is negligible due to the construction of the SNAP (which includes a back scatter shield). The measurement log form in Appendix A for the SNAP has been extended to include the additional information required.

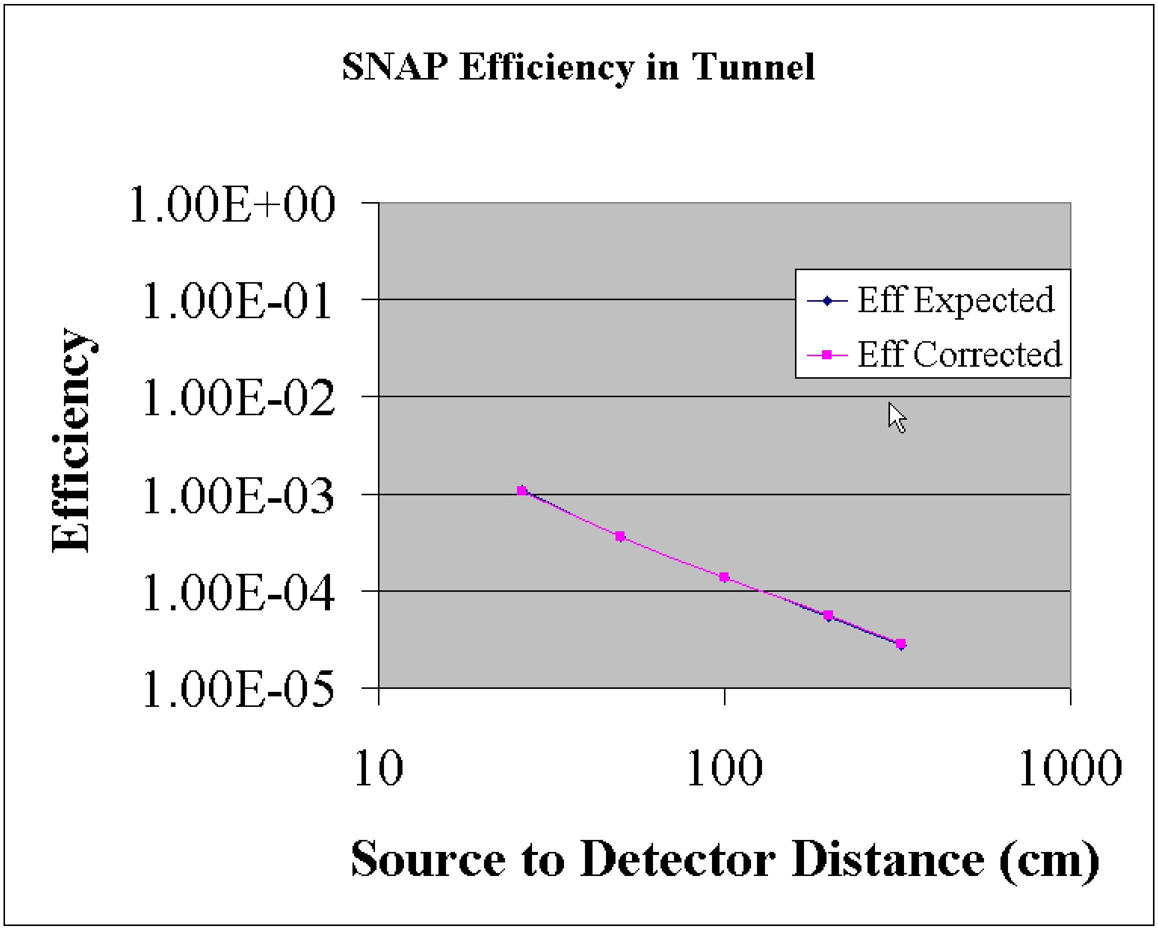


Figure 7 Neutron efficiency in a tunnel.

4 DETECTOR

4.1 Detector Description and Operation

The neutron detector is a stainless steel tube with an active volume 1 inch in diameter and 6 inches long, Reuter-Stokes part number RS-P4-0804-104. The tube is filled with ^{3}He(helium 3) gas to a pressure of 10 atm. Figure 8 is a cutaway view of the SNAP to demonstrate the location of the detector and polyethylene moderators. The moderator design consists of three layers: a polyethylene back-scatter moderator, a cadmium shield, and a polyethylene inner moderator. Neutrons incident on the face of the detector must have sufficient energy ($\approx$.5eV) to pass through the cadmium shield, where they are thermalized by the inner polyethylene sleeve. The thermal neutrons will interact with the ^{3}He tube to produce detectable electrical signals. A polyethylene back-scatter shield thermalizes neutrons approaching the detector from the top, sides, rear, and bottom. SNAP is highly directional so that only neutrons incident from the front with greater than 5 eV energy will be counted by the detector.

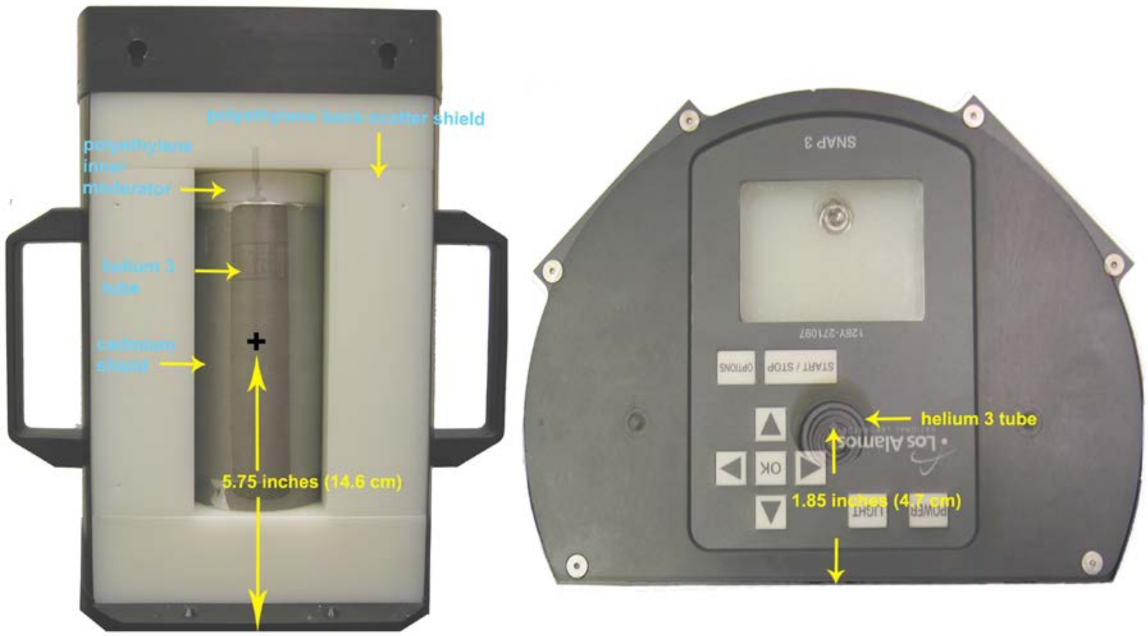


Figure 8 Physical location of Helium 3 Detector & Moderators in SNAP.

4.2 ^{3}He Proportional Gas Tubes Operation

The reaction used to detect neutron is ^{3}He(n,p)^{3}H. The proton and triton leave the reaction with kinetic energy that ionizes the gas. If all the energy is deposited in the gas, the charge collected will generate the thermal peak of the spectrum seen in Figure 9. If one of the particles collides with the wall of the detector before depositing its total energy, a lesser amount of charge will be collected. The plateau shape results because some of the energy of the particle may be used in ionizing the gas before colliding with the wall. A plateau from one-fourth to the full peak height results because the light particle (proton) collides with the detector wall. A second plateau from three-fourths to full peak height is due to the heavy particle (^{3}H or triton) colliding with the wall.

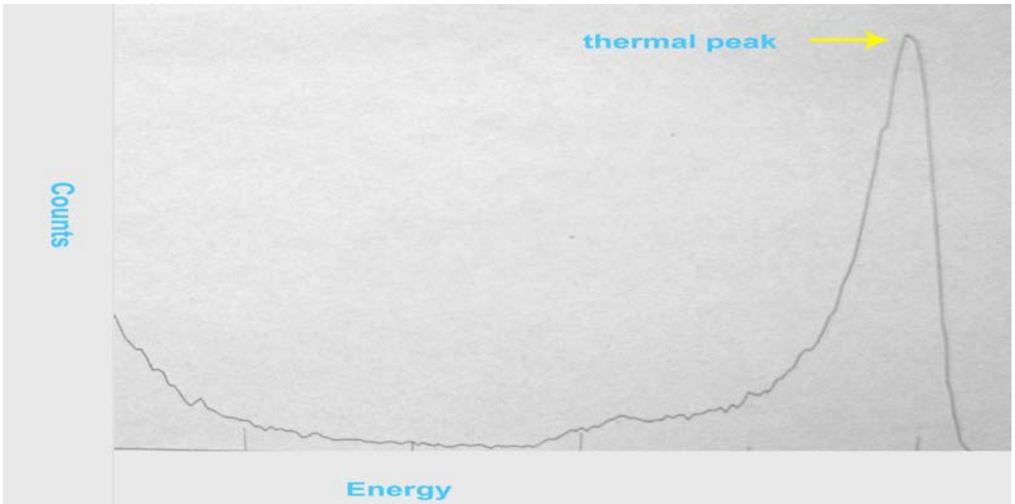


Figure 9 Thermal Neutron Spectrum.

5 PHYSICAL DESCRIPTION

5.1 Top Panel Description

The SNAP top panel, shown in Figure 10, contains the membrane keyboard and LCD display.

The **"POWER"** switch requires a single press to turn the unit "on" or "off". Note that the SNAP cannot be turned "off" while the red Charging LED shown in Figure 11 is lighted. This feature allows the internal fuel gauge to monitor the charge in the battery.

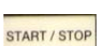
The **"LIGHT"** switch controls the LCD display and keyboard backlights. The backlight is intended for low light conditions and is not visible under normal ambient light conditions. Pressing the **"LIGHT"** switch once turns on the backlights. Pressing a second time increases the backlight intensity. Pressing a third time turns the backlight off.

The "Scroll" keys control the contrast setting of the LCD display in the "Initial Display Menu".

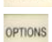
The "up key" increases the contrast.

The "down key" decreases the contrast.

The last contrast setting is saved in battery-backed ram when the unit is turned off.



The "Collect key" initiates data collection with the parameters displayed.



Pressing the "**OPTIONS**" key brings up the options menu.

Figure 10 Top Panel.

5.2 Power Jack Plate

In Figure 11, the "Power Jack" and "Charging LED" are visible through the slot in the cover plate.

The red "Charging LED" lights when the battery is charging. The SNAP cannot be powered down while this LED is on.

The "Power Jack" requires a 2 mm plug. A 6 Volt DC 2A line powered battery charger (CUI STACK™ MODEL EUA-101W-06) is provided with the unit, but any 6V DC charger with a 2 mm plug should work. The unit can be operated while the battery is charging.

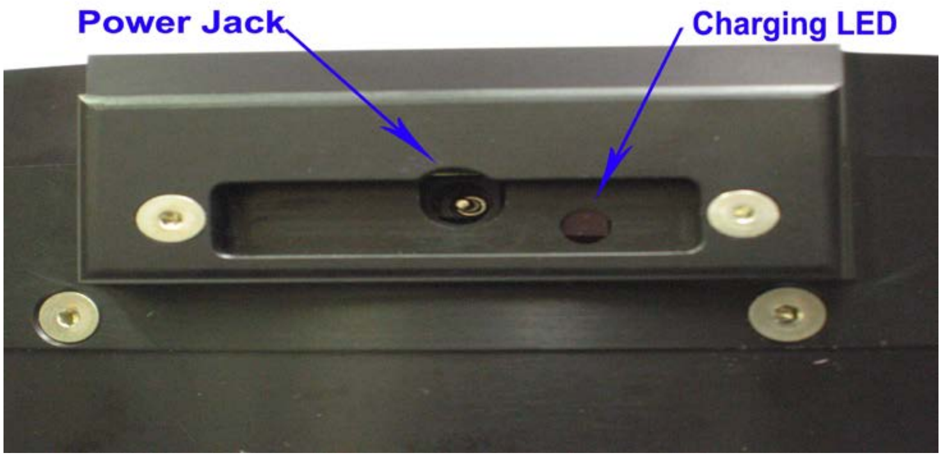


Figure 11 Power Jack Cover Plate.

5.3 Communications Port

Figure 12 is a photograph of the SNAP communications port with the cover plate removed.

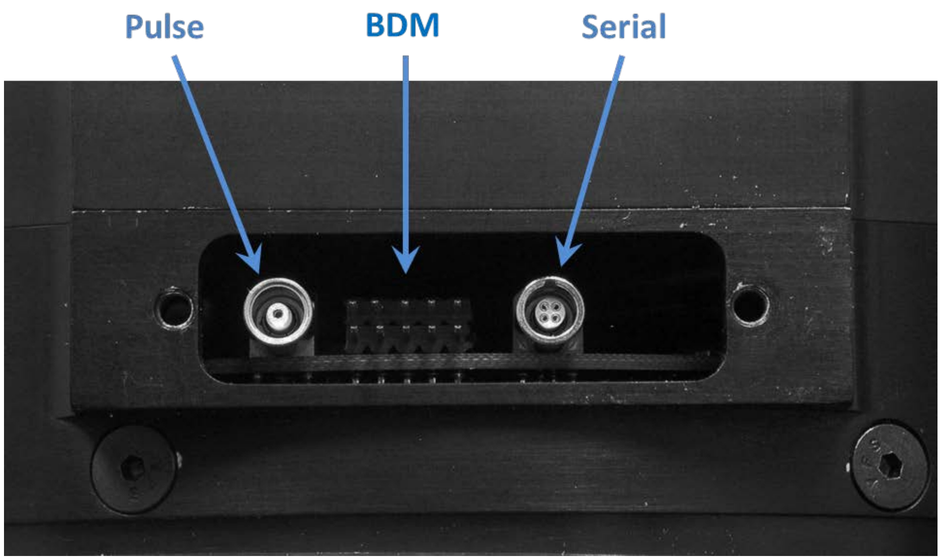


Figure 12 Communications Port with the cover plate removed.

5.3.1 Output Pulse Connector

The LEMO connector on the left in Figure 12 provides an output pulse, amplitude +5 V, width ~6 μs, for every pulse measured by the SNAP. This output is normally connected to the "IN" input of the MC-15 when the MC-15 is also used.

5.3.2 BDM connector

The BDM communication connector is used primarily to program the SNAP. It is a 10 pin connector, and pin 1 is the first pin on the top right side of the connector.

5.3.3 RS-232 serial communication

RS-232 communications are provided using a 4-pin LEMO connector located on the right side of the communications port. Use a serial communications program, such as Hyper-terminal, with the serial port configured for 9600 baud, no parity, 1 stop bit. Configure the port for full duplex operation. Using the computer keyboard, transmit "returns" (Enter key) to the SNAP and observe the received "OK" response on the computer screen. Directions for dumping a file via the serial port are given Section 6.4 below.

6 OPERATION

6.1 Initial Display

Figure 13 is the "Initial Display", which shows the default values for collecting data. The collection time default is 300 seconds or 40,000 counts. The default source-to-detector distance is 50 cm, and the default reflector-to-detector distance is set for 95 cm. To accept and collect data with the parameters displayed, press the START / STOP key. To change these settings, press the OPTIONS key, which brings up the options menu. The ▼▲ keys adjust the contrast setting of the LCD display. The ▲ key increases the contrast and the ▼ key decreases the contrast. The contrast setting is saved in battery-backed ram. The OK and ◀▶ keys are not assigned a function in this screen.

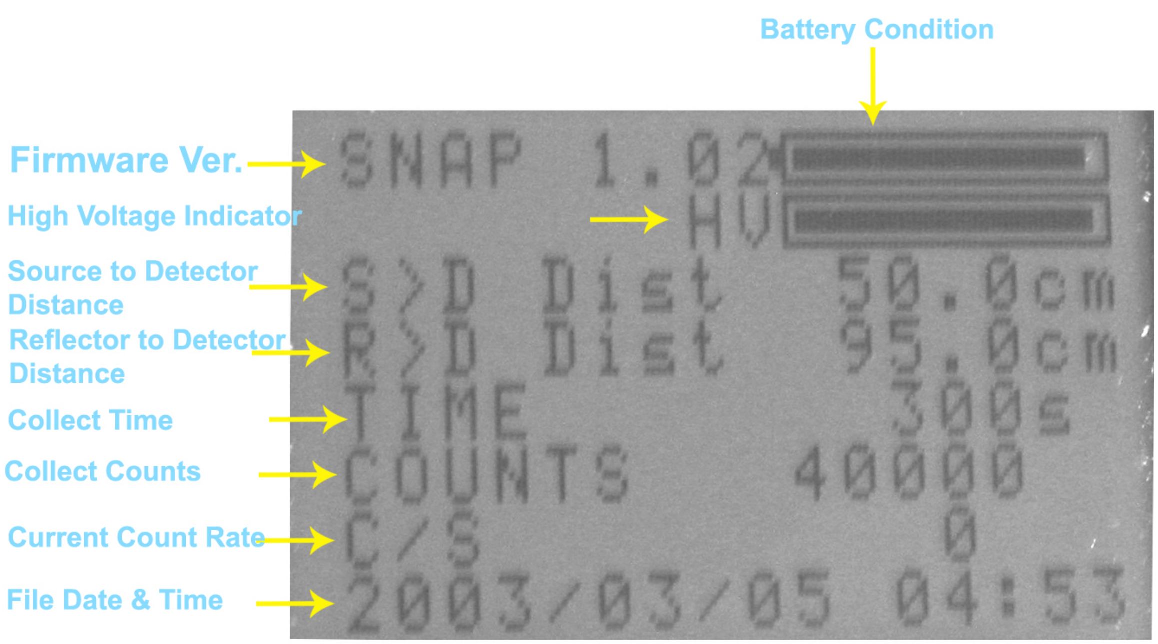


Figure 13 Initial Display.

6.2 Started Screen

Figure 14 is displayed after the operator has pressed the START / STOP key. The time and total counts are displayed and the estimated NSS (Neutron Source Strength) is updated.

Three conditions will end collection. The operator pressing the START / STOP key, the preset number of counts collected, or the preset time elapsed.

Pressing the START / STOP key stops the collection of data. A low-volume continuous tone sounds when data collection stops. You must press the OK key to shut off the tone. The "Initial Display" will be shown.

The ▼▲ keys again adjust the contrast setting of the LCD.

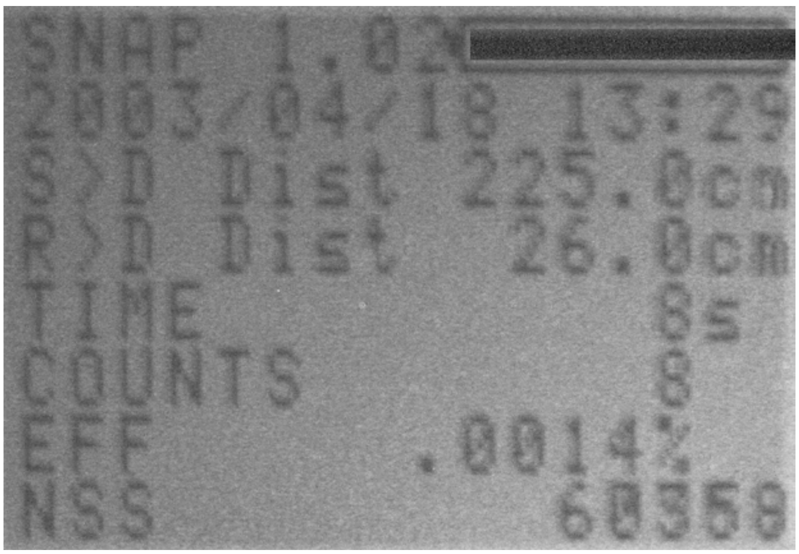


Figure 14 Started

6.3 Options Menu

The "Options Menu" in Figure 15 is displayed when the OPTIONS key is pressed while the "Initial Display" (Figure 13) is shown. Scrolling to any of the first three lines and pressing OK will get you to another page to enable you to modify that parameter. The last four parameters are adjusted on this "Options Menu" (Figure 15) as described in Section 6.9. The ▼▲ keys move the cursor between options. The OK key enters the option selected. The ◀▶ keys are used to change the entries on the last 4 lines.

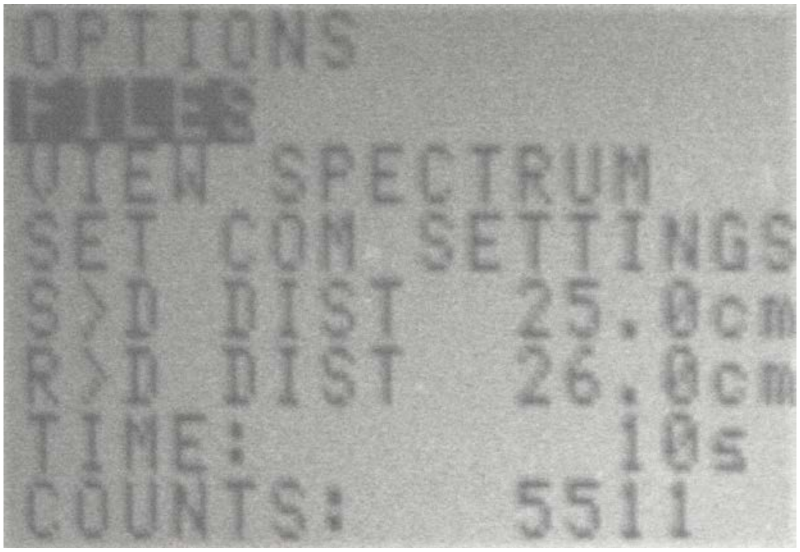


Figure 15 Options Menu, “FILES” highlighted.

6.4 Files

Each time data collection is completed, the collection parameters, date, and results are stored in a sequential numbered file battery backed memory. The Files Display, shown in Figure 16, provides access to the data collections taken on that instrument. Figure 16 displays file number 87. Pressing the OK key exits to the “Initial Display”. Pressing the ▶ key sends the file displayed to the serial port. The ▼▲ keys display the next or previous file stored in memory.

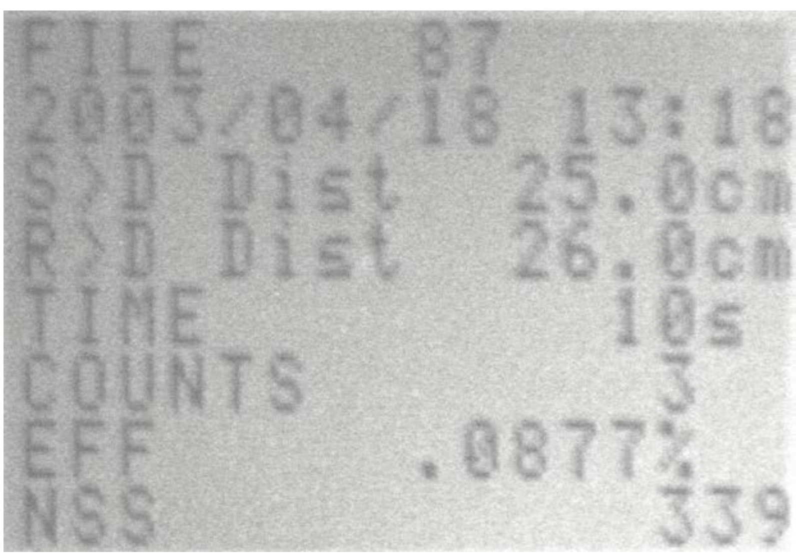


Figure 16 Files Display.

6.5 Options Menu, "View Spectrum"

The MCA (Multi Channel Analyzer) option shown in Figure 17 starts a multichannel analyzer to create a histogram of frequency of occurrence versus pulse height (spectrum). The primary use is to check the operation and calibration of the unit. Pressing the 

key enters the highlighted selection. The  keys move the cursor between options.

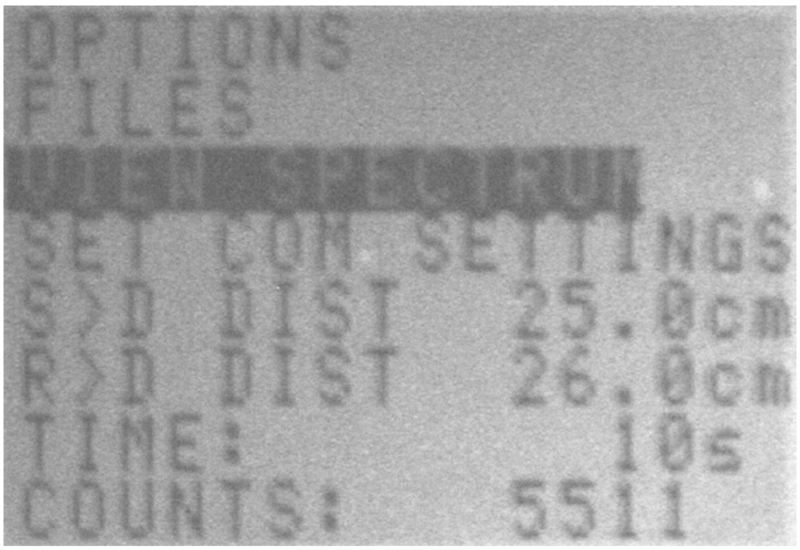


Figure 17 Option Menu, "VIEW SPECRUM" highlighted.

Pressing 

brings up the message shown in Figure 18 that indicates that pressing the

key will start the MCA mode data acquisition.

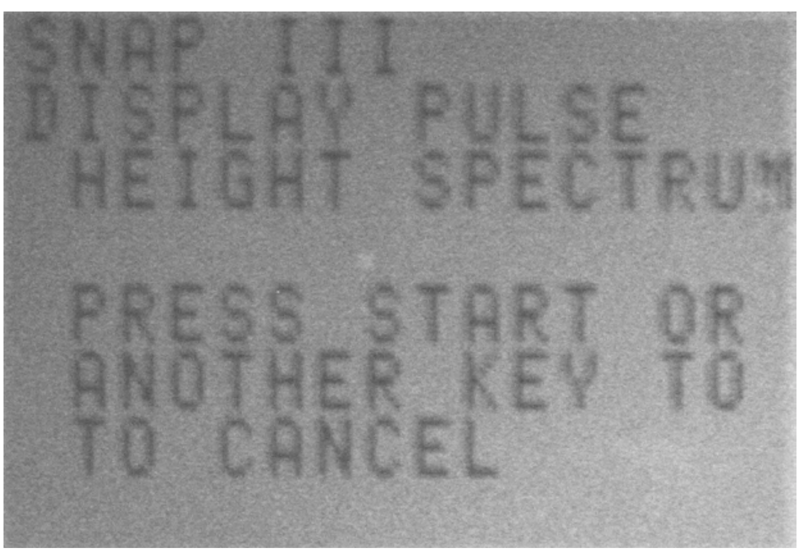


Figure 18 Spectrum Message.

6.6 Spectral Display

Figure 19 shows a typical neutron spectrum. Pressing the  key terminates the acquisition and exits to the “Initial Display” (Figure 13).

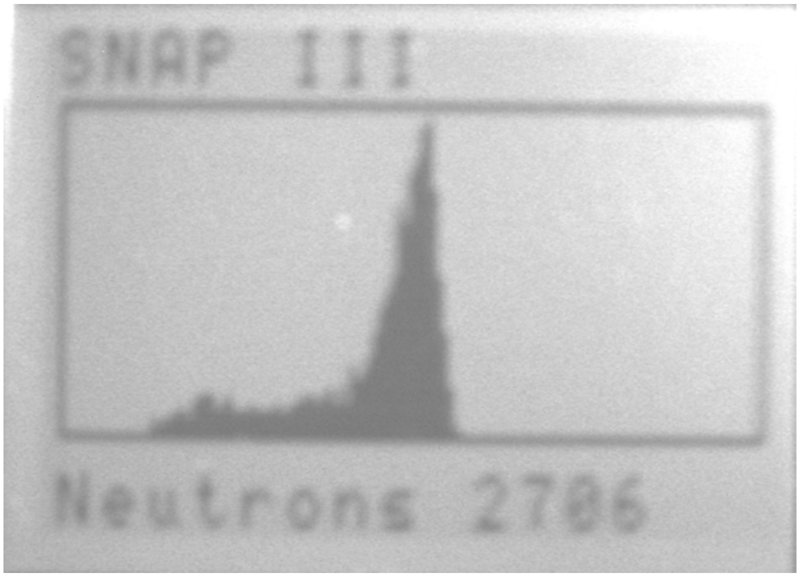


Figure 19 Typical Spectrum.

6.7 Options Menu, “Set COM. SETTINGS”

Figure 20 shows the "OPTIONS" menu with “Set COM. SETTINGS” highlighted. Pressing the  key enters the highlighted selection. The  keys move the cursor between options.

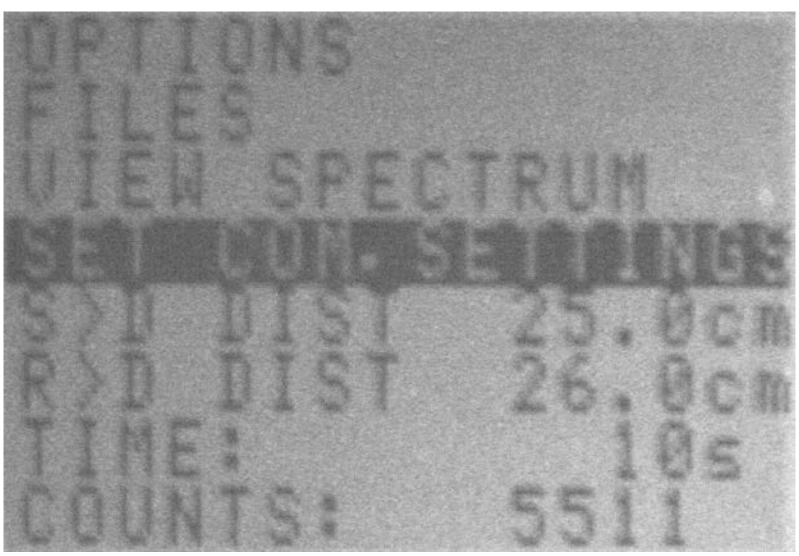


Figure 20 Options Menu, “Set Communication Settings” highlighted.

6.8 Communications Settings Page

The Communications Settings page, shown in Figure 21, enables the operator to change the Baud rate of the serial LEMO port. (The IR mode no longer is available in the SNAP and has been replaced by the 4-pin LEMO serial port. See Figure 12.) The OK key enters the highlighted selection. The ◀▶ keys move the cursor to the Baud Rate number displayed. The ▼▲ keys then increase or decrease the Baud Rate. Figure 22 shows the response when an out of range Baud Rate is entered. Pressing the OK key stores the modified settings.

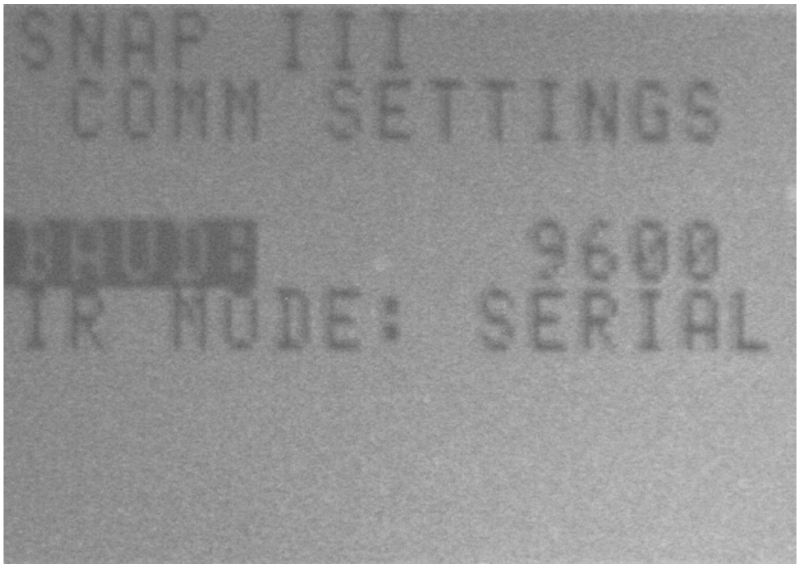


Figure 21 Communications Settings, "Baud" highlighted.

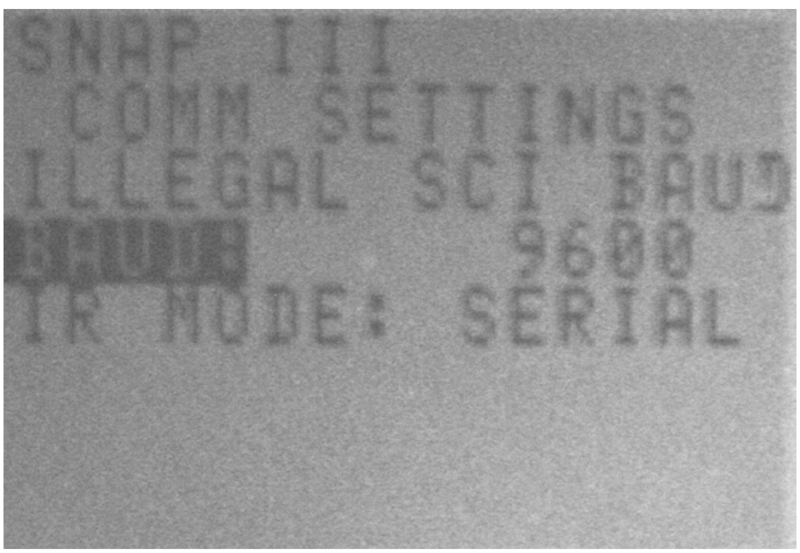


Figure 22 Illegal Baud Rate.

6.9 Options Menu, "S>D DIST" Selected

Figure 23 shows the OPTIONS menu. The last four lines of the "OPTIONS" menu allow the operator to change the collection parameters used to determine the NSS.

S>D is the source-to-detector distance parameter in millimeters.
R>D is the reflector-to-detector distance parameter in centimeters.
TIME sets the collection time in seconds.
COUNTS modifies the total counts to acquire.

The ▼▲ key moves the cursor between the lines. The ◄► keys move the cursor to the parameter to be changed. The ▼▲ keys then increase or decrease the digit value displayed. The OK key moves the cursor to the next parameter on the display. The second OK key stores the values chosen and displays the modified "Initial Display", as shown in Figure 24.

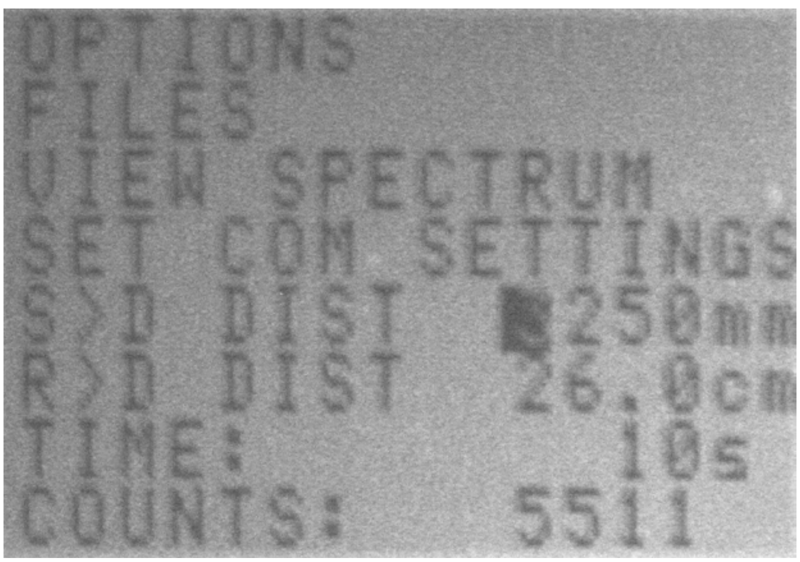


Figure 233 OPTIONS screen, changing source-to-detector distance.

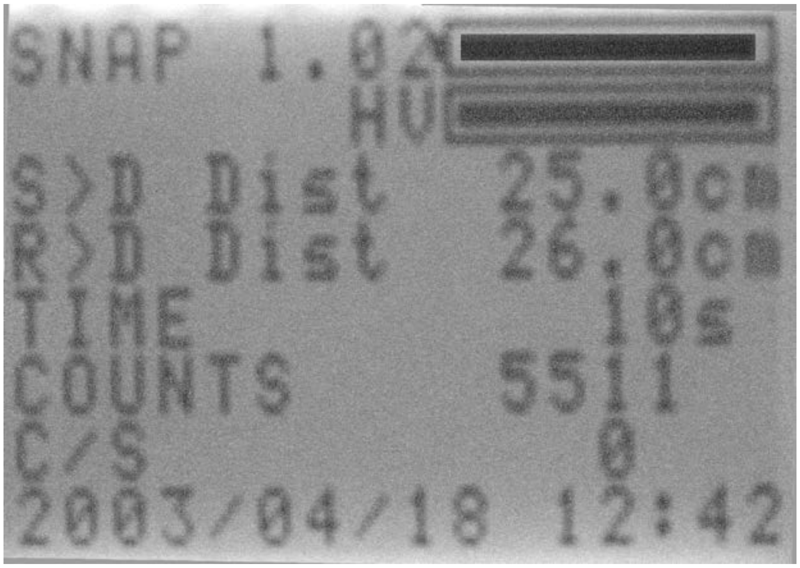


Figure 244 Initial Display, showing modified parameters.

7 CALIBRATION

Field calibration of the SNAP should be attempted only by qualified personnel using the procedures detailed in ER-QA-PRO-0163. Checking the calibration consists of using the SNAP to measure the neutron source strength of a known ^{252}Cf source. Results within 5% of the known value are acceptable.

8 SHIPPING INFORMATION

The SNAP detectors require special hazard documentation for shipment.
The official shipping name is Compressed gases, N.O.S. (Helium and Carbon Dioxide). According to the U.S. Department of Transportation the shipment is Class 2.2. The exemption that Reuter Stokes had for shipping the ^{3}He gas tubes no longer exists.

9 SPECIFICATIONS AND DATA SHEETS

9.1 SNAP III Specifications

Dimensions: 13 in. high 8 in. deep 12 in. wide

Weight: 24.25 lbs

Battery Capacity: minimum 4 hours on full charge

Charger Specifications: 6 volt 2A DC (CUI STACK™ MODEL EUA-101W-06)

9.2 Reuter-Stokes ^{3}He proportional gas tubes

Model Number: RS-P4-0804-104

Mechanical

Maximum diameter:	1.03 in (26.2 mm)
Maximum overall length:	8.06 in (204.7 mm) (including connector)
Maximum weight:	250 gm

Material

Body material:	1100-F aluminum
Connector Material	Brass, silver plated
Connector insulator	teflon
Internal insulator:	alumina ceramic
Primary gas:	^3He
Total pressure:	170.5 psia (1.17 MPa)

Electrical

Resistance:	1.00×10^{12} ohms
Capacitance:	8 pf +20%

Maximum Ratings

Maximum Voltage:	2500 volts
Maximum Temperature:	100 °C

Operating Characteristics

Thermal neutron flux range:	9.2×10^{-4} to $2.90 \times 10^{+3}$nv
Thermal neutron sensitivity:	17.3 cps/nv
Voltage Range:	1400 to 1900 volts
Resolution (FWHM):	< 15 %

Temperature range: -25°to 100°C

9.3 Original Lithium Battery Information

This section contains information about the batteries originally used in the SNAP. These batteries might still be used in some of the SNAP units. Section 9.4 contains more up-to-date information about recent batteries with the same model number.

ICP883448A-SC

Rechargeable Li-ion Battery 3.7V Swiss Made

9.3.1 Battery Charging Curves

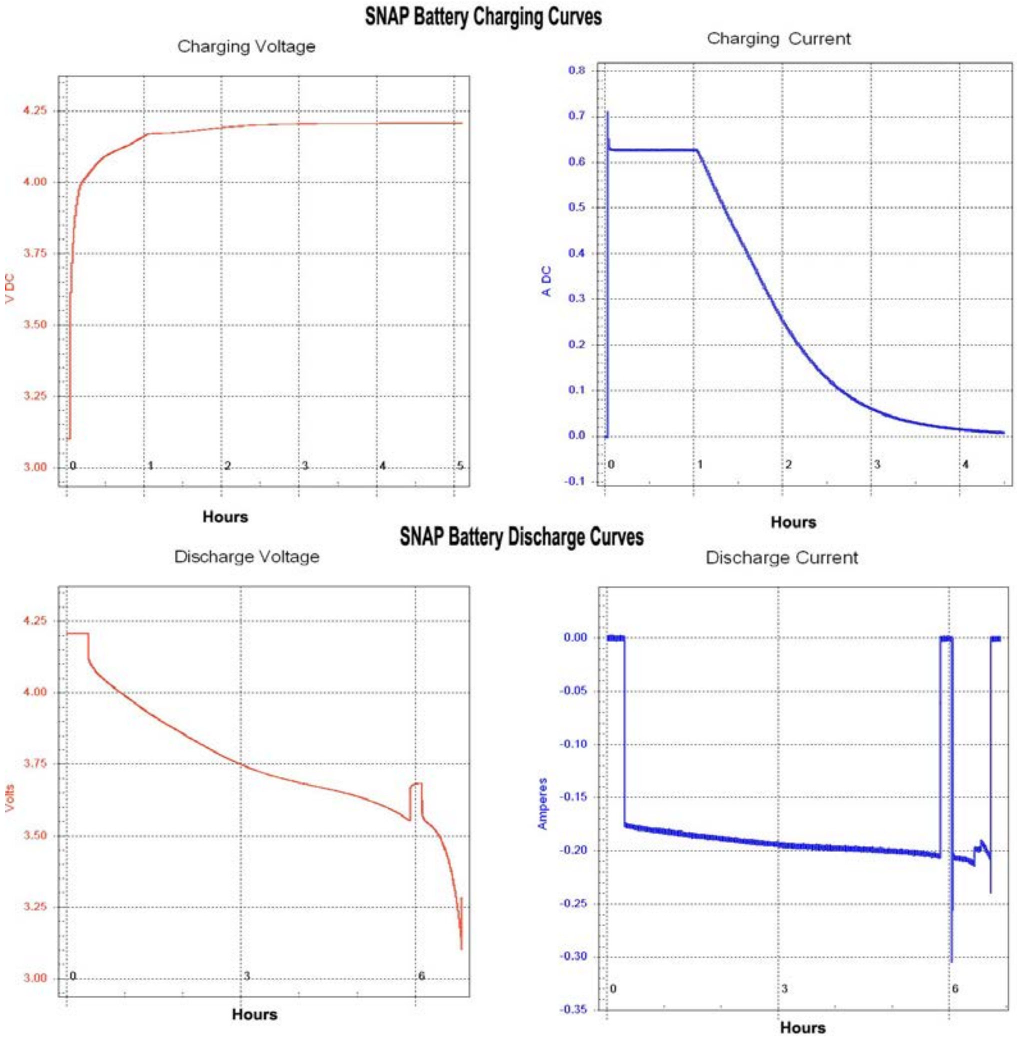


Figure 25 SNAP Battery Curves.

9.3.2 Lithium Battery Specification Sheet

ICP883448A-SC

Specification sheet

renata batteries

2.0 Description and Model

2.1 Description: Rechargeable lithium ion prismatic battery with integrated safety circuit (RSC6180)

2.2 Model: ICP883448A-SC

3.0 Specifications

3.1 Typical Capacity: 1'200 mAh (discharge at C/5 rate at 23°C)

3.2 Charging Voltage: 4.20 +/- 0.05 V

3.3 Average Operating Voltage: 3.7 V nominal (discharge at C/5 rate at 23°C)

3.4 Charging Method: Constant voltage with current limited

3.5 Maximum Charging Current: 1'150 mA

The use of a **standard laboratory power supply device** is recommended where the voltage and the current can be regulated individually. Ask RENATA for more information concerning charging devices.

3.6 Max. Continuous Discharge Current: 2'300 mA

3.7 Low Voltage Cut-off Range: (Final discharge voltage) 2.75 V

The performance, the quality and the service life of the battery may be limited significantly if the above operating parameters are exceeded.

3.8 Casing: Aluminum case and lid
Please note that the aluminum case of the cell is on positive potential.

3.9 Weight: 29.0 grams

3.10 Outer Dimension (Max.):

Height:	48.0 mm
Width:	34.2 mm
Edge Thickness:	8.8 mm
Bulge Thickness:	8.9 mm

3.11 Temperature (Operating):

Charge:	0 to +40°C
Discharge:	-20 to +60°C

3.12 Temperature (Storage): 0 to 45°C

3.13 Energy Density (Volumetric): 304 Wh/l nominal

3.14 Energy Density (Gravimetric): 153 Wh/kg nominal

9.3.2 Lithium Battery UL 1642 Safety Tests

Safety Characteristics

9.1 UL 1642 Safety Standard for Lithium Batteries
"Recognized under the Component Recognition Program of Underwriters Laboratories Inc. (October 30th, 2001)".

The following tests and conditionings were conducted in accordance with the Standard for Lithium Batteries, UL 1642, Third Edition, April 26, 1995.

- Short Circuit Test (at room temperature, fresh and cycled batteries)
- Short Circuit Test (at 60°C [140°F], fresh and cycled batteries)
- Abnormal Charging Test (fresh and cycled batteries)
- Impact Test (fresh and cycled batteries)
- Crush Test (fresh and cycled batteries)
- Shock Test (fresh and cycled batteries)
- Vibration Test (fresh and cycled batteries)
- Heating Test (fresh and cycled batteries)
- Temperature Cycling Test (fresh and cycled batteries)
- Altitude Simulation Test (fresh and cycled batteries)
- Projectile Test
- Test for Flaming Particles

9.3.3 Lithium Battery Safety Circuit

RENATA Safety Circuitry RSC6180

The safety circuitry RSC6180 protects the battery type ICP883448A-SC from destruction if current or voltage values outside the normal operating range are applied.

9.1 Typical limiting characteristics of the safety circuitry are defined as follows:

• Maximum charging current:	3.0A
• Overcharging protection limit:	4.35V
• Discharging current:	3.0A
• Lower discharging protection limit:	2.45V

9.2 Further remarks

- The safety circuitry is short circuit safe.
- The battery is protected by the safety circuitry up to a voltage of 8.5VDC* if a faulty or wrong power supply device is used.
- Although the safety circuitry can absorb a maximum voltage up to 8.5VDC*, exposure beyond the limiting characteristics mentioned above may affect reliability or cause malfunction of the circuitry. Therefore do not charge the battery under conditions not specified by RENATA S.A..
- It is not the task of the safety circuitry to take over the operational monitoring functions of a battery charger.

* A safety circuitry up to a voltage of 12VDC is under development

9.4 Recent Lithium Battery Information

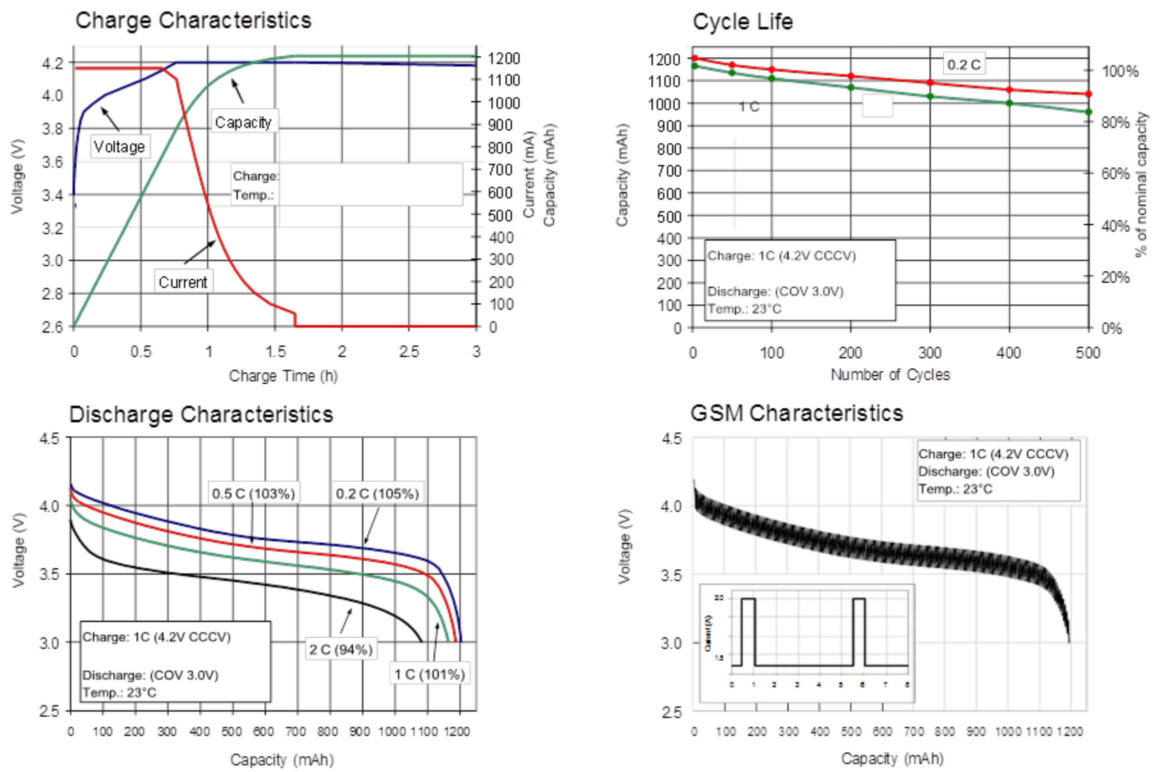
Technical Data Sheet

Specifications (Battery with Safety Circuit RSC Li-10)

Dimensions 1)	Thicknes s Width Height	8.60 +/-0.3 mm 34.00 +/-0.2
Typical Capacity 2)	1'200 mAh	
Nominal Capacity	1'150 mAh	
Nominal Voltage 2)	3.7V	
Voltage Range	4.20V -	
Weight 1)	29.0 g	
Casing	Aluminum lid and case (positive terminal)	
Energy Density (Volumetric) 2)	310 Wh/l	
– Bare cell (without Safety Circuit) 316 Wh/l		
Energy Density (Gravimetric) 2)	153 Wh/kg	
– Bare cell (without Safety Circuit) 153 Wh/kg		

1) of a fresh cell (including safety circuit)
2) charging condition: CCCV, 4.2V, max. 1C, 3 hours or C/20 at 23°C - 0.2C mA discharge current, COV 3.0V at 23°C

Typical Battery Performance



Warnings

RENATA batteries are equipped with a safety vent having a special solder with a melting point of about 100°C.

If a cell is used in abnormal conditions causing a rise of temperature (i.e. short circuit, over-charge, abusive storage at temperature higher than 100°C), the solder melts and allows release of the pressure in the cell.

Therefore,
- Solder only to the pads of the safety circuit, max. 350°C for 3 seconds.
- Avoid blocking or impairing the action of the safety vent on the cell.

For more information, please ask for RENATA's instructions for battery connection.

Appendix A Measurement Log Form

IDFT Tracking Number:	NIS-6 Number:

Measurement Results # 1

File #	Time	AcqTime	Counts	Eff. %	NSS	Notes:

Distances

S>D	R>D1	R>D2	R>D3	R>D4	R>D5

Reflector Materials

	Material R1	**Material R2**	**Material R3**	**Material R4**	**Material R5**

Measurement Results # 2

File #	Time	AcqTime	Counts	Eff. %	NSS	Notes:

Distances

S>D	R>D1	R>D2	R>D3	R>D4	R>D5

Reflector Materials

	Material R1	**Material R2**	**Material R3**	**Material R4**	**Material R5**

Measurement Results # 3

File #	Time	AcqTime	Counts	Eff. %	NSS	Notes:

Distances

S>D	R>D1	R>D2	R>D3	R>D4	R>D5

Reflector Materials

	Material R1	**Material R2**	**Material R3**	**Material R4**	**Material R5**

Measurement Results # 4						
File #	Time	AcqTime	Counts	Eff. %	NSS	Notes:

Distances					
S>D	R>D1	R>D2	R>D3	R>D4	R>D5
Reflector Materials					
	Material R1	**Material R2**	**Material R3**	**Material R4**	**Material R5**

Measurement Results # 5						
File #	Time	AcqTime	Counts	Eff. %	NSS	Notes:

Distances					
S>D	R>D1	R>D2	R>D3	R>D4	R>D5
Reflector Materials					
	Material R1	**Material R2**	**Material R3**	**Material R4**	**Material R5**

Measurement Results # 6						
File #	Time	AcqTime	Counts	Eff. %	NSS	Notes:

Distances					
S>D	R>D1	R>D2	R>D3	R>D4	R>D5
Reflector Materials					
	Material R1	**Material R2**	**Material R3**	**Material R4**	**Material R5**